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Better Answers With Soil and Plant Analyses

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Turfgrass problems are often caused by either too little or too much of certain mineral elements in the soil. The former are nutrient deficiency problems, requiring fertilization to correct. The latter are generally salinity problems which require the opposite treatment, i.e., a leaching to wash the excess of mineral elements, or salts, out of the soil.

Often it is difficult to diagnose these problems by observation alone. Attempting to do so has led some turfgrass managers into the mistake of applying the opposite treatment of that required, thereby aggravating the problem. For example, salinity problems, which should be treated by leaching, are sometimes treated by adding more fertilizer instead.

In dealing with these problems then, the first step is to make sure they are diagnosed correctly. Here is where soil and plant analysis can be of value. Before these diagnostic aids can be helpful, however, research must first establish what levels of mineral elements are associated with deficiencies and excesses.

Up until just a few years ago little such information had been developed in relation to turfgrass. Recently, however, a number of useful soil and plant analysis guidelines have become available. Following is a discussion of the application of these research findings to field problems.

Salinity

Salinity problems, which are common in much of California, are caused by an excess of soluble salts in soils. This condition can arise either by the accumulation of salts present in irrigation waters or as a result of high water tables, which allow salts to move up and accumulate at the soil surface.

With good drainage and use of sufficient irrigation water, salinity problems can be prevented. Often, however, because of poor water quality or impermeable soils, control of salinity is difficult, and it becomes necessary to live with some salt in soils. One way this can be done, within limits, is by planting salt tolerant species. The table below lists several turfgrasses according to their salt tolerance.

SALT TOLERANCE OF TURFGRASSES (1)

Low Salt Tolerance	Medium Salt Tolerance	High Salt Tolerance
Kentucky bluegrass	Alta fescue	Puccinellia distans
Highland bentgrass	Perennial ryegrass	Common bermuda
Red fescue		Hybrid bermuda
Meadow fescue		Tiffway
		Tiffgreen
		Sunturf
		Seaside bentgrass
		Zoysia
		St. Augustinegrass

The grasses of low salt tolerance require that the soil salinity level in the root zone be less than 4 millimhos if presentable appearance is to be maintained. The maximum salinity level permissable for grasses of medium tolerance is about 8 millimhos, and for highly tolerant ones, about 15 millimhos.

Excess Sadium (Alkali)

The increased use of marginal lands, some of which have a high sodium content, has created a need for information on tolerance of turfgrasses to sodium. Five varieties have been studied: Common bermuda, Kentucky bluegrass, Alta fescue, Seaside bentgrass, and *Puccinellia distans (2).*

None of these grasses was found to be particularly sensitive to sodium. All can probably be used at exchangeable sodium percentage levels up to 15 at least. *Puccinellia distans* and Seaside bentgrass which were found to be the most tolerant probably can be grown on soils exchangeable sodium percentage levels up to about 30.

The exchangeable sodium percentage in some California soils exceeds the above turfgrass tolerance levels. For example, in the areas that are developing along the coast where the soil material consists of shoreline dredgings the exchangeable sodium percentage can be expected to be about 50. Even higher levels are commonly found in many of the saline-alkali soils located in the interior, such as along the west side of the San Joaquin Valley. Reclamation of such soils should precede the planting of even the most tolerant turfgrasses.

Boron Toxicity

Boron in small amounts is essential for plant growth. In larger amounts it acts as a plant poison. Toxic levels of boron occur in a number of soils in California, so it is important to have some guideline as to the tolerance level of turfgrasses. Such information has been obtained for the following: Kentucky bluegrass, Seaside bent, Alta fescue, Highland bent and *Puccinellia distans (3).*

All of these grasses proved to be highly tolerant to boron. Judging from this research one can expect these grasses to grow at a normal rate even when the boron level is as high as 10 parts per million (in the saturation extract).

Some soils in California contain boron levels considerably higher than 10 parts per million. Generally these soils have a high soluble salt and/or high sodium content as well, requiring leaching before plants can be grown. The leaching to remove the salts and/or sodium may remove the excess boron. This should be confirmed, however, by a soil test before planting, for boron is more difficultly leached from soils than most other salts.

