NOTE:

The following "Cable Vault Room Enclosure Integrity Test" was repeated and performed three times to gather information with the room in various ventilation configurations. Therefore certain steps in procedure sections 5,6,&7 are NA'd since these steps did not apply to that configuration or the step was previously performed. Taken in composite, all procedure steps were completed and were controlled by this procedure or other plant procedures.

TEST PROCEDURE

CABLE VAULT ROOM ENCLOSURE INTEGRITY TEST

1.0 PURPOSE

This procedure provides a method to equate Cable Vault enclosure leakage to worst case Carbon Dioxide leakage. Enclosure leakage will be determined by the tracer gas and door fan test procedure outlined below. The calculation method provided by NFPA 12A, App. B, 1989 edition makes it possible to predict the level of the descending interface of the CO2/air mixture with respect to time. This calculated value provides a conservative prediction of the CO2 concentration and maximum hold time for the Cable Vault room.

2.0 DISCUSSION

2.1 Background

The CO2 total flooding system was installed in the Cable Vault to provide protection from a potential deep seated fire. The original installation was a manually activated system, which was installed in 1970. In 1977 the system was upgraded to an automatically initiated system with second shot capability provided from the west switchgear room. The system was not discharge tested for design concentration as such a test was not required by NFPA 12, 1968 or 1973 edition.

In 1977 a Tech Spec ammendment was issued which reflected the modifications to the Cable Vault CO2 system. The Safety Evaluation Report which was issued in support of this ammendment, refers to the design criteria for the system. At the time of installation the system was tested to the criteria of the National Fire Protection Association standard for CO2 systems (NFPA-12, 1977). The standard of record at that time did not require a full discharge test. Recently, the NRC, claiming the powers of the Authority Having Jurisdiction, has interpreted that a full discharge test is required to prove the adequacy of the CO2 system (ref. 3.9).

In the response to the VY response to the notice of violation, the NRC stated that they would entertain an alternate to the full discharge test if a conclusive test method could be designed (ref. 3.10).

The 1989 Edition of NFPA 12A, The Standard on Halon 1301 Fire Extinguishing Systems includes an Enclosure Integrity Procedure in Appendix B. This test was developed for the subcommittee of the NFPA 12A committee which was charged with the task of developing an acceptable alternative to full discharge testing of Halon 1301 gaseous fire suppression systems. Appendix B is the result of the efforts of the subcommittee and the research team. This alternative test was presented to the NFPA 12A committee and approved. The test was then added to the draft of the new edition of the code. This draft was then reviewed by the membership of the NFPA and approved by them for inclusion in the 1989 edition of the code.

In cases where a substantial differential pressure exists across the boundary of the enclosure additional test methods are required. In this case the differential pressure across the Cable Vault - Reactor Building wall may be as much as 1 1/2 inches of water. To ensure that this boundary of the enclosure is leak tight, a tracer gas test will be conducted prior to the Enclosure Integrity test. The tracer gas test will ensure the integrity of the Cable Vault - Reactor Building wall thus guarenteeing the validity of the model used in the Enclosure Integrity test analysis.

To meet the recent NRC interpretation of NFPA 12, and to test the adequacy and operability of the CO2 system, a tracer gas test and an Enclosure Integrity Test will be completed in the Cable Vault room. This will verify that the Cable Vault CO2 system is physically capable of providing and maintaining a CO2 concentration of 50% CO2 (by volume) for a period of ten minutes. In the event that these criteria are not achieved, further evaluation will be performed with the potential for the performance of additional Enclosure Integrity tests.

2.1.1 The Engineering Support Department is the organization with the overall responsibility for the test.

2.1.2 The vendor for these tests will be Retrotech Energy Innovations Limited.

2.1.3 The vendor will provide the personnel for the completion of the tracer gas test and the Enclosure Integrity test.

2.1.4 The tracer gas and tracer gas analyzer equipment will be provided by Vermont Yankee.

2.1.5 A calibrated door fan assembly will be provided by the vendor for the completion of this test.

2.1.6 In support of the test a Temporary Modification (89-53) may be installed to provide controlled ventilation of the Cable Vault room during a CO2 discharge.

2.1.7 The results of the Enclosure Integrity test will dictate the necessity for the installation of the Temporary Modification.

2.2 Safety Evaluation

2.2.1 Safety Class

The Cable Vault automatic total flooding CO2 suppression system (mechanical equipment, piping, and electrical control equipment) is a non-safety class system. The CO2 system provides fire protection for safety class electrical cable and equipment, and is therefore designated a Vital fire protection system. The walls which comprise the boundaries of the Cable Vault are designated as Vital Fire Barriers. These walls provide protection from fires which may occur outside of the Cable Vault. Additionally, the walls are designed to confine a fire which may occur within the Cable Vault. The walls also serve the function of confining the CO2 which will be discharged in the event of a fire within the Cable Vault.

2.2.2 System/Test Discussion

The automatic total flooding high pressure CO2 fire suppression system provides protection from a deep seated electrical fire for the Cable Vault. The system was installed in accordance with the requirements of the National Fire Protection Association (NFPA) fire code No. 12, 1969, 1973, and 1977 editions. The required concentration for this application is 50% CO2 by volume. The design flow rate is 840 lbs/min of CO2 for 200 seconds. This will provide a CO2 concentration of 30% within two minutes, and a 50% concentration within seven minutes. The design "soak" time at 50% concentration is ten minutes. The design calculations are documented in Reference 3.8.

The discharge of CO2 in the Cable Vault raises a potential life safety consideration. Since CO2 is an asphyxiant, this test procedure addresses precautions that ensure that a 50.73(a)(2)(x) event (i.e. hampering site personnel) does not occur. The completion of this test procedure will not involve the actual discharge of CO2.

The initial portion of this test involves the introduction of a tracer gas to the Cable Vault atmosphere. The tracer gas to be utilized in this test is Sulfur Hexafluoride (SF6). The tracer gas will be used in concentrations of 250 ppm or less. This level of SF6 is well below the toxic limit of 1000 ppm. The Toxic Gas Monitoring System is not capable of detecting SF6, therefore the Control Room Ventilation system and the Toxic Gas Monitoring system will be left in their normal operating configurations.

The potential for overpressurization of the room due to the discharge of CO2 has been evaluated utilizing the guidance provided in NFPA No. 12; 1989. This possibility will be examined through a comparison of the Equivalent Leakage Area as determined by this test with the required free venting area as determined by the NFPA 12 code requirements. This ensures that sufficient vent area will be available to prevent excessive pressure buildup within the room during CO2 discharge.

A review of the Switchgear room CO2 full discharge test results indicated that controlled venting of the room during the initial phase of the CO2 discharge was necessary. This provided a controlled means of evacuating air and allowing for a uniform concentration of CO2 throughout the room. This test will determine the need for the installation of such a controlled venting mechanism in the Cable Vault. Should these test results indicate the necessity for a controlled ventilation, Temporary Modification 89-53 will be installed. The controlled ventilation will be provided by delaying the deenergization and closure of the exhaust fan and damper for approximately three minutes. This will prevent the pressurization of the Cable Vault room and will enhance the distribution of CO2.

By controlling and minimizing the pressure within the room by delayed closure of the exhaust damper (TM 89-53), it is assured that wall, door, and fire barrier seal integrity will be maintained during the discharge test.

The tracer gas and Enclosure Integrity test of the Cable Vault will verify the design capabilities of the total flooding CO2 system.

2.3 This test does not present significant hazards not described or implicit in the safety analysis report, and there is reasonable assurance that the health and safety of the public will not be endangered in that:

2.3.1 The probability of occurrence of an accident is not increased in that the Enclosure Integrity test will only slightly increase the air pressure within the room. There will be no change in ambient temperature, nor any adverse impact on the operability of equipment or systems. The tracer gas test will be conducted at a concentration well below the toxic limits. To ensure that licensing commitments and fire protection standards are maintained, the continuous fire watch will be continued throughout the test. Although the automatic initiation of the

CO_2 system will be disabled, the system will still be available for manual activation. This will provide an equivalent or better level of fire protection for the Cable Vault during the implementation of this test.

and

2.3.2 The consequences of an accident is not increased in that the tracer gas test or the Enclosure Integrity test will in no way affect the operation of equipment powered or controlled by cables or components located in this area.

and

2.3.3 The probability of equipment malfunction is not increased because the Enclosure Integrity test only serves to slightly increase the rooms air presure. Neither the tracer gas test nor the Enclosure Integrity test alters the condition or configuration of any equipment within or outside of the Cable Vault room.

and

2.3.4 The consequences of equipment malfunction is not increased because the introduction of SF_6 or the pressurization of the room will have no detrimental effect on the operability of equipment within the Cable Vault or Reactor Building.

and

2.3.5 The possibility for an accident of a different type than previously analysed is not created in that this test does not change or modify the intent of the design or equipment configurations. The CO_2 system will remain available for manual activation.

and

2.3.6 The possibility of malfunction of a different type than previously analysed is not created because this test does not change the bases for any previous analyses.

and

2.3.7 The margin of safety as defined in the basis for any technical specification is not reduced because this test makes no changes to any safety limits or controls.

2.4 Based upon the above this test does not constitute an unreviewed safety question as defined in 10CFR50.59(a)(2).

3.0 REFERENCES

3.1 NFPA No. 12, 1973 edition, Standard on Carbon Dioxide Extinguishing Systems

3.2 NFPA No. 12, 1985 edition, Standard on Carbon Dioxide Extinguishing Systems

3.3 NFPA No. 12, 1989 edition, Standard on Carbon Dioxide Extinguishing Systems

3.4 NFPA No. 12A, 1989 edition, App. B, Enclosure Integrity Test Procedure (attached)

3.5 "Enclosure Integrity Procedure for Halon 1301 Total Flooding Fire Suppression Systems", January 10, 1989, Edited by Casey C. Grant, P.E.

3.6 "Cardox" Fire Extinguishing Equipment Operation and Service Manual

3.7 PDCR 79-06; Switchgear/Cable Vault Suppression Systems

3.8 "Cardox" High Pressure Carbon Dioxide Flow Calculations dated 04-02-70

3.9 Letter, USNRC to VYNPC, NVY 89-108, dated 05-18-89

3.10 Letter, USNRC to VYNPC, NVY 89-172, dated 08-21-89

4.0 APPARATUS

4.1 Enclosure Integrity Test Equipment (provided by RETROTEC)

4.2 Tracer Gas analyzer (provided by VY)

PREREQUISITES

		Verified/Date
5.1	Vendor personnel on site.	E/T 10-31-89
5.2	Test equipment calibration data provided by vendor.	E/T 10-31-89
5.3	Fire Control Permit initiated as required by AP 0042.	E/T 10-31-89
5.4	Material Safety Data Sheet on file for tracer gas.	E/T 10-31-89
5.5	Secure papers and light objects which may be affected by the air currents from the door fan.	E/T 10-31-89
5.6	Place a smoke ejector unit with two lengths of flexible ducting in the Cable Vault Battery room prior to beginning the test. (Tech Spec section 3.10.B.2.a)	E/T 10-31-89
5.7	Provide the capability for hydrogen sampling of the Cable Vault Battery room atmosphere should the test exceed 12 hours in length. (Tech Spec requirement, section 4.10.B.2) exhaust fan shutdown restored at 17:45.	not required 14:45 and
5.8	The Security Shift Supervisor has been notified of the test schedule.	E/T 10-31-89

5.9 Verify that all personnel not involved with this test procedure have evacuated the Cable Vault room. (The continuous fire watch will be maintained within the Cable Vault room.) E/T 10-31-89

6.0 PRECAUTIONS

Verified/Date

6.1 Observe precautions in the Vermont Yankee Safety Manual. E/T 10-31-89

6.2 Caution shall be exercised when working in the vicinity of energized circuits. E/T 10-31-89

7.0 PROCEDURE

Verified/Date

7.1 Notify Shift Supervisor prior to beginning test. E/T 10-31-89

7.2 Verify that the Cable Vault room doors are closed and latched. E/T 10-31-89

NOTE

The following steps will disable the automatic discharge portion of the Cable Vault CO2 system.

7.3 Close the valve on the CO2 pilot cylinder. E/T [illegible] 10-31-8

7.4 Disconnect the two flexible pipes from the pilot cylinder pipe to the two discharge initiating heads on the CO2 cylinders. E/T [illegible] 10-31-8

7.4.a Disconnect leads 13 (red) and 14 (green) on TB2 in the junction box directly above the Cable Vault panel in accordance with AP 0020. These leads are for the ETL's of the supply air fire dampers. [illegible] 10/31/89

7.4.b Manually release the supply air fire dampers. [illegible] 10/31/89

NOTE

The following action will cause an alarm on the local Cable Vault panel as well as the Control Room Pyrotronics panel.

Caution

Do not place the activate/abort switch in the "Second Shot" position.

7.5 Activate the Cable Vault CO2 system by placing the activate/abort switch in the 1st shot position. [illegible] 10/31/89

7.6 Verify that the following inlet and exhaust dampers have closed: E/T 10-31-89

a. Computer Room supply ventilation damper.
b. Cable Vault supply ventilation fire damper.
c. Cable Vault supply ventilation air operated louvers.
d. Cable Vault exhaust ventilation damper.

NOTE

The tracer gas/air exchange test will be conducted by vendor personnel.

7.7 Position tracer gas/air exchange test equipment in the cable vault. N/A E/T 10-31-8

7.8 Start tracer gas blowers to ensure complete mixing of tracer gas.

7.9 Start tracer gas analyzer, calibrate, and establish baseline. see note on leader for procedure

7.10 Add tracer gas to air entering blowers until approximately 250 ppm of tracer gas is attained in the outlet air and level remains stable.

7.11 Maintain blowers in a running state while monitoring and recording gas concentration.

7.12 Ensure that blowers do not direct flow towards known openings in the enclosure.

7.13 Continue test for 1 1/2 hours, or until initial concentration decreases to 50%.

7.14 Secure test equipment.

7.15 Seal all supply dampers with poly film and tape.

7.16 Repeat steps 7.10 through 7.13.

7.17 Upon completion of both tests, purge the room of the tracer gas utilizing the Cable Vault exhaust fan.

7.18 Remove any poly film which was installed on supply dampers.

7.19 Seal those leakage areas which will be detrimental to the proper operation of the Cable Vault CO2 system using OP 5981.

7.20 Remove tracer gas/air exchange test equipment from the Cable Vault room.

7.21 Shutdown exhaust fan.

7.22 Verify that exhaust damper and supply dampers are closed.

7.23 Station Security personnel at Door 103. E/T 10-31-89

7.24 Open Door 103 and secure in the open position. E/T 10-31-89

NOTE

The Enclosure Integrity Test will be conducted by vendor personnel.

7.25 Install door fan unit in the opening of Door 103. E/T 10-31-89

7.26 Pressurize room and determine static pressure within the Cable Vault as directed by NFPA 12A, App. B, section B-2.5.2. E/T 10-31-89

7.27 Make adjustments as necessary to minimize static pressure. (eg fire barrier seal leaks) N/A RCD 10/31/89

7.28 Repeat measurement of static pressure of the Cable Vault. N/A RCD 10/31/89

7.29 Determine the column pressure as directed by NFPA 12A, App. B, section B-2.6.1.3. E/T 10-31-89

7.30 Depressurize the Cable Vault to column pressure. E/T 10-31-89

7.31 Measure air flow. E/T 10-31-89

7.32 Pressurize the Cable Vault to column pressure. E/T 10-31-89

7.33 Calculate Equvalent Leakage Area as directed by NFPA 12A, App. B, section B-2.6.3.5. E/T 10-31-89

7.34 Identify leakage areas within the Cable Vault. N/A RCD 10/31/89

7.35 Generate Maintenance Requests as required to seal those leakage areas which will be detrimental to the proper operation of the Cable Vault CO2 system. N/A RCD 10/31/89

7.36 The ESS shall evaluate the Enclosure Integrity test results and determine if additional free venting area is required. N/A RCD 10/31/89

Note:

If additional Free Vent area is required, a time delay may be installed on the Cable Vault room exhaust damper. The ESS shall initiate other processes if this action is deemed insufficient.

7.37 Install TM # 89-53 as required to ensure sufficient free venting area. NA RCD 10/31/89

7.38 Repeat test steps 7.28 through 7.31 to verify the proper operation of the TM 89-53 and the succesful sealing of excessive leakage paths. NA RCD 10/31/89

7.39 Secure the test equipment upon completion of the test. NA RCD 10/31/89

NA's - see note on header to this procedure

7.40 Remove all test equipment from the Cable Vault room. Test equipment left in Cable Vault for further Testing on 11-01-89. — Data - 10/31/89 all notes and data leader to this procedure

7.41 Secure Door 103 in the closed position. — E/T 10-31-89

7.42 Reset the activate/abort switch to the Abort position. — E/T 10-31-89

7.42.a Restore the ETL's on the supply duct dampers. Independent verification of this action is required. — DDA 10/31/89 / PBB 10/31/89

7.42.b Reconnect leads 13 and 14 on TB2 in junction box directly above the Cable Vault panel. Independent verification of this action is required. — DDA 10/31/89 / PBB 10/31/89

7.43 Reconnect the two flexible pipes to the two discharge initiating heads on the CO2 cylinders. Independent verification of this action is required.

7.44 Open the valve to the pilot cylinder. Independent verification of this action is required.

7.45 Check for leaks with a soap solution at the point where the two flexible pipes were reconnected in step 7.41. Independent verification of this action is required.

This portion was not completed 10-31-89 due to further Testing on 11-01-89.

7.46 Deleted.

7.47 Reset activate/abort switch to the Normal position. — E/T 10-31-89

7.48 Reset Cable Vault CO2 control panel. — E/T 10-31-89

7.49 Clear all alarms from local panel. — E/T 10-31-89

7.50 Clear alarm from Control Room panel. — E/T 10-31-89

7.51 Verify that Computer Room supply damper has reopened. — DDA 10/31/89

7.52 Verify that the Cable Vault supply damper and air operated louver have reopened. — DDA 10/31/89

7.53 Verify that the Cable Vault Exhaust damper has reopened. — DDA 10/31/89

7.54 Notify Shift Supervisor that the test is complete. — E/T 10-31-89

8.0 DATA

	Verified/Date
8.1 Verify that all required data was collected.	E/T 10-31-89

3.3 NFPA No. 12, 1989 edition, Standard on Carbon Dioxide Extinguishing Systems

3.4 NFPA No. 12A, 1989 edition, App. B, Enclosure Integrity Test Procedure (attached)

3.5 "Enclosure Integrity Procedure for Halon 1301 Total Flooding Fire Suppression Systems", January 10, 1989, Edited by Casey C. Grant, P.E.

3.6 "Cardox" Fire Extinguishing Equipment Operation and Service Manual

3.7 PDCR 79-06; Switchgear/Cable Vault Suppression Systems

3.8 "Cardox" High Pressure Carbon Dioxide Flow Calculations dated 04-02-70

3.9 Letter, USNRC to VYNPC, NVY 89-108, dated 05-18-89

3.10 Letter, USNRC to VYNPC, NVY 89-172, dated 08-21-89

4.0 APPARATUS

4.1 Enclosure Integrity Test Equipment (provided by RETROTEC)

4.2 Tracer Gas analyzer (provided by VY)

PREREQUISITES

		Verified/Date
5.1	Vendor personnel on site.	E/T 11-01-89
5.2	Test equipment calibration data provided by vendor.	E/T 11-01-89
5.3	Fire Control Permit initiated as required by AP 0042.	E/T 11-01-89
5.4	Material Safety Data Sheet on file for tracer gas.	E/T 11-01-89
5.5	Secure papers and light objects which may be affected by the air currents from the door fan.	E/T 11-01-89
5.6	Place a smoke ejector unit with two lengths of flexible ducting in the Cable Vault Battery room prior to beginning the test. (Tech Spec section 3.10.B.2.a)	E/T 11-01-89
5.7	Provide the capability for hydrogen sampling of the Cable Vault Battery room atmosphere should the test exceed 12 hours in length. (Tech Spec requirement, section 4.10.B.2) Ventilation secured at 09:30 hrs. Ventilation restored at 19:30 hrs.	all work on hands to this procedure NCR N/A 11/1/89
5.8	The Security Shift Supervisor has been notified of the test schedule.	E/T 11-01-89

5.9 Verify that all personnel not involved with this test procedure have evacuated the Cable Vault room. (The continuous fire watch will be maintained within the Cable Vault room.) C/T 11-01-89

6.0 PRECAUTIONS

Verified/Date

6.1 Observe precautions in the Vermont Yankee Safety Manual. C/T 11-01-89

6.2 Caution shall be exercised when working in the vicinity of energized circuits. C/T 11-01-89

7.0 PROCEDURE

Verified/Date

7.1 Notify Shift Supervisor prior to beginning test. C/T 11-01-89

7.2 Verify that the Cable Vault room doors are closed and latched. C/T 11-01-89

NOTE

The following steps will disable the automatic discharge portion of the Cable Vault CO2 system.

7.3 Close the valve on the CO2 pilot cylinder. DSS 11/1/89

7.4 Disconnect the two flexible pipes from the pilot cylinder pipe to the two discharge initiating heads on the CO2 cylinders. DSS 11/1/89

7.4.a Disconnect leads 13 (red) and 14 (green) on TB2 in the junction box directly above the Cable Vault panel in accordance with AP 0020. These leads are for the ETL's of the supply air fire dampers. DSS 11/1/89

7.4.b Manually release the supply air fire dampers. DSS 11/1/89.

NOTE

The following action will cause an alarm on the local Cable Vault panel as well as the Control Room Pyrotronics panel.

Caution

Do not place the activate/abort switch in the "Second Shot" position.

7.5 Activate the Cable Vault CO2 system by placing the activate/abort switch in the 1st shot position. DPF

7.6 Verify that the following inlet and exhaust dampers have closed: C/T 11-01-89

a. Computer Room supply ventilation damper.
b. Cable Vault supply ventilation fire damper.
c. Cable Vault supply ventilation air operated louvers.
d. Cable Vault exhaust ventilation damper.

NOTE

The tracer gas/air exchange test will be conducted by vendor personnel.

7.7 Position tracer gas/air exchange test equipment in the cable vault. C/T 11-01-89

7.8 Start tracer gas blowers to ensure complete mixing of tracer gas. C/T 11-01-89

7.9 Start tracer gas analyzer, calibrate, and establish baseline. C/T 11-01-89

7.10 Add tracer gas to air entering blowers until approximately 250 ppm of tracer gas is attained in the outlet air and level remains stable. C/T 11-01-89

7.11 Maintain blowers in a running state while monitoring and recording gas concentration. C/T 11-01-89

7.12 Ensure that blowers do not direct flow towards known openings in the enclosure. C/T 11-01-89

7.13 Continue test for 1 1/2 hours, or until initial concentration decreases to 50%. C/T 11-01-89 *

7.14 Secure test equipment. C/T 11-01-89

7.15 Seal all supply dampers with poly film and tape. C/T 11-01-89

7.16 Repeat steps 7.10 through 7.13. C/T 11-01-89

7.17 Upon completion of both tests, purge the room of the tracer gas utilizing the Cable Vault exhaust fan. KED 11/1/89

7.18 Remove any poly film which was installed on supply dampers. KED 11/1/89

7.19 Seal those leakage areas which will be detrimental to the proper operation of the Cable Vault CO2 system using OP 5981. None Sealed KED 11/1/89

7.20 Remove tracer gas/air exchange test equipment from the Cable Vault room. To be left in room KED 11/1/89

7.21 Shutdown exhaust fan. KED 11/1/89

7.22 Verify that exhaust damper and supply dampers are closed. KED 11/1/89

7.16a Roger stop 10 through 7.19 with dots sealed with p.e.

Test #1 terminated at 50% concentration at 35 minutes
Test #2 terminated at 50% concentration at 30 minutes.
Test #3 terminated at 50% concentration at 49 minutes

7.23 Station Security personnel at Door 103. [illegible] 11/1/89

7.24 Open Door 103 and secure in the open position. [illegible] 11/1/89

NOTE

The Enclosure Integrity Test will be conducted by vendor personnel.

7.25 Install door fan unit in the opening of Door 103. [illegible] 11/1/89

7.26 Pressurize room and determine static pressure within the Cable Vault as directed by NFPA 12A, App. B, section B-2.5.2. [illegible] 11/1/89

7.27 Make adjustments as necessary to minimize static pressure. (eg fire barrier seal leaks) [illegible] 11/1/89

7.28 Repeat measurement of static pressure of the Cable Vault. [illegible] 11/1/89

7.29 Determine the column pressure as directed by NFPA 12A, App. B, section B-2.6.1.3. [illegible] 11/1/89

7.30 Depressurize the Cable Vault to column pressure. [illegible] 11/1/89

7.31 Measure air flow. [illegible] 11/1/89

7.32 Pressurize the Cable Vault to column pressure. [illegible] 11/1/89

7.33 Calculate Equvalent Leakage Area as directed by NFPA 12A, App. B, section B-2.6.3.5. [illegible] 11/1/89

7.34 Identify leakage areas within the Cable Vault. [illegible] 11/1/89

7.35 Generate Maintenance Requests as required to seal those leakage areas which will be detrimental to the proper operation of the Cable Vault CO2 system. NA none found [illegible] 11/1/89

7.36 The ESS shall evaluate the Enclosure Integrity test results and determine if additional free venting area is required. [illegible] 11/1/89

Note:

If additional Free Vent area is required, a time delay may be installed on the Cable Vault room exhaust damper. The ESS shall initiate other processes if this action is deemed insufficient.

7.37 Install TM # 89-53 as required to ensure sufficient free venting area. 11/1/89 [illegible]

7.38 Repeat test steps 7.28 through 7.31 to verify the proper operation of the TM 89-53 and the succesful sealing of excessive leakage paths. 11/1/89 [illegible]

7.39 Secure the test equipment upon completion of the test. 11/1/89 [illegible]

7.40 Remove all test equipment from the Cable Vault room. — To be left in room [illegible] 11/1/89

7.41 Secure Door 103 in the closed position. — [illegible] 11/1/89

7.42 Reset the activate/abort switch to the Abort position. — [illegible] 11/1/89

7.42.a Restore the ETL's on the supply duct dampers. Independent verification of this action is required. — by S Apple 10% [illegible] 11/1/89 by Rajpaul [illegible] 11/1/89

7.42.b Reconnect leads 13 and 14 on TB2 in junction box directly above the Cable Vault panel. Independent verification of this action is required. — RLB 11/1/89 [illegible]

7.43 Reconnect the two flexible pipes to the two discharge initiating heads on the CO2 cylinders. Independent verification of this action is required. — NA [illegible] 11/1/89 see [illegible] to main procedure (NOTE)

7.44 Open the valve to the pilot cylinder. Independent verification of this action is required.

7.45 Check for leaks with a soap solution at the point where the two flexible pipes were reconnected in step 7.41. Independent verification of this action is required.

7.46 Deleted.

7.47 Reset activate/abort switch to the Normal position. — [illegible] 11/1/89

7.48 Reset Cable Vault CO2 control panel. — [illegible] 11/1/89

7.49 Clear all alarms from local panel. — [illegible] 11/1/89

7.50 Clear alarm from Control Room panel. — [illegible] 11/1/89

7.51 Verify that Computer Room supply damper has reopened. — [illegible] 11/1/89

7.52 Verify that the Cable Vault supply damper and air operated louver have reopened. — [illegible] 11/1/89

7.53 Verify that the Cable Vault Exhaust damper has reopened. — [illegible] 11/1/89

7.54 Notify Shift Supervisor that the test is complete. — [illegible] 11/1/89 3:30 PM

8.0 DATA

Verified/Date

8.1 Verify that all required data was collected. — [illegible] 11-02-89

3.3 NFPA No. 12, 1989 edition, Standard on Carbon Dioxide Extinguishing Systems

3.4 NFPA No. 12A, 1989 edition, App. B, Enclosure Integrity Test Procedure (attached)

3.5 "Enclosure Integrity Procedure for Halon 1301 Total Flooding Fire Suppression Systems", January 10, 1989, Edited by Casey C. Grant, P.E.

3.6 "Cardox" Fire Extinguishing Equipment Operation and Service Manual

3.7 PDCR 79-06; Switchgear/Cable Vault Suppression Systems

3.8 "Cardox" High Pressure Carbon Dioxide Flow Calculations dated 04-02-70

3.9 Letter, USNRC to VYNPC, NVY 89-108, dated 05-18-89

3.10 Letter, USNRC to VYNPC, NVY 89-172, dated 08-21-89

4.0 APPARATUS

4.1 Enclosure Integrity Test Equipment (provided by RETROTEC)

4.2 Tracer Gas analyzer (provided by VY)

PREREQUISITES

		Verified/Date
5.1	Vendor personnel on site.	EJT 11-02-89
5.2	Test equipment calibration data provided by vendor.	EJT 11-02-89
5.3	Fire Control Permit initiated as required by AP 0042.	EJT 11-02-89
5.4	Material Safety Data Sheet on file for tracer gas.	EJT 11-02-89
5.5	Secure papers and light objects which may be affected by the air currents from the door fan.	EJT 11-02-89
5.6	Place a smoke ejector unit with two lengths of flexible ducting in the Cable Vault Battery room prior to beginning the test. (Tech Spec section 3.10.B.2.a)	EJT 11-02-89
5.7	Provide the capability for hydrogen sampling of the Cable Vault Battery room atmosphere should the test exceed 12 hours in length. (Tech Spec requirement, section 4.10.B.2) HVAC secured at 12:45 hrs. HVAC restored at 15:30 hrs	N/A DCC 11/3/89
5.8	The Security Shift Supervisor has been notified of the test schedule.	EJT 11-02-89

5.9 Verify that all personnel not involved with this test procedure have evacuated the Cable Vault room. (The continuous fire watch will be maintained within the Cable Vault room.) E/T 11-02-89

6.0 PRECAUTIONS

Verified/Date

6.1 Observe precautions in the Vermont Yankee Safety Manual. E/T 11-02-89

6.2 Caution shall be exercised when working in the vicinity of energized circuits. E/T 11-02-89

7.0 PROCEDURE

Verified/Date

7.1 Notify Shift Supervisor prior to beginning test. E/T 11-02-89

7.2 Verify that the Cable Vault room doors are closed and latched. E/T 11-02-89

NOTE

The following steps will disable the automatic discharge portion of the Cable Vault CO2 system.

7.3 Close the valve on the CO2 pilot cylinder. DEK 11/2/89

7.4 Disconnect the two flexible pipes from the pilot cylinder pipe to the two discharge initiating heads on the CO2 cylinders. DEK 11/2/89

7.4.a Disconnect leads 13 (red) and 14 (green) on TB2 in the junction box directly above the Cable Vault panel in accordance with AP 0020. These leads are for the ETL's of the supply air fire dampers. DEK 11/2/89

7.4.b Manually release the supply air fire dampers. DEK 11/2/89

NOTE

The following action will cause an alarm on the local Cable Vault panel as well as the Control Room Pyrotronics panel.

Caution

Do not place the activate/abort switch in the "Second Shot" position.

7.5 Activate the Cable Vault CO2 system by placing the activate/abort switch in the 1st shot position. E/T 11-02-89

7.6 Verify that the following inlet and exhaust dampers have closed: BL 11/2/89

a. Computer Room supply ventilation damper.
b. Cable Vault supply ventilation fire damper.
c. Cable Vault supply ventilation air operated louvers.
d. Cable Vault exhaust ventilation damper.

NOTE

The tracer gas/air exchange test will be conducted by vendor personnel. N/A

7.7 Position tracer gas/air exchange test equipment in the cable vault.

7.8 Start tracer gas blowers to ensure complete mixing of tracer gas.

7.9 Start tracer gas analyzer, calibrate, and establish baseline.

7.10 Add tracer gas to air entering blowers until approximately 250 ppm of tracer gas is attained in the outlet air and level remains stable.

7.11 Maintain blowers in a running state while monitoring and recording gas concentration.

7.12 Ensure that blowers do not direct flow towards known openings in the enclosure.

7.13 Continue test for 1 1/2 hours, or until initial concentration decreases to 50%.

7.14 Secure test equipment.

7.15 Seal all supply dampers with poly film and tape.

7.16 Repeat steps 7.10 through 7.13.

7.17 Upon completion of both tests, purge the room of the tracer gas utilizing the Cable Vault exhaust fan.

7.18 Remove any poly film which was installed on supply dampers.

7.19 Seal those leakage areas which will be detrimental to the proper operation of the Cable Vault CO2 system using OP 5981.

7.20 Remove tracer gas/air exchange test equipment from the Cable Vault room.

7.21 Shutdown exhaust fan.

7.22 Verify that exhaust damper and supply dampers are closed.

Tracer gas Testing completed on 11-01-89 BL/7

see note on leader to this procedure.

7.23 Station Security personnel at Door 103. E/T 11-02-89

7.24 Open Door 103 and secure in the open position. E/T 11-02-89

NOTE

The Enclosure Integrity Test will be conducted by vendor personnel.

7.25 Install door fan unit in the opening of Door 103. E/T 11-02-89

7.26 Pressurize room and determine static pressure within the Cable Vault as directed by NFPA 12A, App. B, section B-2.5.2. E/T 11-02-89

7.27 Make adjustments as necessary to minimize static pressure. (eg fire barrier seal leaks) * N/A

7.28 Repeat measurement of static pressure of the Cable Vault. * N/A

7.29 Determine the column pressure as directed by NFPA 12A, App. B, section B-2.6.1.3. E/T 11-02-89

7.30 Depressurize the Cable Vault to column pressure. E/T 11-02-89

7.31 Measure air flow. E/T 11-02-89

7.32 Pressurize the Cable Vault to column pressure. E/T 11-02-89

7.33 Calculate Equvalent Leakage Area as directed by NFPA 12A, App. B, section B-2.6.3.5. E/T 11-02-89

7.34 Identify leakage areas within the Cable Vault. E/T 11-02-89

7.35 Generate Maintenance Requests as required to seal those leakage areas which will be detrimental to the proper operation of the Cable Vault CO2 system. N/A

7.36 The ESS shall evaluate the Enclosure Integrity test results and determine if additional free venting area is required. Completed 11-01-89

Note:

If additional Free Vent area is required, a time delay may be installed on the Cable Vault room exhaust damper. The ESS shall initiate other processes if this action is deemed insufficient.

7.37 Install TM # 89-53 as required to ensure sufficient free venting area. Completed 11-01-89

7.38 Repeat test steps 7.28 through 7.31 to verify the proper operation of the TM 89-53 and the succesful sealing of excessive leakage paths.

7.39 Secure the test equipment upon completion of the test.

* This test was performed with supply & exhaust dampers sealed and floor drains sealed. (see note on header to this procedure)

7.40 Remove all test equipment from the Cable Vault room. E/T 11-03-89

7.41 Secure Door 103 in the closed position. E/T 11-02-89

7.42 Reset the activate/abort switch to the Abort position. E/T 11-02-89

7.42.a Restore the ETL's on the supply duct dampers. Independent verification of this action is required. [illegible] 11/2/89 / [illegible] 11/2/89

7.42.b Reconnect leads 13 and 14 on TB2 in junction box directly above the Cable Vault panel. Independent verification of this action is required. [illegible] 11/2/89 / [illegible] 11/2/89

7.43 Reconnect the two flexible pipes to the two discharge initiating heads on the CO2 cylinders. Independent verification of this action is required. [illegible] 11/2/89 / [illegible] 11/2/89

7.44 Open the valve to the pilot cylinder. Independent verification of this action is required. [illegible] 11/2/89 / [illegible] 11/2/89

7.45 Check for leaks with a soap solution at the point where the two flexible pipes were reconnected in step 7.41. Independent verification of this action is required. [illegible] 11/2/89 / [illegible] 11/2/89

7.46 Deleted.

7.47 Reset activate/abort switch to the Normal position. E/T 11-02-89

7.48 Reset Cable Vault CO2 control panel. E/T 11-02-89

7.49 Clear all alarms from local panel. E/T 11-02-89

7.50 Clear alarm from Control Room panel. E/T 11-02-89

7.51 Verify that Computer Room supply damper has reopened. E/T 11-02-89

7.52 Verify that the Cable Vault supply damper and air operated louver have reopened. E/T 11-02-89

7.53 Verify that the Cable Vault Exhaust damper has reopened. E/T 11-02-89

7.54 Notify Shift Supervisor that the test is complete. E/T 11-02-89

8.0 DATA

Verified/Date

8.1 Verify that all required data was collected. E/T 11-02-89

9.0 INSPECTION AND TEST ACCEPTANCE

		Verified/Date
9.1	Verify that all procedure steps have been completed.	E/T 11-03-89
9.2	Verify that all discrepancies have been resolved.	E/T 11-03-89
9.3	The ESS shall evaluate the height of the 50% CO2/air descending interface against the critical elevation of 7 feet at time equals 10 minutes. (Ref. 3.4, section B-2.7.1.7)	E/T 11-03-89
9.4	Notify the TSS of of system status/acceptability.	E/T 11-02-89

10.0 FINAL CONDITIONS

		Verified/Date
10.1	Full Cardox cylinders in place.	E/T 11-02-89
10.2	Full pilot bottle in place.	E/T 11-02-89
10.3	Pilot bottle valve open.	E/T 11-02-89
10.4	Continuous fire watch in place.	E/T 11-02-89
10.5	ETL's replaced and circuits restored. # No ETL's required replacement due to minor change.	E/T 11-02-89
10.6	All alarms cleared (local and Control Room panels).	E/T 11-02-89
10.7	All test equipment removed. (tracer gas/air exchange measurement equipment and enclosure integrity test equipment)	E/T 11-03-89
10.8	Temporary Modification 89-53 (Cable Vault exhaust damper time delay) installed if required.	E/T 11-02-89
10.9	Shift Supervisor notified of test completion and acceptability of test results.	E/T 11-02-89
10.10	Test Procedure data sheets completed.	E/T 11-03-89

11.0 EVALUATION

Evaluation of collected data and the vendors test report will be completed by the Plant Fire Protection Coordinator and ESS as a portion of the test procedure.

12.0 NOTIFICATION

Verified/Date

Notify the Engineering Support Records Clerk that this test procedure is completed. 11-01-89

PORC recommends approval of this Test Procedure pending:

1) incorporation of a caution statement regarding "positioning of the actuate/abort switch" in the "Second Shot" position.

2) Resolution of PORC question concerning toxic ~~gas~~ Received 10/30/89 by-products of SF6 in combination with electrical arcing.

Prepared by: 10-30-89

Reviewed by OQG: 10.30 89

Reviewed by ESS: 10/30/89

Reviewed by PORC: 8980 10/30/89

Approved by PM: 10/30/89.

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O.BOX 157
VERNON, VERMONT 05354

CABLE VAULT CO_2 FREE VENT AREA REPORT DATE NOV-15-89

PAGE NO. 1 OF 3

SUBJECT

PREPARED BY 1736 CHECKED BY DCB 11/15/89 REVIEWED [signature] 11/15/89

1. TITLE: DETERMINATION OF CABLE VAULT'S NET FREE VENTED AREA

2. THE CABLE VAULT AREA IS DESIGNATED AS "VITAL"; THE STRUCTURE IS "SAFETY-RELATED, SEISMIC". SAFETY CLASS III

3. PROBLEM DESCRIPTION: DETERMINE NET FREE VENTED AREA WITHIN THE CABLE VAULT AREA WITH CONSIDERATIONS FOR EXISTING AIR FLOW.

4. DESIGN INPUT: PRESSURE RELIEF VENTING AS SPECIFIED BY NFPA 12, 1989 EDITION SECTION 2-6.2, FROM SECTION 2-6.2.1

5. ASSUMPTIONS:
   5.1 THE EXPANSION OF CARBON DIOXIDE TO BE 9 FT^3/lb (.56 $m^3/$

6. CALCULATIONS: FOLLOWING PAGE

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O. Box 157
VERNON, VERMONT 05354

REPORT DATE 02-21-89

SUBJECT Cable Vault CO_2 free vent area

PREPARED BY [illegible] CHECKED BY [illegible] REVIEWED [illegible]

From Section 2-6.2.1

$$X = \frac{Q}{1.3\sqrt{P}}$$

Where: X = free venting area in in^2
Q = Calculated carbon dioxide flow rate in lbs/min.
P = Allowable strength of enclosure in lbs/ft^2

From Table 2-6.2.3

P = 25 lb/ft^2 for Light Building Construction

From Cardox High Pressure Carbon Dioxide Flow Calculations dated 04-02-70 (Ref. 8 of this pkg).

Q = 840 lbs/min

$$X = \frac{840\ lbs/min}{1.3\sqrt{25\ lb/ft^2}}$$

$$= 129.23\ in^2$$

Assume 130 in^2 of free venting area for light building constructic

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O.BOX 157
VERNON, VERMONT 05354

REPORT DATE

SUBJECT

PREPARED BY MJL CHECKED BY [illegible] 11/15/89 REVIEWED [illegible]

8. CONCLUSIONS:

NET FREE VENTED SPACE = 130 in^2

9. REFERENCES:

9.1 NFPA 12, 1989 EDITION, "PRESSURE RELIEF VENTING"; SECTION 2-6.2.1

10. ATTACHMENTS:

NONE

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O.BOX 157
VERNON, VERMONT 05354

REPORT DATE 11-15-89

PAGE NO. Cover Sheet only (Pg 0 of 4)
Pg 1, 2, 3, 4 attached

SUBJECT Calculation of Equivalent Leakage Area in the Cable Vault

PREPARED BY [illegible] CHECKED BY [illegible] 11/15/89 REVIEWED [illegible]

Calculation Package is attached.

Calculation of Equivalent Leakage Area

1) Problem Description

The purpose of this calculation is to determine the Equivalent Leakage Area for the Cable Vault Room. Equivalent Leakage Area (ELA) is defined by NFPA 12A, App. B as the total combined area of all leaks, cracks, joints, and porous surfaces that act as leakage paths through the enclosure envelope. The ELA is represented as the theoretical area of a sharp edged orifice which would exist if the flow into or out of the entire enclosure at a given pressure were to pass solely through it.

On October 31, November 1, and November 2, 1989, data was gathered by Retrotec Energy Inovations Ltd. personnel to determine the ELA for the Cable Vault. This information, in conjunction with these calculations allowed for a prediction of the Equivalent Leakage Area as well as the peak pressure anticipated during a CO2 discharge.

2) Method of Solution

The Equivalent Leakage Area was determined utilizing the approved methodology provided in Appendix B of NFPA 12A, The Standard on Halon 1301 Fire Extinguishing Systems. The density of a 6 percent Halon 1301 mixture is nearly equivalent to the density of a 50 percent CO2 mixture, therefore this methodolgy can be utilized for CO2 systems as well as Halon 1301.

From section B-2.6.3 of Appendix B to Reference 1:

a) No corrections were applied for air temperature. On the days when the testing was conducted external and internal air temperature difference was negligible. For this reason, air flow did not require correction.

b) As defined by the standard, corrections for barometric pressure will cancel, and corrections for humidity are too small to be of concern.

c) Following the completion of door fan measurements in the pressurization and the de-pressurization modes, the leakage area is calculated for each direction. The leakage area is calculated assuming the density of air is 1.202 kg/cu meter and the discharge coefficient for a hole in a flat plate (door fan) is 0.61. The ELA equation is:

$$A = (1.271)(Q)/(dP_m)^{0.5}$$

Where:

A = Area of leaks (m^2)
Q = Door fan flow (m^3/s)
dP_m = Door fan pressure for Q (Pa)

The final value for A is determined by averaging the areas obtained under both a positive and negative pressure.

A standard conversion of the metric units results in the following equation which will be utilized to determine the ELA in English units. (See Pg 4 of 4)

$$A = Q / (dP^{0.5} \times 1.0764)$$

Where:

A = Area of leaks (in^2)
Q = Door fan flow (scfm)
dP = Door fan pressure for Q (~~psi~~ P_a) L/T

3) References

3.1 NFPA 12A, The Standard on Halon 1301 Fire Extinguishing Systems, 1989 Edition; Appendix B, Enclosure Integrity Procedure

4) Equations

Equations are provided in Section 2, Method of Solution.

5) Design Inputs

Provided as Attachment 1, Retrotech Test Data.

6) Assumptions

Assumptions have been stated in Section 2, Method of Solution.

7) Calculations

Q_N = Flow from Negative Pressure Test = 1294 scfm.

Q_P = Flow from Positive Pressure Test = 454 scfm.

dP_N = Differential Pressure from Negative Pressure Test = 13 ~~psi~~ P_a L/T

dP_P = Differential Pressure from Positive Pressure Test = 11 ~~psi~~ P_a L/T

$$A = Q / (dP^{0.5} \times 1.0764)$$

A_N = ELA for Negative Pressure Test = 333 in^2

A_P = ELA for Positive Pressure Test = 127 in^2

Average ELA = $(A_N + A_P) / 2$

Average ELA = 230 in^2

J) Conclusions

The above calculation provides an Equivalent Leakage area of 230 square inches. This value, compared with the value derived from NFPA 12, Section 2-6.2, Pressure Releif Venting, indicates an acceptable amount of free venting area for the Cable Vault room.

Further calculations will utilize this information to predict the peak pressure attained during a CO2 system discharge within the Cable Vault.

Prepared by: E/Tubb & Retrotec 11-15-89

Checked by: DC Dinoia 11/15/89

Reviewed by: D. M. Metcalf 11/15/89

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O. BOX 157
VERNON, VERMONT 05354

REPORT DATE 11-15-89

PAGE NO. 9 of 14

SUBJECT CABLE VAULT LEAKAGE

PREPARED BY MRS CHECKED BY [illegible] REVIEWED [signature]

DETERMINE "CONSTANT" TO BE USED WITH EQUATION FOR LEAKAGE AREA; IF TEST DATA IS IN "ENGLISH" UNITS RATHER THAN "METRIC" UNITS;

METRIC VERSION: $A = \frac{(1.271)\,Q_c}{\sqrt{\Delta P}}$ (1.271 ← CONSTANT)

A = M^2
Q_c = M^3/SEC
ΔP = PASCALS

ENGLISH CONVERSION: (TO HAVE A IN "IN^2" AND Q_c IN C.F.M.)

$$\frac{A}{\left(144\frac{IN^2}{FT^2}\right)\left(\frac{3.281\,FT}{M}\right)^2} = \frac{(1.271)(Q_c)}{\left(3.281\frac{FT}{M}\right)^3}\,\frac{1\,MIN}{(60\,SEC)}$$

$$A = .9297\,\frac{Q_c}{\sqrt{\Delta P}}$$

OR

$$A = \frac{Q_c}{1.0764\sqrt{\Delta P}}$$

WHERE $A = IN^2$
$Q_c = CFM$
ΔP = PASCALS

CHECK: $Q_c = 579$ CFM
$\Delta P = 13$ PASCALS

$$A = \frac{579}{1.0764\sqrt{13}} = 149\ IN^2$$

CONVERT TO METRIC UNITS

$$Q_c = (579\ CFM)\left(\frac{1\,M}{3.281\,FT}\right)^3\left(\frac{1\,MIN}{60\,SEC}\right) = .2732\ M^3/SEC$$

$$A_{METRIC} = \frac{(1.271)(.2732\ M^3/SEC)}{\sqrt{13}} = .0963\ M^2$$

OK

$$.0963\ M^2 = .0963\,M^2\left(\frac{3.281\,FT}{1\,M}\right)^2\left(\frac{12\,IN}{1\,FT}\right)^2 = 149\ IN^2 \checkmark$$

CONSTANT IS CORRECT

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O.BOX 157
VERNON, VERMONT 05354

REPORT DATE 11-15-89

PAGE NO. 1 of 4

SUBJECT Calculation of Peak Pressure During CO_2 discharge in the Cable Vault.

PREPARED BY [illegible] CHECKED BY [illegible] 11/15/89 REVIEWED [illegible] 11/15/89.

Calculation Package is attached.

Calculation of Peak Pressure During Discharge

Problem Description

The purpose of this calculation is to determine the maximum pressure which will be developed in the Cable Vault during a discharge of the CO2 system. NFPA 12, the Standard on Carbon Dioxide Extinguishing Systems, 1989 Edition, provides guidance in determining necessary leakage area for very tight enclosures. This method accounts for the discharge rate of the installed system as well as the structural strength of the enclosure.

On October 31, November 1, and November 2, 1989, data was gathered by Retrotec Energy Inovations Ltd. personnel to determine the Equivalent Leakage Area for the Cable Vault. This information, in conjunction with these calculations allowed for a prediction of the Equivalent Leakage Area as well as the maximum pressure anticipated during a CO2 discharge.

2) Method of Solution

The maximum pressure was determined utilizing the approved methodology provided in NFPA 12, section 2-6.2, Pressure Relief Venting. This calculation assumes the expansion of the CO2 to be 9 cu ft/lb.

From section 2-6.2.1 of Reference 3.1:

$$X = Q / (1.3)\ (P)^{0.5}$$

Where:

X = Free venting Area (in^2)

Q = Calculated carbon dioxide flow rate (lbs/min)

P = Allowable strength of the enclosure (psf)

From Table 2-6.2.3 of Reference 3.1:

Type Construction	Windage	Pressure	In. H20	PSI	Bars-gage
Light Building	100 MPH	25 psf	5	.175	0.012

To determine the maximum pressure anticipated, the above calculation can rearranged to:

$$P = (Q/1.3\ X)^2$$

Where:

X = ELA (in) * 0.61

0.61 is the discharge coefficient for a hole in a flat plate.

eferences

3.1 NFPA 12, The Standard on Carbon Dioxide Extinguishing Systems, 1989 Edition

3.2 "Cardox" High Pressure Carbon Dioxide Flow Calculations dated 04-20-70

4) Equations

Equations are provided in Section 2, Method of Solution.

5) Design Inputs

Provided as Attachment #1; Retrotech Test Data.

6) Assumptions

Assumptions have been stated in Section 2, Method of Solution.

7) Calculations

Q = 840 lbs/min as defined by Reference #2.

X = (discharge coefficient of 0.61)(ELA = 20 in^2 of leakage around door.)

= (0.61)(230 + 20)

= 152.5

P = $(Q / 1.3 * X)^2$

= $(840/(1.3)(152.5))^2$

= 17.95 psf

= 3.45 inches of water

8) Conclusions

The above calculation provides a maximum pressure during the discharge of CO2 in the Cable Vault. The value of 5 inches of water as specified by NFPA 12 is for light building construction. The enclosure which makes up the Cable Vault is of much heavier construction, with the exception of the doors. The values for light building construction account for the construction of the doors. The value predicted by this calculation demonstrates that the room will remain intact during a discharge of the CO2 system in the Cable Vault.

Prepared by: [signature] & Retrotec 11-15-89

Checked by: [signature] 11/15/89

Reviewed by: [signature] 11/15/89.

CALCULATION OF MAXIMUM PRESSURE SPIKE EXPECTED PER NFPA 12, ASSUMING COMPLETE GAS EVAPORATION

INVERT EQUATION : $x = Q/1.3\sqrt{P}$

TO SOLVE FOR P : $P = \left(\frac{Q}{1.3x}\right)^2$

FOR VY CABLE VAULT, $Q = 840$ lbs/min

$x = \frac{250^*}{344}$ in^2 GLM $\times .61 =$

144 in^2 effective leakage Area

$P = \left(\frac{840}{1.3 \times \frac{144}{152.5}}\right)^2 = \frac{17.95^*}{19.32}$ lbs/sq.ft $= \frac{3.45^*}{3.86}$ in H_2O

IF DAMPER (SHUTTER) NOT OPEN : $x = 122 \times .61 = 74.4$ in^2

$P = \left(\frac{840}{1.3 \times 74.4}\right)^2 = 75.48/5 = 15.08$ in H_2O

* Corrections made by E/T per Telecon w Brendan Reid.

OK Comm. 11/15/89.

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O. Box 157
VERNON, VERMONT 05354

REPORT DATE 11-15-89

SUBJECT Cable Vault Air Leakage by Tracer Dilution Method

PREPARED BY [illegible] CHECKED BY [illegible] 11/15/89 REVIEWED [illegible]

1) Problem Description:

The purpose of this calculation is to determine the air exchange rate of the Cable Vault enclosure. This was completed consistent with ASTM E 741-80. (Ref. 3.1)

2) Method of Solution:

The air exchange rate was calculated utilizing a computer model provided by Retrotech Energy Innovations Ltd. This model has been verified as acceptable by the vendor. (Ref 3.2)

3) References:

3.1 ASTM E 741-80, Standard Practice for Measuring Air Leakage Rate by the Tracer Dilution Method. - Equation 4 (Finite Difference)

3.2 Telecon with Brendan Reid of Retrotech, DCG, and EJT, 11-15-89, 15:30 hrs. Brendan Reid stated that the computer model had been verified. A copy of the verification will be provided.

4) Equations:

Provided by Ref 3.1 and the Computer model.

5) Design Inputs:

Provided by Ref 3.1

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O. BOX 157
VERNON, VERMONT 05354

REPORT DATE 11-15-89

SUBJECT

PREPARED BY [illegible] CHECKED BY [illegible] 11/15/89 REVIEWED [illegible]

6) Assumptions:

As stated in Ref 3.1

7) Calculations:

Provided by computer model.

The computer model provided an air exchange rate of 640 scfm.

8) Conclusions:

The air exchange rate for the Cable Vault in its CO_2 discharge design configuration is 640 scfm.

This information will be utilized in a standard decay rate calculation to determine duration of a 50 % concentration.

CALCULATION OF TOTAL AIR EXCHANGE FLOW:

TRACER TEST #1 UNSEALED : 634 cfm

TRACER TEST #2 SUPPLY DAMPER SEALED : 609 cfm

CONCLUSION : SUPPLY DAMPER CONTRIBUTION = 25 cfm

TRACER TEST #3 DAMPER + DOORS SEALED = 558 cfm

PREDICTED AIR FLOW WITH DAMPER UNSEALED YET DOORS SEALED:

558 + 25 = 583 cfm

CALCULATION OF COMBINED AIR EXCHANGE + CO_2 INDUCED FLOW

① CO_2 INDUCED FLOW RATE CALCULATED USING NFPA 12A (SEE ATTACHED PRINTOUT)

MODEL CALCULATES TIME TO HAVE INTERFACE DROP 1% OF ROOM HEIGHT, I.E 8.5 FT × .99 = 8.415 FT

THIS EQUALS 1% OF ROOM VOLUME I.E. 32417 × .01 = 324 cf.

1% HEIGHT DROP TAKES 2.32 minutes,

LOSS RATE = 324 cfm / 2.32 min = 140 CFM

② ADD BOTH EFFECTS' FLOWS IN QUADRATURE DUE TO INTERACTIVE

$(583^2 + 140^2)^{.5}$ = 600 cfm

WORST CASE CALCULATION OF CONCENTRATION LOSS FROM 65 TO 50%

15 / 65 = 23% OF ROOM VOLUME = 7480 CUBIC FEET

7480 / 600 = 12.47 MINUTES

NOTE THAT THIS SIMPLISTIC APPROACH DOES NOT TAKE INTO ACCOUNT DIMINISHING CONCENTRATION OF MIXTURE LEAVING ROOM.

TRACER GAS AIR EXCHANGE TEST
LOCATION: UT CABLE VAULT UNSEALED #1
TEST DATE: NOV 1 89

TIME =	0.000	SF6 =	190.000
TIME =	2.000	SF6 =	181.000
TIME =	4.000	SF6 =	177.000
TIME =	6.000	SF6 =	170.000
TIME =	8.000	SF6 =	166.000
TIME =	10.000	SF6 =	161.000
TIME =	12.000	SF6 =	156.000
TIME =	14.000	SF6 =	149.000
TIME =	16.000	SF6 =	143.000
TIME =	18.000	SF6 =	138.000
TIME =	20.000	SF6 =	132.000
TIME =	22.000	SF6 =	126.000
TIME =	24.000	SF6 =	123.000
TIME =	26.000	SF6 =	117.000
TIME =	28.000	SF6 =	112.000
TIME =	30.000	SF6 =	106.000
TIME =	32.000	SF6 =	101.000
TIME =	34.000	SF6 =	97.000

CORRELATION= 0.997
CONSTANT= 193.228
ACPH= 1.174
VOLUME= 32417.000
CFM= 634.814

TRACER GAS AIR EXCHANGE TEST
LOCATION: UY CABLE VAULT SUPPLY SEALED
TEST 2
TEST DATE: NOV 1 89

TIME =	0.000	SF6 =	176.000
TIME =	2.000	SF6 =	171.000
TIME =	4.000	SF6 =	166.000
TIME =	6.000	SF6 =	161.000
TIME =	7.000	SF6 =	159.000
TIME =	11.000	SF6 =	150.000
TIME =	12.000	SF6 =	149.000
TIME =	14.000	SF6 =	144.000
TIME =	16.000	SF6 =	138.000
TIME =	18.000	SF6 =	134.000
TIME =	20.000	SF6 =	130.000
TIME =	22.000	SF6 =	122.000
TIME =	24.000	SF6 =	119.000
TIME =	26.000	SF6 =	114.000
TIME =	28.000	SF6 =	110.000
TIME =	30.000	SF6 =	105.000
TIME =	32.000	SF6 =	101.000
TIME =	34.000	SF6 =	95.000
TIME =	36.000	SF6 =	92.000
TIME =	38.000	SF6 =	87.000
TIME =	40.000	SF6 =	84.000
TIME =	42.000	SF6 =	81.000
TIME =	23.000	SF6 =	121.000

CORRELATION=	0.996
CONSTANT=	182.973
ACPH=	1.127
VOLUME=	32417.000
CFM=	609.381

TRACER GAS AIR EXCHANGE TEST
LOCATION: UY 3
TEST DATE: NOV 1 89

TIME =	0.000	SF6 =	176.000
TIME =	2.000	SF6 =	175.000
TIME =	4.000	SF6 =	172.000
TIME =	6.000	SF6 =	168.000
TIME =	8.000	SF6 =	164.000
TIME =	10.000	SF6 =	159.000
TIME =	12.000	SF6 =	155.000
TIME =	14.000	SF6 =	151.000
TIME =	16.000	SF6 =	144.000
TIME =	18.000	SF6 =	140.000
TIME =	20.000	SF6 =	136.000
TIME =	22.000	SF6 =	130.000
TIME =	24.000	SF6 =	127.000
TIME =	26.000	SF6 =	123.000
TIME =	27.000	SF6 =	121.000
TIME =	28.000	SF6 =	119.000
TIME =	30.000	SF6 =	119.000
TIME =	32.000	SF6 =	110.000
TIME =	36.000	SF6 =	103.000
TIME =	38.000	SF6 =	98.000
TIME =	40.000	SF6 =	95.000
TIME =	42.000	SF6 =	91.000
TIME =	44.000	SF6 =	88.000
TIME =	46.000	SF6 =	83.000
TIME =	48.000	SF6 =	81.000
TIME =	48.000	SF6 =	76.000

CORRELATION= 0.995
CONSTANT= 187.976
ACPH= 1.032
VOLUME= 32412.000
CFM= 557.969

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O. BOX 157
VERNON, VERMONT 05354

REPORT DATE 11/15/89

PAGE NO. 1 of 7 with attachment (3 Pgs) additional

SUBJECT CABLE VAULT VOLUME

PREPARED BY MRS CHECKED BY [illegible] 11/15/89 REVIEWED D. M. Trotell

1. TITLE: DETERMINATION OF CABLE VAULT'S NET AIR VOLUME

2. THE CABLE VAULT AREA IS DESIGNATED AS "VITAL", THE STRUCTURE IS "SAFETY-RELATED, SEISMIC". SAFETY CLASS III

3. PROBLEM DESCRIPTION: DETERMINE NET AIR VOLUME WITHIN THE CABLE VAULT AREA WITH CONSIDERATIONS FOR EXISTING SOLID OBJECTS AND ROOM PROTRUTIONS/PENETRATIONS (WHICH WOULD ADD TO THE ROOM'S VOLUME)

4. DESIGN INPUT:
   4.1 ALL DIM'S FIELD VERIFIED

5. ASSUMPTIONS:
   5.1 ASSUME 3x24" TRAYS ARE 20% FULL
   5.2 ASSUME 4 3x24 TRAYS ARE 100% FULL
   5.3 BATTERY ROOM IS PART OF CABLE VAULT VOLUME

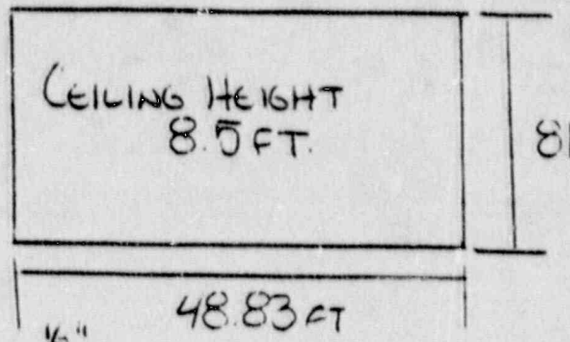
6. CALCULATIONS & SKETCHES

THE METHOD OF ANALYSIS WILL BE TO DETERMINE "GROSS VOLUME" OF ROOM BASED ON OVERALL DIM'S. THEN DETERMINE THE "NET VOLUME" BY ADDING VOLUMES OF PENETRATIONS/PROTRUTIONS AND SUBTRACTING ANY SOLID OBJECTS WHICH DISPLACE ANY AIR (ie COLUMNS, BEAMS, CABLES, ETC.)

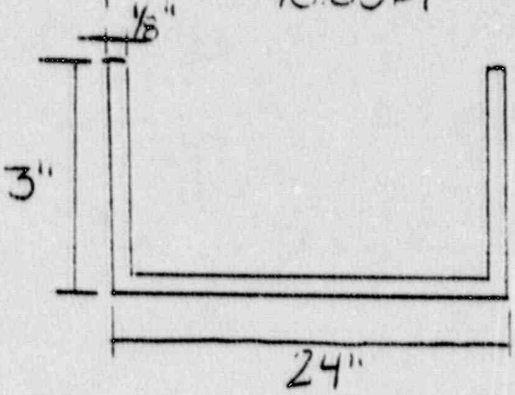
CABLE VAULT VOLUME

BY MRS CHK'd ~~DDS~~ 11/15/89 DATE 9/30/89

7. CALC'S UMM 11/15 PG NO 2 of 7



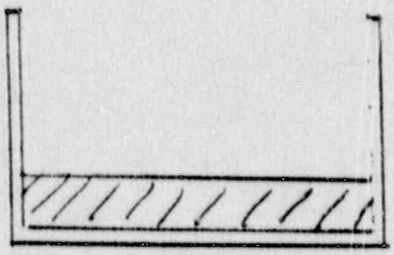
TOTAL VOLUME
(8.5)(48.83)(8167)
= 33897.5 FT^3



(1/8)(24+3+3)(264)(12) = 11880 IN^3
= 6.875 FT^3

FACTOR OF (1.1) TO ACCOUNT FOR UNISTRUT BRACING = 7.5625 FT^3

9 TRAYS = 7.5625 × 9 = 68.0625 FT^3



20% of WIRE IN 9 TRAYS

(3" × 24") (264) (20%) = 26.4 FT^3

9 TRAYS × 26.4 FT^3 = 237.6 FT^3

VOLUME OF 4 FULL TRAYS

(3 IN)(2 FT)(29 FEET) = 14.5 FT^3

4 TRAYS × 14.5 FT^3 = 58 FT^3

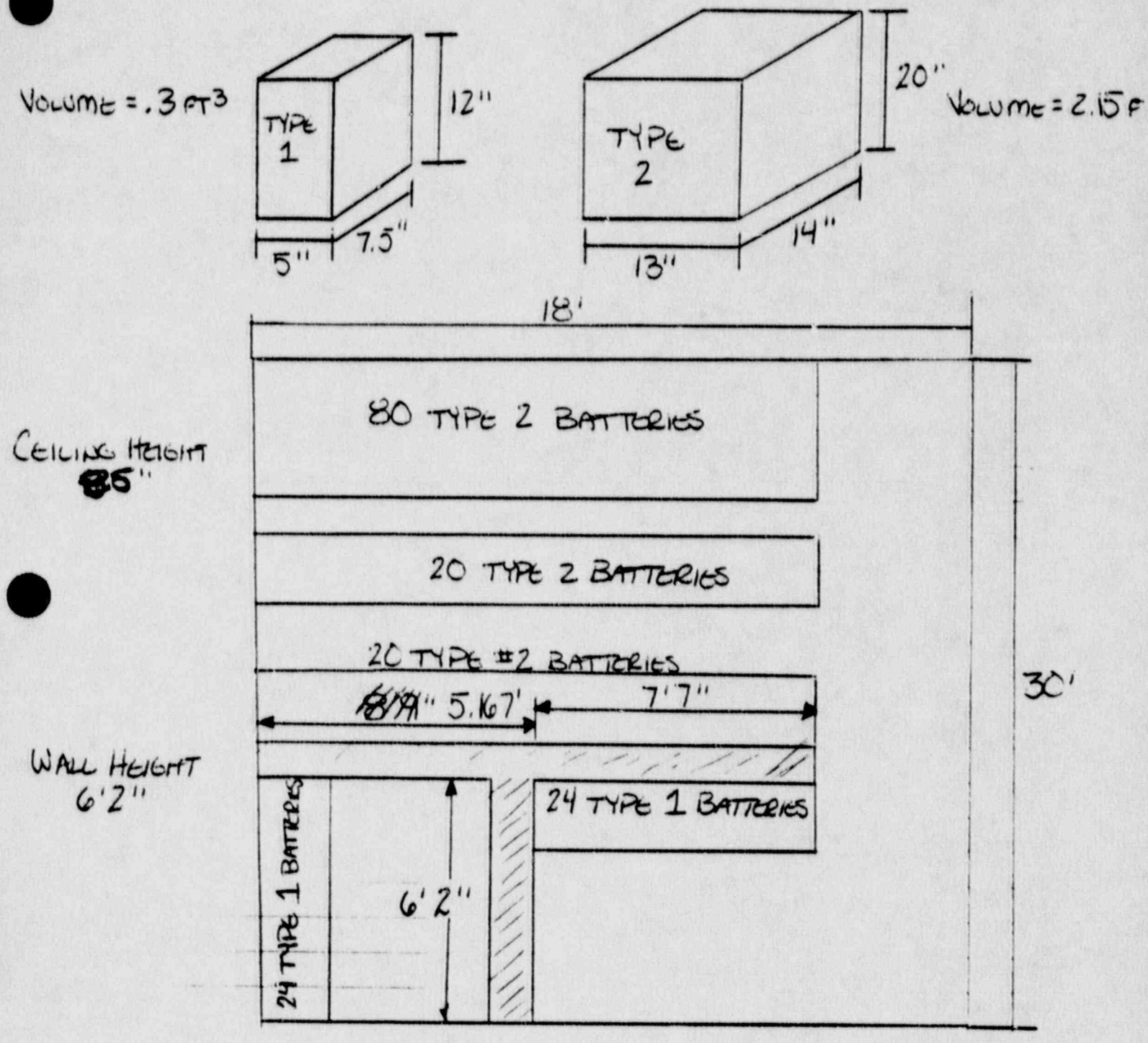
BATTERY ROOM

CABLE VAULT VOLUME

BY: MRS CHK'D [illegible] 11/15/89

DATE (9/30 11/15/89

Page 3 of 7



VOLUME OF TYPE 1 BATTERIES $48 \times .3 = 14.4\ FT^3$

VOLUME OF TYPE 2 BATTERIES $120 \times 2.15 = 258\ FT^3$

VOLUME OF DIVIDING WALL $= 52.38\ FT^3$

VOLUME OF OUTSIDE WALL $(8IN) \times (96FT) \times (85FT) = 544\ FT^3$

TOTAL VOLUME = 868.80 FT3

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O. BOX 157
VERNON, VERMONT 05354

(9/30/89)

REPORT DATE 11/15/89

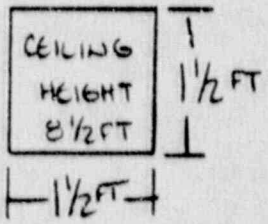
PAGE NO. 4 of 7

SUBJECT

PREPARED BY MJL CHECKED BY [illegible] 11/15/89 REVIEWED [illegible]

CALCULATIONS FOR UNVENTED SPACE VOLUME

1) 4 CONCRETE COLUMNS



(4 COLUMNS)(1.5')(1.5')(8.5')

= 76.5 FT³

2) 3 UNVENTED BOXES

BOX #1	3.5' × 3' × 2.5'	= 26.25'	
BOX #2	1.5' × 5' × 2'	= 15.0'	= 61.5 FT³
BOX #3	1.5' × 3' × 4.5'	= 20.25'	

3) WALL BETWEEN GENERATORS 16' × 6' × .66' = 64.0 FT³

4) VARIOUS WALL SPACE 24.332 FT³

TOTAL UNVENTED VOLUME = 76.5 + 61.5 + 64.0 + 24.332

= 206.4 FT³

NEW VOLUME = 33897.5 FT³

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O.BOX 157
VERNON, VERMONT 05354

(9/30/89)

REPORT DATE 11/15/89

PAGE NO. 5 of 7

SUBJECT

PREPARED BY MRS CHECKED BY [illegible] 11/15/89 REVIEWED [illegible]

INCREASES IN ROOM VOLUME;

CEILING PEN'S

TYPE ① L = 11'-5"
W = 1'-9"
H = 1'-5"

VOLUME = (11'-5")(1'-9")(1'-5")(6 PEN'S)

$V_1 = 169.8\ ft^3$ +

TYPE ② L = 14'-2"
W = 1'-6"
H = 1'-5"

VOLUME = (14'-2")(1'-6")(1'-5")(4 PEN'S)

$V_2 = 120.4\ ft^3$ +

TYPE ③ L = 19'
W = 21"
H = 18"

VOLUME = (19')(21"/12)(1.5') =

$V_3 = 49.9\ ft^3$ +

TYPE ④ L = 9'-6"
W = 21"
H = 18"

VOLUME = (9.5')(21"/12)(1.5') =

$V_4 = 24.94\ ft^3$ +

@ MG'S; $V = [(5'-6")(1'-6")(21"/12)]_{2\ t_{A+B}} = V_5 = 28.8\ ft^3$ +

BACK DOOR; V = (3'-5")(1'-6")(6'-5") = $V_6 = 32.89\ ft^3$ +

PEN @ BACK WALL NEAR DOOR = (2'-1")(2.5')(4.5') = $V_7 = 23.44\ ft^3$ +

PEN @ BACK WALL, CENTER = (5')(28"/12)(5'-9") = $V_8 = 67.08\ ft^3$ +

PEN @ BACK WALL*, RIGHT SIDE = (4')(28"/12)(5'-9") = $V_9 = 53.7\ ft^3$

* ASSUMED DIM'S

TOTAL PEN'S = $571\ ft^3$

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O.BOX 157
VERNON, VERMONT 05354

REPORT DATE 9/30/89

SUBJECT CABLE VAULT VOLUME

PREPARED BY MRS CHECKED BY RBK 11/15/89 REVIEWED [illegible]

DECREASES IN ROOM VOLUME:

COLUMNS = (6)(1.5' x 1.5')(8.5'H) = 114.8 ft³ (-)

BEAMS (SHORT) = $(\frac{12"}{12})(\frac{22"}{12})(16')(9\ \text{BEAMS})$ = 264 ft³

BEAMS (LONG) = $(\frac{13"}{12})(\frac{22"}{12})(19.5)(2\ \text{BEAMS})$ = 71.5 ft³

$(\frac{12}{12})(\frac{22"}{12})(20)(4\ \text{BEAMS})$ = 147 ft³

$(\frac{12}{12})(\frac{22}{12})(21.5')(2\ \text{BEAMS})$ = 78.8 ft³

561 ft³ (-)

NET CABLE VAULT VOLUME:

GROSS VOLUME = 33,897.5
PEN'S + 571.2

TRAYS (9 HIGH)	- 68.
WIRING (@ 9 HIGH'S)	- 237.6
TRAYS (4 HIGH, FULL)	- 58.
BOXES (UNVENTED)	- 206.4
BATTERIES + WALLS	- 805
COLUMNS	- 115
BEAMS	- 561

NET VOLUME = 32,417 ft³
CABLE VAULT

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O.BOX 157
VERNON, VERMONT 05354

REPORT DATE 11/30/87

PAGE NO. 5 of 7

SUBJECT CABLE VAULT VOLUME

PREPARED BY MRS CHECKED BY [illegible] REVIEWED [illegible]

8. CONCLUSION

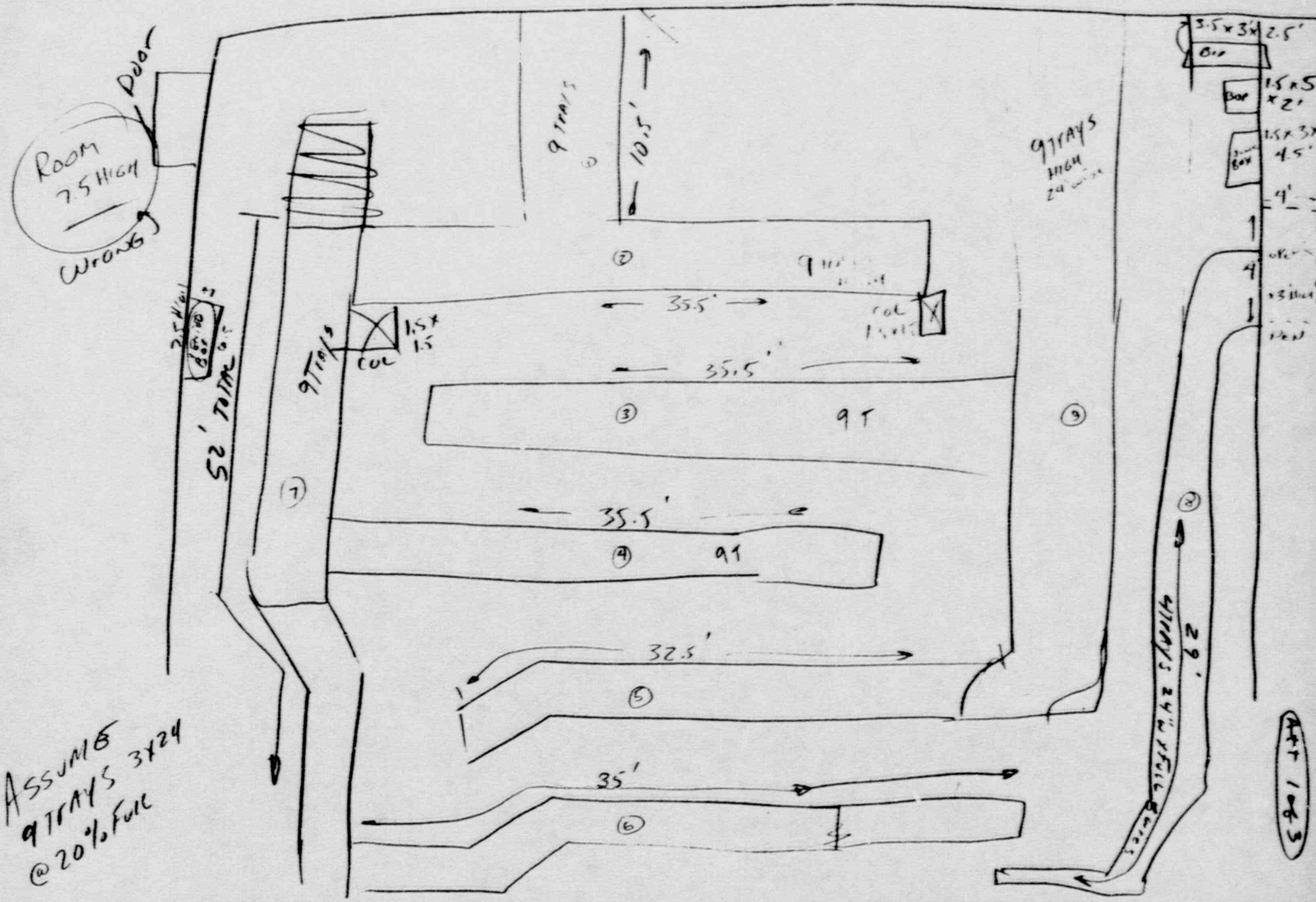
NET CABLE VAULT VOLUME = 32,417 CUBIC FT.

9. REF

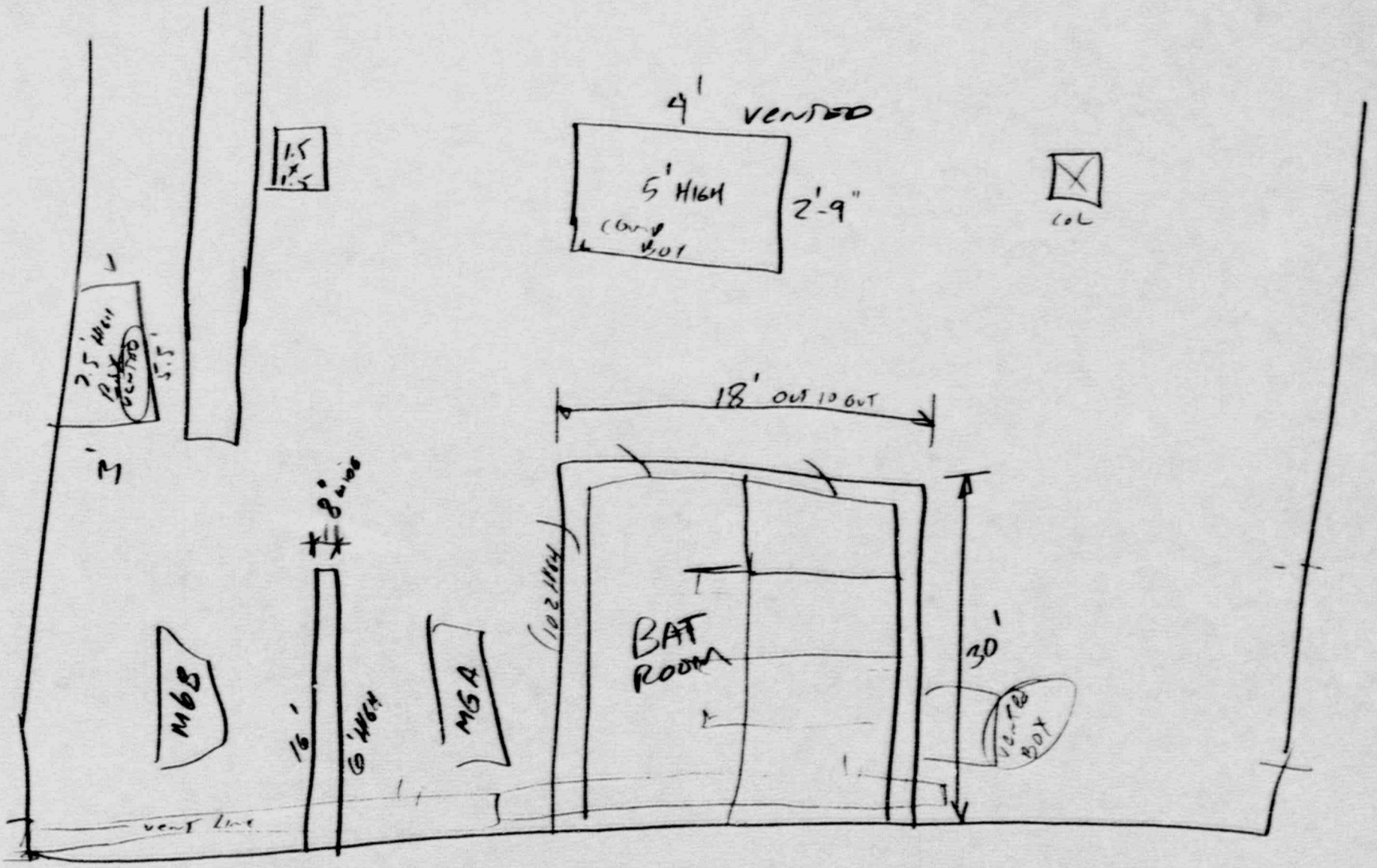
VY DRWG FH-16547 SHT. 1 of 2 "CADDEX"

10. ATTACHMENT:

FIELD SKETCHES / DIM'S
Attachment - 3 of 3



ROOM 7.5 HIGH
WRONG
Door
52' TOTAL
9 TRAYS
1.5 x 1.5
COL
9 TRAYS
10.5'
35.5'
35.5'
9 T
35.5'
9 T
32.5'
35'
9 TRAYS HIGH 24" wide
3.5 x 3' x 2.5'
1.5 x 5' x 2'
1.5 x 3' x 4.5'
Box
4'
29'
4 TRAYS 24" W x FULL
ATT 1 of 3
ASSUME 9 TRAYS 3x24 @ 20% FULL


4'
VENTED
5' HIGH
2'-9"
COL
18' OUT TO OUT
BAT ROOM
30'
MH 2 of 3

HEIGHT TO CEILING PEN 9'-10"
LENGTH OF " PEN 11'-5"
WIDTH OF " " 1'-9" } ||||||

Type 2 LENGTH 14'-2"
WIDE 1'-6" } ||||

Type 3 LENGTH 19'
DEPTH 18"
WIDTH 21" } ||

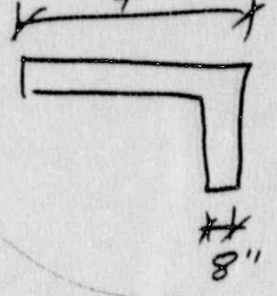
BACK WALL PEN #1 28" DEEP
5' WIDE
5'-9" HIGH

BACK WALL PEN NEAR DOOR
DEPTH = 2'-1"
WIDTH = 2'-6"
HIGH = 4'-6"

Beams 12" DEEP x 22" WIDE

Type 4 LG 9'-6"
DEPTH 18"
WIDTH 21"

Block wall near MG's



6'-1" HIGH

DOOR opening
3'-5" WIDE
1'-6" DEEP
6'-5" HIGH

PEN @ MG's CEILING
L = 5'-6"
D = 1'-6"
W = 21" WIDE } ||

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O. Box 157
VERNON, VERMONT 05354

REPORT DATE 11-15-89

SUBJECT Cable Vault CO_2 Descending Interface Model. Hold Time

PREPARED BY EJT CHECKED BY DCG 11/15/89 REVIEWED

1) Problem Description:

The purpose of this calculation is to determine the descending interface of CO_2/air over time. This calculation has been performed utilizing a computer model provided by Retrotech Energy Innovations Ltd. The model provided has been verified according to NFPA 12A requirements.

