Test Report No. ITR-92-3aN

(Addendum)

The Effects of pH and Thermal Exposure on the Head Loss of Series A Shreds, NRC Guide 1.82

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Addendum to the report of May 18, 1992

"Experimental Measurements on the Characteristics of Flow Transport, Pressure Drop and Jet Impact on Thermal Insulation"

The Effects of pH and Thermal Exposure on the Head Loss of Series A Shreds

Previous measurements at Illinois Institute of Technology have shown negligible effect of pH on the insulation shreds compared to "aging" of the material as it sat in the pipe flow facility. However it has been suggested that the insulation fibers may become sensitive to pH level after the binder has been removed. The following tests were aimed at determining if thermal exposure and/or pH level has a significant effect on the head loss of Series A shreds.

Sample Preparation - Thermal Exposure

All samples tested were Series A type[1] insulation. A block of insulation 7.1 by 7.1 inches nominally 6 inches thick was placed on the surface of a horizontal hot plate. The sides of the sample were surrounded by insulation 2 inches thick to reduce the loss of heat from the edges. The hot plate was set at 650 °F (343 °C) with the top surface of the insulation open to the room. During the initial two hours of heating a noticeable odor was present as the binder was burned away. After two hours of heating the odor was no longer noticeable indicating the sample reached an equilibrium temperature distribution. Once equilibrium was reached we do not believe there was any significant change in the binder composition of the insulation, but the heating was continued for a total of 24 hours. The sample was weighed before and after the heat exposure, and approximately 1 gram from the initial weight of 191 grams was lost.

The sample of insulation had a yellowish color before the heat exposure. After heating the layer closest to the plate was completely white indicating the binder had been removed leaving only the bare glass fibers. The white fibers were extremely fragile and almost powder-like. The layers of insulation above the heated surface had colors that gradually changed from white to gray to brown. The top layers were the original yellow color. Judging from the color distribution, the loss of heat from the edges did not appear to be significant. During the heat treatment the top of the insulation was only slightly warm to the touch.

After heat treatment the 6 inch thick block of insulation was cut into 1/4 x 1/4 x 1/8 inch shreds. The volume of the shredded insulation mixture was much larger than the initial uncut insulation. All the shreds were placed in a plastic bag and stirred together to form a randomized homogeneous mixture of the different colors of insulation. The white binderless component represented about 1/4 of the volume of insulation. The mixture of insulation was then separated into piles corresponding to the nominal thickness of 0.5

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[1] Series A - Thermal Wrap ® Insulation Type 'K'

inches, 3.0 inches and 6.0 inches based on the volume of the initial block. For example, to obtain a nominal thickness of 3 inches, the original mixture was separated into two piles of equal sizes. As an independent test of the nominal sample thickness, the piles were weighed to check that the percentage of the weight corresponded to the percentage of volume. The nominal 3.0 inch thick pile weighed 95 grams, i.e., one half of the initial 190 grams for the 6.0 inch pile.

The samples were placed into the top of the standard test pipe apparatus described in the May 18, 1992 report for Transco. The samples were allowed to distribute themselves randomly over the screen. Approach flow velocities were varied from 0.05 ft/s to 0.5 ft/s. The tests were conducted at approximately 60 °C (140 °F) water temperature.

Results

The initial tests were conducted with ordinary tap water at a temperature of 62 °C and a "neutral" pH = 7.5. A comparison of the results is shown on a linear scale in Fig. a1 and on a logarithmic scale Fig. a2. The data obtained in earlier tests described in Table 3 for preconditioned shreds have been compared with the thermally exposed shreds for thicknesses of 0.5 inches, 3 inches and 6 inches. The agreement between the different sets of data is within the uncertainty in the measurements. Although the thermally exposed samples had slightly lower head loss for this particular set of tests, the difference is within experimental uncertainty. From the agreement between the different data sets it is apparent that removing the binder by heating the sample at 650 °F (343 °C) will not have a significant effect on the head loss beyond the preconditioned samples.

