Keeping an eye on the target
Sterilizing practice for veterinary nurses

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Introduction to instrument care and sterilizing practice
What has changed?
Historically veterinary practice has relied on the steam autoclave to “sterilize” their instruments and haven’t had cause to give further attention to this discipline because of the low number of post-operative infection rates. This number may be in part, due to the current low level of antibiotic resistant bacteria within the field of veterinary medicine.

Since the advent of HIV and MRSA (methicillin-resistant Staphylococcus aureus), the general public has become far more aware of the post-operative risks of surgical intervention, hospital processes and particularly those processes within the realm of infection control.

As instrument cleaning, disinfection and sterilization comes under the scope of infection control practice, it stands to reason that veterinary practice now finds itself under closer scrutiny in regards to infection control processes and practices.

Whilst there are many veterinary text books and research papers with a broad overview of sterilizing practice, including a nominal mention within the AVA and NZVA standards, with a slightly more detailed mention in the BestPractice® standards, there are no compelling guidelines on sterilization practices for veterinary hospitals in Australia and New Zealand.

In veterinary practice oversight of instrument care, sterilizing and disinfection is often left up to a senior veterinary nurse or practice manager who may have gained basic knowledge through various veterinary nursing education providers. There is however a lack of in-depth knowledge equivalent to our human veterinary nursing counterparts and a reliance on anecdotal practices.

Current guidelines
Guiding bodies such as the Australian and New Zealand Standards have recognized a need for veterinary practices inclusion in written national guidelines. A start has been made in the AS4187-2003, Cleaning, disinfecting and sterilizing reusable medical and surgical instruments and equipment, and maintenance of associated environments in health care facilities, where specific mention is made in point 1.1 Scope of the document, “The standard may be suitable for application to the instruments and equipment used exclusively on animals in veterinary practice”.

Whilst the standard is not a legally binding document, it is recognized as an industry guideline and discusses potential best outcomes for veterinary practices engaging in elective and emergent surgical procedures.

In the United States there is a plethora of information, guidelines and standards available, most notably the Center for Disease Control (CDC), the Association of Perioperative Registered Nurses (AORN), Healthcare Infection Control Practices Advisory Committee (HICPAC) and the American Journal of Infection Control.

As a (veterinary) medical profession, it is incumbent upon veterinary practice staff to be able to defend their infection control processes within the clinic or hospital, and to recognize correct instrument processing and sterilization as a part of the positive outcome for their patients.

Processing environment
The instrument processing area ought to be isolated from all other activities so that potential contamination of clean or sterile supplies is reduced. A dedicated room is considered optimal.

The facility should have efficient ventilation, with floor, wall, surface finishes, air conditioning and humidity taken into consideration to facilitate ease of cleaning, safety and comfort for staff.

Cleaning techniques should be designed to avoid generation of aerosols, e.g. utilizing deep sinks and ultrasonic cleaners with lids.

Work/traffic flow
The instrument processing area should have a work flow that encourages separate processing, starting from cleaning contaminated goods, instrument inspection, instrument processing, starting from cleaning contaminated goods, instrument inspection, instrument packaging, sterilizing then storage without cross-over of traffic. Ideally the room would have a separate entry and exit.

A simple floor plan is outlined on page 7.

Disinfection or sterilization?
So how do we determine what treatment contaminated instruments and equipment require for effective processing?

In 1968 Earle Spaulding devised a rational approach to disinfection and sterilization. This is commonly referred to as Spaulding’s classification. Spaulding believed that instruments and equipment should be cleaned and reprocessed according to the level of risk...
associated with their intended use.

Even though Spaulding’s classification was devised in 1968, it still is as relevant today as when he introduced it.

Spaulding’s risk classification within veterinary education appears to be gaining recognition as a starting point in determining the appropriate process for decontamination and sterilization.

Spaulding’s Risk Classification

<table>
<thead>
<tr>
<th>Category of Risk</th>
<th>Application</th>
<th>Example of items</th>
<th>Process to be used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>Entry or penetration into sterile tissue, a cavity or blood-stream.</td>
<td>Surgical instruments, surgical implants.</td>
<td>All items must be sterile.</td>
</tr>
<tr>
<td>Semi-Critical</td>
<td>Contact with intact non-sterile mucosa or non-intact skin.</td>
<td>Flexible endoscopes, anaesthetic equipment.</td>
<td>Sterilization is preferable where possible, otherwise high level disinfection is required.</td>
</tr>
<tr>
<td>Non-Critical</td>
<td>Contact with intact skin.</td>
<td>Exam tables, blood pressure cuffs.</td>
<td>Clean as necessary with detergent and water.</td>
</tr>
</tbody>
</table>

Heat sensitive items
Flexible endoscopes come under the semi-critical category and can be sterilized in peracetic acid (Steris) or ethylene oxide units however these machines are currently rare in veterinary practice.

Steamb sterilization isn’t suitable for flexible endoscopes due to their heat sensitive nature, therefore at a minimum they should be subjected to high level disinfection.

