Planning for this issue began shortly after the U.S. Environmental Protection Agency (EPA) announced that it would propose a rule intended to reduce mercury waste from dental offices. The agency plans to focus its technology assessment on amalgam separators, devices designed to capture amalgam waste from dental office wastewater lines before it discharges into public sewer systems. Several states currently require these devices.

In anticipation of the EPA’s proposed rule, the ADA Laboratories purchased and evaluated nine separators available in the U.S. to determine their amalgam removal efficiency. The bottom line—all nine amalgam separators passed the ISO 11143 requirement of 95 percent amalgam removal efficiency. However, you’ll want to take note of the individual devices maximum fillable volume and bypass mechanisms, which are discussed in the evaluation. We’ve also included an article, “Amalgam Separators: Practical Issues for Purchasing, Installing and Maintaining Amalgam Separators,” to help with buying decisions.

At the time of this publication, the EPA is expected to publish a final rule in the next two years. The ADA will keep you posted.

This is our second issue going fully online as a digital magazine and as a PDF that you can print. An executive summary of the issue appears in the August JADA. I’d like to hear your feedback. I’d also like to know what products or product categories are of most interest to you in your practice. Drop me a line at pprrclinical@ada.org.
In 2010, the U.S. Environmental Protection Agency (EPA) announced its intention to propose a rule to reduce mercury waste from dental offices. The agency intends to focus its technology assessment on amalgam separators and is preparing a regulatory proposal for review.¹,²

Amalgam Separator Technology
Amalgam separators are devices designed to capture amalgam particles from dental office wastewater through sedimentation, filtration, centrifugation, or a combination of these mechanisms. Some separators may also use ion exchange technology to remove mercury from wastewater.

Sedimentation units. These separators reduce the speed of wastewater flow, which allows amalgam particles to sink to the bottom of the unit. Sedimentation units have baffles or tanks that allow heavy materials entering the unit to deposit on the bottom where they collect for recycling.

In this simplified example (See Figure 1) of a separator using sedimentation technology, the wastewater enters from the operatory suction line. The fluids and solids separate from the air, which continues to flow to the vacuum system. The amalgam particles then sink to the bottom of the device and the water continues to flow to the vacuum system and outlet.

Centrifuge units. Centrifuge-based separators use centrifugal force to separate amalgam particles from dental office wastewater.

In this simplified example (See Figure 2) of a centrifuge-based separator, water enters the amalgam separator from the operatory suction line. The amalgam particles fall to the bottom of the container.

Filtration units. Depending on the types of filters used, these separators remove various sizes of amalgam particles contained in the wastewater.

In this simplified example (See Figure 3) of filtration separator technology, wastewater enters the separator from the operatory suction line. The filtration media, which varies depending on the device, captures amalgam particles before the wastewater exits the system.

Combination Units. Combination amalgam separators use a combination of centrifuge, sedimentation or filtration methods to remove amalgam particles.

---

¹,² Hwai-Nan Chou, MS, Julia Anglen, BS, BA

Figure 1. Sedimentation Separator Technology.

Figure 2. Centrifuge Separator Technology.
Introduction
Amalgam waste comes from expended amalgam capsules, unused scraps, chairside traps, vacuum pump filters and amalgam separator collection containers. Placing or removing amalgam restorations produces amalgam waste particles that can be suctioned into the dental unit vacuum line and, ultimately, discharged into the public sewer system. Although chairside traps and vacuum filters remove some of the amalgam particles from the dental wastewater stream, amalgam particles that remain in the wastewater can settle along the waste pipe’s walls or be discharged into the sewer.

Amalgam separators are devices designed to capture amalgam waste from the dental office wastewater line before it discharges into the sewer. Separator systems capture scrap amalgam particles that are too fine to be removed by a chairside trap or a screen. The configuration, office size, and operation of the dental office can significantly affect the choice of separator. The choice can also be affected by an amalgam separator’s operation and maintenance requirements.

The standard by which amalgam separators are most commonly evaluated is ISO Standard 11143 for Amalgam Separators (American National Standards Organizations/American Dental Association (ANSI/ADA) Specification No. 108:2009). The standard was developed by the International Organization for Standardization (ISO), a worldwide federation of national standards bodies. The amalgam separator standard was first issued in 1999 and the current version, as of this writing, was issued in 2008. The standard specifies requirements for the efficiency of amalgam separators and the test procedures for determining efficiency. It also includes requirements for the safe functioning of the separator, along with marking, instructions for use, operation and maintenance.

Materials and Methods
The ADA Laboratories purchased and evaluated nine amalgam separators available in the United States to determine their efficiency of amalgam removal. Table 1 lists all amalgam separators tested with product information provided by each manufacturer.
Nine Separators Purchased for Evaluation

