TVA

Tennessee Valley Authority, Post Office Box 2000, Spring City, Tennessee 37381

MAY 2 6 1995

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Gentlemen:

In the Matter of the Application of	)	Docket Nos. 50-390
Tennessee Valley Authority	)	50-391

WATTS BAR NUCLEAR PLANT (WBN) - REPLY TO REQUEST FOR ADDITIONAL INFORMATION REGARDING CARBON DIOXIDE AUTOMATIC FIRE SUPPRESSION SYSTEMS (TAC NO. M63648)

The purpose of this letter is to provide TVA's response to NRC's request for additional information (RAI) dated May 10, 1995, regarding the adequacy of the WBN carbon dioxide fire suppression systems in the auxiliary instrument rooms, emergency diesel generator (EDG) engine rooms, and EDG electric board rooms. TVA's response to each of the RAI items is provided in the Enclosure 1.

This letter provides TVA's basis for concluding that CO_2 fire suppression systems required by applicable licensing requirements are capable of extinguishing fires. Accordingly, the letter also provides TVA's response to address concerns discussed in Inspection Report 50-390, 391/95-16 dated April 6, 1995.

Enclosure 2 lists the commitment contained in this submittal. If you have any questions, please contact Mr. P. L. Pace at (615)365-1824.

Sincerely,

Raul Baron

Raul R. Baron
Nuclear Assurance
and Licensing Manager (Acting)

Enclosures
cc: See page 2

D030

Enclosures
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50-390 TVA WATTS BAR 1

REPLY TO REQUEST FOR ADDL INFO RE CARBON DIOXIDE AUTOMATIC FIRE SUPPRESSION SYSTEMS

REC'D W/LTR DTD 05/26/95....9506050013

ENCLOSURE 1
WATTS BAR NUCLEAR PLANT (WBN)
REPLY TO REQUEST FOR ADDITIONAL INFORMATION

The following provides TVA's response to Inspection Report 50-390, 391/95-16 dated April 6, 1995, and the Staff's request for additional information (RAI) dated May 10, 1995, regarding the adequacy of the WBN carbon dioxide fire suppression systems.

NRC INFORMATION REQUEST - ITEM 1

"NFPA 12-1973, Section 2232 states, "For deep seated fires, the required extinguishing concentration shall be maintained for a sufficient period of time to allow the smoldering to be extinguished and the material to cool to a point at which re-ignition will not occur when the inert atmosphere is dissipated." In addition, NFPA 12-1973, Section 241 states, "The quality of carbon dioxide for deep seated type fires is based on fairly tight enclosures because the concentration must be maintained for a substantial period of time to assure complete extinguishment." Considering the results of the Sandia tests and the recommendations of NFPA 12-1989 edition, to maintain a 50-percent CO_2 concentration for 20 minutes for dry electrical hazards in general, justify how the current CO_2 system designs meet Section 2232 of your code of reference. In support of your justification, submit the results of fire tests or experiments that substantiate your position that no soak time is required to suppress deep seated fires."

TVA RESPONSE

- Background

WBN design documents for areas involving deep seated fires do not specify a pre-determined soak time since the NFPA guidelines used to design and install the CO_2 systems did not specify a soak time. However, it should be noted that the actual soak times achieved during system testing (either using door fan tests or CO_2 dump tests) are adequate to meet the applicable NFPA guidelines from the TVA code of record for WBN (NFPA 1973 Edition).

The CO_2 systems installed at WBN were designed and supplied by Chemtron Fire Systems in 1978. The NFPA code of record in effect for CO_2 system designs was NFPA 12-1973. The original design basis (Attachment 1) for the system was as follows:

ROOM NAME	SPECIFIED %/TIME	HOLD TIME
Auxiliary Instrument Rm 1	30% / 2 min	
	50% / 7 min	
	50%	10-min
Auxiliary Instrument Rm 2	30% / 2 min	
	50% / 7 min	
	50%	10-min
Diesel Generator Engine Rm 1A-A	34% / 1 min	None
Diesel Generator Engine Rm 1B-B	34% / 1 min	None
Diesel Generator Engine Rm 2A-A	34% / 1 min	None
Diesel Generator Engine Rm 2B-B	34% / 1 min	None

Required soak times were not well established at the time of the system design (Attachment 2). This can be attributed to:

1. Non-definitive code requirements (e.g., "sufficient period of time to allow the smoldering to be extinguished and the material to cool"), and

2. Lack of fire testing (e.g., Sandia National Lab NUREG/CR-3656 was published in 1986).

TVA determined the design to be adequate in that:

1. The system would be quick to respond and extinguish the fire in its incipient stage before it had the chance to become deep seated, and

2. With the fire extinguished or controlled, adequate time was available for fire brigade response.

Results of Sandia National Laboratories Testing and Applicability to WBN

The Sandia National Laboratories testing described in NUREG/CR-3656 provides sufficient information from which conclusions can be drawn about the concentration and soak time needed to extinguish deep seated fires. The Sandia test report stated, "The objective of the suppression tests was to determine the minimum soak time and/or spray duration necessary to suppress electrical cable tray fires and prevent reignition of the fire using the following suppression systems and agents:

1. Halon 1301 following NFPA-12A, 1977;
2. Water; sprinkler systems following NFPA-13, 1980 and directed water spray systems following NFPA-15, 1977;
3. Carbon dioxide (CO_2) following NFPA-12, 1980"

A key difference between the TVA and Sandia tests is the manner in which soak time is evaluated. In the Sandia testing, soak time was considered to be the "length of time that the ventilation system was turned off and the exhaust vent closed so that no air was exchanged in the room." The Sandia soak times for CO_2 application included a delay time for personnel safety evacuation. At WBN, soak time does not include an initial delay time - it only includes the time that CO_2 is actually applied.

For example, in Sandia test number 83, cable fires were induced to cause a fully developed fire, and then the ventilation system was shutdown and the dampers closed. Two minutes later the CO_2 was discharged into the room. Approximately 2 minutes after starting of discharge of CO_2, the concentration in the room was 50%. The discharge of CO_2 continued for approximately 2 more minutes and reached a peak concentration of approximately 58%. Concentration began to rapidly dissipate and in approximately 1 minute was below 50%. The concentration reached a low value of approximately 45%. Approximately 1 minute later, a second discharge of CO_2 was initiated and continued for approximately 2 minutes. Upon completion of the second discharge of CO_2, ventilation was restored. (See Figure 36 of the Sandia report - Attachment 3). From Figure 34 of the report (Attachment 3) it can be seen that the cables reignited approximately 1 minute after ventilation was restored to the room.

There are two significant observations to note from the data the test provides:

1. The total time that the CO_2 concentration was above 50% was approximately 4 minutes. The total time there was CO_2 in the room before ventilation was restored was 8 minutes.

2. The cables did not reignite until ventilation was restored to the room.

Test number 85 was conducted in a manner similar to Test 83 except that the cables were not qualified. In test 85, it took approximately 2½ minutes to achieve 50% concentration and the concentration peaked approximately 6 minutes later at approximately 57%. At the end of the discharge, concentration rapidly dropped for approximately 1 minute at which time a second 1 minute discharge of CO_2 was initiated. Ventilation was restored approximately 1 minute later. Reignition of cables did not occur.

There are two significant observations to note from the data the test provides:

1. The total time the CO_2 concentration was above 50% was approximately 5½ minutes. The total time there was CO_2 in the room before ventilation was restored was 8 minutes.

2. The cables did not reignite even when ventilation was restored to the room.

As discussed above, Sandia tests confirm CO_2 soak times less than 20 minutes are able to extinguish deep seated cable tray fires, even if the concentration falls slightly below 50%. The maximum time the Sandia tests maintained 50% concentration was approximately 5½ minutes. The only time that qualified cables reignited after a "10 minute soak time" (actual time CO_2 in the room was 8 minutes) was when ventilation was restored. Per the Sandia report, no reignition of the qualified cables occurred when the "soak time" was increased to 15 minutes. Since the 15 minutes would include a 2 minute delay, the actual time that CO_2 was in the room would be approximately 13 minutes. According to the Sandia report there was no reignition of unqualified cables when the "soak time" was only 10 minutes.

Another important consideration is the method of achieving and the length of time required to achieve a deep seated fire. The Sandia test used Bunsen burners located directly below the cable trays for 18 minutes to establish fully involved cable trays. The burners were turned off and the trays were allowed to freeburn for another minute and then the ventilation was secured and dampers closed. At this time the "soak time" was started. According to the Sandia report, there was no reignition of the unqualified cables when the "soak time" was only 10 minutes and no reignition of the qualified cables when the "soak time" was 15 minutes.

Also, it can be seen from the rapid decay of CO_2 shown in Sandia Figures 36 and 37 that the test room was not a tight room. In contrast, the WBN auxiliary instrument rooms are very tight and are able to maintain the CO_2 for a substantial period of time. A graphical representation of the Sandia test results overlaid with the WBN auxiliary instrument room discharge test (Attachment 4) shows that the WBN enclosure is much tighter that the Sandia enclosure. Door fan pressurization tests (Attachment 5) demonstrate that the rooms are capable of maintaining tightness for an extended period of time. The CO_2 concentration tests demonstrated the tightness of the room since the concentration only dropped approximately 8% in 15 minutes. By contrast, the Sandia test concentration dropped approximately 13% in 2 minutes.