As endotracheal (ET) tubes come into contact with intact non-sterile mucosa, they should be sterilized however many plastic, silicone or vinyl ET tubes in veterinary practice are heat sensitive and can’t be sterilized therefore they should be subjected to high level disinfection, thoroughly rinsed and dried before use. If either of these processes aren’t possible, thorough cleaning with an enzymatic detergent and total drying should be completed before re-use.

There is still ongoing doubt and controversy regarding sterilization of rigid endoscopes used in laparoscopy or arthroscopy however, as these instruments penetrate sterile tissue therefore they should be subjected to high level disinfection, preferably with an enzymatic detergent and total drying should be completed before re-use.

On reflection I believe the ongoing discussion as to whether high level disinfection or sterilization ought to be used is associated with the older model of rigid endoscopes that could not be subjected to steam or high temperatures. These telescopes filled the veterinary market as the uptake of newer sterilizable models increased in human hospitals. If a practice owns an older style endoscope then high level disinfection must take place.

No matter which process you select, the prerequisite is CLEANING, CLEANING, CLEANING.

You can clean without sterilization but you can’t sterilize without thorough cleaning!

How clean is clean?
Most references and texts recommend effective or thorough cleaning must be performed before sterilization of surgical instruments that enter sterile tissue, however there is no current testing mechanism available in the clinical setting to give “real time” verification of bio burden after the cleaning process.

It’s been reported that thorough cleaning can remove up to 99.9% of gross bio burden, therefore each individual instrument or environmental surface should be closely inspected to ensure all visible gross organic material has been removed.

Cleaning does not require a disinfectant solution.

Why do we clean?
Simply put, biostatics or biocidal agents require complete access to all surfaces of the instruments or equipment we are processing. The presence of blood, pus, serum or faecal matter interferes with this process, effectively protecting potential pathogenic material and acts as a physical barrier to the disinfectant or biocide.

When bioburden is left behind
Any bio burden left on improperly cleaned instruments or surfaces may lead to pathogenic material being left behind and can lead to its survival despite being subjected to sterilization. If an improperly cleaned instrument is subjected to a high temperature steam sterilizing process, the bio burden can create a protective covering film “micro scab”, effectively protecting the pathogenic material within it. It’s reasonable to extrapolate that when the “contaminated” instrument is introduced to the sterile tissue of a patient, the natural body defenses liberates the material, thus potentially causing an infectious process.

The old adage still holds true that “what you CAN’T see CAN hurt you.”
In addition to enabling proper disinfection or sterilization, effective cleaning contributes to the reduction of any potential damage to an instrument, particularly in the joints and crevices where large particles can cause misalignment or warping.

**Instrument cleaning begins in the operative field (point of use)**

Gross blood and body fluids left to dry on surgical instruments causes pitting and staining therefore cleaning begins at the operative field.

The surgical assistant can assist with the cleaning process by wiping bloodied and dirty instruments with a clean swab moistened with sterile water as the procedure is in process. Saline should never be used, as this solution can cause corrosion and surface rust.

**Transport of contaminated instruments and linens**

Before transportation can occur, all sharp items such as scalpel blades and suture needles must be discarded into the appropriate container. Additionally biological waste such as single use drapes, gowns, gloves, swabs etc. should be contained within the surgical suite as this can prevent blood and debris from drying onto the instruments.

Chlorhexidine scrub solution contributes to instrument corrosion and damage of the passivation layer.

A dedicated surgical instrument detergent containing a mild alkaline detergent solution in the pH range of 8.0 – 10.8 is often recommended because these solutions normally provide good soil removal[1]. However some studies have indicated that a neutral detergent is less corrosive on aluminium containers hence I tend to follow the recommendation of a neutral pH 7-8 solution.

The manufacturers material safety data sheet (MSDS) document should be read before use of any solution.

The ideal surgical instrument cleaning detergent should be:

- Biodegradable
- Non-corrosive
- Non-toxic
- Non-abrasive
- Low foaming
- Free rinsing
- Preferably liquid
- Neutral or mild alkaline formulation

**Additional precautions**

- Strictly follow manufacturer’s directions for dilution.
- Do not mix solutions unless indicated.
- Have an MSDS available, including first aid instructions.
- Store appropriately.
- Dissimilar metals should not be cleaned or sterilized together as this may cause electrolytic corrosion.
- Sodium chloride (saline) damages stainless steel instruments.
- Iodine and bleach will stain, pit or damage.
- Engraving instruments damages the passivation layer.
- Instrument colored tape isn’t recommended.
- Instrument milk will not fix a damaged or inferior instrument.
- Mineral oil or silicone lubricants should not be used because they can harbor microorganisms and prevent biocidal access.
- Air powered or electrical instruments should be lubricated using the type of lubricant according to the manufacturer’s recommendations.
- The use of distilled water where possible also negates the risk of normal tap water staining instruments.

**Manual cleaning methods**

As previously stated, the aim of cleaning is to remove all organic, inorganic and microbial material.

