PERFORMANCE TESTING OF AUTOMATIC IRRIGATION EQUIPMENT FOR SURFACE IRRIGATION

Technical Report

Enyo Agbodo, Jeremy Cape and Ailsa Willis

Australian Irrigation Technology Centre

The Levels Campus, SA 5095

National Program *for*
Irrigation Research and Development

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Contents

Acknowledgments

AITC wishes to thank the following for their assistance with this project.
Equipment manufacturers: Ian O'Brien, Geoff Fry, Neville Miles, Murray Nottle, John Padman, Richard Tallis.
Steering Committee members: Bert Bloem, Geoff Fry, Chris Hunter, Andrew Laidlaw, Alan Lavis, David Lawler, Murray Nottle, John Padman, Tony Pomeroy, Derek Poulton, David Rosenbaum

SUMMARY

There is a range of automatic flood irrigation equipment (AFIE) currently available in Australia. Benefits to both farmers who adopt the equipment and water supply authorities have been identified and it is hoped to improve the rate of adoption of AFIE.

As part of this project preliminary standards for AFIE were established, based on engineering principles and the field experience of farmers and extension officers. An evaluation of the equipment was carried out in relation to the standards, to provide objective information for farmers in equipment purchase decisions.

Manufacturers of AFIE commercially available at the commencement of the project were contacted and invited to participate. All the equipment tested was contributed by the manufacturers.

All AFIE laboratory tested during the project was shown to function in accordance with expectations based on manufacturer's specifications. Each device successfully operated through an endurance test. Maximum loading capabilities appropriate to the mode of operation were determined for each device.

Information from field evaluation of AFIE with regard to installation and reliability is also provided.

INTRODUCTION

The AITC, in collaboration with Goulburn-Murray Water, NSW Department of Agriculture, Agriculture Victoria and automatic flood irrigation equipment (AFIE) manufacturers, undertook the project *Performance Testing of Automatic Irrigation Equipment for Flood Irrigation*. The project was sponsored by the National Program for Irrigation Research and Development (NPIRD).

The project objectives were:

1. To develop performance criteria and standards for AFIE.
2. To provide an independent assessment of AFIE currently being sold in Australia.
3. To publish the results and extend to the farming community, to increase the awareness of farmers and the industry of equipment reliability, safety and maintenance.
4. To develop improved standards for AFIE, more suited to the needs of farmers.

A steering committee was established (see member list in Appendix A) to define the limits of the project, to gain manufacturers and irrigators agreement and participation in the project and to identify essential and desirable characteristics of automatic devices.

While the benefits of AFIE have been identified by farmers (many existing devices were invented by farmers), the rate of adoption of such technology is very low. For example, in the 1996 Automatic Irrigation Census for Flood Irrigation in Northern Victoria [2], only about 0.5 percent of irrigated properties in the district were identified with automated irrigation. A high proportion of properties using AFIE are dairy farms, however only about 4 percent of dairy farmers have adopted some form of automatic irrigation system.

Most farmers wait for several years after a new practice has been proven in the area before adopting the technology. There are many theories developed in regard to the acceptance of innovation. Five stages of acceptance - awareness, interest, evaluation, trial and adoption - are intensively discussed in extension related literature. [1]

In a study of attitudes of dairy farmers about the automation of flood irrigation it was found that approximately 50 percent of the 83 Murray Valley Irrigation Area farmers surveyed, had limited knowledge or no knowledge of AFIE.

The potential benefits to the farmers include reduced labour requirements, greater convenience (including uninterrupted sleep) and flexibility. An increase in irrigation water use efficiency is likely with benefits of improved pasture productivity, lowered nutrient leaching and reduced drainage flows and accession to groundwater. Other environmental benefits include lowering of potential chemical pollution of waterways, salt transport downstream and factors contributing to blue green algae blooms.

AFIE is relatively new to the irrigation industry. While some of the available equipment has been in use for several decades, many devices have become available only recently and some are still in a developmental stage. In addition many depend upon technology drawn from other industries, hence progress reflects technological advances made in other areas.

Before adopting new technology, farmers require information with which to assess their options. Particularly in a relatively new industry, sourcing objective data to use as the basis for product selection can be a time consuming and daunting process. Farmers have indicated the types of information and features that they consider most relevant in decision making.

This project aims to provide data as a valid basis for comparison and to assist farmers in decision making.

AUTOMATIC FLOOD IRRIGATION EQUIPMENT

Manufacturers of AFIE commercially available at the time were contacted and invited to participate in the project. The following devices were made available by the manufacturers and have undergone testing at the AITC. A list of manufacturers and contact details is given in Appendix B.

Hydraulic systems	- Miles Hydraulic
	- O'B Hydraulic
Pneumatic systems	- Padman Pneumatic
Mechanical Timers	- Padman Mechanical Timer
Electronic systems	- Electronic Irrigation Systems P/L
	- Vapod Electronic

This is a comparatively new industry and manufacturers are continually developing and improving their devices. Since equipment was submitted for testing several of the devices have been altered. Where this has been brought to AITC's attention, and affects or potentially affects performance characteristics that were investigated in the trial, mention has been made.

The devices represented all systems commercially available in Australia at the time with the exception of

- - the Irrigation Concepts electronic system, which was unavailable from the manufacturer for the duration of the test program.

- the Watermate Irrigation Control System, manufactured by Geoff Fry. This system uses hydraulic rams, controlled by programmable controller and low voltage solenoid valves. The system components are sourced externally for each system according to demand, rather than being constructed by the irrigation system supplier. For this reason and because there were two other hydraulic systems using rams under test, it was decided in communication with the supplier not to subject this system to laboratory testing.

In addition to the above, at the time of the project AITC was made aware of three other prototype systems still in the early stages of development. These were not sufficiently advanced to be included in the trial. Due to ongoing development, manufacturers of both these and the commercially available AFIE should be contacted for up to date details concerning their devices.

Since the trial, Baywatch Irrigation have manufactured a portable electronic system operating on a timer. The automatic equipment has a rechargeable battery operated timer and an electronic motor to raise or lower the irrigation structure.

The project did not include alarm systems placed in the bay to alert the user when water reaches that position. Alarm systems do not control the flow of water.

THE STANDARD

The preliminary standard for AFIE was based upon the observations of farmers and extension officers and the engineering principles involved. Existing relevant standards were considered and referenced where appropriate.

The content of a standard must realistically reflect the important functional characteristics and specifications of the equipment within it's scope. At the same time test procedures must be simple and easily replicated. The test procedures in the AFIE standard attempt to simulate field conditions in the laboratory, testing for important performance characteristics while eliminating many of the variables that would occur in the field.

A standard for AFIE was prepared and made available to stakeholders (farmers, equipment manufacturers, researchers) for comment in mid-1996. These people were asked to make additions, suggestions and comments regarding the standard. Their responses were considered in completion of the draft standard. A copy of the draft standard is given in Appendix C.

In summary the standard provides for specification and assessment of AFIE. under the following categories:

- Classification
- Marking
- General Requirements
- Safety
- Construction and Materials (materials and strength)
- Functional Characteristics and Requirements
- Installation
- Equipment testing
- Function. Operate the equipment through open/close cycles to determine whether the device operates successfully through the full cycle and returns to the appropriate final state.
- Load Capacity. Determine maximum load capacity for the device.
- Endurance. Operate equipment intended for permanent installation through 250 cycles, mobile equipment through 100 cycles, then retest for function.
- Information to be Provided by the Manufacturer.

EQUIPMENT SELECTION

Testing of equipment against a standard can provide information enabling a potential user to make a decision on the most suitable device for their particular application. However, the standard only covers attributes of the device itself. In making a decision the user must also assess other factors.

For example, proximity of the equipment supplier, the services offered (such as installation options and after sales service), their reputation and product backup, should all be considered. The type of equipment purchased will determine the scope, location, time frame and cost of repairs, should difficulties or damage occur.
Depending upon the technology involved, some systems may be repaired on site by the farmer while others require specialist attention. Should the need arise in the future will it be possible to extend or upgrade the system and is the AFIE compatible with other types of equipment?

With regard to the device itself, suitability for an application or location needs to be assessed. Equipment must be used for an appropriate purpose to perform well.

The AFIE provided by the manufacturers was evaluated by the methods outlined in the draft standard. Assessment of the equipment was carried out alongside development of the draft standard and hence was instrumental in developing some sections of the document.

While undergoing testing at the AITC, systems were also assessed for features likely to be of importance to the farmer as selection criteria. For example, suitable applications of the system, features critical to reliable operation, and potential degree of automation. These results are presented in this report in a summary table to give the reader an overview and appreciation of all devices. (See Table 1.)

Table 1.

System	Suitable outlet types	External influences critical to operation	System fixed or portable	Potential degree of automation	Irrigation duration control	Mode of activation
Hydraulic systems - Miles - O'B -Watermate Irrigation Control	Most outlets Any outlet Most outlets	Water supply pressure Water supply pressure	Fixed Fixed Fixed	7 day span auto cycle Auto cycle Auto cycle	Timer Bay sensor Timer	Water computer controls water to hydraulic ram. Timer and bay sensors control the water pressure that activates a valve controlling a hydraulic ram. Controller and solenoid valves control hydraulic rams.
Pneumatic systems - Padman	Pipe or flap		Fixed	Auto cycle	Bay sensor	Bay sensor signal transmitted by air pressure. Timer or manual start.
Mechanical systems - Padman	Pipe or flap		Portable	Auto cycle	Timer	Mechanical timers open and close gate.
Electronic systems - Electronic Irrigation Systems P/L - Vapod Baywatch Irrigation	All doors Rectangular gate Rectangular gate or flap		Portable Portable Portable	Full cycle One bay	Bay sensor Bay sensor with timer backup Timer	Bay sensor transmits radio signal to door controller. Tank on gate empties to open gate, fills with water again to close.

Part 1 EQUIPMENT ASSESSMENT RESULTS

1.1 Classification

Automatic flood irrigation equipment currently available in Australia can be grouped into three classifications.

- Pneumatic and hydraulic devices. Use hydraulics or pneumatics to activate the bay outlet.
- Mechanical timer devices. Bay outlet is activated by a mechanical timer.
- Electronic. Bay outlet is activated by an electronic device (includes radio operated devices).

Pneumatic systems	- Padman Pneumatic
Hydraulic systems	- Miles Hydraulic
	- O'B Hydraulic
Mechanical timers	- Padman Mechanical Timer
Electronic systems	- Electronic Irrigation Systems P/L
	- Vapod Electronic

1.2 Marking

Of the above systems, the manufacturer was identified on all equipment except the Miles. Only the Electronic Irrigation Systems device was identified with a model number. The safe maximum rated pressure was not readily visible on any of the hydraulic systems.

1.3 Safety

The most likely result of failure of AFIE is non-occurrence of a planned irrigation. However maintenance checks must be carried out to ensure that equipment continues to function safely and reliably. Safety depends not only on the equipment but also on the installer and user.

During use any equipment should be approached with caution and care should be taken to keep clear of rams and other moving parts during operation. Components acting suddenly and with force, such as the pneumatic rams on the Padman devices, should be installed on protected sites for the safety of both device and animals. Maintenance should include checks to ensure that fastenings such as the bolts securing the pneumatic rams, do not loosen.

All of the electronic equipment operates on low voltages using rechargeable batteries.

1.4 Functional characteristics and requirements.

1.4.1 Pneumatic and hydraulic devices.

Fittings on all devices were adequately accessible to allow easy installation and use during testing at the AITC.

Hydraulic devices. The water supply to hydraulic devices should be contaminant free and filtration used if necessary to protect:
- Miles: The Nylex Gardena Water computer and Water Distributor
- O'B: The O'B valve.

Pneumatic devices. The air lines to pneumatic devices should meet manufacturer's installation and diameter recommendations to ensure that condensation does not cause blockages.

1.4.2 Mechanical Timers

Adjustment to reduce set time on the mechanical timer on the Padman system is possible but not recommended. The dial of the timer itself has graduations of half an hour and a range from 0 to 24 hours on both start and stop timers.

1.4.3 Electronic devices

The Electronic Irrigation Systems P/L system was operated at the AITC using an external power supply to enable endurance testing. However, the manufacturer expects the bay sensor and door controller battery to last up to 5 days without charging. The receiver may be left plugged into the charger all the time.

The Electronic Irrigation Systems P/L has Type Approval from the Department of Transport and Communications for their door controller.

1.5 Information to be provided by the manufacturer

In order to acquire, install, operate and maintain equipment to it's full potential, the user must have access to clear, concise instructions and information. This is also in the best interests of the manufacturer and distributor, to minimise unnecessary interaction and maximise consumer satisfaction. It should be assumed that the reader has only limited knowledge.

The capabilities of standard office equipment and printing services now available are such that any AFIE manufacturer can provide tidy, well presented literature. The content of the literature, however, may require a little may forethought in order to effectively cover all of the necessary issues and information. The draft standard lists many types of information that should be included.

The standard of presentation and content of literature provided with tested equipment varied. It must be kept in mind that the equipment supplied for testing is in various stages of development and marketing, from sources having very different aims in the irrigation market place. The potential benefits from each system are not necessarily reflected in the scale of the marketing effort. At one end of the scale the system comprises a significant product in the range distributed by a commercial irrigation equipment supplier. At the other extreme, the equipment was initially made by an irrigator as a cost-effective solution to an irrigation requirement. The devices are now constructed and supplied as an interest rather than a competitive commercial venture.

The literature provided is developing alongside the AFIE and upon request AITC received additional written information concerning several systems, while the project was in progress. The information provided in most cases was adequate and was assessed as follows when compared to the data to be provided by the manufacturer, listed in the draft standard.

