



RESINTECH

RESINTECH ASM-10-HP APPLICATION BULLETIN

ARSENIC REMOVAL FROM DRINKING WATER



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Introduction

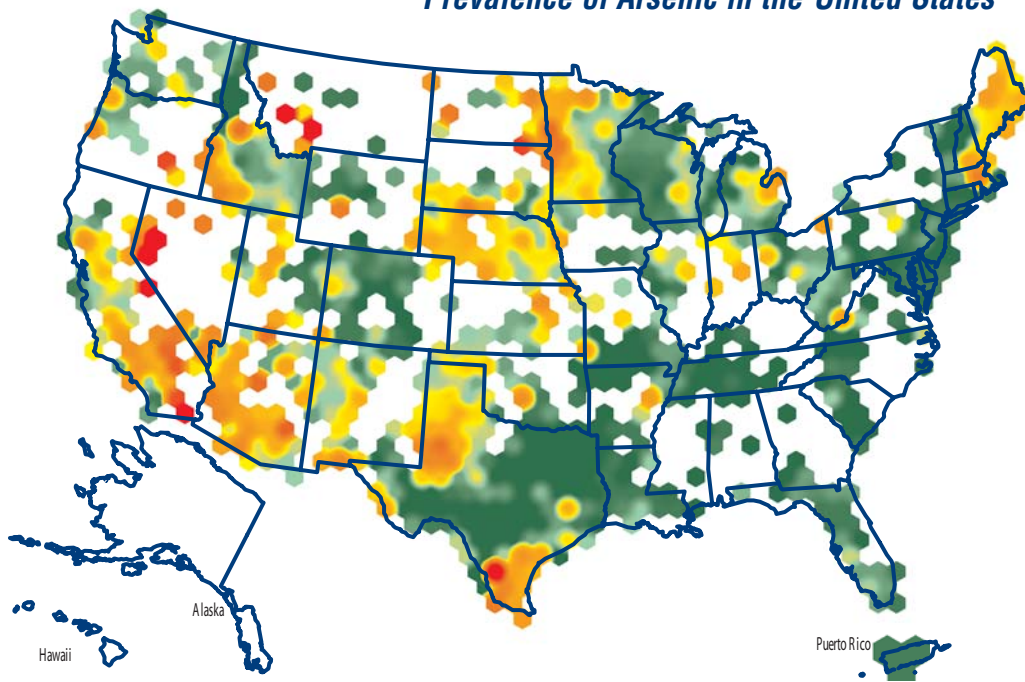
ResinTech ASM-10-HP is a strongly basic hybrid anion exchange resin specially formulated to selectively remove arsenic. Physically, ResinTech ASM-10-HP is a robust gel type anion exchange resin. Certain types of ion exchange resins, including ResinTech SBG1, the parent resin of ASM-10-HP, are listed by the US Food and Drug Administration for direct and indirect contact with food and have been used for treatment of drinking waters for more than 50 years. ResinTech ASM-10-HP falls into this category and is certified to the ANSI/NSF 61* standard for filter medias used in potable water and carries the WQA Gold Seal of approval. ResinTech ASM-10-HP is patent pending.

ResinTech ASM-10-HP is extremely selective for arsenic and will generally reduce arsenic concentrations to below the typical detection limit of 1 ppb. It has very fast kinetics and low-pressure loss.

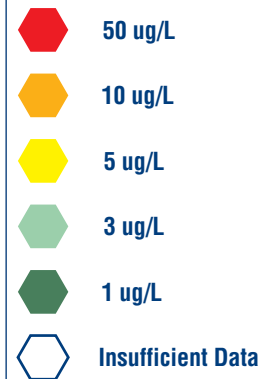
ResinTech ASM-10-HP is fully regenerable and can be used over and over again without loss of media or capacity. While treating water that falls within the potable water TDS and pH guideline, ResinTech ASM-10-HP does not dissolve, compress, become soft during use, nor does it slough iron. These attributes allow for economical trouble-free installations and long life.

ResinTech ASM-10-HP is available from ResinTech, Inc. and its authorized distributors. It may be purchased in bulk form, in ready-to-use disposable cartridges through the Aries Division, or in pre-filled exchange tanks of various sizes. In this bulletin, you will learn about arsenic, arsenic selective medias, and how to design and size an arsenic removal system correctly, using the ResinTech ASM-10-HP media.

Prevalence of Arsenic in the United States



Arsenic concentrations in at least 25% of samples exceed:



Information based on May 2000 USGS Survey.
Map Courtesy of USGS.



Reference: May 2000 USGS Ground water Study
http://water.usgs.gov/nawqa/trace/pubs/geo_v46n11/fig2.html

*Certification lists are shown on the WQA gold seal website – www.wqa.org.

