Level, Flow and Temperature Instrumentation for Nuclear Power Utility Applications

Flow Switches and Alarms for Air, Gases and Liquids
Level Switches and Alarms
Level Gauges
Air and Gas Mass Flow Meters
Continuous Class 1E Supplier Since 1978
Qualified to IEEE 323, IEEE 344
ISO 9001 Certified, NUPIC Approved
QA in Accordance with 10CFR50 App. B, ANSI N45.2, ASME NQA-1
Item Dedication Program
New Results with FCI

- Improve Plant Thermal Efficiency
- Reduce Instrumentation Requirements
- Reduce Piping Footprint and Tap Points
- Reduce Power, Cabling and Wiring Requirements
- Increase Reliability for Critical Systems
- Reduce Installation and Maintenance Costs
- Save Time with Expert Global Service, Training and Support
- Meet New Nuclear Industry Certifications and Qualifications
- Simplify Documentation, Material Testing and Certifications
Nuclear Power Resurgence

Today, nuclear utility design engineers, plant engineers and operators are delivering the most competitive energy in the world. While current operating facilities continue to safely improve performance, a reemergence of interest is driving new construction and extended plant re-licensing. Activity levels are high and strong, proven partners are needed for sustainable success. The next generation of nuclear power plants will achieve even greater efficiencies, lower operational costs and faster construction time. Requirements for new construction demand less piping, mechanical equipment, cement and other base footprint materials. These new plants will provide improved operating efficiencies and better asset utilization.

FCI is nuclear power’s proven partner for driving instrumentation costs down while reducing maintenance and increasing safety, plant performance and labor efficiencies. FCI is ready to help you meet new nuclear plant I&C operating strategies like defense-in-depth, and objectives including diversity, redundancy and independence.

FCI Nuclear — Committed to the Nuclear Power Industry

Since 1978, FCI has designed and produced level, flow and temperature instruments that improve plant performance, protect equipment and maintain vital processes. Our unique expertise in the nuclear power industry delivers valuable time and cost savings during both construction and operational phases.

FCI delivers products that meet nuclear industry requirements from crib house intake to containment to balance-of-plant applications. Products stand ready for harsh environments under guidelines of IEEE 323, IEEE 344, IEEE 382; Class 1E Seismic Category 1.

FCI Quality Assurance meets 10CFR50 Appendix B and complies with 10CFR21, ANSI N45.2 and NQA-1. FCI has developed products that comply with software quality control standard D0178, and are capable of meeting new and emerging nuclear industry software QC and digital I&C standards applicable to microcomputer-based instrumentation.

FCI is ISO 9001 certified and manufacturing processes comply with NUPIC and NIAC. An item dedication program is maintained in-house.

FCI Nuclear Power Instrumentation at Work

FCI products are operating in more than 30 different applications in more than 115 nuclear power plants operated by:

- American Electric Power
- Arizona Public Service
- Constellation Nuclear
- Detroit Edison
- Dominion
- Duke Power
- Energy Northwest
- Entergy Nuclear
- Exelon Corp
- First Energy Nuclear Op Co
- Florida Power & Light Co
- Luminant Energy
- Nebraska Public Power District
- Omaha Public Power
- PPL Susquehanna LLC
- PG&E
- Progress Energy
- South Carolina Electric & Gas
- Southern Cal Edison
- Southern Nuclear Op Co
- STP Nuclear Op Co
- TVA
- Xcel Energy
- Assoc Nuclear Vald
- Comission Fed Electric
- ENEL
- ENHR, SA
- Hidroelectrica, SA
- Korea Electric Power
- National Power
- Nuclear Elec
- Nuclenor
- Ontario Hydro/Bruce Nuclear
- Taiwan Power
Meet Supply Chain Objectives

FCI is the only manufacturer of thermal dispersion technology flow meters, flow switches, level switches and level gauges accredited for both nuclear safety related and balance-of-plant applications.

The FCI Instrumentation Advantage

Reduce Instrumentation, Power, Wiring, Cabling and Installation – FCI multi-variable sensors reduce requirements for purchasing, installing, powering, maintaining and documenting additional instruments.

Thermal dispersion level and flow measurement products are inherently dual-function, providing both level and temperature, or flow and temperature outputs with just one sensor.

Because FCI thermal dispersion flow products are direct mass flow measuring, they do not require the addition of temperature and/or pressure sensors to be installed in the process to compute inferred mass flow. The elimination of these devices delivers significant savings in instruments.

Reduce Cost per kWh – Replacing a single Delta P (DP) orifice plate flow meter with an FCI thermal dispersion flow meter eliminates significant pressure losses, which can achieve substantial cost savings. For example, in a 5’ x 5’ air duct flowing at 50 feet per second, DP will lose 1/28 PSI more than FCI’s thermal meter. At $0.10 per kWh energy cost, the DP device pressure loss costs $21 per day, or nearly $460,000 over a 60 year life more to operate than a comparable FCI thermal flow meter.

