Department of the Interior
Bureau of Reclamation

OPERATION AND MAINTENANCE EQUIPMENT AND PROCEDURES

RELEASE NO. 31

January, February and March 1960

Contents

COVER

CARTOONS SELL VALUE OF PREVENTIVE MAINTENANCE

A series of clever original cartoons, pointing up the importance of preventive tractor maintenance, is offered free to owners and operators of construction equipment. Printed in four colors on heavy paper, the eye-catching 11- by 13-inch posters contain no advertising and are suitable for tacking on field shacks, shop walls, and bulletin boards. Featuring cartoon characters in typical job situations, the series sells proper tractor maintenance in a humorous, enjoyable manner and is keyed to seasonal problems. You can order as many copies as you need of this cartoon (shown on the cover) by sending your name, title, address and company name to J. I. Case Company, Industrial Advertising Department, Racine, Wisconsin. New cartoons will be mailed to you as released.

* * * * *

OPERATION AND MAINTENANCE

EQUIPMENT AND PROCEDURES

Release No. 31

January, February and March - 1960

INTRODUCTION

This is the time of year that many operators on our Northern Irrigation Projects are overhauling and repairing maintenance equipment. Accordingly, we have asked permission of several publishers to reprint articles in this issue of the bulletin relating to general and preventive maintenance. The cartoon on the cover of this issue is one of a series that you may obtain that are aimed toward encouraging proper care, operation and maintenance. To obtain the series see back of front cover page.

This bulletin, published quarterly, is circulated for the benefit of irrigation project operation and maintenance people. Its principal purpose is to serve as a medium of exchanging operation and maintenance information. It is hoped that the labor-saving devices or less costly equipment developed by the resourceful water users will be a step toward commercial development of equipment for use on irrigation projects in a continued effort to reduce costs and increase operating efficiency.

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

* * * * *

Division of Irrigation Operations
Commissioner's Office
Denver, Colorado

AIR TOOL MAINTENANCE

In the hands of good operators portable air tools can save time and reduce costs on many jobs. Yet, the best operator is only as good as the demolition tool, impact wrench, clay digger, backfill tamper, or other air tool he is handling.

Too often, the performance of air tools is permitted to fall off drastically because of lack of attention to basic maintenance. Poorly maintained air tools are costly from two points of view. First, expensive labor produces less per hour as the tool's performance deteriorates. Secondly, worn tools consume more air.

John Scott Andrew, Sales Engineer in the Pneumatic Division of the Chicago Pneumatic Tool Company, writing for Construction Methods and Equipment, states that air tools, though precision-engineered, are constructed to withstand a terrific amount of abuse. But a little common sense goes a long way toward keeping performance up, repair bills down. Three "musts" for efficient air tool performance are:

1. A clean, dry, and ample air supply.

2. Adequate and proper lubrication.

3. Periodic inspection and replacement of worn parts.

Air Supply

In both reciprocating and rotary air tools, close clearances between certain moving parts are essential. Dirt or dust in the air supply cause rapid deterioration of these parts.

Most air tools have wire-mesh strainers in their air inlets to prevent entry of foreign particles. However, if the air is not filtered before it reaches the air inlet of the tool, these screens quickly become clogged, choking the air supply and necessitating frequent cleaning. Wherever possible, porous element-type air filters should be installed in the air lines and cleaned frequently.

Moisture in the air supply adversely affects tool performance in several ways. Excessive moisture interferes with proper lubrication and can result in rusting of internal parts. Ice formation within the tool's air passages creates back pressure that restricts the output. Again, moisture exhausted by the tool can be extremely irritating to the operator. Most air line filters are reasonably effective in removing moisture, but unusually wet air may require the use of a moisture separa-

tor in each branch of the air piping.

Portable air tools, with few exceptions, are designed to operate at 90 psi, gaged at the tool inlet while the machine is operating. This means that the delivery pressure at the compressor must be greater than 90 psi to compensate for the unavoidable pressure drop in the air lines. It also means that all air piping, fittings, and hoses must be of sufficient size to keep this pressure drop to a minimum.

If the air pressure falls below 90 psi at the tool inlet when the tool is operating, it is likely that either the compressor is not capable of delivering the required volume of air or the delivery pressure at the compressor is not high enough to compensate for the pressure drop.

It is also important to bear in mind that other tools may be operating from the same air supply. Therefore all tools working off a particular air supply must be in normal operation if an accurate pressure check is to be made.

Lubrication

An intelligent automobile owner would not use his car without having it properly lubricated. An intelligent air tool operator should not try to operate his equipment, without a similar lubrication.

Special oils are available for lubrication of air tools, and manufacturer's recommendations should be followed carefully. These special oils have three important functions in addition to the obvious one of friction reduction between moving parts.

First, oil serves as a sealer between closely fitting parts, limiting air leakage and increasing efficiency. Second, it acts as a coolant, dissipating heat from high friction surfaces. Third, oil actually absorbs moisture in the air, forming an emulsion. This action does not interfere with the oil's lubricating qualities, and rusting is unlikely even though this emulsified moisture may remain in the tool during long periods of idleness.

Many air tools have built-in oil reservoirs to provide continuous lubrication. These should be filled daily, and a small amount of oil should be poured into the tool's air inlet each morning prior to operation.

It is often difficult to provide adequate supervision to guarantee that these reservoirs are kept filled. A widely used and highly recommended method of assuring proper air tool lubrication is to install lubricators in the air line.

These line oilers are available in various capacities and pipe sizes. Keeping them filled becomes the job of regular maintenance personnel.

Where long hose lines are used, line oilers suitable for insertion between two lengths of hose or for attachment to the tool inlet are available.

Naturally, a filter or moisture separator should never be located downstream from a lubricator. Conversely, if a pressure regulator is required in the line, it should be located downstream from the filter or separator and upstream from the lubricator.

Inspection

Despite careful lubrication and scrupulous observation of the air supply, the constant use and abuse to which air tools are subjected mean that a periodic maintenance plan must be scheduled, and worn parts repaired or replaced. It is imperative that this schedule be maintained. The particular tools to be inspected should be taken from production and sent to the maintenance shop on schedule. Otherwise, one worn part might cause irreparable damage.

Once a procedure is established and a schedule maintained, preventive maintenance is relatively easy. In the hands of skilled tool maintenance personnel, the machines should be completely disassembled and all parts washed. Kerosene will serve as an effective cleaner for most parts. Maintenance personnel should be warned, however, not to wash sealed bearings in a solvent.

Air screens and filters should be cleaned or replaced if damaged. The felt wicks in the oil packets should be cleaned carefully or replaced if hard.

Rotary Equipment

Rotary vane motors must be carefully inspected for wear. Excessively worn or scored end plates and cylinder liners should be replaced. If the blades are worn at the ends so that they are shorter than the rotor, or if the long edges which contact the cylinder liner are worn noticeably, they should be replaced.

