

INTRODUCING THE MOVING SPRINKLER IRRIGATION

PRÉSENTATION DE LA MÉTHODE DE DÉPLACEMENT D'IRRIGATION PAR ASPERSION

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ABSTRACT

Sprinkler irrigation is a method of applying irrigation water which is similar to natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground. The pump supply system, sprinklers and operating conditions must be designed to enable a uniform application of water.

Moving Sprinkler irrigation system is a semi-fixed Sprinkler irrigation system and used in most parts of Iran. It is designed to ensure maximum water saving, combining high quality, affordability and ease of installation.

In this paper, design and specifications of moving sprinkler irrigation system will be presented.

Key words: *Moving sprinkler, Sprinkler design, Gravity and pumping alternatives, Design specifications.*

RESUME

L'irrigation par aspersion est une méthode d'application de l'eau d'irrigation qui est similaire aux précipitations naturelles. L'eau est distribuée par un système de tuyaux, généralement par pompage. Elle est ensuite pulvérisée dans l'air par asperseur pour qu'elle tombe en forme de petites gouttes d'eau sur le sol. Pour permettre une application uniforme de l'eau, il faut concevoir un système de distribution par pompe, les asperseurs et les conditions d'exploitation.

Le système d'irrigation par aspersion portable est un système semi-fixe qui est utilisé dans la plupart des régions de l'Iran. Il est conçu pour assurer l'économie maximum d'eau ainsi que la haute qualité et la facilité d'installation.

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Ce rapport présente la conception et les spécifications du système d'irrigation par aspersion portable.

Mots clés: *Asperseur portable, conception d'aspersion, alternatifs de la gravité et du pompage, spécifications de conception*

1. INTRODUCTION

Sprinkler irrigation is the application of water in the form of a spray formed from the flow of water under pressure through small orifices or nozzles. The pressure is usually obtained by pumping, although it may be obtained by gravity if the water source is high enough above the area irrigated. Properly designed, installed, maintained and managed irrigation systems greatly reduce the volume of irrigation water that is wasted every year.

This paper is part of the effort to promote properly designed moving sprinkler irrigation systems.

2. SYSTEM LAYOUT AND COMPONENT PARTS

The layout of the system is the standard one consisting of a head control, a pipe distribution network (mains, sub mains and manifolds where needed), CI belts, pipe risers, quick connect valves, laterals and a number of sprinklers (Figure 1).

The head control is simple and includes only the regulating valves (shutoff, Non-return, air, etc.). The main and sub main pipelines are usually buried 75-650 mm HDPE or GRP pipes. The CI Belts are located along the laterals (Sm) at the same wide spacing as the sprinkler laterals (SL) or different spacing. The sprinkler laterals are usually buried 40-90 mm HDPE pipes.

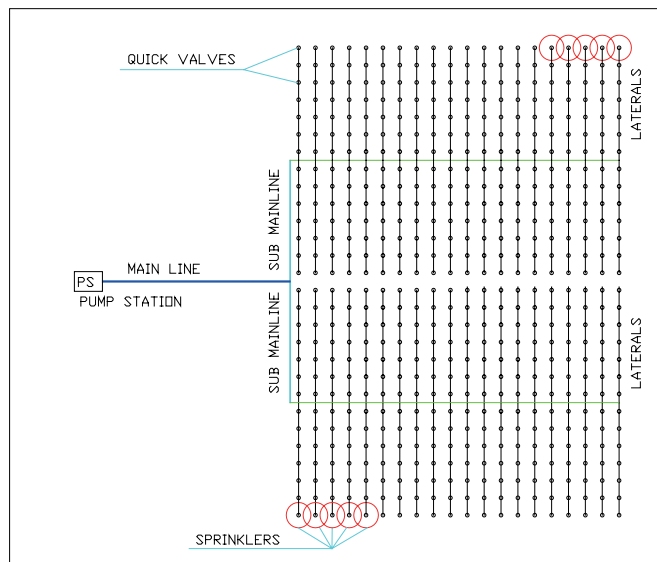


Fig. 1. Moving sprinkler irrigation system layout

2.1. Sprinklers and spacing ranges

When selecting the proper sprinklers for a project, a number of factors should be considered. Some of these factors are:

- Type of sprinklers
- Size and shape of the areas to be watered
- Types of plant material to be irrigated
- Water pressure and flow available
- Local environmental conditions such as wind, temperature, and precipitation
- Soil type and the rate at which it can accept water
- Compatibility of the sprinklers components (which can be joined together)

The size and shape of the areas to be irrigated often determine what type of sprinkler will be used. The goal is to select the type of sprinklers that will cover the area properly using the least number of sprinklers. The type of plant material to be irrigated can also dictate which type of sprinkler is to be used.

Each type of Sprinkler has a performance range for proper operation and these ranges must fit within the available flow and pressure criteria, both of which are a function of the water supply.

Areas with special climatic conditions will require special sprinklers. Windy areas may demand low-angle sprinklers that keep the water near the ground where it resists being blown away. Excessive summer heat in arid climates may need either higher flow sprinklers or multiple irrigation cycles with standard sprinklers to maintain the required water status in the soil to support plant uptake of water.

The sprinkler's application rate cannot exceed the soil's ability to accept water. Low precipitation rate sprinklers may be required to adjust the rate of water application to the intake rate of the soil. Also, low discharge sprinklers are usually needed on slopes to reduce the potential for runoff and erosion.

The model number of the sprinkler or nozzle is specified in the legend of the irrigation plan. The operating pressure range of the unit is also noted so that the designer will know the pressure requirements for the desired performance. This range is usually the minimum to maximum pressures under which the sprinkler will deliver good distribution of water throughout the entire area of coverage.



Fig. 2. Typical sprinkler nozzles used for moving sprinkler irrigation system

The area under the first 60% of the sprinkler’s radius is generally sufficiently irrigated to grow vegetation without the need for an overlapping sprinkler. Beyond this 60% line, the amount of water diminishes with distance. The maximum spacing recommended, therefore, is such that its 60% of radius line meets the 60% line of its neighbor. The 40% remaining distance is irrigated by both the neighbouring sprinklers and gets adequate water then. In cases where the soil is very coarse, wind speed is high, humidity is low or temperature is high, closer spacing is recommended. Head-to-head, or 50% sprinkler spacing, is the most common spacing used in moving sprinkler irrigation. Where winds are a threat to good coverage, spacing as close as 40% may be required.

One of the main reasons for carefully selecting the sprinklers is so they can be accurately plotted on the plan. Once the designer chooses the equipment, proper spacing is the next critical step. The site information will usually dictate what spacing pattern would be most suitable.

There are three main types of sprinkler spacing patterns and a number of variations to adapt these patterns to special situations.

The square pattern, in which the sprinklers are equidistant is used for irrigating areas that are square themselves, or have borders at 90° angles to each other. Although the square pattern is the weakest for proper coverage if not used carefully, the irrigated area often rules out the use of other patterns. The weakness in square spacing is poor area coverage. When the sprinklers are spaced head-to head along the sides of the square pattern, the distance between sprinklers in opposite corners of the square is over 70%. This 70% diagonal stretch across the square pattern can leave a weak spot at the center. The wind may move the weak spot slightly away from the center and summer heat may make the weak spot quite large. To minimize the effects of wind when using the square pattern, closer spacings (which require more sprinklers) are recommended. The recommendation on the chart for low or no wind

is for 55% spacing. And on projects with higher winds, the spacing should be reduced as indicated below for sites with wind Use:

Maximum velocity(km/h)	Spacing (%)
0 to 5	55
6-11	50
13-19	45

The triangular pattern is generally used where the area to be irrigated has irregular boundaries or borders that are open to over spray, or do not require part-circle sprinklers. The equilateral triangle pattern, has some advantages over square spacing. Because the rows of sprinklers are offset from adjacent rows to establish the triangular pattern, the weak spot, which appears in the case of square spacing is absent in triangular spacing. In most cases, the sprinklers can be spaced farther apart using triangular spacing than with square spacing. This additional distance between sprinklers means that fewer sprinklers will be required on the project. Fewer sprinklers on the site means less equipment cost for the project, less installation time and lower maintenance costs over the life of the system.

