Extending Barge Life:
A Case History on Barge Restoration

Carl Piedmont, Poseidon Barge Corporation

From: The Power of Paint & Coatings; Conference Proceedings 2010
Phoenix, AZ ▪ February 7-10, 2010

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EXTENDING BARGE LIFE:
A CASE HISTORY ON BARGE RESTORATION

Carl Piedmont

Poseidon Barge Corporation
Fort Wayne, IN USA

During uncertain economic times like these, barge owners look to new economics and efficiencies to continue to grow business or their bottom line. One manufacturer examined barge restoration, reworked operations and applied progressive technologies to increase restoration speed and quality all while cutting costs.

This manufacturer found how rethinking their entire sectional work barge manufacturing and restoration process had huge financial ramifications that could speed overall construction time - while extending protective coating performance. The finding that the blasting and coating process represented significant cost and serious impact on other construction practices prompted important and meaningful changes. This presentation will (1) discuss the direct and indirect costs associated with abrasive blasting; (2) compare the costs of ordinary and sponge-based composite abrasive blasting methods; and (3) outline the decision-base for conducting on-site abrasive blasting versus sub-contracting abrasive blasting offsite.

Regardless of the industry, during challenging times, the question of how to maintain quality and output while reducing costs is often posed. For one barge manufacturer, the question was asked not as a last ditch effort to maintain profitability, but more as an opportunity for growth and continuous improvement.

This barge manufacturer looked at inefficiencies (or bottle necks) in the production process that required the most time and also those that stood out as activities which disrupted their critical path of manufacturing. In keeping with the principles of lean manufacturing, reduced cycle-time and overall waste reduction, the production process was mapped out. The analysis led to a decision to “Insource” blasting and coating operations rather than “Outsource” them. By doing so they were able to better control both barge quality and production schedule.

One major step in the finishing process that stood out was abrasive blasting and painting operations. Management recognized that 70 to 80% of the total manufacturing time per barge was consumed by blasting and painting operations. While it took an average of two and half days to assemble and weld a barge and another half-day of final finishing, it took up to twelve days, depending on weather and season, to complete blasting and painting operations.

Once blasting and painting was identified as an opportunity for change, management began looking for ways to accelerate the process - without compromising quality. Their current operation included transportation to a sandblasting and painting facility (one day): blasting which took over a day, waiting anywhere from four to nine days for painting and curing, and then one day of transportation back to the manufacturing facility. The cost of painting and abrasive blasting was $3,200 per barge with transportation to and from the facility charged at $200.

Management knew that the choice to add blasting and painting capabilities as an in-house operation would provide instant benefit. Aside from any required upfront capital investment, moving these operations in-house would automatically reduce blasting and painting time by two days and reduce the cost by $200 per barge – with no transportation time or transportation charge.

It should be noted that the facility was already equipped with a space for blasting (Fig.A) and painting (Fig.B), with room dimensions 30 x 80 feet (9m x 25m), so the internal assessment only included the types of abrasive and painting systems which were most appropriate.

The barge manufacturer already had a blasting room (Fig. A) and painting room (Fig. B) to conduct spot repairs.

The next step was to select abrasive types, which would naturally lead to specific blast room and air-handling requirements. A major constraint regarding the use of conventional abrasive was controlling airborne emissions. The barge manufacturer's property was directly across the street from a 350-plus student grade school and several homes were situated on its perimeter, so the barge manufacturer was especially concerned with dust generation.

The coating used by this manufacturer was a two-part, chemically cured semi-gloss marine-grade epoxy. It was applied in thicknesses from 6-12 mils wet with the total dry film measuring 12-14 mils. Two coats were applied to form the entire system. Drying time for both coats ranged from 36-48 hours in the colder winter months and 9-12 hours during the warmer summer months.