Bearings in the end plates should be examined carefully. The outer race should roll freely while the inner race is being held firmly. If there is any perceptible play, either radially or axially, between the inner and the outer race, the bearing should be replaced.

Clean the interior of the compressor portion if foreign matter is present that would interfere with free movement of the blades within the rotor. To clean, it is necessary to remove and disassemble the compressor portion, but it is not usually necessary to pull the floating head plates and bearing cones from the ends of the rotors.

Cleaning may be done by brushing and scraping, using solvents when necessary to soften the deposits. Caution must be used when

cleaning blades. They should never be cleaned with water solutions or with any strong solvents but merely cleaned with a soft cloth moistened lightly with kerosene, benzene, or diesel fuel. Deposits can be scraped or sandpapered off.

Percussion tools such as chipping hammers, clay diggers, and backfill tampers should be disassembled and inspected periodically. Tools used outdoors or stored in unheated areas should be inspected more frequently than others.

Scored cylinders or "sloppy" fitting pistons should be replaced or reconditioned. Most tool manufacturers either offer reconditioning service or they can recommend reputable organizations which will do such work. The valve parts should be carefully examined for wear, and all air passages in the handle, valve case and cylinder should be blown clear.

A thorough inspection of the chisel bushing in the nose of the tool is of particular importance. There are two reasons for replacing a worn chisel bushing. First, when the chisel is inserted in the bushing, it closes the lower end of the cylinder. Therefore, the better the fit between the bushing and the chisel shank, the less air leakage there will be out the front of the tool on the return stroke. Second, the striking faces of the piston and the chisel shank must be maintained parallel to each other to minimize wear in the cylinder and maximize power. This is impossible if the fit between the bushing and the shank is loose enough to permit cocking the chisel in the tool.

Just as the use of an ineffective air tool can handicap a worker, so can an ineffective accessory handicap the tool. Wrench sockets should be the correct size for the particular nut or bolt and should fit snugly on the wrench shank. Grinding wheels that are out of round should be dressed. Wheels that cannot be balanced should be discarded. Hammer chisel points should be ground to shape frequently, and chisels should be discarded when the shanks are worn.

The importance of following the manufacturer's recommendations on the proper maintenance of each tool cannot be over-emphasized. Do not hesitate to consult a representative of the manufacturer regarding any maintenance points that may not be completely covered in the instruction book that is furnished with the tool.

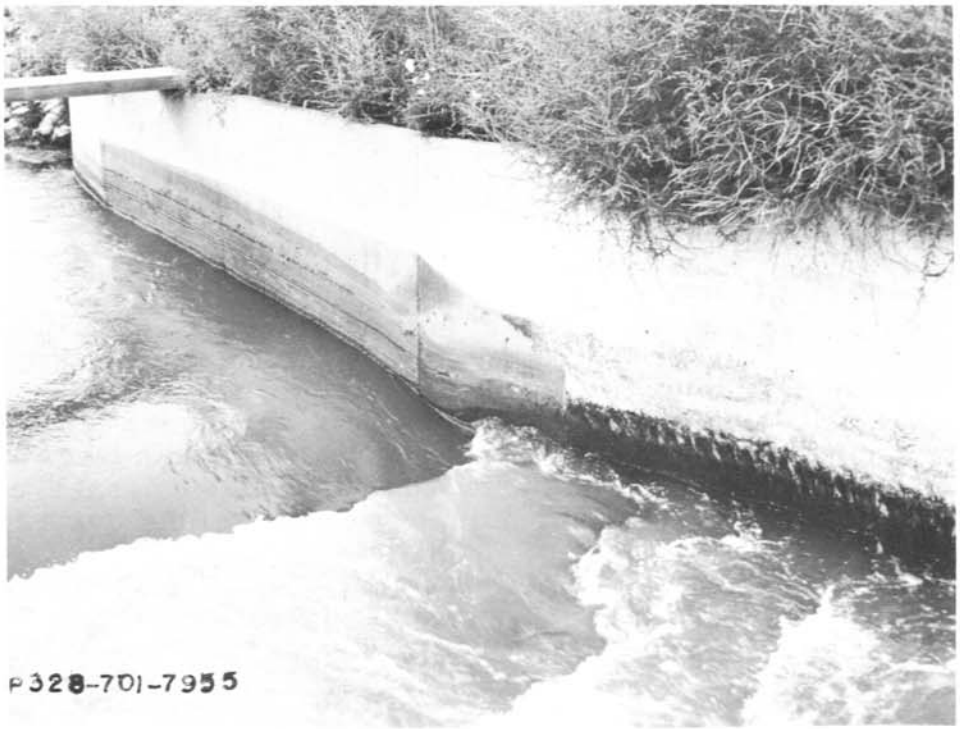
A thoughtfully planned and scrupulously supervised maintenance program will improve the productive output of air tools, sharply reduce downtime, improve safety records, and effect genuine savings in repair costs.

* * * * *

COPPER BASE PAINT RETARDS ALGAE GROWTH

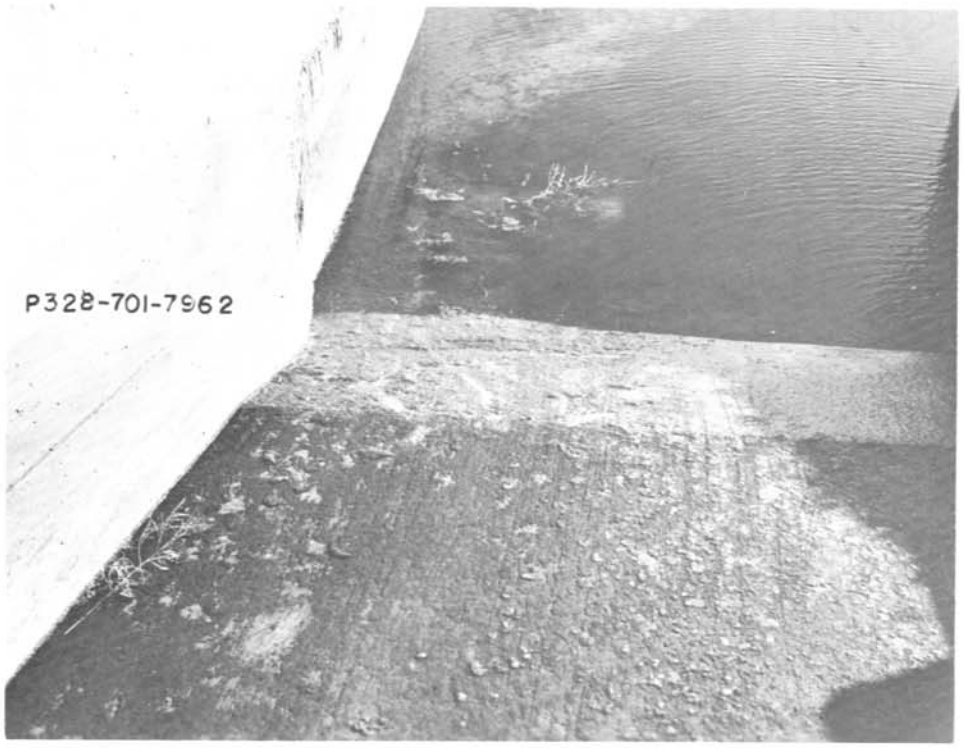
During the 1958 irrigation season, a considerable growth of algae formed on a Parshall flume on the Meeker-Driftwood Canal system, Frenchman-Cambridge Division, Missouri River Basin Project, Nebraska. The growth was so dense that it affected the rating of the flume used to measure water deliveries to the canal. Periodic applications of copper sulfate to the water in the canal helped kill some of the moss (algae), but enough moss remained on the flume to affect the rating.

