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TEXAS UTILITIES GENERATING COMPANY

SKYWAY TOWER · 400 NORTH OLIVE STREET, L.B. 81 · DALLAS, TEXAS 75201

WILLIAM G. COUNSIL
EXECUTIVE VICE PRESIDENT

May 2, 1986

Vincent S. Noonan
Director PWR Project Directorate #5
Division of PWR Licensing - A
U.S. Nuclear Regulatory Commission
Washington, D.C. 20599

Reference: Letter to W. G. Counsil (TUGCO), from V. S. Noonan (NRC)

Subject: NRC Staff Request for Additional Information on Comanche Peak Response Results Reports for ISAPs (I.a.4, I.b.3, II.b, III.d and VII.b.2) dated April 28, 1986.

Dear Mr. Noonan:

Enclosed herewith is the information requested by the referenced letter. Should you have any questions or need further clarification, please contact Mr. John W. Beck at (214) 979-8646.

Very truly yours,

John W. Beck

John W. Beck for
W. G. Council

JWB/feo

Enclosure

cc: Service List

Limited Distribution

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ENCLOSURE

REFERENCE: DOCKET NOS. 50-445 and 50-446

REQUEST FOR ADDITIONAL INFORMATION FOR THE FIVE ISAP RESULTS REPORTS (I.a.4, I.b.3, II.b, III.d, and VII.b.2) AND FUTURE RESULTS REPORTS.

QUESTION:

1. Address those questions raised in ASLB Memorandum, Proposed Memorandum and Order dated April 14, 1986, and provide appropriate documentation.

RESPONSE:

The SRT expects to publish responses to the Board's questions, as propounded in its "Proposed Memorandum" and modified during the pre-hearing conference of April 22, 1986, in the form and time frame described at that conference. See Tr. 24353 (4/22/86).

QUESTION:

2. Address whether the issues raised in the results reports had implications of deficiencies in the QA/QC program, design and/or construction and reference documents that will be provided to the staff that will address these implications.

RESPONSE:

These issues fall into two categories: issues relating to design, construction or testing identified during the conduct of action plans, and the evaluation of action plan results for impact on collective evaluations of the design, hardware, testing program or QA/QC program. For the first category, Review Team Leaders have and continue to formally notify each other of findings in the conduct of their respective action plans that could impact or require investigation in the context of another Review Team Leader's ISAP or DSAP. In addition, deficiencies identified during the conduct of some action plans may be evaluated for impact within that specific action plan Results Report.

For the second category, the intent of the Collective Evaluation Reports described in Section VI of the CPRT Program Plan, though not explicitly stated, is to address the implications of any design, hardware, testing or QA/QC deficiencies discovered during the conduct of any Issue Specific Action Plan (ISAP) or Discipline Specific Action Plan (DSAP) in the appropriate Collection Evaluation Report. These Collective Evaluation Reports will be issued during the latter stages of the CPRT Program.

REQUEST FOR ADDITIONAL INFORMATION (Cont'd)

QUESTION:

3. Where an ISAP resulted in corrective action, address the status of the corrective action and identify the method you plan for communicating to the staff the corrective action is completed.

RESPONSE:

Specific corrective action initiated as a result of discrepancies identified during the course of implementing ISAPs are translated to Project NCRs, TDDRs and TDCRs in accordance with the Project's Program.

With respect to Results Reports I.a.4, I.b.3, II.b, III.d and VII.b.2 no corrective action beyond the scope of specific deficiencies has been recommended to the project.

To the extent that the Program Plan might require third-party oversight of corrective action in any case, reporting of this overview will be done as set forth in Appendix H, Section B, Paragraph 3.

QUESTION:

4. Describe how findings from one ISAP, which relate to a particular ISAP that is being addressed are considered.

RESPONSE:

We do not understand the question as posed.

I.a.4 Agreement Between Drawings and Field Terminations

QUESTION:

1. For the instances identified by the NRC TRT and Region IV, and CPRT where the drawings have not yet been revised, to reflect the existing field termination conditions, provide the actions you are taking to upgrade your as-built field termination drawings.

RESPONSE:

For discrepancies identified by the NRC-TRT and CPRT, the drawings have been revised or the field terminations corrected such that the field terminations are appropriately reflected on the drawings. Discrepancies identified to the Project by NRC Region IV have been documented on NCRs and TDDRs. When these are dispositioned the field terminations and drawings will agree.

To the extent the question encompasses nonterminated spare conductors, the project drawings will not be revised to reflect the field; because such conformity is neither a design nor project requirement.

QUESTION:

2. What is the basis for considering terminated and non-terminated spare conductors as valid population sample items for essential Class 1E Systems.

RESPONSE:

The basis for including spare conductors in the population was as follows:

- Spare conductors could potentially be involved with functional deficiencies (e.g., a spare conductor reversed with a functional conductor, a spare conductor connected to an active circuit, etc.), thus information concerning spares should not be bypassed.

- Conductors that were once functional were often converted to spares by design change, and it was considered to be important to check these conductors for adequacy of the design change implementation process.

- The NRC/TRT checked and addressed spares. One of their findings involved spare conductors that had once been functional and (after being spared by design change) were not lifted from their respective terminal points.

I.b.3 Conduit to Cable Tray Separation

QUESTION:

Provide the following information:

(1) Gibbs and Hill analysis report on conduit separation:

(3) DCA-15917 mentioned on page 2 of the Results Report which reduced the conduit separation to one inch (this may be included in the G&H analysis report), and

(4) Gibbs and Hill memo EE-863, 1/17/84, which contained simplified analysis reviewed by NRC-TRT on site (this may be included in the G&H analysis report);

RESPONSE:

The information requested in items 1, 3 and 4 is attached. These documents are all contained in the Results Report Working File or Project Document Control Center.

ITEM	DOCUMENT	ISAP I.b.3 FILE NO.
(1)	GTN-71266	I.b.3 - 8A.022
	GTN-71284	I.b.3 - 8A.023
	CPRT-294	I.b.3 - 8A.028
(3)	DCA-15917	(from Document Control Center)
(4)	TWX #14,958	I.b.3 - 8A.001
	GTN-69531	I.b.3 - 8A.002
	Sandia Report	I.b.3 - 8B.001

QUESTION:

(2) Documentation to indicate that TUGCO has approved the Gibbs and Hill analysis report:

RESPONSE:

A FSAR change request which utilizes the Gibbs & Hill analysis as supporting documentation is being prepared. When submitted, it will document TUGCO's acceptance of the analysis.

I.6.3-8A.001

SENT BY TELECOPY

ARMS
INDEXED

DATE

9-20-84

8:30 A.M.

Ery

SEPTEMBER 20, 1984
TWX #14,958
ATTN: R. E. BALLARD / T. R. VARDARO / S. P. MARTINOVICH

SUB: NRC REQUEST FOR ADDITIONAL INFORMATION

THE NRC TECHNICAL REVIEW TEAM (TRT) HAS REQUESTED ADDITIONAL INFORMATION IN THE AREA OF ELECTRICAL SEPARATION. THEIR SPECIFIC REQUEST IS AS FOLLOWS:

"THE TRT FOUND THAT THE EXISTING TUEC ANALYSIS SUBSTANTIATING THE ADEQUACY OF THE CRITERIA FOR SEPARATION BETWEEN CONDUITS AND CABLE TRAYS HAD NOT BEEN REVIEWED BY THE NRC STAFF.

ACCORDINGLY, TUEC SHALL SUBMIT THE ANALYSIS THAT SUBSTANTIATES THE ACCEPTABILITY OF THE CRITERIA STATED IN THE ELECTRICAL SPECIFICATIONS GOVERNING THE SEPARATION BETWEEN INDEPENDENT CONDUITS AND CABLE TRAYS."

WE HAVE DISCUSSED THIS REQUEST WITH T. R. VARDARO AND S. P. MARTINOVICH.

PLEASE PROCEED IMMEDIATELY TO FORMULATE THE REQUIRED RESPONSE AND TELECOPY IT TO US. A TIMELY RESPONSE IS OF UTMOST IMPORTANCE TO US. AS SUCH, OVERTIME IS AUTHORIZED AND EXPECTED IN ORDER TO GET THE RESPONSE AS SOON AS POSSIBLE.

IF YOU HAVE ANY QUESTIONS OR REQUIRE ADDITIONAL INFORMATION, PLEASE ADVISE.

W. I. VOGELSANG - ELECTRICAL ENGINEERING

L. M. POPPLEWELL
PROJECT ENGINEERING MANAGER
CPSES JOBSITE
910/890-8660 TUGCO GRSE

LMP:WIV:ery

CC: ARMS - D C C
FILE

35-1195
RECEIVED

SEP 20 1984

DOCUMENT CONTROL

I.b.3-8A.002

SMM[redacted]o/187*, SPMartinovich, PNLalaji, ~~Outgoing~~, PMMilam, Bleck

A Dravo Company

September 27, 1984

GTN- 69531

Texas Utilities Generating Company
Post Office Box 1002
Glen Rose, Texas 76043

Attention: Mr. J. B. George
Vice President/Project Gen. Manager

Gentlemen:

TEXAS UTILITIES GENERATING COMPANY
COMANCHE PEAK STEAM ELECTRIC STATION
G&H PROJECT NO.2323
NRC REQUEST FOR ADDITIONAL INFO
ELECTRICAL SEPARATION CRITERIA
REF: TWX-14958 (9-20-84)

Attached please find the analysis requested in the referenced TWX substantiating the adequacy of the criteria for separation between conduits and cable trays. An advance copy of this analysis was telecopied to W.I. Vogelsang on Monday 9-24-84. (We have also transmitted under separate cover, one copy of Sandia Laboratories Report on Cable Tray Fire Tests (SAND77-1125C). Please advise if we can provide any additional assistance.

Very truly yours,

GIBBS & HILL, INC.

S M Marano

Robert E. Ballard, Jr.
Director of Projects

REBa-PNL-SPM:sce
1 Letter + Attachment

cc: ARMS (B&R Site) OL
W. I. Vogelsang (TUSI Site) 1L + Attachment

Dravo

Gibbs & Hill, Inc.

September 24, 1984

To: W. I. Vogelsang

Per your request to Sam Martinovich enclosed please find one copy of Sandia Laboratories Report on Cable Tray Fire Tests (SAND77-1125C) and one copy of report entitled Separation Criteria as prepared by SPMartinovich and telecopied to you on September 24.

S. M. Marano

SEPARATION CRITERIA

The raceway separation criteria utilized in the Gibbs & Hill electrical drawings and specifications is based upon the requirements of IEEE-384, 1974 and Regulatory Guide 1.75 (Rev. 1, 1/75). Although very specific criteria is provided in the Standard and Regulatory Guide for separation between cable trays, no specific criteria is provided for separation between conduits and cable trays.

In developing the separation details currently in Specification ES-100 and on Drawing E1-1702-02, it was recognized that conduit provides a raceway medium which effectively isolates internal events (e.g., faults) from the external surroundings. In this regard, a conduit system provides enclosure integrity far superior to that of enclosed tray with covers and/or solid bottoms and splice plates between sections. Therefore, the same criteria required by the Standard and Regulatory Guide specifically for trays, need not be arbitrarily applied to conduits. In comparing rigid conduit to enclosed tray, it was noted that conduit has:

1. Substantially heavier gauge body than tray - providing a more effective heat sink than equivalent cross-sectional area of tray.

2. Threaded connections providing essentially air-tight medium which inhibits internal combustion and effectively isolates internal events from the existing surroundings.

3. Size typically limited to 5-inch OD thus limiting both volume of cables (combustibles) contained and exposed surface area.

4. Curved surface providing radial distribution of heat and much less favorable heat transfer characteristics to or from an adjacent tray than a flat surface of equivalent area.

Thus, in many instances, conduits satisfy the Standard's requirements for a barrier*.

*IEEE 384 defines a barrier as -- "A device or structure interposed between Class 1E equipment or circuits and a potential source of damage to limit damage to Class 1E systems to an acceptable level."

TRANSMITTED BY TELECOPIER
9-24-84

Details 45 through 49, 52 through 55 and 57 on E1-1702-02 identify the separation requirements between cable tray and conduit. In general, these details require a minimum of 3-foot horizontal and 3-foot vertical separation in all general plant areas, and 1-foot horizontal and 2-foot vertical separation in the cable spreading room. This separation is reduced to 1-inch only in those instances where the conduit is considered to be an effective barrier as discussed below.

For the details shown in ES-100 and on Drawing E1-1702-02, a conduit has been considered to be an effective barrier whenever it is at least 1-inch away from circuits or raceway of a dissimilar train and:

a. It contains no Class 1E or associated circuits or,

b. It does not traverse directly above or in front/behind a horizontal or vertical tray, respectively, of dissimilar train.

When a conduit contains no Class 1E or associated circuits, for example, it clearly satisfies the requirements of a barrier. It should be noted that the barrier need not limit damage to non-safety circuits to any level. Logically then, a conduit containing non-Class 1E circuits can be placed up to 1-inch from the top, bottom or sides of a Class 1E open ladder tray since the conduit provides a protective barrier separated by at least 1-inch from the Class 1E circuits (see Detail 49, E1-1702-02).

It is recognized that the converse is not true and conduits containing safety-related circuits may require more than 1-inch separation from open trays of dissimilar train depending upon orientation of conduit and tray.

This has been considered in the separation criteria where in general, the minimum required separation in any direction exceeds 12 inches.

The results of cable tray fire tests performed by Sandia[1] Laboratories for NRC (subsequent to issuance of IEEE-384, 1974), to confirm the suitability of then current design standards and regulatory guides, are supportive of the judgments used in developing Conduit Separation Criteria for CPSES back in 1975 regarding self-induced fire effects on IEEE-383 qualified cables.

Summarizing some of the more significant findings in the Sandia Report:

1. In electrically initiated fires, the intense period of the fire persisted at a particular location for between 40 and 240 seconds before die out began to occur. This is less than the time required to consistently ignite a tray of IEEE-383 qualified cables in the propane-fueled exposure fires (typically 300 seconds).

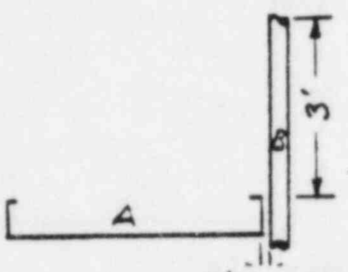
2. In the electrically initiated fire, cables in the tray 10.5 inches above the donor (fire) tray were exposed to a convective heat flux of about 6000 BTU/hr/ft^2, which corresponds to a local gas temperature of approx. 1000 degrees F. The circuits remained functional and samples of the insulation from the bottom of the tray over the fire zone which were given elongation measurements, showed less than a 10 percent increase.

3. The luminous zone of the electrically initiated fire was optically thin which enabled immersed objects to radiate heat to the cooler surroundings. Thus equilibrium surface temperatures of engulfed cylindrical objects varied from about 1200 degrees F just above the tray to 650 degrees F at a height of 10 inches. (Note that minimum vertical separation of 24 inches utilized on CPSES is more than twice this distance and maximum temperatures are anticipated to be well below temperatures successfully withstood during the fire tests.)

4. In the electrically initiated fire, heat transfer to immersed objects is convection dominated with radiation accounting for no more than 30 percent of the total heat flux, even in the luminous region. (Logically then, conduits beside or below horizontal trys are shielded from the major, convective heat flux.)

Probably the strongest evidence in support of CPSES conduit separation is the results of the exposure fire test conducted by Sandia in which conduits and trays were included. In these tests, 14 trays were stacked 10.5 inches apart. Directly above each tray within 10.5 inches, a conduit containing additional cables was located. No separation was provided between any conduit and the bottom of the tray above. Although all circuits in the conduits above the third tray failed during the exposure fire (the conductors short-circuiting to the conduit and each other), circuits in the lower two (2) conduits maintained circuit integrity throughout the duration of the exposure fire. Considering that the fire in the lower two (2) trays was more severe than an electrically initiated fire, being externally fueled and of longer duration, the results provide a conservative worst case.

Recognizing that the Sandia tests are not plant specific, the following analysis is presented to demonstrate with margin, the adequacy of CPSES conduit/tray separation. A hypothetical worst case is chosen whereby an open horizontal tray is separated by only an air gap from a vertical conduit (note that E1-1702-02 requies a minimum of 12 inches in Detail 47). See Figure below:



Since the conduit is vertically oriented, convective heat transfer is essentially negligible. Reference 1 establishes the time-mean height of the luminous zone as 5 to 7 inches above the tray and the radiated heat flux (for a cylindrical object immersed in the fire) as 7000 BTU/hr/ft^2.

Since exposed cables of one train cannot run within 3-feet vertically of another train per IEEE-384, it can be very conservatively assumed that the minimum length of conduit will never be less than this distance. Assuming this entire radiated heat flux were transferred to 50 percent of the conduit circumference (facing the tray) over a length of 7-inches corresponding to the height of the luminous zone, the heat input rate is given as:

$$q\ in = 7000 \times \frac{.5(\pi\ d)\ 7"}{144"/ft^2}\ Btu/hr.$$

Where d = conduit diameter (inches)

Since the only heat dissipation considered herein will be via convection to surrounding air, the worst case value of 'd' is for the minimum conduit size. Per NEC, a 1-inch trade size conduit has an inside diameter of 1.05 inches. This will be assumed also for the outside diameter.

Then q in = 7000 x .08018 = 561 Btu/hr.

The heat dissipated to surroundings is given by:

q out = $hA\Delta T$ (ref. 2)

Where ΔT = difference between conduit surface temperature and surrounding air

A = free surface area of conduit for convection

$h = C\,(\Delta T)^{0.25}$ for natural convection of a solid surface in still air

$C = 0.4/_d\ 0.25$ for vertical pipes more than 2 ft in length with diameter = d (inches)

Assuming: q in = q out

q in = $hA\Delta T$ or T = q in$/hA$

$$\text{and } A = \frac{\pi d}{144}\,[36" - .5(7")] = .744\ ft^2$$

$$h = 0.4/d^{0.25}\,(\Delta T)^{0.25} = 0.395\,(\Delta T)^{0.25}$$

$$\text{then } \Delta T = \frac{561}{(.395)(.744)\,\Delta T^{.25}} \quad \text{or } \Delta T^{1.25} = 1908.2$$

and ΔT = 421 degrees F

Even in a 122 degree F ambient, the maximum conduit surface temperature would not exceed 543 degrees F (122 + 421). This is well below the temperatures to which exposed cables were subjected (1000 degrees F local gas) in reference 1 with satisfactory results. The analysis herein is also extremely conservative in that conduit supports (and heat conducted to them) and radiant heat dissipation are neglected, a continuous 7-inch flame is assumed adjacent to the conduit, a conduit length of only 3-feet is assumed, and only an air-gap separation is assumed between conduit and tray.

1) Sandia Report No. SAND77-1125C
2) General Electric Handbook 2nd Edition, C. E. O'Rourke

I.b.3 BA.C22

Gibbs & Hill, Inc.

11 Penn Plaza
New York, New York 10001
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Domestic: 127636/968694
International: 428813/234475

A Dravo Company

February 28, 1986

GTN-71266

Texas Utilities Generating Company
Post Office Box 1002
Glen Rose, Texas 76043

Attention: Mr. J. B. George
Vice President/Project Gen. Mgr.

Gentlemen:

TEXAS UTILITIES GENERATING COMPANY
COMANCHE PEAK STEAM ELECTRIC STATION
G&H PROJECT NO. 2323
CONDUIT TO CABLE TRAY SEPARATION
REF 1: TRT ITEM 1.b.3
REF 2: GTN-70600 DTD 9/19/85

Enclosed please find Gibbs & Hill's Tray/Conduit Separation Criteria for incorporation in the TRT Item 1.b.3 results report. Mechanical calculation No. 800, Rev. 1 will be transmitted under separate cover on Monday, March 3, 1986 upon completion of design review.

The criteria and analysis are in agreement with and support the FSAR change request previously submitted via reference 2. Therefore, no additional changes to the FSAR regarding this subject are anticipated.

Please advise if you have any questions or require further assistance.

Very truly yours,

GIBBS & HILL, Inc.

Robert E. Ballard, Jr.
Director of Projects

REBa-JIr-SPM:lc
1 Letter
CC: ARMS (B&R Site) OL
Drams W. I. Vogelsang (TUSI Site) 1L 1A

TRAY/CONDUIT SEPARATION CRITERIA

Introduction

The raceway separation criteria utilized in the Gibbs & Hill electrical drawings and specifications for the Comanche Peak Steam Electric Station (CPSES) are based upon the requirements of IEEE-384, 1974 and Regulatory Guide 1.75 (Rev. 1, 1/75). Although very specific criteria are provided in the Standard and Regulatory Guide for separation between cable trays, the same degree of specificity is not provided for separation between conduits and cable trays.

This discussion will therefore present the methodology used in applying IEEE-384, 1974 and Regulatory Guide 1.75 (Rev. 1, 1/75) to conduits requiring separation from cable trays of redundant* safety trains. Separation details are shown on Drawing E1-1702-02 which, as stated therein, apply when hazards are limited to failures or faults internal to electrical equipment or raceways. Where other potential hazards from sources such as missiles, high energy line breaks, pipe whip or external fires exist, greater separation may be required. Such conditions however, are beyond the scope of the drawing and this discussion.

It is apparent from the discussion in the foreward to IEEE-384, 1974 (and in the subsequent revision in 1977) that the minimum separation distances in the standard were based upon the potential effects of an electrical fire. Regarding the additional work needed to arrive at a standard wire and cable test to determine if lesser separation distances could be called out, the standard states - "such a test should be designed to provide data on potential propagation to circuits above, below, and adjacent to a cable fire." In the 1977 revision, the forward states that "the distances that are given for separation between trays required to be separated in areas of limited hazard potential are based on current available data from actual cable fire situations and are considered to provide an adequate degree of separation." In both revisions of the standard, the separation distances indicated between trays are the same.

Consistent with the standard's intent, the most severe hazard considered herein will be an electrical fault of sufficient magnitude and duration to cause a fire in the raceway. The results of actual electrically initiated cable tray fire tests on IEEE-383 qualified cables performed by Sandia (Ref. 1) will be used to provide the characterization of such a fire and to evaluate a thermal analysis of a worst case configuration.

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* The term "redundant" as used herein, applies to different safety-related trains or safety and non safety-related trains.

Discussion

In developing the separation details currently on Drawing E1-1702-02 it was recognized that conduit provides a raceway medium which effectively isolates internal events (e.g. faults) from the external surroundings. In this regard, a conduit system provides enclosure integrity which is superior to that of enclosed tray with covers and/or solid bottoms and splice plates between sections. Therefore, the same criteria required by the Standard and Regulatory Guide specifically for trays need not be arbitrarily applied to conduits.

In general, the separation distances required by IEEE-384 between redundant cable trays is three feet between trays separated horizontally and five feet between trays separated vertically. This separation applies to open ventilated cable trays in general plant areas in which potential hazards such as missiles, external fires, and pipe whip are excluded. Lesser separation is permitted in limited hazard areas such as the cable spreading room where the minimum required horizontal and vertical separation between redundant trays are reduced to one foot and three feet respectively. The standard requires that where these distances are used to provide adequate physical separation:

(1) Cables and raceways involved shall be flame retardant

(2) The design basis shall be that the cable trays will not be filled above the side rails

(3) Hazards shall be limited to failures or faults internal to the electrical equipment (raceways) or cables

Where termination arrangements preclude maintaining the above separation distances, the standard requires that the redundant circuits shall be run in enclosed raceways that qualify as barriers. A minimum distance of one inch is required between these redundant enclosed raceways. Regulatory Guide 1.75, Rev.1 is in agreement with these provisions of the standard and for the balance of this discussion, reference to the "standard" will mean IEEE-384, 1974 and Regulatory Guide 1.75, Rev. 1 as applicable.

Figures 2 and 3 in IEEE-384 depict arrangements of redundant cable trays enclosed with solid bottoms and/or covers which will satisfy the separation criteria therein. Applicable details in these figures are shown below.

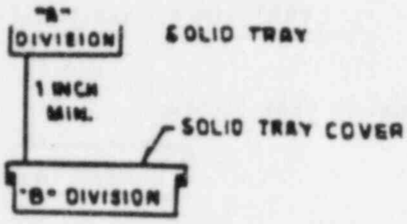

FIGURE 2

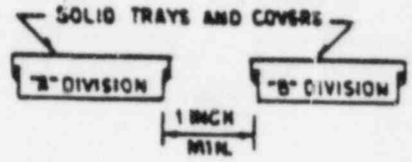

FIGURE 3

In the above figures, the standard provides examples of "enclosed raceway". It should be noted however, that in Figure 2 the trays are not totally enclosed as in Figure 3. Thus, as would be expected, orientation of the raceway is obviously a consideration as is the degree of enclosure which is commensurate with the hazard potential. No examples of acceptable separation between a conduit and a redundant cable tray are illustrated. However, a one inch separation is implicit per Figure 3 when the trays are enclosed and conduits are considered to be "enclosed raceways". Separation requirements between conduits and open trays must be determined by similar reasoning and analysis where required.

The CPSES separation criteria are consistent with the requirements of the standard for tray separation and in addition, define conduit separation requirements which are intended to provide an equivalent level of protection for redundant circuits. The results of cable tray fire tests (Ref 1) performed by Sandia Laboratories for NRC (subsequent to issuance of IEEE-384, 1974), to confirm the suitability of then current design Standards and Regulatory Guides, are supportive of the rationale used in developing raceway separation criteria for CPSES in 1975 regarding self-induced fire effects on IEEE-383 qualified cables.

Details 45 thru 49, 52 thru 55 and 57 on drawing E1-1702-02 identify the balance-of-plant (BOP) separation requirements between cable tray and conduit. (Detail 60 is a special case for the Nuclear Instrumentation System (NIS) conduits which addresses specific requirements of the Nuclear Steam Supply System (NSSS) vendor. These NIS conduit separation requirements will not be discussed here, however in all cases the NIS requirements either meet or exceed the BOP conduit separation criteria.)

These details can be grouped into four basic categories:

1) Safety-related conduits located above horizontal trays of redundant safety train (Details 46 and 48)

2) Safety-related conduits located adjacent to or below horizontal trays of redundant safety train (Details 45, 47 and 57)

3) Safety-related horizontal or vertical conduits located parallel to or crossing vertical trays of redundant safety train (Details 52 thru 55)

4) Non safety-related conduits located above, beside or below safety-related horizontal or vertical trays (Detail 49)

In general, these details require a minimum of 3-foot horizontal and 3-foot vertical separation in all general plant areas and 1-foot horizontal and 2-foot vertical separation in the cable spreading room. This separation is reduced to 1-inch only in those instances where the conduit is considered to be an effective barrier as discussed below.

The orientation of conduit and tray in the electrically-initiated fire tests (Ref. 1) conducted by Sandia included all configurations in categories 1 and 2 above except for the conduit running parallel with and 1-inch from the side rail of the tray as in Detail 45 of Drawing E1-1702-02. Conduits used in the Sandia tests consisted of 3-inch schedule 40 pipe, whereas the minimum conduit size used at CPSES is 1/2-inch nominal ID. An analysis (Ref. 3) was performed to address these differences between the as-built and test configurations and justify adequacy of the CPSES conduit separation criteria.

The Sandia tests also demonstrated acceptable separation with only 10.5-inch vertical spacing between trays, far less than the minimum 24-inch required between a tray and redundant conduit on Drawing E1-1702-02. It must be emphasized that in these electrically initiated fire tests, "exposed" cables in overlying trays were subjected to the high temperature gases (approximately 1000 F) from the fire without damage. This provides additional assurance that cables in conduits at more than twice this distance above a tray will be adequately protected.

The separation of vertical trays from conduits (category 3 above) shown on Drawing E1-1702-02 is equivalent to that shown in IEEE-384, 1974 for redundant trays and therefore does not require further justification, particularly considering the additional protection afforded by the conduits.

In comparing rigid conduit to an enclosed tray, it should be noted that conduit has:

a. Heavier gauge body than tray - providing a more effective heat sink than equivalent surface area of tray

b. Threaded connections providing an essentially air-tight medium which inhibits internal combustion and effectively isolates internal events from the surroundings.

c. Size limited to 5-inch nominal ID thus limiting both volume of cables (combustibles) contained and exposed surface area.

d. Curved surface providing radial distribution of heat and therefore much less favorable heat transfer characteristics to or from an adjacent tray than a flat surface of equivalent area.