When comparing thermal technologies, FCI’s constant power thermal dispersion measurement technique uses far less power than variable power techniques – 8 Watts less per meter on average.

Moreover, FCI produces significant balance-of-plant and operational savings solutions. For example, FCI solves level gauging challenges and eliminates labor for manual tank gauging in radwaste tanks, which separate flocculent or beads from the circulating water. In this case, FCI’s no moving parts solution replaces both manual checking and unreliable mechanical floats while also reading radwaste interface quantities and temperature. Using FCI instruments results in improved clear water circulation control and plant efficiency. More operational savings examples are given in the application illustrations below.

Unique ‘Flow + Temperature’ and ‘Level + Temperature’ Sensing Technology

FCI’s thermal dispersion technology excels in applications where both flow and temperature or level and temperature are measured. Temperature sensing is inherent in FCI’s thermal dispersion flow and level measurement technology. A single sensor provides dual measuring functions. Nuclear plant operations save weight, save space, and save costs over two or more discreet sensors. You realize reduced qualification installation costs and complexity.

Reacto Core Coolant
- Flow and Temperature, Level and Temperature

Radwaste Interface
- Level, Interface Detection and Temperature
Spares Reduction, Labor Savings

By standardizing on FLT93 products for both flow and level applications, spares inventory is greatly reduced and maintenance staff training is leveraged for productivity improvements.

Ease of Use – Single penetration points for sensor elements provide easy mechanical connection to the process and simplified wire-up to power input and outputs. Field set switch points and calibration with complete system precheck verification provides accurate alarm and metering with total confidence.

Critical Equipment Protection, Plant Integrity Validation – Level, flow and temperature detection is critical to numerous processes within every nuclear power plant operation. Examples include operational integrity of turbines, pumps, cooling systems and valves, as well as process off-gases and HVAC systems.

FCI provides flow sensor solutions for line sizes from 1/8” to the largest of stacks and ducts. FCI products are designed robustly with proven track records, MTBF ratings in excess of 100 years, SIL-2 ratings, and an exacting specification of nuclear plant certification pedigrees.

FCI’s no moving parts technology is the safest choice for critical equipment protection and plant integrity validation.

Technological Advantage – With no moving parts to clog, stick or foul, FCI thermal dispersion units are virtually maintenance free, needing little more than an occasional wipe down. It is a fail-safe technology that translates to an increase in both reliability and tangible savings in maintenance costs.
Innovations like system precheck in switches and VeriCal™ in-situ calibration verification in flow meters, demonstrate FCI’s commitment to continuously improving features and functions that increase installed reliability and performance.

Whether your nuclear plant retains traditional analog process interfaces (like 4-20 mA and contact closures) or advances to digital bus communications, FCI products are available. Industrial bus communications such as HART, Foundation Fieldbus and Profibus are available in FCI products now or as field upgrades.

Confidence — Since 1978, FCI’s continuous service to the nuclear industry speaks volumes.

Global support assures that specifying FCI products is a sound decision for any plant in the world. Global nuclear regulatory agency approvals, certifications and participation in nuclear industry supply-chain programs mean FCI can deliver products to the standards demanded by the industry. This high level of dedication and commitment to the nuclear industry means FCI is a supplier you can depend on — today and tomorrow.
FCI is the world’s number one ranked supplier of thermal flow meters and flow switches, as independently reported by Control Magazine. Breakthroughs like equal mass sensing, advanced signal processing, high accuracy calibrations and the ability to mitigate installation challenges make FCI the right partner for modern nuclear power.

An Engineering Partnership

It is FCI’s ability and passion to develop special designs for our customers. Here is just one of thousands of examples:

A nuclear plant customer had a level application, but access to the tank was blocked by an overhead structure. FCI responded to the challenge by developing a “flex joint” sensor so the level sensor array could be “bent” during installation (see figure below).

FCI’s team of application engineers, nuclear plant specialists, computer and software engineers are an integral part of the FCI solution and experience. Post-sales support from FCI is available around the clock. In addition to FCI’s 24 / 7 service hot line, FCI has multiple service, support and calibration depots, and a global team of field service engineers that can be dispatched quickly to your site.

When unique engineering situations occur and application challenges are found that leave you with little time or painfully expensive options, contact FCI. FCI will develop specifications with you and design the right instrument solution to meet your application.

Figure 1: Flex Joint Option — Installation Solution for Tight Spaces and Low Headroom

Shown in extended position prior to bending, straightening and rigidizing.

