# 3051 Monocrystalline Silicon Single/Dual-Flange Level Gauge

## I. Product Definition

The 3051 Monocrystalline Silicon Smart Flange Level Transmitter is a smart, remote differential pressure level measurement instrument based on **monocrystalline silicon MEMS high-precision sensing technology**. It is available in two configurations: **single-flange** and **double-flange**. The instrument consists of an isolation flange, an oil-filled capillary tube, a monocrystalline silicon sensor core, and an intelligent digital display head. It enables continuous measurement of liquid level, interface level, and density in atmospheric pressure, sealed pressurized, vacuum, high-temperature, corrosive, and viscous media prone to crystallization.

The instrument supports **local LCD display, 4–20 mA analog output, and HART digital communication**. It features intelligent compensation for temperature and static pressure, as well as self-diagnostic capabilities. As a versatile, high-precision level transmitter for industrial storage tanks, reactors, and pressure vessels, it is directly compatible with traditional 3051 series installation and communication standards, enabling the replacement of imported products with domestically manufactured alternatives.

## II. Core Features

1. High-precision monocrystalline silicon sensing with high stability, minimal temperature drift, and excellent linearity;
2. Isolated diaphragm + silicone oil capillary remote transmission structure eliminates tube blockages and is suitable for viscous, crystallizing, particulate-containing, and corrosive media;
3. Single-flange design for atmospheric open tanks; dual-flange design compensates for internal pressure fluctuations, making it suitable for sealed pressurized and vacuum tanks;
4. Built-in rotatable LCD display allows direct on-site reading of liquid level, differential pressure, and percentage;
5. Standard two-wire 24 V DC power supply with 4–20 mA + HART dual signal output;
6. Intelligent digital compensation automatically corrects measurement errors caused by temperature and static pressure;
7. Supports remote configuration of zero point, span, and damping, as well as fault diagnosis;
8. Multiple diaphragm materials available (316L, Hastelloy, tantalum) to accommodate both highly and mildly corrosive environments;
9. Capable of measuring liquid level, interface level, and density—one instrument with multiple functions.

## III. Working Principle

The device operates based on the **static pressure level formula P=ρgh**. The pressure from the medium's liquid column acts on the flanged isolation diaphragm and is transmitted without loss through high-purity silicone oil inside the capillary tube to the monocrystalline silicon sensor core. The chip converts the physical pressure into a standard electrical signal, which is then converted into an accurate level value after digital processing by the MCU and compensation for temperature and static pressure.

The single-flange design vents the negative pressure side to atmosphere, making it suitable for measuring in atmospheric-pressure tanks; the dual-flange design uses differential pressure on both high- and low-pressure sides to offset the vapor pressure inside the tank, completely eliminating interference from tank pressure fluctuations, making it suitable for sealed pressure vessels. The final data is displayed on a local screen and converted into 4–20 mA or HART signals for transmission to the automation system.

## IV. Core Value & Solutions to Pain Points

Q1: Do viscous, crystallizing, or impurity-containing media easily clog tubes, resulting in high maintenance requirements?
A1: The diaphragm isolation and pressure-tube-free design prevent the medium from entering the instrument's interior, eliminating clogging at the source and significantly reducing maintenance frequency.

Q2: Do pressure fluctuations in sealed, pressurized, or vacuum tanks cause ordinary level transmitters to provide inaccurate measurements?
A2: Dual-flange differential pressure measurement automatically compensates for vapor pressure interference, retaining only the true pressure of the liquid column to ensure stable, drift-free measurements.

Q3: Do you need both on-site reading and remote data transmission capabilities, but find equipment costs high and installation cumbersome?
A3: A single device integrates local digital display, remote transmission, and HART communication, eliminating the need for additional auxiliary instruments and saving on installation and equipment costs.

Q4: Does the instrument suffer from severe measurement drift due to large day-night temperature differences and significant fluctuations in operating temperatures?
A4: The monocrystalline silicon chip, combined with an intelligent dual-compensation algorithm for temperature and static pressure, offers strong resistance to temperature drift, ensuring stable measurement around the clock.

Q5: Is it difficult to replace existing 3051 devices during retrofits of older projects?
A5: Fully compatible with traditional 3051 installation dimensions, flange specifications, and the HART protocol, allowing for direct in-situ replacement without the need to modify piping or programming.

Q6: Are instruments prone to damage and diaphragms prone to rupture in corrosive media environments?
A6: Supports customization with diaphragms made from multiple materials, suitable for various corrosive media such as water, oil, weak acids, strong alkalis, and seawater, offering broad adaptability and high safety.

Q7: Is commissioning difficult, and are faults hard to diagnose quickly?
A7: Supports HART remote configuration and local self-diagnostic error reporting, allowing for commissioning and troubleshooting without disassembling the unit.

Q8: Are transmitters prone to damage in high-temperature environments?
A8: The oil-filled capillary isolation structure provides thermal insulation; high-temperature media only come into contact with the diaphragm, protecting the core sensing components and making the device suitable for high-temperature applications.

