Beating the “Bugs”: Sterilization Is Instrumental

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Veterinary technicians are considered integral to the care and maintenance of surgical instruments and equipment. By knowing how to prevent infection with methicillin-resistant *Staphylococcus intermedius* and methicillin-resistant *Staphylococcus aureus* as well as nosocomial (health care–associated) infections, veterinary technicians can significantly improve the quality of care of hospitalized surgical patients. Veterinary technicians can play a key role by ensuring that proper protocols and procedures are in place to minimize (1) the morbidity and mortality associated with surgical site infections and (2) the costs associated with treatment. An effective infection control program should consist of a multipronged approach that may include selection of appropriate perioperative antimicrobials and disinfectants, the best practices for surgical preparation (e.g., clipping, draping), proper “housekeeping” methods (e.g., thorough, regular cleaning of the operating room; appropriate handling and storage of sterile goods), and adequate sterile processing of instruments and equipment.

The adequate performance of veterinary staff, processes, and equipment is necessary to consistently achieve the highest level of sterility assurance. Individuals who perform sterile processing should have the following goals:

- Ensure that every item is sterile after every sterilization cycle
- Minimize the risk of nosocomial infection
- Meet regulatory requirements by using best practices
- Maintain integrity by promptly detecting faulty processes and implementing steps to prevent failures in the future
- Ensure quality control by consistently monitoring sterilization processes and maintaining a recordkeeping system

Inconsistent processes and/or equipment malfunction can jeopardize sterile processing. According to Susan Flynn, BESc, CSPDT, although utility and equipment problems (e.g., poor steam quality or purity, low temperatures, inadequate air removal) may negatively affect steam sterilization, human error accounts for ~85% of processing-related problems. Human errors include incorrect selection of instrument packaging materials, cycle parameters (TABLE 1), biologic indicators, or process challenge devices and incorrect loading of the autoclave. Therefore, it is imperative to implement a system that allows continuous quality control while eliminating or minimizing waste.

### Instrument Decontamination and Cleaning

Blood, pus, and other secretions may contain chloride ions, which, when left to dry on surgical instruments, may cause staining, pitting, and corrosion. Unwashed and/or dirty surgical instruments should be rinsed under running water within 10 minutes after use. If instruments cannot be cleaned immediately after use, they should be kept damp until they can be properly cleaned.

<table>
<thead>
<tr>
<th>Item</th>
<th>Exposure time 250°F (121°C)</th>
<th>Exposure time 270°F (132°C)</th>
<th>Exposure time 275°F (135°C)</th>
<th>Drying times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrapped instruments</td>
<td>30 minutes</td>
<td>15 minutes</td>
<td>15–45 minutes</td>
<td></td>
</tr>
<tr>
<td>Textile Packs</td>
<td>30 minutes</td>
<td>25 minutes</td>
<td>15–30 minutes</td>
<td></td>
</tr>
<tr>
<td>Wrapped Utensils</td>
<td>30 minutes</td>
<td>15 minutes</td>
<td>15–30 minutes</td>
<td></td>
</tr>
<tr>
<td>Unwrapped nonporous items (e.g., instruments)</td>
<td>3 minutes</td>
<td>3 minutes</td>
<td>0–1 minutes</td>
<td></td>
</tr>
<tr>
<td>Unwrapped nonporous and porous items in a mixed load</td>
<td>10 minutes</td>
<td>10 minutes</td>
<td>0–1 minutes</td>
<td></td>
</tr>
</tbody>
</table>

This table represents variations in sterilizer manufacturers’ recommendations for exposure at different temperatures. Please consult the manufacturer’s recommendations for each sterilizer.

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*Table 1. Minimum Cycle Times for Gravity-Displacement Steam Sterilizer Cycles.*

Susan Flynn, BESc, CSPDT, technical service specialist, 3M Health Care, Sterilization Assurance Group, St. Paul, MN, oral communication, April 2008. CSPDT = central sterile processing and distribution technician.
Placement of instruments in an ultrasonic cleaner containing a neutral-pH solution for 10 to 20 minutes can clean instruments 16 times more effectively than hand washing alone.1,2