RESOLUTION

Based on the above, TVA agrees that a minimum soak time should be specified for the locations where a deep seated fire is of concern. At WBN, the only locations protected by CO_2 where protection for a deep seated fire is necessary is the Unit 1 and 2 auxiliary instrument rooms. The auxiliary instrument rooms have a primary combustible loading of electrical cables in the cable trays. Therefore, TVA will revise the design description for the CO_2 system supplying the auxiliary instrument rooms (Units 1 and 2) to include a minimum soak time. The soak time will be to maintain CO_2 concentration greater than 45% for at least 15 minutes.

TVA concludes that the 1978 designed automatic CO_2 suppression system provided for the auxiliary instrument rooms at Watts Bar are adequately designed (with upgrades and as verified by tests) for a deep seated fire. TVA detection and suppression system would detect and suppress any fire with the potential of the severity needed to induce a deep seated fire. The defense in depth fire protection at Watts Bar ensures that the fire protection provided for the auxiliary instrument rooms are in compliance with the applicable sections of NFPA 12-1973 and therefore meet the regulatory requirements as found in Branch Technical Position (BTP) 9-5.1, Appendix A, paragraph F.6 and 10CFR50, Appendix R, paragraph III.G.3.

NRC INFORMATION REQUEST - ITEM 2

"Recent system discharge testing has not demonstrated favorable results which would provide reasonable assurance that the CO_2 systems will properly perform, and develop the CO_2 concentrations and maintain them for a period of time sufficient to suppress a deep seated fire.

Therefore, justify your current position that there is not a need to reconfirm, by test, that all CO_2 suppression systems installed in plant areas important to safety meet the system performance criteria of Section 2523 (design concentration achieved within 7 minutes with a rate of discharge not less than that required to develop a concentration of 30 percent in 2 minutes) of NFPA-12, and that an adequate soak time to address all related fire hazards within the protected area can be accomplished. In addition, provide a description of your CO_2 system full discharge (concentration) test methodology, its acceptance criteria, all past test results, including a description of pre-test room conditions (e.g. actions taken to reduce leakage such as taping of door frames, plugging open penetrations), and your schedule for conducting future tests."

TVA RESPONSE

Background

The only CO_2 protected rooms at Watts Bar that require automatic suppression are the two auxiliary instrument rooms and the four diesel generator engine rooms[1]. Suppression is required in the auxiliary instrument rooms in order to comply with 10CFR50, Appendix R, paragraph III.G.3. Suppression is required in the diesel generator engine rooms in order to comply with BTP 9-5.1, Appendix A, paragraph F.9.d.

Auxiliary Instrument Rooms

The acceptance criteria for the auxiliary instrument rooms described in TVA's response to Item 1 has been satisfied without further testing based on the following:

1. Door fan pressurization tests demonstrated that the auxiliary instrument rooms are capable of maintaining an adequate concentration of CO_2 for an extended period of time (Attachment 5).

2. CO_2 concentration tests (dump tests) in the Unit 2 auxiliary instrument room demonstrated the tightness of the room since the concentration only dropped approximately 8% in 15 minutes (Attachment 6).

3. The CO_2 system timers have been increased to ensure that an appropriate amount of CO_2 is injected into the rooms.

4. The Unit 1 auxiliary instrument room is bounded by Unit 2 auxiliary instrument room.

Unit 2 auxiliary instrument room CO_2 concentration tests were performed twice using the manual trip feature of the CO_2 timer. CO_2 concentration was monitored and recorded at three locations in the room. The monitor located at 75% room height was used to determine if the acceptance criteria was met. During Test number 1, room pressure rose above the acceptance criteria resulting in action to stop the test. The room was too tight and an additional vent path was required to prevent room over pressurization.

During the second test, the Unit 2 auxiliary instrument room was tested in its normal configuration with the exception that the upper access door in the Battery Room Exhaust duct located in the northeast corner of the room was opened to simulate the vent path. No taping of doors and frames was done. Penetrations (pipe, cable tray, and conduits) were sealed per design as part of the Watts Bar Penetration Seal Upgrade Program prior to the CO_2 concentration tests.

As can be see in the attached graphs (Attachment 6), the auxiliary instrument room CO_2 concentration achieved a concentration of 49%-50%. To ensure greater than 50% CO_2 concentration in the auxiliary instrument rooms, the discharge

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[1] The diesel generator board rooms do not require an automatic CO_2 suppression system since these rooms are separated from adjacent safety trains by 3-hour rated barriers.

timer was increased by 12 seconds, which will result in a concentration of approximately 53%.

Conclusion

A graphical overlay representation of the Sandia test results and WBN Unit 2 auxiliary instrument room is shown in Attachment 4. Note that at the start of the discharge of CO_2 in the Sandia tests the room's CO_2 concentration was approximately 5%-9%. It appears that this initial contribution of CO_2 is due to the diffusion flaming combustion of the cables. This is consistent with the discussions of the physical chemistry of combustion in fires as presented by D.D. Drysdale in his book "An Introduction to Fire Dynamics." This additional CO_2 that is produced in an actual fire will contribute to the CO_2 system discharge and produce a synergetic effect on smothering the fire (i.e., reducing the oxygen content of the atmosphere by dilution to a level where the atmosphere no longer will support combustion). As noted, the WBN test results, with the additional CO_2 that would result from the timer increase, ensures a sufficient concentration for extinguishment as bounded by the Sandia tests. Therefore, the performance criteria of NFPA 12-1973, Section 2523 have been met and adequate concentration levels and soak times have been accomplished.

The justification for not performing a full discharge test for Unit 1 auxiliary instrument room is that the Unit 2 auxiliary instrument room testing bounds the Unit 1 auxiliary instrument room as follows:

1. A door fan pressurization test (Attachment 4) demonstrated that the expected hold time for Unit 1 auxiliary instrument room was equivalent to the hold time for Unit 2 auxiliary instrument room.

2. The Unit 1 auxiliary instrument room CO_2 piping downstream of the room selector valve is equivalent to the Unit 2 room.

3. The Unit 1 room is smaller (3480 ft^3 vs 3740 ft^3).

4. The Unit 1 room has a smaller in situ combustible fuel load due to fewer feet of cable trays (approximately 1840 feet of 18 inch tray and approximately 290 feet of 12 inch tray vs approximately 2160 feet of 18 inch tray and approximately 310 feet of 12 inch tray).

Diesel Generator Engine Rooms

The performance criteria of NFPA-12, Section 2523 have been met and an adequate concentration level and soak time were achieved during the March 1995 testing. The following provides TVA's basis for determining the appropriate design concentration and soak time.

Branch Technical Position (BTP) 9-5.1, Appendix A, part F.9 and 10CFR50, Appendix R, section III.G.2.a, require diesel generators to be separated from each other and other areas of the plant by fire barriers having a minimum fire resistance rating of 3 hours. In addition BTP 9-5.1 requires that when day tanks cannot be separated from the diesel generator an automatic suppression system should be provided. One acceptable method of fire suppression (BTP 9.5-1, section F.9.d) is to provide an automatic gas suppression system (Halon or CO_2) to combat diesel generator and/or lubricating oil fires.

The Diesel Generator Building is a separate building and each diesel generator and its associated equipment is separated from the other diesel generators by fire barriers having a minimum fire resistance rating of 3 hours. This meets the requirements of BTP 9-5.1, Appendix A, part F.9 and 10CFR50, Appendix R, section III.G.2.a.

The design basis of the CO_2 suppression system provided for the diesel generator rooms is for a fuel oil hazard (surface fire). This is the type of hazard identified in BTP 9-5.1, Appendix A, part F.9.d. The code in effect during the system design was NFPA 12-1973. The original design criteria for the CO_2 suppression system in the Diesel Generator Building was established by TVA and awarded to Chemtron Fire Systems for implementation by TVA contract number 76K71-83209. The code requirements for a surface fire (flooding factor, storage capacity, and discharge time) were calculated by the vendor for each diesel generator engine room. The first page of each calculation (Attachment 1) documented the hazard type (fuel oil - surface fire) and the minimum design concentration (34%). These design requirements for a surface fire have not changed from NFPA 12-1973 thru NFPA 12-1993 (current edition).

The original acceptance tests (Attachment 1) performed in 1979 for each of the diesel generator engine rooms demonstrated that the design concentration (34%) was achieved within the required time (actual concentration achieved in each of the rooms was at least 40%). The capacity of the CO_2 storage tank is large enough to allow two full discharge times for any of the rooms.

The primary fire hazard in the diesel generator engine rooms is the diesel fuel. NFPA 12, Section A-223 (Attachment 2) states, "Proper selection of the type of fire that the system should be designed to extinguish is important and, in many cases, will require sound judgement after careful consideration of all the various factors involved." One of those factors is, "Will a deep seated fire develop, considering the speed of detection and application of the contemplated system?" The expected fire will be a Class B fire (i.e., diesel fuel). A diesel fuel oil fire is a surface type fire. The applicable section of NFPA 12-1973 is Section 23, "Carbon Dioxide Requirements for Surface Fires" and Section 25, "Distribution System." Since the diesel generator engine rooms also contain the generator, Section 2534 (rotating electrical equipment) is applicable and the acceptance criteria was revised to require that a CO_2 concentration of at least 30% be maintained for at least 20 minutes. This new acceptance criteria is more conservative than the original design basis criteria and has been achieved as demonstrated by testing (Attachment 6).

