

FISH TANK PROCESSING

in Animal Facilities

properly done

Arbeitskreis
Käfigaufbereitung
(Working Group for
Cage Processing)
1. issue 2020

AK

KAB



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1 Introduction

The work group cage processing (WG CP, AK KAB) has made it their aim to provide a guideline for planning, procuring, and operating aquatic processing systems and single components. Thus planners, manufacturers, and users alike are addressed in this brochure.

In aquatic animal facilities, it is necessary to process tanks, tank lids, breeding tanks, accessories, hand nets, transport trolleys, work clothes and other equipment. To process all the items as safely and efficiently as possible, technical quality is essential. It is also important that the systems in use can be handled conveniently and all individual components interact smoothly. The processing procedure is often done in a room close to the aquatic animal facility or in centrally located processing areas.

Considering the complexity of the processing procedure, including potential interface issues, and the high hygienic standards required for processing, it is necessary to standardise the procedure and concretise the structural requirements.

For fish tanks, it is recommended to use specific cleaning systems and process chemicals. Sharing cleaning systems, for example for rodent cages, is not advisable.

When designing the most important processing item – the tank – the first and most crucial factor to consider is the animal. Further requirements are defined by occupational health aspects and economically efficient work procedures.

The following chapters provide information on:

- Processing cycles for fish tanks and accessories
- Requirements of the processing items
- Tank processing procedure step by step
- Structural requirements
- Operation and operating
- Rating the performance of cleaning stations
- Ecological requirements
- Frequent defects and material damages
- Literature, standards, publications
- Terms / definitions

In the available first edition of this brochure, the WG CP (AK KAB) focuses on the processing of zebrafish tanks, frequently used in research, that are easy to handle and automatically processable. The brochure also includes aspects of processing larger tanks that are used for zebrafish but mostly for other species and require manual processing to some extent.

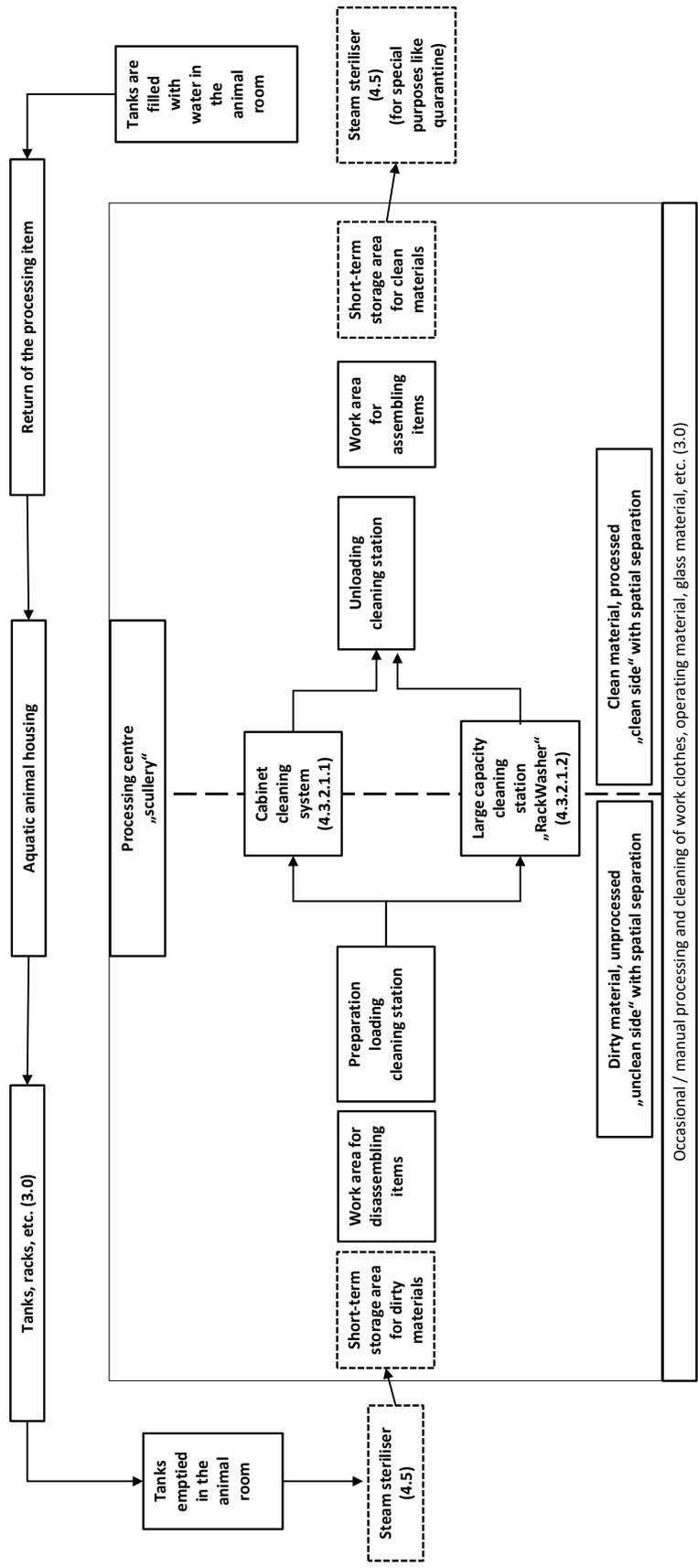
For additional information, especially regarding issues that are of minor importance for aquatic animal housing, the reader will, in some chapters, be referred to the “orange” WG CP (AK KAB) brochure, which focuses on rodent facilities.

2 Tank processing cycles

The following figure shows the interaction of components and functions when tanks are processed in a processing centre.

Fig. 2-1: Processing cycle in a processing centre

Note: Dashed boxes can be but do not have to be part of the processing cycle as shown below.



3 Processing equipment requirements

After depicting the processing cycle in chapter 2, the items to be processed in this procedure shall now be described. Information will be provided on material, range, and design of the items. Automatic processing will be of main interest.

3.1 Product overview

Below you will find a list of items commonly used for automatic processing:

Table 3-1

Synthetic materials	Metals	Glass
Tanks	Tanks	Tanks
Spawning boxes	Mobile work and laboratory benches	Breeding bowls
Feeding bottles	Storage and transport racks	Enrichment products
Filter material (bag filter, pads)	Accessory baskets	
Hand net	Cartridges for drum filters	
Enrichment products		



Fig. 3-1: Examples of how to load a cleaning station from practical experience

Please note: Other than shown in the above table, it can be necessary to process the listed items manually for either technical or economic reasons (low utilisation or lack of funding).

The following items usually undergo a manual processing only:

- Components of aquatic processing systems
- Built-in tanks and aquatic housing racks
- Breeding systems for food animals
- Mass spawning systems

The following items can be used for aquatic animal facilities, although their use is not imperative. Information on processing these items can be found in other publications, for example in "Veterinary Instrument Processing" ("Green Brochure"), please see chapter 10:

- Surgical instruments and operating tables
- Components for automatic feeding systems
- Ladders and footstools
- Computers
- Microscopes
- Power tools

3.2 Product material

When determining the requirements of a processing item, individual data and conditions are of key interest. Depending on the mechanical, thermal, and chemical resistance as well as on the frequency of the material turnover, the handling of individual items can vary significantly.

Below you will find a description of commonly used materials and their most important characteristics.

3.2.1 Synthetic materials

The following synthetic materials are generally used:

- Polycarbonate (PC, e.g. Makrolon®)
If the release of Bisphenol-A during steam sterilisation is not permissible or desirable, it is advisable to avoid processing items made of polycarbonate.
- Polysulphone (PSU)
- Polyvinyl chloride (PVC-U)
- Polyethylene (PE)
- Polypropylene (PP)
- Polystyrene (PS)
- Acrylic polymer
- Elastomers (e.g. silicone)
- Acrylonitrile butadiene styrene copolymer (ABS)
- Composites (glass fibre reinforced material, e.g. Trespa®)
- Miscellaneous materials for wheels and casters (see chapter 4.1)

In fish tanks, polycarbonate, polysulphone, and silicone (moulded parts) are generally used. Below you will find a table showing the characteristics of those synthetics:

Table 3-2

Material	Steam sterilisable up to ¹	Characteristics ¹
Polycarbonate	121 °C	<ul style="list-style-type: none"> • transparent, clear, or slightly tinted • increased wear when sterilised on a regular basis (see chapter 9) • problematic with alkaline residue (see chapter 9)
Polysulphone	134 °C	<ul style="list-style-type: none"> • transparent, or slightly tinted • suitable for frequent sterilising • physically and chemically high-resistant • problematic with usage of unsuitable rinsers (see chapter 9)
Silicone (moulded parts)	143 °C	<ul style="list-style-type: none"> • transparent, or coloured

¹Please note: The above-mentioned data is meant as a rough guideline. For product-specific questions, please follow the manufacturer's instructions.

