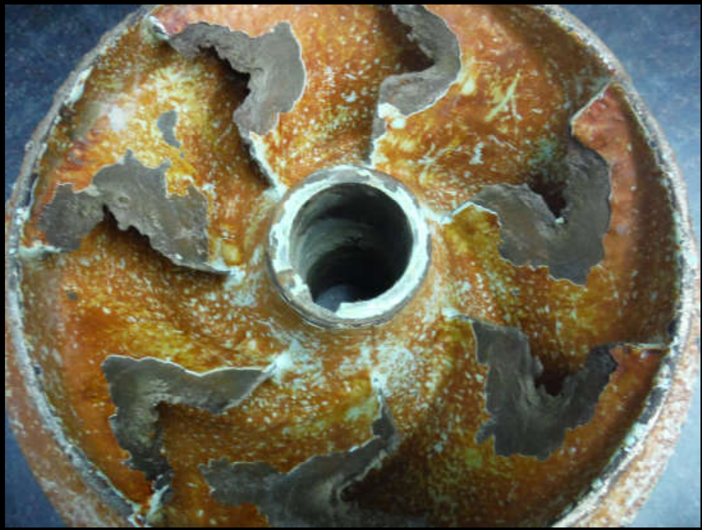
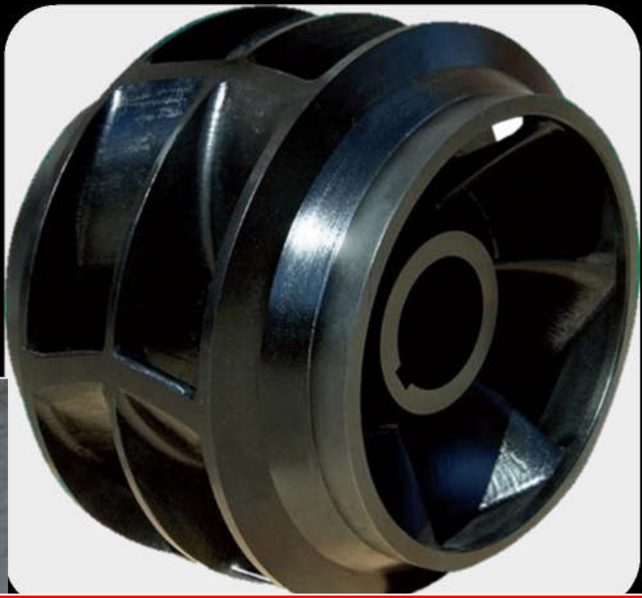
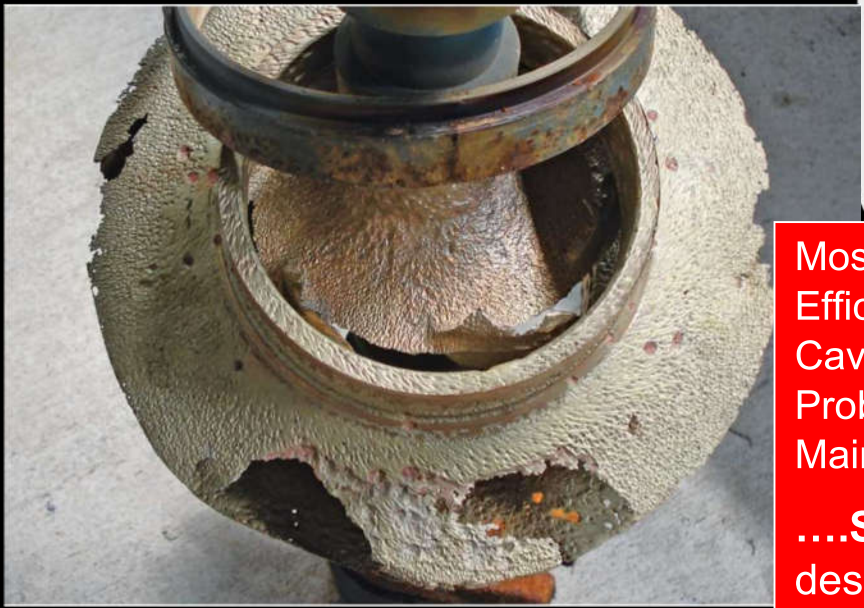
Cavitation Problems - and How SIMSITE® Solves Them!







