EXTENDING THE LIFE OF MOLECULAR SIEVE DEHYDRATION SWITCHING VALVES

ABSTRACT

The molecular sieve dehydration unit is an important process in any plant that uses natural gas as a feed stock. These units are critical in drying natural gas and the processes that follow such as the extraction of Natural Gas Liquids and the production of Liquefied Natural Gas. Switching valves are vital to the proper and efficient operation of these molecular sieve dehydration units. Common issues have been identified that, if understood and addressed in a timely fashion, can help the following:

1. Avoid start-up problems, both at newly constructed facilities and following major shutdowns. This will allow the units to start up on schedule.
2. Improve the ability of the unit to properly dry the natural gas feedstock, increasing the throughput of the unit.
3. Extend the life of the dryer switching valves, saving money in costly, unscheduled repairs.
4. Reduce unexpected shutdowns. This will keep the revenue stream flowing.

Introduction: Why is This Important?

The molecular sieve dehydration unit is an important process in any plant that uses natural gas as a feedstock. Whether the plant is processing natural gas to make LNG, ammonia, or is processing gas to extract NGL's, it is imperative the gas is properly dried. Water in the wet gas passed along into subsequent processes can cause the formation of hydrates or destroy valuable catalyst.

Molecular sieve dehydration is currently the process by which almost all water is removed from gas. The switching valves (gas in, gas out, regeneration in, regeneration out, pressuring and de-pressuring) are critical components in this process. If these valves do not perform as expected, the drying process will be compromised and molecular sieve drying unit will not dry the gas to the required specifications.

Valve Selection

Selection of the proper valve type for use as a molecular sieve switching valve is the first step to success in a properly operating system. Several valve manufacturers claim the valve type they offer is perfect for molecular sieve switching valve applications but few have a proven track record in actual service. Many valve types have been tried in this critical service, but few have performed well. Of all of the valve types utilized for switching valves in molecular sieve dehydration service, the rising stem ball valve has a superior and proven track record. Let's understand why:

Characteristic Requirements

First and foremost in a dryer the valve must seal tightly. If it is not possible to obtain tight shutoff, the leaky valve allows wet gas to enter the drying tower during the regeneration cycle. This leakage lengthens the regeneration cycle, wastes precious energy, and will not allow the desiccant to be fully regenerated, resulting in increased operating costs.

The valve must also withstand high regeneration temperatures. Taking into consideration temperatures typically found in regeneration cycles and considering temporary excursions above typical regeneration temperatures, the switching valve should be designed for a maximum of 800 degrees F (426 degrees C).

The valves must be capable of withstanding the frequent cycling that is characteristic of dehydration cycles. For example, if a system is on eight hour cycles a valve could cycle three times per day, 7 days per week, and 365 days per year. If planned maintenance of the system is every five years and this maintenance includes rebuilding of the beds and repair of the switching valves, the valve could see 5500 cycles between repairs. Not many valve types are capable of withstanding this many cycles in a hot, dry, and sometimes hostile environment.

The rising stem ball valve provides tight shutoff, withstands frequent cycling, and handles high temperatures better than other valve types in this service. Other valve types do not have an equal track record in molecular sieve dehydration service because no other valve provides the tight seal and friction free operation in the same manner as a rising stem ball valve (no rubbing between sealing surfaces).

Common Pitfalls

Taking shortcuts or trying to lower costs of a unit by selecting unproven valve designs typically proves to be a false economy. Everyone desires lower costs and a premium product for a discount price, but in the case of dehydration switching valves buying cheaper products usually proves to be most expensive course of action. John Ruskin, (8 February 1819 – 20 January 1900) English art critic and social thinker, said it best:

> *It's unwise to pay too much, but it's worse to pay too little. When you pay too much you lose a little money, that's all. When you pay too little, you sometimes lose everything, because the thing you bought was incapable of doing the thing it was bought to do.*
>
> *The common law of business balance prohibits paying a little and getting a lot. It can't be done. If you deal with the lowest bidder, it is well to add something for the risk you run. And if you do that, you will have enough to pay for something better. (Ruskin)*[1]

Because of the operating conditions and characteristics previously mentioned, the most cost effective way to save money on dryer valves is to purchase proven technology during the planning and construction of the plant. This "buy it once" mentality almost always results in a process that performs within the required specifications with significant reductions in downtime or unexpected shutdowns. Remember, one minor disruption in production offsets any savings realized by buying a cheaper valve.