3.2.2 Glass

There are two types of glass that must be distinguished, silicate glass and acrylic glass.

In glass fish tanks, so-called "float glass" is generally used. It has a very hard surface and is more scratch resistant than other glasses.

When steam sterilising glass tanks, it is important to consider that the glass panes are often sealed with silicone. In this case, it may be necessary to use lower temperatures.

According to glass tank manufacturers, however, no limitations regarding temperatures (within a range of -40°C to 120°C) or chemical qualities (high resistance to acids and leaches) are to be expected when putting glass tanks with applied silicone into washing systems.

Many fish tanks are made of acrylic glass. The synonymously used „Plexiglas“ is a trade name for acrylic glass (chemical name: polymethyl methacrylate, short PMMA), owned by Evonik Röhm GmbH.

PMMA is well malleable and tintable and can be joined by gluing or welding. It is weatherproof and non-aging as well as resistant to acids and leaches of average concentration. It is also more translucent than silicate glass. To avoid stress crack corrosion, however, acrylic glass must not be cleaned with alcohol or solvents.

3.2.3 Stainless steel

Stainless steel is often used and well suitable for processing items in aquatic housing. Usually, so-called “V2A-steels” are used (1.4301, AISI 304, X5CrNi1810) or with tank systems „V4A“ (1.4404, AISI 316L, X2CrNiMo17-12-2). Decisive in all cases is the machining and working of the steel, especially the pre-machining and finishing of welds and surfaces.

Stainless steel, however, meet its limits when it encounters chlorides (e.g. chlorinated disinfectants, see chapter 9.5) or evaporated chlorinated tank water. To avoid this and to achieve optimal corrosion resistance, aquatic racks are powder-coated.

3.2.4 Other materials

For other materials used in aquatic housing, like earthenware pipes or snail shells, users or manufacturers must define specific requirements.

3.3 Information on the design of processing items

Regarding the design of processing items, the following aspects should be considered:

- Sharp edges are dangerous for humans and animals; they can be avoided by being deburred.
- Voids are difficult to clean and can be avoided, for example, with seal-welded tube frame designs.
- „Absorbing voids“ should be avoided, if possible, without causing functional limitations.
- A joint-reduced design is advisable to avoid dirty corners (hygiene) and capillary actions (drying).
- Flat surfaces are recommended for easy cleaning and drying.
- Ergonomic aspects should be considered.
- Items should be stackable for effective use of transport and storage facilities.
- The design should be maintenance-friendly, for example by providing easy access to filters and other components.

4 Tank processing step by step

4.1 Transport and storage systems

For cleaning and sterilisation, where necessary, all processing items must be brought out and back into the aquatic animal rooms. In this process, the items are moved constantly. They are transported one-way to all areas (aquatic animal rooms, hallways, processing centre) where they are briefly stored. The so-called transport and storage trolleys employed for this task are usually cleaned and disinfected manually only.

Below you will find a description of the general requirements, materials, and designs of transport and storage systems.

4.1.1 General requirements of the transport and storage systems

To ensure a smooth workflow, transport and storage systems used in aquatic animal facilities should meet the following requirements:

- The transport and storage systems should match the entire facility system (doors, lifts, cleaning stations, sterilisers, where necessary, and locks) and be suitable for the processing items (see chapter 3).
- The systems should be well planned; to this end, transport and storage capacities should be examined in advance. When choosing appropriate transport and storage systems, manufacturers should be contacted for assistance. The handling of the systems should be easy and convenient for a single person.
- The systems should be resistant to detergents and disinfectants (see chapter 9).
- They should be designed for universal use, for storage and transport purposes, and, if needed, as workbenches in the animal housing area.
- They should have high, waterproof walls on all four sides to prevent the stacked tanks from overturning, to ensure safe transport and retain residual water in the tanks.

4.1.2 Examples of commonly used transport and storage systems

Table 4-1

Types	Common measurements (HxWxD in mm)	Transport and storage of
Universal transport and storage trolley	1.500 - 1.900 x 500 - 600 x 1.000 - 1.500	Various processing items <ul style="list-style-type: none"> • open tanks and their lids stacked • closed tanks • accessory baskets



Fig. 4-1: Examples of universal transport and storage trolleys

4.1.3 Materials

Due to high mechanically, thermally, and chemically induced material strain, especially during cleaning, stainless steel is a material often used and well suited for transport and storage trolleys (see chapter 3.2.2).

For wheels and fenders (collision protection), several synthetic materials are appropriate. Often used are wheels made of glass fibre reinforced Nylon® or polyvinyl sulfone (soft, smooth running) or Bakelit® (harder, loud wheel and driving noise, but thermally higher resistant).

4.1.4 Design and structure

Please consider the following important aspects of transport and storage systems, depending on their type of use:

- Wheels and fenders must be thermally and chemically resistant to avoid damages during the cleaning, disinfection, and sterilisation process.
- The total structure, and wheel structure in particular, must withstand the process-induced strain during cleaning and disinfection (maximum load to be calculated).
- Height adjustable planes ensure a flexible use.
- Wheels, handbrakes, and fenders, as well as other movable parts (wear parts) should be easy to change.
- If lifts are used for transport, large-dimensioned wheels (100 mm diameter plus) are necessary to avoid issues and accidents caused by the gap between lift car and floor. For occupational safety reasons as well as to prevent wheel damages, large gaps are not advisable.

In addition to that, please pay attention to the information given on design in chapter 3.3.

4.2 Emptying components

To minimise the amount of dirt being carried over into a cleaning chamber, tanks must be emptied prior to being cleaned in the cleaning stations, as described in chapter 4.3. The way of emptying tanks varies, depending on their size and system. Generally, tanks are being emptied of water, possibly mixed with used enrichment products, and remaining feed.

Below you will find a description of components that allow for a convenient, efficient, and, most importantly, safe emptying of smaller synthetic tanks.

When processing dirty tanks, it is necessary to first clean the tanks from thick residues of feed and faeces to avoid heavy foaming which can lead to a significantly reduced cleaning result. This is particularly the case with automatic processing.

4.2.1 Emptying of tanks

4.2.1.1 Sanitary aspects

Used water can cause several potential health issues. There is a risk of germ infections caused by exposure to animal faeces, as well as a risk of generating allergens caused by feed remains sticking to tank lids.

Another important aspect to consider is the human musculoskeletal system. Constant repetitious work like the manual emptying of tanks often leads to muscular tensions and chronic afflictions of the back, neck, and shoulder area.

The effects of repetitious work, comparable to emptying tanks, as well as possible preventive measures have been examined in scientific studies. For further information, please see chapter 10.

Aquatic animal facilities are wet areas. Damp or wet floors have to be expected at all times. It is advisable to wear protective clothing like slip-resistant or nonslip shoes and waterproof aprons. Working with protective gloves in aquatic areas has benefits but also disadvantages. Before using them, a thorough risk assessment should be carried out, also regarding a potential dermal transmission of germs between human and animal, so-called zoonosis.

4.2.1.2 Handling of dirty water

When handling tanks, wearing the work clothes specified in the risk assessment (e.g. gloves) should be mandatory. Before emptying the used tanks, the transport systems described in chapter 4.1 should be moved next to the utility sinks and locked. Enrichment products must be removed prior to emptying the tanks.

4.2.1.3 Design of utility sinks

In aquatic animal facilities, the cleaning stations are often outside the animal housing area. As transporting full tanks is difficult, tanks are being emptied within the housing area prior to being processed in the cleaning stations. The room around the utility sinks should be spacious enough for a comfortable parking of stacked tanks.

Please note when working with transgenic S1 fish lines: To avoid contamination of wastewater with S1 organisms (particularly fish larvae of transgenic fish lines), the plugholes must be covered with net inserts that are removable, fine-meshed, and easy to clean. Alternatively, after consulting the relevant authorities, other methods can be used (e.g. thermal inactivation) to clean the wastewater from all transgenic organisms.