The high performance coating system, as specified from the coating supplier, called for a minimum blast cleanliness level of SSPC SP-6 - Commercial Blast Cleaning which corresponds to a NACE 3 or Swedish (ISO) standard $Sa2_1$. With an applied wet-film thickness of 6-12 mils per coat and a total dry film thickness measuring 12-14 mils, the required profile was between 1-2.5mils (or 25-62.5 microns). So the abrasive type chosen would need to achieve the profile and blast cleanliness level. In this situation, a sponge-based composite abrasive with bonded 60-grit aluminum oxide provided a plus-or-minus 2 mil (50micron) profile. Management witnessed a capability demonstration to validate the performance (profile-ability and production speeds) as well as the dust and rebound suppressing characteristics asserted by the manufacturer. Based on that demonstration, management made the decision to first try sponge-based composite abrasives with only simplistic air management. They chose to (1) open the large blast room doors to the outside environment and (2) use an industrial 2,400cfm (68m^3/min) fan vented outside (fig.1).

(Fig. 1) 2,400cfm fan used to reduce negative air issues

(Fig. 2) New sectional barge to be abrasive blasted

Each sectional work barge (fig.2) was 40 feet (12 meters) long, 10 feet (3 meters) wide and five feet (1.5 meters) deep, representing 1,300 square feet (120 square meters). Shop-primed A36 carbon steel was used to build each sectional barge. On all exterior sides of the barge, the shop primer is removed during the blasting and profiling process.

Phase 1: Blasting and Painting in-House

Abrasive blasting was carried out in a room designated for abrasive blasting only. The room was equipped with an advanced 400-liter pressure vessel (fig.3). The vessel, also supplied by the abrasive manufacturer, is modified to allow for precise regulation of media and air pressure during blasting. Other vessel enhancements, because of the larger than average particle size, include an abrasive agitator in the vessel, a larger orifice exiting the bottom of the vessel, 2-inch piping and a comprehensive control panel with adjustment and reading-gauges for blast pressure, media feed rate (in the air stream) and line pressure. The unit is also equipped with an emergency stop button.

(Fig.3) 400-Liter Specialized Pressure Vessel

(Fig.4) Pneumatic sieve-based classifiers separate reusable media from waste

A #8 wide-entry, venturi nozzle used to maximize abrasive flow and reduce drag, was connected to the blast vessel via a 50 foot (15.25 meter) hose. To power the blast vessel the barge manufacturer purchased a 375cfm (10.62m^3/min) portable diesel compressor.

Because the media is larger than other conventional abrasive particles it can be easily separated and classified for reuse. As a result, this same abrasive manufacturer supplies electric and pneumatic sieve-based classifiers (fig.4) designed to separate reusable media from waste. The waste stream consists of contaminants removed from the surface. It’s important to note that sponge-based composite abrasives are capable of entrapping surface contaminants on the substrate. During the classification (recycling) process contaminants are removed from the porous cell structure. When blasted over and over sponge-based composite particles become smaller. When the particles become small enough to drop below the smallest sieve, they drop out into the waste stream as well. Reusable media is then loaded back into the blast vessel.

For 1.5 years blasting took place using this equipment setup. During this time, it would take 9-10 hours to blast each 1,300 square foot (120 meter) barge, which included six fifteen-minute nozzle breaks for media collection and recycling. The production rate per barge was 2.6-2.9ft^2 per minute (14.5m^2-16m^2 per hour) (Fig.5). In terms of abrasive requirements, sponge-based composite abrasives were reused from 7 to 8 times, so between 360 and 390 pounds (164 and 177 kg) were consumed per barge. The cost of abrasives during Phase One was $2.13 per pound, so the total cost of abrasives to blast

(Fig .5) Blasting sectional work barge with sponge-based composite abrasives

each barge was between $766 and $830. The cost was $.59-$.64 per square foot or $6.38-$6.91 per square meter.