Though able to grow well at high boron levels, all of the above grasses will develop some tip burn, which can mar their appearance. If clipped frequently to remove the affected tissue, a presentable appearance can be maintained. A better alternative, however, would be to reduce the boron level in the soil by leaching.

Mocronutrient Supply

Both soil and plant analysis guidelines have been developed recently in connection with turfgrass nutrition. Optimum nitrogen, phosphorus, and potassium levels for Newport bluegrass are shown below.

OPTIMUM LEVELS FOR NEWPORT BLUEGRASS*

Element	Percent of dry wt. of clippings
N	4.0 – 4.5
P	0.34 – 0.45
K	1.0 – 1.2

*Information from Dr. V. B. Youngner

Though the above levels are specific for Newport bluegrass, they should provide reasonably good guidelines for other turfgrasses until further information becomes available.

Also recently completed was a study to determine the critical soil phosphorus level for turfgrasses (4). The results, summarized below are based on the sodium bicarbonate extraction method.

SOIL PHOSPHORUS LEVELS

Deficient	Possibly deficient	Adequate
Less than 5ppm	5 - 8 ppm	More than 8 ppm

Varieties studied were common bermuda, Kentucky bluegrass, Highland bentgrass, Emerald zoysia, and Alta fescue. All 5 varieties responded similarly, indicating that the above soil phosphorus levels are generally applicable to turfgrasses.

Soil and plant analysis guidelines in addition to those discussed above will soon be available from research currently underway at the University of California. All of these diagnostic criteria should be put to work wherever possible to help take some of the guesswork out of turfgrass management.

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California's 50,000 Acre Golf Course

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50,000 acres of golf courses constitute one of Califomia's most intensive farming enterprises. These golf courses produce neither food nor fiber, but do provide landscaped, open areas for the recreation and enjoyment of millions of California residents and tourists. The location of most of the golf courses in and near cities, and the level of their intensive care, increases the significance of their contribution to the economy of California. To determine the magnitude of this segment of the turfgrass industry, my office compiled information from a statewide survey.

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In 1954 and again in 1961, estimates were made of the total investment cost and annual maintenance cost of turfgrass in California. In 1961, conservatively developed estimates showed a $900 million investment in turfgrass, with approximately $300 million in annual maintenance costs. Much of this investment and maintenance cost can be attributed to the average home lawns. Although this is the most important dollar segment of the industry, the individual home lawn represents a relatively small investment, both initially and for continuing maintenance. The portion of this survey dealing with golf courses was based on fewer than 200 golf courses. Maintenance costs were given at just under $12 million and acreage at less than 12,000 acres. We were conservative and we knew we were, but without a complete survey, we chose to err on the low side rather than on the high side.

Today, California is approaching 500 golf courses – ranging in size from Par 3's, situated on fewer than 10 acres, to 36 hole golf courses that encompass more than 300 acres. These courses are located on about 50,000 acres of the California landscape. It will cost in excess of $30 million a year to keep this acreage green and playable for the thousands of golfers who will play over 14 million regulation 18-hole rounds of golf this coming year.

How did we arrive at these figures, and is our information valid? Starting in June of 1963, survey cards were sent to every known golf course in California, asking 11 basic questions concerning the size and scope of the golf course. By late May 1964, we had contacted over 440 golf courses and had received replies to each of the questions from at least 50 per cent of the golf courses. We separated the golf courses into four categories: regulation 18-hole, regulation 9-hole, Par 3, 9-or 18-hole, and regulation golf courses having 27 or more holes. In June 1964, we terminated the survey with 444 golf courses as the total figure. Before the information on these 444 golf courses could be tabulated, we learned of 41 additional courses that had been missed or that would be in operation by January 1965. On recent trips through California, we located several more courses which brought the total to just over 500.

From the standpoint of a surveyor, golf course superintendents in general are poor record-keepers. Most golf courses are managed by people with years of experience who can give reasonable estimates where actual data are not available. Because we knew that some estimations would be necessary, we set as a goal a 40-50 per cent sampling rather than the customary 20 per cent. We are indebted to the 257 out of 444 courses that responded to the survey, and to the members of the California Federated Golf Course Superintendents Association who gave their support to this survey. Not all golf courses gave answers to each question. Whenever answers were not clear, or appeared unrealistic, we made every attempt to check the answer. If it could not be verified, it was not included in the survey. This accounts for the less than 50 per cent sampling in the Par 3 golf courses, where information concerning costs was not given in many cases. Even here, the lowest percentage sampling was greater than 25 per cent.