2) The descending interface over time was determined using the approved methodology provided in App B of NFPA 12A (Ref. 3.1). The method has been verified as correct. (Ref. 3.2)

3) 3.1) NFPA 12A, Standard on Halon 1301 Fire Extinguishing Systems, 1989 Edition; Appendix B.

3.2) Telecon with Brendan Reid of Retrotec Energy Innovations Ltd, and DCG and EJT. 11-15-89, 15:30 hrs. Brendan Reid indicated that the computer model had been verified per NFPA 12A, App. B.

4) Equations

Provided by the Computer model.

5) Design Inputs

Provided by Ref 3.1

6) Assumptions

As stated in Ref. 3.1

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O. BOX 157
VERNON, VERMONT 05354

REPORT DATE 11-15-89

SUBJECT

PREPARED BY [illegible] CHECKED BY [illegible] 11/15/89 REVIEWED [illegible]

7) Calculations

Provided by computer model.

Results attached. on Pg 3 of 3

8) Conclusion

The results produced by the computer model and presented by Retrotech predict a 50 % Concentration of CO_2 at 7 feet above the floor for a period of 25 minutes following discharge.

Pg 3 of 3

USED TO CALCULATE WORST CASE CO2 LEAK RATE DUE TO CO2 COOLING

RETROTEC DISCHARGE SIMULATOR VER. HA3

HALON 1301 RETENTION TIME PREDICTION MODEL

Testing Company: RETROTEC
Technician Name: REID
Date of Test: NOV 2 89
Location: UY CABLE VAULT
NORMAL RETENTION CONFIGURATION
Walls Go Slab To Slab.
Gas Being Modelled: 1301
Lbs. of Agent Not Entered
Protected Room Volume (cu ft): 32417
Elevation Above Sea Level (ft): 0.00
Room Height (ft): 8.50
Minimum Protected Height (ft): 8.415
Minimum Retention Time (min): 10.00
Initial Halon Concent. (%): 8.19 65%.
Room Static Pressure NEG pa: 0.00 Ca.
Avg. Total Room ELA (sq in): 122.00
Assumed BCLA (sq in): 61.00

*****

This Room FAILS the Test as the Procedure predicts that it will take 2.32 minutes for the halon/air interface to drop below the minimum protected height.

AHJ Acceptance:

X _____

This Software Conforms To The 1989 NFPA 12A Room Integrity Procedure

RM= 1.810 PC= 10.376 pa. 10.376 pa
AT= 0.048 ALL= 0.024 FA= 0.500
C3= 2.695 C4= 0.000 CF= 1.000
QR= 354 T= 139

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O.BOX 157
VERNON, VERMONT 05354

REPORT DATE 11-15-89

PAGE NO. 1 of 6

SUBJECT CABLE VAULT LEAKAGE / Hold Time for Stuck Open Door Model

PREPARED BY MRS CHECKED BY [signature] 11/15/89 REVIEWED [signature]

1. TITLE: CABLE VAULT CO_2 CONCENTRATION LEAK DOWN

2. PROBLEM DESCRIPTION:

THIS CALCULATION IS PERFORMED TO DETERMINE THE TIME REQUIRED FOR THE CO_2 CONCENTRATION TO DROP TO 50%; GIVEN A MAX. CO_2 CONCENTRATION OF 65% AND A FIXED LEAKAGE RATE OF 640.2 CFM.

3. METHOD OF SOLUTION:

THE METHOD OF SOLUTION WILL FOLLOW THE ASTM STANDARD E-741-80 WHICH UTILIZES THE "TRACER DILUTION METHOD". THE "TRACER DILUTION" EQUATION IS GIVEN BELOW;

$$C = C_0 e^{-(Kt/V)}$$

WHERE: C = NEW CONCENTRATION (%)
C_0 = INITIAL CONC. (%)
K = LEAKAGE RATE (CFM)
t = TIME (MIN)
V = VOLUME (FT^3)
e = 2.718

A "BASIC" PROGRAM WAS WRITTEN TO INCREMENT TIME (T) AND SOLVE FOR C.

4. ASSUMPTIONS:

4.1 LEAKAGE RATE IS CONSTANT
4.2 PRESSURE IS CONSTANT
4.3 VOLUME IS CONSTANT

5. DESIGN INPUT:

5.1 $V = 32,417\ FT^3$ (PER REF. 9.1)
5.2 $K = 640.22$ CFM (PER REF. 9.2)
5.3 $C_0 = 65\%$ (PER REF. 9.2)

VERMONT YANKEE NUCLEAR POWER CORPORATION
P.O.BOX 157
VERNON, VERMONT 05354

REPORT DATE 11-15-89

SUBJECT CABLE VAULT LEAKAGE

PREPARED BY MRS CHECKED BY [illegible] 11/15/89 REVIEWED [illegible]

6. COMPUTER CODES;
   6.1 TEXAS INSTRUMENTS TI 99/4A EXTENDED BASIC
   6.2 GW BASIC

7. CALCULATION/ANALYSIS

7.1 SEE ATTACHED COMPUTER PRINT-OUT FOR COMPLETE ANALYSIS FROM TIME = 0 MIN. THRU TIME = 20 MIN.

7.2 BENCH-MARK / COMPUTER PROGRAM VERIFICATION;

CHECK NEW CONC. @ TIME = 14 MIN.

$$C = (65)\left[(2.718)^{-(x)}\right]$$

$$x = (640.22)(14)/32{,}417 = 0.2764$$

$$\therefore C = 49.30\ \% \Leftarrow \text{COMPARES WITH COMPUTER RUN} \Rightarrow 49.298\ \% \quad \text{OK}$$

8.0 CONCLUSION / RESULTS

THE TIME REQUIRED TO REACH A CO_2 CONCENTRATION OF 50% (FROM AN INITIAL HIGH OF 65%) IS APPROX. 13.2 MIN.'s

9.0 REFERENCES:
   9.1 DETERMINATION OF CABLE VAULT VOLUME (VY CALC)
   9.2 CABLE VAULT LEAKAGE TEST
   9.3 ASTM E-741-80

10. ATTACHMENTS
   10.1 COMPUTER PRINT-OUT "CABLE VAULT CO_2 CONCENTRATION"

CO2 CONCENTRATION IN CABLE VAULT AREA
USING "TRACER" DILUTION METHOD
(ASTM# E-741-80)

ROOM VOLUME= 32417 CUBIC FEET
LEAKAGE RATE= 640.22574 C.F.M.
INITIAL CO2 CONCENTRATION= 65 PERCENT

AT TIME=T+ 0 MIN.; THE REVISED CO2 CONC.= 65 PERCENT

AT TIME=T+ .2 MIN.; THE REVISED CO2 CONC.= 64.74376041 PERCENT

AT TIME=T+ .4 MIN.; THE REVISED CO2 CONC.= 64.48853096 PERCENT

AT TIME=T+ .6 MIN.; THE REVISED CO2 CONC.= 64.23430766 PERCENT

AT TIME=T+ .8 MIN.; THE REVISED CO2 CONC.= 63.98108654 PERCENT

AT TIME=T+ 1 MIN.; THE REVISED CO2 CONC.= 63.72886366 PERCENT

AT TIME=T+ 1.2 MIN.; THE REVISED CO2 CONC.= 63.47763508 PERCENT

AT TIME=T+ 1.4 MIN.; THE REVISED CO2 CONC.= 63.22739688 PERCENT

AT TIME=T+ 1.6 MIN.; THE REVISED CO2 CONC.= 62.97814516 PERCENT

AT TIME=T+ 1.8 MIN.; THE REVISED CO2 CONC.= 62.72987602 PERCENT

AT TIME=T+ 2 MIN.; THE REVISED CO2 CONC.= 62.4825856 PERCENT

AT TIME=T+ 2.2 MIN.; THE REVISED CO2 CONC.= 62.23627003 PERCENT

AT TIME=T+ 2.4 MIN.; THE REVISED CO2 CONC.= 61.99092547 PERCENT

AT TIME=T+ 2.6 MIN.; THE REVISED CO2 CONC.= 61.7465481 PERCENT

AT TIME=T+ 2.8 MIN.; THE REVISED CO2 CONC.= 61.5031341 PERCENT

AT TIME=T+ 3 MIN.; THE REVISED CO2 CONC.= 61.26067967 PERCENT

AT TIME=T+ 3.2 MIN.; THE REVISED CO2 CONC.= 61.01918104 PERCENT

AT TIME=T+ 3.4 MIN.; THE REVISED CO2 CONC.= 60.77863443 PERCENT

AT TIME=T+ 3.6 MIN.; THE REVISED CO2 CONC.= 60.53903609 PERCENT

AT TIME=T+ 3.8 MIN.; THE REVISED CO2 CONC.= 60.30038228 PERCENT

AT TIME=T+ 4 MIN.; THE REVISED CO2 CONC.= 60.06266928 PERCENT

AT TIME=T+ 4.2 MIN.; THE REVISED CO2 CONC.= 59.82589337 PERCENT

AT TIME=T+ 4.4 MIN.; THE REVISED CO2 CONC.= 59.59005088 PERCENT

AT TIME=T+ 4.6 MIN.; THE REVISED CO2 CONC.= 59.35513811 PERCENT

AT TIME=T+ 4.8 MIN.; THE REVISED CO2 CONC.= 59.1211514 PERCENT

AT TIME=T+ 5 MIN.; THE REVISED CO2 CONC.= 58.8880871 PERCENT

AT TIME=T+ 5.2 MIN.; THE REVISED CO2 CONC.= 58.33594156 PERCENT

AT TIME=T+ 5.4 MIN.; THE REVISED CO2 CONC.= 58.4247112 PERCENT

AT TIME=T+ 5.6 MIN.; THE REVISED CO2 CONC.= 58.19439237 PERCENT

AT TIME=T+ 5.8 MIN.; THE REVISED CO2 CONC.= 57.96498149 PERCENT

AT TIME=T+ 6 MIN.; THE REVISED CO2 CONC.= 57.73647499 PERCENT

AT TIME=T+ 6.2 MIN.; THE REVISED CO2 CONC.= 57.50886929 PERCENT

AT TIME=T+ 6.4 MIN.; THE REVISED CO2 CONC.= 57.28216084 PERCENT

AT TIME=T+ 6.6 MIN.; THE REVISED CO2 CONC.= 57.05634612 PERCENT

AT TIME=T+ 6.8 MIN.; THE REVISED CO2 CONC.= 56.83142158 PERCENT

AT TIME=T+ 7 MIN.; THE REVISED CO2 CONC.= 56.60738374 PERCENT

AT TIME=T+ 7.2 MIN.; THE REVISED CO2 CONC.= 56.38422908 PERCENT

AT TIME=T+ 7.4 MIN.; THE REVISED CO2 CONC.= 56.16195413 PERCENT

AT TIME=T+ 7.6 MIN.; THE REVISED CO2 CONC.= 55.94055543 PERCENT

AT TIME=T+ 7.8 MIN.; THE REVISED CO2 CONC.= 55.72002951 PERCENT

AT TIME=T+ 8 MIN.; THE REVISED CO2 CONC.= 55.50037293 PERCENT

AT TIME=T+ 8.2 MIN.; THE REVISED CO2 CONC.= 55.28158227 PERCENT

AT TIME=T+ 8.4 MIN.; THE REVISED CO2 CONC.= 55.06365412 PERCENT

AT TIME=T+ 8.6 MIN.; THE REVISED CO2 CONC.= 54.84656508 PERCENT

AT TIME=T+ 8.8 MIN.; THE REVISED CO2 CONC.= 54.63037175 PERCENT

AT TIME=T+ 9 MIN.; THE REVISED CO2 CONC.= 54.41501077 PERCENT

AT TIME=T+ 9.2 MIN.; THE REVISED CO2 CONC.= 54.20049877 PERCENT

AT TIME=T+ 9.4 MIN.; THE REVISED CO2 CONC.= 53.98683241 PERCENT

AT TIME=T+ 9.6 MIN.; THE REVISED CO2 CONC.= 53.77400835 PERCENT

AT TIME=T+ 9.8 MIN.; THE REVISED CO2 CONC.= 53.56202328 PERCENT

AT TIME=T+ 10 MIN.; THE REVISED CO2 CONC.= 53.35087388 PERCENT

AT TIME=T+ 10.2 MIN.; THE REVISED CO2 CONC.= 53.14055687 PERCENT

AT TIME=T+ 10.4 MIN.; THE REVISED CO2 CONC.= 52.93106895 PERCENT

AT TIME=T+ 10.6 MIN.; THE REVISED CO2 CONC.= 52.72240687 PERCENT

AT TIME=T+ 10.8 MIN.; THE REVISED CO2 CONC.= 52.51456737 PERCENT

AT TIME=T+ 11 MIN.; THE REVISED CO2 CONC.= 52.3075472 PERCENT

AT TIME=T+ 11.2 MIN.; THE REVISED CO2 CONC.= 52.10134313 PERCENT

AT TIME=T+ 11.4 MIN.; THE REVISED CO2 CONC.= 51.89595195 PERCENT

AT TIME=T+ 11.6 MIN.; THE REVISED CO2 CONC.= 51.69137046 PERCENT

AT TIME=T+ 12 MIN.; THE REVISED CO2 CONC.= 51.28462375 PERCENT

AT TIME=T+ 12.2 MIN.; THE REVISED CO2 CONC.= 51.0824522 PERCENT

AT TIME=T+ 12.4 MIN.; THE REVISED CO2 CONC.= 50.88107764 PERCENT

AT TIME=T+ 12.6 MIN.; THE REVISED CO2 CONC.= 50.68049693 PERCENT

AT TIME=T+ 12.8 MIN.; THE REVISED CO2 CONC.= 50.48070693 PERCENT

AT TIME=T+ 13 MIN.; THE REVISED CO2 CONC.= 50.28170454 PERCENT

AT TIME=T+ 13.2 MIN.; THE REVISED CO2 CONC.= 50.08348665 PERCENT

AT TIME=T+ 13.4 MIN.; THE REVISED CO2 CONC.= 49.88605016 PERCENT

AT TIME=T+ 13.6 MIN.; THE REVISED CO2 CONC.= 49.68939199 PERCENT

AT TIME=T+ 13.8 MIN.; THE REVISED CO2 CONC.= 49.49350907 PERCENT

AT TIME=T+ 14 MIN.; THE REVISED CO2 CONC.= 49.29839836 PERCENT

AT TIME=T+ 14.2 MIN.; THE REVISED CO2 CONC.= 49.1040568 PERCENT

AT TIME=T+ 14.4 MIN.; THE REVISED CO2 CONC.= 48.91048137 PERCENT

AT TIME=T+ 14.6 MIN.; THE REVISED CO2 CONC.= 48.71766904 PERCENT

AT TIME=T+ 14.8 MIN.; THE REVISED CO2 CONC.= 48.5256168 PERCENT

AT TIME=T+ 15 MIN.; THE REVISED CO2 CONC.= 48.33432166 PERCENT

AT TIME=T+ 15.2 MIN.; THE REVISED CO2 CONC.= 48.14378064 PERCENT

AT TIME=T+ 15.4 MIN.; THE REVISED CO2 CONC.= 47.95399075 PERCENT

AT TIME=T+ 15.6 MIN.; THE REVISED CO2 CONC.= 47.76494905 PERCENT

AT TIME=T+ 15.8 MIN.; THE REVISED CO2 CONC.= 47.57665257 PERCENT

AT TIME=T+ 16 MIN.; THE REVISED CO2 CONC.= 47.38909839 PERCENT

AT TIME=T+ 16.2 MIN.; THE REVISED CO2 CONC.= 47.20228358 PERCENT

AT TIME=T+ 16.4 MIN.; THE REVISED CO2 CONC.= 47.01620521 PERCENT

AT TIME=T+ 16.6 MIN.; THE REVISED CO2 CONC.= 46.8308604 PERCENT

AT TIME=T+ 16.8 MIN.; THE REVISED CO2 CONC.= 46.64624624 PERCENT

AT TIME=T+ 17 MIN.; THE REVISED CO2 CONC.= 46.46235985 PERCENT

AT TIME=T+ 17.2 MIN.; THE REVISED CO2 CONC.= 46.27919838 PERCENT

AT TIME=T+ 17.4 MIN.; THE REVISED CO2 CONC.= 46.09675895 PERCENT

AT TIME=T+ 17.6 MIN.; THE REVISED CO2 CONC.= 45.91503873 PERCENT

AT TIME=T+ 17.8 MIN.; THE REVISED CO2 CONC.= 45.73403487 PERCENT

AT TIME=T+ 18 MIN.; THE REVISED CO2 CONC.= 45.55374456 PERCENT

AT TIME=T+ 18.2 MIN.; THE REVISED CO2 CONC.= 45.37416498 PERCENT

AT TIME=T+ 18.6 MIN.; THE REVISED CO2 CONC.= 45.01712682 PERCENT

AT TIME=T+ 18.8 MIN.; THE REVISED CO2 CONC.= 44.83966267 PERCENT

AT TIME=T+ 19 MIN.; THE REVISED CO2 CONC.= 44.6628981 PERCENT

AT TIME=T+ 19.2 MIN.; THE REVISED CO2 CONC.= 44.48683037 PERCENT

AT TIME=T+ 19.4 MIN.; THE REVISED CO2 CONC.= 44.31145672 PERCENT

AT TIME=T+ 19.6 MIN.; THE REVISED CO2 CONC.= 44.13677443 PERCENT

AT TIME=T+ 19.8 MIN.; THE REVISED CO2 CONC.= 43.96278075 PERCENT

AT TIME=T+ 20 MIN.; THE REVISED CO2 CONC.= 43.78947298 PERCENT

REFERENCES

1 NFPA No. 12, 1973 edition, Standard on Carbon Dioxide Extinguishing Systems

2 NFPA No. 12, 1985 edition, Standard on Carbon Dioxide Extinguishing Systems

3 NFPA No. 12, 1989 edition, Standard on Carbon Dioxide Extinguishing Systems

4 NFPA No. 12A, 1989 edition, App. B, Enclosure Integrity Test Procedure

5 "Enclosure Integrity Procedure for Halon 1301 Total Flooding Fire Suppression Systems", January 10, 1989, Edited by Casey C. Grant, P.E.

6 "Cardox" Fire Extinguishing Equipment Operation and Service Manual

7 PDCR 79-06; Switchgear/Cable Vault Suppression Systems

8 "Cardox" High Pressure Carbon Dioxide Flow Calculations dated 04-02-70

9 Letter, USNRC to VYNPC, NVY 89-108, dated 05-18-89

10 Letter, VYNPC to USNRC, BVY 89-52, dated 06-16-89

11 Letter, USNRC to VYNPC, NVY 89-172, dated 08-21-89

12 ASTM E 741-80, Standard Practice for Measuring Air Leakage Rate by the Tracer Dilution Method

13 Safety Evaluation Report, Supporting Ammendment No. 43 to Facility Operating License No. DPR-28, Vermont Yankee Nuclear Power Station, Docket No. 50-271.

14 "Chemical Engineers Handbook", Fifth Edition; 1973; Robert H. Perry, Consultant; pg. 4-20 to 4-23.

FACTORY INSURANCE ASSOCIATION
HARTFORD CHICAGO SAN FRANCISCO

Sheet 5
W. J. CIULEWICZ
ENGINEER

OFFICE
68 WOODLAND STREET
HARTFORD, CONN. 06105
(203) 525-5501

RESIDENCE
117 CONWAY STREET
SOUTH DEERFIELD, MASS. 01373
(413) 665-4031

OPERATION and SERVICE MANUAL

CARDOX®

fire extinguishing equipment...

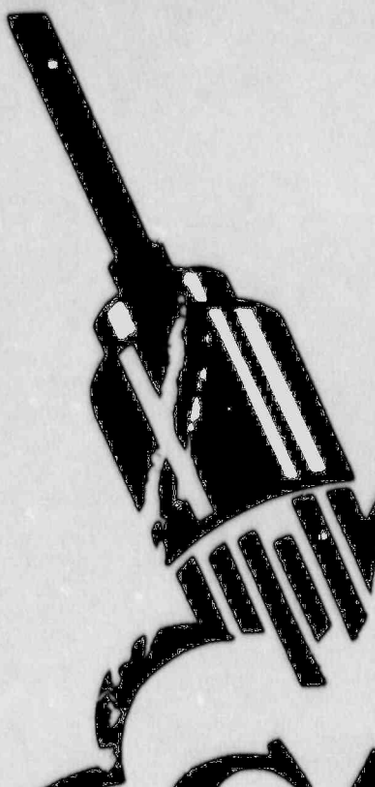
CHEMETRON CORPORATION CARDOX DIVISION • CHICAGO, ILLINOIS 60611 CHEMETRON

CARDOX FIRE EXTINGUISHING EQUIPMENT
INDEX OF PLATES

JOB	PLATE NO.	DESCRIPTION	
———	Folio 8-2	Cardox High Pressure Carbon Dioxide Fire System	
———	Folio 8-3	How to Specify Cardox Systems	
———	H-1	Typical System Arrangement Rate-of-Rise	
———	H-2	Typical System Arrangement Electric Thermostat	
———	H-3	Typical System Arrangement Pneumatic Dura-Speed	
———	H-4,5	Schematic Series 60 Single Hazard, Multiple Hazard	
		50-75 LB. CYLINDER RACKS	
———	H-9A	1 Row 1 Side	1 - 2 Cylinder
———	H-11,13	1 Row 1 Side	3 - 6 Cylinder & 7 -12 Cylinder
———	H-15,17	2 Row Back to Back	5 - 12 & 13 - 24 Cylinder
———	H-19,21	2 Row 1 Side	6 - 12 Cylinder & 14 - 24 Cylinder
———	H-22,24	Cylinder Clamping - Even Cylinder	
———	H-24A,24B	Cylinder Clamping - Odd Cylinder	
		100 LB. CYLINDER RACKS	
———	H-9B	1 Row 1 Side	1 - Cylinder
———	H-12,14	1 Row 1 Side	3 - 6 & 7 - 12 Cylinder
———	H-16,18	2 Row Back to Back	5 - 12 & 13 - 24 Cylinder
———	H-20,21A	2 Row 1 Side	6 - 12 & 14 - 24 Cylinder
———	H-23A,24C	Clamping	Even - Cylinder
———	H-24D,24E	Clamping	Odd - Cylinder
		STORAGE SECTION	
———	H-25	Beam Scale - 50 & 75 lb. Cylinder	
———	H-26A,27P	50 - 75 - 100 lb. Cylinder & Cylinder Valve With Parts	
———	H-29,30	Discharge Head Pressure Oper. Less Handwheel & With Handwheel	
———	H-31	1/2" Flexible Connector	
———	H-35,34A	Discharge Head Pilot Operated W/HW & Without Handwheel	
		PILOTING SECTION	
———	H-36,36A	Pilot Connection Kit Dual - Single	
———	H-38	1/4" Shuttle Valve	
———	H-39,39A	Switch Valve - Main to Reserve & Mounting Details	
———	H-40,40F	Control Cabinet Series 64 & Servicing Details	
———	H-40B,40E	Actuator Valve & Solenoid Actuator Assembly	
———	40G	Actuator Valve Mounting Detail	
———	H-40H,40J	Control Cabinet Series 64 (NITROGEN) and Servicing Details	
———	H-41,41A	10 lb. Control Cylinder & 5 lb. Control Cylinder	
———	H-42,42AA	Ermeto Fitting Assembly Instructions & Tubing-Fittings Listings	

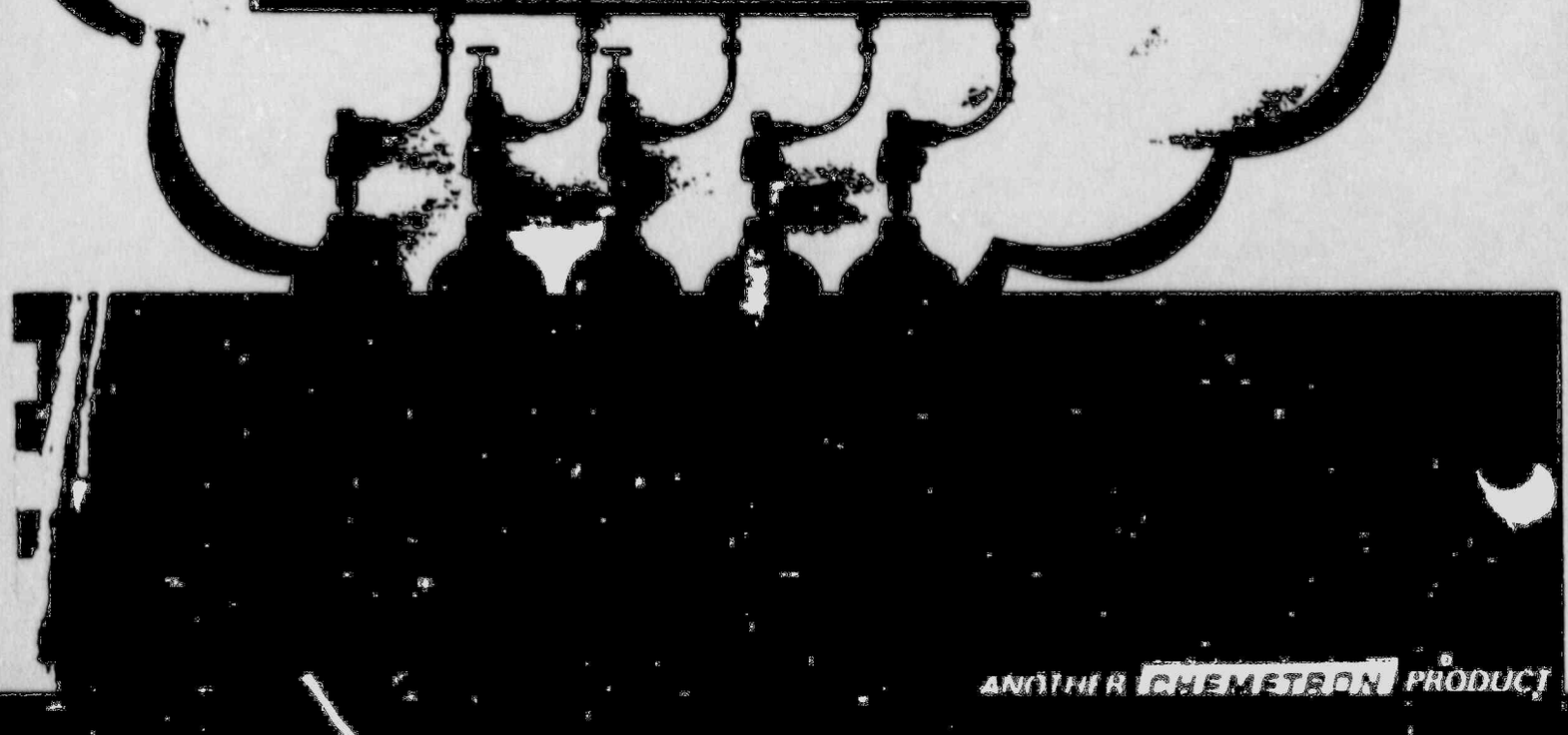
JOB	PLATE NO.	DESCRIPTION
		ACTUATION SECTION
———	H-43-44	Electric Thermostat & Cardox Smoke Detector
———	H-43A,43B	Rate-of-Rise Release & Installation
———	H-43C	Mercury Check
———	H-46	Pushbutton Station - Electric
———	H-47	Solenoid Valve
———	H-48	Pneumatic Remote Manuel
		NOZZLE
———	H-50,50A	Spot Nozzle and Flange Mounting Kit
———	H-50C	Seal Cap - Metal
———	H-50D	Tankside Nozzle
———	H-51,52	Orifice Nozzle & Total Flood Nozzle
———	H-52A	Wide Angle Nozzle (Total Flood)
		VALVES
———	H-53B,53C	1/4" Pilot Control Valve Pneumatic Lock and Pilot Control Valve Mounting Detail
———	H-54,54A	1" - 2" & 1/2", 3/4" Selector Valve
———	H-54B	Master Selector Valve 1/2" & 3/4"
———	H-55,56	Hi-Flow Check Valve 1/2" - 2" & Bleeder Valve
———	H-57A	Frangible Disc Relief
		MISCELLANEOUS MECHANICAL & ELECTRICAL EQUIPMENT
———	H-58	Pressure Release
———	H-59	4-Pole Pressure Switch - Weatherproof
———	H-59A,59B	4 & 2-Pole Pressure Switch - Explosion-proof
———	H-60,61	Pneumatic Discharge Delay & Valve Detail
———	H-62A	CO_2 Whistle
		HOSEREEL/RACKS
———	H-64,65	Hosereel Mounting and Hoserack Mounting
		SPECIFICATIONS
———	H-70	Mechanical & Electrical Installation
———	H-72	Installation, Inspection & Test
———	H-4HP	Field Test Report
———	AET-60	Electric Specifications
———	APR-60	Rate-of-Rise Specifications

Double Plate Numbers Indicate Printing Both Sides
Plate Numbers Checked are Included in Partial Sets



CARDOX®

high-pressure
carbon dioxide
fire extinguishing
systems



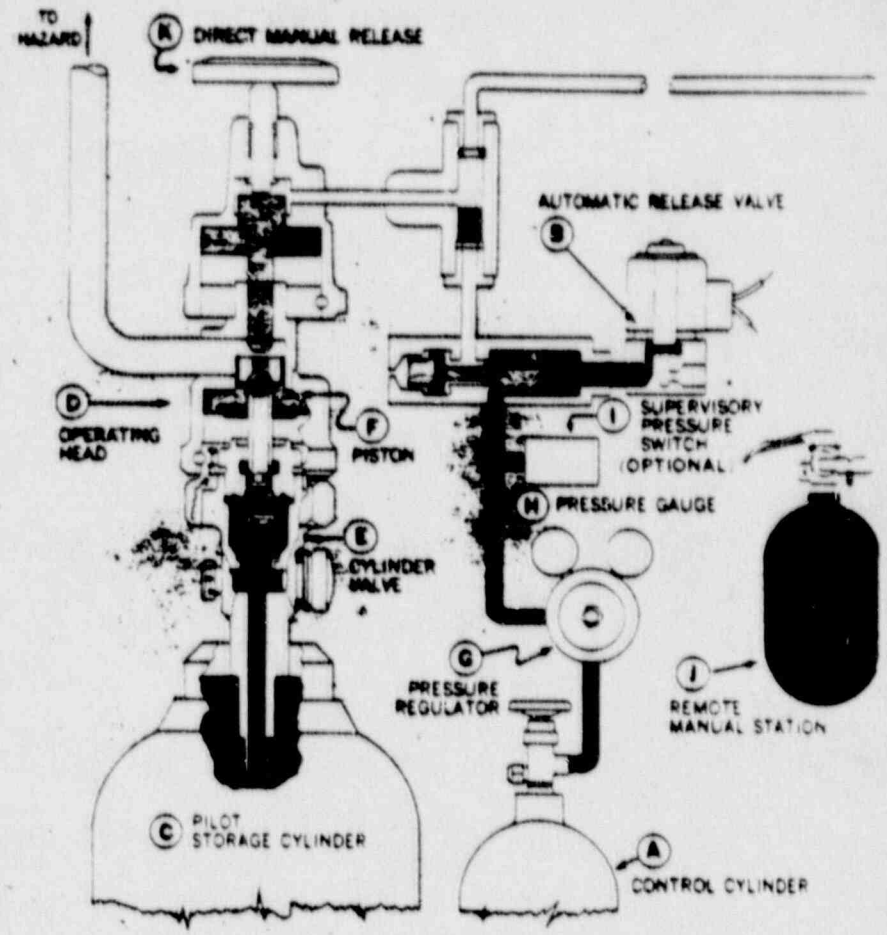
HOW THE CARDOX® HIGH-PRESSURE SYSTEM WORKS

The CARDOX High-Pressure System operates on efficient pneumatic principles. Pressure is used to open valves, release doors and dampers, and to operate switches and accessories. Operating pressures are multiplied by large pistons to give safety factors of more than 10 to 1. No cables, pulleys, equalizers or falling weights are used in the CARDOX System. Operating parts are located internally, thus eliminating the need for bulky protective cages. CARDOX Systems can be independent of external electric power sources.

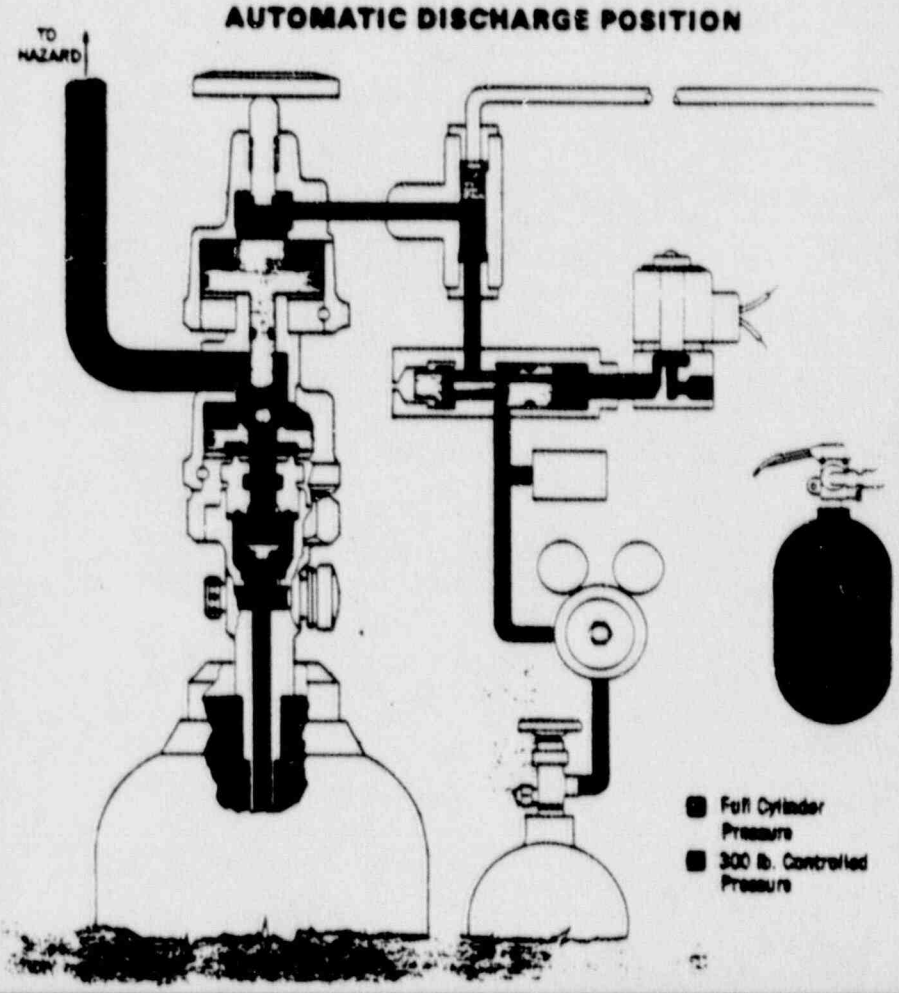
The typical CARDOX System has three independent means of actuation . . .

AUTOMATIC
REMOTE MANUAL
DIRECT MANUAL

STANDBY POSITION



AUTOMATIC DISCHARGE POSITION

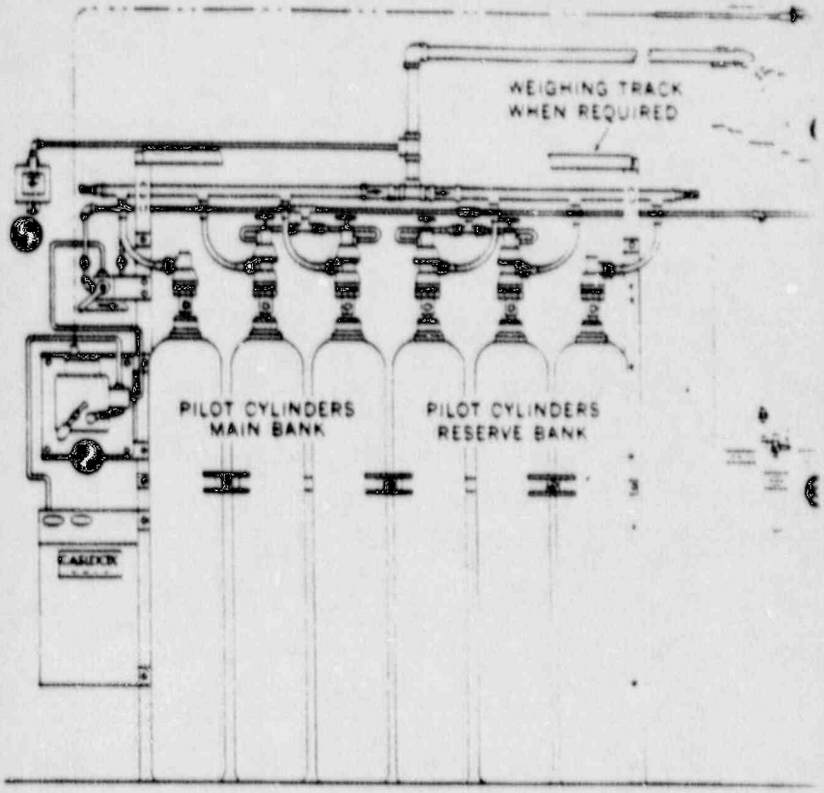


THE [illegible] OF [illegible] DIOXIDE FOR FIRE PROTECTION

NONCONDUCTOR. [illegible] dioxide [illegible] on high voltage [illegible] without danger or [illegible]

ADAPTABILITY. [illegible] for a wide range of [illegible] materials involving both surface and deep-seated fires—small or large, indoors or outdoors.

TYPICAL CARDOX HIGH-PRESSURE SYSTEM LAYOU



MAJOR COMPONENTS

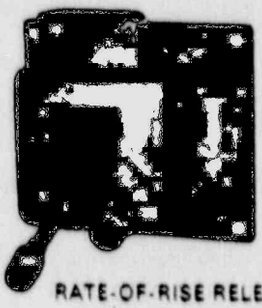
1

ELECTRIC THERMOSTAT

FUSIBLE HEAD FUSE

HEAT ACTUATED DE

2

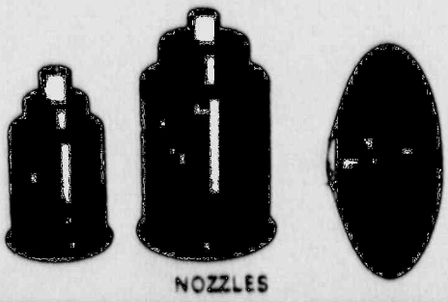


RATE-OF-RISE RELEASE

4

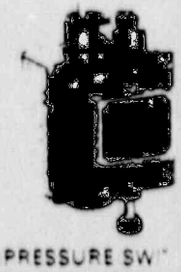
REMOTE MANUAL STATIC

3



NOZZLES

5



PRESSURE SW

PERFORMANCE ENGINEERING THE CARDOX WAY

METHODS (

AUTOMATIC ACTUATION is powered by a cylinder **A** of carbon dioxide entirely separate from the fire extinguishing supply, as shown in the diagram. Carbon dioxide vapor under 300 psig regulated pressure is supplied continuously to a normally closed automatic release valve, **B**. This valve is connected to detection devices in the hazard area through a separate circuit of tubing or wiring, depending on whether rate-of-rise or electrical detectors are used. A signal from a detector will cause the release valve to open. 300 psig carbon dioxide vapor then is delivered to operating head **D** of pilot cylinder **C** to start discharge into the manifold. Manifold pressure then operates all other connected heads. These are self-energizing and hold the cylinder valves **E** open while the system discharges completely.

10 to 1 SAFETY FACTOR. The pistons **F** of all cylinder discharge heads have an operating ratio of more than 10 to 1, so that a cylinder at a pressure of 2,300 psig (at 130°F.) can be opened by a piston pressure of 230 psig.

Control pressure of 300 psig is maintained automatically through the pressure regulator **G** in the control center. It requires an average of two ounces of carbon dioxide to actuate a system . . . the control cylinder has a capacity of five pounds.

SUPERVISED CONTROL PRESSURE. Control pressure availability is visually supervised by an indicating pressure gauge **H.** Additional supervision is available when specified from gauge contacts **I** connected to a trouble alarm. The alarm will signal if pressure falls to 275 psig while there is still sufficient reserve to actuate the system. These novel monitoring features foster reliance in the readiness of the system to operate and help keep plant personnel aware that the protection is there to be used.

METHODS OF DETECTION—Pneumatic Rate of Rise. The expansion of air in the heat-actu-

CARDOX SERVICE

Cardox maintains supply depots in strategic locations to provide its fire protection and industrial users with trouble-free, worry-free service. Through its own large fleet of transport trucks and railway cars, Cardox can supply its customers with pounds or tons of carbon dioxide whenever it's needed.

Cardox has an organization of installation supervisors and field service engineers available for any location.

Also, Cardox has an extensive and highly trained engineering staff ready and able to appraise all fire hazards. They can advise on how vulnerable it is and what is the best method of safeguarding it. All Cardox systems are "Performance Engineered" for the hazard involved.

This is another BIG Cardox "extra" at no extra cost.

CARDOX® L(

OF ACTUATION

ated devices (H.A.D.) is multiplied by a diaphragm to trip a latch and open the Release valve (at B) causing discharge. External power is not required.

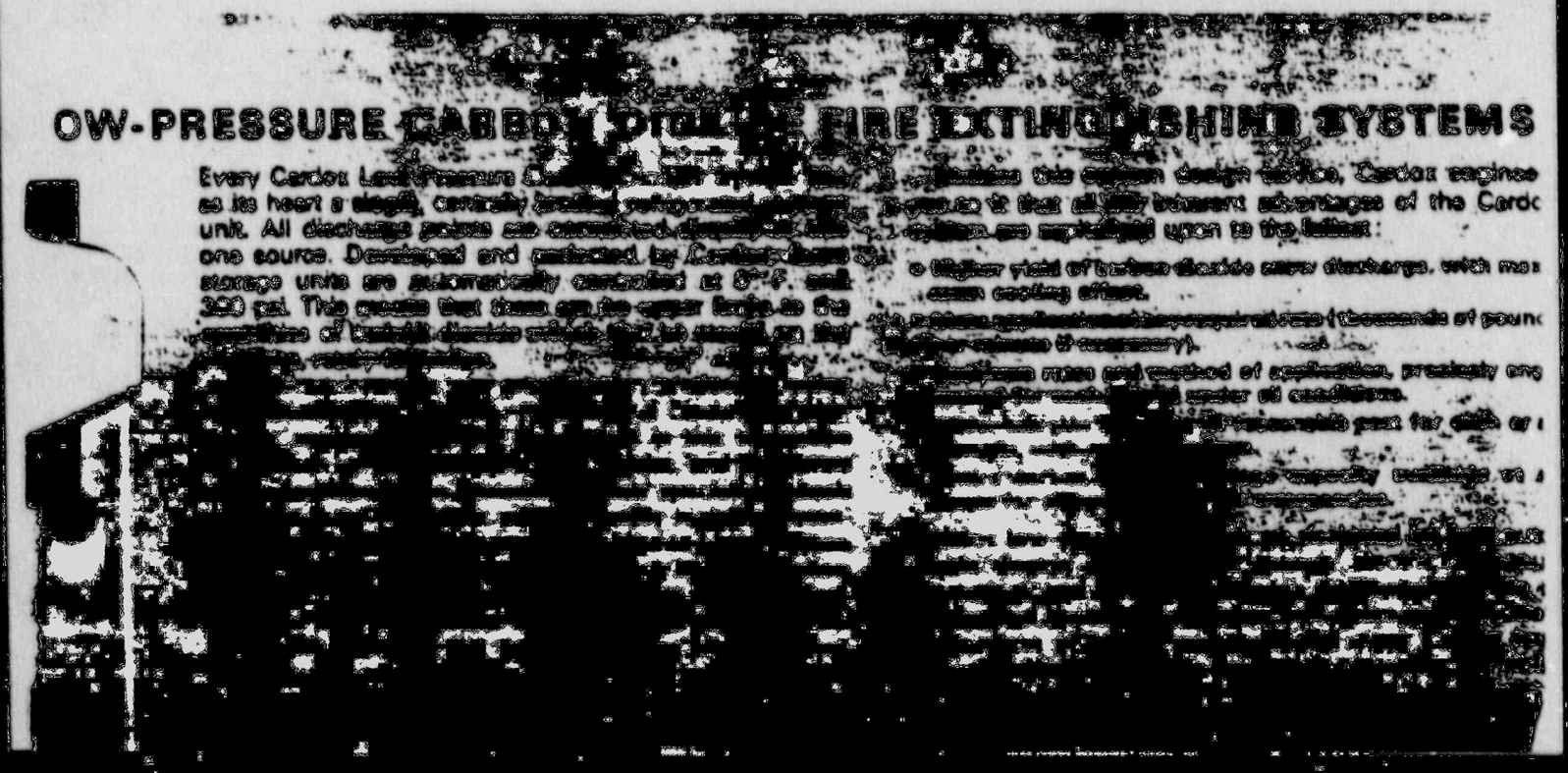
Electrical Heat or Smoke Detection. A solenoid-operated valve (at B) is released by an electric heat or smoke detector causing system discharge.

Fixed Temperature Fusible Head. Fusible heads located in or over the hazard and connected to the release valve by gas-tight tubing can be used. Melting of the fusible latch releases the pilot pressure and causes system discharge. ***The advantage of the Cardox Fusible System is the constant supervision of the detection line as well as the system control pressure.***

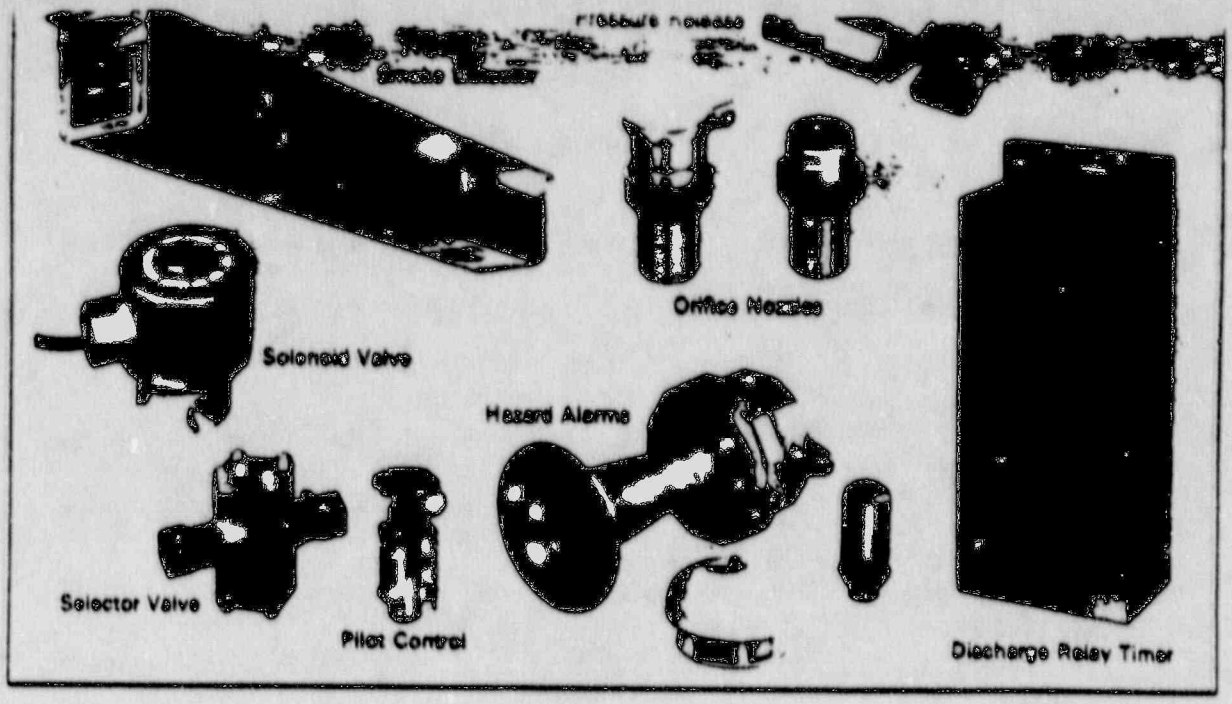
REMOTE MANUAL ACTUATION also is performed with pressure from a self-contained supply entirely independent of any other means of actuation or external power. A small cylinder of carbon dioxide located near the hazard or other spot remote from the cylinder bank connected with ¼" pipe to the pilot cylinder.

Momentary hand operation releases enough carbon dioxide to pressurize the pilot head to initiate discharge. As the pressure in the release cylinder is substantially higher than 300 psi the 10 to 1 operating ratio of the pilot cylinder discharge head assures instantaneous release. ***There are no cables to stretch or bind, and no equalizers or other adjustments.***

DIRECT MANUAL ACTUATION of the system is done by handwheel K at the cylinder bank. An easy partial turn of the wheel is sufficient to "crack" the cylinder valve and release pressure to cause full opening and complete discharge of the system. The handwheel is compact and not subject to accidental operation. Long levers, cables or weights are not used. Actuation is mechanical and direct, and entirely independent of all other means.



OW-PRESSURE CARBON DIOXIDE FIRE EXTINGUISHING SYSTEMS



OPTIONAL COMPONENTS

DELAYED DISCHARGE. Delayed discharge may be included as a personnel safety feature, usually for systems to flood large rooms. Generally, this feature affects only the automatic release and delays discharge long enough for the space to be evacuated. An alarm gives a clear warning of impending discharge as soon as a detector signals fire. Remote and direct manual releases bypass the delay to cause immediate discharge. ***This arrangement results in a cylinder manifold clear of stop valves which must be actuated by auxiliary controls for immediate discharge.*** (In special instances, it may be desirable to impose the delay on the manual releases as well, in which case a stop valve is included in the manifold.)

The discharge delay timer consists of a pilot-operated valve and accumulator designed for 300-1,000 psig working pressures. A needle valve controls the timing which is adjustable between 5 and 90 seconds. Longer delays are possible with larger accumulators, but are seldom required.

RESERVE BANKS. Reserve banks of cylinders provide continued protection while the main bank is being serviced after discharge or during routine inspection. They also provide a second shot if needed. There is a choice of methods for actuating the reserve. A manually operated switching valve is included in the automatic release circuit. Its lever is moved to "Reserve" after the control system has been reset.

Remote manual actuation is the same as for the main bank, using a duplicate release near the hazard. Similarly, the reserve bank pilot cylinders have handwheels for direct manual actuation.

The cylinder manifold is separated into two sections with full flow check valves. Each end of the manifold has a bleeder valve to prevent accidental leakage from pressurizing the idle bank. This valve will close if the manifold section pressure exceeds 20 psig, as during discharge.

Main and reserve banks perform identical functions in CARDOX Systems.

MULTIPLE HAZARDS. Multiple hazards may be protected from a common supply by the use of the pneumatic selector, or directional valves. This is essentially an economy measure to be used only if there is strong assurance that only one hazard may be involved at any one time.

Similar controls are provided for each hazard. Selector valves are pilot controlled and operated by line pressure. The pilot control is actuated by pressure from the automatic and remote manual releases. Feedback from the delivery side locks the control open pneumatically until discharge is complete and the actuating system is reset. ***The selector valve then closes automatically. The automatic reset feature eliminates the danger of splitting discharge with another hazard as could occur if the selector valve control always had to be reset manually.*** The pilot control also has a direct manual operator. The pilot control is separate from the selector valve and can be installed at any convenient location.

Multiple hazard systems usually include reserve banks. In CARDOX Systems the manual and automatic controls perform duplicate functions so that either bank may be set off first.

CARDOX DIVISION OF CHEMETRON CORPORATION CHEMETRON
840 N. Michigan Avenue, Chicago, Illinois 60611

CARDOX® FIRE EXTINGUISHING EQUIPMENT

How to Specify HIGH PRESSURE CARBON DIOXIDE SYSTEMS HIGH PRESSURE HAND HOSE LINE SYSTEMS PORTABLE FIRE EXTINGUISHERS

1. The following guide specifications offer a number of choices. The specification writer should select those which best suit the situation by deleting items in parentheses which are not required.
2. The specifications basically describe function so that bidders will understand what is needed and why.
3. A number of paragraphs describe functions and arrangements which can best be provided by Cardox systems. Some of these features are exclusive with Cardox "Performance Engineered" systems and their superiority is obvious.

EXAMPLES

III B.—The operating ratio of 10:1 is the highest in the industry and assures reliable and fast release of carbon dioxide from cylinders. The handwheel operator, unlike a lever, is compact and is not subject to accidental operation. The resilient seal of the operating piston on the cylinder valve permits hand tight connections.

III E 1.—The Cardox Smoke Detector is described. It is considered to be the finest of its type and, where it serves the purpose, a good investment.

This paragraph also requires that automatic actuation shall be powered from a separate monitored pneumatic supply. This feature, pioneered by Cardox, is an obvious improvement over drop weights. It increases the reliability of automatic actuation and permits *entirely independent* means of manual actuation, the only modern system with this feature.

III E 2.—This paragraph emphasizes the advantages of the Cardox pneumatic remote release, including the elimination of cables, pulleys and weights, and in providing duplicate functions for main and reserve banks.

III F.—The section on selector valves is descriptive of Cardox systems in that the release of the selector valve pilot operator is performed pneumatically and the pilot operator is self-resetting after automatic or remote manual release. The pilot operator and selector valve may be located together at the hazard or cylinder storage or they may be widely separated. The latter is a distinctive Cardox system advantage.

III G 1.—The Cardox discharge delay normally is installed in the automatic control line so that it is entirely by-passed by manual releases. This feature eliminates the need for a stop valve in the cylinder header and auxiliary by-pass controls which tend to impede flow and complicate the control system.

4. Should circumstances dictate preference for a less complete specification, Sections I, II, IV, VI and VII might suffice. The risk in a condensed specification is that it indicates willingness to accept a minimum system. Such systems may constitute an expense but not necessarily an investment in reliable fire protection.

• • • • •

I. SCOPE: This specification covers a high pressure carbon dioxide fire extinguishing system for protection of the following hazard(s):

Describe the hazard(s), giving

A. Name and location
B. Dimensions (refer to drawings and provide)
C. Nature of combustible materials involved.

II. FEATURES: The system shall be designed in accordance with requirements of National Board of Fire Underwriters Pamphlet No. 12 and the insurance carrier (Specify Factory Insurance Association, Associated Factory Mutual Fire Insurance Companies, etc.) and shall provide the following principal features:

A. Automatic detection and release by (fixed temperature electric thermostat) (smoke detector) (pneumatic rate-of-rise).
B. Remote manual actuation by a pneumatic release that operates directly on pilot discharge heads and is *entirely independent* of automatic releases.
C. Direct manual actuation at the cylinder bank.
D. A connected reserve bank of cylinders duplicating all functions of the main bank.
E. Hazard alarm.
F. Delayed discharge for ( ) seconds after automatic release only.
G. Pressure switch shut-down of electrical equipment. (Fans, conveyors, paint or fuel pumps, mixers, etc.)
H. Pressure release. (Doors, windows, dampers, louvers, and fuel supply valves.)
I. System must be operable Automatically (II A), Remote Manually (II B) and Direct Manually (II C) without any dropping weights or pull cables.

III. DETAILS:

A. **CYLINDERS:** Cylinder assemblies shall be of 75-pound capacity at 68 percent filling density and shall conform to regulations of the Interstate Commerce Commission. Cylinders shall be fitted with a resilient pressure seat type valve and shall have a threaded steel cap for physical protection of the valve during handling and shipment. Cylinders shall be stored in steel racks designed to hold the cylinders securely in an upright position with clamps or straps. Rack uprights (for systems of 3 or more cylinders) shall also be

designed to support the pipe manifold connecting the cylinders. The uprights shall be spanned with a bar to support a portable weighing device, when specified. The arrangement of cylinders in the rack shall be such as to require the least floor space, including service aisles.

B. DISCHARGE HEADS: Each cylinder shall be fitted with a swivel joint pressure-operated discharge head. Each head shall include an integral check valve to prevent major loss of carbon dioxide during system discharge if the cylinder is disconnected. Heads on pilot cylinders shall incorporate a piston to be operated by pressure from the automatic and remote manual releases. The ratio of piston area to cylinder valve seat area shall be not less than 10:1. Pilot heads shall also include a direct manual handwheel operator not subject to accidental release by falling weights. Handwheels shall be locked in inactive position with pin and seal wire. The swivel joint for connecting all heads to cylinder valves shall be designed for hand-tight make up. The gas seal shall be made by a resilient insert of the operating piston on the top of the cylinder valve to eliminate the use of gaskets.

C. FLEXIBLE CONNECTORS: Each discharge head shall be connected to the manifold with metal braid-reinforced flexible metal hose with ½-inch bore. One end shall have a union joint for easy connection to the discharge head without causing twist in the hose.

D. MANIFOLD: The manifold shall be fabricated of galvanized pipe and fittings. Tees with ½-inch branches shall be spaced on 10-inch centers for cylinder connections. Pipe in sizes through ¾-inch shall be standard weight (schedule 40) steel and in sizes over ¾-inch extra heavy (schedule 80) steel. Standard malleable iron banded fittings shall be used up through ¾-inch, extra heavy malleable iron fittings through 2-inch and forged steel fittings in larger sizes. (Manifold sections serving main and reserve banks, respectively, shall be separated with check valves. Each section shall also include means for venting small accidental back leakage through a check valve that might set off the idle bank. The vent shall close automatically when the section is discharging to prevent loss of gas.) (For selector valve systems add: "A pressure relief device shall be provided in a common section of piping and shall be designed to operate between 2400 and 3000 psi.")

E. CONTROLS:

1. AUTOMATIC: (*For Electric Thermostat Detection*—The system shall be released automatically if the temperature in the hazard reaches the thermostat setting. Closing of the normally-open switch element in a thermostat shall cause opening of a normally-deenergized, normally-closed solenoid valve to admit control pressure to the pilot cylinder discharge heads.)

(*For Pneumatic Rate-of-Rise Detection*—The system shall be released automatically if the temperature in the hazard increases faster than the pneumatic rate-of-rise release setting. Operation of the release shall cause opening of a valve to admit control pressure to the pilot cylinder discharge heads.)

(*For Smoke Detection*—The system shall be released automatically if the smoke content of the room reaches a predetermined level. The smoke detector shall be a two-stage device, with the second operating at twice the obscurity level of the first. The first stage shall be connected to a trouble alarm. The second stage shall actuate the system. The smoke detector shall include a fixed temperature electric thermostat which will detect the fire if heat intensity builds up faster than smoke density. The smoke detector shall include a trouble circuit which will indicate power failure. Actuation of the second stage or of the thermostat shall cause opening of a normally-deenergized, normally-closed solenoid valve to admit control pressure to the pilot cylinder discharge heads.)

(A manually-operated pneumatic switching valve shall be provided for diversion of released control pressure to the pilot cylinders of the reserve bank after discharge of the main bank.)

Control pressure shall be contained in a small cylinder separate from the main storage and shall be continuously monitored.

2. REMOTE MANUAL: A pneumatic remote manual release shall be located accessibly near the hazard and piped to the pilot cylinders. Cables and weights shall not be used. The release shall consist essentially of a small cylinder of carbon dioxide with siphon tube and manually-operated valve. The valve, when operated, shall admit carbon dioxide through a shuttle valve to the pilot cylinder discharge heads. (A second release shall be provided for the reserve bank. Main and reserve bank releases shall perform similar functions and shall be direct and independent of the automatic release.) (Where selector valves are involved, it shall be possible to open the valve by operation of either release.)

3. DIRECT MANUAL: Pilot cylinder discharge heads shall be fitted with handwheel manual operators. (In systems with selector valves the pilot operators for the valves shall also be fitted with manual operators.)

F. DISTRIBUTION SYSTEM: The carbon dioxide shall be discharged through nozzles in the hazard. The nozzles shall be sized and located to provide the rates of discharge and coverage needed to extinguish the fire. The size of pipe and nozzles shall be determined on the basis of calculated flow and terminal pressures. Flow charts and nozzle data shall be in accordance with standards

approved by Underwriters' Laboratories and Factory Mutual Engineering Division. Nozzles shall be fabricated of corrosion-resistant materials or shall be finished with a protective coating. Nozzles in which the horn, or shell, and orifice piece are separate elements shall be designed so that the orifice piece is connected directly to the supply pipe. Separate orifice plates, which can be accidentally left out without being readily noticed, shall not be used.

(For selector valve systems, add—Systems protecting more than one hazard selectively shall have a pilot-operated valve for each hazard in the distribution piping. Pilot operators shall be pneumatic and shall have an operating ratio of at least 4:1. They shall be designed to be actuated pneumatically by either the automatic or the remote manual release or by direct manual operator to pass line pressure to the piston chamber of the selector valve. The discharge from the pilot operator shall also feed back through a shuttle valve to the head of the pilot operator to lock it open until discharge is complete. Resetting the control system shall cause the selector valve to close automatically. Operators which need to be reset manually and, if overlooked, could split the discharge into several hazards simultaneously, shall not be provided. Selector valves shall be opened equally by main and reserve bank automatic and remote manual control regardless of order of release.

G. ACCESSORIES:

1. DISCHARGE DELAY: The system shall include an adjustable pneumatic timing device, consisting essentially of a differential valve and accumulator, to delay discharge for ( ) seconds after operation of the automatic release only. The timer shall not delay manual releases.
2. PRESSURE SWITCH: The system shall include ( ) normally-open and ( ) normally-closed contacts to control the following equipment:

   (List all items and give power characteristics. Also indicate whether switches shall be designed for standard, weatherproof or explosionproof service. Include hazard alarms as items.)

   Switches shall be heavy duty double-pole, single-throw, two to a unit. The assembly shall include a manual operator for start and reset. Pressure switches shall be installed in the distribution piping in such manner as to assure operation under all means of system release, unless otherwise specified.
3. PRESSURE RELEASE: The system shall include ( ) pressure trips to release (List the number of dampers, doors, windows, louvers, lids and valves to be operated. List separately those which require up to 25-pound pull and those which need more). The release shall consist essentially of a stainless steel cylinder and piston with a spring clip arranged for a perpendicular pull.
4. HAZARD ALARM: The system shall include an alarm of outstanding sound level and distinctive tone to announce discharge in the hazard. The alarm shall be connected to the pressure switch which shall be arranged to be actuated by all means of release. (Indicate whether alarm is for standard, weatherproof or explosionproof service.)
5. PORTABLE SCALE: A portable direct-reading beam scale assembly shall be provided to permit weighing cylinders in place by loosening cylinder clamps and disconnecting the discharge head of the cylinder being weighed. It shall not be necessary to disconnect any control connections. The storage rack shall include a track to support the scale.
6. SHUT-OFF VALVE: The system shall include a normally-open (solenoid-operated) (weight-operated) valve in the (identify fuel or other material to be shut down, size of pipe, pressure and temperature) supply line. The valve shall close when the system discharges.

IV. INSTALLATION: Materials and labor to install the system shall be provided as follows:

	PURCHASER	SELLER
Mechanical	☐	☐
Electrical	☐	☐
Painting	☐	☐

A. MECHANICAL INSTALLATION shall include setting up and mounting all system equipment connected to the piping; pipe and fittings, including necessary hangers and brackets, and all non-electrical elements of the control system in accordance with the seller's installation instructions. In all instances Purchaser shall provide the material and labor to connect system pressure releases to doors, dampers, etc., being released. Trenching, tunneling, filling, breaking and cutting through walls, floors, etc., shall be performed by (Purchaser) (Seller).

B. ELECTRICAL INSTALLATION shall include mounting electrical components and connecting with wire and conduit to system switches and valves in accordance with Seller's installation instructions. In all instances Purchaser shall provide reliable electrical power into a Purchaser-Supplied fusible disconnect switch or circuit breaker and shall connect system pressure switches to Purchaser's equipment being controlled.

V. INSTRUCTIONS: The system shall include permanent type nameplates and condensed instruction plates to identify the system and instruct in its use under emergency conditions. ( ) copies of operating and maintenance instructions shall be provided.

VI. ACCEPTANCE TESTS: Seller shall provide a technician to inspect the completed installation and to

supervise the acceptance test. Seller shall be entitled to two weeks' advance notice of the test date. Tests shall include (complete discharge into each hazard, with instrumented concentrated readings) (complete discharge into each hazard with visual observation of distribution) ("puff" discharge of sufficient cylinders, as determined by Seller to check function of pressure-operated devices and to determine if discharge openings are unobstructed). The number of recharges necessary to restore the system to full capacity after tests shall be provided by (Seller) (Purchaser). Purchaser shall be responsible for all costs of repeat acceptance tests.

VII. SERVICE CONTRACT: The system shall be inspected (semi-annually) (annually) under a service contract with Seller's authorized representative. A weight check shall be made of all cylinders and a "puff" discharge test performed to determine readiness to perform. Recommendations shall be made to Purchaser for any corrections needed.

VIII. EXCEPTIONS: Any exceptions to these specifications shall be clearly spelled out in bid and will be subject to approval.

HAND HOSE LINES

I. SCOPE: This specification covers a high pressure hand hose line carbon dioxide fire extinguishing system for protection of the following hazard(s):

A. Name and location.
B. Dimensions (refer to drawings and provide).
C. Nature of combustible materials involved.

II. FEATURES: The system shall be designed in accordance with requirements of National Board of Fire Underwriters Pamphlet No. 12 and the insurance carrier (Specify Factory Insurance Association, Associated Factory Mutual Fire Insurance Companies, etc.) and shall provide the following principal features:

A. Direct manual actuation at the cylinder bank.
B. Remote manual actuation at each hose reel.
C. A connected reserve bank of cylinders.

III. DETAILS:

A. **CYLINDERS:** Same as for High Pressure System Specifications, Section IIIA. A separate cylinder supply shall be used for hose reel systems.
B. **DISCHARGE HEADS:** Same as High Pressure System Specifications Section IIIB.
C. **FLEXIBLE CONNECTORS:** Same as High Pressure System Specifications Section IIIC.
D. **MANIFOLD:** Same as High Pressure System Specifications Section IIID.
E. **CONTROLS:**
   1. **DIRECT MANUAL RELEASE:** Pilot cylinder discharge heads shall be fitted with handwheel manual operators.
   2. **REMOTE MANUAL RELEASE:** A remote release shall be located at each hose reel and piped to the pilot cylinder. The release shall consist essentially of a small cylinder of carbon dioxide with siphon tube and manually-operated valve. A second release shall be provided for a reserve bank, when specified; main and reserve bank releases shall perform duplicate functions. The pipe connection to each reel or rack shall, when specified, include a normally-open manual shut-off valve to permit disconnection of the hose without putting the rest of the system out of service.
F. **HOSE AND LINES:** The cylinder manifold shall be connected to the hose reels or hose racks with galvanized steel pipe of adequate size to support discharge from any one nozzle.
   1. **REEL ASSEMBLY:** Each assembly shall consist essentially of a trunnion-mounted drum on which is coiled (____) feet of ½-inch I.D. rubber-covered high pressure hose. The drum axle shall have a rotating swivel joint at the inlet and a female hose thread outlet connection.
   2. **RACK ASSEMBLY:** Each assembly shall consist essentially of wall-mounted cleats supporting (____) feet of ½-inch I.D. rubber-covered high pressure hose in Figure Eight coil.
   3. **DISCHARGE NOZZLE ASSEMBLY:** Each assembly shall consist essentially of a horn type nozzle and handgrip of non-conductive materials, and a squeeze-grip type quick-opening and closing valve. A clip shall be provided for fastening the assembly to the wall.

IV. INSTALLATION: Same as High Pressure System Specifications Section IV.

V. INSTRUCTIONS: Same as High Pressure System Specifications Section V.

VI. SERVICE CONTRACT: Same as High Pressure System Specifications Section VII.

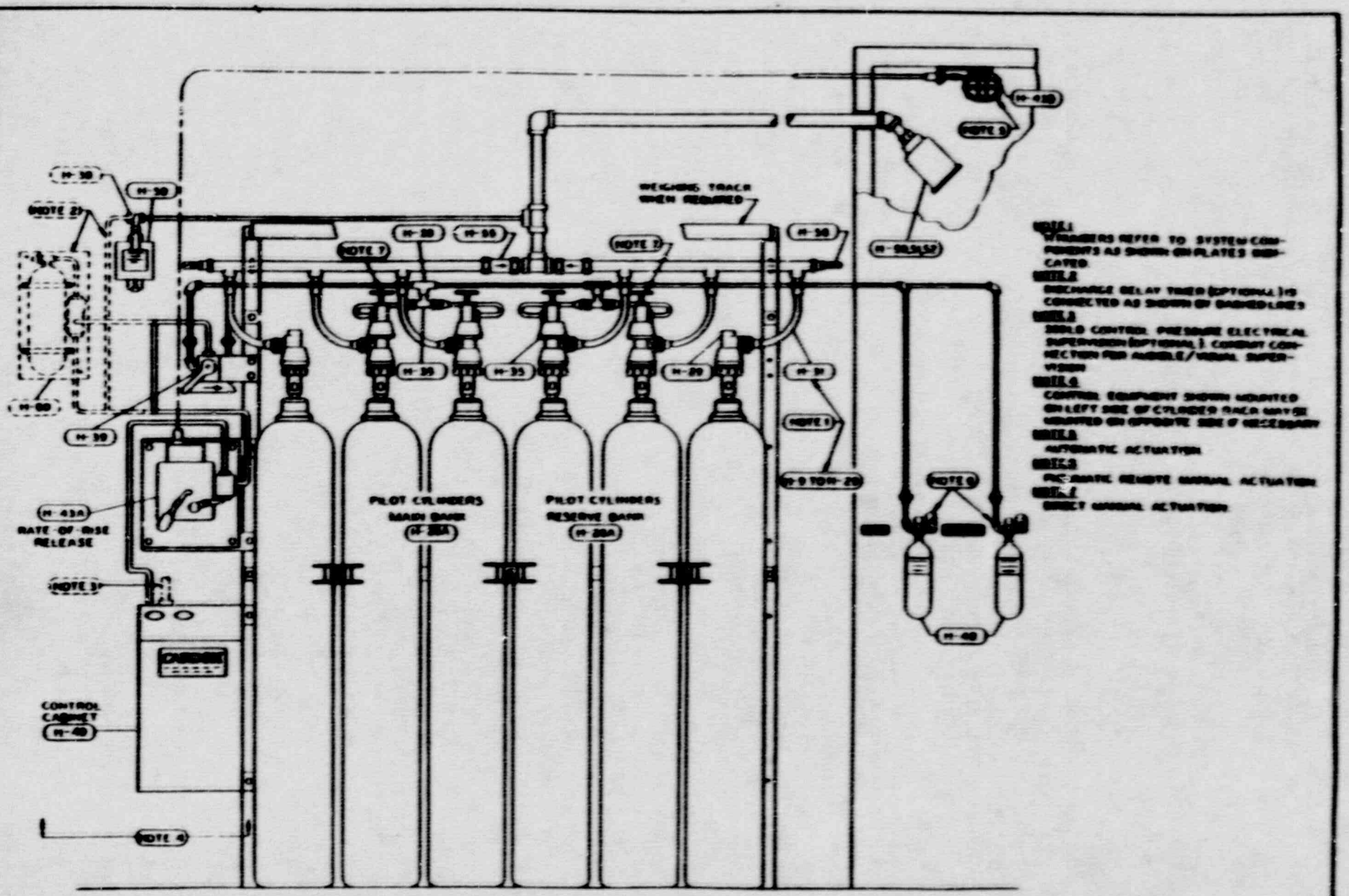
For further details refer to N.B.F.U. Pamphlet No. 12.

PORTABLE EXTINGUISHING EQUIPMENT

Refer to National Board of Fire Underwriters' Pamphlet No. 10 for classification and distribution of Hand Portable Extinguishers.

When specifying Carbon Dioxide Extinguishers always specify the highest Underwriters' Rating—(They cost no more).

2½	Pound	U.L. Rating	2BC
5	Pound	U.L. Rating	4BC
10	Pound	U.L. Rating	8BC
12	Pound	U.L. Rating	10BC
15	Pound	U.L. Rating	12BC
20	Pound	U.L. Rating	12BC



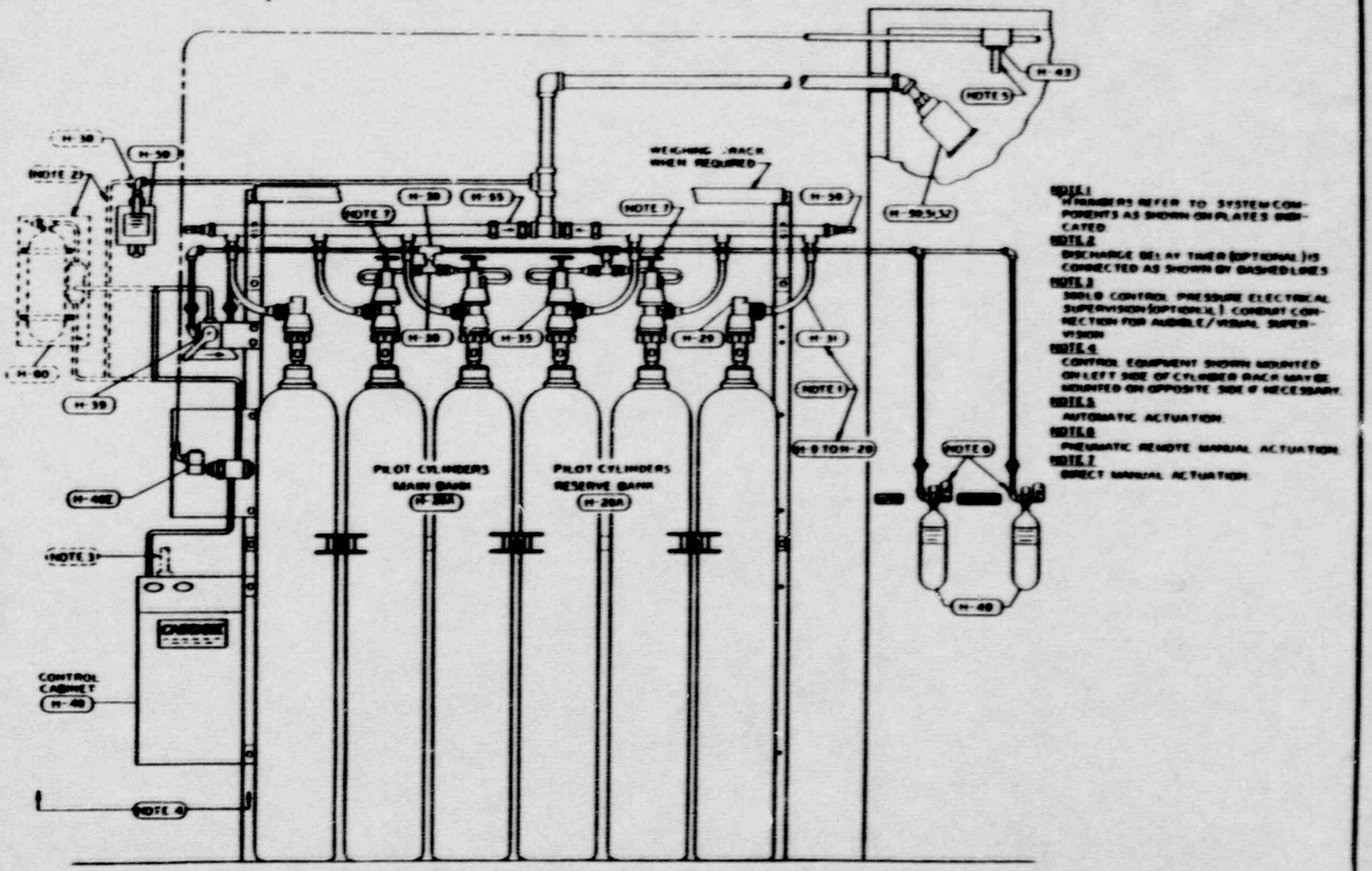
CARDOX HIGH PRESSURE SYSTEM
TYPICAL - SERIES 60-64

RATE-OF-RISE
AUTO. ACTUATION

DRG. NO. C4890

CARDOX

fire extinguishing equipment...



CARDOX HIGH PRESSURE SYSTEM TYPICAL - SERIES 60-64

ELECTRIC THERMOSTAT AUTO. ACTUATION

DRG. NO. C46307

CARDOX

fire extinguishing equipment...

ISSUED 8-64

PLATE NO. H-2

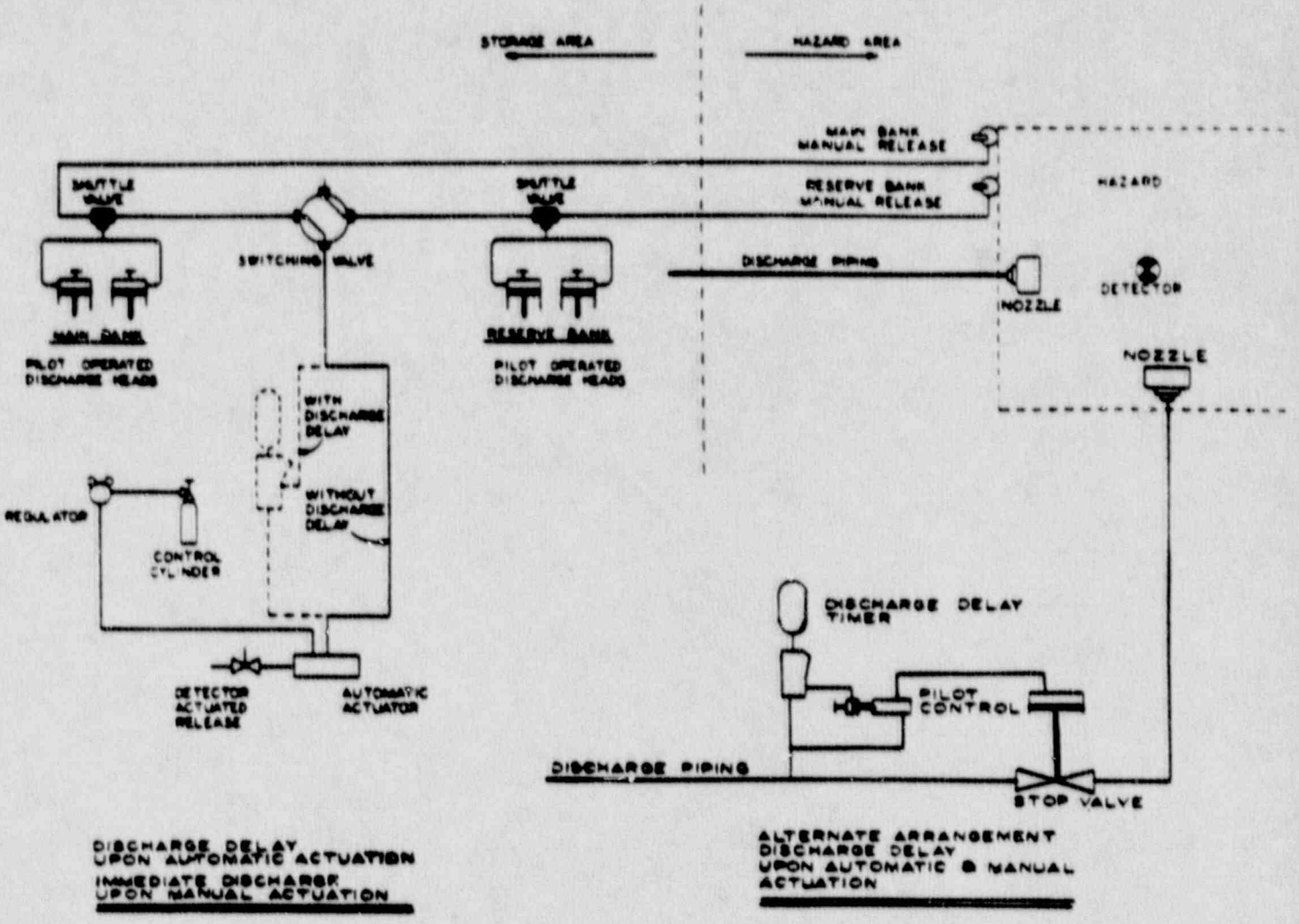
C 212

CPC

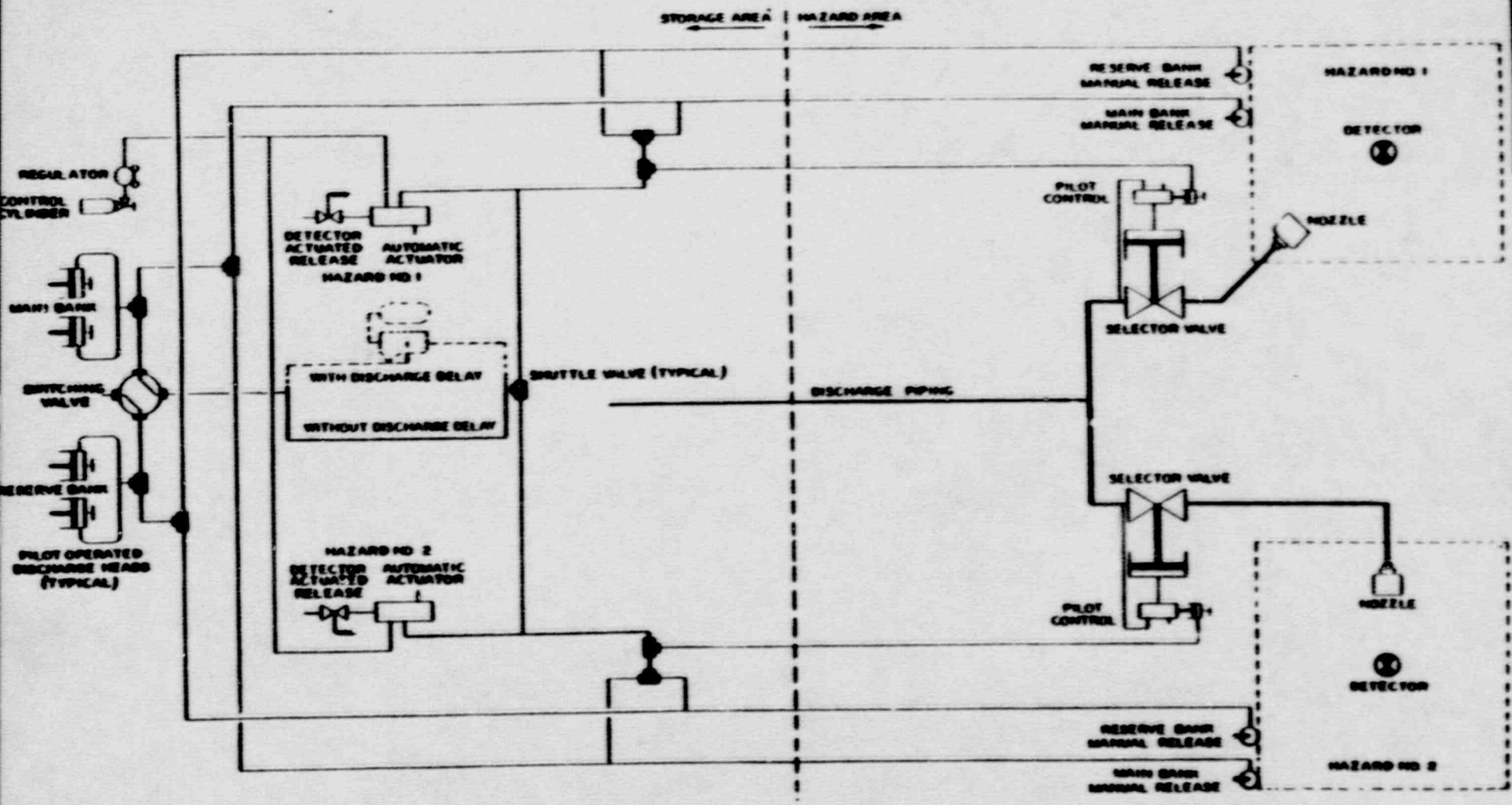
CARDOX HIGH PRESSURE SYSTEM
TYPICAL – SERIES 60-64
PNEUMATIC DURA-SPEED
AUTO. ACTUATION
DRG NO. C40

PLATE NO. H-3

CAMDOX fire extinguishing equipment...



