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March 15, 1989

Dr. Thomas E. Murley, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Dresden Station Units 2 and 3
Quad Cities Station Units 1 and 2
Flued Head Anchor (FHA) Reassessment
Program Supplemental Information
<u>NRC Docket Nos. 50-237/249 and 50-254/265</u>

References (a): Conference call between NRR (T.M. Ross, et al.) and CECo/S&L (J. Silady, et al.) on March 8, 1989.

(b): Letter from I.M. Johnson to T.E Murley dated February 21, 1989.

Dear Dr. Murley:

During the Reference (a) conference call, additional information was requested concerning calculational details of the Flued Head Anchor Reassessment Program which has been conducted by Sargent and Lundy Engineers for Commonwealth Edison Company. This transmittal documents the clarification provided during the call in the form of revised pages to the attachment of the Reference (b) letter on the same subject.

The clarification involves a more explicit discussion of how the shear tension interaction is considered for rock anchors and thru bolts when shear lugs are not present, consisting of a design control summary sheet which now includes the equation for the interaction. Also included are the applicable pages from ACI 349 and its Appendix B.

A001
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It is our understanding that this transmittal completes all remaining open items concerning the Staff's review of the Flued Head Anchor program.

Very truly yours,

J A Silady

J. A. Silady
Nuclear Licensing Administrator

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Attachments (2)

cc: A.B. Davis - Regional Administrator, RIII
T.M. Ross - Project Manager, NRR
B.L. Siegel - Project Manager, NRR
R.L. Higgins - Senior Resident Inspector, Quad Cities
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March 13, 1989
Project No. 8188-05

Commonwealth Edison Company
Dresden - Units 2 & 3
Quad Cities - Units 1 & 2

FLUED HEAD ANCHOR REASSESSMENT PROGRAM
SUBMITTAL OF SUPPLEMENTAL INFORMATION
System Code: 1600

Mr. S. Javidan
Principal BWR Engineer
Commonwealth Edison Company
P. O. Box 767 - 35 FNW
Chicago, IL 60690

Dear Mr. Javidan:

Attached for transmittal to the NRC please find the following information:

- A confirmation of how the shear tension interaction is considered for rock anchors and thru bolts when shear lugs are not present consisting of a design control summary sheet which now includes the equation for the interaction. Also included are the applicable pages from ACI 349 and it's Appendix B.

It is my understanding that your Licensing Department will transmit this information to the NRC for use in their close out report.

Yours very truly,

P. A. Gazda

P. A. Gazda
Senior Structural Project Engineer

PAG/gs
Attachment
Copies:
W. B. Fancher (1/0)
R. Mirochna (1/0)
J. Silady (1/1)
R. Jason (1/0)
A. Walser (1/0)
P. C. Bhatt (1/1)

Notes:

a. The concrete cone capacity for the individual anchors and/or anchor assemblies shall be calculated as follows:

$$\text{Concrete cone capacity } Pd = 4 \times \phi \times \sqrt{f'c}\ (Ap)$$

where:

- Ap = Projected Concrete Cone Area
- $\phi = 0.85$ - All embedments are located in a compression zone or in a tension zone where the tension stress at the surface of the concrete is less than $5\,\phi\sqrt{f'c}$.
- f'c = Actual in-place concrete strength based upon concrete cylinder data.
- Effective embedment depth will be determined in accordance with Figure B7-1 of ACI 349 Appendix B.
- The effective projected net area shall be reduced to account for overlapping cones from adjacent anchors and/or assemblies as well as the influence of the penetration sleeve which intersects the cone surface. (See Page 0.22)
- The effect of the near face reinforcing may be utilized to increase the capacity of the concrete cones.
- The shear lugs are considered effective to transfer the applied shear in accordance with the requirements of ACI 349 Appendix B when a state of compression exists in the plane of the concrete element in the vicinity of shear lugs and normal to the face of the shear lug. If the shear lugs are ineffective or non-existent, the anchor bolts shall be assumed to transfer the shear in combination with tension by the shear-friction provisions of ACI-349 Appendix B. R3

