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Seafish Standard Design Purification Systems: Operating Manual for the Large Scale Multi-Layer System

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Seafish

Origin Way
Europarc
Grimsby DN37 9TZ

T: +44 (0)1472 252 300
F: +44 (0)1472 268 792
E: seafish@seafish.co.uk

www.seafish.org

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Updated March 2018 by Pyke and Deane Aquaculture Consultants
Email: consultmandy@hushmail.com

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Contents

1. The Development of Multi-Layer Purification

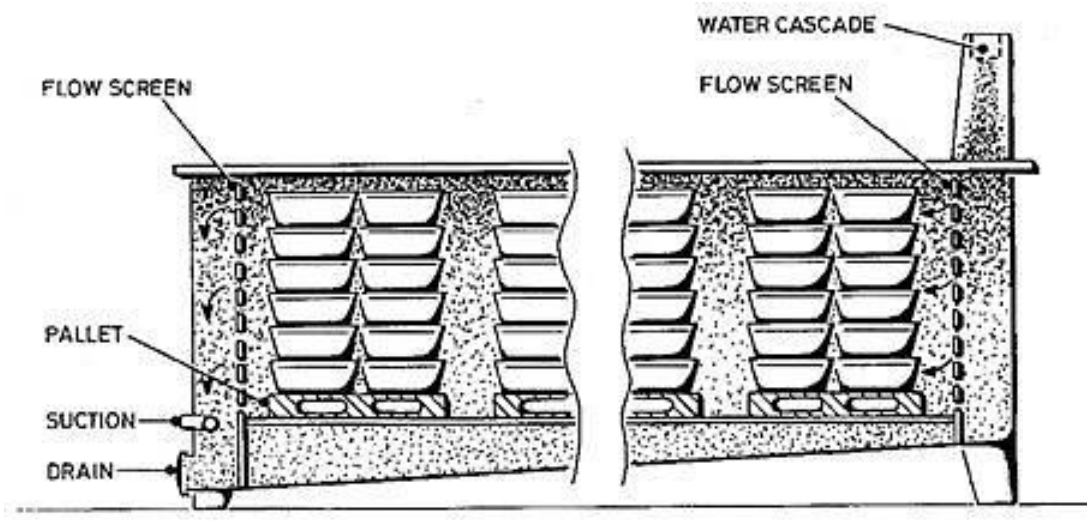
Historically, in the UK, the purification of oysters and clams was permitted with containers stacked three high. The stacking of containers of mussels was not permitted and this resulted in large, shallow, outdoor purification tanks that were exposed to the elements and over which there was no real control of seawater temperature. To improve environmental control requires the stacking of mollusc containers to reduce floor area, hence enabling the tank to be installed inside a building. Seafish investigated the purification of stacked containers of mussels and, following extensive trials, successfully demonstrated that under controlled conditions they could be stacked six high. This is now an accepted practice in the UK for mussel purification.

2. How Does the Seafish Multi-Layer Purification System Work?

The molluscs are held in mesh type containers stacked in a tank between a pair of perforated flow screens. Seawater enters the tank via a cascade or jets onto the water surface at one end of the tank between the flow screen and the end of the tank. The water then passes through the flow screen and through the stacked containers before passing through the second flow screen. Water exits the tank via a suction pipe clear of the tank bottom between the second flow screen and the end of the tank.

Flow screen

Seawater is re-circulated via a pump and the flow rate is controlled by a valve and flowmeter. This control is essential if the system is to operate effectively. The flow screens are necessary to ensure an even flow of water and hence supply of oxygen to all the molluscs in the stacked containers. In addition, the water disturbance created by high flow aeration is contained by the flow screen at the input end effectively. The seawater receives microbiological treatment by passing through an enclosed ultraviolet light (UV) sterilisation unit.



Side view of a multi-layer system

The molluscs function naturally in the clean seawater and purge themselves of bacteriological contamination. Detritus settles on the base of the tank.

3. The Approval of Purification Systems

For England, Wales and Northern Ireland approval will be decided by a Local Authority (LA) Authorized Officer (AO). AOs will follow the guidance provided by the Food Standards Authority (FSA)[1]. The Food Business Operator (FBO) should prepare for the approval process and have a Food Safety Management Plan (FSMP) in place based on Hazard Analysis and Critical Control Point (HACCP)[2]. Conditional Approval, (CA) can be granted by an AO, however this must not last more than six months. If the 'establishment' is not fully compliant within this time, approval must be withdrawn. The FBO must provide evidence to the AO to demonstrate compliance. Bacteriological tests are the responsibility of the operator of the purification system and can prove time consuming and costly, particularly if repeat testing is required. Approval in Scotland is overseen by Food Standards Scotland (FSS)[3].

The AO will approve a system only if satisfied that it is designed and operated in accordance with basic rules and that there is sufficient evidence to demonstrate that the system will purify bivalve molluscs satisfactorily. This may require them to make a site visit before approval, to carry out a technical inspection, and for a bacteriological test to be carried out. The bacteriological tests are the responsibility of the operator of the purification system and can prove time consuming and costly, particularly if repeat testing is required.

4. The Standard Design Concept

The range of standard design purification systems developed by Seafish are built to specified designs that meet the technical requirements and which have been tested extensively in a wide range of conditions. Being proven designs, bacteriological testing is less stringent and consequently they have a more predictable, simplified, less time consuming and less expensive approval procedure.

