

AREVA UHP Cavitation Peening Update

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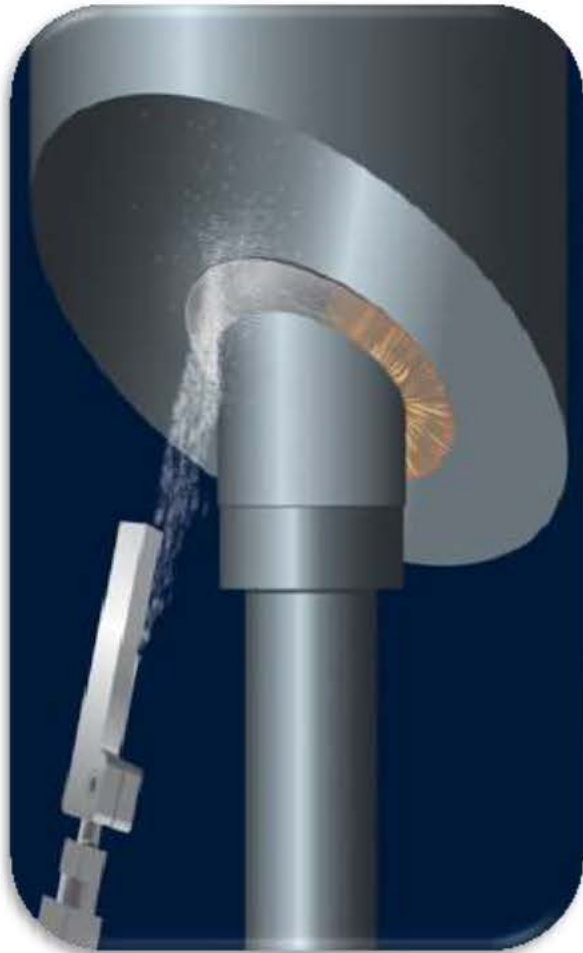
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Overview AREVA Peening Technology & Industry Update

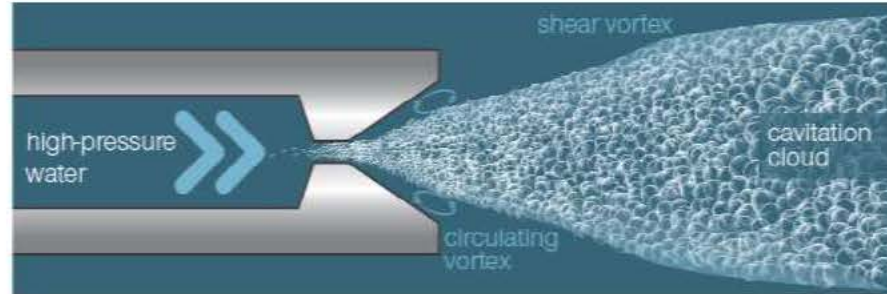


What is Ultra High Pressure (UHP) Cavitation Peening?



Ultra High Velocity Jet

Creates pressure below that of vapor pressure in water



Cavitation

Vapor bubbles form in water



Shock Waves

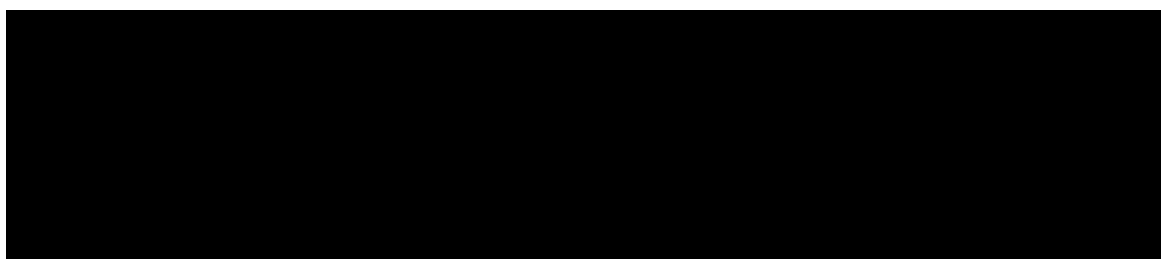
Occur from bubble collapse at surface generating high pressures on the material

Compressive Stresses

In the surface layer of material results

[Video](#)