Thus, when a conduit contains no safety-related (Class 1E or associated) circuits (category 4 above), it clearly satisifies IEEE-384, 1974 requirements of a barrier*. The barrier need not limit damage of non-safety circuits to any level. Consequently, only failures of the non safety-related circuits affecting safety-related circuits are of concern. Logically then, a conduit containing non safety-related circuits can be placed up to 1-inch from the top, bottom or sides of a Class 1E open ladder tray since the conduit provides a protective barrier separated by at least 1-inch from the Class 1E or associated circuits.

It is recognized that the converse is not true and conduits containing safety-related circuits may require more than 1-inch separation from open trays of a redundant train depending upon orientation of the conduit and tray. This has been considered in the separation criteria shown on Drawing E1-1702-02 where in general, the minimum required separation in any direction is 12-inches or more. The allowable separation is reduced to less than 12-inches (1-inch minimum) only when the conduit does not extend above the side rail of the open tray.

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*IEEE-384, 1974 defines a barrier as -- "A device or structure interposed between Class 1E equipment or circuits and a potential source of damage to limit damage to Class 1E systems to an acceptable level."

Results of Analysis

Analysis were performed (Ref. 3) using finite element techniques and computer heat transfer program HEATING-5 to determine the effects of an electrically-initiated fire in an open ladder cable tray on a 1/2-inch conduit located 1-inch away either beside or below the tray. Key parameters taken from reference 1 characterizing the tray fire were the vertical variation of total heat flux (worst case from October 5, 1976 fire in Figure 11 of the report), flame and gas temperature, and duration of exposure of the conduit to the heat source. The model assumed the heat flux to impinge on an 8-inch segment of conduit located directly below the fire . (This was considered worse than having the conduit beside the tray where much of the radiative heat flux would be blocked by the tray side rail.) The heat flux was assumed constant in this region. This assumption is conservative since the report (Ref. 1) indicated that "the flame zone does not comprise a continuous line fire, but instead consists of one or more "axisymmetric" luminous zones which are on the order of 5 to 8 inches in "diameter" at the base". No credit was taken for the decrease in radiative heat flux with increasing distance (note that conduits located 1-inch below ladder trays are actually more than 1-inch away from the cables due to the height and thickness of the tray rungs which raise the cables approximately 7/8-inch from the tray bottom). No credit was also taken for blockage of heat flux by the cables in the tray or heat absorbed by the cables in the conduit.

The maximum temperature calculated on the conduit surface was 357 F (180.6 C). This temperature cccured at a point directly below the center of the flame (mid point of the 8-inch conduit segment). Temperatures dropped sharply away from this point along the conduit to about 240 F at 4-inches, and below 170 F at 6-inches. The maximum temperature calculated was not a steady-state value due to the transient nature of the event (approximately 6 minutes) as shown in Figure 10 of the report (Ref. 1) for the October 5, 1976 fire. The report characterizes this fire as "one of the most intense and longest duration of those studied".

Conclusion

The analysis performed presents a comparative basis for evaluating the effectiveness of CPSES separation against cable tray and conduit configurations used in actual fire tests. The Sandia report (Ref. 1) referred to provides a characterization of electrically initiated cable tray fires which, as stated in the report, does not vary greatly from one fire to the next. One of the objectives of the test was to use cables representative of those used in the nuclear industry. The report indicates that 13 leading architect-engineer firms, 13 utility companies and 13 cable manufacturers were included in the industry survey which preceded the testing. Twenty (20) different cable types were screened on the basis of popularity of use, small scale electrically initiated cable insulation fire tests, UL FR-1 flame test and pyrolizer and thermal chromatograph testing (which measured insulation outgassing as a function of temperature). The cable constructions tested are representative of those used most extensively at CPSES, namely XLPE and EPR insulations with CSPE (Hypalon) jackets. The cables used in the full scale testing were, as a worst case, all XLPE insulated, with single conductor cables having no jacket and 3-conductor cables having an XLPE jacket.

Summarizing some of the more significant findings in the Sandia Report:

a. In electrically initiated fires, the intense period of the fire persisted at a particular location for between 40 and 240 seconds* before die-out began to occur. This is less than the time required to consistently ignite a tray of IEEE-383 qualified cables in the propane-fueled exposure fires (typically 300 seconds).

b. In the electrically initiated fire, cables in the tray 10.5 inches above the donor (fire) tray were exposed to a convective heat flux of about 6,000 BTU/hr/ft2 , which corresponds to a local gas temperature of approximately 1000 degrees F. The circuits remained functional and samples of the insulation from the bottom of the tray over the fire zone which were given elongation measurements, showed less than a 10 percent increase.

c. The luminous zone of the electrically initiated fire was optically thin which enabled immersed objects to radiate heat to the cooler surroundings. Thus, equilibrium surface temperatures of engulfed cylindrical objects varied from about 1200 degrees F just above the tray to 650 degrees F at a height of 10 inches. (Note that minimum vertical separation of 24-inches utilized in the CPSES design is more than twice this distance and maximum temperatures are anticipated to be well below temperatures successfully withstood during the fire tests.

d. In the electrically initiated fire, heat transfer to immersed objects is convection dominated with radiation accounting for no more than 30 percent of the total heat flux, even in the luminous region. (Logically then, conduits beside or below horizontal trays are shielded from the major, convective heat flux.)

---

*The high currents required for cable ignition open-circuited the conductors during this period, removing the fault current.

Computer analyses (Ref. 3) of the effects of the most severe fire encountered during testing (Ref. 1) on the smallest size conduit used at CPSES (1/2-inch) resulted in a maximum conduit temperature of approximately 181 C. Actual temperatures expected would be appreciably lower due to the assumptions made in the analysis that the heat flux resulted from a continuous 8-inch line fire and the fact that effects of distance and cable blockage on the radiative heat input flux was neglected.

All safety-related cables used at CPSES have an emergency overload rating of at least 130 C for 100 hours per specifications. In addition, the cables are designed to withstand temperatures up to 250 C under short circuit conditions. The fire analyzed will therefore not subject the cables to temperatures exceeding design conditions.

Additional evidence which supports the adequacy of CPSES conduit separation is provided in the results of the propane-fueled exposure fire tests (Ref. 2) also conducted by Sandia in which conduits and trays were included. In these tests, 14 trays were stacked 10.5-inch vertically and 8-inch horizontally apart. Directly below each tray (except for the bottom tray exposed to the propane-fueled source) was a conduit containing additional cables. No separation was provided between any conduit and the tray bottom. Although all circuits in the conduits above the third tray failed during the exposure fire (the conductors short-circuiting to the conduit and each other), circuits in the lower two (2) conduits maintained circuit integrity throughout the duration of the exposure fire. Considering that the fire in the lower two (2) trays was more severe than in an electrically initiated fire, being larger in size and of longer duration, the results provide a conservative indication of the adequacy of protection offered by conduits during the less severe electrical fire even when installed as in the tests (with no separation of a conduit from the tray bottom, and conduits only 10.5-inch above an open tray) with significantly less separation than provided for in the CPSES design (conduits separated a minimum of 1-inch from the bottom or side of a tray and 24-inch minimum from the top of an open tray).

References

1. Sandia Report No. SAND77-1125C

2. L. J. Klamerus, "Cable Tray Fire Tests" - IEEE paper A79091-0 (SAND77-1424)

3. Gibbs & Hill Mechanical Dept. Calculation No. 800, Rev. 1.

SPEC, HAH, TUGCO (2), AM (4)

CHANGE INDEX:OEI ____
: II ____
:III XX

COMANCHE PEAK STEAM ELECTRIC STATION
DESIGN CHANGE AUTHORIZATION

(WILL) (XXXXXXX) BE INCORPORATED IN DESIGN DOCUMENT DCA NO. 15,917

1. SAFETY RELATED DOCUMENT: XX YES ____ NO

2. ORIGINATOR: CPPE XX ORIGINAL DESIGNER ____

3. DESCRIPTION:

A. APPLICABLE SPEC/XXX/XXXXXXX 2323-ES-100 REV. 2

B. DETAILS Revise the following paragraph and sketch details for ES-100:

4.11.3.2. Separation Distance for Conduits

(2) Minimum separation between a conduit containing safety related cables and the top of an open tray having different train or channel shall be 2'-0" in cable spreading room and 3'-0" in general plant area. When it is impossible to maintain this separation, the distance may be reduced to one (1) inch where a solid cover is provided (see Dwg.2323-E1-1702-01, detail 38). Minimum separation between a conduit containing safety related cables and the bottom or side of an open tray (solid bottom or ladder) having different train or channel shall be one (1) inch. When a conduit conduit containing non-safety related cables is above, beside, or below an open tray (solid bottom or ladder) having different train or channel,

(Continued on Page 2)

4. SUPPORTING DOCUMENTATION:

8505-1195

FOR OFFICE AND ENGINEERING USE ONLY

RECEIVED
JAN 2? 1983
DOCUMENT CONTROL

5. APPROVAL SIGNATURES: CEC:gh 1-25-83

A. ORIGINATOR: [signature] DATE 1-25-83

B. DESIGN REPRESENTATIVE: [signature] DATE 1-26-83

6. VENDOR TRANSMITTAL REQUIRED: YES ____ NO XX

7. STANDARD DISTRIBUTION:

ARMS (ORIGINAL)	(1)	Clark Conzatti	EE	(1)
QUALITY ENGINEERING	(1)	Fred Powers	EE	(1)
TS FOR ORIG. DESIGN	(1)			
WESTINGHOUSE - SITE	(1)			
COMPLETIONS	(1)			
JERRY HENSON-PROD. CONTROL	(1)			

C

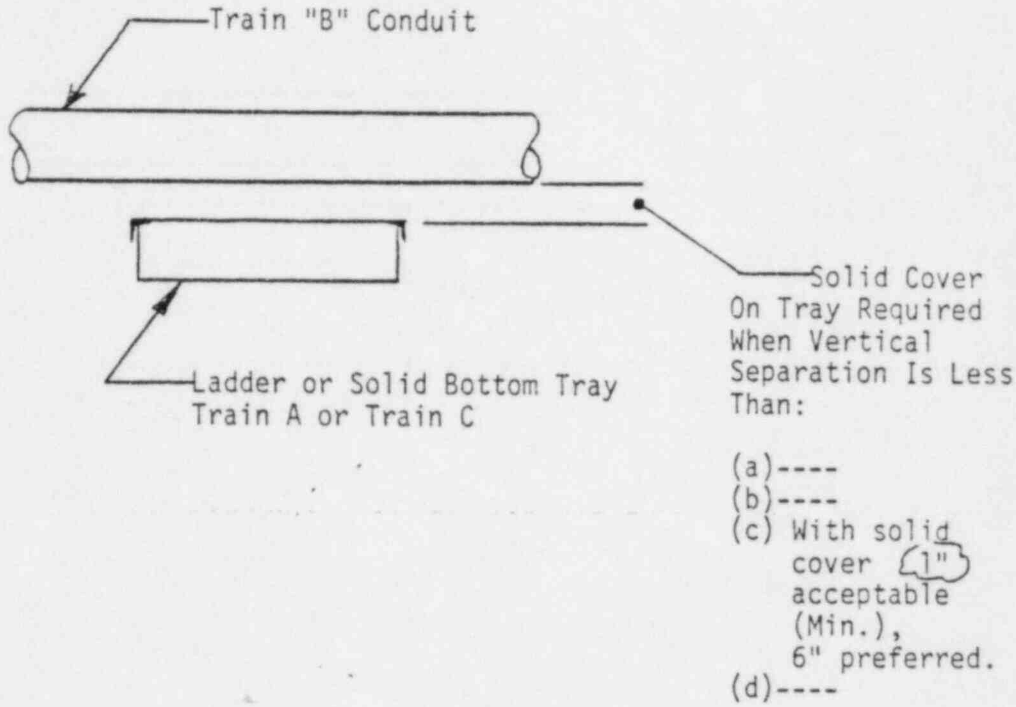
DETAILS: (Continued from Page 1)

Paragraph 4.11.3.2

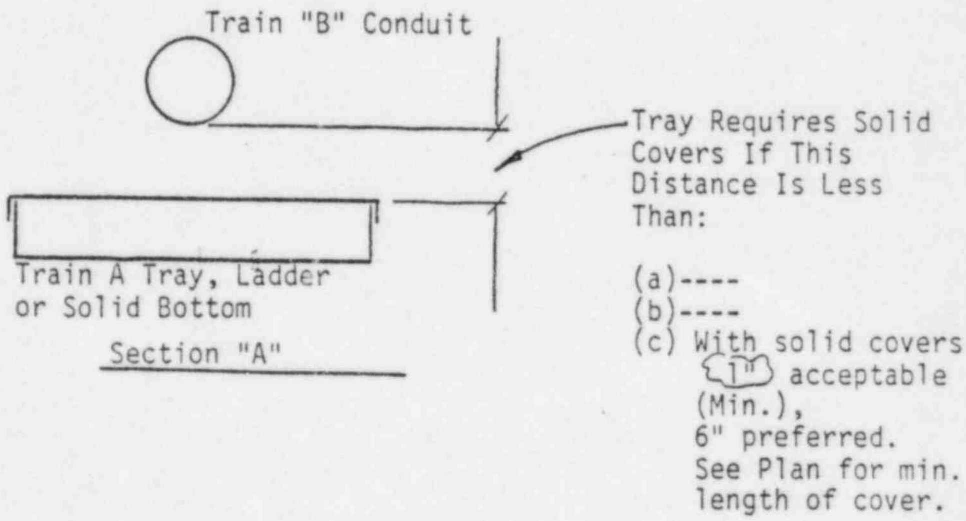
minimum separation shall be one (1) inch. There is no separation required between raceway of same train or channel.

See Separation Sketches "A" and "B".

Separation Sketch "A"



Separation Sketch "B"



Section "A"

I.b3-8A.023

Gibbs & Hill, Inc.

Penn Plaza
New York, New York 10001
212 760-

GTN-71284 March 6, 1986

Texas Utilities Generating Company
Post Office Box 1002
Glen Rose, Texas 76043

Attention: Mr. J. B. George
Vice President Project Gen. Mgr.

Gentlemen:

TEXAS UTILITIES GENERATING COMPANY
COMANCHE PEAK STEAM ELECTRIC STATION
G&H PROJECT NO. 2323
CONDUIT TO CABLE TRAY SEPARATION
REF: GTN-71266 DTD 2/28/86

Enclosed per the referenced letter is a copy of Mechanical Department Calculation No. 800, Rev. 1 for your information and use.

Design review of this activity is complete and documentation has been transmitted through normal procedures to duplicate file.

Very truly yours,

GIBBS & HILL, Inc.

Robert E. Ballard, Jr.
Director of Projects

REBa-JIr:lc
1 Letter

CC: ARMS (B&R Site) OL
W. I. Vogelsang (TUSI Site) 1L 1A

Dravo

DESIGN REVIEW

RECORD FORM

Texas Utilities Services, Inc. — CLIENT | Comanche Peak S.E.S. — PROJECT | 2323 — G&H Job No.

Title: Conduit Temperatures During Cable Tray Fire

[ ] Drawing [X] Calculation [ ] Specification

800 — DOCUMENT NO. | 1 — REVISION NO. | 1-2-86 — DATE | RS

COMMENTS ARE AS NOTED ON DOCUMENT SHEETS LISTED BELOW EXCEPT AS STATED HEREIN:

NONE

REQUIRED ACTION NONE

[signature] — DESIGN REVIEW ENGINEER | 2/28/86 — REVIEW DATE

REQUIRED ACTION SATISFACTORILY COMPLETED YES [ ] NO [ ]

COMMENTS

DESIGN REVIEW ENGINEER | REVIEW DATE

MECHANICAL DESIGN VERIFICATION CHECKLIST
CALCULATIONS AND ANALYSES

Project Comanche Peak Steam Electric Station G&H Job No. 2323

Filing Code 800 Rev. No. 1 Date 1-2-86

Subject Conduit Temperatures During Cable Tray Fire

Item	Considered by Des. Rev'r
1. Appropriate Nuclear Safety Related designation marked on cover sheet	✓
2. Filing code, revision, and page no. noted on each page	✓
3. Properly signed by preparer and checker	✓
4. Purpose of calculation properly stated	✓
5. Input data properly listed and referenced	✓
6. Assumptions are reasonable, properly listed and referenced	✓
7. Items to be re-verified, later in design, identified	✓
8. References listed, including revision no., page no., letter no., section no., etc. as applicable REF 1, 2, 3	✓
9. Method is accepted practice; formulas applicable, referenced and identified by equation no. or page no., etc.	✓

MECHANICAL DESIGN VERIFICATION CHECKLIST
CALCULATIONS AND ANALYSES

Project Comanche Peak Steam Electric Station G&H Job No. 2323

Filing Code 800 Rev. No. 1 Date 1-2-86

Subject Conduit Temperatures During Cable Tray Fire

Item	Considered by Des. Rev'r
10. General approach and accuracy are reasonable; output reasonable compared to input	✓
11. Spot check of mathematics or check by alternate method indicates accuracy is reasonable	✓
12. Computer program approved for use HEATING 5	✓
13. Consistent with project guide	✓
14. Consistent with FSAR	✓
15. NSSS and other vendors interface requirements complied with referenced	✓
16. Codes, Standards and Regulatory Guide requirements complied with and referenced	✓
17. All required modes of operation considered and listed	✓
18. Safety Class/Seismic Category identified	✓
19. Interface with other calculations and other disciplines listed and compatibility verified	✓

MECHANICAL DESIGN VERIFICATION CHECKLIST
CALCULATIONS AND ANALYSES

Project Comanche Peak Steam Electric Station G&H Job No. 2323

Filing Code 800 Rev. No. 1 Date 1-2-86

Subject Conduit Temperatures During Cable Tray Fire

Item	Considered by Des. Rev'r
20. Results to be used in design are identified and are responsive to the purpose of the calculation for sufficiency, accuracy, safety margins, and compliance with applicable Regulatory Guides, Codes and Standards, etc.	
21. Complete equipment parameters are listed	-

NOTE: As a minimum, all items on this checklist shall be considered by the design review engineer. If relevant to the input material being reviewed, the item shall be check marked (✓), otherwise the item shall be marked not applicable (NA) by the design review engineer.

Signature of Design Review Engineer [signature] Date [illegible]

Gibbs & Hill, Inc.

Calculation Cover Sheet

G&H Job No. [illegible] Client [illegible]

Calculation Number 8[illegible]

Number of Sheets in Original Issue 7

Subject CONDUIT TEMPERATURES DURING CABLE TRAY [illegible]

☒ Nuclear Safety Related

☐ Non-Nuclear Safety Related—QA Program Applicable

☐ Non-Nuclear Safety Related

Revision	Sheets Deleted	Sheets Added	Sheets Revised	Job Engineer Signature	Job Engineer Date
Original				[illegible]	[illegible]
1	5	5, 5a, 5b, 5c, 5d, 5e, 5f, 8, 9	1, 2, 3, 4, 6, 7		[illegible]

F-167, 4-81

Gibbs & Hill, Inc. Job No. 2323 Client TUGCO

Subject CONDUIT TEMPERATURES DURING CABLE TRAY FIRE

Calculation Number 200 Sheet No. 1

Revision	0	Date	Rev. 1	Date	Rev.	Date	Rev.	Date	Rev.	Date
Checking Method #	1									
Preparer	DKR	7-22-85	DKR	1-2-86						
Checker	MLW	7/30/85	[illegible]	2/27/86						
	-			[illegible]						

PURPOSE: TO CALCULATE THE TEMPERATURES OF ELECTRICAL CONDUIT LOCATED NEAR A CABLE TRAY CONTAINING BURNING CABLES (FROM AN ELECTRICALLY INITIATED FIRE). CONDUITS ARE LOCATED

1) BESIDE THE TRAY
2) ABOVE THE TRAY
3) BELOW THE TRAY

THIS CALCULATION LIMITS ITSELF TO A TRANSIENT ANALYSIS CONSISTENT WITH THE FIRE CHARACTERISTICS PRESENTED IN REF. 1. THE RESULTS SHOULD NOT BE USED FOR OTHER SITUATIONS WITHOUT CONFIRMING THE APPLICABILITY OF THIS CALCULATION TO THE OTHER SITUATIONS.

ASSUMPTIONS:

1. HEAT FLUX USED IS ASSUMED TO CONSERVATIVELY ENVELOPE THE FLUX FROM THE MOST SEVERE FIRE DESCRIBED IN REF. 1.
2. CONDUITS IN THE PATH OF COMBUSTION GASES ARE COMPLETELY SURROUNDED BY THESE GASES.
3. FOR THE CASE BEING ANALYZED, THE CABLE TRAY IS LOCATED IN AN OPEN AREA, ALLOWING ADEQUATE SPACE FOR FREE CONVECTION USE.
4. COMBINED HEAT TRANSFER COEFFICIENTS FOR AIR FLOW (CONVECTION & RADIATION) ARE CALCULATED CONSERVATIVELY.

Checking Method #
1 Line-by-line checking
2 Alternative Calculation Results compared
3 Identical Calculation Results compared
4 Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 2323 Client TUGCO

Subject CONDUIT TEMPERATURES DURING CABLE TRAY FIRE

Calculation Number 300 Sheet No. 1

Revision	0	Date	Rev	Date	Rev	Date	Rev	Date	Rev	Date
[illegible]	1									
Preparer	[illegible]	7/22/85	DKR	1/2/86						
Checker	MLJ	7/30/85	[illegible]	2/27/86						

REFERENCES:

1. 'CABLE TRAY FIRE TESTS', SANDIA LABORATORIES, ALBUQUERQUE, N.M. REPORT NO. SAND77-1125C
2. 'PRINCIPLES OF HEAT TRANSFER', 3RD ED, F. KREITH.
3. 'HEATING 5', COMPUTER PROGRAM, OAK RIDGE NATIONAL LABORATORY, VERSION 2.
4. G&H ELECTRICAL DRAWING 2323-E1-1702-02 (Separation Criteria)
5. MEMO. EE-956, DATED 8/6/85, S. MARTINOVICH TO D. RAO.
6. MEMO. EE999 DATED 12/18/85, S. MARTINOVICH TO D. RAO. 1

CALCULATION:

THIS CALCULATION FOLLOWS CLOSELY THE METHODS USED IN THE EXPERIMENTS DESCRIBED IN REF. 1 AND UTILIZES CABLE FIRE CHARACTERIZATIONS FROM REF. 1 FOR HEAT FLUXES, FLAME AND GAS TEMPERATURES, AND GAS HEAT TRANSFER COEFFICIENT. CHARACTERISTICS OF MOST SEVERE FIRE (10/6/76 FIRE, p. 24, REF. 1) WERE USED. AIR HEAT TRANSFER CO-EFFICIENTS WERE TAKEN FROM REF. 2.

THE COMPUTER PROGRAM HEATING-5 REF. 3 WAS USED TO CALCULATE TEMPERATURE-TIME HISTORIES IN THE CONDUITS. THE MAXIMUM TEMPERATURE ON THE INSIDE WALL OF THE CONDUIT WAS DETERMINED. THIS IS THE MAXIMUM TEMPERATURE THAT THE CABLES INSIDE THE CONDUIT WILL BE EXPOSED TO. THE LUMINOUS FLAME HEIGHT 1

Checking Method #
1 Line-by-line checking
2 Alternative Calculation Results compared
3 Identical Calculation Results compared
4 Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. [illegible] Client [illegible]

Subject [illegible]

Calculation Number 3 [illegible] Sheet No. 3

Revision	[illegible]	Date	Rev	Date	Rev	Date	Rev	Date	Rev	Date
[illegible]	1									
Preparer	DKR	7-22-85	DKR	1/2/86						
Checker	MLu	7/30/85	[illegible]	2/27/86						

FLUCTUATES BETWEEN 4" AND 10" IN HEIGHT (PER REF. 1, S-3)
ABOVE THE BURNING 3" HIGH CABLE
TRAY. THE TRAY WAS ASSUMED TO BE HORIZONTAL.

FOR CASE 2) THE CONDUIT WAS ASSUMED TO BE
1 FOOT FROM THE TRAY, ORIENTED VERTICALLY. FOR THIS
CONDITION, FROM REF. 1, p.23, T = 1900 F, $\frac{q}{A})_{MAX}$ = 7000 BTU/HR-FT^2
(RADIATIVE). CONVECTIVE HEAT FLUX WOULD BE NEGLIGIBLE
IN THE REGION OPPOSITE THE FLAME. THIS IS BECAUSE
A BLANKET OF COOL AIR WOULD FLOW BETWEEN THE TRAY
AND THE CONDUIT. COMBUSTION AIR IS SUPPLIED AT 122 F
(FORCED CONVECTION) FROM UNDER AND AROUND THE TRAY.
THE PORTION OF THE CYLINDER THAT IS NOT EXPOSED TO
THE FLAME AND GAS LOSES HEAT TO THE [illegible]
AT 122F (NATURAL CONVECTION). (SEE BELOW, FIG. 1)

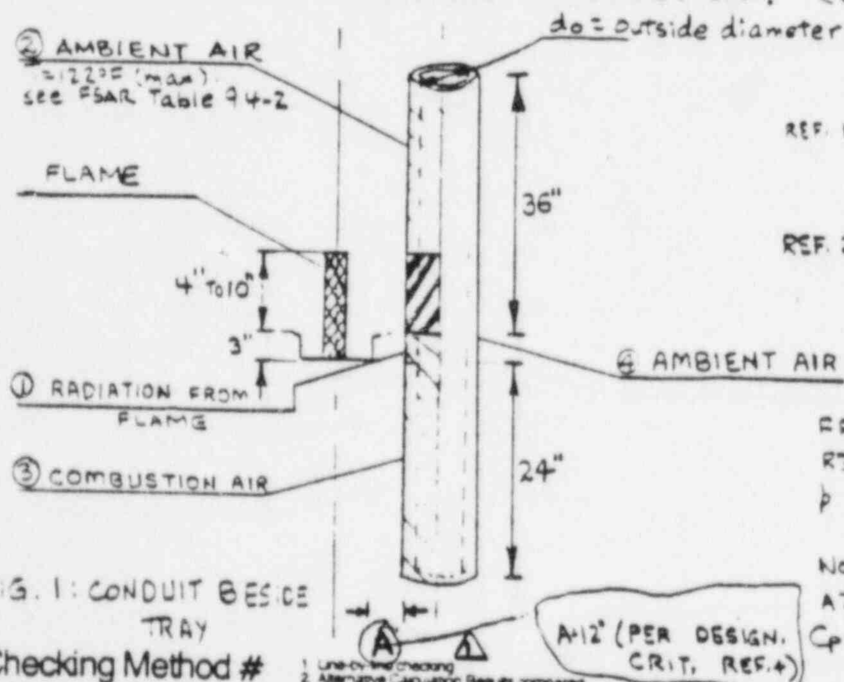


FIG. 1: CONDUIT BESIDE TRAY

REF. 1: ① q/A = 7000 Btu/hr-ft^2, ② 1900 F

REF. 2:
② $h = h_c + h_r$ - Natural Convection and Radiation
③ $h = h_c + h_r$ - Forced Convection and Radiation
④ $h = h_c + h_r$ - Natural Convection and Radiation

FROM REF. 2 p 634: STEEL PROPERTIES: ρ = 475 LB/FT^3 [illegible]
C_p = 0.11 BTU/LB-F @ 32 F
k = 25.0 BTU/HR-FT-F [illegible]
[illegible] 25.0 BTU/HR-FT-F @ 1022 F

NOTE: ρ & C_p ARE SELECTED CONSERVATIVELY AT THE TEMPERATURE OF INTEREST. C_p IS HIGHER, ρ INSIGNIFICANTLY DIFFERENT.

Checking Method #
1 Line-by-line checking
2 Alternative Calculation Results compared
3 Identical Calculation Results compared
4 Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc. Job No. 2323 Client T-G-C

Subject CONDUIT TEMPERATURES DURING CABLE TRAY FIRE

Calculation Number 800 Sheet No. 4

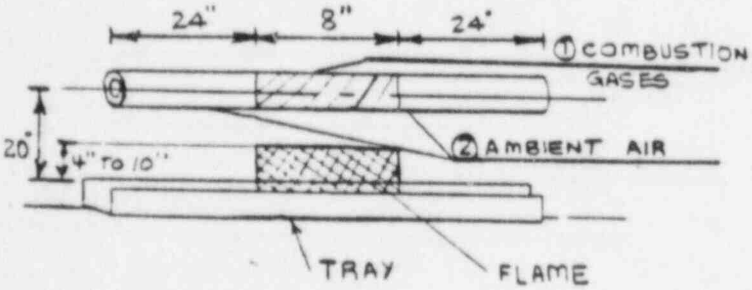
Revision	0	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Safety related			1							
Preparer	CKR	7/4/85	DKT	1/2/86						
Checker	MLu	7/30/85	CAC	2/26/86						

CASE b) ASSUMES THE CONDUIT LOCATED 20 INCHES ABOVE THE TRAY AND PARALLEL TO THE AXIS OF THE TRAY. FOR THIS CONDITION, FROM REF 1, p-26, $q/A_{max} = 3000$ Btu/hr-ft² FOR THE 10/5/76 CASE. (THIS IS THE MOST INTENSE FIRE SEE p-24 OF REF. 1). USING THE METHOD ON p-... OF ...

$$\frac{q}{A} = h(T - T_{cw}) \; ; \quad 3000 = 7(T - 70) \quad T = 498.5\,°F$$

(ESTIMATED GAS TEMP.)