## Product Specifications

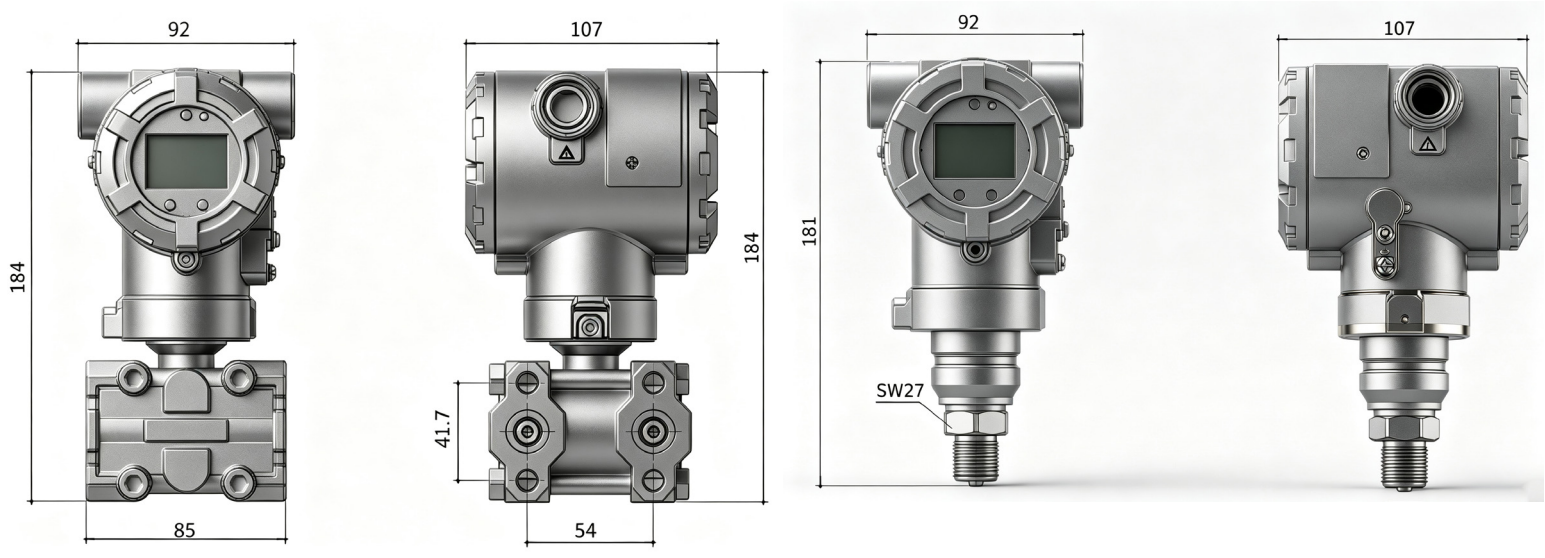
I. Basic Electrical Parameters
--- Sensor Element: Monocrystalline silicon MEMS piezoresistive sensor
--- Signal Output: Two-wire 4–20 mA analog signal with superimposed HART digital communication
--- Measurement Accuracy: ±0.075% FS (standard), optional ±0.05% FS
--- Range Ratio: Up to 100:1; supports zero and span shift (positive/negative)
--- Response Time: ≤100 ms; damping configurable in the field
--- Loop Load: Maximum 700 Ω when powered by 24 VDC (≥250 Ω required for HART communication)
--- Electrical Protection: Reverse polarity protection, output current limiting protection; insulation strength ≥2 kV AC
--- Wetted Diaphragm: 316L, Hastelloy C, or tantalum (selectable); flat diaphragm or insert tube diaphragm (selectable)
--- Filling Fluid: Standard silicone oil, high-temperature silicone oil, or low-temperature silicone oil (selectable)

II. Isolation Performance Parameters
--- Isolation Structure: Flanged isolation diaphragm + oil-filled capillary remote isolation; the medium does not enter the transmitter body
--- Static Pressure Resistance: Selectable according to flange pressure ratings PN16/PN40
--- Overpressure Capacity: 1.5 times the rated static pressure for short-term overload
--- Media Isolation: The measurement chamber is completely isolated from the electrical chamber, preventing media from entering the circuitry
--- Pressure Relief Protection: An integrated safety pressure relief mechanism on the back of the transmitter provides overpressure relief to protect equipment and personnel

III. Power Supply & Power Consumption Parameters
--- Power Supply: Two-wire loop-powered
--- Supply Voltage: 12–42 V DC, typically 24 V DC
--- Power Consumption: Determined by loop current (4–20 mA); the instrument body has no independent power distribution output
--- Power Distribution Output: No power distribution function; outputs only 4–20 mA + HART signals

IV. Environmental Parameters
--- Operating Temperature (with LCD display): -20°C to +70°C
--- Storage Temperature: -40°C to +85°C
--- Ambient Humidity: 0–95% RH, non-condensing
--- Protection Rating: IP66
--- Explosion-Proof Rating (Optional): Intrinsically Safe Exia II CT4; Flameproof Exd II BT6; Intrinsically Safe models require use with a corresponding safety barrier
--- Medium Temperature: Determined by the specifications of the silicone oil filling; select low-temperature or high-temperature versions as needed

V. Physical Parameters
--- Mounting Type: Single flange (atmospheric open tank), double flange (sealed pressurized/vacuum tank); flange standards: HG/ANSI; commonly used sizes: DN50/DN80
--- Display: 330° rotatable backlit LCD digital display; allows on-site reading of level, differential pressure, and percentage
-- - Housing Material: Low-copper cast aluminum housing with anti-corrosion coating; M20×1.5 cable gland
--- Protection Details: Sealed stuffing box; junction box sealed with O-rings; corrosion-resistant spray-coated housing, suitable for outdoor and humid environments



# Scenario-Based Selection Guide

I. Key Selection Criteria

1. Signal Type: The standard output is a two-wire 4–20 mA signal superimposed with a HART digital signal; for applications requiring only switch interlocks, an additional alarm module must be installed, as the instrument itself does not provide a passive switch output. Select this instrument if real-time data upload to a DCS/PLC is required.

2. Number of Channels: A single instrument provides one measurement channel. A single-flange configuration measures liquid level in open tanks; a dual-flange configuration can measure liquid level, interface level, and density in closed tanks. Multiple independent measurement points require multiple instruments.

3. Power Supply: Powered by a two-wire loop, typically 24 V DC, with no need for a separate power cable; the loop load must meet the minimum 250 Ω requirement for HART communication.

4. Explosion-Proof Requirements: Standard non-explosion-proof models must not be used in flammable or explosive hazardous areas; for explosion-proof applications, select intrinsically safe or flameproof types as needed. Intrinsically safe circuits must be equipped with corresponding safety barriers.

5. Installation Environment: Evaluate ambient temperature, humidity, vibration, dust, and condensation; install vibration-damping brackets in high-vibration conditions; ensure IP66 protection in humid environments; if the medium is corrosive, verify the materials of the diaphragm and flanges.

6. Process Medium: For viscous, crystallizing, or solid-particle-containing media, select a remote-transmission flange structure; select the wetted diaphragm material (316L / Hastelloy C / tantalum) based on the medium's corrosion level; select the appropriate silicone oil filling based on the medium's temperature.

7. Measurement Range and Flanges: Determine the differential pressure range based on the actual liquid level height, allowing for a safety margin; Determine flange standards, DN specifications, and capillary tube length based on the tank's connection points and installation distance.