Electronic Irrigation Systems P/L.	Good
Padman pneumatic/hydraulic.	Limited to installation.
Miles.	Good.
Vapod.	Good.
O'B.	Satisfactory

It has been observed that problems which occur with the more reliable AFIE tend to be the fault of the operator. Manufacturers may like to upgrade the standard of organisation and presentation of their instructions and information, in light of this.

Part 2 EQUIPMENT TESTING

Laboratory testing of six systems was carried out at the AITC, with field information on AFIE gathered by Agriculture Victoria, with assistance from Goulburn-Murray Water. [2].

Goulburn-Murray Water, NSW Agriculture and Agriculture Victoria staff have regular communication with farmers using automatic flood irrigation equipment in the field. The field information presented in this report is a summary of general knowledge and specific information gathering activities, presented in relation to the different categories of automatic flood irrigation equipment (hydraulic, pneumatic, mechanical etc).

2.1 Field Evaluation

The following section concerning field evaluation of AFIE presents information from a census of irrigators in the gravity irrigated area of Northern Victoria. [2] The census identified 37 systems which are currently available on the market, being used on farms.

Installation

Most of the irrigation systems were rated as relatively easy or easier to install. The systems that were rated difficult or very difficult to install were accounted for by only three of twentyone irrigators who had systems which involve burying polythene pipe into the ground (hydraulic and pneumatic systems).

Two thirds of the irrigators said they had problems with their automatic irrigation system immediately after installation. These initial problems were not specific to any one type of automation. Two thirds of those who experienced these problems said they were easily fixed. Generally hydraulic and pneumatic systems and mechanical timers could be repaired by the irrigator. Electronic systems were more difficult to repair and in most cases needed to be returned to the manufacturer to be repaired.

Channel maintenance. There is a need to increase maintenance of channels and equipment to ensure that the equipment works correctly. Channels should be fenced to protect automatic units from stock damage. Weeds need to be kept to a minimum to allow the channel to operate efficiently.

Reliability of systems

Overall 32 of 37 systems were rated as reliable or better while five farmers said their system was unreliable or totally unreliable. The full range different types of AFIE (hydraulic, pneumatic, mechanical and electronic systems) received unreliable ratings.

36 of the 37 systems were rated as relatively simple or simple to operate. The remaining system was not working and the operator rated it as difficult to operate.

Hydraulic systems. Water pressure is used to transmit signals from sensors to outlet structures, operate valves and drive hydraulic rams, opening or closing bay outlets. The available water supply must consistently meet manufacturer's requirements for hydraulic systems to function reliably.

Pneumatic systems. Pneumatic systems use air pressure to open or close bay outlets. Condensation in the air tube can cause failure to operate. Using larger diameter tube helps to avoid this problem.

Electronic systems. A radio signal transmitted from a bay sensor activates an electronic unit to open or close the bay outlet structure. Electronic systems depend upon rechargeable batteries.

A number of irrigators pointed out that automatic irrigation is only as reliable as the operator and particular care needs to be taken to install the system correctly, to maintain it and to set the system up correctly for irrigation.

Often failures of AFIE are due to human error in setting and maintaining systems. Manual systems can also have failures with alarm clocks failing to wake irrigators and irrigators forgetting to open or close structures.

Water use

66 percent of irrigators said that they use less water after installing automation and 67 percent of irrigators said they had reduced irrigation runoff. It was difficult for irrigators to estimate by how much water use and runoff were reduced. It was pointed out that reductions in water use and runoff were dependent on the standard of irrigation management prior to the installation of automation.

Irrigators believed they had reduced water use because:

- Water was being shut off at a more accurate point down the bay. It was felt that with automation more attention was being paid to the point at which water was shut off down the bay and runoff was reduced because of this.
- Individual bays were being watered more quickly and less water was being absorbed into the soil, particularly on sandy soils.
- An element of human error was eliminated with automation. With manual irrigation there was a chance that irrigators would sleep in or temporarily forget to switch the water on to another bay.

It was concluded from the results of the census that some very reliable systems of automatic irrigation have been developed and have performed to the satisfaction of irrigators in Northern Victoria.

2.2 Laboratory Testing

Test results are summarised in Table 2.

Equipment was evaluated in the laboratory in relation to the preliminary standard under the following categories.

- Function
- Load capacity
- Endurance

During testing field conditions were simulated while attempting to eliminate variables, thus providing repeatable test procedures. For example, masses replaced hydraulic loads and bay outlets such as sliding gates or flaps, unless the gate was an integral part of the automatic

device. Pulley systems were used to apply loads in the horizontal direction where appropriate.

Equipment was operated within manufacturer's specified operating ranges. Systems incorporating a sensor were initiated by applying external stimuli simulating field conditions.

The equipment testing focused on the devices and sensors for each system. Following is a list of the system components tested for each manufacturer.

Miles Hydraulic.	Ram with bucket. Nylex Water Distributor.
O'B Hydraulic.	O'B valve and ram.
Padman Pneumatic.	Double acting Padman pneumatic controller.
Padman Mechanical Timer.	Padman autotimer.
Electronic Irrigation Systems P/L	Bay sensor and door controller.
Vapod Electronic	Sensor and swinging bay gate/tank.

Function

Each device was operated through a full cycle to ensure that the device performed successfully and ended in the appropriate final state.

All devices passed this test with the exception that the battery supplied in the prototype Vapod bay sensor was not functioning and was substituted for using an external power supply. The manufacturer has since further developed the rechargeable battery power supply and solar panel.

Load capacity

Some devices are intended to be used with existing irrigation structures, others replace part of the irrigation structure. When added to an existing irrigation structure, the loads on the devices will vary from installation to installation. Some loads will depend on the type of outlet structure and it's state of repair. Load may be contributed to by hydrostatic pressure or a slide gate jamming, for example.

For some devices the potential load has an upper limit because of the way the device works, rather than the irrigation structures it is installed with. In this case it would be inappropriate to compare devices on the basis of maximum load capacity. Instead, consider whether the devices are able to meet the likely load requirements for the field situation where they are to be used. Maximum load in the field may be relatively constant, perhaps due to hydrostatic forces and the mass of the device.

The Miles ram and bucket in a pipe outlet or Vapod gate and tank are examples where the gate is an integral part of the automatic device and replaces part of the bay outlet structure. Similarly, the load on any device used with a Padman flap will be limited because a hinged device that replaces a sliding bay gate will not need to overcome the potential load of that gate jamming.

Some devices may be loaded both when opening and shutting a bay outlet, while others have little or no load to overcome while carrying out one of these operations. This was taken into account in determining load capacity. For example, the Padman devices both allow an outlet to fall open and need only apply force when closing a bay outlet. They were tested for load capacity of the power (closing) arm only.

There are variables in the way a device is set up that influence performance capabilities, even within the manufacturers recommended operating range. This was assessed.

Hydraulic devices were tested at the both the upper and lower limits of the manufacturer specified operating pressure range to determine the effect on ability to function and on maximum load capacity. The Miles device may be installed horizontally or vertically and was tested for load capacity both while extending and retracting. Travel time for the O'B device was significantly affected by load and was therefore recorded.

The length of slack in cable to be taken up before the pivoting power arm was loaded was varied for both Padman devices.

Devices were tested for load capacity following endurance testing.

Endurance

Permanently installed equipment was tested for a minimum of 250 cycles, mobile equipment for a minimum of 100 cycles. This was based on the assumption that equipment could be expected to last 10 years with 25 operations a year for permanent and 10 operations a year for mobile AFIE. Where external loading was applicable a 5kg mass was used.

All AFIE endurance tested completed at least 4 times the number of cycles expected in 10 years successfully. None failed during endurance testing.

Table 2.

Device	Function	Load capacity (kg)			Endurance	
Padman pneumatic	*Pass*	Lift *4.1kg* *16* *33*	Cable length *No slack* *0.1m slack* *0.2m slack*		*250 cycles* *Pass*	
Miles hydraulic	*Pass*	Pressure [1] *30PSI (207kPa)* *50PSI (345kPa)*	Extend ram (horizontal) *57kg* *101*	Retract ram (horizontal) *50kg* *92*	*1014 cycles* *Pass*	
O'B hydraulic	*Pass*	Pressure *20PSI (138kPa)* *50PSI (345kPa)*	Retract ram (lift) *76kg max load* *38.5* *0* *242kg max load* *121* *0*	Travel time (minutes) *36 min lift, 2 min lower* *5 min lift , 3 min lower* *Valve not switching* [2] *38 min lift* *4 min lift* *2 min lift, 3 min lower*	*1011 cycles* *Pass*	
Padman mechanical timer	*Pass*	Lift *10.6kg* *16* *18*	Cable length *No slack* *0.1m slack* *0.2m slack*		*200 cycles* *Pass*	
Electronic Irrigation Systems P/L	*Pass*	*Lift 18kg*			*1036 cycles* *Pass*	
Vapod electronic	*Pass*	n/a			See 3. below	

Notes

1. **Miles.** Maximum expected loads in the field for a Miles ram installed in a pipe outlet:
   - Horizontal ram. Max load due to hydrostatic pressure on bucket with 0.45m water depth over ram is approx 32kg.
   - Vertical ram. Max load due to lifting 12" pot full of water is approx 20kg.
2. **O'B.** At 20PSI (138kPa) supply pressure, O'B valve would not switch ports. Switched ports successfully at 150kPa. Travel time to lift was significantly affected by load. Manufacturer has since modified the O'B valve.
3. **Vapod.** The Vapod gate/tank replaces the rectangular gate in a bay outlet. Load is due to hydrostatic pressure and self weight. Load capacity testing is therefore irrelevant for this device. As a prototype device at that stage, endurance testing was not carried out.

REFERENCES

[1] Attitudes of Dairy Farmers about the Automation of Flood Irrigation. Rabi Maskey. Irrigation Officer. Cobram District Office. Institute of Sustainable Agriculture, Agriculture Victoria. March 1996.

[2] Automatic Irrigation Census for Flood Irrigation in Northern Victoria. Rob O'Connor. Echuca, Agriculture Victoria. 1996.

[3] Automation for Flood Irrigation. David Lawler. Echuca, Agriculture Victoria. 1995

[4] Automatic Irrigation 1992. Gill Fry and Derek Poulton. Rural Water Corporation.

[5] Automatic Irrigation Survey. Gill Fry. 1992.

Appendix A . Steering committee members

Title	First Name	Last Name	Organisation	Address	Location	Post Code	State
Mr	Jeremy	CAPE	AITC	The Levels Campus	POORAKA	SA	5095
Mr	Alan	LAVIS	Goulburn-Murray Water	PO Box 165	TATURA	VIC	3616
Mr	Derek	POULTON	Goulburn-Murray Water	PO Box 165	TATURA	VIC	3616
Mr	David	LAWLER	Agriculture Victoria	225 Packenham St	ECHUCA	VIC	3564
Mr	Chris	HUNTER		RMB 3810	KYABRAM	VIC	3620
Mr	David	ROSENBAUM	NSW Agriculture	PO Box 736	DENILIQUIN	NSW	2710
Mr	Tony	POMEROY		Calawarra	DENILIQUIN	NSW	2710
Mr	Andrew	LAIDLAW	Irrigation Concepts	Level 1, 54 Malop St	GEELONG	VIC	3220
Mr	John	PADMAN	Precision Irrigation	Murray Valley Hway	STRATHMERTON	VIC	3641
Mr	Geoff	FRY	F & F Irrigation	King Albert Avenue	LEITCHVILLE	VIC	3567
Mr	Murray	NOTTLE	Vapod Engineering	8/37 Oak Street	ASHFIELD	NSW	2131
Mr	Bert	BLOEM	Solar Irri-Gate	15 Cedar Street	LEETON	NSW	2705

Appendix B . Manufacturers of Automatic Flood Irrigation Equipment.

This list includes manufacturers of several devices that have become available since the start of the project.

Manufacturer	Contact name	Address	Phone/fax
Miles	Neville Miles	RMB 2442 Kyabram, VIC 3620	ph 03 5826 0367 mobile 015 848 849
O'B Automation Irrigation	Ian O'Brien	Findlays Rd Leitchville, VIC 3567	ph/fax 03 5456 7439
Precision Irrigation	John Padman	Murray Valley Highway Strathmerton, VIC 3641	ph 03 5874 5282 fax 03 5874 5685
Electronic Irrigation Systems P/L	Richard Tallis	PO Box 10, Dookie VIC 3646	ph 03 5828 6393 fax 03 5828 6457 mobile 015 344 700
Vapod Engineering	Murray Nottle	8/37 Oak Street Ashfield, NSW 2131	ph/fax 02 9799 6514 mobile 014 838 934
Baywatch Irrigation	Chris & Nancy Kay Rod & Carol McFadzean	RMB 2450 Kyabram, VIC RMB 2022 Undera, VIC 3629	ph 5855 2470 ph 5826 0447
F&F Irrigation	Geoff Fry	King Albert Street Leitchville, VIC 3567	ph 018 997 168 fax 03 5456 7558

Appendix C . AUTOMATIC FLOOD IRRIGATION EQUIPMENT

DRAFT STANDARD

CONTENTS

AUTOMATIC FLOOD IRRIGATION EQUIPMENT

SECTION 1 SCOPE

This standard specifies design, operational and functional requirements of automatic flood irrigation equipment, test methods and data to be supplied by the manufacturer to permit correct installation and operation in the field.

It applies to all automatic flood irrigation equipment whose operation is either hydraulic, pneumatic, radio signal, electronic signal, electronic or mechanical timing based. It develops design considerations, performance criteria and standards for equipment.

