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White Paper
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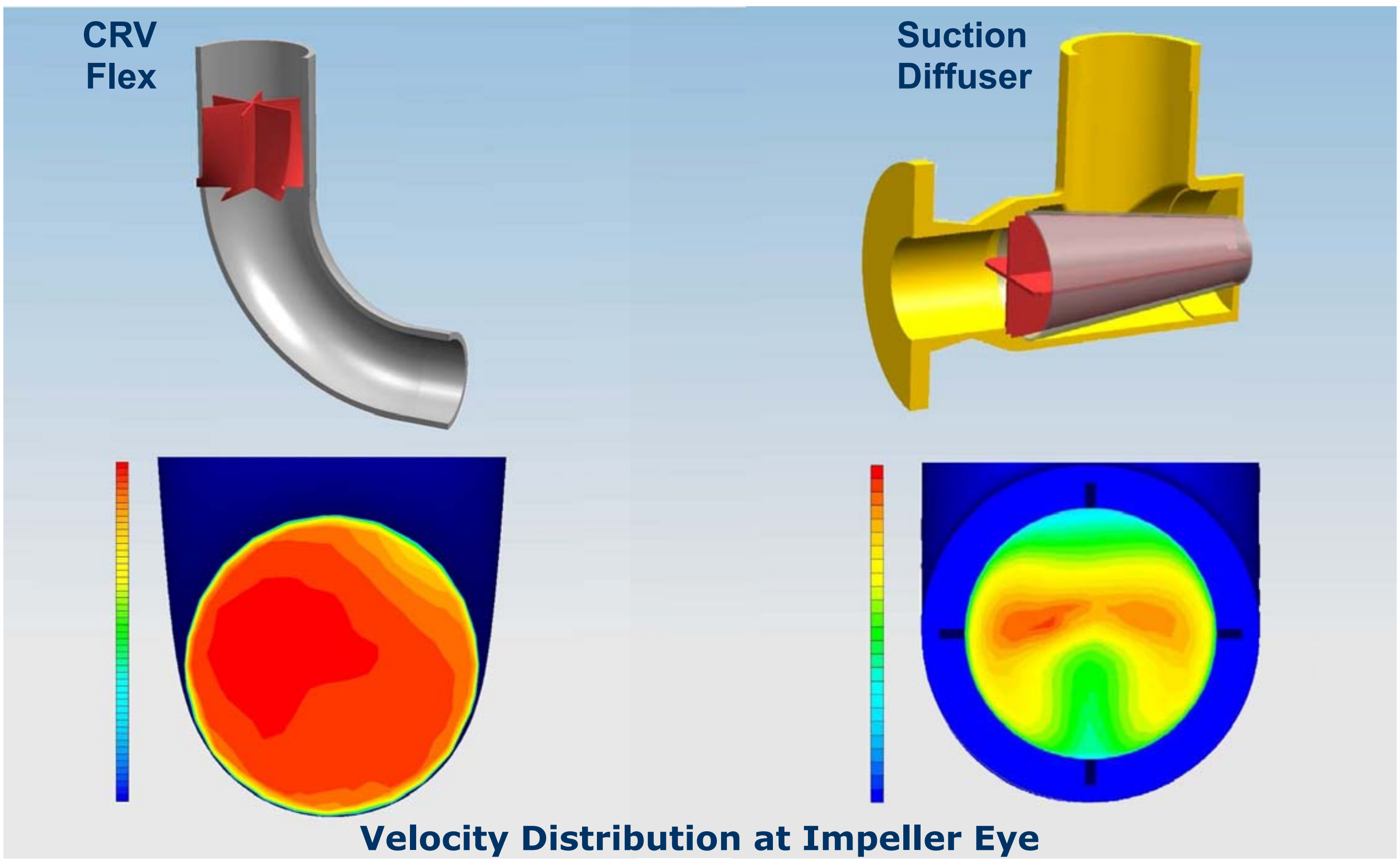
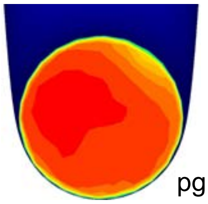


Flow Analysis of 2 Suction Diffusers and a CRV Flex Using Computational Fluid Dynamics (CFD)

Executive Summary:

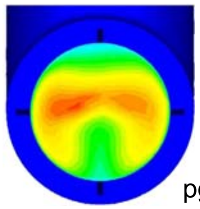
Conclusion: The CRV Flex provides a better flow profile entering the pump, therefore better pump performance, than a suction diffuser. The CRV Flex also has a significantly lower pressure drop.

CRV



pg. 5B

Suction Diffuser



pg. 7A

	Pressure Drop, psi		
	Conical Screen	Cylindrical Screen	CRV
4 ft/s	0.682	0.671	0.37
10 ft/s	4.288	4.46	2.19

pg. 4A & 6B

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.

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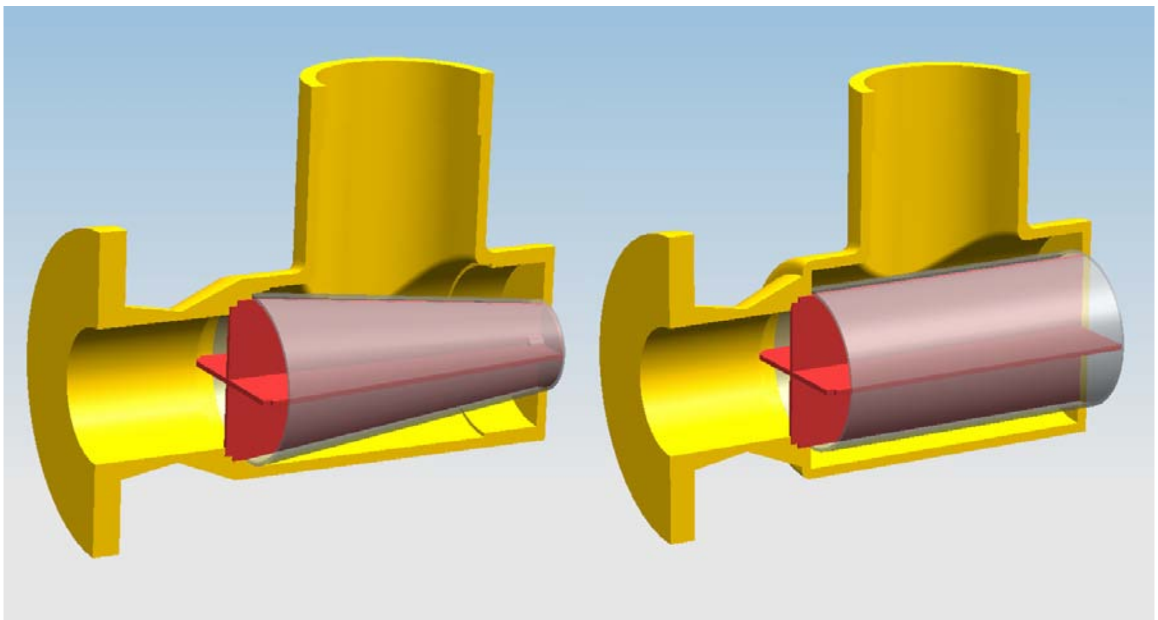
SUCTION DIFFUSER SIMULATION



Metraflex Suction Diffuser Simulation

James C. Neville
Project Engineer, Engineering Services
Blue Ridge Numerics, Inc.
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.

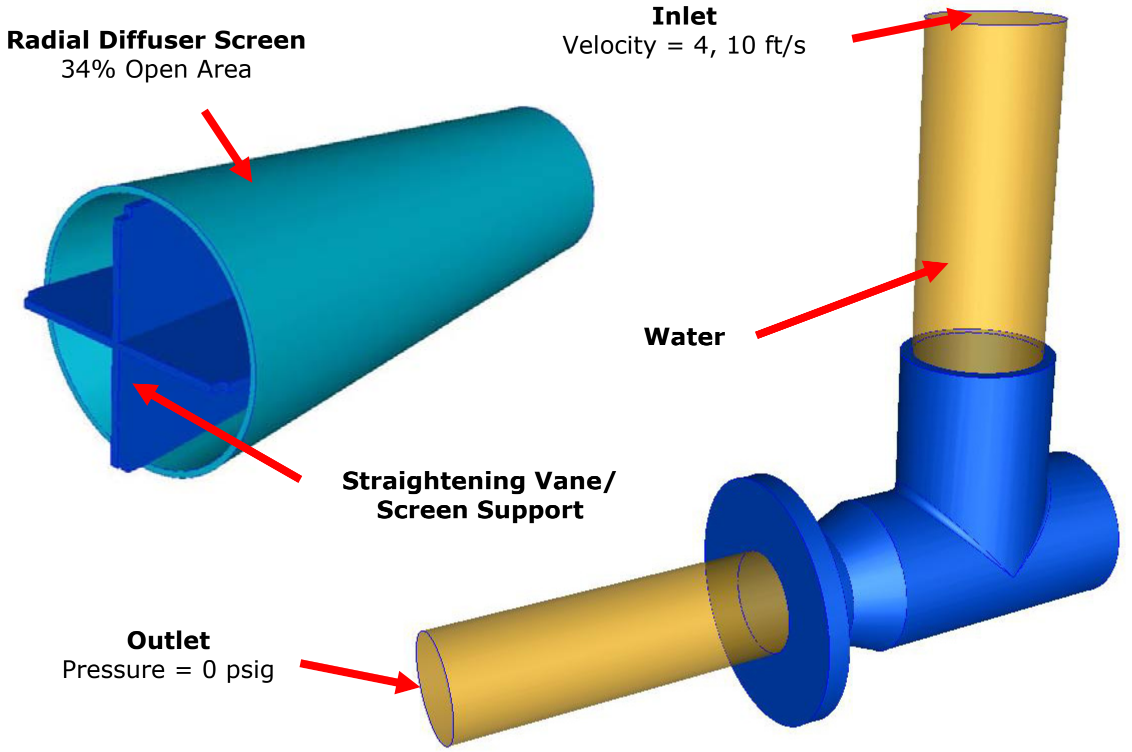


Figure 1. CFdesign analysis setup conditions.

