Every Innovation
Has a Mission

# AREVA Surface Mitigation:
## Ultra-High-Pressure Cavitation Peening

AREVA
forward-looking energy

Mitigate primary water stress corrosion cracking (PWSCC) risk for the remaining life of your plant — at a lower cost and outage impact than traditional component replacement or repair methods.

## Every Innovation Has a Mission

Imagine that you had a way to stop primary water stress corrosion cracking (PWSCC) with a risk-free process that uses only water — a solution that does absolutely no harm to the surface of your components and provides a depth of compression that exceeds MRP requirements. **It's here — AREVA's Ultra High Pressure (UHP) Cavitation Peening.** Our mission is to develop timeless solutions to stop plant aging — all while meeting your cost, schedule, safety, and performance goals.

## Expanding Your Options

AREVA's UHP cavitation peening process is a surface mitigation solution that is applicable to the key components of the primary system — reactor vessel head (RVH) nozzle penetrations, bottom mounted nozzle (BMN) instrumentation penetrations, and reactor vessel primary nozzles. These components — comprised of Alloy 600 welded with Alloy 82 /182 — are highly susceptible to PWSCC, caused by a combination of three factors:

- A susceptible material — in this case Alloy 600 and Alloy 82 /182
- A corrosive environment — in this case the primary system borated water at high temperatures and pressures
- Tensile stresses at the wetted surface created during the manufacturing process — specifically, welding heat-affected zones

Industry-wide, inspections have continued to reveal indications of PWSCC in these aging components. Plant operators have historically had two options — component replacement or repairs — both of which are costly and significantly impact outage critical path.

As the industry addresses these challenges to ensure safe extended operation, AREVA brings the right experts to the table to provide a real, highly cost-effective new option — surface mitigation — to stop PWSCC before it starts without draining your capital budget.

## A Timeless Solution to Stop Plant Aging

AREVA's UHP cavitation peening process uses submerged, ultra-high-pressure water jets to work the surface of reactor vessel components. The high-pressure water flow creates vapor bubbles. As these vapor bubbles collapse on the component's surface, shock waves travel into the material and create compressive residual stresses. Rather than allowing operational stresses to create multiple, random fractures on a component's surface, cavitation peening creates compressive stresses on the surface of the material in a controlled manner, preventing PWSCC initiation.

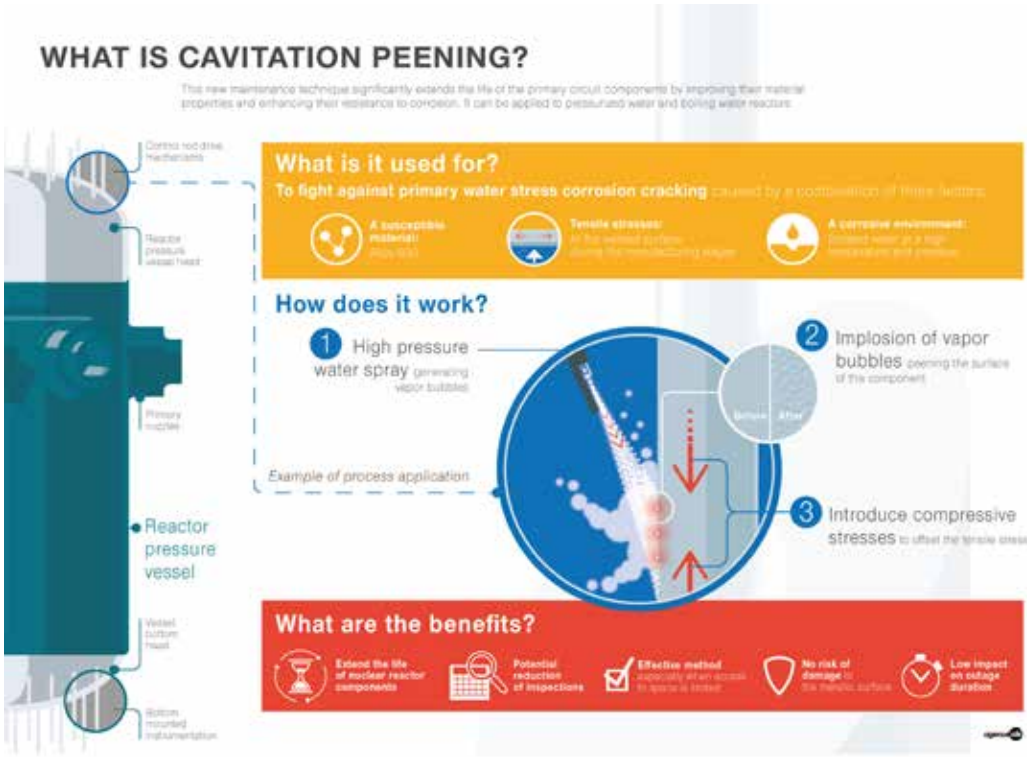
AREVA's innovative new process operates at a higher pressure with less restrictive parameters than other mitigation alternatives, achieving a higher depth of compression and allowing a more efficient overall implementation schedule.

