Long Term Evaluation of
Zebra Mussel Resistant Materials of Construction
for
Intake Screens and Assemblies
Update on Field Installation Test

Michael Ekholm – Application Engineer

Johnson Screens
1950 Old Hwy. 8, New Brighton, MN 55112 (Physical Address)
PO Box 64118, St. Paul, MN 55164 (Mailing Address)
(651)-638-3132 (Fax)
(651)-636-3900 (Phone)
(651)-638-3110 (Direct Dial, Mike Ekholm)

Abstract:

Johnson Screens, a division of US Filter, has been a leading manufacturer of passive intake screens and fish diversion panels for use in lakes, streams, rivers and reservoirs. As part of an ongoing effort to improve the efficiency and usable life of the screens, a proprietary alloy that resists attachment of Zebra mussels has been developed. A recent physical examination of a Z-Alloy screen in an actual power plant intake application in Lake Michigan has discovered that the mussels have not attached to the screen even after more than 6 years of flawless service. The material does not lose effectiveness over time, does not affect the environment and does not require reapplication during service.

The passive intake design allows unobtrusive continuous intake of water without moving parts to wear out or excessive noise to disturb the environment. The high efficiency control of flow velocity near the screen surface allows fish and other wildlife to avoid being entrapped by the screen, while reducing the possibility of debris attaching to the screen cylinders. The patented design for flow control allows for the most efficient screen design. In addition, a Hydroburst system, which uses compressed air to purge the screen surface, can be employed to further reduce any possibly of interruptions of operation due to maintenance.

In addition to the passive intake, Z-Alloy can be used in a variety of screen configurations including fish diversion screens, trash racks, inline strainers or other custom geometries. Challenging shapes that require special forming, welding or other fabrication techniques will not reduce the alloy's effectiveness against the Zebra mussel.

Coupling the proven efficient design of the passive intake screen, with a Zebra mussel resistant alloy creates an initial intake solution that will not have problems with Zebra mussels.

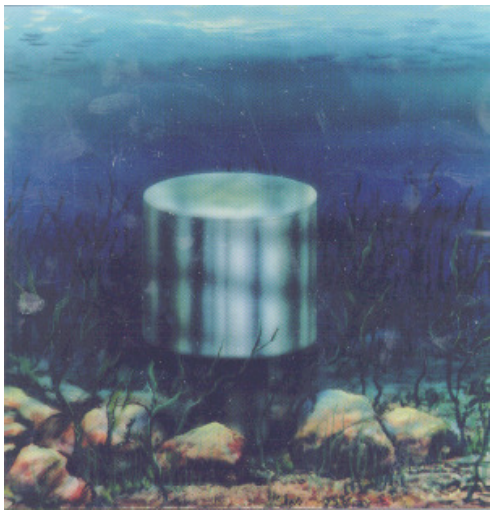
Introduction:

The Zebra mussels that have invaded the great lakes region have created many serious problems for those relying on lakes and rivers in the area for a water source. While these bodies of water have seen some benefits from the continuous siphoning of contaminants by the mussels, their choice of residence has had profound effect on the effectiveness of the systems used to draw the water to its intended location. As the Zebra Mussel attaches to the outside surfaces of these raw water intake systems, it blocks the available area of the screens used to prevent the intake of undesirable matter and protect the surrounding environment. As more of the screen becomes blocked, the velocity of the flow through the screen increased given the same volumetric flow requirements. This increase will cause increased pressure drops through the screen, increases in the pumping capacity required and can cause the screen to be in violation of EPA and Fish & Wildlife guidelines. Eventually, given the rapid proliferation of the Zebra mussel, the screen will become completely blocked requiring its cleaning by costly diving operations or shut down and replacement of the screen.

Since the screen intakes are so strongly affected by the attachment of Zebra mussels, a solution had to be found to prevent their attachment to the screens. The Z-Alloy material used in both coupon field tests and in installed screening equipment has shown conclusive evidence of being that solution.

