Flow Analysis of 2 Suction Diffusers and a CRV Flex Using Computational Fluid Dynamics (CFD)
Executive Summary:

Conclusion: The CRV Flex provides a better flow profile entering the pump, therefore better pump performance, than a suction diffuser. The CRV Flex also has a significantly lower pressure drop.

Introduction:

Two CFD simulations are contained herein. Both analyze leading products used to condition and improve flow entering a pump. The first CFD analysis is of two popular styles of suction diffusers: the traditional cylindrical screen diffuser and the more recent model with a conical diffuser screen.

The second simulation is of the CRV Flex. A fixed vane device placed in front of the pump’s suction side elbow which imparts a half revolution to the media flowing through the elbow (see back cover). This minimal deflection of flow negates the turbulence caused by the geometry of the 90 degree elbow and produces measurably better flow conditions and lower pressure drops than a suction diffuser.

Methodology:

Modeled were 4” x 3” reducing suction diffusers and a 4” x 3” reducing CRV Flex. Both designs were simulated at fluid velocities of 4 ft/sec and 10 ft/sec to determine overall pressure drops as well as the condition of the flow exiting the devices. Flow conditions between these ranges, slightly below and above can be interpolated from the data.

Simulations were conducted using CF Design version 9.0 from Blue Ridge Numerics, Inc.

<table>
<thead>
<tr>
<th>Pressure Drop, psi</th>
<th>Conical Screen</th>
<th>Cylindrical Screen</th>
<th>CRV</th>
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</thead>
<tbody>
<tr>
<td>4 ft/s</td>
<td>0.682</td>
<td>0.671</td>
<td>0.37</td>
</tr>
<tr>
<td>10 ft/s</td>
<td>4.288</td>
<td>4.46</td>
<td>2.19</td>
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CRV in a REDUCING ELBOW SIMULATION

SUCTION DIFFUSER SIMULATION

pg. 4A & 6B

CRV Suction Diffuser

pg. 5B

Suction Diffuser

pg. 7A
Metraflex Suction Diffuser Simulation

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October 31, 2006
Project Summary:

A computational fluid dynamics analysis was performed on the Metraflex 4” x 3” suction diffuser to determine the overall pressure drop through the diffuser as well as the condition of the flow exiting the device. Furthermore, an analysis was performed on a cylindrical screen design (constant screen cross-section) for a performance comparison. Both designs were simulated at fluid velocities of 4 and 10 ft/s. The simulations were conducted using CFdesign version 9.0 from Blue Ridge Numerics, Inc.

Project Methodology:

The CFdesign analysis setup is shown below in Figure 1. Additional pipe lengths were modeled upstream and downstream of the diffuser to ensure fully developed flow at the device and at the constant pressure outlet.

Simulation Assumptions:

Various assumptions were made for the simulation of the suction diffuser and are listed below:

- Steady-state conditions
- Incompressible flow
- Water modeled at standard temperature and pressure
- Screen diffuser modeled as a distributed radial resistance (34% open area)
- Thermal effects negligible

Figure 1. CFdesign analysis setup conditions.
Results:

Cut-surfaces showing pressure results are displayed in Figures 2-5 below. These cut-surfaces are oriented in such a way that they bisect the flow passing through the device. Figures 2 and 3 show results from the 4 ft/s inlet flow case while Figure 4 and 5 show those from the 10 ft/s case. The pressure drop across each design is summarized in Table 1.

Figure 2. Cut-surface showing pressure data. (Conical diffuser, 4 ft/s)

Figure 3. Cut-surface showing pressure data. (Cylindrical diffuser, 4 ft/s)
Figure 4. Cut-surface showing pressure data. (Conical diffuser, 10 ft/s)

Figure 5. Cut-surface showing pressure data. (Cylindrical diffuser, 10 ft/s)

Table 1. Pressure delta summary across the device for each screen type and inlet flow velocity.

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Contours of fluid velocity magnitude through the device are shown in Figures 6-9 below. It is clear that several areas around the diffuser screen do not experience significant fluid flow and can be considered areas of stagnation. The effect of the cross-like screen support can be seen in the fluid velocity results. Higher velocities were found in the top two chambers, especially in the conical diffuser analyses. It is shown that the cylindrical diffuser provides a more uniform fluid velocity among the four inner chambers.

