WATER OPERATION AND MAINTENANCE

BULLETIN NO. 107

MARCH 1979

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UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Reclamation

The Water Operation and Maintenance Bulletin is published quarterly for the benefit of those operating water-supply systems. Its principal purpose is to serve as a medium of exchanging operation and maintenance information. It is hoped that the reports herein concerning laborsaving devices and less costly equipment and procedures will result in improved efficiency and reduced costs of the systems for those operators adapting these ideas to their needs.

To assure proper recognition of those individuals whose suggestions are published in the bulletins, the suggestion number as well as the person's name is given. All Bureau offices are reminded to notify their Suggestions Award Committee when a suggestion is adopted.

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Division of Operation
and Maintenance Technical Services
Engineering and Research Center
Denver, Colorado 80225

Trencher excavating trench for installaton of 100-mm (4-in) diameter slotted corrugated plastic drain tubing on Unit 166, Block 20, Columbia Basin Project, Washington. The large cobbles were excavated by the trenchers without mishap. The conveyor may be adjusted to vary location of toe of waste pile.

SI METRIC

WATER OPERATION AND MAINTENANCE
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INTRODUCTION

A new flume design, how to build and operate it, is described in the article starting on page 1. It makes open channel water measurement simple, accurate, and inexpensive.

Proper care of herbicide sprayer equipment, as shown in the article starting on page 9, is an important prerequisite for consistent application rates.

Have you ever had a tiger by the tail and lived to tell the tale? Read the article on page 11, it could prevent serious injury or help save a life.

Drainage is made a little easier to understand. Starting on page 13 are excerpts taken from the Bureau of Reclamation Drainage Manual.

Put that fire out quickly! Knowledge of the different types of extinguishers for the different types of fires will help. See page 19.

NEW FLUME BREAKTHROUGH FOR DITCH IRRIGATORS[1]

Now it's possible to measure water flow in open channels easily and economically.

New design methods for critical-flow flumes installed in open channels make on-farm measurement simple, accurate, and inexpensive.

Eight flumes were installed at the University of Arizona Agricultural Research Center, Phoenix, Arizona. The materials, mostly concrete and lumber (forms) cost less than $100 for the eight flumes. Total construction time for all the flumes is less than 70 hours. At $9 per hour for labor, the cost of each flume with attached readout gage would be less than $90.

Figure 1 shows the layout of the University of Arizona Agricultural Research Center (research complex and 97.2-ha (240-acre) farm). The fields are irrigated from concrete-lined ditches. Water is delivered to the southeast corner of the farm by the Salt River Project, which is the local irrigation district. From this point, the water travels through one of two pipelines. One pipeline parallels the south edge of the farm and has three outlets into concrete-lined ditches. The other pipeline outlets irrigation water

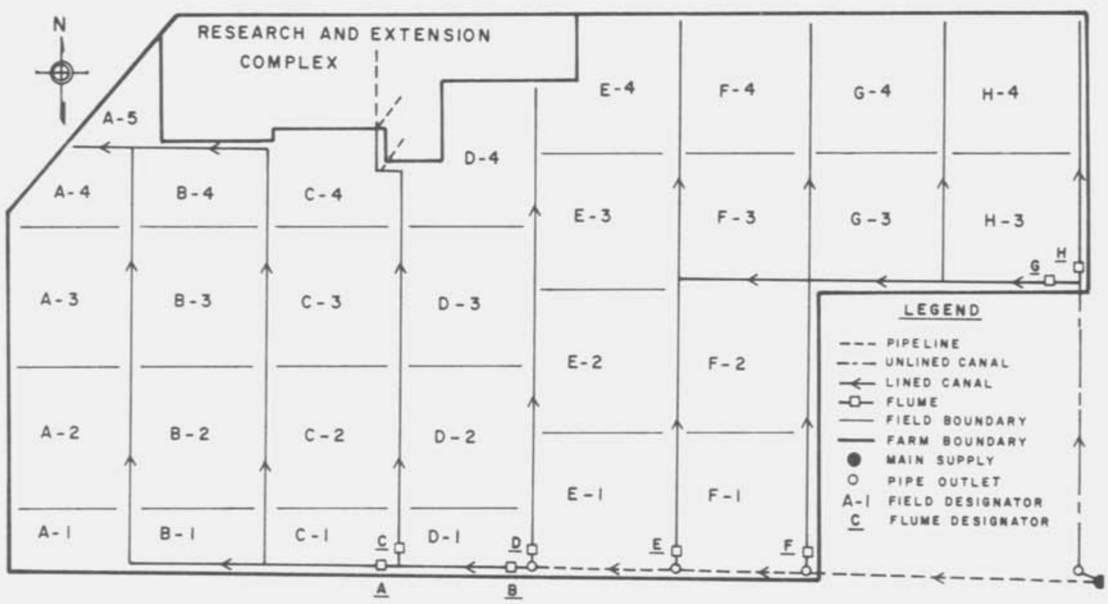

Figure 1. Flume layout of the University of Arizona Agricultural Research Center.

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[1] This article written by Albert J. Clemmens and John A. Replogle, U.S. Water Conservation Laboratory, appeared in the April 1978 issue of Irrigation Age, and is reprinted with special permission of the editor and author.

CORRECTION

Please make following correction to your copy of Bulletin No. 107:

Page 2, first paragraph, first line:

Change "minimum" to "maximum"

GPO 851-964

into an unlined ditch that parallels the east side of the farm, eventually entering lined ditches on the farm.

The flows used are typically 170-255 L/s (6-9 ft^3/s), with a minimum of 283 L/s (10 ft^3/s). Flow is often divided on the farm, with approximately 28 L/s (1 ft^3/s) going to experimental plots or lawns of the research and extension complex; and the remaining flow to one of the fields. The location of the flumes is shown in figure 1, with one flume for each possible entrance into the open channel distribution system (flumes B, D, E, F, G, and H), and extra flumes A and C to accommodate the dividing of the water.

The concrete ditches are 600-mm (24-in) deep with a 300-mm (1-ft) bottom and 1:1 sideslopes. At most of the proposed flume locations, there had been about 200 to 225 mm (8 to 9 in) of freeboard at the 255 L/s (9 ft^3/s) delivery. The ditches on the east side of fields E-1, F-1, and H-3, however, are on a nearly flat grade with only about 75 mm (3 in) of freeboard at 255 L/s (9 ft^3/s).

