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Laverman, R.J., Haynie, T.J., and Newbury, J.F.,

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Testing Program
to Measure Hydrocarbon Emissions
From a Controlled
Internal Floating Roof Tank

for

American Petroleum Institute
Committee on Evaporation Loss Measurement
Task Group 2519

Final Report
CBI Contract No. 05000

Chicago Bridge & Iron Company
March 1982

TESTING PROGRAM
TO MEASURE HYDROCARBON EMISSIONS
FROM A CONTROLLED
INTERNAL FLOATING ROOF TANK

FOR

AMERICAN PETROLEUM INSTITUTE
COMMITTEE ON EVAPORATION LOSS MEASUREMENT
TASK GROUP 2519

BY

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FINAL REPORT

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CHICAGO BRIDGE & IRON COMPANY

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SUMMARY

The American Petroleum Institute (API) intends to revise their Bulletins 2519 [1]* and 2523 [8] for use in estimating product loss or atmospheric emissions from internal floating roof tanks (IFRT). This revision will be developed from an information data base gathered from several sources including: field tank test data; pilot tank test data; laboratory test data; wind tunnel test data; and survey information. In revising the bulletins, it is intended to evaluate the independent emission contribution of each IFRT component including: seals; roof seams; and roof fittings.

To develop part of the information data base, an "IFRT Test Program" was performed by Chicago Bridge & Iron Company (CBI) under CBI Contract 05000 for the API. The Test Program was divided into four (4) phases:

<u>Phase 1</u>: Pilot Tank Emission Tests on a Bolted, Noncontact IFR

<u>Phase 2</u>: Pilot Tank Emission Tests on a Welded, Contact IFR

<u>Phase 3</u>: Pilot Tank Emission Tests on a Bolted, Contact IFR

<u>Phase 4</u>: Bench Scale Emission Tests on IFR Deck Fittings

The test conditions which were specified for use during Phases 1 through 3 were intended to permit an evaluation of the emission effects due to:

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*Numbers in brackets indicate reference numbers at the end of this report.

- Primary Seal Type
- Primary Seal Gaps
- Secondary Seal Type
- Secondary Seal Gaps
- Roof Seams
- Roof Fittings
- Internal Air Flow Distribution
- Roof Elevation
- Product Type (Both Single Component Products and Mixtures)
- Product Vapor Pressure

Phase 4 involved measuring the emissions from selected generic types of typical roof fittings including: column well; roof drain; adjustable leg; sample well; etc.

The Test Program was performed at CBI's Emission Test Tank Facility located at their Research Department in Plainfield, Illinois. Phases 1 through 3 were performed in a 20 ft. diameter IFR test tank. Phase 4 was performed in a test room equipped with five (5) similar apparatus to measure deck fitting emissions under controlled environment conditions.

In addition to the test work described above for Phase 1 through 4, the scope of the program was later expanded to include: laboratory and bench scale permeation rate tests on selected seal fabrics; and laboratory evaporation tests on several types of products.

The entire IFRT Test Program in the pilot IFR test tank extended from August, 1980 through October, 1981. After the completion of Phases 1, 2 and 3 in August, 1981, a complete review by the API of the test data indicated the need to supplement the results with additional tests. These additional tests involved all three of

The IFR's previously tested, and the additional tests were performed as Phases 1R, 2R and 3R, ending in October, 1981.

The IFR roof types used in this test program were selected so as to represent the three most common generic types of IFR's. The fabrication details used on the IFR's is typical of commercial construction, and the fit of the primary and secondary seals are typical of a commercial fitting seal.

This report presents the results of the IFRT Test Program. A detailed description of the chronological sequence of events during the program is contained in Appendix A.

The measured test tank data is tabulated in Appendix B, and the test results are plotted in a series of figures contained in Sections 2.3, 3.3 and 4.3 for Phase 1, 2 and 3, respectively. The measured bench scale roof fitting emission data is tabulated in Appendix E, and the test results are summarized in Section 5.1. Some observations regarding the trends in test results are made in these sections, but it is not the intent of this report to present a complete analysis of the test results. The test results will be thoroughly evaluated by the API Committee on Evaporation Loss Measurement, Task Group 2519 as they prepare for the revision of API Bulletin 2519. Conclusions from the test results regarding the emission contribution of IFRT components will be developed by Task Group 2519.

Nomenclature

Symbol	Description	Units
ΔC_M	Measured (outlet-inlet) total by hydrocarbon concentration change referred to the basis on which the THA is calibrated (normally a propane basis)	ppmv
ΔC_N	Normalized (outlet-inlet) total hydrocarbon concentration change referred to the basis on which the THA is calibrated (normally a propane basis)	ppmv
E	Emission rate	lbm/day
M	Molecular weight of the hydrocarbon used to calibrate the THA	lbm/lbm
P_M	Vapor pressure of the product at its test temperature	psia
P_N	Vapor pressure of the product to which the THA concentration change readings are normalized	psia
Q	Air flow rate	scfm
V	Ambient wind speed	mi/hr

Unit Description

lbm	Pound mass
lbf	Pound force
lbmole	Pound mole
ppmv	Parts per million on a volume basis
scfm	Standard cubic feet per minute
psia	Pound force per square inch, absolute

Chemical Compound Notation

C3	Propane
nC5	Normal pentane
nC6	Normal hexane

Nomenclature
(Continued)

Symbol	Chemical Compound Notation
C6H6	Benzene
nC7	Normal heptane
nC8	Normal octane
iC8	Iso octane
C3/nC8	Propane and normal octane mixture
nC5/nC8	Normal pentane and normal octane mixture

1.0 Introduction

1.1 Objectives

The primary objectives of the IFRT Test Program were to:

(1). perform hydrocarbon emission tests in a 20 ft. diameter pilot IFR test tank using three (3) different types of IFR's under a series of specified test conditions to permit evaluation of the emission contribution from the seals, roof seams and roof fittings.

(2). perform bench scale emission tests on selected roof fittings.

In addition to the above primary objectives, the scope of test work was expanded to include: laboratory and bench scale hydrocarbon permeation rate tests on selected seal fabrics; and laboratory evaporation tests on several types of hydrocarbon products.

1.2 Test Facility Description

The emission test program was performed in a covered floating roof test tank at CBI's Plainfield, Illinois, Research Facility. Figure 1.1 is a process and instrumentation schematic of the test tank facility.

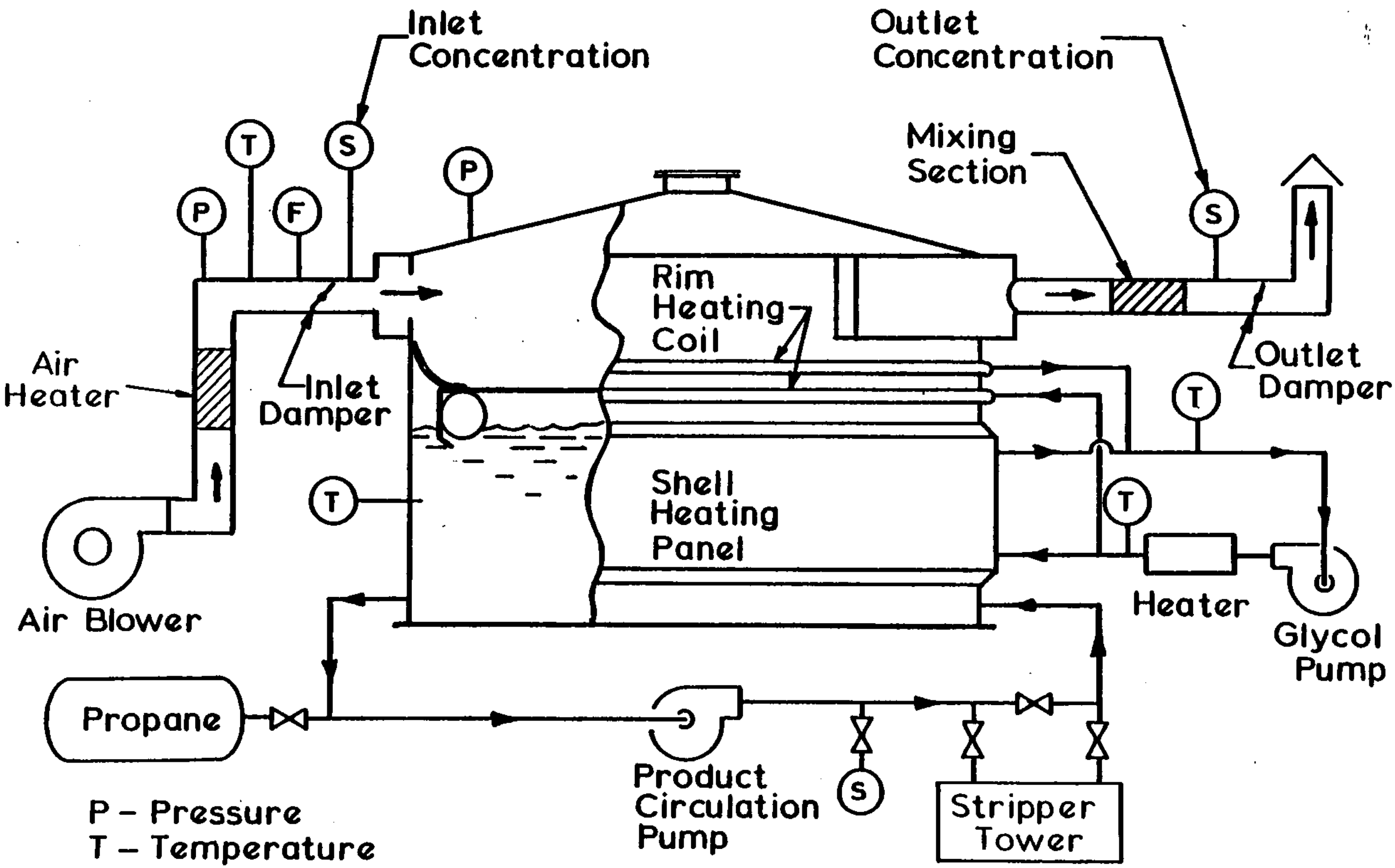
The test tank is 20 ft. in diameter and has a 9 ft. shell height. The lower 5 ft.-3 in. of the tank shell is provided with a heating/cooling jacket through which a heated or cooled water/ethylene glycol mixture is continuously circulated to control the product temperature. This jacket is insulated externally, and the tank rests on Foamglas load bearing insulating blocks.

Access into the interior of the test tank for the purpose of interchanging the types of internal floating roofs is provided by means of a flanged and bolted exterior cone roof. Personnel access into the test tank is provided by means of a 30 in. diameter manhole in the cone roof.

The test tank has numerous fittings provided for instrumentation, product addition or withdrawal, and product mixing.

Since these tests included product mixtures of propane and normal octane (C3/nC8), mixing was periodically required. The mixing system is comprised of a recirculating pipeline and a product circulation pump. Samples of the product were taken at the sample point located at the discharge of the circulation pump. To increase the vapor pressure of the C3/nC8 mixture, propane was injected into the product at the suction of the circulation pump. To reduce the vapor pressure of the C3/nC8 mixture, a stripper tower was added to the test facility during Phase 3. The stripper tower was 10 in. dia. by 12 ft.-6 in. long and was packed with 3/8 in. dia. Pall Rings. The product was transferred by the circulation pump to the top of the stripper tower, where it flowed

Fig. 1.1 Process And Instrumentation Schematic



P – Pressure
T – Temperature
F – Flow
S – Sample

downward over the packing countercurrent to air, which stripped the propane out of the product. From the bottom of the elevated stripper tower the product flowed by gravity back to the test tank.

The effect of ambient wind blowing through the shell vents of an IFRT into the vapor space above the IFR was simulated by means of a blower connected to the test tank. A 7 in. dia. insulated air duct connected the blower outlet to the test tank air inlet distribution plenum. The blower outlet temperature, pressure and air flow rate were measured. A pitot tube was utilized to measure the air velocity in the duct.

During Phase 1 of the test program, it was observed that the emission rate was affected by the temperature of the inlet air. Since it was the purpose of the test program to control and systematically vary the pertinent variables which affect emissions, an air heater was installed in the inlet air duct so that the inlet air temperature could be controlled at specified values.

The total hydrocarbon concentration of both the test tank inlet and outlet air were continuously measured using two Beckman Instruments, Inc., Model 400, Total Hydrocarbon Analyzers (THA). These instruments were zeroed and spanned during each 8 hr. shift on certified zero and span gases. Several different span gases with differing contents of gases were utilized so that the THA instrument could be spanned with a gas mixture whose content was close to the instrument reading for the test sample.

1.3 Test Method

Each of the emission tests performed in the test tank used essentially the same method. Prior to starting a test, the specified test conditions (shown in Tables 3.1, 4.1 and 5.1) were established. These test conditions included:

- Roof Type
- Primary Seal Type
- Primary Seal Gap Condition
- Secondary Seal Type
- Secondary Seal Gap Condition
- Roof Elevation
- Air Flow Distribution Type
- Deck Fitting Seal Condition
- Product Type
- Product Vapor Pressure
- Air Inlet Temperature

Test Procedure

A test consisted of measuring the emissions at several different equivalent ambient wind speeds from approximately 5 to 35 mi/hr. The test facility was manned three 8 hr. shifts per day (2 technicians per shift), and test data was recorded every 1/2 hr. The test data included:

- Inlet Air Flow Rate (i.e. blower discharge duct air velocity, pressure and temperature)
- Total Hydrocarbon Concentrations (air inlet and outlet)
- System Temperatures (ambient, product liquid, product rim vapor, product deck vapor, etc.).

Although the total hydrocarbon analyzers operated continuously, their readings were logged every 1/2 hr.

Steady State Criteria

After a given wind speed setting was established, the average of three (3) previous consecutive 1/2 hr. outlet concentration readings was compared to a new concentration reading. If the new reading was within 5% of the average of the three previous readings the system was considered to be at essentially steady state. The wind speed would then be adjusted to a new value, and again readings would be taken until the above criteria for steady state was met. Normally, it would take about 4 hrs. for the system to meet the steady state criteria.

Seal Gap Placement

During certain tests, intentional gaps were placed between a seal (either the primary or secondary seal) and the tank shell. The gap areas used were either 1 or 3 $in.^2$/ft. dia. (i.e. for the 20 ft. diameter test tank, 20 or 60 $in.^2$, respectively). For tests with 20 $in.^2$ of gap area, two 10 $in.^2$ gap area spacer bars were used, one each located on the NE and SW positions of the tank shell. For tests with 60 $in.^2$ gap area, four 15 $in.^2$ gap area spacer bars were used, one each located on the NE, SE, SW and NW positions of the tank shell.

Roof Component Sealing

During tests, it was necessary to seal off certain roof components. This was accomplished by using pieces of 0.020 in. thick polyurethane coated nylon fabric which was taped over the roof componen with aluminum backed duct tape.

Propane/Normal Octane Mixture Vapor Pressure Determination

Most of the emission tests performed in the test tank and several of the deck fitting emission tests utilized a product which was a mixture of propane (Commercial Grade) and normal octane (High Purity Grade). The product vapor pressure was varied by either adding propane to the mixture or stripping propane from the mixture.

During the course of the emission tests which utilized the mixture of propane/normal octane (C3/nC8), product samples were periodically taken. The dates and times when the test tank product was sampled are indicated on the Calendar of Events (Figures A1 through A15 in Appendix A) by the symbol S . These sample dates and the related tank emission test numbers are also listed on the vapor pressure maps (Figures D1 through D3 in Appendix D).

Precautions were taken in sampling the product to insure that it represented the contents of the test tank. Prior to sampling, the product recirculation pump was turned on for a period of about 1 hour to mix the contents of the test tank. The product sample was taken from the discharge of the recirculation pump in a 1 liter, screw top, glass sample bottle which was held in a plastic container packed with crushed ice. After sampling, the lid of the sample bottle was screwed tightly in place to prevent contamination or loss of sample product vapor.

In the laboratory, the sample bottle packed in its crushed ice plastic container was placed on a magnetic stirrer plate. The magnetic stir bar contained in the sample bottle was allowed to mix the sample and establish thermal equilibrium at 32°F.

After a period of about 1 hr., during which time thermal equilibrium of the sample was allowed to occur, the sample bottle cap was removed and replaced with a stopper containing two stainless steel tubes. One tube extended into the liquid to the bottom of the sample bottle and was used for sparging a small quantity of air through the sample. The other tube was connected to a demister in the sample bottle vapor space.

The sample was sparged with a controlled small flow rate of air for a short period of time to produce a saturated air/hydrocarbon vapor mixture at 32°F in the sample bottle vapor space and effluent tube. The sample bottle effluent tube was connected to the injection port of a Carle Instruments, Inc., Model 111 Gas Chromatograph.

The measured composition of the saturated vapor samples from the product sample bottles are summarized in Table D1 of Appendix D. These tabulated vapor compositions are actually the average of three successive vapor composition measurements from the same product sample.

The liquid compositions listed in Table D1 were determined from the measured vapor compositions by using the NGPA Mark V Thermodynamic Property Computer Program. Using the measured vapor composition and barometric pressure, the computer program calculated the corresponding liquid composition at its dewpoint condition.

Finally, after subtracting the air constituents from the calculated liquid composition, the computer program calculated the liquid vapor pressure at specified temperatures. These calculated vapor pressures at temperatures between 30 and 100°F are listed in Table D1.

Also shown at the bottom of Table D1 are the corresponding test tank emission test numbers for which the vapor pressure data was used. In many cases, more than one liquid sample applied to the same emission test. In most of these cases it was assumed that the product vapor pressure varied linearly with time between sample times. Thus, from a knowledge of the product temperature and the date and time of the specific test point, the product vapor pressure could be determined for that test point. In certain tests where the emission rate was very low, the average of several product sample analyses was used to determine the product vapor pressure (i.e. no time decay of product vapor pressure over the test period was considered).

In addition to using the NGPA Mark V Computer program to determine the product vapor pressure for each product sample composition analysis, the computer program was also used to determine the product vapor molecular weight. When these vapor molecular weights were plotted as a function of vapor pressure and temperature, it was found that a generalized plot could be constructed for C3/nC8 mixtures. Figure D4 is the resulting plot, and this plot was used to determine the product vapor molecular weight for each test.

Test Data

Tables B1, B2 and B3 in Appendix B summarize the measured test tank data. The values of air flow rate (scfm), product temperature (^{o}F) and measured (outlet-inlet) concentration (ppmv) listed in these tables at the specified test dates and times are average values. The values listed are an average of four (4) consecutive half hour readings, ending with the readings at the date and times specified in the tables.

The measured (outlet-inlet) total hydrocarbon concentration change ΔC_M was normalized to a concentration change ΔC_N at a common vapor pressure by means of following equation:

$$\Delta C_N = \Delta C_M \frac{\left\{ \dfrac{\left(\dfrac{P_N}{14.7}\right)}{\left[1 + \left(1 - \dfrac{P_N}{14.7}\right)^{0.5}\right]^2} \right\}}{\left\{ \dfrac{\left(\dfrac{P_M}{14.7}\right)}{\left[1 + \left(1 - \dfrac{P_M}{14.7}\right)^{0.5}\right]^2} \right\}}$$

where: ΔC_M = Measured (outlet-inlet) total hydrocarbon concentration change referred to the basis on which the THA was calibrated (normally a propane basis), (ppmv)

ΔC_N = Normalized (outlet-inlet) total hydrocarbon concentration change referred to the basis on which the THA was calibrated (normally a propane basis), (ppmv)

P_M = Vapor pressure of the product at its test temperature, (psia)

P_N = Vapor pressure to which the total hydrocarbon concentration readings were normalized, (psia)

For air flow distribution Type 1, the equivalent ambient wind speec V corresponding to the air flow rate Q was determined from the following equation (see Appendix H for its derivation):

$$V = \frac{Q}{(53.0)}$$

where: V = Equivalent ambient wind speed, (mi/hr)

Q = Air flow rate, (scfm)

The emission rate E was determined from the following equation:

$$E = \left[\left(\frac{60\ \text{min}}{\text{hr}}\right)\left(\frac{24\ \text{hr}}{\text{day}}\right)\left(\frac{1\ \text{lbmole}}{379.49\ \text{scf}}\right)\left(\frac{1\ \text{fraction}}{10^6\ \text{ppm}}\right)\right] QM\Delta C_N$$

$$E = (3.79X10^{-6})\ QM\Delta C_N$$

where: Q = Air flow rate (scfm)

ΔC_N = Normalized (outlet-inlet) total hydrocarbon concentration change referred to the basis on which the THA was calibrated, (ppmv)

M - Molecular weight of the hydrocarbon used to calibrate the THA, (lbm/lbmole)

E = Emission rate at the vapor pressure to which the total hydrocarbon concentration change was normalized, (lbm/day)

2.0 Bolted, Noncontact IFR Emission Tests

2.1 IFR Description

The bolted, noncontact IFR used during Phases 1 and 1R of the test program was supplied by Ultraflote Corporation.

Figure 2.1 is a plan view of the IFR. Floatation of the roof was provided by 8 sealed tubular floats of varying lengths from 4 ft. to 16 ft.-4 in. The roof was 18 ft.-10 in. diameter with an 7 in. wide rim space. The roof was of essentially all aluminum construction and had 8 fixed legs. The deck consisted of sheets of 0.023 in. thick aluminum sheet attached to clamping bars and the circumferential rim plate. The total length of clamped deck seams was 36 ft.

