# New Zealand Piped Irrigation System Performance Assessment Code of Practice

## PART F: Traveller

Note: This is Part F of a series of nine (Parts A–I).

# Part F: Contents

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The Code is presented as a series of booklets, each with a defined purpose.

**Part A: An Introduction to Performance Assessment**
Part A provides an overview of performance assessment, explains the broad philosophy behind assessment approaches taken throughout the Performance Assessment series, and contains specific formulae and reporting standards.

**Part B: Compliance and Water Supply Checklists**
Part B relates to all system types. It contains recommendations for checks to ensure compliance with regulations, rules and consent conditions, safe effective operation of water supply systems.

**Parts C–H: System Performance Assessments**
(Part F = this booklet)
Parts C–H contain guidelines and recommendations for Operational Checks, System Calibrations and In-field Performance Assessments specific to a range of irrigation system types.

**Part I: Conducting Energy Efficiency Assessments and Seasonal Irrigation Efficiency**

**IrrigationNZ Technical Glossary**
The Glossary and Calculations are common with the NZPIS Design Code of Practice.



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# Introduction

## Purpose

The *New Zealand Piped Irrigation System Performance Assessment Code of Practice* provides nationally recognised guidelines to measure and benchmark performance of agricultural irrigation.

Part F is specific to traveller irrigation systems. It makes recommendations for planning and conducting assessments and reporting on the performance of irrigation systems and their management. Its focus is on key performance indicators that are common with the New Zealand Piped Irrigation Systems Design Standards..

It was developed to provide guidelines for irrigators and others undertaking evaluations of such equipment as a 'snapshot exercise' under prevailing field conditions.

**SYSTEM PERFORMANCE**

The Code recognises different levels of performance assessment depending on purpose. In increasing level of complexity, system performance assessment includes:

- Operational Checks
- System Calibration
- In-field Performance Assessment.

## Related documentation

- **New Zealand Piped Irrigation System Performance Assessment Code of Practice:**
  - Part A: An Introduction to Performance Assessment
    Part A provides an overview of performance assessment, explains the broad philosophy behind assessment approaches taken throughout the Performance Assessment series, and contains specific formulae and reporting standards.
  - Part B: Compliance and Water Supply Checklists
    Part B relates to all system types. It makes recommendations for checks to ensure compliance with regulations, rules and consent conditions, safe effective operation of water supply systems and energy efficiency assessments of pumps and delivery systems.
  - Parts C–H: System Performance Assessments
    Parts C–H contains guidelines and recommendations for performance assessments specific to a range of irrigation system types.
- **New Zealand Piped Irrigation Systems Design Code of Practice**
- **New Zealand Piped Irrigation Systems Design Standards**
- **New Zealand Piped Irrigation Systems Installation Code of Practice**
- **New Zealand Water Measurement Code of Practice**
- **New Zealand Irrigation Technical Glossary**

# System description

A traveller irrigation machine irrigates a field sequentially, strip by strip by drawing a ‘gun-cart’ equipped with a water distribution system across a field.

Water is discharged under pressure from a water distribution system mounted on the gun-cart as it travels across the field. A traveller is intended to be moved to, and operate from, several supply points established in advance in the field.

Irrigated strips overlap at the edges to ensure even coverage. The evenness of application across the irrigated strip, and the evenness of application as the traveller passes across the field both contribute to overall irrigation distribution uniformity.

Three broad categories are recognised each having a structure that includes a reel, spool or winch and a travelling water distribution system.

**A. REEL MACHINES (HARD HOSE)**

Reel machines have a stationary reel anchored at the run end. The reel acts as a winch, coiling a delivery tube that both supplies water to the distribution system and drags the gun-cart along the field.

**B. TRAVELLER MACHINES (SOFT HOSE)**

Traveller machines have a cable that is anchored at the run end. The water distribution system and a travelling winch are mounted on the gun-cart. The winch pulls the gun-cart along by coiling the cable on to the reel. The gun-cart drags the delivery hose across the field.

**C. SELF PROPELLED REEL MACHINES**

Self propelled reel machines carry both a reel and the water distribution system and draw themselves across the field by coiling the anchored delivery tube on to the reel.

In addition, there are three different water distribution mechanisms: big gun, fixed boom and rotating boom. Each of these requires slightly different evaluation procedures to identify causes on non-uniformity.

Traveller irrigation machines make irrigation feasible in many areas where other techniques are not suitable. They are easily transported between fields even over relatively long distances, and can be used to irrigate irregularly shaped areas.

# Special features for analysis

**OVERLAPPING STRIPS**

The uniformity of water application for an entire field is likely to be increased through the overlapping of adjacent irrigation strips.

Field application uniformity can be estimated by virtual overlays of test data from a single irrigation strip. The machine’s performance is measured for one set position, and measurements from outer edges mapped on to the corresponding measurements on the opposite side.

**CHANGING TRAVEL SPEED**

The speed of a travelling irrigation machine may change as successive layers are laid upon the reel or winch, or because ground conditions create different amounts of drag on the gun-cart.

Field evaluations can estimate the effect of varying travel speeds on distribution uniformity by making multiple transverse measurements and completing a longitudinal speed assessment.

**WIND EFFECTS**

The performance of a travelling irrigation machine can be greatly affected by wind, particularly when gun-type nozzles are used on high angle settings.

The uniformity testing should be carried out in conditions representative of those commonly experienced in the field. Wind speed and direction should be measured and recorded.