Background:

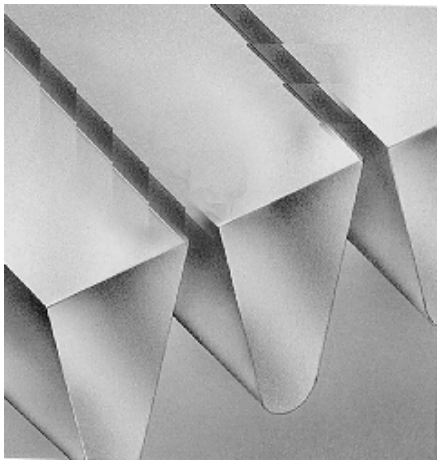
Johnson passive intake screens are used in a wide range of raw water intake conditions. Screens of this type are used in a wide variety of applications; from architectural uses to installations in the extremely harsh environments found in the petro-chemical industry. While the screens can be formed into an almost unlimited array of geometries, Johnson has developed some standard configurations to be used directly for passive water intake systems. These include “Tee” and “Drum” type cylindrical configurations, flat screen panels (used for basic intakes and fish diversion applications), sieve screens to product hydroturbines, and other custom configurations.

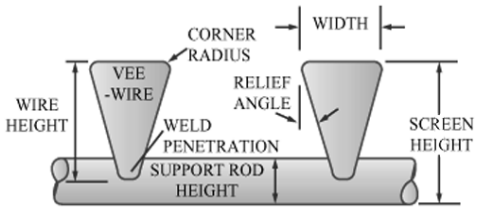


Drum Type Intake

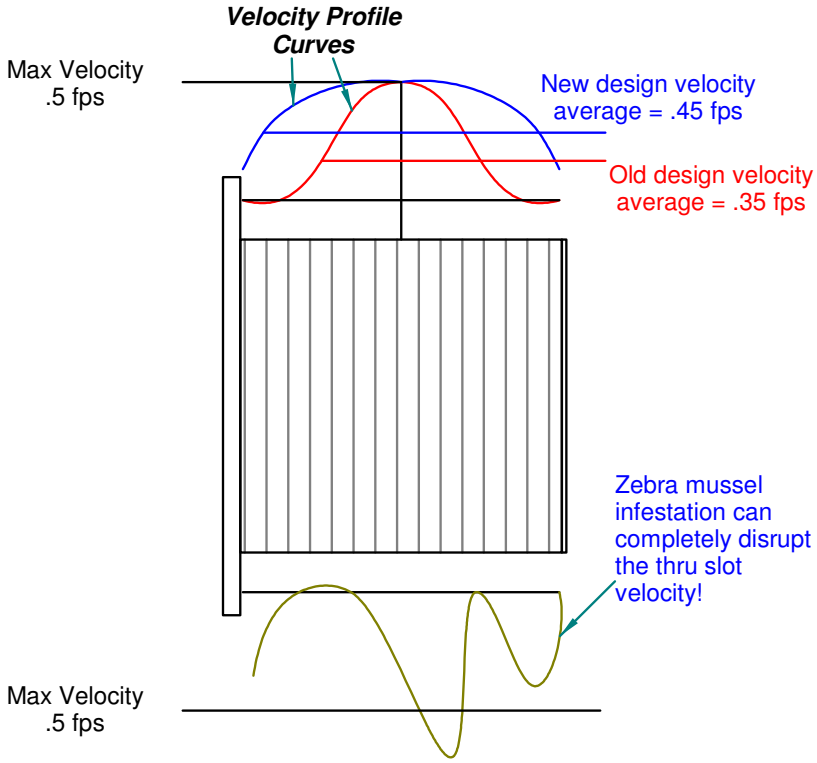
Tee Type Intake

The Vee-Wire used to fabricate the screens is naturally resistant to clogging due to its triangular geometry. Objects passing through the surface of retention (the flat part of the triangular wire) will tend to pass completely through the screen. Objects that willfully attach to the screen, such as the Zebra mussel, will have a clean surface on which to secure themselves. This makes the screens very attractive to the mussels.