II. Industry-Specific Selection Recommendations

1. Chemical Industry: Use single-flange transmitters for standard non-explosion-proof, atmospheric-pressure storage tanks; use double-flange transmitters for sealed reactors and vacuum tanks; pair with Hastelloy or tantalum diaphragms for viscous, crystallizing, or corrosive media; select intrinsically safe or flameproof versions for explosion-hazard areas.

2. Power Industry: Use double flanges for deaerators and condensate tanks; use single flanges for open-top wastewater and clean water storage tanks; prioritize 316L diaphragms to accommodate on-site vibration conditions, and configure high-temperature silicone oil to handle high-temperature media.

3. Metallurgical Industry: For cooling water tanks, wastewater tanks, and oil tanks—where media contain impurities prone to sedimentation—select single or double flanges. Insertion-type diaphragms may be used to prevent sediment from covering the diaphragm; add vibration-damping brackets in areas subject to strong vibrations.

4. Pharmaceutical Industry: For clean ingredient tanks and purified water tanks, prioritize 316L polished diaphragms; use double flanges for sealed process tanks; select standard flanges for non-explosion-proof cleanrooms, and customize sanitary flanges for applications with hygiene requirements.

5. Smart Manufacturing Industry: Storage tanks and oil stations for automated production lines; select single or double flanges depending on whether the tank is pressurized; enable HART communication for remote parameter configuration and reading, and integrate with PLC systems.

III. Common Selection Misconceptions

1. Ignoring Isolation Levels: Standard pressure-tapping transmitters cannot replace flanged remote transmission structures; do not select pressure-tapping structures for viscous or crystallizing media, as they are highly prone to clogging.

2. Incorrect Signal Range Selection: Selecting a range that is too wide results in poor measurement accuracy at low liquid levels; a range that is too narrow makes the sensor susceptible to damage from overpressure caused by medium surges; for pulsating conditions, reserve a safety margin of 1.25 times the range.

3. Neglecting Load Matching: When the HART communication loop resistance is below 250 Ω, the handheld communicator cannot establish communication; the total loop load must not exceed the instrument's maximum load limit.

4. Incorrect selection of general-purpose models in explosion-proof environments: Standard non-explosion-proof models must never be used directly in flammable or explosive hazardous areas, as this poses a safety hazard; explosion-proof environments require the use of dedicated explosion-proof models.

5. Improper selection of diaphragm material: Using a 316L diaphragm for highly corrosive media can cause corrosion, rupture, and leakage; these should be upgraded to Hastelloy or tantalum materials.

IV. Customization Recommendations

1. Customization for Non-Standard Operating Conditions: For high-temperature or low-temperature media, special-grade silicone oil can be used; for media prone to deposition, select a diaphragm with an insertion sleeve; non-standard flange specifications, flange grades, and capillary tube lengths can be customized.

2. Material Customization: Wetted parts can be customized with polished finishes and sanitary flanges to meet the cleanliness requirements of pharmaceutical and food processing applications.

3. Special Requirements: For multi-parameter data acquisition, a single instrument supports only single-channel measurement; multi-measurement-point solutions require multiple instruments for independent data collection; field display accessories and mounting brackets can be customized as needed.

4. Factory Pre-configuration: For bulk orders, the range, offset, and damping parameters can be preset at the factory according to customer requirements, reducing on-site commissioning efforts.

## Installation and Commissioning Specifications

I. Pre-Installation Preparation

1. **Parts Verification**: Verify the instrument model, range, flange specifications, capillary tube length, and diaphragm material; inspect the instrument head, flanges, and capillary tubes to ensure there is no deformation or damage, and that all seals are present.

2. **Environmental Inspection**: Confirm that the on-site temperature, vibration, and corrosive environment comply with the instrument's specifications; in explosion-proof areas, verify that the instrument's explosion-proof rating matches the hazardous area classification.

3. **Tool List**: Wrenches, flathead screwdrivers, multimeter, pressure calibration device, wire strippers, electrical tape, grounding wire.

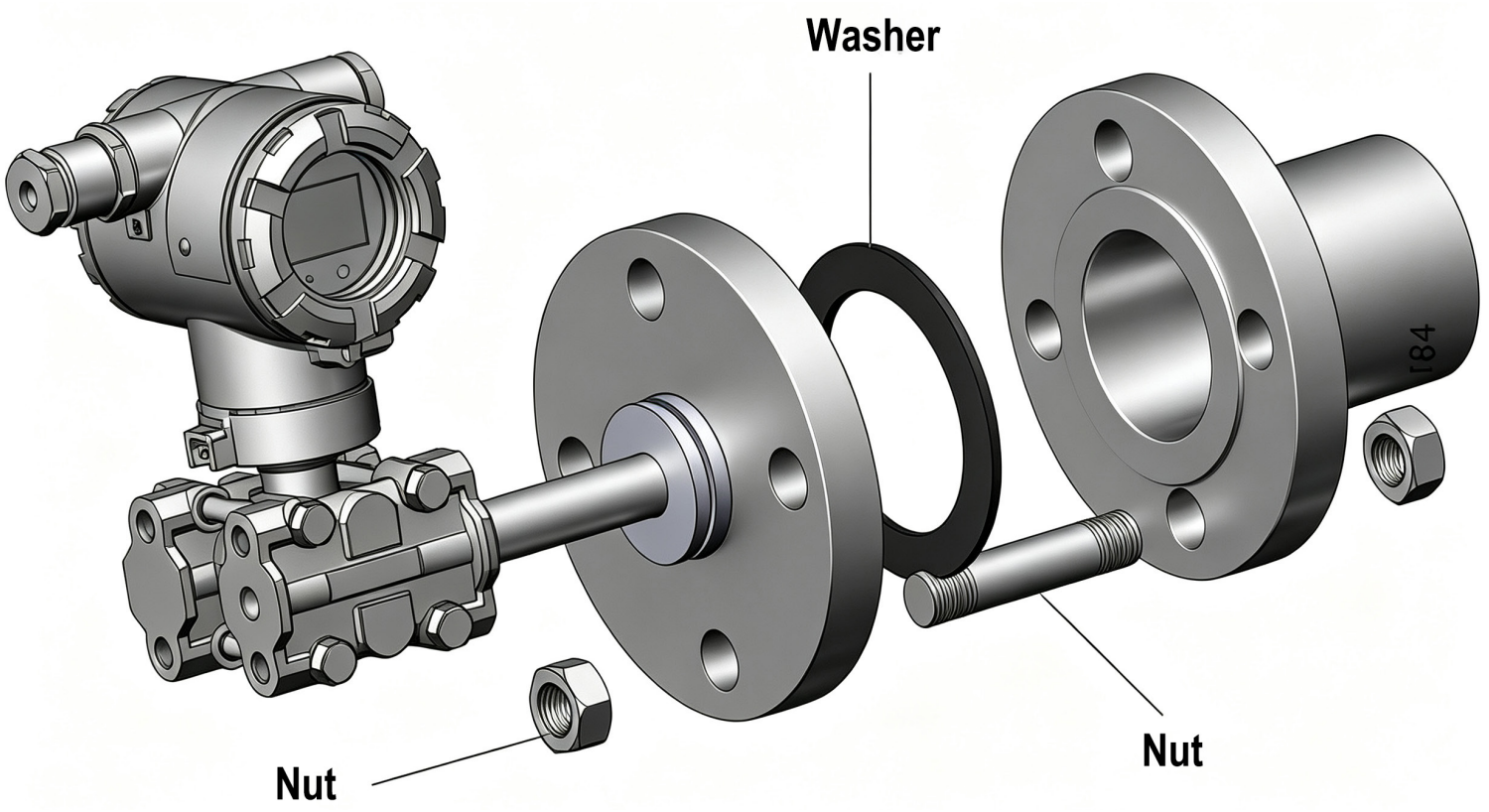
4. **Safety Precautions**: Depressurize the tank before construction; disconnect power before working in explosion-proof areas; wear protective gear when handling high-temperature or corrosive media; do not bend or crush the capillary tube.