**FIELD VARIABILITY**

The performance of a travelling irrigation machine may vary at different positions in the field. Contributing factors include topographic variation and elevation changes and soil drag effects.

A machine operating on a relatively flat, homogenous field should have similar performance in all positions. The assessor and client should discuss what testing is desired and the conditions under which any tests should be conducted.

**HIGH OPERATING PRESSURES**

Relatively high operating pressures, particularly for big guns, minimises the effect of terrain pressure change effects on flow or distribution pattern.

**STATIONARY OPERATION**

Travelling irrigators may be operated stationary at either end of the strip to ensure at least the target application depth is applied. This increased losses by deep drainage from the section of the wetted area that is ‘over watered’. Field uniformity and application efficiency are reduced, more so on short runs.

**ALTERNATE SETS**

Travellers may be set in different positions during successive irrigation rotations. If set positions are moved one half of set-width, the compensation can increase overall uniformity.

# 1. Operational checklist

This is a minimum list of checks of travelling irrigators that should be made.

**Be safety conscious – electrical and mechanical hazards may be present.**

Every system should be supplied with a System Operation Manual. The manual may include extra checks not listed here. It will give more detail than this checklist including information specific to your system.

### SYSTEM OFF CHECKS

#### Hose reel (or cable reel)

1. Visually check structure condition for corrosion or damage
2. Visually check wheel lug bolts, tyre condition and pressure
3. Visually check gearboxes, drive shafts
   - Lubricate as required
4. Check cable winch action and ratchets for wear and freedom of movement
5. Tighten all bolts, check pins
6. Lubricate as specified in manual
7. Visually check seals and flanges

#### Gun cart

8. Visually check structure condition, corrosion or damage
9. Visually check wheel lug bolts, tyre condition and pressure
10. Tighten all bolts, check pins
11. Visually check condition of other connections
    - Lubricate as specified in manual
12. Visually check seals and flanges
13. Visually check rotating boom turntable not worn, allows free turning

#### Drag hose

14. Visually check condition for wear, kinks or other damage
15. Visually check boots
    - Tighten bands if necessary

#### Sprinklers

16. Check sprinklers fitted are as specified in sprinkler chart
17. Inspect nozzle orifice condition
    - Replace if wear detectable
18. Ensure rotating nozzles are free turning and cages not damaged
19. Check splash plate condition, angle and alignment

#### Gun

20. Check components for looseness, freedom of movement
21. Check outlet nozzle orifice condition
    - Replace if wear detectable

#### Control unit

22. Visually inspect electronic controls
23. Check battery charge.

### SYSTEM ON CHECKS

**WARNING:**

**Before starting ensure nothing is parked in front of the irrigator.**

#### Pump

1. Complete checks as specified earlier in Section 1

#### Headworks

2. Complete checks as specified earlier in Section 1
3. Check the flow rate of each station

#### Pipe network

4. Check for leaks along mainline

#### System pressure

5. Check pump pressure while system operating
6. Check pressure before and after filters

#### Off-takes/hydrants

7. Check hydrants are not leaking
8. Check all off-take pressures correct

   NOTE: Hydrant must be in use to get valid pressure reading

   NOTE: Check farthest and highest hydrant positions to ensure adequate pressure

### Hose reel (or cable reel)

9. Check the reel is turning smoothly
10. Check the hose or cable is winding in correctly
11. Check the inlet pressure gauge
    - Replace if necessary
12. Check the inlet pressure

    **NOTE:** Check pressure at the furthest hydrant for most extreme situation
13. Check the turbine is functioning correctly

### Gun cart

14. Check the cart is moving correctly
15. Check the inlet pressure
    - Replace gauge if necessary
16. Check there are no leaks

### Drag hose

17. Check there are no leaks
18. Check the hose is not misshapen

### Sprinklers

19. Check each sprinkler is turning correctly and cage not damaged
    - Repair or replace as necessary
20. Check there are no leaks
    - Repair or replace as necessary
21. Check the pressure above last sprinkler, above pressure regulator if fitted

    **NOTE:** This requires installation of a test point. A ¾" BSP Tee above the pressure regulator is usually suitable. Reduce to ¼" BSP for standard pressure gauge.

### Gun

22. Check gun is operating correctly
23. Check gun angles are correct, gun switches direction at correct locations

### Control unit

24. Check any control unit is functioning correctly.

# 2. Calibrating travelling irrigation systems

The Irrigation Calibration method for travelling irrigation systems assesses the amount of water being applied during an irrigation event. It is based on measurements of water collected in a line of containers spaced across the path of travel.

Applied Depth, Application Intensity and Distribution Uniformity are calculated. This allows the manager to determine the speed required to apply the target depth, and whether the system is applying the same amount of water across the irrigation block.

By repeating the process in other irrigation blocks or runs, a plan to apply target depths in each block across the whole property can be determined.

## 2.1 What will the testing show?

The main things the calibration test will show are:

**Applied depth**
The 'rainfall equivalent' depth of water the irrigation system is applying on average at the particular travel speed. Compare the measured applied depth to target application to determine machine speed adjustment to correct applied depths.

**Application intensity**
The rate (mm/hour) at which water is being applied, equivalent to rainfall intensity. If intensity exceeds soil infiltration capacity, ponding, redistribution and runoff will reduce irrigation effectiveness and efficiency.

