W.A. Kates® company
A TAUBE COMPANY

FUNDAMENTALS OF FLOW CONTROL OPERATION

THE KATES FLOW RATE CONTROLLER

Accurate flow control without a flow control loop? Sound impossible? Well it's not and it's been right at your fingertips for almost 50 years.

To many engineers, accurate flow rate control infers a flow control loop or system. This system must include three or more distinct pieces of equipment, each piece containing one or more mechanical devices or linkages. Two or more transducings of any flow error signal are required, and the fluid characteristics of one or more signaling and/or power media are involved. The entire system arrangement is fundamentally characterized by its use of an orifice of fixed area as a sensor.

In contrast, accurate flow rate control can be affected by a single control unit requiring no external cooperated equipment of any kind. No transducing of the original flow error signal is necessary. Since no external signaling and/or power media are involved, no characteristics of these affect operating characteristics of the control. The entire scheme is characterized by its use of a flow sensing orifice which is adjustable in area. A picture contrasting the two methods of control can be obtained most rapidly and clearly by starting with the basic fundamentals of the two schemes.

With Fixed Orifice

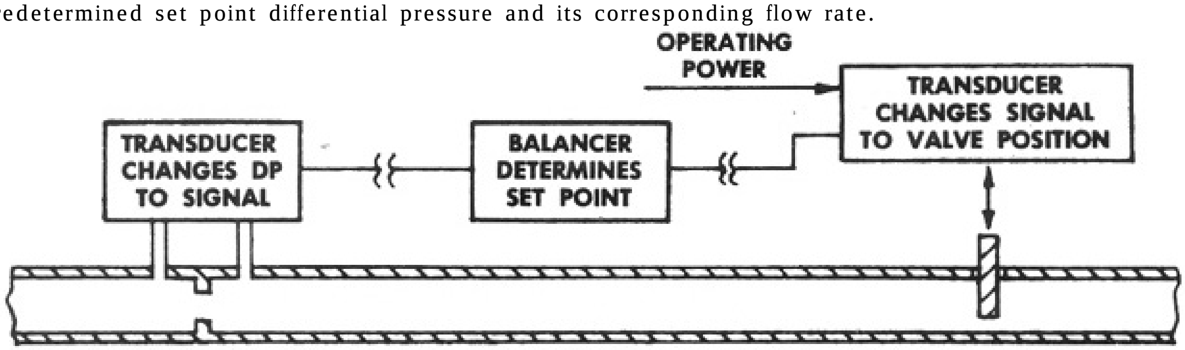
Orifice area is fixed. Pressure drop across the orifice varies with the flow rate according to a square root law. Set point is changed by changing the balance action of the pressure drop signal.

With Kates Adjustable Orifice

Orifice area is adjustable. Pressure drop across the orifice is automatically maintained constant. Set point is changed by changing the orifice area

The Idea - With Fixed Orifice

Flow rate is sensed by an orifice of fixed area. The pressure drop or pressure differential across the orifice is proportional to the square of the rate of flow. This differential pressure operates a mechanical-fluid or mechanical-electrical transducing mechanism. The signal from this mechanism is sent to a controller having an adjustable balance or set point. Controller operates a valve. Opening or closing of this valve maintains the predetermined set point differential pressure and its corresponding flow rate.



The System - With Fixed Orifice

The block diagram visualizes the elements of the fixed orifice system and their relation to each other. Operation as outlined above is apparent.

Such fixed orifice systems require isolation of the orifice by straight pipe lengths of 10-15 pipe diameters if an accurate pressure differential indication is to be obtained. This substantially precludes any compacting by unitization. It necessitates transducing the pressure differential, transmitting a signal by some secondary media (air, liquid, electricity), and one or more transducings to obtain corrective action of a valve. Obviously the ultimate or overall corrective action depends the accuracy and reliability of two or more transducers, and the characteristics the secondary media. And, of course, there is also involved the structure and operating characteristics of the balancing device for set point adjustment.

The accuracy and reliability of each system component can be determined by test. However, the accuracy and reliability of the scheme as a whole must inevitably reflect a summation of these characteristics for all the separate elements, and their interaction. Also, if indication, overall and recording modes all agree, this is no warranty of absolute accuracy. A real audit of control performance can be obtained only from a second independent flow metering device.

