CONTENTS
Moving irrigation systems

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1 Introduction

The number of moving irrigation systems in use in South Africa has increased since 1970. Moving irrigation systems are, as the name indicates, machines with sprinklers or sprayers that move across a field distributing water and are opposed to systems where pipes and sprinklers are moved by hand.

With moving systems management aspects are simpler, scheduling can be done more accurately and labour problems are largely reduced or eradicated. Growers are mainly persuaded to change from conventional irrigation systems to moving irrigation systems because of labour and management. Labour management and the availability of willing workers, especially in the cold seasons, are important considerations.

A further advantage is that it is much easier to apply smaller amounts of water more frequently, for example 15 mm to 30 mm every 2 to 5 days. This is a high advantage with some crops in certain growth stages especially at germination on problem soils. It is also easier to apply overhead fertigation to meet crop demands.

Moving systems are mainly applicable to agronomic and gardening crops and pastures. They are not applied to orchards and fruit cultivation, as permanent systems are better suited and not much more costly.

The key to economic justification of moving systems is to utilise them maximally. At least two and if practically possible, three crops per year should be irrigated with the same system. For economic justification therefore, the system should wear down and not rust apart.

This chapter consists of an introductory portion with the information mainly originating from the **Irrigation Design Manual** (1996) and the **Valley Design Manual** (1988), as well as practical information regarding the installation, evaluation and operation of moving systems.

2 System types

Moving systems include all systems that move while applying water to the surface of a field.

2.1 Centre pivots

A centre pivot consists of steel frames and pipes which are supported at approximately 50 m intervals by an A-frame on two wheels.

2.1.1 General

All centre pivots are constructed from the following basic components:

- Pivot structure
  This is used to anchor the centre pivot. The whole structure rotates around it.

- Span
  This is the basic structural unit with which a centre pivot is constructed. A unit consists of the main pipe in which the water flows, the frame which supports the pipe and the driving mechanism. Spans are distinguished from each other based on the following variables:

Table 10.1: General centre pivot spans available

Span length [m]	**Pipe diameter [mm]**	**Mass [kg]**
32	168	2 268
38	168	2 449
45	168	2 631
52	150	2 648
56	150	3 130
32	203	2 722
38	203	3 266
52 (corner system)	150	2 948
56 (corner system)	150	3 084

- Length and pipe diameter
  Any combination of pipe sizes and spans on a specific centre pivot may be identified by a model number.

- Crop clearance height
  The manufacturer can supply details of the crop clearance height of the different span lengths for a specific type of centre pivot. The crop clearance must be considered where a hill is present between two towers. Depending on the height of the structure, the length of a span and the slope of the hill, the crop clearance of 4 m for the high profile cannot shrink(reduce) to 0,3 m for a low profile 56 m span on a 5% slope.

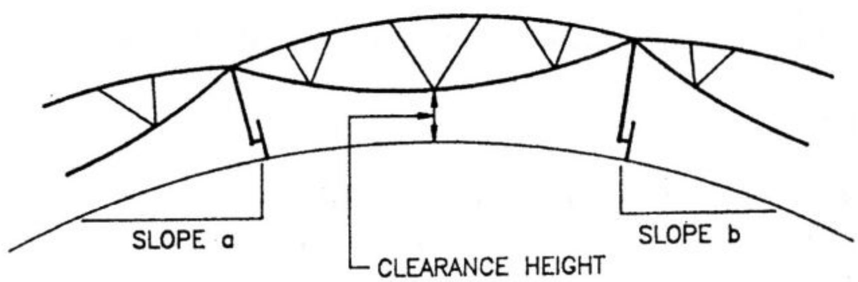

Figure 10.1: Crop clearance height

- Towability
  The following restrictions apply to towable centre pivots:

  - Soil type and topography
    Guard against clay soils and cross slopes along the towing route.

  - Centre pivot length
    The maximum number of spans for a towable centre pivot must be obtained from the manufacturer.

  - Roads
    A six metre wide road with a level surface must be made to tow the centre pivot along. Take care where centre pivots have to be towed over contour mounds.

- Span combination
  Only certain span combinations may be towed. Contact the manufacturer for relevant details. Seeing that short spans are more stable than long ones, they should always be placed closest to the centre.

- Electricity supply
  The centre pivot's electricity supply must be disconnected before the centre pivot is moved to another position.

