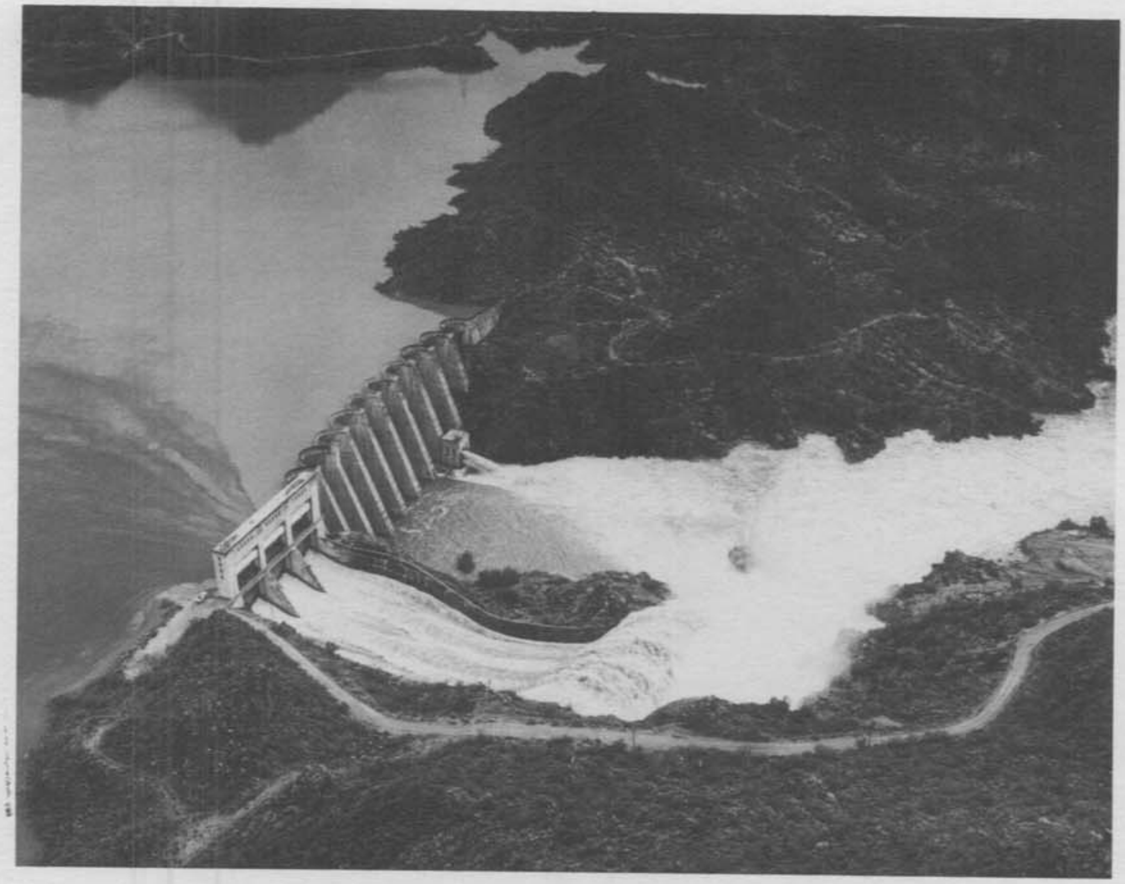
WATER OPERATION AND MAINTENANCE

BULLETIN NO. 150

December 1989



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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 information for use by Reclamation personnel and water user groups for operating and maintaining project facilities.

While every attempt is made to insure high quality and accurate information, Reclamation cannot warrant nor be responsible for the use or misuse of information that is furnished in this bulletin.

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Cover photograph:

Bartlett Dam & Reservoir — Salt River Project, Arizona.

UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION

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GUIDELINES
FOR REMOVAL OF TREES AND OTHER VEGETATIVE GROWTH FROM EARTH DAMS, DIKES, AND CONVEYANCE FEATURES[1]

Growth of trees and other significant vegetation on or adjacent to earth dams, dikes, and conveyance features, should be prevented from becoming established for the following reasons:

1. To allow proper surveillance and inspection of the structures and adjacent areas for seepage, cracking, sinkholes, settlement, deflection, and other signs of distress

2. To allow adequate access for normal and emergency operation and maintenance (O&M) activities

3. To prevent damage to the structures due to root growth, such as shortened seepage paths through embankments; voids in embankments from decayed roots or toppled trees; expansion of cracks or joints of concrete walls, canal lining, or pipes; and plugging of perforated or open-jointed drainage pipes

4. To discourage animal/rodent activity (by eliminating their food source and habitat), thereby preventing voids within embankments and possible shortened seepage paths

5. To allow adequate flow-carrying capability of water conveyance channels (e.g., spillway inlet and outlet channels; open canals, laterals, and drains)

The growth of trees and potentially detrimental vegetation should be prevented during its early stages as part of the operating office's (or entity's) normal O&M program. Early control is generally the most cost-effective means of avoiding potential adverse effects on these structures from their continued growth. Control efforts may consist of applying herbicides, spraying, cutting, and/or removing the trees or undesirable vegetation.

Suggested clearance zones (areas of control) adjacent to these structures are provided within these guidelines. Concerted efforts should be made to maintain these clearance zones. However, site-specific conditions such as landscaping, accessibility, erosion susceptibility of material in the area, type of abutment material, original construction clearance zone, right-of-way easement, etc., may influence the necessity or success of these control efforts.

Should trees and/or other significant vegetation become established, proper O&M of earth embankment dams, dikes, and conveyance features, may require their discriminate removal. During the Review of Operation and Maintenance (RO&M) examination for the facility or system, the examiners should use these guidelines along with their experience and professional judgment to evaluate the need for removal of such established growth.

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[1] These Guidelines (revised April 1989) supersede those published in Bulletins No. 131 and 143.

If trees and other significant growth are identified by the examination team in locations delineated by these guidelines, a determination should be made regarding their need for removal. If the identified vegetation is deemed to be in a location such that its existence is not considered to be detrimental and therefore does not require removal, sufficient justification should be provided during the examination and included within the associated examination report to support that determination.

When, in the opinion of an RO&M examination team, such established growth requires removal, specific followup procedures should be addressed as part of the examination. Such procedures may include the need for right-of-way easement determination, the need for an assessment for potential environmental impacts (any impact assessments should be coordinated with designated regional or project office environmental staff), whether removal of the root system is necessary and to what extent, the method of removal and recompaction of material within the void created, and the need for any erosion stabilization measures.

National Environmental Policy Act compliance is required relative to such tree and vegetation removal. Additionally, the application of herbicides should comply with applicable provisions of the Endangered Species Act. The determination of appropriate procedures to be followed in assessing potential environmental impacts and mitigation (including those to wildlife and its habitat) will be the responsibility of each regional and/or project office. This will include the preparation of an appropriate National Environmental Policy Act document and an assessment of the need for mitigation prior to the onset of removal activities. Appropriate National Environmental Policy Act compliance may include a Categorical Exclusion Checklist, an environmental assessment followed by a Finding of No Significant Impact, or an Environmental Impact Statement.

The following guidelines and associated clearance zones should be used for all Reclamation earth dams, dikes, and conveyance features. They are not considered "policy"; rather, they are guides which should be used with reasonable judgment and practicality.

1. Trees and detrimental vegetative growth should be prevented from becoming established on the surface of all earth dam, dike, and conveyance feature embankments. A small amount of shallow-rooted vegetation may be acceptable to aid in erosion protection and slope stabilization. Mowing of grass and other small vegetation is desirable and may be necessary to allow proper surveillance of the surfaces and observation of animal/rodent activity.

2. A clearance zone of 25 feet beyond each contact (groins and toes) of earth dam embankments and dikes should be maintained of all trees and detrimental vegetation. Similarly, a clearance zone of 15 feet should be maintained beyond the outside toe of all fill sections/embankments for open canals and laterals. These clearance zones may need to be extended for seepage areas or other conditions where proper surveillance or access may be warranted.

3. Earth dam, dike, and conveyance feature (open canal and lateral) embankments having large tree growth or stumps from previously cut trees on or near them should be evaluated, usually in conjunction with an RO&M examination, for any necessary future action (i.e., monitor, excavation and backfill, rebuild, etc.). Generally, sizable

old root systems of large trees should be grubbed out and the embankment replaced and compacted to prevent the development of piping action or erosion. Likewise, any sizable voids resulting from animal/rodent burrowing activity should be filled and compacted. Seeding may be necessary for protection of surface erosion.

4. Spillway inlet and outlet channels, outlet works discharge channels, and other open conveyance channels (open canals, laterals, and drains) should be free of vegetative growth that could significantly impede waterflow or reduce design capacity.

5. A clearance zone of 25 feet adjacent to all concrete structures associated with such facilities should be maintained of all trees and detrimental vegetative growth to prevent damage from root growth, to allow proper surveillance, and to allow adequate O&M access.

6. Associated cut slopes adjacent to open canals and laterals should be kept clear of vegetation which, if toppled and/or uprooted, could affect operations or O&M access.

7. For pipe conveyance systems (such as siphons, aqueducts, discharge lines, perforated or open-jointed drains, etc.), to provide O&M access and to prevent root encroachment, a clearance zone should be maintained 15 feet from each side of the pipeline. However, in some cases, farming of annual crops over pipelines may be permissible.

CONDUIT REPAIR

Pittsford Penstock Rehabilitation[1]

by J. Douglas Graham and Tom Kahl[2]

When a 70-year-old steel penstock began developing numerous pinhole leaks, Central Vermont Public Service examined replacement and repair alternatives. Installing a fiberglass lining solved the problem, provided significant savings in comparison to replacement, and minimized environmental disturbance.

The East Pittsford penstock of the CVPS (Central Vermont Public Service) Corporation is located approximately 15 miles northeast of Rutland, Vermont. It extends over 3 miles with a total elevation relief of 485 feet, connecting the Chittenden Reservoir with a 3-MW powerhouse in East Pittsford. The original penstock had been installed in 1917. The upper 2.6 miles between the dam and the surge tank was originally constructed of partially buried wood stave pipe. A portion of the penstock was replaced by steel pipe in 1934 and an additional portion was replaced in 1986. The lower 0.6-mile section between the surge tank and the powerhouse was originally constructed with steel pipe buried a few feet below the ground. The only maintenance performed over the years had been bituminous painting of exposed areas of the pipe exterior.

In April of 1987, during a routine maintenance penstock walkdown, workers noticed flowing water along the 600-foot section of the penstock immediately downstream of the surge tank. Selective digging revealed several active leaks along the bottom of the pipe. These leaks were immediately welded and the station placed back into service. But due to the penstock's age, these leaks raised concern about the continuing serviceability of this portion of the penstock.

This section of the penstock, part of the original construction, consists of a buried, 54-inch-inside-diameter, 3/8-inch-thick steel pipe. The circumferential seams are riveted and the longitudinal seams consist of a swaged "Lock-Bar"-type joint. Because this length of the penstock is immediately below the surge tank, it experiences a maximum total static and water hammer pressure of 231 psig. The approximate middle third of this portion of the penstock plunges down a 65 percent slope. The upper section of the pipe is accessible only by a steep and deeply rutted four-wheel-drive road. Site access and environmental impact were further complicated by a new residence that was being constructed at the bottom of the hillside, just a few feet away from the penstock right-of-way. The justification of any repair was severely constrained by the economic reality that over 2 miles of the penstock was more than 50 years old. Therefore, the rehabiliation

[1] This article was published in the April 1989 issue of Hydro Review, HCI Publications, 410 Archibald Street, Kansas City MO 64111.

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costs for any single portion of the penstock needed to be low — an interesting mix of project constraints.

The rough terrain and heavy vegetation surrounding the pipe contributed to the complexity of the problem, thus adding to the cost of the project.

Evaluation of Options

At the request of CVPS, preliminary designs were prepared by Kleinschmidt Associates, a consulting firm in Pittsfield, Maine, for replacing the Lock-Bar penstock by new steel pipe, with options for either above or below ground. A third design option was simply encasing the outside of the existing pipe in a reinforced concrete shell. Wood stave replacement was also investigated.