In addition to the diesel fuel (primary hazard), the rooms also contain other combustibles. Each room has seven 18 inch wide and two 9 inch wide cable trays which contain circuits that terminate in the room. An electrically initiated fire from the circuits in the trays is not considered to be a credible event. The circuits are protected by adequately sized circuit breakers/fuses such that a fault on a circuit will cause the breaker/fuse to trip/open before the cable insulation reaches its auto ignition temperature. This is in agreement with A-223 of NFPA 12 (Attachment 2).

The 17th edition of the NFPA Fire Protection Handbook, Section 5, chapter 17 states, "Surface burning fires, such as flammable liquid fires, are normally extinguished during a 1 minute carbon dioxide discharge. Leakage compensation must be in addition to the basic quantity." Since the diesel fuel is the primary hazard in the engine rooms, these CO_2 suppression systems for the rooms were designed for a surface fire. However, as stated earlier the generator is considered to be rotating electrical equipment and the criteria has been revised accordingly. Door fan leakage tests (Attachment 5) were performed in late 1994 and demonstrated the actual room leakage rate to be acceptable for this change to the design basis of the system.

CO_2 concentration tests were performed in diesel generator engine room 2B-B using the manual trip feature of the CO_2 timer. Room 2B-B was selected since it is the room furthest from the CO_2 storage tank. The room was tested in its normal configuration. The exhaust fans were running, fire dampers in the ceiling were open, and doors were closed. Initiation of CO_2 automatically shut down the exhaust fans, but the dampers in the ceiling do not automatically close. No taping of doors and frames was done. Penetrations (pipe, cable tray, and conduits) were sealed per design as part of the Watts Bar Penetration Seal Upgrade Program prior to the CO_2 test.

The full discharge test conducted on March 3, 1995, in engine room 2B-B demonstrated that the CO_2 concentration exceeded 40% within 1 minute (peaked at approximately 44%) and was still above 40% after 20 minutes (Attachment 6). This system as tested in 1995 exceeds the design basis and the code of record requirements.

The requirements for a deep seated fire do not apply due to the presence of a limited quantity of electrical cables in the room. As demonstrated by the Sandia National Laboratories tests, it is difficult to get a fully developed cable tray fire. For qualified cables, it took approximately 18 minutes to obtain fully developed fire in horizontal cable trays and this was with bunsen burners located immediately under the trays. In the diesel engine rooms the trays are located near the ceiling and the exposure fire would be on the floor. The CO_2 detection system would sense the fire before the cable insulation would reach its auto-ignition temperature and initiate CO_2 suppression. There would be no deep seated cable fire because a fire would not have time to create a fully developed cable tray fire before CO_2 discharged and extinguished the fire.

The function of the automatic CO_2 suppression system in the Diesel Generator Building is to provide an immediate fire control/suppression activity in the event of a fire. Early actuation of the suppression system is by an automatic detection system. This detection system also provides notification to the main control room operators who in turn notify the site fire brigade. This early actuation of the CO_2 system is capable of extinguishing/controlling a fire until the fire brigade can respond and provide final extinguishment and remove any material involved in the fire (see Section 2232 of NFPA 12). In the event the detection system is inoperable, a fire watch is established in accordance with the Fire Protection Report.

TVA maintains a trained crew of fire fighters onsite around the clock. These crews receive classroom training and live fire training at the Nickajack Fire Training facility as well as regularly scheduled training drills onsite. Training records for the site fire brigade drills show that the fire brigade can respond within 13 to 19 minutes to the Diesel Generator Building. The response time includes time to actuate the CO_2 suppression system and sample the air for habitability (the CO_2 system is sized to allow a second full discharge). The response time is within the 20 minute soak time requirement for the engine rooms. Upon arrival, the Incident Commander has the following options for final extinguishment:

1. Initiate another full dump of CO_2 into the room, or
2. Use standpipe and hose system in the diesel building, or
3. Use nearby fire hydrants.

Conclusion

The fire protection system provided for the diesel generator engine room 2B-B is appropriately designed and has been tested to demonstrate that it is fully adequate for the hazards. No further testing is necessary.

Door fan pressurization tests were performed in accordance with NFPA 12A-1989, Appendix B, on each of the diesel generator engine rooms. The results show the retention time for these rooms is equal to or exceeds the retention time for engine room 2B-B. Since the CO_2 concentration was maintained for a sufficient length of time in room 2B-B, it is reasonable to conclude that the concentration will be maintained in the other three rooms. Each of the four diesel generator engine rooms are alike in the following respects:

a. Room volume
b. Equipment (layout and type)
c. CO_2 piping size and number of nozzles downstream of the room selector valve

TVA has determined that the results of the CO_2 test for room 2B-B bound the other three rooms and additional full scale discharge tests are not required.

NRC INFORMATION REQUEST - ITEM 3

"The current designs of the Watts Bar CO_2 suppression systems are not sized to compensate for appreciable leakage of CO_2 from the protected space; this condition can affect the overall fire suppression performance of the system. Recent testing has demonstrated that in these compartments, the CO_2 concentration is quickly affected by excessive leakage. NFPA-12, Section 253 states, "Where leakage is appreciable and the design concentration must be obtained quickly and maintained for an extended period of time, CO_2 provided for leakage compensation may be applied at a reduced rate." Describe the measures that will be taken to minimize leakage from these rooms and what test methods will be used to demonstrate that the CO_2 suppression system will meet its performance objectives. In addition, describe your surveillance testing program for controlling room leakage and assessing its potential impact on the effectiveness and operability of a CO_2 suppression system."

TVA RESPONSE

TVA does not agree with the above assessment of the WBN CO_2 systems located in areas requiring suppression systems. The CO_2 suppression systems serving the auxiliary instrument rooms and diesel generator rooms are appropriately sized. As shown in the CO_2 concentration charts provided Attachment 6, the auxiliary instrument rooms and diesel generator rooms do not have "appreciable leakage." The rooms are tight enough to maintain the required CO_2 concentration for an appropriate length of time. Also, TVA has demonstrated the capability of the

CO_2 suppression systems to deliver the appropriate amount of CO_2, with adequate reserve capacity. It is important to note that it was necessary to add additional venting capability to the auxiliary instrument rooms because they are so tight that a pressure release path had to be provided.

The diesel generator engine rooms were tested (dump test and door fan pressurization) in their normal configuration. The exhaust fans were running, fire dampers in the ceiling were open, and doors were closed. Initiation of CO_2 automatically shut down the exhaust fans, but the dampers in the ceiling are not required to close. No taping of doors and frames was done. Penetrations (pipe, cable tray, and conduits) were sealed as part of the Watts Bar Penetration Seal Upgrade Program prior to the CO_2 test.

The Unit 2 auxiliary instrument room was tested in its normal configuration with the exception that the upper access door in the battery room exhaust duct located in the northeast corner of the room was opened. This was done because the room was too tight and an additional vent path was required to prevent over pressurization of the room. A permanent modification is being implemented to provide for this vent path. No taping of doors and frames was done. Penetrations (pipe, cable tray, and conduits) were completed as part of the Watts Bar Penetration Seal Upgrade Program prior to the CO_2 test.

The operational requirements and testing and inspection requirements for the CO_2 systems will be maintained and tested as described in Part II, section 14.4, of the WBN Fire Protection Report (see additional details in the Bases provided for Section 14.4). The requirements include scheduled inspections of penetration seals, fire doors, fire dampers, detection systems, and suppression systems. These measures are adequate to ensure that the CO_2 suppression systems will continue to meet their performance objectives. In addition, a Fire Protection Impairment program establishes appropriate compensatory measures if one of these components/systems is breached or out of service.

CONCLUSION

As described above, the testing performed to date has demonstrated the ability of the CO_2 suppression systems to meet their performance objectives. No further tests or measures to minimize leakage from the rooms are needed. Also, the measures described in the Fire Protection Report provide an adequate level of confidence that the CO_2 suppression systems will continue to perform acceptably.

NRC INFORMATION REQUEST - ITEM 4

"In reviewing the fire hazards associated with rooms protected by CO_2 suppression systems, the diesel generator room has several major fire hazards which required diverse CO_2 concentrations. For example, for combustible liquid surface fires (diesel fuel), the minimum concentration is 34 percent with no soak time (refer to NFPA-12-1973, Section 23, "Carbon Dioxide Requirements For Surface Fires"), for rotating electrical equipment, the minimum concentration is 30 percent with a soak time of 20 minutes (refer to NFPA-12-1973, Section 253, "Extended Rate of Application"), and for deep-seated dry electrical fire hazards, the minimum concentration is 50 percent with a soak time ranging from 10 to 20 minutes (refer to Sandia test results and NFPA-12-1973, Section 2-4, "Carbon Dioxide Requirements for Deep-seated Fires"). Considering these diverse fire hazards in the diesel generator rooms, provide your technical bases, including test results, which demonstrate how the current CO_2 suppression system design is capable of suppressing fires associated with these diverse fire hazards."

TVA RESPONSE

As discussed above, the total flooding CO_2 system provided for the diesel generator engine rooms is adequate for the hazards and meets the design basis requirements for a surface fire involving combustible liquids (primary hazard) and rotating electrical equipment. In summary, TVA's conclusion is based on the following:

1. The full discharge tests met NFPA 12-1973 code requirements for a CO_2 total flooding suppression system.

2. The rooms meet the requirements of BTP 9-5.1, Appendix A, Section F.9

3. The rooms meet the requirements of 10CFR50, Appendix R, section III.G.2.a (i.e., the diesel generators are adequately separated by 3-hour fire barriers and a fire will not involve more than one diesel).