Of prime interest to the University of California is the total size of the industry. We arrived at this figure by finding the average figure for each type of golf course and then multiplying by the total number of golf courses in that category. We all know there is no such thing as an "average" golf course. Many times we attempt to compare ourselves with the average, and if we are above the average, we are content. In California we have a wide range of soils, climate, and available water which have a direct effect on size and cost of golf course operations. Our averages show that water costs for a regulation 18-hole golf course in California is from less than $1,000 to more than $35,000. Certainly, averages have some value to the individual golf course, but only if used with considerable judgment in comparing one course with an "average."

Presented on the accompanying tables are the total figures for each of the four categories of golf courses. Note that the grand totals for rounds of golf played per year have been adjusted to be equivalent to a complete 18 holes for 1 round. We obtained the grand total for each category by multiplying the number of courses by the average figure for the courses that reported.

What are some of the important things this survey told us? Let's look first at manpower. On these 444 golf courses, 3,391 individuals are employed to manage, supervise, and execute the labor tasks of growing a specialized grass for a specific recreational use. It costs $26,467,016 each year to accomplish this task. This money is expended on 47,161 acres of which 33,252 acres are mowed and irrigated regularly. We do this to satisfy the demands of thousands of golfers who play 14,368,368 rounds of golf (1 round of golf equaling 18 holes).

It would be interesting to speculate on the value of California's 50,000-acre golf course. We know that development costs vary as widely, if not more widely than maintenance costs. An average, conservative estimate of $2,500 per acre to develop a course with complete irrigation system has been proposed. Cost of land is another extremely variable item. Certainly we know that many older courses are situated on land which would sell for several thousand dollars an acre. At today's prices, it is difficult to by land situated near populated areas for less than $2,500 per acre. At a total development cost of $5,000 per acre, we would find that California's 50,000-acre golf course would have a value of $250 million. I am sure that, if we were to run an accurate survey, we would find this value to be a conservative figure, since many of the courses are within cities such as San Francisco, Los Angeles, Long Beach, San Diego, etc.

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The size and value of the golf course industry in California is more than twice the 1961 estimate. Many of us wonder if we have not been too conservative in estimating the size and value of the total turf industry. Those persons vitally concerned with turf should consider well the importance of a complete turfgrass survey of California, and the impact such a survey would have on the recreation-minded public and governmental agencies of California. We talk about the value of this industry or that industry in creating jobs and wealth for our state. The turfgrass industry also creates wealth. We spend millions of dollars each year to establish and maintain green landscapes for the financial benefit of thousands and for the enjoyment of all.

18-HOLE GOLF COURSES

	No. Report. ing	Total	Average	Projected California Total (228)
Rounds of golf played per year	115	$4,960,497	$43,135	$ 9,834,780
Acres in golf course site	136	19,375	142	32,376
Acres mowed and irrigated	134	13,505	101	23,028
Size of greens (sq. ft.)	136	783,487	5,761	549 acres
Cost of water	118	$951,405	$ 8,063	$1,838,364
Supervision and labor cost	123	$6,044,121	$49,139	$11,203,692
Total turf maintenance cost	125	$ 9,732,967	$77,864	$17,752,992
Turf maintenance personnel	132	1,309	9.9	2,257

(Cost information is based only on the turf and landscape maintenance of golf courses).