These provisions shall be applied by assessing interaction equation for thru bolts and rock anchors as follows: Section B.6.3.2

Thru Bolts $$\frac{T}{T_{all}} + \frac{V}{\mu V_{all}} \leq 1.0$$ R3

Rock Anchors $$\frac{T + V/\mu}{T_{all}} \leq 1.0$$

where T = applied tension force
V = applied shear force
μ = coefficient of friction per ACI Section B.6.2.2.2

T_{all} = allowable tension force
= ϕ As Fy for thru bolts, where $\phi = 0.9$ (Section B.6.2.1.1)
= per Notes b&c for rock anchors
V_{all} = allowable shear force
= ϕ AsFy for thru bolts, where $\phi = 0.85$ (Section B.6.2.2.2.)

R3

b. The design strength for an individual anchor, where the cone capacity exceeds the ultimate tensile capacity of the rock anchor, shall be established as:

$$T_{all} = 0.9 \text{ As Fy}$$

- (As fut) shall be taken as 75,000 lbs. for 1" diameter and 38,000 lbs. for 3/4" diameter, Super High Tensile "Spin-Lock" bolts in accordance William's published design data.

- (As fy) shall be taken as 60,000 lbs. for 1" diameter and 30,000 lbs. for 3/4" diameter, Super High Tensile "Spin-Lock" bolts in accordance William's published design data.

c. For anchor assemblies in which the concrete cone capacity, Pd, is less than the ultimate strength of the concrete anchor, the design strength of the anchor shall not exceed:

.33 Pd for seismic load cases (1B and 2)
.5 Pd for pipe break load case (3)
.72 Pd for operability only

R3

For Rock Bolt stiffness, see Page 0.20.

d. See Page 0.13 for ultimate capacities of wedge and shell anchors (DC-SE-01-CE). The factor of safety is applied to the entire assembly rather than to individual anchors. Shear and tension are combined using an elliptical shear/tension interaction equation to the 5/3 power.

tensile stress component. (c) The bearing area of the anchor head is approximately evenly distributed around the perimeter of the tensile stress component.

B.5 — Anchorage requirements

B.5.1 — Anchorage design shall be controlled by the strength of embedment steel unless otherwise specified in this appendix.

B.5.1.1 — Tension

Steel strength controls when the design pullout strength of the concrete P_d as determined in Section B.4.2 exceeds the minimum specified tensile strength of the tensile stress component (based on f_{ut}) of the embedment steel, and full load transfer is accomplished from steel to concrete within the depth of the anchorage by one of the following methods:

(a) A mechanical anchor at the base of the tensile stress components which satisfies the requirements of Section B.4.5.2. To prevent failure due to lateral bursting forces at anchor heads, the minimum side cover distance m shall be determined such that the lateral concrete design strength (based on a uniform tensile stress of $4\phi\sqrt{f_c'}$ acting on an effective area, including overlapping stress cones, defined by projecting a 45 deg cone from the anchor head to the free surface) exceeds the lateral bursting force unless the requirements of Section B.4.4 are met. The ϕ factor shall be taken as 0.85.

(b) Reinforcing bars with development lengths in accordance with the requirements of Chapter 12, for anchor steel composed of reinforcement.

B.5.1.2 — Shear

B.5.1.2.1 — Anchor Bolts, Studs, or Bars

For anchor bolts, studs, or bars, the minimum side distance m for shear loading toward a free edge shall be such that the concrete design strength (based on a uniform tensile stress of $4\phi\sqrt{f_c'}$ acting on an effective area defined by projecting a 45 deg half-cone to the free surface from the centerline of the anchor at the shearing place) exceeds the ultimate shear strength of the bolts, studs, or bars (based on f_{ut}).

