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Irrigation equipment — Automatic irrigation systems — Hydraulic control

Matériel d'irrigation — Systèmes d'irrigation automatiques — Régulation hydraulique

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ISO/TR 8059 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry.*

The reasons which led to the decision to publish this document in the form of a Technical Report type 3 are explained in the Introduction.

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0 Introduction

Automatic irrigation systems are a relatively new concept that began to develop in the second half of the 20th century. A brief review of the background of this development is therefore in order.

Food production by world agriculture depends primarily on the availability of water : food consumption increases with the increase in world population. Available resources of water that can be used by agriculture are limited. Consequently, they have become a restricting factor which demands that new water resources be developed and that strict control be exercised over existing resources. An in-depth study of plant growth requirements has repeatedly shown that improved and increased plant yields are not necessarily achieved by the application of greater quantities of water. In fact, water quantities may in many cases be reduced, provided that the water is applied in a scientific and controlled way.

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These requirements have a direct bearing on the extent and nature of human involvement in irrigation procedures. As irrigation methods become more sophisticated, so do the demands on human involvement become more complex. Much work must be devoted to supervising water application systems. The operator's responsibilities increase proportionately, and these factors make it difficult to fill the requirements of suitable and competent manpower.

The solution to these problems can be summarized in two words : control and automation.

Since irrigation operations are performed during specific periods of time, it may be reasonably assumed that irrigation control could be achieved through time control. This concept was used for a short time during the early stages of the development of automatic control devices, but was discarded later. The attempt to apply the time concept for quantitative control is an indirect approach based on two assumptions :

a) the rate of flow is known;

b) the rate of flow is constant.

Assumption a) is based on data supplied by the manufacturers of other system components, such as : sprinklers, drippers, pipes, valves. These data mostly present flow rates as a function of water pressure and pressure loss, which are then used as a basis for hydraulic design.

Assumption b) is in fact a combination of two separate and independent assumptions, namely :

1) supply pressure is constant;

2) the system features do not change with time.

These assumptions are not borne out by modern irrigation systems.

The flow of water at any given moment depends on the supply pressure and the resistance of the irrigation system. Changes in these factors have a great effect on the rate of flow of the water. As a result, the deviations in the quantities of water supplied may reach high percentages, when control is based on measuring the duration of water application. Several examples of changes in flow rates may serve as illustrations :

— gradual clogging of filters causes a gradual lessening of flow;

— gradual clogging of low-flow dispersion elements, such as drippers, causes reduction of flow;

— wear of sprinkler nozzles causes increased water flow;

— sediment formation on the inner walls of water pipes causes reduction of flow;

— replacement of pipes or other components by others of different flow resistance changes the water-conducting capacity.

In all these cases it was shown that the control of water quantities in irrigation through time-measurement does not and cannot provide suitable criteria. It must, therefore, be concluded that the only method capable of providing factual irrigation data, at any given moment, and permitting the use of such information for effective irrigation control, is by means of direct measurement of applied water quantities.

The interconnection between the need for control through accurate water measurement and reduced dependence on the human factor combined with the accelerated intensification of modern irrigation have resulted in the development of automatic control means.

At first, the basic instruments were developed to permit automatic quantitative control at a single specific point. These instruments are a combination of water meter, hydraulic valve and an adjustable setting device. Turning a knob and selecting the desired dose of water opens the valve, and the water is continuously measured as it flows through the valve. When the full dose has been delivered, the valve is closed by the water pressure of the pipeline, without requiring an external source of energy.

During the following stage, special-purpose accessories were developed, enabling the interconnection of any number of volumetric metering valves to form an automatic sequential system, where the operation of each valve is activated by the preceding valve. This method increases the efficiency of the entire irrigation system by maximum utilization of the distribution system.

The automatic sequential irrigation systems opened up an important new phase in the effective control of agrotechnical water requirements, while reducing dependence on human factors. As so frequently happens, the tools that were developed and the opportunities they created gave rise to new conditions which, in turn, created new requirements and new challenges.

Additional variables were included in the framework of control : irrigation design according to requirements of scheduling, timing pulse-mode irrigation, dosing of fertilizers, flow control, detection of failures in the field, etc. These systems are based on electronic control devices and will be covered by a separate technical report.

