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CYGNA
ENERGY SERVICES

2121 N. California Blvd., Suite 390, Walnut Creek, CA 94596 415/934-5733

March 3, 1988
84056.138

Mrs. Juanita Ellis
President, CASE
1426 S. Polk
Dallas, TX 75224

Subject: Communications Report Transmittal No. 42
Independent Assessment Program - All Phases
Comanche Peak Steam Electric Station
TU Electric
Job No. 84056

Dear Mrs. Ellis:

Enclosed please find communications reports associated with the cable tray audits. A list of the enclosed communications reports appears in Attachment 1.

If you have any questions or desire to discuss any of these documents, please do not hesitate to call.

Very truly yours,

J.R. [signature] for

N. H. Williams
Project Manager

NHW/amh
Attachments

cc: Mr. J. Redding (TU Electric)
Mr. W. Counsil (TU Electric)
Mr. J. Muffett (TU Electric)
Mr. L. Nace (TU Electric)
Mr. G. Ashley (Impell)
Mr. D. Pigott (Orrick, Herrington & Sutcliffe)
Mr. C. Grimes (USNRC)
Ms. A. Vietti-Cook (USNRC)
Mr. R. Alexandru (Ebasco)

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ATTACHMENT 1

List of Enclosed Communications Reports

DATE	TIME
04/27/87	11:15 a.m.
05/15/87	11:00 a.m.
06/22/87	2:00 p.m.
06/23/87	10:00 a.m.
06/23/87	2:15 p.m.
06/24/87	11:00 a.m.
06/25/87	11:40 a.m.
06/26/87	10:30 a.m.
06/26/87	1:00 p.m.
07/09/87	5:00 p.m.
07/10/87	10:00 a.m.
07/17/87	2:45 p.m.
07/23/87	10:45 a.m.
08/04/87	9:00 a.m.
09/03/87	10:00 a.m.
09/14/87	8:30 a.m.
09/15/87	2:15 p.m.
09/21/87	2:00 p.m.
09/30/87	11:45 a.m.
10/02/87	7:30 a.m.
10/06/87	12:40 p.m.
10/16/87	1:55 p.m.
11/03/87	9:15 a.m.
11/03/87	2:20 p.m.
11/04/87	9:50 a.m.
11/06/87	10:00 a.m.
11/19/87	3:00 p.m.
11/23/87	11:20 a.m.
12/08/87	11:30 a.m.
12/18/87	12:30 p.m.

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Communications Report

Company:	CES	☐ Telecon	☒ Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	04/27/87
Subject:	Ebasco Cable Tray Audit	Time:	11:15
		Place:	Ebasco, N.Y.
Participants:	Pat Harrison	of	Ebasco
	John Russ		Cygna

Item	Comments	Required Action By
	Cygna requested a copy of the AISC detailing manual for use during the audit. Ebasco provided the following: 1. AISC "Structural Steel Detailing", 2nd Edition. 2. AISC "Detailing for Steel Construction". TUE\042787-F.CON	

Signed: J. P. Russ for N. H. Williams

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Mr. K. Parikh
Ms. D. Leong
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Communications Report

Company: CES	☐ Telecon	☒ Conference Report	
Project: TU Electric CPSES IAP Phase 4		Job No.	84056
		Date:	05/15/87
Subject: Cable Tray Support Design Review Impell Audit		Time:	11:00 a.m.
		Place:	Lincolnshire, IL
Participants: G. Ashley, C. Aboujaoude		of	Impell
B. Shakibnia, D. Leong, W. Horstman			Cygna

Item	Comments	Required Action By

Impell provided responses to several of the concerns raised by Cygna on May 14, 1987:

A. Seismic Load Combination Study (Impell Calculation M-49)

1. The response spectrum used in the comparison was generated from the synthetic time history used for the time history analysis. There was no added conservatism associated with the curve fit.

2. The supports chosen for comparison were those showing high member interaction ratios and large dead loads.

3. Based on a review of the output, critical items were chosen for tabulation in the calculations. Reactions were not deemed critical, and, therefore, were not tabulated.

B. Load Combinations for Base Angles/Plates

The loads from each load combination are treated as a set. Enveloping of forces/moments is not performed.

Cygna noted that this practice was not consistent with the approach used by Ebasco.

Signed: J. P. Rue for N. H. Williams

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C. Use of Time History Analysis

Impell reviewed the Standard Review Plan for the requirements for time history analysis used in the qualifications of systems. They were unable to locate the requirement for more than one time history for linear systems. Seven time histories are required for non-linear systems.

Impell feels that the use of single analysis is adequate if three uncorrelated time histories are used for the three spatial directions.

Cygna stated that they would verify the requirements for linear time history analyses.

D. Out-of-Plane Loading on Tiers (Calculation M-57)

Impell stated that the selection of tier lengths, tray widths and tray locations used in the calculation was based on configurations typically requiring the application of minor axis moment reduction. Due to the low torsional stiffness of the posts, the tier behavior most closely resembles a simply supported member in the weak axis direction. Impell performed a test case analysis using the torsional stiffness of a 16 inch long C6 x 8.2 tier. The introduction to Impell Calculation M-57 states that the posts are soft in torsion. The fixed end cases were only included as a validation that the end moments were not significantly reduced by dividing the load between two points.

E. Overlap Criteria Development (Impell Calculation M-13)

1. Impell indicated that the overlap factor of 1.10 was not based on the results of Calculation M-13, but was based solely on the Brookhaven recommendations. Impell stated that the results of the calculation show that an increase factor is not necessary. Given the histogram of the results presented, Impell concluded that there is a high confidence that underprediction of support loads using the overlap process will not occur.

   Cygna noted that these calculations were not a true statistical sample, and that such conclusions may not be justified.

Item	Comments	Required Action By

2. The reactions and tray loads on supports were chosen by Impell for comparison as they are representative of the trends exhibited by all components.

3. Impell reviewed the discrepancies noted by Cygna in the forces and reactions for portions of the model distant from the overlap region. They feel that the number of occurrences of these discrepancies is not significant to the overall results. They realize that the overlap procedure is an approximation and do not expect 100% correlation.

4. Impell feels that it is sufficient to evaluate any support common to two partial models for the loads from each model independently and that there is no need to envelop the results from each model.

5. For ganged supports, the lumped mass used to represent the non-modelled tray is attached to the support via a spring. The spring rate is selected to give a frequency corresponding to flexure of the tray being represented. This will account for the dynamic response of the cable tray.

6. Impell has not reviewed the cited example of a system with multiple ganged supports and will respond to Cygna's concerns at a later time. Based on the tray flexibility, they feel that there will not be a significant effect on the supports due to the coupling provided by the cable tray. Their results indicate that the response of the cable tray systems is dominated by the support flexibility.

   For the longitudinal direction, a fictitious longitudinal spring is attached to the ganged supports, and the total tributary longitudinal mass is included. This should be very conservative. (See Impell Project Instruction PI-02, sheet 30.)

7. Longitudinal loading in partial models should be adequately captured. The study included one test case having a longitudinal span of 50 feet.

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Communications Report

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Company:	CES	☐ Telecon	☒ Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	6/22/87
Subject:	Cable Tray Support Design Review Ebasco Audit	Time:	2:00 p.m.
		Place:	New York, NY
Participants:	P. Harrison, Bob Keilbach	of	EBASCO
	W.R. Horstman, B. Shakibnia		Cygna

Item	Comments	Required Action By
	<u>Partial Penetration Welds on Skewed Gusset Plates Used on Longitudinal Supports</u> Cygna requested further information on the qualification of partial penetration welds on skewed gusset plates. Ebasco stated that the welds are checked for completeness, and, if incomplete, are to be built-up flush with the surface of the gusset plates. Ebasco uses one-half the thickness of the beveled member as the effective throat for design verification. Cygna was shown a copy of the Brown & Root qualification testing document. \TUE\062287-D.CON	

Signed: J. P. Russ for N. H. Williams

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Communications Report

Company:	CES	☐ Telecon	☒ Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	06/23/87
Subject:	Cable Tray Support Design Review Ebasco Audit	Time:	10:00 p.m.
		Place:	New York, N.Y.
Participants:	P. Harrison, J. Swanson,	of	Ebasco
	J. Christudeous, Bob Chen		Ebasco
	W.R. Horstman, B. Shakibma		Cygna

Item	Comments	Required Action By

1.0 Load Combination Method

In response to Cygna's concern regarding the validity of Ebasco's load combination method, Ebasco demonstrated that their version of STRUDL does combine the loads at the stress level rather than the force level. This was illustrated by analysis of an "L" shaped determinate frame with a downward load at the cantilevered end. Ebasco will provide a copy of the sample output and a brief description which will be transmitted to Cygna via TU Electric.

2.0 Bolt Holes in Member Flanges

Cygna noted that the reduced section properties shown in Table 36.2 of the Ebasco General Instruction, and those shown on PI-11 of Impell are different for the same sections. Cygna reviewed the Ebasco calculation for reduced section properties (Volume 1, Book 25, Revision 0). In that calculation, Ebasco accounts for the effect of a 3/4" diameter bolt hole at the channel flange tip. Basically, Ebasco used an "exact" approach which considers neutral axis shift and the flange slope. Cygna will review the corresponding Impell calculation to determine the source of the discrepancy.

3.0 Effective Section at Anchorages of Composite Members

Reference: Ebasco white paper response to Cygna's question raised on May 1, 1987. (GIR issue 24F)

Signed: J. P. Chen for N. H. Williams

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Based on the finite element analysis provided to Cygna along with the white paper, Ebasco concluded that for composite channel sections welded to a base angle, the connection will participate in resisting torsion and that the weld is more critical than the shear in the composite section.

Cygna questioned the degree of participation of the connection in resisting torsion (i.e., semi-fixed vs. fully fixed). Cygna stated it was not clear how the criticality of the weld versus the shear stress in member was justified.

Ebasco will compare the results of the finite element analysis to the COMBS program results, and will justify why the weld is more critical than the shear stress in the member.

4.0 Nodal Point Spacing for Braces

Reference: Ebasco white paper response to Cygna's questions raised on May 1, 1987 (GIR issues 1, 6A, 6B, 10E)

Cygna requested confirmation as to whether both dead load and self-weight excitation were used to calculate the additional contribution of dead load stresses of members with intermediate node points to the overall member stress interaction. Ebasco confirmed that dead load and self-weight contributions were considered.

5.0 STRUDL Stress Evaluation

Cygna asked for the basis of determining Cm in equation 1.6-1a of the AISC Specifications for use in STRUDL code check.

Ebasco replied that engineers manually input the Cm value in STRUDL code check, and that the value is determined based on criteria 3 of AISC.

Cygna asked whether members, as opposed to individual elements, are scanned over their entire length to locate the maximum Mx amd My for use in equation 1.6-1a.

Ebasco stated that STRUDL checks equation 1.6-1a for each element in the member and does not scan over the entire member length to locate the maximum moments. Ebasco will investigate the effects of this issue on member qualification.

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Communications Report

Company:	CES	☐ Telecon	☒ Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	06/23/87
Subject:	Cable Tray Support Review Ebasco Audit - Weld Base Metal Evaluation	Time:	02:15 p.m.
		Place:	New York, NY
Participants:	P. Harrison, J. Veikos	of	Ebasco
	B. Shakibnia, B. Atalay, W. Horstman		Cygna

Item	Comments	Required Action By

Ebasco summarized the weld base metal evaluation that they had performed. The evaluation is shown in Attachment 6 of the letter from J. P. Padalino of Ebasco to L. Nace of TU Electric, dated May 15, 1987. According to the Ebasco summary:

- o A typical post-to-tier connection with horizontal welds was studied. The post was chosen as a C4x5.4 and the tier as a C6x8.2. Although this is not a typical field configuration, the choice of the sections was based on a sketch made by Cygna during the May 1, 1987 audit.

- o The post is modeled as an elastic foundation, with the load being distributed from the weld to the post. The elastic foundation width is taken as 7 in. which is the unwrapped width of the post.

- o The tier is modeled as a beam on elastic foundation distributing the weld load. Because of its short length (3 in.), the tier deforms predominantly in shear. Therefore, the flexural moment of inertia of the tier (beam on elastic foundation) is decreased.

- o The loading is based on the capacity of one line of weld. The horizontal (perpendicular to post web) and vertical loads are considered separately since these two will be the bounding extremes.

Signed: J. P. Rice for N. H. Williams

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	o The equations given by M. Hetenyi, *Beams on Elastic Foundation*, University of Michigan Press, Paragraph 1900, were used to calculate the post stresses. Cygna disagreed with the use of Paragraph 1900 of Hetenyi's book in that this implicitly assumes that the beam, i.e., the tier distributing the load, is 7 in. long. However, the actual length is shorter. Ebasco stated that they would perform a reevaluation on the basis of the Cygna concern noted above. TUE\062387-A.CON	

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Communications Report

Company:	CES	☐ Telecon	☒ Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.: 84056 Date: 06/24/87	
Subject:	Cable Tray Support Design Review Ebasco Audit - Cable Tray/Hanger System Testing	Time: 11:00 a.m. Place: New York, NY	
Participants:	B. Atalay, W. Horstman	of	Cygna
	F. Hettinger, P. Harrison		Ebasco

Item	Comments	Required Action By

References:

1. Final Summary Report - Comanche Peak Cable Tray Tests," ANCO Engineers Inc., Document No. A-000181, Revision 0, January, 1987.

2. CTH Post-Test Analysis Correlation" Ebasco Comanche Peak SES Cable Tray Hangers, Volume I, Book 24, Revision 0, February 17, 1987.

Cygna provided the following questions and comments arising from its review of References 1 and 2.

A. Questions and Comments on Reference 1

A.1 Test Program, Data Acquisition, Input Loads

a. Each test configuration was unique: i.e., all test cases were different from each other in some respect. Therefore, parametric relationships cannot be developed; and, any particular conclusion attributed to a particular parameter may in fact be due to variation in another parameter. Cygna asked if the scope of the test program was limited to just showing a margin over all configurations.

Signed: J. P. Rua for N. H. Williams

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In particular, the test program did not include sufficient samples to preclude the possibility of brittle failure mechanism such as:

- o buckling - only one test case (TC), TC6, contained configurations which considered buckling
- o Edge distance violations - only two lessened edge distances were considered: supports (S) S4 of TC3 and S2 of TC7.

Cygna asked if the small number of samples was enough to address potential buckling and edge distance violation failures? If the above is not true, how can one treat all the tests used as back-up to the code requirements? The fact that there were no overall failures and the specimens remained stable merely demonstrates the existence of factors of safety implicit in a code design.

b. The dynamic interaction between the test (shake) table and the test specimens was not monitored properly (except for TC7). This poses a limitation on the interpretation and use of the test data as stated on the last line of p. 76 of Reference 1.

c. The discrepancy between the "visual" and "transducer data" tray slippages (see Tables 4.19 and 4.20 of Reference 1) must be addressed from the point of view of measurement accuracy. In addition to the above discrepancy, numerous "resolution," "noise," etc. problems associated with data acquisition are mentioned throughout Reference 1.

d. The test response spectra (TRS) falls below the required response spectra (RRS) at frequency, f = 4 Hz on p. 156 of Reference 1. Cygna noted that some system frequencies are less than 4 Hz.

e. The following discrepancies revealed by real transducer data presented in Appendix D of Reference 1 indicates an actuator control or accelerometer accuracy problem with reference to the maximum shake table input accelerations at S3 (data channels 7, 8 and 9). These indications are as follows:

- o 1.0 SSE accelerations on pp. D-3 and D-11 of Reference 1 do not agree, although p. 5 of

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Communications Report

Item	Comments	Required Action By

Reference 1 states that "seismic" and "systems behavior" tests used the same time histories.

- o Some OBE input (pp. D-7) is greater than SSE input.
- o 1.9 SSE input (pp. D-15) is not equal to 1.9 x (1.0 SSE input; pp. D-11) although pp. 5 states that fragility tests were run using the same time history as was used for the SSE, but amplified above the SSE.