During Phase One 105 barges were manufactured, consuming 39,000 pounds of abrasive at a cost of **$83,070**. Hourly labor for the blaster and painter combined was charged at $36 per hour (78 weeks x 40 hours per week x $36 per hour) and totaled **$112,320**. The cost for the advanced abrasive pressure vessel, recycling classifier and the diesel compressor was **$44,735**. The compressor consumed approximately three gallons per hour when abrasive blasting. With an average price during Phase One of $2.87[2] per gallon and abrasive blasting taking a maximum of ten hours per barge, the fuel estimate per barge was $86 (or $2.87 x 3 gallons per hour x 10 hours per barge) and **$9,040** was the fuel cost for all 105 barges)[1]. It cost $210 in paint for each barge (or $21/gallon x 10 required gallons) which was **$22,050** for all barges. The total including equipment, abrasive media, paint, labor and fuel was **$271,215**.

(Fig .6) Before abrasive blasting

(Fig.7) After abrasive blasting and painting

When comparing the sub-contracting of abrasive blasting and painting operations to conducting the same operations in-facility, the barge manufacturer recognized those 105 barges if out-sourced would have cost $357,000 (or 105 x $3,400), while in-house blasting and painting cost **$271,215** - a total savings $85,785. The cost per barge for blasting and painting went from $3,400 to $2,583 (or $271,215/105 barges) in Phase One. Also important, the barge manufacturer cut manufacturing time per barge by 50%. And further, blasting and painting went from taking up 80 to 85% of the total manufacturing time per barge to a maximum 62.5%.

Phase Two – Blasting and Painting In-house (refinement of the process)

During the time this manufacturer made the switch to blasting and painting in-house, demand for their sectional work barges continued to increase. After a year and half, the challenge to further decrease the time to manufacture each barge (or essentially make more) continued. With blasting and painting operations still occupying a maximum of 62.5% of the total manufacturing time per barge, management felt there was still room for improvement with this process.

The first area of particular interest to management was compressed air. The initial 375cfm compressor (10.6m³/min) used in Phase One was the minimum recommended by the abrasive blast vessel manufacturer so this was the first improvement to be specifically addressed. During this time the cost of diesel fuel was dramatically increasing so an electric-powered compressor was preferred over a petroleum fuel-based system. The barge manufacturer purchased a 100-horse power, 475cfm (13.45m³/min) electric-powered compressor which did not work well. The response time to actual blasting when the deadman triggers was pressed was sluggish, and for the many necessary starts and stops required by the blaster, it made the process even less efficient.

Prior to making further changes, the manufacturer moved all equipment, other than the enhanced pressure vessel and the classifying recycler unit, outside of the facility and into an empty container. An electric space heater was purchased to maintain temperature above freezing in the container. A 500 gallon (1,900 liter) receiving tank was installed to provide more responsiveness during the start and stop process of abrasive blasting. The system did work, but not to the standards of management. As a result a 1,300 gallon (5,000 liter) receiving tank was purchased (Fig.8) as well as a 150hp, 675cfm (19.11m³/min) electric compressor (Fig.9). The blaster also switched from using a #8 wide-entry silicon carbide venturi nozzle to a #10 wide-entry venturi nozzle to increase the blast pattern. With all other blast procedures and equipment remaining the same, the blast pressure was increased from 95psi (6.6 bar) in Phase One to between 120 and

(Fig .8) 1,300 gallon (5,000 liter) receiving tank

(Fig.9) 150hp, 675cfm (19.11m³/min) electric compressor

125psi (8.3 and 8.6 bar)(the maximum recommended blast pressure by the vessel manufacturer)[3] in Phase Two. The expansion tank also provided enough back-pressure to reduce the start-stop wait times throughout the day. The results from these equipment improvements were wide-spread.

