RELATED CORRESPONDENCE

Commonwealth Edison
One First National Plaza, Chicago, Illinois
Address Reply to: Post Office Box 767
Chicago, Illinois 60690

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USNRC

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October 22, 1984

Mr. James G. Keppler
Regional Administrator
Directorate of Inspection and
Enforcement - Region III
U.S. Nuclear Regulatory Commission
799 Roosevelt Road
Glen Ellyn, IL 60137

Subject: Supplemental Response to Questions Concerning Slenderness Ratio and Lateral Unbraced Length of Certain Support Steel Members -- Byron Unit 1, NRC Docket No. 50-454

References: (a) T.R. Tramm letter to H.R. Denton; dated October 12, 1984

(b) J.F. Streeter letter to Cordell Reed; dated October 4, 1984

Dear Mr. Keppler:

The purpose of this letter is to supplement the information provided in Reference (a) concerning the results of our evaluation of the slenderness ratio and lateral unbraced length limitations applied to certain component support steel members on Byron Unit 1. This evaluation is intended to resolve the questions raised in Section C.7.d and D.2 contained in Reference (b).

These matters have been discussed at some length with your staff, and the materials provided as Attachments 1 and 2 document information previously supplied informally to support their review. Specifically, in the attachments just noted, we have delineated those framing members that will be modified to resolve questions raised by the NRC Staff concerning the appropriate interpretation of AISC Code requirements effecting slenderness limitations (KL/r) on frame members, and an unbraced length (L/t) used in the design of steel angles in such frames.

Commonwealth Edison

Although this letter documents our commitment to modify the effected members to conform to the NRC Staff interpretation, we do not believe the Staff's interpretation reflects accepted design practice under the AISC Code. We have provided to your Staff technical information and analyses in support of our position, but that information was not considered adequate to resolve this Code question. Therefore, we have reviewed these matters with current and past members of the AISC including their regional engineers and Director of Engineering, and will pursue a formal Code inquiry on the subject. Based on the informal discussions held thus far with the Code body, we are confident that we will receive a formal AISC Code interpretation which supports our position. At such time as the formal interpretation by the AISC Code is received, we will initiate further discussions with the NRC Staff.

As has been stated, in order to resolve this question and avoid unnecessary delay of Byron 1 operation, we will make the limited modifications required to conform to the NRC Staff position on this matter. In that regard, Attachment 3 to this letter delineates the modification control plan that will be implemented to assure the expeditious and satisfactory completion of the required work.

If there are any further questions on this matter, please direct them to my attention.

Yours truly,

L. O. DelGeorge

L. O. DelGeorge
Assistant Vice-President

Attachments

cc: J. Streeter - NRC RIII

ATTACHMENT 1

Concern C.7.d:

Review of Category I conduit supports typical support types and load tables Dwg. 6E-0-3393B - Support type CF and MCF (Floor to Ceiling) and type CC and CP maximum load tables. It appears that the KL/r for many of those shown exceeds 200 (Reference Calc. Book 19.1.3).

Response C.7.d:

The allowable load tables shown on Sargent & Lundy design drawing 6E-0-3393B, "Category I Conduit Supports - Typical Support and Load Tables," are designed based on AISC specifications as stated in FSAR Section 3.10.3.2.2 (p. 3.10-6) and not on any undocumented information contained in the Unistrut catalog. The slenderness ratio limitation of 200 does not pertain to the member types indicated as CC, CP, CF, and MCF since they are tension members, as demonstrated by the connection details provided on the design drawings.

AISC recommends a maximum slenderness ratio of 300 for tension members. According to the AISC commentary on Section 1.8, "The slenderness limitations recommended for tension members are not essential to the structural integrity of such members; they

Concern C.7.d: (con't).

merely afford a degree of stiffness such that undesirable lateral movement ('slapping' or vibration) will be avoided. These limitations are not mandatory." The attached sketch shows hanger H056 on drawing 6/20-E-3052 which is the cable tray hanger that was alleged to have a KL/r ratio exceeding allowable limits. The vertical member has a calculated KL/r value of 192. The internal diagonal has a calculated KL/r value of 208.

The design of compression members for all component supports for Byron, Unit 1 (i.e., conduit supports, instrument supports, pipe supports, cable tray supports and HVAC supports) meets the appropriate requirements of the AISC specification. Allowable axial compressive loads have been calculated in conformance with paragraphs 1.5.1.3.1 and 1.5.1.3.2 of the AISC specification. The maximum slenderness ratios meet the requirements of paragraph 1.8.4 of the AISC specification. In assigning the maximum permissible slenderness ratio for these compression members, a distinction has been made between "compression system" and "tension system" component supports. Compression system supports are those component supports which are either floor or wall mounted whose members have an axial compressive stress under gravity or sustained loads or members which brace or provide stability to these compression members under gravity or sustained loads. The slenderness ratio for all compression

Concern C.7.d: (con't).

members in "compression system" supports has been limited to 200. "Tension system" supports are those component supports which are hung from the ceiling whose members are either in axial tension or have no axial stress under gravity or sustained loads. The slenderness ratio for members in tension systems which are subject to compression only under seismic loads has been limited to 300. This compressive stress is short term (less than one second) and reversible due to the frequency and vibratory nature of the design basis seismic event.

A survey has been conducted to determine the actual in-place slenderness ratios for all members subject to compression loads in all component supports (approximately 50,000 supports) for Byron Unit 1. All compression members in both "compression system" and "tension system" conduit, instrument and pipe supports for Byron Unit 1 have slenderness ratios less than 200. Table 1, attached, lists those "tension system" HVAC hanger diagonal and vertical members with slenderness ratios greater than 200 which are subject to compression only under the seismic event. Table 2, attached, lists those "tension system" cable tray hanger diagonal and vertical members with slenderness ratios greater than 200 which are subject to compression only under the seismic event. The ratio of the actual axial compressive stress (fa) to the allowable axial compressive

Concern C.7.d: (con't).

stress (Fa) is also summarized for each member listed in Tables 1 and 2. It should also be noted that the total number of compression members in "tension system" HVAC or cable tray hangers with slenderness ratios between 200 and 300 is only approximately 0.4 percent of the total number of compression members in the total population of these hangers for Byron Unit 1.