Most pumps DO NOT operate at the Best Efficiency Point (BEP) which leads to Cavitation Problems, High Radial Loading Problems, Shaft Deflection Problems, Maintenance Problems and Inefficiency!

….SIMSITE® Pumps & Impellers are designed specifically for the Best Efficiency Point (BEP) and Therefore Outlast & Outperform All Metallics!!!

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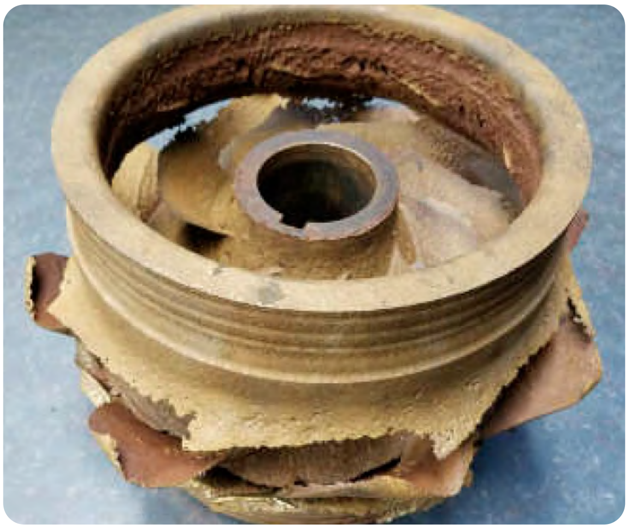
Cavitation & Recirculation Problems and How **SIMSITE®** **Pumps & Impellers** Solve those Problems

Cavitation is the result of liquid somewhere in a pump vaporizing, forming small bubbles and the bubbles later collapsing. As the bubbles collapse they take material creating cavities, holes, and weak spots. Cavitation occurs whenever the absolute pressure of the liquid is reduced to or below the vapor pressure of the liquid being pumped.

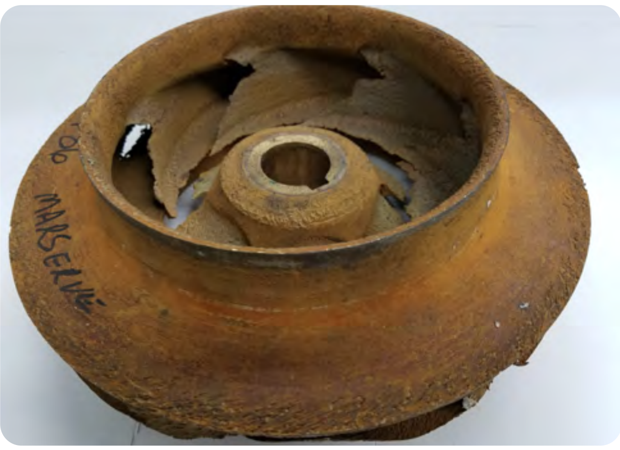
The bubbles that are formed move to places of higher pressure, collapse with great bursting force and causes metallic fatigue and severe pitting.



Cavitation Problems have increased as the number or high energy pumps operating in a broad range of capacities have increased including long duties at flows substantially below, or above, the BEP (best efficiency point) capacity and especially lower than the optimum impeller inlet capacity called shockless capacity, or the "Safe Operating Range."

Cavitation is an operational problem that occurs when the pump is operated away from the Best Efficiency Point (safe operating range) which means that the pump operates in the "1" with Suction and Discharge Re-Circulation and High Radial Loading which adversely affected performance, efficiency and operating conditions.

This is a huge problem when Customers purchase "Production Type Pumps." The Pumps are NOT designed specifically for the Customer's Operating Point (OP) Production Pumps can only come "close." Therefore, most pumps DO NOT operate at the Best Efficiency Point (BEP) leading to Cavitation Problems, High Radial Loading Problems, Maintenance Problems and Inefficiency!