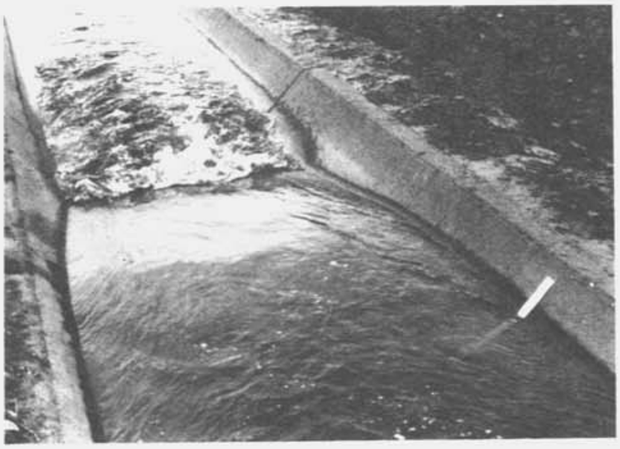


Figure 2. Flow through flume G at 210 L/s (7.5 ft^3/s)

Figure 3 shows representative normal flow depths (flow depths without the flume in place) for measured discharge rates at proposed flume locations. These depth-discharge values were used to design different flumes for different flow conditions. Other important information is the depth of flow just upstream from the flume (at the gage location shown in table 1 and in figure 4a). The two curves in figure 3 indicate the depth at the gage versus the discharge through the flume for two different sized flumes, one for a 225-mm (9-in) sill and one for a 300-mm (12-in) sill (see dimensions in figure 4 and table 1).

The selection of the proper sill is based on two criteria. First, the sill must be high enough so that the flume will not be submerged; that is, affected by downstream backwater. This requires a drop in the water surface of 38 to 63 mm (1.5 to 2.5 in) as it passes through the flume. Second, the sill must be low enough so that the canal walls will not be overtopped at the maximum expected flow rate. With these criteria in mind, a 225-mm (9-in) sill was chosen for flumes A, B, C, D, G, and a 300-mm (12-in) sill for E, F, and H.

Flume H will be operating very close to the submerged condition at high flow rates, with only about 35 mm (1.4 in) of drop through the flume. A temporary 300-mm (12-in) sill was placed in the canal to check for submergence. It verified that a 300-mm (12-in) sill would not cause submerged flow conditions. Note that despite the apparent damming of the canal, the flow is not significantly obstructed. Even for the 300-mm (12-in) sill, 350 L/s (12.5 ft^3/s) will not overtop the canal, figure 3. For other size canals, similar flumes can be designed.

In practice, the flume calibration is based on a reference from the top of the sill rather than canal bottom. Table 2 gives the flume calibration in both vertical depth and wall-slope distance as

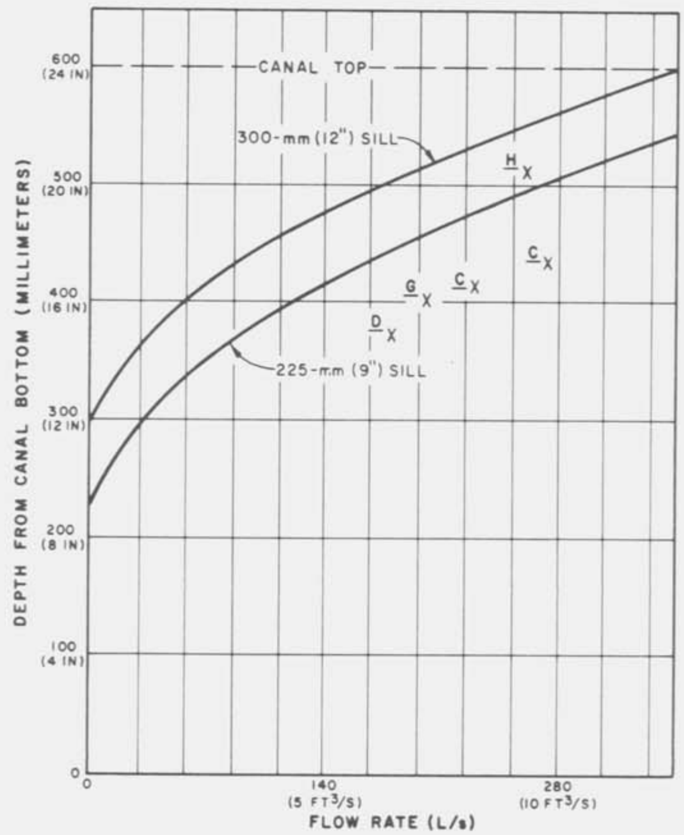


Figure 3. Depth discharge curves for 225- and 300-mm (9- and 12-in) sill heights. Individual points represent independently measured depth-discharge relationships for free-flowing canal at proposed flume locations. To avoid submergence, choose a sill height with a curve that lies above points. Too high a sill may cause canal overtopping.

referenced from the elevation of the sill top. The wall-slope distance is used for marking the gages and the vertical depths are used for registering (zeroing) wall-mounted gages. The calibrations for almost any size flume are derivable from mathematical modeling that has been verified by laboratory testing.

Analysis shows that high accuracy (on the order of plus or minus 2 percent) can be maintained using sill-based referencing even though the construction height of the sills may be off by as much as 12.5 mm (1/2 in). Likewise, an error of 12.5 mm (1/2 in) in sill width would only cause about 1.5 percent error. However, at a discharge of 227 L/s (8 ft^3/s), an error of 12.5 mm (1/2 in) in depth reading could cause nearly a 10-percent error. To get sufficient accuracy, the gages should be carefully registered by surveying to the most often used discharge, in this case 227 L/s (8 ft^3/s).