In each case listed on the chart, the length of the pattern remains at 60% spacing, while the distance across the wind is decreased to combat increasing velocities. For sites experiencing problem of non-uniformity in area coverage by the sprinklers due to wind, the guideline in the following Table may be used:

Maximum velocity(km/h)	Spacing (%)
0 to 5	50
6-11	45
13-19	40

After being specified, how many inches (millimeters) of water per week or per day will be required to properly maintain the plant material for the project, the next thing to know is the rate at which the sprinklers will apply the water. The precipitation rate of the sprinklers should be calculated to determine first if the rate exceeds the soil's intake rate (which it shouldn't) and, secondly, if the rate will apply enough water during acceptable operating times to meet the irrigation requirement (which it should).

The average precipitation rate is expressed in inches per hour (millimeters per hour).

2.2. Pipes

The main and sub main pipelines are usually buried 75-650-mm HDPE or GRP pipes. The pipes are selected depending on the supply and purchase price.

GRP pipes, Filament-wound glass reinforced thermosetting resin pipe systems (polyester and vinyl ester) offer superior corrosion resistance and a combination of high mechanical and physical properties which have been proved in the most severe operating conditions all

over the world. Nominal size of pipe and fitting is based on internal diameter. The complete list of the used Pipes shows in Table 1.

Nominal pressure classes, Pipes and fittings are classified according to nominal pressure. Standard pressure classes are 4, 6, 10, 16, 20 and 25 bar. Intermediate or higher pressure classes are considered on request or depending on the design conditions.

Specific pipe stiffness classes. Pipes are also classified according to specific pipe stiffness. Standard stiffness classes are 1250, 2500, 5000 and 10000 Pa. Intermediate or higher stiffness classes are available on request or depending on the design conditions.

Table 1. List of nominal sizes (Nominal Diameter) GRP pipes

mm	inch	mm	inch	mm	inch
300	12	700	28	1200	48
350	14	750	30	1300	52
400	16	800	32	1400	56
450	18	850	34	1500	60
500	20	900	36	1600	64
550	22	950	38	1800	72
600	24	1000	40	1900	76
650	26	1100	44	2000	80

PE Pipes. Typical size of PE pipes use for the main, sub main and lateral pipelines are shown in Table2.

Table2- PE Pipe (Polyethylene Pipe)