B.5.1.2.2 — Shear Lugs

(a) Shear lugs shall be considered effective only when located in a concrete compression zone developed between the embedment and the concrete and transverse to the direction of the shear force for a given load combination.

(b) When multiple shear lugs are used to establish the design shear strength in a given direction, the magnitude of the alloted shear to each lug shall be in direct proportion to the total shear, the number of lugs, and the shear stiffness of each lug.

(c) For shear lugs bearing in the direction of a free edge, the concrete design shear strength for each lug shall be determined based on a uniform tensile stress of $4\phi\sqrt{f_c'}$ acting on an effective stress area defined by projecting a 45 deg plane from the bearing edges of the shear lug to the free surface unless the requirements of Section B.4.4 are met. Bearing area of the shear lug shall be excluded from the projected area. The ϕ factor shall be taken as 0.85.

(d) When multiple shear lugs are used to establish design shear strength in a given direction, the face-to-face dimension between shear lugs shall not be less than that $0.7h\sqrt{f_c'}$ where h is the lug depth.

B.5.1.3 — For combined tension and shear, the depth of embedment shall be in accordance with Section B.5.1.1 and the minimum edge distance in accordance with Section B.5.1.2(a).

B.5.1.4 — Where reinforcement is provided in accordance with Section B.4.4, the minimum side cover distance shall not be less than one-third that required by Section B.5.1.2. Under no conditions shall the edge distance be less than the concrete cover requirements for reinforcement in Section 7.7 of this Code.

B.6 — Design requirements for embedment steel

B.6.1 — Embedment material shall be defined by the Engineer in the contract documents.

B.6.2 — The design strength for embedments shall be based on a maximum steel stress of ϕf_y. The following values for ϕ shall be used:

B.6.2.1 — Tension, compression, and bending

B.6.2.1.1 — Tension $\phi = 0.9$. Design tensile strength shall be ϕf_y or $0.8 f_{ut}$, whichever is less.

B.6.2.1.2 — Compression and bending $\phi = 0.9$.

B.6.2.2 — Shear

B.6.2.2.1 — Structural shapes and fabricated steel sections and shear lugs

$\phi = 0.55$.

B.6.2.2.2 — The shear-friction provisions of Section 11.7 of this Code (as modified in this section) shall be applied to bolts, studs, and bars using ϕ of 0.85. The design yield strength f_y shall not exceed 120,000 psi. The coefficient of friction μ shall be as follows:

(a) 0.9 for concrete or grout against as-rolled steel with the contact plane a full plate thickness below the concrete surface.

(b) 0.7 for concrete or grout against as-rolled steel with contact plane for coincidental with the concrete surface.

(c) 0.55 for grouted conditions with the contact plane between grout and as-rolled steel exterior to the concrete surface.

B.6.3 — Combined tension and shear

B.6.3.1 — For structural shapes and fabricated steel sections, the web shall be designed for the shear and the flanges designed for the tension, compression, and bending.

B.6.3.2 — For bolts, studs, and bars, the area of steel required for tension by Section B.6.2.1 and shear by Section B.6.2.2 shall be considered additive.

B.6.4 — The tensile stress area of a threaded anchor shall be taken as:

$$0.7854\left[D - \frac{0.9743}{n}\right]^2$$

where D is the major thread diameter and n is the number of threads per in.

B.6.5 — The tensile stress area of Section B.6.4 shall be applied to all threaded anchors subject to direct tensile and shear stress.

B.7 — Expansion anchors

This section provides minimum requirements for the design of typical expansion anchors used in concrete structures and does not restrict the use of other expansion anchors provided the expansion anchors are designed and tested in accordance with the requirements of this section.

B.7.1 — Design requirements

Expansion anchors shall be designed to assure that the design strength of concrete for a given expansion anchor or group of expansion anchors is greater than the strength of the anchor steel except as permitted in Section B.7.2. This requirement shall be met by satisfying the requirements of Sections B.7.1.1 or B.7.1.2.