Flume Construction

Each flume consists of two sections, a sill and a ramp, and as such, resembles a broad-crested weir, figures 4 and 5. The dimensions for the two flume sizes are given in table 1. The sill was poured first. A wooden form was made for each sill, consisting of: (a) two end pieces made from 12.5-mm (1/2-in) plywood which had the cross-sectional shape of the sill in figure 4b and were notched at

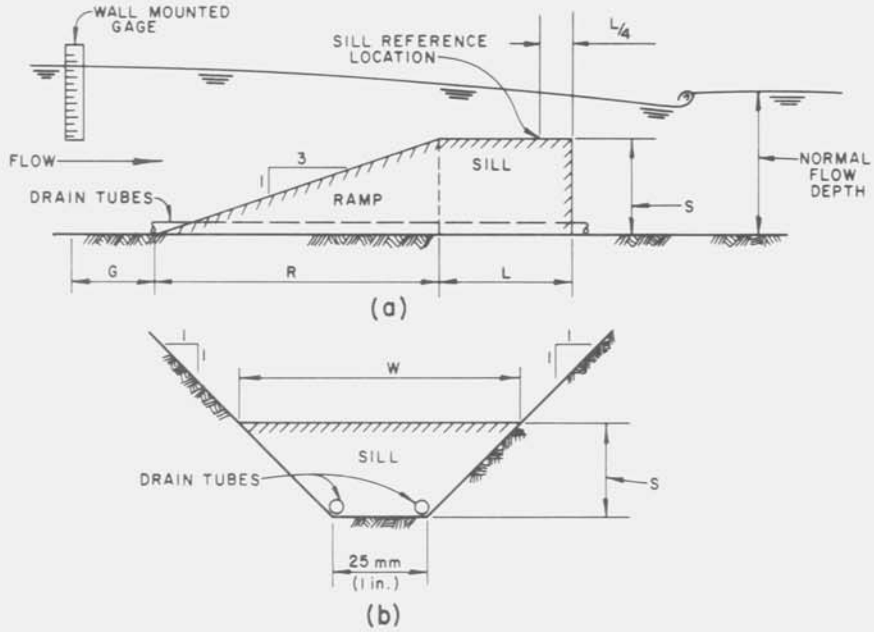
Table 1. Flume Dimensions

	Sill height S	Sill length L	Sill width W	Ramp length R	Gage location G
225-mm sill (9-in)	225-mm (9-in)	600-mm (24-in)	750-mm (30-in)	675-mm (27-in)	300-mm (12-in)
300-mm sill (12-in)	300-mm (12-in)	450-mm (18-in)	900-mm (36-in)	900-mm (36-in)	300-mm (12-in)

Table 2. Flume calibrations: Vertical Depth and Wall-slope Distance
(1:1 sideslopes - 300-mm (12 in) bottom)

	Vertical Depth (millimeters) (inches)		Wall-slope Distance (millimeters) (inches)	
Flow rate L/s (ft^3/s)	225-mm sill (9-in)	300-mm sill (12-in)	225-mm sill (9-in)	300-mm sill (12-in)
28 (1)	74 (2.95)	67 (2.66)	104 (4.17)	94 (3.76)
56 (2)	112 (4.49)	102 (4.08)	159 (6.35)	144 (5.77)
84 (3)	143 (5.71)	130 (5.21)	202 (8.07)	184 (7.37)
112 (4)	169 (6.74)	155 (6.19)	239 (9.54)	219 (8.76)
140 (5)	192 (7.66)	177 (7.06)	271 (10.83)	250 (9.99)
168 (6)	212 (8.49)	196 (7.85)	300 (12.00)	278 (11.10)
196 (7)	231 (9.25)	215 (8.58)	327 (13.09)	303 (12.13)
224 (8)	249 (9.95)	232 (9.26)	352 (14.08)	327 (13.09)
252 (9)	266 (10.62)	248 (9.90)	376 (15.03)	350 (14.00)
280 (10)	281 (11.24)	263 (10.50)	398 (15.90)	371 (14.85)
308 (11)	296 (11.83)	277 (11.07)	418 (16.73)	392 (15.66)
336 (12)	310 (12.40)	291 (11.62)	438 (17.53)	411 (16.43)

* For ease of conversion, in this article, the numerical relationship of 1 inch = 25 millimeters was used rather than the exact relationship



Figures 4a and b

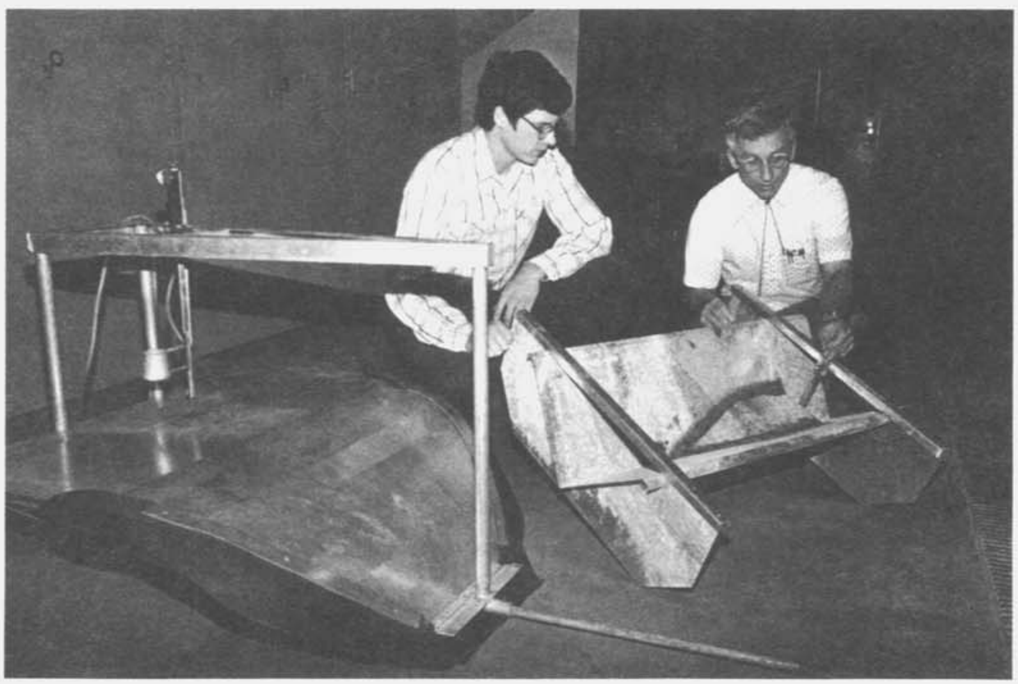


Figure 5. Research hydraulic engineers Albert Clemmens and John Replogle with portable aluminum flumes used in determining dimensions of concrete flumes to be installed in farm ditches.

the bottom to allow insertion of 25-mm (1-in) diameter plastic pipe to drain the ditch for mosquito control; (b) wire ties, used to hold the end pieces together while the concrete sets; and (c) wooden spacers, used to hold the end pieces apart temporarily until the concrete could be poured. The end pieces of the sill form were used not only to contain the concrete but to provide level guide edges for screeding.