SECTION 2 REFERENCED DOCUMENTS

The following standards contain provisions which are referred to in this text and constitute provisions of this standard.

AS/NZS 1044:1995	Limits and methods of measurement of radio disturbance characteristics of electrical motor-operated and thermal appliances for household and similar purposes, electric tools and similar electric apparatus.
AS 1046	Letters and symbols for use in electrotechnology.
AS 1101.1	Graphical symbols for general engineering: Hydraulic and pneumatic systems.
AS 1102	Graphical symbols for use in electrotechnology.
AS 1174 - 1971	Methods for measurement of radio transmitters. Part 1 General conditions of measurement, frequency output power and power consumption. Part 2 Bandwidth, out-of-band power and power of non-essential operations
AS 1188-1990:	Radio transmitters and similar equipment - Safe Practices.
AS 1470	Health and Safety at Work - Principles and Practices
AS 1543	Electrical equipment of industrial machines
AS 2671:1983	Hydraulic Systems and Components.
AS 2788:1985	Pneumatic Systems and Components
AS 3000	SAA Wiring Rules
AS 4024.1 -1992	Safeguarding of machinery. Part 1 General principles.
AS 4086-1993	Secondary batteries for use with stand-alone power systems. Part 1 General requirements.
AS 4268	Radio equipment and systems - Short range devices.
AS/NZS 4355-1995	Radio communications equipment used in handphone and citizen band services operating at frequencies not exceeding 30 Mhz.

SECTION 3 DEFINITIONS

For the purposes of this performance standard, the definitions below apply.

3.1 **Automatic Flood Irrigation Equipment**: A system incorporating a device or device and sensor acting together in an irrigation system to either cause a change in the direction of flow of water or prevent the flow of water in open channels systems. From hence to be referred to as equipment.

3.2 **Permanently installed equipment**. Automatic flood irrigation equipment intended by the manufacturer for installation and use at a single location.

3.3 **Mobile equipment**. Automatic flood irrigation equipment intended to be moved to enable use at a number of locations.

3.4 **Device**. That part of an equipment (which is) mounted on an irrigation structure.

3.5 **Sensor**: That part of equipment located at a suitable position in a bay which signals the device to operate.

3.6 **Bay**: An area intended for irrigation by controlled flooding

3.7 **Bay Outlet**. A structure used to control and regulate the discharge of water from a channel on to a bay.
A structure through or over which water is discharged from a channel onto a bay.

3.8 **Channel**. An artificial watercourse for supplying water to and within farms.

3.9 **Channel check**. A mechanical structure in a channel which controls the direction of flow and/or water level.

3.10 **Culvert Pipe**. A pipe or group of pipes suitably placed to carry water underground.

3.11 **Minimum water working level**. Lowest working level declared by manufacturer at which sensor produces signal to operate outlet.

3.12 **Operation**. The action of an outlet opening or closing.

SECTION 4 CLASSIFICATION

Automatic flood irrigation equipment is grouped into three classifications (see 4.1 to 4.3) in accordance with the primary mechanism activating the device. The same mechanism may also operate the device.

4.1 **Pneumatic and hydraulic**. System where hydraulics or pneumatics are used to activate the device.

4.2 **Mechanical timer devices**. System incorporating a mechanical timer which activates the device.

4.3 **Electronic**. System activated by an electronic device. This group includes radio operated devices.

SECTION 5 MARKING

The following particulars shall be shown correctly in permanent and readily visible form on all components.

a) Name and/or identification of the manufacturer and/or supplier.
b) Type or model number.
c) Safe maximum continuously rated pressure and/or voltage.

Where lack of available space would result in lettering too small to be legible, information may be restricted to a minimum of manufacturer's name and either type number or model number. Where this is the case, all other information as set out in this Clause shall be provided in accompanying documentation.

SECTION 6 GENERAL REQUIREMENTS

6.1 Operating requirements. The equipment should comply with the following requirements:

a) Operating temperatures. The full range of ambient operating temperature to which the equipment is subjected may be 1° to 60° C. The equipment shall operate satisfactorily under these conditions.
b) Weatherproofing. Equipment intended for use outdoors must be weatherproof.
c) Water resistance and quality. Equipment should be water resistant (waterproof for immersible components) and operate satisfactorily in irrigation water, including water with salinity up to 2 dS/m. Where applicable equipment shall operate under submerged conditions.
d) Corrosion. Components of equipment which may be liable to corrosion should be adequately protected from corrosion.

6.2 Installation

a) Components shall be installed in accordance with manufacturer's recommendations and in accordance with AS 4024 *Safeguarding of Machinery Part 1 General principles.*
b) The system must be installed to ensure that all components of the system requiring user interaction are safely and easily accessible and visible to the user.
c) All components of the equipment shall be protected, where practicable, from unintentional operation.
d) Permanent equipment should be protected, for example by installation in areas fenced off from livestock and heavy vehicle loading.
e) Where applicable, equipment shall be licensed.
f) Electrical equipment and installation work shall comply with AS 1543 and AS 3000.

6.3 Components. If applicable, depending on the mode of operation, all components shall abide by AS 2788, AS 2671 and AS 4268.2 or AS/NZS 4355

SECTION 7 SAFETY

In the design of equipment, all aspects of possible operation and failure (including sensor signal transmission failure) shall be considered. Components shall be selected and applied so that during operation or in the event of failure, safety of personnel shall be the prime consideration and damage to equipment minimised.

Devices shall make provision for manual operation of the irrigation system.

Additionally,

a) all components within equipment shall operate within the manufacturer's specification;

b) the equipment shall be designed and constructed so that components are located where they are accessible, visible and can be safely adjusted and serviced;

c) all matters pertaining to safety shall comply with the requirements of the relevant Statutory Authority, AS 4024 Part 1 and AS 1188.

SECTION 8 CONSTRUCTION AND MATERIALS

8.1 Materials. Materials shall be suitable and safe for the intended purpose. Where the properties essential to the correct performance of any material are in doubt, the properties of such material shall be determined by appropriate testing. Exposed materials should not be unduly sensitive to chemicals commonly used in agriculture.

8.2 Strength. In the course of their transportation and use devices may be subjected to many conditions. For example, vibration during transportation or interference from livestock. Equipment should be robust enough for farm usage and resistant damage from vermin, stock and micro-organisms and other potential hazards.

In permanent installations, the manufacturer must specify whether devices are able to withstand loadings (for example due to vehicles or livestock) or must be protected, for example fenced off.

SECTION 9 PNEUMATIC AND HYDRAULIC DEVICES

9.1 Functional characteristics and requirements.

9.1.1 Cylinders and rams. The following shall be considered:

a) The stroke, length, loading and conditions of assembly shall be such as will prevent bending or buckling of the piston rod in the extended position.

b) Seals or seal assemblies shall be easily replaceable.

c) Cylinder ends shall be protected from impact damage due to high loads.

d) Exclusion devices shall be fitted to minimise contaminant ingress from the environment.

e) Where practicable, cylinders shall be installed with ports uppermost.

f) Every connection to pipework shall be accessible for tightening without disturbing adjacent pipelines or components, particularly where pipelines terminate in a cluster of fittings.

9.2 Installation.

a) Pipelines shall be installed so they are protected against predictable damage and do not restrict access for adjustment, repairs or replacement of components.

b) Flexible hoses shall be installed so as to have enough length to prevent sharp flexing and straining of the hose during the equipment operation.

c) Filters shall be installed where they are readily accessible and means provided for changing the filter elements without shutting down the system.

SECTION 10 MECHANICAL TIMER OPERATED DEVICES

10.1 Functional characteristics and requirements.

a) Graduations on all timer devices shall permit accurate setting of watering time to the nearest half hour or less.
b) Timing devices must permit the user to adjust the set time after an initial selection is made.
c) The system shall be protected from ingress of contaminants.
d) Components requiring maintenance by the user must be easily accessible using standard or manufacturer-supplied tools.

10.2 Installation.

Install in accordance with the requirements of section 6.2.

SECTION 11 ELECTRONIC AND RADIO OPERATED DEVICES

11.1 Functional characteristics and requirements.

a) Battery recharging. Where applicable batteries must be capable of at least ten operations before needing recharging and shall comply with AS 4086.
b) Equipment operation shall not be initiated by any chance occurrence (rain, wind etc).
c) Manufacturers using off the shelf radio communications equipment should ensure that such equipment abides by AS 4268, AS/NZS 4355:1995 and AS/NZS 1044:1995.
d) A CB radio transmitter shall be capable of operating only on a channel designated in Table 1 of AS/NZS 4355:1995.

11.2 Installation

The manufacturer shall provide installation procedures to enable the user to attain best possible reception in environments with hills and obstructions.

SECTION 12 TEST CONDITIONS

12.1 General test conditions. Sensors shall be tested at ambient air temperature conditions.
The temperature of water used during testing shall be between 0 and 35° C. If the manufacturer recommends the use of filtered water, a filter meeting the manufacturer's recommendations shall be installed to ensure compliance with those recommendations.

12.2 Accuracy of measuring devices. Water pressure, time, mass and flow rate shall be measured with an error not exceeding ±2% of the actual values.

12.3 Sampling requirements. The test specimen shall be taken at random.

12.4 Test equipment. All pipes and fittings directly connected to the equipment under test shall be in accordance with the manufacturer's specifications.

12.5 Simulation of field conditions. The equipment will incorporate a device and possibly a sensor. The device, and sensor where applicable, must be set up using a bay outlet or a structure simulating a bay outlet, in accordance with manufacturer's instructions.

12.5.1 Devices intended to be used in conjunction with existing bay outlet structures. Load using a mass or mass suspended from a cable and pulley system, to simulate operation of an outlet type deemed suitable by the manufacturer. Attach the load at the manufacturer specified point.
Observe manufacturer's instructions regarding the length of slack in any cable attached to the device.

Device with hinged/pivoting arms. The load should be suspended on a cable below the attachment point when the arm is in the starting position. Pass the cable over a pulley to maintain the lateral position of the mass below the starting position of the attachment point. See Figure 1.

Device extending/retracting or winding. For example ram lifting/lowering slide gate, ram plugging/unplugging a pipe outlet. Apply load along axis of device movement. See Figure 2.

12.5.2 Devices intended for installation as part of bay outlet.
Where a device is used in the place of a flap, gate or similar part of a bay outlet, the load used for testing the device should reflect the magnitude of load likely to occur in the field. In this situation load on the device may be due, for example, to the weight of the device, enclosed water or hydrostatic pressure.

Figure 1.

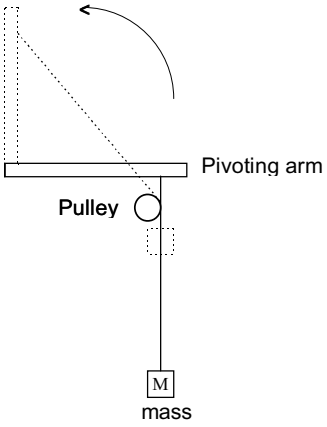
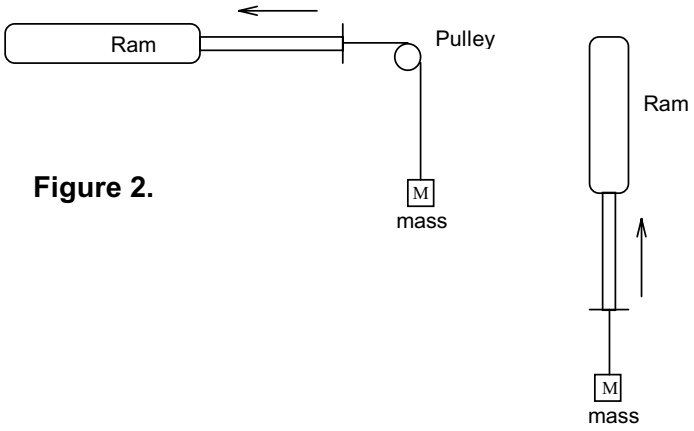


Figure 2.



SECTION 13 TEST METHODS AND REQUIREMENTS

Conduct tests in the following order.

13.1 Function. Where it is intended by the manufacturer that the system be reset manually prior to each cycle, this step should be performed in accordance with manufacturer's instructions.
Observe each cycle to determine whether the device operates successfully through the full cycle and returns to the appropriate final state.

13.1.1 Systems incorporating device only. Initiate the system to operate the device through a full open/close cycle of duration within the manufacturer's specified operating range. Repeat 5 times.

13.1.2 Systems incorporating device and sensor. Apply external stimuli simulating field operation to activate the sensor, initiating a full open/close cycle of duration within the manufacturer's specified range. Repeat 5 times.

13.2 Load capacity. Determine maximum load capacity for the device.
Load the device in accordance with section 12.5. Increase load by adding increments of no greater than 10 kg. After each incremental increase initiate operation of the device. Record the greatest load under which the device can successfully complete a full open/close cycle.

13.3 Endurance. Load the device with 5kg mass*. (Load should reflect field load and needs to be verified by field measurement).*

It is assumed that permanently installed equipment has 25 operations per irrigation season and mobile equipment has 10 operations per season. For a equipment expected to last at least ten years, these assumptions translate into 250 and 100 operations respectively.
Permanently installed equipment shall be tested for 250 cycles, initiated by a manufacturer specified signal or procedure. Mobile equipment shall be tested for 100 cycles, initiated by a manufacturer specified signal or procedure.
Record the number of cycles completed. Record the number and nature of any failures, and number of cycles successfully completed before the occurrence of failures. If necessary, consult the manufacturer or their nominated representative to determine the cause of the failure.

After the full number of cycles specified above have been completed, carry out testing in accordance with section 13.1.