9-HOLE GOLF COURSES

	No. Report-ing	Total	Average	Projected Cal i fami a Total (228)
Rounds of golf played per year	54	$1,350,211	$25,004	$2,875,460
Acres in golf course site	64	4,464	69.75	8,021
Acres mowed and irrigated	64	2,905	45.4	5,221
Size of greens (sq. ft.)	63	263,600	4,184	100.7
Cost of water	48	$120,664	$2,514	$289,110
Supervision and labor cost	50	$802,066	$16,041	1,844,715
Total turf maintenance cost	48	$1,263,362	$26,320	$3,026,800
Turf maintenance personnel	46	170	3.7	426

27 OR MORE HOLE GOLF COURSES

	No. Report-ing	Total	Average	Projected California Total (23)
Rounds of golf played per year	15	$1,785,252	$ 19,017	2,965,022
Acres in golf course site	18	4,246	235.88	5,425.2
Acres mowed and irrigated	18	3,037	168.7	3,880.l
Size of greens(sq.ft.) (33.5 holes/course)	18	93,600	5,200	93.17
Cost of water	14	$209,470	$14,962	$344,126
Supervision and labor cost	15	$ 1,563,932	$ 104,262	$2,398,026
Total turf maintenance cost	15	$2,406,894	$ 160,460	$3,690,580
Turf maintenance personnel	17	321	18.9	434.7

(Cost information is based only on the turf and landscape maintenance of golf courses)

PAR 3 GOLF COURSES

(Figures based on 9-hole Par 3, but total includes Par 3 as if they were a Phole course.)

	No. Report-ing	Total	Average	Projected California Total (78)
Rounds of golf played per year	29	$972,710	$33,542	$2,616,276
Acres in golf course site	32	547	17.1	1,339
Acres mowed and irrigated	34	491	14.4	1.123
Size of greens (sq. ft.)	40	128,216	3,205	52.32 acres
Cost of water	25	$46,163	$ 1,775	$138,450
Supervision and labor cost	27	$ 490,909	$15,589	$l,215,942
Total turf maintenance cost	23	$588,772	$25,598	$1,996,644
Turf maintenance personnel	34	119	3.5	273

(Cost information is based only on the turf and landscape maintenance of golf courses)

Characteristics of Pipe Used for Sprinkler Systems

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In the design of a permanent underground sprinkler system the type of pipe used is just as important as the sprinkler components in obtaining the best results at a reasonable cost. Every year materials are being improved and new materials are being introduced which are tending to replace the older and perhaps better known types of material due to superior quality and cost advantage. In the application of the newer types of material used in pipe, careful analysis and consideration has to be given to major factors such as life expectancy, adaptability, physical properties and costs. Experience, where new materials are being used, is extremely important. For these reasons, and in view of the fact that discussions of material used in piping is such a broad subject, only the following materials will be discussed:

Pipe sixes of 2" and less :
1. Steel
2. Copper
3. Thermoplastics

Sizes of 3" and larger:
1. Cast iron
2. Asbestos cement

Galvanized steel pipe has been used extensively, particularly in the earlier days of sprinkler systems. This has even been more true of Southern California than in other parts of the country. Advancement in the availability of other piping materials, however, is gradually obsoleting the use of galvanized steel pipe in underground sprinkler systems.

Black steel pipe has never been suitable for sprinkler systems, primarily due to the build up of rust and scale on the pipe walls, and its extreme susceptibility to various corrosive conditions encountered underground. Wrought iron has better characteristics, but is expensive.

Galvanized piping is very little better than black steel pipe, partially due to the fact that the galvanizing used is normally very light, and when the galvanized coating is damaged the pipe is subject to the same problems as black steel pipe, namely rust and scale. A few of the disadvantages are as follows:

1. Unpredictable life expectancy due to the conditions of the water which the pipe is conducting, and the ground condition in which the pipe is installed.

2. Galvanizing and other coatings are of very little assistance in combating corrosion due to their vulnerability in handling and the inability to seal the many joints encountered in the installation of a sprinkler system. 90% of the pipe can be perhaps protected perfectly, but if the pipe fails at joints, or in any one spot, the system has been rendered ineffective.

3. Choking of pipe due to hardness and scale. Unfortunately steel pipe seems to have an affinity for calcium and similar materials carried in the water which it is transmitting. Galvanized coatings are of no assistance in this respect. Other types of coatings are rarely, if ever, used on the interior of the pipe.

4. Inflexibility of the material itself makes the pipe subject to breakage at threaded joints, and difficult to install.

5. Expensive to install.

6. Unpredictable long term performance as a fluid conductor.

Advantages

1.High tensile strength when pipe is in good condition.

