VIEWPOINTS

Achieving Cr6 Compliance: A How-to Guide for Water Systems

In October 2024, the State Water Resources Control Board (SWRCB) in California adopted a new Maximum Contaminant Level (MCL) of 10 parts per billion (ppb) for hexavalent chromium (Cr6), making it the lowest MCL in the nation for this toxic and carcinogenetic contaminant. This regulation will affect approximately 500 wells operated by around 300 municipalities, which have elevated levels of Cr6 in their groundwater supplies that exceed the state's regulatory limit, providing water to five million households across California.

Communities affected by the regulations must achieve compliance within two to four years, depending on the number of service connections:

- > 10,000 service connections by Oct. 1, 2026
- Between 1,000-9,999 service connections by Oct. 1, 2027
- < 1,000 service connections by Oct. 1, 2028

These systems must submit a detailed compliance plan that meets all state requirements within 90 days of their compliance date for all sources that exceed the Cr6 MCL.

Three Best Available Technologies (BATs) for treating Cr6 and ensuring compliance with the MCL have been outlined in the regulation and subsequent modifications to California Code of Regulations, Title 22. These BATs include ion exchange, reverse osmosis, and reduction-coagulation-filtration (RCF), using either bulk ferrous chloride or the in-situ electrolytic generation of stannous. Since the use of bulk ferrous chloride requires an oxidation stage to remove excess iron and minimize the risk of reconverting Cr3 to Cr6, the process is more appropriately defined as RCOF (reduction-coagulation-oxidation-filtration) instead of RCF.

Water systems are not required to adopt a BAT to comply with the Cr6 regulation, but any proposed treatment must adhere to Title 22 guidelines for state approval. To validate a Cr6 removal treatment system, systems must conduct an onsite demonstration to validate the performance of the technology to ensure compliance with the Cr6 MCL. The demonstration must evaluate a Cr6 system representative of full-scale operations under typical field conditions, including various ambient conditions, Cr6 levels, reagent dosing rates, and potential failure modes. A water system must also submit an operations plan that ensures reliable and continuous performance with the technology to meet the Cr6 MCL. The operations plan must include a performance monitoring program detailing how and when treatment compliance will be verified.

Optimizing Cr6 Management: Key Strategies and Performance Criteria for Water Systems

When planning for Cr6 treatment, water systems should focus on three key areas: lowering Cr6 levels to below 10 ppb, verifying technology compliance with state regulations, and establishing options for remote online monitoring to enable real-time access to treatment outcomes and ongoing maintenance observations. In vendor collaborations, essential performance criteria—economic, environmental, and operational—should guide the evaluation of treatment technologies. A comparative analysis of RCOF with a bulk ferrous reagent, ion exchange with strong base anion (SBA), and RCF with an on-site generated stannous reagent is provided in Table 1.

Table 1. Comparison of Performance Criteria for Cr6 Removal Treatment Processes

	RCOF: Bulk Ferrous Reagent	Ion Exchange/SBA	RCF: On-Site Generated Stannous Reagent
GHG Emissions	Medium	High	Low
Interferences	Medium-High	High	None
Reagent Dose	High	None	Low
Sludge Generation	High	None	Low
Toxic Residuals	None	Yes	None
System Footprint	Large	Medium-Large	Small
Latency	High	Medium-High	Low
Process Controllability	Low-Medium	Low-Medium	High
Overall Complexity	High	High	Low
Cost	$$$	$$$$	$

GHG Emissions. Understanding the amount of greenhouse gas (GHG) emissions emitted from water treatment technologies is vital for environmental sustainability, cost management and public health. Communities striving for resilience against climate change will want to be aware of the energy consumed by a treatment process, how energy efficiency can be improved, how operational efficiency can be achieved, and if renewable energy sources are available.

Interferences. Understanding how specific water quality parameters, such as pH, and various interferences—like arsenic, phosphate, total organic carbon, silica, sulfate, uranium, and vanadium—affect the performance of treatment processes is crucial for evaluating the effectiveness of Cr6 treatment systems and their associated costs. When a treatment system faces challenges due to multiple water matrix interferences, it may require operational and process adjustments to address these effects. However, such adjustments often lead to increased capital and operational costs. Additionally, in the case of ion exchange with SBA, it is important to closely examine how the raw water quality impacts the toxicity of both the liquid and solid waste generated during the regeneration process.

Reagent Dose. With respect to RCOF and RCF treatment systems, the amount of reagent (ferrous or on-site generated stannous) that is needed to treat a unit of water volume (mg/L, ppm, etc.) should be considered. A much higher reagent dose of ferrous than stannous is required to treat equivalent amounts of Cr6 in water; up to 10 times more ferrous may be required to achieve the same treatment goals as stannous.