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

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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.

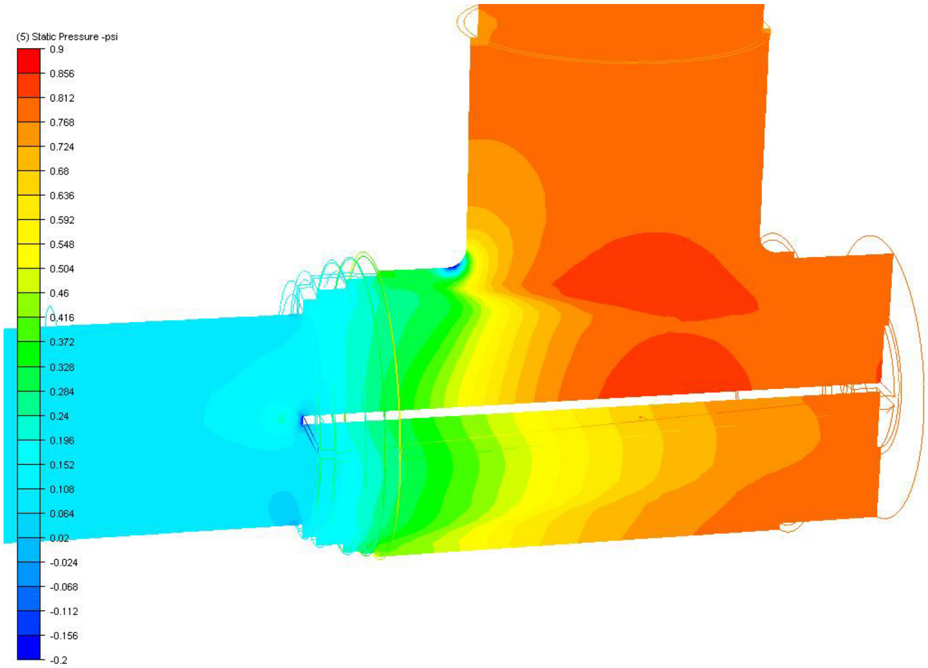

Figure 2. Cut-surface showing pressure data. (Conical diffuser, 4 ft/s)

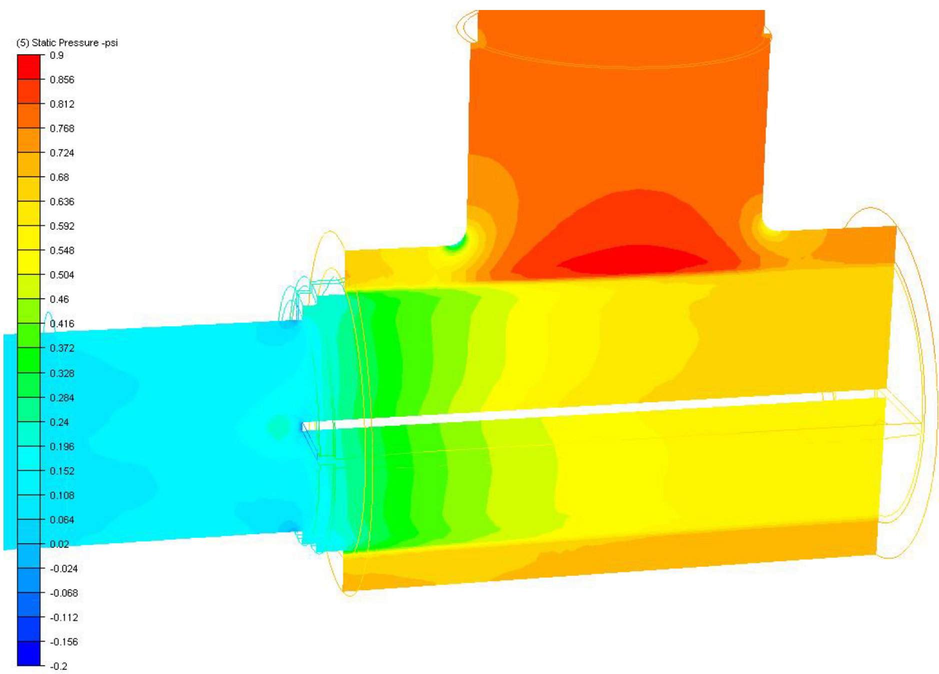

Figure 3. Cut-surface showing pressure data. (Cylindrical diffuser, 4 ft/s)

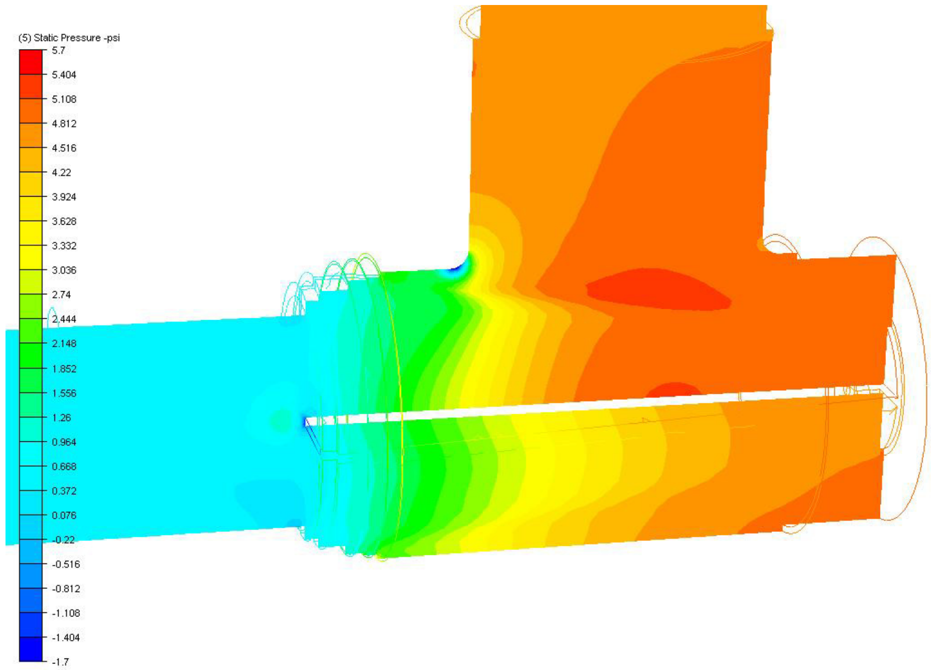

Figure 4. Cut-surface showing pressure data. (Conical diffuser, 10 ft/s)

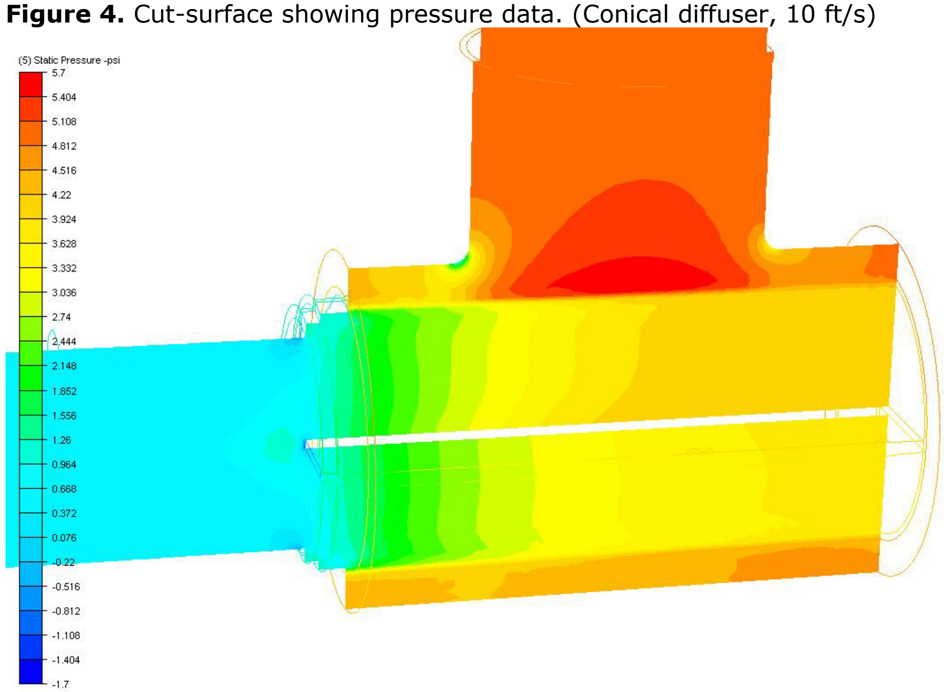

Figure 5. Cut-surface showing pressure data. (Cylindrical diffuser, 10 ft/s)

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

	Pressure Drop, psi	
	Conical Screen	**Cylindrical Screen**
4 ft/s	**0.682**	**0.671**
10 ft/s	**4.288**	**4.46**

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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.

