

# Thermo Scientific Dionex ICS-4000 Capillary HPIC System

Integrated Reagent-Free High-Pressure Ion Chromatography System

The Thermo Scientific™ Dionex™ ICS-4000 Capillary HPIC™ system is the first integrated high-pressure capillary ion chromatography (IC) system on the market and provides an impressive combination of ease-of-use and high-end performance. Capillary IC technology provides Always On, Always Ready capability to routine applications.

- High-pressure operation for fast separations and high resolution
- Continuous operation reduces calibration and equilibration
- Integrated system with options for conductivity, electrochemical, and charge detection capabilities



- Integrated design delivers simplified operation while providing detection options for a wide and expanding variety of applications
- Capillary flow rates (0.2–0.6 mm column i.d.) combined with Reagent-Free™ ion chromatography system technology allow months of continuous operation with just one liter of water
- Excellent flow rate accuracy, eluent generator stability, and temperature control deliver high retention time reproducibility, baseline stability, and sensitivity
- Electrolytic eluent generation offers high purity and unparalleled control and reproducibility for isocratic and gradient elution up to 200 mM
- Innovative Thermo Scientific™ Dionex™ IC Cube™ module provides cartridge-based approach to configuring and using capillary consumables
- Precisely controlled chromatography and detector temperature zones maintain baseline stability and improve application performance
- Thermo Scientific™ Dionex™ Chromeleon™ Chromatography Data System software unifies and simplifies system control, operation, data collection, and reporting

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## Integrated Ease-of-Use

- Integrated system performs all types of capillary IC separations using suppressed conductivity, electrochemical, or new charge (QD) detection modes
- Space-efficient design saves valuable bench space
- Color touchpad displays key operating conditions and provides convenient system configuration and control at the instrument
- Tilt-up display and top cover provide ready access to eluent generation components

## Capillary Ion Chromatography

- System is always ready, decreasing calibration and equilibration time
- Consumes just 5.25 L of water per year at typical capillary flow rates, reducing eluent disposal costs
- EG cartridge lasts for 18 months of continuous operation under typical conditions
- Routine and challenging separations are supported with a wide range of column selectivities
- HPIC columns provide high-efficiency and Fast IC separations, maximizing information and throughput
- Easy configuration with IC Cube consumable cartridges
- Excellent ease-of-use with fewer connections and precision-cut tubing
- Reduced sample sizes for low-volume sampling, as low as 0.4  $\mu\text{L}$
- Reduced cost-of-ownership—system's time-saving features free up lab staff to perform other important tasks and increase productivity
- Unmatched sensitivity with direct-injection IC-MS and IC-MS/MS

## Reagent-Free Ion Chromatography

- Electrolytic eluent and regenerant production minimizes time, labor, operation costs, and eluent preparation errors
- Eluent generation provides reliable, reproducible eluent concentrations from deionized water; gradient elution becomes routine, and generated eluents offer the lowest conductivity backgrounds possible
- Eluent generator control supports all capillary-format RFIC column chemistries

## High Performance

- Dual-stepper motor pump provides precise and accurate capillary flow performance with the power to support high-pressure, high-efficiency HPIC columns and separations
- Advanced, digital autoranging detectors provide accurate detection of major and minor constituents in a single run
- Thermally controlled chromatography zone maintains a stable environment for Dionex IC Cube components and detectors, providing reproducibility and reliability.
- Dionex IC Cube cartridge provides optimized plumbing of columns, suppressors, and other flow components, reducing dead volume and improving peak efficiencies
- Cooling or heating for the column provides day-to-day consistency, ensuring reproducibility and stability.
- Built-in vacuum degas provides in-line degassing of eluents, ensuring reproducibility and protection of eluents from contamination and decomposition
- Inert, metal-free PEEK™ components throughout the system ensure compatibility and metal contamination-free chromatography

## Digital Cam Capillary IC Pump

A new implementation of a classic design provides precise and accurate capillary flow performance with the power to support high-pressure, high-efficiency HPIC columns and separations

