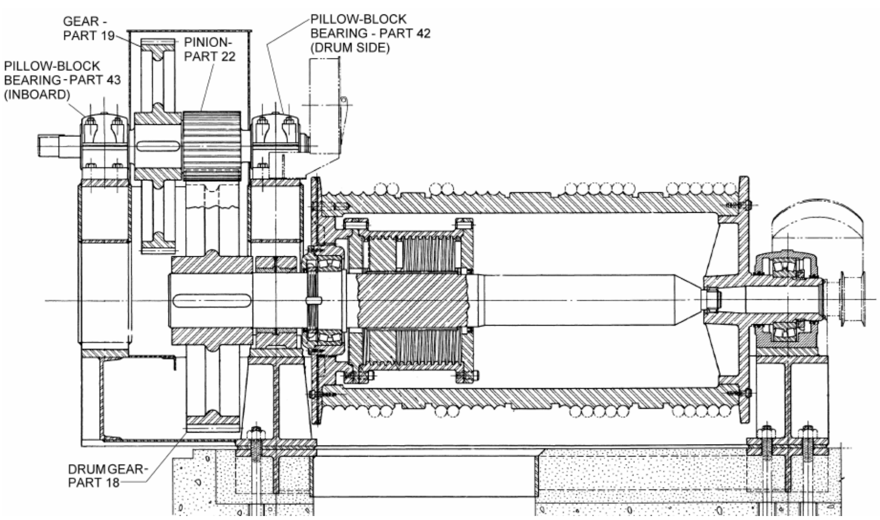
RECLAMATION

Managing Water in the West

Water Operation and Maintenance Bulletin

No. 212



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This *Water Operation and Maintenance Bulletin* is published quarterly for the benefit of water supply system operators. Its principal purpose is to serve as a medium to exchange information for use by Bureau of Reclamation personnel and water user groups in operating and maintaining project facilities.

The *Water Operation and Maintenance Bulletin* and subject index may be accessed on the Internet at: <**http://www.usbr.gov/pmts/infrastructure/inspection/waterbulletin**>.

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Cover photograph *–Section through drum gearing.*

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Always Brush Your Teeth on a Regular Basis

The north hoist pillow block failed during a recent gate test for the radial gates at Trenton Dam. McCook Field Office personnel contacted mechanical engineers John Shisler and Alex Ritt to visit the site in southwest Nebraska to inspect the damage and recommend a course of action.

Trenton Dam, which impounds Swanson Lake, was completed in 1953. The dam is located on the Republican River near Trenton, Nebraska. It is an earthfill structure with a gated spillway at the left abutment. Each gate is 42 feet wide by 30 feet high and is referenced according to its location (i.e., north, middle, and south). The three radial gates for the spillway are controlled by a complex hoist arrangement that includes an automatic system of floats and counterweights interconnected by wire ropes to the hoist drums (see figure 1). The two floats used for each gate weigh 40,000 pounds each. A counterweight weighing 163,000 pounds is a key hoist component for each gate. When the floatwells are dry (the condition during the gate test), the overall load on the hoist drums to lift each gate is about 40,000 pounds (from the gate leaf) plus smaller frictional loads from the gate side seals and trunnions.