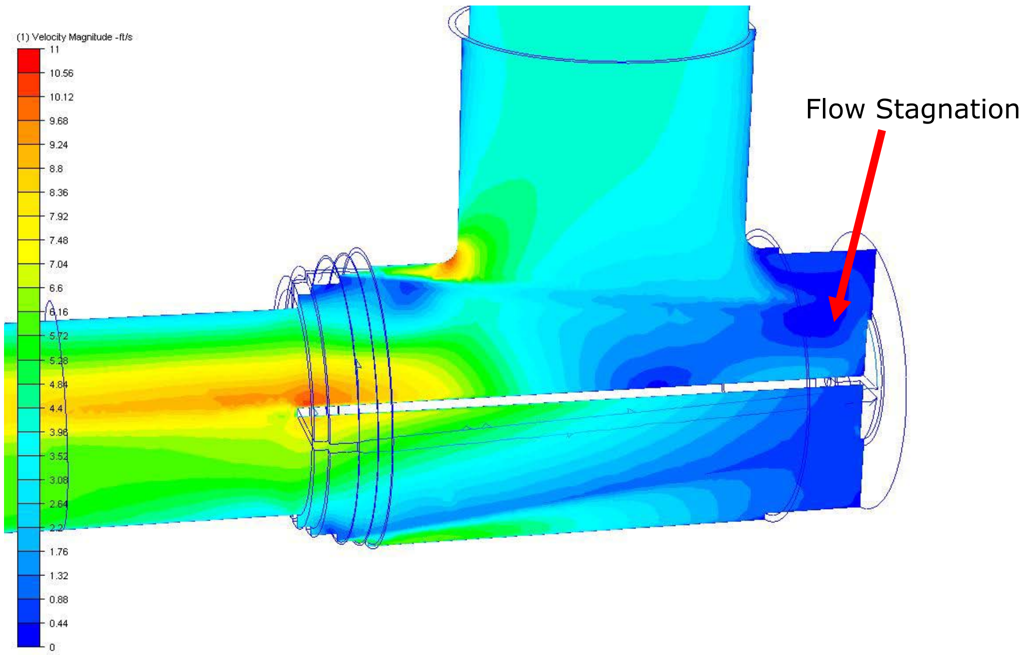

Figure 6. Cut-surface showing fluid velocity magnitude. (Conical diffuser, 4 ft/s)

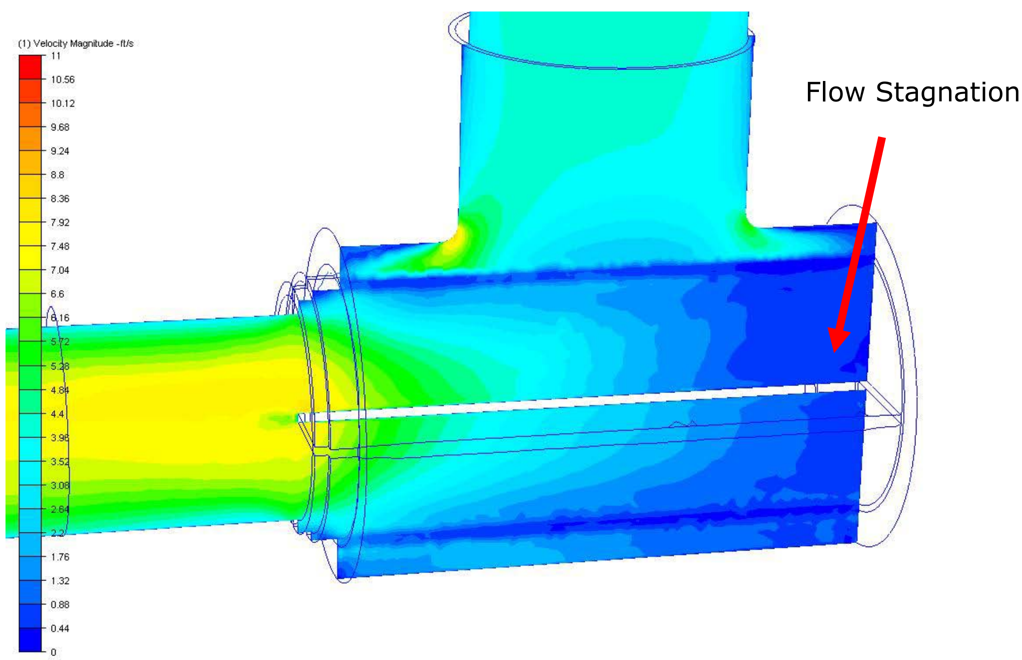

Figure 7. Cut-surface showing fluid velocity magnitude. (Cylindrical diffuser, 4 ft/s)

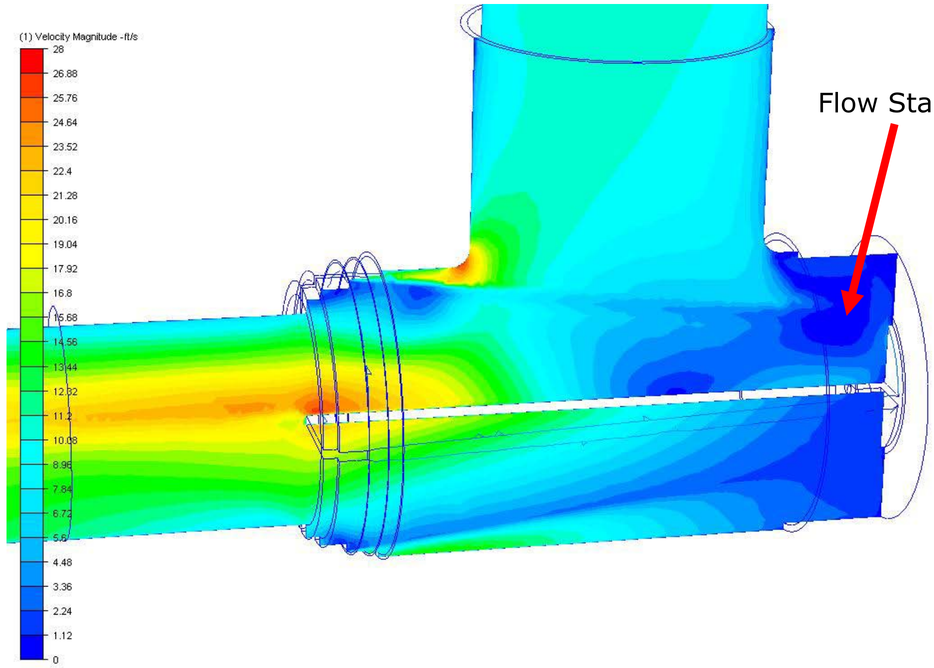

Figure 8. Cut-surface showing fluid velocity magnitude. (Conical diffuser, 10 ft/s)

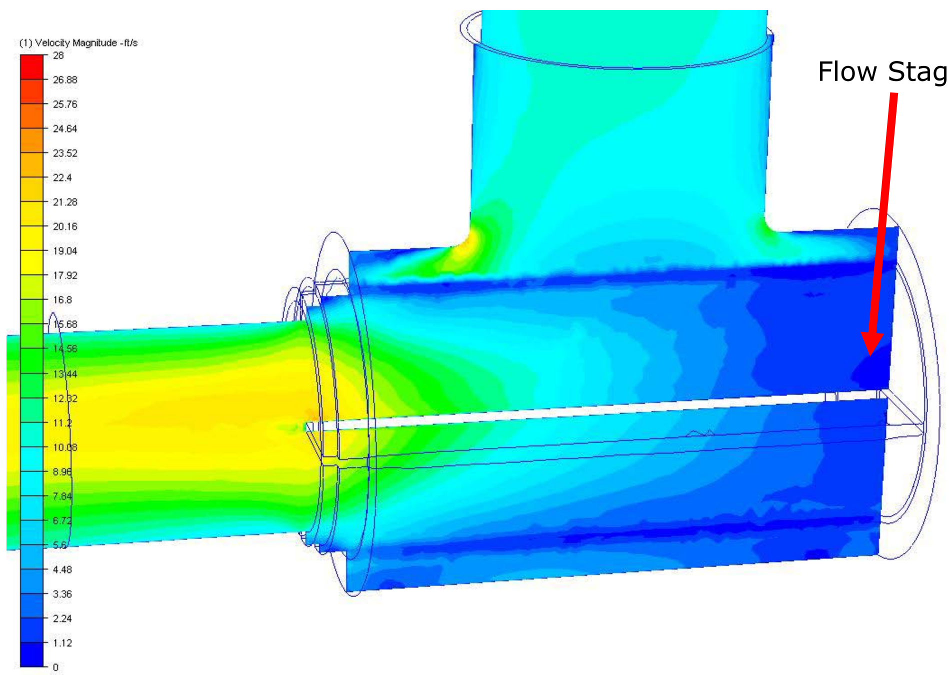

Figure 9. Cut-surface showing fluid velocity magnitude. (Cylindrical diffuser, 10 ft/s)

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.