5. Types of Standard Design Multi-Layer Systems Available

Currently, there are both medium- and large-scale standard design multi-layer systems in use in the UK, with nominal capacities of 750 kg and 1500 kg of mussels capacity per tank and seawater requirements of 2,600 litres and 9,200 litres per tank respectively. Multiple tank systems are in use of up to 12 tonnes capacity. The medium-scale system is available both in glass reinforced plastic and marine grade stainless steel at similar cost and is the subject of a separate manual. The large-scale system has been made in stainless steel only. The choice of tank material can have some effect on the need for seawater heating or chilling. Fibreglass is an insulative material. The fibreglass system tends, therefore, to retain heat and usually operates with water temperatures a few degrees above surrounding air temperature. This can be an advantage during winter months when ambient temperatures are low or for species that require higher seawater temperatures, and can reduce the need for heating. However, chilling is more likely to be required in these tanks when ambient temperatures are high, particularly during the summer. Stainless steel has little insulative property and can therefore be operated in marginally higher surrounding temperature conditions without chilling. It is more likely to require heating if operated in cool ambient temperatures. A stainless-steel tank may be longer lasting than a fibreglass tank.

6. Seawater Supply

The FBO is responsible for the quality of natural seawater used. The seawater must be free from contamination in quantities that may adversely affect the molluscs or be subsequently harmful to the consumer. Either natural or artificial seawater can be used. The FBO is responsible for the quality of natural seawater used. Guidance on this subject has been produced by Seafish and Cefas It should be 'clean' and not contain any contaminants that could become a threat to human health[4].

Factors affecting the suitability of seawater are:

Turbidity: Turbidity is the measure of particles or opacity in seawater that obstructs light. It can be measured in Nephelometric Turbidity Units (NTU). An advisory limit for depuration plants has been set at less than 15 NTUs. Any obstruction to the transparency of seawater will inhibit the ability of UV light to

[1] https://www.food.gov.uk/enforcement/monitoring/shellfish/shellfish-purification
[2] https://www.food.gov.uk/business-industry/food-hygiene/haccp
[3] http://www.foodstandards.gov.scot/business-and-industry/industry-specific-advice/fish-and-shellfish
[4] https://www.cefas.co.uk/media/52850/2012-water-quality-in-purification-leaflet.pdf

disable bacteria. Turbidity meters can be obtained should there be a problem with turbidity for a plant.

Salinity: This must suit the particular species of bivalve mollusc being held and should ideally be similar to the area from which they were harvested. Seawater salinity should be checked ideally before the tank is being filled.

The seawater salinity must be within the range required for the species, and can be measured using a hydrometer. If the reading shows the salinity to be too low or high it should be re-checked and if still incorrect the water must not be used. Salinity can be too high if an incorrect mix of artificial seawater has been used or evaporation has occurred over a period of re-use. Salinity that is too low can result from an incorrect artificial seawater mix or, in the case of natural seawater, too much dilution from a natural freshwater source. For natural seawater supply it may be possible to wait for a change in tidal conditions. The salinity of artificial seawater can be adjusted by dilution with tap water or adding extra salt. Care must be taken to maintain the correct mixture of salts.

Some of the most common minimum levels of salinity are given in the table below.

Minimum Seawater Salinity

Species	Min salinity ($^0/_{00}$)
Pacific oysters (*C. gigas*)	20.5
Native oysters (*O edulis*)	25.0
Mussels (*Mytilus* spp.)	19.0
Cockles (*C. edule*)	20.0
Hard clam (*M. mercenaria*)	20.5
Native clam (*T. decussatus*)	20.5
Manila clam (*T. philippinarium*)	20.5
Razor clam (*Ensis* spp.)	30
Scallops (*P. maximus*)	35
Thick trough shell (*S. solida*)	30
Peppery furrow shell (*S. plana*)	20.5
Sand gaper (*Mya arenaria*)	25

Microbiological Treatment: Initial low levels of microbiological contamination are reduced by UV treatment of the water before it enters the tank. Repeated cycling of water through a low wattage UV bank over time can reduce bacterial contamination if high wattage lamps are not available[5,6]. The use of ozone to supplement but not replace UV treatments is permitted and should be included in the FSMP if used[7,8].

Position of Seawater Intake: This must not draw in waste from other discharges, it should be sufficiently below the water surface to avoid poor quality surface water and be above the seabed where mud or fine sand are present. The times when suitable seawater may be drawn may be limited by tide and this may require the provision of water storage tanks ashore.

[5] Cefas 'Ultraviolet disinfection in depuration systems in England & Wales'
[6] WHO http://www.who.int/water_sanitation_health/emerging/depuration.pdf
[7] https://www.cefas.co.uk/media/52849/20100827-ozone-discussion-document-uk-final.pdf
[8] https://www.food.gov.uk/sites/default/files/multimedia/pdfs/enforcement/enfni10039annb.pdf

Artificial Seawater: Artificial Seawater has higher initial cost but can offer considerable advantages where systems are to be operated inland or local supplies of natural seawater are considered unsuitable. Advice on the production and use of artificial seawater is given in a Seafish technical advisory document on the Reuse of seawater for purification systems[9].

7. System Installation

Tank location should avoid direct sunlight. The tank must be levelled such that the tank floor slopes to its drain valve.

The seawater re-circulation equipment consists of suction pipe, pump, flow control valves, UV sterilisation unit, flowmeter, spray pipe and interconnecting pipework. 'T' pieces either side of the pump provide for tank filling and emptying. A circuit diagram is shown in Section 9.5.

The seawater re-circulation equipment may be installed on site by the manufacturer or be self-assembled provided the manufacturer's instructions are followed. Care should be taken to keep the pump clear of the floor and to install it and the UV in a dry area away from any splashing from the tank and from washing down, and clear of the handling of containers. The equipment is usually placed at the back or end of the tank. All valves must be accessible and the flowmeter and at least one end cap of each UV lamp unit clearly visible. Pipework and equipment should be installed such that they drain when the system is emptied to avoid leaving areas of stagnant water when not in use. If this is not practical then means of draining specific pipework or equipment should be included. Access for maintenance is important, particularly to the UV sterilisation unit, which will require periodic cleaning and tube replacement.

The tank is usually filled and emptied via the circulation pump, which has double valves on its suction and delivery sides to re-direct input from tank re-circulation to seawater supply, for filling, and to re-direct output from re-circulation to emptying. Flow rate is controlled by a valve on the delivery side. Single three-way valves can be fitted instead of the double valve configuration to simplify operation.

