Application Note:

Vacuum for Automated Liquid Handling

Automated liquid handling systems process large quantities of samples, enabling rapid, precise, and reproducible assays. Vacuum plays a critical role in several common process steps which are carried out by liquid handling systems. Selecting the right vacuum pump to support these steps improves the performance, reliability, and control capabilities of the liquid handling system.

The Need for Vacuum in Automated Liquid Handling Systems

There are several common ways vacuum is used in liquid handling systems. Two of the most common include aspiration of waste, reagents, and buffers; and filtration as part of the sample preparation process.

Dispense-and-aspirate routines are a fundamental element of preparing multiwell plates for ELISA and other assays. Aspirating fluid from microwell plates in a repeatable and precise manner is critical to ensure that unbound materials are removed and solutions are not diluted. Subsequently, wash solutions, reagents and buffers must be added in a precise manner (or gently added) to not disturb bound materials. Plate washers, designed for exactly this purpose, rely upon vacuum pumps that provide consistent, low-maintenance, and quiet vacuum. As fluid is aspirated from the microwell plate, small differences in the fluid level in the wells and small differences in the fluid flow rate through the manifold can create a big problem if the pump is not strong enough to overcome air which flows in through empty wells. Yet a vacuum that is too strong – too deep – is also problematic. Vacuum that is too deep can boil reagents. Or when working with sensitive samples (e.g., low-adherent cells), an excessively strong vacuum can aspirate away the sample.

Vacuum also plays an important role in sample prep. A common part of sample prep is to filter samples under vacuum, for example when working with nucleic acid extraction and purification. As with fluid aspiration, it is important that the vacuum be strong and in the right range. During the filtration process, leaks can develop as liquid reagents from each individual well empty at slightly different rates. The pump must be able to maintain a steady vacuum level in spite of variable air leakage into the filtration manifold. A stable and appropriate vacuum level are key to completing the filtration process, and the assay, in a quick and repeatable fashion.

Basic Pump Requirements

The purpose of automated liquid handling systems being to process high volumes of samples, any vacuum pump needs to support high throughput in the lab. At the most fundamental level, that means that any pump used must be quiet, reliable, and durable.

Because these pumps are installed in lab environments where researchers are often working – and thinking – it's important that the pumps operate quietly so that they are not disruptive. A well-designed pump runs quietly so that scientists in the lab do not even notice it. Diaphragm vacuum pumps are well-matched with the technical requirements for the system designer as well as the user's requirements. They can provide the appropriate flow and vacuum level in a compact pump that generates minimal noise and vibration. By utilizing variable-speed motor control, diaphragm pumps can run whisper-quiet while providing precisely controlled vacuum.

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Having a reliable pump means that downtime for maintenance is minimized, and therefore productive uptime is maximized. A critical factor in finding a reliable pump is the construction of the pump, in particular the wetted materials used. Many buffers and reagents are corrosive, so the wetted materials must be able to withstand exposure to these chemicals.

Selecting a durable pump means you can count on it to last for the life of the automated liquid handling system. The only thing worse than an unreliable pump that requires frequent maintenance is a pump that bring the system down because it has failed. Here again, chemical resistance plays an important role, as does the underlying pump technology. Manufacturers offer a wide variety of different pump technologies, most of which are ill-suited to the flow and vacuum requirements, maintenance requirements, and chemical compatibility requirements. Diaphragm pumps are used extensively with automated liquid handling systems because they match up well with all three needs.

Beyond the Basics

A vacuum pump can also provide differentiating capabilities that make automation easier to implement and make the liquid handling system a more flexible tool for scientists. Some systems can use simple relays that are actuated by the control system to switch the pump on and off as needed. Or systems use valve manifolds to regulate flow. From a designer's perspective, these solutions work, but they increase system complexity and part count – which negatively impact reliability. They are also less energy-efficient. A simpler, more elegant, and more reliable solution is to use a motor-speed controlled vacuum pump to adjust the vacuum level and flow. Motor-speed control of the vacuum pump allows for extraordinarily precise control of the vacuum level; it also makes the vacuum pump ultra-quiet. System automation is supported via communication protocols such as RS-232 and Modbus TCP, which simplifies the control system while at the same time giving scientists greater flexibility in adjusting vacuum parameters to suit their needs.

VACUUBRAND's Solutions for Automatic Liquid Handling

VACUUBRAND's line of chemistry-resistant diaphragm pumps offers a wide range of solutions for automatic liquid handling systems. Our chemistry diaphragm pumps have typical service intervals of 15,000 hours and are made with fluoropolymer- and perfluoroelastomer-wetted materials, meeting the reliability and durability requirements for automated liquid handling. With the exacting precision of German engineering and manufacturing, the pumps deliver the strong suction needed at the right vacuum level. And with unparalleled VARIO® motor speed control, pumps run near silently and allow vacuum to levels to be set or programmed according to the needs of each scientist using the system.