DANGO & DIENENTHAL

Filtertechnik GmbH

MUSSEL STOP

GB

Mussel larvae in cooling water circuits

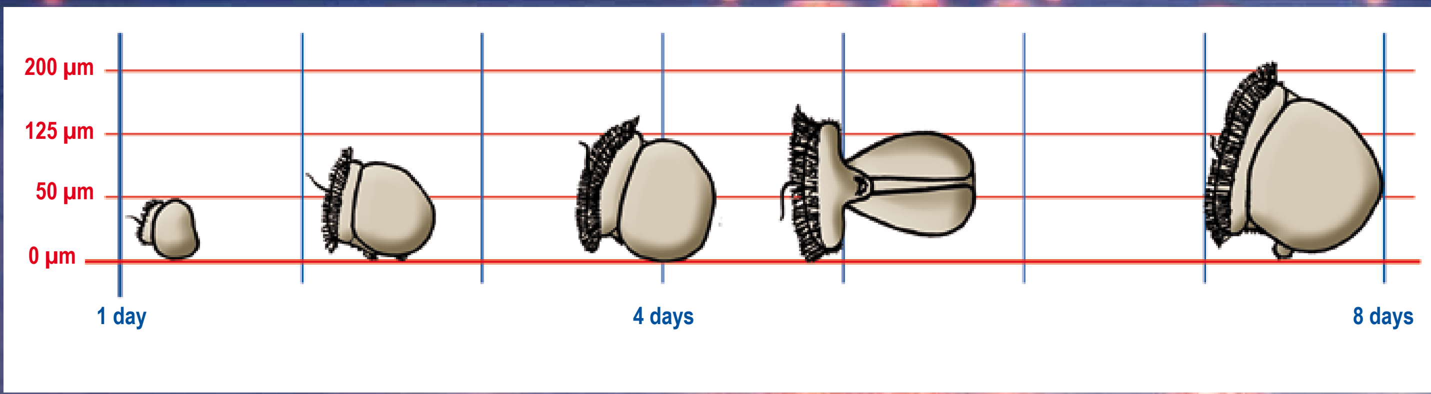

Fig.1 Growth of a zebra mussel larvae

Problem case: Zebra mussel

For many years, the zebra mussel (lat.: Dreissena polymorpha) has been spreading to countless rivers and lakes throughout the globe. For industry, this rapid increase means damages in the millions of dollars. With this infestation in our lakes and rivers, the zebra mussels are transported into the cooling circuits of industrial plants where they interfere with the proper function of plate and tube heat exchangers.

In most cases, the mussels and their larvae are killed using chemicals and then flushed out of the pipes afterwards. Unfortunately, the chemical treatment method has environmental issues and is also very expensive.

A very effective way of fighting the mussels even in their early larvae stage is to purchase mechanical filter units with MUSSEL STOP system by DANGO & DIENENTHAL.