In ultrasonic cleaning, high-frequency sound waves are produced by a generator located within an ultrasonic unit (a small, metal tank filled with liquid cleaning solution). A unique vibration pattern is created by alternating high and low pressures during the cleaning cycle as sound waves disperse throughout the tank. During the low-pressure stage, millions of tiny bubbles form cavities in a process called cavitation. During the high-pressure stage, the bubbles collapse or implode, releasing enormous amounts of energy. The bubbles contact all surfaces, cracks, and crevices in every direction, removing debris from the objects being cleaned. SweepZone Technology (L&R Manufacturing Company) enhances ultrasonic performance by alternating frequencies to create a cleaning grid that sweeps through the tank, resulting in a more efficient cleaning pattern and a shorter cleaning time (FIGURE 1A). Units that use SweepZone Technology reduce the occurrence of “hot spots” (areas of intense, constant cleaning power) associated with traditional ultrasonic cleaning technology4 (FIGURE 1B).

A well-mixed, neutral-pH ultrasonic cleaning solution should always be used to avoid increased surface tension and to optimize cavitation.3 To ensure removal of all air bubbles, freshly made ultrasonic cleaning solutions should be degassed by operating the ultrasonic cleaner for 10 minutes immediately after each new batch of cleaning solution is made and before instruments are introduced.4 Instruments should be placed in the ultrasonic cleaner with ratchets and box locks fully opened and exposed to maximize cleaning. The ultrasonic cleaner should not be overloaded. To prevent cross-plating, instruments composed of different metals should not be included in the same cleaning cycle.5 Instruments should be thoroughly rinsed when removed from the ultrasonic cleaner. It may be advisable to rinse instruments in distilled water because tap water can contain a high concentration of minerals that contribute to staining.

In general, heated ultrasonic cleaning solutions have not measurably improved cleaning results or times.5 Therefore, a heated tank feature is not imperative for purchasing an ultrasonic cleaner. Ultrasonic cleaning solutions should be changed daily, or sooner if the solution appears cloudy or dirty.3

Lubrication

After surgical instruments have been thoroughly cleaned and dried, they should be lubricated.2 Proper lubrication of surgical instruments (1) helps prevent damage due to rubbing and scraping and (2) minimizes dulling and staining. All surgical instruments with moving parts (e.g., joints, box locks, ratchets, screws) should be lubricated. All moving parts should be lubricated before autoclaving, and only lubricants approved for steam sterilization should be used. The use of lubricant sprays may be preferable to lubricant baths because the latter may contain bacteria from previously dipped instruments. Furthermore, lubricant sprays can be less expensive and usually require less counter space than most bath solutions5 (FIGURE 2).

**Gross Debris Removal**

Instruments should be washed within 20 minutes after surgery with a neutral-pH (i.e., 7 or 8) soap designed specifically for surgical instruments. High-pH (>8) cleaners, dish soap, iodine, bleach, cold-soak solutions, chlorhexidine-based solutions, laundry detergent, and hand scrubs may cause spotting and corrosion and, therefore, are not recommended. Instruments should be cleaned of all visible debris by hand washing before placement in an ultrasonic cleaner.1,2 It is important to use an instrument cleaning brush to remove all organic material from the jaw serrations, teeth, and hinges (box locks) of instruments.

Cannulated items (e.g., Frasier suction tips, arthroscopic trocars) should be cleaned using a three-step process: (1) flush the lumen, (2) pass a cleaning brush completely through the lumen, and (3) rinse with water.

**Ultrasonic Cleaning**

The use of ultrasonic cleaners is growing in popularity, predominantly due to their efficiency, effectiveness, and ease of use.
**Sterilization Methods**

**Cold Sterilization**

Cold sterilization is not recommended for disinfecting high-quality surgical instruments because immersing instruments in solutions containing benzyl ammonium chloride can loosen tungsten carbide (e.g., gold-handled instruments). Prolonged immersion of surgical instruments in any solution can be damaging; therefore, surgical instruments should never be immersed for more than 20 minutes.

**Steam Autoclaving**

To help prevent infection, all surgical instruments must be sterilized before surgery. The predominant sterilization method at most veterinary practices is steam sterilization by gravity-displacement autoclaving. All instruments should be thoroughly cleaned, lubricated, and properly packaged before steam sterilization. Autoclaving instruments with the ratchets open helps prevent box locks from cracking and ensures appropriate steam penetration. Important tips for steam sterilization follow:

- Always fill the sterilizer reservoir with distilled water to ensure the purity of steam generated for sterilization. Tap water contains minerals that can cause staining when left to dry on surgical instruments and can contribute to the buildup of minerals within the sterilizer.
- Clean the steam-line filter (if present) regularly according to the manufacturer’s guidelines.
- Clean the autoclave chamber weekly to prevent buildup of scale and, therefore, to optimize functionality. Autoclave cleaning may consist of using an approved autoclave cleaner during a special cleaning cycle, wiping out the autoclave after it has cooled, and using a stiff, nylon-bristle brush to scrub the inside of the chamber. After scrubbing the chamber, wipe it out with clean towels. Remember to wipe the gasket inside the door.