Construction, Start-up, and Commissioning

The construction, start-up, and plant commissioning phases are critical in bringing a new plant or system online. It is possible to avoid many common problems seen in dehydration switching valves by implementing proper techniques and procedures during the construction and start-up phases of the project. The most common valve issue seen during the construction/start up is foreign matter in the valves. This foreign matter typically comes from the construction of the piping into which the valves are installed.

Welding operations, by their nature, are dirty. It is recommended to clean welding residue from the lines before installing the valves, which is best be accomplished by flushing the entire system. If this flushing operation is properly done, most foreign matter will be removed. Only when the lines are clean should installation and operation of the valves commence. Damage to valves can occur if this critical cleaning operation is not performed. The most common debris found in piping and valves following construction include weld slag and miscellaneous debris from the construction process.

Hard particles in weld slag can damage coatings, platings, and overlays. If a valve closes on the particulate, the base material can yield, compromising the integrity of the coatings. Once this occurs, the coatings, especially hard coatings such as tungsten carbide and Stellite®[2], may crack and chip exacerbating the problem. This damages the valve sealing surfaces significantly. Chipping and flaking of these hard materials cause even more damage as they come in contact with other components in the system.

The following are examples of damage caused by weld slag during construction that were found at startup.

Figure 1

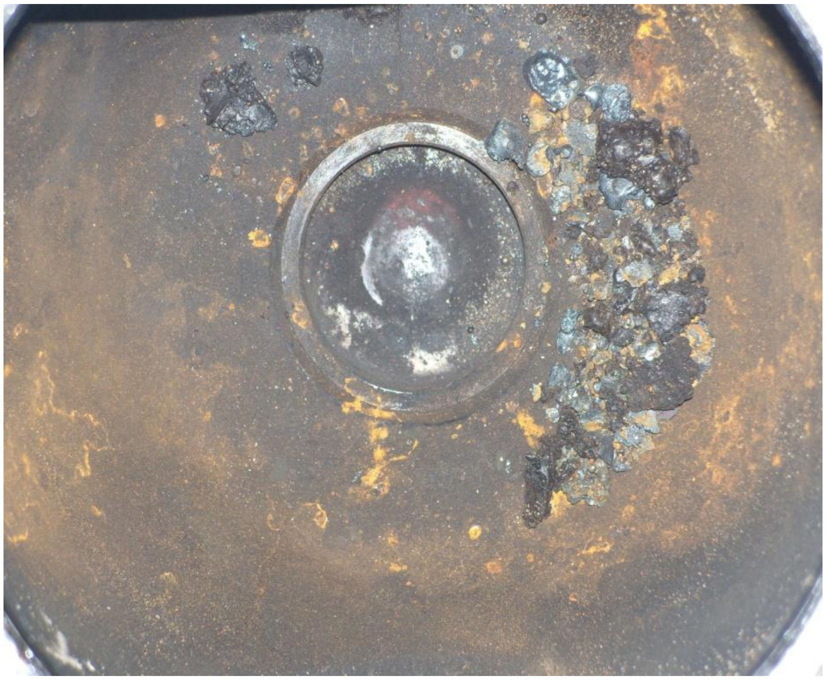


Figure 2

Figure 3

It is common for other types of debris to find their way into piping systems during the construction phase. These can be anything from bits and pieces of wood, juice cans, safety helmets, hand tools, or other debris left behind by construction crews. Anything left in the pipe can be a source of damage to valve components. It is highly advisable to conduct a thorough visual inspection of the piping followed by flushing the system in order to remove the debris before installing the valves. A thorough cleaning of the entire system is critical for a successful start-up.

Most molecular sieve dehydration switching valves are automated and actuator operation directly affects valve operation and performance. Pneumatic actuators are the most common actuator type used in this service. For pneumatic actuators, it is important that supply lines be adequately sized to supply the appropriate volume of instrument air to smoothly open and close the valves without jumping (starving the actuator for air pressure). Saving a few dollars by using smaller instrument lines at the time of construction can adversely affect the smooth, efficient operation of critical service valves once the plant is in operation. When the valves do not work properly the unit does not work properly.

