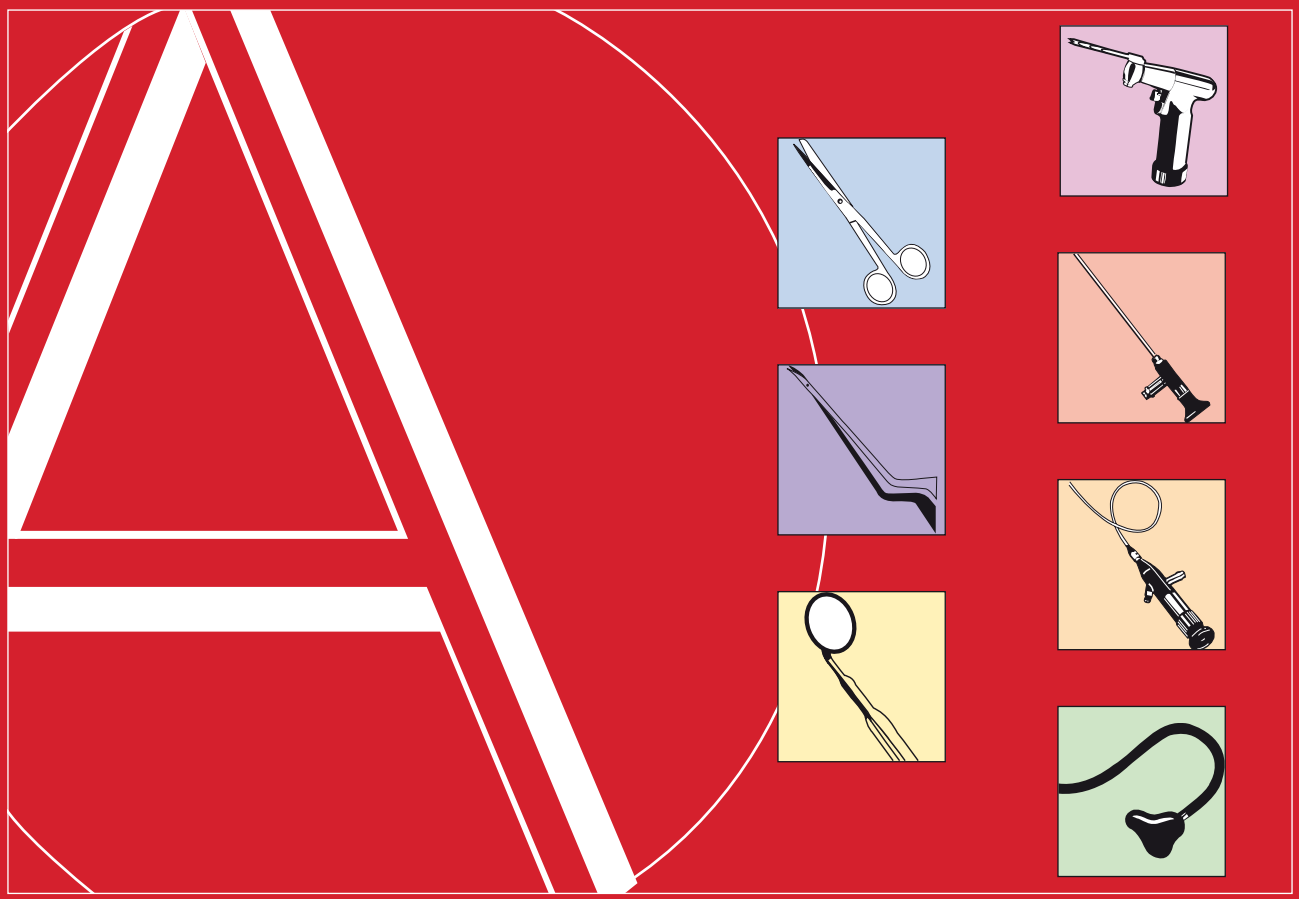
Proper Maintenance of Instruments



Instrument Preparation
Working Group

9

Proper Maintenance of Instruments

9. edition, 2009

Surgical instruments
Microsurgical instruments
Dental instruments
Surgical motor systems
MIS instruments, rigid endoscopes and HF instruments
Flexible endoscopes and accessories
Flexible instruments and respiration systems

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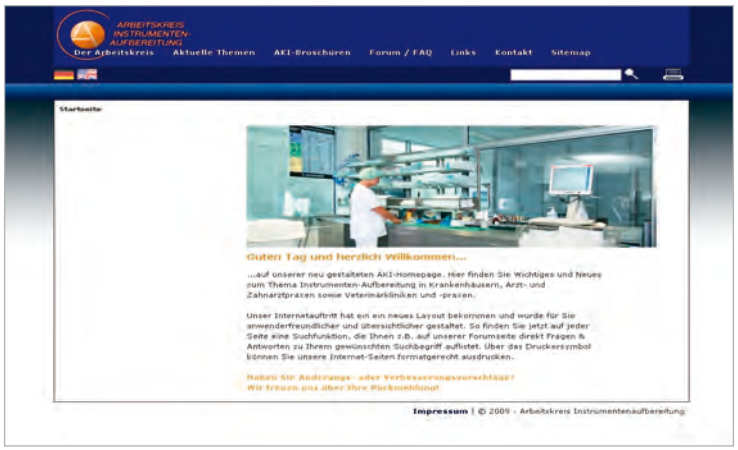

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Proper Maintenance of Instruments

Table of Contents

Preface

Thirty years after the appearance of the first edition, this is the 9th edition of "Proper Maintenance of Instruments". This new edition is clear proof of its importance, and also of the great interest shown in this "Red booklet". Its international relevance is reflected in the fact that the previous version has been published in 17 languages, and other language versions are planned.

The first edition appeared in 1979 and must have seemed very advanced then, at a time when the concept of "Central Sterilization" was still in its infancy. Since then reconditioning has undergone major changes.

Instrument preparation has developed from a small appendage to the operating room into an independent central Sterile Supply Department (CSSD):

- a move away from an open area with wildly conflicting different activities and procedures, to a department that is strictly divided into different zones,
- a move away from mainly manual working towards automated instrument and device preparation,
- a movement away from the unrestricted and uncontrolled reusing of medical instruments that should be disposed of after use, to responsible reuse of instruments, or a ban on such reuse,
- a move away from the use of chemical and biological indicators towards physical validation of sterilization processes,
- a move away from a quality check at the end of the sterilization process towards permanent monitoring of each step of the decontamination process, and also
- a move away from untrained staff to highly qualified personnel.

In other words, sterile preparation has developed from a department concentrating on the sterilization process to a department with a comprehensive "reconditioning approach".

However the fact that all these changes have taken place does not mean that there is no room for further improvement. Quite the opposite. The introduction of traceability and quality systems, the centralization of these specialist departments - even outside the hospital - combined with economic and ecological approaches, and the need to balance various activities represent new challenges.

It is obvious that the CSSD endeavors to provide a highly professional service in the hospital environment, as is expected. Quite rightly old procedures and working methods are being scrutinized. The traditional rules of thumb are no longer acceptable; all our activities should be underpinned by science.

Without doubt the "Instrument Preparation Working Party" has made an important contribution to this development of the CSSD into an exemplary department such as we see today.

The aim of this development and the core activity of the CSSD is, and continues to be, to prepare medical products of the best possible quality for the providers and for the patients. This should take place in a reproducible manner.

Although the title of this booklet appears to indicate otherwise, in fact it deals appropriately with every aspect of the reconditioning of surgical instruments. The main benefit is that it concentrates on the important information. Basic facts are discussed and explained clearly, plainly and in practical terms. As a consequence it takes special account of what actually happens in daily practice. All this has contributed to the fact that this booklet has become a standard work, frequently consulted within sterilization department, regardless of the stage of development they might have reached.

The booklet has contributed to solving the widest possible range of preparation problems and continues to do so today. Quite rightly it concentrates on "cleaning", i.e. on one of the most important steps in the decontamination process.

Every contribution, however small, that helps to improve the quality of the end products is a step in the right direction. However, in practice instrument preparation is a way-marker, pointing the way towards a standardization of the processes in sterilization departments throughout the world.

Wim Renders
President World Forum for Hospital Sterile Supply

Introduction

Instruments are a major asset and represent a significant share of the total capital spending of a hospital. The practical experience recorded in this guide, together with a description of fundamental interrelationships, is intended to help users to keep their reusable instruments in good working order and preserve their value for many years, by ensuring proper care and maintenance. It should be emphasized that the recommended measures must always be carried out in accordance with the manufacturer's instructions, pertinent hygiene requirements and official safety-at-work guidelines.

Instrument processing is increasingly subject to legislation (Medical Devices Act, Medical Devices Directive), with a general tendency towards a worldwide harmonization.

In addition, there are direct legal requirements that need to be observed e.g. the German "Betreiberverordnung" (Operator Regulations), which implements the Medical Devices Directive (MDD). They provide detailed instructions in the form of validation measures that should be carried out by the Central Sterile Supply Department (CSSD). Compliance with such requirements can best be assured and documented within the context of a quality system (QS). As this "Red Booklet" has a distinctly process-oriented structure according to the reconditioning procedures and based on the provisions of DIN EN ISO 17664, it can be incorporated directly into a process-oriented system.

section	Red Booklet	section	RKI recommendation*	section	EN ISO 17664: 2007
1	Materials and design				
2	Media used for instrument processing				
3	How to Treat Brand-New and Repaired Instruments				
4	Treatment Recommendation for Returned Goods				
5	Preparation for Cleaning and Disinfecting	2.1	Preparing non-used medical products	3.3	Preparation at the place of use
6.1	Manual Cleaning and Disinfecting Cleaning	2.2	Preparation of used medical products	3.4	Preparation for cleaning
6.2	Machine-Based Cleaning and Disinfecting			3.5	Cleaning
6.3	Ultrasonic Cleaning and Disinfecting	2.2.1	Preparation for processing, cleaning/ disinfecting, rinsing and drying	3.6	Disinfecting
7	Final Disinfection			3.7	Drying
8	Checks and Care	2.2.2	Checking technical-functional safety	3.8	Checks, maintenance, testing
9	Packaging	2.2.3	Packaging	3.9	Packaging
10	Sterilization	2.2.4	Sterilization	3.10	Sterilization
		2.2.5	Marking		
		2.2.6	Release		
		2.2.7	Documentation		
11	Storage	2.2.8	Transportation and storage	3.11	Storage
12	Surface changes, deposits, corrosion, aging, swelling and stress fractures				

Comparison of structure EN ISO 17664, RKI Recommendation and Red booklet

*Hygiene requirements for the sterile processing of medical devices. Recommendation: Federal Health Gazette 44/2001, 1115-1126

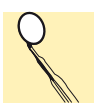
Each section starts with handling instructions for surgical instruments, including general instructions for the product groups described below. Special instructions for these product groups are given under the following symbols:


Surgical instruments


Flexible endoscopes and accessories


Microsurgical instruments


Flexible instruments and respiration systems


Dental instruments*


Surgical motor systems


Minimal invasive surgery instruments, rigid endoscopes and instruments of high-frequency surgery (HF)

* For detailed information relating to the preparation of dental instruments, please refer to the yellow AKI booklet "Proper Maintenance of Dental Instrument".

However, one should keep in mind that these product-specific instructions must always be seen in the context of the general instructions given for all instruments in a particular section.

A wide-spread misconception that "high-grade steel" or "stainless steel" are virtually indestructible and extremely durable needs to be corrected: even stainless steel can be adversely affected by a wide range of potential attack - whether mechanical, thermal or chemical.

Nonetheless, as long as you understand the material and its characteristics and know how to handle these products, you will be able to extend the trouble-free life of your stainless steel instruments.

Microsurgical instruments require particularly careful reprocessing. Due to the requirements of the applications, these instruments are very delicate and incorporate very delicate and fine filigree parts.

Dental instruments also need special care due to their great variety and the particular materials used in each case.

The same applies to individual components of surgical motor systems, especially those that may be used only under sterile conditions and therefore need to be cleaned and resterilized after use, such as hand-held battery and compressed-air driven devices or handpieces.

Other instrument groups for which special processing instructions are provided in this guide are MIS instruments, rigid endoscopes, HF instruments, flexible endoscopes and flexible instruments.

Needless to say, users of medical devices expect well-known manufacturers to exercise the greatest of care in both selecting the right materials and manufacturing the product. Because of this, the user can count on medical devices that are optimally adapted to the intended purpose and provide excellent functionality. But to retain the value of the instruments in the long run, the user himself must make a significant contribution i.e. by ensuring correct treatment and care. To explain how this is done is the purpose of this guide.

Disposable instruments

Disposal instruments are intended for once-only use, because their conformity assessment covers such use only. This is why this booklet contains no instructions on how to recondition disposal instruments.

General notes and instructions

Basically, the reprocessing of medical devices comprises:

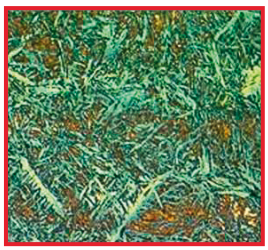
- Preparation (pretreatment, collecting, precleaning and, where applicable, taking the instruments apart).
- Cleaning, disinfecting, final rinse, drying (if required).
- Visual inspection of cleanliness and condition of material.
- Care and repair where required.
- Functional test.
- Marking.
- Where applicable, packaging and sterilization, approval for reuse and storage.

National regulations, such as the German Operator Regulations relating to medical devices and the recommendations of the Robert Koch Institute (RKI) entitled "Anforderungen an die Hygiene bei der Aufbereitung von Medizinprodukten" [Hygiene requirements to be observed when reprocessing medical devices], demand quality control and assurance in these processes. It is the owner's/operator's responsibility to evaluate the risks, to classify the various risk areas, to provide written standard work instructions that clearly define each step in the process, and to ensure adequate documentation. Validated cleaning, disinfecting and sterilization processes, supplemented by defined configurations for loading the washer-disinfectors (W/Ds) and sterilizers, are an indispensable prerequisite for quality assurance.

It is particularly important to follow the manufacturer's instructions in the instruction manual, not only because ignoring them might lead to expensive replacements or repairs, but also because incorrect reprocessing or product failure might endanger the patient or third parties. We urge you to consult the manufacturer if you have any doubts.

For thermostable medical products, machine-based reprocessing with thermal disinfection and steam sterilization are the preferred methods.

Instruments and components which are exclusively provided for once only use must be disposed of after use.



Color etching - martensitic microstructure on corrosion-resistant instrument steel - hardened (magnified 500 times)

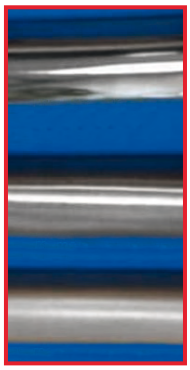
1. Materials and design

1.1 Materials

When producing medical devices, the manufacturer must design them to be fit for their intended purpose not only in design, manufacture and finish, but also by selecting adequate materials. For surgical instruments generally only stainless steel (hardened, non-rusting) can meet the tough requirements in terms of elasticity, tenacity, rigidity, blade characteristics, resistance to wear and maximum corrosion resistance.

Corrosion resistance/ passive layer

The corrosion resistance of stainless steel primarily depends on the quality and thickness of the passive layer. This is a protective layer of iron/chromium oxide that results from the chemical reaction between the chromium in the steel alloy (at least 12%) and oxygen in the ambient air. This layer is not affected by the specific surface finish of the product (matte or high-gloss). In fact its formation and growth are influenced by the following factors:

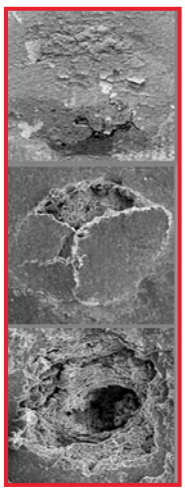


Surface finishes on instruments

- Composition of the alloy,
- Microstructure of the material, which is influenced by heat treatment (e.g. forging, tempering, annealing, welding, soldering),
- Surface finish and condition, e.g. roughness or smoothness,
- Handling and reprocessing conditions,
- The service life and number of reprocessing cycles.