The survey determined that two vertical HVAC hanger members in a "tension system" support had slenderness ratios exceeding 300. The ratio of the actual axial compression stress to the allowable axial compression stress is only .35 and is, therefore, not considered to be safety significant. These members will, however, be modified to reduce their slenderness ratios to below 200 since they exceeded our original acceptance criteria.

The use of an allowable slenderness ratio of 300 for members which are subject to compression only under the seismic event in "tension system" supports is justified in our opinion for the following reasons:

1. The actual compressive stress in these members is less than the allowable compressive stress calculated by AISC

Concern C.7.d: (con't).

equation 1.5-2.

2. These members do not have axial compressive stress under gravity or sustained loads. The compressive stress in these members is due solely to the short term seismic event unlike building columns. Also, gravity alone will insure these hanger members remain stable during a seismic event and are restored to their original position after a seismic event.

3. The ratio of the actual compressive stress (fa) to the allowable compressive stress (Fa) in these members is extremely low (approximately 0.1 - 0.2) for a majority of these members.

4. The HVAC and cable tray hangers for Byron Unit 1 have been designed individually, by conservatively ignoring the integrated system behavior of these hangers. Analytical studies have demonstrated that when all hangers on a given floor elevation are modelled as a unit, the seismic response is enhanced and the stresses in the hangers are significantly lower compared to those determined by an individual analysis.

Concern C.7.d: (con't).

5. The buckling capacity of compression members under dynamic loading is appreciably higher than under static loading.

6. Recent laboratory tests combined with the observed performance of tension type supports in actual earthquakes have demonstrated the inherent strength and ductility of this type of system.

7. Non-linear, finite element, time history analysis have been performed which demonstrate the ability of tension type hanger systems to withstand seismic events of 2 to 4 times the design basis earthquake.

The maximum slenderness ratio of 200 which is given in paragraph 1.8.4 of the AISC specification is intended for compression members in building structures, such as building columns. The suggested, nonmandatory AISC slenderness ratio limit for tension members is 300. The 200 limit for compression members is not based on any analytical consideration. As stated in Professor Bresler's textbook (ref. 1), this limit has been established on an arbitrary basis and is largely due to the consideration of effects of potential accidental loads or the effects of construction loads that are not included in the design. For example, horizontal bracing members may be used as a walkway

Concern C.7.d: (con't).

during construction or they may be used as support for temporary construction equipment, which may result in unexpected bending deformation of these axially loaded members. Therefore, if members subject to compression are free from such effects, and have been properly designed considering the effect of the actual slenderness ratio on stability which is the case of the Byron Unit 1 component supports, the members subject to compression will carry their design load without buckling. It should also be pointed out that several European steel building codes such as Germany and France and the Australian code permit maximum slenderness ratios up to 260 for compression members (reference 2).

The allowable axial compressive stress for members with slenderness ratios between 200 and 300 for Byron Unit 1 have been calculated in accordance with AISC equation 1.5-2 using the actual in-place Kl/r. As shown in the following Table A, the ratio of actual compressive stress to the allowable compressive stress is extremely low for most members with KL/r greater than 200.

Concern C.7.d: (con't).

TABLE A

SUMMARY OF MEMBERS WITH SLENDERNESS RATIOS EXCEEDING 200

	Average $\frac{fa}{Fa}$*	Total Number of Members
Cable Tray Vertical Hanger Members	0.12	18
Cable Tray Diagonal Members	0.20	9
HVAC Vertical Hanger Members	0.29	30
HVAC Diagonal Members	0.19	1

*Fa=1.6xAISC equation 1.5.2

It should be noted that the allowable compressive stress which has been conservatively calculated in accordance with AISC equation 1.5-2, applies to primary members. The AISC specification recognizes that these allowable stresses may be increased by using AISC equation 1.5-3 for bracing members and secondary members. The HVAC and cable tray diagonal members are secondary members per the definition of AISC. If this is taken into account, an additional 30% to 60% increase in the allowable compression stress may be permitted.

Concern C.7.d: (con't).

Slenderness ratio (stability) limits specified in building codes are intended for compression members subjected to sustained, constant-directional compressive loads to insure stability against static buckling. These allowable stresses are conservative when a member is loaded with a rapidly varying (transient) and constantly reversible vibratory loads induced by earthquake motion. Members subjected to vibratory type loads exhibit considerably higher dynamic stability limits primarily due to the transient nature of the loads. In such cases the relative rate of growth of the compressive force is sufficiently rapid that the elements of the compression member tending to buckle do not succeed in shifting in a direction normal to the axis of the member. For the earthquake type transient vibratory motions where a member is subjected to transient compression immediately followed by transient tension, the work done by the axial load does not continuously increase but is offset by opposing work done by the tensile load which restores equilibrium in the member tending to buckle. Thus, transient dynamic loads in excess of the static buckling load can be applied without buckling the member (reference 3-8).

The inherent strength of lightly braced cable tray raceway systems has been determined by recent tests (reference 9). These lightly braced systems have been used in earlier

Concern C.7.d: (con't).

generation nuclear plants. Based on over 2000 individual dynamic tests conducted, it was concluded that lightly braced raceway systems can be expected to survive severe earthquakes (up to a 0.75g SSE) with no loss of function in the circuits they support. The conclusion is significant because these systems were not specifically designed for these high SSE levels. It should be noted that the 0.75g test level is several times the 0.2g Byron SSE level.

The results of these extensive full scale testing programs and confirmatory data from plants actuall subjected to strong motion earthquakes up to 0.5g ground motion acceleration support the conclusion that even lightly braced or unbraced cable raceway support systems have a large inherent capacity to resist seismic motions. The Byron raceway system has been designed to perform significantly better under the postulated SSE event than those tested because the design used for Byron is substantially more conservative than the raceway system in the earlier generation plants, or those tested in references 9, 10, and 11 or those in non-nuclear power installations which have been subjected to large earthquakes.

In conclusion, it is our opinion that the design of all members subject to compression in all component supports for Byron Unit-

Concern C.7.d: (con't).