Another issue that contributes directly to cavitation problems with production type pumps is that CAVITATION INCREASES by the third exponent of speed.

Recirculation Cavitation

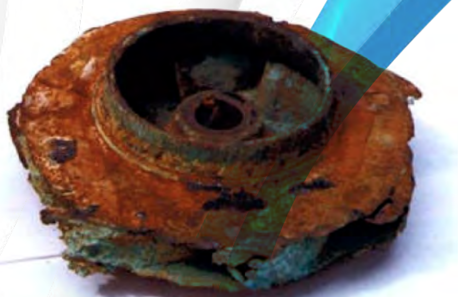
A very common hydraulic problem that occurs when the pump operates at a performance, which is different from the original design point is an occurrence called recirculation cavitation. When two flow paths within a fluid are moving in opposite directions and they are in close proximity to each other, vortices form between the two directions of flow causing high fluid velocities and turbulence, resulting in pockets of low pressure where cavitation occurs.

Suction Recirculation Cavitation occurs when fluid entering the pump suction is reversed, resulting in high velocity vortexes in or near the impeller eye. Theses high velocities produce low localized pressures at the center of the vortex resulting in cavitation damage, which occurs in the impeller eye in between the impeller vanes on the pressure side of the inlet vanes near the impeller eye. The recirculation cavitation damage increases the farther away the pump operates from the best efficiency point (BEP).

Discharge Recirculation Cavitation occurs when fluid leaving the impeller discharge may be reversed causing high velocity vortexes between the two flow directions, causing low-pressure areas. When these low-pressure areas drop below the vapor pressure of the fluid being pumped cavitation occurs. Discharge recirculation cavitation occurs on the discharge side of the impeller and the damage increases the farther away from the best efficiency point (BEP) the pump operates.

Suction Recirculation Cavitation: Damage in fresh water after only 3 months of operation!

Suction Recirculation Cavitation damage.



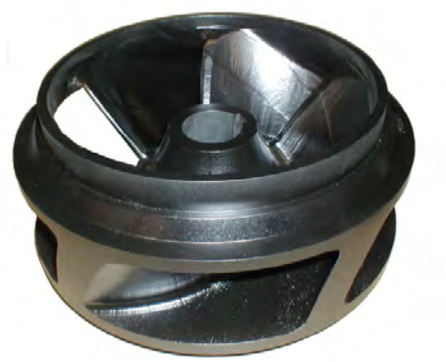
Discharge Recirculation Cavitation

The problem intensifies when a hydraulic parameter called suction specific speed (NSS) is high. Suction specific speed is the geometric relationship between the impeller eye diameter, the impeller outside diameter, and the NPSHr. (Net Positive Head Required) It is an indirect indication of the impeller eye being too large, but it also depends on several other factors related to the impeller design, installation, and application.

There are certain engineering rules and principles related to minimum allowable flow: as a function of pump energy, specific speed (NS), suction specific speed (NSS), and other factors. When violated, these rules and principles can cause trouble and problems.

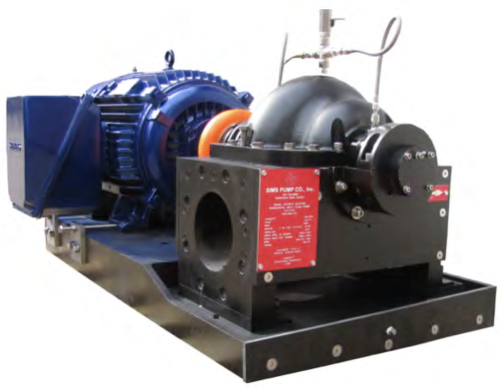
The Solution

The solution to eliminate Cavitation is to purchase SIMSITE® Pumps and SIMSITE® Impellers, which are designed and engineered specifically for the Customer's Operating Point (OP) making that performance the Best Efficiency Point! (BEP)



A SIMSITE® Impeller Specifically Designed, Engineered and machined to eliminate Cavitation!