THIS CASE ASSUMES THAT THE FIRE IS 8 INCHES LONG (ref 1, p.20) AND THAT A FURTHER TWO FEET OF CONDUIT ON EITHER SIDE IS LOCATED IN STILL AIR AT 122 F.



① COMBUSTION GASES
$q/A = 3000$ Btu/hr ft²
④ 498.5 F

② $h = h_c + h_r$ - Natural Convection and Radiation

FIG. 2 CONDUIT ABOVE TRAY

* $T_{cw} = 70$ F IS CALCULATED USING $\frac{q}{A} \cong 15000$ BTU/HR-FT², $T = 2200$ F
$h = 7$ BTU/HR-FT² F

Checking Method #
1 Line-by-line checking
2 Alternative Calculation Results compared
3 Identical Calculation Results compared
4 Compare inputs and results of computer with corresponding inputs and results of similar codes

F-166, 7-82

Gibbs & Hill, Inc. Job No. [illegible] Client [illegible]

Subject: Conduit Temperatures During Cable Tray Fire

Calculation Number: 300 Sheet No. 5

Revision		Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Same Revision			1							
Preparer			[illegible]	2/2[illegible]						
Checker			[illegible]	2/26/[illegible]						

Case c) assumes the conduit located one inch below the cable tray* and parallel to the axis of the cable tray. The conduit and the cable tray are each oriented horizontally. For this configuration, (see reference 1, p. 28) $q/A)_{max} = 7000 \frac{BTU}{hr \cdot ft^2}$ (radiative) at a flame temperature of $T_f = 1900°F$. Convective heat flux would be negligible in this case because combustion air would be drawn up from under the tray at a temperature of 122°F.

This case assumes that the fire is 8 inches long and that two feet of conduit on either side of the fire is located in still air at 122°F.

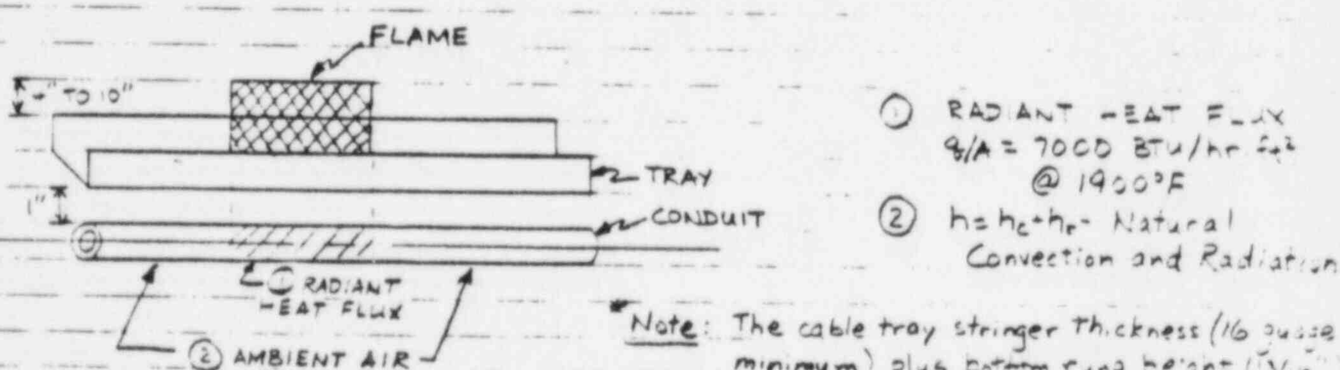


FIG. 3 CONDUIT BELOW TRAY

*Note: The cable tray stringer thickness (16 gauge minimum) plus bottom rung height (13/16") equals 0.876". Therefore, the conduit is at least 1.876" from the burning cables. See T.J. Cope drawings GG-06SL-12-06-CP, GG-18SL-12-06-CP and GG-30SL-12-06-CP.

Checking Method #
1 Line-by-line checking
2 Alternative Calculation Results compared
3 Identical Calculation Results compared
4 Compare inputs and results of computer with corresponding inputs and results of similar codes.

F-166, 7-82

Gibbs & Hill, Inc.	Job No. 2323	Client TUGCO
Subject: Conduit Temperatures During Cable Tray Fire		
Calculation Number 200		Sheet No. 52

	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Sheets Affected			1							
Preparer				2/21/86						
Checker				2/26/86						

The configuration shown in case b) has already been addressed in reference 1 with regard to conduits which are above the burning cable tray but within one foot of the cable tray. The plot on page 25 of reference 1 shows the temperature response of exposed cables at heights of 3/8", 6", 9" and 11" above the burning cables. The case which resembles case b) the most is the one at the 11" height. The maximum temperature recorded in the test was ≈ 300°F. The temperature at 20" will be lower since the combustion gases cool as they rise, and, per reference 1, convection is the dominant heat transfer mechanism in this case. Therefore, case b) will not be analyzed.

Since cases a) and c) are somewhat similar, let us consider the following. As the distance between the conduit and the fire increases, a smaller percentage of the conduit surface area receives the radiant energy. In addition, radiation heat flux varies inversely with distance squared. Since the conduit in case a) is farther than the one in case b), the case a) conduit will receive less radiant heat. Therefore case c) is more severe than case a), and case a) will not be analyzed.

Checking Method #
1 Line-by-line checking
2 Alternative Calculation Results compared
3 Identical Calculation Results compared
4 Compare inputs and results of computer with corresponding inputs and results of similar codes

F-166, 7-82

	Date	Rev	Date	Rev	Date	Rev	Date	Rev	Date
		1							
Preparer		M	2/21/86						
Checker			1/24/86						

Conduits at the CPSES range in size from ½" to 6" nominal diameter. In order to select the conduit size which will result in maximum temperature, let us consider the following. Represent the conduit as a fin extending from a heat source. The solution to the fin problem is given in reference 2, p. 59.

$$q_{fin} = \sqrt{hPkA}\,(T_s - T_\infty)$$

Now: $P = \pi d_o$

$$A = \frac{\pi}{4}(d_o^2 - d_i^2) = \frac{\pi}{4}(d_o - d_i)(d_o + d_i) = \frac{\pi}{2}\,t\,(d_o + d_i)$$

where: d_o = conduit outside diameter
d_i = conduit inside diameter
t = conduit wall thickness

Also: $q_{fin} \propto d_o$ and $h \propto \left(\frac{1}{d_o}\right)^{1/4}$

Therefore we can say:

$$d_o \propto \left[\left(\frac{1}{d_o^{.25}}\right)(d_o)(d_o + d_i)\,t\right]^{\frac{1}{2}}(\Delta T)$$

$$\text{Constant} = \left[\left(\frac{1}{d_o^{.25}}\right)\left(1 + \frac{d_i}{d_o}\right)t\right]^{\frac{1}{2}}(\Delta T)$$

The combination of d_o, d_i and t which minimizes the term in the square root bracket will result in the highest temperature. Based on the information in reference 6, the ½" conduit is the worst case.

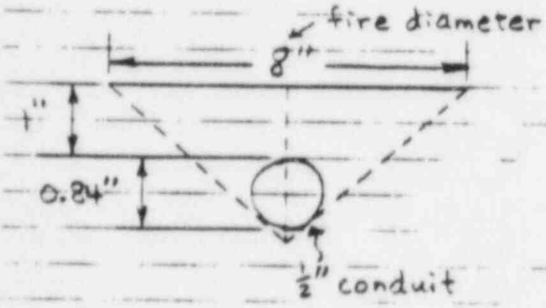
Gibbs & Hill, Inc. Job No. [illegible] Client [illegible]

Subject: Conduit Temperature During Cable Tray Fire

Calculation Number: 200 Sheet No. 5c

[illegible]		Rev	Date	Rev	Date	Rev	Date	Rev	Date
Preparer		MLW	2/2/86						
Checker		[illegible]	2/26/86						

For case c) we must compute the percentage of the conduit circumference which will receive the radiant heat energy.

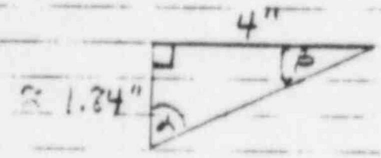


From reference 6; 1/2" conduit

$d_i = 0.622$ in. $\Rightarrow r_i = 0.311$ in. $= 0.0259$ ft

$d_o = 0.840$ in. $\Rightarrow r_o = 0.420$ in. $= 0.0350$ ft

$t = r_o - r_i = 0.109$ in. $= 0.0091$ ft.



$\tan\alpha \approx \frac{4}{1.84} = 2.1739$

$\therefore \alpha \approx 65.3°$ $\beta \approx 24.7° = 0.431$ rad

The total amount of conduit to receive radiant heat energy is

$360 - 2(24.7) = 310.6°$

Since there is circular symmetry, let us consider one half of the conduit.

From $0° < \theta < 24.7°$ (no heat input)

$24.7° < \theta < 180°$ (radiant heat input)

Checking Method #
1 Line-by-line checking
2 Alternative Calculation Results compared
3 Identical Calculation Results compared
4 Compare inputs and results of computer with corresponding inputs and results of similar codes.

F-166, 7-82

Gibbs & Hill, Inc. Job No. [illegible] Client [illegible]

Subject Conduit Temperatures During Cable Tray Fire

Calculation Number 200 Sheet No. 5d

Rev.		Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Design Verifier										
Preparer			M	[illegible]						
Checker			NC	2/26/84						

The fire varies with time as shown in reference 1, page 25.

For case c), using curve ②, the calorimeter temperature rises from 70°F at t=0 seconds to 1200°F at t=30 seconds. The temperature remains at 1200°F up to 240 seconds, and drops to 400°F at t=360 seconds. The radiative heat flux when $T_{surface} = 1200°F$ is approximately 7000 $\frac{BTU}{hr \cdot ft^2}$.

In order to determine the heat flux at $T_{surface} = 400°F$ the corresponding flame temperature must be determined first.

Using the heat balance shown in reference 1, [illegible]

$$h(T_f - T_s) + \epsilon\sigma(T_f^4 - T_s^4) = (1-\epsilon)\sigma(T_s^4 - T_\infty^4)$$

the flame temperature can be determined.

<u>Given</u>: $\epsilon = 0.15$, $h = 7 \frac{BTU}{hr \cdot ft^2 \cdot °F}$

$T_{surface} = T_s = 400°F = 860°R$ $T_\infty = 70°F = 530°R$

$$7(T_f - 860) + (0.15)(0.1714\times10^{-8})[T_f^4 - (860)^4] = (1-0.15)(0.1714\times10^{-8})[(860)^4 - (530)^4]$$

$$7T_f - 6020 + 2.571\times10^{-10}T_f^4 - 140.64 = 681.98$$

$$2.571\times10^{-10}T_f^4 + 7T_f = 6842.62$$

$$\therefore T_f \approx 948°R = 488°F \quad \text{(Flame temperature)}$$

Checking Method #
1 Line-by-line checking
2 Alternative Calculation Results compared
3 Identical Calculation Results compared
4 Compare inputs and results of computer with corresponding inputs and results of similar codes

F-166, 7-82

Gibbs & Hill, Inc.	Job No. [illegible]	Client [illegible]
Subject	Conduit Temperatures During Cable Tray Fire	
Calculation Number	200	Sheet No. 50

	Rev	Date	Rev	Date	Rev	Date	Rev	Date	Rev	Date
Preparer				2/2/86						
Checker				2/26/86						

From the flame temperature, the heat flux leaving the flame will be calculated.

$$q_r'' = \epsilon\sigma(T_f^4 - T_s^4)$$

$$q_r'' = (0.15)(0.1714\times10^{-8})\left[(948)^4 - (860)^4\right]$$

$$q_r'' = 67.0 \frac{BTU}{hr\cdot ft^2} \quad (\text{at } T_s = 400°F)$$

The following input will be used.

Time (seconds)	Heat Flux ($\frac{BTU}{hr\cdot ft^2}$)
0.0	0.0
30.0	7000.0
240.0	7000.0
360.0	67.0

The heat flux is assumed to impinge on the 8 inch segment of the conduit which is directly below the fire. The heat flux is assumed to be constant in this region. No credit is taken for the decrease in radiative heat flux with increasing distance. No heat flux is applied to the remainder of the conduit. It is more conservative with regard to the maximum conduit temperature to apply a constant heat flux to the 8 inch region and neglect the end effects of the heat flux in the other region. No credit is taken for blockage of heat flux due to the existence of adjacent cables in the tray.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes.

Gibbs & Hill, Inc.	Job No. 6383	Client TUGCO
Subject: Conduit Temperatures During Cable Tray Fire		
Calculation Number 900		Sheet No. 5?

	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Preparer										
Checker										

Preparer	[illegible]	2/21/86
Checker	CAC	2/26/86

The conduit is assumed to lose heat by convection and radiation to the environment.

a) Natural Convection from Horizontal Cylinders

$$Nu = \frac{h d_o}{k} = 0.53 \, (Gr_d Pr)^{\frac{1}{4}}$$ (ref. 2, p.322)

where $Pr > 0.5$ and $10^3 < Gr_d < 10^9$

From ref. 2, p.636: (Air properties @ 200°F)

$k = 0.0174 \frac{BTU}{hr \cdot ft \cdot °F}$, $Pr = 0.72$, $\frac{g\beta\rho^2}{\mu^2} = 0.85 \times 10^6 \frac{1}{ft^3 \, °F}$

$$h = \frac{0.53\,k}{d_o}\left[\left(\frac{g\beta\rho^2 d_o^3 (\Delta T)}{\mu^2}\right)(P_r)\right]^{\frac{1}{4}}$$

$$h = \frac{(0.53)(0.0174)}{(0.07)}\left[(0.85 \times 10^6)(0.07)^3(0.72)\right]^{\frac{1}{4}} (\Delta T)^{\frac{1}{4}}$$

$$h = 0.5 \, (\Delta T)^{\frac{1}{4}}$$

b) Radiation

$\epsilon = 0.3$ Zinc Galvanized Sheet (ref. 2, p. 237)

$\epsilon\sigma = (0.3)(0.1714 \times 10^{-8}) = 5.142 \times 10^{-10} \frac{BTU}{hr \cdot ft^2 \cdot °R^4}$

(For conservatism, the shape factor is assumed to be 1.0)

Checking Method #
1 Line-by-line checking
2 Alternative Calculation Results compared
3 Identical Calculation Results compared
4 Compare inputs and results of computer with corresponding inputs and results of similar codes

Gibbs & Hill, Inc. Job No. 2323 Client TUGCO

Subject CONDUIT TEMPERATURES DURING CABLE TRAY FIRE

Calculation Number 200 Sheet No. 6

Revision		Date	Rev.	Date	Rev	Date	Rev.	Date	Rev	Date
Safety Related										
Preparer	DKR	7/22/85	DKR	1/5/86						
Checker	MLU	7/30/85	CAC	2/26/86						

INPUT DATA SET FOR CASE C

```
//MLUSECTF JOB (G48,'11320','002323006','5076'),'M.LUBRANO 15FL -1019',
// CLASS=C,NOTIFY=MLU,MSGCLASS=0
// EXEC HEAT5V2
//FT06F001 DD SYSOUT=*
//SYSIN DD *
  CPSES ELECTRIC CABLE TRAY FIRE, 1/2" CONDUIT 1" BELOW BURNING TRAY
     2400          1         3         2                               1         2
        2          3         3                    1                    9
      500
       -1                                   0.00002                  0.0      0.15
        1          1    0.0259    0.0350      0.431      3.14        2.0      2.33
        1                                 1
        2          2    0.0259    0.0350      0.431      3.14        0.0       2.0
        1                                 2
        3          2    0.0259    0.0350        0.0     0.431        0.0      2.33
        1                                 2
        1     STEEL1      22.0     490.0       0.11
        2     STEEL2      26.0     490.0       0.11
        1      122.0
        1          1     122.0
          5.14E-10         0.5      0.25        0.3         1
                                                 -1
        2          1     122.0
          5.14E-10         0.5      0.25
   0.0259     0.0350
        1
      0.0      0.431      3.14
        2          6
      0.0        2.0      2.33
       24          4
        1          5
      0.0        0.0     0.008    7000.0      0.067    7000.0        0.1      67.0
      0.2       67.0
/*
//
```

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes

F-166, 7-82

Gibbs & Hill, Inc. Job No. 2323 Client TUGCO

Subject CONDUIT TEMPERATURES DURING CABLE TRAY FIRE

Calculation Number 800 Sheet No. 7

Rev.		Date	Rev. 1	Date	Rev.	Date	Rev.	Date	Rev.	Date
Sheets Affected	1									
Preparer	DKR		DKR	1/2/86						
Checker	MLU	7/2/85	[illegible]	2/26/86						

RESULTS: FOR A CABLE TRAY FIRE, THE TEMPERATURE OF NEARBY CONDUITS WILL INCREASE WITH TIME UNTIL THE INCIDENT HEAT FLUX DECREASES APPRECIABLY. FOR CASE C) THE MAXIMUM TEMPERATURE OF THE ½" CONDUIT IS 357 °F (SEE COMPUTER PRINTOUT MLU$ECTF JOB 439 FEBRUARY 21, 1986). THIS OCCURS AT A POINT DIRECTLY BELOW THE CENTER OF THE FLAME ABOUT 290 SECONDS AFTER FIRE INITIATION. PLOTS OF MAXIMUM CONDUIT TEMPERATURE VERSUS TIME AND CONDUIT TEMPERATURE PROFILE AT THE TIME OF MAXIMUM TEMPERATURE ARE ON SHEETS 8 AND 9.

NOTE THAT THE TEMPERATURES LISTED ABOVE OCCUR IN THE FIRST 6 MINUTES FOLLOWING INITIATION OF THE FIRE. THEY DO NOT REPRESENT STEADY-STATE CONDITIONS. THE HEAT FLUX FROM THE MOST SEVERE ELECTRICALLY INITIATED FIRE WAS USED IN THIS CALCULATION. THERMOCOUPLES 3/8" ABOVE BURNING CABLES RECORDED A DECREASE IN INTENSITY FROM ≅ 1200F TO < 400F WITHIN SIX MINUTES (REF 1, p. 25), WITH FIRE INTENSITY DECREASING AFTER FOUR MINUTES. BEYOND FOUR MINUTES, A FIRE OF THIS NATURE WILL RESULT IN TEMPERATURES LOWER THAN THE MAXIMUM TEMPERATURES CALCULATED IN THIS ANALYSIS.

Checking Method #
1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes

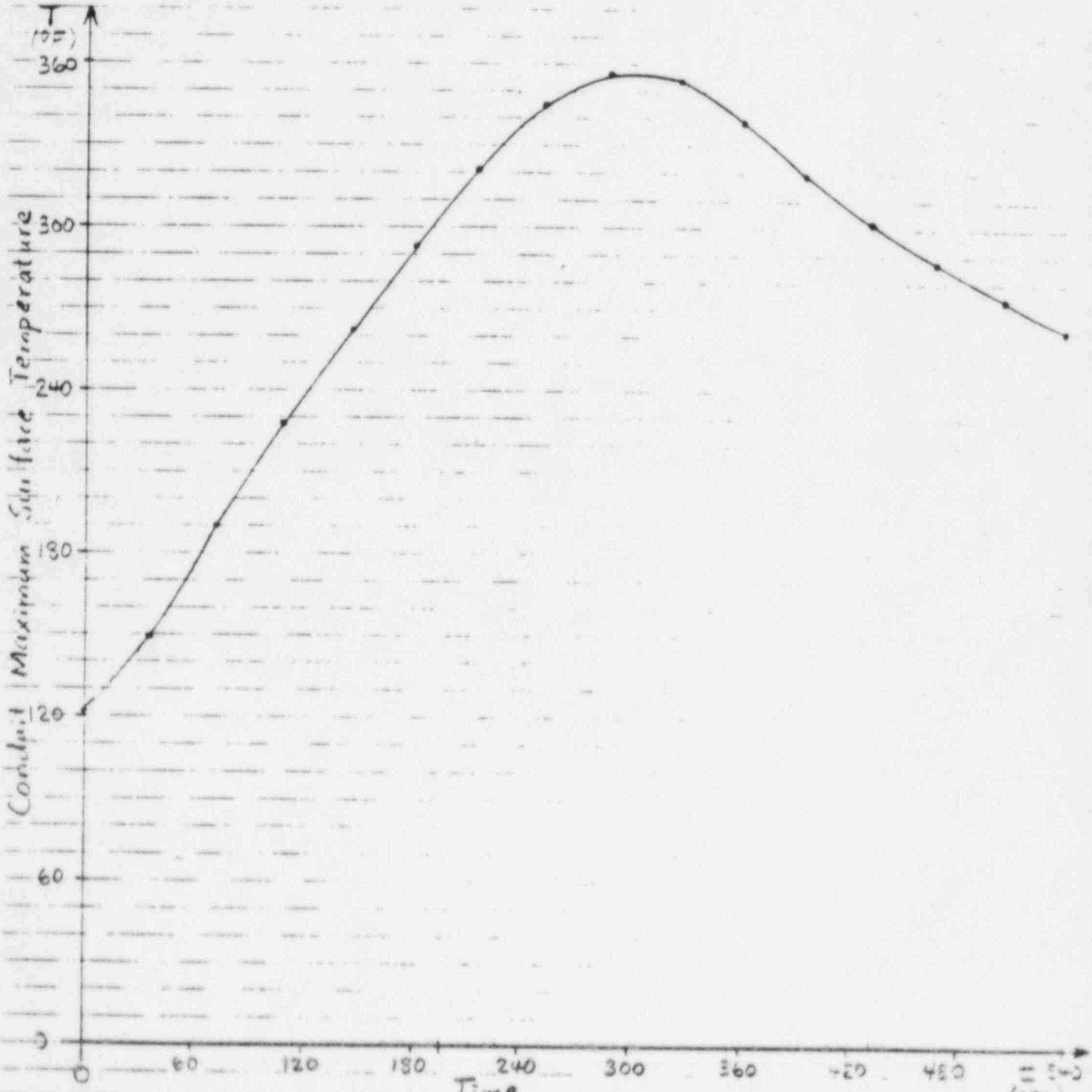
Gibbs & Hill. Inc. Job No. 2323 Client TUGCo

Subject Conduit Temperatures During Cable Tray Fire

Calculation Number 200 Sheet No. 8

Preparer	M. [illegible] 2-2-86				
Checker	CAC 2/26/86				

Case c) Conduit Maximum Temperature versus Time at the point of maximum temperature (z = 2.33 ft)



Checking Method #

1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar codes

F-166, 7-82

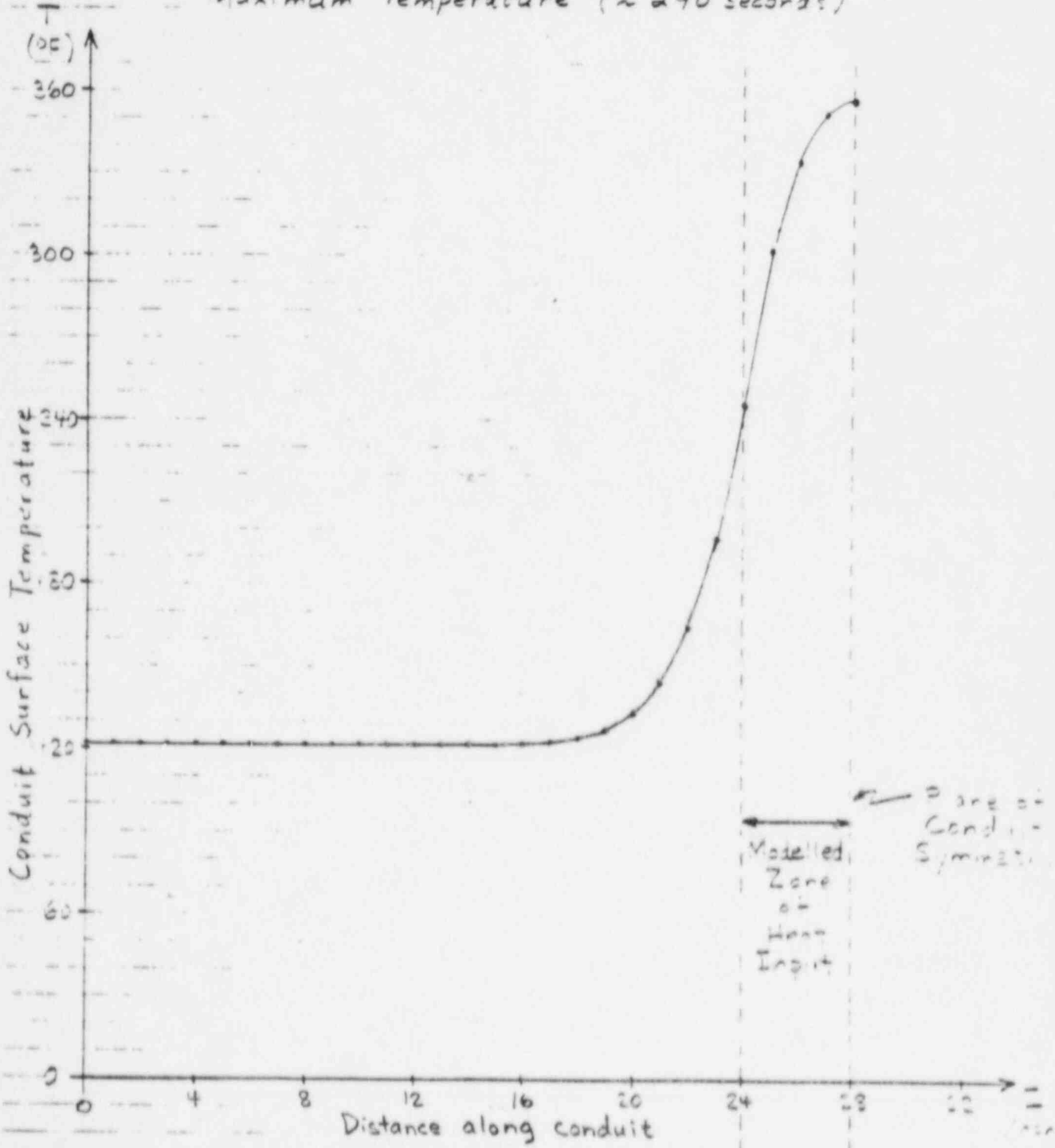
Gibbs & Hill, Inc. Job No. [illegible] Client [illegible]

Subject [illegible]

Calculation Number [illegible] Sheet No. [illegible]

Rev.		Date	Rev.	Date	Rev.	Date	Rev.	Date	Rev.	Date
Preparer			[illegible]							
Checker			[illegible]	[illegible]						

Case c) Conduit Temperature Profile at the Time of Maximum Temperature (≈ 290 seconds)



Checking Method #

1. Line-by-line checking
2. Alternative Calculation Results compared
3. Identical Calculation Results compared
4. Compare inputs and results of computer with corresponding inputs and results of similar cases

F-166, 7-82

CPRT-294

INTEROFFICE MEMORANDUM

TO: Howard A. Levin

FROM: John J. Mallanda

DATE: March 12, 1986

SUBJECT: Action Plan I.b.3 Design Observations

During the implementation of Action Plan I.b.3, "Conduit to Cable Tray Separation", the Electrical Review Team noted two design observations that by themselves did not indicate an adverse trend. However, I believe these observations, since they involve design criteria, should be included with other findings generated by the Design Adequacy Program (DAP) to determine if an adverse trend exists.

The original issue as identified by the NRC is:

> "The TRT found no evidence that the existing G&H analysis for establishing the criteria for a 1-inch separation between rigid conduits and cable trays, as stated in G&H Electrical Erection Specification 2323-ES-100, had been evaluated by the NRC staff for Comanche Peak. This analysis should have been referenced in the FSAR."

