CASE STUDY | PETROCHEMICAL | BOILER FEED WATER

How Alpont Methanol Stopped Replacing Boiler Feed Water Orifice Plates Every Three Months

An engineering case study from Restrict Flow LLC. The Anti-Cavitate Orifice Plate™ in AL6XN super austenitic stainless steel absorbs 740 PSI of differential pressure across one device, ending a multi year cycle of unplanned plant shutdowns at a methanol production facility.

BFW Pump A discharge piping at Alpont Methanol's Oregon, Ohio facility, photographed during the period when the original multi stage configuration was in service. Two standard restriction orifice plates were installed in series in the upper and lower flange sets visible above the pump motor. Plate failures in this configuration drove a quarterly cycle of unplanned plant shutdowns.

Executive Summary

For several years, the boiler feed water pump system at Alpont Methanol's Oregon, Ohio facility ran on a punishing maintenance cycle. Every three months, give or take, a standard restriction orifice plate in the BFW pump discharge piping would fail. Each failure announced itself with violent cavitation and downstream noise, and each one required a full plant shutdown to replace the failed component. The plant absorbed the lost production and the maintenance cost on a quarterly basis. They ran this way for years.

Working with Jeff Chappel, Chief Engineer at Restrict Flow LLC, Alpont replaced the legacy two plate restriction orifice configuration with one Anti-Cavitate Orifice Plate™ machined from AL6XN super austenitic stainless steel. The new component absorbs the full 740 PSI differential between BFW pump discharge and the downstream system, dropping line pressure from 750 PSI to 10 PSI at 175 GPM, across one engineered device.

Since the Anti-Cavitate Orifice Plate™ went into service, Alpont Methanol has not experienced a single orifice plate failure. The same component that previously required quarterly replacement has run continuously without remediation. A four month inspection confirmed no measurable wear on the plate and no pitting in the downstream pipe spool. The customer subsequently issued a follow up purchase order for an identical plate on the parallel BFW pump.

This case study documents the failure mode of the original configuration, the engineering work behind the replacement, the role of metallurgy in surviving high pH boiler feed water service, and the field results that ended the quarterly shutdown cycle.

The Customer

Alpont Methanol, operated by Interstate Chemical Company, produces methanol from natural gas at its facility in Oregon, Ohio. Like virtually all steam based industrial processes, the plant depends on continuously available, treated boiler feed water at controlled pressure. The reliability of every downstream operation, including steam generation, heat recovery, and process heat, is gated by the performance of the BFW pump train.

The BFW pump system at the facility uses parallel pumps (designated A and B) of identical specification. Each pump discharges into piping that requires substantial pressure reduction before water reaches its downstream destination. That pressure reduction is the application that drives this case study.

The Original Configuration

The legacy BFW pump discharge used two standard flat restriction orifice plates installed in series, separated by a vertical pipe spool. The plates were 1/2 inch thick T316L stainless steel, designed for 2 inch Schedule 40 pipe in a 600# RF SW flange set. Each plate was sized to carry a portion of the total pressure drop, with the spool between them allowing some pressure recovery before the second plate. A 90 degree elbow sat upstream of the arrangement, an isolation valve sat downstream.

This is a textbook approach to high differential pressure orifice service: stage the pressure drop across multiple plates so that no individual plate produces a vena contracta pressure low enough to flash the fluid into vapor. The conventional wisdom is that staging keeps each plate inside a cavitation safe envelope.

In this application, the staged approach did not prevent damaging cavitation.

Operating Conditions

Parameter	Value
Pipe size	2 inch, Schedule 40
Flange rating	600# RF SW
Inlet pressure	750 PSI
Outlet pressure	10 PSI
Differential pressure	740 PSI
Flow rate	175 GPM
Operating temperature	190 °F
Fluid	RO water with chemical treatment
Treated pH range	8.80 to 9.20
Original plate material	T316L stainless steel, 1/2 inch thick
Original plate replacement interval	Approximately every three months for several years

Water Chemistry

Boiler feed water at the Alpont facility is treated with a chemical program designed for oxygen scavenging, metal passivation, and steam line corrosion control. The combined treatment maintains BFW pH between 8.80 and 9.20, a deliberately elevated range that protects carbon steel piping from acid attack while keeping dissolved oxygen levels low enough to prevent oxidative corrosion.

This is a critical detail. High purity BFW at elevated pH and 190 °F service temperature is a chemically aggressive environment for metals. Not because of bulk corrosion, but because of localized attack. Trace chloride ingress, combined with elevated pH and continuous flow, can initiate pitting and crevice corrosion in austenitic stainless steels that would be perfectly stable in most other services. This water chemistry drove the material decision discussed later in this paper.