B.7.1.1 — Design by analysis

(a) Tension: The design pullout strength of concrete P_d shall be as defined in Section B.4.2 except that the effective stress area shall be defined by the projected area of the stress cones radiating toward the concrete surface from the innermost expansion contact surface between the expansion anchor and the drilled hole. Refer to Fig. B.7-1 for typical details. The design pullout strength of concrete shall be equal to or greater than the minimum specified tensile strength or average tensile strength if a minimum is not defined for the expansion anchor. The minimum edge distance shall be in accordance with the requirement of Section B.5.1.1(a).

(b) Shear: Expansion anchors subject to shear shall meet the requirements of Section B.5.1.2.1.

(c) For combined tension and shear, the depth of embedment shall be in accordance with Section B.7.1.1(a) and the minimum edge distance in accordance with Section B.7.1.1(b).

(d) The Design requirements for embedment steel shall be in accordance with Section B.6.0.

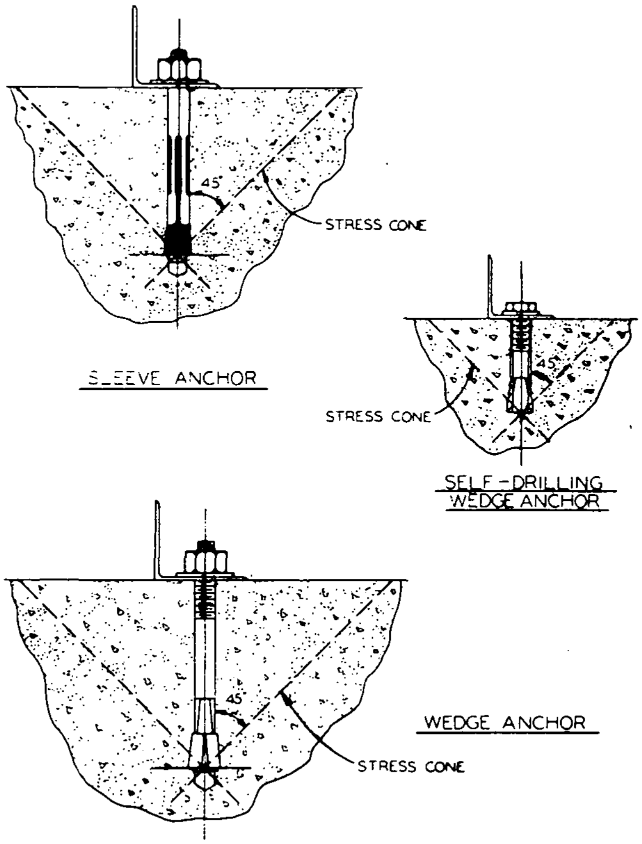

Fig. B.7-1—Typical details of expansion anchors

B.7.1.2 — Design by testing

Tests shall be conducted to verify that the concrete will develop the steel strength of the expansion anchor. Design by test results shall be restricted to tests that are representative of the anchor spacing and load application.

B.7.1.3 — Strength reduction factors

The requirements of Section B.6 shall apply except that the ϕ factors for expansion anchors shall be 0.9 times the values specified in Section B.6.2.

B.7.2 — Alternative design requirements

For expansion anchors that do not meet the requirement of Section B.7.1, the design strength shall be 0.33 times the average tension and shear test failure loads. The average test failure load shall be equal to the average of the test loads carried by test anchors at failure (maximum load) or at a magnitude of displacement of test anchors as specified by the Engineer.

11.7 — Shear-friction

11.7.1 – Provisions of Section 11.7 are to be applied where it is appropriate to consider shear transfer across a given plane, such as: an existing or potential crack, an interface between dissimilar materials, or an interface between two concretes cast at different times.

11.7.2 – Design of cross sections subject to shear transfer as described in Section 11.7.1 shall be based on Eq. (11-1), where V_n is calculated in accordance with provisions of Section 11.7.3 or 11.7.4.