Upon investigation of this issue, the Electrical Review Team noted the following two design observations:

1) No analyses existed when the original criteria was incorporated into design and construction documents. The basis appears to be engineering judgment based on experience with other nuclear projects. The one inch separation between safety-related conduit and cable trays was originally sent to TUGCO via Gibbs & Hill letter GTN-2441 dated February 19, 1975 which included the document, "Criteria for Separation of Class 1E Equipment and Circuits". Additional criteria involving conduit above cable trays was added to the Electrical Erection Specification 2323-ES-100 via DCA-6132, Revision 0, dated November 16, 1979. Again, engineering judgment appears to have been the basis.

2) The Gibbs & Hill analysis eventually used to verify the adequacy of a one-inch separation between conduits and cable trays contained inconsistent assumptions after design review was complete. The latest revision of this analysis is attached to letter GTN-70439 dated August 20, 1985, and the Design Review confirmation was transmitted via GTN-70614 dated September 23, 1985.

Two assumptions that were considered inconsistent are:

- The analysis states that the smallest conduit size is the worst case since the only heat dissipation considered is convection. However, the equations presented indicate that the largest diameter would give the highest temperatures (worst case). Subsequent analyses indicate that the smallest size is indeed the worst case.

- The assumption that a three foot section of conduit would be at the maximum temperature is inconsistent. Subsequent analyses indicate that the maximum temperature is at the point in the middle of the flame region and temperatures die away rather rapidly as the distance from the flame increases.

Several other assumption were considered questionable. For example, the analysis assumed that a one-inch conduit was the smallest size. Specification ES-100 indicates that 1/2 and 3/4 inch conduit were used at the site. A walkdown has not been performed to determine the smallest conduit routed one-inch from a redundant open cable tray.

Attached for your information and use are copies of the documents noted above.

If you require any further information please contact me or Bob Bizzak. Please let me know what your conclusions are regarding the above design observations.

John J. Mallanda

J. J. Mallanda

JJM/ls

cc: T. G. Tyler (w/o attachments)
R. J. Bizzak (w/o attachments)
CPRT File I.b.3 (w/o attachments)
CPRT File (w/o attachments)

I.b.3 - 08.001

SAND 771125C

CONF-771018 - 1

CABLE TRAY FIRE TESTS

L. J. Klamerus, 5432
R. H. Nilson, 1262

Sandia Laboratories
Albuquerque, New Mexico

(SAND77-1125C)

Abstract

Funds were authorized by the Nuclear Regulatory Commission to provide data needed for confirmation of the suitability of current design standards and regulatory guides for fire protection and control in water reactor power plants. This paper summarizes the activities of this program through March 1977. It describes a survey of industry in order to determine current design practices. The adequacy of cable tray spacing designated in Regulatory Guide 1.75 was chosen for evaluation. Using electrical cable types currently being selected for new nuclear power plant construction, a screening test was designed and completed to select two cable constructions which were used in subsequent full scale tests. Seven full scale tests were run and resulted in no functional damage to cables in trays adjacent to that cable tray in which a fire was electrically initiated. Characterization of these fires was made and reveal a margin of safety in the separation criteria of the regulatory guide for electrically initiated fires in IEEE-383 qualified cable.

Introduction

The Office of Nuclear Regulatory Research of the United States Nuclear Regulatory Commission is conducting confirmatory research in areas considered important to protecting the health and safety of the public. Fire protection, as established by NUREG-0050, "Recommendations Related to Browns Ferry Fire," is one such critical area of research.

The objectives of the Fire Protection Research Project at Sandia Laboratories are (1) to provide data either to confirm the suitability of current design standards and regulatory guides for fire protection and control in light water reactor power plants or to indicate areas where they should be updated; (2) to obtain data that will provide improved technical basis either for modification of the standards and guides or for new standards and guides if necessary. Such changes are to be made where appropriate to decrease the vulnerability of the plant to fire; to provide for better control of fires; to mitigate the effects of fires on plant safety systems; and to remove unnecessary design restriction; (3) to obtain fire effects data for water reactor safety system equipment and to assess improved equipment, design concepts, and fire prevention data and methods that can be used to reduce vulnerability of plant safety to fire.

Background

When the project was initiated in July 1974, the only task assigned was to provide the experimental and analytical information to evaluate the adequacy of cable tray spacing designated in Regulatory Guide 1.75, "Physical Independence of Electrical Systems, Section 5.14, General Plant Areas." This section of the guide covers separation of protective systems in areas of the plant where power cables are included and the only source of fuel is that provided by the cable materials. All evaluations were to involve the testing of equipment and configurations representative of those going into new nuclear power plant designs.

It was decided that a survey of industry should be made to determine current design practices. The cooperation by members of the nuclear power industry was outstanding. Either personal visits or correspondence elicited responses from 13 leading architect-engineering firms, 13 utility companies, and 13 cable manufacturers. Three nuclear power plants were also visited, although design practices of existing nuclear power plants were not included for evaluation. Information obtained during this survey has proven very valuable in determining cable constructions, cable tray constructions, cable loading, and types of cable assignments in cable trays. The survey also solicited information about previous incidents and experiences including the cable tray fire at San Onofre 1 in 1968 and the subsequent investigation to determine the cause.[2]

A primary concern was to insure that the test facility truly represented the reactor plant area. The discussions with architectural and engineering firms were particularly valuable for improving the realism of the proposed tests.

Since we had been warned of the difficulties of electrically initiating a fire in power cable it was decided early in the project to conduct the test with 12 AWG, the smallest power cable normally used in nuclear power plants in order to minimize the amperage demands in the test setup. A preliminary heat transfer analysis was also performed at that early date. A rough analysis was all that was considered necessary to determine the approximate current required to raise cable insulation to a combustible temperature and to determine if the conductor temperature is at its melting point (1083°C) when the outside of the cable insulation is at its combustion temperature. The analysis showed that

1981°F

currents in the range of 100-120 amperes would raise the cable insulation to its combustible temperature. This agreed with subsequent testing.

With the results of the survey and the preliminary analysis as guidelines, a test facility was developed to perform full scale testing of cable fires of electrically initiated origin. Although it was originally intended to test all known types of cable currently specified and acceptable for use in nuclear power plant design and construction, the large number of cable types coupled with budget limitations precluded such broad testing. Therefore, screening was indicated that would lead to selection for testing of two typical cable types that would be most likely of propagating a fire and would present a conservative approach.

Cable Screening Tests

A survey of utility companies, architect-engineering firms, and cable manufacturereres, ascertained their preferences of insulation and jacket materials. The inquiries stipulated that the cable types must be those currently being installed in or would be included in the design of nuclear power plants. As a result of this constraint, all cable types suggested were capable of passing IEEE Standard 383-74.[3]

There were thirty-nine replies from industry which cited 20 different cable types that were being considered for use in new construction. Screening was necessary to cut this list to manageable size and allow full scale testing to proceed. The first cut was made on the basis of popularity. The leading types were crosslinked polyethylene with or without some jacket material (34 percent), EPR with a Hypalon jacket (23 percent), and EPR with a Neoprene jacket (19 percent).

Considerations of the cost of filling cable trays in a full scale test prompted a further screening test to obtain two different cable types that were "most likely to propagate a fire." The screening tests were performed merely to rank the various cable types in some manner. The relative differences between results were small thereby subjecting the conclusions to dispute, especially if proprietary interests were involved. When burn length differences are measured in millimeters, as they were in one of the tests, it is difficult to attach true significance to those differences.

The relative ranking of the cable types was based on three different evaluations. They were chosen to complement other evaluations, not to duplicate them. The oxygen index test which has been done on all of the cable insulation types under consideration is a case in point. The three types reported here are a small scale electrically initiated cable insulation fire test, Underwriter Laboratories FR-1 flame test,[4] and a pyrolyzer and thermal chromatograph test (measure of insulation outgassing as a function of temperature).

Electrically Initiated Cable Insulation Fire Test

To determine the amount of current needed to produce a flame, five small scale tests were performed on five different electrical cables. The cable types were:

Cable #1 - Single conductor #12 AWG, 45 mil (1.14 mm) EPR, 30 mil (0.76 mm) Hypalon jacket, 600 V.

Cable #2 - Single conductor #12 AWG, 47 mil (1.19 mm) chlorinated rubber (proprietary), 47 mil (1.19 mm) chlorinated polymer (proprietary) jacket, 600 V.

Cable #3 - Single conductor #12 AWG, 47 mil (1.19 mm) EPR, 15 mil (0.38 mm) Neoprene jacket, 600 V.

Cable #4 - Single conductor #12 AWG, 30 mil (0.76 mm) crosslinked PE, no jacket, 600 V (Supplier B).

Cable #5 - Three conductor #12 AWG, 30 mil (0.76 mm) crosslinked PE, silicon glass tape, 65 mil (1.65 mm) crosslinked PE jacket, 600 V (Supplier A).

Figure 1 shows how the cables were arranged in a cable tray for each test. Current was increased in increments of 5 amperes every 10 minutes until a flame was observed. Cable #1 flamed at 130 amps, Cable #2 flamed at 130 amps, Cable #3 flamed at 124 amps (while increasing to 125), Cable #4 at 120 amps, and Cable #5 at 120 amps. The spread of currents measured and observations of flame extent (flames extinguished shortly after the conductor open circuited) make all results appear close, but relative positions were assigned with the better cables being the ones with the highest current for flaming to occur.

FR-1 Flame Test

Underwriter Laboratories FR-1 Flame Test was chosen as another screening test. It was not intended to be used as a pass-fail test (for which the test was devised) but to establish a rank based on length of burn and burn damage. It was expected that all cables tested would pass this test, and they did. In order to fail, the paper flag 10 inches (254 mm) above the flame impact point must burn. See Figure 2.

The test was conducted in a three-sided metal enclosure under an exhaust hood. The metal enclosure was 12 inches (305 mm) wide, 14 inches (356 mm) deep, 24 inches (610 mm) high, and the top and front were open. An 18-inch (457 mm) specimen cut from a sample length of each cable was secured with its longitudinal axis vertical in the center of the enclosure. Figure 2 shows the test configuration.

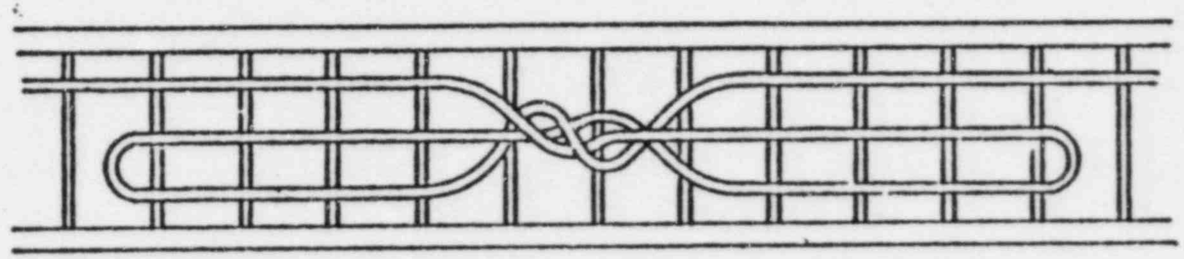


Figure 1. Cable Configuration for Electrical Ignition

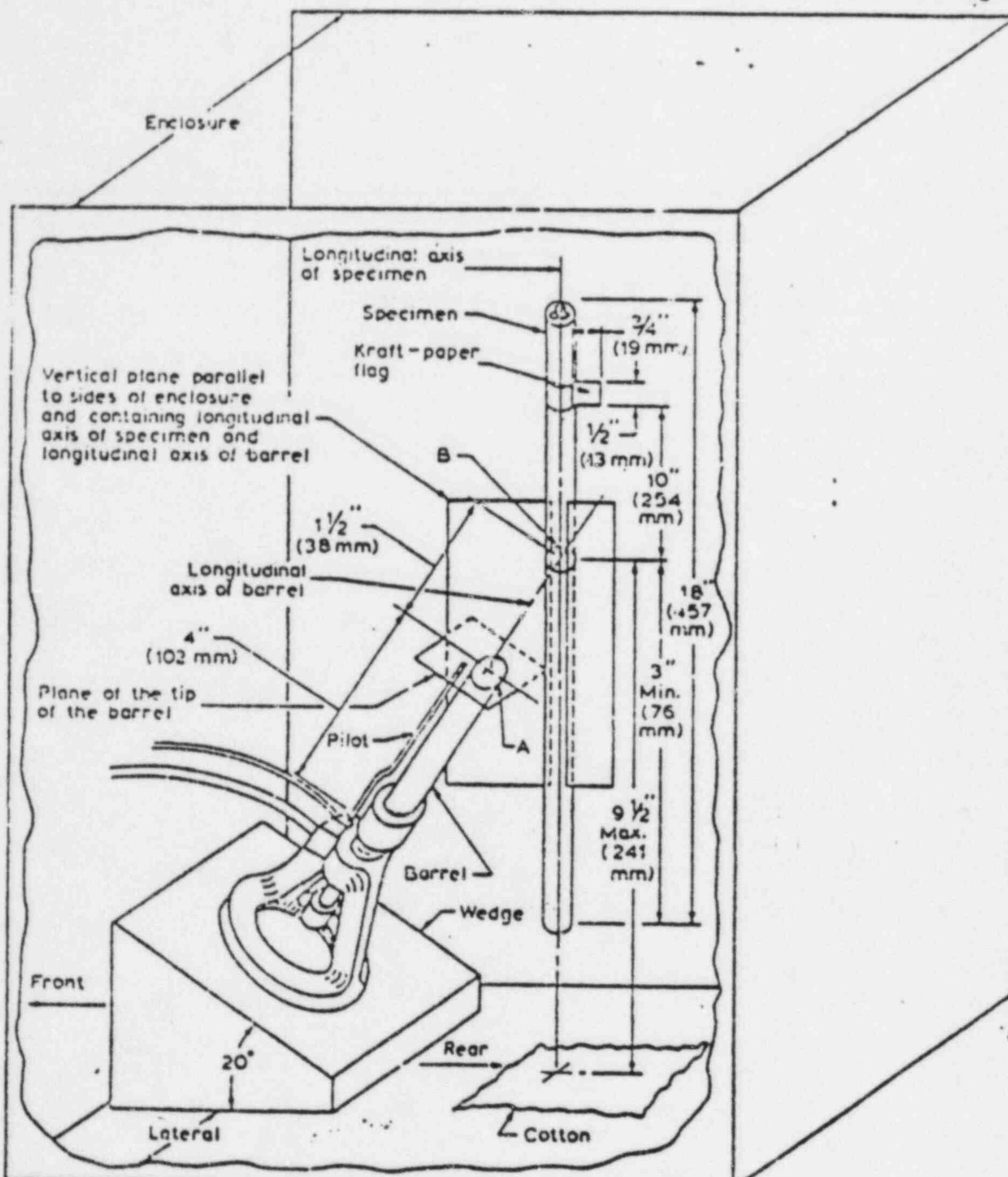


Figure 2. Essential Dimensions of Apparatus and Specimen of Vertical Flame Test

A Tirrell gas burner (which differs from a Bunsen burner in that the air flow as well as the flow of gas is adjustable) supplied the flame. The barrel of the burner extended 4 inches (102 mm) above the air inlets and its inside diameter was 3/8 inch (9.5 mm). While the barrel was vertical, the overall height of the flame was adjusted to 5 inches (127 mm). The blue inner core was 1-1/2 inches (38 mm) high and the temperature at its tip was approximately 815 °C (1500 °F).

A wedge was secured to the base of the burner to provide a sloping surface of 20 degrees from the vertical. This wedge was positioned to place the point A 1-1/2 inches (38 mm) from the point B, Figure 2. Point B is the point at which the tip of the blue inner core touched the center of the front of the specimen. A half-inch (13 mm) wide strip of kraft paper was attached around the specimen with its lower edge 10 inches (254 mm) above B and with the paper protruding 3/4 inch (19 mm) to provide a flag. See Figure 3.

The test procedure was to apply flame to point B for 15 seconds, turn it off for 15 seconds, on again to point B for 15 seconds, etc., for a total of five 15-second applications of the gas flame to the specimen with 15 seconds between applications. In no case was the specimen flaming from the previous application of the flame when the 15 second "off" period had ended. The duration of flaming of these specimens after each removal of the gas flame never exceeded five seconds. After the cable specimens cooled, burn lengths were measured beginning at point B.

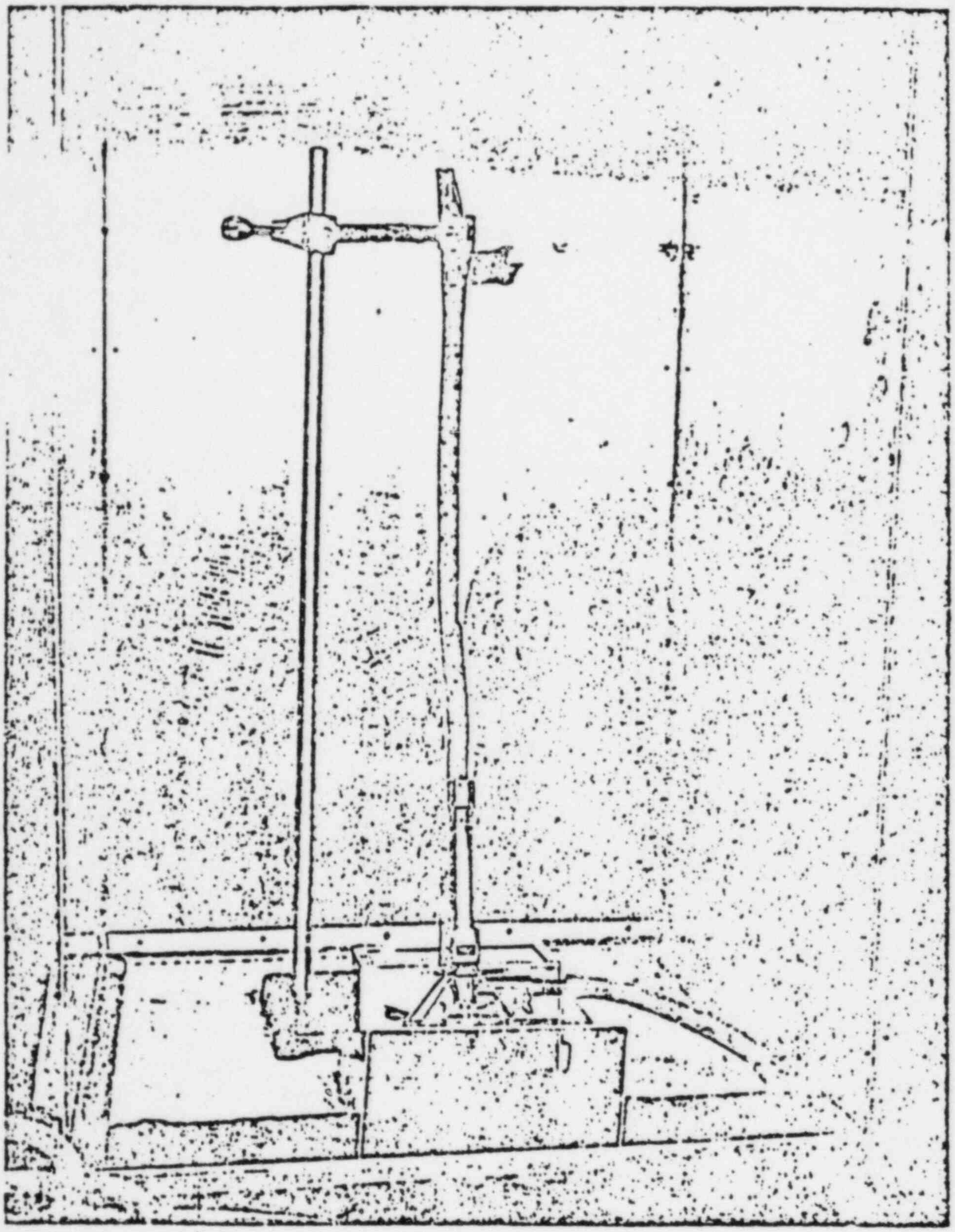


Figure 3. FR-1 Test

Eight cables were used as test specimens.[1]

Cable #1 - Single conductor #12 AWG, 45 mil (1.14 mm) EPR, 30 mil (0.76 mm) Hypalon jacket, 600 V.

Cable #2 - Three conductor #12 AWG, 15 mil (0.38 mm) EPR, 60 mil (1.52 mm) Hypalon jacket, 600 V.

Cable #3 - Single conductor #12 AWG, 47 mil (1.19 mm) chlorinated rubber (proprietary), 47 mil (1.19 mm) chlorinated polymer (proprietary) jacket, 600 V.

Cable #4 - Single conductor #12 AWG, 47 mil (1.19 mm) chlorinated rubber (proprietary), 65 mil (1.65 mm) chlorinated polymer (proprietary) jacket, 600 V.

Cable #5 - Three conductor #12 AWG, 47 mil (1.19 mm) chlorinated rubber (proprietary), 65 mil (1.65 mm) chlorinated polymer (proprietary) jacket, 600 V.

Cable #6 - Single conductor #12 AWG, 47 mil (1.19 mm) EPR, 15 mil (0.38 mm) Neoprene jacket, 600 V.

Cable #7 - Three conductor #12 AWG, 30 mil (0.76 mm) crosslinked PE, silicon glass tape, 65 mil (1.65 mm) crosslinked PE jacket, 600 V (Supplier A).

Cable #8 - Single conductor #12 AWG, 30 mil (0.76 mm) crosslinked PE, no jacket, 600 V (Supplier B).

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[1] Eight cables were used in the two screening tests requiring short samples while five were used in the electrical test requiring longer samples. If those three which had not seen all three tests had been marginal performers additional lengths would have been obtained and given the electrical test.

Comparative results from UL FR-1 test were:

Cable Type	Burn Length (mm)	Comments
#1	76.2	jacket opened
#2	44.5	jacket not opened
#3	50.8	jacket opened
#4	63.5	jacket opened
#5	63.5	jacket not opened
#6	61.0	jacket opened
#7	69.9	jacket opened
#8	73.7	no jacket

Pyrolizer and Thermal Chromatograph Test

The last screening test used a pyrolizer on a thermal chromatograph interfaced to a gas chromatograph/mass spectrometer. Thermodecomposition chromatographs were obtained as a function of temperature and the area under each curve was measured. Approximately 50 mg of jacket material was used in each test and the temperature of the specimen raised from ambient to 600 °C at 20 °C/min. The material driven off below 300 °C was analyzed to test the hypothesis that large amounts of material driven off at lower temperatures was an undesirable characteristic. Since outgassing of combustible materials or fire retardants at these low temperatures was theorized as being undesirable, larger areas under the thermodecomposition chromatographs were assigned an undesirable rating. Figure 4 shows a typical chromatograph.

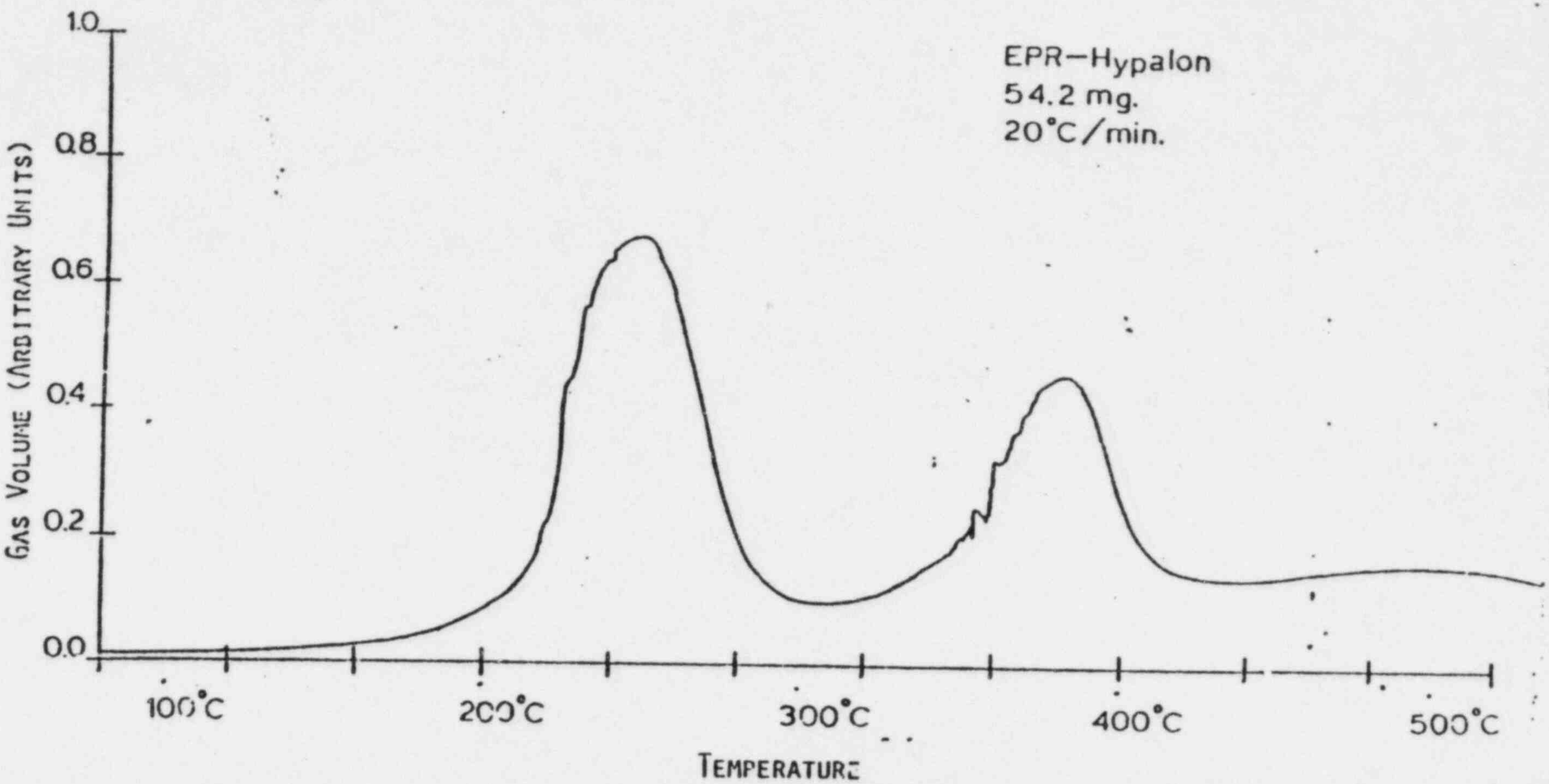


Figure 4. Gas Chromatograph

The normalized areas on the chromatographs for the same cable types previously described in the UL FR-1 test are:

Cable Type	Normalized Area
#1	1.2
#2	1.6
#3	4.3
#4	4.6
#5	1.8
#6	1.0
#7	4.9
#8	7.7

Screening Test Conclusions

Although the small scale electrically initiated cable insulations fire test and the UL FR-1 Fire Test indicated none of these cables would be capable of propagating a fire (in support of IEEE 383 qualification) cables #7 and #8 in the last two tests (same as cables #4 and #5 in the first test) were designated as the cable types to be used in the full scale tests by a relative figure of merit. Work performed in Europe in 1975[5] on radiation and fire resistance of cable-insulating materials was recently brought to our attention and is in good agreement with our ratings.

Full Scale Testing

Three phases of full scale testing have been completed. All involved electrically initiated fires in horizontally oriented cable trays. The first phase was intended to evaluate the adequacy of cable tray spacing as designated in Regulatory Guide 1.75, "Physical Independence of Electrical Systems, Section 5.14, General Plant Areas." For this phase vertical separation of independent division is designated as 5 feet (1.52 m) and the horizontal separation as 3 feet (0.91 m).

The second phase was concerned with varying the separation distance between cable trays. Phase three required a stacking or matrix of fourteen cable trays as one division with cable trays representing the second division separated by distances as specified in Regulatory Guide 1.75. The vertical and horizontal separation in the first division was 10.5 inches (0.27 m) and 8 inches (0.20 m) while the separation between divisions was 5 feet (1.52 m) and 3 feet (0.91 m). All testing involved equipment and cables representative of that going into new nuclear power plant designs. See Figures 5, 6, and 7 depicting the three different test setups for the three phases.

Coupons of aluminum, galvanized iron, and mild steel were hung in the building and periodically removed for corrosion analysis. A profilometer is used for this purpose and has not shown significant corrosion products.