SECTION 14 INFORMATION TO BE PROVIDED BY THE MANUFACTURER

14.1 Technical information. The following information shall be provided with the equipment where applicable:

a) Operating procedures.
b) Testing procedures.
c) Servicing procedures.
d) Outlet types to which the equipment is suited.
e) System specifications including where applicable
   - Mass and size of any weights used in equipment.
   - Pressure range for pressure-operated equipment.
   - Voltage, power rating of each electrically operated component.
   - Frequency range, effective distance and power rating of radio equipment.
   - Current and insulation rating for all electrical cables or wires.
   - Pipe sizes and material.
f) Type of ancillary components and specification and quantity of replacement elements.
g) Circuit diagrams. Where necessary for installation, operation and user servicing, a circuit diagram giving the relationship of the functional elements of the equipment shall be supplied with the equipment. Circuit diagrams shall use graphical symbols from AS 1101.1, AS 1046 and AS 1102.
h) Connection points, bleed points, orifice fittings, weight suspension points and the like should be identified as applicable in regards to position, type, size, weight and purpose.

14.2 Special site conditions. In addition to the data and specifications required for system design, the purchaser shall advise the supplier of the unusual conditions that may affect the equipment such as the following:

a) Excessive pollutants, humidity, altitude, temperature, corrosive atmosphere.
b) The existence of a fire hazard.
c) The use of irrigation water of salinity greater than 2 dS/m.

14.3 Transportation.

Where the construction of the equipment necessitates transporting in sections, removed links and their corresponding terminal ports and connectors shall be identically marked.

All components shall be packaged in a manner that protects them from damage, distortion, corrosion, vibration and ingress of contaminants and preserves their identity during transport.

Exposed openings in the equipment shall be sealed against contaminant entry and male threads shall be protected.

Portable equipment should be portable. Not excessively heavy or bulky. Should meet the health and safety requirements of AS 1470.

14.4 Maintenance information.

Where applicable, the following information shall be provided by means of manuals, data sheets, marking plates and the like.

a) Details of outlet opening and closing procedures
b) Details of adjustment procedures
c) Location of lubrication points and the type of lubricant required.
d) Maintenance procedures for unique assemblies

e) Location of air bags, drains, filters, test points, strainers, motors, trip mechanisms and the like that require scheduled maintenance.
f) Parts list identifying components and assemblies which make up the equipment.
g) Spare parts list detailing the quantity and type of components, subassemblies and units recommended by the equipment manufacturer to be held in store for preventive maintenance and general repair to keep the equipment in good working condition.
h) Recommended plan for preventive maintenance.
i) Details of battery maintenance.
j) Where standard manuals and data sheets cover a range of model options, the equipment and equipment actually supplied shall be identified without ambiguity and all information not relevant shall be so marked.

APPENDIX A PNEUMATIC AND HYDRAULIC DEVICES

Tests shall be carried out in accordance with section 13.

A.1 Function

Operate the device through 5 cycles. Observe the system during testing. During each cycle components should complete their range of movements and functions and return to the appropriate finishing position. Note hydraulic or pneumatic leakages from other than intended air or water discharge or relief points.

For hydraulic devices where a range of water supply pressures is specified by the manufacturer, operate the device through 5 cycles using the maximum pressure and minimum pressure.

A.2 Load capacity

Where a range of hydraulic water supply pressures is specified by the manufacturer, load tests shall be carried out at least at each of the maximum pressure and minimum pressure.

A.3 Endurance

Where a range of hydraulic water supply pressures is specified by the manufacturer, tests shall be carried out at a pressure between the maximum and minimum operating pressures.

APPENDIX B MECHANICAL TIMER OPERATED DEVICES

Tests shall be carried out in accordance with section 13.

B.1 Function

Set mechanical timers to any time greater than one hour, within the manufacturer specified operating range, to initiate the open/close cycle.

B.2 Load capacity

B.3 Endurance

APPENDIX C ELECTRONIC AND RADIO OPERATED DEVICES

Tests shall be carried out in accordance with section 13.

C.1 Function

C.1.1 System components relying upon transmitted signals shall be operated in close proximity over 5 test cycles.

Testing of aspects of system signal transmission and reception shall be carried out separately to tests of other aspects of system function. All radiocommunications equipment used in Australia must be licensed in some way, and must also comply with the Equipment/Australian standards relevant to that licence. Systems must be assessed against the relevant licence conditions and equipment standards to determine suitability and legality for Australian use.

C.2 Load capacity

Batteries in powered systems shall be fully charges before testing and again during the test program if necessary.

C.3 Endurance

External mains supply may be used to power components or systems that would normally be battery powered, for the purpose of conducting endurance testing.

AUTOMATIC IRRIGATION EQUIPMENT FOR SURFACE IRRIGATION

Draft Standard

August 1997

Prepared by the
Australian Irrigation Technology Centre

AUTOMATIC IRRIGATION EQUIPMENT FOR SURFACE IRRIGATION

Draft Standard

CONTENTS

AUTOMATIC IRRIGATION EQUIPMENT FOR FLOOD IRRIGATION

SECTION 1 SCOPE

This standard specifies design, operational and functional requirements of automatic flood irrigation equipment, test methods and data to be supplied by the manufacturer to permit correct installation and operation in the field.

It applies to all automatic flood irrigation equipment whose operation is either hydraulic, pneumatic, radio signal, electronic signal, electronic or mechanical timing based. It develops design considerations, performance criteria and standards for equipment.

SECTION 2 REFERENCED DOCUMENTS

The following standards contain provisions which are referred to in this text and constitute provisions of this standard.

AS/NZS 1044:1995	Limits and methods of measurement of radio disturbance characteristics of electrical motor-operated and thermal appliances for household and similar purposes, electric tools and similar electric apparatus.
AS 1046	Letters and symbols for use in electrotechnology.
AS 1101.1	Graphical symbols for general engineering: Hydraulic and pneumatic systems.
AS 1102	Graphical symbols for use in electrotechnology.
AS 1174 - 1971	Methods for measurement of radio transmitters. Part 1 General conditions of measurement, frequency output power and power consumption. Part 2 Bandwidth, out-of-band power and power of non-essential operations
AS 1188-1990:	Radio transmitters and similar equipment - Safe Practices.
AS 1470	Health and Safety at Work - Principles and Practices
AS 1543	Electrical equipment of industrial machines
AS 2671:1983	Hydraulic Systems and Components.
AS 2788:1985	Pneumatic Systems and Components
AS 3000	SAA Wiring Rules
AS 4024.1 -1992	Safeguarding of machinery. Part 1 General principles.
AS 4086-1993	Secondary batteries for use with stand-alone power systems. Part 1 General requirements.
AS 4268	Radio equipment and systems - Short range devices.
AS/NZS 4355-1995	Radio communications equipment used in handphone and citizen band services operating at frequencies not exceeding 30 Mhz.

SECTION 3 DEFINITIONS

For the purposes of this performance standard, the definitions below apply.

3.1 **Automatic Flood Irrigation Equipment**: A system incorporating a device or device and sensor acting together in an irrigation system to either cause a change in the direction of flow of water or prevent the flow of water in open channels systems. From hence to be referred to as equipment.

3.2 **Permanently installed equipment**. Automatic flood irrigation equipment intended by the manufacturer for installation and use at a single location.

3.3 **Mobile equipment**. Automatic flood irrigation equipment intended to be moved to enable use at a number of locations.

3.4 **Device**. That part of an equipment (which is) mounted on an irrigation structure.

3.5 **Sensor**: That part of equipment located at a suitable position in a bay which signals the device to operate.

3.6 **Bay**: An area intended for irrigation by controlled flooding

3.7 **Bay Outlet**. A structure used to control and regulate the discharge of water from a channel on to a bay.
A structure through or over which water is discharged from a channel onto a bay.

3.8 **Channel**. An artificial watercourse for supplying water to and within farms.

3.9 **Channel check**. A mechanical structure in a channel which controls the direction of flow and/or water level.

3.10 **Culvert Pipe**. A pipe or group of pipes suitably placed to carry water underground.

3.11 **Minimum water working level**. Lowest working level declared by manufacturer at which sensor produces signal to operate outlet.

3.12 **Operation**. The action of an outlet opening or closing.

SECTION 4 CLASSIFICATION

Automatic flood irrigation equipment is grouped into three classifications (see 4.1 to 4.3) in accordance with the primary mechanism activating the device. The same mechanism may also operate the device.

4.1 **Pneumatic and hydraulic**. System where hydraulics or pneumatics are used to activate the device.

4.2 **Mechanical timer devices**. System incorporating a mechanical timer which activates the device.

4.3 **Electronic**. System activated by an electronic device. This group includes radio operated devices.

SECTION 5 MARKING

The following particulars shall be shown correctly in permanent and readily visible form on all components.

a) Name and/or identification of the manufacturer and/or supplier.
b) Type or model number.
c) Safe maximum continuously rated pressure and/or voltage.

Where lack of available space would result in lettering too small to be legible, information may be restricted to a minimum of manufacturer's name and either type number or model number. Where this is the case, all other information as set out in this Clause shall be provided in accompanying documentation.

SECTION 6 GENERAL REQUIREMENTS

6.1 Operating requirements. The equipment should comply with the following requirements:

a) Operating temperatures. The full range of ambient operating temperature to which the equipment is subjected may be 1° to 60° C. The equipment shall operate satisfactorily under these conditions.
b) Weatherproofing. Equipment intended for use outdoors must be weatherproof.
c) Water resistance and quality. Equipment should be water resistant (waterproof for immersible components) and operate satisfactorily in irrigation water, including water with salinity up to 2 dS/m. Where applicable equipment shall operate under submerged conditions.
d) Corrosion. Components of equipment which may be liable to corrosion should be adequately protected from corrosion.

6.2 Installation

a) Components shall be installed in accordance with manufacturer's recommendations and in accordance with AS 4024 *Safeguarding of Machinery Part 1 General principles.*
b) The system must be installed to ensure that all components of the system requiring user interaction are safely and easily accessible and visible to the user.
c) All components of the equipment shall be protected, where practicable, from unintentional operation.
d) Permanent equipment should be protected, for example by installation in areas fenced off from livestock and heavy vehicle loading.
e) Where applicable, equipment shall be licensed.
f) Electrical equipment and installation work shall comply with AS 1543 and AS 3000.

6.3 Components. If applicable, depending on the mode of operation, all components shall abide by AS 2788, AS 2671 and AS 4268.2 or AS/NZS 4355

SECTION 7 SAFETY

In the design of equipment, all aspects of possible operation and failure (including sensor signal transmission failure) shall be considered. Components shall be selected and applied so that during operation or in the event of failure, safety of personnel shall be the prime consideration and damage to equipment minimised.

Devices shall make provision for manual operation of the irrigation system.

Additionally,

a) all components within equipment shall operate within the manufacturer's specification;

b) the equipment shall be designed and constructed so that components are located where they are accessible, visible and can be safely adjusted and serviced;

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SECTION 8 CONSTRUCTION AND MATERIALS

8.1 Materials. Materials shall be suitable and safe for the intended purpose. Where the properties essential to the correct performance of any material are in doubt, the properties of such material shall be determined by appropriate testing. Exposed materials should not be unduly sensitive to chemicals commonly used in agriculture.

8.2 Strength. In the course of their transportation and use devices may be subjected to many conditions. For example, vibration during transportation or interference from livestock. Equipment should be robust enough for farm usage and resistant damage from vermin, stock and micro-organisms and other potential hazards.

In permanent installations, the manufacturer must specify whether devices are able to withstand loadings (for example due to vehicles or livestock) or must be protected, for example fenced off.

SECTION 9 PNEUMATIC AND HYDRAULIC DEVICES

9.1 Functional characteristics and requirements.

9.1.1 Cylinders and rams. The following shall be considered:

a) The stroke, length, loading and conditions of assembly shall be such as will prevent bending or buckling of the piston rod in the extended position.

b) Seals or seal assemblies shall be easily replaceable.

c) Cylinder ends shall be protected from impact damage due to high loads.

d) Exclusion devices shall be fitted to minimise contaminant ingress from the environment.

e) Where practicable, cylinders shall be installed with ports uppermost.

f) Every connection to pipework shall be accessible for tightening without disturbing adjacent pipelines or components, particularly where pipelines terminate in a cluster of fittings.

9.2 Installation.

a) Pipelines shall be installed so they are protected against predictable damage and do not restrict access for adjustment, repairs or replacement of components.

b) Flexible hoses shall be installed so as to have enough length to prevent sharp flexing and straining of the hose during the equipment operation.

c) Filters shall be installed where they are readily accessible and means provided for changing the filter elements without shutting down the system.

SECTION 10 MECHANICAL TIMER OPERATED DEVICES

10.1 Functional characteristics and requirements.

a) Graduations on all timer devices shall permit accurate setting of watering time to the nearest half hour or less.
b) Timing devices must permit the user to adjust the set time after an initial selection is made.
c) The system shall be protected from ingress of contaminants.
d) Components requiring maintenance by the user must be easily accessible using standard or manufacturer-supplied tools.

10.2 Installation.

Install in accordance with the requirements of section 6.2.

SECTION 11 ELECTRONIC AND RADIO OPERATED DEVICES

11.1 Functional characteristics and requirements.

a) Battery recharging. Where applicable batteries must be capable of at least ten operations before needing recharging and shall comply with AS 4086.
b) Equipment operation shall not be initiated by any chance occurrence (rain, wind etc).
c) Manufacturers using off the shelf radio communications equipment should ensure that such equipment abides by AS 4268, AS/NZS 4355:1995 and AS/NZS 1044:1995.
d) A CB radio transmitter shall be capable of operating only on a channel designated in Table 1 of AS/NZS 4355:1995.