As this Technical Report represents a guide to current technical knowledge of automatic irrigation systems run by hydraulic control, it has been decided to publish it in the form of a Technical Report rather than an International Standard.

1 Scope and field of application

This Technical Report deals with automatic irrigation systems based on hydraulic devices using only the energy that can be obtained from the water in the irrigation system : it gives main definitions and a classification of these systems.

This Technical Report applies to automatic control systems, in which the control of water application is achieved by means of water quantity measurement. Semi-automatic control systems are used with irrigation systems under pressure and are capable of controlling the delivery of a preset quantity for one irrigation cycle. Each subsequent irrigation cycle requires a further manual operation to preset the required water quantities.

2 Reference

ISO 7714, *Irrigation equipment — Volumetric valves — General requirements and test methods.*

3 Definitions

For the purposes of this Technical Report, the following definitions apply.

3.1 volumetric valve : Valve that shuts off the water flow to the irrigation system after a preset (measured) quantity of water has passed through the valve. Closing of the valve may be by means of a mechanical or hydraulic valve.

3.2 hydraulic valve : Valve that performs the opening and closing operations of an irrigation system by applying or releasing the existing water pressure in the system.

3.3 semi-automatic irrigation system : Irrigation system that includes a control system capable of shutting off the irrigation system automatically after a preset quantity of water has passed through the valve.

The control system must be manually reset to deliver the required dose of water for any new irrigation cycle.

3.4 sequential activation : Activation of several valves one after the other, so that each valve begins operation after the preceding valve in the series has delivered its preset quantity of water for irrigation.

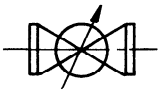
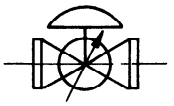
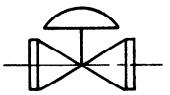
3.5 control tubing : Small diameter tubing that transmits a command hydraulically, by line pressure, to and from the pressure chamber of the hydraulic valve.

3.6 water dose : Measured quantity of water, required to fill the needs of a given crop area in one irrigation cycle.

3.7 irrigation interval : Time interval between the start of one irrigation application and the start of the following irrigation application to the same area.

4 Graphical symbols

Graphical symbols will be given in a future International Standard. However, until such Standard is issued, the following symbols are shown to permit the understanding of the figures in this Technical Report.

Designation	Symbol	Remarks
Mechanical volumetric valve		
Hydraulic volumetric valve		
Hydraulic valve		
Control tubing		

5 Classification

Irrigation systems with automatic hydraulic control are classified as indicated in 5.1 and 5.2.

NOTE — For the classification, general requirements and test methods for volumetric values, see ISO 7714.

5.1 Single volumetric valves

5.1.1 Volumetric valves including a built-in mechanical shut-off mechanism

Such valves are produced in small sizes, in which the mechanical shut-off does not cause water surges.

5.1.2 Volumetric valves with hydraulic shut-off

Volumetric valves with hydraulic shut-off, which come in sizes of 37,7 mm and greater, are manufactured in two forms :

a) the hydraulic valve is an integral part of the volumetric valve;

b) the hydraulic valve is a separate unit and receives a command from the water meter.

5.2 Sequential system of volumetric valves

5.2.1 General

A sequential system comprises the following components :

a) volumetric valves;

b) hydraulic valves;

c) control tubing.

5.2.2 Sequential systems for mechanical volumetric valves

5.2.2.1 Model A — Hydraulic valves installed in the main supply line (see figure 1)

At the beginning of the irrigation cycle, all or part of the volumetric valves are manually preset to the quantities of water they are required to deliver. All the hydraulic valves in the main supply line are open, but the main valve is closed.

When the main supply valve is opened to start the irrigation cycle, water flows from the main line to the first set of laterals through the volumetric valve at its inlet. Concurrently, pressure builds up in the upper part of the pressure chamber of the valve and closes the hydraulic valve in the main supply line.

When the predetermined quantity of water has been delivered to the first set of laterals, the volumetric valve closes automatically. The water pressure in the laterals drops to practically zero. Pressure in the hydraulic valve cylinder is released and the water pressure in the main supply line opens the hydraulic valve. As a result, the water flows to the second set of laterals and into the pressure chamber of the adjacent hydraulic valve. As before, the built-up pressure closes the hydraulic valve in the main line and the sequence of operations is repeated until the predetermined quantity of water has been delivered.

