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New Zealand Piped Irrigation System Performance Assessment Code of Practice

PART E: Sprayline

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

Part E: Contents

Date of Issue: January 2023

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 E = 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.

Ministry for Primary Industries
Manatū Ahu Matua

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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 E is specific to sprayline 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 sprayline irrigation system irrigates a field by sequentially moving a static line of sprinklers to predetermined parallel locations across a field. Water is discharged under pressure from the sprinklers which are set at even intervals along a lateral pipeline.

Irrigated strips overlap at the edges to ensure even coverage. The evenness of application across the irrigated strip, and the evenness of application along the length of the sprayline, both contribute to overall irrigation distribution uniformity.

Sprayline systems make irrigation feasible where other techniques are not suitable. They can be used to irrigate irregularly shaped areas and some types are easily transported between fields. They are readily removed from the field to allow cultivation and other practices to be carried out unhindered.

Recognised categories include hand-move pipes, side-roll systems, and various towable spraylines. They may operate singly or as multiple units.

A. HAND-MOVE PIPES

Hand-move pipes are typically aluminium pipe lengths that clip together with quick couplings to fit field dimensions. A sprinkler is mounted on a riser at one end of each pipe section, so the sprinkler spacing is set.

Shifting is manual, with pipe sections separated, moved and re-joined at each position.

B. SIDE-ROLL SYSTEMS

Side-roll systems consist of sprinklers mounted on aluminium or steel pipeline sections. Each section acts as the spindle of a centrally fitted wheel. Repeating units are joined to form the sprayline to fit field dimensions. The sprinklers are mounted on rotating couplings to ensure horizontal alignment regardless of spindle position. Sprinklers are mounted at pipeline height.

Shifting is done by rolling the complete line sideways to the next position in the irrigation sequence.

C. TOWABLE SPRAYLINES

Towable spraylines consist of sprinklers fitted at set intervals on a polyethylene lateral. The sprayline length is generally set.

Shifting is done by towing the complete sprayline by one end to the next position in the field.

D. MULTIPLE SPRAYLINES

Multiple sprayline systems operate more than one sprayline concurrently from a series of hydrants. Application intensities may vary between individual spraylines, particularly if pressure varies significantly. This can be managed if control systems allow different irrigation event durations.

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 sprayline is measured for one set position, and measurements from outer edges mapped on to the corresponding measurements on the opposite side.

WIND EFFECTS

The performance of pressurised spray systems such as spraylines can be greatly affected by wind, particularly when nozzles are used on high angle settings or at high pressures that create smaller droplet sizes. Strong cross winds are likely to have greatest effects.

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 irrigation systems may vary at different positions in the field. Contributing factors include topographic variation and elevation changes, lateral pipe lengths, and variable distances from headworks to lateral pipe inlets.

Systems set out in varying topography are subject to pressure effects. In addition, systems that cover large areas may have pressure differences resulting from mainline and sub-main friction losses.

If field elevation varies significantly, consider increasing the number of tests to increase accuracy of distribution uniformity assessments. Record the (relative) elevations of each test site, and draw a profile sketch along a typical lateral if necessary.

OFF-TARGET APPLICATION

Spraylines may be operated with sprinklers set at either end of the strip to ensure at least the target application depth is applied to the whole crop. A variable percentage of water will be applied off target so application efficiency is reduced, more so on short runs.

ALTERNATE SETS

Spraylines 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 sprayline irrigation systems 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

Filtration

1. Check condition of filters and filter media
   - No leakage from seals or joints
   - Rings/screens are clean with no holes
   - Pressure gauges are fitted and in good condition.

Fertigation/chemigation

2. Ensure the system is physically sound
   - No signs of corrosion
   - System clean, no blockages
   - No leaks
   - Backflow prevention is installed as required

Control valves and offtakes

3. Ensure wiring and hydraulic lines are secure
4. Ensure manual valves are correctly set
5. Ensure hydrants are secure

Flushing points

6. Check flushing points are accessible
7. Ensure caps are in place

Pipe network

8. Visually inspect sub-mains/headers as possible
9. Visually inspect laterals are undamaged

Laterals

10. Visually check laterals undamaged
11. Check tapping saddles/connections secure
12. Inspect risers for wear or damage

Sprinklers

13. Check sprinklers fitted are as specified in sprinkler chart
14. Inspect for damage or blockage, and moving parts are free
15. Ensure alignment is correct