In the vast majority of veterinary practices in Australia and New Zealand, manual cleaning of surgical instruments is still the method used to achieve this.

Washer/disinfectors are more widely used in human hospital Central Sterile Supply Departments (CSSD). Washer/disinfector units are often subject to colonization and formation of biofilms if not routinely cleaned[1].

Manual cleaning of instruments should follow the rigid steps of a pre-clean rinse, soaking in an appropriate detergent, post-clean rinsing then thorough drying.
Pre-clean rinse
Rinse the instrument set under cool running water. This will remove the initial gross blood and soil. (Avoid hot water as this will bake the blood and soil onto the surface of the instrument which will make it very difficult to remove as well as interfering with the sterilizing process).

Instrument soak
Soaking and cleaning in a deep sink of warm water (45°C) mixed with an appropriate cleaning detergent. Adherence to the manufacturer’s instructions, particularly for soaking times and dilution rates is critical. Instruments must be scrubbed under the water, so that aerosols are contained to avoid contaminating the environment or adversely affect the staff member.

Careful cleaning of serrations and box joints should be achieved by use a soft brush. Harsh scouring pads or pastes can damage the passivation layer of instruments, leaving them vulnerable to damage, rusting or pitting.

Mechanical cleaning
Mechanical cleaners include ultrasonic cleaners or washer/disinfector machines. I will only be discussing ultrasonic cleaning machines, as these are more commonly used in veterinary practice.

Ultrasonic cleaners are primarily used for stainless steel instruments with joints or serrations whereas absorbent materials such as plastic and rubber cannot be cleaned in these units as they absorb the vibrations, preventing the oscillation process. Lensed equipment such as endoscopes are damaged by this process. For safety reasons, staff should not place their hands into the unit whilst its oscillating as this may damage joints.

Take note that due to the fine vibrations of an ultrasonic cleaner, a slight blunting of sharp instruments may occur.

The mechanical method employs the use of an ultrasonic cleaning machine. These machines are available as a bench top or a stand-alone model and are of particular value when cleaning large numbers or difficult to clean instruments.

Ultrasonic machines clean by a process called cavitation. This process creates waves or oscillations within the water tank as a sound wave, well above the normal hearing range at 20,000 cycles per second. These sound waves create millions of sub-microscopic bubbles that collapse beneath the dirt and debris, imploding it from the surface of the instrument.

A low-foaming, neutral or mild alkaline detergent must be used. Normal detergents create excessive bubbles when the machine is oscillating and interferes negatively with the cleaning process.

Before use, the ultrasonic cleaner should be de-gassed (this removes dissolved oxygen in the solution). If de-gassing isn’t performed prior to use, it prevents the bubbles from imploding, resulting in a poor cleaning process.

Degassing is completed by filling the unit with fresh water and detergent. The machine is then run without instruments in the unit to remove all gases.

Instruments should be placed in an ultrasonic basket or perforated tray and should not lie on the floor of the unit.

Tanks should be emptied and cleaned daily or when the solution becomes visibly soiled.

How do you know if your ultrasonic cleaner is actually working?
Ultrasonic cleaners ought to be tested for its cleaning performance on a daily or weekly basis, to ensure the unit is working correctly otherwise instruments may not be cleaned appropriately.

The easiest and most common method of testing is to use aluminum foil (approximately .025mm thick) purchased from the supermarket.

Testing Procedure:
1. Cut a section of aluminum foil to suit the dimensions of the tank, with extra depth to hold onto but small enough not to touch the sides or bottom of the tank.
2. Immerse the aluminum foil into the tank water, holding in a vertical position.
3. Operate the ultrasonic machine for 10-15 seconds.
4. A consistent pattern of perforation should result with varying sizes of holes.

If the foil has any blank spots without holes or wrinkles, this indicates a problem with the cleaner and a service is required. If your foil looks like this image after the test, then you have an acceptable result.

Once the test is completed, the water should be drained and replaced with fresh water and cleaning solution, to ensure no foil residue is left in the cleaning tank.

Post clean rinse
Once clean, rinse the instruments thoroughly, in warm to hot running water to remove all chemical residues. Using hot water facilitates the sanitation process and aids in subsequent drying of the instruments.
Drying of instruments

Instruments should be dried thoroughly within a drying cabinet or manually dried individually with a lint free cloth prior to assembling and packaging. Drying cabinets are rare in veterinary hospitals, hence manual drying is commonly performed.

Drying is an important step in reducing the potential of re-contamination during inspection and assembly as well as avoiding rusting, staining or steam quality problems.

Instruments that have any residual moisture may contribute to some common problems such as, wet loads, wet steam and perforation of paper packaging material.

**Inspection**

Inspect the instruments for any malfunction or damage, particularly needle holders that won’t grip, blunt scissors or misaligned hemostats and forceps.

**Ratchets**

Check instrument ratchets by closing on the first ratchet, then holding the instrument by the tip, gently tap the instrument onto a flat surface. The ratchet should stay closed. If ratchets spring open, attention is required to fix the alignment.