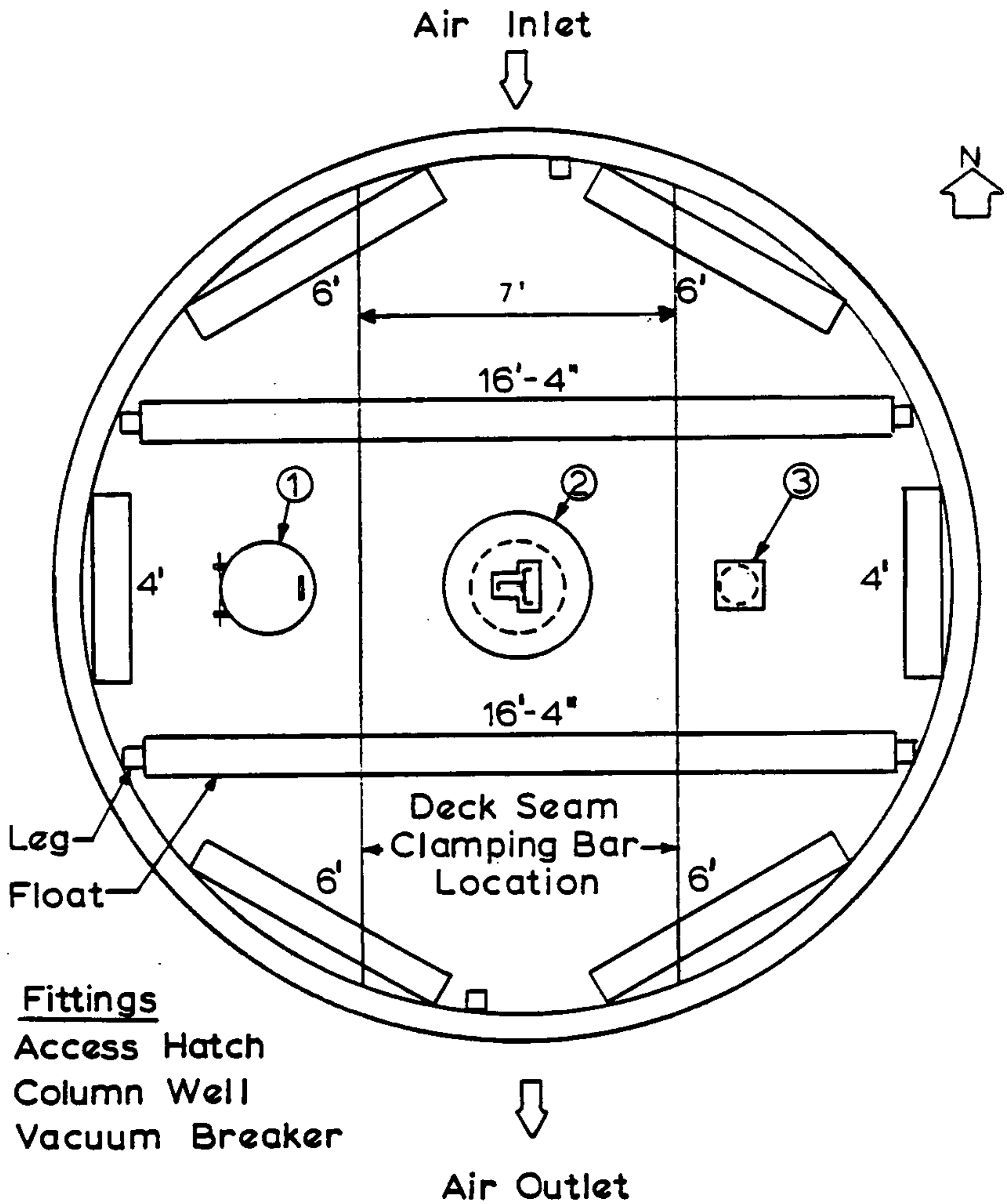
The roof was equipped with 3 deck fittings:

(1). access hatch
(2). column well
(3). vacuum breaker

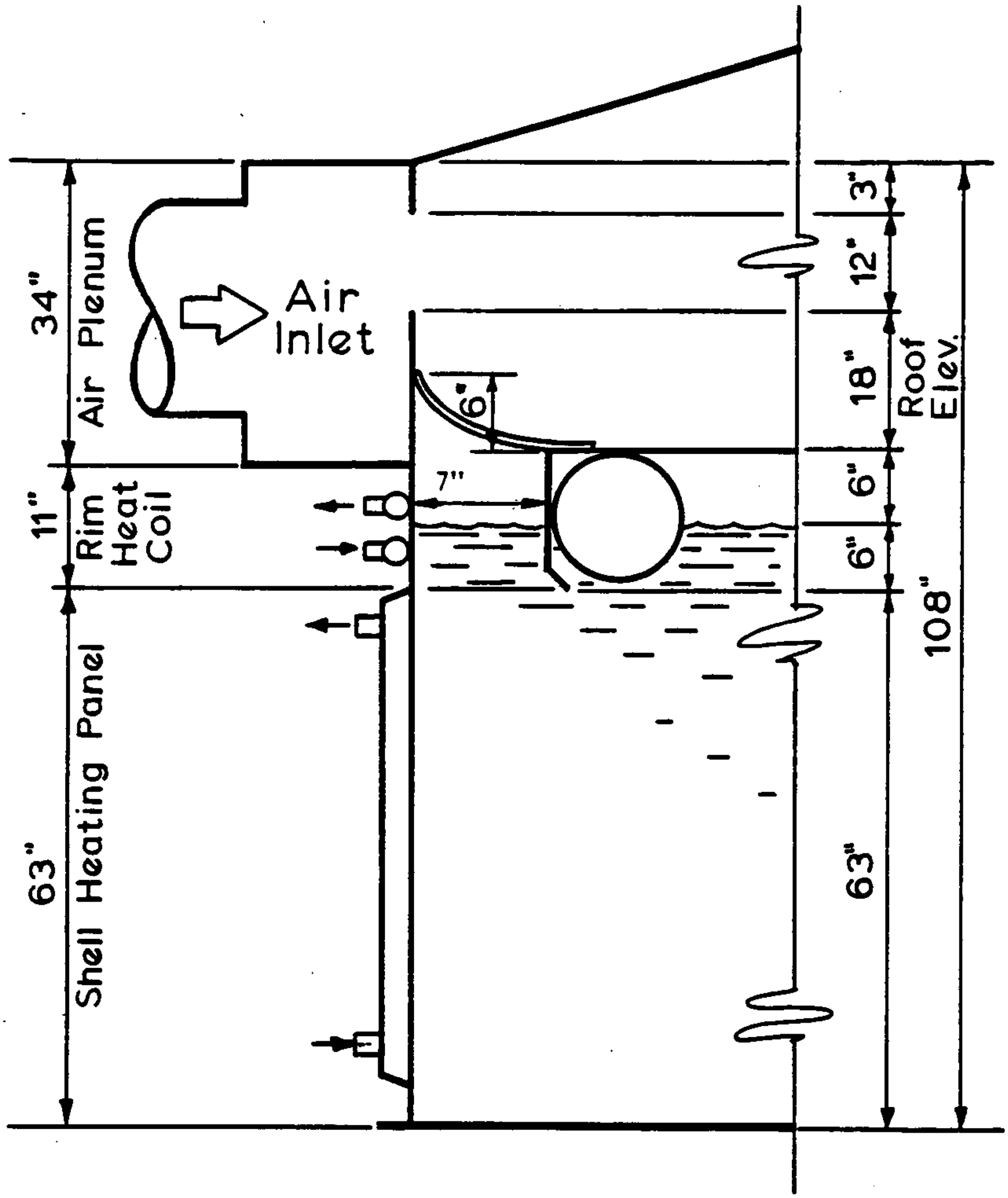
Figure 2.2 is an elevation view of the IFR, where it is shown floating at one of its test positions. The roof was tested at 4 different roof elevations (18, 30, 36 and 54 in.). All roof elevation dimensions refer to the distance between the bottom of the air inlet opening of the test tank and the top of the IFR deck. The roof was equipped with both a vapor mounted, flexible wiper primary seal (shown in Fig. 2.2) and a flexible wiper secondary seal, which was mounted 6 in. above the primary seal.

Figure 2.3 shows the thermocouple locations. Measurements of the liquid, vapor and deck temperatures were made on the North, South, and West sides of the IFR. These liquid temperatures were measured approximately 1 in. below the liquid surface. In the rim area of the IFR, measurements were made of the vapor temperature below the primary seal and between the primary seal and secondary seals on the North, South and West sides of the IFR.

Figure 2.1
Plan View Of Noncontact
Bolted IFR

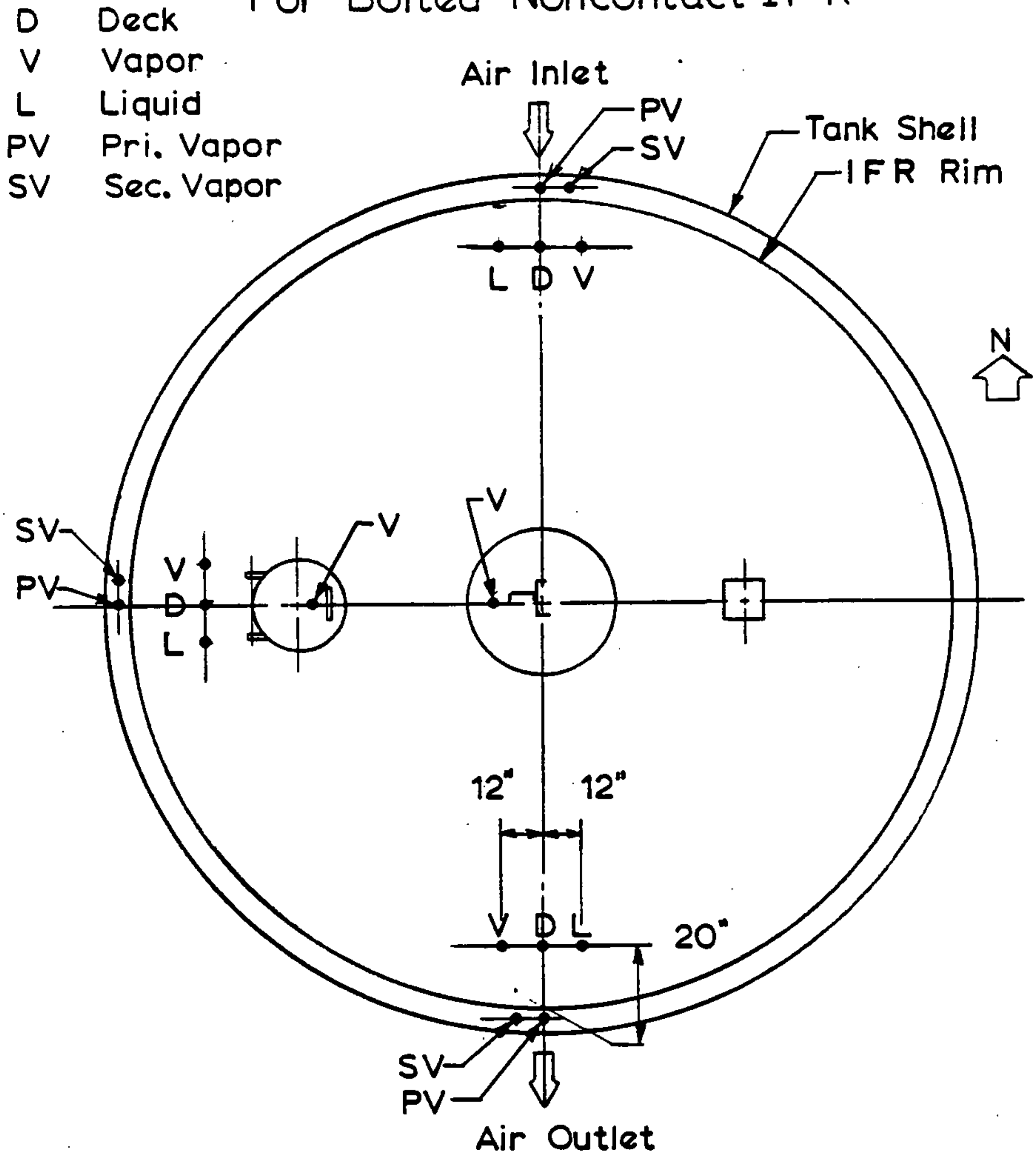


Fittings
1 Access Hatch
2 Column Well
3 Vacuum Breaker



Elevation View Of Noncontact
Bolted IFR In Test Tank
Figure 2.2

Figure 2.3
Thermocouple Locations
For Bolted Noncontact IFR



Plan View Of IFR

2.2 Test Conditions

Table 2.1 summarizes the test conditions used during Phases 1 (Tests Nos. API1 through API34) and Phase 1R (Test Nos. API73 through API77 on the bolted, noncontact IFR. The chronological sequence of events during these phases is described in Appendix A.

During the course of the testing program with the bolted, noncontact IFR, three different primary seals (all of the same construction) were utilized. They are referred to in this report as the "original primary seal", the "first replacement primary seal", and the "second replacement primary seal". Some differences in emissions was observed with these three different primary seals, and these differences seemed to depend on the fit of the seal to the tank shell.

Pressure tightness tests were performed on both the primary seals and the roof deck. The results of the pressure tightness tests are summarized in Appendix I.

The initial tests performed during Phase 1 indicated some dependence of emissions on the temperature difference between the tank inlet air and the product. Since the tank inlet air temperature depended on the varying ambient temperature, a heater was installed in the inlet air duct after Test API19 to permit the inlet air temperature to be controlled. Tests were performed where the temperature difference (air inlet-product) was systematically varied at -15, 0 and +15F° to determine the affect of this temperature difference on emissions. For the majority of the subsequent tests this temperature difference was kept at about 0F°.

TABLE 2.1 SUMMARY OF TEST CONDITIONS FOR PHASE 1 AND 1R

Test No.	Product Type	Nominal Vap. Press. (psia)	Gap Area (in^2/ft dia.) Pri.	Gap Area (in^2/ft dia.) Sec.	Roof Components: Column Well	Roof Components: Deck Fittings	Roof Components: Deck Seams	Roof Elev. Below Air Inlet (in)	Air Flow Type	Nominal (Air-Prod.) Temp. Diff. (°F)	Notes
Phase 1:											
API 1	C3/nC8	5.0	0	-	Unsealed	Unsealed	Unsealed	18	1	Variable	[8]
API 2	C3/nC8	5.0	0	-	Unsealed	Unsealed	Unsealed	18	2	Variable	
API 3	C3/nC8	5.0	0	-	Unsealed	Unsealed	Unsealed	30	1	Variable	
API 4	C3/nC8	5.0	0	-	Unsealed	Unsealed	Unsealed	54	1	Variable	
API 5	C3/nC8	5.0	0	-	Unsealed	Unsealed	Unsealed	54	2	Variable	
API 6	C3/nC8	5.0	0	-	Sealed	Sealed	Unsealed	18	1	Variable	
API 7	C3/nC8	5.0	1	-	Sealed	Sealed	Unsealed	18	1	Variable	
API 8	C3/nC8	5.0	3	-	Sealed	Sealed	Unsealed	18	1	Variable	
API 9	C3/nC8	0.5	3	-	Sealed	Sealed	Unsealed	18	1	Variable	
API 10	C3/nC8	0.5	1	-	Sealed	Sealed	Unsealed	18	1	Variable	
API 11	C3/nC8	0.5	0	-	Sealed	Sealed	Unsealed	18	1	Variable	
API 12	C3/nC8	0.5	0 [1]	-	Sealed	Sealed	Unsealed	18	1	Variable	
New Primary Seal Installed											
API 13	nC8	0.5	0	-	Sealed	Sealed	Unsealed	18	1	Variable	[8]
API 14	nC8	0.5	1	-	Sealed	Sealed	Unsealed	18	1	Variable	
API 15	C3/nC8	5.0	0	-	Unsealed	Unsealed	Unsealed	18	4	Variable	
API 16	C3/nC8	5.0	0	-	Unsealed	Unsealed	Unsealed	18	3	Variable	
API 17	C3/nC8	5.0	0	0	Sealed	Sealed	Unsealed	18	1	Variable	
API 18	C3/nC8	5.0	3	0	Sealed	Sealed	Unsealed	18	1	Variable	
API 19	C3/nC8	5.0	3	1	Sealed	Sealed	Unsealed	18	1	Variable	
API 19A	C3/nC8	5.0	3	1[2]	Sealed	Sealed	Unsealed	18	1	Variable	

TABLE 2.1 SUMMARY OF TEST CONDITIONS FOR PHASE 1 AND 1R (continued)

Test No.	Product Type	Nominal Vap. Press. (psia)	Gap Area (in^2/ft dia.) Pri.	Sec.	Roof Components: Column Well	Deck Fittings	Deck Seams	Roof Elev. Below Air Inlet (in)	Air Flow Type	Nominal (Air-Prod.) Temp. Diff. (°F)	Notes
Air Duct Heater Installed											
API 20	C3/nC8	Variable	0	-	Unsealed	Unsealed	Unsealed	18	1	0	[3]
API 21A	C3/nC8	5.0	0	-	Unsealed	Unsealed	Unsealed	18	1	-15	
API 21B	C3/nC8	5.0	0	-	Unsealed	Unsealed	Unsealed	18	1	0	
API 21C	C3/nC8	5.0	0	-	Unsealed	Unsealed	Unsealed	18	1	+15	
API 21D	C3/nC8	5.0	0	-	Unsealed	Unsealed	Unsealed	18	1	0	[4]
API 21E	C3/nC8	5.0	0	-	Unsealed	Unsealed	Unsealed	18	1	Variable	
API 22A	C3/nC8	5.0	1	-	Unsealed	Unsealed	Unsealed	18	1	-15	
API 22B	C3/nC8	5.0	1	-	Unsealed	Unsealed	Unsealed	18	1	0	
API 22C	C3/nC8	5.0	1	-	Unsealed	Unsealed	Unsealed	18	1	+15	
API 22D	C3/nC8	5.0	1	-	Unsealed	Unsealed	Unsealed	18	1	Variable	
API 23	C3/nC8	5.0	Sealed	-	Sealed	Sealed	Unsealed	18	1	0	
API 24	C3/nC8	5.0	Sealed	-	Unsealed	Sealed	Unsealed	18	1	0	
API 25	C3/nC8	5.0	Sealed	-	Unsealed	Unsealed	Unsealed	18	1	0	
API 26A	C3/nC8	3.5	1	-	Unsealed	Unsealed	Unsealed	18	1	0	
API 26B	C3/nC8	2.5	1	-	Unsealed	Unsealed	Unsealed	18	1	0	
API 27A	C3/nC8	0.5	1	-	Unsealed	Unsealed	Unsealed	18	1	-15	
API 27B	C3/nC8	0.5	1	-	Unsealed	Unsealed	Unsealed	18	1	0	
API 27C	C3/nC8	0.5	1	-	Unsealed	Unsealed	Unsealed	18	1	+15	
API 28	C3/nC8	0.5	0	-	Unsealed	Unsealed	Unsealed	18	1	0	
API 29	nC8	0.5	1	-	Unsealed	Unsealed	Unsealed	18	1	0	[5]
API 29R	nC8	0.5	1	-	Unsealed	Unsealed	Unsealed	18	1	0	
API 30	nC8	0.5	0	-	Unsealed	Unsealed	Unsealed	18	1	0	[5]
API 30R	nC8	0.5	0	-	Unsealed	Unsealed	Unsealed	18	1	0	
API 31	nC8	0.5	1	0	Unsealed	Unsealed	Unsealed	18	1	0	
API 31A	nC8	0.5	1	0	Unsealed	Unsealed	Unsealed	18	1	+15	
API 32	nC6	2.5	0	-	Unsealed	Unsealed	Unsealed	18	1	0	
API 33	nC6	2.5	1	-	Unsealed	Unsealed	Unsealed	18	1	0	
API 33A	nC6	2.5	1	-	Unsealed	Unsealed	Unsealed	18	1	+15	
API 34	nC6	2.5	1	-	Unsealed	Unsealed	Unsealed	36	1	0	
API 34A	nC6	2.5	1	-	Unsealed	Unsealed	Unsealed	36	1	+15	

TABLE 2.1 SUMMARY OF TEST CONDITIONS FOR PHASE 1 AND 1R (continued)

Test No.	Product Type	Nominal Vap. Press. (psia)	Gap Area (in^2/ft dia.) Pri.	Sec.	Roof Components Column Well	Deck Fittings	Deck Seams	Roof Elev. Below Air Inlet (in)	Air Flow Type	Nominal (Air-Prod.) Temp. Diff. (°F)	Notes
Phase 1R:											
API 73	C3/nC8	5.0	0	-	Unsealed	Unsealed	Unsealed	18	1	0	[7]
API 73A	C3/nC8	5.0	0	-	Unsealed[6]	Unsealed	Unsealed	18	1	0	
API 74	C3/nC8	5.0	0	-	Unsealed[6]	Unsealed	Unsealed	36	1	0	
API 75	C3/nC8	5.0	3	-	Unsealed[6]	Unsealed	Unsealed	36	1	0	
API 76	C3/nC8	5.0	Sealed	-	Sealed	Sealed	Unsealed	36	1	0	
API 76R	C3/nC8	5.0	Sealed	-	Sealed	Sealed	Unsealed	36	1	0	
API 77	C3/nC8	5.0	Sealed	-	Sealed	Sealed	Sealed	36	1	0	

Notes:
[1]. Seal closure devices were installed to eliminate all unintentional gaps.
[2]. Gaps in the secondary seal were rotated 45° to position them directly above the primary seal gaps.
[3]. Emission test data is questionable due to variable product temperature causing nonequilibrium conditions.
[4]. Emission test data is questionable due to nonequilibrium condition in the rim vapor space due to prior air purge.
[5]. Emission test data is questionable due to air inlet heater control problems.
[6]. A column well gasket was used during this test.
[7]. Emission test data is questionable due to nonequilibrium condition of product caused by insufficient mixing.
[8]. This emissions test was performed before the inlet air duct heater was installed.

Air Flow Distribution Types

During Phase 1 of the test program, an attempt was made to investigate the affect of 4 different types of air flow distribution on emissions. Figure 2.4 is a summary description of air flow distribution Types 1 through 4.

There are 10 openings in either the air inlet or outlet plenum, each about 1 ft^2 in area. For Type 1 air flow distribution, all of the inlet and outlet plenum openings were used, and vertical slats were positioned in certain plenum openings to shape the inlet and outlet air flow distribution more closely to that determined from wind tunnel tests [4]. Based on measured wind tunnel pressure coefficient data, Appendix H describes the derivation of the relationship between the air flow rate Q (scfm) and equivalent ambient wind speed V (mi/hr) for the Type 1 air flow distribution.

For a small diameter IFRT, the number of shell vents would be limited to only a few (a minimum of 4). Depending on how these few shell vents were oriented relative to the ambient wind direction, they could give internal flow distribution patterns which are different than those in larger diameter tanks (i.e. tanks which have many shell vents would be expected to have a Type 1 air flow distribution).

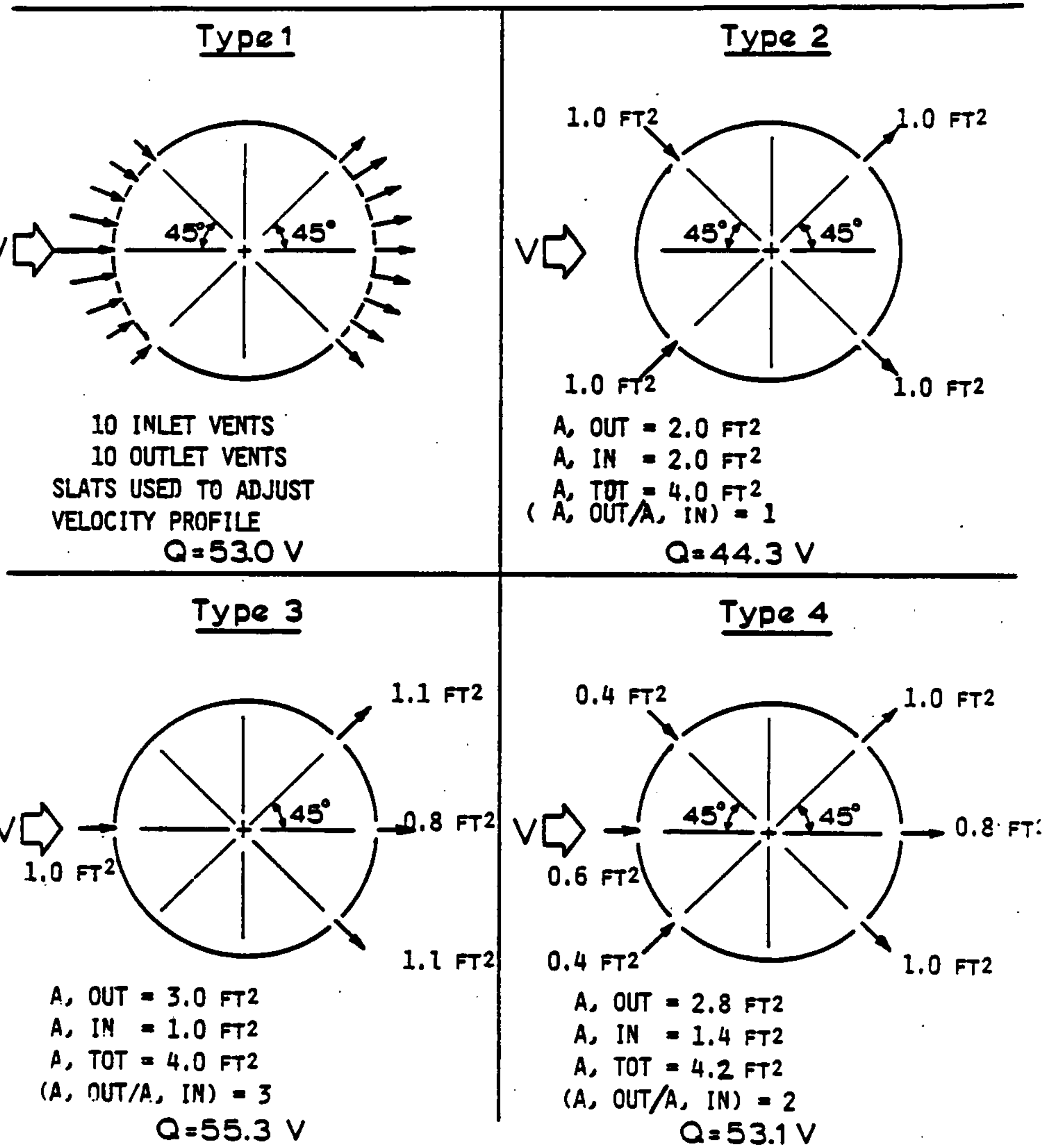
Air flow distribution Types 2, 3 and 4, which may apply to small diameter IFRT's, were selected for evaluation. For these types of air flow distribution, most of the plenum openings were completely closed. Figure 2.4 summarizes the number, area and location of plenum openings used for Types 2, 3 and 4. Also shown on Figure 2.4 are the relationships between air flow rate Q and equivalent ambient wind speed V for each type of air flow distribution. These relationships were derived from measured wind tunnel-pressure coefficient data in a manner similar to that shown in Appendix H for Type 1 air flow distribution.