Similarly, the water flow continues sequentially from one set of laterals to the next, and follows through until all preset volumetric valves have been activated.

These systems are used when the distance between irrigation groups is very great and the use of control tubing is impractical.

5.2.2.2 Model B — Hydraulic valves installed in laterals (see figure 2)

These systems operate on the same principle as that described in 5.2.2.1 for Model A, except that the hydraulic valves are installed in the irrigation laterals, and the connection between stations is maintained by means of control tubing.

5.2.3 Sequential systems for hydraulic volumetric valves

5.2.3.1 Model C — Hydraulic volumetric valves installed in irrigation laterals (see figure 3)

At the beginning of the irrigation cycle, the main supply valve is opened, and all volumetric valves are manually preset to the quantities of water they are required to deliver. All volumetric valves remain closed, except the first valve, which opens when preset.

The system is designed so that the water pressure from the first volumetric valve is transmitted through the control tubing to keep the second volumetric valve closed. The second volumetric valve then keeps the third valve closed, and the same closing action continues up to the last volumetric valve in the system.

When the predetermined quantity of water has been delivered to the first lateral, the first volumetric valve closes automatically. Pressure is released and the water pressure of the main supply line opens the next lateral valve. Water flows into the second irrigation lateral and continues to flow until the entire preset quantity of water has been delivered.

Similarly, as pressure is released from one volumetric valve, the water pressure in the main supply line opens the following valve. Water flow thus continues sequentially from one lateral to the next and follows through automatically until the entire irrigation cycle is completed.

5.2.3.2 Model D — Sequential systems using representative hydraulic volumetric valves (see figure 4)

These systems are designed for irrigation units, each of which comprises several laterals irrigating simultaneously.

In certain cases, it is necessary to apply a sequential irrigation system to several groups of laterals at one and the same time. The installation of a single sequential system in the main supply line is very expensive. Moreover, the installation of a hydraulic volumetric valve on each lateral individually does not ensure that the entire group of laterals will operate in concert to transmit the command to the next station. In such cases, it is customary to install a sequential volumetric valve in one of the laterals of the group, and only hydraulic valves on the other laterals. All the hydraulic valves in the group are connected to each other and to the volumetric valve of the group by means of control tubing and tubing respectively. The volumetric valve is connected sequentially to the volumetric valve of the group of laterals following in order. Each volumetric valve is preset to the quantity of water required only by its group of laterals, and when it closes, all the hydraulic valves of the group close with it. The next-in-line volumetric valve opens as described in 5.2.2.2 for Model B systems and, concomitantly, all the hydraulic valves of the group open.

The measuring accuracy of these systems is the same as that of a large volumetric valve installed at the head of the main supply line, which delivers the quantity of water required by the entire irrigation unit (see figure 4, main valve shown in dotted lines). The measuring accuracy depends of course on the rate of flow in cubic metres per hour required by the sprinklers, sprayers and drippers of the irrigation unit.