A supplementary aeration system may be fitted to give additional re-oxygenation at higher seawater temperatures. Filtered air is supplied by rotary fan to an air diffuser that must be located on the tank floor beneath the water cascade between the tank wall and flow screen. Air flow is controlled by a valve and flowmeter.

If artificial seawater is to be used, or if the seawater is to be re-used, a separate reservoir will have to be installed. This must be suitable for seawater use, have a drain at its lowest point for flushing out waste and an operating outlet pipe clear of the base. This must be accessible for inspection and cleaning and if outdoors must be covered. A capacity of at least 10.5 m^3 will be needed. A single reservoir can serve several purification tanks used in sequence.

Connection to a single-phase power supply is required for the UV sterilisation unit. The pump may require single or three phase supply.

All connections and switches used within the working area where the system is installed must be hose proof. IP66 classification is recommended. Cables must not be left trailing on the floor.

8. Initial Testing

A new system must be run firstly with seawater only, to check that the water circulation system will operate correctly and that there are no leaking joints, and then be left to run overnight. The filling procedure is given in section 9.5. Leaks will probably be a result of joints being inadequately tightened. The system must be able to operate at the required water flow of 9.5 m^3/hr. Check the operation of the water spray bar or cascade. Water must jet or fall into the area between the tank wall and flow screen. The UV lamps must operate correctly. After draining down, the tank should be cleaned as described in Section 10.3.

[9] http://www.seafish.org/media/Publications/FS32_07_09_Reuseofseawaterforpurificationsystemsystems.pdf

9. System Operation

When used for purification, the operating requirements specified in the FSMP must be followed. Although the instructions given in this manual are in line with established practices, the FSMP apply to each individual system and may incorporate special operating requirements depending on the particular circumstances of operation.

Purification is a batch process. Firstly, the tank is loaded with molluscs, then the tank is filled with seawater and water circulation commences. After the requisite period the seawater is emptied from the tank and then the purified molluscs can be removed. The system must not be disturbed (i.e. molluscs added or removed) during the period of immersion. When loaded mechanically, it is feasible to fill the tank with seawater prior to loading the molluscs.

Batches of molluscs from different sources must be kept separate for documentation purposes, enabling the tracing of molluscs back to source, but different batches from the same category of harvesting area can be held in the same tank. The Regulations prohibit the mixing of species in a tank. The mixing of species would be harmful if the tank conditions did not suit all the species concerned. In multiple tank installations the re- circulating seawater must not be shared during purification by tanks at different stages of the purification cycle.

9.1 Mollusc Supply

It is often forgotten when handling live bivalve molluscs that they are a live animal and even though encased in a hard shell they are easily damaged and physically or thermally shocked. Molluscs must be in good intrinsic condition if they are to be active when re-immersed and it is advisable, therefore, that the handling history between harvesting and arrival at the purification or dispatch centre is known and acceptable.

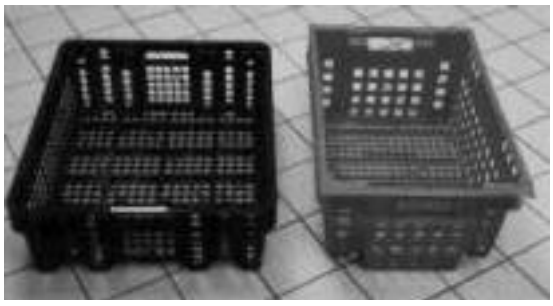
Depending upon species and harvesting techniques, damage to a few molluscs may be inevitable. However, if more than a few molluscs are dead, gaping or showing signs of excessive shell damage, then the batch should be rejected. The time from harvesting should be known, as molluscs should not be out of seawater for more than a few days before re-immersion. For some species, such as those grown in sub-littoral areas and not used to being out of water, this time period must be short. For cockles a maximum of 12[10] hours is recommended. When out of seawater a raw material storage temperature of between 2°C and 10°C is generally recommended, however, native oysters should not be held at less than 4°C and mussels can be iced.

When approaching their spawning season, bivalve molluscs are more susceptible to shock, and great care needs to be taken if spawning in the tank is to be avoided. Molluscs are weakened by spawning and often they are not harvested until they have sufficiently recovered.

9.2 Mollusc Containers

The containers used for stacking inside the purification tank must have suitable open mesh sides to allow water flow, and open mesh bottoms to permit faeces, silt, sand, etc. to settle out. Three container types have been used in the large-scale multi-layer system.

The Allibert 11037 box is stacked 5 deep whereas the Allibert 11031 and Paxton CV4820P stack 6 deep. Only one type can be used as they are not inter-stackable. Alternative suitable trays may be used.



Paxton CV4820p and Allibert 11037

Manufacturer Type	External Size (mm)	No. for Tank
Allibert 11037	600 x 400 x 236	100
Allibert 11031	600 x 400 x 180	96
Paxton CV4820P	600 x 500 x 185	96

Suitable Container Types

[10] Minutes of Meeting to discuss depuration issues – Cefas/FSA/Seafish 1 December 2008 Aviation House, London

9.3 Loading the Containers with Molluscs

The molluscs must have been thoroughly washed with clean water to remove silt, sand and weed before being put into the purification tank, and care taken not to roughly handle them. Any dead or damaged molluscs should be removed. Molluscs can be washed in the containers but not when the containers are stacked.

Container Loading

Species	Allibert 11037		Allibert 11031/Paxton CV4820P	
	Depth	Nominal Amount	Depth	Nominal Amount
Mussels	100mm	15kg	80mm	15kg
Pacific Oysters	Double Layer	83 oysters	Double layer	125 oysters
Native Oysters	Single Over-lapping Layer	83 oysters	Single Over-lapping Layer	125 oysters
Clams	80mm	17kg	80mm	21kg
Cockles	100mm	15kg	80mm	15kg

The molluscs must be placed in the containers at depths no greater than those specified in the table above. The nominal weight (or number in the case of oysters) is only a guide and will vary with season and harvesting area.

