Dam Metallized in Freezing Conditions To Beat Schedule

by Lori R. Huffman, *Associate Editor*

Beginning in mid-November 1998 and working almost continuously through the end of May 1999, a contractor endured frigid winter weather to abrasive blast and metallize the St. Andrews Lock and Dam in Lockport, Manitoba, Canada. The dam is the largest of the world's three camere-type moveable dams, which use wooden curtains that are lifted and lowered on steel frames to regulate water levels. ("Camere" is the name of the river over which this type of dam was first used.)

Tendered by the Public Works and Government Services Canada (PWGSC) in the summer of 1998, the $8 million contract specified that the 380,000 sq ft (35,300 sq m) of structural steel be solvent cleaned, abrasive blasted, and metallized with 85/15 zinc aluminum. The project's completion date was set as March 31, 2000. In spite of work limitations due to the operation of the lock and dam, the contractor completed the project on June 23, 1999, 9 months ahead of schedule.

The federal government has owned and operated the camere-style dam since its construction in 1910, says John Davidson, senior project manager with PWGSC. The structure was built to facilitate transportation along the Red River by regulating water levels. In 1913, a road deck was installed to link west and east Lockport. A paper Davidson co-authored about the metallizing project describes the structure as follows.

"The structure consists of six identical 38.6 m [127.4 ft] long river spans that house a 6-bay spillway with a camere-type moveable dam, a lock, a seventh 38.6 m [127.4 ft] overland span adjacent to the east approach, three east approach spans totaling 73.0 m [240.9 ft] and an 89.9 m [296.7 ft] west approach comprised of two spans. The six river spans are made up of three trusses, upper framing members supporting the road above, a working floor providing access to the moveable dam, a main floor, sway bracing and the moveable dam frames. The main trusses are comprised of built-up lat-

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Fig. 2 - Containment structures for blasting, metallizing, and climate control throughout job.
Photo courtesy of PWGSC and Wardrop Engineering

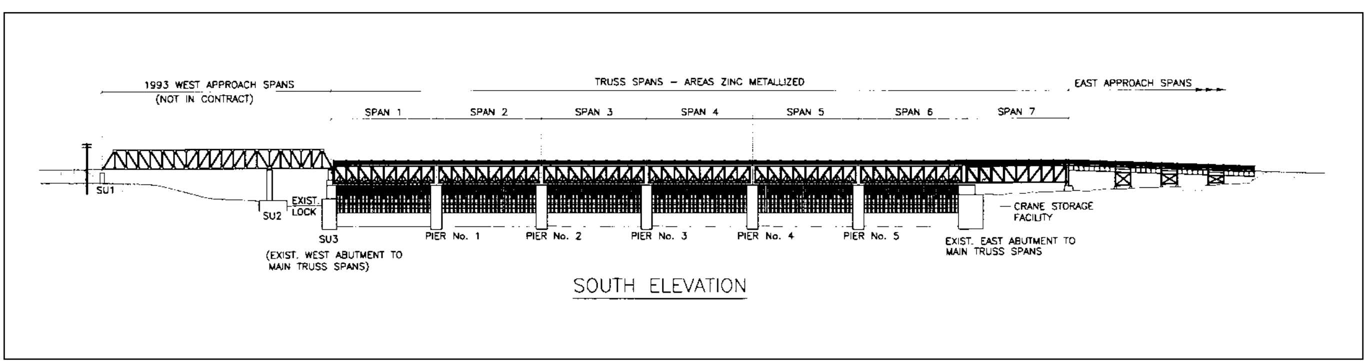

Fig. 1 - Schematic shows metallizing project on St. Andrews Lock and Dam in relation to whole structure
Courtesy of PWGSC and Wardrop Engineering

tice box beams riveted together. Channels, I-beams, and latticed built-up sections were employed to make up the other components of the structure. Below the working floor are the moveable, tapered/ built-up, dam frame girders. These are supported by an elaborate system consisting of steel hangars, thrust wedges, and steel castings. The seventh span is made up of two main trusses identical to those supporting the road deck in Spans 1-6. It also includes a crane storage facility."[1] Figure 1 is a schematic of the lock and dam.

