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Why Hot Water Pipes in Household Plumbing Burst More Frequently Than Cold Water Pipes

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WHY HOT WATER PIPES IN HOUSEHOLD PLUMBING BURST MORE FREQUENTLY THAN COLD WATER PIPES.

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Plumbers often notice that the hot water pipes in a plumbing system that lead to the bathroom or kitchen burst more frequently than the pipes carrying cold water. It is said that the ratio is at least four to one. The "Cold Water" usually freezes so as to lessen the flow of water in the pipes, or to stop the flow altogether, but the freezing seldom bursts the pipes unless the temperature is very low.

In verifying the plumber's observations the exact conditions as they exist in the pipes were not obtained, but some of the essential features were approached by substituting glass test tubes for the pipes. The freezing conditions were simulated by filling one set of tubes with tap water, freshly drawn, and by filling an alternate set of tubes with tap water which had been boiled and then cooled to the temperature of the water in the other tubes. The glass tubes were of especial advantage in that the visible appearance inside the tubes gave valuable information on what was occurring in the respective cases.

The tests carried out fully substantiated the phenomenon that hot water pipes burst more frequently than cold water pipes. On seven different occasions over fifty pairs of tubes were used, filled alternately with boiled and unboiled water, brought to the same temperature. They were placed in the open air when the temperature was below the freezing point. The times of freezing varied from a half hour, or even less, to three or four hours. The tubes were of varying size but most of them were one centimeter in diameter.

Of fifty pairs of tubes used twenty-two pairs burst, and in eighteen pairs the boiled broke before the unboiled, and in four pairs the unboiled broke first.

The observations of the plumbers being verified, the next step was to find an explanation of the phenomenon. One day, when the tubes had been filled with both kinds of water and left standing, it was noticed that the tubes holding the unboiled tap water had their walls covered with air bubbles while the others were perfectly clear. This observation, along with observations made on the drop of temperature, gave some very valuable information toward the explanation of the phenomenon. The temperature drop was read by filling comparatively large tubes with boiled and unboiled water at exactly the same temperature. The temperature was approximately the same until at about zero or a little lower where the unboiled water began to freeze. The boiled water, however, continued to cool until from minus two to minus five degrees centigrade, when it suddenly crystallized into ice, while the temperature again rose to zero.

This difference in freezing probably was due to the fact that air particles, with their impurities, form nuclei where crystallization into ice may set in. In the unboiled water crystallization begins at zero, but in the boiled it is delayed while the water cools to several degrees below zero. Then when it does set in, the water freezes more rigidly into the tube, as the ice forms just as soon in the center as on the outside, which is not the case with unboiled water. This rigid freezing causes greater pressure to be exerted on the walls of the tube, making it harder for the ice to slide away. Then on further expansion of the ice, the tube bursts.

On studying the ice of both kinds of water it was noticed that a white, cloudy core existed in the center. The core was much smaller in the ice from the boiled water. On breaking these tubes in two, this center was found to be slushy and honeycombed, and the whole central portion of the tube filled with air bubbles. Professor Quincke of the University of Heidelberg (Proc. Roy. Soc. Canada 3, p. 24, 1909) explained the presence of the air in the center by the fact that at the boundary line between the ice and the water in a freezing solution a surface tension exists which forces the air and salts away. It is precisely the same action that causes the ice of impure pond water to be purer than the mother liquid.

In studying the drop of temperature we noticed that the boiled water froze just as solid in the center as on the outside when freezing started. In the unboiled water, however, the ice formed on the walls and slowly froze toward the center. Thus in the very act of freezing a core would form in the center of the unboiled water which would not appear so easily in the boiled water. Then the occluded air, as explained above, is forced into this core of the unboiled water. Thus, when the ice freezes toward the center, enough of this central mixture of ice and water is forced away to take up the expansion of the ice. This was proven experimentally. Eleven pairs of tubes were filled alternately with boiled and unboiled water and frozen, and the eleven tubes having the greatest expansion out of the top were noted. Ten of them contained ice of unboiled water, and one of boiled water. In the plumbing system, this slushy center, instead of forcing the column of ice away as in the test tubes, is itself forced toward the terminals of the exposed pipe.

Thus we may say that boiled water freezes nearer to the natural conditions than the unboiled. In other words, the unboiled water would freeze just as quickly as the boiled water if it were air free, or vice versa, the boiled water would freeze like the unboiled if it contained air. The latter was proven experimentally. Twelve tubes were taken, six filled with unboiled water and six filled with boiled water that had been saturated with air. The tubes burst approximately at the same time, as was anticipated.

The air in the freezing of the liquid, as we saw before, separates out and forms little white spots in the ice. This weakens the ice and makes it more mobile, more easily forced away, when pressure, due to further expansion, is exercised upon it, than if it were solid. K. R. Koch (Ann. d. Phys. 41, pp. 709-727, 1913) found the ice containing air bubbles to have a lower elasticity than air-free ice. In other words, air weakens the ice. This weak ice has a lower perpendicular pressure on the walls of the tubes, and, therefore, the probability of the tubes bursting is lessened.

The air in the water also acts as a compressible medium, that is, when the ice expands by freezing, the air is compressed to make room for the expansion of the ice.

Finally to prove that chemical reaction was negligible, boiled and unboiled distilled water, which is practically free from chemical impurities, was set to freeze. Adeney (Phil. Mag. pp. 361, 9, 1905) found that water absorbs air. The boiled water broke the tubes first, as expected. Then the boiled, distilled water was saturated with air and set out together with unboiled water to freeze. The boiled water broke the tubes first.

In summing up the results of the experiments it was concluded that the occluded air effects the difference in bursting. It does this first, by acting as nuclei for crystallization so that ordinary water freezes less solidly than boiled water. Second, by causing the ice to freeze less solidly, especially at the center, until a very low temperature is reached the pressure along the center is relieved by the water and slush flowing away. Third, the air acts as a compressible medium, which relieves the pressure by an unknown amount.

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