1 meets the requirements of the AISC specification and meets or exceeds all specified limits and quality requirements imposed by the U. S. Code of Federal Regulations, 10CFR Part 50, Appendix B. We believe we have satisfactorily demonstrated that the slenderness ratio limitation of 200 referenced in the AISC specification, which is not based on any analytical premise, does not pertain to members subject to transient compression loads in "tension systems". We will, however, modify all members identified in Tables 1 and 2 to reduce their slenderness ratio to less than 200 to satisfy the requirement imposed by the NRC.

LIST OF REFERENCES

Reference 1: B. Bresler, T. Y. Lin and J. B. Scalz. "Design of Steel Structures", 2nd edition, John Wiley & Sons, Inc., New York, p. 422.

Reference 2: L. S. Beedle, T. V. Galambos and Lamert Tall "Structural Steel Design" The Ronald Press Company, New York, p. 318 and 319.

Reference 3: "Structural Design of Tall Steel Buildings," Council on Tall Buildings & Urban Habitat, Monograph Vol. SB, Section 4.6 on stability under Dynamic and Repeated Load. American Society of Civil Engineers, 1979, p. 315-316.

Reference 4: "Stability of Elastic Systems", Volmer, A; Translated from the Russian Defense Supply Agency, November 15, 1965.

Reference 5: "Dynamic Stability of Structures", Proceedings of an International Conference held at Northwestern University, Evanston, Illinois, October 18-20, 1965; Edited by George Hermann, Pergamon Press Ltd, 1967.

Concern C.7.d: (con't).

Reference 6: Housner, G. W., "Dynamic Behavior of Supercritically Loaded Struts", Journal of the Engineering Mechanics Division, ASCE, EM5, October 1962, pp. 41-65.

Reference 7: Ready, J.M., "Dynamic Buckling of Pinned Columns", David W. Taylor, Naval Ship R&D Center, Bethesda, Md.

Reference 8: Davidson, J. F., "Buckling of Struts under Dynamic Loading", Journal of the Mechanics and Physics of Solids, Vol. 2, pp. 54-66, 1963.

Reference 9: Test Report, Release 4 (Final) Cable Tray and Conduit Raceway Seismic Test Program, prepared for and in collaboration with Bechtel Power Corporation by ANCO Engineers, Inc., California, December 1978.

Reference 10: Shaking-Table Testing for Seismic Evaluation of Electrical Raceway System, prepared for SEP Owners Group by URS/John A. Blume & Associates, April 1983.

Reference 11: Analytical Techniques, Models and Seismic Evaluation of Electrical Raceway Systems, prepared for the SEP Owners Group by URS/John A. Blume & Associates, August 1983.

C.7.d (Continued)

Hanger No.: H056
Drawing No: 6/20-E-1-3052
Building: Auxiliary

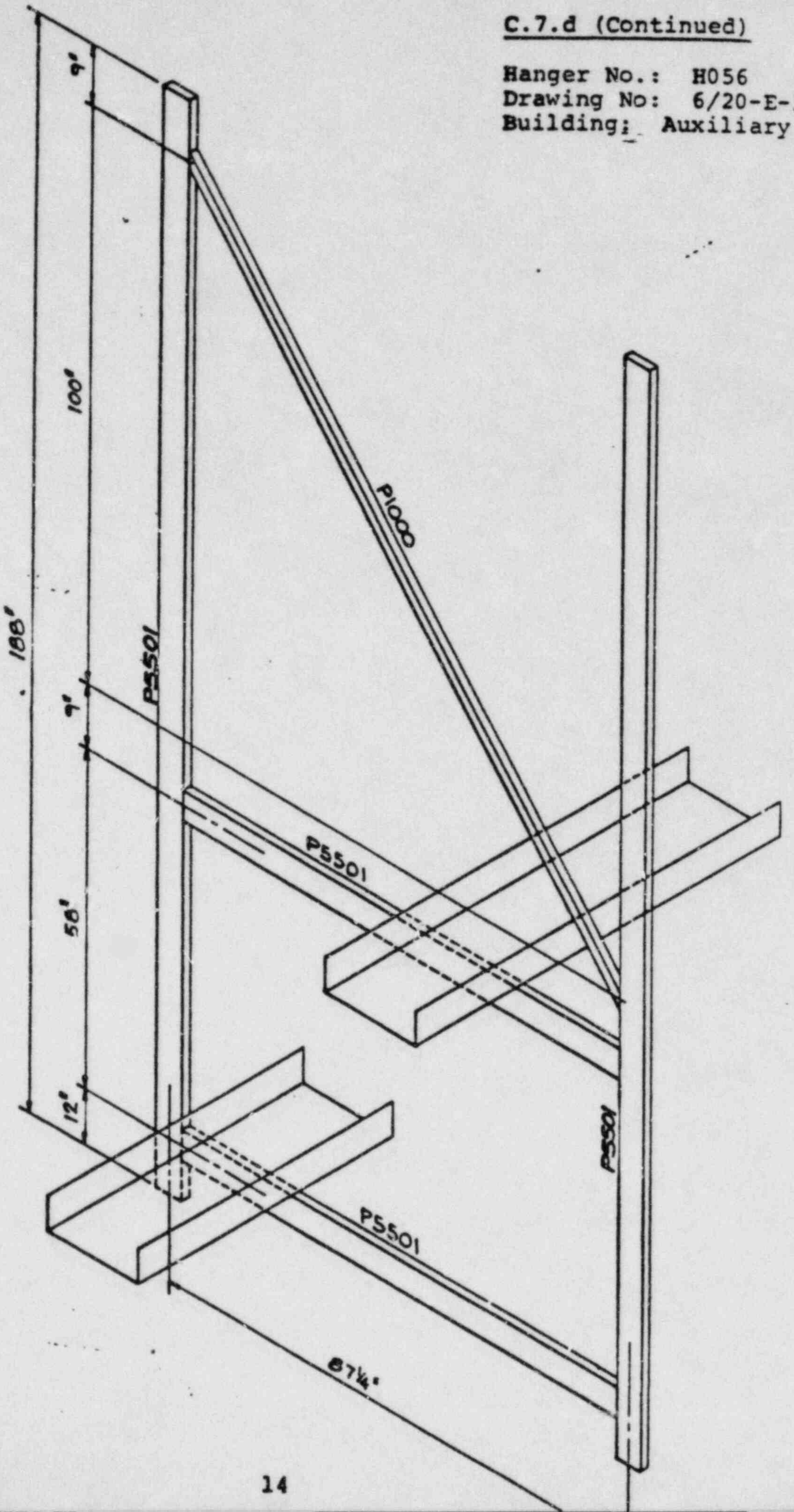

TABLE 1
BYRON - UNIT 1
HVAC MEMBER-SLENDERNESS RATIO SURVEY
TENSION SYSTEM (CEILING MOUNTED)