4. The rooms do not have significant leakage and are able to maintain relatively high concentrations of CO_2 for extended periods of time.

5. A deep seated fire (i.e., cable tray fire) is not considered because the CO_2 suppression system would extinguish an exposure fire that could involve the trays.

6. Watts Bar maintains a well trained Fire Operations Unit that can rapidly respond to fires on site.

ATTACHMENT 1

CHEMTRON CALCULATION SHEETS

AND AUXILIARY INSTRUMENT ROOM CHARTS

SHEET 8.1

CHEMETRON **Cardox Products**
Chemetron Corporation

(REVISED 1/8/77)

Low Pressure Carbon Dioxide Flow Calculations

SYSTEM FOR TENNESSEE VALLEY AUTHORITY
plant name
WATTS BAR NUCLEAR POWER PLANT
location
HAZARD DIESEL GENERATOR RM: 1A-A
FUEL OIL (SURFACE FIRE)
combustible material
DRAWING NO. EL-19638

SHT. 1 REVISED 9-30-77 DP

CALC. SHEET 1 OF 5
BY JAH 7/8/77
PROPOSAL NO. L-3250
JOB NO. EL-19638
INSURANCE REF. NO.

TVA: CONTRACT 76K71-83209

HAZARD EFFECTIVE DISCHARGE PERIOD, DESIGN FLOW RATE AND STORAGE REQUIREMENT

	Effective Discharge Period (in seconds)	Design Flow Rate (lbs. per min. liquid)	Lbs. CO_2 Storage Sub Totals	Lbs. CO_2 Storage Storage Totals
TOTAL FLOODING (TF) – Requirement is 2470 lbs. CO_2	6		128	
Vapor discharge period and vapor discharge	54	of 3275	= 2948	
Effective discharge period, design flow rate and storage	60	3275		3076
Total Discharge Period, Design Flow Rate and Storage				
LOCAL APPLICATION (LA)				
Minimum effective discharge period – 30 seconds				
Plus high temperature condition				
Plus other		of	=	
Effective discharge period, design flow rate and storage				
Vapor discharge period and vapor discharge				
Total Discharge Period, Design Flow Rate and Storage				

TVA OCT 11 1977
PROJECT: WATTS BAR
CONTRACT NO. 76K71-83209
USE: Fire Protection
CHECKED:

COMBINED LOCAL APPLICATION & TOTAL FLOODING
(from LA and TF figures above)

Local application design flow rate	
Total flooding design flow rate	
Total Hazard Design Flow Rate	

APPROVED
This approval does not relieve the contractor from any part of his responsibility for the correctness of design, details and dimensions.
TENNESSEE VALLEY AUTHORITY
Date DEC 7 '13.
(MECH ENGG BR) By: D. R. PATTERSON

EXTENDED DISCHARGE

	Period	Design Flow Rate	Sub Totals	Storage Totals
Initial Discharge Period and Design Flow Rate		of	=	
Extended Discharge Period and Design Flow Rate		of	=	
FINAL DISCHARGE PERIOD, DESIGN FLOW RATE AND STORAGE	60	3275		3076

LOW PRESSURE STORAGE: 6 ton for MULTIPLE shot protection.

REMARKS:

MINIMUM DESIGN CONCENTRATION FOR THIS HAZARD IS 34% PER NFPA 12. FLOW REQUIREMENT FOR 34% = 1990 LB. PER MINUTE (MINIMUM RATE).

DIXIE ENGINEERING CO., Rept.
403 Brown - Marx Bldg.

PM-THJ-102192
SHEET 86

CHEMETRON

Cardox Products
Chemetron Corporation

Pg 7 of 50

REVISED 7/8/77

Low Pressure Carbon Dioxide Flow Calculations

CALC. SHEET 1 OF 5
BY JAH DATE 7/8/77
PROPOSAL NO. L-50
JOB NO. FL-19898
INSURANCE REF. NO.

SYSTEM FOR TENNESSEE VALLEY AUTHORITY
(plant name) WATTS BAR NUCLEAR POWER PLANT
(location)
HAZARD DIESEL GENERATOR RM. 1B-B,
FUEL OIL (SURFACE FIRE)
(combustible material)
DRAWING NO. FL-19878

SHT. 1 REVISED 9-30-77 JP

T.V.A. CONTRACT 76K71-83209

HAZARD EFFECTIVE DISCHARGE PERIOD, DESIGN FLOW RATE AND STORAGE REQUIREMENT

	Effective Discharge Period (in seconds)	Design Flow Rate (lbs. per min. liquid)	Lbs. CO_2 Storage: Sub Totals	Lbs. CO_2 Storage: Storage Totals
TOTAL FLOODING (TF) – Requirement is 2470 lbs. CO_2				
Vapor discharge period and vapor discharge	9		174	
Effective discharge period, design flow rate and storage	51	of 3206	= 2725	
Total Discharge Period, Design Flow Rate and Storage	60	3206		2899
LOCAL APPLICATION (LA)				
Minimum effective discharge period – 30 seconds				
Plus high temperature condition				
Plus other				
Effective discharge period, design flow rate and storage		of	=	
Vapor discharge period and vapor discharge				
Total Discharge Period, Design Flow Rate and Storage				

COMBINED LOCAL APPLICATION & TOTAL FLOODING
(from LA and TF figures above)

	Design Flow Rate
Local application design flow rate	
Total flooding design flow rate	
Total Hazard Design Flow Rate	

EXTENDED DISCHARGE

	Period	Design Flow Rate	Storage
Initial Discharge Period and Design Flow Rate	of	=	
Extended Discharge Period and Design Flow Rate	of	=	
FINAL DISCHARGE PERIOD, DESIGN FLOW RATE AND STORAGE	60	3206	2899

LOW PRESSURE STORAGE: 6 ton for MULTIPLE shot protection.

REMARKS:

MINIMUM DESIGN CONCENTRATION FOR THIS HAZARD IS 34% PER NFPA 12. FLOW REQUIREMENT FOR 34% = 1990 LB. PER MINUTE (MINIMUM RATE).

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PM-THJ-102192
SHEET 91

CHEMETRON **Cardox Products**
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[REVISED 7/8/77

Low Pressure Carbon Dioxide Flow Calculations

SYSTEM FOR TENNESSEE VALLEY AUTHORITY
plant name WATTS BAR NUCLEAR POWER PLANT
location
HAZARD DIESEL GENERATOR RM. 2A-A.
FUEL OIL (SURFACE FIRE)
combustible material
DRAWING NO. EL-13228

SHT. 1 REVISED 9-3-77

CALC. SHEET 1 OF 5
BY JAH DATE 7/8/77
PROPOSAL NO. L-1250
JOB NO. EL-19398
INSURANCE REF. NO.

T.V.A. CONTRACT 76K71-83209

HAZARD EFFECTIVE DISCHARGE PERIOD, DESIGN FLOW RATE AND STORAGE REQUIREMENT

	Effective Discharge Period (in seconds)	Design Flow Rate (lbs. per min. liquid)	lbs. CO_2 Storage Sub Totals	lbs. CO_2 Storage Storage Totals
TOTAL FLOODING (TF) - Requirement is 2470 lbs. CO_2				
Vapor discharge period and vapor discharge	7		151	
Effective discharge period, design flow rate and storage	53	of 3225 =	2849	3000
Total Discharge Period, Design Flow Rate and Storage	60	3225		
LOCAL APPLICATION (LA)				
Minimum effective discharge period - 30 seconds				
Plus high temperature condition				
Plus other				
Effective discharge period, design flow rate and storage		of	=	
Vapor discharge period and vapor discharge				
Total Discharge Period, Design Flow Rate and Storage				

COMBINED LOCAL APPLICATION & TOTAL FLOODING
(From LA and TF figures above)

Local application design flow rate	
Total flooding design flow rate	
Total Hazard Design Flow Rate	

EXTENDED DISCHARGE

	Period	Flow Rate	Storage
Initial Discharge Period and Design Flow Rate		of	=
Extended Discharge Period and Design Flow Rate		of	=

FINAL DISCHARGE PERIOD, DESIGN FLOW RATE AND STORAGE. 60 | 3225 | 3000

LOW PRESSURE STORAGE: 6 ton for MULTIPLE shot protection.

REMARKS:

MINIMUM DESIGN CONCENTRATION FOR THIS HAZARD IS 34% PER NFPA 12. FLOW REQUIREMENT FOR 34% = 1990 LB. PER MINUTE (MINIMUM RATE).

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... 35203

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SHEET 96

CHEMETRON **Cardox Products** Pg 17 of 50
Chemetron Corporation

[REVISED 7/8/77]

Low Pressure Carbon Dioxide Flow Calculations

SYSTEM FOR TENNESSEE VALLEY AUTHORITY
(plant name) WATTS BAR NUCLEAR POWER PLANT
(location)
HAZARD DIESEL GENERATOR RM. 2B-B.
FUEL OIL (SURFACE FIRE)
(combustible material)
DRAWING NO. EL-19553

SHT. 1 REVISED 4-30-77

CALC. SHEET 1 OF 5
BY JAH DATE 7/8/77
PROPOSAL NO. L-3620
JOB NO. EL-19895
INSURANCE REF. NO.

