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MITIGATING PIPE AND RISER HYDRAULIC PIPELINE ISSUES WITH THE I-RISER PLUS

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INTRODUCTION

Surface irrigation is still the most dominant irrigation method used in the Australian agricultural market.

One of the surface irrigation methods is Pipe and Riser systems for delivery of water to border check irrigation bays. In recent times, this application has seen the introduction of pumps and pipes, with the objective to pump higher flows, in less time, to increase irrigation efficiency, reduce water consumption and reduce labour.

To achieve increased water use efficiency, the irrigator must have tighter control over the watering interval. Pipe and Riser systems provide irrigators with greater flexibility with irrigation scheduling. A single bay can be irrigated one day and another bay on the opposite side of the system or farm can be irrigated straight afterwards.

Traditional channel systems are less flexible, as groups of bays often need to be irrigated one after the other to take advantage of the channel being filled.

In reviewing pressurised Pipe and Riser installations market feedback indicates a growing concern over a number of common problems. These include, some systems not following irrigation designs, installation, operation awareness and appropriateness of some of the equipment being used specifically relating to risers and the automation of risers. Consequently an increasing number of pipe and riser systems are failing, incurring large repair costs.

AWMA, who specialise in the manufacturer of water control infrastructure, undertook a project to design and manufacture an innovative new riser branded the “i-Riser”, which incorporates a number of unique features that will significantly improve riser performance.

PRODUCT OVERVIEW

Risers are the outlet valve within a pipe and riser system for delivering water to border check irrigation systems. Advantages of risers include that they seal against high pressures, limited pressure loss and can direct a large volume of water onto the ground in an efficient manner.

Risers can be operated manually or automated. A range of options exist within these categories, these include:

- Manual. The irrigator manually opens or shuts the riser using a handle attached to a spindle.
- Portable timers can be attached to the 12 volt actuators to close and open risers at a predetermined time.
- Roving head automation. This is a portable version of the fully automated system. The riser incorporates an actuator that can be controlled by a roving (portable) automated head unit. The head unit is moved around as required and plugged into the riser, facilitating full automation.
- Full automation, where risers are permanently automated and operated by a scheduling program to open and close, remotely via PC's or smart mobile devices such as iPhones and iPads.

Department of Primary Industries Victoria states "Anecdotal evidence from irrigators that have installed manual pipe and riser systems suggests automation is a necessity. Many irrigators find pipe and riser systems operate in such a way that they are under more pressure and reduced timeframes when irrigating and eventually automate the system to alleviate this work load. This is especially important where flow rates have increased significantly." *(Pipe and Riser Irrigation Systems Choosing the right system by Department of Primary Industries Victoria.)*

ISSUES ASSOCIATED WITH PIPE AND RISER SYSTEMS

Since the introduction of pressurised Pipe and Riser systems there has been an increase in the number of reported system failures, such as pipeline, leaks, blow outs and pipeline collapse.

Factors contributing to these failures include:

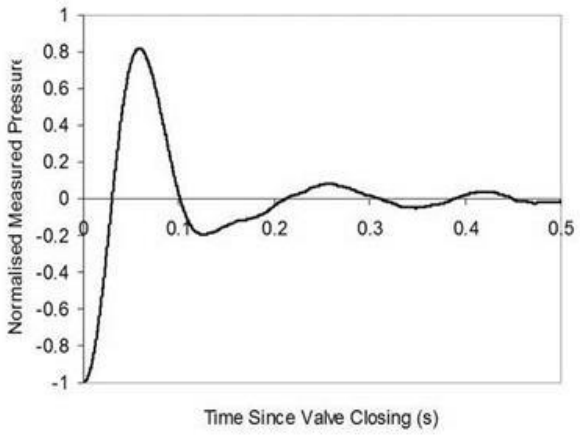
a. Inadequate installation of the polyethylene pipe, poor excavation, insufficient quality bedding, backfill and compaction.
b. Poor pump control.
c. Pipeline hydraulic issues, splits/bursts caused by excessive air and vacuum conditions. Limited or no use of air and vacuum relief valves.
d. Poor quality riser design, resulting in inability to seal and leakage damaging pasture, crops and paddocks.
e. Inadequate training of irrigators in how to operate the system in a manner that diminishes the potential for erratic hydraulic performance.