- Variable-speed, serial dual-piston, digital cam design delivers consistent flow rates and quiet detector baselines
- Pressure ripple < 0.2% above 2000 psi
- Pump flow components are chemically inert, made with high-quality PEEK heads and fittings, inert polymer seals, and sapphire pistons
- User-selectable pressure limits automatically stop pump flow in the event of leaks, flow restrictions, or depleted eluent reservoir
- In-line vacuum degassing of eluent ensures flow reliability and prevents eluent contamination from dissolved gasses
- Optional, automated integrated piston seal wash prolongs seal lifetime with manually-prepared eluent by preventing eluent crystallization on the seal surfaces

## Eluent Generator

The eluent generator electrolytically generates high-purity eluents on-line, performing gradient separations as easily as isocratic applications. Reagent-Free IC is the powerful combination of “Just Add Water” electrolytic technologies; eluent generation and purification, and suppression.

- The eluent generator delivers eluent concentrations from 0.1–200 mM for KOH and MSA
- Typical flow rate of 10  $\mu\text{L}/\text{min}$  consumes only 15 mL of eluent per day
- Eluents are generated from deionized water using an EG cartridge and then polished of contaminants using one of the Thermo Scientific Dionex CR-TC Continuously Regenerating Trap Columns
- Control, status, and diagnostics are provided with Chromeleon software
- On-line eluent generation extends the lifetime of pump pistons and seals because the pump only delivers water

## Thermal Compartment

The Thermal Compartment provides a temperature controlled zone for chromatography and detection. The compartment provides a cool ambient environment for electrolytic suppression and QD detection, while allowing a heated zone for optimum electrochemical (ED) detection.

- Forced-air, Peltier temperature control stabilizes ambient operating conditions and reduces temperature gradients for critical system components
- Controlled zone stabilizes operation for the Dionex IC Cube components, detector electronics, and detector cells (ED and QD)
- Temperature is user-settable

## Capillary IC Cube

Sharing the same capillary consumables packaging as the Dionex ICS-5000+, the Dionex IC Cube cartridge design provides convenient plumbing of columns, suppressors, and other flow components. Cartridge-based designs include pre-cut tubing and color-coded connections for ease of configuration and plumbing. The IC Cube cartridge provides conductive heating for the column.

Consumables and devices that are consolidated in the Dionex IC Cube cartridge are:

- Eluent generation degasser
- Injection valve
- Separation and guard column
- Electrolytic suppressor
- Carbonate removal device (for anions)

## Versatile Detector Options

The Dionex ICS-4000 system can be configured with either a conductivity detector (CD) or an electrochemical detector (ED). The new charge detector (QD) can also be configured with the conductivity detector to provide a new, complementary detection mode for weakly-dissociated species. Any of the detectors is user installable using only a screwdriver. The QD is typically configured with a CD, but can be configured in the system alone.



CD Conductivity Detector

## CD Features

- Microprocessor-controlled digital signal processing detects high and low concentrations of analytes in the same run
- Supports all IC and RFIC system applications with maximum range up to 15,000  $\mu$ S
- Control through Chromeleon software or locally through TTL inputs
- Electronics are integrated between cell and detector for greater stability
- Innovative built-in electronics allow for easy calibration and diagnostics

## ED Features

- Cell body design provides consistent torque to cell electrode for consistent installation and mounting of working electrode
- Uses microprocessor-controlled digital signal processing
- Supports DC amperometry, pulsed amperometry, or integrated pulsed amperometry detection modes
- The integrated pulsed amperometry mode provides complete freedom to change the waveform profile's number of segments, duration of each segment, and voltage applied at each segment
- Uses either pH-Ag/AgCl, Ag/AgCl, or Palladium Hydrogen (PdH) reference electrode; new one-piece PdH reference electrode provides consistency and reliability
- Control through Chromeleon software or locally through TTL inputs
- Cell and detector electronics are integrated to minimize noise, maximize electrical isolation and shielding, and maximize thermal stability
- Innovative, built-in electronics for easy calibrations and diagnostics