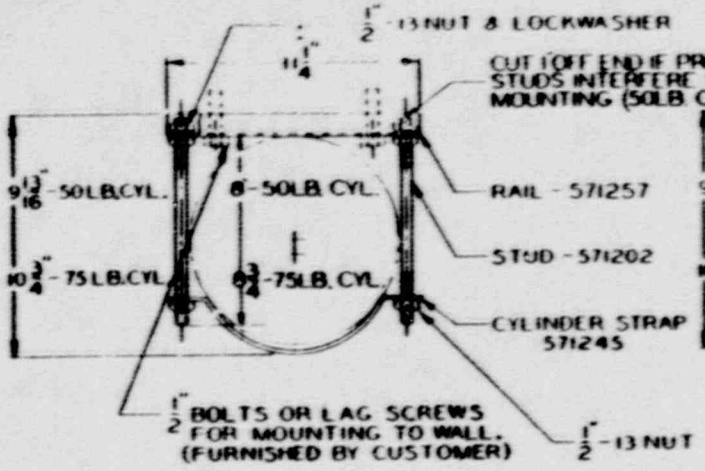
SCHEMATIC ARRANGEMENT
SERIES 60 AUTOMATIC SYSTEM
WITH RESERVE BANK



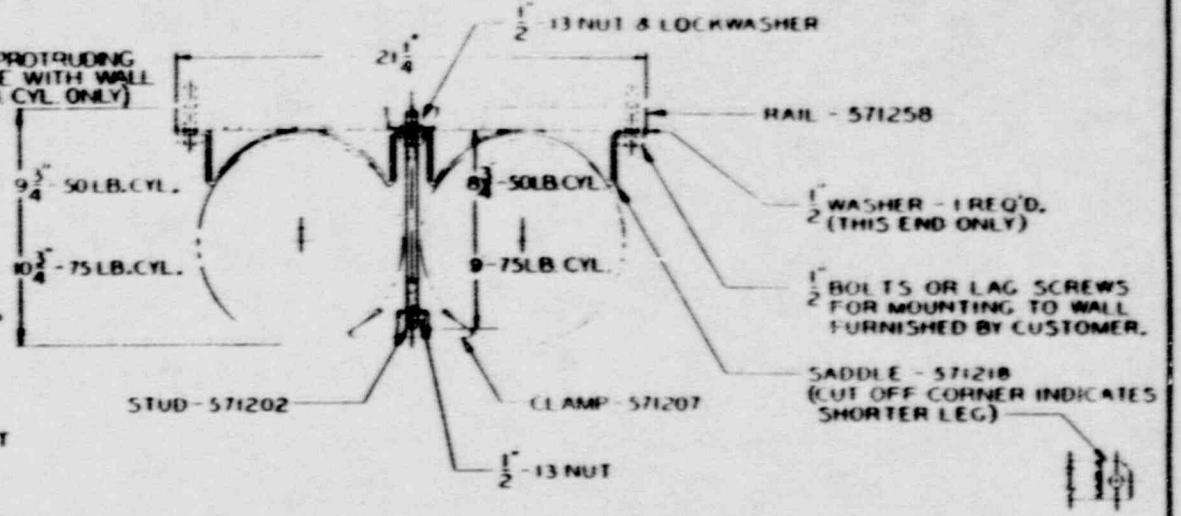
SCHEMATIC ARRANGEMENT
SERIES 60 MULTIPLE HAZARD AUTOMATIC
ELECTRIC SYSTEM WITH RESERVE BANK

REVISED 5-91

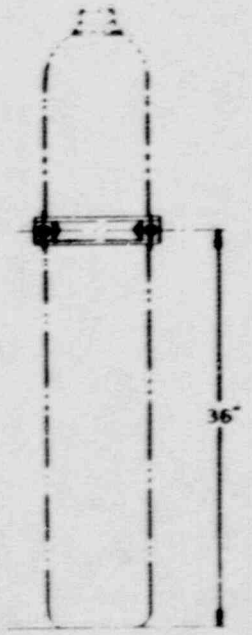
PLATE NO. H-9A



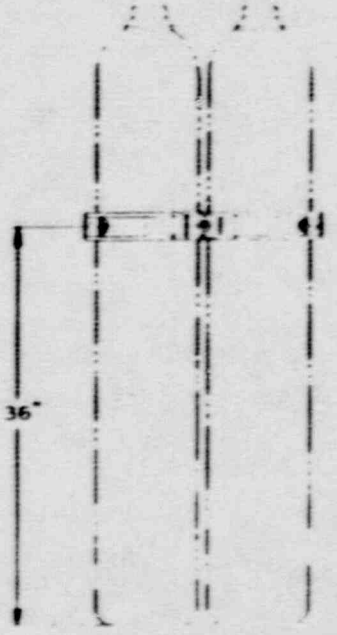
TOP VIEW
ONE CYLINDER RACK ASSEMBLY



TOP VIEW
TWO CYLINDER RACK ASSEMBLY



FRONT VIEW



FRONT VIEW

CARDOX

RACK ASSEMBLY - TYPICAL INSTALLATION OF ONE AND TWO CYLINDERS - WALL MOUNTED - 50 LB. & 75 LB. CAP

C41566

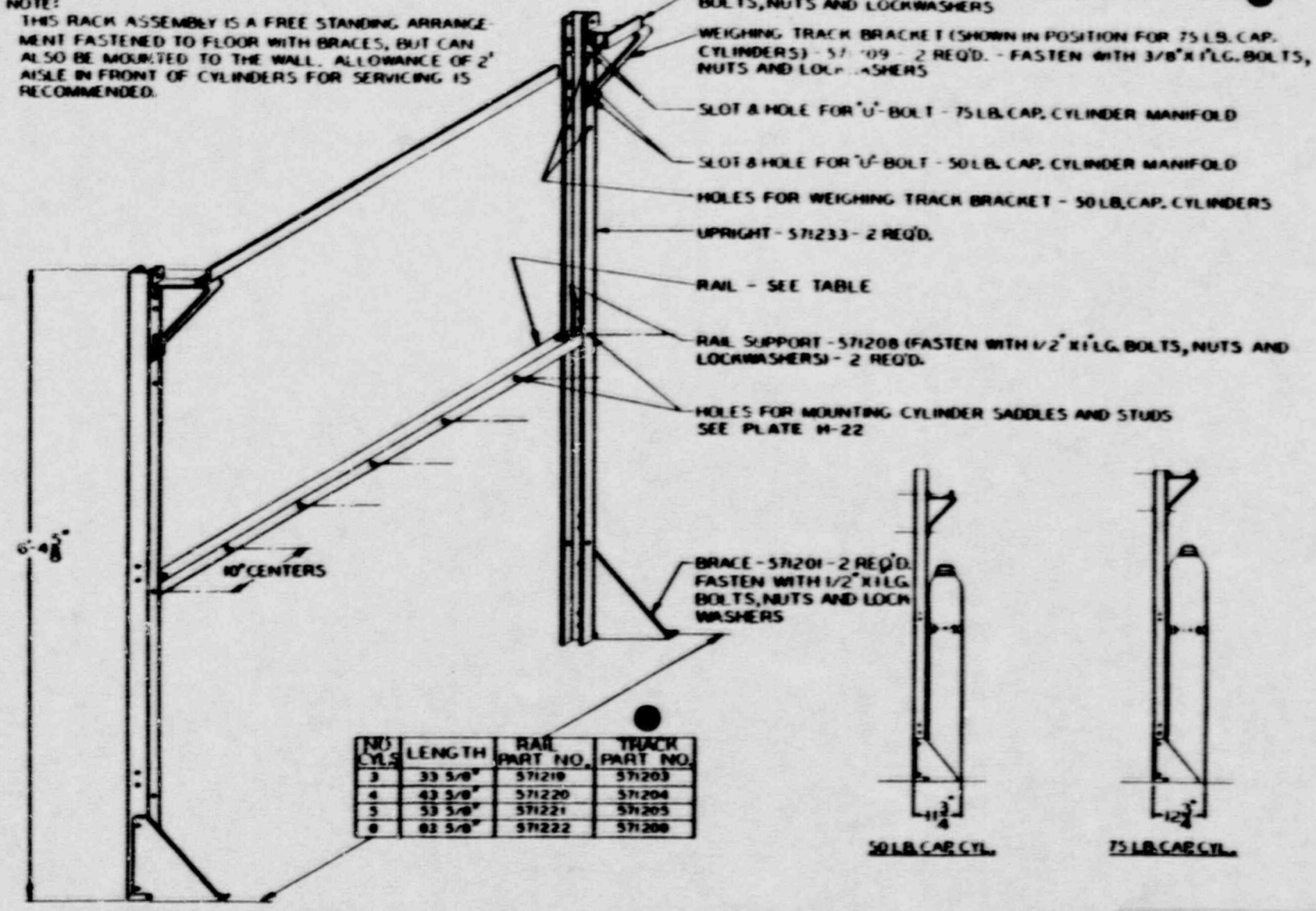
C41566

REVISED 3-61

PLATE NO. H-11

C-400—CPC—50K-

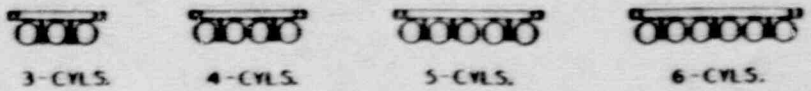
NOTE:
THIS RACK ASSEMBLY IS A FREE STANDING ARRANGEMENT FASTENED TO FLOOR WITH BRACES, BUT CAN ALSO BE MOUNTED TO THE WALL. ALLOWANCE OF 2' AISLE IN FRONT OF CYLINDERS FOR SERVICING IS RECOMMENDED.



50 LB. CAP. CYL.

75 LB. CAP. CYL.

NO. CYLS.	LENGTH	RAIL PART NO.	TRACK PART NO.
3	33 5/8"	571219	571203
4	43 5/8"	571220	571204
5	53 5/8"	571221	571205
6	63 5/8"	571222	571206



3-CYLS. 4-CYLS. 5-CYLS. 6-CYLS.

● INCLUDED ONLY WHEN SCALE KIT SPECIFIED IN CONTRACT

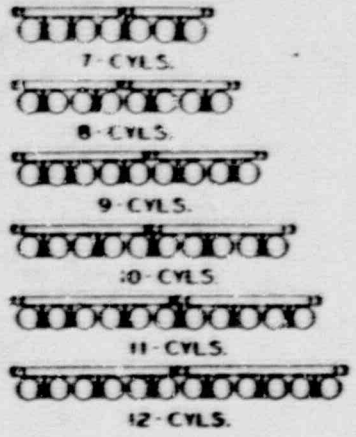
CARDOX

RACK ASSEMBLY - TYPICAL INSTALLATION OF 3 TO 6 CYLINDERS 50 & 75 LB. CAP. SINGLE ROW - WEIGHING TRACK

SCALE 3/8" | SHEET 32 | C41555

REVISED 3-61

PLATE NO. H-13



WEIGHING TRACK - SEE TABLE - FASTEN WITH 3/8"x1"LG. BOLTS, NUTS & LOCKWASHERS

WEIGHING TRACK BRACKET (SHOWN IN POSITION FOR 75 LB. CAP. CYLS.) - 571209 - 3 REQ'D. - FASTEN WITH 3/8"x1"LG. BOLTS, NUTS AND LOCKWASHERS

SLOT & HOLE FOR U-BOLT - 75 LB. CAP. CYLINDER MANIFOLD

SLOT & HOLE FOR U-BOLT - 50 LB. CAP. CYLINDER MANIFOLD

HOLES FOR WEIGHING TRACK BRACKET - 50 LB. CAP. CYLINDERS

UPRIGHT - 571233 - 3 REQ'D.

RAIL SUPPORT - 571208 (FASTEN WITH 1/2" x 1"LG. BOLTS, NUTS & LOCKWASHERS) - 5 REQ'D.

RAIL - SEE TABLE

HOLES FOR MOUNTING CYLINDER SADDLES AND STUDS SEE PLATE H-22

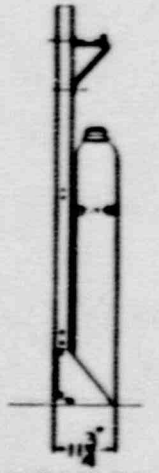
1/2"x1"LG. BOLT, NUT & LOCKWASHER

BRACE 571201 2 REQ'D.

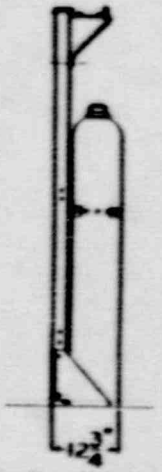
6'-4 3/8"

10" CENTERS

NO. CYLS.	LENGTH	RAIL PART NO.		TRACK PART NO.	
7	6'-1 5/8"	571220	571219	571204	571203
8	6'-11 5/8"	(2) 571220		(2) 571204	
9	7'-9 5/8"	571221	571220	571205	571204
10	8'-7 5/8"	(2) 571221		(2) 571205	
11	9'-5 5/8"	571222	571221	571206	571205
12	10'-3 5/8"	(2) 571222		(2) 571206	



50 LB CAP. CYL.



75 LB CAP. CYL.

NOTE:
THIS RACK ASSEMBLY IS A FREE STANDING ARRANGEMENT FASTENED TO FLOOR WITH BRACES, BUT CAN ALSO BE MOUNTED TO THE WALL. ALLOWANCE OF 2' AISLE IN FRONT OF CYLINDERS FOR SERVICING IS RECOMMENDED.

● INCLUDED ONLY WHEN SCALE KIT SPECIFIED IN CONTRACT.

CARBOX

RACK ASSEMBLY - TYPICAL INSTALLATION OF 7 TO 12 CYLINDERS - 50 & 75 LB. CAP. SINGLE ROW - WEIGHING TRACK

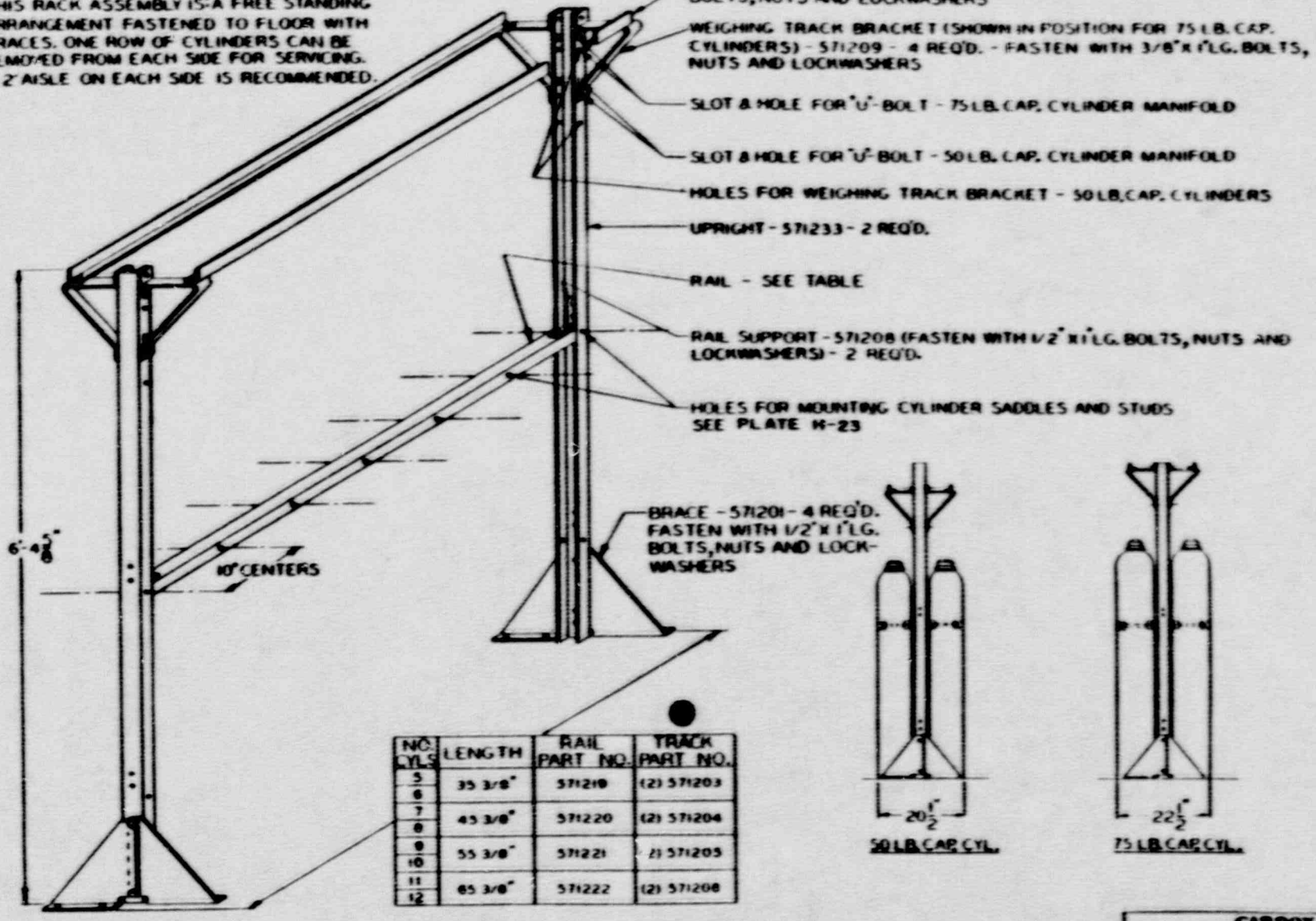
C41557

REVISED 3-61

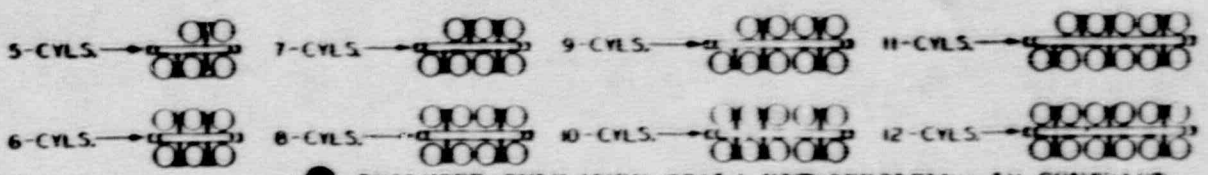
PLATE NO. H-15

C-450-CPC-5000

NOTE:
THIS RACK ASSEMBLY IS A FREE STANDING ARRANGEMENT FASTENED TO FLOOR WITH BRACES. ONE ROW OF CYLINDERS CAN BE REMOVED FROM EACH SIDE FOR SERVICING. A 2' AISLE ON EACH SIDE IS RECOMMENDED.



NO. CYLS.	LENGTH	RAIL PART NO.	TRACK PART NO.
5	35 3/8"	571219	(2) 571203
6			
7	45 3/8"	571220	(2) 571204
8			
9	55 3/8"	571221	(2) 571205
10			
11	65 3/8"	571222	(2) 571206
12			



INCLUDED ONLY WHEN SCALE IS SPECIFIED IN CONTRACT.

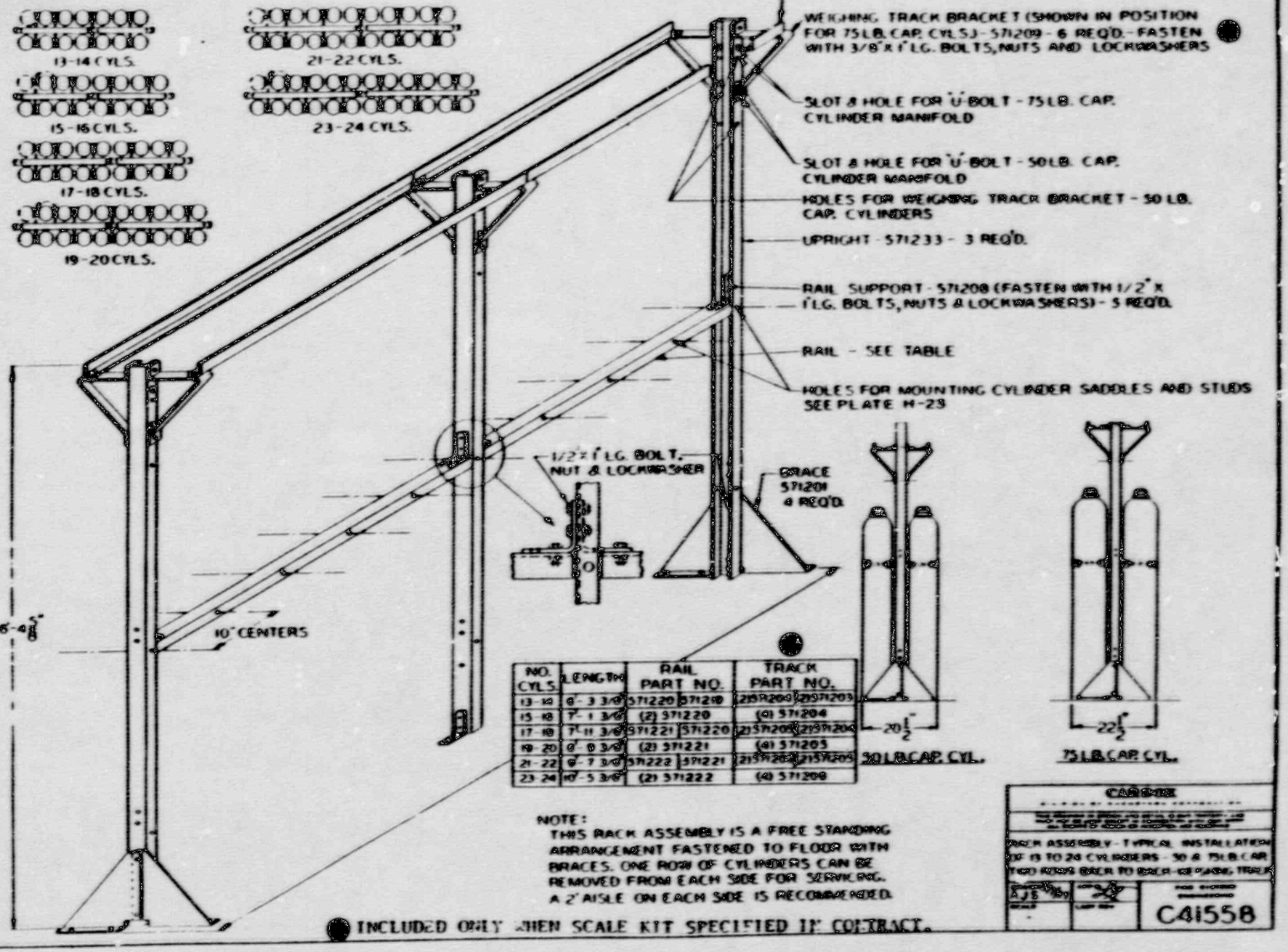
CARDOX

RACK ASSEMBLY - TYPICAL INSTALLATION OF 5 TO 12 CYLINDERS - 50 & 75 LB. CAP. TWO ROWS BACK TO BACK WITH AISLE

C41556

REVISED 3-61

PLATE NO. H-17



NO. CYLS.	LENGTH	RAIL PART NO.	TRACK PART NO.
13-14	6'-3 3/8"	571220	571208
15-16	7'-1 3/8"	(2) 571220	(6) 571204
17-18	7'-11 3/8"	571221	571220
19-20	8'-9 3/8"	(2) 571221	(4) 571205
21-22	9'-7 3/8"	571222	571221
23-24	10'-5 3/8"	(2) 571222	(4) 571208

NOTE:
THIS RACK ASSEMBLY IS A FREE STANDING ARRANGEMENT FASTENED TO FLOOR WITH BRACES. ONE ROW OF CYLINDERS CAN BE REMOVED FROM EACH SIDE FOR SERVICING. A 2' AISLE ON EACH SIDE IS RECOMMENDED.

● INCLUDED ONLY WHEN SCALE KIT SPECIFIED IN CONTRACT.

CARRIER

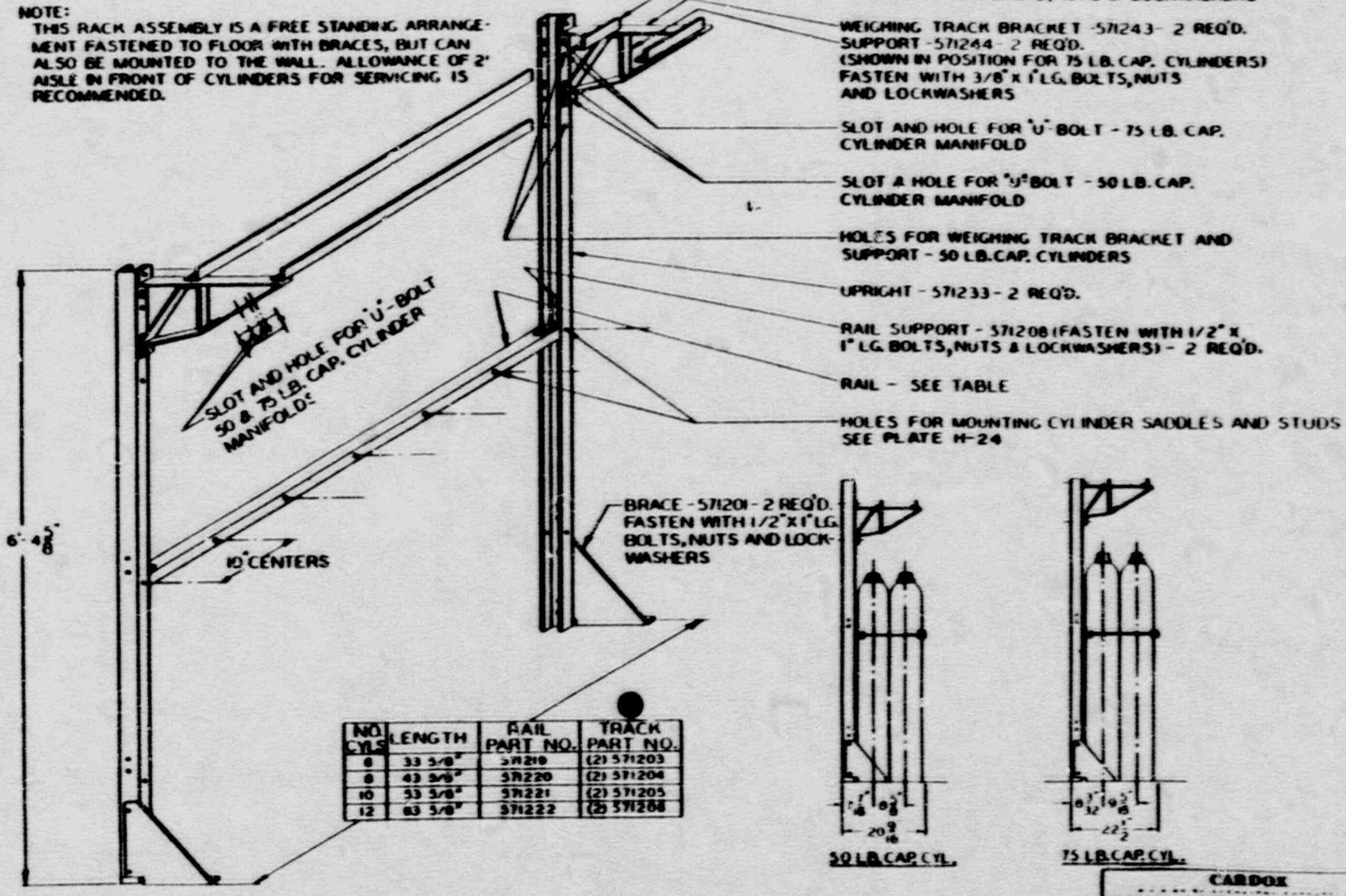
RACK ASSEMBLY - TYPICAL INSTALLATION OF 13 TO 24 CYLINDERS - 50 & 75 LB. CAP. TWO ROWS BACK TO BACK - SERVICE FROM TRUCK

C41558

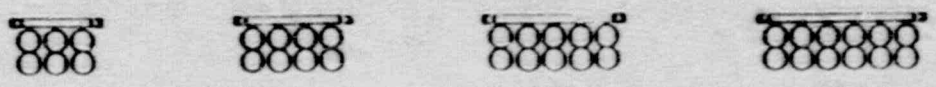
REVISED 3-61

PLATE NO. H-19

NOTE:
THIS RACK ASSEMBLY IS A FREE STANDING ARRANGEMENT FASTENED TO FLOOR WITH BRACES, BUT CAN ALSO BE MOUNTED TO THE WALL. ALLOWANCE OF 2' AISLE IN FRONT OF CYLINDERS FOR SERVICING IS RECOMMENDED.



NO. CYLS.	LENGTH	RAIL PART NO.	TRACK PART NO.
6	33 5/8"	571219	(2) 571203
8	43 5/8"	571220	(2) 571204
10	53 5/8"	571221	(2) 571205
12	63 5/8"	571222	(2) 571206



INCLUDED ONLY WHEN SCALE KIT IS SPECIFIED IN CONTRACT.

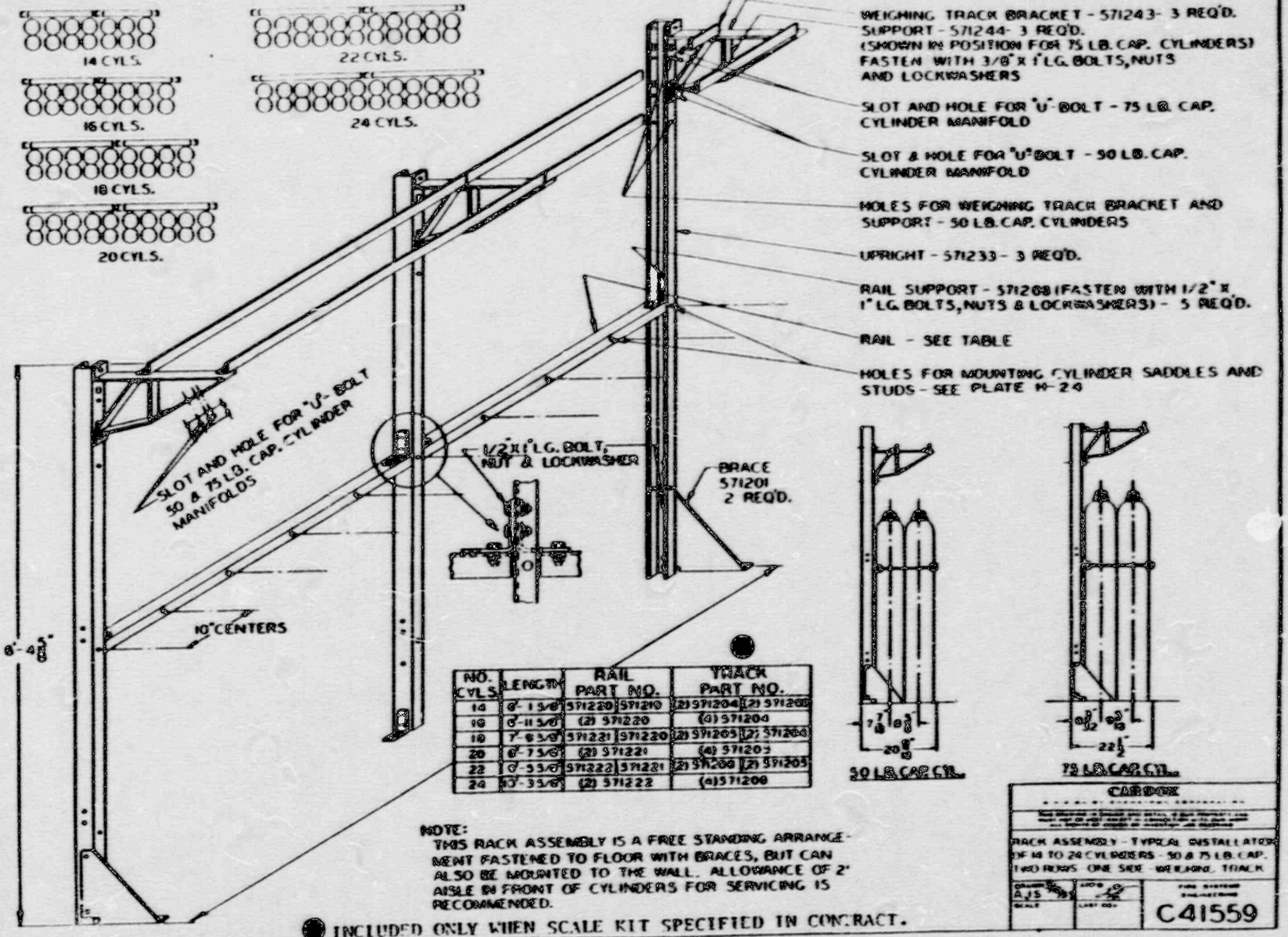
CARDOX

RACK ASSEMBLY TYPICAL INSTALLATION OF 6 TO 12 CYLINDERS 50 & 75 LB. CAP. TWO ROWS ONE OR WEIGHING TRACK

C494-500 CPC

REVISED 3-61

PLATE NO. N-21



NO. CYLS.	LENGTH	RAIL PART NO.		YRACK PART NO.	
14	6'-1 5/8"	571220	571210	(2) 571204	(2) 571205
16	6'-11 5/8"	(2) 571220		(4) 571204	
18	7'-9 5/8"	571221	571220	(2) 571205	(2) 571204
20	8'-7 5/8"	(2) 571221		(4) 571205	
22	9'-5 5/8"	571222	571221	(2) 571206	(2) 571205
24	10'-3 5/8"	(2) 571222		(4) 571206	

NOTE:
THIS RACK ASSEMBLY IS A FREE STANDING ARRANGEMENT FASTENED TO FLOOR WITH BRACES, BUT CAN ALSO BE MOUNTED TO THE WALL. ALLOWANCE OF 2' AISLE IN FRONT OF CYLINDERS FOR SERVICING IS RECOMMENDED.

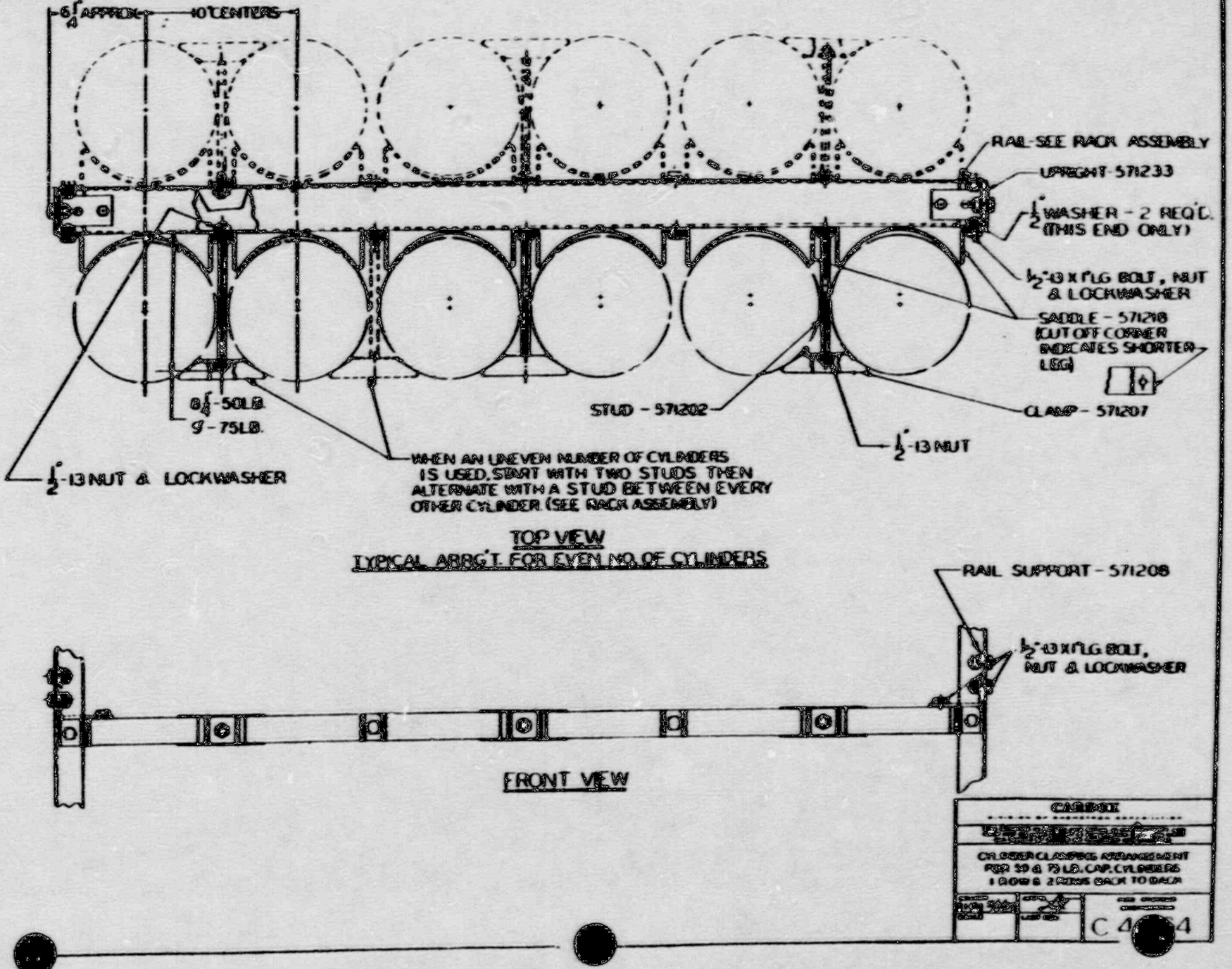
● INCLUDED ONLY WHEN SCALE KIT SPECIFIED IN CONTRACT.

CAR DOCK

RACK ASSEMBLY - TYPICAL INSTALLATION OF 14 TO 24 CYLINDERS - 50 & 75 LB. CAP. TWO ROWS ONE SIDE - WEIGHING TRACK

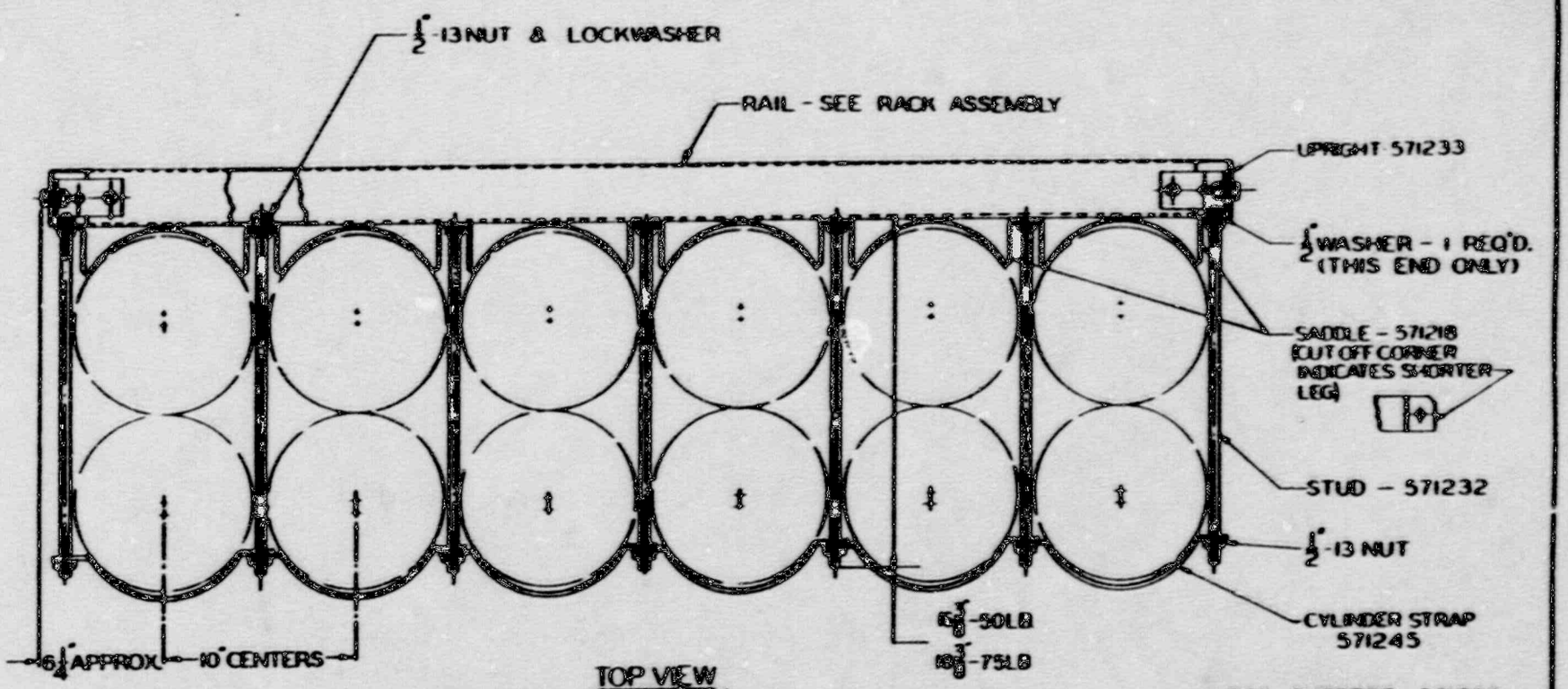
AJS

C41559


6" APPROX.
10" CENTERS
RAIL-SEE RACK ASSEMBLY
UPRIGHT-571233
½" WASHER - 2 REQ'D. (THIS END ONLY)
½"-13 x 1" LG BOLT, NUT & LOCKWASHER
SADDLE - 571210 (CUT OFF CORNER INDICATES SHORTER LEG)
CLAMP - 571207
STUD - 571202
½"-13 NUT
8 @ 50 LB.
9 - 75 LB.
½"-13 NUT & LOCKWASHER
WHEN AN UNEVEN NUMBER OF CYLINDERS IS USED, START WITH TWO STUDS THEN ALTERNATE WITH A STUD BETWEEN EVERY OTHER CYLINDER (SEE RACK ASSEMBLY)
TOP VIEW
TYPICAL ARRG'T. FOR EVEN NO. OF CYLINDERS
RAIL SUPPORT - 571208
½"-13 x 1" LG BOLT, NUT & LOCKWASHER
FRONT VIEW
CYLINDER CLASSIFICATION ARRANGEMENT
FOR 50 & 75 LB. CAP. CYLINDERS
1 ROW & 2 ROWS BACK TO BACK
C 4 4
REVISED 4-68
PLATE NO. H-22
C-67 CRC

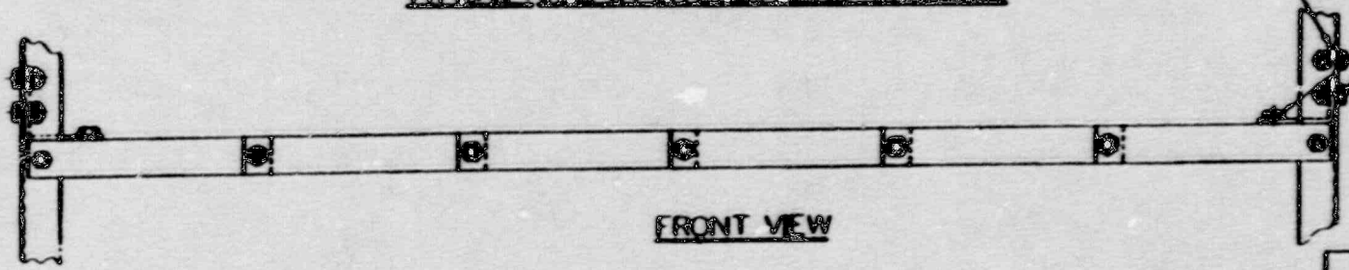
REVISED 5-01

PLATE NO M-24



TOP VIEW

TYPICAL ARR'G'T. FOR EVEN NO. OF CYLINDERS



FRONT VIEW

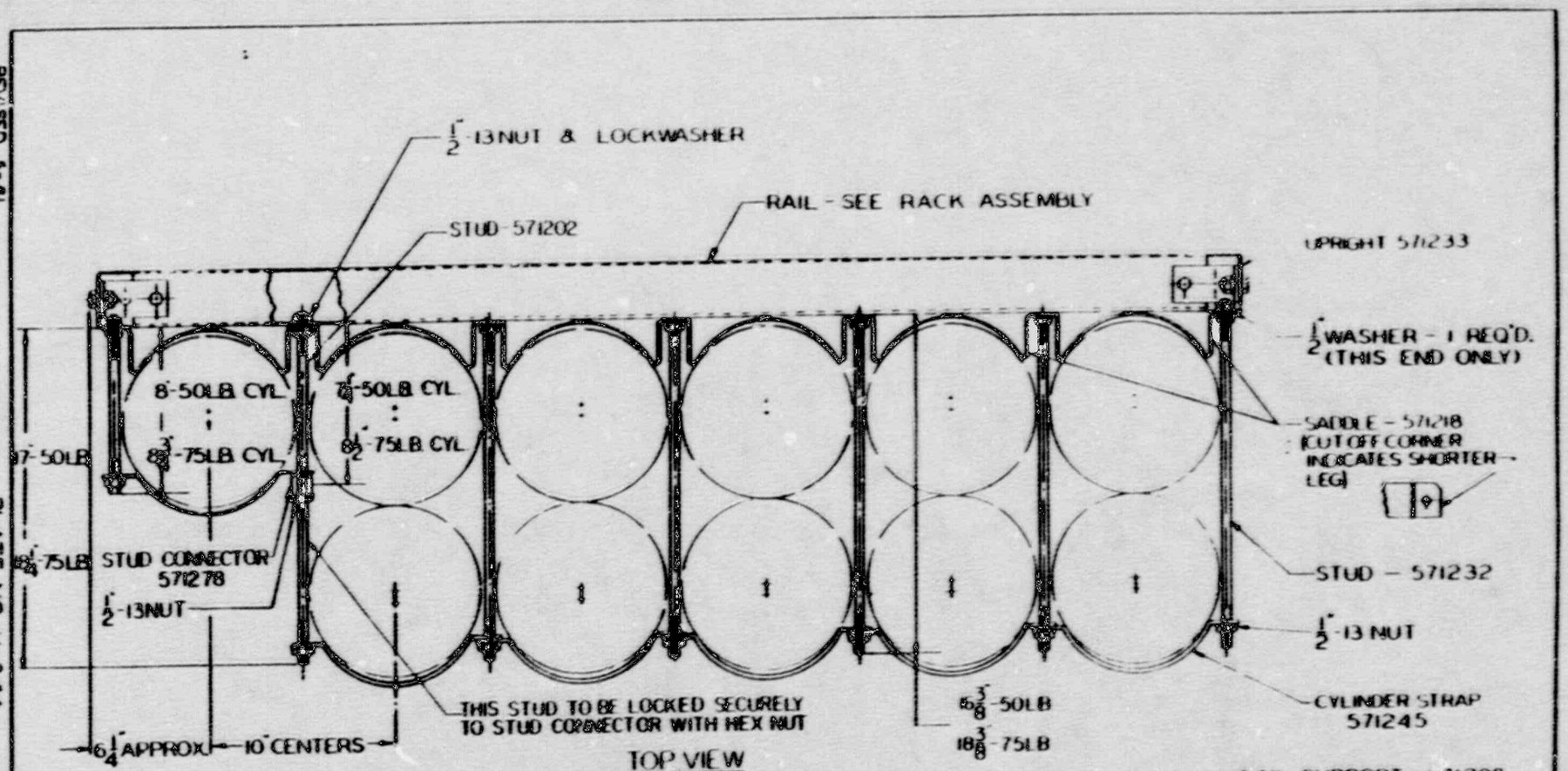
CAR END

CYLINDER CLAMPING ARRANGEMENT FOR 20 & 25 LB. CAR CYLINDERS TWO RACKS - ONE SIDE

C41565

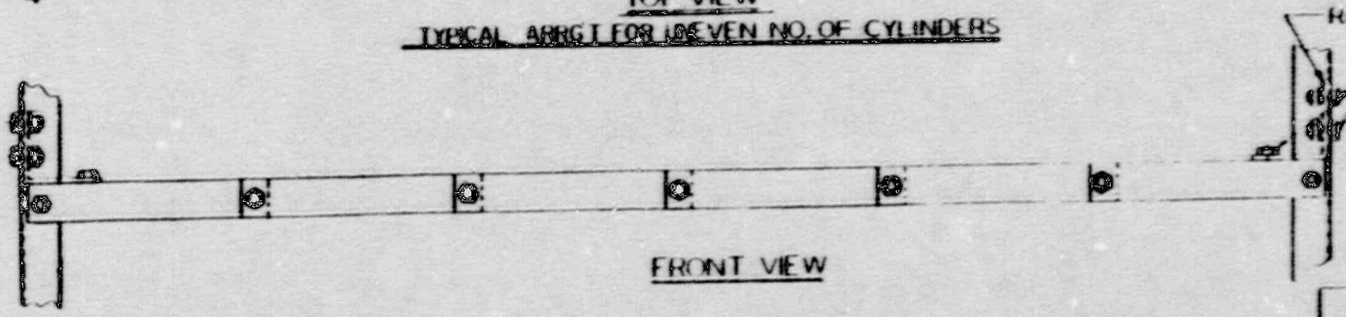
REVISED 5-81

PLATE NO. H-24A



TOP VIEW

TYPICAL ARRGT FOR UNEVEN NO. OF CYLINDERS



FRONT VIEW

CARDOX

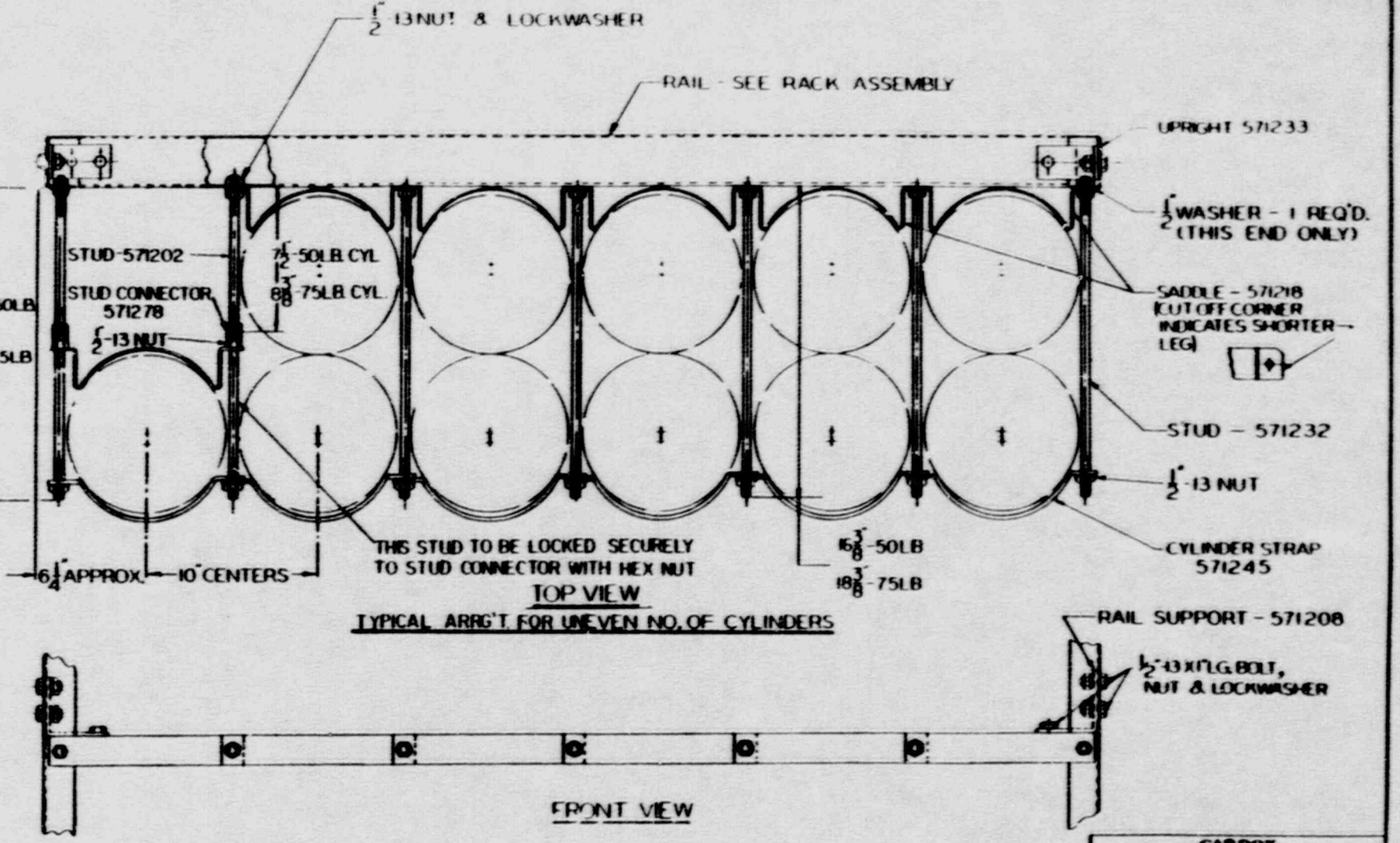
CYLINDER CLAMPING ARRANGEMENT FOR 50 & 75 LB. CAP. CYLINDERS TWO ROWS - ONE SIDE

C 41[illegible]-1

C451 230-CPC

REVISED 5-61

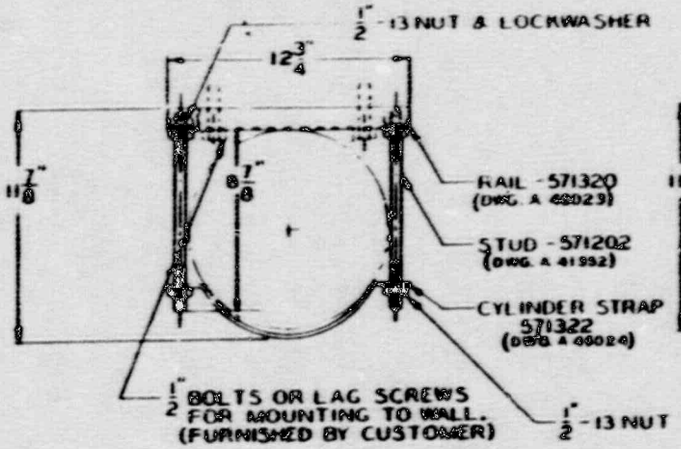
PLATE NO. H-24B



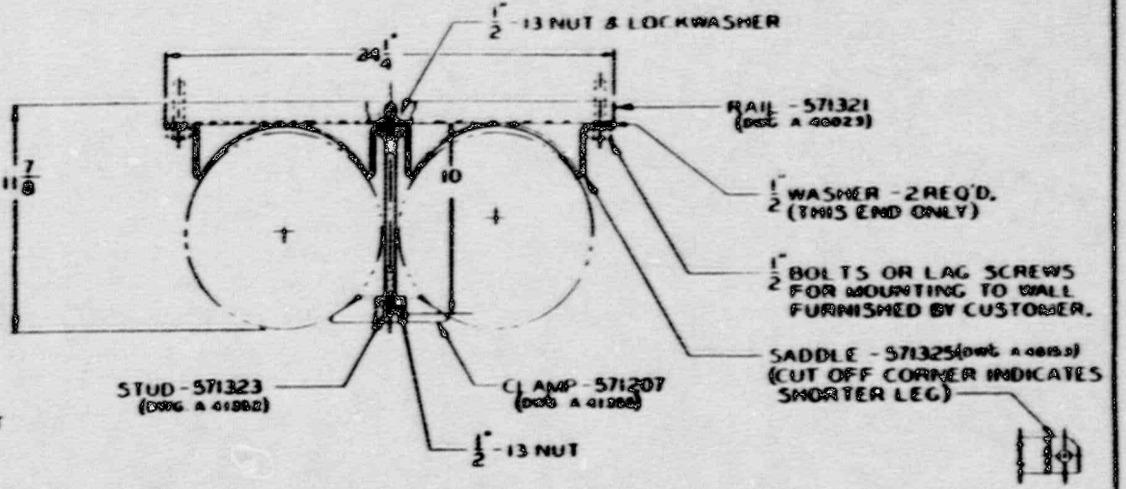
CARBOX

CYLINDER CLAMPING ARRANGEMENT FOR 50 & 75 LB. CAP. CYLINDERS TWO ROWS - ONE SIDE

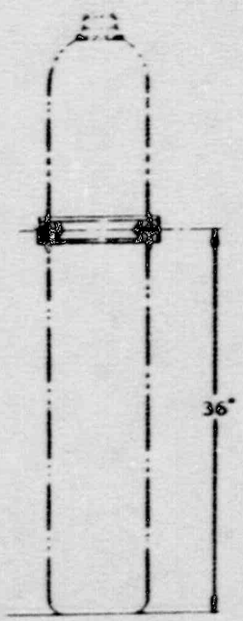
C41565-2



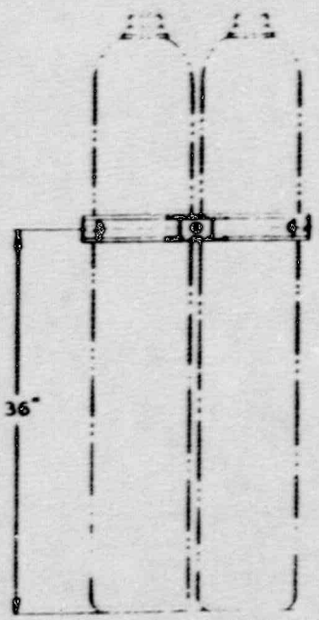
TOP VIEW
ONE CYLINDER RACK ASSEMBLY



TOP VIEW
TWO CYLINDER RACK ASSEMBLY



FRONT VIEW



FRONT VIEW

CARLISLE

RACK ASSEMBLY - TYPICAL INSTALLATION OF ONE AND TWO CYLINDERS - WALL MOUNTED - 100 LB CAP

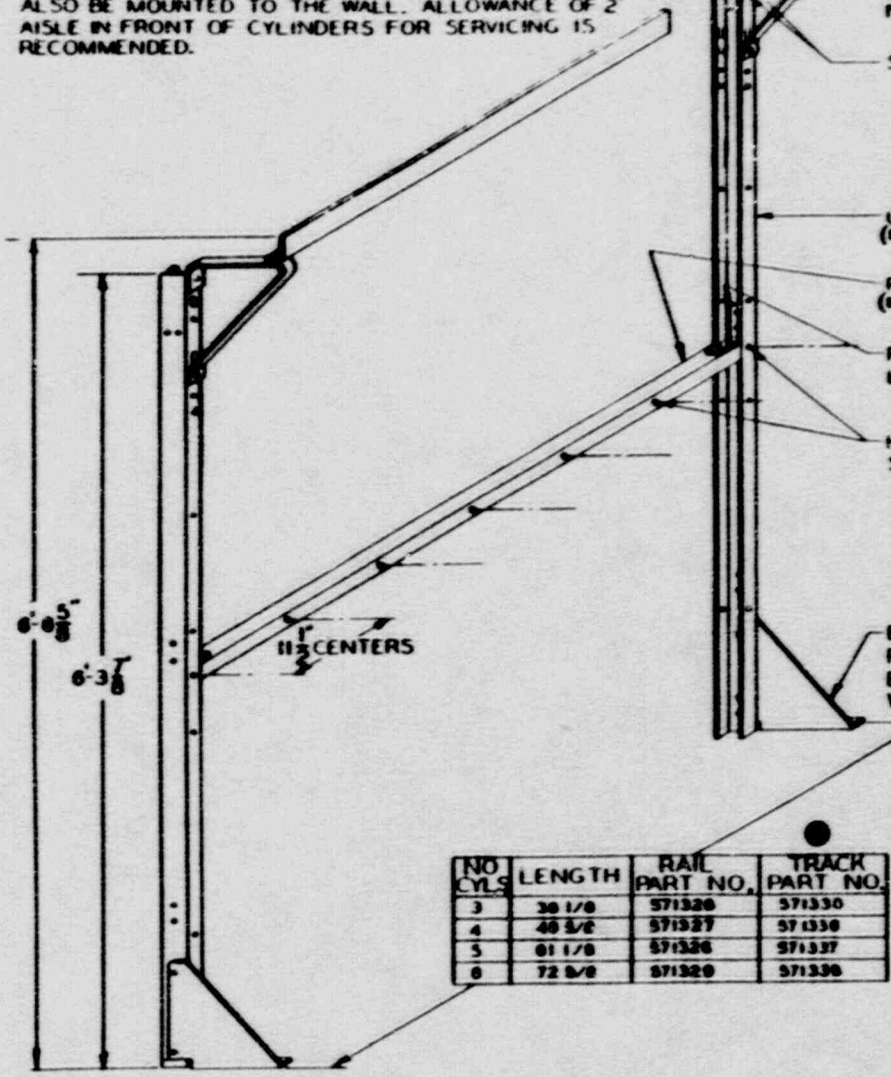
C 57

ISSUED 12-93

PLATE NO. H-98

C 401 CPC 0/96

NOTE:
THIS RACK ASSEMBLY IS A FREE STANDING ARRANGEMENT FASTENED TO FLOOR WITH BRACES, BUT CAN ALSO BE MOUNTED TO THE WALL. ALLOWANCE OF 2" AISLE IN FRONT OF CYLINDERS FOR SERVICING IS RECOMMENDED.



WEIGHING TRACK - SEE TABLE - FASTEN WITH 3/8" x 1" LG. BOLTS, NUTS AND LOCKWASHERS (WEIGH TRACK DWG A 40152)

WEIGHING TRACK BRACKET (DWG B 40158) ●
571332 2 REQ'D. - FASTEN WITH 3/8" X 1" LG. BOLTS, NUTS AND LOCKWASHERS

SLOT & HOLE FOR "U" BOLT 100 LB. CAP. CYLINDER MANIFOLD

UPRIGHT - 571233 - 2 REQ'D. (DWG B 41304)

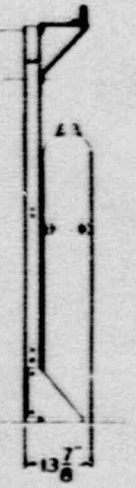
RAIL - SEE TABLE (DWG A 40181)

RAIL SUPPORT - 571208 (FASTEN WITH 1/2" X 1" LG. BOLTS, NUTS AND LOCKWASHERS) - 2 REQ'D. (RAIL SUPPORT DWG A 41353)

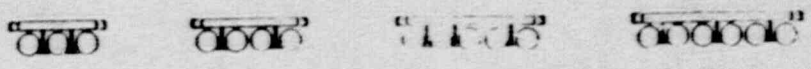
HOLES FOR MOUNTING CYLINDER SADDLES AND STUDS SEE PLATE H-23A

BRACE - 571201 - 2 REQ'D (DWG A 41200) FASTEN WITH 1/2" X 1" LG. BOLTS, NUTS AND LOCK WASHERS

NO. CYLS.	LENGTH	RAIL PART NO.	TRACK PART NO.
3	30 1/8	571326	571330
4	48 5/8	571327	571330
5	61 1/8	571328	571337
6	72 5/8	571329	571338



100 LB. CAP. CYL.



3 - CYLS. 4 - CYLS. 6 CYLS.

● INCLUDED ONLY WHEN SCALE KIT IS SPECIFIED IN CONTRACT

CARDOX

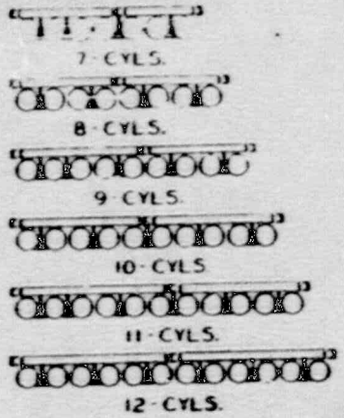
RACK ASSEMBLY FOR 3 TO 6 CYLINDERS

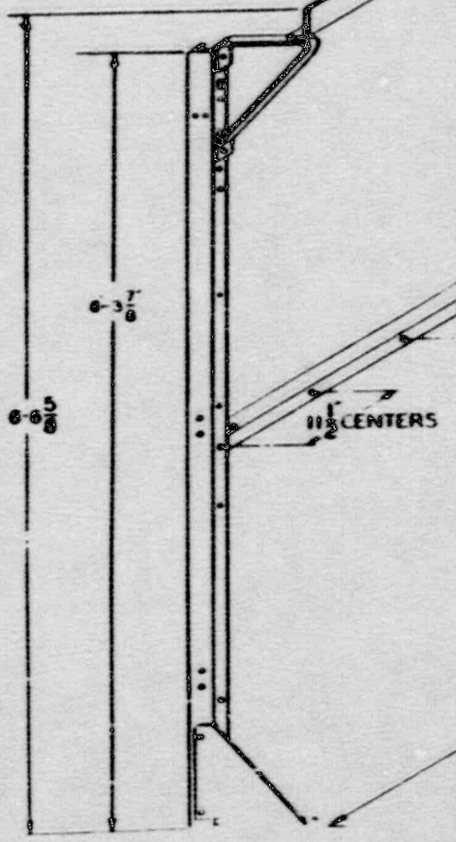
C 46158

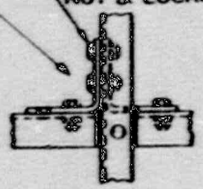
ISSUED 12-63 PLATE H-12 C-448-C/C

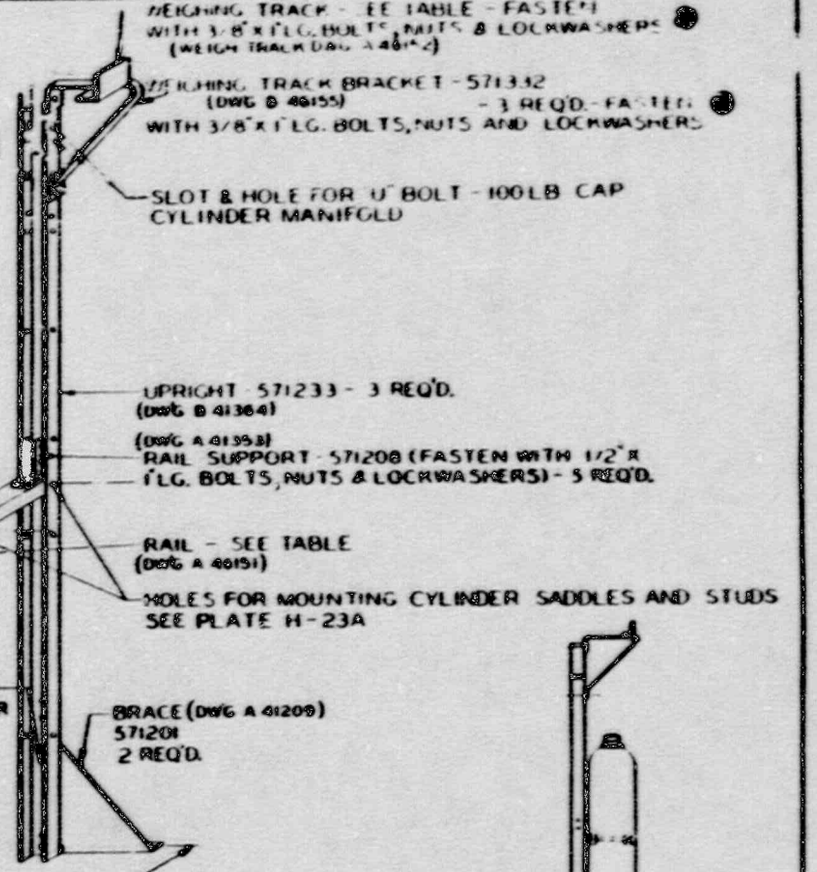
ISSUED 12-03

PLATE H-14









100 LB CAP. CYL.

NO. CYLS.	LENGTH	RAIL PART NO.		TRACK PART NO.	
7	7'-0 1/8"	571287	571320	571330	571330
8	7'-11 5/8"	(2) 571287		(2) 571330	
9	8'-11 1/8"	571320	571287	571287	571330
10	9'-10 5/8"	(2) 571320		(2) 571287	
11	10'-10 1/8"	571320	571320	571330	571287
12	11'-9 5/8"	(2) 571320		(2) 571330	

NOTE:
THIS RACK ASSEMBLY IS A FREE STANDING ARRANGEMENT FASTENED TO FLOOR WITH BRACES, BUT CAN ALSO BE MOUNTED TO THE WALL. ALLOWANCE OF 2' AISLE IN FRONT OF CYLINDERS FOR SERVICING IS RECOMMENDED.

● INCLUDED ONLY WHEN SCALE KIT IS SPECIFIED IN CONTRACT

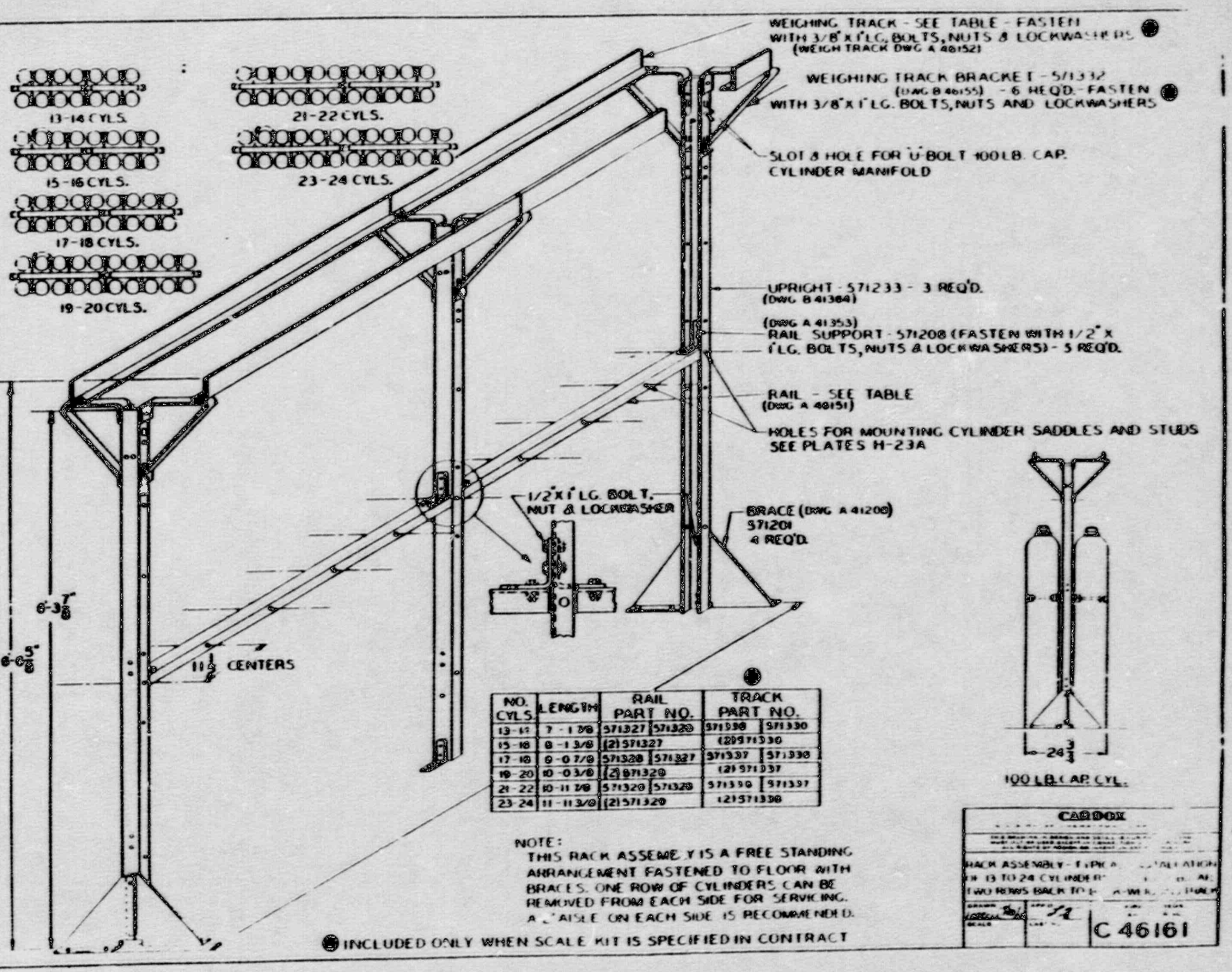
CARDOX

RACK ASSEMBLY - TYPICAL INSTALLATION OF 7 TO 12 CYLINDERS FOR USE IN A 4-SINGLE ROW WEIGHT TRACK

C 46159

ISSUED 12-63

PLATE H-18



NO. CYLS.	LENGTH	RAIL PART NO.		TRACK PART NO.	
13-14	7'-1 7/8"	571327	571329	571330	571330
15-16	8'-1 3/8"	(2) 571327		(2) 571330	
17-18	9'-0 7/8"	571328	571327	571337	571338
19-20	10'-0 3/8"	(2) 571329		(2) 571337	
21-22	10'-11 7/8"	571329	571329	571339	571337
23-24	11'-11 3/8"	(2) 571329		(2) 571339	

NOTE:
THIS RACK ASSEMBLY IS A FREE STANDING ARRANGEMENT FASTENED TO FLOOR WITH BRACES. ONE ROW OF CYLINDERS CAN BE REMOVED FROM EACH SIDE FOR SERVICING. A 2' AISLE ON EACH SIDE IS RECOMMENDED.

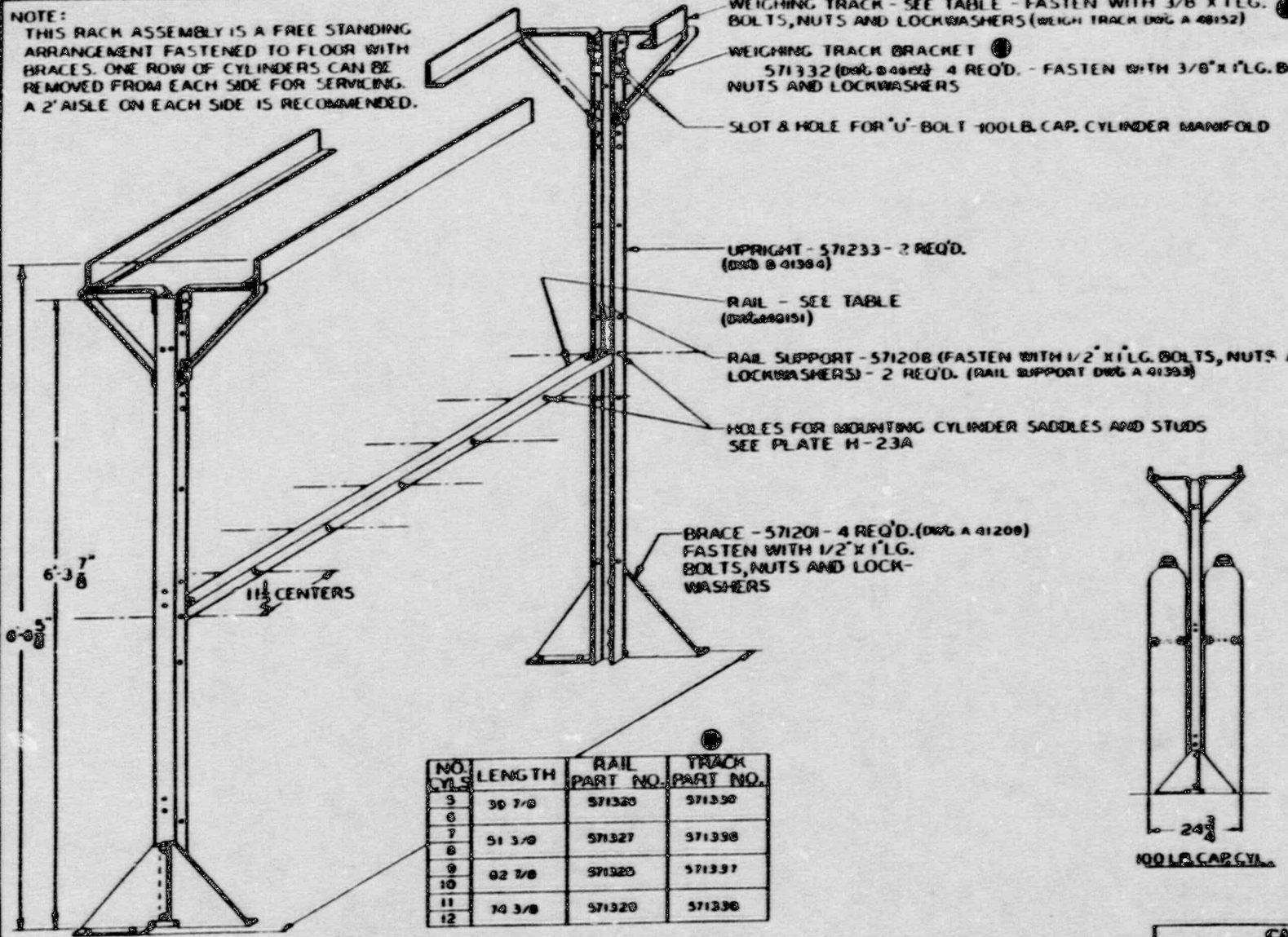
● INCLUDED ONLY WHEN SCALE KIT IS SPECIFIED IN CONTRACT

CAGE CO.