A SIMSITE® Impeller Specifically Designed, Engineered and machined to eliminate Cavitation! Unlike other pump manufacturers, SIMS PUMP designs, engineers, and manufactures SIMSITE® Structural Carbon Fiber Composite Pumps & Impellers which are 100% machined on 5 to 8 axis machining centers from solid blocks of our patented SIMSITE® Structural Carbon Fiber Composite specificially for the Customer's Performance Requiremnts.



SIMS PUMPS, Impellers & Pump Upgrades last much longer than metallic products, becasuse the Operating Point (OP) is the Best Efficiency Point (BEP). SIMSITE® Pumps & Impellers are much more efficient and they do not require constant maintenance and repair like metallic off-the-shelf pumps & impellers!

SIMS PUMP can improve the efficiency of ANY Centrifugal Pump, and can extend the Life of any centrifugal pump just by upgrading the Impellers, Casing Rings, and guide bearings!

The Return-On-Investment (ROI) of a SIMSITE® Carbon Fiber Impeller & Ring Set is less than one year! The same applies for a SIMS PUMP and for an All-SIMSITE® Structural Composite Pump!

The solution to eliminate Cavitation is to purchase SIMSITE® Pumps and SIMSITE® Impellers, which are designed and engineered specifically for the Customer's Operating Point (OP) making that performance the Best Efficiency Point! (BEP) Unlike other pump manufacturers, SIMS PUMP designs, engineers, and manufactures SIMSITE® Structural Carbon Fiber Composite Pumps & Impellers which are 100% machined on 5 to 8 axis machining centers from solid blocks of our patented SIMSITE® Structural Carbon Fiber Composite specificially for the Customer's Performance Requiremnts. SIMS PUMPS, Impellers & Pump Upgrades last much longer than metallic products, becasuse the Operating Point (OP) is the Best Efficiency Point (BEP). SIMSITE® Pumps & Impellers are much more efficient and they do not require constant maintenance and repair like metallic off-the-shelf pumps & impellers! SIMS PUMP can improve the efficiency of ANY Centrifugal Pump, and can extend the Life of any centrifugal pump just by upgrading the Impellers, Casing Rings, and guide bearings! The Return-On-Investment (ROI) of a SIMSITE® Carbon Fiber Impeller & Ring Set is less than one year! The same applies for a SIMS PUMP and for an All-SIMSITE® Structural Composite Pump!