About Arsenic Selective Medias

Arsenate forms covalent bonds with iron and certain other metal cations at neutral pH, thus forming insoluble salts. For example, iron and/or aluminum based coagulants can be added to water containing arsenic and will precipitate arsenic along with the coagulation process. Precipitated arsenic can then be filtered out of the water by a variety of filtration methods. Arsenite forms coordinate bonds with the same metal cations. Coordinate bonds are much weaker than covalent bonds. Coordinate bonds are also pH sensitive generally forming more readily at higher pH

Coagulation followed by filtration is widely practiced by large municipal water treatment plants and is one very viable method to remove arsenic from drinking waters, particularly where coagulation is needed for other reasons (such as suspended solids removal). The drawback to coagulation and filtration is that it requires a fairly sophisticated operation and is susceptible to upsets if the process is not carefully controlled. Coagulation processes generally require someone be present full time to operate and adjust the system and frequent monitoring to verify the system is operating efficiently.

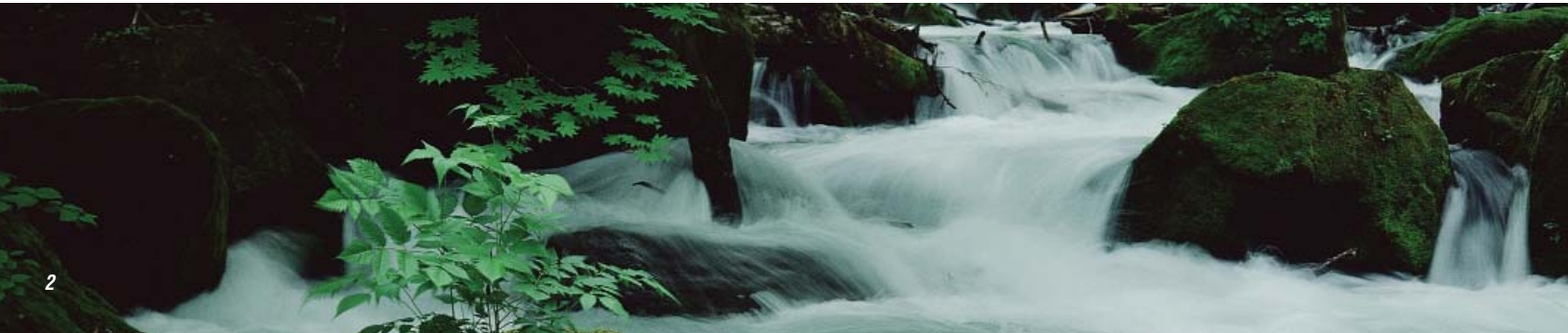
The same metal cations can be precipitated with certain chemicals, and then manufactured into powder or larger particles having a variety of shapes and sizes. These compounds retain some (or all) of their ability to precipitate arsenic. When the size of the powder particles is sufficiently large and the shape sufficiently porous to allow the passage of water, and exhibit useable capacity for arsenic removal, they can be classified as arsenic selective medias.

Not all arsenic selective medias are created equal. It is a difficult task to produce a metal oxide/hydroxide precipitant porous enough to have

fast adsorption rates, sufficiently large enough to have a high fraction of void spaces for water to flow through, yet hard enough to be durable and not to compact under pressure. Inevitably, some compromises must be made. Medias that have very small particle size have high-pressure loss and are susceptible to channeling. Medias that are large and porous may be soft and turn to mush after long periods of use. Medias that are large and hard tend to have very slow adsorption and/or low capacity, except for ion exchange resins.

About ResinTech ASM-10-HP

Strong base anion resins have high selectivity for arsenate and moderate selectivity for arsenite. While they have been used for arsenic removal from water for many years they have one important drawback. The selectivity for arsenate is lower than the selectivity for sulfate. When sulfate is present (almost every potable water supply), and the system is overrun, the sulfate will displace arsenate from the resin and arsenate will appear in the effluent at higher concentrations than in the inlet. This effect is often referred to as “dumping” or chromatographic peaking. If strong base anion resins used for arsenic removal are run past the point of exhaustion on sulfate-containing waters, the arsenic level in the outlet can rise above the level in the inlet.



Arsenate ions exchanged into ResinTech ASM-10-HP first enter the gel phase of the resin in the same manner as with an ordinary ion exchange resin. However, once inside the gel phase, the arsenate is exposed to the immobilized iron and immediately precipitates onto the iron, thus leaving the resin free to react with more arsenic while the iron-bound arsenic remains trapped inside. Although the arsenate and arsenite reactions with iron chemistry are the same for all iron-based medias, there are several important differences with ASM-10-HP.

Why Choose ASM-10-HP?

Clean, Dust-Free Media

Can be Regenerated

Easily Adapted to Existing Equipment

Superior Physical Strength

Excellent Flow Characteristics

High Capacity & Low Leakage

Economical



ResinTech ASM-10-HP magnified approximately 15x

- Ion exchange reactions are very fast, much faster than precipitation reactions. The initial capture of arsenate by ResinTech ASM-10-HP is by ion exchange, thus the removal rate of arsenic from the inlet liquid is much faster than ordinary iron based media.
- ResinTech ASM-10-HP is made from spherical particles having a very high void fraction (greater than 30%) and therefore the media has very low pressure loss, typically less than 5 PSI across the resin bed.
- ResinTech ASM-10-HP is very strong and durable, suitable for hundreds of exhaustion and regeneration cycles and has a useful life comparable to ordinary strongly basic resins such as ResinTech SBG1-HP (the parent resin). ResinTech ASM-10-HP is not susceptible to compaction.
- ResinTech ASM-10-HP retains its original strong base exchange functionality. It can be used simultaneously to remove nitrate, uranium, chromate and other objectionable anions while removing arsenate.
- ASM-10-HP is stable over the entire acceptable pH range of potable water, six (6) to nine (9). No iron sloughage occurs at pHs above 4.



