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Fish protection technologies: a status report

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Abstract

Section 316(b) of the Clean Water Act has required that "best technology available" (BTA) be used to minimize adverse environmental impacts resulting from operation of the cooling water intake structure (CWIS). The primary effects of CWIS operations are the entrainment of small aquatic organisms through the cooling water system and the impingement of larger life stages on traveling water screens. Extensive research has been conducted since the early 1970s in attempts to develop technologies that will minimize entrainment and impingement. As a result, a suite of technologies is available that can be considered for application as the BTA at the CWIS. Available technologies include fish collection systems, fish diversion systems, physical barriers and behavioral barriers. The ability of a given technology to meet BTA requirements is influenced by a wide variety of biological, environmental and engineering factors that must be evaluated on a site-specific basis. The status of systems and devices in each category of fish protection alternatives is presented. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Fish protections; Water intakes; 316(b); Best technology available; Fish diversion; Fish collection; Behavioral barriers

1. Introduction

Section 316(b) of the Clean Water Act has required that "best technology available" (BTA) be used to minimize adverse environmental impacts (AEI) resulting from operation of cooling water intake structures (CWIS). The primary effects of CWIS operations are associated with the entrainment of small aquatic organisms through the cooling water system and the impingement of larger life stages on traveling water screens. Extensive research has been conducted since the early 1970s in attempts to develop technologies that will minimize entrainment and impingement. As a result, a suite of technologies is available that can be considered for application as the BTA at the CWIS. An overview of the status of fish protection technologies is presented below. A comprehensive review of

these technologies is presented in a recent Electric Power Research Institute report (EPRI, 1999).

2. Fish collection systems

2.1. Modified traveling water screens

Conventional traveling water screens have been modified to incorporate modifications that improve survival of impinged fish. Such state-of-the-art modifications act to enhance fish survival related to screen impingement and spraywash removal. Screens modified in this manner are commonly called "Ristroph Screens". Each screen basket is equipped with a water-filled lifting bucket which safely contains collected fish as they are carried upward with the rotation of the screen. The screens operate continuously to minimize impingement time. When each bucket passes over the top of the screen, fish are gently rinsed into a collection trough by a low-pressure spraywash system. Once collected, the fish are transported back to a safe release

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DESCRIPTION:

Wedgewire screens are designed to reduce entrainment by physical exclusion and by exploiting hydrodynamics. Physical exclusion occurs when the mesh size of the screen is smaller than the organisms susceptible to entrainment. Hydrodynamic exclusion results from maintenance of a low through-slot velocity, which, because of the screen's cylindrical configuration, is quickly dissipated, thereby allowing organisms to escape the flow field (Weisberd et al, 1984). The screens can be fine or wide mesh. The name of these screens arise from the triangular or "wedge" cross section of the wire that makes up the screen. The screen is composed of wedgewire loops welded at the apex of their triangular cross section to supporting axial rods presenting the base of the cross section to the incoming flow (Pagano et al, 1977). A cylindrical wedgewire screen is shown in the figure below. Wedgewire screens are also called profile screens or Johnson screens.

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Schematic of Cylindrical Wedgewire Screen (Pagano et al, 1977)

TESTING FACILITIES AND/OR FACILITIES USING THE TECHNOLOGY:

Wide mesh wedgewire screens are used at two large power plants, Eddystone and Campbell. Smaller facilities with wedgewire screens include Logan and Cope with fine mesh and Jeffrey with wide mesh (EPRI 1999).

RESEARCH/OPERATION FINDINGS:

- In-situ observations have shown that impingement is virtually eliminated when wedgewire screens are used (Hanson, 1977; Weisberg et al, 1984).
- At Campbell Unit 3, impingement of gizzard shad, smelt, yellow perch, alewife, and shiner species is significantly lower than Units 1 and 2 that do not have wedgewire screens (EPRI, 1999).
- The cooling water intakes for Eddystone Units 1 and 2 were retrofitted with wedgewire screens because over 3 million fish were reportedly impinged over a 20-month period. The wedgewire screens have generally eliminated impingement at Eddystone (EPRI, 1999).
- Laboratory studies (Heuer and Tomljanovitch, 1978) and prototype field studies (Lifton, 1979; Delmarva Power and Light, 1982; Weisberg et al, 1983) have shown that fine mesh wedgewire screens reduce entrainment.
- One study (Hanson, 1977) found that entrainment of fish eggs (striped bass), ranging in diameter from 1.8 mm to 3.2 mm, could be eliminated with a cylindrical wedgewire screen incorporating 0.5 mm slot openings. However, striped bass larvae, measuring 5.2 mm to 9.2 mm were generally entrained through a 1 mm slot at a level exceeding 75 percent within one minute of release in the test flume.
- At the Logan Generating Station in New Jersey, monitoring shows shows 90 percent less entrainment of larvae and eggs through the 1 mm wedgewire screen than conventional screens. In situ testing of 1 and 2-mm wedgewire screens was performed in the St. John River for the Seminole Generating Station Units 1 and 2 in Florida in the late 1970s. This testing showed virtually no impingement and 99 and 62 percent reductions in larvae entrainment for the 1-mm and 2-mm screens, respectively, over conventional screen (9.5 mm) systems (EPRI, 1999).

DESIGN CONSIDERATIONS:

- To minimize clogging, the screen should be located in an ambient current of at least 1 feet per second (ft/sec).
- A uniform velocity distribution along the screen face is required to minimize the entrapment of motile organisms and to minimize the need of debris backflushing.
- In northern latitudes, provisions for the prevention of frazil ice formation on the screens must be considered.
- Allowance should be provided below the screens for silt accumulation to avoid blockage of the water flow (Mussalli et al, 1980).

ADVANTAGES:

- Wedgewire screens have been demonstrated to reduce impingement and entrainment in laboratory and prototype field studies.

LIMITATIONS:

- The physical size of the screening device is limiting in most passive systems, thus, requiring the clustering of a number of screening units. Siltation, biofouling and frazil ice also limit areas where passive screens such as wedgewire can be utilized.
- Because of these limitations, wedgewire screens may be more suitable for closed-cycle make-up intakes than once-through systems. Closed-cycle systems require less flow and fewer screens than once-through intakes; back-up conventional screens can therefore be used during maintenance work on the wedge-wire screens (Mussalli et al, 1980).

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