Control unit

16. Visually inspect electronic controls
17. Check battery charge.

SYSTEM ON CHECKS

Pump

1. Complete checks as specified in *Part B: Water Supply Performance Assessment*

Headworks

2. Complete checks as specified in *Part B: Water Supply Performance Assessment*
3. Check the flow rate of each station

Pipe network

4. Check for leaks along mainline
5. Check for leaks along sub-mains
6. Check for leaks along laterals
7. Check laterals flush clear

System pressure

8. Check pump pressure for each station
9. Check pressure before and after filters
10. Check all off-take pressures correct
11. Check the lateral end-pressure

Offtakes and control points

12. Check hydrants are not leaking

Sprinklers

13. Visually assess application pattern
14. Ensure moving sprinkler parts free.

2. Calibrating sprayline irrigation systems

The Irrigation Calibration method for sprayline irrigation systems assesses the amount of water being applied during an irrigation event. It is based on measurement of water collected in two transects of containers set across the sprayline.

Applied Depth, Application Intensity and Distribution Uniformity are calculated. This allows the manager to determine the maximum depth that can be applied without causing drainage, the time required to apply the target depth, and whether the system is applying the same amount of water across the irrigation area.

By repeating the process at other sprayline positions and in other irrigation stations, 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:

Mean station applied depth
The rainfall equivalent depth of water the irrigation system is applying on average to each station. Compare the measured applied depth to target application to calibrate each station. Adjust station run times to correct applied depths.

Soil applied depth
The rainfall equivalent depth of water being applied to the area actually wetted by the irrigation system.

Application intensity
The rainfall equivalent depth of water being applied per hour. 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 station run time
Calculates the irrigation duration to ensure 7/8ths of each sprayline position or irrigation station gets at least the Target Application Depth. It accounts for variations in outlet spacing, flow rate and uniformity.

WHEN SHOULD CALIBRATION BE DONE?
Complete the calibration test if commissioning any new areas and after any major changes. Calibration should be repeated as part of system checks at the start of every season.

NOTE:
Sprayline irrigation system 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 station locations
- 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

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

- 24 containers of same opening diameter (>150mm)
  – 9 Litre buckets have been found suitable
- 1 measuring cylinder
  – 1 or 2 Litre for larger volumes (large containers, long run times)
  – 100mL or 200mL for smaller volumes (small containers, short run times)
- 1 tape measure (50m)
- 1 stop watch
- 1 pen or pencil
- 1 recording sheet.

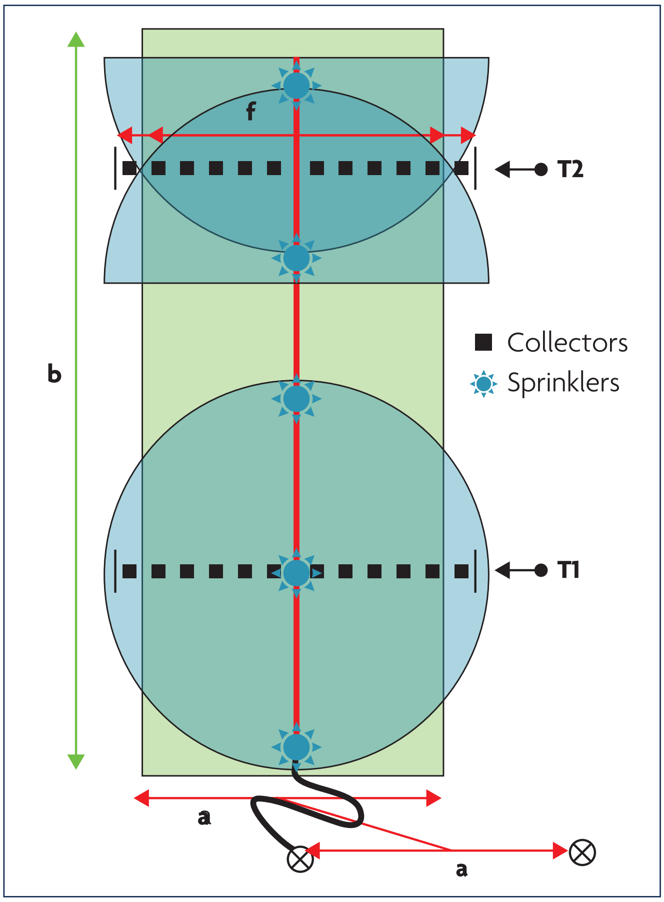

Figure 2.1. Sprayline calibration layout

Sampling method

The calibration check is based on two lines of collectors (transects) placed across representative spraylines. This assesses whether the same depth is applied at the start and end of the sprayline. The calculations give an average value for the whole sprayline based on both transects.