The second series of tests was conducted to determine if the insulation would be affected by extended exposure to high temperature water at an elevated pH. The water temperature was kept at 60 °C and the pH was raised to 9.5 by the addition of Borax to the reservoir. A 3 inch thick sample of Series A shreds was used in this experiment. The shreds were taken from the same 6 inch sample described above, that had been thermally exposed for 24 hours to heating at 650 °F. The shreds were dropped into the top of the test pipe and allowed to fall randomly on the screen.

Earlier tests with flow at a constant velocity of approximately 0.2 ft/s showed that head loss would increase with time. The data from that test is shown in Fig. 9 of the May 18 report. As described in the report, the change in head loss was measured over a 16 day period. The head loss was measured about once a day by changing the velocity from 0.1 ft/s to 0.5 ft/s. After approximately 9 days of exposure the insulation did not show any significant changes. The insulation on the screen appeared to become more compact with time as settling of the material occurred. It is believed that this "aging" effect was associated with the fibers breaking and shifting of the material, which would lead to fewer interstitial voids for the flow to pass through. Any reduction in the voids resulted in a higher head loss.

In the current experiment a baseline test at neutral pH was conducted first, to check for any effect of pH on thermally exposed insulation. The 3 inch thick layer of series A shreds were exposed for 24 hours to flow at a speed of 0.28 ft/sec. The results of this test have been compared to the elevated pH = 9.5 case and a second neutral case in Fig a3. The high pH test is plotted as the dashed line in the figure, and the two neutral cases are shown as solid lines. The sample in the high pH test had a pressure drop at the

onset of the test of 2.26 ft of water compared to 1.70 ft of water and 2.3 ft of water for the two neutral pH samples. The large difference in the initial values of the head loss results from the non-uniformity of the sample distribution over the screen. When the insulation had a uniform distribution over the screen the head loss tended to be high, and when there was a noticeable variation in thickness the head loss was lower. To test that the results were sensitive to the distribution of the insulation the experiment was repeated a third time with neutral pH water and a nominally 3 inch thick layer of series A insulation. However, this time the shreds were dropped into the test pipe in large clumps to prevent a uniform distribution over the screen. The sample was visibly non uniform over the screen with large variations in the thickness. The test was repeated with water at 60 °C and a flow rate of 0.28 ft/sec. As expected the head loss was much lower (1.1 ft of water) than with the uniformly distributed insulation (2.3 ft of water). Clearly, the large variation in the initial value of the head loss is a result of the different distributions of the insulation on the screen, not the effect of pH.

The more important issue is the *rate of increase* of the head loss with time. If the higher pH water were degrading the insulation and increasing the head loss, then the percentage increase in head loss over the 24 hour period would be higher. The data in Fig. a3 shows a 25 percent increase in head loss over 24 hours for the high pH test compared to 39 percent and 17 percent for the two neutral pH tests. The rates of increase are comparable to each other, hence there does not appear to be an adverse effect on the material caused by exposure of the insulation to water at pH = 9.5.

Conclusions

Tests were conducted on Series A type insulation that had been exposed to 24 hours of heating at 650 °F. The heating baked away a substantial portion of the binder holding the fibers in place. The purpose of the tests was to determine if removing the binder had a significant effect on the head loss, and to determine if the insulation would be affected by high pH levels. In the first case, samples with nominal thicknesses ranging from 0.5 inches to 6 inches were tested. The differences between the preconditioned data and the thermally exposed material were insignificant. In the second case, 3 inch thick samples were exposed to flow at 0.28 ft/sec with a pH = 9.5 level. The head loss increase was measured over a 24 hour period. The rate of increase in the high pH case was comparable to the "aging" effects observed with neutral pH tests. Therefore, it appears that within the parameters of these tests neither pH nor thermal exposure have a significant influence on the head loss.