Prior to the 1959 irrigation season, two coats of copper-base proprietory antifouling paint was applied to the throat of the 12-foot concrete Parshall flume as shown below. The result of this paint application was that the growth of algae in the throat of the flume during 1959 was negligible.



A view of the flume looking upstream is presented in the photograph above showing the left side of the flume and the copper-base coating applied. Growth of algae on the side of the flume downstream from the painted throat is apparent.

Toward the end of the irrigation season there was evidence that some of the protective paint was wearing off. This was especially true of the bottom of the flume and the lower sides, as illustrated on the following page. In order for the algae protection to be maintained, the Project Manager, McCook, Nebraska, believes the flume must be painted again before the next irrigation season.



In the above photograph, taken at the end of the irrigation season, the downstream section of the treated Parshall flume and the untreated section below the flume throat are shown. In the untreated area, long strings of algae growth are visible, while there is practically no algae in the treated section. The treated bottom has a very thin layer of algae and much of the paint had started to wear. Also evident are areas of loss of protective paint at the bottom of the sides of the flume.

The cost of applying a total of 2-1/2 gallons of the copper base antifouling paint in two coats was approximately $63.00. The cost as estimated by maintenance personnel is broken down as follows:

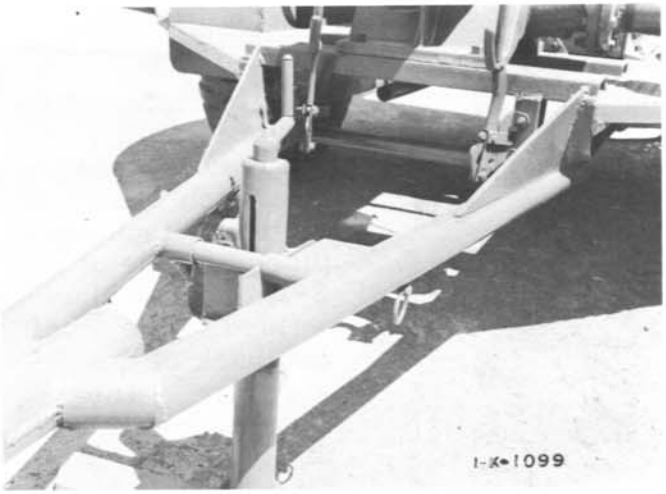
Labor and transportation of labor	$35.00
2-1/2 gallons of paint at $9.62	24.00
Muriatic acid (surface preparation of concrete). .	3.00
Broom	1.00
Total	$63.00

The paint used contained 14.7 percent active ingredients expressed as metallic copper, and 85.3 percent inert ingredients. A source of the paint may be obtained by writing the Project Manager, Kansas River Projects, U. S. Bureau of Reclamation, P. O. Box 737, McCook, Nebraska, or the Commissioner's Office, U. S. Bureau of Reclamation, Building 53, Denver Federal Center, Denver 25, Colorado, Attention: D-400.

* * * * *

SCREW TYPE PARKING STAND
(Suggestion R2-60-40)

The Friant Division of the Fresno Operations Field Branch, Central Valley Project, California, has several pieces of trailer-mounted equipment that are front-end heavy. This causes unnecessary heavy lifting and backstrain on the operators when hitching-up or unhitching the equipment. To overcome this, Frank W. Athos made up some folding screw-type parking stands for all equipment, one of which is shown in the photographs below.



The stands are made of a 1-1/2 inch bolt and nut enclosed in a slotted 2-1/2 inch pipe, as shown in the photograph at left. The nut is welded to a support plate and one end of the bolt swivelled to a bottom plate. The other end runs through a guide plate at the top of the 2-1/2 pipe and a crank is attached. By turning the crank, the parking stand will adjust the tongue to the height desired.

The entire screw assembly, including the support plate and guide, are hinged to the trailer tongue and positioned by a spring-loaded pin making it possible to fold the assembly, as shown in the lower photograph, and provide clearance during travel.

The stand incorporates both mechanical and safety features. It also is very useful in the leveling of equipment when it is parked on rough terrain.

For further details of construction, write the Supervisor, Friant Unit, Fresno Operations Field Branch, Bureau of Reclamation, Fresno, California, or the Regional Director, Bureau of Reclamation, Sacramento, California.

* * * * *

SWIVELLED TONGUE-HITCH
(Suggestion R2-60-41)

The tongue-hitch shown in the photographs below was developed on the Friant Division of the Central Valley Project, California, by Frank W. Athos, to facilitate hitching, unhitching and travel of trailer mounted equipment. Due to the differences in the heights of the various tractor hitches the equipment hitch was often mismatched and not level, causing an unbalanced load on the tongue.

The problem was solved by Mr. Athos by fabrication of the swivelled hitch on the trailers, as shown. The hitch was made from a 3-inch pipe placed inside of a 3-1/2 inch collar welded to the front and back of the inside pipe. The larger pipe was drilled for an oil hole to provide for lubrication and the prevention of rust.

Using this type of a swivelled tongue, the equipment rides level allowing the correct amount of weight to pull the vehicle. It is also much easier for the equipment operator to hitch and unhitch the heaviest type of trailer mounted equipment with less danger and strain. The photographs also show the screw-type parking stand developed by Mr. Athos and described in a previous article.

The swivelled tongue hitch has been adopted and installed on all tongue pulled equipment used on the Friant Division.

* * * * *

STARTING YOUR DIESEL ENGINE IN COLD WEATHER

(The following material was prepared by Herb Orwig, development engineer for the Trojan Division, The Yale & Towne Manufacturing Co. Reprinted by permission of Pacific Builder and Engineer, 2418 3rd Ave., Seattle 1, Washington, January 1960 issue; further reproduction is prohibited).

