MUSSEL STOP
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 larval stage is to purchase mechanical filter units with MUSSEL STOP system by DANGO & DIENENTHAL.
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. 6 Mussel infestation of filter elements and piping systems

Fig. 8 Mussel infestation in the industry
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 micron (0.008") 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.
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.

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 (0.012”) 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 cavitation forces are destroying the larvae as they pass through the filter element. Appropriate tests have shown that the cavitation 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
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.

The cartridge filter example in numbers:
River water station with a flowrate of 950 gpm

Technical data:

- Flow rate \( Q = 950 \text{ gpm} = 2.12 \text{ ft}^3/\text{s} \)
- Filter fineness = 300 micron (0.012")
- Filter area gross \( (A_{\text{gross}}) = 9.35 \text{ ft}^2 \)
- The open filter area (filter area net) of a slotted wedge wire screen with 300 micron is about 26 %
- Filter area net \( (A_{\text{net}}) = 2.43 \text{ ft}^2 \)

Filtration flow speed

\[
\nu = \frac{Q}{A_{\text{net}}} = \frac{2.12 \text{ ft}^3/\text{s}}{2.43 \text{ ft}^2} = 0.87 \text{ ft/s}
\]

Calculation of mussel larvae rotation acceleration:

- Size of mussel larvae \( d = 300 \text{ micron} \) (0.012") \( r = 150 \text{ micron} \) (0.006")
- Acceleration \( \alpha = \frac{\text{Peripheral velocity}^2}{\text{Mussel larvae radius}} \)

\[
\alpha = \frac{(0.87 \text{ ft/s})^2}{0.0005 \text{ ft}} = 1.514 \text{ ft/s}^2
\]

The earth acceleration \( g \) is 32.20 ft/s². An usual cartridge filter reach a maximum earth acceleration of 1,514 ft/s² or 47 g.

Fig. 12

Raw water – Working pressure

Clean water – Working pressure

Fig. 14

Mussel and mussel larvae are able to pass the slotted wedge wire screen

Low filtration velocity

Fig. 12

Mussel larvae radius

Large filter area

Filtration velocity

Mussel larvae

Rotation acceleration

Peripherial velocity

Flow rate

Filter area

Fig. 14
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 cavitation energy. This provides the deformation and damage of the mussel larvae on the slot flanks.

The MUSSEL STOP example in numbers:

River water station with a flowrate of 950 gpm

Technical data:

Flow rate \( Q = 950 \text{ gpm} = 2.12 \text{ ft}^3/\text{s} \)
Filter fineness = 300 micron (0.012")

Filter area gross \( (A_{\text{gross}}) = 1.4 \text{ ft}^2 \)
The open filter area (filter area net) of a slotted wedge wire screen with 300 micron is about 26%
Filter area net \( (A_{\text{net}}) = 0.364 \text{ ft}^2 \)

Filtration flow speed \( \dot{V} = \frac{\text{flow rate } Q}{\text{Filter area net } (A_{\text{net}})} \)
\( \dot{V} = \frac{2.12 \text{ ft}^3/\text{s}}{0.364 \text{ ft}^2} \dot{V} = 5.82 \text{ ft/s} \)

Calculation of mussel larvae rotation acceleration:

Size of mussel larvae \( d = 300 \text{ micron (0.012")}; r = 150 \text{ micron (0.006"}) \)

Acceleration \( \ddot{a} = \frac{\text{Peripheral velocity}^2 (\dot{V}^2)}{\text{Mussel larvae radius (r')}} \)
\( \ddot{a} = \frac{(5.82 \text{ ft/s})^2}{0.0005\text{ft}} \ddot{a} = 67,745 \text{ ft/s}^2 \)

The earth acceleration (g) is 32.20 ft/s². So we reach an earth acceleration of approx. 67,745 ft/s² or 2,105 g with our MUSSEL STOP System.
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.
Conventional cleaning process

- Chlorine
- Bromine
- Chlorine dioxide
- Chloramines
- Ozone
- Potassium permanganate

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>flow rate</td>
<td>20 gpm to 46,200 gpm</td>
</tr>
<tr>
<td>filter fineness</td>
<td>≥ 5 microns</td>
</tr>
<tr>
<td>operating pressure</td>
<td>12 to 900 psi</td>
</tr>
<tr>
<td>pressure loss with clean filter</td>
<td>1 to 4 psi</td>
</tr>
<tr>
<td>flange size</td>
<td>2” to 40”</td>
</tr>
<tr>
<td>temperature</td>
<td>14 to 230 °F</td>
</tr>
<tr>
<td>automatic backwash</td>
<td>✓</td>
</tr>
</tbody>
</table>
**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](http://www.dds-filter.com) for more information on this filter system.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>flow rate</strong></td>
<td>4 gpm to 110,000 gpm</td>
</tr>
<tr>
<td><strong>filter fineness</strong></td>
<td>≥ 50 microns to 5,000 microns</td>
</tr>
<tr>
<td><strong>operating pressure</strong></td>
<td>22 to 900 psi</td>
</tr>
<tr>
<td><strong>pressure loss with clean filter</strong></td>
<td>1 to 4 psi</td>
</tr>
<tr>
<td><strong>flange size</strong></td>
<td>2&quot; to 120&quot;</td>
</tr>
<tr>
<td><strong>temperature</strong></td>
<td>– 13 to +392 °F</td>
</tr>
<tr>
<td><strong>automatic / manual backwash</strong></td>
<td>✓</td>
</tr>
</tbody>
</table>
## High-risk equipment and circumstances, which may lead to mussel infestation

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

### Vulnerable to a Dreissena Mussel Infestation?

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

### Additional advantages Filterautomat
- high backwash speed (up to 13 - 33 fps)
- 100 % cleaning of the whole filter surface
- inline construction
- robust construction
- small water loss for backwashing
- crushing of coarse particles
- fine filtration ≥ 5 micron (0.0002") 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
- tested unit with ready-made cabling

### Additional advantages JET Filter
- high backwash speed (up to 33 fps)
- 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