Fig. 4-2: Utility sink in use



Fig. 4-3: Net insert; removable and easy to clear

Size: Ergonomic working heights are set between approximately 800 and 900 mm. Reasonable sink dimensions, depending on the size of the tanks, vary between 600 and 800 mm in length and 600 and 1.000 mm in width. Sinks must also be deep enough (e.g. 500 mm) to avoid water gushes.

Structure: Sinks should have soft joints to avoid dirty corners.

Material: Stainless steel (material 1.4301 or more significant) and polypropylene offer the greatest advantages regarding durability and cleaning.

Cleaning: The design of the sink should allow for a convenient cleaning. A general cleaning should be done daily, an intensive cleaning weekly.

4.3 Cleaning / Rinsing / Drying of tank parts

4.3.1 Manual cleaning of tanks

Permanently installed tanks and tanks that are too large for automatic cleaning stations must be cleaned manually. This applies to glass tanks in particular.

Generally, there are two ways of manual cleaning:

1. Cleaning during operation; this means the cleaning is done while the animals are present in the tanks.
2. Cleaning while the animals are absent.

In recirculation systems, it must be avoided that dirty water, possibly polluted with cleaning chemicals, flows back into the water cycle.

Cleaning during operation

Tanks should be cleaned at the latest when algal or biofilm growth is discernible.

There are special sponges available, some with blades, to remove firm encrustations. To avoid damages (scratches) during cleaning, it is important that cleaning sponge and tank material are compatible.

Some laboratories use water snails to remove algae from the tanks. It must be ensured, however, that the snails are from controlled, pathogen-free breeds to rule out a possible transmission of pathogen germs.

Cleaning while animals are absent

Other than during operation, special chemicals can be used for cleaning when the animals are absent. In this case, the guidelines of tank manufacturer and chemicals manufacturer should be followed.

There are several steps to the cleaning process:

1. Emptying the tank
2. Disconnecting or isolating the tank, if a circulation system is used
3. Cleaning the tank, with detergent where applicable
4. Suctioning out the dirty water / detergent
5. Rinsing
6. Screening for cleaning residues

4.3.2 Cleaning machine requirements

The function of cleaning machines in the processing centre of an aquatic animal facility is to clean and decontaminate, where necessary, used processing items (see chapter 3), pursuant to user-specific standards and conditions. This cleaning process is carried out with suitable process chemicals following an effective and standardised cleaning procedure that consists of a cleaning with re-used detergent solution (so-called detergent liquor) and an imperative freshwater rinsing. The materials of the cleaning stations and dosing systems must be resistant to the process chemicals used to remove soiling in aquatic systems.

Depending on the degree of soiling and the efficacy of the cleaning station, a manual pre-cleaning can be necessary.

Below you will find a description of the most important machine types, process steps, and technical components of automatic processing.

4.3.2.1 Machine types and their common structure

In the processing cycle (see chapter 2) you will find a description of the different machine types that can principally be used for cleaning processing items.

Conveyor washers require a lot of space and personnel and would only be economically feasible with a high number of processing items, approx 10.000 fish tanks per week. Most aquatic housings, however, have smaller weekly numbers, which means conveyor washers are rarely used and thus not listed here.

Table 4-2

	Common processing items	Common dimensions of effective cleaning chamber (h x w x d in mm)	Common overall dimensions of a unit (h x w x d in mm)	Number of doors
Cabinet cleaning systems (front loader or hood machine)	Tanks Accessories	600 - 800 x ca. 1300 x 600 - 800	1700 - 2000 ¹ x 1400 - 1900 x ca. 1000	1
Large-capacity cleaning station	Tanks on special loading racks Accessories	ca. 2100 x 900 - 1200 x 1800 - 3000	2500 - 3100 x 2200 - 3500 x 2300 - 3500	1 / 2

¹ Height when closed. Machines with vertically opened hood / door can measure up to 3000 mm.

4.3.2.1.1 Cabinet cleaning systems for tanks

Below you will find common designs of cabinet cleaning systems:

- Cleaning systems with front doors (sliding or hinged doors)
- Cleaning systems with hoods for opening the top



Fig. 4-4: Cabinet cleaning system for tanks with sliding door



Fig. 4-5: Cabinet cleaning system with hood (additional pre-rinse and unloading tables where necessary)

These stations work discontinuously, which means they work in batch mode. They usually come with one door in either swing, sliding, or hinged door design. The hood or door opens either manually or automatically.

4.3.2.1.2 Large-capacity cleaning station

This machine type allows for a cleaning of tanks on special loading racks. It provides flat floor access, which means the machine is either placed in a pit or accessible by ramps.

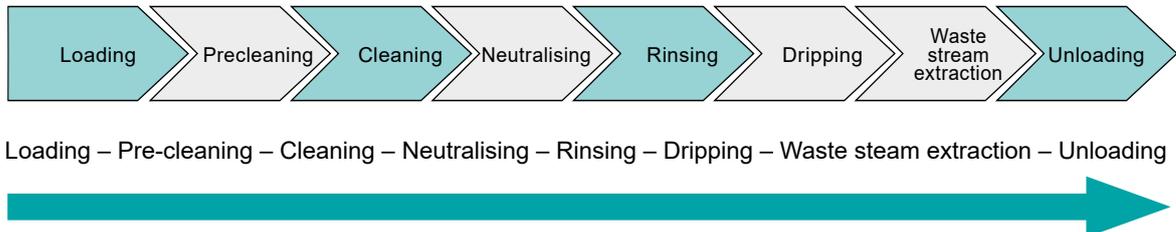
These stations work in batch mode. They come with one or two doors, for example as drive-through cleaning stations that separate dirty section from clean section, with doors in either swing, sliding, or hinged design. The door opens either manually or automatically.



Fig. 4-6: Large-capacity cleaning station for racks, tanks, and transport systems

4.3.2.2 Process steps of an ideal automatic cleaning procedure

The primary goal of processing should be a clean and residue-free tank that can go back into the animal rooms without causing any harm.



Loading – Pre-cleaning – Cleaning – Neutralising – Rinsing – Dripping – Waste steam extraction – Unloading

Fig. 4-7: Necessary (light green) and potentially required (grey) process steps of automatic cleaning procedures

Loading

Loading means that the cleaning items are placed on loading trolleys in cabinet or large-capacity cleaning stations. Loading also includes the moving of loading trolleys into the cleaning chamber.

For an optimal cleaning of items, it is necessary to follow the provided loading guidelines.

Pre-cleaning

When tanks are heavily soiled or encrusted (biofilm or algae), an automatic pre-cleaning will highly improve the cleaning result. It is also recommended in addition or in preference to a manual pre-cleaning.

Cleaning

Hot water from a tank mixed with detergent is sprayed on the processing items via nozzle assembly. In large-capacity washers for tanks, the detergent liquor is collected in a collecting tank beneath the cleaning chamber. From there, it is pumped back into the cleaning tank. In cabinet and conveyor belt cleaning machines, the water is collected in the cleaning tank which is placed underneath. By circulating the detergent liquor, the cleaning items can be sprayed with a high-volume flow without feeding fresh water.

To reduce the amount of water, the detergent liquor is re-used in large part for subsequent charges and only a small amount of liquor is renewed.

(For information on discharging non pH neutral and / or hot wastewater, see chapter 5.2.6)

Neutralising

To make sure there is no residue left, surfaces cleaned with alkaline detergents should be neutralised with an acid process chemical. The neutralisation follows directly after the cleaning and prior to rinsing the items.

(For information on discharging non pH neutral and / or hot wastewater, see chapter 5.2.6)

Rinsing

Any detergent residues are removed with clear water that is sprayed on the cleaning items via rinsing nozzles. To avoid lime or salt stains on the items, it is advisable to use deionised water.

When cleaning tanks, the use of rinse aids must be avoided to rule out potentially adverse effects on the animal and on the experiment. (Please note: Rinse aids stay on surfaces, as they are intended to.)

Dripping

To reduce the amount of water necessary for rinsing off the detergent, it is helpful with cabinet and large-capacity washers to let the detergent drip off the tanks' surface. This is achieved after a sufficient waiting period.