An oxygen analyzer and gas sample manifold were installed and gas samples were taken before and during the fires. There was no depletion of oxygen found in the fire area. Flame retardant antimony bromide and an organophosphate were found in the gas samples as well as a high molecular wax material.

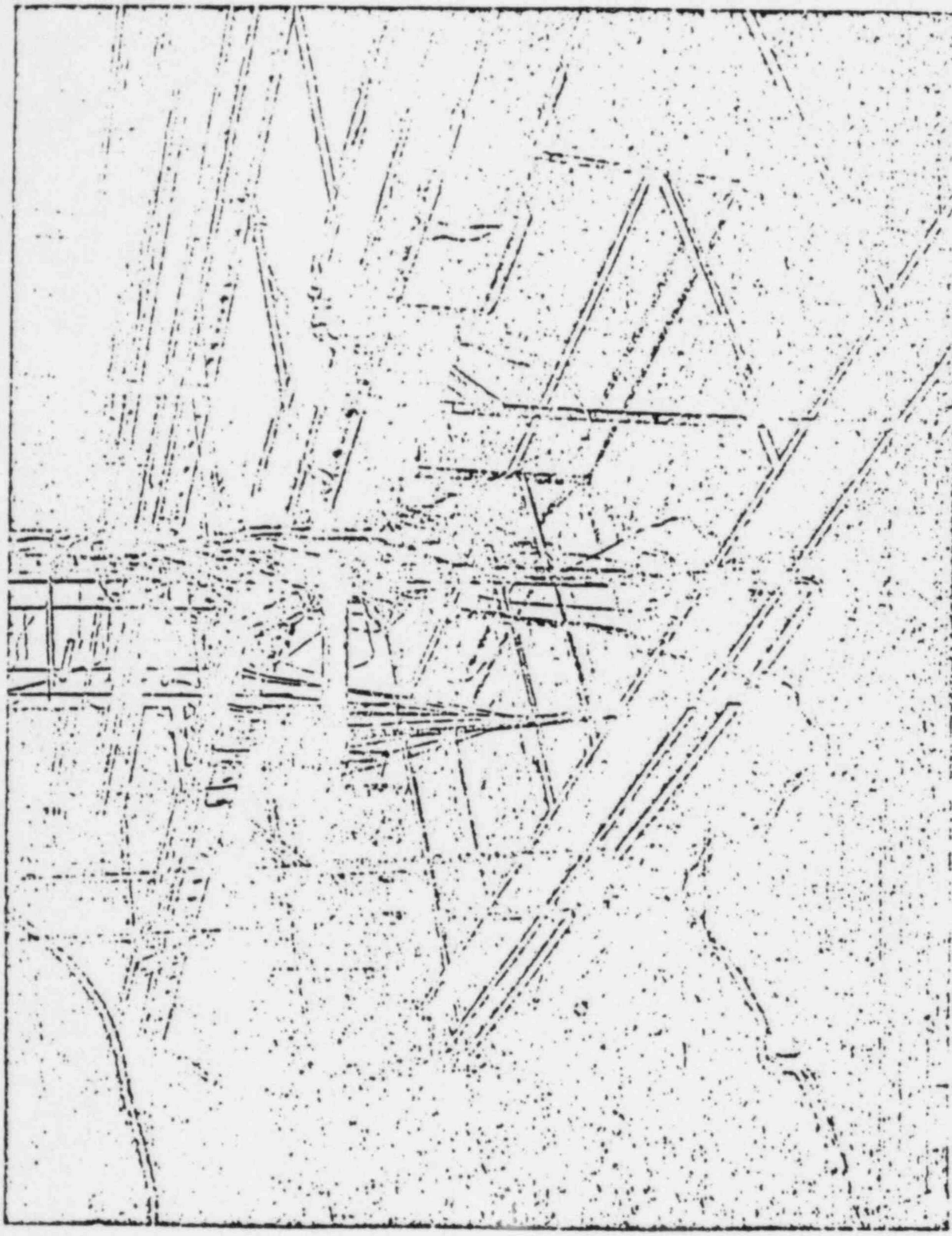


Figure 5

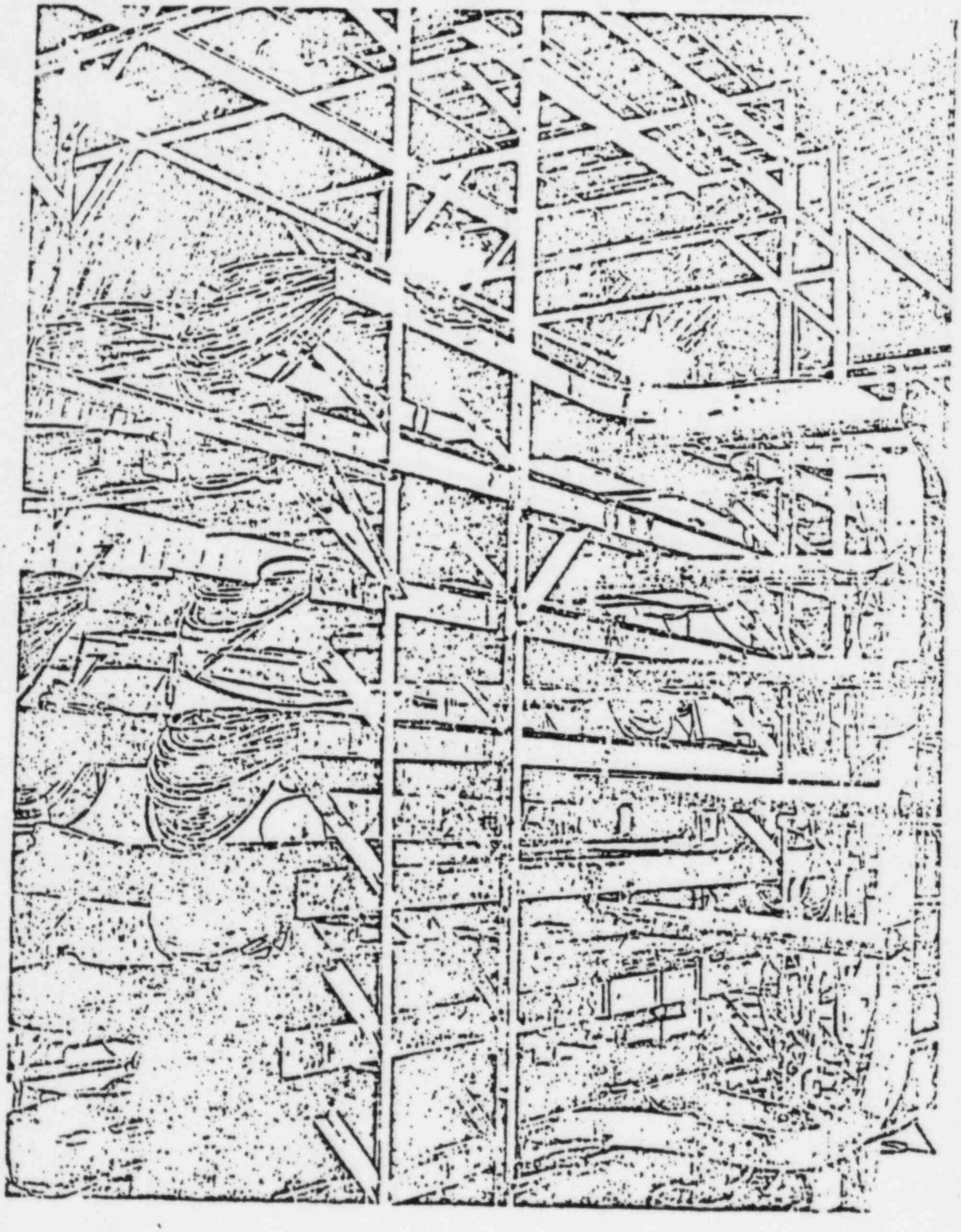


Figure 7. Phase Three Test Setup

Remote controlled cameras were installed for closed circuit television, color movies, photographic thermometry, and infrared thermography. Television was used to monitor the testing and in determining the proper time to attempt gas ignition (explosive bridgewires and electric matches were spaced over the ignition point and simulated arcing), to take gas samples, and to start movie cameras. The movies not only provided a record of the event but gave information on the ignition mechanism as well as measurement of flame velocity. Despite a lack of success in igniting the gases with simulated arcing the movies show the combustible gases do indeed ignite as the flame producing mechanism. Measurement of flame velocity was needed so that the convective heat transfer coefficient could be calculated. The photographic thermometry and infrared thermography were to supplement the discrete spatial measurements taken with thermocouples and slug calorimeters.

On each test a minimum of 31 thermocouples and slug calorimeters were placed in the test setup and connected to recorders. Results of these measurements are discussed in the following section on the characterization of the fires.

Air velocity was varied somewhat during the tests because of conflicting opinions on worst case conditions. Opinions varied between zero flow, which might be encountered in a cable spreading room, to high air velocity providing abundant oxygen, which might be encountered near an exhaust fan in the open plant area. As a compromise, air velocities for the different tests ranged between 2 ft/min (0.01 m/sec) and 30 ft/min (0.15 m/sec). These measurements were made with a hot wire anemometer before each test; only fan exhaust velocities were monitored during the test.

Seven full scale tests were run in the three phases previously described. Spacing was reduced in phase two to 10.5 inches (0.27 m) vertically and 8 inches (0.20 m) horizontally. In all seven tests all circuits other than the ignition tray circuits remained functional. This was determined by operation of these circuits for some period of time after the test. In addition, samples of the cable insulation at the bottom of the tray over the fire zone were given insulation elongation measurements to determine mechanical change. These measurements showed less than a 10% increase in elongation due to the fire. Quite often this small increase is attributed to a small change in crosslinking due to heat.

Characterization of Cable Tray Fires

Characterization of the cable tray fires is based upon a review of the data that were collected in the full scale testing described above.

The sources of data include:

1. Color Movies
2. Radiation Thermometry
3. Slug Calorimeters and Thermocouples
4. Thermovision (infrared detection)

This information is used to investigate the following characteristics of the fire:

1. Size and Duration
2. Flame Temperature
3. Gas Velocity
4. Optical Thickness (apparent emissivity)

Consideration is also given to the thermal response of simple cylindrical objects which are engulfed by the fire. Approximate calculations provide estimates for:

1. Convective and Radiative Heat Transfer
2. Equilibrium (Steady-State) Surface Temperature

There is no attempt to use the data to evaluate the likelihood of fire spreading to an overlying tray, because this requires consideration of the geometric arrangement of the exposed cables and the kinetics of decomposition[6].

It is emphasized that the measurements and analysis techniques are approximate in nature, and are intended only to provide an overview of the gross characteristics of the fire. Within this framework, the data are found to be self-consistent and in reasonable agreement with theoretical expectations and comparative data.

Color Movies

Observation and analysis of the 16 and 100 frames/second motion pictures of the cable tray fire tests have proved enlightening in characterizing cable fires. (Figure 8 is an illustrative sequence shot at 16 frames/second.) For example, the following observations tend to characterize the pictured fires.

(1) The flame zone does not comprise a continuous line fire, but instead consists of one or more "axisymmetric" luminous zones which are on the order of 5 to 8 inches in "diameter" at the base.

(2) Although migration along the tray may occur, the propagation is quite slow.

(3) The height of the luminous zone varies rapidly, ranging from 5 to 10 inches above the burning tray.

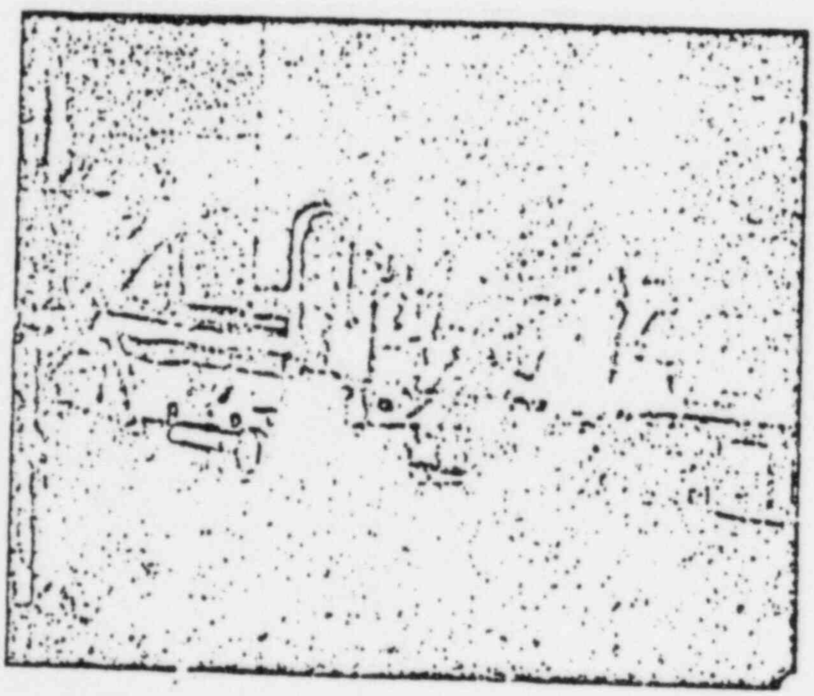
(4) The time scale for variations of the luminous zone extent is on the order of 1/10 second.

(5) The flame is turbulent with luminous eddies clearly visible.

(6) By tracking the upward progress of small luminous eddies which are shed from the flame, the gas velocity (time-mean) is estimated to be in the range from 3 to 4 feet/second (0.9-1.22 m/s) Variations from this range are quite small, even over a large number of measurements in different cable tray fire tests. Also it does not appear that velocity is decreasing substantially in the vertical direction, at least in the first foot of rise.

These characteristics of the cable fires do not vary greatly from one fire to the next, even though significant variations in the duration are observed.

1.



2.

Figure 8. Cable Tray Fire (1/16 Second between frames)

Flame Temperatures

Radiation thermometry is used to determine the temperature distribution in the fire. At chosen times, photographs are taken through two different narrow band filters ($\Delta\lambda = .03\mu$) which are centered at $\lambda = .55\mu$ and $\lambda = .65\mu$. The negatives are scanned with a microdensitometer to determine the exposure distribution. The intensity of radiation received along a particular line of sight is found by a comparison of the exposure at a particular point (small area) on the negative with that produced by a calibrated lamp which is also in the field of view. The "brightness temperature" or corresponding blackbody temperature for each point is then calculated from the Planck function.[7]

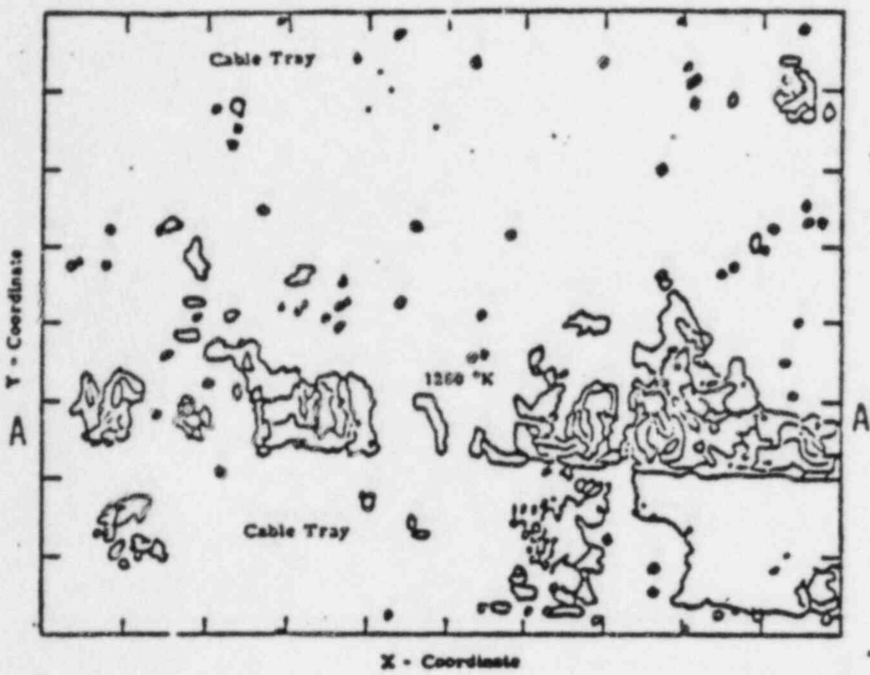
A typical plot of the isotherms (brightness temperature) obtained from the radiation thermometry is included in Figure 9. All areas enclosed by the isotherms are at temperatures above 1260°K, the lower cutoff on sensitivity of the film. Maximum temperatures are roughly 1500°K. Figure 9 also shows the variation of temperature with horizontal position, taken as the hottest vertical location just above the tray (Section A-A in isotherm plot).

Since the flame zone is not optically thick, the apparent emissivity is less than unity and it is necessary to correct the temperature measurements.[7] However, the magnitude of temperature corrections is relatively small. For example, a five-fold reduction in apparent monochromatic emissivity ($\epsilon\lambda = 1.0 \rightarrow 0.2$) only requires a correction of about 100°K between the true temperature of the flame and the above brightness measurements. The measured flame temperatures are well below adiabatic flame temperature, and are in agreement with theoretical expectations.[8]

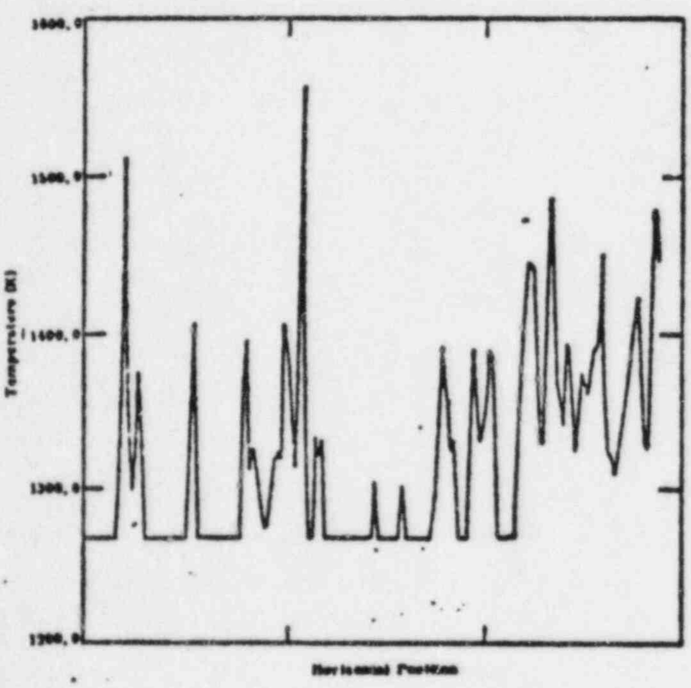
Thermocouples and Calorimeters

The array of thermocouples and copper slug calorimeters above the ignition tray provides two types of information:

(a) heat fluxes (combined convection and radiation) that are determined from the transient temperature response of the calorimeters;



Isotherm Contours



Temperature Profile Along Tray at Height A/A in Above

Figure 9. Photometric Thermometry (11/15/76)

(b) steady state temperature which may be significantly less than the local gas temperature due to radiation through the flame

Figure 10 shows the temperature response of selected calorimeters (Nos. 1, 7, 9, and 11) and a sheathed thermocouple (No. 2) for the fire test of 5 October 1976. The separation between cable trays is approximately two feet. This particular fire is one of the most intense and longest duration of those studied. It is seen that the intensity of the thermal environment falls off very rapidly in the region from 5 to 11 inches (.13 to .28 m) above the fire. This height roughly corresponds to the the upper edge of the luminous zone.

In view of their relatively slow time response, the calorimeters and even the thermocouple rarely reach a quasisteady temperature level. However, in the fire test of 5 October 1976, thermocouple No. 2 reaches and holds 1150°F for a short period at early and at late times, and in the intervening period the temperature is clearly steady at 700°F. These quasisteady temperatures are confirmed by similar data from calorimeter No. 1 which is also located about 3/8 inch (9.5 mm) above the burning tray. It is noted that these temperatures do not represent local gas temperatures, but rather the temperature of a surface immersed in the flame.

Figure 11 shows the variation of cold-wall heat flux with height above the burning tray for several fires. Each of these data points is calculated from the initial slope of the temperature vs. time curve for a particular calorimeter. It is seen that a significant reduction in heating rate occurs from the base of the flame to the upper reach of the luminous zone. Although these are significant variations in heat flux distribution from one fire to the next, the two more intense fires (October 5 and November 15) are very similar, as are three lesser fires (July 21, August 13, and December 16). It is likely that some of the differences are due to unintentional changes in position of the instrumentation relative to the flame zone because the exact location of the flame could not be controlled.

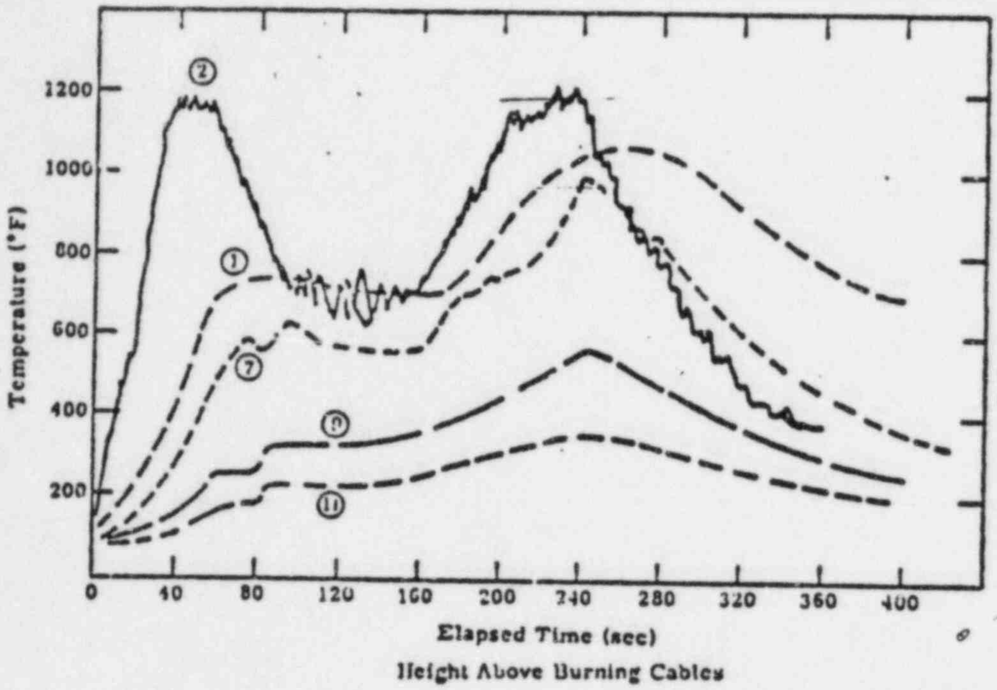


Figure 10. Temperature Response of Thermocouples and Slug Calorimeters (10/5/76)

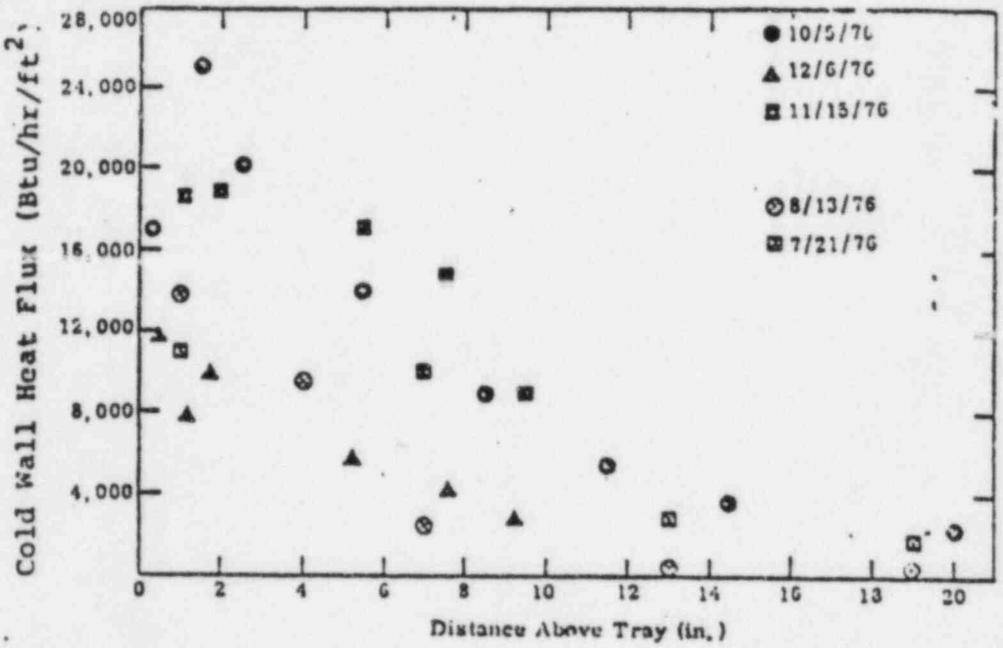


Figure 11. Vertical Variation of Heat Flux

Thermovision

An infrared detection system marketed under the trade name "Thermovision" was used to monitor the cable tray fire tests. The field of view is continuously scanned by a mirror system, and for each point in the field the amplitude of the voltage signal from the detector is converted to a gray "color level" (intensity) which is displayed on a black and white monitor. A movie is made from the monitor to provide a qualitative overview of the development of the fire, and at later times particular frames are extracted for quantitative analysis.

Selected frames from the thermovision movie are scanned by a microdensitometer to obtain a quantitative map of the degree of exposure. The exposure levels are then interpreted as levels of IR radiation intensity using the calibration charts provided by the manufacturer.

Since the broad band (thermovision) measurement of IR intensity is fairly sensitive to the effective flame emissivity, this IR intensity can be used in conjunction with the previous estimates of flame temperature to calculate the flame emissivity. Based on the procedure described by Sato and Matsumoto[9] the total emissivity of the flame is found to be on the order of $\bar{\epsilon} \approx 0.15$. When this result is compared with the theoretical calculations of Felske and Tien[10], it is concluded that particulate (soot) concentrations in flame are on the order of 10^{-6} cm^3/cm^3, which falls within the expected range of concentration.[11,12]

Analysis of Fire Test Data

Heat transfer from the flame to an engulfed object occurs by both convection and radiation. Although the calorimeters provide a measurement of total heat flux, it is also of interest to know the relative importance of convective and radiative contributions. The following paragraphs outline some approximate calculations which answer this question and at the same time show that all of the measurements (flame temperature, total heat flux, velocity, infrared radiation, thermocouples) comprise a reasonably self-consistent characterization of the cable tray fires.

At a location just slightly above the burning tray we have the following measurements of flame temperature, total emissivity, and flame velocity: $T_f \simeq 1300°K$, $\bar{\epsilon} \simeq 0.15$, $V \simeq 3$ ft/sec. Using this velocity and properties of air, the mean convective heat transfer coefficient for a small cylindrical object (e.g., 3/8" calorimeter) is approximately[13] $\bar{h} = 7$ BTU/hr/ft^2/°F. The convective and radiative contributions to the cold wall heat flux can then be separately calculated as follows:

$$q_c'' = \left(\bar{h}\ T_f - T_{cw}\right) \simeq 13{,}000 \text{ BTU/hr/ft}^2$$

$$q_r'' = \epsilon\sigma\left(T_f^4 - T_{cw}^4\right) \simeq 7{,}000 \text{ BTU/hr/ft}^2$$

This shows that convection accounts for about 67% of the total flux. Note that the total heat flux (convection and radiation) is in good agreement with the calorimeter data shown previously in Figure 11.

In view of the above calculations, it is useful to reconsider the vertical variations of cold-wall heat flux shown in Figure 11. It is seen that the heat flux is roughly 13,000 BTU/hr/ft^2 (the nominal convection rate) at a height of 5 to 7 inches (0.13-0.18 m) above the tray. From the color movies, this level also corresponds to the time-mean height of the luminous zone. It is therefore expected that convection dominates above this level. In the upper nonluminous region the gas temperature falls off rapidly due to entrainment of cool air and turbulent mixing. At a height of 10 inches (0.25 m) above the fire the cold-wall heat flux is only about 6,000 BTU/hr/ft^2, which corresponds to a local gas temperature of 1000°F (900°K), assuming convection alone and a velocity of 3 ft/sec (0.91 m/sec).

