New Zealand Guideline for the Safe Management of Irrigation Systems with Effluent, Fertiliser and/or Agrichemical Injection

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This document is intended for designers and installers of Irrigation Systems with Effluent, Fertiliser and/or Agrichemical Injection. This may include engineers, equipment suppliers, and specialist irrigation designers.

The design, installation and testing processes described in this guideline are intended to be applied to agricultural irrigation systems. They do not amend or replace other industry performance indicators, guidelines, codes of practice or standards.

This document is intended as an industry best practice guideline. Designers and installers should interpret it according to the requirements of individual properties and owners. All decisions made must also comply with statutes, regulations, and other legal requirements and industry standards.

Introduction

This guideline covers safe management practices and more specifically the recommended safety devices and systems to be used when injecting effluent, fertilisers, herbicides, pesticides and other agrichemicals (referred to as 'agrichemicals' from now on) into irrigation systems. It has been adapted from ASABE 409.1 MAR 1989 R2009.

This guideline is not intended to replace backflow protection device recommendations for irrigation systems connected to a sanitary system in New Zealand. AS/NZS 2845 (2010) is the applicable standard for these scenarios. For irrigation systems where the water source is also used for rural drinking water the New Zealand Drinking Water standards may apply and impose conditions relating to hazards management.

It is common for irrigators to apply agrichemicals through their irrigation systems in New Zealand. This is commonly known as chemigation or fertigation (referred to as 'chemigation' from now on). If correctly diluted (in accordance with the manufacturers mixing instructions) agrichemicals can be very effectively, efficiently and safely applied by injecting them into water flowing through a properly engineered irrigation and injection system.

For chemigation there is a degree of risk, dependent on both the nature of injected agrichemical and the system management practices, that the pollution of the receiving environment or importantly the water supply can occur. Under most situations, appropriate system management practices and an appropriate backflow prevention system installed and maintained on the agrichemical injection and irrigation equipment can help reduce the risk.

The two specific hazards to be guarded against are –

1. Agrichemical being drawn into the water supply
2. Water flow through the injection dilution tank and overflow of diluted agrichemical onto the ground

The typical causes of the specific hazard occurring are, but not limited to –

1. an unexpected shutdown of the irrigation pumping plant due to mechanical or electrical failure while there is still an open path to the water source
2. a controlled irrigation pumping plant shutdown while the injection equipment fails to shutdown, with an open path to the water source
3. the injection system stopping while the irrigation pump continues to operate with an open path to the agrichemical mixing tank
4. an inappropriate specified backflow prevention device
5. the failure of a backflow prevention device between the agrichemical and the water source

It is recommended that a hazard assessment process is undertaken to look at the potential for contamination occurring and appropriate system component specification undertaken. If you are unsure about the risks associated with the chemicals you intend to use or the risk to the water source or receiving environment you must seek advice.

This guideline outlines the safety requirements which will help prevent the hazards described above for a dedicated irrigation water source, for example a groundwater bore take from an aquifer, or a direct take from a surface water body. It also describes testing procedures to be followed for backflow safety devices not covered under AS/NZS 2845 (2010).

The equipment required for mixing or storing the agrichemicals is not covered in detail by this guideline. NZS 8409:2004 Code of Practice for the Management of Agrichemicals, and the Hazardous Substance and New Organisms Act 1996 (HSNO) contain the relevant agrichemical management requirements for New Zealand.

Definitions

Backflow prevention system – The combination of all the safety measures used in an irrigation system with agrichemical injection to prevent water pollution or contamination by preventing the flow of diluted agrichemical solution in the opposite direction of that intended.

Backflow prevention device – A safety device, usually used alongside other safety features such as interlocking devices, to prevent water pollution or contamination by preventing the flow of irrigation liquid in the opposite direction of that intended.

Check valve – A device to provide positive closure which effectively prohibits a reversal of flow when operation of the irrigation system pumping plant or injection unit fails or is shut down.

Interlock devices – Safety equipment used including both mechanical and electrical devices to ensure that if the irrigation pumping plant stops, the injection pump will also stop. Devices may also be used to shut down the irrigation system if the injection system fails.

The backflow prevention system

The installation of a backflow prevention system is required in an irrigation supply line to help prevent backflow of agrichemical into the water source (both surface water and groundwater bores), for example if the irrigation pump unexpectedly shuts down.