Waste steam extraction

To lower the humidity in the washing chamber, it is recommended, in addition to dripping, to have cooler or dryer ambient air sucked into the washing chamber and release the chamber air into the outside exhaust air. This way, the discharge of moist air in the ambience is also reduced.

By extending the duration of discharging waste steam, the washer will be dried to a certain degree.

Unloading

Unloading means the cleaning items are taken out of the cleaning chamber.

4.3.2.3 Technical components

Cleaning chamber

Every surface of the cleaning chamber that encounters processing items should be flat and have round corners. Dead spots and gaps should be avoided. To make sure the processing liquids run off completely and to avoid residues in the cleaning chamber as well as in the cleaning and rinsing tanks, a sufficient incline of the surface is recommended.

Apart from imperative devices like guide rails, nozzle holders, and splash water pans, components that are not necessary inside the chamber like water pipes and pumps should not be built in. For hygienic and maintenance reasons, these components should be placed outside the cleaning chamber.

To stop dirt particles from getting into the circulation system, which might cause a clogging of the nozzles, fine-meshed strainers are to be considered in the drain-off area of the cleaning chamber. For cleaning purposes, the strainers should be easily accessible, ideally from outside the cleaning chamber.

Modern cleaning stations are equipped with self-cleaning filters that extract any dirt particles continuously and automatically from the cleaning station.

Every junction, gasket, or grommet of the splash-proof cleaning chamber must be chemically resistant to the process chemicals in use. Furthermore, all components should be made of stainless steel (material 1.4301 or more significant) or suitable synthetics to ensure they are temperature-resistant and mechanically resistant.

The exterior walls of the cleaning chamber as well as the cleaning and rinsing tanks should meet – if applicable – the required DIN 4140.

In the table below you will find further characteristics of cleaning chambers:

Table 4-3

Cabinet cleaning machine for tanks	<ul style="list-style-type: none"> • one or two loading levels • application of several attachments (e.g. insert baskets, carrier for cleaning items, etc.)
Large-capacity cleaning station for tanks	<ul style="list-style-type: none"> • chamber floor layout for flexible use of loading trolleys with different track widths • interior light • emergency shutdown device with door release unit in the cleaning chamber

Cleaning and rinsing tanks

Regarding form, design, and choice of material, cleaning and rinsing tanks should meet the same requirements as cleaning chambers. Depending on the machine type, the tanks can be placed beneath, above, next to, or inside the cleaning chamber. There can be several tanks necessary, depending on the type of cleaning procedure and machine.

Nozzle systems

For a successful cleaning, the nozzle system is crucial. It must ensure that a sufficient amount of detergent solution and rinsing water in particular is spread across each processing item. With cabinet cleaning machines and large-capacity cleaning stations for tanks, it is advisable to have nozzles mounted on flexible spray arms to avoid spray shadow. For an optimal cleaning performance, nozzle pressure and pump volume flow must be adjusted to the capacity and size of heat exchanger, washing and rinsing tanks, and metering devices. Only a thorough and careful implementation of these measures will lead to an effective, safe, and repeatable cleaning result.

The nozzles are usually made of stainless steel or synthetic material. They can be fed through either one or two pipe systems.

The following factors are decisive for a successful cleaning:

- Number, arrangement, and design of the nozzles
- Spray pressure
- Volume flow rate (e.g. litres per minute) of the detergent solution
- Spray and tilt angle of the nozzles
- Nozzle motion, e.g. oscillatory, rotary, linearly moved or fixed
- Cleaning-friendly nozzle systems, e.g. screwed-in nozzles, removable nozzle arms

Loading systems

In cabinet cleaning machines for tanks, the processing items are placed on different loading levels. To ensure that all liquids drip off the surfaces sufficiently, it is generally beneficial, especially with tanks, to put them in a slightly tilted position. Given the variety of processing items, usually item-specific loading attachments are required.

In large-capacity cleaning stations for tanks, the processing items are moved into the cleaning chamber on special loading trolleys via flat floor access. To avoid spray shadow and to ensure an effective cleaning, the processing items must be fixed on the trolleys in a suitable position, adjusted to the nozzle arrangement. Given the variety of processing items, usually item-specific loading trolleys are required.

Loading attachments and loading trolleys should be made of stainless steel (e.g. material 1.4301) or suitable synthetic materials. The casters must be resistant to process chemicals and operating temperatures. For hygienic reasons, voids and dead spots should be eliminated through suitable structural considerations.

Machine cladding

The cladding of the cleaning machines consists preferably of stainless steel with a conventional surface treatment (e.g. grinding). For maintenance purposes, the entrance to the aggregate area should be of sufficient size. The cladding parts therein should be designed as doors or should otherwise be easy to open and remove.

Aggregate and maintenance area

The necessary pumps, pipes, valves, tanks, metering devices, etc. are placed in the aggregate area that can vary in design, depending on the machine type.

It is important, however, that the built-in units are arranged clearly and maintenance-friendly.

Process measuring and control technology (pmc)

Machine control

Cleaning machines should run a complete program automatically. The required program is selected on a control panel (installed on the loading side or on the control cabinet, e.g. keypad, touchscreen). It is recommended to build in programmable logic controllers (plc) or microprocessor controllers. This way, a change in process parameters (also password protected) is possible, if needed.

Displays and monitoring

Cleaning machines should be equipped with control and display instruments for the following parameters:

- Operator-selected program
- Adjusted parameters
- Process steps of the operating sequence
- Remaining program time
- Temperatures of detergent solution and rinsing water
- Temperature of the cleaning chamber
- End of program when in batch mode
- Empty or fill level signal of the process chemical (canisters or barrels)
- Notice of malfunction

Safety-related components

Cleaning machines must be equipped with safety installations according to the VDE (German Association for Electrical, Electronic and Information Technologies) and meet the requirements of government safety organizations, where applicable. Machines must further have the CE mark of conformity (please also see risk assessment of the operator in chapter 6.4 of the orange WG CP (AK KAB) brochure).

Safety installations include a well accessible emergency shutdown device and, for large-capacity cleaning stations, chamber doors with locking devices to prevent them from being opened when a program is run. This is necessary to protect the operating personnel and to prevent hot steam from leaking into the working rooms. Also, an emergency release inside walk-in cleaning chambers is recommended as well as a device for program interruption when the chamber is opened during operation.

Control cabinet

All electronic and control-related components as well as pushbuttons, signal lamps, etc. must be placed in a splash water protected control cabinet with protection category IP 54 or higher. All electric utilities built in the aggregate area must be designed according to protection category IP 54 or higher.

4.3.2.4 Documentation

The papers accompanying a cleaning machine should be supplied in the language of the respective country and should consist of the following documents:

- Manual with maintenance instruction and troubleshooting
- Electrical plan
- Process scheme
- List of spare parts

The supply lines, disposal lines, equipment, and other building measures required for those machines are described in chapter 5.

4.3.3 Process chemical requirements

Process chemicals and their specific characteristics must be suitable for cleaning machines and their operation purpose. To avoid damages of the processing items listed in this brochure as well as of the cleaning machines, only process chemicals that were developed specifically for aquatic systems and are thus verifiably suitable for the here described cleaning process must be used.

It is advisable to meter process chemicals automatically from the delivered container, e.g. canister or barrel (see chapter 5.5 of the orange WG CP (AK KAB) brochure.)

In detail, process chemicals must meet the following requirements:

4.3.3.1 Process chemicals

The process chemicals must be adjusted to the described technical conditions of the cleaning machines, where necessary; they must not cause any interfering foam or deposits (see chapter 4.3.1 of the orange WB CP (AK KAB) brochure). To avoid health hazards when handling process chemicals, the manufacturer's instructions on the safety data sheet must be followed.

4.3.3.1.1 Detergent

Alkaline detergents combined with H₂O₂ containing detergents have proved successful.

For certain applications, e.g. increased algal growth, alkaline detergents containing active chlorine can be used. Active chlorine, however, is potentially hazardous to health and when used must be sufficiently rinsed off the surface of the tanks to rule out any risk for the animals.

4.3.3.1.2 Neutraliser

Acid neutralisers can be used to help remove alkaline detergents. Depending on the case of operation, acid process chemicals can help avoid water salt deposits on the processing items.

4.3.3.1.3 Rinse aids

Rinse aids must not be used in the cleaning process of aquatic tanks. Any residues of cleaning chemicals must be safely removed through sufficient rinsing with deionised water.