A.B. Dental Trends
890-1500 In-Line Separator

Air Techniques, Inc.
Acadia Amalgam Separator

Capsule Technologies, Inc.
AsDex AS9 Model - AS10

Dental Recycling North America
BU-10 Amalgam Separator

Liberty Boss Amalgam Separator

Pure Water Development LLC
ECO II Amalgam Separator

R&D Services, Inc.
The Amalgam Collector CE18 Amalgam Separator

Rebec Solutions
Rebec 400 Series Amalgam Separator

SolmeteX
Hg S Amalgam Separator
### Table 1. Summary of Product Features*

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Amalgam Separator</th>
<th>Chairs Served</th>
<th>Indicators for malfunction or replacement?</th>
<th>Holding Capacity</th>
<th>Collection Service Offered?</th>
<th>Meets ISO 11143 95% removal requirement?</th>
<th>Expected Annual Cost</th>
</tr>
</thead>
</table>
| A.B. Dental Trends  
800-817-6704 amalgamseparation.com | 890-1500 In-Line Separator | 12 | Date reminder sticker provided. Overflow sensor with alarm is an option. | 5.7 Liters | Yes. Recycling and shipping to recycler are included in purchase. | Yes | $328.60 based on 5 year depreciation |
| Air Techniques, Inc.  
800-AIR-TECH airtechniques.com | Acadia Amalgam Separator | Up to 10 | Optional alert module available with lights and audible signals to full condition | 3 Liters | No collection service. Recycling service is available. | Yes | Replacement Filter with Recycle Kit: $145.00  
Replacement Filter: $310.00  
Recycling Kit Only: $115.00 |
| Capsule Technologies, Inc.  
amalgam9.com 952-933-4147 | AsDex AS9 Model- AS10 | 1 | No | 1.4 Liters | Yes. Recycle directions on the separator label. | Yes | One-time System cost $233.00  
Replacement Separator $99.00 |
| Dental Recycling North America  
800-360-1001 drna.com | BU-10 Amalgam Separator | 1 to 8 | BU10 canister is replaced annually to ensure proper functioning. | 10 liters | Annual recycling program includes replacement unit, recycling, and waste disposal documentation. | Yes | Retail cost of BU10 Amalgam Separator: $750  
Estimated Installation Cost: $200  
Annual Cost of replacement canister with recycling: $500  
MRU Amalgam Separator: $1,395 |
716-853-3703 marsbiomed.com | Liberty Boss | 1 to 17 | No. The design makes it virtually impossible to overflow. | 1 Gallon | Yes. Entire unit is sent via FedEx to one of Veolia Environmental’s sites. | Yes | 1 to 3 chairs: $316.33 + local installation costs  
4 to 10 chairs: $774.50 + local installation costs  
11 to 17 chairs: $1,549.00 + local installation costs  
Pair of “quick” disconnects: $100. |
| Pure Water Development LLC  
877-638-2797 ectwo.com | ECO II | 6 | Sticker on container shows 100% fill level. | 3 Liters | Yes. Full unit sent to authorized storage facility using prepaid UPS or FedEx shipping label. | Yes | Initial cost: $595 + costs for installation about $100 $150, if done by service technician.  
Exchange unit + recycling $349 + costs for exchange about $50 to $100, if done by service technician. |
| R&D Services, Inc.  
800-816-4993 theamalgamcollector.com | The Amalgam Collector CE18 | 2 to 5 | N/A | 10 Liters | No. Uses referral partners. | Yes | Initial cost $875 + $150 to install.  
Average annual cost less than $50.  
Auto Siphon Valve, $425 |
| Rebec Solutions  
800-569-1088 rebecsolutions.com | Rebec 400 Series | 1 to 6 Dental Chairs | No. Rebec alerts the dental dealer when the recycle time comes | 2.5 Gallons | Uses a recycle partner for disposal and all record keeping and documentation. | Yes | $1185  
Collector recycle cost: $445 |
| SolmeteX  
800-216-5505 solmetex.com | Hg 5 | 1 to 10 | No | 1.86 Liters | Yes. Purchase of new container includes box and UPS label for shipping to recycler. | Yes | Initial cost + installation approximately $950.00.  
Subsequent years, a minimum of $300.00 per collection container with recycling. |

* Technical information, product features and estimated costs presented in this table were obtained from manufacturers’ responses to the ADA Professional Product Review’s Technical Product Specification form. The devices were purchased for the evaluation.
Amalgam Removal Efficiency Test

Methods. The ADA Laboratories tested each amalgam separator in two conditions: “empty” to simulate the efficiency of the separator when initially installed and “full” to simulate the efficiency of the separator just before replacement as specified by ISO Standard 11143:2008 (ANSI/ADA Specification No. 108:2009). The “full” condition means that the amalgam separator is filled to 95% stated capacity with 70% glass beads of 1 mm diameter and 25% amalgam scrap with a maximum particle size of 0.3 mm. Scientists repeated tests three times for the “empty” and “full” conditions. The mean value of amalgam removal efficiency was calculated for each condition.

Results
The results show that all nine amalgam separators passed the ISO 11143 requirement of 95 percent amalgam removal efficiency.

Discussion
For evaluation purposes, manufacturers must state the maximum fillable volume (MFV) for their amalgam separator. ISO 11143:2008 defines MFV as the “level or volume defined by the maximum waste solids/sludge collecting capacity of the removable collecting container of the amalgam separator at which the efficiency is unaffected.”

The MFV is different from the holding capacity (HC), which refers to the entire volume (solids and liquids) that the separator can hold. These two distinctly different terms are sometimes used interchangeably in manufacturers’ literature, which may be confusing for users. To clarify, the MFV is the measurement needed to evaluate the efficiency of an amalgam separator, not the holding capacity. It is important to understand both the MFV and the HC when purchasing and using an amalgam separator.

For testing purposes according to the ISO standard, a full amalgam separator should be filled with glass beads of 1 mm diameter to 70% of the MFV and the remaining volume filled to 95% MFV with amalgam scrap with a maximum particle size of 0.3 mm.