The condition of the screen surface is critical to one of the key design factors in a passive screen element. A passive screen operates by drawing water across its surface as evenly as possible. This feature allows the screen to remain under a critical maximum intake velocity (normally .5 fps) that does not affect the environment around the screen (preventing impingement of fish and light debris). The velocity at the screen surface varies with the position along the length of the screen. In the newest patented Johnson design, the control of this velocity is such that it is nearly even (within 90%) across the entire screen surface. With this performance efficiency, the size of the screens can be significantly reduced from previous designs. This superior performance does require that the screens remain free of Zebra mussel attachment to operate efficiently.



Suitability in terms of environmental impact of an intake for a given application is determined by the average velocity through the screen openings (slots). The average velocity is determined by the efficiency of the screen and the size of the screen (the size of the screen being determined by the available area of the screen). As the zebra mussels attach to the screen surface, the screen area is reduced. This will result either in a reduction in flow capacity, or cause the screen slot velocity to exceed the limits necessary to protect the environment around the intake point. While the screens are normally equipped with a Hydroburst[tm] system, an air backwashing device used to automatically clean the screen surface at periodic intervals, the attachment strength of the zebra mussels exceeds the capacity of a normal system to dislodge them.

A method to prevent the Zebra mussels from attaching to the screens had to be found to allow users of raw intake systems to continue to benefit from the advantages of the passive intake screens. The solution had to share those benefits:

1. Meet Screening Regulations
2. No power requirements
3. Low maintenance requirements
4. Durable
5. Basic installation
6. Low environmental impact
7. Efficient Design
8. No moving parts

Solution:

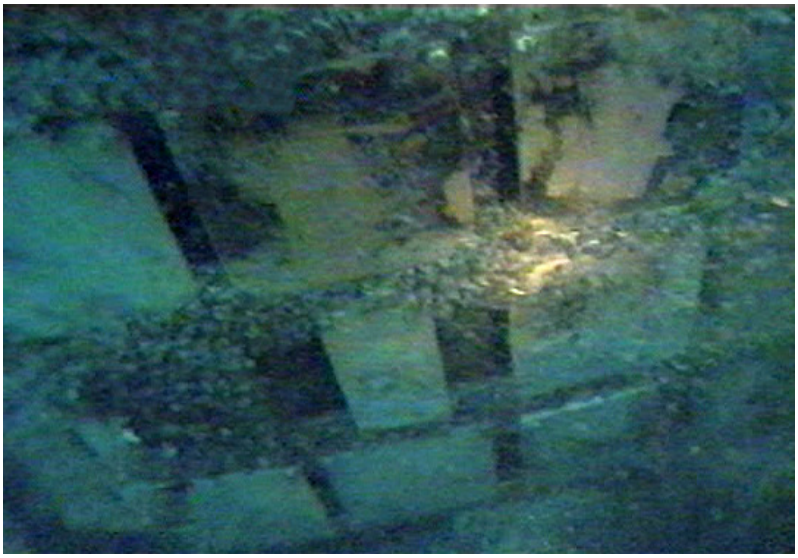
Out of the several approaches to the prevention of Zebra mussel attachment to the screen, the general concept that seemed to be most in line with the passive nature of the screen was to build it out of something that the Zebra mussels did not like to attach to. This was a simple solution to offer, as it would not require continual maintenance or other ongoing costs to use, but could prove impossible to implement if an alloy could not be found. A wide array of special alloys and metal treatments were investigated before the current material, Z-Alloy, was formulated. This material could be used to fabricate the VEE-WIRE screens used in the Johnson Intakes (as well as the non-screen components used in the assemblies). If this material could truly resist the attachment of Zebra mussels over a long period of time, it would be the ideal solution for use in passive intake screens having these advantages:

1. Does not adversely effect environment.
2. Is a passive deterrent – no effective operating costs.
3. Does not lose effectiveness over time.

A concept, which is truly valid for this problem, however, must be rigorously tested before warranting a legitimate offer as true solution to the Zebra mussel problem. The systems for which these screens are used are too critical (fire control, municipal water, nuclear plants etc..) to consider using an untried method to control Zebra mussels.