- Pivot flex
  A flexible pivot coupling is necessary where the anchor tower is on level ground and the first tower moves on a slope of more than 4% (downhill or uphill) regarding the anchor tower. The manufacturer must be contacted to obtain the flexibility of the centre pivot coupling at the centre of the pivot. Contact the manufacturer to obtain the flexibility of the coupling at the centre of the centre pivot. The coupling can only accommodate a certain percentage slope (a) between the centre and the first driving unit. The allowable slope differs for the different tower lengths and between different centre pivot models.

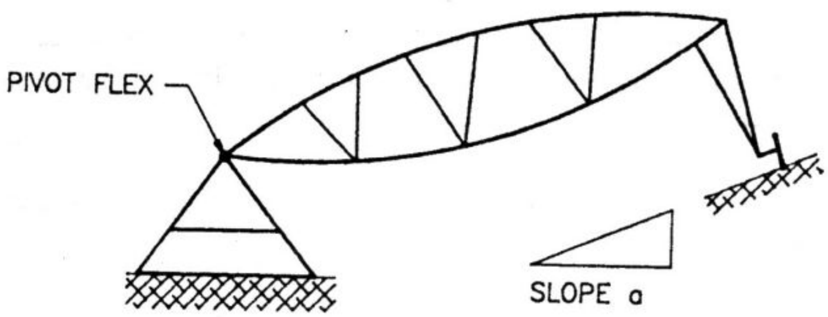

Figure 14.2: Pivot flex

- Overhang
  The overhang is mounted at the end of the centre pivot to irrigate an additional area.

- Slope
  When a centre pivot is designed for a specific field, the topography of the land must be thoroughly investigated in addition to the above factors. Each centre pivot has certain slope limitations due to the structural and driving power design.

  The adaptability of the system to all remaining slopes must be investigated.

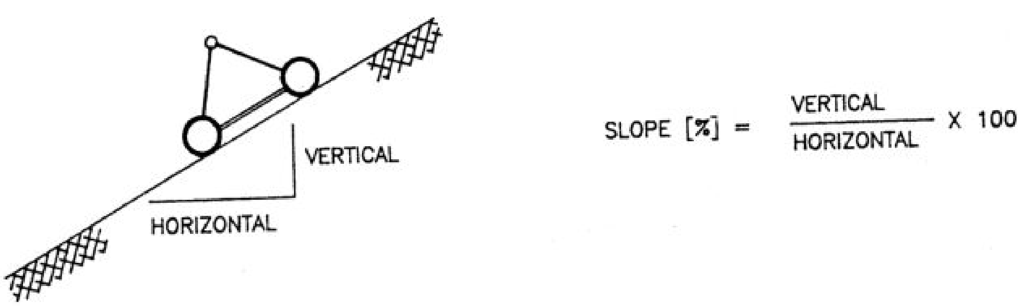

Figure 10.3: Slope limitations for centre pivots

The climbing ability of a centre pivot is limited by structural requirements and driving power. Attention should be given to ascending as well as descending slopes as it may result in variations in speed. The slope absorption at the towers and torque and swivel action at the couplings must be kept within the particular manufacturer's specifications. A slope combination of 14% to 30% is possible (Reinders, 1998).

2.1.2 Safety of centre pivots

There are two safety mechanisms for centre pivot irrigation systems. With the first type the pump switches off if the centre pivot should stop and with the second type the centre pivot switches off if the pump should stop.

Switching off of pump

If the centre pivot should stop after hours, it will discharge at that position until someone switches off the pump. To prevent such overwetting conditions, a signal must be sent to the pump to switch off the moment the centre pivot stops moving.

The signal may be transmitted by one of the following methods:

- Butterfly valve method
  An electrically operated butterfly valve is installed in the pipeline at the centre pivot inlet. The valve solenoid is connected to the centre pivot's 220 V safety circuit. Furthermore a pressure release valve is installed near the centre pivot inlet. A pressure switch or no-flow switch may be installed at the pump.

  As soon as the centre pivot switches off, the valve solenoid is activated slowly, closing the valve. Pressure build-up in the pipe causes the pressure switch or no-flow switch to switch the pump off. The pressure release valve limits water hammer in the pipeline. Before this method is used, pipe classes, pump shut-off pressure and adjustment of release and pressure valves must be thoroughly taken into account.

- Cable method
  This method makes use of a safety cable which directly connects the centre pivot control panel with the switchboard of an electric or diesel motor.

  The centre pivot control panel has a standard terminal connection point for a safety cable. The cable is connected in such a way, that it has a supply voltage of 24 V (AC) while the centre pivot is in operation. The pump switch must be connected to a 24 V (AC) relay (normally open). As soon as the centre pivot stops, power to the cable will be cut and the relay will switch the pump off.