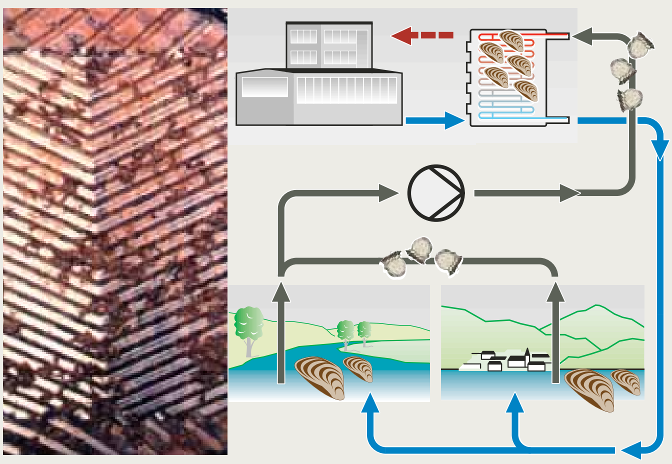

Fig. 3 Mussel infestation of a heat exchanger without filter

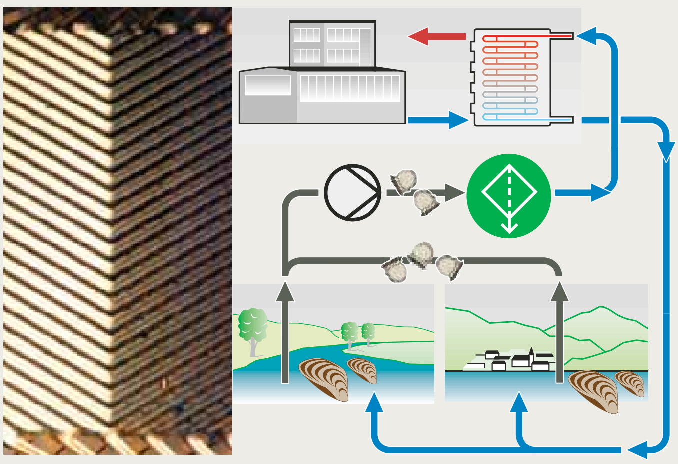

Fig. 4 Problem-free operating heat exchanger, protected from mussel infestation by a DANGO & DIENENTHAL filter with MUSSEL STOP

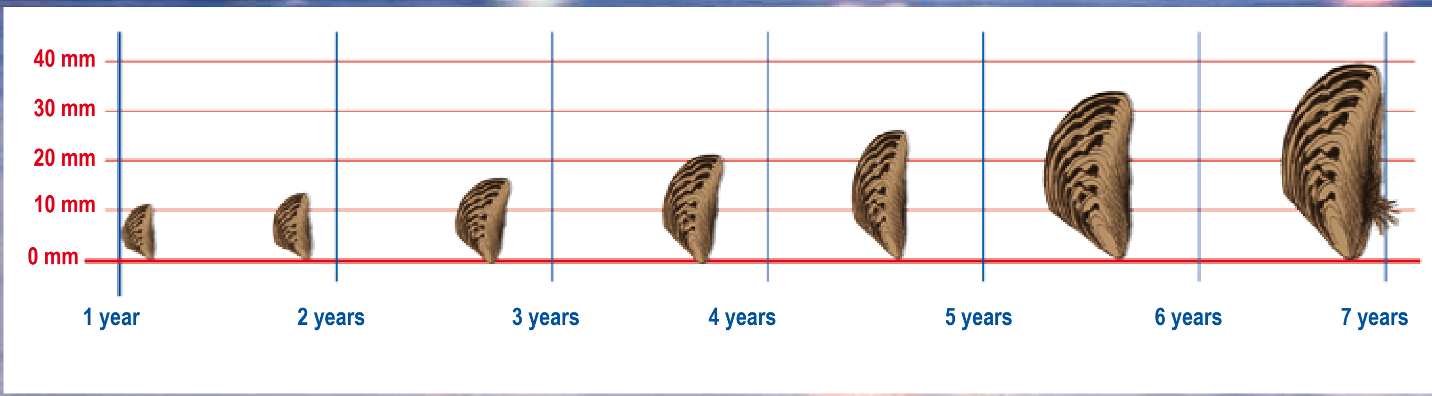

Fig. 2 Growth of a sexually mature zebra mussel

The spread of the zebra mussel

Just like the closely related quagga mussel, the zebra mussel came from the waters of western Asia. Nowadays, it is known and often feared on all continents. The larvae of the naturally useful animals were in all probability spread across the world's oceans in the ballast water tanks of large cargo ships. The rapid growth and spread of the mussel larvae caught the industry unprepared. The potential dangers as well as the resulting damages were not immediately realized until it was too late.

Today, power plants, steel works and chemical companies are suffering enormously from the infestation of these lake and river inhabitants. As they breed in the cooling water, they are putting whole pipe systems and heat exchanging plants out of operation, causing damages of millions of dollars every year.

Fig. 5 Spread of the zebra mussel in Europe

Fig. 6 Mussel infestation of filterelements and piping systems

Fig. 8 Mussel infestation in the industry

Fig. 7 Mussel infestation of tube heat exchanger

The devastating consequences for industrial plants using lake and river water

The zebra mussel has few natural enemies in foreign ecosystems. Therefore, it can grow and spread fast and uncontrolled. Once a population has established itself in a lake or river, there is no reasonable chance of stopping thousands of tiny mussel larvae from being pumped into the cooling circuits of the local industrial plants. They grow inside the pipe systems to a size of 200 μm within 8 days, attaching to and blocking heat exchangers, spray nozzles and even whole pipe systems. As a result, the cooling of the production process is interrupted. After a while, this problem will as a rule lead to the inevitable shutdown of the plant in order to avoid equipment damage. In this case, the plant owner would not only have to pay for the subsequent costs of the production standstill but also for the cleansing of the cooling circuits from mussels before the production can restart. Unfortunately, this ties up manpower and creates additional costs.

