CHAPTER 6

STORAGE FACILITIES

6.9 Trash Racks And Safety Grates

Trash racks and safety grates serve several functions:

- they trap larger debris well away from the entrance to the outlet works so they will not clog the critical portions of the works;
- they trap debris in such a way that relatively easy removal is possible;
- they keep people and large animals out of confined conveyance and outlet areas;
- they provide a safety system whereby persons caught in them will be stopped prior to the very high velocity flows immediately at the entrance to outlet works and persons will be carried up and onto the outlet works allowing for the ability to climb to safety; and
- well designed trash racks can have an aesthetically pleasing appearance.

When designed well trash racks serve these purposes without interfering significantly with the hydraulic capacity of the outlet (or inlet in the case of conveyance structures) (ASCE, 1985, Allred-Coonrod, 1991). The location and size of the trash rack depends on a number of factors including: losses through the rack, structural convenience, safety, and size of outlet.

Trash racks at entrances to pipes and conduits should be sloped at about 3H:1V to 5H:1V to allow trash to slide up the rack with flow pressure and rising water level, the slower the approach flow the flatter the angle. Rack opening rules-of-thumb abound in the literature. Figure 6.9-1 gives opening estimates based on outlet diameter (UDFCD, 1992). Judgment should be used in that an area with higher debris (e.g. a wooded area) may require more opening space.

The bar opening space for small pipes should be less than the pipe diameter. For larger diameter pipes openings should be 6 inches or less. Collapsible racks have been used in some places if clogging becomes excessive or a person becomes pinned to the rack. Alternately debris for culvert openings can be caught upstream from the opening by using pipes placed in the ground or a chain safety net (USBR, 1978, UDFCD, 1991). Racks can be hinged on top to allow for easy opening and cleaning.

The control for the outlet should not shift to the grate. Nor should the grate cause the headwater to rise above planned levels. Therefore headlosses through the grate should be calculated. A number of empirical loss equations exist though many contain difficult to estimate variables. Two will be given to allow for comparison.

Metcalf & Eddy (1972) give the following equation (based on German experiments) for losses. Grate openings should be calculated assuming a certain percent of blockage as a

worst case to determine losses and upstream head. Often 40 to 50 percent is chosen as a working assumption.

$$H_g = K_{g1}(w/x)^{4/3}(V_u^{\ 2}/2g)Sin\,\theta_g$$

(EQ-6.9-1)

Where: H_g = head loss through grate, ft

K_{g1} = bar shape factor:

2.42 – sharp edged rectangular

1.83 – rectangular bars with semicircular upstream faces

1.79 – circular bars

1.67 – rectangular bars with semicircular up- and downstream faces

w = maximum cross sectional bar width facing the flow, in.

x = minimum clear spacing between bars, in.

V_u = approach velocity, ft/s

θ = angle of the grate with respect to the horizontal, degrees

The Corps of Engineers (HDC, 1988) has developed curves for trash racks based on similar and additional tests. These curves are for vertical racks but presumably they can be adjusted, in a manner similar to the previous equation, through multiplication by the sine of the angle of the grate with respect to the horizontal.

$$H_g = K_{g2}\,V_u^{\ 2}/2g$$

(EQ-6.9-2)

Where: K_{g2} is defined from a series of fit curves as:

- sharp edged rectangular (length/thickness = 10)

K_{g2} = $0.00158 - 0.03217\,A_r + 7.1786\,A_r^2$

- sharp edged rectangular (length/thickness = 5)

K_{g2} = $0.00731 + 0.69453\,A_r + 7.0856\,A_r^2$

- round edged rectangular (length/thickness =10.9)

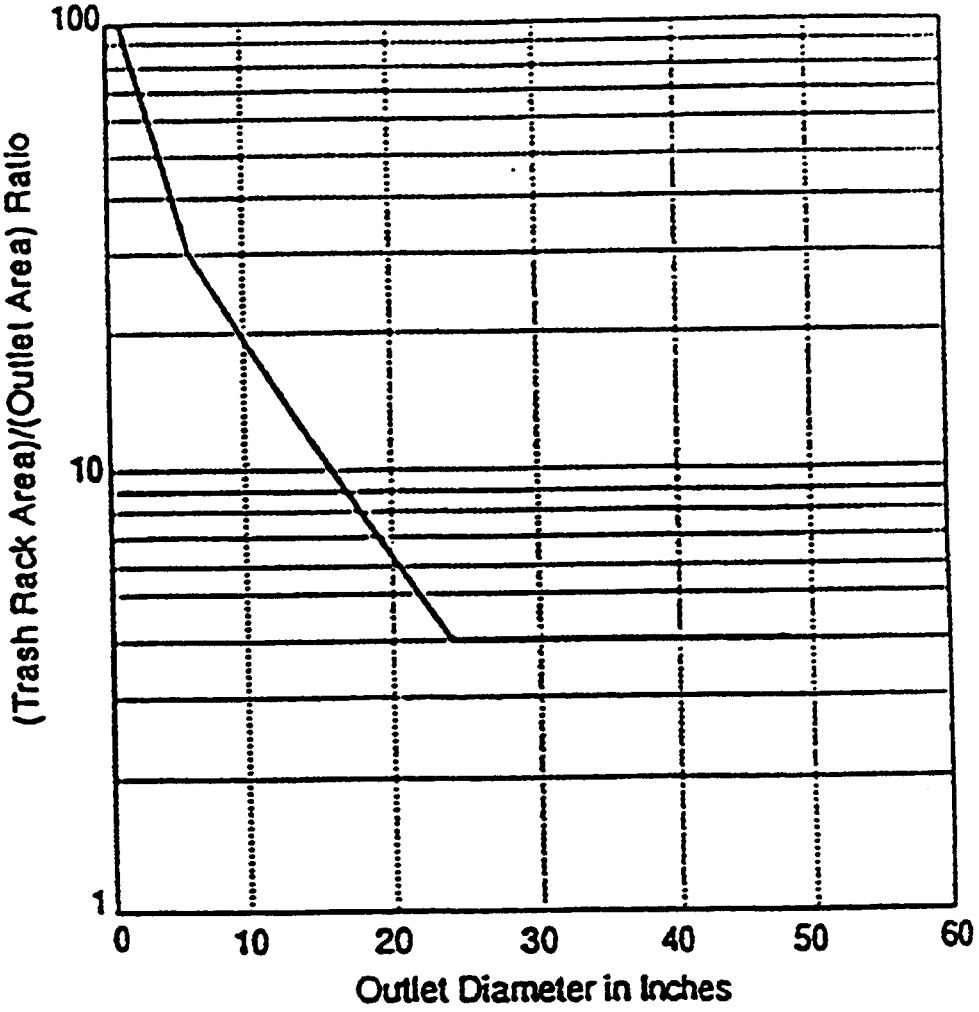
K_{g2} = $0.00101 + 0.02520\,A + 6.0000\,A_r^2$

- circular cross section

K_{g2} = $0.00866 + 0.13589\,A_r + 6.0357\,A_r^2$

and A_r is the ratio of the area of the bars to the area of the grate section.

Figure 6.9-1



Minimum Rack Size vs. Outlet diameter (UDCFD, 1992)

END OF SECTION 6.9