9.4 Loading the Tank with Containers

Before loading, the flow screens and any associated locking pins must be in place.

The tank is usually loaded mechanically by overhead crane with the containers first stacked outside the tank on plastic pallets. Care must be taken to position the containers correctly over the pallet without overhanging it and to orientate them such that they sit on the moulded location points of the container below and not directly onto the molluscs. A purpose-built frame can be used to lift the loaded pallets into the tank and care must be taken to ensure that the lifting frame is properly located on the pallet. Pallets sit in the bays provided in the tank and must be orientated to sit on the supports welded to the tank sides. Containers must not be stacked directly against flow screens, a clearance of at least 50mm should be provided.

If the tank is loaded manually, it would be necessary initially, for one operator to pass containers to another working inside the tank.

Bivalve molluscs require adequate levels of dissolved oxygen in the seawater if they are to function, and this can become a problem as seawater temperature rises. In order to ensure that an adequate level of dissolved oxygen is maintained it is sometimes necessary to limit the tank loading capacity at higher temperatures or to increase the flow rate whilst taking account of the UV dose. Alternatively, a venturi may be fitted onto the water supply pipe to the spray bar. These options may be stipulated in the FSMP.

If the tank is to be only part loaded the containers should be stacked to full tank width and depth at one end of the tank to maintain an even water flow through the molluscs rather than by-passing them. Additional seawater will be required to make up for the missing volume of molluscs.

9.5 Filling the Tank with Seawater

Before filling, the UV treatment unit must be switched on and care must be taken to ensure all tubes are functioning correctly. This is usually indicated by an annular ring of green/blue light at the end caps of each unit or other indicator. If the light flickers, is dull or is not on refer to Section 11.4.

For systems operating with a seawater reservoir the system is filled from the reservoir with circulation pump on, flow rate control valve E (if fitted, or D if not) set and the remaining valves open or shut as

indicated in the circuit diagram. Valves must be correctly set to ensure seawater enters the tank via the UV steriliser and not the suction pipework.

When the seawater level is at the top surface of the containers the valves are operated as shown in the circuit diagram for seawater circulation.

When a single reservoir is used to serve more than one purification tank, particular care must be taken with valve settings to ensure that seawater is not directed into the wrong tank. The flow control valve E (if fitted or D if not) should now be checked to maintain the required water flow of 9.5 m^3/hr. If this cannot be achieved, refer to Section 11.3. If the flowmeter is of the in-line flow-through type and fitted as an integral part of the pipework system, the flow is usually read from the widest part of the indicator.

In-line flowmeter

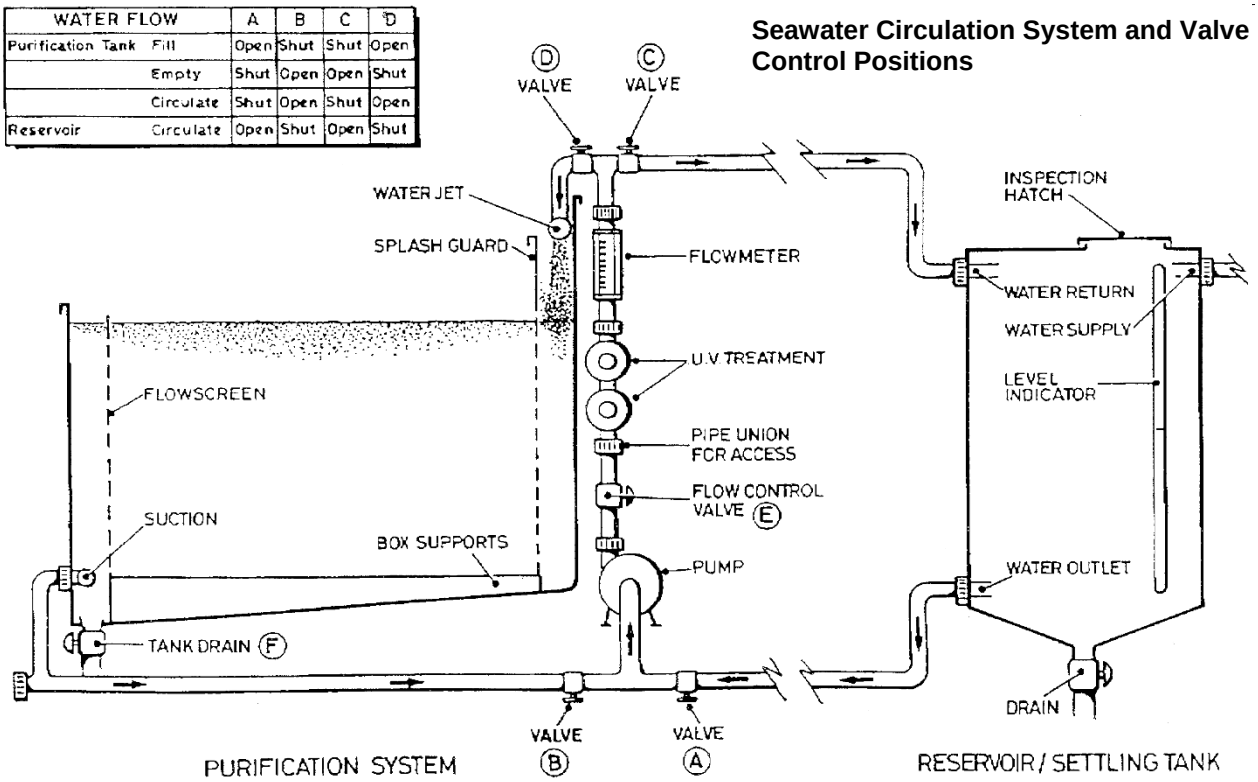
If a supplementary aeration system is fitted, the air supply should be regulated at no more than 20 litres of air per minute to limit foaming.
If no reservoir is used and seawater is supplied directly, it must still enter the tank via the UV unit. However, the circulation pump fitted is not of a self-priming type and cannot be used to draw water from a level below it. In this case a separate pump will have to be used. This pump should deliver water at about the specified system flow rate to maintain effective UV treatment. The seals on the UV unit may burst if pressure in the pipework is excessive. Flow control via valve E (if fitted), which is located before the UV unit, will prevent this.