  The discrepancy between the OBE TRS's shown on pp. 145 and 165 of Reference 1 may be another indication of the above problem.

f. Some specimens for TC1, TC2 and TC4 were instrumented with a total of 24 strain gages/load washers. Cygna asked why results utilizing these records were not presented.

g. The riser portion of the schematic of TC4 as shown on pp. 46 of Reference 1 is misleading. The riser ends near the top elevation of the C4 tier member and does not "cantilever" out above the tier. Thus, the desired inertia effects may not be induced on support S5.

h. With reference to the method of application of three-directional "earthquake" test base input as described on pp. 8, 79-80, and 181 of Reference 1, it is understood that the transverse (T) excitation is dependent on (i.e., a linear function of) the vertical (V) input. Yet, the T and V input time history plots shown on Figs. 4.19 (a), 4.20 (a), and 4.24 (a), and 4.25 (a) do not confirm this.

A.2 <u>Determination of Natural Frequencies, Mode Shapes</u>

a. Reference 1 states that numerous difficulties were encountered in identifying natural frequencies and mode shapes. Occasionally, subjective criteria based on "known physical characteristics," etc. were used to accept or ignore some modes or frequencies. Natural frequencies and mode shapes were determined in a number of ways: using "random," "sine dwell," and "hammer" tests. In general, differences exist among frequencies and mode shapes identified using the different approaches. Specifically:

Item	Comments	Required Action By

(1) Some mode shapes could be identified using the "hammer" test method, but their frequencies do not appear among the modes identified using "random" tests. Examples are the modes with frequencies of 4.1 Hz for TC6 and 5.8 Hz for TC7 (See pp. 132 and 134 of Reference 1, respectively.)

(2) For the TC7, 50% fill level test, the frequencies shown in Table 4.6 and Appendix C of Reference 1 are not in agreement. At the 0.25 grms load level, pp. C-12 shows a frequency of 5.6 Hz. This frequency is not in Table 4.6. At the 0.45 grms load level, pp. C-15 and C-16 show frequencies of 5.6, 9.6 and 18 Hz, none of which are in Table 4.6.

b. Cygna asked why test reports (frequencies, mode shapes, modal damping) were not presented for 0% fill level tests conducted in TC2 and TC4.

c. With reference to Figs. 4.1 and 4.2 of Reference 1:

- o The softening, i.e., decrease of frequency with increasing excitation, is attributed to accumulation of small amounts of slippage, but not to plastic deformation (see p. 98). Cygna asked how plastic deformation could be ruled out as a cause of the "softening"?

- o Figs. 4.1 and 4.2 exhibit some "hardening," i.e., a positive slope in the load vs. frequency relationship, especially for larger load levels. These positive slopes are counterintuitive, and imply material strain hardening or the introduction of geometric stiffness. Both possibilities are undesirable. Another case of "hardening" can be observed in Table 4.1 of Reference 1 for the 10% fill level test where the frequency increases from 9.2 Hz to 10.4 Hz by increasing the load level from 0.25 grms to 0.45 grms.

A.3 <u>Determination of Damping</u>

a. As stated on pp. 99-100 of Reference 1, the determination of modal damping from seismic test data could not be accomplished successfully. Instead, an attempt is made to interpret and extrapolate "random" test data to obtain seismic level damping values. The

Item	Comments	Required Action By

attempt, as described on pp. 99-100, is based on subjective qualitative concepts such as "similarity," "somewhat similarity," "matching at and near a frequency." The resulting seismic damping values are given in the second and third paragraphs of p. 179 of Reference 1. According to those paragraphs, out of the six test cases (TC1, 2, 3, 4, 6, 7):

- o The TC1 data point of 6.5% damping is excluded.
- o No damping data is available for TC2, 100% fill level in Table 4.13.
- o Cases TC3 and TC6 are excluded.

Only the "random" test data from TC4 and TC7 are available to deduce the seismic damping values of 5.6% and 9.8%for OBE and SSE, respectively. As described above, these reports are not measured directly in tests but are based on a questionable method, and a limited data base. Therefore, the use of any damping value greater than 4% and 7% for OBE and SSE, respectively, is questionable, especially the damping values of 10% and 20% proposed in the "key results" section of Reference 1 (see p. 2 of Reference 1) is hard to accept.

b. With reference to Figs. 4.12 and 4.13 of Reference 1, he negative slopes, i.e., decreasing damping with increasing excitation level, are counterintuitive. Similarly, the decrease of damping from 10.3% to 6.5% with an increase of input from 0.25 grms to 0.45 grms (TC1, 10% fill level test; see Table 4.12 of Reference 1) is unexpected.

c. In Tables 4.12 through 4.17 of Reference 1 certain modes are denoted by "--," and it is stated that damping could not be calculated for these modes because resonate frequencies were poorly defined. However, Tables 4.1 through 4.6 report frequencies for these same modes.

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1 The third paragraph of p. 179 of Reference 1 shows this quantity as 6.8%. The same quantity is shown as 9.8% on the second paragraph of the same page. It is believed that the "6.8%" value is a typographical error.

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d. For TC7, 0.45 grms input level, and 50% fill level test no frequency is identified for mode T1 in Table 4.6 of Reference 1, yet the modal damping for the same mode is given as 21.9% in Table 4.17. Note that p. C-15 shows the frequency for that mode as 9.6 Hz. The damping values of 16.8% and 10.1% shown in Table 4.17 do not agree with the damping values calculated on p. C-15 and C-16.

A.4 <u>Minor Questions, Information Requests</u>

a. With reference to p. A-11 of Reference 1, please clarify why weldment improvements were made.

b. With reference to p. A-21 of Reference 1, please clarify why 10% and 75% fill tests in TC2 were deleted.

c. With reference to p. A-64, please explain how the 5.5 in. misalignment of S3 of TC6 was accomplished.

d. Was the test cable ever weighed? Is the 35 psf value used in the analyses for cable weight accurate?

e. Please reconcile the following elbow drop deformation measured in TC7.

Reference 1 Page No.	Displacement (inches)
121	0.25
D-6	1.18
D-14	1.94

B. <u>Questions and Comments on Reference 2</u>

1. Only TC7 results are correlated. Why were other TC results not correlated?

   Ebasco responded by stating that correlation was assigned to Impell. Ebasco attempted just one correlation to demonstrate conservatisms in ESM.

2. What is the required response spectrum (RRS)?In SAE CP05, Ebasco specified unbroadened RRS as input (see pp. 10-23 of SAE CP05). ANCO broadened those RRS as shown on pp. 137-140 of the ANCO test plan, Doc. No. A-000150. These broadened RRS differ from the original broadened RRS. (The original broadened RRS were developed by Gibbs and Hill; see p. 54 of Ebasco General Instructions for Cable Tray

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Hanger Analysis for CPSES No. 1 and 2, Reference 5, for an example.)

3. Which Revision 0 edition of the ANCO test report wasbeing used by Ebasco for correlation? Cygna's copy of the test report is marked January, 1987, Revision 0. The cover sheet for Reference 2 references a Revision 0 of the test report dated July, 1986. However, page 7 of Reference 2 lists a Revision 0 of the test report dated September, 1986.

4. The ESM and RSM analyses use a set of digitized test response spectra (TRS) given in appendix B of Reference 2. Which TRS were chosen? Note that there were more than one OBE and SSE tests each, and the TRS was different in the different OBE (or SSE) tests, as well as in different supports. (See comment A.1.e.) The TRS shown on pp. B2 through B7 of Reference 2 are for support S3. In the RSM analysis, was an "average," "envelope" or "multiple" response spectrum used?

5. The tests seem to contradict the "no longitudinal connectivity" assumption. (See the poor longitudinal displacement correlation on p. A-6 of Reference 2.)

   Ebasco stated that they have changed their position on "connectivity" and now assume that the cable trays are connected to the supports. However, Reference 2 may not

6. What were the clamp stiffness and anchorage stiffness values used in the correlation analyses?

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2 Ebasco said that they have changed their stand on "connectivity" and no longer assume no connectivity. However, they said they may leave Reference [2] as is, i.e., not revise due to change of the connectivity assumption, and have Impell's correlation study be the correlation study of record.
be revised due to the change in the connectivity assumption. Impell's correlation study may be the correlation study of record.

Item	Comments	Required Action By
	7. If a model was turned and a frequency match was achieved (see conclusion 2, p. 6 of Reference 2), any differences in results under loading must be due to differences between the response spectra method used in the analysis and the time history method implicit in the test. Cygna stated that this difference (or conservatism) has to be quantified and taken into account before other conservatisms in modeling techniques can be claimed. With reference to the same conclusion, Cygna asked how can test and analysis frequencies match if the "connectivity" assumption (see comment B.5 above) is inaccurate. In other words, if the "connectivity" assumption were to be changed, can the frequency match still be achieved?	
	8. The ANCO test results quoted in Reference 2 do not agree with test results reported by ANCO in Reference 1. This is shown by comparing Reference 2, p. A-2 with Reference 1, pp. D-9, D-10, and Reference 2, p. A-3 with Reference 1, pp. D-5, D-6.	
	9. The RSM displacements calculated for the midspan of bend (≈7 in.) are excessive. See pp. A-2 and A-3 of Reference 2. Such high displacements imply failure.	
	10. Ebasco's analysis results shown on p. A-3 of Reference 2 do not agree with the Impell analysis results (see Table 6.3 of "CPSES Cable Tray System Analysis/Test Correlation," Impell Corporation Report No. 09-0210-0017, Revision 0, February, 1987).	
	11. The test modal frequencies, mode shapes for modes with 4.0 Hz and 5.6 Hz, quoted on p. A-9 of Reference 2 cannot be found in the ANCO test report (Reference 1). Reference 1 shows the 4.0 Hz mode as a transverse mode while Reference 2 quotes this as a vertical mode.	
	12. The computer runs mentioned on p. C-9 of Reference 2 are not among the computer runs in computer output books 24A and 24B.	
	13. The cable weight appears as 32 psf on p. C-14. Why is this different than the customary weight of 35 psf?	
	14. Why is span "e + h" considered with S4 on p. C-14?	
	TUE\062487-A.CON	

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Communications Report

Company:	CES	☐ Telecon	☒ Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	06/25/87
Subject:	Cable Tray Support Design Review Ebasco Audit	Time:	11:40 a.m.
		Place:	New York, NY
Participants:	P. Harrison	of	Ebasco
	W. R. Horstman, B. Shakibnia		Cygna

Item	Comments	Required Action By

Major Axis Bending Due to Transverse Loading

Reference: Ebasco white paper response to Cygna's generic questions raised on May 1, 1987. (GIR issue 24A).

Based on a review of the referenced white paper and Ebasco Calculation No. 3306.514 - Dept No. 558, Cygna raised the following questions:

- o Were the samples chosen representative of the supports with highest interaction ratios for tiers?
- o Why was torsion not included, since connectivity is to be considered according to the requirements of Attachment Z to the General Instructions?

Ebasco's responses:

- o The samples were chosen to be representative of the supports, but not necessarily those with highest tier interaction ratios. Ebasco will verify the basis of the representativeness.
- o The calculation was performed prior to implementation of Attachment Z. All calculations will be revisited to account for the effects of connectivity. Ebasco feels that the inclusion of connectivity will not increase the 3% difference in combined stresses, but may decrease it, since the initial stress will increase after inclusion of torsion.

Signed: J. P. Rue for N. H. Williams

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Item	Comments	Required Action By
	o Ebasco will check to see if there are any means of determining which CTH's have the highest interaction ratios for tiers. <u>Partial Penetration Welds on Skewed Gusset Plates Used on Longitudinal Support Braces</u> o Cygna requested further clarification on qualification of partial penetration welds on skewed gusset plates. o Ebasco confirmed that welds are checked for completeness, and are to be built up flush with the gusset plates. Ebasco uses one-half the thickness of the bevelled member as the effective throat for design verification and showed Cygna a copy of Brown & Root qualification testing document. TUE\062587-B.CON	

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Communications Report

Company:	CES	☐ Telecon	☒ Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	6/26/87
Subject:	Cable Tray Support Review Ebasco Audit - Kinematic Condensation	Time:	10:30 a.m.
		Place:	New York, NY
Participants:	N. Williams, S. Tumminelli, D. Leong,	of	Cygna
	B. Atalay, W. Horstman		Cygna
	F. Hottinger, P. Harrison, S.J. Chen,		Ebasco
	M. Chuaprasert		Ebasco

Item	Comments	Required Action By

Reference: 1. Letter from J.P. Padalino (Ebasco) to L. Nace (TU Electric), dated May 15, 1987.

Cygna stated that they had reviewed Attachment 1 to Reference 1 and disagreed with the application of the Guyan kinematic condensation technique to determine the frequency at a point. The reasons for this disagreement are as follows:

1. Guyan reduction is not a filtering technique. The reduction does not allow an accurate prediction of the frequency at a specified mass point. The accuracy of the procedure depends on the mass and stiffness distribution in the system to which the condensation is applied. The technique is especially susceptible to inaccuracies if the mass distribution in the system is somewhat uniform, or if, at the pint of condensation, the mass is low or the point is not well supported.

2. For the particular case of application, some cable tray support mass will be left out due to the condensation. Consequently, the forces exciting the conduit will be underestimated by the amount of the cable tray support inertia left out.

Signed: J.P. Rue for N.H. Williams

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Item	Comments	Required Action By
	Ebasco responded that the condensation was used as a screening technique to determine if the frequency was less than or larger than a threshold valve (14.5 Hz). The purpose is not the determination of frequency for cable tray support analysis or qualification. Ebasco felt that the approach was more accurate than the conventional "unit load/stiffness/tributary weight" route. Ebasco cited the good correlation of the three sample analyses demonstrated in their position paper. Cygna reiterated their reservations and said that they would evaluate this issue. TUE\062687-B.CON	

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Communications Report

Company:	CES	☐ Telecon	☒ Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	06/26/87
Subject:	Cable Tray Support Design Review	Time:	01:00 p.m.
	Ebasco Audit - Exit Meeting	Place:	Ebasco, (NY)
Participants:	S. Harrison (via telephone)	of	TU Electric
	P. Harrison, F. Hettinger, R. Alexander		Ebasco
	N. Williams, D. Leong, B. Shakibnia, W. Horstman		Cygna

Item	Comments	Required Action By

I. Summary and Status of Issues Discussed

Cygna provided a summary and status for each of the major topics discussed or reviewed in the audits conducted on the week of June 21, 1987 through June 26, 1987.

A. Multi-modal Response Multiplier

See discussion in June 26, 1987, 11:30 a.m. communication report.

B. Cable Tray Clamps

Cygna has reviewed of testing and evaluation procedure. There are no questions at this time.

C. Cable Tray Qualification

The review of cable tray qualification is not complete. Cygna has several questions which can be discussed via a telephone conference.

D. Cable Tray System Dynamic Test Program

Cygna provided Ebasco with questions on June 24, 1987. Ebasco will respond to these during the testing audits to be held in Walnut Creek during July.

Signed: J. P. Rie for N. H. Williams

Page 1 of 4

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Item	Comments	Required Action By

E. Review of Longitudinal Supports

Cygna's questions regarding the modelling of eccentricities at the tray attachment point for longitudinal trapeze supports has been addressed through revisions to Attachments B1 and B2 of the General Instructions.

Cygna has several additional questions regarding the choice of effective length factors for longitudinal supports having the post members oriented differently than considered in the effective length factor development study. These can be discussed via a telephone conference call.

F. Load Combination Method

Cygna has accepted the verbal response provided by Ebasco. Ebasco will provide a copy of the sample computer output illustrating their approach and a brief written summary.

G. P-delta STRUDL Stress Evaluation

Cygna presented a question to Ebasco regarding the interpretation of AISC equation 1.6-1(a) in the STRUDL stress evaluation on June 23, 1987.