Emergence of high costs in case of cleansing

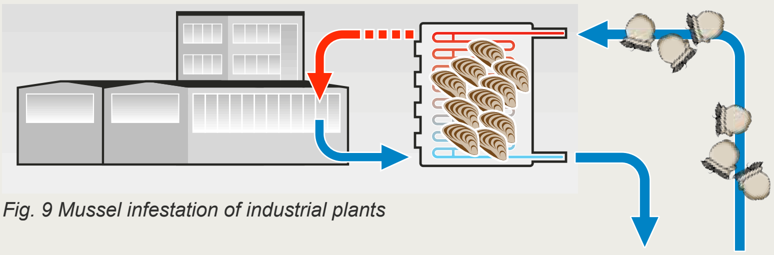

Fig. 9 Mussel infestation of industrial plants

In practice, especially plate and tube heat exchangers, spray nozzles and complete pipe systems are heavily affected, because mussels and mussel larvae in spite of the increased flow velocity are able to lock on to these components using their byssus threads.

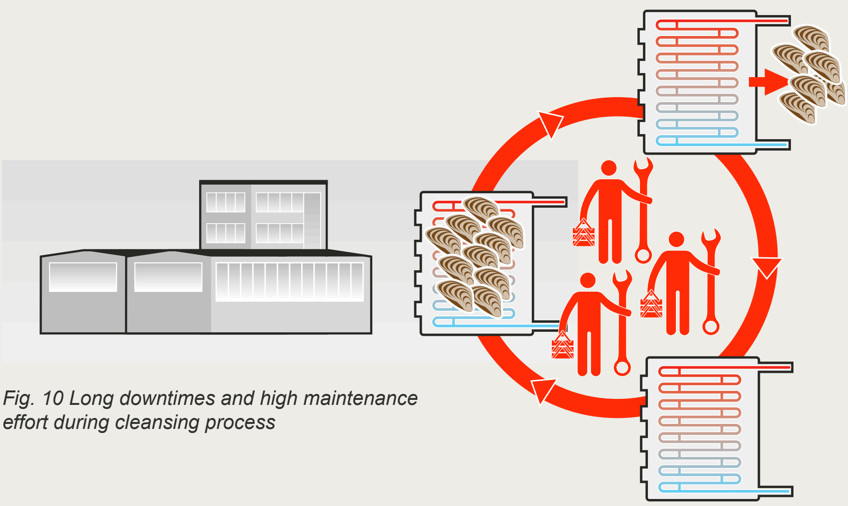

Fig. 10 Long downtimes and high maintenance effort during cleansing process

The cleansing of this equipment can only be realized in the context of system downtimes and high personnel deployment. Moreover, additional costs are caused by the production loss because of the lengthy cleansing process. Depending on the plant size and including disassembly and reassembly of the affected components, this process may take several days.

Effective problem solution with MUSSEL STOP

By operating a MUSSEL STOP system by DANGO & DIENENTHAL, the mussel infestation of cooling components in all industries can be avoided effectively. This effectiveness is a result of the unique slot design with a filter fineness of approx. 300 micron in Filterautomats and JET Filters including MUSSEL STOP. The optimum relation of filter surface and flow rate allows for very high filtration velocities, greatly accelerating the mussel larvae in combination with the special slot geometry. At that point, strong caviation forces are destroying the larvae as they pass through the filter element. Appropriate tests have shown that the caviation force should be at least 1,000 g to kill the mussel larvae effectively. Filterautomats and JET Filters with MUSSEL STOP by DANGO & DIENENTHAL do meet these parameters.