Serial Number	Floor Elev.	Drawing Number M-	Hanger Number	Member Type 1	2	3	4	$\frac{Kl}{r}$	f_a (ksi)	F_a (ksi)	$\frac{f_a}{Fa}$
A1	364-0	1311-5	S-322				X	237	1.33	4.27	0.31
A2							X	237	1.33	4.27	0.31
A3	401-0	1313-3	S-1210				X	212	1.12	5.33	0.21
A4							X	212	1.12	5.33	0.21
A5	401-0	1313-3	S-1211				X	219	0.20	4.97	0.04
A6							X	219	0.20	4.97	0.04
A7	401-0	1313-5	S-1104				X	285	0.47	2.96	0.16
A8							X	285	0.47	2.96	0.16
A9	401-0	1313-5	S-1108				X	219	1.75	4.98	0.35
A10							X	219	1.75	4.98	0.35
A11	401-0	1313-5	S-1110				X	245	0.29	3.98	0.07
A12							X	245	0.29	3.98	0.07
A13	463-5	1326-4	S-2214				X	485	0.36	1.02	0.35
A14							X	485	0.36	1.02	0.35

NOTE: Fa is based on 1.6 x AISC equation 1.5-2
All of these hangers are located in the Auxiliary Building.

Concern C.7.d: (con't).

Serial Number	Floor Elev.	Drawing Number M-	Hanger Number	Member Type 1	2	3	4	Kl/r	f_a (ksi)	F_a (ksi)	f_a/F_a
A15	463-5	1326-4	S-2233				X	289	1.10	2.89	0.38
A16							X	289	1.10	2.89	0.38
A17	463-5	1326-4	S-2237				X	258	3.00	3.58	0.84
A18							X	258	3.00	3.58	0.84
A19	346-0	1310-6	S-218				X	202	0.07	5.86	0.01
A20							X	202	0.07	5.86	0.01
A21	383/373	1312-2	S-607				X	259	1.22	3.57	0.34
A22							X	259	1.22	3.57	0.34
A23	383/373	1312-7	S-791				X	209	2.33	5.47	0.43
A24							X	209	2.33	5.47	0.43
A25	451-0	1323-10	S-3899				X	222	1.48	4.83	0.31
A26							X	222	1.48	4.83	0.31
A27	451-0	1323-10	S-3901				X	206	2.19	5.64	0.39
A28							X	206	2.19	5.64	0.39
A29	373/383	1312-10	S-545		X			210	0.41	2.20	0.19
A30	364	1311-5	S-323				X	267	0.78	3.35	0.23
A31							X	267	0.78	3.35	0.23

NOTE: Fa is based on 1.6 x AISC equation 1.5-2
All of these hangers are located in the Auxiliary Building.

TABLE 2
BYRON - UNIT 1
CABLE TRAY MEMBER
SLENDERNESS RATIO SURVEY
TENSION SYSTEM (CEILING-MOUNTED)

Serial Number	Floor Elev.	Drawing Number E-	Hanger Number	Member Type 1	2	3	4	$\frac{Kl}{r}$	f_a (ksi)	F_a (ksi)	$\frac{f_a}{F_a}$
A1	401-0	0-3033	4H3			X		244	0.21	4.01	0.05
A2	401-0	0-3033	4H3			X		243	0.21	4.06	0.05
A3	426-0	1-3052	H069			X		215	0.70	5.16	0.14
A4	426-0	1-3052	H069			X		215	0.59	5.16	0.11
A5	426-0	1-3052	H103	X				209	2.08	5.47	0.38
A6	426-0	1-3052	H063	X				222	2.22	4.85	0.46
A7	426-0	1-3052	H056	X				208	2.20	5.52	0.40
A8	426-0	1-3052	H090				X	238	0.52	4.23	0.12
A9	426-0	1-3052	H090				X	243	0.47	4.04	0.12
A10	426-0	1-3052	H118				X	207	0.76	5.60	0.14
A11	426-0	1-3052	H118				X	217	0.83	5.09	0.16
A12	401-0	0-3031	70H1				X	204	0.74	5.72	0.13
A13	401-0	0-3031	70H1				X	204	0.74	5.72	0.13

NOTE: F_a is based on 1.6 x AISC equation 1.5-2

A series Serial Numbers are in Auxiliary Building
C series Serial Numbers are in the Containment.

NOTE: F_a is based on 1.6 x AISC equation 1.5-2

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Serial Number	Floor Elev.	Drawing Number E-	Hanger Number	Member Type 1	2	3	4	$\frac{Kl}{r}$	f_a (ksi)	F_a (ksi)	$\frac{f_a}{F_a}$
A14	426-0	1-3053	H004			X		282	0.26	3.00	0.09
A15	426-0	1-3053	H004			X		282	0.26	3.00	0.09
C1	426-0	1-3251	H8				X	213	0.87	5.24	0.17
C2							X	213	0.87	5.24	0.17
[illegible]	426-0	1-3254	H9				X	222	0.80	4.84	0.17
C4							X	222	0.80	4.84	0.17
[illegible]	426-0	1-3251	H9				X	217	0.43	5.06	0.09
C6							X	206	0.42	5.64	0.08
[illegible]	426-0	1-3251	H10				X	222	0.45	4.84	0.09
[illegible]							X	206	0.43	5.64	0.08
[illegible]	426-0	1-3251	H5				X	214	0.63	5.22	0.12
[illegible]							X	214	0.63	5.22	0.12
[illegible]		[illegible]	H6				[illegible]	[illegible]			[illegible]

Concern C.7.d: (con't).