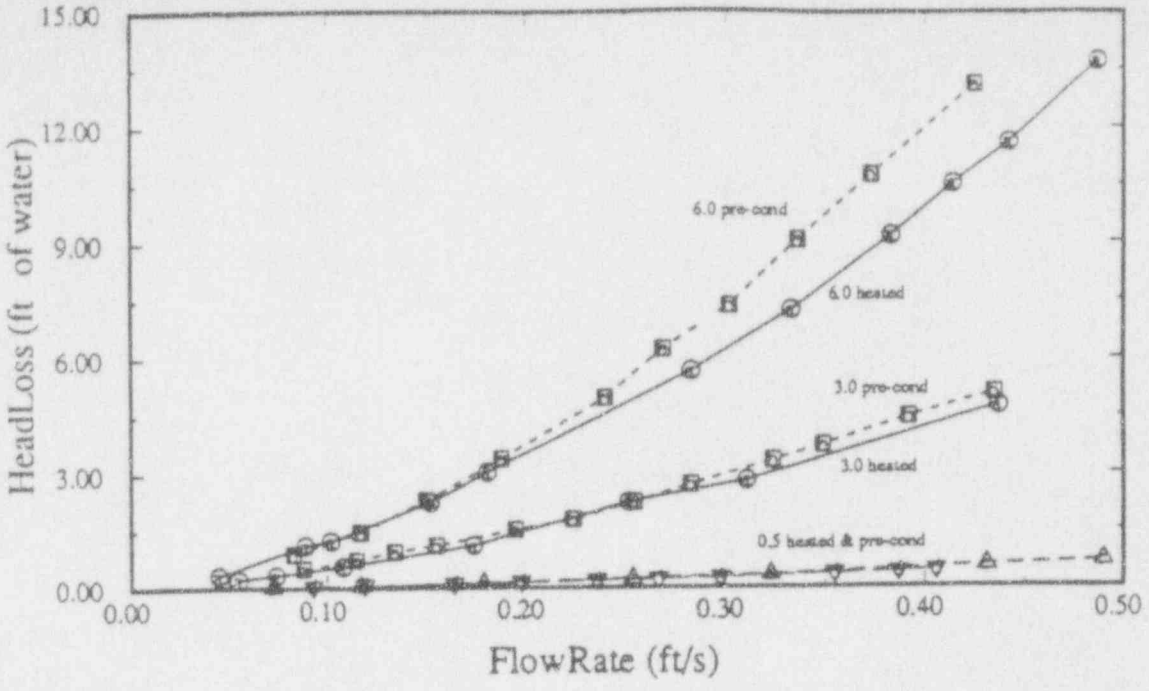

Figure a1 - Head loss of thermally exposed Series A shreds compared to preconditioned shreds. Tests at T = 60 °C (140 °F).