Table 3 includes the MFV as indicated in the manufacturer’s user guide, whether the MFV is marked clearly on the separator, and whether the amount of amalgam sludge collected can be monitored visually. Some amalgam separators provide a mark on their collecting capsule that indicates the MFV. However, not all of the separators’ collecting capsules are transparent. Although a mark may be present, the user can’t monitor the amount of amalgam sludge collected inside, rendering the mark useless. Only three amalgam separators had clearly marked MFVs and transparent collecting capsules that indicate when the amalgam sludge has filled to capacity and requires maintenance. The last column indicates whether the ADA Laboratories test observation corresponds to the manufacturer’s MFV.

Three manufacturers provided MFVs that do not correspond with the values found in the ADA Laboratory evaluations. Two manufacturers, M.A.R.S (Liberty Boss) and Air Techniques (Acadia), reported MFV values that were higher.

Table 2. Amalgam Removal Efficiency Test

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model</th>
<th>Observed Amalgam Separator Type*</th>
<th>Tested Maximum Flow Rate (L/min)</th>
<th>Empty Separator</th>
<th>Full Separator</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.B. Dental Trends</td>
<td>890-1500</td>
<td>S, F</td>
<td>2.00</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Air Techniques</td>
<td>Acadia</td>
<td>S, F</td>
<td>1.00</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Capsule Technologies</td>
<td>Asdex AS-9</td>
<td>F</td>
<td>1.00</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>DNA</td>
<td>BU-10</td>
<td>S</td>
<td>1.00</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>M.A.R.S.</td>
<td>Liberty Boss</td>
<td>S, F</td>
<td>1.00</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Pure Water Metasys</td>
<td>CEO II</td>
<td>S, F</td>
<td>1.00</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>R&amp;D Service</td>
<td>C18</td>
<td>S</td>
<td>1.00</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Rebec</td>
<td>400 Series</td>
<td>S, F</td>
<td>1.00</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>SolmeteX</td>
<td>Hg 5</td>
<td>S, F</td>
<td>1.00</td>
<td>Pass</td>
<td>Pass</td>
</tr>
</tbody>
</table>

* S= Sedimentation, F= Filtration
than the values found experimentally, meaning these units need replacing sooner than the manufacturer indicates. Alternatively, the MFV reported by DRNA (BU-10) was less than we found experimentally, meaning this unit can be replaced later than indicated by the manufacturer. (Although DRNA’s BU-10 volume probably exceeds 77mL by an undetermined amount, consult the manufacturer for additional information.)

**Bypass Mechanism**

Seven of the amalgam separators we tested had bypass mechanisms, which allow suction power to remain the same even when the collecting capsule is full. These mechanisms accomplish this by completely bypassing the collecting capsule and permitting unprocessed drainage to flow directly into the public wastewater system. The advantage of the bypass mechanism is that dental operation will not be interrupted when the separator is full. However, this also means that the separator’s ability to remove amalgam particles is reduced—and with the suction unaffected, the dentist will be unaware that the separator needs maintenance, thus prolonging contamination of the wastewater system.

The Asdex AS9 (Capsule Technologies) and the Liberty Boss (M.A.R.S) are the only two separators evaluated that did not have a bypass mechanism, meaning the suction power will diminish gradually when the unit is filled to capacity. Alternatively, when all of the other units are filled to capacity, suction power will not be affected, but the separator’s ability to remove amalgam particles will be reduced and with the suction unaffected, the dentist will be unaware that the separator needs maintenance, thus prolonging contamination of the wastewater system.

**Conclusions**

Although the test results show that all nine amalgam separators passed the ISO 11143 requirement of 95 percent amalgam removal efficiency, dentists should be aware that maximum fillable volume is a critical factor in understanding how to maintain an amalgam separator. Purchasers and users should note the separator’s maximum fillable volume at the time of installation and recognize it as an indicator as to when the separator should be replaced.


The authors wish to thank Mark Stone, DDS, of the Naval Institute for Dental and Biological Research at Great Lakes, Illinois, and David Berzins, PhD, Graduate Program Director for Dental Biomaterials and Associate Professor, General Dental Sciences at Marquette University in Milwaukee, Wisconsin, for providing non-contact (unused) dental amalgam scraps for the evaluation.

Mr. Hwai-Nan Chou is manager of chemistry, Research and Laboratories, Division of Science, American Dental Association, 211E. Chicago Ave., Chicago, Ill. 60611. E-mail chou@ada.org. Address reprint requests to Mr. Chou.

Ms. Julia Anglen is a research assistant, North Bridge Staffing, Chicago, Ill.

Disclosure. Neither of the authors reported any disclosures.

