Appendix D
Air Bubbler Gate Recess Flusher

D-1.

High flow air bubblers placed in the gate recess will effectively clear debris and ice. Standard pipe is used for the supply and distribution lines. The supply feed is from the quoin end. Proper spacing and nozzle size will ensure maximum nozzle flow for a given air supply. A typical recess flusher installation is shown in Figure D-1. Air discharge from the orifices is calculated by:

$$Q_o\ (L^{-3}T^{-1}) = \frac{C_d \pi d^2}{4}\ (2\Delta P\ /\ \rho_a)^{1/2}$$

C_d = loss coefficient, sharp-edged circular orifice

d = orifice diameter

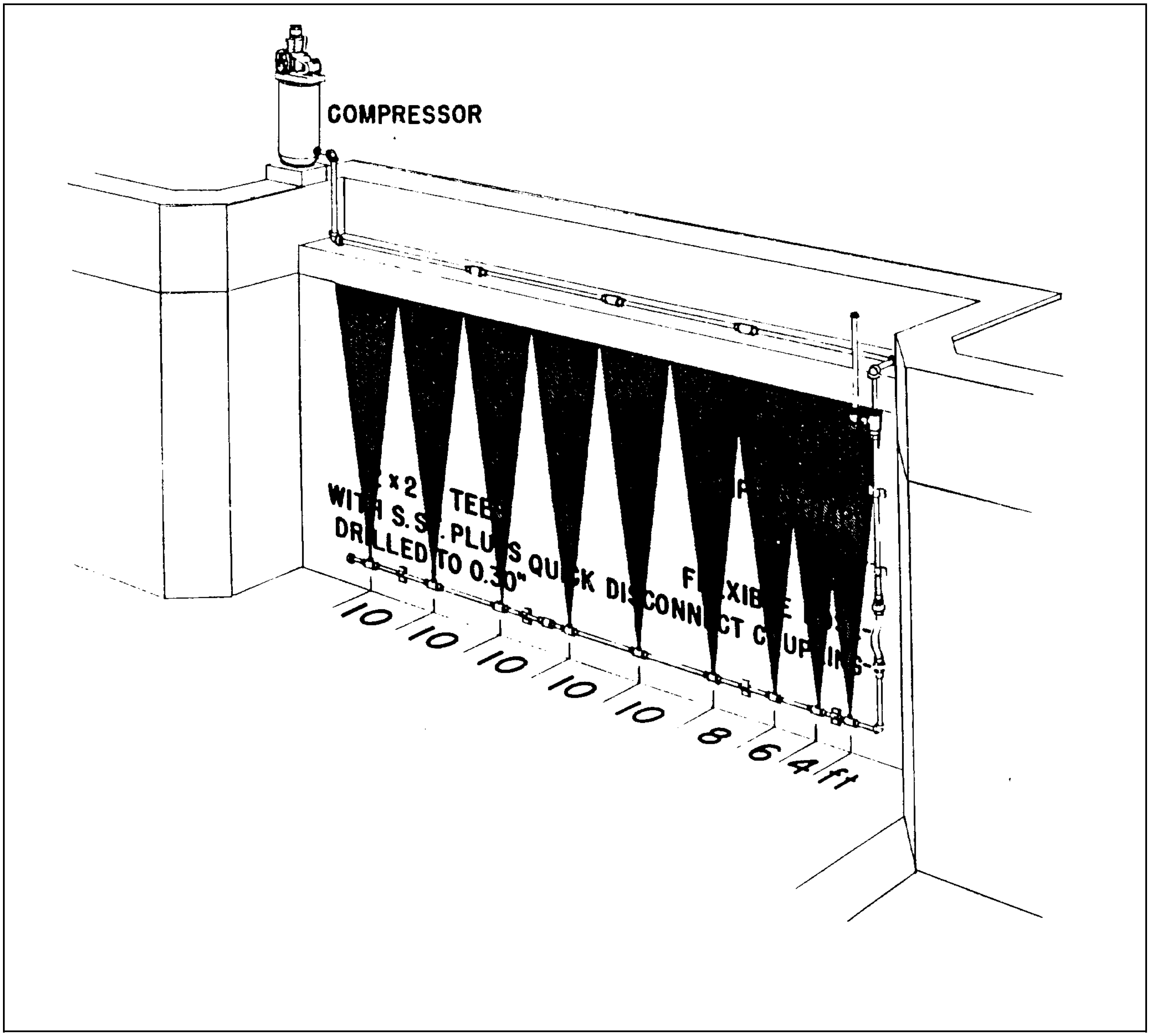

Figure D-1. Emsworth Lock & Dam, Ohio River, Air Screen Gate Recess Flusher

ΔP = pressure difference between inside and outside of distribution line at the nozzle

ρ_a = mass density of air

The pressure losses due to friction in the lines are calculated using the friction loss equation for turbulent flow:

$$\Delta P_f \ (F \ L^{-2}) = \frac{f \rho_a \ L \ v^2}{2Dg}$$

f = friction factor

L = equivalent length of pipe

v = air velocity

D = pipe diameter

g = gravitational constant

D-2.

The numerical analyses for air discharge rates are determined by an iterative procedure starting with a trial dead-end pressure and the end orifice. Working toward the supply source, the air flow and pressure at each orifice and in the supply line are calculated to obtain a calculated compressor pressure. The trial dead-end pressure is then adjusted and the procedure repeated until the calculated and the true compressor pressures agree. The sum of the nozzle flows gives the required compressor capacity. The initial trial dead-end pressure is taken as:

$$P_d = P_w + 0.25 \ (p_c - p_w)$$

P_c = true compressor pressure

$P_w = \rho_w$ g h

ρ_w = mass density of water

h = submergence depth

Subsequent trial pressures are estimated by:

$$P_{d(new)} = P_w + (P_{d(old)} - P_w) \ (p_c - p_w) \ / \ (p - p_w)$$

p = calculated compressor pressure

$P_{d(new)}$ and $P_{d(old)}$ = new and old trial dead-end pressures

D-3.

Output pressure must be high enough to overcome hydrostatic pressure at the submergence depth, frictional losses in the supply and distribution lines, and still provide a pressure differential at the last orifice to drive the air out at the desired rate. Supply and distribution line diameters should be large enough so that frictional pressure losses along the line are small. A small increase in line diameters often results in significant reduction in frictional losses and results in more uniform discharge rates along the line. Orifice diameter and spacing should be selected to maximize rates. Too large an orifice diameter can result in all the air being discharged at one end. Submergence depth will be dictated by operational limitations but should be lower than the expected depth of trash pile-up. Typical installation depths are 10 to 15 ft.

D-4.

Standard piping techniques can be used for strapping and supply and distribution line make-up. The distribution line can be assembled from standard pipe fittings, e.g., a tee-connection at nozzle locations with a drilled pipe plug used for the nozzle.