(mm)	PN 3.2		PN 4		PN 6.3		PN 8		PN 10		PN 12.5		PN 16		PN 20	
	SDR 41		SDR 32		SDR 21		SDR 17		SDR 13.6		SDR 11		SDR 9		SDR 7.4	
	e(mm)	w(kg/m)	e(mm)	w(kg/m)	e(mm)	w(kg/m)	e(mm)	w(kg/m)	e(mm)	w(kg/m)	e(mm)	w(kg/m)	e(mm)	w(kg/m)	e(mm)	w(kg/m)
20									1.8	0.107	1.9	0.112	2.3	0.133	2.8	0.154
25							1.8	0.137	1.9	0.144	2.3	0.171	2.8	0.2	3.5	0.24
32							1.9	0.187	2.4	0.232	2.9	0.272	3.6	0.327	4.4	0.386
40					1.9	0.239	2.4	0.295	3	0.356	3.7	0.43	4.5	0.509	5.5	0.6
50			1.8	0.287	2.4	0.374	3	0.453	3.7	0.549	4.6	0.666	5.6	0.788	6.9	0.936
63	1.8	0.364	2	0.399	3	0.58	3.8	0.721	4.7	0.873	5.8	1.05	7.1	1.26	8.6	1.47
75	1.9	0.457	2.3	0.551	3.6	0.828	4.5	1.02	5.6	1.24	6.8	1.47	8.4	1.76	10.3	2.09
90	2.2	0.643	2.8	0.791	4.3	1.18	5.4	1.46	6.7	1.77	8.2	2.12	10.1	2.54	12.3	3
110	2.7	0.943	3.4	1.17	5.3	1.77	6.6	2.17	8.1	2.62	10	3.14	12.3	3.78	15.1	4.49
125	3.1	1.23	3.9	1.51	6	2.27	7.4	2.76	9.2	3.37	11.4	4.08	14	4.87	17.1	5.77
140	3.5	1.54	4.3	1.88	6.7	2.83	8.3	3.46	10.3	4.22	12.7	5.08	15.7	6.11	19.2	7.25
160	4	2	4.9	2.42	7.7	3.72	9.5	4.52	11.8	5.5	14.6	6.67	17.9	7.96	21.9	9.44
180	4.4	2.49	5.5	3.07	8.6	4.67	10.7	5.71	13.3	6.98	16.4	8.42	20.1	10.1	24.6	11.9
200	4.9	3.05	6.2	3.84	9.6	5.78	11.9	7.05	14.7	8.56	18.2	10.4	22.4	12.4	27.4	14.8
225	5.5	3.86	6.9	4.77	10.8	7.3	13.4	8.93	16.6	10.9	20.5	13.1	25.2	15.8	30.8	18.6
250	6.2	4.83	7.7	5.92	11.9	8.93	14.8	11	18.4	13.4	22.7	16.2	27.9	19.4	34.2	23
280	6.9	5.98	8.6	7.4	13.4	11.3	16.6	13.7	20.6	16.8	25.4	20.3	31.3	24.3	38.3	28.9
315	7.7	7.52	9.7	9.37	15	14.2	18.7	17.4	23.2	21.2	28.6	25.6	35.2	30.8	43.1	36.5
355	8.7	9.55	10.9	11.8	16.9	18	21.1	22.1	26.1	26.9	32.2	32.5	39.7	39.1	48.5	46.3
400	9.8	12.1	12.3	15.1	19.1	22.9	23.7	28	29.4	34.1	41.3	41.3	44.7	49.6	54.7	58.8



3. DESIGN CRITERIA AND CONSIDERATIONS

3.1. Basic Hydraulics

Hydraulics is defined as the study of fluid behavior, at rest and in motion. Properly designed piping, with sound hydraulics, can greatly reduce maintenance problems over the life of an irrigation system. Controlling the water flow velocity, holding velocity within proper limits reduces wear on the system components and lengthens service life. Poor hydraulic design results in poor performance of the irrigation system, leading to stressed landscaping material, or even broken pipes and flood damage. In addition to wasting money, a poor hydraulic design will often waste water. Hydraulic analysis is important to minimize financial risks, produce efficient designs and eliminate waste.

3.2. Static Water Pressure

There are two ways to create static water pressure. Water height can create pressure. By elevating water in tanks, towers and reservoirs, above where the water is needed, static pressure is created. Water systems may also be pressurized by a pump or a pump can be used to increase, or boost, pressure. Whether from elevation differences or by mechanical means, understanding the static pressure at the water source for an irrigation system is where hydraulic calculations begin.