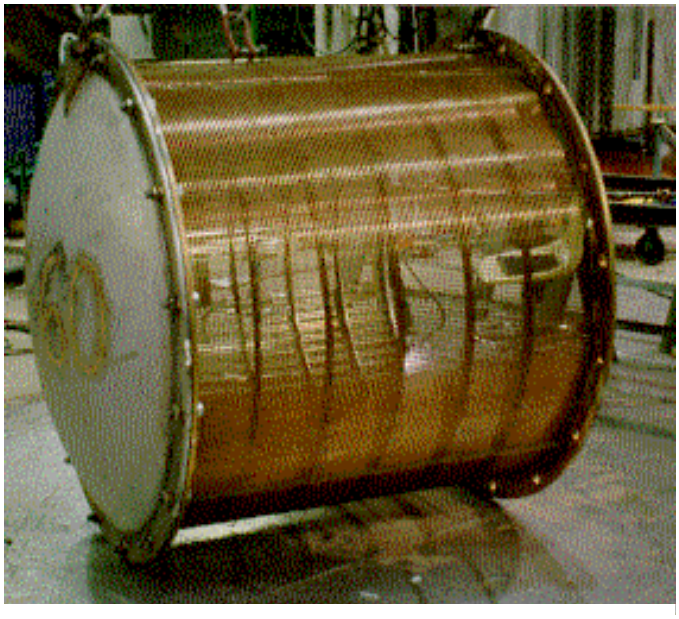
Initial Testing:

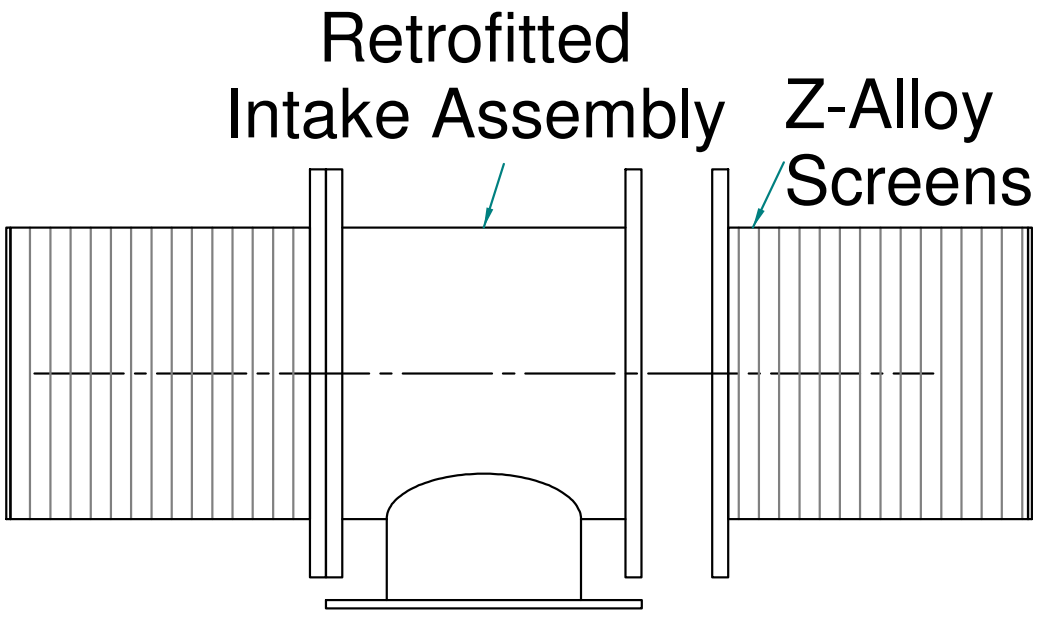
The material was first tested in coupon form in Lake St. Clair between 1990 and 1993. These initial tests are outlined in a paper presented at the 1994 Aquatic Nuisance Species Conference by Dick Maxson, a product development engineer with Johnson Screens. (This paper can be provided upon request). The Z-Alloy material was developed as a result of the success of these tests. The coupon and screen segment tests were later conducted in Lake Michigan, with similar highly successful results. The coupons made from the Z-Alloy material, showed little or no attachment over extended periods of time. Coupons of other material (Acrylics, 304 stainless steel), did show significant densities of Zebra mussels (598,000 /m2 for the 304 stainless screens). Coated materials tended to oxidize, and were ruled out as potential candidates for an effective long term solution. At the conclusion of the coupon tests, a site was chosen in Lake Michigan for a full-scale test of the alloy.