## QD Features

- Detector complements suppressed conductivity detection by measuring the total current generated solely by the analyte – a measurement directly proportional to the normality of the analyte
- Microprocessor-controlled digital signal processing provides wide dynamic range
- Detector requires Thermo Scientific™ Dionex™ CES™ Capillary Electrolytic Suppressor to be installed before QD cell
- Cell drive and signal processing electronics install next to CD detector. QD Cell mounts to front of electronics. Both assemblies mount within the thermal compartment to provide stability and reliability
- Control through Chromeleon software or locally through TTL inputs
- Innovative built-in electronics allow for easy calibration and diagnostics



Charge Detector



Electrochemical Detector

## Integrated System

- The integrated design of the Dionex ICS-4000 delivers dedicated performance in a small footprint, saving critical bench space and presenting an easy-to-use system to a wide range of users
- Color touchpad displays key operating conditions and provides convenient system configuration and control at the instrument
- Tilt-up top cover keeps Thermo Scientific Dionex EGC eluent generation cartridge and Dionex CR-TC located out-of-sight, yet readily accessible for maintenance or 18 month replacement; the display tilts forward to allow local control while cover is open for servicing
- Eluent shut-off valve is located in upper tray – electrically controlled valve provides positive shut-off of source for easy pump servicing
- Bottle tray holds 1 L, 2 L or 4 L bottles, plus dedicated location for seal wash bottle; separate drain for management of tray's secondary containment
- Leak management and detection is optimized for low capillary flow rates and higher-volume bottle sources

## Specifications

### Pump

Type	Dual-piston (in series), dual motor, digital cam, microprocessor controlled, variable speed.
Construction	Chemically inert, metal-free PEEK pump heads and flow path; compatible with aqueous eluents from pH 0–14 and reversed-phase solvents
Pressure Range	0–41 MPa (0–6000 psi)
Flow Rate Range	0.001–0.100 mL/min with settable flow increments at 0.0001 mL/min, typical working range of 5–20 $\mu$ L/min
Flow Rate Precision	< 0.1%
Flow Rate Accuracy	< 0.1%
Pressure Ripple	< 0.2% at 10 $\mu$ L/min
Reservoir Pressure	None required; optional regulator assembly available
Vacuum Degasser (Analytical and Capillary)	Integrated
Piston Seal Wash	Option, automatic operation
RFIC-EG Gradients	0.1–200 mM
Gradient Profiles	Any combination of an unlimited number of linear, convex, and concave positive and negative gradient profiles
Eluent On/Off Valve	Electrically actuated, standard
Leak Sensor	Optical, standard

### Eluent Generator

Eluent Concentration Range	0.1–200 mM
Flow Rates	0.001–0.100 mL/min
Maximum Operating Pressure	35 MPa (5000 psi)
Maximum Solvent Concentration	Cations: None Anions: 25% methanol
Gradient Profiles	Standard – any combination of an unlimited number of linear, convex, and concave positive and negative gradient profiles

### Thermal Compartment

Single Temperature Zone	Temp. Range: 10–40 °C (minimum temperature: ambient -15 °C) (maximum temperature: ambient +20 °C) Temperature Accuracy: $\pm$ 0.5 °C Temperature Stability: $\pm$ 0.2 °C Temperature Precision: $\pm$ 0.2 °C
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### Capillary IC Cube

IC Cube Cartridge Holds the Following	Injection Valve EG Degasser Column and Guard Carbonate Removal Device Capillary Suppressor
Capillary Column Heater	15–80 °C
Flow Path	Plumbing configuration 0.4 mm columns, fully inert, PEEK

### Suppression Modes

Electrolytic Suppression, Self-Regenerating, Recycle Mode
Electrolytic Suppression, Self-Regenerating, External Water Mode
Non-Suppressed Conductivity