Dealing with overlap

Sprayline irrigation typically has overlap from adjacent sets. 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 is the combined effect of overlapped sets.

Figure 2.2 shows how the two rows of collector buckets are laid out relative to the sprayline wetted strip. This enables the overlap of adjacent spraylines to be included in calibrations.

Testing layout

1. Place a marker half way between two adjacent operating positions or “Sets”
2. Repeat on the other side of the set. The two markers define the Irrigated Strip or Lane (see “a” in Figure 2.1)
3. Mark the extent of obvious wetting when the irrigation runs. This is the “Wetted Width” (f in Figure 2.1)

   NOTE: If the wetted width is greater than the lane width, account for overlap.
4. Place one bucket half way between the edge of the lane and the edge of the wetted width [L6 in Figure 2.2]
5. Mirror this inside the edge of the lane, placing another bucket at the same spacing from the edge of the lane [L5 in Figure 2.2]
6. Arrange four more buckets at even spacing to cover the area back to the centre line (the lateral pipe) [L4–L1 in Figure 2.2]. The spacing may be different to the overlap buckets
7. Repeat Steps 4, 5 & 6 on the right hand side (R1–R6 in Figure 2.2)
8. Then repeat Steps 4 to 7 at position T2 (L7–12 and R7–12 in Figure 2.2).

NOTE:
If the system has no overlap between lanes, leave out buckets L6, L12, R6 and R12. Spread ten buckets at each transect and don’t do overlap calculations.

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

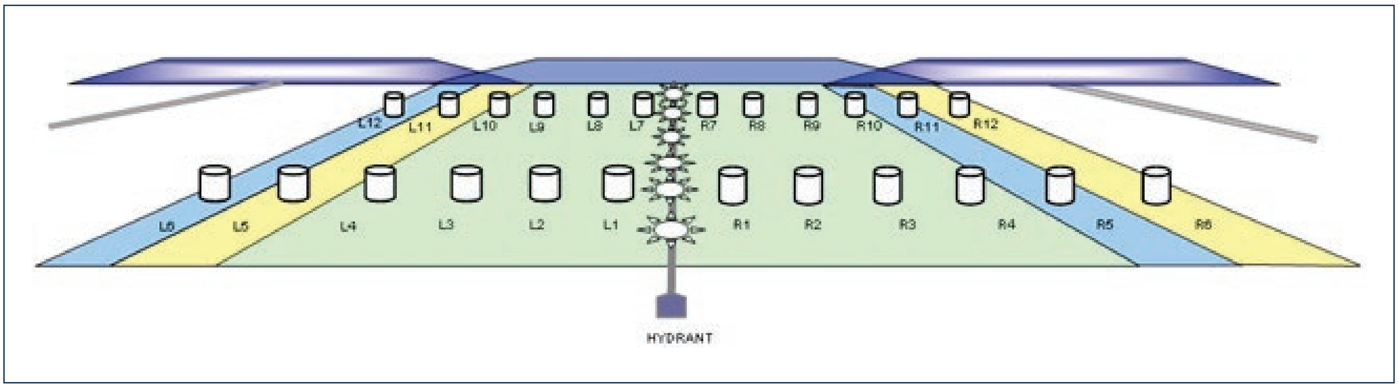

Figure 2.2. Sprayline wetted strip, overlap and collector placement

FIELD MEASUREMENTS

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

Management information

1. Record the Target Irrigation Depth
2. Record the Normal Irrigation Event Duration

System measurements

3. Measure the Outlet Pressure at the pump
4. Measure the Pressure at the Entry to the sprayline
5. Measure the system Flow Rate

Sprinkler measurements

6. Measure the distance between sprinklers along a lateral

   NOTE: It is often best to use an average distance between a number of sprinklers.