**Distribution uniformity DU**
Distribution Uniformity describes the evenness with which water is applied. The higher the DU the better the system is performing. And the higher the uniformity, the more confident you can be that your measurements are truly representative of your system's performance.

**Excess water use EWF**
The excess water use factor identifies how much extra water is required during a set event because of non-uniformity.

**Adjusted machine speed**
Calculates the machine speed required to ensure 7/8ths of the area gets at least the Target Application Depth. It accounts for flow rate and uniformity.

### WHEN SHOULD CALIBRATION BE DONE?

Complete the calibration test if commissioning a new machine and after any major changes. Calibration should be repeated as part of system checks at the start of every season.

NOTE: Travelling irrigator performance can be significantly affected by weather conditions. Consider wind conditions when testing: Calm conditions may give a better assessment of the system's potential performance but if wind is normal for the site, testing may proceed.

NOTE: Pressure variation will significantly alter performance: consider testing:

- at different hydrant positions
- different field elevations or
- when alternative water-takes reduce system pressure.

## 2.2 Calibration process

Before starting, ensure System Operational Checks (Section 1) have been completed.

Calibration is a four step process:

1. Gathering information about the system
2. Calculating performance indicator values
3. Comparing results with expectations
4. Adjusting irrigation system settings as required to achieve intended performance.

### GATHERING INFORMATION

The calibration check is based on a line of collectors (transects) placed across the traveller run. It can be useful to repeat the test at the start and end of a run to check performance is consistent. Changing terrain, or heavy drag hoses can affect machine performance.

**Equipment**
Equipment needs are very basic and most should already be available on the property. A suggested list includes:

- 22 containers of same known opening diameter (>150mm)
  - 9 Litre buckets have been found suitable
- 1 measuring cylinder
  - 1 or 2 Litre for larger volumes (large containers, slow speeds)
  - 100mL or 200mL for smaller volumes (small containers, fast speeds)
- 1 tape measure (50m)
- 2 flags or fence standards
- 1 stop watch
- 1 pen or pencil
- 1 recording sheet.

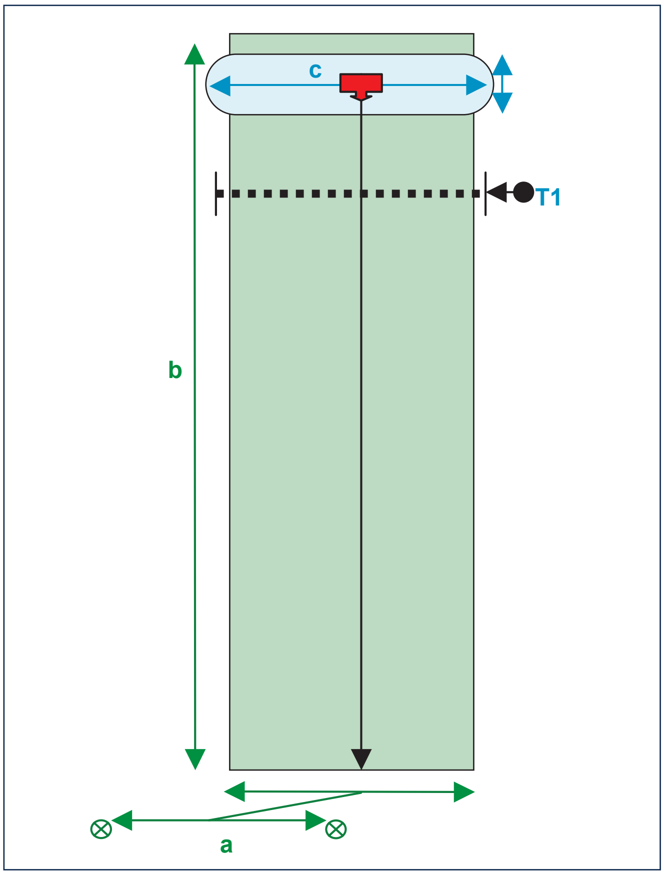


Figure 2.1. Layout of calibration test for travelling irrigators

## Dealing with overlap

If irrigation from adjacent runs overlaps, this must be taken into account. To account for overlap, buckets are placed in the overlap zone and measured depths combined. The effective depth and evenness assumes the combined effect of adjacent runs.

1. Place markers half way between the test hydrant and the hydrant to the left (See Figure 2.1)
2. Repeat on the right hand side. The space between the markers is the Run Width (a in Figure 2.1)
3. Mark the extent of obvious wetting when the irrigator runs. This is the "Wetted Width" (c in Figure 2.1)
4. If the Wetted Width is greater than the Run Width, account for overlap.

## Sampling method

Set out collectors.

1. Place one bucket half way between the edge of the lane and the edge of the wetted width (see 'L11' in Figure 2.2)
2. Mirror this inside the edge of the run, setting another bucket at the same spacing from the edge of the run (see 'L10 in Figure 2.2)
3. Arrange nine more buckets at even spacing to cover the area back to the centre line (the hose or cable) (see 'L9–L1' in Figure 2.2). The spacing may be different to overlap buckets
4. Repeat 4, 5 and 6 on the right hand side.

