Title: STUDY OF THE EFFECTS OF AGGRESSIVE WATERS ON TRANSITE PIPE

SUMMARY

In Langelier's original paper[1], it was noted that the deposition of a calcium carbonate salt coating on the interior surface of pipe will practically eliminate corrosion. The equation developed by Langelier to predict the tendency of water to either precipitate or dissolve $CaCO_3$ is as follows:

$$\text{Saturation Index} = pH_{actual} - pH_{saturation}$$

$$= pH - (pK_2 - pK_s) + pCa + pAlK$$

where a positive index indicates the tendency to form scale and a negative index the likelihood of corrosion. For most potable water supplies, this formula may be simplified[2] to:

$$\text{Saturation (Langelier) Index} = pH + \log (AH) - 12$$

$$[\text{or, Aggressive Index} = pH + \log (AH)]$$

where A and H are the total alkalinity and calcium hardness, respectively, expressed in mg $CaCO_3$/l. While the Saturation Index has been generally accepted as a means of predicting corrosion protection for metal pipes, (i.e., a positive Saturation Index), it has been established in laboratory tests and by field experience that A/C is suitable for use with waters with a Saturation Index in the range of 0 to -2.0. In order to clarify the effects and interactions of the three main factors (alkalinity, hardness and pH), used in calculating the Saturation Index, a laboratory study was conducted.

In this study, water solutions were prepared from de-ionized water, calcium chloride and sodium bicarbonate to produce the desired ranges of alkalinity and hardness. Dissolved carbon dioxide and sodium hydroxide were used to produce buffer solutions of the desired pH. "Plugs" were removed from the wall of 6 in. Class 150 TRANSITE pipe produced at Manville and Denison. These "cubes" of TRANSITE were cleaned and coated with epoxy on the sides and outer surface of pipe exposing 0.25 sq in., weighed, measured for thickness and tested for surface hardness (Barcol). These samples were then placed in the appropriate solutions and changes in the alkalinity, hardness and pH of the solutions were monitored according to standard procedures.[3] If large changes in the chemical composition of any of the water solutions occurred due to leaching from the samples, the water was then replaced with fresh solutions.

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At the end of specified time intervals, duplicate pipe samples were removed from duplicate water solutions and evaluated for changes in weight, thickness, surface hardness and appearance. Table 1 summarizes the experimental design.

It should be noted that this study did not investigate those areas where precipitation of calcium carbonate would predominate. It is assumed that the Saturation Index is valid in predicting the formation of a coating and insuring the long term stability of the pipe. This study was restricted to those conditions where the Saturation Index indicates that a protective coating would not be formed but where, nevertheless, there is evidence that corrosion of A/C pipe does not necessarily take place ($-2.0 <$ Saturation Index < 0). Also, it should be noted that this analysis is not intended to simulate field conditions. Factors such as pipe flow characteristics, the presence of various dissolved solids, temperature effects, etc., were not examined.

In attempting to correlate the various estimates of pipe corrosion with the Saturation Index, it was discovered that there is little, if any, dependence of corrosion on the alkalinity or hardness of the water. Only pH was found to be of any significance in ascertaining attack on the A/C pipe. Including the first several days of testing, when leaching of the pipe was most variable and most severe, it is difficult to detect any attack in the pipe at a pH of approximately 7.75 (or greater), and there is no statistically significant attack until pH drops below approximately 7.45 regardless of the alkalinity or hardness of the water solutions. After an initial period of contact with these waters of approximately 1 week, it appears that no detectable attack is experienced above a pH 7.6, and during later periods (100-150 days), waters of pH 7.25 or more appear to produce no detectable corrosion of the pipe. At or above this pH range (7.25 - 7.75), there are no detectable changes in alkalinity or hardness of the water solutions due to leaching of the pipe and no definite changes in surface hardness of the exposed pipe. All samples increased in weight and decreased in thickness on the average.. These apparent discrepancies may be explained by the continued hydration of the cement in water and the shrinkage due to drying of the samples after removal from the solutions. In fact comparisons between the 100 day samples and the 150 day samples, which were dried similarly, show no additional loss in thickness over this period. Relationships between the various measures of A/C pipe corrosion and pH were obtained through linear regression analyses with correlation coefficients of approximately 0.9. These data are presented in Figures 1-3. No differences in attack were observed between pipe produced at the two separate locations using different cements.

