POWER Engineering

Cost Benefits of Critical Valve Repair in the Heat Recovery Steam Generator

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Current global power generation market conditions, driven by an abundance of natural gas fuel, recent advances in gas turbine technologies and more efficient combined-cycle component operation, have placed enormous demands on critical valves within thermal generation systems. Seeking to align their technical and commercial goals, market leaders are challenging traditional mindsets by performing new, objective analyses of valve lifecycles and product costs to determine the most judicious strategies for keeping their power plants operating at optimal efficiency.

Corporations that had focused solely on large-ticket critical components – turbines, generators, heat recovery steam generators (HRSGs), boiler feed water pumps (BFWPs), etc. – are now turning toward a more inclusive approach that takes into account generation components, such as valves, once considered non-critical to daily operations. In the face of ever-evolving electrical dispatch requirements, these components are taking on renewed importance as they move from monthly or biannual service duty to a daily cycle.

This article focuses on two of these now-critical components, small bore vent valves and drain valves, reporting research findings that repairing these valves is more prudent and economical than replacing them. Why focus on vent and drain valves? Modern advance frame combined-cycle power facilities operate in a dispatch environment where cold starts, accelerated ramp rates and low load conditions are the norm and where Balance of Plant (BOP) equipment accounts for more than half of all forced outages. Analysis by Pentair Valves & Controls revealed that valves are a significant contributing factor in forced outages, primarily based on their application numbers and the severity of their service applications. As we segregated the valves based on their duty service as it relates to cycling activity, we found that small to medium bore equipment drain and vent valves with higher duty cycles exhibit a critical component profile not previously associated with these former commodity, or buy-out, valves.

Pentair proceeded to review valve products designed for combined-cycle power facilities in these small to medium bore drain and vent applications. Applications were selected for their severe duty cycles (temperature and flow), directly related to cycling of the combustion turbine/heat recovery steam generator, and their strict boiler and piping code design requirements. Our project objective, beyond continuous product improvement, was to evaluate the products' overall contribution to the customer's corporate strategy objectives as previously outlined. This research would also compare a repairable product to a replacement product to determine which offered superior benefits.

The project team comprised Pentair Valves & Controls design and manufacturing experts, independent power generation consultants and product end-users. To ensure objectivity, the team also enlisted the services of independent global consulting firm Energy Werks Consulting, LLC, recognized for its work in the global power generation business sector.

The Study

We selected Pentair's 1.5" 1700#-4500# Yarway Welbond High-Pressure Globe valve for evaluation. This valve's design is consistent with our previous Six Sigma forced outage research findings. It exhibits a high profile of widespread application in the global power generation market for HRSG drain and vent applications. It also boasts a long tradition in power generation service applications in general, and it is refurbishable, often fitted with an automated operator for cyclic duty.

Our objective was to independently review and analyze the average actual repair cycle cost associated with this valve, operated within a specific thermal cycling duty for an HRSG vent and drain application. In our study, these valves were located predominantly in automated vent applications for the HRSG, while larger bore Pentair (4"-6") valves were applied to the HRSG drain applications, primarily based on individual HRSG module design criteria. Each of the combined-cycle units utilized in the study exceeded 250 MW in total generation capacity, were of advance frame combustion turbine design, were equipped with a triple-drum HRSG, had been automated specifically for cycling duty, and were operating in the North American power generation market. These units see multiple fast starts and cold starts, and varying daily load-range conditions, and operate within a generation grid where renewable energy is present. As our study progressed, it became apparent that certain valve repair and manufacturing impact similarities among this valve design class grouping could be identified and then extrapolated to the larger (4"-6") Pentair valves not included in our study.

This case study provides insight into the typical costs associated with the average lifecycle of a repairable Yarway Welbond 1.5", 1700#-4500# pressure class valve operating in standard steam service application. The specific product utilized for this detailed cost analysis was the Yarway Welbond 1.5", F-22 material, 1700# pressure class valve, operating in the HRSG automated vent service for power generation application. Both hard and soft costs related to these valves' lifecycles will be determined. These severe service duty valves do require periodic inspection and maintenance as part of normal operations.

Repair vs. Replacement Cost Summary

Example A reflects the hard costs associated with a typical Yarway Welbond valve repair after routine periods of operational service. Scope of repair consists of the valve disassembly/reassembly, the use of Yarway specialized tooling for the refurbishment of the valve seat, lapping of valve disc assembly (if required) and valve stem packing replacement.

Example "A" Repair			1
			Cost
Tooling	Yarway Valve Tooling P/N 5617B		*
Material	Insulation		*
	Valve Packing Set		$130.00
Labor	Applied Labor rate/hour		$100.00
	X number of hours		2.5
	X numbers of Workers		1
		Subtotal	$250.00
		Total	**$380.00**

*Yarway Welbond 1.5", 1700# pressure class valve tooling (packing and backseat removal part #5617B) consists of a mandrel with reusable cutters sized specifically for the valve being refurbished. This tool can be obtained from the OEM (suggested list price is $2,700 each). Tooling cost will be applied to each valve refurbishment cost cycle in the Repair vs. Replace analysis table.

*Insulation costs are not calculated in the repair summary, since the valve remains in position, and packing may be accessed without disturbing the existing valve body insulation.

Typical 2.5 hours to inspect and repair using the proper valve tool kit.

Example B reflects the hard costs of a typical Yarway Welbond valve replacement after routine operational service. Scope of replacement consists of insulation removal, valve removal, valve replacement, weld procedure, NDE procedure, and insulating the valve body and adjacent piping.