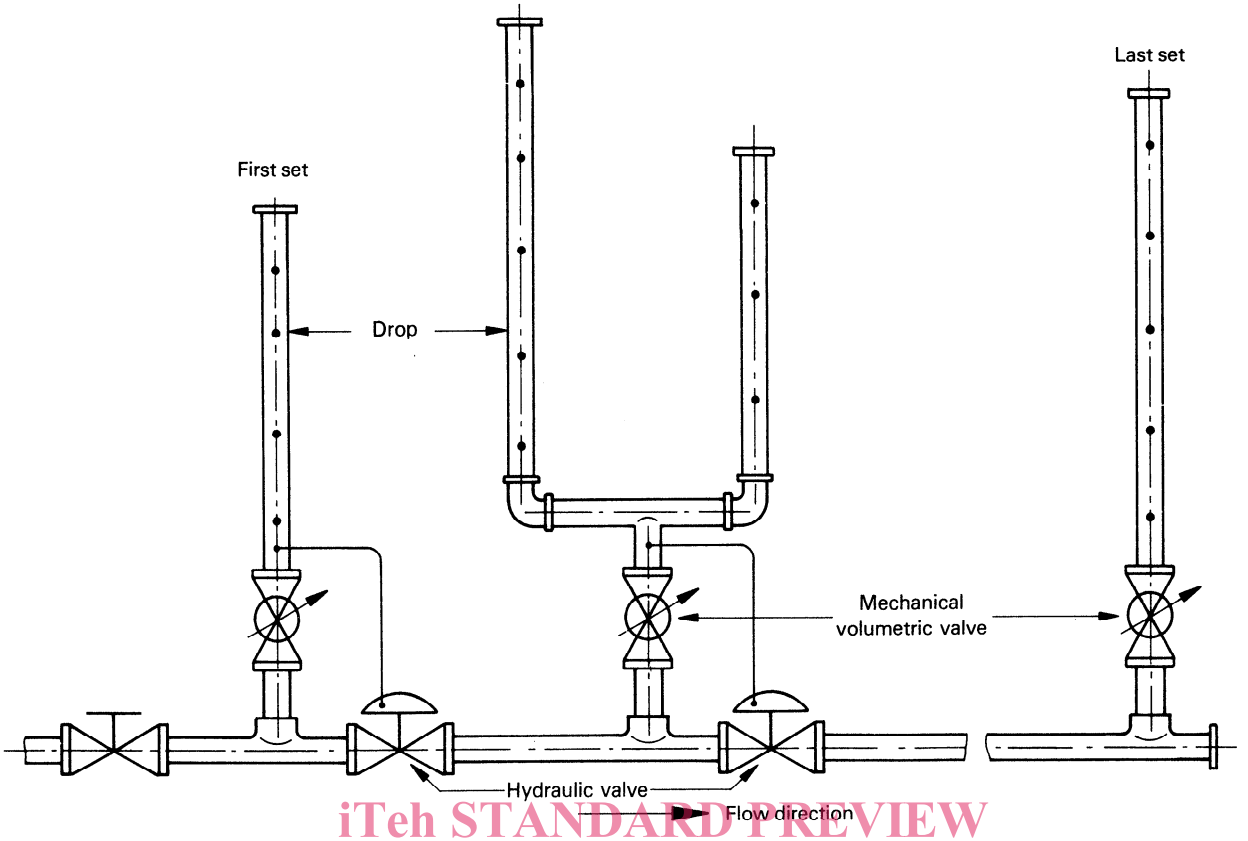


Figure 1 — Irrigation system with hydraulic valve on main supply line and mechanical volumetric valve on lateral drop