The key requirements for all backflow prevention systems include –

1. The installation of a backflow prevention device between the water supply and the point of the agrichemical injection.
2. Not all irrigation systems are pressurised by means of a pump. In gravity / siphon systems the backflow prevention device is to be located below the siphon or if no siphon upstream of the point of injection.
3. When injection is on the suction side of a water supply pump the backflow prevention device must be suited to a low pressure scenario.
4. All device(s) used in backflow prevention must be positioned and oriented according to the manufacturer's specifications.
5. A backflow prevention device is also required in the agrichemical injection line to prevent water from flowing from the irrigation system into the agrichemical mixing tank. An appropriately specified and maintained check valve located in the agrichemical injection line meets this requirement. In addition, an appropriately specified and maintained normally closed solenoid valve at the agrichemical mixing tank outlet, placed in the suction line of the injection pump and energised (i.e. open) only when there is power to both the injection pump and the irrigation pump, will help guard against backflow and prevent mixing tank overflow under shutdown conditions.
6. Selection of the appropriate backflow prevention devices for the backflow prevention systems depends upon the characteristics of the agrichemical being deployed, the water source and the irrigation system. Concerns include whether injected material is toxic and/or corrosive and whether there can be back-pressure and/or back-siphonage (a vacuum situation in the water source).
7. Local regulations must be followed in selecting the appropriate backflow prevention system. Check consent conditions as sometimes the type of backflow prevention device to be installed is stipulated. **Before installation, consultation must take place between the regional council and installation contractor to discuss type of device to be installed and all relevant safety measures in the proposed system.**
8. Backflow prevention systems must be regularly maintained according to manufacturers' recommendations to keep all check valves, low pressure drains, interlocking devices and vacuum breakers, free of corrosion or other build-up and functioning properly any time the system is operating.

Types of backflow prevention devices

1) REDUCED-PRESSURE-PRINCIPLE DEVICE

This device consists of two independently acting check valves, plus a pressure differential relief valve that is located between the two check valves. It can be used for both back-siphonage and back-pressure control and can handle most agrichemicals. A minimum clearance of 300 mm above ground level is suggested to ensure an air gap between the relief valve and any water or agrichemical that might puddle beneath the device. Where the consequences from contamination are high then a Reduced Pressure Zone Device (RPZ) is recommended as the minimum specification. If the water source is used to supply community water schemes or is located adjacent to a community water source specific advice should be sought.

2) AIR GAP

An air gap is a physical separation between the free flowing discharge end of a water pipeline and an open or non-pressurized receiving vessel. To have an acceptable air gap, the end of the discharge pipe must be located a distance of at least twice the diameter of the pipe above the topmost rim of the receiving vessel. In no case can this distance be less than 25 mm. This is a simple and effective type of protection. However, an additional pump may be required downstream of the receiving vessel to pressurise the water before it enters the irrigation system.

3) DOUBLE CHECK VALVE

The double check valve assembly is composed of two single, independently acting check valves and can handle both back-siphonage and back-pressure. A low pressure drain and inspection port as described under (4), should be installed immediately upstream of this system. A testable double check valve device is normally acceptable in reduced hazard situations.

4) CHEMIGATION CHECK VALVE

A Chemigation check valve must comply with the American Society of Agricultural and Biological Engineers Standard ASABE EP409.1 Safety Devices for Chemigation. The preferred chemigation check valve shall comprise of the following:

- a spring loaded check valve with positive closing action and watertight seal (not metal to metal),
- a low pressure drain valve installed on the bottom side of the valve body, upstream of the main check valve to drain away any minor check valve leakage. If the drain is within 6 meters of the water source a pipe should be provided to carry drainage away,
- an air/vacuum relief valve installed on top of the pipe upstream of the check valve to prevent back siphonage. This can be combined with an inspection port to check for leaks and/or inspection of the low pressure drain valve,
- a test port downstream of the check valve for purposes of pressurising the chamber to test the integrity of the check valve seal.

Where the water source is for agricultural purposes and the risk of contamination is low a testable chemigation check valve may be used but only as part of a backflow prevention system with a number of other checks in place to prevent backflow of irrigation water to the water source. For information on the installation of chemigation check valves refer to Appendix A.

5) PRESSURE-VACUUM BREAKER

The pressure-vacuum breaker contains, within a single body, a spring-loaded check valve and a spring loaded, air-entry valve which opens to admit air whenever the pressure within the body upstream of the check valve approaches atmospheric.
The pressure-vacuum breaker should not be installed where there can be back-pressure, only where there can be back-siphonage.
The pressure-vacuum breaker can have shutoff valves downstream of the device. It must be installed at least 300 mm above the highest downstream outlet.