---

**Table 3. Summary of Maximum Fillable Volume (MFV)**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Manufacturer’s MFV</th>
<th>MFV is clearly marked on device</th>
<th>Amalgam sludge level clearly visible</th>
<th>MFV found in evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.B. Dental Trends</td>
<td>267 mL</td>
<td>No</td>
<td>No</td>
<td>Could not verify</td>
</tr>
<tr>
<td>Air Techniques</td>
<td>1 L</td>
<td>Yes</td>
<td>No</td>
<td>0.6 L</td>
</tr>
<tr>
<td>Capsule Technologies</td>
<td>362 mL</td>
<td>No</td>
<td>Yes</td>
<td>362 mL</td>
</tr>
<tr>
<td>DRNA</td>
<td>77 mL</td>
<td>No</td>
<td>No</td>
<td>&gt;More than 77 mL*</td>
</tr>
<tr>
<td>M.A.R.S.</td>
<td>1 Gallon</td>
<td>Yes</td>
<td>No</td>
<td>2 L</td>
</tr>
<tr>
<td>Pure Water Metasys</td>
<td>0.6 L</td>
<td>Yes</td>
<td>Yes</td>
<td>0.6 L</td>
</tr>
<tr>
<td>R&amp;D Service</td>
<td>1.4 L</td>
<td>Yes</td>
<td>Yes</td>
<td>1.4 L</td>
</tr>
<tr>
<td>Rebec</td>
<td>1.3 L</td>
<td>No</td>
<td>No</td>
<td>1.3 L</td>
</tr>
<tr>
<td>SolmeteX</td>
<td>0.91 L</td>
<td>Yes</td>
<td>Yes</td>
<td>0.91 L</td>
</tr>
</tbody>
</table>

* DRNA’s BU-10 volume probably exceeds 77mL by an undetermined amount. Consult the manufacturer for additional information.
A 2003 article published in the Journal of the American Dental Association (JADA) outlined a growing environmental concern over the accumulation of mercury in the tissue of some fish species. The concern prompted local, state and federal agencies to pursue stricter regulation of mercury released into public sewer systems. Although dental offices contribute a low overall percentage of mercury to the environment, they remain one of the most frequently referenced sources of mercury added to public sewer systems in the form of dental amalgam. Although mercury in dental amalgam is not immediately bioavailable—it has not been shown to contribute significantly to the problem of mercury in fish tissue—environmental agencies continue to develop regulations and/or outreach programs on a state and local basis encouraging, or in some areas, mandating, dental offices to install amalgam separators. The separators are intended to reduce amalgam discharges beyond those already achieved by chairside traps and vacuum filters. A dental office’s waste infrastructure and office procedures have been shown to significantly affect the choice of a suitable separator. Offices will also encounter important differences in operating and maintaining separator units properly. Anticipated federal requirements regarding separator installation will also be a key consideration for dental offices that do not currently have separators.

Overview. This article outlines key factors related to office infrastructure and operation that dentists should consider when investing in an amalgam separator. Since the initial article appeared, new local, state and federal regulations have been enacted or are under review, increasing the need for dental practitioners to understand the potential impacts of these requirements. The ADA amended its Best Management Practices to include amalgam separators in 2007. This article also provides a broad view of the recommended best practices to effectively manage and control potential amalgam discharges from all dental office activities, including cleanout and disposal of chairside traps and vacuum traps, cleaning of dental lines, and design or renovation of dental facilities.

Conclusions and Practical Implications. Before purchasing or installing an amalgam separator, consider factors specific to the available models, including size and maintenance requirements. Office-specific factors, such as plumbing configuration, available space for installation and subsequent access to that space for equipment replacement and maintenance, and building codes or lease stipulations may affect equipment choice and installation. Dentists should consider the effect an amalgam separator could have on existing suction equipment, as well as the short- and long-term costs, including maintenance and parts replacement. Dentists should also closely follow the development of potential new state and federal requirements that may include annual certifications, agency inspections and recycling, maintenance and recordkeeping requirements.

Placement and removal of dental amalgam restorations generates amalgam waste particles that can be suctioned into the dental unit vacuum line and some of the amalgam waste particles could be discharged into the public sewer system and eventually flow to the sewage treatment plant or publicly owned treatment plant (POTW). Chairside traps and vacuum pump filters generally remove up to 76 percent of the amalgam particles from the wastewater stream. However, some amalgam waste particles still enter the sewer system.

Amalgam separators are devices designed to increase removal of amalgam waste particles from dental office discharge. A variety of amalgam separators are currently available. Some of these units have been tested by the ADA, and the most recent test results are summarized on page 2 of this issue of the ADA Professional Product Review. Amalgam particles in dental office wastewater can range in size from colloidal particles (smaller than 0.45 microns) to those larger than 3 millimeters. To capture these various sized particles from waste discharge, amalgam separator units typically use one or more of several separation techniques: sedimentation, filtration, centrifugation or ion exchange. Sedimentation-based separator units have baffles or tanks that reduce the speed of the wastewater flow, allowing amalgam particles, which are about 10 times heavier than water, to sink to the bottom of the unit. Filtration units also can remove amalgam particles, in addition to colloidal particles and dissolved mercury, depending on the types of filters used.
Centrifuge-based separator units spin wastewater, relying on centrifugal force to draw the amalgam particles to the sides of the unit. Ion-exchange systems take advantage of the tendencies of certain chemicals to bind with dissolved mercury in the dental water stream.

When selecting a separator for their offices, dentists should consider:

- space
- utility requirements;
- dental office/building constraints;
- regulatory requirements;
- ease of maintenance and replacement;
- effect on suction equipment; and
- purchase, installation and maintenance costs.

To help summarize and simplify this process, a buyer’s checklist is included. (See Table 1. Amalgam Separator Buyer’s Checklist.)

**Space Requirements.** Amalgam separator sizing is a major consideration for selection and installation. Models may range in size from approximately 3 inches in diameter, occupying a 9-inch-square area, to 4 feet by 2 feet (1152 in²). The heights of units vary from 9 to 36 inches.