11.7.3 — A crack bar shall be assumed to occur along the shear plane considered. Required area of shear-friction reinforcement A_{rf} across the shear plane may be designed using either Section 11.7.4 or any other shear transfer design methods that result in prediction of strength in substantial agreement with results of comprehensive tests.

11.7.3.1 – Provisions of Sections 11.7.5 through 11.7.10 shall apply for all calculations of shear transfer strength.

11.7.4 – *Shear-friction design method*

11.7.4.1 – When shear-friction reinforcement is perpendicular to shear plane, shear strength V_n shall be computed by

$$V_n = A_{vf} f_y \mu \qquad (11\text{-}26)$$

where μ is coefficient of friction in accordance with Section 11.7.4.3.

11.7.4.2 – When shear-friction reinforcement is inclined to shear plane, such that the shear force produces tension in shear-friction reinforcement, shear strength V_n shall be computed by

$$V_n = A_{vf} f_y (\theta \sin \alpha_f + \cos \alpha_f) \qquad (11\text{-}27)$$

where α_f is the angle between shear-friction reinforcement and shear plane.

11.7.4.3 — Coefficient of friction μ in Eq. (11-26) and Eq. (11-27) shall be

Concrete placed monolithically	1.4
Concrete placed against hardened concrete with surface intentionally roughened as specified in Section 11.7.9	1.0
Concrete placed against hardened concrete not intentionally roughened	0.6
Concrete anchored to as-rolled structural steel by headed studs or by reinforcing bars (see Section 11.7.10)	0.7

11.7.5 – Shear strength V_n shall not be taken greater than $0.2f_c'A_c$ nor $800A_c$ in pounds, where A_c is area of concrete section resisting shear transfer.

11.7.6 – Design yield strength of shear-friction reinforcement shall not exceed 60,000 psi.

11.7.7 – Net tension across shear plane shall be resisted by additional reinforcement. Permanent net compression across shear plane may be taken as additive to the force in the shear-friction reinforcement $A_{vf}f_y$, when calculating required A_{vf}.

11.7.8 – Shear-friction reinforcement shall be appropriately placed along the shear plane and shall be anchored to develop the specified yield strength on both sides by embedment, hooks, or welding to special devices.

11.7.9 – For the purpose of Section 11.7, when concrete is placed against previously hardened concrete, the interface for shear transfer shall be clean and free of laitance. If μ is assumed equal to 1.0λ, interface shall be roughened to a full amplitude of approximatley ¼ in.

11.7.10 – When shear is transferred between as-rolled steel and concrete using headed studs or welded reinforcing bars, steel shall be clean and free of paint.

11.8 – Special provisions for deep flexural members

11.8.1 – Provisions of Section 11.8 shall apply for members with ℓ_n/d less than 5 and loaded at top or compression face.

11.8.2 – Design of deep flexural members for shear shall be based on Eq. (11-1) and (11-2), where shear strength V_c shall be in accordance with Section 11.8.5 or 11.8.6, and shear strength V_s shall be in accordance with Section 11.8.7.

11.8.3 – Shear strength V_n for deep flexural members shall not be taken greater than $8\sqrt{f_c'}b_w d$ when ℓ_n/d is less than 2. When ℓ_n/d is between 2 and 5,

$$V_n = \frac{2}{3}\left(10 + \frac{\ell_n}{d}\right)\sqrt{f_c'}b_w d \qquad (11\text{-}27)$$

11.8.4 – Critical section for shear measured from face of support shall be taken at a distance $0.15\ell_n$ for uniformly loaded beams and $0.50a$ for beams with concentrated loads, but not greater than d.

11.8.5 – Unless a more detailed calculation is made in accordance with Section 11.8.6,

$$V_c = 2\sqrt{f_c'}b_w d \qquad (11\text{-}28)$$