7. Measure the distance between adjacent sets (sprayline positions)

   NOTE: Take an average spacing between several laterals.

8. Record the number of sets
9. Determine the area for each Block
   [Lateral length x lateral spacing x lateral number]

Application test

10. Run the system and record the duration

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

11. Measure the collector bucket mouth diameter
12. 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

Complete overlap adjustments

1. Add the volume collected in collector L6 to the volume of R5
2. Add the volume collected in collector R6 to the volume of L5
3. Add the volume collected in collector L12 to the volume of R11
4. Add the volume collected in collector R12 to the volume of L11

   NOTE: Remaining calculations use the twenty overlapped volumes in the two transects.

Applied depth

5. Calculate Applied Depth
   - 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)^2 ÷ 4.

Application intensity

6. Calculate Application Intensity
   - Application Intensity (mm/h)
     = Applied Depth (mm) ÷ Test Duration (h).
7. Calculate Block Flow Rate (m^3/h)
   - Block Flow Rate = Application intensity (mm/h) x Block Area (ha) x 10.

Distribution uniformity

8. Calculate the Distribution Uniformity (DU_{lq})
   - DU_{lq} = Low quarter average volume
     ÷ average volume
   - Low Quarter Average Volume (mL) = Average of lowest 5 collected volumes.

Excess water use EWF

9. Calculate Excess Water Use Factor (EWF)
   - EWF (%) = 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 Estimated soil infiltration rate
5. Compare with observations of ponding

Distribution uniformity DU

6. 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.

Run time

2. Calculate Adjusted Run Time
   - Adjusted Run Time (h)
= Target Depth ÷ DU ÷ Application Intensity

   NOTE: Including DU ensures the Run Time applies sufficient water to adequately irrigate 7/8th of the field.

3. Performance assessment of sprayline irrigation systems

This schedule presents procedures for conducting efficient and reliable irrigation evaluations of sprayline 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 assessment.

TECHNICAL MATERIALS – RELEVANT STANDARDS

Spray Irrigation Performance

ISO 7749-2: 1990 Agricultural irrigation equipment – Rotating sprinklers – Part 2: Uniformity of distribution and test methods

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

ISO 8026:1995/Amd.1:2000 Agricultural irrigation equipment – Sprayers – General requirements and test methods AMENDMENT 1

Overlap Accounting

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

ISO 8224/1 – 1985 Traveller irrigation machines – Part 1: Laboratory and field test methods

3.1 Data collection

This schedule outlines procedures to be followed when assessing performance of sprayline 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.