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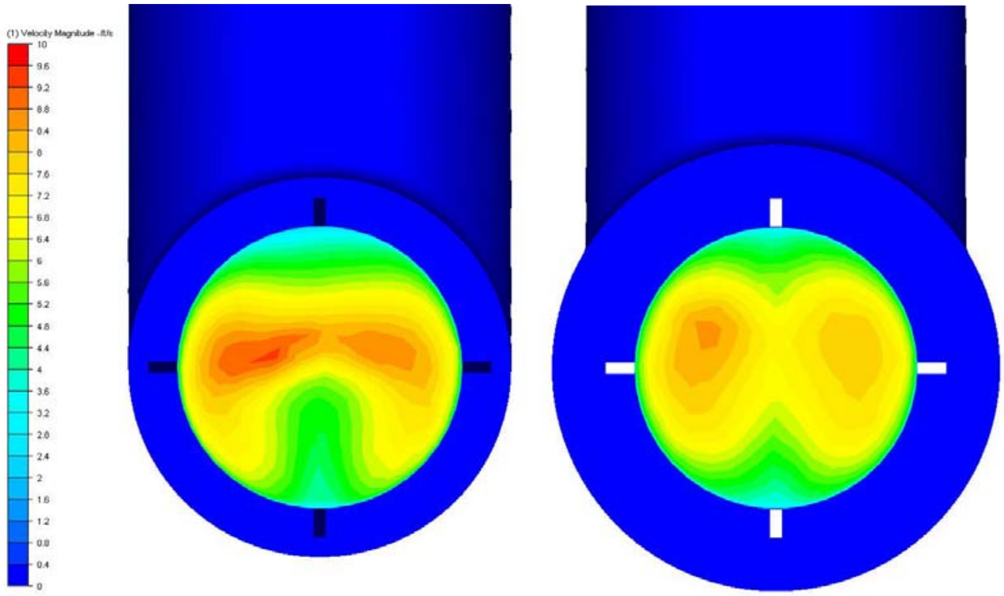
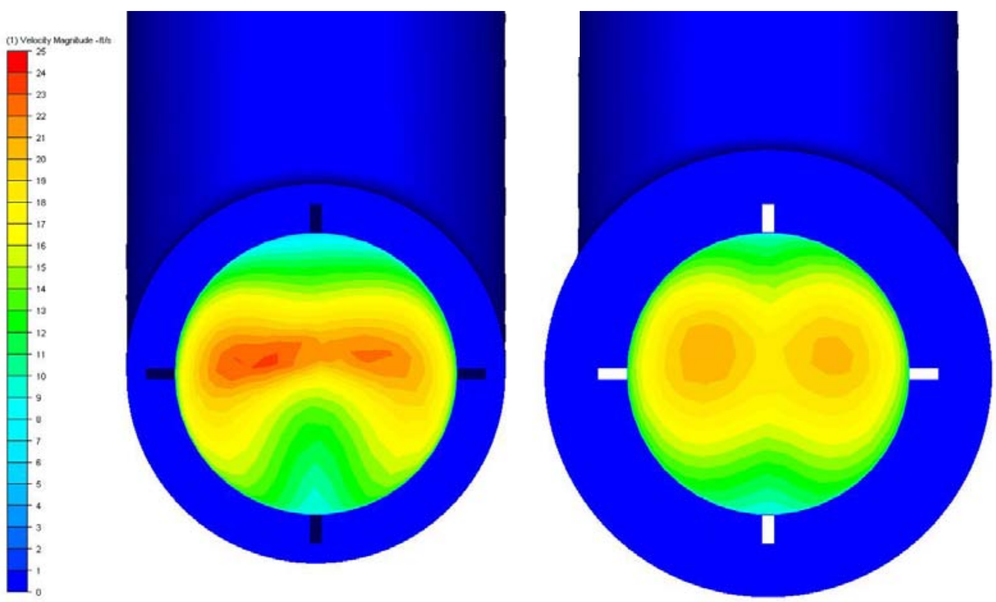
A comparison of the flow profiles approximately 3 inches downstream of the device is shown below in Figure 10. In both the 4 and 10 ft/s scenarios, the cylindrical diffuser screen provided a significantly more uniform outlet flow.

4 ft/s Inlet Flow



Conical Diffuser **Cylindrical Diffuser**

10 ft/s Inlet Flow



Conical Diffuser **Cylindrical Diffuser**

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.

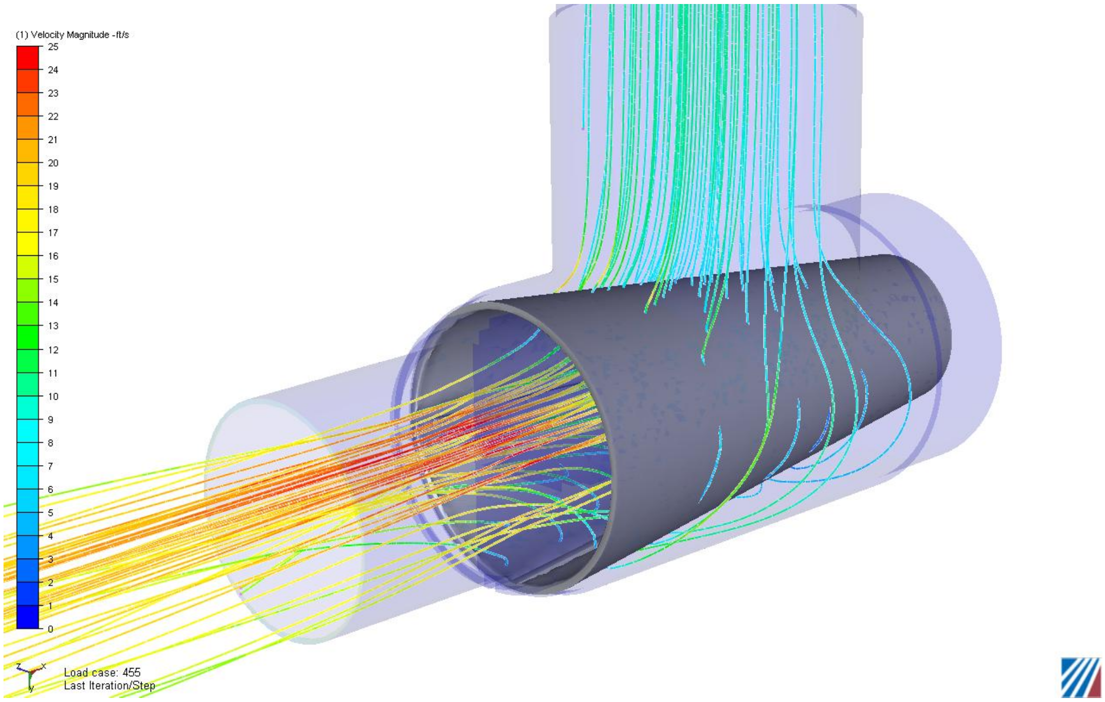


Figure 11. Fluid particle traces. (Conical diffuser)

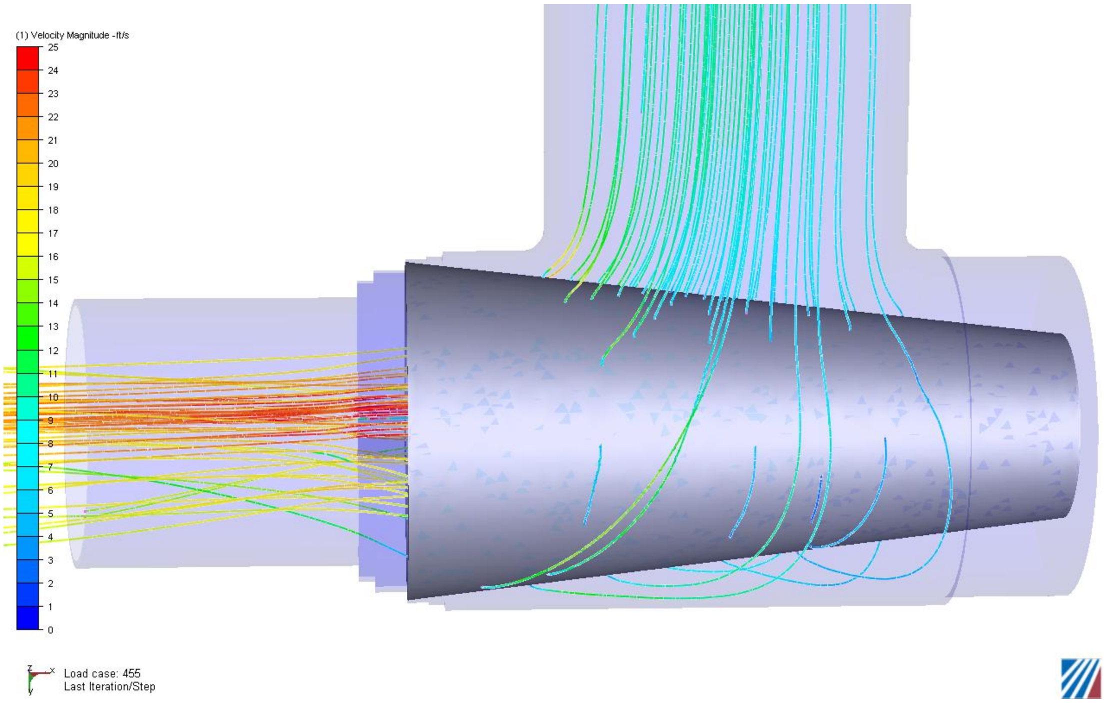


Figure 12. Fluid particle traces. (Conical diffuser)

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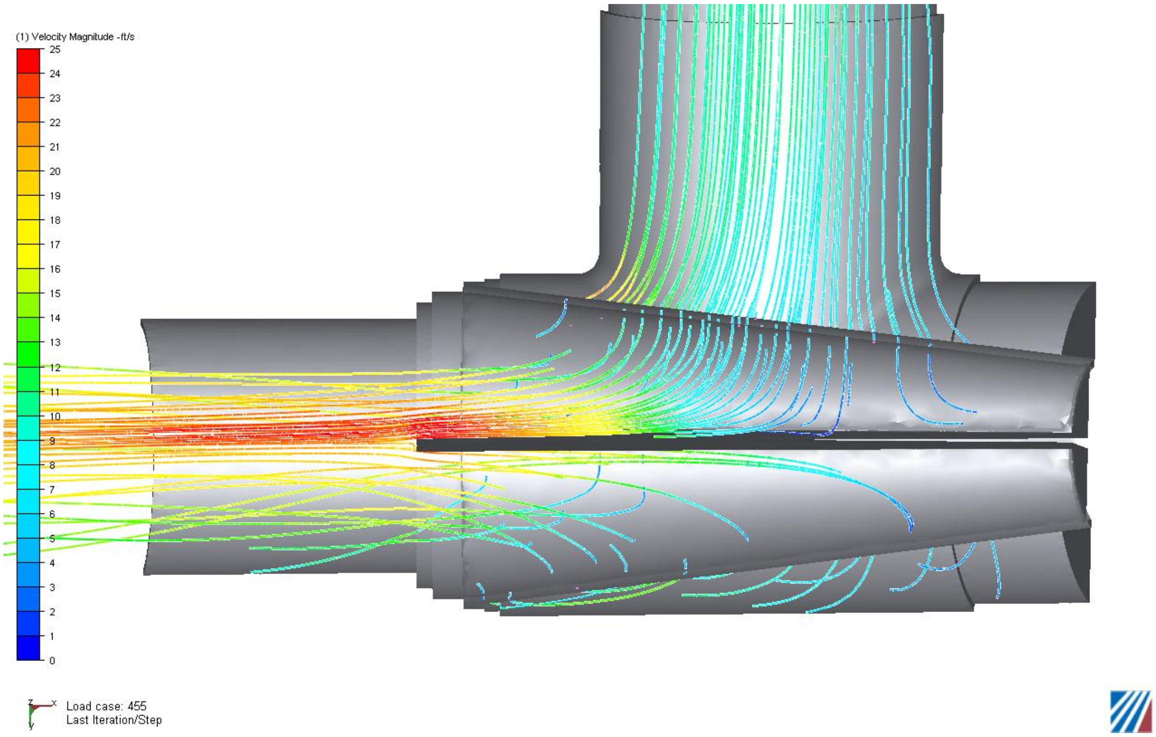