Ebasco indicated that they had checked with P-Delta, Inc., and learned that STRUDL performs the stress evaluation on an element-by-element basis. A scan is not made over an entire member to determine maximum bending stresses. Ebasco believes that the implementation of the stress evaluation in STRUDL is acceptable.

Cygna will evaluate Ebasco's response and provide any comments at a later date.

H. Single Angle Members

Cygna will review Ebasco's response and provide any comments at a later date.

I. Bolt Holes in Member Flanges

Cygna has reviewed Ebasco's calculations and has no questions on their approach. Cygna will review Impell's calculation in order to determine the reason for the discrepancy between the two consultants' results.

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Communications Report

Item	Comments	Required Action By

J. Partial Penetration Welds

Cygna has discussed partial penetration groove welds with Ebasco and has no further questions at this time.

K. Kinematic Condensation to One Mass Point

See the Communications Report for June 26, 1987, 10:30 a.m.

L. Additional Major Axis Bending Due to Transverse Load

Cygna has reviewed Ebasco's response on this topic. Two questions have been raised:

- o Is it necessary to revise the response after Attachment Z of the General Instruction (longitudinal connectivity) is implemented?
- o Were the supports selected for examples in the response representative of all cable tray hangers?

M. Effective Section at Anchorage of Composite Members

Ebasco will provide a comparison of the stresses shown in the finite element analysis provided in the response with those calculated using "COMBS" program.

N. Enhancement of the COMBS Verification Manual

The supplemental verification covers all program features. Cygna has no further questions.

O. Nodal Point Spacing on Braces

Cygna has no further questions on this response.

P. Weld Base Metal Evaluation

As discussed on June 23, 1987, Cygna has several questions on the response for this topic. Ebasco will provide a revised response.

Q. Bolt Hole Oversize Study

As discussed on June 25, 1987, Cygna has a number of questions on this study. Cygna requested permission to contact Robert Iotti (Ebasco) at the CPSES site to discuss the study. TU Electric agreed to Cygna's request.

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Communications Report

Item	Comments	Required Action By
	R. Responses to Specific Cygna Questions on 12 Calculation Packages Cygna has discussed and resolved comments on several of the calculations. Several questions remain which can be addressed via a telephone conference. II. <u>Document Requests</u> Cygna requested that copies of the following Ebasco documents be transmitted to Cygna via TU Electric: SAG.CP18 Tray and Fitting Design Verifications Procedure SAG.CP19 Cable Tray Clamp Design Verification Procedure SAG.CP28 Multi-modal Response Multiplier Screening Criteria SAG.CP34 General Instructions The position paper on the statistical evaluations and impact of oversize bolt holes in cable tray hangers was also requested. TUE/062687-A.CON	

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Communications Report

Company:	CES	☐ Telecon	☒ Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	7/9/87
Subject:	Cable Tray Review Multimode Response Multiplier	Time:	5:00 p.m.
		Place:	Impell, WC
Participants:	S. Harrison	of	TU Electric
	P. Harrison, F. Hettinger		Ebasco
	D.K. Leong, J.P. Russ, N.H. Williams		Cygna

Item	Comments	Required Action By
	Cygna provided Ebasco with a summary of their concerns regarding the MRM study. This is provided in the attachment to this communications report. Basically, Cygna does not feel that the study adequately covers the range of parameters present in the CPSES systems. The lack of trends shown in the current analyses does not support Ebasco's positions that the cases analyzed are controlling. Ebasco agreed to review Cygna's summary and respond in a conference call the following week.	

Signed: J.P. Russ for N.H. Williams

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Item	Comments	Required Action By

ATTACHMENT

MRM Concerns

The parametric study in Book 15, Section II is intended to demonstrate the applicability of the 1.25 MRM factor used in the Ebasco ESM analyses. The MRM includes a multimode response factor and load distribution factor. For those cases where the 1.25 factor is exceeded, a screening procedure is developed to address potentially higher MRM.

There are numerous combinations of parameters in the MRM study, including span length, spectral input, support stiffness, and number of spans. Despite the amount of information obtained from the studies, Cygna does not feel that the range of parameters adequately covers the population at CPSES, nor were they varied in a systematic manner in order to determine trends in results.

The basic analyses considered four 6-foot spans. Support stiffnesses and the ratio of lengths of adjacent spans were varied. Spans at CPSES can range up to 8 or 9 feet in length, with a wide range of stiffness variations. The choice of cable tray size and span length, in conjunction with the spectral shape, influences the final dynamic response of the system. These parameters should also be considered and varied in the study. Although Ebasco claims to have considered a wide range of system frequencies in their study, they are referring to the first mode frequency of the system. The total response of a system depends on where the higher modes fall with respect to the first mode (the relative contribution of modes). Thus, two systems can have identical first mode frequencies, but different higher mode distributions, different dynamic response, and different MRM.

Ebasco claims that the equal span models give higher MRM results. By reviewing the data provided in the calculation, that conclusion is not always valid. In fact, a certain lack of trends is noted when one parameter is varied across a range of values. The lack of trends is more apparent for cases where SRSS combination and/or time history analysis had been used instead of the Reg Guide 1.92 combination. Ebasco employed these analysis methods where they determined that the modes were being combined in a needlessly conservative manner. Although Ebasco attributed the anomalies to the modal combination and numerical sensitivities in the models, it is impossible to separate out these additional effects from the parametric effects. Thus, the accuracy of the MRM values determined in these cases and all others is questionable.

Communications Report

Item	Comments	Required Action By

The screening criteria is based in results of the MRM study, but does not fully utilize all the data available. There are MRMs coming out of the study which are far in excess of those in the screening criteria. Although the screening criteria is not actually incorrect in omitting these values (since they fall outside the cases tabulated and must be considered specially), there is a concern that the value that will be used will conflict with those developed in the study. Additionally, the (1.5 x peak) option for dynamic load is not valid, as the 1.5 value is purely a dynamic amplification factor and does not address load distribution.

In short, the MRM study does not systematically consider the total range of parameters and their combinations in the CPSES population. The study includes additional implicit variables or numerical bias which cannot be quantified. The screening criteria has not been developed to fully utilize the available information and leaves doubt as to the use of a proper MRM for supports which fall outside of the tabulated cases.

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Communications Report

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Company:	CES	☐ Telecon	☒ Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.:	84056
		Date:	07/10/87
Subject:	Status of Cable Tray Issues	Time:	10:00 a.m.
		Place:	Impell, WC
Participants:	J. Russ	of	Cygna
	S. Harrison		TU Electric
	G. Ashley, R. Kaczkowski		Impell
	D. Williams		QEST

Item	Comments	Required Action By

Cygna met with TU Electric, Impell and QEST to status the cable tray support review issues that affect Impell. A conference call to status those issues affecting Ebasco will be held at 7:00 a.m. on Monday, July 13, 1987. Cygna noted that the list was by no means complete and that other issues could be added.

RIL 1 Controlling Load Case for Design

Cygna is presently reviewing Impell Report IM-P-004.

RIL 2 Seismic Response Combination Method

Cygna is presently reviewing Impell Report IM-P-002.

RIL 3 Anchor Bolt Design

Cygna is presently reviewing the issue on gaps under base plates.

Impell must address Cygna's concern on the combination method used to determine the stress in a base angle. Cygna's review indicates that if the combination is done correctly, the base angle stresses may control the design.

Cygna is considering the differences in the boundary stiffnesses as part of the cumulative effects review.

Signed: J. R. Russ for N. H. Williams

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Communications Report

Item	Comments	Required Action By
	RIL 4 Design of Compression Members	
	Impell must provide Cygna with an evaluation of the k-factors for supports with rotated posts.	
	In regard to the engineering evaluations by CPRT third party previously requested by Cygna, TU Electric stated that the licensing group was still considering the impact of providing Cygna with these documents. The present view is that the IAP and third party reviews should be kept as separate and independent as possible. If these positions are changed, Cygna will be provided with the documents.	
	RIL 7 Design of Angle Braces Neglecting Loading Eccentricity	
	Impell must provide a response on the use of the 95% of the Euler buckling allowable in the determination of the controlling lengths for twist-buckling.	
	RIL 9 Reduction in Channel Section Properties Due to Clamp Bolt Holes	
	Cygna noted that there are differences in the section properties reported by Ebasco and Impell for channels with bolt holes in them. Cygna has reviewed the Ebasco work and noted the methodology and must recompare it with Impell's in order to understand the difference. Prior to any request for documents, Cygna may telephone Impell for discussion.	
	RIL 14.B The Value of "1" in AISC Equation 1.5-7	
	Impell stated that they had discussed this issue with the AISC staff and that AISC did not recommend using the entire post height as the value for use in AISC equation 1.5-7. Cygna stated that further discussion on this topic may be necessary.	
	RIL 16.H Base Angles Welded to Embedded Plates	
	Cygna asked if there were any numerical evaluations that formed the basis for the conclusion behind Impell's White Paper. Impell replied that there were none other than contained in the paper itself. Cygna stated that they would contact Impell if further evaluations may be necessary.	

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1020.01b

Item	Comments	Required Action By
RIL 19	FSAR Load Combinations Impell must provide revision 2 to Impell Calculation M-27.	
RIL 24.B	Minor Axis Bending Due to Eccentric Transverse Tray Loads During a previous audit of Impell, Cygna had demonstrated that an additional minor axis bending stress of 1.2 ksi may be induced into the tier members by the eccentric application of transverse tray loads. Impell feels that this value is negligible. Cygna requested justification for this assumption.	
RIL 24.F	End Conditions for Composite Tee-Channels Impell is to provide an evaluation of the connection.	
RIL 25	Cable Tray Qualification Cygna is presently reviewing the cable tray qualifications.	
RIL 32	Conduits Attached to Cable Trays or Supports TU stated that all the cable tray spans are being walked down and any attachments are being identified. Any attachments will be evaluated on a case-by-case basis. For attached conduits, the conduit and the connection will be analyzed by the conduit group while the cable tray will be analyzed by the cognizant cable tray contractor.	
RIL 33	As-Built Walkdown Procedures The issue on walkdown tolerances is open. A conference call on the topic may be arranged between Impell and Cygna. Other commitments were also noted by Impell. Impell stated that they are committed to providing a response on the member length used in AISC equation 1.6-1a. After some discussion, Cygna stated that they felt that justification for the lumping of conduit masses onto cable tray supports was required. Justification for neglecting the eccentric application of shear loads to one-bolt base angles was also requested.	

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Communications Report

Company:	CES	☐ Telecon	☒ Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	07/17/87
Subject:	Cable Tray Support Design Review Cable Tray/Hanger System Dynamic Testing	Time:	2:45 - 7:45 p.m.
		Place:	Impell, Walnut Creek
Participants:	B. Atalay, J. Russ	of	Cygna
	D. Williams		QEST

Item	Comments	Required Action By

References

1. "Final Summary Report - Comanche Peak Cable Tray Tests", Document No. A-00181, Revision 0, dated January, 1987, ANCO Engineers, Inc.

2. "Data Package for Case 7 - Comanche Peak Cable Tray Tests, Document No. A-000187, Revision 1, dated May, 1987, ANCO Engineers, Inc.

3. "CPSES Cable Tray System Analysis/Test Correlation, Report No. 09-0210-0017, Revision 0, Dated February, 1987, Impell Corporation.

4. Calculation TC7-PT1, Revision 1, dated December 1986, Impell Corporation.

5. "Data Package for Case 6 - Comanche Peak Cable Tray Tests, Document No. A-000186, Revision 0, dated February, 1987, ANCO Engineers, Inc.

6. Calculation C6-PT1, Revision 1, dated February, 1987, Impell Corporation

Cygna had the following questions and comments resulting from its review of References 1 through 6.

Signed: J. P. Russ for N. H. Williams

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Communications Report

Item	Comments	Required Action By

1. The variation of the test case (TC) 7 vertical mode V1 frequency with excitation level is not consistent in ANCO documents, References 1 and 2. This is shown by comparing Figure 1.1 of Reference 1 with p. A-3 of Reference 2.

2. In Reference 2, pp. B-15 and B-16 show a response shape with a frequency of 7.2 Hz. The shape has a maximum amplitude at data channel 14 – table support (S) 5 in the transverse direction. Furthermore, the trays exhibit a constant amplitude response shape. Are the above measurements accurate and reasonable? If there is an inaccuracy in the sine-dwell method of determining this test response shape, how does this inaccuracy in the method affect other response mode shapes?

3. a. The following damping ratios, shown in Table 4.17 of Reference 1 for TC7, 0.25 grms random input are not shown in Appendix D of Reference 2:

   11.9% and 23.0% for mode T2
   7.1% for mode T3, and
   7.1% for mode V1

   b. Similarly, the damping ratio of 5.5% shown for the TC7 V1 mode in Figure 4.12 of Reference 1 is not shown on p. D-3 of Reference 2.

   Cygna asked that the above be reconciled.

4. On the third unnumbered page of Appendix D of Reference 4, Impell states that clamps did not suffer permanent deformation and damage during the seismic level tests. This contradicts the ANCO observations on pp. I-4 and I-6 of Reference 2 where the results of tests 7.42.8 and 7.46.14 are reported.

5. Impell's statements regarding the magnitude of tray slippage on the last unnumbered page of Appendix D of Reference 4 are not in agreement. The following tray slippage values are reported by ANCO in Reference 2.

Maximum Tray Slippage (inches)	Data Channel No.	Reference 2 Page Number
0.17	38	J-6
0.17	38	J-16
0.50	37	J-22
0.50	37	J-34
0.50	37	J-50

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Item	Comments	Required Action By
	6. Table 2.2 of Reference 4 shows that a 3.2 Hz mode was identified from the test results using transfer functions (TF) Nos. 9 and 11. The 3.2 Hz mode is not obvious in the plot of TF No. 9 in Figure 2.3.i of Reference 4.	
	7. For the 12.0 Hz mode, the mode shape plot and description appearing on pp. B-17 and C-4 of Reference 2, respectively, are not in agreement. On p. C-4, the mode is described as having maximum amplitude at the upper tray. Page B-17 (of Reference 2) and Table 2.2 of Reference 4, show the maximum amplitude occuring in the lower tray. Cygna requested that these discrepancies be reconciled.	
	8. The TF shown in Figure 2.3.j of Reference 4 is the only evidence of the measurement of a 14.0 Hz modal frequency. Is this evidence sufficient to postulate a modal frequency?	
	9. In Appendix A of Reference 4, longitudinal offset dimensions L7 and L8 for support S1 are modelled as 3'0". Cygna requested verification of this dimension.	
	10. The average longitudinal test response spectrum (TRS) is shown in Appendix C of Reference 4. This TRS significantly exceeds the RRS near 4.2 Hz. Cygna expressed concerns similar to those expressed for the transverse direction TRS being in excess of the RRS (See Item 8 of Cygna Conference Report dated July 8 through July 9, 1987.	
	11. Cygna requsted an audit of Impell Calculations M-10 and M-28 which address clamp stiffness values.	
	12. For TC6, support S1, the transverse rotational stiffness value at the specimen boundary is not available; therefore, the corresponding value from TC7 is used for TC6. In Reference 6, the use of the rotational stiffness value from TC7 is justified by performing a sensitivity analysis and concluding that results are not sensitive to rotational stiffness. Cygna feels that this statement contradicts the significance of the rotational stiffness implicitly claimed for TC7 in References 3 and 4.	
	13. The test results for bare supports of TC6 are reported in Appendix J of Reference 5. Cygna asked why these bare supports test results were not being used to calculate the boundary spring stiffnesses for TC6 instead of using the	

Item	Comments	Required Action By

stiffnesses from TC7.

14. Impell shows in Reference 4 that a mode was measured with a frequency of 8.5 Hz. Impell tried to correlate this mode with a mode which has an analytically predicted frequency of 10.7 Hz. The frequency correlation, i.e., 8.5 Hz and 10.7 Hz, is not very satisfactory. Furthermore, the measured and analytical shapes of these modes (plotted in Figure 4.2.c. of Reference 4) do not correlate well, especially around supports S1 and S2.

