CHAPTER 2: Pressure piped irrigation techniques

PRESSURE PIPED IRRIGATION SYSTEMS

A pressure piped irrigation system is a network installation consisting of pipes, fittings and other devices properly designed and installed to supply water under pressure from the source of the water to the irrigable area.

The basic differences between traditional surface irrigation and piped irrigation techniques are:

- The water flow regime: With traditional surface methods the size of the stream should be large, while in pressure piped irrigation systems very small flows, even 1 m^3/h, can be utilized.
- The route direction of the flow: With traditional surface methods the irrigation water is conveyed from the source and distributed to the field through open canals and ditches by gravity following the field contours. The piped system conveys and distributes the irrigation water in closed pipes by pressure following the most convenient (shortest) route, regardless of the slope and topography of the area.
- The area irrigated simultaneously: With traditional surface methods the water is applied in large volumes per unit of area, while piped irrigation systems distribute the water at small rates over a very large area.
- The external energy (pressure) required: Traditional surface gravity methods do not need external energy for operation, while piped irrigation systems require a certain pressure, 2–3 bars, which is provided from a pumping unit or from a supply tank situated at a high point.

NETWORK LAYOUT

The pipelines that convey and distribute the irrigation water to the individual plots are usually buried, and are so protected from farming operations and traffic hazards. Offtake hydrants, rising on the surface, are located at various spots according to the planned layout. With surface methods the irrigation water can be delivered directly to the open ditches feeding the furrows or the basins.

In micro-irrigation and other complete systems, e.g. sprinkler, the hydrants are coupled with smaller manifold feeder pipelines placed along the edges of the plots. These feed the lateral irrigating lines which are laid

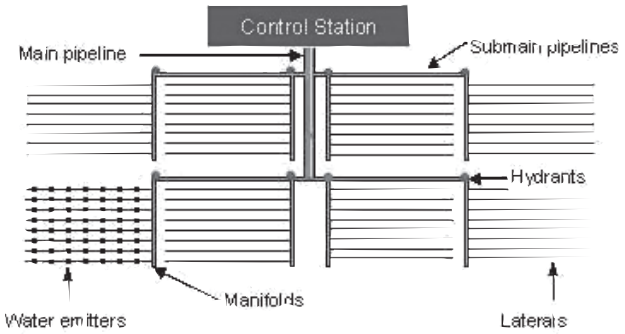
along the plants rows perpendicular to the manifolds. The laterals are equipped with water emitters at frequent spaces and distribute uniformly the irrigation water to the plants under certain pressure.

There are many kinds of irrigation systems. However, a thorough examination of the various system layouts, the equipment and the principles in operation shows that the same approach is always employed from the planning procedure to their application and that all of them have most of their features and components parts in common.

In all piped systems the main component parts (Figure 2.1) are:

- the control station (head control unit);
- the mains and submains (pipelines);
- the hydrants;
- the manifolds (feeder pipelines);
- the laterals (irrigating pipelines) with the emitters.

FIGURE 2.1 - Scheme of a network layout.



Head control. This consists of a supply line (rigid polyvinyle chloride or PVC, or threaded galvanized steel) installed horizontally at a minimum height of 60 cm above ground. It is equipped with an air release valve, a check valve, two ¾ inch hose outlets for connection with the fertilizer injector, a shut-off valve between the two outlets, a fertilizer injector and a filter. Where a gravel filter or a hydrocyclone sand separator is needed, it is installed at the beginning of the unit complex.

Main pipeline. It is the largest diameter pipeline of the network, capable of conveying the flow of the system under favourable hydraulic conditions of flow velocity and friction losses. The pipes used are generally buried

permanent assembly rigid PVC, black high density polyethylene (HDPE), layflat hose, and quick coupling galvanized light steel pipes in sizes ranging from 63 to 160 mm (2–6 inches) depending on the area of the farm.

Submains. These are smaller diameter pipelines which extend from the main lines and to which the system flow is diverted for distribution to the various plots. The pipes are the same kind as the mains.

Offtake hydrants. These are fitted on the submains or the mains and equipped with a 2–3 inches shut-off valve. They deliver the whole or part of the flow to the manifolds (feeder lines).

Manifolds (feeder lines). These are pipelines of a smaller diameter than the submains and are connected to the hydrants and laid, usually on the surface, along the plot edges to feed the laterals. They can be of any kind of pipe available (usually HDPE) in sizes of 2–3 inches.

Laterals (irrigating lines). These are the smallest diameter pipelines of the system. They are fitted to the manifolds, perpendicular to them, at fixed positions, laid along the plants rows and equipped with water emitters at fixed frequent spacings.

Emitters. A water emitter for irrigation is a device of any kind, type and size which, fitted on a pipe, is operated under pressure to discharge water in any form: by shooting water jets into the air (sprinklers), by small spray or mist (sprayers), by continuous drops (drippers), by small stream or fountain (bubblers, gates and openings on pipes, small diameter hoses), etc.

These component parts replace the ones in the traditional surface systems, i.e. the main gate, the main and submain canals, the canal gates the field ditches, and the furrows or the basins, respectively (Figure 2.2).

FIGURE 2.2 - Improved surface irrigation method with pipes.

SYSTEM CLASSIFICATION

Piped irrigation systems are classified according to the pressure required for operation, the method of delivering water to plants, and the type of installation.