**Needle holders**

Visual examination is best to assess jaw wear, as the distal tip jaw tread wears out before anywhere else. The needle holder ought to be able to grip a standard needle on the second ratchet without twisting.

**Bone cutters & rongeurs**

Bone cutters or rongeurs should be able to cut cleanly through a piece of card the same thickness as a manila folder.

Withdraw faulty instruments from service immediately.

**Sorting**

The facility should have checklists (SOP’s – Standard Operating Procedures) available for identification and numbers of surgical instrument in sets. A copy of the checklist can be included in the instrument set for the surgeon or assisting veterinary nurse to check off.

Assemble instruments in similar groups on instrument stringers, (the old commonly used instrument pins make it difficult to keep instruments open for processing).

Whether an instrument has been used or not during the procedure, it should be considered contaminated and processed accordingly with the rest of the set.

An instrument set ought not to be sterilized unless it is complete.

**Instrument stains**

| Brown/orange | Caused by use of Chlorhexidine, inappropriate detergents, baked on blood or saline exposure. | Don’t wash instruments in Chlorhexidine, detergents not designed for instrument cleaning or expose to saline. |
| Dark brown/black | Use of inappropriate detergent or dried blood. | Use appropriate detergent and clean thoroughly. |
| Bluish/black | Stainless steel and chrome plated instruments sterilized together may cause carbon particles to settle on the instrument, giving a rust appearance. | Don’t sterilize dissimilar metals together, particularly single use with good quality stainless steel. |

**Wrapping**

**What’s the purpose?**

The intention of packaging is to protect the sterilized articles from contamination until they are ready to be used or aseptically delivered to the sterile field.

**Selection criteria**

There are many types of packaging materials on the market today, making selection difficult. When selecting packaging material the following criteria ought to be considered:

- Must be compatible with the sterilizing process being used.
- Must be able to be adequately closed or sealed.
- It must be permeable to air, steam and allow removal of same.
- Must be resistant to penetration by microorganisms following sterilization.
- Free from loose particles and fibres.
- No toxic ingredients or fast dyes in their manufacture.
- Perforation, damage and tear resistant when handled.

Five types of packaging commonly used in the veterinary setting:
- Paper bags.
- Laminate packs.
- Linen.
- Synthetic materials.
- Aluminum trays and boxes.

1. **Paper bags** - Useful for small light, non-sharp items such as swabs or cotton buds; they’re cheap and easily obtained. Disadvantages are; they are easily perforated when wet, items can’t be visualized and heavy items can break through. Double bagging is required.

2. **Laminate packs/window packs** - Are a combination of transparent heat stable plastic film laminated to treated paper. These are multifunctional, relatively cheap, come in pre-cut sizes or in rolls of various widths. You can fit several small items in them and instruments can be identified through the window side. However due to the paper side they have similar disadvantages as outlined above. Double bagging is required.

Nylon packaging is well known for its retention of air and should not be used.

3. **Linen material** - Often referred to as muslin or linen is usually a 50% polyester, 50% cotton blend and comes in a variety of colors, the most common color used is “forest green”. The green is chosen for its clinically proven aesthetic soothing effect on the eyes. Typically used for wrapping instrument sets, drape or gown packs.

4. **Synthetic materials** - Synthetic disposable material has superior barrier qualities compared to the others mentioned above. They will have varying degrees of moisture resistance, depending on which product you buy.

Real time cost comparisons often show disposable materials can be cheaper than the laborious task of purchasing, making, repair, washing, folding and sterilizing of reusable linen.

Reusing single-use packaging is not an acceptable practice and should be discouraged as the material’s integrity cannot be relied upon.

5. **Instrument containers** - Aluminum and stainless steel instrument containers are used for storing or autoclaving a wide range of surgical instruments, particularly orthopaedic implants, rigid endoscopes etc.

**Wrapping methods**
Wrapping techniques are designed to protect the sterile instruments until use as well as reducing the risk of contamination when opening or delivering to the operative field.

A parcel, envelope or modified parcel pack configuration ought to be selected as the wrapping method.
A sequential wrap, (a package within a package) can be a combination of one linen and one disposable sheet (with the disposable being the outer wrap), or two disposable sheets.

Or either of the above folded non-sequentially (wrapped at the same time).

Avoid any gaps or wrapping too tightly as this may hinder steam penetration.

Failure to wrap appropriately subjects the sterile articles to potential contamination.

Sealing packages
Packages must be sealed completely to protect the sterilized instrument from contamination.

Whilst heat sealing is the best method for securing contents in paper bags and laminates, autoclave tape may be used. When using tape, begin by folding the corners of the open bag or laminate inwards, followed by three width wide folds of the entire width of the open end. Secure the full width with autoclave tape.

Large bundles are secured by four generous length strips of tape on each side.

Self-sealing pouches or bags should be used in accordance with the manufacturer’s instructions.

Heat sealers are applied to paper (medical paper bags) or film to paper (window packs/laminates).