Coupons shown are similar to those used in the initial tests. This photo was taken from the video of the current long-term test presented in this paper. The areas free of attachment are the Z-Alloy test coupons. Areas showing attachment are the stainless framework and control coupons. The various Z-Alloy samples were made to test how different weld configurations and heat treatments would affect the resistance of the alloy.

The J.H. Campbell power plant, located 100 miles up shore on the eastern side of Lake Michigan was chosen for the first fully operation screen test site. The operators of the plant had used the passive intake screens for several years, but had recently been experiencing problems with Zebra mussels attaching to and blocking the screens. Access covers had to be installed on the existing screens to facilitate the frequent cleaning by divers required to allow the screens to operate. In many cases, even this was not adequate to keep up with the proliferation of the mussels. The screens were periodically lifted out and cleaned on shore to clear the 1-3" of mussels that grew on the screen surface. During one of these removals and reinstallations, a screen made from Z-Alloy was retrofitted onto one of the operational intake assemblies.

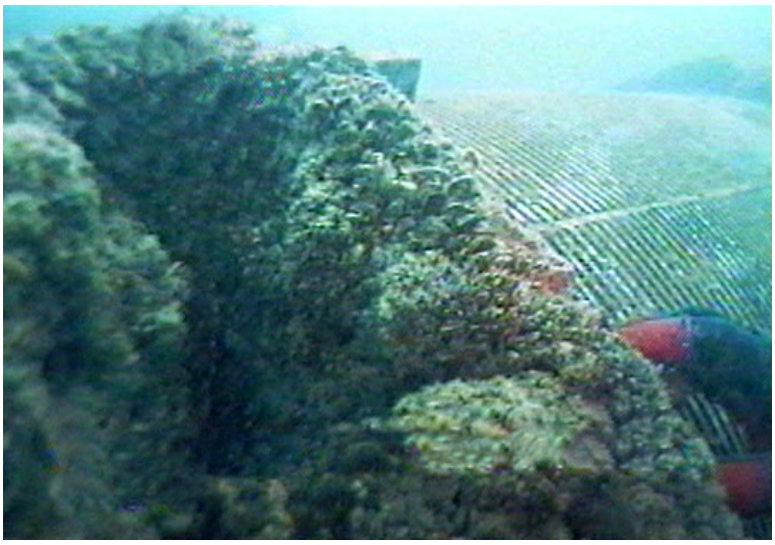




These screens were installed in 1993 and showed very good results in their initial performance. The element not fully tested in the coupon and initial screen tests, was how well the Z-Alloy would perform over an extended period of time. The only way to test this element was to keep the screen installed and examine the condition of the screen at regular intervals to verify the effectiveness of the alloy against Zebra mussels.

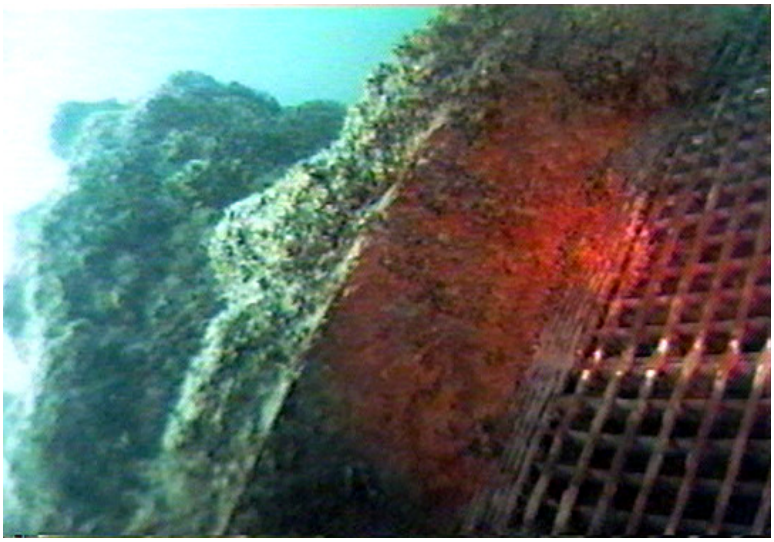
Latest Update:

Operators at the J.H. Campbell plant offered to bring a video camera with them on their scheduled maintenance dive in November 1999. The images obtained clearly show how well the Z-Alloy material is working against Zebra mussels.



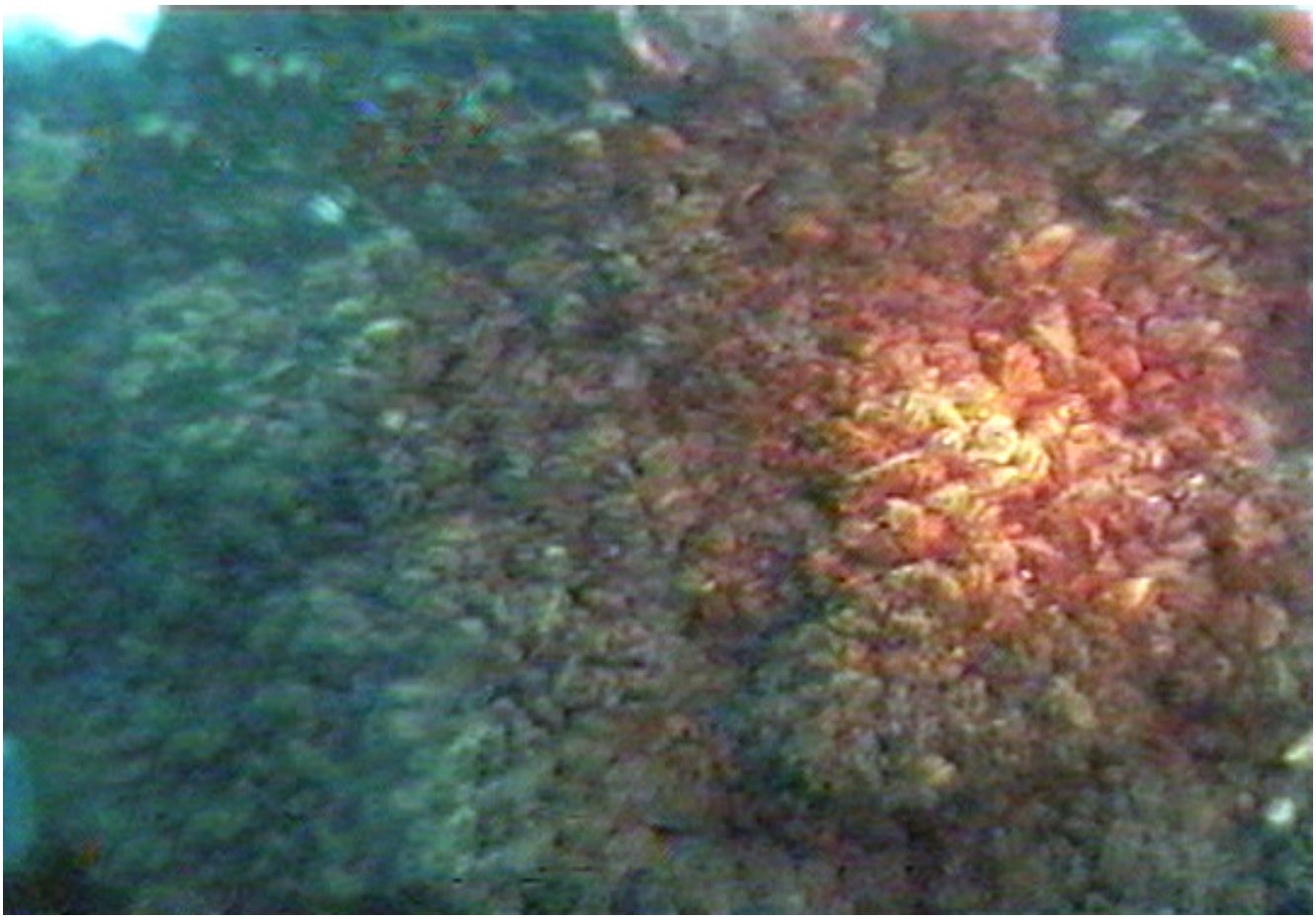
As the screens were attached to a 304 stainless structure, the full surface of the assembly was not protected from attachment by the Z-Alloy material. While this hybrid of materials does allow a thick covering to continue to develop on the structural (non-screening) portion of the complete assembly, it does clearly provide a dividing line between the control material (304 SS) and the test material (Z-Alloy).