  The following sizes of two-core cable may be used:

Length:	Shorter than 1 000 m:	1,5 mm^2
	1 000 - 2 000 m:	2,5 mm^2

- Radio signals
  This method works on the same principle as the cable method except that the impulse from the centre pivot to the pump is given by radio signal.

  A radio transmitter is mounted at the centre pivot control panel and a receiver at the switchboard. As soon as the centre pivot switches off, a radio signal is sent to the pump, cutting the power supply.

- Siren
  If the centre pivot is operating close to a home or if it is always under supervision, a siren may be mounted on it. As soon as the centre pivot switches off, the siren warns someone who then physically switches the pump off. The siren may use 220 V or 24 V.

- Electrical safety
  This method may be used if the centre pivot and pump operate from the same transformer. The method is as follows:

  A monitor is clamped around one of the live cores of the 4 core supply cable and connected to a relay in the pump starter. Whenever the centre pivot does not draw any current for a specific period, the pump automatically switches off.

Switching off of centre pivot

If a short power failure occurs, the pump may switch off, while the centre pivot will continue to move. If this happens after hours, the centre pivot must return dry the following day which could cause falling behind in the cycle. The general remedy is to attach a low pressure switch to the centre pivot. As soon as the pump fails, the centre pivot pressure will drop and the system will shut down.

Low temperature safety

Temperature switches are freely available throughout the market place but should be used with great caution on centre pivots.

The problem lies therein that water does not always freeze at the same temperature. Depending on atmospheric conditions, freezing may occur at temperatures as high at as 9°C. Depending on the setting on the switch it may cause the centre pivot to switch off unnecessarily or even too late.

Wind safety

In windy areas centre pivots must be anchored when not in use.

2.1.3 Application

Centre pivots can be used for different applications because of the variety of available sprinklers.

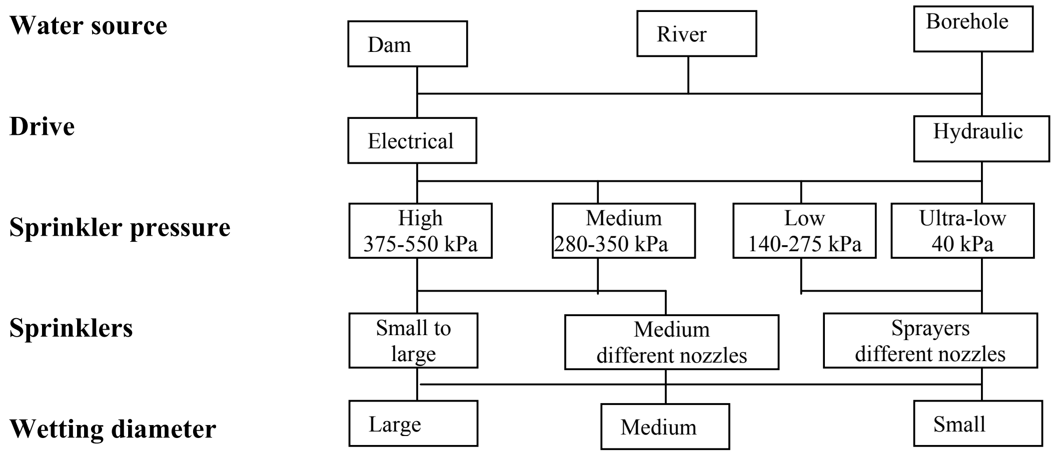

Figure 10.4: Schematic classification of pivot points (adapted Reinders, 1998)

2.2 Travelling irrigators

Travelling irrigators consist of a big gun sprinkler mounted on a trolley. The trolley moves slowly across the field while the sprinkler irrigates. Parallel strips are irrigated in this way.

Water is supplied by an underground main line which is laid in the middle of the field. The sprinkler moves perpendicular to the main line in specifically spaced strips. Strip spacing depends on the wetted diameter of the big gun and varies between 60% and 80% of the diameter, depending on wind conditions. A hydrant is installed on the main line opposite each strip, for connection to the sprinkler. Actuation can take place by one of three methods:

- A drum on the trolley is hydraulically driven and rolls up a cable which is anchored at the other end of the field. In this way the sprinkler is dragged across the field. The water source is connected to the sprinkler with a flexible hose which is dragged behind the trolley. A disadvantage of this model is that it has a costly supply pipe which can wear while an advantage is that a strip of up to 400 m can be irrigated per set.