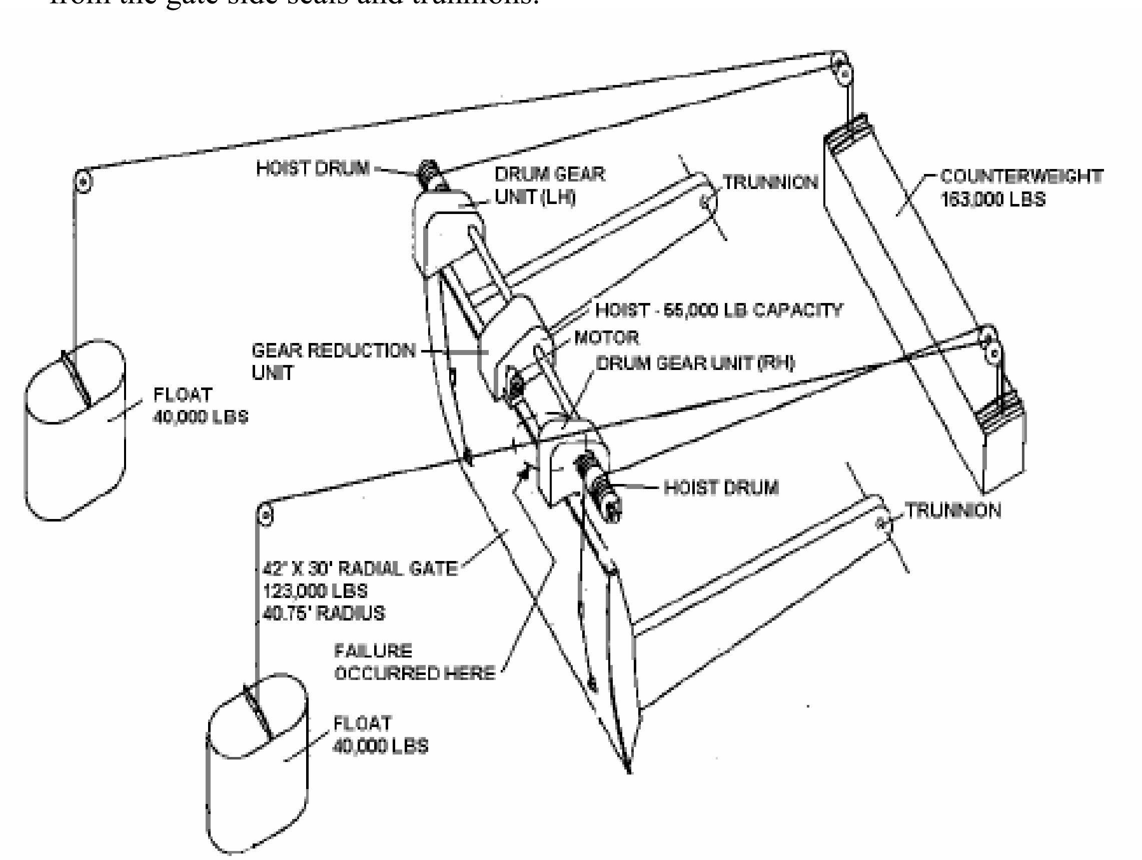

Figure 1.—Hoist arrangement.

The north radial gate was raised and lowered successfully during a Comprehensive Facility Review in the fall of 2004. On March 29, 2005, the north gate had been raised to a 6-inch vertical height when suddenly two loud bangs were heard by the operating personnel. Upon realizing that firearms were not being discharged, the power to the hoist was immediately turned off, automatically engaging the motor brake to hold the load. The pillow block bearing castings, which support the pinion drive shaft of the right hand drum and gear unit, had fractured. As a precaution, a 6- by 6-inch wood blocking was placed under the gate leaf, leaving a small gap between the gate leaf bottom and the blocking, to prevent the gate leaf from dropping to the spillway crest. The gate remained in this position until the site visit on April 7, 2005.

During the site visit, Messrs. Shisler and Ritt met with Terry Seitz, Supervisory Civil Engineer at the McCook Field Office, and Charlie Mack, Reservoir Superintendent at Trenton Dam. After a safety meeting was held to review the job hazard analysis, it was agreed that the hoist should not be dismantled until the mechanical energy of the gate, floats, and counterweight had been arrested and the electrical power to the hoist had been removed by locking out and tagging the controls.

During the hoist inspection, it was noted that the two cast housings of the bearings on the pinion shaft, which drives the drum gear, were fractured. The pinion shaft and gear are situated above the drum gear, and the housing of the bearing on the drum end of the shaft (Part 42) and was completely cracked and separated (see figure 2 and photo 1).