15. The following questions and comments result form Cygna's review of computer run No. 209 of Reference 4, and the manner in which the results of that run are interpreted in Reference 4.

    a. Mode Nos. 9, 12, 15 and 17 which have significant participation factors are not included in the correlation comparison.

    b. Modes with frequencies of 5.0, 11.1 and 13.8 Hz have low participation factors, and yet these analytically predicted modes were selected for correlation with measured modes.

    c. The correlation between the measured (at 12.0 Hz) and the analytical (at 11.1 Hz) modes shown in Figure 4.2.d is not satisfactory.

16. Cygna noted that plots of mode shapes of the "refined" model were not available in Reference 4. Without such plots it was difficult for Cygna to ascertain the mode shape descriptions and correlations claims in Reference 4. Cygna asked if the mode shapes were ever plotted, and requested to review the plots if they existed.

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Communications Report

Company:	CES	☐ Telecon	☒ Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	7/23/87
Subject:	Cable Tray Support Design Review Ebasco Audit - Document Request	Time:	10:45 a.m.
		Place:	New York, NY
Participants:	P. Harrison	of	Ebasco
	W. Horstman		Cygna

Item	Comments	Required Action By
	Cygna requested the calculation packages for the following longitudinal trapeze supports for use during the review: CTH - 1 - 481 CTH - 1 - 1268 CTH - 1 - 3360 CTH - 1 - 3936 CTH - 1 - 3957 CTH - 1 - 5143 CTH - 1 - 5324 CTH - 1 - 5629 CTH - 1 - 6064 CTH - 1 - 6348 \TUE\072387-D.CON	

Signed: J.P. Ross for W. H. Williams

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Communications Report

Company: CES	☐ Telecon	☒ Conference Report	
Project: TU Electric CPSES IAP Phase 4		Job No. 84056	
		Date: 08/04/87-08/06/87	
Subject: Cable Tray Support Design Review Cable Tray System Dynamic Testing		Time: 9:00 a.m. - 5:00 p.m.	
		Place: Impell, WC	
Participants: B. Atalay, J. Russ (part-time)		of Cygna	
B. Shakibnia (part-time), W. Horstman (part-time)		Cygna	
R. T. Kaczkowski, D. Williams (part-time)		Impell	
Z. T. Shi (part-time)		Ebasco	

Item	Comments	Required Action By
	Cygna and Impell discussed the Cygna questions and comments shown in Cygna conference report dated July 17, 1987. For the sake of brevity, the questions and comments are not repeated here. For the questions and comments and References 1 through 6, see Cygna Conference Report dated July 17, 1987 hereinafter referred to as Reference 7.	
1.	Cygna comment No. 1 of Reference 7 will be relayed to ANCO to reconcile the V1 mode frequencies shown in Fig. 4.1 of Reference 1 and p. A-3 of Reference 2.	
2.	In response to Cygna comment No. 2 of Reference 7, Impell said that they relied more on their own transfer function (TF) method of mode shape determination than on ANCO's measured response shapes. Impell noted that although pp. B-15 and B-16 of the ANCO data package (Reference 2) show that the shake table possesses maximum response for the mode near 7.2 Hz, the cable tray test system also has significant response. This is borne out on p. C-11 of Reference 1, and also by the TF plots (Fig. 2.3 of Reference 4). Impell said that the results of the sine-dwell method used by ANCO should be interpreted with caution and that they would include a note to this effect in References 3 and 4.	

Signed: J. C. Russ for N. H. Williams

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Communications Report

Item	Comments	Required Action By
3.	Cygna noted some inconsistencies in the damping ratios reported by ANCO in References 1 and 2. (See Cygna comment nos. 3a and 3b of Reference 7.) These inconsistencies will be relayed to ANCO and ANCO will verify the accuracy of test case (TC) 7 damping ratios.	
4.	In response to Cygna comment no. 4 of Reference 7, Impell said that it would revise the clamp damage descriptions in Appendix D of Reference 4, and make these descriptions consistent with the damage descriptions in Appendix I of Reference 2.	
5.	In response to Cygna comment no. 5 of Reference 7. Impell said that the anomalous readings of data channels 37 and 38 could be due to a number of reasons including: - The transducers could be offset i.e., the readings quoted by Cygna may not be absolute values, but rather values relative to an offset transducer zero position; or - The transducer may be defective. Such transducers were encountered in the earlier tests but were "changed out" upon encounter.	
6.	In regards to Cygna comment no. 6 of Reference 7, Impell acknowledged that there was weak evidence, i.e., only one TF plot, to assert that a 3.2 Hz mode was measured. Since this mode could not be identified analytically, Impell now feels that it may be more prudent to remove this mode from among the measured modes in Table 3.1 of Reference 4. Impell will study the options and address this comment in the next revision of Reference 4. Impell will also add a note addressing and limiting the scope of the modal analysis/test correlation in the next revision of Reference 4.	
7.	The inconsistencies noted by Cygna comment no. 7 of Reference 7 will be relayed to ANCO to clarify the mode shape for the 12 Hz mode. If ANCO decides that their description on p. C-4 of Reference 2 is accurate (and the description on p. B-17 of Reference 2 is not accurate), Impell will reevaluate their description of the mode in Table 2.2 of Reference 4 since that description is in agreement with the one on p. B-17 of Reference 2.	
8.	In response to Cygna comment no. 8 of Reference 7, Impell said that only one transducer was available that could identify the 10.0 Hz mode. This was due to the nature of the mode shape which had significant amplitude only past the bend. No other transducer could have identified this motion. Impell will add a note to the next revision of Reference 4 regarding the lack of additional data.	

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Item	Comments	Required Action By
9.	In response to Cygna comment no. 9 of Reference 7, Impell will verify the accuracy of the dimensions L-7 and L-8 used in Appendix A or Reference 4.	
10.	In response to Cygna comment no. 10 of Reference 7, Impell said that the test response spectra (TRS) input were satisfactory. Due to the test system limitations, it is unrealistic to expect a good match between the required response spectra (RRS) and the TRS. The best that could be done, however, was to match the RRS at the frequency of interest. The frequencies of interest were know prior to seismic tests since they were determined in the random tests.	
11.	Impell said that impell Calculations M-10 and M-28 regarding clamp stiffness values were available for review.	
12.	In response to Cygna comment no. 12 of Reference 7, Impell said that the TC6 support 1 transverse frequency was not sensitive to boundary longitudinal rotational spring stiffness. this is because of the slenderness and flexibility of S1 of TC6.	
13.	In response to Cygna comment no. 13 of Reference 7, Impell said it was not clear why ANCO included the bare supports tests results in Reference 5, and that ANCO should provide the clarification. Impell added that the TC6 bare support tests were for calibration of strain gages, but not for determination of boundary spring stiffness.	
14.	In response to Cygna comment no. 14 of Reference 7, Impell acknowledged the poor correlation of the mode shape and frequency of the 8.5 Hz mode as shown in Fig. 4.2c of Reference 4. Impell thought that the test mode shape plotted in the figure was probably picking up contributions from the closely spaced 6.8 Hz mode. Impell thought this could account for the poor correlation near S1 and S2. Impell said they would appropriately "caveat" the correlation of this mode in the next revision of Reference 4. Cygna also noted that Table 2-2 of Reference 4 shows only two TFs were used to identify the test mode shape, whereas Fig. 4.2c showed eight TF points plotted. Impell said that they would reconcile the difference.	
15.	a. i. In response to Cygna comment no. 15a of Reference 7, Impell said that mode nos. 9, 12 and 17 (with frequencies of 7.23, 9.38 and 12.57 Hz, respectively) predicted by the "production" model were fallacious modes. These modes were a result of the low clamp stiffness used in the "production" model and did not appear among the measured test modes. This, in fact, is one of the reasons for revising the clamp stiffnesses from their "production" model values	

to the "refined" model values. Mode nos. 9 and 12 disappear when higher clamp stiffnesses are used in the "refined" model.

A mode similar to mode 17 of the "production" model still appears in the "refined" model (as mode 10 with a frequency of 14.95 Hz), but the nature of these two modes is somewhat different. This is discussed in item (c) below.

ii. In Cygna comment 15 a of Reference 7, Cygna had asked why mode no. 15 with a frequency of 10.83 Hz (in addition to mode nos. 9, 12, and 17 discussed above) had not been picked for correlation although it had significant participation. Impell acknowledged that this was an error. The test mode shape of the 12.0 Hz mode was erroneously correlated to the 11.1 Hz mode of the "production" model, while the 12.0 Hz mode should have been correlated to the 10.83 Hz mode. Impell said that they would correct this error.

b. In response to Cygna comment no. 15b of Reference 7, Impell said that the modes with frequencies 5.0 and 13.8 Hz were local modes, and therefore, the use of these modes which have low participation factors is justifiable. Additionally, the mass ratio (a measure of participation factor) of 0.037 for the 13.8 Hz mode is really not too low. With regard to the 11.1 Hz mode, Impell said that it was picked for correlation erroneously, and it should not have been picked. See Item 15.a.ii, above.

c. In response to Cygna comment no. 15c of Reference 7, Impell said that the correlation in Fig. 4.2.d of Reference 4 was within testing accuracy. It was noted that in Fig. 4.2.d, the plotted analytical mode is for 10.8 Hz, and not for 11.1 Hz as labelled (see items 15.a.ii, and 15.b, above).

16. In response to Cygna's request for mode shape plots of the "refined" model (see Cygna comment no. 16 of Reference 7) Impell said that such plots were never generated and, therefore, are not available for Cygna's review. Impell added that they performed the correlations by studying the mode shape printouts.

The above completes the discussions on the sixteen questions and comments raised by Cygna during the July 17, 1987 meeting. Additional discussions were held as follows:

a. Cygna noted that mode 9 (frequency = 9.1 Hz) of TC 7, model 4 (the "refined" model) had a very low participation factor. Cygna asked why this mode was picked for correlation with the test

Item	Comments	Required Action By

mode having a frequency of 8.5 Hz. Impell said that the test mode having a frequency of 8.5 Hz. Impell said that the analytical model showed a maximum modal amplitude at the third span, similar to measurements from the tests for the 8.1 Hz mode. Due to lack of additional evidence and because of the earlier questions on the 8.5 Hz mode (see Item 14, above), Impell said that they would study this mode further, and address the concerns in the next revision of Reference 4.

b. Cygna noted that mode 14 (frequency = 11.54 Hz) of TC7, model 4 (the "refined" model) had a large participation factor in the vertical direction, and asked why no such vertical mode was measured in tests. Cygna also noted that vertical TF nos. 5 and 67 also showed some test response near 11.5 - 12.0 Hz, and asked if this response could be used to correlate mode 4. Impell said that they would attempt to demonstrate the above correlation.

c. Cygna noted that mode 20 (frequency = 14.75 Hz) of TC7, model 4 (the "refined" model) had a large participation factor in the longitudinal direction, and asked why no such longitudinal mode was measured in tests. Impell said that they would try to identify a measured longitudinal mode at around 15 Hz, and, if not successful, they would explain why this mode was not identified among the test results.

With regard to the same mode, Cygna commented that, according to the mode shape printout, this mode was similar in shape to mode 17 of model 1 (the "production" model) which, one expected, should have disappeared due to the increase of clamp stiffness. See Item 15.a.i, above. Impell responded that there was a subtle difference in the shapes of mode 17 of model 1 and mode 20 of model 4 that could justifiably exist due to the torsional flexibility of the tiers for support S1. At the lower tier of S1, the modal amplitudes are as shown in Figure 1.

d. i. Cygna asked if the transverse tier displacements used in the buckling (axial force determination) analysis in the Appendix E of Reference 6 for TC6 were occurring at the same instant. (See also Fig. 3.6 of Reference 3.) Impell said that that was the case.

ii. With regard to the same analysis, Cygna asked what the vertical displacements at that same time instant were, and if the vertical displacements had been input in the ("IMNSAP") analysis. Impell said that vertical displacement measurements were not available, and that their omission was conservative. However, Impell added

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Item	Comments	Required Action By

that they would investigate the effect of omission of vertical displacements on the conclusions of their IMNSAP analysis.

iii. With regard to the same analysis, Cygna noted that the results reported on p. 7-21 of Reference 6 indicated that the extreme fibers of the equivalent cross-section used to model the C4 post members were yielding. Cygna asked if this meant the TC6 configuration was at an incipient buckling stage. Impell said that their design verification procedures had factors of safety, and, in practice, actual posts are never subjected to high axial loads such as those input to TC6 posts.

e. Cygna noted that there was only one vertical transducer mounted on the tray (data channel 36). Cygna asked how the shapes of the vertical modes, measured at 5.0 and 9.5-10.5 Hz could be presumed to be asymmetric and symmetric, respectively, given the lack of adequate instrumentation. Impell said that the TFs shown in Figs. H-3a and H-3b of Ref. 6 ascertained a modal frequency near 6.75 Hz, and the time history plot of Fig. H-3c of Reference 6 ascertained a mode near 10 Hz. Cygna acknowledge that there could be such modal frequencies, but questioned the presumed test mode shapes. Impell said that they would clarify how the shapes of the vertical modes were identified.

f. Cygna noted that the computer output associated with TC6 "production" model showed the asymmetric vertical mode at the frequency of 6.6 Hz, but not at 6.8 as shown in Reference 3 and 6. Impell said that they would correct this error.

g. Impell said that they would revise the incorrect heading of Table 5.3 of Reference 4 from "Model 4, Model 5" to "Model 3, Model 4".

h. Cygna noted that TC6 "best case" model analysis had clamp rotational stiffnesses input as 0.01 k-in/rad. in all three directions. These values are in contradiction to the following proposed clamp stiffnesses:

Axis of Rotational Stiffness	Stiffness
Vertical	Rigid
Longitudinal	Rigid
Transverse	22.4 k-in/rad.

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Furthermore, with a clamp rotational stiffnesses of 0.001 k-in/rad. it is claimed that good correlation with the test results is achieved. Cygna asked how the proposed increase in clamp stiffnesses could be justified since even a 0.01 k-in/rad clamp stiffness provided good correlation.

Impell said, although the vertical and longitudinal rotational stiffnesses were input as 0.01 k-in/rad., effectively, they were large, since the tray width was modelled and large translation clamp stiffness values were input with a moment arm equal to the tray width between them. Impell acknowledges that the transverse rotational stiffness should have been 22.4 k-in/rad. instead of the 0.01 k-in/rad. input.

i. In the next revision of Reference 5, Impell will clarify that the terms "production" and "refined" are not used in the same context for TCs 6 and 7 since the current usage is:

"Production" Model	"Refined" Model Transverse Rotational Clamp Stiffness (K-in/rad.)
TC6 "new" tray inertia	0
TC7 "old" tray inertia	22.4

Additionally in Fig. 6.1 of Reference 6, the term "refined" model for TC6 is used to denote a model in which the tray width is modelled. This is inconsistent with the TC7 "refined" model notation since, in the TC7 "refined" model, the tray width is not modelled.

j. Cygna asked for a summary of Impell's justifications for revising the clamp stiffnesses from their original ("production" model) values to their higher stiffness ("refined" model) values.

Impell summarized as follows:

Impell Calculation M-10 contains the derivation of the original clamp stiffnesses using a mechanics of materials approach. In the current design verification (DV) work, "rigid" clamp stiffness values are specified in Impell Procedure PI-11. Past DV work, i.e., work done prior to revision of the clamp stiffnesses by PI11, is generally not revisited or revised. Earlier (pre-PI-11 revision) qualification, as well as M-10 itself, are not invalidated. The TC 7 correlation calculations (Reference 4) showed the "production" model clamp stiffnesses resulted in

Item	Comments	Required Action By

unrealistic modes (see Item 15.a.i) and high total displacements at supports and tray spans (see Table 6.3 of Reference 3). Furthermore, the tests showed that there was very little tray slippage. Based on these observations, the longitudinal and vertical translation clamp stiffnesses were revised in PI-11 to the "rigid" values. The transverse rotational clamp stiffness is not being revised from its earlier M-10 value. The remaining clamp stiffnesses, i.e., transverse translational, and longitudinal and vertical rotational stiffnesses were already high and were revised upward in PI-11 to the rigid values solely for the sake of convenience.

