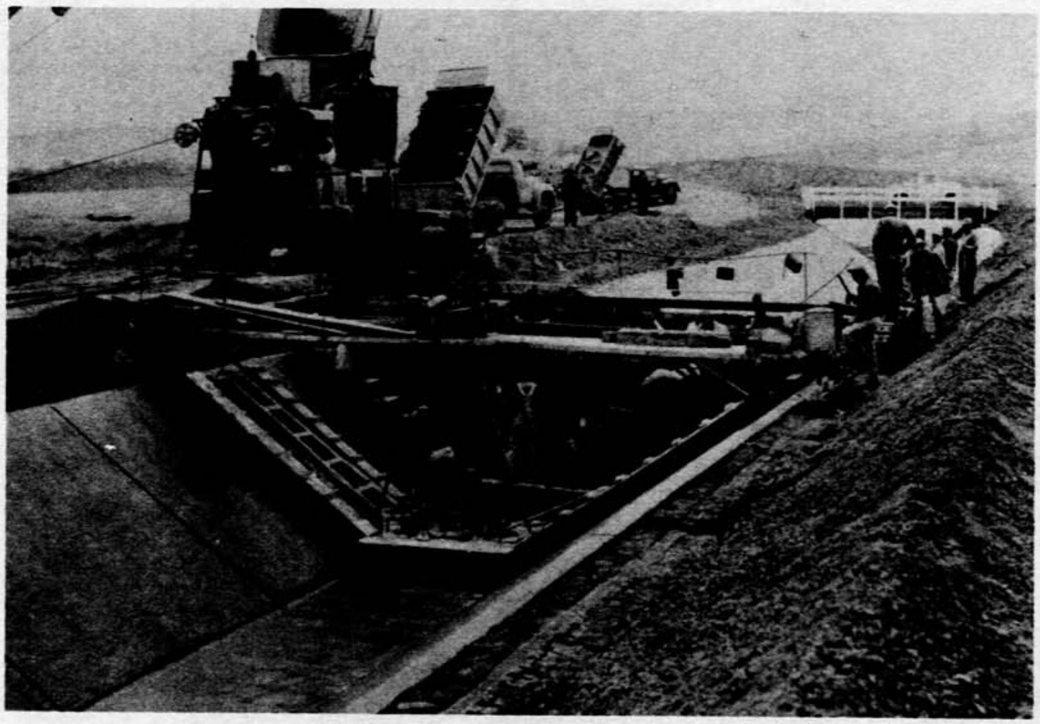
WATER OPERATION AND MAINTENANCE

BULLETIN NO. 78

DECEMBER 1971



IN THIS ISSUE

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 labor-saving 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 Water Operation
and Maintenance
Engineering and Research Center
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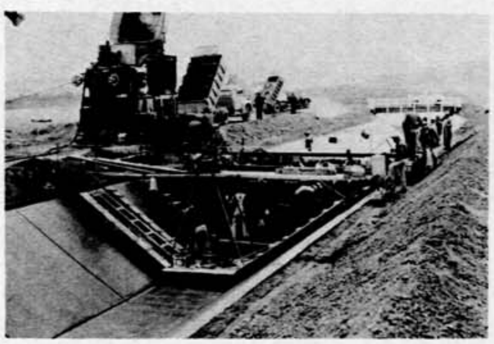

COVER PHOTOGRAPH:

This is a caterpillar track-mounted lining machine in operation on the Putah South Canal, Solano Project, California. It is operated hydraulically and guided from a control station at the front of the machine. Photo SO 3694-CV

UNITED STATES DEPARTMENT OF THE INTERIOR
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Secretary

BUREAU OF RECLAMATION
Ellis L. Armstrong
Commissioner

WATER OPERATION AND MAINTENANCE
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INTRODUCTION

A request for suggested methods of placing concrete for canal linings is the reason for the article beginning on page 1. Various methods used for best results are described.

Automobile safety is always a timely subject. Two such articles appear on page 6, one on Radial Tires and the other on Tailgating.

Many materials offer promise for the conveyance of irrigation water in pipe. Beginning on page 7 is a report on field testing of pipe material being investigated by the Bureau of Reclamation.

Attention is called to a Research report beginning on page 14. The report was prepared by the Division of General Research of the Bureau of Reclamation from tests and studies made at the Bureau's Engineering and Research Center, Denver, Colorado, to standardize and modify existing procedures used in the design of a short, impact-type stilling basin.

Starting on page 19 is an article to provide general information to anyone concerned with chlorine gas. The article contains recommendations for its safe handling, transportation, and storage and also suggests precautionary measures that should be taken for the safety of those who handle and work with this potentially dangerous gas.

PLACING CONCRETE FOR CANAL LININGS 1/

Placing methods for concrete range from the hand method commonly used on small canals or laterals to the longitudinally operating slip-form machine. The simplest hand operation is placing unreinforced lining in small laterals and farm ditches, where the concrete is poured and spread on the sides and bottom. Screed guides are laid on the subgrade and the concrete is screeded up the slope to proper thickness. Ten-foot screed panels are quite practicable for two man operation. Consolidation of these thin slabs is accomplished mainly in the screeding operation. One or two passes with a long-handled steel trowel completes the finishing. Transverse grooves are cut at 6-foot intervals and the lining is cured by use of sealing compound. Mixes for this method should be well sanded to simplify the labor of placing and finishing.

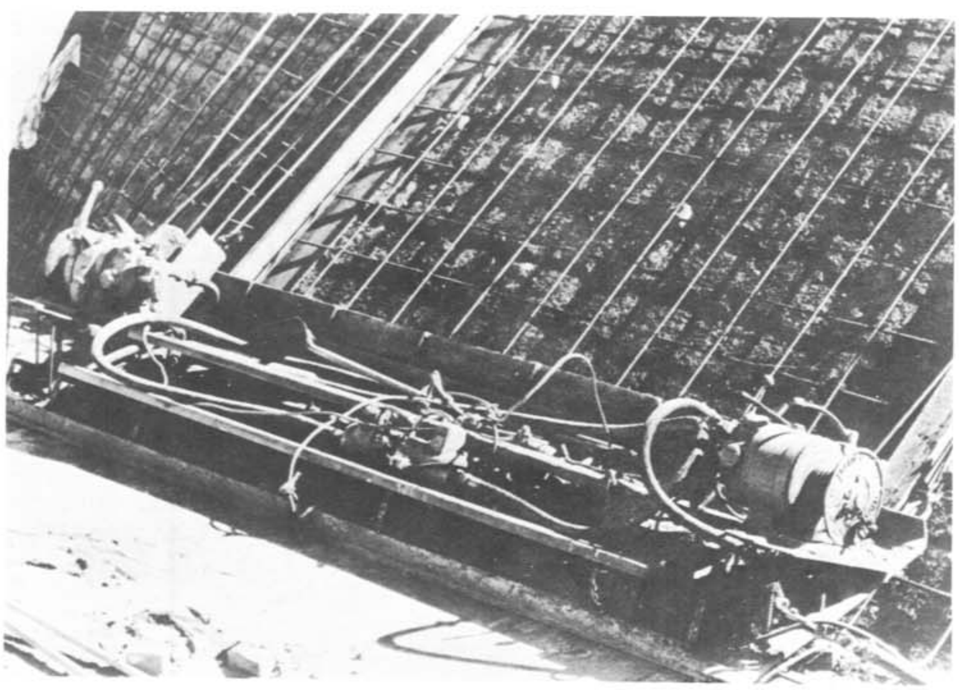
When constructed by hand, the larger linings are usually placed in alternate panels to facilitate placing, finishing, and curing operations. There may also be some reduction in overall shrinkage cracking if enough time elapses before placing the intervening panels. In this method, it is best to place the bottom slab first to provide support at the toes of the side panels. The panels are screeded up the slope, the concrete being vibrated ahead of the screed.