The following table illustrates the range of prices, obtained from contractors in the summer of 1987, for the various design options. The prices for fiberglass lining and wood stave pipes were investigated after it was decided that steel pipe repair or replacement would be too costly. As the table shows, fiberglass lining had the lowest minimum cost, although the range of bid prices for this repair option was quite large. It is also noteworthy that replacement with a wood stave pipeline would have been less costly than replacement with steel. (Using a wood stave pipeline would require increasing the minimum governor and valve closing time on the turbines from 12 to 60 seconds.) The 3/8-inch wall steel pipe by itself, not installed, would have cost about $175,000. The difficult site access conditions resulted in higher than normal installation bids.

Contractor bid price for penstock replacement or repair — 600 feet, 60-inch inside diameter

Replacement/remedy	Price range ($ thousands)
Buried steel pipe	404-580
Above ground steel pipe	475-477
Concrete encasement	460-596
Wood stave	266
Fiberglass lining	226-390

It was then decided to investigate, in detail, the condition of the existing pipe. Selected sections of the penstock interior were descaled using power and hand wire brushes and sanders. Some evidence of an originally installed inside coating was noticed. The depths of the corrosion pits were measured by ultrasonic thickness testing, supplemented with a pipe pit gage. The number of pits per unit of surface area were recorded.

The cleaned inside pipe surface showed random cratering due to galvanic corrosion. Care was taken to detect any cratering pattern that would seriously concentrate the pipe hoop stresses. Particular attention was given to the longitudinal Lock-Bar swage area. Neither the swage itself nor the immediate plate showed any significant corrosion. Material cracking was not evident and, for the most part, the pitting did not concentrate the shell stresses above tolerable limits. The rivet heads on the circumferential seams did not exhibit objectionable deterioration. Portions of the penstock that were unearthed showed minimal corrosion on the pipe exterior, and the original exterior bituminous penstock coating was in good condition. Based on these findings, repair and reuse of the existing penstock were then considered. The 25,000 pits estimated from the visual examination to be present eliminated as a practical solution an attempt to locate and weld all the potentially leaking pinholes as a workable solution. Sandblasting and painting the inside could inhibit further corrosion, but would offer no protection against pinhole leaks. It seemed desirable to investigate the possibility of lining the pipe. Therefore, several vendors for both cement and fiberglass linings were consulted. Several cement lining vendors discouraged the use of cement lining in this application, because of the exposure of the pipe to freeze-thaw action and the relatively high water velocity.

On the other hand, there appeared to be several good reasons for applying a fiberglass lining:

- Properly installed, a fiberglass lining should offer a significantly extended service life and stop any further interior pipe corrosion.
- All existing and potential pinhole leaks would be sealed.
- Frictional head loss would not be appreciably increased, if at all, because the pipe inside diameter would decrease by only 1/2 inch and the finished interior surface would be appreciably smoother than corroded steel. These two opposing factors would tend to balance out.
- Since all the work would be done inside the pipe, there would be limited environmental disturbance during construction and no permanent visual impact.

- The cost of the lining would be 40 percent less than the lowest bid received for new steel replacement pipe.

Construction Details

In late September 1987, I. W. Construction Services of Houston, Texas, began work. A 1.3-million Btu LP gas heater and blower were used to provide a venting updraft and to cure the fiberglass.

The interior of the penstock was first abrasive-blasted to a white-metal condition. Welded patches were placed in a few selected areas that had severe pitting. Immediately after blasting, each area was primed to preserve the white-metal condition. Next, the corrosion pits were filled with a putty material to make a smooth surface. Spaces around rivets were also filled with putty and tapered to provide a gradual buildup over contours. High-tensile-strength fiberglass reinforcement was embedded into the putty and saturated with resin. After this layer cured, two layers of chopped strand mat were applied and allowed to cure. Two topcoats containing abrasion-resistant additives and wax sealers were then applied to complete the system. A metal band was lapped over the leading upstream edge of the fiberglass-to-steel transition to provide additional protection against the possibility that waterflow might separate the fiberglass from the steel. The thickness of the fiberglass at the downstream terminus of the lining was tapered to prevent localized turbulence. The $250,000 repair project was completed on December 10, 1987, after 11 weeks of work.

Performance

Inspection of the penstock interior in early September 1988, after 10 months of continuous service, did not reveal any visual evidence of lining wear or distress, nor are we aware of any leaks. The surface appeared as smooth and clean as immediately after the initial installation. According to I. W. Construction Services, the coating is expected to last "a lifetime plus."

Although fiberglass lining is usually considered to be expensive/more costly than total penstock replacement, for penstock locations where the use of standard construction techniques and equipment would be difficult, or where the environment would be adversely affected, fiberglass lining may offer a practical rehabilitation alternative.

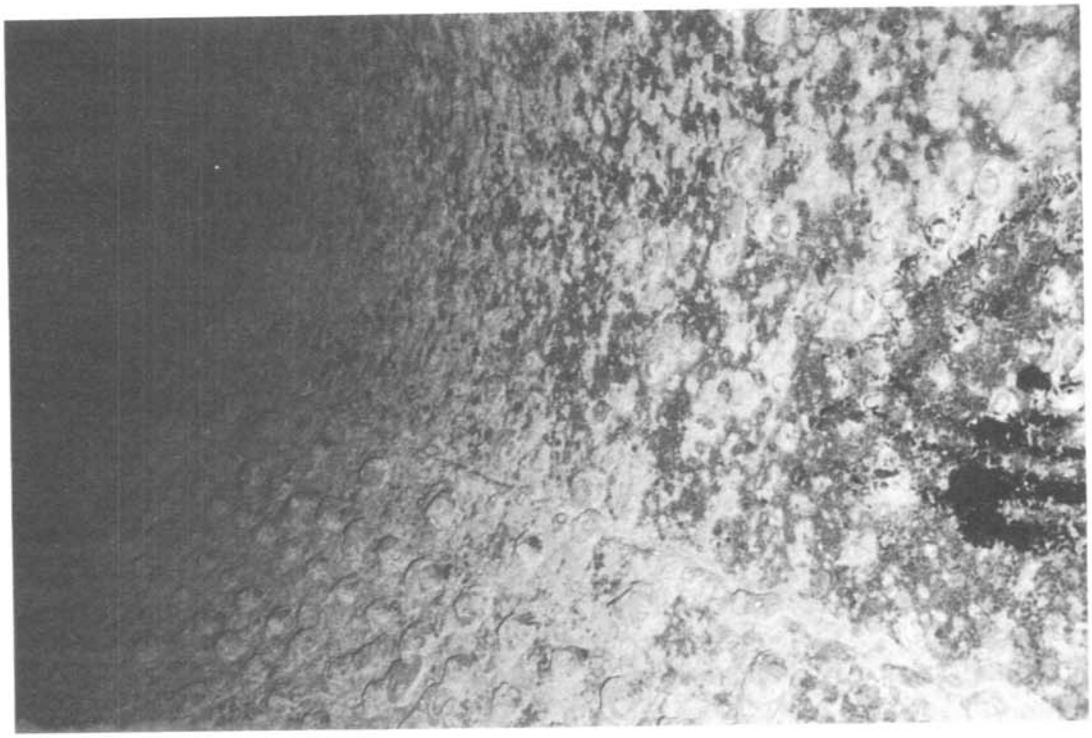

Figure 1. – Condition of interior surface of penstock before preparation for repair. Note that rivet heads add to the roughness of the surface.

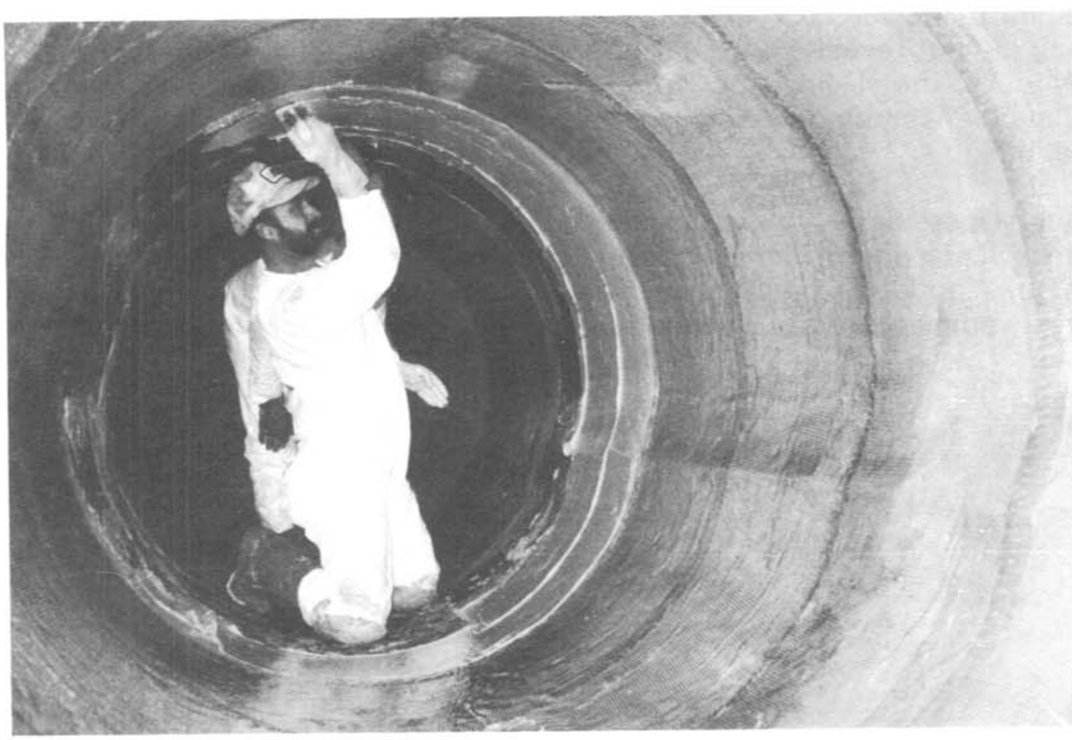

Figure 2. – After the damaged surface has been abrasive blasted, a putty material is applied over corrosion pits and around rivets to make a smooth surface.

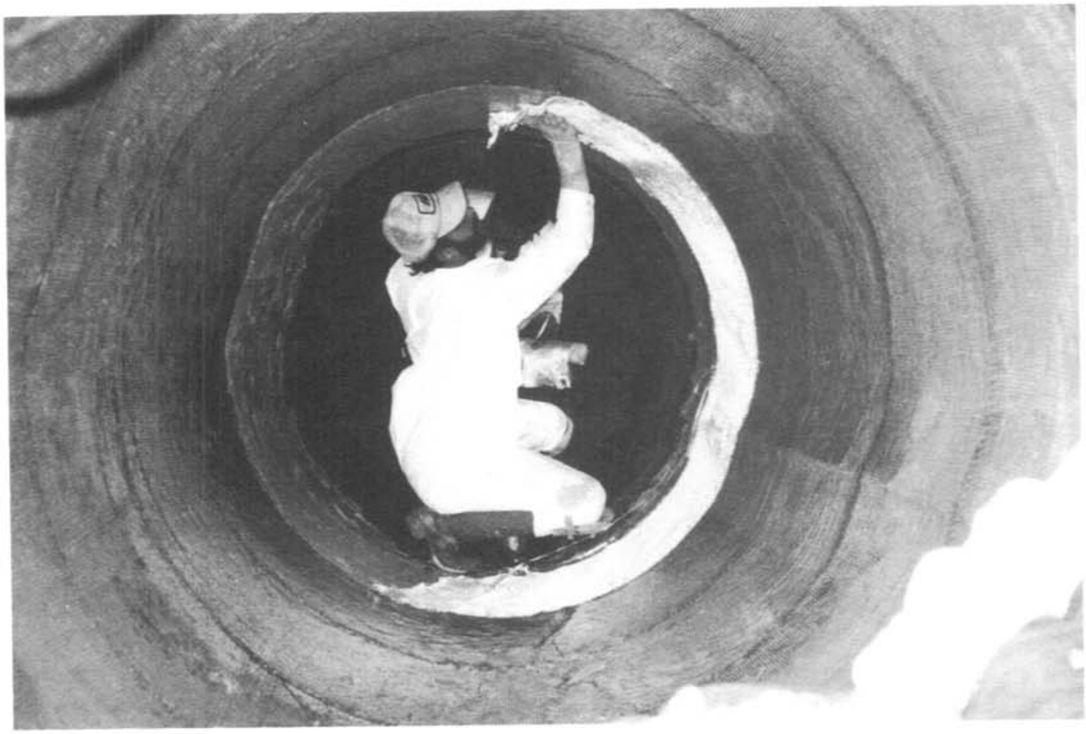

Figure 3. - High-tensile-strength fiberglass reinforcement is embedded in the putty.