   NOTE: If the system has no overlap, leave buckets L11 and R11 out. Spread ten buckets each side of the irrigator and don't do overlaps in the calculations

   NOTE: If the system has more than 25% overlap, this method may not give fair representation of effects

Mark speed test positions

5. Place a marker flag beside the cable or hose, either side of the collector bucket transect
6. Record the distance between the flags

   NOTE: Put flags at least 5m each side of the transect. Ensure marker flags are visible from outside the wetting area so they can be seen during testing

## Management information

7. Record the Target Irrigation Depth
8. Record the Normal Irrigation Event Duration
9. Measure the Run Length (b in Figure 2.1)

   NOTE: It is often best to use an average distance for several runs in a paddock
10. Measure the Run Width (often hydrant positions) (a in Figure 2.1)

    NOTE: Take an average spacing between several hydrants
11. Record the number of runs
12. Determine the area of the Block (Run length x run spacing x run number).

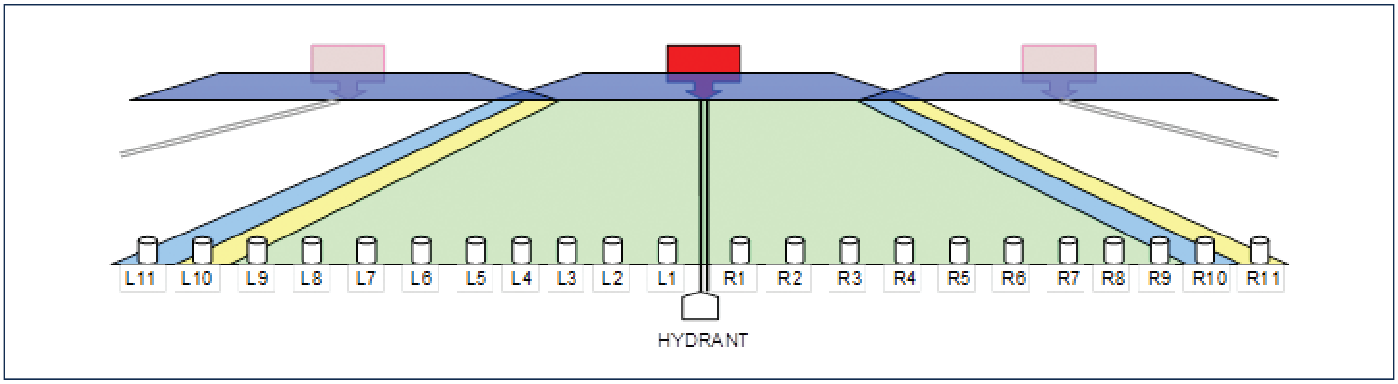


Figure 2.2. Collector bucket positions relative to irrigation lane and wetted width

## FIELD MEASUREMENTS

Repeat the following field measurements and calculations in each area of interest.

### System measurements

1. Measure the Outlet Pressure at the pump
2. Measure the Pressure at the Entry to the irrigator
3. Measure the system Flow Rate

### Application test

4. Run the system and record the duration

   **NOTE:** Ensure run time is long enough to collect enough water to measure accurately

5. Record the time the traveller passes the first marker flag
6. Record the time the traveller passes the second marker flag
7. Measure the collector bucket mouth diameter
8. Measure the volume of water caught in each container and record on the Record Sheet

   **NOTE:** Take care to record each reading in the correct position so overlap calculations are correct.

## CALCULATE PERFORMANCE INDICATOR VALUES

### Irrigator speed

1. Speed (m/min) = Distance travelled ÷ Time taken
   - Distance travelled (m) = distance between marker flags
   - Time taken (min) = Time at second marker flag – Time at first marker flag

### Complete overlap adjustments

2. Add the volume collected in collector L11 to the volume of R10
3. Add the volume collected in collector R11 to the volume of L10

   **NOTE:** Remaining calculations use only twenty volumes

### Applied depth

4. Calculate Applied Depth (mm) [Average Volume collected ÷ Collector opening area]
   - Average Volume Collected (mL) = Sum of all collected ÷ number of collectors
   - Collector opening area ($m^2$) = Pi x Collector diameter (m) x Collector diameter (m) ÷ 4

### Application intensity

5. Calculate Application Intensity (mm/h) [Applied Depth (mm) x Irrigator Speed (m/min) x 60 ÷ Wetting Pattern Width (m)]

### System flow rate

6. Calculate Flow Rate (L/s)
   - Hydrant/Lane Spacing (m) x Applied Depth (mm) x Irrigator Speed (m/min) / 60]

### Distribution uniformity

7. Calculate the Distribution Uniformity DU [Low quarter average volume ÷ average volume]
   - Low Quarter Average Volume (mL) = Average of the lowest five collected volumes

### Excess water use EWF

8. Calculate Excess Water Use Factor (%) [DU Adjusted Depth ÷ Applied Depth x 100]
   - DU Adjusted Depth (mm) = (Applied Depth ÷ DU) – Applied Depth

## COMPARE RESULTS WITH EXPECTATIONS

### Flow rates

1. Compare calculated System Flow Rate with Water Meter Flow Rate

### Applied depth

2. Calculate Target Depth to Applied Depth ratio = Target Depth ÷ Applied Depth
   a. < 1 – under applying
   b. = 1 – correct
   c. > 1 – over applying

   Acceptable variances: 0.90–1.10 (0.95–1.05 is better)