Most efficient placement of concrete on slopes is accomplished by use of a weighted, unvibrated steel-faced slip-form screed about 27 inches wide in the direction of movement. The screed may be pulled up the slope by equipment on the berm as in photograph 1 on page 2, or by airhoists mounted on the slip form as in photograph 2 on the same page. Figure 1 on page 3, shows how the concrete should be vibrated internally just ahead of slip form. Under proper conditions of operation the surface made by the slip form will require no further screeding and very little finishing. The slip form itself should not be vibrated, as this procedure causes a swell in the concrete emerging from the lower edge. This excess concrete is not only laborious to remove, but it also emphasizes sags that tend to form at longitudinal bars.

Many improvements have been made in the longitudinally operating slip-form machines for lining canals of all sizes since the first machine of this type was used on the Umatilla Project of the Bureau of Reclamation in 1915. The greatest progress in operating efficiency has taken place during the past 20 years in connection with extensive canal lining operations on Bureau projects. Lining machines have been developed which are hydraulically operated and controlled as well as some which are electrically controlled to line and grade.

1/ This article was taken in part from the Concrete Manual, Seventh Edition, Chapter VI. This is a Water Resources Technical Publication, printed for the Bureau of Reclamation by the Superintendent of Documents, Washington, D.C.

Photograph 1 (PX-D-33031)



Photograph 2 (PX-D-33036)

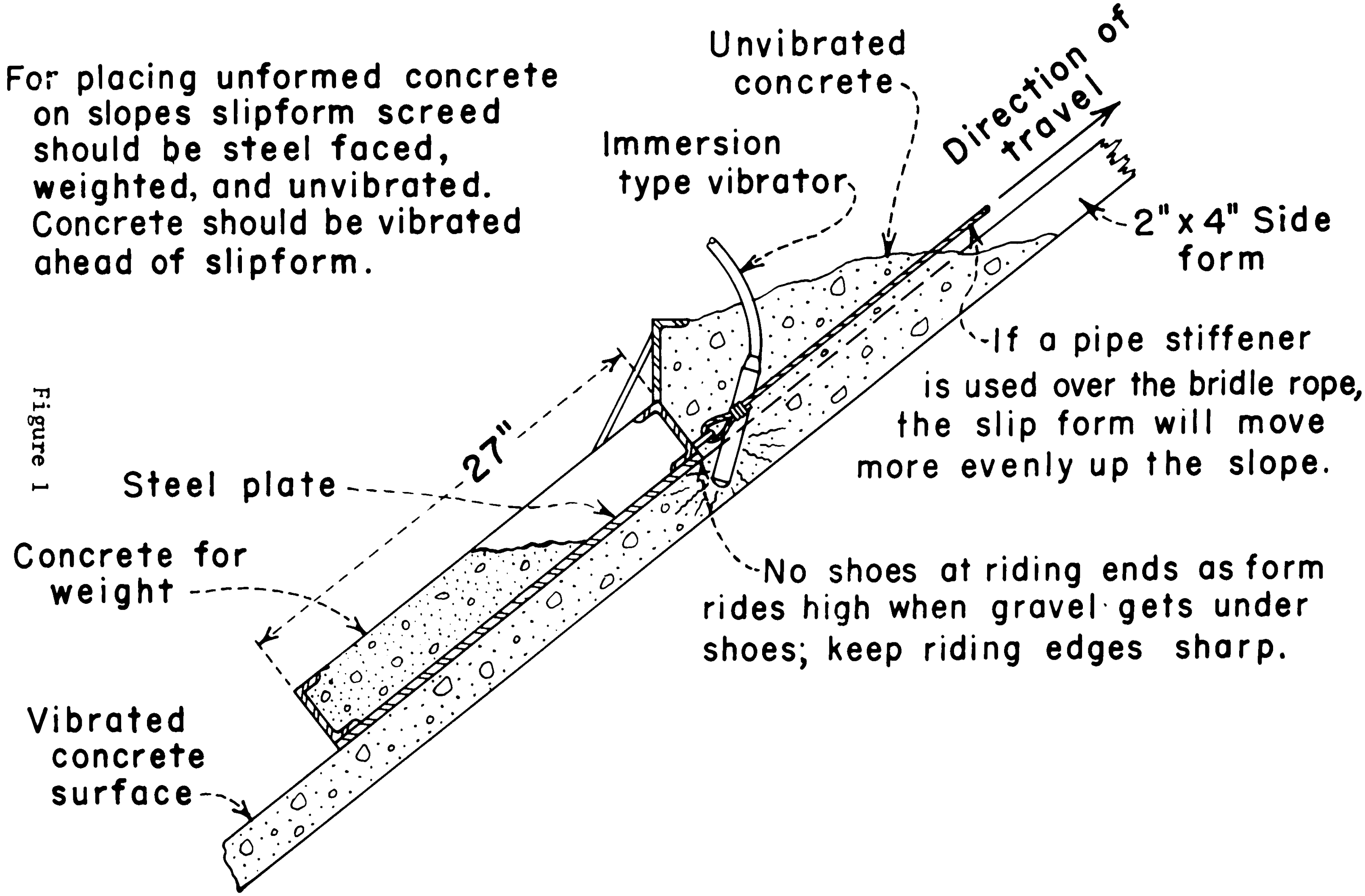
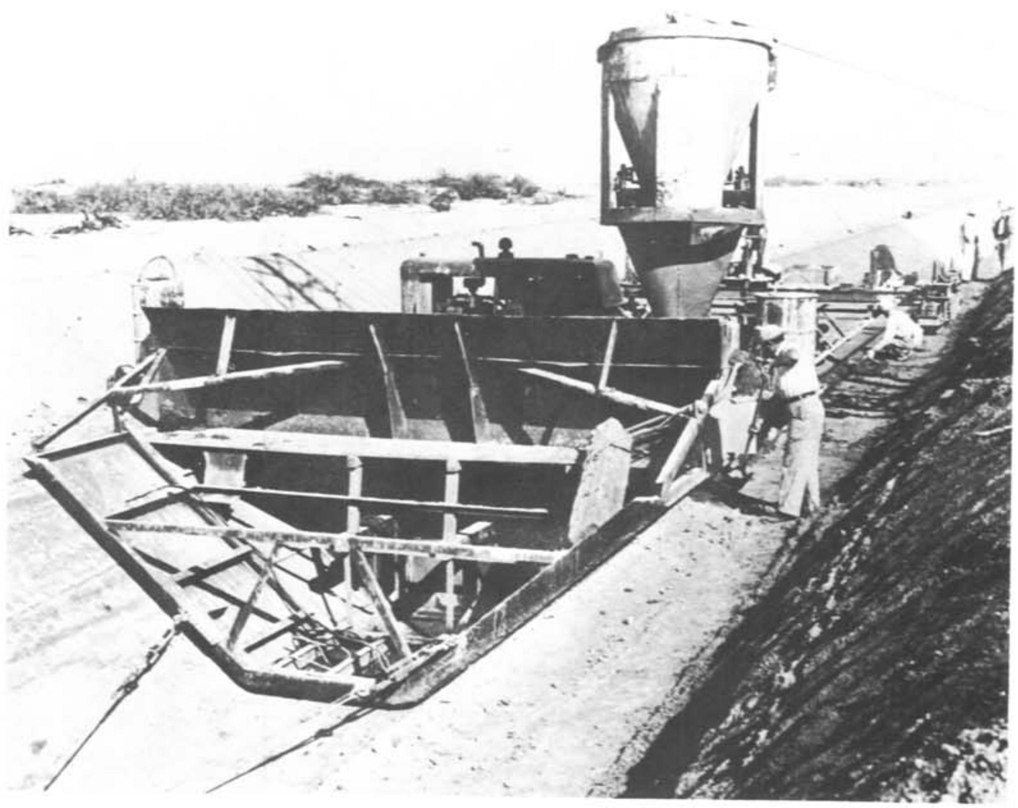