It is common practice for actuator manufacturers to prepare the actuators for shipment by installing special plugs in some of the actuator ports to avoid damage during shipping or to keep oil used for damping action in the appropriate cylinders or tanks. These shipping plugs are normally conspicuously marked and the appropriate plug attached to the actuation to be used during operation. If these shipping plugs are not removed and replaced with the appropriate fitting, this can adversely affect actuator performance to the point the actuator may not work at all. Also, it is mandatory to follow the actuator manufacturer’s installation instructions and to consult the manufacturer or manufacturer’s representative if there are any questions or concerns.

In cases where electric actuators are preferred, it is imperative the actuator settings are consistent with the valve on which it is installed. Some valves are torque seated while other valve types are position seated. It is critical that the electric actuator be properly set or the valve may not close or open fully, adversely affecting performance. When in doubt, consult both the valve manufacturer and the electric actuator manufacturer for guidance. Improper torque settings and/or position settings are commonplace when field personnel unfamiliar with the operation of the valve or actuator adjust these settings. This typically results in poor valve performance or valve damage.

Operation

It is normal for dust or fine powder to escape the beds, especially following new construction or the reworking of a drying tower that involved the change out of desiccant. Valves designed for this service, especially the rising stem ball valves mentioned earlier, will handle normal dust and carry over without issue.

Once a plant is past the construction and start-up phases and has been in operation for a period of time, the most common cause of damage to valve sealing surfaces is molecular sieve desiccant escaping the screens and finding their way into the valves.

If the desiccant escapes the tower, it can find its way between the valve sealing surfaces. This may result in damage to the closure members when the valve closes on this material, yielding the base material supporting the hard facing. No valve trim is designed to adequately handle this foreign material. The solution is proper installation of the molecular sieve desiccant and ceramic balls that make up the components in the drying tower and proper installation of the screens.

Figure 4 is a picture of molecular sieve desiccant that escaped the tower and was found in a gas outlet valve.