A thorough maintenance painting of the dam had not occurred since the early 1970s. Most of the existing coatings on the structure were composed of lead-based alkyds. The condition of these coatings varied, depending on the location of the coated steel. Steel members directly under the road surface were in fairly good condition, while the truss and box beams closer to the water were failing, says Jamie Turcotte, project coordinator for the contractor.

Selecting the Coatings and Altering the Specification

The recently completed work was a continuation of a $25 million rehabilitation project done by PWGSC. In 1996, the owner hired Wardrop Engineering to select the coating system and administer the contract. Surface preparation and coating were to take place on the six river spans, the dam frames above the water line, and the single overland span adjacent to the east approach.

The engineering firm conducted a cost-benefit analysis of topcoated and untopcoated metallizing versus over 70 combinations of high-performance coating systems, including inorganic zinc/high-build epoxy/ polyurethane, coal tar epoxy, moisture-cured urethanes, and calcium sulfonate. The aim of the analysis was to find the most cost-effective system for a 50-year service life. According to Robert van Ginkel, principal project manager for the engineering firm that consulted on the job, the cost-benefit analysis considered the location of the substrate to be coated and the constraints peculiar to the lock and dam. The analysis also considered materials and labor costs, application costs, containment requirements, overhead and inspection costs, and winter work costs, as detailed in Reference 1.

The study showed that although the initial cost of metallizing was higher than that of traditional coatings, the operation and maintenance costs for metallizing were lower than costs for liquid-applied coatings, says Davidson.

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For the purposes of coating selection and cost-benefit analysis, the engineering firm divided the structure into four corrosion zones. These zones were included in the specification document to identify areas that would be metallized or coated with a calcium sulfonate coating. A calcium sulfonate coating was originally specified on part of the structure because PWGSC believed that metallizing the entire structure would be cost prohibitive, says Davidson.

Making up Zone 1 was the submerged portion of the retractable dam frames, which was deemed too badly corroded to be rehabilitated and was instead slated for replacement. Zone 2 included the above water portion of the dam frames, three bridge trusses 5.9 ft (1.8 m) above the bottom chord, and the main and working floors of the structure. This area, exposed to water spray from the dam, was subject to corrosion and was to be metallized. Zone 3 (the remainder of the 6 trusses) and Zone 4 (the floor beams and stringers under the road deck) were to be coated with a calcium sulfonate system.

Once the project was awarded to a prequalified contractor, PWGSC issued a change order to specify metallizing for Zones 3 and 4. Davidson explains that the contractor was asked to submit two bids for the work, one for metallizing some areas and coating others with calcium sulfonate, and the other for metallizing all areas. A lower than expected metallizing bid coupled with the long-term operations and maintenance savings offered by metallizing led PWGSC to metallize all areas.

Job Holds Many Challenges

Working around the operation requirements of the dam was one of the chief challenges for the contractor. With the prospect of interrupted work and nearly complete demobilization demands, the contractor decided instead to work through the winter months when the dam was out of service. Because operations would face interruption again in the middle of May when the dam resumed operations and because of the expense involved in heating containments for two winters, the contractor launched an aggressive work schedule to complete the whole project in one winter and spring, says Turcotte.

Riveted, built-up box beams and lattice work would make access with abrasive blasting and metallizing equipment difficult, he adds. The project's location in an environmentally sensitive area and the presence of lead-based paint on the structure added another challenge to the job—total containment of the operation. The structure is situated over a nautical waterway popular for sport fishing and tourism. Previous work done to the lock and dam over the last 10 years had already generated environmental lawsuits, so the present contract was clear on the need to contain all particulate from the blasting operation, notes Turcotte.

Project Demands Influence Equipment Selection

The project would require application equipment to be run almost continuously, yield high production rates, and be handled easily. The contractor evaluated metallizing equipment from six manufacturers.

After narrowing its choice to two candidates, the contractor invited both manufacturers to demonstrate their equipment. The contractor based its decision on the deposition rates determined at the demonstration, the ability of the equipment to spray 3⁄16-inch (4.8 mm) 85/15 zinc aluminum wire, the size and weight of the equipment, and the weight of the gun and leads. Ultimately, the contractor purchased 7 units for the project, says Turcotte.