3.3. Collecting Site Information

Complete and proper design of irrigation system follows this eight-step procedure. The steps in this procedure must be taken in this order to reduce the chances of overlooking important factors in the process. The steps are:

1. Obtaining site information
2. Determining the irrigation requirement
3. Determining water and power supply
4. Selecting sprinklers and other equipment
5. Lateral layout (or “circuiting” sprinklers), locating valves and main lines

6. Sizing pipe and valves and calculating total system Pressure loss
7. Locating controllers and sizing wire
8. Preparing the final irrigation plan

Obtaining site information is a very important step in the design procedure. Complete and accurate field information is essential for designing an efficient underground sprinkler system. Without an accurate site plan of the field conditions, there is little hope of an accurate irrigation plan.

The common sprinkler spacing in moving sprinkler irrigation systems is 10, 12, 15, 20, 25 or 30 m along the laterals and 10, 12, 15, 20, 25 or 30 m between the laterals. However, they have proved most practical as the close spacing; low discharge and precipitation rates of 7-20 mm/h give better results. The height of the sprinklers above ground should be a minimum of 60 cm for low-growing crops. For high-growing crops, the height should be adjusted accordingly.

The design procedure is the same as for the solid set sprinkler irrigation systems. The sprinkler laterals are laid across the field perpendicular to the Manifold line (mains or sub mains) on lateral positions in accordance with the designed S_m spacing, every 15, 20, 25 or 30 m.

The number of sprinkler operating simultaneously, capable of delivering the flow of the system, is called the set of working sprinkler; these sprinklers are fewer in number than their positions. Therefore, after the completion of their operation at one position, the set of sprinklers is moved to the next position and so on. The number of sprinkler positions should be a multiple of the number of working sprinkler per set. In moving sprinkler irrigation systems, the sprinkler positions can be extended on lateral lines to cover a distance of up to 150 m. In this system, instead of the lateral positions and movements in hand –move irrigation systems, there are sprinkler positions and movements (shifts). The working sprinklers are located in the field over quick connect valves until the irrigation is complete. The working sprinklers can be moved one to four times a day. It is gradually moved along the laterals until the whole field is irrigated.

4. SUMMARY AND CONCLUSIONS

4.1. Irrigation Scheduling Program

With moving sprinkler irrigation, the whole area is wetted and, thus, a larger volume of soil is wetted. This allows a relatively lower water content in the soil to be maintained than is the case with localized methods, thereby increasing the irrigation interval. The larger the volume of wetted soil, the later the crop goes into deficit. The preparation of the irrigation program follows the standard procedure, i.e. taking into consideration the soil moisture holding capacity, the plant physiology (root depth, growing stages, crop coefficient, etc.) and the climate. The irrigation efficiency is about 75 percent. In general, the irrigation dosage application depth for deep rooted field crops under sprinkling ranges from 40 to 100 mm. With a precipitation rate of about 14 mm/h, the operating time at each position is approximately 3-7 hours. Irrigation intervals of two weeks are common in sprinkler irrigation.

4.2. Cost

Total purchase and installation costs of the system are about US\$4000/ha to US\$ 5500/ha and varied in different parts of country. A cost analysis shows that the purchase costs is about 50 to 65% and installation and performance and installation costs are about 35 to 50%.

4.3. Advantages

- High irrigation application efficiency - 75 percent.
- Easy implementation and operation
- Adaptability for all types of soils and heterogeneous topography of the land
- Adaptability for many kinds of field crops and small irregular plots.
- Involves unskilled labor
- Suitable for lands under the Small Land Holding Conditions
- High flexibility

4.4. Disadvantages

- More expensive than hand moved and wheel moved irrigation systems but cheaper than solid set irrigation systems.
- Need high labor for working

REFERENCES

- A.Phocaides, FAO consult, 2000. Technical Hand book on pressurized irrigation techniques, FAO, Rome.
- Rain bird Co., 2001. Landscape irrigation design manual.
- Mahabghodds consulting Eng., 2010, Criteria and fundamental design principles for sprinkler irrigation systems, Givi irrigation and drainage network.
- Mahabghodds consulting Eng., 2010, Technical report of Givi irrigation and drainage network.