The ditches were cleaned prior to placing the forms. The forms were set into the ditch, leveled with a carpenter's level, shimmed to position with pieces of wood shingle, and the drain tubes set into place. As the concrete was poured, the spacers were removed. Once the forms were filled, the surface was screeded level and trowel finished. While the surface need not be smooth (broom finish is acceptable) it must not have any major irregularities.

Once the concrete had taken initial set, the forms for the upstream half of the sills were removed and a concrete ramp was hand trowelled into place. The exact shape of the ramp is not critical, but it should approximate a 3:1 slope, as indicated in figure 4. It should be finished flush with the sill edge making sure that it is not higher than the sill. The ramp does not have to taper to zero thickness; it can be abruptly ended at the point where it becomes 50 to 75 mm (2 to 3 in) thick.

The side-wall gages were made from 3.125 x 37.5-mm (0.125 x 1.5-in) aluminum bar stock and were individually stamped using chisel, hammer, and a metal-stamping die set (for example, at 104.25 mm (4.17 in) from the zero end, stamp "-1-" on a gage adapted to the 225-mm (9-in) sill, table 2).

Holes for gage placement can be drilled with either a battery powered drill or an electric drill and a generator. Six and 35 hundredths-millimeter (1/4-in) holes were drilled into the side of the ditch at the gage location (figure 4a). Lead anchors were placed into the holes and stainless steel screws screwed into the anchors to hold the gage in place. The gage was surveyed into place prior to drilling to determine the approximate location of the holes, and rechecked after final attachment. Slotted holes can be made in the gages for easy installation.

To compensate for a nonlevel top, the rod reading should be taken on the sill along the center line and approximately at the sill reference location (figure 4a). The 227-L/s (8-ft^3/s) mark on the gage should be located on the canal wall as shown in figure 4a at the proper elevation above the sill (for the 300-mm (12-in) sill), 231.5 mm (9.26 in) above the sill (table 2). The gage would then be most accurate around 227 L/s (8 ft^3/s), and errors, if any, would be relegated to the least used flow rates. Flume C was registered at 28.3 L/s (1 ft^3/s) since it will be used primarily in the lower flow range. However, ditch sideslopes at flume C were so good that a check on the 227-L/s (8-ft^3/s) mark showed it to be off by less than 0.0009 m (0.003 ft); so that high accuracy exists throughout the flow range.

Cost Analysis

Table 3 shows a breakdown of the total time spent and materials used in placing the eight flumes on the University of Arizona farm. One 1.2 by 2.4-m (4 by 8-ft) sheet was used to construct the end pieces for the sill forms. These end pieces and the spacers were saved and can be reused. The wire ties were the only nonreusable items. Slightly more than 1 m^3 (1.5 yd^3) of concrete was used in the eight flumes. The cost shown represents the cost for premixed concrete, including a rental trailer. Mixing on site would probably have reduced both the cost of the concrete and the time for pouring the ramps. In large quantities, baked enamel gages can be custom ordered for about $20 each.

Figure 6. Field staff using portable flume on research farm to determine sill height required for permanent flume installation.

Table 3. Cost Analysis for Eight Flumes

	Labor, hours		Dollars
Building and tying forms	8	Forms	18
Placing forms	1	Concrete (1.15 m^3) (1.5 yd^3)	66
Pouring sills	12		
Pouring ramps	10	Drain tubes (21 3 m) (70 ft)	7
Stamping gages	24		
Installing gages	11	Gages	2
	66		$93

Per flume cost = 8.25 hours of labor plus $11.50

RESEARCHER TALKS ABOUT NEW FLUME

"This device is more economical, more accurate, and easier to install than any flume that has ever been available. It makes other types obsolete."

"That's a strong statement, but we can support it," said USDA's Dr. John Replogle, research hydraulic engineer, who has devoted considerable time during the last 10 years developing the new, critical-flow measuring device.

"Cost of the new flume is 1/10 to 1/3 of other types, it's precise within plus or minus 2 percent, compared to about plus or minus 10 percent precision with submerged flow flumes, and it can be installed in a single day."

Replogle compared the new flume to two other types of measuring devices, the standard thin-plated weir and the Parshall flume.

"In order to make a thin-plated weir work, you must have more head than is usually available in most fields. They work fine when you can afford 0.6 or 0.9 m (2 or 3 ft) of water surface drop. But this is hard to find on most irrigation farms. The Parshall flume has about a dozen surfaces that must be formed or constructed very precisely, making it very expensive to build in the field. Our flume allows for both unevenness of ditch proportions, as well as some sloppiness of construction."

Other differences? "With other types of flumes, we had to jackhammer the ditch and tailor it to fit the flume. Now we can make the flume fit the ditch. That's highly desirable when you consider we have 14 million ha (35 million acres) with existing canal systems; admittedly, a lot of these hectares (acres) are serviced by unlined canals, so you would not have to start with the jackhammer.

"With a wall-mounted gage, giving a direct reading, technical assistance is only necessary during construction of the flume. You need no books or charts or tables. And, you can't read the wrong tables if you don't have any. With the wall-gage arrangement, you don't even have to get out of your pickup to take a reading."

What if you have earthen ditches? Replogle says that by building a simple form and pouring 2.4 or 2.7 m (8 or 9 ft) of concrete to form a ditch-like section, the sill-type flume can still be used.

The researcher is hopeful that the flume will be adopted quickly. He cites several reasons.

"Overirrigation causes wasted water, leaching of fertilizer nutrients, flooding, and downstream pollution. High efficiency systems, such as level basins, which are being used in increasing numbers, aren't very forgiving when too much water is used. In hot climates, too much water will scald sensitive plants. Also, energy costs, especially in pumping districts, penalize overirrigation. And, of course, crop yields in general suffer from either too much or too little water.

"It simply boils down to the fact that you can't do a good job of irrigation without measurement.

"To measure is to know."

CHECK SPRAYER PARTS NOW FOR EVEN HERBICIDE DISTRIBUTION[2]

An improperly calibrated sprayer may be wasting your herbicide and robbing you of top yields.

Even if you follow label instructions, you may not be getting the correct herbicide application because the sprayer is not in top working condition. Because of this, Dr. Douglas Murphy, Stauffer Chemical Company agronomist, suggests a careful sprayer inspection.