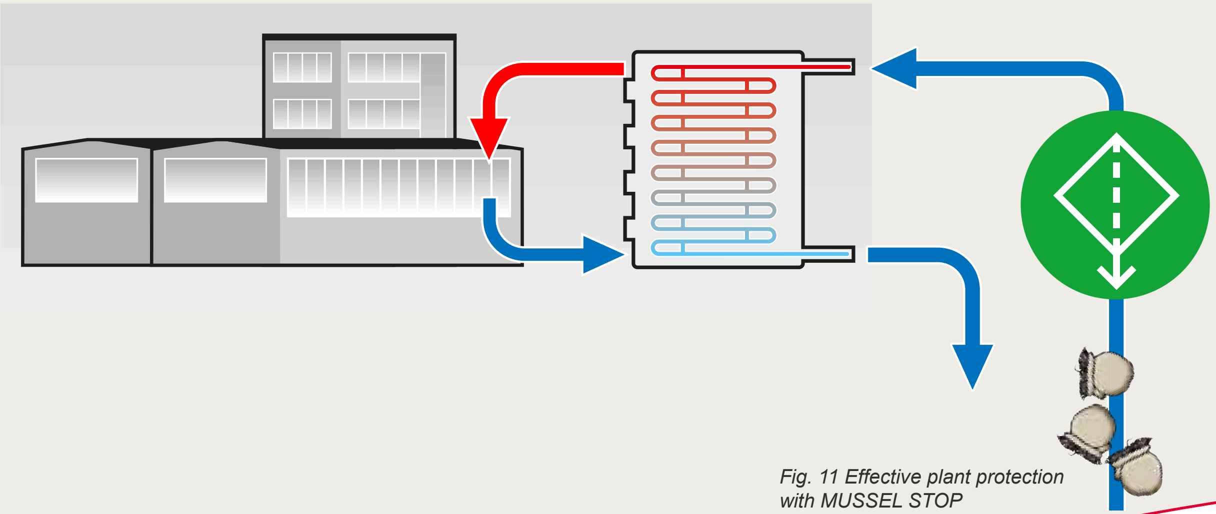

Fig. 11 Effective plant protection with MUSSEL STOP

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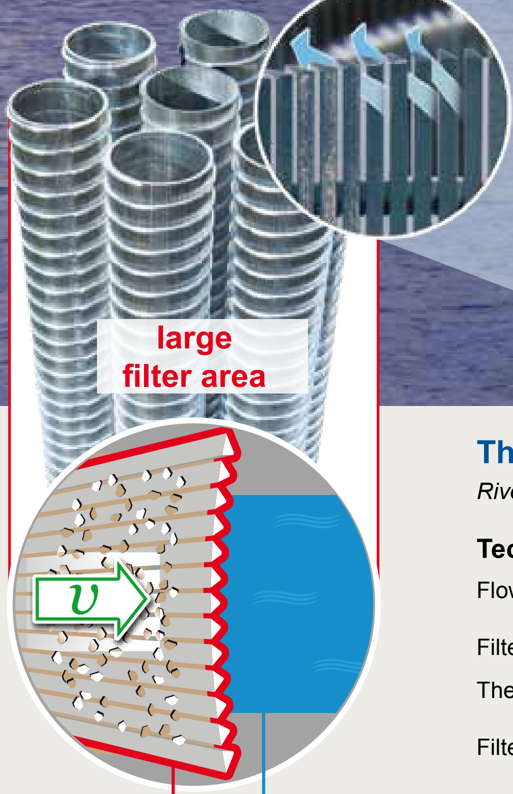
The wrong approach: Large filter surface, low filtration velocity

Using the example of a conventional cartridge filter it can be shown that this method can not generate the necessary flow velocity to effectively combat the mussel larvae. In this case, the filter surface of the machine is too large to generate the demanded filtration velocities.

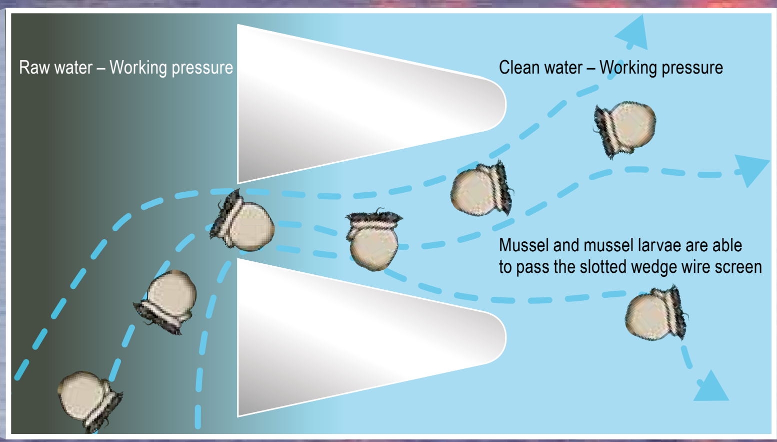


Filtration velocity

Flow rate

$$v = \frac{Q}{A}$$

Filter area



Low filtration velocity

Fig. 12

The cartridge filter example in numbers:

River water station with a flow rate of 220 m³/h

Technical data:

Flow rate Q = 220 m³/h = 0,061 m³/s Filter fineness = 300 µm

Filter area gross (A_{gross}) = 8700 cm² = 0,87 m²

The open filter area (filter area net)) of a slotted wedge wire screen with 300 µm is about 26 %

