AS SEEN IN THE WINTER 2006 ISSUE OF...
Valve MAGAZINE

OEM VERSUS NON-OEM PARTS... YOU MAKE THE CALL

WHILE THE PURCHASE PRICE OF REPLACEMENT VALVE PARTS FROM A REPLICATOR MAY BE LESS THAN FROM AN OEM, THE RISK TO PLANT PERFORMANCE AND SAFETY MAY BE SIGNIFICANTLY GREATER.

BY TED GRABAU

In today's world of lower budgets and increased pressure to do more with less, plant personnel must continually search for lower costs of doing business. One cost-reduction technique commonly used is to purchase replacement control valve parts from parts replicators or local machine shops at lower prices than those charged by the original equipment manufacturers (OEMs). However, the possible consequences of using replicated parts for the many critical valve applications in a plant must be assessed against any savings. This article presents facts to consider regarding purchasing reverse-engineered or replicated control valve parts to help users determine if initial cost savings are worth the potential risks.

But even beyond some of the technical operating issues that can hinge directly on OEM replacement parts, another consideration is critical. That is the fact that OEMs are heavily involved not only in their own companies, but also in the industries they serve. They do so directly (using their own financial and personnel resources) to help develop and apply industry codes and standards. Replicators typically do not participate in these efforts, leaving enhancements in plant safety and efficiency up to OEMs to create. Put even more simply, OEMs invest in the industries they serve; replicators do not.

Meanwhile, parts replicators face uncertainties in the reverse-engineering process in three critical areas: dimensions, materials of construction, and performance testing.

DIMENSIONAL REVERSE ENGINEERING

Measuring Complex and/or Large Parts. Some parts are either extremely complex or large enough that the only way to measure their conformance to dimensional specifications is by using a coordinate measuring machine (CMM). A CMM uses accurate measuring systems and sophisticated software to locate component features in three dimensions and simultaneously relate those features to each other. CMMs offer much more capability than even the most diligent inspector using micrometers and gage blocks. OEMs expend large capital investments in CMMs and other specialty inspection equipment so they can qualify the accuracy of machining processes and perform final inspections of parts.

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Dimensions and Tolerances. The original designers use criteria known only to them in forming the relationships between features on a valve, actuator, and instrument assembly. The relationships and tolerances between these components are documented using state-of-the-art dimensioning language in conformance with the ASME Y14 series of standards. This language expresses to the foundry person or molder, as well as the machinist, exactly which features of one component must relate to mating components and by what tolerances. This allows casting rigging and machining fixtures to be built and used to accomplish those features' requirements. Design personnel at OEMs and their suppliers are trained on use of the latest documentation standards and updated as requirements change so that they speak a common language. Replicators cannot know the original design intent; therefore, they cannot properly assign datum features and related tolerances. Without proper geometric dimensioning and tolerance data, a reproduction facility cannot accurately recreate replacement parts.

Statistical Samples vs. Population. To replicate the original tolerances and relationships of different features, a replicator would need an extremely large population of the parts and a thorough statistical analysis of each one. With sufficient time, expertise, and forensic tools, it is possible to ascertain which parts are used in a single production run on a particular machine tool and which are not. But reality is different from possibility; even "quality" parts replicators do not go to this extreme as evidenced by OEMs' experiences with competition from replicators on products where only 20 total valves exist in the world.

Inaccuracy in Surface Finish Assessments. Surface finishes or textures are not all created equal. OEMs have proprietary specifications that document processes and procedures for achieving consistent textures on critical surfaces, such as the surfaces for gaskets, primary seats and seals, bearings, and valve stems or shafts (especially where they contact packing.) Surface profilometers may calculate the same "R_a" scale value for two surfaces from different processes of derivation, but different processes create fundamentally different surface finishes with different performance characteristics. For example, grinding, polishing, and roller burnishing can each achieve the same surface finish value, but each has a different set of characteristics to achieve the end result. They each result in a particular combination of waviness (which is generally determined by the speeds and feeds of a machine tool), roughness (as determined by the contour and condition of the tool), and aggressiveness (i.e., aggressive surface finishes will pull fibers from a cloth) make a significant difference in length of service life of packing and bearings. OEMs develop and benchmark surface technology by rigorous testing over decades of different surface finishes accomplished by different processes and parameters. It is virtually impossible for a replicator to reverse engineer the surface finish requirements to accomplish the same result.