- Another model consists of a drum around which the water supply pipe is rolled. The drum is mounted on a trolley. The big gun is connected to the supply pipe and mounted on a smaller trolley or sled. The large trolley is set up in the middle of the field directly opposite the main line. The big gun on the sled is then dragged to the edge of the field by tractor, unrolling the supply pipe from the drum. When the big gun begins to irrigate, the drum is hydraulically driven, rolling up the supply pipe and dragging the big gun in. When the sled reaches the trolley and drum, the trolley is rotated through 180° and the remaining half of the field is irrigated in the same way.

- The drum around which the water supply pipe is rolled and the big gun are mounted on the same trolley. The supply pipe of ordinary high density polyethylene is connected to the hydrant on the main pipe at one end of the field. The trolley is then dragged to the opposite end of the field by tractor. When the water supply is activated, the trolley is hydraulically driven and moves all along the supply pipe to the hydrant. When the hydrant at the end of the strip is reached, the water supply is automatically cut and the machine is ready to be moved to the next strip.

The advantage of this system is that strips do not necessarily have to follow a straight line. The supply pipe may be laid along the contour and the trolley, which has a steering mechanism, will follow it.

Travelling irrigators are especially suited to pastures and sugar cane, but are also applied to other types of agronomic crops. They still require more labour than centre pivots as they have to be moved once every 12 or 24 hours by tractor. They are generally used on uneven surfaces not suited for centre pivots but where travelling irrigators may be used practically. The moving direction must be such that the pressure difference between the upper and lower ends of a strip does not exceed 20% of the working pressure. The limiting factors with travelling irrigators are the condition of roads, prevailing winds and the high working pressure required. A point of importance with traveling guns is among others the variation in speed with which they travel. The amount to be irrigated will vary in the same relation as the speed. The maximum permissible speed variation between highest and lowest speed is 10%. It is also important to allow the sprinkler at the beginning and end of the strip a specific recommended time to stand and irrigate to obtain an acceptable distribution of water.

2.3 Rotating boom systems

The design of rotating booms merely entails reading off applications per hour from manufacturer's tables. A suitable travelling time or standing time can be determined from the crop requirements and the soil water holding capacity.

It is important to note that a triangular spacing is used with a static boom as a rectangular spacing causes weak distribution with a dry area between the four positions. It is advisable to plot the positions and wetted circles on the site plans.

With rotating boom systems a strip spacing of 85% of the wetted diameter produces the best distribution efficiency, namely 91%.

2.4 Linear systems

Linear systems are very similar to centre pivots as regards construction except that they do not rotate about a central point.

Driving is usually electrical or hydraulic with a diesel motor mounted on the machine or also electrical or hydraulic where an external pump with draglines is used.

Water is supplied by:

- a channel in the middle or at the side of the field, parallel to the movement direction from which the linear system's motor pumps the water;
- hydrants which are connected to the linear system with a flexible drag-line and make use of pressure from an external pumping station; and
- an automatic coupling system where the linear system is coupled to the hydrants and use is also made of an external pump.

The system is guided by censors which follow a cable stretched across the length of the field. Linear system routing is further accomplished by switches or valves on each tower which keep each span length in line.

3 Installation

It is very important that the limitations as prescribed by the manufacturers for the placing of different towers for towable as well as non-towable models be attended to during design and erection. To simplify installation, installation must preferably be done along a hard surface such as a road.

4 Evaluation after installation

A basic evaluation must be done on the system after installation, to ensure that the system complies with the design specifications.

Table 2: Proposed basic evaluation procedure after installation

Subject / Item	**Measurement/Evaluation**	**Action if measurements / evaluation does not conform to the design specifications**
Operating pressure	Determine the pivot pressure and pressure at the beginnning of towers with a pressure gauge and compare with the required pressured as specified on the peak design form	Contact designer for trouble shooting
Emitter delivery	Measure the delivery in a container for one minute on at least three emitters on a tower	If or a delivery variation of more than 10% occurs, as specified in the technical report, contact the designer.
System lay-out	Verify the emitter package by determining whether the correct nozzles and pressure regulators (if applicable) are installed in the correct positions. Compare installed pipe diameters with those on the plan.	Re-install according to plan
Equipment	Compare the installed, electric motors, and motor speed with the specifications as per design report. (High-speed motors must be half of the total motors + 1)	Contact designer for replacement of faulty equipment
General installation	Examine if any leakages occur in the system	Repair leaks
System capacity	Determine system flow rate by taking the reading from the flow meter.	If a flow rate deviation of more than 10% from the average occurs, as specified in the peak design form, contact the designer.