Production increases came from two areas. First, with an automatic burst of operating air from the receiving tank, the blaster had less stop-start delays. Second, with the 20-25% increase in blast pressure (or abrasive velocity) and a larger blast pattern, the blaster was able to prepare each barge within 6-7.5 hours, while in Phase One it took between 9 and 10 hours. So the blasting time per barge was cut by 2.5 to 3 hours thereby increasing production speeds by .4-.5ft²/min (2.2-2.8m²/hour).

Due to the large nozzle and these process improvements abrasive consumption significantly dropped, compared to the consumption in Phase One. The blaster was able to recycle the abrasives 10-11 times. Blasting each barge took 240 pounds (109 kg) while in Phase One it took between 360 and 390 pounds. This was a 34-39% drop (or a 120-150 pound (54.4-68 kg) savings in media requirements per barge.

The hours required to blast and paint each barge also dropped and so did other costs. For example, the hours required to abrasive blast each barge dropped from a maximum of ten hours in Phase One to seven hours in Phase Two – a savings of three hours or $48 per barge (3 hours x $18/hour). With 205 barges produced in Phase Two, the barge manufacturer saved $9,840.

In Phase Two, 240 pounds (1,089kg) were consumed per barge. The total abrasives consumed during that year was **$102,240** ($2.13 x 240 = $511.20 x 200 barges). Annual labor was charged at **$77,875** (52 weeks x 40 hours x $37.44), which included a 4% increase. The cost of a newly installed receiving tank, electric compressor and space heater was **$32,000**. The new 150 horse power compressor, running at 70% maximum load consumed approximately 78 kilowatts per blast hour. As a result, the cost for electricity per barge was $53.51 (or 150hp = 112kw; 112kw x 70% load = 78.4 kW x 7 hours blasting per barge x $0.098 per kW). The electrical cost for all 205 barges was **$10,970.** The $210 cost in paint for each barge remained the same with no significant changes, so the paint cost for the 200 barges was **$42,000**. The total including equipment, abrasive media, paint, labor and fuel was **$265,085**. So the cost per barge was $1,325 ($265,085/200). From Phase One to Phase Two, the cost per barge dropped from $2,583 to $1,325 – or over 48%.

Waste Generation and Disposal:

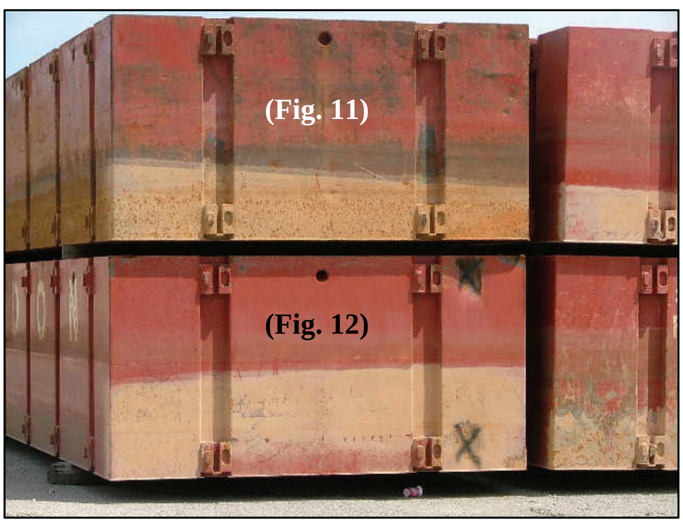
The barge manufacturer did not query their former sandblasting and painting contractor to find out how much waste was generated during the sandblasting of each barge. However, they did compare the pounds consumed from Phases One and Two. In Phase One between 360 and 390 pounds (164 and 177 kg) were consumed per barge, so to blast all 105 barges, between 37,800 to 40,950 pounds (17,220 to 18,585 kg) of spent abrasives were disposed. In Phase Two 240 pounds (118 kg) were consumed per barge. With 200 barges completed, 48,000 pounds (23,600 kg) were consumed. As a result, the barge manufacturer was able to blast nearly double the number of barges (from 105-200) but expended/disposed of only 14% more waste. If no improvement in recycle rate was realized from Phases One to Two, the total amount of waste per barge in Phase Two would have been 72,000-78,000 lb (32,660-35,380kg) rather than 48,000 pounds (23,600 kg).

