# Adsorption on Unburned Carbon in Fly Ash and Development of an Improved Foam Index Test

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**Summary**

The suitability of a fly ash as a pozzolanic additive to concrete depends upon several factors related to its carbon content. It is the carbon's porous surface area which is important in determining the capacity of the carbon to adsorb air entrainment admixtures (AEAs) [1,2]. It is this adsorption that causes the problems in concrete freeze-thaw resistance and which dictates the rejection of large amounts of commercial utility ash. The ability of the carbon to adsorb AEA depends upon not only its surface area, but also the accessibility of that area and its polarity [3], factors that are well-known in activated carbon design. Recognition of this has led to the identification of ozonation as a tool for rendering ash carbon surfaces polar and thus of lower AEA adsorption capacity [4].

One of the key requirements for systematic design of activated carbons is that certain well-defined benchmark tests be available for evaluating the carbons. The same is true in evaluating AEA adsorption mitigation procedures. Historically, the well-known "foam index" test has served this purpose. Unfortunately, this is not a standardized procedure and different laboratories have used different methods for performing it. Moreover, there are a great many candidate AEAs that can be used for the test. Thus there has never been good comparability of results from lab-to-lab, or even within a single lab, if the AEA supply is changed.

We present research on several chemically pure candidate surfactants tested against commercial AEAs utilizing many commercial utility ashes from the Brown University ash sample bank. These easily obtained chemical surfactants offer hope for development of a standardized foam index test that can allow true inter-laboratory comparisons.

The commercial AEAs that were examined as part of this study were Darex II™ and Air 40™. The candidate pure surfactant materials were sodium dodecyl sulfate (SDS), abietic acid sodium salt and dodecyl benzenesulfonic acid salt (DBS). While the latter pure materials would not be considered as commercial AEAs, they closely mimic the behavior of the commercial AEA compounds under the usual foam index-type test conditions. Just as in the normal foam index test, no special equipment is needed for performing the test. The endpoint is, as usual, visually determined from the stable foam on a fly ash-cement-water mixture.

It was observed that the foam index results using Darex II and Air 40 were very well correlated with one another, for a large number of class F ashes. The same was true when the foam index results of the SDS, abietic acid salt and DBS were compared with the commercial AEAs. There were, however, some significant differences in the amounts of the different agents required to reach the foam endpoint- some agents are more effective than others. The ratios of surfactant requirements for different ashes in the set were, however, independent of the type of surfactant. Based upon the results obtained here, the most convenient choice of surfactant appeared to be DBS. This material is a good candidate for establishing a standard foam index test.

This research program also revealed other interesting features of the foam index test. It was learned that certain test conditions should not be varied beyond certain bounds. For example, it is sometimes tempting to reduce the amount of ash in the foam index test, in order to more quickly reach the endpoint. The foam index values obtained by "correction" for the reduced amount of ash may, however, be substantially too high, if the amount of ash is reduced beyond a certain critical threshold. The dependence of measured foam index on both pH and different ionizing salts was also explored. The results suggest that the test is very sensitive to subtle variations in the test mixture. For example, the choice of Portland cement can make a large difference in the amount of AEA required to reach a stable endpoint, though these differences are often masked by the cement "blank" that is routinely performed as part of the test.

**References**


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