Figure 2: Containment Building Level Gauge

- Drywell and Mid-Loop Levels

Figure 3: Drain Line Flow Sensors

- Detect Slightest Leakage
FCI — Your Expert Partner

FCI continues to be at the forefront of advances in thermal dispersion flow and level measurement technology. With continuous innovation and investment in sensor designs, sensor packaging, electronics and calibration, you can count on FCI’s products to deliver the highest accuracy and repeatability along with the longest service life.

Sensor Innovation – FCI pioneered the first equal mass sensor configuration. This design ensures that sensor elements consistently track process changes at identical rates and magnitudes. These equal mass sensors greatly broadened the range of applications and flow rates for thermal technology.

Further, FCI has applied new heat path aging and materials optimization techniques which provide higher performance at lower costs.

Temperature Compensation Sets FCI Apart – Temperature compensation circuitry ensures thermal dispersion instruments perform to specification regardless of temperature swings in the measured process fluid or the ambient environment. This important functionality is standard in FCI products while often overlooked or minimized by other manufacturers. Individual sensors are normalized in reference fluids, then precise correction factors are applied within built-in temperature compensation electronics. The result is a stable, drift-free measurement immune to the effects of fluid and/or ambient temperature changes.

Unequalled Calibration and NIST Traceable Facilities – FCI invested extensively to bring high accuracy calibration and NIST traceable facilities in-house. Optimized sensing requires knowledge of the process fluid because the cooling rate is a function of thermo-physical properties, such as viscosity, density, specific heat, thermal conductivity, and coefficient of thermal expansion.

While new modeling and equivalency methodologies have become effective at approaching reference gas calibrations, it remains clear that the highest level of performance is achieved with actual gas and actual liquid calibrations. FCI’s capability to perform these actual fluid calibrations with automated data collection and reference standards results in superior instrument calibration and performance.

FCI Product Selection Overview

<table>
<thead>
<tr>
<th>Function</th>
<th>Media</th>
<th>FLT93 Series</th>
<th>FLT93M Series</th>
<th>Nutec Series</th>
<th>CL86</th>
<th>LT81</th>
<th>ST50/ST75 Series</th>
<th>ST98 Series</th>
<th>GF90/GF32 Series</th>
<th>MT86/MT31 Series</th>
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</thead>
<tbody>
<tr>
<td>Point Level</td>
<td>Liquid</td>
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<tr>
<td>Multi-Point Level</td>
<td>Liquid</td>
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<tr>
<td>Continuous Level</td>
<td>Liquid</td>
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<td>Flow Switch/Alarm</td>
<td>Air &amp; Gases</td>
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<tr>
<td>Flow Switch/Alarm</td>
<td>Liquid</td>
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<tr>
<td>Flow Meter</td>
<td>Air &amp; Gases</td>
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<td>Temperature Switch/Alarm</td>
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</table>
FCI Calibration Ensures Installed Accuracy

All FCI products are tested and calibrated to rigorous standards so that you get the instrument that does the job specified. To design and produce the highest quality flow instrumentation, FCI operates a world-class, fully NIST traceable flow calibration laboratory that is certified to meet such stringent standards as MIL-STD 45662A and ANSI/ NCSL Z-540.

Other suppliers are often limited to air and water calibrations then rely on un-validated theoretical equivalencies for other fluids. This procedure can be inadequate and result in installed errors well outside published specifications. To eliminate this risk, for most fluids, FCI thermal dispersion flow instruments are calibrated using the actual fluid, as well as the actual temperature and process conditions of your application. The result is a flow instrument you can install with total confidence and assurance that it meets your application.

Transferring Laboratory Results to the Field – FCI products and their calibration processes are designed to provide optimum performance in their actual installation. FCI’s years of experience and in-depth understanding of real-world conditions such as straight-run, fluid stratification, transitional flow profiles, swirl turbulence, temperature changes and pulsation are factored into product designs and the calibration process. The end result is a thermal dispersion flow or level measurement product you can count on to provide superior installed performance.

Examples include “in-line” configurations that fix the sensing element in a spool-piece section so the measurement is unaffected by installation variation effects such as pitch, yaw, rotation or depth. Other examples include lock-in-place or keyed mechanical stays, multi-point sensor arrays, best-practice installation guides, flow conditioners, flat profile calibrations and extended range temperature compensation.

Sensor improvements, temperature compensation, calibration and transferring product to the field assure total confidence in FCI products.