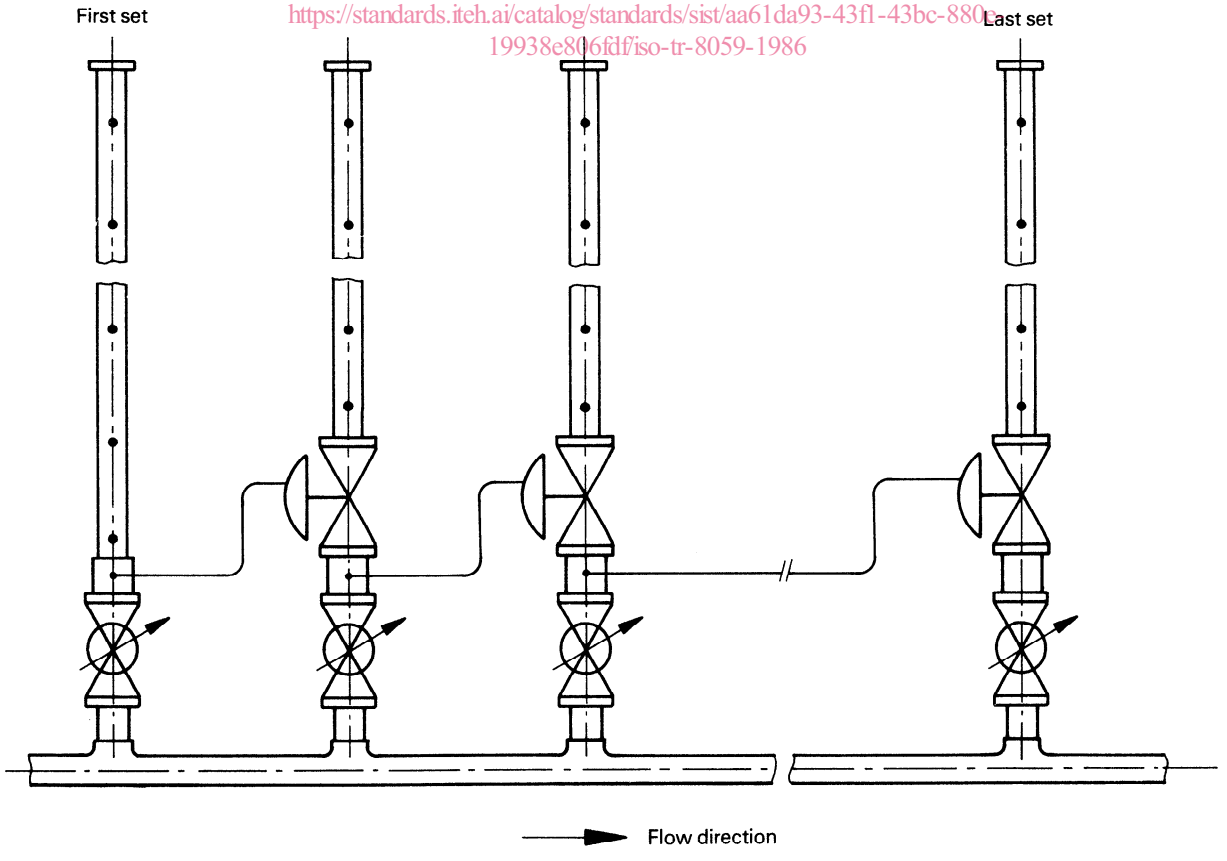


Figure 2 — Irrigation system with hydraulic valve and mechanical volumetric valve on lateral drop