RACK ASSEMBLY - TYPICAL ARRANGEMENT FOR 13 TO 24 CYLINDERS [illegible] TWO ROWS BACK TO BACK [illegible]

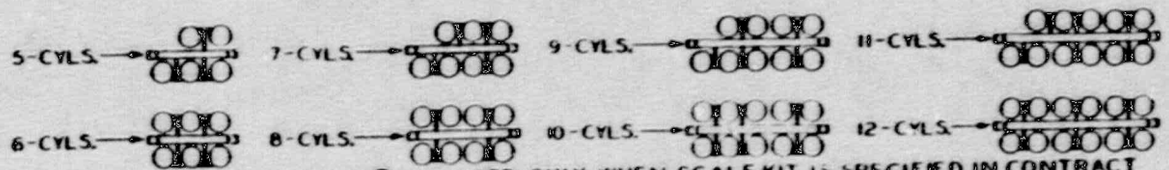
C 46161

NOTE:
THIS RACK ASSEMBLY IS A FREE STANDING ARRANGEMENT FASTENED TO FLOOR WITH BRACES. ONE ROW OF CYLINDERS CAN BE REMOVED FROM EACH SIDE FOR SERVICING. A 2' AISLE ON EACH SIDE IS RECOMMENDED.



NO. CYLS	LENGTH	RAIL PART NO.	TRACK PART NO.
5	30 7/8	571326	571330
6			
7	51 3/8	571327	571398
8			
9	82 7/8	571328	571337
10			
11	103 3/8	571329	571339
12			

100 LB CAP CYL.



● INCLUDED ONLY WHEN SCALE KIT IS SPECIFIED IN CONTRACT

CAPACITY

RACK ASSEMBLY - TYPICAL INSTALLATION OF 5 TO 12 CYLINDERS - 100 LB. CAP. TWO ROWS BACK TO BACK W/ CENTRAL TRACK

C 46160

ISSUED 12-63

PLATE H-18

C449-C8C

ISSUED 12-63

PLATE M-20

C-4505-PC

NOTE:
THIS RACK ASSEMBLY IS A FREE STANDING ARRANGEMENT FASTENED TO FLOOR WITH BRACES, BUT CAN ALSO BE MOUNTED TO THE WALL. ALLOWANCE OF 2' AISLE IN FRONT OF CYLINDERS FOR SERVICING IS RECOMMENDED.

(DWG A 40152)
WEIGHING TRACK - SEE TABLE - FASTEN WITH 3/8" x 1" LG. BOLTS, NUTS & LOCKWASHERS

(DWG B 40156)
WEIGHING TRACK BRACKET - 571333 - 2 REQ'D.

SUPPORT - 571331 - 2 REQ'D.
(DWG A 40154)
FASTEN WITH 3/8" x 1" LG. BOLTS, NUTS AND LOCKWASHERS

SLOT AND HOLE FOR "U" BOLT - 100 LB. CAP. CYLINDER MANIFOLD

(DWG B 41384)
UPRIGHT - 571233 - 2 REQ'D.

(DWG A 41393)
RAIL SUPPORT - 571208 (FASTEN WITH 1/2" x 1" LG. BOLTS, NUTS & LOCKWASHERS) - 2 REQ'D.

(DWG A 40191)
RAIL - SEE TABLE

HOLES FOR MOUNTING CYLINDER SADDLES AND STUDS SEE PLATES M-24C M-24D & M-24E

SLOT AND HOLE FOR "U" BOLT 100 LB. CAP. CYLINDER MANIFOLDS

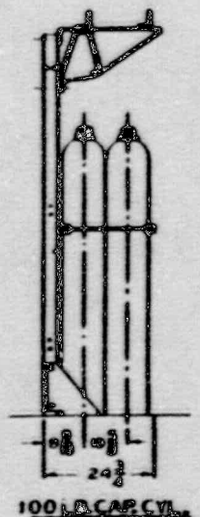
6'-6 5/8"

6'-3 7/8"

11½" CENTERS

(DWG A 41200)
BRACE - 571211 - 2 REQ'D.
FASTEN WITH 1/2" x 1" LG. BOLTS, NUTS AND LOCKWASHERS

NO. CYLS.	LENGTH	RAIL PART NO.	TRACK PART NO.
6	36 1/8"	571328	(2) 571330
8	48 5/8"	571327	(2) 571336
10	61 1/8"	571326	(2) 571337
12	73 5/8"	571329	(2) 571335



100 LB CAP CYL.

6 CYLS.

8 CYLS.

10 CYLS.

12 CYLS.

● INCLUDED ONLY WHEN SCALE KIT IS SPECIFIED IN CONTRACT

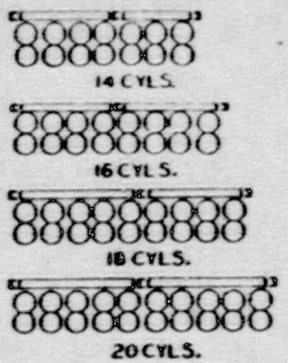
CARBOX

RACK ASSEMBLY - TYPICAL INSTALLATION OF 6 TO 12 CYLINDERS - 100 LB. CAP. TWO BANKS - ONE SIDE WEIGHING TRACK

C 46162

ISSUED 12-63

PLATE H-21A



WEIGHING TRACK - SEE TABLE - FASTEN WITH 3/8" X 1" LG. BOLTS, NUTS & LOCKWASHERS (WEIGH TRACK DWG A 40152)

WEIGHING TRACK BRACKET - 571333 - 3 REQ'D. (DWG B 48150)

SUPPORT - 571331 - 3 REQ'D (DWG A 48194) FASTEN WITH 3/8" X 1" LG. BOLTS, NUTS AND LOCKWASHERS

SLOT AND HOLE FOR "U" BOLT - 100 LB. CAP. CYLINDER MANIFOLD

(DWG B 41384) UPRIGHT - 571233 - 3 REQ'D.

(DWG A 41393) RAIL SUPPORT - 571208 (FASTEN WITH 1/2" X 1" LG. BOLTS, NUTS & LOCKWASHERS) - 5 REQ'D.

RAIL - SEE TABLE (DWG A 48191)

HOLES FOR MOUNTING CYLINDER SADDLES AND STUDS - SEE PLATES H-24C H-24D & H-24E

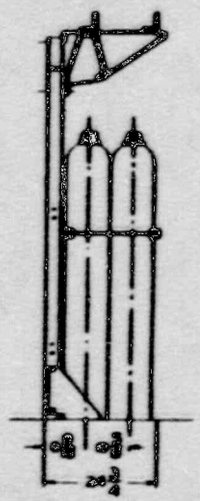
SLOT AND HOLE FOR "U" BOLT 100 LB. CAP. CYLINDER MANIFOLDS

1/2" X 1" LG. BOLT, NUT & LOCKWASHER

BRACE (DWG A 41208) 571208 2 REQ'D.

6'-3"

11½" CENTERS



100 LB. CAP. CYL.

NO. CYLS.	LENGTH	RAIL PART NO.		TRACK PART NO.	
14	7'-0 1/8"	571327	571328	[illegible]	[illegible]
16	7'-11 3/8"	(2) 571327		(4) 571330	
18	8'-11 1/8"	571328	571327	[illegible]	[illegible]
20	9'-10 5/8"	(2) 571328		(4) 571331	
22	10'-10 1/8"	571328	571328	[illegible]	[illegible]
24	11'-9 5/8"	(2) 571328		(4) 571330	

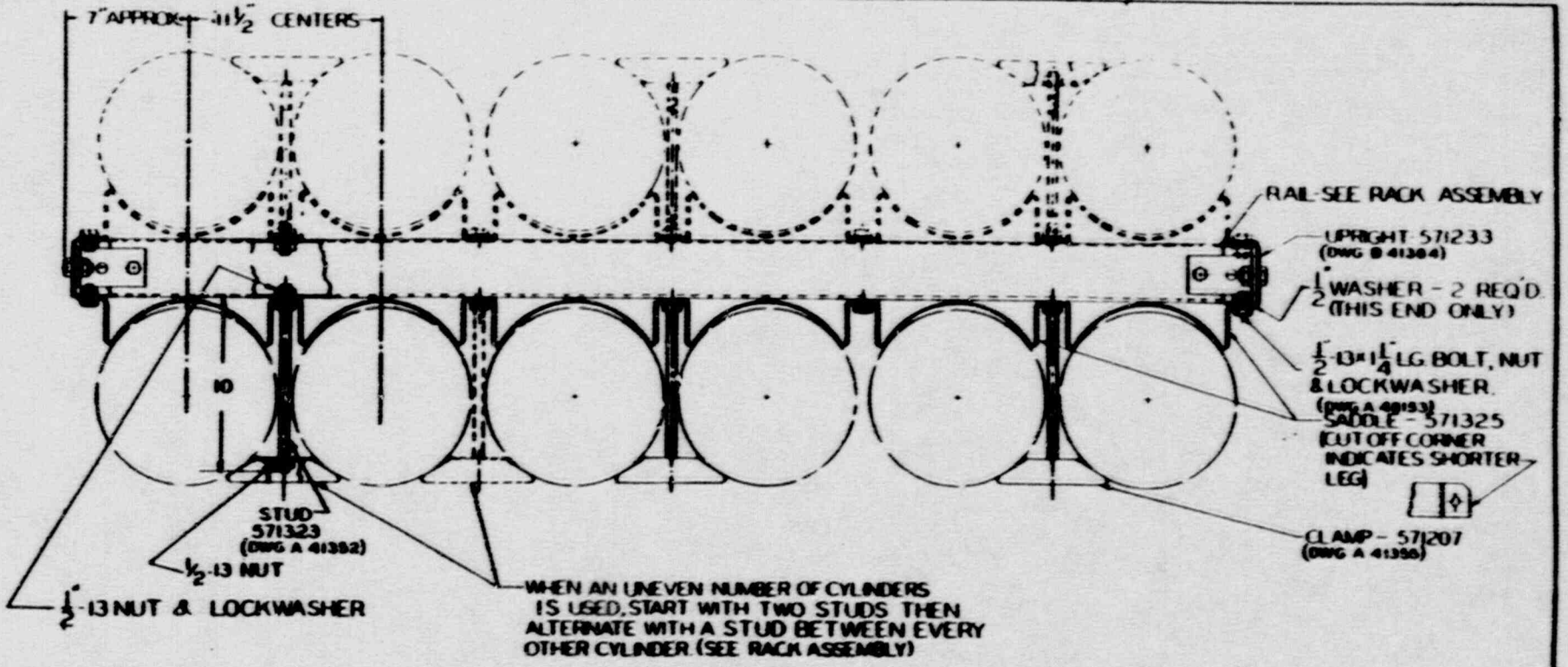
NOTE:
THIS RACK ASSEMBLY IS A FREE STANDING ARRANGEMENT FASTENED TO FLOOR WITH BRACES, BUT CAN ALSO BE MOUNTED TO THE WALL. ALLOWANCE OF 2' AISLE IN FRONT OF CYLINDERS FOR SERVICING IS RECOMMENDED.

● INCLUDED ONLY WHEN SCALE KIT IS SPECIFIED IN CONTRACT

CARBOX

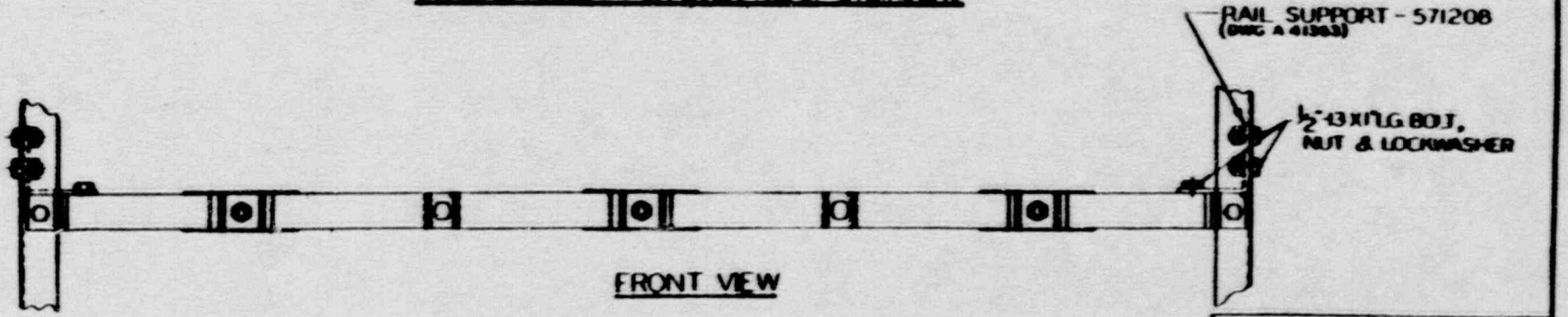
RACK ASSEMBLY - TYPICAL INSTALLATION OF 14 TO 24 CYLINDERS - 100 LB. CAP. (100) REMS - ONE SIDE WELDING, TRAILER

C 46163



TOP VIEW

TYPICAL ARRG'T. FOR EVEN NO. OF CYLINDERS



FRONT VIEW

CARBOX

CYLINDER CLAMPING ARRANGEMENT
FOR 100 LB. CAP. CYLINDERS
1 ROW & 2 ROWS BACK TO BACK

C 46164

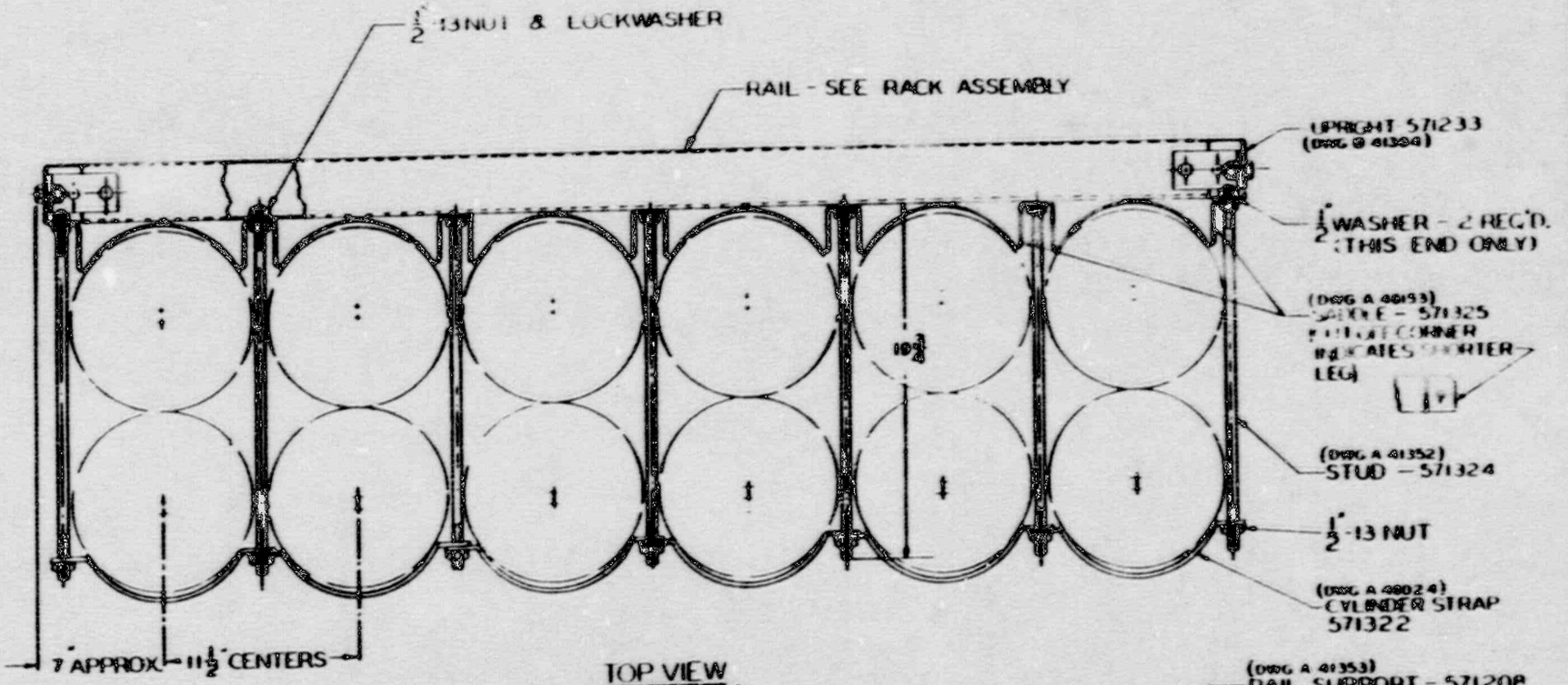
ISSUED 12-43

PLATE NO. H-23A

C-453-OPC

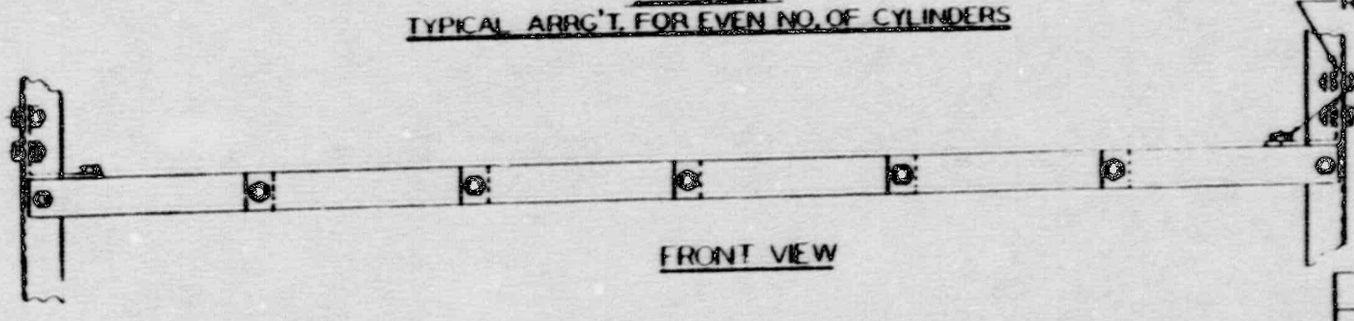
ISSUED 12-63

PLATE NO H-24C



TOP VIEW

TYPICAL ARRG'T. FOR EVEN NO. OF CYLINDERS



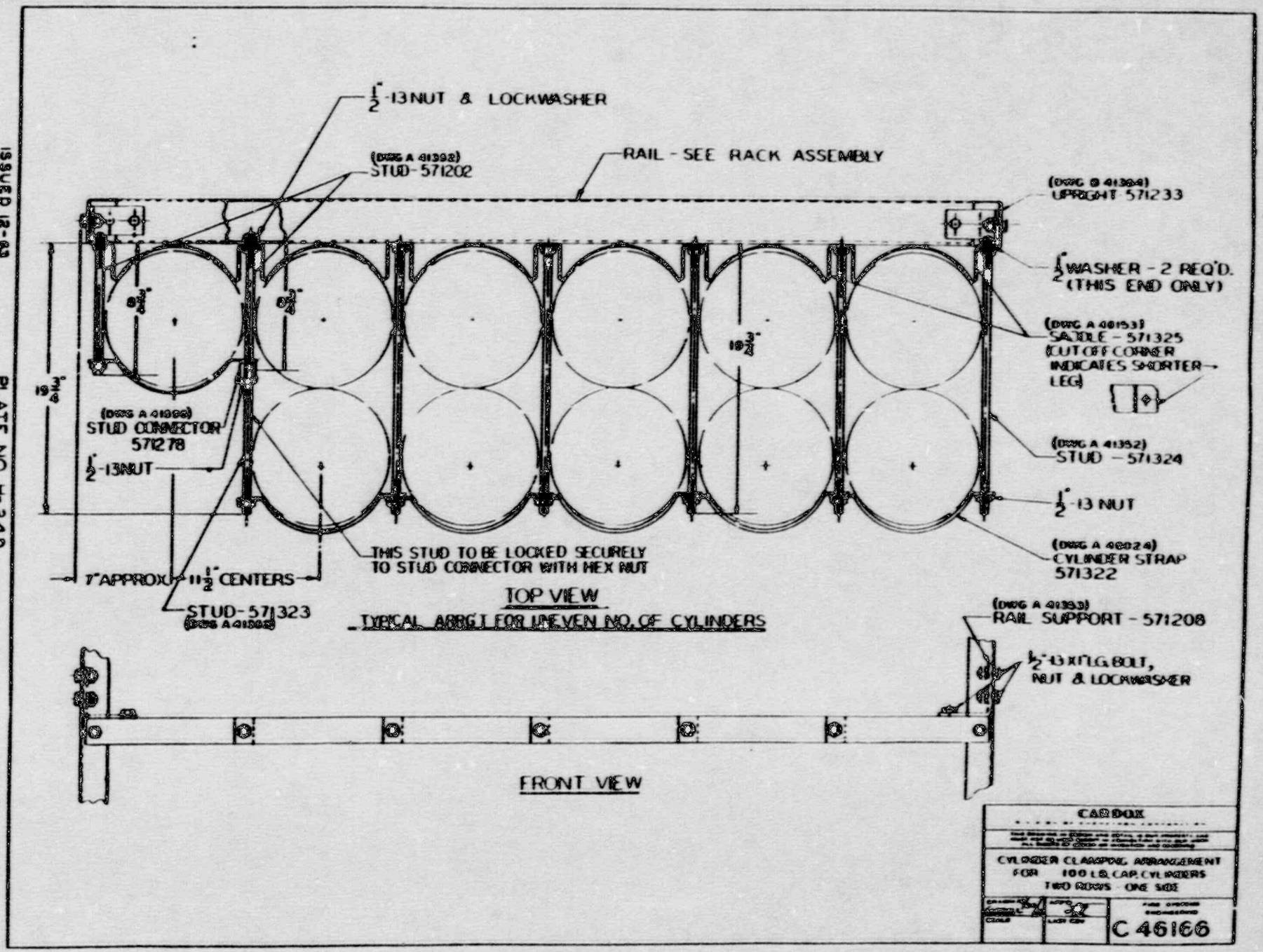
FRONT VIEW

CARDOX

CYLINDER CLAMPING ARRANGEMENT
FOR 100 LB CAP CYLINDERS
TWO ROWS - ONE SIDE

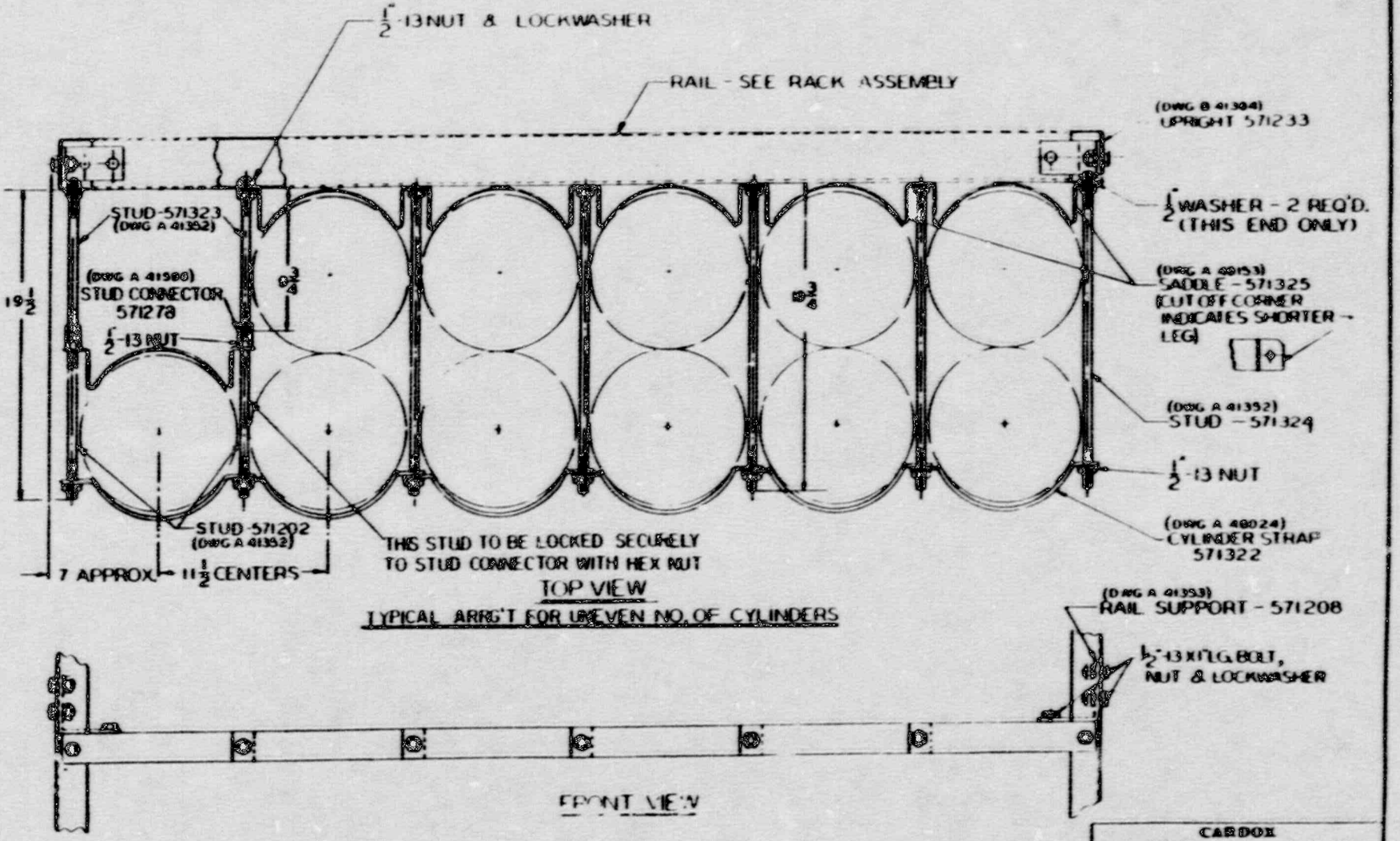
C 46165

-CPC-500-


½"-13 NUT & LOCKWASHER
(DWG A 41392) STUD-571202
RAIL - SEE RACK ASSEMBLY
(DWG B 41394) UPRIGHT 571233
½" WASHER - 2 REQ'D. (THIS END ONLY)
(DWG A 40153) SADDLE - 571325 (CUT OFF CORNER INDICATES SHORTER LEG)
(DWG A 41392) STUD - 571324
½"-13 NUT
(DWG A 40024) CYLINDER STRAP 571322
(DWG A 41393) STUD CONNECTOR 571278
½"-13 NUT
THIS STUD TO BE LOCKED SECURELY TO STUD CONNECTOR WITH HEX NUT
7" APPROX
11½" CENTERS
STUD-571323 (DWG A 41393)
8¾"
7"
19¾"
19¾"
TOP VIEW
TYPICAL ARRGT FOR UP EVEN NO. OF CYLINDERS
(DWG A 41393) RAIL SUPPORT - 571208
½"-13 HEX HD. BOLT, NUT & LOCKWASHER
FRONT VIEW
CARDOX
CYLINDER CLAMPING ARRANGEMENT FOR 100 LB. CAP. CYLINDERS TWO ROWS - ONE SIDE
C 46166
ISSUED 12-63
PLATE NO. H-240
C453-CPC

ISSUED 12-63

PLATE NO. H-24E

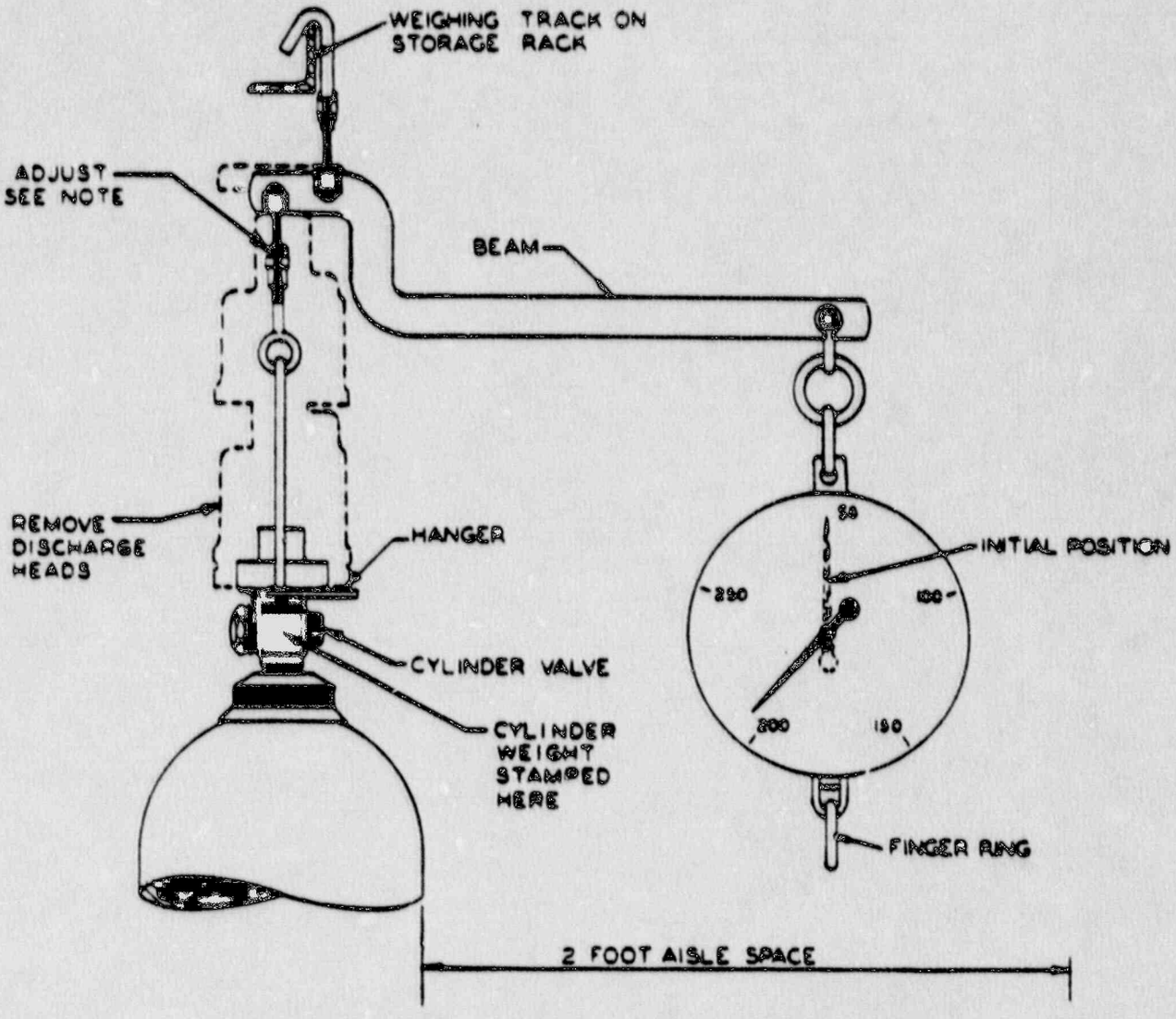


CARDOX

CYLINDER CLAMPING ARRANGEMENT
FOR 100 LB. [illegible]
TWO ROWS [illegible]

C 46167

CARDOX fire extinguishing equipment...



NOTE:

TO WEIGH-LOOSEN CYLINDER CLAMPS, POSITION HANGER ON CYLINDER VALVE. PULL DOWN ON FINGER RING UNTIL SCALE BEAM IS HORIZONTAL AND CYLINDER IS JUST OFF FLOOR. ADJUST HANGER ARM IF NECESSARY. READ WEIGHT DIRECTLY.

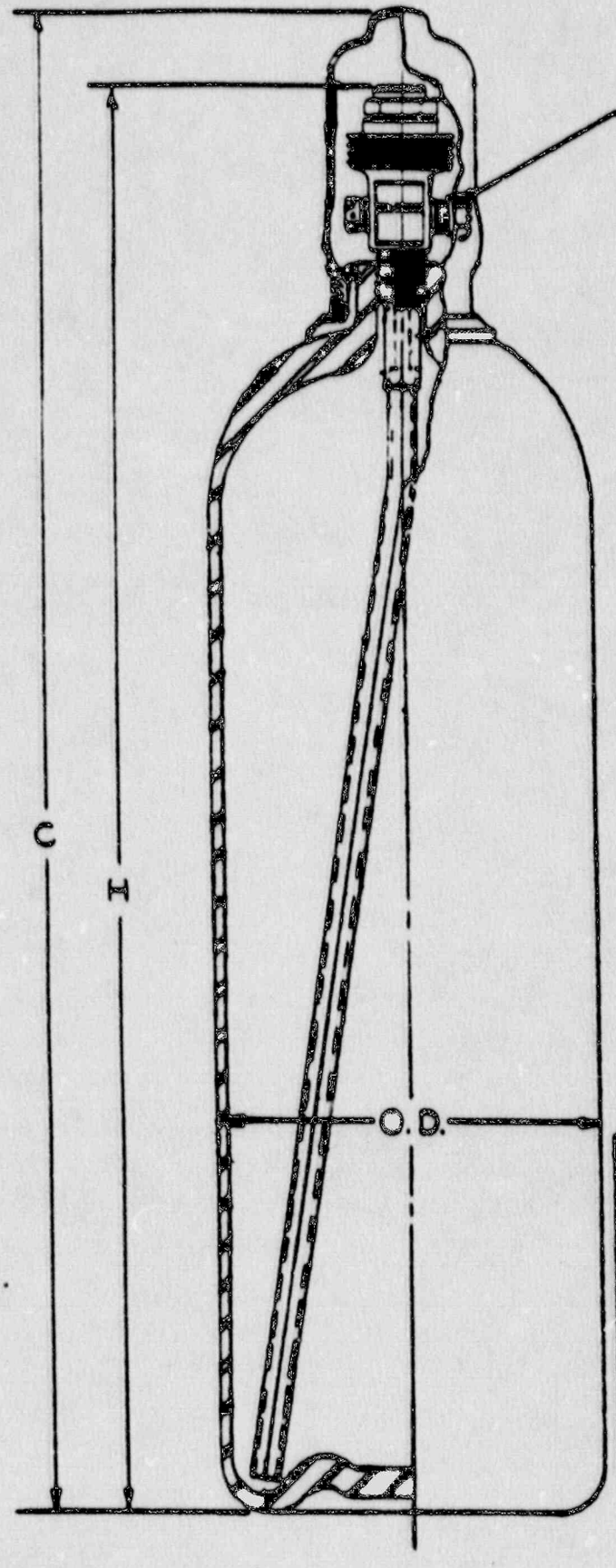
CARDOX
BEAM SCALE PORTABLE WEIGHING DEVICE

MODEL NO. B41377
PART NO. 5729

Revised 1-62

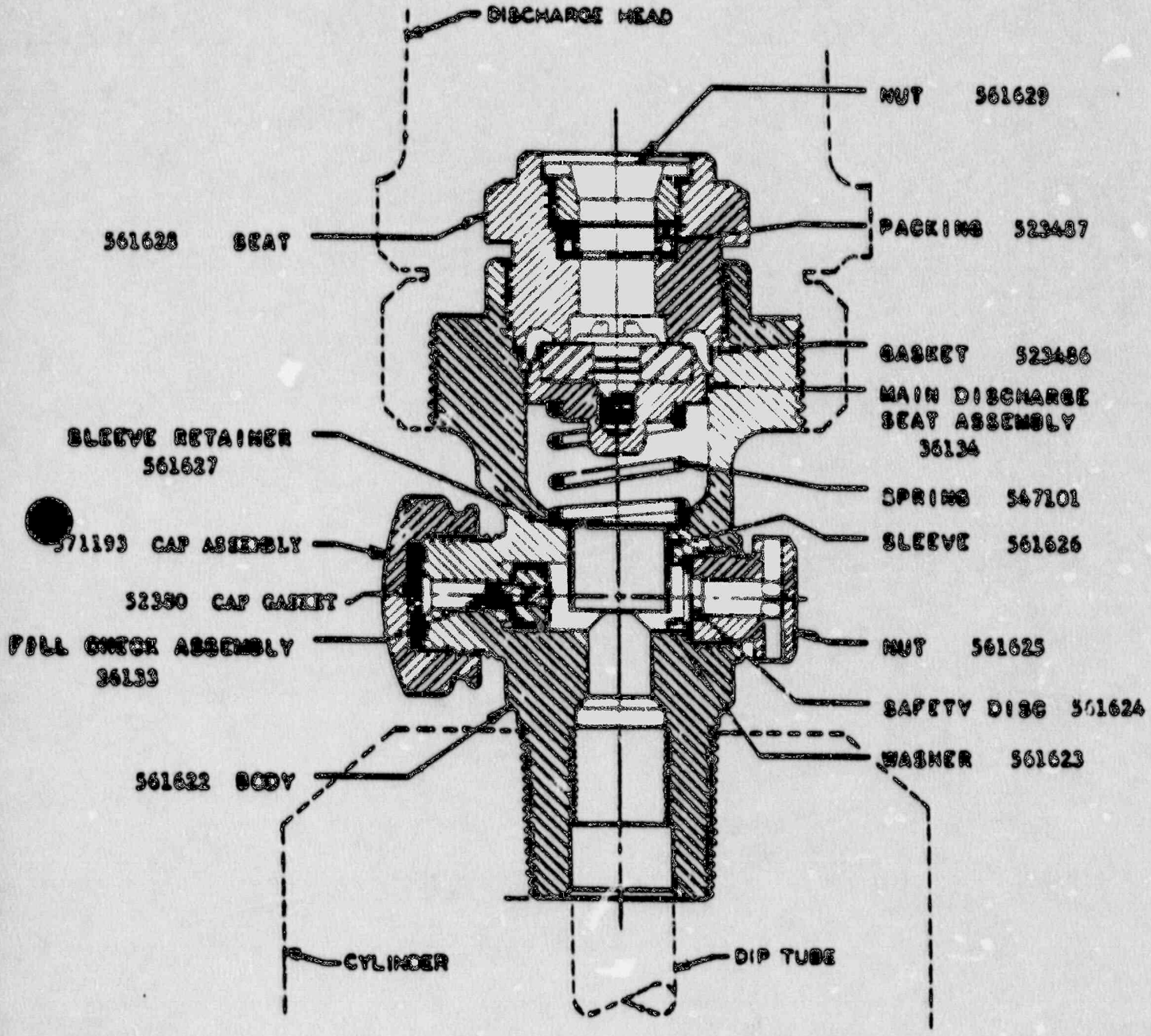
PLATE NO. H-23

CARDOX fire extinguishing equipment...



CARDOX
CYLINDER ASSEMBLY

	50 LB.	75 LB.	100 LB
PART NO.	37125	3714	37138
O.D.	8 3/8	9 5/16	10 5/8
H	59 1/4	80 1/4	62 1/4
C	58 3/4	81 3/4	63 3/4
AVERAGE WEIGHT	162	220	29

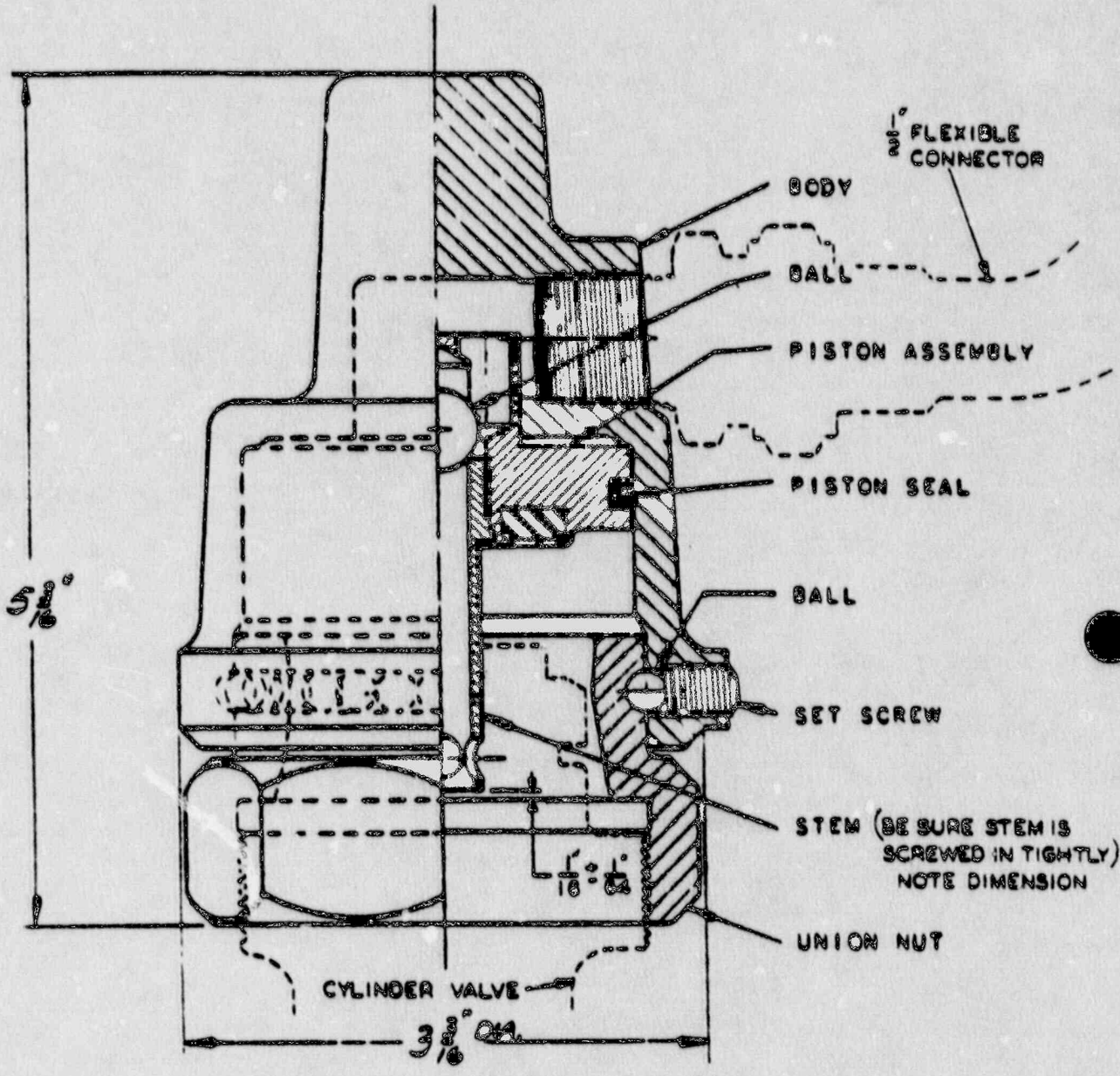


CARDOX CYLINDER VALVE

PART NO.-161527

MODEL NO.-FC34937

CARDOX fire extinguishing equipment...

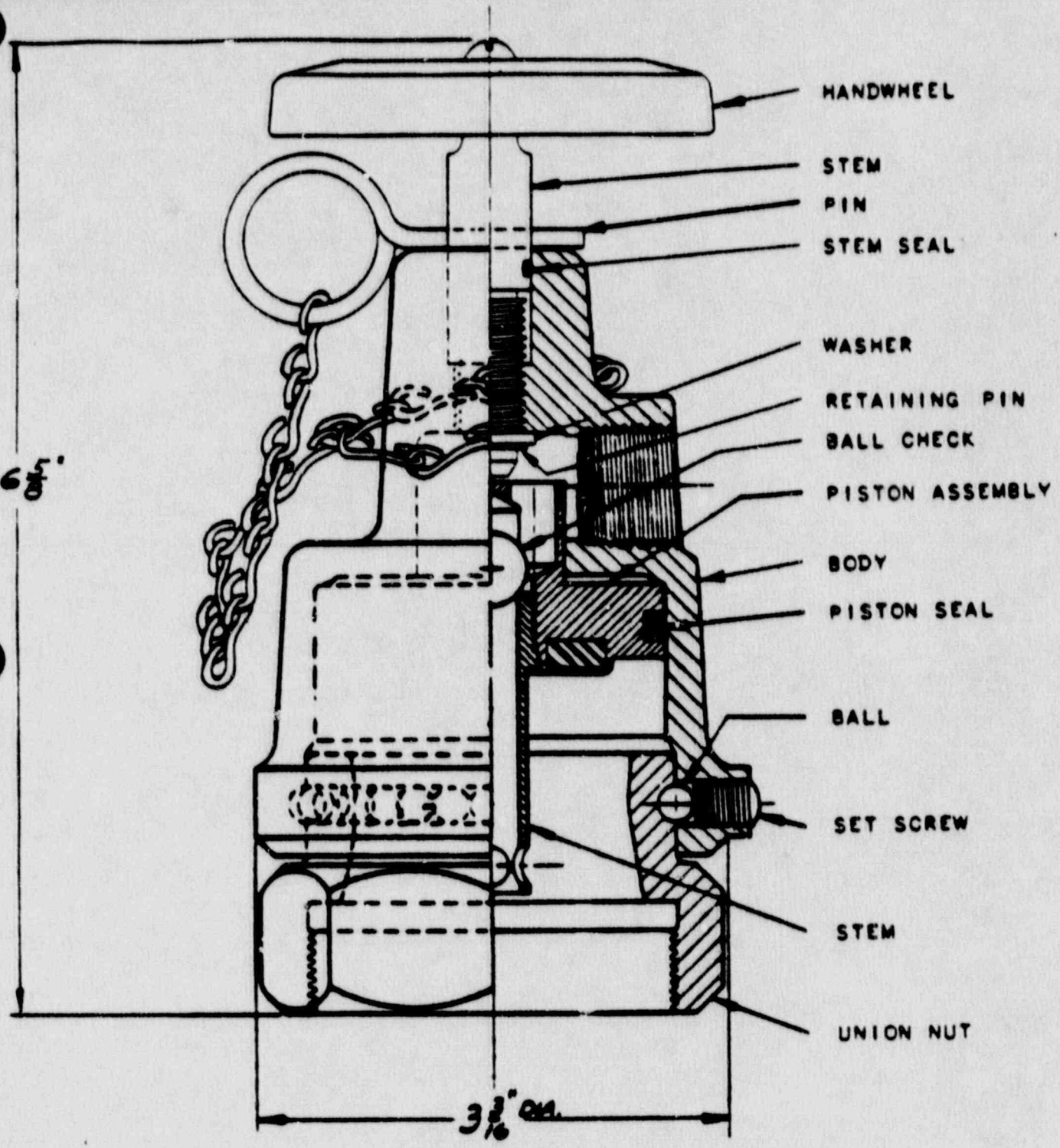


CARDOX
DISCHARGE HEAD
PART NO.-36130
MODEL NO.- FB34922

Revised 1-62

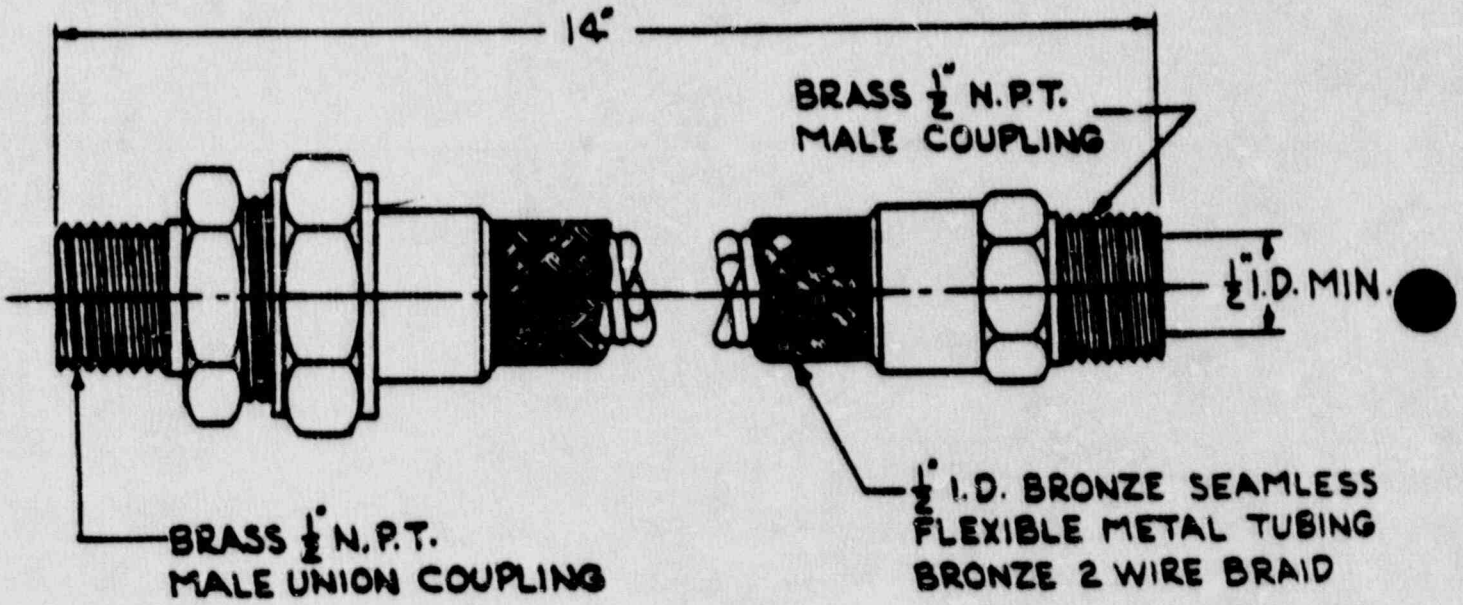
PLATE NO. H-29

CARDOX fire extinguishing equipment...



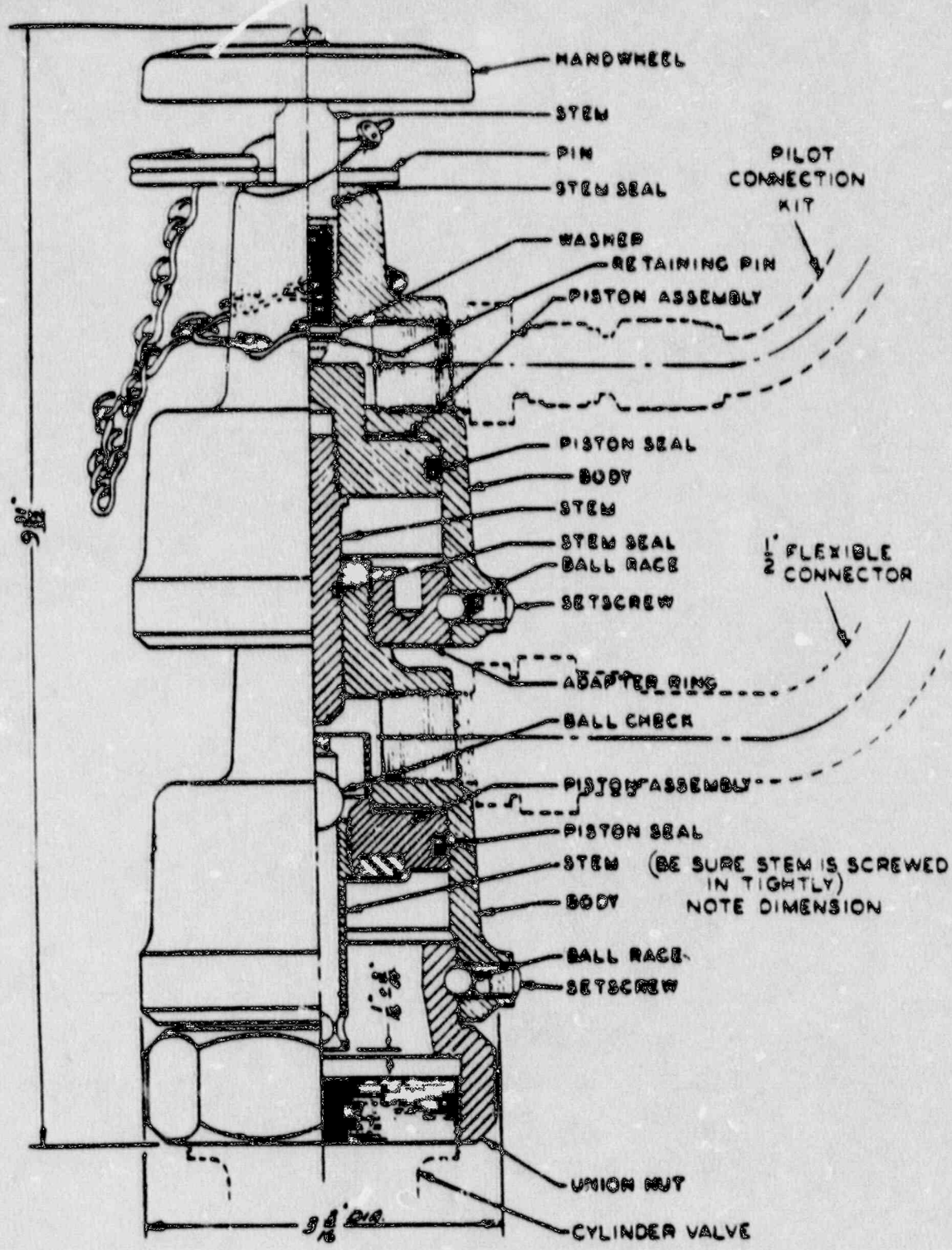
CARDOX
DISCHARGE HEAD
PART NO.-36137
MODEL NO.-FB34990

CARDOX fire extinguishing equipment...



CARDOX
FLEXIBLE CONNECTOR
PART NO.-571194

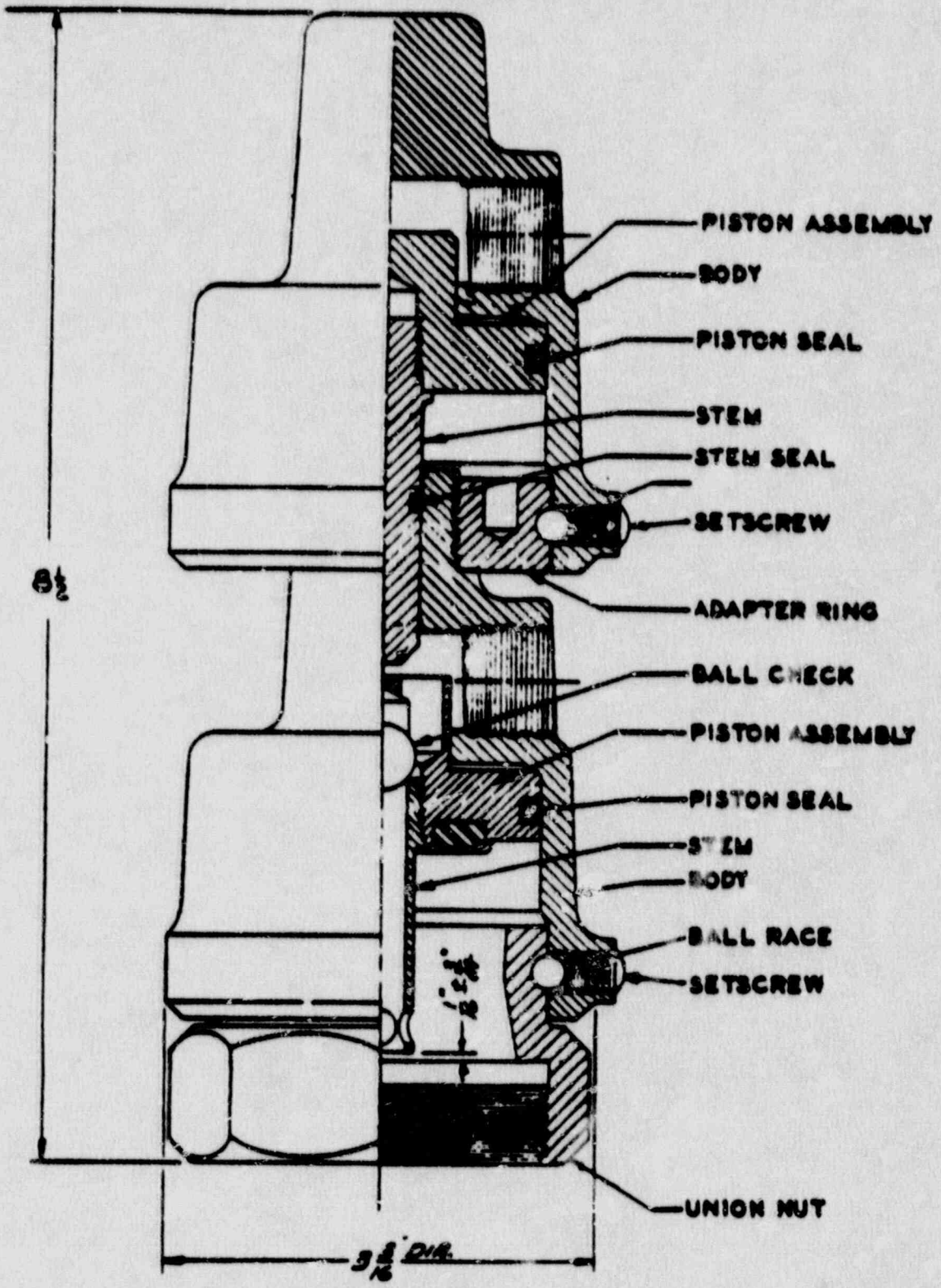
CARDOX fire extinguishing equipment...



CARDOX
PILOT OPERATED DISCHARGE HEAD
PART NO.- 161653
MODEL NO.- C41872A

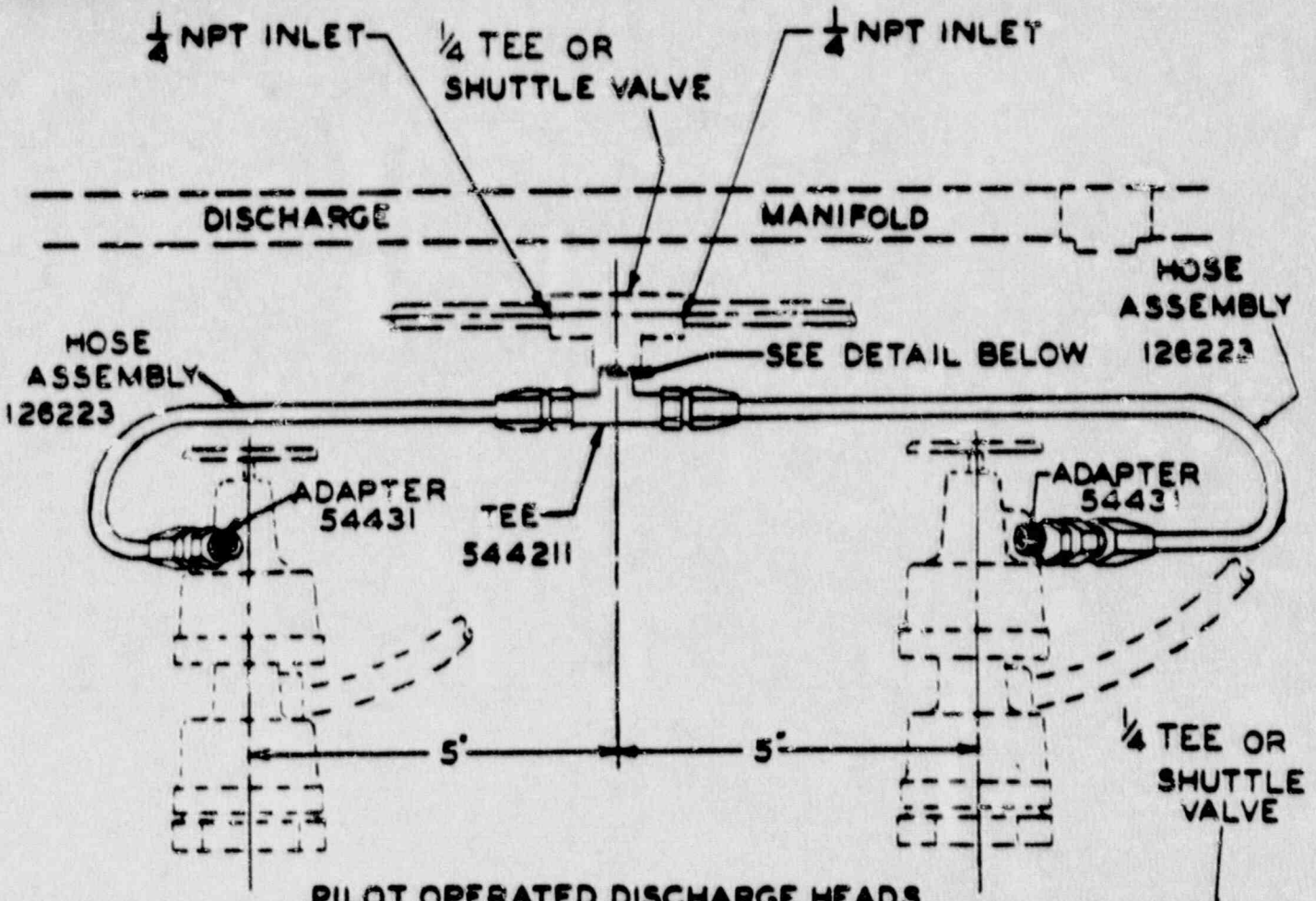
Revised 10-62 PLATE NO. H-35

CARDOX fire extinguishing equipment...



CARDOX
PILOT OPERATED DISCHARGE HEAD
PART NO.- 161654
MODEL NO.- C41871A

[redacted] fire extinguishing equipment...



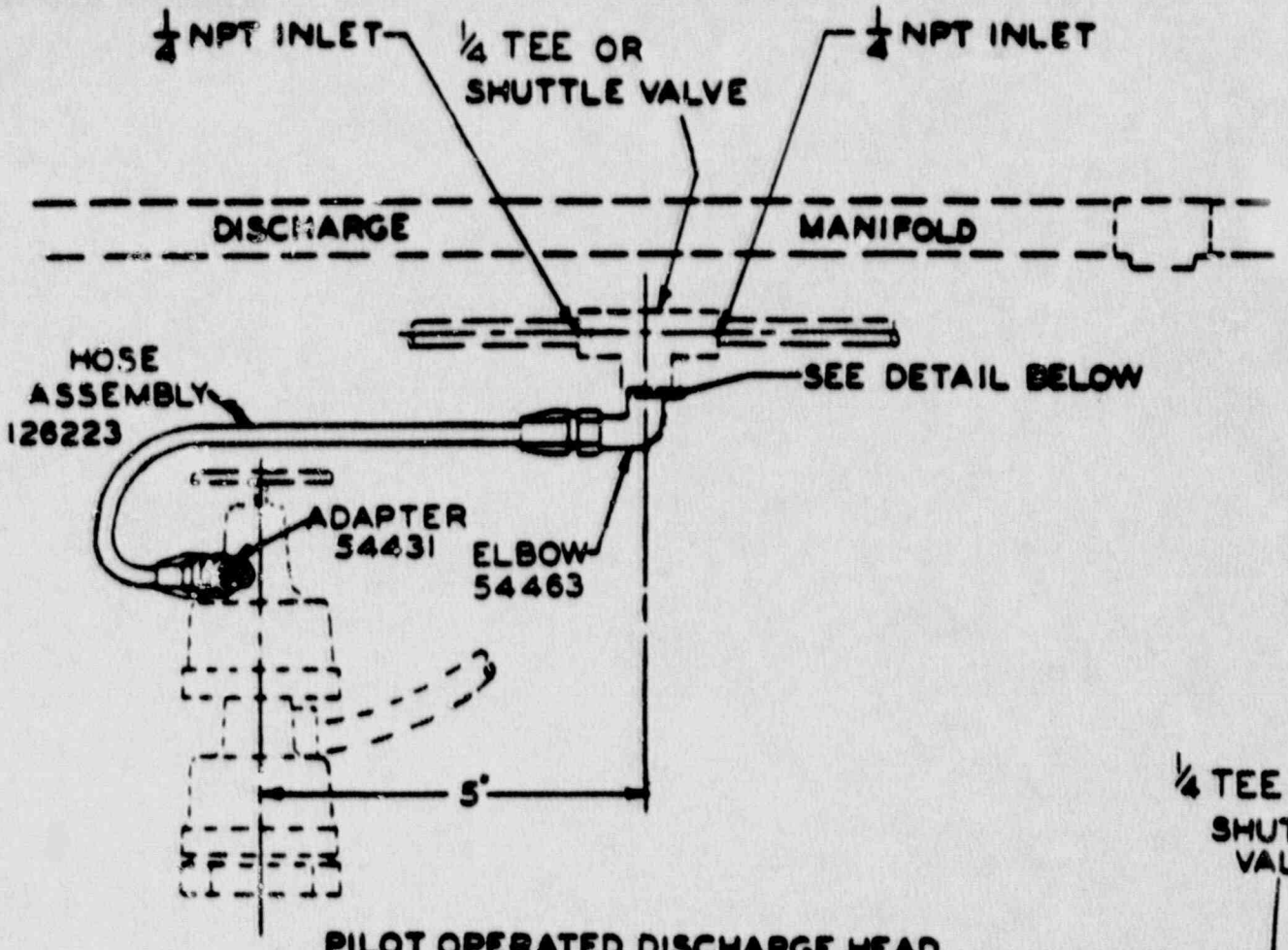
CARDOX

PILOT CONNECTION KIT

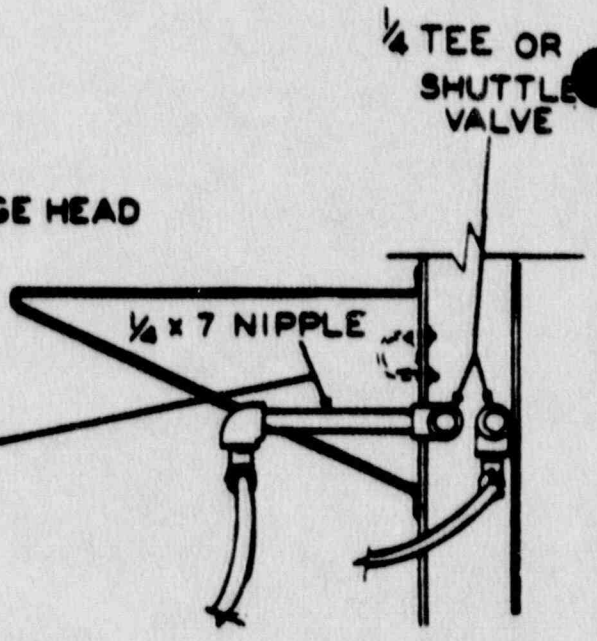
2 PILOT OPERATED DISCHARGE HEADS

PART NO. - 36142

[redacted] fire extinguishing equipment...



PILOT OPERATED DISCHARGE HEAD



IF PILOT CYLINDERS ARE IN THE FRONT ROW OF A TWO ROW CYLINDER BANK THE ¼ x 7 NIPPLE IS REQUIRED.

2 ROW INSTALLATION

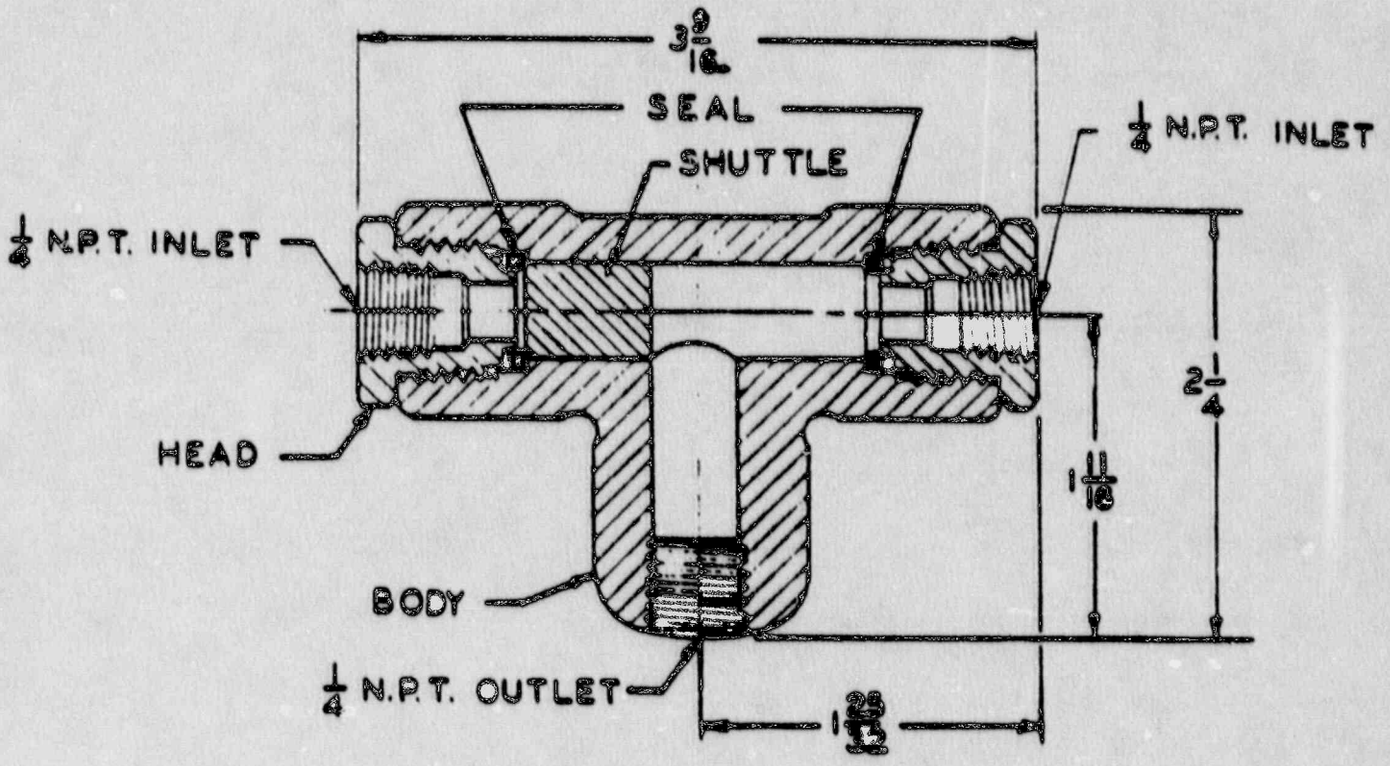
CARDOX

PILOT CONNECTION KIT

1 PILOT OPERATED DISCHARGE HEAD

PART NO. - 36143
DRAWING - A41893

CARDOX fire extinguishing equipment...



CARDOX
SHUTTLE VALVE

PART NO. - 161256

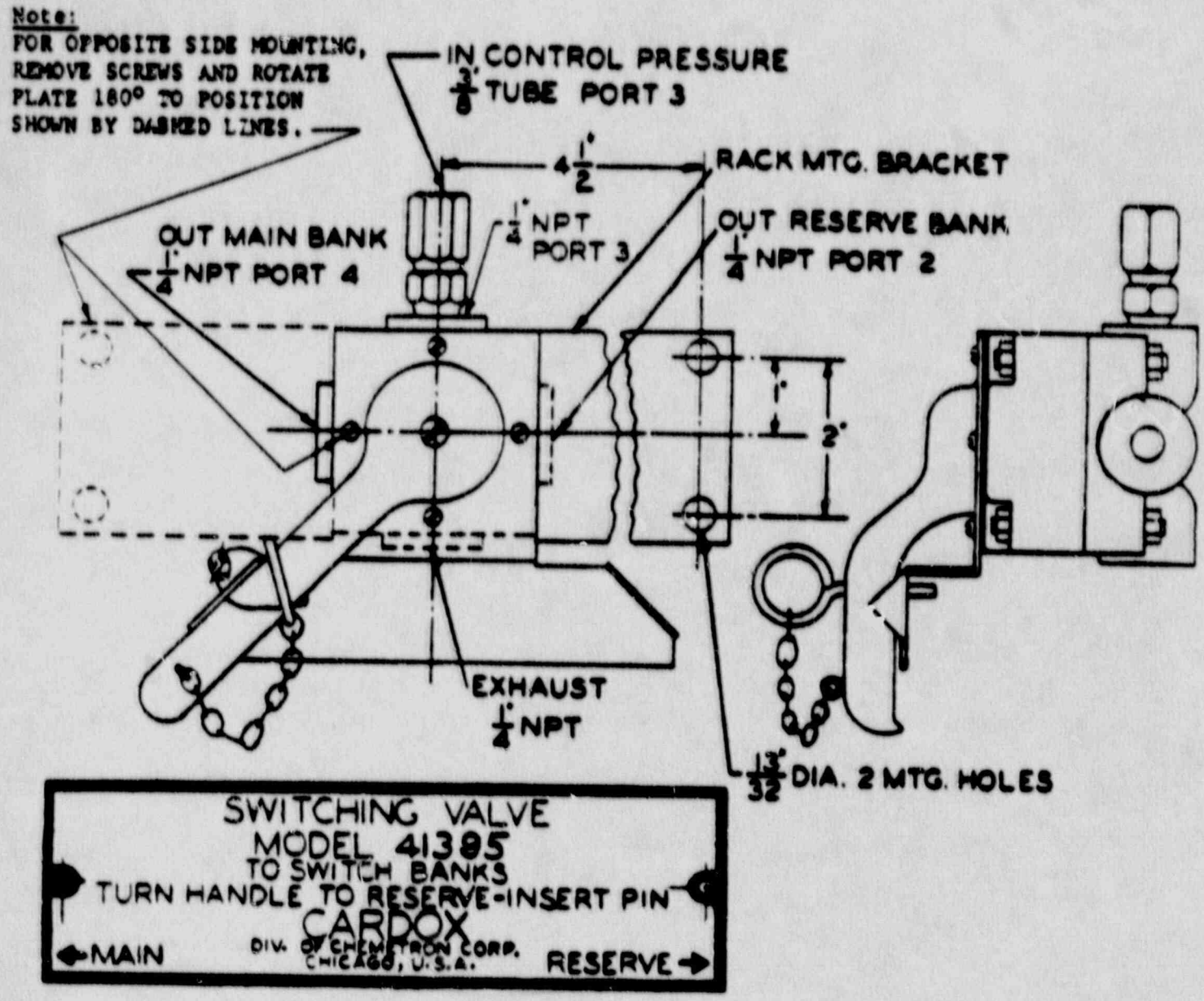
MODEL NO. - A 41400

REV. 4-62

PLATE NO. H-38

C-269 CPC

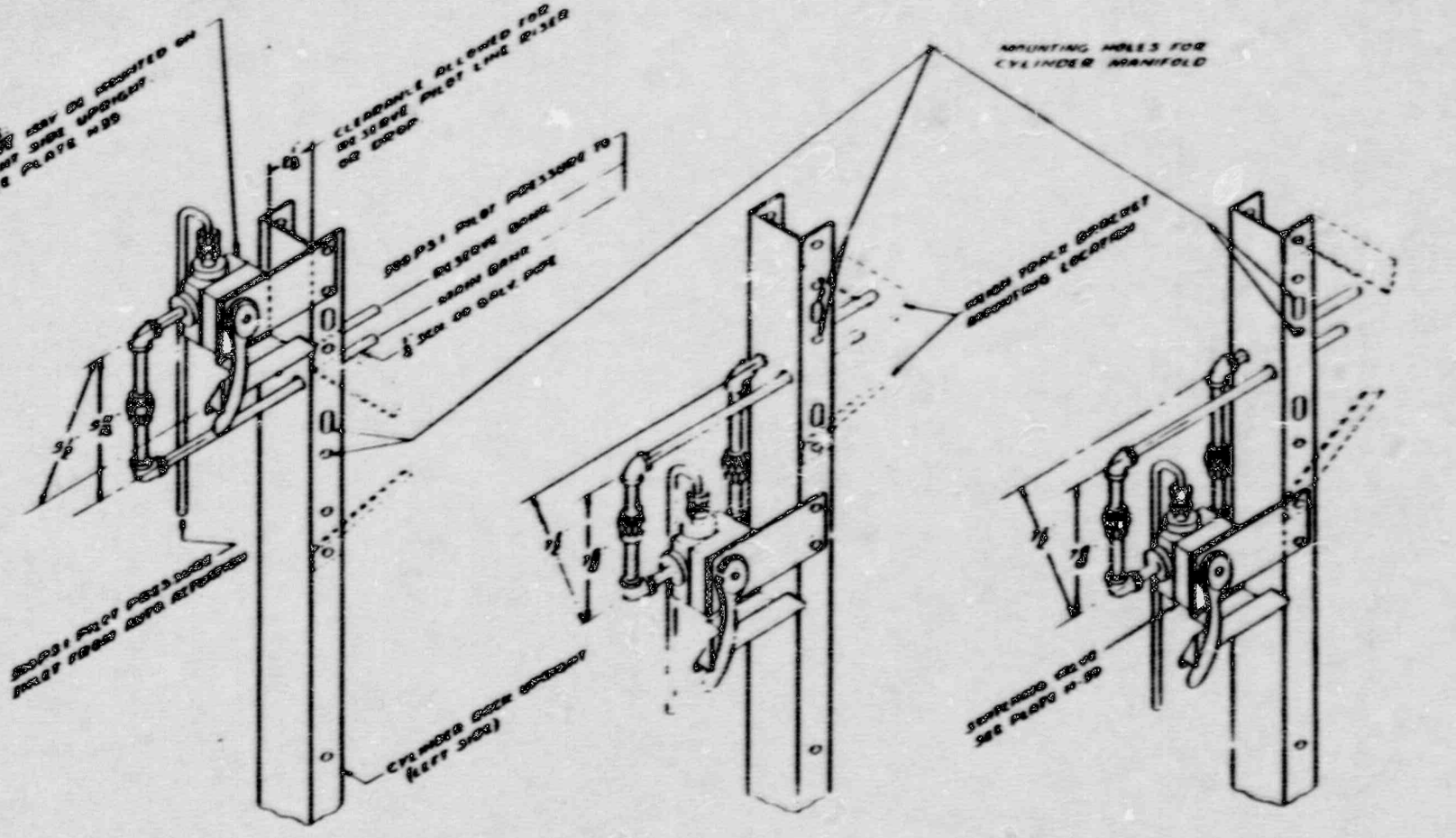
[redacted] fire extinguishing equipment...



CARDOX SWITCHING VALVE

PART NO. - 161595

MODEL NO. - 41395



50LB CYLINDER ARRANGEMENT

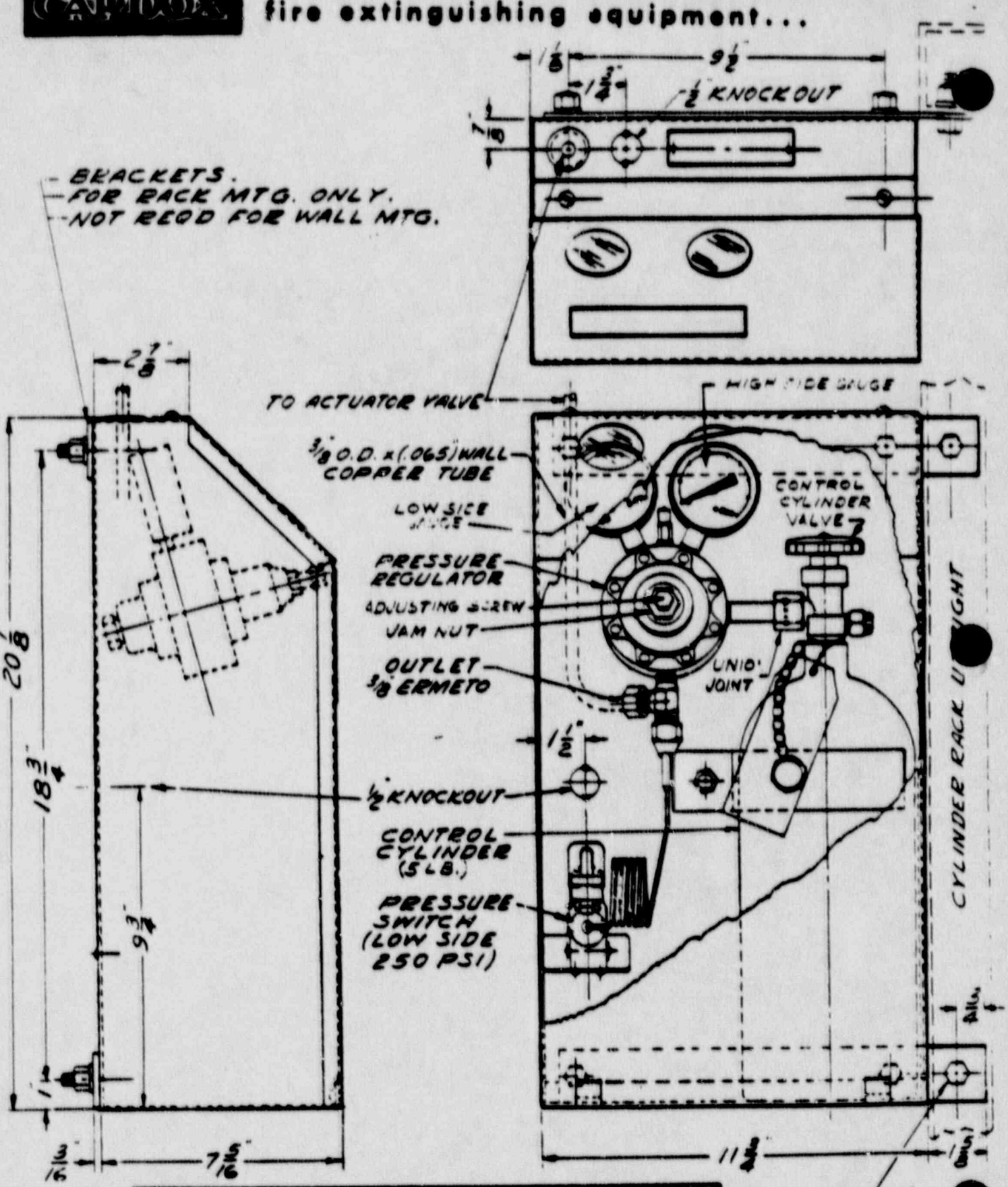
75LB CYLINDER ARRANGEMENT

100LB CYLINDER ARRANGEMENT

SWITCHING VALVE
CONNECTION & MOUNTING DETAILS

DWG. NO C 49092

CARDOX fire extinguishing equipment...