A Lasting Commitment – FCI has never wavered from its commitment to advancing the technology and serving the nuclear industry with lasting results. FCI is a proven partner for your success.
High Reliability, No Moving Parts
Dual Function, Level and Temperature
AC, DC and Loop Powering Options
3 Phase Interface
Interface Between Two Non-Miscible Fluids
Easy to Install
Rugged, Heavy-Duty

FCI level switches and transmitters provide fast response, accurate fluid level alarms and set-point controls. Units sense the temperature difference between a heated sensor and an unheated reference sensor, where the difference is greatest in the absence of liquid and decreases proportionally as the elements are submerged in various fluids with varying thermal conductivities.

For example, when submerged in radwaste interface applications with air, water and pelletized water, the heated sensor cools as it dissipates heat. In turn, each media changes in the magnitude of the temperature difference. An electronic control circuit converts the RTD temperature difference into signal for either set-point alarm, control or continuous level transmission.

Because all fluids exhibit different heat transfer characteristics, FCI’s highly sensitive level switch technology can detect historically difficult interface applications between fluids such as liquids, gases, emulsions, slurries and foam, regardless of their physical properties. In the radwaste water example (page 4), where temperature stratification is reversed, FCI solves this phenomenon with special time delays to correctly allow stabilized signaling and accurate measurement.

Typical Level and Interface Output Signals

<table>
<thead>
<tr>
<th>Model/Series</th>
<th>N-FLT93 Series</th>
<th>LS2000 Series</th>
</tr>
</thead>
</table>
| Key Features and Applications | • Heavy-Duty  
• Dual, 6A Relays  
• Exclusive Precheck Circuitry  
• 3 year Warranty  
• SIL-2 Rated, 118 Year MTBF | • Low Cost  
• Replacement for Mechanical Level Switches  
• 6A Relay  
• Two-wire, loop powering option |
| Media Compatibility | Water  
All Other Liquids  
Slurries  
Interface | | |
| Measurements and Outputs | Level  
Temperature | | |
| Media Temperature Service | -100°F to 850°F  
(-73°C to 454°C) | -40°F to 250°F  
(-40°C to 121°C) |
| Wetted Materials Available | Stainless Steel, Hastelloy, Monel, Tantalum, Others | Stainless Steel |
| Transmitter Outputs and Displays | Analog Outputs  
Relay or Contact Closure | | |
| Transmitter Mounting | Integral  
Remote | | |
| Nuclear Safety Certification | | Contact FCI |
| Radiation | Sensor  
Electronics  
2 x 10⁸ RADS  
5 x 10⁸ RADS | |
| Aging | 40 years at 150°F [66°C], extendable to 60 years  
Relay: 5100 full load cycles | |
| Seismic | Sensor and Electronics:  
Biaxial: 3g SSE ZPA  
RIM: 6.4g SSE (FLT93 High Temperature versions, 8g SSE ZPA) | |
### Key Features and Applications

**FLT93M**
- Heavy-Duty
- Up to 8 Sense Points
- Up to 120" [3048 mm] Length
- 6A Relay
- Radwaste Interface Detection
- 3 year Warranty
- SIL-2 Rated, 110 Year MTBF

**CL86**
- True Continuous Level
- Up to 180" [30 m] Length
- Wet or Dry Detection
- Custom Flex Joint Design Solves Installation Challenges

### Media Compatibility

<table>
<thead>
<tr>
<th>Media Type</th>
<th>FLT93M</th>
<th>CL86</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td>All Other Liquids</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td>Slurries</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td>Interface</td>
<td>☑️</td>
<td>☑️</td>
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</table>

### Measurements and Outputs

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<thead>
<tr>
<th>Measurement</th>
<th>FLT93M</th>
<th>CL86</th>
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</thead>
<tbody>
<tr>
<td>Level</td>
<td></td>
<td></td>
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<tr>
<td>Temperature</td>
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</tbody>
</table>

### Media Temperature Service

<table>
<thead>
<tr>
<th>Temperature</th>
<th>FLT93M</th>
<th>CL86</th>
</tr>
</thead>
<tbody>
<tr>
<td>-100 °F to 500 °F</td>
<td>[-73 °C to 260 °C]</td>
<td>32 °F to 360 °F</td>
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</table>

### Wetted Materials Available

<table>
<thead>
<tr>
<th>Available Material</th>
<th>FLT93M</th>
<th>CL86</th>
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</thead>
<tbody>
<tr>
<td>Stainless Steel, Hastelloy</td>
<td>☑️</td>
<td>☑️</td>
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</table>

### Transmitter Outputs and Displays

<table>
<thead>
<tr>
<th>Outputs and Displays</th>
<th>FLT93M</th>
<th>CL86</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Outputs</td>
<td></td>
<td>☑️</td>
</tr>
<tr>
<td>Relay or Contact Closure</td>
<td>☑️</td>
<td>☑️</td>
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### Transmitter Mounting