Chlorides are dangerous

Passive layers are extremely resistant to many chemical substances. Depending on the factors mentioned above, on every passive layer there are areas with a specific crystallographic structure where the passive layer is very susceptible to corrosive attack, particularly when in a damp or aqueous environment. Among the few substances that can attack and destroy this layer are halogen salts (halides), the most common and dangerous of them being chlorides. Chlorides tend to react with the passive layer in a process leading to the well-known, chloride-induced damage called "pitting corrosion". Depending on the concentration of chlorides, the damage caused ranges from a few sparse points of attack (visible as small black dots), to a completely damaged instrument surface covered with large deep holes. Chlorides also cause "stress corrosion cracking".

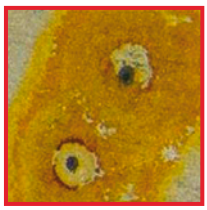


Scanning electron microscope image, chloride-induced pitting

With increasing service life, the passivated layer tends to get thicker. From experience, this causes a decrease in corrosive attack because the probability of chlorides penetrating all the way down to the unprotected base material is reduced.

Chloride sources in the instrument usage and processing cycle:

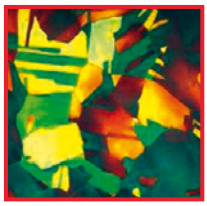
- Fresh-water chloride content (depending on the source of the supply).
- Insufficient demineralization of the water used for the final rinse and steam sterilization.



Regenerating salt containing chloride caused massive pitting on the surface of the instrument. Causes: leaking ion-exchanger connection in the W/D.

- Regeneration salt carryover, leakage or spillage from ion exchangers used for water softening.
- Use of agents not permitted for or improperly used in the treatment of surgical instruments.
- Isotonic solutions (such as physiological salt solutions), etchtants and drug residues.
- Organic residues (body fluids such as blood, chloride content 3,200-3,550 mg/ltr, saliva, sweat) dried on the surfaces
- Laundry, textiles, packaging materials.

Pitting and stress corrosion cracking are seldom or never observed in a chloride-free or low-chloride environment. This is irrespective of the degree of gloss and the given passive layer of the instrument surface. If corrosion only occurs on new,high-quality instruments processed in the same cycle with older instruments, the reason can probably be found in the instrument processing conditions. In all cases investigated so far, treatment had taken place under conditions that individually or collectively approached or exceeded the limits of process security.



Color etching - austenitic microstructure on corrosion and acid-resistant instrument steel (magnified 500 times)

As well as heat-treatable chromium steels standardized non-hardenable chromium steels with modified chromium contents and rust-/acid-resistant chromium-nickel steels are used to make instruments as well in accordance with EN ISO 7153-1. Their mechanical properties are limited however, so that the use of these steels is restricted to certain types of instruments.

For instruments used in endoscopy and minimally invasive surgery, a great variety of materials is employed, depending on the given application technique and the particular instrument design. The most important of these are:

- Rust-/acid-proof chromium-nickel steels (also as welding filler).
- Pure titanium or titanium alloy.
- Non-ferrous heavy metal alloys with surface finishing (e.g. chromium-/nickel-plated brass).
- Light metals (e.g. anodized aluminum).
- Non-corrosion-resistant steels (e.g. for coated assemblies and components).
- Glass (for optical systems).
- Ceramics.
- Cements and other bonding agents.
- Solder.
- Plastics and rubber.

Special processes may be required depending on the material combination used

Combination of these very different materials in a particular instrument places restrictions on the treatment processes. In other words, these items may require special treatment apart from standardized instrument processing. These are described in the manufacturer's user instructions.

The design and application requirements of flexible instruments and respiration systems also make it necessary to combine a variety of materials (which are more or less identical with those used for endoscopes). Here, the most frequently used materials are rubber and latex (based on natural rubber) and various synthetic materials, especially silicone elastomers (or silicone rubber).

For surgical motor systems, the full range of materials described in this guide is used, because of the design and manufacturing requirements involved. Stainless, heat-treatable chromium steels, for example, are used for drill bits, cutters, burrs, saw blades and gear components, while sterilizable plastic materials are usually used for handles, switches, gear components or cables and flexible tubes.

Special treatment methods may be necessary for varnished housing made of unalloyed sheet steel, handpieces with Colored graduations (indicating gear ratios) or anodized aluminum housings (as used for handpieces and elbows). For appropriate treatment recommendations, refer to the manufacturer's instructions. In addition to special processing requirements, lubrication is also essential for heavy-duty shafts as well as for bearing and gear components made of stainless steel (and in some cases, also for those made of non-stainless quenched and tempered steels or bronze materials).

1.2 Design

The capacity for processing medical products is of extreme importance for patient and user safety. At the design and development stage of a medical product it is necessary to consider its capacity for good reconditioning after use. However, the focus must also be on the function as well as its capacity for processing. Often the mechanism required is accommodated in the tiniest of spaces, in order to avoid discomfort to the patient.

Optimum cleaning results can be achieved if the medical product can be dismantled as much as possible. But there are limits here too. It is possible to dismantle many medical products only with great difficulty - for example jointed instruments used in minimal invasion surgery with diameters of less than 3 mm, because users are unable to dismantle and reassemble these filigree-thin components. Another important point is the choice of materials and joining techniques. Since at 134 °C steam sterilization

represents the most important sterilization method, the materials used must be temperature-resistant. A further requirement of the materials selected is the alkaline resistance at the places where prion contamination is possible.

In order to achieve optimum processing results, everyone involved needs to co-operate closely: from the medical product manufacturer, the manufacturers of automatic washers/disinfectors and sterilizers, to the manufacturers of process chemicals. When purchasing medical products it is recommended that those responsible for processing instruments are included in the process at an early stage.

2. Media used for instrument processing

2.1 Water

The quality of water used for instrument processing has a considerable influence on depreciation in value.

Water fulfills a variety of functions in the treatment process, including:

- Dissolves cleaners and other treatment agents.
- Transmission of mechanical forces and transfer of heat to the surface of the items to be washed.
- Dissolves soluble dirt and impurities.
- Flushes away cleaning and treatment solutions.
- Thermal disinfection in machine processing.
- Is used for steam sterilization.

Use correct water quality!

Unfavorable water composition can have an adverse effect both on the treatment process and on the appearance of the instruments and materials. This is why water quality in sufficient quantity is already important when planning on-site plumbing installations.

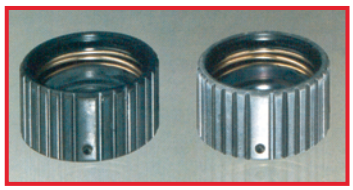
While any natural water contains dissolved salts, concentrations vary depending on the source of the water and how it is collected.

Depending on water hardness and temperature, the fresh water used can lead to the formation of a hard layer (lime deposits, scale) that is difficult to dissolve. It is even possible for corrosion to occur underneath such deposits.

Scale is acid-soluble and can thus be removed with an acid-based cleaner. However, make sure to observe the manufacturer's instructions regarding material compatibility.

Aluminum might be attacked by softened water.

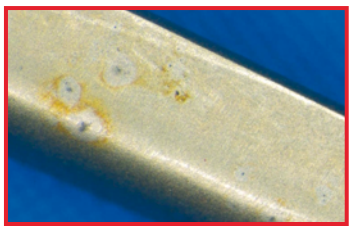
In softened water, the above-mentioned "hardeners" have been replaced by sodium salts. However, this does not reduce the total load of substances contained in the water.



When using softened water, alkalinity can greatly increase as a function of temperature and exposure. Especially when thermal disinfection is used in the final rinse, aluminum surfaces might be subject to attack.

Chlorides are dangerous

When water evaporates, some substances contained in it remain as visible mineral residues. Chlorides dissolved in water are particularly critical substances for example because they tend to cause pitting even on stainless steel instruments if present in higher concentrations.



Pitting induced by chlorides on instrument

The danger of chloride-induced pitting generally rises with:

- An increase in the chloride content,
- An increase in temperature,
- Decreasing pH-value,
- Increasing exposure time,
- Insufficient drying,
- Concentration of chloride resulting from adherence of dry residues to instrument surfaces after evaporation.

While the causal relationships between the chloride content of the water and pitting are not always predictable, Experience shows that the probability of pitting is low as long as the chloride content does not exceed a level of approx. 120 mg/l (equivalent to 200 mg/l NaCl) at room temperature. With increasing chloride concentrations however, the risk of pitting will increase rapidly, too. It should also be noted that when water evaporates in the drying process, the chloride content of water droplets may drastically exceed the limit of 120 mg/l.

To prevent excessive chloride concentrations and subsequent pitting, we recommend using fully demineralized water for the final rinse.

Substances contained in the water used, such as silicic acid, may cause discolorations.

Instruments discolored by silicic acid

Discolored surfaces on scalpel handle

Use fully demineralized water for the final rinse!

Note: Recognized analytical procedures must be used to ensure compliance.

Source: DIN EN 285, version 2006

Other substances may cause brownish, bluish, gray-black or iridescent discolorations even when present in small quantities. Such discolorations may be caused by silicates/silicic acids contained in the water, or by compounds containing iron, copper or manganese. As a rule however, such discolorations are harmless, constituting very thin residual layers that do not cause or facilitate corrosion.

Apart from its natural constituents, drinking water sometimes contains rust, generally flushed from corroded pipework. During the processing cycle this rust tends to adhere to instruments, causing rust spots (extraneous rust) and subsequent corrosion.

The use of fully demineralized water in the final rinse is not only recommended for the reasons described above (i.e. preventing chloride-induced corrosion), but also because it helps to keep the surfaces of the instruments free from stains and discolorations, and stabilizes anodized aluminum surfaces. Fully demineralized water for the final rinse does not leave dried crystalline residues which could have a negative effect on any later low-temperature sterilization procedures.

Since there is currently no specific standard regarding the use of fully demineralized water in machine-based treatment processes, we recommend the use of water of boiler feed quality for washer-disinfectors in which medical devices are treated (as defined in DIN EN 285, Appendix B)

Contamination in the supply water to an assigned steam generator

Substance/property	Supply water
Mineral residues	≤ 10 mg/l
Silicates (SiO_2)	≤ 1 mg/l
Iron	≤ 0.2 mg/l
Cadmium	≤ 0.005 mg/l
Lead	≤ 0.05 mg/l
Heavy metal residues, except for iron, cadmium, lead	≤ 0.1 mg/l
Chloride (Ci')	≤ 2 mg/l
Phosphate (P_2O_5)	≤ 0.5 mg/l
Conductivity (at 25 °C)*	≤ 5 µS/cm
pH value (degree of acidity)	5-7.5
Appearance	colorless, clear, no deposits
Hardness ∑ (of alkaline earth ions)	≤ 0.02 mmol/l

* At variance to this table, experience has shown that conductivity of approximately 15 µS/cm can be tolerated.

If ion exchangers are used in the production of fully demineralized water, glaze-like discolorations may occur as a result of the specific behavior of silicic acid. This cannot be controlled through the conductivity value in the regeneration process! Make sure to consult an expert in this case.

To optimize the process and to achieve consistent quality of results, we recommend that you use fully demineralized water at all steps of the program.

2.2 Process chemicals

Process chemicals used to process medical instruments must be developed, tested and manufactured in Europe, in accordance with the European Medical Devices Directive [20].

- Cleaners, neutralizing agents, rinsing and care agents are classified as class I medical devices and are identified by the CE mark on the label.
- Process chemicals with anti-microbial effect, used for disinfecting. cleaning or manual/automatic final disinfection at room temperature or raised temperature are classified in Europe and Class II Medical Devices and these are identified by the CE mark, combined with a four-digit number identifying the responsible Notified Body.

When developing the product, the manufacturer of the process chemicals must ensure that the composition of the products is optimized with regard to the desired effects of application, such as cleaning efficiency, anti-microbial effectiveness, or the care properties, taking into account compatibility with the materials used to manufacture the instruments, as well as the bio-compatibility with any adhering residues containing human tissue at the place where the instrument is to be used. The manufacturer of the process chemicals must provide evidence of the compatibility of the materials, if necessary in conjunction with the manufacturer of the corresponding medical instruments. Bio-compatibility must be tested and assessed in accordance with ISO 10993 "Biological Assessment of Medical Devices"

Optimum application properties, materials compatibility and bio-compatibility of the process chemicals are achieved only under the application conditions as recommended by the manufacturer. The manufacturer must describe in detail the application conditions (on the label, technical datasheet) and users must observe these instructions. Special attention must be paid to the concentrations of the process chemicals in the applications solutions and to temperature and exposure time. The process chemical documents are supplemented by safety data sheets and, if applicable upon request by the user, by experts' reports on materials compatibility, effectiveness, ecological properties and bio-compatibility.

The ingredients of various process chemicals may interfere with one another. Thus, for example, the constituents of a cleaner can have a negative effect on the effectiveness of a disinfecting agent if small quantities of the cleaner get into the disinfectant solution. For this reason it is recommended that only inter-coordinated process chemicals from a single manufacturer should be used in a closed processing cycle.

3. How to Treat Brand-New and Repaired Instruments

Preparation

Brand-new instruments and those returned from repair must be removed from their transportation packaging before storing and/or inclusion in the instrument usage and processing cycle. Any protective caps or foils must also be removed.
Before using brand-new and repaired instruments, they must be sent through the entire processing cycle in the same manner as used instruments.

Cleaning is mandatory!

The cleaning step should never be skipped because residuesl (e.g. from packing materials or care agents) could lead to the formation of stains or deposits during sterilization.
Always check cleaning results by visual inspection. As a rule, the instruments should be visibly clean after the cleaning stage.
The passive layer of brand-new instruments is necessarily still thin, and so these instruments tend to be more sensitive to critical treatment conditions than are older used instruments.

Storage

Brand-new instruments and instruments returned from repair must be stored only at room temperature in dry rooms or cabinets. Otherwise condensate may build up inside plastic packages as a result of temperature fluctuations. This may cause subsequent corrosion damage.
Instruments should never be stored near chemicals such as active chlorine which emit corrosive vapors.

To avoid mechanical damage during processing, microsurgical instruments should be stored in suitable racks or retainers right from the start.

Flexible instruments must be stored in their original packaging in a dry, cool and dark place. When restocking your supplies, keep in mind that flexible instruments made of rubber or latex will age even if stored unused.

Functional parts of respiration systems frequently incorporate valves or diaphragms which tend to become blocked by internal surfaces sticking together during longer storage periods. Always test valves or diaphragms before using instruments.

4. Treatment Recommendation for Returned Goods

In our context, returned goods are defined as packaged medical devices which, irrespective of whether they have been used or not, are returned to the manufacturer.
The reasons for return can be manifold: necessary repair or servicing; return of leased instruments; for checks to be carried out on products that are being clinically tested; in the case of complaints; return of explants for scientific investigation or damage analysis, etc.
Note that an infection risk exists for any person dealing with products actually or potentially contaminated. It is most important to minimize this risk by implementing adequate and reliable treatment processes.

The above guideline implies that goods may be returned only if they

- have been properly disinfected and declared hygienically safe, or
- are visibly marked as "non-decontaminated" and delivered in sufficiently safe packaging.

The decontamination of products to be returned should be carried out as soon as possible after use, as in the normal supply and reprocessing cycle. This prevents subsequent damage e.g. pitting, caused by blood chlorides.