Figure 13. Fluid particle traces. (Conical diffuser)

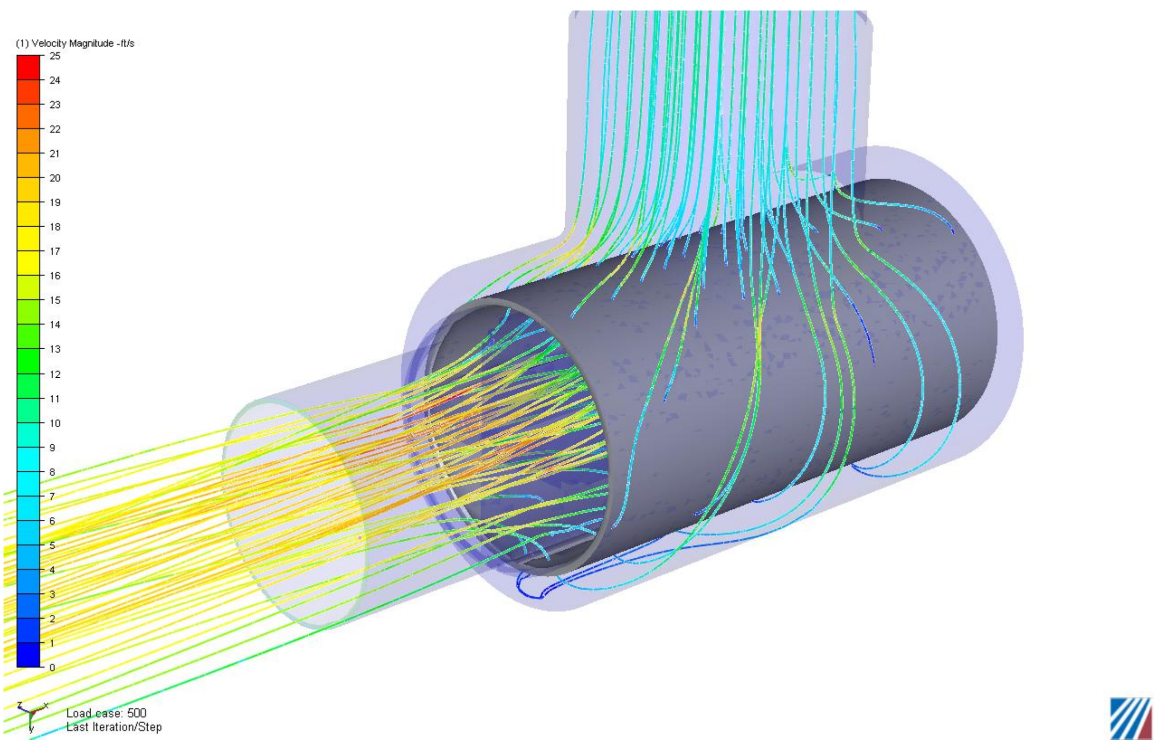

Figure 14. Fluid particle traces. (Cylindrical diffuser)

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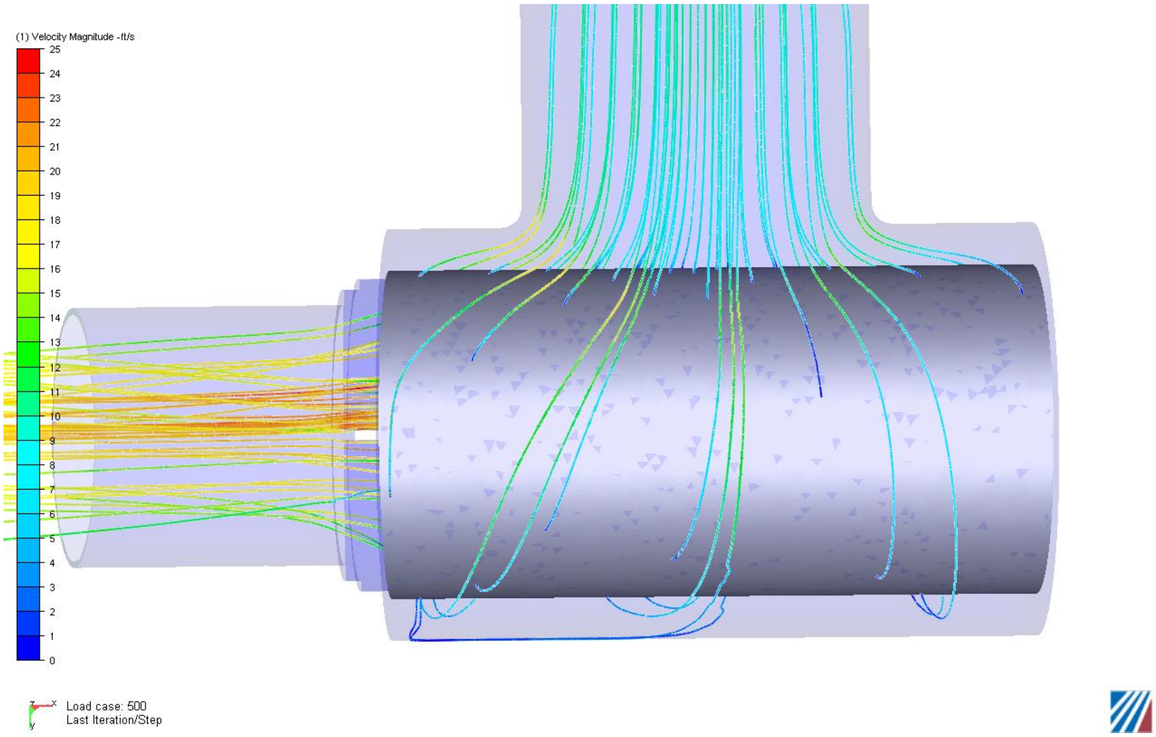

Figure 15. Fluid particle traces. (Cylindrical diffuser)

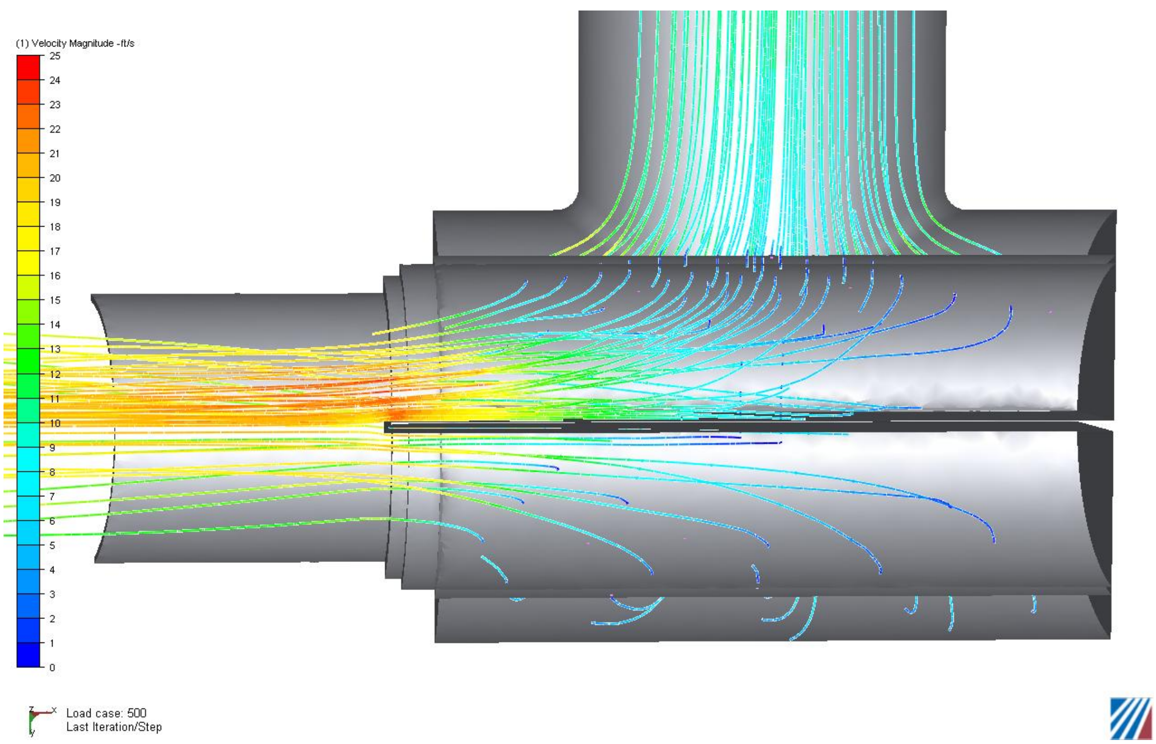

Figure 16. Fluid particle traces. (Cylindrical diffuser)

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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.