<table>
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<tr>
<th>Mounting Options</th>
<th>FLT93M</th>
<th>CL86</th>
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</thead>
<tbody>
<tr>
<td>Integral</td>
<td>☑️</td>
<td></td>
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<tr>
<td>Remote</td>
<td></td>
<td>☑️</td>
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</table>

### Nuclear Safety Certification

<table>
<thead>
<tr>
<th>Certification</th>
<th>FLT93M</th>
<th>CL86</th>
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</thead>
<tbody>
<tr>
<td>☑️</td>
<td></td>
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</table>

### Radiation

<table>
<thead>
<tr>
<th>Type</th>
<th>FLT93M</th>
<th>CL86</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor</td>
<td>$2 \times 10^6$ RADS</td>
<td>$1 \times 10^6$ RADS</td>
</tr>
<tr>
<td>Electronics</td>
<td>$5 \times 10^5$ RADS</td>
<td>$1 \times 10^5$ RADS (shielded)</td>
</tr>
</tbody>
</table>

### Aging

<table>
<thead>
<tr>
<th>FLT93M</th>
<th>CL86</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 years at 150 °F [66 °C], extendable to 60 years</td>
<td>40 years at 120 °F [49 °C], extendable to 60 years</td>
</tr>
<tr>
<td>Relay: 5100 full load cycles</td>
<td>Analog Output</td>
</tr>
</tbody>
</table>

### Seismic

<table>
<thead>
<tr>
<th>FLT93M</th>
<th>CL86</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor and Electronics: Biaxial: 3g SSE ZPA RIM: 6.4g SSE (FLT93 High Temperature versions, 8g SSE ZPA)</td>
<td>Sensor: Biaxial: 1g SSE ZPA Electronics: Biaxial: 2g SSE ZPA</td>
</tr>
</tbody>
</table>

### Level Applications
- Sump Flood Level
- Spent Resin Interface
- Containment Water Level
- Containment Building Sump Level
- SCRAM Discharge Level
- Condensate Pot Level
- Tank Level
- Mid Loop Level
- Suppression Pool Level
- Dry Well Level
- Spent Fuel Pool Level
- Pond Level
- Accumulator Level
- Turbine Oil Level
- Steam Drain Level
- Loop Seal Level
- Oil Reservoir Level
- Room/Area Flooding Alarm
- Fuel Pool Level
- Chemical and Volume Control
- Boric Acid
- Main Steam MSCV Hydraulic Tank Level
- Main Steam Reheater Drain Tank Level
- Main Steam Condensate Storage Tank Level
- Auxiliary Boiler Water Level
- Auxiliary Boiler Fuel Level
- Generating System Lube Oil Alarm
- Generating System Stator Cooling Water Level
- Diesel Generator Lube Oil/Fuel/Water Level
- Steam Generator Level
- Feedwater Level
- Ice Condenser Reactor Containment Level
- Water Treatment Systems Level
- Circulating Water Systems Level
- Service Water Systems Level
- Crib House Systems Level
- LOCA Alarm/Switch
FCI flow instruments utilize thermal dispersion technology that applies the principle of measuring the heat loss, or cooling effect, created by a flowing fluid. Using two thermowell-encased precision RTDs, heat is applied to one to create a differential temperature between the two. The temperature difference is greatest at no flow. As flow velocity increases, heat dissipates and changes the magnitude of the temperature difference between the RTDs.

FCI offers the widest selection of thermal dispersion flow products, from models for metering virtually any gas to switch/alarms for most liquids, slurries and gases.

FCI technology offers fast response, accurate fluid sensing, field adjustable set points and factory installed temperature, pressure and flow capabilities to suit a broad range of safety monitoring and balance-of-plant applications. (See sample applications listed on page 13.)

**High Reliability, No Moving Parts**
**Dual Function, Flow and Temperature**
**Line Sizes from 1/8” [3mm] to Stacks and Ducts**
**Widest Measuring Ranges**
**Nuclear Safety Certified Versions**
**Analog, Relays and Digital Bus Outputs**
**Qualified to 40 Years Continued Service**

Flow Solutions

![Flow Solutions Diagram]