To better understand the internal air flow patterns caused by air flow distribution Types 1 through 4, vapor space velocity surveys were performed. The results of these surveys are described in Appendix C.

Emission tests (Tests Nos. 1, 2, 4, 5, 15 and 16) were performed to evaluate the affect of air flow distribution Types 1 through 4 on emissions.

It was felt that air flow distribution Type 1 more closely represented the typical IFRT, and thus was Type 1 used for the rest of the emission test program.

Figure 2.4
Air Flow Distribution Types



2.3 Test Results

The measured test data for Phase 1 and 1R are tabulated in Table B1 in Appendix B, and are plotted on Figures 2.5 through 2.20. The tests plotted on these figures were selected to illustrate the emission effects of certain variables. Listed below are some observations which were made from a preliminary examination of the test results. It is not intended in this report to present a listing of all of the conclusions that can be drawn from the test results, since this will result from a complete review of the test data by the API-CELM-Task Group 2519.

It was observed that most of the tests showed little or no dependency of emissions on ambient wind speed, especially for wind speeds below 20 mi/hr. Table 2.2 tabulates the average emissions for each test in Phases 1 and 1R for all of the data points with wind speeds less than or equal to 20 mi/hr. Thus, to determine the effect of a particular parameter on emissions for wind speeds less than 20 mi/hr, it is only necessary to form differences between the emission values listed in Table 2.2 for the tests where the effects of the parameter were varied.

The effect of roof elevation on emissions is shown in Figures 2.5, 2.6 and 2.17. In general, roof elevation variation did not appear to significantly affect losses.

The effect of air flow distribution pattern on emissions is shown in Figure 2.10 for air flow Types 1 through 4. There was a discernable emission difference for these types of air flow distribution patterns. However, as is noted in Appendix C, the air flow distribution pattern caused by Type 1 is more indicative of that which would be expected to occur in the broad population of IFRT's.

The effect of (air-product) temperature difference on emissions is shown in Figure 2.12, where differences of -15, 0 and +15F° produced only small effects on the emissions, especially with an ungapped primary seal.

The effect of primary seal gaps on emissions is shown: in Figure 2.7 for the original primary seal; in Figure 2.12 for the first replacement primary seal; and in Figure 2.18 for the second replacement primary seal. Small gaps (i.e. 1 in^2/ft dia.) did not seem to have a significant effect on emissions. It was also observed that the emissions resulting from the second replacement primary seal were lower than both the original and first replacement primary seals.

The effect of primary and secondary seal gaps on emissions is shown in Figures 2.11. Some reduction in emissions can be observed with the use of secondary seals.

The effect of deck fittings on emissions is shown in Figures 2.13 and 2.18. From Figure 2.13 it can be seen that the column well (ungasketed) was the major contributor to the emissions from the deck fittings used in Phase 1.

The effect of vapor pressure on emissions is shown in Figures 2.19 and 2.20. Although emissions in general appeared to increase with increasing vapor pressure, the vapor pressure function cannot be discerned from Figure 2.20 due to the experimental difficulties experienced during Phase 1 in stripping propane from the product in the tank. After the stripper tower was added to the test facility in Phase 3, a carefully controlled series of emission tests at variable vapor pressure produced test data that should allow the vapor pressure function to be determined.

TABLE 2.2 SUMMARY OF EMISSION TEST RESULTS FOR BOLTED, NONCONTACT IFR

Test No.	Average Vap. Press. (psia)	Nominal Vap. Press. (psia)	Vapor Mole Wt. (lbm/lbmole)	Emissions [1] at Average Vap. Press. (lbm/day)	Emissions [1] at Average Vap. Press. (lbmole/day)	Emissions [1] at Nom. Vap Press (lbm/day)	Emissions [1] at Nom. Vap Press (lbmole/day)	Standard Deviation (%)
API 1	4.75	5.00	47.1	10.5	0.223	11.2	0.238	10.1
API 2	2.85	5.00	51.0	(9.20)[2]	(0.180) [2]	(17.7) [2]	(0.347) [2]	27.5
API 3	5.05	5.00	47.3	14.5	0.307	14.3	0.302	8.23
API 4	4.30	5.00	48.0	13.2	0.275	15.8	0.329	10.5
API 5	4.65	5.00	47.6	(17.2) [2]	(0.361) [2]	(18.8) [2]	(0.395) [2]	17.3
API 6	4.80	5.00	47.8	13.9	0.291	14.6	0.305	10.2
API 7	4.75	5.00	47.7	12.6	0.264	13.4	0.281	10.6
API 8	5.00	5.00	47.4	14.6	0.308	14.6	0.308	16.0
API 9	0.50	0.50	63.5	(16.9) [3]	(0.266) [3]	(16.9) [3]	(0.266) [3]	68.5
API10	0.41	0.50	72.5	(1.76)[3]	(0.0243) [3]	(2.15)[3]	(0.0297) [3]	53.2
API11	0.38	0.50	77.5	(7.41) [3]	(0.0956) [3]	(9.79)[3]	(0.126) [3]	81.8
API12	0.40	0.50	76.5	(0.681)[3]	(0.00890)[3]	(0.854)[3]	(0.0112) [3]	28.3
API13	0.44	0.50	111.	5.10	0.0459	5.81	0.0523	5.82
API14	0.46	0.50	110.	(7.94) [3]	(0.0722) [3]	(8.64) [3]	(0.0785) [3]	30.8
API15	3.80	5.00	46.0	(10.8) [2]	(0.235) [2]	(15.0) [2]	(0.326) [2]	35.0
API16	3.70	5.00	46.1	(21.5) [2]	(0.466) [2]	(30.7) [2]	(0.666) [2]	54.6
API17	5.15	5.00	45.9	2.54	0.0553	2.45	0.0534	6.85
API18	5.00	5.00	45.9	4.50	0.0980	4.50	0.0980	11.1
API19	4.95	5.00	45.9	5.69	0.124	5.76	0.125	22.7
API19A	5.00	5.00	45.9	5.96	0.130	5.96	0.130	19.3
API19, 19A	4.95	5.00	45.9	5.81	0.127	5.88	0.128	19.5
API21A	2.75	5.00	47.5	2.27	0.0478	4.55	0.0958	11.1
API21B	2.70	5.00	47.5	2.06	0.0434	4.21	0.0886	9.10
API21C	2.65	5.00	47.5	2.08	0.0438	4.33	0.0912	8.31
API21A, B, C	2.70	5.00	47.5	2.12	0.0446	4.34	0.0914	8.49

TABLE 2.2 SUMMARY OF EMISSION TEST RESULTS FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Average Vap. Press. (psia)	Nominal Vap. Press. (psia)	Vapor Mole Wt. (lbm/lbmole)	Emissions [1] at Average Vap. Press. (lbm/day)	Emissions [1] at Average Vap. Press. (lbmole/day)	Emissions [1] at Nom. Vap. Press. (lbm/day)	Emissions [1] at Nom. Vap. Press. (lbmole/day)	Standard Deviation (%)
API22A	3.85	5.00	45.8	5.29	0.116	7.23	0.158	12.5
API22B	3.85	5.00	45.8	5.90	0.129	8.06	0.176	9.16
API22C	3.85	5.00	45.8	6.79	0.148	9.28	0.203	8.78
API22A, B, C	3.85	5.00	45.8	5.98	0.131	8.18	0.179	13.5
API23	6.85	5.00	45.8	5.05	0.110	3.36	0.0734	11.9
API24	7.05	5.00	45.8	7.22	0.158	4.62	0.101	10.1
API25	7.20	5.00	45.8	6.79	0.148	4.22	0.0921	5.47
API26A	3.80	3.50	46.3	3.74	0.0808	3.40	0.0734	8.34
API26B	2.40	2.50	48.5	2.61	0.0538	2.73	0.0563	9.39
API27A	0.72	0.50	61.0	2.53	0.0415	1.74	0.0285	9.70
API27B	0.72	0.50	61.0	1.90	0.0311	1.31	0.0215	21.6
API27C	0.72	0.50	61.0	2.41	0.0395	1.66	0.0272	6.84
API27A, B, C	0.72	0.50	61.0	2.23	0.0366	1.54	0.0252	18.9
API28	0.71	0.50	62.0	1.60	0.0258	1.09	0.0176	12.0
API29R	0.29	0.50	105.	(4.68) [2]	(0.0446) [2]	(8.13)[2]	(0.0774) [2]	53.2
API30	0.29	0.50	105.	1.92	0.0183	3.35	0.0319	10.4
API31	0.27	0.50	108.	(1.99) [3]	(0.0184) [3]	(3.71)[3]	(0.0344) [3]	33.0
API31A	0.27	0.50	108.	(0.959)[3]	(0.00888) [3]	(1.79)[3]	(0.0166) [3]	41.0
API31,31A	0.27	0.50	108.	(1.64) [3]	(0.0152) [3]	(3.07)[3]	(0.0284) [3]	46.0
API32	2.05	2.50	86.2	(1.64) [3]	(0.0190) [3]	(2.04)[3]	(0.0237) [3]	26.2
API33	2.35	2.50	86.2	(2.12) [4]	(0.0246) [4]	(2.27)[4]	(0.0263) [4]	-
API33A	2.35	2.50	86.2	(2.30)[3]	(0.0267) [3]	(2.46)[3]	(0.0285) [3]	34.8
API33, 33A	2.35	2.50	86.2	(2.27)[3]	(0.0263) [3]	(2.43)[3]	(0.0282) [3]	32.2
API34	2.45	2.50	86.2	2.21	0.0256	2.26	0.0262	4.77
API34A	2.45	2.50	86.2	2.88	0.0334	2.94	0.0341	18.7

TABLE 2.2 SUMMARY OF EMISSION TEST RESULTS FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Average Vap. Press. (psia)	Nominal Vap. Press. (psia)	Vapor Mole Wt. (lbm/lbmole)	Emissions [1] at Average Vap. Press. (lbm/day)	Emissions [1] at Average Vap. Press. (lbmole/day)	Emissions [1] at Nom. Vap. Press. (lbm/day)	Emissions [1] at Nom. Vap. Press. (lbmole/day)	Standard Deviation (%)
API34, 34A	2.45	2.50	86.2	2.59	0.0300	2.65	0.0307	20.2
API73A	5.80	5.00	46.6	3.04	0.0652	2.52	0.0541	21.0
API74	5.40	5.00	46.6	3.02	0.0648	2.74	0.0588	7.07
API75	5.35	5.00	46.7	3.40	0.0728	3.13	0.0670	8.08
API76	5.25	5.00	46.8	2.73	0.0583	2.57	0.0549	19.2
API76R	5.25	5.00	46.8	2.21	0.0472	2.08	0.0444	9.76
API76, 76R	5.25	5.00	46.8	2.52	0.0538	2.37	0.0506	19.4
API77	5.15	5.00	47.1	1.75	0.0372	1.69	0.0359	12.0

Notes: [1]. Emission values tabulated are the average emission value for all data points with wind speeds less than or equal to 20 mi/hr.
[2]. Test results indicate a strong wind speed dependance.
[3]. Excessive data scatter.
[4]. Only one data point with wind speed less than or equal to 20 mi/hr was recorded.

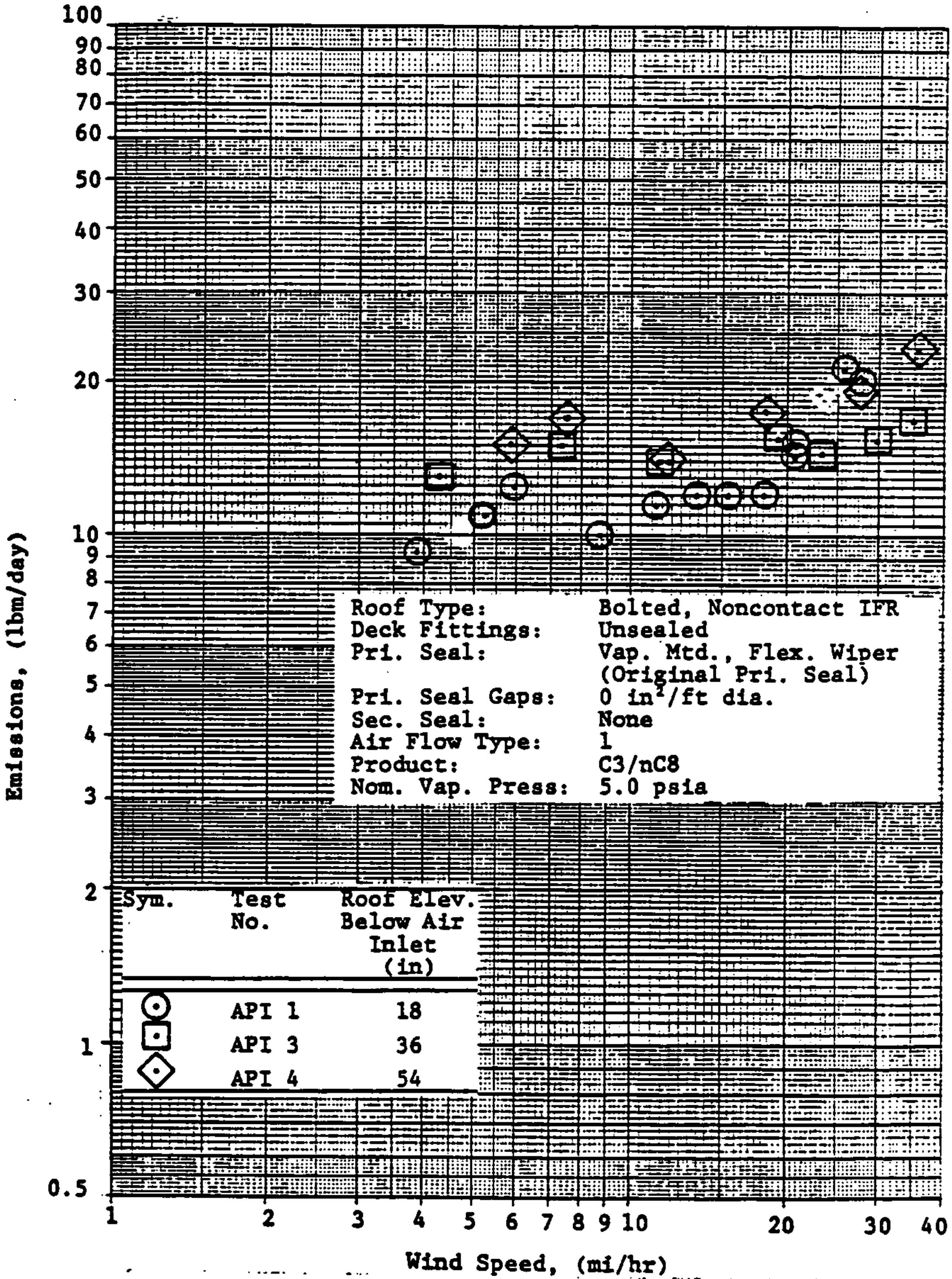


Figure 2.5 Effect of Roof Elevation on Emissions for the Original Primary Seal With Type 1 Air Flow Distribution

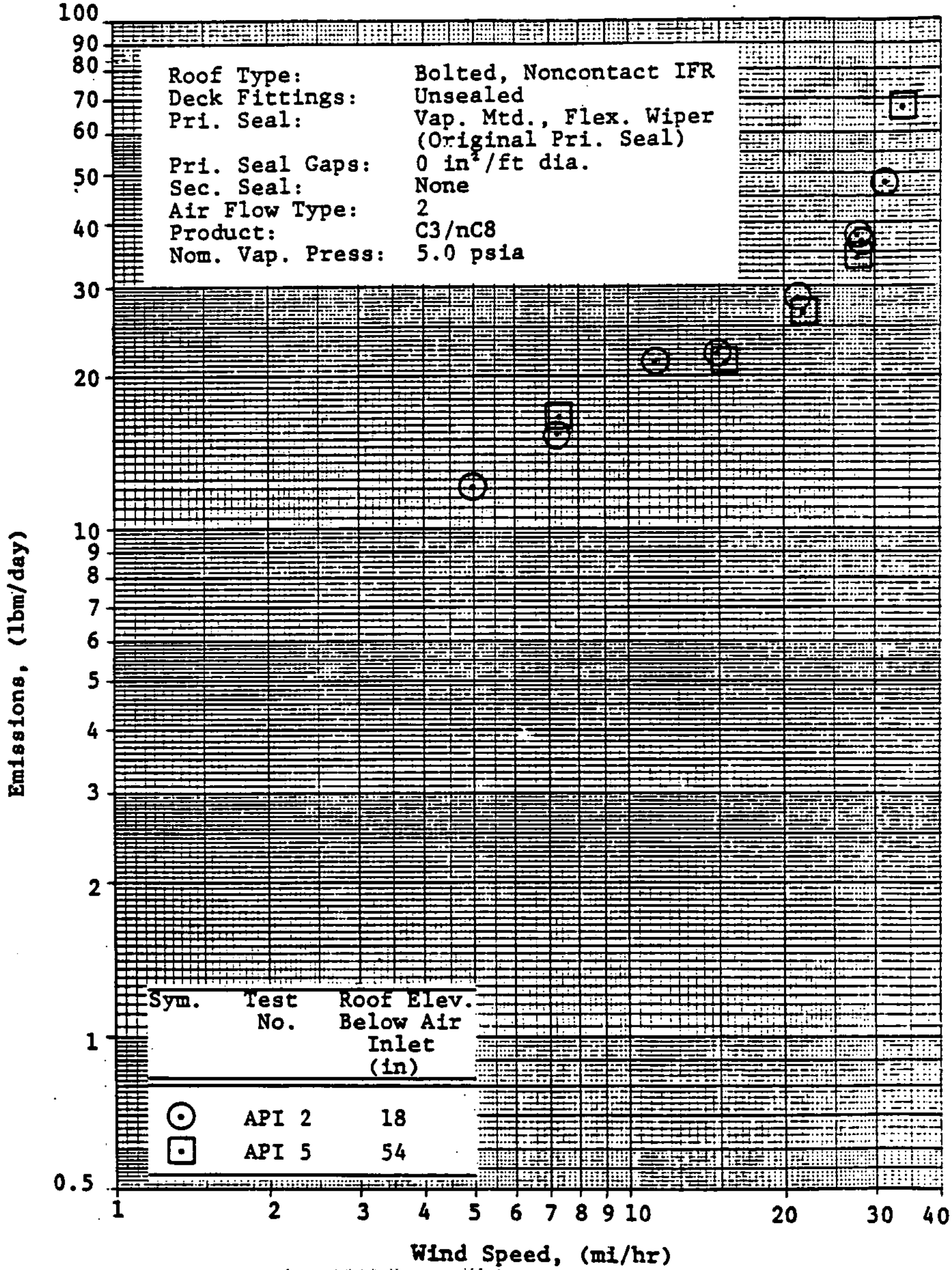


Figure 2.6 Effect of Roof Elevation on Emissions for the Original Primary Seal With Type 2 Air Flow Distribution

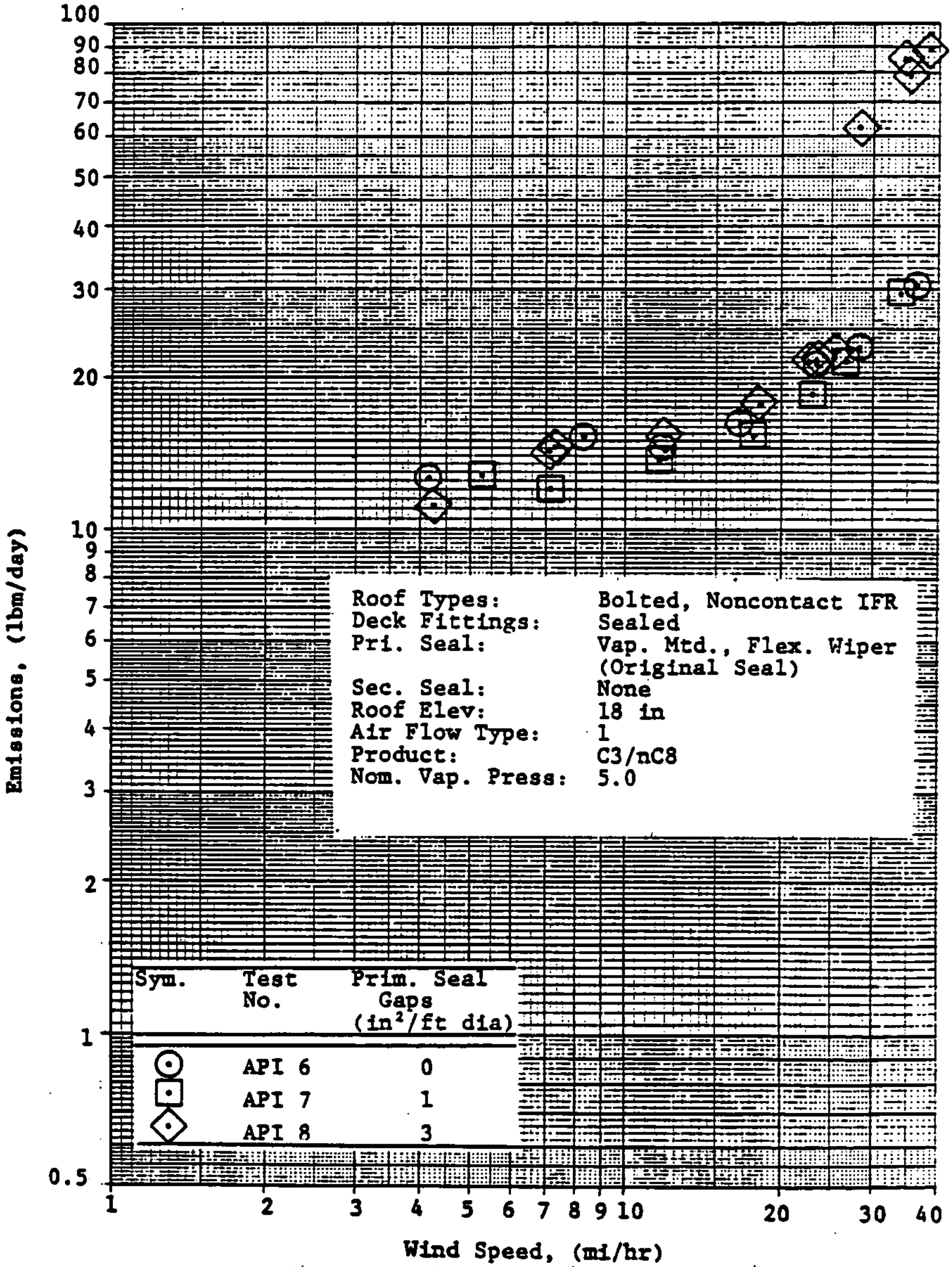


Figure 2.7 Effect of Primary Seal Gaps on Emissions for the Original Primary Seal with a 5.0psia Vapor Pressure C3/nC8 Mixture