The most important components to inspect are the pump, nozzle tips, agitation system, and the pressure regulator.

Nozzle Tips

The nozzle tip may be the most neglected sprayer component. Yet, these tips make the difference in uniform herbicide distribution on foliage or the soil surface.

Nozzle tips should be checked for wear at least every other day when abrasive chemical materials are being applied, especially if brass tips are used. Nozzle tips have a tendency to wear and, in many cases, become larger, delivering too much herbicide. Tests show that wettable powders may wear tips enough to increase application rates by 12 percent after spraying just 20 ha (50 acres).

One way to stretch nozzle life is proper cleaning. Tips should be removed and washed. If this isn't practical, you can use a soft toothbrush to remove clogging. Don't clean tips with nails or wire because these items may enlarge the orifice. Replacing the nozzle tips each year is a good practice to help insure proper herbicide coverage.

Brass and aluminum nozzle tips are the least expensive but have the shortest life span. Plastic tips will last about twice as long as brass tips while stainless steel tips, the most expensive, will last three times longer than brass tips.

The three major categories of spray nozzles are flat spray, cone spray, and flood spray nozzles.

Cone spray nozzles are designed to operate at higher pressures than flat spray nozzles. Cone nozzles are either solid or hollow nozzles. The solid cone operates at high pressures and is best suited for insecticide application. On the other hand, hollow cone nozzles operate efficiently at a range of 200 to 350 kPa (30 to 50 lb/in^2). They deliver a small volume of spray which is best suited for post emergence application.

For broadcast applications of preplant incorporated and preemergence herbicides, a small volume of liquid is sufficient for adequate coverage of the soil and good weed control. Because of this, flat fan nozzles are best suited for these types of applications.

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[2] Reprinted by special permission of the editor from Nebraska Farmer, March 4, 1978 issue.

Flood type nozzles are useful for high volume coverage at low pressures. These nozzles deliver a spray of large droplets in relation to flat spray and cone nozzles. This is an advantage where drift from herbicide could be a problem.

Roller Pumps

The most common pumps on herbicide sprayers are roller and centrifugal types. Each has its advantages and disadvantages. Roller pumps, according to Murphy, generally cost less, are easier to maintain, and will operate efficiently at tractor power takeoff speeds. But they also may wear more easily than the centrifugal pump.

Abrasive chemicals can be used safely in centrifugal pumps. These pumps also can deliver high volumes of liquid at relatively low pressures. However, centrifugal pumps require some type of "speed-up mechanism," such as a belt or pulley.

Moderate Agitation

Constant agitation is another important factor in insuring uniform herbicide mixture. Without it, herbicides can settle to the bottom of the tank causing uneven application. Moderate agitation is needed to offset this problem. Don't use excessive agitation when tank mixing several chemicals, because one of the chemicals may settle out and set up in the spray tank.

Check small quantities of the chemicals in a jar before tank mixing if you have any doubts about the compatibility of a particular combination.

A faulty pressure regulator can cause varied application rates and thus inconsistent weed control. It is important to have the pressure regulator in top working condition for maintaining a constant delivery of the spray mixture.

YOU MAY HAVE A TIGER BY THE TAIL![3]

Rollin Schnieder, Extension safety leader at the University of Nebraska, sent word about a fatal accident involving the use of a nylon tow rope. He also mentioned other incidents in his state with these ropes that could very well have resulted in death or serious injury.

The young man who was killed was using a 38-mm (1-1/2-in) nylon rope attached to a tractor to pull an earth mover. When the rope separated, it brought along a piece of chain that crashed through the rear window of the tractor cab, striking the operator in the back of the head. The same accident nearly claimed another life when a man standing by outside was almost run over by the duals as he tried to jump onto the tractor and get into the cab to stop the rig.

In another mishap, which could have been worse, a man was pulling a piece of equipment with a tractor when something snapped. A clevis on the end of the rope was thrown forward between the tractor's dual rear wheels with such force that the operator was afraid if he tried to get it out he would damage the tires. One of the duals had to be removed to retrieve the clevis. Had the clevis been fired at a slightly different angle, it could have literally destroyed the operator.

Nylon towing ropes are popular because more energy can be thrown into them, such as by a running start, than into ordinary ropes or chains. They act like a big spring, stretching up to 35 percent, which then provides tremendous recoil action and extra "umph" to dislodge a mired vehicle, stump, or tree, or to get a heavy static load moving. Also, for all their strength, they are much lighter and easier to handle than chain. Long lengths pose no problem and make it possible to tow from points of good traction, some distance from the towed vehicle or object. Twenty-five-mm (1-in) ropes are rated for 11 250 kg (25,000 lb), and 38-mm (1-1/2-in) ropes will top 27 000 kg (60,000 lb), enough for some pretty husky tractors or obstinate loads.

During a recent Nebraska Tractor Power and Safety Day, Schnieder used a 25.4-mm (1-in) nylon rope to pull another tractor out of a mudhole they prepared for the demonstration. The 9.1-m (30-ft) rope stretched about 2 m (6 ft) when the towing tractor "hit" the load from a running start. Schnieder pointed out, however, that if the rope or hitch were to fail, it could flip forward like a giant slingshot. The greatest danger comes if a piece of metal, such as a clevis or shackle, is thrown forward with it.

A lot of pent-up energy can be suddenly released by recoil of the nylon tow rope due to excessive stress or improper hitch. In one case, a Nebraska man was using a crawler tractor with a 38-mm (1-1/2-in) nylon rope to pull trees. It broke loose and a schackle on the end of the rope shot right through a 16-mm (5/8-in) cast-iron differential case. Again, luck was with the operator, as it could have killed him instantly.

Schnieder cited a fourth incident in which a van was being pulled from mud by a new pickup truck. A nylon rope was attached to the bumpers of both vehicles. When the truck "hit" the load, its rear bumper was wrenched off and crashed through the front windshield of the van.

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[3] Reprinted by special permission from the Editor, Farm Safety Review, National Safety Council.

