PAP 894

Hendrick Screen Test

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Background

In the last decade, increasing concern for fisheries has created interest in excluding fish from water diversions with minimal impact to fish. In order to accomplish this objective, an improved understanding of fish screen hydraulics and fishery response to various conditions is needed. Resource agencies have adopted standards requiring screens to meet a maximum approach velocity criteria of 0.2 ft/s in some areas. As a result, the Water Resources Research Laboratory (WRRL) at the U.S. Bureau of Reclamation (Reclamation) in Denver, is currently conducting research to study the performance of cylindrical fish screens for shedding debris and to provide an effective positive barrier for fish exclusion. Included as a part of this program, a 12 inch tee screen manufactured by Hendrick Screen was loaned to Reclamation for performance evaluation.

The Model

The Hendrick tee screen (figure 1) was tested in a WRRL facility designed to test fish screens. The facility consists of a 5.5-ft-wide by 5-ft-deep recirculating flume (figure 2). The screen was installed on a pipe leading to the suction side of a recirculating pump and located beside a clear plexiglass window to allow clear viewing during screen operation. The outer cylinder of the Hendrick screen is 12 inches in diameter and contains an inside core designed with a graduated hole pattern to provide a more uniform intake flow distribution through all areas of the screen. Flow velocity in the flume and through the screen were controlled by adjusting control valves on pipes extending from the recirculating pump.

Figure 1. Hendrick 12 inch tee screen.

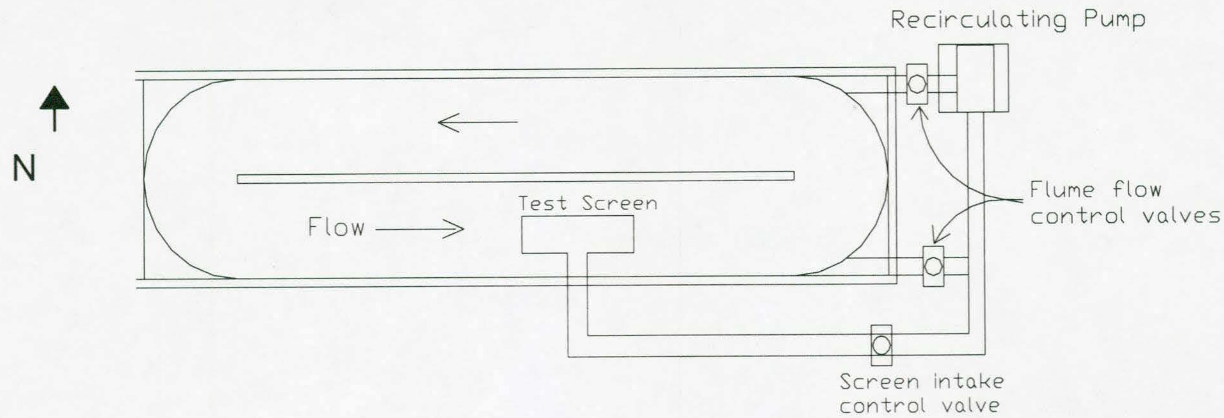


Figure 2. Layout of fish screen test facility.

Study Objectives

Model tests were conducted with the screen oriented with the screen surface parallel to the flow as shown in figure 2.

Tests were conducted with the screen operating under two different intake flow rates:

a) 750 gal/min
b) 500 gal/min

Investigations were conducted to determine:

1) The approach velocity distribution into the screen (normal velocity component measured ½ -in. and 3-in. from the face of the screen) measured at 2 inch intervals along the length of the screen with:

a) a 0.5 ft/s sweeping velocity (velocity component parallel to screen surface)

b) a near-zero sweeping or reduced flume velocity component (typical of lake or reservoir installations).

2) The screen's ability to shed large aquatic debris (Elodea was used for these tests).

3) Head loss through the screen.

Test Setup and Results

In order to simulate an approximate reservoir withdrawal condition, the flume discharge valve was completely closed so that flow was discharging through the test screen only. A true reservoir condition could not be simulated in the flume. However, reasonable quiescent conditions were created by installing a perforated plate upstream from the screen during reservoir tests.

For the river condition, flow vanes were installed upstream from the screen installation to provide a more uniform sweeping flow distribution after rounding the sharp corner of the flume.