However, decontamination is not indicated where such treatment would alter or destroy the product, prevent proper analysis, or distort its results. If in doubt, consult the manufacturer of the product.

Possible procedural options include enclosure of an individual or collective declaration containing all information required (see for example, the BVMed). Such a collective declaration given to the manufacturer or other receiving or processing entity, should contain at least the following information:

- Date of manufacture/validity.
- Confirmation that from that date onwards, all goods returned can be considered hygienically safe unless clearly and visibly marked otherwise.
- Contact details to enable the clarification of any questions concerning the goods and the receipt of returns.

5. Preparation for Cleaning and Disinfecting

The first steps in a proper reprocessing cycle are taken in the operating theatre. Coarse contamination, residues from hemostatics, skin disinfectants, and lubricants, as well as caustic drugs should, wherever possible, be removed before the instruments are set down.

Chlorides are dangerous

Corrosion caused by immersion in physiological salt solution over a period of several hours

Deformation caused by improper handling

Never immerse stainless steel instruments in an isotonic solution (such as physiological salt solution). This is because prolonged instrument contact with saline solution leads to pitting and stress corrosion cracking.

Careless dropping can also damage instruments. For example, the hardened (tungsten carbide) tips of scissors may come off, or small clamps may be bent. To avoid damage, always put your instruments down carefully after use. Do not overload instrument trays. Waste, skin disinfectant residues, saline solutions etc., may not be put in disposal containers. Disposal containers should also be kept closed, to prevent possible residues drying onto the instruments.

In hospitals with a Central Sterile Supply Department (CSSD), (also called Sterile Processing Department - SPD), closed systems are used to transport contaminated medical devices from the operating theatres and wards to the CSSD. Wherever possible, so-called "dry disposal" should be preferred.

When using wet disposal, it is advisable to immerse the instruments in a combined detergent-disinfectant solution that has no protein-fixing effect. Disinfecting agents containing aldehyde should be avoided, because they have a fixing effect.

As regards concentration and exposure time, as well as the addition of cleaning intensifiers, the manufacturer's instructions should be followed under all circumstances.

Avoid long intervals between use and treatment for reuse!

Because of the corrosion risk and cleaning factors, long intervals between instrument use and processing for reuse (e.g. overnight or over the weekend) should be avoided, irrespective of the disposal method used (i.e., wet or dry). Experience has shown that in the case of dry disposal, in practice intervals of up to 6 hours pose no problem.

The instruments must be placed into instrument carriers (trays, racks) that are suitable for machine-based cleaning procedures.

Effective cleaning requires that articulated instruments (such as scissors, clamps, forceps) be processed in the open position to minimize surface overlapping. The trays, racks, holders, supports, etc., must be such that subsequent cleaning in ultrasound basins or washer-disinfectors will not be hampered by areas inaccessible to ultrasound or water. Complex instruments must be taken apart for cleaning in accordance with the manufacturer's instructions. Instruments not used for surgical intervention must be treated in the same way as instruments that were actually used.

Special racks or appropriate storage fixtures must be used for micro-surgical instruments, and where appropriate loading trolleys using specially adapted cleaning technology.

Dental materials adhering to dental instruments (such as filling materials or acid cement removers) must be cleaned away immediately after use. Otherwise, the material will harden on the instrument and/or cause corrosion. Dental cement must preferably be removed with a swab immediately after use at the patient's chair.

Surgical motor systems must be taken apart immediately after use, following the manufacturer's instructions. If the manufacturer's instructions call for special storage systems in readiness for machine handling, such systems must be used.

Simple tools, such as drill bits or saw blades, can be processed in the same way as surgical instruments, provided that they are not categorized as disposable (single-use) medical devices.

Hose/tubing sets used for cooling liquids or spray nozzles must be rinsed with water from the rinsing bottle immediately after disconnection, and then be checked for leaks (visual inspection; see section 8).

To prevent damage to fine instruments
they must be transported in the containers or holders provided for the purpose. MIS instruments, endoscopes and HF instruments that can be taken apart, must be disassembled in accordance with the manufacturer's instructions prior to cleaning. Optics must be placed in special containers.

Dried-on residues are particularly critical in the case of instruments used in surgical endoscopy because such deposits are difficult to remove from small lumens, and may impair or destroy the functionality of joints. This is why these instruments should always be processed immediately after use. Where cleaning proves to be difficult using the available methods or procedures, we recommend that HF instruments are pre-treated with 3 % hydrogen peroxide solution in order to remove any coagulated residues.

Handles and cables for HF surgery can be pre-treated in the same way as surgical instruments.

In the case of flexible endoscopes, the insertion part must be wiped with a lint-free cloth immediately after use. This cloth should be saturated with an instrument-cleaning, cleaner-disinfectant solution which has no protein-fixing effect. To avoid encrustation and clogging, the discharge duct as well as other channels should also be rinsed with the same solution. To rinse the air/water channel, water from the rinsing bottle can be used.

Before entering the next stage of the treatment process, a leak test must first be carried out in accordance with the manufacturer's instructions. This ensures the early detection of leaks and perforations and the prevention of more serious damage (as could be caused by penetrating liquids).
A defective endoscope must be returned to the manufacturer immediately, together with a description of the problem. If it has not been sufficiently cleaned and disinfected, this must be clearly and visibly indicated on the liquid-tight packaging.

Flexible instruments and respiration systems must always be taken apart (in accordance with the manufacturer's instructions) to ensure proper processing for reuse. Make sure to handle cones, sealing surfaces, threaded connections and valve plates carefully, protecting them from mechanical damage.
Prior to treatment, absorbers must be checked for respiration deposits (respiratory lime deposits). Any such residue found must be completely removed from the absorbers.

Sensors may only be treated in accordance with the manufacturer's instructions.

When using wet disposal, flexible instruments with lockable cavities (such as larynx masks, certain other masks) must be closed.

6. Manual and Machine-Based Cleaning and Disinfecting

6.1 Manual Cleaning/Disinfecting Cleaning

For manual cleaning, active non-protein-fixing cleaners with or without antimicrobial effect and/or enzymes are used. If disinfecting cleaning is required, the disinfecting capability should be proven under "dirty conditions" (high protein load) in accordance with European (EN) standards, or corresponding national regulations.

As regards detergents and disinfectants, the manufacturer's instructions concerning concentration, temperature and exposure time should always be strictly observed! When treating non-stainless-steel instruments, the manufacturer's instructions on material compatibility are of particular importance.
The cleaning/disinfecting solutions used should be freshly prepared on a daily basis. Where contaminations levels are high, it is advisable to prepare fresh solutions at even shorter intervals.

If solutions are used for too long, the following problems may occur:

- Corrosion risk due to contamination levels.
- Corrosion risk due to increased concentration of cleaning/disinfecting solution as a result of evaporation.
- Insufficient disinfection due to accumulated contamination (loss of active agent/protein effect).

Articulated instruments must be placed into the solution open, thus minimizing obscured surface area. Narrow-lumened instruments such as flexible tubes and cannulas, and instruments incorporating cavities are always difficult to process. This is why it is important to make sure that the internal surfaces are thoroughly and completely in contact with the solution.

Dissolve powders completely!

If powdery products are used, the powder must be fully dissolved in the water before immersing the instruments. Undissolved particles may cause surface damage and clog narrow instrument channels.

We recommend using soft, lint-free cloths or towels, plastic brushes or cleaning guns for cleaning. Following manual cleaning or disinfection and cleaning, make sure to rinse instruments adequately and thoroughly with clear running water. This manual procedure removes dirt residues that may still adhere to the surfaces of the instruments.

Stains caused by high salt content of rinse water

To prevent water spots, use only fully demineralized water, which is microbiologically at a minimum of drinking water quality. After this the instruments must be dried carefully immediately. Compressed air drying is preferred to other drying methods (such as drying with a cloth), because it is not only a very gentle but also highly effective technique.

The main reasons for mechanical damage in manual treatment processes include:

- Use of metal brushes,
- Use of coarse scouring agents,
- Use of too much force,
- Dropping or bumping of instruments.

Microsurgical instruments are especially prone to mechanical damage.

Dental instruments can usually be treated in the same manner as surgical instruments. For instruments requiring special treatment, please see the following instructions:
Handpieces, elbows and turbines should never be immersed in a solution. Instead their external surfaces should be sprayed with a suitable disinfectant or wiped with a disinfectant. As regards cleaning their internal surfaces, and taking appropriate maintenance and care measures, observe the manufacturer's instructions.

Dental instruments with rotating components not manufactured from stainless steel may be immersed only in special disinfecting and cleaning solutions that are specifically suitable for their materials. To prevent corrosion, a short rinse is followed by immediate drying and treatment with an anticorrosive agent suitable for sterilization. In the case of ceramic or plastic-bonded abrasive tools, check first whether the agents used are suitable for these instruments. The use of unsuitable cleaners and disinfectants could destroy bonding agents, endangering shaft fixation!

Instruments for root-canal treatment are highly susceptible to mechanical damage and therefore should be processed separately and for handling purposes, should be placed in special stands. For cleaning and disinfecting remove the silicon stoppers in order to adjust the depth of preparation. If such instruments have colored, anodized handles, do not treat them with alkaline solutions because this would impair or destroy their color-coding function.

Avoid ingress of liquids!

Motor systems must be wiped with a cleaning surface disinfectant. Apart from lint-free cloths, soft brushes can also be used for cleaning in these cases. After spraying the surfaces with a disinfectant and allowing time for the spray to take effect as specified by the manufacturer, the surfaces are wiped clean. Following cleaning and disinfecting, make sure to rinse the surfaces under running water, holding the handles at an angle in order to prevent water from penetrating into the couplings or other components. Never immerse these products in water or other treatment solutions! In the case of accidental ingress of liquids, these must be removed at once.

In the case of battery-powered machines, be sure to remove the batteries prior to cleaning and disinfecting. Moreover, avoid direct contact between electrical components and the cleaning/disinfecting solution. For potential battery cleaning and disinfecting, refer to the manufacturer's instructions.

When using compressed air to dry machines and handpieces, make sure that you never point the compressed air gun at bearing seats or at the seals, since such action can damage the bearings and seals. Simple reusable tools can be treated like surgical instruments.

MIS instruments and rigid endoscopes are susceptible to mechanical damage. Systems or components with cavities and channels/ducts must be treated with particular care to ensure effective cleaning.

Minimum requirements include:

- Removal of all gaskets.
- Opening of all orifices.
- Disassembly in accordance with the manufacturer's instructions.
- Rinsing of all cavities.

Rinsing forceps with irrigation connection

When immersing such instruments in a cleaning/disinfecting solution, make sure that the cavities are free from air bubbles so that all the inner surfaces are completely wetted. (To check, agitate the item or hold it at an angle).

If instruments with an irrigation connector cannot be taken apart, they must be sufficiently flushed with a cleaning or disinfection and cleaning solution. Make sure that the distal end of the instrument is adequately flushed as well.

Cleaning the lens of an endoscope

The glass surfaces of optical systems should be cleaned by rubbing gently with a cotton swab saturated with alcohol. (Use swabs manufactured using a wooden or alcohol-resistant plastic material).

Instruments with coagulation residues that cannot be removed even by intensive cleaning (e.g. with 3% hydrogen peroxide solution, brushes or ultrasound) must be discarded, because their proper functioning and their required sterile condition can no longer be guaranteed.

Remove valves and caps from flexible endoscopes prior to processing. This is the only way to ensure that the channels can be thoroughly cleaned and flushed. Cleaning is effected by immersing the flexible endoscope in a cleaning or disinfection and cleaning solution and wiping external surfaces thoroughly.

The channels are first cleaned with the brush supplied with the system, and are then rinsed with a cleaning or disinfection and cleaning solution. Some manufacturers also offer a hand pump for this purpose. The distal end (optics, Albarran lever, etc.) must be cleaned with particular care.

Flexible instruments with lockable cavities (e.g. larynx masks with balloons, or respiration/resuscitation masks) must be cleaned and disinfected in closed condition to protect the cavities from ingress of liquids. Rubber and flexible instruments may require a longer final rinse. Appropriate drying must be carried out to ensure sufficient drying.

6.2 Machine-Based Cleaning and Disinfecting

Cleaning and disinfecting can best be standardized when using machine-based processes. Always keep in mind that proper cleaning is essential for retaining the value of your instruments as well as for successful sterilization. The International Standard (EN ISO 15883) and/or the national versions of that standard (e.g. DIN EN ISO 15883) and national guidelines state that only validated machine cleaning and disinfecting procedures should be used. The general requirements of washer/disinfectors (W/Ds) are stipulated in Part 1 of ISO 15883, the requirements apply both to single-chamber W/Ds and to multi-chamber W/Ds (indexing belt conveyor systems).

Machine processing should preferably be preceded by dry disposal. In the case of wet disposal, either suitable low-foam cleaners and disinfectants must be used, or the items must first be thoroughly rinsed. This is because foam significantly impairs the water flow in machine-based cleaning processes and can affect the result.

This also applies if heavily soiled instruments (problematic encrustations on HF instruments, filling-material residues adhering to dental instruments, etc.) have been pre-treated manually or with ultrasound.

When using machine-based processes (in a washer/disinfector), the following should be observed (see also 6.2.3):

Ensure correct loading!

- To ensure effective cleaning, all trays, inserts, holders, etc., must be loaded correctly. Articulated instruments must be opened for loading.
- Avoid overloading trays to ensure that all instrument surfaces can be readily accessed by the cleaning/disinfecting solutions. Always consult the established loading templates for validation purposes.
- When placing large instruments on trays, make sure that they do not obscure other instruments, thus preventing proper cleaning.
- Instruments with cavities or hollow spaces (such as turbines, trocar sleeves, respiration systems) need careful cleaning and rinsing on the inside as well. For this purpose, special (instrument-specific) inserts with appropriate rinsing facilities should be used.
- The instruments must be arranged in such a way as to prevent mechanical damage through contact.

Optical changes to color anodized aluminum occurs even in mildly alkaline solutions

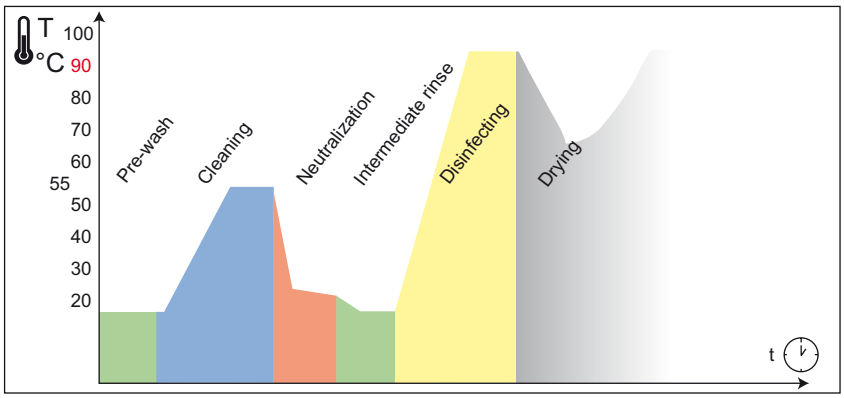
Colored, anodized aluminum parts may fade as a result of machine-based cleaning, thereby losing their coding function. However, if neutral-pH detergents are used and fully demineralized water is employed for the final rinse (and for thermal disinfection as well), such instruments can be cleaned and disinfected together with other instruments.

The items should be removed from the machine immediately upon completion of the program. If they are left in the closed machine, the residual moisture may cause corrosion.

As a rule, it is advisable to use processes where cleaning is carried out at a separate stage prior to disinfection. For machine-based processes, both thermal and chemothermal disinfection options are available. As a rule, thermal disinfection is the better choice. Therefore, you should take the suitability of medical products for machine treatment with thermal disinfection into account at the purchasing stage.