A story recently appeared in a Pennsylvania newspaper about the disturbing outcome of a giant tug-of-war involving 2,200 junior high school students. They were using a 16-mm (5/8-in) 610-m (2000-ft) long nylon rope for the competition. When the rope suddenly snapped, students near the point of the break relaxed their grip, but those in the back continued to pull. The rope whipped through the hands of some of those who had relaxed. At least four of the kids suffered severed fingers or fingertips, and nearly 200 sustained other hand and finger injuries. "The rope sliced through muscle, tendon, and bone," said a spokeswoman at a nearby medical center. "It could have been the snap or the nylon rope running through their hands at such high speed that took the fingers right off. Some of the children were cut so deeply that the tendons were severed in both hands," she reported.

Nylon ropes certainly have their place, but they must be used with care. There should be no metal at the end of the rope such as a clevis, shackle, or chain to become a deadly missile in case of failure. Bystanders should be well back, as a snapping rope could cut them down. Inspect the rope often and avoid dragging it around. Make sure the rope is big enough for the job. In the case of the Pennsylvania youngsters, a 16-mm (5/8-in) rope simply couldn't take the energetic pull of 2,200. Make sure that the hitch is secure – with a running start, you are subjecting it to tremendous stress.

Probably there are other such incidences in other states. If you know of any in your area, we would like to know about it. And please warn users of nylon ropes out your way to be careful! They can be lethal.

DRAINAGE[4]

A simple but comprehensive definition of adequate drainage is the removal of excess water and salt from the soil at a rate which will permit normal plant growth. Adequate drainage also may be defined as the amount of drainage necessary for agriculture to be maintained successfully and perpetually. The prime objective should be to design and construct a drainage system which has optimum integration of soils, crops, irrigation, and drainage. The benefits of adequate drainage are: a longer growing season, increased soil tilth, early and more vigorous plant growth, larger yields, a wider selection of crops, decreased cost of production, vector and weed control, and dry, firm land surfaces.

Drainage can be either natural or artificial. Most lands have some natural surface and subsurface drainage. When natural drainage is inadequate to handle the water reaching the land by either natural or artificial means, manmade or so-called "artificial" drainage is required. Artificial drainage thus fills the gap between that provided by nature and the established need. This is usually done by supplementing existing natural systems. For example, natural watercourses can be deepened or, where no suitable ones exist, new watercourses can be constructed. Almost every physical aspect and condition of lands, as well as man's potential agricultural use of them, will affect the ultimate drainage requirement.

Drainage Nomenclature

Drainage nomenclature is somewhat complex and has been developed from conditions such as the source of water to be moved, when and where the drains are to be built, and their function. Drains may be either surface or subsurface, open or pipe, constructed concurrently with project development or deferred. They sometimes consist of wells (recharge, relief, or pumped) and may fall within various functional classifications:

Surface drainage.–Surface drainage is the removal of water from the surface of the land. The water may be from excess precipitation, water applied in irrigation, losses from conveyance channels and storage facilities, or water which has seeped from ground water at a higher elevation. Control of surface water is normally accomplished by providing channels to facilitate its removal.

Subsurface drainage.–Subsurface drainage is the removal or control of ground water and the removal or control of salts, using water as the vehicle. The source of water may be percolation from precipitation or irrigation; leakage from canals, drains, or surface water bodies at higher elevations; or from artesian aquifers. Generally, any drain or well which is designed to control or lower the ground water is considered subsurface drainage.

Open and pipe drains.–Open drains are channels with an exposed water surface. Pipe drains are buried pipe regardless of material, size, or shape. Generally, all of the nomenclature for other types of drains may be applied to either open or pipe drains. Drain size and purpose, physical condition of the soils, topography, required drain spacing, and annual operation and maintenance costs largely dictate whether drains are to be open or pipe.

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[4] Excerpts from Drainage Manual published by Bureau of Reclamation, 1978.

Deferred drainage.–Deferred drainage is that which is provided after project works have been constructed and the irrigation has begun. The deferral of construction of such drains usually is necessary because of the difficulty of locating and designing them accurately before the lands are irrigated and the drainage problem becomes evident. The term "deferred drainage" is more often applied to subsurface drainage since the need for surface drains which are to be constructed as a part of the initial project works is generally more evident. Bureau of Reclamation policy requires that deferred drainage be included in the project plan and cost estimate. Only an estimate can be made as to when these expenditures will be required. Experience with past projects shows that about 50 percent of these drains are installed during the first 15 years of project operation. Drainage installations are essentially complete after 30 years unless major changes in water use occur.

Function of drains.–The nomenclature used for technical aspects of drainage is based on the function of the drain. The five types of drains are designated relief, interceptor, collector, suboutlet, and outlet:

Relief and interceptor drains are installations with the principal function of controlling ground-water levels. They form the upstream portion of the land drainage system, and the distinction between them is based on the slope of the ground-water body they control. Relief drains are used to effect a lowering of ground water over relatively large flat areas where the source is percolation from precipitation or irrigation, and where gradients of both the water table and subsurface strata do not permit sufficient lateral movement of the ground water. Interceptor drains are used to cut off or intercept ground water which is moving downslope from some source. Both relief and interceptor drains may be constructed as either open or pipe drains. They are designed as open drains when they are required to receive irrigation surface waste and excess precipitation from adjacent fields.

Collector drains receive water from subsurface relief or interceptor drains and from farm surface drains carrying irrigation surface waste and storm runoff. Because collector drains control ground water as well as receive flow from tributary subsurface drains, they must be designed with a normal water surface at or below the depth which will provide effective subsurface drainage in adjacent or tributary areas. They may be either open or pipe drains depending on the volume of water to be handled, the available gradient, and whether their tributaries are open or pipe drains.

Suboutlet drains have the principal function of conveying water from collector drains to the outlet drain. In general, they are located in topographic lows such as draws and creeks but can also be constructed drains. These drains receive inflows from a number of collector drains and canal and lateral wasteways. Suboutlet drains are similar in function to collector drains, except they usually are not required to serve as subsurface drains in the control of ground water to prescribed elevations. They may be located entirely within the project area or they can be the outlet for lands not included in the project.

Outlet drains convey collected water away from the drained areas or project. The outlet drain is usually a natural channel in the topographic low for the area to be drained, but where a natural channel does not exist, one can be constructed.

Inverted, relief, or pumped wells.—These special installations may be used to dispose of surface water, to control ground-water levels, or to relieve hydraulic pressures where local physical conditions can be adapted for their use.