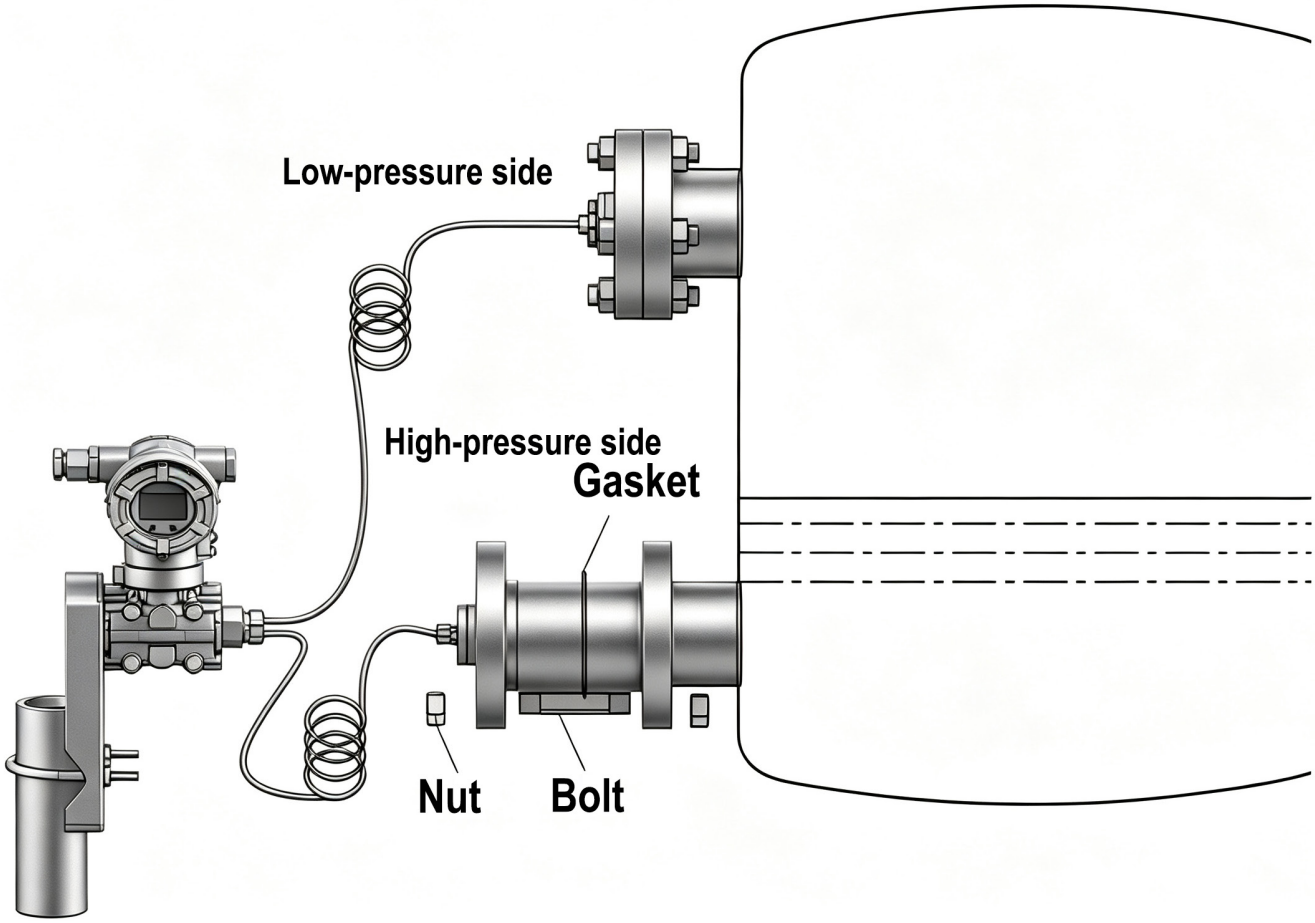
II. Standard Installation Procedures

1. **Flange Mounting**: Install the flange onto the tank's pressure tapping port and tighten the bolts evenly in a diagonal pattern; do not apply force to one side only, as this may compress the diaphragm. The transmitter body should be mounted below the flange, and the capillary tube should be allowed to form a natural curve to prevent stretching.

2. **Wiring Specifications**: For two-wire instruments, the terminals are distinguished by positive and negative power supply polarity; **there are no separate input terminals**—the 4–20 mA signal and power supply share the same circuit; the cable must pass through the junction box packing gland and be securely sealed.

3. **Grounding Requirements**: Connect the instrument housing to protective ground; ground the shielded cable at one end only (ground at the control cabinet side; leave the shield floating at the instrument end); signal circuits must not share cable trays with high-power power cables.