Filter area net (A_{net}) = 2262 cm² = 0,2262 m²

Filtration flow speed $v = \frac{\text{Flow rate } Q}{\text{Filter area net } (A_{net})}$

$v = \frac{0{,}061 \text{ m}^3/\text{s}}{0{,}2262 \text{ m}^2}$ v = 0,269 m/s

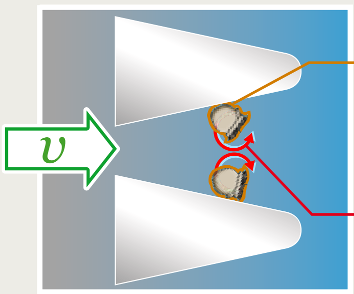


Fig. 14

Calculation of mussel larvae rotation acceleration:

Size of mussel larvae = d = 300 µm, r = 150 µm

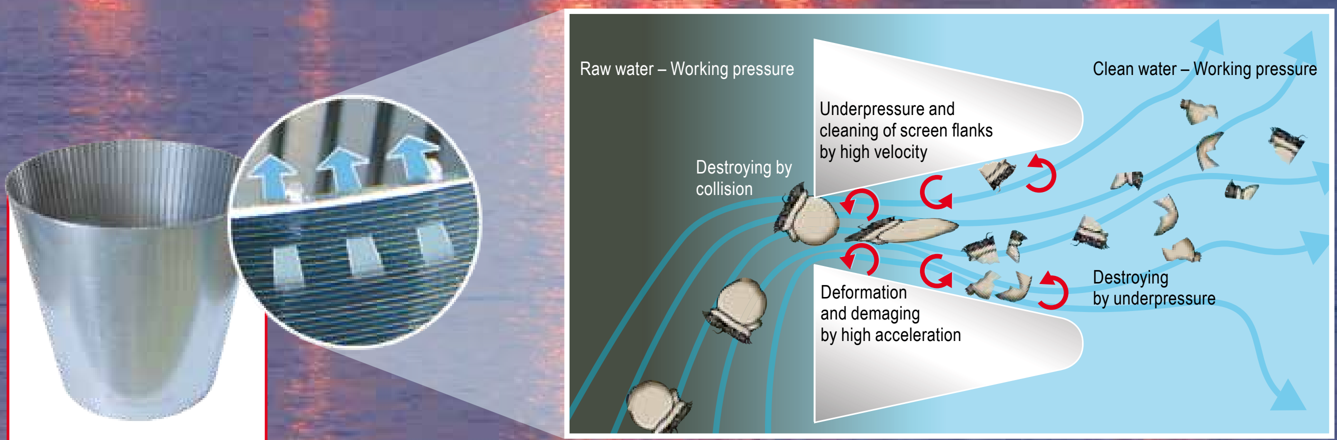
Acceleration (a) = $\frac{\text{Peripherial velocity}^2\ (v^2)}{\text{Mussel larvae radius } (r)}$

$a = \frac{(0{,}269 \text{ m/s})^2}{0{,}00015 \text{ m}}$ a = 482 m/s²

The earth acceleration (g) is 9,81 m/s². An usual cartridge filter reach a maximum earth acceleration of 47 g-force.

The effective solution: High filtration velocity with MUSSEL STOP

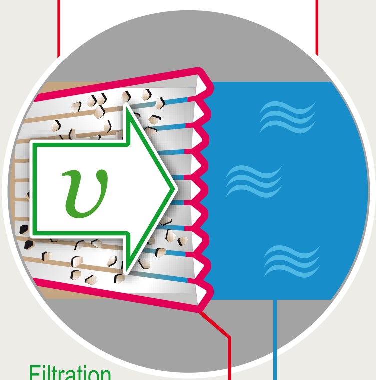
Thanks to its smaller filter surface, the DANGO & DIENENTHAL filter unit with MUSSEL STOP is able to transform the energy of the filtration velocity into caviation energy. This provides the deformation and damage of the mussel larvae on the slot flanks.



small filter area

High filtration velocity

Fig. 13



$$v = \frac{Q}{A}$$

The MUSSEL STOP example in numbers:

River water station with a flow rate of 220 m³/h

Technical data:

Flow rate Q = 220 m³/h = 0,061 m³/s Filter fineness = 300 µm

Filter area gross (A_{gross}) = 1300 cm² = 0,13 m²

The open filter area (filter area net)) of a slotted wedge wire screen with 300 µm is about 26 %