For placing unformed concrete on slopes slipform screed should be steel faced, weighted, and unvibrated. Concrete should be vibrated ahead of slipform.
Unvibrated concrete
Immersion type vibrator
Direction of travel
2" x 4" Side form
If a pipe stiffener is used over the bridle rope, the slip form will move more evenly up the slope.
27"
Steel plate
Concrete for weight
No shoes at riding ends as form rides high when gravel gets under shoes; keep riding edges sharp.
Vibrated concrete surface

Figure 1

Experience has shown that steel reinforcement in concrete canal linings is normally not needed, and since about 1946 concrete linings constructed by the Bureau have been unreinforced except in specific instances where structural safety is imperative.

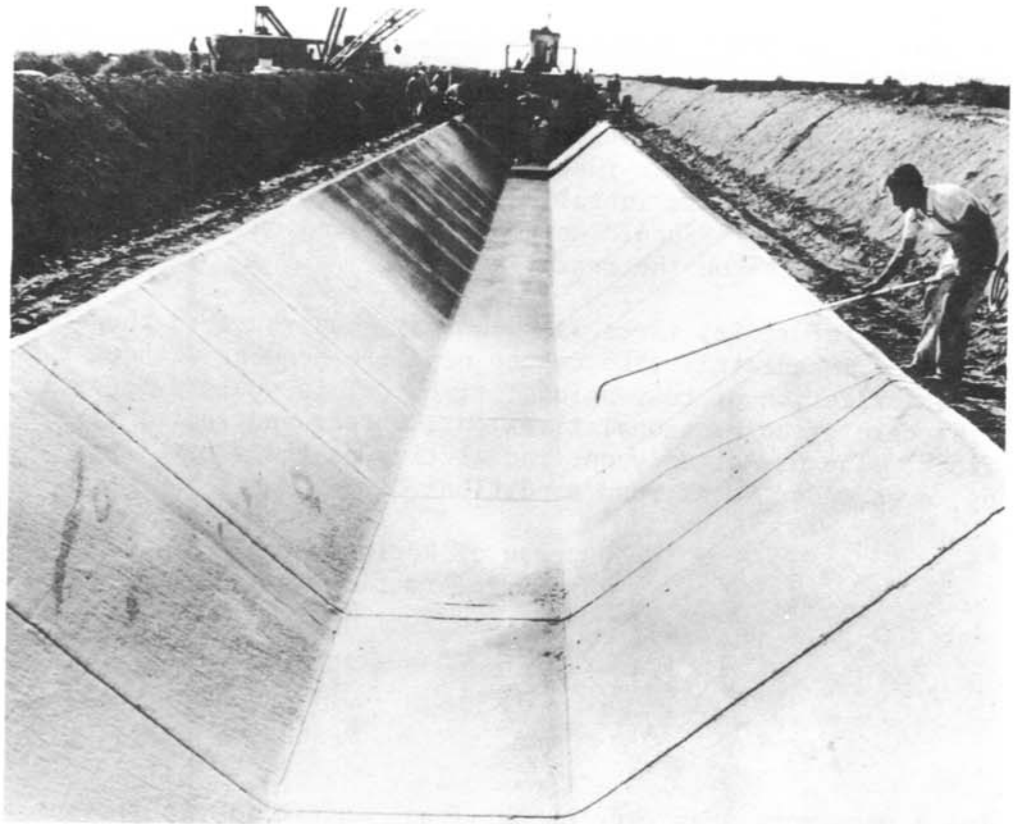
Another change in the direction of economy which has accompanied elimination of reinforcement is the relaxation of tolerances in alinement, grade, thickness, and finish of concrete linings. Current Bureau specifications permit departure from established line of 4 inches on curves and 2 inches on tangents and departure of 1 inch on grade, and allow a 10-percent reduction in thickness provided each day's placement averages full thickness.

A simplified type of construction has been adopted for linings in relatively small canals and in laterals and farm ditches to reduce costs and at the same time maintain the durability and serviceability of the work. This type of construction makes use of a subgrade-guided slip form, as shown in photograph 3 below. With reasonable care in operation, no difficulty is experienced in placing linings with subgrade-guided slip forms to the specific tolerances. The quality of materials, proportioning and mixing, uniformity in placing, and



Photograph 3 (PX-D-32056)

curing of these linings should be equal to similar requirements for linings used on the larger canals. A reduction in these requirements would seriously impair the durability and result in very little decrease in cost. Photograph 4 below shows a workman spraying sealing compound on a new canal lining to conserve the moisture necessary for curing.



Photograph 4 (PX-D-33040)

Except for gaps or rock pockets, surfaces are generally acceptable as they emerge from the slip form. Substantial savings can be realized only by high hourly and daily production resulting from a minimum of refinements in workmanship and from cooperative and practical inspection.

* * * * *

Common Sense--which, one would say, means the shortest line between two points, and Worry--is the interest paid by those who borrow trouble.

RADIAL TIRES (Safety)

After a driver lost his life in a motor vehicle accident, investigation revealed that the car was equipped with a radial tire on the right front wheel, and with conventional tires on the remaining three wheels. This condition was considered a significant accident cause factor. It was suspected that the radial tire held a true track, while the conventional tires lost traction and caused the skid that resulted in a head-on collision.

The mixing of radial and conventional tires is a safety hazard! Preferably, radial tires should be installed on all four wheels. However, if only two radial tires are installed, they should always be used on the rear wheels. Radials should never be installed on front wheels with conventional tires on the rear.

The basic design of radial tires is such that when you turn the steering wheel, they immediately take up the new tire heading without the normal side deflection of conventional tires. This would produce a skid in the case of conventional tires on the rear and radial tires on the front. The use of only one radial tire on the front is highly dangerous, even under ideal road conditions.