Velocity Measurements and Dye Tests

Velocities were measured with a Sontek acoustic doppler velocimeter (ADV probe) at 2-in. intervals at the top, north, and south center lines along the length of the screen, starting ½ inch from the leading edge, to determine the overall flow distribution. Screen performance was evaluated by measuring approach velocities at a 3-in distance from the screen surface, as required to meet resource agency screen velocity criteria (figures 3a, 4a, 5a, and 6a). Velocities were also measured at a distance of 0.5-in. from the screen to give an indication of the near screen velocity field (figures 3b,4b,5b, and 6b). For all test cases, positive approach velocities indicate flow is going into the screen, while positive sweeping velocities indicate flow is in the downstream direction. Dye tests were also used to visually verify the results from these tests.
It is worth noting that because it is impossible to measure velocities over the entire screen control surface, the velocities measured at positions along the three centerlines (0.5 in. and 3.0 in. from the screen face) cannot necessarily be extrapolated to represent total through-screen flow and to satisfy continuity. In addition, there may be some flow recirculation that occurs within the outside tube. However, although assessing the total through-screen flow is important information for the manufacturer and designer of the screen, it does not affect the screen's ability to meet required screen criteria. Current National Marine Fisheries Service criteria is based on approach velocities measured at a 3-in. distance from the screen face.

Debris Tests

Tests were conducted to test screen performance for shedding large debris. For these tests, observations were used to assess screen performance while operating at high capacity (750 gpm). Elodea, which is a stringy aquatic weed that has a tendency to wrap around obstacles in the flow, was deposited into the flume. Small amounts of debris collected at various locations on the screen face; most notably, immediately upstream from the intake pipe extending from the tee. Some debris also collected near the outer reaches of the tee where the inner core openings were largest. Much of the debris that collected on the face of the screen was readily swept off when a sweeping velocity of 0.5 ft/s was introduced into the flume.

Head loss

A pressure tap was installed at the centerline of the screen discharge pipe approximately 3.5 ft downstream from the screen to determine the head loss through the screen. Head loss as a function of screen intake flow is shown in figure 7.

Conclusions

Figures 3 through 6 show the flow distribution along the length of the screen for each case tested. The following conclusions were determined from the study:

- The figures demonstrate that the inner core design, with larger holes located near the end of each leg of the tee, overcompensates for the additional losses experienced at those locations. As a result, screen approach velocities are highest near the outer reaches of the tee.

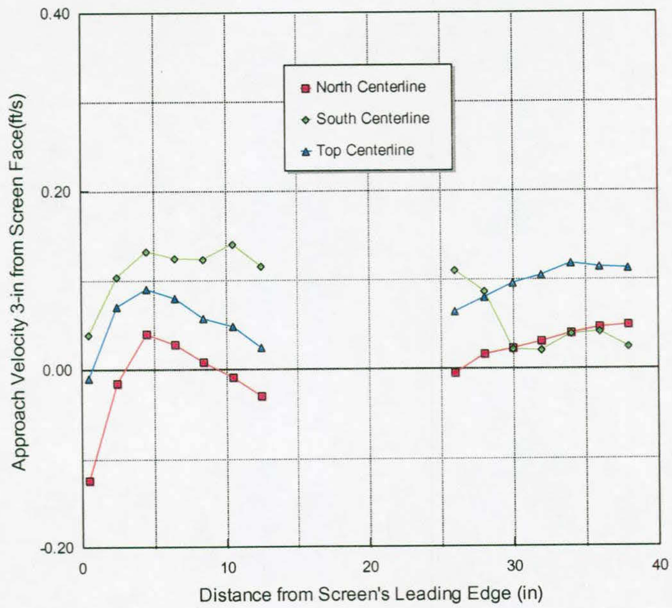
- When a small sweeping component of 0.5 ft/s is introduced into the flume, the separation zone created near the leading edge is small. However, although the separation zone is small, it does cause the effective screen area to be reduced, resulting in a slight increase in approach velocities measured downstream from this zone.

- Although velocity distribution is not uniform along the length of the screen, National Marine Fisheries Service (NMFS) most stringent criteria for positive barrier screens for fish exclusion (approach velocities less than 0.2 ft/s measured 3 inches from the screen face) is achieved for all test cases.