III. Wiring Instructions

The instrument uses a two-wire circuit: Connect terminal “+” to the positive terminal of the 24 V DC power supply, and terminal “–” to the signal input terminal of the DCS/PLC. The system provides power to the circuit.

Shielded cable: The shield must be grounded only at the control room end; on the instrument side, the shield must be insulated to prevent ground loop interference.

Correct vs. Incorrect:

Correct: Circuits are connected in series; the stuffing box is securely sealed; the shield is grounded at one end only; power cables and signal cables are routed separately.

Incorrect: Direct parallel power supply; shield grounded at both ends; stuffing box not sealed; power and signal cables routed in the same conduit.

> Note: Explosion-proof instruments must strictly adhere to intrinsically safe circuit wiring specifications, and safety barriers must be installed on the control room side.

IV. Power-On Commissioning Procedure

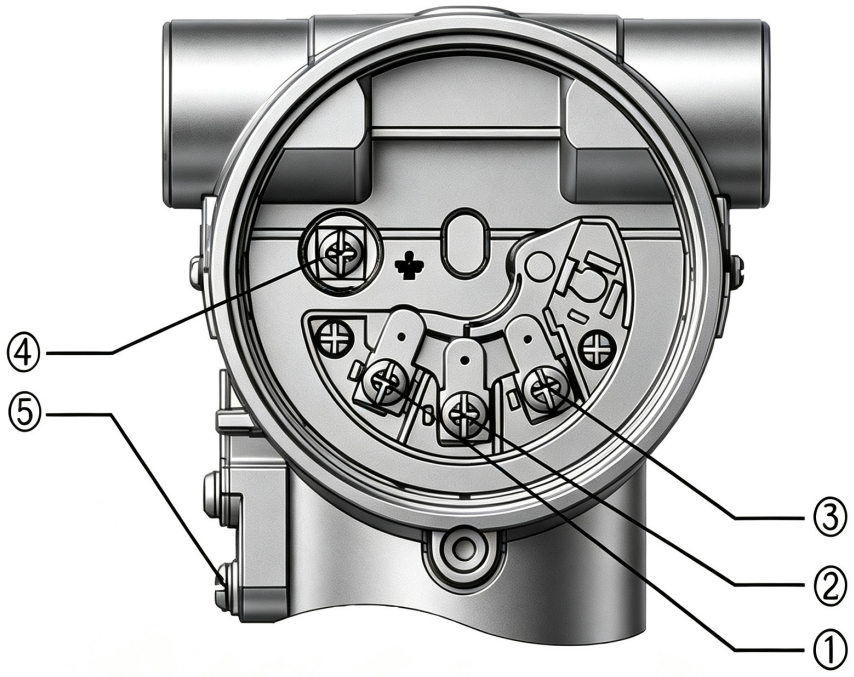
1. **No-Load Test**: Confirm that the tank is depressurized and the instrument is vented to atmosphere. Power on the instrument to verify that the LCD display is normal and no error codes are present.
2. **Zero Calibration**: Perform zero calibration under no-load conditions; set the range, damping, and units according to process specifications.
3. **Signal Verification**: Apply standard pressure, read the 4–20 mA output current, and verify that the meter reading matches the control system’s reading; remote configuration can be performed using a HART handheld communicator.
4. **Accuracy Verification**: Perform calibration at a minimum of three points—zero, 50% FS, and full scale—ensuring that the error meets the product’s accuracy specifications.
5. **Operational Status Check**: Normal display of measured values on the screen indicates the device is in working condition; if a fault code appears, troubleshoot according to the fault table in the manual.

V. Installation Precautions

1. Never exceed the rated supply voltage; the supply voltage must not exceed 42 V DC. Do not strike or compress the diaphragm directly.
2. Keep signal cables away from sources of strong electrical interference, such as variable frequency drives and high-power motors, and avoid laying them in parallel over long distances.
3. In humid or condensing environments, the terminal box must be securely locked and the stuffing box sealed; the housing O-ring must not be missing or damaged.
4. Do not forcefully stretch or bend the capillary tube; do not place any weight on the capillary tube.
5. For explosion-proof models, it is strictly prohibited to damage the explosion-proof surfaces or open the cover without authorization; otherwise, the explosion-proof protection will be compromised.