Cygna requested that all of the above justifications be put in one position paper and be quantitatively justified. Impell said that they would provide such a position paper.

Cygna summarized its understanding of the results of the cable tray system dynamic tests as follows:

i. The test results can be used to demonstrate the overall integrity of cable tray systems. However, due to the number of concerns raised by Cygna regarding the correlation attempt, Cygna feels that the claimed correlation should be interpreted cautiously.

ii. The use of 4% and 7% damping in DV effort for OBE and SSE events is appropriate. However, the existence of higher damping values claimed on p. 2 of Reference 1 cannot be substantiated by the test results.

iii. The resolution of every generic issue is based on analytical methods with the cable tray system dynamic test results being used only for "added confidence" in the analytical methods used. The only area where the DV effort is utilizing test results in a quantitative manner is in the revision of clamp stiffnesses from original Impell calculation M-10 values to "rigid" values. This aspect will be further evaluated upon receipt of the Impell position paper on the subject. (See Item (j) above.)

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Communications Report

Company:	CES	☐ Telecon	☒ Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No:	84056
		Date:	9/3/87
Subject:	Status of Cable Tray Support Review Issues List	Time:	10:00 a.m.
		Place:	CPSES Site
Participants:	S. Harrison, J. Muffett	of	TU Electric
	P. Harrison		Ebasco
	G. Ashley		Impell
	J. Russ, N. Williams		Cygna

Item	Comments	Required Action By

Cygna met with TU Electric, Ebasco and Impell to status the audit of the cable tray support design verification program and to establish a common list of action items that could be worked from.

Cygna stated that the term cumulative effects would be defined as those assumptions or processes used in the design verification program that were not quantified, but could in some fashion erode the margin to the design allowables. Cygna noted that assumptions on the contributions of the effects of eccentricities are the primary considerations in the cumulative effects review. Cygna will develop a list of the eccentricities with which they have concerns during the discussion on the RIL.

Impell noted that a database exists which shows the margin levels in the various cable tray support members. Impell also stated that the approach that had been taken in the design verification process was reasonable. Cygna replied that use of a reasonable approach is not sufficient justification and must be provided with a quantification of the effects of the various assumptions that had been made in the design process. Impell stated that they would provide a copy of the database to show that the margins in the support members are low and would support the assumptions that were used in the design verification process. Impell stated that they would provide a white paper to address the effects of weld eccentricities on the adequacy of the welds. Impell Calculation M-12 was also revised to consider the effects of eccentricities.

Signed: J. P. Russ for N. H. Williams

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The status of the outstanding issues listed in the Cable Tray Review Issue List (RIL), revision 14 was discussed as well as the actions to be taken by the various parties is summarized below.

/ Issue 1 - Controlling Load Case for Design

1. Cygna must review the joint position paper on the margins against buckling.

Review Issue 2 - Seismic Response Combination Method

2. Cygna must review the Ebasco study on load combination which as been provided.

3. Impell will provide a study that shows that the time history methodology that they had used for the comparison was enveloping for the plant. The evaluation that they had performed considered both the upper and lower elevations of the plant. The evaluation has shown that the effect of the combination is significant only when the dead weight contribution is large. Impell also uses an enveloped time history from the floor response spectrum.

Impell noted that the RIL description did not state whether Cygna accepted the approach used by Impell, i.e., the comparison of a time history to a response spectrum analysis. Cygna stated that the acceptability of the method would be discussed with the reviewing engineer and the RIL would be updated to be more specific.

Review Issue 4 - Design of Compression Members

Sub-issue A

4. Cygna asked what Ebasco and Impell do when an individual support configuration is not enveloped by the configurations that were used in developing the effective length factors for buckling. Impell stated that, in such cases, the engineer is instructed to see their group leader. Ebasco and Impell suggested that Cygna check their review scope for examples of such an case to determine the action taken by the contractors.

Sub-issue B

5. Ebasco has transmitted a response on the effective length factors for longitudinal supports which have their posts rotated 90 degrees from the configuration assumed for transverse trapeze supports. Impell is completing their study and will

transmit it to TU Electric so that it may be transmitted to Cygna.

Sub-issue D

6. TU Electric will provide a paper on weld undercut and member acceptability in light of the usage of the VWAC at CPSES.

Sub-issue E

7. Cygna had expressed concerns that the measurement tolerances for plumbness were not properly considered in Ebasco's and Impell's evaluations. The particular concern was with the 5 degree tolerance on angular measurements. Impell stated that tolerance was not used to measure plumbness, but other angles. TU Electric stated that plumbness was checked by using laser surveying equipment. TU Electric will provide Cygna with the procedures for the surveying tasks.

Review Issue 6 - Support Frame Dead and Inertial Loads

8. Ebasco will provide, via a revised response, the rationale employed for selecting the hangers in the sample of 200 that exhibits the acceptability of their previous response.

Review Issue 7 - Design of Angle Braces Neglecting Loading Eccentricity

Sub-issue B

9. Cygna had expressed concern on Impell's use of the 1.2 factor to account for the use of geometric properties in the stress evaluation of stresses in base angles. This concern was based on the use of equal moments to develop the factor of 1.2. Such a condition may not exist for angles which have the opposite legs welded or for out-of-plane bending. Impell and Cygna stated that they would check the development calculation to determine any effects of this concern.

10. Cygna noted that in one of their discussions with Impell, one of the angle sections in their member property database was not compact. Impell stated that on p. 49 of their SUPERPOST theoretical manual it is noted that all angle sections in the database are compact. Cygna will determine which angle sections were noted as non-compact and discuss this issue with Impell.

Item	Comments	Required Action By

11. Impell will revise PI-03 to include the Calculation M-22 compactness criteria and transmit it to Cygna for review.

12. Impell will revise PI-11 to remove the use of the geometric radius of gyration in the calculation of the reduced effective member lengths and transmit it to Cygna for review.

13. Cygna asked how the differences in the assumptions used by Ebasco and Impell for the end conditions for in-plane angle braces for trapeze frames was to be reconciled. In Impell Calculation M-12, Impell concludes that the end fixity of the braces is more important than the consideration of the eccentricities, which is in direct contradiction with Ebasco's practices. In response, Impell noted that the frame action of the supports would absorb the moment than the angles which were less stiff flexurally. Impell stated that the database that was being provided to Cygna would show the effect of the moments due to fixity on the angles. Cygna stated that they would review the database but noted that the database was for longitudinal braces only.

Sub-issue C

14. Impell has revised Calculation M-12 to remove the use of 95% of the Euler buckling length. This will be provided to Cygna for review. Cygna stated that the revision to M-12 was required because there was a difference between the cut-off lengths used by Ebasco and Impell and Cygna wished to investigate the differences.

15. Cygna had requested that Ebasco and Impell provide a justification of the use of the twist-buckling lengths in their criteria (which is based on a concentrically applied axial load) to the end conditions with the same leg welded at both ends of the members and opposite legs welded at the each end of the members. Impell and Ebasco stated that their approach to the twist-buckling of angles was correct and that they considered the applied moments due to any eccentrically applied load. Cygna stated that they had performed a study which to investigate this concern and the results had shown a significant reduction in the allowable values.

In order to provide Ebasco and Impell with some insight into Cygna's efforts, Cygna contacted the responsible engineer who provided a brief description which was relayed to Ebasco and Impell. A summary of that approach is contained in Attachment 1. In order to more fully discuss Cygna's study, a conference call was planned for Wednesday, September 9, 1987.

Item	Comments	Required Action By

Review Issue 8 - Dynamic amplification Factors (DAF), Tributary Tray Support Reactions and Missing Mass Effects

16. Ebasco will provide Cygna with a copy of the final MRM report for review.

Review Issue 9 - Reduction in Channel Section Properties Due to Clamp Bolt Holes

17. Ebasco will provide the responses to Cygna's questions on the bolt hole studies.

18. Impell will provide a copy of Calculation M-65 so that Cygna may study the differences between the reduced section properties used by Ebasco and Impell. Impell stated that their recollection was that Calculation M-65 assumed the reduction in the section occurred at the flange tips.

Review Issue 12 - Working Point Deviation Study

19. Ebasco will provide a response to Cygna's concern on the modelling assumptions used for considering the working point deviation.

Review Issue 13 - Reduced Spectral Accelerations

20. Ebasco will provide a response to Cygna's concern on the vertical location of the lumped masses in longitudinal supports.

Review Issue 14 - Non-conformance with AISC Specifications

Sub-issue B

21. Ebasco and Impell will provide a response to Cygna's concern on the use of the tier-to-tier distances in the calculation of the allowable flexural stresses. Impell stated that they felt that the distance used was appropriate based on their communications with AISC and the fact that inflection points in a member's moment diagram could be used for bracing. Impell stated that such points would be located at the tier-post connections.

Sub-issue E

22. Cygna stated that they would clarify their concern and discuss it at a later date.

Item	Comments	Required Action By

Sub-issue F

23. Ebasco will provide a response to Cygna's questions on oversize bolt holes.

Sub-issue H

24. Ebasco and Impell stated that they both use Cm = 1.0 even though a smaller value could be justified. Cygna reviewed the appropriate sections of the AISC code and stated that the approach seemed appropriate, but would study it further.

Review Issue 15 - Member Substitution

25. See Review Issue 16.A

Review Issue 16 - Weld Design and Specifications

Sub-issue A

26. Ebasco will provide all references to the hidden attributes study. Presently, Cygna is only missing the study on base-metal defects.

Sub-issue B

27. See Review Issue 16.A

Sub-issue C

28. Impell will provide a response on the effects of the weld eccentricities.

Sub-issue D

29. Ebasco will provide a copy of their revised response to Cygna for review.

30. Impell will provide a copy of PI-03 to Cygna for review.

Sub-issue G

31. Impell will provide the requested references to Cygna.

Sub-issue H

32. Ebasco and Cygna will have a conference call to discuss Cygna's concerns on the weld qualification. It was noted that the

effective weld throat assumed in the design verification has been reduced to 40% of the gusset plate thickness. This is as a result of ultrasonic testing performed on a sample size of welds. A report documenting this study will be provided to Cygna.

Review Issue 18 - Cable Tray Clamps

33. Impell will provide a white paper on revised tray clamp stiffness values and response to Cygna's questions on the cable tray system testing.

34. Cygna will complete the review of the Ebasco procedures on clamp testing and qualification.

35. Cygna will audit Impell Project Instruction PI-06.

Review Issue 19 - FSAR Load Combinations

36. Impell will provide a copy of Calculation M-27, revision 2 for Cygna's review.

Review Issue 20 - Differences Between the Installation and the Design/Construction Drawings without Appropriate Documentation

37. Cygna will transfer this issue to the Design Control review except for the issue listed below.

Sub-issue MM

38. TU Electric will provide the procedures for the CARDS module for Cygna's review after they become available on September 21, 1987.

39. Impell stated that Calculation M-39 has been revised and will show that the weight contributions of the cover and side-rail extensions are small and will not erode the 10% margin that was to be used for future cable additions. The revised calculation will be provided for Cygna's review.

Review Issue 21 - Design Control

40. See Review Issue 20.MM.

Review Issue 23 - Loading in STRESS Models

41. Ebasco will provide the calculations justifying the application of the transverse tray loads at the posts for Cygna's review.

Item	Comments	Required Action By

Review Issue 24 - Design of Flexural Members

Sub-issue B

42. Ebasco has provided the calculation on the additional major-axis moment in the tiers due to transverse load to TU Electric for transmittal to Cygna. Cygna will review upon receipt.

Sub-issue B

43. Impell will provide a response to Cygna's concern on minor-axis bending due to transverse loads.

Sub-issue C

44. Ebasco will provide the justification for the location of the vertical tray load on the tier members that was originally prepared for the third party reviewers.

Sub-issue D

45. Ebasco will provide a response to Cygna's concern on the location of the longitudinal tray forces for one- and two-bolt clamps.

Sub-issue E

46. TU Electric will provide the study involving VWAC (which is attached to the FSAR) and undercut for Cygna's review.

Sub-issue F

47. Ebasco is providing a revised response on the boundary conditions of composite channels attached to base angles.

48. Impell will provide a response on the boundary conditions of composite channels attached to base angles.

49. Ebasco and Cygna will discuss the methodology used to analyze the composite channel sections with multiple bracing points during a conference call.

50. Ebasco uses the combined section properties for composite sections. These properties are taken directly from the COMBS output.

Sub-issue H

Item	Comments	Required Action By

51. Ebasco no longer uses the factor to account for warping normal stresses. Ebasco's General Instructions have been revised to require that the warping normal stresses be added into the interaction equation.

Review Issue 25 - Cable Tray Qualification

52. See Review Issue 8.

Sub-issue B

53. Ebasco has transmitted SAG.CP-18 to TU Electric for transmittal to Cygna for review. Cygna will review upon receipt.

54. Cygna must complete their review of Ebasco's cable tray qualification program.

55. Cygna must audit Impell's cable tray qualification program.

Sub-issue C

56. TU Electric stated that the test performed in the resolution of the SDAR were complete and the results will be available in a reading room at Impell's Walnut Creek offices. The procedures used for the implementation of the test results are contained in Ebasco's SAG.CP-18 and Impell's PI-06.

Sub-issue D

57. Ebasco has transmitted SAG.CP-18 to TU Electric for transmittal to Cygna for review. Cygna will review upon receipt.

58. Cygna will review Impell's Project Instruction PI-06.

Review Issue 26 - Base Angle Design

59. Impell will provide a response to Cygna concerns on the base angle qualifications.

Review Issue 27 - Support Qualification by Similarity

60. Ebasco stated that the database is not used for any design qualification efforts.

Item	Comments	Required Action By

61. In response to Cygna's questions on how Attachment Z related activities will be performed for grouped supports, Ebasco provided the following response:

    a. A frequency and static analysis will be performed for every support.

    b. If the loads from the static analysis are less than those from the analysis of the mother support, the mother support analysis will be attached to the individual support. If the loads from the individual support analysis are greater than those from the mother support analysis, a new qualification will be performed.

    Ebasco stated that most supports will have a stand-alone package at the completion of the Attachment Z activities.

Review Issue 30 - Cable Tray Damping Values

62. Tentatively closed based on the results of Cygna's review of the cable tray system dynamic testing.

The four parties agreed to discuss the remaining review issues at a later point date. Those issues are 31, 32, 33, 34, 3, 10 and 14E.

Additionally TU Electric stated that they would meet with Ebasco and Impell to discuss the cumulative effects of the following issues on the cable tray support design verification:

a. VWAC (RIL 4.D)
b. Angle brace eccentricities (RIL 7.B)
c. Angle brace boundary conditions (RIL 7.B)
d. The vertical eccentricity of the tray mass in frequency calculations in Ebasco calculations (RIL 13.B)
e. Weld connection eccentricities (RIL 16.C)
f. Major axis bending due to transverse tray loads (RIL 24.A)
g. Minor axis bending due to transverse tray loads (RIL 24.B)
h. Torsion due to vertical tray loading (RIL 24.C)
i. Torsion due to longitudinal tray loading (RIL 24.D)

Cygna stated that there were other eccentricities to be considered but are listed in the review issues that were not discussed. If an attempt is to be made to address Cygna's concerns, then these eccentricities should be considered.

ATTACHMENT 1

Summary of Cygna's Approach to the Evaluation of Angle Twist-buckling

1. The finite element analyses were elastic. Inelastic analyses were not performed.

2. Three cases were considered: concentrically applied load, the same angle leg welded at each end of the member and the opposite leg welded at each end of the member.