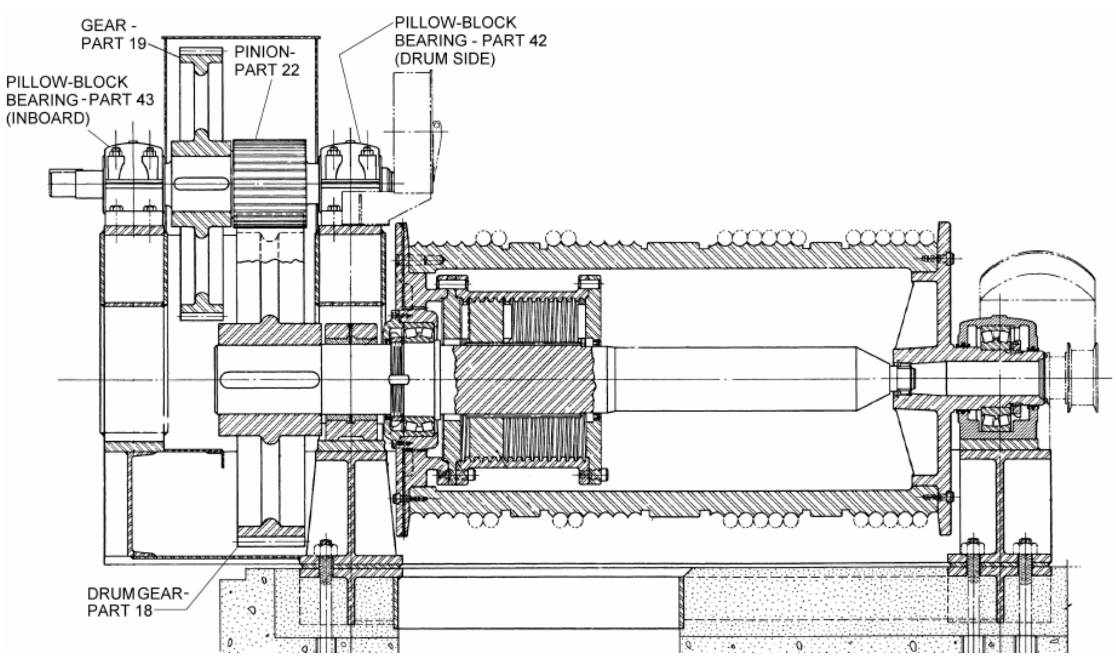

Figure 2.—Section through drum gearing.

Photo 1.—Fractured casting – pillow block bearing (Part 42).

The bearing (Part 43 in figure 2) housing on the inboard side of the shaft was severely cracked, but had not completely separated or lifted. It was clear that the bearing housings had cracked from large separation forces generated by the pinion/gear (Parts 22 and 18 in figure 2) mesh. A large amount of bird debris was present in and around the gearing unit. The upper portion or the circumference of the drum gear contained significant amounts of a compressed mixture of bird droppings, feathers, and dirt between the gear teeth (see photo 2).

Photo 2.—Debris in gear teeth.

Two 30-ton capacity hydraulic bottle-type jacks were used to raise the gate, one at each side of the gate, directly under the rope attachment points on the leaf. The gate was raised so the jacks carried the weight, then lowered fully onto the wood blocking, using the manual release lever on the hoist motor to allow the drums to rotate. Once the gate was lowered onto the blocking, the weight of the floats and counterweight system was supported by the gate leaf and there was no danger of them moving.

Inspection of the hoist resumed, and the dismantling of the damaged portion of the hoist began. The bearing housing bolts were removed, and the pinion shaft was removed using a small chain hoist that was suspended from the roadway bridge beams. The pinion and drum gear teeth did not show any signs of uneven wear or damage, and no portions of the gear teeth were missing. No rocks or other items were present, other than the bird debris, which would have caused separation of the mesh. Using a screwdriver tip to scrape the bird debris that had accumulated at the gear tooth roots confirmed that the material was extremely hard packed and was, in some cases, up to ½" thick (see photo 3).