Additional examinations are in progress to analyze these water solutions for asbestos fiber. In conclusion, the Saturation Index may be used to determine the potential for the formation of a protective coating in pipe for any given water supply. However, if these calculations reveal a negative Saturation Index, an examination of pH alone should be conducted to decide if there will be any detectable or significant attack on the pipe. It appears that after an initial flushing of the pipe, waters as low as pH 7.25 are acceptable for use with A/C pipe. In addition, it should be emphasized that even in cases where corrosion of A/C pipe might be detected (pH < 7.25), the rates of attack might be insignificant - no reduction in product service life and no significant release of asbestos fibers from the pipe. See Figure 4 for a summary of the water conditions under which A/C pipe would be unaffected. Additional field studies are recommended to establish the pH range in which A/C pipe may be used without corrosion or release of asbestos fibers when the Saturation Index is negative and to determine the effects of additional factors such as temperature, etc., on the stability of A/C pipe.

Contents: Summary, Appendices, References and Bibliography.

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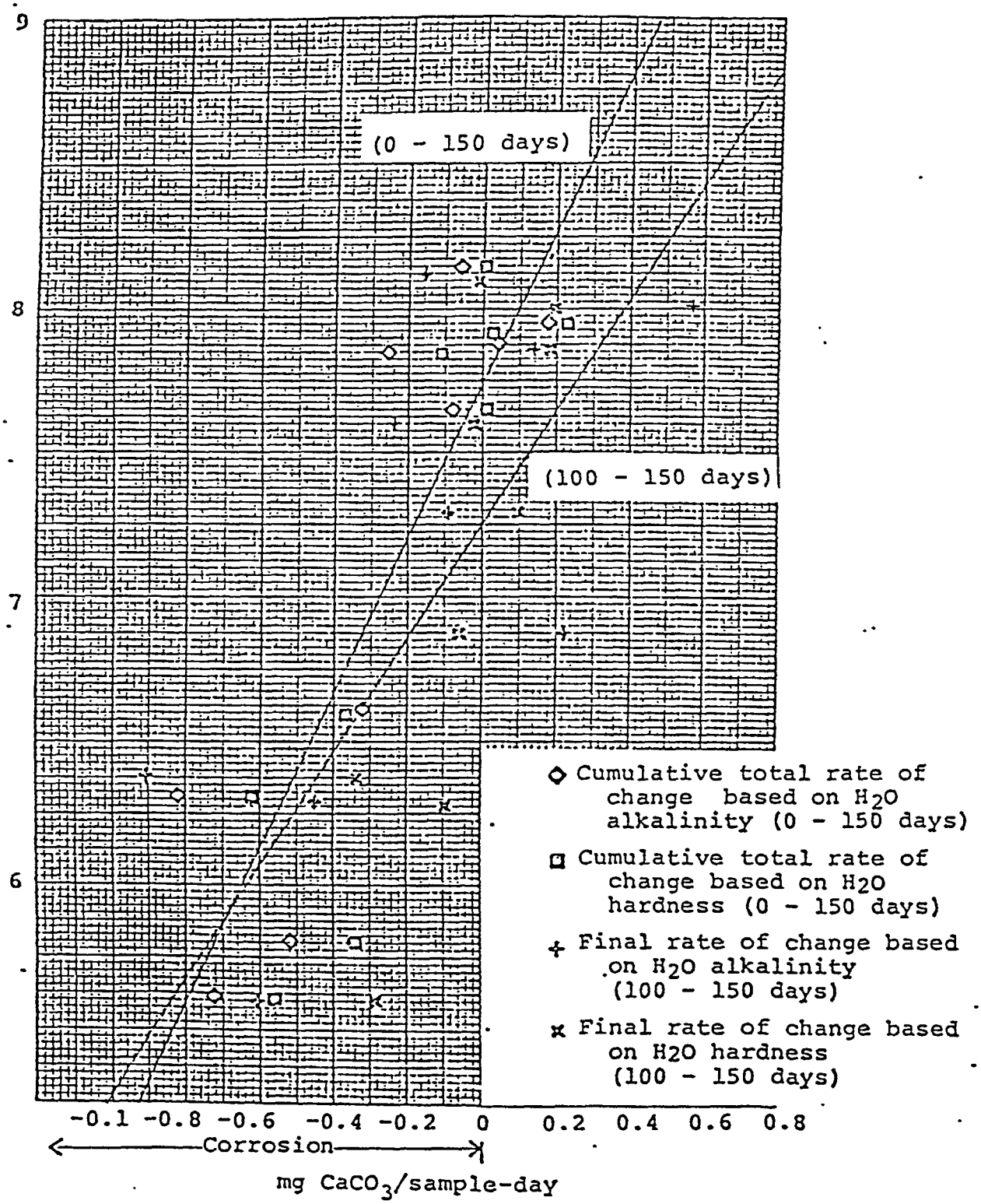
APPENDIX I