REVERSE ENGINEERING MATERIALS OF CONSTRUCTION

Heat Treatments and Thermal History

Metallography. All materials have processing considerations that achieve their intended special properties. Some materials—such as duplex stainless steels, high nickel alloys and high temperature chome-moly steels—are particularly sensitive to welding, heat treatment, and trace element content, especially castings. The science of maintaining special corrosion and high-temperature properties is not widely known and requires metallurgical verification and physical testing. Control and verification requires significant technological expertise and lab equipment, an investment that can be justified by only a few OEMs and even fewer parts replicators (if any).

NACE Requirements. NACE requirements have recently been completely rewritten for MR0175 and expanded to include a new MR0103 for refining applications as opposed to up-stream processes. Compliance to these specifications has always been complex and now needs to be reconsidered because of new, significant changes. Compliance with the older MR0175 version does not ensure compliance with the current revision. Very few OEMs have been active in writing these specifications or qualifying materials to achieve these specifications. Participation by employees of parts replicators in the NACE process has not been observed.

Proprietary Coatings. Coating and weld overlay processes are known to be

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extremely sensitive to process conditions, surface preparation, and chemistry. OEMs spend extensive resources testing coatings and performance sensitivities of processing parameters. Wear-resistant coatings also must be optimized to be thick enough for long wear, but thin enough that part distortion or spalling do not become issues. Recently, a coating supplier to a major OEM called to clarify the company's coating specification on an errant base material. Upon further investigation, the supplier discovered the part that was to be coated was actually from a replicator and parroted a proprietary OEM specification. Unfortunately, the specification was called out on the wrong base material so it had too little coating thickness to perform. This particular coating is extremely dependent on base material composition and requires numerous iterations of metallurgical examination for optimization to perform successfully. Failure of the coating would result in the valve plug seizing inside the cage during operation and loss of process control.

Lack of Industry Standards for Nonmetallic and Composite Components. According to process plant survey results, "soft" parts are the most common cause for valve maintenance or unscheduled outages. Engineering plastics and elastomers are governed by very few materials standards compared to metals and are extremely sensitive to formulation and processing techniques of their producers. Therefore, material properties must be confirmed by laboratory and in-product testing. A typical example is the variability that can be experienced when ordering a supplier's standard 70 durometer nitrile O-ring. Nitrile rubber is a copolymer of acrylonitrile and butadiene rubber whose volume fraction—as well as many other ingredients such as the cure system, fillers, plasticizers, anti-degradents, and processing aids—can vary immensely. Variability in final properties include a low embrittlement temperature that ranges from between -65° F and -20° F, hydrocarbon swell resistance that ranges from 5% to 50%, and compression set ranging from 2% to 25%. The consequences that these variations in properties can cause include fracture of the O-ring during flexure at low temperature, loss of seal due to reduced strength, shape retention issues when exposed to oil, or loss of seal due to minor temperature excursions.

Laboratory testing against well-established benchmarks, a thorough understanding of customer service conditions, and in-product verification are critical for successful performance. Responsible OEMs make significant investments in analytical test equipment and engineering resources and they maintain a long-term database of testing benchmarks.

PERFORMANCE TESTING

Design Verification and Optimization

A vital part of product development is testing, which occurs at multiple levels and at different stages of that development. It starts with fundamental questions that address what contact stress is the threshold for galling between two materials, or how a linear flow characteristic can best be accomplished. As the product develops, testing is applied to the prototypes so the learning process determines if the individual components of an assembly will work together properly. Tests performed on production-ready prototypes include proof-of-design hydrostatic testing of complicated body and bonnet castings to confirm finite elemental analyses and determine maximum stress locations and values. Also performed at the production-ready prototype stage is flow testing to determine capacity, verify flow characteristics, and to measure dynamic flow stability. Dynamic flow stability and incipient cavitation are then verified by flow testing and these results are used to correlate to computational fluid dynamic (CFD) models to predict transient conditions. To date, CFD can accurately predict locations where flow turbulence or cavitation impingement will occur; however, accurately predicting the threshold of physical damage is not yet possible. CFD also accurately predicts flow capacities and pressure staging, which enables trim geometries to be optimized for dynamic performance and maximum/minimum material conditions to be analyzed before prototyping.