<table>
<thead>
<tr>
<th>Model/Series</th>
<th>FLT93 Series</th>
<th>Nutec Series</th>
<th>ST50 / ST51 / ST75</th>
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<tbody>
<tr>
<td><strong>Key Features and Applications</strong></td>
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<tr>
<td>Heavy-Duty</td>
<td>Low Cost</td>
<td>Low Cost</td>
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<tr>
<td>Dual, 6A Relays</td>
<td>Replacement for Mechanical Level Switches</td>
<td>Compact Size</td>
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<tr>
<td>Exclusive Precheck Fail Guard</td>
<td>Two-wire, Loop Powering Option</td>
<td>Triple Analog Outputs</td>
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<tr>
<td>3 year Warranty</td>
<td>Exclusive Non-intrusive Design</td>
<td>Vortab® Flow Conditioning (ST75V)</td>
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</tr>
<tr>
<td>SIL-2 Rated, 110 Year MTBF</td>
<td>High Flow Rate</td>
<td>Wireless IR Comm</td>
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<tr>
<td>High Pressure Ratings</td>
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<table>
<thead>
<tr>
<th>Media Compatibility</th>
<th>Air</th>
<th>Gas</th>
<th>Water</th>
<th>Other Liquids</th>
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<table>
<thead>
<tr>
<th>Installation Type</th>
<th>Insertion</th>
<th>In-Line (spool piece)</th>
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<tbody>
<tr>
<td></td>
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<td>(FLT93L) (FS2000L) (ST75)</td>
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<table>
<thead>
<tr>
<th>Measurements and Outputs</th>
<th>Flow Rate</th>
<th>Total Flow</th>
<th>Temperature</th>
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<tr>
<th>Media Temperature Service</th>
<th>-100°F to 850°F [-73 °C to 454 °C]</th>
<th>-40°F to 250°F [-40 °C to 121 °C]</th>
<th>0°F to 250°F [-18 °C to 121 °C]</th>
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<tr>
<th>Wetted Materials Available</th>
<th>Stainless Steel, Hastelloy, Monel, Tantalum, Others</th>
<th>Stainless Steel</th>
<th>Stainless Steel</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>Transmitter Outputs and Displays</th>
<th>Analog Outputs</th>
<th>Pulse Output Total Flow \ Relay/Contact Closure</th>
<th>Digital Serial Output</th>
<th>Bus Comms</th>
<th>Other (IR to PDA)</th>
<th>Digital Display</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(IR to PDA)</td>
<td>Optional</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Transmitter Mounting</th>
<th>Integral</th>
<th>Remote</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Nuclear Safety Certification | | Contact FCI | Contact FCI |
|-------------------------------|----------------|-------------|

<table>
<thead>
<tr>
<th>Radiation</th>
<th>Sensor Electronics</th>
<th>2 x 10⁶ RADS</th>
<th>5 x 10⁶ RADS</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Aging</th>
<th>40 years at 150 F, extendable to 66 years</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Seismic</th>
<th>Sensor and Electronics: Bi axial: 3g SSE ZPA; RIM: 6.4g SSE (FLT93 High Temperature versions, 8g SSE ZPA)</th>
</tr>
</thead>
</table>
### Flow Meters

<table>
<thead>
<tr>
<th>ST98 Series</th>
<th>GF90 / GF92</th>
<th>MT86 / MT91</th>
<th>N-LT80 Series</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key Features</strong></td>
<td><strong>Key Features</strong></td>
<td><strong>Key Features</strong></td>
<td><strong>Key Features</strong></td>
</tr>
<tr>
<td>• Rugged</td>
<td>• Three Calibrations</td>
<td>• Large Line, Stacks and Ducts</td>
<td>• Nuclear Safety Certification</td>
</tr>
<tr>
<td>• Ex Rated</td>
<td>• Built-in Keyboard</td>
<td>• Multiple Sensors</td>
<td>• Dual Calibrations</td>
</tr>
<tr>
<td>• Bus Comms</td>
<td>• Widest Flow Range</td>
<td>• Automatically Averaged</td>
<td>• Wide Flow Range</td>
</tr>
<tr>
<td>• High Accuracy</td>
<td>• Turndowns to 1000:1</td>
<td>• Up to 16 Sensors per System</td>
<td>• Analog and Relay Outputs</td>
</tr>
<tr>
<td>• Vortab Flow Conditioning (ST98L)</td>
<td>• VeriCal™ In-situ Calibration</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sensor:</th>
<th>Sensor:</th>
<th>Sensor:</th>
<th>Sensor:</th>
</tr>
</thead>
<tbody>
<tr>
<td>8g SSE ZPA RIM: 4.5g</td>
<td>3g SSE ZPA RIM: 4.5g</td>
<td>8g SSE ZPA RIM: 4.5g</td>
<td>3g SSE ZPA</td>
</tr>
<tr>
<td><strong>Electronics:</strong></td>
<td><strong>Electronics:</strong></td>
<td><strong>Electronics:</strong></td>
<td><strong>Electronics:</strong></td>
</tr>
<tr>
<td>Biaxial:</td>
<td>Biaxial:</td>
<td>Biaxial:</td>
<td>Biaxial:</td>
</tr>
<tr>
<td>8g SSE ZPA</td>
<td>3g SSE ZPA</td>
<td>8g SSE ZPA</td>
<td>3g SSE ZPA</td>
</tr>
</tbody>
</table>

