

## 3.5 Inadequate Admixtures

### Description:

Admixtures are materials, other than cement, water, aggregates, and reinforcement, used as ingredient of concrete and added to the batch immediately before or during mixing. Original records indicate that the two admixtures used were a water reducing retarding admixture (Daratard by W.R. Grace conforms to ASTM C-494) and air entraining admixture (Darex by W.R. Grace conforms to ASTM C-260). Air entrainment is normally added to concrete exposed to potentially destructive exposure such as freezing thawing cycles. It may also provide a limited benefit in workability improvement. Water reducer/retarder improves workability of low slump concrete while allowing more time for placing in high temperature conditions. Admixture use must be carefully controlled since excessive amounts of air can result in strength deficiencies, whereas excessive amounts of retarders can lead to delays in setting and early strength gain.

### Data to be collected and Analyzed:

1. Original specifications. (FM 3.5 Exhibit 1)
2. Concrete mix designs (FM 3.5 Exhibit 2)
3. Records of pour tickets (FM 3.5 Exhibits 3) and analysis of air measured (FM 3.5 Exhibit 4)
4. Petrographic analysis (FM 3.5. Exhibit 5, 6 and 7)

### Verified Refuting Evidence:

See attached sheet

### Verified Supporting Evidence:

None

*Draft*

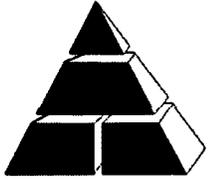
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May identify additional perspective on this issue as RCA related efforts proceeds

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## 3.5 Inadequate Admixtures, Cont.

### Verified Refuting Evidence:

- a. Project specifications (SP-5569) provide guidelines for admixture use (FM 3.5 Exhibit 1). Final specifications dated June 23, 1971 require 3-6% air entrainment, allow the use of Daratard, and forbid the use of admixtures containing Calcium Chloride.
- b. Review of concrete mix designs (FM 3.5 Exhibit 2) and pour tickets (examples in FM 3.5 Exhibit 3) indicate that specifications were followed. Fly ash and admixtures containing calcium chloride were not used in concrete.
- c. Analysis of total air content tests performed during construction show compliance with specified range of 3-6% air (FM 3.5 Exhibit 4).
- d. Petrographic analysis was performed during the dome repair and in 2009. Analysis of Petrographic reports follows:
  - i. Original Petrography report by Erlin and Hime dated 5/10/1976 (FM 3.5 Exhibit 5) concluded that total air content was 5.5% and the "parameters of the air-void system are judged to be effective for protecting critically saturated concrete exposed to cyclic freezing."
  - ii. CTL Petrography Report dated 11/2/2009 (FM 3.5 Exhibit 6) estimated that the concrete had 2-4% air content and that it could be considered "marginally air entrained..."
  - iii. MacTec report dated 11/11/2009 (FM 3.5 Exhibit 7) indicated that "the concrete appeared to be air entrained and had a total air content estimated to around 2 to 3%."

Conclusion: All documents reviewed show that the admixtures meet all requirements and are not a contributing factor in the delamination.

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