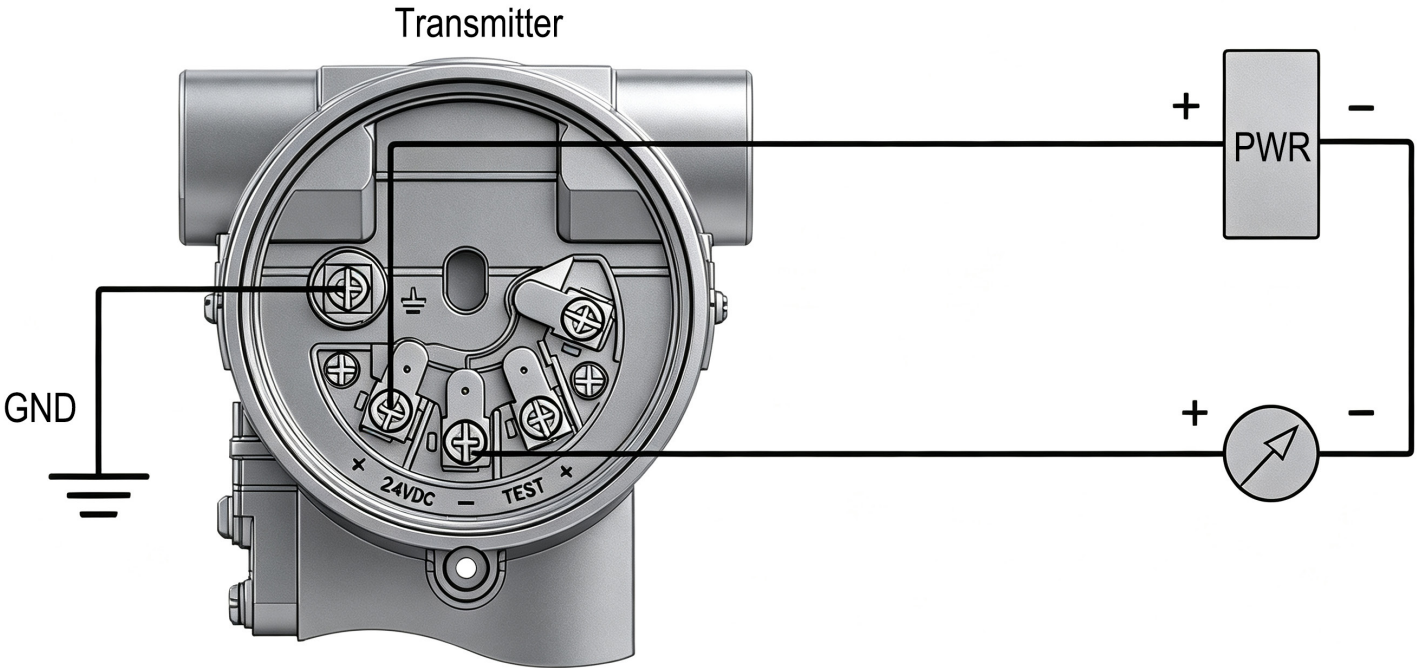
# Electrical Connections

## Transmitter Terminal Blocks

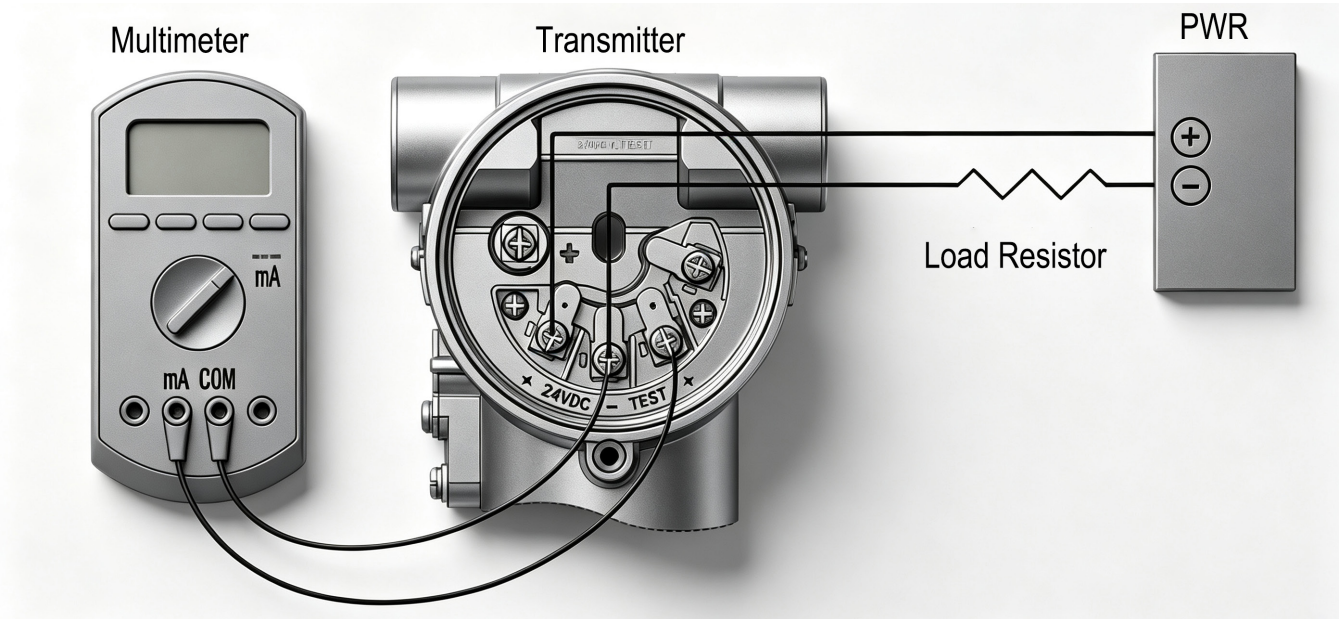



1. Transmitter Power Positive
2. Transmitter Power Negative(4–20 mA Test Terminal Negative)
3. 4–20 mA Test Terminal Positive
4. Internal Ground Screw
5. External Ground Screw