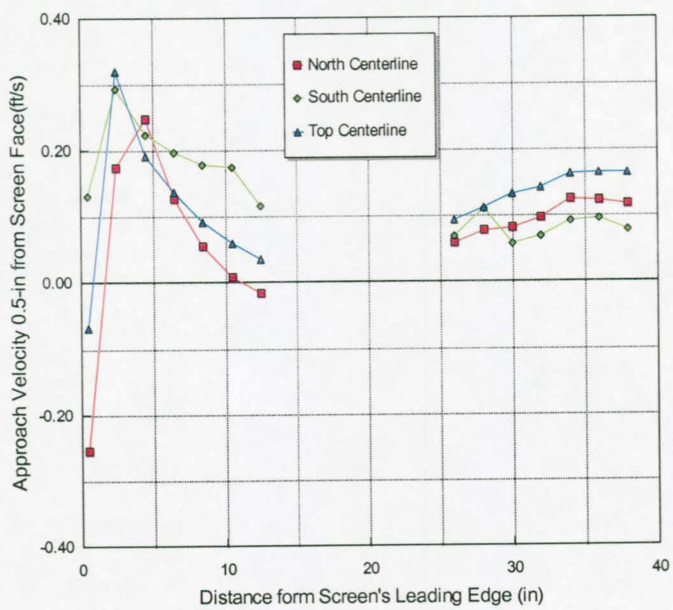
- When a sweeping velocity component is introduced into the flume, velocities measured downstream from the tee on the south side are somewhat erratic, due to the large area of recirculation that occurs downstream from the intake pipe joining the tee.

- Although only small amounts of debris collected on the screen while operating at maximum capacity, it may be necessary to incorporate some type of screen cleaning mechanism or operate below maximum capacity to prevent exceeding maximum fish screening criteria when debris is present.

- Head loss measured through the screen was 0.84 ft and 2.1 ft for intake flows of 500 gpm and 750 gpm respectively.

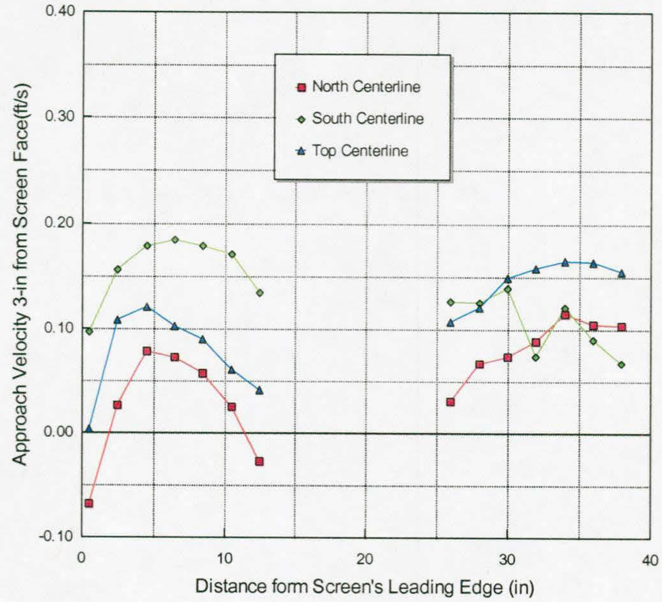


a)



b)

Figure 3. Screen approach velocities measured for a screen intake flow of 500 gpm and with a 0.5 ft/s sweeping velocity at a distance of a) 3 inches and b) 0.5 inches from screen face.



a)