## Specifications

### Conductivity Detector

Electronics Type	Microprocessor controlled digital signal processing, autoranging
Cell Drive	8 kHz square wave
Linearity	1%
Resolution	0.00238 nS/cm
Output Range	Digital Signal Range: 0–15,000 $\mu$ S/cm Analog Signal Range: 0–15,000 $\mu$ S/cm
Noise, Wet	< 0.2 nS at 23 $\mu$ S/cm background < 0.1 nS at 1 $\mu$ S/cm background
Filter	Rise times 0 to 10 s, programmable
Sampling Rate	1 to 100 Hz, user settable or automatic
Cell Temperature	5 °C above TC temperature to 60 °C maximum. User settable, working range is identical to settable range.
Cell Temperature Stability	< 0.001 °C
Cell Temperature Compensation	Default 1.7% per °C; programmable from 0–3% per °C
Flow Cell Maximum Pressure	10 MPa (1500 psi)
Flow Cell Volume	0.02 $\mu$ L
Cell Electrodes	Passivated 316 stainless steel. Compatible with MSA
Cell Body	Chemically inert polymer
Heat Exchanger	Inert, tortuous-path for low axial dispersion

### Electrochemical Detector

Electronics Type	Microprocessor-controlled digital signal processing
Electronic Noise (Wet Noise)	IPAD (Au electrode) < 50 pC at 10 mM KOH, DC Amperometry (GC) < 10 pA at catecholamine eluent
Potential Range	-2.0 to 2.0 V in 0.001 V increments
Signal Range (Digital and Analog)	Integrated Amperometry: 50 pC to 200 $\mu$ C DC Amperometry: 5 pA to 74 $\mu$ A
Filter	0–10 s response time, user settable
Control Mode	Local or remote control using relay closures or TTL, or control using Chromeleon software
Cell Body	Titanium body with PEEK inlet tubing Compatible with 0.2–0.6 mm i.d. columns
Working Electrodes	Conventional: gold, glassy carbon, platinum, and silver Disposable: gold, platinum, carbon, and silver
Reference Electrodes	pH-Ag/AgCl combination, one piece design PdH, one piece design
Autoranging	Yes
Analog Output	User selectable full scale of 10, 100, or 1000 mV
Cell Volume at Working Electrode	< 0.2 $\mu$ L
Maximum Cell Operating Pressure	0.7 MPa (100 psi)

### Charge Detector

Electronics Type	Microprocessor controlled digital signal processing, autoranging
Linearity	1%
Output Range	Digital Signal Range: 0–20 $\mu$ A Analog Signal Range: 0–20 $\mu$ A
QD Cell Maximum Pressure	0.7 MPa (100 psi)

## Specifications

### System Software

Software	Chromeleon Chromatography Data System software, supports Microsoft Windows® 7
Automated Procedure Wizards	Standard feature
System Smart Startup and Shutdown	Standard feature
System Wellness and Predictive Performance	Standard feature
Application Templates	Standard feature
Automation Support of 3rd Party Instruments	Fully controls over 300 different instruments from more than 30 manufacturers, including GC, HPLC, and MS
Customizable System Control Panels	Standard feature
Signal Channels	Pump pressure
Data Trending Plots	All numerical device parameters
System Status Virtual Channels	Standard feature
Power Failure Protection	Standard feature
System Trigger Commands and Conditionals	Standard feature
Daily Audit Trail	Standard feature
Sample Audit Trail	Standard feature
System Calibration Storage	Factory, present and previous. Completely user selectable.
Customized Reporting	Standard feature with unlimited report workbooks
GLP Compliance	Optional
System Trigger Commands and Conditionals	Standard feature
Daily Audit Trail	Standard feature
Sample Audit Trail	Standard feature
System Calibration Storage	Factory, present and previous. Completely user selectable.
Customized Reporting	Standard feature with unlimited report workbooks
GLP Compliance	Optional

### Physical Specifications

Power Requirements	100–240 V ac, 50-60 Hz autoranging
Operating Temperature	4–40 °C (40–104 °F); cold-room compatible (4 °C) as long as system power remains on
Operating Humidity Range	5–95% relative, noncondensing
Control Modes	Full control through front panel and Chromeleon software; alternative control through TTL or relay closures; two relay outputs, two TTL outputs, four programmable inputs
USB Communication Protocol	One USB input; one built-in two output USB hub
Leak Detection	Built-in, optical sensor
Dimensions (h × w × d)	56.1 cm × 22.4 cm × 62.2 cm (22.1 in × 8.8 in × 24.5 in)
Weight	25 kg (55 lb)

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