**Other Sterilization Methods**

Other low-temperature chemical sterilization methods (e.g., hydrogen peroxide gas plasma [Sterrad system], chemical vapor combinations, ozone, ethylene oxide) may be convenient for processing items incompatible with steam sterilization but are used less frequently in private practice due to the impracticality and hazardous nature of these agents.

**Pack Assembly and Sterile Processing**

Before use, all packaging materials should be equilibrated for at least 2 hours at room temperature (68°F to 73.4°F [20°C to 23°C]) and a relative humidity of 30% to 60%. Before wrapping items for sterilization, it is imperative to ensure that they are dry, clean, and undamaged. Instruments with multiple parts should be disassembled before sterilization.

**Using Peel Pouches**

Peel pouch wraps should allow adequate penetration and removal of the sterilant and air, resist tearing, and prevent contamination of contents. These wraps should be easy to seal, easy to open without tearing, and able to withstand the conditions of the sterilization process. When labeling peel pouches, use an indelible (permanent) marker and write only on the front of the pouch (on the film or transparent side of the pouch, or on the paper located above the adhesive strip). Never write on the back of the pouch, on the paper (or breathable) part. Packaging items in pouches that are too small or too large may cause pouches to rupture. Furthermore, pouches that are too large take up additional space that could be used for sterilizing and storing additional pouches.

When placing items in pouches, ensure that handles or grasping ends are inserted first. Remove as much air as possible and ensure that pouches are properly sealed (e.g., prevent wrinkles and air bubbles). When using cut-to-size (roll-type stock) sterilization
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A. Sieve-type filters
- Woven linen pattern

B. Probability-type filters
(SMS polypropylene)
- Dense microfibers create a tortuous path

Figure 4. Central sterilization wraps filter out bacteria in one of two ways. (A) Linen and paper wraps function as sieve-type filters. (B) Sterilization wraps made of SMS polypropylene (Kimberly-Clark) are composed of dense microfibers that function as probability-type filters; this type of filter provides a more reliable barrier against dust and airborne bacteria.

Figure 5. When multiple pouches are sterilized, a specially designed spiral metal rack (which resembles a spiral letter holder) should be used as a standing aid to permit proper steam flow throughout the chamber.

tubing, always leave approximately 1.5 to 2 inches outside of the heat seal to allow the item to be easily opened after sterilization.5 Roll sterilization tubing should never be sealed using paper clips, pins, or staplers.

For sharp or delicate instruments, apply protector tips on the ends to prevent pouch damage and provide cushioning during sterilization. Protector tips may be vented (fenestrated) or unvented.6 Pouches should never be folded before or after sterilization because folding can compromise the pouch materials or interfere with sterilization by trapping air and preventing proper penetration of the sterilant.6 To prevent pouch rupture (“blow out”) due to packaging items too tightly, allow at least 1 inch of space between the item and the pouch seals on all four sides.5,6 Use cut-to-size roll sterilization tubing for pouching long items. Items that fit poorly inside a pouch due to excessive size, weight, or shape should be packaged using another method, such as wrapping in drape material.

Double pouching may be considered when multiple items must be sterilized together (e.g., a set of extra towel clamps) and to better facilitate aseptic presentation of small items to the sterile field. To ensure adequate sterilant penetration, double-pouched items should be wrapped so that the inner and outer pouches are arranged by film to film. When double peel pouch wraps are used, protector tips must be placed on instruments in a manner that does not impede contact with the sterilant. Additionally, rubber bands or latex tubing should not be used to secure items together. Internal chemical process indicators should be placed inside the innermost pouch before sealing.5,6 The manufacturer’s instructions should always be followed.8

Using Drape Materials
Good central sterilization wraps are engineered to block bacteria while allowing sterilant to readily pass through. Although the Food and Drug Administration has not established standard specifications for class II sterilization wraps, manufacturers have agreed (1) to demonstrate appropriate scientific evidence that packaging materials (a) are specifically designed and suitable for the recommended sterilization methods and cycles and (b) provide an effective barrier to contamination when used according to the manufacturer’s written instructions and (2) to provide adequate in-service education and instructions for use and reuse.7