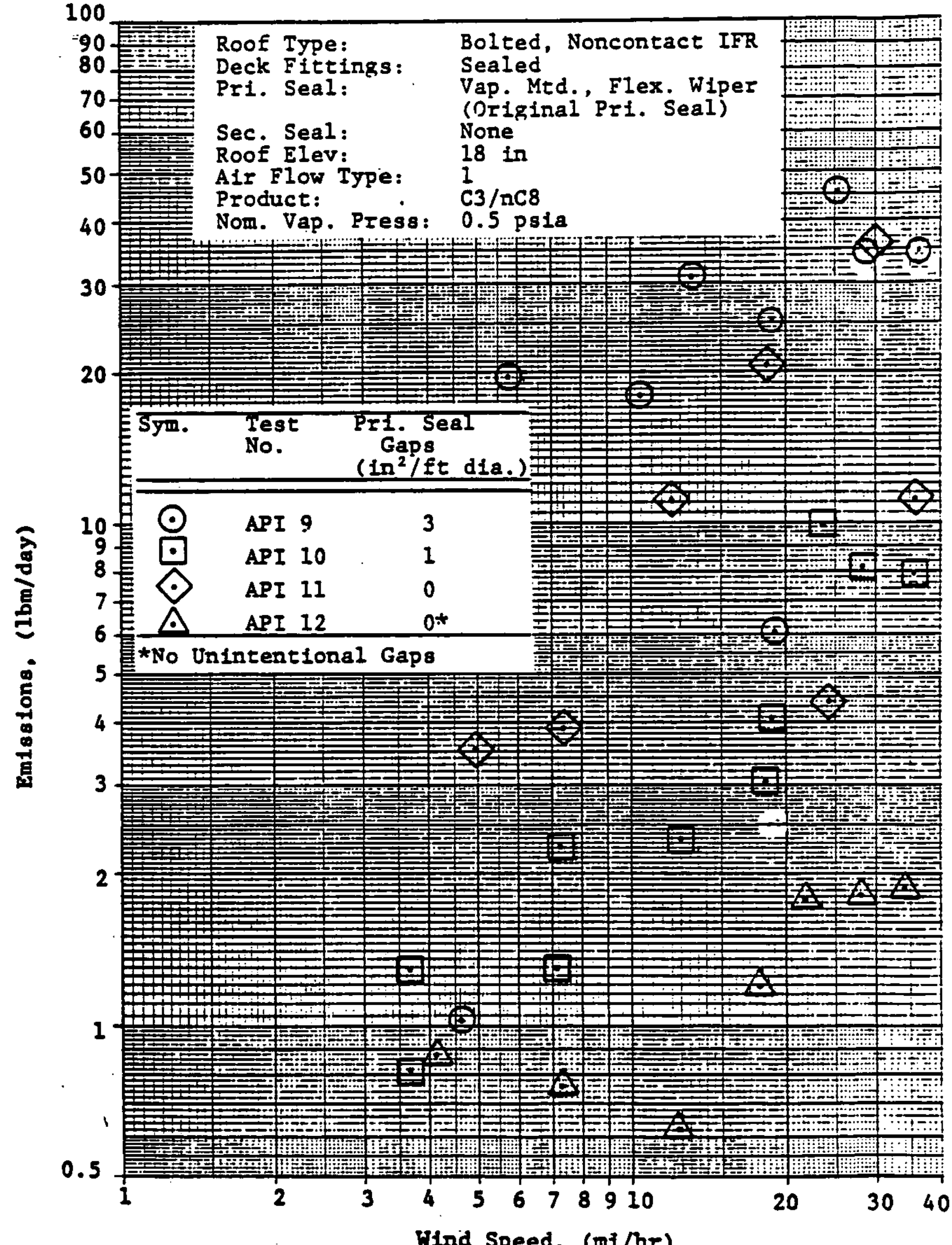


Figure 2.8 Effect of Primary Seal Gaps on Emissions for the Original Primary Seal With a 0.5 psia Vapor Pressure C3/nC8 Mixture

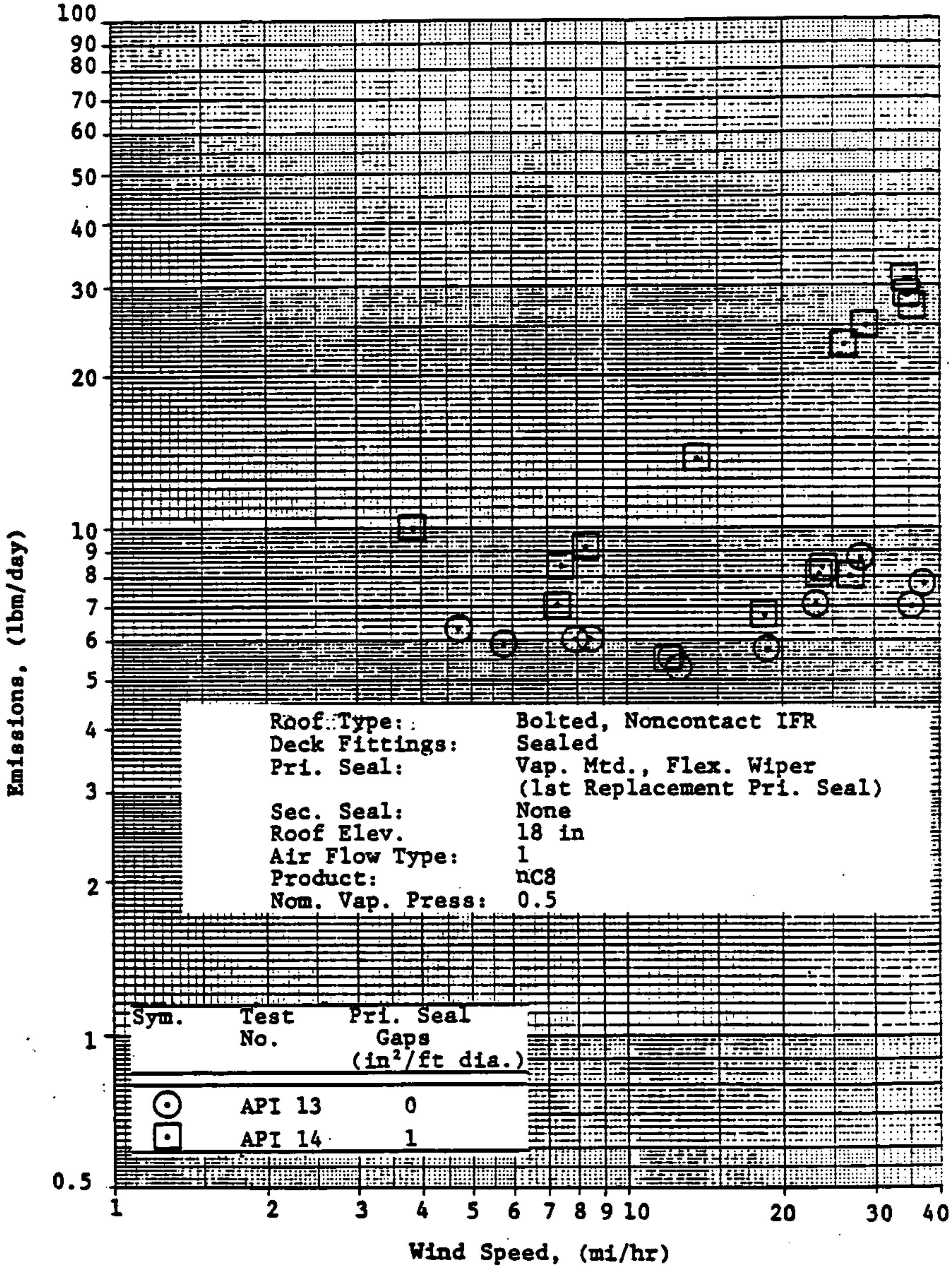


Figure 2.9 Effect of Primary Seal Gaps on Emissions for the First Replacement Primary Seal With nC8 Product

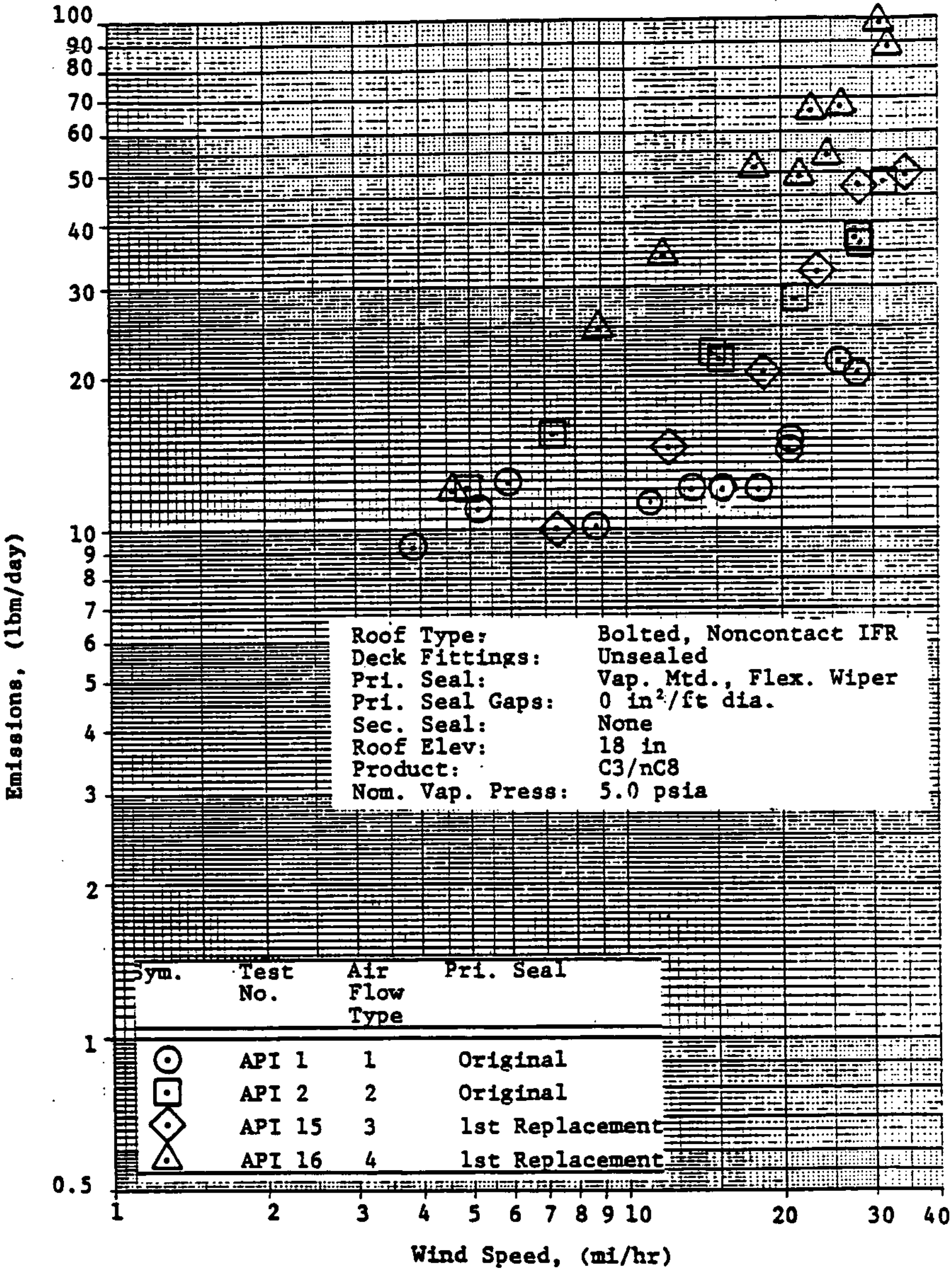


Figure 2.10 Effect of Air Flow Distribution on Emissions

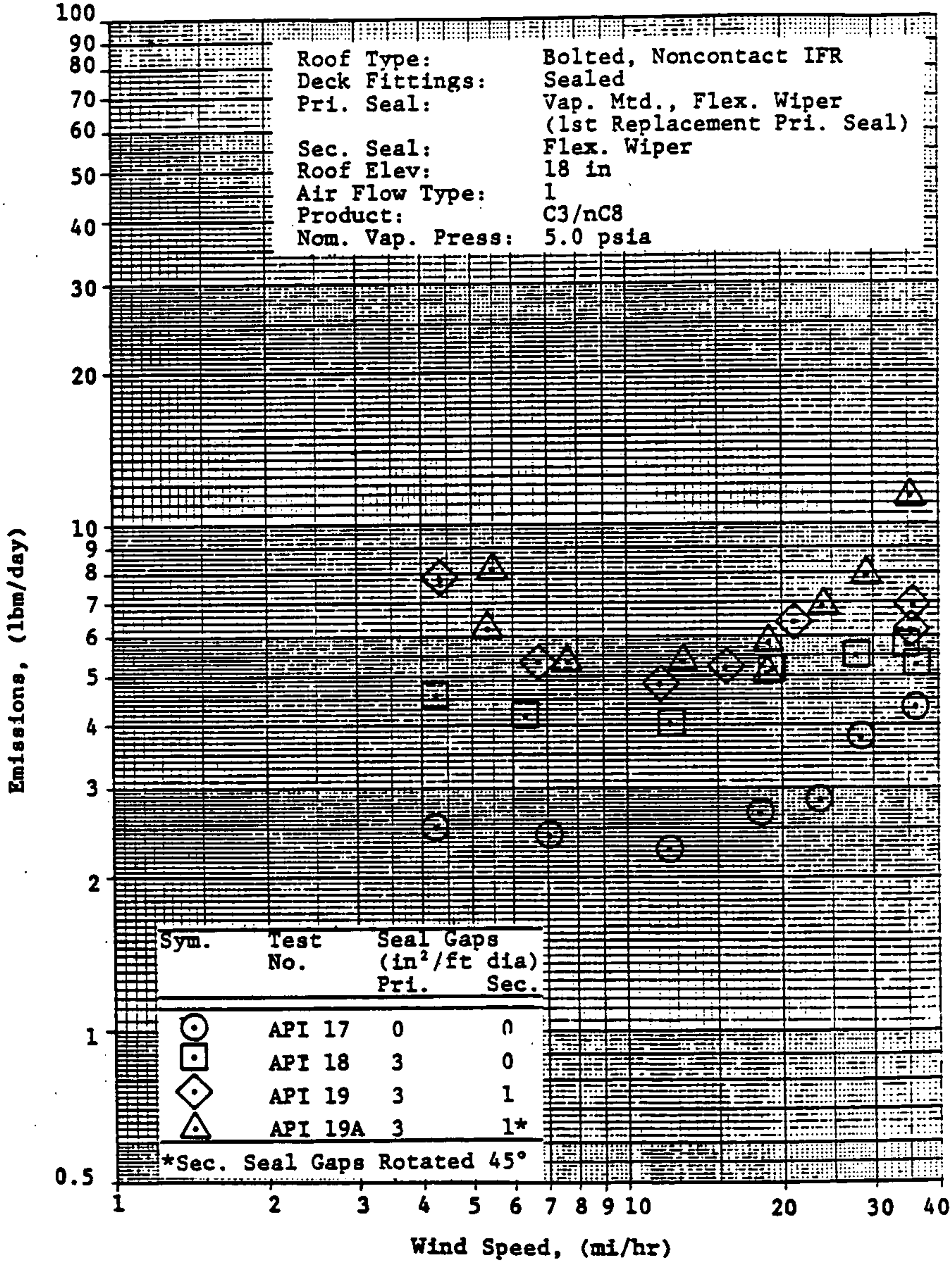


Figure 2.11 Effect of Primary and Secondary Seal Gaps on Emissions for First Replacement Primary Seal

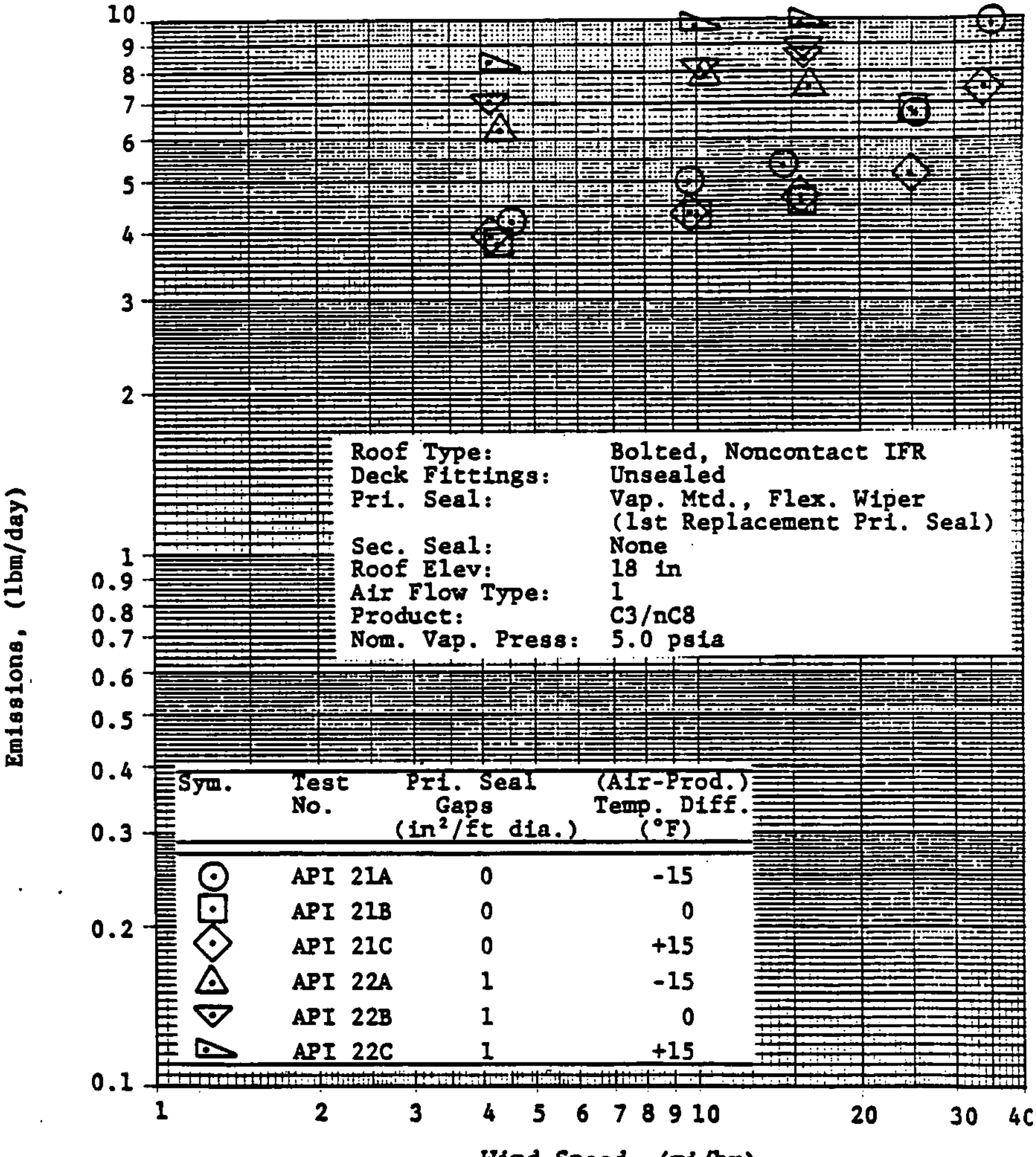


Figure 2.12 Effect of Primary Seal Gaps and (Air-Prod.) Temperature Difference on Emissions for the 1st Replacement Primary Seal