A separator’s performance relies, in part, on correct installation within the dental office’s existing wastewater and vacuum system. There are generally three distinct installation locations: directly within the vacuum system piping, or “in-line,” at or near individual operatory chairs; in-line at a central location upstream of the vacuum pump; or at the outlet side of the air/water separator. Most systems are designed to be installed in-line between the dental operatories and the vacuum pump. An evaluation of amalgam separators installed in dental offices showed that amalgam waste particles were adequately collected in amalgam separators installed after the chair side trap or vacuum pump filter traps.⁹

**Utility Requirements.** Many separators rely on gravity or the vacuum system to operate and therefore do not require an electrical power source beyond that needed to power the vacuum system. However, some units do require electrical power connections for the control panel or to operate pumps that remove the settled effluent from the separator unit and discharge it to the sewer. Typically, these pumps are designed to operate at the end of the day or overnight, when the vacuum system is turned off.

**Dental Office/Building Constraints**

In addition to the size of the unit, a number of other factors can affect placement and installation of amalgam separators including:

- building configuration;
- available installation space;
- access to centralized plumbing lines; and
- office space leasing agreements.

**Building configuration.** Building configuration primarily refers to the existing plumbing set up in your office. For example, if the office is centrally plumbed, with all of the plumbing systems draining into one pipe, you may need to modify your plumbing so that only drainage from amalgam-generating sources runs through the separator. Additional water flows (for example, from cuspidors, sinks and operatories used exclusively for hygiene appointments) can adversely affect performance of separators. All sources that generate amalgam waste should be identified and, when feasible, plumbed separately to the separator.

**Installation space.** Many dental offices face space limitations, particularly those that do not have access to a basement. Before investing in a separator, dentists should determine whether the separator will be installed in the basement or in the office. Many dental offices install vacuum systems and air/water separators at the basement level to conserve office space. In that situation, separator installation is usually easier, as there is sufficient space upstream of the vacuum system to collect flow.

Installation can be more complicated in offices without basements. These offices often install vacuum systems in utility closets or cabinets, which limits the available space upstream for the amalgam separator. In some cases, space limitations may require the use of chair-side amalgam separators in individual operatories.

**Access to plumbing lines and amalgam separators.** Dental office staff needs suitable access to inspect and maintain the separator. Dental practices that share plumbing or vacuum systems—as is often the case in multi-unit office buildings—will need to coordinate maintenance activities so as not to interfere with work schedules. Such coordination is particularly important if vacuum systems must be turned off for maintenance activities, or basement or closet access must be provided.

Continued on next page
Offices in large, multi-story buildings also will likely face plumbing access issues as flows typically will be connected with larger building waste pipes that may or may not be easily accessed. Practices in such buildings may need to consider chair-side systems or systems that install upstream of the vacuum pump, depending on space availability.

Office-space leasing agreements. Many commercial lease agreements contain language that restricts the tenant’s ability to modify the building infrastructure. Dentists who lease office space should review the terms of their lease to determine whether they can make any electrical or plumbing connections under the existing agreement. More recently, some landlords, in response to local zoning requirements, have begun to require dental practices that lease space in a multitenant building to segregate and collect all dental wastewater discharges. It is unclear at this point whether such requirements eliminate the need for an installed amalgam separator.

Dentists who lease their offices as well as those who have space in a multi-unit building may wish to consult with their lawyer to determine liability should a pipe break or waste release occur at or near a separator they have installed.

Proposed Federal Standards
The U.S. Environmental Protection Agency has undertaken an initiative initiated a rulemaking process to mandate the installation of amalgam separators for all dental offices, subject to specific conditions. Exact details of the proposed rule are not available at the time of this printing, as the agency draft remains in final interagency review prior to release for comment by the general public. At this point, it is anticipated that the rule will be out for comment sometime in the next two years.

Disposal of Amalgam Waste
Many amalgam separator manufacturers offer recycling programs as a part of their service, which allows spent or full cartridges/separators to be shipped to recycling facilities. Offices should check with vendors to find out whether that service is available in their state and whether there are any storage requirements. It is also recommended that dental office waste procedures comply with ANSI/ADA Specification 109: “Procedures for Storing Dental Amalgam Waste and Requirements for Amalgam Waste Storage/ Shipment Containers.”

As the waste generator, dental offices are responsible for ensuring proper disposal of amalgam waste—whether they have contracted with a vendor-sponsored program or have arranged for a recycler independently. Offices should ask for, and separator vendors or recyclers should be willing to provide, appropriate documentation to demonstrate that they are working with reputable waste handlers (see “Ask Your Amalgam Recycler” on Page 14.)

Plumbing code requirements. Dentists should investigate state and municipal plumbing code requirements before selecting and installing a separator system. In Massachusetts, for example, systems installed upstream of the vacuum system are classified as a part of the dental facility equipment and are exempt from facility plumbing code requirements. However, systems that are installed downstream of the vacuum system and discharge directly to the sewer system are subject to local plumbing requirements, and require permitting and installation by a licensed plumber. Most states and cities have different requirements, and offices should check with vendors and their local plumbing inspector to ensure that they meet local ordinance requirements.

Local wastewater treatment plant approved equipment lists. As noted earlier, some wastewater treatment facilities have lists of “approved” amalgam separators and vendors. These lists may be issued as a regulatory requirement (for example, as an amendment to local sewer ordinances) or as guidance included in “Best Management Practices” programs. Dental offices should check with local officials to determine whether any specific requirements exist in their area. Dental offices also should ask how often they need to renew approval or certification for installed units.