When the mollusc containers are loaded mechanically, it is possible to fill the tank direct from source with seawater (by-passing the UV) and then circulating the water via the UV for a period of about one hour before the molluscs are loaded into the tank.

It is essential that at the start of the purification cycle the molluscs are covered with seawater by at least 80 mm for mussels and 30 mm for other species. During immersion molluscs should open their shells slightly to permit respiratory/filter feeding activity and will tend to move up within the container, effectively reducing the depth of water above them. Also, the molluscs may have lost inter-valvular fluid during storage and replenish it as their shells open. The molluscs must remain covered during purification.

WATER FLOW		A	B	C	D
Purification Tank	Fill	Open	Shut	Shut	Open
	Empty	Shut	Open	Open	Shut
	Circulate	Shut	Open	Shut	Open
Reservoir	Circulate	Open	Shut	Open	Shut

Seawater Circulation System and Valve Control Positions



9.6 Seawater Salinity

Seawater salinity should be checked whilst the tank is being filled.

The seawater salinity must be within the range required for the species as given in Section 6, and can be measured using a hydrometer as described in Section 13.2. If the reading shows the salinity to be too low or high it should be re-checked and if still incorrect the water must not be used.

Salinity can be too high if an incorrect mix of artificial seawater has been used or evaporation has occurred over a period of re-use. Salinity that is too low can result from an incorrect artificial seawater mix or, in the case of natural seawater, too much dilution from a natural freshwater source. For natural seawater supply it may be possible to wait for a change in tidal condition.

The salinity of artificial seawater can be adjusted by dilution with tap water or adding extra salt. Care must be taken to maintain the correct mixture of salts.

9.7 Seawater Temperature

Mollusc activity is dependent upon seawater temperature and adequate dissolved oxygen levels. Minimum seawater temperatures are stipulated for the purification of each species to ensure adequate mollusc filtration activity. A maximum seawater temperature is stipulated for mussels which have a high oxygen demand. In addition, if seawater temperature is too high all molluscs will weaken, spawn or die and so maximum temperatures are recommended for all species. These depend upon species, growing conditions and season. The temperatures normally required for purification are shown below.

Seawater Temperature

Species	Minimum	Maximum
Mussels	5^{O}C	15^{O}C
Native Oysters	5^{O}C	15^{O}C
Pacific Oysters	8^{O}C	18^{O}C
Clams	12^{O}C	20^{O}C
Cockles	7^{O}C	16^{O}C

Large temperature differentials between molluscs and seawater when filling the purification system should be avoided as they may reduce mollusc activity, induce spawning or even cause mortality. To avoid this, molluscs should be allowed to reach the required temperature slowly.

If suitable minimum seawater temperatures cannot be maintained the system must not be used for purification.

Seawater chillers and heaters can be provided[11]. These must be installed and operated such that the water flow is not disrupted or local hot or cold spots created in the part of the tank where the molluscs are held.

9.8 Mollusc Activity

When the molluscs are immersed in seawater they should exhibit signs of activity by slightly opening their shell halves. Often air bubbles will be seen rising to the water surface as entrapped air is released. After a few hours the shell halves should be more open and, depending upon species, mantles or syphons should be visible. Some species are more active than others. Mussels are often active within minutes whereas hard shell clams exhibit intermittent activity. After the first overnight period the molluscs should be active and the seawater clear (tank bottom visible). If not, the system should be drained down and the reason sought. Inactive molluscs will not purify satisfactorily.

[11] FAO Fisheries Technical Paper http://www.fao.org/3/a-i0201e.pdf Bivalve Depuration: Fundamental and Practical Application.

Foaming on the water surface is created as a result of the build-up of dissolved waste excreted by molluscs. The amount of foam will depend upon species, level of activity and the extent of re-use of seawater. It is not normally a problem but if foaming is excessive it will flow over the tank sides and will reduce the seawater level such that the molluscs are not adequately covered. In this case, action must be taken to reduce foaming (Section 11.5).

Surface foaming

9.9 Immersion Time

For purification the minimum immersion time required will usually be 42 hours. It is possible in certain circumstances to reduce the depuration time[12]. However, this can only be done with the approval of the AO[13]. The immersion period can be extended prior to draining down, if it is desired, to store the full load of molluscs in the system. Extended storage of cockles is not recommended as they become exhausted and die.

If during a purification cycle the system should stop operating, the time lost must be made up to ensure the required purification time has been achieved. If the system has been stopped or operating at a reduced flow for more than a few hours the molluscs may have been weakened. If they show signs of weakness such as gaping, or even mortality, the molluscs must not be consigned for human consumption.

9.10 Draining the Tank and Unloading Molluscs

At no time whilst they are immersed must molluscs be disturbed or removed as this can cause re-suspension and ingestion of settled out material. The tank must be drained before removing the molluscs. To drain the tank the seawater is diverted away from the spray bar or cascade, to waste or reservoir by operating the valves as shown in the seawater circulation diagram. This continues the same direction and rate of water flow in the tank, thereby reducing the chance of any re-suspension of material. Once pump suction is lost the water flow will stop and pump and UV can be switched off. Some water will be left in the bottom of the tank but it will be below the containers and is run to waste with the detritus by opening the final main tank drain door (F). Where the water is not re-used and is drained to waste, the main tank drain door must not be opened until the water level has fallen below the containers.