TYPE	MODEL NO.	PART NO.
WITH PRESS. SWITCH	D46070-1	110222
WITH-OUT PRESS. SWITCH	D46070	110223

CARDOX CONTROL CABINET ASSEMBLY

ANSUL fire extinguishing equipment...

HIGH PRESSURE CARBON DIOXIDE FIRE EXTINGUISHING SYSTEM SERVICING INSTRUCTIONS - CONTROL SYSTEM (MODEL D-6070 CONTROL CABINET)

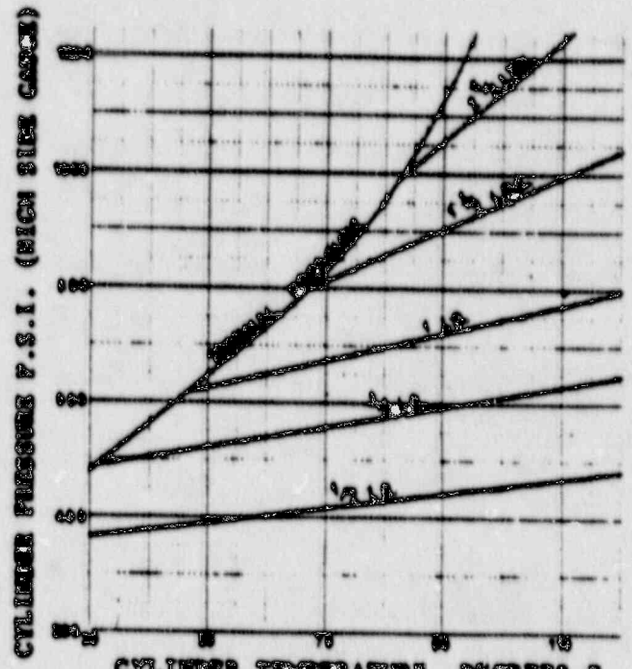
WARNING WHILE SYSTEM IS BEING SERVICED OR UNDER TEST, PILOT DISCHARGE HOSES SHOULD BE DISCONNECTED FROM THE VALVE AND DISCHARGE INTO CYLINDERS TO PREVENT ACCIDENTAL DISCHARGE.

GENERAL

AUTOMATIC RELEASE OF THE SYSTEM DEPENDS ON HAVING CONTROL PRESSURE AVAILABLE WHEN NEEDED. THE CONTROL SYSTEM MUST BE ABSOLUTELY TIGHT FROM THE CONTROL CYLINDERS TO THE RELEASE VALVE.

THE LOW SIDE GAUGE ON REGULATOR (CONTROL PRESSURE) IS TO READ APPROXIMATELY 190 TO 210. IT IS NORMAL FOR CARBON DIOXIDE PRESSURE TO VARY WITH CHANGES IN TEMPERATURE. THE LOW SIDE WILL VARY SLIGHTLY BUT THE HIGH SIDE WILL VARY CONSIDERABLY.

TO ACCURATELY DETERMINE THE AMOUNT OF CARBON DIOXIDE IN A CYLINDER IT MUST BE WEIGHED. THE APPROXIMATE AMOUNT CAN BE DETERMINED FROM THE GRAPH ON THE RIGHT. THE FIVE POUND CONTROL CYLINDERS WILL MAINTAIN RELEASE NORMAL PRESSURES UNTIL IT HAS LOST 60 TO 70% OF ITS CONTENTS. THE CONTROL CYLINDERS SHOULD BE RECHARGED WHEN THE HIGH SIDE GAUGE READING IS ABOUT 100 BELOW NORMAL PRESSURE, AND ATTEMPT SHOULD BE MADE TO LOCATE CAUSE OF GAS LOSS.



EXAMPLE OF USE OF GRAPH: IF CYLINDER TEMPERATURE IS 70° AND HIGH SIDE GAUGE READING IS 750, THE CONTROL CYLINDERS WOULD HAVE SLIGHTLY OVER ONE POUND OF CARBON DIOXIDE, AND MUST BE RECHARGED.

A- CONTROL CYLINDER WEIGHT CHECK

1. REMOVE PILOT DISCHARGE HOSES AND CLOSE CONTROL CYLINDER VALVE.
2. OPEN UNION JOINT, REMOVE CONTROL CYLINDER, WEIGH, RECHARGE IF NECESSARY, RECORD ON CARD, REINSTALL CONTROL CYLINDER WITH GASKET, TIGHTEN UNION JOINT, AND OPEN CONTROL CYLINDER VALVE. LOW SIDE PRESSURE GAUGE SHOULD READ 200.
3. TO INCREASE PRESSURE LOOSEN JAM NUT AND SLOWLY TURN ADJUSTING SCREW CLOCKWISE UNTIL LOW SIDE PRESSURE READS 300. TIGHTEN JAM NUT.
4. TO DECREASE PRESSURE, CLOSE CONTROL CYLINDER VALVE, LOOSEN JAM NUT, TURN ADJUSTING SCREW CLOCKWISE 1/4 TURN AND LOOSEN UNION JOINT UNTIL PRESSURE IS EXHAUSTED. TURN ADJUSTING SCREW COUNTER-CLOCKWISE ONE TURN AND TIGHTEN UNION JOINT. OPEN CONTROL CYLINDER VALVE AND SLOWLY TURN ADJUSTING SCREW CLOCKWISE UNTIL LOW SIDE PRESSURE READS 300 AND TIGHTEN JAM NUT.

   NOTE: IF ADJUSTING SCREW IS DIFFICULT TO TURN, EXHAUST PRESSURE AS INSTRUCTED IN STEP 4-4, REMOVE ADJUSTING SCREW AND LUBRICATE THREADS AND BEARINGS.

5. RETRACT STEMS IF EXTENDED IN PILOT DISCHARGE HOSES AND REINSTALL TO PILOT CYLINDERS.

   NOTE: IT IS NORMAL FOR CONTROL SYSTEMS WITH ACTUATOR VALVES TO GO THROUGH A CYCLE WHILE THE SYSTEM IS BEING PRESSURIZED, SAME AS IF SYSTEM HAD OPERATED AUTOMATICALLY. THE HISSING SOUND WILL STOP WHEN THE GAS IN THE ACTUATING SYSTEM, INCLUDING ANY DISCHARGE DELAY TIMER, HAS BEEN EXHAUSTED.

B- LOW PRESSURE CHECK

IF PRESSURE DROPS BELOW 250 PSI, OR IF ALARM, LIGHT, ETC. OF SUPERVISED SYSTEMS OPERATES:

1. REMOVE PILOT DISCHARGE HOSES.
2. MAKE CERTAIN CONTROL CYLINDER VALVE IS OPEN AND REGULATOR IS ADJUSTED TO 300.
3. CHECK WEIGHT OF CONTROL CYLINDERS AS INSTRUCTED IN SECTION A.
4. IF CONTROL CYLINDERS HAS LOST WEIGHT AS A RESULT OF LEAKAGE, LOCATE LEAKS WITH SOAP SOLUTION, LEAK TEST, OR HALOGEN LEAK DETECTOR. AFTER CORRECTING ALL LEAKS, TIGHTNESS OF SYSTEM CAN BE DETERMINED BY PRESSURE RECESSION TEST AS OUTLINED IN SECTIONS C, D AND E.
5. CHECK PRESSURE SWITCH AND ELECTRICAL CONNECTIONS.
6. CONNECT FULL CONTROL CYLINDER AND COMPLETE SYSTEM AS INSTRUCTED IN SECTION A.

C- PRESSURE RECESSION TEST FOR LEAKS

WITH THE PRESSURE RECESSION METHOD OF TEST THE SIZE OR RATE OF LEAKAGE CAN BE DETERMINED. A CALCULATED LEAKAGE RATE OF ONE POUND PER YEAR IS CONSIDERED TIGHT. HIGHER RATES INDICATE LEAKS WHICH MUST BE LOCATED AND ELIMINATED.

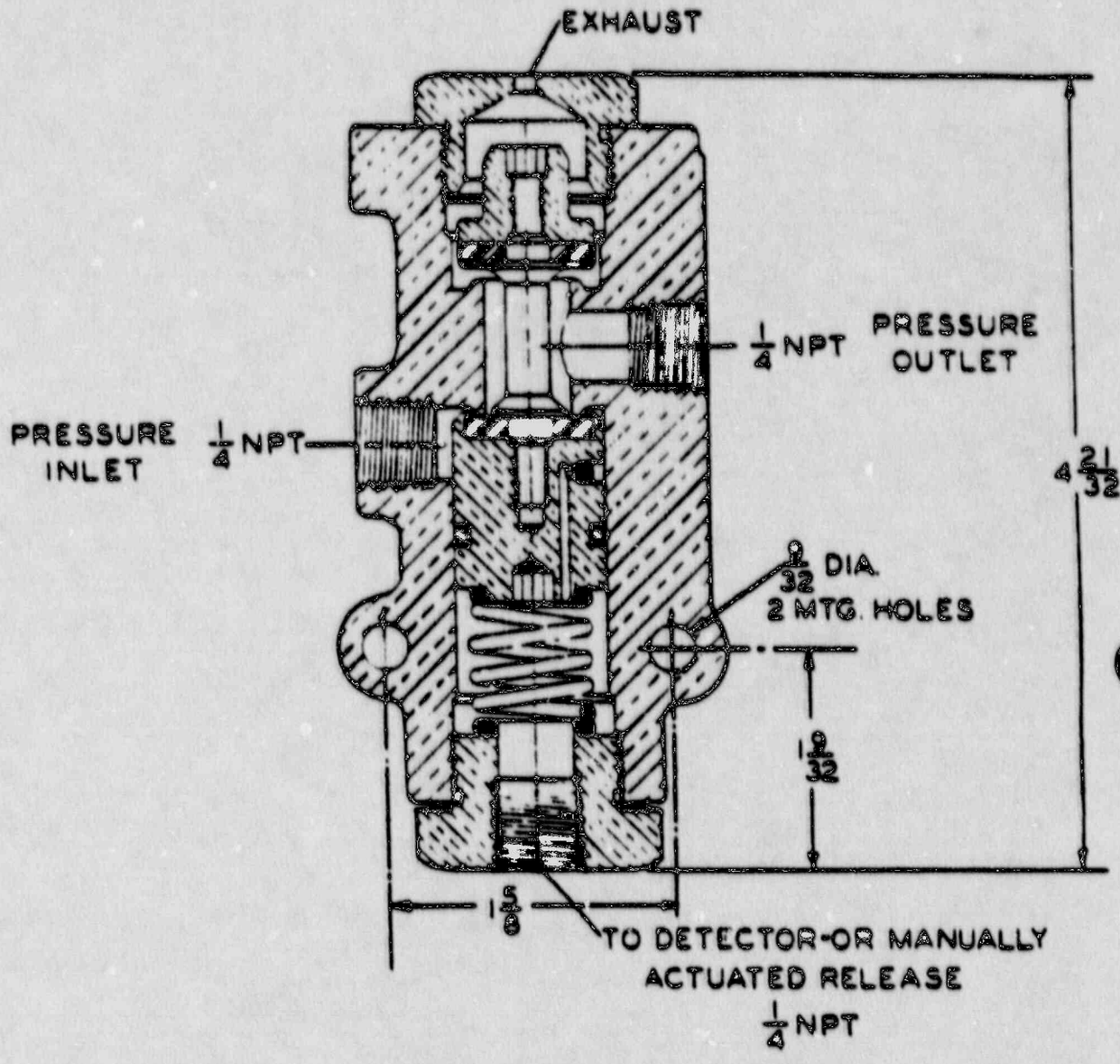
D- HIGH SIDE PRESSURE RECESSION TEST

1. REMOVE PILOT DISCHARGE HOSES.
2. CLOSE CONTROL CYLINDER VALVE.
3. EXHAUST PRESSURE FROM CONTROL SYSTEM BY LOOSENING JAM NUT ON REGULATOR, TURN ADJUSTING SCREW CLOCKWISE 1/4 TURN, LOOSEN UNION JOINT UNTIL PRESSURE IS EXHAUSTED.
4. TURN ADJUSTING SCREW COUNTER-CLOCKWISE UNTIL LOOSE AND TIGHTEN UNION JOINT.
5. OPEN AND THEN TIGHTLY CLOSE CONTROL CYLINDER VALVE.
6. OBSERVE PRESSURE GAUGES. LOW SIDE SHOULD READ ON PRESSURE, HIGH SIDE SHOULD REMAIN CONSTANT. IF HIGH SIDE GAUGE PRESSURE DROPS, LOCATE AND ELIMINATE LEAK. IF PRESSURE REMAINS CONSTANT FOR A 30-MINUTE PERIOD, HIGH SIDE SHALL BE CONSIDERED TIGHT.
7. RE-OPEN CONTROL CYLINDER VALVE. THERE SHOULD BE AN INCREASE ON HIGH PRESSURE GAUGE.

E- LOW SIDE PRESSURE RECESSION TEST

1. REMOVE PILOT DISCHARGE HOSES.
2. ADJUST REGULATOR TO 300 ON LOW PRESSURE GAUGE; TURN BACK OFF ADJUSTING SCREW ONE-HALF TURN.
3. CLOSE CONTROL CYLINDER VALVE TIGHTLY; CRACK UNION JOINT UNTIL HIGH PRESSURE GAUGE READS ZERO AND RETIGHTEN UNION JOINT.
4. ALLOW SYSTEM TO STAND FOR ABOUT ONE-HALF HOUR TO REACH ROOM TEMPERATURE. CHECK PRESSURE GAUGES PERIODICALLY. A RISE ABOVE 300 MAY BE DUE TO WARMING OF THE SYSTEM, WHICH IS NORMAL. A PRESSURE DROP INDICATES A GROSS LEAK. IF THE HIGH SIDE SHOWS AN INCREASE ALONG WITH A DROP ON THE LOW SIDE, CHECK FOR LEAKS ON LOW SIDE WHICH ARE CAUSING REGULATOR TO OPEN TO MEET DEMAND. AN INCREASE ON THE HIGH SIDE ONLY INDICATES THAT THE CONTROL CYLINDER VALVE IS NOT CLOSED TIGHTLY.
5. AFTER OBVIOUS LEAKS HAVE BEEN ELIMINATED, RECORD TEMPERATURE, TIME AND LOW PRESSURE GAUGE READINGS.
6. CALCULATE ANNUAL LEAKAGE RATE BY THE FORMULA $\frac{V \times P}{20 \times T} = $ _____ LBS. PER YEAR; WHERE V IS VOLUME IN CUBIC INCHES UNDER CONTAINERS PRESSURED, P IS CHANGE IN PRESSURE (PSI), AND T IS ELAPSED TIME IN HOURS. USE A VOLUME OF 20 FOR ONE HAZARD SYSTEMS. ADD 10 FOR EACH ADDITIONAL HAZARD. THE ELAPSED TIME IN HOURS FOR TESTING PRESSURE RECESSION IS DETERMINED BY DIVIDING V BY 4. FOR EXAMPLE: IF V IS 20, THE TEST SHALL BE RUN FOR AT LEAST 5 HOURS, DURING WHICH TIME THE LOW PRESSURE GAUGE READING MAY DROP NO MORE THAN 5. THE LONGER THE TEST, THE HIGHER THE DEGREE OF ACCURACY. LONG TESTS ARE PARTICULARLY IMPORTANT IF THE ROOM TEMPERATURE RISES. SLIGHT WARMING OF THE SYSTEM WILL RAISE THE PRESSURE AND TEND TO HIDE SMALL LEAKS.
7. AFTER TEST, TURN ADJUSTING SCREW CLOCKWISE 1/4 TURN AND LOOSEN UNION JOINT UNTIL PRESSURE IS EXHAUSTED. RE-TIGHTEN UNION JOINT, OPEN CONTROL CYLINDER VALVE, ADJUST REGULATOR TO 300 TO RESTORE SYSTEM AND TIGHTEN JAM NUT TO LOCK ADJUSTING SCREW.
8. RETRACT STEMS IF EXTENDED IN PILOT DISCHARGE HOSES AND REINSTALL TO PILOT CYLINDERS.

[redacted] fire extinguishing equipment...



CARDOX ACTUATOR VALVE

PART NO. - 31096

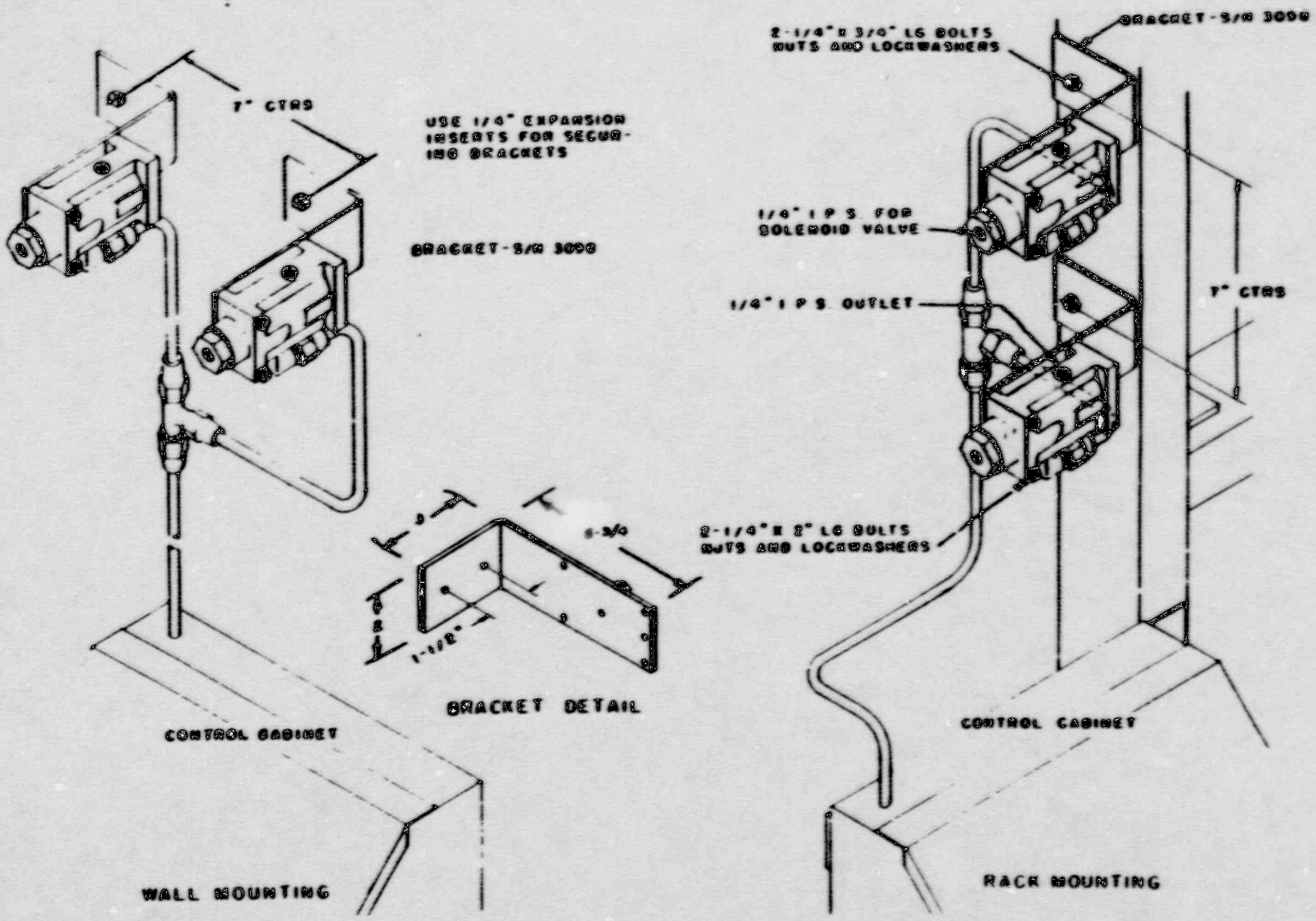
MODEL NO. - C 41781

PNEUMATIC ELECTRIC ACTUATOR AND ACTUATOR VALVE — SERIES 60

ISSUED 11-66

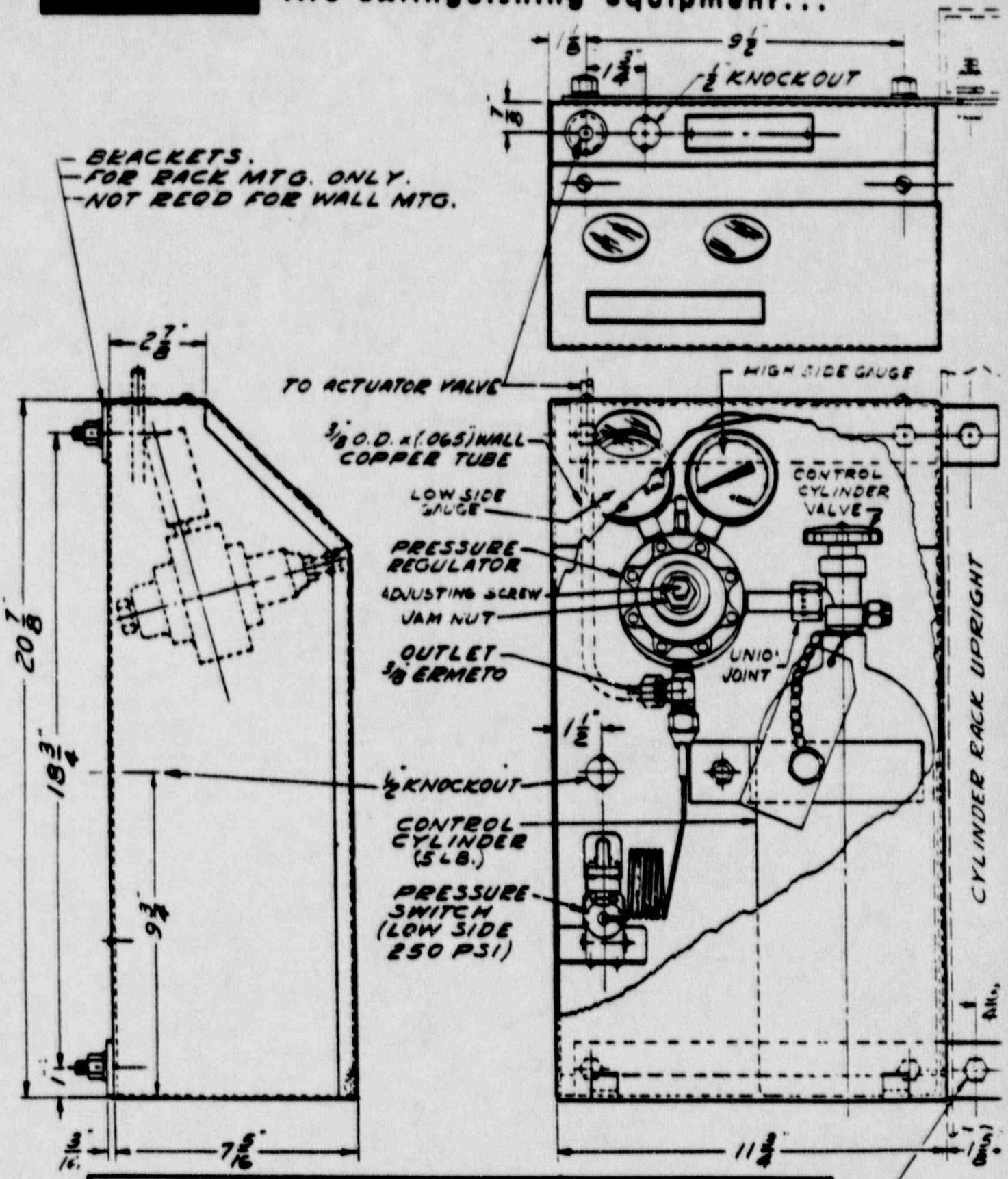
PLATE NO. M-406

C-501



ACTUATOR VALVE MOUNTING DETAIL

CARDOX fire extinguishing equipment...



TYPE	MODEL NO.	PART NO.	DRWG NO.
WITH PRESS. SWITCH	D46070-2	110229	D4607063
WITH-OUT PRESS. SWITCH	D46070-3	110230	D4607064

CARDOX CONTROL CABINET ASSEMBLY

NITROGEN (N_2)

ISSUED 1-67

[illegible] CARBON DIOXIDE
[illegible]
[illegible] - CONTROL SYSTEM
(CONTROL CABINET - MODELS [illegible] AND [illegible])

NITROGEN (N_2)

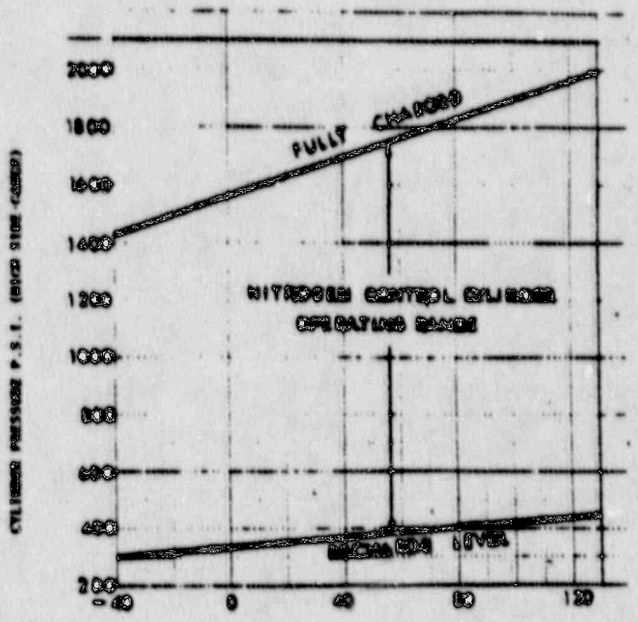
WARNING: WHILE SYSTEM IS BEING SERVICED OR UNDER TEST, PILOT DISCHARGE HEADS SHOULD BE DISCONNECTED FROM THE MAIN AND RESERVE TANK CYLINDERS TO PREVENT ACCIDENTAL DISCHARGE.

AUTOMATIC RELEASE OF THE SYSTEM DEPENDS ON NITROGEN CONTROL PRESSURE AVAILABLE WHEN NEEDED. THE CONTROL SYSTEM MUST BE ABSOLUTELY TIGHT FROM THE CONTROL CYLINDER TO THE RELEASE VALVE.

THE REGULATOR SHOULD BE SET TO MAINTAIN A MINIMUM LOW SIDE PRESSURE OF 290 TO 310 PSI. IT IS NORMAL FOR THE PRESSURE TO CHANGE WITH AMBIENT TEMPERATURE. THIS MAY RESULT IN LOW SIDE PRESSURE EXCEEDING 350 PSI DURING PERIODS OF INCREASING AMBIENT TEMPERATURE.

TO DETERMINE THE CHARGE OF THE NITROGEN (N_2) CONTROL CYLINDER, IT IS NECESSARY TO READ THE HIGH SIDE PRESSURE GAUGE AND KNOWING THE APPROXIMATE AMBIENT TEMPERATURE. IT IS NOT NECESSARY TO DISCHARGE THE NITROGEN CONTROL CYLINDER UNLESS THE PRESSURE TEMPERATURE CO-ORDINATE FALLS BELOW THE INDICATED DISCHARGE LEVEL ON THE CHART AT RIGHT. IF THE SYSTEM HAS NOT BEEN ACTUATED, THIS LOSS OF HIGH SIDE PRESSURE IS DUE TO A LEAK IN THE CONTROL PRESSURE SYSTEM. IF THE NITROGEN CONTROL CYLINDER REQUIRES CHARGING MORE THAN ONCE A YEAR, THE CONTROL PRESSURE SYSTEM LEAK IS EXCESSIVE AND SHOULD BE ELIMINATED.

EXAMPLE USE OF CHART: IF THE APPROXIMATE AMBIENT CONTROL CYLINDER TEMPERATURE IS 70°F. AND THE HIGH SIDE GAUGE READING IS 1000 PSI, THE CONTROL CYLINDER SHOULD BE SLIGHTLY LESS THAN FULLY CHARGED.



CYLINDER TEMPERATURE, DEGREES F
(NOT NECESSARILY ROOM TEMPERATURE)
5 POUND CONTROL CYLINDER

A CONTROL CYLINDER INSTALLATION AND RECHARGE

1. REMOVE PILOT DISCHARGE HEADS!
2. CLOSE CONTROL CYLINDER VALVE.
3. OPEN UNION JOINT BETWEEN REGULATOR AND CONTROL CYLINDER, REMOVE CONTROL CYLINDER AND RECHARGE (IF NECESSARY), ASSEMBLE ON CARD, REINSTALL CONTROL CYLINDER AND TIGHTEN UNION JOINT SECURELY.
4. SLOWLY OPEN CONTROL CYLINDER VALVE. LOW SIDE PRESSURE GAUGE SHOULD READ 300 PSI.
5. TO INCREASE LOW SIDE PRESSURE, LOOSEN REGULATOR JAM NUT AND SLOWLY TURN ADJUSTING SCREW CLOCKWISE UNTIL LOW SIDE PRESSURE GAUGE READS 300. TIGHTEN JAM NUT.
6. TO DECREASE LOW SIDE CONTROL PRESSURE, CLOSE CONTROL CYLINDER VALVE, LOOSEN JAM NUT, TURN ADJUSTING SCREW COUNTERCLOCKWISE 1/4 TURN AND LOOSEN UNION JOINT BETWEEN REGULATOR AND CONTROL CYLINDER UNTIL PRESSURE IS EXHAUSTED. TURN ADJUSTING SCREW COUNTER-CLOCKWISE ONE TURN AND TIGHTEN UNION JOINT SECURELY. SLOWLY OPEN CONTROL CYLINDER VALVE AND TURN ADJUSTING SCREW CLOCKWISE UNTIL LOW SIDE PRESSURE READS 300. TIGHTEN JAM NUT.

   NOTE: IF ADJUSTING SCREW IS DIFFICULT TO TURN, REMOVE PRESSURE AS INSTRUCTED IN STEP A-6, REMOVE ADJUSTING SCREW AND LIGHTLY LUBRICATE THREADS.

7. RESEAT STEMS OF PILOT DISCHARGE HEADS (PUSH DOWN FIRMLY TO INSURE HEAD) AND REINSTALL HEADS ON PILOT CYLINDERS.

   NOTE: ANYTIME THE CONTROL SYSTEM IS PRESSURIZED AFTER BEING DE-PRESSURIZED THE SYSTEM WILL GO THROUGH A COMPLETE CYCLE AS THOUGH IT HAD BEEN AUTOMATICALLY ACTUATED. THIS IS NORMAL AND IS THE REASON FOR REMOVAL OF PILOT DISCHARGE HEADS DURING THIS OPERATION.

   IF THE CONTROL SYSTEM IS BUBBLE TIGHT AND ALL ACTUATING DEVICES ARE RESET, THE HISSING SOUND OF VENTING PRESSURE WILL STOP WHEN THE CONTROL DEVICES HAVE BEEN RECHARGED. AT THIS POINT THE SYSTEM IS ON STAND-BY, READY TO OPERATE.

B LOW PRESSURE CHECK

IF PRESSURE DROPS BELOW 250 PSI, OR IF ALARM, LIGHT, ETC. ON SUPERVISED SYSTEMS OPERATES:

1. REMOVE PILOT DISCHARGE HEADS.
2. MAKE CERTAIN CONTROL CYLINDER VALVE IS OPEN AND REGULATOR IS ADJUSTED TO 300.
3. CHECK HIGH SIDE PRESSURE AS INSTRUCTED IN SECTION A.
4. IF CONTROL CYLINDER HAS LOST PRESSURE AS A RESULT OF LEAKAGE, LOCATE LEAKS WITH SOAP SOLUTION, LEAK TEC ETC.. AFTER CORRECTING ALL LEAKS, TIGHTNESS OF SYSTEM CAN BE DETERMINED BY PRESSURE RECORDING TEST AS OUTLINED IN SECTIONS C, D AND E.
5. CHECK PRESSURE SWITCH AND ELECTRICAL CONNECTIONS.
6. RECHARGE FULL CONTROL CYLINDER AND COMPLETE SYSTEM AS INSTRUCTED IN SECTION A.

C PRESSURE RECORDING TEST FOR LEAKS

WITH THE PRESSURE RECORDING METHOD OF TEST THE RATE OF LEAKAGE CAN BE DETERMINED. IF THE CALCULATED PRESSURE DROP IS LESS THAN 100 PSI PER YEAR, THE SYSTEM IS CONSIDERED TIGHT AND ACCEPTABLE. GREATER RATES INDICATE LEAKS WHICH MUST BE LOCATED AND ELIMINATED.

D HIGH SIDE PRESSURE RECORDING TEST

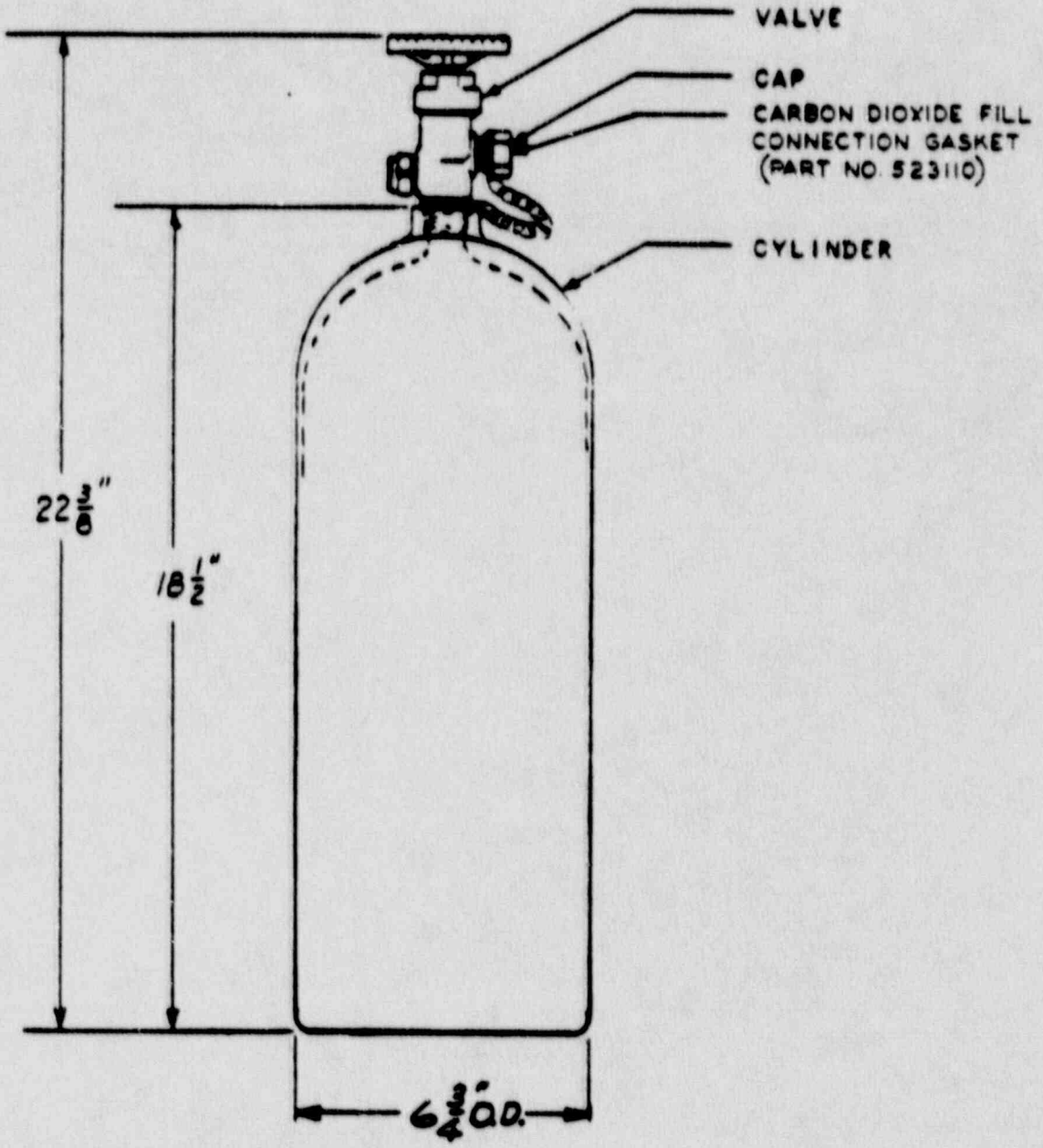
1. REMOVE PILOT DISCHARGE HEADS.
2. CLOSE CONTROL CYLINDER VALVE.
3. EXHAUST PRESSURE FROM CONTROL SYSTEM BY LOOSENING JAM NUT ON REGULATOR, TURN ADJUSTING SCREW COUNTERCLOCKWISE 1/4 TURN, LOOSEN UNION JOINT UNTIL PRESSURE IS EXHAUSTED.
4. TURN ADJUSTING SCREW COUNTER-CLOCKWISE UNTIL LOOSE AND TIGHTEN UNION JOINT.
5. OPEN AND THEN TIGHTLY CLOSE CONTROL CYLINDER VALVE.
6. OBSERVE PRESSURE GAUGES. LOW SIDE SHOULD SHOW NO PRESSURE, HIGH SIDE SHOULD REMAIN CONSTANT. IF HIGH SIDE GAUGE PRESSURE DROPS, LOCATE AND ELIMINATE LEAK. IF PRESSURE REMAINS CONSTANT FOR A 30-MINUTE PERIOD, HIGH SIDE SHALL BE CONSIDERED TIGHT.
7. RE-OPEN CONTROL CYLINDER VALVE. THERE SHOULD BE NO INCREASE ON HIGH PRESSURE GAUGE.

E LOW SIDE PRESSURE RECORDING TEST

1. REMOVE PILOT DISCHARGE HEADS.
2. ADJUST REGULATOR TO 300 ON LOW PRESSURE GAUGE; THEN BACK OFF ADJUSTING SCREW ONE-HALF TURN.
3. CLOSE CONTROL CYLINDER VALVE TIGHTLY; CRACK UNION JOINT UNTIL HIGH PRESSURE GAUGE READS ZERO AND RETIGHTEN UNION JOINT.
4. ALLOW SYSTEM TO STAND FOR ABOUT ONE-HALF HOUR TO REACH ROOM TEMPERATURE. CHECK PRESSURE GAUGES PERIODICALLY. A RISE ABOVE 300 MAY BE DUE TO WARMING OF THE SYSTEM, WHICH IS NORMAL. A PERSISTED DROP INDICATES A GROSS LEAK. IF THE HIGH SIDE SHOWS AN INCREASE ALONG WITH A DROP ON THE LOW SIDE, CHECK FOR LEAKS OR LOW SIDE WHICH ARE CAUSING REGULATOR TO OPEN TO MEET DEMAND. AN INCREASE ON THE HIGH SIDE ONLY INDICATES THAT THE CONTROL CYLINDER VALVE IS NOT CLOSED TIGHTLY.
5. AFTER DEVICES LEAKS HAVE BEEN ELIMINATED, RECORD TEMPERATURE, TIME AND LOW PRESSURE GAUGE READING.
6. CALCULATE ANNUAL LEAKAGE RATE BY THE FORMULA $\frac{300}{I} \times$ CYLINDER PRESSURE DROP PER YEAR; WHERE THE I IS CHANGE IN PRESSURE (PSI) AND I IS ELAPSED TIME IN HOURS. THE FORMULA CONSTANT 300 INCLUDES A VOLUME FOR TUBING, ETC. USUAL TEST FOR AN AVERAGE SYSTEM. TWO MINIMUM TIME FOR PRESSURE RECORDING TEST IS 4 HOURS. THE LONGER THE TEST, THE HIGHER THE DEGREE OF ACCURACY. LONG TESTS ARE PARTICULARLY IMPORTANT IF THE ROOM TEMPERATURE RISES DURING THE TEST SINCE WARMING OF THE SYSTEM WILL RAISE THE PRESSURE AND TEND TO HIDE SMALL LEAKS.

   IF THE PRESSURE DROP AS CALCULATED FROM THE RECORDING EXCEEDS 100 PSI PER YEAR, THE SYSTEM SHOULD BE CHECKED FOR LEAKAGE.
7. AFTER TEST, TURN ADJUSTING SCREW CLOCKWISE 3/4 TURN, LOOSEN UNION JOINT UNTIL PRESSURE IS EXHAUSTED, AND THEN TURN ADJUSTING SCREW COUNTER-CLOCKWISE ONE TURN. RETIGHTEN UNION JOINT. OPEN CONTROL CYLINDER VALVE, ADJUST REGULATOR TO 300 TO RESTORE SYSTEM AND TIGHTEN JAM NUT TO LOCK ADJUSTING SCREW.
8. RESET STEMS IF DEPRESSED IN PILOT DISCHARGE HEADS AND REINSTALL TO PILOT CYLINDERS.

CARDOX fire extinguishing equipment...

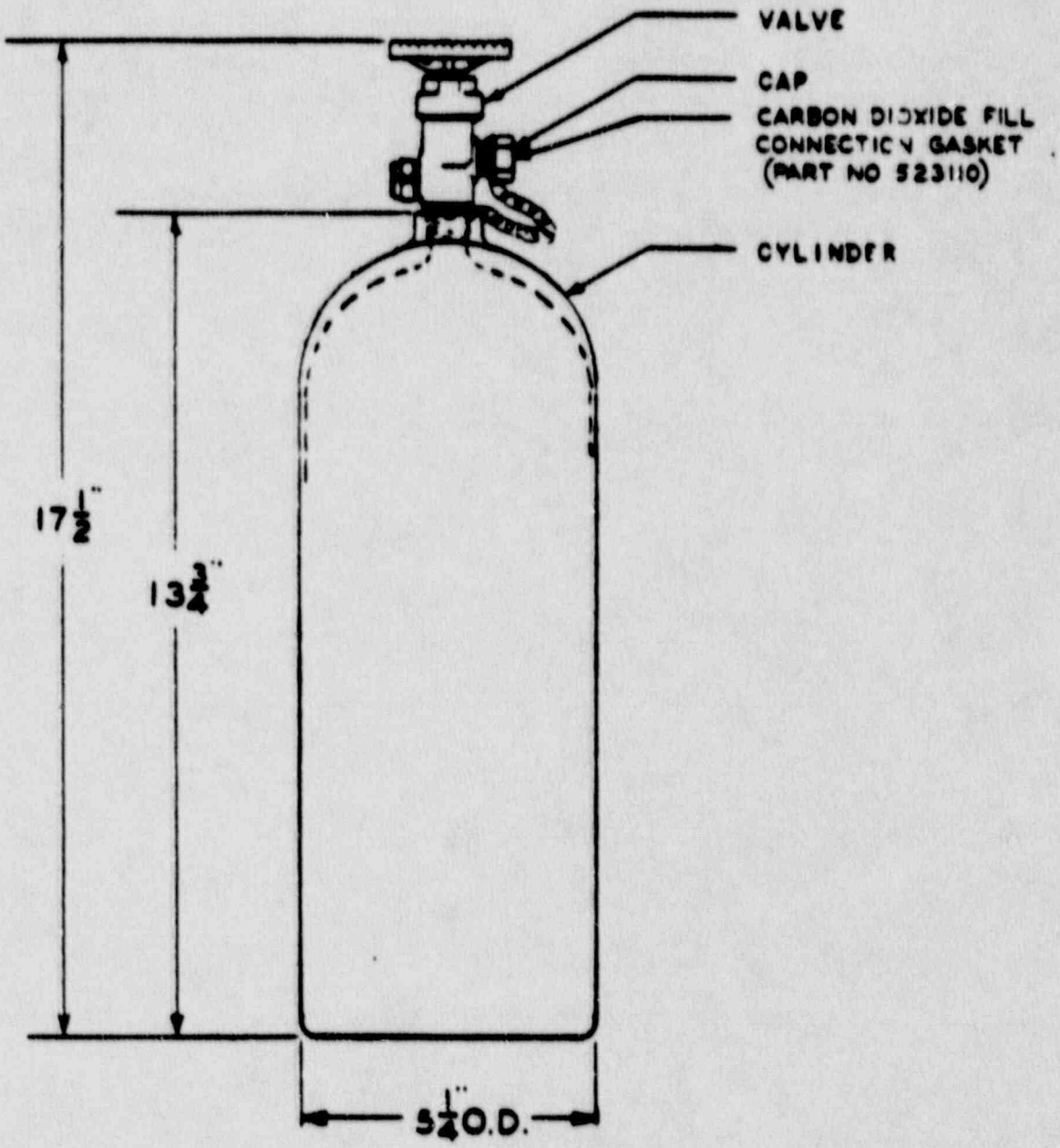


CONTROL GAS	PART NO.	DRAWING NO.	AVERAGE WT.
CARBON DIOXIDE	37126	FA-34986	34 POUNDS
NITROGEN	37133	FA-41368	27 POUNDS

CARDOX

CONTROL CYLINDER ASSEMBLY

[redacted] fire extinguishing equipment...

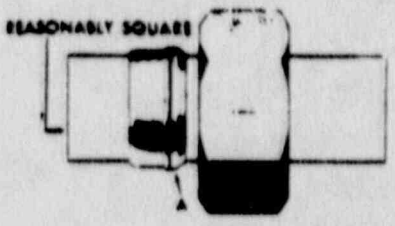


CONTROL GAS	PART NO.	DRAWING NO.	AVERAGE WT.
CARBON DIOXIDE	37137	A46074	16 POUNDS

CARDOX

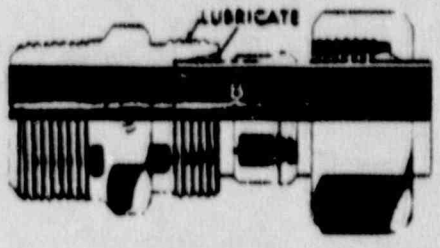
5 LB. CONTROL CYLINDER ASSEMBLY

ASSEMBLY INSTRUCTIONS FOR ERMETO FITTINGS



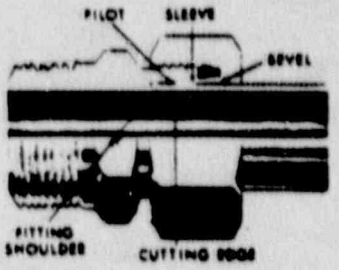
1 **Slide Nut and then the Sleeve on Tube.**

Be sure sleeve is not on backwards. Head of sleeve "A" must be towards nut.



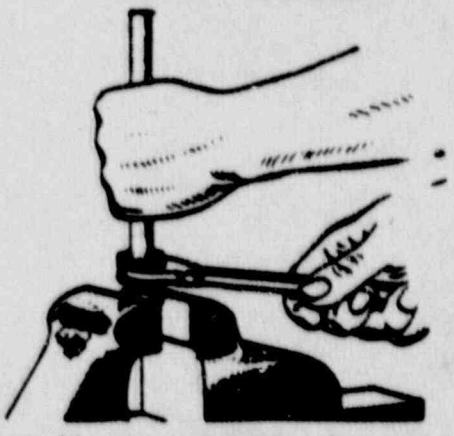
2 **Insert Tube into Fitting.**

Be sure tube is bottomed on fitting shoulder at point "B." Lubricate with oil.



3 **Turn Nut slowly with wrench while turning Tube with other hand.**

When sleeve grips the tube, that is, when the tube can no longer be revolved by hand—STOP—and note position of wrench. This is the "Ring Grip" point.

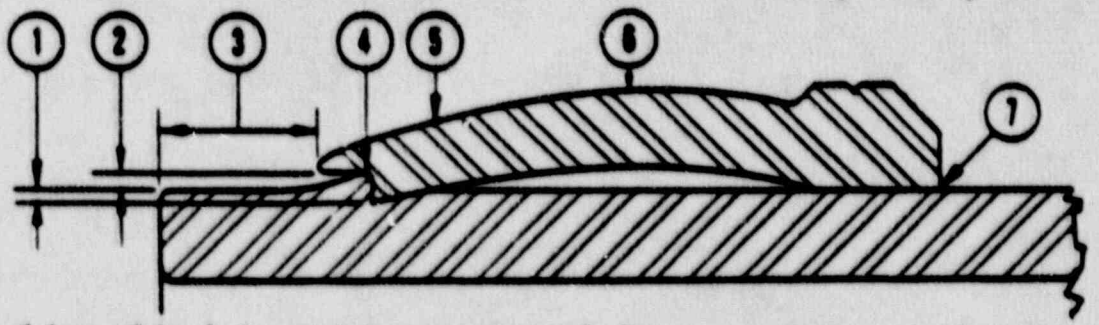


4 **Turn Nut past "Ring Grip" point 1¼ to 1½ turns for 8000 series.**

The operation described in steps 1 through 4 is called "Presetting".

NOTE: To tighten an Ermeto joint that has been disassembled, turn nut with wrench until a sharp increase in torque is noted. From this point apply from [redacted] 1/4 to 1/2 turn on 8,000 series fittings. This is called the "resetting" operation following "presetting" described above.

When the assembly procedure for Ermeto fittings is followed correctly; these points will be evident.



1 Cutting edge of sleeve will be imbedded in tubing to its full depth.

2 Pilot edge of sleeve should be close to or touching O.D. of tubing.

3 Distance between end of tube and leading or pilot edge of sleeve will be at least 1/8"

4 Metal will be piled ahead of cutting edge of sleeve under pilot.

5 Contact area of sleeve will show evidence of being in perfect contact with tapered seat of fitting.

6 Sleeve will show evidence of being bowed within its elastic limits.

7 Back of sleeve will be in contact with tube.

NOTE: Performance of fitting will not be affected if sleeve rotates on tube after disassembly.

CONTROL TUBING AND FITTINGS

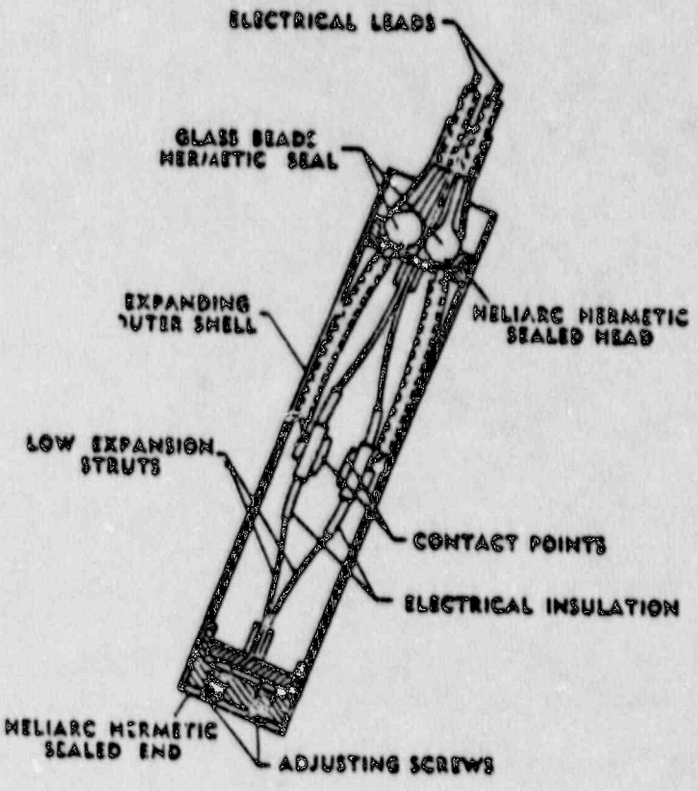
PART NO.	DESCRIPTION	
560108	3/8" Copper Tubing (.065 wall). Order by length.	
544287-Q	Union (Control tubing).	3/8" Tube
544612	Cap (Cap-off tubing).	3/8" Tube
544287-Y	Male Connector	3/8" Tube x 3/8" Pipe
544590	Male Connector (Cardox Rate-of-Rise)	3/8" Tube x 1/8" Pipe
571211	Female Tee (Duro-Speed Head)	3/8" Tube x 1/2" Pipe x 3/8" Tube
544282-Q	Male Connector (Sprinkler Rate-of-Rise)	3/8" Tube x 1/2" Pipe
544282-P	Tee Union (Tubing Junction)	3/8" Tube, 3-Way
544282-E	Male Connector (Switching Valve & Selector Valve & Solenoid Valve)	3/8" Tube x 1/4" Pipe
544282-A	90° Male Elbow (at Actuator Valve)	3/8" Tube x 1/4" Pipe
544282-H	90° Female Elbow	3/8" Tube x 1/4" Pipe
544338	Nut 3/8" Ermeto	
544379	Nut 1/4" Ermeto	
544358	Sleeve 3/8" Ermeto	
544282-B	Female Connector - Tubing to pipe	3/8" Tube x 1/4" Pipe

RATE-OF-RISE TUBING AND FITTINGS

[redacted] NO.	DESCRIPTION
560277	1/8" O.D. Copper Tubing .020" Wall - Soft Temper
544636	1/8" Union, Inverted Flare, Brass, Complete with Nuts.
544637	1/8" Tee, Inverted Flare, Brass, Complete with Nuts.
544638	1/8" Cross, Inverted Flare, Brass, Complete with Nuts.
544639	1/8" Nut, Inverted Flare, Brass (for above fittings).

CARDOX fire extinguishing equipment...

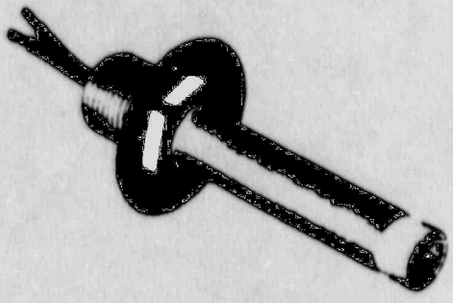
Principle of Operation



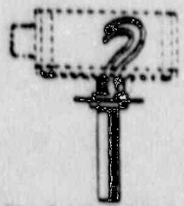
The two fine silver contacts are mounted on, but electrically insulated from, two curved struts that have a low expansion coefficient. This assembly is mounted under compression in a tubular stainless steel shell having a high coefficient of expansion.

Temperature changes cause the shell to expand or contract — exerting magnified motion to the contacts which close the instant the surrounding air reaches the temperature for which the unit is set regardless of the rate of air temperature rise. The shell is the basic temperature sensitive part . . . always in contact with the surrounding air.

VERTICAL MODEL

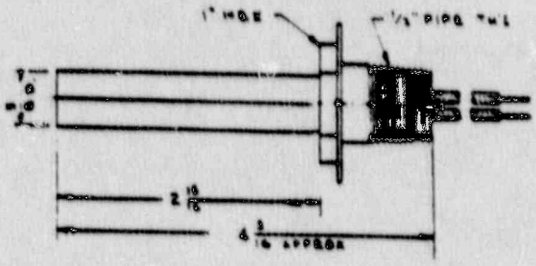


FOR ORDINARY USE — The basic DETECT-A-FIRE unit may be mounted to any approved junction box with ⅞" diameter opening by using ½-14-IPS mounting nuts. Can be used with conduited or non-conduited wiring.



FOR HAZARDOUS LOCATIONS — Mount DETECT-A-FIRE unit to Crouse-Hinds CPS 021 cover and Form 20 Condulet at installation, for explosion-proof system.

Mount DETECT-A-FIRE unit to Appleton Electric BFCS hub cover and Form 20 Unilet at installation, for explosion-proof system. Use of this box excludes Class I, Group C.

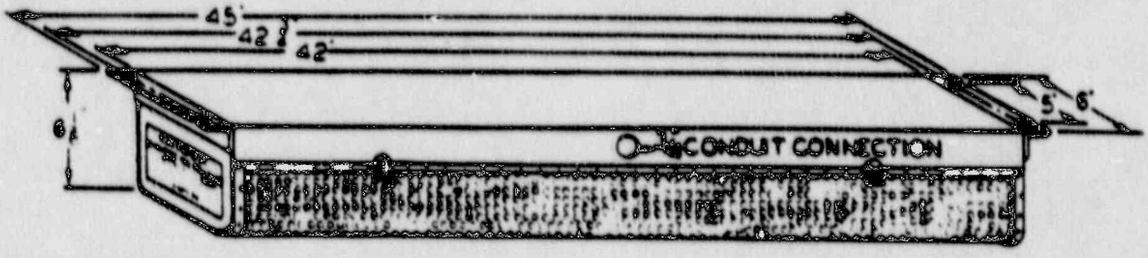


TYPE	CONTACT ARRANGEMENT	OPERATION ON TEMP. RISE	TEMPERATURE RATING		CARDOX STOCK NO.	ELECTRICAL RATINGS
			DEGREES	COLOR CODE		
2TIBI	NORMALLY OPEN	CLOSES.	140	YELLOW	130117	9 AMPS. 125V A.C.
			190	WHITE	130131	
			225	WHITE	19094	
			325	RED	130100	
			450	GREEN	19099	0.5 AMPS. 125V D.C.
			600	ORANGE	130122	
			725	ORANGE WITH BLACK DOT	130123	

SPACING - 50' BETWEEN UNITS ON SMOOTH CEILING
25' FROM PARTITIONS OR WALLS

ELECTRIC THERMOSTATS

CARDOX fire extinguishing equipment...



THE CARDOX SMOKE DETECTOR is a TWO-STAGE DETECTOR. What does this mean? Just this:

THE FIRST STAGE gives a warning signal indicating that smoke is detected in small quantities, thus providing time to make preliminary examination of the premises. This affords the opportunity to remove any smoldering material or to apply first-aid equipment for extinguishment.

If the smoking increases without attention, the SECOND STAGE operates a fixed fire extinguishing system, signals the fire department or causes any desired alarms or signals to function.

HEAT DETECTION is also provided. This can be paralleled with either the FIRST OR SECOND STAGE, thus offering protection against either smoke or heat or BOTH. (Heat detection is normally tied in with the second stage.)

FASTER DETECTION is accompliahed with the CARDOX SMOKE DETECTOR because the unit is located *in the hazard*. There are no delays while smoke samples are drawn through piping to a remotely located instrument.

POSITIVE LOCATION OF DETECTION is assured because the Detector is located in the area where detection is desired. There is no chance for confusion or mistaking where the signal comes from. Signals or indicators can be placed at any *one location* or *any number of locations*, as desired in your building or plant.

INSTALLATION IS SIMPLE—The CARDOX SMOKE DETECTOR is as easy to install as a light fixture. No expensive piping system is required to gather smoke samples.

MAINTENANCE IS SIMPLE—Periodic visual inspections to prevent dust accumulation are all that is required. Tubes used in the Detector are as easy to install as the common radio tube. Accumulation of dust due to improper or negligent maintenance will show up by a signal from the FIRST STAGE.

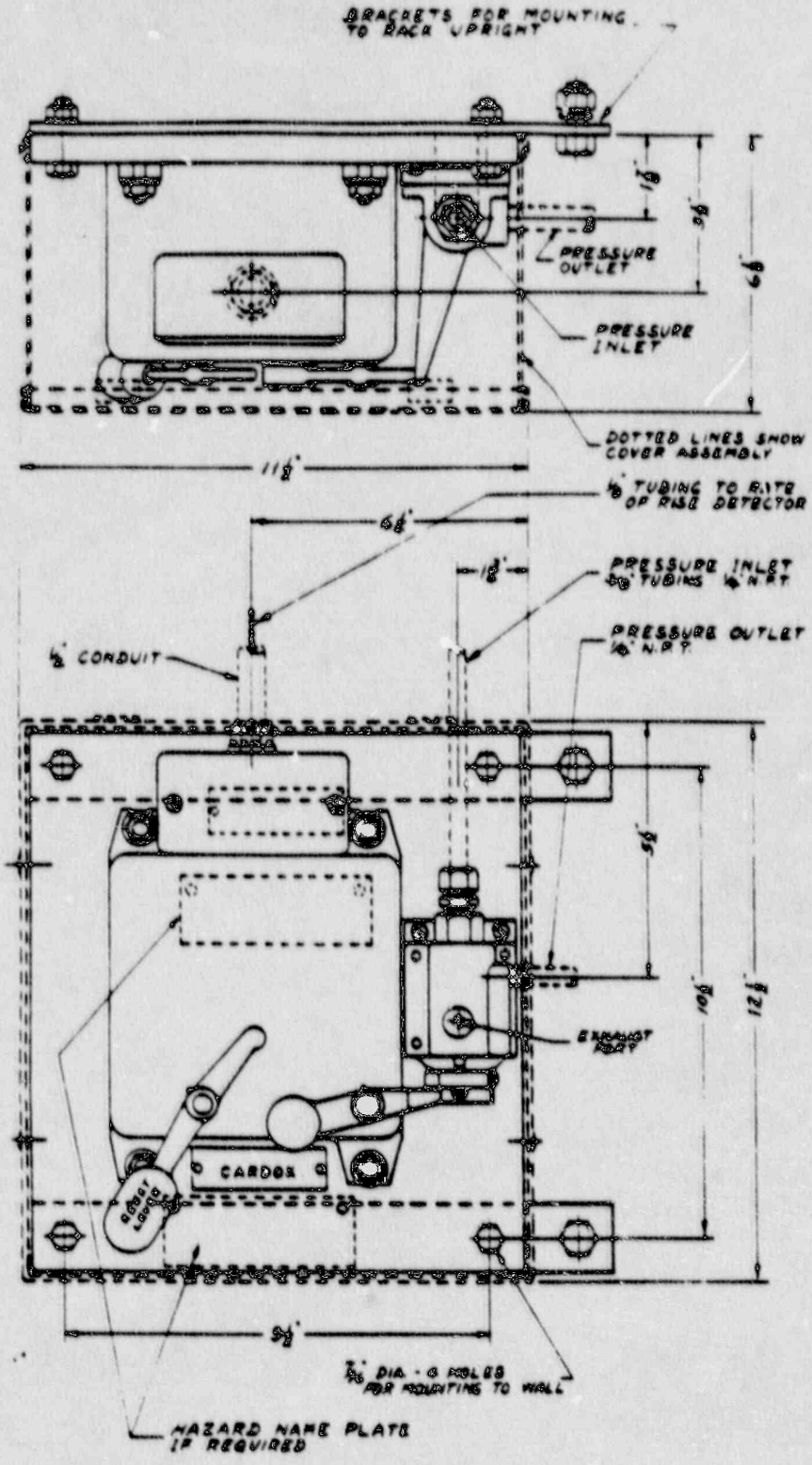
There are no moving parts — NO BLOWERS — NO MOTORS.

Filament circuits are supervised in such a way that filament failures actuate the FIRST STAGE signal or trouble alarm as desired—no actuation of the SECOND STAGE possible.

CARDOX SMOKE DETECTOR

PART NO. 11719
MODEL NO. FE21663

CARDOX fire extinguishing equipment...



GROUP NUMBER	PART NUMBER	PRESSURE SETTING	VEN RATI
C41582-1	110174	½"	40
C41582-2	110175	1½"	20
C41582-3	110176	2"	20
C41582-4	110177	1½"	10
C41582-5	110173	2"	10
C41582-6	110178	1½"	5
C41582-7	110179	2"	5
C41582-8	110180	2½"	5
C41582-9	110181	3"	5
C41582-10	110182	2"	3
C41582-11	110183	3"	3
C41582-12	110184	3"	2

NOTES:

FOR COVER ASSEMBLY ORDER STOCK NO. 3102 DRAWING NO. B46143.

DISCARD MOUNTING BRACKETS IF UNIT IS WALL MOUNTED.

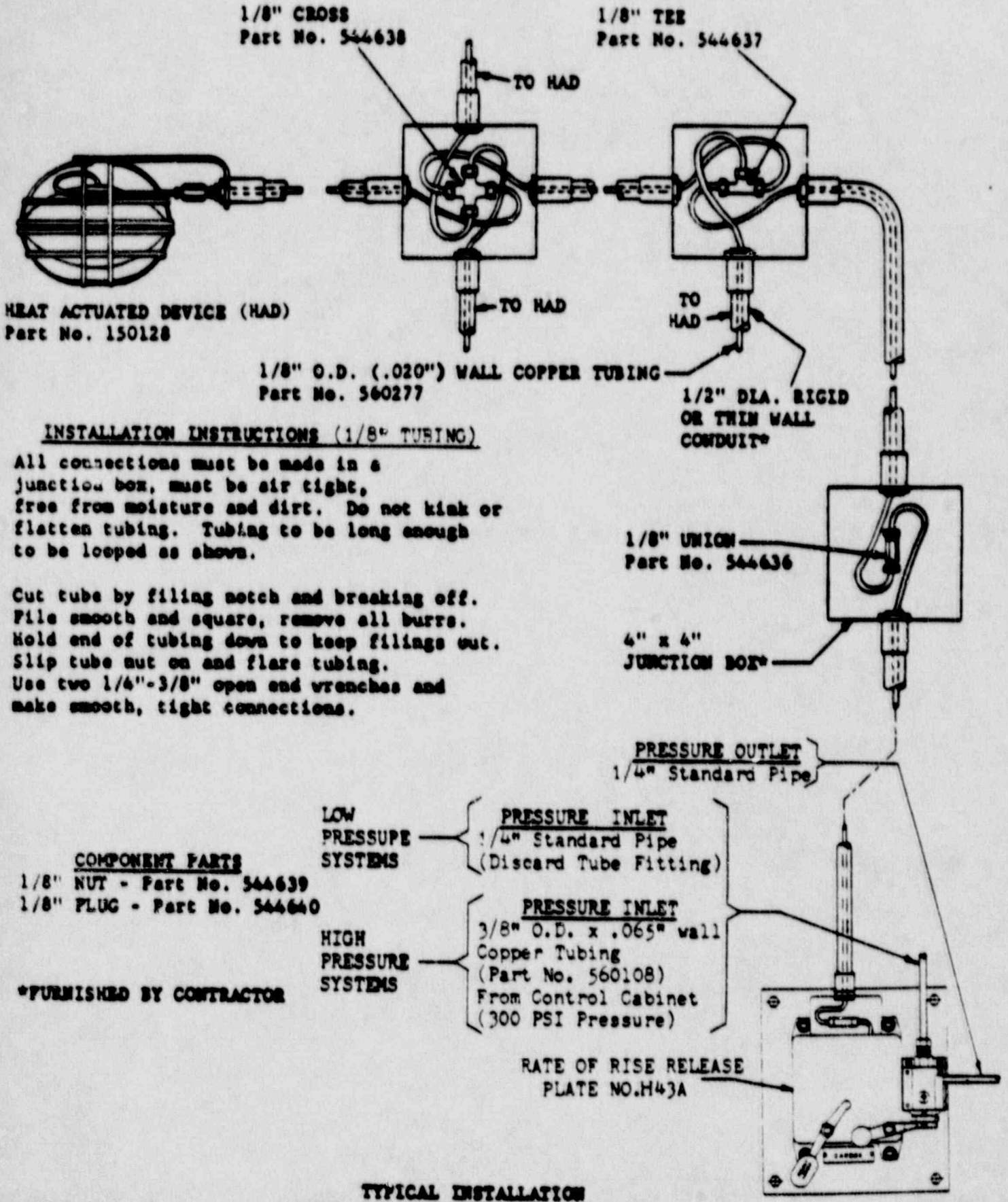
CARDOX
PNEUMATIC RATE OF RISE RELEASE AND VALVE ASSEMBLY
MODEL NO. C41582

REVISED 12-64

PLATE NO. M-43A

C457CPC

GARDNER fire extinguishing equipment...



INSTALLATION INSTRUCTIONS (1/8" TUBING)

All connections must be made in a junction box, must be air tight, free from moisture and dirt. Do not kink or flatten tubing. Tubing to be long enough to be looped as shown.

Cut tube by filing notch and breaking off. File smooth and square, remove all burrs. Hold end of tubing down to keep filings out. Slip tube nut on and flare tubing. Use two 1/4"-3/8" open end wrenches and make smooth, tight connections.

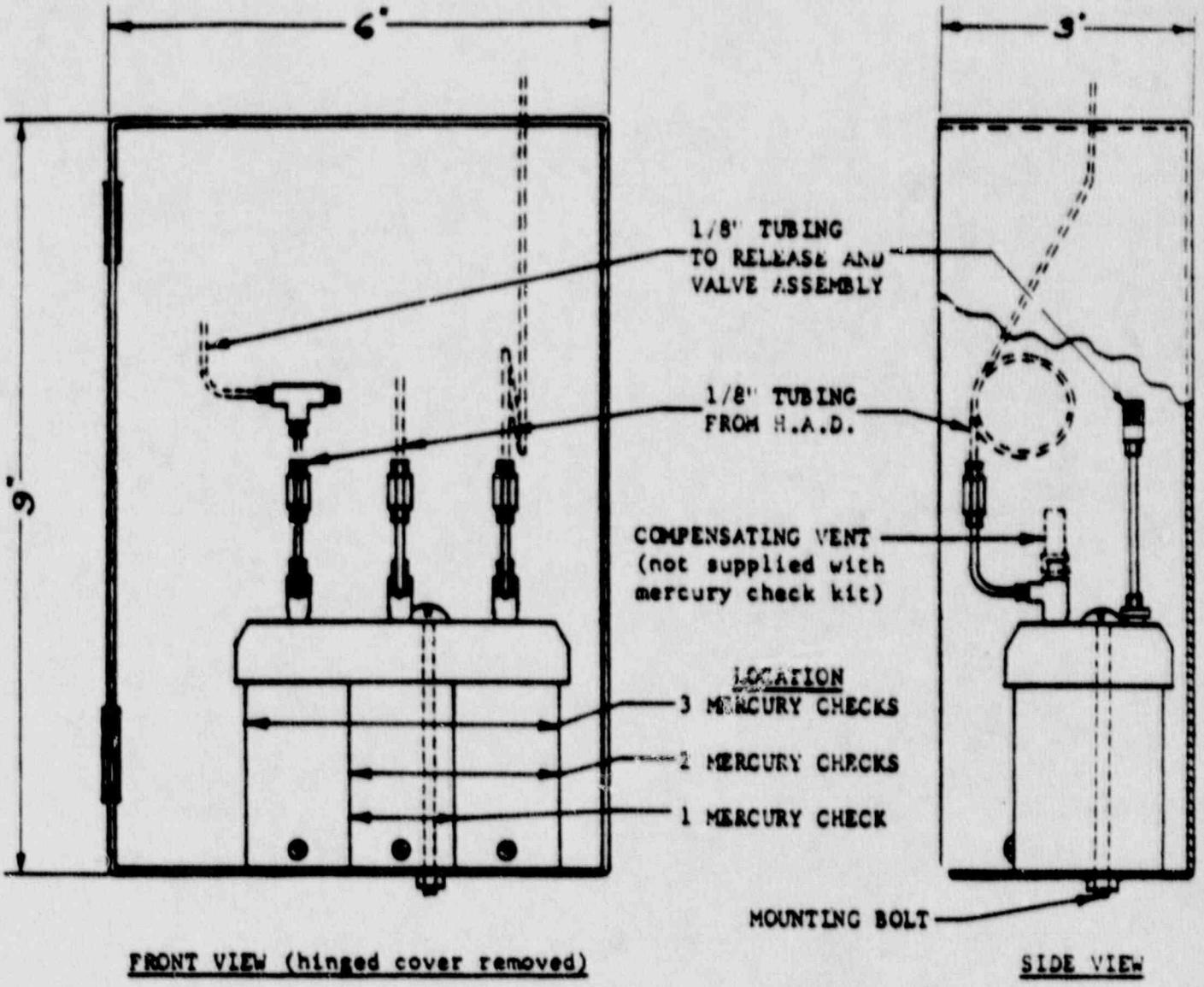
COMPONENT PARTS

1/8" NUT - Part No. 544639
1/8" PLUG - Part No. 544640

*FURNISHED BY CONTRACTOR

TYPICAL INSTALLATION
PNEUMATIC RATE OF RISE DETECTION

[redacted] fire extinguishing equipment...



ONE UNIT MERCURY CHECK KIT - Stock No. 150135 - Drg. No. A46329

TWO UNIT MERCURY CHECK KIT - Stock No. 150136 - Drg. No. A46329

THREE UNIT MERCURY CHECK KIT - Stock No. 150137 - Drg. No. A46329

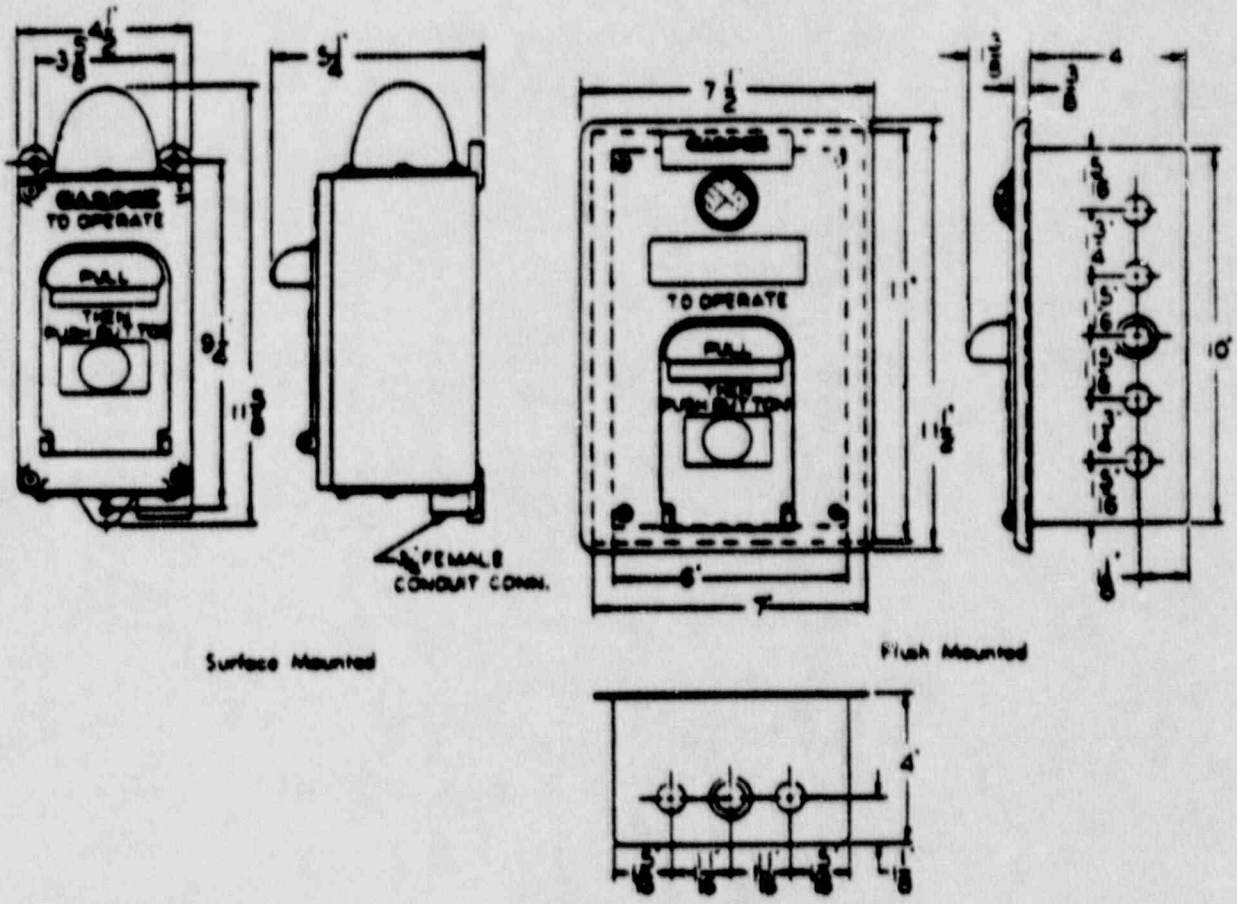
Mercury check kits are shipped unassembled with all parts packed in cabinet. Union nuts are supplied with kit. Compensating vents are supplied seperately.

CARDOX
MERCURY CHECK
PNEUMATIC RATE OF RISE DETECTION SYSTEM

PLATE NO. H-43C

C-483- -CPC-

[redacted] fire extinguishing equipment...



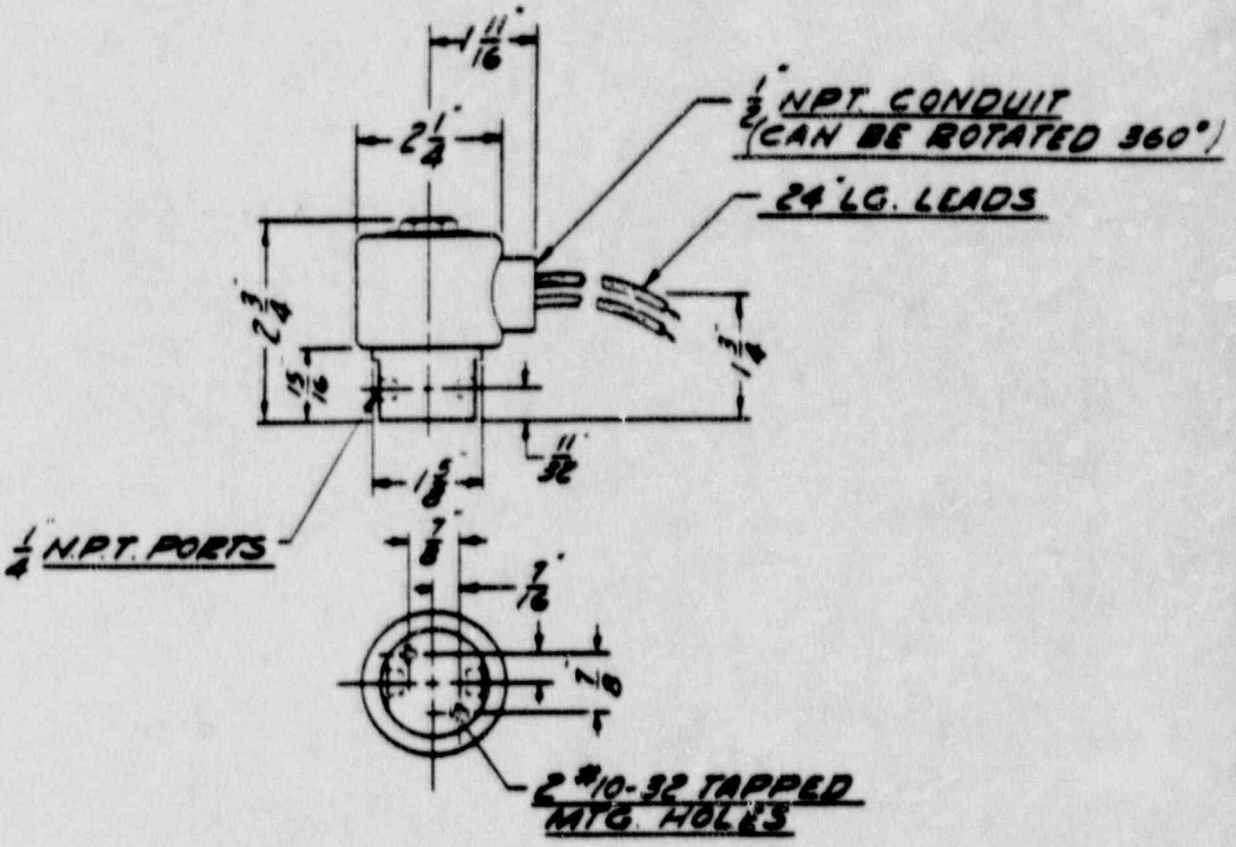
CARDOX

MANUAL RELEASE STATIONS-ELECTRIC (PUSH-BUTTON OPERATED)

MODEL NO.	PART NO.	TYPE
24337-1	143180	SURFACE-MOUNTED, MOM. CONT. 110-125V AC/DC
24337-2	143181	SURFACE-MOUNTED, MOM. CONT. 250V DC
24346-1	•	FLUSH-MOUNTED 110-125V AC/DC
24346-2	•	FLUSH-MOUNTED 250V DC
24302	143174	SURFACE-MOUNTED "ON-OFF" 110-125 V AC/DC
24342	•	FLUSH-MOUNTED, "ON-OFF" 110-125 V AC/DC

• ORDER BY MODEL NO. PARTS SUPPLIED DISASSEMBLED FOR EASY INSTALLATION.

CARDOX fire extinguishing equipment...



TWO-WAY, NORMALLY CLOSED SOLENOID VALVE
ORIFICE SIZE: 1/8" DIA.
OPERATING PRESSURE: 300 PSI
OPERATING VOLTAGE: (SEE TABLE)
VALVE CAN BE MOUNTED IN ANY POSITION

DRAWING NO.	OPERATING VOLTAGE	VALVE STOCK NO.	COIL STOCK NO.	NAME-PLT. STOCK NO.
A42419	115V-60CY.	161277	520109	536768
A42444	120VDC	161281	520110	536768
A45927	115V-25CY.	161633	520111	536768
A45928	230VDC	161634	520112	536768
A45995	24 VDC	161306	520109	536768

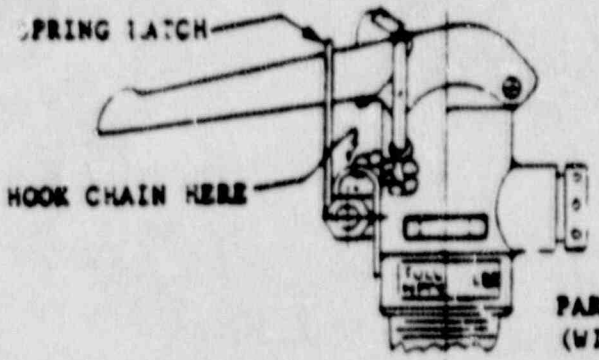
USED WITH ELECTRIC DETECTORS AND ACTUATORS FOR RELEASING PRESSURE IN CONTROL SYSTEM.