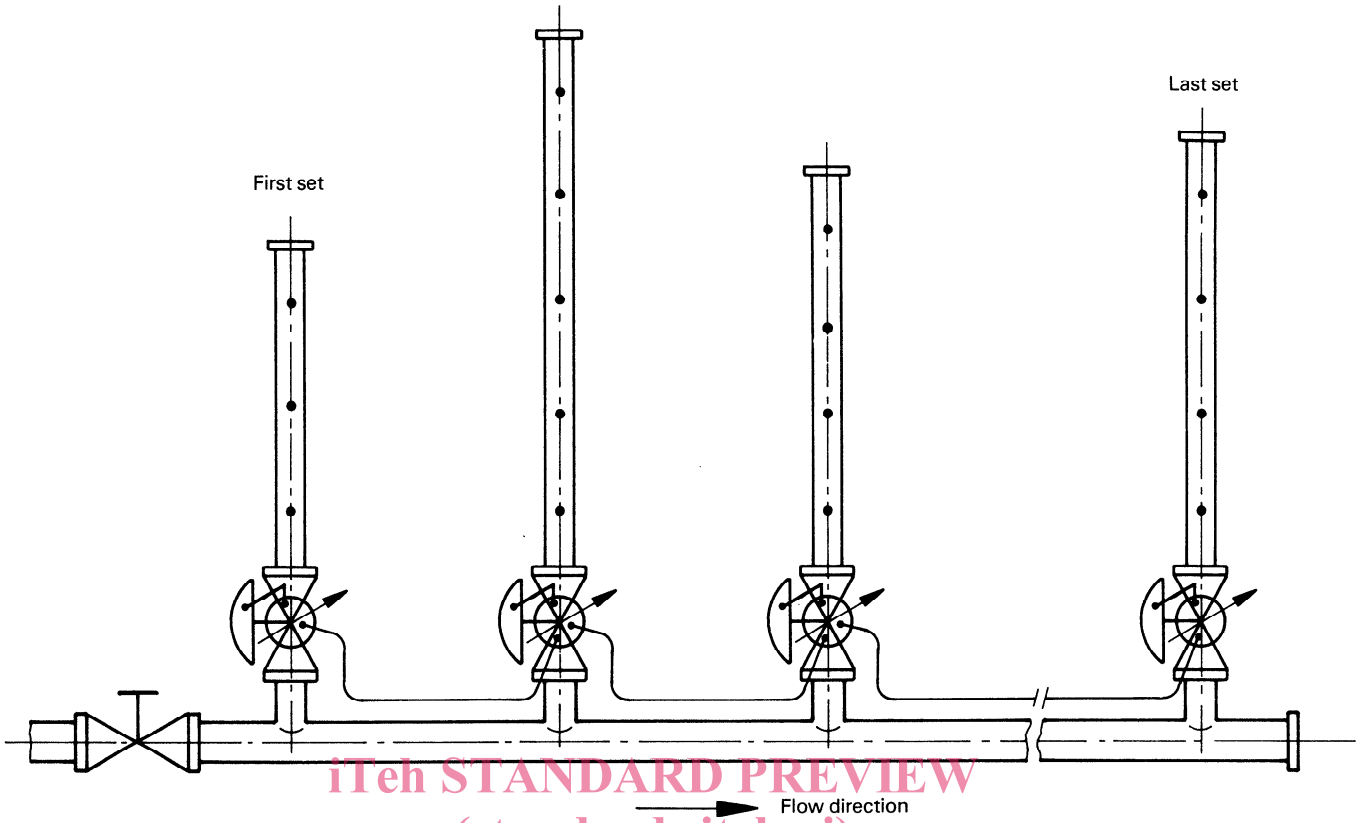


Figure 3 — Irrigation system with hydraulic volumetric valve on lateral drop

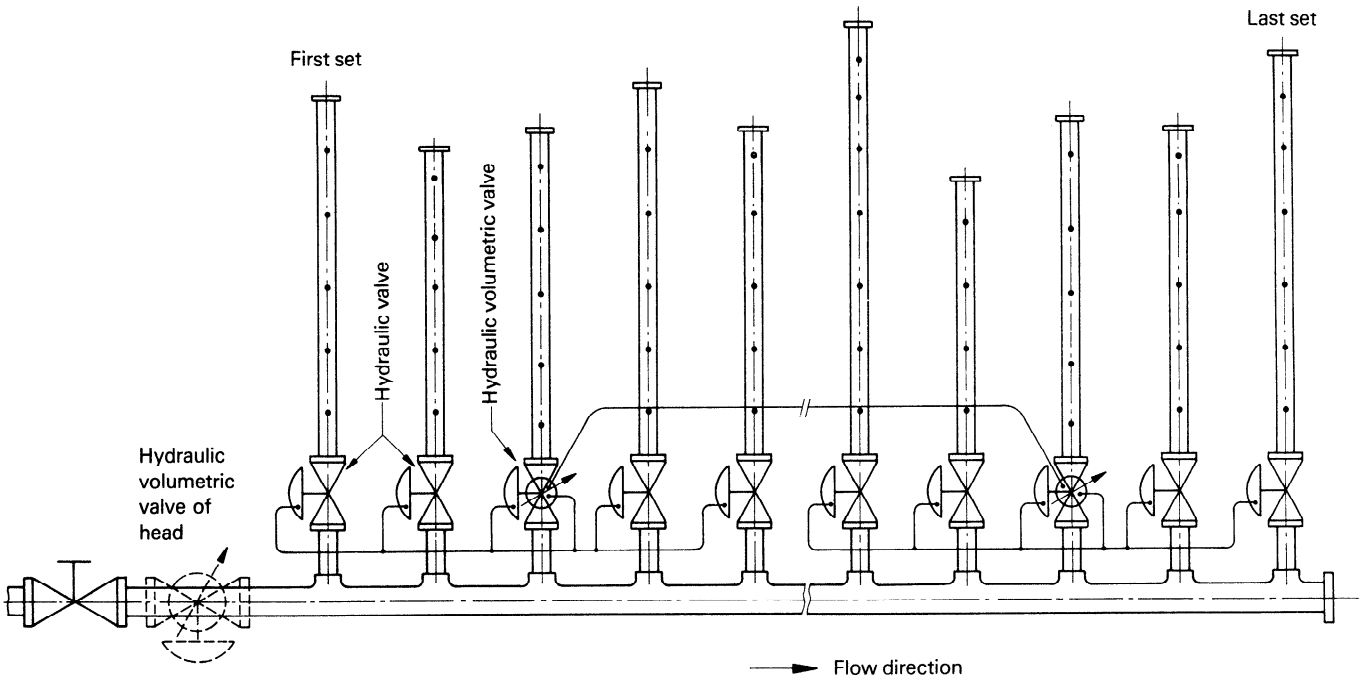


Figure 4 — Irrigation system with hydraulic valve on lateral drop and hydraulic volumetric valve group of lateral drops

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