Cavitation peening is a well understood, proven process

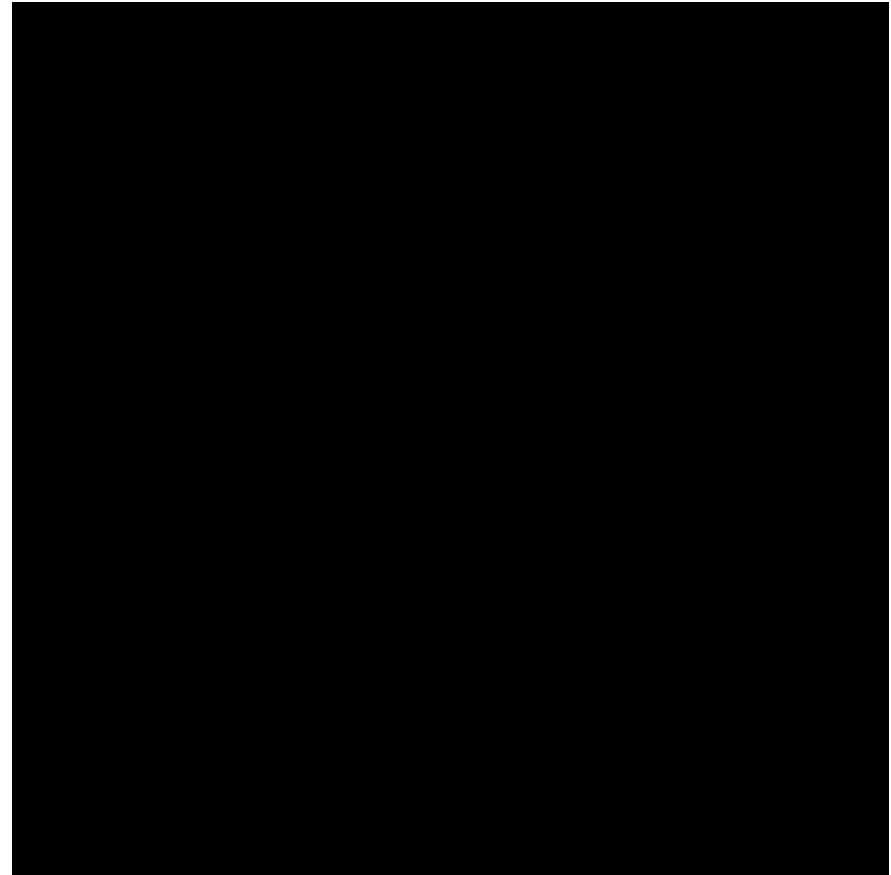


■ Unique Technologies

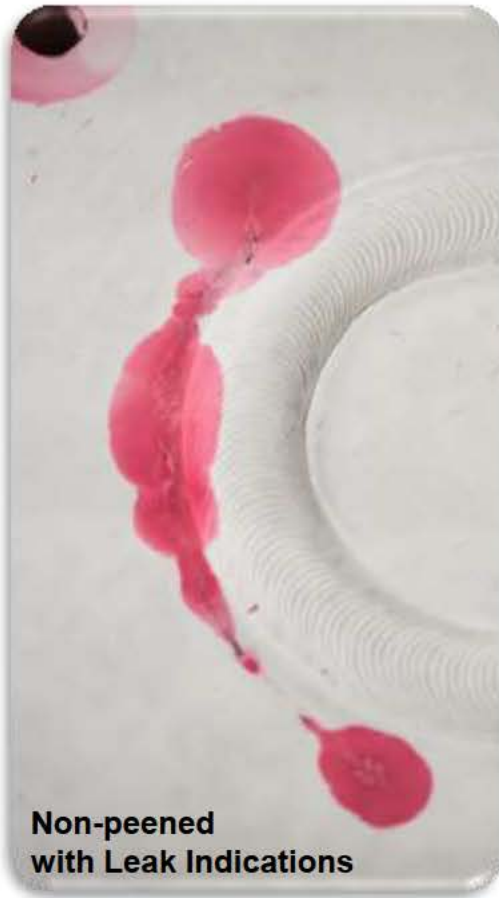
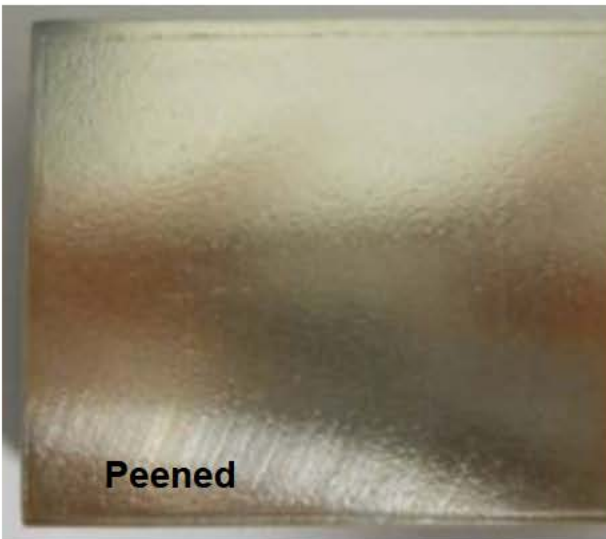
- ◆ UHP Cavitation peening (Patented)
- ◆ Hyperbaric testing
- ◆ Controlled depth abrasive jet milling
- ◆ High speed ceramic machining
- ◆ Selective coating removal
- ◆ Precision 5-axis machining
- ◆ Downhole energy tooling
- ◆ Nuclear cleaning & decommissioning tooling