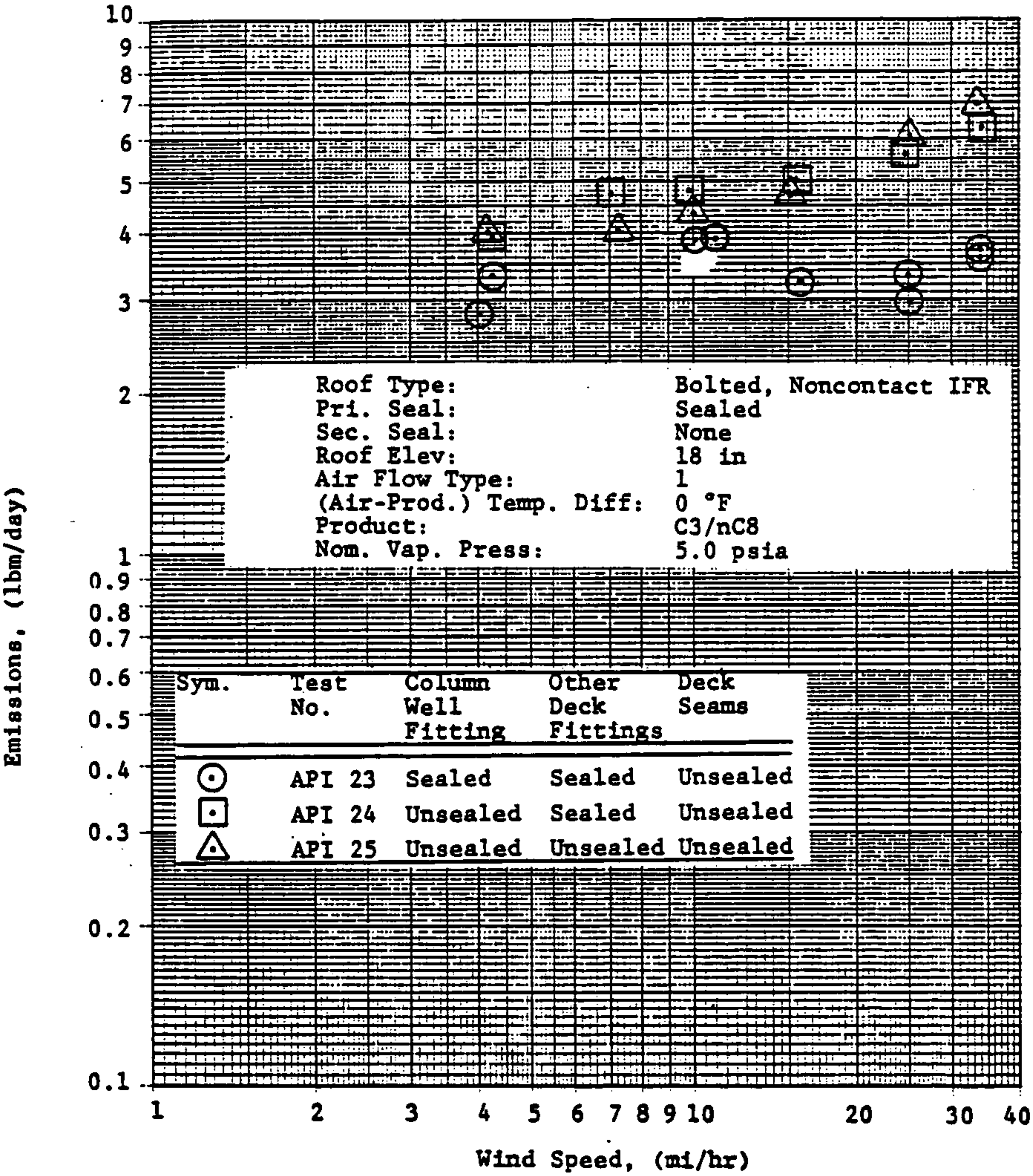


Figure 2.13 Effect of Deck Fittings on Emissions

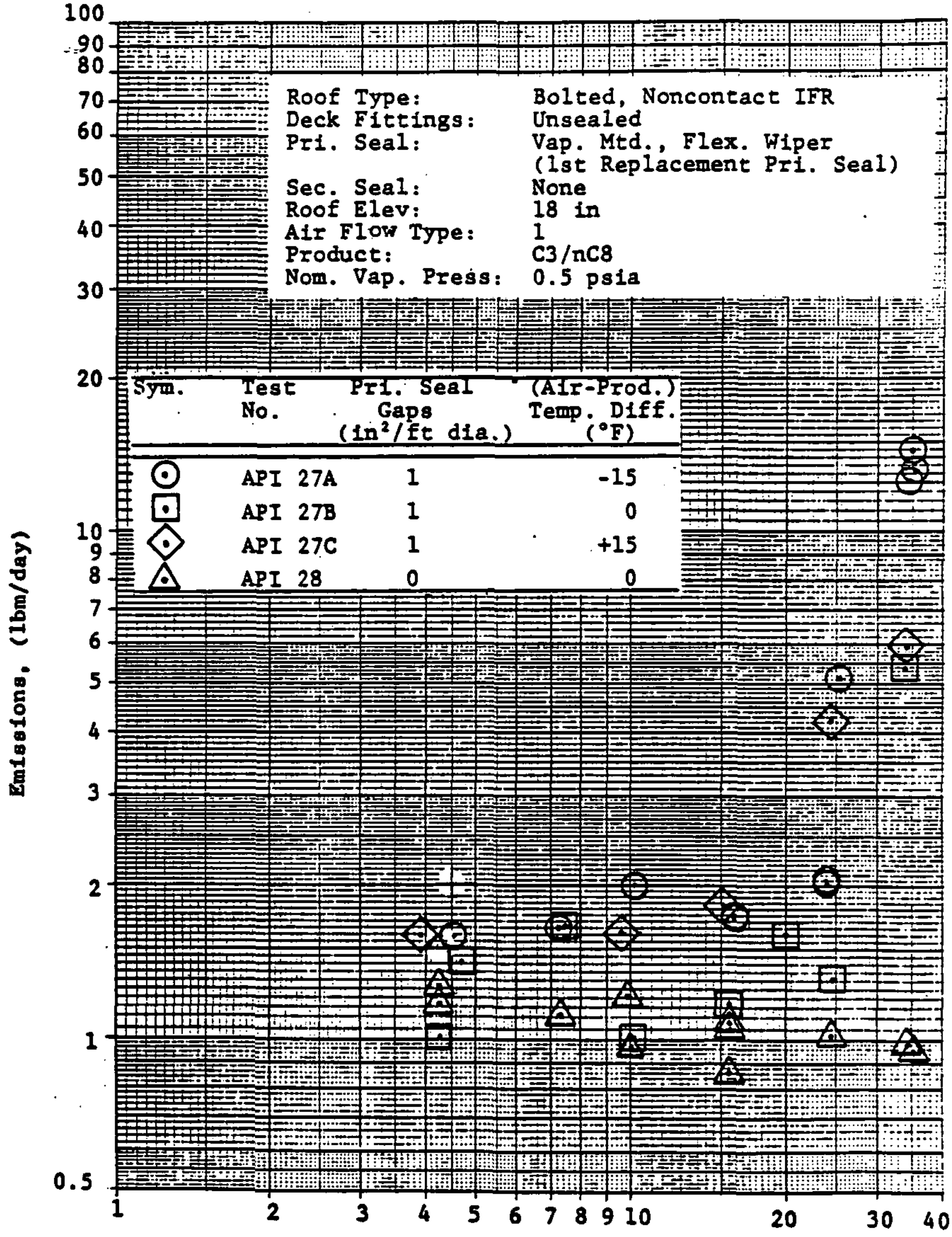


Figure 2.14 Effect of Primary Seal Gaps on Emissions for the 1st Replacement Primary Seal With a 0.5 psia Vapor Pressure C3/nC8 Mixture

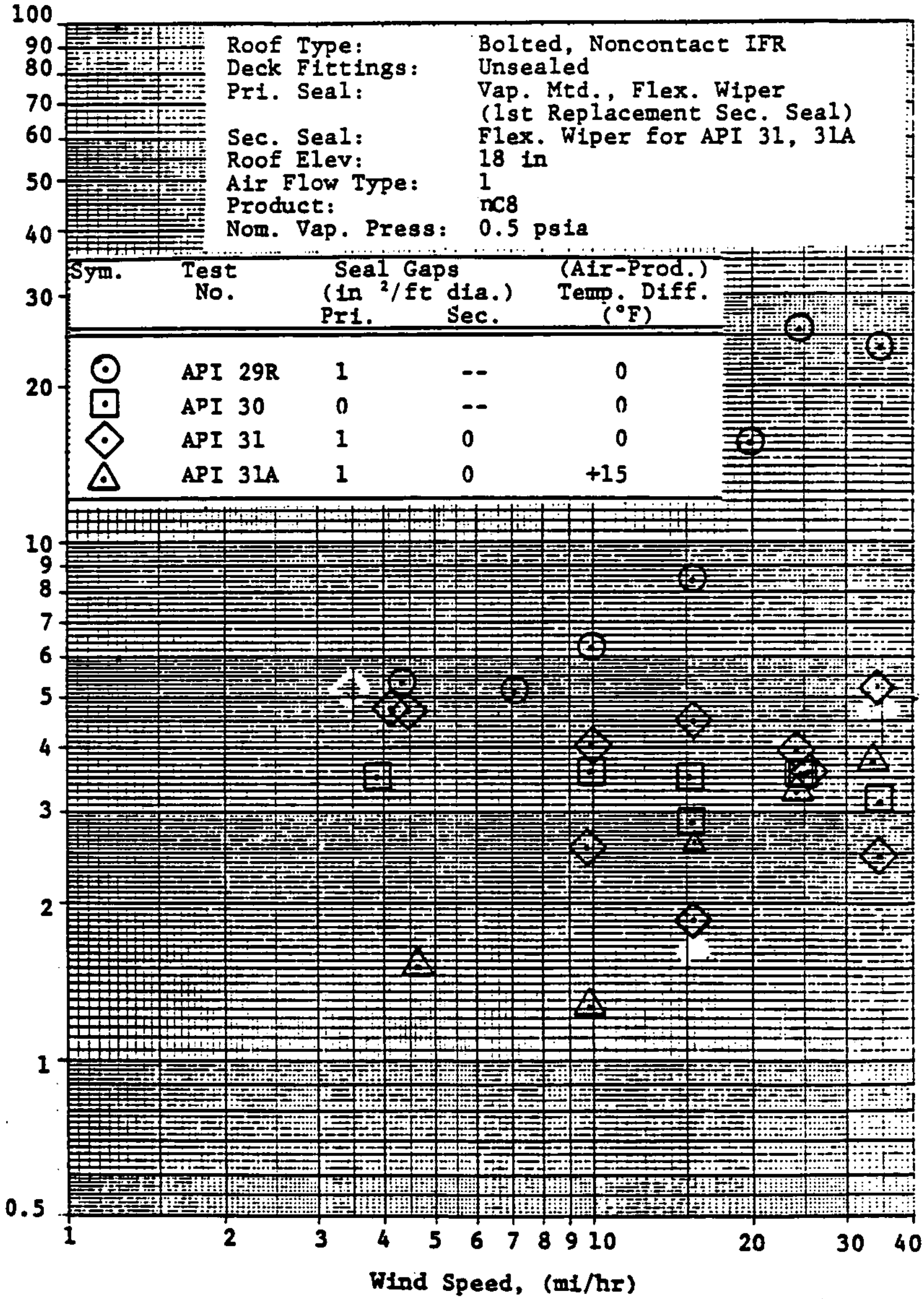


Figure 2.15 Effect of Primary and Secondary Seal Gaps on Emissions for the 1st Replacement Primary Seal With nC8

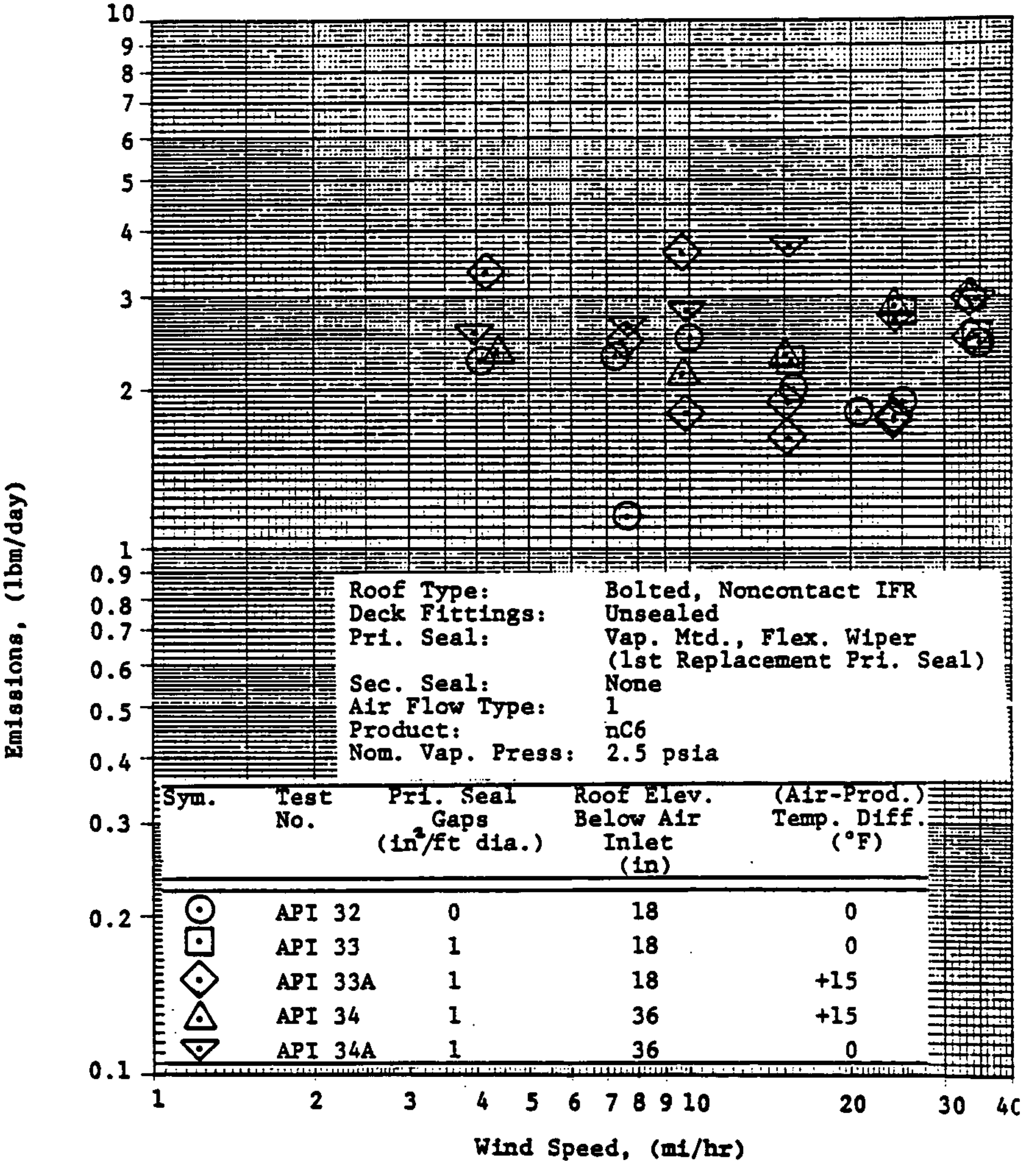


Figure 2.16 Effect of Primary Seal Gaps and Roof Elevation on Emiss
for the 1st Replacement Primary Seal With nC6

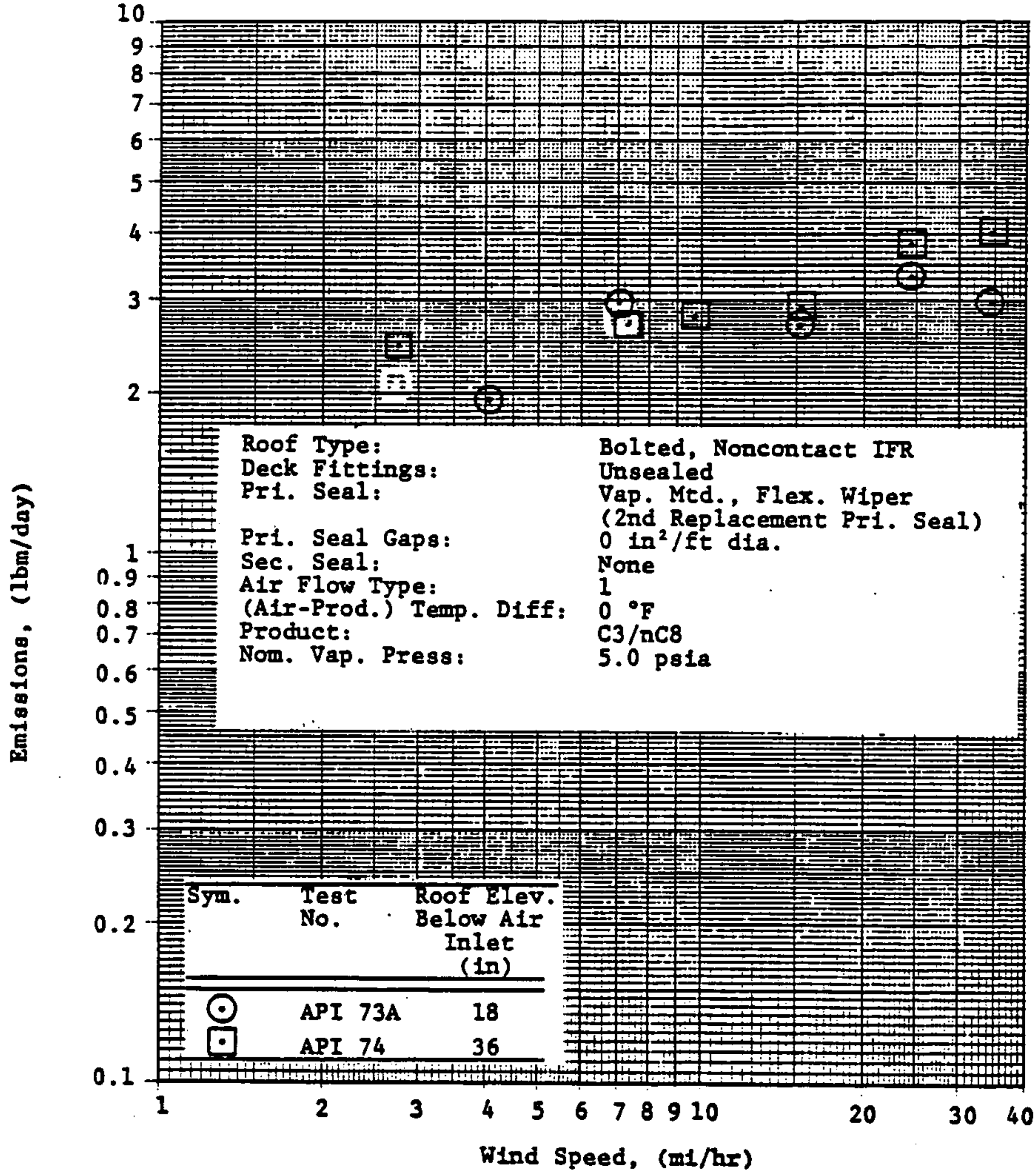


Figure 2.17 Effect of Roof Elevation on Emissions for the 2nd Replacement Primary Seal

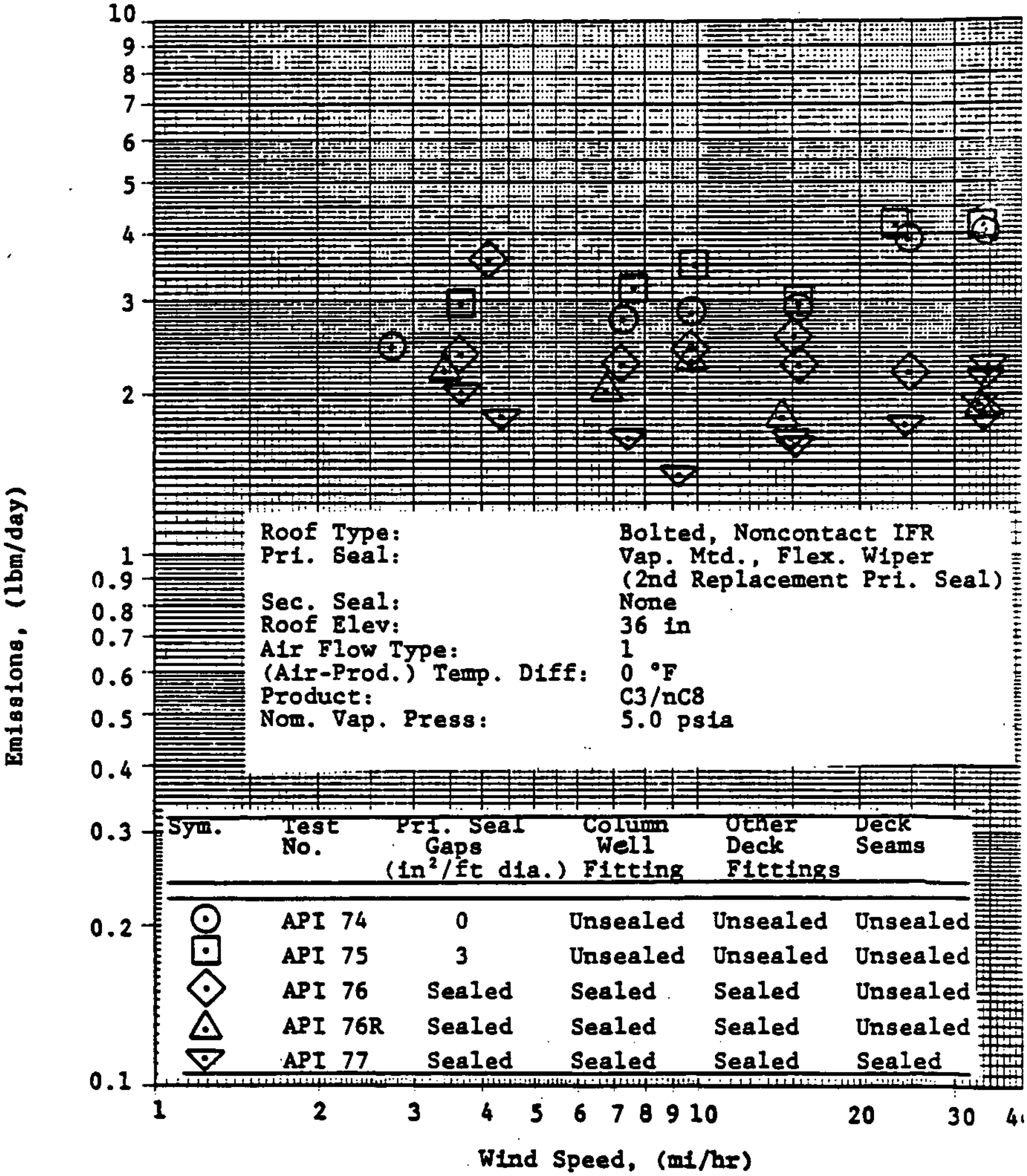


Figure 2.18 Effect of Primary Seal Gaps and Deck Fittings on Emissions for the 2nd Replacement Primary Seal.

