

Report

XXXXXXXX WATER SUPPLY SCHEME

WATERHAMMER ANALYSIS AND CONTROL

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INTRODUCTION

This report presents the findings of a computer analysis of the requirements for waterhammer control on the pump/rising main system that delivers water from XXXXXXX to the XXXXXXX Reservoir in County XXXXXXX.

PUMP/RISING MAIN DETAILS

Pump type: Weir Uniglide SDD 100/125		
Standard pump speed (rpm)		2930
Moment of inertia of pump set (kg m ²)		1.0
Rising main: Asbestos Cement, Class 20		
Length (m)		5320
Internal diameter (mm)		243
Pipe wall thickness (mm)		21.5
Young's modulus for pipe material (N/m ²)		2.5x10 ¹⁰
Sump operating water level (mOD)		48.0
Rising main delivery level (mOD)		117.2

STEADY FLOW CONDITIONS

The pump and system curves are plotted on Fig 1, defining the following pump duty point:

Pumps in operation	Manometric head (m)	Discharge (l/s)
1	94.4	51.6

WATERHAMMER ANALYSIS

The most severe waterhammer conditions are caused by sudden pump trip-out under maximum flow conditions. The unsteady flow and boundary condition equations, which define flow in the system, following sudden pump trip-out, were solved by a computerised numerical procedure based on the method of characteristics (Casey, 1992).

The results for the trip-out of the duty pump are presented on Fig 2, which includes the following:

1. the rising main profile
2. the maximum and minimum pressure envelopes following pump trip-out
3. the steady flow hydraulic gradient line (HGL)
4. the vapour pressure limit line

The pressure graphs are plotted as potential head (mOD) and hence the gauge pressure at any point is the vertical difference between the plotted pressure line and the rising main elevation at that point.

Examination of the plotted results on Fig 2 shows that, under pump trip-out conditions, the minimum pressure would drop to vapour level over most of the rising main length. Also, the maximum gauge pressure would exceed the limiting value of 10 bar for Class 20 AC main. As this is an unacceptable operating condition, waterhammer control is required on this system. An air vessel is considered the most suitable control device for this application.