■ Customers



UHP Cavitation Peening Surface Finish



Cavitation peened surfaces are not adverse to NDE

Why AREVA Selected UHP Cavitation Peening

- Compressive stress depths meet or exceed MRP requirements
- No abrupt edge between peened and unpeened regions
- Very tolerant to surface conditions and geometries
- Very robust process with a large saturation zone
- Does not require complicated tooling
- No FME concerns
- Safe for both personnel and component when operated within the controlled boundaries

AREVA scored UHP Cavitation Peening as the best mitigation process



AREVA RV Head Peening Technology Update



AREVA's 1st RVH Peening Implementation Completed Successfully

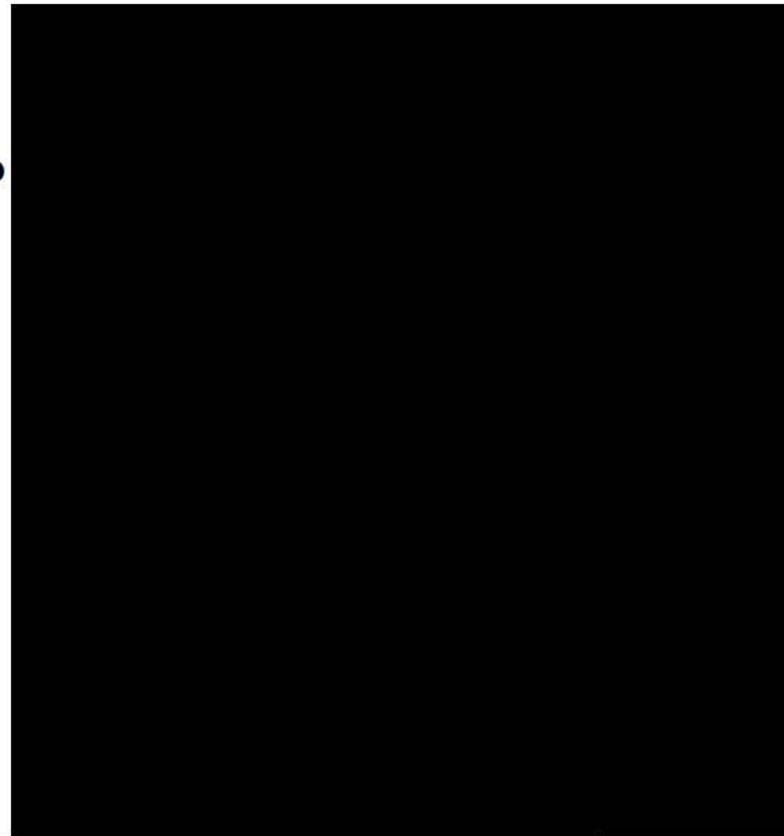
- Completed within a sub 30 day outage window
- Safety, HU, dose & PCE goals were all met
- Headstand modifications were implemented seamlessly and did not affect critical path
- With NRC approval, peening will provide for inspection relief that will reduce operating costs and dose

Cavitation Peening is a PROVEN Technology that will Maintain Your Asset for the Life of Your Plant

RV Head Peening All OD Surfaces



- ▶ Alloy 600 (nozzle): .xxx” + depth of compressive stress
 - ◆ Depth of compression eliminates flaw detection gap
- ▶ Alloy 82/182 (j-groove weld): .xxx” + depth of compressive stress
- ▶ Most adaptable process to the j-groove / nozzle geometry

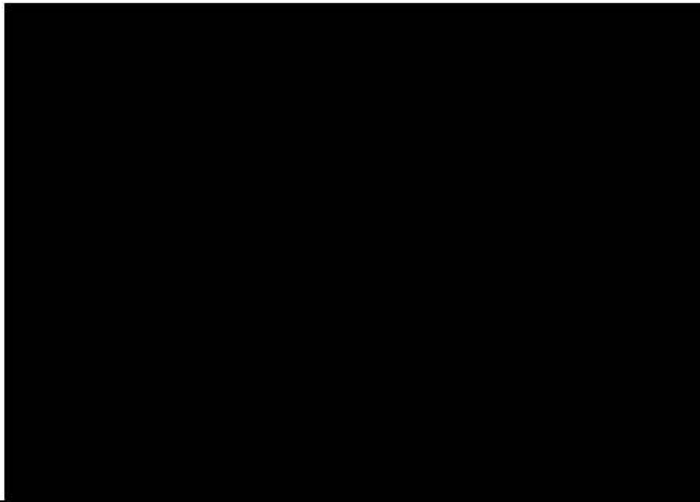


AREVA's UHP Peening eliminates flaw detection gap and Depth of compressive stress exceeds MRP requirement of 0.40"