Example "B" Repair			2
			Cost
Tooling	Equipment		*
Material	Insulation		* $225.00
	Vlave		$1,600.00
Labor	Applied Labor rate/hour		$100.00
	X number of hours		6
	X numbers of Workers		2
		Subtotal	$1200.00
		Total	**$3,025.00**

*Equipment cost has been excluded from this cost exercise, since it may vary significantly by location, company and corporate accounting practices. It should be noted that even a conservative Operations & Maintenance (O&M) accounting of equipment costs associated with the valve replacement procedure example would include basic hand and power tools, and welding equipment funding @10 percent of project total value ($302.50) per occurrence.

*Insulation costs vary significantly based on the type of material and overall piping configuration. Reusable valve/piping insulating "blankets," often accounted for in piping project capital budgets, vs. in-kind insulation replacement, accounted for in daily O&M budgets, highlights this cost disparity. In each example presented (A and B), an average cost of labor and material for turnkey installation methodology was utilized. The valve replacement project cost assumptions DO NOT include labor mobilization and demobilization costs. It is assumed the work scope is performed on location by craft personnel.

Soft Costs Associated with Valve Replacement

Although more difficult to quantify, soft costs must be accounted for in the Repair vs. Replace decision process. In recent years, site operational responsibilities and global stewardship in the industry have increased the traditional list of soft costs associated with performing routine valve maintenance tasks. The following activities impact the realized cost of the replacement valve project considerably, but have minimal impact on the actual project cost.

Inventory Control: Valve manufacturer, size, material, pressure rating, configuration, quantity, etc. all must be updated and recorded in warehouse inventory control and workforce management software programs each time a valve is replaced in a process system.

Welding: Prior to the physical practice of welding the replacement valve into the process system, you must validate and record the welder's qualifications, confirm that the weld procedure is correct for the valve and connecting piping material, and process application. Local, regional, state and national governing codes directly and indirectly associated with the welding process may translate into additional cost burdens for this activity. Individual underwriters' requirements for further historical record retention of the "valve replacement event" can prove to be an unexpected/hidden overhead cost.

Nondestructive Examination (NDE): Minimum code requirements are visual NDE with further escalation in NDE work scope based on the valve material and process application.

Environmental: Environmental activities and related costs will deviate significantly based on project location and governing regulations. Impact costs may range from local industrial waste disposal policies of the discarded valve to the carbon footprint taxes associated with the manufacturing process of the replacement valve. Often these environmental impacts cannot be isolated to single project event or maintenance activity, and are considered in the overall site (environmental plan).

Conclusions

This study revealed that the cost to repair this type of critical thermal valve is significantly lower than the cost to replace it after every cycle. The fact that Pentair's Yarway Welbond repairable valves can be repaired inline is an additional benefit. Repairing is also a more sustainable solution, as is reduces the total process cycle.

Initial Capital Cost			3
	Valve	$1,600.00	
	Insulation	$225.00	
	Craft Labor (Welding)	$1,050.00	
	Non Destructive Examination	$150.00	
	Total	**$3,025.00**	
Repair Cycle 1	$380.00	**Replacement Cycle 1**	$3,025.00
Repair Cycle 2	$380.00	**Replacement Cycle 2**	$3,025.00
Repair Cycle 3	$380.00	**Replacement Cycle 3**	$3,025.00
***Tooling**	$2,700.00		
	Total $3,840.00		**Total $9,075.00**

More detail is provided in the following points:

- The first maintenance cycle of the Yarway Welbond repairable, 1.5", F-22 material, 1700# pressure class valve provides the opportunity to refurbish internal valve components vs. replacing the valve at a direct cost reduction of $1,745 per maintenance cycle. The total lifecycle cost associated with the valve is primarily determined by the number of maintenance refurbishment events the internal valve components (Stellite seat) provide. Manufacturer documentation suggests a minimum of three valve seat refurbishments are achievable prior to replacing the valve body or other significant valve components under routine service application. Based on manufacturer repair data for routine valve service in steam application, the following economy of savings could be realized by the user.

  *Tooling cost has been amortized into each of the valves' repair cycles @$900 per occurrence based on a single valve's maintenance requirements in this standalone business case. This significantly discounts the economy of scale for tooling, considering an average power generation facility would have more than 50 valves requiring this specific tool application.

- Data generated through this study indicate that every repairable small bore valve functioning in these duty cycles routinely will provide significant savings over their entire service lifecycle, in comparison to a valve designed to be discarded after each and every service cycle. Given that each combined-cycle unit in operation today utilizes a minimum of 50 1.5"-2.0" valves within this pressure class, functioning in steam vent, steam vent blocking and drain applications, annual valve savings could exceed $261,000.

- In addition to the economic benefits, repairing vs. replacing valves is consistent with corporations' commitment to environmental stewardship. Our industry has depended in the past, and shall depend well into the foreseeable future, on renewable resources at all levels of the power generation market spectrum. Whether we define a renewable resource at the macro level of a source like wind or solar electrical production, or at the micro level of a repairable, recyclable plant component, our primary objectives remain the same: industry sustainability and profitability. All successful corporate strategies today and for future global power generation markets will be required to address the question of product sustainability. Competition for everything from raw goods in manufacturing to end-users in developed generation markets will have a profound impact on our daily operations.

> Phrases such as "going green" and "environmentally friendly" have been replaced by phrases like "cost-effective manufacturing environment" and "long-term fixed O&M costs." Reducing the steps in any manufacturing or repair process cycle will ultimately reduce the process cycle cost. The marriage of good business processes and strong quality control measures with consistent repair practices will result in best-in-class methodologies. Recycling or the refurbishment of most resources utilized in our industry today by definition reduces the total process cycle and is part of a cost-effective, sustainable business model.

Repairing valves is a viable option for combined cycles or coal-fired plants. Pentair's Yarway Welbond repairable valves are a cost-effective and responsible solution for today's power plant operators.