With no disposal data from blasting prior to Phase One the barge manufacturer could not compare media waste in pounds and volume accordingly. It could determine with simple analysis that if sponge-based composite abrasives were recycled a minimum of ten times in Phase Two, the waste stream when using non-recyclable conventional abrasives would have been ten times this value. Disposal of the abrasives in both Phases took place in an existing, general-use eight cubic yard (216ft^3 / 6.1m^3) dumpster (Fig. 10).

(Fig .10) Waste abrasive was disposed in a commercial eight cubic yard (216ft^3 / 6.1m^3) dumpster

Protective Coating Life:

With respect to the coating process, no comparison was included in this analysis because no changes or additions were made to coating type, equipment or application during Phase One and Two. This also includes prior operations conducted by the blasting and painting contractor assuming they complied with the coating specification. The barge manufacturer already owned an industrial sprayer for conducting periodic spot repairs to their fleet of rental barges. A 2.2 horse power, brushless commercial/industrial sprayer (and gun) were used for this purpose and used throughout Phases One and Two. There were however notable changes in the protective quality of the coating.



(Fig .11 *top*) 1.5 year old coating failure from sandblasted rental barge (Fig .12 *bottom*) Two-plus year old coating from sponge-based composite blasted rental barge

The manufacturer recognized the benefit of extended coating life, which manifested as the reduced need to re-blast and paint their rented sectional barges painted during both Phases. Prior to switching to sponge-based composite abrasive blasting, barges between 1 to 1.5 years old required touch-up blasting (Fig. 11) and painting - at a minimum. Such activities were deemed necessary when the coating failure was estimated to be greater than 5% of the total area of the barge.

After abrasive blasting and painting operations were moved to the manufacturer’s facility, the number of spot repairs (including warranty repairs) gradually decreased.

In fact, barges blasted in Phase One or later (all in excess of 1.5 years old) had not returned for maintenance painting (Fig.12). Up until the drafting of this paper, (two-plus years after Phase Two started) the manufacture reports no subsequent coating maintenance.

Conclusion:

It wasn't until this barge manufacturer's management challenged employees to reduce costs while holding quality, that they…

- Identified the operations that were most disruptive to the critical path of manufacturing
- Identified the operations that requiring the most time to complete
- Identified the operations that were the least efficient and
- Considered new technologies that led to a departure from conventional methods

The organization recognized that abrasive blasting and painting operations were the most disruptive and time-consuming process compared to all other manufacturing operations. In this case, outsourcing turned out being more costly and less effective than conducting the same operations in-facility. Blasting and painting went from being a maximum twelve-day process costing $3,400 to less than a 5-day process costing $1,325. The barge manufacturer also reduced the operational impact of blasting and painting from a maximum of 80% down to less than 60%. Overall, their margin increased by reducing manufacturing costs, making dramatic efficiency improvements while improving coating quality and longevity – ultimately offering more reliable, longer lasting sectional work barges.

Author's Note:

The barge manufacturer would have liked to quantify the value of dust and rebound suppression during sponge-based composite abrasive blasting. In some cases this value would (1) be related to not needing an extensive air handling system and (2) would link these benefits financially to more consistent/better quality surface preparation (with the enhanced visibility attribute provided by the abrasives during blasting).

References:

1. The Society of Protective Coatings, "Visual Standard for Abrasive Blast Cleaned Steel," Section 4.2, Third Printing, (March 1998).

2. The US Energy Administration, Independent Statistics and Analysis, "Annual Retail Gasoline and Diesel Price", 2007.

3. Sponge-Jet, Inc., "Sponge-Jet 400-HP User Manual", p.5 (February 2008).