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Technical Circular :-35.

Sub: Provision of Water Hammer Control Devices in rural and Urban Water Supply Scheme. Estimation of water hammer pressures and selection of Air Cushion Valves and Zero Velocity valves.

Ref: Member Secretary [Tech], MJP, Mumbai's Circular No. MJP/MS/TS.I/350/1562 dated 28th May, 1998.

Under above circular it was instructed to provide water hammer control devices on all rising mains. The correct parameters to be considered in the estimation of water hammer pressures at the pump end are ;

i] Velocity of pressure wave[a]
ii] Steady state velocity of flow in the pipeline [V_o]
iii] Time required for closure of flow and pipeline characteristic time [2L/a]
iv] Frictional losses in the pipeline [h_f]

The effect of the above four parameters in estimating water hammer pressure is discussed below in brief :

[i] Velocity of Pressure Wave
[i.e. Wave Celerity "a"]

Water hammer pressure increases with rise in the value of pressure wave velocity "a" which depends on material, diameter and wall thickness of the pipe.

[ii] Steady State Velocity in the Pipe Line [V_o]

During closure of flow, velocity in the pipeline changes from its steady state value to zero, therefore, water hammer pressure depends on the steady state value of the velocity V_o. This velocity has to be estimated correctly under various conditions of operation of the pipeline, [like one pump working or number of pumps working at a time] for immediate stage, intermediate stage and ultimate stage of the project. In new pipelines, value of Hazen-Willium coefficient 'C' would be more and some times may be as high as 140 which reduces the frictional losses resulting in increase in discharge as per performance curve of the pump. This possible increase in discharge should be accounted for while estimating the steady state velocity in the estimation of the water hammer pressure.

Pump characteristic curve should invariably be available for this analysis.

[iii] Time Required for Closure of Flow

Time required for closure of flow [from steady state velocity to zero velocity] is important parameter. If this time is less than the characteristic time of pipeline i.e., 2L/a, then the closure should be treated as *sudden closure*. In such cases, moment of inertia of the pump and motor will have no effect on water hammer pressure.

Further, in case the flow stops in time greater than 2L/a water hammer pressure should be estimated from the consideration of slow closure which would involve detailed and complicated analysis of water hammer pressures. Therefore, effect of pump-motor inertia may not be considered in both the above cases.

[iv] Frictional Losses in the Pipe Line

Water hammer pressures should be estimated in both the cases as below :

[a] When frictional losses are neglected.
[b] When frictional losses are considered.

It should be noted that when frictional losses are considered, values of both upsurge and downsurge are reduced. While calculating the upsurge and downsurge frictional losses should be neglected at all stages including fixing the initial level of hydraulic grade line [HGL]. This aspect is overlooked or neglected many times, which leads to wrong results.

1. **Estimation of Water Hammer**

For sudden stoppage of flow, water Hammer pressures are

$$\Delta h = \frac{aV_o}{g} \quad [1]$$

$$h_{max} = HGL = \frac{aV_o}{g} \quad [2]$$

$$h_{min} = HGL - \frac{aV_o}{g} \quad [3]$$

Equations 1, 2 and 3 are <u>valid only when frictional losses are neglected</u>. Hence for pumping mains for which frictional head has been considered, the Equations 1, 2 and 3 can not be used. Following equations shall be used for pipelines where frictional head loss is considered:

[i] Minimum Pressure in Pipeline :

While estimating minimum pressures in pipeline [Figure 1] due to sudden closure of flow or power failure, the following relation should be applied.

Lowest elevation Of HGL at pump Outlet due to water hammer condition	=	Steady State Elevation of HGL at pump outlet considering frictional head loss $(-)\ \frac{aV_o}{g}\ (-)\ \frac{h_f}{\sqrt{2}}$ [4]

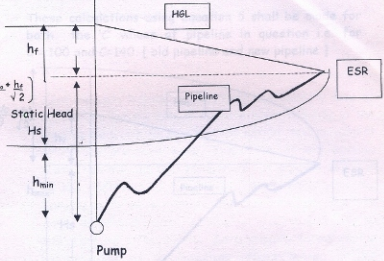


Figure 1 : Minimum Pressure at Pump outlet

[ii] Maximum Pressure in Pipeline :

While estimating maximum pressures in pipeline [Figure 2], the following relations should be used.

Highest elevation Of HGL at pump Outlet due to water hammer condition	+	Elevation of HGL at outlet of pumping main [i.e. ESR FSL] $(+)\ \frac{aV_o}{g}(+)\ \frac{h_f}{\sqrt{2}}$ [5]

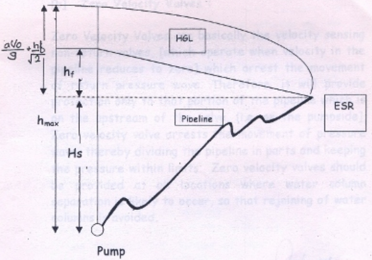
Where :

V_o = actual velocity of flow in the pipeline during steady flow condition.

h_f = total head loss in pipeline during steady flow and

a = celerity of pressure wave.

These calculations using equation 5 shall be made for both the 'C' values of pipeline in question i.e. for C = 100 and C=140. [old pipeline and new pipeline]



2. **Selection of *Air* cushion Valves and Zero Velocity Valves**

[a] *Air Cushion Valves [ACV]* :

Air cushion valves basically function as vacuum breakers and are provided to avoid vacuum in the pipeline. Production of vacuum in pipeline may cause problems of

[i] Collapse of pipeline

and

[ii] Column separation in the pipeline.

Location of ACV : It shall be so located that the level difference between two ACVs should be about 7 m, in general.

[b] Zero Velocity Valves :

Zero Velocity Valves are basically the velocity sensing non-return valves, [which operate when velocity in the pipeline reduces to zero] which arrest the movement of return pressure wave. Therefore, it will provide protection only to that portion of the pipeline which is on the upstream of the valve. [i.e. on the pumpside]. Zero velocity valve arrests the movement of pressure wave, thereby dividing the pipeline in parts and keeping the pressure within limits. Zero velocity valves should be provided at all locations where water column separation is likely to occur, so that rejoining of water columns is avoided.

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[Tech]

To:
All Chief Engineers, MJP.