The Failure Mode: What Came Out After Three Months

Every three months or so, the operations team at Alpont would hear it. Violent cavitation in the BFW discharge, downstream noise rising to the level of an emergency, and the plant would go through the procedure that had become routine: isolate the pump, lock out the energy, drain the line, and open the flange sets to remove what was left of the failed plate.

BFW Pump A discharge piping isolated and locked out for one of many quarterly orifice plate replacements under the original multi stage configuration. The DANGER LOTO tag and the UPPER and LOWER flange identification tags marked a procedure that recurred every three months for several years.

The two images below document what came out of the system on one of those replacements. They are two faces of the same plate, photographed after approximately three months in BFW service.

One face: continuous wear across the surface. The bore is still mostly defined.

The opposite face: violent destruction at the bore from cavitation collapse.

The plate began as a standard 1/2 inch thick T316L stainless steel orifice with a 0.6296 inch precision bore, mill finish, and a 600# rating. Both faces show wear from continuous cavitation exposure. One face has been violently destroyed at the bore. The handle stamping is still legible. The functional part of the plate is gone.

This was not gradual wear. This was the failure mode that produced the violent cavitation and downstream noise the operations team learned to recognize as the signal that another shutdown was coming. Once the bore opens up, flow accelerates, cavitation intensifies, and the failure cascades. The plate goes from working to wasted in a window measured in hours.

Why It Happened: Cavitation Between the Plates

The wear pattern is a textbook presentation of cavitation in the region between two staged plates. As fluid passes the first plate, pressure recovers along the connecting pipe spool. Any vapor bubbles formed at the first plate's vena contracta collapse against the pipe wall and the upstream face of the second plate. The high velocity microjets produced by those collapses cut into stainless steel like sandblasting, with damage that compounds at every cycle.

In multi stage flat plate configurations under high differential pressure, the space between the plates is exactly where the worst cavitation damage occurs. The Alpont system was performing as designed thermodynamically. The pressure drop was being achieved. The system was sacrificing material integrity to do it, and the bill came due every three months.

Why It Got Worse: Material Limitations

The choice of metallurgy contributed to the failure cycle. Type 316L stainless steel is a reasonable default for general process piping, but it is not always sufficient for high pH BFW service at elevated temperature, particularly when there is active cavitation to expose fresh metal surfaces.

Cavitation erosion is mechanical, but the freshly exposed metal it creates is immediately vulnerable to chemical attack. In a high pH, high purity water environment with continuous flow at 190 °F, even trace chloride exposure can initiate pitting and crevice corrosion in 304 and 316 stainless. The combined mechanism accelerates failure rates well beyond what either pure cavitation or pure corrosion would produce alone.

A complete solution had to address both problems at once. The geometry that created the cavitation, and the material that had to survive the chemistry.

The Solution: Anti-Cavitate Orifice Plate™ in AL6XN

The Anti-Cavitate Orifice Plate™ is Restrict Flow's proprietary anti-cavitation technology. The plate's geometry is not disclosed publicly, but its behavior in service can be summarized straightforwardly. It absorbs a large pressure differential without producing the vapor bubble collapse zone that defines damaging cavitation. Pressure drop happens cleanly across one device. Downstream pressure stabilizes without bubbles imploding against pipe walls or downstream metal.

The engineering basis for this approach was developed by Jeff Chappel during his work designing nuclear flow elements for primary cooling systems. The Anti-Cavitate Orifice Plate™ was first demonstrated in Abu Dhabi in 2010 as part of the United Arab Emirates Nuclear Power Program kickoff, alongside the U.S. delegation led by Energy Secretary Steven Chu. Related flow element designs developed by Restrict Flow engineering have been applied in nuclear cooling system applications and in advanced reactor development programs.

Material Selection: AL6XN

The Alpont application required AL6XN super austenitic stainless steel, not 304 or 316. AL6XN is a high molybdenum, high nickel grade engineered for environments where standard austenitic stainless runs out of corrosion resistance. Compared to T316L, AL6XN provides:

- Superior pitting and crevice corrosion resistance in chloride bearing environments.
- Higher tolerance for high pH, high purity water at elevated service temperature.
- Resistance to chloride stress corrosion cracking, a known failure mode for 304 and 316 in BFW service.
- Excellent erosion resistance when paired with anti-cavitation geometry.

For an industrial plant running BFW at pH 8.80 to 9.20 with continuous oxygen scavenging chemistry and 190 °F service, this material upgrade is not optional. It is what allows the plate to survive the service environment indefinitely while standard 316L plates fail in three months. Over a multi year service life, the math heavily favors the better material.

This is one of the most common engineering misses we see in the field. The plate geometry gets attention. The metallurgy gets the default. Both have to be right.

Design and Code Compliance

The plate was designed in accordance with ASME B31.3 Process Piping for the customer's service conditions. Restrict Flow also supports B31.1 Power Piping for steam and high temperature water applications, marine service piping, and government nuclear processes including PDR (Preliminary Design Review), CDR (Critical Design Review), and safety review participation.