3. Compare Applied Depth with Soil Moisture Deficit
   - Applied Depth < Soil Moisture Deficit ÷ DU

### Application intensity

4. Compare the calculated Application Intensity to expectations

### Distribution uniformity DU

5. Interpret calculated DU value
   - DU > 0.90 Uniformity is very good
     the system is performing very well
   - 0.90 – 0.80 Uniformity is good
     performance better than average
   - 0.80 – 0.70 Uniformity is fair
     performance could be improved
   - 0.70 – 0.60 Uniformity is poor
     system should be investigated
   - DU < 0.60 Uniformity is unacceptable
     system must be investigated

## ADJUST IRRIGATION SYSTEM SETTINGS

### Check key performance indicators

1. If Applied Depth or Uniformity are unacceptable
   - Repeat Operational Checks
   - Ensure system is at recommended operating pressure
   - Get professional assistance

### Irrigator speed

2. Calculate Adjusted Speed (m/min)
   - Irrigator Speed x (Target Depth ÷ DU) ÷ Applied Depth

   NOTE: Including DU ensures the irrigator applies sufficient extra water to adequately irrigate 7/8th plants.

# 3. Performance assessment of travelling irrigation systems

This schedule presents procedures for conducting efficient and reliable irrigation evaluations of travelling irrigation systems.

Procedures for planning, conducting, analysing and reporting system performance are described. They are intended to promote efficient work practices and informative reporting that facilitates easy comparison of systems.

NOTE:
Complete Operational Checks (See Section 1) before commencing a system evaluation.

**TECHNICAL MATERIALS – RELEVANT STANDARDS**

**Spray Irrigation Performance**
ISO 8224-1:2002 Traveller irrigation machines – Part 1: Operational characteristics and laboratory and field test methods Confirmed 2009

ISO 15886-3:2012 Agricultural irrigation equipment – Sprinklers – Part 3: Characterization of distribution and test methods

ISO 8026:2009 Agricultural irrigation equipment – Sprayers – General requirements and test methods

Overlap Accounting

ISO 8224-1:2002 Traveller irrigation machines – Part 1: Operational characteristics and laboratory and field test methods Confirmed 2009.

## 3.1 Data collection

This schedule outlines procedures to be followed when assessing performance of travelling irrigation systems under prevailing field conditions.

Because test conditions will vary, key conditions must be measured and recorded to assist any comparisons between subsequent tests of the same system, or when benchmarking against other systems.

NOTE:
To provide farmer general operation/management information, test conditions should be representative of those experienced in normal operation.

NOTE:
For System Commissioning or fulfilling specific purchase contract criteria, adherence to test condition limitations such as wind speed should be ensured.

**TEST SITE**

**Location**
Select a test location that is most representative of the system as a whole.

If the irrigation site is not level, conduct the test in an area having elevation differences that are within the design specifications of the sprinkler package.

**Site variability**
If site elevation varies significantly, consider multiple tests to increase accuracy of distribution uniformity assessments. This may involve several grid uniformity tests or a combination of grid uniformity and pressure flow uniformity tests.

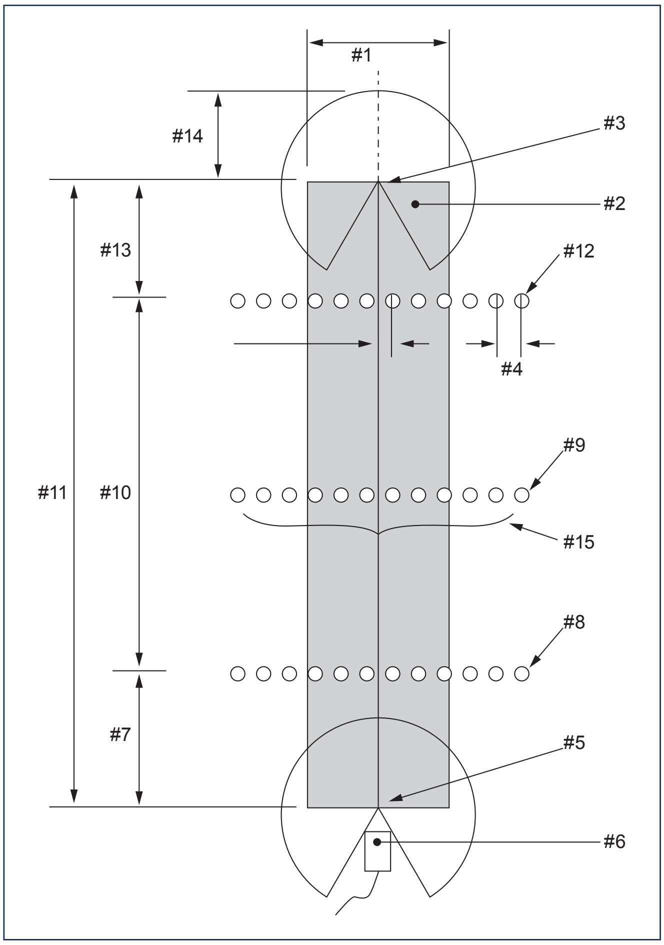


Figure 3.1. Field collector layout (from ISO 8224-1:2002)

1. Irrigation strip width, lane width, E
2. Irrigation strip accounting for overlap
3. Distribution system; initial position
4. Collector spacing, $s_c$
5. Distribution system: final stop position
6. Fixed end of travelling irrigation machine
7. End guard > wetted radius (14)
8. Position of last line of collectors, n
9. Position of intermediate line of collectors, i
10. Transverse line layout zone (>50% $L_t$)
11. Length of strip, travel path length, $L_t$
12. Position of first line of collectors, 1
13. End guard greater than wetted radius 14
14. Distribution system wetted radius, $r_w$
15. Extent of collector lines

## SYSTEM OPERATION

### System pressure

1. Complete the test at normal operating pressure or as agreed by client and tester
   - Ensure the pressure is maintained during the test
   - Ensure pressure measurements include lowest and highest areas.