Bureau of Reclamation
Staff Information Letter, July 30, 1971

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TAILGATING

Tailgating caused more than one-fourth of all automobile collisions in New York State during 1967. Of 304,541 collision accidents, the New York Motor Vehicles Department listed "following too closely" as a contributory cause in 82,257 instances involving personal injury or car damage. The answer to "How close is too close?" varies with road and weather, speed, hour of the day, and physical condition of both the car and driver. The Greater New York Safety Council recommends maintaining a distance between cars on normal roads of at least one car length for each 10 mph of speed under the best possible conditions. This ratio should be doubled on expressways, the Council cautions.

The recommended defensive action for the driver being tailgated is to slow down by gradually easing off the gas pedal, steer as far right as feasible, and encourage the tailgater to pass. The Council warns against the practice of the first driver's tapping his brakes to signal tailgaters to fall back because of the danger of braking too severely, causing the tailgater to run into the car ahead before he can stop.

FIELD TESTING OF PLASTIC AND PLASTIC-CLAD PIPES 1/

The Bureau of Reclamation, as a major developer of irrigation and drainage projects in the western United States, has had a long and continuing interest in the development of new materials for use on these projects. Within the past ten years or so, a host of new synthetic polymeric materials has been made available; however, specific research and development of these materials with respect to irrigation and drainage requirements have undergone somewhat slower progress. When the capability to manufacture pipe from these new materials in the sizes commonly used in large irrigation projects was developed, numerous test-and-evaluation programs were initiated.

Laboratory tests can establish the properties of the new materials and the pipe sections. They cannot give a complete picture of the effects of different construction methods or such variables as the interaction of the pipe, the compacted backfill around the pipe, and the trench walls. Field-testing actual pipe installations is the only method by which many of these variables can be evaluated. For this reason, the Bureau of Reclamation is engaged in a number of such tests to evaluate reinforced plastic mortar (RPM), polyvinyl chloride (PVC), and vinyl-clad aluminum pipe. Typical installations at which field testing has been performed by the Bureau are at the Carrington Irrigation Branch Station, North Dakota State University; the Sargent Unit, Pick-Sloan Missouri Basin Program, Sargent, Nebraska; and the reservation Division of the Yuma Project, Yuma, Arizona.

Polyvinyl Chloride & Vinyl-clad Aluminum Pipe

The Carrington Irrigation Branch Station is a part of the Agricultural Experiment Station at North Dakota State University. It is a relatively new facility established by the North Dakota state legislature in 1957. The station serves as a demonstration unit--a "show-n-tell" area where modern irrigation-farming practices can be observed. Within this context, an attempt has been made to use the more recently developed irrigation materials and equipment. The Bureau of Reclamation contracted with the university and participated in the installation of the pipe listed in Table 1 during 1968 and 1969; the pipes were donated by various manufacturers.

1/ Reprinted from a paper presented at the American Water Works Association Annual Conference of June 17, 1971, by Carl E. Selander, Materials Engineer, and Richard A. Simonds, Civil Engineer; both of the E&R Center, Bureau of Reclamation, Denver, Colorado, and was published in the American Water Works Association Journal, July 1971.

TABLE 1

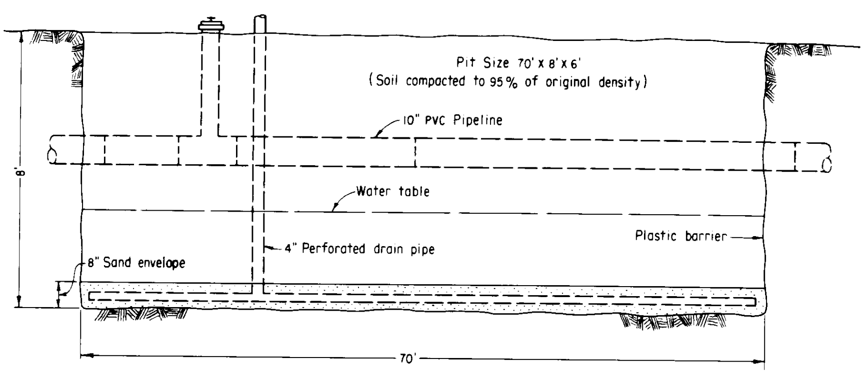
Test Pipe Installed by Bureau of Reclamation (1968-9)

Type	Diameter-in.	Installed length-ft
PVC	6	1,780
PVC	8	360
PVC	10	320
PVC	12	600
Vinyl-clad aluminum	6	600
Vinyl-clad aluminum	8	600

Of prime concern in the use of these types of pipe in North Dakota is their performance when buried within the frost zone in the ground. Placing the pipe below the frostline would require burial depths of 6-7 feet, resulting in extremely high project cost. Placing the pipe within the frost zone is an acceptable alternative, provided provision is made to drain the line during the annual freeze.

Concern about Frost Action

To determine the effects of frost action on a pipeline, an area with an artificial, high water table was constructed. A trench, 6 feet wide, 8 feet deep, and 70 feet long, was dug along the alignment of a reach of 10-inch PVC low-head pipe. The pit was lined with 0.006-inch PVC plastic sheeting and then backfilled with an 8-inch layer of sand over a perforated drainage pipe that had a riser extending to the surface. (See Figure 1 below.) The drain pipe and sand layer permitted charging of the water table from the surface. The soil removed from the pit was used to backfill the pit and was compacted in 6-inch layers.



SIMULATED WATER TABLE
FIGURE 1

After backfilling the pit, a wheel trencher was used to cut a 14-inch-wide trench for installing the PVC pipe through the artificial water-table area.

In order to determine the stress in the pipe due to temperature and frost action, strain gages were installed on both the pipe in the artificial water table area and adjacent pipe outside the water table area. Additionally, some 37 vertical reference points were established on the PVC and the vinyl-clad aluminum pipe to measure any heaving action of the frozen soil. The strain-gage results are not yet available, and only one year's data on the reference-point elevations have been received. These data suggest that frost heaving is not likely to be a serious problem in the moderately well-drained soils of the Carrington Station. Only minor changes in elevation were observed, even in the artificial water-table area where the average upward movement was 0.02 foot. A slight downward movement of the aluminum line was observed, which, it is felt, was due to settlement of the backfill placed under portions of the pipeline to achieve grade for drainage of the line.

Deflection Characteristics

The "low-head" PVC irrigation pipe installed at the Carrington Station is designed to withstand operating pressures of no more than 22 psi. Therefore, it has a thin wall and is fairly flexible when subjected to external forces such as are imposed by an earth load (on top of the pipe) and any additional live load.

The behavior of flexible steel conduits under load has been well-documented, but little has been done in the United States to determine the behavior of flexible plastic pipe after burial. This objective was scheduled for another series of tests carried out at the Carrington Station. The low-head PVC pipe was installed with various bedding and backfilling conditions. Internal-diameter measurements were taken to determine the initial deflections along the pipe, and twice-yearly measurements will be taken to determine any changes over a period of time.

The pipe was installed so as to obtain varying amounts of side support. As might be expected, those methods that did not entail compaction of the soil at the sides of the pipe, such as pushing the backfill material into the trench by machine, resulted in appreciable deflections. These deflections were observed to be as high as 22 percent with 4 feet of earth load. On the other hand, considerable side support was obtained by hand-compacting the backfill to one half the diameter of the pipe and placing the remainder by machine. Depending on the amount of compaction, this method produced deflections that varied from very little (under 3 feet of earth load) to such proportions that the vertical diameter was greater than the horizontal diameter. Various methods using puddling, or ponding, techniques resulted in deflections of 5-12 percent under 3 feet of earth load. These figures can be made more meaningful by use of comparisons. Collapse of a flexible conduit is considered imminent at a deflection of approximately 20 percent of its initial diameter, and it is current engineering practice to use a design criterion of 5 percent maximum initial deflection to ensure against conduit failure from collapse.

