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April 10, 1984

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Mr. James G. Keppler
Regional Administrator
U.S. Nuclear Regulatory Commission
Region III
799 Roosevelt Road
Glen Ellyn, IL 60137

Subject: Braidwood Station Units 1 and 2
Open Item Concerning Total
Chloride Ion Content in Concrete
NRC Docket Nos. 50-456 and 50-457

Reference (a): R. F. Heishman letter to Byron Lee, Jr.
dated August 7, 1978.

Dear Mr. Keppler:

Reference (a) contains an unresolved item number 456/78-06-03; 457/78-06-03 concerning total chloride ion content in concrete at Braidwood Station. Specifically, the Region had concern with the impact of the additional chloride ion content contained in the aggregate and admixtures relative to the acceptability of total chloride ion content of the mixing water used for concrete production. Further, the Region had concerns with evidence of mineral and iron oxide deposits on the tendon tunnel walls. The purpose of this letter is to provide information which should allow for the Region's closure in this matter.

On February 17, 1983, Commonwealth Edison made an engineering presentation at the Region concerning these topics. The Attachment to this letter documents our presentation and in our judgment, provides the technical basis for closing out the open item.

Please address any questions that you or your staff may have concerning this matter to this office.

Very truly yours,

E. Douglas Swartz

E. Douglas Swartz
Nuclear Licensing Administrator

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Attachment

cc: Region III Inspector - Braidwood

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Attachment 1

Braidwood Station

Presentation to NRC Region III

February 17, 1983

Chloride Content in Concrete and

Evidence of Corrosion in Tendon Tunnels

Chloride Content in Concrete

ACI Committee 201 ("Guide to Durable Concrete" ACI-201.2R-77, American Concrete Institute, 1977) has recommended, and ACI-318 and ACI-301 have adopted, a lower bound limit on chloride content of 0.06% by weight of cement, for prestressed concrete. This value is based on the premise that the prestressing steel is in direct contact with the concrete. The prestressing steel at Braidwood is contained in sheathing filled with grease for corrosion protection, and therefore, the 0.06% limit is not applicable. The ACI-201 limit for concrete exposed to chloride in service is 0.10%. However, based on current information, ACI-318-83 has adopted a 0.15% limit for concrete exposed to chloride in service. As stated in Section 4.5.4 of the commentary, "The more liberal limits were developed after consultation with ACI Committee 201 on durability and 222 on corrosion, and are considered to represent the best information available at the time of adoption". The 0.15% limit on chlorides in concrete is most applicable to Braidwood.

The 0.15% limit for concrete exposed to chlorides is conservative since it is intended for the worst exposure normally expected (bridge decks or seawater exposure) where the chloride ion content may exceed 19,000 ppm. The actual chloride ion content of the groundwater at Braidwood is less than 350 ppm.

It should also be noted that the ACI limit is on water soluble chlorides. Due to the difficulty in determining the amount of chlorides which are water soluble, the total amount of chlorides present are compared to these limits. Also, some of the chlorides which are initially water soluble are chemically combined with the hydrated cement, further reducing the chlorides available to induce corrosion.

Sargent & Lundy performed an analysis of the total chlorides in the concrete mix for the Containment using conservative values and quantities for the constituent materials as follows:

1. The concrete mix with the greatest water and cement contents were used since these materials contribute the majority of the chloride ions.

2. Chloride contents were less than 350 ppm during the time concrete was placed below grade level. (Only concrete below grade is exposed to chlorides in the groundwater.) The upperbound value of 350 ppm was used in the analysis.

3. For admixtures, the maximum amount of chloride allowed by Specification F/L-2722, 1% by weight, was used whereas the actual amount determined by tests did not exceed 0.15%.

4. The chloride content of coarse and fine aggregate was not measurable (less than 1 ppm) and therefore, was taken as 0%.

As shown in Table 1, the upper bound limit on the ratio of chloride content to cement is 0.027%. This is far below the ACI limit of 0.15% for reinforced concrete exposed to chlorides and even well below the 0.06% limit for prestressed concrete.

The limit of 500 ppm on chloride ion in the mixing water found in Specification F/L-2722 provides control on the largest contributor to the total chloride content in the concrete. The ASME 1977 edition provided for a limit of 250 ppm for water but had no limit on the total chloride content in the concrete. In the 1980 edition summer 1980 addenda, the limit on chloride content in water was deleted and replaced by a limit of 400 ppm on chloride content in the cement paste. As shown in Table 1, the chloride content, using the same conservative assumptions, is 184 ppm. The specification limit on chlorides in water of 500 ppm has limited total chlorides in concrete to acceptable levels.

Iron Oxide Deposits on Tendon Tunnel Walls

Mr. Gallagher, after his inspection of the tendon tunnels, noted "the apparent effects of groundwater in the form of corrosion of the embedded steel (reinforcing) and by the presence of deposits of iron oxide on the walls of the tendon gallery", where groundwater was leaking through cracks in the walls.

On August 22, 1980, a Level III ASME/ACI Nuclear Engineer Inspector, examined areas in the tendon tunnel. Where the concrete was cracked and iron oxide deposits were present, concrete was removed for approximately 4 inches behind the interior face reinforcing steel. Examination of these areas yielded no evidence of corrosion on the reinforcing steel. In addition, no discoloration of concrete was found at the exposed crack approximately 4 inches behind the reinforcing steel, thus discounting the potential for corrosion of reinforcing steel at the exterior face of the tendon tunnel.

Furthermore, during the inspection, it was determined that a waterproofing system using metallic grout was used to repair cracks. The reddish-brown deposits occurred only at the repaired cracks with the rust confined to areas containing the metallic grout. To minimize future groundwater leakage into the tendon tunnels, these cracks have been repaired using a concrete waterproofing system acceptable for safety related work and which does not contain a metallic grout.

TABLE 1

CHLORIDE ION PER CUBIC YARD OF CONCRETE

CONSTITUENT		LB/CUYD		CHLORIDE RATIO		CHLORIDE LB/CUYD
Water	=	315	X	0.00035	=	0.1102
Cement	=	680	X	0.00007	=	0.0476
*Admixtures	=	2.58	X	0.01	=	0.0258
Total Paste	=	997.58 LB/CUYD		Total Chlorides	=	0.1836 LB/CUYD

Ratio of Total Chloride to Cement = 0.1836/680 = 0.00027
= 270 ppm
= 0.027%

Ratio of Total Chloride to Paste = 0.1836/997.6 = 0.000184
= 184 ppm
= 0.018%

* Weight of Chlorides in Admixtures can be Calculated as:

(5+28) = 33 FL.OZ/CUYD Air Entrainment & Water Reducing Admixtures

$$\frac{33 \text{ Ounces/Cu.Yd.}}{128 \text{ Ounces/gallon}} \times 8.33 \frac{\text{lbs.}}{\text{gallon}} \times 1.2 \text{ (specific gravity)}$$

= 2.58 LB/CUYD