NOTE: F_a is based on 1.6 x AISC equation 1.5-2

A series Serial Numbers are in Auxiliary Building
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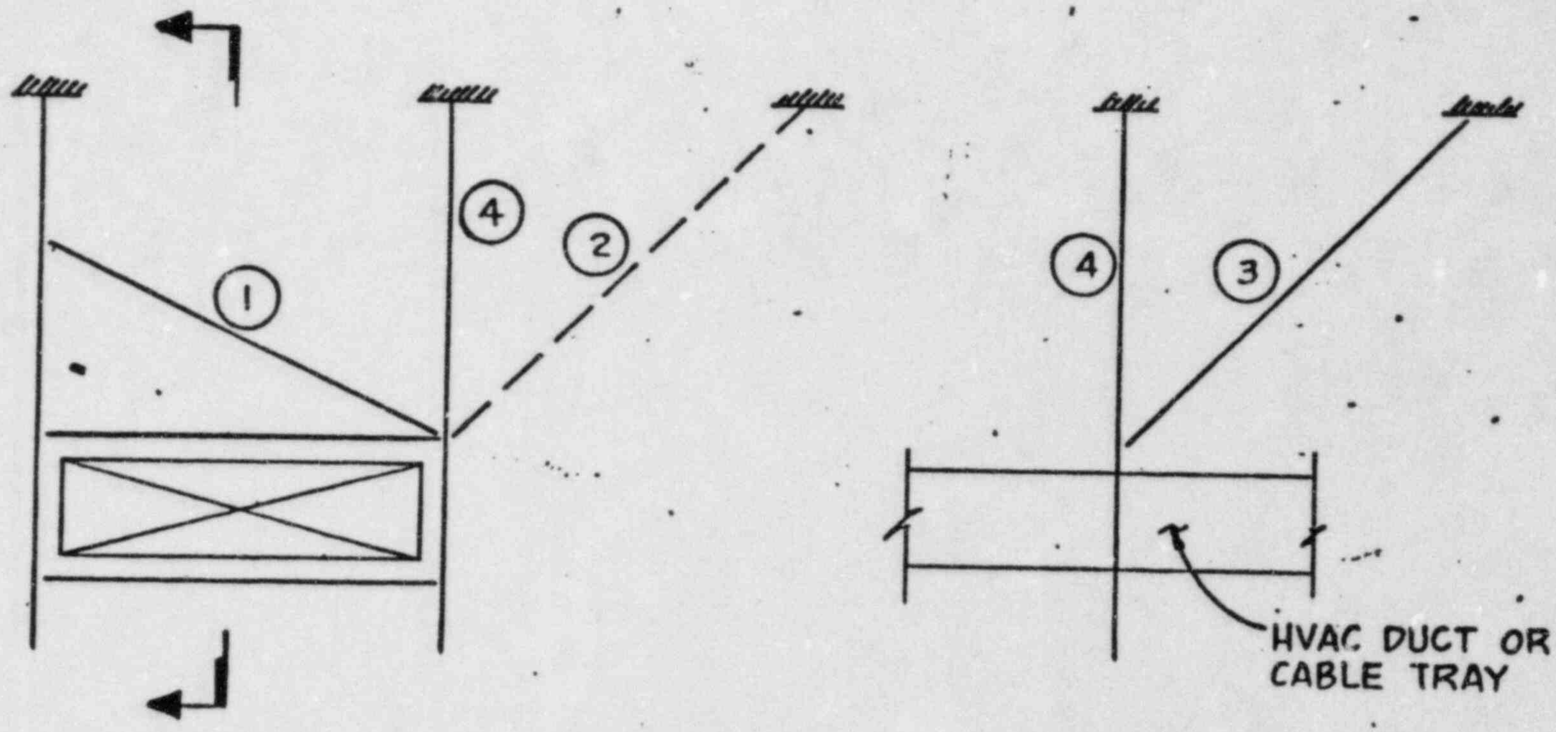

ELEVATION

(1) INPLANE DIAGONAL

(2) INPLANE BRACE

SECTION

(3) LONGITUDINAL BRACE

(4) VERTICAL MEMBER

TYPES OF MEMBERS
NOMENCLATURE FOR TABLES 1 AND 2

ATTACHMENT 2

Concern D.2

Review of PIPSYS Program Documentation

From notes - on page 14.4 there were penciled in changes to documentation + changed to - kl/r was changed to $(Kl/r)^2$. No apparent check of maximum unbraced length (AISC 1.5.1.6b) or (UBC Sec. 2702.(b)4.(v)).

Response

The PIPSYS Manual reviewed by the Intervenor belonged to the program author. The penciled in changes indicated corrections to typographical errors in the manual. The program itself is correct and was not affected by the typographical errors in the User's Manual.

The PIPSYS Program was developed in 1974 and was used for the design of the cable tray and HVAC hangers for Byron-Unit 1. The PIPSYS Program is based upon the design provisions of the 7th edition of the AISC specification. Angle sections have not been used in the design of the cable tray hanger members. Angle sections were used as diagonal bracing members, however, in certain situations. These diagonal bracing members are not subjected to flexural loads. The design of HVAC hangers for Byron-Unit 1 primarily utilizes angle sections for both the hanger members and the in-plane and out-of-plane diagonal bracing members.

The design of the angle sections for the HVAC hangers subjected to flexural loads was performed in accordance with the 7th edition of the AISC specification. AISC states (page 2-22) that the allowable flexural stress for angle sections may be taken as 0.6 Fy provided adequate lateral support is present for the compression leg. This allowable stress is applicable for all angle sections which meet the width to thickness requirement (b/t) as defined in Section 1.9 of this specification ($76/\sqrt{Fy}$). All angle sections provided for the Byron-Unit 1 HVAC supports meet the requirements of Section 1.9 of the AISC specification. The AISC code did not give guidance concerning requirements for lateral support for angles subjected to flexure. Section 1.5.1.4.6b of the AISC specification concerning unbraced lengths does not pertain to angle sections. We have received verbal confirmation from Mr. Robert Gavin and Mr. John Edinger, former Regional Engineer and Assistant Director of AISC respectively, confirming this position. The non-applicability of Section 1.5.1.4.6b for angle sections has also been stated in the First Quarter 1984 <u>AISC Engineering Journal</u> (Reference 1).