6) ATMOSPHERIC VACUUM BREAKER.

An atmospheric vacuum breaker has a movable element or plunger which prevents spilling from the device during pressurised flow and opens to provide an air inlet following cessation of flow if a vacuum (back suction) occurs. **This system cannot be installed where back-pressure persists and can be used only to prevent back-siphonage.** An atmospheric unit should not be used with shutoff valves downstream and must be installed at least 150 mm above the highest outlet or the topmost overflow rim of a non pressurized tank. These units are installed primarily in lawn and turf irrigation systems that are connected to potable water supplies, but in some instances will work for agricultural irrigation systems.

Note: A simple swing gate or spring check valve used for normal reverse flow preventing in a pipe line is NOT considered to be an adequate backflow prevention device in terms of contamination prevention in New Zealand. A correctly specified backflow prevention device from the above list needs to be selected and is likely needed as an additional system component to the simple check valve in a headworks.

Testing of backflow prevention devices

TESTING OF BACKFLOW PREVENTION VALVES.

All valves shall be tested prior to being made operational and at least once in every twelve months thereafter. The consent conditions may require a test certificate be supplied to the Regional Authority within one month of the installation and at each successive test date. The WaterNZ and Master Plumbers Gasfitters and Drainlayers Industry standard for the Field testing of backflow prevention devices and verification of air gaps (2011) contains testing procedures for all devices referred to in this guideline with the exception of chemigation check valves. These are covered separately in Appendix B.

TESTING OF RPZ VALVES.

The consent conditions may require RPZ valves to be tested by an Independently Qualified Person (IQP) who holds a current certification from a recognised authority when the risk situation is determined to be high or a drinking water source could be contaminated. Normal servicing and condition assessment outside of stipulated consent requirement should be done by a suitably qualified technician as these valves are not normally serviceable by irrigation system operators.

TESTING OF CHEMIGATION VALVES.

These valves must be tested by a Suitably Qualified Person, who has the approval of the Regional Authority. An example test procedure can be found in Appendix B.

Considerations for agrichemical injection

There are four main types of agrichemical injection methods, positive displacement and centrifugal pumps, venturi and pressure differential.

Positive displacement pumps are piston pumps or diaphragm pumps. They pump the agrichemical from the mixing tank into the irrigation line. Once piston pumps are calibrated to a given rate, they are accurate. However they must be stopped to change calibration. Also due to their exposed surfaces are often subject to corrosion.

Diaphragm pumps are made of a chemically resistant material and thus have improved lifespans over piston. They are also accurate but have the advantage of being able to be adjusted as they run. Both these pumps inject at a constant rate regardless of flow or pressure changes in the system.

Centrifugal pumps require the pressure produced by the injection pump be higher than the pressure in the irrigation line to operate. The injection flow rate of the agrichemical therefore depends on the pressure in the irrigation line – the higher the pressure ratio between the irrigation line and the centrifugal injection pump the less the injection flow rate is from it. As a result centrifugal pumps require careful calibration. Centrifugal pumps are not recommended for use where the agrichemical injection rate must be precisely controlled.

For all pumped systems the injection point must be upstream of the main back flow prevention device and the injector pump interlocked with the irrigation pump. If any part of the irrigation system is above the injection point, a check valve is required either upstream or downstream (as appropriate for the scenario) of the injection point to prevent back drainage into the agrichemical mixing tank.

Venturi Injectors are installed in parallel to the irrigation line and use a portion of the irrigation flow to perform the injection function. They create a negative pressure through the differential pressure from one side of the device to the other (usually 20%) This then causes the agrichemical mix to flow into the injector. Since the injection rate depends on the pressure differential, any pressure fluctuations in the system change the injection rate. When flow to the irrigation system stops so does the flow through the venturi injector (providing the agrichemical mixing tank is below the injection point).

Pressure Differential – Pressurised mixing tanks and Proportional injectors. Mixing tank injection systems divert water from the irrigation line, mix it with the agrichemical and then draw it again. A measured amount of agrichemical required for one injection is placed in the mixing tank. The injection into the irrigation line is also often controlled by a metering device installed on the downstream side of the injector. The drawback of this method is the injection rate (the concentration) changes as the agrichemical becomes diluted (as more water enters the tank during injection).