5 Management

It is important that moving systems are managed correctly to ensure the effective application of water.

Figure 10.5: Placing of rain meters for pivot point evaluation

5.1 Switching on and off

The following procedure can be followed when irrigation is to be done with a pivot point:

- Ensure that there are no vehicles or any other equipment near the pivot that can cause an obstruction.
- Change the WET/DRY switch to the "WET" position.
- Close the mainline's valve partially.
- Switch on the pump.
- Open the valve slowly until the mainline is filled with water.
- Change the main switch to the "on" position.
- Change the STOP/RUN switch to the "run" position.
- Set the percentage switch.
- Press and select the AHEAD/REVERSE switch (Ahead means clockwise and reverse means anti-clockwise).

To stop the system, change the STOP/RUN switch to the "stop" position, change the main switch to the "off" position and switch off the pump.

Alignment of centre pivots is very important, since problems with alignment can lead to excessively high tension in the pivot structure that can shorten the life of the motor and gearbox lifespan and can cause structural damage. The manufacturer's prescriptions must be followed with caution.

5.2 Water application

The development of a computer supported control system for pivot and the use of pressure regulators with nozzles, has simplified the effective control of irrigation water of pivots.

Figure 10.6: Typical control panels of pivots

It still remains extremely important to operate the system correctly to make effective water application possible. Scheduling aids such as soil water sensors and scheduling programmes are discussed in **Chapter 12: Irrigation scheduling.**

The following is recommended to limit water losses:

- Do not apply too little water per cycle. It is normally advisable to apply not less than 5 mm per application. The reason therefore is that, with a smaller application, a shallow depth of wetting is obtained and soil water application is less effective, as a result of interception by the leaf cover and evaporation from the soil. A low application can also lead to a too shallow root development.
- In regions with constant prevailing winds, the distortion can be compensated by making speed adjustment in multiples of half days. This will result in the same spot in the field not being irrigated at the same time of the day. Irrigation must be ceased if the wind speed is greater than 20 km/h (Van der Ryst, 1990).
- Any nozzle that applies water with small drops at high rate, must be avoided. Small drops will be blown away by the wind and lead to evaporation.
- By alternating irrigation during the day and the night, losses will be limited to less than 10% at a time.
- Nozzles must be checked for blockage regularly. A sieve must be installed at the pivot centre to remove material from the system that can cause blockage. The distribution pattern must be inspected once per season to identify and replace worn nozzles.
- The water must be applied as close as possible to the crop to limit losses.

During periods of water restrictions, the following can be considered for different types of set-ups.

Permanent:

- Divide the field into segments and spread out planting dates for the same crop, so that all the crops do not reach their peak requirements at the same time. This can also reduce the risk if unforeseen breakages are experienced.
- Plant different crops so that the peak requirements are spread out.
- If unforeseen circumstances should occur, supplementary irrigation can be applied to a portion of the field.

Seasonally movable:
In some regions, with the correct choice of crops, it is possible to put in two harvests per year. As soon as the requirement for the first crop begins to decrease, the pivot can be moved to a second circle to begin soil preparation.

Cycle movable:
Never try to handle too many circles with one pivot point. It is difficult to irrigate 3 circles with one pivot. Also consider different crops or the same crop with different planting dates on the various circles.

The following is recommended for solving problems regarding infiltration and the forming of wheel tracks:

- Some soils tend to compact towards the end of a season. Keep check on the soil for weakening in infiltration rate and do not irrigate too much at a time.
- For soils with poor infiltration, alternative tilling practices must be considered. The forming of puddles between rows or stubble tilling or gypsum application can improve infiltration rate tremendously.
- Some soils tend to make deep tracks early in the season if it is tilled too shallow. If heavy irrigation is applied, water remains in the tracks and the tracks become deeper with each revolution. Deeper tilling or lighter initial irrigation can avoid this.
- It is important to first apply a very light irrigation on a tilled field. This ensures that the wheel tracks are not too deep. The onus is on the farmer to ensure that wheel tracks are never deeper than 150 mm. Deep wheel tracks can cause mechanical damage if the machine should move out of line.
- On soils where problems are experienced with deep tracks, circular tilling can be considered. Tilling can then be done between rows during the season to fill the tracks.
- With corner systems, it must be kept in mind that the extended tower section is much heavier than the other towers. It is also inclined to make deeper tracks. Give attention to tracks with the first revolution. The extended tower section's wheels cross the trench in which the alignment cables are buried in a few places. Heavy irrigation in the first revolution can possibly cause the pivot to get bogged down.