Figure 4

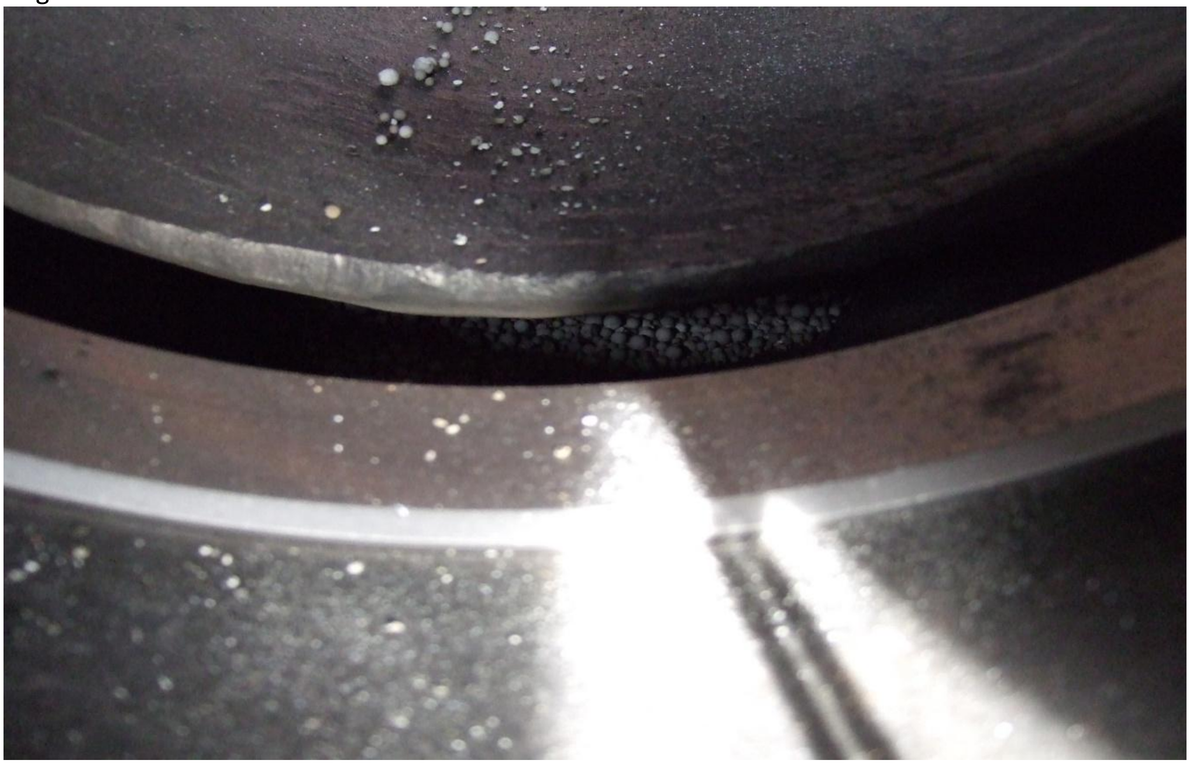


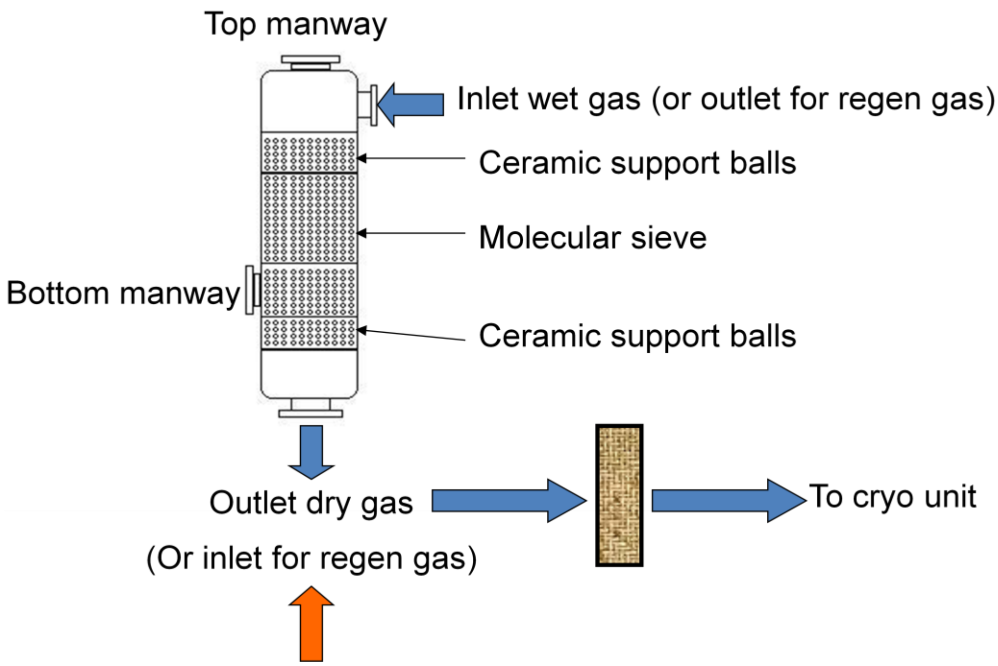
Figure 5 shows typical seat damage caused by molecular sieve desiccant.

Figure 5

It is common practice to use a special wire mesh screen at the bottom of each tower to trap particulate that escapes the beds. The size of these screens are designed for the size of the desiccant balls used and are quite effective in trapping material that gets past the ceramic balls in the drying tower. Problems arise when the size of the particulate and the screen size do not match. A good example of this is a system designed for desiccant supplied in 1/16” balls or pellets. As long as the pellets maintain their original size and shape all is well. But because of outside influences (liquids in the gas supply, incorrect selection of desiccant, mechanical damage caused by improper loading procedures, etc.) the desiccant can break down into smaller pieces and these pieces escape the screens and get into the outlet valves.   Figure 6 is a representation of a typical molecular sieve tower.

Figure 6

Molecular Sieve Tower



Once seat damage has occurred and seat leakage begins to cause concerns in the efficiency of the unit, a common practice for well intentioned operators is to attempt to get the valves to "seal tighter." This attempt usually means increasing the closing air pressure on the instrument regulator. This results in more closing force being applied to the valve and may result in a temporary improvement in sealing. In the long run, however, this results in additional damage to valve internal components and only makes the problem worse.