Past experience has shown that owners of diesel powered equipment often have difficulty starting the engine in cold weather because of a lack of knowledge about diesels. Since the combustion principles of diesels are different from gasolines, it naturally follows that the starting technique is also different. A thorough understanding of cold weather diesel facts will enable the diesel equipment owner to start the engine quickly and efficiently and also eliminate possibility of damage to the engine.

Let us first look at the rules:

1. Keep engine in good operating condition. Good valve and ring seating provide maximum compression necessary for easier starts and smooth running. Clean injector tips assure proper atomizing and even distribution of fuel.

2. Keep battery at peak charge. Low temperatures alone reduce battery efficiency and rob cranking power.

3. For best results use either starting fluid or glow plugs as directed.

4. Keep fuel clean and fuel lines free of water or air locks.

5. If shelter is available for your equipment, use it.

The diesel engine has no spark plugs so it relies on high compression in the cylinder to heat air in the cylinder enough to burn the fuel injected into it. When the engine is cold the metal parts rapidly absorb the heat in the cylinder and thus prevent ignition. This happens every cold day so that the engine needs help to get started.

Assuming the starter is turning the engine at normal starting speed, there are two ways to get proper starting conditions: One, heat the air introduced into the cylinders; the other, help out with a fuel that burns at a lower temperature than diesel fuel. In some open chamber diesels, such as Cummins, a glow plug is mounted in the intake manifold. When fuel is sprayed onto this glowing element a small fire is kindled in the intake manifold and this heated air is drawn into the cylinder giving enough boost to start the engine in most instances.

Engines with a precombustion chamber design usually mount the glow plug in this small precombustion chamber so that ignition begins in a fractional part of compressed air in each cylinder where fuel is injected. Usually failure in starting with glow plugs comes because the operator is too impatient to allow the plug to heat fully before he begins cranking.

Ether and ether base fluids are fuels with a lower flash point, or temperature, at which they begin to burn. This method is better liked because it gives instantaneous results. Ether fluids are high energy fuels and if used carelessly or too freely can cause serious mechanical engine damage because of abnormal compression pressures.

In an engine with a glow plug in the intake manifold NEVER use ether and the glow plug at the same time. A nasty backfire or perhaps even more serious damage could result.

Very cold weather causes crankcase oil to become very viscous or, in other words, thick. Obviously it is difficult for the oil pump to circulate thickened oil so that the initial start starves cylinder walls and bearings of oil for a short time. It is especially important to avoid speeding the engine during this critical period. There are multiple viscosity oils on the present market which are thinner when they are cold. These oils have a low viscosity oil base with certain resins added and thicken as they warm up. Diesel engine makers have been reluctant to approve their use, therefore, always follow your engine maker's oil recommendation.

Most automotive type diesels have an electric cranking motor as a utility starter. Since accessory loads vary so widely, the choice of batteries has always been the result of experience. Under normal conditions most batteries are adequate but cold weather causes frequent failures. Generally speaking, more and larger plates mean a greater reserve of cranking power. If your battery is in good condition but fails to start your engine by not lasting long enough, a larger battery will crank your engine longer. Price, physical size and weight are all good indications of battery size. Gasoline starting engines give unlimited cranking duration once started. Air starters are excellent since they usually give higher cranking speed but a regular mobile compressor unit is usually needed to supply enough air.

If a shed is available to shelter your equipment use it to your advantage. Fully enclosed sheds can be heated enough to be of real benefit in starting the engine since the air crankcase oil and coolant all get the benefit of the warmth.

After your diesel engine is started and running smoothly it will warm up to its most efficient operating temperature more quickly if it is run through its ordinary work cycle at a moderate pace. A good rule is to let the engine temperature come up to nearly normal before demanding full engine power.

* * * * *

SEALANT TIGHTENS BULLDOZER TRACKS

Keeping pad bolts tight on the tracks of bulldozers is a construction job maintenance problem which the Construction Department of the Merritt-Chapman & Scott Corporation has solved by using a locking sealant. Ira Davidson, general maintenance superintendent, tried the new thread-locking sealant on the pads of heavy equipment. Because of the terrific impact loads experienced while working on rock and frozen earth, maintenance crews had to retighten the pad nuts and bolts every two or three weeks. This meant taking the equipment out of service for half a day while two men tightened each of the 344 nuts and bolts on the large tracks. Then, Davidson tried the sealant and after twelve weeks of operation, working 132 hours per week, he found the bolts were still tight.

These special heat-treated pad bolts are 7/8-inch in diameter, have a special nut, and cost about $300 per set. Loosening causes excessive wear on both the bolts and the track rails. Replacement rails cost from two to three thousand dollars. Merritt-Chapman & Scott use a grade of the sealant which permits taking up on the nuts should stretching occur in the bolt.

The method of treating the parts with the sealant is simple. The nuts and bolts are first soaked for a few minutes in a pail of degreasing solution (Trichloroethylene preferred). After they have dried, the bolts are inserted in their holes in the track which has been laid out flat. Then a man with a box of nuts and a plastic squeeze bottle of the sealant moves along beside the track first treating a nut by squeezing a drop or two of the sealant into the threads and then applying it to the bolt. The nut is just given a couple of turns to hold it on until tightened. After all the nuts are in place, the bolts are tightened with a power impact wrench. The sealant hardens in 3 to 4 hours at 70 degrees F (somewhat longer at lower temperature) after which the nut is locked on the bolt.

The above method describes treatment of new bolts and nuts during track overhaul. Treatment of installed parts is possible provided bolt threads are clear enough to allow the sealant to penetrate.

Success on the pad bolts has led to the use of the sealant on a variety of applications on several heavy construction vehicles. It is being used to retain engine bearings, where wear has caused slippage. In this application the sealant acts as a "liquid shim" and fills the clearance between bearing and housing. The sealant is effectively used to lock in the studs on the differential carrier, the studs which hold the power take-off and on the track roll bolts. The sealant will lock

track roller bushings in cases where wear has caused slippage.

The sealant is a thin liquid which hardens in a metal joint to form a tough seal. It comes fully prepared...no mixing and no heat are required. Catalytic action of the metal surfaces, aided by the absence of air, causes the sealant to harden into a tough heat and oil resistant bond. This tough plastic grips threaded fasteners so securely that no amount of vibration will shake them loose, yet they can be removed with ordinary tools. It comes in different strengths which apply any desired locking torque, ranging from a light drag suitable for adjustment screws to a locking force exceeding the torsional strength of large screws.