**Flow Applications**
- Effluent Stack Flow Monitoring
- HVAC - Air/Liquid Monitoring
- Radiation Monitoring and Sampling Systems
- Fire Protection Flow Monitoring
- Chemical and Volume Control System Sampling
- Auxiliary Boiler Combustion Air Flow Balancing
- Diesel Combustion Air Flow Balancing
- N₂ Compressor Storage Flow
- H₂ Storage Flow
- Auxiliary Building Sampling
- Containment Building Sampling
- Fuel Storage Building Sampling
- Relief Valve Flow Detection
- Main Steam System Flow Monitoring
- Containment Building Pressurization Flow
- Valve Stem Leak Off Flow
- Drain Line Systems Flow
- Waste Gas Decay Tank Outflow
- Water Hammer Flow Prevention
- MSIV Leak Detection Alarm
- Power Operation Relief Valve Flow Sensing
- Radiation Monitoring System Sample Flow
- Reactor Heat Vent Flow
- Reactor Coolant Pump Seal Flow
- Reactor Pump Motor Cooling Flow
- Auxiliary Feed Water Pump Minimum Flow
- Tank Discharge Flow
- Ventilation Stack Flow
- Hydrogen Water Chemical Flow
- Vacuum Pump Flow
- Safety Injection System Flow
- Crib House Intake Flow
- Component Cooling System Flow
- Circulating Water System Flow
- Feedwater Systems Flow
- Generating Systems Flow
- Feedwater System Lube Oil Flow
- Generating System Lube Oil Flow
- Steam Dump Flow
- Containment Spray System Flow
- Water Treatment/Purification Systems Flow
- Circulating Water Systems Flow
- Service Water System Leakage Alarm
- LOCA Alarm Switch

**Model N-MT86 only**

### ST98 Series

<table>
<thead>
<tr>
<th>Media Compatibility</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel, Hastelloy</td>
<td>Reactor Heat Vent Flow</td>
</tr>
<tr>
<td>Stainless Steel, Hastelloy, Monel, Tantalum</td>
<td>Nuclear Safety Monitoring</td>
</tr>
<tr>
<td>Stainless Steel, Hastelloy, Others</td>
<td>Containment Building Pressurization Flow</td>
</tr>
<tr>
<td>Stainless Steel, Hastelloy</td>
<td>Valve Stem Leak Off Flow</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature Range</th>
<th>Media Compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40 °C to 850 °C</td>
<td>Stainless Steel, Hastelloy, Monel, Tantalum</td>
</tr>
<tr>
<td>-100 °F to 121 °F</td>
<td>Stainless Steel, Hastelloy, Others</td>
</tr>
<tr>
<td>-50 °F to 850 °F</td>
<td>Stainless Steel, Hastelloy</td>
</tr>
<tr>
<td>-100°F to 850°F</td>
<td>Optional</td>
</tr>
</tbody>
</table>

**Options**
- Contact FCI
- Optional

**Specifications**
- 2 x 10⁸ RADS
- 5 x 10⁸ RADS
- 40 years at 130°F [55°C], extendable to 60 years
- 40 years at 150°F [66°C], extendable to 60 years
- Relay: 50,000 full load cycles

**Electronics:**
- Biaxial: 8g SSE ZPA RIM: 4.5g
- Electronics: Biaxial: 8g SSE ZPA
- Electronics: Biaxial: 3g SSE ZPA
Heat Exchangers

- Flow / No Flow Detection, Temperature

Relays can be precision-set for alarm trips on high/low, high/higher or low/lower conditions. These all-welded sensing elements measure in ranges from -100 °F to 850 °F [-73 °C to 454 °C] and provide process connection choices from NPT to flanged.

Just like FCI's flow meters and level switches, these temperature sensors achieve superior reliability and require very little maintenance for the most demanding safety-rated and balance-of-plant applications. They are also easy to install.

Contact FCI with your application and engineering specifications to obtain details on a temperature instrument designed to match them.

**Temperature Switches and Alarms — Available Capabilities**

<table>
<thead>
<tr>
<th>Sensor Type</th>
<th>RTD; Platinum, Balco, or others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>-100 °F to 850 °F [-73 °C to 454 °C]</td>
</tr>
<tr>
<td>Accuracy</td>
<td>±0.2 °F [±0.1 °C]</td>
</tr>
<tr>
<td>Repeatability</td>
<td>±0.1 °F [±0.1 °C]</td>
</tr>
<tr>
<td>Sensor Element Wetted Materials</td>
<td>316L Stainless Steel (std.) Hastelloy C-276, Monel, Titanium, others</td>
</tr>
<tr>
<td>Flow Element Construction</td>
<td>All Welded</td>
</tr>
<tr>
<td>Outputs/Control Circuit</td>
<td>Single Relay, Dual Relays, 4-20mA, other DC</td>
</tr>
<tr>
<td>Remote Mountable Electronics</td>
<td>Yes</td>
</tr>
<tr>
<td>Enclosure Type</td>
<td>All Metal, Fiberglass; NEMA 4 or NEMA 4X [IP67]; Rack-Mount</td>
</tr>
<tr>
<td>Power Supply</td>
<td>AC or DC</td>
</tr>
<tr>
<td>Nuclear Safety Rated</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Temperature Applications**