ANALYSIS OF A/C PIPE CORROSION AS AFFECTED BY ALKALINITY, HARDNESS AND pH

Trial No.	H_2O Compositions (nominal values) Hardness, ppm $CaCO_3$	Alkalinity, ppm $CaCO_3$	pH	Calculated Saturation Index	Sample Test* Periods, Days
1	10	10	6	-4	1,10,50,100,150
2	10	10	8	-2	1,10,50,100,150
3	100	10	6	-3	1,10,50,100,150
4	10	100	6	-3	1,10,50,100,150
5	100	10	8	-1	1,10,50,100,150
6	10	100	8	-1	1,10,50,100,150
7	100	100	6	-2	1,10,50,100,150
8	100	100	8	0	1,10,50,100,150
9	50	50	7	-1.6	1,10,50,100,150

*Changes in sample weight, thickness, and surface hardness were measured at the specified intervals; changes in alkalinity, hardness and pH of the water solutions were measured on a nearly continuous basis.

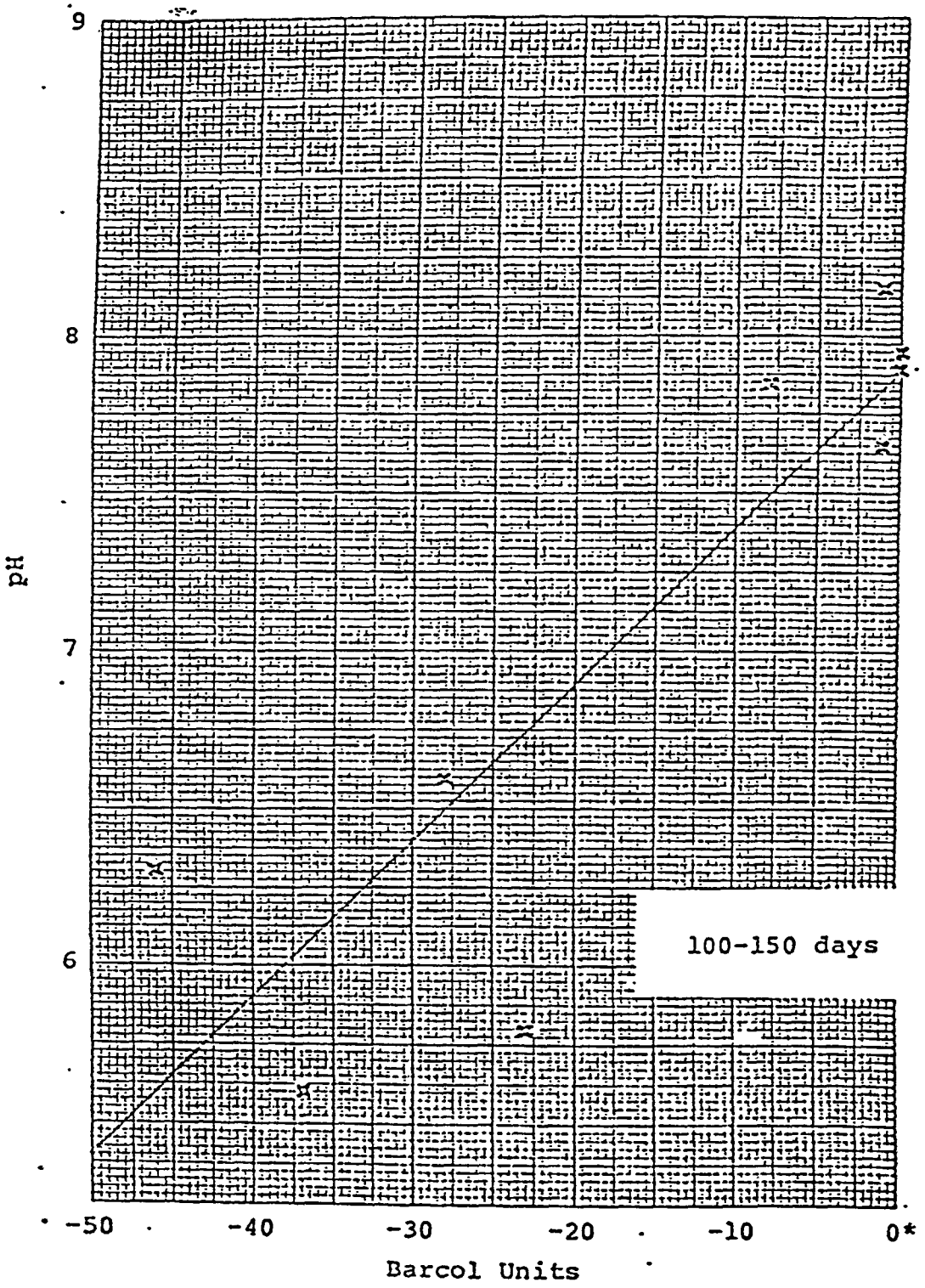
FIGURE 1. EFFECT OF pH ON CHANGES IN CHEMICAL COMPOSITION OF WATER DUE TO CORROSION OF A/C PIPE



