PREVENTION OF ICE FORMATIONS BY AIR BUBBLING
A COLD WEATHER HYDRAULIC OPERATION
ON THE NEW ENGLAND ELECTRIC SYSTEM

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The "Air Bubbler System" is a scheme used to prevent the formation of surface ice adjacent to gates, flashboards, and forebay booms at hydro-electric generating plants. It is necessary to keep ice from adhering to these appurtenances during the freezing months. A gate is of no value to pass the flood waters of the melting snows if it is loaded down with ice. Flashboards cannot be kept in place and sealed against leakage when the pond ice crowds against them. The ice cover following the rise and fall of the pond from the load cycling of plant dislodges the flashboards.

The old hand method employed the use of ice chisels and needle bars to keep a channel of open water adjacent to flashboards and gates. This was a costly job and a bitterly cold one too, with a raw wind blowing down the pond and below zero temperatures. Man can stand to be out under these conditions for only short intervals and then has to get under cover.

The air bubbler system, as used in several of the New England Electric System's hydro-electric plants, is the agitation of water, allowing air to escape from an orifice, bubbling through the water, from a depth of 15 or 20 feet. It is found that the rising bubbles of air stir up, or agitate the relatively warmer water existing several feet below the surface. This agitation is sufficient to prevent ice cover forming where such a turbulence is created. This is a simple device accomplished by a simple method of application.

The first air bubbler system known to have operated was at the Holtwood Plant of the Pennsylvania Water and Power Company. About the year 1916 a write-up appeared in a technical publication in which was described the use of air to keep flood gates free of ice. This resulted in an experiment conducted by the New England Power Company, trying out the scheme on an installation on the Deerfield River.

A small, used air compressor was belted to a motor and bubblers were installed in the guides of a flood-gate at the No. 3 dam in Shelburne Falls, Mass. There was nothing automatic about the rig. It was manually started when a cold spell of weather set in and shut down when the temperature moderated the following day. A garden hose submerged with a nozzle on the end did the trick. The idea was born, a procedure proven, but the scheme died. The compressor was too small and it ran hot. The then young power company did not have the money or time in those early days to spend on just an idea.

So it lay dormant for several years while the thawing of gates and guides was accomplished by the use of live steam. Not until several years later with the beginning of the Fifteen Mile Falls development on the upper reaches of the Connecticut River in 1930, was further consideration given to the bubbler system. About this time the Pennsylvania Power and Light Company was observed to have had an installation set up to use air bubbling on taintor gates. This was at the Wallen Paupack Plant at Hawley, Penn. on the Lackawaxen River. As a result of this observation and the apparent success they were having, the scheme of using bubblers behind the flashboards at a new plant was developed. A pipe header was built in the crest of the McIndoes Dam which successfully carried an air bubbling arrangement. For two winters hand methods kept the 800 feet of flashboards at the Comerford Plant free from the encroachment of pond ice. This was heartbreaking work on a three foot channel some 800 feet long back of the flashboards. Then a bubbler system was devised.

The use of the hose and weighted nozzle set the pattern for future installations. A 3" pipe header along the Comerford spillway bridge supplied air to 132 garden hoses spaced at intervals along the flashboards. These hoses, dangling in the water, allowed air to bubble up to the surface, producing constant turbulence and were successful in keeping an open channel of water alongside the flashboards.

By the Comerford experience, modifications were made at the McIndoes Plant. Three taintor gates and two stanchion flashboard sections were added to the 300 feet of pin type flashboards, and the scheme worked to keep these free of ice encroachment during the winter.

At the Vernon Plant on the Connecticut River in 1935, a pipe run of some 360 feet was installed across the east end of the spillway section of the dam. Air nozzle orifices successfully kept the ice from forming along the flashboards at this location. The bubbler system worked so successfully and represented such a saving in manpower that in 1949, after some experimental work, four booms were equipped with bubblers.

The system of bubbling air through water was now so successful as to make it an engineered installation at Wilder Plant, the latest of our hydro-electric developments on the Connecticut River near White River Junction, Vermont. On this installation I will go into detail, to give you the features of construction, air requirements, and experiences involved in the operation.

The bubbler system at Wilder has for an air supply, a Joy 8 x 5 compressor rated for 150 cubic feet of air per minute. It operates at a normal pressure of 10 pounds per square inch. If freeze-ups or other difficulties are encountered to pinch off the delivery of air, an unloader is set to operate at about 20 pounds per square inch pressure. Experience has proven that these bubbler systems operate efficiently at about 10 pounds per square inch pressure. The compressor is a hard-worked piece of equipment which runs continuously during its period of operation throughout the winter months.

From the compressor, the air is delivered to a cylindrical receiver about 2 feet in diameter and 6 feet in height.

The air next passes through an after-cooler and separator to deliver air to a 2½" dia. main airline to the dam. This air is now at about 42°F. and relatively free of moisture. Air is supplied to the so-called overflow section of the dam.