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The manufacturer shall provide installation procedures to enable the user to attain best possible reception in environments with hills and obstructions.

SECTION 12 TEST CONDITIONS

12.1 General test conditions. Sensors shall be tested at ambient air temperature conditions.

The temperature of water used during testing shall be between 0 and 35^{o} C. If the manufacturer recommends the use of filtered water, a filter meeting the manufacturer's recommendations shall be installed to ensure compliance with those recommendations.

12.2 Accuracy of measuring devices. Water pressure, time, mass and flow rate shall be measured with an error not exceeding $\pm$2% of the actual values.

12.3 Sampling requirements. The test specimen shall be taken at random.

12.4 Test equipment. All pipes and fittings directly connected to the equipment under test shall be in accordance with the manufacturer's specifications.

12.5 Simulation of field conditions. The equipment will incorporate a device and possibly a sensor. The device, and sensor where applicable, must be set up using a bay outlet or a structure simulating a bay outlet, in accordance with manufacturer's instructions.

12.5.1 Devices intended to be used in conjunction with existing bay outlet structures. Load using a mass or mass suspended from a cable and pulley system, to simulate operation of an outlet type deemed suitable by the manufacturer. Attach the load at the manufacturer specified point.

Observe manufacturer's instructions regarding the length of slack in any cable attached to the device.

Device with hinged/pivoting arms. The load should be suspended on a cable below the attachment point when the arm is in the starting position. Pass the cable over a pulley to maintain the lateral position of the mass below the starting position of the attachment point. See Figure 1.

Device extending/retracting or winding. For example ram lifting/lowering slide gate, ram plugging/unplugging a pipe outlet. Apply load along axis of device movement. See Figure 2.

12.5.2 Devices intended for installation as part of bay outlet.

Where a device is used in the place of a flap, gate or similar part of a bay outlet, the load used for testing the device should reflect the magnitude of load likely to occur in the field. In this situation load on the device may be due, for example, to the weight of the device, enclosed water or hydrostatic pressure.

Figure 1.

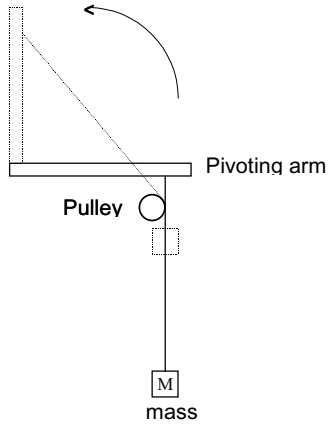
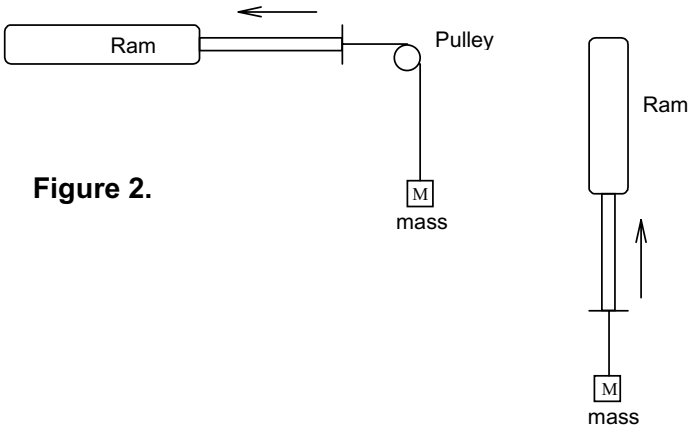


Figure 2.



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Conduct tests in the following order.

13.1 Function. Where it is intended by the manufacturer that the system be reset manually prior to each cycle, this step should be performed in accordance with manufacturer's instructions.
Observe each cycle to determine whether the device operates successfully through the full cycle and returns to the appropriate final state.

13.1.1 Systems incorporating device only. Initiate the system to operate the device through a full open/close cycle of duration within the manufacturer's specified operating range. Repeat 5 times.

13.1.2 Systems incorporating device and sensor. Apply external stimuli simulating field operation to activate the sensor, initiating a full open/close cycle of duration within the manufacturer's specified range. Repeat 5 times.

13.2 Load capacity. Determine maximum load capacity for the device.
Load the device in accordance with section 12.5. Increase load by adding increments of no greater than 10 kg. After each incremental increase initiate operation of the device. Record the greatest load under which the device can successfully complete a full open/close cycle.

13.3 Endurance. Load the device with 5kg mass*. (Load should reflect field load and needs to be verified by field measurement).*

It is assumed that permanently installed equipment has 25 operations per irrigation season and mobile equipment has 10 operations per season. For a equipment expected to last at least ten years, these assumptions translate into 250 and 100 operations respectively.
Permanently installed equipment shall be tested for 250 cycles, initiated by a manufacturer specified signal or procedure. Mobile equipment shall be tested for 100 cycles, initiated by a manufacturer specified signal or procedure.
Record the number of cycles completed. Record the number and nature of any failures, and number of cycles successfully completed before the occurrence of failures. If necessary, consult the manufacturer or their nominated representative to determine the cause of the failure.

After the full number of cycles specified above have been completed, carry out testing in accordance with section 13.1.

SECTION 14 INFORMATION TO BE PROVIDED BY THE MANUFACTURER

14.1 Technical information. The following information shall be provided with the equipment where applicable:

a) Operating procedures.
b) Testing procedures.
c) Servicing procedures.
d) Outlet types to which the equipment is suited.
e) System specifications including where applicable
   - Mass and size of any weights used in equipment.
   - Pressure range for pressure-operated equipment.
   - Voltage, power rating of each electrically operated component.
   - Frequency range, effective distance and power rating of radio equipment.
   - Current and insulation rating for all electrical cables or wires.
   - Pipe sizes and material.
f) Type of ancillary components and specification and quantity of replacement elements.
g) Circuit diagrams. Where necessary for installation, operation and user servicing, a circuit diagram giving the relationship of the functional elements of the equipment shall be supplied with the equipment. Circuit diagrams shall use graphical symbols from AS 1101.1, AS 1046 and AS 1102.
h) Connection points, bleed points, orifice fittings, weight suspension points and the like should be identified as applicable in regards to position, type, size, weight and purpose.

14.2 Special site conditions. In addition to the data and specifications required for system design, the purchaser shall advise the supplier of the unusual conditions that may affect the equipment such as the following:

a) Excessive pollutants, humidity, altitude, temperature, corrosive atmosphere.
b) The existence of a fire hazard.
c) The use of irrigation water of salinity greater than 2 dS/m.

14.3 Transportation.

Where the construction of the equipment necessitates transporting in sections, removed links and their corresponding terminal ports and connectors shall be identically marked.

All components shall be packaged in a manner that protects them from damage, distortion, corrosion, vibration and ingress of contaminants and preserves their identity during transport.

Exposed openings in the equipment shall be sealed against contaminant entry and male threads shall be protected.

Portable equipment should be portable. Not excessively heavy or bulky. Should meet the health and safety requirements of AS 1470.

14.4 Maintenance information.

Where applicable, the following information shall be provided by means of manuals, data sheets, marking plates and the like.

a) Details of outlet opening and closing procedures
b) Details of adjustment procedures
c) Location of lubrication points and the type of lubricant required.
d) Maintenance procedures for unique assemblies

e) Location of air bags, drains, filters, test points, strainers, motors, trip mechanisms and the like that require scheduled maintenance.
f) Parts list identifying components and assemblies which make up the equipment.
g) Spare parts list detailing the quantity and type of components, subassemblies and units recommended by the equipment manufacturer to be held in store for preventive maintenance and general repair to keep the equipment in good working condition.
h) Recommended plan for preventive maintenance.
i) Details of battery maintenance.
j) Where standard manuals and data sheets cover a range of model options, the equipment and equipment actually supplied shall be identified without ambiguity and all information not relevant shall be so marked.

APPENDIX A PNEUMATIC AND HYDRAULIC DEVICES

Tests shall be carried out in accordance with section 13.

A.1 Function

Operate the device through 5 cycles. Observe the system during testing. During each cycle components should complete their range of movements and functions and return to the appropriate finishing position. Note hydraulic or pneumatic leakages from other than intended air or water discharge or relief points.
For hydraulic devices where a range of water supply pressures is specified by the manufacturer, operate the device through 5 cycles using the maximum pressure and minimum pressure.

A.2 Load capacity

Where a range of hydraulic water supply pressures is specified by the manufacturer, load tests shall be carried out at least at each of the maximum pressure and minimum pressure.

A.3 Endurance

Where a range of hydraulic water supply pressures is specified by the manufacturer, tests shall be carried out at a pressure between the maximum and minimum operating pressures.

APPENDIX B MECHANICAL TIMER OPERATED DEVICES

Tests shall be carried out in accordance with section 13.

B.1 Function

Set mechanical timers to any time greater than one hour, within the manufacturer specified operating range, to initiate the open/close cycle.

B.2 Load capacity

B.3 Endurance

APPENDIX C ELECTRONIC AND RADIO OPERATED DEVICES

Tests shall be carried out in accordance with section 13.

C.1 Function

C.1.1 System components relying upon transmitted signals shall be operated in close proximity over 5 test cycles.

Testing of aspects of system signal transmission and reception shall be carried out separately to tests of other aspects of system function. All radiocommunications equipment used in Australia must be licensed in some way, and must also comply with the Equipment/Australian standards relevant to that licence. Systems must be assessed against the relevant licence conditions and equipment standards to determine suitability and legality for Australian use.

C.2 Load capacity

Batteries in powered systems shall be fully charges before testing and again during the test program if necessary.

C.3 Endurance

External mains supply may be used to power components or systems that would normally be battery powered, for the purpose of conducting endurance testing.

PERFORMANCE TESTING OF AUTOMATIC IRRIGATION EQUIPMENT FOR SURFACE IRRIGATION

Technical Report

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Contents

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Equipment manufacturers: Ian O'Brien, Geoff Fry, Neville Miles, Murray Nottle, John Padman, Richard Tallis.
Steering Committee members: Bert Bloem, Geoff Fry, Chris Hunter, Andrew Laidlaw, Alan Lavis, David Lawler, Murray Nottle, John Padman, Tony Pomeroy, Derek Poulton, David Rosenbaum

SUMMARY

There is a range of automatic flood irrigation equipment (AFIE) currently available in Australia. Benefits to both farmers who adopt the equipment and water supply authorities have been identified and it is hoped to improve the rate of adoption of AFIE.

As part of this project preliminary standards for AFIE were established, based on engineering principles and the field experience of farmers and extension officers. An evaluation of the equipment was carried out in relation to the standards, to provide objective information for farmers in equipment purchase decisions.

Manufacturers of AFIE commercially available at the commencement of the project were contacted and invited to participate. All the equipment tested was contributed by the manufacturers.

All AFIE laboratory tested during the project was shown to function in accordance with expectations based on manufacturer's specifications. Each device successfully operated through an endurance test. Maximum loading capabilities appropriate to the mode of operation were determined for each device.

Information from field evaluation of AFIE with regard to installation and reliability is also provided.

INTRODUCTION

The AITC, in collaboration with Goulburn-Murray Water, NSW Department of Agriculture, Agriculture Victoria and automatic flood irrigation equipment (AFIE) manufacturers, undertook the project *Performance Testing of Automatic Irrigation Equipment for Flood Irrigation*. The project was sponsored by the National Program for Irrigation Research and Development (NPIRD).

The project objectives were:

1. To develop performance criteria and standards for AFIE.
2. To provide an independent assessment of AFIE currently being sold in Australia.
3. To publish the results and extend to the farming community, to increase the awareness of farmers and the industry of equipment reliability, safety and maintenance.
4. To develop improved standards for AFIE, more suited to the needs of farmers.

A steering committee was established (see member list in Appendix A) to define the limits of the project, to gain manufacturers and irrigators agreement and participation in the project and to identify essential and desirable characteristics of automatic devices.

While the benefits of AFIE have been identified by farmers (many existing devices were invented by farmers), the rate of adoption of such technology is very low. For example, in the 1996 Automatic Irrigation Census for Flood Irrigation in Northern Victoria [2], only about 0.5 percent of irrigated properties in the district were identified with automated irrigation. A high proportion of properties using AFIE are dairy farms, however only about 4 percent of dairy farmers have adopted some form of automatic irrigation system.

Most farmers wait for several years after a new practice has been proven in the area before adopting the technology. There are many theories developed in regard to the acceptance of innovation. Five stages of acceptance - awareness, interest, evaluation, trial and adoption - are intensively discussed in extension related literature. [1]

In a study of attitudes of dairy farmers about the automation of flood irrigation it was found that approximately 50 percent of the 83 Murray Valley Irrigation Area farmers surveyed, had limited knowledge or no knowledge of AFIE.

The potential benefits to the farmers include reduced labour requirements, greater convenience (including uninterrupted sleep) and flexibility. An increase in irrigation water use efficiency is likely with benefits of improved pasture productivity, lowered nutrient leaching and reduced drainage flows and accession to groundwater. Other environmental benefits include lowering of potential chemical pollution of waterways, salt transport downstream and factors contributing to blue green algae blooms.

AFIE is relatively new to the irrigation industry. While some of the available equipment has been in use for several decades, many devices have become available only recently and some are still in a developmental stage. In addition many depend upon technology drawn from other industries, hence progress reflects technological advances made in other areas.

Before adopting new technology, farmers require information with which to assess their options. Particularly in a relatively new industry, sourcing objective data to use as the basis for product selection can be a time consuming and daunting process. Farmers have indicated the types of information and features that they consider most relevant in decision making.