Separators that incorporate advanced treatment of amalgam-containing waste (such as chemical binding/ion exchange) may be necessary if the local utility or regulatory body has adopted very stringent mercury-reduction requirements.

Ease of Maintenance and Replacement
Maintenance of installed separators is an important and often overlooked component to ensure that the separator unit is operating as designed. It is critical to note that the installation of a separator is only the first step; it must be properly maintained, including regular changes in collection canisters or, depending upon the unit, switching out units in order to ensure that collection rates remain as designed. In general, a separator collection unit should be switched at a frequency of 6 to 12 months; however, this can vary depending upon the volume of materials handled and number of operatories plumbed to the separator unit. A separator that is allowed to fill beyond its capacity result in complete bypass of amalgam particles from collection.
The maintenance requirements and schedules for amalgam separators vary widely and should be considered before buying. Smaller practices, with fewer support staff, for example, may choose to purchase a system that provides longer maintenance intervals and fewer inspection requirements.

Before purchasing a separator, there are several questions that should be posed to potential vendors. Ask about maintenance requirements and request copies of system manuals to compare features and manufacturers’ recommendations. Sales brochures may not provide sufficient details on maintenance requirements, making the operations and maintenance manuals an important resource for accurately determining maintenance needs. Vendors also should be willing to provide a reference list with contact information for similar dental offices that have installed their separator. Direct experience in operating a system is valuable information for the prospective buyer.

Offices may want to ask vendors about the recommended treatment schedule and procedure to limit biological growth within the system. Some vendors recommend the use of a sterilant solution added chairside once per week to control such growth. Others recommend a daily treatment with non-foaming cleaning solutions. The amount of cleaner used and frequency of use will generally be determined by the length of the vacuum system lines and the amount of biological materials introduced into the system. Dentists should not use bleach or other corrosive solutions to clean out lines as they may remobilize bound mercury within the lines and reduce the effectiveness of separator units.23

In general, the in-line systems require more frequent inspection and maintenance to prevent blockages. For example, some models require a series of initial inspections to calibrate the system to office flows, as well as a daily check of the system thereafter to determine when the fluid in the unit needs to be decanted and the outlet tube height adjusted for proper operation. Other systems, however, require only annual maintenance or replacement.

Dentists should talk to the vendor about the potential effect the practice can anticipate should the separator break down. Ask questions that will help determine what type of post-installation servicing the vendor offers. Know the typical response time for removing or replacing a system in the event of clogging or failure, or whether canister or tank replacement needs to be performed by a vendor technician.

Ask how the amalgam separator unit indicates when a collection canister or cartridge is full and requires replacement. ISO standard 11143 specifies that units should provide “an auditory or visual sign, signal or other kind of indicator” that provides the user with information that maintenance/replacement is required. Operation of units beyond their capacity will often result in bypass and discharge of waste amalgam into the sewer system. These indicators may not always be obvious from a visual inspection of the unit.

Establish whether there are special material handling instructions or state or local amalgam waste handling regulations. Secure a list of recommended cleaners for use with the specific amalgam separator.

**Effect on Suction Equipment**

Dental offices need to understand how specific separator units may affect existing vacuum systems. Units placed upstream of vacuum systems must be carefully installed to prevent loss of suction. The most common reasons for reduced vacuum suction include improper fittings, excessive hose bends or angles, or long hose runs (≥ 4 to 6 feet, depending on the model) added to existing vacuum pump piping. Vacuum systems are designed to provide a pre-set level of suction that is expressed in inches of mercury, and a typical unit is installed at a vacuum level of 7 to 10 inches of mercury. After installing the separator, the installer should test the vacuum system performance under typical conditions, such as multiple operatories and associated evacuators in use as well as under closed conditions to ensure that suction has not been compromised. In general, a noticeable loss in vacuum indicates a potential installation problem.

Clogs in the line also can degrade vacuum performance. Systems that are designed to be installed directly in the vacuum line potentially are prone to clogging due to non-amalgam materials being carried in-line to the vacuum system filters. Offices that are centrally plumbed would have a system more prone to clogs due to the flow of amalgam and non-amalgam wastes, such as prophylaxis pastes and other solids, as would offices where the plumbing has long horizontal runs and/or numerous bends in the piping.

As noted earlier, these offices may need to re-plumb as part of the installation process. If plumbing reconfiguration is not an option, these practices could conduct more frequent inspection/maintenance of separator equipment to maintain sufficient vacuum pressures. Centrally plumbed offices also should look more closely at systems that are installed at the discharge side of air/water separators. These systems are designed to be drained when the vacuum system is turned off.