It was recognized that AISC did not provide guidance concerning lateral support requirements for angles subjected to bending during the development of the PIPSYS Program in 1974. Two Australian papers published in 1969 and 1973 were reviewed concerning the design of laterally unsupported angles (References 2 and 3). These papers indicated that an allowable flexural stress of 0.66Fy may be used when the unsupported length to thickness ratio (L/t) is as large as 690 for angles with width to thickness (B/t) ratios equal to 16. These papers also demonstrated that for width to thickness ratios less than 16 larger unsupported length to thickness ratios are also permitted.

Table 1, attached, lists the allowable L/t ratios for all angle sizes used in the Byron-Unit 1 HVAC hanger members for a permissible allowable bending stress of 0.66Fy determined per the requirements of References 1 thru 3. All HVAC hanger angle members for Byron-Unit 1 meet these requirements. (The maximum L/t for Byron-Unit 1 equals 402).

The Australian research, in combination with the following properties and behavior of the HVAC supports designed for Byron-Unit 1, justifies the use of an allowable stress of 0.6 Fy for angles for an unsupported length to thickness ratio equal to 700 or more:

1. The maximum moment in the hanger members in the HVAC supports always occurs at a point of lateral support, such as, at the intersection of the horizontal to vertical members and at the support point for the vertical members.

Concern D.2 (con't.)

2. The HVAC ducts themselves are integrally welded to the horizontal and vertical hanger members. This attachment provides full lateral support and prevents flexural buckling of the angles.

3. The restraint afforded at the intersection of the horizontal and vertical members and the contribution of the duct stiffness prevents the angle sections from rotating about their principal axes. This restraint insures that the angles will bend about their geometric axes. Research has indicated that when lateral support is provided at the location of the applied load, a beam of any shape may be designed on the basis of simple bending theory (Reference 4). Lateral torsional buckling about the major principal axis will not occur.

The AISC during the past several years has endorsed the Australian research as the appropriate basis for the design of angles subjected to flexure (References 2 and 3). The use of the 0.6 Fy allowable flexural stress has been recommended by AISC in Reference 1. Specifically, it states "....based on Australian research an allowable bending stress of 0.6 Fy can conveniently be used as a rule of thumb for the design of angle members in flexure ...." The AISC has also endorsed the results of the Australian research in their lecture series "Steel Design Current Practice" which was offered to the structural engineering profession throughout the United States in 1983.

During recent discussions with the NRC concerning the design of angles subject to flexure, the NRC has, in our opinion, arbitrarily imposed a maximum unsupported length criteria of L/t less than 270. A survey of the unsupported lengths of all HVAC hanger angle members for Byron Unit-1 has been conducted.

Table 2, attached, lists all members (12 total) whose unsupported lengths an L/t ratio of 270. It is our opinion that the current design of all angle sections meets all AISC criteria as confirmed by AISC. The AISC endorsed design criteria permits unsupported lengths equal to L/t ratios of 700 or greater. The largest L/t for Byron Unit-1 is 402. We will, however, modify all angles identified in Table 2 to reduce the unsupported lengths to L/t ratios less than 270 to comply with the NRC imposed criteria.

Concern D.2 (con't.)

References:

1. J. M. Leigh, B. F. Thomas, and M. G. Lay, "Safe Load for Laterally Unsupported Angles," AISC ENGINEERING JOURNAL, First Quarter, 1984.

2. J. M. Leigh and M. G. Lay, "The Design of Laterally Unsupported Angles," BHP Technical Bulletin 13(3), November 1969, pp. 24-29.

3. B. F. Thomas, J. M. Leigh and M. G. Lay, "The Behavior of Laterally Unsupported Angles," Civil Engineering Transctions, The Institute of Engineers, Australia 1973.

4. "Basic Steel Design" by Bruce G. Johnston, Fun-Jen Lin and T. F. Galambos, 2nd edition 1980.

TABLE I

Table of allowable L/t ratios
for angle sizes used in HVAC
hanger design (F_y = 36 ksi)
Allowable bending stress (F_b) = 0.66 F_y

Angle Sizes	B/t Ratio	L/t Ratio
2-1/2 x 2-1/2 x 1/2	5	990
4 x 4 x 3/4, 1 x 1 x 3/16	5.33	990
3 x 3 x 1/2, 1-1/2 x 1-1/2 x 1/4	6	990
4 x 4 x 1/2, 2 x 2 x 1/4, 1-1/2 x 1-1/2 x 3/16	8	927
3 x 3 x 1/4	12	823
3-1/2 x 3-1/2 x 1/4	14	748
4 x 4 x 1/4	16	690

TABLE - 2
BYRON -- UNIT 1
HVAC VERTICAL MEMBER L/t SURVEY

Serial Number	Floor Elev.	Drawing Number M-	Hanger Number	L/T > 270	Remarks
A1	401-0	1313-3	S-1210	379	
A2				393	
A3	451-0	1293-1	S-1823	338	
A4				334	
A5	451-0	1293-1	S-1826	328	Leg-1
A6	451-0	1293-2	S-1838	402	Leg-1
A7	401-0	1313-2	S-1215	304	Leg-1
A8	463-5	1326-4	S-2230	301	Leg-1
A9	451-0	1323-9	S-1897	328	
A10				308	
A11	401-0	1313-5	S-1104	317	
A12				317	

NOTE: All of these hangers are located in the Auxiliary Building.

ATTACHMENT 3

Modification Control Plan for

Component Support Framing

As a result of concerns raised by members of the NRC Staff on the application of certain structural design codes, we have agreed to initiate a program of design review and field modification of certain of the subject items. The following outlines our intent relative to control of the performance of this work.

For those support members which are located in the Unit 1 containment building, we will complete the design review and implementation of any design modifications required as a result of this review prior to transfer and loading of fuel elements into the Unit 1 reactor. At present, it appears that the work scope of this activity is limited to the modification of 12 cable pan vertical members encompassing 6 separate hangers. The physical modifications required are such that they are identical to or similar to other construction activities, and will not require development of new or revised implementation procedures for performance of the work and associated inspections. We anticipate this work should be completed by end of day, October 22, 1984.