4.3.3.2 Characteristics and physical parameters

4.3.3.2.1 Material compatibility

When used under correct service conditions, the process chemicals should not cause corrosion or other material damages within the manufacturer-stated life expectancy of the processing items (see chapter 3).

4.3.3.2.2 Metering and concentration

The metering of the process chemicals can be done centrally or peripherally (see chapter 5.5 of the orange WG CP (AK KAB) brochure). Information on dosages is provided by the manufacturer on the container labels. For detailed information, please see the corresponding data record sheet.

A manufacturer of process chemicals can further list a method for concentration checks (+/- 10% of the set point, e.g. titration or electric conductivity measurement).

4.3.3.2.3 Temperature

The process chemicals must be usable in the temperature range of the specified cleaning procedure, as recommended by the manufacturers of the processing items and cleaning machines.

4.3.3.2.4 Changing the detergent solution

The detergent solution is to be regenerated or changed as may be necessary. To achieve a proper cleaning result, depending on the processing item, tanks, dirt strainers and nozzles must be checked regularly and cleaned daily, where required (see chapter 6 of the orange WG CP (AK KAB) brochure).

4.3.3.3 Documentation and safety

For every process chemical, the manufacturer needs to provide a data record sheet and material safety data sheet. The operator needs to compile operating instructions.

4.4 Tank filling

After being cleaned, the tanks are usually stacked and stored until further usage.

The water temperature generally depends on the needs of the species housed in the tank.

Tanks are usually filled with fresh system water taken from the aquatic housing facility or from another place with access to a supply of system water. As fish are sensitive to sudden chemical and physical changes (pH value, salinity, temperature) in their environment, system water is the best choice.

Tanks should be filled with system water just before they are used. For hygienic reasons, water storage over a longer period is not advisable.

4.5 Steam sterilisation

As steam sterilisation is a rare event in aquatic animal facilities, please refer to chapter 4.5 of the orange WG CP (AK KAB) brochure for more information.

5 Structural requirements

For a correct functioning of all processing relevant machines, a professional planning (please also see chapter 6.1 of the orange WG CP (AK KAB) brochure), constructional preparation, and correct adjusting of the utility supply and disposal system is essential.

5.1 Differentiation of performance

When acquiring a cleaning machine, it is important to note that the technical crew of the assigned trade is responsible for connecting machines to installations (supply air / discharge air / heating steam / water / compressed air / electric supply line). Shut-off devices must be provided by the customer.

To prepare a layout drawing, the manufacturer must be provided by the customer / operator with all necessary documents.

5.2 Requirements of utilities and utility systems for cleaning stations

The manufacturer must inform the customer / operator in time about the type, quality, and quantity of utilities the customer is expected to provide as well as about measures that must be taken on site to set up, connect, and operate the cleaning machine.

The operator must adhere to the manufacturer-stated requirements regarding quality and quantity of utilities, including supply and discharge systems. If the requirements are not followed, it can be expected that the machine will not work sufficiently. The result might be a poor performance in cleaning, rinsing, and drying, insufficient sterilisation, extended batch times, and damages to the processing items as well as the machines.

Please note the following aspects regarding media and interfaces.

5.2.1 Water, softened water, and deionised water

Water used for processing tanks and their accessories must meet the following limits, possibly by being processed first, for example through softening or demineralisation.

Softened water

Appearance	colourless, clear
Total hardness to	3° d or 0,5 mmol/l
pH value	5 - 9
Evaporation residue	< 500 mg/l
Chlorides	< 100 mg/l

To avoid stains on the processing items from dissolved salts in the softened water, the WG CP (AK KAB) advises to use deionised water, at least for the final rinsing step.

Deionised water

Deionised water is processed water according to EN 285, producible for example through reverse osmosis (R/O):

Appearance	colourless, clear without deposits
Electric conductivity (at 25°C)	≤ 5 µS/cm
Hardness (amount of alkaline earth ions)	≤ 0,1 °d or ≤ 0,02 mmol/l
pH value	5 - 7,5
Evaporation residue	≤ 10 mg/l
Chlorides	≤ 2 mg/l
Phosphate (P ₂ O ₅)	≤ 0,5 mg/l
Silicates as SiO ₂	≤ 1 mg/l
Iron	≤ 0,2 mg/l
Lead	≤ 0,05 mg/l
Cadmium	≤ 0,005 mg/l
Heavy metal residues (except iron, cadmium, lead)	≤ 0,1 mg/l

Note:

For a best possible automatic processing, it is advisable to use deionised water to avoid corrosion and staining, see chapter 9. In derogation from the above listed data, experience shows that for deionised water, a conductivity of ca. 15 µS/cm is tolerable.

The water connection must be installed according to DVGW guidelines (German Technical and Scientific Association for Gas and Water). An important aspect to consider is the material compatibility of the pipework.

Before shipping the machines out, the manufacturer must provide the operator with the following construction-relevant information on water supply:

- Flow pressure at the interconnection of machine and building installations
- Connection dimension
- Maximum capacity (peak value)
- Maximum consumption per hour
- Water quality / hardness
- Water temperature

5.2.2 Steam

The customer is required to dewater the steam pipes and equip them with a filter placed directly before the machine. Horizontal pipes must be passed toward the consumption point with an incline of 1:50. The steam pipes must be insulated against heat loss according to the Heat Insulation Ordinance.

5.2.2.1 Heating steam

Steam quality required for heating cleaning machines:

Table 5-1

Parameter	Units	Max values
Steam dryness	kg steam/kg steam + water	> 0,95
Total hardness	mmol/l	≤ 0,02
pH value	pH	5 - 9
Conductivity (at 20 °C)	µS/cm	≤ 10
Appearance		colourless, clear
Chlorides (Cl ⁻)	mg/l	-
Iron	mg/l	≤ 0,1
Cadmium	mg/l	-
Lead	mg/l	-
Heavy metal residues (except iron, cadmium, and lead)	mg/l	-
Silicates as SiO ₂	mg/l	≤ 15
Phosphates (P ₂ O ₅)	mg/l	-
Dirt particles	size in µm	≤ 300

5.2.2.2 Requirements of heating steam

The manufacturer must provide the operator with the following information:

- Minimum overpressure at the interconnection of machine and building installations
- Connection dimensions (e.g. DN 20 PN 16)
- Maximum capacity (peak value)
- Maximum consumption per hour
- Steam quality (see above)

Depending on the above-mentioned steam quality, the operator should opt for special materials (preferably stainless steel) for building in the steam pipes. The machine manufacturer must be informed about the material used for the pipework.

5.2.3 Condensate

Machines operated with steam always produce condensation that can be fed back, if needed. The operator must be informed about the arising amount of condensate as well as the pipe dimension.

5.2.4 Compressed air

Compressed air (industrial grade – filtered and oil-free) is used for pneumatic work and control procedures. It must be available at the interconnection point with an overpressure of 6-8 bar.

Quality of compressed air used for pneumatic control procedures:

Maximum size of dirt particles	40 µm, according to ISO 8573-1 grade 5
Dew point	+3 °C, according to ISO 8573-1 grade 4
Maximum oil content	0,1 mg/m ³ , according to ISO 8573-1 grade 2

The manufacturer must inform the operator about:

- Connection dimension
- Maximum capacity (peak value)
- Maximum consumption per hour

5.2.5 Electricity

The technical connection conditions must comply with DIN EN VDE 0100. On the part of the operator / costumer, the following mains connection must be provided:

Nominal voltage	3 x 400 V	(3/N/PE)
Nominal frequency	50 Hz	

(The manufacturer must be informed about any variations of these values.)

The operator must provide for a lockable main switch inside the power supply line of each machine. The manufacturer must inform the operator about:

- Connected load (maximum power input)
- Backup
- Consumption per hour (maximum consumption)

5.2.6 Wastewater

In principle, DIN 1986 (drainage systems for buildings and properties) applies here. If special local wastewater regulations are to be considered, the costumer must notify the manufacturer. The manufacturer must in return inform the costumer about the required connection dimensions and amount of wastewater to be expected.

The drainpipes must be resistant to the process chemicals in use. If necessary, a wastewater neutralisation or cooling in the machine must be provided.