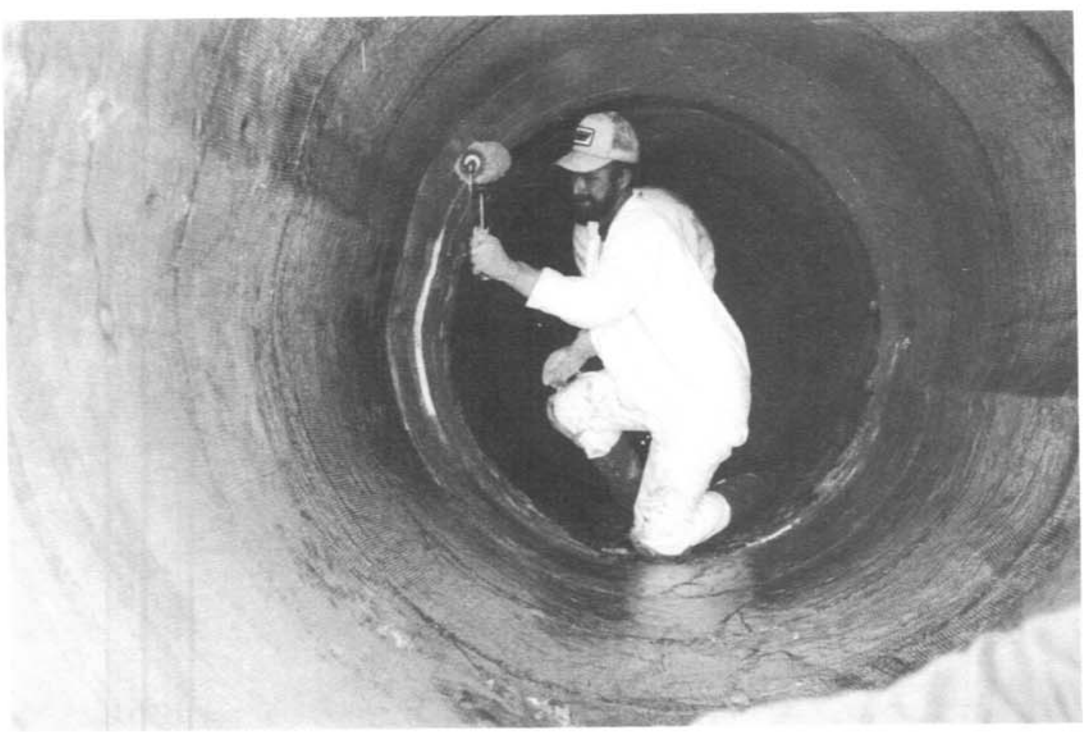

Figure 4. - The fiberglass is then saturated with resin and allowed to cure.

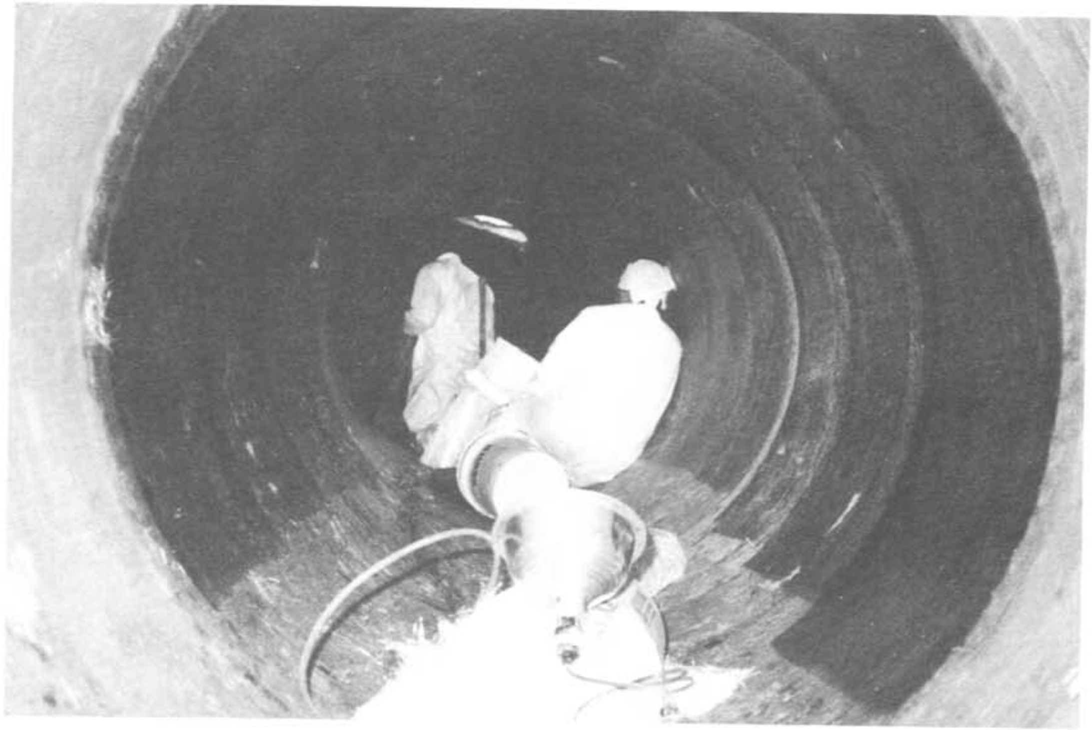

Figure 5. - Two layers of chopped mat are applied (above) and allowed to cure. After this, two top coats containing abrasion-resistant additives and wax sealers will be applied to complete the coating system.

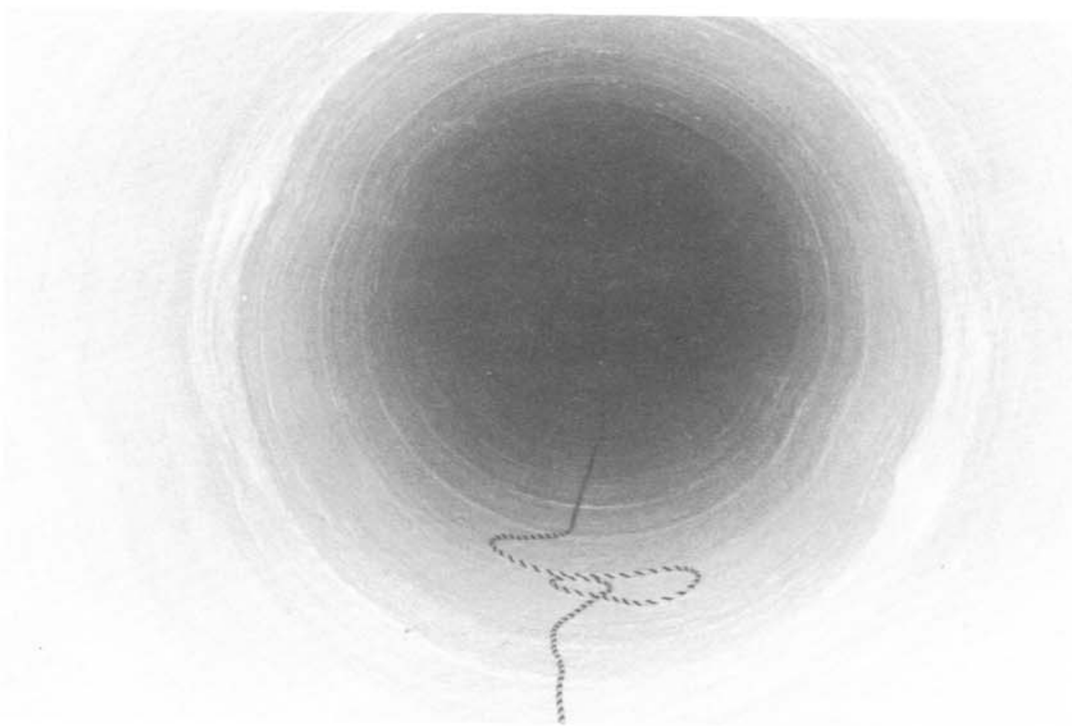

Figure 6. - When the project has been completed, the interior of the penstock shows the desired smooth surface which, according to the supplier, should last over 25 years.

NEW SAFETY STANDARDS RELEASED

A team, representing all five Regions consisting of safety, water, and power personnel, has prepared a new safety publication entitled *Reclamation Operation and Maintenance Safety Standards* (ROMSS).

ROMSS applies to all Reclamation operation and maintenance (O&M) activities (both force account and O&M work under contract). Numbered copies have been distributed to the regional offices for distribution to Reclamation personnel.

ROMSS is available in a soft cover, comb binder (unnumbered version) for non-Reclamation personnel. Copies may be obtained by writing the Bureau of Reclamation, attention D-7923A, PO Box 25007, Denver, Colorado 80225; price $7.30 — foreign remit an additional $1.80 for handling and mailing.

AN AGENCY FOR ALL RECREATION REASONS

Richard A. Crysdale[1]

What agency completed the world's second largest archeological undertaking, has a professional golf association (PGA) tournament caliber golf course (used and viewed by thousands in person and millions on television), and is assisting Guam and Saipan develop a tourism market in the South Pacific?

Right! The Bureau of Reclamation! Surprised?

Established in 1902 to develop water resources, the Bureau of Reclamation (Reclamation) has perhaps a more diversified involvement in recreation and in opportunities for planning and management than any other Federal agency. Reclamation has the diverse staff of experts in the physical, biological, and social sciences required to develop water resources within and outside the United States. With the growing popularity of water as a recreation resource, Reclamation has a vital and diversified role to play in the recreation use of its projects.

Reclamation manages over 7 million acres (1.4 percent of the Federal estate), and 285 of its 350 water development projects offer recreation opportunities in the 17 Western States. In 1986, over 78.5 million people visited areas under Reclamation's management, including 1.7 million surface-acres; 4.6 million acres of land; 12,735 miles of shoreline; and 513 miles of trails. Recreational activities range from the use of amphibious ultralight aircraft to zoological appreciation in visitor centers. Reclamation significantly influences all water-oriented activity in the western playground of America. "Diversity" characterizes Reclamation's recreation involvement.

During the 1970's, Reclamation conducted the $12-million, 10-year archeological investigation on the Dolores Project near Cortez, Colorado. This area is rich in Anasazi culture. Reclamation archeologists conducted the curation and interpretation of the artifacts for preserving and understanding our country's ancestors. Today, thousands of people visit the Anasazi Heritage Center designed and built by Reclamation and operated by a sister agency, the Bureau of Land Management. Only the archeological undertaking to salvage the ancient Egyptian culture during construction of the Aswan High Dam required greater efforts than the Dolores Project.

The PGA has a tournament players' club which includes the two new top quality golf courses on Central Arizona Project land. Reclamation provided the land to the City of Scottsdale and cost-shared the development of these golf courses. Over 300,000 people attended the 1989 Phoenix tournament, setting an all-time record of on-site viewers.

Reclamation's unique recreation activities include the operation of visitor centers and tours at its water developments. For example, millions of visitors tour Hoover, Grand Coulee, and Glen Canyon Dams as a part of their recreation itinerary. (Since 1935, Hoover alone has had 26 million visitors.) Visitors experience mental enrichment and

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gain a better understanding of hydroelectric power and the complexity of water development.

Over 2,000 people, half from outside the United States, annually tour Reclamation's world-renowned hydraulics laboratory in Denver. In this lab, water planning concepts are modeled for projects still on the drawing board, and problems associated with existing projects within and outside the United States are solved. During January and February 1989, at the request of other recreation agencies, Reclamation engineers were studying two recreation models for safer river running on the South Platte River in Colorado and the Salt River in Arizona. The models, each occupying over 1,500 ft2, were specifically designed to study river hydraulics and safe boating passage over diversion structures.

Other areas of study include the recreational impact of waterflow changes, the carrying capacity of water bodies, and the development of resource/land management plans for Reclamation's 285 water projects. A recent study on Lake Berryessa, California, where users are concerned about water safety and overcrowding, identified 44 recreation activities occurring on just the 19,800-surface-acre reservoir.

Other countries are coming to Reclamation for assistance in recreation planning for their undeveloped reservoirs. Reclamation has assisted 115 countries in the development of water, primarily as water supplies and hydroelectric power. Recreation expertise is another dimension in the services offered to these countries.