6.2.1 Machine-Based Cleaning and Thermal Disinfection

In thermal processes, disinfecting is carried out at temperatures above 65 °C for the corresponding exposure time. As a measure of the disinfecting capability, the A_0 value has been introduced (DIN EN ISO 15883-1, Appendix A). It determines the temperature-time relation as a function of microbiological contamination and the intended purpose of the medical devices involved (e.g. A_0 3000 = 90 °C and 5 minutes exposure time).
The program structure depends on the outcome requirements for cleaning, disinfecting and rinse quality and on the items to be treated.
A machine-based treatment program with thermal disinfection typically includes the following steps or stages:



Cleaning program with thermal disinfection

1. Pre-wash
Cold water without any additives, to remove coarse dirt and foaming substances.

2. Cleaning
Hot or cold water (fully demineralized if possible); cleaning is usually carried out at temperatures of 40-60 °C depending on the load, for at least 5 minutes.

Use suitable cleaning agents!

Suitable neutral-pH or alkaline products can be used for cleaning.
The choice of cleaning agent selection depends on the materials and properties of the instruments to be treated, the necessary cleaning efficiency and on national guidelines and recommendations) as issued, for example, by the German Robert Koch Institute).
Increased chloride concentrations (natural levels, isotonic solutions) in the water used could cause pitting or stress corrosion cracking. Such hazards can be avoided by using alkaline cleaning agents or fully demineralized water.

Carry-over of cleaning agent residues due to insufficient rinsing

3. First intermediate rinse
with hot or cold water. Adding an acidic neutralizer facilitates the removal of alkaline detergent residues. Even when using a neutral detergent, it may be advisable to add an acidic neutralizer in order to prevent deposits (e.g. in cases where the water used has a high salt content).

4. Second intermediate rinse
With hot or cold water, no additives (use fully demineralized water if possible) Depending on the items to be processed and on the rinsing quality and safety level required, such as ophthalmic instruments, several intermediate rinses without additives will take place.

5. Thermal disinfection/final rinse
Fully demineralized water, thermal disinfecting takes place at temperatures of 80-95 °C and for the corresponding exposure time as per the A_0 concept, EN ISO 15883.
Using fully demineralized water prevents spotting, stains, deposits and corrosion on the surfaces of the instruments. It also prevents the formation of crystals which can interfere with the sterilization process.
If you add a final rinse agent to shorten the drying period, make sure to check the material compatibility of the processed items.

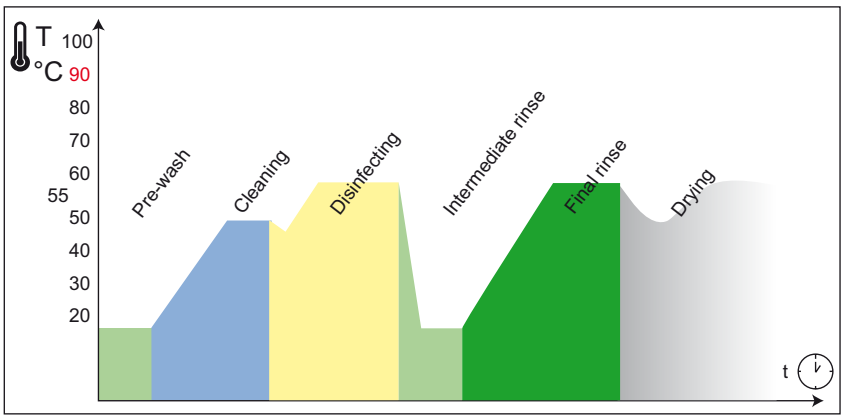
6. Drying
Sufficient drying must be ensured either through the washer-disinfector or by taking other appropriate measures.
With regard to the process chemicals used, the manufacturer's instructions concerning concentration, temperature and exposure time should always be observed. This guarantees good results and keeps the instrument materials intact to the greatest possible degree. It must be possible to verify the automatic volume dosing of liquid process chemicals.

Observe the manufacture's instructions!

6.2.2 Machine-Based Cleaning and Chemothermal Disinfection

Thermally sensitive medical devices are treated chemothermally. This means that a disinfectant especially suitable for machine-based disinfection is used after the cleaning stage. The temperature must be limited in all rinsing phases as well as during drying.

In chemothermal processes (as per EN ISO 15883-4), cleaning is carried out at defined temperatures generally <65 °C, for flexible endoscopes < 60 °C) and for disinfecting a special disinfectant suitable for machine treatment is added in corresponding concentration for specified exposure times.
Example of a cleaning program with chemothermal disinfection:



Cleaning program with chemothermal disinfection:

1. Pre-wash
Cold water without any additives, to remove coarse dirt and foaming substances (such as residues from pre-treatment).

2. Cleaning
Hot or cold water (fully demineralized if possible); cleaning takes place at temperatures of 40-60 °C for at least 5 minutes.
Suitable neutral-pH or alkaline products can be used as cleaning agents. The choice of cleaning agent depends on the materials and properties of the instruments to be treated and on the required cleaning efficiency.

3. Chemothermal disinfection
Hot or cold water (fully demineralized if possible).
Chemothermal disinfection takes place at (≤ 60 °C, using a special disinfectant with proven effectiveness and suitable for machine-based disinfection.

4. Intermediate rinse
Hot or cold water (if appropriate fully demineralized water) with no additive (if appropriate additional intermediate rinses to ensure that the disinfectant has been sufficiently well rinsed away to ensure non-toxicity).

5. Final rinse
Use fully demineralized water. The final rinse is carried out at max. 60 °C. Using fully demineralized water prevents spotting, stains, deposits and corrosion on the surfaces of the instruments.
If you add a final rinse agent to shorten the drying period, make sure to check the material compatibility.

6. Drying

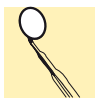
Sufficient drying must be ensured either through the washer-disinfector or by taking other appropriate measures. The drying temperature should be set to suit the temperature stability of the processed items (e.g. 65 °C).

Observe the manufacture's instructions!

With regard to the process chemicals used, the manufacturer's instructions concerning concentration, temperature and exposure time should always be observed. This guarantees good results and keeps the instrument materials intact to the greatest possible degree. It must be possible to verify the automatic volume dosing of liquid process chemicals.

6.2.3 Instrument Groups Requiring Special Treatment

Microsurgical instruments can be machine-cleaned and disinfected in the same manner as other surgical instruments, provided the instruments are safely held in place (e.g. by using racks or other suitable supports) and an effective rinsing method is used.



Dental instruments can also be machine-treated in the same way as surgical instruments. However, the following specific points need to be observed:

- Probes and other easily damaged instruments must be placed on racks or special holding devices for protection.
- Instruments with rotating components such as drill bits, cutters, burrs or abrasive tools are only conditionally suitable for machine treatment. It can be necessary to carry out an additional pre-treatment by ultrasound.
- Instruments for root-canal treatment may only be machine-processed if each item is held in place securely and safely by appropriate supports. Otherwise, ultrasonic bath treatment is preferable.
- Handpieces and elbows can be machine-processed where this is permitted by the manufacturer, and special rinsing fixtures are available for rinsing by the turbine drive's spray, air channel and air infeed recirculation system.
- Specula are subject to wear. For example, silver-backed glass mirrors may become dull as a result of machine treatment. Rhodium-metallized mirrors, in contrast, are more resistant to thermal and chemical influences but are easily damaged by mechanical impact.

Surgical motor systems may only be machine-processed if the manufacturer allows such treatment in connection with aids and facilities. Tools approved for use in medical applications can be machine-treated in the same way as surgical instruments.

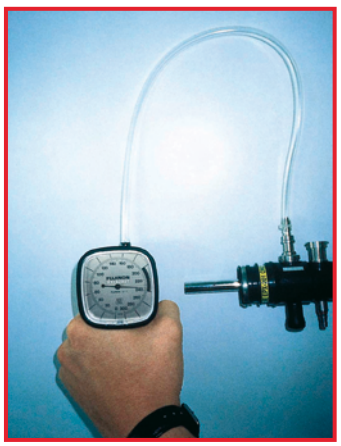
Ensure internal rinse!

MIS instruments, rigid endoscopes and HF instruments must be disassembled for machine processing in accordance with the manufacturer's instructions. All seals/gaskets must be removed and all orifices opened.
Use machine-based processes only where approved by the manufacturer of the product. To avoid damage, fix the items securely in place. The machine and loading trays used must have appropriate facilities that allow sufficient and reliable internal rinsing in the case of hollow instruments as well.

Discard

Instruments with stubborn coagulation residues that cannot be removed by additional intensive cleaning (e.g. 3% hydrogen peroxide solution, with a brush or ultrasound) must be discarded as proper functioning and hygienic can no longer be guaranteed.

Flexible endoscopes may only be machine-processed if special washer-disinfectors are used. If endoscopes are pretreated manually prior to machine-based cleaning and disinfection, all detergents and disinfectants used must be compatible with each other. This prevents poor results as well as endoscope surface damage and excessive foaming inside the machine.



Manual leakage test on flexible endoscope

Prior to machine treatment, a leak test must be carried out in accordance with the manufacturer's instructions. This ensures the early detection of leaks and perforations in order to avoid subsequent more serious damage (e.g. caused by penetrating liquids). Some machines can carry out a leak test automatically, either before the program starts, or while it is running. Defective endoscopes must be returned to the manufacturer, together with a description of the problem.
Alkaline detergents may damage endoscopes, so it is important to use only special cleaners and disinfectants suitable for the machine treatment of flexible endoscopes. Throughout the cleaning and disinfecting cycles the maximum temperature of 60 °C may never be exceeded. Moreover, the instructions provided by the endoscope manufacturer must always be carefully observed.

During the process, the endoscope must be securely kept in place inside the machine. Use appropriate devices to ensure that all external surfaces as well as the inside of all channels/ducts are thoroughly and reliably cleaned and flushed.

Suitable technical processes must be employed to ensure that the water used for the final rinse is of a quality that prevents renewed germ growth on disinfected endoscopes.
Prior to storing endoscopes for later use, proper drying is necessary to prevent the growth of microorganisms. Drying can be done in an automatic washer-disinfector or by using a suitable drying cabinet.

Flexible instruments with lockable cavities (such as tubes with balloons, respiration/resuscitation masks, etc.) must be cleaned and disinfected in their closed condition so that no liquid enters the cavities. To prevent the mask bulge from being overstretched, discharge some of the air prior to treatment (remove the plug, squeeze out some air, then replace the plug).

It is necessary to be extra careful when processing rubber instruments, because detergent or disinfectant residues can cause irreversible damage during subsequent drying or sterilization. This is due to the fact that such residues may cause the surface of the material to depolymerize and become sticky. Latex coatings tend to blister off.

Ensure complete drying!

Residues adhering to functional parts of respiration systems are particularly damaging. It is also vital that all such parts are completely dried, as even very small amounts of moisture may cause malfunctioning. Functional parts of respiration systems of anesthesia machines have been specifically designed by the manufacturer, and therefore must be processed in accordance with the manufacturer's instructions.

Flexible thermally-sensitive instruments (e.g. PVC products) must never be processed (disinfected, cleaned or dried) at temperatures above 60 °C. Flexible instruments such as rubber/latex instruments made from natural rubber, may not be dried at temperatures above 95 °C, as higher temperatures would greatly reduce their useful lives. The recommended temperature range for drying here is 70-80 °C.

6.3 Ultrasonic Cleaning and Disinfecting

Ultrasonic treatment is a very good choice to help with cleaning instruments made of stainless steel or hard plastic materials. Instruments sensitive to mechanical impact (e.g. microsurgical or dental instruments) can likewise be gently and thoroughly cleaned and disinfected with the help of ultrasound. Powerful ultrasonic devices are able to dissolve encrustations in places that are difficult to access otherwise.

Ultrasonic cleaning is used:

- as an effective mechanical method supporting manual cleaning processes.
- for removing tenacious encrustations before or after machine treatment.
- as an integral part of machine-based processing cycles, thus supporting other measures for improved cleaning results.
- for time-saving disinfection while providing intensive cleaning.

To secure optimal cleaning results when using ultrasound, observe the following:

- Fill the bath in accordance with the manufacturer's instructions.
- Add a suitable cleaning agent or a combined cleaner-disinfectant.
- When using both disinfectant and cleaning agents, the concentration, temperature and ultrasound treatment/exposure time must be chosen in accordance with the manufacturer's instructions to ensure compatibility.
- We recommend using hot water for the bath as follows:
- Water temperatures above 50 °C can lead to blood encrustations due to protein denaturation.
- Freshly prepared disinfection or cleaning solutions require degassing before their first use.

Apart from a properly prepared bath, the following basic rules should always be observed to ensure good cleaning results:

- The items to be treated must be fully immersed in the cleaning solution.
- Articulated instruments, scissors etc. must be opened in order to minimize the obscured surface areas.
- Use only suitable trays (e.g. wire trays) that do not obstruct the ultrasonic cleaning process.
- Large-surface, bulky instruments such as lead hands must be stored so that they do not obstruct the passage of sound waves or create anechoic zones. Such items must be placed vertically or on top of the other instruments.
- Do not overload trays.
- Ultrasound baths should be prepared freshly each day, taking care to observe national guidelines as well as the manufacturer‘s instructions. As high contamination levels impair ultrasonic cleaning and promote corrosion, more frequent replacement of ultrasound solution may be necessary, depending on the requirements of specific cases.
- Given efficient modern equipment, ultrasonic treatment times of approx. 3 minutes at frequencies of around 35 kHz should be sufficient.
- If disinfection and cleaning are carried out simultaneously, make sure to use suitable products, paying attention to concentration and exposure time requirements.

If shorter exposure times and/or lower concentrations are recommended when using cleaners and disinfectants with ultrasound, such values must always be checked and corroborated by microbiological examinations (expert opinions), taking account of temperature, frequency range and germ spectrum.
Following ultrasonic treatment, the instruments must be thoroughly rinsed manually. The manual rinse can be carried out with fresh tap water, taking care that all cleaner and disinfectant residues are completely removed in the process. To avoid water spots, we recommend using fully demineralized water for the final rinse.

Microsurgical instruments must be stored on special racks in order to prevent damage.

To prevent surface and soldering seam damage on dental instruments, never add acid cement remover to the ultrasonic bath.

Handpieces, elbows and turbines should never be treated by immersion in an ultrasonic bath.

Due to the materials used in their construction, dental instruments with rotating components must be treated often with special disinfectants and cleaning agents. Prior to ultrasonic treatment, they should be placed on special racks to avoid contact damage among the instruments (e.g. by sharp cutting edges). After a quick rinse under running water followed by immediate drying, dental instruments with rotating components must be treated with a sterilization-stable anticorrosive agent. Polishing and flexible instruments cannot be processed in the ultrasonic bath, because the elasticity absorbs the ultrasound.

Specula may be damaged by ultrasonic bath treatment.

With the exception of simple tools and accessories, motor systems should never be treated in an ultrasonic bath.

In the case of MIS instruments, rigid endoscopes and HF instruments, ultrasonic bath treatment is allowed only for those parts for which the manufacturer has given his explicit approval.

Camera systems and optical cables may never be cleaned in an ultrasonic bath.

No ultrasonic cleaning!

In the case of instruments used in HF surgery, a 3 % H_2O_2 solution speeds up the removal of encrustations.

Flexible endoscopes must never be treated in an ultrasonic bath. However their accessories (such as valves, caps, biting rings or forceps) can be treated in this way.
Elastic instruments do not respond well to ultrasonic processing, as ultrasonic waves have only a limited effect on them.

Functional parts of respiration systems may not be processed in an ultrasonic bath.