This paper deals with the major cause for failures to date, (c) above "Pipeline hydraulic issues".

PIPELINE HYDRAULIC ISSUES

Surge pressure, or water hammer, are terms used to describe dynamic pressure changes in a pipe system. They occur whenever there is a deviation from the steady state condition, i.e.; when the velocity of the fluid is increased or decreased waves of positive or negative pressure (also known as column separation) may be generated. Causes of this condition are:

- Opening or closing of a valve or riser
- Pump start up or shutdown
- Change in pump speed
- Entrapped air



The adjacent graph shows a typical pressure wave caused by closing a valve in a pipeline. This pressure wave can cause major problems, from noise and vibration to **pipe collapse.**

Another concern associated with regular dynamic pressure changes is fatigue of the pipeline. The key factors to consider are the size and frequency of these changes. The life of a pipeline experiencing continued fatigue will be greatly reduced. Some recent pipeline failures have only been in operation for 3 years.

Most Pipe and Riser installations use PE 100 Polyethylene pipe, class PN4 pressure rating. PN4 has a maximum positive pressure rating of 40 metre head. (392Kpa).

This maximum pressure rating is considered appropriate for Pipe and Riser systems that are typically operating at 8 to 10 metre head.

However PN4 is far less capable of handling negative pressure (vacuum) conditions. Maximum continuous negative pressure (vacuum) rating is only (-0.9) metre head (-9Kpa).

The limited ability of PN4 to handle negative pressure (vacuum) conditions is presenting a real concern in the industry.

Evidence from installed systems indicates that a number of pressurised Pipe and Riser **pipeline failures**, (pipe collapsing and splitting) are a direct result of dynamic pressure changes creating a negative pressure (vacuum) condition.

Therefore it is critical that the pipeline design includes practices to control or mitigate surges in pressurised pipe systems. These include specifying operational procedures that minimise the risk of surges, precise pump selection and installing surge-protection equipment such as a surge tank and or combination (air/vacuum) relief valves will all play a role in controlling water surges.

In relation to Combination air valves these must be located at high points in the pipeline for the following reasons:

- To allow air to escape when filling pipelines with water
- To allow air to enter when draining pipelines
- To prevent air pockets at system high points caused by entrained or dissolved air
- To prevent negative (suction) pressure after system shutdown

On pipelines with long rising grades or flat runs where there are no significant high points or grade changes, it is recommended that combination valves should be placed at least every 300 metres.

<u>Operational Efficiencies</u>

In addition to causing hydraulic issues, air in pipelines will have the following operational impacts:

- Reduced pump efficiencies
- Increased energy costs
- Noise and vibration
- Lower flow rates
- Increased corrosion potential
- Inaccurate flowmeter readings

THE SOLUTION - i-Riser^{TM} Plus

After becoming aware of the hydraulic concerns of numerous installed pipeline systems AWMA developed the i-Riser^{TM} Plus.

The riser is often situated at the highest point in a pipeline installation which is the location where positive or negative air pockets can accumulate. This characteristic means that the i-Riser^{TM} Plus is ideally positioned to mitigate the above hydraulic problems.

The i-Riser™ Plus design incorporates both air and vacuum automatic release ability in a fully integrated package.

The inlet of the i-Riser™ Plus is a 355 mm diameter intake which acts as a large "accumulation chamber" in the pipeline for any potential air pockets.
The i-Riser™ Plus has the ability to allow for the entrance of large volumes of air during pipe draining as well as the release of air pockets during working conditions, subsequently mitigating the development of air pockets and vacuum conditions.