Stability of A/C Pipe as Determined by Changes in Chemical Composition of Water

APPENDIX II

FIGURE 2. EFFECT OF pH ON CHANGES IN SURFACE HARDNESS OF THE PIPE DUE TO CORROSION

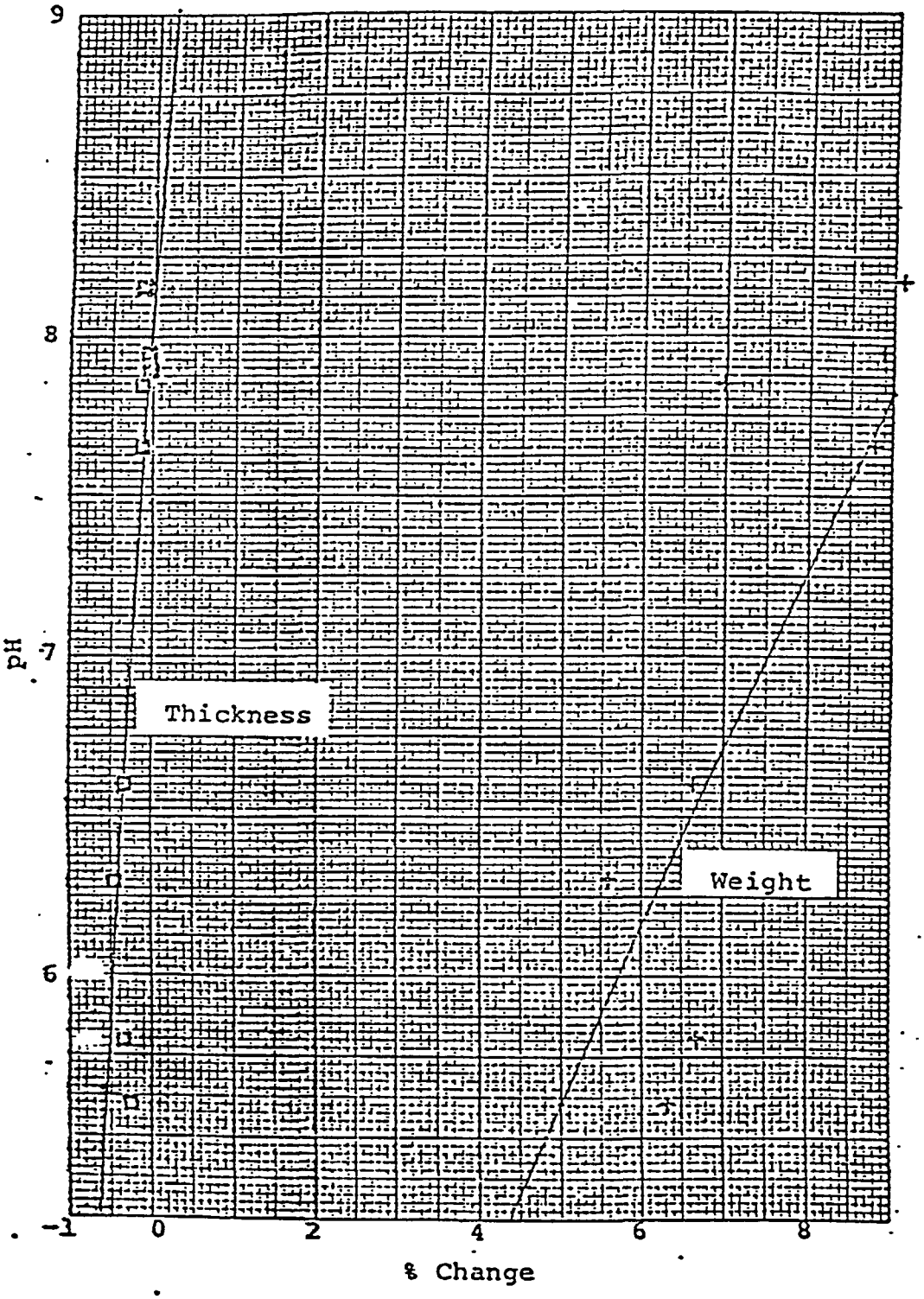


Stability of A/C Pipe as Determined by Changes in Surface Hardness of the Pipe

*(0 ≅ 95 units)