7. Final Disinfection

A final disinfection is carried out for instruments that cannot be sterilized or where sterilization is not required. In most cases, this applies to thermally sensitive instruments such as flexible endoscopes or equipment used in anesthetics.

Final disinfection can be performed either manually or mechanically at room temperature, or mechanically at higher temperatures using a chemothermal or thermal process. For machine-based thermal and chemothermal disinfecting processes with integrated cleaning stage, refer to section 6.2.
When using chemical processes for final disinfection, aldehydes, organic peroxo compounds or alkylamines are primarily used as microbicidal agents (either alone or in combination with cleaning components and/or corrosion inhibitors and additives). The effectiveness of the disinfectants used should be proven under "clean conditions" (no contamination) in accordance with European (EN) 14885 standards or equivalent local guidelines.

Observe material compatibility!

Material compatibility is a function of the instrument material, the composition of the disinfectant, temperature, exposure time, concentration, and the pH-value of the solution used.

Aldehyde-based disinfectants are usually highly compatible with instrument materials.
Regards organic peroxo compounds, particularly disinfectants containing peracetic acid, compatibility greatly depends on the composition of the disinfectant and the specific conditions of use.
When using disinfectants containing alkylamines, the chemical structure of this agent strongly influences material compatibility with regard to elastomers and adhesive/glued joints. In the case of silicone elastomers, extended treatment with alkylamine-based disinfectants may lead to hardening.

Disinfectants based on organic peroxo compounds or alkylamines must be categorized as "sensitive" in terms of instrument material compatibility. For this reason, the manufacturers' tested and validated instructions must be strictly observed.
Inasmuch as the same products are used for disinfection and cleaning and the final disinfection, separate solutions must be employed for the two steps. If products based on different agents are used, product compatibility must be ensured (to prevent the formation of deposits, for example).

Ensure complete wetting!

In chemical final disinfection, it is important to ensure that all surfaces to be disinfected are completely covered by the solution, including the gaps in articulated instruments, and any channels or cavities.

Following disinfection, the instruments must be rinsed thoroughly with sterile, fully demineralized water to completely remove any residues, and must then be dried immediately. If compressed air is used for drying, the air must be passed through a sterilizing filter.
We recommend using disinfecting solutions for no longer than one day. If the manufacturer recommends or allows longer use, the agent concentration should be checked regularly (at least daily), because losses can occur either during the introduction and removal of instruments, or due to chemical reactions. The solution should be disposed of as soon as the concentration limit value - up to which the manufacturer guarantees the action spectrum expected by the user - is reached. For suitable methods for checking concentration, consult the manufacturer of the product.

Flexible endoscopes are sufficiently rinsed externally as well as internally with water in accordance with the cleaning instructions given in section 6.1, and are then immersed in a disinfecting solution. It is important to ensure that the endoscope is completely covered by the solution and that all channels are completely filled or wetted by the solution flowing through them.
In the case of flexible endoscopes, this can be done with a hand pump or by using a program-controlled automatic pump system. Make sure to disinfect the discharge ducts as well! Following chemical disinfection, external surfaces and all channels of the endoscope must be thoroughly rinsed to remove any residues. To avoid water spots, use only fully demineralized water. Additional sterile filtration prevents unwelcome recontamination.
To dry the external surfaces of flexible endoscopes, use a lint-free cloth. The channels should be dried with a hand or discharge pump or with compressed air at max. 0.5 bar, depending on the manufacturer's instructions. The use of sterile (filtered) compressed air prevents unwelcome recontamination.

In the case of flexible instruments made of plastic or rubber, white spots are caused by the penetration of water into the instrument's surface. Such spots can only be removed by drying.

To prevent diaphragm damage in functional parts of respiration systems, do not use compressed air for drying!

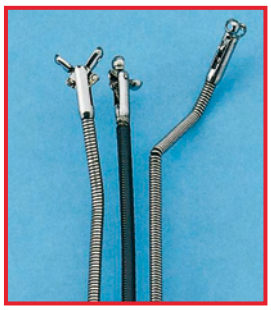
8. Checks and Care

Cleanness

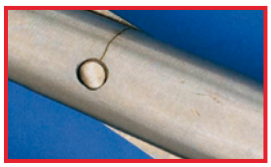
Sufficient cleaning standards are absolutely vital for successful sterilization. Instruments to be sterilized must be macroscopically clean, i.e. free from visible residues. This is checked by visual inspection. Critical areas such as handle structures, joints or jaw serration (particularly atraumatic toothing) require especially careful checking.

It is advisable to use working lights with magnifying lenses of 3 to 6 diopters when checking filigree working ends. If there is doubt as to the level of cleanliness, particularly in the case of instruments with hollow areas, chemical tests for protein and blood must be carried out.

All instruments with lumens, such as cannulas or sheath tubes etc., must be checked for patency (free passage, no obstructions). Clogged instruments must be reprocessed. If this does not help, such instruments must be replaced.



Biopsy forceps damaged by sheer force



Hairline fracture next to scissor hinge

Integrity

Poorly cleaned instruments must be recleaned (as described below) and then rinsed sufficiently:

- Manual cleaning, if necessary with ultrasound (see section 6)
- Immersion in a 3 % H_2O_2 solution (for approx. 5 minutes)

To prevent damage and consequential corrosion due to metal abrasion, never use metal brushes or metal sponges for removing stains.

Instruments with hairline cracks in the joint areas, as well those that are damaged, distorted or otherwise worn, must be replaced because their functionality can no longer be fully guaranteed.

Surface changes

Instruments with corrosion residues or damaged nickel-chromium coating need special processing. Such treatment is not mandatory, however, in the case of discolorations and/or stains.

For detailed information and recommendations on this topic, please refer to section 12.

Care

Fretting corrosion due to inadequate lubrication

"fretting"

Maintenance and care measures are usually carried out prior to the functional check.

Maintenance or care means targeted application of instrument milk to the joints, hinges, locks, threads or friction surfaces of instruments such as clamps, scissors or punches, after they have been carefully cleaned and disinfected.
This prevents metal-on-metal friction and therefore constitutes a preventive measure against corrosion caused by chafing.
In this way, the instruments are kept functional and hinge action maintained.

Requirements for care agents for surgical instruments:

- Paraffin/white oil basis,
- Biocompatible in accordance with the current European or United States Pharmacopoeia,
- Suitable for steam sterilization and vapor-permeable.

Instruments must not be treated with care agents containing silicon oil. This can adversely affect the instrument's functionality and also the steam sterilization results as well.

Proper performance of care measures:
Allow the instruments to cool down to room temperature before opening and closing the instruments because otherwise metal abrasion might occur when the parts rub against each other. Such "fretting" would impair the instrument's ease of movement or even destroy its functionality altogether.

The care agent must be applied manually and accurately to joints, threads and friction surfaces. This applies in particular to articulated instruments treated in special washing procedures using a hydrogen peroxide additive. The care agent must be distributed evenly by operating the joints/friction surfaces. Any excess care agent must be removed with a lint-free cloth.

Spraying the instruments or applying the care agent mechanically is not sufficient, nor does it provide additional corrosion protection. Dipping baths should not be used because of the germ infestation hazard.
Never process plastic surfaces with instrument care agents.

Function

As surgical instruments are made for specific application purposes, the functional tests must be carried out so that items that fail to serve their intended purpose are reliably recognized and discarded. If in doubt, consult the instrument manufacturer for suitable testing methods.

Articulated and threaded instruments must be lubricated before subjecting them to a functional test using a squirt oiler or through targeted application of drops of oil.

Separable instruments are tested in their assembled condition.

Medical products due for repair must be sent through the entire processing cycle to fulfill the requirements of hygiene.

After the check, microsurgical instruments must be stored in the special racks designed for them that prevent transportation damage. If indicated, suitable facilities should be employed to secure them against dislocation.

Care

Dental instruments are usually serviced in the same manner as surgical instruments. However, there are some exceptions:

- A few dental instruments with rotating components (drill bits, cutters, burrs, reamers) must be treated with an anti-corrosion agent which is suitable for use with sterilizing media such as steam or hot air, immediately after drying.
- Handpieces, elbows and turbines must be treated with special agents in accordance with the manufacturer's instructions due to their complicated internal design.

Care

As proper lubrication and maintenance is a vital factor for long-term value retention in the case of motor systems, the manufacturer's instructions should be carefully followed. For non-sealed handpieces, e.g. many micro-handpieces with a motor connection according to DIN 13940/ISO 3964, a special spray must be used for internal cleaning and lubrication.

A few drops of special oil are applied to the air intake duct of compressed air motors. To facilitate the distribution of the oil inside, the motor is run with compressed air for a few seconds. This excludes maintenance-free compressed air motors, labelled accordingly. As a rule, all movable external parts, such as pushbuttons or tool couplings, should be properly lubricated, unless expressly forbidden by the manufacturer. Make sure to use only lubricants approved by the manufacturer.

Function

Before sterilization, surgical motors and their accessories must be subjected to a functional test, in accordance with the manufacturer's instructions. All compressed air components must in addition be subjected to a leak test and be visually inspected for potential defects, especially the compressed air hoses and motors. To check the air intake duct, it is necessary to connect the air hose to the compressed air connector. Leaks can then be detected either acoustically or by submerging the hose in water.

To check the air discharge duct, the compressed air motor must also be connected to the compressed air hose. After starting the motor, leaks can best be detected by submerging the hose in water.

Simple tools must be checked in accordance with the instructions for general surgical instruments. To prevent transportation damage, tools should be stored in special racks or secured using appropriate devices.

The flexible tube sets used for cooling liquids can be checked for leakage with a clamp and large-volume syringe. The tubing is filled with water, and a clamp applied to one end. Then water is injected by syringe at the other end.

Cleanness

Residues on endoscope glass surfaces, optical fiber cables and camera heads can be removed with a swab soaked in alcohol.
For this purpose swabs made of wood or alcohol-resistant plastic should be used. Swabs including metal should be avoided as they may scratch glass surfaces. Note also that alcohol is not suitable for removing blood residues.

Glass surfaces with stubborn deposits (e.g. in the case of oculars, lenses or light connectors) can be treated with a detergent or cleaning procedure recommended by the manufacturer.
If deposits or tarnish cannot be removed in this way, the instrument must be sent back to the manufacturer for inspection.

Integrity

Worn parts, defective components, gaskets and sealing rings must be checked for integrity before each sterilization cycle. If damaged, they must be replaced at once.
Damaged, blunt and/or distorted cannulas must be taken out and discarded.

Damaged insulation on HF instrument

Instruments with damaged insulation must be replaced immediately because they would pose a risk to patients, users and third parties.

Optical fiber cables and endoscopes must be checked for fiber breakage by holding the distal end against a light source and looking into the cable at the other end (the connector side of optic).
Fiber breakage is indicated by black spots in the waveguide. If more than about 30% of the fibers are broken, the light output at the distal end is no longer adequate. If this is the case, the cables or endoscopes must be returned to the manufacturer for repair. Check endoscope cover glasses for relevant scratch marks and/or cracks. These can result in leaks, causing the optic to fail.

Care

Application of care agents, either manual or mechanical, should be avoided with optical systems, gaskets and current-carrying components because this could cause significant problems and lead to loss of function.

Joints, threads and friction surfaces, as well as non-maintenance-free connections on rigid endoscopes must be treated with instrument oil in accordance with the manufacturer's instructions. Alternatively, lubricating milk can be used if permitted by the manufacturer.

Function

A function test ensures the proper functioning of MIS instruments and rigid endoscopes. Such a test must always be carried out on the fully assembled instrument. The item must subsequently be taken apart again if sterilization is necessary. Make sure you proceed in accordance with the manufacturer's instructions when assembling and disassembling the instrument

Channels of flexible endoscopes must be checked for free passage (no obstructions).

Cleanness

Glass surfaces of flexible endoscopes (lenses, oculars and light entry/ exit surfaces) must be checked for cleanness in the same way as for rigid endoscopes.

Integrity

Gaskets, sealing rings, valves, caps and other parts which wear out, must be checked for integrity after each treatment cycle. If damaged or worn, they must be replaced at once.
Endoscopes with damaged feed and/or elbow tubing, or other defects, must be taken out and sent for repair.

Care

Swelling at distal end of fiberscope

In the case of flexible endoscopes, always check whether the valves (if incorporated) need treating with an instrument care agent before use.

Note that the endoscope surface must not be sprayed because spray propellants damage these instruments.

Only grease-free gels may be used as lubricants, in accordance with the manufacturer's instructions. Vaseline or agents containing paraffin cause swelling or softening in plastic components (see also "Surface Changes" section!).

Function/integrity

Immediately after an endoscopic operation, all functions of the instrument must be checked or tested in accordance with the manufacturer's instructions.

Respiration systems must be checked in accordance with the manufacturer's instructions, to ensure that they are in proper working order, and are functioning properly.

Flexible instruments must be checked for proper functioning in accordance with their intended purpose. The most important checks and tests include:

- Checking the integrity of balloons.
- Checking balloon filling systems for non-leaking.
- Checking instrument lumens for obstructions.
- Testing connectors for functional safety (e.g. ISO connectors).
- Inspecting tracheal tubes for distortion, e.g. radii.
- Checking polysulphone connectors and similar products for stress cracks.

Make sure to remove and discard any damaged or defective instruments! Frequent damage includes:

- Blistering, scaling.
- Surface cracks (e.g. ozone cracks; crazing/orange-peel effect, i.e. network of directionless micro-cracks); stress cracks in plastic components.
- Sticky surfaces.
- Hardening.
- Porous surfaces.

Care

Flexible instruments and respiration systems may never be treated with lubricants or care agents before sterilization. Where required, special servicing and care measures are always indicated by the manufacturer.

Never use silicone oil!

Flexible instruments made of silicone rubber must not be treated with silicone oil because it may cause swelling, thus destroying the instrument's functionality. To prevent swelling in rubber and latex instruments, never use agents containing paraffin!

Repair

Damaged medical products, or products that are no longer functioning properly must be sent for repair or scrapped.

Maintenance

Always send medical products to the manufacturer for servicing as per the maintenance schedule.

9. Packaging

International standard EN ISO 11607 Parts 1 and 2 apply to packed items requiring sterilization. The standard stipulates the packaging material (Part 1) and the validation of the packaging process (Part 2).

Sterile barrier system

The packaging for items for sterilization must be of a type representing a sterile barrier system. Its task is to prevent micro-organisms from entering the packaging, and to removal under aseptic conditions.
It must also be possible to open the package easily under aseptic conditions.
The sterile barrier system represents a microbial barrier which prevents recontamination under specified conditions. Such conditions include:

- Temperature
- Pressure
- Humidity
- Sunlight
- Cleanness
- Pathogen contamination

Protective packaging

The protective packaging is additional packing designed to prevent damage from occurring to the sterile barrier system from the moment it is put together until the moment of use.

Packaging types

The sterile barrier system can be a reusable system (sterilising container) or a disposal product (non-woven fabric, paper, transparent bag).
Containers and storage systems help to retain the value of instruments.

The packaging has a considerable effect on sterilization results, for which reason the packaging system (sterile barrier system and protective packaging) must be compatible with the sterilization procedure.
The packaging material must not absorb the sterilizing agent beyond a reasonable limit, and must not cause any alterations in the sterilizing agent. The sterilization process validation also investigates the suitability of the packaging. The processes involved in forming the pack, seal and composition that previously took place must also be validated.
Whenever new materials are used that have not yet been properly validated, the performance assessment (validation) must be repeated.

Drying

To retain the value of the instruments it is also important that they are sufficiently dried, because residual humidity can cause corrosion damage. If non-woven fabric is used, care should be taken to ensure that this does not interfere with the drying process.

Marking

It must be possible to mark and identify the package with information such as:

- Sterilization date,
- Packer,
- Expiry or "use before" date (if date has been defined),
- Contents.