Reinforced Plastic Mortar Pipe

On the Reservation Division of the Yuma Project in California, the Bureau of Reclamation is conducting field tests with reinforced plastic mortar (RPM) pipe. At two different locations, 30-inch-diameter, 100-psi pressure pipe has been installed to replace two existing open laterals. One installation, the Toronto Lateral, is 625 feet in length and has 4 feet of earth cover; the other, Apache Lateral 2, is 660 feet long with 4-5 feet of cover. The main objectives of this field test are to evaluate the performance of RPM pipe under controlled field conditions and to measure the deflections of RPM pipe laid in various bedding conditions.

The results of this field test should supply additional information on bedding conditions required to keep the pipe deflections within a specified limit. In addition, because the bottom of the trench for the Apache Lateral 2 was placed 6-9 inches below the ground water table, the highly permeable soil allows the water to flow readily into the trench. Project forces did not dewater the trench; consequently, an evaluation can be made of the problems associated with laying RPM pipe under such adverse conditions.

Different Conditions

On the Toronto Lateral, five different types of bedding were used: vibrated-sand bedding, loose-sand bedding, loose-natural-earth bedding, pneumatically tamped bedding and puddled-natural-earth bedding. All of these beddings were placed to 0.7 of the OD of the pipe above the bottom of the trench. The trench was then backfilled by machine. Measurements of the inside vertical and horizontal diameters were made on each piece of pipe before the bedding was placed and after the backfill was completed. Again, the necessity of providing good side support for a flexible pipe was demonstrated.

Figure 2 shows loose-sand bedding being placed around the pipe. Where such loose material was used for bedding, the initial pipe deflections ranged as high as 9 percent; the pneumatically tamped bedding resulted in a slight vertical elongation; the vibrated-sand bedding also gave very good side support and resultant deflections were just under 1 percent; initial deflections, where puddled natural earth bedding was used, were 2-4 percent.

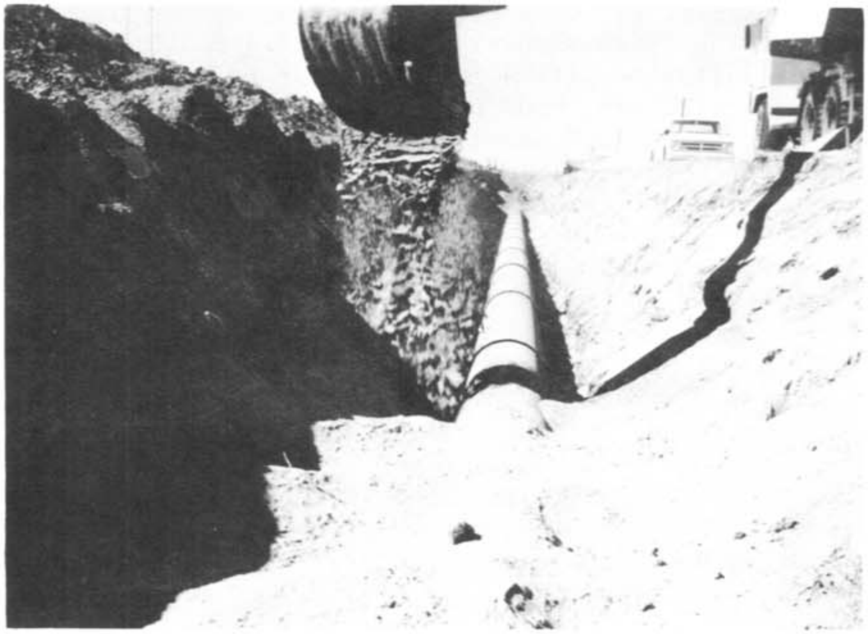


Figure 2 (P35-D-68835)

Additional measurements were taken four months after the installation was completed. In almost all cases, the deflection increased a few tenths of 1 percent except for the areas containing loose-natural-earth bedding. The deflections in these areas increased as much as 2 percent, and the maximum deflection measured was just over 10 percent.

Added Pressure

An abundant supply of large concrete blocks, each approximately 1 cubic yard in volume and weighing 2-3 tons, was available near the Toronto Lateral. These blocks presented an opportunity to apply a surcharge load to the buried pipe in an attempt to duplicate in the field a laboratory test* that the Bureau has been performing.

On the Toronto Lateral, the backfill was removed to a depth of 2 feet over one section of pipe and the concrete blocks were stacked in layers over the pipe in an effort to obtain a deflection of approximately 5 percent. Measurements of the inside diameters were taken before the surcharge was applied and after each successive layer of blocks was placed. Eight blocks were placed in three layers, resulting in a structure approximately 9 feet high, at

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* Bury a 6-foot length of 18- to 24-inch-diameter pipe in a large soil box with varying degrees of compaction of the soil and apply a surcharge by means of a 5-million-pound Universal testing machine.

which point a decision was made not to proceed further for safety reasons. The final surcharge was 1,069 psf. The pipe had originally been installed with 4 feet of cover in an area allocated to the use of vibrated-sand bedding. The initial pipe deflection due to the 4-foot earth load was less than 1 percent. With the application of the surcharge, the deflection increased to approximately 3 percent, considerably less than the original objective of 5 percent.

Ground-Water Problems

Since RPM pipe has rubber-gasketed joints, the pipe could be laid for Apache Lateral 2 without problems despite the murky water in the bottom of the trench. The bottom of the trench was 6 to 9 inches below the ground-water table, and it could not be determined whether the installation resulted in good watertight joints. Since pressure head on the pipeline would not exceed 10 feet, no effort was made to determine whether sand or dirt particles in the water would cause problems if the joints were subjected to high pressure.

On this lateral also, the deflections of the pipe will be monitored. Two types of bedding conditions have been used. On approximately two thirds of the pipeline, the bedding was placed in 1-foot lifts to 0.7 of the pipe OD; with each lift water settled. The bedding for the remainder of the line was puddled to 0.7 of the OD. Deflection data for this pipeline have not yet been received.

Additional PVC Testing

The test installations at the Carrington Station and on the Yuma Project are typical of the field tests performed by the Bureau in which technical data are obtained over a period of years. Typical of another type of field test is the Sargent Unit, Pick-Sloan Missouri Basin Program, Sargent, Nebraska. To eliminate a difficult-to-maintain reach of open lateral with associated check and drop structures, 2,480 feet of 10-inch-diameter and 80 feet of 8-inch-diameter PVC pipe were installed in April 1969.

No particular test program was established for the installation of the 10-inch pipe by a two-man crew. Instead, normal operating procedures are being followed by the conservancy district operating the line, and any problems with initial installation or during later operation or maintenance will be reported.