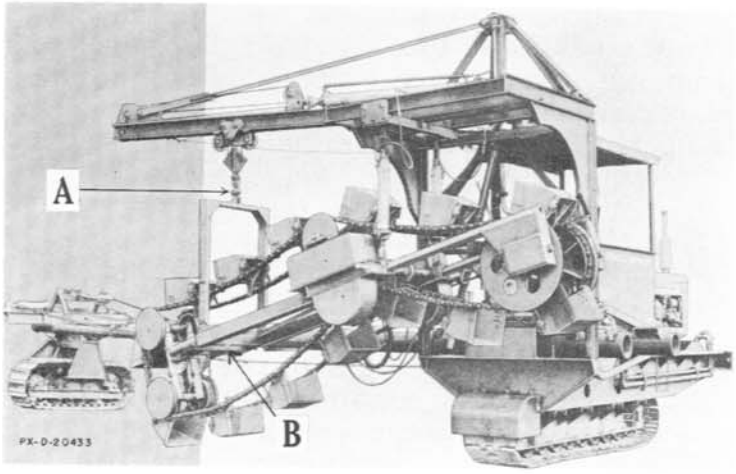
In addition to locking threaded fasteners, the sealant is used to mount bearings and bushings without press fits, to hold hardened sleeves to shafts, and to seal threaded and sleeve joints against fluids under high pressure.

The sealant is carried in stock by selected bearing distributors and industrial distributors throughout the country. For further information, write King Publications at the above given address.

* * * * *

RAISING DREDGER BUCKET ASSEMBLY
(Suggestion R5 RG-59-12)

The operation of a dredger for canal maintenance on the Las Cruces Field Branch, Rio Grande Project, New Mexico, had been hampered because the bucket assembly could not be raised high enough to clear turnouts and checks. This inconvenience interrupted the productive work of the machine--making it necessary to move the machine out of position and re-position it again on the other side of the structure.



General maintenance operator, Ramon M. Carrillo's solution to the problem is shown in the illustration at left. In order to raise the bucket assembly to a higher level than is possible in the normal position, he disconnects the hitch from location "A" and moves it to an eyehole on the crossbeam marked "B".

* * * * *

PLASTIC LINING A BY-PASS CHANNEL

Construction of the West Main Canal of a unit of the Harlingen Division, Lower Rio Grande Rehabilitation Project, Texas, was complicated by the necessity of supplying water to the irrigators during the growing season. Accordingly, it was necessary to construct a by-pass channel around the construction area. The channel had to be lined to prevent seepage and the wetting of adjacent earth materials. A polyetheylene plastic material 6 mils in thickness was used for the lining as shown below.

The plastic material was purchased from a local distributor in 100 foot rolls 24 feet wide for $37 per roll. The plastic was black in color.

Adjacent sheets of the material were joined by folding or rolling the ends together on the underside of the lining. A small transverse groove was excavated in the subgrade to receive this fold. As shown in the photograph, the top edges were weighted with earth after installation.

The original installation consisted of approximately 1,000 linear feet. After the adjacent reach of canal had been completed and returned to service, the polyethylene plastic was taken up and reinstalled along with additional material in a second by-pass channel 2,600 feet in length. There was no wasteage in re-use of the material, except for a section that had to be cut to accommodate a temporary pipe access crossing.

The plastic lining proved very effective and the only difficulty encountered was that of handling the large sheets during installation on windy days.

* * * * *

BARBED WIRE PIPE SAFETY BARRIER
(Suggestion R2-59-183)

Despite daily patrols, fences, locked gates, barriers and signs, the Central Valley Project, California, must be continuously alert to canal safety. A recent addition to the canal safety installations is a barbed wire barrier placed around pipe lines that must cross the waterways, and which as shown below, are used by the careless or adventurous as walkways.

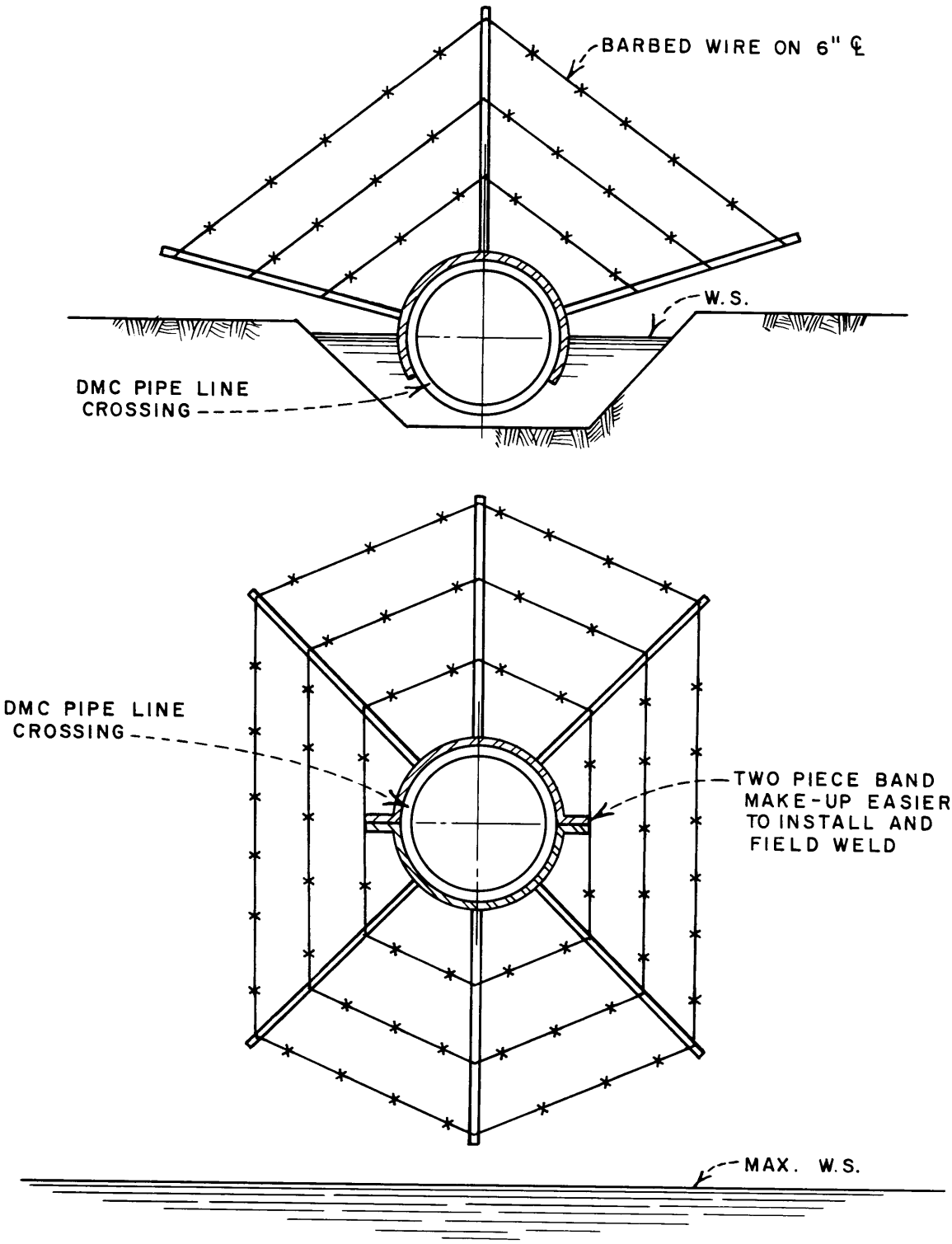
The Bureau of Reclamation has tried safety education programs, safety devices, and trespassing citations to keep fishermen and children away from the more dangerous locations along the canals. Even so, twenty persons have found death in the swift, concrete-lined canals of the project. Use of the pipe lines across the canals as walkways resulted in two drownings during 1958. To prevent the dangerous use of the pipe lines as walkways, Edward J. Deleski, Foreman, Water Operations Section, Tracy Operations Field Branch of the project suggested the barbed wire barrier shown below and in the sketches on the following page.