The remaining population of the subject items which may require modification are located in the auxiliary building. Again, we believe the modifications are such that the work will not require development of new or revised implementation procedures and requisite inspection procedures. With regard to performing this work activity during and after fuel loading operations, the work will be performed under the control of existing administrative programs which provide the appropriate plant operating personnel with notification of work activities. These include, but are not limited to, Nuclear Work Requests, Construction Work Records, and Pre-Operational Test Deficiencies. The administrative control system to be employed is dependent upon the state of Release to Operations of the specific system. For those systems which by the licensed Technical Specifications, as amended, are required to be OPERABLE, the Nuclear Work Request system is the method which will be employed. This system provides the highest level of review and scrutiny in the hierarchy of the three systems. Each Nuclear Work Request is reviewed by an Operating Engineer and includes, but is not limited to, a review for Technical Specification requirements. In addition, the review of these specific Nuclear Work Requests will give consideration to the effect of the subject work, as it relates to system operability, on any redundant trains of the safety-related systems affected.

For those systems which are not required to be OPERABLE by the Technical Specifications, as amended, either Nuclear Work Requests or Construction Work Records will be the method employed to provide administrative control. The Construction Work Record is employed on those systems which have acceptably completed Pre-Operational Testing. This control system requires review of the work activitiy by the Pre-Operational Testing Coordinator and additionally, requires shift operating authorization in order to commence work and requires subsequent notification of job completion. For work on those system which have yet to complete their Pre-Operational Testing, the work will be performed under the administrative control of the Pre-Operational Test Deficiency system. This system requires notification of the Pre-Operational Test Coordinator/Engineer.

Inherent in all three systems is the requirement that establishment, where needed, of equipment out-of-service is through the plant equipment out-of-service control system. Likewise, upon receipt of the operating license, performance of the work will be conducted under the additional fire protection criteria outlined in our June 14, 1984 letter from D. L. Farrar to H. R. Denton.

The control systems identified above have been employed over the entire period of time associated with the Pre-Operational Testing activities associated with Byron Unit 1 and have been successful in providing responsible plant operating and testing personnel notification of ongoing construction work activities. Additionally, we have completed two hot operational activities concurrent with performance of work identical to the work associated with the subject modifications. We, therefore, have demonstrated by experience that work activities of this nature can be performed and controlled by cognizant plant operations personnel. The subject work will be completed prior to Byron Unit 1 initial criticality.

Commonwealth Edison
One First National Plaza, Chicago, Illinois
Address Reply to: Post Office Box 767
Chicago, Illinois 60690

October 12, 1984

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Byron Generating Station Units 1 and 2
Braidwood Generating Station Units 1 and 2
Design Concerns
NRC Docket Nos. 50-454/455 and 50-456/457

Reference (a): October 4, 1984, letter from J. F. Streeter to Cordell Reed.

Dear Mr. Denton:

This letter provides responses to the concerns regarding Byron and Braidwood stations which were provided to Commonwealth Edison in reference (a). Our responses address the concerns as clarified in our discussion with the NRC Staff on October 8, 1984. Six copies of the responses are enclosed.

Please address further questions regarding this matter to this office.

Very truly yours,

T. R. Tramm

T. R. Tramm
Nuclear Licensing Administrator

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Concern C.7.d:

Review of Category I conduit supports typical supports types and load tables Dwg. 6E-0-3393B - Support type CF and MCF (Floor to Ceiling) and type CC and CP maximum load tables. It appears that the KL/r for many of those shown exceeds 200. (Reference Calc. Book 19.1.3)

Response C.7.d:

The allowable load tables shown on Sargent & Lundy design drawing 6E-0-3393B, "Category I Conduit Supports - Typical Support and Load Tables," are designed based on AISC Specifications as stated in FSAR section 3.10.3.2.2 (p. 3.10-6) and not on any undocumented information contained in the Unistrut catalog. There is no effective length factor "K" to consider since the member types indicated CC, CP, CF, and MCF are tension members, as demonstrated by the connection details provided on the design drawings.

According to AISC Commentary Section 1.8, the last paragraph, "The slenderness limitations recommended for tension members are not essential to the structural integrity of such members; they merely afford a degree of stiffness such that undesirable lateral movement ('slapping' or vibration) will be avoided. These limitations are not mandatory."

C.7.d (Continued)

The attached sketch shows hanger E056 on drawing 6/20-E-1-3052 which is the cable tray hanger that was alleged to have a KL/r ratio exceeding allowable limits.

The vertical member has a calculated KL/r value of 192. The internal diagonal has a calculated KL/r value of 208.

Although the internal diagonal has a KL/r value slightly higher than 200, it is a secondary member in the sense that it does not carry gravity loads (i.e., cable or tray weight) and is not required for stability of the hanger. This diagonal only resists lateral loads due to a seismic event. The loads are of short duration and are reversible. Therefore, the local buckling due to this short term transient will not effect the overall behavior or structural integrity of the support.

The allowable axial stresses for this hanger were calculated using Equation 1.5-2 from the AISC Specifications, which states:

$$F_a = \frac{12\pi^2 E}{23(KL/r)^2}$$

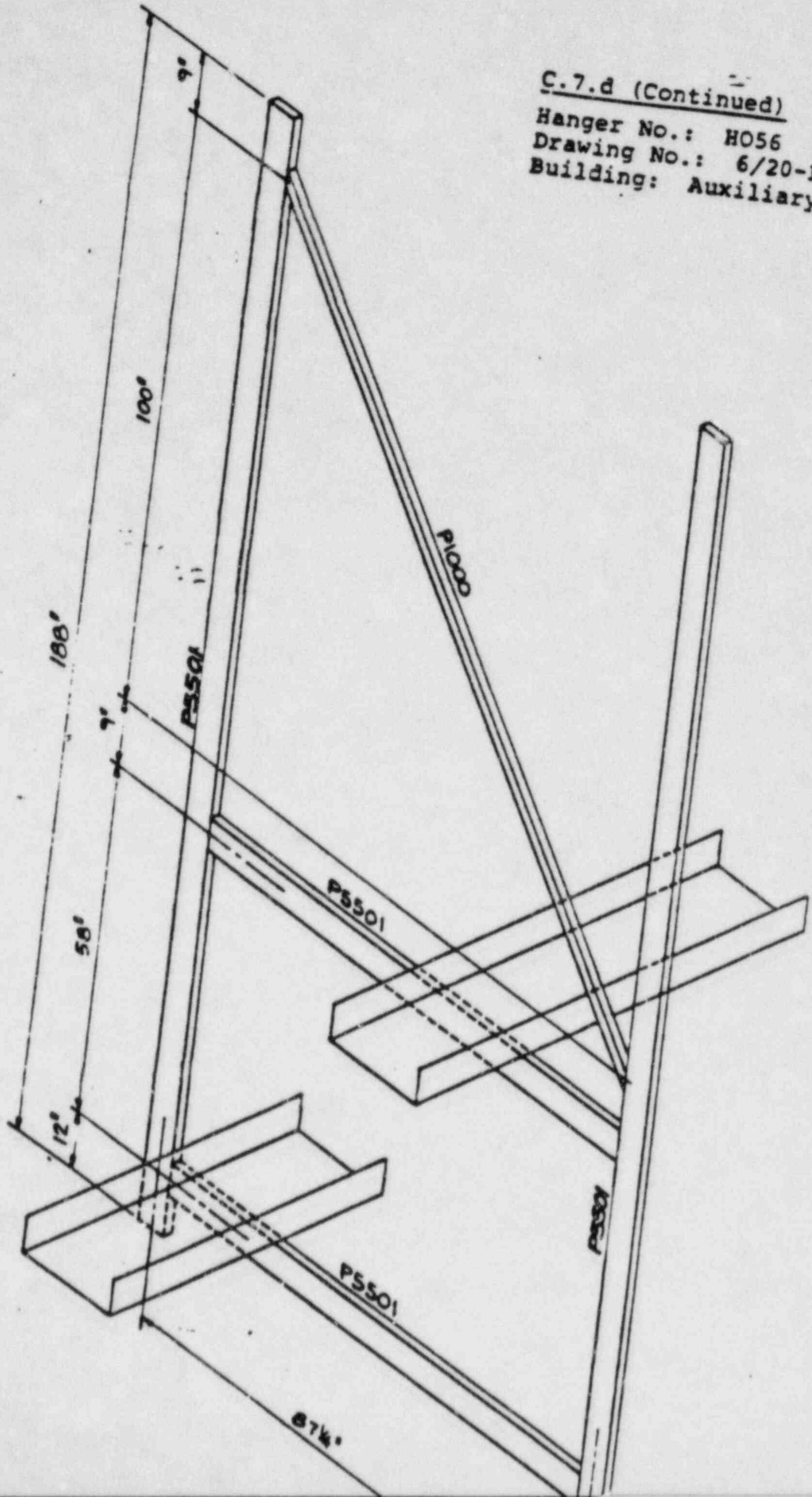
The actual KL/r ratios for the hanger were used in this equation, and the allowable stresses were reduced accordingly.

C.7.d (Continued)

In addition, this hanger is top supported and is a tension type system. Therefore, this hanger will not locally buckle. However, if local buckling should occur in this type of system, the diagonal would be restored to its original configuration due to the vertical gravity load and the reversible longitudinal loads.

C.7.d (Continued)

Hanger No.: H056
Drawing No.: 6/20-E-1-3052
Building: Auxiliary



Concern D.2:

Review of PIPSYS Program Documentation

From notes - On page 14.4 there were penciled in changes to documentation + changed to - and kl/2 was changed to $(kl/2)^2$. No apparent check of maximum unbraced length (AISC 1.5.1.4.6b) or (UBC Sec. 2702.(b)4.(v))

Response D.2:

The PIPSYS Manual shown to Intervenors belonged to one of the program authors. The penciled in changes show corrections to typographical errors in the manual. The program itself correctly calculates these values.

The version of PIPSYS Program referenced here is used for design and analysis of HVAC and cable tray hangers. The design of hangers using angle sections is governed by AISC Specification. Angle sections are not used for cable tray supports. They are used for HVAC hangers.

In the design of angle members, the actual unbraced length has been used to calculate allowable axial loads and to calculate moment amplification factors when the member is subjected to combined axial and flexural loading. (Equation 1.6-1a AISC).

D.2 (Continued)

The allowable bending stress for angle members is taken as 1.6 times 0.6 Fy in PIPSYS. The AISC specification does not have a specific provision for determining allowable bending stress for angle members at the present time. AISC 1.5.1.6b as referred is not intended for angle members. We have discussed this item with AISC officer Mr. Robert Gavin, and this is also confirmed by AISC in their Engineering Journal, First Quarter 1984 (Ref. 1). In addition AISC stated that Fb=0.6Fy may be used as a convenient rule of thumb based on the Australian research (Ref. 2). Unbraced lengths were not limited to 76 $b_f/\sqrt{Fy}$ based on the following considerations:

1. The maximum moment in the hanger always occurs at the point of lateral support. This reduces the potential for member flexural buckling.

2. Governing design load is a seismic loading which is of short duration and reversible loading. Thus momentary local buckling, should it occur, does not impair the load carrying capacity of the hanger.

3. Based on Australian research on the behavior of laterally unsupported angles under flexural loads (Ref. 2 and 3), it can be found that the allowable bending stress for OBE load of 0.66 Fy is applicable for unbraced support lengths up to 14'-6" when a moment is applied about an axis parallel to either leg. For angles thicker than 1/4", larger unbraced lengths can be used.

D.2 (Continued)

Similarly, an allowable bending stress of 0.6Fy is acceptable for unbraced lengths up to 10'-6" when a moment is applied about the major principal axis. For minor principal axis bending, the allowable bending stress can always be taken as 0.6 Fy. For Byron and Braidwood, the maximum unbraced length for hangers is 15 feet, and in many cases, much shorter members are used. The use of 0.6 Fy as the allowable bending stress is justified.

References:

1. J. M. Leigh, B. F. Thomas and M. G. Lay, "Safe Load for Laterally Unsupported Angles," AISC Engineering Journal, First quarter, 1984.

2. J. M. Leigh and M. G. Lay, "The Design of Laterally Unsupported Angles," BHP Technical Bulletin 13(3), Nov. 1969, pp. 24-29.

3. B. F. Thomas, J. M. Leigh and M. G. Lay, "The Behavior of Laterally Unsupported Angles," Civil Engineering Transactions, The Institute of Engineers, Australia, 1973.