Specifications delivered for this project:

- **Material:** AL6XN super austenitic stainless steel
- **Plate thickness at flange face:** 0.375 inch
- **Pipe specification:** 2 inch, Schedule 40
- **Flange specification:** 600# RF SW
- **Handle:** 5 inch length, permanently marked with INLET on the upstream side, customer PO number, and restrictflow.com

Installation and Commissioning

The Anti-Cavitate Orifice Plate™ was installed in August 2020 in the lower flange position of the BFW Pump A discharge piping. The previous upper flange position, which had held the second of the two original standard plates, was filled with a spacer to maintain the original pipe geometry without modification. Per Restrict Flow's design guidance, the engineered profile of the plate faces upstream and the handle is installed with the INLET marking visible on the upstream side. The customer's millwright crew handled the physical installation. Restrict Flow's engineering team provided installation guidance and confirmed handle orientation and flange torque pattern before the system was returned to service.

The Anti-Cavitate Orifice Plate™ in service at Alpont Methanol, installed in the lower flange position. Only the handle is visible from outside the piping. The plate body absorbs the 740 PSI pressure differential between the flange faces.

Flow development was a meaningful part of the engineering conversation. The ideal installation location for any restriction orifice plate is in a straight run of pipe, with 6 to 12 pipe diameters of clear length both upstream and downstream of the plate. Elbows, valves, and other flow disturbances within that envelope can degrade plate performance for any restriction orifice technology.

The Alpont piping geometry did not allow for ideal flow development on both sides of the plate. The choice was where to put it: the upper flange position, immediately below the isolation valve, or the lower flange position, immediately above the 90 degree elbow at the pump discharge. The lower position was selected. Cavitation behavior is determined primarily by what happens downstream of the orifice as pressure recovers, and the lower position gives the fluid the longest available run of clean vertical pipe to reconstitute its flow profile after passing through the device. The full pipe spool that previously sat between the two original standard plates now serves as downstream flow development space.

To validate performance under these installation conditions, a removal and inspection was scheduled for the first available pump down opportunity.

Four Month Inspection: Verifying Performance

In December 2020, approximately four months after installation, BFW Pump A was taken offline and the orifice plate was removed for inspection. The customer's plant engineering team documented the condition of the plate and the surrounding piping before the system was restored to service.

Plate Condition

The Anti-Cavitate Orifice Plate™ showed only minor surface discoloration consistent with normal exposure to treated BFW at 190 °F. No measurable erosion. No detectable wear. No evidence of cavitation damage on either upstream or downstream faces. The handle markings remained legible. The plate was returned to service with no remediation required.

Compared to the destruction documented in the failure mode photographs above, this is the kind of result that verifies the engineering analysis.

Downstream Spool and Pipe

The downstream pipe spool, the section that had previously absorbed continuous cavitation damage in the original two plate configuration, was similarly intact. No pitting damage. No erosion patterns. No detectable wall thinning. The metal was holding up exactly as the engineering analysis predicted once the cavitation source was eliminated.

Customer Feedback

In a post inspection email to Restrict Flow, the plant engineer at Alpont confirmed:

> *"Other than some discoloration, the plate was in perfect condition with no signs of erosion. Despite the cavitation noise, there was also no sign of pitting damage in the downstream spool or pipe… it seems like a successful solution to our primary problem."*

The customer noted some residual cavitation noise, which Restrict Flow engineering investigated and discussed with the plant. The most likely source is flow turbulence at adjacent piping features (a 90 degree elbow and isolation valve in close proximity) rather than damaging cavitation at the plate itself. The inspection findings support that interpretation. No corresponding wear or pitting was found anywhere in the inspected section.

Based on the inspection results, Alpont Methanol issued a follow up purchase order for an identical Anti-Cavitate Orifice Plate™ for the parallel BFW Pump B.

The Result That Matters: Zero Failures

The four month inspection confirmed what the engineering analysis predicted. The result that matters most to plant operations is what happened over the months and years that followed.

Since the Anti-Cavitate Orifice Plate™ went into service, the BFW pump system at Alpont Methanol has not experienced a single orifice plate failure. No quarterly shutdowns. No plant downtime attributable to the orifice. No emergency replacements. No more violent cavitation events announcing that another plate had wasted through.

The same component that drove a multi year cycle of unplanned shutdowns has, in its replacement form, become a non event in plant maintenance planning. The orifice plate is no longer something the plant has to think about.

For Alpont Methanol's operations team, this is what success looks like in BFW service. An engineered solution that runs.

The operational cost of quarterly plant shutdowns, lost production, and repeated plate replacements over several years substantially exceeded the installed cost of the Anti-Cavitate Orifice Plate™. For plants running on similar maintenance cycles, the economic case is straightforward.