5.2.7 Process discharge air

The cleaning chambers / cleaning tunnels must be vented with a fan inside the machine or with an on-site exhaust fan. The so extracted air must be discharged to atmosphere through separate pipes provided by the customer. The extracted air contains water vapour and waste steam, possibly mixed with detergent residues. Consequently, the pipes must be watertight as well as temperature- and acid-resistant. A suitable discharge of condensation must be ensured.

The manufacturer must inform the operator about:

- Volume flow in m³/h
- Discharge air temperature
- Discharge air humidity
- Connection dimensions

For pipes that suffer high pressure loss, the operator is advised to install an additional fan at the end of each affected pipe.

To maintain the desired relative room air pressure, the different amounts of discharge air (general discharge air from the supply centre, discharge air from machines) must be taken into consideration.

Note: With air pipes and exhaust pipes that encounter H₂O₂, special care must be taken when choosing the relevant pipe materials.

6 Operation and operating

After describing the technical coherencies and necessities in the previous chapters, important aspects for operating the machines to achieve a desired result shall be discussed.

6.1 How operation is influenced by planning

When putting an aquatic animal facility into operation, it will show whether the machines and the operational concept were well-engineered. The planning is highly complex and very much subject to individual conditions and project-specific circumstances. Although this brochure cannot fully cover all aspects of a complete planning, some important considerations shall be described below.

For an efficient operation and a smooth flow of material, cleaning machines for aquatic tanks and accessories must be well arranged to each other and placed according to the room dimensions (see chapter 2). Therefore, the following aspects must be incorporated in an iterative planning process at an early stage.

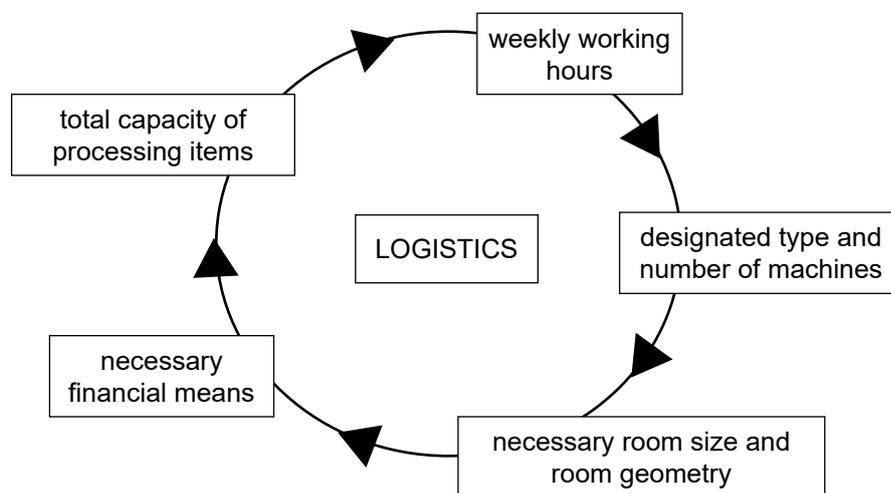


Figure. 6-1 Iterative planning process

To get the appropriate dimensioning of the machines, it is important to first determine the capacity of the different processing items (see chapter 3) arising in the animal laboratory at the final stage of the extension. For this purpose, it is necessary to know not only the number of items (e.g. tanks, tank lids, breeding tanks, accessories, fishnets, transport trolleys, etc.) but also their cleaning intervals. This data plus the weekly working hours will define potential machine concepts (type and number of machines) and with that the number of personnel (not further discussed here) as well as the necessary spatial and financial requirements. Ergonomic aspects (working heights, “arm lengths”, weights, etc.) and well approved loading models (stack heights, arrangement of items in the machines, etc.) must be considered as well.

When planning in detail, the following aspects must be taken into account:

- Downtimes and response times
- Redundancies
- Areas inside the supply centre to use as storage room / buffer / short-term storage
- Areas for process chemicals and dosing stations
- Accessibility for service work
- Replacement option / façade opening for big, non-demountable machine parts
- Occupational safety regulations / occupational safety measures
- Cleaning and, where needed, disinfection of the machines in use

The quality of workmanship is highly significant for the operation of an aquatic animal facility. The machines must be easy to operate and equipped with technical precautionary measures to prevent faulty operations as best as possible.

Occupational safety is also an important aspect to be considered in these general conditions:

- Catching body parts in moving machine parts
- Temperature of the processing items when unloaded from the machines
- Peripheral temperature of the cleaning machines
- Chemical fumes
- Temperature at the workplace
- Relative air humidity at the workplace
- Sound pressure level at the workplace
- Working heights of the different machines (ergonomic: 800 - 900 mm)
- Exposure to allergens
- Exposure to dust

6.2 Putting into operation

It is part of the manufacturer's responsibility to put the machines into operation for the first time or to name an expert who does so in his place. Thereby, all operation, control, and safety devices must be checked for function and correct adjustment.

6.3 Handover

The manufacturer must hand over the following documents to the operator: the machine-accompanying papers, including a declaration of conformity, instruction manuals, and maintenance papers as well as, if agreed upon, a performance record (see chapter 7) of the machine.

Note:

For large machines, a test run is recommended. If so desired, it must be specified before issuing a tender. A factory acceptance test might also be reasonable.

6.4 Operating personnel

The manufacturer must instruct the operating personnel when handing over the machines and introduce them to the instruction manual. It is, however, the operator's responsibility to ensure that the personnel are fully instructed (operating instructions) and familiar with the machines. The operator must furthermore compile an occupational risk assessment (according to § 5 Labour Protection Law, § 3 Ordinance on Industrial Safety and Health, § 4 Ordinance on Biological Agents, § 6 Ordinance on Hazardous Substances).

6.5 Machine book

It is necessary to keep a machine book where all extraordinary incidents (e.g. malfunctions) and routine work (e.g. maintenance and overhaul) as well as changes in adjustment of parameters are recorded.

6.6 User guide

The user guide must be provided in the language of the respective country the machines are shipped to. It must be kept on-site at a well accessible place, so all operating personnel can consult the guide as needed. A short form of the user guide must be applied well visible in close vicinity to the operating area.

6.7 Operating instructions

The machine operating instructions provide in universally understandable form all information necessary for a proper running of the machine. The instructions are generally compiled by the operator, taking as basis the user information of the manufacturer. Corresponding manufacturer-provided templates, adjustable to the specific situation on-site, are helpful to the operator.

6.8 Setting the procedural parameters

When operating the machines, it is important to comply with the parameters specified in the user guide and used during the test run, if applicable. These parameters are for example temperature, contact time, concentration of the process chemicals. If it proves necessary to adjust those parameters to local conditions, it must be recorded in the machine book and possibly verified with another test run.

Residues and dirt in the tanks can vary between institutes. Therefore, the necessary process parameters can differ and must be set individually, if needed.

The values shown in the table below are recommendations gathered from different experiences that can vary individually.

In the table you will find examples for running procedures and parameters of programs most common for cleaning machines.

Discontinuously working cleaning machines

Table 6-1

Machine	Cabinet-cleaning machine	Large-capacity cleaning machine
Pre-rinse temperature	ca. 20 °C	ca. 20 °C
Pre-rinse time	ca. 30 sec.	ca. 30 sec.
Cleaning temperature	ca. 75 °C	ca. 75 °C
Cleaning time	ca. 900 sec.	ca. 900 sec.
Neutralisation temperature	ca. 60 °C	ca. 60 °C
Neutralisation time	ca. 20 sec.	ca. 20 sec.
Post-rinse temperature	ca. 20 °C	ca. 20 °C
Post-rinse time	ca. 60 sec.	ca. 60 sec.
Waste steam extraction/venting	ca. 20 sec.	ca. 20 sec.
Detergent concentration	2 - 5 ml/l	2 - 5 ml/l

The values shown in the table above are recommendations gathered from different applications that can vary considerably depending on the case of application, as stated before.

6.9 Checking and monitoring

The routine measures prescribed in the user guide and operating instructions must be implemented in the indicated intervals. These measures include:

- Check of concentration, temperature, and, if needed, pH value or conductivity of the detergent solution
- Replacement of the detergent solution by emptying the cleaning tank (see chapter 4.3.2.2.4)
- Routine cleaning of strainers and containers
- Check for clogging and correct spray position of nozzles

6.10 Inspection of the cleaning result

Effectivity checks are of great relevance for a facility. For evaluating the performance of cleaning machines these checks must be done according to the instructions in chapter 7.