In the process of filling the pipeline with water prior to back-filling the trench, an 80-foot section of pipe broke. An investigation revealed that the probable cause of failure was the operation of a control valve at the lower end of the line that imposed water-hammer surges on the line. The section was repaired and the installation has performed satisfactorily since. From these and other project installations, the Bureau hopes to obtain a better knowledge of these types of pipe.

Conclusion

The technical data gathered from these tests will enable designers to formulate more accurate and more efficient design criteria. The installation of new types of pipe in actual operating systems will enable future users not only to be aware of what problems to anticipate but what advantages may be realized.

Increasingly important is the fact that buried pipelines neither remove any great amount of land from production, nor do they allow any water to be lost from evaporation or infiltration. Through the use of new materials, a project that might otherwise not be built may prove to be feasible. In an era of continually rising costs, the underlying philosophy behind all of the Bureau's test programs is to strive continually for a better completed project at an optimum cost.

* * * * *

Safety Belt Protection--An analysis of 28,000 accidents by Volvo showed no deaths of persons who wore lap-shoulder safety belts in accidents up to 60 miles an hour. An examination of accidents by General Motors revealed that in 160 cases in which persons wore lap-shoulder belts, only two persons were killed and each died under unusual circumstances unrelated to the belts. Ford Motor Company estimates that if 90 percent of all drivers and passengers had worn just their lap belts in 1969, about 9,800 lives would have been saved, and if 90 percent had used lap-shoulder harnesses 14,400 fewer lives would have been lost.

HYDRAULIC DESIGN OF STILLING BASIN FOR PIPE OR CHANNEL OUTLETS 1/

High-energy forces in flowing or falling water must be contained or dissipated to prevent damaging scour or erosion of downstream channels.

Various means for energy dissipation are employed at hydraulic installations. Stilling basins are among the most common. Ten types, I through X, are used by the Bureau of Reclamation. (The Roman numeral classifications are internal Bureau designations.) The variety of operating conditions necessitates this wide range of stilling basin designs.

Criteria for design of the ten stilling basin types were first summarized in Engineering Monograph No. 25, published in 1958 and revised in 1963. The monograph was based on a series of earlier papers and laboratory reports.

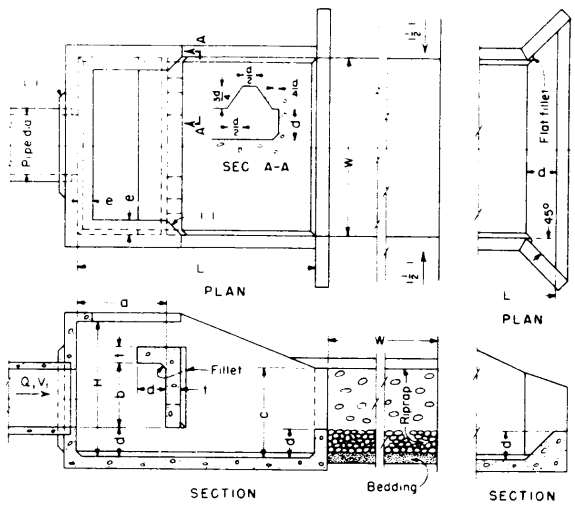
The procedures for designing the Type VI stilling basin recently were updated and modified to reflect results of field experience and more extensive model studies in Research Report No. 24.

Development of the Type VI short impact-type basin originated with a need for some 50 or more low-head stilling structures on a single irrigation project. Relatively small basins providing energy dissipation independent of tailwater were required.

The information in the report is intended for water resource centers, government agencies, municipal and industrial water operators, and hydraulics and irrigation systems designers.

Figure 1 on next page shows the general design of Type VI impact stilling basin. Figure 2 on same page indicates the minimum width of basin that can be used for a range of Froude numbers. For best results, the basin should be designed for the minimum width indicated in the figure.

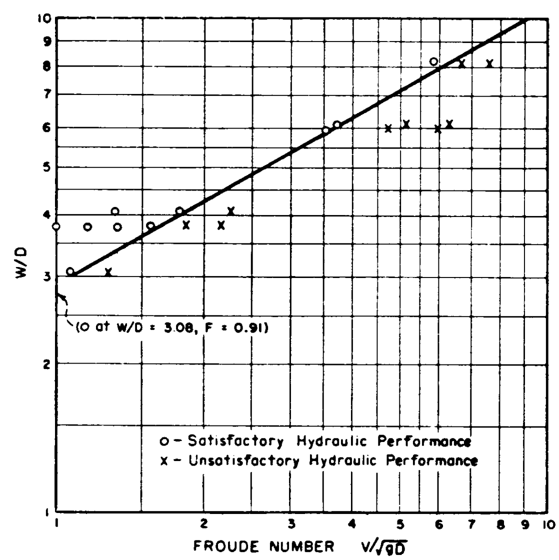
1/ Extracted from Research Report No. 24, a Water Resources Technical Publication, by G. L. Beichley, Division of General Research, E&R Center, Denver, Colorado, and printed for the Bureau of Reclamation by the Superintendent of Documents, Washington, D.C.



H = 3/4 (W)
L = 4/3 (W)
a = 1/2 (W)
b = 3/8 (W)

c = 1/2 (W)
d = 1/6 (W)
e = 1/12 (W)
t = 1/12 (W), suggested minimum
Riprap stone size diameter = 1/20 (W)

Figure 1.—General design of the Type VI impact stilli. g basin.



"W" is the inside width of the basin.
"D" represents the depth of flow entering the basin and is the square root of the flow area.
"V" is the velocity of the incoming flow.
The tailwater depth is uncontrolled.

Figure 2.—Design width of basin.

Design Conclusions and Recommendations

The following procedures and rules are recommended in the design of the Type VI basin:

1. Given a design discharge "Q," determine the velocity "V" and Froude number "F" of the incoming flow. If the Froude number is more than 10, use of this basin is not practicable. In computing the Froude number, assume the depth "D" to be the square root of the cross sectional area of the flow at the entrance "Q/V."

2. The flow is usually from a pipe. If the pipe flows partially full, it should be vented at the upstream end.

3. If the entrance pipe slopes downward, the outlet end of the pipe should be turned horizontal, or the invert filled to form a horizontal surface, for at least one pipe diameter upstream from the portal. For slopes 15° or greater, the horizontal length of pipe or fillet should be two or more diameters.

4. If the flow enters the basin from a rectangular open channel, the channel walls should be as high as the basin walls and the invert should be horizontal for a minimum of two channel widths upstream from the basin.

5. Having determined the Froude number, enter Figure 2 to find the minimum required width of basin.

6. Figure 2 shows data points above the recommended width that provides satisfactory operation for basins larger than the design limit; however, if the basin is too large, the incoming jet will pass under the hanging baffle to reduce the effectiveness of the basin. Since the basin will be larger than need be for less than design flows, the basin should not be oversized for the design flow.

7. Relate the basin dimensions to the basin width in accordance with Figure 1. The dimension "t" is a suggested minimum thickness for the hanging baffle and is not related to the hydraulic performance of the structure.

8. To prevent the possibility of cavitation or impact damage to the basin, the entrance velocity should be limited to about 50 feet (15.24 meters) per second.

9. Riprap with a well-graded mixture of stones, most of which have diameters equal to one-twentieth of the basin width, should be placed to a depth equal to the height of end sill for a distance equivalent to one basin width downstream from the end sill.