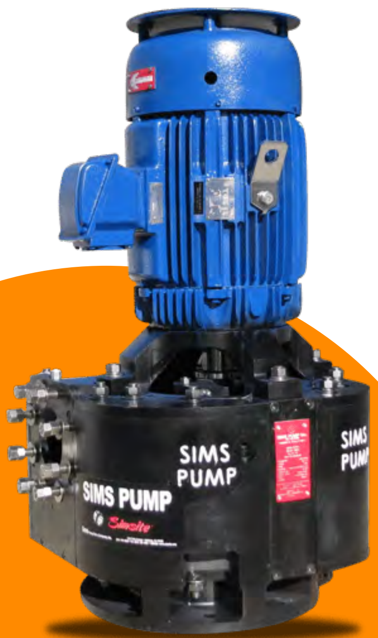
Definitions

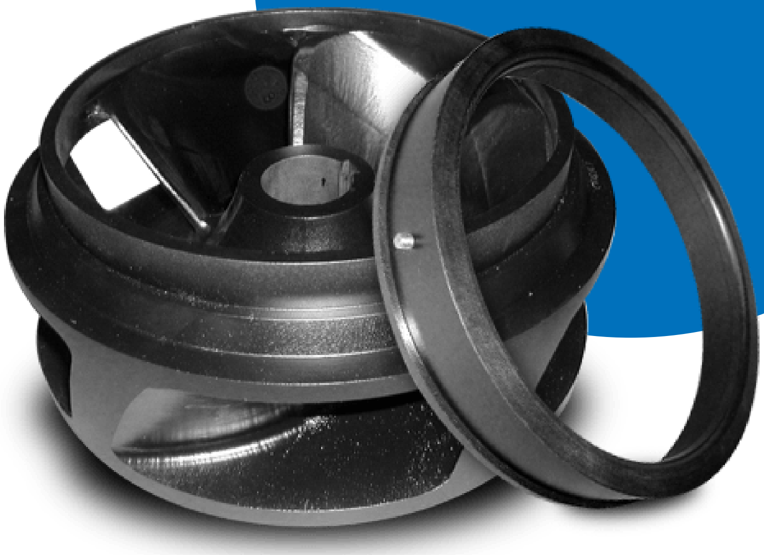
Rotating Stall.

A hydraulic phenomenon called rotating stall sets-in, which is essentially a back-flow that leaves the impeller eye and progresses backwards. This can result in violent piping vibrations, pressure pulsations, and premature wear of the components and cavitation problems.

Shockless Capacity.

The optimum capacity for the design of the impeller eye inlet. Shockless Capacity is a capacity that corresponds to the zero incidence angle (smooth matching of the flow direction with the blade inlet angle and the impeller inlet geometry.)





Cavitation Inception.

Cavitation inception can occur at NPSHA levels 5 - 20 times higher than NPSHR . Cavitation damage can occur below the inception point but still higher than NPSHR depending on factors such as peripheral velocity at the eye and pump operating capacity as a function of the shockless capacity.

Peripheral Velocity at the Impeller Eye.

If the peripheral velocity at the eye of the impeller is greater than 100 ft./sec. then it is an important factor in contributing to cavitation.

SCSS (SHEET CAVITATION SUCTION SIDE)

Ø1

At flow rates below Shockless (Qsl) (The optimum capacity for the design of the impeller eye inlet), cavitation damage occurs on the visible side of the vanes. (The low pressure side of the vanes.)

* Flow Reversal @ the Impeller Eye on the Low Pressure Side of the Impeller Vanes

* The Shockless Capacity (Impeller Inlet Optimum Capacity - Qsl) is Greater than the Operating Capacity (Q) which is Greater than the Onset of Suction Recirculation (Qrs)

*** Qsl > Q > Qrs**

SOLUTION:

- Reduce the Shockless Capacity by Reducing the Area in theImpeller Eye, which Increases the Through Flow, or Meridional Velocity
- Add an Impeller Inducer
- Use Various throttling Devices at the Inlet
- Add Inlet Guide Vanes at the Pump Suction

PERMANENT SOLUTION:

- REDESIGN THE IMPELLER INLET VANES AND EYE USING A SIMSITE® IMPELLER.

SCPS (SHEET CAVITATION PRESSURE SIDE)

02

At flow rates above Shockless (Qsl) (The optimum capacity for the design of the impeller eye inlet), cavitation damage occurs on the hidden side of the vane. (The high pressure side.)

* Flow Reversal @ the Impeller Eye on the Pressure Side (Hidden Side) of the Impeller Vanes

* The Capacity(Q) is Greater than the Shockless Capacity (Qsl)

*** Q > Qsl**

SOLUTION:

- Increase the Shockless Capacity (Qsl) By Cuting Back the InletVane Leading Edges
- Add a Blade Leading Edge Inducer
- Design an Impeller Inducer

PERMANENT SOLUTION:

- REPLACE THE EXISTING IMPELLER WITH AREDESIGNED AND ENGINEERED SIMSITE® IMPELLER

VCSR (VORTEX CAVITATION SUCTION RECIRCULATION)

A vortex is generated by the shear forces at the interface between the reverse flow leaving the impeller and the ordinary forward flow entering the impeller. When the inlet pressure is low enough and the strength of the vortex high enough, the pressure in the vortex core drops below the saturation pressure and cavitation results. Suction Recirculation Cavitation increases when the pump is operated closer toshutoff.

* Suction Recirculation Cavitation on the Pressure Side of the Vane, Commonly Referred to as "Suction Recirculation."