Continued on next page
### Office Considerations

<table>
<thead>
<tr>
<th>Factor</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operators, chairs (Number)</td>
<td>Offices with four or more chairs should consider central, not chairside units, with sufficient capacity to handle multiple chair flows</td>
</tr>
<tr>
<td>Amalgam restorations placed or removed per day (Number/day)</td>
<td>Offices that perform more than 40 amalgam-related activities per week(^*) may need a unit with a large storage capacity</td>
</tr>
<tr>
<td>Office operations (Number days/week)</td>
<td>Consider combining similar flows with other offices if possible to share/reduce costs</td>
</tr>
<tr>
<td>Dental practices located in your building</td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>Do you own or lease your space?</td>
<td>Confirm that plumbing system modifications are consistent with lease provisions</td>
</tr>
<tr>
<td>Would lease stipulations affect installation of a separator?</td>
<td></td>
</tr>
<tr>
<td>What terms are included for utilities maintenance?</td>
<td></td>
</tr>
<tr>
<td>Do you operate a wet/dry cuspidors?</td>
<td>Wet cuspidors should be plumbed to a separate line if possible. If not possible, your separator should have a holding or surge tank with sufficient capacity</td>
</tr>
</tbody>
</table>

### Building Configuration

<table>
<thead>
<tr>
<th>Factor</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is sufficient space available to the air/water/separator drain line and sewer line connection?</td>
<td>Certain separators rely on gravity flow and require adequate space from the air/water, separator line to connect to the drain system.</td>
</tr>
<tr>
<td>Access to electrical power (voltage)</td>
<td>Check the power supply needs for each model under consideration</td>
</tr>
<tr>
<td>Size and material of existing sewer connection</td>
<td>Separator installation should not constrict existing vacuum or drain line requirements</td>
</tr>
</tbody>
</table>

### Vacuum System

<table>
<thead>
<tr>
<th>Factor</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you operate wet or dry vacuum system?</td>
<td>Wet ring vacuum pumps generate additional water flow that will require greater storage capacity</td>
</tr>
<tr>
<td>Will any warranty be affected by third party installations?</td>
<td>Some warranties may be invalidated if parts of the system are modified by third parties</td>
</tr>
<tr>
<td>Is the vacuum system dedicated to your office?</td>
<td>Group practices that share vacuum systems may want to re-plumb or split costs associated with the amalgam separator</td>
</tr>
<tr>
<td>Location of the vacuum system?</td>
<td>Office-level systems may require smaller units</td>
</tr>
<tr>
<td>Basement</td>
<td></td>
</tr>
<tr>
<td>Office</td>
<td></td>
</tr>
<tr>
<td>Space available adjacent to vacuum system (height, length and width)?</td>
<td>Access to upstream piping is critical for maintenance and inspection of systems</td>
</tr>
</tbody>
</table>

### Separator specifications

<table>
<thead>
<tr>
<th>Factor</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended installation location(†)</td>
<td>Evaluate model information against the specific conditions for your practice (space, plumbing, access, workload, regulatory considerations, etc.) Ask manufacturers for protocols to determine when cartridges or replacement collection units are needed</td>
</tr>
<tr>
<td>Capacity (in chairs)</td>
<td></td>
</tr>
<tr>
<td>Maximum flow rate</td>
<td></td>
</tr>
<tr>
<td>Ease of Maintenance</td>
<td></td>
</tr>
<tr>
<td>Life-cycle cost(‡)</td>
<td></td>
</tr>
</tbody>
</table>

### Other considerations

<table>
<thead>
<tr>
<th>Factor</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>In your group practice, who is responsible for</td>
<td>Group practices that share vacuum lines may need to discuss how the addition of an amalgam separator will affect allocation of cost and responsibilities as well as make arrangements for access to the unit.</td>
</tr>
<tr>
<td>Equipment servicing and maintenance</td>
<td></td>
</tr>
<tr>
<td>Water/sewage/utilities</td>
<td></td>
</tr>
<tr>
<td>Amalgam collection/recycling</td>
<td></td>
</tr>
</tbody>
</table>

---


† See Figure for typical installation locations

‡ See “Calculating Life-Cycle Cost”
Finally, dental offices should review the warranty information for their vacuum systems and contact their vendors to determine whether installation of a separator within the vacuum system could void the equipment warranty. Some manufacturers may not honor warranties on their equipment if parts of the system are modified by third parties. For your own protection, you should get all warranty-related information in writing.

Cost

As with the purchase of any equipment, cost is clearly a key issue when choosing an amalgam separator. True side-by-side comparisons of system costs are difficult because numerous pricing and leasing programs exist. For example, some vendors offer purchase plans for just the system, while others provide lease-based systems that include replacement of filter cartridges or ion exchange cartridges and recycling of amalgam waste. A system is provided below that dentists can use to estimate the life-cycle cost of purchasing or leasing and maintaining an amalgam separator (See “Calculating Life-Cycle Cost”). Essentially, any approach used to compare the cost of separators should analyze upfront and ongoing expenses, including:

- purchase price;
- installation fee(s);
- ancillary parts included in cost (such as mounting plates, connection fittings);
- cost of replacement parts and accessories;
- cost of replacement tanks or cartridges, including shipping and other sometimes “hidden” fees; and
- office maintenance costs, labor.

The cost of replacement parts is often overlooked when buyers are evaluating cost. Be sure to ask about these and an estimated replacement schedule. For many systems, replacement cartridges can be up to 20 to 25 percent of the initial unit price. In addition, one should recognize that the frequency of replacement and therefore the cost of parts and maintenance will depend, in part, on each practice’s patient load and the number of amalgam restorations that are placed or removed. While the manufacturer can estimate these figures, you will need to consider factors specific to your own practice to more accurately predict the cost of a system.

In addition, keep in mind that some of your current maintenance costs, including labor, could change as a result of installing a separator. For example, if you install the separator ahead of the existing vacuum pump filters in your system, you may be able to slightly reduce the estimated maintenance cost for pump filter changes as fewer may be needed with this set up.