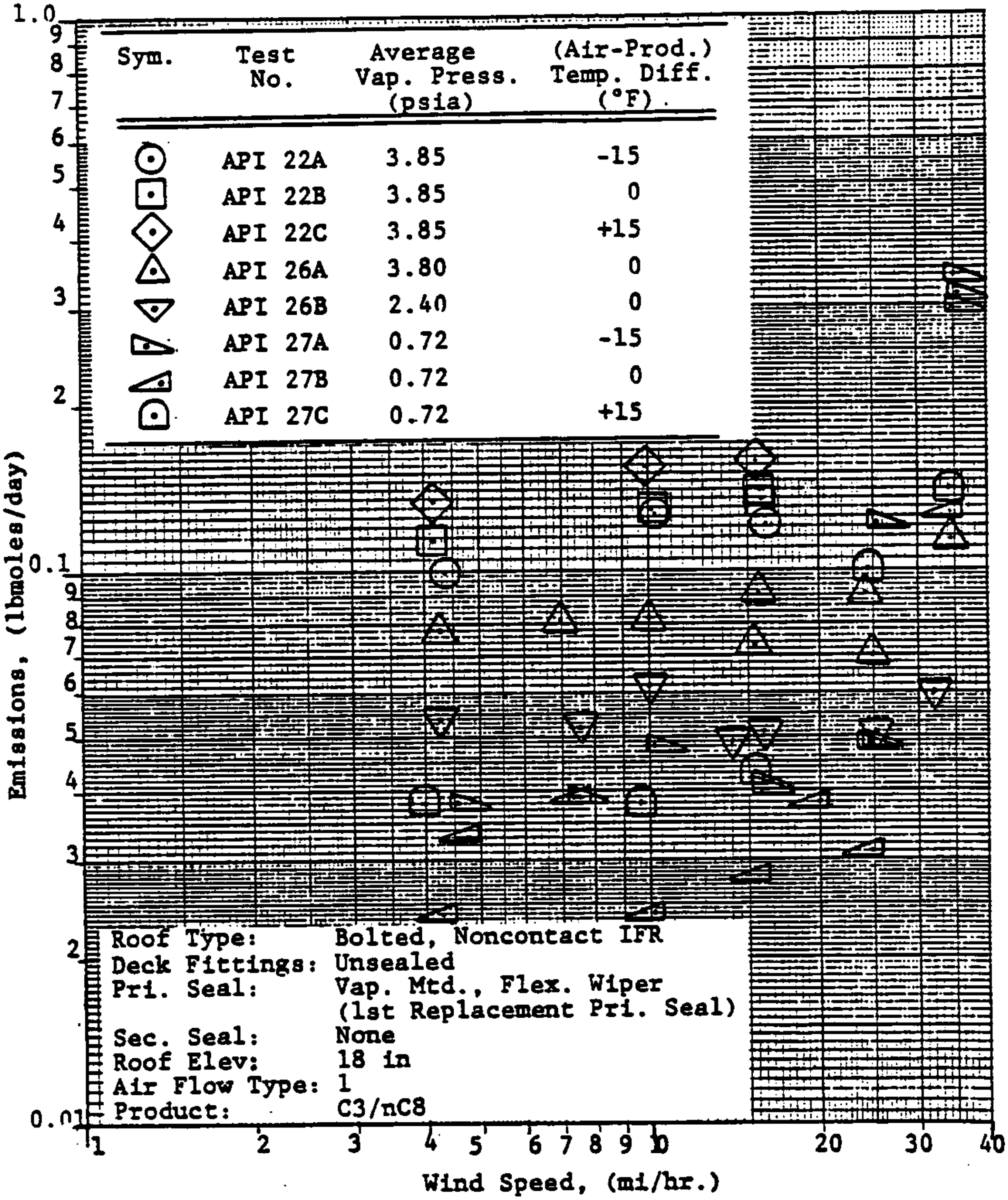
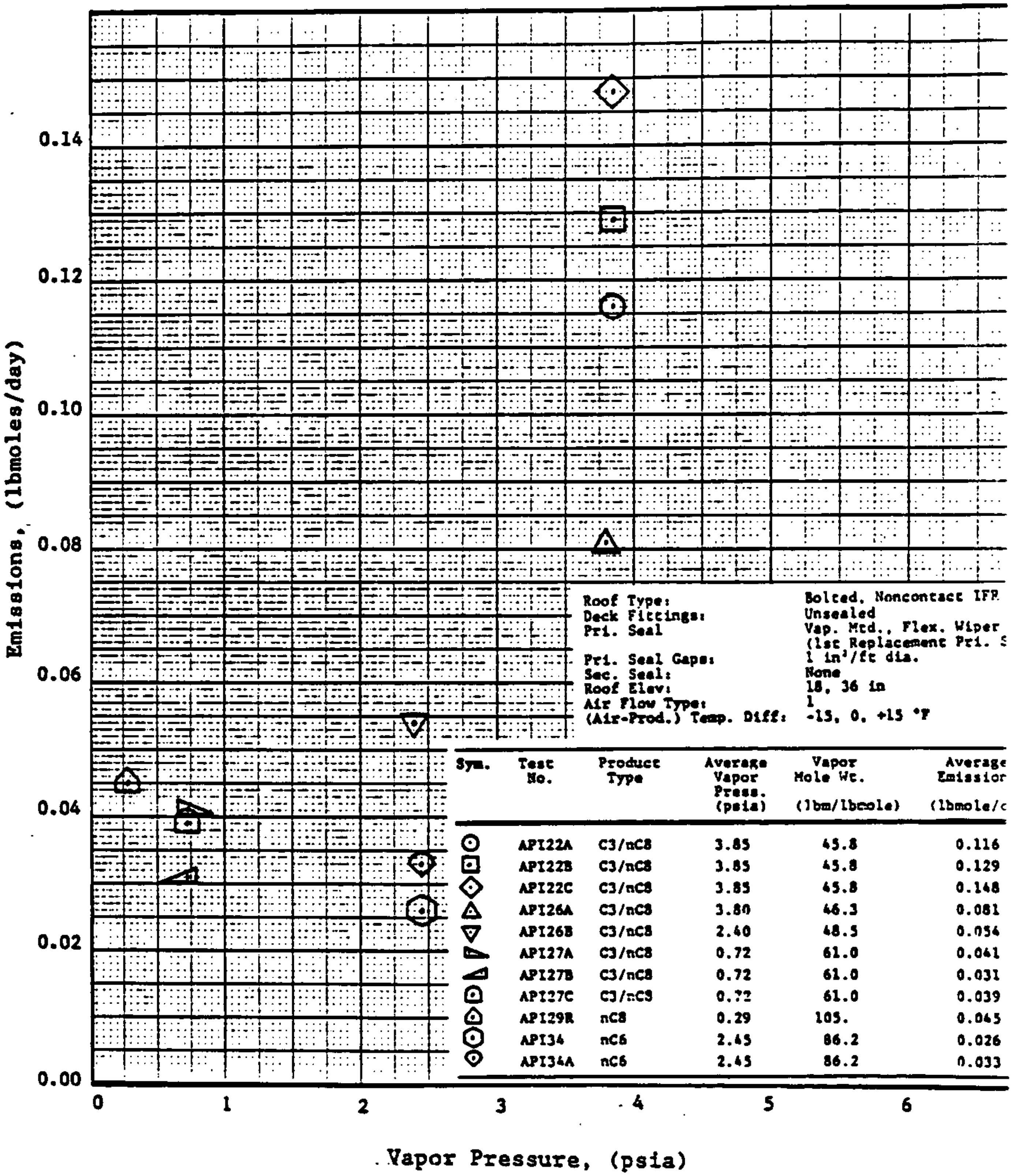


Figure 2.19 Effect of Vapor Pressure on Emissions for the 1st Replacement Primary Seal



Sym.	Test No.	Product Type	Average Vapor Press. (psia)	Vapor Mole Wt. (lbm/lbmole)	Average Emissior (lbmole/c
	API22A	C3/nC8	3.85	45.8	0.116
	API22B	C3/nC8	3.85	45.8	0.129
	API22C	C3/nC8	3.85	45.8	0.148
	API26A	C3/nC8	3.80	46.3	0.081
	API26B	C3/nC8	2.40	48.5	0.054
	API27A	C3/nC8	0.72	61.0	0.041
	API27B	C3/nC8	0.72	61.0	0.031
	API27C	C3/nC8	0.72	61.0	0.039
	API29R	nC8	0.29	105.	0.045
	API34	nC6	2.45	86.2	0.026
	API34A	nC6	2.45	86.2	0.033

Figure 2.20 Effect of Product Type and Vapor Pressure on Emissions

3.0 Welded, Contact IFR Emission Tests

3.1 IFR Description

The welded, contact IFR used during Phases 2 and 2R of the test program was supplied by Chicago Bridge & Iron Company.

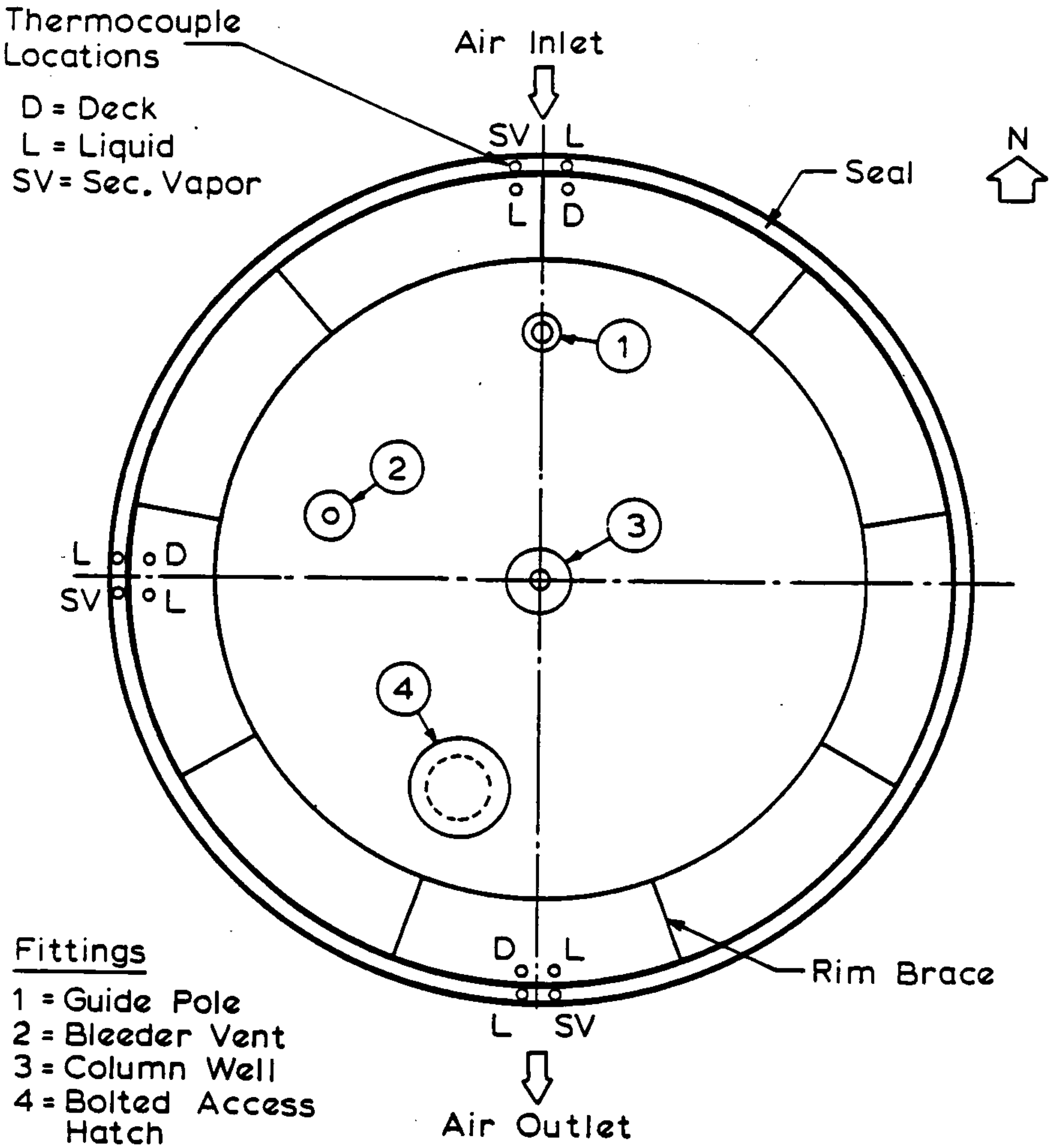
Figure 3.1 is a plan view of the IFR. Since the roof was a contact type, floatation was provided by product displacement. The roof was 19 ft-1 in. diameter with a 5-1/2 in. wide rim space. The roof was constructed of 3/16 in. thick carbon steel, and had 3 fixed legs. A total of 4 deck fittings were installed:

(1) guide pole
(2) bleeder vent
(3) column well
(4) bolted access hatch

Figure 3.2 is an elevation view of the IFR, where it is shown floating at a 36 in. roof elevation position. At this elevation, the outer edge of the secondary seal extended to the top of the shell heating panel, and thus the temperature of the tank shell in the rim space was controlled by the temperature of the circulating liquid in the tank shell heating panels. The roof was equipped with a liquid mounted, resilient foam filled primary seal and a 15 in. wide, rim mounted, flexible wiper secondary seal.

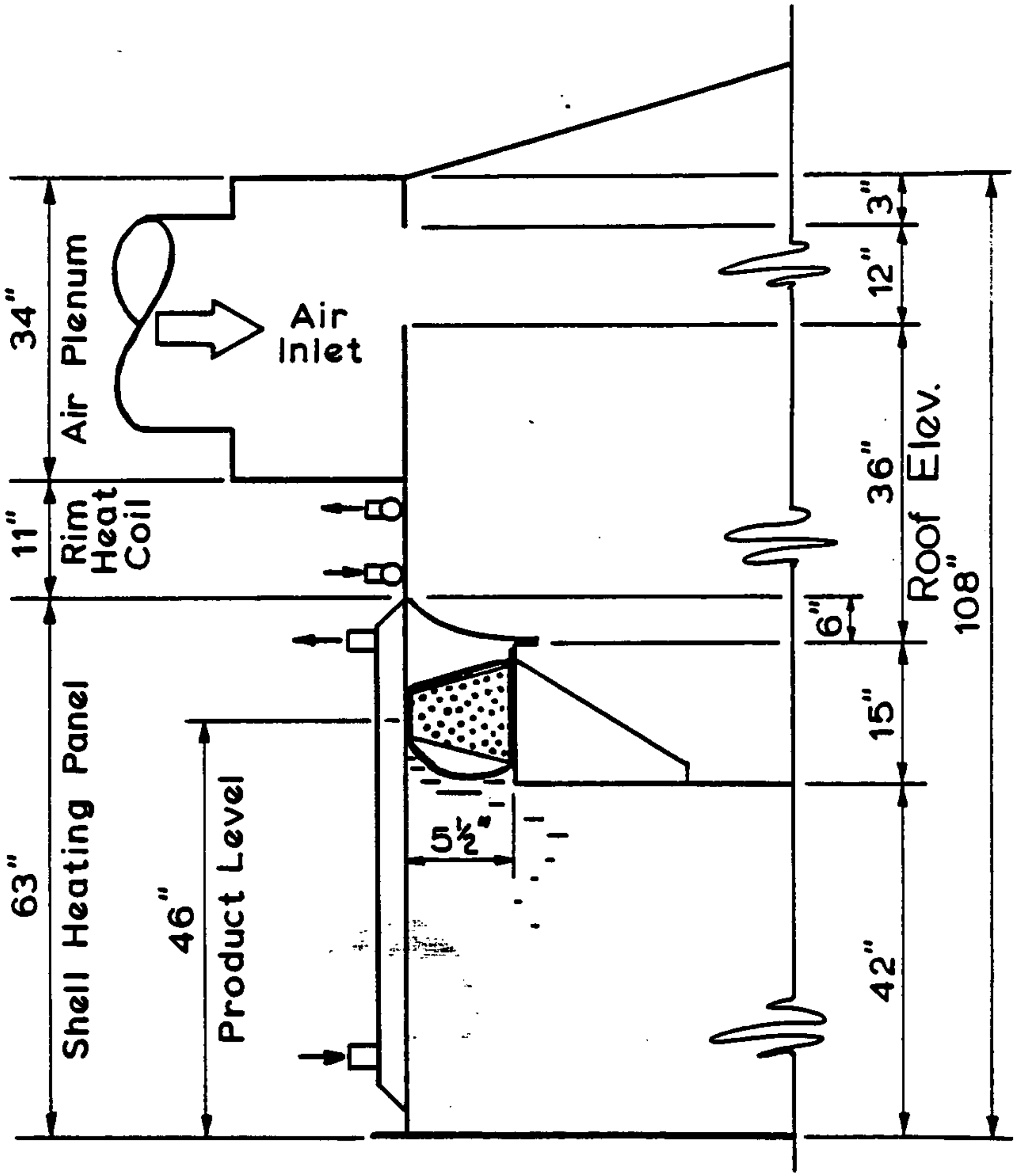
Figure 3.1 also shows the thermocouple locations. Measurements of the liquid and deck temperatures were made on the

North, South and West sides of the IFR. The liquid temperature was measured approximately 1 in. below the bottom of the roof deck. In the rim area of the IFR, measurements were made of the liquid temperature, and the vapor temperature between the primary and secondary seals on the North, South and West sides of the IFR.



PLAN VIEW OF CONTACT WELDED I F R

Figure 3.1



Elevation View Of Contact
Welded I F R In Test Tank
Figure 3.2

3.2 Test Conditions

Table 3.1 summarizes the test conditions used during Phase 2 (Test Nos. API35 through API51) and Phase 2R (Test Nos. API67 through API72). The chronological sequence of events is described in Appendix A.

During the performance of Test API44 it was noticed that one of the deck thermocouple fittings was damp from a small amount of product seepage. The cause of this seepage was then sealed, and a few of the previous tests (Tests Nos. API37 and API44) were repeated (Tests Nos. API45 and API48) to determine the emission contribution from the seeping product during Tests API35 through API44.

Most of the tests performed during Phases 2 and 2R were at a roof elevation of 36 in. since this permitted the tank shell in the IFR rim area to be temperature controlled by the liquid circulating through the tank shell heating panels.

Test API51 was performed with the test conditions adjusted to simulate an external floating roof tank (EFRT). The purpose of this test was to determine the emission rate of an EFR equipped with a liquid mounted, resilient filled primary seal when the product is a pure component.

TABLE 3.1 SUMMARY OF TEST CONDITIONS FOR PHASES 2 AND 2R [1]

Test No.	Product Type	Nominal Vap. Press (psia)	Gap Area (in^2/ft dia.) Pri.	Gap Area (in^2/ft dia.) Sec.	Roof Components Column Well	Roof Components Deck Fittings	Roof Elev. Below Air Inlet (in)	Notes
Phase 2								
API 35	C3/nC8	5.0	0	-	Unsealed	Unsealed	18	[2]
API 36	C3/nC8	5.0	1	-	Unsealed	Unsealed	18	[2]
API 37	C3/nC8	5.0	0	-	Unsealed	Unsealed	36	[2]
API 38	C3/nC8	5.0	0.5	-	Unsealed	Unsealed	36	[2]
API 39	C3/nC8	5.0	3	-	Unsealed	Unsealed	36	[2]
API 40	C3/nC8	5.0	1	-	Unsealed	Unsealed	36	[2]
API 41	C3/nC8	5.0	0	0	Sealed	Sealed	36	[2]
API 42	C3/nC8	5.0	1	0	Sealed	Sealed	36	[2]
API 43	C3/nC8	5.0	3	1	Sealed	Sealed	36	[2]
API 44	C3/nC8	5.0	Sealed	-	Sealed	Sealed	36	[2]
Repaired Product Seepage Through Thermocouple Fitting								
API 45	C3/nC8	5.0	Sealed	-	Sealed	Sealed	36	
API 46	C3/nC8	5.0	Sealed	-	Unsealed	Sealed	36	
API 47	C3/nC8	5.0	Sealed	-	Unsealed	Unsealed	36	
API 48	C3/nC8	5.0	0	-	Unsealed	Unsealed	36	
API 49	C3/nC8	5.0	0	-	Sealed	Sealed	36	
API 50	nC8	0.5	1	-	Unsealed	Unsealed	18	[3]
API 51	nC8	0.5	1	-	Unsealed	Unsealed	18	[3], [4]

TABLE 5.1 SUMMARY OF TEST CONDITIONS FOR PHASES 2 AND 2R [1] (continued)

Test No.	Product Type	Nominal Vap. Press (psia)	Gap Area (in^2/ft dia.)		Roof Components		Roof Elev. Below Air Inlet (in)	Notes
			Pri.	Sec.	Column Well	Deck Fittings		
Phase 2R:								
API 67A	nC8	0.5	1	-	Unsealed	Unsealed	36	[3]
API 67	nC8	0.5	1	-	Unsealed	Unsealed	36	
API 68	nC6	2.5	1	-	Unsealed	Unsealed	36	
API 69	nC6	2.5	1	0	Unsealed	Unsealed	36	
API 70	C3/nC8	5.0	1	0	Unsealed	Unsealed	36	
API 71	C3/nC8	5.0	1	-	Unsealed	Unsealed	36	
API 71A	C3/nC8	5.0	1	-	Unsealed	Unsealed	36	[5]
API 72	C3/nC8	2.5	1	-	Unsealed	Unsealed	36	

Notes: [1]. During both Phases 2 and 2R, Type 1 air flow distribution is used and the nominal (air-product) temperature difference was kept at zero.
[2]. Product seepage through a thermocouple fitting occurred during this test.
[3]. Product contained trace amount of propane.
[4]. During this test the air flow rate was increased to simulate an external floating roof.
[5]. During this test the inlet air and product heaters were turned off, and the wind speed was kept constant at about 10 mi/hr.

3.3 Test Results

The measured test data for Phase 2 and 2R are tabulated in Table B2 in Appendix B, and are plotted on Figures 3.3 throug 3.14.

Again, it was observed that most of the tests showed little or no dependency of emissions on ambient wind speed, especial for wind speeds below 20 mi/hr. Table 3.2 tabulates the average emissions for each test in Phase 2 and 2R for all the data points with wind speeds less than or equal to 20 mi/hr. Note that the average emission values listed for Test API35 through Test API44 are corrected for the emission contributio due to product seepage through a thermocouple fitting using the results listed in Tables 3.3 and 3.4.

During Phase 2 the effect of roof elevation on emissions was again determined. Figure 3.3 shows that roof elevation variation did not appear to significantly effect emissions.

The effect of primary seal gaps on emissions is shown in Figure 3.4, where for small gaps (i.e. 1 in^2/ft dia.) the variation did not appear to significantly effect emissions.

The effect of primary and secondary seal gaps on emissions is shown in Figure 3.5. Comparing the results of Test API40 to those of Test API42 shows some reduction in emissions with the use of a secondary seal. This effect can also be seen from Figure 3.12 by comparing Test API71 with Test API70.

The effect of deck fittings on emissions is shown in Figures 3.7 and 3.8.

The effect of vapor pressure on emissions is shown in Figures 3.13 and 3.14. Also plotted on Figure 3.14 are the results of Test C19 [2] and Test EPA7 [5], which are tabulated for reference in Tables B4 and B5, respectively. Test C19, performed with a C3/nC8 mixture agrees well with the results of the current test program, but Test EPA7, performed with benzene, has significantly higher emissions.

The effect of wind speed on emissions for a simulated external floating roof (EFR) with a liquid mounted primary seal and nC8 product is shown in Figure 3.9. During this test, the EFR was simulated with the contact, welded IFR by increasing the air flow rate through the test tank to simulate ambient wind effects on the EFR. It should be noted, however, that during this test the IFR deck fittings were not sealed, and the product was contaminated with 0.15 mole % propane.

TABLE 3.2 SUMMARY OF EMISSION TEST RESULTS FOR WELDED, CONTACT IFR

Test No.	Average Vap. Press. (psia)	Nominal Vap. Press. (psia)	Vapor Mole Wt. (lbm/lbmole)	Emissions [1] at Average Vap. Press. (lbm/day)	[2]	Emissions [1] at Average Vap. Press. (lbmole/day)	[2]	Emissions [1] at Nom. Vap. Press. (lbm/day)	[2]	Emissions [1] at Nom. Vap. Press. (lbmole/day)	[2]	Standard Deviation (%)
API35	4.05	5.00	47.5	1.30	0.949	0.0274	0.0200	1.67	1.22	0.0352	0.0257	20.7
API36	4.00	5.00	47.5	1.14	0.793	0.0240	0.0167	1.49	1.04	0.0314	0.0219	19.8
API37	4.00	5.00	47.5	1.04	0.693	0.0219	0.0146	1.36	0.907	0.0286	0.0191	4.20
API38	3.95	5.00	47.6	1.19	0.848	0.0250	0.0178	1.58	1.13	0.0332	0.0237	8.37
API39	4.15	5.00	47.2	1.70	1.34	0.0360	0.0284	2.13	1.68	0.0451	0.0356	15.5
API40	5.25	5.00	46.8	1.42	0.946	0.0303	0.0202	1.34	0.894	0.0286	0.0191	7.68
API41	5.20	5.00	46.8	0.772	0.303	0.0165	0.00650	0.735	0.289	0.0157	0.00616	7.92
API42	5.20	5.00	46.8	0.841	0.372	0.0180	0.00800	0.801	0.355	0.0171	0.00756	5.64
API43	5.10	5.00	46.5	1.21	0.756	0.0260	0.0162	1.18	0.736	0.0254	0.0159	17.8
API44	4.70	5.00	46.4	0.800	0.390	0.0172	0.00835	0.863	0.420	0.0186	0.00906	6.39
API45	4.85	5.00	46.4	0.353		0.00761		0.366		0.00789		20.3
API46	4.95	5.00	46.5	0.419		0.00901		0.424		0.00912		5.70
API47	4.90	5.00	46.5	0.741		0.0159		0.760		0.0163		13.9
API48	4.95	5.00	46.6	0.932		0.020		0.944		0.0203		6.34
API49	5.00	5.00	46.6	0.772		0.0166		0.772		0.0166		8.43
API50	0.60	0.50	87.0	(0.350)	[3]	(0.00402)	[3]	(0.291)	[3]	(0.00334)	[3]	31.9
API51	0.60	0.50	87.5	—	[4]	—	[4]	—	[4]	—	[4]	—
API67A	0.43	0.50	97.5	(0.572)	[3]	(0.00587)	[3]	(0.667)	[3]	(0.00684)	[3]	40.8
API67	0.36	0.50	112.	0.413		0.00369		0.576		0.00514		9.37
API68	3.05	2.50	86.2	1.08		0.0125		0.868		0.0101		7.36
API69	3.05	2.50	86.2	0.712		0.00826		0.571		0.00662		21.9
API70	6.20	5.00	46.3	1.12		0.0242		0.853		0.0184		16.4
API71	6.20	5.00	46.3	1.51		0.0326		1.15		0.0248		11.6
API71A	5.95	5.00	46.2	1.27		0.0275		1.02		0.0221		14.4
API72	2.40	2.50	51.2	0.768		0.0150		0.803		0.0157		7.87

Notes: [1]. Emission values tabulated are the average emission value for all data points with wind speeds less than or equal to 20 mi/hr.
[2]. Emission values corrected for product seepage through thermocouple fitting. See Table 3.4 for correction factors.
[3]. Excessive data scatter.
[4]. During this test, the air flow rate was increased to simulate an external floating roof.

