IRRIG8Quick

Irrigation Energy Quick Test

Delivery System Efficiency Guidelines

PAGEBLOOMER

What is the Irrigation Quick Test about?

The purpose of this Irrigation Quick Test is to determine the energy efficiency of the headworks and pipelines feeding the irrigation system. See also the guidelines for assessing the efficiency of the pumping system.

IRRIG8Quick is designed so irrigation managers can do testing and calculations themselves. As well as this guideline, a worksheet is available to assist. If findings are unexpected, or suggest low performance, consider getting professional advice.

Why check delivery system performance?

Profitability – Incorrectly sized or physically deteriorated components can waste energy and money. A good system saves money!

Sustainability – energy efficient irrigation minimises energy use and carbon emissions. A good system saves the environment!

Pipe and component selection are important system design considerations. Selecting smaller options may reduce up front capital cost, but increases ongoing energy costs as bigger pumps are required. The correct selections optimise the necessary trade-offs.

A separate IRRIG8Quick Guideline deals with pumping system efficiency. The two guides should be used together.

What is involved?

The IRRIG8Quick Delivery System Efficiency Test is based on measurements collected on farm. Key information is pressure, elevation and flow rate so you need some way of accurately determining these at critical system points.

Combining flow, pressure and elevation allows calculation of the energy losses from friction as water flows through the system, operating under the conditions when tested.

Significant changes to flow rate will change the outcomes. If you use different irrigators, combinations of irrigators or have permanent irrigation systems with blocks of significantly different sizes, the process should be repeated for each different combination.

What needs to be done?

1. Gather information about the system
2. Record the data on the worksheet
3. Work out answers using the worksheet calculations
4. Compare your results with target values

When should testing be done?

Complete the efficiency test when commissioning a new system and after any major changes to the pumping or irrigation systems. It should also be repeated as part of annual maintenance.

Make sure the system operation is 'typical' when you test, so your results are meaningful.

What will the testing show?

The Quick Test will show water velocities in and energy losses from the irrigation system. These are described using 'performance indicators' which apply regardless of system type:

Headworks Efficiency – How much of the energy consumed (and paid for) is lost at the headworks

Hydraulic (Mainline) Velocity and Efficiency – How fast water is moving along the pipeline and the amount of friction loss

Suction Line Lift and Velocity – the maximum suction and speed in the intake pipeline; important for safe pump operation

Annual Energy Cost and Savings – How much energy and money would be saved if the delivery system was operating at typical performance levels

What are the Quick Test's limitations?

The Quick Irrigation Delivery System Efficiency Test will only provide information for the conditions measured. The energy use and efficiency will change if system flow changes.

The more accurate your input values, the more accurate your results. Take care reading pressure and determining elevation changes. Use good equipment in good order.

If you don't already have pressure and suction gauges in place, it may take a little setting up the first time you do this testing. Next time, your equipment will already be in place.

The efficiency value determined is based on guidelines in the Irrigation New Zealand Code of Practice for Irrigation Design.

Get professional help if testing shows unexpected results.

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What is it and what's acceptable?

Headworks Efficiency

Headworks efficiency is a measure of the hydraulic performance of the intake structure, pump and headworks (excluding pump pressure and elevation differences). It considers pressure loss in the system between the water take point and the mainline entry.

Headworks efficiency can be determined from pressure readings and knowledge of elevation changes. We need consistent measurement units; in this guideline pressures are measured in kPa. Elevations are converted from metres to kPa.

Guideline *– basic headworks including water meter, clean filters and gate valves, but excluding pressure control valves*

- Maximum friction headloss < 30 kPa

Unclean filters may cause extra 10–50+ kPa headloss

Query the use of headworks pressure regulators. They are designed to burn off excess pressure. Unless you have changing conditions and need to protect your system, regulators are probably wasteful.

Intake side / Suction Line

A suction pressure gauge fitted at the pump inlet is needed to accurately determine intake side losses.

The maximum lift, *including elevation gain and friction losses*, must not exceed the practical limits for pumps. High water velocities or high pressure losses through suction lines can create major problems including cavitation and complete failure of centrifugal pumps.

Guideline

- Maximum intake suction < 60 kPa
- Maximum suction velocity < 1.5 m/s
  (where pipe sizes are not determined by pressure variation or velocity requirements)

No suction gauge on pump inlet?

With no inlet suction gauge, you can only calculate the headworks efficiency from the pump outlet. (When you complete the IRRIG8Quick Pump Efficiency test, the intake efficiency will be included as part of the overall pumping plant efficiency calculated.)