Feed water Quality Guidelines

(for Potable Water Applications)

Feed water quality (aside from arsenic) should generally be of potable quality. Please consult your ResinTech technical salesman or ResinTech technical staff for recommendations outside the following guidelines:

| | Potable Guidelines | Operating Range of ResinTech ASM-10-HP |
|-----------------|-----------------------|--|
| Conductivity | 2000 micromhos/cm Max | 4000 micromhos/cm Max |
| Chloride | 500 ppm Max | 1000 ppm Max |
| Sulfate | 500 ppm Max | 1000 ppm Max |
| pH | 6.0 to 9.0 | 4.0 to 8.0 |
| Turbidity | 5 NTU Max | 5 NTU Max |
| Chlorine (free) | 0.05 ppm Max | 0.05 ppm Max |

Feedwater Requirements

ResinTech ASM-10-HP is not greatly affected by ordinary ions commonly found in drinking water. Ions, such as sodium, bicarbonate, chloride and sulfate pose no interference unless concentrations are well above the maximum range for drinking water. In general, the TDS (total dissolved solids) should be less than 2000 ppm and no single ion concentration greater than 1000 ppm. Although operation at higher concentrations is possible, the ResinTech technical staff should review any proposed installation outside this guideline.

Substances, such as silica, phosphate, and the oxyanions either interfere with the adsorption or compete for adsorption sites, reducing the arsenic removal capacity. Their presence at any concentration should be noted when requesting sizing and throughput recommendations.

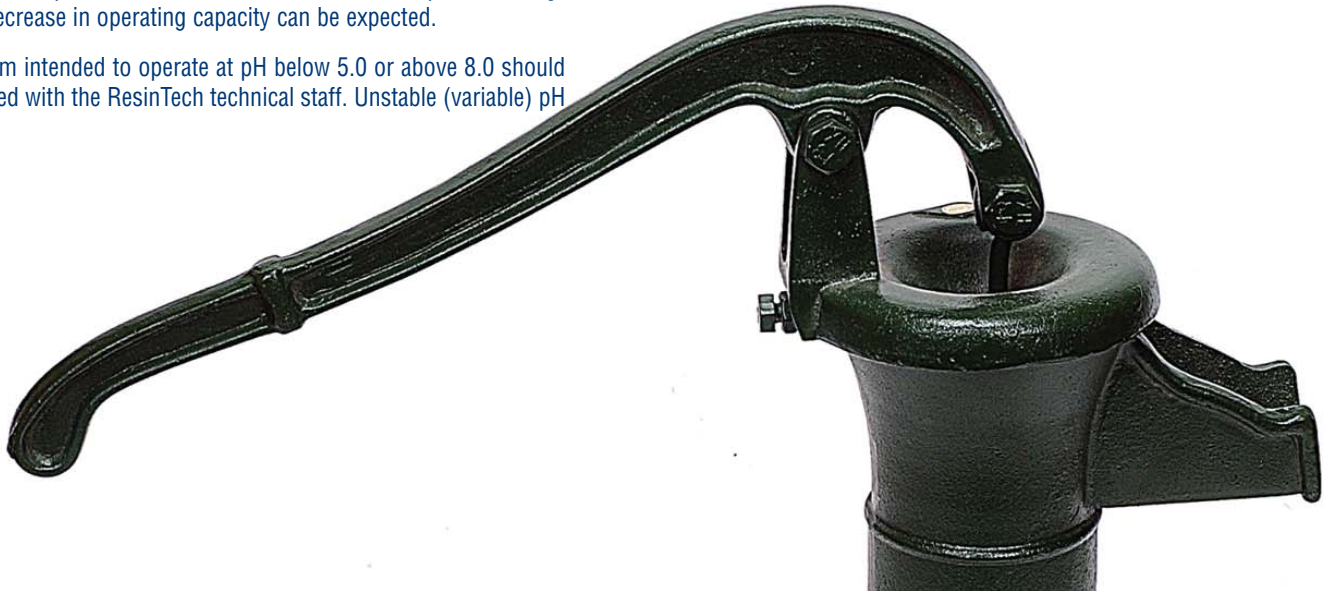
ResinTech ASM-10-HP has limited capacity for arsenite compared to arsenate. It is necessary to know not only the total arsenic concentration, but also the relative fractions of arsenate and arsenite. In cases where the arsenite fraction is greater than 25% of the total arsenic, it is advisable to chlorinate or otherwise pre-oxidize to convert any arsenite to arsenate. For potable waters, the optimum pH range is below 8.0. The operating capacity decreases more and more rapidly as pH rises. At pH levels above 8.0 and when silica is present, a significant decrease in operating capacity can be expected.