TABLE 3.3 SUMMARY OF TESTS USED TO DETERMINE THE EMISSIONS DUE TO THE THERMOCOUPLE FITTING SEEPAGE

Test No.	Seal Gap Area (in^2/ft dia.) Pri.	Sec.	Average Emissions (lbm/day)	Vapor Molecular Weight (lbm/lbmole)	Thermocouple Seepage
API44	sealed		0.863	46.4	yes
API45	sealed		0.366	46.4	no
API37	0	-	1.36	47.5	yes
API48	0	-	0.944	46.6	no

Roof Type: Welded, Contact IFR
Product Type: C3/nC8
Nom. Vap. Press.: 5.0 psia
Deck Fittings: Sealed
Roof Elev.: 36 in
Notes: [1]. Emission values tablulated are the average emission values for all data points with wind speeds less than or equal to 20 mi/hr.

Determination of Emissions Due to the Thermocouple Fitting Seepage, E_{TC}

$$E_{TC} = \left[\frac{\left(\frac{0.863}{46.4} - \frac{0.366}{46.4}\right) + \left(\frac{1.36}{47.5} - \frac{0.944}{46.6}\right)}{2}\right]$$

E_{TC} = 0.00954 lbmole/day (at 5.0 psia vap. press.)

TABLE 3.4 SUMMARY OF EMISSION CORRECTIONS FOR THERMOCOUPLE FITTING SEEPAGE

Test No.	Average Vapor Pressure (psia)	Nominal Vapor Pressure (psia)	Vapor Molecular Weight (lbm/lbmole)	E_{TC} At Average Vapor Pressure (lbm/day)	(lbmole/day)	E_{TC} At Nominal Vapor Pressure (lbm/day)	(lbmole/day)
API35	4.05	5.00	47.5	0.351	0.00741	0.453	0.00954
API36	4.00	5.00	47.5	0.347	0.00730	0.453	0.00954
API37	4.00	5.00	47.5	0.347	0.00730	0.453	0.00954
API38	3.95	5.00	47.6	0.342	0.00719	0.454	0.00954
API39	4.15	5.00	47.2	0.360	0.00762	0.450	0.00954
API40	5.25	5.00	46.8	0.474	0.0101	0.446	0.00954
API41	5.20	5.00	46.8	0.469	0.0100	0.446	0.00954
API42	5.20	5.00	46.8	0.469	0.0100	0.446	0.00954
API43	5.10	5.00	46.5	0.454	0.00978	0.444	0.00954
API44	4.70	5.00	46.4	0.410	0.00885	0.443	0.00954

