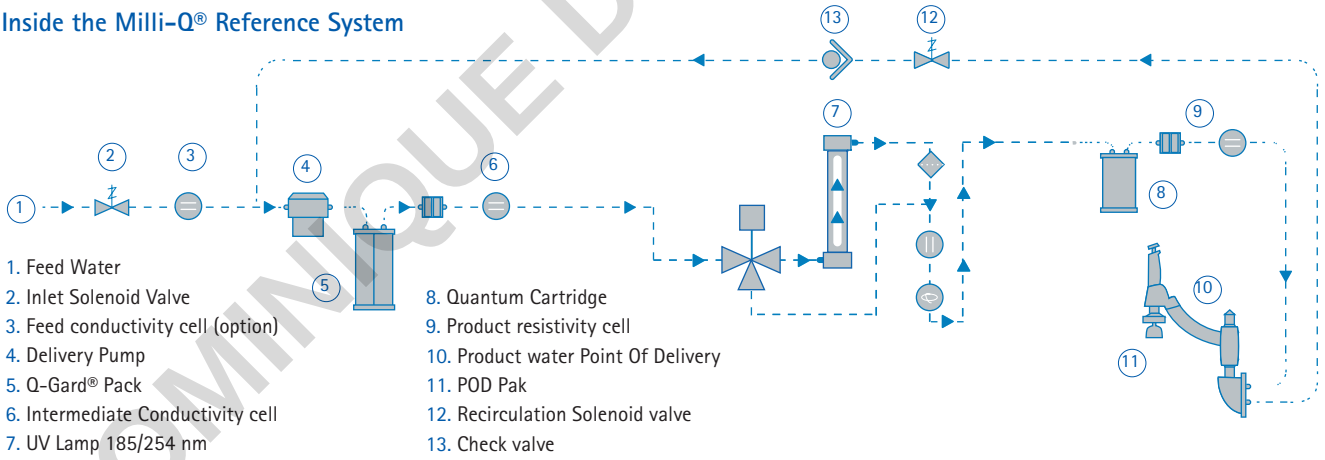
Milli-Q® Reference A+ System

Water purification system with TOC* Indicator



Inside the Milli-Q® Reference System



1. Feed Water
2. Inlet Solenoid Valve
3. Feed conductivity cell (option)
4. Delivery Pump
5. Q-Gard® Pack
6. Intermediate Conductivity cell
7. UV Lamp 185/254 nm
8. Quantum Cartridge
9. Product resistivity cell
10. Product water Point Of Delivery
11. POD Pak
12. Recirculation Solenoid valve
13. Check valve

* Total Oxidizable Carbon

TOC INDICATOR CONCEPT AND BENEFITS

The Milli-Q® Reference A+ system brings you all the benefits of the regular Milli-Q® Reference system, plus additional analytical precision: an indication of the TOC value of the product water.

Much in the way that resistivity measurement ensures that ionic traces in ultrapure water are below the µg/L level, the TOC Indicator warrants that organic contamination in the ultrapure product water is below the 5 ppb limit of the Milli-Q® Reference A+ system's water specification.

This is especially important for the numerous applications that are sensitive to organic contaminants—including the very common analytical technique, HPLC (High Performance Liquid Chromatography).

Merck Millipore's patented on-line TOC monitoring method is well correlated with the A10® monitor's low TOC range monitoring (1 to 10 ppb), and is able to detect any significant organic contamination increase in the water produced. Users can therefore be assured that the organic contamination level of the ultrapure water produced by their Milli-Q® Reference A+ systems is within specifications.

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TOC INDICATOR OPERATION

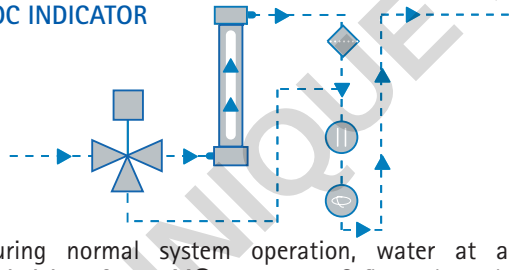
The Milli-Q® Reference A+ system uses an integrated 185/254 nm UV lamp to oxidize neutral organics into charged molecules and facilitate their removal by the mixed bed ion-exchange resin in the polishing cartridge. The TOC Indicator employs this same UV lamp to indicate TOC value by measuring the difference in ultrapure water resistivity upstream and downstream from the UV lamp.