T.V.A. CONTRACT 76K71-83209

HAZARD EFFECTIVE DISCHARGE PERIOD, DESIGN FLOW RATE AND STORAGE REQUIREMENT

	Effective Discharge Period (in seconds)	Design Flow Rate (lbs. per min. liquid)	Lbs. CO_2 Storage Sub Totals	Lbs. CO_2 Storage Storage Totals
TOTAL FLOODING (TF) – Requirement is 2470 lbs. CO_2				
Vapor discharge period and vapor discharge	10		197	
Effective discharge period, design flow rate and storage	50	at 3174	= 2645	
Total Discharge Period, Design Flow Rate and Storage	60	3174		2842
LOCAL APPLICATION (LA)				
Minimum effective discharge period – 30 seconds				
Plus high temperature condition				
Plus other		at	=	
Effective discharge period, design flow rate and storage				
Vapor discharge period and vapor discharge				
Total Discharge Period, Design Flow Rate and Storage				

COMBINED LOCAL APPLICATION & TOTAL FLOODING
(From LA and TF figures above)

Local application design flow rate	
Total flooding design flow rate	
Total Hazard Design Flow Rate	

EXTENDED DISCHARGE

Initial Discharge Period and Design Flow Rate		at	=
Extended Discharge Period and Design Flow Rate		at	=

FINAL DISCHARGE PERIOD, DESIGN FLOW RATE AND STORAGE. 60 | 3174 | 2842

LOW PRESSURE STORAGE: 6 ton for MULTIPLE shot protection.

REMARKS:

MINIMUM DESIGN CONCENTRATION FOR THIS HAZARD IS 34% PER NFPA 12. FLOW REQUIREMENT FOR 34% = 1990 LB. PER MINUTE (MINIMUM RATE).

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BIRMINGHAM, ALA. 35203

EPM-THJ-102R2
SHEET 75

ATTACHMENT 14

Sh 1 of 1

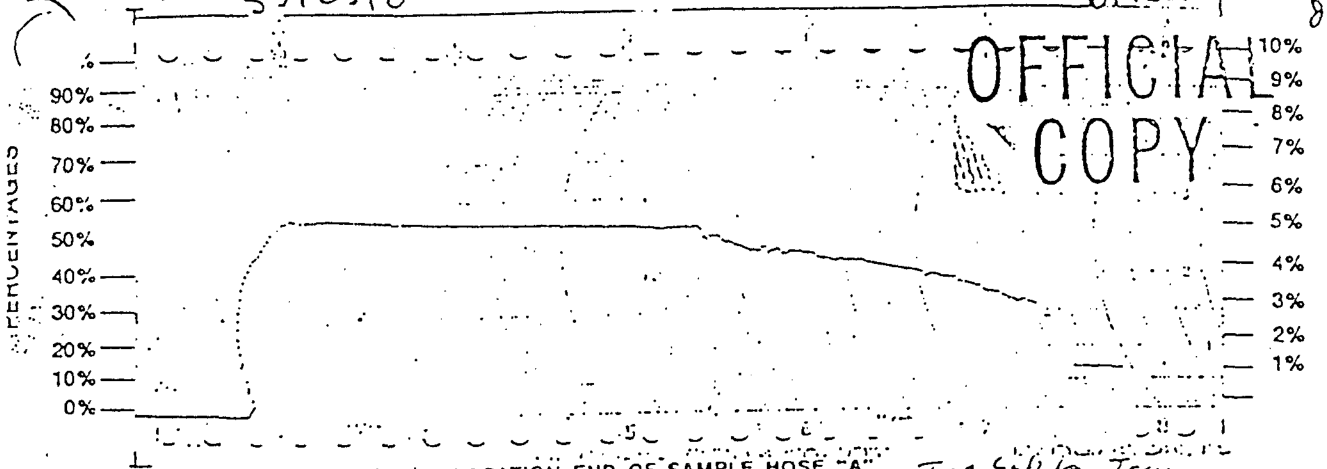
WBNP
UNITS 1&2
11/3/82
JRV
12/8/82

CARDOX JOB NO. FL-1989? CUSTOMER TVA Watts Bar

AREA TESTED Auxiliary Ints. Room #1

STEP 5.10.18 VERTICAL LINE DIVISIONS EQUAL 60 SECONDS → CHART DIRECTION

OFFICIAL COPY



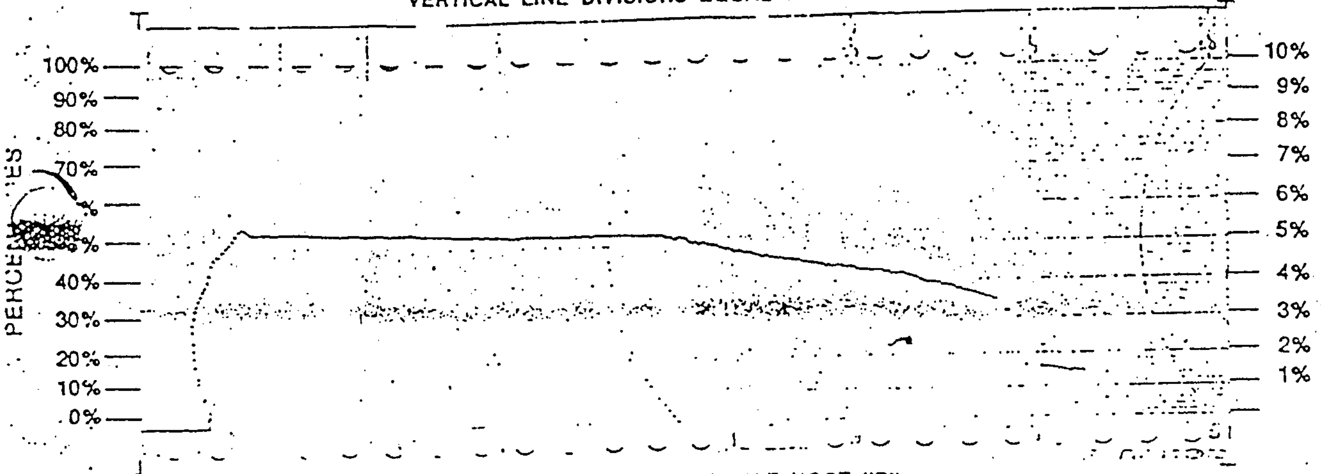
East End LOCATION END OF SAMPLE HOSE "A" Top Cable Tray

DISTANCE FROM: NORTH WALL FT.: EAST WALL FT.: SOUTH WALL FT.: WEST WALL FT.

DISTANCE ABOVE: FLOOR FT.: RAISED FLOOR FT.: SUBFLOOR FT.

HAZARD HEIGHT — FLOOR TO CEILING FT. UNDERFLOOR HEIGHT — FT.

VERTICAL LINE DIVISIONS EQUAL 60 SECONDS



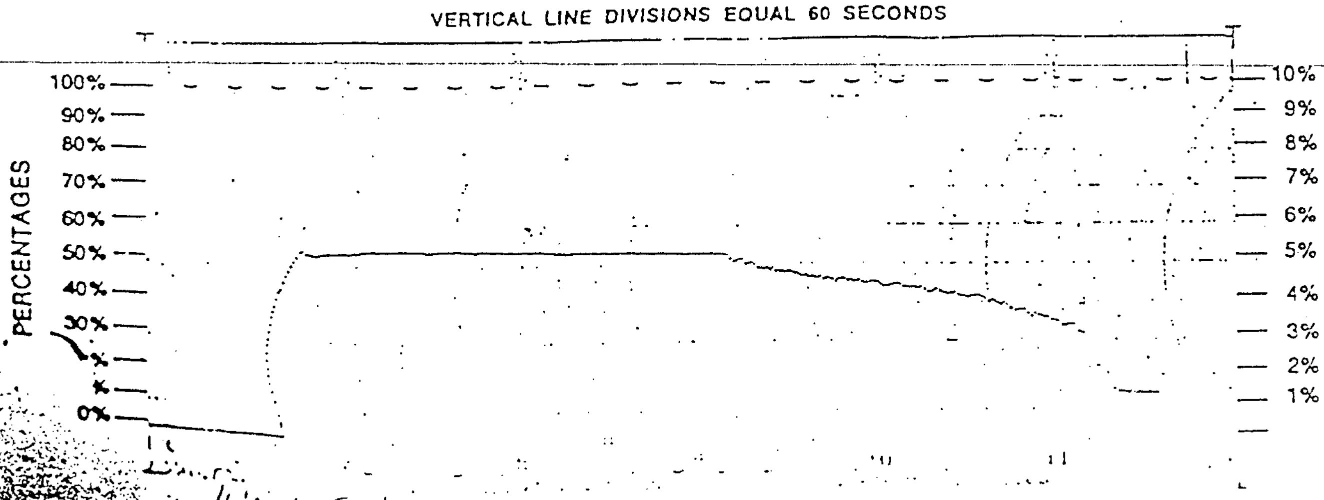
Center Room LOCATION END OF SAMPLE HOSE "B"

DISTANCE FROM: NORTH WALL FT.: EAST WALL FT.: SOUTH WALL FT.: WEST WALL FT.

DISTANCE ABOVE: FLOOR 7' FT.: RAISED FLOOR FT.: SUBFLOOR FT.

HAZARD HEIGHT — FLOOR TO CEILING FT. UNDERFLOOR HEIGHT — FT.