Filter area net (A_{netto}) = 338 cm² = 0,0338 m²

Filtration flow speed $v = \frac{\text{Flow rate } Q}{\text{Filter area net } (A_{net})}$

$$v = \frac{0{,}061 \text{ m}^3/\text{s}}{0{,}0338 \text{ m}^2} \qquad v = 1{,}8 \text{ m/s}$$

Calculation of mussel larvae rotation acceleration:

Size of mussel larvae = d = 300µm, r = 150µm

Acceleration $(a) = \frac{\text{Peripherial}^2 \ (v^2)}{\text{Radius } (r)}$

$$a = \frac{(1{,}80 \text{ m/s})^2}{0{,}00015 \text{ m}} \qquad a = 21600 \text{ m/s}^2$$

The earth acceleration (g) is 9,81 m/s². So we reach an earth acceleration of approx 2.105 g-force with our MUSSEL STOP System.

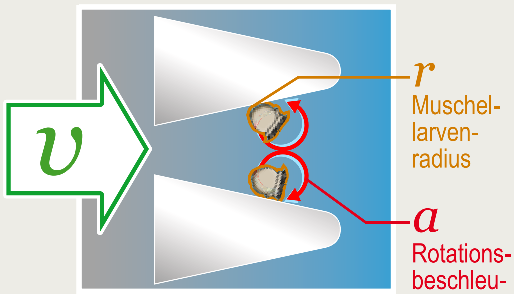


Fig. 15

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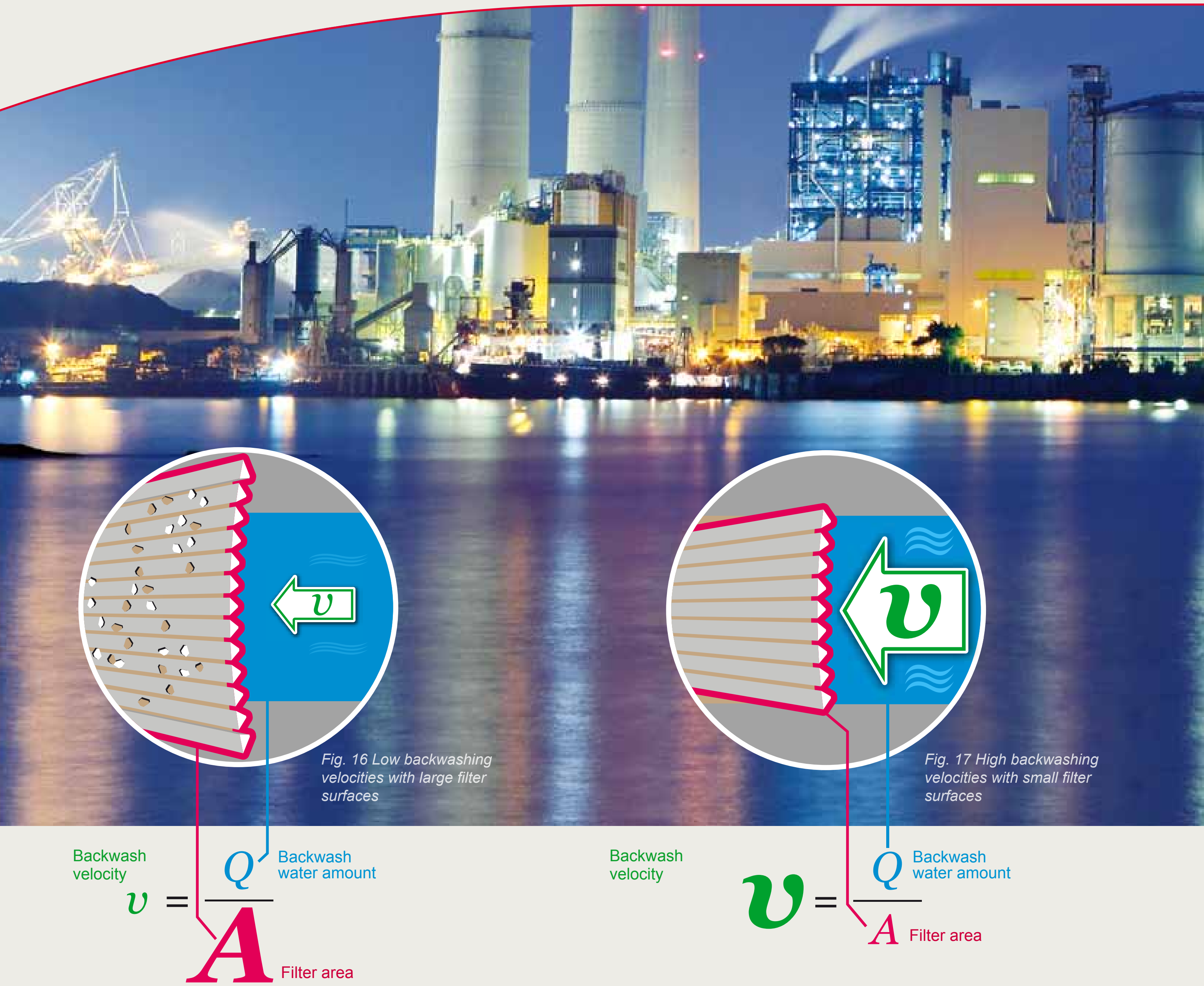