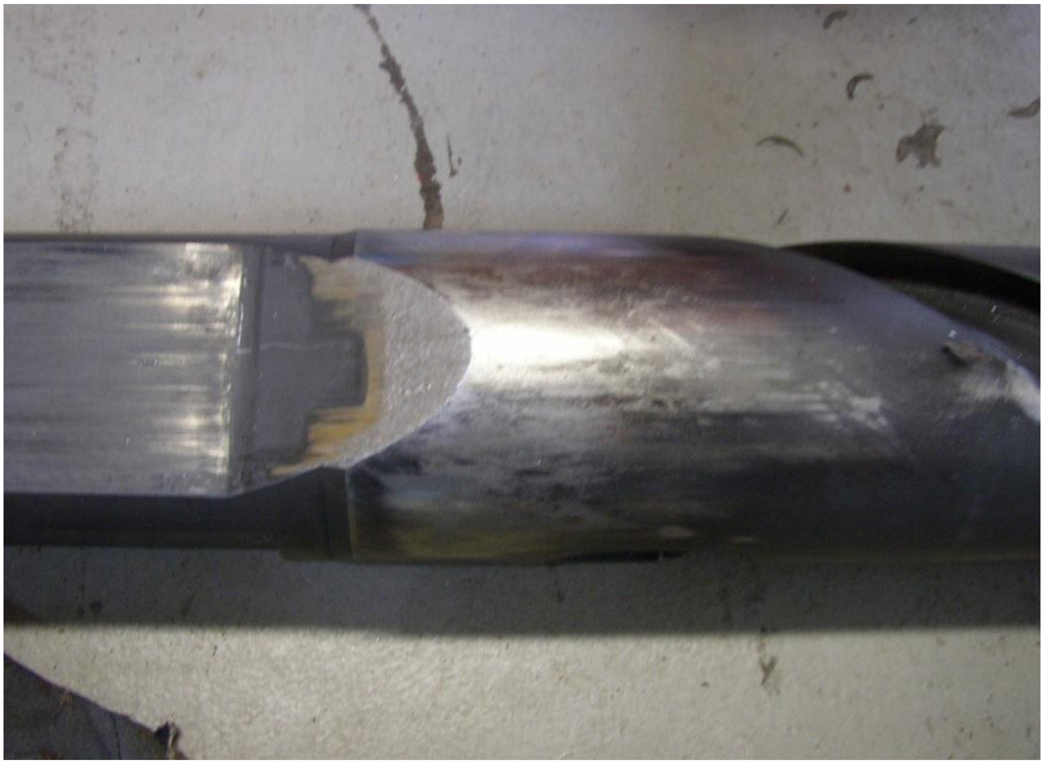
In some cases the air pressure is increased to such a high level the valve components exhibit adhesive wear and the valve can stick in the closed position. The result is an unplanned plant shutdown resulting in a loss of production. Increasing air pressure above the manufacturer's recommendations results in accelerated wear (best case) or complete failure of a key component (worst case). Simply keeping the desiccant in the tower enables the plant to avoid problems.

Figures 7-9 are pictures of typical component damage caused by excessive closing force.

Figure 7

Figure 8

Figure 9



Another common problem in the operation of switching valves is cycling the valves too fast. Most valve manufacturers recommend the minimum speed at which to operate the valve, meaning the valve should not cycle faster than the recommended operating time. Operating the valve faster than recommended causes accelerated wear on critical valve components and premature valve failure. The speed at which the valve actuator opens or closes should be controlled by the instrumentation (in pneumatic actuated valves). The most effective speed controls are adjustable valves placed in the exhaust ports of the three way or four way solenoid valves on the instrument panel. If the speed controls are placed in the supply line the actuator could “starve” for air resulting in jumping or erratic operation. Placing the speed control in the exhaust port eliminates this problem and will allow precise regulation of the valve operating speed. This simple, but often overlooked, detail can greatly extend valve operating life.

Re-pressuring and de-pressuring of the towers is dependent on many factors such as tower size, pressure, flow restrictors, etc., and most experts agree that de-pressuring of the tower should be gradual, no faster than a 50 psi change per minute.[3] Some form of flow control is necessary for the tower to gradually de-pressure and if this flow rate is not taken into consideration and the appropriate flow limiter installed at the time of plant design, high fluid velocities can occur when the de-pressuring valve opens. If this high flow rate is not taken into consideration at the design stage the de-pressuring valve is likely to be damaged. The solution is to consider the potential flow rates at the de-pressuring line and install the appropriate flow restricting devices. Changing trim materials in the valve does not solve this problem.

Turnarounds, Shutdowns, Repair, and Maintenance

Once the plant is operational and all of the construction and start-up bugs have been worked out, it is common for a dryer to operate continuously for an extended period of time, perhaps five years or more. Eventually the beds will require attention and a turnaround is scheduled. During this turnaround it makes economic sense to inspect and repair all equipment in the system so that the next run cycle can be long and trouble free.