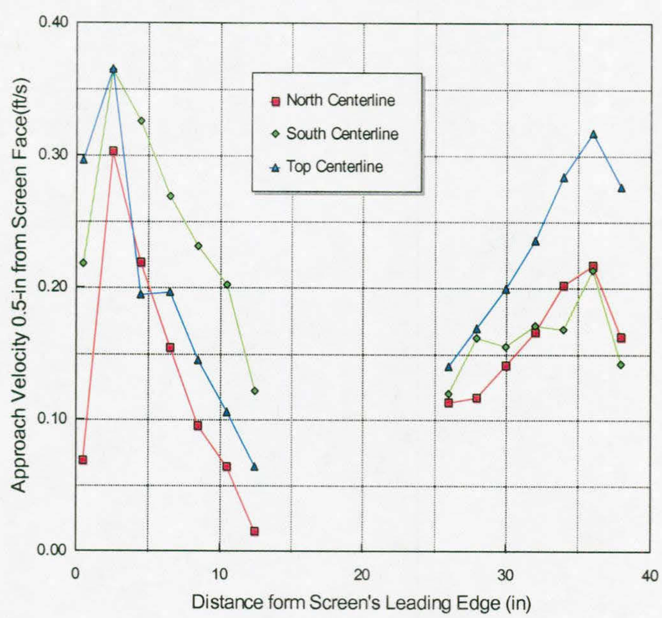
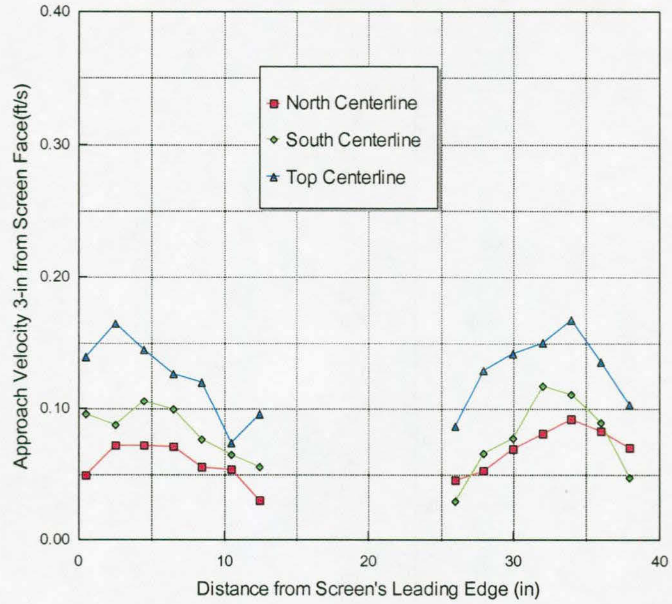
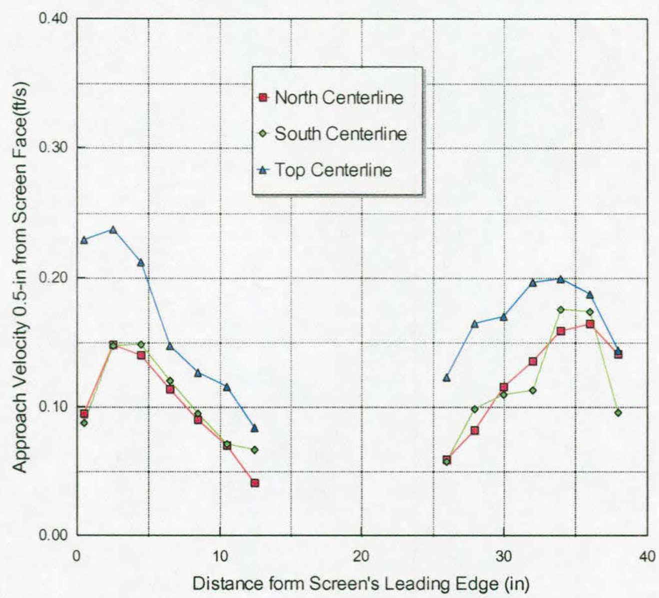


Figure 4. Screen approach velocities measured for a screen intake flow of 750 gpm and with a 0.5 ft/s sweepng velocity at a distance of a) 3 inches and b) 0.5 inches from screen face.

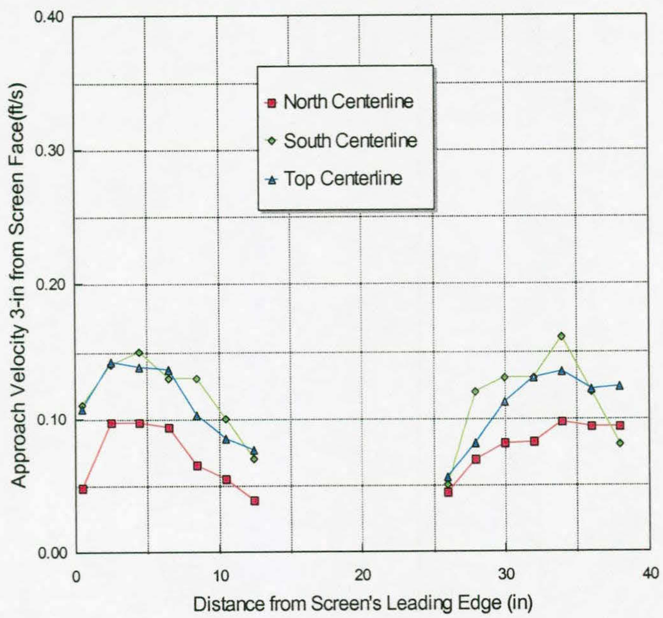


a)

