The University of New South Wales

WATER RESEARCH LABORATORY

REPORT ON TESTS OF OPERATION OF THREE INCH AUTOMATIC FLOW REGULATING VALVES FOR JOHN THOMPSON (AUST.) PTY. LTD.

by

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1. Description of Test

The test programme dealt with in this report is aimed at assessing the application of the design to the following conditions.

Each valve to pass a constant flow of water within ± 5 per cent of the set rate, and to be capable of operating at flows from 2,400 g.p.m. to 3,750 gallons per hour. The applied head at the inlet of the valves to vary between 13 feet and 2 feet, whilst the outlet head ranged from 1 foot to 2 feet.

The valve was tested by coupling in a pipeline containing an orifice meter and a branch pipe leading to a free surface overflow, the total length of pipe to the overflow being approximately 35 feet.

The length of pipe upstream of the valve was necessary to accommodate the meter and to connect the valve in the existing installations. The valve, when installed and in service, will operate with a short pipeline not exceeding nine feet upstream of the valve and for this reason the test conditions represent more severe conditions with regard to upstream transient pressure fluctuations than would be experienced in the normal usage of the valve.

2. Behaviour of Valve Prior to Adjustment and Modification

Preliminary tests revealed that the valve was sensitive to transient head changes upstream, and with the form of testing assembly used no stable response could be obtained. The valve tended to close under high entrance heads or remain open behaving as an orifice under low entrance heads with a tendency to hunt violently in the middle range.

3. Programme Tests for Remedial Findings

Time available for testing was restricted by the need for meeting contract dates. It is generally most desirable in cases such as this to obtain reliable calibrations of the several control apertures before an analysis is completed. Time did not permit of making the necessary modifications to the valves to obtain these readings. Accordingly, efforts were directed in the first instance to achieving stable operation of the valve leaving the question of calibration and correction of seat head versus quantity characteristics for later examination.

4. Details of Valve to which Reference is made in this Report

In order to describe the functions and suggested modifications of the various parts, the following terms have been used in the description which follows and may be related to the individual parts by the item numbers taken from John Thompson (Aust.) Pty.Ltd. Drawing No. W8/210/37.

1. Bottom Valve Body
2. Top Valve Body
3. Valve Body Cover
4. Guide Plate
5. Piston Cylinder
6. Piston
7. Balance Valve
8. Balance Valve Cylinder
9. Shut-off Valve
12. Main Shaft
13. Shut-off Spring
14. Balance Valve Cylinder Spring

5. Description of Valve Function

The modulating control of this type of valve is achieved by balancing the effective weight of the Balance Valve (7) against the pressure difference produced across an externally adjustable gap between the Balance Valve Cylinder (8) and the Guide Plate (4). An increase in flow above the set rate results in lowered pressure above the Valve (7) piston and the valve moves upward against t.. seat at the base of the Piston Cylinder (5) to a stable position and vice versa.

The design assumptions are evidently -

(i) that the valve (7) is truly balanced in regard to pressure distribution about its seat and the velocity across the seat (which is a function of the head dissipation effected by the valve) does not produce local pressure changes in the field of flow which will affect the apparent weight of the valve itself as a submerged element in the water.

(ii) It is also assumed that such pressure changes occurring across the Balance Valve (7) Piston are steady or slow in development thus rendering inertial effects produced by possible over-travel of the valve negligible.

(iii) It is also assumed that the motion of the Balance Valve (7) is practically frictionless.

6. Modification of Valve to improve Stability

Before proceeding with modifications to improve stability, a test tapping was made by drilling a hole through the flange of the Guide Plate (4) from the outer cylindrical surface to the inner cylindrical surface parallel to the faces for the purpose of monitoring the pressures effective on the top of the Balance Valve (7) Piston.

Readings taken as a difference between this pressure and the pressure at the inlet showed that the fluctuating pressures observed during the hunting phase of the valve were developed across the seat between the Balance Valve (7) and its seat. This was confirmed by the sound of the valve striking on the seat which became audible when the pipeline conditions were deliberately adjusted to accentuate the oscillation.

The head difference across the gap between the Balance Valve Cylinder (8) and the Guide Plate (4) was measured as approximately 10½ inches with the valve passing 3000 g.p.h. and the gap set at about 3/8 inches (weight of valve 4 lb. 2 oz.)