Double-Walled Containment Keeps Particulate in, Weather Out

A double-walled containment designed for the project served two purposes: protecting the environment and providing a work area sheltered from ambient conditions almost always below freezing, says Turcotte. The containment measured 140 ft (42 m) long by 50 ft (15 m) wide, by 30 ft (9 m) high, allowing an entire span to be enclosed. The exterior was composed of a proprietary enclosure system constructed of extruded aluminum with "C" channels. Insulated tarps with welt hems were anchored through the channels. Separated from the exterior by a two-foot cavity, the interior

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wall was made of plastic shrink wrap and attached to steel scaffolding with plywood flooring.

The contractor used three containments during the operation: one for abrasive blasting; another for metallizing; and a third for the next area to be worked on. To allow workers a fast transition from one area to the next, the third containment was set up while the other two were in use, says Turcotte (Fig. 2).

Inside the containment, the contractor maintained air movement with three dust collectors (with 60,000 cfm [1,800 cmm], 45,000 cfm [1,350 cmm], and 30,000 cfm [900 cmm] output). Spent abrasive was removed by a vacuum truck and automatic offloader, says Turcotte. Within the metallizing enclosure, gas heaters maintained temperatures above freezing on milder days and just below freezing on days when the ambient temperature was -22 F (-30 C). Gas heaters were also used in the abrasive blasting containment to maintain conditions and an environment comfortable for the blasters, he says.

Blasting and Metallizing the Steel

The contractor's crews operated two, ten-hour shifts seven days a week to complete the abrasive blasting and metallizing, says Turcotte. Twelve workers on the night shift handled the preliminary abrasive blasting. Because of the difficulty of achieving bright lighting at night, another four to six workers performed the touchup blasting during the day, he says. Seven metallizers also worked during the day.

The specification required solvent washing (SSPC-SP 1) to remove chloride and oil contamination from the steel, then blasting to an SSPC-SP 10 (Near-White Metal) finish with a two- to three-mil (50- to 75-micrometer) profile. Areas of pack rust in joints were to be abrasive blasted to a depth equal to or greater than the width of the joint, metallized, then sealed with an elastomeric caulk, says Turcotte. In the humid areas above the dam gates, steel connections were to be metallized, then stripe coated with a urethane mastic.

The contractor used coal slag for blasting. Spent abrasive, paint debris, and dust from the dust collectors were tested for hazardous content at an independent laboratory. According to Turcotte, hazardous waste was transported to a licensed waste disposal site. Waste classified as non-hazardous was disposed of in a certified landfill licensed for solid industrial non-hazardous waste.

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Following approval of the surface preparation by all inspectors, the contractor applied the 85/15 zinc aluminum metallizing by arc spray equipment. The specification called for a minimum 10-mil (250-micrometer) thick coating; the dry film thickness of the metallizing averaged 12-13 mils (300-325 micrometers), owing to the actual surface profile of the steel, which measured 3 to 4 mils (75 to 100 micrometers), says Turcotte.

The greater profile was attributed to the contractor's use of blast pressures of 110 to 120 psi (758 to 827 kPa) to remove tightly adherent pack rust from the steel.[1] Because metallizing relies on its mechanical bond for adhesion, says van Ginkel, the deeper profile was beneficial. Also, the profile required the deposition of a thicker coat of metallizing, thus increasing the amount of zinc available for cathodic protection.

The specification required a minimum adhesion value of 700 psi (48 MPa) for the metallizing when application took place with steel in air temperatures of less than 39.2 F (4 C). Measured adhesion values ranged from 700 to 1,100 psi (48 to 76 MPa).[1] Adhesion was checked on an hourly/daily basis using pull-off adhesion testers. Thickness measurements were taken using coating thickness and tooke gauges.

Considerations for Safety, Health, and the Environment

The contractor followed an extensive worker protection program, producing a job-specific safety manual for the work and keeping a safety manager on staff. In addition to its regular training, the contractor held three, one-day worker training sessions on lead, general health and safety, confined spaces, and traffic control, says Turcotte. It also conducted a pre-job safety hazard analysis and formed an on-site safety committee, he says.