Proportional mixers are modified pressurised mixing tanks. In this case the agrichemical is placed in a collapsible bag which separates the agrichemical from the water. The amount of agrichemical forced into the proportioning valve is replaced with displacement water outside the agrichemical solution bag. As water enters the tank it displaces agrichemical and never returns into the system. This overcomes the dilution issues of mixing tanks.

Disadvantage for both methods are that pressure and flow changes in the system alter the rate of injection, which might or might not be proportional to the desired rate.

For both venturi and pressure differential systems, depending on the nature of the irrigation line pressurisation including assessing if any part of the irrigation system is above the venturi or pressure differential system, a check valve may be required upstream or downstream (as appropriate for the scenario) of the injection point to prevent back drainage into the agrichemical mixing tank. Again the injection point must also be upstream of the main back flow prevention device.

Injection port location. The injection port in the irrigation system must be located downstream from the irrigation line backflow prevention device and also located higher than the top of the agrichemical mixing tank. This will help prevent drainage of the agrichemical mix into the irrigation system post a chemigation event. The injection port should be located as close as practicable to the irrigation system to minimise the volume of water in the pipe between the point of injection and the irrigation system, unless this line is being used for mixing purposes.

Backflow prevention in the injection line. A spring-loaded, chemically-resistant check valve is required at the injection port of the irrigation system to prevent water from flowing from the irrigation system into the agrichemical mixing tank when the injection pump is stopped. This will prevent the agrichemical mixing tank from overflowing. If a pumped injection system is used this should also be interlocked with the irrigation pump. See Appendix C for more information on interlocking.

Considerations for safe chemigation practice

- All system components that come into direct contact with agrichemicals must be agrichemical and sunlight resistant and capable of withstanding the maximum pressure expected.
- An appropriately specified filter should be placed on the agrichemical suction line to protect the injection system components. This device may need to be inspected after each use particularly where the chemical concentrate contains particulate or oily substances, common with prilled compounds or organic fertilizer types.
- All agrichemical supply and mixing tanks, injection pumps, etc., should be located a safe distance from sources of electric arc or spark to reduce the explosion hazard caused by the flammability of some agrichemicals.
- Operating instructions for the agrichemical injection device must be made available to all operators and should also be prominently displayed next to the device.
- A water source should be provided near the agrichemical dilution tank and injection pump for washing off any agrichemicals that contact the skin. If the water outlet used is from the irrigation system it must be located between the backflow prevention device and the water supply to ensure fresh water is used in emergencies.
- Protective equipment (in accordance with the agrichemical material data sheet) should be worn when mixing agrichemicals
- Concentrated agrichemicals should generally be added to water in preparing dilutions in the agrichemical supply tank unless directions specify otherwise.
- The surface topography in the vicinity of the well or water source should be graded so that any spilled agrichemical runs away from the water supply, and also ensure there is no run-off into any nearby waterways. It may be necessary to create a bunded spill containment area where the hazard risk is assessed as high.
- Should a spill or backflow situation occur into a groundwater source, the irrigation pump and the irrigation system should be started and kept running to purge the system and your regional council or unitary authority notified immediately to evaluate the severity of the situation.
- All agrichemicals, whether in concentrate or dilute form, should be clearly labelled and stored with their identity and directions for use and always stored in an appropriate and secure area.

- It is illegal to use an agrichemical in a manner inconsistent with its labelling. Before injecting any fertiliser, pesticide (insecticide, fungicide or nematicide) or herbicide through an irrigation system, read and understand the entire label and follow all label instructions and precautions, including procedures for storage, worker protection, entry exclusion periods and disposal of agrichemicals and containers.
- Contact your regional council or unitary authority to identify specific local regulations and requirements related to chemigation.
- **It is important that the Regional Council or Local Authority are notified immediately if there has been or there is concern that a cross contamination event may have occurred.**

References

- AS-NZS 2845-1: Water supply – Backflow prevention devices – Materials, design and performance requirements, 2010
- Boundary Backflow Prevention for Drinking Water Supplies, WaterNZ, 2013
- Field testing of backflow prevention devices and verification of air gaps, Master Plumbers Gasfitters & Drainlayers NZ & WaterNZ, 2011
- NZS 8409: Code of Practice for the Management of Agrichemicals, 2004
- Safety Devices for Chemigation, ASABE EP409.1, March 1989 (revised 2009)
- The Hazardous Substance and New Organisms Act 1996 (HSNO)