Of the various metals which have been used for piping, copper tubing has generally been the most satisfactory for underground sprinkler systems. Copper has good corrosion resistant characteristics, with the exception of exposure to salt or sulphur. It has good physical properties and has a low flow resistance on initial installation as well as long term service. In some instances, however, some problems have been experienced with coatings due to hardness of water being handled.

In actuality, the cost of the copper system need not be as high as most people think when the proper types of material are used. It is certainly no higher than steel systems calling for special pipe coatings, and where copper tubing of the proper type is used, it is much more easily installed than steel with its slip type socket fittings. Copper pipe is generally available in three basic types; namely, Type M, Type L and Type K.

In actuality, Type M is the most reasonable in cost, and when properly engineered to the system is quite suitable for underground sprinkler work. This contradicts, somewhat, some of the recommendations made for copper pipe by the manufacturers themselves, but their concern is generally in pressure lines with considerably different requirements than a sprinkler system.

Type L is generally used for interior plumbing, since it has a medium wall thickness somewhat heavier than Type M, and may be obtained in a hard drawn or soft annealed state.

Type K is the heaviest, and is generally recommended for underground water service by the industry. It is extremely expensive, however, and probably its best use in sprinkler work is pressure lines on the upstream side of the control valves.

There are many pros and cons on the application of copper tubing to sprinkler systems, and some of the foregoing statements may be disputed by the manufacturers of copper tubing themselves, however, it is doubtful if most of these manufacturers have ever given proper consideration to the application of copper in underground sprinkler systems as such. In any case, it is questionable whether copper has much of a future in sprinkler work due to the rapid advances being made in thermoplastic pipe at the present time.

Since thermoplastic pipe has been making tremendous advances in its general acceptability and usage in the irrigation field, and since, as a material, it is the least understood by the trade, we will endeavor to present data here that will be of assistance in its proper selection and use.

Since many and varied groups of basic plastic materials have been made into pipe, it is well at least to mention several of these materials with which the trade has become more or less familiar. It should be remembered that plastic pipe is an extremely broad term, and that in order to obtain the type of piping material desired it is absolutely necessary that the proper material be specified. The more familiar grades of thermoplastic pipe are:

1. Polyethylene
2. Cellulose Acetate Butyrate (CAB)
3. Acrylonitrile Butadiene Styrene (ABS)
4. Polyvinyl Chloride (PVC)

Of the four grades listed above, the last two, namely ABS and PVC are receiving, by far, the greatest usage. Both of these materials are easy to work with, assemble and install. In sprinkler work they lend themselves to a solvent welding procedure which is inexpensive and quick in producing satisfactory joints.

For the sake of this discussion we will concentrate on developing PVC so far as its classification; types of PVC used and the method in which it should be specified in order to obtain suitable physical requirements for the application for which it is to be applied. Although many are not familiar with the current standards, the Society of the Plastic Industry, through the Plastic Pipe Institute, has standardized on the various factors so that generalizations can be made in the preparation of specifications for a given job.

PIPE DESIGN DATA

On January 1, 1963 new standards went into effect covering the design of plastic pipe. This, of course, was in addition to Schedule 40 and 80 which are well established. The basis of design under the new standards is to present working pressure classes rather than schedules. This is accomplished by setting up standard dimensional ratios (S.D.R.). This is a relationship of wall thickness and diameter on I.P.S. pipe.

$$\text{The S. D. R. is: } \frac{\text{Outside Diameter}}{\text{Wall Thickness}}$$

The S.D.R.'s covered by the new standards are: 13.5, 17, 21, 27, 32.5, 41 and 64.They are based on incremental increases of 25%.

DESIGN TENSILE STRENGTH is used in a formula along with the S.D.R. to determine a given working pressure. The tensile strength of a material is determined by a Committee of the Plastics Pipe Institute, using data compiled from 100,000 hours of actual laboratory tests. Design tensile strengths are minimums, and the actual computed strength may fall between 2 design strengths; in which case it is relegated to the lowest. Design tensile strengths are also in incremental increases of 25%.