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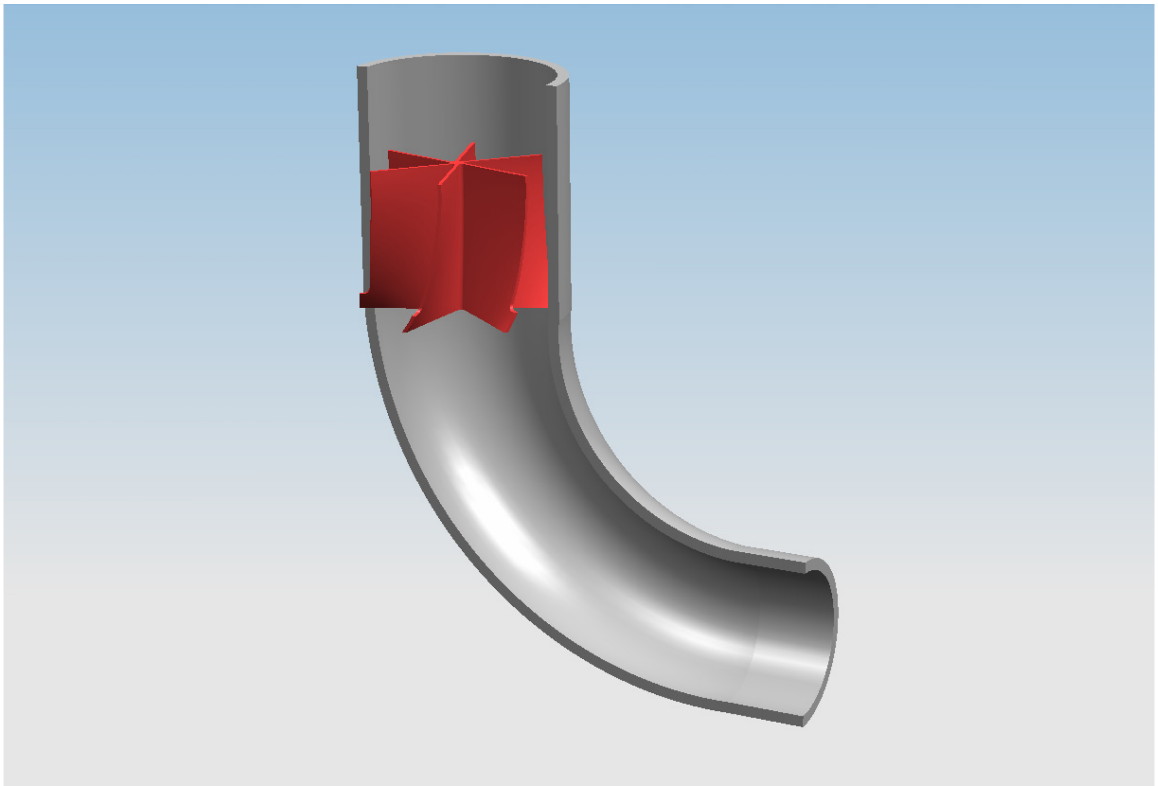

Metraflex CRV in a Reducing Elbow Simulation

James C. Neville
Project Engineer, Engineering Services
Blue Ridge Numerics, Inc.
January 26, 2006

CRV in a REDUCING ELBOW SIMMULATION

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.

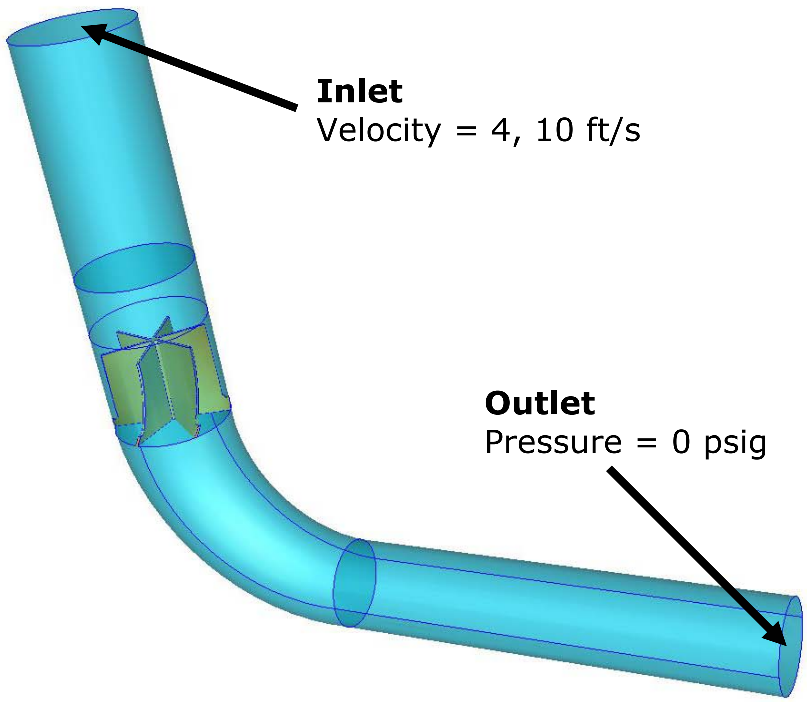

Figure 1. CFdesign analysis setup conditions.

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

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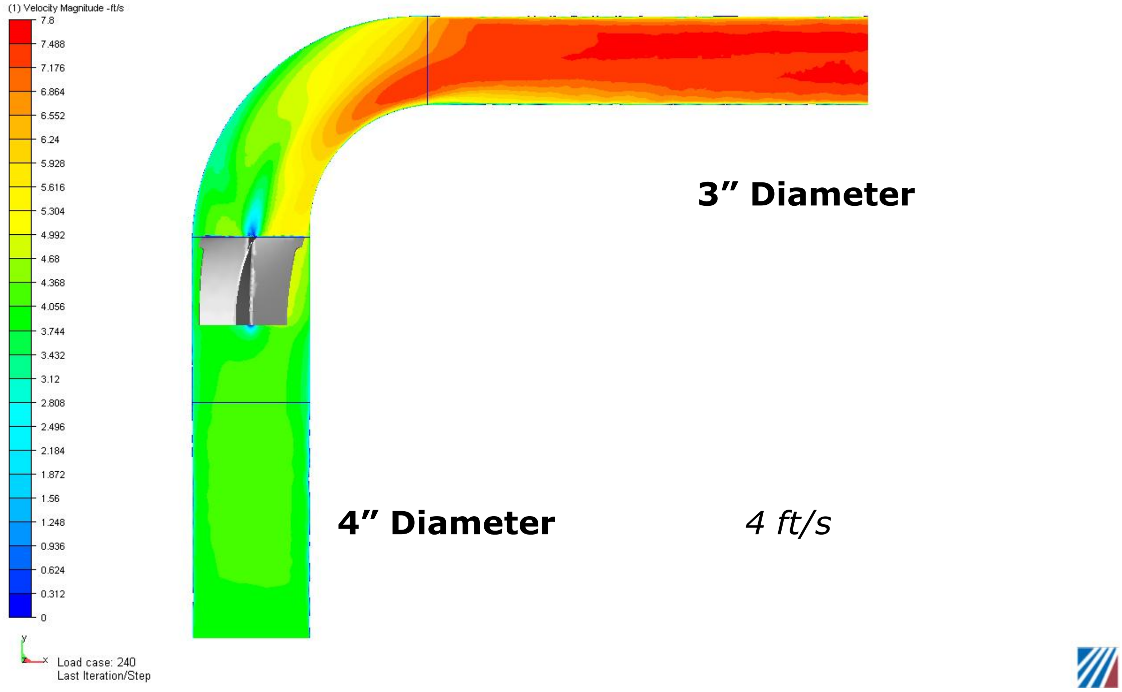
Results:

Cut-surfaces 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.



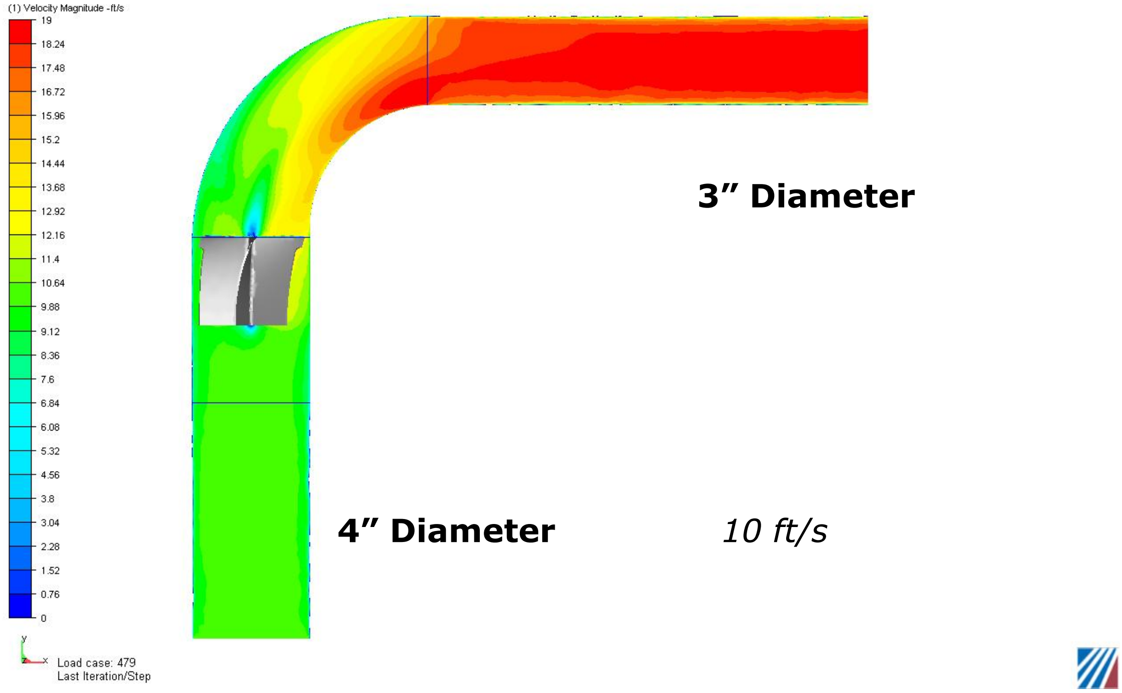


Figure 2. Cut-surface showing velocity contours through the reducing elbow.

