

Planning, design and installation of irrigation schemes —

Part 5: Guide for irrigation equipment

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Committees responsible for this British Standard

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- Agricultural Engineers' Association
- British Agricultural and Garden Machinery Association Ltd.
- Health and Safety Executive
- Ministry of Agriculture, Fisheries and Food
- National Farmers' Union
- Silsoe College
- Silsoe Research institute
- UK Irrigation Association
- National Rivers Authority
- Well Drillers' Association

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Foreword

This Part of BS 7562 has been prepared under the direction of the Agricultural Machinery and Implements Standards Policy Committee and contains recommendations on good practice in the planning, design and installation of irrigation schemes in the UK, together with information and guidance. It is intended for the use of engineers and farmers having some knowledge of the subject. It embodies the experience of engineers successfully engaged on the design and construction of irrigation schemes so that other reasonably qualified engineers may use it as a basis for the design of similar irrigation schemes.

This Part of BS 7562 contains information and represents good practice at the time it was written and, inevitably, technical developments may render parts of it obsolescent in time. It is the responsibility of engineers concerned with the design and construction of schemes to remain conversant with developments which have taken place since publication.

This standard has been prepared in six Parts as follows.

- *Part 1: Glossary of terms;*
- *Part 2: Guide for acquisition of site data;*
- *Part 3: Irrigation water requirements¹⁾;*
- *Part 4: Guide to water resources;*
- *Part 5: Guide for irrigation equipment;*
- *Part 6: Guide for feasibility and implementation procedures.*

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 26, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

¹⁾ In preparation.

1 Scope

This Part of BS 7562 gives guidance on the equipment required for irrigation schemes. It deals specifically with sprinkler and trickle/bubbler irrigation as the most common methods of irrigation in the UK and covers in-field irrigation equipment, pipelines, pump installations, and pump suction and delivery pipework.

2 Informative references

This Part of BS 7562 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions

For the purposes of this Part of BS 7562 the definitions given in BS 7562-1:1992 apply.

4 Sprinkle in-field equipment

4.1 Introduction

This is the equipment which is laid out, temporarily or permanently, in the field being irrigated. A wide range of in-field equipment is available but that commonly used in the UK is described in this British Standard. A classification is provided in Table 1.

The selection of appropriate in-field irrigation equipment is based on many factors including capital cost, operating cost, labour requirements and suitability for the farm.

4.2 Water application devices

4.2.1 General

The function of water application devices is to apply water as uniformly as possible to the crop and soil. The most common application devices used to apply water are rotary impact sprinklers, guns and fixed spray heads.

4.2.2 Rotary impact sprinklers

Rotary impact sprinklers are the devices most in use for spraying water.

Sprinklers of varying sizes may be used on a wide range of irrigation systems including conventional and mobile lateral systems, see Table 1.

The design and performance requirements for rotary impact sprinklers are described in BS 7459-1 and BS 7459-2.

Sprinklers should be operated within the manufacturers' specified range of pressures for uniform water application. Sprinkler operation with too high a pressure will cause excessive break up of the water jet, loss of wetted radius and excess water applied near the sprinkler head. Low operating pressure at the sprinkler will result in inadequate break up of the jet, large droplets and uneven application of water.

The size of the nozzle(s) determines the sprinkler discharge and the wetted diameter. Nozzle diameters range from 2 mm to 3 mm up to 50 mm. Sprinklers may have one or two nozzles.

Common trajectory angles for sprinklers are 24° and 30° measured from the horizontal. Such sprinklers are used on a wide variety of irrigation systems, including hand move and mechanical move equipment. Low angle sprinklers, having trajectory angles ranging from 0° up to about 15° produce a profile which is less subject to distortion by wind but may not be as uniform in application. Typical applications for low angle sprinklers include under tree orchard irrigation and centre pivots operating in windy conditions.

The average application rate from the sprinklers (in millimetres per hour) should not exceed the basic infiltration rate (in millimetres per hour) of the soil. This ensures that water infiltrates into the soil thus avoiding the problem of surface water run-off.

The uniformity of water application is described by Christiansen's coefficient of uniformity. Details of the coefficient and its measurement are provided in BS 7459-2. The choice of the most appropriate uniformity coefficient depends largely on the crop being irrigated.