Any system intended to operate at pH below 5.0 or above 8.0 should be reviewed with the ResinTech technical staff. Unstable (variable) pH

levels during the service cycle can lead to unstable performance and can cause desorption of arsenic and other substances, especially at higher operating pH levels (above 7.5).

Suspended solids will tend to accumulate in the media's void spaces and on the bed surface over the very long service cycle. High levels of suspended solids or substances that may precipitate during the loading process, such as iron from well water sources, will require periodic backflushing to maintain void spaces and prevent channeling. For suspended solids greater than 1 NTU, pre-filtration is recommended. Periodic backwashing at weekly or bi-weekly intervals is suggested for installations expected to last more than one month between change outs or regeneration.

Calcium carbonate scale will blind off the media and could eventually cement the bed together. Water with a positive Langelier scaling index above 0.3 should be reviewed by the ResinTech technical staff prior to finalizing a system design. In some cases, it may be advisable to reduce pH and/or pre-soften the water to reduce scaling potential. However, even small variations in pH resulting from erratic chemical feed rates or changing water flow rates can cause performance degradation and premature leakage.



Sizing a System

Systems using ResinTech ASM-10-HP are generally sized for flow rate requirements as the throughputs are very large and change-outs (or regenerations) occur infrequently. Inlet pressure and connection sizes generally determine maximum flow rate, thus it is the tank size and not the media volume that is used to determine sizing. The exception is when ResinTech ASM-10-HP will be replacing some other media. Here, the original media volume requirements must be considered and possibly maintained to comply with the mechanical requirements of the system, even though less ResinTech ASM-10-HP may be required to meet the throughput requirement of the system.

Suggested Operating Conditions

Flow Rate* 1 to 10 gpm/cu. ft.
Temperature 140°F max.

* Flows as high as 20 gpm/cu. ft. have been tested successfully. However, pressure loss increases exponentially with increasing flow and when an inlet supply contains even small amounts of suspended solids; bed pluggage is likely at the highest possible flow rates.

Calculating Operating Capacity

The base throughput capacity of ResinTech ASM-10-HP for arsenic in gallons per cubic foot at unit volume flow rates up to 7 gpm/cu. ft. is approximately 700,000 gallons per cubic foot. This is based on waters containing 50 ppb of As⁺⁵ at neutral pH with no silica, vanadium, phosphate, sulfide or other oxyanions. For other arsenic concentrations, the following formula will give the approximate gallonage at flow rates below 7 gallons per cubic foot per minute.

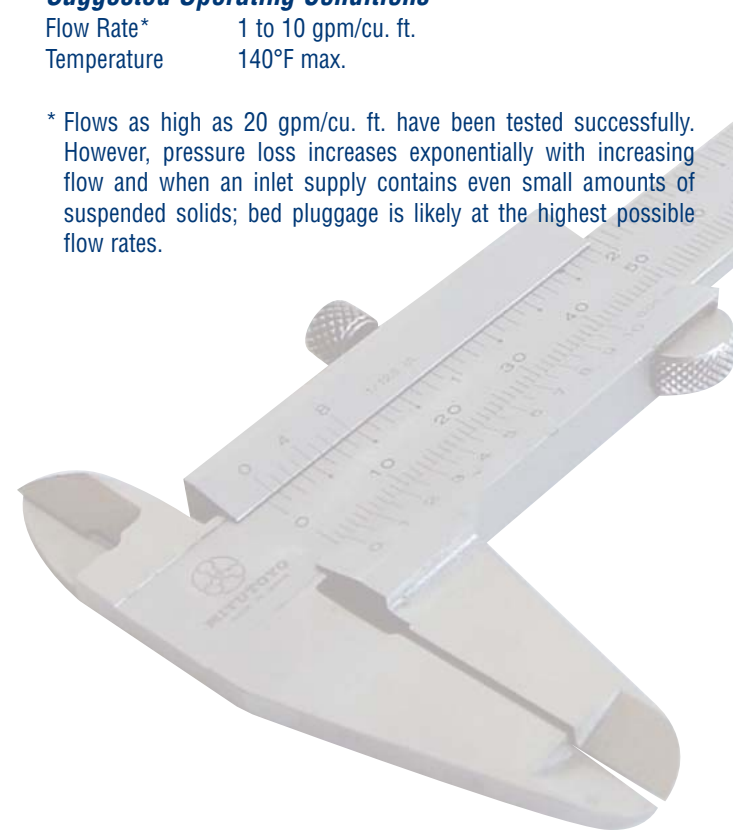
Base operating capacity, gallons per cubic foot = $34,000,000 / (\text{As ppb})$

For example, a water with 35 ppb of As would treat approximately $34,000,000 / 35 \text{ ppb} = 971,000$ gallons per cu. ft. between change-outs.

The operating capacity of ResinTech ASM-10-HP decreases with increasing pH. Below pH of 7.0, silica and pH have a relatively minor impact on performance. As the pH rises, their presence causes reduced operating capacities. For operation above pH 7.5, we suggest you consult the ResinTech technical staff for specific capacity estimates and sensitivity factors that could impact performance.