Photo 3.—Debris gouged with screwdriver tip.

The other gear units on this hoist and those on the other two hoists did not appear to have similar accumulated debris on the exposed gear teeth. It was reported that the gear teeth had not been cleaned in a number of years. During the examination, it was noted that the bases of the bearings had not moved and were held firmly in place by their bolts.

When the bearing bolts were removed, it was noted that the bolt shafts were corroded and had lost a significant amount of diameter between the head and the threads (see photo 4). The bolts are used with steel washers through slotted holes in the base of the bearing castings. The washers are not always positioned to cover the slot completely, allowing water to pool inside of the slots, causing the corrosion of the bolts (see photo 5).

Photo 4.—Bearing bolt corrosion.

Photo 5.—Slotted holes not covered by washer.

The gear teeth for the pinion/drum gear mesh are 20º stub involute. This type of tooth has a clearance of approximately ⅛ inch (tip of tooth to root of meshed gear). The valley between teeth had been filled with compressed debris, and the design clearance no longer existed. Any additional bearing clearance was exceeded as well. With no room to completely mesh, the gears were forced to separate, which resulted in the upward force on the shaft. The teeth that were packed the fullest with debris were the ones that would have been meshed with the pinion during the beginning of the lifting process, when the bearing housings were fractured.

It was concluded that the debris mixture caused the gear mesh to separate, which fractured the bearing castings. It is likely that most of the buildup of debris that caused this problem occurred over the recent winter months of inactivity.

The bearings were manufactured by SKF in the 1950s and can be replaced with similar models.

The bolts and washers of the bearing housings will need to be replaced. After the bearings are bolted down, the annulus area around the bolts in the slots of the bearing bases should be sealed with caulk to keep water out.

The gear teeth should be cleaned by power washing, and the screening should be improved to keep birds from inhabiting the gear units. In the future, closer monitoring of the gears should confirm that the problem has not reoccurred.

Modified Surcharge Operating Criteria

by Lew Hall[1] and Benjamin Claggett[2]

Choke Canyon Dam and Reservoir, constructed between 1976 and 1982, is located on the Frio River between Corpus Christi and San Antonio, Texas. It is a fairly large reservoir, having a conservation capacity of 695,271 acre-feet and a surcharge capacity of 346,568 acre-feet. The dam is a zoned earthfill structure with a crest length of approximately 3.5 miles, including a gated emergency spillway. The maximum section is 114.14 feet above the streambed.

There is no authorized flood control component on this project; therefore, the reservoir rises directly from the conservation pool into the surcharge pool. Under probable maximum flood (PMF) inflow conditions, seven 50- by 24-foot radial gates can release 258,000 cubic feet per second (ft^3/s). The PMF has a peak inflow of 323,000 ft^3/s and a 15-day volume of 2,772,000 acre-feet.

Several U.S. Geological Survey maintained hydrometeorological reporting stations are located in Choke Canyon's watershed that provide near real-time river stage, flow rate, and precipitation data. The hydrologic data are available over the Internet on a number of Web pages as well as from the Bureau of Reclamation's (Reclamation) Hydromet system.

As on other Reclamation dams, the surcharge pool was designed for the protection of the structure from unusually large inflow events. The Standing Operating Procedures (SOP) surcharge operating criteria called for raising the spillway gates according to an operating curve designed to safely pass the PMF. It is noteworthy that this operating curve is dependent only on reservoir elevation and calls for significant releases at relatively low levels of the surcharge pool.

Over the years since the dam's completion, the reservoir has commonly been considered to be "normally low," roughly 20 feet below top of conservation pool. Prior to 2002, Choke Canyon's water level had risen into the surcharge pool on only two occasions—once in 1987 and again in 1992. Neither of these events resulted in releases that seriously threatened downstream developments.