Since the flame is optically thin, a cylindrical object placed in the fire (thermocouple, calorimeter, cable) will, if the fire continues long enough, reach an equilibrium temperature which is well below the temperature of the surrounding medium. This steady-state surface temperature T_s can be estimated from the following energy balance in which heating of the surface by convection and radiation is equated with the cooling afforded by radiation from the surface which passes through the flame to the cool surroundings at T_∞:

$$\bar{h}\left(T - T_s\right) + \bar{\epsilon}\sigma\left(T^4 - T_s^4\right) = (1 - \bar{\epsilon})\sigma \left(T_s^4 - T_\infty^4\right)$$

At a point near the tray, $T \approx 1300°K$, $\bar{\epsilon} \approx 0.1$, and $\bar{h} \approx 7$. These values give a steady surface temperature of about 1100°F (870°K), in good agreement with the quasisteady temperature recorded by thermocouple No. 2 in Figure 10. Note that calorimeter No. 1 also approached this temperature before the fire began to die out.

It is interesting also to calculate the equilibrium surface temperature at a height of 10 inches (0.25 m) above the tray. Based on the measurement of cold-wall heat flux the local gas temperature was estimated as 1000°F, assuming convection alone. Using the steady energy balance with T = 1000°F, the equilibrium surface temperature at the 10 inch (0.25 m) level is approximately 650°F.

The above estimates of equilibrium surface temperature are indicative of the steady state surface temperature of a single electrical cable which is subjected to fire. In an overlying tray, cables are closely spaced and the details of the geometric configuration become important. Thus, higher surface temperatures probably are attainable because radiant losses from the exposed cable are blocked by adjacent cables and convective velocities may be higher than in the single cable configuration. On the other hand, the duration of the fire may not be sufficient to realize equilibrium conditions, as was usually observed with thermocouples and slug calorimeters in the test fires. In any case, the temperature of exposed cables cannot exceed the temperature of the surrounding medium which is estimated as roughly 1000°F at the height of 10 inches (0.25 m).

Summary of Characterization

Essential features of the cable tray fires are outlined below. Although based on worst case conditions, these observations are generally representative of the entire sequence of fire tests.

(1) The intense period of the fire persists at a particular location for between 40 and 240 seconds before die-out begins to occur (e.g., 240 seconds in Figure 10).

(2) The luminous flame zones fluctuate rapidly between 4 and 10 inches (0.1-0.25 m) in height.

(3) Gas temperature in the luminous zone is roughly 1900°F (1300°K).

(4) Gas temperature at 10 inches (0.25 m) above the burning tray is estimated as 1000°F.

(5) Velocity of rising gasses is approximately 3 to 4 feet/second (0.91-1.22 m/sec).

(6) The luminous zone is optically thin with an apparent emissivity on the order of $\bar{\epsilon} = 0.1$.

(7) Heat transfer to immersed objects is convection dominated with radiation accounting for no more than 30% of the total heat flux, even in the luminous region.

(8) Equilibrium surface temperature of engulfed cylindrical objects varies from about 1200°F just above the tray to 650°F at a height of 10 inches (0.25 m).

Although the above measurements and analytical estimates are approximate, they are indicative of the gross characteristics of the fire.

It is noted that the present cable tray fires differ greatly from large fires which are often considered in safety studies. Due to the small physical dimensions of the present flame, radiation from the flame is less than 20 percent ($\epsilon < 0.2$) of that encountered in large fires, and convection therefore dominates. In large fires convection usually accounts [illegible] less than 25 percent of the total heat transfer[14]. Also, objects immersed in a large fire will eventually reach temperature equilibrium with the flames. This may not occur in the optically thin cable tray fires because an engulfed surface is able to radiate through the flame to the cool surroundings. Thus, the cable tray fires comprise a considerably less severe thermal environment than a large fire, even though the flame temperatures are of comparable magnitude for the two cases.

Summary and Conclusions

The first objective was to obtain data through experiments to aid in evaluating the effectiveness of cable tray separation as a means of assuring functional integrity of redundant safety systems. The first task undertaken to meet this objective was to survey the industry in order to determine current design practices particularly with regard to the materials used. Of these materials primary interest was focused on types of electrical cable constructions being used in new nuclear power plant design. A screening test was applied to these types in order to concentrate on two electrical cable constructions representing a conservative approach. The evaluation covered separation of protective systems in areas of the plant where power cables are included and no source of fuel exists except that provided by the cable materials. Thus, all fires in this project have been electrically initiated.

Seven quick-look reports[15-21] and a progress report[22] have been issued describing full scale tests included in the period covered by this paper. Separation distances between cable trays of 5 feet (1.52 m) vertically and 3 feet (0.91 m) horizontally were used in phase one tests. Four tests were run in phase two with spacing reduced in stages to 10.5 inches (0.27 m) vertically and 8 inches (0.20 m) horizontally. Phase three involved three tests of a large matrix of trays arranged in such a manner that 14 cable trays closely spaced represented one division while 3 trays separated 5 feet (1.52 m) vertically and 3 feet (0.91 m) from that matrix represented the redundant division. In all these tests an overcurrent in one or two 12 AWG conductors of an electrical cable in an open cable tray was the source of fire. Trays were filled with electrical cable to the top of the 4 inch (0.10 m) siderails.

Fire initiation appears to be from combustible gas initiation as seen in pictures taken during that time period. Typical of this initiation is the sequence taken during initiation of a fire on November 15, 1976. This is shown by Figure 12 where the gaseous ignition appears beyond a photometric calibration lamp.

The maximum duration of any fire obtained was 29 minutes with the mean time approximately 6 minutes. At no time did the cables in trays displaced from the ignition tray begin to burn. All circuits in these trays remained functional and elongation measurements taken of insulation closest to the fire showed no major (< 10%) change.

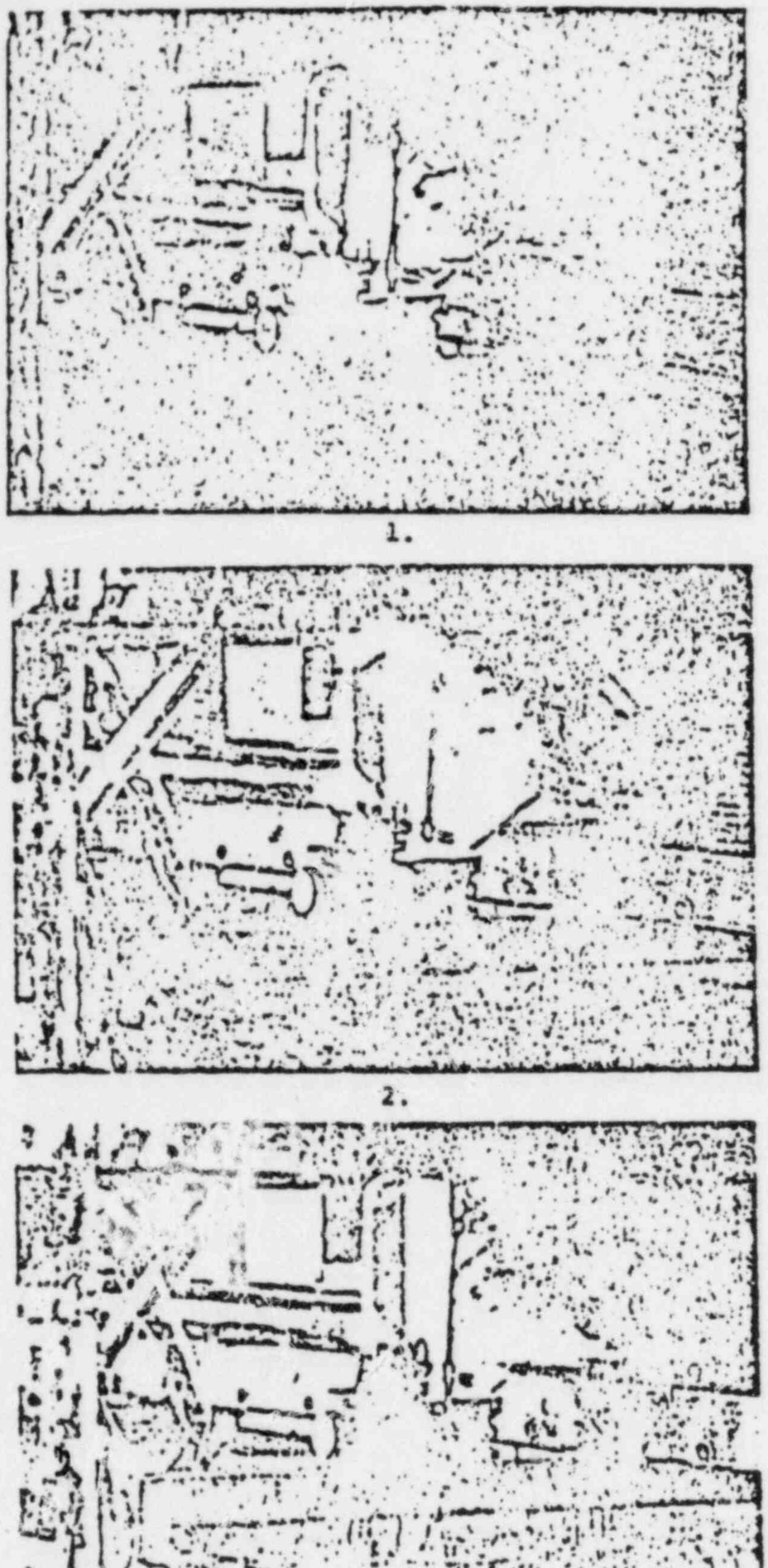


Figure 12. Ignition Mechanism (1/16 second between frames)

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II.b Concrete Compression Strength

QUESTION:

1. Paragraph 2 on page 13 of ISAP II.b Results Report refers to errors in the Schmidt Hammer test program identified by third-party review, and refers to them as "not significant." Provide the basis for your concluding that the errors are not significant.

RESPONSE:

The statement in the II.b Results Report regarding the "error rate" relates to our initial use of an incomplete population (concrete volume established by identifying truckloads poured during each of the periods under evaluation) and subsequently determining a more complete though not exactly complete population. In the Results Report we conclude that the "error rate" in not exactly determining the population size was not significant.

The initial evaluation of the hammer indication data (101 data points for the CAI and 99 for the CC) was conducted on an incomplete truckload population (see transcripts of TUGCO-NRC meeting of 3/6/85 and F. Webster, "Additional Background for TUGCO-NRC Meeting of 3/6/85," CPRT File II.b.4a-008, May, 1985). The missing truckloads represented approximately 20-30 percent of the total number of truckloads. To complete the population determination, an attempt was made to identify all previously unidentified truckloads, and a proportional sample was selected from those additional truckloads identified. This augmented sample was then added to the original sample. The resulting evaluation of the hammer data (presented in the II.b Results Report) included 119 data points for the CAI and 132 for the CC. The added data did not change the conclusion that the CAI hammer indication is within 5 percent of the CC hammer indication at the tenth percentile level.

If the population could have been completely determined an additional seven samples for the CAI population and two samples from the CC population would have been taken. If these additional samples were randomly selected from the remaining truckloads excluded, these test values should be dispersed among the other data (as was observed during the effort described above). Therefore, the distributions shown in Figure 3 of the Results Report would be changed very little and the conclusions not at all.

QUESTION:

2. Review of Figure 1 of page 20 of ISAP II.b Results Report shows that CAI compression strength is approximately 9.4% less than CC compression strength at the 10th percentile level. It appears that this level of deviation was judged by applicants as not "significantly lower" than CC compression strength to trigger a need to implement calibration of the Schmidt Hammer test. Discuss the technical basis for the judgement.

II.b Concrete Compression Strength (Cont'd)

RESPONSE:

The design compressive strength of 4000 psi is 18.4 percent lower than the tenth percentile cylinder strength of the CC. If one assumes the CAI cylinder data is valid, then it is seen from Figure 1 of the Results Report that the CAI strength is only 9.3 percent lower than the CC at the tenth percentile level, and is well above the design strength of 4000 psi. However, the validity of the CAI cylinder data has been questioned and the CPRT investigation was established to determine whether or not the CAI strength is not more than 18.4 percent lower than the CC strength. This is done in the II.b Results Report through the use of the Schmidt Hammer tests in association with the CC cylinder data.

A difference of 18.4 percent in compressive strength corresponds to a relative change in hammer indication of approximately 10 percent, based on the slope of the hammer indication vs. compressive strength curve (see Operating Instructions Concrete Test Hammer Types N and NR, copyright 1977, PROCEQ, Zurich, Switzerland; and Attachment A of F. Webster, "Target Tenth Percentile," CPRT File II.b.4a-003, February, 1985). The tenth percentile CAI hammer indication reported in the Results Report is only 2.5 percent lower than the CC hammer indication, and when we evaluate at a 95 percent confidence level the CAI hammer data is determined to be no more than 5 percent lower than the CC hammer data at the tenth percentile. This is less than the 10 percent difference in hammer data that would be required to signal that the CAI tenth percentile compressive strength is at the 4000 psi level, or lower. This provided reasonable assurance that the CAI tenth percentile cylinder strength is well above the 4000 psi design level. Therefore, it is unnecessary to further refine the relationship between hammer indications and compressive strength in the present application.

QUESTION:

3. The resolution to ISAP II.b as presented in the Results Report may not be able to identify localized problems where the number of falsified records is small. Discuss potential safety implications on overall adequacy of the concrete strength due to such localized problems.

RESPONSE:

As discussed in the II.b Results Report, there are two general types of potential falsification. The first, and the focus of this discussion, is the masking of out-of-specification concrete by recording it to be within specification. The second, and of less concern, is the false recording of concrete test data for within specification concrete when tests were not performed. Neither of these two types of falsification appear to have occurred in any systematic way. There is a potential for not detecting specific examples of the first type where the number of falsified records is small; however, as discussed below, the engineering significance of such situations is limited.

The methodology of our investigation was constructed such that if this type of localized falsification occurred, it would have been detected unless it had occurred very infrequently. Thus, our discussion is focused on evaluation of the engineering significance of a very small volume of concrete that may potentially be out-of-specification.

ACI Standard 214-77 addresses the implications of out-of-specification concrete as related to the ACI criterion permitting ten-percent of cylinder tests to fall below the design strength. Specifically, the following excerpt from Chapter 4 of this Standard is also applicable to evaluation of potentially lower strength concrete due to falsification:

"4.1--General

The strength of control cylinders is generally the only tangible evidence of the quality of concrete used in constructing a structure. Because of the possible disparity between the strength of test cylinders and the load-carrying capacity of a structure it is unwise to place any reliance on inadequate strength data.

The number of tests lower than the desired strength is more important in computing the load-carrying capacity of concrete structures than the average strength obtained. It is impractical, however, to specify a minimum strength since there is always the possibility of even lower strengths, even when control is good. It is also recognized that the cylinders may not accurately represent the concrete in each portion of the structure. Factors of safety are provided in design equations which allow for deviations from specified strengths without jeopardizing the safety of the structure. These have been evolved on the basis of construction practices, design procedures, and quality control techniques used by the construction industry. It should also be remembered that for a given mean strength, if a small percentage of the test results fall below the design strength, a corresponding large percentage of the test results will be greater than the design strength with an equally large probability of being located in a critical area. The consequences of a localized zone of low-strength concrete in a structure depend on many factors; included are the probability of early overload, the location and magnitude of the low-quality zone in the structural unit, the degree of reliance placed on strength in design, the initial cause of the low strength, and the consequences, economic and otherwise, of structural failure.

The final criterion which allows for a certain probability of tests falling below f'_c used in design is a designer's decision based on his intimate knowledge of the conditions that are likely to prevail. 'Building Code Requirements for Reinforced Concrete (ACI 318-71),' provides guidelines in this regard, as do other building codes and specifications.

To satisfy strength performance requirements expressed in this fashion the average strength of concrete must be in excess of f'_c, the design strength. The amount of excess strength depends on the expected variability of test results as expressed by a coefficient of variation or standard deviation, and on the allowable proportion of low tests."

II.b Concrete Compression Strength (Cont'd)

It should be noted that the criterion of allowing 10 percent or less of the cylinder strengths to fall below the design strength of 4000 psi is more than met by the CAI truckload population, which means that the frequency of potentially understrength concrete (regardless of whether it is masked by falsification or not) is very low. A supporting consideration is the fact that, with age, average concrete strength asymptotically increases above the 28 day strength on the order of 24% at one year (ref: A. M. Neville, "Properties of Concrete", J. Wiley, 1975, P.258-9) and continues to increase thereafter. Therefore, based upon the II.b results and general structural considerations, the chances of a potentially understrength concrete being coupled with a critical structural element are even lower.

III.d Preoperational Testing

QUESTION:

1. Section 5.4.1 of the Results Report stated, in part, that System Test Engineers (STEs) "...did use current design documents in the conduct of preoperational and prerequisite testing activities." During an inspection of documentation related to the 60 preoperational test samples that were evaluated by the CPRT, the NRC inspector identified 26 preoperational tests that were performed where the STEs failed to update the revisions of design documents referenced in Section 3.0 of the test procedures. The documentation clearly showed the CPRT's awareness of this discrepancy, but it was not identified in accordance with Appendix E of the Program Plan. The NRC inspector informed the CPRT that failure to identify the discrepancy was deviation from Program Plan commitments. The Results Report should have addressed this discrepancy. The staff needs to know what actions were taken to determine whether this was a DCC problem or an STE problem, what impact this had on the objectives of the ISAP, and what assurance exists that other tests of safety related components and systems, not evaluated under this ISAP, were conducted using current design documents.

RESPONSE:

CP-SAP-21, "Conduct of Testing," contains the requirement for the review and update of test procedures. The administrative procedure was not explicit as to how the STE review and update should be documented. However, the STE was required to update the test procedure to be in accordance with the latest design information, therefore, but was left to his own discretion as to the method of documenting the update.

Close examination of the specific procedures revealed that they had, in fact, always been updated, but that sometimes the updates were recorded only in those sections of the test procedures containing the action statements (i.e., sections other than Section 3.0). The procedures had been updated by the Test Procedure Deviation form in accordance with CP-SAP-12, "Deviations to Test Instructions/ Procedures."

The CPRT third-party concluded that the absence of specific notations to the reference section (Section 3.0) of the test procedures was neither a deviation nor indicative of a DCC or an STE problem. In those cases where the reference section had been updated, it was easy for the RTL to verify that the STE review and update had been accomplished. In those cases where the reference section had not been updated, any design change would have to be verified as being implemented in the remaining sections of the procedure. In all cases, it was possible for the RTL to confirm that implementation had occurred. Each design change requiring a response by the Startup organization was, in fact, incorporated into the test procedure.

III.d Preoperational Testing (Cont'd)

Based on the foregoing, the objectives of the action plan were met and there is reasonable assurance that the document control problems which existed prior to 1984 did not adversely affect the testing program. Reasonable assurance regarding the extrapolatability of sample observations derives from the facts (1) that there was a start-up administrative procedure which required such revisions and (2) that in all sampled cases the procedure was followed with.

QUESTION:

2. During the inspection of documentation related to the 60 preoperational test samples that were evaluated by the CPRT, the NRC inspector identified an unresolved issue regarding twelve screening checklists that were not completely filled in. Three of the twelve checklists failed to show the CPRT's review to ensure the associated preoperational tests were conducted using current design documents. This issue must be resolved before the staff will be able to accept the Results Report.

RESPONSE:

It is believed that the requisite data to demonstrate the adequacy of CPRT's review is available on 9 of the 12 checklists. The other three checklists were overlooked during the final file review. For these three, all the information required to perform the evaluations is contained in the various files, but the checklists are not completed properly. The project central file will be amended to correct this discrepancy.

VII.b.2 Valve Disassembly

QUESTION:

1. Section 4.1.2 of the Results Report states, "in addition to proper matching of components, the procedures were reviewed for (sic) damage during the disassembly, storage and reassembly process."

   Please provide the results of this review.

RESPONSE:

As discussed in the "Procedure Review" portion of Section 5.2 (page 14 through 16) of the Results Report, the procedures used for valve disassembly - CP-CPM-6.9 or CP-CPM-9.18 - have always contained provisions to package disassembled valve parts. The purpose of this packaging (in a heavy duty plastic bag or wooden box marked with the valve tag number) as stated in CP-CPM-9.18 is "to prevent loss or damage and to maintain traceability." This practice was found to be adequate to identify damaged parts.

Additionally, the operational travelers and QC checklist for valves (QCV's) reviewed during the sample reinspections all contain a sign off by the craftsmen, QC engineer, or in the vast majority of cases - both, verifying all internals have been cleaned/prepared for reassembly. This constitutes a final check for visible damage prior to reassembly. See, e.g., action plan working file Section 5.0 (Item I-M-VALV-122).

QUESTION:

2. Section 5.2 (page 12 of 20, last paragraph) addresses differences in non-ASME and ASME manufacturing processes for the bonnets. The Results Report states that physical and chemical properties identified in the material specification would be the same for both and also that post manufacturing testing would be the same.

   Please address how you considered the differences between ASME Code and commercial requirements such as material identification and traceability, welding and weld repairs, personnel qualifications, and nondestructive examinations.

RESPONSE:

The conclusion as stated in the Results Report is that there is "no substantive effect of interchanging a ASME bonnet with a non-ASME bonnet on ITT Grinnell diaphragm valves." This conclusion was based on discussions with the manufacturer's QA Division Manager as documented in the action plan working file number 9.0 item 9.0-25 (copy attached). It was recognized that there are differences in the quality assurance programs under which the ASME and commercial grade bonnets are manufactured, but this was determined not to be significant in this particular instance since post manufacturing testing is identical for both ASME and non-ASME (commercial) bonnets.

VII.b.2 Valve Disassembly (Cont'd)

QUESTION:

3. It should be noted that NRC Inspection Report 50-445/85-14; 50-446/85-11 identified an unresolved item (Appendix E, paragraph 6.j) pertaining to the differences identified between the Westinghouse and Gibbs & Hill (G&H) Lines Designation Tables, and differences between G&H Tables and Code Data Sheets.

   Please provide the necessary information for resolution of this unresolved item (445/85-14-U-15).

   This question is in no way related to the conduct of ISAP VII.b.2.

RESPONSE:

TNE is currentl performing an extensive line by line comparison between the G&H and Westinghouse Line Lists. Members of Gibbs & Hill's Design Engineering Department, Westinghouse's Design Engineering Department and TNE's Mechanical Engineering Department are involved in this review. The objective is to identify and reconcile all differences between the two lists and to determine the correct condition in each case. Site system flow diagrams and Westinghouse design flow diagrams are also being reviewed to insure that both are in agreement with one another and are consistent with both Line Lists. Following this review, TNE will compare the questionable Valve Code Data Sheets to their respective line number for final assurance that the valves are acceptable for their applicable conditions.

QUESTION:

4. On page 1 in second paragraph under Section 3.0 reference is made to a valve testing program (a) Identify the program and/or programs and clearly indicate the scope i.e., how many and what type of valves are included, what types of valves are excluded, etc. (b) the loss or damage of valve parts is a QA programmatic concern when it's repetitive and uncontrolled, even if its documented. Explain how this issue is addressed in your implementation process.

   Section 4.1.2 the third paragraph addresses an evaluation of the adequacy of present procedures. Was there a sampling inspection of valves (and documentation) installed under the present procedures? What are present procedures as opposed to past procedures?

RESPONSE:

The system test engineer is required (by CP-SAP-20) to walkdown each system. The valves in the system are inspected (Section 4.4) for proper flow direction, accessibility, bolt tightness, stem travel, operability (smoothness, etc.), packing, etc. This is required for all valves in the system; safety-related as well as BOP.

VII.b.2 Valve Disassembly (Cont'd)

Additionally, some valves are checked/tested for operability over and beyond those in CP-SAP-20, such as:

- All Motor Operated Valves are tested in accordance with XCP-EE10
- All Air Operated Valves are tested in accordance with XCP-EE11
- The Main Steam Isolation Valves are tested in accordance with 1/2 CP-PT-3401
- All the Steam Generator Relief Valves 1/2 CP-PT-3402
- All valves used for containment isolation are local leak test (10CFR50 Appendix J) to 1/2 CP-PT-7501
- The RCS Boundary Check Valves are tested to 1-CP-PT-5709 and 2-CP-PT-5706

In the sample of 106 valves, there was one instance of a lost valve bonnet and one instance of damage sustained to a bonnet requiring replacement. Both had been properly documented by TUGCO on Nonconformance Reports (NCRs). As less than one percent of the sample items indicated a loss of valve parts and less than one percent damage, the Issue Coordinator and Review Team Leader do not consider this to be a programmatic concern of repetitive and uncontrolled loss or damage. Had this condition been determined to be a programmatic concern, the action plan would have been expanded or corrective action would have been recommended to the Project. As stated in Section 3.0 of the Results Report, the action plan focused on the undocumented interchanging of parts.

It should be noted that the ISAP, as it pertained to damage, was only concerned with damage sustained during valve part storage as per the allegation. Other cases of valve damage were found in the sample items. This damage had nothing to do with the valve disassembly/reassembly process. Our review revealed that repair had been accomplished satisfactorily.

The sample included valves which had been disassembled and reassembled under past or "earlier" procedures, valves which had been disassembled and reassembled under "present" procedures, and several valves which were disassembled more than once and so were dis/reassembled under both past and present procedures. Present procedures as used in the Results Report means CP-CPM-9.18 issued in mid-1983. Early procedures were those used prior to that date. Section 5.2 of the Results Report discusses the details of both procedures.

QUESTION:

5. Section 4.1.3 second paragraph states in part an evaluation was made to define potential code violations.

   - What are they? They should be identified.

VII.b.2 Valve Disassembly (Cont'd)

RESPONSE:

The evaluation for potential code class violations mentioned in the second paragraph of Section 4.1.3 was done as part of the analysis discussed in the first paragraph of this section. This analysis is contained in the action plan working file as document no. 6.0, item 6B-6 (copy attached). Revision 1 dated 11/25/85 of the analysis was inadvertently omitted from the action plan file and has now been added.

QUESTION:

6. Section 4.1.4 first sentence states that reinspection of valves which were disassembled was performed to provide assurance that the valves were reassembled using the correct components.

   It is not clear how, or from what documentation, the correct components were identified.

RESPONSE:

The acceptance criteria are stated in Section 4.6 of the Results Report.

QUESTION:

7. Section 4.2 procedures are not identified per program plan attachment 3 ISAP format.

RESPONSE:

The procedures in effect are CP-CPM-9.18 Rev. 0, dated 6/8/83 and QI-QAP-11.1-26 Rev. 18, dated 12/19/85.

QUESTION:

8. Section 4.6 appears to apply to only diaphragm valves - what was the basis acceptance of other types of valves with interchangeable top works and trim.

RESPONSE:

The criteria of Section 4.6 applied to all valves inspected under this action plan.

QUESTION:

9. Section 5.1 second paragraph states that the review installation procedures, revisions and dates should be identified.

VII.b.2 Valve Disassembly (Cont'd)

RESPONSE:

This information can be found in action plan working file 6A, items 6A-1 and 6A-2 (copies attached).

QUESTION:

10. Section 5.0 page 11 first paragraph states that a lost bonnet and a damaged bonnet were not deviations because they were properly identified on NCRs and PETs.

    The valve type, size, gag numbers, date of installation, the NCR and PET numbers should also state if the NPV-1 form was revised, or annotated.

RESPONSE:

The NCR and/or PET associated with these valves, or any similar conditions, serve as the key to initiating any required code documentation relative to the repair or replacement. When NPV-1 certified parts of a component are replaced or repaired, an ASME Section XI NIS-2 form is executed to maintain component certification acceptability; this form is completed prior to N-3 certification of the Unit, and is utilized in lieu of annotating or revising an ASME Section III NPV-1 Data Report, which is not permitted by the Code.

QUESTION:

11. Section 5.0 page 11 fourth paragraph states that two types of ITT Grinnell valves were supplied. This paragraph should also provide complete identification of the valve types (manufacturer's drawing or identification numbers), valve sizes, rating and applicable code class.

RESPONSE:

This information can be found in action plan working file 6.0, item 6B-5 (copy attached). (Note that the Generic Safety Consequence Analysis attached to this item is superceded by Revision 1 which is provided in response to item no. 5 above.)

QUESTION:

12. Section 5.0 fifth paragraph states in part: For some application...the applications should be identified (page 11).

RESPONSE:

The applications of the valves rated 300 psi at 150° F. were those within the scope of the NSSS Vendor supply. Westinghouse always specifies this type valve regardless of the application, system or plant for which their NSSS is supplied, for reason of standardization.

VII.b.2 Valve Disassembly (Cont'd)

The ITT Grinnell standard valve discussed in paragraph four of page 11 of the Results Report is used in all non-NSSS applications.