VERTICAL LINE DIVISIONS EQUAL 60 SECONDS



West End LOCATION END OF SAMPLE HOSE "C"

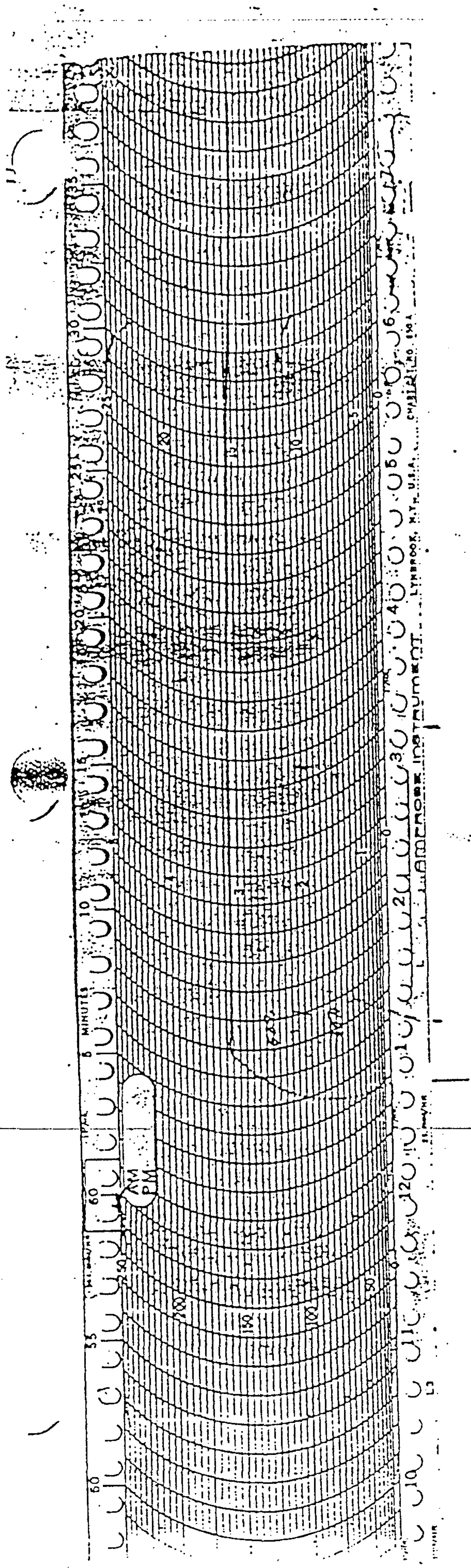
DISTANCE FROM: NORTH WALL FT.: EAST WALL FT.: SOUTH WALL FT.: WEST WALL FT.

DISTANCE ABOVE: FLOOR 17' FT.: RAISED FLOOR FT.: SUBFLOOR FT.

HAZARD HEIGHT — FLOOR TO CEILING FT. UNDERFLOOR HEIGHT FT.

UNIT 2 AUX. INST. ROOM. WBNP UNITS 1&2

SAMPLE POINT #1 (FLOOR LEVEL)



30% CONCENTRATION @ T = 50 SEC.

50% CONCENTRATION @ T = 2 MIN - 5 SEC

50% CONCENTRATION HELD > 10 MIN

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↑ CHART
DIRECTION

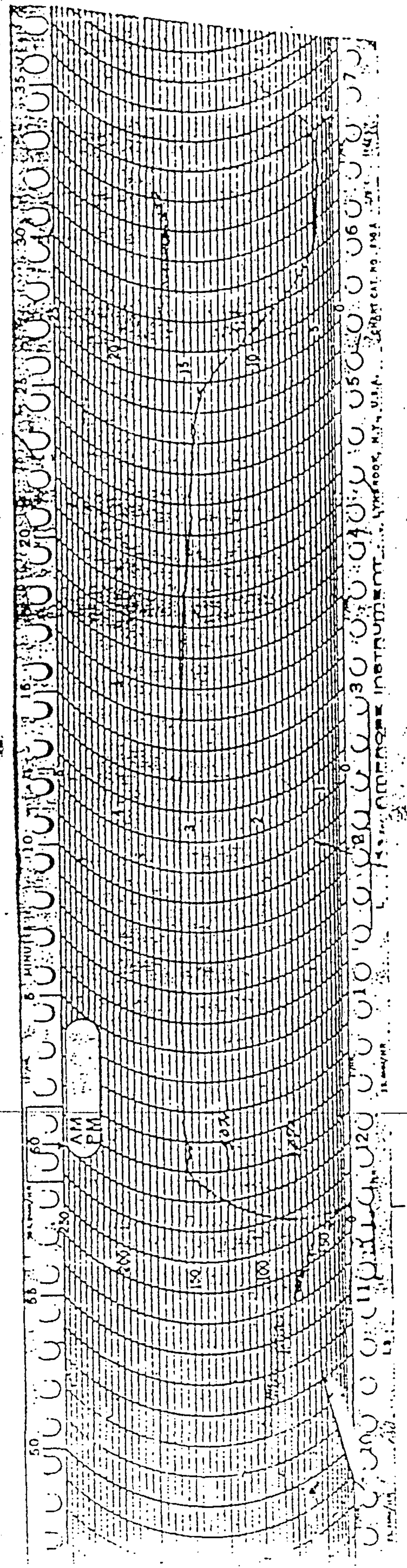
STEP. 5.11.18

EPM-THJ-102192
SHEET 77

ATT. 15

Sh 2 of 3

WBNP
UNITS 1&2



UNIT 2 AUX. INST. ROOM

SAMPLE POINT #2 (86" ABOVE FLOOR)

30% CONCENTRATION @ T= 50 SEC

50% CONCENTRATION @ T= 2 MIN. - 5 SEC

50% CONCENTRATION HELD > 10 MIN

11-25-83

OFFICIAL
COPY

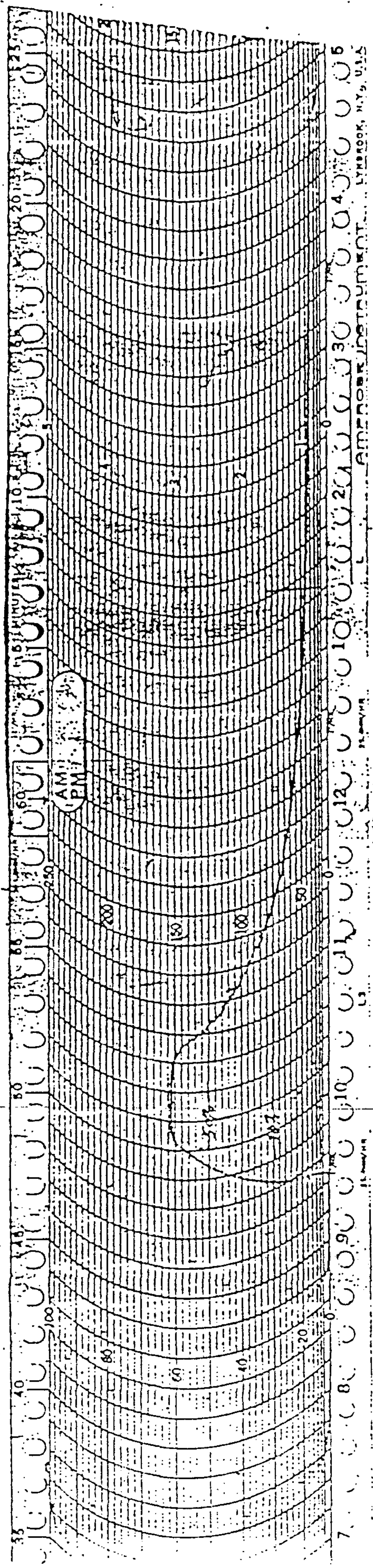
STEP 5.11.18

CHART
DIRECTION

ATTACHMENT 15

UNIT 2 AUX. INST ROOM WBNP UNITS 1/2

SAMPLE POINT # 3 (170" ABOVE FLOOR)



30% CONCENTRATION @ T= 55 SEC

50% CONCENTRATION @ T= 2MIN-5SEC

50% CONCENTRATION HELD 4MIN-50SEC

11-25-83

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COPY

STEP 5.11.18

↑ CHART
DIRECTION

ATTACHMENT 2

NFPA 12-1973

SECTION A-223

SECTION A-223

TYPES OF FIRES

"Practically all hazards that contain materials that would produce surface fires may contain varying amounts of materials that would produce deep seated fires. Proper selection of the type of fire that the system should be designed to extinguish is important and, in many cases, will require sound judgment after careful consideration of all the various factors involved.

Basically, such a decision will be based on the following:

1. Will a deep seated fire develop, considering the speed of detection and application of the contemplated system?

2. If a deep seated fire does develop, (a) will it be of a minor nature, (b) will the circumstances be such that it will not cause a re-flash of the material that produced the surface fire, and (c) can arrangements be set up to put it out manually after the CO_2 discharge before it causes trouble?

3. Are the values involved, or the importance of equipment involved, such that the ultimate protection is justified regardless of the extra cost of providing a system that will extinguish deep seated fires?

It will be seen that with a remote possibility of the deep seated fire causing trouble there are many cases where taking this remote risk may be justified, and a system to extinguish surface fire may properly be selected. As an example, electrical transformers and other oil-filled electrical equipment have quite commonly been treated as producing surface fires, although there may be a chance that a heated core will produce a deep seated fire in electrical insulation. On the other hand, the importance of some of the electrical equipment to production may be such that treating the hazard as a deep seated fire will be justified.