The contractor provided workers with decontamination and shower facilities, protective clothing, and respiratory protection. Supplied air respirators were used during blasting and blow down, positive-flow filtered air respirators were used in transit to the work area within the containment, and HEPA-filtered half mask respirators were used at all other times. The contractor also implemented a medical surveillance program, which included on-site audiometric testing and blood lead level testing, says Turcotte.

In addition to the use of the double-walled containment, a program of testing and monitoring of occupational and ambient air, soil, wastewater, dust deposition, blasting waste, and filter dust was undertaken. In addition, breathing air samples were collected and analyzed.

The contractor provided a site-specific safety plan, environmental compliance plan, and hazardous waste disposal plan in addition to its general safety policy and lead abatement program.

Layers of Inspections

Inspection of the surface preparation and metallizing was of primary importance on this project, owing to the unforgiving nature of metallizing, says van Ginkel. According to Turcotte, the project encompassed four layers of inspection. First, the blasters on the job would review their work, followed by the contractor's job inspector. Then the contractor's NACE Level III inspector would sign off on the work. Finally, the Public Works' third-party inspector, also certified by NACE, would approve or disapprove of the completed work.

According to Francis Burke, president of the inspection company hired by the owner, if areas did not conform to the specifications, the inspector would inform the contractor's inspector and have the abrasive blasters or metallizing applicators return and rectify the problems.

Davidson notes because of the complexity of the structure, the contractor had to go over some areas a number of times to remove the original mill scale and make sure the areas behind rivets were adequately prepared. Metallizing the steel was also tricky, says Burke, because areas could be easily missed owing to the similar appearance of bare blasted steel and metallizing.

According to Burke, the contractor did a good job. "When problems were brought to their attention, they cleared them up quickly. The contractor was dedicated to doing the job well and on time," he says.

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Five-Year Warranty with a Twist
As stipulated by the contract, the contractor provided a five-year, single-source warranty on the metallizing. The unique aspect of the warranty, according to van Ginkel, is that the contractor was required to give the owner $300,000, to be held in reserve during the warranty period. After completing three-, four-, and five-year inspections and any necessary repairs to the metallizing, the contractor will be given $100,000 and the interest accrued on the $300,000 after the five-year inspection, says van Ginkel.

Less than 5% of the total contract, the warranty money is enough to ensure a good job, but not so much as to increase the tender price of the contract or place a financial burden on the contractor, van Ginkel notes.

The engineering firm will be responsible for providing follow-up inspections on the dam and bridge as part of the warranty provisions, he says.

Following up the Project
"[The job] restored my faith in project coordination," says Davidson. "The project went very well, and everyone involved worked as a team to accomplish a complicated task in a short amount of time."

The project was conducted when the dam frames were raised. When lowered, the PWGSC found that some areas had been missed, says Davidson. The contractor returned to the site in September for touch-up metallizing, says Turcotte.

Clara Industrial Services Ltd. (Thunder Bay, Ontario) managed the project and prepared and metallized the structural steel. Wardrop Engineering (Winnipeg, Manitoba) performed the cost-benefit analysis, coating selection, and contract administration. To-Spec (Ottawa, Ontario) performed inspections for the owner. Mulder's Inspection Services (Hamilton, Ontario) performed inspections for the contractor. The exterior containment was made by Walton Technology, Inc. (Richardson, TX). Scaffold Connection (Edmonton, Alberta) installed the containment and manufactured the shrink wrap plastic. Thermion Metallizing Systems, Ltd. (Silverdale, WA) manufactures the metallizing equipment. Carboline (St. Louis, MO) supplied the urethane mastic coating. ❑

Reference
1. *John Davidson, David Bowen, Kristina Hunter, and Robert van Ginkel, "Fortifying the St. Andrews Lock and Dam—Zinc Arc Spray Metallizing," presented at The March 99 Workshop, sponsored by Wardrop Engineering, March 23, 1999, Winnipeg, Manitoba.*