* CAPACITY (Q) < Onset of Suction Recirculation Capacity (Qrs)

*** Q < Qrs**

SOLUTION:

- Operate the Pump Closer to the Design Point
- Redesign the Impeller for the Current Performance
- Reduce the Impeller Eye Diameter Area
- Redesign the Impeller Inlet Vanes to Induce Flow
- Increase the Area Between the Vanes
- Impeller Eye Throttling Devices
- Inducer For Low Flow Capacity
- Inlet Guide Vanes

PERMANENT SOLUTION:

- REDESIGN THE IMPELLER WITH A SIMSITE® IMPELLER THAT IS DESIGNED FOR THE SYSTEM (CURRENT) OPERATING POINT.
- REDESIGN THE IMPELLER WITH A SIMSITE® IMPELLER WITH A LARGER AREA BETWEEN THE IMPELLER VANES AND A SMALLER EYE DIAMETER.

CVCI (CORNER VORTEX CAVITATION INLET)

Cavitation which occurs between the vanes on the suction side (Visible Side of the Vanes low pressure side) and the impeller hub surface. Corner vortex results from intense shear forces associated with the secondary flow patterns due to the interaction of the blade surface velocity and the boundary layers of the impeller hub surface.

* Flow Reversal on the Low Pressure (Visible) Side of the Vanes Near the Impeller Hub

* Capacity (Q) Is Less Than the Shockless Capacity (Qsl) (The optimum capacity for the design of the impeller eye inlet

* $Q < Qsl$

SOLUTION:

- Reduce the Incidence Flow Angle at the Impeller Blade Root
- Add Various Inlet Throttling Devices
- Add Inlet Guide Vanes

PERMANENT SOLUTION:

- REDESIGN THE IMPELLER INLET USING A SIMSITE® IMPELLER AND ADD A CONE INSERT @ HUB.

FDC (FLOW DISTORTION CAVITATION)

⌀5

This type of cavitation is produced by flow distortion at the impeller eye which is induced as a result of the suction inlet geometry (the inlet pump chamber (Casing Volute), and/or the suction piping).

* Cavitation Produced By Flow Distrotion at the Impeller Eye

* The Flow through Velocity is Not Uniform

* Usually a Very High Operating Capacity (Q)

SOLUTION:

- Redesign the Impeller for the Operating Capacity or Reduce Capacity
- Baffles
- Add Guide Banes in the Suction Casing
- Add a Special Insert at the Impeller Eye

PERMANENT SOLUTION:

- REDESIGN THE IMPELLER WITH A SIMSITE® IMPELLER DESIGNED FOR THE PRESENT OPERATING CAPACITY.

DRC (DISCHARGE RECIRCULATION CAVITATION) Ø6

Cavitation damage that occurs on the discharge side of the vane on the pressure or visible side.

* Cavitation Produced By a Flow Reversal at the Impeller Discharge (Exit Port) Resulting from Too Much Flow.

SOLUTION:

- Redesign the Impeller for a Reduced Flow
- Trim the Impeller Diameter By an Appropriate Amount
- Increase the Cutwater Diameter

PERMANENT SOLUTION:

- REDESIGN THE IMPELLER WITH A SIMSITE® IMPELLER THAT IS DESIGNED FOR A REDUCED FLOW @ DISCHARGE.