This project aims to provide data as a valid basis for comparison and to assist farmers in decision making.

AUTOMATIC FLOOD IRRIGATION EQUIPMENT

Manufacturers of AFIE commercially available at the time were contacted and invited to participate in the project. The following devices were made available by the manufacturers and have undergone testing at the AITC. A list of manufacturers and contact details is given in Appendix B.

Hydraulic systems	- Miles Hydraulic
	- O'B Hydraulic
Pneumatic systems	- Padman Pneumatic
Mechanical Timers	- Padman Mechanical Timer
Electronic systems	- Electronic Irrigation Systems P/L
	- Vapod Electronic

This is a comparatively new industry and manufacturers are continually developing and improving their devices. Since equipment was submitted for testing several of the devices have been altered. Where this has been brought to AITC's attention, and affects or potentially affects performance characteristics that were investigated in the trial, mention has been made.

The devices represented all systems commercially available in Australia at the time with the exception of

- - the Irrigation Concepts electronic system, which was unavailable from the manufacturer for the duration of the test program.

- the Watermate Irrigation Control System, manufactured by Geoff Fry. This system uses hydraulic rams, controlled by programmable controller and low voltage solenoid valves. The system components are sourced externally for each system according to demand, rather than being constructed by the irrigation system supplier. For this reason and because there were two other hydraulic systems using rams under test, it was decided in communication with the supplier not to subject this system to laboratory testing.

In addition to the above, at the time of the project AITC was made aware of three other prototype systems still in the early stages of development. These were not sufficiently advanced to be included in the trial. Due to ongoing development, manufacturers of both these and the commercially available AFIE should be contacted for up to date details concerning their devices.

Since the trial, Baywatch Irrigation have manufactured a portable electronic system operating on a timer. The automatic equipment has a rechargeable battery operated timer and an electronic motor to raise or lower the irrigation structure.

The project did not include alarm systems placed in the bay to alert the user when water reaches that position. Alarm systems do not control the flow of water.

THE STANDARD

The preliminary standard for AFIE was based upon the observations of farmers and extension officers and the engineering principles involved. Existing relevant standards were considered and referenced where appropriate.

The content of a standard must realistically reflect the important functional characteristics and specifications of the equipment within it's scope. At the same time test procedures must be simple and easily replicated. The test procedures in the AFIE standard attempt to simulate field conditions in the laboratory, testing for important performance characteristics while eliminating many of the variables that would occur in the field.

A standard for AFIE was prepared and made available to stakeholders (farmers, equipment manufacturers, researchers) for comment in mid-1996. These people were asked to make additions, suggestions and comments regarding the standard. Their responses were considered in completion of the draft standard. A copy of the draft standard is given in Appendix C.

In summary the standard provides for specification and assessment of AFIE. under the following categories:

- Classification
- Marking
- General Requirements
- Safety
- Construction and Materials (materials and strength)
- Functional Characteristics and Requirements
- Installation
- Equipment testing
- Function. Operate the equipment through open/close cycles to determine whether the device operates successfully through the full cycle and returns to the appropriate final state.
- Load Capacity. Determine maximum load capacity for the device.
- Endurance. Operate equipment intended for permanent installation through 250 cycles, mobile equipment through 100 cycles, then retest for function.
- Information to be Provided by the Manufacturer.

EQUIPMENT SELECTION

Testing of equipment against a standard can provide information enabling a potential user to make a decision on the most suitable device for their particular application. However, the standard only covers attributes of the device itself. In making a decision the user must also assess other factors.

For example, proximity of the equipment supplier, the services offered (such as installation options and after sales service), their reputation and product backup, should all be considered. The type of equipment purchased will determine the scope, location, time frame and cost of repairs, should difficulties or damage occur.
Depending upon the technology involved, some systems may be repaired on site by the farmer while others require specialist attention. Should the need arise in the future will it be possible to extend or upgrade the system and is the AFIE compatible with other types of equipment?

With regard to the device itself, suitability for an application or location needs to be assessed. Equipment must be used for an appropriate purpose to perform well.

The AFIE provided by the manufacturers was evaluated by the methods outlined in the draft standard. Assessment of the equipment was carried out alongside development of the draft standard and hence was instrumental in developing some sections of the document.

While undergoing testing at the AITC, systems were also assessed for features likely to be of importance to the farmer as selection criteria. For example, suitable applications of the system, features critical to reliable operation, and potential degree of automation. These results are presented in this report in a summary table to give the reader an overview and appreciation of all devices. (See Table 1.)

Table 1.

System	Suitable outlet types	External influences critical to operation	System fixed or portable	Potential degree of automation	Irrigation duration control	Mode of activation
Hydraulic systems - Miles - O'B -Watermate Irrigation Control	Most outlets Any outlet Most outlets	Water supply pressure Water supply pressure	Fixed Fixed Fixed	7 day span auto cycle Auto cycle Auto cycle	Timer Bay sensor Timer	Water computer controls water to hydraulic ram. Timer and bay sensors control the water pressure that activates a valve controlling a hydraulic ram. Controller and solenoid valves control hydraulic rams.
Pneumatic systems - Padman	Pipe or flap		Fixed	Auto cycle	Bay sensor	Bay sensor signal transmitted by air pressure. Timer or manual start.
Mechanical systems - Padman	Pipe or flap		Portable	Auto cycle	Timer	Mechanical timers open and close gate.
Electronic systems - Electronic Irrigation Systems P/L - Vapod Baywatch Irrigation	All doors Rectangular gate Rectangular gate or flap		Portable Portable Portable	Full cycle One bay	Bay sensor Bay sensor with timer backup Timer	Bay sensor transmits radio signal to door controller. Tank on gate empties to open gate, fills with water again to close.

Part 1 EQUIPMENT ASSESSMENT RESULTS

1.1 Classification

Automatic flood irrigation equipment currently available in Australia can be grouped into three classifications.

- Pneumatic and hydraulic devices. Use hydraulics or pneumatics to activate the bay outlet.
- Mechanical timer devices. Bay outlet is activated by a mechanical timer.
- Electronic. Bay outlet is activated by an electronic device (includes radio operated devices).

Pneumatic systems	- Padman Pneumatic
Hydraulic systems	- Miles Hydraulic
	- O'B Hydraulic
Mechanical timers	- Padman Mechanical Timer
Electronic systems	- Electronic Irrigation Systems P/L
	- Vapod Electronic

1.2 Marking

Of the above systems, the manufacturer was identified on all equipment except the Miles. Only the Electronic Irrigation Systems device was identified with a model number. The safe maximum rated pressure was not readily visible on any of the hydraulic systems.

1.3 Safety

The most likely result of failure of AFIE is non-occurrence of a planned irrigation. However maintenance checks must be carried out to ensure that equipment continues to function safely and reliably. Safety depends not only on the equipment but also on the installer and user.

During use any equipment should be approached with caution and care should be taken to keep clear of rams and other moving parts during operation. Components acting suddenly and with force, such as the pneumatic rams on the Padman devices, should be installed on protected sites for the safety of both device and animals. Maintenance should include checks to ensure that fastenings such as the bolts securing the pneumatic rams, do not loosen.

All of the electronic equipment operates on low voltages using rechargeable batteries.

1.4 Functional characteristics and requirements.

1.4.1 Pneumatic and hydraulic devices.

Fittings on all devices were adequately accessible to allow easy installation and use during testing at the AITC.

Hydraulic devices. The water supply to hydraulic devices should be contaminant free and filtration used if necessary to protect:
- Miles: The Nylex Gardena Water computer and Water Distributor
- O'B: The O'B valve.

Pneumatic devices. The air lines to pneumatic devices should meet manufacturer's installation and diameter recommendations to ensure that condensation does not cause blockages.

1.4.2 Mechanical Timers

Adjustment to reduce set time on the mechanical timer on the Padman system is possible but not recommended. The dial of the timer itself has graduations of half an hour and a range from 0 to 24 hours on both start and stop timers.

1.4.3 Electronic devices

The Electronic Irrigation Systems P/L system was operated at the AITC using an external power supply to enable endurance testing. However, the manufacturer expects the bay sensor and door controller battery to last up to 5 days without charging. The receiver may be left plugged into the charger all the time.

The Electronic Irrigation Systems P/L has Type Approval from the Department of Transport and Communications for their door controller.

1.5 Information to be provided by the manufacturer

In order to acquire, install, operate and maintain equipment to it's full potential, the user must have access to clear, concise instructions and information. This is also in the best interests of the manufacturer and distributor, to minimise unnecessary interaction and maximise consumer satisfaction. It should be assumed that the reader has only limited knowledge.

The capabilities of standard office equipment and printing services now available are such that any AFIE manufacturer can provide tidy, well presented literature. The content of the literature, however, may require a little may forethought in order to effectively cover all of the necessary issues and information. The draft standard lists many types of information that should be included.

The standard of presentation and content of literature provided with tested equipment varied. It must be kept in mind that the equipment supplied for testing is in various stages of development and marketing, from sources having very different aims in the irrigation market place. The potential benefits from each system are not necessarily reflected in the scale of the marketing effort. At one end of the scale the system comprises a significant product in the range distributed by a commercial irrigation equipment supplier. At the other extreme, the equipment was initially made by an irrigator as a cost-effective solution to an irrigation requirement. The devices are now constructed and supplied as an interest rather than a competitive commercial venture.

The literature provided is developing alongside the AFIE and upon request AITC received additional written information concerning several systems, while the project was in progress. The information provided in most cases was adequate and was assessed as follows when compared to the data to be provided by the manufacturer, listed in the draft standard.

Electronic Irrigation Systems P/L.	Good
Padman pneumatic/hydraulic.	Limited to installation.
Miles.	Good.
Vapod.	Good.
O'B.	Satisfactory

It has been observed that problems which occur with the more reliable AFIE tend to be the fault of the operator. Manufacturers may like to upgrade the standard of organisation and presentation of their instructions and information, in light of this.

Part 2 EQUIPMENT TESTING

Laboratory testing of six systems was carried out at the AITC, with field information on AFIE gathered by Agriculture Victoria, with assistance from Goulburn-Murray Water. [2].

Goulburn-Murray Water, NSW Agriculture and Agriculture Victoria staff have regular communication with farmers using automatic flood irrigation equipment in the field. The field information presented in this report is a summary of general knowledge and specific information gathering activities, presented in relation to the different categories of automatic flood irrigation equipment (hydraulic, pneumatic, mechanical etc).

2.1 Field Evaluation

The following section concerning field evaluation of AFIE presents information from a census of irrigators in the gravity irrigated area of Northern Victoria. [2] The census identified 37 systems which are currently available on the market, being used on farms.

Installation

Most of the irrigation systems were rated as relatively easy or easier to install. The systems that were rated difficult or very difficult to install were accounted for by only three of twentyone irrigators who had systems which involve burying polythene pipe into the ground (hydraulic and pneumatic systems).

Two thirds of the irrigators said they had problems with their automatic irrigation system immediately after installation. These initial problems were not specific to any one type of automation. Two thirds of those who experienced these problems said they were easily fixed. Generally hydraulic and pneumatic systems and mechanical timers could be repaired by the irrigator. Electronic systems were more difficult to repair and in most cases needed to be returned to the manufacturer to be repaired.

Channel maintenance. There is a need to increase maintenance of channels and equipment to ensure that the equipment works correctly. Channels should be fenced to protect automatic units from stock damage. Weeds need to be kept to a minimum to allow the channel to operate efficiently.

Reliability of systems

Overall 32 of 37 systems were rated as reliable or better while five farmers said their system was unreliable or totally unreliable. The full range different types of AFIE (hydraulic, pneumatic, mechanical and electronic systems) received unreliable ratings.

36 of the 37 systems were rated as relatively simple or simple to operate. The remaining system was not working and the operator rated it as difficult to operate.

Hydraulic systems. Water pressure is used to transmit signals from sensors to outlet structures, operate valves and drive hydraulic rams, opening or closing bay outlets. The available water supply must consistently meet manufacturer's requirements for hydraulic systems to function reliably.

Pneumatic systems. Pneumatic systems use air pressure to open or close bay outlets. Condensation in the air tube can cause failure to operate. Using larger diameter tube helps to avoid this problem.

Electronic systems. A radio signal transmitted from a bay sensor activates an electronic unit to open or close the bay outlet structure. Electronic systems depend upon rechargeable batteries.

A number of irrigators pointed out that automatic irrigation is only as reliable as the operator and particular care needs to be taken to install the system correctly, to maintain it and to set the system up correctly for irrigation.

Often failures of AFIE are due to human error in setting and maintaining systems. Manual systems can also have failures with alarm clocks failing to wake irrigators and irrigators forgetting to open or close structures.

Water use

66 percent of irrigators said that they use less water after installing automation and 67 percent of irrigators said they had reduced irrigation runoff. It was difficult for irrigators to estimate by how much water use and runoff were reduced. It was pointed out that reductions in water use and runoff were dependent on the standard of irrigation management prior to the installation of automation.

Irrigators believed they had reduced water use because:

- Water was being shut off at a more accurate point down the bay. It was felt that with automation more attention was being paid to the point at which water was shut off down the bay and runoff was reduced because of this.
- Individual bays were being watered more quickly and less water was being absorbed into the soil, particularly on sandy soils.
- An element of human error was eliminated with automation. With manual irrigation there was a chance that irrigators would sleep in or temporarily forget to switch the water on to another bay.

It was concluded from the results of the census that some very reliable systems of automatic irrigation have been developed and have performed to the satisfaction of irrigators in Northern Victoria.

2.2 Laboratory Testing

Test results are summarised in Table 2.