The way in which a central sterilization wrap filters bacteria depends on the material in the wrap. Paper and linen/muslin (textile) wraps function as sieve-type filters, which is why textiles lose effectiveness with age, excessive washing, and use: the spaces between the threads enlarge, allowing bacteria to pass through. Wraps made of SMS polypropylene (Kimberly-Clark) have dense microfibers and function as probability-type (tortuous-path) filters, which are more reliable than sieve-type filters for filtering dust particles and microorganisms7 (FIGURE 4).

Reusable textile wraps should be delinted and carefully inspected for holes, worn spots, or defects in the fabric before each use. Paper wraps should not be reused.

Loading the Autoclave
Every item to be sterilized should be loosely packed in the autoclave and should not contact the inside walls or the top of the autoclave chamber. Because the film side of peel pouches is impervious to the sterilant, they should be loosely packed with the paper side of each against the film side of another so that all pouches face the same direction.

To permit proper steam flow, pouches should be kept upright in spiral metal racks5 (FIGURE 5). Pouches should not be stacked on top of each other during sterilization.

Surgical packs wrapped in drape material should be placed in the autoclave so that steam can freely circulate around all items (FIGURE 6). Pans or trays used for sterilizing surgical packs should
be fenestrated to permit better steam penetration and drying. For the most efficient sterilization, place heavier (metal instrument) packs on bottom shelves and lighter, more delicate instruments or textile items on upper shelves.

To avoid compromising the barrier properties of packaging materials and contaminating the contents, it is important to cool items at the end of the sterilization cycle and before handling. Furthermore, it is advisable to avoid placing warm or hot processed items on cool or cold surfaces because condensation may occur, causing breaches in packaging materials, which can also lead to contamination of the contents.

Sterilization Process Monitoring

Variations in the sterilization cycle may be due to factors such as the condition of the sterilizer equipment, the frequency of equipment use, the experience of the sterilizer operator, or steam quality. Whether sterilization has been adequate cannot be verified by mere visual inspection. Therefore, the use of monitoring devices for ensuring adequate sterilization is recommended for the following reasons:

- Confirming the probability of the absence of organisms on medical devices
- Detecting and verifying sterilization failures as soon as possible
- Preventing the use of medical devices that have not been adequately sterilized
- Improving patient outcomes and safety
- Controlling costs

Physical Monitors

Physical monitors (previously called mechanical monitors) can verify that the parameters of a sterilization cycle met the manufacturer’s guidelines. Physical monitors may include unit-specific devices such as recording charts, printouts, gauges, or digital displays. Most physical monitors only record the conditions of one location in the sterilizer and cannot assess other physical conditions that may affect the sterility of a load, such as whether proper packaging and loading protocols were followed.

Chemical Indicators

Chemical indicators are used to monitor (1) one or more parameters required for successful sterilization or (2) specific tests of sterilization equipment. Chemical indicators may be used externally or internally. Those designed for external use are predominantly used to differentiate between processed and unprocessed units. Internal chemical indicators should be placed inside the package in the area where sterilant may have the most difficulty penetrating (FIGURE 7). While internal indicators do not guarantee sterility, they can indicate whether sterilization conditions were met within a package.

Six classes of chemical indicators are used to assess parameters identified as essential or critical to sterilization. For example, the critical parameters for effective steam sterilization may include time, temperature, and water (as delivered by saturated steam); however, the critical parameters for effective ethylene oxide sterilization may include time, temperature, relative humidity, and ethylene oxide concentration.

Some chemical indicators use reactive-ink technology, which produces a chemical reaction caused by exposure to process variables, resulting in a color change. With moving front chemical indicators, tablets melt in response to steam and heat and wick down a paper path (FIGURE 8).

Class 1 indicators (process indicators) are used (1) externally for exposure control (e.g., indicator tapes) and (2) with individual units to distinguish between processed and unprocessed items. Class 1 indicators are relatively simple and are designed to react to one or more critical process variables.

Class 2 indicators test sterilizer performance during a specific test, such as a Bowie-Dick test. Bowie-Dick testing can detect anomalies such as air leaks, inadequate air removal, inadequate...
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steam penetration, or the presence of noncondensable gases (air or gases from boiler additives) in vacuum-assisted sterilizers.