The overflow section of the Wilder Dam is 525 feet long. In this concrete structure are six taintor gates each 36 feet long, four 50-foot stanchion flashboard sections and two skimmer gates, 15 feet and 10 feet wide respectively, each at opposite ends of the spillway.

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The main 2½" dia. airline to the dam reduces to 2" dia. crossing the dam between the taintor gates and the stanchion flashboard section. As the volume of air requirements diminish in crossing the dam, a further reduction of the main line is made after passing by two of the four stanchions to a 1½" dia. pipe.

From the main header across the dam are connected smaller pipe headers for the supply of air to each individual gate. The 15-foot skimmer gate operates with a ¾" dia. pipe header supplying 3 bubblers. Each of the six taintor gates operates with a 1" dia. pipe header supplying 5 bubblers. The bubbler for the four stanchion flashboard sections receives air directly from the main line.

After passing the taintor gate section, the main airline is reduced to 2" and thence 1½" dia. pipe. Each of the stanchion sections is supplied with 6 bubblers. A 10-foot skimmer gate at the far end of the dam ends the bubbler system with 2 bubblers and one bleeder bubbler to drain moisture. A total of 60 bubblers are connected up for winter operation.

Now I will describe in detail the individual bubblers. The assembly is a length of the least expensive ⅝" rubber garden hose, one end being connected to the air supply at the pipe headers and the opposite end carrying the weighted air nozzle which is dropped into the water a few feet away from the gate or flashboards which are to be kept free of ice.

This weighted air nozzle is made up of a piece of ¼" x 12" pipe set into a concrete cone of about 5" diameter by 5" high. This weighs the hose down against the jet action of the escaping air. A ⅜" brass cap screw is tapped into the end of this ¼" pipe. Through the cap screw is drilled a ⅛" hole which functions as a metered orifice to discharge the air under water.

These bubbler hoses are cut to lengths to put the orifice down to about a 15-foot submergence below full pond elevation.

This system of bubbling air through the water operates continually during the freezing weather. It does an excellent job and is appreciated by those who have had the unpleasant experiences of hand chopping methods.

Of course, for every good accomplishment we enjoy, there are thorns in the details to remind us that nothing is mechanically perfect. It must be admitted that we experience troubles, for which we have not found the proper corrective measures. During the cold spells of weather, with temperatures way below freezing, the system works perfectly. After one of these protracted sub-zero periods and the temperature moderates, the sun warms up the pipe headers to above the melting point. Trouble with the system is now apt to develop.

The air supply to the bubblers diminishes and here and there they stop functioning completely. During this period, the line of bubblers needs constant attention. As yet, corrective measures have not been developed to overcome this condition.

Very little water is released from the compressed air in its passage through the after-cooler and separator. Inside air of the power-house is taken in by the compressor. All indications are that the air is relatively dry. The temperature of this air is 42°F. when it is discharged into the airlines to the dam. It is cooled by the outside air temperature in its passage through the headers. As long as the frost or ice formation inside the pipes adheres to the pipe walls, the system is trouble free. However, as the warming effects of the sun, during above-freezing ambient temperatures, begin to loosen this ice coat, it is the solid particles migrating to constricted areas that reduces the free flow of air.

The best remedy for this trouble is to shut down the system on days when the temperature is safely above the freezing point and bleed off the headers before starting up the compressor. On days when the temperature is too low for this procedure, the ice stoppage is thawed with a blow-torch if the constriction is in the header system. If the trouble is in the hose or nozzle, a spare hose is connected up in a few minutes and the frozen one hung up in a warm place to thaw.

A few general remarks may be made, based on the experience of four installations:

Pressure of air delivered to the system is in the order of 10 pounds per square inch.

At Vernon they use 6½ pounds per square inch until the effect of below zero temperatures reduce the open water areas. They then increase the agitation by boosting the pressure to 26 pounds per square inch.

Air compressor deliveries vary with the installation from 112 cfm to 225 cfm, dependent, of course, on the number of bubblers designed to be operated. Also dependent on the air requirements is the nozzle orifice diameter which varies from ⅛" at Wilder and Vernon to 5/32" at Comerford.

In general we experience air requirements between 1.5 cfm per hose to 2.6 cfm per hose dependent on the nozzle orifice. This can be broken down to a rule of thumb figure of about 2 cfm per nozzle.

Submergence of the orifice is between 15 and 20 feet below the water surface.

There are other minor details which the field has worked out to make for a better system. These for the most part, are all mechanical, such as expansion joint changes on the long headers, quick coupling detail in connection with hose changing, bleeding connections for the blowing down of the lines, etc.

It may be concluded that we have a workable system, satisfactory to the operating personnel of the plants and economically justified by the scrutinizing eyes of those watching the economies of any operation. Some day we hope to have a completely trouble-free installation.