Equipment was evaluated in the laboratory in relation to the preliminary standard under the following categories.

- Function
- Load capacity
- Endurance

During testing field conditions were simulated while attempting to eliminate variables, thus providing repeatable test procedures. For example, masses replaced hydraulic loads and bay outlets such as sliding gates or flaps, unless the gate was an integral part of the automatic

device. Pulley systems were used to apply loads in the horizontal direction where appropriate.

Equipment was operated within manufacturer's specified operating ranges. Systems incorporating a sensor were initiated by applying external stimuli simulating field conditions.

The equipment testing focused on the devices and sensors for each system. Following is a list of the system components tested for each manufacturer.

Miles Hydraulic.	Ram with bucket. Nylex Water Distributor.
O'B Hydraulic.	O'B valve and ram.
Padman Pneumatic.	Double acting Padman pneumatic controller.
Padman Mechanical Timer.	Padman autotimer.
Electronic Irrigation Systems P/L	Bay sensor and door controller.
Vapod Electronic	Sensor and swinging bay gate/tank.

Function

Each device was operated through a full cycle to ensure that the device performed successfully and ended in the appropriate final state.

All devices passed this test with the exception that the battery supplied in the prototype Vapod bay sensor was not functioning and was substituted for using an external power supply. The manufacturer has since further developed the rechargeable battery power supply and solar panel.

Load capacity

Some devices are intended to be used with existing irrigation structures, others replace part of the irrigation structure. When added to an existing irrigation structure, the loads on the devices will vary from installation to installation. Some loads will depend on the type of outlet structure and it's state of repair. Load may be contributed to by hydrostatic pressure or a slide gate jamming, for example.

For some devices the potential load has an upper limit because of the way the device works, rather than the irrigation structures it is installed with. In this case it would be inappropriate to compare devices on the basis of maximum load capacity. Instead, consider whether the devices are able to meet the likely load requirements for the field situation where they are to be used. Maximum load in the field may be relatively constant, perhaps due to hydrostatic forces and the mass of the device.

The Miles ram and bucket in a pipe outlet or Vapod gate and tank are examples where the gate is an integral part of the automatic device and replaces part of the bay outlet structure. Similarly, the load on any device used with a Padman flap will be limited because a hinged device that replaces a sliding bay gate will not need to overcome the potential load of that gate jamming.

Some devices may be loaded both when opening and shutting a bay outlet, while others have little or no load to overcome while carrying out one of these operations. This was taken into account in determining load capacity. For example, the Padman devices both allow an outlet to fall open and need only apply force when closing a bay outlet. They were tested for load capacity of the power (closing) arm only.

There are variables in the way a device is set up that influence performance capabilities, even within the manufacturers recommended operating range. This was assessed.

Hydraulic devices were tested at the both the upper and lower limits of the manufacturer specified operating pressure range to determine the effect on ability to function and on maximum load capacity. The Miles device may be installed horizontally or vertically and was tested for load capacity both while extending and retracting. Travel time for the O'B device was significantly affected by load and was therefore recorded.

The length of slack in cable to be taken up before the pivoting power arm was loaded was varied for both Padman devices.

Devices were tested for load capacity following endurance testing.

Endurance

Permanently installed equipment was tested for a minimum of 250 cycles, mobile equipment for a minimum of 100 cycles. This was based on the assumption that equipment could be expected to last 10 years with 25 operations a year for permanent and 10 operations a year for mobile AFIE. Where external loading was applicable a 5kg mass was used.

All AFIE endurance tested completed at least 4 times the number of cycles expected in 10 years successfully. None failed during endurance testing.

Table 2.

Device	Function	Load capacity (kg)			Endurance	
Padman pneumatic	*Pass*	Lift *4.1kg* *16* *33*	Cable length *No slack* *0.1m slack* *0.2m slack*		*250 cycles* *Pass*	
Miles hydraulic	*Pass*	Pressure [1] *30PSI (207kPa)* *50PSI (345kPa)*	Extend ram (horizontal) *57kg* *101*	Retract ram (horizontal) *50kg* *92*	*1014 cycles* *Pass*	
O'B hydraulic	*Pass*	Pressure *20PSI (138kPa)* *50PSI (345kPa)*	Retract ram (lift) *76kg max load* *38.5* *0* *242kg max load* *121* *0*	Travel time (minutes) *36 min lift, 2 min lower* *5 min lift , 3 min lower* *Valve not switching* [2] *38 min lift* *4 min lift* *2 min lift, 3 min lower*	*1011 cycles* *Pass*	
Padman mechanical timer	*Pass*	Lift *10.6kg* *16* *18*	Cable length *No slack* *0.1m slack* *0.2m slack*		*200 cycles* *Pass*	
Electronic Irrigation Systems P/L	*Pass*	*Lift 18kg*			*1036 cycles* *Pass*	
Vapod electronic	*Pass*	n/a			See 3. below	

Notes

1. **Miles.** Maximum expected loads in the field for a Miles ram installed in a pipe outlet:
   - Horizontal ram. Max load due to hydrostatic pressure on bucket with 0.45m water depth over ram is approx 32kg.
   - Vertical ram. Max load due to lifting 12" pot full of water is approx 20kg.
2. **O'B.** At 20PSI (138kPa) supply pressure, O'B valve would not switch ports. Switched ports successfully at 150kPa. Travel time to lift was significantly affected by load. Manufacturer has since modified the O'B valve.
3. **Vapod.** The Vapod gate/tank replaces the rectangular gate in a bay outlet. Load is due to hydrostatic pressure and self weight. Load capacity testing is therefore irrelevant for this device. As a prototype device at that stage, endurance testing was not carried out.

REFERENCES

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[4] Automatic Irrigation 1992. Gill Fry and Derek Poulton. Rural Water Corporation.

[5] Automatic Irrigation Survey. Gill Fry. 1992.

Appendix A . Steering committee members

Title	First Name	Last Name	Organisation	Address	Location	Post Code	State
Mr	Jeremy	CAPE	AITC	The Levels Campus	POORAKA	SA	5095
Mr	Alan	LAVIS	Goulburn-Murray Water	PO Box 165	TATURA	VIC	3616
Mr	Derek	POULTON	Goulburn-Murray Water	PO Box 165	TATURA	VIC	3616
Mr	David	LAWLER	Agriculture Victoria	225 Packenham St	ECHUCA	VIC	3564
Mr	Chris	HUNTER		RMB 3810	KYABRAM	VIC	3620
Mr	David	ROSENBAUM	NSW Agriculture	PO Box 736	DENILIQUIN	NSW	2710
Mr	Tony	POMEROY		Calawarra	DENILIQUIN	NSW	2710
Mr	Andrew	LAIDLAW	Irrigation Concepts	Level 1, 54 Malop St	GEELONG	VIC	3220
Mr	John	PADMAN	Precision Irrigation	Murray Valley Hway	STRATHMERTON	VIC	3641
Mr	Geoff	FRY	F & F Irrigation	King Albert Avenue	LEITCHVILLE	VIC	3567
Mr	Murray	NOTTLE	Vapod Engineering	8/37 Oak Street	ASHFIELD	NSW	2131
Mr	Bert	BLOEM	Solar Irri-Gate	15 Cedar Street	LEETON	NSW	2705

Appendix B . Manufacturers of Automatic Flood Irrigation Equipment.

This list includes manufacturers of several devices that have become available since the start of the project.

Manufacturer	Contact name	Address	Phone/fax
Miles	Neville Miles	RMB 2442 Kyabram, VIC 3620	ph 03 5826 0367 mobile 015 848 849
O'B Automation Irrigation	Ian O'Brien	Findlays Rd Leitchville, VIC 3567	ph/fax 03 5456 7439
Precision Irrigation	John Padman	Murray Valley Highway Strathmerton, VIC 3641	ph 03 5874 5282 fax 03 5874 5685
Electronic Irrigation Systems P/L	Richard Tallis	PO Box 10, Dookie VIC 3646	ph 03 5828 6393 fax 03 5828 6457 mobile 015 344 700
Vapod Engineering	Murray Nottle	8/37 Oak Street Ashfield, NSW 2131	ph/fax 02 9799 6514 mobile 014 838 934
Baywatch Irrigation	Chris & Nancy Kay Rod & Carol McFadzean	RMB 2450 Kyabram, VIC RMB 2022 Undera, VIC 3629	ph 5855 2470 ph 5826 0447
F&F Irrigation	Geoff Fry	King Albert Street Leitchville, VIC 3567	ph 018 997 168 fax 03 5456 7558

Appendix C . AUTOMATIC FLOOD IRRIGATION EQUIPMENT

DRAFT STANDARD

CONTENTS

AUTOMATIC FLOOD IRRIGATION EQUIPMENT

SECTION 1 SCOPE

This standard specifies design, operational and functional requirements of automatic flood irrigation equipment, test methods and data to be supplied by the manufacturer to permit correct installation and operation in the field.

It applies to all automatic flood irrigation equipment whose operation is either hydraulic, pneumatic, radio signal, electronic signal, electronic or mechanical timing based. It develops design considerations, performance criteria and standards for equipment.

SECTION 2 REFERENCED DOCUMENTS

The following standards contain provisions which are referred to in this text and constitute provisions of this standard.

AS/NZS 1044:1995	Limits and methods of measurement of radio disturbance characteristics of electrical motor-operated and thermal appliances for household and similar purposes, electric tools and similar electric apparatus.
AS 1046	Letters and symbols for use in electrotechnology.
AS 1101.1	Graphical symbols for general engineering: Hydraulic and pneumatic systems.
AS 1102	Graphical symbols for use in electrotechnology.
AS 1174 - 1971	Methods for measurement of radio transmitters. Part 1 General conditions of measurement, frequency output power and power consumption. Part 2 Bandwidth, out-of-band power and power of non-essential operations
AS 1188-1990:	Radio transmitters and similar equipment - Safe Practices.
AS 1470	Health and Safety at Work - Principles and Practices
AS 1543	Electrical equipment of industrial machines
AS 2671:1983	Hydraulic Systems and Components.
AS 2788:1985	Pneumatic Systems and Components
AS 3000	SAA Wiring Rules
AS 4024.1 -1992	Safeguarding of machinery. Part 1 General principles.
AS 4086-1993	Secondary batteries for use with stand-alone power systems. Part 1 General requirements.
AS 4268	Radio equipment and systems - Short range devices.
AS/NZS 4355-1995	Radio communications equipment used in handphone and citizen band services operating at frequencies not exceeding 30 Mhz.

SECTION 3 DEFINITIONS

For the purposes of this performance standard, the definitions below apply.

3.1 **Automatic Flood Irrigation Equipment**: A system incorporating a device or device and sensor acting together in an irrigation system to either cause a change in the direction of flow of water or prevent the flow of water in open channels systems. From hence to be referred to as equipment.

3.2 **Permanently installed equipment**. Automatic flood irrigation equipment intended by the manufacturer for installation and use at a single location.

3.3 **Mobile equipment**. Automatic flood irrigation equipment intended to be moved to enable use at a number of locations.

3.4 **Device**. That part of an equipment (which is) mounted on an irrigation structure.

3.5 **Sensor**: That part of equipment located at a suitable position in a bay which signals the device to operate.

3.6 **Bay**: An area intended for irrigation by controlled flooding

3.7 **Bay Outlet**. A structure used to control and regulate the discharge of water from a channel on to a bay.
A structure through or over which water is discharged from a channel onto a bay.

3.8 **Channel**. An artificial watercourse for supplying water to and within farms.

3.9 **Channel check**. A mechanical structure in a channel which controls the direction of flow and/or water level.

3.10 **Culvert Pipe**. A pipe or group of pipes suitably placed to carry water underground.

3.11 **Minimum water working level**. Lowest working level declared by manufacturer at which sensor produces signal to operate outlet.

3.12 **Operation**. The action of an outlet opening or closing.

SECTION 4 CLASSIFICATION

Automatic flood irrigation equipment is grouped into three classifications (see 4.1 to 4.3) in accordance with the primary mechanism activating the device. The same mechanism may also operate the device.

4.1 **Pneumatic and hydraulic**. System where hydraulics or pneumatics are used to activate the device.

4.2 **Mechanical timer devices**. System incorporating a mechanical timer which activates the device.

4.3 **Electronic**. System activated by an electronic device. This group includes radio operated devices.

SECTION 5 MARKING

The following particulars shall be shown correctly in permanent and readily visible form on all components.

a) Name and/or identification of the manufacturer and/or supplier.
b) Type or model number.
c) Safe maximum continuously rated pressure and/or voltage.

Where lack of available space would result in lettering too small to be legible, information may be restricted to a minimum of manufacturer's name and either type number or model number. Where this is the case, all other information as set out in this Clause shall be provided in accompanying documentation.

SECTION 6 GENERAL REQUIREMENTS

6.1 Operating requirements. The equipment should comply with the following requirements:

a) Operating temperatures. The full range of ambient operating temperature to which the equipment is subjected may be 1° to 60° C. The equipment shall operate satisfactorily under these conditions.
b) Weatherproofing. Equipment intended for use outdoors must be weatherproof.
c) Water resistance and quality. Equipment should be water resistant (waterproof for immersible components) and operate satisfactorily in irrigation water, including water with salinity up to 2 dS/m. Where applicable equipment shall operate under submerged conditions.
d) Corrosion. Components of equipment which may be liable to corrosion should be adequately protected from corrosion.