Photo courtesy of Oakland Tribune-Parade--Lonnie Wilson, photographer.

Photo courtesy of Oakland Tribune-Parade--Lonnie Wilson, photographer.

The barrier can be constructed for use on pipe lines that are well above the maximum water surface, as shown in the photographs above and on the lower sketch on the following page, or for those that are partly awash, as shown in the upper sketch. Steel bands to which 1-inch steel reinforcing bars are welded provide for quick field assembly. The barbed wire is strung on the bars at about 6-inch centers.

* * * * *


BARBED WIRE ON 6" ℄
W.S.
DMC PIPE LINE
CROSSING
DMC PIPE LINE
CROSSING
TWO PIECE BAND
MAKE-UP EASIER
TO INSTALL AND
FIELD WELD
MAX. W.S.

RECLAMATION'S USE OF PROTECTIVE COATINGS FOR SUBMERGED AND BURIED METALWORK

(This paper written by P. W. Lewis and J. L. Kiewit, Engineers, Bureau of Reclamation, Denver, Colorado,

The Bureau of Reclamation designs and constructs water conservation projects and structures in the 17 Western States. On these projects, large areas of vital metalwork are exposed to corrosion in soil and fresh water over a long period of time, such that corrosion becomes an important factor in the life of the structure. To control corrosion, the Bureau relies primarily on protective coatings. This paper discusses coating selections for the most important exposures, and the job site inspection and quality control which are instrumental in achieving ultimate coating performance. It also reviews the Bureau's laboratory and field evaluation testing of promising new coatings, giving the first report on an important new field test.

Current Practice

In any major structure, several different fresh water corrosion environments will be found. Since penstock piping will usually be continuously filled, coal-tar enamel provides excellent protection. For buried piping and other water-bearing piping exposed aboveground and always in service, and thus not subject to severe temperature fluctuations, coal-tar enamel or cement mortar is used. However, when it is contemplated that piping exposed aboveground may be empty for extended periods, the Bureau has found that a 3-coat vinyl resin paint 1/ gives satisfactory protection, but of shorter duration and requiring more maintenance than coal-tar enamel.

Certain other metalwork associated with the penstocks is not well suited for protection with coal-tar enamel. Such metalwork as the butterfly valves and wicket gates, through which water passes to the generators, are usually coated with cold-applied coal-tar paint, CA-50. 2/ At the head of the penstock, trashrack metalwork constitutes a shape which is difficult to coat; and in this situation, coal-tar pitch, 3/ applied by dipping, has been found very effective.

Many major structures and most canals include radial gates of varying sizes for controlling the flow of water; parts of these will be in submerged, alternately submerged, and in atmospheric exposure. The Bureau has found that a 6-coat vinyl resin paint 4/ provides excellent protection against corrosion as well as resistance to abrasion and sunlight on large gates.

Smaller gates, such as will be found on turnout structures,

Numbers refer to references at end of report.

are protected with phenolic red-lead primer 5/ and phenolic aluminum topcoats. 6/ The merits of zinc as an economical protective coating have also been recognized by permitting these small turnout gates to be galvanized as an alternate to painting, and reports from the projects near Yuma, Arizona, indicate that zinc coating applied by flame spray is proving effective in the corrosive waters of the Colorado River.

The exterior of piping to be buried will be in an environment including most of the corrosive effects of fresh water immersion. To this will be added potential damage to the coating from placement of backfill materials and from subsequent soil stresses when the pipe is in service. Extensive laboratory tests 7/ were conducted by the Bureau to ascertain which pipe wrapping systems will provide protection against damage to the coating from backfill and soil stresses. From these investigations, the Bureau has concluded that good protection against both corrosion and damage to the coating can be provided by cement mortar or coal-tar enamel. The integrity of the coal-tar enamel coating must be assured by also specifying one or more embedded or bonded wrapping materials. These include a glass mat or fabric to be embedded in the enamel and coal-tar-saturated asbestos felt and Kraft paper outer wraps.

Regarding the above selections, fresh water is considered to be a generally corrosive medium; however, wide variations in corrosivity have been encountered in waters of the Bureau of Reclamation area. Protection of metalwork must be planned for lengthy periods, 50 years and up, as opposed to the much shorter expected service periods in other corrosion atmospheres such as in an industrial plant where obsolescence is more of a governing factor. To accomplish this protection, mainly standard specification coatings are used, and the results with these have been very good. Outstanding among these protective materials are coal-tar enamel and cement mortar, the performance of which up to the present time has generally been so good as to make their ultimate service beyond accurate prediction. Among the thin-film paints, vinyl resin-based paints have shown particularly good protective qualities.

There is, however, much more to effective protection of metalwork than the selection of paint materials if the best service from the paints selected is to be realized.