6.11 Maintenance measures

To ensure a safe and repeatable machine operation, it is required to carry out maintenance measures, as prescribed by the manufacturer, on a regular basis, including all necessary inspection, maintenance, and overhaul procedures (as defined according to DIN 31051). Only trained experts are to implement these measures. Attention should be paid to the following aspects:

- All safety instructions must be followed.
- Process parameters must be checked.
- It must be checked if all suitable process chemicals are used in correct concentration.
- Manufacturer-recommended spare parts must be used.

When replacing machine parts that might cause a change in the cleaning process parameters, an extraordinary check is required.

As maintenance work requires specialised knowledge and special tooling, concluding a maintenance contract with the manufacturer is strongly recommended. Such a contract might even be a prerequisite for asserting warranty claims.

An appropriate evaluation of different maintenance contract offers, for example regarding service specifications, is only possible, if the maintenance services are sufficiently specified and thus comparable.

7 Performance evaluation checks for cleaning machines

7.1 Requirements

Current studies (see chapter 10) show that biofilm is a good matrix for harmful bacteria, including mycobacterium spec. These zoonosis organisms not only affect fish but also humans.

To proof the presence of biofilm and its nearly invisible residues (as proof of an incomplete cleaning), the so-called ATP test is commonly performed.

Obviously, during any automatic cleaning, the biofilm must be removed effectively and repeatably. It must be checked whether the ATP test is also applicable here.

For the next edition of this brochure, the work group will explain what is precisely required in the individual process steps and what methods can be applied to screen the respective results. With that it will introduce a definition of the kind of tests to be performed.

The objective is to certify those cleaning machines, based on a testing procedure, that meet all necessary requirements and will verifiably prove successful in practice on a daily basis.



Figure. 7-1 Picture of a soiled tank with different algae types as well as biofilm noticeable

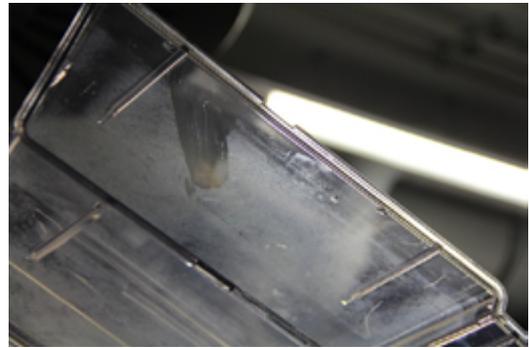


Figure. 7-2 Incomplete removal of biofilm on a synthetic tank

Post-rinsing

8 Ecological requirements

Processing machines for tanks, feed bottles, racks, and other items used in aquatic laboratory animal housing must produce flawless results during all time of operation, consuming as less energy, water, and process chemicals as possible. Thus, for ecological reasons, processing machines should meet the following requirements:

Petri dish

In aquatic animal facilities, petri dishes are commonly used, usually disposable synthetic ones. For ecological reasons, it could be considered to re-use these dishes after a thorough cleaning. For this, the ideally just slightly soiled petri dishes are soaked in diluted chlorine bleach and afterwards rinsed thoroughly with deionised water. As embryos and larvae will come in direct contact with the dishes, it is not advisable to use further detergents. Potential residues of those on the dishes could harm the delicate animals. The chlorine bleach can be re-used several times.

Dishes used in toxicological or pharmacological studies as well as heavily soiled petri dishes should not be re-used.

Water

Regarding water consumption, processing procedures are to be preferred where most of the water can be reutilised within the automatic cleaning process. After being filtered in a process tank, the oxidising alkaline detergent liquor can be saved and re-used without affecting the cleaning success. A final rinsing, however, should always be done with fresh, deionised water.

Energy

A flawless operation needs a certain amount of energy. To keep this energy expenditure as low as possible, it is necessary to exploit all economically useful, state-of-the-art options.

Process chemicals

To achieve a repeatable cleaning result, the usage concentration of process chemicals must be kept constant during all time of operation. Manufacturers of washers and process chemicals offer a number of metering devices up to centrally operating metering stations to ensure that operators get the exact dosage of chemicals they need. Overdosing would entail avoidable environmental stress, underdosing a poor cleaning result. Process chemicals must be developed from resources that put the least stress on the environment. Due to the nature of the soiling to be removed, the application solutions of the detergents have an acid to alkaline pH range.

The most important ingredients of process chemicals are:

Alkalines

Alkalines help the cleaning process by expanding and removing organic soil residues like starch, protein, and fat, which leads to a high alkaline pH value of the detergent solution. Due to a dilution of alkalines in the internal sewage system with partly acid sewage, the pH value of the washing sewage will be reduced to the limit value defined in the Sewage Law. If this is not the case, it should be considered to build in a neutralising system.

Phosphates

Phosphates absorb the water's hardness components and help the cleaning process with their emulsifying and dispersing effect. Along with inorganic nitrogen compounds, phosphates are among the most important nutrients in water. Excessive phosphate supply will lead to an intensified bio production (overfertilisation).

In sewage plants with a precipitation level (3rd level), phosphates are widely eliminated.

Phosphate substitutes

Phosphate substitutes can replace real phosphates only in some subareas. They are used to bind water hardness, the same as real phosphates. When considering the application of substitutes for binding water hardness, a comprehensive use cannot be fully recommended due to ecological objections, for example their lack of biodegradability.

Active oxygen carrier

Active oxygen (e.g. hydrogen peroxide) is used for germ reduction and oxidative decomposition of organic residues combined with alkalinity. The use of hydrogen peroxide does not produce ecologically harmful degradation products.

Active chlorine carrier

Active chlorine is used for germ reduction and oxidative decomposition of organic residues. As active chlorine, due to its property of generating AOX, is rated as pollutive, its use is more and more abandoned.

Tensides

Tensides reduce the interfacial tension of the detergent solution or the rinsing water and must be biodegradable, which means they are degraded in sewage plants with the help of microorganisms.

Acids

Inorganic or organic acids in acid detergents remove mineral residues. Acids generate a low (acid) pH value in the application solution. Due to a dilution of acids in the machine or facility own sewage system, the pH value of washing sewage will be neutralised to the limit value defined in the Sewage Law. If this is not the case, it should be considered to build in a neutralising system.

Container

To minimise the stress on the environment, containers of process chemicals should be made of synthetic materials (like PE or PP). Before the used containers can be properly disposed, they must be emptied completely. The number of empty synthetic units can be reduced by using large reusable containers. For this, instead of coming in single-use canisters, process chemicals can be delivered in refillable containers.

Wastewater

Operators of washers in laboratory animal facilities usually discharge their wastewater indirectly into the sewage system and must follow the discharge regulations set by local authorities. These regulations can differ depending on each city or community. The operators must pay a sewage charge covering the costs for the wastewater load, sewer system, operation of sewage plants, and wastewater monitoring. To motivate operators to reduce the number of contaminants they discharge, many cities and communities have introduced so-called sewage coefficients. By means of analysis data, they rate the actual contamination caused by each indirect discharger. Based on this contamination data, an individual, operator-specific sewage charge is calculated (polluter pay principle).

Apart from this operator-specific sewage charge, there are also mandatory water pollution limits for indirect dischargers based on federal law (Ordinance on Indirect Dischargers) that may not be exceeded. Due to their high dilution, biocidal agents and other ingredients of process chemicals do not affect the biological treatment of wastewater in sewage plants. When reaching the permissible temperature limit, cleaning machines can be fed cold water to cool down the wastewater.

Exhaust air

In aquatic animal facilities, there are two types of exhaust air to be considered:

- General exhaust air coming from the supply centre (discharged via on-site vent pipes)
- Exhaust air coming from cleaning machines

Exhaust air from cleaning machines is often very humid and hot. It is discharged from the machine during and after the washing process through on-site vent systems, either through a permanent connection or through an exhaust air chimney. A system for heat recovery might be useful. Given the process temperatures and process chemicals, the exhaust ducts of a facility must be temperature-resistant, watertight, and above all corrosion-resistant. Recommended materials are synthetics (e.g. PP – polypropylene, PVC – polyvinyl chloride) and stainless steel.