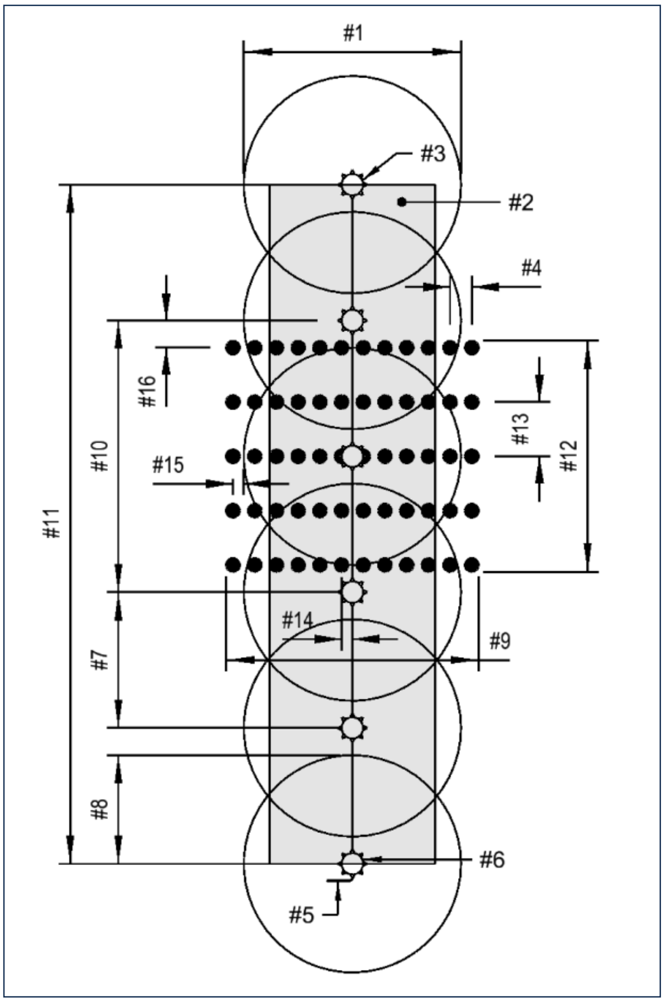

Figure 3.1. Field collector layout for sprayline systems

1. Irrigation strip width, lane width, E
2. Irrigation strip accounting for overlap
3. Sprayline: final sprinkler
4. Collector spacing along the row, s_{cr}
5. Hydrant or end of mainline
6. Sprayline: initial sprinkler
7. Sprinkler spacing D_s
8. Sprinkler wetted radius, r_w
9. Extent of collector columns (columns run parallel to the delivery hose)
10. Transverse line layout zone (= 2 D_s)
11. Length of strip, sprayline length, Lt
12. Extent of collector rows (rows transect the delivery hose)
13. Collector spacing down the column, s_{cc}
14. Distance of the first collector off the delivery half (half row spacing)
15. Distance of the last collector outside the wetted radius (half row spacing)
16. Distance of the first collector in from the end sprinkler (half column spacing).

SYSTEM SURVEY

System layout

1. Prepare a map of the system recording the headworks, mainline, take-off points, sub-mains, manifolds and laterals
2. Mark location of pressure regulators, flush valves and positions where tests are to be conducted (see example Figure 3.1)

Topography

3. Determine elevation differences between test sites and across the station as a whole.
   - Prepare a sketch of the profile along a typical lateral

Irrigation strip

4. Measure the irrigation strip length and width as defined in Figure 3.1
5. Record the number of strips (lanes) per set (operating at once)
6. Record the number of shifts (lanes) per hydrant

Off-target application (F_{TARGET})

7. Estimate the proportion of discharge that falls outside the target area (off the ends of the sprayline or sides of the field as a whole).

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
   - The number of spraylines and sprinklers operating should remain constant during the test.

Test duration

3. Record the normal operation irrigation set time
4. Record the test duration time
   - Apply sufficient volume 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, following the procedures outlined in the *Technical Glossary.*

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

Off-target application (F_{TARGET})

13. Estimate the proportion of discharge that falls outside the target area (off the edges of the field as a whole)

Runoff

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

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
5. Check for presence of contaminants in lines: sand, bacteria/algae, precipitates etc

Sprayline leaks

6. Check for damage to spraylines or misfit connections
7. Assess scale of leakages if any

Sprinklers

8. Record the nozzle type and orifice(s) fitted
   - Verify that the sprinkler package matches the design specifications.
9. Measure sprinkler spacing along the sprayline
10. Measure sprinkler height above canopy
11. Check sprinklers are operating and set correctly (to horizontal)
12. Randomly select at least 12 sprinklers or sprayers along the length of the machine
    - Inspect them for blockages and record the cause of any blockages found
    - Assess orifice wear with a gauge tool or drill bit.

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

For multiple block solid-set and long lateral systems:

6. Measure Pressure at each hydrant

Sprayline pressure

7. Measure sprinkler pressures:
   - At first available pressure test point or sprinkler downstream of the hydrant
   - At a sprinkler in the middle of the sprayline
   - At the last sprinkler or end of the sprayline.

NOTE:
If pressure is read at a sprinkler, use a pressure gauge with a pitot attachment.

NOTE:
Sprayline pressures cannot be inferred from readings at the sprinkler if pressure regulators are installed.

SPRINKLER PERFORMANCE

Wetted radius

1. Determine the wetted width of the sprayline (sprinkler wetted radius) to the nearest 10cm in at least three locations

Sprinkler pressure / flow

2. Measure the pressures and flows from at least four adjacent sprinklers near the middle of a single lateral
   - Avoid the inlet end if possible as pressure variation will typically be high
   - Ensure sprinklers chosen are of the same specification
   - Capture all flow without flooding the nozzle or affecting pressure
   - Shroud the sprinkler or sprayer with a loose hose and collect discharge for at least 30 seconds or 20 litres
   - Measure and record the volume collected (mL)and time (sec).