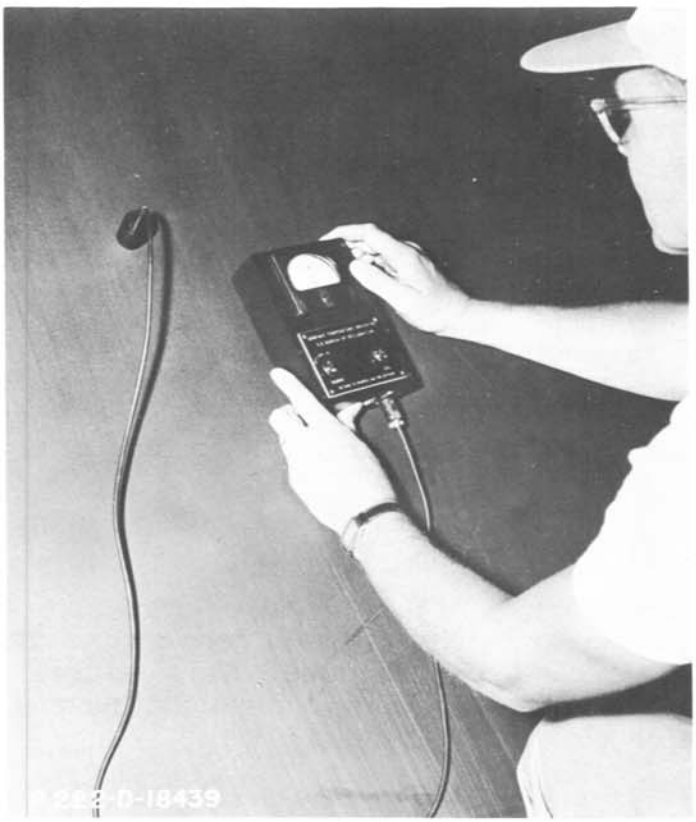
Quality Control

Quality control is an essential feature of the Bureau painting program. The Bureau tests the particular batches of paint delivered to the job site for conformance to the standard specifications. This assures that the project owner gets what he pays for and is an important phase of a satisfactory completed paint job.

Job Site Application Inspection

Proper application of the protective coatings is considered to be at least as important to corrosion control as paint selection and quality control, and it is often more difficult to accomplish. Unlike many parts of construction, the quality of an applied coating may not readily be assessed by a final examination and knowledge of a few readily measured materials properties. That each step in applying paint has been done properly must be confirmed at the time, and the Bureau insists on full specifications compliance at the time the job is accepted. Job site painting proceeds under such a wide variety of handicaps, such as weather, accessibility, and shape of the metalwork, that it is sometimes remarkable that results are as good as they are. Field inspection is the tool which assures good results.

The Bureau's experience bears out that of others, that quality of surface preparation is fundamental to the performance of coatings in fresh water immersion. Paints purporting to immobilize rust by one means or another have not been proved, to the Bureau's satisfaction at least, for immersion exposure, and removal of rust, dirt, and mill scale by sandblasting remains the best field method of surface preparation. Sandblasting is considered essential preparation for any continuously submerged coating. Inspection of the cleaning by Bureau personnel at the site assures that the "sandblasting to base metal" requirement of Bureau specifications has been met, thus removing all contaminants and providing mechanical "tooth" for adhesion of the coatings.



Following surface preparation and during application of paint, the inspectors make a variety of simple but important tests, such as the bond and continuity testing of coal-tar enamel and thickness and application temperature for all paints. As shown in the photograph at left, a surface temperature gage is being employed to determine if the metal surface is above the minimum temperature for painting; this is one of several essential tests required during application to assure a sound coating.

Laboratory Evaluation Testing

The methods employed by the Bureau for the selection of coatings may be of interest. Since it does no formulation preparation of its own, the Bureau relies on the industry to supply it with superior paints. Unfortunately, new paints often fall considerably short of justifying exaggerated claims made for them soon after they are placed on the market. To save the cost of a field failure, four well known laboratory tests are used by the Bureau to screen out the obviously unsuitable materials and give a strong indication of fundamentally improved corrosion protection offered by new products. These tests include:

1. Fresh water immersion 8/
2. Salt spray fog box 9/
3. Outdoor weathering exposure 10/
4. Weatherometer 11/

In addition, special tests are devised to evaluate coatings for special needs. The Bureau's soil stress test of coatings for buried exposure is one such test and is still in progress. As an example of a more recent special test, a question arose as to which coatings would best resist the effects of abrasion or erosion from sand- and silt-laden water in penstock or siphon piping. Eight-inch-diameter, 8-inch long pipe sections were, therefore, lined with coatings the Bureau uses and others being evaluated by the laboratory. The test piping sections were sealed to contain a sand or gravel slurry and then rotated for several hundred thousand revolutions. This testing is still underway; however, in a progress report, 12/ cement mortar, neoprene, coal-tar enamel, a catalyzed phenolic coating, pipeline asphalt enamel, and a high penetration asphalt are indicated as having the best erosion resistance of about 15 linings tested to date. The selection of a particular lining for use in siphon or penstock piping where erosion is expected would, of course, depend upon a number of its characteristics. This test, however, has provided valuable data concerning this particular property.

Field Evaluation Testing

Often, of course, laboratory tests do not tell the whole story; much remains to be learned in the field. Accordingly, the Bureau further evaluates coatings showing promise in the laboratory by applying larger areas of these coatings in a field test.

Bureau field tests of appreciable scope include the Shadow Mountain Reservoir test for coatings for exposed irrigation piping, which carries water in summer and is empty in winter. Thirty-inch-diameter pipe sections were coated and lined, then trucked to Shadow Mountain Reservoir in the mountains of Colorado for exposure, being immersed

during the summer months in the inlet canal and then stored on the shore for the winter. Considerable information was gained from this test during 6 years' exposure. 13/ Briefly, some of the more important results follow:

1. Coal-tar enamel demonstrated its usual excellent protective qualities, but did not perform satisfactorily when extreme cold was involved. Hairline cracking was found even in 10-penetration enamel after several years, and the damage worsened progressively as the penetration decreased. Considerable portions of enamel, having penetration below 5, disbonded and spalled off during the first winter's exposure, when a temperature of minus 41° F. was recorded. One interesting sidelight was that rusting progressed very slowly and caused negligible damage to the metal at cracks in the enamel. Nonetheless, enamel is not considered a suitable coating for the aboveground cold weather exposures.

2. Cement mortar containing entrained air and applied 1 hour after mixing withstood the exposure quite well, sustaining only a few hairline cracks which may have been caused by handling as well as by drying shrinkage and temperature changes. However, caution is indicated by the poor performance of another mortar lining tried in this test. This mix had no air entrainment and exhibited excessive drying shrinkage, and cracked and spalled severely, failing in less than 2 years.

3. Vinyl polysulfide and neoprene paints have done very well, as have Bureau of Reclamation specification paints, cold applied coal-tar paint, CA-50, and VR-6 vinyl resin paint.

The Shadow Mountain test has now been moved to Denver, the extreme low temperature phase having been completed.

Another field test of considerable scope was begun at Shasta Dam 10 years ago. It is planned to inspect these lining materials again later this year. However, in evaluating the performance of the coatings after 8 years' service, the phenolics and vinyls predominate among the Class A linings, and coal-tar enamel is so far unaffected by exposure in the remainder of the penstock. 14/

Reminiscent of the extensive Shasta tests in which fairly large areas of lining materials were applied in the field, and in consideration of the very rapid progress being made these days in the field of protective coatings, the Bureau has just initiated a sizeable new field test. During August 1959, 280 linear feet of 6-foot-diameter piping were lined with experimental materials in the pipe fabricator's plant in Denver, and were then delivered to the Southside Canal, Collbran Project, near Grand Junction, Colorado. When installed as part of a buried siphon, the piping will be exposed to continuous fresh water immersion with water velocities up to 8.8 feet per second during the operating season. It is expected that this portion of the siphon will

usually be empty during the winter months. Operations at the Southside Canal will commence in 1960, and it is planned to inspect the linings after the first, second, and fourth years of service, and thereafter as indicated by their condition.