With the passage of a new fishing policy, Reclamation is cooperating with nature to enhance fisheries and fishing opportunities. For example, marina breakwaters at Lake Roosevelt in Arizona are being designed by Reclamation for providing a harbor, fishery habitat, and fishing access. Extensive aquatic ecology studies by Reclamation scientists have been conducted to protect and enhance fisheries in the 17 Western States.

Reclamation is diversified in the recreation management of its 285 projects. The Federal Water Development Recreation Act of 1965 allows Reclamation to cost-share development of recreation and fish and wildlife facilities with other governmental agencies. The number of recreation areas managed by governmental agencies are:

Federal (including Reclamation)	135
State	125
Local	63

These agencies, through contractual agreement with Reclamation, manage developments ranging from Lake Powell and Lake Mead National Recreation Areas to Folsom South Canal bike trails in Sacramento, California. Reclamation manages 47 additional recreation areas on its projects. Reclamation has specific authority to plan, develop, operate, and maintain recreation at only one project — Lake Berryessa in California. The ranger force there includes three permanent and six seasonal employees, plus four lifeguards. Reclamation does not have law enforcement authority at any of its projects.

In Reclamation's total work force of 7,000 employees, recreation-related specialists include outdoor recreation planners, landscape architects, fish and wildlife biologists, archeologists, and historians. In 1981, Reclamation employed 95 people with recreation responsibilities. In 1988, the reorganized Reclamation is committed to greater resource management and is staffing accordingly.

Principal problems facing Reclamation include the management of areas receiving overwhelming recreation use and the lack of authority to properly manage its lands for recreation. In the past, Reclamation has relied heavily upon the Young Adults Corps, Youth Conservation Corps (both defunct), and the Job Corps to develop recreation facilities.

Many Reclamation water developments receive visitation which exceeds the facility's capacities, resulting in an overflow and indiscriminate use of undeveloped lands adjacent to the reservoirs. Uncontrolled use by off-road vehicles, campers, picnickers, and other water-oriented activities has resulted in severe resource deterioration. Under the reorganization, Reclamation is attempting through legislation to turn these problems around. We are seeking greater land management authority and a greater commitment to implement resource management plans for all our projects.

The popularity of water in recreation is no secret. The Outdoor Recreation Resources Review Commission acknowledged that 44 percent of Americans preferred water-oriented activities in 1962. Recent U.S. Forest Service studies indicate that water activities "increased substantially" in all regions of the country. President Reagan, in his 1987 National Safe Boating Week message, indicated that 68 million Americans would use boats that year; that is nearly 1 American in 4 using this recreation luxury item. According to the National Marine Manufacturers Association, Americans bought more than 724,000 new boats in 1987, adding to a fleet of 17 million pleasure boats.

Our Western water resources are basically fixed; they are probably all that will ever be available to meet the demands of future generations for water-based recreation. Reclamation's mandate parallels the National Park Service's commitment to preserve this resource for future use. Water developments will be to 21st century people what the National Parks are to people of the 20th century. Reclamation water developments are the last uncut diamonds in our nation's recreation resource treasure chest. We cannot afford to squander them. Indeed, Reclamation has a significant role in recreation now, and especially in the future.

Photos 1 and 2 show hydraulic models of a boat chute that Reclamation engineers are designing to allow safe passage of rafts, canoes, and kayaks around a diversion structure on the South Platte River near Denver, Colorado. The consultant and Reclamation are in a partnership to prevent further recreation accidents. Other states are beginning to ask Reclamation for similar assistance.

Photo 1. – Hydraulic model designed and being built in Reclamation's research laboratory at the Denver Federal Center.

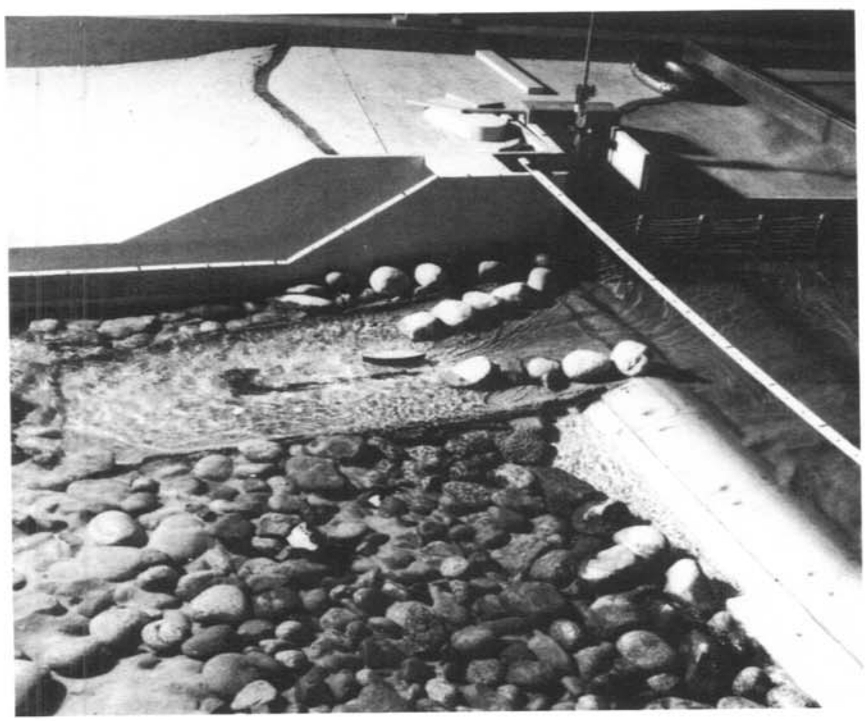

Photo 2. – Another view of the hydraulic model being designed and built in Reclamation's research laboratory at the Denver Federal Center.

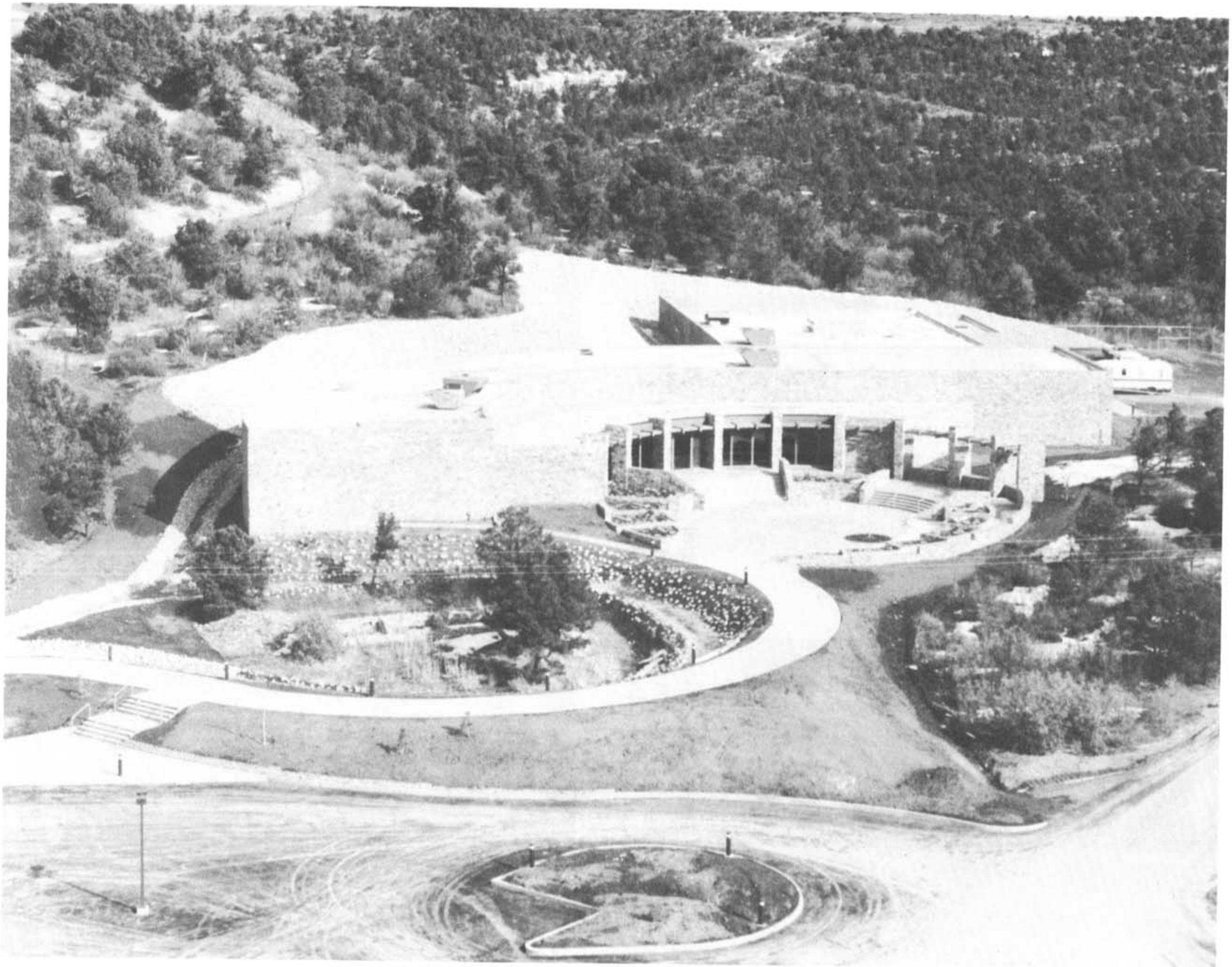

Photo 3. - The Dolores Project Visitor Center, designed and built by Reclamation follows the kiva theme of the Anasazi culture which archeologists are studying in southwest Colorado.

REHABILITATION OF CROW DAM GATE TOWER

by Robert V. Todd[1]

Crow Dam, located approximately 7 miles southeast of Ronan, Montana, was completed in 1933. The dam is owned by the Bureau of Indian Affairs (BIA) and operated by the Flathead Irrigation and Power Project in St. Ingnatius, Montana. The outlet works, which are adjacent to the left abutment of the dam, consist of a concrete intake structure with trashracks, a transition to a concrete pressure tunnel, a hand-operated butterfly valve, a concrete gate tower and annulus, a downstream tunnel containing a gooseneck, and a concrete stilling basin (figure 1).

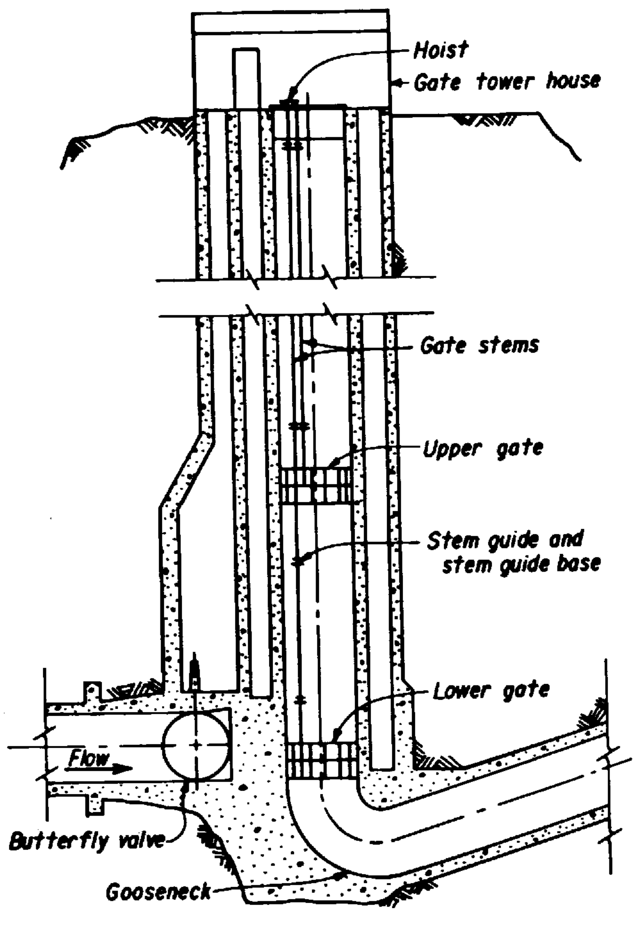

Figure 1. - Gate tower

The shaft of the concrete gate tower is 94 feet high; it contains two 6-foot-diameter by 3-foot-high cast-iron cylinder gates, which are used for making releases for irrigation. One gate is located at the bottom of the tower; the other is 24 feet higher. Normal water demand requires only one gate to be partially opened. At partial openings, fluctuating

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hydraulic loads act on the bottom of the gates and through the gate stems to the top of the gate tower. The mechanical structures respond dynamically like a large mass on a soft spring. Resulting displacements of the gates and stems under fluctuating loads have caused failures of the gates, stems, and guides.