CARDOX ELECTRICALLY OPERATED (SOLENOID) VALVE

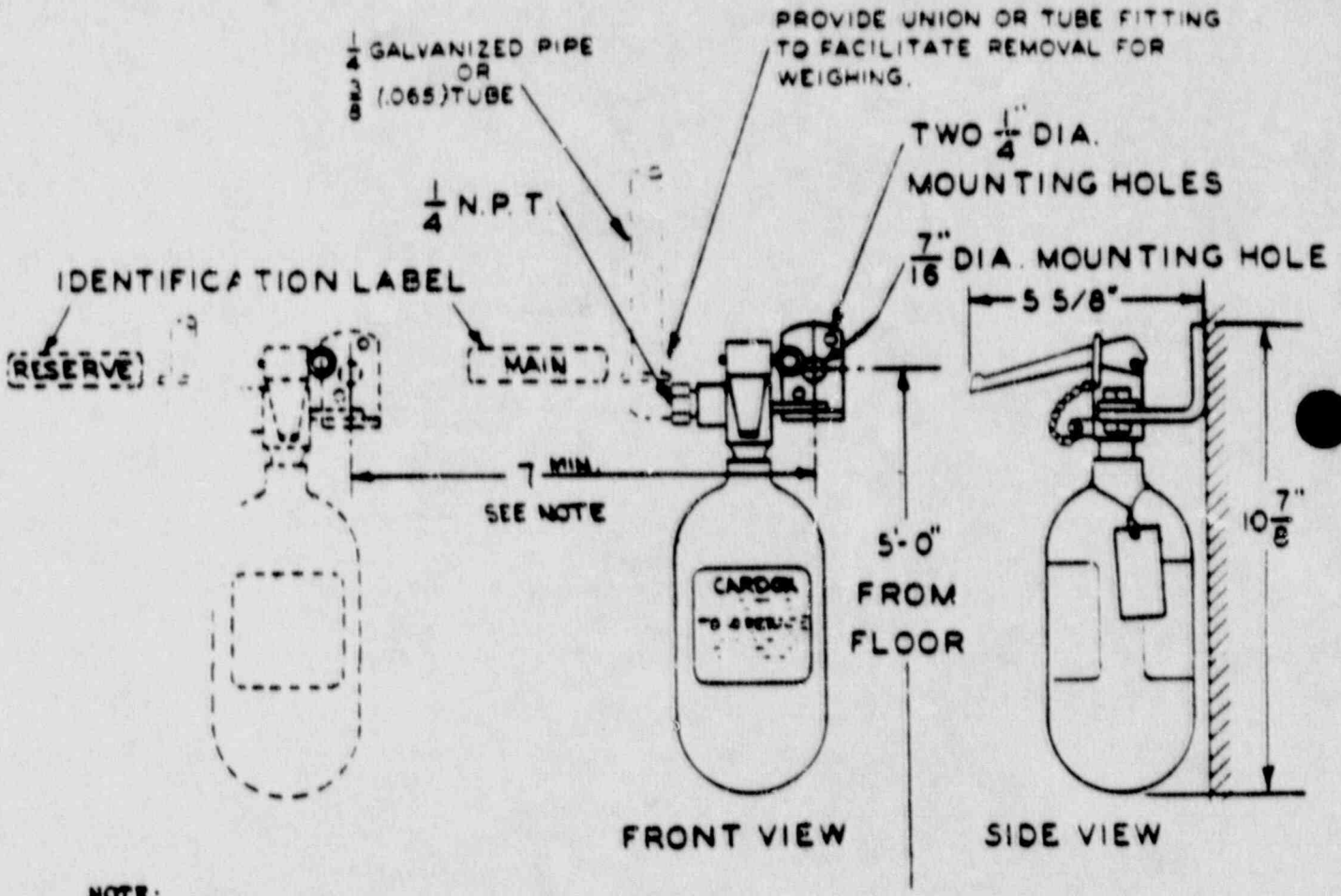
(REF. DWG. NO. B46055)

PLATE NO. H-47

[redacted] fire extinguishing equipment...



PART NO. 17131
(WITH LATCH)



NOTE:
IDENTIFICATION LABEL & LOCATION DIMENSION APPLIES ONLY WHEN SECOND STATION IS ADDED FOR RESERVE BANK.

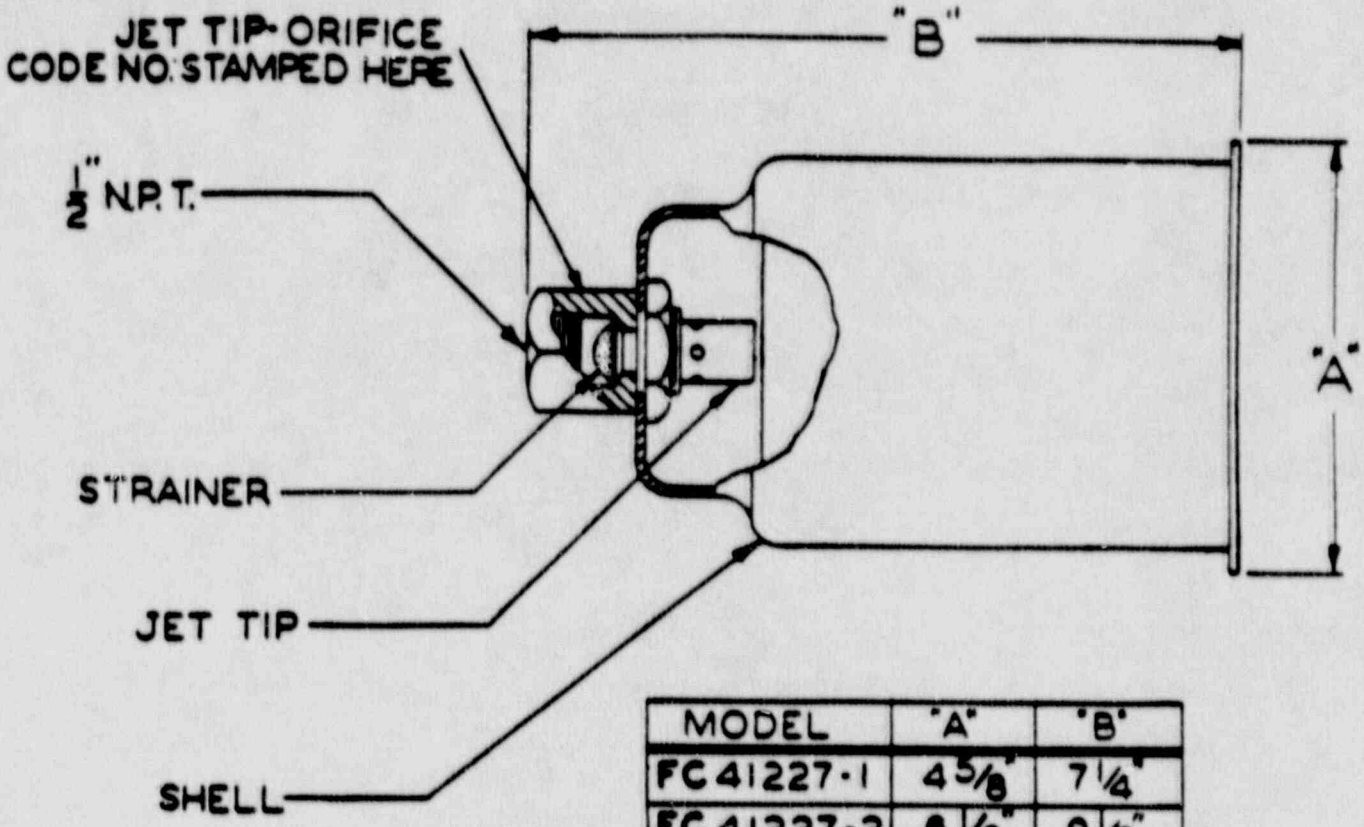
PART NO. 17128
(LESS LATCH)

CARDOX
REMOTE MANUAL RELEASE STATION

PART NO. 17128 WITHOUT SPRING LATCH
PART NO. 17131 WITH SPRING LATCH

MODEL NO. B 41874

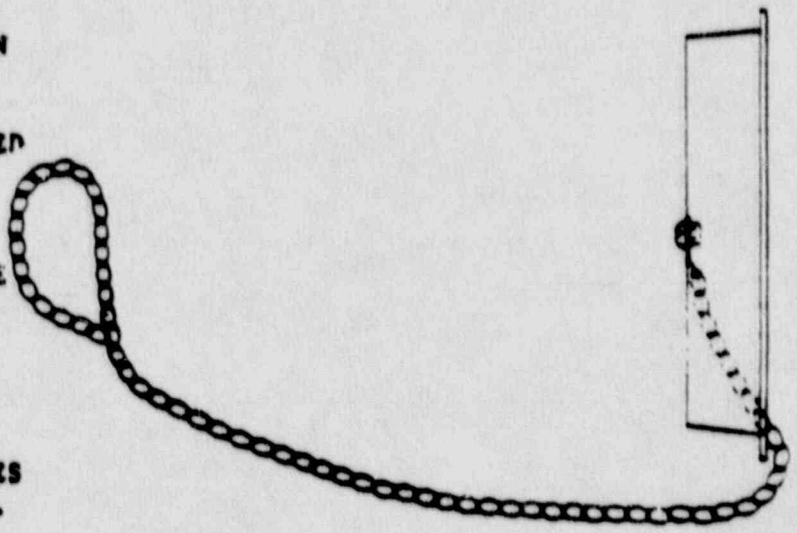
CARDOX fire extinguishing equipment...



MODEL	"A"	"B"
FC41227-1	4 5/8"	7 1/4"
FC41227-2	6 1/8"	9 1/2"

PLASTIC SEAL CAPS ARE USED TO PREVENT CLOGGING OF NOZZLES IN SPRAY BOOTHS OR OTHER SUCH SITUATIONS WHERE THE OPEN END OF THE NOZZLE IS EASILY REACHED AND WHERE TEMPERATURES DO NOT EXCEED 175°F. CAPS MUST BE CALLED FOR INDIVIDUALLY AND, WHEN SHIPPED, WILL BE SEPARATE FROM NOZZLE ASSEMBLIES.
TO ATTACH - WRAP CHAIN AROUND HEXAGONAL PIPE CONNECTION AND LINK TO ITSELF TO FORM LOOP.

SEAL CAPS USED FOR TEMPERATURES ABOVE 175°F. SEE PLATE H-50A.



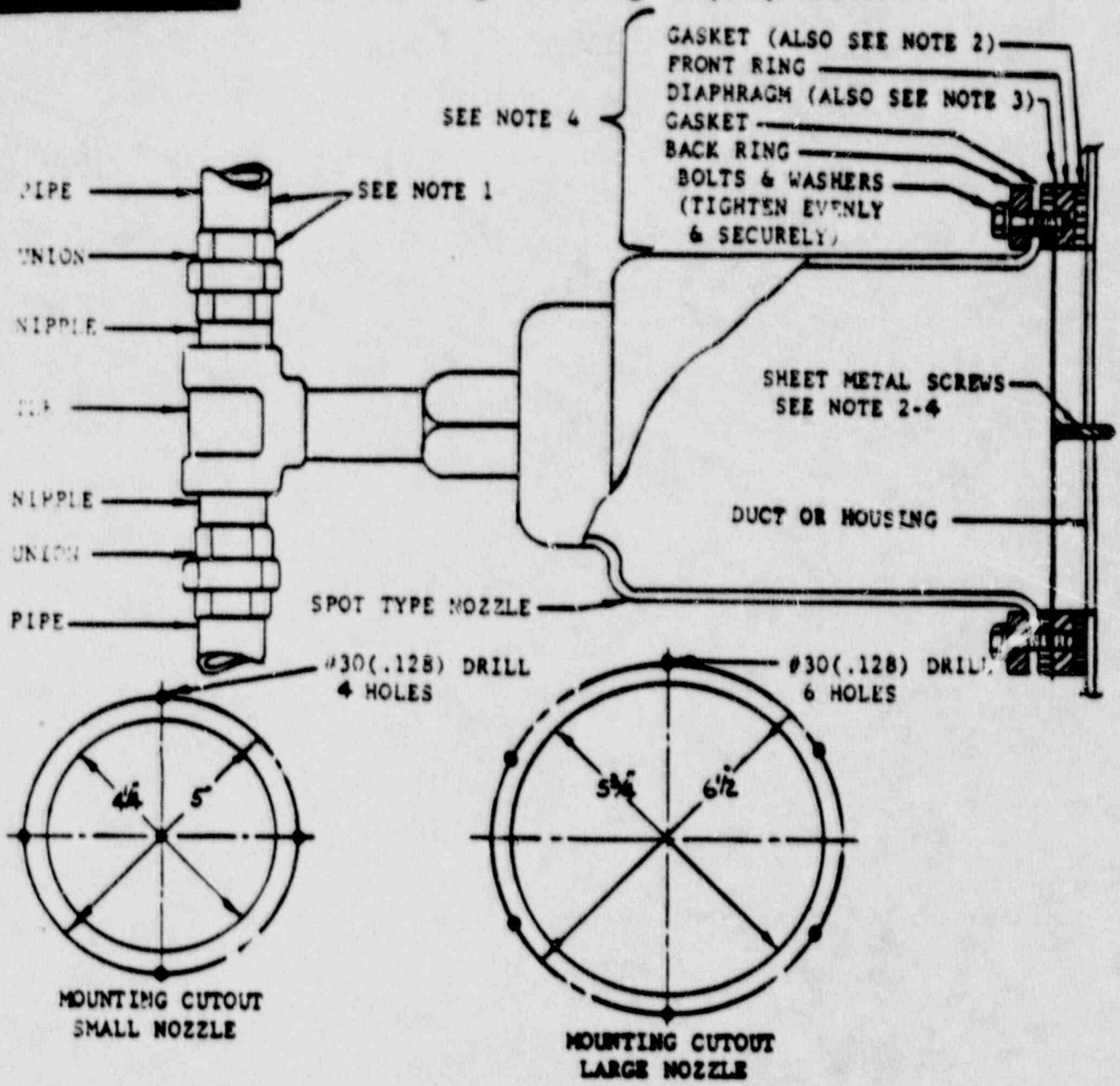
SEAL CAP FOR FC 41227-1 NOZZLE PART NO. 137396

SEAL CAP FOR FC 41227-2 NOZZLE PART NO. 137395

CARDOX
DISCHARGE NOZZLE
SPOT TYPE

CARDOX

fire extinguishing equipment...



MOUNTING CUTOUT SMALL NOZZLE

MOUNTING CUTOUT LARGE NOZZLE

INSTALLATION NOTES:

1. WHEN THE NOZZLE IS LOCATED AT THE END OF A GIVEN PIPE RUN, A UNION AND A SHORT NIPPLE ARE TO BE REPLACED BY A CAPPED 6" NIPPLE, THEREBY PROVIDING A DIRT OR BLOWOUT POCKET AT THE END OF THE PIPE RUN.

2. WHEN THE NOZZLE IS NOT LOCATED ON A DUCT OR HOUSING, ONE GASKET AND THE SHEET METAL SCREWS SHALL BE DISCARDED.

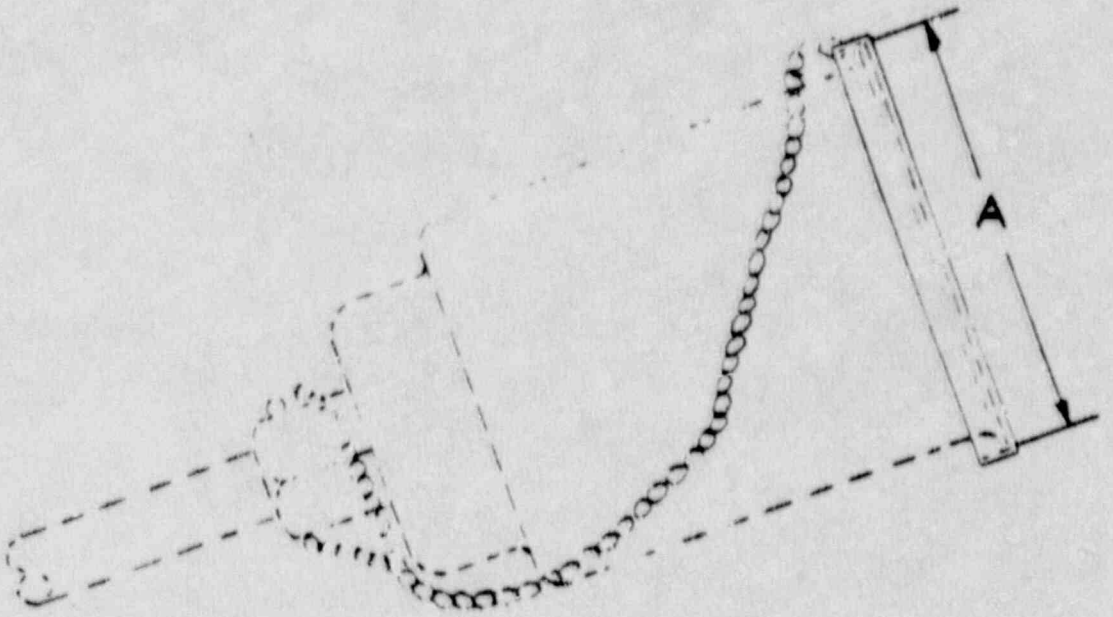
3. WHEN THE NOZZLE IS MOUNTED ON A DUCT OR HOUSING, BUT IS NOT TO BE COVERED, THE DIAPHRAGM SHALL BE DISCARDED.

4. THESE ITEMS SHIPPED AS A KIT:
   CARDOX STOCK NO. 137393 DRAWING A42128 (FOR SMALL SPOT TYPE NOZZLE)
   CARDOX STOCK NO. 137392 DRAWING A42127 (FOR LARGE SPOT TYPE NOZZLE)

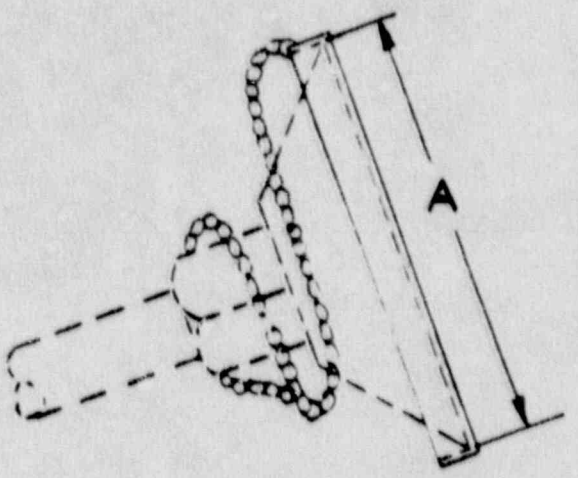
5. ALL PIPE AND FITTINGS TO BE SUPPLIED BY INSTALLER.

CARDOX DISCHARGE NOZZLE

CARDOX fire extinguishing equipment...

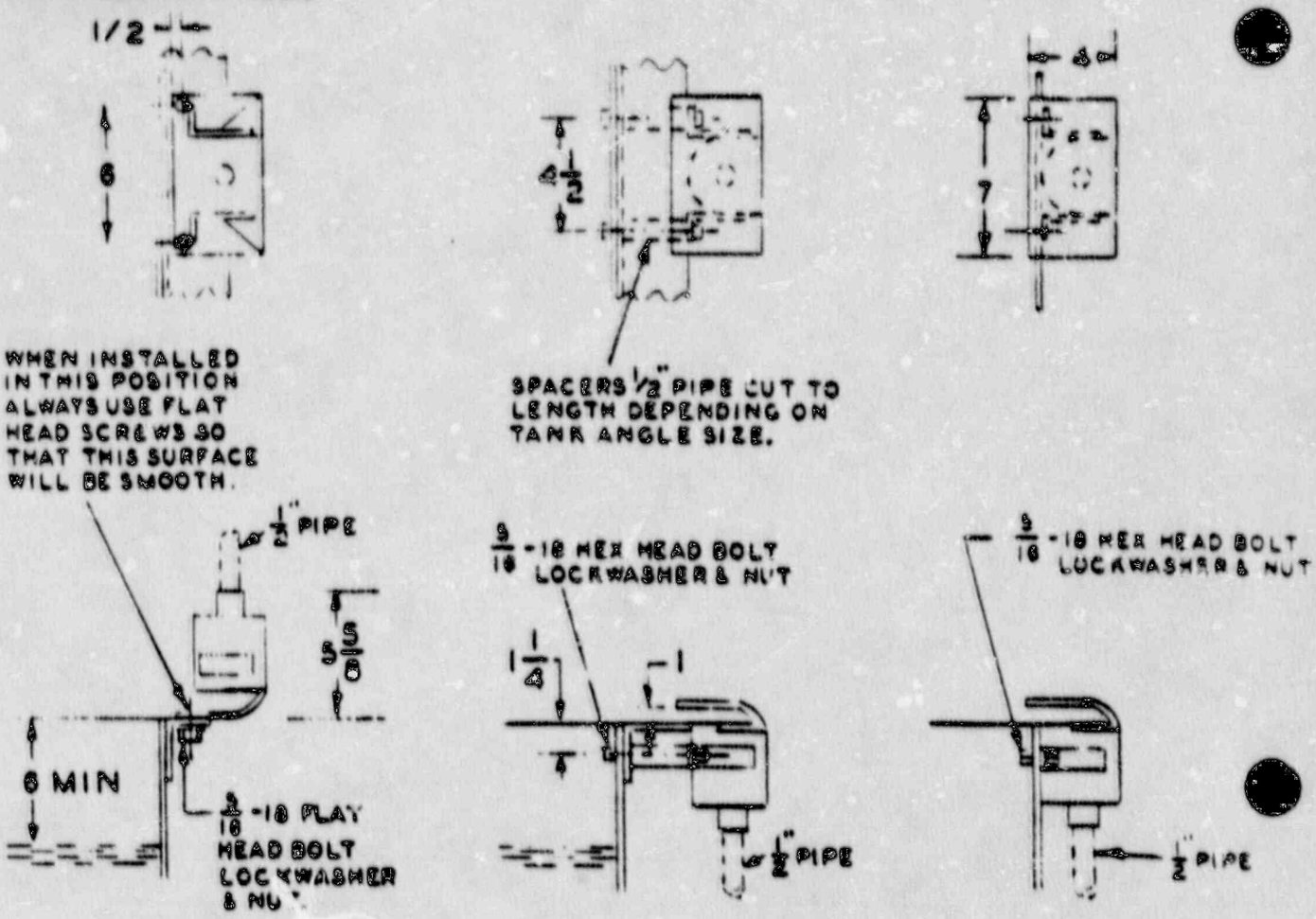


SEAL CAP ASSEMBLY	"A" DIA	FOR SPOT TYPE NOZZLE MODEL NO.	FOR TOTAL FLOOD NOZZLE MODEL NO.
137470	4 5/8"	FC 41227-1	
137471	6 1/8"	FC 41227-2	C 45999



CARDOX
SEAL CAP ASSEMBLY

fire extinguishing equipment...



INVERTED MOUNTING

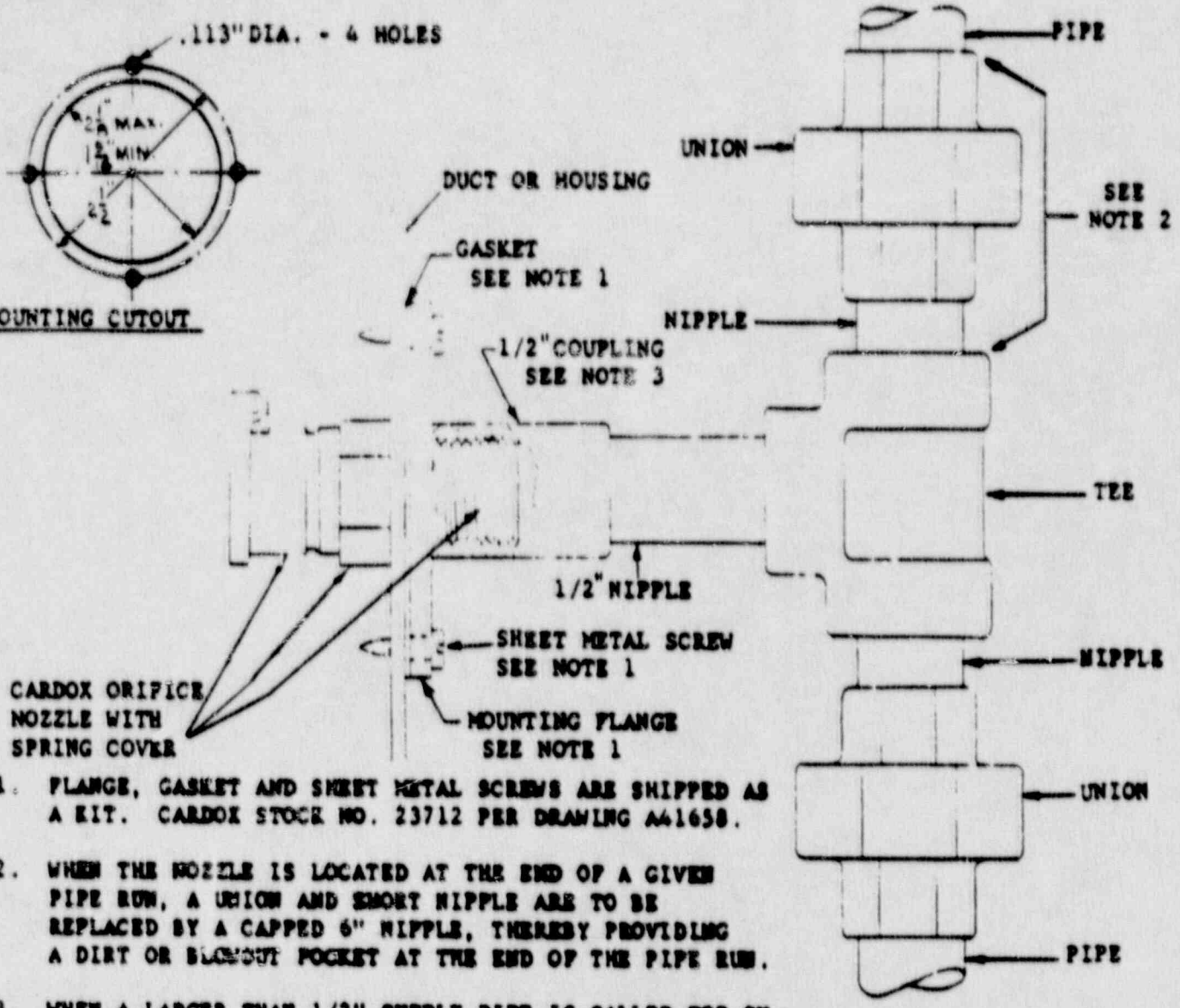
FLUSH MOUNTING

LIMITATIONS:

1. MAXIMUM AREA OF COVERAGE
   - A. LIQUID SURFACE ____ 9.5 SQ FT
   - B. COATED SURFACE ____ 13.3 SQ FT
2. MAXIMUM LINEAR SPACING
   - A. NOZZLE TO NOZZLE ____ 40 IN
   - B. NOZZLE TO CORNER ____ 20 IN
3. MAXIMUM DISTANCE ACROSS HAZARD
   - A. ONE SIDE OF HAZARD ____ 4 FT
   - B. BOTH SIDES OF HAZARD ____ 8 FT
4. FREEBOARD
   - MINIMUM DISTANCE NOZZLE TO LIQUID SURFACE ____ 6 IN

TANKSIDE NOZZLE

CARDOX fire extinguishing equipment...



1. FLANGE, GASKET AND SHEET METAL SCREWS ARE SHIPPED AS A KIT. CARDOX STOCK NO. 23712 PER DRAWING A41658.

2. WHEN THE NOZZLE IS LOCATED AT THE END OF A GIVEN PIPE RUN, A UNION AND SHORT NIPPLE ARE TO BE REPLACED BY A CAPPED 6" NIPPLE, THEREBY PROVIDING A DIRT OR BLOWOUT POCKET AT THE END OF THE PIPE RUN.

3. WHEN A LARGER THAN 1/2" SUPPLY PIPE IS CALLED FOR ON THE SPECIFIC JOB DRAWINGS, THE 1/2" COUPLING IS TO BE REPLACED BY A CONCENTRIC REDUCER OF THE SIZE SPECIFIED. (COUPLING OR REDUCER TO BE MADE UP TIGHT AGAINST THE MOUNTING FLANGE).

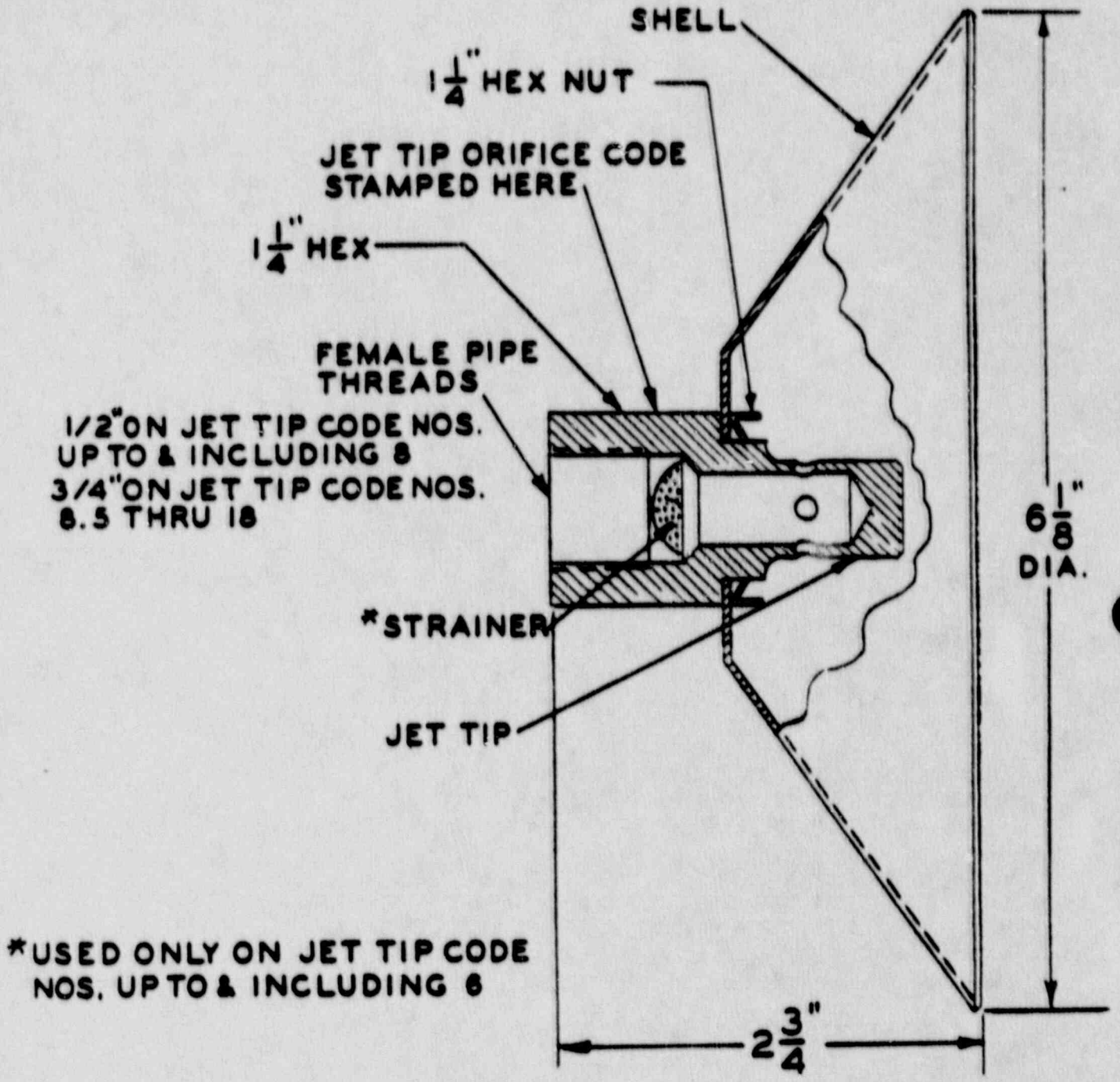
4. ALL PIPE AND FITTINGS TO BE SUPPLIED BY INSTALLER.

OPEN - MODELS A41652-A41835
COVERED - MODEL NO. A41654

CARDOX
ORIFICE NOZZLE

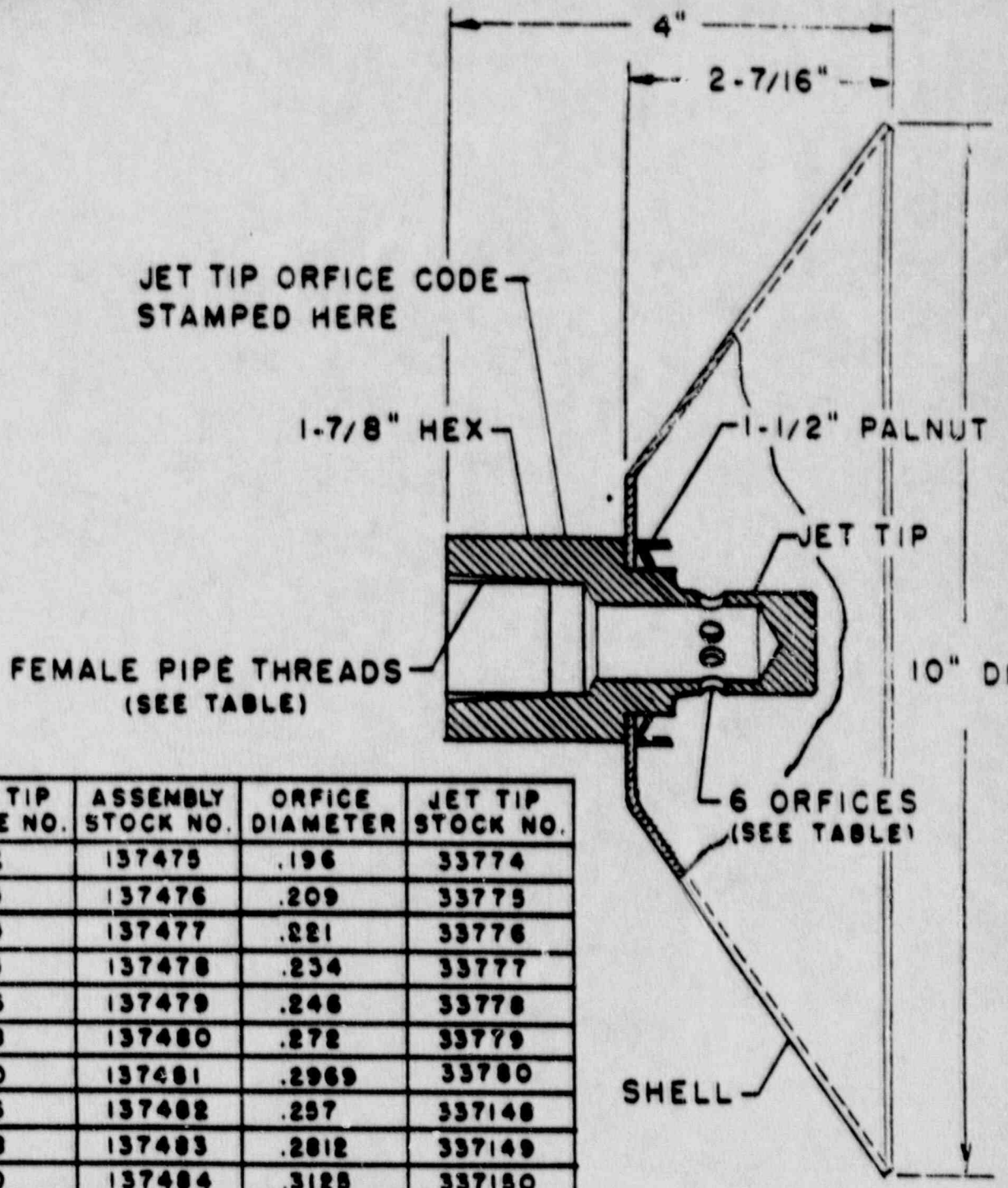
REVISED

[redacted] fire extinguishing equipment...



CARDOX
TOTAL FLOOD NOZZLE
MODEL NO. C 45999

CARDOX fire extinguishing equipment...



FEMALE NPT	JET TIP CODE NO.	ASSEMBLY STOCK NO.	ORFICE DIAMETER	JET TIP STOCK NO.
1"	12	137475	.196	33774
1"	13	137476	.209	33775
1"	14	137477	.221	33776
1"	15	137478	.234	33777
1"	16	137479	.246	33778
1"	18	137480	.272	33779
1"	20	137481	.2969	33780
1-1/4"	16	137482	.257	337148
1-1/4"	18	137483	.2812	337149
1-1/4"	20	137484	.3125	337150
1-1/4"	22	137485	.339	337151
1-1/4"	24	137486	.368	337152
1-1/4"	26	137487	.397	337153
1-1/4"	28	137488	.4219	337154

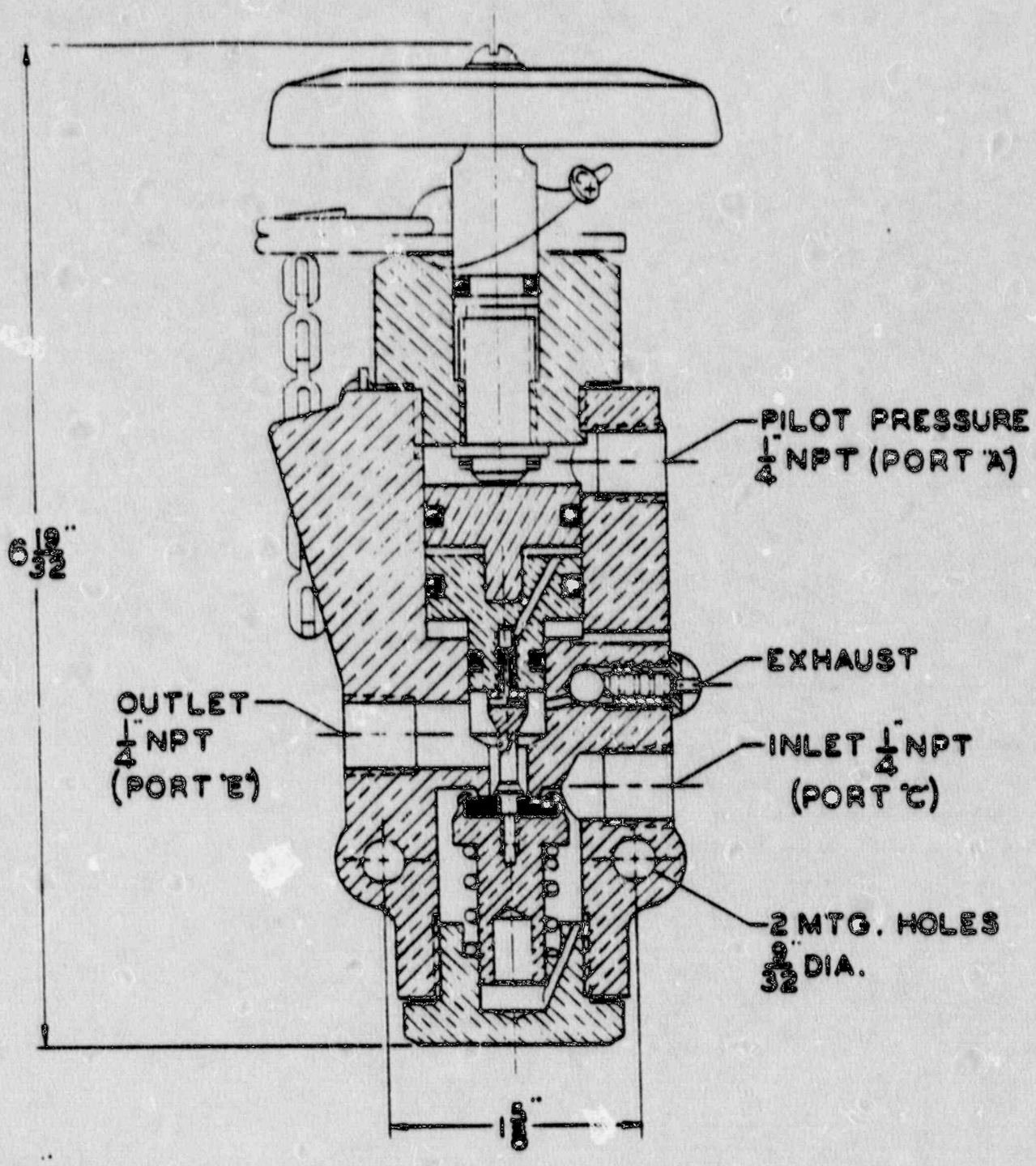
CARDOX
WIDE ANGLE NOZZLE
(TOTAL FLOOD)
MODEL NO. C46000

ISSUED 1-67

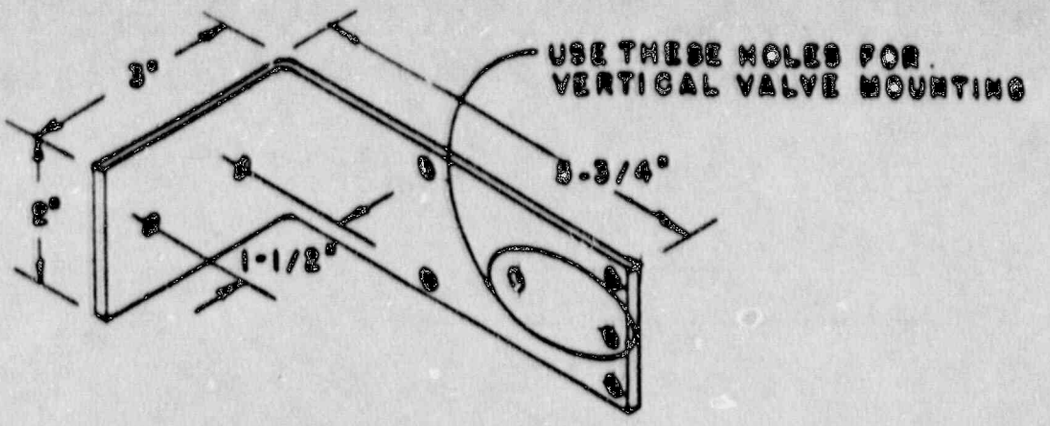
PLATE NO. 52A

C507—

CARDOX fire extinguishing equipment...

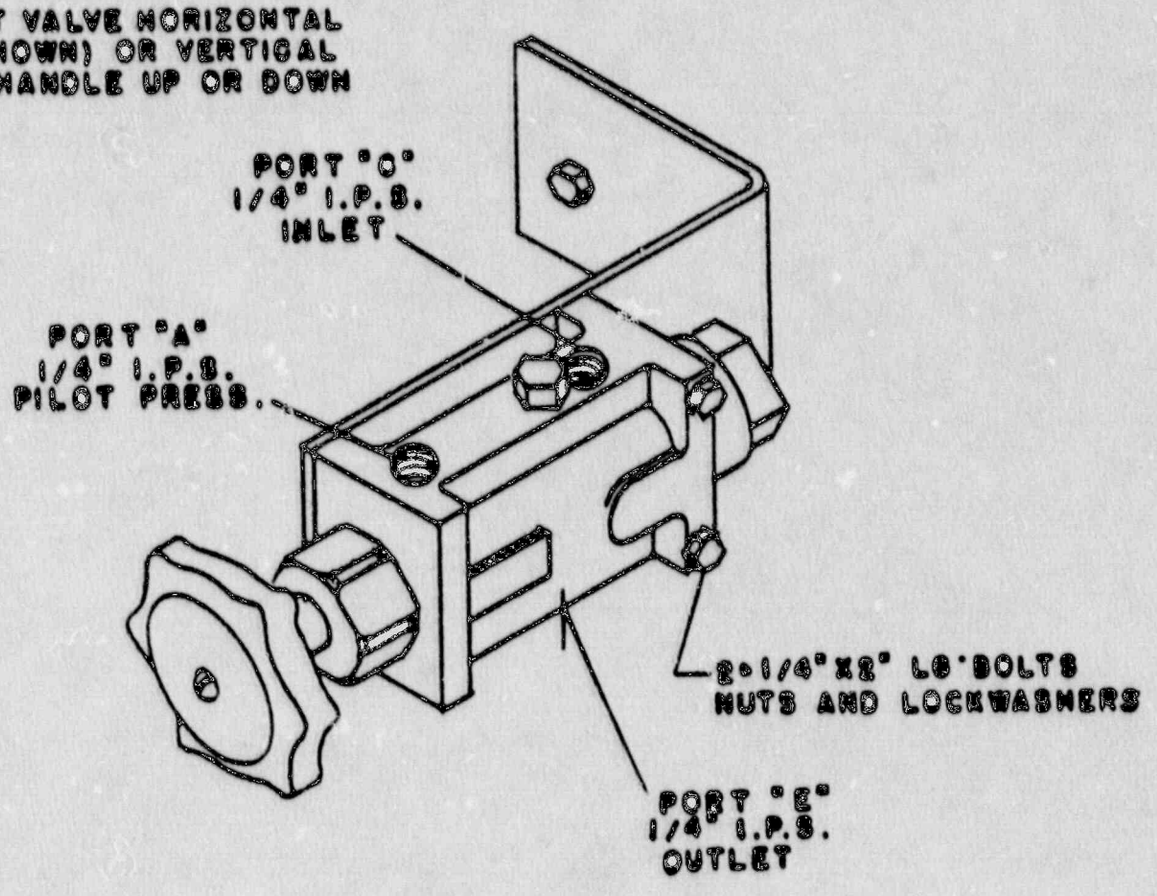


CARDOX
PILOT CONTROL VALVE
PART NO. 161640
MODEL NO. C45982



BRACKET DETAIL
S/N 3098

MOUNT VALVE HORIZONTAL (AS SHOWN) OR VERTICAL WITH HANDLE UP OR DOWN



PILOT CONTROL VALVE MOUNTING DETAIL

CARDOX fire extinguishing equipment...

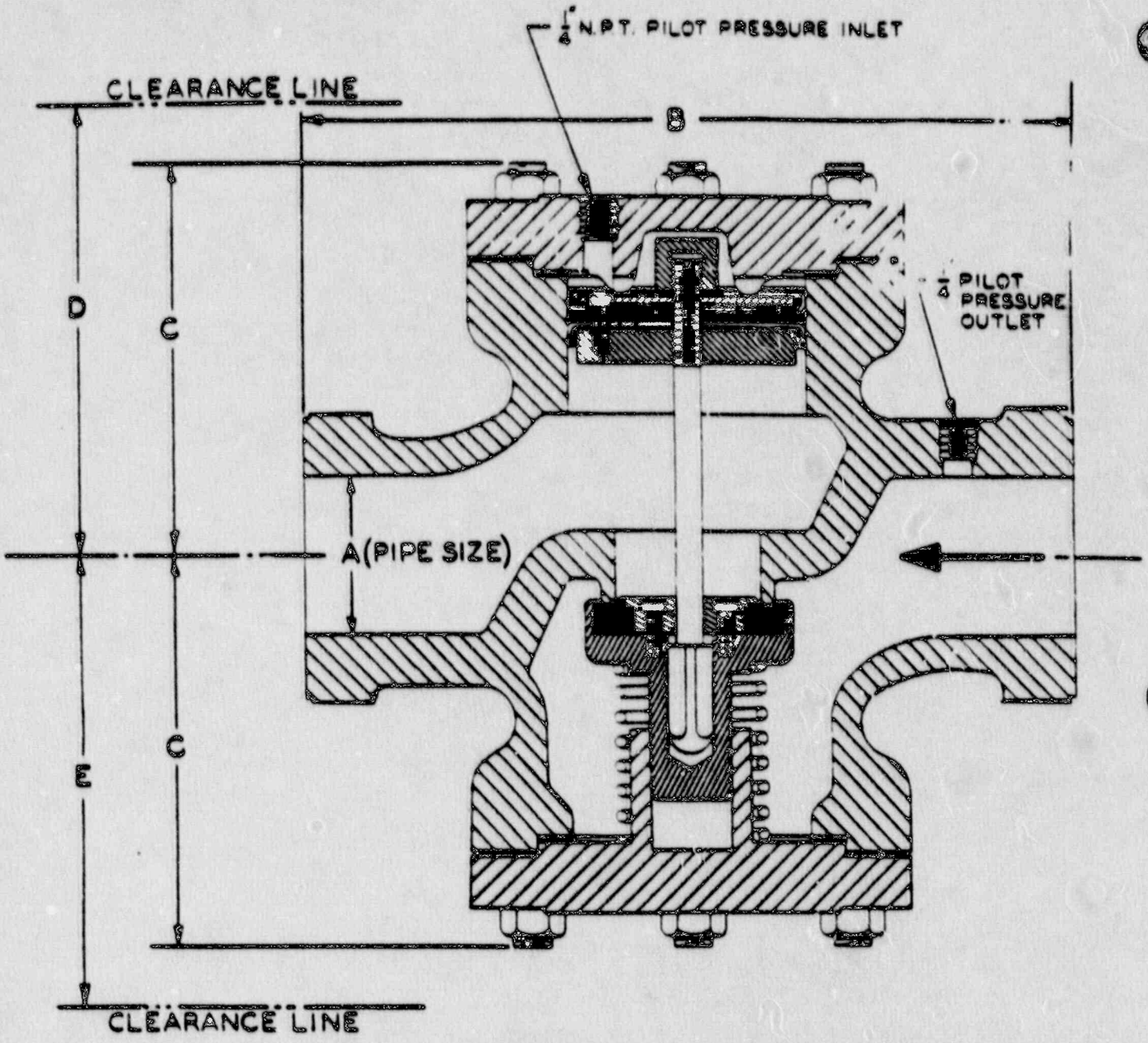
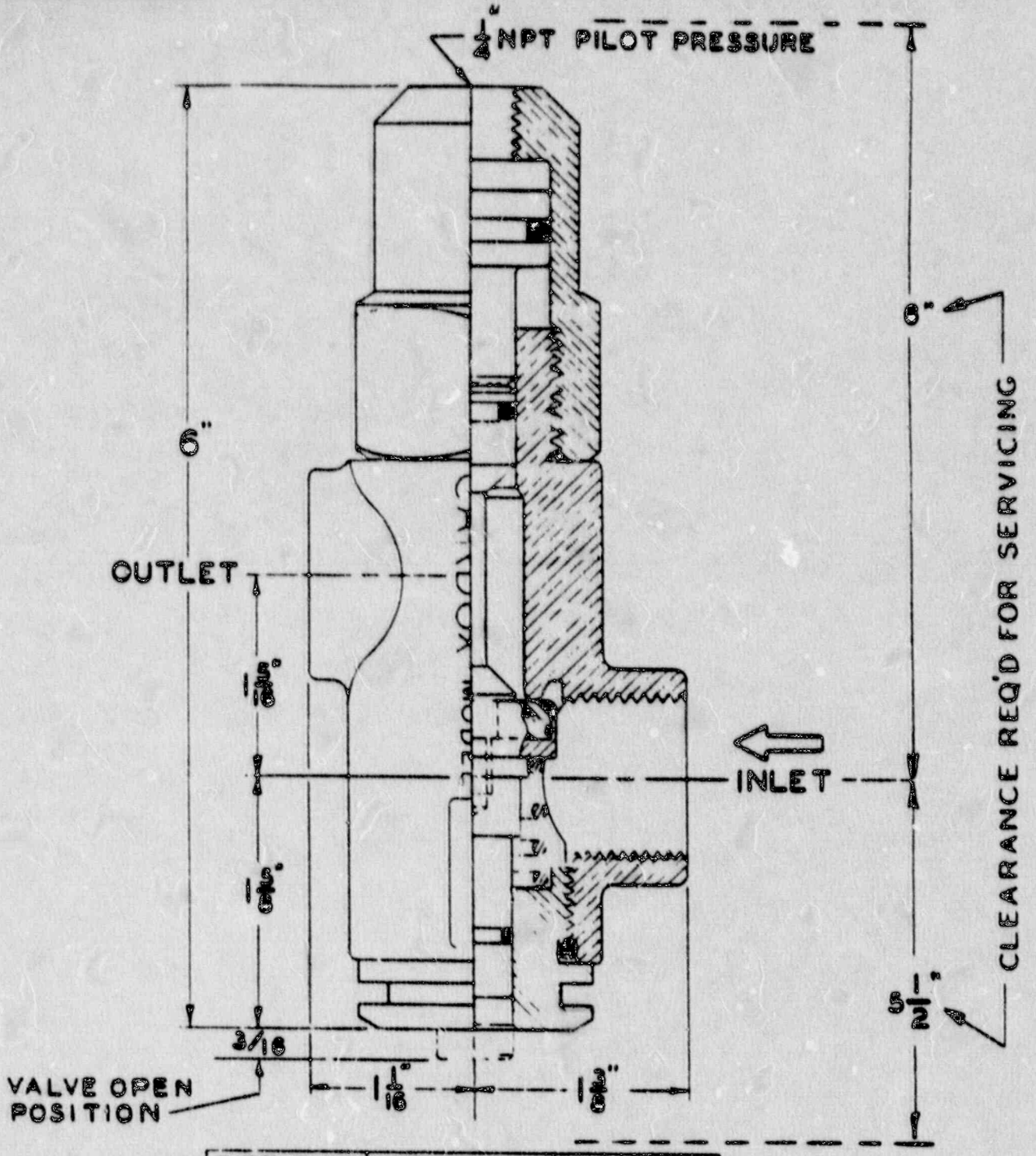


TABLE OF DIMENSIONS, INCHES

MODEL NO.	PART NO.	A	B	C	D	E	MAX. WIDTH
FD 34039	161371	1	8 ½	3 ¼	12	8	4
FD 41272	161540	1 ¼	9	3 ⅞	12	7	5
FD 23907	161369	1 ½	9 ½	4 ⅛	13	8	5
FD 23909	161370	2	10 ½	5 ¾	14	9	6

CARDOX
SELECTOR VALVE

CARDOX fire extinguishing equipment...

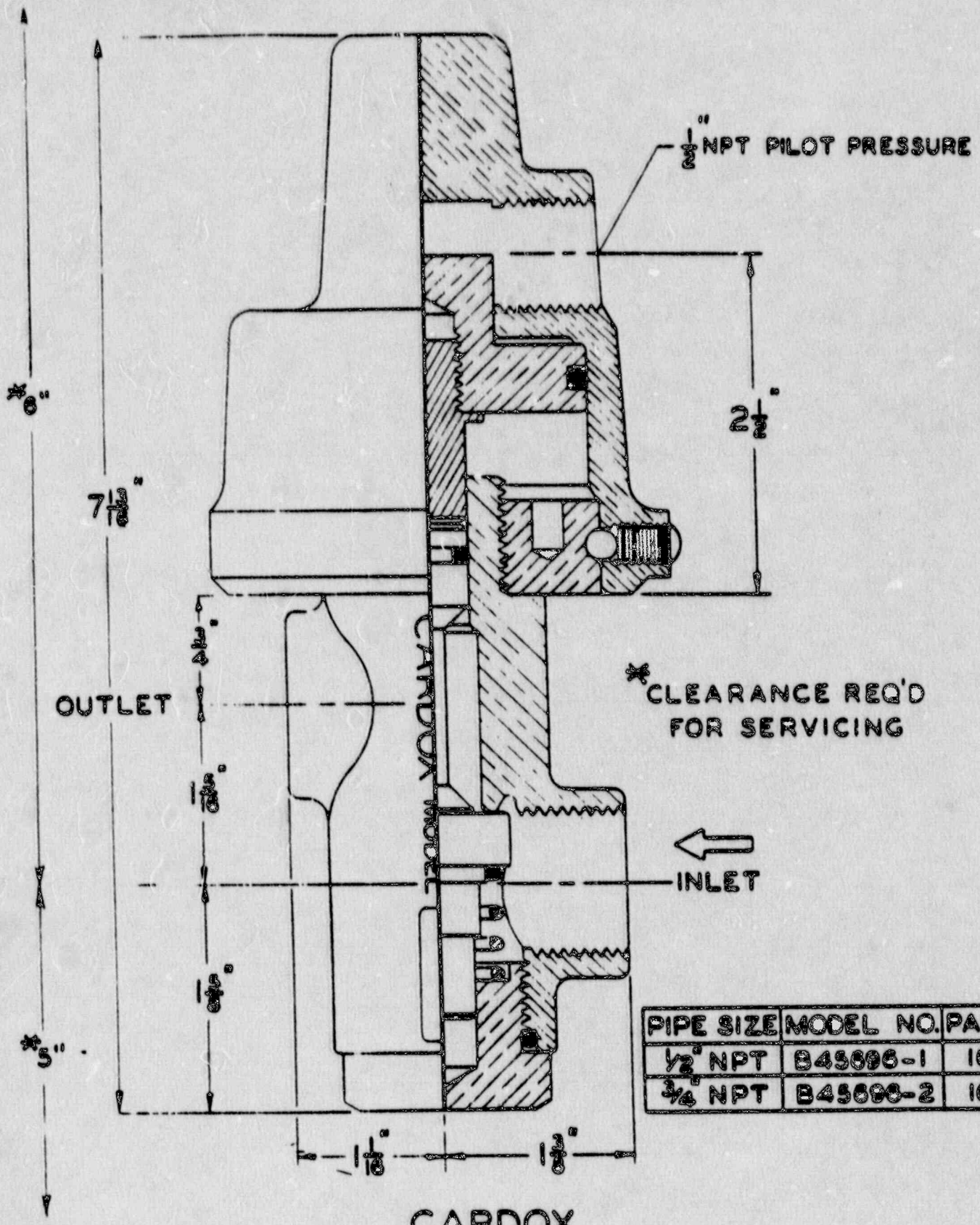


PIPE SIZE	MODEL NO.	PART NO.
1/2" NPT	B45695-1	36147
3/4" NPT	B45695-2	36148

CARDOX
SELECTOR VALVE

Issued 11-67 PLATE NO. H-5.4A

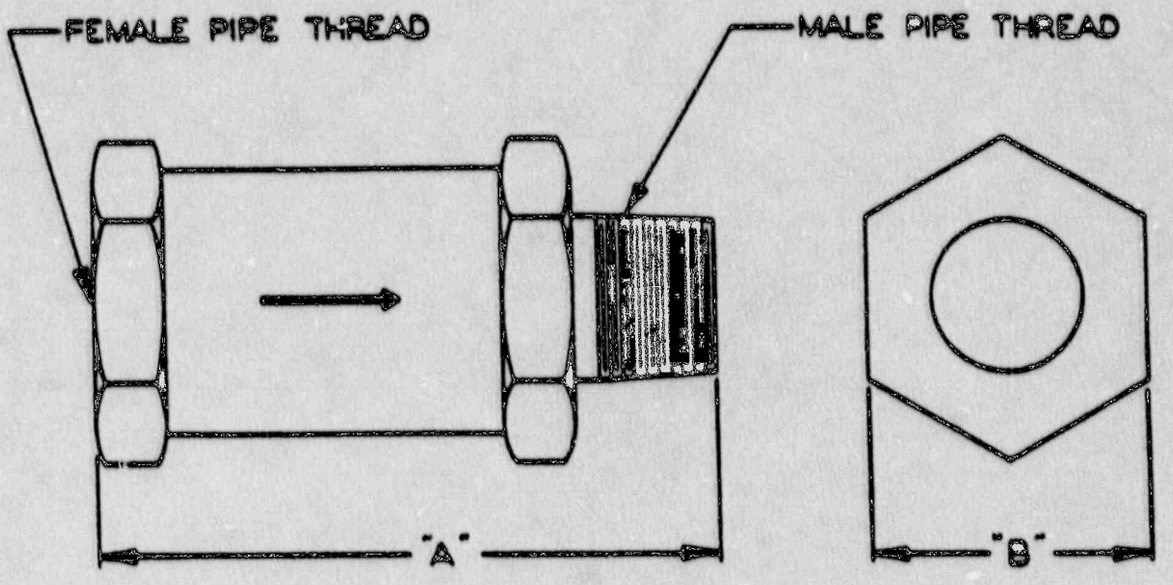
CARDOX fire extinguishing equipment...



PIPE SIZE	MODEL NO.	PART NO.
1/2" NPT	B45696-1	161824
3/4" NPT	B45696-2	161825

CARDOX SELECTOR VALVE MASTER TYPE

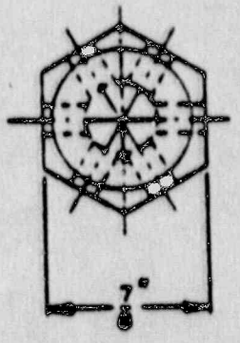
fire extinguishing equipment...

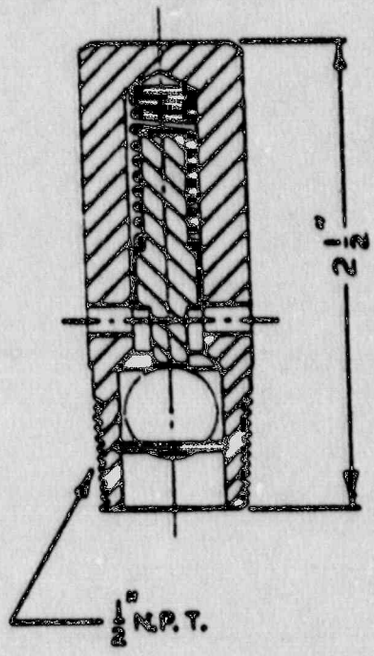


SIZE	"A"	"B"	PART NO.
½"	3 5/8"	1 9/16"	161237
¾"	4 ¼"	1 7/8"	161238
1"	5"	2 ¼"	161239
1¼"	5 7/16"	2 5/8"	161240
1½"	6 3/8"	3"	161241

CARDOX
CHECK VALVE

CARDOX fire extinguishing equipment...

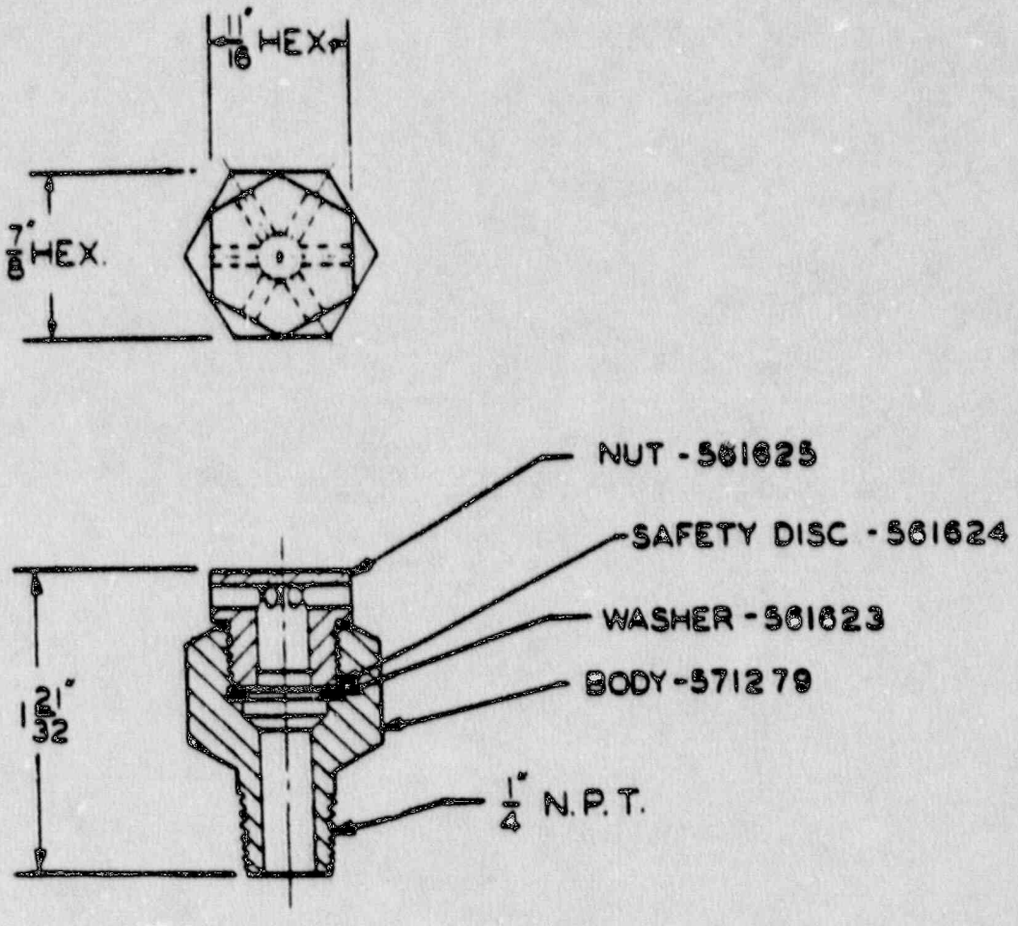




INSTALLED IN CYLINDER MANIFOLD TO VENT ACCIDENTAL LEAKAGE THROUGH CHECK VALVE WHICH MIGHT SET OFF RESERVE CYLINDERS, CLOSES IF SYSTEM IS DISCHARGED NORMALLY WHEN MANIFOLD PRESSURE REACHES APPROXIMATELY 20 PSI.

CARDOX
BLEEDER VALVE
PART NO.-161573

CARDOX fire extinguishing equipment...



REF. BURSTING PRESSURE 2650 TO 3000 P.S.I.

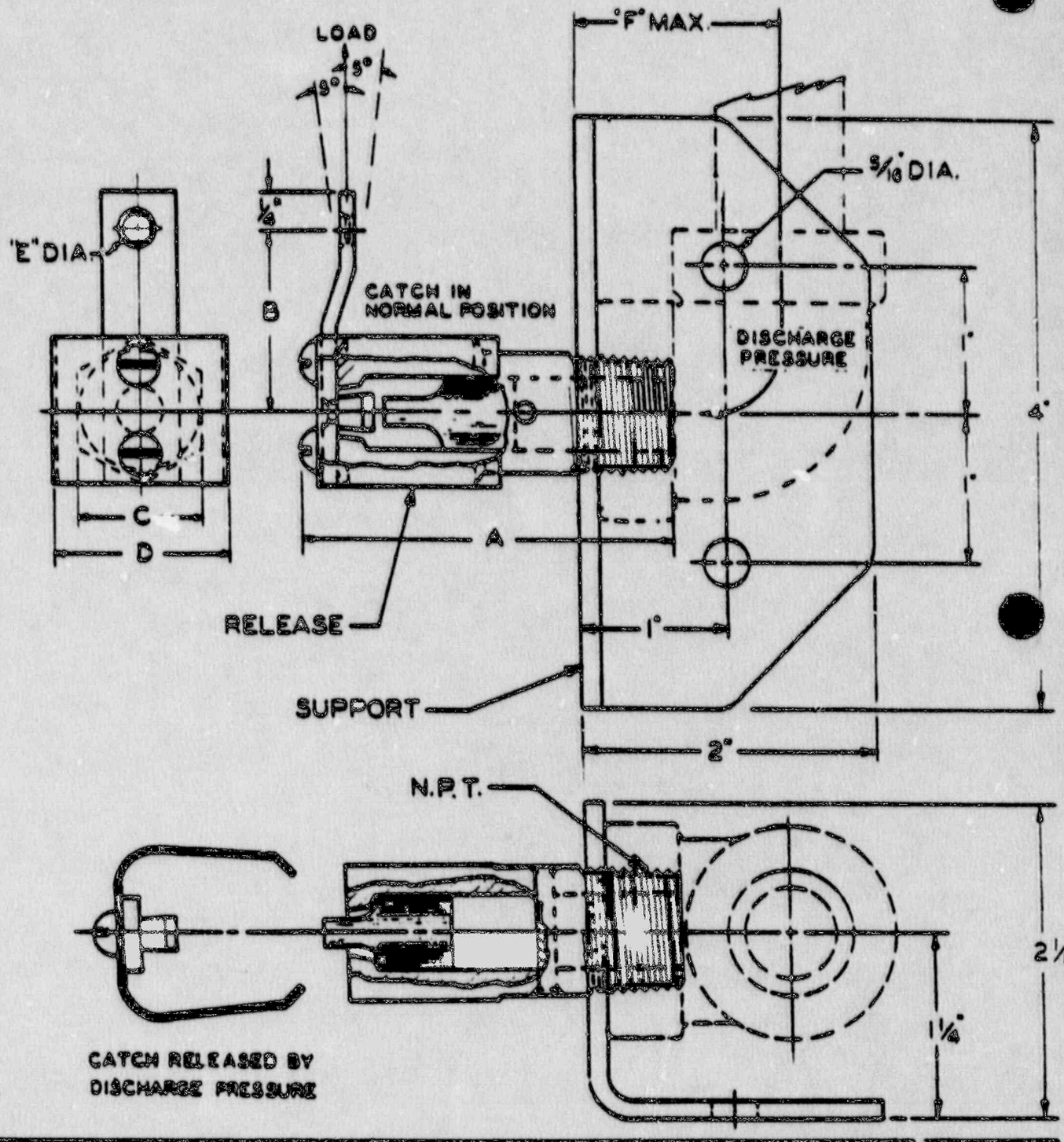
CARDOX
FRANGIBLE DISC RELIEF VALVE ASSEMBLY

PART NO. 3718

MODEL A 41597

PLATE NO. M-57A

CARDOX fire extinguishing equipment...

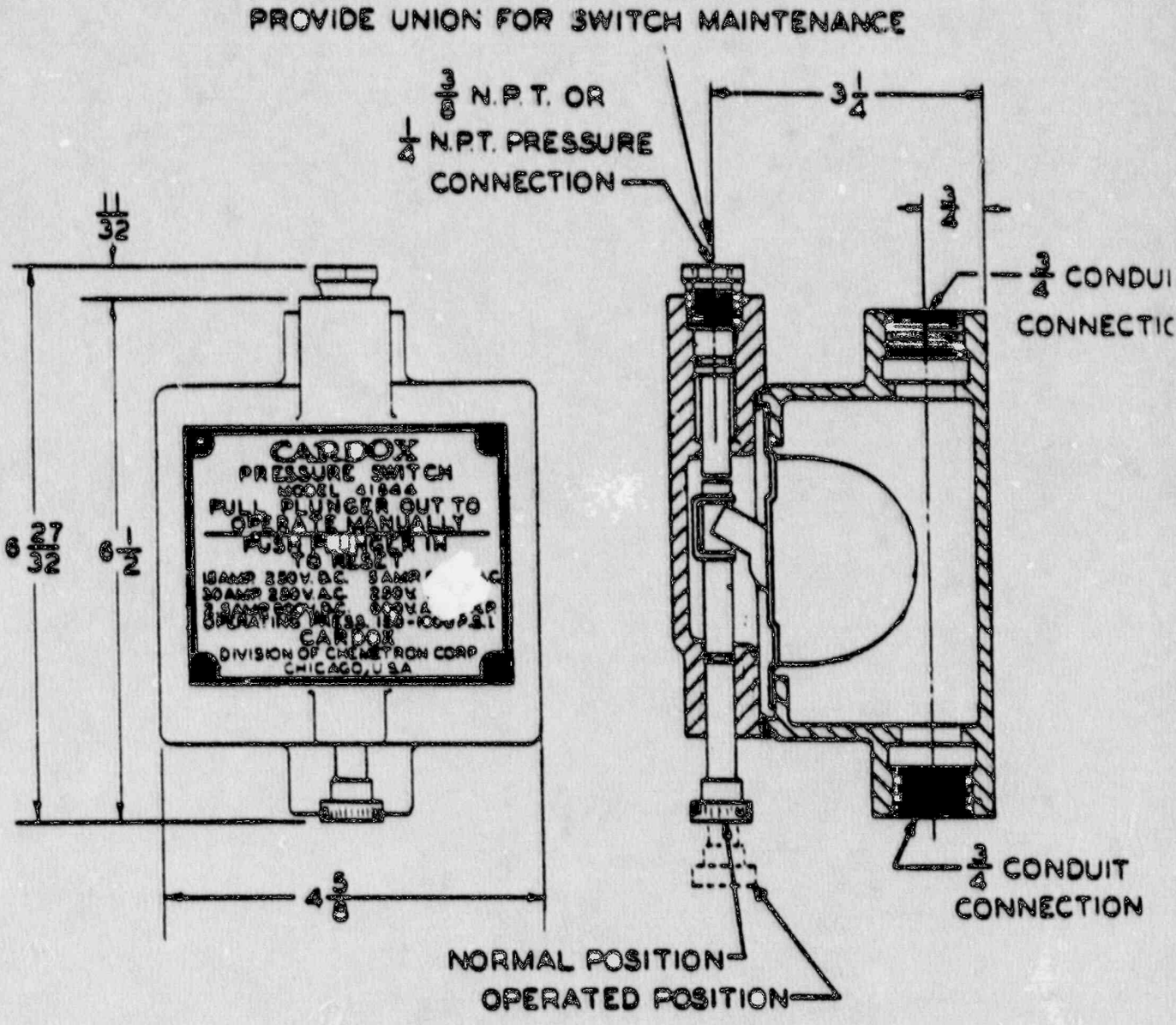


RELEASE SIZE	MODEL NO.	PART NO.	A	B	C	D	E	MAX. LOAD	SUPPORT NO.	PART NO.	F
1/2	FA-21015	10315	2 5/32	1 1/4	7/8	1 5/32	3/16	25 LBS.	A 45830	539749	1 3/
1	FA-21032	10316	3 5/32	1 3/4	1 3/8	1 21/32	7/32	100 LBS.	A 45831	539750	1

CARDOX PRESSURE RELEASE

Revised 1-62

fire extinguishing equipment...



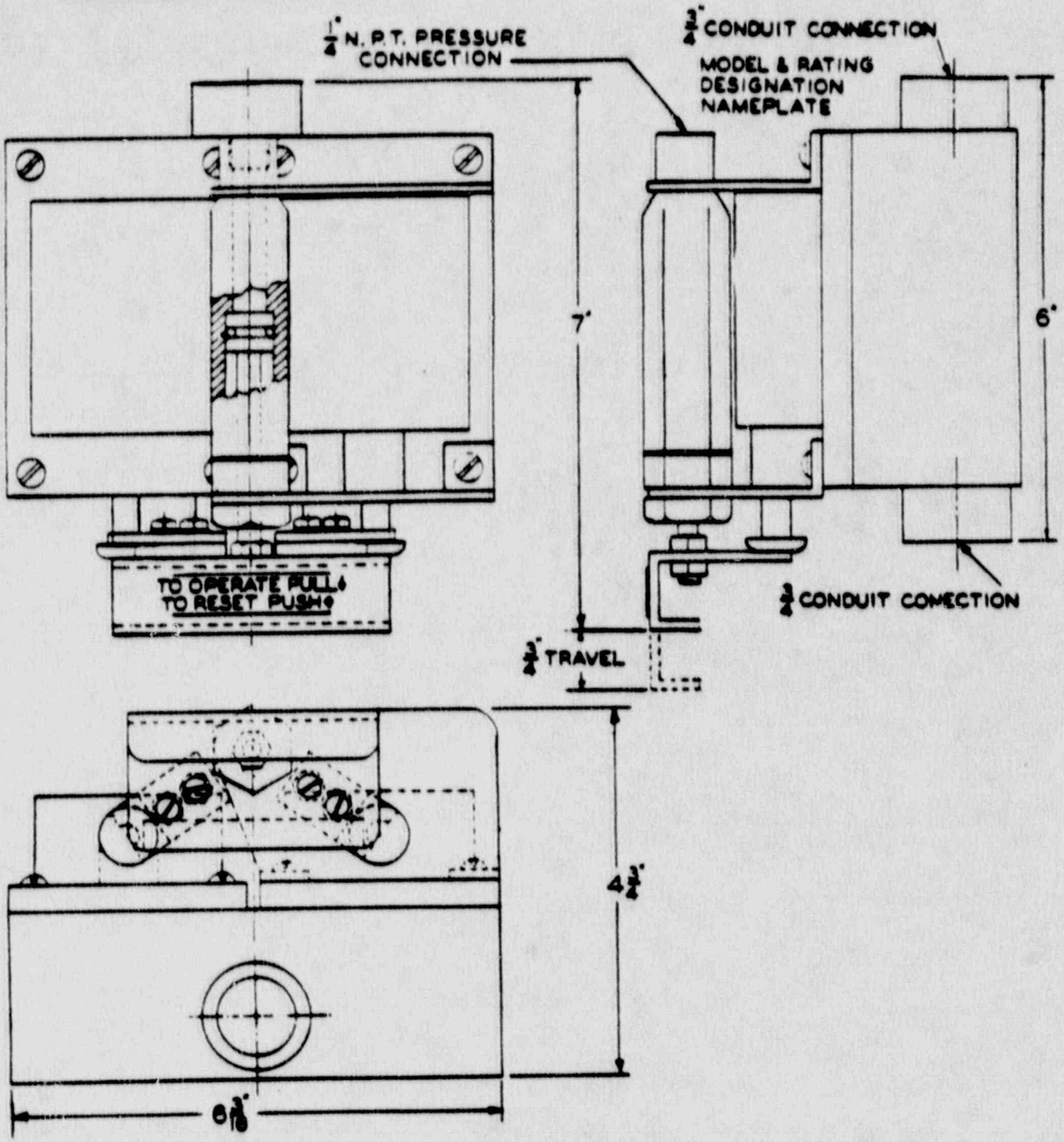
CARDOX
4 POLE WEATHERPROOF PRESSURE SWITCH
(TWO 2 POLE SINGLE THROW SWITCHES)

NORMAL POSITION — 2 N.O. AND 2 N.C. CONTACTS
ALTERNATE POSITION 1 — 4 N.O. CONTACTS } FIELD ARRANGEMENTS
ALTERNATE POSITION 2 — 4 N.C. CONTACTS }

PART NO. — 11765
MODEL NO. — 41644

DATE 11-60

CARDOX fire extinguishing equipment...



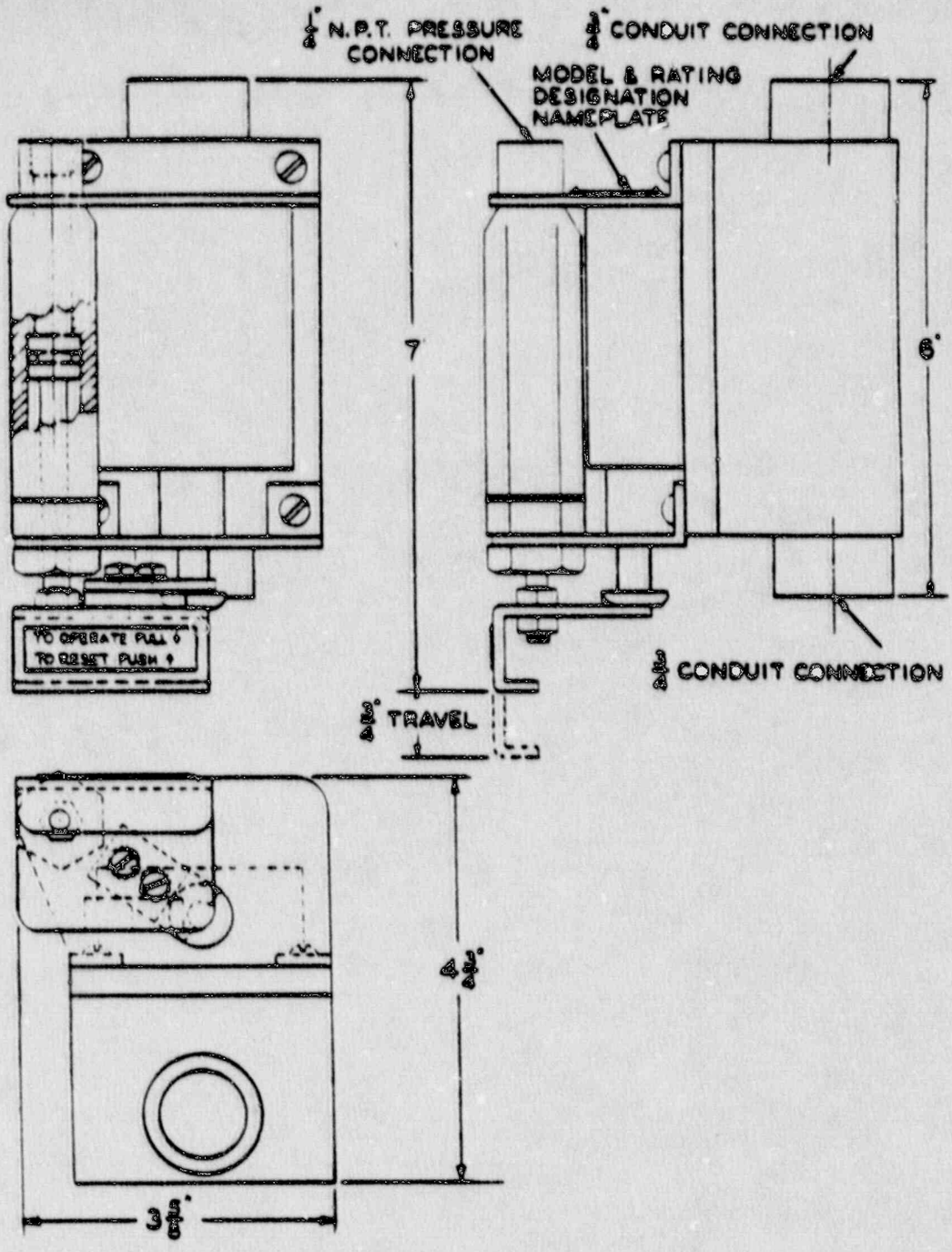
CARDOX
4 POLE EXPLOSIONPROOF PRESSURE SWITCH
(TWO 2 POLE SINGLE THROW SWITCHES)

NORMAL POSITION — 2 N.O. AND 2 N.C. CONTACTS
ALTERNATE POSITION 1 — 4 N.O. CONTACTS } FIELD ARRANGEMENTS
ALTERNATE POSITION 2 — 4 N.C. CONTACTS }

PART NO. — 11769

MODEL NO. — C 42059

CARDOX fire extinguishing equipment...