Phosphate also competes for adsorption sites; however phosphate often combines with calcium or other cations to form complex anions or colloidal precipitants. Although phosphate does have an adverse effect on the throughput of ASM-10-HP, the effect is generally minimal because the colloids and complex anions do not come into direct contact with the iron hidden inside the resin.

TDS caused by salts, such as sodium bicarbonate, calcium chloride and magnesium sulfate, has practically no effect on ResinTech ASM-10-HP throughput until the concentration is greater than 1000 ppm. Several other anions, if present, will decrease performance. When Present, the following substances are exchangeable and should be added to the arsenate concentration for purposes of calculating throughput (see table on page 7). Also, a pH higher than 7.0 and the presence silica has negative impacts on capacity.



Tank Sizing

The following table can be used to select tank sizes for various flow rates. Many other tank sizes may also be used.

| Tank Size, Inches (Dia x Hgt.) | Pipe Size, Inches | Resin Volume ASM-10-HP | Minimum Flow | Normal Flow | Peak Flow | Backwash Flow |
|--------------------------------|-------------------|------------------------|--------------|-------------|-----------|---------------|
| 9 x 48 | 3/4 | 1.0 cu.ft. | 1.0 GPM | 3-7 GPM | 10 GPM | 3.0 GPM |
| 10 x 54 | 3/4 | 1.5 cu.ft. | 1.5 GPM | 4-10 GPM | 15 GPM | 3.5 GPM |
| 14 x 47 | 1 | 2.5 cu.ft. | 2.5 GPM | 7-18 GPM | 15* GPM | 7.0 GPM |
| 16 x 65 | 1 | 4.0 cu.ft. | 4.0 GPM | 12-28 GPM | 15* GPM | 9.0 GPM |
| 21 x 62 | 1 1/2 | 8.0 cu.ft. | 8.0 GPM | 24-56 GPM | 40* GPM | 11.0 GPM |
| 24 x 72 | 2 | 10.0 cu.ft. | 10.0 GPM | 30-70 GPM | 80* GPM | 20.0 GPM |

* Flow rate limited by pipe size, not by resin volume.

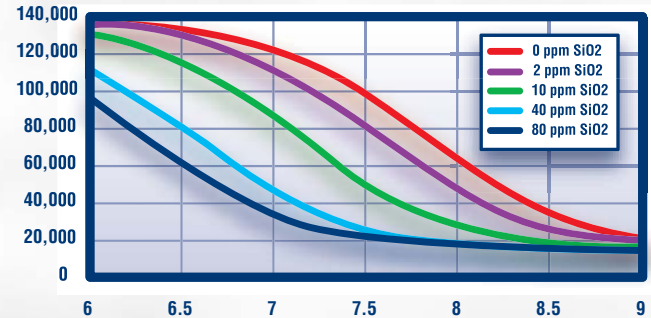
ResinTech suggests using a coarse sand support bed that completely covers the underdrain. Such a support bed provides a flat surface for the resin to rest on and helps promote equal distribution, even at very low flow rates, and helps to reduce pressure losses at the underdrain entrance.

Capacity Curves

The following charts may be used in a general way to predict throughput for similar waters.

Please consult the ResinTech technical staff for throughput recommendations. Due to the complexity of throughput calculations and their dependence on a complete water analysis, no throughput recommendation should be considered a guarantee of performance.

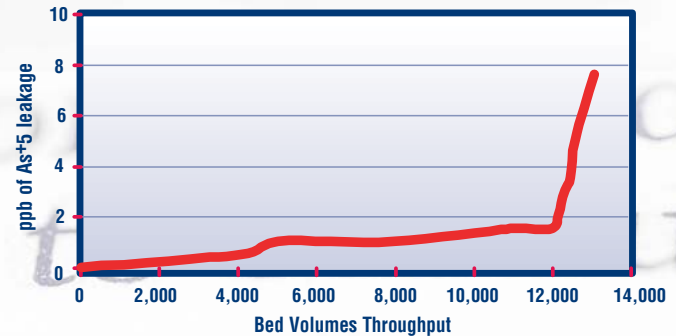
Effect of pH and Silica



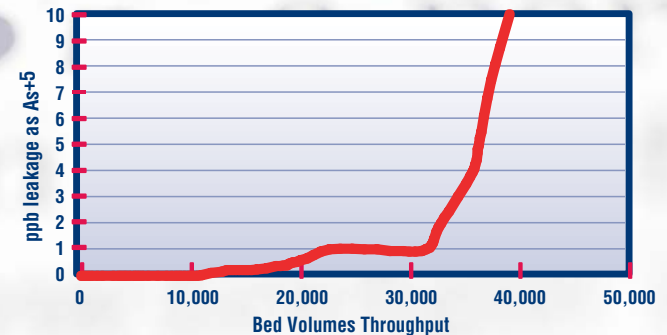
Sulfate = 200 ppm as SO_4 , Arsenic = 50 ppb as As^{+5} ,
Nitrate = 2 ppm as NO_3 , Chloride = 64 ppm as Cl , Bicarbonate = 50 ppm as HCO_3