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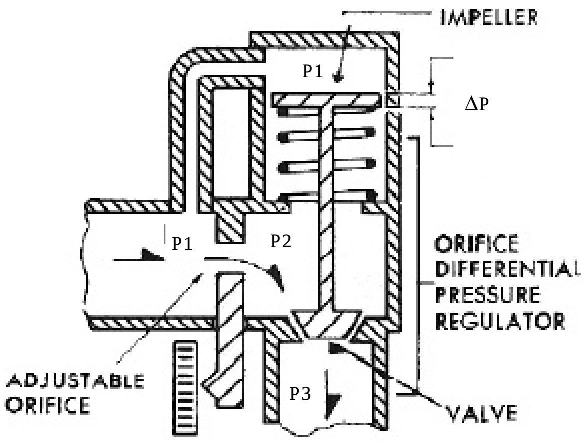
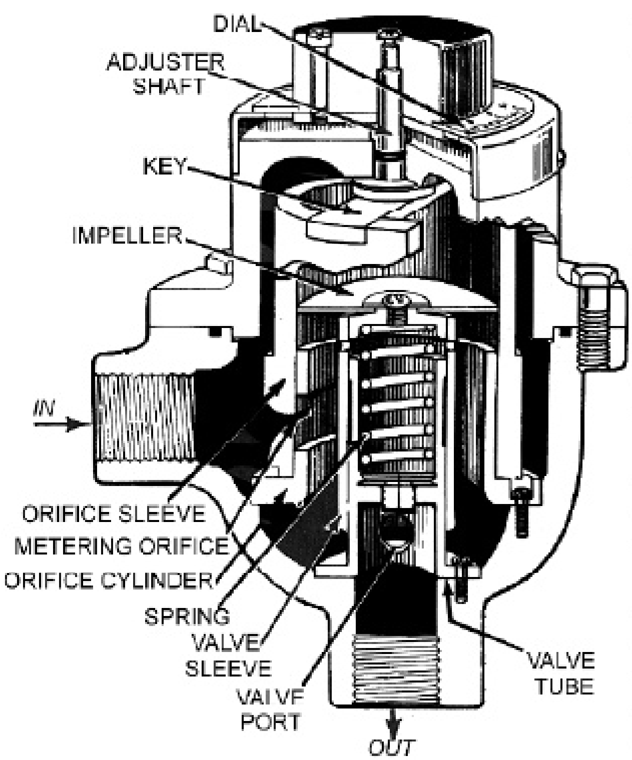
With Kates Adjustable Orifice



The Idea

The Kates Flow Rate Controller uses an adjustable-area orifice as a sensory element. Pressure differential across this orifice is automatically maintained constant, regardless of the orifice area. Total flow rate is therefore directly proportion to orifice area. Orifice and automatic differential pressure regulator are enclosed in a single housing, with a calibrated flow-rate indicating dial



The Unit

The drawing at the left shows a typical Kates Flow Rate Controller and its parts. The metering orifice is formed by an arcurate slot in a cylinder (orifice sleeve) and a second slot in an inner (orifice) cylinder around which the first (orifice sleeve) can be rotated. When the two slots match or coincide, the orifice has its maximum open area; when the outer orifice sleeve is rotated, the open length of slot and the open area decrease in proportion to the angle of rotation of the sleeve. As the slots extend 160°, rotation through this angle reduces orifice area to zero.

The automatic differential pressure regulator includes the impeller, spring, valve sleeve and valve tube. The impeller disc reciprocates in the upper part of the orifice sleeve, driven by the force balance between orifice differential pressure across it and the spring force. The impeller is rigidly connected to the valve sleeve, so it closes or opens the valve ports as the force balance dictates, maintaining orifice differential pressure and holding orifice flow at the valve determined by the differential pressure and the orifice area.

Accuracy of the Kates Flow Rate Controller is complete accuracy of control as obtained in service; no external devices require consideration.