Appendix A – Chemigation valve installation

A Chemigation valve -

- shall be positioned, oriented and installed according to the manufacturer's specifications between the water source and the effluent injection line and downstream of any water metering device. When installing the device particular attention should be paid to the interlocking of the irrigation and chemigation control systems.
- must be located at a sufficient height above ground (minimum of 300mm) level to prevent the low pressure drain from being submerged by localised flooding
- shall be maintained to keep all check valves, low pressure drain valves and vacuum/air breakers free of corrosion or other build up and functioning properly any time the system is operating.
- must be manufactured from materials suitable for contact with the complete range of agrichemicals intended for use in the system, including springs, seals, valve body and connections. Ideally the Chemigation valve should be easily serviceable so that wearing parts can be inspected and their condition assessed.

Appendix B – Testing of Chemigation Valves

With the downstream isolation valve closed, the discharge chamber of the Chemigation valve should be pressurised via the test port to a pressure no less than the rated operating pressure of the device. The valve should sustain this pressure for a period of not less than 30 minutes. The preferred method of recording the test would be to use a digital pressure gauge capable of providing a traceable plot indicating time and pressure.

The test certificate should include details of the consent number, bore number, test procedure including pressures, site GPS co-ordinates, copy of the test plot and a photo of the overall installation showing the location of the chemigation valve, isolation valves and point of injection. The company conducting the test must ensure that the certificate is signed by the person who conducted the test and is the authorised representative of that company.

Appendix C – Interlocking irrigation and agrichemical injection devices

1. ***For an irrigation pump driven by an internal combustion engine,*** an easy method to interlock the injection pump with the irrigation pump is to drive the agrichemical injection pump by belt from the drive shaft of the irrigation pump or an accessory pulley of the engine. This will ensure that the agrichemical injection pump stops operating if the irrigation pump stops. Interlocking of pumps is shown in Figure 2 for an internal-combustion-engine powered system.

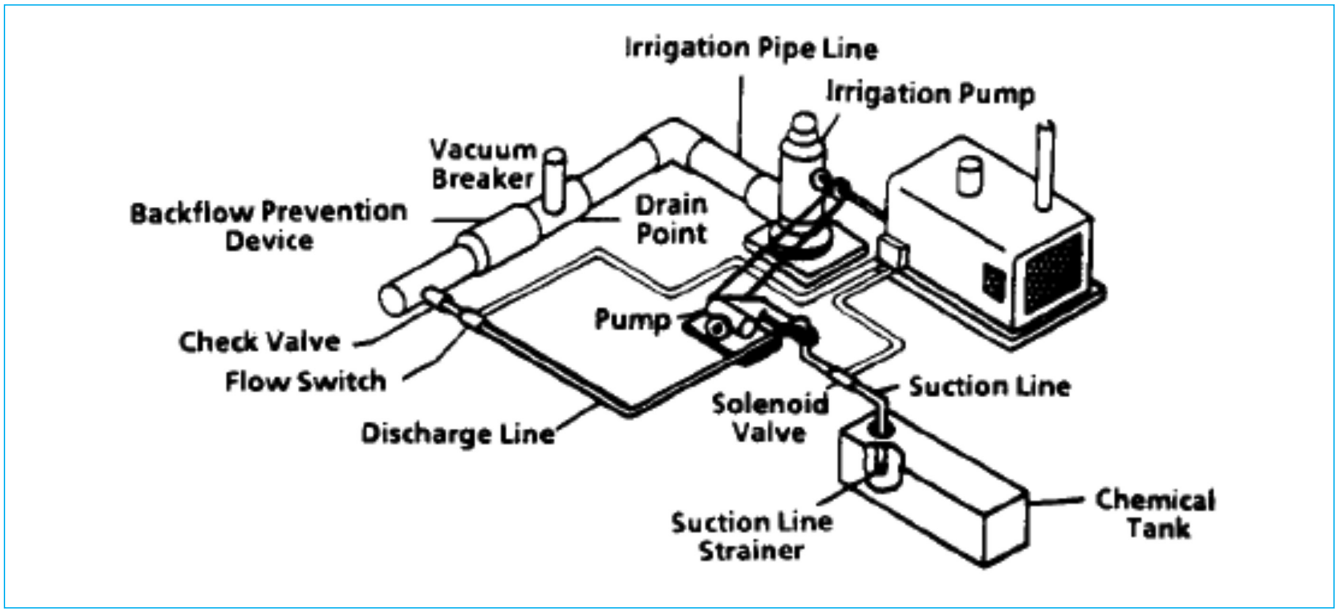

Figure 1. Safety devices for injection of chemicals in irrigation systems.