After sterilization the heat seal may be slightly weakened. The seal will become robust again once cooling occurs.

Labelling requirements
• Never use ball point pens as the tip may penetrate the wrapping material; use indelible non-toxic felt tipped pens, e.g. skin marking pens instead. The incorrect use of a marker pen can potentially give off toxic fumes during the autoclave process.
• Always write on the sterilizer indicator tape or on the clear side of laminate packs.
• Don’t write on paper packaging as the ink may bleed or leach onto your sterilized instrument which could be transferred to your patient during surgery.
• Include content information; date of sterilization, instrument type and staff member initials.

Sterilizing methods
Gas plasma (hydrogen peroxide) – Sterrad System
• Hydrogen peroxide vapor and low temperature (42°C).
• Kills by causing irreversible cell damage.
• Useful for heat and moisture-sensitive instruments such as endoscopes, cardiac catheters, plastic, rubber, some implants and electronic circuitry.
• Unable to process Teflon, cotton, some implants and electronic circuitry.
• Notifications made as in steam sterilization.

Dry heat
• Elevated temperature in dry heat oven (160-180°C).
• Kills by oxidation (turns into vapour) of cells.
• Useful for micro cutting instruments, suture needles, waxes, petroleum jelly, glassware and powders.
• Cycle time one to two hours.
• Materials that could burn can’t be sterilized in dry heat ovens.

Steam under pressure (autoclaves)
• Steam sterilizers are cheap to run.
• Non-toxic, safe and simple to use.
• Effective.
• Can be used for wrapped and unwrapped items.
• Temperatures selected are usually 121°C or 132°C.
• Heat sensitive items can’t be sterilized in steam.
• The most commonly used sterilizing process in veterinary practice.

The microbial target
There are five groups of microorganisms we need to consider, Algae, Protozoa, Fungi, Viruses and Bacteria, however it’s the reproductive spore of bacteria that is targeted for sterilization because of its high resistance to destruction.

Peracetic acid – Steris System
• Liquid chemical sterilant.
• Kills by disrupting the cell membrane and denaturation of cells.
• Developed for sterilizing endoscopes.
• Good penetration of medical packaging and some plastics.
• Useful for heat sensitive equipment that are able to be immersed in liquids, such as plastic, rubber or instruments with lumens (the space within tubular structures).
• Also useful for any medical device that can withstand liquid immersion.
• Peracetic acid sterilization is for immediate use of items and not applicable for items requiring packaging or storing.
• Cycle time is approximately 30 minutes.

Ethylene oxide (EO) gas
• Kills by changing the chemical structure of cell components.
• As for gas plasma EO is useful for heat and moisture-sensitive instruments such as endoscopes, cardiac catheters, plastic, rubber, some implants and electronic circuitry.
• EO can penetrate medical packaging and some plastics.
• Very toxic and flammable.
are the ones with the big bulges. There are faint blue strands which are flagella on the vegetative cells.

**Sterilization**

It’s relatively easy to kill most bacteria at temperatures 100°C in boiling water for one minute but the spores produced by the gram-positive Bacillus and Clostridium bacteria are very resistant and require much higher temperatures to achieve total destruction.

**Sterilization is an absolute state, there is no such thing as almost or sort of sterile. It either is or isn’t.**

The FDA and associations such as Association of periOperative Registered Nurses (AORN) and the Association for Professionals in Infection Control (APIC) define a sterilized device as having been processed in a system that delivers a sterility assurance level at 10-6. This is a one in a million chance of a non-sterile occurrence.

**Steam under pressure sterilization**

Bacterial and spore destruction is accomplished by coagulation. Similar to the way an egg is poached.

Boiling water at atmospheric pressure, at sea level, will have a measured temperature of 100°C. This boiling water vaporizes and turns into steam. However if you subject that steam to pressure in a pressure vessel, the temperatures attained are much higher. These higher temperatures are the ones we require for sterilization.

Pressure vessels (commonly called autoclaves or sterilizers) are used to achieve high temperatures with dry saturated steam. Dry saturated steam refers to steam that does not produce water droplets and the condensate in equal balance with evaporation. Dry saturated steam has a 97% dryness factor with a 3% water vapor.

Sterilization takes place when the dry saturated steam under pressure, condenses on to the load, where it gives up its latent heat and transfers that extra heat onto the load within the sterilizer chamber.

**Types of steam sterilizers**

There are four types of steam sterilizers commonly seen in practice.

1. Pre-vacuum for porous and cannulated loads.
2. Downward displacement for porous loads only.
3. A bench top displacement type with drying capacity.
4. A bench top displacement type without drying capacity (commonly used as a flash sterilizer).

**Sterilizing time**

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Chamber Pressure</th>
<th>Holding Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>121°C</td>
<td>101 Kpa</td>
<td>15 minutes</td>
</tr>
<tr>
<td>132°C</td>
<td>203 Kpa</td>
<td>4 minutes</td>
</tr>
</tbody>
</table>

Holding times are for unwrapped articles. Consideration must be given for the time it takes for steam to penetrate through the packaging material. (Penetration time will depend on the type and thickness of wrapping used).