Sludge Generation. The amount of sludge produced by the treatment process (RCOF or RCF) per volume of treated water is closely related to the dosage of reagents used. Higher chemical demand or reagent dosage results in more frequent backwashing and significantly increases waste generation. The volume of sludge generated by stannous is up to 10 times lower than that produced by ferrous. Additionally, it is important to note that the sludge produced from stannous has beneficial reuse applications. When assessing overall treatment process waste, an RCF system using an onsite-generated stannous reagent generates significantly less waste compared to an SBA ion exchange system. For every kilogram of Cr6 removed, a stannous-based RCF system produces less than five dry gallons of waste. In contrast, the ion exchange with SBA generates between 6,000 and 15,000 gallons of waste.

Toxic Residuals. Understanding whether the Cr6 treatment process produces toxic residuals is essential for accurately determining the total compliance costs associated with a given technology. Regarding sludge generation, the stannous-based RCF system produces non-hazardous waste. This waste consists of a mixture of tin and chromium oxide, which can be reused as a sorbent in wastewater treatment processes. In contrast, the ion exchange SBA process generates significant hazardous and radioactive waste, requiring special handling and disposal, and resulting in substantial operating costs that are not reflected in Table 2.

System Footprint. When considering a Cr6 treatment process, it is important to account for the footprint and space required by the equipment. Water systems are encouraged to carefully review the process diagrams of the proposed technology to fully understand all the components involved in the design and their associated footprint requirements.

Latency. The time between when a Cr6 treatment system process change is (re)initiated and water quality complies is fundamental to understanding how the technology will work in real-world applications. Typical well utilization rates range between 25 – 50%, making it important to use a technology that is stable, efficient, and effective. Wells operate in "stop-run" mode where fast and adequate treatment system response is critical for the treatment systems' timely and reliable stabilization following a restart. Consequently, if a treatment technology operates with a high level of latency, treated water quality will be compromised, and it will need to be wasted to sewage until it is in compliance.

Process Controllability. The ability to control the Cr6 treatment process without requiring multiple and difficult approaches with a high risk of failure is essential. For example, in a ferrous-based RCOF system process, chlorine and a coagulant are required. These represent additional points of failure that require supervision and impose additional chemical and handling costs. It is also important to understand how the Cr6 treatment system is controlled, monitored and adjusted to meet real-time contaminant levels and other variations in water quality.

Overall Complexity. The level of complexity the Cr6 treatment process requires from the water system and operational staff is an important consideration. When a treatment technology is fully automated and calibrated, minimal operational oversight is required and staff utilization for other essential tasks at the plant can be achieved.

Cost. The capital cost to treat a unit of water volume is most expensive with ion exchange, and most economical with an RCF system using an on-site generated stannous reagent (Table 2). In addition to having the highest capital cost, the ion exchange SBA process has substantial operating costs associated with the removal and treatment of significant volumes of toxic waste. For example, for a 2,800 gpm design flow ion exchange SBA Cr6 removal process will need to dispose of 10,000 gallons a week of toxic waste.

Table 2. Capital Cost Comparison for Cr6 Removal Treatment Processes

	RCOF: Bulk Ferrous Reagent	Ion Exchange/SBA	RCF: On-Site Generated Stannous Reagent
100 gpm design flow[1]	$1.4M	$1.6M	$730K
2,800 gpm design flow[2]	$5.7M	$7.1M	$3.2M

1. SWRCB 2022

2. Hazen and Sawyer 2022

It should be noted that the costs of a ferrous reagent RCOF system does not include continuous monitoring of treated water quality to ensure the system is operating, whereas the on-site generated stannous reagent RCF system includes this real-time monitoring cost.

The drastic cost differential between the technologies is maintained across small-to-large design flow capacities. The following has been stated about RCF and ion exchange, including Weak Base Anion (WBA) and SBA:

"At the proposed MCL of 10 ug/L, RCF [Reduction, Coagulation and Filtration] is calculated to be the least expensive treatment for all but 11 sources."

In addition to the capital cost, water systems should pay close attention to operating costs. For example, the cost of treatment is affected by the amount of water lost during the treatment process due to system latency and the backwash process. When significant losses occur, such as those from a ferrous-based RCOF system, the water must be discharged to the sewage system. If a sewage system is unavailable, one must be built, or the wastewater must be trucked away for disposal.

Achieving Safety and Sustainability

By focusing on effective Cr6 management strategies and carefully evaluating treatment options against performance metrics—such as environmental impact, operational efficiency and cost— water systems can work towards achieving regulatory compliance and enhancing the safety and sustainability of their water supply.

Ultimately, the path to compliance is not just a regulatory requirement. It is an opportunity to optimize operations and protect public health. Water systems that prioritize scalable, cost-effective, and environmentally conscious solutions will be better equipped to meet evolving regulatory demands while building trust with the communities they serve. By acting decisively and strategically, utilities can transform compliance challenges into catalysts for innovation and future-ready water management.

a: 1225 E. Arques Avenue, Sunnyvale, CA 94085 | t: +1 (408) 523-1900
e: info@ams-h2o.com | w: ams-h2o.com