NSF high pH Challenge

(pH 8.5, SiO_2 20ppm, AS 50 ppb as As^{+5} , Flow= 0.8 BV/min)



(35 ppb As^{+5} , 14 ppb V, 20 ppm SiO_2 , pH 8)



Removal of Other Contaminants by ASM-10-HP

ResinTech ASM-10-HP retains its original Type I strong base ion exchange resin characteristics. As such, it will exchange with and remove other contaminants in the manner typical of such products. It initially functions as a chloride cycle anion exchanger and will remove sulfates, nitrates and alkalinity (unless buffered), until the chloride exchange sites have come to equilibrium with the feed water. During the initial portion of the operating cycle there may be some pH depression due to the removal of alkalinity. The pH will then rise back to influent levels and stay there throughout the remainder of the exhaustion cycle. Sulfates will continue to be removed along with nitrates, uranium and arsenic. As the resin continues to exhaust, nitrates will eventually begin to leak. If the resin is used for nitrate removal also, this is the point where the resin is regenerated or replaced. Otherwise, nitrate levels will continue increase, possibly to higher levels than in the inlet depending on the initial nitrate, sulfate and TDS levels. Silica will be partially reduced for up to several thousand gallons per cubic foot. Eventually, silica and sulfate removal ceases and these appear in the effluent equal to influent levels, while the resin continues to remove arsenic. The foregoing typically occurs during startup, which represents less than 1% of the volume to reach 10 ppb arsenic leakage.

Certain ions, such as uranium, which forms complex anions that have very high selectivity for the strong base exchange groups will continue to be removed for many thousands of bed volumes. Thus ResinTech ASM-10-HP is a very good media for reducing uranium concentrations in water, in addition to arsenic.

Nitrate and chromate are removed until the chloride exchange sites are depleted. Although the useful throughput for these ions may only be

a few hundred bed volumes, regeneration with sodium chloride will restore the chloride form capacity of the resin and allow continued operation for removal of these contaminants, in addition to arsenic. In such dual-use cases, arsenic capacity can be extended indefinitely by employing Counter-current Regeneration (CCR).

The scope of dual-purpose operation is complex and site specific and is not covered in detail in this bulletin. Please contact ResinTech technical staff for help in designing systems that will remove other contaminants in addition to arsenic.

Other Contaminants Removed by ASM-10-HP

Uranium

Vanadium

Chromium

Nitrate

Sulfide

Silica

(not considered a contaminant of potable water but removed during the initial portion of the exhaustion)



Domestic Applications

Point-of-Entry (POE) vs. Point-of-Use (POU)

POE treatment is more expensive than POU and less efficient because some of the water it treats is not used for human consumption or contact i.e. toilets.

Consider the following factors:

1. What is the local municipality doing about arsenic levels in the water?
2. What do they recommend?
3. Who drinks water and from which taps?
4. Is the water used for showering or bathing?
5. How high a concentration of arsenic is in the water?

Arsenic is adsorbed through the skin. Early animal tests showed approximately 6% adsorption in monkeys. Recent research with human subjects demonstrated that showering in water containing 100 ppb of arsenic resulted in significantly elevated arsenic levels in urine for several days following.

If the arsenic concentration is only less than 10 ppb, it should not matter as this has been defined as acceptable or safe by the EPA. At levels greater than 10 ppb the added cost of whole house treatment might be a worthwhile investment and offer “peace of mind”. There is no right or wrong answer, only different level of risk.



Pretreatment Requirements

Pretreatment requirements for ResinTech ASM-10-HP are generally minimal, as the media is quite sturdy and resistant to fouling. However, as with any media that has a very long exhaustion cycle, ResinTech ASM-10-HP can be overcome by high levels of suspended solids or other foulants and can become biologically fouled with algae and mold.

We recommend prefiltration ahead of the ResinTech ASM-10-HP media whenever the raw water turbidity is greater than 5 NTU.

Whenever arsenite is more than 25% of the total arsenic or 5 ppb or greater, the feed water should be chlorinated to convert arsenite (As^{+3}) to arsenate (As^{+5}).

When free chlorine is greater than 0.05 ppm, the feed water should be dechlorinated before contacting the resin.

When iron is greater than 0.5 ppm, or manganese greater than 0.2 ppm these contaminants should be removed ahead of the resin bed.

ResinTech ASM-10-HP Pretreatment

PRECHLORINATION

- ***Converts As^{+3} to As^{+5}***
- ***Follow by granular carbon for dechlorination***

PREFILTRATION

- ***Removal of suspended solids***

SOFTENING

- ***Removal of scale forming compounds***
- ***Removal of radium or other cationic contaminants***