Finally, be sure to ask questions of the supplier to determine what other costs may apply. For example, if you are signing a contract that includes the purchase of a separator as well as the pickup or mail back of full collection canisters, are all shipping costs included in your contract fee. Some of these units when full can weigh 25 lbs. or more, requiring relatively higher shipping fees.

Conclusion

This article highlighted the changing technical environment facing dentists who generate amalgam waste and have not yet installed amalgam separators. There are important questions and considerations that dental offices should review before contacting vendors that will guide their discussions. The bottom line is that one size does not fit all, and office configurations and operations can significantly affect the selection and installation of an amalgam separator. Dentists should pay close attention to the development of local, state and federal regulations regarding the installation of approved amalgam separators and for any additional changes for requirements concerning amalgam handling and best management practices for recycling.

Although this article was developed in cooperation with the ADA Council on Scientific Affairs and the Division of Science, the opinions expressed herein are those of the author and do not necessarily reflect the views and positions of the Council, the ADA Division of Science or the Association.

Mr. McManus has 26 years of environmental management and consulting experience within industry, public utilities and government agencies. As a former director of the Massachusetts Water Resources Authority’s industrial pretreatment program, he was responsible for compliance with EPA pretreatment regulations and federal/state permit conditions related to industrial wastewater permitting, health and safety, toxics management and emergency response.

He is a Senior Program Director at EBI, specializing in the implementation of environmental compliance and waste management programs for dental, health care, institutional and biotechnology facilities. Mr. McManus has provided training and technical support for the American Dental Association and numerous state dental societies on the topic of dental amalgam control and recycling, including the linkage between dental facilities and sewerage treatment plants, dental best management practices, and an overview of available amalgam collection/separation technologies and installation guidelines. He also manages dental waste and safety training programs for Massachusetts, New Hampshire, Maine Dental Societies as their endorsed waste management provider. Mr. McManus holds BA and MA degrees in marine resource management and a Masters of Business Administration degree from Boston University.

Disclosure: Mr. McManus is Senior Program Director, EnviroBusiness, Inc., 21 B Street, Burlington, MA 01803, kmcmanus@ebiconsulting.com.

Continued on next page
Calculating Life-Cycle Cost of Amalgam Separators

Life-cycle costing, as the name suggests, estimates the cost a piece of equipment will run from the time it is purchased until it is replaced. The following sample calculations are based on a life expectancy of five years. This calculation considers initial purchase price, cost of replacement parts, labor costs associated with maintenance and inspection, and so forth. The sample worksheets below illustrate both separator purchase scenarios in present-day U.S. dollar values.

Table 2. Purchasing Equipment

<table>
<thead>
<tr>
<th>Cost</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(§)</td>
<td>(§)</td>
<td>(§)</td>
<td>(§)</td>
<td>(§)</td>
<td>(§)</td>
<td>(§)</td>
</tr>
<tr>
<td>Purchase price</td>
<td>850</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>850</td>
</tr>
<tr>
<td>Installation*</td>
<td>250</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>250</td>
</tr>
<tr>
<td>&quot;Tank, cartridge replacement†&quot;</td>
<td>--</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>1000</td>
</tr>
<tr>
<td>Inspection‡</td>
<td>25</td>
<td>26</td>
<td>27</td>
<td>28</td>
<td>29</td>
<td>135</td>
</tr>
<tr>
<td>Maintenance**</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>27</td>
</tr>
<tr>
<td>Recycling Preparation††</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Recycler fees‡‡</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>250</td>
</tr>
<tr>
<td>**Total</td>
<td>1181</td>
<td>335</td>
<td>336</td>
<td>337</td>
<td>338</td>
<td>2527</td>
</tr>
</tbody>
</table>

* Plumber/electrician for 3 hours at $50/hr.
† Annual cartridge replacement.
‡ Five-minute inspections twice a month by dental assistant at a salary of $14/hr.
** Two 15-minute maintenance sessions a year by dental assistant at a salary of $14/hr.
†† Preparing recycling once a year (approx. 15 min.) by dental assistant at a salary of $14/hr.
‡‡ Some manufacturers bundle recycling costs into purchase price.

References
Ask Your Amalgam Recycler*

What kind of amalgam waste do you accept? †

- Do your services include pick up of amalgam waste from dental offices? If not, can amalgam waste be shipped to you?
- Do you provide packaging for storage, pick up or shipping of amalgam waste?
- If packaging is not provided, how should the waste be packaged?
- What types of waste can be packaged together?
- Do you accept whole filters from the vacuum pump for recycling?
- Is disinfection required for amalgam waste?
- How much do your services cost?
- Do you pay for clean non-contact, "scrap," amalgam?
- Do you accept extracted teeth with amalgam restorations?
- Does your company have an Environmental Protection Agency or applicable state license to recycle/reclaim this material?
- Does the company use the proper forms required by the EPA and state agencies?
- To whom do you sell recovered mercury and silver from my amalgam waste?

* Since the generator of the waste is responsible for proper disposal, dentists should get these replies in writing from their recycler.
† Amalgam waste can be classified as "contact" and "non-contact" or "scrap." As suggested, "contact" refers to amalgam that has been in contact with the patient (removed restorations, carving scraps). "Non-contact amalgam" is excess mix leftover at the end of a dental procedure.