10. Sterilization

Within the scope of European (EN) standards, the application of sterile instruments on or in the patient requires proper cleaning and disinfecting, followed by sterilization in approved packaging, on the basis of a validated sterilization process. Following such treatment, the sterile items must be stored in accordance with the rules and provisions governing sterile supplies. Consequently, it is important to use only sterilization methods and sterilizers that allow validated sterilization processes.

Sterilization accessories and packaging materials must be selected in accordance with the items to be sterilized as well as with the sterilization method used.

In this context, the user instructions for the sterilizer used must be strictly observed.

For thermostable products, steam sterilization is the method of choice!

10.1 Steam Sterilization

Steam sterilization is performed with saturated steam, usually at 134 °C.

Stain formation due to "running" chemoindicators!

If chemoindicators are used in large numbers in a sterilization batch, this may lead to stains on instrument surfaces, especially if there is direct contact between instruments. This particularly applies to silver products or products with silver-plated surfaces.

If validated steam sterilization processes are used in accordance with ISO 17665, EN 554 (or DIN 58946 Part 6 in Germany) and all process-relevant parameters such as pressure, temperature and the proportion of non-condensible gases in steam are being documented it is possible to do without chemoindicators or bioindicators for batch control, provided that the three parameters relevant to the procedure are permanently monitored.

Ensure steam quality in accordance with EN 285!

The sterilization steam used must be free from impurities and should neither impair the sterilization process nor damage the sterilizer or the items to be sterilized.

To ensure this, the tolerances specified in EN 285, Table B.1, relating to the quality of the boiler feed water and the condensate may not be exceeded. Otherwise corrosion may be result from contaminants such as rust particles from the piping system, or discolorations on instrument surface may be caused by an excessive silicic acid levels.

Marbling caused by impurities in steam condensate

Contamination in the condensate from steam supply to sterilizers, measured at the sterilizer infeed

Substance/property	Condensate
Silicates (SiO_2)	≤ 0.1 mg/l
Iron	≤ 0.1 mg/l
Cadmium	≤ 0.005 mg/l
Lead	≤ 0.05 mg/l
Heavy metal residues, except for iron, cadmium, lead	≤ 0.1 mg/l
Chloride (Cl-)	≤ 0.1 mg/l
Phosphate (P_2O_5)	≤ 0.1 mg/l
Conductivity (at 25 °C)	≤ 3 µS/cm
pH value (degree of acidity)	5-7
Appearance	colorless, clear, no deposits
Hardness ∑ (of alkaline earth ions)	≤ 0.02 mmol/l

Note: See 22.4 for the procedure for taking condensate samples.

Source: DIN EN 285, version 2006

If the feed water contains large quantities of bicarbonate hardness, this increases the inert gas content of the sterilization steam, and therefore may adversely affect the sterilization result.

Corrosion hazards due to residual humidity/ dampness!

Damp or wet containers pose instrument corrosion hazards. Poor and insufficient drying is frequently caused by incorrectly organized loading and the use of less suitable types of non-woven fabrics for drying.

In principal, heavy sieves should be placed at the lowest level, so that the majority of the accumulated condensate can drain off directly. Special drying measures must be adopted when validating items weighing more than 10 kg (according to EN 868) per sterilizing unit (30x30x60 cm). In practice, residual moisture in the form of a few drops of water capable of evaporating within 15 minutes is tolerated, but actual pools of water are not acceptable! Even so, a few drops of water may cause some spotting. To prevent residual moisture altogether, consult the manufacturer of your sterilizer for relevant procedures.

Dental instruments can usually be steam-sterilized in the same way as surgical instruments. Should separate treatment be required, the following instructions apply for steam sterilization:

- Dental instruments with rotating components (e.g. drill bits or burrs) are steam-sterilizable.
- Handpieces and elbows should be steam-sterilized at 134 °C wherever possible to keep treatment time to a minimum.
- In the case of drive systems, consult the manufacturer's instructions to determine whether or not steam sterilization is permitted.
- Specula can be steam-sterilized, but being subject to wear, will soon become dull as a result of the ingress of moisture. This is possible because of the different expansion coefficients of different materials.

All surgical motor systems used under sterile conditions can be steam-sterilized at 134 °C.
Make sure the manufacturer's instructions are observed, e.g. on fixing during sterilization.

Kinking reduces service life and impairs the functionality!

Compressed-air hoses need to be protected against mechanical damage (such as compression or kinking) during sterilization. The permitted bending radii should therefore be observed when storing such items in sterilization trays.

As regards battery-powered systems, make sure to strictly observe the manufacturer's instructions concerning compatibility. Long exposure of battery-powered motors to the effects of temperature considerably reduce the charge status.

MIS instruments, rigid endoscopes, optical fiber cables and HF instruments can usually be sterilized in the same manner as surgical instruments. Steam-sterilizable optical systems should be sterilized at 134 °C rather than at 121 °C, due to the shorter exposure time (and correspondingly lower thermal stress). Alternatively the H_2O_2 gas-plasma sterilization process

can be used. This completely avoids thermal stress. To avoid mechanical damage, optical systems should always be stored securely in accordance with the manufacturer's instructions during sterilization.

Flexible endoscopes are not steam-sterilizable due to their limited heat stability. A low-temperature sterilization method must therefore be used in cases where sterilization is required. However, all items used endoscopically (such as forceps, catheters, etc.) must be steam-sterilized.

Flexible instruments made of silicone elastomer or natural rubber or latex, with and without a balloon, can be steam-sterilized. Due to the lower thermal stress tolerance, it is preferable to sterilize them at 134 °C. Items made of thermoplastic materials however, are only steam-sterilizable if they are marked as such, or if such treatment is expressly permitted by the manufacturer.

When steam-sterilizing flexible instruments, all cavities e.g. bulge of mask, balloon, must remain open during sterilization, to prevent damage caused by pressure variations.
Cavities locked with a valve must be completely emptied i.e. made water- and air-free, with a syringe before sterilization.

Functional parts of respiration systems can be steam-sterilized at 134 °C. Cavities must remain open to prevent valve damage.

10.2 Hot-Air Sterilization

Although hot-air sterilization no longer represents the state of the art, it is still being used in isolated cases. If sterilization is still effected with a hot-air sterilizer, the following instructions continue to be effective and must be observed:

At temperatures above 185 °C, paraffin oil will resinify. This destroys its lubricating function and thus reduces the instrument's functionality.

Prescribed temperature should not be exceeded!

If the specified temperature is significantly exceeded, there is a corrosion hazard, in addition to a risk of loss of hardness. Consequently, functionality is compromised, making instruments useless in many cases. Similarly, plastics such as color rings may be adversely affected or even destroyed at higher temperatures.

To ensure uniform heat distribution in the sterilization chamber, and thus in the items to be treated, the sterilizer loading instructions must be strictly observed!
MIS instruments and endoscopes may never be sterilized with hot air!

10.3 Low-Temperature Sterilization

Gas sterilization and gas plasma systems are Low-Temperature Sterilization procedures. All these procedures work with chemical agents at temperatures between 37 and 75 °C.

When choosing the low-temperature sterilization procedure please take particular notice of the processing instructions specified by the manufacturer of the medical product.

It is possible that the concentrations of agents will differ depending on the type, procedure and year of manufacture of the sterilizers used, and errors would cause various amounts of damage to the processed products.

Due to the possibility of harmful interactions a medical product should always be sterilized in a low-temperature sterilization process!

Depending on the sterilization procedure different kinds of packaging are permitted. In general, containers used for steam sterilization are not suitable. For environmental reasons as well as patient- and personnel-related safety reasons, these methods should only be used for items that cannot be steam-sterilized!

Items sterilized with ethylene oxide require adequate aeration following sterilization (and before reuse). Aeration times may vary considerably, depending on ventilation conditions and the product treated. For reliable aeration times, always consult the instrument manufacturer and/or observe the corresponding instructions.

Sterilization with EO gas may only be used for motor systems if expressly specified by the manufacturer.

Non-steam-sterilizable rigid optical systems (telescopes) can be sterilized at low temperatures in accordance with the manufacturer's instructions.

Flexible endoscopes can be sterilized up to a maximum temperature of 60 °C, using a sterilization method permitted by the manufacturer.

For sterilization the flexible endoscope must be packed in a transparent tube, in the extended condition wherever possible. Make sure the aeration cap is placed on the inlet connector, otherwise the instrument could be irreversibly damaged.

To ensure protection against mechanical damage, the sealed-in flexible endoscope must be held securely on the sterilizer tray. Make sure that the loop diameter is no less than 30 cm.

Following sterilization and adequate aeration (if required), flexible endoscopes must always be stored in their extended state to avoid deformation and kinks.

Flexible instruments made of heat-sensitive plastic are not steam-sterilizable, but are sterilized using one of the methods indicated by the manufacturer.
Cavities locked with a valve must be fully evacuated and all water removed with a syringe prior to sterilization.

Flexible instruments made of rubber, as well as functional parts of respiration systems, should not be gas-sterilized, as they can more effectively be steam-sterilized.

When sterilizing medical devices incorporating a battery (such as cardiac pacemakers or implantable defibrillators), bear in mind that the battery charge may be reduced during the process, depending on temperature and treatment time.

11. Storage

11.1 Storing Non-Sterile Instruments

Instruments stored in poor conditions can corrode. To prevent this they should be stored in dry and dust-free conditions. Major temperature fluctuations should be avoided in order to prevent accumulation of moisture (condensate) on instrument surfaces.

Chemicals may destroy metals when in direct contact with them, or may emit corrosive vapors. Never store your instruments near chemicals!

The storage of instruments must be organized in such a way that they cannot damage one another. Appropriate systems must be used to ensure this; such systems improve overall clarity of the organization, while also reducing the danger of injury to users.

Closed storage systems are preferable in order to ensure additional protection against pathogens.

Flexible endoscopes must not be stored in transportation cases. They should be stored under dry and dark conditions. Endoscopes must be sufficiently dry before storage. Valves and caps must be removed and stored separately, under dry and dust-free conditions. It is advisable to hang up endoscopes during storage, using special cabinets that should be located near the place of use.

To prevent premature failure of flexible instruments, avoid kinking or overstretching during storage (use only suitable connectors!).

11.2 Storing Sterile Instruments

To guarantee instrument sterility up to the time of use on the patient, germ-tight packaging is absolutely essential.

Further requirements for protected storage of sterile supplies and prevention of corrosion damage include a dust-free and dry environment and the prevention of temperature fluctuations. Such conditions permit storage for six months (or more). For details, refer to DIN EN 868 and Table 1 of the German standard DIN 58 953, Part 9.

Proper storage of sterilized endoscopes requires storing them with the shaft unkinked and/or laid out in a sufficiently large loop. Following degassing, such items should be stored in a closed cabinet so as to be protected against contamination.

12. Surface Changes, Deposits, Corrosion, Aging, Swelling and Stress Cracks

In daily practice and over time many medical devices are subject to surface changes due to chemical, thermal and/or physical impact. If not directly caused by normal usage, the origin of such changes can usually be found in the reprocessing conditions.

If surface changes occur, it is advisable to proceed systematically in the following order in order to remove and avoid surface damage:

- Determine nature, origin and cause.
- Assess risks.
- Process/treat the items in accordance with the manufacturer's recommendations to correct changes where necessary.
- Take appropriate measures to prevent reoccurrence, then validate your entire instrument treatment processes.

Reworking or repair of affected products makes sense only if the causes of the surface changes have been determined and eliminated.

All examples given below are based on the systematic 4-step approach outlined above. These examples cover the most frequent surface changes in metallic instruments made of stainless steels and/or plastic or rubber products.

12.1 Metal/Deposits – Organic Residues

Type of surface change

Blood residues in the closed joint area
Cause: Instrument was closed for cleaning.

Clean in closed joint area
Reason: Instrument was open for cleaning.

Rust and/or blood-colored deposits can often be seen.

Origin & causes

Immediately after the operation caused by operational residues (blood, protein) by salt residues, by drug residues.

- Dried on because the interval between use and processing is too long.
- Use of unsuitable instrument disinfectants.

- Transferred by contaminated cleaning and disinfecting agent.
- Insufficient rinsing after cleaning.
- Insufficient cleaning efficiency caused by areas inaccessible to ultrasound in ultrasound cleaning.
- Inadequate maintenance/servicing of the cleaning and disinfecting unit.
- Fixing caused by water feed temperature being too high (exceeding 45 °C) in first water intake cycle.
- Ineffective rinsing (insufficient water flow through or around the instruments, insufficient rinse pressure, inaccessible areas).
- Insufficient cleaning efficiency due to foam formation, for example due to high amounts of blood or cleaner or disinfectant residues carried over from the ultrasonic or immersion bath.
- Improper loading due to use of wrong instrument trolley/trays or overloading.
- Insufficient cleaning efficiency, because the instruments/devices were not open and/or badly position.

Treatment recommendations

- Recleaning with ultrasound.
- Targeted manual recleaning.
- Immersion in a 3 % H_2O_2 solution (for approx. 5 minutes).

Preventive measures

- Remove all coarse contamination, especially salt solutions immediately after the operation.
- Factors causing drying or fixing exclude: drying by reducing the period between use and processing (under 6 hours).
- The use of suitable aldehyde and alcohol-free desinfectants for wet disposal.
- Ensure cold water pre-rinse.
- Correction program sequence in cleaning and disinfecting units.

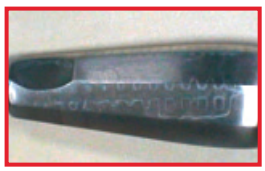
Risk assessment

- Hygiene risk - danger of infection for patients. Can lead to corrosion even with stainless steel because blood, for example, contains chloride ions. If present in higher concentrations, these ions cause pitting and/or stress-crack corrosion.

12.2 Metal/Deposits – Process Chemical Residues

Depending on the extent of the residues, instrument type and surface quality, various sizes of bright-to-dark gray deposits / discoloration may appear. The ability to detect this can be reinforced even further by sterilization.

Type of surface change



Hollow handle with visible residues

Suitable injector tray for cleaning and rinsing ophthalmic instruments

Incorrect loading/tipped kidney-shaped bowls

Origin & causes

Process chemicals that have not been removed sufficiently (inaccessible areas, incorrect loading) during the intermediate and/or final rinses.

Treatment recommendations

- Wipe off with a fuzz-free cloth.
- Acid-based cleaning with special cleaners as recommended by the instrument manufacturer.

Preventive measures

Ensure sufficient intermediate and/or final rinsing with fully demineralized water or correct the loading. The manufacturer's instructions regarding disassembly and cleaning must be followed strictly!

Particularly in the case of ophthalmic instruments patients could be exposed to risk of chemical burns caused by alkaline deposits.

Risk assessment

Discolored surfaces can also be caused by residues of process chemicals, as described in other sections.

12.3 Metal/Deposits – Spotting Caused by Lime

Type of surface change

Rinsing chamber with heavy limescale deposits

Consequence: Instruments have limescale residues

Stains/discolorations of a milky white to gray color. Depending on specific conditions, these changes may extend across a larger surface or take the form of irregular spots with sharply defined borders, distributed across the instrument's surface (and/or the washer-disinfector's internal surfaces).

Origin & causes

Excessive lime in the water used for the cleaning stage or at the final rinse.

Treatment recommendations

- Wipe-off with a fuzz-free cloth.
- Acid-based cleaning with special cleaners as recommended by the instrument manufacturer.

Preventive measures

- Cleaning and as necessary intermediate rinses with demineralized water.
- Use of fully demineralized water for the final rinse, to prevent stain formation in machine-based reprocessing.

Risk assessment

- No corrosion, only aesthetic significance.