Previous attempts to use this method resulted in devices with an important drawback: they did not take into account the fact that all organic molecules are not oxidized at the same speed and that the nature of organics in feed water may change depending on the geographical location and the time of year. These TOC indicators were calibrated in factories using feed water containing a specific mix of organic substances—and they performed reasonably well—*with the same feed water.* However, they were unable to adapt their operation to feed water variations, and often delivered erratic results when the mix of neutral organic molecules in the feed water was changed. Consequently, these devices could very well indicate low product water TOC in cases where the TOC value was actually high.

On the other hand, the TOC Indicator in the Milli-Q® Reference A+ system uses an operating process that includes a patented "TOC Curve Check" phase, which adjusts the TOC analysis results each night to the evolution of the mix of organics in the system's feed water. The same patented process allows taking into account possible variations of UV light intensity that might be due to deposits on the quartz sleeve surrounding the lamp.

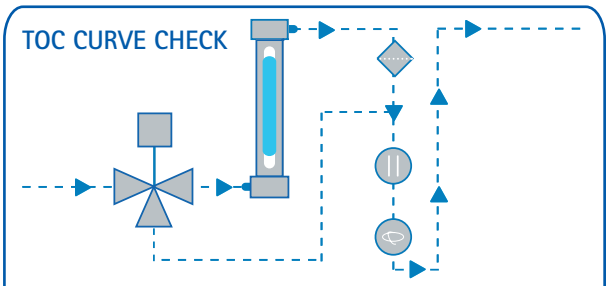
Merck Millipore's patented process ensures that the TOC values displayed by the Milli-Q® Reference A+ system are reasonably accurate for TOC levels within 1 and 10 ppb. The system will also indicate any increase in TOC values above this level.

TOC INDICATOR



During normal system operation, water at a resistivity of 18.2 MΩ·cm @ 25 °C flows through the 185/254 nm UV lamp. Water conductivity and temperature are measured at the outlet of the UV lamp whenever water is recirculated or delivered. Oxidation by the UV lamp of the neutral organics into charged molecules generates a conductivity increase whose value is converted to a TOC value by an algorithm. To ensure that the algorithm takes into account any variations in the nature of the water's organic compounds or possible decrease in UV light intensity, a "TOC Curve Check" is performed every day.

TOC CURVE CHECK



Once a day, or when the user requires, the system performs a "TOC Curve Check." During this operation, the water flow is diverted from the UV lamp. This allows the system (1) to check that the water resistivity entering the lamp is still at 18.2 MΩ·cm @ 25 °C and (2) to capture a water sample inside the UV lamp. The first sample will be oxidized for 20 seconds, then released and its conductivity measured. This process is repeated several times with increasing oxidation times (the second sample is oxidized for 30 seconds before release and measurement, the third for 40 seconds, etc.). The data collected are used to build a curve of the conductivity as a function of oxidation time. During the day, this curve is used to generate valid TOC measurements based on the small conductivity variation resulting from the passage of the water through the UV lamp.

TOC INDICATOR AND MONITOR

The differences between a Merck Millipore TOC Indicator and a Merck Millipore TOC Monitor (A10) are listed in the table below.

Parameter	TOC Indicator	TOC Monitor
Monitoring Frequency	Once per second	Once every 5 minutes - N.B. This is not very important as TOC values typically do not change very quickly
Accurate TOC Detection Range	1 - 10 ppb	1 - 999 ppb
TOC Values Display	1 - 999 ppb	1 - 999 ppb
Calibration to reference solutions	NO	YES
Certificate of Calibration	NO	YES
TOC Curve Check	YES	NO - The TOC curve check process is not required as the TOC monitor is calibrated to reference solutions
Suitability test as required by USP	NO	YES
Cost	Low	Medium

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