### Sprinkler package

2. If the water distribution systems allows for different arrangements, use one setting that represents normal operation

### Pressure

3. Run tests at the normal operating pressure, or as mutually agreed upon by client and tester
   - Ensure the pressure is maintained during the test
   - To maintain constant pressure, ensure the system is not affected by other significant system draw-offs such as other irrigation machines or dairy sheds.

### Machine speed

4. Select a machine speed for the test that is representative of that normally selected for irrigation, and apply sufficient depth for reliable measurements to be obtained.

## ENVIRONMENTAL MEASUREMENTS

### Wind

1. Record the direction and speed of the wind during the test period, and plot against relevant test locations on a map
   - Wind speed and direction relative to the sprayline should be monitored at intervals of not more than 15 minutes and recorded
   - Wind conditions at the time of the test should be representative of those experienced in normal operation
   - Wind speeds greater than 3m/s can have significant effects on uniformity.

NOTE:
At speeds greater than 3m/s the tester and client must understand the limitations of the test results. The uniformity test should not be used as a valid measure of the sprinkler package if the mean wind velocity exceeds 3m/s.

### Evaporation

The uniformity test should be conducted during periods that minimise the effect of evaporation, such as at night or early morning or in winter months.

2. Record the time of day, estimated or measured temperature and humidity when the test is conducted
3. Record the temperature and humidity in the test zone during the test period
4. Determine evaporation rates using evaporation collectors identical to those used in uniformity testing
   - Place a control collector in a representative location upwind of the test area
   - Adjust readings for evaporation loss.

## FIELD OBSERVATIONS

### Crop type

1. Record the site's planting history for previous season and year
2. Note crops planted in the area under examination, and stage of growth

### Crop appearance

3. Observe the crop for signs of stress or growth difference. Patchiness is indicative of poor system performance
4. Measure or estimate the crop ground cover proportion

### Soils

5. Dig or auger several holes within the irrigated area
6. Determine the soil texture and depth of rooting
7. Estimate or otherwise determine soil infiltration rate and soil water holding capacity
8. Assess the depth of water penetration
9. Note any soil features that indicate wetness, poor drainage or related properties and identify causes

### Ponding

10. Assess the amount of ponding that occurs within the irrigated area while the system is operating
11. Note if water is ponding, running over the ground, or causing soil movement
12. Estimate the percentage of water lost

### Runoff

13. Assess the amount of runoff from the irrigated area as a result of irrigation
    - Only consider volumes leaving the irrigated area

### Wheel ruts

14. Assess the presence and degree of wheel or skid rutting in the travel path
    - Assess if machine speed is likely to be affected by ruts.

## SYSTEM CHECKS

### Water supply

1. Complete checks of the water supply including pumping system and mainline as specified in *Part B: Compliance and Water Supply Checklists*

### Filtration

2. Check filters and note nature and degree of contamination or blockage
3. Identify when the filter was last checked or cleaned
4. Identify if automatic cleaning or back-flushing is fitted and operational

### System leakages

5. Conduct an overall visual check (as possible) of headworks, mainline, hydrants, connection lines and the distribution system to identify any leakages or other losses from the system

### Sprinkler package

6. Before testing a system, verify that the sprinkler package has been installed according to the design specifications, unless specified otherwise by the client

### Guns

7. Record the nozzle age, type and orifice(s) fitted
8. Measure the diameter of the orifice and assess for wear
9. Record the vertical and sector angle settings

### Fixed booms

10. Record the nozzle age, type(s) and orifice(s) fitted
11. Randomly select a number of sprinklers or sprayers along the length of a fixed boom. Inspect them for blockages and record the cause of any blockages found. Assess orifice wear with a gauge tool or drill bit
12. Check sprinkler height above canopy meets manufacturer's recommendations

### Rotating booms

13. Record the nozzle age, type(s) and orifice(s) fitted
14. Assess nozzle orifices for wear
15. Ensure boom rotation is correct and unhindered.
16. Check sprinkler height above canopy meets manufacturer's recommendations

### Machine speed

17. The uniformity of speed along the path of travel can affect the field uniformity
18. Measurement of travel speed at intervals along the path can identify a potential cause of non-uniformity, and is needed to compare machine flow rates and measured application rates

### Stationary operation ($T_S$)

19. Measure the time the machine is operated stationary at the beginning and at the end of the strip

### Transverse test speeds ($S_T$)

20. Measure the machine test speed in the field as the machine passes over collectors used for each transverse application uniformity assessment
    - As the wetting zone reaches each line of collectors, mark a point on the delivery tube (hose) or winch cable, and mark the corresponding point in the field with a peg. Record the time
    - When the wetting zone no longer reaches any collectors in the line, place a second peg in the ground corresponding to the mark on the tube, and record the time
    - Measure the distance between the two pegs and calculate the travel speed.

### Longitudinal speed uniformity ($S_L$)

21. Establish a sample of segments, each 5m long, along the travel path
    - There should be at least one segment for each layer of delivery tube or cable on the winch reel.
22. Record the location of each segment as the distance of the gun-cart from the final end point of the strip
23. Calculate segment travel speed for each segment = segment length / time taken
24. Determine the mean travel speed along the travel path from the total time required to travel the strip length
    - Do not include any time operating stationary at either end.