The long-term value of cavitation peening far outweighs the initial investment. You can always do a component replacement, or keep addressing indications with expensive repair methods. Or you can deploy one simple mitigation technique to significantly reduce risk.

Mitigation of all susceptible components is less expensive than future repairs, and you minimize the risk of extended plant shutdown and additional capital expenses.

## Features & Benefits

- Prevents primary water stress corrosion cracking (PWSCC)
- Provides asset life extension by stopping the degradation process
- Compressive stress depths exceed MRP requirements
- Reduces the risk of emergent repairs
- Lower cost than future repairs or replacements
- All wetted nozzle surfaces are mitigated
- Additional schedule and cost savings when in-service inspection (ISI) and surface mitigation scopes are combined
- No harm to component surfaces
- Process uses only water; no FME concerns
- Does not leave abrupt edges between peened and non-peened regions
- Mitigation with inspection provides asset warranty which could help with asset capitalization




## Bottom Mounted Nozzles

AREVA's UHP cavitation peening process stops PWSCC in its earliest stages, before a repair is required. And when performed during your 10-year reactor vessel in-service inspection, AREVA can inspect your BMNs and complete peening, saving several days of critical path time, significantly reducing your cost as compared to a BMN repair.

- Compressive stress depth: > .063" (1.5 mm) on BMN OD surfaces
- Compressive stress depth: > .020" (0.5 mm) on BMN ID surfaces
- No abrupt edge between peened and non-peened regions
- Very tolerant to surface conditions and geometries
- Very robust process with a large saturation zone
- Less complicated tooling, more flexible, and less risk than laser technology
- No FME concerns
- Safe for both personnel and components

## Nearly 60 U.S. plants have the potential for BMN PWSCC.

In particular, B&W-design BMNs have a higher susceptibility to PWSCC than those of most Westinghouse plants due to repairs after original fabrication implemented prior to startup. Cavitation peening eliminates the high residual stress from these repairs as well as FME concerns from circumferential cracking of repair welds. As ISI exams move to twenty-year intervals, you can avoid an emergent BMN leak that requires time off the grid to repair a defective nozzle. With compact, qualified, state-of-the-art tooling for all three NSSS-design BMNs, including the field repaired B&W BMNs, AREVA can deliver proven protection to ensure your BMN performance well into the future.

AREVA BMN peening & NDE is the most cost-effective solution. With seamless operations between inspection and peening activities using synergized crews and equipment, AREVA has consistently improved Vessel Occupancy Time (VOT) during 10-year ISI examinations to the most recent record of completion in less than 3 days. AREVA tooling and NDE techniques are the recognized “Industry Best” for the majority of scopes, and all are field proven. We have won three Top Industry Practice (TIP) awards in the past five years with two earning “Best of the Best” designation. Our top priority is to deliver innovative solutions and secure operational excellence by reducing critical path time.

# Reactor Vessel Head Nozzles

AREVA's UHP cavitation peening process is the only solution available for non-intrusive RVH nozzle OD and ID surface mitigation with no enterprise risk and an implementation schedule that offers savings for both dose and critical path time. In addition, our customers can realize the following benefits:

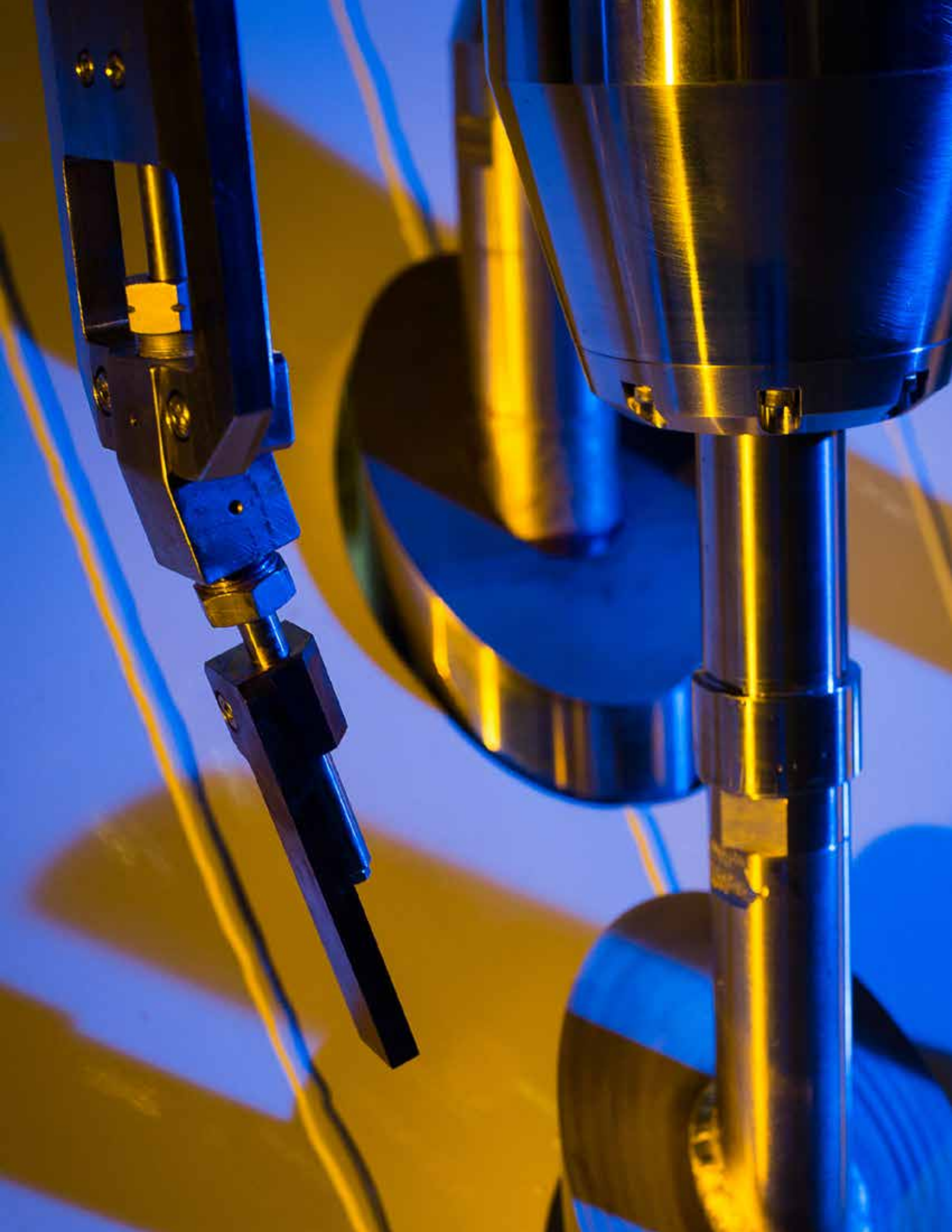
- Eliminates or delays need to replace RV head
- Best implementation schedule for OD & ID coverage
- AREVA is the only vendor that can peen the CRDM nozzle ID without removing or modifying the thermal sleeves
- Improves potential for inspection relief
- Depth of compressive stress exceeds MRP requirements
- Less complexity, more flexibility, easier and safer delivery, and higher confidence for success than laser technology
- Our under-head experience is second to none — AREVA has performed 134 of 177 RV head repairs since 2000
- AREVA repair approach addresses all flaw scenarios
- AREVA has never performed a re-repair on an IDTB location

AREVA's integrated NDE and RVH peening can save valuable inspection and transition time.

Using an under-head manipulator, AREVA can deliver both RVH penetration NDE and cavitation peening tooling, minimizing equipment turnover time and allowing operation of two systems in parallel.