MATERIAL DESIGNATIONS or nomenclature describes not only the basic plastic, but also gives the type, grade, and design tensile strength. For example, PVC 1220 is Polyvinyl Chloride. Type 1, Grade 2, with the first 2 digits of the design tensile strength of 2000 psi; hence PVC 1220.

DESIGN WORKING PRESSURE, or CLASS for I.P.S. Pipe is computed by use of the formula:

$$\text{Working Pressure} = \frac{2 \times \text{Tensile Strength (Design)}}{\text{S.D.R. } -1}$$

By having the S.D.R. figure and the design tensile strength of the material to be used (from the description), the working pressure of a pipe can be easily computed. Conversely, with the working pressure and S.D.R., the tensile strength can be determined.

An example, using PVC 1220 and S.D.R. 13.5

$$\text{Working Pressure} = \frac{2 \times 2000}{13.5-1} = \frac{4000}{12/5} = 320 \text{ p.s.i. (Class 315)}$$

IMPORTANT. The so called “working pressure” as used in the foregoing is actually a maximum allowable pressure, and makes no provision for surge or hammer. A safety factor is included in the design working pressure of the pipe. However, it is important to consider the surge or hammer potential of any water system when selecting a working pressure. High surge can easily produce pressures 5-6 times the static pressure within a given system. In no cases should a pipe be specified that does not have a rated pressure equal the highest pressure encountered in the system, including surge and hammer.

NOTE: Most of the extruders today are running TYPE 1 PVC material rather than TYPE 2 due to its' higher tensile strength. TYPE 1 is frequently referred to as normal impact material and TYPE 2 as high impact.

Under these new standards, it is highly recommended that specifications for PVC pipe always call for the new class pipe rather than the old schedule pipes, since this will give the most economical application of material on any given job. It should be remembered, however, that although the class distinctions indicate a pressure limit, that this does not include adequate pressures to compensate for surge that can be induced in the pipe itself. Pressure developed in piping due to surge and hammer are a function of the velocity of the fluid carried.

It is a fallacy to assume that no surge occurs in the piping of a sprinkler system, as this is not a true "open end" system. Velocities vary in the sprinkler lines due to initial inrush from the valve opening, back pressure due to restrictions of the sprinkler nozzles and elevation differentials in the sprinkler battery all of which affect this phenomena. With these facts in mind, the true working pressure within the piping of a sprinkler system will never be the same as the static pressure and when allowances are made properly for surge it requires consideration of pressures which may exceed the static pressure many times. Good design practice in piping rarely permits the use of flows in excess of 5 or 6 ft. per second. However, there are so many variables such as the pressure at which the water is supplied and the volume discharged by the sprinklers themselves, that even if design maintains a predicted maximum velocity, this could be exceeded due to the lack of control of the pressure and volume of water available at the source used. In other words, even when adequate allowances are made in the design, an additional factor of safety should be considered.

Unfortunately, very few manufacturers of plastic pipe present their material in such a way that it is easily ascertained as to the class of pipe most suitable for a given installation. Charts are available for all classes of PVC pipe, and should be insisted upon by the designer. Although the standards are the same for all manufacturers, claims without qualifications can be most confusing.

Although generally not a major factor in underground irrigation systems, it should always be remembered that temperature variations have a decided effect on plastic pipe. Since plastics have a relatively high coefficient of expansion, consideration must be given to this characteristic on installation. PVC 21110 has a coefficient of .0001" per inch centigrade degree. Should 1,000 ft. of PVC pipe be laid in a straight line, when the pipe temperature is 100° Fahrenheit (37.8° Centigrade) and the temperature drops to 50° Fahrenheit (10° Centigrade) the total reduction in length would be approximately 33". For this reason it is recommended that the pipe be laid loosely in the trench, and if long runs are encountered, that it be snaked between cross connections to prevent difficulty. The example used is an exaggerated one, and is rarely encountered.

Temperature also affects the tensile strength of the pipe in such a manner that its strength is reduced with increases in temperature. In a sprinkler system it is rare for the pipe to be subjected to any wide range in temperature, and it is quite unusual to anticipate water temperatures in sprinkler systems to exceed 90°.

All materials used in plastic pipe have different properties with relation to their impact strength. Some are flexible and some are extremely rigid. PVC has good impact characteristics, being tough and highly resistant to impact loads, most of which occur in the handling and installation of the pipe itself.