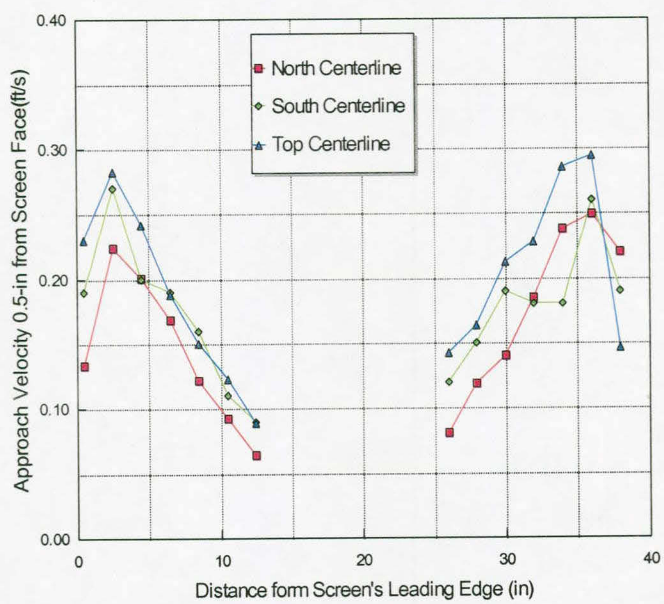


b)

Figure 5. Screen approach velocities measured for a screen intake flow of 500 gpm and with near zero sweeping velocity at a distance of a) 3 inches and b) 0.5 inches from screen face.



a)



b)

Figure 6. Screen approach velocities measured for a screen intake flow of 750 gpm and with near zero sweeping velocity at a distance of a) 3 inches and b) 0.5 inches from screen face.

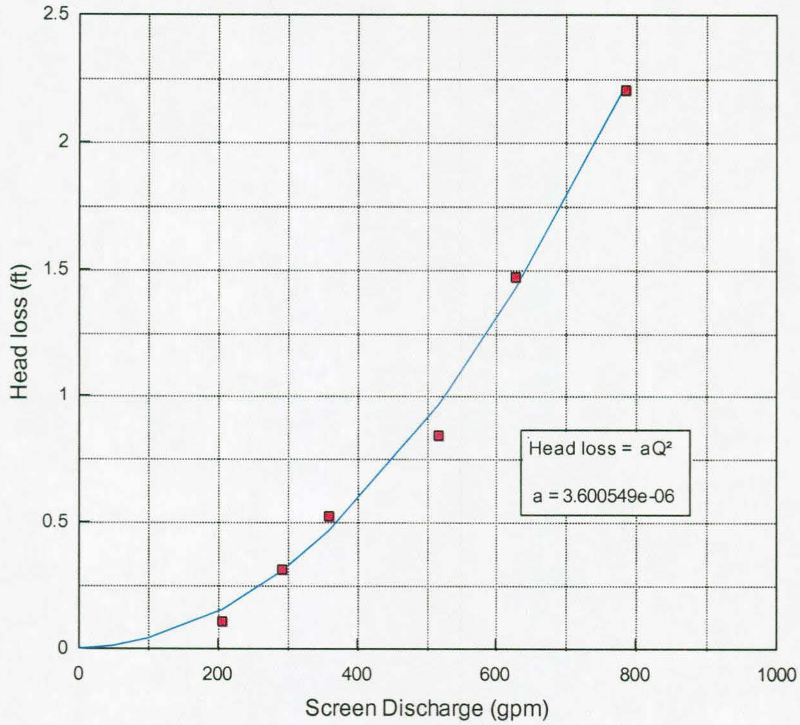


Figure 7. Head loss as a function of screen intake flow.