FUNDAMENTALS OF LIQUID LEVEL CONTROLLERS IN VESSELS

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INTRODUCTION

Liquid level controllers play a critical part in the separation of gas, oil, and water from the well stream. This is accomplished with the use of vessels designed to hold fluids long enough to allow the natural gas to be released from the hydrocarbon liquid. Fluids need to be retained a minimum of one minute for a two phase separator and three minutes for a three phase separator, depending on the manufacturer. The configuration of the liquid level controller and dump valve, dictates how long these fluids will remain in the vessel. Two types of configurations are throttle or snap mode. Throttle control is a constant releasing of liquids in the vessel to match the rate of incoming liquids. Snap mode is the accumulation of liquids to a predetermined high level and then releasing the liquids to a predetermined low level. Liquid level control is typically accomplished with the use of three different styles of controllers; mechanical, pneumatic, and floatless. Each controller has its own unique style of controlling liquids and this paper will examine how they function, their limitations, their applications, and the different valves they operate.

MECHANICAL

The Mechanical level controller (fig 1) is probably the most basic of the three styles of controllers and easiest to operate. It is typically limited to low pressure vessels of 500 psi and below and used in two phase separation or top level control. Common applications include, separators and free water knock outs. These are typically installed through a weld neck and secured to a plate by bolts or welding, with the plate assembly attached to the weld neck by the use of a hammer union nut. The main components of a Mechanical level controller include the float, float arm, trunnion, linkage rod and the lever operated valve. The Mechanical level controller consists of a float connected to a trunnion assembly that transfers the float movement to a lever operated valve. As the liquid level in the vessels rises the float is forced upwards, causing the trunnion assembly to rotate. As the trunnion rotates it pushes the linkage rod down on the lever of the dump valve. This causes the valve to open and decreases the liquid level

Mechanical level controllers are throttling action; this means they match the amount of liquid entering the vessel with the amount of liquid being removed from the vessel to maintain a constant level. It is up to the operator to match the flow rate thru the vessel with the appropriate sized valve in order to maintain the desired level in the vessel. If the valve is too small then the vessel will overflow, if the valve is too large premature damage to the valve can occur. When throttling a valve, industry standard is to operate between 50% to 85% capacity of the valve. This opens the valve enough to minimize wear on the seat and cage area and allows for the best area of control.

Mechanical level controllers are typically top level controllers but can be used to interface if set up properly. Since the float is hollow, it is possible to fill the float with sand to weigh it down enough to sink in the top level fluid but float in the lower level fluid. Another method is to simply fill the float with the top level fluid. Interfacing will take some trial and error so the best way to set the float is out of the vessel in a bucket filled with the two fluids. Interfacing does take closing force away from the float, meaning there may not be sufficient opening and closing force to operate the valve. When interfacing it is best to have the linkage rod as close to the trunnion assembly as possible and as far out on the lever of the valve as possible, this maximizes the closing force to the valve.

Typically the Mechanical level controller is the most reliable and maintenance free but from time to time problems will occur. Some common problems are shown below.

Controller Problems	Possible Causes
Leaking stuffing box on the trunnion	Loose stuffing box nut Worn Teflon packing around the trunnion shaft
Valve will not shut tight	Worn soft seat on the valve Eroded valve cage Insufficient force from the float

Valve will not open	Leaking float Stuffing box nut is too tight Improperly adjusted linkage rod

PNEUMATIC CONTROLLERS

Pneumatic level controllers (fig 2) are the most versatile of the 3 styles of level controllers. Common applications include separators, free water knock outs, scrubbers, and production units. They have the ability to operate in high pressure vessels, usually up to 4000 psi and can work in either snap or throttle control. Pneumatic controllers use a displacer in the fluid instead of a float to generate force that actuates a pilot to open or close a valve. The displacer is typically made from high temperature plastic or stainless steel. As liquid level rises in the vessel the fluid rises on the displacer and generates force (or makes the displacer lighter). The motion of the displacer is transferred outside the vessel to the controller by the use of a waggle arm. The movement of the waggle arm determines if the pilot of the level controller has a pneumatic output or not. The pneumatic output of the controller is sent to a pneumatic actuated valve that is able to be positioned by how much pressure is sent to the valve actuator. Typical instrument air pressure for level controllers and valves is 35 psi.