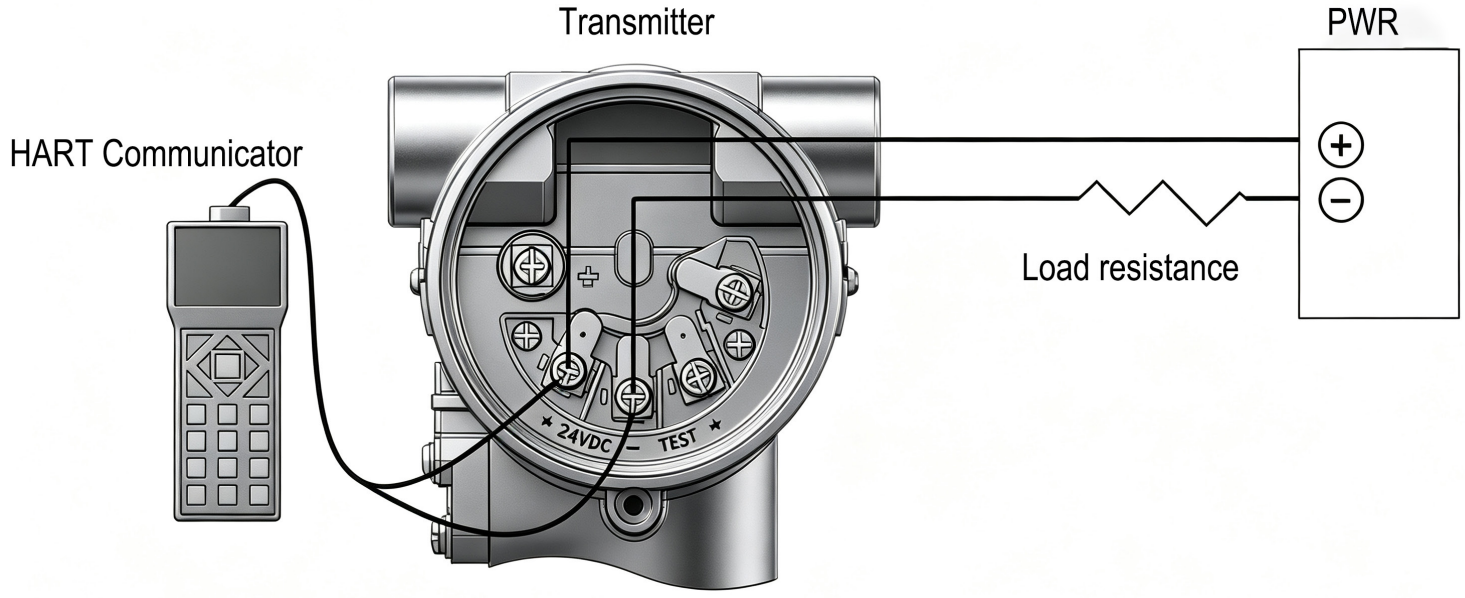
## Transmitter Power Connection Diagram



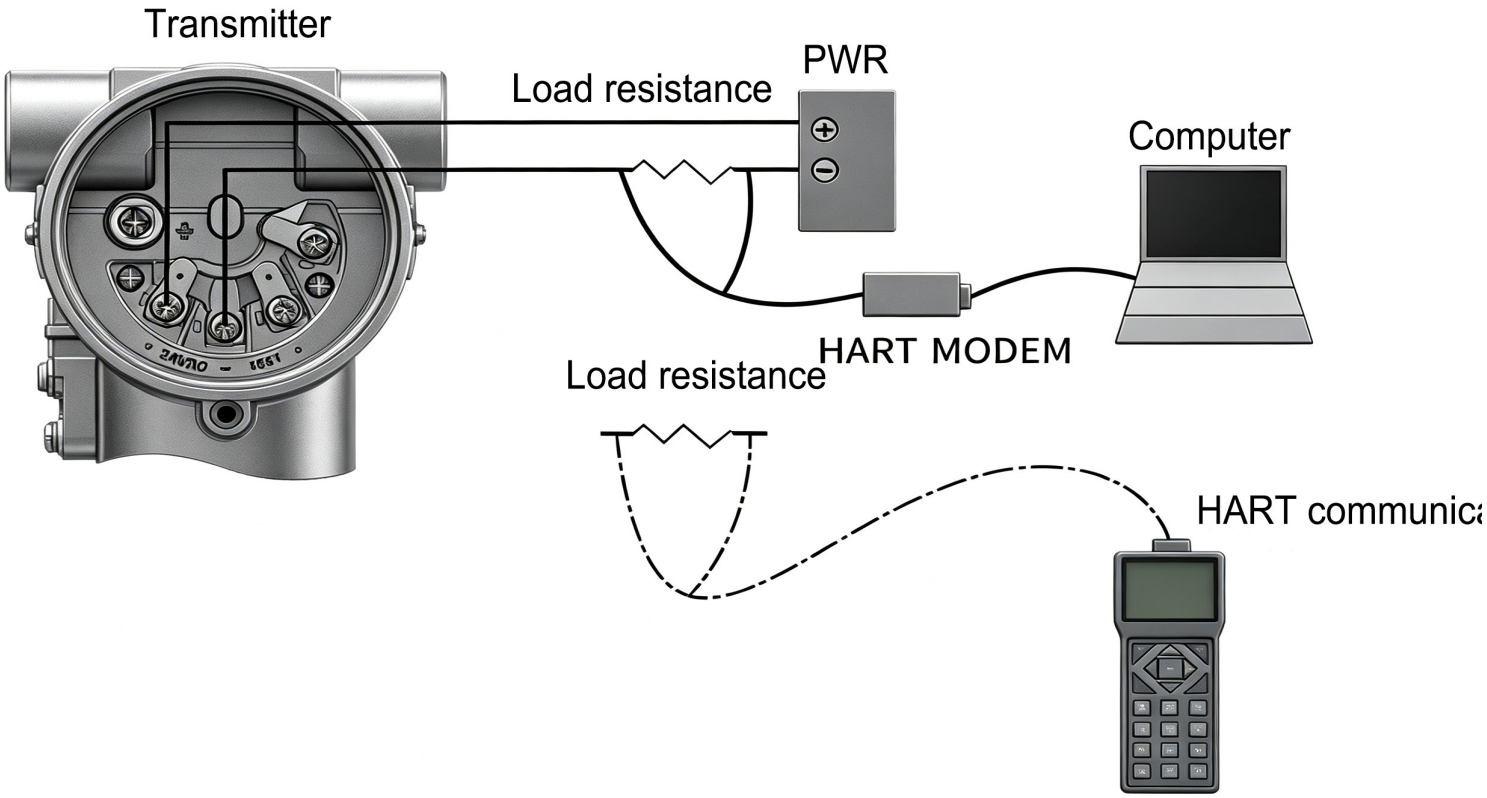

## Power Supply Test Instrument Links



Connecting the HART Communicator on the Transmitter Side




Connection of a computer or HART communicator to the power supply




## Recommendations for Daily Use & Operations and Maintenance

I. Key Points for Routine Inspections

1. **Monitoring of Operating Conditions and Signal Stability**

Verify daily that the on-site digital display matches the remote data from the control system, and observe that the readings show no sudden changes, no drift, and no hysteresis; confirm that the 4–20 mA output is stable, with no abnormal fluctuations or connection failure errors.

2. **Visual Inspection and Seal Check**

Inspect the transmitter housing, junction box, and stuffing box to ensure they are properly sealed and free of water ingress, dust, or condensation; check that the flange diaphragm is free of scaling, crystallization, corrosion, or deformation; and ensure the capillary tube is free of compression, stretching, or kinks.

3. **Environmental Temperature and Humidity Monitoring**

Maintain the operating environment temperature and humidity within the rated range. Conduct focused inspections in high-temperature, low-temperature, humid, and outdoor conditions to prevent instrument failures caused by prolonged temperature exceedances, condensation, or water accumulation.

4. **Installation Condition Inspection**

Check that brackets and flange bolts are secure and that the instrument does not wobble; pay close attention to the operational stability of instruments located near equipment subject to strong vibrations.