If the elevation of the channel bed is below the end sill, the velocity of flow entering the channel will be increased and the riprap stone size should be increased also. The drop in elevation from sill to bed must be added to the velocity head of the flow at the end sill, as determined from figure 3, to obtain the average velocity of flow entering the tailwater channel. The velocity can be used to determine the size of stones required.

10. Tailwater depth other than that created by the natural slope of the channel is not required. However, a smoother water surface will be obtained and smaller riprap stones can be used by increasing the tailwater depth in the channel to a depth of d+b/2 (see figure 1 for definition of "d" and "b") above the basin floor.

11. This basin is more effective in the dissipation of energy than the hydraulic jump, figure 3. Prototype basins have operated successfully with entrance velocities up to 38 feet per second, and the recommended riprap size requirement has been verified by the performance of these basins.

12. The alternate end sill design (figure 1) utilizing the 45° wingwall is not required but will reduce the drop in water surface elevation from end sill to channel (figure 3) and reduce channel erosion.

13. No practical method of making the basin self-cleaning of debris, such as Russian thistles, was found. Where debris is a problem, screening devices are recommended at the entrance to and over the top of the structure. If thistles are allowed to enter the basin, they will not wash out.

14. During periods of nonoperation, sediment may accumulate in the basin. Notches in the baffle (figure 1) are recommended to provide two jets that will start the erosion of the sediment which will eventually be washed from the basin. However, the basin is capable of satisfactorily discharging the entire design flow over the top of the baffle for short periods of time.

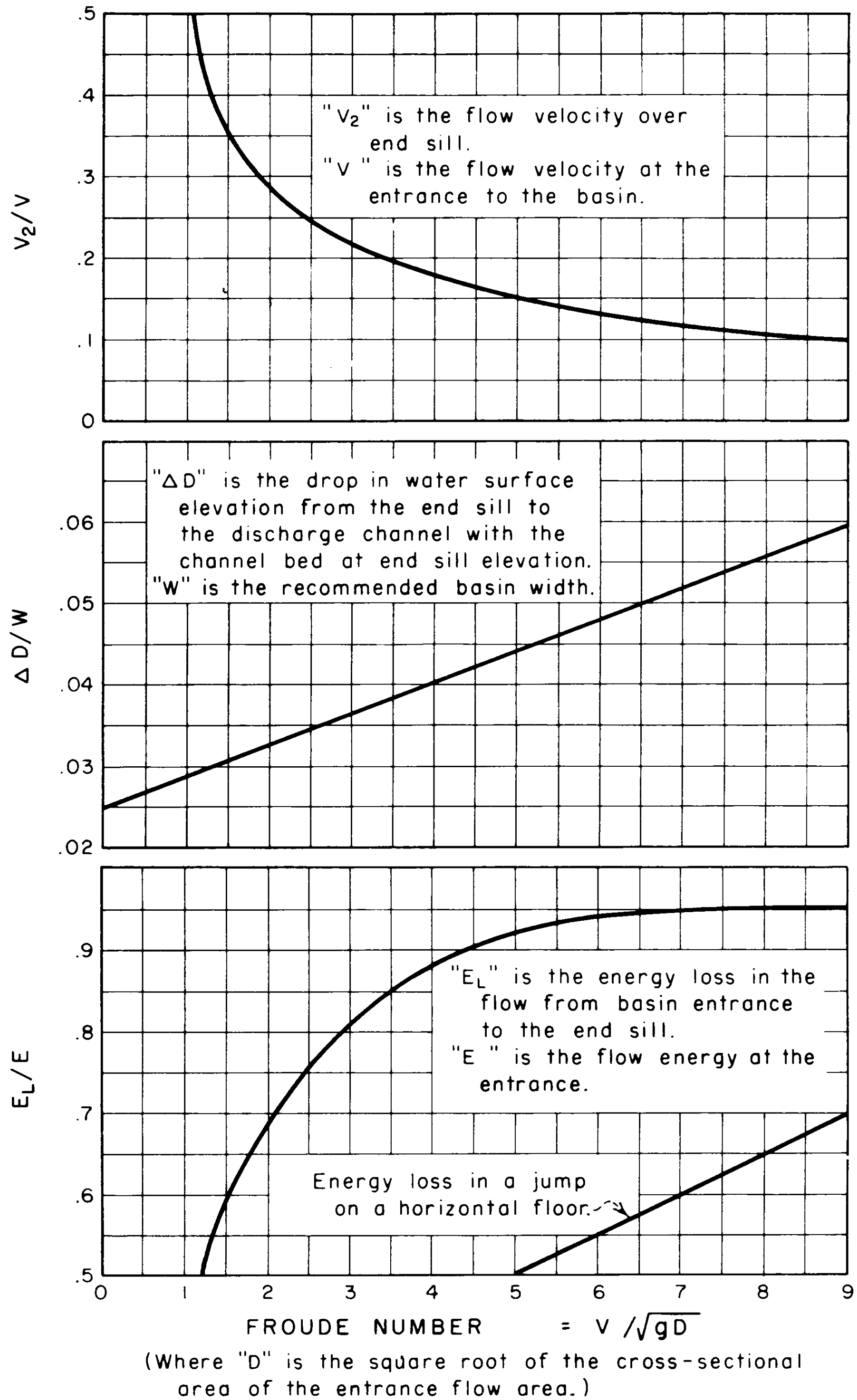


Figure 3.—End sill velocity, water surface drop from end sill, and energy loss through basin.

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CHLORINE GAS--A HAZARD

Chlorine is a heavy, greenish-yellow nonflammable gas which is easily liquified and is supplied commercially as a liquid under pressure in cylinders and larger containers. It is used for the purification of water in many water supply treatment plants. It also may be introduced into a water system to prevent algae growth which prevents normal water flow in a pipeline and affects new water quality.

The gas is an irritant to the respiratory system and is said to be dangerous on short exposures to atmospheres containing 40 to 60 ppm. Exposures to high concentrations can be fatal. One ppm has been suggested as the maximum acceptable concentration for continuous exposure. This limiting concentration is probably unnecessarily low for either safety or comfort. A gas mask of the acid type will provide protection from concentrations up to about 2 percent by volume in the air at which point skin irritation becomes serious.

Treatment Upon Exposure

A person who has been exposed to chlorine should be taken from the gas area and kept as quiet as possible. Rest is essential. He should be kept warm and quiet on his back with his head elevated. A physician should be called immediately. Because of its fairly low solubility in water, chlorine is an irritant to the deeper as well as the upper respiratory system and its serious effects may be delayed for 5 or 6 to 24 hours. People who have been exposed to vapors should consequently be kept under observation for at least 24 hours.

In mild cases of throat irritation from chlorine, milk will give mild relief. Epinephrine or ephedrine will give relief shortly after exposure when the distress is mainly from bronchial spasms.

Inhalation of oxygen where the carbon dioxide and oxygen mixture is helpful in chlorine poisoning particularly if positive pressure breathing can be given. If breathing has apparently ceased, artificial respiration should be started at once, and it will be more effective if oxygen inhalation can be given at the same time.