The formula is - sterilizing time + safety margin time + penetration time = total holding (sterilization) time. Your drying time is then added on.

E.g. 4 minutes + 2 minutes (safety margin time) + 16 minutes (penetration time) = 22 minutes sterilizing time.

Add on the average 25 minutes drying time = 47 minutes total sterilizing and drying cycle.

**Penetration times can be determined by your service provider by performing a thermocouple test.**

**Loading the sterilizer chamber**

When loading the sterilizer it’s essential that steam can penetrate all articles. Incorrect loading allows air to become trapped within the packages or chamber. Any air trapped within the chamber will inhibit effective steam penetration, rendering the entire load “non-sterile”.

- Articles should be loaded vertically.
- If mixed loads of metal items and linen are sterilized together, the linen is placed on the upper shelf and the metal items on the lower.
- Goods should not touch the side of the chamber walls.
- Bowls and hollow equipment should be placed upside down.
- Laminate packs should be on edge or flat with the paper side down.
- It’s better to have less in the chamber than to pack it too tightly.

**Unloading**

- The sterilized load should be warm but dry to the touch when the cycle is completed.
- Use protective thermal gloves.
- Packs should be allowed to return to normal room temperature before handling otherwise condensate can be created allowing contaminants from your hands to wick through to the contents.
- Minimize handling of sterilized packs so packing material isn’t damaged.
- Don’t carry packages under the armpit or close to the body.
- Store as soon as possible after cooling.
- Any item dropped on the floor ought to be considered contaminated and should be re-packed with new wrap and re-sterilized.
- The packs should be stored and used in date sequence.

**Monitoring of steam sterilizer loads**

(What’s your evidence?)

There are three methods of monitoring:

- Chemical, physical and biological.

**Chemical indicators:** Are divided into internal or external indicators and graded into six classes. Class 1 being the most basic and Class 6 the most complex.

Class 1 - Chemical indicators are the least reliable type as they are a simple paper product impregnated with dye. They have no relevance to the verification of the sterilizing process, except to indicate the item has been subjected to a heat source. The most common Class 1 chemical indicator is autoclave tape or internal indicators that are small strips placed inside packs that turn from white to black.

Class 2 - An example of a Class 2 indicator is the Bowie Dick used in steam sterilizers, to test for presence of air in the sterilizing chamber. These should be used every day to test the chamber before a load is processed.

Class 3 - Are single parameter indicators. They react to a chosen parameter such as time or temperature but not both.

Class 4 - Will react to two or more parameters, typically, time and temperature.

Class 5 - Referred to as an Integrator. They
can be used in gravity and pre-vacuum sterilizers with a reliable response to all critical variables required. These are the chemical indicator of choice if biological spore testing is not available.

Class 6 - Are an emulating indicator and responds to all critical variables required with a slightly higher reliability than the Class 5. More suited to pre-vacuum sterilizers.

**Physical parameters:** - Are those attached to your machine e.g., temperature, jacket pressure and chamber pressure gauges.

Close monitoring of these should alert you to any potential problems. For example at a temperature of 132°C, the pressure correlation is 203kPa and a temperature of 121°C will require a 101kPa. If there is a discrepancy between the two readings further investigation is required.

**Biological testing:** - Is comprised of a biological test vial containing bacterial spores. These are placed in your largest bundle within the most centered point of your sterilizer chamber.

Another spore vial is incubated (not sterilized) and used as a control, to measure against the sterilized vial. Incubation takes a minimum of one hour. As described in ASNZ 4187, Bacillus Stearothermophilus, a very hardy spore, is the organism of choice when monitoring steam sterilization.

**Trouble shooting**

**Wet loads after sterilization**

As already stated, the steam required for correct sterilization is dry saturated steam, (steam without droplets of moisture). Dry saturated steam is considered of a high quality when it is within the range of 97%-100% dryness. Anything under 97% will produce excess moisture, whilst anything over 100% will produce excess heat.