3. Elastic analyses were performed to determine the location of Cc. Elastic equations were used for the region where kl/r were greater than Cc. A crush load was calculated for the case where kl/r = 0. Between the point of crush and Cc, the curve used by Bleich was fit to the data to simulate the inelastic region.

4. Compactness criteria was checked.

5. The results of the study were compared to AISC to determine if the approach previously used at the plant was correct.

6. The results of Cygna's study show that for a concentric load case of a 3-1/2x3-1/2x3/8 angle, the critical length below which twist-buckling would occur is approximately 80 inches.

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Communications Report

Company:	CES	[X] Telecon	[ ] Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	9/14/87
Subject:	Twist-buckling of Angles	Time:	8:30 a.m.
		Place:	Walnut Creek
Participants:	P. Harrison	of	Ebasco
	G. Ashley		Impell
	M. Engelman		Cygna (Boston)
	J. Russ		Cygna

Item	Comments	Required Action By

A conference call was held to discuss in detail Cygna's study on the twist-buckling of angles.

Cygna began by noting that the purpose of the study was to evaluate the critical buckling stress for two angle sections, L3x3x3/8 and L3-1/2x3-1/2x3/8 for three sets of boundary conditions which are listed below:

CASE	DESCRIPTION
1	Concentric loading
2	Opposite legs loaded at opposite ends
3	Same leg loaded at opposite ends

The angle lengths ranged from 18 to 156 inches, which are representative of the lengths found at CPSES.

The investigation consisted of an elastic finite element analysis of the two angle sections and the three boundary conditions. The calculation has eight parts. A brief description for each part follows:

1. Development of the elastic finite element models.

2. Perform sensitivity studies to determine the appropriate model parameters, i.e., mesh size, element type, etc., to adequately

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predict torsional flexural behavior.

3. Perform an elastic buckling analysis of Case 1 and compare with closed form solutions. The buckling load and the eigenvector were extracted. The comparison to the closed form solution showed agreement to within 2%.

4. Perform elastic buckling analyses for Cases 2 and 3 and compare the results of the Case analyses against solutions provided in the literature.

5. Convert all results to elastic buckling stresses.

6. Determine the transition point between elastic and inelastic buckling behavior, the crush load for zero length column and determine a reasonable curve fit between the two points.

7. Construct the critical stress curve for the entire range of lengths and consider the effects of moment magnification and member end restraint on these stresses.

8. Determine the appropriate factors of safety over the elastic and inelastic buckling regions and calculate allowable stresses versus slenderness ratios for all cases.

Cygna then provided details on the results of the analyses for Cases 1, 2 and 3.

Results for Case 1

Three parameters were determined to be important when constructing the finite element models so that the twist-buckling behavior of the angles could be adequately predicted. These are the stiffness matrix, the stress-stiffening matrix and the master degree of freedom and node numbering sequence. The first two parameters are affected by the mesh size and the element type. The final was investigated to determine its affect on the results.

The results of the analysis for Case 1 showed the buckling behavior was torsinal-flexural and flexural buckling for all lengths. These results matched the closed form solution to within 2%. The analysis correctly predicted the eigenvectors for the first five modes for all lengths. The transition length between torsional-flexural and flexural behavior for the 3-1/2 inch angle was predicted to be approximately 30 inches which correlated well with the closed form solution. The eigenvalues were predicted to be within 2% of the closed form solution and the torsional flexural results to within 1%.

From these results, Cygna concluded that the buckling analysis accurately predicted the elastic buckling eigenvalues and eigenvectors for the torsional-flexural and the flexural failure modes for all lengths. Thus, Cygna decided that the use of the models would be appropriate for use in evaluating Cases 2 and 3.

<u>Results for Cases 2 and 3</u>

The elastic buckling failure for Case 2 was torsional-weak axis flexural for all lengths from 18 to 156 inches. The elastic buckling lengths were reduced for all lengths, i.e., there was no transition point. For the longer lengths, the flexural failure mode dominated and matched the AISC predicted pure flexural behavior within 10%. for the shorter lengths, the torsional component dominated and the eigenvalues were dramatically reduced from the pure flexural and elastic buckling results. Twisting of one end relative to the other was predicted. Cygna noted that for a length of 18 inches, the predicted response was 16% of the Euler predicted response.

The elastic buckling failure for Case 3 was coupled torsional-strong axis flexural-weak axis flexural for all lengths, which agrees with the theory. As for Case 2, the elastic buckling loads were reduced for all lengths with no transition point. For the longer lengths, the flexural component of the eigenvector dominated and the eigenvalues were only slightly reduced from the AISC pure flexure. The short lengths had a somewhat non-descript failure mode. Failure occurred by buckling of the loaded leg causing a midspan rotation and flexure of the non-loaded leg. The twisting always occurred at midspan.

The results of the Case 3 analysis were compared with the theoretical closed form differential equations solutions. All eigenvalues compared within 1.25% over the entire range of lengths. The closed form solution was from a paper by Marsh (1969). In Marsh's paper, he compared the theoretical solution with experimental results and showed excellent agreement when the theoretical results were factored by 0.90 to account for residual stresses and out-of-straightness.

The failure load and the transition point between elastic and inelastic buckling were then determined for Cases 2 and 3.

For Case 2, the failure load was based on a secant approach. Failure was assumed at first yield. The failure load was calculated using static analysis results. Some conservatisms such as residual stresses were removed from the calculation. The Case 3 failure load was based on ultimate strength using data from analytical and experimental tests.

Item	Comments	Required Action By

In determining the transition point, the elastic results were considered valid when the summation of the residual compressive stresses, the bending stresses and the axial stresses were less than 36 Ksi. The proportional limit was then calculated. Cc was calculated by the following formula:

$$C_c = \pi \sqrt{(E) / (\sigma_p)}$$

where:

E = Young's modulus
σ_p = Proportional limit

Cc was calculated as 160.6 and 164.6 for Cases 2 and 3, respectively. The lengths that corresponded to these values were 110 and 113 inches, respectively. The static analysis results were used to calculate the axial and bending stresses. The residual stresses were taken as 25% of yield as recommend in a paper by Usami and Galambos (1971)

The curve fit techniques originally developed by Bleich (1952) and currently used by AISC were used. AISC uses a proportional limit equal to 50% of yield because of the assumption that residual compressive stresses are also 50% of yield. These values have been shown to represent a good compromise for the actual column strength curves. The curve fitting was to match the two end points and the slope at kl/r = 0.0 and kl/r = Cc. The AISC curve fit is parabolic and matches the end points and slope with a proportional limit of 50% of yield. Since Cygna considers residual compressive stresses of 25% of yield, a fifth order equation was required to match the end points and the slope.

The results of the curve fit showed excellent correlation with a slight overprediction of buckling loads for the shorter lengths. The same curve fit was used for Cases 2 and 3 where bending stresses are present. For Case 1, where bending stresses do not exist, the AISC curve fit was used.

<u>Calculation of Critical Buckling Stresses</u>

Cygna summarized the results for all cases. Case 1 was essentially identical with AISC. Case 3 was compared with three analyses with similar loadings and end conditions. The three papers were by Usami and Galambos (1971), Usami and Fukamoto (1972) and Chuemei (1984). The first paper compared theoretical and test results, the second reported test results and the third used finite element

elasto-platic and test results. The comparison for Case 3 showed very good agreement.

Cases 2 and 3 were compared against three commonly used codes: AISC, ASCE Manual No. 52 and the European Convention for Constructional Steel Work (ECCS). The comparisons were the results of the Cygna analysis to the requirements for pure axial load, i.e., no moments due to eccentric load application. For lengths less than 100 inches, the L3-1/2x3-1/2x3/8, Case 2 and 3 were significantly lower than AISC and ASCE. The ECCS was closely matched for lengths greater than 60 inches. For the shortest lengths, the results for Case 3 were 58% of the AISC predicted results and the results for Case 2 were 50% of the AISC predicted results.

As a result of the above analyses, Cygna concluded that for shorter angles in particular, that Gibbs & Hill's practice of designing single angle braces without consideration of the eccentrically applied axial load underpredicted the critical stress in the angle.

Determination Appropriate Factors of Safety for the Elastic and Inelastic Buckling Regions

Cygna's goal in this section was to arrive at an allowable stress versus the angle length for Cases 2 and 3. The reduction in elastic buckling loads due to midspan deflection was examined for Case 3. Cases 1 and 2 do not produce static deflections at midspan. To accomplish this objective, Cygna essentially performed a P-delta analysis. The additional movement due to P-delta effects were considered as an equivalent eccentricity. This eccentricity was added to the original eccentricity and new buckling loads were calculated from the solution of the differential equations as given by Marsh (1969) and Timoshenko (1961). The P-delta effects had a negligible effect on the elastic buckling loads for long angles. Therefore, the secondary P-delta effects could be ignored without any decrease in the elastic buckling loads.

Other Work

Cygna began, but did not complete, an investigation into the reduction into the critical inelastic buckling loads due to the effects of initial crookedness and initial curvature due to deadweight.

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Communications Report

Company:	CES	[X] Telecon	[ ] Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	9/15/87
Subject:	Status of Cable Tray Support Review Issues List	Time:	2:15 p.m.
		Place:	Walnut Creek
Participants:	S. Harrison	of	TU Electric
	P. Harrison		Ebasco
	G. Ashley		Impell
	W. Horstman, D. Leong, J. Russ, N. Williams		Cygna

Item	Comments	Required Action By

REFERENCES

Communications Report between S. Harrison, J. Muffett (TU Electric), P. Harrison (Ebasco), G. Ashley (Impell), J. Russ, N. Williams (Cygna), dated September 3, 1987, 10:00 a.m.

A conference call was held to discuss and status the Review Issues that were not covered in the referenced Communications Report.

Review Issue 3 - Anchor Bolt Design

Sub-issue A

Cygna stated that they had completed the review of the grouting and shimming procedures. These procedures state that if the gap under the base plate is greater than 1/16 inch, the gap must be grouted to assure that the contact area is greater than 80% of the surface area of the attachment. If the gap is equal to or less than 1/16 inch, grouting is not required. Cygna stated that the only way to reach the required torque on the anchorages for the case with a gap of 1/16 inch or less is to use shims. The shims are generally 5" x 5". Thus, for an L6x6x3/4 base angle, the base angle could be cantilevered over the shim. For such a situation, the prying factors calculated by Impell and Ebasco may not be applicable since the point of bearing against the concrete would change. Cygna noted that Ebasco had performed a study to show that the bearing pressure against the concrete was acceptable, but did not examine

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this concern. Cygna noted that the analytical and installation procedures must be consistent. Cygna requested an evaluation to consider the effects of the shims on the prying factors used by Ebasco and Impell. Two configuration were suggested for evaluation: a base angle and a two-bolt base plate.

1. Ebasco and Impell will provide an evaluation of the effects of shims on the prying factors.

Cygna noted that the configurations used by Impell in developing their prying factors differed from those that Ebasco used, yet the prying factors for both consultants are the same. Impell used the methodology used by Ebasco in developing their prying factors. Cygna asked why there was a difference. Impell noted that they had verified the Ebasco approach before using it in their production work and had noted some conservatisms, but decided to use the Ebasco prying factors for consistency.

Cygna asked why there were differences in the boundary condition stiffnesses used by Ebasco and Impell when the hardware was identical. Impell stated that they had performed a study which stated that the use of one stiffness value was appropriate.

Cygna also asked Impell to quantify the effects of the neglect of the eccentricity between the center-of-gravity of the post and the outstanding leg of the base angle on the prying factors and the stiffnesses. Impell stated that Cygna's concern was being addressed in the overall response to questions on eccentricities.

2. Impell will provide a response to Cygna's question on the effect of the eccentricity between the center-of-gravity of the post and the outstanding leg of the base angle.

It was noted that a response to Cygna's concern on the effect of the eccentricity between the application point of the shear loads and the bold in one-bolt base angles will be addressed by Ebasco and Impell.

3. Ebasco will provide a response on the effect of the eccentricity between the point of load application and the bolt for one-bolt base angles.

4. Impell will provide a response on the effect of the eccentricity between the point of load application and the bolt for one-bolt base angles.

Item	Comments	Required Action By

Review Issue 10 - System Concept

No actions are required as the effects discussed are being considered as part of the concerns on eccentricities.

5. Cygna will review the Review Issue List (RIL) to reflect the above statement.

Review Issue 14 - Non-conformance with AISC Specifications

Sub-issue E

6. Cygna will discuss the methodology used by Ebasco to evaluate the acceptability of gusset plates during the audit scheduled for the week of September 21, 1987.

Review Issue 31 - Modelling of Boundary Conditions

No actions are required. This issue is related to bolt hole oversizes in base angles.

Review Issue 32 - Conduits Attached to Cable Trays or Supports

Sub-section A

After initiating the conduit audits, Cygna had determined the approach used by the conduit design verification group in analyzing conduits attached to cable tray supports. The conduit group requires that the cable tray support have a minimum frequency. If that frequency is met, the design accelerations from the S-0910 package can be used with the tributary conduit span. If not, an RSM analysis must be performed using the stiffness of the cable tray support as part of the RSM analysis. Cygna noted that Ebasco, for ESM analyses, calculates the tributary conduit load and multiplies it by the peak of the appropriate 2% or 3% response spectrum including a factor of 1.5. This load is applied to the cable tray support. Cygna was not clear on Ebasco's procedures for RSM analysis. Cygna also noted that Impell simply lumps the conduit mass to their systems model. Cygna wanted justification that the approaches used between the consultants and between the consultants and the conduit design verification groups was consistent. If such consistencies were not present, Cygna requested justification.

Ebasco stated that Attachment U of the General Instructions is used for ESM analyses. A similar procedure is used for RSM analyses. Impell stated that the conduit group provides the conduit

Item	Comments	Required Action By

attachment loads from their analysis to Impell on a Report of Loads (ROL) form. Impell compares these loads to those predicted by their analysis. Cygna asked what steps Impell would take if the loads reported by the conduit group were larger than those predicted in the Impell analysis. Impell stated that they would apply the reported conduit loads as point loads in their model and perform a static analysis.

7. Cygna will review the procedures used by Impell and Ebasco for consideration of conduit loads on cable tray supports.

Sub-section B

Cygna requested copies of the walkdown procedures for recording attachments to cable trays. TU Electric stated that they would verify if the procedures were complete and provide them if they were.

8. TU Electric will provide Cygna with copies of the walkdown procedures for attachments to cable trays.

Sub-section C

Cygna stated that the approach on kinematic condensation described to Ebasco in a previous audit was acceptable. Cygna requested the revised procedures to review the specified methodology. Ebasco stated that the results of the work on kinematic condensation ere included in the revised General Instructions, a copy of which was sent to TU Electric for transmittal to Cygna.

9. Cygna will review the revised procedure on kinematic condensation.

Review Issue 33 - As-built Walkdown Procedures

Sub-section A

Cygna noted that the RIL refers to questions from the May audit at Ebasco which were written prior to the white paper on tolerances. Cygna stated that the greatest concern is with the 1 inch tolerance on the anchorage location, especially Hilti Kwik-bolts. Impell replied that their opinion was that a 1 inch tolerance on a 1 inch anchor would not have a significant effect. They also noted that Stone & Webster (SWEC) was performing a walkdown for spacing and edge distance violations. Cygna acknowledged SWEC's activities, and noted that SWEC was reporting spacing violations between concrete attachments with instructions that the contractor responsible for the attachment utilize "defensible tolerances" in the

Item	Comments	Required Action By

evaluation of the spacing violation. Impell stated that they had performed a study for new installations which showed that tolerances of 3 inches on bolt spacing and 1-1/2 inches on bolt location were acceptable. Cygna requested this study for review and stated that if any other tolerances were a concern they would be discussed at a future date, preferable at the next scheduled audit of Ebasco in New York.