The side of the joining flange that is made from the 304 material is covered by Zebra mussels. The side made from Z-Alloy is free of attachment. There can be seen some normal light debris (which would be cleared during a normal Hydroburst air backwash cycle), but no permanent attachment of Zebra mussels. The Z-Alloy screens were not cleaned since the initial installation and have not caused any interruption of service due to blockage for any reason.



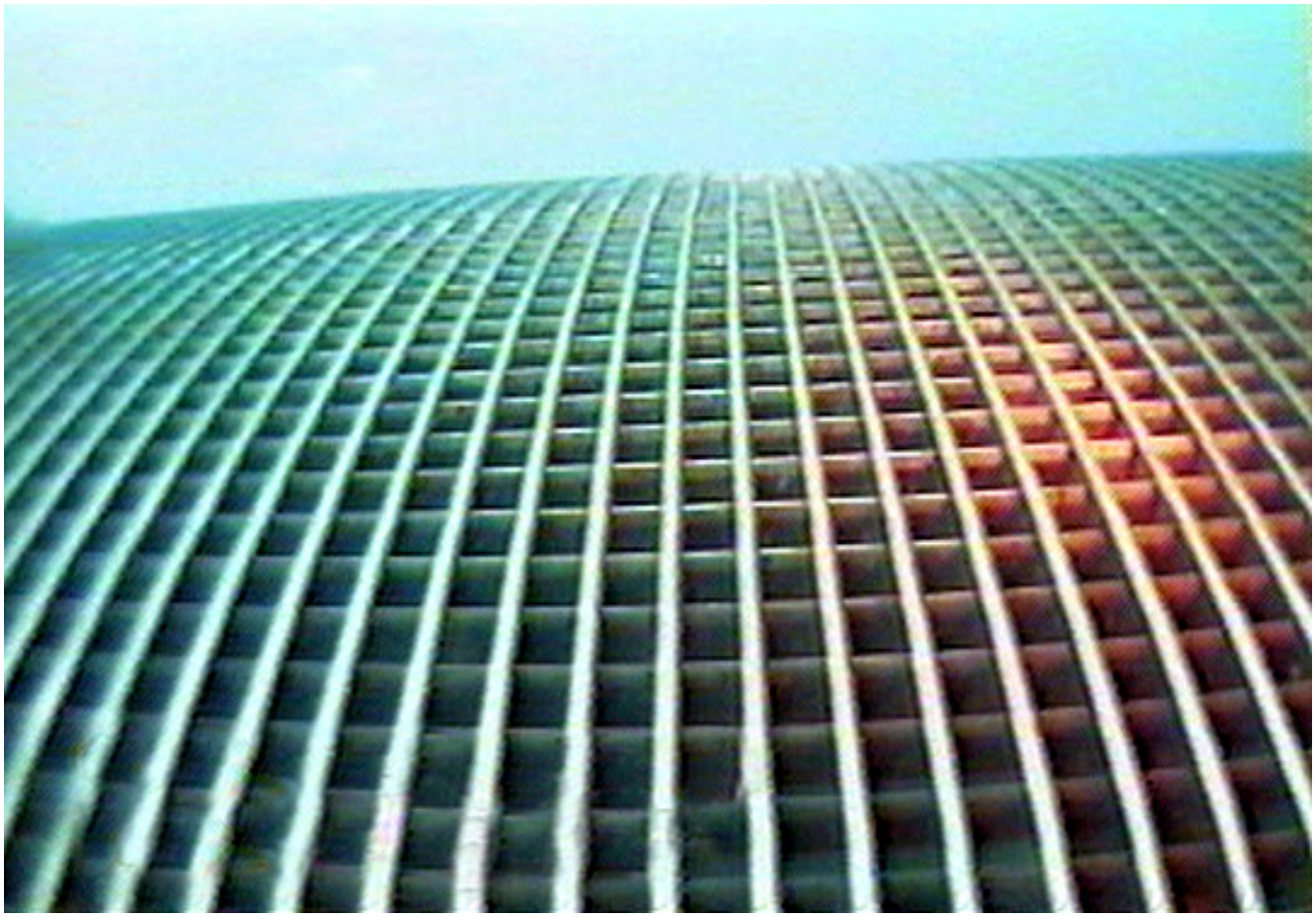
Additional scenes from the video show even more dramatic results of the long-term installation test.