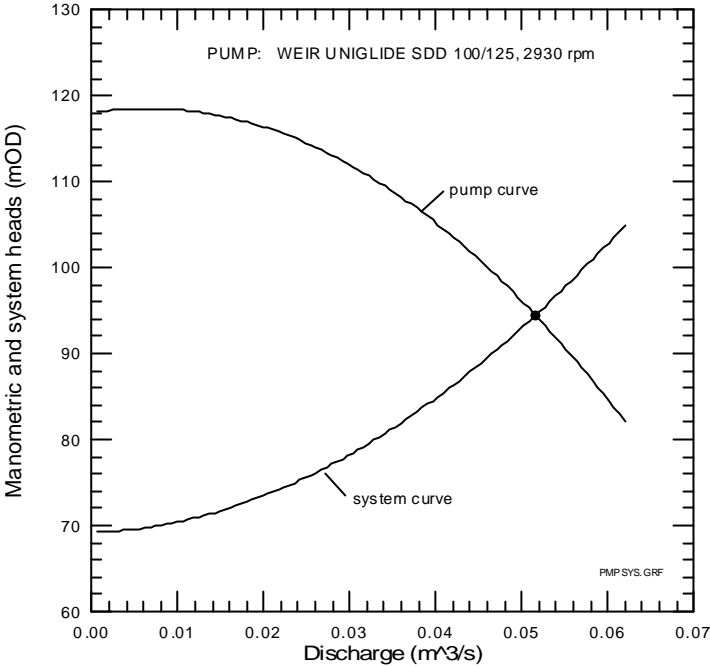


Fig 1 Pump and system curves

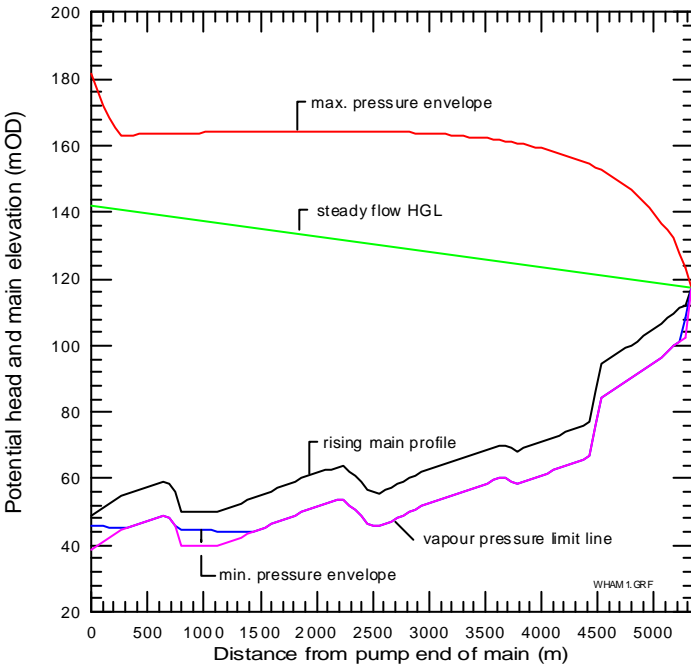


Fig 2 Rising main pressure fluctuation envelopes due to pump trip-out

Following a series of trial computer runs, the following air vessel system was selected:

Air vessel volume	1.60 m ³
Air cushion volume under steady flow conditions	0.75 m ³
Connecting throttle pipe diameter	75 mm

The plotted pressure envelopes for the protected system, following a pump trip-out, are plotted on Fig 3. The plotted results show that (a) negative pressure in the rising main is eliminated and (b) the maximum pressure on the protected system (at pump end of rising main) is 95.3m at the pump end of the rising main. Hence, the system is adequately protected against damaging waterhammer effects.

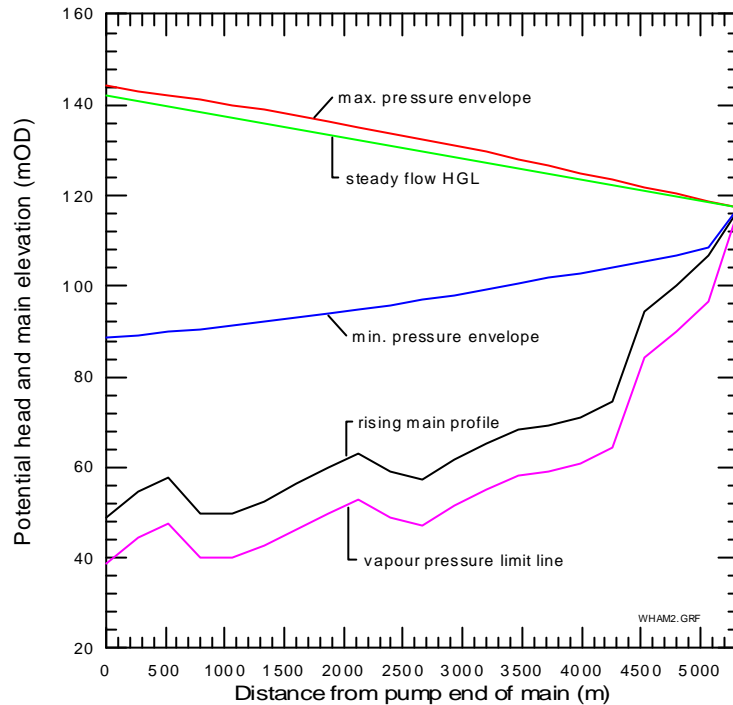


Fig 3 Pressure fluctuation envelopes due to pump trip-out
System protected by an air vessel as specified in text

RECOMMENDATION

An air vessel system of the following specification is recommended:

Air vessel volume	1.60 m ³
Air cushion volume under steady flow conditions	0.75 m ³
Connecting throttle pipe diameter	75 mm

Professor T J Casey
Date: 28 June 2002

Reference

Casey, T J (1992) Water and Wastewater Engineering Hydraulics, Oxford University Press, Oxford.