The spacing between sprinklers should be as recommended by the manufacturer and shown in performance tables. The wetted patterns from sprinklers should overlap to achieve an appropriate coefficient of uniformity. The degree of overlap will vary according to the water application pattern and the wind conditions.

Table 1 — A classification of sprinkle irrigation systems used in the UK

Systems		Water application devices
Conventional systems	— portable — hand move — roll move — tow line — semi-permanent — sprinkler hop — pipe grid — hose pull — permanent	Mainly use small rotary impact sprinklers, but guns, fixed sprays and bubblers are also used
Mobile gun systems	— hose drag — hose pull	Mainly guns, but in some cases the gun is replaced with a boom device with small rotary impact sprinklers or fixed sprays
Mobile lateral systems	— centre pivot — linear move	Small rotary impact sprinklers or fixed sprays
Spray lines	— stationary — oscillating — rotating	Fixed sprays

Wind will distort the wetting patterns of sprinklers. The amount of distortion depends upon the wind speed and the size of the water droplets. The greater the wind speed and the smaller the water droplets the more distortion will occur. Wind distortion can be counteracted by spacing the sprinklers closer together but care should be taken as this may also increase the application rate. If the application rate exceeds the infiltration rate of the soil, run-off may occur. The direction of the wind may be an additional problem especially if the wind direction changes during the irrigation set. In this situation the best results may be obtained by ignoring the effects of wind altogether and operating the sprinklers on their recommended spacings for low wind speeds.

4.2.3 Guns

Guns are large rotary sprinklers which have a large wetted diameter. They are commonly used in mobile systems in the UK but they can also be used in conventional systems.

Guns may be used on various irrigation systems either fixed or mobile. They normally have discharges from 10 m³/h up to and above 125 m³/h and operate at pressures from 2.0 bar²⁾ up to and above 8.0 bar. The selection of the operating pressure depends upon nozzle size and type and droplet size required.

Water droplet sizes from guns may be unacceptably large for certain soil types and crops, causing damage to both soil and crop. Careful selection of nozzle diameter and type and operating pressure should be made to ensure that the resultant droplets are suitable for the soil and the crop.

Gun nozzle diameters can vary from 12 mm up to and above 40 mm.

Two main types of nozzle are available; ring nozzles and taper nozzles. Ring nozzles are designed to produce acceptable droplet sizes at lower operating pressures. Taper nozzles are designed to produce the maximum wetted throw but droplet sizes are increased.

The throw is not only affected by the operating pressure and nozzle diameter and type but also by the construction of the gun. The length of the range tube and its diameter, plus the use of straightening vanes inside the range tube, combine to affect the maximum throw.

The application rate tends to be greater than for the small rotary impact sprinklers. The recommended spacing depends upon the wetted diameter, wind speed and direction and the required coefficient of uniformity. Gun spacing recommendations vary according to whether the gun is working on a grid system, a mobile unit or is used on a centre pivot or linear move.

2) $1 \text{ bar} = 10^5 \text{ N/m}^2 = 10^5 \text{ Pa}$.

Guns may be used for full or part circle irrigation. Full circle irrigation would usually be applicable to fixed grid irrigation systems. Mobile gun systems usually use part circle applications of 270° to 300° arc. Guns may also be used on the end of centre pivots and linear move machines to irrigate an arc of 180° or less.

There are two main types of drive systems used for rotating the gun. Impact drives operate using the water flow that leaves the nozzle moving an impact arm up and down or sideways causing the gun to rotate. Gear drives operate by passing a small quantity of the main supply through or over a turbine gear drive assembly. This causes the gun itself to rotate via a gear mechanism.

The drive mechanism may be affected by water quality. Care should be taken with gear drive systems to ensure that grit or other particles do not cause the drive system to fail. Filtration equipment may be required for some systems.

Guns normally operate with trajectory angles between 18° and 25°. Low angle guns may be used on applications where wind affects the gun performance, but the wetted diameter of the gun is reduced. Adjustable trajectory guns may be suitable for certain situations such as operating in high wind conditions where reduced wind drift is required.