Automatic i-Riser™ Plus

The i-Riser™ Plus valve plate incorporates a Vacuum Relief Diaphragm that is normally in the closed position. In the advent of the pipeline draining and to limit a negative pressure occurrence in the pipeline the diaphragm moves off the valve plate admitting a large volume of air into the pipeline replacing the withdrawing water column and preventing destructive vacuum conditions. As soon as the water column returns, the diaphragm will gradually reseat against the valve plate.

The i-Riser™ Plus incorporates a large orifice area of 5028mm^2 to provide an air intake, vacuum release capacity greater than that of a typical 3" Combination full port Air Relief Valve (ARV).

If we consider a typical Pipe and Riser application, with a maximum flow rate of 15ML/D (625 M3/hr). During pump shut down (or power out at the pumps), it is common to have negative pressures known as "Column separation" form in the pipeline at many locations. The i-Riser™ Plus with an air inflow capacity of approximately 800 M3/hr would limit the pipe to (-5Kpa) of vacuum, within the vacuum rating of PN4 pipe (-9Kpa). Installation of the i-Riser™ Plus in multiple locations along the pipeline will reduce the risk of excess vacuum along the pipeline mitigating pipe collapse and ensuring pipe longevity.

To provide air relief, the i-Riser™ Plus incorporates a Bermad A10 Automatic ARV. At the first stage of water column return, air that replaced the withdrawing water column is discharged through ARV orifice, at a controlled flow rate, ensuring eventual evacuation of all the air.

During pressurised operation of a pipeline, air accumulates in the upper part of the ARV chamber, causing the float to gravitate downwards. This in turn causes the automatic orifice of the ARV to open, releasing the accumulated air. Once the air is discharged, the water level and float rise, closing the automatic orifice.
With its advanced design and automatic orifice, this valve provides excellent protection against air accumulation, ensuring that the pipeline water flow reaches its designed maximum capacity.

The A10 Air Relief valve is mounted inside the i-Riser^{TM} Plus housing providing complete mechanical protection.

The combination of the vacuum relief and controlled automatic air release capabilities of the i-Riser^{TM} Plus acts as an anti-slam ARV preventing the potential for column separation within the riser itself.

Pipe and Riser bays vary in width from 40 to 100 metres, typically 50 metres wide. Although it would be ideal, it is not required that the i-Riser^{TM} Plus be installed at every riser outlet. To provide adequate protection installation of the I-Riser Plus option is recommended approximately every 300 metres of the pipeline, subject to bay width riser outlets. On this basis i-Riser^{TM} Plus is also ideal for replacement of existing risers of any brand in critical locations on properties that are experiencing hydraulic pipeline issues.

CONCLUSION

There has been a number of polyethylene pipeline failures in pressurised Pipe and Riser systems due to dynamic pressure changes creating vacuum conditions within the pipeline that are exceeding the pressure rating of PE 100 Polyethylene pipe, class PN4 of (-9Kpa)

Another concern associated with regular dynamic pressure changes is fatigue of the pipeline. The life of a pipeline experiencing continued fatigue will be greatly reduced.

Whilst installing higher rated pipe such as PN6.3 or PN8 with higher vacuum specifications is one solution, this would be cost prohibitive for Pipe and Riser applications.

Pipeline design must include practices to control or mitigate dynamic pressure changes in pressurised pipe systems. These include specifying operational procedures that minimise the risk of surges, precise pump selection and installing, surge-protection equipment such as Combination Air Valves will all play a role in controlling water surges for long term pipeline protection.

The i-Riser™ Plus with its excellent inherent air, vacuum relief and surge protection capabilities is the ideal means of mitigating hydraulic issues for new installations or easily retrofitted to existing systems.

Because the i-Riser™ Plus functions as a Riser outlet with Air and Vacuum relief ability it is a very economical solution, being significantly lower cost than equivalently sized Combination Air Valves.

Whilst the i-Riser™ Plus mitigates the development of serious hydraulic conditions, it is recommended that all pipeline design principles should be followed. This may include the installation of separate Combination Air Valves in critical points, such as the Pump station, road or channel crossings and pipe size transitions.
