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Process Control In The Pharmaceutical Industry

In the pharmaceutical industry, process control instruments and equipment are fundamental to achieving consistent product quality, process reliability, and regulatory compliance. Among the key parameters that must be closely monitored and controlled are flow, level, temperature, pressure, and moisture content – each essential to maintaining the integrity and performance of pharmaceutical products. In addition to these instruments, rotary shear-type, pressure-sealed valves play an important role in ensuring accurate control, cleanliness, and containment in critical manufacturing environments.

Flow control instruments are used throughout liquid and gas handling systems to ensure that the correct volumes of materials – such as solvents, active ingredients, and excipients – are delivered at the required rates. **Coriolis**, ultrasonic, and electromagnetic flowmeters are commonly employed due to their accuracy and hygienic design, suitable for pharmaceutical-grade applications. In modern automated systems, flow transmitters and control valves maintain consistent flow under varying pressure and viscosity conditions, which is particularly important in continuous manufacturing lines and sterile processing operations.

Rheonik Coriolis Mass Flow Meters

Barksdale "Shear-Seal" Directional Valves

Rotary shear-type, pressure-sealed valves are a specific category of flow control components that are highly valued in pharmaceutical applications where containment, sterility, and durability are paramount. These valves operate using a rotating disk or plug with a shearing action that cleanly cuts through fluids, slurries, or viscous materials as they open or close. Their design minimizes dead space and product hold-up, reducing the risk of contamination or cross-batch residue. The pressure-sealed construction ensures tight shutoff even under high-pressure or vacuum conditions, maintaining system integrity and preventing leaks. Because they can handle a wide range of pressures and temperatures, these valves are often used in systems involving clean steam, CIP (clean-in-place), and SIP (steam-in-place) operations. Their smooth internal surfaces and self-cleaning action also make them ideal for handling sensitive formulations, biopharmaceutical fluids, and aseptic processes where sterility and precision are critical.

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Level control instruments are used to monitor and regulate the volume of liquids or slurries in tanks, reactors, and buffer vessels. Maintaining proper levels ensures operational stability, prevents overflow or cavitation, and supports consistent product quality. Common level-sensing technologies include **radar**, ultrasonic, and **RF admittance transmitters**, which can be integrated with automated control systems to maintain accurate filling and discharge operations. Level measurement is also vital in bioreactors and crystallization vessels, where stable process conditions are essential to yield and reproducibility.

Magnetrol Eclipse 706 Hygienic Guided Wave Radar

Drexelbrook RF Admittance Level Instruments

Temperature control is another vital aspect of pharmaceutical manufacturing. Many reactions, fermentations, and crystallization processes are highly temperature-sensitive, requiring precise control to achieve the desired chemical or biological outcomes. Resistance temperature detectors (RTDs) and thermocouples are standard instruments used for high-accuracy temperature monitoring. Automated temperature control loops regulate heating or cooling media in jackets or heat exchangers, ensuring that product temperatures remain within validated limits. In sterilization and aseptic production, temperature control also ensures that microbial decontamination is achieved without damaging equipment or altering product characteristics.

Barksdale BPS3000 series electronic pressure switch

Barksdale BTS 3000 Electronic Temperature Switch

Pressure Control Instruments, such as transmitters, regulators, and relief valves, help maintain safe and stable conditions in closed systems. Pressure stability is particularly important in filtration, lyophilization (freeze-drying), and gas exchange operations within bioreactors. Rotary shear-type valves are often integrated into these systems for their ability to maintain tight sealing under pressure, preventing leaks that could compromise sterility or lead to product loss.

AMETEK Brookfield Computrac Max 4000XL Moisture Analyser

Moisture Measurement in Solids, typically determined using **Loss on Drying (LOD)** techniques, is another critical component of process control. Moisture levels directly influence the stability, compressibility, and dissolution rate of powders and granules. The LOD method involves heating a sample to a controlled temperature and measuring the weight loss due to evaporation. Modern moisture analysers automate this process, providing rapid, precise results that ensure drying processes – such as in granulation, spray drying, or tablet coating – achieve consistent endpoints. Maintaining appropriate moisture levels is essential to prevent microbial growth, chemical degradation, and poor product performance.

When integrated within a modern automated control system, these instruments and valves form a cohesive framework for monitoring and maintaining process stability. Data collected from flow, level, temperature, pressure, and moisture sensors – as well as valve position feedback – can be logged, trended, and analysed in real time for process optimization and compliance documentation. Advanced control strategies, such as PID (proportional-integral-derivative) and model predictive control (MPC), further enhance stability and efficiency by automatically adjusting parameters based on feedback.

In summary, the effective control of flow, level, temperature, pressure, and moisture, combined with the use of rotary shear-type, pressure-sealed valves, underpins the reliability and quality of pharmaceutical manufacturing. Together, these technologies ensure that processes remain sterile, stable, and compliant with stringent Good Manufacturing Practice (GMP) standards. By integrating precise measurement and robust mechanical control, pharmaceutical companies can achieve consistent production of safe, high-quality medicines with improved efficiency and reduced risk of contamination.

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