General pointers:

- Do not leave implements standing in the field – they may be in the way of the pivot and cause damage.
- Do not irrigate when it is too cold – the pivot can freeze.
- Park the pivot in the service road during tilling. High equipment such as tractors or harvesters can damage the pivot when they try to move below it.
- Use a strong enough tractor to tow the pivot. Avoid at all times that the pivot is tugged forward. Also look out for wheel tracks in the towing path.

Water application of a pivot is changed by changing the running speed of the pivot point and can be determined as follows:

The revolution time at 100% speed adjustment can be calculated as follows:

$$t = \frac{2\,\pi\,r}{60\,v} = \frac{0{,}1047\,r}{v} \qquad (10.1)$$

where t = rotation time at 100% speed setting [hour]
r = distance of pivot to last drive wheel [m]
v = travel speed of last wheel at 100% speed setting [mm/m]

The gross application per revolution can be determined as follows:

$$BT = \frac{Qt}{10A} \qquad (10.2)$$

where BT = gross application at 100% speed setting [mm]
Q = pivot flow rate [m³/h]
t = rotation time at 100% speed setting [hour]
A = area [ha]

A schedule can now be drawn up for the amount of gross application at different percentage speed settings of the pivot.

$$t_v = \frac{t}{v_v} \qquad (10.3)$$

where t_v = rotation time at a specific % speed setting [hour]
v_v = specific speed setting [fraction]

This equation can only be used as a first approximation for determining the water application. Because of factors beyond the producer's control, such as soil conditions, wheel slip and pivot pressure, variations can occur. A better schedule can however only be drawn up after installation with physical readings in the field.

For the calculation of rotation times and application rates, the applicable information, e.g. motor speed for different types of drives and tyre sizes, can be obtained from the manufacturer.

Table 10.3: Tyres and motors available for pivots

Type of drive	**Motor speed [rpm]**	**Speed (m/min) for different wheel sizes**				
		11,2" × 24"	**13,6" × 24"**	**14,9" × 24"**	**16,9" × 24"**	**11,2" × 38"**
Worm (standard)	25	1,55	1,65	1,72	1,83	2,12
Worm (high)	47	2,89	3,08	3,21	3,42	3,95
Screw (standard)	28	1,76	1,87	1,88	2,07	2,40
Screw (high)	56	3,51	3,74	3,90	4,16	4,80

Tyre pressure is very important for the effective operation of the system and must be checked at least three times during the irrigation season. Low tyre pressure will damage the tyres and propulsion mechanisms. The manufacturer must be consulted about the correct tyre size for a specific pivot point and slope. The following directives can be used:

Sandy soils:	11,2 × 24
Heavier soils (>6% clay):	13,6 × 24 (cash crops)
	14,9 × 24 (perennial crops)

Example 10.1:

Determine the revolution time and gross application at a 50% speed setting for the following case:

Pivot point length:	*308,3m*
Distance to furthest wheel:	*282,8m*
Pivot flow rate:	*101m³/h*
Motor speed according to manufacturer's brochure:	*1,64 m/min*
Wheel slip allowed:	*3%*

Solution:

$$Drive\ speed = 1{,}64 \times \left(1 - \frac{3}{100}\right)$$
$$= 1{,}59\ m/min$$

According to Equation 10.1:

$$Rotation\ \ time = \frac{0{,}1047r}{v}$$
$$= \frac{0{,}1047 \times 282{,}8}{1{,}59}\ h$$
$$= 18{,}6\ hours$$

$$Area = \pi R^2$$
$$= \pi \times 308{,}3^2\ m^2$$
$$= 29{,}85\ ha$$

According to equation 10.2:

$$Gross\ application = \frac{Qt}{10A}$$
$$= \frac{101 \times 18{,}6}{10 \times 29{,}85}\ mm$$
$$= 6{,}3\ mm$$

At a 50% speed setting:

According to Equation 10.3:

$$t_v = \frac{18{,}6}{0{,}5}\ hours$$
$$= 37{,}2\ hours$$

$$GA = \frac{6{,}3}{0{,}5}\ mm$$
$$= 12{,}6\ mm$$

Similar calculations can be done for any other required speed setting

7 Troubleshooting tables

Table 10.4: Troubleshooting table for centre pivots

Problem	Possible causes	Solution
Pivot won't move	No power at control switchboard	Contact electrician
	Single phase at control switchboard	Contact electrician
	No power at control circuit	Contact electrician
	Timer switch out of order	Contact electrician
	End tower motor out of order	Contact electrician
	Motion sensor timer out of adjustment	Contact electrician
	First tower auxiliary contactor inoperative	Contact electrician
Pivots move out of line	Single phase to control switchboard	Contact electrician
	Loose wire or poor connection between switchboard and misaligned tower	Contact electrician
	Tower's heat starter tripped out	Contact electrician
	Tyre pressure too low	Pump tyres according to manufacturer's specifications
	Variation in slope of field too great	Change tilling methods in field
	Wheels make too deep tracks in field	Repair wheel tracks and change drainage direction of water
	Alignment limit switch inoperative	Check operation. Replace if necessary
Pivot won't move back automatically	Reverse switch out of order	Contact electrician
	Control switch in "off" or "manual control" position	Change switch to automatic position
Pivot does not stop automatically	Stop limit and stop selector switch is incorrectly wired	Contact electrician
	Control panel badly wired	Contact electrician
Movement sensor timer switches pivots off	Movement sensor out of order	Contact electrician
	Timer switch not set	Set time switch as prescribed in operating instructions
	First tower's switch out of order	Contact electrician
	Loose wires between first tower and movement sensor time switch	Contact electrician
	First tower activating switch out of order	Contact electrician
Pivot keeps on going/running	Short circuit between wires	Contact electrician
	Contacts of limit switch corroded	Replace switch
	Incorrect wiring of end tower and booster pump	Contact electrician
End tower nozzle does not close	Limit switch out of order	Contact electrician
	"Collector ring" wiring faulty	Contact electrician
	Filter of diaphragm valve blocked	Clean filter
	Obstruction in line to diaphragm valve	Clean line
	Weak induction coil in diaphragm valve	Contact electrician
	Relay of end tower badly wired or out of order	Contact electrician
Safety circuit "open"	Defective micro switch	Contact electrician
	End tower wiring faulty	Contact electrician
	Pivot's alignment faulty	Contact electrician

Problem	Possible causes	Solution
	Broken wire in span cable	Remove and replace
Booster pump out of order	No water in lines	Check water source
	Booster pump switch faulty	Contact electrician
	Booster pump motor turns in wrong direction	Contact electrician
	Booster pump pressure switch set at high pressure	Adjust
	Booster pump wired incorrectly	Contact electrician

8 Maintenance

All routine services as discussed in the owner's manual must be followed precisely**.** Since a pivot consists of moving parts and movement usually takes place as a result of electrical energy, the equipment can be potentially dangerous. Keep the following safety precautions in mind:

- Never try to switch on the system before it is thoroughly earthed.
- Never use circuit breakers greater than the recommended specifications.
- Never remove any panel or open a tower panel before you have switched off the power yourself. Do not trust anyone else with this task.
- Keep the panel cabinet locked as far as possible. This will prevent unnecessary tampering with the pivot.
- Prevent mist spray from the pivot on the skin and inhaling when chemicals are applied through the system.
- Never adjust the end nozzle while it is in operation
- Never try to climb on the pivot with a ladder while it is in operation.

Overhang:
Since the overhang is suspended on cables, the build-up of sand and silt can cause structural problems– especially if the pivot is towed. It is therefor essential that the pivot be flushed regularly. Start with checking how soon the drainage valves get blocked after the pump is switched off. This gives an indication of how regularly the pivot must be flushed. It is no use removing the drainage valves after the pump is switched off. Remove the sand trapper and drainage valves at each tower and rinse out the dirt while the pump is in operation.

Sprinklers:
As soon as blockages are noticed, the sprinklers must be removed and cleaned. Never use a piece of wire to clean the nozzle from the outside. It is advisable to check the regulator at the same time. In many cases, the regulator blocks up partially before the nozzle gets blocked.
If chemicals are applied, sprinklers must be checked for wear at least once per season. Uneven application of irrigation can be catastrophic for the crop.

Gearboxes:
The lubricants for pivot gearboxes as prescribed by the manufacturers must be used. The oil must be drained from the gearboxes after each irrigation season.