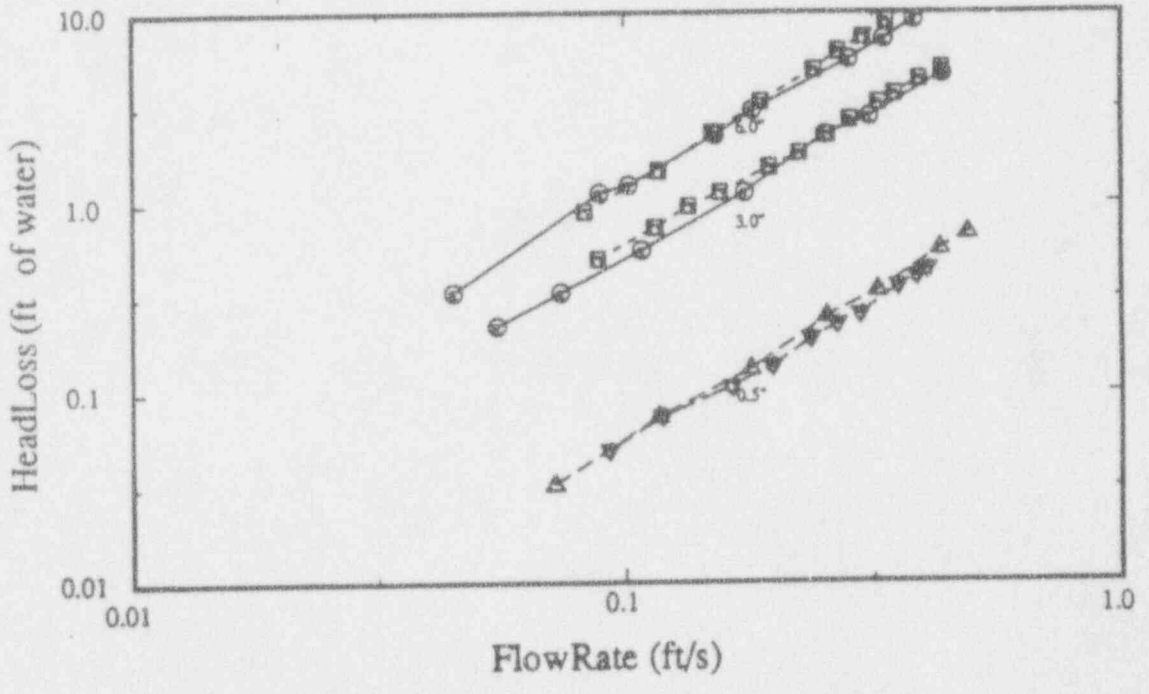

Figure a2 - Head loss of thermally exposed Series A shreds compared to preconditioned shreds. Tests at T = 60 °C (140 °F).

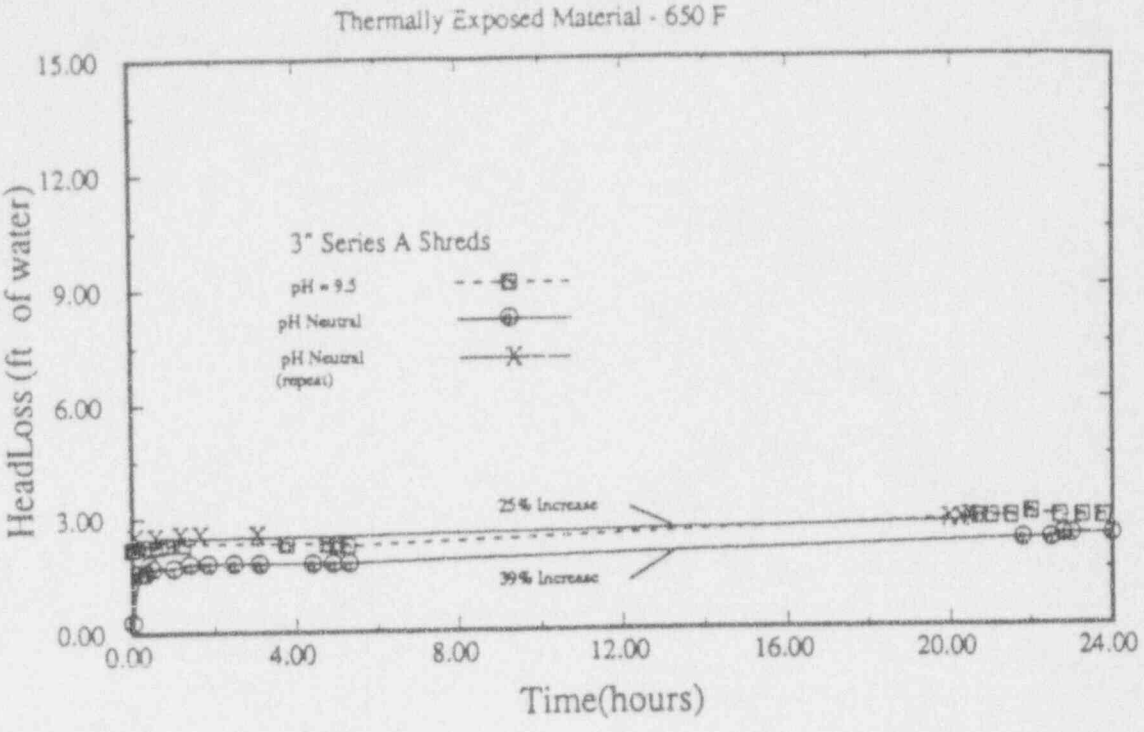

Figure a3 - Variation in head loss of Series A shreds with time. Nominally 3 inch thick samples with neutral pH and pH = 9.5 were tested at a flow rate of 0.28 ft/sec.