Adjusted pressure:flow test

The effect of pressure change on sprinkler discharge is determined using the discharge coefficient. If a manufacturer's value is unavailable, or is queried, the discharge coefficient can be determined from measurements of the same emitters at different operating pressures.

3. Repeat the sprinkler pressure:flow measurements after adjusting the lateral pressure by about 20%

NOTE: After this test, reset the system to its normal operating conditions.

Grid uniformity test

4. Arrange a grid of collectors between three correctly functioning adjacent sprinklers along a representative part of the sprayline (Refer to Figure 3.2)
   - The grid should be 60 collectors. 12 columns and 5 rows (columns are parallel to the delivery hose)
   - Ensure the first and last collectors in the columns are positioned one half spacing from the first and last test sprinklers respectively
   - The first collector in each row must be half a row spacing off the delivery line
   - The last collector In each row must extend to a half row spacing outside the wetted radius of the water distribution system, allowing for any skewing as a result of wind effects. (The grid must extend beyond the sprinkler wetted radius on both sides of the sprayline).

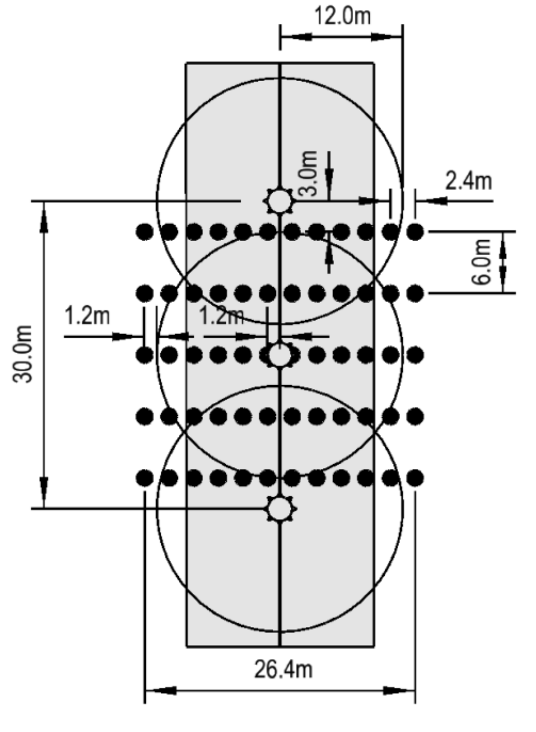

Figure 3.2. Bucket spacing example for a pod system with 15m sprinkler spacings and a 12m throw radius.

5. Measure and record the position of each collector relative to the sprayline
   - Row spacing: 30m/5 = 6m spacing (first row to be a half spacing from the sprinkler (3m)
   - Column spacing: 12m/5 = 2.4m between buckets. The first collector Is a half spacing off the delivery hose (1.2m) and the last collector is 1.2m outside the wetted radius.

Operation

6. Record the test duration time
   - Collect sufficient volume for reliable measurements to be obtained.

NOTE:
The test could run for a complete irrigation set. However, in the interests of time efficiency, a shorter duration may be agreed in consultation with the system owner.

NOTE:
To avoid unequal collection times, shut the system off before reading collectors.

OPTIONAL TESTS

Additional tests

1. Repeat tests as required to determine distribution uniformity under different weather (wind) conditions, or with the sprayline or other spraylines in different field location or fields

NOTE:
On highly variable terrain, a sprinkler pressure:flow test should be considered to establish performance variability across the entire system.

Pressure derived flows

2. Calculate pressure derived flows for each of the pressure measurements taken along the sprayline (see Sprayline Pressure)
   - Use the pressure:flow relationship.

NOTE:
If the emitter discharge exponent and coefficient are not available from manufacturers' data they can be determined as earlier described.

For most sprinklers, the discharge exponent (x) is approximately 0.5.

3.2 Data analysis

SYSTEM

Irrigated area

1. Calculate the irrigated area of the test sprayline
   - Sprayline Area = Sprayline Length x Strip Width
2. Calculate the area irrigated per set
   - Set Area = Sprayline Area x Number of Strips per set
3. Calculate the total area irrigated
   - Total Area = Set Area x Number of Shifts.