Pneumatic level controllers work from Archimedes principle; this states that a body immersed in a fluid is buoyed up by a force equal to the weight of the displaced fluid. This is why level controllers have a spring adjustment, it controls the weight of the displacer, allowing it to float in water; otherwise a displacer will sink in liquid. The displacer's force is created by how much of it is immersed in water because force is equal to the weight of the displaced fluid.

A common configuration for level controllers is snap acting, this allows the liquid in a vessel to accumulate to a pre determined high level in the vessel then dumps the liquid out of the vessel to a pre determined low level. The span of the level is determined by two factors; the length of the displacer and the tangent arm (or proportionate band in the pilot assembly). We determined that a displacer works by being submersed in fluid until it becomes lighter than the fluid and starts to float. The volume of the displacer under the fluid dictates the length of the span, if you wanted to decrease the span a bigger outside diameter float could be used because it would generate more volume with less submersion. To increase the span a smaller outside diameter float could be use because it would require more submersions to have the same volume. Another method to increase span would be to use a split float, by cutting a float in half and connecting the two pieces with a chain or steel cable you can increase the span by the length of the cable. The tangent arm controls the length of the span by acting like a fulcrum since the movement of the waggle arm is transferred to the pilot with the tangent arm. The further out on the tangent arm the more travel by the waggle arm is required to actuate the pilot.

Pneumatic level controllers are often used in throttle applications. The level controller gives a pneumatic output to position the dump valve so it matches inlet flow. This is done with the use of a specific valve trim called equal percentage. This is the recommended trim to use for precision control or regulation. Do not try to throttle with a snap or quick open trim because the valve will not be stable. Equal percentage trim has a smaller change in flow compared to stem travel than snap or nominal, allowing the valve to be more stable against volume changes by not over compensating to change in flow.

When interfacing two liquids, the Pneumatic level controller is the best choice because they have the ability to control the buoyancy of the displacer with the adjustment spring. Interfacing is when the level controller is controlling the lower fluid, this is usually water with a layer of oil above it. The object is to allow the displacer to sink in the top fluid yet float in the bottom fluid. This is done by adjusting the spring that makes the displacer buoyant. Like the Mechanical level controller, this can be adjusted outside the vessel by using a bucket filled with the two liquids. Simply lift the bucket up to submerge the displacer and adjust the spring tension to allow the pilot to actuate in the lower fluid. Interfacing can be tricky, and all Pneumatic level controllers have a minimum specific gravity differential they can interface with. These specifications should be published by the manufacture. If you are having trouble interfacing due to specific gravity differential, try using a larger displacer. A larger diameter float will have more force per level of submersion.

FLOATLESS LEVEL CONTROLLERS

Floatless level controllers (fig 3) are typically used in smaller vessels if there is not enough room for a float, but can be used in any sized vessel. Floatless level controllers consist of a main diaphragm assembly that transfers movement to a pilot assembly by the use of a waggle arm. Vessel gas pressure is connected to the top side of the main diaphragm assembly and liquid head pressure is connected to the lower half of the diaphragm. Connections are usually ¼ npt for gas and 1" npt for liquid. The mounting location of the floatless controller is what determines the low liquid set point in the vessel. When the liquid head level in the vessel is even with the main diaphragm assembly, the diaphragm has equal force above and below. This equilibrium results in the pilot having no output. As liquid level increases, the main diaphragm assembly is forced upwards due to liquid head pressure. This upward movement is transferred to the pilot assembly through a waggle arm and actuates the pilot to send pneumatic pressure to open a valve. As the liquid head decreases due to opening of the dump valve, the main diaphragm assembly is forced downward and the movement is again transferred to the pilot by the waggle arm and results in the dump valve closing.

The height of the liquid head is determined by a spring placed in the upper half of the main diaphragm assembly. This spring holds the diaphragm assembly down until enough liquid head is acquired to force the main diaphragm upwards; usually 1 foot of liquid head is equal to .433 psi. This spring is typically light weight and adjustable to control how high the liquid head can be controlled.