Often a decision will involve consultation of the authority having jurisdiction, the owner and the engineers of the company supplying the equipment. The comparative costs between a system that is designed to extinguish a surface fire and one designed to extinguish a deep seated fire may be the deciding factor. In all cases, it is advisable that all interested parties know clearly any risks involved if the system is designed only to extinguish a surface fire, and the additional costs that are involved if a system is designed to extinguish a deep seated fire."

ATTACHMENT 3

SANDIA LABORATORY TEST REPORT

FIGURES 34, 36 & 37

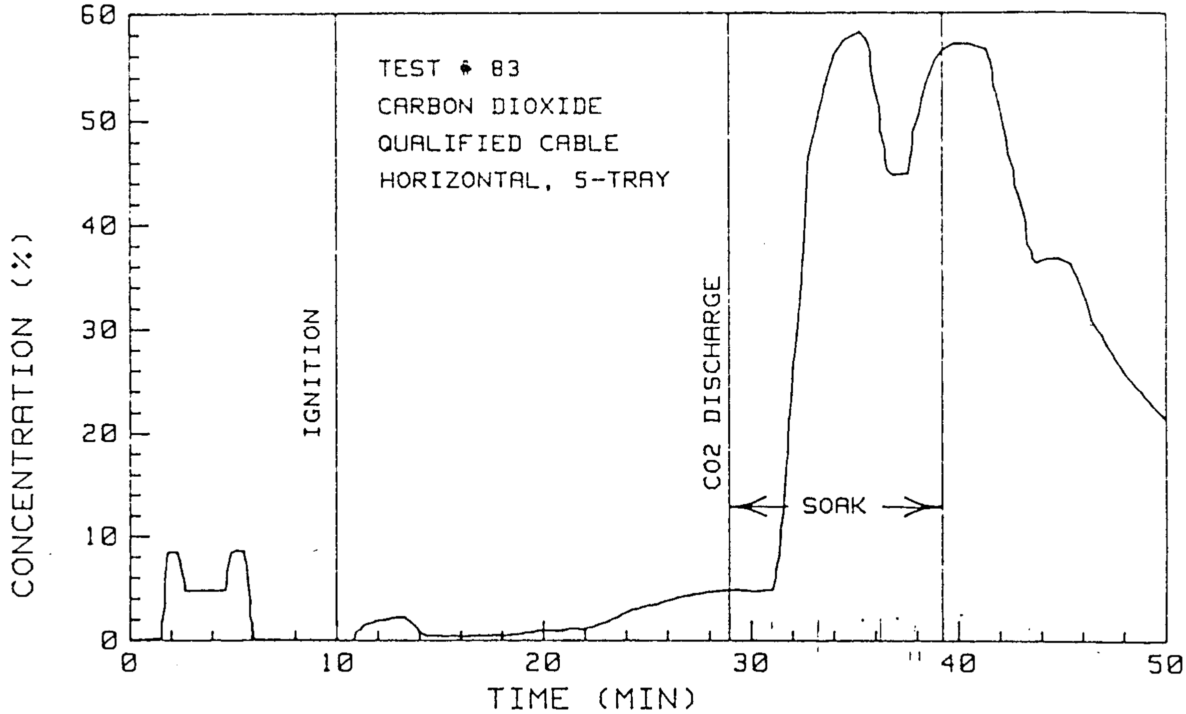


Figure 36. Carbon Dioxide Concentration, Test 83

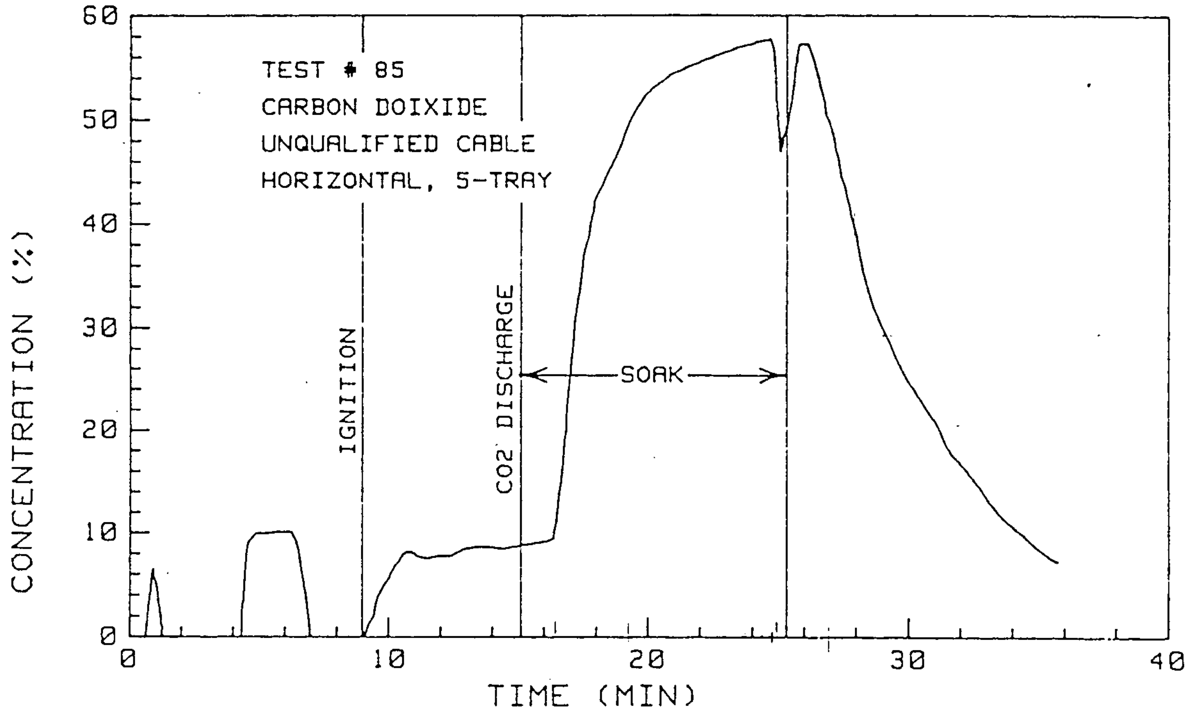


Figure 37. Carbon Dioxide Concentration, Test 85

ATTACHMENT 4

WATTS BAR - SANDIA LABORATORY

TEST RESULT OVERLAY

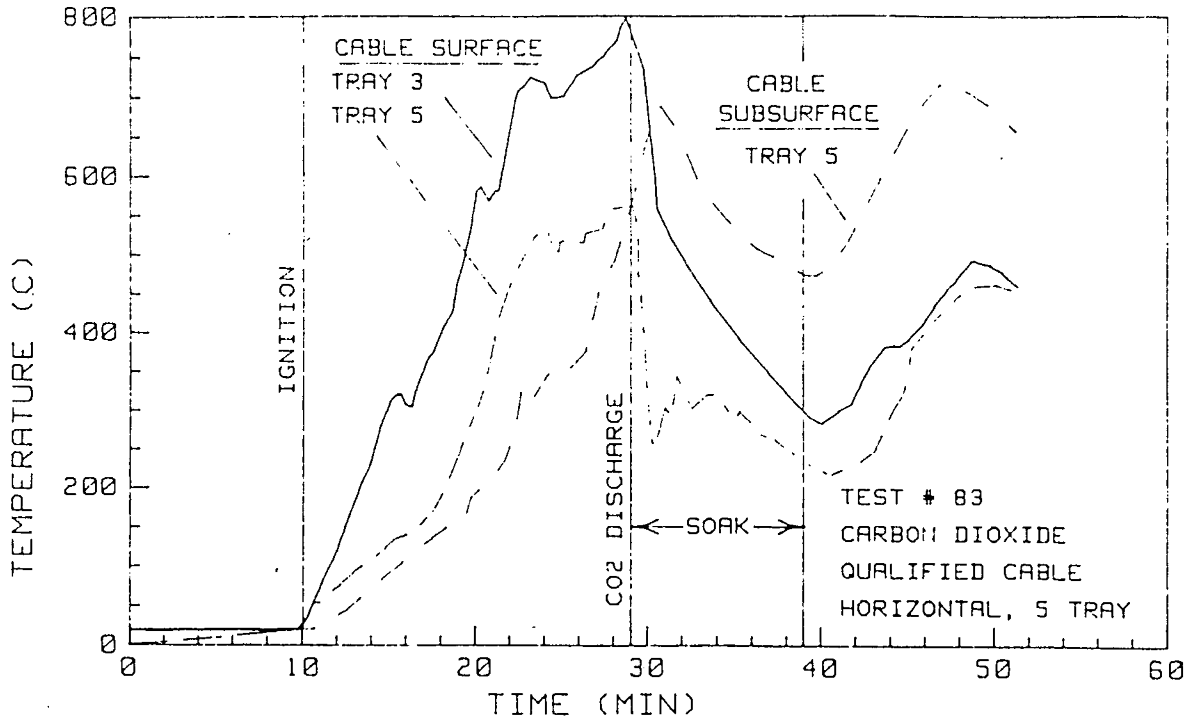


Figure 34. Cable Surface Temperatures, Centered in Trays 3 and 5, Test 83

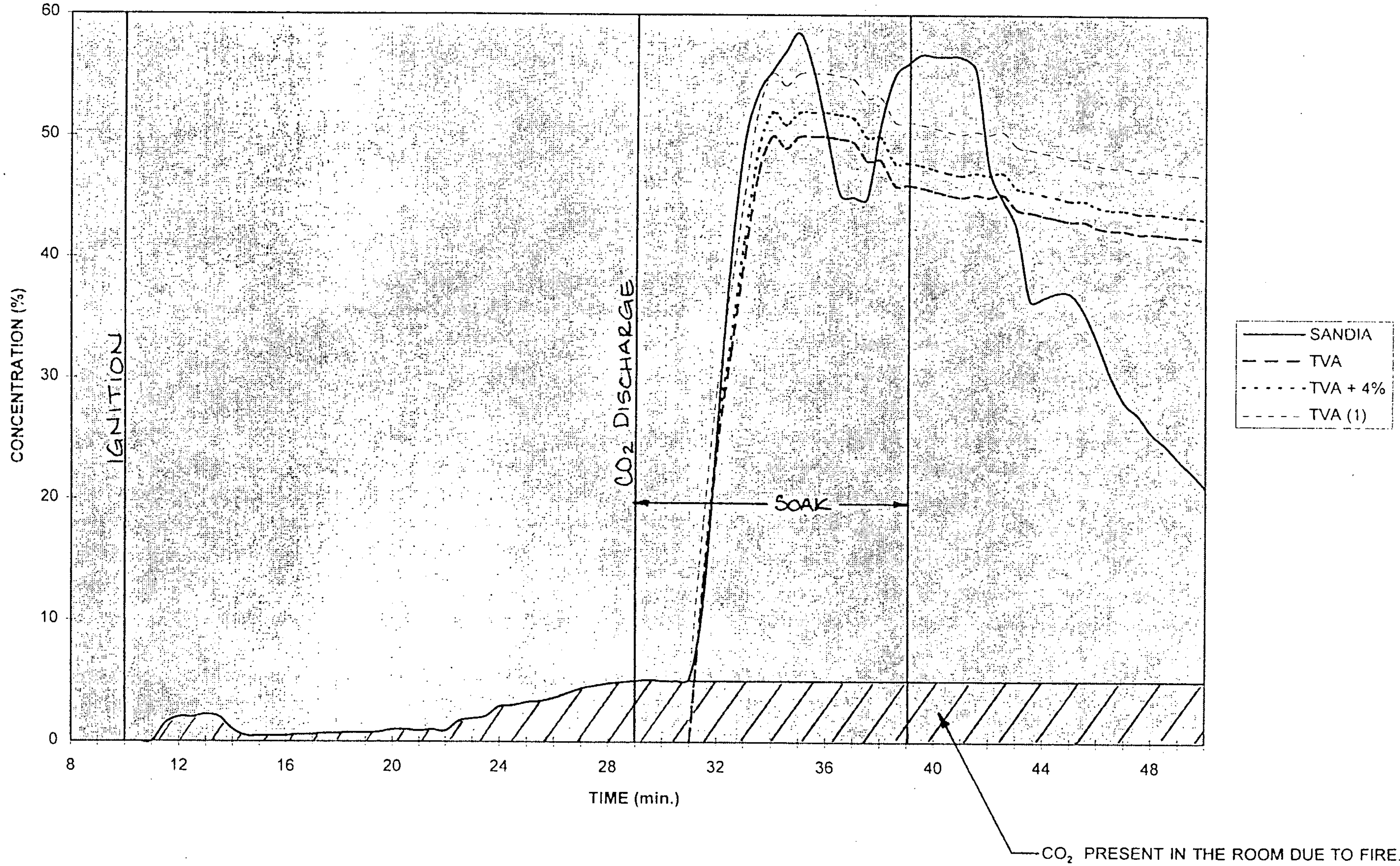
(approximately the 39-minute mark), the temperatures climbed again. This indicated continuing smoldering combustion or flames. The cable surface temperature in tray 5 cooled from 560° to 270°C within 1 minute (~290°C/minute). After ventilation was restarted the cable temperature rose to above 700°C, showing reignition of the cables.