The part circle mechanism fitted to guns should provide adequate adjustment to cover the range of arcs required. Usually the range is between 45° and 330°. When returning to the start position, the reverse action of impact driven guns may occur at high speed. In this case the riser assembly should be strong enough to resist the forces. Operator safety should be considered where there is a risk that a gun may hit the operator when fast reversing. Slow reverse action sectoring devices are often now used on guns and these produce less strain on the connection assemblies.

The thrust forces resulting from gun operation may be high due to the flows and pressures used and the construction of the riser is critical for correct gun performance. The riser strength should be sufficient with its support to prevent flexing of the riser which may cause either failure or poor gun performance. Risers used on grid systems should be designed with adequate support structures to ensure that when the gun is operating the riser is sufficiently stable. The riser should be of suitable diameter to ensure that the velocity of water through it is not excessive causing high turbulence which may affect the performance from the gun. Risers fitted to the trolley units used on self travellers should be sufficiently strong to resist breakage. The trolley base should be so designed that there is no risk of tipping over when operating under normal irrigation conditions.

4.2.4 Fixed spray heads

Fixed spray heads may be used to apply water either to the total ground area or to a specific area around a plant.

Spray jets may be used on conventional irrigation systems, such as under tree irrigation and also on centre pivots and linear move machines.

4.3 Sprinkle irrigation systems

NOTE The irrigation systems most commonly used in the UK are listed and classified in Table 1.

4.3.1 Conventional systems

4.3.1.1 General

Conventional systems are the most common type of system in use and comprise pipes, small rotary impact sprinklers and risers which are moved, often by hand, around the field to complete an irrigation. A characteristic of this type of system is that the pipes and sprinklers are stationary during irrigation and then moved between irrigations.

4.3.1.2 *Portable*

The most basic and simplest system is the portable hand-move system. The pipes and sprinklers are all portable and moved by hand for each irrigation. As this tends to be very labour intensive, several developments have been made to this system to reduce the labour input.

If the field layout allows, the laterals which carry the sprinklers should be laid along the contours to ensure as little pressure variation as possible caused by difference in height. The lateral may be operated down the slope provided that the maximum pressure variation along the lateral does not exceed 20 % of the sprinkler's recommended operating pressure. If the slope would cause a greater pressure variation, then pressure regulators should be fitted to the sprinklers to produce correct operation. A pressure regulator may be fitted under the sprinkler inlet connection or a pressure regulating/flow controlling nozzle may be inserted at the nozzle. Sprinkler laterals may be laid out up the slope where this is the only possible layout. Pressure regulating or flow regulating devices should be fitted to the sprinkler where the pressure variation along the lateral is greater than 20 % of the sprinkler's recommended operating pressure.

Ideally, sprinkler laterals should be laid out at right angles to the prevailing wind for a more uniform irrigation. This should take preference over layout in relation to contours.

The number of irrigation sets per day depends on the depth of water to be applied at the rate per hour and the time it takes to move the sprinkler laterals. The fewer the number of irrigation sets per day and the longer the number of hours per set the greater will be the total possible operating hours per day.

The application rate (in millimetres per hour) relates to the application heads applying water on a unit area operating on a grid system, either square, rectangular or triangular. The application rate per hour calculated here is used to estimate the total depth applied during the irrigation set.

Several factors affect the sprinkler spacing, both along the lateral and between laterals. These include wind speed, coefficient of uniformity, application rate, the crop and the soil. Sprinkler spacing should be reduced according to wind speed.

The lateral pipe diameter is chosen so that the pressure loss along the lateral is less than 20 % of the recommended operating pressure of the sprinkler. In this way the changes in pressure will not seriously affect sprinkler performance and uniformity.

Normally sprinkler laterals should not exceed 100 mm in diameter as bigger pipes are much heavier and are more difficult to move around the field.

Pipe lengths usually used for sprinkler laterals are either 6 m or 9 m. Pipes that are 6 m are lighter in weight, are easier to connect and disconnect and are preferred, especially if large diameter laterals are used.

Sprinkler risers should be of sufficient height to allow the sprinkler to irrigate over the top of the crop and should be adequately supported to avoid bending and vibration as the sprinkler rotates.

Both aluminium and steel lightweight galvanized steel pipes may be subject to corrosion if fertilizers or other chemicals are applied through the irrigation system. The manufacturer of the pipe and fittings should be consulted if this practice is considered.