Fig. 16 Low backwashing velocities with large filter surfaces

Fig. 17 High backwashing velocities with small filter surfaces

Low-maintenance operation with MUSSEL STOP

For an effective elimination of mussel larvae, a high backwashing velocity is just as desirable as a high filtration velocity. Many filter systems with large filter surfaces do not provide any of these features (Fig. 16). Hence, mussels, sand and other solids, which locked on to the filter element, cannot be separated during the backwashing process. In contrast, Filterautomats and JET Filters with MUSSEL STOP show their advantages here as well: backwashing velocities of up to 33 fps (Fig. 17) guarantee an effective cleansing of the filter element and therefore low-maintenance operation of the whole plant.

Fig. 18 MUSSEL STOP system at river filtration

Conventional cleaning process

- Chlorine
- Bromine
- Chlorine dioxidea
- Chloramines
- Ozone
- Potassium permanganate

- Freezing of pipe system
- Heating of pipe system
- Drying up of pipe system
- Deoxygenation

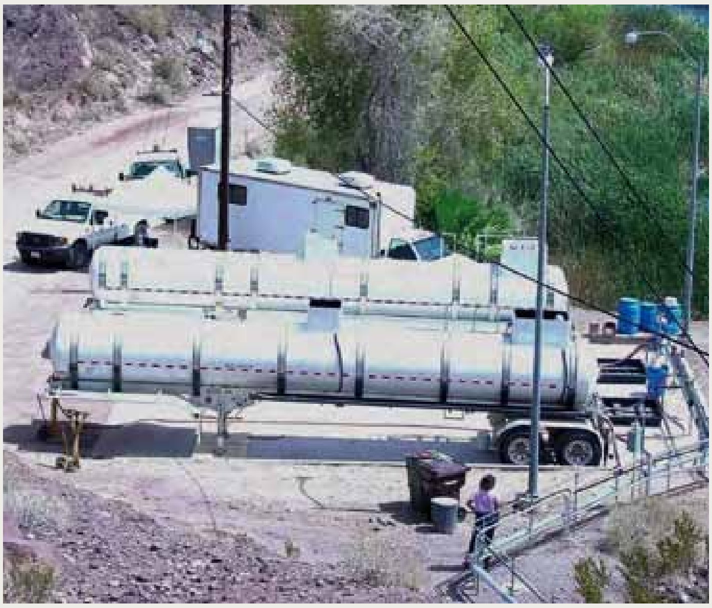

Fig. 19 Oxidizing chemical treatment

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The MUSSEL STOP internal layer

To keep the MUSSEL STOP system in Filterautomats and JET Filters by DANGO & DIENENTHAL as resistant as possible to mussel infestation and fouling, the inner housing is coated with a special kind of epoxy resin. This protective layer has an extremely smooth surface, mussel larvae and other microorganisms are not able to lock on to. In this way, the optimum protection of the filter is ensured.

Fig. 20 DANGO & DIENENTHAL filter housing and baskets, coated with epoxy resin

Defencelessly exposed with gravel filters

Gravel and sand filter units are still often used for the filtration of river and lake water. But unfortunately, because of the mussel larva size during the early stages of development they are able to slip through the hollows of the gravel bed to get to the clean water side. That is why these systems are not suitable for the protection of industrial plants from mussel infestation.

Additionally, sand and gravel filters cannot provide effective back washing of the mussel larvae, because their specific weight is just too low.

Besides an unsatisfying rate of mussel and mussel larvae separation, sand and gravel filters have further disadvantages:

- high purchase costs
- high space requirements
- high maintenance efforts
- high operational costs

Fig. 21 Gravel filter construction

Fig. 22 Filtration process

Fig. 23 Backwash process

Filterautomat

The Filterautomat with MUSSEL STOP is characterized by its outstanding robust design. By means of the rotating tapered filter drum even large mussels and other solids in the river and lake water can be killed or shredded.