Engineering Takeaways for Plant and Reliability Engineers

For plant engineers, reliability engineers, and rotating equipment specialists facing similar high differential pressure restriction orifice service, several principles emerge from this project.

1. Cavitation between staged plates is the most common cause of repeat orifice failures.

Multi stage flat orifice arrangements appear to be a conservative engineering choice but actually create the conditions for the most damaging form of cavitation. Vapor bubbles formed at the first plate collapse against the second plate and the spool wall in between. Wear in the spool and bore destruction at the downstream plate are the diagnostic signatures. Quarterly replacement cycles are the operational signature.

2. One engineered plate can do the work of two flat plates, with no failures.

When the geometry is engineered for pressure recovery management rather than simple flow restriction, one device can absorb the full differential pressure with no inter plate region for bubbles to collapse in. The Alpont application now takes 740 PSI of differential across one Anti-Cavitate Orifice Plate™ with no observed erosion.

3. Material selection cannot be an afterthought.

High pH BFW chemistry, elevated service temperatures, and any cavitation activity will find weaknesses in standard 304 or 316 stainless. AL6XN, or another super austenitic, duplex, or super duplex grade, is often warranted for restriction orifice service in BFW, condensate, and high purity water applications. The cost of the better material is small compared to the cost of one plant shutdown.

4. When flow development cannot be ideal on both sides, prioritize downstream pipe length.

The standard 6 to 12 pipe diameters of clear pipe on both sides of the plate is the best practice when geometry allows it. When it does not, downstream pipe length is the more important of the two. Cavitation behavior is determined by pressure recovery downstream of the orifice, not by upstream flow uniformity. The Alpont installation places the Anti-Cavitate Orifice Plate™ in the lower flange position immediately above the 90 degree elbow at the pump discharge, with the full vertical pipe spool above it serving as downstream flow development space. The plate is performing without measurable wear in this configuration.

5. Schedule an early inspection on nonideal installations.

For installations where flow development conditions are not ideal, schedule a removal and inspection at the first available pump down. Direct visual confirmation of plate and downstream pipe condition gives the plant evidence that the solution will hold for the long term, and identifies any need for adjustment before damage accumulates.

About the Anti-Cavitate Orifice Plate™

The Anti-Cavitate Orifice Plate™ is a trademarked anti-cavitation technology developed by Restrict Flow LLC. It is in service in nuclear power plants, paper mills, pharmaceutical facilities, petrochemical plants, methanol production, and other industrial facilities requiring high to low flow pressure reduction.

Each Anti-Cavitate Orifice Plate™ is custom engineered for the customer's specific flow conditions, fluid properties, pipe and flange specifications, material requirements, and applicable design code (B31.1, B31.3, marine, or nuclear). Standard restriction orifice plates and flat plate solutions are also available through the Restrict Flow online store for less demanding services.

About Restrict Flow LLC

Restrict Flow LLC is a Service Disabled Veteran Owned Small Business (SDVOSB) headquartered in Friendswood, Texas. The company specializes in custom orifice plates, anti-cavitation flow restriction technology, and fluid flow process engineering and consulting for industrial, power, marine, nuclear, paper, pharmaceutical, and petrochemical applications. Our team supports power piping (B31.1), process piping (B31.3), marine applications, and government nuclear processes including PDR, CDR, and safety reviews.

Jeff Chappel, Chief Engineer

Jeff Chappel leads engineering at Restrict Flow LLC. He holds a Bachelor's degree in Aeronautical Engineering from Embry-Riddle Aeronautical University and a Master of Business Administration from the C.T. Bauer College of Business at the University of Houston.

His career spans more than two decades of fluid flow design and operations across nuclear, chemical, power, and industrial sectors. Prior to founding the company that became Restrict Flow, Jeff served fourteen years at United Space Alliance, where he supported NASA's Space Shuttle and International Space Station programs at Johnson Space Center, leading project management and program oversight for a 14,000 employee aerospace contractor. He subsequently developed flow element designs that have been applied in nuclear cooling system applications and in advanced reactor development programs.

In 2010, Jeff was invited to attend the United Arab Emirates Nuclear Power Program kickoff meetings in Abu Dhabi alongside the U.S. delegation led by Secretary of Energy Steven Chu. The Anti-Cavitate Orifice Plate™ was first demonstrated at this event.

Jeff is a published contributor to Pumps & Systems magazine on the subject of cavitation in industrial piping systems.

Request a Sizing Consultation

Restrict Flow provides direct engineering consultation for every customer application. Whether you have a specific set of flow conditions that need to be met or are looking at the system from a larger reliability perspective, our engineering team will work with you to define the right solution.

To discuss a specific application, request a sizing consultation, or receive a quote:

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