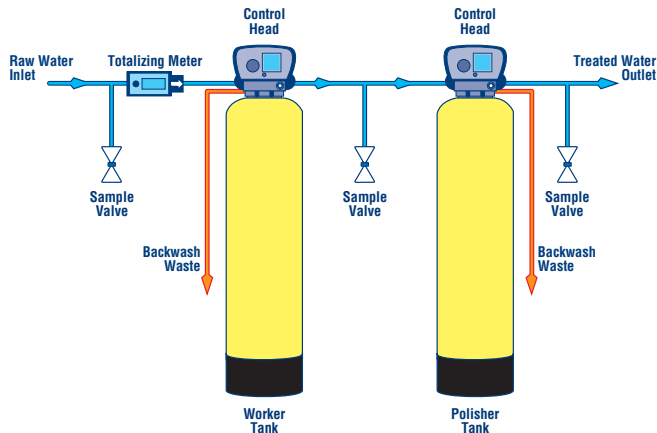
Installation Requirements

The use of a two tank “round robin” system where the first tank is the working bed and the second tank is the polishing or guard bed is recommended to minimize the possibility of premature arsenic leakage. When arsenic breakthrough of the first bed occurs, the media is removed and replaced or regenerated, then put back online as the polishing bed. The old polishing bed is placed first and becomes the new working bed. Monitoring is performed in between the worker and polishing beds. This configuration provides the maximum possible protection against arsenic break through.

Where a worker/polisher bed configuration cannot be provided, it is suggested that the capacity be derated and testing schedules increased so that change outs are performed well in advance of breakthrough and increasing leakage levels are detected before substantial leakages occur. All systems, especially single bed systems should include a water meter to permit accurate monitoring of usage along with frequent monitoring.

Suggested System Components

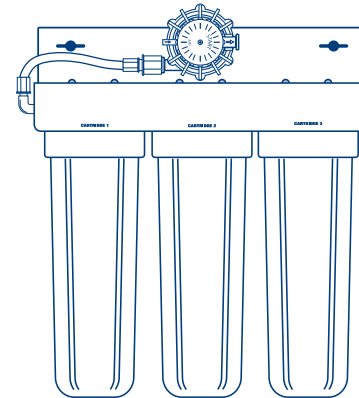
Treatment of Water by ASM-10-HP



Point of Entry water treatment system

Additional Suggestions

1. Install sample valves at the effluent of every tank for monitoring.
2. Include isolation and bypass valves for each tank so that the tank can be valved out for service or replacement, when necessary.
3. Include both backwash and rinse valving, even if the media will not be regenerated.
4. Systems that use prechlorination should include carbon prefiltration to remove excess chlorine ahead of the ResinTech ASM-10-HP bed.
5. Systems where the feed water contains other objectionable contaminants, such as suspended solids, turbidity, high organic color, iron, manganese etc., should include pretreatment systems for those contaminants ahead of the ResinTech ASM-10-HP media.
6. Design the system to accommodate the highest pH level of the raw water to ensure against premature arsenic leakage.