- Only one head lift necessary
- Containment deck installed before RV head is set, not after inspection
- Same manipulator used for inspection and peening
- Integrated / synergized crew
- Single point of contact for our customers
- Maximum flexibility performing NDE

**The integrated system endurance testing will be complete this fall and ready to deploy this winter with our first implementation scheduled for March 2016.**



## Reactor Vessel Primary Nozzles

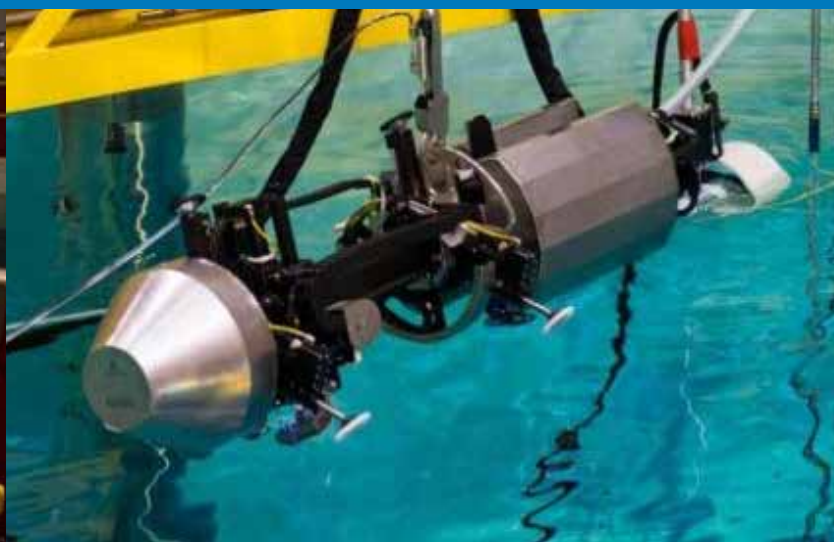
Mitigation of RV primary nozzles using AREVA's UHP cavitation peening prevents crack initiation and ensures existing shallow indications do not grow to an unacceptable size — all at a lower cost and with less impact to critical path than other mitigation techniques. No access to the OD of the primary nozzles? No problem — cavitation peening is delivered from the ID and can be used at sites that do not have access to the OD of the nozzles.

AREVA can also provide an integrated approach for ISI and mitigation of your primary nozzles. With a simple, robust underwater delivery platform based on AREVA's existing technology, mitigation can take place in parallel with your ISI and allow you to minimize the critical path schedule and reduce costs.

AREVA's surface mitigation solution is compliant with Code Case N-770-4 to return your plant to a 10-year inspection cycle. In 2015, AREVA will complete final qualifications of the UHP cavitation peening process for Westinghouse 3 and 4 loop RV primary nozzle designs.

- Simple, robust delivery platform uses existing AREVA technology
- Depth of compression meets or exceeds MRP requirements
- Mitigation can be performed in parallel with 10-year ISI
- Repair contingency for shallow flaws

Simple, robust underwater delivery platform



## No Substitute for Experience

AREVA maintains an extensive résumé of Alloy 600 repairs and component replacement capabilities. Our Component Repair & Replacement team has over a decade of experience with high-pressure water jet technologies, and AREVA is the only vendor who has performed water jet surface mitigation in the U.S. commercial nuclear industry. Our BMN and RV Head ID and OD peening systems have been developed and qualified to mitigate BMNs and RVH nozzles for all three NSSS designs.

Helping nuclear plants successfully navigate present energy market shifts is key to providing low-carbon solutions for our nation and communities in the 21st century. That's why AREVA has a track record of making life easier for its customers. Our culture focuses on single-point accountability, lessons learned, and operational excellence.

**You get the benefit of AREVA's regulatory experience bringing cavitation peening to the operating nuclear fleet and industry as a whole.**

AREVA in North America (AREVA Inc.) combines U.S. and Canadian leadership to supply high added-value products and services to support the operation of the nuclear fleet. Globally, AREVA is present throughout the entire nuclear cycle, from uranium mining to used fuel recycling, including nuclear reactor design and operating services. AREVA is recognized by utilities around the world for its expertise, its skills in cutting-edge technologies, and its dedication to the highest level of safety. Through partnerships, the company is active in the renewable energy sector. AREVA Inc.'s 4,300 employees are helping build tomorrow's energy model: supplying ever safer, cleaner and more economical energy to the greatest number of people.

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Energy is our future, don't waste it!

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**ANP:U-562-V3-16-ENG**