Many desirable advantages are inherent in plastic pipe. In the first place, its cost, when applied properly, is extremely reasonable, and rust and corrosion do not affect plastic pipe since it is non-metallic. This is true as well for electrolysis, to which all metal is subject to a greater or less degree.

Its cost savings is reflected in labor, since it is extremely easy to install and, of course, its inside finishes are such that a much greater flow for the same amount of pressure loss can be obtained over pipe of other materials of the same inside diameter.

On larger sprinkler systems where 3" and larger pipe is required, cast iron and transite (asbestos cement) pipe are generally used. Economy is the principal reason for using different pipe materials in the larger sizes. Cast iron pipe has an experience record of more than 150 years of satisfactory service. It is the only ferrous metal pipe truly satisfactory for underground installation which rust will not normally destroy. Although cast iron pipe becomes coated with rust, this very coating protects it after very slight penetration. It is generally available in working pressures of 50 to 300 PSI, and the so called Class 150 is normally used for sprinkler systems.

Pressure ratings must again allow for usage and water hammer conditions, and if installed under thoroughfares should anticipate shock from traffic loads since it is sensitive to impact.

Today it is being somewhat limited in use due to its cost and the fact that it is somewhat difficult to install compared to other materials that are available.

Probably the most widely used material for larger size pipe in sprinkler systems is cement asbestos. Cement asbestos pipe is normally available in 100, 150 and 200 PSI ratings. For its size it is relatively easy to install and reasonable in cost. Special joints are being provided in asbestos cement pipe which enables it to be assembled by pushing it together mechanically, eliminating caulking, such as is frequently required on cast iron pipe. Incidentally, a wide variety of fittings for this pipe are readily available. A certain amount of care, however, must be taken in its' installation, and due to the type of fittings used, abrupt turns must be blocked carefully. The pipe is somewhat more brittle than cast iron, so that handling and installation techniques are a little more restricted. Excessive earth loads and surface loads should be avoided. Trenches should be prepared so that the pipe will lay level in the trench and should be protected from boulders. Practically all of the manufacturers of cement asbestos pipe maintain field personnel for instructing inexperienced installers in the proper use of their products.

Since asbestos-cement pipe is nonmetallic and not subject to corrosion or the gathering of foreign matter on its internal surface, and since its internal surface is extremely smooth flow losses are low. As a result, long term predictable performance, so highly desirable in sprinkler systems, is one of its outstanding characteristics.

In summary, the following characteristics of the pipe used in any given sprinkler system should receive consideration on the following points:

1. LIFE EXPECTANCY. Life expectancy is extremely important on cemeteries, parks, schools and golf course. Long life expectancy should also be designed into the average residential system. Other applications, such as general agricultural, would allow more consideration to marginal design, particularly if it is anticipated that only a short term life can be expected. As we have tried to illustrate, life expectancy frequently becomes involved with the physical properties of the material used.

2. PHYSICAL PROPERTIES. The resistance of the material used to corrosive conditions which may be present due to its environment. Such conditions can preclude completely the use of certain types of piping material. The strength of the pipe with reference to the pressure conditions to which it will be subjected should be analyzed carefully to ascertain whether the pipe is strong enough to handle the job at hand. Hydraulic characteristics; namely its resistance to flow (friction loss) should be analyzed on a comparative basis. For example, the flow characteristics of plastic pipe are so much better than that of steel pipe that the next nominal smaller size can frequently be used without detriment to the performance of the sprinkler system. This, of course, is important to any cost comparisons.

3. ADAPTABILITY. Adaptability and the ease of installation and maintenance of the overall material selected should be compatable with the sprinkler system design. Too frequently maintenance problems are overlooked in the selection of the type of material and its installation.

4. COMPARATIVE COST. It is recognized, of course, that the basic function of the pipe is to conduct water to the sprinkler heads efficiently and dependably. When the various foregoing items are investigated from the standpoint of the job, and given their proper weight, then a minimum allowable cost for the piping can be determined. Pitfalls such as comparison of materials, size for size, must be eliminated to arrive at the final conclusion.

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