Elevation change

Increasing elevation unavoidably requires energy. In determining system efficiency, elevation effects are discounted so the pipe work and other system components can be assessed fairly. The intake elevation is the surface level of the water supply, not the position of the actual intake itself which must be under water.

In this Guideline, elevations in metres are converted to kilopascals (kPa) using specific gravity (SG). The standard factor is SG = 9.8, but if your measurements are less than 95% accurate, you could just multiply metres by 10 to get kilopascals.

Hydraulic (Mainline) Efficiency

Hydraulic efficiency refers to the proportion of energy lost carrying water from the headworks to the entry to the 'irrigator' itself. The 'irrigator' might be a traveller, a pivot or a block of micro-irrigation. Hydraulic efficiency is an assessment of mainline performance. It can be determined from pressure readings and knowledge of elevation changes.

Guideline

- Mainline friction loss < 100 kPa
  (unless there is need to burn off pressure, such as in gravity supplied systems).

- Mainline friction loss 4 - 12 kPa/100m pipe

Higher speeds cause higher friction losses and increase the risk of damage through surges and water hammer. In high sediment conditions, minimum velocities may be needed to avoid blockages.

Large diameter pipes subject to uncontrolled starting and stopping are particularly sensitive. The INZ Code of Practice for Irrigation Design recommends maximum water velocities:

Guideline

Condition / location	Max Velocity
< 150 mm diameter pipe	
• open end, controlled start & stop	< 3.0 m/s
• uncontrolled start and stop	< 1.5 m/s
>150 mm diameter pipe	
• open ended, controlled start & stop	< 2.0 m/s
• uncontrolled start and stop	< 1.0 m/s

Why does efficiency change?

There are two basic reasons why a system is inefficient:

1) it has physically deteriorated, and/or

2) it is not suitable for the required operating conditions (i.e. required flow).

If the losses are higher than expected, assess the cost of efficiency improvement. In some cases, relatively minor changes can give considerable on-going energy savings.

What is excess energy loss costing?

The opportunity cost of inefficiency is calculated from energy cost, energy consumption and the relative efficiency of your system compared to guideline values.

This test does not account for extra capital investment that may be required to reduce losses by using larger pipelines and components.

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Determining Performance

The efficiency of your delivery system can be estimated from flow rates, pressures and elevation changes. The information should be easy to obtain, and calculations needed are set out below.

What equipment will you need?

- This guide and the worksheet
- Pressure gauge
- Vacuum (suction) gauge
- Tape measure
- Pen or pencil

Field measurements

- Water meter readings
- Elevation (height) at water level, pump, mainline entry and mainline exit
- Pressure readings at pump inlet and outlet
- Pressure readings at mainline entry and exit

Table A: Headworks Efficiency

The basic question is, "How much of the pressure created is remaining after water passes through the headworks?"

Pressure in the system is the result of pump input and pipeline friction losses, and changes in elevation. Elevation effects are discounted to focus on the efficiency of pipes and components.

Follow the steps in Table A of the Worksheet to calculate the efficiency of your system.

Notes:

Elevation accuracy is important! Work to the nearest tenth of a metre. Remember: 0.1 m is about 1 kPa

You can use actual elevations above sea level, or just call the water level 100.0m and determine all other elevations relative to that.

Intake elevation is the surface level of the water supply, not the position of the actual intake itself which must be under water. The level may drop in a well when the system is running.

Pump inlet elevation is determined relative to the water level at the intake. It will be positive from a bore, but may be negative from a higher dam.

Elevation change will be usually positive from a bore or river but may be negative from a dam. Multiply metres head by specific gravity to get elevation and pressure both in kilopascals (kPa).

Intake pressure is 0 kPa unless there is a pre-pump or community pipe providing pressure.

Change in head combines the effects of elevation and friction and is measured by the difference in pressure on the inlet vacuum gauge and the intake pressure.

Friction loss is the difference between the change in head and the elevation change. It changes with intake screen size and type and pipe diameter.

Mainline entry is the point where the headworks stop. It will be after control valves, filters, meters and injection points etc.

Total friction headloss combines values from both the inlet and outlet sides of the pump.

Headworks Efficiency is a measure of the amount of energy consumed that is converted to useful work.

Table B: Hydraulic (Mainline) Efficiency

Hydraulic efficiency asks the same questions about the mainline. It considers friction losses and is calculated from the change in total head and elevation differences between the entry to, and exit from, the mainline.

Follow the steps in Table B of the Worksheet to calculate mainline efficiency.

Notes:

Elevation accuracy is important! As with the headworks measurements, work as accurately as you can, to the nearest 0.1 m if possible.

Mainline entry pressure and elevation are the same as those for the Headworks exit.

Mainline length is recorded in metres.