Liquid level controllers are available in snap or throttle service and a wide range of control pressures. In throttle mode the Liquid level controller will maintain a pre determined height above the controllers mounted location. The controller will give a pneumatic output to position the liquid dump valve to match incoming flow. The liquid level height is determined by the adjustable spring on top the main sensing diaphragm. In snap mode the Liquid level controller will accumulate a liquid height and then open the dump valve to reduce liquid level to the controllers installed height. The length of the accumulated span is based on the adjustment spring in the main sensing diaphragm.

CONCLUSION

All three of the liquid level controllers discussed have their own unique quality. The mechanical level controller will be for throttle service only and is hard to interface. The mechanical level controller usually requires the least amount of maintenance and is the easiest to operate. The pneumatic level controller offers both snap and throttle and has the ability to interface. The pneumatic controller requires supply gas that is not always available on low pressure vessels. The floatless level controller is most popular for smaller vessels. A floatless controller does not have the ability to interface and is probable the hardest to operate.

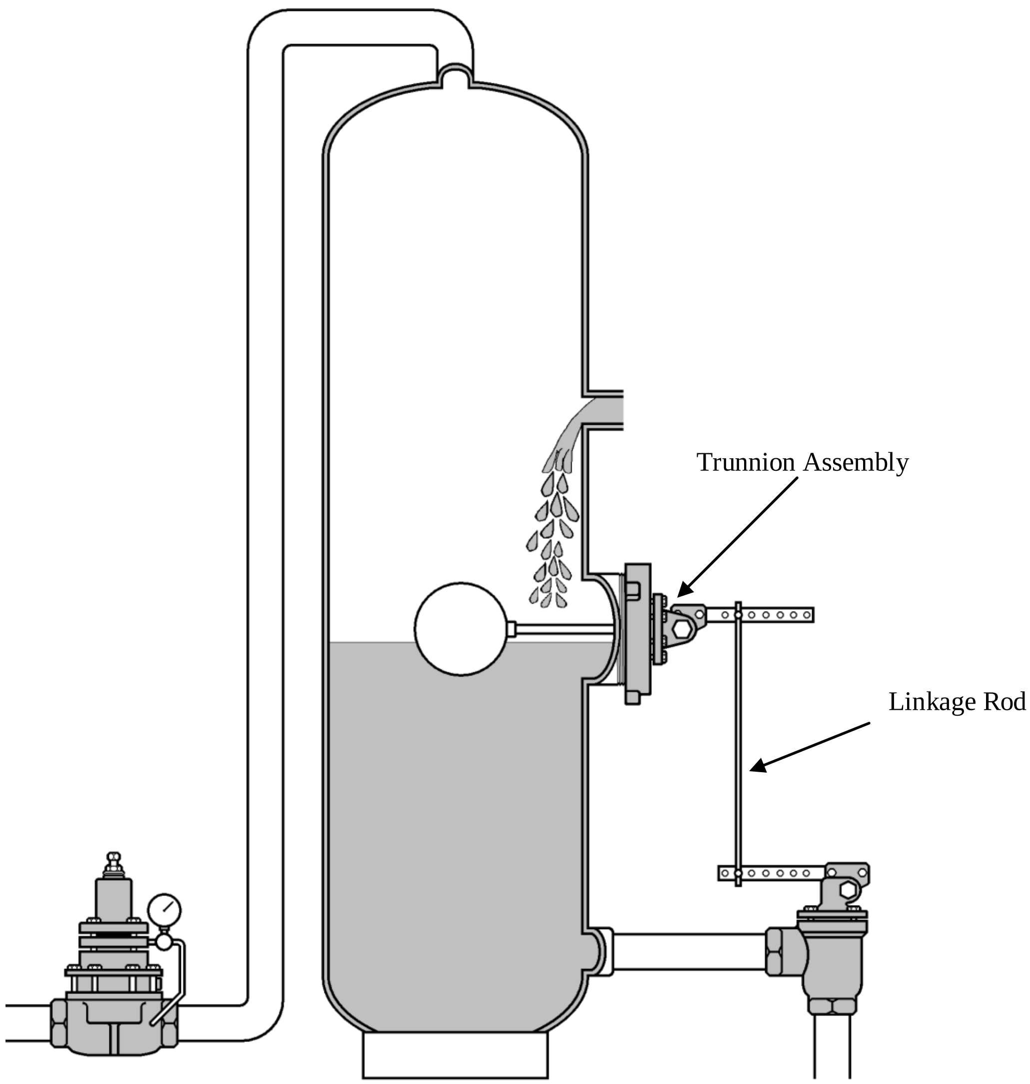

Figure 1

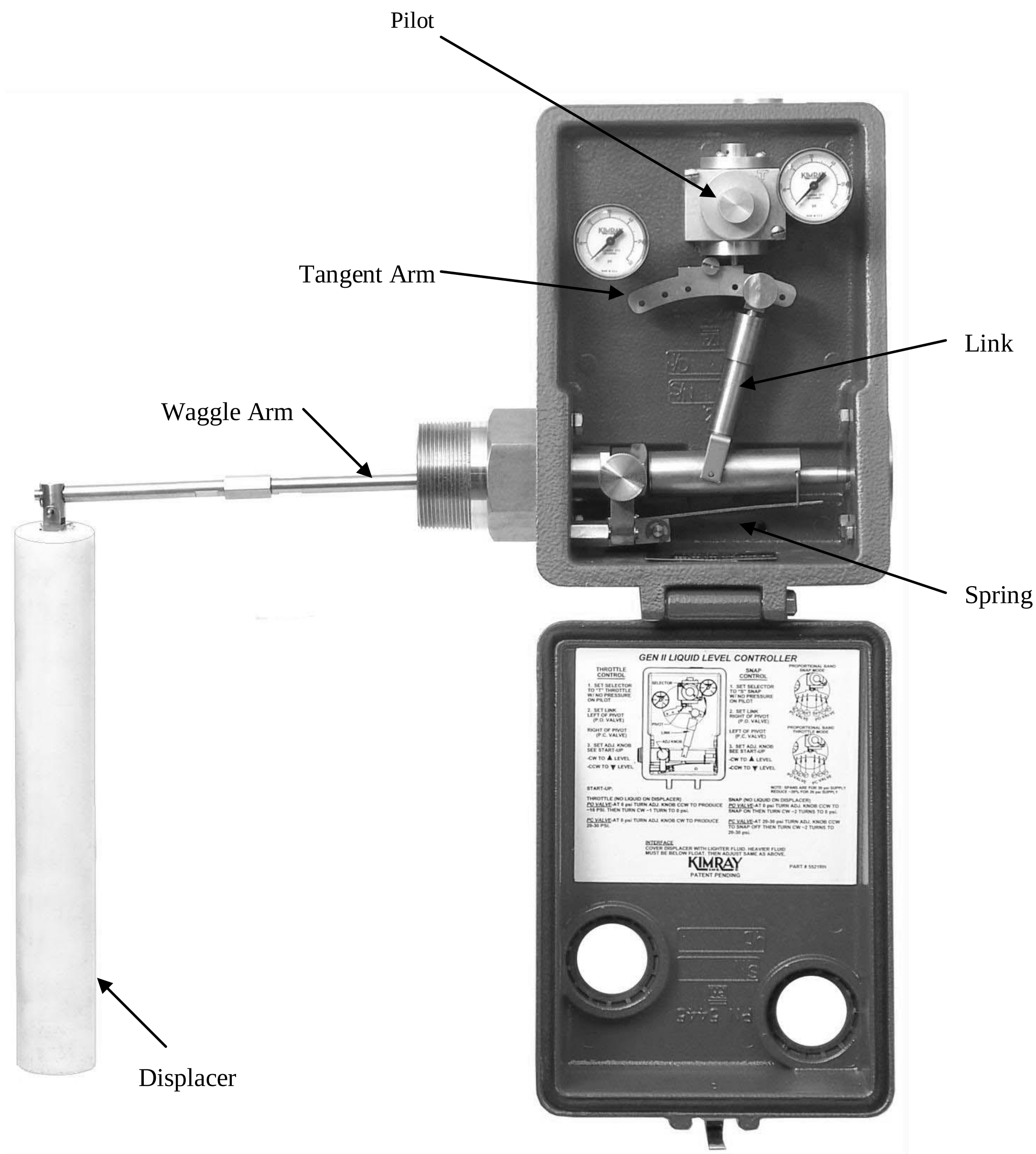
Pilot
Tangent Arm
Link
Waggle Arm
Spring
Displacer
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Figure 2