Since July 2002, Choke Canyon Reservoir has entered the surcharge pool on about 15 occasions, including 3 events that were federally declared disasters.

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Inflow and rainfall data from Hydromet reporting stations, National Weather Service radar, and the River Forecast Center have allowed the Oklahoma-Texas Area Office to consider release options prior to flows arriving at the reservoir. A number of release strategies have been used in the course of these inflow events, including releases from the conservation pool on a couple of occasions as the water user, the City of Corpus Christi, agreed to.

In the course of these surcharge events, a disparity became apparent between SOPs and releases recognized as being necessary. The recurring questions were, “With estimated or known volumes of water entering the reservoir, what should the release rate be based on if they are initiated prior to the reservoir rise?” Also, “If information is available that allows us to determine approximately what elevation the reservoir will rise up to and we have the opportunity to lessen downstream impacts, what should Reclamation responsibly do with the information?”

It occurred to the Oklahoma-Texas Area Facility Operations Group that if predicted inflows, or riverflows that were well upstream, were modeled through the reservoir as if the spillway gates were operated as called for under the original design, the theoretical reservoir crest of that event could be used as a target elevation. Releases initiated prior to the observed reservoir rise could be modeled so that the reservoir crests at the target elevation – the level the reservoir would have reached anyway. Since the spillway gates are opened prior to the expected reservoir rise, maximum releases are much less than those called for in the spillway gate operating curve.

Adjustments to releases according to changes in actual inflows or conditions can be completed on a continual basis throughout the event. New target elevations can be determined, as necessary, as the event develops, and if upstream information should ever become unavailable, operations resort back to the original spillway gate operating curve.

A modified “Surcharge Operating Criteria” SOP paragraph with accompanying appendix material was drafted by the Oklahoma-Texas Area Office and reviewed by the Great Plains Regional Office and Technical Service Center. An approved decision memorandum was transmitted June 28, 2005, and a SOP revision for Choke Canyon Dam that includes the method described above is forthcoming.

Unlike most Reclamation projects, it is noted that there is no flood control component at Choke Canyon Reservoir. This method is not proposed, or necessarily believed to be, an option at other reservoirs. However, technological advances in hydrological data reporting and hydrometeorological prediction capability in this instance are being used to reduce downstream impacts while continuing to protect the facility.

For additional information concerning this article, contact Lew Hall at <lhall@gp.usbr.gov> or Benjamin Claggett at <bclaggett@gp.usbr.gov>.

Looking downstream from the crest of Choke Canyon Dam during a September 2001 event. The inundated structures are part of the South Shore Unit recreational facilities of Choke Canyon State Park.