It is obvious by comparison that the gap between the Balance Valve and its seat will be about 3/8 inches ranging down to about 5/32 inches when the valve is dissipating 13 feet of head at 3000 g.p.h.

The smallness of this gap means that the regulation of the valve must be effected over very small displacements rendering the valve susceptible to over-regulation and hunting effects.

Dashpot Control

Modification of the Valve seat was considered out of the question in the time available and a simpler approach was adopted in inserting a restricting orifice plate drilled with 12 3/16" diameter trial holes in four groups of three to match the four parts in the lowerside of the Balance Valve Cylinder (8). By rotating the plate 1, 2 or 3 holes in each group could be made effective as orifice holes and the lower section of the Balance Valve Cylinder was thus converted into a dashpot to control sudden movements of the Balance Valve (7). After several trials five effective holes were found to give satisfactory results. It should be noted that the area through this orifice plate is dependent to an extent on the leakage rate past the Balance Valve (7). Piston and thus it is dependent on the fit of the piston in the cylinder.

The piston fit under these circumstances should be the best attainable under workshop or production conditions but to ensure as far as possible freedom from friction a floating piston is considered desirable rather than the fitting of a piston ring.

Spring Stiffnesses

Using the Balance Valve Cylinder (8) as a dashpot necessitated the Balance Valve Cylinder Spring (14) being stiffened to withstand back thrust under the worst conditions of dashpot action. A change from the design stiffness of 12 lbs. per inch to approximately 60 lbs. per inch appears to meet this requirement. The Shut-off Spring (13) may also require stiffening to ensure a tight seat between the Shut-off Valve (9) and the Balance Valve Cylinder (8).

Freedom of Fit of Balance Valve (8)

Throughout the tests considerable trouble was experienced in obtaining consistent results due to a tendency for the Balance Valve (8) to pick up on high spots on the machined surface of the Balance Valve Cylinder (8) bore and it was not until these irregularities were traced and mitigated that steady operation of the valve became feasible.

7. Test Results

The detection and elimination of the causes of unsteady behaviour took a considerable time and the valves were despatched from the laboratory under directions from John Thompson and Co.Ltd. as soon as stable operation was achieved in order to satisfy the Company's contract commitments.

Further adjustment mainly concerned with seat modifications of the Balance Valve (7) appear necessary to bring the valve into the specified range of tolerance on the design flow.

The following table gives particulars of the behaviour of the valve on test just prior to despatch to the workshops for minor adjustment on route to the site for installation.

Effective Head over Valve feet	Discharge Gallons per Hour	Percent Q referred to Q at 9.5 feet Head = 3025 g.p.m.
10.5	2955	-2.31 per cent
8.0	3060	+1.4 " "
7.6	3030	+ .1 " "
6.1	3160	+4.15 " "
4.6	3290	+8.15 " "
2.4	3415	+15 " "

Comment on the Design and Operation of the Valve

Notwithstanding the trouble encountered in obtaining satisfactory operation of the valve in these tests the principles followed in the design of the valve appear to be sound and the irregularities experienced appear to be due to -

(1) Small travel required by this design for regulation over the design range of heads.

A suggestion to overcome this disability is to use a fixed sleeve with triangular ports vertex upwards in conjunction with a sharp edged balance valve of the type shown on Dwg. No. W8/210/37.

(2) Lack of damping dashpot on the balance valve piston. This was arranged as described previously in this report.

(3) Balance Valve Cylinder Spring too soft.

(4) Slight irregularities on the machined surfaces of the active parts of the valve proved a source of sticking, upsetting the smoothness regulation.

Recommendations

(1) The alignment of the active parts of the valve is effected on the main shaft and misalignment due to machining irregularities tends to sponsor sticking of the moving parts.

It is therefore recommended that for future models the shaft to be finished by grinding. Other parts to remain as at present but with finer limits on the fitting tolerances.

(2) Referring to Paragraph (1) under 'Comment' above, a separate series of tests of trial port openings is recommended to ascertain the proportions and shapes of openings to give regulation within the specified range of tolerance for discharge and to obtain a calibration in terms of head loss and discharge for such openings as may be found satisfactory from the tests.