MODELLING VORTEX FLOW CONTROL DEVICES

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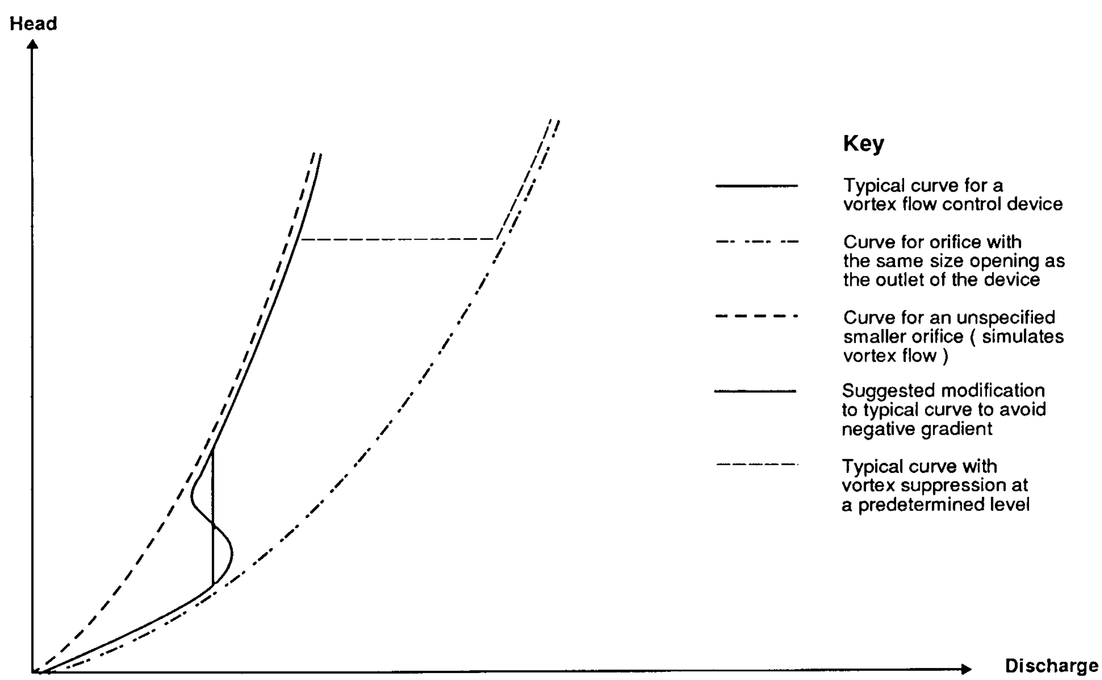
1. INTRODUCTION

Vortex flow control devices (e.g. the Hydro-Brake®) generally consist of a stainless steel unit with no moving parts. They operate by directing the flow to rotate inside a cylindrical vessel towards a central outlet. This generates a vortex with an air filled core which allows the openings to be larger than the equivalent conventional orifice, reducing the likelihood of blockages.

At low flows, before the vortex is initiated, the discharge characteristic follows that for an orifice with the same area as the opening in the device. As the head increases the vortex initiates, and after a period of instability the discharge characteristic follows the curve for an orifice of a smaller area. Producing a 'kickback' on the curve (see Figure 1). An optional feature allows the vortex to be suppressed at a predetermined level. When this occurs, the discharge characteristic will revert to that of the larger orifice. This feature may be useful to increase flow downstream just before the onset of upstream flooding or when a tank is full.

If the outlet from the device becomes drowned downstream then this will affect the performance. If the depth downstream is less than 1.2 times the outlet diameter it is claimed (Ref 1) that there is no effect on the discharge characteristic as the air filled core of the vortex still vents to atmospheric pressure.
Above this level the effect on the characteristic is dependant on the head upstream of



the device. At low heads the vortex will collapse and the characteristic will revert to that of the larger orifice. This will also occur if there is a negative head across the device. With high heads upstream of the device the vortex remains but with increased air pressures inside the core. This reduces the operating head to the differential head across the unit.

In general the vortex control will pass forward greater flows before the vortex is initiated than an orifice set to pass forward the same flows at higher heads when the vortex has been initiated. In some cases this can result in considerable savings in the volume of upstream storage required.

2. MODELLING VORTEX FLOW CONTROL DEVICES

2.1 Introduction

Vortex flow control devices can be modelled as the continuation outlets on on-line or off-line tanks with the various simulation programs. They can be represented in one of four ways:

i) As an orifice with an area equivalent to the reduced flow area of the device. This gives a reasonable approximation over the working range of the device other than at very low heads (before the vortex is initiated) or when the vortex has collapsed. This method is an approximation which ignores any potential savings in upstream storage due to increased discharge before the vortex initiates,

ii) Using a limiting discharge downstream to design to a maximum flow. This method is even more of an approximation than the first method. This is very simplistic representation of the head discharge curve and may significantly underestimate the volume of storage required. For this reason this method is not recommended.

iii) By defining a head discharge relationship for the continuation or return pipe using a user defined head discharge relationship.

iv) By specifying the Hydro-Brake which is supported in some software, giving the values of design head and the maximum flow for that head.

For initial design or planning purposes it is suggested that method i) is used. If the reduced storage is not likely to be significant then this may suffice. The reductions in storage are unlikely to be significant where:

a) The device is to be designed to operate at high heads and low flows, or

b) where the required storage is small.

Where a more rigorous analysis is required then methods (iii) or (iv) should be used.

2.2 USE OF HEAD DISCHARGE CURVES

For details of how to use this in your particular software see the software supplier's user manual or help system.

Users should note that the flows are normally calculated from the difference in head between the upstream and downstream sides of the device. If you do not know how your software calculates this check the manual or help system.

One common limitation of software is an inability to simulate curves where there is a negative gradient (i.e. where the flow decreases for an increase in operating head). A modification has therefore to be made to the curve in the area where the vortex is initiated (see Figure 1).

Particular attention should be paid to what happens if the highest head value is exceeded as different software handles this in different ways. In general it would be wise to ensure that values are given for the whole rage of likely operating heads.

As usual when modelling tanks users should be careful to check the results for possible mathematical instabilities.

3. REFERENCES

1. Smisson, R P M, 'The modelling of Hydro-Brake™ flow controls using WASSP'. WaPUG Spring Meeting 1987.

AMENDMENTS

Ver	Description	Date
1.	First Published	March 1986
2.	Updated	September 1989
3.	Updated	February 1998
4.	Updated	March 2009