Selection of the optimum drainage plan and the design and construction of adequate and successful drainage facilities depend upon the reliability and adequacy of the basic drainage data. The data requirements for a particular drainage problem vary with the type of problem and the degree of importance of the investigations or report being prepared. The basic data must be sufficiently representative to permit selection of a good drainage plan from which a functionally sound drainage system can be designed and constructed. Cost estimates must be made which are reasonably accurate for the purposes intended. Inadequate or unreliable data introduce serious risks in determining the drainage requirements and cost estimates.

The basic data must provide a knowledge of: (1) capacity of the soils to transmit water; (2) amount, source, movement, and chemical characteristics of the water that must be transmitted; and (3) available hydraulic gradients, both natural and those induced by man. Sufficient data must be gathered to esitmate the effects of the drainage plan on both the social and economic environment.

Operation and Maintenance of Drainage Systems

Efficient drainage systems must ultimately be provided on all irrigation projects when natural drainage conditions are inadequate to remove surplus water and salt. This surplus water may include waste from the irrigated farms, surface runoff from snow and rainfall, seepage and leakage from project canals and distribution systems, artesian water, and percolation from farm irrigation. Timely performance of preventive and regular maintenance on project drainage systems is absolutely necessary if the systems are to perform the functions for which they were designed and built. Project drainage systems should be thoroughly examined periodically to determine if they are functioning properly and if maintenance is required.

Occasionally, operation and maintenance forces on Bureau of Reclamation projects are required to design and construct open and pipe drains. These drains should be designed and constructed under the same criteria used when the work is done by Reclamation engineers.

Buried Pipe Drainage Systems .—Buried pipe drainage systems properly installed, generally need very little care to keep them operating satisfactorily; however, newly constructed systems required close vigilance during the early years of operation. Proper care of the system during this early period will increase the effectiveness of the drains and will often eliminate the need for future costly maintenance. Drainage system failures or partial failures are usually associated with unstable soil conditions which cause shifts in pipe alinement and grade; collapsed tubing; pulled joints; and plugged outlets, pipes, and manholes.

a. Pipe drain outlet.—All pipe outlets should be inspected in the spring and after heavy rainstorms to ensure that the pipe still has a free fall into the open drain and that no erosion has occurred on the side slopes which could cause the outlet pipe to be displaced.

Flap gates, when required on the pipe outlet to keep floodwater in the open drain from backing up into the pipe, should be inspected at least once a month. Rodent screens that have been installed on pipe outlets should be checked periodically to be sure they are in place. Where rodent screens have not been installed, the pipe outlet should be inspected periodically for rodent nests. All pipe outlets should be protected by fencing if farm animals are allowed in the area.

b. Manholes or sand traps.–Manholes are used at any point on a pipe drain where they can be justified and at junctions and major changes in alinement. It is very important that the manholes be kept clean, and particularly important during the initial operation of the system. Manholes should be inspected once a week when the drains are first laid, since failure to clean them has often caused many drainage systems to become plugged. Pumps are available which can be used to remove sand from manholes. Any erosion or settlement around the outside of the manhole should be repaired immediately. Manholes should not be used as surface waste disposal outlets, and no one should be permitted to remove the top 0.9-m (3-ft) section, replace the cover, and thereby bury the structure without written consent of the control agency. Water levels should not be allowed in the manholes higher than the top of the inlet pipe.

When using mechanical cleaning rods in manholes, care should be taken so that the whipping motion of the cleaning cable does not damage the ends of the inlet and outlet pipes. Silt and sand trapped in the manhole should be cleaned following any drain cleaning upstream.

Manhole covers should be fastened down securely at all times, except during cleaning operations or inspection. This is to keep trash out and to prevent small children and animals from falling into the manhole.

c. General maintenance of pipe drains.–A record should be established immediately after a drain is completed on the amount of flow at each manhole and at the drain outlet. This can be done by measuring the depth of water in the pipes that discharge into the manholes and by actually measuring discharge at the drain outlet. If the discharge at any of the measuring points drops suddenly, additional investigations should be made since there is a good possibility a segment of the drain has been completely or partially plugged. The area along the pipe drain should be inspected for sinkholes, wet spots, or tree growth, as these are good indicators of potential trouble locations.

If a small sinkhole is discovered, it should be backfilled and inspected later for any additional settlement. If a large sinkhole is found, a fairly large hole should be dug down to the drain because large sinkholes often develop over broken pipe or over joints that have separated. If the pipe is broken, it should be replaced immediately. Joints that have pulled apart can be repaired satisfactorily by placing pipe butts (broken pieces of pipe) over the joint and backfilling around the joint with gravel.

Wet spots that suddenly appear over pipe drains are good indicators that the drain has been completely or partially plugged. If the drain is only partially plugged with sediment, the plug can often be removed by placing a ball somewhat smaller than the pipe upstream from the wet spot. This method has been used very successfully to flush sand and silt from pipe drains. Sewer rods can also be used both in concrete and clay pipe to probe and clear the drain. In recent years, high-pressure jets have been particularly useful in cleaning plastic tubing drains. In some cases, a plug in the drain will have to be located and removed by uncovering and replacing a section of the drain.

Broken pipe, pulled joints, or plugged drains should be repaired as soon as possible so that the drainage system will function as intended. Plugs in older pipe drains are usually caused by tree or plant roots. Copper sulfate injected into the drain system will usually kill the roots, and by using a cleaning tool operated from the downstream side, the dead roots can be broken off and washed out to the nearest manhole for removal. When manholes are not available, a hole should be excavated to the drain downstream from the plug and one or more pipe joints removed so that the cleaning equipment can be inserted into the pipe. When using this method, a screen should always be placed over the pipe opening on the downstream side to prevent roots or other material from entering this portion of the drain.

Periodic checks should be made along the pipe drains to ensure that trees and shrubs have not started to grow over or near the drains. New growth should be killed by spraying with acceptable chemicals, if practicable. If there are trees and shrubs growing near the drains that cannot be removed, the drain should be treated with copper sulfate to kill the roots. The first treatment should be made in April or early May, and if the roots are a serious problem a second treatment should be made in August. The copper sulfate will not stop new root growth, so this treatment will have to be made annually. State water quality standards must be followed closely when drains are treated with copper sulfate or other chemicals.