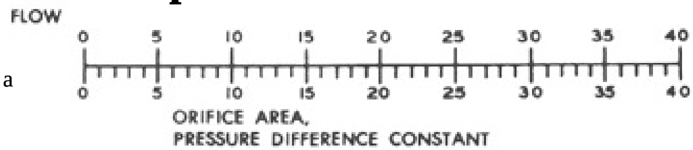
Deviation from set point depends on response of the differential pressure regulator, and is the same for all orifice openings. Translated into terms of service performance, this means that per cent deviation from set point is the same at 20% of maximum flow as it is at 30%, or at full scale.

For a wide range of combinations of fluids and fluid circuits, corrective action of the Kates Flow Control occurs in approximately one second. However, it is obvious that the corrective action of any control driven by power from the fluid stream depends on the power source driving the stream, the fluid, and the fluid circuit characteristics. Therefore no universally attainable operating time can be stated. Operating time is inherently low, however, because there is no transducing of flow signals and because of the rigid connection of the force balance member to the corrective valve.

Flow Scales Compared

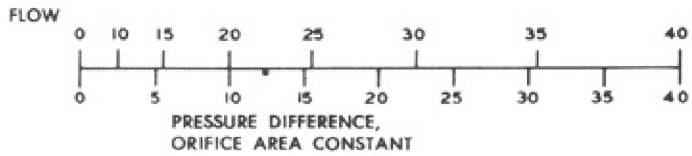
Adjustable Kates Orifice

Flow is directly proportional to orifice area. This gives a "straight-line" uniform scale, equally sensitive at high and low ends.



Fixed Orifice

With a fixed orifice, flow varies as the square root of the pressure drop. Flow is open and sensitive at high flows, compressed and insensitive at low flows.



Advantages of the Kates Flow Rate Controller

1 - AUTOMATICALLY CORRECTS FOR ANY CHANGES TO THE INLET OR OUTLET PRESSURE TO MAINTAIN THE SET POINT FLOW TO +/- 1.5% OF SETTING.
2 - Flow is directly proportional to orifice area.
3 - “Straight-line” uniform linear scale.
4 - Accuracy by means of a self-operating single unit.
5 - No need for 10 - 20 straight runs of pipe diameter upstream or downstream to insure control accuracy.
6 - No electric, air or hydraulic connections are required.
7 - Large turndown ratio typical 25 to 1 or better.
8 - Fast acting.
9 - On liquid service, moving parts are immersed in the fluid which helps prohibit hunting or oscillation.
10 -Simple design and few parts eliminated the many calibration and adjustments checks required of a typical flow rate control system.
11 -Capable of taking large pressure drops.
12 -Automatically takes whatever pressure drop is required to deliver the required flow.
13 -Cf & Cv are not a factor—Control set point is maintained as long as there is a minimum differential pressure of 10 psi between the inlet of the Kates and the outlet of the system.
14 -Sizing does not require formulas. It is only necessary to know the required flow and select the correct range.
15 -LOW INITIAL COST AND LOW OPERATING COSTS.

How a Kates Works

Excerpt from the Kates Sizing Program • Version 1.2

"A Kates Valve controls flow by maintaining a constant pressure differential across a metered orifice. The simplicity of its design begins with the Internal Differential Regulating Valve (IDRV). It is free to move inside of the Kates valve and is attached with a spring.

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When fully extended the IDRV will cover the exit port. When the inlet pressure is applied, the top of the impeller sees the upstream pressure, P1, and is forced down. Subsequently, fluid flows through the metered orifice resulting in an internal pressure, P2. Further pressure is dropped across the exit orifice resulting in the discharge pressure, P3.

The IDRV is in equilibrium when the upstream pressure is reacted by the internal pressure plus the force of the spring. If the internal pressure is too low, then the IDRV will move down decreasing the area of the exit port. This will in turn increase the internal pressure. Thus the pressure across the impeller, as well as the metered orifice, is maintained to be constant. When the upstream pressure fluctuates, the internal pressure will adjust accordingly. When the downstream pressure fluctuates, the IDRV will adjust the size of the exit port to maintain the internal pressure.

The flow rate can be adjusted by changing the area of metered orifice. This is done through the control knob on the top of the valve.

With a Kates controller, maintain your flow to within 1-1/2% of the setpoint, regardless of pressure variations. Just set it and forget it!"

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