10. Impell will provide Cygna with a copy of the study on anchorage spacing and bolt locations

11. Cygna will discuss concerns on tolerances with Ebasco and Impell.

Sub-section B

Cygna stated that they had reviewed the Visual Weld Acceptance Criteria (VWAC) procedures for weld inspection in light of the margin reduction evaluation for cumulative effects. Cygna stated that since cumulative effects were being considered as those reductions in margin based on assumed behavior, then it was necessary for the reductions implicitly allowed in VWAC be evaluated for the configurations unique to CPSES. Impell stated that VWAC was based on the inherent conservatisms in AWS welding procedures. VWAC simply states that those conservatisms are so large that the 8% increase in stress noted in the VWAC document could be neglected. It was also noted that VWAC does not have limitations on weld configuration. TU Electric stated that the VWAC procedure was accepted by the NRC and was included in the CPSES FSAR. TU Electric stated that they would provide Cygna with the documentation on VWAC from the NRC and would check with their licensing group to see if limitations were imposed on the use of VWAC.

12. TU Electric will provide documentation on the NRC acceptance of VWAC for CPSES and will check if any restrictions on its usage were imposed.

Sub-section C

Cygna requested copies of procedures QI-QP-11.4 and QI-QP-11.3-29 to verify the recordation of tray covers and tray spacing. Impell stated that tray covers were always considered in the analysis. TU Electric stated that the spacing and cover issue was mainly an electrical issue, but would provide the procedures.

13. TU Electric will provide procedures QI-QP-11.4 and QI-QP-11.3-29 to Cygna for review.

Item	Comments	Required Action By

Review Issue 34 - System Analysis Methodologies

Sub-issue A

This issue deals with the corrective action for a reported SUPERPIPE error and the overlap procedures used by Ebasco and Impell.

Impell stated that error report SP-004 was addressed in a white paper previously provided to Cygna. Cygna stated that the white paper only addressed the analysis reviewed by Cygna where the error was discovered. Cygna's concern was with the overall impact that the error had on other analyses. Impell stated that an evaluation had been made and documented in a Technical Quality Report (TQR). Cygna requested a copy of the TQR for review. Impell stated that they would provide documentation to assure Cygna that the impact of the error on other analyses was considered.

14. Impell will provide documentation on the review of error SP-004 in other project analyses.

Sub-issue B

Cygna stated that the concerns expressed in this sub-issue are in regards to the overlap factor and the methodologies used by Impell in reducing the size of their cable tray systems models for ease of analysis. Primarily Cygna's concern were with the development of the ratios of the predicted forces between the partial models and the full models. Impell stated that the ratios of the loads showed that the overlap of 1.10 as given in the Brookhaven paper was validated by their analyses. Cygna disagreed and referenced their concerns. Cygna also voiced their concern with the comparison between the full model using the CQC combination and the half model using the closely spaced modal combination. Impell stated that CQC was used for both models. Cygna referenced the overlap model study report, which states that CQC was used only for the full model. Impell stated that they would provide a response to Cygna's concerns. Cygna requested that the response be closely referenced to specific portions of Impell's analyses and criteria.

15. Impell will provide a response to Cygna's concerns on overlap.

Secondary Wall Displacements

Cygna stated that during the review of the SWEC's activities in support of the civil/structural action plan, Cygna had noted SWEC had analyzed secondary walls at CPSES at the request of the cable

Item	Comments	Required Action By
	tray and conduit groups. Cygna asked how the displacements from the analyses of the secondary walls were going to be used. Impell stated that all 118 secondary walls were walked down to evaluate what types of support was analyzed using enveloped displacements. The results showed that all supports attached to secondary walls were not affected by the displacements. Cygna asked about the effects of the secondary wall displacements on any cable trays attached directly to the walls. Impell stated that there would be no effect on any trays.	
	16. Cygna will evaluate the response on secondary wall displacements.	
	Cygna stated that they were concerned that the calculations that they were reviewing were not current. It was noted that Cygna could not make conclusions on the acceptability of the approaches used by the consultants if the criteria and the approaches were going to change with time and Cygna was not informed. TU Electric replied that delays sometimes occur in site licensing that may affect document transmittal to Cygna.	
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Communications Report

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Company:	CES	[X] Telecon	[ ] Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	9/21/87
Subject:	Cable Tray Audit- New York Contact	Time:	2:00 p.m.
		Place:	New York, NY
Participants:	P. Harrison	of	Ebasco
	J. Russ		Cygna

Item	Comments	Required Action By
	Ebasco stated the Mr. Harry Schoopman would be Cygna's contact for providing information and arranging meetings to discuss cable tray issues. \TUE\092187-B.TEL	

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Communications Report

Company:	CES	[X] Telecon	[ ] Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	9/30/87
Subject:	Angle Twist-Buckling	Time:	11:45 a.m.
		Place:	Walnut Creek
Participants:	P. Harrison	of	Ebasco
	J. Russ		Cygna

Item	Comments	Required Action By
	Ebasco telephoned to discuss the required Ebasco actions to address Cygna's concern on twist-buckling. Cygna replied that they were making a comparison between the results of their study and the methods used by Ebasco and Impell.	

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Communications Report

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Company:	CES	[X] Telecon	[ ] Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	10/02/87
Subject:	Meeting Schedule	Time:	7:30 a.m.
		Place:	Walnut Creek
Participants:	S. Harrison	of	TU Electric
	J. Russ		Cygna

Item	Comments	Required Action By
	Cygna spoke with TU Electric on the proposed schedule of meetings and audits. Cygna requested that the meetings on cable tray issue resolution, scheduled for October 8 and 8, 1987, be rescheduled for October 12 and 13, 1987. This request was due to the presence of the minority owners in Cygna's offices during the week of October 9 to photocopy the Cygna engineer's personal notes and files. Cygna expected that this would cause some disruption in the normal work activities. Cygna requested a change in the proposed conduit audit to the week of October 19, 1987. The schedule change will allow an extra week to study the responses in the reading room being set up in Impell's Walnut Creek offices. TU Electric agreed with the proposed schedule change.	
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Communications Report

Company:	CES	[X] Telecon	[ ] Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	10/06/87
Subject:	Eccentricity Concerns	Time:	12:40 p.m.
		Place:	Walnut Creek
Participants:	P. Harrison	of	Ebasco
	J. Russ		Cygna

Item	Comments	Required Action By
	Cygna spoke with Ebasco to discuss Ebasco's questions on Cygna's concerns on eccentricities.	
1.	<u>Eccentricities for One- and Two-bolt Clamps</u> Ebasco stated that the evaluation for the differences between the two clamp configurations is found in Ebasco Calculations Volume I, Book 7, and Volume I, Book 2, Item 11.	
2.	<u>Eccentricity for Vertical Loads</u> The present analysis for the eccentricity of downward vertical loads is found in Ebasco Calculation Volume I, Book 7. Cygna noted that this analysis covered the behavior under downwards directed loads, but does not adequately address upwards directed loads.	
3.	Ebasco Transmittals Ebasco has transmitted to TU Electric, for transmittal to Cygna, the current revisions of the General Instructions and SAG.CP-11. The other requested material has been sent to the reading room set up at Impell's Walnut Creek offices. Ebasco and Cygna will discuss eccentricities during the meetings scheduled for October 12 and 13, 1987. \TUE\100687-A.TEL	

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Communications Report

Company:	CES	☐ Telecon	☒ Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	10/16/87
Subject:	Impell Calculation M-28	Time:	1:55 p.m.
		Place:	Walnut Creek
Participants:	R. Kaczkowski	of	Impell
	J. Russ		Cygna

Item	Comments	Required Action By
	After a review of Impell Calculation M-28, Cygna noted that the modeling procedure developed in the calculation may under-estimate torsional moments. The concern was not with member shear stresses, but rather with the moments induced into the connections. Cantilever supports were thought not to be a problem, which Cygna agreed with. Impell will provide a response to Cygna's concerns. \TUE\101687-C.CON	

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Communications Report

Company:	CES	[X] Telecon	[ ] Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	11/03/87
Subject:	Reading Room Documents Cable Tray/Hanger System Dynamic Testing	Time:	9:15 a.m.
		Place:	Walnut Creek
Participants:	S. Harrison	of	TU Electric
	P. Harrison, F. Hettinger		Ebasco
	G. Ashley		Impell
	J. Russ		Cygna

Item	Comments	Required Action By

Impell stated that they were sending the following documents to the reading room:

* Impell white paper IM-P-0019 on overlap
* Impell white paper IM-P-0017 and Impell Calculation M-49 on load combinations
* Supporting documentation for Impell white paper IM-P-0005

Cygna noted that they were presently reviewing the responses that were in the reading room and would attempt to speak to Impel later in the week regarding some of the calculations.

Cygna also noted that the review issues were being statused and would hold a conference call with TU Electric, Ebasco and Impell at 2:30 today.

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Communications Report

Company:	CES	[X] Telecon	[ ] Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	11/03/87
Subject:	Review Issue Status	Time:	2:20 p.m.
		Place:	Walnut Creek
Participants:	S. Harrison	of	TU Electric
	P. Harrison, F. Hettinger		Ebasco
	J. Russ		Cygna

Item	Comments	Required Action By
	Cygna read the status list in Attachment 1 to this communications report to TU Electric and Ebasco Ebasco stated that one example analysis of a cable tray support with multiply braced composite channels was sent to the reading room. Ebasco also noted that SAG.CP18 has been revised. The revision incorporates the results of the MRM study justifying an MRM vaue of 1.25 for cable tray qualification. Additionally, somc conduit material is being sent to the reading room. Cygna noted that they would hold a conference call with Impell on Wednesday, November 4, 1987 to status the cable tray issues. TUE\110387-B.TEL	

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ATTACHMENT 1

CABLE TRAY SUPPORT
REVIEW ISSUE STATUS

RIL NO.	ISSUE DESCRIPTION	ACTION BY	RECIEVED
1	Margin levels in M-12	Impell	Yes
2	Load Combination	Impell	
3	Gaps under base plates	Ebasco	Yes
3	Eccentricity of one-bolt base angles	Ebasco	
3	Eccentricity of one-bolt base angles	Impell	
4	Revised effective length factors for longitudinal trapeze supports	Impell	Yes
4	Weld undercut		
4	Plumbness measurement procedures	TU	Yes
6	Rational for sample on support frame inertial loads	Ebasco	Yes
7	Revised Impell Project Instruction PI-03 to include compactness criteria	Impell	Yes
7	Revised Impell Project Instruction PI-11 to exclude the use of geometric properties for refined effective lengths	Impell	Yes
7	Revised Impell Calculation M-12 to correct the use of 95% of Fcr	Impell	Yes
8	Provide revised General Instructions	Ebasco	Yes
9	Provide Book 22 and respond to Cygna concerns	Ebasco	Yes
9	Provide revised Impell Calculation M-65	Impell	Yes
12	Provide joint working point study	Impell	
13	Provide response to Cygna concerns on location of longitudinal mass for calculation of tray frequency	Ebasco	

RIL NO.	ISSUE DESCRIPTION	ACTION BY	RECIEVED
16	Provide calculation section on base metal damage	Ebasco	Yes
16	Provide study on weld eccentricities	Impell	Yes
16	Revised response on base metal thickness	Ebasco	
18	Provide calculations for clamp qualification	Impell	
20	Provide CARDS procedures	TU	
23	Place study on location of transverse loads at posts in reading room	Ebasco	Yes
24	Place study of location of transverse loads at top of tier in reading room	Ebasco	Yes
24	Provide response on effects of minor axis bending	Impell	Yes
24	Provide evaluation of applicability of present location of vertical load	Ebasco	Yes
25	Provide results of SDAR on tray side-rails and splice connectors	TU	Yes
25	Provide calculations M-34 and M-66	Impell	
30	Provide revisions to Impell and ANCO system dynamic test reports	Impell	
32	Provide study on conduits attached to cable trays	Impell	
32	Provide walkdown procedures for attachments to cable trays	TU	Yes
33	Provide calculation addressing tolerances for spacing of anchor bolts	Impell	Yes
33	Provide procedures for walkdown of tray covers	TU	Yes
34	Provide response to Cygna's concerns on overlap	Impell	

RIL NO.	ISSUE DESCRIPTION	ACTION BY	RECIEVED
34	Provide response to Cygna's concerns on SUPERPIPE error SP-004	Impell	

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Communications Report

Company:	CES	[X] Telecon	[ ] Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	11/04/87
Subject:	Review Issue Status	Time:	9:50 a.m.
		Place:	Walnut Creek
Participants:	R. Kaczkowski	of	Impell
	J. Russ		Cygna

Item	Comments	Required Action By
	Cygna read the status list in Attachment 1 to this communications report to Impell. TUE\110487-a.TEL	

Signed: J. P. Russ for N. H. Williams

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ATTACHMENT 1

CABLE TRAY SUPPORT
REVIEW ISSUE STATUS

RIL NO.	ISSUE DESCRIPTION	ACTION BY	RECIEVED
1	Margin levels in M-12	Impell	Yes
2	Load Combination	Impell	
3	Gaps under base plates	Ebasco	Yes
3	Eccentricity of one-bolt base angles	Ebasco	
3	Eccentricity of one-bolt base angles	Impell	
4	Revised effective length factors for longitudinal trapeze supports	Impell	Yes
4	Weld undercut		
4	Plumbness measurement procedures	TU	Yes
6	Rational for sample on support frame inertial loads	Ebasco	Yes
7	Revised Impell Project Instruction PI-03 to include compactness criteria	Impell	Yes
7	Revised Impell Project Instruction PI-11 to exclude the use of geometric properties for refined effective lengths	Impell	Yes
7	Revised Impell Calculation M-12 to correct the use of 95% of Fcr	Impell	Yes
8	Provide revised General Instructions	Ebasco	Yes
9	Provide Book 22 and respond to Cygna concerns	Ebasco	Yes
9	Provide revised Impell Calculation M-65	Impell	Yes
12	Provide joint working point study	Impell	
13	Provide response to Cygna concerns on location of longitudinal mass for calculation of tray frequency	Ebasco	

RIL NO.	ISSUE DESCRIPTION	ACTION BY	RECIEVED
16	Provide calculation section on base metal damage	Ebasco	Yes
16	Provide study on weld eccentricities	Impell	Yes
16	Revised response on base metal thickness	Ebasco	
18	Provide calculations for clamp qualification	Impell	
20	Provide CARDS procedures	TU	
23	Place study on location of transverse loads at posts in reading room	Ebasco	Yes
24	Place study of location of transverse loads at top of tier in reading room	Ebasco	Yes
24	Provide response on effects of minor axis bending	Impell	Yes
24	Provide evaluation of applicability of present location of vertical load	Ebasco	Yes
25	Provide results of SDAR on tray side-rails and splice connectors	TU	Yes
25	Provide calculations M-34 and M-66	Impell	
30	Provide revisions to Impell and ANCO system dynamic test reports	Impell	
32	Provide study on conduits attached to cable trays	Impell	
32	Provide walkdown procedures for attachments to cable trays	TU	Yes
33	Provide calculation addressing tolerances for spacing of anchor bolts	Impell	Yes
33	Provide procedures for walkdown of tray covers	TU	Yes
34	Provide response to Cygna's concerns on overlap	Impell	

RIL NO.	ISSUE DESCRIPTION	ACTION BY	RECIEVED
34	Provide response to Cygna's concerns on SUPERPIPE error SP-004	Impell	

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Communications Report

Company:	CES	[ ] Telecon	[X] Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.: 84056 Date: 11/06/87	
Subject:	Error SP-004, Base Angle Stiffnesses and Base Angles with Gaps	Time: 10:00 a.m. Place: Walnut Creek	
Participants:	J. Nandi	of	TU Electric
	G. Ashley		Impell
	D. Leong, C. Morelock, J. Russ		Cygna

Item	Comments	Required Action By
	Cygna met with Impell to discuss the SUPERPIPE error SP-004, Impell's choice of base angle stiffnesses and base angles with gaps.	
1.	Superpipe Error SP-004	
	Cygna stated that they were concerned that SUPERPIPE outputs other than the one checked in the Impell Technical Quality Report (TQR) might be affected. The chronology of the error is as follows:	
	<u>Prior to December 1, 1986</u>	
	Impell engineers are using SUPERPIPE version 19A. This version of the program contains an error which requires a specified fix to assure correct results.	
	<u>December 1, 1986 to January 28, 1987</u>	
	On December 1, 1986, SUPERPIPE version 21A is released. This version of SUPERPIPE did not contain the error that existed in version 19A. Thus, the fix was no longer required if using version 21A. Additionally, Impell Project Procedure PI-02 did not address the error. It was during this time period that the analysis that Cygna reviewed was performed. That analysis used SUPERPIPE version 21A, but also used the fix that was intended for use with version 19A.	