- Reactor Coolant Loop Temperature
- Turbine/Feedwater Temperature
- Containment Building Temperature
- Heat Sink Temperature
- Containment Fan Cooler System Temperature
- Circulating Water System Temperature
- Component Cooling System Temperature
- Spent Fuel Pit Cooling System Temperature
- HVAC: Temperature Monitoring, Switching
  - Crib House Intake Temperature
  - Control Room Temperature
  - Heater Bay Temperature
  - Turbine Room Temperature
  - Containment Building Temperature
  - Fuel Storage Building Temperature
  - Sampling Room Temperature
  - Chem Lab Temperature

**Nuclear Qualified Temperature Switches and Alarms**

It is no surprise that FCI nuclear capabilities also include extremely accurate temperature switches and alarms. That is because FCI utilizes precision temperature measurement technology in its entire line of flow and level instruments.

FCI uses precision RTD sensing elements, joined with nuclear approved electronics and enclosures, to create highly accurate temperature measurement instruments for the most demanding nuclear industry applications. These instruments are produced in the same FCI nuclear industry certified manufacturing facility, using the same certified quality control processes, that are in place to ensure the quality and performance of FCI’s level and flow solutions.

FCI products are highly adaptable and can be customized. For example, FCI’s FLT93 Series Flow / Level / Temperature switches are easily configured for use as a temperature switch/alarm.

Versions with a single temperature sensing element, or a totally redundant dual-sensor system, can also be produced.

Temperature Solutions

14
Flow Conditioning Solutions

Flow Conditioners Reduce Piping, Improve Plant Efficiency

Flow conditioners are an effective, proven solution for reducing pipe straight-run requirements needed to achieve accurate, repeatable flow meter measurements and for improved reliability and long-life operation of pumps, compressors and control valves.

Conditioning For Flow Meters

- Reduce Flow Meter Straight-Run Requirements up to 75%
- Eliminates Profile Distortions and Swirl
- Lowest Pressure Drop Technology
- Improves All Flow Meter Measurements:
  - Thermal
  - Ultrasonic
  - Magnetic
  - Vortex Shedding
  - Turbine Meters
  - Pitot Tube

Vortab Flow Conditioning

- Removes Swirl and Creates Uniform Flow Profile

Swirl Reduction Tabs – The swirl reduction tabs remove swirl by generating small vortices (swirls) opposite to the main swirl. These cumulatively cancel the larger main swirl.

Profile Condition Tabs – Three sets of profile conditioning tabs produce vigorous cross-stream mixing which rapidly mixes faster velocity regions with slower regions. This mixing quickly produces a homogeneous (i.e., conditioned) velocity profile. In addition, uneven particulate distributions or temperature profiles are made more uniform through this process.

Settling Distance – For flow meters, three to four pipe diameters of settling distance between the flow conditioner and flow meter installation location are required to fully condition the flow stream. For pumps and compressors, there are no settling distance requirements and the flow conditioners can be coupled directly to inlets.

Conditioning for Process and Plant Equipment

- Increase Pump and Compressor Efficiency
- Decrease Pump Noise, Cavitation and Maintenance Intervals
- Improve Process Temperature and Pressure Stratification

Patented Vortab® flow conditioners, supplied by FCI, provide technology recommended most by flow and process control experts to eliminate both flow swirl and flow profile distortions.

Vortab creates repeatable flow in as little as 7 pipe diameters. With process equipment and flow meters specifying 20, 35 and even up to 100+ pipe diameters for proper operation, the savings in pipe run are obvious and can be dramatic.

Vortab technology creates the least pressure drop and therefore results in a significant savings in energy costs over other flow conditioning techniques. Finally, because Vortab does not have constriction holes or orifices they are immune to clogging and fouling.

Vortab flow conditioners are available in mechanical designs to meet your installation parameters. A spool-piece meter run section, an insertable sleeve, a field weldable kit and an elbow piece are available to accommodate a variety of installation needs.
Visit FCI on the Worldwide Web: www.fluidcomponents.com

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Phone: 31-13-5159989  Fax: 31-13-5799036

FCI is ISO 9001:2000 and AS9100 Certified

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