Class 3 indicators (single-variable indicators) are designed to react to one critical variable and to indicate exposure to sterilization at a stated value (e.g., the stated value of 250°F [121.1°C] must be met for >16.5 minutes).

Class 4 indicators (multivariable indicators, usually paper strips) are designed to react to two or more critical variables. These indicators reveal exposure to a sterilization cycle at stated values.

Class 5 indicators (integrating indicators) are designed to react to all critical variables. The stated values for class 5 indicators are equivalent to the performance requirements for biologic indicators (International Organization for Standardization 11138 series, 2006). The response of the indicator must correlate to a biologic indicator at three time/temperature relationships; for example, 250°F (121.1°C), 275°F (135°C), and at least one temperature in between (e.g., 263°F [128.3°C]). Stated values must be listed on the product or label or in the instructions (FIGURE 8).

Class 6 indicators (emulating indicators) are cycle verification indicators designed to react to all critical variables for specified sterilization cycles. The stated values are generated from the critical variables of the specified sterilization process. They are cycle specific and must pass an appropriate dry heat test, and the response does not correlate to a biologic indicator.

Biologic Indicators

Biologic indicators contain >100,000 viable spores of a highly resistant organism (e.g., Geobacillus stearothermophilus [formerly Bacillus stearothermophilus]) on a strip; therefore, biologic indicators are considered to be the most reliable type of indicator. Using a biologic indicator during a sterilization cycle is the only direct method of demonstrating lethality within a particular load (FIGURE 9). Nonetheless, it is important to understand that sterilization may be inadequate even if a biologic indicator result is negative. It is still possible to receive a negative result from a biologic indicator and a positive result from a chemical indicator elsewhere in the load. Reasons for sterilization failure can be numerous and depend on the method of sterilization. Although the sterilant may have penetrated the location of the biologic indicator within the pack, it may not have penetrated the contents of the entire load. Additionally, a vacuum leak or air pocket may have been present, the sterilant may have been of poor quality, the volume of sterilant may have been inadequate, the package may have been too dense, or the load may have been packed too tightly, preventing adequate penetration of the sterilant.

Biologic indicators may also be used during low-temperature sterilization, such as when using ethylene oxide, hydrogen peroxide gas plasma, or ozone.

Process Challenge Devices

The use of process challenge devices (e.g., a Bowie-Dick test) containing a biologic indicator (with or without a class 5 chemical indicator) ensures efficient air removal in dynamic air-removal (i.e., vacuum-assisted) steam sterilizers or detection of trapped air that is likely to compromise sterility. In large facilities, process challenge devices are often used at the beginning of each day.

Shelf Life of Sterile Goods

Although some hospitals continue to rotate and resterilize dated items based on the time-related, shelf-life practice, many hospitals have switched to an event-related, shelf-life practice. The event-related practice dictates that a product should remain sterile until some event causes it to become contaminated. The probability that an item will become contaminated increases over time and with increased handling. Factors that may affect shelf life include the quality of the packaging material, the amount of handling, the
conditions during transportation, the storage conditions, device degradation (past expiration dates), and inventory control. The ANSI/AAMI ST79 guidelines (pages 76 through 77) recommend the following:

- Follow the packaging manufacturer’s instructions for use. Some manufacturers provide expiration dates for their products.
- Handle sterile items carefully. Avoid dragging, sliding, crushing, bending, compressing, puncturing, or dropping the packaging. Always thoroughly inspect the packaging visually to ensure its integrity before issuing an item.
- Reusable instrument carts or other transport vehicles should be cleaned and dried after each use. All items placed on a cart should be arranged so that they are not crushed or otherwise damaged or contaminated. Loaded carts with open lower shelves or wire racks should have a physical barrier present to prevent contamination by traffic or housekeeping activities (e.g., splashing mop water, “rooster-tail” effect [occurs when moving wheels pick up moisture or other floor contaminants and spin them upward]).
- Ensure appropriate humidity and temperature control in the area where sterile products are stored. In general, the temperature in storage areas should be approximately 75°F (24°C), and the humidity should not exceed 70%. There should also be at least four air changes per hour.
- Sterile medical and surgical items should be stored at least 8 to 10 inches above the floor, at least 18 inches below the ceiling or level of sprinkler heads, and at least 2 inches from outside walls. Do not store items next to or beneath sinks, under exposed water or sewer pipes, or anywhere they could become wet. Additionally, do not store sterile supplies on floors or windowsills.
- Closed cabinets and covered storage containers are considered the best ways to protect and store sterile items because dust accumulation and air movement are limited, inadvertent contact and handling are discouraged or minimized, and items are protected from insects and vermin.
- Always rotate sterile goods so that older processed items are used before recently processed ones.