Unloading of containers is a reversal of the loading procedure, with care being taken to ensure that the lifting frame is correctly located on the pallet. Once unloaded the molluscs must be washed with clean water and the required sorting and packing operations carried out. As the finished product must be alive, this should be done with care to minimise shock and damage. Packaging must be clean and labels attached as instructed by the local Food Authority. A product storage temperature of 2°C to 5°C is generally recommended, however, native oysters should not be held at less than 4°C and mussels can be iced.

The containers and tank should be washed whilst wet before silt, etc. dries on. With the drain door (F) open the sediment in the bottom of the tank can be flushed out to waste, taking care to close the drain door securely once this has been done.

If only some of the molluscs are to be packed after purification and the system is to be used for immersed storage of the remainder, the system must still be emptied and washed out. Containers of molluscs that are to be put back into the system must first be hosed down. Instructions on part-loading the system given in section 9.4 should be followed.

The position of the suction pipe in the tank is such that 1000 litres drain to waste and if the seawater is to

[12] http://www.seafish.org/media/publications/Red_Dep_Time_V3IB_RF.pdf
[13] https://www.food.gov.uk/sites/default/files/reduced-purification-times-shellfish.pdf

be re-used this will have to be replenished with new seawater as necessary. Also, in warm weather there may be a need to make up evaporative losses.

9.11 Monitoring the System Operation

For a purification centre, details of molluscs received, start and finish times of purification and details of subsequent consignment must be recorded and checks of seawater salinity, temperature and UV lamp life made. These details are best recorded in tabular form using a log sheet such as that shown at the end of the manual. The source column could include movement document number. It is recommended that seawater temperature is measured at the start, middle and end of purification.

If a time recorder is not fitted to the UV sterilisation unit then hours switched on should be recorded cumulatively to give an indication as to when the lamps need replacement (Section 10.2).

The comment column can be used to note anything that occurred during purification such as a power cut or pump failure and subsequent action taken. The dates also allow a check on seawater re-usage.

If more than one purification system is used each should have its own log sheet to avoid confusion.

Log sheets must be filled in legibly and be kept somewhere dry, such as an office, and not be left lying around in the purification or dispatch centre. It is a good idea to keep basic system details of start and finish time, salinity and temperature on a chalk or pen board mounted on a wall. This serves as a daily reminder of status and can be transferred to the log book on a weekly basis.

9.12 Seawater Re-Use

The FSMP can prescribe conditions under which seawater can be re-used for each purification system and generally permit re-use over a specified period of time. However, this period is prescribed as the maximum limit of water usage and the operator of a purification system must satisfy himself at each successive re-use within the period that the water quality is adequate.

If molluscs appear inactive when immersed (see section 11.6) and water quality is suspected, new seawater should be used. If seawater quality was the cause, molluscs will usually become active when re-immersed in the new seawater.

The re-use of seawater for successive purification cycles can result in dissolved waste from the molluscs accumulating in the seawater to a level which may inhibit purification. This depends upon the species of molluscs, their intrinsic condition, the loading of the purification system and the seawater temperature. The large-scale system was originally developed for mussel purification with the re-use of artificial seawater, and it has a high seawater to mussel ratio and 10% make up after each use. The re-use of seawater over a period of one month would normally be permitted.

When re-using seawater, the salinity will increase as a result of evaporation, particularly when temperatures are high, and care must be taken to ensure it does not go beyond the prescribed level.

Further advice on the re-use of seawater should be sought from Seafish.

9.13 Microbiological Sampling

Operators of purification systems are required to carry out microbiological testing on samples of molluscs. Microbiological sampling for end product testing and or system efficacy can only be determined by the FBO as they will understand the risks associated with the batch and processes under their control.

Sampling frequency will be based upon the assumed level of microbial contamination on harvesting, standards of operation at the purification centre and adherence to industry good practice guidelines. The laboratory should carry out a prescribed microbiological or viral analysis procedure.

A sample of molluscs must contain sufficient shellfish flesh for a test to be carried out; 10-15 molluscs would normally be taken as a sample. With large molluscs it may be possible to use less (although never less than 6). Dead or gaping molluscs should not be used. The laboratory will advise if sample size is inadequate and sometimes will not accept samples below a certain number, so it is advisable to check.

The sample molluscs should be put into a clean plastic bag and be kept in cool conditions, ideally at 4°C

(an insulated box containing freezer packs is the method normally used) and be delivered to the laboratory within 24 hours. Molluscs must not be frozen. The samples must be labelled to enable identification. The microbiological results must show that the purified molluscs comply with any relevant legislative or FSMP requirements. If these standards are not met then the AO must be contacted for further advice.

10. Cleaning and Maintenance

10.1 Pump Filter

A course screen filter may be fitted to the pump on the suction side to prevent any large shell pieces from entering the pump and causing damage. This requires occasional cleaning and is removed (with the pump switched off) by unscrewing the filter housing cap from the pump. If the tank is full of water, the valve between pump and suction pipe must first be closed. The filter is then lifted out and rinsed with clean tap water. With the cleaned filter replaced the cap can be screwed back on after first ensuring that the sealing ring and housing face are clear of any shell or debris.

Care must be taken not to cross the threads. The cap should be tightened firmly.

10.2 Ultra Violet Light (UV) Sterilisation Unit

The system is usually fitted with six 30-watt UV lamps contained within a single cylindrical drum housing although six single tube units could be used instead. Alternatively, industrial size UV units may be used.