The new Southside Canal test includes 36 different coating systems employing 42 separate materials (in this case, each combination of materials applied has been considered a separate coating system; thus, adjacent coatings may differ only in that a metal conditioner or a special primer was used). In all, approximately 22 basic linings are represented in the 36 coating systems. The linings were applied as closely as possible in accordance with manufacturer's instructions and with his representative on hand to advise on procedures and techniques in order to obtain the best results. The photograph at left shows test lining material being applied by conventional air spraying. Other materials were applied by brushing, rolling, and hand daubing. The thickness and characteristics of each coat and the application conditions were recorded, and the appearance and continuity of the final lining were noted.

It is interesting to observe the trend which is evident in this latest test. In the Shasta test, not a single lining included a material of the multicomponent type, that is, one which requires mixing two or more components shortly prior to application, producing a material with a limited pot life. In the Southside Canal test, 21 systems had one or more coats of a multicomponent paint. Also, since Shasta, various new resins and modifications thereof have performed well enough in laboratory screening tests, or have achieved sufficient prominence in the field to justify inclusion in this field test. In addition to these, neoprene and chlorinated rubber, aluminum and zinc as sprayed metals, zinc as the pigment in several paints, vinyl red-lead paint, and asphalt enamel are represented in the test. By way of providing "controls" and a comparison of present Bureau coatings for this exposure with those which may someday replace them, Type IV red-lead and VR-3 vinyl resin paints were also applied, and coal-tar enamel protects the remainder of the siphon interior.

The linings in this test should provide some valuable and interesting comparisons.

First, the new resins; three samples are of the epoxy coal-tar combination type. From the vigor with which the industry has promoted this type of coating, others must have found it promising. Bureau laboratory tests have indicated that good performance might be expected. Straight urethane is represented in one lining, and urethane is combined with coal-tar in another. Two linings are of the modified phenolic and epoxy modified phenolic type. Straight vinyl and epoxy resins are present as components of mastic paints. Thus, the test includes the principal resin ingredients of protective coatings to achieve prominence in the industry in recent years.

Second, this test examines the protective possibilities of zinc coatings rather fully. Zinc is exposed as a flame-sprayed lining and as the essential pigment in both organic and inorganic vehicles. In addition, certain of these were topcoated with vinyl or phenolic materials. The possibilities of the later systems are appealing: As is well known, zinc protects steel by sacrificing galvanically at small exposed steel areas, and the duration of such protection should be indicated by this test. In theory, organic topcoats should, in themselves, offer additional protection; however, their combination with zinc should multiply their period of effectiveness. Yet another advantage may exist when deterioration of the topcoats is observed. Maintenance in the form of touch-up painting or a complete single topcoat may restore the system as a whole to nearly its original condition before the ferrous-base metal has been attacked. In maintenance, it may prove feasible to replace sand-blast surface preparation with the much cheaper and more expedient wire brushing. Continued maintenance in this manner may offer the possibility for very long-term protection of the base metal.

It may be well to consider what the Bureau expects to learn from a field test such as the Southside Canal test. Durability is a primary consideration, of course, and a rugged material having a potentiality of over 20 years' service with a minimum of maintenance is sought in this test. The desired lining should be suitable for exposure in empty steel piping aboveground. It must, therefore, resist wetting and drying and freezing and thawing and extremes of temperature.

Also of interest are the manner and ease with which the lining can be applied in the field where conditions are often less than ideal. Heat and cold, high humidity, difficult shapes to coat, and limited access generally complicate the work to some degree on each job. Requirements for highly skilled applicators or specialized and unusual equipment add to the cost and may make the best quality of work difficult to obtain in some cases. For these reasons, particular note was taken during application of the Southside Canal test lining materials of the complexity of the operation. A record was made, for instance, where

extraordinarily high quality surface preparation was required, where the nature of material raised obstacles, and where spray techniques were likely to baffle the ordinary painter. Fortunately, few serious problems arose among the coatings selected for the test, and most of the linings appear well adapted for Bureau field application.

Last, and certainly not least, cost will strongly affect the eventual selections from among the better performing lining materials. The initial cost reflects material costs and the applicator's expenses in coping with the conditions discussed, while applying the required number of coats. If these costs are reasonable and the expected long service with minimum maintenance is realized through the use of superior coating materials, then the ultimate objective of the protective coatings investigations will be achieved as lower annual cost per square foot for corrosion control.

In summary, the Bureau's more commonly used coatings have been given for the principal corrosive fresh water and buried exposures associated with large and small Reclamation projects. The desired end product is a durable, economical coating which will do its job of protecting metalwork with dependability and a minimum of maintenance. Such a coating will result not only from correct selection, but from careful attention to its proper application to a well prepared surface. Diligent inspection serves to insure the success of the application. Also, control testing of coating materials is essential to maintain quality standards. These are the steps necessary to assure a successful coating for the protection of Bureau metalwork against corrosion.

References

1. Bureau of Reclamation Specifications for Vinyl Resin Paint, VR-3.

2. Bureau of Reclamation Specifications for CA-50 Cold Applied Coal-tar Paint.

3. Federal Specifications R-P-381, Type II.

4. Bureau of Reclamation Specifications for Vinyl Resin Paint, VR-6.

5. Federal Specifications TT-P-86a, Type IV.

6. Federal Specifications TT-V-119, with Aluminum Paste TT-A-468a, Type II, Class B.

7. Bureau of Reclamation Paint Laboratory Report No. P-57, Performance of Exterior Pipe Coatings and Wraps in Laboratory Soil Test--Progress Report.

8. Bureau of Reclamation Paint Laboratory Report No. P-59, Fresh Water Immersion Tests of Protective Coatings for Iron and Steel.

9. Method 6061 of Federal Test Method Standard No. 141, Using the 20% Salt Spray.

10. Method 6161 of Federal Test Method Standard No. 141, except that the test is conducted at Denver, Colorado.

11. Method 6152 of Federal Test Method Standard No. 141.

12. Bureau of Reclamation Paint Laboratory Report No. P-66, Erosion Studies of Pipe Lining Materials--A Progress Report.

13. Bureau of Reclamation Protective Coatings Laboratory Report No. P-58, Experimental Coatings on 30-inch-diameter Pipe Sections Exposed at Shadow Mountain Reservoir--Second Interim Report.

14. Bureau of Reclamation Paint Laboratory Report No. P-72, Eighth-year Evaluation of Experimental Test Linings In Shasta Dam Penstock.

* * * * *