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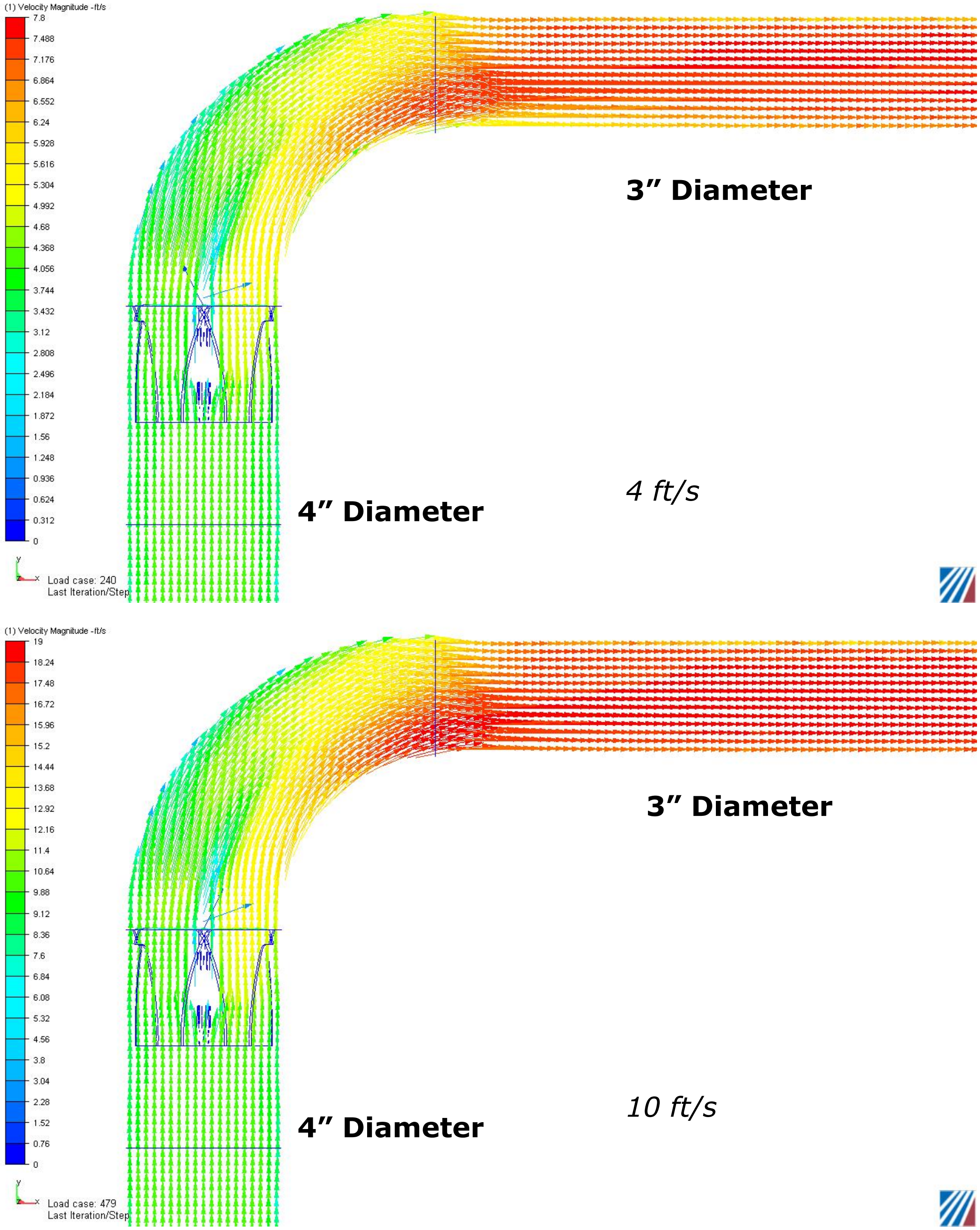

Figure 3. Cut-surface showing velocity vectors through the reducing elbow.

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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.

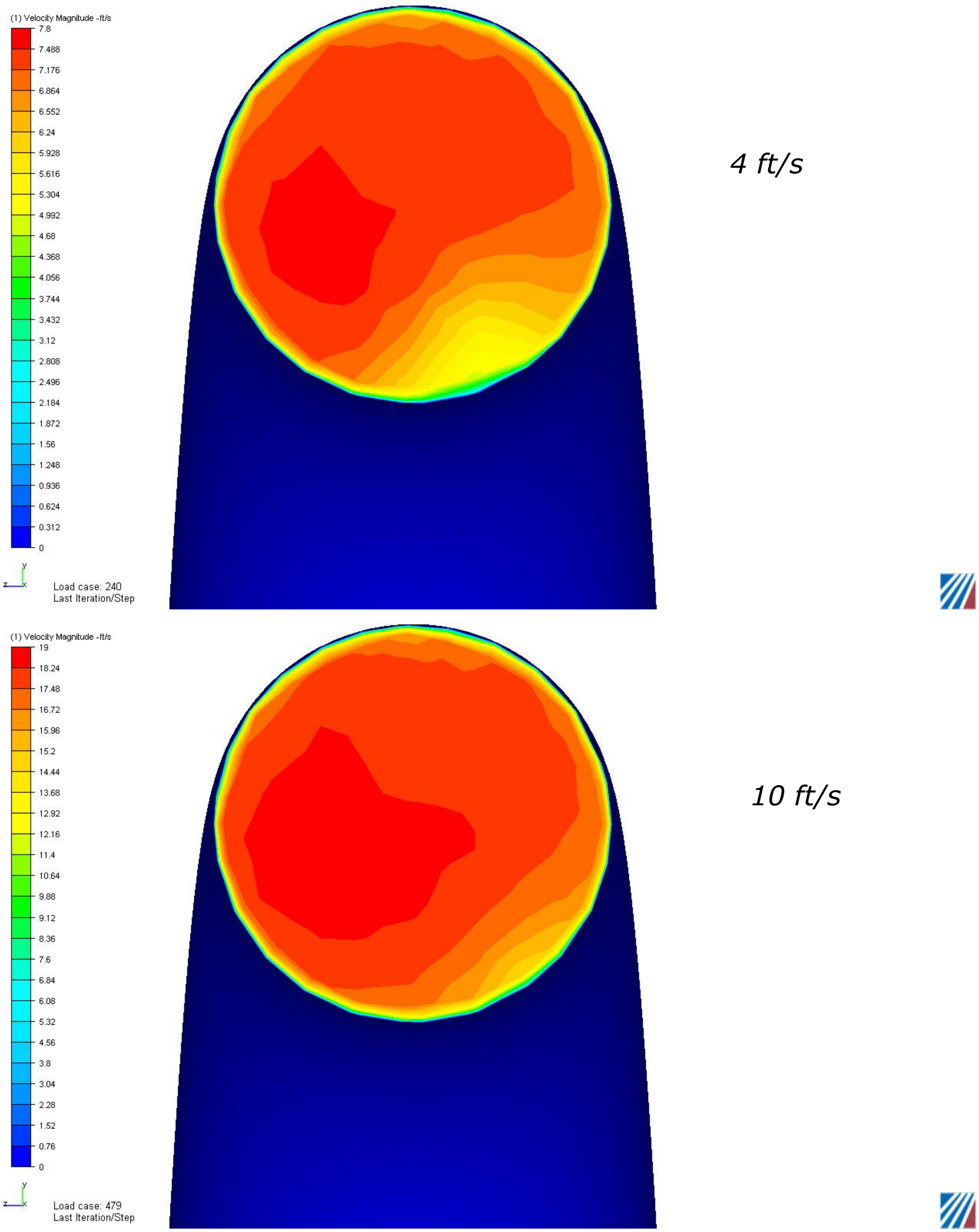

Figure 4. Velocity distribution normal to the flow 3" downstream of the elbow.

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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.