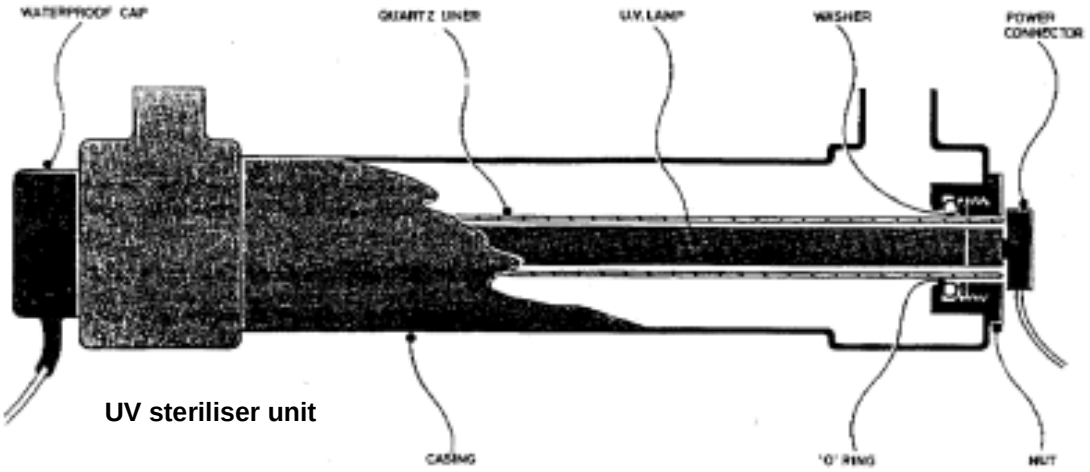
6 lamp UV steriliser

Safety: UV light is dangerous to the eyes and skin and the lamp must never be operated outside its housing. A green/blue glow can be seen from each tube at the ends of the unit to indicate that it is on in normal use. Before any cleaning or maintenance is carried out the electrical power must be switched off.

Lamp Replacement: The lamps gradually deteriorate in use and must be changed as specified in the FSMP. This may be based upon the intervals specified by the lamp manufacturer in terms of hours of use, however, a calendar time interval may be given instead.

To replace a lamp:

- Switch off the power
- Carefully pull-off the lamp connectors and covers from either end, supporting the tube if mounted vertically
- Gently slide the lamp out of the quartz sleeve
- Fit the new lamp in the reverse procedure



UV steriliser unit

Cleaning: The quartz sleeve may need cleaning occasionally as a result of sediment building up on its outer surface. The accumulation of sediment will depend upon the clarity of the water supply and it is recommended that the sleeve is checked after a few weeks to give a guide to the frequency of cleaning required.
To remove the quartz sleeve:

- Switch off the power and remove the UV lamp as described above
- Make sure the water has been drained out of the unit
- Unscrew the end nuts and remove the "O" ring seals and washers (this is sometimes difficult). The tube will need support at the bottom of the unit if mounted vertically to prevent it falling out
- Withdraw the quartz sleeve, taking care to handle it at the ends only, and inspect it carefully. If cracked the sleeve must be replaced. The sleeve should be cleaned with soapy water and gentle brushing if necessary. The sleeves discolour after many years of use and if badly stained should be replaced
- Rinse and dry the sleeve and replace it in the unit. Inserting a clean wooden dowel into the sleeve can assist in this and reduce the chance of breakage
- Replace "O" rings and washers and tighten the nuts with hand pressure only and, if necessary, re-connect to the plumbing system
- Turn on the water and check for leaks
- Replace the lamp

If access to the UV unit for servicing is difficult it may be easier to first remove it from the tank.

10.3 Purification System Cleaning

After each purification cycle the purification tank should be thoroughly flushed out with clean water to remove silt and shell debris. Containers should be hosed down.

To prevent accumulation of slime and dirt the tank and pipework should periodically be cleaned with a suitable cleaning agent. Hypochlorite solution (as found in household bleach) is recommended. The empty containers should be loaded into the tank, the system filled with tap water and the hypochlorite added (with care, following manufacturer's instructions). It should then be switched on and left for a few hours, preferably overnight. After cleaning the system must be thoroughly flushed through with clean water to remove any traces of residual chlorine, which will harm molluscs.

Cleaning agents must be stored in a safe place away from the mollusc handling and purification areas.

10.4 Sand Filter

If a sand filter is used for seawater supply (it must not be fitted such that it forms part of seawater re-circulation), care must be taken to follow the manufacturers operating instructions. In particular the pressure gauge should be checked as excess pressure indicates the filter is becoming clogged and requires back flushing.

11. Possible Problems and Answers

Occasionally things can go wrong due to equipment failure, poor handling, poor seawater quality or poor intrinsic quality of the molluscs, or simply incorrect operating procedure. The following gives some of the more likely problems and answers but by no means covers every possibility. If the cause of a problem cannot be found, further advice should be sought by contacting Seafish.

11.1 Difficulty in Filling the Tank with Seawater

- Water level in reservoir too low (below pump)
- Air lock in supply pipework
- Valves incorrectly set
- Pump filter partly blocked

11.2 Water Flow Stopped

- Power supply off (if circuit trip in control box will not re-set, contact electrician)
- Pump failure
- Control valve turned off
- Pump filter blocked

- Water level in tank below suction pipe

11.3 Water Will Not Flow at Required Rate
- Pump filter partly blocked
- Pipework fouled with marine growth (in particular spray bar)
- Air leak on pump suction. When this occurs, air can be seen passing through the sight tube of the flowmeter
- Valves partly blocked or incorrectly set
- Worn pump

11.4 UV Lamp Unit Not On or Flickering
If the green/blue light does not appear at the ends of the unit when switched on, or the lamp flickers, the unit is not operating correctly.