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Communications Report

Item	Comments	Required Action By
	<u>January 28, 1987 and later</u> On January 28, 1987, an addendum to Impell Project Instruction PI-02 was released. This addendum specified the modeling procedures to be used when using either version of SUPERPIPE. Impell stated that they prepared a TQR on the analysis that was reviewed by Cygna. The TQR process included a review of the subject calculation and a corrective action phase, wherein other calculations were reviewed. A random sample of calculations were chosen and reviewed. Impell noted that this review did not show any other problems. Cygna noted that the TQR documentation does not indicate that a generic review was performed. Impell stated that they would talk to the design reviewer to determine the basis of the corrective actions. Cygna noted that two time periods were of interest: The period prior to the discovery of the error in SUPERPIPE version 19A and the period between December 1, 1986 and the issuance of the addendum to Project Instruction PI-02. Cygna asked that Impell provide documentation that showed corrective action was performed or reasons why corrective action was not performed. Impell stated that they would provide documentation that showed error identification, corrective action and that preventative action was taken. Additionally, Impell noted that the analysis that Cygna reviewed was preliminary and most likely has been revised.	
2.	Base Angle Stiffnesses Cygna noted that Impell had used rigid stiffness values for several degrees of freedom when modeling the boundary conditions of cable tray supports with base angles and base plates. Yet, Impell's analysis of the base angles showed that the several of the stiffnesses were not rigid and had stiffness values of approximately 30 K/in. Impell will provide a response to Cygna's concerns.	
3.	Base Angles with Gaps Cygna noted that Ebasco had provided a response to the concerns on the behavior of base angles with gaps under them. The configuration was a 48" long 5 x 5 base angle with 5 x 5 shims under the anchor bolts. This analysis did not match the configuration described by Cygna which called for a short 6 x 6 base angle with 5 x 5 shims. Impell and TU Electric will discuss Cygna's comments and provide a response. \TUE\110687-A.CON	

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Communications Report

Company:	CES	☐ Telecon	☒ Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	11/19/87
Subject:	Cable Tray Qualification MRM For Tray Stress	Time:	3:00 p.m.
		Place:	Impell WC
Participants:	S. J. Chen	of	Ebasco
	D.K. Leong		Cygna

Item	Comments	Required Action By

Ebasco's cable tray stress MRM study is patterned after their cable tray support load MRM study. For the basic Model A configuration (equal spans with center support stiffness varied), several cases with varied adjacent support frequencies were analyzed. For most other cases (with other parameters varied), only the model with 15 Hz adjacent support frequencies was analyzed. Cygna was concerned that conclusions were being drawn for generic systems based on limited data.

For example, Cygna had expressed concern that the 12 Hz cutoff frequency for the lateral direction in the screening criteria was derived from the results of one set of analyses. The seismic spectrum for the Safeguards Building, E-W direction at elevation 852.5' was used in these analyses. In order to judge the adequacy of the single set, Cygna compared results of this system to the systems with 15 Hz adjacent support frequencies to determine if the set of parameters for the 12 Hz model was critical.

When results for the 15 Hz system with the Safeguards 852.5' vertical spectrum oriented in the lateral direction were compared with the results with the E-W direction, oriented in the lateral direction, a 10% increase was shown for the former case. Since the lateral direction MRMs reported for the 12 Hz model with E-W direction input were slightly above the 1.25 limit, Cygna asked whether the results may increase if the vertical spectrum were applied in the lateral direction instead of the E-W spectrum.

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Item	Comments	Required Action By

Ebasco stressed that the conservatism in the prediction of the ESM system frequency and other analysis parameters generally offset any unconservatism in the calculated MRMs. For the particular case described above, Ebasco compared the spectra in the areas around 12 Hz and 15 Hz to show that the MRM increase for the 12 Hz model, going from the E-W direction spectrum to the vertical spectrum, would be less than that of the 15 Hz model.

Cygna and Ebasco first discussed the 15 Hz model. Ebasco pointed out that the frequency range of interest for this model is 13.1 Hz (the lower bound prediction for the ESM) to 16.0 Hz (the upper bound calculated frequency for the RSM). In this frequency range, the E-W spectrum has a small slope, while the vertical spectrum is nearly flat. In going from the E-W to the vertical spectrum, the MRM increases approximately 10%.

Next, the 12 Hz model was compared to the 15 Hz model. The frequency range of interest for the 12 Hz model is 11.0 Hz (the lower bound prediction for the ESM) to 13.3 Hz (the upper bound calculated frequency for the RSM). In this frequency range, the E-W spectrum has a moderate slope. The vertical spectrum has a slightly smaller slope than the E-W; however, the difference in slope for the 12 Hz model is less than that of the 15 Hz model. Therefore, the increase in MRM for the 12 Hz model subjected to the vertical spectrum will be less than that for the 15 Hz model.

Cygna asked whether there were any spectra which were flatter than the vertical spectrum for Safeguards 852.5' in the 12 Hz region. This would produce higher MRMs than predicted here. Ebasco replied that the Safeguards 852.5' vertical spectrum was about the flattest; therefore, the MRM values predicted in the study are representative.

Additionally, Ebasco stated that the trays were generally overstressed only when the spans were long or the unit weight was high. Tables 18 and 19 of the study present results for longer and heavier spans, showing that the MRMs are significantly reduced for the critical spans. This indicates that the slight unconservatism in determining the screening frequency does not cause unconservative MRMs to be used in the critical cases of high tray stress. For those cases, the 1.25 MRM value is very conservative.

Cygna stated that the study for tray stress MRMs is basically equivalent to that for the support load MRMs, utilizing the same models and parameters. Cygna noted that the tray stress MRMs were similar to the "adjacent support MRMs" in the previous study in that they became very high as α became low. Ebasco agreed that was true in the low α regions, but added that the tray stress

Item	Comments	Required Action By

MRMs were more like the "center support MRMs" in the high α regions.

To affirm that the tray stress MRMs were also dependent on β, Ebasco pointed out that the MRMs were almost identical for the following two cases where the Z direction support frequency was 20 Hz and the Y direction support frequency was 12 Hz:

α	$\beta_Z = 1.86$	$\beta_Y = 1.84$
.5	1.17	0.74
1.0	0.77	0.74
1.5	1.11	1.12
2.0	1.22	1.26
3.0	1.23	1.28
5.0	1.22	1.25

Ebasco also pointed out that there were slight differences in the response trends of the tray stress and support load studies. In the support load study, the MRMs for the center support were maximized at α values of around 1.0. In the tray stress study, the MRMs peaked at higher α values (around 3.0 to 5.0).

Cygna asked whether the same conclusions could be drawn for the stresses in bends and tees as were drawn for the support loads around those fittings. Ebasco replied that they believed that, since β was lower for those configurations, the tray stress MRMs would also be lower than MRMs for straight runs.

Cygna stated that they would complete their review of the tray stress MRM study. Ebasco will prepare a response to the items discussed above and will formalize it when Cygna has completed the review.

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Communications Report

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Company:	CES	[X] Telecon	[ ] Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	11/23/87
Subject:	Analysis of Multiply - supported Composite Channels	Time:	11:20 a.m.
		Place:	Walnut Creek
Participants:	J. Christoudias, P. Harrison, J. Swanson	of	Ebasco
	W. Horstman, J. Russ, B. Shakibnia		Cygna

Item	Comments	Required Action By
	Cygna held a conference call with Ebaco to discuss Ebasco's calculation for CTH-1-3134, a cable tray support with a composite tee-channel which is braced at multiple points. Cygna asked the following questions:	
1.	On pages 15-30, the torsional analysis of the composite member is performed. How is the COMBS analysis used in the member qualification?	
	The warping stresses from the COMBS analysis are combined with the stresses from the STRUDL analysis.	
2.	On page 15, only two trays are considered, yet four trays are supported. Please reconcile this discrepancy.	
	Ebasco agreed that only two trays were considered, but noted that enveloping loads were used in the analysis and that all four trays were considered in the analysis after page 78. The additional analysis on page 78 was due to a revision in the COMBS program. The new version of COMBS now includes shearing stresses. All affected calculation packages were upgraded to include the new version of COMBS.	
	Cygna also asked Ebasco how secondary walls were considered. Ebasco stated that the Impell analysis was to be considered a joint position. TUE\112387-A.TEL	

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Communications Report

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Company:	CES	[X] Telecon	[ ] Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.	84056
		Date:	12/08/87
Subject:	Significant Open Items	Time:	11:30 a.m.
		Place:	Walnut Creek
Participants:	J. Muffett, S. Harrison	of	TU Electric
	G. Ashley		Impell
	J. Russ, N. Williams		Cygna

Item	Comments	Required Action By

Cygna discussed the following topics in preparation for a meeting scheduled on Wednesday and Thursday, December 9 and 10, 1987:

1. Review of margin database

   Cygna stated that they would discuss the sorts of the margin database that were necessary to assess the impact of cumulative effects and limitations on buckling allowables on the design verification of cable tray supports.

2. Impell load combination

   In response to Cygna's concerns noted during the week of November 20, 1987, Impell stated that they were providing a revised calculation on the load combination methods. This response includes an analysis of the systems using an OBE spectra and will be available on December 9, 1987.

3. Impell base connection stiffnesses

   In response to Cygna's concerns from early November, Impell is providing a response on the effects that reduced base angle stiffnesses would have on the system analyses. This response will be available on December 9, 1987.

Signed: J. B. Russ for N. H. Williams

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Item	Comments	Required Action By

4. One-bolt base angles

Cygna noted that the Ebasco response was received on December 7, 1987 but the Impell response had not been received as of this date. Impell stated that the response will be provided on December 9, 1987.

5. Working point procedure

Cygna stated that this issue was discussed in Revision 14 of the Review Issues List. Impell stated that they would provide a response on December 9, 1987 that indicated that the working point modeling procedure was used for only 16 cable tray supports. The 16 supports were reviewed for impact and the working point modeling procedure was removed from the work instructions. TU Electric noted that Ebasco was working on a response that would generically address the working point as well as supports on an individual basis.

6. AISC Equation 1.5-7

Impell will provide research information on the capability of rigid connections to provide support of the compression for lateral torsional buckling. The papers to be provided by Impell are in addition to the work originally promised on December 1, 1987.

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Communications Report

Company:	CES	☐ Telecon	☒ Conference Report
Project:	TU Electric CPSES IAP Phase 4	Job No.: 84056 Date: 12/18/87	
Subject:	Cable Tray Support Design Review Tray Clamp Behavior	Time: 12:30 p.m. Place: Dallas, TX	
Participants:	R. Alexandru, H. Hettiner, P. Harrison	of	Ebasco
	S. Harrison, J. Moffett		TU Electric
	G. Ashley, R. Kaczkowski		Impell
	D. Leong, J. Russ, W. Horstman		Cygna

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Cable Tray Clamp Behavior

Cygna met with the TU Electric, Ebasco and Impell to discuss the behavioral characteristics of friction type cable tray clamps assumed by Impell and Ebasco. Cygna's major concern is that the load transfer mechanisms assumed in the cable tray support analysis are not consistent with the loading considered in the tray clamp qualification testing and analyses.

To clarify a point raised in a discussion held on December 10, 1987, Cygna indicated that the statements regarding tray clamp behavior included in the Cable Tray Support Review Issues List (RIL) were intended to summarize the position taken by Gibbs & Hill, Inc. (G&H) with respect to the original cable tray support design calculations. Cygna was not endorsing the assumptions made by G&H but was merely indicating that certain assumptions may be inconsistent or were not adequately justified.

The primary behavioral concern remaining for cable tray clamps is the load transfer mechanism for longitudinal loads with friction (Types A, C and G) clamps. The longitudinal load must be transferred through friction since a positive mechanical linkage between the tray and the support member (tier) does not exist. For friction type clamps, several installation situations are possible:

(a) The tray rests on top of tier and the clamp is cinched due to tightening (Types A and C);

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(b) The tray rests on top of tier and the clamp is not cinched due to over-sized clamp dimensions on Types A and C or due to the nature of Type G clamps resulting in gaps between the tray and clamp.

(c) The tray does not rest on top of tier (the support tier elevation is lower than the elevation of the bottom of the tray) resulting in a gap between tray and support and the clamps cannot be cinched so gaps may also exist between the tray and clamp.

When subjected to tri-directional seismic motion, it is assumed that the tray displacements will close any gaps to allow load transfer from the tray to the support (vertical and horizontal transverse loading) and that friction will transfer the longitudinal loading. For the sake of this discussion, Cygna is not questioning the validity of the longitudinal load transfer by friction, Cygna's concern is the location of the friction force transfer and how this force is treated in the cable tray clamp evaluation. Since the friction can only occur in conjunction with a normal force, the friction load application point will vary, depending on the direction of the other seismic loads.

Several cases exist:

(a) Downwards seismic load combined with dead weight resulting in a normal force between the tray and the tier.

(b) Upwards seismic load exceeds dead weight, resulting in a normal force between the tray and the top of the clamp.

(c) Horizontal seismic load resulting in a normal force between the tray and one of the tray clamps.

Since any of these situations may occur and (c) will occur in combination with (a) or (b), the friction load is distributed between the clamps and the tier. Cygna believes that this distribution of loading must be considered in the clamp qualification procedure. Currently, Impell and Ebasco assume that all of the longitudinal load is resisted by friction between the tier and the tray, so the clamps are not required to resist any longitudinal load.

TU Electric indicated that the behavior of the cable tray-clamp interface is a very complex problem. Due to the presence of gaps the load transfer is not linear-elastic in nature, and would require a nonlinear finite element model to correctly capture. Such a model is far to complex foı the level of detail considered in the cable tray system analyses.

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Due to the varied installation configurations allowed for cable tray clamps, it is not feasible to develop frictional capacities in the manner used for the conduit clamps. TU Electric stated that a method could not easily be used to predict the longitudinal load capacity of friction type clamps.

Impell indicated that clamp types A and C would not have significant longitudinal load capacity since the application of a longitudinal load would result in pivoting of the clamp about the axis of the single bolt used to attach the clamp to the tier.

If the clamp pivoted about the bolt, all longitudinal connectivity is lost, and the tray will slip relative to the support and all longitudinal tray load would need to be resisted by a longitudinal support on the tray run. Only clamp type G, which is welded to the tier, would develop any significant load, but since these clamps are very strong, the longitudinal load will not impact the clamp qualification.

To justify the assumptions of longitudinal connectivity and longitudinal load transfer solely by friction between the tray and tier, TU Electric relies on the results of the system dynamic tests. TU Electric feels that the tests supported connectivity through the observation that the relative longitudinal displacements between the trays and supports were small. Ratcheting of the clamp along the tray was not observed. Adequacy of the friction clamps to resist longitudinal load was demonstrated by the fact that failures of friction clamps due to longitudinal loading were not observed in any of the test specimens, even at input levels two or more times greater than SSE levels.

TU Electric believes that the test results are adequate proof of their assumptions. If Cygna disagrees with this conclusion, TU Electric requested that Cygna provide a specific definition of the proof necessary to satisfy their concerns on clamp behavior.

Cygna indicated that internal discussion will be necessary before a response is possible.

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