QUESTION:

13. Section 5.0 page 12 first paragraph is not clear in its description of valve modifications.

    1 - were the modifications made specifically for CPSES valves at the specified 300 PSIG, or

    2 - are these valves just different configurations furnished by the supplier when the user specifies service conditions, pressure/ temperature, that are higher than design.

RESPONSE:

See response to question no. 12.

QUESTION:

14. Section 5.0 page 13 second paragraph, identifies two valves by tag numbers.

    This paragraph should further identify the manufacturer's drawing or identification number, size, rating, code class and date of installation. Additionally this paragraph should identify the documents (e.g., NCR, IR, PET) that substantiated acceptance of the installed valve body and bonnet.

RESPONSE:

The information requested is:

Valve Tag No. 2-8422
Mfg. Dwg. No. - SD-C-100552 Rating 300 psig at 150°F. Class 2
Size - 3" Install. Traveler No. MW81-1105-4900
Reinspection Pkg. No. - I-M-VALV-44 dated 10/16/81

Valve Tag No. 2-7131B
Mfg. Dwg. No. - SD-C-100551 Rating 300 psig at 150°F. Class 3
Size - 3" Install. Traveler No. MW7980361-4100
Reinspection Pkg. No. - I-M-VALV-56 dated 10/23/79

This information is in the reinspection packages found in action plan working file Section 5.0.

The acceptance of the installed valves is documented on the installation traveler. No NCR or PET was in effect documenting the deviation at the time of the CPRT inspection of the valve which is the reason the deviation was declared.

VII.b.2 Valve Disassembly (Cont'd)

QUESTION:

15. Section 5.0 page 13 the second and third paragraphs, identify two valves by tag number. These paragraphs should also identify the manufacturer's drawing or identification number, size, rating and code class and date of installation.

RESPONSE:

This information is:

Valve Tag No. 1-7046
Mfg. Dwg. No. - SD-C-101609 Rating 300 psig at 150°F. Class 3
Size - 3" Install. Traveler No. MW80-1020-4900
Reinspection Pkg. No. - I-M-VALV-9 dated 11/11/81

Valve Tag No. XSF-179
Mfg. Dwg. No. - SD-C-105686 Rating 255 psig at 150°F. Class 3
Size - 3" Install. Traveler No. MW79-081-4700
Reinspection Pkg. No. - I-M-VALV-67 dated 12/19/79

This information is in the reinspection packages found in action plan working file section 5.0.

QUESTION:

16. Section 5.0 page 14 first paragraph states that because the installed valves (with deviations) match the numbers recorded on the operations travelers, this means that the bonnets were interchanged prior to issue for installation.

The staff finds that this deduction may not be valid if the valve was disassembled, installed and reassembled on the same day. If the traveler records these operations as performed on the same date (same shift), there is no assurance that the required information was recorded prior to disassembly. Another potential is the switching of valve tags.

RESPONSE:

The installation of these valves, as documented on the installation traveler in the reinspection packages, showed that the valve bonnets were removed and stored for a period of months, and then reassembled when all welding was complete and the line was installed in the field. Switching of valve tags would not cause the noted deviations as numbers stamped on the valve body and bonnet were used for the reinspection.

VII.b.2 Valve Disassembly (Cont'd)

QUESTION:

17. Section 5.0 page 14 second paragraph relates to travelers for the other two valves that were written prior to the practice of recording bonnet markings...

This paragraph should identify the two valves in question, the date installed, the procedure and applicable revision at the time of installation.

RESPONSE:

The valves in question are valve tag nos. 2-7131B and XSF-179 discussed on page 13. They were installed under procedure no. CP-CPM-6.9 Rev. 0, dated 10/6/78 on 10/23/79 and 12/19/79 respectively, based on traveler completion dates.

QUESTION:

18. Section 5.0 page 15 second paragraph refers to early procedures. The specific procedures, revisions and dates should be identified.

RESPONSE:

CP-CPM-6.9 Rev. 0 was the project source procedure which contained integrated Construction/ QC direction for the disassembly/reassembly of valves on CPSES. CP-CPM-6.9 was divided into subsections shortly after its issuance, and the requirements for valve disassembly/ reassembly were then encompassed in CP-CPM-6.9E. CP-CPM-6.9/CP-CPM-6.9E Rev. 0 (2/6/80) set forth the following requirements with respect to valve disassembly/reassembly:

Detailed instructions, including the general requirements of CP-CPM-6.9/CP-CPM-6.9E, would be provided to Construction/QC via an Operational Traveler (OT), prepared and approved in accordance with CP-CPM-6.3; and,

Section 3.14 of CP-CPM-6.9/CP-CPM-6.9E requires, in part

"All parts removed from the valve shall be stored in a heavy duty plastic bag, or in the case of a large valve a wooden or cardboard box. The MS [Millwright Superintendent] shall mark the box/bag with the valve number.

"Any valve that will remain dismantled for an extended period of time will have the bag/box of parts stored in a secure place in the Millwright Shop or Warehouse. If the MS estimates that the valve will remain disassembled for only a short period or that it is too large to be easily removed from the work area, then the bag/box may remain in the field."

VII.b.2 Valve Disassembly (Cont'd)

The above requirements remained as written through DCN #5 to CP-CPM-6.9E Rev. 6 (8/1/83), at which time they were deleted and CP-CPM-9.18 (Rev. 0, 6/8/83) was referenced. Additionally, Quality Instruction QI-QAP-11.1-39A Rev. 0 was issued on 6/8/83 to prescribe specific QC inspection and documentation requirements for valve disassembly/reassembly.

Additional details can be found in action plan working file 7.0, items 7.0-1 and 7.0-2 (copies attached).

QUESTION:

19. Section 5.0 page 15 third paragraph last sentence states; sufficient information for evaluating valve storage prior to this time is not available.

The issue of concern was the storage of disassembled valve components. The TRT found that the storage at installation locations was poorly controlled. The paragraph should address the storage of disassembled valve components.

Additionally, this paragraph refers to an effective program implemented by Millwrights.

This "Effective Program" should be addressed in the aspect of the implementation of an identified procedure and the verification of training of millwright personnel in the applicable procedure.

RESPONSE:

The Results Report does refer to the storage of valve parts. It was intended to relate that the Millwrights had effectively implemented the existing program. See response to Question 18. Records for the training of Millwright personnel are on file in the Construction Department Training Records.

QUESTION:

20. Section 5.0 page 15 the fourth paragraph states that the issue related to documentation of the interchange of valve bonnets was recognized by TUGCO...

This paragraph should state the basis (NCR's, IRs, etc.) for TUGCO's recognition and address this subject by including the identification of the procedures, revisions and dates.

VII.b.2 Valve Disassembly (Cont'd)

RESPONSE:

The RTL did not identify a specific event or discrete occurrence. The recognition was manifest by the recording of body and bonnet numbers on travelers which began in late 1980. This was a general practice within existing procedures. It was formally proceduralized by TUGCO with the issuance of CP-CPM-9.18 Rev. 0 in June 1983.

QUESTION:

21. Section 5.0 page 16 the second paragraph states that the QC checklist requires recording of the bonnet identification number.

For the installation of valves, since valve tags can also be interchanged, the staff finds that the procedure should require that the checklist should record both the body and bonnet identification.

RESPONSE:

As stated in the first paragraph on page 16 of the Results Report, the checklist does require recording of both body and bonnet identification numbers stamped on the valve parts.

QUESTION:

22. Section 5.0 page 16 third paragraph states the administrative action was taken (by TUGCO) in the startup test program.

The administrative action should be identified in terms of identification of any applicable procedures, revisions and the CPRT verification of the training of personnel.

RESPONSE:

The administrative action taken by TUGCO in 1985 was to require control of all work processes during the construction phase of CPSES, through implementation of the work package concept defined in the CP-CPM-7.1 series of procedures. Verification of program implementation and the awareness of project personnel with the program was evident from the process in which CPRT was required to obtain project documentation, prepare inspection packages and initiate work processes.

The only question of applicability during implementation of the CP-CPM-7.1 (series) involved the Start-up Organization, which, as documented in the action plan working file 7.0 item 7.0-4, was resolved by letter CPPA #45,538.

VII.b.2 Valve Disassembly (Cont'd)

QUESTION:

23. Section 5.0 page 16 the fourth paragraph cites an example identified by the TRT as evidence of procedure implementation and effectiveness.

The TRT also identified (in SSER-11) numerous PETs that documented the interchange as replacements for lost and/or damaged valve components. The staff wishes to emphasize that the issue essentially was procedural inadequacy to control the interchange, loss and damage of disassembled valve components. The staff disagrees with the CPRTs reasoning that this is an example of procedure effectiveness. The TRT stated that although the deficiency was reported on the NCR, and procedures were in place, the loss and damage continued to occur.

RESPONSE:

See the response to question 4.

QUESTION:

24. Section 5.6 page 18 identification and discussion of Corrective Action first paragraph is vague.

The paragraph should identify the level of responsibility of the changed personnel and identify the procedure, revisions and dates as they apply to the subject of this paragraph.

RESPONSE:

As addressed in response to questions 18 and 19, the corrective action was to implement effectively the existing program rather than developing a program to implement. Implementation was effected at the craftsman level and procedural compliance was and is stressed at the supervisory levels.

QUESTION:

25. Section 5.7 page 19 Out-of-Scope Observations.

The paragraph refers in part to: acceptable TUGCO Procedures...

The procedures should be identified.

RESPONSE:

CP-QAP-12.4 Rev. 1, dated 12/28/83.

VII.b.2 Valve Disassembly (Cont'd)

QUESTION:

26. Section 6.0 page 20 the second paragraph states that procedures were reviewed and found to be adequate except for .. and further, the last sentence states that improvements to the control process since 1983 ...

The procedures, revisions and dates should be identified, and the improvements to the control process should be specifically detailed in this paragraph.

RESPONSE:

See response to question no. 18.

QUESTION:

27. Section 7.0 page 20 does not clearly identify any of the results of the implementation of this plan (e.g., procedure inadequacy, lack of control, etc.) that must be addressed by TUGCO, and then evaluated under ISAP VII.a.2.

RESPONSE:

TUGCO must disposition the 4 identified via the Project NCR process. No programmatic concerns were identified during the conduct of this ISAP (See response to question 20).

ISAP VII.a.2 will assess handling of any programmatic corrective actions by TUGCO. One of the specific allegations being investigated in ISAP VII.a.2 is the portion of the TRT issue on valve dis/reassembly (as stated in AQ-52 of SSER-11) that concerns "effective programmatic corrective action was not implemented... ."

Evaluation
Research
Corporation

OFFICE MEMORANDUM

QA/QC-RT-076

TO: J. Hansel

FROM: M. Solon

DATE: April 8, 1985

SUBJECT: Valve Disassembly, Issue VII.b.2 Generic Valve Evaluation

Summary

Documentation (i.e. specifications, vendor instruction manuals and drawings) were reviewed to determine which generic valve types required disassembly prior to welded installation into the piping systems.

It is concluded that diaphragm valves, manufactured by ITT-Grinnell, are the only valves which required disassembly prior to weldup. Purchase orders CP-0020A, 0020B, 0604 and 0001 (S.0.0220) contain nuclear safety related (Q) diaphragm valves with the potential for mismatching valve bodies and internals when the valves were reassembled. The number of valves in these purchase orders is approximately 600 total for Units 1, 2 and Common.

Non-Q diaphragm valves contained in purchase orders CP-0021B.1, 0021D and 0604 are identical in form and fit to the Q valves, and will be considered as a source for mismatching internals and valve bodies.

Discussion

In accordance with the Action Plan, para. 4.1.1, an evaluation was made to determine the generic valve types that require disassembly and removal of internals prior to welding. Project specifications, drawings and vendor instruction manuals were reviewed. The latest specification index pages containing valves were marked up, and Table 1 was prepared to summarize the results of the documentation review.

All Q valve types were reviewed first. For those valve types that were found to require disassembly, similar non-Q valve types were evaluated as a possible source for mismatching non-Q internals with Q valve bodies. Valves supplied with vendor packaged equipment were not reviewed. Specific discussion of all valve types, by specification, follows.

Referring to Table 1, Page 1:

(1) The vendor instruction manuals for the diaphragm valves (MS-20A, 20B) require that the bonnet assembly be removed to protect the diaphragm during weldup into the piping system.

(2) The vendor instruction manuals for the bulk valve orders (MS-20A.1, 20.B.1, 20.B.2) do not require valve disassembly for welded installation into the piping system.

(3) The specification for the rubber lined check valves (MS-20B.3) has only four 24 inch valves. These valves, which are in the service water system, are all valve type 24CC302WA, Notes 3, 39 and are identical. Therefore, there is no need for further evaluation of potential mismatch.

(4) Butterfly/wafer disc valves use bolted installation exclusively.

Referring to Table 1, Page 2:

(1) The non-Q diaphragm (MS-21B.1, 21D) require valve disassembly for weldup. They are identical in form and fit to the Q diaphragm valves, and will therefore, be considered a potential discrepancy source for the Q valves.

(2) The remaining non-Q valves (MS-21A, 21B, 21C, 21D.2, 21E) have no Q valve counterpart that requires disassembly; and therefore, they were not reviewed.

Referring to Table 1, Page 3:

(1) No review is required for the non-Q circulating water valves (MS-75).

Referring to Table 1, Page 4:

(1) The main steam valves (MS-76, 77, 78, 79) are special valves and therefore were not reviewed.

(2) Review of the specifications and vendor instruction manuals for the butterfly deluge valves and the HVAC containment isolation valves (MS-82.1, 86) showed the valve installations to be bolted.

Referring to Table 1, Page 5:

(1) Review of the Q and non-Q control valves (MS-600, 601) shows that where soft seats are used, the internals must be removed prior to welded installation. Specification MS-600 (Q valves) has only four valves with soft seats. These valves (HV-4710, 4711, Data Sheets AO-19) are identical 4 inch 150 psi carbon steel globe valves. Specification MS-601 (non-Q) does not contain non-Q valves of similar configuration. Therefore, mismatch of valve internals and bodies need not be considered.

(2) The vendor instruction manual for the process solenoid valves (MS-603) does not require valve disassembly.

(3) The instruction manual for the power operated diaphragm valves (MS-604) requires valve disassembly before welded installation. The specification contains four Q valves. These are identical 150 psi 4 inch stainless steel valves (Tag No. HV-5157, 5158, Data Sheets A2-12, 13). Specification MS-604 contains 1, 2 and 3 inch air operated non-Q valves. These valves, Q and non-Q, are similar dimensionally to the air operated Q diaphragm valves in the NSSS purchase order, CP-0001 (S.0.0220). Therefore, there is a potential for mismatching parts.

Referring to Table 1, Page 6:

(1) The non-Q automatic pump recirculation valves (MS-627) need not be reviewed.

(2) Per the specification for the pilot solenoid valves (MS-632), the valve ends are threaded.

(3) The NSSS purchase order CP-0001 (Shop Order 0220) contains valves supplied by Rockwell, Fisher, Velan, Copes Vulcan, Crosby, Westinghouse and ITT-Grinnell. Vendor drawings and instruction manuals were reviewed to reach the following conclusions:

(a) The Crosby valves are safety and relief valves, and are not considered.

(b) The Rockwell, Fisher, Velan valves have metal seats and do not require disassembly before weldup.

(c) Some Copes Vulcan valves have non-metallic seats. However, the instruction manual does not require valve disassembly before weldup.

(d) The ITT-Grinnell valves include 3 and 4 inch manual Q valves, similar dimensionally to those in MS-20B; and air operated Q valves from 3/4 inch to 4 inch, of which the 1, 2, 3, 4 inch valves are similar dimensionally to those in MS-604. Therefore, these valves, with the possible exception of the 3/4 inch valves, will be added to the population of valves with the potential for having mismatched parts.

Further review and evaluation is required to better define the sub populations, taking into consideration the characteristics of the valve topworks. This effort will be limited to the ITT-Grinnell valves in purchase orders CP-020A, 020B, 0604 and 0001 (S.O. 0220).

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cc: D. Alexander
V. Hoffman
P. E. Ortstadt
File VII.b.2.4B

MS/sl

SPEC. NO.	TITLE	Documentation Problem: [illegible]	Documentation Problem: INSTR [illegible]	COMMENTS
MS-17	Condensate Demineralizer System			
MS-18	Nuclear Process Filters			
MS-19A	Turbine Oil Conditioning Equipment			
MS-19B	Turbine Oil Conditioning Equipment			
*MS-20	Control Valve Bodies			Incl in MS-600
*MS-20A ITT Grinnell	Manual & Self-Actuated Steel Valves 2.0 inches & Smaller Saunders Diaphragm Type	✓	✓	Disass'y/Reass'y req'd. for removal of internals. 269 Q valves involved
*MS-20A.1 Rockwell	Manual & Self-Actuated Steel Valves 2.0 inches & Smaller		✓	Removal of internals NOT req'd
*MS-20B ITT Grinnell	Manual Motor Operated & Self-Actuated Steel Diaphragm Valves 2.5 inches & Larger	✓	✓	Disass'y/Reass'y req'd to remove internals. 79 Q valves involved
*MS-20B.1 Borg-Warner	Manual, Power-Operated & Self-Actuated Steel Valves 2.5 inches & Larger		✓	Removal of internals NOT req'd
*MS-20B.2 Rockwell	Manual & Self-Actuated Steel Valves 2.5 inches & Greater		✓	Removal of internals NOT req'd
*MS-20B.3 TRW	Rubber Lined Steel Check Valves	✓		4 identical 24" valves Evaluation not req'd
*MS-20B.4	Excess Flow Check Valves			No valves have been ordered on this spec
*MS-20C.1 Posi Seal	Manual Motor Operated & Self-Actuated Butterfly/Wafer Disc. Valves			Only bolted installation for this valve type

*Nuclear Safety Related

TABLE 1

DOCUMENTATION REVIEW

SPEC. NO.	TITLE	DOCUMENT REVIEW: SPEC	DOCUMENT REVIEW: INSTR MANUAL	COMMENTS
~~*MS-20D~~	~~Valve Operators~~			
~~MS-21~~	~~Valve Extension Stems~~			
MS-21A	Manual & Self-Actuated Bronze & Cast Iron Valves 2.0 inches & Smaller-Non-Nuclear			Non-Q valves Review not req'd
MS-21B	Manual & Self-Actuated Steel Valves 2.0 inches & Smaller			(Non-Q valves Review not req'd)
MS-21B.1 ITT Grinnell	Manual & Self-Actuated Steel Valves 2.0 inches & Smaller (Saunders Diaphragm Type)	✓	✓	Non-Q valves (approx 385 vlvs). Identical in form & fit to MS-20A Consider as source for discrepancy
MS-21C	Manual and Self-Actuated Bronze & Cast Iron Valves 2-1/2 inches & Larger			Non-Q valves Review not req'd
MS-21D ITT Grinnell	Manual & Self-Actuated Steel Valves (Saunders Diaphragm Type) 2.5 inches & Greater Non-Nuclear	✓	✓	Non-Q valves (approx 125 vlvs) Identical in form & fit to MS-20B Consider as source for discrepancy
MS-21D.1	Manual Power Operated & Self-Actuated Steel Valves 2.5 inches & Larger			Non-Q valves Review not req'd
MS-21D.2	Power Operated Extraction Steam Check Valves Non-nuclear			(Non-Q valves Review not req'd)
MS-21E	Butterfly Wafer Disc. Valves			(Non-Q valves Review not req'd)
~~MS-22~~	~~Fire Protection Pumps~~			
~~MS-23~~	~~Main Condenser~~			
~~MS-24~~	~~Feedwater Heaters~~			
~~MS-25~~	~~Traveling Water Screens~~			

*Nuclear Safety Related

TABLE 1

DOCUMENTATION REVIEW

SPEC. NO.	TITLE
MS-67B	Tank Diaphragms
MS-68	Field Fabricated Tanks Non-Nuclear
MS-68A	Potable Water Storage Tank
*MS-69A	Valve Isolation Tanks
MS-70	Pressure Vessels Non-Nuclear
MS-70A	Blowdown System Pressure Vessel
+MS-70B	Pressure Vessels-Non-Nuclear
*MS-71A	Expansion Joints-Nuclear
MS-71B	Expansion Joints-Non Nuc.
MS-72	Rubber Expansion Joints
MS-73	Plumbing & Fittings
MS-73A	Fire Protection-Underground Piping & Fittings
*MS-74	Mechanical Penetrations
MS-75	Circulating Water Valves

Non-Q valves. Evaluation not req'd

*Nuclear Safety Related
+Not Issued
**Non-Nuclear Safety Related
Q.A. Program Applicable

TABLE I
DOCUMENTATION REVIEW
PAGE 3 OF 6

SPEC. NO.	TITLE	Docum. Reviews: SPEC	Docum. Reviews: INSTR. MANUAL	COMMENTS
*MS-76	Main Steam Isolation Valves			Special valves. No review req'd.
*MS-77	Main Steam Safety Valves			
*MS-78	Main Steam Relief Valves			
MS-79	Steam Dump Valves			
MS-80A	Centrifugal Water Chillers			
*MS-80B	Centrifugal Water Chillers			
*MS-81	Emergency Fan-Coil Units			
*MS-82	Atmospheric Cleanup Trains			
*MS-82.1	Pneumatically Actuated Butterfly Deluge Valves	✓	✓	Bolted installation
MS-83A	HVAC-Fans			
*MS-83B	HVAC-Fans (Nuclear)			
*MS-84	HVAC-Dampers			
*MS-84.1	Superpipe Break Isolation Dampers			
*MS-85	HVAC Ducts, Louvers, and Accessories			
*MS-86 Posi-Seal	HVAC-Cont. Isolation Valves	✓	✓	Bolted installation

*Nuclear Safety Related
+Not Issued

TABLE I

DOCUMENTATION REVIEW

SPEC. NO.	TITLE	DOCUM REVIEW: SPEC	DOCUM REVIEW: INSTR MANUAL	COMMENTS
*MS-600 Fisher	Power Operated Control Valves-Nuclear	✓	✓	Requires soft seat internals to be removed. There are 4 identical 4" vlvs with soft seat mat'l. Mismatch not possible - See MS-601
MS-601 Fisher	Control Valves Non-Nuclear	✓	✓	No 4" vlvs of same type as MS-600 with soft seats
*MS-603 Valcor	Process Solenoid Valves	✓	✓	Disass'y Not req'd
*MS-604 ITT-Grinnell	Power Operated Diaphragm Valves	✓	✓	Requires removal of internals. Q and non-Q air-op vlvs similar to CP-0001(5.0.0220) Q vlv
*MS-605	Main Control Boards			
MS-606	Instrument Racks and Local Panels			
MS-607	Humidity Detection Equip			
*MS-608	Chlorine Detectors			
+MS-609	Paint			
MS-610	Thermocouple & Resistance Temp. Detectors			
*MS-611A	Electronic Pressure & Differential Pressure Transmitters			
*MS-611B	Analog Control System			

*Nuclear Safety Related
+Not Issued
**Non - Nuclear Safety Related
Q.A. Program Applicable

TABLE 1

DOCUMENTATION REVIEW

SPEC. NO.	TITLE	DOCUM. REVIEW: SPEC	DOCUM. REVIEW: INSTR MANUAL	COMMENTS
MS-626	Instrument Tubing & Fittings-Non-Nuclear			
MS-627	Automatic Pump Recirc. Valves			Non-Q valves No review req'd
*MS-628	Instrumentation Racks			
+MS-629	Safety Assessment Systems			
*MS-630	Heat Resistance Temp. Detector (RTD) Array Assy Level Transmitters			
*MS-631	Subcooled Margin Monitor			
*MS-631A	Core Cooling Monitor System			
*MS-632 ASCO	Solenoid Pilot Valves	✓		Valve ends are threaded
CP-0001	NSSS SHOP ORDER 0220	Dwg's & instr. man. reviewed		ITT-Grinnell diaphragm valves are disassembled prior to welding Other mfgr's valves do not require disass'y

*Nuclear Safety Related
+Not issued

TABLE I

DOCUMENTATION REVIEW

Evaluation
Research
Corporation

OFFICE MEMORANDUM

QA/QC-RT-090

TO: J. L. Hansel

FROM: M. Solon

DATE: May 2, 1985

SUBJECT: Valve Disassembly, Issue VII.b.2 Additional Generic Valve Evaluation

References:

(1) Office Memorandum, M. Solon to J. Hansel, "Generic Valve Evaluation", dated 04/08/85

(2) SDAR CP-83-01, Corrective Action for Borg-Warner Check Valves

(3) Telecon, M. Solon to P. Milinazzo, "Disassembly and Reassembly of Borg-Warner Check Valves", dated 04/22/85

Summary

Reference 1 evaluated the generic valve types which required disassembly prior to welded installation into the piping system. The objective of this further evaluation is to determine if there are generic valve types which required disassembly and subsequent reassembly after the valves were delivered to the site.

It was determined that although many types of valves were disassembled and reassembled for purge, flush, test and repair, there was only one generic valve type (in addition to those in Ref. 1) which required disassembly. These were check valves supplied by the Borg-Warner Nuclear Valve Division (B-W), under P.O. No. CP-0020B.1. There are approximately 160 valves, total for Units 1, 2 and Common, which fall into this generic type valve category.

It was concluded that of this total only some of the low pressure (150 and 300 psi) valves could be reassembled with an incorrect body/bonnet generic configuration. All valves in question are ASME III, Code Class 2, and therefore, code classification violations could not have occurred.

Discussion

B-W check valves were found to have possible design and manufacturing deficiencies (Reference 2), which required that the valves already on site be disassembled for inspection and repair if required.

Review of the B-W check valve drawings, with confirmation by the vendor (Reference 3) resulted in the conclusion that valve bodies and bonnets of the same size and pressure rating could have been reassembled, regardless of ASME III Code Class (Class 2, 3) or material (carbon, stainless steel). However, per the specification (MS-20-B.1, paragraph 3.3.3) the valves were all supplied as Class 2.

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A matrix of B-W check valve types is given in Table 1. All valves are ASME III, Code Class 2. Valve types which have the same body/bonnet fit-up are circled. The valves which could be reassembled with incorrect bonnet and internals are as follows:

3 inch/150 psi (carbon and stainless steel)
4 inch/150 psi (carbon and stainless steel)
10 inch/150 psi (CS and SS) and 300 psi (CS)

There are approximately 70 valves falling into these categories.

Valves which were disassembled, other than those defined herein and in Reference 1, will be identified by reviewing operations travelers.

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ERC File
File VII.b.2-4B
File VII.b.2-9

MS/sl

Attachments

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TABLE 1

BORG-WARNER CHECK VALVE TYPES

ANSI PRESS RATING	3 INCH	4 INCH	6 INCH	8 INCH	10 INCH	16 INCH
150 psi	CS/SS	CS/SS	CS	CS	CS/SS	
300 psi					SS ~~CS~~ △1	SS
900 psi	CS	CS	CS	CS		

NOTES: (1) ALL VALVES ARE ASME III, CODE CLASS 2

(2) SS = STAINLESS STL BODY & BONNET

CS = CARBON STL BODY & BONNET

(3) ☐ = SAME VALVE BODY/BONNET FITTUP

Rev △1 5/14/85

Evaluation
Research
Corporation

OFFICE MEMORANDUM

QA/QC-RT-103

TO: J. L. Hansel

FROM: M. Solon

DATE: May 20, 1985

SUBJECT: Valve Disassembly, Issue VII.b.2, Generic Safety Consequences Analysis

REFERENCES:
1. Memorandum QA/QC-RT-076, "Valve Disassembly, Issue VII.b.2 Generic Valve Evaluation," April 8, 1985
2. Memorandum QA/QC-RT-090, "Valve Disassembly, Issue VII.b.2 Additional Generic Valve Evaluation," May 2, 1985
3. Telecon, M. Solon and B. Borst (ITT-Grinnell), April 9, 1985
4. Telecon, M. Solon and B. Borst (ITT-Grinnell, May 15, 1985
5. Telecon, M. Solon and P. Milinazzo (Borg-Warner), April 22, 1985

SUMMARY

The generic valve types that required disassembly and reassembly were identified in References 1 and 2. The safety implications resulting from reassembly of incorrect valve components were evaluated, and are summarized as follows:

1. Manual and air operated ITT-Grinnell diaphragm valves (except the 3/4 inch, stainless steel, Class 3, air operated valves), if reassembled with incorrect bonnet assemblies, could result in significant safety implications ranging from violation of the ASME III code* to failure of the valve.