Friction losses are often considered in 100 m lengths of mainline. The calculations have a factor built in to convert headloss per metre to headloss per 100 m.

Excess mainline friction is the difference between the maximum 100 kPa for a mainline and the value you calculate for your system.

Excess friction loss/100 m compares the maximum reasonable loss of 12 kPa/100 m with the value you calculate for your system.

Energy Costs

The excess friction loss (if any) from headworks and from the mainline is combined with the cost of pumping (creating the total energy) determined from the IRRIG8Quick Pump Efficiency Test.

Table C: Pipe velocities

Excess velocity in pipes causes excess friction, and increases the risk of pipe damage from water hammer and other shock loads.

The internal pipe diameter must be known, and is not the 'nominal diameter' of the pipe in most cases. Either measure a sample or check with your supplier to ensure you have the right value. Small diameter errors cause big velocity errors.

Pipe section area calculations convert diameters in mm to cross sectional areas in square metres.

Excess velocities are the difference between the recommended maximum values and your results. Positive answers mean excess velocity.

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Example Worksheet for IRRIG8Quick Delivery System Efficiency Test

Enter elevations, pressures and other data and complete the Calculations as directed
Enter information using the measurement units (e.g. kilopascals or metres) specified
to ensure calculated answers have the correct units.
Compare your results with standard recommendations

Table A: Headworks Inlet Efficiency

Inlet-side Efficiency

a	Water surface elevation when operating – include drawdown (m)	*0.0*
b	Pump inlet elevation (m)	*4.0*
c	Change in elevation head (kPa) *[(b – a) x SG]*	*39*
d	Water intake pressure (kPa)	*0*
e	Pump inlet pressure (kPa)	*-55*
f	Change in pressure head (kPa) *[d – e]*	*55*
g	Friction headloss (kPa) *[f – c]*	*16*

Outlet-side Efficiency

h	Pump outlet elevation (m)	*4.0*
j	Mainline entry elevation (m)	*4.0*
k	Change head (kPa) *[(h – g) x SG]*	*0*
m	Pump outlet pressure (kPa)	*450*
n	Pressure at mainline entry (kPa)	*425*
p	Change in pressure head (kPa) *[m – n]*	*25*
q	Friction headloss (kPa) *[p – k]*	*25*

Total Headworks Efficiency

r	Total friction headloss (kPa) *[g + q]*	*41*
s	Total pressure head (kPa) *[f + p]*	*80*
t	Headworks Efficiency *[(s – r) / s] x 100*	*49*

Excess Energy Cost

u	Excess headworks friction loss (kPa) *[r – 30]*	*11*
w	Excess system friction ratio *[u / s]*	*0.1345*
y	Annual Energy Cost ($ pa) From Pump Efficiency Quick Test	*9,846*
z	Annual energy loss cost $ pa *[w x y]*	*1324.3*

Table B: Mainline Efficiency

a	Mainline entry elevation (m)	*4.0*
b	Mainline exit elevation (m)	*7.0*
c	Change in elevation head (kPa) *[(b – a) x SG]*	*29*
d	Mainline entry pressure (kPa)	*425*
e	Mainline exit pressure (kPa)	*300*
f	Change in head (kPa) *[d – e]*	*125*
g	Friction headloss (kPa) *[f – c]*	*96*
h	Excess mainline friction (kPa) *[100 - g]*	*4*
j	Mainline length (m)	*860*
k	Friction loss (kPa/100m) *[g / j x 100]*	*11*
m	Excess mainline friction (kPa/100m) *[12 - k]*	*1*

Excess Energy Cost

n	Excess mainline friction loss (kPa) *[greater of h or m]*	*4*
p	Excess system friction ratio *[n / f]*	*0.032*
q	Annual Energy Cost ($ pa) From Pump Efficiency Test	*9,846*
r	Annual energy loss cost $ pa *[p x q]*	*315.07*

Table C: Pipe Velocities

a	System flow rate (m^3/hr)	*192*
b	Intake pipe internal diameter (mm)	*200*
c	Intake pipe section area (m2) *[3.14 x (b / 2000) ^{2}]*	*0.0314*
d	Intake pipe velocity (m/s) *[(a / 3600) / c]*	*1.7*
e	Excess intake velocity (m/s)	*0.2*
f	Mainline internal diameter (mm)	*200*
g	Mainline section area (m2) [3.14 x (f / 2000) ^{2}]	*0.0314*
h	Mainline velocity (m/s) *[(a / 3600) / g]*	*1.7*
j	Standard velocity max for conditions (m/s)	*2.0*
k	Relative velocity (m/s) *[h - j]*	*-0.3*

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