To ensure proper operation of the unit, rebuilding of the beds must receive the same care and attention that was given at the time of construction. It is necessary to remove and replace the ceramic balls and desiccant and to inspect and replace the screens along with all of the packing. It is common for an operator to experience problems on start-up similar to those during initial plant start-up. Loading of the ceramic balls and desiccant is critical and the same care and attention to detail is critical to keep the ceramic balls and desiccant in the tower and out of the valves. While this may seem elementary, many operators are forced to re-learn these start-up lessons immediately following a turnaround.

It is a common practice, and highly recommended, to refurbish the switching valves during a turnaround. As mentioned earlier, these valves are critical to the operation of the system and have seen the same harsh operating conditions as the tower.

There are two schools of thought as to the extent of repairs performed during a turnaround. One is to inspect and replace only those components exhibiting damage or wear. This approach may make sense in cases where the service support and spare parts are easily accessible. Additional parts, if necessary, could be expedited and additional service personnel called in when needed. If this approach is chosen, care must be taken to ensure parts are available and can be acquired within the time frame. If the plant is isolated in a location where importation of parts is difficult and visas for service personnel are problematic, or the valve components are special (special material, size, pressure class, etc), this approach is less viable.

The alternate approach is to prepare to replace all components in the valve and have these parts on hand prior to shutdown. While this approach seems the most expensive alternative it may save money in the long run by avoiding costly delays. Both approaches have their merits; each operator must decide which is best for their operation.

In addition to the valves, consideration should also be given to the actuators. Whether electric or pneumatic, the actuator is the key component in the successful operation of the dryer. It is easy to focus on the repair of the tower and the valves and completely overlook the actuators. It is best to consult the actuator manufacturer for recommendations on the frequency of maintenance, or repair and recommended spare parts to keep on hand. Remember the actuator can stop the operation of your plant just as quickly as any other critical component.

It is also highly recommended that personnel chosen to conduct the repairs on valves and actuators be qualified to perform the task. Any company can claim to have the expertise to repair valves and actuators to factory specifications; few however have the factory training or necessary knowledge. Saving a few dollars here can cost many dollars later in the form of unplanned shutdowns or poor performance from the valves/actuators that were repaired. Let the buyer beware!

Proper routine or preventative maintenance is another way to extend valve life and/or eliminate that “call in the middle of the night.” Valve and actuator manufacturers will have a recommended preventative maintenance schedule for their products and these schedules are based on the experience they have accumulated over the years. Following these recommendations can save much more than you pay and prove to be a valuable investment.

Conclusions

Extending the operating life on switching valves used in molecular sieve dehydration service is not rocket science; it is simply paying attention to some simple details.

1. Install the valves into a clean system.
2. Keep the molecular sieve desiccant and ceramic balls in the drying tower.
3. Maintain recommended air pressure on the actuator so the appropriate closing force is applied (and not exceeded).
4. Control the speed of operation to conform to manufacturer recommendations.
5. Ensure properly sized instrument piping is installed.
6. Follow the manufacturer’s recommended preventative maintenance program.
7. Properly repair valves and actuators according to the manufacturer’s recommended procedures.
8. Consult the valve and actuator manufacturer for the appropriate repair parts.

If these simple steps are followed, the life of your molecular sieve dehydration switching valve will be greatly extended and will improve performance.

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[1] Ruskin, John. Common Law of Business
[2] Stellite is a trademarked name of the Deloro Stellite Company
[3] Gas Processors Suppliers Association. (2004) Engineering Data Book 12th Edition. (Volume 1 Section 1-15). Tulsa, OK. Gas Processors Suppliers Association

The Author

Mike Wood is currently the Business Development Manager focusing on the Gas Processing & LNG market for Orbit valves for Cameron International Corporation. He began his career with Orbit Valve Company in June 1974 and has held various management positions including posts in Venezuela and is credited with start-up Aftermarket operations in Point Lisas, Trinidad, Chengdu, China, and Edmonton, Alberta. He spent 15 years of his career in Orbit/Cameron’s Aftermarket organization working closely with global customers in the areas of quality, design, and performance on valve-related challenges. He is highly regarded in the valve industry as a Rising Stem Ball Valve expert, particularly in the investigation and repair of valves in the oil/gas processing industry. With his combined 36+ years of valve, actuation and process experience, Mike provides a wealth of mechanical and automation solutions where customers use critical service valves in the gas processing industry.

CAMERON

Valves & Measurement
3250 Briarpark Drive, Suite 300
Houston, TX 77042
USA Toll 800 323 9160

For the most current contact and location information go to: www.c-a-m.com