12.4 Metal/Deposits – Silicates and Other Mineral Compounds

Type of surface change

Typical silicate discoloration in the rinsing chamber and on the surface of the instrument caused by cleaning agent containing silicate, or excessive levels of silicic acid in the water.

Typical silicate discoloration on the surface of the instrument after steam sterilization caused by excessive silicic acid levels in the demineralized water.

Yellowish-brown to blue-violet discolorations of various forms, ranging from extended and rainbow-like tarnish to colored spots or droplet-shaped stains on instruments, washer-disinfectors and sterilization chambers.

Origin & causes

- Silicic acid leakage in the production of fully demineralized water when using ion exchangers and reverse-osmosis water treatment equipment.
- Carry-over of cleaner residues containing silicates into the final rinse in machine treatment processes, due to insufficient intermediate rinsing.
- Other mineral substances contained in the final rinse water of machine-based cleaning processes or in the steam condensate, e.g. copper from the pipework system.

Treatment recommendations

- Mineral deposits can be removed by acid-based cleaning using special detergents as recommended by the manufacturer.
- Stubborn deposits (silicate build-up) can be removed with agents containing hydrofluoric acid.
- Mechanical surface treatment by the manufacturer or.
- Implementation of repair by a qualified repair service agent.

Preventive measures

Use silicic acid-free, fully demineralized water for final rinse in machine processing. Prevent cleaner carry-over by:

- Correct tray loading and proper positioning/fixation of items with hollow spaces in which liquids can accumulate (e.g. kidney-shaped bowls).
- Ensure correct functioning of dispensing equipment.
- Ensure sufficient neutralization and intermediate rinsing in machine-based cleaning processes.
- Use water quality as specified in EN 285 (Appendix B, Table B.1) or DIN 58946, Part 6, for steam sterilization.

Risk assessment

- No corrosion, only aesthetic effect; no hygienic hazards
- The laser-lettered labels of instruments may be adversely affected (bleached) when treating them with acid-based cleaners. This may result in poor legibility, thus impairing or even destroying their coding function.

12.5 Metal/Deposits – Discoloration Due to Oxidation

Type of surface change

Retractors with discolored black shaft in hardened Cr-steel with the handle and blade remaining bright, made from non-hardenable CrNI steel.

Details of clamp: Lock and ring area.

Section - titan valves:
Left-hand Valve – brand new.
Right-hand valve – machine-cleaned.
The change in color is generally even. However it can also occur in patches.

A shiny, gray-black passive chromium oxide layer is only formed in the case of hardenable non-stainless steels, frequently initially identifiable with cutting instruments (e.g. scissors), but also in the case of blunt instruments (e.g. forceps, thumb forceps).

In the case of titanium materials (pure titanium or alloys) surface discoloration may be formed with uniform varying coloration (e.g. gray, blue, violet, red, golden yellow, green) or with blotchy multicolor discoloration.

Origin & causes

In the case of the above stainless steels, in the case of machine cleaning by the neutralizer carried away in the last rinsing stage and/or by other factors forming passive layers are not yet identified. Passive layers may be transparent (is usual) to black in the case of stainless steels, depending on the composition, density and thickness. The tendency to form gray-black chromium oxide passive layers depends in particular on the ratio chromium content/carbon content, alongside the influences of the material composition referred to above. In practice, this means that the higher the carbon content, the faster a gray-black discoloration may become visible.

In the case of titanium materials, damp heat and/or cleaning chemicals used in the various reprocessing stages may lead to oxidation of the surface and hence to discoloration of the surface.
Titanium oxide deposits may be transparent or multicolored/colored depending on the composition, density and thickness.

Treatment recommendations

Not recommended due to the properties of the deposit, but may be carried out at the manufacturer or a qualified repair service as necessary in both cases only by appropriate surface treatment (mechanical in the case of steel, chemical in the case of titanium). In the case of stainless steels, removing the deposit with a basic cleaner has no effect on account of significantly increased resistance to corrosion.

Preventive measures

In the case of stainless steels, ensure precise dosing of the neutralizer. Exclude carry over of the neutralizer with adequate final rinsing.
In the case of titanium materials virtually unavoidable or not avoidable, because the nature of the material means it always reacts with the surface more or less visibly as a result of the ambient conditions prevailing during reprocessing (temperature, chemicals, humidity).

Risk assessment

No corrosion – aesthetic effect
If, in the case of titanium materials, any identification/coding function lost as a result of discolorations, e.g. color coding of the blade width in the case of valves (see picture), does not present a safety risk, color changes due to the formation of different properties of oxide layers is completely unproblematic. i. e. there are no restrictions with regard to biocompatibiliy, hygiene, function or lifetime.

12.6 Metal/Deposits – Discoloration/Loss of color colored plasma layers

Type of surface change

Example: black, TiAIN coated punch. Inside colors, or coat complete removed with undamaged, gilded components (end screw, springs)

Punch: when new

Origin & causes

Surface reaction from cleaning solutions to which hydrogen peroxide has been added, and/or wash solutions, for example those with high alkalinity at pH > 10, combined with temperatures of above 70 °C.
Black titan aluminum nitride (TiAIN) and titan aluminum carbon nitride (TiAICN) layers and products / components originally coated with gold-yellow zirkonium nitride (ZrN) and titan nitride (TiN).

Treatment recommendations

As a result of repair, recoat.

Preventive measures

Use only neutral or mild-alkaline cleaner. Do not exceed a temperature of 70 °C when using alkaline cleaners.

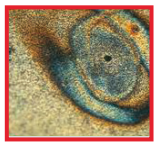
Risk assessment

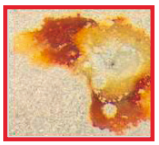
Reduced wearing properties and increased reflection. Note: Because of the extremely strong cleaning effect of such special cleaning programs the friction surfaces of metal instruments must be oiled following each step of cleaning. Otherwise there is a high risk of "metal pitting" or fretting corrosion.

12.7 Metal/Corrosion – Pitting Corrosion

Type of surface change

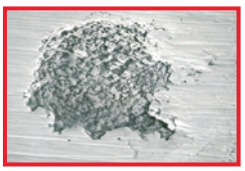
Scissors with pitting





Pitting on tweezers. Causes: Over-aging of color-coding band allows harmful substances containing chloride to infiltrate.

Example of pitting



Pitting - seen under a scanning electron microscope - magnified 200 times

Pinprick-like corrosion holes in stainless steel, frequently microscopically small, surrounded by sparkling, reddish-brown or multi-colored corrosion spots, often associated with circular corrosion deposits around the corrosion hole. (Not to be confused with material-specific cavities or foreign-matter inclusions that may occur in lo-quality instrument steels, or with contact corrosion symptoms when only stainless steel instruments are used.)

Origin & causes

- In stainless steel, caused by exposure to halide ions (bromides, iodides and chlorides), but especially chlorides, that locally break through the passive layer of instrument steel, thus causing pitting.
- Dried-on organic residues, e.g. blood, pus, secretions (see Section 12.1 Metal/Deposits - Organic Residues)
- Frequently pitting is due to the use of liquids with a high chloride content, or more specifically, to dry residues of such liquids adhering to the instrument surfaces, e.g. if the concentration of chlorides in the final rinse water is too high, or if residues of physiological salt solutions remain on the instruments.
- Brand-new instruments are particularly susceptible to attack by media containing chlorides, due to their still thin passive layer. Instruments that have been in use for some time are more resistant to chloride attack, because they have developed a thicker passive layer.

Treatment recommendations

Corrosion products can be dissolved with an acid-based cleaner used in accordance with the manufacturer's instructions. The remaining corrosion holes may be treated mechanically (reworking either by the manufacturer or by a qualified repair service provider).

Preventive measures

Chloride-induced pitting can usually be prevented by using low-chloride concentrations in the water used for reprocessing, and minimizing ins-trument exposure to other liquids containing chlorides, such as

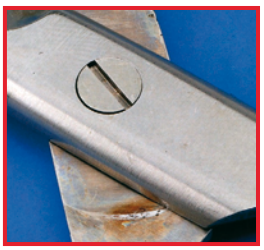
physiological salt solutions.

Risk assessment

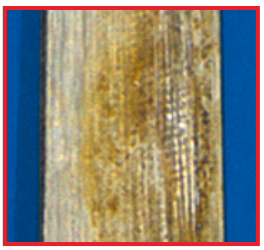
- Severely corroded instruments should be immediately withdrawn from service (and the instrument processing cycle) for reasons of patient and user safety!
- To retain the value of instruments, the causes of pitting corrosion must be eliminated.
- Corrosion holes can pose a hygienic hazard and may lead to stress corrosion cracking as well.

12.8 Metal/Corrosion – Wear Friction Corrosion

Type of surface change



Hinge area in scissors



Bone punch, friction surface on sliding section indicates onset of friction corrosion..

Prevention: Careful treatment with instrument oil

Brown stains/discolorations or rust formation around an area that has been chafed.

Origin & causes

Insufficient lubrication and/or foreign bodies lead to corrosion of the metallic friction surfaces that move relative to each other (especially in locks/joints and sliding paths of for example, punching instruments). This forms micro-abrasion, which can make the surface extremely rough and destroys the passive layer.
In these sensitized areas, humidity or deposits (e.g. blood residues) can easily accumulate - a process that usually leads to corrosion.

Treatment recommendations

- Discard defective instruments or have them repaired where possible
- Regrinding and/or polishing can usually repair corrosion damage.
- Repeated reworking affects the handling/controllability and thus the functionality of the instrument, making it useless.

Preventive measures

- Allow the instruments to cool down to room temperature
- Proper instrument care and servicing: accurately apply a lubricant to the instrument prior to performing the functional check
- Manually apply the lubricant directly to the joint area (using drops or spray)
- Distribute the lubricant uniformly in the joint by opening and closing the instrument in the joint area several times.

Lubricants suitable for instrument care must:

- be based on, for example, liquid paraffin (paraffin oil)/ white oil,
- be in conformity with the currently valid pharmacopoeia.
- It must be vapor-permeable / suitable for steam sterilization at the boundary surface between the material and the oil film.
- Jamming of the joints due to accumulated lubricant must be prevented.

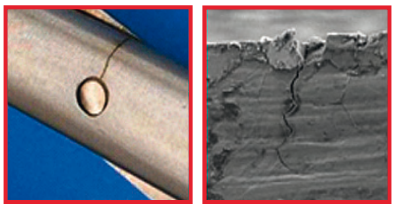
Do not use lubricants on rubber and latex articles, as this leads to swelling.

Risk assessment

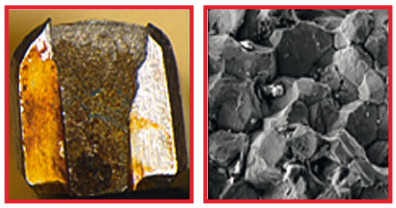
Impairs or completely destroys the instrument's functionality. Fretting corrosion may lead to pitting.

12.9 Metal/Corrosion – Stress Corrosion Cracking

Type of surface change



Detail: Scissors hinge joint with typical intercrystalline crack.



Detail: Jaw clamp with typical grainy, intercrystalline fractured structure.

Electrolytic/anodic stress-crack corrosion (or stress corrosion cracking) usually leads to visible cracks and fractures.

In some cases, crack formation is not visible because its origin is hidden according to circumstances (e.g. in the joint of a pair of scissors), possibly with crack propagation to fracture.

Very frequently, the non-deformed and possibly hidden fracture surfaces are indicative of the growth of the crack (typically associated with corrosion products).

Origin & causes

This type of corrosion often affects areas or components subject to high tensile stress

- due to design and/or manufacturing reasons (such as rivet or screw connections, welded or soldered connections or so-called press fit connections)
- Stress corrosion cracking can also be caused by improper repair (e.g. application of inadmissibly high straightening forces).

- Cleaning/processing the item in a state of high tension (e.g. when the ratchet is fully closed).
- Processing overstressed or strained instruments in a corrosion-promoting environment, especially at higher temperatures.
  The main corrosion cause is water containing chlorides, but surgical residues, drugs and the like must also be taken into account.

Treatment recommendations

None (cannot be corrected)

Preventive measures

- Clean jointed instruments in open position and sterilize them with the ratchet locked in the first tooth at the farthest.
- Reduce the chloride load to a minimum (for example, reduce surgical and drug residues; use only suitable water for cleaning, final rinse and sterilization).
- Avoid improper handling that could lead to overstressing.
- Have your instruments repaired only by the manufacturer or a qualified and specially authorized repair service provider.

Risk assessment

- For reasons of patient and user safety, withdraw affected instruments from service and from the instrument processing cycle at once!
- To retain the value of your instruments, eliminate the cause of corrosion.

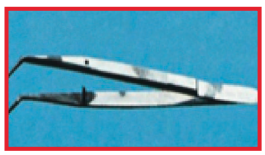
12.10 Metal/Corrosion – Surface Corrosion

Type of surface change

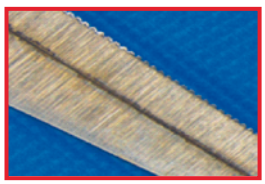
Surface of blade affected due to humidity. Causes: Composition of materials, normal steel, so disposable product.

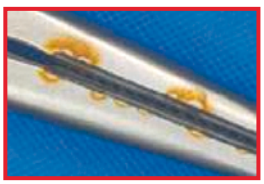
Material affected at partially defective chrome coating. Causes: Humidity causes corrosion to form on unprotected carrier material (normal steel).

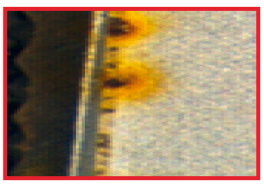
Etching effect on surface of instrument. Causes: Effects of over-dosed acids.



Partial etching effect and deposits of an etching agent causing hemostasis on the surface of the instrument. Causes: contact time too long

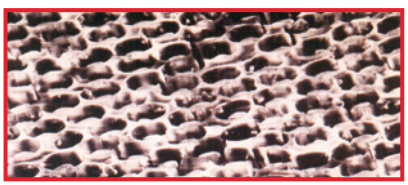






Etching effect on soldered seams. On hard-metal scissors, hard-metal tweezers and needle holders
Cause: Effects of acid due to over-dosing of neutralizing chemicals or due to using acid-based cleaners.

Material affected at aluminum handle
Cause: Unsuitable alkaline cleaner



Detail - optical fiber cable material affected
Cause: Alkaline effect due to non-compliance with the manufacturer's instructions to use a neutral cleaner.

Material affected on natural/colored anodized aluminum surface of containers.
Causes: alkaline washer solution above permitted level

- On stainless steel mostly a uniform, flat-gray surface attack that quite often leads to subsequent damage in the form of corrosive deposits.
- In non-stainless steel products (e.g. disposable products such as scalpel blades, or old instruments not made of stainless steel, typically with damaged or peeled-off chromium surface layers), usually extreme corrosion on a matt black surface.

- In naturally anodized surfaces, whitish-gray corrosion products, with crater formation in cases of strong attack.
- In colored, anodized surfaces, color partially or completely faded, with discoloration and material erosion in cases of strong attack.
- Dark staining and material erosion at soldering points.

Origin & causes

- Chemical and electrochemical influences only in connection with an excessive acid content on
  - Stainless steel
  - Soldered connections
- Long-term impact of water/condensate in the case of stainless steel.
- Effect of acids or too high alkalinity in anodized surfaces, adhesives and optical fiber cables.

Treatment recommendations

- Rust removal through acid-based cleaning in the case of stainless steel if the damage is still superficial, and/or mechanical treatment of soldering points (if applicable) by the instrument manufacturer or a qualified repair service provider.
- If anodized or sintered carbide (TC/Co) surfaces are affected, the damage is irreparable.