RV Head Peening Open Penetration IDs

- ▶ Nozzles without thermal sleeves (such as thermocouples, spare nozzles)
- ▶ > .xxx” depth of compressive stress
- ▶ Seal around open penetration and flood up



Depth of compressive stress exceeds MRP requirement of .010”

RV Head Peening ID Annulus with Thermal Sleeves

- ▶ Greater than .xxx” (.xx mm) depth of compression on all PWSCC susceptible CRDM ID surfaces
- ▶ Exceeds the MRP requirement of .010”
- ▶ The only vendor that can peen the annulus without removing or modifying the thermal sleeves

AREVA's Cavitation Peening is the solution for ID surface mitigation

UHP Cavitation Peening Qualification

- ▶ The peening process effectiveness was demonstrated on full scale representative mockups at the nominal, max and min ranges of essential variables used for site implementation
 - ◆ Full scale nozzle mockups include material and geometry constraints
- ▶ X-ray diffraction was used to determine the residual stress on peened full scale representative mockups
 - ◆ Confirm the desired peening coverage and depth of compression has been achieved
- ▶ A qualification report is provided to the utility that documents how all requirements are met
 - ◆ Topical Report / Relief Request / ASME Code

Essential variable range for qualification mockups and site implementation are the same

Process Control and Verification

- ▶ Essential variables are controlled/monitored to ensure acceptable results are achieved
- ▶ The tooling control system records the value of each essential variable
 - ◆ The electronic data will be reviewed/verified post-process
- ▶ The operator has a real-time display of all essential variables
- ▶ If an essential variable gets outside of the qualified limits the operator is immediately alerted

*In – process verification /
post – process verification*



RV Primary Nozzle Cavitation Peening



Primary Nozzle Mitigation UHP Cavitation Peening

*Self-propelled tool to minimize time required to
move between nozzles*

Primary Nozzle Mitigation UHP Cavitation Peening



***Low dose, remote delivery -
alleviates polar crane use***

Primary Nozzle Mitigation UHP Cavitation Peening



Typical Primary Nozzle UHP Cavitation Peening Schedule

| | |
|---|--------|
| Rx Vessel Turnover to AREVA | x days |
| Typical 3-Loop On Component Cavitation Peening of RCS Primary Nozzles | x days |
| Demob Equipment | x day |

Typical Primary Nozzle UHP Cavitation Peening Dose

Dose estimate is approximately x REM

Significant dose reduction compared to other mitigation techniques

Peening can prevent PWSCC, reduce risk of flaw propagation, provide inspection relief, and transition your plant to a 10-year inspection cycle - all with a proven process

Primary Nozzle Mitigation Repair Contingency



Repair contingency for shallow flaws

BMN Cavitation Peening

Equipment Development

OD & ID Surface Tooling



Qualified state-of-the-art tooling ready to deploy

Typical BMN Cavitation Peening Schedule

- BMN tooling and process – Qualified
- Synergies with AREVA ISI inspections
- Typical 3 Loop BMN peening implementation schedule:
 - ◆ Includes peening of ID & OD, all 50 nozzles x days on component
- Depth of ID compressive stress .xxx”
- Greater than .xxx” depth of OD nozzle compressive stress exceeds .040” MRP min

Regulatory Compliance



Regulatory Compliance

- ***NRC SE fully supports inspection relief for RV Head and Primary Nozzles as defined in MRP-335R3***
- **Safety Evaluation for MRP-335R3 has been released**
 - ◆ Extend your RV Head inspection interval to 10 years
 - ◆ Extend your RV Primary Nozzle Inspection cycles to 10 years
- **Code Cases N-770-4 and N-729-5 are approved by ASME to provide inspection relief for RV Head and RV Primary Nozzles**
- **No Code Case for BMN peening**
- **The NRC is not imposing any additional BMN inspection requirements**
 - ◆ **Current requirement: bare metal visual examination every other refuel outage**

Why Peen RV Heads, Primary BMN Nozzles

- Mitigation prevents PWSCC initiation
- Mitigation provides asset life extension through elimination of the degradation process
- Cost of cavitation peening is less than the cost of emergent repairs
- Eliminates potential for repair and outage contingency cost
- AREVA exceeds the compressive stress requirements per MRP

Mitigate now or repair/replace later