II. Regular Maintenance Plan
1. **Cleaning Schedule**
Clean once every 6 months under normal operating conditions; clean once every 3 months in environments with dust, oil, corrosion, or crystallization. Use only a lint-free soft cloth and a neutral solvent to clean the diaphragm and the instrument body. **Do not scratch or strike the diaphragm or capillary tube with hard objects under any circumstances.**
2. **Wiring and Structural Fastening Inspection**
Every six months, thoroughly tighten the terminal blocks, ground wires, shielding layers, flange bolts, and mounting brackets; for explosion-proof instruments, pay special attention to inspecting the explosion-proof sealing surfaces and cable gland connections to prevent looseness, loose connections, or oxidation.
3. **Accuracy Retesting and Parameter Calibration**
Under normal operating conditions, **perform accuracy calibration once a year**; for process interlocks and critical metering points, calibrate every 6 months. Use a standard pressure source to perform multi-point calibration at zero, 50%, 75%, and full scale, while simultaneously verifying HART parameters, damping, range, and offset values to ensure measurement accuracy meets standards.
4. **Operating Condition Adaptation Check**
Periodically verify the state of the medium. For media prone to crystallization or high viscosity, regularly inspect the diaphragm for deposits and clean them promptly to prevent long-term buildup from affecting measurements.

III. Long-Term Maintenance Tips
1. **Dust and Moisture Protection**
Maintain the integrity of the junction box and instrument housing seals at all times; install dehumidification and insulation measures in humid environments or those with large temperature fluctuations; Ensure outdoor instruments are protected against rain, sunlight, and water exposure to prevent moisture from entering the electrical compartment.
2. **Interference Mitigation**
Route signal cables separately, away from variable frequency drives and high-power equipment; strictly adhere to **single-ended grounding** for shielded cables to eliminate ground potential difference interference and stabilize the measurement signal.
3. **Protection Against Vibration**
Install vibration-damping mounts in areas with high-vibration equipment; allow for natural bending in capillary tubes to avoid rigid stress and tension, thereby extending the service life of the silicone oil isolation structure.
4. **Protection in Extreme Environments**
In high-temperature conditions, the instrument core is protected by the capillary tube's thermal insulation structure; in low-temperature conditions, measures are taken to prevent the medium from freezing; in corrosive environments, the corrosion protection status of the diaphragm is inspected regularly in accordance with material specifications, and maintenance or replacement is performed as needed; prolonged operation under overpressure or excessive temperatures is strictly prohibited.
5. **Record-Keeping**
Establish an instrument operation and maintenance log to record inspections, cleaning, calibration, and fault resolution, thereby ensuring standardized and traceable operation and maintenance.

## Troubleshooting & Emergency Response

I. List of Common Malfunctions
Common malfunctions of this equipment include: no signal output, measurement drift exceeding tolerance limits, value fluctuations and distortion, fault alarms triggered, display anomalies, and communication interruptions, covering all abnormal scenarios related to on-site electrical systems, operating conditions, and mechanical structures.

II. Summary of Fault Causes
The primary causes of faults are divided into five categories: wiring errors or loose connections, abnormal power supply voltage, load mismatch, strong on-site electromagnetic interference, operating conditions exceeding pressure or temperature limits, scaling or corrosion of the flange diaphragm, silicone oil leakage from the capillary tube, improper instrument parameter settings, and aging or damage to the internal mechanism.

III. Step-by-Step Troubleshooting and Repair Methods
1. No Output, No Communication, No Display
Troubleshooting: Check the 24 V DC supply voltage, circuit load, circuit continuity, and positive/negative terminal connections; verify that the junction box is free of water ingress and oxidation, and that terminals are not loose.
Repair: Rewire according to specifications, tighten terminals, and replace damaged cables; restore standard power supply and ensure load compatibility.
Emergency Measure: Temporarily replace the instrument with a spare unit to ensure continuous process monitoring.

2. Signal Drift, Measurement Deviation Exceeds Limits
Troubleshooting: Verify range, offset, and damping parameters; check for scale buildup on the diaphragm, changes in medium density, and zero-point offset; investigate interference from temperature and static pressure.
Repair: Clean deposits from the diaphragm on-site; re-calibrate the zero point and range; adjust the offset and damping parameters; update the medium density parameter.
Emergency Measures: Manually verify readings against on-site liquid level readings; temporarily lock stable parameters; shut down the system for calibration at an appropriate time.

3. Distorted Value Fluctuations and Frequent Spikes
Troubleshooting: Confirm whether power cables and signal cables are routed in the same conduit and whether shield grounding complies with specifications; investigate equipment vibration, medium pulsation, and uneven temperature distribution in the capillary tube.
Remedy: Run signal cables separately and implement single-ended shield grounding; appropriately increase the instrument's damping; isolate the equipment from vibration and prevent the capillary tube from being exposed to direct sunlight or localized high temperatures.

Emergency Measures: Temporarily increase the damping parameter to stabilize remote transmission data.

4. Alarms, Errors, and Self-Diagnostic Anomalies
Troubleshooting: Read the instrument's fault codes to identify abnormalities in the sensor, circuit, or temperature; check the flange and capillary tube for leaks.
Remedy: Correct wiring faults on-site; for hardware failures, cease operation and return the unit to the factory for repair.

5. Inaccurate Measurement Range, Full-Scale Abnormalities
Troubleshooting: Verify that the selected measurement range matches actual operating conditions; check for overpressure, overload, diaphragm deformation, or silicone oil leakage.
Remedy: Recalibrate the measurement range; replace the unit or return it to the factory for repair if structural damage is present.

IV. After-Sales Service Request Guidelines
1. Criteria for Determining a Malfunction (Requiring Service)
After on-site troubleshooting has ruled out issues with wiring, power supply, operating conditions, and parameter settings, a service request must be submitted if any of the following conditions persist: persistent measurement errors that cannot be calibrated, no output or communication, internal mechanism failure with error codes, capillary tube/silicone oil leaks, diaphragm deformation or damage, or chip damage

2. Standard Repair Process
Step 1: Record the instrument model, measurement range, flange specifications, installation conditions, fault symptoms, and error codes; Step 2: Take photos of the nameplate, the faulty instrument face, and the on-site installation; Step 3: Contact the manufacturer's technical support for remote troubleshooting; Step 4: After confirming a hardware failure, return the unit to the factory for inspection, repair, or replacement.

3. Warranty Coverage
Warranty Period: 12 months from the date of manufacture. Warranty Coverage: Under normal operating conditions and when installed and used in accordance with specifications, manufacturing defects in the movement, circuitry, and structural components will be repaired or replaced free of charge. Exclusions: Damage caused by overpressure or overheating, unauthorized disassembly or reassembly, unauthorized opening of the case, physical damage, corrosion or blockage due to operating conditions, on-site wiring errors, or force majeure is not covered by the free warranty.