Heat dissipation

Manufacturers of cleaning machines and sterilisers must minimise the heat dissipation in an economically and technically responsible way. The operator is required to insulate the steam pipes against heat dissipation according to the Heat Insulation Ordinance and the Heating System Ordinance (HeizAnIV).

9 Frequent defects and damages in processing equipment

In aquatic animal facilities, it is not uncommon that processing items (see chapter 3) are soon affected by surface changes, coatings, corrosion, and stress cracks and consequently must be replaced. These damages are often not the result of natural, unavoidable wear, but of physical and chemical impacts due to improper treatment. Below you will find a description of the most important causes of defects and damages in processing equipment as well as suitable preventive measures.

9.1 Material haze (with polycarbonate)

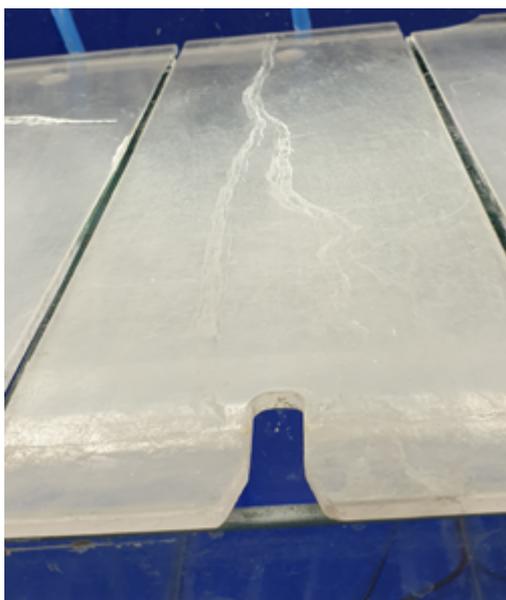


Figure 9-1 Tank parts with material haze

Table 9-1

Source and causes	Preventive measures
Non-rinsed alkaline detergent residues cause decomposition of polycarbonate when being sterilised.	All processing items must be sufficiently rinsed to ensure that all alkaline detergents have been removed from the items' surface. If necessary, the items must be treated with a neutraliser to get a surface with neutral pH value.
Softened water, particularly after being heated, shows an alkaline reaction. This is caused by a cation exchange of the calcium- and magnesium-hardness components in the raw water against sodium salts, which happens during the softening process. As a consequence, alkaline sodium carbonate is generated. When sterilising processing items made of polycarbonate, adhering softened rinsing water can lead to a decomposition of the material.	It is advisable to use deionised water for rinsing.
When generating steam, alkaline correction chemicals can also cause a material decomposition of polycarbonate.	When generating steam, it should conform with the specifications in EN 285.
When processing items, and fish tanks in particular, are sterilised out of an infectious animal housing area, items made of polycarbonate will soon suffer material haze.	If the necessity to sterilise items is likely right from the start, it is advisable to use tanks made of polysulphone or more significant material.

9.2 Coat forming

Table 9-2

Source and causes	Preventive measures
Lime can cause coatings on the surface of processing items.	It is advisable to wash processing items with acid detergents.
Washing-related residues lead to coatings on the surface of processing items.	All processing items must be sufficiently rinsed to ensure that all detergents have been removed from the items' surface.
Using water of insufficient quality can lead to residues or coatings, especially on items with gaps and hollows where liquids cannot run off.	It is recommended to use softened water or preferably deionised water for rinsing.
Coatings can also occur in the sterilisation process when bad quality steam or harmful ingredients are used.	When generating steam, it should conform with the specifications in EN 285.

9.3 Stress cracks



Figure. 9-2 Tank parts with stress cracks

Table 9-3

Source and causes	Preventive measures
Severe mechanical impact, e.g. cutting additional openings, can cause crazes and scratches that might lead to more severe cracking and other damages during the process of sterilisation.	It is advisable to use suitable utensils, e.g. plastic scrapers. A careful handling, transporting, and storing of processing items should be ensured.

9.4 Deformations

Source and causes	Preventive measures
When cleaning and sterilising processing items, depending on the type of synthetic material, unsuitable process temperatures can cause deformations in the item material.	It is recommended to follow the maximum permissible cleaning and sterilisation temperature and time for the respective synthetic materials according to the manufacturer's instructions (see chapter 3).
When carrying and sterilising fish tanks, great stacking heights can cause deformations in the body material.	When performing these procedures, the stacking heights, depending on tank size and material, should be limited to 20 fish tanks max. Please follow the manufacturer's instructions.

9.5 Corrosion / pitting / extraneous rust in rustproof steel (stainless steel 1.4301, 1.4571)

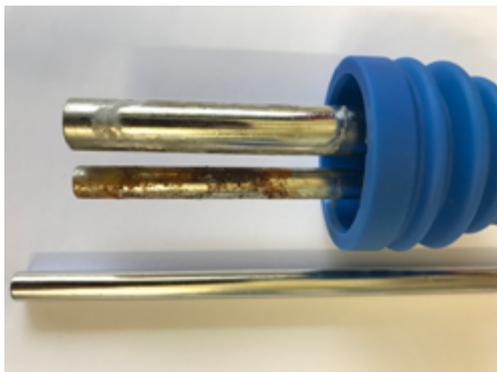


Figure. 9-5 Siphon and stainless steel rack with corrosion

Table 9-5

Source and causes	Preventive measures
Drying of disinfectants containing chloride, or evaporation of floor cleaners etc. containing hydrochloric acid can cause chloride-induced pitting on stainless steel surfaces.	Disinfectants of this kind should be sufficiently rinsed off after completing the required contact time. Alternatively, chloride-free disinfectants can be used. Detergents containing hydrochloric acid should be avoided.
Any improper use (e.g. insufficient rinsing) of detergents containing active chloride leads to pitting.	The processing items must be sufficiently rinsed to ensure that all detergents have been removed from the items' surface.
Extraneous rust contamination from water and/or steam pipes can cause rust coating on the surface.	It is recommended to use suitable pipes (e.g. made of synthetic material or stainless steel) or to process the water accordingly (for limit values, please see 5.2.1 and 5.2.2).

9.6 Scratching of surfaces when manually cleaning synthetic tanks

When manually washing tanks with abrasive cleaning sponges for example, scratches can soon appear on the tanks' surface. Scratched surfaces will reduce the transparency of a tank and make it harder to watch the fish inside. They will also increase algae and biofilm growth on the surface.

For a manual cleaning of synthetic tanks, it is strongly recommended to use soft microfibre cloths. Before using them for the first time, the cloths should be washed to avoid an accidental applying of chemicals on the tanks.

9.7 Cleaning of glued or siliconised glass tanks

If glued glass tanks are washed automatically, the cleaning temperature as well as the chemical composition of the wash liquor should not damage the silicon sealants. The tanks should be loaded in the cleaning station without putting them under tension.

9.8 General aspects of cleaning tanks and tank parts

The health of the fish strongly depends on the quality of the system water they live in. Therefore, extra caution should be exercised when rinsing tanks and tank parts to ensure that no residues of detergent chemicals remain on the items and are carried over into the system water where they can harm the fish. The items should be rinsed sufficiently with deionised water.

The use of rinse aids should generally be avoided when rinsing tanks and tank parts.

9.9 Criteria for scrapping damaged material

Beside the above-mentioned changes in material, a normal washing and sterilisation process will cause material-induced deterioration that can lead to the necessity to discard certain processing items. Therefore, processing items should undergo regular material checks.

10. Literature, standards, publications

Publications:

„Käfigaufbereitung in der Tierhaltung“ (orange Broschüre), Herausgeber Arbeitskreis Käfigaufbereitung (AK KAB), 5. Auflage 2016

„Instrumenten-Aufbereitung im Veterinärbereich“ (grüne Broschüre), Herausgeber Arbeitskreis Instrumentenaufbereitung (AKI)

„Source or Sink: Examining the Role of Biofilms in Transmission of Mycobacterium spp. in Laboratory Zebrafish“, Herausgeber Carolyn T. Chang, Jet'aime Lewis, and Christopher M. Whipps in ZEBRAFISH Volume 16, Number 2, 2019, © Mary Ann Liebert, Inc.

Clutterbuck AL et al. (2007) Biofilms and their relevance to veterinary medicine. *Veterinary Microbiology* 121:1-17.

“The biofilm matrix“, Herausgeber Hans-Curt Flemming und Jost Wingender in Nature Reviews | Microbiology Volume 8, September 2010