Pressure

The pressure of the system is the maximum water pressure required for normal system operation and encompasses: a) the friction losses in the piping network from the control station to the distal end of the system; b) the pressure required at the emitter; and c) the difference in elevation (plus or minus). Systems can be classed as:

- low pressure systems, where the pressure required is 2.0–3.5 bars;
- medium pressure, where the pressure required is 3.5–5.0 bars;
- high pressure, where the pressure required exceeds 5.0 bars.

Water delivery method

The water delivery method is the way the water is distributed to the plants. Systems can be classed as:

- *Sprinkler (overhead) irrigation:* The water is delivered in the form of raindrops precipitated over the entire area. There are many variations of this method in terms of the discharge and diameter coverage, the height of the water jet above ground (overhead, under the foliage), the type of sprinkler mechanism, etc.
- *Surface irrigation (furrow, basin, border, etc.):* The water is delivered to the field plots direct from the main or submain pipelines through the hydrants and it is spread all over the area, or it is side applied.
- *Micro-irrigation (localized irrigation)* by drippers, sprayers, bubblers, microjets, etc. The water is delivered to the plants without being spread over the entire area but by being applied in low rates to a limited soil surface area around the plants.

The water delivery method and the kind of the water emitter are the main characteristics of a piped irrigation system. In many cases they influence and specify the other characteristics (pressure and type of installation) and performances, such as the flow capacity of the system and the duration of application.

The flow capacity of a system is the water flow (in cubic metres per hour or litres per second) given, or designed to meet the irrigation requirements of the irrigable area at peak demand. It is inversely

proportional to the duration of application. Where designed, it is usually the minimum permissible in order to economize on pipe size and other equipment. The duration of application is the time required for the completion of one irrigation cycle.

Type of installation

Systems can be classed as:

- Solid installations (fixed systems), where all the components are laid or installed at fixed permanent or seasonal positions.
- Semi-permanent installations, where the mains and submains are permanent while the laterals are portable, hand move or mechanically move.
- Portable installations, where all the component parts are portable.

PIPED IRRIGATION TECHNIQUES COMPARED WITH TRADITIONAL IRRIGATION METHODS

Irrigation efficiency. In open canal distribution networks, the water losses are estimated at up to 40 percent in unlined ditches and up to 25 percent in lined canals. These losses are due to seepage, phreatophytes and leakage in gates, spillways, etc. In piped systems, no such losses occur. During the application to the plants, the water losses range from 10 percent in localized micro-irrigation (Figure 2.3.) to 30 percent in overhead conventional sprinkler and surface methods (Figure 2.4). As a result, water losses can be minimized and an irrigation efficiency of 75–95 percent can be achieved. In open canals, the irrigation application efficiency ranges from 45 percent to a maximum of 60 percent.

Economic return per unit of water. Piped systems facilitate the manipulation of the irrigation water under more favourable conditions than do open canals. This can result in a yield increase of 10–45 percent and an improvement in quality.

Operation and maintenance (O&M). The man-hours needed in the piped systems range from one-tenth to one-quarter of those required for open canals. Any person can easily operate the piped systems, while the open canals can require skilled labour. In the open canals, expensive operations are carried out to prevent damage caused by roots; seepage through banks; the spread of weeds; siltation and sedimentation; clogging of outlets and gates; etc. In the piped systems, no maintenance or continuous repair of constructions is required. The basic component parts of the piped systems require minimal maintenance during the first seven years. The complete piped system requires a yearly maintenance costing about 5 percent of the initial investment.

Cost. The use of thermoplastic pipes and fittings, made of unplasticized polyvinyl chloride (rigid PVC), low density polyethylene (LDPE), high density polyethylene (HDPE), and polypropylene (PP), which are manufactured in almost every country in many sizes and classes, has reduced the cost of piped irrigation installations to a relatively low level at a time when open canal networks are becoming increasingly expensive.

The initial capital investment for the application of these techniques varies according to the method of irrigation and the type of the installation. The cost of the solid installations for localized methods is higher than that of the semi-portable hand-move sprinkler systems and the piped networks for surface methods. The costs for various piped irrigation systems installations in Europe are presented in Table 2.1 and the average percentage costs of the various parts of a piped system calculated on the basis for smallholdings (about 1.0 ha) are presented in Table 2.2. A detailed cost analysis of all the kinds and types of the piped systems has shown that the pipes (laterals included) account for about 50 percent of the total cost of the system.

The design complexity and the multiplicity of costly equipment is only apparent. The technology of piped irrigation systems is simple and flexible, and the investment yields a good return. Several mechanical difficulties are to be expected in the early stages. Subsequently, the farmers become familiar with the system's features and components and make the best use of it. The application of piped irrigation techniques produces a drastic change in irrigation management practices at farm level.

FIGURE 2.3 - Modern irrigation techniques.

FIGURE 2.4 - Sprinkler irrigation techniques.

TABLE 2.1 - Comparative costs of piped irrigation systems

	Piped surface method			Sprinkler conventional hand-move			Micro-irrigation solid installation		
Area (ha)	1	1-2	2-3	1	1-2	2-3	1	1-2	2-3
Installation cost (US$/ha)	1 700	1 600	1 400	2 800	2 700	2 100	3 950	3 300	3 000
Annual maintenance cost (US$/ha)	85	80	70	140	135	105	200	165	150

Note: Average 1997 prices in Europe.

TABLE 2.2 - Cost breakdown for piped irrigation systems

Component parts	Sophisticated installation	Simple installation
Control station	>23%	13%
Mains, submains and manifolds	10%	21%
Fittings and other accessories	22%	24%
Laterals (pipes and emitters)	45%	42%