Acoustics and noise generation in the valve and transmission outside the valve or piping are very complex technologies. Noise-abating trims are extremely technical to develop and depend heavily on pressure staging, jet formation, and interactions based on hole size, shape, and spacing. Very subtle changes can make big differences in noise levels and frequencies. Successive CFD modeling and flow testing using high technology data acquisition systems are essential tools to refine noise abatement trims, confirm their efficacy, and understand the limits of their application. Trying to replicate noise abatement trims without understanding the technology leaves the customer vulnerable to noise and vibration that can damage equipment and the hearing of plant personnel.

Reliability Testing

Reliability testing is the foundation for successful products. Customers would prefer to install valves and perform minimal maintenance over their service lives. But testing is seldom a single event with confirmed results. Instead, it is an iterative process that includes analysis of failures, improvements in the design, and retesting. Testing is also the final step in the process to learn what isn't known about a new product as it relates to its assembly. It also achieves final verification of performance at maximum and minimum material and process conditions, and compares the new product to existing, successful products. Cycle testing is at the core of reliability. Such testing concentrates on the dynamic components, which include primary seats or seals, packing, bearings or other mating guides, actuator O-rings, seals, or diaphragms.

Fortunately, cycle testing is easily automated. The value of cycle testing is to determine the end of the product life to improve the components that will cause that end and then to cycle again. A robust design is achieved when all components have approximately the same cycle life so the cost vs. service life value is optimized. Very few applications for control valves actually require full stroke cycles. The real value of cycle life testing comes from correlating an accelerated lab test benchmark to an existing product that already has a good reputation for reliability in the field. Once the correlation for high reliability in service is established, all future cycle life tests in the lab can be easily compared with the benchmark.

Operability and shutoff at the temperature extremes appropriate for the product being developed also are lab tested. These tests have been performed from liquid nitrogen temperatures (-196° C) to furnace temperatures as high as 650° C. The performance is then confirmed in customer field trials prior to product introduction. Erosion and wear life is assessed using standard tribology testing in the lab and confirmed in field trials at a customer's severe service applications. When laboratory facilities are lacking, replicating products one component at a time short-circuits the testing, blindly relying on the hope that the OEM's results will be achieved, with the ultimate risk passed on to the customer.

PMI and NDE Testing

Most OEMs have positive material identification (PMI) processes to assure materials specified for the valve assembly made it through the manufacturing process without mishap. Materials of construction are unusually diverse in the valve industry, and all are important to the success of the valve in service. Therefore, final assurance that the materials are as specified is worth a nominal fee at the end of the manufacturing process. Non-destructive examination (NDE), such as radiography, use of liquid penetrant, or mag-flux testing are required by certain codes, and once the investment is made in equipment and trained personnel at an OEM, they frequently are used to develop robust welding and overlay processes even when not required by code. Replicators seldom invest in NDE equipment on-site and must pay outside suppliers for these services, making it much less likely the testing will be done unless required by the customer.

Standards and Certifications

Codes and standards have been developed in the valve industry principally to improve safety for the end user. Interchangeability of components is a secondary consideration to product safety. Each approval process confers more value to the product by further ensuring it is designed and manufactured for safety and reliability. Third-party approvals and documentation of compliance to codes are very costly, both because of certification fees, and in terms of engineering expertise and support effort. Codes, standards, and approvals that OEMs routinely comply with include ASME, ANSI, ASTM, ISA, CSA, FM, CENELEC, ATEX, CE, TUV, FCI, UL, etc. Substitution of replicated components voids all code compliance and third-party approvals, as well as warranties from the OEM. Therefore, the risk of substitution needs to be weighed against savings.

CONCLUSION

We have summarized technical reasons why it is impossible to replicate or reverse engineer an OEM's design and manufacturing procedures and get a reliable part. Use of these parts can also affect third-party approvals, OSHA compliance, insurance coverage, liability of material traceability, warranties, and long-term service support by the OEM.

These parts could be controlling the operations of your plants, which directly equates to your bottom line. Therefore, you have to ask yourself: How much savings would I have to achieve to offset a few hours of plant downtime? Using the right parts for the right process can minimize downtime and increase the quality, throughput, and smooth operation of your plant. Don't be fooled into believing that small variations in the design don't make a difference in form, fit, or function. These variations can shorten the life of the part, which will affect your operations and maintenance budgets, raise utility costs, increase waste and rework, and affect the overall general safety, health, and environment of the plant and your personnel. OEM or non-OEM…you make the call. **VM**

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