***Hydra-AS (HY-111-AS)
Point of Use water treatment system***

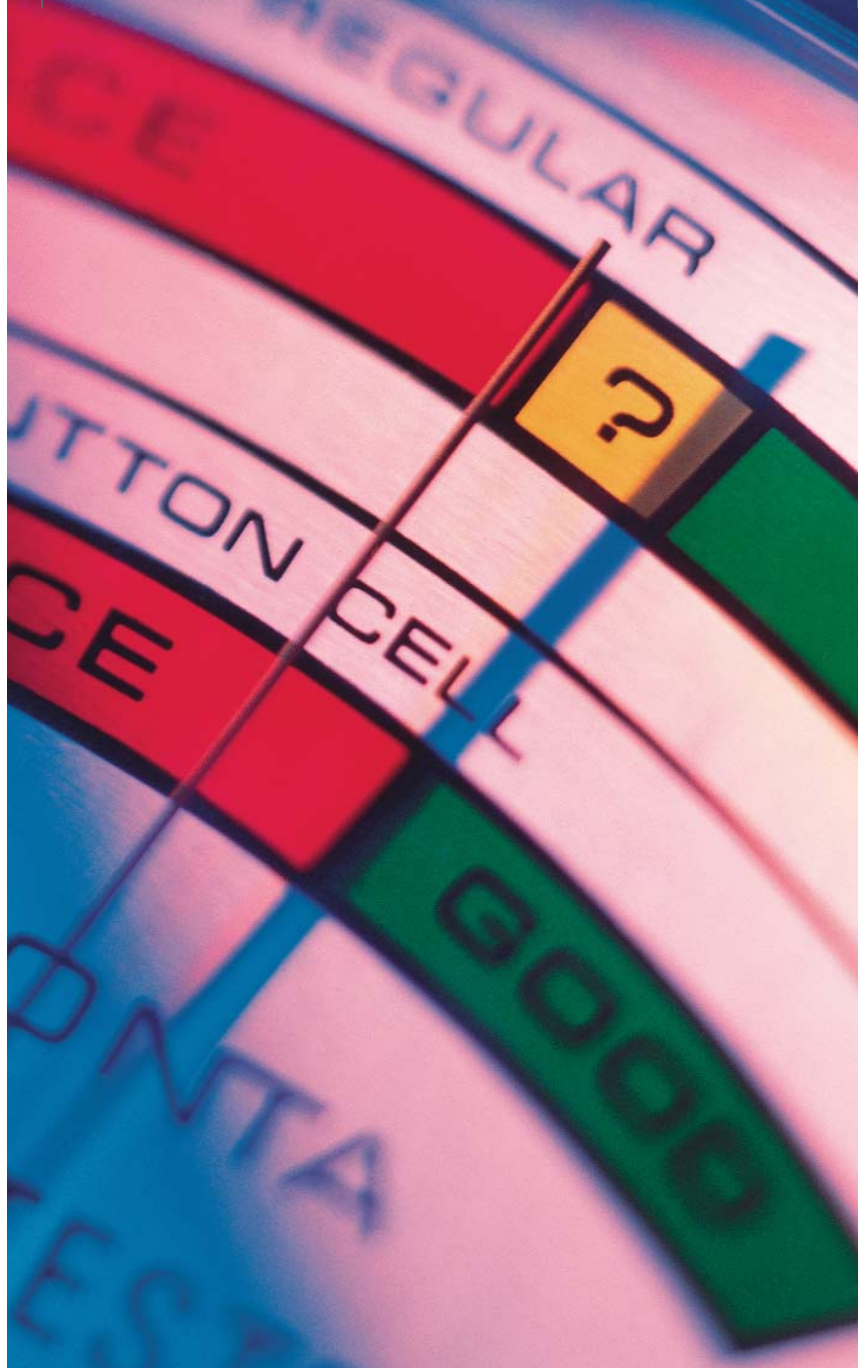
Monitoring

Monitoring is an extremely important part of the arsenic removal process. Arsenic is tasteless, colorless and odorless. Although there is no indirect method to verify the media is working properly and that arsenic levels are being reduced, there are a number of direct test methods, including test strips and water analysis, which can provide system validation. Arsenic test kits are available for purchase from ResinTech and its authorized dealers and distributors.

For worker/polisher bed systems we suggest frequent monitoring (15% intervals based on capacity projections) in between the two tanks and the final effluent.

For single tank systems we suggest more frequent monitoring (5% to 10% intervals based on capacity projections) such that the rising break through levels will be observed in time to prevent effluent levels from exceeding desired limits.

Keeping a log sheet with the date, arsenic test result and gallon throughput readings, noting when change outs occur can be a useful tool to track performance, establish trends and plan change-outs or determine if there is a problem with the system operation.



Regeneration

Regeneration with Sodium Hydroxide

Virtually complete regeneration of arsenic laden ResinTech ASM-10-HP may be accomplished using dilute sodium hydroxide. This procedure is beyond the scope of what might be expected for a residential installation. It is solely intended for large commercial, industrial and/or municipal installations or for portable exchange regeneration plants where there are permanent industrial waste treatment systems and trained operators to deal with arsenic laden waste waters generated by the regeneration process.

A detailed regeneration procedure should be prepared for each system. The following generalized regeneration may be used as a starting point.

1. Backwash with soft water for at least 20 minutes at a flow rate of approximately 4 to 6 gpm/sq. ft. so that the bed expands 40 to 60 %.
2. Apply 30 gallons of 5% sodium hydroxide solution, made with soft water, over a minimum 60-minute period.
3. Follow with a slow rinse using soft water at the same flow rate for 30 minutes.
4. Fast rinse to pH less than 13 and conductivity less than 5000 micromho using soft water (flow rate about the same as the service flow rate).
5. Regenerate with 15 lbs of salt diluted with 30 gals of soft water over a 45 to 60 minute period.
6. Rinse with soft water to pH below 9. If necessary, neutralize the resin bed by adding small amounts of sulfuric or hydrochloric acid while air mixing until the pH of the slurry remains less than 7 for 30 minutes.
7. Rinse with tap water until the effluent conductivity is similar to the tap water (usually less than 500 micromho). Check arsenic concentration prior to returning to service.

Note that local waste regulations may not permit the discharge of spent regenerant solutions containing arsenic and/or sodium hydroxide and/or sodium chloride. It may be necessary to haul the waste regenerants to an acceptable disposal site. In all cases, check with local authorities and follow their directions.

Warning

Sodium hydroxide (sometimes called lye) is a very potent chemical that can cause severe burns. Proper safety gear is essential when working with sodium hydroxide solutions. Be sure to read and follow all safety instructions included with the MSDS that accompanies each shipment of sodium hydroxide.

Disposal of Media

Although ASM-10-HP passes the current EPA TCLP leachables test. This test may not reasonably reflect actual landfill conditions that in certain cases such as the presence of acid wastes that conceivably might cause arsenic to be released. ResinTech recommends compliance with all federal and local laws governing disposal.

In regenerable operation, disposal would consist of regeneration and re-use of the ASM-10-HP media, precipitation and solidification of arsenic followed by re-use or disposal of solid arsenic salts as hazardous waste.

ResinTech Inc., an acknowledged leader in ion exchange, manufactures a broad range of ion exchange resins for water and wastewater treatment, including deionization, softening, metals removal, product purification, resource recovery, and pollution control. In addition to its ion exchange resins, ResinTech supplies activated carbon and inorganic selective exchangers. ResinTech has developed an application technology resource group that includes state-of-the-art laboratories and a group of scientists dedicated to expanding the frontiers of application technology. This group is put to use whenever product or process recommendations are requested, assuring customers get the most cost-effective approach to achieving their process goals.



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