Likely causes are:
- UV lamp faulty and requires replacement
- Starter unit in control box faulty
- Corrosion on terminal ends

11.5 Excessive Foaming
- Water flow greater than that prescribed
- Water re-use. With seawater re-use there can be a gradual build-up of the dissolved waste that causes foaming, particularly with mussels and at higher seawater temperatures. More frequent water Replacement may be necessary
- For systems with supplementary aeration the air supply may be excessive

11.6 Molluscs Appear Inactive Whilst Immersed
- Incorrect salinity
- Seawater temperatures too low or too high
- Seawater quality poor (re-used too often)
- Molluscs in weakened condition as a result of poor handling and/or delays between harvesting and re- immersion
- Molluscs in seasonally weak condition (post spawning)
- Thermal shock. Molluscs subjected to too great a temperature change when re-immersed

11.7 Seawater Becomes Cloudy
If during purification or immersed storage the seawater becomes clouded (usually a milky colour) the molluscs have probably spawned and if held in the system will die. Spawning does occur naturally but can be precipitated by shock and high water temperatures. The clouding of the water should not be confused with the slight turbidity that can sometimes occur when molluscs are initially immersed. This can be caused by mud and silt not removed completely by washing and should disappear within a few hours.

11.8 Molluscs Die or Appear Weak
- Molluscs generally gape when dead or are in a weakened condition, and will not close their shell halves at all or only close them slowly when disturbed
- Molluscs have spawned
- Molluscs in a weakened condition (see Section 11.6)
- Water temperature too high
- Too long a period of immersion
- Molluscs stressed following a period with no water flow

12. Modifications to Purification System

Modifications to the system or its method of operation should not be made without first contacting the AO. The design flow conditions in the system must be maintained if it is to operate effectively and modification may disrupt this. The LA must approve of any changes made.

13. Measurement of Seawater Salinity and Temperature

13.1 Temperature

A hand held digital electronic probe thermometer is recommended. A robust and water-resistant type should be used and its calibration checked at intervals (for example in a container of clean, iced, fresh water). Glass thermometers are prone to breakage and if used to measure seawater temperature this should not be directly in the purification system but in a suitable container (as used for salinity measurement) filled from the tank.

The continuous monitoring of seawater temperature is possible using special sealed units that can be positioned in the purification system.

13.2 Salinity

Seawater salinity should be checked using an hydrometer. These are usually made of glass so care must be taken and measurement made in a suitable container filled from the tank. The container must be clean and be deep and wide enough to allow the hydrometer to float without touching the sides or bottom (a soft drinks bottle with the top cut-off can be used).

The hydrometer will usually give a reading of specific gravity (SG). From this and seawater temperature the conversion chart is used to obtain a salinity reading.

Some hydrometers can give a direct reading of salinity with built in temperature compensation. For this type the salinity conversion chart is not required. Using the traditional type hydrometer:

1. Fill the container with seawater, place on a bench at eye level and let any air settle out
2. Insert the hydrometer (ensuring it is clean) and let it settle making sure it is afloat and not touching the container sides
3. Read the hydrometer scale level with the water surface ignoring the surface tension meniscus around the hydrometer stem. The scale is usually between 1.000 and 1.050 and is a reading of specific gravity (SG)
4. After use, wash the hydrometer and container with tap water

14. Further Information

14.1 Industry Guidelines

Seafish have produced a Good Manufacturing Practice Guidance (GMPG) document[14] on Bivalves. Recommendations are based upon good practice but include legal requirements. The document deals with facilities and equipment and includes purification and the use of purification facilities for conditioning and immersed storage.

14.2 Other Operating Manuals

Seafish have produced a series of these operating manuals for the range of standard design purification systems available. These include shallow tank, vertical stack and bulk bin systems. There is also a manual for those who wish to operate a system constructed to their own design.

Title	Seafish Report No.	ISBN No.
Operating Manual for the Bulk Bin System for Mussels	718	978-1-911073-24-6
Operating Manual for the Large Scale Multi-Layer System	719	978-1-911073-25-3
Operating Manual for the Medium Scale Multi-Layer System	720	978-1-911073-26-0
Operating Manual for the Small Scale Shallow Tank System	721	978-1-911073-27-7
Operating Manual for the Vertical Stack System	722	978-1-911073-28-4

[14] http://www.seafish.org/media/publications/gmpg_bivalves_downloadable.pdf

Generalised Operating Manual for Purification Systems of Non-standard Design	723	978-1-911073-29-1

14.3 Seafish and Seafish Advice

At Seafish[15], our mission is to support a profitable, sustainable and socially responsible future for the seafood industry. Our remit includes everything - and everyone - from fishermen and processors through to importers, retailers and food service providers. We offer an advisory role to industry, local food authorities and government departments. Where resources permit, Seafish will provide general advice when possible and appropriate, and/or signpost enquirers to other sources of information and service providers.

14.4 Artificial Seawater

Artificial Seawater has higher initial cost but can offer considerable advantages where systems are to be operated inland or local supplies of natural seawater are considered unsuitable. Advice on the production and use of artificial seawater is given in a Seafish technical advisory document on the re-use of seawater for purification systems[16].

14.5 Technical Reports

Technical Reports describing much of the work upon which the Multi-Layer Systems have been developed can be obtained from Seafish.

Title	Seafish Report No.
Mussel Purification – Commercial Trial of Multi-Layered Purification	312
Commercial Trial of a Multi-Layer Mussel Purification Tank with re-use of artificial seawater	355
Design and Commission of a Mussel Purification Plant at Kings Lynn	380
Mussel Purification, Development of a Medium-Scale Deep Stack Purification Tank	387

Further information on the operation of the Large Scale Multi-Layer Purification System or any of the above-mentioned publications can be obtained from:

Lee Cocker, Aquaculture Manager and/or Lee Cooper, National Learning and Standards Manager
Seafish, Origin Way, Europarc, Grimsby, NE Lincolnshire DN37 9TZ
Tel: +44 (0)1472 252 300
Fax: +44 (0)1472 268 792
Email: seafish@seafish.co.uk

[15] http://seafish.org/
[16] http://www.seafish.org/media/Publications/FS32_07_09_Reuseofseawaterforpurificationsystems.pdf

Purification System Log Sheet

Species	Amount	Source	Start		Finish		Seawate				UV Hours	Consignment	Comment
			Date	*Time*	*Date*	*Time*	*Sal*	*Temp*	*Temp*	*Temp*			