Excess moisture in the sterilizing chamber, contributes to a process called “Wet

### Activity levels of chemical disinfectants

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<th>Activity Level</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>Intermediate</td>
<td>Bactericidal, fungicidal, variable virucidal &amp; mycobactericidal Fast acting Easy to use Used to disinfect small surfaces such as tops of vials No toxic residue May be used as an instrument grade disinfectant if labeled accordingly by manufacturer</td>
<td>Not sporicidal Affected by organic matter Has no detergent or cleaning properties Hardens rubber and deteriorates glue Flammable Evaporates rapidly No residual action</td>
</tr>
<tr>
<td>Aldehydes</td>
<td>High</td>
<td>Mycobacterial, bactericidal, virucidal, fungicidal, Sporicidal with long contact times &gt; 10 hours</td>
<td>Requires 12 minutes exposure for high level disinfection Must be thoroughly rinsed in sterile water before use Stains protein residue grey Not to be used for environmental disinfection</td>
</tr>
<tr>
<td>Hypochlorite’s (Bleach)</td>
<td>Low - Intermediate</td>
<td>Broad spectrum bactericidal, fungicidal &amp; virucidal Mycobactericidal at (.5%) 5000ppm, No toxic residue Fast acting Inexpensive Unaffected by water hardness Reduces biofilm of surfaces Identifed by having a tuberculocidal activity on label.</td>
<td>At 5% can cause eye irritation, oropharyngeal, oesophageal and gastric burns Corrosive to metals over 500 ppm Inactivated in organic matter Discourages fabrics Releasing a toxic chlorine gas when mixed with acid or ammonia May only be used on instruments if the manufacturer recommends it Do not mix with other detergents or disinfectants</td>
</tr>
<tr>
<td>Phenolics</td>
<td>Low</td>
<td>Bactericidal, tuberculocidal, fungicidal, variable mycobactericidal &amp; virucidal Inexpensive</td>
<td>Adsorbed by porous material and irritates tissue, Stains Slow acting Toxic to neonates Can have a pungent odour</td>
</tr>
</tbody>
</table>
Steam”, it produces a fine mist of water droplets. In other words, it’s ‘too wet’ to reach the high temperatures required for sterilization.

Wet loads hinder the drying process leaving the packages moist at the completion of the cycle. The moist pack is then subjected to microscopic contaminants when the chamber door is opened or by a wicking effect if laid on a bench.

**Causes of Wet Steam**

<table>
<thead>
<tr>
<th>Causes of Wet Steam</th>
<th>Low</th>
<th>Bactericidal, fungicidal, virucidal (enveloped viruses)</th>
<th>Not sporicidal but may be sporostatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overloading of the chamber</td>
<td></td>
<td>Good cleaning agents</td>
<td>Not tuberculocidal, mycobacteria or virucidal (non-enveloped)</td>
</tr>
<tr>
<td>Excessive amounts of metal items in the load</td>
<td></td>
<td>Surface compatible</td>
<td>High water hardness and cotton/gauze reduces effectiveness</td>
</tr>
<tr>
<td>Instruments/equipment not dried prior to packing</td>
<td></td>
<td></td>
<td>Affected by organic matter</td>
</tr>
<tr>
<td>Water retained within coiled tubing or lumen</td>
<td></td>
<td></td>
<td>Inactivated by detergents</td>
</tr>
<tr>
<td>Blocked steam trap</td>
<td></td>
<td></td>
<td>F10 - Not recognized in human infection control processes</td>
</tr>
</tbody>
</table>

**Super-Heated steam**

Is heat added to steam without relative moisture. This kind of steam cools without condensate and lacks the ability to penetrate and transfer its latent heat. Therefore sterilization may not take place.

Linen material and paper may burn or desiccate in the sterilizer due to dehydration.

**Causes of Super-Heated Steam**

<table>
<thead>
<tr>
<th>Causes of Super-Heated Steam</th>
<th>Low</th>
<th>Bactericidal, virucidal and fungicidal</th>
<th>Not sporicidal but may be sporostatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excessive dryness of the load within the chamber</td>
<td></td>
<td>Good cleaning agents</td>
<td>Not tuberculocidal, mycobacteria or virucidal (non-enveloped)</td>
</tr>
<tr>
<td>Steam jacket is holding a higher temperature than chamber or there is a pressure drop in the steam supply</td>
<td></td>
<td>Surface compatible</td>
<td>High water hardness and cotton/gauze reduces effectiveness</td>
</tr>
<tr>
<td>Sterilizer requires a service.</td>
<td></td>
<td>Affected by organic matter</td>
<td>Inactivated by detergents</td>
</tr>
<tr>
<td>Ensure linen always go through a washing cycle before being sterilized.</td>
<td></td>
<td>F10 - Not recognized in human infection control processes</td>
<td></td>
</tr>
</tbody>
</table>
Storage

Requirements for storage
If sterile goods are incorrectly stored, there is a potential for contamination, rendering the instruments or equipment non-sterile.

An ideal storage room/area would have controlled air conditioning with low turbulence, minimal traffic and separate from other activities.

The area must be dry, with humidity in the range of no less than 35% and no more than 70%. Temperature should be no higher than 23 degrees celsius.

Sterile stock should be free from direct sunlight, dust, dampness, insects, vermin and constant handling.

Most human hospitals and larger veterinary sterile store areas will have wire rack compact storage systems however these are only suitable within a controlled environment.

Closed cupboards or shelving systems should be designed with shelving 50mm - 75mm away from the wall, 20cm - 25cm sitting above the floor and 45cm - 50cm away from the ceiling.

Smooth washable surfaces are recommended for ease of cleaning. Routine cleaning of all surfaces should be undertaken.

Sterile items must be kept away from water pipes, and not stored under sinks.

Cardboard boxes are not recommended as storage containers for sterile goods as they are porous, cannot be cleaned and potentially harbor contaminants.