CARDOX

2 POLE EXPLOSIONPROOF PRESSURE SWITCH

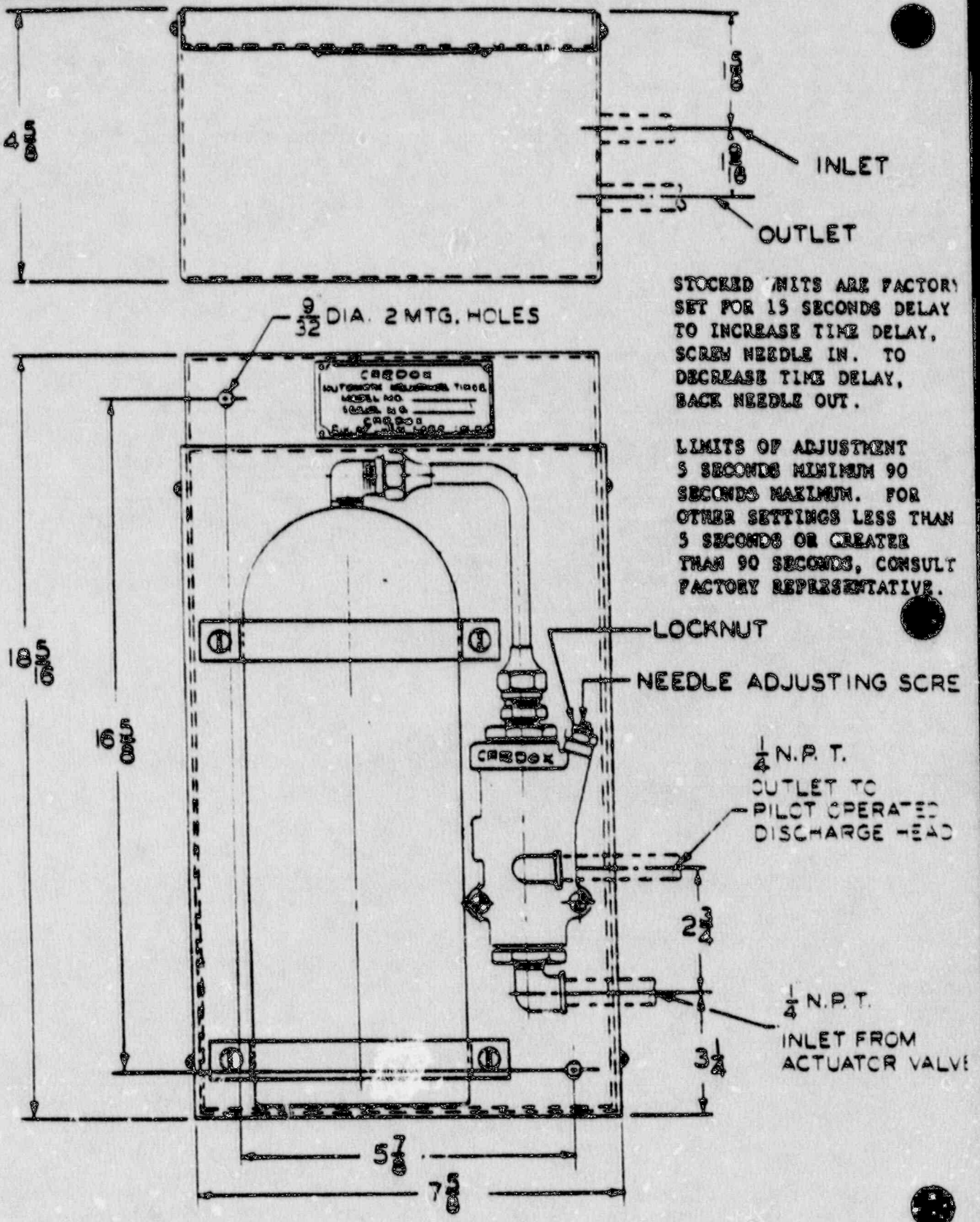
(2 POLE SINGLE THROW SWITCH)

NORMAL POSITION — 2 N.C. CONTACTS
ALTERNATE POSITION — 2 N.O. CONTACTS FIELD ARRANGEMENT

PART NO. — 11770
MODEL NO. — C 42068

PLATE NO. 59B

CARDOX fire extinguishing equipment...

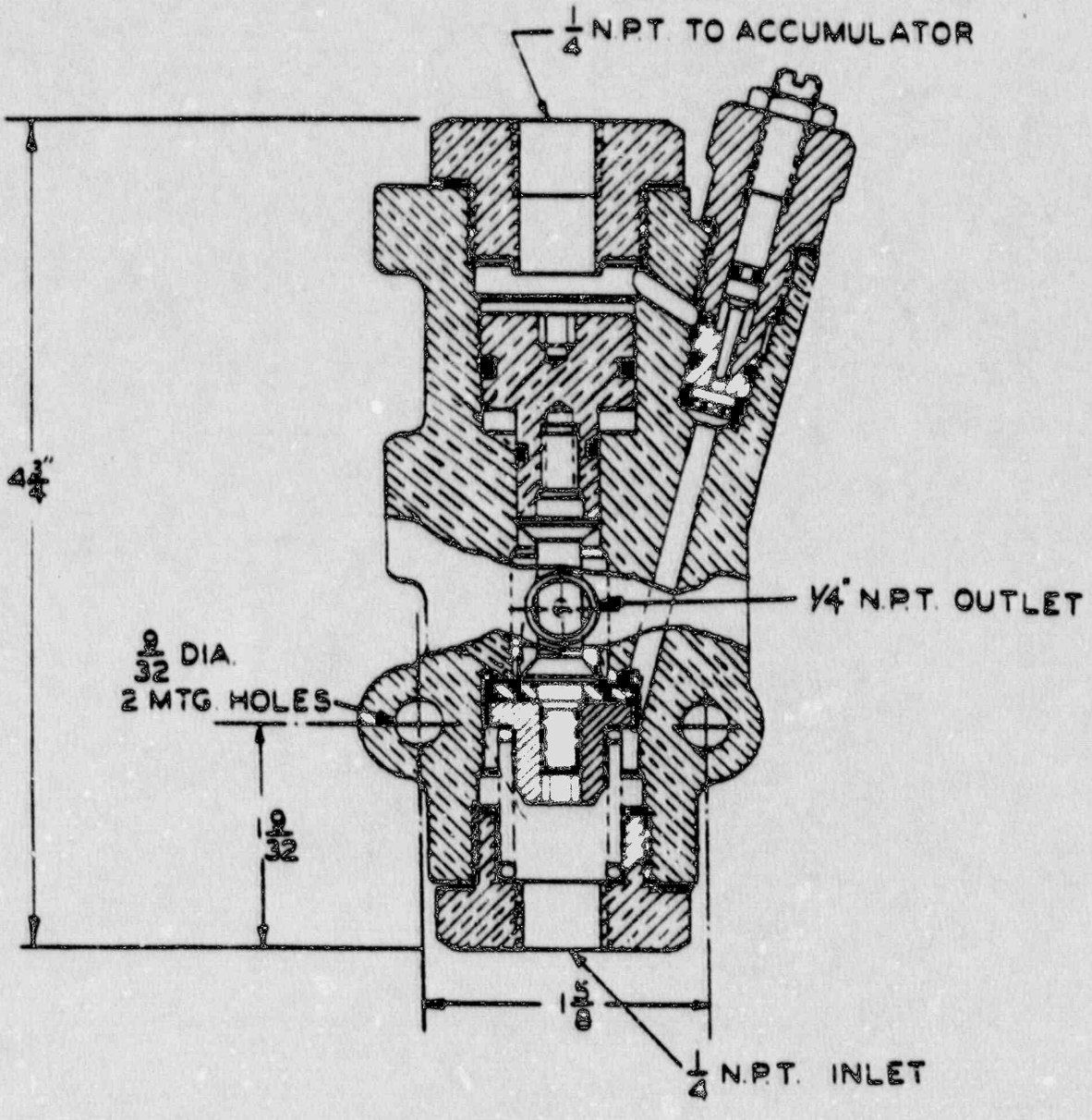


CARDOX
DISCHARGE DELAY
AUTOMATIC MECHANICAL TIMER

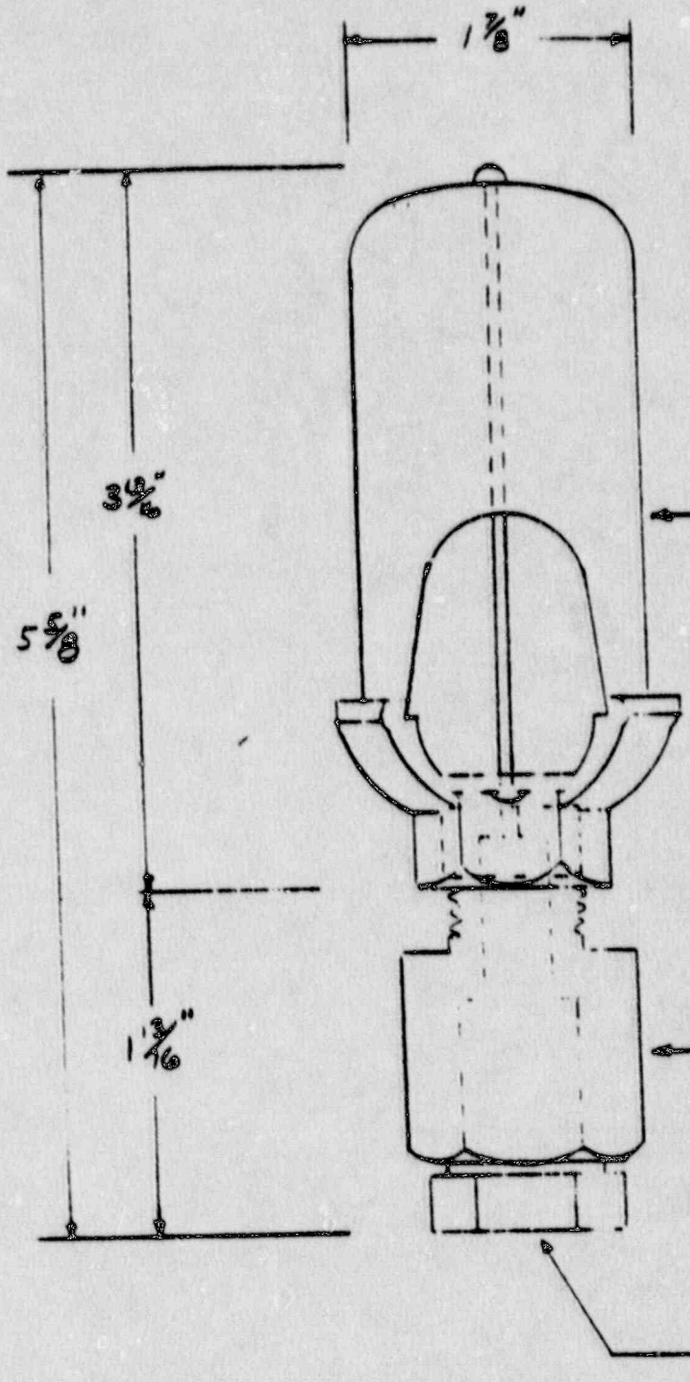
WITHOUT COVER · MODEL NO. C41588-1 PART NO. 110185

WITH COVER · MODEL NO. C41588-2 PART NO. 110186

CARDOX fire extinguishing equipment...



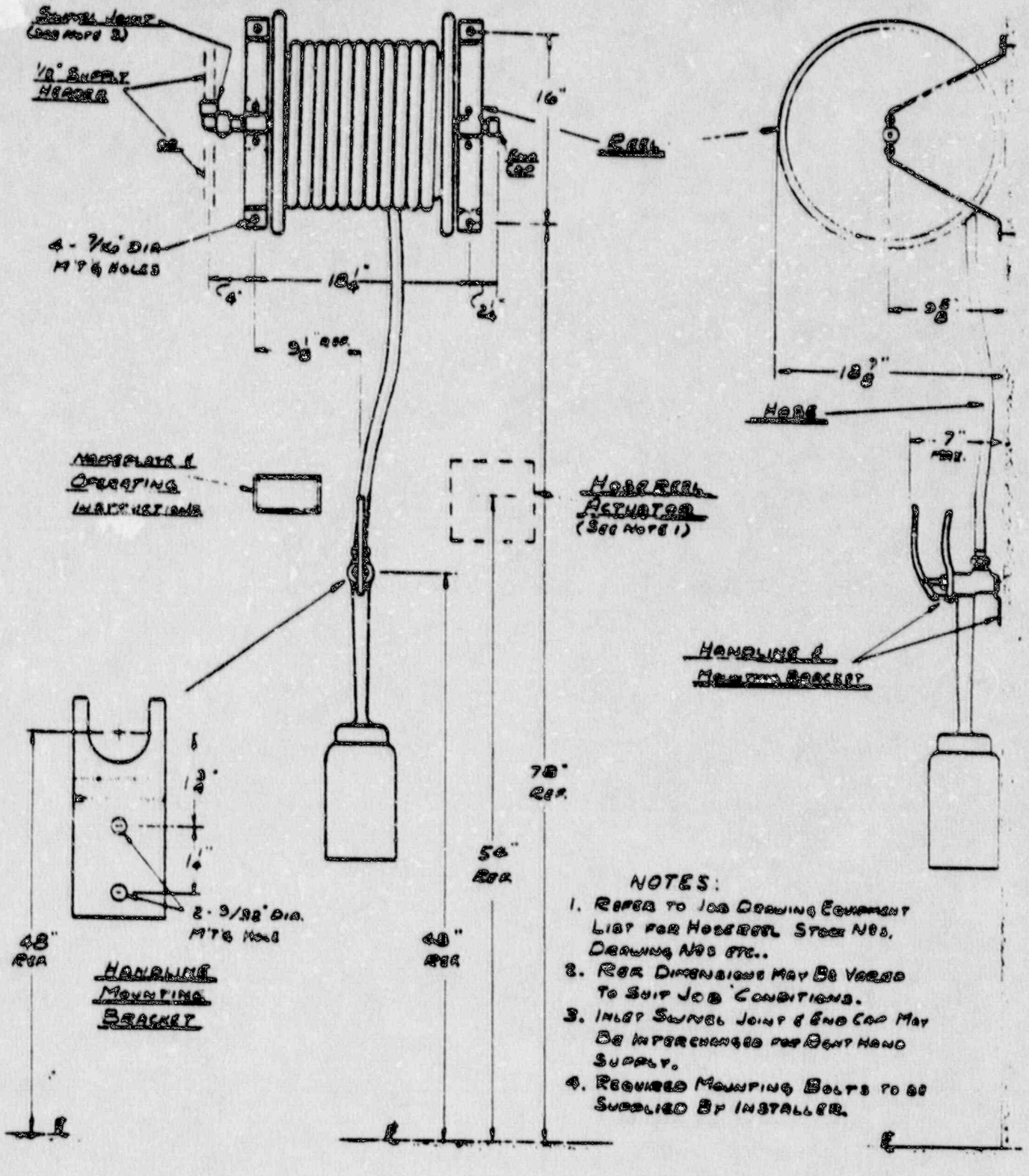
CARDOX
DISCHARGE DELAY VALVE
PART NO. - 31097
MODEL NO. - B41793



TO BE MOUNTED IN VERTICAL POSITION DIRECTLY ABOVE HORIZONTAL SUPPLY PIPE TO ASSURE VAPOR DISCHARGE.

CO_2 WHISTLE ASSEMBLY

* PROPER ORIFICE MUST BE ORDERED FOR CORRECT PRESSURE REQUIREMENTS



NOTES:

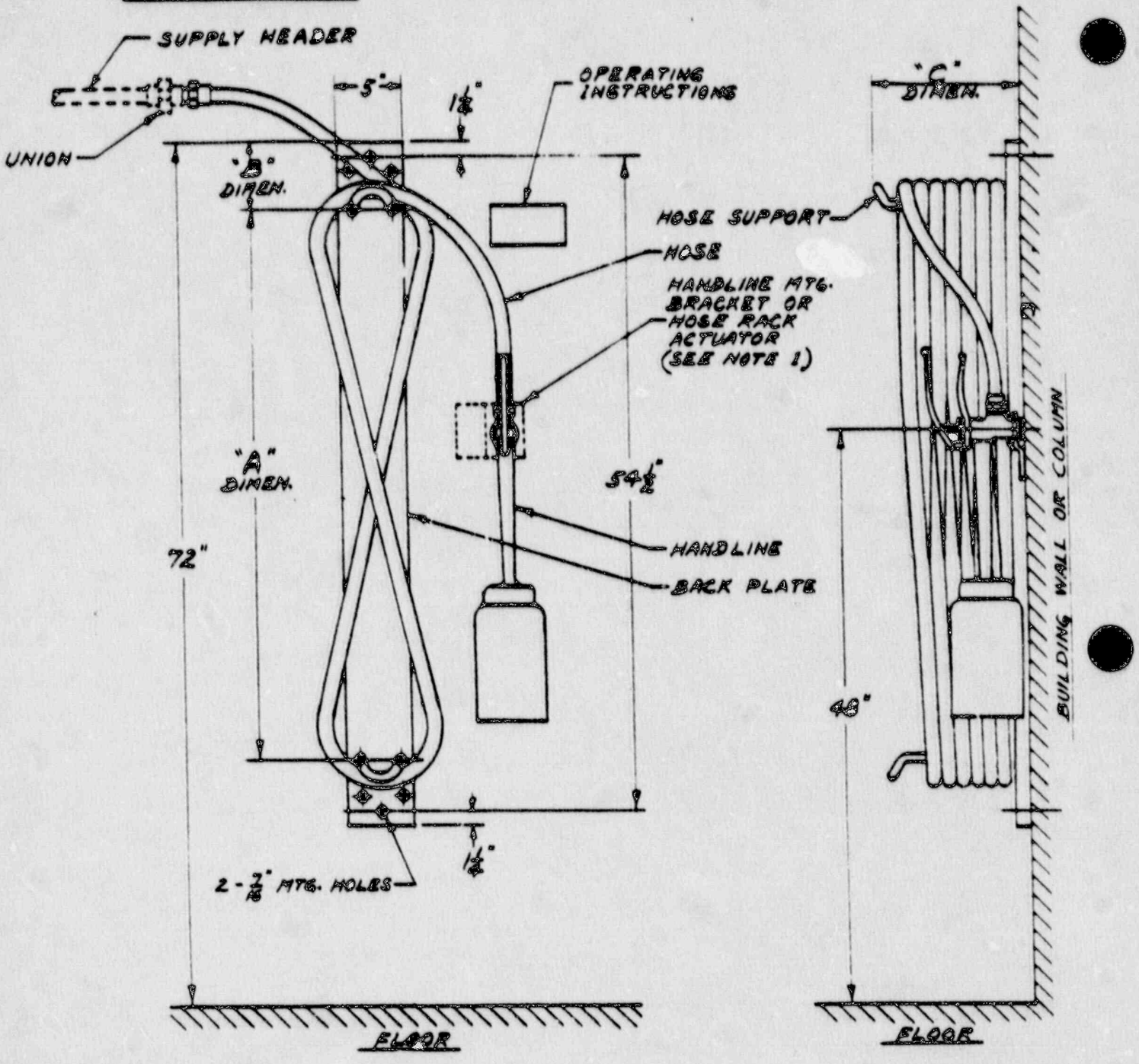
1. Refer to Job Drawing, Equipment List for Hosereel Stock Nos, Drawing Nos etc..
2. Rise Dimensions May Be Varied To Suit Job Conditions.
3. Inlet Swivel Joint & End Cap May Be Interchanged For Right Hand Supply.
4. Required Mounting Bolts To Be Supplied By Installer.

TYPICAL HOSEREEL MOUNTING DETAIL

PLATE NO. H-64

c-463-cpc

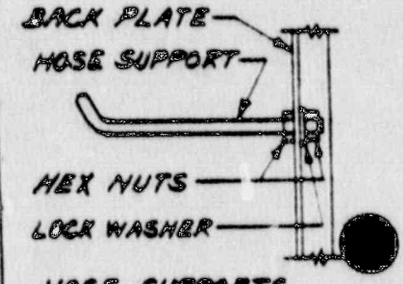
ANSUL fire extinguishing equipment...



NOTES:

1. Refer to Job Drawing Equipment List for Hose Rack Stock Nos., Drawing Nos., etc.
2. Installation Dimensions may be Varied to Suit Job Conditions.
3. Required Mounting Bolts to be Supplied by Installer.

HOSE RACK SIZE	DIMEN. "A"	DIMEN. "B"	DIMEN. "C"
50 Ft. 1/2" Hose 75 Ft. 1/2" Hose 50 Ft. 3/4" Hose	46½"	5¼"	9¼"
100 Ft. 1/2" Hose 75 Ft. 3/4" Hose 100 Ft. 3/4" Hose	49½"	3¾"	13¾"



HOSE SUPPORTS MOUNTING DETAIL

TYPICAL HOSE RACK MOUNTING DETAIL

MECHANICAL AND ELECTRICAL INSTALLATION SPECIFICATIONS
HIGH PRESSURE CARBON DIOXIDE SYSTEMS

GENERAL

A. These specifications contain minimum requirements for installing Cardox Systems and shall govern except where requirements of a specific job specification are more rigid and take precedence. Substandards material and workmanship shall be cause for rejection by Cardox of the installation and the Installation Contractor, hereinafter called "contractor," shall replace and/or reinstall as required to meet Cardox standards at his own expense and without delay.

B. Materials shall be new and of the highest grade, free from defects and imperfections. They shall be products of recognized reputable manufacturers.

C. Workmanship shall be in accordance with the best modern standard practice.

D. Drawings and specifications generally identify work to be done but it is the responsibility of the contractor to VISIT THE PROJECT SITE and acquaint himself with both job and working conditions. Job drawings show distribution piping in schematic and therefore are not necessarily exact. Length and routing may have to be varied somewhat to suit job conditions. Major deviations, however, shall be reported before installation to Cardox — Chicago. Branch piping and nozzle location, in particular, are extremely critical.

MECHANICAL

1. Storage Rack, Manifold and Cylinders.

A. Storage rack parts are furnished for assembly on the job. Install on a level hard surface in a dry location where the surrounding air temperature remains within the range of 32°F to 120°F.

B. The cylinder manifold shall be attached to uprights with "U" bolts.

C. Cylinders are shipped charged with carbon dioxide. Install in rack and clamp in place. Connect cylinders to manifold with Cardox flexible connectors. Pilot cylinders are in No. 2 and No. 3 position from dead end of manifold.

2. Discharge Piping.

A. Pipe shall be galvanized steel.

B. Sizes ¾" and smaller shall be Schedule 40.

C. Sizes 1" and larger shall be Schedule 80.

3. Screwed Pipe Fittings.

A. Pipe fittings shall be galvanized.

B. Where Schedule 40 pipe is specified, fittings shall be 150 pound steam malleable iron banded, 300 pound steam malleable iron or 300 pound ductile iron.

C. Where Schedule 80 pipe through 2" size is specified, fittings shall be 300 pounds steam malleable iron or 1000 pound ductile iron.

D. Where pipe larger than 2" is specified, fittings shall be 2000 pound forged steel.

E. Ductile iron fittings shall be Kuhns Bros. Company manufacture with the identifying mark DKI — NO EXCEPTIONS.

4. Underground Piping.

A. Underground piping shall be Schedule 80 galvanized for all sizes.

B. Pipe joints shall be tested for leaks at 700 psi before preventive corrosion coating is applied.

C. Underground piping shall be given two treatments of pipe coating and spiral wraps of burlap and then a final cover of pipe coating.

D. Trench depth shall be 3 feet below frost line, whichever is deeper.

5. Dirt and Blowoff Pockets.

A. Install beyond last take-off of each main header and sub-header.

B. Pockets should be approximately 18 inches long. Where adverse conditions are encountered, shorter pockets may be used. A 3 inch nipple and cap are minimum.

6. Pipe Reduction.

A. Reduction shall be made with reducing fittings of the same rating specified in 4 above. REDUCING BUSHINGS SHALL NOT BE USED.

7. Pipe Sleeves.

A. Piping through typical building walls, partitions, floor slabs, roof slabs, etc., shall be run through sleeves of Schedule 40 pipe at least two sizes larger than pipe being run and not smaller than 1 inch.

B. Sleeves shall be packed with asbuma and asphaltum or equal so as to be dust tight, where specified.

C. Sleeves through floor slabs shall extend at least 2 inches above floor.

D. Sleeves through roof slabs shall extend above roof 6 to 10 inches and shall be flashed in accordance with local building regulations.

8. Pipe Hangers and Supports.

A. Pipe supports and parts shall be of steel. Conduit, beam and "C" clamps shall not be used.

B. Piping shall be achieved to rigid members, such as walls, ceiling and columns, to prevent longitudinal or lateral sway. Nozzle piping shall be well braced.

C. Hangers and supports shall be of rugged design and shall be installed so that they will not be loosened by movement of the supported pipe.

D. Pipe lines shall not be used to support other pipe lines.

E. Pipe supports shall be installed to avoid interference with other piping, conduit, structures and equipment.

F. Maximum spacing of supports is as follows:

Nominal Pipe Size, in.	¼	⅜	½	1	1¼	1½	2	2½
Maximum Span, ft.	5	5	6	7	8	9	10	11

9. Control Tubing and Fittings.

A. Tubing shall be ¼" soft copper with .065" wall.

B. Weatherhead "Imora" — 8000 Series forged steel compression fittings shall be used in locations normally under continuous pressure.

C. Tubing shall be formed with a tubing bender. Cut tubing ends square and ream. Assemble with true alignment to the center line of fittings, without distortion or torsion.

DL. Support tubing with straps or brackets to prevent sagging.

10. Base-of-Riser Tubing and Fittings.

A. Tubing shall be ⅜" soft copper with .020" wall.

B. Fittings shall be brass inverted flare type.

C. Tubing shall run in ½" thin wall conduit, with 4" junction at tubing joints.

D. Support conduit with straps or brackets to prevent sagging.

11. Valves, Pressure Switches and Remote Manual Releases.

A. Threaded valves, such as selector, check, shuttle and pilot valves, and pressure switches, when installed in rigid pipe lines, shall have a union immediately downstream from the equipment to facilitate inspection, repair or replacement.

B. Valves shall be installed to give sufficient room for expansion of adjoining piping and for repair or removal without interfering with another valve or pipe.

12. Nozzles.

A. Spot nozzles through Code 8 have ½" IPT female connections; larger sizes are ¾". Code 6 and smaller have inlet strainers. Shells are 4" or 5½" I.D.

B. Where nozzles are installed to discharge through tank, booth or duct walls, the contractor shall cut openings to fit Cardox mounting flanges.

C. Orifice nozzles have ½" IPT male connection; where installed through walls of ducts or other equipment, the contractor shall cut openings to fit Cardox mounting flanges.

D. Nozzle size, location and position shall be exactly as shown on job drawing.

13. Pressure Releases.

The pressure releases only are supplied by Cardox. All hardware and other equipment involved in the release function shall be provided by others unless specifically listed on the job drawing.

14. Protective Guards.

Cardox system components normally require no protective guards. Such enclosures, when required, shall be provided by others, unless specifically listed on the job drawing.

15. Workmanship and Fabrication by Contractor.

A. The contractor shall provide the necessary tools, equipment and materials that will allow him to start work promptly and to complete the installation without delay in conformance with these specifications.

B. All discharge piping branches shall be taken from the bottom or side of header piping for better liquid CO_2 flow.

C. Screwed piping and fittings shall have clean cut and full length threads.

D. Screwed pipe joints shall be treated with Teflon tape, glyptal or equal lubricants.

E. All welded joints, where used, shall permit full flow. Mitre weld fittings are not acceptable. NO CHILL RINGS PERMITTED.

F. Piping and tubing shall be reamed free of burs and ridges.

G. Pipe and tubing shall be cleaned thoroughly as assembled. Pull wire flue brush through pipe length several times. Pull clean cloth rags (not burlap or similar), treated with Stoddard's solvent or equal, through pipe length. Cut solvent with 50% carbon tetrachloride when working in hazardous locations. DO NOT USE IN CLOSED SPACES WITHOUT ADEQUATE VENTILATION.

16. Expansion Joints.

A. Contraction caused by a maximum temperature change is based on 1" per 100 feet of steel pipe. Taking up this contraction requires a joint that permits pipe movement. Often, as part of the natural layout of system, a swing joint can serve to give the desired flexibility. In straight runs an expansion joint shall be installed on the basis of one after approximately 100 feet of continuous run and after approximately 100 feet of run thereafter.

17. Field Testing.

A. Testing shall be in accordance with instructions in Plate No. H-72, preferably under the supervision of a Cardox field engineer.

B. Field-installed tubing and pipe lines shall be disconnected from equipment and lines blown clean before tests are started.

C. Control tubing, fittings, valves, and other components under constant pressure shall be tight.

D. Discharge piping and joints shall be tested at 700 psi.

E. Materials other than CO_2 shall not be used for testing, except with written permission of CARDOX DIVISION OF CHEMETRON CORPORATION, 840 North Michigan Avenue, Chicago, Illinois 60611.

18. Painting.

Painting of mechanical components, when required, shall be in accordance with job specifications.

ELECTRICAL

19. **Codes.**

Wiring and equipment shall be installed in accordance with the National Electrical Code and Local Code requirements. Any conflicts between codes shall be referred to Cardox-Chicago for interpretation.

20. **Conduit.**

Shall be rigid, not thin wall type.

21. **Wiring.**

Wire size shall be no smaller than 14 AWG. Insulation shall be suitable for 600 volts and shall be in accordance with Article 310 of the National Electrical Code. Connections shall be twisted, soldered and insulated with plastic electrical tape.

22. **Power Supply.**

A. The power supply for the Cardox System electrical controls shall be from a reliable source not subject to interruption.

B. The power supply shall be protected either by fusible safety switch or circuit breaker supplied by contractor.

23. **Thermostats.**

A. Fenwal type supplied unless otherwise specified.

B. **Standard Installation** — Covers and boxes shall be 4" and shall be furnished by contractor. Mount on flat covers with ½" knockouts using ½" conduit lock nuts.

C. **Explosion-Proof Installation** — Mount on Crouse-Hinds CPS 021 covers for Form 20 Conduluts or Appleton Electric EPGS Hub Covers for EPGS Form 20 Unilets.

D. **Outdoor or Damp Indoor Installation** — Weatherproof fittings shall be used, such as Crouse-Hinds G.S. Series — Form 20 Hub Covers.

24. **Tests of Electrical Work.**

The wiring for each hazard of the Cardox System shall have a minimum resistance to ground of seven (7) megohms and the entire system shall have not less than one (1) megohm resistance to ground.

25. **Painting.**

Conduit, boxes, or other electrical appurtenances or straps, hangers or supports thereof, shall not be painted, unless specifically stated otherwise.

INSTALLATION, INSPECTION AND TEST INSTRUCTIONS
HIGH PRESSURE CARBON DIOXIDE SYSTEMS

INSTALLATION

GENERAL — Cardox systems shall be installed in accordance with good modern practice for handling pressure piping and emergency type of electrical circuits. Since fire protection systems must withstand extreme conditions that may damage other equipment and piping, some common practices for installing ordinary utilities may be inadequate. Accordingly, minimum standards are set forth in job drawings and Installation Specifications (H-70). Particular emphasis is placed on the need for clean piping and tubing.

Inspection and Test Procedures indicate to the Installation Contractor what needs to be done to assure reliable performance of the system. Since he is responsible for correcting faults of installation, it will save time and expense for all concerned if he performs preliminary tests.

SETTING UP THE SYSTEM

(Refer to job drawing for reference to illustrations of individual components.)

1. Assemble storage rack on site. Bolt free-standing uprights to floor with braces. Bolting to wall is preferable for maximum rigidity, in which case floor braces are not needed.

2. Mount ½" control piping through holes in rack uprights. Locate shuttle valve (or tee) for take-off of connection kit hose to pilot cylinders in No. 2 and No. 3 positions in rack, starting at end of manifold farthest from riser.

3. Mount control cabinet on upright at side best suited to installation, bearing in mind accessibility and connection to electric power supply, pressure switches, electric alarms, etc. For multiple hazard system, mount additional actuator valves close to cabinet. Note that "automatic" control pressure normally connects into one end of ¼" pipe in rack, "remote" into the opposite end, and are separated by a double check, or shuttle valve.

4. Mount automatic release valves (rate-of-rise or solenoid) close to control center and connect to actuator valve with ⅜" (.065" wall) copper tubing and Weatherhead ERMATO Series 8000 compression fittings.

5. Mount switching valve and discharge relay and connect with ¼" pipe to outlet of actuator valve and any shuttle valves indicated.

6. Install full control cylinder in control center and start PRESSURE RECESSION TEST.

7. While control center is under test — complete installation but —
   a. do not connect pilot cylinder discharge heads to cylinders;
   b. do not energize electrical circuits.

8. After PRESSURE RECESSION TEST — energize any electrical circuits and inspect system for proper operation of controls and discharge delay timing, following inspection and Test Procedures.

9. Forward Field Test Report No. 4 HP to Cardox Division of Chemetron Corporation, 840 North Michigan Avenue, Chicago, Illinois 60611, ATTENTION: Fire Equipment. If Seller is other than Cardox, such as a distributor, forward report to Seller. Seller, Cardox or other, shall arrange for final inspection and report, as necessary.

10. Clean work site.

INSPECTION AND TEST PROCEDURES

GENERAL — Cardox high pressure carbon dioxide fire extinguishing systems are "PERFORMANCE-ENGINEERED" to high standards. It is essential that the installation and function be inspected to assure compliance with job drawings and installation specifications. A copy of job drawings must be marked after the system is accepted to indicate compliance or deviation and forward promptly to Cardox — Chicago with FIELD TEST REPORT NO. 4 HP to establish the guarantee of the system.

1. Obtain owner's approval before starting final acceptance test and set time for test so that observers will have adequate notice.

2. Adhere to local labor and security restrictions.

3. Arrange for cylinder recharges to be readily available after test.

4. Check weight of all cylinders, which must be fully charged before testing.

5. Always disconnect all pilot cylinder discharge hoses before tests to prevent discharge.

PRESSURE RECESSION — Automatic release of the system depends on having control pressure available when needed. The control system must be absolutely tight from the control cylinder to the release valve. A calculated leakage rate of about one pound per year is considered tight. Higher rates indicate leaks which must be eliminated.

1. Back off pressure regulator adjusting screw until loose.

2. Connect full control cylinder, using new filter gasket, open and then close valve tightly.

3. Observe pressure gauges. Low side should show no pressure; high side should remain constant.

4. Re-open cylinder valve. There should be no increase on high pressure gauge.

5. Adjust regulator to 300 on low pressure gauge; then back off screw one-half turn.

6. Close cylinder valve tightly; crack union joint until high pressure gauge reads zero and retighten union joint.

7. Allow system to stand for about one hour to reach room temperature. Check pressure gauges periodically. A rise above 300 may be due to warming of the system, which is normal. A pressure drop indicates to gross leak. If the high side shows an increase along with a drop on the low side, check for leaks on low side which are causing regulator to open to meet demand. An increase on the high side only indicates that the cylinder valve is not closed tightly. (Detection of small leaks require skill. Test solutions must be clean. Minute leaks may be located with a G.E. Halogen Leak Detector.)

8. After obvious leaks have been eliminated, record temperature, time and low pressure gauge readings in the table below.

Date	Time	Pressure	Temp. °F

Change (T)_____hrs. (P)_____

Enter elapsed time (T) and drop in low pressure gauge reading (P) in Field Report No. 4 HP and calculate Annual Leakage Rate (R) by the formula $\frac{V \times P}{20 \times T} =$ _____ lbs./yr., where (V) is volume in cu. in. under continuous pressure. Use a volume of 30 for one hazard systems. Add 10 for each additional hazard. The minimum time in hours for testing pressure recession is determined by dividing V by 4. For example: — if V is 20, the test shall be run for at least 5 hours, during which time the low pressure gauge reading may drop no more than 5. If the installer follows instructions to start tests before completing the installation, tests can be run 24 hours or longer. The longer the test the higher the degree of accuracy. Long tests are particularly important if the room temperature rises, since warming of the system will raise the pressure and tend to hide small leaks.

9. After test, actuate control system to empty. Reset release valve, re-open control cylinder valve and adjust regulator to 300 to restore system. Do Not Back Off Regulator One-Half Turn.

NOTE: It is normal for control systems with actuator valves to go through a cycle while the system is being pressurized, just as if the automatic release valve had opened. The hissing sound will stop when the gas in the actuating system, including any discharge delay timer, has been exhausted. Do not repeat tests until all hissing has stopped.

RATE-OF-RISE — This system consists essentially of hollow bulbs (HAD) connected through Ye-inch tubing to a diaphragm-operated release mechanism. Air in the HAD expands when heated and a compensating vent in the line permits "breathing" of pressure due to normal temperature changes. A rapid pressure increase due to abnormal temperature rise exceeds the capacity of the vent and causes the diaphragm to extend and trip the release. When the heat source is removed the HAD cools and the release can be reset manually. The vent rating is stamped on the vent proper and on the release nameplate. It indicates the number of seconds for a 1-inch water column in a 9" manometer to drop in relieving a vacuum. The trip pressure setting is factory-stamped on the release nameplate or, in a mercury check, is indicated by stamp or tag applied by the installer. For example, a marking of 2" — 5 signifies a pressure of 2 inches of water and a No. 5 vent. When

mercury checks are used, the release proper usually has a rating of 1/2" — 40, the most sensitive, and the check is adjusted to suit job conditions as determined by thermometer and watch. The tubing system must be tight to make the system work.

Test apparatus includes a 9" and an 18" manometer, rubber tubing, mercury and an electrical test set. A container of hot (175 to 200°F) water is used in combustible atmospheres. Instructions for use and test are packed with each manometer.

Tightness — Use vacuum test method on 18" manometer. Raise water level in right column to obtain a difference of about 8" in the two columns. After an initial drop to about 6" difference, water level should remain constant for one minute.

Pressure Ratings — Use pressure test method on 9" manometer. Maximum difference in water level in the two columns when the release trips is the release rating. The maximum difference when the water level flutters is the rating of a mercury check.

Compensating Vents — These are set at the factory and should not be adjusted. If a rating check is desired, remove vent for test. Use 9" manometer and vacuum test. Clock number of seconds for a 1" column to drop, using 1" slot in metal slide as a guide. Place top of slide at water level. Start timing when water level first appears in slot.

Actuation — Connect tubing to release. Apply heat to HAD to trip release and control pressure will depress piston in pilot discharge head. The release will trip after about 10 to 60 seconds when a heat lamp is used, 2 to 10 seconds when the HAD is submerged in hot water. If system includes discharge delay, piston will be depressed at the end of timing period. After piston has been depressed, close control cylinder valve to conserve gas. Wait about 5 minutes for HAD to cool, then reset release, re-open control cylinder valve and test next HAD. Raise pilot discharge head pistons by thumb pressure after each release. If system includes selector valves, refer to SELECTOR VALVE Tests.

ELECTRIC THERMOSTATS — Test apparatus consists of a heat lamp, iron, heat blower, or pan of water or high flash point liquid heated to at least 20°F above the temperature rating of the thermostat. The normally-open thermostat switch, closing when heated to temperature, will open a solenoid-operated release valve and actuate the system by causing depression of the piston in the pilot discharge head. If there is a discharge delay, continue heat application for at least 15 seconds or the system may reset automatically before the end of the timing cycle. Do not use open flames or hot irons and coils in combustible atmospheres. Test each thermostat in each hazard for operation. Raise pilot discharge head pistons by thumb pressure after each release.

SMOKE DETECTOR — Refer to Cardox Publication C-330.

REMOTE MANUAL STATION — Break seal wire and pull pin. Depress lever for about 2 seconds to pressurize and actuate pilot discharge head piston, then release lever and replace pin. Raise pilot discharge head pistons by thumb pressure after actuation. Test each station. If system contains selector valves, refer to SELECTOR VALVE tests.

SUPERVISORY ALARM — The supervisory pressure switch in the control center has open contacts between 275 and 375 psi. The low side is the important one. Reduce control pressure by closing cylinder valve and actuating automatic release; the supervisory signal should give an alarm. Higher pressure is obtained by tightening the regulator screw. Reset regulator to 300 psi.

DISCHARGE DELAY TIMER — The time cycle is adjusted by a screw on the side of the needle valve. The lock nut must be tight to prevent shifting. The release valve must remain open longer than the delay period. Should the valve close due to cooling of detectors, such as electric thermostats, the timing cycle will stop and the timer will bleed down through the exhaust of the actuator valve.

The time cycle is adjusted by a needle valve. Loosen locknut. Turn screw clockwise to increase delay, counter clockwise to decrease. Starting with needle closed, open 1½ turns for about 15 seconds, 1 turn for about 30 seconds. Tighten locknut after each setting. Accumulator must be emptied before repeating a test. There is a capped tee on the accumulator inlet; loosening the cap will empty the accumulator quickly. The cap must be on tight for proper function. Tag timer with final setting and replace cover.

SWITCHING VALVE — This device transfers automatic control pressure between "Main" and "Reserve" bank pilot discharge heads. Test in both positions when checking automatic releases. Only one set of pilot pistons will be depressed if connections are made to proper ports of valves. Bottom port is open exhaust — do not block!

BLEEDER VALVE — Exhaust from a bleeder valve when the other side of the cylinder manifold is pressurized indicates that foreign material is preventing tight closing of the check valve. Remove and clean check. A slight discharge through a bleeder valve under pressure is normal. Excessive discharge may be caused by dirt in the ball seat. Remove and clean.

NOZZLES — Every nozzle is stamped with an identifying Code Number. In addition, the horn size of spot nozzles is stamped into the shell. Check identification and position against job drawings. THERE SHALL BE NO DEVIATIONS! Spot nozzles have cross-drilled jets which must be unobstructed. Code Numbers 6 and smaller have inlet strainers. Remove nozzles from pipe to inspect and clean strainer.

SELECTOR VALVES — These valves are pressure-operated through a PILOT CONTROL. They open when the pilot control admits line pressure to the piston chamber and close when cylinders are empty.

The pilot control is actuated by control pressure from automatic and remote manual releases. It is locked open pneumatically by line pressure, even if control pressure is interrupted, until the storage cylinders are empty. Accordingly, the automatic or remote manual release must be energized long enough to cause discharge. Obviously, but one selector valve should open at any one time, otherwise there is a fault in the control system.

SHUTTLE VALVES — These devices are essentially two check valves with a common outlet that are used to separate pneumatic circuits. The only moving part is a stainless steel popper that seals against "O" rings at each end of the tee run. Since the "O" rings also seal the end plugs, plugs loosened during makeup of piping could cause leaks. Dirt on rings and popper can also cause leaks, as in any valve. Remove from line and inspect if faulty operation is indicated. Clean or replace "O" rings as necessary.

PRESSURE RELEASE — The spring clip on the release is pushed free when the piston is pressurized, providing the direction of pull is within the 5 degrees limit and the load does not exceed the rating of the release. A slight discharge of carbon dioxide around the piston is normal.

OTHER DEVICES ordinarily do not require special attention, other than checking against job specifications and standards of good workmanship.

ACCEPTANCE

After all tests are completed satisfactorily —

1. Recharge cylinders and mark tags.

2. Replace all locking pins and seal.

3. Reset automatic control system for 300 psig with open valve on control cylinder.

4. Reset pressure switches and releases.

5. Energize electrical circuits.

6. Connect all cylinders. Be sure gasketed cap on cylinder valve fill connection is wrench tight.

7. Complete Field Report No. 4 MP, including marked job drawing, and forward to Cardox Division of Chemetron Corporation, 840 North Michigan Avenue, Chicago, Illinois 60611, ATTENTION: Fire Equipment.

CARDOX fire extinguishing equipment... NO. 4HP

HIGH PRESSURE SYSTEM FIELD TEST REPORT

(Submit separate report for each hazard protected by system)

TEST DATE_____ TIME_____ AM____ PM____ CARDOX JOB No._____

COMPANY_____

LOCATION_____

TEST ENGINEER_____ REPRESENTING_____

OBSERVER TITLE REPRESENTING

_____

_____

_____

_____

HAZARD TESTED_____

INSTALLED PER JOB DRAWING AND SPECIFICATIONS?_____

NO. DETECTORS AND RELEASES: THERMOSTAT_____ HAD_____ SMOKE_____ REMOTE MAN._____ HANDWHEEL_____

NO. TESTED _____ _____ _____ MAN._____

HEAT SOURCE: HOT WATER_____ LAMP_____ IRON_____ OTHER_____

RATE-OF-RISE °F/MIN: A_____ B_____ C_____

VENT RATING: RELEASE _____ MERCURY CHECK_____

VENT TEST, SEC./IN.H_2O _____ _____

PRESSURE RATING _____ _____

PRESSURE TEST, IN. WATER _____ _____

TUBING AND HAD TIGHTNESS_____

CONTROL SYSTEM PRESSURE RECESSION TEST: ROOM TEMP. °F._____ SYSTEM VOLUME (V) _____ CU. IN.

TEST PERIOD (T) _____ HRS. PRESSURE DROP (P) _____ PSIG. LEAKAGE RATE = $\frac{V \times P}{29T}$ = _____ LBS./YR

NO. CYLS. REQUIRED_____ SIZE: 50 LB._____ 75 LB._____ OTHER_____ AIR TEMP. _____°F.

NO. CYLS. DISCHARGED: MAIN BANK RESERVE BANK

PUFF TEST: _____ _____

FULL DISCHARGE: _____ _____

SYSTEM ACTUATED BY_____

DISCHARGE DELAY_____SEC. LIQUID AT NOZZLES_____SECS. AFTER ACTUATION

LIQUID DISCHARGE TIME _____MIN. _____SECS.

NO. ALARMS OPERATED_____

NO. PRESSURE SWITCH SHUTDOWNS: OPERATED FAN_____ PUMP_____ CONVEYOR_____ OTHER_____

NO. PRESSURE RELEASES OPERATED: DAMPER_____ DOOR_____ WINDOW_____ OTHER_____

AFTER TEST -- NOZZLES CLEANED_____ CONTROLS RESET_____ RELEASES RESET_____

FULL CYLINDERS INSTALLED_____

RECHARGED BY_____

ADDRESS_____

C-353-CPC

(Over)

CARDOX

SPECIFICATION
AET/60

HIGH PRESSURE CARBON DIOXIDE FIRE EXTINGUISHING SYSTEM AUTOMATIC ELECTRIC THERMOSTAT RELEASE

I. GENERAL

This specification covers a Cardox "PERFORMANCE-ENGINEERED" carbon dioxide fire extinguishing system designed to be actuated

1. Automatically, by compensated electric thermostat detection and solenoid valve release when the temperature in the hazard reaches the rated setting of the thermostat;
2. Manually, by operation of a remote pneumatic release near the hazard, and
3. Manually, by operation of a handwheel at the cylinder bank.

There are no pull cables, drop weights or other exposed moving parts. Protective enclosures are not required.

II. BASIC COMPONENTS

A. **CYLINDERS** — 50# or 75# capacity alloy steel pressure vessels to ICC specifications, with threaded protective cap, finished red enamel. Pressure seal type valve with forged bronze body and frangible disc safety relief with anti-recoil design. Standard CGA gasketed fill connection with protective cap. Copper siphon tube extends to cylinder bottom to assure liquid discharge.

B. **MANIFOLDS** — Galvanized steel pipe, Schedule 40 to 3/4", Schedule 80 for larger sizes. Galvanized banded malleable iron fittings, 150# to 3/4", 300# to 2". Factory-assembled to assure 10" centers between tees for cylinder connections.

C. **STORAGE RACK** — Black enameled steel framing with formed saddles, brackets and clamps, joined with ca[illegible]-plated hardware to support cylinders, manifolds and other elements. Free standing or wall mount arrange[illegible] to suit installation. Weigh bar and supports included when scale kit specified.

D. **DISCHARGE HEADS** — Pressure-operated type with live swivel union for handtight connection to cylinder valve. Heads on pilot cylinders fitted with "piggy-back" pressure cylinder for automatic or remote manual control, plus pinned handwheel for direct manual release. Dual pilot heads supplied for banks of 3 or more cylinders, one for smaller banks. Forged bronze body. 10:1 operating ratio of piston area to valve seat area.

E. **FLEXIBLE CONNECTORS** — Wire-braided bronze metal hose with full 1/2" bore. 1/2" pipe thread connection. Union joint one end for easy make-up without twist.

F. **HORN NOZZLES** — One piece bronze jet body with 1/2" female pipe thread. No loose orifice plate to be left out. Red enameled spun steel shell attaches with lock nut. 4½" or 6" diameter shell to obtain best discharge. Shell flanged for increased strength and for easy attachment of frangible covers. Flange kit, when specified, permits mounting nozzle on tank or duct wall. Nozzle rating stamped on jet body.

G. **ORIFICE NOZZLES** — Stainless steel body with drilled orifice. 1/2" pipe thread. Used for ducts, cabinets, etc. Stainless steel spring cover to seal out foreign materials added and duct mounting kit supplied when specified. Smaller sizes in brass, with 3/8" flare or 1/4" female pipe connections, include Monel strainer.

III. RELEASES

A. **AUTOMATIC** — Thermostatic switch detectors in hazard are wired to continuously-pressurized solenoid-operated valve at cylinder bank. Normally-open switch contacts close when temperature in hazard reaches rated setting. Solenoid valve opens and releases control pressure to operate pilot discharge heads and cause discharge of system. Control pressure supplied from separate and independent 10# carbon dioxide cylinder through regulator which maintains 300 psig delivery pressure. Steel alloy control cylinder to ICC specifications fitted with handwheel-operated packless valve. Cylinder contents monitored by pressure gauge and high-low pressure switch. 25 psi change in pressure, up or down, closes switch to ring bell, or other specified alarm, to give signal that system needs attention. Solenoid valve resets automatically when thermostats cool.

CARDOX
DIVISION OF CHEMETRON CORPORATION

B. **REMOTE CONTROL** – ICC specification steel alloy cylinder containing 1%# carbon dioxide. Pressure seal type valve connected with 1/4" pipe to pilot discharge heads at cylinder bank. (If system includes automatic release, connection made to same pilot heads as automatic but lines separated by double check, or shuttle valve.) Pull pin and wire seal lock valve lever. Removing pin and depressing lever releases carbon dioxide to pilot heads to cause immediate discharge. Resets automatically when lever released. Entirely independent of automatic release and electric power. No cables, pulleys or weights. No adjustments or equalizing devices.
NOTE: Remote manual station always supplied in automatic release systems unless specifically excluded.

C. **OTHER RELEASES** – Push-button pneumatic or electric remote manual stations can be supplied to suit special conditions. Also, selected sprinkler heads pressurized to 300 psig with carbon dioxide can be used for automatic release under favorable circumstances.

IV. AUXILIARY COMPONENTS

A. **DISCHARGE DELAY** – Panel-mounted forged bronze differential valve connected to steel alloy cylinder accumulator. Stainless steel needle valve standard adjustment of time delay between 5 and 120 seconds. Delays discharge until end of pre-set interval. Resets automatically when automatic release is reset. 1/4" pipe connections. Cover optional. Finished red enamel. Connects into automatic control pressure line between control center and pilot discharge head. Is entirely by-passed by manual releases.

B. **ALARMS** – May be electric or gas-operated to suit installation. 4" bell standard for supervision of automatic control system. Other types used for hazard or discharge warning, depending on noise level and environment. 110-120 V AC standard. DC and explosion-proof supplied when specified.

C. **PRESSURE SWITCHES** – Standard assembly is dual heavy duty double pole single throw tumbler switch in weatherproof conduiet case, finished red enamel. 30 amp. switch elements arranged in pairs of normally-open and normally-closed contacts for alarms and equipment shutdowns. Single piston operates both tumblers. Manual operation included. Manual reset. Explosion-proof assemblies in single or dual double pole single throw version supplied when specified. 1/4" pipe thread pressure inlet connected to discharge piping. If discharge delay included, inlet also connects to automatic control pressure through shuttle valve to assure operation under all conditions.

D. **SHUTTLE VALVE** – Forged bronze tee body with stainless steel shuttle and "O" ring seals forms double check valve. 1/4" female pipe thread connections. Used to isolate sections of pneumatic circuit for selective operation.

E. **PRESSURE RELEASES** – Stainless steel body, piston and spring clip. Clip connects to window, door or damper releasing hardware. 1/2" size supports up to 50#, 1" size up to 100#. Carbon dioxide discharge releases clip, allowing closure to seal opening against excessive loss of gas.

V. RESERVE BANK COMPONENTS

A. **CHECK VALVES** – Through flow types of bronze or plated steel bar stock. Resilient seat for zero leakage. Used in pairs in manifolds to separate main and reserve banks. 1/2" through 2" sizes.

B **BLEEDER VALVE** – Bronze bar stock body with stainless steel ball. 1/2" pipe thread connection seals at 18-20 psig. Vents small back leakage through check valve due to foreign material.

C. **SWITCHING VALVE** – Rotary 4-way valve with ground and lapped seat inserts. Manual lever control to direct automatic control pressure to "MAIN" or "RESERVE" bank. Lever indicates position on nameplate. Locks in position with chained pin and wire seal.

D. **REMOTE MANUAL RELEASE** – Duplicate of release supplied for main bank. Each package includes set of adhesive-backed decals, one each "MAIN" and "RESERVE." One set identifies releases. Other set attaches to manifold sections.

VI. MULTIPLE HAZARD SYSTEM COMPONENTS

A. **SELECTOR VALVES** – Piston-operated globe type valve. Bronze body with screwed ends in sizes to 2". 2:1 operating ratio of piston to valve seat. Valve held open by line pressure on piston when admitted by companion pilot control valve.

B. **PILOT CONTROL VALVE** – Forged bronze valve with 1/4" pipe connections. Fits in branche line between discharge piping and selector valve piston chamber. Pilot actuated by automatic or remote manual control pressure to open valve. Delivery also connected through shuttle valve back to pilot chamber to lock valve open pneumatically until discharge completed and release reset. Pinned handwheel permits manual operation.

RELIEF VALVE – Frangible disc assembly in discharge line ruptures if line pressure exceeds 2,650 psi due to expansion of carbon dioxide trapped between selector valves and manifold. Requires replacement of disc. When specified, self-resetting 1/4" bronze relief valve supplied.

CARDOX

SPECIFICATION
APR/60

HIGH PRESSURE CARBON DIOXIDE
FIRE EXTINGUISHING SYSTEM
AUTOMATIC PNEUMATIC RATE-OF-RISE RELEASE

I. GENERAL

This specification covers a Cardox "PERFORMANCE-ENGINEERED" carbon dioxide fire extinguishing system designed to be actuated

1. Automatically, by a pneumatic rate-of-rise detection and release system when the temperature in the hazard rises faster than a pre-set rate;
2. Manually, by operation of a remote pneumatic release near the hazard, and
3. Manually, by operation of a handwheel at the cylinder bank.

There are no pull cables, drop weights or other exposed moving parts. Protective enclosures are not required.

II. BASIC COMPONENTS

A. **CYLINDERS** – 50# or 75# capacity alloy steel pressure vessels to ICC specifications, with threaded protective cap, finished red enamel. Pressure seal type valve with forged bronze body and frangible disc safety relief with anti-recoil design. Standard CGA gasketed fill connection with protective cap. Copper siphon tube extends to cylinder bottom to assure liquid discharge.

B. **MANIFOLDS** – Galvanized steel pipe, Schedule 40 to 3/4", Schedule 80 for larger sizes. Galvanized banded malleable iron fittings, 150# to 3/4", 300# to 2". Factory assembled to assure 14" centers between tees for cylinder connections.

C. **STORAGE RACK** – Black enameled steel framing with formed saddles, brackets and clamps, joined with cadmium plated hardware to support cylinders, manifolds and other elements. Free standing or wall mount arrangements to suit installation. Weigh bar and supports included when scale kit specified.

D. **DISCHARGE HEADS** – Pressure-operated type with flare swivel union for handtight connection to cylinder valve. Heads on pilot cylinder fitted with "piggy-back" pressure cylinder for automatic or remote manual control, plus pinned handwheel for direct manual release. Dual pilot heads supplied for banks of 3 or more cylinders, one for smaller banks. Forged bronze body. 10:1 operating ratio.

E. **FLEXIBLE CONNECTORS** – Wire-braided bronze metal hose with full 1/2" bore. 1/2" pipe thread connection. Union joint one end for easy make-up without twist.

F. **HORN NOZZLES** – One piece jet body with 1/2" female pipe thread. No loose orifice plate to be left out. Red enameled spun steel shell attaches with lock nut. 4½" or 6" diameter shell to obtain best discharge. Shell flanged for increased strength and for easy attachment of frangible covers. Flange kit, when specified, permits mounting nozzle on tank as close wall. Nozzle-rating stamped on jet body.

G. **ORIFICE NOZZLES** – Stainless steel body with drilled orifice. 1/2" pipe thread. Used for ducts, cabinets, etc. Stainless steel spring cover to seal out foreign material added and duct mounting kit supplied when specified. Smaller sizes in brass, with 3/8" flare or 1/4" female pipe connections, include Monel strainer.

III. RELEASE

A. **AUTOMATIC** – Red-enameled brass bulb heat-actuated devices (HAD) in hazard are connected with small bore tubing to diaphragm-operated release mechanism at cylinder bank. Absorbed heat increases pressure of air in HAD bulb. Gradual pressure changes relieved through calibrated compensating vent in release base. Rapid pressure increase trips release to open valve and direct control pressure to operate pilot discharge heads and cause discharge of system. Control pressure supplied from separate and independent 10# carbon dioxide cylinder through regulator which maintains 300 psig delivery pressure. Steel alloy control cylinder to ICC specifications fitted with handwheel-operated packless valve. Cylinder contents monitored by pressure gauge and high-low pressure switch, 25 psi change in pressure, up or down, closes switch to ring bell, or other specified alarm, to give signal system needs attention. Manual reset of release restores automatic control system.

C-259 CPC

CARDOX

DIVISION OF CHEMETRON

B. REMOTE MANUAL – ICC specification steel alloy cylinder containing 1%# carbon dioxide. Pressure seal type valve connected with 1/4" pipe to pilot discharge heads at cylinder bank. (If system includes automatic release, connection made to same pilot heads as automatic but lines separated by double check, or shuttle valve.) Pull pin and wire seal lock valve lever. Removing pin and depressing lever releases carbon dioxide to pilot heads to cause immediate discharge. Resets automatically when lever released, entirely independent of automatic release and electric power. No cables, pulleys or weights. No adjustments or equalizing devices.
NOTE: Remote manual station [illegible] supplied to automatic release systems unless specifically excluded.

C. OTHER RELEASES – Push-button pneumatic or electric remote manual stations can be supplied to suit special conditions. Also, selected sprinkler heads pressurized to 300 psig with carbon dioxide can be used for automatic release under favorable circumstances.

IV. AUXILIARY COMPONENTS

A. DISCHARGE DELAY – Panel-mounted forged bronze differential valve connected to steel alloy cylinder accumulator. Stainless steel needle valve standard adjustment of time delay between 5 and 120 seconds. Delays discharge until end of pre-set interval. Resets automatically when automatic release is reset. 1/4" pipe connections. Cover optional. Finished red enamel. Connects into automatic control pressure line between control center and pilot discharge head. Is entirely by-passed by manual releases.

B. ALARMS – May be electric or gas-operated to suit installation. 4" bell [illegible] for supervision of automatic control system. Other types used for hazard or discharge warning, depending on noise level and environment. 110-120 V AC standard. DC and explosion-proof supplied when specified.

C. PRESSURE SWITCHES – Standard assembly is dual heavy duty double pole single throw tumbler switch in weatherproof conduit case, finished red enamel. 30 amp. switch shipments arranged in pairs of normally open and normally-closed contacts for alarms and equipment shut downs. Single piston operates both tumblers. Manual operation included. Manual reset. Explosion-proof assemblies in single or dual double pole single throw version supplied when specified. 1/4" pipe thread pressure inlet connected to discharge piping. If discharge delay included, inlet also connects to automatic control pressure through shuttle valve to assure operation under all conditions.

D. SHUTTLE VALVE – Forged bronze two body with stainless steel shuttle and "O" ring seals forms double check valve. 1/4" female pipe thread connections. Used to isolate sections of pneumatic circuit for selective operation.

E. PRESSURE RELEASE – Stainless steel body, piston and spring clip. Clip connects to window, door or damper releasing hardware. 1/2" size supports up to 50#, 1" size up to 100#. Carbon dioxide discharge releases clip, allowing closure to seal opening against excessive loss of gas.

V. [illegible] TANK COMPONENTS

A. CHECK VALVES – Through flow type of bronze or plated steel bar stock. Resilient seat for zero leakage. Used in pairs in manifolds to separate main and reserve banks. 1/2" through 2" series.

B. BLEEDER VALVE – Bronze bar stock body with stainless steel ball. 1/2" thread connection seals at 18-20 psig. Vents small back leakage through check valve due to foreign material.

C. SWITCHING VALVE – Rotary 4-way valve with ground and lapped seat inserts. Manual level control to direct automatic control pressure to "MAIN" or "RESERVE" bank. Lever indicates position on nameplate. Locks in position with chained pin and wire seal.

D. REMOTE MANUAL RELEASE – Duplicate of release supplied for main bank. Each package includes set of adhesive-backed decals, on each "MAIN" and "RESERVE." One set identifies releases. Other sets attaches to manifold sections.

VI. MULTIPLE HAZARD SYSTEM COMPONENTS

A SELECTOR VALVES – Piston-operated globe type valve. Bronze body with screwed ends in sizes to 2". 2:1 operating ratio of piston to valve seat. Valve held open by line pressure on piston when admitted by companion pilot control valve.

B. PILOT CONTROL VALVE – Forged bronze valve with 1/4" pipe connections. Fits in branch line between discharge piping and selector valve piston chamber. Pilot actuated by automatic or remote manual control pressure to open valve. Delivery also connected through shuttle valve back to pilot chamber to lock valve open pneumatically until discharge completed and release reset. Pinned handwheel permits manual operation.

RELIEF VALVE – Frangible disc assembly in discharge line ruptures if line pressure exceeds 2,650 psi due to expansion of carbon dioxide trapped between selector valves and manifold. Requires replacement of disc. When specified, self-resetting 1/4" bronze relief valve supplied.

TESTING OF THE SWITCHGEAR ROOM/CABLE VAULT CO_2 SUPPRESSION
(PDCR 79-6)

1. Purpose

To delineate the precautions, prerequisites, and requirements for the testing of the Switchgear Room/Cable Vault CO_2 Suppression System.

2. Discussion

The existing carbon dioxide system located in the cable vault and the new carbon dioxide system to be installed in the Switchgear Room are designed to suppress a deep-seated cable fire. The Switchgear Room CO_2 System will also serve as a manually operated backup (or second shot) for the cable vault.

Both systems are fully automatic and operate in similar manners. Both systems incorporate a Counting Zone Module CZ-30. Upon the receipt of each of three successive alarms, an output signal is sent from the module to initiate a pre-programmed, sequential emergency response function. The first detector alarm will provide alarm signals at the main and local Pyrotronics panel. The second detector alarm will close all associated fire dampers and secure room exhaust fans. The third detector alarm will initiate the CO_2 system, following a 30-second alarm and evacuation time delay. Indication will also be provided at the main and local pyrotronics panel that the system has been activated.

3. References

a. PO's 12849, 12850

b. PDCR 79-6, Switchgear Room/Cable Vault CO_2 Suppression

c. Consumer Fire & Safety Drawings & Operating Manual

d. Pyrotronics Drawings & Operating Manual

e. Cardox Operation and Service Manual

f. CWD's 587, 1362, 1366, 1506, 1517, 1587 & 1587A

4. Apparatus

a. Volt-Ohm Meter

b. Megger

c. Detector (ionization checker)

d. Tools (as required)

5. **Prerequisites**

		Verified By	Date
a.	Installation Procedure for PDCR 79-6 complete except as noted in the I&T Procedure	[illegible]	7/[illegible]/80
b.	Shift Supervisor notified prior to start of testing	[illegible]	7/[illegible]/80
c.	Circuits checked for shorts and grounds	[illegible]	7/[illegible]/80
d.	Automatic solenoid valves electrically disconnected from CO_2 Systems	[illegible]	7/[illegible]/80
e.	Power to panels connected and energized by authority of Pyrotronic's Field Eng. only	[illegible]	7/[illegible]/80
f.	Warning signs have been posted	[illegible]	7/[illegible]/80
g.	All cable penetrations sealed in accordance with PDCR 79-05	[illegible]	7/[illegible]/80
h.	Manual switches are in NORMAL positions	[illegible]	7/[illegible]/80
i.	All wires to Dampers in Switchgear Room and Cable Vault Room and the CO_2 Solenoid Valves must be disconnected	[illegible]	7/[illegible]/80

6. **Precautions**

a. Caution shall be exercised to prevent the accidental discharge of either CO_2 System

b. Cylinders are to remain disconnected for all testing addressed by this procedure

NOTE: A functional test of the Switchgear Room will be provided by a separate test procedure.

7.0 Test Procedure

A. **Cable Vault**

1.	Wires checked for continuity and meggered	[illegible]	7/[illegible]/80
2.	Check all detectors and record information on Attachment A	[illegible]	7/[illegible]/80
3.	Simulate a fire condition on a first detector	[illegible]	7/[illegible]/80
	a. Verify local panel goes into alarm	[illegible]	7/[illegible]/80

4.	Simulate a fire condition on a second detector	SM	2/11/60
	a. Verify exhaust fan (SEF-3) shuts down	SM	2/11/60
	b. Verify receipt of 24 VDC Signal at the following ETL leads:		
	Cable Vault/Computer Room dampers (2)	SM	2/11/60
	Exhaust Fan (SEF-3) damper	SM	2/11/60
	Battery Room/Cable Vault Dampers (3)	SM	2/11/60
	c. Main and local panels remain in alarm	SM	2/11/60
5.*	Simulate a fire condition on a third detector		
	a.c Main Panel alarms for CO_2 discharge	Ejm	2/21/60
	b.b Cardox System receives signal to operate	Ejm	2/21/60
	c.c Local alarms trip (audio & visual)	Ejm	2/21/60
	d.d Following 30-second evacuation delay, CARDOX System trip signal is at solenoid	Ejm	2/21/60
6.	Clear all alarms and reset Pyrotronics Control Panel	Ejm	2/21/60
7.	Place manual switch in INITIATE Position and verify steps 3, 4, & 5 take place	Ejm	2/21/60
8.	Return switch to NORMAL Position and repeat step 6	Ejm	2/21/60
9.	Repeat steps 3 & 4	Ejm	2/21/60
10.	Place manual switch in ABORT Position	Ejm	2/21/60
11.	Simulate a fire condition on a third detector and verify system does not trip	Ejm	2/21/60
12.	Return manual switch to NORMAL Position and repeat step 6	SM	2/21/60
13	Inform Shift Supervisor that testing in the Cable Vault Area is complete	[illegible]	2/21/60

* System was required to initiate the 5.c CO2 after a 2nd smoke response per the ARC Ejm Minor change 2/21/60

110

B. Switchgear Room

1. Wires checked for continuity and megered

2. Check all detectors and record information on Attachment B

3. Simulate a fire condition on a first detector

   a. Verify local panel goes into alarm

   b. Verify main panel goes into alarm

4. Simulate a fire condition on a second detector

   a. Verify exhaust fan shuts down

   b. Verify receipt of 24 VDC Signal at the damper EIL leads

   c. Main and local panels remain in alarm

5. * Simulate a fire condition on a third detector

   a. Main Panel alarms for CO_2 discharge

   b. CO_2 System receives signal to operate

   c. Local alarms trip (audio & visual)

   d. Thirty second evacuation time delay times out and trip signal initiated

6. Clear all alarms and reset Pyrotronics Control Panel

7. Place manual switch in INITIATE Position and verify steps 3, 4, & 5 take place

8. Return switch to NORMAL Position and repeat step 6

* System was required to initiate the CO_2 with a 2nd detector response per the P.R.

Minor 2/21/80

9. Repeat steps 3 & 4 — EJM 12/3/80

10. Place manual switch in ABORT Position # 22 — SJR 12/2/80

11. Simulate a fire condition on a third detector and verify system does not trip — SJR 12/2/80

12. Return manual switch to NORMAL Position and repeat step 6 — EJM 12/3/80

C. 1. Actuate selector switch for second shot to Cable VAult — SJR 12/2/80

2. a. Local and Main Panels go into alarm — SJR 12/2/80

b. Local alarm (audio and visual) trip — SJR 12/2/80

c. Cable Vault Exhaust fan trips — SJR 12/2/80

d. Isolation dampers ETL's receive signal — SJR 12/2/80

e. Switchgear Directional Valve to Cable Vault trips after 30-second evacuation time delay — SJR 12/2/80

3. Clear all alarms and reset Pyrotronics Control Panel — SJR 12/2/80

8. Acceptance Criteria

a. All detectors function properly — SJR 12/2/80

b. All modules in the Pyrotronics Panels operated properly — SJR 12/2/80

c. Systems operated according to intended design — SJR 12/2/80

9. Final Conditions

a. Control Heads and Directional Valves and Dampers connected to control systems — SJR 12/2/80

b. Systems energized in operating mode — SJR 12/2/80

c. Shift Supervisor notified that CO_2 Systems are operable — SJR 12/2/80

1/2

10. **Evaluation**

An acceptance review of the completed test results by the cognizant individuals shall be performed

11. **Data**

Attached

Prepared By Dennis C Brian Date 10/4/79

Reviewed for OQA Hold Points [illegible] Date 10/8/79

ESS Review [illegible] Date [illegible]

Implementing Dept. Head [illegible] Date [illegible]

PORC [illegible] Date 10/12/79

Plant Superintendent W Kenney Date 10/19/79

193

DIVISION OF GRINNELL CORPORATION

High Pressure Carbon Dioxide Flow Calculations

SYSTEM FOR VERMONT YANKEE NUCLEAR STATION (Last name)

BRATTLEBORO (location), VERMONT

HAZARD 33 125 EL 3 CABLE VAULT

(combustible material)

DRAWING NO.

CALC. SHEET 1 OF 2

BY C.N.G DATE 1-2-

PROPOSAL NO. 12ML-1652

JOB NO. EH-16547

INSURANCE REF. NO.

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 2800 lbs. CO_2				
Minimum flow rate to achieve ____ % within ____ minutes				
Discharge Period, Design Flow Rate and Storage (NOTE: Design Flow Rate must equal or exceed minimum flow rate)	200	840		2800
LOCAL APPLICATION (LA)				
Minimum effective discharge period - 30 seconds				
Plus high temperature condition				
Plus other				
Effective Discharge Period and Design Flow Rate				
Plus 40% for High Pressure System Storage		1.40		
COMBINED LOCAL APPLICATION & TOTAL FLOODING (From LA and TF figures above)				
Local Application				
Total Flood ____ lbs. CO_2 x .7 = ____ lbs. CO_2 within				
Effetive Discharge Period and Design Flow Rate				
EXTENDED DISCHARGE				
Initial Discharge Period and Design Flow Rate				
Extended Discharge Period and Design Flow Rate				
FINAL DISCHARGE PERIOD, DESIGN FLOW RATE AND STORAGE	200	840		2800

HAZARD REQUIRES 29 - 100 lb. Cylinders (2800 lbs. CO_2) for MAIN BANK

and ____ - ____ lb. Cylinders (____ lbs. CO_2) for RESERVE BANK

REMARKS: ____

CARDOX
DIVISION OF CHEMETRON CORPORATION

CALC. SHEET ___ OF ___
BY C.N.G DATE 9-2-7.

FOR VERMONT YANKEE NUCLEAR STATION BRATTLEBORO, VERMONT (plant name / location) PROPOSAL NO. 12HL-1033'/120° E

TO 34128 Ft³ CABLE VAULT JOB NO. EH-16547

PO NO. ___ INSURANCE REF. NO. ___

HAZARD COMPONENTS (dimensions)	Nozzle Identification	TOTAL FLOODING (TF) Volume (cu. ft.)	TF CO_2 Factor (lb./cu. ft.)	TF CO_2 Req'd (pounds)	LOCAL APPLICATION (LA) Rate By Volume: Theoretical Volume (cu. ft.)	LA Rate By Volume: CO_2 Factor (lb./cu. ft. per min.)	LA Rate By Area: Dist. From Surf. (in. ft.) Liquid	LA Rate By Area: Dist. From Surf. (in. ft.) Coated	LA Rate By Area: Design Area (sq. ft.)	NOZZLE DATA: Design Flow Rate (lb./min.)	Terminal PSIA	Req'd Code No.	Act. Code No.	Nozzle Type
CABLE VAULT PROOF	N1	34128	0.083	2500						120	723	6.3	6.0	W.A.
	N2									120	718	6.5	7.0	"
	N3									120	726	6.3	6.0	"
	N4									120	720	6.0	6.0	"
	N5									120	716	6.5	7.0	"
	N6									120	725	6.7	7.0	"
	N7									120	724	6.75	7.0	W.A.

SYSTEM FOR VERMONT YANKEE NUCLEAR STATION (plant name) "BRATTLEBORO" VERMONT (location) BY [illegible] DATE [illegible]

PROPOSAL NO. [illegible]

HAZARD 34138 FC3 CABLE VAULT JOB NO. EH-16547

DRAWING NO. INSURANCE REF NO.

PIPE SECTION	CYL. MAN	CYL - a.	a - A1	A1 - A2
PIPE SIZE / SCHED		1 1/2 / 80	1" / 80	3/4 / [illegible]
actual length		5.0	12.0	13
tee		1 tee Side 8.7	1 tee Side 5.7	1 tee Side 5.[illegible]
ell		1 ell 4.3	2 ell 5.6	
union or cplg				
valve				
		2 tee thru 5.4		
SECTION LENGTH		23.4	23.3	17.[illegible]
FLOW RATE	30	840	240	120
START PSIA	750	743	732	728
START LENGTH		15	45	122
TOTAL EQUIV LENGTH	111	38	68	[illegible]
TERMINAL PSIA	743	732	723	718

PIPE SECTION	a - N3	N3 - N4	A3 - A4	A5 - A6
PIPE SIZE / SCHED	1 1/4 / 80	1 1/4 / 80	1 1/4 / 40	1" / [illegible]
actual length	4.0	8.0	8.0	13
tee	1 tee Side 7.5	1 tee Side 7.5	1 tee Side 7.5	1 tee Side [illegible]
ell				
union or cplg				
valve				
SECTION LENGTH	11.5	15.5	15.5	18.[illegible]
FLOW RATE	600	450	360	230
START PSIA	732	726	720	716
START LENGTH	33	69	153	8[illegible]
TOTAL EQUIV LENGTH	44	54	168	1[illegible]
TERMINAL PSIA	726	720	716	708

PIPE SECTION	N6 - N7			
PIPE SIZE / SCHED	3/4 / 40			
actual length	13			
tee	1 tee Side 4.5			
ell				
union or cplg				
valve				
SECTION LENGTH	17.5			
FLOW RATE	120			
START PSIA	708			
START LENGTH	180			
TOTAL EQUIV LENGTH	197			
TERMINAL PSIA	7[illegible]			

PIPE SECTION				
PIPE SIZE / SCHED				
actual length				
tee				
ell				
union or cplg				
valve				
SECTION LENGTH				
FLOW RATE				
START PSIA				
START LENGTH				
TOTAL EQUIV LENGTH				
TERMINAL PSIA				

DRAFT DW 0171
Response Due 6/1

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
475 ALLENDALE ROAD
KING OF PRUSSIA, PENNSYLVANIA 19406

MAY 18 1989

Docket No. 50-271

RECEIVED
MAY 26 1989
W. P. MURPHY

Vermont Yankee Nuclear Power Corporation
ATTN: Mr. Warren P. Murphy
Vice President and Manager
of Operations
RD 5, Box 169
Ferry Road
Brattleboro, Vermont 05301

Gentlemen:

Subject: Inspection Report No. 50-271/89-04

This letter refers to the routine safety inspection of your Fire Protection Program conducted by Mr. A. Krasopoulos of this office on March 20 - March 23, 1989 at the Vermont Yankee Nuclear Station, Vernon, Vermont. Mr. Krasopoulos discussed the findings of the inspection with Mr. J. Pelletier at the conclusion of the inspection. The findings of the inspection were further discussed in a telephone conversation between Dr. W. Johnston of NRC Region I and Mr. R. Pagodin of your staff on April 21, 1989.

Areas examined during this inspection are described in the NRC Region I Inspection Report which is enclosed with this letter. Within these areas, the inspection consisted of a selective review of procedures and records, interviews with personnel, and observations made by the inspector.

Based on the results of this inspection, it appears that one of your activities was not conducted in full compliance with NRC requirements, as set forth in the Notice of Violation, enclosed herewith as Appendix A. The violation has been categorized by severity level in accordance with the "General Statement of Policy and Procedure for NRC Enforcement Actions," 10 CFR Part 2, Appendix C. You are required to respond to this letter within 30 days and in preparing your response, you should follow the instructions in Appendix A. This violation refers to the operability of the carbon dioxide suppression systems in the cable vault and in the diesel fire pump day tank room.

The responses directed by this letter and the accompanying Notice are not subject to the clearance procedures of the Office of Management and Budget as required by the Paperwork Reduction Act of 1980, PL 96-511.

8906010206 2pp

Your cooperation with us in this matter is appreciated.

Sincerely,

Thomas T. Martin, Director
Division of Reactor Safety

Enclosures:
1. Appendix A, Notice of Violation
2. NRC Region I Inspection Report Number 50-271/89-04

cc: w/encl:
J. Weigand, President and Chief Executive Officer
J. Pelletier, Plant Manager
J. DeVincentis, Vice President, Yankee Atomic Electric Company
R. Capstick, Licensing Engineer, Yankee Atomic Electric Company
J. Gilroy, Director, Vermont Public Interest Research Group, Inc.
G. Sterzinger, Commissioner, Vermont Department of Public Service
P. Agnes, Assistant Secretary of Public Safety, Commonwealth of Massachusetts
Public Document Room (PDR)
Local Public Document Room (LPDR)
Nuclear Safety Information Center (NSIC)
NRC Resident Inspector
State of New Hampshire
State of Vermont
Commonwealth of Massachusetts

APPENDIX A

NOTICE OF VIOLATION

Vermont Yankee Nuclear Power Corp.
Vermont Yankee Nuclear Station

Docket No. 50-271
License No. DPR-28

As a result of the inspection conducted on March 20-23, 1989, and in accordance with the "General Statement of Policy and Procedure for NRC Enforcement Actions", 10 CFR Part 2, Appendix C (Enforcement Policy 1989) the following violation was identified:

Technical Specification 3.13.D requires that the carbon dioxide fire suppression (CO_2) systems located in the cable vault and diesel fire pump day tank room shall be operable whenever equipment in the area protected by the systems is required to be operable. The technical specifications require a continuous fire watch if the CO_2 system in the cable vault is inoperable and an hourly fire watch if the CO_2 system in the fire pump day tank room is inoperable.

LAI 083

In a letter to NRC dated January 31, 1977, the licensee stated that the carbon dioxide systems at Vermont Yankee were designed to meet the requirements of the 1977 National Fire Protection Association (NFPA) Standard 12. NFPA Standard 12 Section 1-7.3 specifies that the installed carbon dioxide systems shall be tested and the tests performed shall be adequate to determine that the system has been properly installed and will function as intended. The CO_2 systems are designed to achieve a 50 percent concentration. In the cable vault, this concentration must be maintained for ten minutes.

Contrary to the above, as of April 21, 1989, the CO_2 systems in the cable vault and in the diesel fire pump day tank room had not been demonstrated to be operable, in that no tests had been performed of their capability to reach and maintain design concentrations of CO_2, and the appropriate fire watches had not been implemented.

This is a Severity Level IV Violation (Supplement I)

Pursuant to 10 CFR 2.201, Vermont Yankee Nuclear Power Corp. is hereby required to submit to this office, within 30 days of the date of the letter transmitting this Notice, a written statement or explanation in reply, including: (1) The reasons for the violations; (2) the corrective steps which have been taken and the results achieved; (3) corrective steps which will be taken to avoid further violations; and (4) the date when full compliance will be achieved. Where good cause is shown, consideration will be given to extending this response time.

INS 3704C
EGD1 1 C1

8906010217 1p.