2. The following Borg-Warner swing check valves, if reassembled with incorrect bonnet assemblies, could result in corrosion problems, potential failure of the bonnet and/or loss of function of the valve:

   a. Three and four inch/150 psi valves
   b. Ten inch/150 psi and 300 psi valves

The combination of valve bodies and bonnet assemblies which can be bolted up are shown in Table 1 (manual diaphragm valves), Table 2 (air-operated diaphragm valves) and Table 3 (Borg-Warner check valves). The potential generic safety consequences of incorrectly reassembled valves are summarized in Table 4.

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* Code violation herein loosely defined as an ASME valve reassembled with a bonnet assembly from a lower ASME class valve.

VII b.2-(6B-5)

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Valves which do not fall into the generic categories defined in References 1 and 2 will be treated on a case by case basis. Since there are many different valve types which were disassembled for test, repair, flush, etc., generic evaluations prior to defining the population are not practical. A recommended approach is given in Section 3 of Discussion.

Discussion

In accordance with the Action Plan, paragraph 4.1.3, an evaluation was made to determine the consequences of reassembling incorrect bonnet assemblies on valves which required disassembly. The two generic types of valves identified in References 1 and 2 were evaluated and are discussed below.

1. ITT-Grinnell Diaphragm Valves

The ITT-Grinnell diaphragm valves were supplied under the following purchase orders:

Purchase Order, CP-	Description
0020A	ASME III, Manual, 2 Inch and Smaller
0020B	ASME III, Manual, 3 and 4 Inches
0604	ASME III and Non-ASME, Power Operated
0001	ASME III, Manual and Power Operated
0021B.1	Non-ASME, Manual, 2 Inch and Smaller
0021D	Non-ASME, Manual, 3 and 4 Inches

Based on References 1, 3 and 4, the following conclusions were drawn regarding possible reassembly configuration errors and resulting differences in valve construction:

a. Valves of the same size have the same body/bonnet fit-up, regardless of ASME III Class (including non-ASME), material and pressure rating.

b. Bonnet material is stainless steel regardless of body material (Stainless Steel or Carbon Steel).

c. Bonnet wall thickness depends on valve size only, and is the same for 150 psi and 300 psi ratings.

d. Diaphragm thickness depends on valve size only, and is the same for 150 psi and 300 psi ratings. However 300 psi, 2 inch, 3 inch and 4 inch valves have a diaphragm support cushion.

e. Two, three and four inch, 300 psi manual valves use a brass spindle; whereas the 150 psi valves and the 300 psi air operated valves use a stainless steel spindle. All other internals are of the same materials.

The following additional information was obtained from the valve drawings.

f. Operator action (air to open or close) was determined and is summarized in Table 2. Except for the 4 inch valves, all the valve operators with the same action were the same size for a given valve size.

g. The 4 inch Class 2 valves have a larger actuator than the 4 inch Class 3 valves.

It is presumed that reassembly of a manual valve with a bonnet assembly having an air operator, or vice versa, is not credible. Such an error would be obvious, both visually and during preop testing.

The evaluation was performed for the highest level of valve (be it ASME Class, pressure rating or material), assuming reassembly with a bonnet from a valve of lower level. In addition, valve operator action and size was considered. The possible reassembly errors were obtained from Table 1 (manual valves) and Table 2 (air operated valves) wherein the number of ASME valves, broken down by class, pressure rating and material, are shown for each valve size. The various types of non-ASME valves are also shown in the tables. Except for the 3/4 inch and 4 inch air operated valves, non-ASME valve bonnets could be installed on the ASME valves.

A summary of the evaluation is given in Table 4, Items 1 through 10B. Except for the 3/4 inch, Class 3, 300 psi, stainless steel valves (Item 7B), reassembly with an incorrect bonnet assembly could result in a code violation and/or potential valve failure or loss of function.

2. Borg-Warner Swing Check Valves

The Borg-Warner swing check valves were supplied as part of purchase order CP-0020B.1. Based on References 2 and 5, the following conclusions were drawn regarding possible reassembly configuration errors and resulting differences in valve construction:

a. Except for the 10 inch valves, only valves of the same size and pressure rating have the same valve body/bonnet fit-up.

b. Ten inch valves have the same body/bonnet fit-up for 150 psi and 300 psi.

c. Carbon steel valves have carbon steel bodies, seats and bonnets. Stainless steel valves have stainless steel bodies, seats and bonnets.

d. Except for the 10 inch carbon steel valves, all valves have stainless steel disks. The 10 inch carbon steel valves have carbon steel disks.

e. All valves were provided as Class 2, regardless of class specified.

The possible reassembly errors were determined from Table 3, wherein the number of valves in each assembleable category is given. Only the 3 and 4 inch 150 psi valves and the 10 inch valves could be reassembled with body/bonnet errors with potential safety significance.

A summary of the analysis is given in Table 4, Items 11 through 13. In each of these cases, reassembly errors could result in valve failure or loss of function.

3. Other Valve Types Dis/Reassembled

Analysis of the generic valves for safety consequences is practical only for the ITT-Grinnell diaphragm valves and Borg-Warner check valves. These valves were known to have required dis/reassembly of all the valves. This type of analysis for the remaining valves that were dis/reassembled for repair, test, flush, etc. should be done on a case by case basis.

The recommended approach would be to include all the other valves* in the population. When a valve is selected as a sample, the documentation should be reviewed to determine if adverse effects could result from errors in reassembly. If no adverse effects are identified, the valve should be discarded from the sample, and another selected. If the evaluation is not conclusive, the valve should remain in the sample, and the evaluation would take place after the valve is inspected, if discrepancies are found.

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File VII.b.2-9
File VII.b.2-4
ERC File

MS/sl

* Other screening criteria, e.g. short time span between disassembly and reassembly, may be considered to eliminate valves from the population.

MANUAL 3/4"

	CS Cl 2	CS Cl 3	SS Cl 2	SS Cl 3
150 #		17 NOTE 1 (TYP)	4	11
300 #				12

MANUAL 1"

	CS Cl 2	CS Cl 3	SS Cl 2	SS Cl 3
150 #		30	6	19
300 #				

MANUAL 2"

	CS Cl 2	CS Cl 3	SS Cl 2	SS Cl 3
150 #		46	11	44
300 #				42

MANUAL 3"

	CS Cl 2	CS Cl 3	SS Cl 2	SS Cl 3
150 #		1	7	27
300 #			23	108

MANUAL 4"

	CS Cl 2	CS Cl 3	SS Cl 2	SS Cl 3
150 #			10	26
300 #			2	5

MANUAL NON-ASME

	3/4"	1"	2"	3"	4"
C. Stl	150 psi		150 psi	150 psi	150 psi
St. Stl		150 psi	150 psi	150 psi 300 psi	150 psi

NOTE: 1. NUMBER OF VALVES

TABLE 1

MANUAL DIAPHRAGM VALVES

3/4" - 300 psi Air Operated - ATO	
CS-CL 2	SS-CL 3
4 Note 1 (TYP)	12

1" - 300 psi Air Operated - ATO		
CS-CL3	SS	
	CL 2	CL 3
1	4	3

2" - 300 psi Air Operated St. Stl.		
CL 2	CL 3	
ATO	ATO	ATC
5	6	10

	3" - St. Stl. Air Operated		
	CL 2	CL 3	
	ATO	ATO	ATC
150 psi		4	
300 psi	3	16	11

	4" - St. Stl. Air Operated		
	CL 2	CL 3	
	ATO	ATO	ATC
150 psi	4		
300 psi		2	1

Non-ASME Air Operated ATO St. Stl.			
1"	2"	3"	
150 psi	150 psi	150 psi	300 psi

TABLE 2
Air Operated Diaphragm Vlvs

Note: 1. Number of values
2. ATO = Air to open
ATC = Air to close

3" - 150 psi	
CS	SS
19 Note 1 (TYP)	16

3" - 900 psi	
CS	SS
6	

Note 1. Number of vlvs

4" - 150 psi	
CS	SS
10	3

4" - 900 psi	
CS	SS
21	

6" - 150 psi	
CS	SS
8	

6" - 900 psi	
CS	SS
28	

8" - 150 psi	
CS	SS
6	

8" - 900 psi	
CS	SS
2	

TABLE 3
BORG-WARNER
CHECK VALVES

	10"	
	CS	SS
150 psi	2	4
300 psi		8

16" - 300 psi	
CS	SS
	12

TABLE 4

GENERIC SAFETY CONSEQUENCES ANALYSIS

ITEM	DESCRIPTION	SAFETY CLASS	PRESSURE RATING	POTENTIAL REASSEMBLY ERROR	POTENTIAL FAILURE & EFFECTS
1	ITT-Grinnell Diaphragm Valve Manual 3/4 inch Stainless Steel	3	300psi	1. Bonnet assembly from C.S. valve 2. Bonnet assembly from 150 psi valve 3. Bonnet assembly from non-ASME valve	1. No failure. All bonnets are St. St. with internals of same materials. 2. No failure. The bonnet and diaphragm thicknesses are the same for 150 psi and 300 psi valves. 3. a. Potential failure during a seismic event. Loss of function, leakage. b. Code violation.
2	ITT-Grinnell Diaphragm Valve Manual 3/4 inch Carbon Steel	2	150 psi	1. Bonnet assembly from non-ASME valve 2. Bonnet assembly from ASME III, Class 3 valve	1. a. Potenital failure during a seismic event. Loss of function, leakage. b. Code violation. 2. Code violation.
3	ITT-Grinnell Diaphragm Valve Manual 1 inch Stainless Steel	2	150	1. Bonnet assembly from C.S. valve 2. Bonnet assembly from non-ASME valve 3. Bonnet assembly ASME III, Class 3 valve	1. No failure. All bonnets are St. St. with internals of same materials. 2. a. Potential failure during a seismic event. Loss of function, leakage. 3. Code violation.

TABLE 4 (Cont'd)
GENERIC SAFETY CONSEQUENCES ANALYSIS (Cont'd)

ITEM	DESCRIPTION	SAFETY CLASS	PRESSURE RATING	POTENTIAL REASSEMBLY ERROR	POTENTIAL FAILURE
4	ITT-Grinnell Diaphragm valve Manual 2 inch Stainless Steel.	3	300	1. Bonnet assembly from C.S. Valve.	1. No failure. All bonnets are St. St. with internals of same materials.
				2. Bonnet assembly from 150 psi valve.	2.a. Galling of St. St. spindle (300 psi valve spindle is brass). Jamming of valve. b. No support cushion. Failure of diaphragm & leakage.
				3. Bonnet assembly from non-ASME Valve.	3.a. Potential failure during a seismic event. Loss of function, leakage. b. Code violation.
5	ITT-Grinnell Diaphragm Valve Manual 2 inch Stainless Steel.	2	150	1. Bonnet assembly from C.S. Valve.	1. No failure. All bonnets are St. St. with internals of same materials.
				2. Bonnet assembly from non-ASME Valve.	2.a. Potential failure during a seismic event. Loss of function & leakage. b. Code violation.
				3. Bonnet assembly from ASME III, Class 3 valve.	3. Code violation.
6	ITT-Grinell Diaphragm Valve Manual 3 inch & 4 inch Stainless Steel.	2	300	1. Bonnet assembly from C.S. Valve.	1. No failure. All bonnets are St. St. with internals of same materials.
				2. Bonnet assembly from 150 psi valve.	2.a. Galling of St. St. spindle (300 psi valve spindle is brass). Jamming of valve. b. No support cushion. Failure of diaphragm & leakage.
				3. Bonnet assembly from non-ASME Valve.	3.a. Potential failure during a seismic event. Loss of function & leakage. b. Code violation.
				4. Bonnet assembly from ASME III, Class 3 valve.	4. Code violation.

TABLE 4 (CONT'D)

GENERIC SAFETY CONSEQUENCES ANALYSIS

ITEM	DESCRIPTION	SAFETY CLASS	PRESSURE RATING	POTENTIAL REASSEMBLY ERROR	POTENTIAL FAILURE
7A	ITT-Grinnell Diaphragm Valve Air operated (ATO) 3/4 inch Carbon Steel	2	300	1. Bonnet and actuator assembly from Class 3 valve	1.a. Code violation. b. No failure. Actuator action and size the same.
7B	Stainless Steel	3	300	1. Bonnet and actuator assembly from C.Stl., Class 2 valve	1.a. No failure. All bonnets are St. St. with internals of the same materials. Actuator action and size the same.
8A	ITT-Grinnell Diaphragm Valve Air operated (ATO) 1 inch Stainless Steel	2	300	1. Bonnet and actuator assembly from C. Stl., Class 3 valve 2. Bonnet and actuator assembly from non-ASME, 150 psi valve	1.a. Code violation b. No failure. All bonnets are St. St. with internals of the same materials. Actuator action and size the same. 2.a. Code violation. b. Potential failure during a seismic event. Loss of function & leakage.
8B		3	300	1. Bonnet and actuator assembly from non-ASME, 150 psi valve	1. Same as 2 above.
9A	ITT-Grinnell Diaphragm Valve Air operated (ATO) 2 inch and 3 inch Stainless Steel	2	300	1. Bonnet and actuator assembly from Class 3 valve with ATC actuator 2. Bonnet and actuator assembly from non-ASME, 150 psi valve	1.a. Code violation. b. Incorrect actuator action and system operation. 2.a. Code violation. b. Potential failure during a seismec event. Loss of function & leakage.
9B	Air operated (ATC)	3	300	1. Bonnet and ATO actuator assembly from non-ASME, 150 psi valve	1. Same as 2 above. 2. Incorrect actuator action and system operation.

TABLE 4 (Cont'd)
GENERIC SAFETY CONSEQUENCES ANALYSIS (Cont'd)

ITEM	DESCRIPTION	SAFETY CLASS	PRESSURE RATING	POTENTIAL REASSEMBLY ERROR	POTENTIAL FAILURE
10 A	ITT-Grinnell Diaphragm valve air operated (ATO) 4 inch Stainless Steel	2	150	1. Bonnet and actuator assembly from class 3, ATO valve. 2. Bonnet & actuator assembly from class 3, ATC valve.	1.a. Code violation b. Smaller actuator; slower valve opening & closing times 2.a. Code violation b. Incorrect actuator action and system operation.
10 B	Air operated (ATC)	3	300	1. Bonnet and actuator assembly from class 2, 150 psi, ATO valve.	1.a. Failure of bonnet seal and/or bonnet cover. External leakage. b. Incorrect actuator action and system operation.
11	Borg-Warner swing check valve 10 inch Stainless 3inch & 4 inch Rev. 1	2	150 psi	1. Bonnet assembly from C.S. valve.	1.a. Corrosion and potential failure of bonnet. Contamination of system from corrosion products. b. Corrosion of C.S. seat. Loss of leak tightness & check valve function.
12	Borg-Warner swing check valve 10 inch Stainless Steel.	2	300 psi	1. Bonnet assembly from 150 psi valve. 2. Bonnet assembly from C.S. valve.	1. Failure of bonnet seal and/or bonnet cover. External leakage. 2.a. Corrosion of bonnet. Potential failure of bonnet. Contamination of system from corrosion products. b. Corrosion of C.S. seat. Loss of leak tightness and check valve function. c. Corrosion and failure of C.S. disk.
13	Borg-Warner swing check valve 10 inch Stainless	2	150 psi	1. Bonnet assembly from C.S. valve.	1.a. Corrosion and potential failure of bonnet. Contamination of system from corrosion products. b. Corrosion of C.S. seat. Loss of leak tightness and check valve function. c. Corrosion and failure of C.S. disk.

Rev. 1 5/23/85

ERC EVALUATION RESEARCH CORPORATION

QA/QC-RT-149

TO: J. L. Hansel

FROM: J. N. Barger

DATE: June 19, 1985

SUBJECT: Valve Disassembly, Issue VII.b.2, Dis/Reassembly Procedural Control

REFERENCE: Memorandum QA/QC-RT-106

Review of the construction and QA procedures have been completed. Based on the review it was found that construction procedure CP-CPM-9.18 Revision 0 and QA procedure QI-QAP 11.1-26 require positive identification of parts for valves listed in supplements of CP-CPM-9.18. This function is controlled by QI-QAP 11.1-26 which requires the use of an approved, standard form, QC Checklist (QCV). The QCV lists inspection points for positive identification of valve parts which includes body, bonnet and disc heat numbers and, where prescribed the application of match marks for alignment purposes. Valves not addressed in supplements of CP-CPM-9.18 are dis/reassembled in accordance with construction operation travelers. These travelers are prepared in accordance with construction procedure CP-CPM-6.3 and further covered in QA procedure QI-QAP 11.1-26. CP-CPM-6.3 requires that the valve part, serial or tag number be recorded on the traveler prior to the start of valve disassembly. Additional positive information such as body, bonnet and disc heat numbers were included in some cases by personnel initiating the traveler, but was not required. Subsequent to issuing CP-CPM-9.18 and QI-QAP 11.1-26, positive identification of most valves were recorded prior to the start of valve disassembly.

A number of valves have been dis/reassembled more than one time. Therefore, it is conceivable that a valve may have been dis/reassembled using the early procedures and again using the current procedures.

Based on the forgoing it is concluded that valves reassembled using early procedures had more potential for reassembly errors than using the procedures now in effect. The significant difference being that the earlier procedures did not require recording the bonnet, body and disc heat number before disassembling the valve. The potential for reassembly error is considerably reduced for valves disassembled for the first time after the establishment of the QCV.

ERC EVALUATION RESEARCH CORPORATION

The assessment made in the reference memorandum has changed due to the large percentage of valves dis/reassembled using early procedures and some valves currently not covered by QCV. Therefore, the subpopulation for Issue VII.b.2 will not be made up of valves dis/reassembled using early procedures. The basis for the subpopulation will be finalized and reported in the near future.

John N. Barger

J. N. Barger

cc: D. J. Alexander
M. Obert
V. Hoffman
FILE VII.b.2-4
File VII.b.2-9 ✓
ERC File

JNB/sp

ERC VALUATION RESEARCH CORPORATION

QA/QC-RT-688

TO: File

FROM: M. Obert

DATE: October 2, 1985

SUBJECT: Review of Procedures Pertinent to Valve Disassembly

The following procedures were reviewed including a review of the historical file of previous revision:

Procedure No.	Title
CP-CPM-6.9	General Piping Procedure
CP-CPM-6.3	Preparation, Approval, and Control of Operation Travelers
CP-CPM-9.18	Valve Disassembly/Reassembly
QI-QAP-11.1-39A	Valve Disassembly/Reassembly
QI-QAP-11.1-26	ASME Pipe Fabrication and Installation Inspections

The results of these reviews are reported in Memorandum QA/QC-RT-149 dated 6/19/85 and in the ISAP VII.b.2 Results Report.

M. P. Obert

MPO/my

VII 6.2-7.0-2

ITEM NUMBER VII.b.2

GENERIC SAFETY CONSEQUENCES ANALYSIS

ITEM	DESCRIPTION	SAFETY CLASS	PRESSURE RATING	POTENTIAL REASSEMBLY ERROR	POTENTIAL FAILURE & EFFECTS
1	ITT-Grinnell Diaphragm Valve Manual 3/4 inch Stainless Steel	3	300 psi	1. Bonnet assembly from C.S. valve.	1. No failure. All bonnets are Stainless Steel with internals of same materials.
				2. Bonnet assembly from 150 psi valve.	2. No failure. The bonnet and diaphragm thicknesses are the same for 150 psi and 300 psi valves.
				3. Bonnet assembly from non-ASME valve.	3. Code violation.
2	ITT-Grinnell Diaphragm Valve Manual 3/4 inch Carbon Steel	2	150 psi	1. Bonnet assembly from non-ASME valve.	1. Code violation.
				2. Bonnet assembly from ASME III, Class 3 valve.	2. Code violation.
3	ITT-Grinnell Diaphragm Valve Manual 1 inch Stainless Steel	2	150	1. Bonnet assembly from C.S. valve.	1. No failure. All bonnets are Stainless Steel with internals of same materials.
				2. Bonnet assembly from non-ASME valve.	2. Code violation.
				3. Bonnet assembly ASME III, Class 3 valve.	3. Code violation.

ITEM NUMBER VII.b.2

GENERIC SAFETY CONSEQUENCES ANALYSIS

TEM	DESCRIPTION	SAFETY CLASS	PRESSURE RATING	POTENTIAL REASSEMBLY ERROR	POTENTIAL FAILURE & EFFECTS
4	ITT-Grinnell Diaphragm valve Manual 2 inch Stainless Steel	3	300	1. Bonnet assembly from C.S. valve.	1. No failure. All bonnets are Stainless Steel with internals of same materials.
				2. Bonnet assembly from 150 psi valve.	2. a. Possible galling of Stainless Steel spindle (300 psi valve spindle is brass). b. No support cushion. Reduced diaphragm life-increased maintenance.
				3. Bonnet assembly from non-ASME valve.	3. Code violation.
5	ITT-Grinnell Diaphragm Valve Manual 2 inch Stainless Steel	2	150	1. Bonnet assembly from C.S. valve.	1. No failure. All bonnets are Stainless Steel with internals of same materials.
				2. Bonnet assembly from non-ASME valve.	2. Code violation.
				3. Bonnet assembly from ASME III, Class 3 valve.	3. Code violation.

ITEM NUMBER VII.b.2

GENERIC SAFETY CONSEQUENCES ANALYSIS

TEM	DESCRIPTION	SAFETY CLASS	PRESSURE RATING	POTENTIAL PEASSEMBLY ERROR	POTENTIAL FAILURE & EFFECTS
6	ITT-Grinnell Diaphragm Valve Manual 3 inch & 4 inch Stainless Steel	2	300	1. Bonnet assembly from C.S. valve.	1. No failure. All bonnets are Stainless Steel with internals of same materials.
				2. Bonnet assembly from 150 psi valve.	2. a. Possible galling of Stainless Steel spindle (300 psi valve spindle is brass). b. No support cushion. Decreased diaphragm life-increased maintenance.
				3. Bonnet assembly from non-ASME valve.	3. Code violation.
				4. Bonnet assembly from ASME III, Class 3 valve.	4. Code violation.
A	ITT-Grinnell Diaphragm Valve Air Operated (ATO) 3/4 inch Carbon Steel	2	300	1. Bonnet and actuator assembly from Class 3 valve.	1. a. Code violation. b. No failure. Actuator action and size the same.
B	Stainless Steel	3	300	1. Bonnet and actuator assembly from C. Stl., Class 2 valve.	1. No failure. All bonnets are Stainless Steel with internals of the same materials. Actuator action and size the same.

ITEM NUMBER VII.b.2

CENERIC SAFETY CONSEQUENCES ANALYSIS

TEM	DESCRIPTION	SAFETY CLASS	PRESSURE RATING	POTENTIAL REASSEMBLY ERROR	POTENTIAL FAILURE & EFFECTS
8A	ITT-Grinnell Diaphragm Valve Air Operated (ATO) 1 inch Stainless Steel	2	300	1. Bonnet and actuator assembly from C. Stl., Class 3 valve.	1. a. Code violati..n. b. No failure. All bonnets are Stainless Steel with internals of the same materials. Actuator action and size the same.
				2. Bonnet and actuator assembly from non-ASME, 150 psi valve.	2. Code violation.
8B		3	300	1. Bonnet and actuator assembly from non-ASME, 150 psi valve.	1. Same as 2 above.
9A	ITT-Grinnell Diaphragm Valve Air Operated (ATO) 2 inch & 3 inch Stainless Steel	2	300	1. Bonnet and actuator assembly from Class 3 valve with ATC actuator.	1. a. Code violation. b. Incorrect actuator action which would be discovered during testing.
				2. Bonnet and actuator assembly from non-ASME, 150 psi valve.	2. Code violation.
9B	Air Operated (ATC)	3	300	1. Bonnet and ATO actuator assembly from non-ASME, 150 psi valve.	1. Same as 2 above. 2. Incorrect actuator action which would be discovered during testing.

ITEM NUMBER VII.b.2

GENERIC SAFETY CONSEQUENCES ANALYSIS

EM	DESCRIPTION	SAFETY CLASS	PRESSURE RATING	POTENTIAL REASSEMBLY ERROR	POTENTIAL FAILURE & EFFECTS
A	ITT-Grinnell Diaphragm Valve Air Operated (ATO) 4 inch Stainless Steel	2	150	1. Bonnet and actuator assembly from Class 3, ATO valve.	1. a. Code violation. b. Smaller actuator. Incorrect actuator action which would be discovered during testing.
				2. Bonnet and actuator assembly from Class 3, ATC valve.	2. a. Code violation. b. Incorrect actuator action which would be discovered during testing.
B	Air Operated (ATC)	3	300	1. Bonnet and actuator assembly from Class 2, 150 psi, ATO valve.	1. a. Incorrect actuator action which would be discovered during testing.
	Borg-Warner Swing Check Valve 3 inch & 4 inch Stainless Steel Rev. 1	2	150 psi	1. Bonnet assembly from C.S. valve.	1. a. Corrosion and potential failure of bonnet. Contamination of system from corrosion products. b. Corrosion of C.S. seat. Loss of leak tightness and check valve function.

ITEM NUMBER VII.b.2

GENERIC SAFETY CONSEQUENCES ANALYSIS

EM	DESCRIPTION	SAFETY CLASS	PRESSURE RATING	POTENTIAL REASSEMBLY ERROR	POTENTIAL FAILURE & EFFECTS
	Borg-Warner Swing Check Valve 10 inch Stainless Steel	2	300 psi	1. Bonnet assembly from 150 psi valve. 2. Bonnet assembly from C.S. valve.	1. Failure of bonnet seal and/or bonnet cover. External leakage. 2. a. Corrosion of bonnet. Potential failure of bonnet. Contamination of system from corrosion products. b. Corrosion of C.S. seat. Loss of leak tightness and check valve function. c. Corrosion and failure of C.S. disk.
	Borg-Warner Swing Check Valve 10 inch Stainless Steel	2	150 psi	1. Bonnet assembly from C.S. valve.	1. a. Corrosion and potential failure of bonnet. Contamination of system from corrosion products. b. Corrosion of C.S. seat. Loss of leak tightness and check valve function. c. Corrosion and failure of C.S. disk.

ERCI Systems Integration and Management Corporation

QA/QC-RT-1638

March 13, 1986

Mr. Frank Milliken
ITT-Grinnell Valve Co., Inc.
P. O. Box 6164
Lancaster, PA. 17603-2064

Dear Frank:

Enclosed please find a Record of Telephone Conversation for our telecon of March 13, 1986. Please review it for correctness and completeness.

Please advise me of any comments at (817) 897-8962. If you have no comments, please note your concurrence (inital and date) and return a copy in the enclosed addressed envelope.

Mike Obert

ERC
c/o Texas Utilities Generating Co.
Comanche Peak Steam Electric Station
P. O. Box 1002
Glen Rose, Texas ¯6043

2600 Virginia Avenue NW, Suite 707, Washington, D.C. 20037 • 202/342-6795

VII.6.2
9.4-25

RECORD OF TELEPHONE CONVERSATION

INCOMING ___ OUTGOING X TIME 10:30 A.M. ~~P.M.~~ DATE. March 13, 1986

Person called: Frank Milliken FOM 3/17/86 Title: QA Division Manager

Representing: ITT-Grinnel Tel. (712) 291-1901

Person Calling: Mike Obert Title: ISAP VII.b.2 Issue Coordinator

Representing: ERC Tel. (871) 897-8962

Other Parties Involved: None

REF. ITEM	TOPICS
1.	I discussed with Mr. Milliken the differences between the bonnet assemblies of an ASME diaphragm valve and a non-ASME diaphragm valve. He stated the differences are as follows: - The castings used for making the bonnets are purchased from the foundry by ITT-G under different specifications. For ASME valves, an ASME material spec. is used and for non-ASME valves an ASTM spec. is used. The same pattern is used for the castings of both ASME and non-ASME bonnets. The only difference in the castings is the paperwork that accompanies them. The chemical and physical properties of the metal required by the ASME material spec. are the same properties specified in the ASTM material spec. - The machining of the bonnets for both ASME and non-ASME bonnets is essentially the same. Again the only differences are in paperwork. - There is more QA involvement in the repair of any defects found in ASME bonnets. - The post manufacturing Non Destructive Examination program is the same for both ASME and non-ASME bonnets so it is not any more likely that a non-ASME valve bonnet with an undetected defect be shipped than an ASME valve bonnet.
2.	It is a correct conclusion that there is no functional difference between an ASME and non-ASME bonnet. They are physically the same with a different "pedigree" or paperwork package.