## SYSTEM FLOW

### Total system flow

1. Record the water flow rate as measured by a fitted water meter with the system operating as normal
    - Wait until flow rates stabilise (up to 15 minutes) before taking readings
    - It may be necessary to take beginning and ending meter readings over a set time period to determine flow rate.

### Energy use

2. Obtain energy consumption data for the period covered by flow measurement
    - Enables calculation of irrigation energy costs.

## SYSTEM PRESSURE

### Headworks pressures

With system operating,

1. Measure pump discharge pressure
2. Measure mainline pressure after filters and control valves

Optionally measure:

3. Filter head loss
4. Pump control valve head loss
5. Throttled manual valve head loss

### Mainline pressures

6. Measure pressure at each hydrant
    - If hydrants are on a common mainline, measure pressures at each hydrant while the system is operating at furthest hydrant from the pump/filter.

NOTE: This is an optional test if problems identified or anticipated

### Machine pressures

7. Measure pressure at the inlet to the machine
8. Measure pressure at the inlet and outlet to the hydrodynamic drive

### Sprinkler pressure

9. Measure pressure at the inlet to the gun or sprinkler package.

## SPRINKLER PERFORMANCE

A wide variety of water distribution systems may be fitted to travelling irrigators. Three different types are recognised; guns, fixed booms and rotating booms.

### Guns

With machine stationary (system operating)

1. Determine the wetted radius of the water distribution system to the nearest 10cm for three radii: in line with, and at 90˚ angles left and right of, the direction of travel

### Fixed booms

With machine stationary (system operating)

2. Determine the wetted length of the water distribution system to the nearest 10cm
3. Measure the flows from 12 sprinklers chosen at random along the length of the boom.
   - Ensure sprinklers chosen are of the same specifications
   - Capture all flow without flooding the nozzle or affecting pressure
   - Shroud the sprinkler or sprayer with a loose pipe or hose and collect discharge in a container of at least 20 litres
   - Measure and record the time in seconds to fill the container. (Filling to the neck of a bottle or drum container will increase accuracy.

### Rotating booms

With machine stationary (system operating)

4. Determine the wetted radius of the water distribution system to the nearest 10cm for three radii: in line with, and at 90˚ angles left and right of, the direction of travel

NOTE: Because the contribution individual sprinklers make to distribution patterns cannot be distinguished, sprinkler measurements are not made.

## TRANSVERSE UNIFORMITY TEST

The transverse uniformity test is of primary importance as it establishes variation across the irrigated strip. Performance is dependent on sprinkler package design and installation, field topography and wind or other disturbances.

### Collector placement

1. Arrange three lines of collectors perpendicular to the delivery tube (hose) or tow cable (Figure 3.1)
   - For reel irrigation machines, establish each transverse line such that different numbers of layers of delivery tube are coiled on the reel
   - Ensure the distance between first and last lines is at least 50% of travel length (Lt)
   - Ensure the first line of collectors is positioned ahead of the irrigator, at a distance more than the wetting radius of the water distribution system so the machine is operating normally when the first water reaches the collectors
   - Ensure the last line is positioned at a distance more than the wetting radius of the water distribution system so water stops reaching the collectors before the machine becomes stationary.
2. There Is no set collector number for each line, this should be determined from the following principles.
   - Select collector spacing (sc) such that the half width of the irrigated strip is a multiple of the collector spacing. E.g. If E = 90m, E/2 = 45m. Select a collector spacing of 3.0, 4.5 or 5.0m
   - The maximum spacing between collectors should be 6m for guns and 3m for sprayers or sprinklers
   - The lines of collectors must extend to the full wetted radius of the water distribution system, allowing for any skewing as a result of wind effects
   - Do not place collectors in wheel tracks.
   - Ensure any collectors between wheels will not be knocked over by the machines frame
3. Measure and record the position of each collector relative to centre of the travel path

### Evaporation

4. Establish collection times to ensure evaporation losses are minimised.

If the test can be run overnight, a single collection early in the morning may acceptable. Otherwise collect each transverse line as the irrigator passes, resetting the control collector volume each time.

## OPTIONAL TESTS

Repeat tests may be run to determine distribution uniformity under different weather (wind) conditions, or with the travelling irrigator in a different field location or locations.

## 3.2 Data analysis

#### SYSTEM

**Irrigated area**

1. Calculate the area irrigated per set (run)
   - Set Area (ha) = Strip Width (m) x (Travel Path Length(m) + 0.75 Wetted Radius(m)) / 10,000
2. Calculate the total area irrigated
   - Total Area = Set Area x Number of Sets

#### PERFORMANCE INDICATORS

**Water supply**

1. Complete calculations of water supply including pumping system and mainline as specified in *Part B: Compliance and Water Supply Checklists*

**Mainline pressure**

2. Calculate the Mean Hydrant Pressure
   - Sum of all pressures / Number of pressure readings
3. Calculate Maximum Hydrant Pressure Variation
   - Highest Hydrant Pressure – Lowest Hydrant Pressure

**Fixed boom sprinkler discharge**

4. Calculate mean discharge from the 12 measured sprinklers as described in 3.1 Fixed booms.

#### APPLICATION DEPTHS

**Required adjustments**

To make valid assessments of travelling irrigator performance, the depths measured by collectors must be adjusted to account for evaporation losses and for the effect of overlaps from adjacent irrigation runs (strips).