6.2 Installation

a) Components shall be installed in accordance with manufacturer's recommendations and in accordance with AS 4024 *Safeguarding of Machinery Part 1 General principles.*
b) The system must be installed to ensure that all components of the system requiring user interaction are safely and easily accessible and visible to the user.
c) All components of the equipment shall be protected, where practicable, from unintentional operation.
d) Permanent equipment should be protected, for example by installation in areas fenced off from livestock and heavy vehicle loading.
e) Where applicable, equipment shall be licensed.
f) Electrical equipment and installation work shall comply with AS 1543 and AS 3000.

6.3 Components. If applicable, depending on the mode of operation, all components shall abide by AS 2788, AS 2671 and AS 4268.2 or AS/NZS 4355

SECTION 7 SAFETY

In the design of equipment, all aspects of possible operation and failure (including sensor signal transmission failure) shall be considered. Components shall be selected and applied so that during operation or in the event of failure, safety of personnel shall be the prime consideration and damage to equipment minimised.

Devices shall make provision for manual operation of the irrigation system.

Additionally,

a) all components within equipment shall operate within the manufacturer's specification;

b) the equipment shall be designed and constructed so that components are located where they are accessible, visible and can be safely adjusted and serviced;

c) all matters pertaining to safety shall comply with the requirements of the relevant Statutory Authority, AS 4024 Part 1 and AS 1188.

SECTION 8 CONSTRUCTION AND MATERIALS

8.1 Materials. Materials shall be suitable and safe for the intended purpose. Where the properties essential to the correct performance of any material are in doubt, the properties of such material shall be determined by appropriate testing. Exposed materials should not be unduly sensitive to chemicals commonly used in agriculture.

8.2 Strength. In the course of their transportation and use devices may be subjected to many conditions. For example, vibration during transportation or interference from livestock. Equipment should be robust enough for farm usage and resistant damage from vermin, stock and micro-organisms and other potential hazards.

In permanent installations, the manufacturer must specify whether devices are able to withstand loadings (for example due to vehicles or livestock) or must be protected, for example fenced off.

SECTION 9 PNEUMATIC AND HYDRAULIC DEVICES

9.1 Functional characteristics and requirements.

9.1.1 Cylinders and rams. The following shall be considered:

a) The stroke, length, loading and conditions of assembly shall be such as will prevent bending or buckling of the piston rod in the extended position.

b) Seals or seal assemblies shall be easily replaceable.

c) Cylinder ends shall be protected from impact damage due to high loads.

d) Exclusion devices shall be fitted to minimise contaminant ingress from the environment.

e) Where practicable, cylinders shall be installed with ports uppermost.

f) Every connection to pipework shall be accessible for tightening without disturbing adjacent pipelines or components, particularly where pipelines terminate in a cluster of fittings.

9.2 Installation.

a) Pipelines shall be installed so they are protected against predictable damage and do not restrict access for adjustment, repairs or replacement of components.

b) Flexible hoses shall be installed so as to have enough length to prevent sharp flexing and straining of the hose during the equipment operation.

c) Filters shall be installed where they are readily accessible and means provided for changing the filter elements without shutting down the system.

SECTION 10 MECHANICAL TIMER OPERATED DEVICES

10.1 Functional characteristics and requirements.

a) Graduations on all timer devices shall permit accurate setting of watering time to the nearest half hour or less.
b) Timing devices must permit the user to adjust the set time after an initial selection is made.
c) The system shall be protected from ingress of contaminants.
d) Components requiring maintenance by the user must be easily accessible using standard or manufacturer-supplied tools.

10.2 Installation.

Install in accordance with the requirements of section 6.2.

SECTION 11 ELECTRONIC AND RADIO OPERATED DEVICES

11.1 Functional characteristics and requirements.

a) Battery recharging. Where applicable batteries must be capable of at least ten operations before needing recharging and shall comply with AS 4086.
b) Equipment operation shall not be initiated by any chance occurrence (rain, wind etc).
c) Manufacturers using off the shelf radio communications equipment should ensure that such equipment abides by AS 4268, AS/NZS 4355:1995 and AS/NZS 1044:1995.
d) A CB radio transmitter shall be capable of operating only on a channel designated in Table 1 of AS/NZS 4355:1995.

11.2 Installation

The manufacturer shall provide installation procedures to enable the user to attain best possible reception in environments with hills and obstructions.

SECTION 12 TEST CONDITIONS

12.1 General test conditions. Sensors shall be tested at ambient air temperature conditions.
The temperature of water used during testing shall be between 0 and 35° C. If the manufacturer recommends the use of filtered water, a filter meeting the manufacturer's recommendations shall be installed to ensure compliance with those recommendations.

12.2 Accuracy of measuring devices. Water pressure, time, mass and flow rate shall be measured with an error not exceeding ±2% of the actual values.

12.3 Sampling requirements. The test specimen shall be taken at random.

12.4 Test equipment. All pipes and fittings directly connected to the equipment under test shall be in accordance with the manufacturer's specifications.

12.5 Simulation of field conditions. The equipment will incorporate a device and possibly a sensor. The device, and sensor where applicable, must be set up using a bay outlet or a structure simulating a bay outlet, in accordance with manufacturer's instructions.

12.5.1 Devices intended to be used in conjunction with existing bay outlet structures. Load using a mass or mass suspended from a cable and pulley system, to simulate operation of an outlet type deemed suitable by the manufacturer. Attach the load at the manufacturer specified point.
Observe manufacturer's instructions regarding the length of slack in any cable attached to the device.

Device with hinged/pivoting arms. The load should be suspended on a cable below the attachment point when the arm is in the starting position. Pass the cable over a pulley to maintain the lateral position of the mass below the starting position of the attachment point. See Figure 1.

Device extending/retracting or winding. For example ram lifting/lowering slide gate, ram plugging/unplugging a pipe outlet. Apply load along axis of device movement. See Figure 2.

12.5.2 Devices intended for installation as part of bay outlet.
Where a device is used in the place of a flap, gate or similar part of a bay outlet, the load used for testing the device should reflect the magnitude of load likely to occur in the field. In this situation load on the device may be due, for example, to the weight of the device, enclosed water or hydrostatic pressure.

Figure 1.

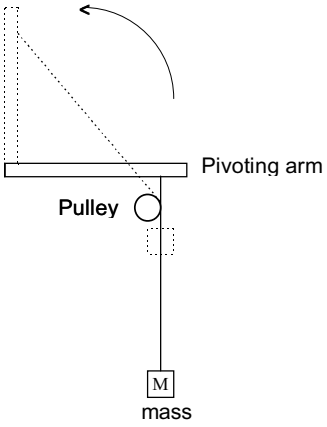
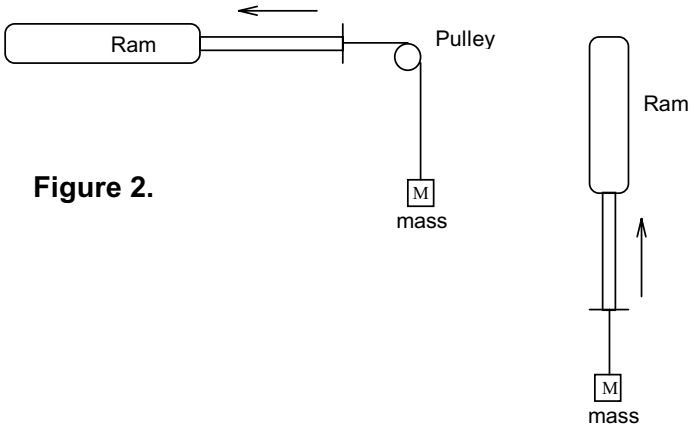


Figure 2.



SECTION 13 TEST METHODS AND REQUIREMENTS

Conduct tests in the following order.

13.1 Function. Where it is intended by the manufacturer that the system be reset manually prior to each cycle, this step should be performed in accordance with manufacturer's instructions.
Observe each cycle to determine whether the device operates successfully through the full cycle and returns to the appropriate final state.

13.1.1 Systems incorporating device only. Initiate the system to operate the device through a full open/close cycle of duration within the manufacturer's specified operating range. Repeat 5 times.

13.1.2 Systems incorporating device and sensor. Apply external stimuli simulating field operation to activate the sensor, initiating a full open/close cycle of duration within the manufacturer's specified range. Repeat 5 times.

13.2 Load capacity. Determine maximum load capacity for the device.
Load the device in accordance with section 12.5. Increase load by adding increments of no greater than 10 kg. After each incremental increase initiate operation of the device. Record the greatest load under which the device can successfully complete a full open/close cycle.

13.3 Endurance. Load the device with 5kg mass*. (Load should reflect field load and needs to be verified by field measurement).*

It is assumed that permanently installed equipment has 25 operations per irrigation season and mobile equipment has 10 operations per season. For a equipment expected to last at least ten years, these assumptions translate into 250 and 100 operations respectively.
Permanently installed equipment shall be tested for 250 cycles, initiated by a manufacturer specified signal or procedure. Mobile equipment shall be tested for 100 cycles, initiated by a manufacturer specified signal or procedure.
Record the number of cycles completed. Record the number and nature of any failures, and number of cycles successfully completed before the occurrence of failures. If necessary, consult the manufacturer or their nominated representative to determine the cause of the failure.

After the full number of cycles specified above have been completed, carry out testing in accordance with section 13.1.

SECTION 14 INFORMATION TO BE PROVIDED BY THE MANUFACTURER

14.1 Technical information. The following information shall be provided with the equipment where applicable:

a) Operating procedures.
b) Testing procedures.
c) Servicing procedures.
d) Outlet types to which the equipment is suited.
e) System specifications including where applicable
   - Mass and size of any weights used in equipment.
   - Pressure range for pressure-operated equipment.
   - Voltage, power rating of each electrically operated component.
   - Frequency range, effective distance and power rating of radio equipment.
   - Current and insulation rating for all electrical cables or wires.
   - Pipe sizes and material.
f) Type of ancillary components and specification and quantity of replacement elements.
g) Circuit diagrams. Where necessary for installation, operation and user servicing, a circuit diagram giving the relationship of the functional elements of the equipment shall be supplied with the equipment. Circuit diagrams shall use graphical symbols from AS 1101.1, AS 1046 and AS 1102.
h) Connection points, bleed points, orifice fittings, weight suspension points and the like should be identified as applicable in regards to position, type, size, weight and purpose.

14.2 Special site conditions. In addition to the data and specifications required for system design, the purchaser shall advise the supplier of the unusual conditions that may affect the equipment such as the following:

a) Excessive pollutants, humidity, altitude, temperature, corrosive atmosphere.
b) The existence of a fire hazard.
c) The use of irrigation water of salinity greater than 2 dS/m.

14.3 Transportation.

Where the construction of the equipment necessitates transporting in sections, removed links and their corresponding terminal ports and connectors shall be identically marked.

All components shall be packaged in a manner that protects them from damage, distortion, corrosion, vibration and ingress of contaminants and preserves their identity during transport.

Exposed openings in the equipment shall be sealed against contaminant entry and male threads shall be protected.

Portable equipment should be portable. Not excessively heavy or bulky. Should meet the health and safety requirements of AS 1470.

14.4 Maintenance information.

Where applicable, the following information shall be provided by means of manuals, data sheets, marking plates and the like.

a) Details of outlet opening and closing procedures
b) Details of adjustment procedures
c) Location of lubrication points and the type of lubricant required.
d) Maintenance procedures for unique assemblies

e) Location of air bags, drains, filters, test points, strainers, motors, trip mechanisms and the like that require scheduled maintenance.
f) Parts list identifying components and assemblies which make up the equipment.
g) Spare parts list detailing the quantity and type of components, subassemblies and units recommended by the equipment manufacturer to be held in store for preventive maintenance and general repair to keep the equipment in good working condition.
h) Recommended plan for preventive maintenance.
i) Details of battery maintenance.
j) Where standard manuals and data sheets cover a range of model options, the equipment and equipment actually supplied shall be identified without ambiguity and all information not relevant shall be so marked.

APPENDIX A PNEUMATIC AND HYDRAULIC DEVICES

Tests shall be carried out in accordance with section 13.

A.1 Function

Operate the device through 5 cycles. Observe the system during testing. During each cycle components should complete their range of movements and functions and return to the appropriate finishing position. Note hydraulic or pneumatic leakages from other than intended air or water discharge or relief points.

For hydraulic devices where a range of water supply pressures is specified by the manufacturer, operate the device through 5 cycles using the maximum pressure and minimum pressure.

A.2 Load capacity

Where a range of hydraulic water supply pressures is specified by the manufacturer, load tests shall be carried out at least at each of the maximum pressure and minimum pressure.

A.3 Endurance

Where a range of hydraulic water supply pressures is specified by the manufacturer, tests shall be carried out at a pressure between the maximum and minimum operating pressures.

APPENDIX B MECHANICAL TIMER OPERATED DEVICES

Tests shall be carried out in accordance with section 13.

B.1 Function

Set mechanical timers to any time greater than one hour, within the manufacturer specified operating range, to initiate the open/close cycle.

B.2 Load capacity

B.3 Endurance

APPENDIX C ELECTRONIC AND RADIO OPERATED DEVICES

Tests shall be carried out in accordance with section 13.

C.1 Function

C.1.1 System components relying upon transmitted signals shall be operated in close proximity over 5 test cycles.

Testing of aspects of system signal transmission and reception shall be carried out separately to tests of other aspects of system function. All radiocommunications equipment used in Australia must be licensed in some way, and must also comply with the Equipment/Australian standards relevant to that licence. Systems must be assessed against the relevant licence conditions and equipment standards to determine suitability and legality for Australian use.

C.2 Load capacity

Batteries in powered systems shall be fully charges before testing and again during the test program if necessary.

C.3 Endurance

External mains supply may be used to power components or systems that would normally be battery powered, for the purpose of conducting endurance testing.