During failure, guide brackets for the gates either break off completely, or the bolts holding them break. The extra radial displacement is then transferred to the first stem guides above the gates. These stem guides crack, and the bolts holding the stem guide base to the concrete wall break; this process continues until finally the stems themselves fail. Then the gates fall onto the seat rings and sustain additional damage. This scenario took place at Crow Dam in 1980 [1].*

With the three sets of stem guide bases for the lower gate broken away from the gate tower wall and the stems broken, engineers decided to hang the lower gate from cables attached to the undamaged stems 42.5 feet above the gate. After only one season of operation, the cables broke, and the lower cylinder gate shell structure sustained cracks [2]. Releases from the gate tower were then possible only through the upper gate. In 1984, the lower cylinder gate was removed, and the open ports in the gate casing were blocked with steel plates [3]. In addition to the damage to the gates and stems, the concrete below each gate sill had been eroded, and the embedded reinforcing bar in the gooseneck concrete section was exposed for several feet.

Rehabilitation Program

Because of the overall deterioration of the gate tower and the associated mechanical equipment, a rehabilitation program was required. Three criteria determined the extent of the rehabilitation work:

1. *Urgency*.–If the upper gate malfunctioned, there would be no means of making controlled releases from the outlet works.

2. *Finance*.–The $600,000 allocation from the safety of dams program for design and construction had to cover the cost of a new spillway as well.

3. *Opportunity*.–The work would have to be performed during one winter shutdown period to be completed before the following spring runoff and irrigation season.

Two rehabilitation options were considered: (a) replacement of the cylinder gates with slide gates, and (b) reconstruction of the cylinder gate system and restoration of the damaged areas of the gate tower. The latter option most closely met the criteria. Because of limited funding, BIA decided to use its own work force to do the rehabilitation work but requested that the Bureau of Reclamation administer the contract and provide technical assistance in preparing specifications.

Casting Versus Weldment

The original cylinder gates, guide brackets, stem guides, and stem guide bases were made of gray cast iron. Initially, the decision was to replace these parts with castings

* Numbers in brackets refer to references at end of article.

similar to the original ones. However, when the specifications were put out for bids in 1985, there was no response. The specifications were then amended to give the contractor the option of using weldments or castings [4]. This change resulted in a number of bids, all quoting the weldment option.

In changing the method of fabrication from a casting to a weldment, BIA had to compensate for the inherent fatigue proneness of a welded structure. A low carbon steel, ASTM A36, was used to make the weldments. It is very ductile and has low notch sensitiveness and is, therefore, a good material for a low stress-fatigue application. It has a minimum ultimate strength of 58,000 lb/in^2. Because of the strength of the steel, the thicknesses of the gate components could have been reduced; however, taking fatigue into consideration nullified the strength advantage, and no change in any component thicknesses was made. To ensure structural integrity of the weldments, workers x-rayed all critical welds and kept fillet welding to a minimum.

Material Changes

The original material for the seating rings for the cylinder gates was cast manganese bronze. This material is no longer commercially available in this form, and the cost to fabricate it would be prohibitive. Therefore, the material for the seating rings was changed to centrifugally cast aluminum bronze, which has the necessary characteristics and is commercially available and reasonably priced. All of the bolts were changed from low carbon steel to stainless steel. This change was made to obtain the superior anticorrosion properties of stainless steel.

Adjustment of Seat Rings

Originally, the cylinder gate casing was a one-piece casting. When the seat rings were installed, the gate could be lowered into the gate casing, a watertightness test could be performed, and the seats could be machined or ground until leakage requirements were met. However, in the case of the replacement gates, making modifications in the field was not practical. To ensure that contact necessary for watertightness could be obtained in the field installation, a test fixture with the same inside profile as the gate casing was specified. The new casing seat rings were installed in the test fixture, the cylinder lower seat was positioned on one of the gate cylinders, and the cylinder upper seat ring was emplaced on the gate cylinder with the clamping ring allowed to float one quarter of an inch. The gate was then lowered into the test fixture so that both sets of gate seat rings made line contact with the casing seat rings.

To obtain the field adjustment of the upper seat ring, five 1-inch-diameter holes were drilled in each of the three clamping rings, between the existing holes, to coincide with the inside face of the cylinder upper seat ring and the gate cylinder. During installation of the gates, the lower gate, with its cylinder bottom seat ring installed, was lowered down the tower so that the gate seated on the bottom casing seat ring. The cylinder upper seat ring was then placed in position, and the clamping rings were installed with shims located between the clamping rings and the top of the gate to maintain a maximum gap of 0.020 inch at location "A" in figure 2.

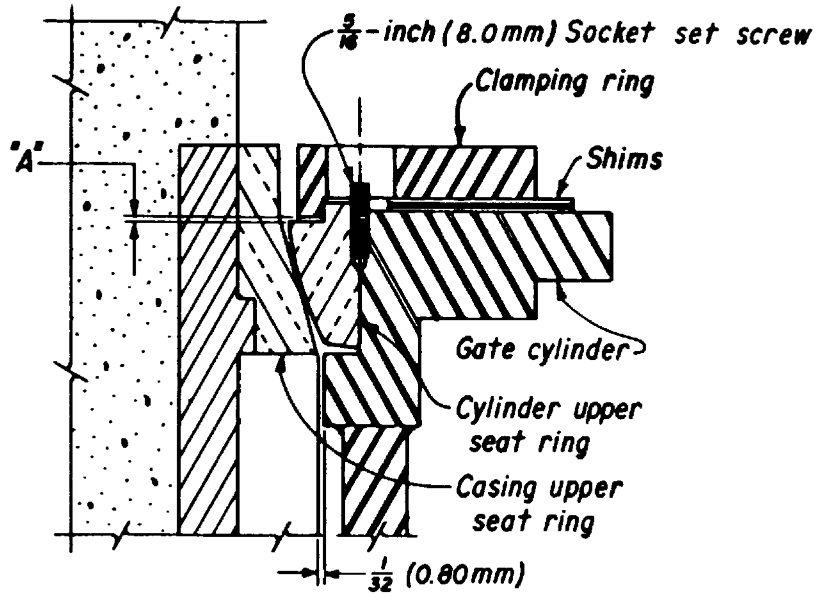

Figure 2. - Upper seating adjustment

Holes were drilled and tapped for socket set screws at the locations of the 1-inch holes in the clamping rings. The shims were then adjusted so that the clamping ring firmly held the seat ring. This procedure ensured that if the lower seat rings were to lose contact after a period of time, the gate weight would not be solely on the set screws.

Molecular Welding Repair System

Both upper- and lower-gate casings had damage on the inside surfaces of the vertical ribs (figure 3). The casing ribs adjacent to the port openings had suffered from erosion, and the fluctuating radial movement of the gate at different openings had caused the casing ribs to break away. Because the gate casing is embedded in concrete, the cost of replacing it would have been extremely high. Also, because the casing is made of cast iron, repairing it with conventional welding techniques would have been difficult. However, molecular welding, a modern technology that uses proprietary materials to build up damaged metallic areas, can be used to repair the type of casing damage found at Crow Dam. A base and solidifier mixed together to form a compound that has nonslump, nonshrink characteristics and a short curing time is ideal for field applications in which access and working conditions are confining and awkward. Once cured, the material has the mechanical properties of a low carbon steel and can be machined or ground for final sizing.

Steps involved in the repair included brushing away any loose contaminates, grit-blasting with copper slag, mixing and applying Belzona Molecular Ceramic R-Metal*, curing for 2 hours, measuring and reapplying the repair material until the buildup was satisfactory, and finally brush coating with 10 to 15 thousandths of Belzona Molecular Ceramic S-Metal* to give added protection against erosion and corrosion.

* These were products used on the rehabilitation work; however, the Bureau of Reclamation does not endorse these products over similar products by other manufacturers.

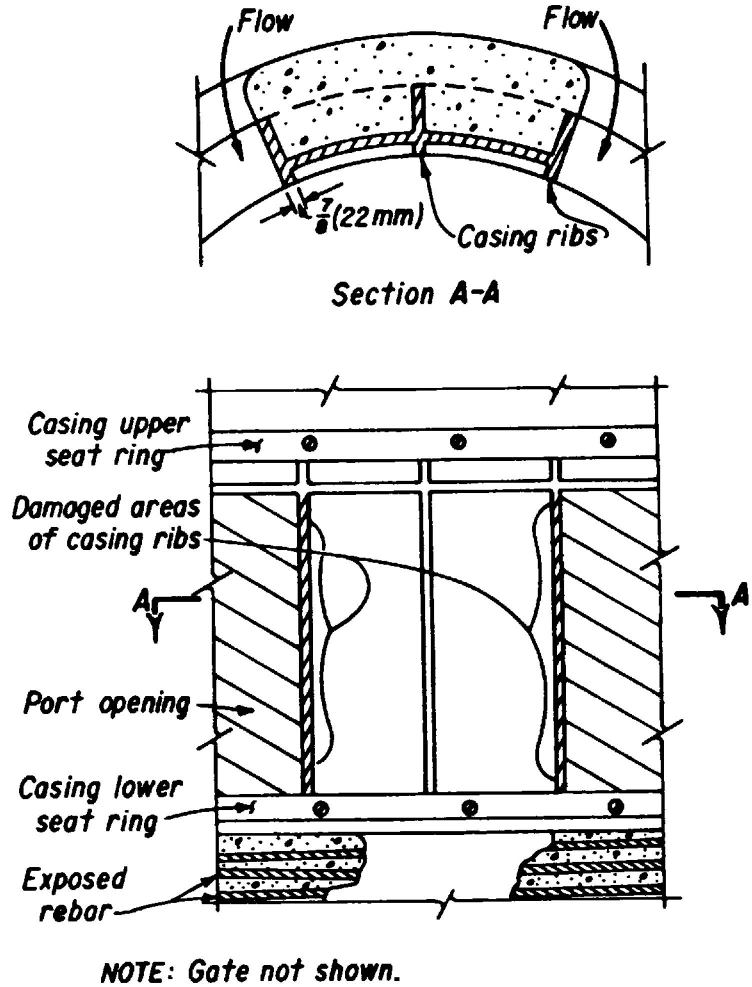

Figure 3. - Gate casing damage

Concrete Repairs

The damaged areas on the inner surface of the gate tower were repaired with epoxy mortar. The badly damaged area of the gooseneck that had exposed reinforcing bars was fitted with a steel liner and backfilled with concrete. Areas around the casings where bonding was required were repaired with Belzona Molecular Magna-Quartz*, a polymeric alloy consisting of organic molecular compounds and inorganic micronized magna-quartz, because of its long-lasting adhesion properties. Each micronized quartz particle is pre-encapsulated with a monomolecular layer of surface-active agents to ensure a homogeneous mixture with no intercrystalline weak points. It cures within 12 hours. Areas to be repaired were cleaned, dried, brush treated with a surface conditioner, filled with magna-quartz, and then leveled with a trowel.

Field Installation of Gates

The field installation of the gates, stems, and guide brackets was accomplished during the winter of 1987-88. Because of the minimal clearances between the gates and the casings, considerable localized grinding of the repaired casing ribs had to be done. This experience proved that it would have been advantageous to have had a template of the outside profile of the gate for checking clearances between gate and casing.

The BIA has two more projects with gate towers that have identical gates to those at Crow Dam. When these gate towers need rehabilitating, the experience obtained from performing the work at Crow Dam will be invaluable, not only from the standpoint of cost and materials tracking but also because of the identification of problem areas and solutions.

Conclusions

The rehabilitation work performed on the gate tower at Crow Dam highlighted a number of areas that should be considered when an old structure needs to be rehabilitated:

- Manufacturing processes change with time, and improved technologies make some processes obsolete or no longer cost-effective.
- The availability and types of materials also change with time; procuring materials called for in the original design may not be possible.
- Original methods of obtaining certain operational requirements may not be practical under the rehabilitation conditions.
- Repairing materials and equipment instead of replacing them may be practical and considerably less expensive.