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*

Sprayline pressure

2. Calculate the Mean Field Pressure
   - Sum of all pressures / Number of pressure readings
3. Calculate Maximum Hydrant Pressure Variation
   - Highest Hydrant Pressure – Lowest Hydrant Pressure
4. Calculate Maximum Sprayline Pressure Loss
   - Greatest difference between highest and lowest pressure on individual spraylines
5. Calculate the maximum pressure variation among all readings
   - Highest reading – Lowest reading

Pressure derived flows

6. Calculate pressure derived flows
   - For each of the pressure measurements taken across the field using the emitter pressure flow relationship.

NOTE: If the discharge exponent and coefficient are not available from manufacturers' data they must be determined from pressure flow data collected in the field.

Pressure distribution uniformity (PDU_{lq})

NOTE: The pressure distribution uniformity coefficient describes a theoretical uniformity determined from pressure variation across the field, and the pressure:discharge performance characteristics of the emitters.

7. Calculate Pressure Distribution Uniformity (PDU_{lq})
   - Calculated from pressure derived flows, using the low quarter uniformity formula Equation 31.

NOTE:
If used in determining Field DU, PDU_{lq} replaces sprinkler flow uniformity, QDU_{lq}.

Application depth

NOTE:
To make valid assessments of sprayline performance, the depths measured by collectors must be adjusted to account for evaporation losses and for the effect of overlaps from adjacent irrigation sets (strips). This *adjusted application depth* can be compared to a total system application depth.

8. Calculate Adjusted Applied Depth
   - 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))^2 ÷ 4.
9. Calculate Equivalent Applied Depth
   - Equivalent Applied Depth (mm) = Adjusted Applied Depth x Set Duration / Test Duration
10. Compare Equivalent Applied Depth to Target Application Depth
    - Report as percentage.
11. Compare Equivalent Applied Depth to soil water holding capacity.

NOTE:
This provides an indication of possible deep percolation, with subsequent impacts on irrigation efficiency, or potential moisture deficit with resultant reduced crop yield.

Total system application depth

12. Calculate application depth based on total system flow, cycle duration and irrigated area

NOTE: This assumes that each strip is overlapped from each side, so each strip receives the full volume of water applied during one irrigation set.

Application intensity

13. Calculate Mean Application Intensity
    - Application Intensity (mm/h) = Adjusted Applied Depth (mm) ÷ Test Duration (h).
14. Compare Mean Application Intensity to Soil Infiltration Rate
    - Report as a percentage
    - Application Intensity should be than Soil Infiltration Rate
    - Compare with observations of surface ponding.
15. Calculate Set Flow Rate (m^3/h)
    - Set Flow Rate = Application intensity (mm/h) x Set Area (ha) x 10.

Field distribution uniformity, FDU_{lq}

16. Estimate overall field distribution uniformity (FDU_{lq})
    - Combine contributing variable factors using the Clemmens-Solomon statistical procedure.

NOTE: Overall uniformity incorporates the distribution pattern of the overlapped sprinklers, and the flow variation from individual sprinklers. It may be adjusted for unequal drainage after system shut-down.

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

Where:

FDU_{lq}	is low quarter field distribution uniformity
GDU_{lq}	is low quarter grid distribution uniformity
QDU_{lq}	is low quarter flow distribution uniformity
$F_{ponding}$	is surface redistribution from ponding
$F_{drainage}$	is uneven drainage factor

Required adjustments

The flow measurements used to assess uniformity are a non-random sample, and cover only part of an irrigation event. Determination of global 'field uniformity' requires that adjustments are made to account for various factors, including pressure variation, flow variation and overlap.

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

Grid distribution uniformity, GDU_{lq}

17. Calculate low quarter grid distribution uniformity, GDU_{lq}
    - First adjust application depths for evaporation and overlap, as described in the Technical Glossary.
18. Calculate GDU_{lq}.

Flow distribution uniformity, QDU_{lq}

19. Calculate low quarter flow distribution uniformity
    - From measured sprinkler flows along the sprayline length using the low quarter uniformity formula.

NOTE: This may be replaced by the Pressure Distribution Uniformity.

Uniformity from alternate sets

20. Calculate a potential distribution uniformity assuming successive irrigation stagger set positions
    - Determine alternate set uniformity by overlaying left side collector data on the right side data.

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 run time

2. Calculate Adjusted Run Time for each set
    - Adjusted Run Time (h) = Target Depth (mm) ÷ EU ÷ Application Intensity (mm/h)

NOTE: Including EU 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.