8.1 Maintenance schedules

Seasonal maintenance must be done at the end of each growing season. This will protect the pivot during the months when it is not in use and lead to the minimal problems at the start of the next season. A maintenance schedule is proposed in the table below:

Table 10.5: Maintenance schedule of pivots

Action	After each revolution	After each 4th revolution	Seasonal
Electrical			
Switch on pivot and listen to each motor and starter. If any abnormal sound is heard, remove and have it serviced.			X
If end tower's light is out, replace electric bulb and remove dust, insects and water where necessary.			X
Check tower panel and main control cabinet. Clean panels, remove dust, insects e.g. wasps, etc.			X
Inspect condition of wiring of pivot			X
Inspect electrical motor cable condition, earth conductor and connections			X
Structure			
Ensure that all bolts and nuts are tightened, Tighten if necessary. Ensure that earth conductors are clean.			X
Grease pivot		X	X
Grease pin that holds swing mechanism of towable pivots to prevent rusting		X	X
Check system for leakages. Repair if necessary			X
Replace gearbox oil			X
Drain and replace lubricants in motors			X
Grease moving parts and roller bearings	X		X
Check U-couplings, grease if necessary			X
Check wheel bolts and adjust as prescribed	X	X	X
Check wheel pressure and adjust as prescribed	X		X
Check flange fittings for leakages, secure and replace if necessary	X		X
Inspect framework for sturdiness – tighten bolts if necessary	X		X
Check if all the safety switches work			X
Check if all the drainage valves work	X		X
Clean sand trap if necessary	X		X
Sprinklers			
Check nozzles for wear, replace if necessary			X
Check is the pressure meter works correctly			X
Check the condition of the sprinklers			X
Check pivot pressure and pressure at beginning of towers			X
Check for blockages in nozzles	X	X	X
Flush the system			X
Equipment			
Check functioning of end nozzles and check nozzle for wear			X

Inspect cut-off action of end nozzle – repair or replace if necessary			X
Check stop in slot micro switch, adjust if necessary	X		X
Test the automatic reverse-action movement of pivots by switching the hand lever forward and back			X
Fill wheel tracks deeper than 150 mm with timber or stones		X	

With linear systems, the following additional measures must be kept in mind when maintenance is done:

- **Drive:**
  All electrical cables must be checked regularly and replaced if necessary. Check bearings and belts and adjust if necessary.

- **Alignment:**
  Check alignment according to manufacturer's prescriptions. Where a system uses a supply line that must be towed, the road must be as even and dry as possible to make the towing of pipe easier.

8.2 Flushing of pivot points

The purpose of the flushing of the system is to remove sand and dirt collected in the pipeline. Sand can cause unnecessary wear of the nozzles and the additional weight of the collected sand can damage the structure. The following flushing procedure can be followed:

- Ensure that the main switch is in the "off" position
- Remove the sand filter, drainage valves at each tower and the lid at the end of the overhang
- Switch on the pump
- Flush the system thoroughly
- Switch off the pump and replace the sand filter, drainage valves and lid at the end of the overhang.

The flushing procedure will normally be carried out after installation of the system, after repairs are done to the pump and the pivot point structure, at the beginning of the irrigation season and when it seems necessary as a result of sand collection in the system.

8.3 Solutions for corrosion problems

Different indexes are used for identifying whether irrigation water is corrosive or will form a deposit. A single index can create the wrong impression and it is therefor recommended that as many indexes as possible is used for estimating the water quality. Tables 10.6 – 10.8 can be used to evaluate the effect of the water on irrigation equipment.

Table 10.6: Langelier – index (DWAF, 1996)

Langelier index	Effect on irrigation equipment
< - 0,2	Increasing problems with corrosion
-0,2 to + 0,2	Limited problems with corrosion or deposit forming
> + 0,2	Increasing problems with deposit forming

Table 10.7: Ryznar index (DWAF, 1996)

Ryznar index	Effect on irrigation systems
<6,5	Tendency to form deposit
>6,5	Tendency to be corrosive

Table 10.8: Corrosion index (DWAF, 1996)

Corrosion index	Effect on irrigation systems
<0,1	Limited corrosion problems
≥0,1	Increasing corrosion problems

There are two approaches that can be followed to solve the problem of corrosion:

- Firstly, the thickness of the galvanising on the pipes can be increased from a minimum of 55 micron as proposed by the SABS, to a value of 100 micron and more. This will lengthen the lifespan of the pipes.
- Alternatively, the pipes can be manufactured from a zinc alloy that contains magnesium, aluminium and lead, or the galvanising can be protected by three coats of epoxy paint (De Beer, 2002). Valley has developed a pipe with polyethylene lining for this purpose.

The owner of the pivot can prevent problems regarding water quality by following maintenance measures, such as by ensuring that the drainage valves function correctly. If the drainage valves are blocked, the fertilizer concentrate will accumulate at the lowest points of the pivot point and aggravate the corrosion process.

7 References

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