For further information, contact the author.

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SPRAY-ON ZINC EXPECTED TO GROW[1]

by Hugh Morrow[2]

North American consumption of zinc for thermally sprayed coatings is expected to grow to match that of Europe. If it does, the result will be a total world metal demand from this application in the region of 50,000 tpy - some of it at the expense of other coating techniques.

Zinc and zinc-aluminum thermally sprayed coatings will compete with those coating systems which are utilized for the long-term corrosion protection of large steel structures. The competing systems include galvanizing, galvanizing plus painting, and the premier three-coat paint systems which are usually based on a zinc-rich primer paint. In marine applications, the thermally sprayed zinc-aluminum alloy coating may compete with thermally sprayed aluminum coatings which are now well accepted.

Five years ago the Zinc Institute and Platt Bros & Co. in the U.S.A. formed the Zinc Metallizers Task Group (ZMTG), and this has been promoting zinc thermal spraying in the North American market ever since. To date, most of its efforts have centered on the bridge market, but other application areas such as railroad cars, water towers, industrial plant steelwork, underground piping and storage tanks, as well as many applications in the marine industry are beginning to establish themselves.

In Canada, the province of Quebec has pioneered the North American zinc thermal spraying market. The world's largest onsite thermally sprayed structure is the Pierre LaPort bridge over the St. Lawrence River. The province has also zinc thermally sprayed many other smaller highway overpass bridges and is quite pleased with the corrosion protection provided. British Columbia has also zinc thermally sprayed a number of bridges in the past few years.

In the U.S.A., the State of Ohio has embarked on an ambitious program to evaluate thermal spraying. Thus far it has zinc sprayed three entire bridges, and is planning more for the future. New York, New Jersey, Connecticut, Rhode Island, Massachusetts, Pennsylvania, and Virginia have all thermally sprayed entire bridges or test sections of bridges in the past 4 years, and thus far, all have shown good results. Interest is spreading to other states which have requested information, have evaluated corrosion coupons, or have already been using zinc thermal spraying in some critical applications. Vermont, for instance, has been using zinc thermal spraying to protect highway bridge bearings.

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[1] Reprinted from the October 1988 issue of Metal Bulletin Monthly, published by Metal Bulletin Incorporated, 220 Fifth Avenue, New York NY 10001, telephone (212) 213-6202.

[2] Hugh Morrow is Chairman of the Zinc Metallizers Task Group (ZMTG), 292 Madison Avenue, New York NY 10017, telephone (212) 578-4750.

Zinc being sprayed on to the steel understructure of a bridge in Ohio; 20 years maintenance-free service is expected as a result.

In the past 4 years too, committees have been formed in a number of the major U.S. societies to consider specifications, corrosion testing, quality control, and inspection of thermally sprayed coatings.

Even though zinc thermal spraying is touted because it is a thick zinc coating, it is also challenging some of the thin zinc coatings as well. In a process known as "hot spray galvanizing," coatings from 1-3 thousandths of an inch of zinc can be successfully and uniformly applied to small hardware items such as nails, bolts, nuts, screws, and washers. These items are normally zinc barrel plated, mechanically plated, or hot-dip galvanized, with each of those processes having advantages and disadvantages. Thus, it is expected that thermal spraying may compete with the mechanical plating and electroplating processes as well as the hot-dip and zinc paint coating methods.

The experimental development of continuously thermal sprayed steel sheet in Japan, the UK, and the Netherlands suggests that thermal spraying could even compete one day with hot-dip continuous galvanizing and electrogalvanizing.

While the implications of the interest in zinc thermal spraying on the total zinc market may not be large, this area could develop into a significant niche market for zinc coatings.

Of the 25,000 tonnes of zinc consumed in thermal spraying in 1982, about 20,000 tonnes was in the European market, the remaining 5,000 tonnes coming from applications in the U.S.A., Canada, Japan, and India. It is expected that use in the U.S.A. and Canada could easily match that in Europe in the future, particularly in view of the critical state of many of the bridges in the U.S.A, their need for constant maintenance, the rapidly increasing cost of that maintenance, and in some cases a completely unsafe condition in the existing bridge.

One of the large advantages of the thermally sprayed coatings from the zinc consumption point of view is that, because a thermally sprayed coating is so much thicker than other zinc coatings, use of this coating will result in far greater zinc consumption than if the same structure had been galvanized or painted with a zinc rich paint. Initial consumption of zinc in a thermal spraying operation would be at least twice that in a galvanizing or painting operation on the same bridge.

It should also be noted that thermal spraying is widely accepted as probably the best method of repairing damaged galvanized coatings, and that zinc thermal spraying is often the only alternative for very large structural members which cannot be galvanized even by the double dipping technique because of kettle size limitations.

In the final analysis, the growth of the zinc thermal spraying market in North America will depend on whether or not the end users continue to embrace the policy of adopting the lowest cost method on an initial basis regardless of the long-term implications. If they begin to be more far-sighted, and to evaluate coatings on total cost (both initial costs and future costs) then the zinc and zinc-aluminum thermally sprayed coatings should grow impressively in the next 20 years, and with it, the demand for zinc.

THERMAL SPRAYING

Zinc thermal spraying is an application technique whereby zinc wire or powder is fed into a thermal spraying gun which converts the solid wire or powder, using either a gas flame or electric arc heat source, into tiny drops of molten zinc which are then rapidly propelled against the suitably prepared steel surface to be protected. There are advantages and disadvantages to each of the input material forms and to each of the heat sources. The most common technique of thermal spraying in use today is the wire-fed, gas-flame gun.

In many ways, the thermally sprayed zinc coating contains elements of both the hot-dipped coatings and the mechanically applied coatings. When the thermally sprayed zinc particle reaches the steel substrate it freezes instantly and deforms around the profile of the surface, forming an adherent layered coating on the very fine scale. Because of the rapid heating, melting, and refreezing of the thermally sprayed alloys, the microstructures and phases present are not those normally found in the more slowly cooled materials. The structures are very fine grained, and often contain considerable amounts of finely divided eutectic phases, the phases which are formed immediately after solidification, or just below the alloy's melting temperature.

The thermal spraying method of applying zinc coatings requires some special conditions, however, and therefore may not always be the ideal coating even though long-term protection from corrosion is required. (The steel substrate to be coated must be properly cleaned, and skilled operators are also needed to apply the coating successfully. Most applications require that the thermally sprayed coating be sealed with low-viscosity sealer on the same day as the thermal spraying is performed.)

Because of some of these conditions, thermal spraying has been viewed in the past as being a very expensive coating system. On an initial cost basis, it may be somewhat more expensive than other zinc coating systems, depending on the particular comparisons made; but in the long term, it is probably the most cost-effective of the zinc coating techniques. Studies in both the UK and the U.S.A. have shown that, for the long-term corrosion protection of large steel structures having a low surface-area-to-weight ratio, zinc thermal spraying is the most cost-effective technique.

Zinc coating thicknesses (thousandths inch)	
Liquid applied	
Hot-dip batch galvanizing	up to 5.0
Hot-dip continuous galvanizing	up to 0.5
Electrolytically applied	
Electroplating	up to 1.0
Electrogalvanizing	up to 0.5
Particulate applied	
Mechanically galvanized	up to 2.0
Zinc-rich paints	up to 3.0
Zinc thermal spraying	up to 10.0

METALIZING SPILLWAY GATES — BLUE MESA DAM

by Richard C. Girvan[1]

The Bureau of Reclamation's Colorado River Storage Project administered a metalizing contract on the spillway gates at Blue Mesa Dam in September and October 1988.

Background Description

Blue Mesa Dam is on the Gunnison River about 30 miles downstream of Gunnison, Colorado. The dam is a zoned earthfill embankment which rises 340 feet above the streambed and has a crest length of 785 feet. The spillway consists of a concrete intake structure controlled by two 25- by 33.5-foot radial gates, a concrete-lined tunnel, concrete flip bucket structure, and a stilling basin.

General Description of Work

The principal components of the work performed under the contract specifications included:

1. Removing the existing VR-6 coating system from both sides of two steel 25- by 33.5-foot radial gates and appurtenant metalwork. Total area of removed coating was approximately 10,268 ft^2, excluding Modification No. 3.

2. Preparing surfaces by abrasive blasting.

3. Applying thermal sprayed (ARC) zinc coating.

4. Applying a top coat of epoxy polyamide to the metalized surfaces.

Contract Administration

The seven bids received ranged from $79,300 to $155,072. The lowest bid by Coastal Coatings, Inc., was almost $4,000 over the engineer's estimate. The award of contract was August 12, 1988. The allotment time for completion of the work was 120 calendar days.

Factors Affecting the Contract

1. Coastal Coatings did not send a representative to the jobsite for a pre-bid visit. This factor resulted in some misunderstandings that would later lead to a contract modification (Modification No. 3).

2. The aforementioned modification concerned the metalizing of the gate seals, clamps, and metal under the seals. This required the seal clamps and seals to be removed, metal areas sandblasted, and all metal to be metalized. The Coastal Coatings

[1] Richard C. Girvan is a Mechanical Engineering Technician with the Bureau of Reclamation's Curecanti Field Division Office, Montrose, Colorado.

representative was very difficult to deal with concerning the extra monies needed to complete the work. There was approximately 238 ft^2 of extra material to be metalized. The money dispute was settled between the Bureau of Reclamation and Coastal Coatings in the amount of $9,868, averaging over $41/$ft^2$.

3. Crew was on-site on September 9, 1988; however, the foreman was required to obtain a first-aid card causing a 5-1/2-day delay.

Construction Operations

Stoplogs were not needed because the reservoir was below the sill for the radial gates. The contractor installed safety netting over the spillway opening. A containment tarp (brand name Envirotarp) was laid over the safety net. This tarp was used to prevent the abrasives, used to remove the VR-6 coating, from entering the spillway. The abrasive waste collected in the tarp was pumped to a waste pile on the surface using an air-operated sand hog. The waste was later removed by a front-end loader. Numerous steel rope safety lines were secured over the spillway. The men used safety belts at all times while working. The contractor used air-operated staging (brand name Spider) for work on the upstream and downstream sides of the gates. The air for all operations was supplied by a Gardner-Denver 1050 Rota-Screw air compressor.

Blasting and Metalizing

Abrasive materials: silica sand, copper slag, and garnet. The contractor disagreed with the specifications regarding the use of silica sand or copper slag as a final blast. His contention was that either material would give the required profile for the metalizing process. The specifications plainly stated that silica sand or copper slag may be used for the initial blast to remove the VR-6 system, but would not be permitted for the final blast. The specifications, however, did not state what type of abrasive would be acceptable. This omission caused a problem that would delay the work and require much paperwork to correct. The abrasive blasting was to be completed allowing enough time for the blasted area to be entirely coated with zinc each day. There were several instances that the blasted area was not coated with zinc due to unforeseen difficulties. These areas were thoroughly inspected for surface rust then brush-blasted with garnet abrasive. This process freshened the blasted area assuring the proper surface preparation prior to metalizing. The zinc was applied with an arc gun (Thermion).

Blasting and metalizing began on September 21, 1988, and was completed on October 15, 1988. The crew worked 25 days straight. One day was used to transfer the safety netting and staging from one spillway gate to the other. Over 100 tons of abrasives were used to remove the VR-6 paint. There was a concern that large amounts of abrasives may have passed the containment tarp and lodged in the spillway air slot. The contractor sent one man down to the spillway slot to inspect and remove abrasives if necessary. He took pictures of the air slot. Little or no abrasives were found; however, approximately 100 pounds of mud and small rocks that had washed down the spillway were removed.

Painting

Top coat — Epoxy polyamide: green primer and gray finish coat
M-P-23331/1 F150 green primer
M-P-23332/2 F151 gray finish coat

Painting began October 17, 1988, and was completed on October 26, 1988. The painting was done using an airless paint pump. The pump had a 1:30 ratio 100lb/in^2 air developed 3,000 lb/in^2 paint pressure at the paint gun nozzle. Two spray guns were operated with this pump.

A paint thickness gauge was used continuously during spraying operations. Paint brushes and rollers were used in some areas. One coat primer (5 mils) and one coat gray (5 mils) were applied to all metalized surfaces. The manufacturer's guidelines were used for curing before top coat was applied. There was some concern as to whether the epoxy would cure due to the cool fall temperatures; however, the temperature never fell below the recommended temperature for proper cure between coats.