U.S. NUCLEAR REGULATORY COMMISSION
REGION I

Report No. 50-271/89-04

Docket No. 50-271

License No. DPR-28

Licensee: Vermont Yankee Nuclear Power Corporation
RD 5, Box 169
Ferry Road
Brattleboro, Vermont 05301

Facility Name: Vermont Yankee Nuclear Power Corporation

Inspection At: Vernon, Vermont

Inspection Conducted: March 20-23, 1989

Inspectors: C. J. Anderson for
A. Krasopoulos, Reactor Engineer — 5/17/89 date

C. J. Anderson for
R. Mathews, Reactor Engineer — 5/17/89 date

Approved by: C. J. Anderson
C. J. Anderson, Chief, Plant Systems Section — 5/17/89 date

Inspection Summary: Inspection on March 20-23, 1989 (Report No. 50-271/89-04)

Areas Inspected: This routine unannounced inspection reviewed the adequacy and implementation of the licensee's Fire Protection Program. The inspection included reviews of the following program aspects: combustible material control, housekeeping conditions, surveillances and testing performed on fire suppression and detection equipment, and fire brigade training. Also, a walkdown of fire suppression systems, in particular the carbon dioxide suppression systems in the cable vault and switchgear rooms, was performed.

Results: The inspector identified a violation regarding operability of the carbon dioxide system in the cable spreading room. Following this inspection, the NRC resident inspector identified a similar violation regarding the operability of the carbon dioxide system in the diesel fire pump day tank room. The operability of these systems was not demonstrated during performance of the initial acceptance tests for these systems. Additional concerns were identified regarding housekeeping conditions, in particular the practice of erecting combustible structures adjacent to safety related buildings, and the depth of engineering involvement in issues affecting the Fire Protection Program.

DETAILS

1.0 Persons Contacted

Vermont Yankee Nuclear Power Corporation (VY)

*J. Pelletier, Plant Manager
*R. Pagodin, Technical Services Superintendent
*D. Girroir, Sr. Quality Assurance (QA) Engineer
E. Taintor, QA Coordinator/Fire Protection Coordinator
*R. Wanchyk, Operations Superintendent
*R. Moschella, Electrical Engineer
P. Johnson, Electrical Engineer
*R. Grippardi, QA Supervisor
*H. Mettell, Engineering Support Supervisor

United States Nuclear Regulatory Commission (NRC)

G. Grant, Sr. Resident Inspector

*Denotes those present at the exit meeting.

2.0 Followup of Previous Inspection Findings

(Closed) Violation (88-04-01) Lack of Emergency Lights in the Control Room, Torus Catwalk and Fire Area FA-RB-5

The NRC identified the violation of 10 CFR 50 Appendix R, Section III.J in that emergency lights were not installed in the above areas.

The licensee installed emergency lighting units in the Control Room prior to the NRC team leaving the site. For the Catwalk area the licensee requested an exemption from the requirement because the area contains lighting units powered from the Emergency Diesels. The NRC granted that exemption. Fire Area RB-5 was re-examined by the licensee by turning off all lights in the area to determine the illumination levels provided by the existing emergency lighting. The illumination was found to be adequate. The above actions satisfy the NRC concerns and this item is closed.

(Open) Unresolved Item (88-04-02) Fire Stops in Reactor Building

The NRC identified the concern that the fire stops installed to provide fire break zones were inadequately installed. These stops were installed in 5 to 7 foot strips on both sides of each fire break area. The correct way of installing the fire stops would be to install the fire retardant thru the entire length of the fire break. The licensee committed to have the fire stops installed at the first opportunity. The licensee stated that they were unable to complete the engineering work associated with the fire stops, therefore, the fire stops will not be installed during this

outage. The engineering work involves an evaluation of the electrical tray seismic supports to assess the impact of the additional weight from the fire retardant. This modification will be completed by the end of 1989 calendar year. The licensee, meanwhile, has in place, roving fire watches.

(Closed) Unresolved Item (88-04-03) Circuit Coordination

During the circuit coordination review of the Appendix R program, the NRC team observed that coordination curves and analyses for the 120V AC and 125V DC circuits were not available. The licensee acknowledged the coordination and documentation concerns and committed to finalize the analyses.

The analyses were completed and the inspector verified the time-current characteristic curves for the 120VAC and 120VDC circuits. The breakers are adequately coordinated except for the breaker of valve V10-17 operator. This valve is used for containment isolation in series with valve V10-18. One of these valves would remain closed because power cables for V10-17 and V10-18 are routed through different fire areas, therefore, a single fire could not disable both valves. The inspector had no further questions. This item is closed.

(Closed) Unresolved Item (88-04-04) High Impedance Fault

The NRC team identified that the analysis of the effect of high impedance faults on all electrical power sources required for safe shutdown was incomplete. The licensee completed this analysis and the inspector reviewed it with regard to fault conditions, assumptions for analysis, breaker set points and safe shutdown operability for 120V AC, 125V DC and 480V AC circuits. The documentation concerning high impedance fault analysis has been completed. Based on this review, the inspector concluded that there is no high impedance fault concern and the safe shutdown load power supplies are adequately protected.

(Closed) Unresolved Item (88-04-05) Inadequate Fuse Protection

The NRC inspection team conducted a review of the common enclosure associated circuit concern to determine the adequacy of the electrical isolation protection. The team observed that 12 AWG conductors were protected with 35 Amp fuses instead of the required 30 Amp fuses. The inspectors reviewed the licensee analysis of the above concern. The 12 AWG conductors identified are cross-linked polyethylene insulated cables rated at 90°C continuous full load operation. The emergency overload rating for this type of cable is 40 Amp at 130°C up to 100 hours, which is still above the rating of the protective fuses. Based on the discussion with

the licensee's staff and review of the licensee's analysis, the inspector concluded that the 35 Amp fuses are adequate to protect the 12 AWG conductor cables. This item is resolved.

3.0 Controls of Combustibles and Ignition Sources

The licensee has in place procedures that control the introduction of combustibles and flammables in safety-related areas. The licensee also has procedures that control the use of ignition sources such as from welding, cutting or grinding operations.

The plant inspection by the inspector did not identify any unacceptable conditions.

4.0 Equipment Maintenance Inspection and Tests

The inspector reviewed several surveillance and testing procedures to determine whether the licensee has developed an adequate surveillance and maintenance program that assures the functionality/operability of the fire protection equipment.

In addition, the inspector reviewed test records to verify compliance with applicable Technical Specification (TS) requirements. A violation was identified as follows:

The inspector reviewed the carbon dioxide (CO_2) systems installed in the cable vault, switchgear and diesel fire pump day tank rooms to verify that each system is capable of performing its required function.

This review involved a system walk-down and a review of the test and surveillance procedures established to assure system operability. The applicable licensing requirements also were reviewed.

Licensing Requirements

The CO_2 systems are required by License Condition 3.F which states that an automatic CO_2 system be provided in the cable spreading room (also referred to as the cable vault), the switchgear room and the diesel fire pump day tank room. The CO_2 systems listed above are required to be operable by Technical Specification 3.13.D.

The licensee in a letter to NRC dated January 31, 1977 from J. French to V. Stello committed to abide by the 1977 National Fire Protection Association Standard No. 12 (NFPA 12). This letter specifically states that the CO_2 system in use at Vermont Yankee was designed to meet the requirements of NFPA 12. NFPA 12 is the guide for the design and installation of CO_2 systems. Section 1-7.3 of this standard specifies that the completed system shall be tested to determine that the system will function as intended. The NRC has adopted the recommendations of NFPA 12. This is stipulated in Appendix A to Branch Technical Position 9.5-1.

The CO2 system design was reviewed by the NRC and was discussed in an NRC Safety Evaluation (SE), supporting License Amendment 43, dated January 13, 1978. The SE states that the design of the CO2 system is acceptable because it can provide 50% concentration in the cable vault and maintain this concentration for ten minutes.

The CO2 concentration and duration of concentration mentioned above are required for the effective extinguishment of deep seated fires that could occur if a fire started in areas such as the cable vault housing electrical equipment.

Procedure and Records Review

The inspector reviewed the procedures which ensure that if a fire occurs in the areas protected by CO2 the proper alarms would activate, the ventilation dampers would close and the system would discharge. The licensee also has procedures verifying that the design quantity of CO2 is available at all times. The review of these procedures did not identify any unacceptable conditions.

The inspector reviewed the CO2 system acceptance test records to verify that the system can deliver the 50% of CO2 concentration for 10 minutes. The licensee presented to the inspector the test results of the full discharge test conducted in the switchgear room. The licensee could not locate the records for tests for the other areas. However, they committed to search for the test records for these areas. The inspector indicated to the licensee that if these tests were not performed, the system operability must be verified by a test.

Regarding the switchgear room test, the licensee indicated that this test identified a condition where the concentration was not maintained at 50% for the entire 10 minutes in some locations of the switchgear room (high in the ceiling). On the advise of their vendor they made system modifications to improve the mixing of the CO2 so that this problem could be eliminated. The modifications included an adjustment to the discharge valve timing to slow CO2 injection. They also made provisions for the ventilation dampers to stay open for five minutes to address room over-pressurization concerns and improve mixing of the CO2 in the room.

The NRC on April 21, 1989 informed the licensee via telephone that since the CO2 test records for the cable vault and the diesel fire pump day tank rooms had not been found and since inadequate evidence exists to verify that the system would function as intended, the system must be assumed inoperable and the compensatory measures specified in the Technical Specifications be placed in effect. As a result of that call the licensee committed to declare the system

inoperable and establish fire watches in accordance with the Technical Specifications. Since compensatory measures for an inoperable CO_2 system were not in effect when this deficiency was identified by the NRC, this was a violation of the Technical Specifications (Violation 89-04-01).

5.0 Quality Assurance (QA) Audit Review

The inspector reviewed the QA audits of the Fire Protection Program. The audits were found to be thorough. Audit finding were adequately resolved. No unacceptable conditions were identified.

6.0 Fire Protection Engineering and Modifications

The inspector observed activities that affect the Fire Protection and noted the following:

1. The fire annunciator panel is located in the Security Room (SAS) within the control room. The security monitoring panel that was recently installed was placed right up to the Fire Panel making panel surveillance and testing difficult.

2. The licensee did not complete the work of the fire stops mentioned in Section 2 of this report. The need for these fire stops was identified in February 1988. The licensee must now erect scaffolds and do the modification work in the Reactor Building when the plant is at power.

3. The NRC, during the Appendix R inspection, could not verify the adequacy of the communication system because using walkie-talkie radios in some plant areas could adversely effect the plant. Walkie-talkies would be used for communications to shutdown the plant from outside the Control Room if a fire forced Control Room evacuation. The licensee committed to determine plant conditions for which use of the communication system is acceptable. The licensee reviewed the communications system and determined that the system would not perform adequately in certain areas. The licensee corrected the problem by installing an antenna to enhance the radio signal. The corrective actions are adequate.

The above items are examples where the engineering group did not perform a thorough job in the Fire Protection Area.

7.0 Fire Brigade Training

7.1 Procedure Review

The inspector reviewed the fire Brigade Training program to verify that this program includes:

a. Requirements for announced and unannounced drills;

b. Requirement for fire brigade training and retraining at prescribed frequencies;

c. Requirements for at least one drill per year to be performed on a "back shift" for each brigade;

d. Requirements for maintenance of training records.

No unacceptable conditions were identified.

7.2 Records Review

The inspector reviewed training records of fire brigade members for calendar years 1988 and 1989 to ascertain that they had attended the required quarterly training and participated in a quarterly drill, and received the annual hands-on fire extinguishment practice. The inspector noted that all fire fighters have received the required training.

However, the inspector observed that the licensee's procedures allow prospective fire brigade members to be on the fire brigade without the initial hands-on fire fighting practice. The concern is that personnel without firefighting experience can be a member of the brigade. The licensee explained that the initial "live" fire fighting training usually takes place during the warm weather months. The inspector verified that the licensee makes every effort to quickly qualify new fire fighters. This effort even includes sending some of them to fire Academies as far away as Texas, but the procedures still allow membership in fire brigade without that training. At the time of the inspection, every member of the brigade had this training. The licensee was told of the concern and they committed to review it. This in an unresolved item. (89-04-02). The inspector also noted that the licensee's record-keeping in this area can be improved. The licensee's staff had a problem locating the required records but ultimately the records were found. TSP 1

8.0 Facility Tour

The inspector examined fire protection water systems, including fire pumps, fire water piping and distribution systems, post indicator valves, hydrants and contents of hose houses. The inspector toured accessible vital and nonvital plant areas and examined fire detection and alarm systems, automatic and manual fixed suppression systems, interior hose stations, fire barrier penetration seals, and fire doors. The inspector observed general plant housekeeping conditions and randomly checked tags of portable extinguishers for evidence of periodic inspections. No deterioration of equipment was noted. The inspection tags attached to extinguishers indicated that monthly inspections were performed.

No unacceptable conditions were identified. However, the inspector observed the following conditions requiring resolution by the licensee:

Housekeeping/Hazard Control

The inspector observed that the licensee installed large wooden structures outside but next to the Reactor Building. These structures although temporary have been there for more than a year. A fire in these structures could affect the plant. The structures have no smoking signs but the inspector observed cigarette butts on the floor.

PSV1 (CAT. B)

The inspector also observed the licensee's practice of storing combustible trash next to the training building. The inspectors observed a large pile of wooden pallets and other combustible trash stored near the building. The inspector expressed the concern that a cigarette from passers-by could ignite these combustibles.

Within the Control Room, the inspectors observed that spare breathing air bottles were stored on the floor. The inspector noted that these bottles represent a missile hazard to people and equipment.

Penetration Review

ESD1

The inspector while in the cable vault inspecting the integrity of the fire seals noted that in the Northwest corner of the room, a sound of air leakage could be heard. This sound was later determined to be air leaking from the Reactor Building to the Control Structure via an apparently degraded penetration seal. That determination was made by the licensee. A work request to repair the seal was issued while the inspectors were still on site.

9.0 Unresolved Items

Unresolved items are matters for which more information is required in order to ascertain whether they are acceptable, violations, or deviations. An unresolved item is discussed in Section 7.0.

10.0 Exit Interview

The inspector met with licensee management representatives (see Section 1.0 for attendees) at the conclusion of the inspection on March 23, 1989. The inspector summarized the scope and findings of the inspection at that time. The inspector also confirmed with the licensee that the report will not contain any proprietary information. The licensee agreed that the inspection report may be placed in the Public Document Room without prior licensee review for proprietary information. (10 CFR 2.790).

At no time during this inspection, was written material provided to the licensee by the inspector.

VERMONT YANKEE
NUCLEAR POWER CORPORATION

Ferry Road, Brattleboro, VT 05301-7002

BVY 89-52

ENGINEERING OFFICE
580 MAIN STREET
BOLTON, MA 01740
(508) 779-6711

June 16, 1989

U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Document Control Desk

References: a) License No. DPR-28 (Docket No. 50-271)
b) Letter, USNRC to VYNPC, NVY 89-108, dated 5/18/89
c) Letter, VYNPC to USNRC, BVY 89-48, dated 6/2/89

Dear Sir:

Subject: Response to Inspection Report 89-04, Notice of Violation

During a routine safety inspection of Vermont Yankee's fire protection program conducted on March 20-23, 1989, a violation of NRC requirements was identified. Our response to this violation is provided below.

VIOLATION

Technical Specification 3.13.D requires that the carbon dioxide fire suppression (CO_2) systems located in the cable vault and diesel fire pump day tank room shall be operable whenever equipment in the area protected by the systems is required to be operable. The technical specifications require a continuous fire watch if the CO_2 system in the cable vault is inoperable and an hourly fire watch if the CO_2 system in the fire pump day tank room is inoperable.

In a letter to the NRC dated January 31, 1977, the licensee stated that the carbon dioxide systems at Vermont Yankee were designed to meet the requirements of the 1977 National Fire Protection Association (NFPA) Standard 12. NFPA Standard 12 Section 1-7.3 specifies that the installed carbon dioxide systems shall be tested and the tests performed shall be adequate to determine that the system has been properly installed and will function as intended. The CO_2 systems are designed to achieve a 50 percent concentration. In the cable vault, this concentration must be maintained for ten minutes.

Contrary to the above, as of April 21, 1989, the CO_2 systems in the cable vault and in the diesel fire pump day tank room had not been demonstrated to be operable, in that no tests had been performed of their capability to reach and maintain design concentrations of CO_2, and the appropriate fire watches had not been implemented.

This is a Severity Level IV Violation (Supplement I)

RESPONSE

Following a careful review of the 1977 National Fire Protection Association (NFPA) Standard 12, we have found nothing to indicate that a Full Discharge Test is required. Based on that review, we disagree with the conclusion reached in the Inspection Report and, based on the following information, respectfully request that this Notice of Violation be withdrawn.

The Inspection Report specifies Section 1-7.3 of (1977) NFPA Standard 12 as the applicable section. It reads as follows:

> "1-7.3 Approval of Installations. The completed system shall be tested by qualified personnel to meet the approval of the authority having jurisdiction. These tests shall be adequate to determine that the system has been properly installed and will function as intended. Only listed or approved equipment and devices shall be used in the systems."

We believe the initial testing, periodic inspection and maintenance described in Section 1-11.1 of NFPA Standard 12 is applicable since initial testing of the CO_2 system is at issue. Section 1-11.1 reads as follows:

> "1-11.1 A manufacturer's test and maintenance procedure shall be provided to the owner for testing and maintenance of the system. The procedure shall provide for the initial testing of the equipment as well as for periodic inspection and maintenance."

Both of these sections are further explained in the Appendix A Explanatory. Of particular note is Section A-1-11.1 (Testing of Systems) of the (1977) NFPA Standard 12 which does not specifically require a full discharge test. Item 15 reads as follows:

> "15. Test
>
> A. Puff test, minimum for acceptance.
> B. Full discharge test as required by owner.
> C. Full discharge test recommended when hydrostatic test is required."

In recent conversations with the NRC staff, we were told that the NRC is the "authority having jurisdiction" and that the NRC requires a full discharge test of the CO_2 systems in accordance with NFPA Standard 12, thus we are in violation of Section 1.7-3 of the Standard. We are unable to find a reference to support the staff position. We agree that had the NRC desired at that time of installation to fulfill into the role of "authority having jurisdiction," then certainly this role would have been fulfilled by NRC. However, at the time of acceptance testing, Vermont Yankee had no indication that the NRC intended to assume this role, thus we assumed the role of "authority having jurisdiction."

Section A-1-11.1 of NFPA Standard 12 states that a puff test is the minimum for acceptance; which Vermont Yankee has performed. Further, the Standard indicates that a full discharge test is at the discretion of the owner. Since Vermont Yankee is the owner and has not required a full discharge test, this section was clearly met.

We have also reviewed later versions of NFPA Standard 12 and agree that, if the system were installed today, a full discharge test would be required. The difference in the 1977 code versus later code revisions, however, clearly demonstrates a change in requirements which further supports our contention that a full discharge test was not required to meet the 1977 code. Vermont Yankee has not been notified by the NRC of any changes to regulatory requirements that would necessitate our compliance to any version of the NFPA standards other than the 1977 NFPA Standard.

Although Vermont Yankee disagrees with the staff position regarding the interpretation of NFPA Standard 12, we have been responsive to NRC concerns. At significant cost to Vermont Yankee, we declared the subject CO_2 systems inoperable and established the appropriate fire watches. The Diesel Fire Pump Room CO_2 system full discharge test has been satisfactorily completed and the system was declared operable. A continuous fire watch is in place in the cable vault although the system remains functional. Complete compensatory measures were previously submitted in Vermont Yankee's Special 30-Day Report (Reference c).

The specific issue involved is whether Vermont Yankee has complied with the testing required for the applicable Fire Suppression Systems in accordance with the 1977 NFPA Standard 12. We firmly believe that we have met this standard, and that the existing systems installed at Vermont Yankee are fully operable. Based on the above discussion, we cannot agree with your conclusions that we are not in full compliance with the applicable requirements. Thus, we respectfully request that the subject Notice of Violation be withdrawn. Additionally, pending NRC approval, Vermont Yankee wishes to declare the Cable Vault CO_2 system operable. We will, however, continue to be responsive to NRC's concerns regarding the Cable Vault CO_2 system. Therefore, after declaring the subject CO_2 system operable, Vermont Yankee will establish a once per hour fire watch. Further, Vermont Yankee will conduct a full discharge test of the Cable Vault CO_2 system as soon as practicable but no later than the end of the next scheduled outage.

We are aware that the issue of operability of CO_2 systems with respect to full discharge testing standards is a recent Region I concern with other licensees as well as Vermont Yankee. At your convenience, we would be willing to meet with appropriate Region I personnel on this issue to discuss our specific situation.

We trust that the above information is sufficient to address the issue; however, should you have any questions or desire additional information, please feel free to contact us.

Very truly yours,

VERMONT YANKEE NUCLEAR POWER CORPORATION

Warren P. Murphy
Vice President and
Manager of Operations

/dm
cc: USNRC Regional Administrator, Region I
USNRC Resident Inspector, VYNPS

RESPONSIBILITY

L.A. Tremblay for distribution

onse to our letter

ning to testing of CO2
your response letter
n 89-04. Section 1-7.3
ducted to determine that
d not performed tests
0 percent concentration
ecified areas. Accord-

ecifically require a
ally require a full
crate through a test
aintain the design
t knowledge, no other
lternate to this
gned.

sts to establish that
fire watch is posted in
the technical specifi-
a full discharge test
no later than the end

Acting Director
tor Safety

ompany
Company
oup, Inc.
c Service
alth of

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
475 ALLENDALE ROAD
KING OF PRUSSIA, PENNSYLVANIA 19406

AUG 21 1989

NVY 89-172

Docket No. 50-271

RESPONSIBILITY
L.A. Tremblay for distribution

Vermont Yankee Nuclear Power Corporation
ATTN: Mr. Warren P. Murphy
Vice President and Manager
of Operations
RD 5, Box 169
Ferry Road
Brattleboro, Vermont 05301

Gentlemen:

Subject: Inspection 50-271/89-04

This refers to your letter dated June 16, 1989, in response to our letter dated May 18, 1989.

Your letter requests withdrawal of the violation pertaining to testing of CO2 systems. No new information was provided to the NRC in your response letter beyond that previously provided in support of Inspection 89-04. Section 1-7.3 of (1977) NFPA standard 12 specifies that tests be conducted to determine that the CO2 system will function as intended. Your staff had not performed tests that demonstrated that the CO2 systems would achieve a 50 percent concentration and maintain the concentration for ten minutes in the specified areas. Accordingly, we have concluded that the violation is valid.

We note your statement that NFPA Standard 12 does not specifically require a full discharge test. We agree that it does not specifically require a full discharge test; however, it does require that you demonstrate through a test that the system will function as intended. This means maintain the design concentration for the specified duration. To our present knowledge, no other test will demonstrate this fact. We will entertain an alternate to this established test if a conclusive test method can be designed.

It is our understanding, that pending your performing tests to establish that the CO2 systems will function as intended, a continuous fire watch is posted in the subject area in accordance with the requirements of the technical specification. Further, we understand that you plan to perform a full discharge test of the cable vault CO2 system as soon as practicable but no later than the end of the next scheduled outage.

LAI
340
(previously assigned)

8908300020 2pp

Your cooperation with us is appreciated.

Sincerely,

Bruce A. Boger, Acting Director
Division of Reactor Safety

cc: w/encl:
J. Weigand, President and Chief Executive Officer
J. Pelletier, Plant Manager
J. DeVincentis, Vice President, Yankee Atomic Electric Company
R. Capstick, Licensing Engineer, Yankee Atomic Electric Company
J. Gilroy, Director, Vermont Public Interest Research Group, Inc.
G. Sterzinger, Commissioner, Vermont Department of Public Service
P. Agnes, Assistant Secretary of Public Safety, Commonwealth of Massachusetts
Public Document Room (PDR)
Local Public Document Room (LPDR)
Nuclear Safety Information Center (NSIC)
NRC Resident Inspector
State of New Hampshire
State of Vermont
Commonwealth of Massachusetts

Designation: E 741 - 80

Att: Joe
From Gary Parrucci

Standard Practice for MEASURING AIR LEAKAGE RATE BY THE TRACER DILUTION METHOD[1]

This standard is issued under the fixed designation E 741; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This practice describes a standardized technique for measuring air change rate in buildings under natural meteorological conditions by tracer gas dilution.

1.2 This practice shall not be used to determine the individual contribution of various building components to the air change rates of a building.

1.3 This is a practice that requires a knowledge of the principles of gas analysis and instrumentation.

1.4 The current state of the art does not possess analytical techniques to extrapolate precisely measured air change rates to meteorological conditions different from those prevailing during measurement.

2. Summary of Practice

2.1 A small amount of tracer gas is introduced into a structure, thoroughly mixed, and the rate of change (decay) in tracer concentration is measured. The air change rate can be determined from the decay rate of tracer concentration with respect to time. On-site meteorological conditions are measured concurrently.

3. Significance

3.1 Air leakage accounts for a significant portion of the thermal space conditioning load; it can introduce outdoor air contaminants in conditioned indoor air, and it can dilute indoor-generated contaminants, thus detracting from or providing for occupant comfort.

3.2 Air leakage rates are difficult to predict analytically because they are functions of building tightness and configuration, inside-outside temperature differences, wind speed and direction, quality of workmanship in construction, and numerous other factors.

3.3 This practice allows measurements of air leakage rates. In applying the results of this practice to the design of buildings, it should be borne in mind that the air leakage characteristics of a structure are affected by building operation, maintenance, and the resistance of the building components to deterioration.

3.4 The air leakage rate of a building is hard to quantify, as it depends on so many variables. The most direct way is to measure it under the field conditions. The tracer dilution method has been proven to be an effective way of measuring the air leakage rate. The fan pressurization method provides an indirect way to relate the air leakage rate or air tightness to the leakage area of a structure.

3.5 The fan pressurization method has several differences from the tracer dilution method. It can be used to compare the relative air tightness of several buildings. It can be used to identify the leakage source and rate of leakage from different components of the same building envelope. It can be used to determine the air leakage reduction for individual retrofit measures applied incrementally to an existing building.

3.6 When the absolute air leakage rate is

[1] This practice is under the jurisdiction of ASTM Committee E-6 on Performance of Building Constructions and is the direct responsibility of Subcommittee E 06.41 on Infiltration Performances.

Current edition approved April 25, 1980. Published August 1980.

needed, the tracer dilution method should be used over a wide range of wind velocities and indoor and outdoor temperature differences. However, the measuring equipment and techniques are relatively complicated for the tracer dilution method, and the data analysis and correlation are more involved. It is best to use the fan pressurization method for diagnostic purposes and resolve the absolute air leakage rate with the tracer dilution method.

4. Descriptions of Terms

4.1 *air leakage rate*—the volume of air movement per unit time, in this specific sense, across the boundary of the building envelope. This movement includes flow through joints, cracks, and porous surfaces, or both.

4.2 *infiltration*—air leakage rate into a building space.

4.3 *exfiltration*—air leakage rate from a building space.

4.4 *air change rate*—air leakage rate in volume units per hour divided by the building space volume with identical volume units (normally expressed in air changes per hour, ACH or ACPH).

4.5 *tracer gas*—a gas that can be mixed with air and measured in very small concentrations, making it possible to detect air movements and measure air change rates.

4.6 *building space*—the volume of a building that exchanges air with outside ambient air. In most cases, this volume is the deliberately conditioned space within a building, generally not including the attic space, basement space, and attached structures, unless such spaces are connected to the heating and air conditioning system, as a crawl space plenum.

4.7 *building envelope*—the exterior shell enclosing the interior space.

5. Apparatus

5.1 The description of apparatus in this section is general in nature and any equipment capable of performing the test measurements within the allowable tolerances is permitted. An appendix is provided which documents both tracer gases and their measurement instrumentation which have been used in tracer dilution studies.

5.2 *Major Components:*

5.2.1 *Tracer Gas Monitor*—A device to measure whichever tracer gas is used in the study.

5.2.2 *Sampling Network*—A network consisting of tubing, tubing junctions, a pump, and possibly an aspirator. This network is used to draw samples from remote locations within a structure, blend them, and bring the blended sample to a convenient place for analysis. In general, it is best to avoid plasticized tubing such as vinyl and use copper, stainless steel, or possibly polypropylene or nylon. The experimenter should be aware that surface absorption within the sampling network can be a major source of confusion in any concentration decay measurement.

5.2.3 *Syringes*—Usually disposable syringes are used to inject gas samples when the tracer gas monitor is a gas chromatograph.

5.2.4 *Circulating Fans*—Fans are used to circulate air within a structure. They should be capable of circulating air over 360°. Oscillating or hassock fans are preferred.

5.2.5 *Meteorology Stations*—A portable meteorology station that records wind speed and direction, outside temperature, and, if available, relative humidity, is used to obtain on-site meteorological data.

5.2.6 *Barometer*—A device to measure local barometric pressure is required. If one is not available, barometric pressure from the nearest weather station is obtained for the time during which measurements are performed. These data are corrected for any elevation difference between the weather station and the test structure.

5.2.7 *Tracer Gas*—A cylinder or container of gas chosen from among those listed in the appendix is necessary as a source of the tracer used in the test.

6. Safety Precautions

6.1 The maximum allowable concentration in air for each of the tracer gases that have been used for tracer dilution air leakage measurements is provided in the appendix. Under no circumstances should this concentration be exceeded. Good experimental practice is to ensure that the maximum allowable concentration of the particular tracer is less than this maximum by at least a factor of four. *Under no circumstances should the initial tracer gas concentration exceed the OSHA time-weighted average for substances included in the latest OSHA-controlled gases list.*

7. Procedure

7.1 The assumption underlying the tracer gas measurement of air change rate is that for perfect mixing with steady air flow, the loss rate of tracer gas concentration conforms to the exponential dilution law, that is, the loss rate or dilution of an escaping gas is proportional to its concentration. Mathematically, this assumption leads to Eq 1. A detailed derivation and discussion of this equation are contained in Footnotes D and G to Table A1.1.

$$C = C_0 e^{-It} \quad (1)$$

where:

C = tracer gas concentration at time t,
C_0 = tracer gas concentration at time = 0,
I = air change rate, and
t = time.

7.2 *Injection and Mixing of Tracer Gas*—At one or more points in the test structure, release an amount of tracer gas sufficient to produce an easily discernible response in the gas-measuring instrument. The location of release is governed by the location of air handling system(s) or mixing fans in a structure with no air-handling system. This release can be done with a disposable syringe filled with tracer gas.

7.3 In a building with central heating and air conditioning system(s), the main fan(s) is operated continuously. Introduce tracer gas into the main supply or return duct(s) preferably in the vicinity of the main fan(s).

7.4 Leaks in the ductwork system may produce an incremental increase in the air leakage rate. There are two methods to assess this leakage. (See 7.4.1 and 7.4.2 below.)

7.4.1 After beginning a test, as in 7.3, operate the main fan(s) only for initial mixing and shortly before sampling.

7.4.2 Use portable fans for mixing after initiating a test as in 7.3. Perform the remainder of the test as in 7.5.

7.4.3 Comparison of the air leakage determined by 7.4.1 or 7.4.2 and 7.3 indicates the leakage due to ductwork.

7.5 In a building without central heating and air conditioning system(s), release tracer gas at one or more points within the structure. Use fans to circulate the air and mix the gas. Take care not to affect the pressure distribution within the structure. Open all doors connecting contiguous living spaces.

8. Sampling

8.1 Before taking gas samples, allow at least 30 min for mixing.

8.2 To test for homogeneity in tracer gas concentration, take samples from a number of building spaces. When concentrations differ by less than 5 % of the average concentration measured within the structure, begin monitoring the decay of tracer concentration. In a residential structure, two or more samples from widely separated locations are required. In multistory structures, two widely separated samples per floor are required.

8.3 Tracer samples may be measured at a single central location by taking individual samples (grab samples) at a number of distinct locations, or by drawing samples from a number of locations through a common network (multipoint sampling).

8.3.1 When multipoint sampling is used, place sensors at strategic points within the test structure and feed to a central measuring terminal. For methods that analyze air with a single measurement device, use a sampling network to bring blended air samples to the analyzer. A diagram of a sampling network and a sampling junction is given in Figs. 1 and 2. Note that if the dilution rate in different rooms or floors is different, samples drawn by this method yield air leakage rates slightly less than the true average rate. For example, if one of the rooms or floors is leaking air at twice the rate of the other (1 ACPH and 0.5 ACPH), analysis of the blended samples of the two will lead to an air leakage rate estimate about 4 % lower than the true average rate.

9. Calibration

9.1 State the method of calibration of the gas analyzer. If the analyzer is not provided with a manufacturer's calibration, perform an on-site calibration. Use standard mixtures of at least two different concentrations in the range anticipated in an actual test.

10. Calculation

10.1 Rearrange Eq 1 as follows:

$$I = \frac{1}{t} \ln \frac{C_0}{C} \quad (2)$$

where:

C = measured time-dependent concentration,
C_0 = concentration at $t = 0$,

I = air change rate, and
t = time.

Equation 2 is the starting point for several means of calculating air change rate from concentration and time measurements.

10.2 *Graphical Method*—Plot the natural logarithm of concentration on a linear scale against time in hours on a linear scale. The measurements should fall on a straight line with time, provided the air change rate remains constant. Scatter of points is expected and a straight line may have to be faired in the "best fit" sense. A minimum of three points over 1 h should be used to determine this straight line.

10.2.1 On the straight line determined in 10.2, pick two points with coordinates (C_1, t_1) and (C_2, t_2) where C_i is the concentration at time t. Calculate I, the air change rate, as follows:

$$I = \frac{\ln C_2 - \ln C_1}{t_2 - t_1} \quad (3)$$

This technique is illustrated in Fig. 3.

10.2.2 This method lends itself quite nicely to field study of the data, since one can easily plot the log of concentration as a function of time. It is less sensitive to errors in concentration than other methods. It has the further advantage that a graph provides a visual display of any departures in the exponential decay law. So long as the data fall on a reasonably straight line, one has confidence that the data obtained are valid within the assumptions necessary for the validity of the tracer dilution method. One *caveat* that should be observed during any measurement interval is that the data points used in determining in air leakage rate should encompass the mean winds observed during the course of the measurement.

10.2.3 When many data points are obtained, a least-square computer program is used to calculate a best fit to the straight line.

10.3 *Finite Difference Method*—Calculate the air change rate after each sampling using the finite difference form of Eq 2, as follows:

$$I = \frac{L}{V} = \frac{1}{(t_{i+1} - t_i)} \ln \frac{C_i}{C_{i+1}} \quad (4)$$

where:

L = leakage rate,
V = room volume,
t_i = time at ith interval, and
C_i = tracer concentration at ith sample interval.

For measurement over N sampling intervals, one may form a mean and standard deviation as follows:

$$\text{Mean } I = \bar{I} = \frac{1}{N} \Sigma I$$

$$\text{Standard deviation} = S_I = \sqrt{\frac{\Sigma I^2 - (\Sigma I)^2/N}{N-1}} \quad (5)$$

The air change rate, $I = L/V$, is "best fit" to the sample values of this parameter. The best fit for I is the mean, and is determined from the test data in accordance with Eq 5. This method has the advantage of simplicity, but it is very sensitive to errors in concentration or the effects of poor mixing, especially when short sampling intervals are used.

10.4 *Decay Time Method*—Concentration decay usually occurs quickly. This fact allows for a rapid means of estimating I. For example, with time measured in minutes, the time for one half of the initial concentration to decay is noted as $t_{1/2}$ and the I estimate is given by $41.59/t_{1/2}$. Similar ratios are given for other decay fractions and are shown in Table 1. These ratios are simply computed for C/C_0 ratios of ¼, ⅜, ½, etc. The measurer has to record the time that a desired ratio is encountered.

11. Report

11.1 The report should include the information listed. As much of this information as possible should be included to facilitate comparison with other data at a later time.

11.1.1 *Measurement Characterization:*

- Air Mixing: Method of initial mixing and method of maintaining mixing during the measurement if one is used
- Air Sampling: Location of sampling site, sample interval, initial sample time, method of sampling
- Tracer Gas: Type, initial concentration, method of introduction
- Detector: Type and method of calibration
- Type of Calculation: Finite difference, decay time, graphical, least square

11.1.2 *Meteorological Conditions:*

- Location and height of meteorological measurement

- Wind speed and direction (both maximum and average)
- Temperature and measurement technique.
- Barometric pressure and measurement technique.
- Relative humidity or wet bulb temperature and measurement technique.

11.1.3 *Test Space Characterization:*

- Structure Type: Residential, commercial, industrial, other
- Location of Structure Relative to: Proximity to other structures (give type) and roadways

  Description of surrounding terrain (give type, that is, gullies, mountain, mounds, cliffs, etc.)

  Structure orientation and elevation relative to items above
- Windows: Type, dimensions, number, location in test space
- Doors: Type, dimensions, number, location in test space.
- Walls: Interior and exterior
- Noticeable areas of leakage
- Location of chimneys, vents, and other such specified opening
- Type and capacity of heating, ventilation, and air-conditioning systems

11.1.4 *Test Space Operating Characteristics:*

- Doors: Open or closed
- Windows: Open or closed
- HVAC System: On or off
- Vent Fans: On or off
- Special Circumstances or Characteristics: Occupied, unoccupied
- Indoor temperature and measurement technique
- Barometric pressure and measurement technique
- Relative humidity and measurement technique

12. Precision and Accuracy

12.1 At present, insufficient data exist for purposes of precision and accuracy determination. A reasonable estimate of the *uncertainty* in a given air change rate determination is of the order of 10 % or less.

12.2 Note that the air change rate is a strong function of indoor-outdoor temperature difference and wind speed and direction. When interpreting or comparing air change rate data, the fact that a pressure and temperature dependence does exist should be borne in mind. It can have a strong effect on the results.

TABLE 1 Decay Ratios to Compute ACPH

Concentration Ratio	Decay Time, minutes	I, ACPH
$\frac{3}{4}$	$t_{3/4}$	$17.26/t_{3/4}$
$\frac{2}{3}$	$t_{2/3}$	$24.33/t_{2/3}$
$\frac{1}{2}$	$t_{1/2}$	$41.59/t_{1/2}$
$\frac{1}{3}$	$t_{1/3}$	$65.92/t_{1/3}$
$\frac{1}{4}$	$t_{1/4}$	$83.18/t_{1/4}$
$\frac{1}{6}$	$t_{1/6}$	$124.77/t_{1/6}$

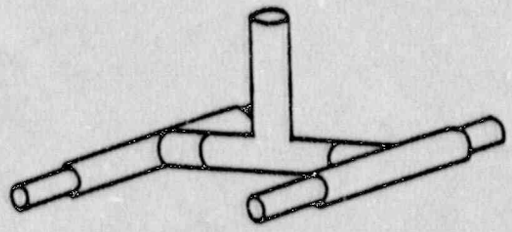


FIG. 1 Four-Point Sampling Junction

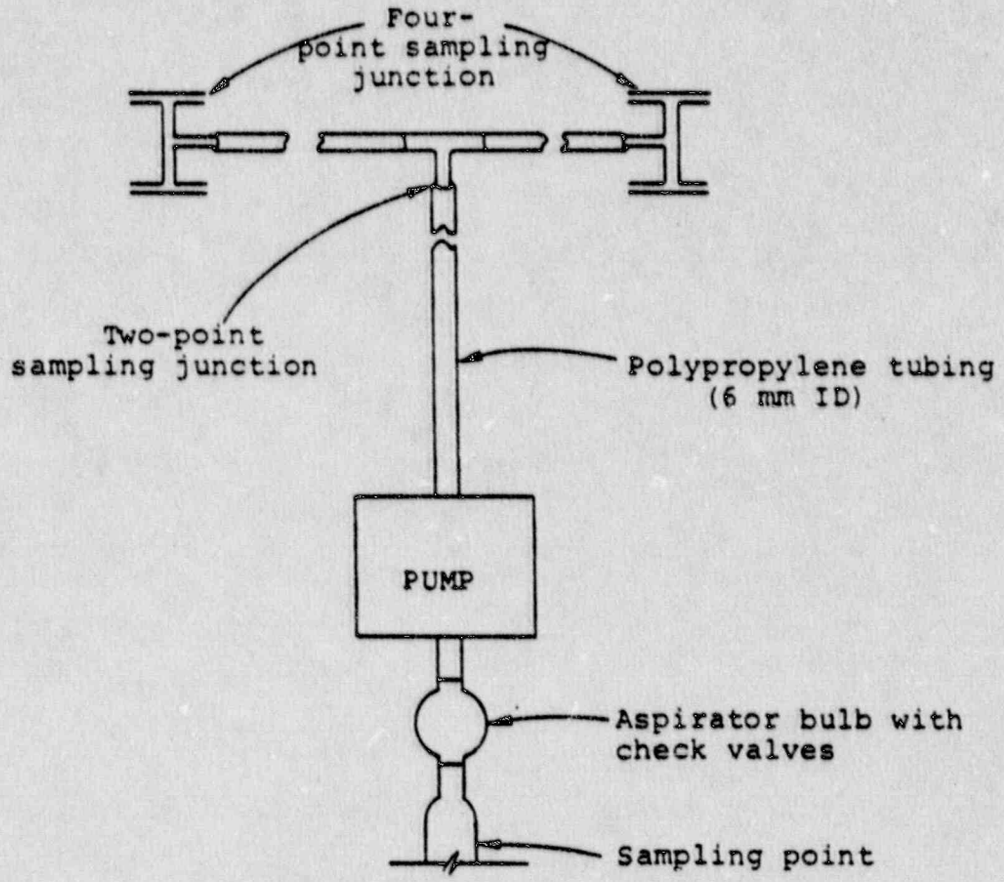
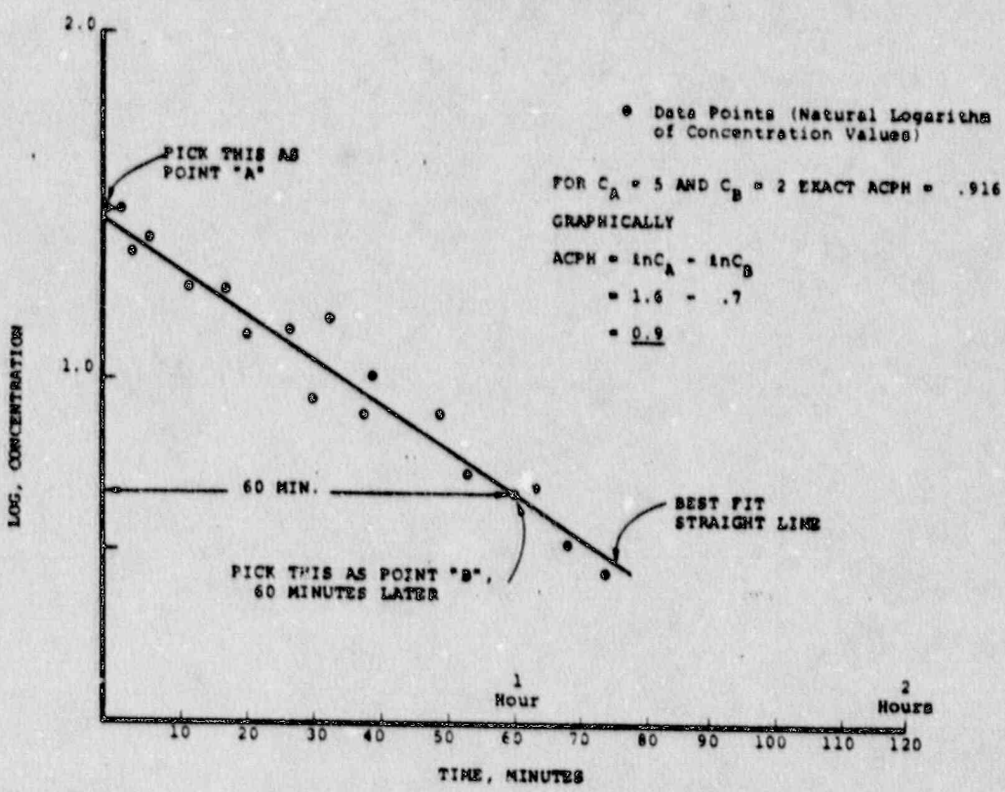


FIG. 2 Diagrammatic Representation of Symmetrical Eight-Point Sampling System



NOTE—Shorter test times may be employed provided that correct time interval is used in calculating air change rate.

FIG. 3 Graphical Determination of Air Change Rate

APPENDIX

A1. SUMMARY OF TRACER GASES USED IN AIR LEAKAGE MEASUREMENTS

A1.1 This appendix presents a compilation of gases and associated instrumental techniques that have been used to perform air leakage measurements as well as a table of typical background levels of these gases. Note that some of these gases may not be suitable for use under present-day guidelines for health and safety. Nevertheless, these gases are presented for historical completeness.

A1.2 In general, the desirable characteristics of a tracer gas are:

- Measurable at very low concentrations
- Inert, nonpolar, and not absorbed
- Nontoxic, nonallergenic
- Nonflammable and nonexplosive
- Easily and inexpensively measurable
- Not a normal constituent of air
- Measurable by a technique that is free of interference by substances normally in air.

No single gas fulfills all these conditions.

A1.3 It should be emphasized that the measurement of air change rate by the tracer dilution method is independent of which tracer is selected.

TABLE A1.1 Gases and Techniques for Tracer Dilution Method

Tracer	Measuring Apparatus	Maximum Allowable Concentration in Air (vol/vol)	Minimum Detectable Concentration, ppm	Toxicology[1]	Chemical Inertness	Comments[1]
Hydrogen	Katharometer[1]	4% (lower explosive limit)	200	nontoxic	extremely reactive in presence of oxygen and heat or flame	flammable or explosive in presence of oxygen and heat or flame
Helium	Katharometer[1,9]		300	nontoxic	nonreactive	nonreactive
Carbon monoxide	infrared absorption; heat of absorption measurement[10]; gas chromatograph followed by reduction to methane and measurement with flame ionization detector[1]	50 ppm 0.4	5	combines with hemoglobin to produce asphyxia	can be dangerous when exposed to open flame	can also react with oxygen in air in sufficient concentration; may explode when exposed to open flame
Carbon dioxide	infrared absorption;[10] gas chromatograph with thermal conductivity detector	5000 ppm	1 70	nontoxic	very soluble in water	
Sulfur hexafluoride	electron capture[1,4,6]; gas chromatograph	1000 ppm	0.000002	nontoxic	chemically inert when pure	When heated to decomposition (550°C) toxic byproducts may be formed
Nitrous oxide	infrared absorption[1,4]	25 ppm[11]	1	nontoxic	very soluble in water	can form explosive mixtures in air
Ethane	flame ionization detector;[1] gas chromatograph with flame ionization detector	3% (lower explosive limit)	5	nontoxic	will burn when exposed to flame	may explode in presence of oxygen and heat or flame

TABLE A1.1 *Continued*

Tracer	Measuring Apparatus	Maximum Allowable Concentration in Air (vol/vol)	Minimum Detectable Concentration, ppm	Toxicology[J]	Chemical Inertness	Comments[L]
Methane	infrared absorption[N]	5 % (lower explosive limit)	5	nontoxic	will burn when exposed to flame	may explode in presence of oxygen and heat or flame

[A] Dick, J. B., "Measurements of Ventilation Using Tracer Gas Technique." *Heating, Piping, and Air Conditioning Journal*, HPHOAM, Vol 23, No. 5, May 1950, pp. 131 - 137.

[B] Cobientz, C. W., and Achenbach, P. R., "Design and Performance of a Portable Infiltration Meter," *ASHRAE Transactions* ASHTAG, Vol 69, 1963, pp. 358 - 365.

[C] Elins, H. R., and Wensman, C. W., "Natural Ventilation of Modern Tightly Constructed Homes." Paper presented at American Gas Association-Institute of Gas Technology Conference on Natural Gas Research and Technology, Chicago, Ill., Feb. 28 - March 3, 1971.

[D] Hill, J. E., and Kusuda, T., "Dynamic Characteristics of Air Infiltration." *ASHRAE Transactions*, ASHTAG, Vol 81, Part I, 1975, pp. 168 - 185.

[E] Drivas, P. J., Simmonds, P. G., and Shair, F. H., "Experimental Characterization of Ventilation Systems in Buildings." *Environmental Science and Technology*, ESTHAG, Vol 6, No. 7, 1972, pp. 577 - 666.

[F] Harrje, D. T., et al, "Automated Instrumentation for Air Infiltration in Buildings." Center for Environmental Studies, Engineering Quadrangle, Princeton University, Princeton, N.J., Report No. 13.

[G] Hunt, C. M., and Treado, S. J., "A Prototype Semi-Automated System for Measuring Air Infiltration in Buildings Using Sulfur Hexafluoride as a Tracer Gas." *National Bureau of Standards Technical Note 898*, March 1976.

[H] Prado, R., Leonard, R. G., and Goldschmidt, V., "Measurement of Infiltration in a Mobile Home." Purdue University Report.

[I] Porter, K., and Volman, D. F., "Flame Ionization Detection of Carbon Monoxide for Gas Chromatographic Analysis." *Analytical Chemistry*, ANCHAM, Vol 34, No. 7, June 1962, pp. 748 - 749.

[J] Lidwell, O. M., "The Evaluation of Ventilation." *Journal of Hygiene*, JOHYAY, Vol 58, 1960, pp. 297 - 305.

[K] Howard, J. S., "Ventilation Measurements in Houses and the Influence of Wall Ventilators." Commonwealth of Australia, DBR Report No. 347, *Building Science*, BUSCBE, Vol 1, 1966, pp. 251 - 257.

[L] Sax, N. I., *Dangerous Properties of Industrial Materials*, Third Edition, Van Nostrand, New York, 1968.

[M] *Occupational Exposure to Anesthetic Gases and Vapors* Department of Health, Education and Welfare (NIOSH), U. S. Government Printing Office, Washington, D. C., 1977.

[N] Janssen, J. E., Torborg, R. H., and Bonne, V., "Measurement of Heating System Dynamics for Computation of Sensoral Efficiency," *ASHRAE Transactions*, ASHTAG, Vol 83, 1977.

TABLE A1.2 Atmospheric Constituents

Compound	Average Tropospheric Background Concentrations, ppm	Typical Indoor and Urban Ambient Concentrations, ppm	Anthropogenic Sources	References
H_2	0.5	0.5	...	A
He	5.2	5.2	...	A
CO	0.1	5–50	combustion	A
CO_2	320	30–5000	combustion	A
N_2O	0.3	0.3–several ppm	combustion	B, C, D
Ethane	1.5×10^{-3}	0.1	incomplete combustion	A, F
Methane	1.5	2–5	incomplete combustion	A, F
SF_6	10^{-8}	10^{-5}	telephone switching stations	G, H

[A] Williamson, S. F., *Fundamentals of Air Pollution*, Addison-Wesley, Reading, Mass., 1973.

[B] Pierotti, D., and Rasmussen, R. A., "Combustion as a Source of Nitrous Oxide in the Atmosphere," *Geophysical Research Letter*, GPRLAJ, Vol 3, No. 5, 1976, pp. 615 - 618.

[C] Rasmussen, R. A., Drasnec, J., and Pierotti, D., "N_2O Analysis in the Atmosphere via Electron Capture-Gas Chromatography," *Geophysical Research Letter*, GPRLAJ, Vol 3, No. 10, October 1976, pp. 615 - 618.

[D] Weiss, R. F., and Craig, H., "Production of Atmospheric Nitrous Oxide by Combustion," *Geophysical Research Letter*, GPRLAJ, Vol 3, No. 12, December 1976, pp. 751 - 753.

[E] *Air Quality Criteria for Hydrocarbons*, National Air Pollution Control Association Publication No. AP-64, U. S. Department of Health, Education and Welfare, Washington, D. C., 1970.

[F] Rasmussen, K. H., Taheri, M., and Kabel, R. L., "Global Emissions and Natural Processes for Removal of Gaseous Pollutants," *Water, Air, and Soil Pollution*, WAPLAC, Vol 4, March 1975, pp. 33 - 64.

[G] Lillian, D., Singh, H. B., Appleby, A., Lobban, L., Arnts, R., Gumpert, R., Hague, R., Toomly, J., Kazazis, J., Antell, M., Hansen, D., Scott, B., "Atmospheric Fates of Halogenated Compounds," *Environmental Science and Technology*, ESTHAG, Vol 9, November 1975, p. 1042.

[H] Simmonds, P. G., Shoemake, G. R., Lovelock, J. E., Lord, H. C., "Improvements in the Determination of Sulfur Hexafluoride for Use as a Meteorological Tracer," *Analytical Chemistry*, ANCHAM, Vol 44, No. 4, April 1972, p. 860.

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

SUPPORTING AMENDMENT NO. 43 TO

FACILITY OPERATING LICENSE NO. DPR-28

VERMONT YANKEE NUCLEAR POWER CORPORATION

VERMONT YANKEE NUCLEAR POWER STATION

DOCKET NO. 50-271

2.0 FIRE PROTECTION GUIDELINES

2.1 Overall Objectives

The overall objectives of the fire protection program in a nuclear power plant are to:

(1) reduce the likelihood of occurrence of fires;

(2) promptly detect and extinguish fires when they occur;

(3) maintain the capability to safely shutdown the plant when fires occur; and

(4) prevent the release of a significant amount of radioactive material, when fires occur.

2.2 General Design Criterion 3 - Fire Protection

The Commission's basic criterion for fire protection is set forth in General Design Criterion 3, Appendix A to 10 CFR Part 50, which states:

> "Structures, systems, and components important to safety shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions.
>
> "Noncombustible and heat resistant materials shall be used wherever practical throughout the unit, particularly in locations such as the containment and the control room.
>
> "Fire detection and protection systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fires on structures, systems, and components important to safety.
>
> "Fire fighting systems shall be designed to assure that their rupture or inadvertent operation does not significantly impair the safety capability of these structures, systems, and components."

Guidance on the implementation of General Design Criterion 3 for existing nuclear power plants is provided in Appendix A of Branch Technical Position 9.5-1, "Guidelines for Fire Protection for Nuclear Power Plants."

We have used the guidance in Appendix A where appropriate for the existing conditions. We have also evaluated alternatives proposed by the licensee to assure that the overall objectives outlined in Section 2.1 are met for the

We find that, subject to implementation of the above described modification, the protection provided to protect safety systems from the effects of suppression system operation or fire water damage satisfies the objectives identified in Section 2.1 and is, therefore, acceptable.

4.3.2 Gas Fire Suppression Systems

A total flooding manually-actuated high pressure CO_2 system protects the cable spreading room and battery room. Upon actuation of the system the entire 2800 cu. ft. of CO_2 is discharged in a little over three minutes. A 50 percent concentration of CO_2 is reached and can be maintained for ten minutes. This is a single shot system. The power for the system actuation is from the 120V Vital A.C. Bus. Ventilation dampers between the computer room and cable spreading room close upon actuation of the CO_2 system.

We find that the design of the gas fire suppression system satisfies the objectives identified in Section 2.1 and is, therefore, acceptable.

4.3.3 Portable Fire Extinguishers

Portable dry chemical and carbon dioxide fire extinguishers have been distributed throughout the plant. The fire extinguishers meet the requirements of the National Fire Protection Association.

We find that the portable fire extinguishers satisfy the objectives identified in Section 2.1 of this report and are, therefore, acceptable.

4.4 Ventilation Systems and Breathing Equipment

Normal ventilation systems are available in most areas to exhaust smoke. However, the capability of the exhaust system for smoke removal in each area has not been analyzed. The licensee has proposed to provide portable ventilation units at strategic locations to allow fire fighters to exhaust smoke from areas for access. Procedures would be developed for the use of this equipment.

A sufficient number of self-contained breathing units are provided at the facility to meet the needs of the operating crew and fire brigade in a fire situation. Ten spare bottles are provided as back-up. The licensee has proposed to provide a recharging capability or new apparatus which has a greater service life to insure a supply of emergency breathing air for a period of six hours.

We find that, subject to implementation of the above described modification to extend the supply of breathing air, these measures satisfy the objectives identified in Section 2.1 of this report and are, therefore, acceptable. We find that, subject to implementation of the above described modifications to provide portable ventilation equipment for fire fighting access, the means to exhaust smoke areas satisfy the objectives identified in Section 2.1 of this report and are, therefore, acceptable.

5.13.6 Modifications

The licensee has proposed the following modifications. The plastic ceiling lighting panels will be replaced with a noncombustible material. The control room access doors will be replaced with three-hour fire rated doors and the window will be provided with three-hour rated protection. The combustible office construction in the control room will be removed and replaced with one-hour fire rated noncombustible construction. These office walls will extend to the underside of the roof above and the observation window in the office wall will be replaced with wire glass and steel frames. The office complex will have self closing Class C fire doors and smoke detectors which alarm in the control room. A Class C fire door will be provided to isolate the kitchen from the control room.

Portable fire extinguishers rated for Class A fires will be provided in the control room. Two 100 pound CO_2 or equivalent Halon extinguishers will be provided in the control room. These units will provide adequate reach and duration to extinguish fires in the walk-through control boards. The ventilation penetrations will be modified to provide three-hour rated fire dampers in the penetration between the control room and the turbine building. Smoke detectors will be provided at the opening in the top of the walk-through control boards and at the ceiling for general area protection. Smoke detectors will be provided in electrical equipment enclosures and in the intake ducts of the control room ventilation system. On detection of smoke, the ventilation system may be manually transferred to the recirculation mode.

We find that, subject to implementation of the above described modifications, the fire protection for this area satisfies the objectives identified in Section 2.1 of this report and is, therefore, acceptable.

5.14 Cable Spreading Room

5.14.1 Safety-Related Equipment

The cable spreading room is located directly below the control room. The area contains redundant divisions of safety-related electrical cables. The area provides access to an adjacent battery room. The reactor protection system motor generator sets are located in this area.

5.14.2 Combustibles

The combustibles in this area consist of a large amount of electric cable insulation.

5.14.3 Consequences if No Fire Suppression

A postulated fire in this room could involve cables of both redundant divisions. Nonsafety-related cables provide pathways for the spread of fire between redundant divisions. Physical separation between redundant divisions of electrical cables does not assure that fire damage would be limited to a single division.

As noted in Section 4.1, the fire protection measures for the cable spreading area, including modifications, do not provide assurance that fires will not result in damage to redundant safe shutdown systems. However, local control of equipment permits safe shutdown independent of fire damage in the cable spreading area.

5.14.4 Fire Protection System

Smoke detectors are provided in the area which alarm in the control room. A total flooding CO_2 fire suppression system consisting of 28-100 lb CO_2 cylinders is located in the room. This system is manually actuated from inside or outside the area. Two portable fire extinguishers are located inside the area, and one portable fire extinguisher is located outside the area. A hose station is located outside the area for backup protection. A door provides access from the service building and a 1-hour fire rated door leads out onto the radwaste building roof.

5.14.5 Adequacy of Fire Protection

An automatic suppression should be provided to insure prompt response to minimize the potential for fire damage to safety-related systems. All cable trays and risers are of totally enclosed galvanized sheet metal construction which limits extinguishment by fire suppression agents. Installed smoke detectors would give warning of an incipient fire. Manual fire fighting could be inhibited due to the arrangement of cable trays in the area and due to the production of heat and smoke. The ventilation supply is through an unprotected opening in the wall to the adjacent computer room and poses an unacceptable fire exposure hazard. The doors and penetrations to the battery rooms are unprotected.

5.14.6 Modifications

The licensee has proposed the following modifications. Automatic three-hour fire rated protection will be provided to protect the ventilation opening between this area and the computer room. The access door to the service building will be replaced with a three-hour fire rated door. All cable penetrations between this area from adjacent areas will be upgraded to provide three-hour fire rated protection. The covers will be removed from the trays to facilitate extinguishment by the CO_2 system or manual means. Fire stops will be installed in any cable trays which connect between different divisions of safety-related trays. The CO_2 system will be changed to an automatically actuated system. Since the design for an automatic CO_2 system has not been completed, a supplement to this report will address the method of system actuation and those interlock features incorporated to disable the system when personnel are working in the area. A CO_2 system to be provided for the switchgear room will be used to provide a backup manually actuated suppression system for the cable spreading area.

We find that, subject to implementation of the above described modifications, the fire protection for this area satisfies the objectives identified in Section 2.1 of this report and is, therefore, acceptable.

Novak, Lynn, and Harrington (F 10). The method designs the experimental program based on the information content, and provides for a sequential program of investigation. The basic assumption is the presence of scale-up differences between separate stages of development. The method would direct the operating conditions toward the optimum area. A batch polymerization reaction was used as the example.

Scale-up by Combined Method. The technique of using dimensional similitude in combination with mathematical modeling was employed (F 11) in the design of a pilot plant and in evaluating the results to provide the basis for scale-up to a commercial scale plant. A differential equation describing the material balance around a section of the system was first derived, and the equation made dimensionless by appropriate substitutions. Scale-up criteria were then established by evaluating the dimensionless groups. A mathematical model was next developed, based on the kinetics of the reaction, describing the effect of process variables on the conversion, yield, catalyst activity, etc. Kinetic parameters were determined by means of both analog and digital computers. A reaction of the type: $A \xrightarrow{k_1} R \xrightarrow{k_2} C$ was used as an example. The computer simulation also covered such operations as catalyst regeneration, product separation, and recycle, for the purpose of developing a realistic commercial scale plant.

Scale-up by Conventional Method. Development of a production-scale fluidized-bed calciner (69 in. diameter) for the conversion of aqueous radioactive wastes to a solid form resulted from pilot plant studies of three different scales (8, 12, and 24 in. diameter) (F 12). Operating data from the pilot plants and the production plant were compared with respect to particle size control, in-bed heat transfer, product properties, and fluidization characteristics. Most of the pilot plant data were applicable to the production unit.

Another conventional scale-up technique has been illustrated (F 13) in the design of fluidized-drop-tube reactor systems that are used in such reactions as the alkylation and isomerization of hydrocarbons catalyzed by H_2SO_4 or HF. Three geometrically similar reaction vessels (7.5, 19, and 40 in. diameter) were employed in the scale-up studies. An insight into the behavior of a commercial-scale system was achieved by conducting the catalyst holding experiments at higher superficial velocities than those in the 40-in. vessel.

REACTOR DESIGN

Since all chemical processes are centered around the chemical reactor, a most important factor in determining the over-all process economy is the design of the reactor. Unlike equipment for mass or heat transport processes, there is no straightforward method for designing equipment to carry out a chemical reaction. This is because the design of a chemical reactor is governed primarily by the specific reaction system concerned.

At the start of the design work, the following information is presumably available: (*a*) the reaction type (simple or complex); (*b*) the need for catalyst; (*c*) phases involved; (*d*) the mode of temperature and pressure control (isothermal, adiabatic, or other, the need for pressure, vacuum, etc.); and (*e*) the production capacity. In addition, basic data required include: (1) the chemical rate equations and variation of rate parameters with temperature, pressure, etc.; (2) the heat- and mass-transfer characteristics; and (3) physical properties of all the components taking part in the reaction. When the above information and data become available, the preliminary selection and sizing of the reactor can proceed.

Table 4-10 has been prepared to facilitate location of information needed in reactor design, most of which is discussed in detail in the paragraphs to follow. Sources of chemical rate data for industrially important reactions are found in Tables 4-16 through 4-19. For information characteristic of catalytic processes, refer to the material presented under Catalytic Reactors (page 4-29 ff.).

Reactor Types

Chemical reactors employed in various industrial processes come in a variety of designs which do not always bear any specific relation to the reaction type or the type of operation. Frequently, equipment of several different designs are used for the same reaction.

In general, chemical reactors have been broadly classified in two ways, one according to the type of operation and the other according to design features. The former classification is mainly for homogeneous reactions, and divides the reactors into batch, continuous, or semicontinuous type. A brief description of these types follows:

Batch Reactor. This type takes in all the reactants at the beginning and processes them according to a predetermined course of action during which no material is fed into or removed from the reactor. Usually it is in a form of tank with or without agitation, and is used primarily in a small-scale production. Most of the basic kinetic data for reactor design are obtained from this type.

Continuous Reactor. Reactants are introduced and products withdrawn simultaneously in a continuous manner in this type of reactor. It may assume the shape of a tank, a tubular structure, or a tower, and finds extensive application in large-scale plants for the purpose of reducing the operating cost and facilitating control of product quality.

Semicontinuous Reactor. In this category belong reactors that do not fit either of the above two types. In one case some of the reactants are charged at the beginning, whereas the remaining are fed continuously as the reaction progresses. Another type is similar to a batch reactor except that one or more of the products is removed continuously.

Chemical reactors have also been classified according to the design features as follows:

Tank Reactor. This is probably the most common type of reactor in use in the chemical industry. In most instances it is equipped with some means of agitation (e.g., stirring, rocking, or shaking) as well as provision for heat transfer (e.g., jacket, external and internal heat exchangers). This type can accommodate either batch (Fig. 4-3a) or continuous operation (Fig. 4-3b) over wide ranges of temperatures and pressure. With the exception of very viscous liquids, a close approximation to perfect mixing (back mixing) can be achieved in a stirred tank reactor. In a continuous operation, several stirred-tank reactors may be connected in series (Fig. 4-3c). Also in use in continuous operation is a single reaction vessel divided into a number of compartments, each of which is equivalent to a stirred tank reactor (Fig. 4-3d and e).

Tubular Reactor. This type of reactor is constructed of either a single continuous tube (Fig. 4-4b) or several tubes in parallel (Fig. 4-4a). The reactants enter at one end of the reactor, and the products leave from the other end, with a continuous variation in the composition of the reacting mixture in between. Heat transfer to or from the reactor may be accomplished by means of a jacket or a shell-and-tube design (Fig. 4-4a). The reactor tubes may be packed with catalyst pellets or inert solids. The tubular reactor finds application in cases where back mixing of the reaction mixture in the flow direction is undesirable. Large-scale gaseous reactions such as the cracking of hydrocarbons, the conversion of SO_2 to SO_3, and the oxidation of NO to NO_2, are examples of the application of tubular reactors.

Tower Reactor. A vertical cylindrical structure with a large height-to-diameter ratio characterizes this type of reactor. It may have hollow or solid packing (reactant, catalyst, or inert) or may be simply an empty tower, and is employed in continuous processes involving heterogeneous reactions. Examples are the lime kiln, and gas absorption units for gas-liquid reactions including packed towers, plate towers, and spray towers.

Fluidized-bed Reactor. This is a vertical cylindrical vessel containing fine solid particles that are either catalysts or reactants. The fluid reactant stream is introduced at the bottom of the reactor at a rate such that solids are floated in the fluid stream without

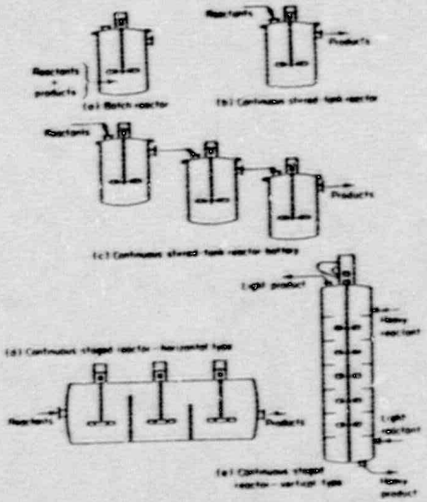


Fig. 4-3 Stirred-tank reactors.

Table 4-10 Quick Index to Reactor Design

Reactor type	Stirred tank (jacketed heat transfer)	Stirred tank (coiled heat transfer)	Tubular	Tower	Fluidized bed
Type of operation and reaction	Batch (small scale); semibatch, or continuous (large scale); homogeneous liquid phase; may have solids suspension (catalyst or reactant); high degree of back mixing		Single tube (small scale) or multitubular (large scale); may have packed catalyst bed; low degree of back mixing; homogeneous or heterogeneous	Continuous heterogeneous reactions; may have baffles or solids packing (catalyst, inert, or reactant)	Solid-fluid reactions; catalytic or non-catalytic
Reactor capacity equation*	Batch: Eq. (4-68); Table 4-11 Continuous (back mix): Eq. (4-70); Table 4-11 Multiple reactor system (back mix): Eqs. (4-71); (4-72)		Single plug flow: Eq. (4-70); Table 4-11 Multiple reactor system (plug flow): Eqs. (4-73); (4-74)	Gas-liquid and liquid-liquid systems: see Sec. 14 Solid-fluid systems: Eq. (4-70)	Eq. (4-70); Table 4-11 (as a back-mix reactor)
Mass transfer data			Packed-bed reactor: Eqs. (4-98); (4-97); (4-99); Figs. 4-14, 4-15	Gas-liquid: Secs. 14 and 18; Eqs. [illegible] Eq. (4-94); Sec. [illegible] Fluid-solid (packed bed): Eqs. (4-98); (4-97); (4-99); Figs. 4-14, 4-15	Eqs. (4-98); (4-97); (4-99); Figs. 4-14, 4-15
Heat transfer data	Eq. (4-96); Sec. 11	Eq. (4-100); Sec. 11	Homogeneous flow: Sec. 10, 11 Heterogeneous flow: Eqs. (4-101), (4-102), (4-103), (4-104); Fig. 4-16; Sec. 10	Packed bed: Eqs. (4-101), (4-102), (4-103), (4-104); Fig. 4-16	Eq. 4-96; Eqs. (4-105), (4-106), (4-107), (4-108); (4-109)
Fluid dynamic data	Sec. 10	Sec. 11	Empty tube: Sec. 5 Packed beds: Eq. (4-88) and Sec. 5	Packed tower: Sec. 18	References (F 6); (F 7)

*Based on the assumption of ideal reactor. For cases with serious deviations from ideal behavior, see pp. 4-25 ff. and the references given therein.

being carried out of the system. Under this condition the entire bed of particles behaves like a boiling liquid, which tends to equalize the composition of the reaction mixture and temperature throughout the bed (*i.e.*, some degree of back mixing is obtained). This is generally considered one of the distinct advantages of the fluidized

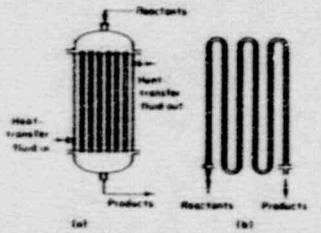


Fig. 4-4 Tubular reactors.

bed reactor. The attrition of catalyst with entrainment of the resulting fines is one of the disadvantages. It has been applied extensively to solid-fluid reactions, such as the catalytic cracking of petroleum hydrocarbons, the conversion of uranium oxides to uranium fluorides, the reduction of some mineral ores, and the gasification of coal. A detailed discussion of the design features of fluidized-bed systems appears in Sec. 20.

Slurry-phase Reactor. This type of reactor is characterized by a vertical column containing fine catalyst particles slurried with a liquid medium (*e.g.*, oil), which may be one of the reactants. The gas reactant bubbling through the slurry dissolves into the liquid medium where catalyzed reaction takes place. This technique facilitates control of the temperature because of the high heat capacity and favorable heat-transfer characteristics of the liquid. Examples of production-scale slurry reactors are found in the hydrocracking of residual fuel oils (C-1 to C-3).

Basic Design Equations

Major considerations in the design of a reactor system from the standpoint of process economics include the production capacity of the reactor and its capability in giving a desired product composition. The latter consideration is especially important in a process dealing with multiple reactions. To be able to select and size a reactor, some common parameters are required that permit a systematic comparison of various types of reactors.

The design equations are generally based on three types of ideal reactors. The first is the **batch reactor** discussed previously (see Reactor Types). All the reactants are introduced into the batch reactor, and no product is discharged until the process is concluded. This represents an unsteady state process in regard to the composition of the reaction mixture. An assumption of complete mixing implies a homogeneous composition in the reactor at any instant.

The **plug-flow** reactor is the second type, which assumes complete mixing in the radial direction but allows for no diffusion in the flow direction (*i.e.*, no back mixing). As a result, the velocity, temperature, and composition profiles are flat over any cross-sectional area perpendicular to the flow, but the composition varies along the flow path.

The third type of ideal reactor is the **back-mix** (or stirred-tank) reactor with a steady-state continuous flow of feed and product streams. The feed entering the reactor immediately assumes a final uniform composition throughout the reactor because of perfect mixing. Accordingly, the exit stream would have the same composition as that within the reactor.

Reactor Capacity. The parameter that has been commonly used as a measure of the reactor capacity is either the **mean residence time** θ or the **space time** τ. The mean residence time is the average of time periods during which individual portions of the reaction mixture stay in the reactor, and is mathematically described by a general form

$$\theta = -\int_{N_{A_0}}^{N_A} \frac{dN_A}{V(-r_A)} \tag{4-68}$$

where N_{A_0} and N_A are moles of reactant A entering and leaving the reactor, respectively. In the case of a flow reactor, V is the reactor volume actually occupied by the reaction mixture, and $-r_A$ represents the rate of disappearance of A. Equation (4-68) results from the material balance around the reactor, and is applicable to the batch and the plug flow reactors defined above. In terms of the fractional conversion x_A, Eq. (4-68) becomes

$$\theta = N_{A_0}\int_0^{x_A} \frac{dx_A}{V(-r_A)} \tag{4-68a}$$

Both Eqs. (4-68) and (4-68a) deal with a general case to which the volume V occupied by the reaction mixture may change with the progress of reaction. For a batch reactor, θ may be considered as the average time required to obtain a desired conversion of a reactant for a given size of batch.

In the case of a back-mix reactor the mean residence time θ can be represented by

$$\theta = \frac{N_{A_0}x_A}{V(-r_A)} \tag{4-68b}$$

If V varies linearly with the fractional conversion x_A as in Eq. (4-28), then Eq. (4-68b) can be written as

$$\theta = \frac{N_{A_0}x_A}{V_0(1+\varepsilon_A x_A)(-r_A)} = \frac{C_{A_0}x_A}{(1+\varepsilon_A x_A)(-r_A)} \tag{4-68c}$$

where V_0 is the volume of the reaction mixture under feed conditions. Similarly, when the relation in Eq. (4-28) holds for the plug flow reactor, Eq. (4-68a) assumes the form

$$\theta = C_{A_0}\int_0^{x_A} \frac{dx_A}{(1+\varepsilon_A x_A)(-r_A)} \tag{4-68d}$$

Under steady-flow conditions with a constant fluid density, θ for a continuous flow reactor may be computed from $\theta = V/v_0$, here v_0 is the volumetric flow rate of the reaction mixture.

In real continuous reactors behavior of the reaction mixture may deviate considerably from the ideality assumed for the back mix and the plug flow reactors, respectively (see page 4-28 ff. for details). Consequently, the mean residence time θ has little significance in such reactors since individual portions of the reacting fluid may have widely different values of θ owing to non-ideal flow through the reactor.

On the other hand, the **space time** τ is defined as the time elapsed in processing one reactor volume of feed at specified conditions. That is, a space time of 1.5 hr implies that 1.5 hr would be required to process one reactor volume of feed at known conditions. The reciprocal of the space time is termed the **space velocity** S. The mathematical expression is

$$\tau = \frac{V}{F/\rho} = \frac{V}{F_{A_0}/C_{A_0}} = \frac{V}{v_0} = \frac{1}{S} \tag{4-70}$$

where F and F_{A_0} are the flow rates, in moles/unit time, of the total feed and of reactant A in the feed, respectively, ρ is the molal density, in moles/unit volume, of the feed, C_{A_0} is the concentration of A in the feed, and v_0 is the volumetric flow rate of feed at entering conditions.

Thus, it is seen that θ and τ are in general different unless the fluid density remains constant throughout the reactor. The mean residence time θ is used primarily to indicate the capacity of a batch reactor, whereas the volumetric feed capacity of a continuous flow

Table 4-11 Basic Design Equations—Capacity of Single Ideal Reactors*

Type of reactor	General design equation	Design equation with $V = V_0(1 + \varepsilon_A x_A)$†	Design equation for either unit nth order reaction with $V = V_0(1 + \varepsilon_A x_A)$†
Batch, V = const	$\theta = C_{A_0}\int \frac{dx_A}{-r_A}$	$= C_{A_0}\int \frac{dx_A}{-r_A}$	$= \frac{1}{kC_{A_0}^{n-1}}\int \frac{dx_A}{(1-x_A)^n}$
Batch, $\varepsilon_A = \text{const}$	$\theta = N_{A_0}\int \frac{dx_A}{V(-r_A)}$	$= C_{A_0}\int \frac{dx_A}{(1+\varepsilon_A x_A)(-r_A)}$	$= \frac{1}{kC_{A_0}^{n-1}}\int \frac{(1+\varepsilon_A x_A)^{n-1}}{(1-x_A)^n}dx_A$
Plug flow	$\theta = \frac{1}{S} = C_{A_0}\int \frac{dx_A}{-r_A}$	$= C_{A_0}\int \frac{dx_A}{-r_A}$	$= \frac{1}{kC_{A_0}^{n-1}}\int \frac{(1+\varepsilon_A x_A)^n}{(1-x_A)^n}dx_A$
Back-mix reactor	$\theta = \frac{1}{S} = \frac{C_{A_0}x_A}{-r_A}$	$= \frac{C_{A_0}x_A}{-r_A}$	$= \frac{1}{kC_{A_0}^{n-1}}\frac{x_A(1+\varepsilon_A x_A)^n}{(1-x_A)^n}$

$\varepsilon_A = (V_{x_A=1} - V_{x_A=0})/V_{x_A=0}$ and $dx_A = -dN_A/C_{A_0}V$ only when $\varepsilon_A = 0$.
† = total pressure

*Adapted from Levenspiel, "Chemical Reaction Engineering," Wiley, New York, 1962.
†See Eq. (4-28).

reactor is represented by the space time τ or the space velocity S. As expressed by Eq. (4-68), calculation of θ requires knowledge of the rate expression as well as the variation in V with progress of the reaction. By contrast, τ, as defined by Eq. (4-70), is determined from the data for the feed under the specified conditions.

Listed in Table 4-11 are mathematical expressions for the mean residence time and the space time as a measure of capacity for various ideal reactors. These equations have been derived based on material balances and rate expressions, and cover both general and special cases, including that of an isothermal nth order reaction.

Sizing of a reactor using the equations in Table 4-11 may be illustrated by a general example for a plug-flow reactor. The space time τ can be estimated from the laboratory kinetic data through the expression

$$\tau = C_{A_0}\int \frac{dx_A}{-r_A}$$

Then from the definition of τ [Eq. (4-70)],

$$V = \frac{F_{A_0}}{C_{A_0}}\tau = v_0\tau$$

Hence, the required capacity of the reactor is computed from the specified feed rate and feed concentration of component A, and the space time.

Material and Energy Balances. Equations representing the material and energy balances are also required in the design of a chemical reactor system. A material balance describes the rates of chemical transformation of various components in terms of a specific rate expression, the feed-flow rate, and the reactor volume. Thus the composition of the reaction mixture can be computed from the material balance. The rate of heat liberation or absorption expressed as a function of the reaction rate and various thermal properties of the reaction system is obtained from an energy balance. This information is then used in the design of the heat-transfer equipment for the reactor system.

Material- and energy-balance equations for different types of reactors and various operations are summarized in Table 4-12, based on a complex reaction system of the following stoichiometry:

$$\begin{aligned} A + B &\xrightarrow{r_1} P \\ B + P &\xrightarrow{r_2} S \end{aligned}$$

The net forward rates are r_1 and r_2, respectively, for the first and second reactions, but no specific rate expression (*i.e.*, reaction mechanism) is assigned. These equations assume that no products P and S are present in the feed stream. Also presented in Table 4-12 are the applications, advantages, and disadvantages of various reactor types. The nomenclature applicable to Table 4-12 appears below.

A_w = heat-transfer area, sq ft
C_{A_0}, C_{B_0} = feed concentration of components A and B, moles/cu ft
C_p = molal heat capacity of ith component, Btu/(mole)(°F)
C_i = feed concentration of component *i*, moles/cu ft
D = reactor diameter, ft
F = feed rate, moles/sec
H_{i_0} = enthalpy of ith component in feed stream, Btu/mole
H_i = enthalpy of ith component, Btu/mole
$\Delta H_1, \Delta H_2$ = heat of reaction for reactions 1 and 2, respectively, Btu/mole
l = length along a tubular reactor, ft
N_i = number of moles of component *i*
r = reaction rate, moles/(sec)(cu ft)
r' = reaction rate, moles/(sec)(lb. of catalyst)
T = temperature of reacting mixture, °F
T_0 = reference temperature, °F
T_w = temperature of heat source or sink to or from which the reaction mixture is transferring heat, °F
U = over-all heat-transfer coefficient, Btu/(sec)(sq ft)(°F)
V_0 = initial volume of reaction mixture, cu ft
V = reactor volume, cu ft
v = reaction-mixture velocity, ft/sec
x_A = mole fraction of component A
ρ = molal density of reacting mixture at any point in tube, moles/cu ft
ρ_b = catalyst density (as packed), lb/cu ft
ρ_F = molar density of feed, moles/cu ft
θ = time, sec

Design Equations for Multiple-reactor Systems. When the reactor system consists of several reactors, the equations shown in Tables 4-11 and 4-12 are applicable to any single reactor in the system. The over-all performance of the system depends not only on the reactor type but also on the manner in which the reactors are connected (*i.e.*, series, parallel, or a combination of the two). In general, when a parallel arrangement of reactors exists in the system, the optimum system efficiency can be approached by adjusting the flow such that the compositions of the exit streams from the individual parallel branches before merging would be approximately the same.

Back-mix Reactors. For a system having m equal-sized back-mix reactors in series in which a reaction of a simple order is taking place under constant-volume conditions, the following expression can be derived from a material balance.
For first-order reaction

$$\theta_{\text{total all}} = \frac{m}{k}\left[\left(\frac{C_{A_0}}{C_{A_m}}\right)^{1/m} - 1\right] \tag{4-71}$$

where C_{A_m} is the concentration of A in the discharge stream from