CAVITATION

Diagnosis For Damage Failures

FAILURE MODE		OPERATING CAPACITY	DAMAGE PATTERN		GEOMETRY PECULIARITY
FLOW MECHANISM	NAME		LOCATION	ASPECT	
SHEET CAVITATION (PS)	SCPS	Q>Qsl	BLADE PRESSURE SIDE (PS)	PITTING	–
SHEET CAVITATION (SS)	SCPS	Qsl>Q>Qrs	BLADE SUCTION SIDE (SS)	PITTING	–
VORTEX CAVITATION (SR)	VCSR	Q<Qrs	BLADE PRESSURE SIDE AT MID SPAN	SINGLE LARGE CRATER	–
CORNER VORTEX CAVITATION	CVCI	Q<Qsl	FILLET BETWEEN BLADE SS AND HUB	DEEP CRATERS (DRILLING) PERFORATION PITTING/HOLES	–
FLOW DISTORTION CAVITATION	FDC	HIGH (OFTEN)	BLADE PS (MOSTLY)	PITTING	SIDE SUCTION CASING AND /OR SUCTION ELBOW
FLOW IMBALANCE (SHEET CAVIT. AND/OR VORTEX CAVIT.)	FIC	ANY	DIFFERENT AT EACH EYE	PITTING CRATERS	DOUBLE SUCT. IMPELLER
IMPELLER OUTLET AND/OR DIFFUSER (VOLUTE) INLET					
CAVITATION DUE TO IMPELLER-DIFFUSER (VOL.) INTERACTION	CIDI	Q<Qsl	IMPELLER BLADE PS AND/OR DIFFUSER (VOLUTE) BLADE SS	INNUMEROUS MINIC RATERS	SMALL RADICAL CLEARANCE (GAP B)
CORNER VORTEX CAVITATION (EXIT)	CVCE	ANY (LOW MORE LIKELY)	FILLET BETWEEN BLADE AND SHROUDS (IMP. AND/OR DIFF.)	DEEP CRATERS	SMALL ZERO FILLET RADIUS

Sims since 1919

CAVITATION

Solution Strategy For Damage Failures

<table>
<tr><th colspan="2">FAILURE MODE</th><th colspan="3">TEMPORARY FIX</th><th colspan="2">PERMANENT FIX</th></tr>
<tr><th>FLOW MECHANISM</th><th>NAME</th><th>GEOMETRY</th><th>MATERIAL</th><th>SYSTEM</th><th>GEOMETRY</th><th>MATERIAL</th></tr>
<tr><td>SHEET CAVITATION (PS)</td><td>SCPS</td><td>BLADE LEADING EDGE INDUCER</td><td rowspan="6">WELDING (DPECIAL CASES)
UPGRADE:
A) CAVIT. RESISTANT MATERIALS</td><td rowspan="8">FLOW STRAIGH-TENERS VANED ELBOWS (MITRA TYPE OR SPECIAL DESIGN) POSSIBLE</td><td rowspan="4">CHANGE IMPELLER DESIGN (INDUCER OR VANES)</td><td rowspan="8">SIMSITE COMPOSITE IMPELLERS</td></tr>
<tr><td>SHEET CAVITATION (SS)</td><td>SCPS</td><td rowspan="3">VARIOUS THROTTLING INLET DEVICES INDUCE INLET GUIDE VANES</td></tr>
<tr><td>VORTEX CAVITATION (SR)</td><td>VCSR</td></tr>
<tr><td>CORNER VORTEX CAVITATION</td><td>CVCI</td></tr>
<tr><td>FLOW DISTORTION CAVITATION</td><td>FDC</td><td rowspan="2">BAFFLES, GUIDE VANES IN SUCTION CASING SPECIAL INSERT AT IMPELLER EYE</td><td rowspan="2">IMPELLER AND/OR SUCTION CASING</td></tr>
<tr><td>FLOW IMBALANCE (SHEET CAVIT. AND/OR VORTEX CAVIT.)</td><td>FIC</td></tr>
<tr><td>CAVITATION DUE TO IMPELLER-DIFFUSER (VOL.) INTERACTION</td><td>CIDI</td><td>LARGE GAP IMP. DIFF. BLADE MODIFICATION</td><td rowspan="2">LOCAL REPAIR WITH SPECIAL ALLOY DEPENDING ON BASE METAL</td><td rowspan="2">IMPELLER AND/OR DIFFUSER BLADE (VOLUTE) CUTWATER</td></tr>
<tr><td>CORNER VORTEX CAVITATION (EXIT)</td><td>CVCE</td><td>LARGE FILLET RADIUS BLADE MODIFICATION</td></tr>
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