Guidelines for temperature, humidity, and dew point came from the United States Navy Department.

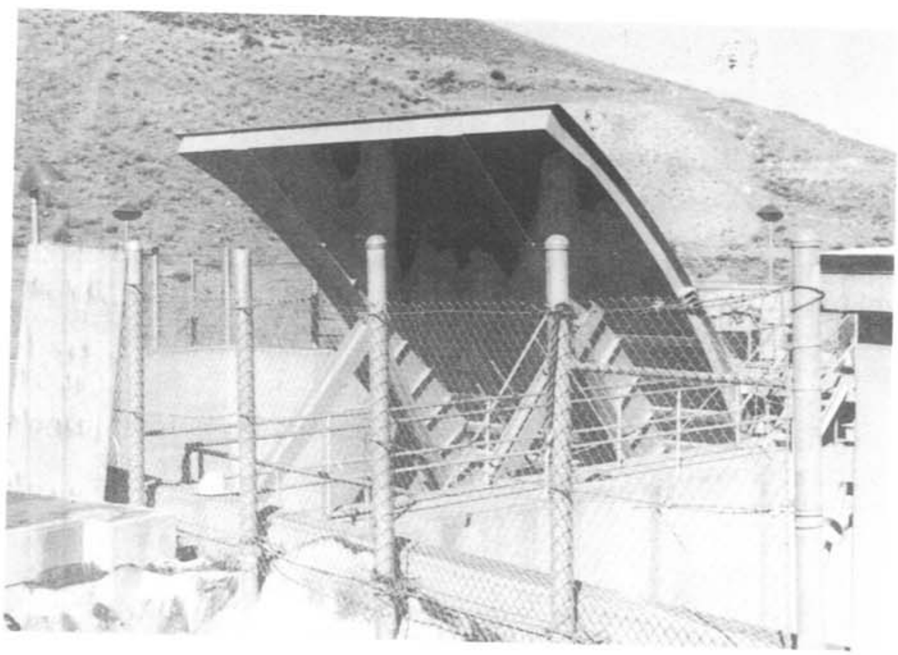
Summary

The job, without the extra seal work (Modification No. 3), encompassed 10,628 ft^2 for the bid price of $79,300 or $7.46/ft^2. The modification for the seals cost $9,868.13 for approximately 238 ft^2 or $41.46/ft^2. This raised the price per square foot for the total work area to $8.21.

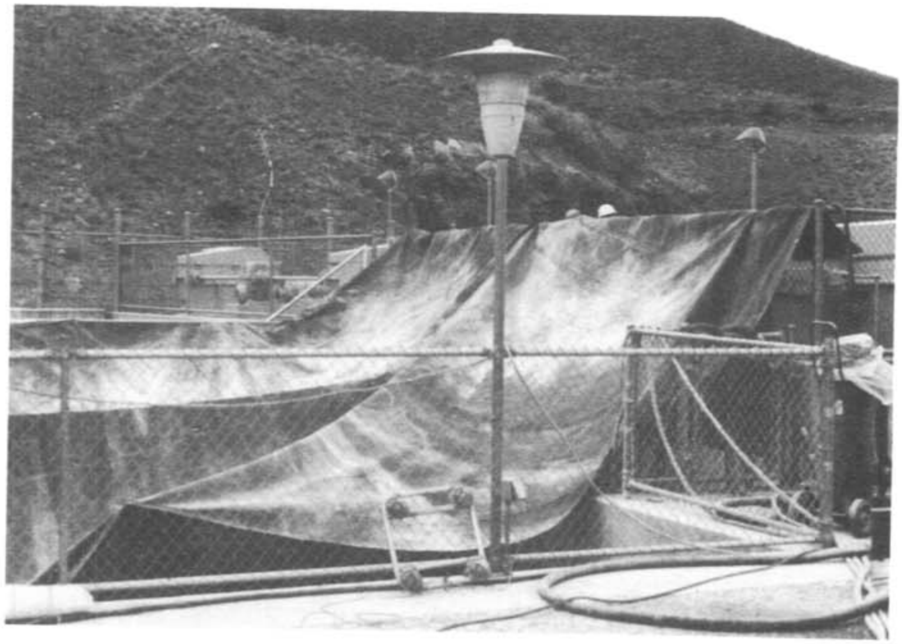
It should be noted that if the details of the seal work had been covered in the specifications, the winning bid would not have been much higher. The cost for the metalizing system would then be comparable to the six-coat vinyl resin system (VR-6) which is the most commonly used system for spillway gates.

The Colorado River Storage Project office has purchased a metalizing arc system. The unit is being kept at Glen Canyon Dam.

Thermion arc gun with spray nozzle.



First coat of epoxy polyamide green primer.



Envirotarp used to contain abrasives.

Metalizing operation with Envirotarp below the work area to collect abrasives and spillage.

METALIZING RADIAL GATES — McCLUSKY CANAL

by Gordon E. Johnson[1]

A contract was awarded to Stevens Welding Service, Glenburn, North Dakota, for $30,411 on September 23, 1988, for metalizing radial gates on the McClusky Canal, Garrison Diversion Unit. The contractor was given 330 days to complete the work, with completion date of September 12, 1989.

The worksite was located at station 2081+00, Reach 3A on the McClusky Canal or approximately 19 miles northeast of Wilton, North Dakota.

The specifications called for sandblasting the entire radial gates, gate arms, clamp bars, electrical panelboard, and gate hoist assemblies, except the drive shafts; then applying a metalizing system to the gates, gate arms, and clamp bars; and applying either an epoxy paint system or metalizing system to the gate hoist assemblies and electrical panelboard. The contractor elected to bid the work for metalizing the gate hoist assemblies and electrical panelboard.

Prior to awarding the contract for the work, the Government had removed the seals and clamp bars and had raised the gates to a position where the top gate arms were approximately 19° from vertical. In this position, the bottom of the gates were blocked up with timbers laid upon the equipment deck slab.

The approximate face dimension of each of the two gates is 19 feet 6 inches high by 16 feet wide.

The existing coating on the gates consisted of a VR-6 paint system in a condition ranging from very good in some areas to other areas with severe rusting problems. Prior to beginning any onsite work, the contractor had taken the clamp bars to his shop at Glenburn to experiment with the removal of the VR-6 system. He found that silica sand did not readily remove the VR-6 paint. The product which he found to be effective in removing the VR-6 was a coal slag, referred to as "Black Diamond," with a grit of 20–40 Rc.

The specifications required a sand recovery system to be used to prevent sand from the blasting operation from entering the canal. The contractor chose to work during the winter so that his working platforms and sand recovery system could be supported by the ice in the canal. The contractor mobilized equipment to the worksite on February 26, 1989.

Although sandblasting and then metalizing of the gate hoisting equipment was part of the contract, we later deleted this requirement. It was believed that we would be exposing this equipment to possible damage during the sandblasting and metalizing process. Masking would be required to keep grit from getting inside the motors and to minimize damage to bearings, etc. The masked areas would also later have to be prepared and metalized. We felt that adequate surface preparation to insure good bonding

[1] Gordon E. Johnson is a Resident Engineer employed by the Bureau of Reclamation's Harvey Construction Field Office, Harvey, North Dakota.

may have been hard to obtain. We believe that in order to effectively metalize this equipment, it should be completely disassembled and metalized under shop conditions.

The blasting machine used, manufactured by Pauli & Griffin, had a maximum working pressure of 125 lb/in^2. A 1-1/4-inch hose with 3/8-inch nozzle was used for most of the work. In order to prepare the surface on the back side of the gates, a smaller more flexible hose with a 1/4-inch nozzle was used around the "I" beams and other areas difficult to access.

After completion of the initial blasting procedure to remove the VR-6 system and prior to metalizing, the gates were covered with tarps supported by a metal frame structure to shelter the work from adverse weather conditions.

The control of surface preparation, surface profile, and surface moisture is of utmost importance to insure that a satisfactory metalized product is obtained. This was stressed prior to and during the metalizing process and monitored closely.

The procedure for surface preparation prior to metalizing included lightly sandblasting the surface with silica sand to white metal (conforming to NACE No. 1), then blowing it clean. In the event the surface may have been contaminated with oil, etc., the surface was wiped with xylene prior to the sandblasting. Our inspector's and the contractor's employees wore white cotton gloves at all times to minimize the chance of contamination to the surface.

To monitor the surface profile, press-o-film (as manufactured by Testex, Inc.) was used. The use of the "Black Diamond" gave a minimum profile depth of 3 mils, this created a desirable surface profile depth to insure good bonding of the zinc.

To monitor the possibility of surface moisture, psychrometers are very effective. A rule of thumb is to not allow the application of a coating until the air temperature is a minimum of 5 °F above the dew point of the surface to be coated.

The specifications called for the metalizing material to be a zinc wire with minimum purity of 99.9 percent. The contractor's supplier was METCO, Inc., whose main office is in Westbury, New York. The metalizing was accomplished using a METCO type 10E flame spray gun, fueled by acetylene and oxygen controlled with pressure gauges and flow indicators, with the zinc wire fed from a dispenser through the rear of the applicator.

The metalizing process commenced on March 7, 1989. The specifications required that the zinc coating be applied in a minimum of two layers with a minimum thickness of each layer of zinc coating to be 4 mils. The zinc coatings were applied on small rectangular areas with the initial coat applied with a horizontal motion followed by a coat applied vertically. Additional coats were applied if the minimum 8-mil thickness was not obtained.

Initially the mil thickness of the coating was measured with an elcometer Model 101 coating thickness gauge and a Mikrotest magnetic coating gauge. These instruments seemed to work fairly well while the work was being performed on the front face of the gate. However, as the metalizing operation moved to the backside, inconsistent thickness readings occurred, especially in close proximity to the wide flange beam stiffeners. Accurate readings could not be obtained due to the magnetic influence of the larger masses of metal. We found that an electronic thickness measuring gauge equipped with a remote magnetic induction-type probe would give us an accurate reading of the thickness of the coating at any given location.

During the metalizing application, the contractor felt that more zinc was being used than had been recommended by the manufacturer. This was partially accounted for by the fact that many areas actually received far more than the 8-mil coating thickness. In addition, the inexperience of the crew, and the configuration of steel on the backside of the gates where the gun could not be held perpendicular to the surface in a lot of hard to get at areas, significant deflection of the zinc occurred. The metalizing gun should be held perpendicular to the surface being coated in order to insure uniform coverage and minimize rebound or deflection of the metal. It was determined that when the gun was held about 6 inches from the surface being metalized, the most uniform coverage was obtained with a minimum rebound. If held too far away, significant metal was lost to rebound.

Upon completion of the metalizing, a vinyl butyl primer and aluminum vinyl seal coat were applied. In addition, to protect the surface in the area of the cable rún, an 18-inch-wide, 40-mil-thick polyurethane elastomer strip on each vertical edge of both radial gates was applied. In this area a urethane zinc phosphate primer was applied directly to the metalizing to provide a minimum 2-mil profile to ensure good bonding of the elastomer.