The ease of connection and disconnection of coupling lateral pipes should be considered carefully when selecting the type to be used. Couplings that can be operated by one person may be favoured where labour is short.

Sprinkler risers may have either permanent or quick coupling connections to the sprinkler lateral. The type of riser used depends upon the method of operation of the system, the riser height and the stability required.

The following briefly describes types of portable hand-move systems.

a) *Roll-move system*

The roll-move system comprises a sprinkler lateral mounted on wheel assemblies so that the lateral forms the axle for the wheels. The sprinkler lateral is stationary while irrigating. The water supply to the lateral is closed off when it is moved. A power unit provides the power source for driving the wheels.

It is preferable that the system is operated in level fields to alleviate potential problems that may be caused by uneven ground. If used on sloping ground, the system should be aligned with the lateral at right angles to the land contours. If it is operated running parallel to the contours there is a risk that the unit may run down the slope while the system is operating. Brake equipment may be fitted to the wheel assembly to prevent this happening.

A balance weight self-levelling device is included in the connection for each of the sprinklers to ensure that the sprinkler operates in the vertical position when irrigating.

b) *Towline system*

The towline irrigation system uses equipment similar to that used for the conventional hand move portable system. The lateral pipe is mounted on wheeled bases so that it can be towed from one irrigation set position to another. Special fittings are required for the base of the sprinkler pipe and also to support the pipe couplings.

Usual diameters on towline sprinkler laterals are 75 mm and 100 mm. Larger diameter pipe may be heavy to pull and therefore more difficult to move. Smaller diameter pipe may not have the strength suitable for the pulling operation.

4.3.1.3 *Permanent systems*

When sufficient laterals and sprinklers are provided to cover the whole irrigated area so that no equipment needs to be moved during the irrigation season the system is called a solid-set system. The pipes are laid out at the beginning of the season and collected at the end.

When the pipes and sprinklers are left in place from season to season the same system is generally referred to as permanent. It is usually used on permanent crops such as orchards.

4.3.1.4 *Semi-permanent systems*

4.3.1.4.1 *General*

This range of systems has some equipment which is permanently fixed whilst other equipment is moved around the field. Generally this increases the capital cost of the system but greatly reduces the labour required for operations.

4.3.1.4.2 *Hop systems*

A hop system combines the basic characteristics of the portable hand move system with the ability to move the sprinklers to alternative positions along the lateral. This reduces the number of times that the laterals are moved.

It may be possible to operate for a greater number of hours per day using this system.

The application rate is calculated for a single sprinkler head application as there is no immediate overlap between the sprinklers. Application rates are therefore suitable for a wide range of soils and crops.

4.3.1.4.3 *Pipe grid systems*

A pipe grid system consists of a complete field layout of pipes, made of either aluminium or lightweight galvanized steel. The pipes, usually 25 mm diameter, are normally laid down at the beginning of the season. Only the sprinklers are moved to complete the irrigation cycles.

4.3.1.4.4 *Hose-pull system*

A hose-pull system comprises a sprinkler complete with a stand and support assembly connected to the lateral by a flexible hose. The assembly can operate in several different positions from one connection point working on a grid layout.

4.3.2 *Mobile gun systems*

4.3.2.1 *General*

Mobile systems are distinct from conventional systems because they are moving when applying irrigation water rather than being stationary. This usually improves application uniformity. It also greatly reduces the labour required for irrigation.

Mobile gun systems use a large single gun type sprinkler to apply water.

4.3.2.2 *Hose-pull system*

This system uses a hard hose which is wound onto a large diameter drum and a gun sprinkler mounted on a trolley. The equipment is operated by towing out the gun and trolley to the furthest position for irrigation in the field. The system is started up and as the gun and trolley irrigate, the hose drum rotates slowly to wind in the hose and the gun. For subsequent set positions the hose drum may simply be rotated or may be moved to another hydrant point position.