Food, drink or non-sterile goods must not be stored with sterile items.

How long does a sterilized item remain sterile on the shelf?

Many text books recommend a period of time for sterility depending on the type of packaging, however this is not quite accurate.

As an example, if an item is wrapped in a laminate pack and the recommendation is that this should be sterile for a period of two weeks, it is easily debunked if I were to pour a cup of coffee all over it. Therefore the two week timeframe has no relevance!

Shelf life is dependent on external events that compromise the integrity of the protective barrier of the sterilized item, such as choice of packaging material, correct sterilization process, handling and storage, rather than a given time frame. Therefore, shelf life is event related not time related (Gardner & Peel, 1998).

Historically many hospitals and veterinary practices would routinely re-sterilize all items not used within the “standard” timeframe however evidence suggests this does not offer any additional assurance. On the contrary it suggests a compromised package may not be re-sterilized until the given timeframe has been completed.

It is still standard practice to avoid prolonged storage by ensuring sensible stock levels and efficient rotation of stock.

Disinfection

Pathogen resistance

Microorganisms differ in the levels of methods for inactivation or kill. There is a standard recognition of pathogens in decreasing order of resistance. The following chart is indicative of the pathogen involved and resulting disease with recommended sterilization or level of disinfection required. Please note this chart does not include all pathogens or diseases commonly seen in veterinary practice.

Chemical disinfectants

Disinfectants are for use on inanimate objects and should not be used as an anti-septic. Its intention is to reduce the number of microbial contaminants on instruments, equipment or environmental surfaces.

Cleaning must always precede disinfection.

Disinfectants may be high, intermediate or low level. Choosing the level required is determined by referring to Spaulding’s risk classification and the items intended use.

High level disinfection is not a sterilization process.

Factors in disinfectant efficacy

It’s well documented that efficacy of disinfectants is highly reliant on pre-cleaning but in addition, contact time is crucial together with accurate concentration, water (for dilution) quality and temperature.

Many manufacturers will also state or list...
different contact times to treat different microorganisms, however unless you have evidence of the pathogens you are dealing with, it is unlikely you will know what contamination level you have; therefore as a rule of thumb, it’s suggested you use the longest contact time recommended by the manufacturer.

Interestingly enough, many popular disinfectants require long contact times, equally some studies suggest that the disinfectant solution dries out before the full recommended contact time has been completed, and consequently there may be a failure to achieve the stated biostatic or biocidal outcome.

Therefore the general recommendation, when choosing a disinfectant is that it ought to have a fast biocidal action.

Solutions should be freshly made for use unless specified by the manufacturer.

Disinfectants should never be mixed with another solution without the manufacturer’s explicit recommendation.

When selecting a disinfectant
Consider the following:
• What level of disinfection is required according to Spaulding’s risk classification, critical, semi-critical or non-critical?
• What level of disinfectant is it, low, intermediate or high?
• Is it TGA (Therapeutic Goods Association) approved?
• Is it compatible to the item you want to disinfect?
• Does the product have independent studies for efficacy?
• Is it user friendly?
• Is it cost effective?

Read the label
Always read the label on the disinfectants carefully and ascertain what activity the disinfectant has on various pathogens. For instance if a label declares the disinfectant is sporicidal, ask yourself what is it sporicidal to?

As an example, if a solution states it’s sporicidal to Mycosporum canis, be aware that this is ringworm (a fungal spore), not a bacterial spore. Therefore the solution is not a true sporicidal in the interpretation of the hierarchy of pathogenic microorganisms.

The ideal disinfectant
• Should be broad spectrum for gram negative and gram positive bacteria.
• Fast acting with a rapid kill.
• Kills viruses (non-enveloped and enveloped).
• Active against multi drug resistant organisms.
• Have activity against pathogenic fungi (i.e. Candida spp).
• Be active in the presence of organic matter.
• Non toxic.
• Environmentally friendly.

Currently there is no one “ideal” disinfectant for all circumstances therefore selection should be based on which targets have to be met and which compromises can be agreed on.

Selection of environmental cleaning & disinfection methods
Within the veterinary practice, cleaning and disinfection methods can be categorized into those that have low levels of contamination or high levels of contamination.

Typically surfaces with low level contamination such as reception desks, offices, walls, doors, windows, do not require disinfection unless they are visibly soiled with faeces, urine or body fluids. These can be cleaned with water and detergent.

Surfaces with potential high level contamination will include areas such as animal housing, exam tables, operating tables or floors (subject to soiling), will require at a minimum thorough cleaning, followed by drying then a low level disinfectant applied according to the manufacturers guidelines at the longest contact time recommended.

In conclusion
Although there is a myriad of products on the market, it is up to the user to ensure that the correct solution is chosen on evidence based information, not sales representatives trying to sell a product.

The author does not endorse any product depicted in any images.

References
13. Hernandez, A., et al., Assessment of in-
vitro efficacy of 1% Virkon (R) against bacteria, fungi, viruses and spores by means of AFNOR guidelines.