Care of Huck Towels, Gowns, and Cloth Drapes

If towels and drapes must be reused, laundry detergent should be used sparingly. Laundered towels and drapes can retain soap particles and deposit them on instrument surfaces during sterilization. It may be prudent to run all laundered surgical textiles through an extra rinse cycle to remove excess soap particles.

Because textiles can also retain bleach chemicals, the use of bleach is often precluded while laundering surgical cloth drapes, gowns, and huck towels. Bleach can also damage fabric threads, decreasing the quality of fabrics over time.

Some gown manufacturers provide a usage grid located near the lower hem. A grid box can be marked each time the gown is used. Once all the grid boxes have been marked, the gown should be removed from service (FIGURE 10).

Recordkeeping

The final step for ensuring successful sterilization monitoring is to maintain a recordkeeping system that documents all items and their monitoring devices. Once the appropriate methods and techniques have been employed to ensure quality sterilization, proper storage, transport, and use protocols must also be followed to guarantee the probability of sterilization at multiple levels.

Glossary

Cross-plating (reverse plating)—occurs when two different types of metals are ultrasonically processed together (e.g., stainless-steel instruments processed with chrome instruments) and subsequently exposed to saline, blood, or potassium chloride, resulting in bluish black surface stains that are difficult to remove.

Steam dryness—an imperative, critical variable that affects all types of steam sterilization. Steam dryness is expressed as a dryness fraction, and the level of noncondensable gas is expressed as a fraction by volume. Ideal steam dryness should be between 97% and 100%. The level of noncondensable gas should be minimized to avoid impairing proper steam penetration. Steam that is too dry can result in superheating and, subsequently, suboptimal sterilization conditions. Conversely, the presence of excessive moisture in steam results in damp loads containing porous materials or uneven temperature distribution in loads containing nonporous materials.

Steam purity—the degree to which steam is free of dissolved and suspended particles, water-treatment chemicals, and other contaminants.

Steam quality—steam characteristics reflecting the dryness fraction (weight of dry steam present in a mixture of dry, saturated steam and entrained water) and the level of noncondensable gas (air or other gas that does not condense at the temperature and pressure used during the sterilization process).

References


FIGURE 10. Some gown manufacturers provide a usage grid near the bottom hem of the gown. Once all the grid boxes on the gown have been filled in, the gown should be removed from service.
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Which of the following is a benefit of sterilization wraps made of SMS polypropylene?</td>
<td>a. Sieve-type filters are superior for trapping dust particles and bacteria.</td>
</tr>
<tr>
<td>2. When double pouching individual instruments for steam sterilization,</td>
<td>a. Place the internal chemical indicator in the outer pouch, where it can be easily seen.</td>
</tr>
<tr>
<td>3. Biologic indicators typically contain a high number of viable spores of a resistant organism, such as</td>
<td>a. Geobacillus stearothermophilus.</td>
</tr>
<tr>
<td>4. Cleaning surgical instruments of varying metal types simultaneously in an ultrasonic cleaner may result in</td>
<td>a. Rusting.</td>
</tr>
<tr>
<td>5. An external indicator tape is an example of a class ____ chemical indicator.</td>
<td>a. 1</td>
</tr>
<tr>
<td>6. Ideally, surgical instruments should be washed with a(n) ____ surgical instrument detergent within ____ minutes after surgery.</td>
<td>a. Alkaline; 10</td>
</tr>
<tr>
<td>7. The minimum cycle time for sterilizing textile packs in a gravity displacement steam sterilizer at 250°F is ____ minutes.</td>
<td>a. 15</td>
</tr>
<tr>
<td>8. Class ____ chemical indicators have performance requirements equivalent to those of biologic indicators.</td>
<td>a. 3</td>
</tr>
<tr>
<td>9. For cleaning surgical instruments, ultrasonic cleaners are ____ times more effective than hand washing.</td>
<td>a. 8</td>
</tr>
<tr>
<td>10. Which of the following is recommended for loading items into an autoclave for sterilization?</td>
<td>a. Stack pouched items carefully on top of textile packs.</td>
</tr>
</tbody>
</table>