For unqualified cable in the horizontal orientation (Test 85), the cable surface temperatures (Figure 35) show a continuous decrease after the carbon dioxide discharge. Note that the cable surface temperature at the top of the tray initially dropped very steeply from 440°C to 230°C within 1.5 minutes (140°C/minute). The temperature at the center of the tray did not experience this steep initial drop because the overlying cables provide shielding from the cooling effect of the carbon dioxide.

3.6.3 Suppression Effectiveness and Summary of Results

The carbon dioxide suppression system (50 percent concentration) was effective in extinguishing fully developed cable tray fires, provided there was a sufficient soak time and the room was adequately sealed. The carbon dioxide suppression system effectively starves the fire. In all cases where qualified cables were tested, there was continued

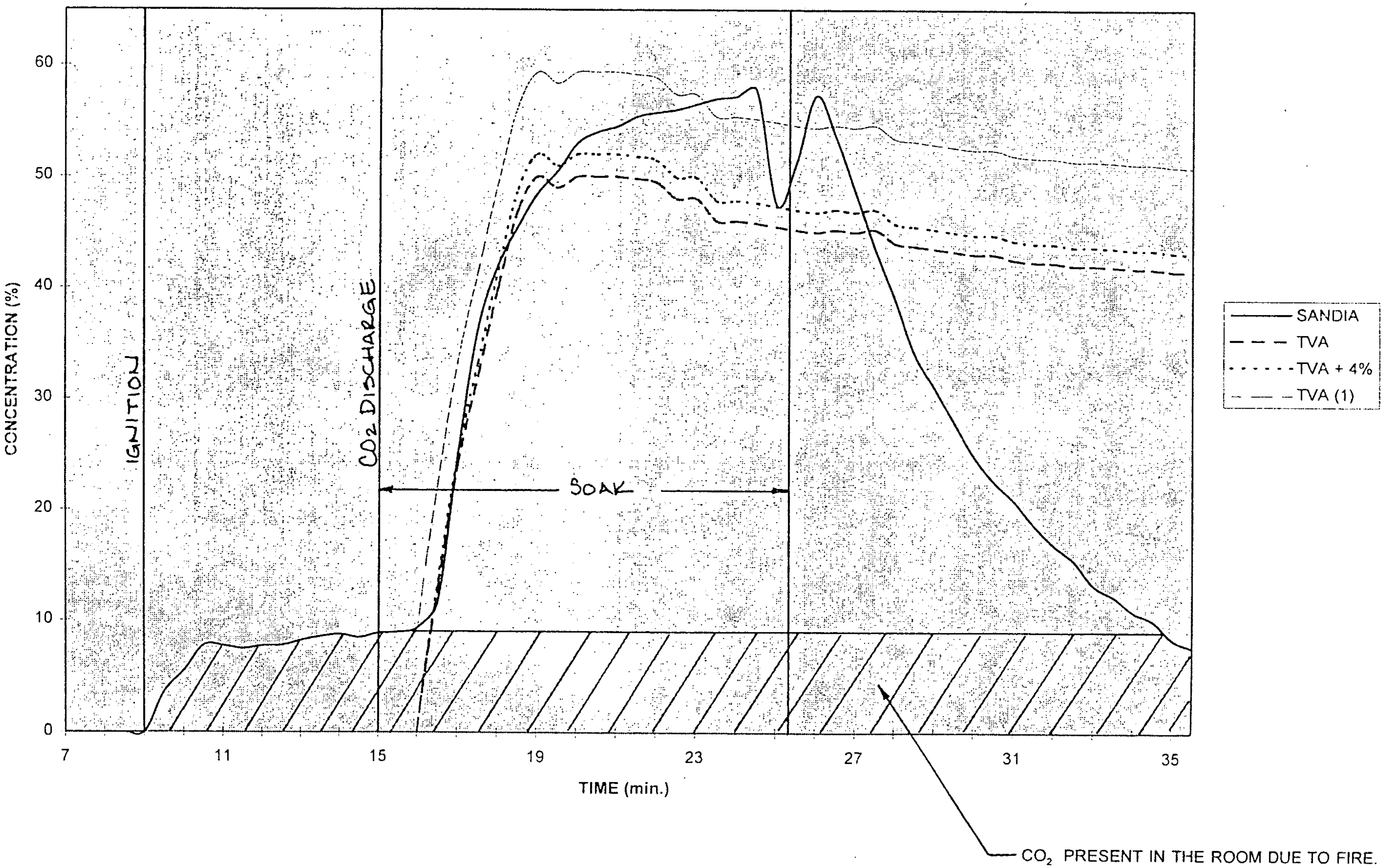
COMPARISON BETWEEN
SANDIA AND TVA CARBON DIOXIDE CONCENTRATION TESTS
(Sandia Figure 36)



(1) EXPECTED TVA PERFORMANCE BASED UPON EQUIVALENT SANDIA FIRE CONDITIONS TO INCLUDE CO_2 LEVELS CONTRIBUTED BY THE FIRE

COMPARISON BETWEEN SANDIA AND TVA CARBON DIOXIDE CONCENTRATION TESTS

(Sandia Figure 37)



(1) EXPECTED TVA PERFORMANCE BASED UPON EQUIVALENT SANDIA FIRE CONDITIONS TO INCLUDE CO_2 LEVELS CONTRIBUTED BY THE FIRE

ATTACHMENT 5

DOOR FAN TESTS

AUXILIARY INSTRUMENT ROOMS

AND DIESEL GENERATOR ROOMS