This view of the stainless steel structural plate used in the assembly shows a high density of attachment. As these pictures were taken by workers during a maintenance dive, an accurate count of the population was not available. Estimates have been conservatively made at between 100,000-200,000 / m^2 . As discussed earlier, the coupon tests using accurate population counts showed even higher densities under the same general conditions and at a nearby location.



This picture is also indicative of the population density that was observed on the stainless steel screen surfaces prior to the use of the Z-Alloy material. The next video excerpt shows the screen as it currently looks.

This shot was taken from the center of the screen and clearly shows the lack of attachment by any mussels. This remarkable view is of a screen that has been in effective service for over 6 years at the time the video was made.



The screens will continue in service, and regular observations/videos made to record the progress of the test. The effectiveness of the alloy is not now expected to be reduced over the service life of the screen, or over any reasonable period of time. It will resist attachment as long as there is some material for a Zebra mussel to consider attaching to. As the alloy has also shown superior corrosion resistance in addition to its outstanding resistance to Zebra mussels, it is expected that the screen will be in attachment free service for some time to come.

Conclusions:

While Johnson will continue to investigate new uses of this material, the results of this long-term field test indicate that the alloy is fully effective in resisting Zebra mussels. No further research to qualify the alloy suitable for this application are deemed necessary for its use in general service. The alloy is effective, is suitable for service and can be considered to prevent the attachment of Zebra mussels on passive intake screens. The installations made after this initial test using the Z-Alloy material will also be monitored as additional support to this conclusion. Thus far, there have been no instances of Zebra mussel attachment on any installation.

The alloy is currently available for general use in a variety of intake systems and configurations in addition to the standard system referenced in this paper. Copies of the paper describing the previous test and video results of the ongoing test are available. Additional inquiries and research by other parties will also be considered.

References:

1. "Practical Manual for Zebra Mussel Monitoring and Control" by Renata Claudi and Gerald Mackie. CRC Press 1994. ISBN 0-87371-985-9
2. "Unique alloys prevent zebra mussel attachment" Power Engineering magazine, October 1995 by Brian Ranschaert at Consumers Power and Dick Maxon at Johnson Screens
3. "Evaluation of Zebra Mussel Resistant Materials of Construction". Paper presented at the 1994 Aquatic Nuisance Species Conference by Dick Maxson.

Author:

Michael Ekholm is an application engineer for US Filter for the past 5 years, and was a product design engineer for the company 5 years prior to that. He has a Bachelor of Science degree in Aerospace Engineering and is currently applying for a second degree in Computer Science both from the University of Minnesota, Institute of Technology. Mike has been involved in designing and improving raw water intake assemblies for a variety of installation locations and conditions as well as applying our screen technology to a wide range of industries.