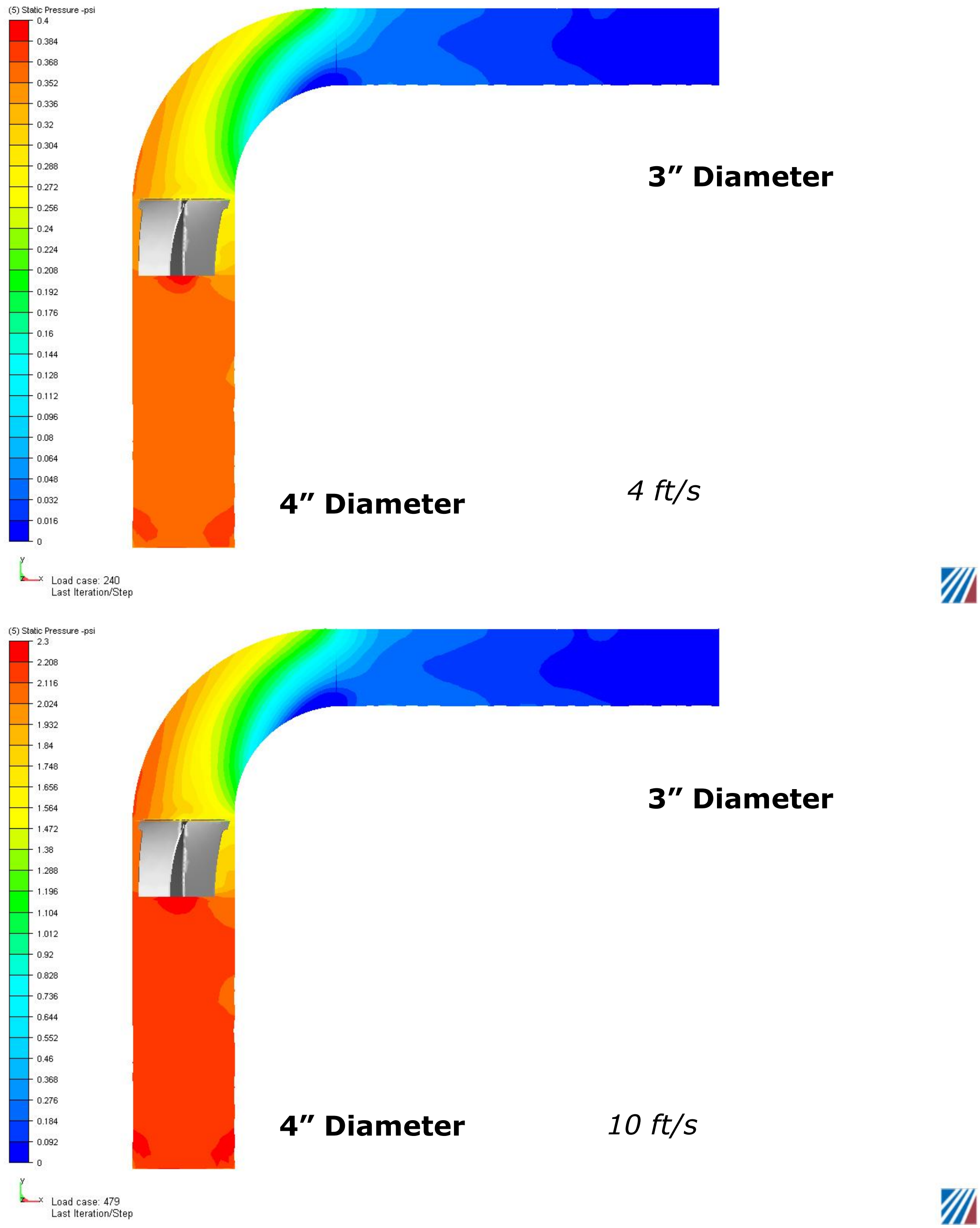

Figure 5. Cut-surface showing pressure gradients through the elbow.

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.

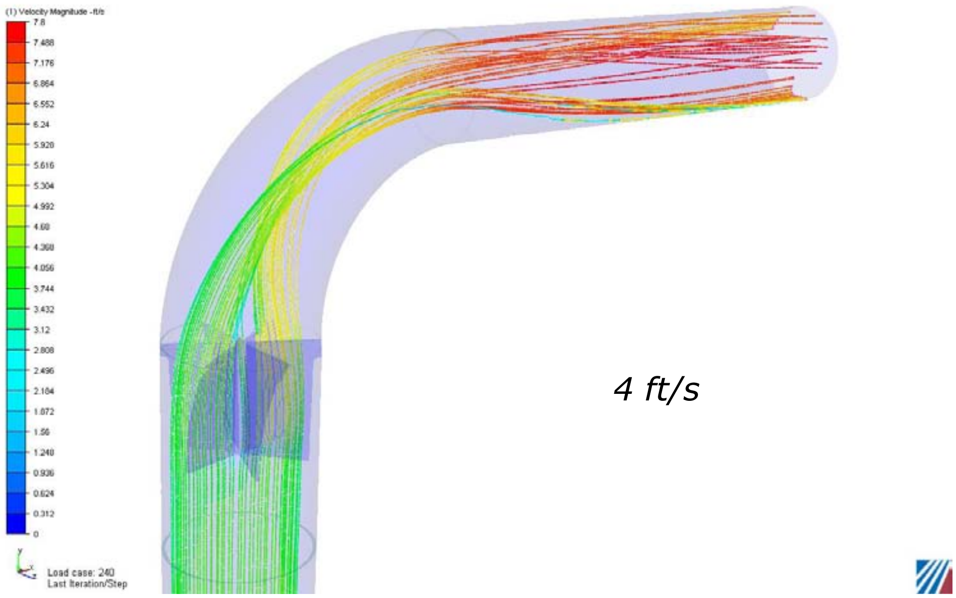

Figure 6. Fluid particle traces shown for the 4 ft/s flow rate.

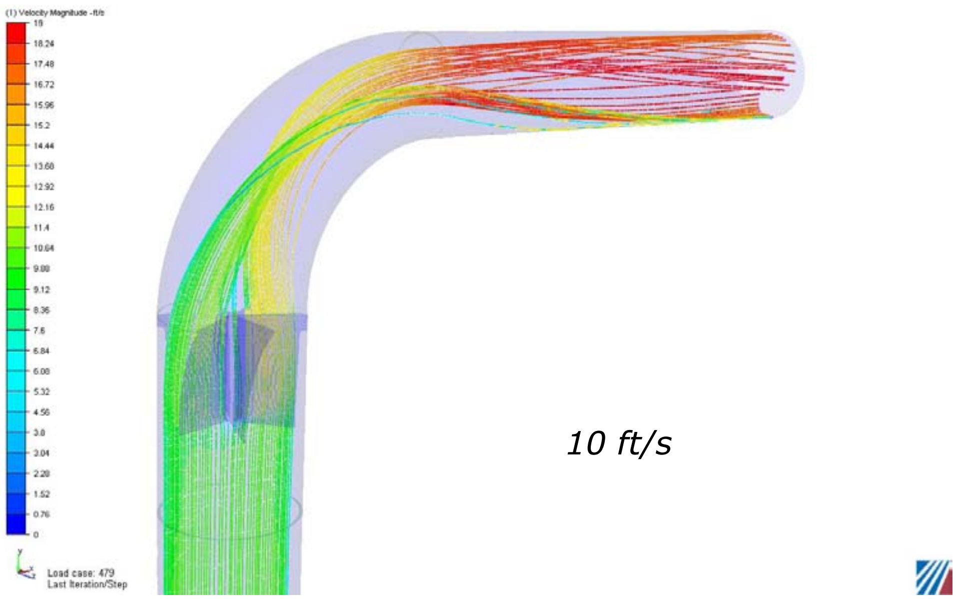

Figure 7. Fluid particle traces shown for the 10 ft/s flow rate.

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.

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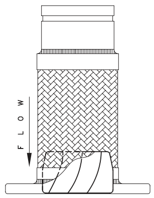
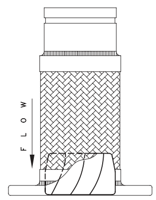
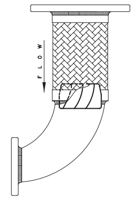
Standard CRV® Flex Configurations



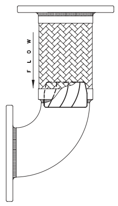
CRV Flex with 150# plate flange x groove end for connecting to a short radius elbow



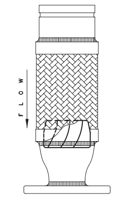
CRV Flex with 150# plate flange x groove end for connecting to a long radius elbow



CRV Flex with 150# plate flange with 90º reducing elbow

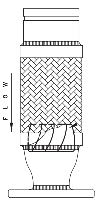


CRV Flex with 150# plate flanges with long radius 90º elbow

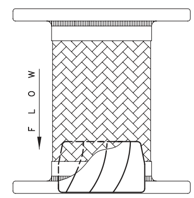


CRV Flex with 150# plate flange x groove end with concentric reducer for connecting to a long radius elbow

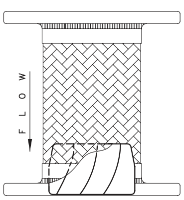
Stationary, curved fins rotate flow so it moves smoothly through the elbow



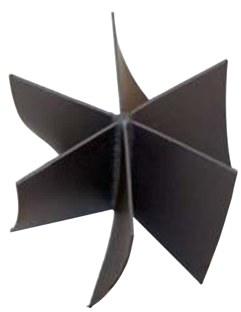
CRV Flex with 150# plate flange x groove end with concentric reducer for connecting to a short radius elbow



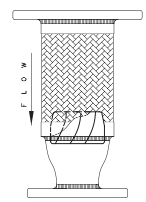
CRV Flex with 150# plate flanges for connecting to a long radius elbow



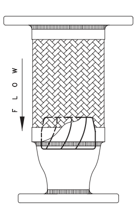
CRV Flex with 150# plate flanges for connecting to a short radius elbow



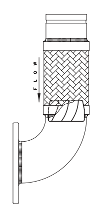
Pictured is the CRV vane in our CRV Flex straight pump connector. This configuration is designed to be installed before a suction elbow. The CRV Flex is also supplied with the elbow and in any of the configurations illustrated.



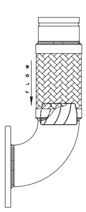
CRV Flex with 150# plate flanges with concentric reducer for connecting to a long radius elbow



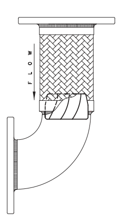
CRV Flex with 150# plate flange with concentric reducer for connecting to a short radius elbow



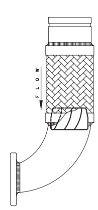
CRV Flex with 150# plate flange x groove end with long radius 90º elbow



CRV Flex with 150# plate flange x groove end with short radius 90º elbow



CRV Flex with 150# plate flanges with short radius 90º elbow



CRV Flex with 150# plate flange x groove end with 90º reducing elbow