Open drainage systems.–Open drains require regular maintenance to keep them functioning as designed. The frequency and degree of this maintenance depend upon the climate, amount of rainfall, and the depth that the ground-water table must be kept below the ground surface. Shallow surface drains in stable material generally require only spot cleaning annually and a complete cleaning about every 5 years. In unstable soils, annual cleaning might be required along the bottom of the drains to maintain design depth, particularly if pipe drains outlet into the open drain. In the more stable soils and deep open drains, chemicals used periodically will prevent or kill weeds, willows, and tules. The weeds should be removed after they have been killed by chemicals so that the drain section is kept clean. All open drains will require some degree of maintenance after a large storm. A special problem is keeping open drains clear of tumbleweeds, which can cause serious erosion problems around structures.

All spoil banks should be planted to grass and should be releveled and replanted after bank cleaning. This is done mainly to stabilize the excavated material to keep it from blowing or washing back into the drain and to provide a suitable roadway for maintenance. The side slopes of the open drain, particularly the sides above the water surface, should also be planted to grass and fertilized every 2 years. Maintenance roads require spot repair in the spring and after large storms.

Inlet openings, made through open drain banks for surface water, should be installed using pipe inlets or lined channels. Properly installed, these inlets usually require inspections only after large storms or when the open drain is being cleaned. Under no condition should an unlined cut be allowed through the drain bank. When pipes smaller than 450-mm (18-in) diameter are used for these surface inlets, they should be inspected frequently during the spring to see if weeds have plugged the pipe. All grade control structures should be inspected periodically to check for undercutting or settlement and to determine that the trashracks and baffles are not plugged with weeds.

All livestock water accesses to the drain should be covered with rock riprap or paved with concrete and fenced. All fences across the drain section should be inspected and cleaned of weeds and trash each spring and after large storms.

Wide-bottomed, shallow floodway channels should be greased on the bottom and sides. The grass should be clipped to a height of 100 or 125 mm (4 or 5 in) at least once a year. The banks and sides should be fertilized as needed. Grazing on these grassed areas should be controlled, particularly in early spring.

Natural waterways used as drains should be left in their natural state as much as possible. Spot filling of eroded sections with rock or gravel should keep the channel stable, and smaller sections that erode under perennial flows should be rock lined. All inlets for surplus irrigation or rainfall runoff should consist of pipe inlets with riprap placed under the pipe.

Wastewater disposal ponds.–Wastewater disposal ponds are effective only in areas where the ponds can be bottomed in permeable sands and gravel with an adequate natural outlet or can be of such size as to store and evaporate drainwaters entering the pond. The ponds will operate as intended, provided the silt which accumulates in the bottom is removed periodically. A record should be kept on the discharge of ponds. Staff gages can be installed and readings taken at regular intervals to determine how fast the water seeps out of the pond. When the rate of discharge decreases considerably, it is time to clean the pond. A good grass cover should be maintained on the dikes around ponds by periodic fertilization and watering if required.

Inlet structures, which have been constructed to bring surface wastewater from the fields into the ponds, should be kept in good repair. Settling basins or silt traps ahead of the inlet structure should be kept clean to minimize the need for cleaning the ponds.

Drainage observation wells.–Observation wells, properly installed, require minimum maintenance. However, any sudden change in the water table depth or a constant water table depth over a 3- or 4-month period usually indicates a plugged well. The work involved in cleaning the well can vary from pumping silt and sand from the well to pulling the pipe in the well and installing it in a new hole. The most common need for maintenance results from the pipe in the well being bent or pulled out by farm or highway equipment. To keep a reliable and complete record of the water table, these damaged wells should be reinstalled and protected by a 100 by 100-mm (4 by 4-in) painted post. All automatic recorders installed on observation wells require constant maintenance to keep the clock and recorder operating properly.

The Drainage Manual is a publication of the Bureau of Reclamation and may be obtained from the Engineering and Research Center, code 922, P O Box 25007, Denver CO 80225; or from the Superintendent of Documents, U.S. Government Printing Office, Washington DC 20402, for $7.25.

EXTINGUISHERS, LIKE FIRES, DIFFER; BUY THE CORRECT TYPE[5]

Not all fires are equal. Because of this, it is important that everyone know the proper extinguisher to buy for the different types of fire they might have to fight, says University of Nebraska Institute of Agriculture Extension Safety Specialist Rollin Schnieder.

Schnieder points out that there are four general classes of fire: A, B, C, and D.

Class A fires include combustible solids such as building, hay and straw, feed, trees, and brush, and many items of furniture.

Class B fires include flammable liquids such as gasoline, kerosene, paints, paint thinners, some solvents and specific agricultural chemicals.

Class C fires include all electrical equipment or any fire involving danger of electrical shock.

Class D fires involve metals that will burn (such as magnesium).

Schnieder says it is important when buying an extinguisher to check to see what fires it will control. "Usually either one or more of the letter designations (A, B, C, or D) are given on the label of the extinguisher. This tells you which type of fire or fires the extinguisher can be used on."

Schnieder explains that there are four different types of extinguishers presently on the market. These include those that use water, dry chemicals and carbon dioxide.

There are two different types of extinguishers that contain water–pump and air-charged extinguishers. Both can be used only on Class A fires, have a discharge length of up to 12.2 m (40 ft) and must be recharged after use.

The water pump extinguisher must be operated by hand when used, whereas the air-charged type contains a trigger to release the water. Both control fires by cooling them.

There are basically two different types of dry chemical extinguishers. Those that control A, B, C, and D fires and those that control only B and C fires.

Both control fires by smothering them, have a discharge of up to 3.7 m (12 ft), must be recharged annually or after use and use a trigger to release the chemical. The only difference between the two is in the classes of fires they control.

Like the dry chemical extinguisher, the carbon dioxide type also controls fires by smothering them. It uses a trigger and must be recharged annually or after use.

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[5] Reprinted with special permission of the Editor, Nebraska Farmer, from the October 7, 1978 issue.

However, the carbon dioxide extinguisher can be used on only class B and C fires (and small surface class A fires) and has a discharge of only 0.6 to 1.8 m (2 to 6 ft).

Schnieder points out that dirt or baking soda can also be used to control class B and C fires.

It is important that extinguishers be inspected and recharged periodically, at least once yearly, to maintain their full strength, Schnieder says.

He also suggests placing the extinguishers in different areas.

"Kitchens and entries into basements should have dry chemical or carbon dioxide extinguishers. Garages or machine sheds should have dry chemical and carbon dioxide extinguishers with a shovel for throwing dirt or sand. Barns should have water, dry chemical and carbon dioxide extinguishers."

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