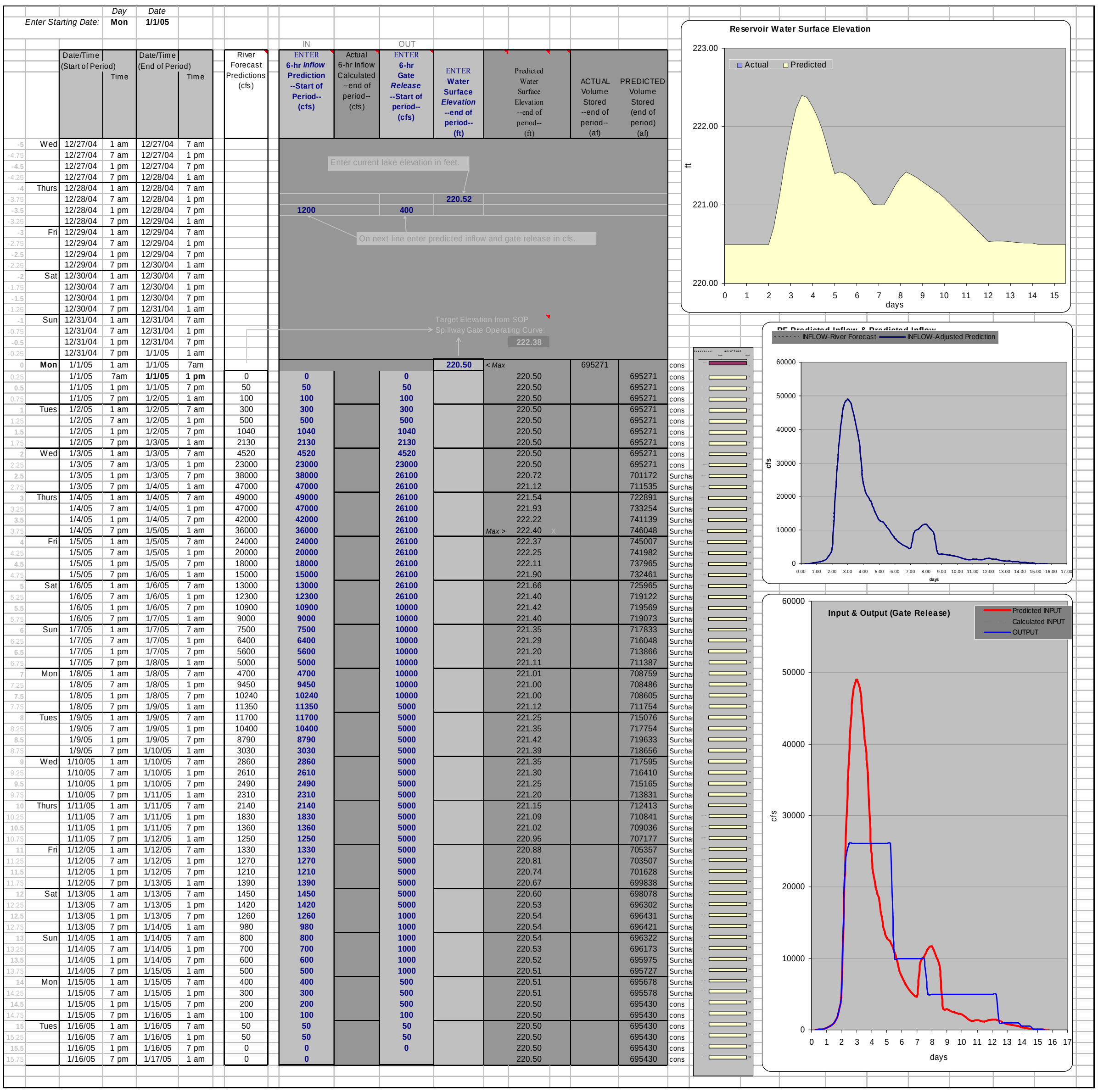
Choke Canyon Dam surcharge releases being made during a July 2002 event.

Aerial photo of Choke Canyon Dam and Reservoir, December 1998.
South Shore Unit recreational facilities visible in lower left.

Downstream of Choke Canyon Dam during surcharge operations at State Highway 72 looking (east) towards the city of Three Rivers, Texas, September 2002. Normally, this section of the highway is 1 to 2 miles from the Frio and Atascosa Rivers.

Below is a view of a spreadsheet model used to (1) determine the target reservoir elevation, (2) predict the reservoir crest, (3) and monitor an event. As an event develops, actual inflows and recorded reservoir elevations are entered into the spreadsheet so that adjustments may be made as necessary. The spreadsheet generates graphic representations of predicted and actual values. A similar spreadsheet is used to route inflows through a reservoir as if releases were being made based only on observed reservoir rise and to determine the target elevation.

In the near future, we will print an in-depth article on the flood operations spreadsheet. It will further explain the program, its applications, and its uses and functions. If applicable to their facilities, managers could then apply the process to their individual operations as needed.



Mission

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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 operation and maintenance ideas.

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

Prospective articles should be submitted to one of the Bureau of Reclamation contacts listed below:

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