Preventive measures

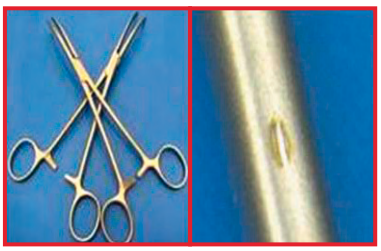
- In the case of soldered instruments always observe the application recommendations when using acid cleaners and neutralizing agents.
- Remove and discard disposable products made of steel or old steel instruments with damaged surfaces, and replace them with stainless steel products.
- Avoid long-term exposure to moisture (condensate).
- Treat instruments with anodized surfaces in a neutral-pH/mildly alkaline environment.

Risk assessment

- If surface treatment proves ineffective, replace the affected instruments with new ones (otherwise there is a risk of subsequent rust formation or film rust).
- Loss of color-coding function in anodized instruments.

12.11 Metal/Corrosion – Contact Corrosion

Type of surface change



Contact Corrosion Stainless steel / stainless steel

Contact Corrosion Stainless steel/brass

- When using only stainless steel instruments, small dot- or ring-shaped, brownish-blue discolorations with slight corrosion in the contact areas can occur. This type of contact corrosion is frequently mistaken for pitting. Upon closer examination however, it becomes clear that there is no hole in the center of the corrosion spot. Rather, the surface structure is slightly rubbed smooth in these places.

Origin & causes

The classic variant of contact corrosion occurs in a material combination involving stainless steel and non-ferrous metals (German silver, brass, copper). Depending on the ambient conditions, e.g. humidity, this generally also leads to corrosion deposits in the contact areas and usually beyond them as well.

When using only stainless steel instruments, contact corrosion has so far been observed only after the machine washing cycle. Microfriction at the contact points leads to partial abrasion of the passive layer. Thus the corrosion protection is temporarily removed in these places, which in turn leads to the surface changes described above.

Treatment recommendations

In the classic material combination stainless steel/brass, when the instrument stock typically contains old and new instruments (old/chromium-plated and new/stainless steel instruments), this type of corrosion occurs during cleaning as well as during sterilization, due to a damaged and/or incomplete chromium or nickel layer (e.g. in the case of hollow handles or retractors).

When only stainless steel instruments are used, there is no need to remove contact corrosion symptoms because such surface changes, due to their low severity (i.e. quantity of deposits involved), pose no risk either to the affected instruments or to other, unaffected items. Experience shows that such surface symptoms usually disappear after a few processing cycles. Acid media (neutralizing agents) usually dissolve these deposits at once, which in turn accelerates the passivation process.

If contact corrosion occurs as a result of protective layer damage in nickel- or chromium-plated instruments, there is usually no remedy. If in doubt, contact the instrument manufacturer.

Preventive measures

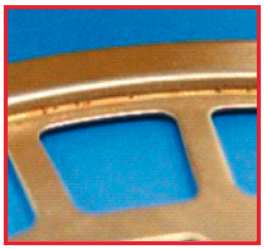
Avoid vibration when cleaning (e.g. ultrasound treatment, machine reprocessing) stainless steel instruments (e.g. by ensuring that the cleaning/disinfecting apparatus, or washer-disinfector, stands firmly on level ground). Replace nickel- or chromium-plated instruments which have damaged (scaly, peeled-off) protective layers, with stainless steel instruments.

Risk assessment

As experience shows, there is no risk for affected or unaffected items when only stainless steel instruments are used, since the low amount of deposits is insufficient to cause damage. Nor is there a patient hazard in this case. However, when both stainless steel and non-ferrous instruments are used, considerable damage can be caused to intact instruments, depending on the extent of the protective layer damage involved.

12.12 Metal/Corrosion – Extraneous and Film Rust/Subsequent Rust

Type of surface change



Left-hand filter holder showing particulate corrosion
Cause: Heavy corrosion on sterilizing chamber results in light and subsequent corrosion damage

- Individual, irregularly dispersed rust particles.
- Brown, mostly locally limited corrosion deposits (rust formation).
- Given large-surface contact with very rusty products, subsequent damage in the form of "instrument impressions" may occur.

Origin & causes

- Rust particles carried over from the pipework.
- Use of water containing iron or rust, or use of steam containing rust particles.
- Corrosion products (rust) that adhere to non-corrosion-resistant disposable products such as scalpel blades, may be dislodged during the sterilization process and dispersed over other instruments.
- Continued use and reprocessing of non-corrosion-resistant steels (often old instruments) whose protective layer has been damaged or completely dislodged.

Treatment recommendations

Given a slight and only superficial attack, removal of the deposits with acid-based cleaning may be an option (only for stainless steels), but it is necessary to check afterwards whether the instrument surface is still intact.

Provided the damage is still superficial, it may be possible for the instrument to be treated mechanically (reworked) by the manufacturer or a qualified repair service provider.

Preventive measures

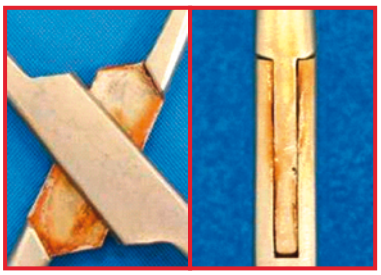
- Disposable items made of steel must not be reprocessed. (no reuse!)
- Discard, or treat separately, any non-stainless instruments and materials.
- Avoid using cheap products (e.g. accessories available in do-it-yourself chains).
- Carry out effective construction measures to prevent pipework rust particles from entering the cleaning and sterilization stages (e.g. by filtering the feed water mechanically before it enters the washer or sterilizer).

Risk assessment

- A single rusty instrument may be enough to cause subsequent corrosive damage in all of the instruments contained in the tray.
- If rust particles are carried over from the pipework, many of the instruments processed may be affected and thus lose value).

12.13 Metal/Corrosion – Crevice Corrosion

Type of surface change



Hinge area - clamp

Joined area - tweezer ends

- Since crevice corrosion is a locally-accelerated type of corrosion, it leads to corrosion deposits only in crevice areas (e.g. in the joint crevice of the two halves of a pair of forceps, in joint gaps or in pressed-in or screwed-in working ends in the case of probes, for example). Crevice corrosion can also occur in gaps between metal and other materials.
- Frequently residues (particularly organic ones) are mistaken for crevice corrosion

Origin & causes

- Crevice corrosion tends to occur in gaps of critical width if the prevailing ambient conditions are favorable (e.g. insufficient drying). Under these conditions the passive layer is vulnerable to attack. It can no longer regenerate, as the oxygen supply to the metal surfaces is impeded. The rust then works its way out of the gap or crevice.ult, rust formation will occur in the presence of humidity and higher salt concentrations.

Treatment recommendations

- Treat affected instruments in accordance with the manufacturer's directions.
- Mechanical treatment (reworking) of the instrument by the manufacturer or an authorized repair service.

Preventive measures

- Remove coarse dirt immediately (RKI recommendation: "The single most important measure for preventing this type of corrosion is the adequate drying of narrow joint crevices").
- Use rinsing water with a low salt content (preferably fully demineralized water).

Risk assessment

Spread of rust to other instruments is usually excluded. In severe cases, however, the rust might affect intact instruments and cause subsequent damage there as well (see also "Extraneous and film rust/subsequent rust").

12.14 Plastic/Rubber – Aging

Type of surface change

Aging tear in a breathing mask

- Brown stains/discolorations, and possible crack formation, in rubber and latex products.
- Softening or hardening.
- Many plastic materials turn yellow or become brittle.
- Silicone elastomers are extremely resistant to aging but tend to turn yellow.

Origin & causes

- Dry heat impact.
- Straining and overstretching during storage.
- Sunlight, UV radiation.
- Oxygen impact (oxidation, true aging).
- Ozone impact.

Treatment recommendations

None (cannot be corrected)

Preventive measures

If possible store instruments in dark and cool conditions.

Risk assessment

If the changes are application- and/or risk-relevant, withdraw affected instruments (depending on aging condition)

12.15 Plastic-phenolic resin/Harex – Aging and Fading

Type of surface change

Chisel handles
New: shiny-medium brown
Aged: matt dark brown

Hollow guide probe; surface as new: shiny-medium brown faded: faded to matt white

Possible replacement for Harex: PEEK or PPSU

Origin & causes

Aging: many years of use, preferably in combination with the use of disinfecting solutions.
Fading: Treatment in cleaning solutions with hydrogen peroxide additive.

Treatment recommendations

Not possible in either case. However when possible, when ordering new supplies change to instruments containing resistant plastics.

Preventive measures

Not possible in the case of aging. Fading can be avoided by using cleaning agents containing no oxidating additives.

Risk assessment

No need - cosmetic effect.

12.16 Plastic/Rubber – Swelling

Type of surface change

Swollen insertion tube caused by using unsuitable care agent.

Right: Swollen seals caused by incorrectly applied instrument oil.
Left: New seals

Right: Leaking flap valve on a trocar caused by the seal swelling as a consequence of contact with oil.
Left: New flap valve

- Swollen, softened, sticky surfaces of plastic, rubber or latex products.
- Thin-walled parts can split open or burst.
- Material becomes brittle and hardens.

Origin & causes

Penetration of gases or liquids into the surface. Swelling can be reversible and temporary if due to the impact of volatile spray solvents or propellants. The same symptom can also occur if rubber or certain plastics come into contact with gaseous anesthetics. However, irreversible swelling can be caused by contact with oils (paraffin oil), Vaseline and unsuitable

disinfectants (e.g. phenol derivatives). Silicone rubber shows a reversible reaction to spray propellants and gaseous anesthetics, but irreversible damage is caused by silicone oils, solvents and some disinfecting agents (e.g. amines).

Treatment recommendations

None (cannot be corrected)

Preventive measures

Avoid contact/exposure, depending on material (see "Origin & causes").

Risk assessment

Depending on degree of swelling, stop using affected instruments if existing surface changes are application- and/or risk-relevant.

12.17 Plastic – Stress Cracks

Type of surface change

Stress crack

Stress-crack corrosion, e.g. in polysulphone, leads to visible cracks or fractures.

Origin & causes

Stress cracks tend to occur in those areas of a medical device in which increased internal stresses are present for manufacturing reasons.

Under specific instrument processing conditions (e.g. insufficient rinsing, high temperatures, presence of certain surface-active chemicals), cracks tend to develop in these areas.

Treatment recommendations

None (cannot be corrected)

Preventive measures

Do not use process chemicals that favour the formation of stress corrosion cracking. Ensure a sufficient final rinse with demineralized water. The manufacturer's processing instructions must always be followed.

Risk assessment

Affected instruments should be withdrawn from service (and the instrument processing cycle) at once for reasons of patient and user safety!

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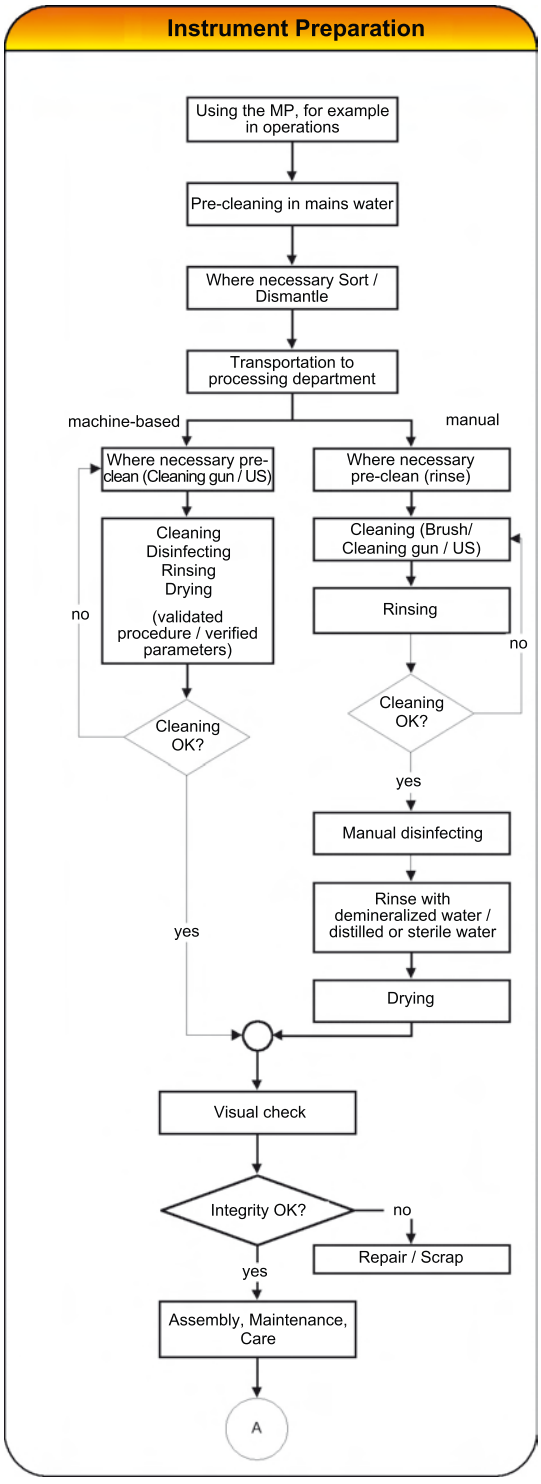

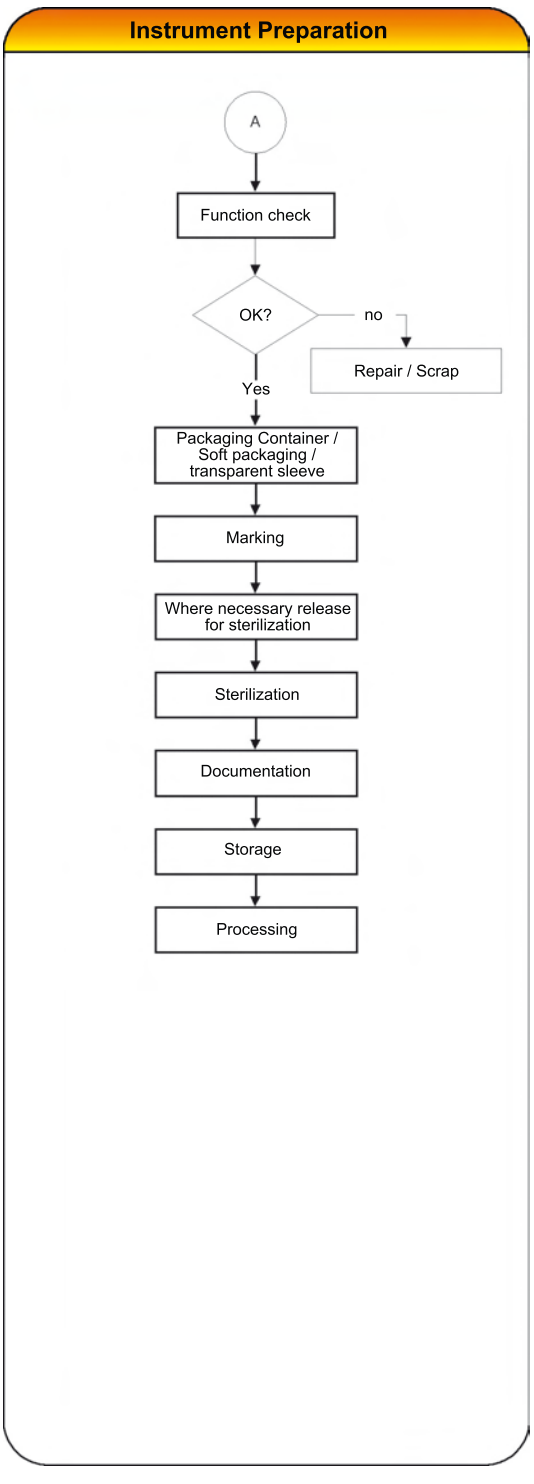

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