APPENDIX II

FIGURE 3. EFFECT OF pH ON CHANGES IN WEIGHT AND THICKNESS OF A/C PIPE SAMPLE DUE TO CORROSION*

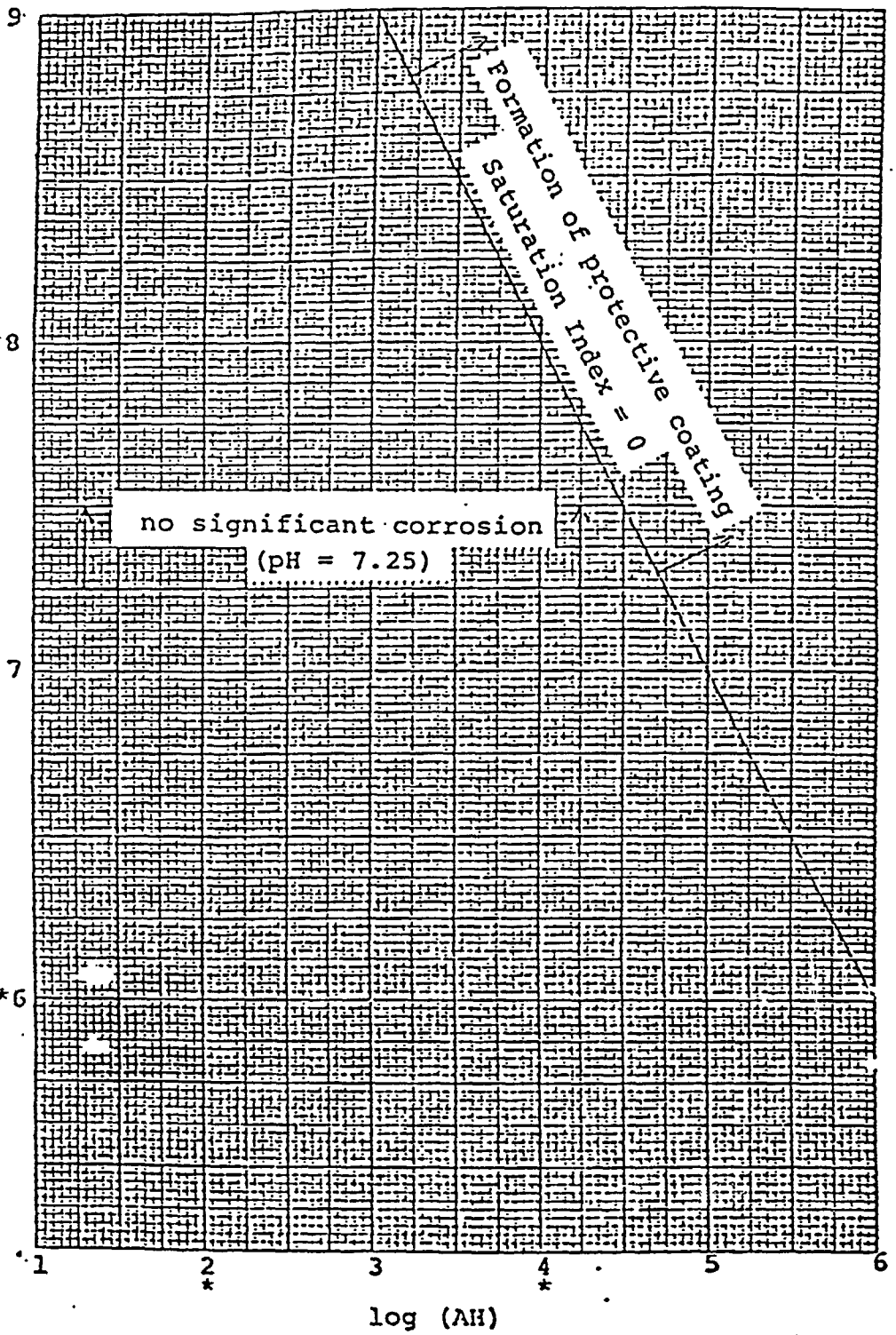


Stability of A/C Pipe as Determined by Changes in Sample Weight and Thickness

*Unadjusted for increased weight due to cement hydration during water storage and for decreased thickness due to

APPENDIX II

FIGURE 4. EFFECTS OF WATER COMPOSITION ON A/C PIPE



*Limits of study

REFERENCES

[1]Langelier, W. F., J. Am. Water Works Assoc., 28 (10) pp. 1500 - 1521, (1936).

[2]AWWA Standard for Asbestos-Cement Pressure Pipe, 4 in. through 24 in., for Water and Other Liquids. AWWA C400-75, Revision of C400-73. AWWA, Denver, Colorado 1975.

[3]Standard Methods for the Examination of Water, Sewage and Industrial Wastes, Tenth Edition, New York (1955).

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