Please see **www.dds-filter.com** for more information on this filter system.

flow rate	**5 m³/h to 10,500 m³/h**
filter fineness	**≥ 5 µm**
operating pressure	**0.8 to 63 bar**
pressure loss with clean filter	**0.1 to 0.3 bar**
flange size	**DN 50 to DN 1,00**
temperature	**– 10 to + 110 °C**
automatic backwash	✓

Fig. 26

Fig. 24 Filtration process

Fig. 25 Backwash process

JET Filter

The JET Filter as well provides the MUSSEL STOP system. Thanks to its unique construction it does not demand any moving internal parts. Intake and outlet are in-line designed – opposing and on the same level. The JET Filter is available in all common material variants. It impresses with a maximum of variability, is produced in different sizes and can be mounted either horizontally or vertically.

Please see **www.dds-filter.com** for more information on this filter system.

flow rate	**1 m³/h to 25,000 m³/h**
filter fineness	**≥ 50 µm, ≤ 5 mm**
operating pressure	**1.5 to 63 bar**
pressure loss with clean filter	**DN 50 to DN 3,000**
flange size	**DN 50 to DN 3,000**
temperature	**– 25 to + 200 °C**
automatic / manual backwash	✓

Fig. 27

High-risk equipment and circumstances, which may lead to mussel infestation

Piping	Circulating water systems	Service water systems
Traveling screens	Once through	Pumps
Water towers	Pumps	Piping
Trash racks	Piping	Raw water makeup
Trash bars	Condenser water boxes	Heat exchangers
Forebays	Condenser tubes	Emergency systems
Holding ponds	Fire protection systems	Area coolers
Storage tanks	Main pumps	Seal water systems
Wet wells	Jockey pumps	Strainers
Pump wells	Submerged pumps	Drag valves
Pump suction chambers	Intake structures	Makeup demineralizers
Lift pumps	Intake screens	Circulation systems
Pump bell housings	Intake tunnels	Emergency water systems
Screen wash systems		

Vulnerable to a Dreissena Mussel Infestation?

Parameter	Adults do not survive long term	Uncertainty of veliger survival	Moderate Infestation Level	High Potential Infestation Level
Calcium (mg/L)	< 8 to < 10	< 15	16 - 24	≥ 24
Alkalinity (mg CaCO3/L)	< 30	30 - 55	45 - 100	> 100
Total Hardness (mg CaCO3/L)	< 30	30 - 55	45 - 100	> 100
pH	< 7.0 or > 9.5	7.1 - 7.5 or 9.0 - 9.5	7.5 - 8.0 or 8.8 - 9.0	8.2 - 8.8
Mean Summer Temperature (°F)	< 64	64 - 68 or > 83	68 - 72 or 77 - 83	72 - 75
Dissolved Oxygen mg/L (% saturation)	< 3 (25%)	4 - 7 (25 - 50%)	7 - 8 (50 - 75%)	≥ 8 (> 75%)
Conductivity (µS/cm)	< 30	30 - 60	60 - 110	≥ 110
Salinity (g/L)	> 10	8 - 10	5 - 8	< 5
Secchi depth (m)	< 1 > 8	1 - 2 or 6 - 8	4 - 6	2 - 4
Chlorophyll a (µg/L)	< 2.0 or > 25	2.0 - 2.5 or 20 - 25	8 - 20	2.5 - 8
Total phosphorous (µg/L)	< 5 or > 50	5 - 10 or 35 - 50	10 - 25	25 - 35

Additional advantages Filterautomat with MUSSEL STOP

- high backwash speed (up to 4 - 10m/s)
- 100 % cleaning of the whole filter surface
- inline construction
- robust construction
- small water loss for backwashing
- crushing of coarse particles
- fine filtration ≥ 5 µm possible
- constant charging of the whole filter surface
- insert of slotted sieve, wire-cloth screen or perforated plate
- easy to maintain because of the inspection port

Additional advantages JET Filter with MUSSEL STOP

- high backwash speed (up to 10 m/s)
- any mounting position (horizontally / vertically)
- simple installation (inline construction)
- low wear (no movable parts in the filter)
- low backwash water loss
- no differential pressure increase during the filtering process
- wide range of materials
- ready-made cabling
- special design possible on customer's request

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