Photo 1. - McClusky Canal. Contractor is using a coal slag grit to sandblast and remove the VR-6 paint off the outside face of the south gate on Reach 3A, New Johns Lake. 3/4/89

Photo 2. - McClusky Canal. Contractor is using an airless paint sprayer to apply the aluminum vinyl seal coat to the inside of the south radial gate at New Johns Lake. 3/8/89

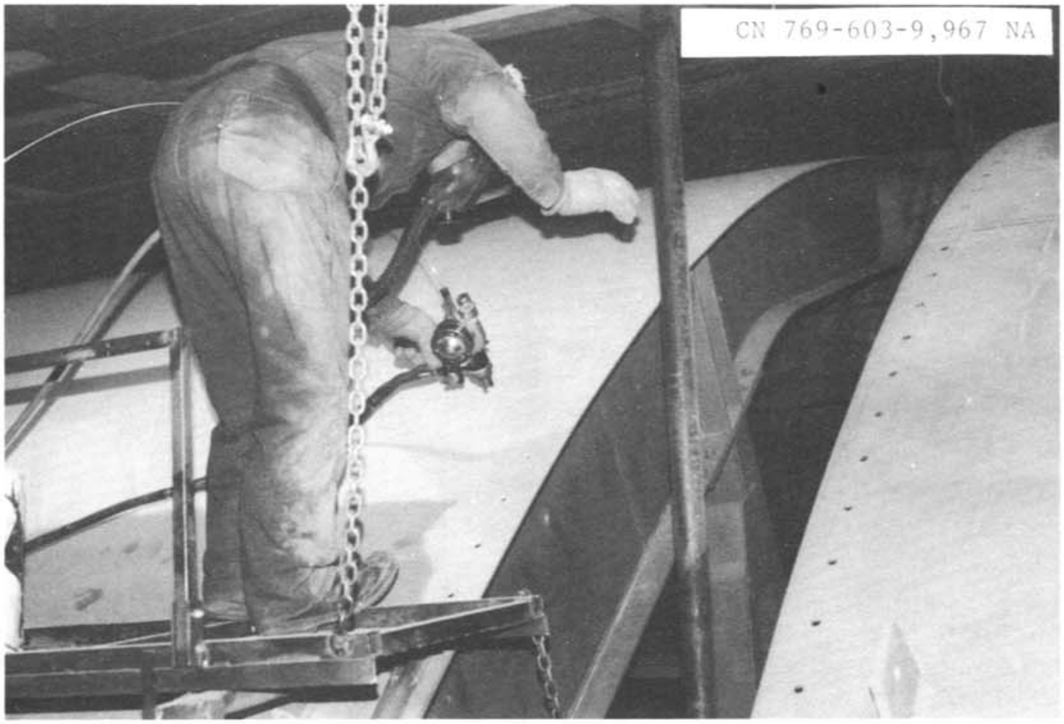


Photo 3. - McClusky Canal. Contractor applying zinc to surface to north gate. Note position of metalizing gun. 3/8/89

Photo 4. - McClusky Canal. Contractor applying the inital zinc coating to the 2-foot-wide section that was sandblasted just prior to metalizing. A Metco wire gas spray applicator was used to apply the zinc coating. The zinc wire is being pulled through the rear of the applicator, and the hoses attached to the bottom of the applicator supply the acetylene and oxygen.

CAUTION REGARDING THERMAL SPRAY COATINGS FOR TURBINE AND LARGE PUMP CAVITATION REPAIR OR PROTECTION[1]

Thermal spray coatings which include coatings applied by wire flame spray, powder flame spray, electric arc spray, and plasma spray are currently being marketed by several suppliers and manufacturers as alternatives to conventional welding techniques to apply cavitation-resistant overlays of stainless steel alloys and stellites. As a result, we have had numerous requests for information concerning thermal spray coatings from project offices throughout Reclamation.

The main disadvantage with thermal spray coatings is a relatively low bond strength to the parent metal. At best, one company claims a possible bond strength of 12,000 lb/in^2. Other industry sources reported 9,000 lb/in^2 would be overly optimistic. A weld overlay applied by conventional stick or MIG (metal inert gas) processes will be fused to the parent metal and, therefore, have a bond strength equal to the strength of the parent metal; i.e., 70,000 lb/in^2.

A literature search was made to locate field and laboratory test data on the performance of the **thermal spray coatings in cavitation environments**. Several sources reported poor erosion rates or failure by delamination of all thermal spray coatings tested. Coatings tested included stellite coatings and a variety of stainless steel alloy coatings. **No literature was located which reported a successful application in a severe cavitation environment.**

In addition, the thermal spray coatings are porous. Without a sealer coat of an epoxy or elastomeric coating or other paint-type coating, water will penetrate and could lead to corrosion problems in the parent metal beneath the coating. A sealer coat will not resist cavitation for any length of time.

If the thermal coating is a very hard material such as stellite, seal coated with an epoxy, subsequent removal of the coating residue for weld repair may be difficult as the epoxy is not conductive for air arcing and the stellite is difficult to grind.

In severe cavitation environments such as inside turbines and large pumps, we recommend thermal spray coatings only be considered on an experimental basis. If thermal sprays are used, they should initially be applied to a very small accessible area of the turbine. The coating materials and procedures should be well documented, and frequent inspections scheduled.

We would be interested in hearing about any experience you have had with thermal spray coatings on turbines and large pumps.

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[1] Excerpts from a memorandum dated June 2, 1989, to all Regional Directors, authored by Bill Duncan, Mechanical Engineer, Bureau of Reclamation, PO Box 25007, Denver, Colorado 80225.

SPOTLIGHT ON BARTLETT DAM & RESERVOIR

Salt River Project, Arizona

Bartlett Dam was constructed in 1936-1939 by the Bureau of Reclamation. The dam is a multiple-arch concrete structure on the Verde River 46 miles northeast of Phoenix, Arizona. It has a structural height of 287 feet, contains 182,000 yd^3 of concrete, and creates a reservoir with a capacity of 178,000 acre-feet. The dam is operated and maintained by the Salt River Agricultural Improvement and Power District.

The two original 66-inch-diameter needle valves located in the outlet works have been replaced by two 79-inch-diameter fixed-cone valves with sliding hoods. Both of these new valves operate satisfactorily. Tests were performed in December 1988, and February and April of 1989. Maximum discharge is limited to valve openings of 75 percent, at which point control moves to the upstream 72-inch butterfly valves. (More information on needle valve replacement can be found in Bulletin No. 144.)

An article on repair of erosion damage below the spillway may be found in Bulletin No. 139, page 24.

Recreation

Bartlett Reservoir is used for year-round boating and fishing, primarily for channel catfish.

Benefits

Irrigation has transformed a part of the Arizona desert into fertile farmland where millions of dollars worth of crops are produced annually. A large portion of the land produces two crops per year. Principal crops are alfalfa, cotton, fruits, vegetables, and pasture.

Early History

A large part of the Salt River Valley was irrigated and cultivated in prehistoric times, but abandoned before white men entered the valley. Irrigation of the valley by white settlers began about 1867. The riverflow was erratic, varying from a small stream to enormous floods. Shortly after settlement began, and especially during years of drought, the supply of water at low river stages was inadequate for the land in cultivation. Riverflows in excess of immediate needs or canal capacities were lost, due to lack of storage facilities. Maintenance of the brush and rock diversion dams also became a problem, for they were often washed out at the beginning of a flood and could not be replaced until the water was again low in the river. Years of good water supply were followed by years of drought, causing the loss of valuable vineyards and orchards.

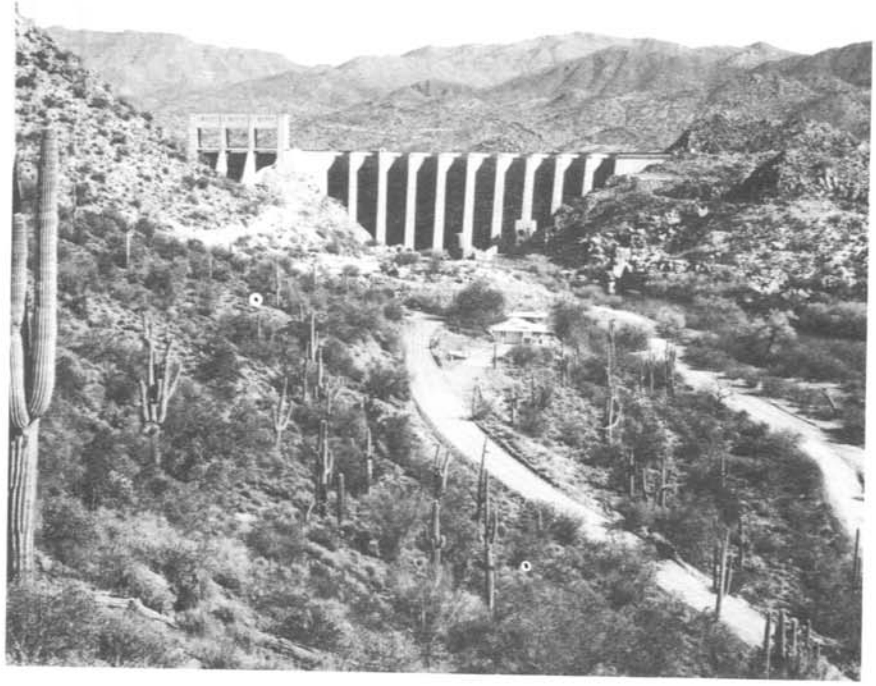

Figure 1. - Elevation view of Bartlett Dam showing operator's residence in center. 1/29/64

Figure 2. - Bartlett Dam showing reservoir full with a flow through the spillway of approximately 14,000 ft^3/s. 4/15/41

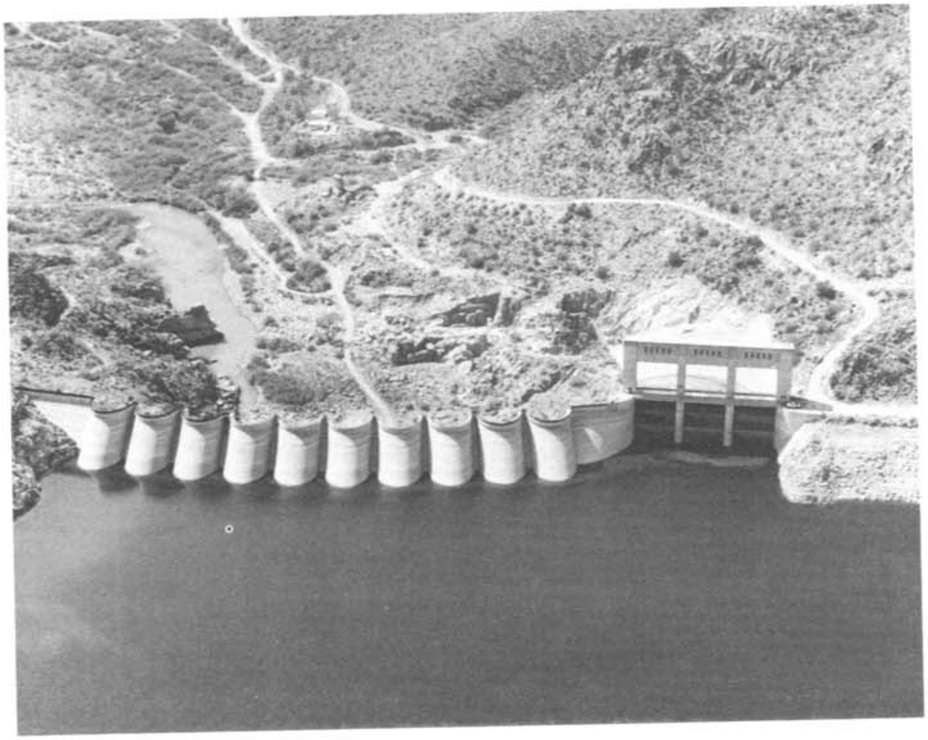

Figure 3. – Upsteam aerial view of Bartlett Dam. 3/21/74

Figure 4. – Aerial view of Bartlett Dam showing approximately 70,000 ft^3/s being released from the reservoir which was filled with recent heavy rains. 3/3/78

Figure 5. - Downstream aerial view of Bartlett Dam and Reservoir. 9/3/76

Figure 6. - Aerial view of Bartlett Reservoir with dam shown to the left. 9/3/76

STATEMENT REGARDING COST INDEX

The O&M (operation and maintenance) cost index has been included in the December issue of the Bulletin for the past 3 years. This year, it has been decided that the index will be prepared separately.

Copies will be available from the Regional Offices and the Denver Office, code D-5210, sometime before the end of the year.

Mission of the Bureau of Reclamation

The Bureau of Reclamation of the U.S. Department of the Interior is responsible for the development and conservation of the Nation's water resources in the Western United States.

The Bureau's original purpose "to provide for the reclamation of arid and semiarid lands in the West" today covers a wide range of interrelated functions. These include providing municipal and industrial water supplies; hydroelectric power generation; irrigation water for agriculture; water quality improvement; flood control; river navigation; river regulation and control; fish and wildlife enhancement; outdoor recreation; and research on water-related design, construction, materials, atmospheric management, and wind and solar power.

Bureau programs most frequently are the result of close cooperation with the U.S. Congress, other Federal agencies, States, local governments, academic institutions, water-user organizations, and other concerned groups.

The purpose of this Bulletin is to serve as a medium of exchanging operation and maintenance information. Its success depends upon your help in obtaining and submitting new and useful O&M ideas.

Advertise your district's or project's resourcefulness by having an article published in the bulletin! So let us hear from you soon.

Prospective material should be submitted through your Bureau of Reclamation Regional office.