2. *For an electric motor-driven irrigation pump*, a separate electric motor is usually used to power the chemical injection pump. The electric controls for the irrigation pump, irrigation system, and injection system should be wired so that all three systems shut down if any one of these fails. Figure 3 illustrates this configuration.

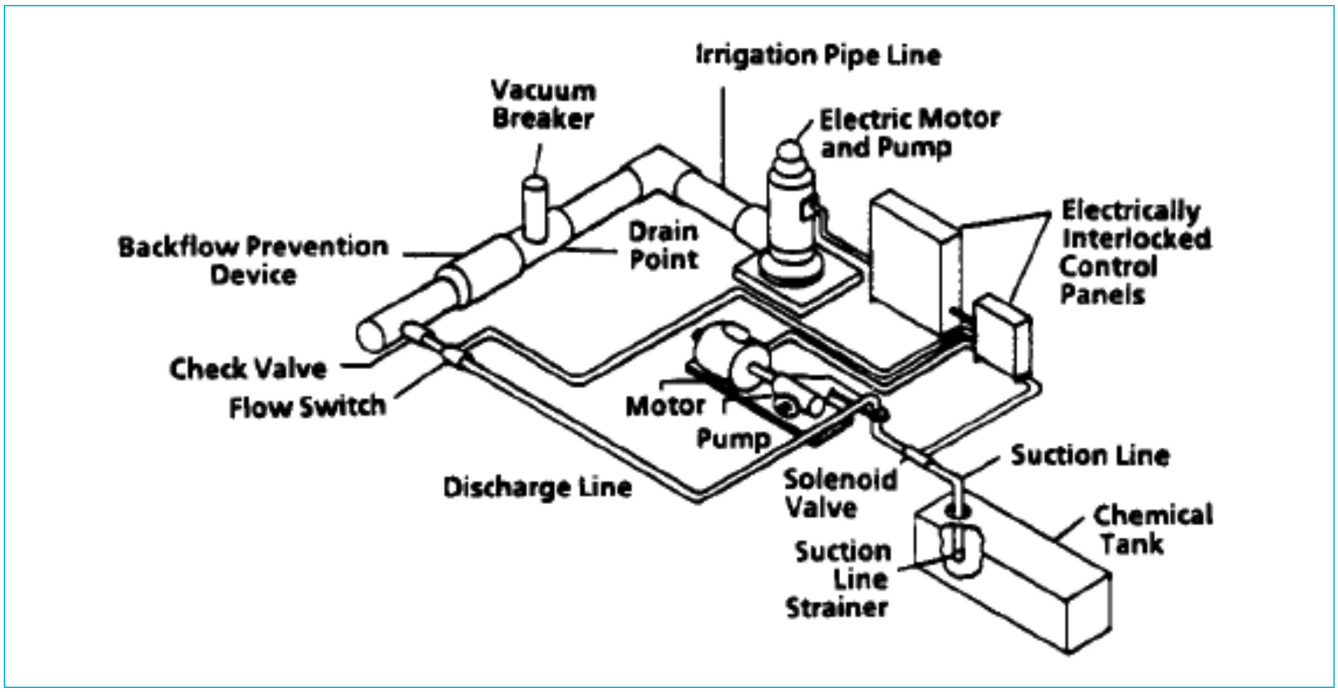

Figure 2. Safety devices for injection of chemicals in irrigation systems.

For an injection pump remotely situated from the irrigation pump and irrigation pump power source, a direct shutdown interlock of the irrigation and injection pump may be impractical. In this case the backflow prevention device installer should discuss with the Regional Council solutions to ensure satisfactory interlocking of the system.

3. *In addition -*

a) An injection line flow sensor is recommended on the pressure side of the injection pump just upstream from the agrichemical line check valve. This device should be wired to assure agrichemical injection system shutdown in case flow in the injection line ceases. This could be as a result of injection pump failure, loss of prime, chemical tank is emptied, or injection port becomes plugged.

b) A normally closed solenoid valve should be installed in the injection pump headworks. The position of the solenoid valve in either the discharge or suction side of the pump would depend on the type of pump used. The valve should be installed according to the pump suppliers recommendations.