**Evaporation adjustment**

1. Make adjustments for evaporation losses as set out in *Glossary and Calculations: Evaporation from collectors*

**Overlap accounting**

For water distribution systems intended to operate with areas of overlap, application depths must be adjusted to account for overlap effects.

2. Account for overlap as described in in *Glossary and Calculations: Overlapping systems*

**Total machine application depth**

3. Calculate Application Depth based on total machine flow, cycle duration and irrigated area
   - This assumes that each strip is overlapped from each side, so each strip receives the full volume of water applied during one travel run.

**Transverse line application depth**

4. Calculate the mean application depth within the wetted strip for each transverse line, after adjusting for evaporation and overlap
5. Calculate the minimum and maximum application depths after adjustments as above

**Wetted strip application depth**

6. Calculate mean application depths for the strip as the mean of the transverse line adjusted depths
7. Determine the overall minimum and maximum application depths.

#### DISTRIBUTION UNIFORMITY

A determination of field DU is a prime output from evaluations. Distribution uniformity from multiple transect tests is adjusted to account for other contributing factors including run-off and off-target application.

NOTE: Distribution uniformity is not an efficiency measurement so is reported as a decimal value.

**Uniformity coefficient**

The statistical uniformity coefficient based on Christiansen's Uniformity Co-efficient is an alternative measure that can be reported.

NOTE: The uniformity co-efficient is not an efficiency measurement so is reported as a decimal value.

#### SYSTEM UNIFORMITY

**Required adjustments**

Determination of global 'field uniformity' requires that adjustments are made to account for various factors, including pressure variation, overlap and unequal system drainage.

Adjustments are also required to account for evaporative losses from collectors while field data collection is undertaken.

**Field distribution uniformity, $FDU_{lq}$**

1. Estimate overall field distribution uniformity ($FDU_{lq}$) by combining contributing variable factors using the Clemmens-Solomon statistical procedure

Overall uniformity incorporates the grid distribution uniformity of the distribution system (gun or boom) assessed from overlapped multiple transect uniformity tests. It may be adjusted for run-off or off-target application.

$$FDU_{lq} = [1 - \sqrt{(1 - GDU_{lq})^2 + (1 - F_{ponding})^2}$$

Where:

$FDU_{lq}$ is low quarter field distribution uniformity

$GDU_{lq}$ is low quarter grid distribution uniformity

$F_{ponding}$ is surface redistribution from ponding

#### Grid distribution uniformity, $GDU_{lq}$

2. Calculate $GDU_{lq}$ from all adjusted depths from all transects

NOTE:
Create a virtual grid comprising all transect tests.

#### Off-target factor

3. Calculate an adjustment factor for off-target application and field runoff from estimates of the percentage of total take represented by these contributing factors

#### Flow distribution uniformity, $QDU_{lq}$ (fixed boom systems only)

4. Calculate low quarter flow distribution uniformity from measured sprinkler flows along the boom length using the low quarter uniformity formula Equation 30.

### APPLICATION INTENSITIES

The Instantaneous Application Intensities under traveller irrigation machines may be very high. High instantaneous application rates can lead to ponding and surface redistribution.

However with guns or rotating booms, any area is watered for only very short periods each rotation, so soil infiltration will often accept these rates. Under fixed booms the area is watered continuously and ponding may be more apparent.

#### Instantaneous application intensity

1. Calculate the Mean Application Intensity (mm/h) for each transect from Mean Adjusted Applied Depths, Travel Speed and the Wetting Area of the distribution system
   - The maximum application rate at central points will be greater than the average overall application intensity if the intensity reduces toward the edge of the wetted strip.

#### Wetting area of distribution system

Fixed boom
The wetting area of a fixed boom is mean sprinkler wetted diameter times effective width of the boom.

Rotating boom
The wetting area of a rotating boom is area of a circle based on effective wetting diameter of boom

Big Gun
The wetting area of a big gun can be estimated as half the area of a circle based on the effective wetted radius of the gun trajectory.

### MACHINE SPEED

#### Travel speed at transverse lines

1. Determine the travel speed at each transverse line

#### Speed of travelling irrigator

2. Calculate the speed at each segment (m/h).
3. Determine the mean speed by dividing the full strip length (m) by the time taken to water the strip (hours) excluding any stationary time at either end
4. Determine the mean, the maximum and minimum speeds

#### Longitudinal speed uniformity

5. Determine the maximum deviation in travel speed
6. Determine the coefficient of variation in travel speed

## 3.3 Adjust irrigation system settings

### APPLIED DEPTH

1. Compare Mean Set Applied Depths to Target Depth
   - Adjust set run time to achieve target applied depth

#### Adjusted machine speed

2. Calculate Adjusted Machine Speed
   - Adjusted Machine Speed (m/h) = Machine Test Speed (m/h) x (Target Depth / Distance Adjusted Applied Depth) ÷ $DU_{lq}$

   NOTE: Including $DU_{lq}$ ensures the Run Time applies sufficient water to adequately irrigate 7/8th plants

#### Distribution uniformity

3. Identify impact of variables contributing to non-uniformity
   - Repeat Operational Checks (Section 1)
   - Adjust system components to achieve best performance
   - Ensure system is at recommended operating pressure
   - Get professional assistance.