Figure 6. Cut-surface showing fluid velocity magnitude. (Conical diffuser, 4 ft/s)

Figure 7. Cut-surface showing fluid velocity magnitude. (Cylindrical diffuser, 4 ft/s)
Both designs showed that approximately 53% of the total fluid volume travels through the top two inner diffuser chambers, yet the difference in peak velocities between the upper and lower chambers was consistently higher in the conical design. This shows that the fluid velocity distribution exiting the screen diffuser region is more uniform with a cylindrical screen diffuser.
A comparison of the flow profiles approximately 3 inches downstream of the device is shown below in Figure 10. In both the 4 and 10 ft/s scenarios, the cylindrical diffuser screen provided a significantly more uniform outlet flow.

**Figure 10.** Fluid velocity profiles approximately 3 inches downstream of the diffuser screen.
Fluid particle traces released into the inlet stream are shown below in Figures 11-16. These traces help to visualize the fluid path as it travels through the device. In particular, Figures 13 and 16 highlight the areas of flow stagnation around the screen and the higher speed flow exiting the upper two inner diffuser chambers.

**Figure 11.** Fluid particle traces. (Conical diffuser)

**Figure 12.** Fluid particle traces. (Conical diffuser)
Figure 13. Fluid particle traces. (Conical diffuser)

Figure 14. Fluid particle traces. (Cylindrical diffuser)
Figure 15. Fluid particle traces. (Cylindrical diffuser)

Figure 16. Fluid particle traces. (Cylindrical diffuser)
Conclusions:

After reviewing the results obtained through CFD analysis, it is clear that the main difference in performance between the two diffuser screen designs is to be found in the downstream flow profiles. While the overall pressure drop through each suction diffuser is almost identical, the downstream flow profile is more uniform with a cylindrical diffuser. Both designs showed similar areas of minimal fluid flow through several portions of the diffuser screen.
Metraflex CRV in a Reducing Elbow Simulation

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January 26, 2006
**Project Summary:**

The Metraflex six-bladed CRV flow conditioner was analyzed to determine its effect in a 4” to 3” reducing elbow at water velocities of 4 and 10 feet per second. The simulations were conducted using CFdesign version 9.0 from Blue Ridge Numerics, Inc.

**Project Methodology:**

The CFdesign analysis setup is shown below in Figure 1. Additional pipe lengths were modeled upstream and downstream of the elbow to ensure fully developed flow at the CRV and at the constant pressure outlet.

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**Simulation Assumptions:**

Various assumptions were made for the simulation of the elbow and are listed below:

- Steady-state conditions
- Incompressible flow
- Water modeled at standard temperature and pressure
- Constant water properties
- Thermal effects negligible
**Results:**

Cut-surfases showing the velocity profile and velocity vectors for both analyses are shown below in Figures 2 and 3, respectively. Note that there is very little discernable flow separation around the reducing elbow with the CRV in place. The CRV aides in providing a more uniform velocity profile beyond the reducing elbow.

*Figure 2. Cut-surface showing velocity contours through the reducing elbow.*
Figure 3. Cut-surface showing velocity vectors through the reducing elbow.
A cut-surface of velocity approximately three inches downstream of the elbow is shown in Figure 4. Both analyses show similar velocity profiles, with slightly lower velocity regions near the bottom of the pipe due to the swirling action of the CRV.

![Figure 4. Velocity distribution normal to the flow 3” downstream of the elbow.](image)
The pressure gradient for both analyses is shown below in Figure 5. The total pressure drop through the CRV and elbow was found to be 0.37 psig for the 4 ft/s case and 2.19 psig for the 10 ft/s case.

**Figure 5.** Cut-surface showing pressure gradients through the elbow.
Figures 6 and 7 below show particle traces released from various points on the pipe inlet. These traces show where individual fluid particles will travel as they pass through the system. Note the similar flow patterns shown for both flow rates. The swirling effect of the CRV is clearly visible.

**Figure 6.** Fluid particle traces shown for the 4 ft/s flow rate.

**Figure 7.** Fluid particle traces shown for the 10 ft/s flow rate.

**Conclusions:**

The Metraflex CRV flow conditioner is shown to provide a near uniform velocity distribution downstream of the elbow. The CRV is effective in eliminating the large recirculation regions that would develop downstream of the elbow without a flow conditioner.
**Standard CRV® Flex Configurations**

Pictured is the CRV vane in our CRV Flex straight pump connector. This configuration is designed to be installed before a suction elbow. The CRV Flex is also supplied with the elbow and in any of the configurations illustrated.

Stationary, curved fins rotate flow so it moves smoothly through the elbow.