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WHITE PAPER

Designing Fluidic Systems for Harsh Life Science, Environmental, Medical and Diagnostic Environments

As engineers look to design fluidics systems for life science equipment, careful attention must be paid to the system's environment. While many life science instruments work with innocuous materials, others require wetted paths to withstand aggressive environments that would quickly render the system useless or inaccurate if not properly designed.

Here we look discuss a few key environmental conditions to consider when designing fluidic systems for harsh life science environments.

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Solvents

Solvents are commonplace in life science, environmental, medical and diagnostic applications. Though often aqueous and relatively benign in nature, many instruments use alcohols and petrochemical-based solvents as sample carriers, stabilizers, dehydrants, or disinfectants that can deteriorate lesser chemically inert wetted paths. A fluid transfer path that uses plastics to save on instrument space, weight, and production cost must be assessed for chemical compatibility to ensure these wetted materials will hold up to long term solvent exposure. Not only should these materials to be assessed, but any bonding agents used to adhere them must also be reviewed for chemical compatibility. If instrument weight is not of great concern, and flow paths are simple to machine, various metals such as aluminum or stainless steel may be a more cost effective option for production. In highly sensitive analytical applications such as gas chromatography sample preparation, not only is it important for these materials to maintain their structural integrity, but they must also exhibit minimal outgassing or leeching to mitigate sample contamination and inaccurate instrument readouts.

Acids and Bases

Acids and bases are also commonly used across a wide variety of life science instruments for specific applications. For example, to determine the pH concentrations in a solution, scientists often use titration equipment to quantify these levels which includes the dispensing of high concentration acids and bases. In this environment, even otherwise durable metals may pit or corrode over a short period of time causing instrument failure. Inert plastics like PTFE can be a suitable alternative to metals and more reactive plastics to maintain fluidic system integrity. System fittings and connectors must also be evaluated to ensure they are inert to limit leak points in the system.

Particulates

For pneumatic systems, filtered intakes can mitigate the concern for particulate build up and clogs. If filters are properly maintained or replaced, system flow paths can remain clean and in good working order for the life of the instrument. In fluidic systems carrying biological materials, particulate build up can be problematic. As fluid channels get smaller with the miniaturization of point of care instruments, the chance for particulate build up and subsequent clogs are of great concern for maintaining optimal system performance. This can be addressed in assay design with wash or flush steps as part of the protocol, but the wetted path materials must be compatible with these wash fluids. In addition to chemical compatibility concerns, pressure build ups must be understood when designing the flow paths. As these pressures build up, they can compromise the integrity of the fluid path walls. In genetic or proteomic expression assays, the concern for carryover and cross-contamination is paramount. Where possible, the design should lay out channels with limited tortuous flow paths to mitigate particulate buildup and decrease chance of material carryover from run to run. This includes avoiding tubing bends where pooling, buildup or kinks are possible. When the fluidic path is manifolded, the machining of rounded bends in manifold fluidic channel design will also mitigate flow path particulate buildup.

Temperature and Pressure

Scientific equipment can undergo extreme temperature changes to carry out reactions and assays. For example, short path distillation equipment used by scientists to extract essential oils for study must operate at many hundreds of degrees Celsius. Conversely, freeze drying or lyophilization of biological samples for biotherapeutics such as insulin or other personalized medicines require temperatures as low as -80ºC. Flow paths in these environments must be able to withstand such temperature changes from ambient to very hot or very cold, so designers must understand the material properties of components across temperature ranges for the intended system applications. Any actuation within the flow path such as a proportional valve for vacuum control must be responsive enough in these temperature ranges to maintain desired pressures. Flow paths must not warp or distort due to extreme heat or cold. In both examples, extreme pressure changes also occur that could dramatically impact flow path materials that are not mechanically resilient at these temperatures.

Overall, designing flow paths in harsh environments can be a challenge. Designers must find solutions that maintain system integrity, deliver on performance, and do so all while keeping material and production costs at a minimum. A deep understanding of the assay, chemical compatibility, and materials science are essential to deliver quality solutions to customers for successful system integration.

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