Handling of Leaking Gas Cylinders

The handling of cylinders containing chlorine gas is no different from that of other compressed gas cylinders. However, in spite of the most careful inspection, compressed gas cylinders and larger containers will occasionally leak, commonly because of unnecessary rough handling. The Chlorine Institute gives the following recommendations for handling leaking chlorine containers:

1. Correct the condition promptly. Telephone your chlorine supplier or any chlorine producer if you need help.

2. Keep on the windward side of the leak and higher than the leak.

3. Permit only authorized training personnel equipped with gas masks to investigate. Keep all other persons away from the affected area.

4. If the leak is extensive, try to warn all persons in the path of the fumes.

5. If a leak occurs in equipment in which chlorine is used, close the valve of the chlorine container immediately.

6. If chlorine is escaping as a liquid, turn the container so that the chlorine gas escapes. The quantity of gas escaping from a leak is about one-fifteenth the amount the liquid which would escape through a hole of the same size.

7. Do not apply water to a chlorine leak.

8. If a chlorine leak occurs in transit in a congested area, keep the conveyance moving, if possible, until it reaches an open area. If the conveying vehicle is wrecked, shift the container or containers so that the liquid won't leak if chlorine gas is escaping. If possible, transfer the containers to a suitable conveyance and transport them to open country.

9. Pinhole leaks in cylinders and ton containers may sometimes be temporarily stopped by tapered hardwood pegs, or metal grip pins driven into the holes. First turn the containers so that only gas is escaping. Use extreme care in driving the plug because the wall area surrounding the hole may be thin and crumble. When this emergency measure is taken, empty the cylinder as quickly as possible.

10. At usual points of storage and use, make emergency preparation for disposing of chlorine from leaking containers. Chlorine may be absorbed in caustic soda, soda ash or hydrated wine solution. Caustic soda is recommended because it absorbs chlorine most readily.

11. Provide a suitable container to hold the solution in a convenient location. Pass the chlorine into the solution through an iron pipe or rubber hose, weighted to hold it under the surface. Discuss the details of such preparation with the chlorine producer.

Care in Using Chlorine Gas

A recent incident within the Bureau of Reclamation indicated the need for a program governing the moving, storage and maintenance precautions to be used in connection with chlorine gas. Accordingly, a power maintenance instruction on "Chlorine Gas System Precautions" has been printed for the guidance and direction of all Bureau personnel who have been delegated the responsibility of handling chlorine gas. Pertinent portions of the instructions adopted for water operations are being reprinted in the following paragraphs.

Moving Cylinders or Other Containers

In moving cylinders or other chlorine gas containers:

1. Never move a chlorine container or cylinder unless the cylinder or container valvehood is in place.

2. Do not drop a container or allow an object to strike the container with force.

3. Never apply heat to chlorine containers or their valves.

4. A hand truck having a clamp support at least two-thirds of the way up the cylinder should be used when moving the cylinders.

5. When lifting a cylinder when using a crane or hoist, a special cradle or carrier should be used. Never use a rope-sling, chain, or magnetic device.

6. Never lift a cylinder by means of the protection hood.

Storage of Cylinders or Containers

In the storage of cylinders or other chlorine gas containers:

1. One extra full or empty container may be racked and stored in the chlorine room. All other containers should be stored outside of attended plants. The storage area should be dry and protected from all heat sources including the sun.

2. Never store containers near turpentine, ether, anhydrosen-amonia, finely divided metals, hydrocarbons, oxygen cylinders, acetylene cylinders or any flammable materials.

3. The storage area should be clean, well vented to atmosphere, and remote from elevators, gangways, ventilating systems or any other area that would disperse a leaking gas rapidly throughout the building.

4. Valve protectors should always be on during storage.

5. Cylinders should be stored in an upright position, not stacked, and free of other stored material.

Operation and Maintenance

In the operation and maintenance of chlorine gas containers:

1. Never tamper with fusable plug safety devices on containers.

2. Never alter or repair the container or its valve if damaged. The chlorine supplier should be advised.

3. Never place a container in a bath of hot water or apply direct heat to increase the flow rate or for any other reason.

4. A flexible connection should be used between the container and the piping system. Copper tubing suitable for 500 psig (3/8-inch od by .035-inch wall is recommended). Yokes, clamps, and adapters are recommended for connection to the container valve outlet.

5. Never do maintenance work on the system unless the tank valve is closed.

6. When a container is empty its valve should be closed, lines disconnected, and the valve tested for leaks. If okay, an outlet cap should be applied promptly and the valve protection hood attached. If the valve does not seat on first trial, open and close it lightly until proper seating is obtained. Never use a hammer or any other instrument to affect a tight valve closure.

7. To detect a leak, apply a cloth to the end of a stick, soak cloth with ammonia water and hold close to suspected area (do not get the ammonia in direct contact with brass). A white cloud of ammonia chloride will result if there is a chlorine leak (a commercial supply of 26° baume ammonia water should always be available, household ammonia is not strong enough).

Precautionary Measures

Some important precautions to follow for personal safety:

1. Do not enter a chlorine-contaminated area unless wearing self-contained breathing apparatus which should be on hand in all plants where the gas is being used. Canister type chlorine masks do not afford protection if chlorine concentrations exceed 1 percent and the oxygen concentration is below 16 percent.

2. Should a leak develop in the piping system, shut off the chlorine supply and dispose of system gas still under pressure prior to repairing the leak. Should a major leak develop either in the piping or in the cylinder which cannot be controlled, clear the area of personnel and exhaust the fumes to the outside.

3. In the event of a cylinder valve leak, tighten the packing nut with a special wrench. Should the leak continue, replace the protective cap on the valve and remove the cylinder to the outside.

4. If the cylinder leaks, turn the cylinder at an angle which will permit gas instead of liquid to escape. This will minimize the amount of chlorine lost through the leak.

5. Do not use water on a chlorine leak.

6. In the event of fire, cylinders should be removed from the fire zone immediately.

In addition to the general information above, the following specific instructions were provided employees of one operating agency that uses chlorine gas.

1. All project personnel who service chlorinators must use self-contained air masks at all stations and also carry air masks in their trucks. A few leaks have been discovered at various times in the chlorinating equipment but most of these leaks have been of minor consequence; however, a major leak does occur occasionally.

2. Personnel should be aware at all times that chlorine gas is heavier than air and precautionary measures should be taken this gas being heavier than air will seek the lowest level. It will flow down stairways, elevator shafts, etc. Operators of chlorination equipment should not attempt to repair a major leak if alone. Assistance should be called immediately and they should standby while repairs are being made.

3. A few employees have inhaled a small quantity of chlorine gas but there has been no injuries or damage to equipment other than some corrosive effect on electrical equipment.

4. It was noted that all exhaust fans in use on some projects have the electrical switches close to the fan and in the same room in which the equipment is housed. This, they say, is not a good practice. They feel it would be well to consider placing switches in an adjoining room so if a leak does occur, the operator does not have to enter a gas-filled room to turn on the exhaust fan.

5. Consideration should also be given in building a plant where chlorination of water is being performed so that if a leak does occur it will not flow into inhabited areas. A gas leak did occur on one of the reservoirs and people in that area about one-third of a mile away down the hill could detect the odor of the chlorine gas and reported it to the project office.

6. For practical and economical reasons, all of the chlorination should be done from the large 1-ton cylinders where this is possible.

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GPO 839-018