4.3.2.3 *Hose-drag system*

The hose-drag system comprises a gun mounted on a chassis with a cable drum winding mechanism, a length of winding in cable and anchor and a length of flexible lay-flat hose. The irrigation system operates by positioning the chassis, complete with gun, at the end of the field. The tow cable is pulled out to the other end of the field and anchored. The flexible hose is connected to the chassis and to the water supply valve point. As the gun irrigates, the cable drum gradually winds in, pulling itself along the cable and at the same time dragging the lay-flat hose behind it. If a central water supply valve is used for the supply of water, the irrigation unit can cover twice the area as it is able to irrigate both sides of the valve point. For example, if the machine uses 200 m of hose then it is possible to cover a 400 m wetted strip per irrigation set.

4.3.3 *Mobile lateral systems*

4.3.3.1 *General*

Many new irrigation systems have been developed in recent years to try and combine the advantages of conventional sprinkler systems with the mobility of rainguns. These are called mobile lateral systems because they use laterals which move continuously while irrigating.

4.3.3.2 Centre pivot systems

This comprises a lateral pipe supported by a series of towers on wheel drive assemblies. The lateral rotates slowly around a central point irrigating a circular area.

Centre pivots can usually irrigate large areas up to 100 ha with one machine and can be highly automated.

The maximum length of lateral depends on the construction features of the centre pivot and the configuration of the pipe spans. Pivots with 125 mm diameters usually have a limitation of up to 400 m length.

Although normally the most economic centre pivot unit is one that rotates in a circle it is also possible to irrigate part circles and to have corner systems and end gun units connected and to the centre pivot. End guns add additional capacity to the machine so that it can irrigate into corners of rectangular fields and awkward field shapes.

Due to normally high coefficient of uniformity from a centre pivot irrigation system, it may be practicable to apply chemicals and fertilizers through the irrigation system.

Application head accessories include drop arms, drop pipes and booms. Drop arms may be used in conjunction with spray nozzles to allow the water to be applied near the soil surface and to the top of the crop. The effects of windrift and evaporation may be reduced by this procedure.

Booms may be connected to the centre pivot pipe spans to enable water to be applied at low pressure as a fine even spray pattern using spray heads. The use of a boom allows the application of water over a wider area and should reduce the instantaneous application rate and improve the infiltration rate into the soil.

4.3.3.3 Linear-move system

The linear move irrigation system comprises irrigation equipment which is designed to irrigate a square or rectangular area whilst moving slowly across the field. System components are similar in construction to the centre pivot using tower spans, and lateral pipes connected to the tower spans.

Water is either fed to the centre of the machine or supplied to one end, being taken from either an open ditch or canal or from water supply points or hydrants on a pressurized main. A central power unit, which may comprise a pump unit on an open water supply system, uses a generator unit to provide the electrical power for operating the linear move.

4.3.4 Spraylines

4.3.4.1 General

Sprayline irrigation equipment uses fixed spray heads and may be fixed upon supports above ground level. It can either be static, oscillate from side to side or rotate while irrigating.

4.3.4.2 Fixed/oscillating system

The area irrigated by sprayline equipment is usually small in comparison with other types of irrigation system.

Small diameter fixed spray nozzles are installed on the lateral and so it may be necessary to use a filter at the water source to avoid blockage.

Spraylines apply water at low application rates. Variation of application rate can only be achieved by using different size nozzles or a change of pressure, but the range of nozzle sizes is limited.

The sprayline operates at relatively low pressure and therefore pressure regulating or pressure compensating facilities are not normally used. Thus fields should be as level as possible along the run of the sprayline lateral pipe to avoid excessive pressure variation.

Sprayline equipment usually uses piping with a diameter of either 25 mm, 32 mm or 50 mm. Due to the small diameter of the sprayline, flow rates that can be achieved per sprayline are relatively low.

The sprayline is usually supported above the crop either on short or tall trestles or spikes.

Wind may adversely affect performance due to the small spray droplets discharged from the nozzles. To counteract some of the effects of wind on the spray it may be possible to offset the nozzles and/or the oscillating mechanism so that better irrigation is achieved.

The irrigated area per set depends upon the length of the sprayline lateral and the width between the subsequent sprayline operating positions. A typical area of 0.1 ha per irrigation set is approximately the maximum possible from this type of irrigation equipment per sprayline lateral.

4.3.4.3 Rotating spraylines

A rotating sprayline comprises an irrigator unit fitted with booms which rotate by the water pressure from the jets fitted to the booms. The unit is stationary during irrigation. At the end of the set the system is closed down and the unit moved to its subsequent position.