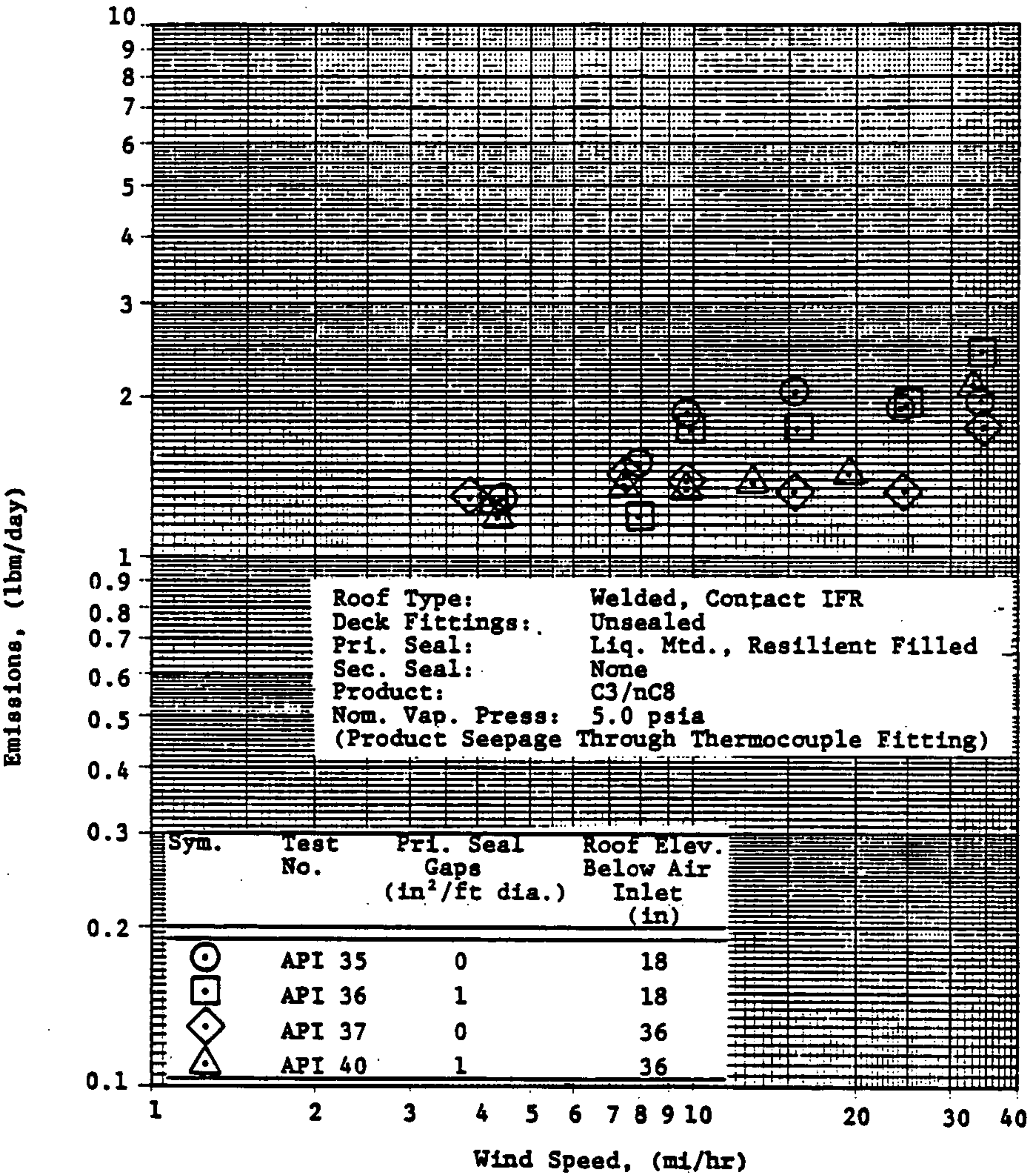


Figure 3.3 Effect of Primary Seal Gaps and Roof Elevation on Emissions

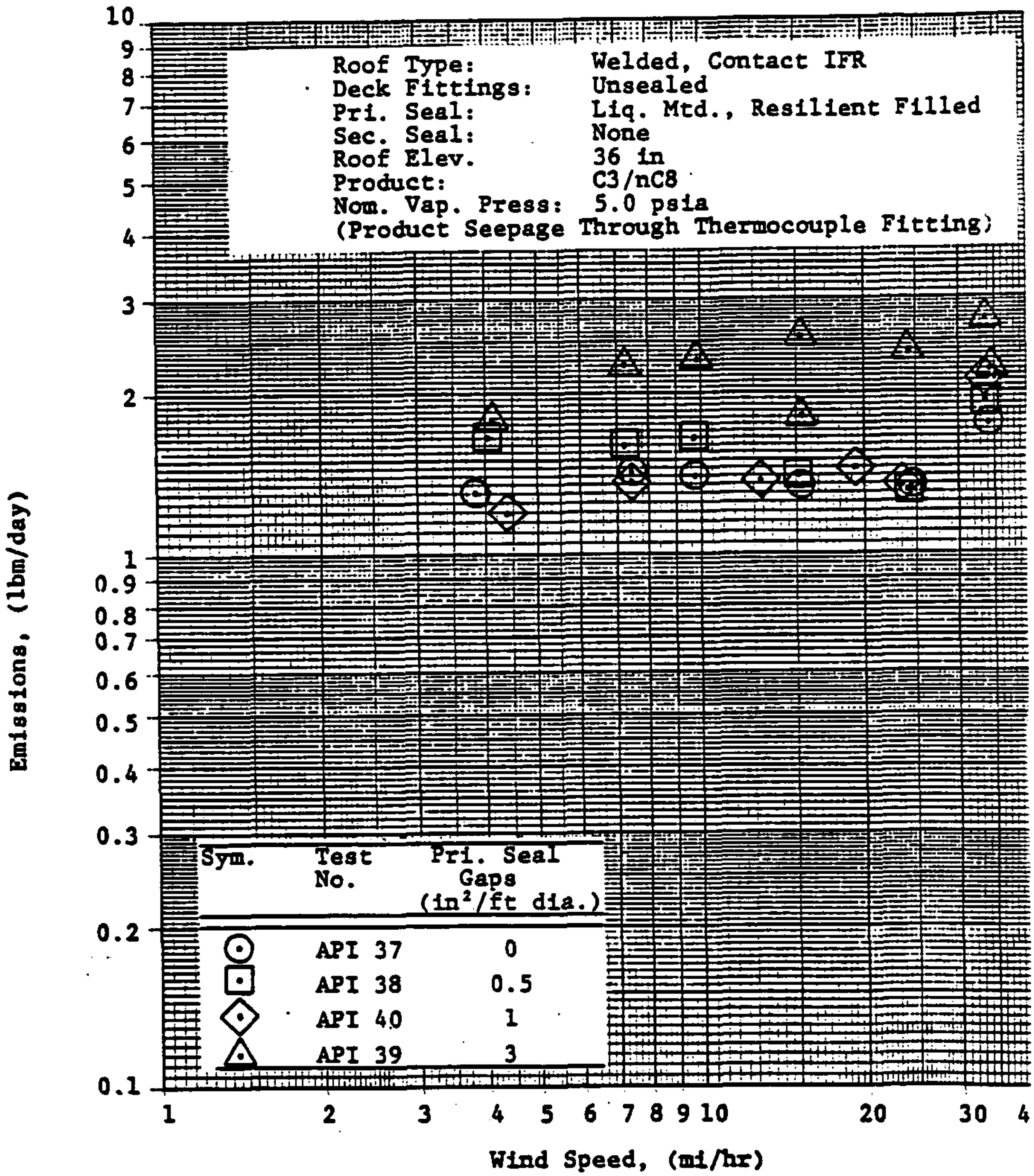


Figure 3.4 Effect of Primary Seal Gaps on Emissions

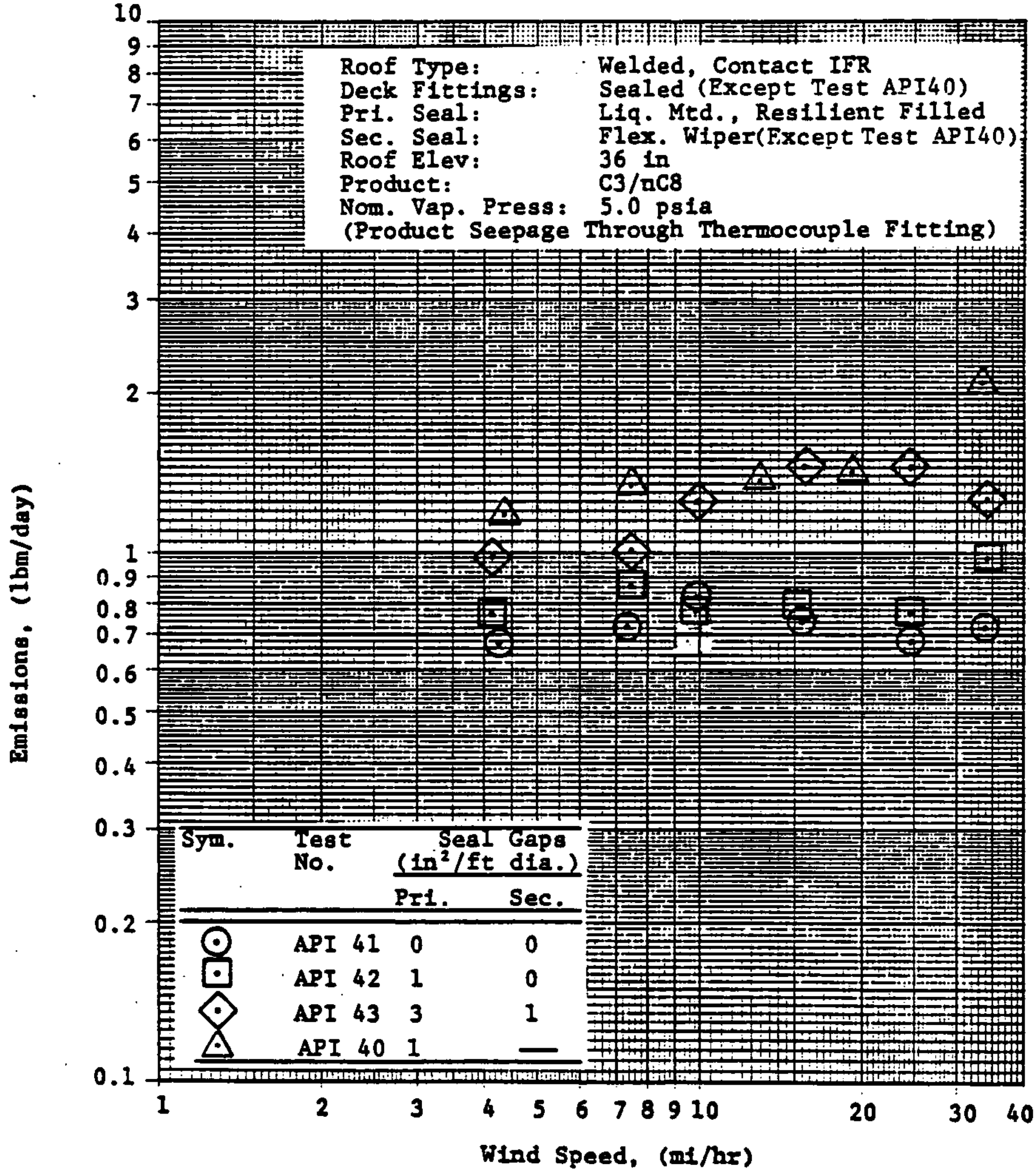


Figure 3.5 Effect of Primary and Secondary Seal Gaps on Emissions

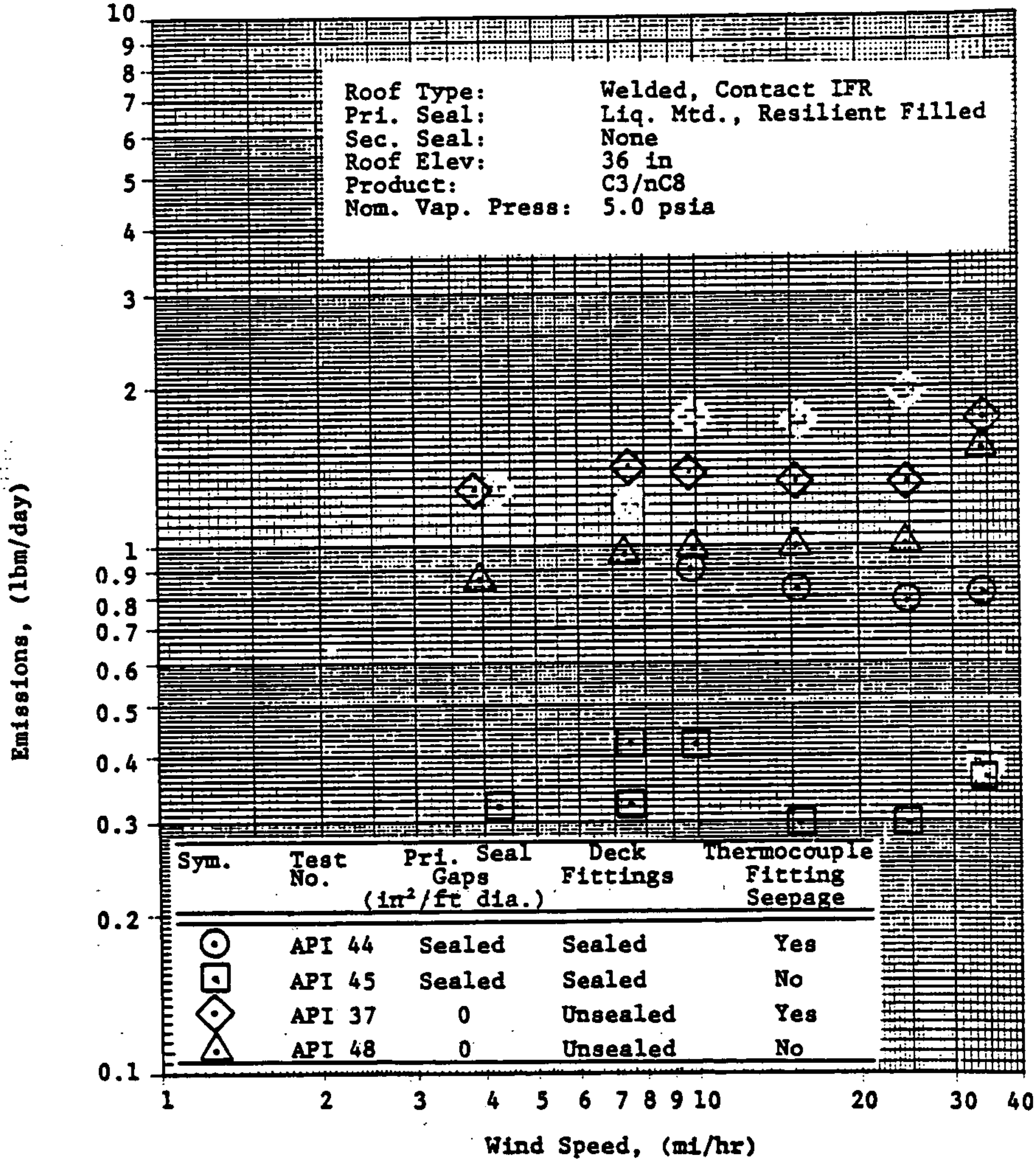


Figure 3.6 Effect of Thermocouple Fitting Seepage on Emissions

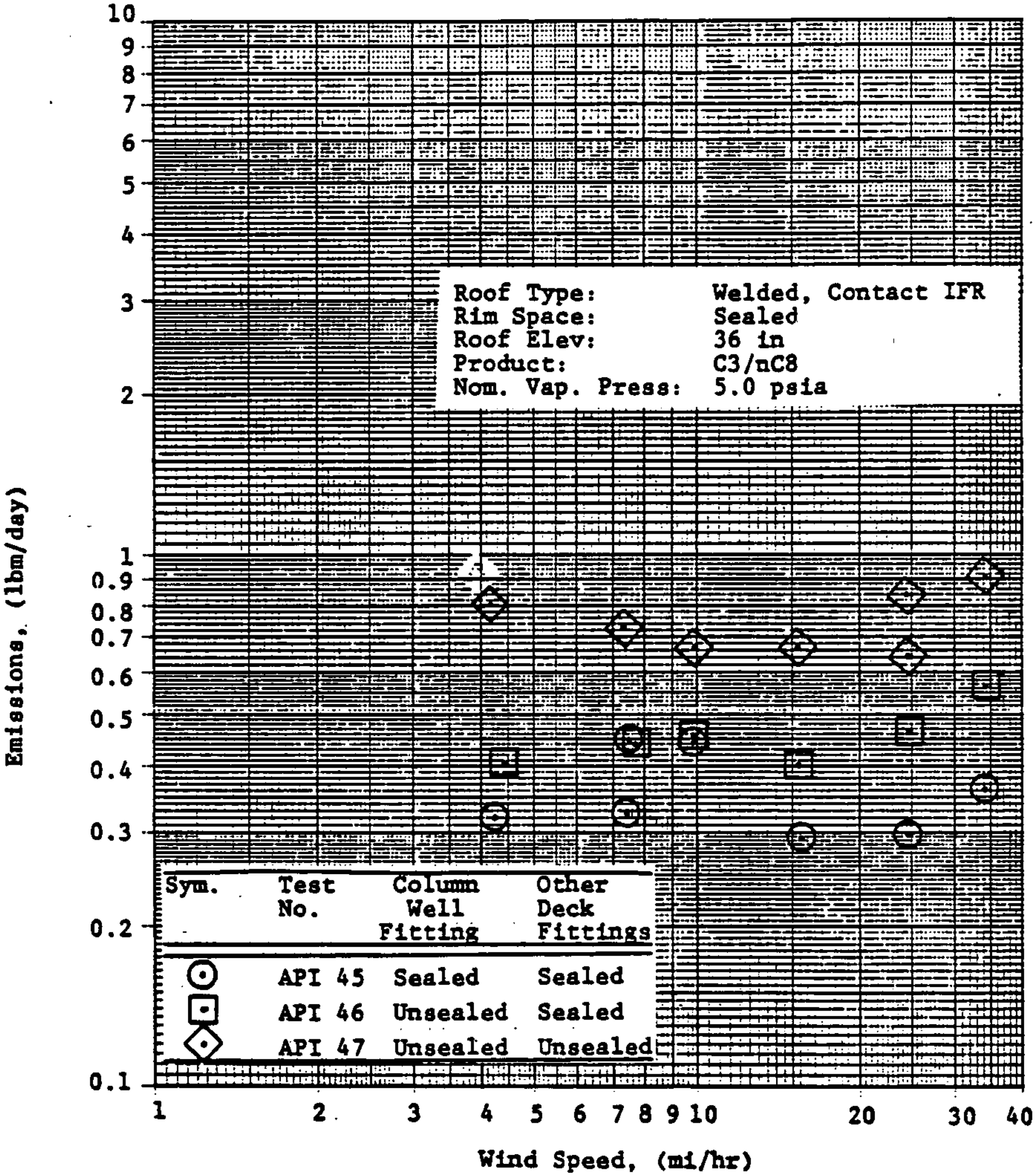


Figure 3.7 Effect of Deck Fittings on Emissions for a Sealed Rim Space

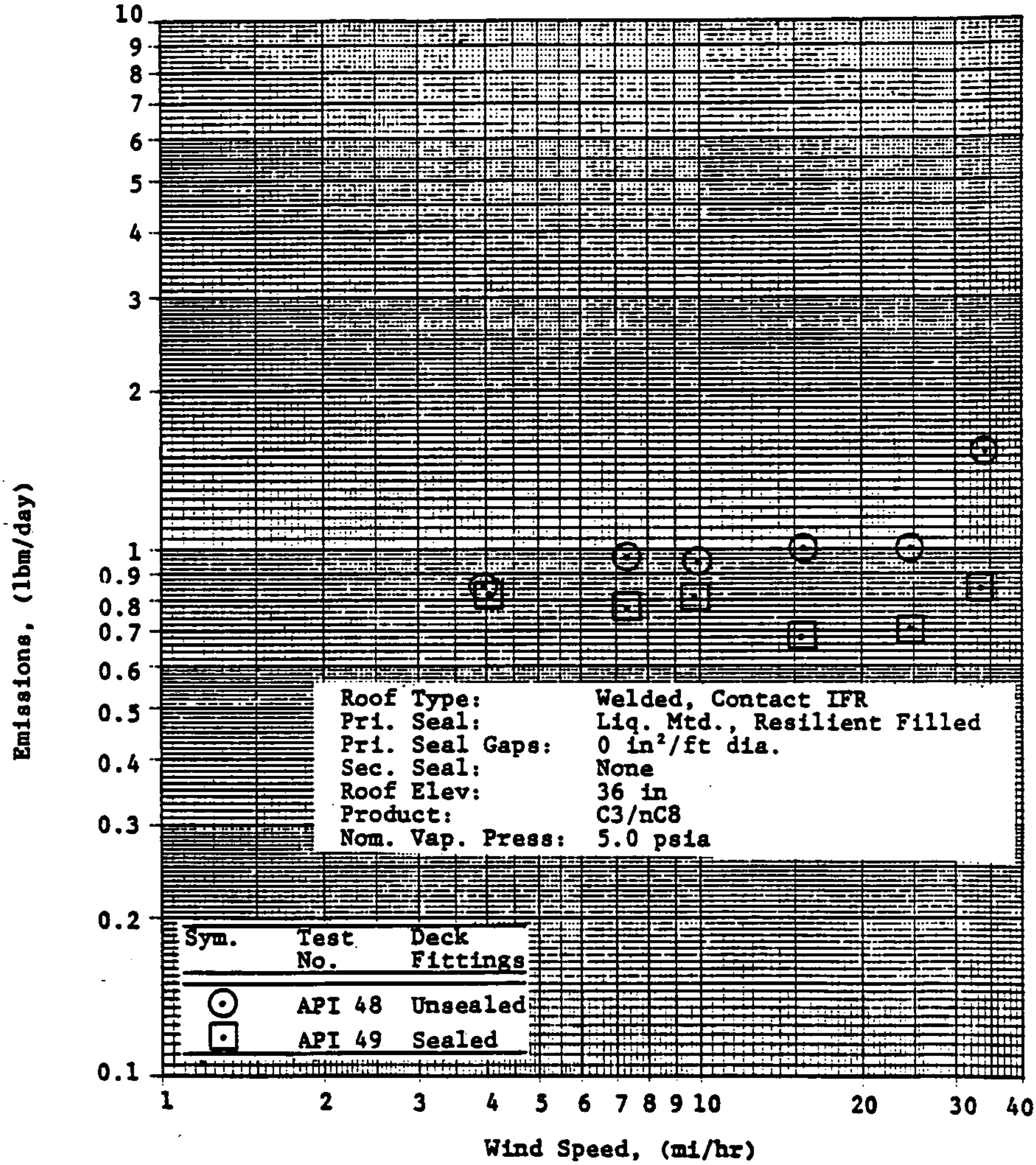


Figure 3.8 Effect of Deck Fittings on Emission for an Ungapped Primary Seal

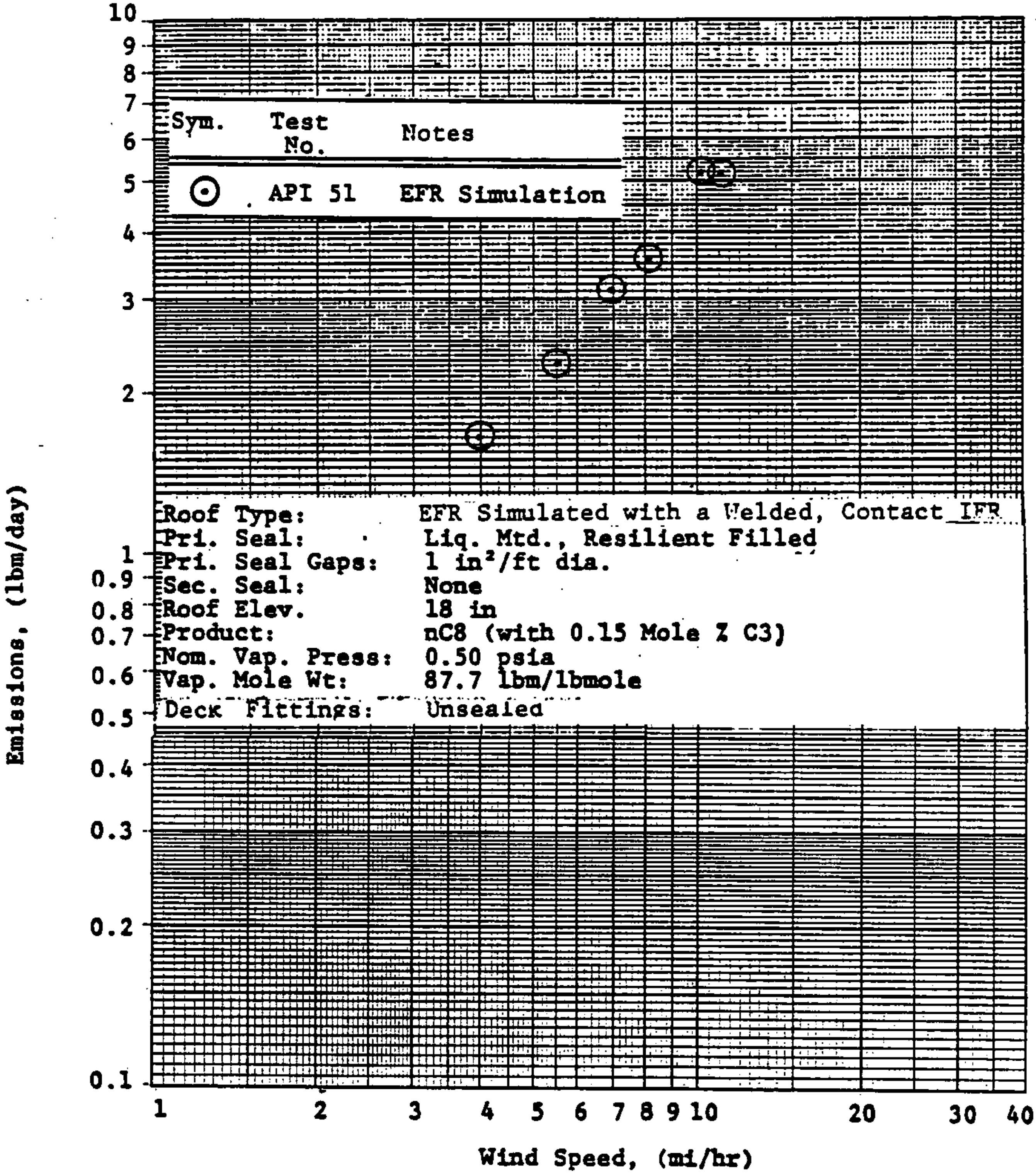


Figure 3.9 Effect of Wind Speed on Emissions for a Simulated External Floating Roof With A Liquid Mounted Primary Seal and nC8 Product

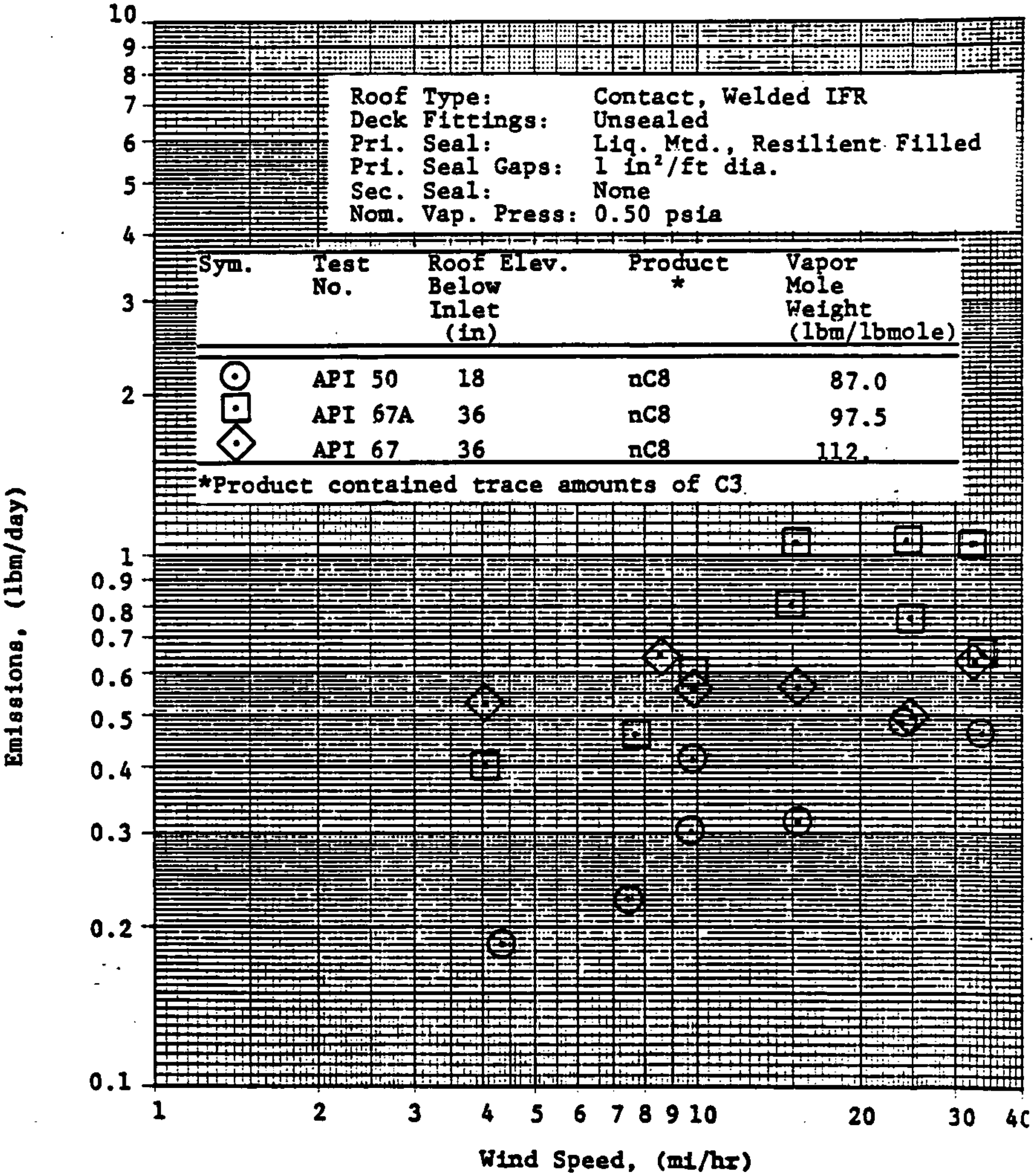


Figure 3.10 Emissions of the Contact, Welded IFR with nC8 Product

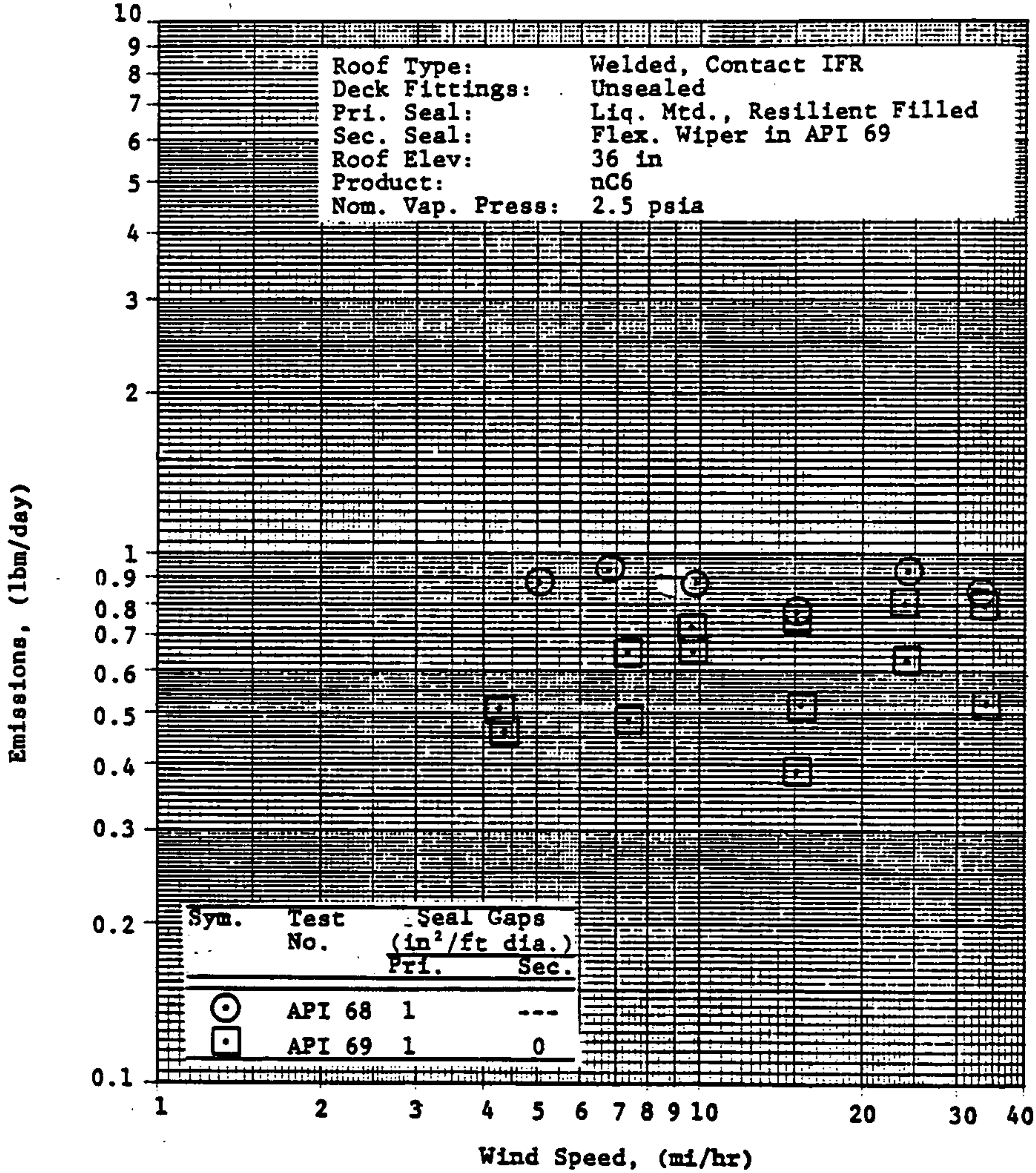


Figure 3.11 Effect of Secondary Seal on Emissions With nC6 Product

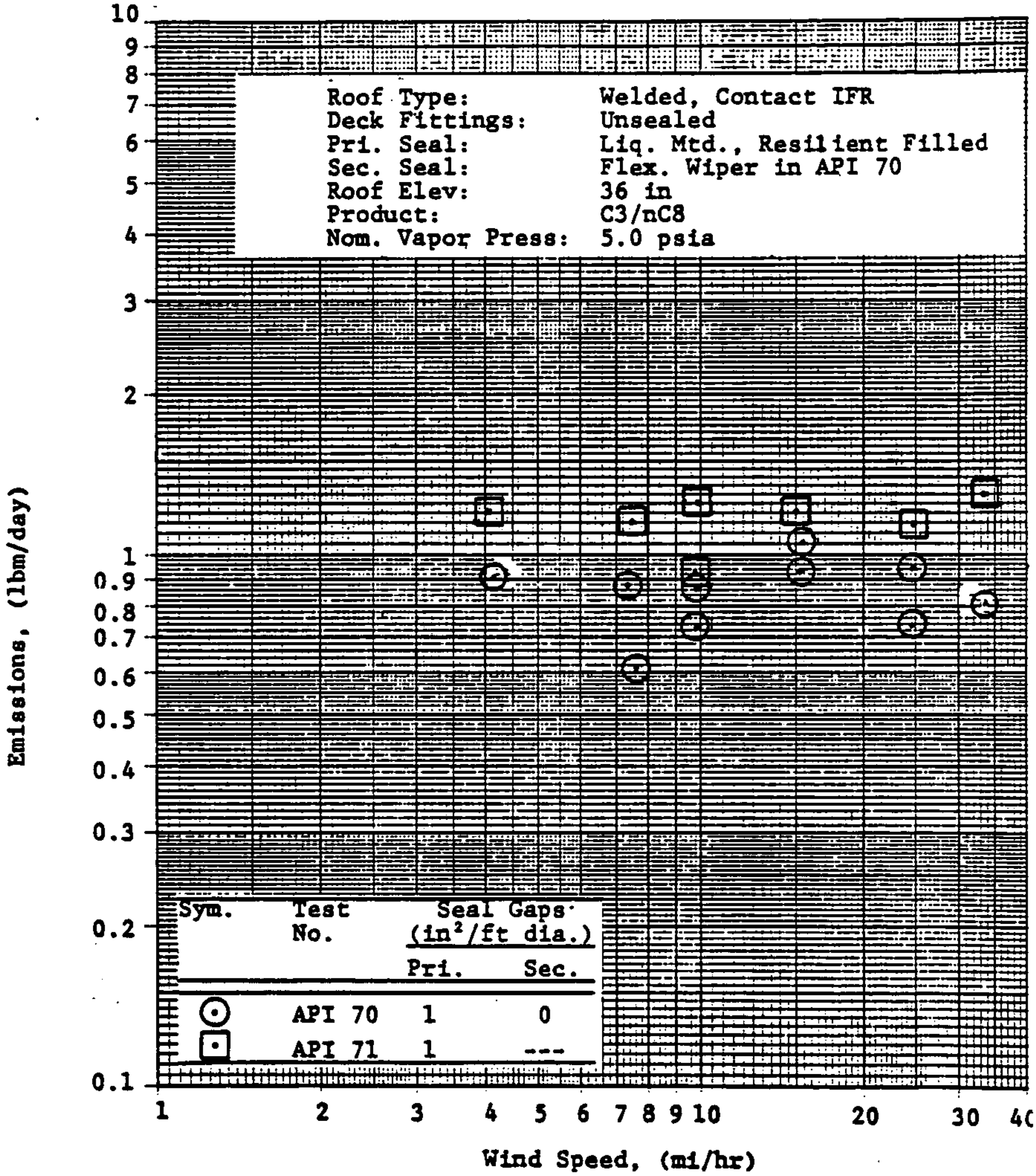


Figure 3.12 Effect of Secondary Seal on Emissions With a C3/nC8 Mixture

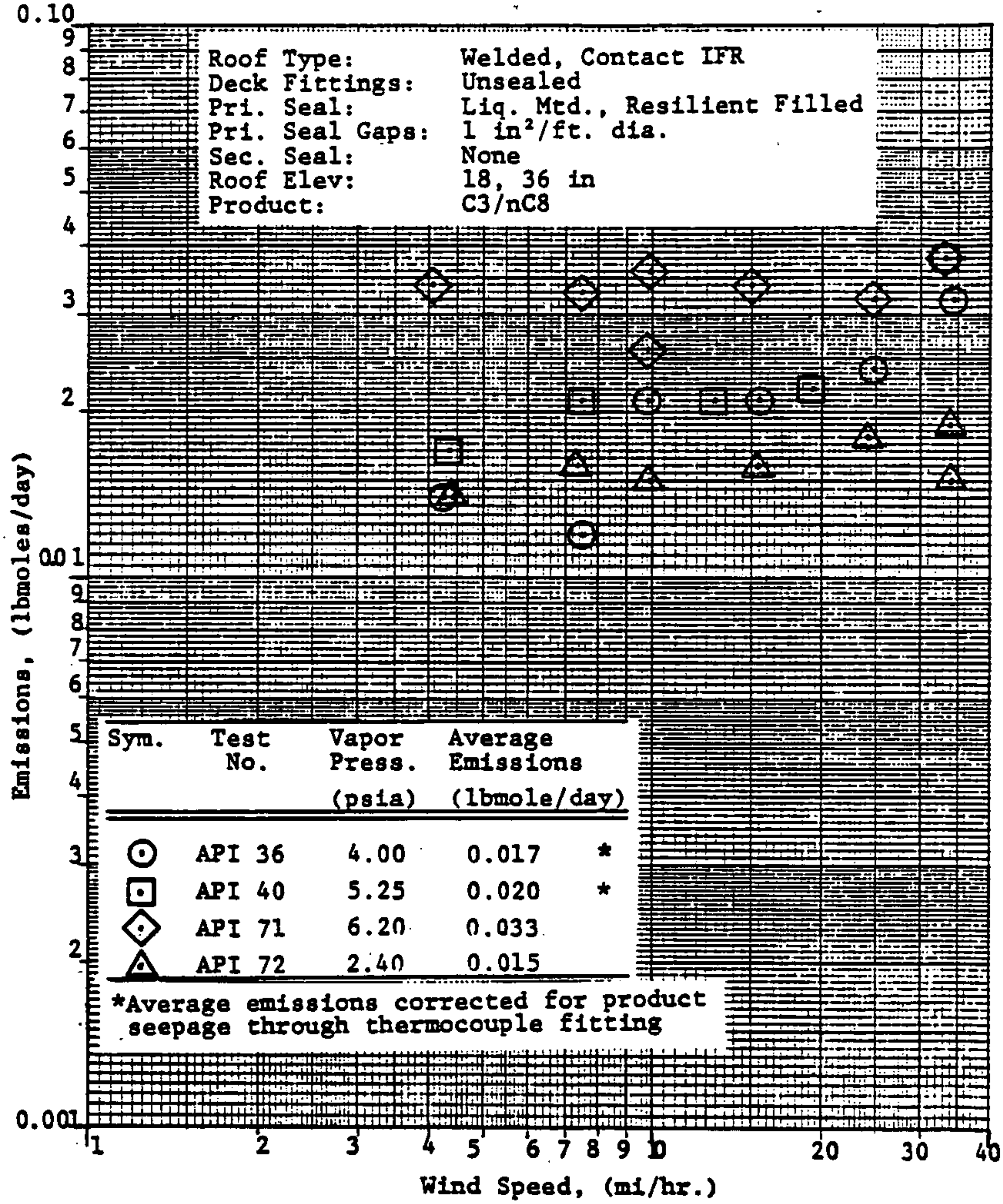
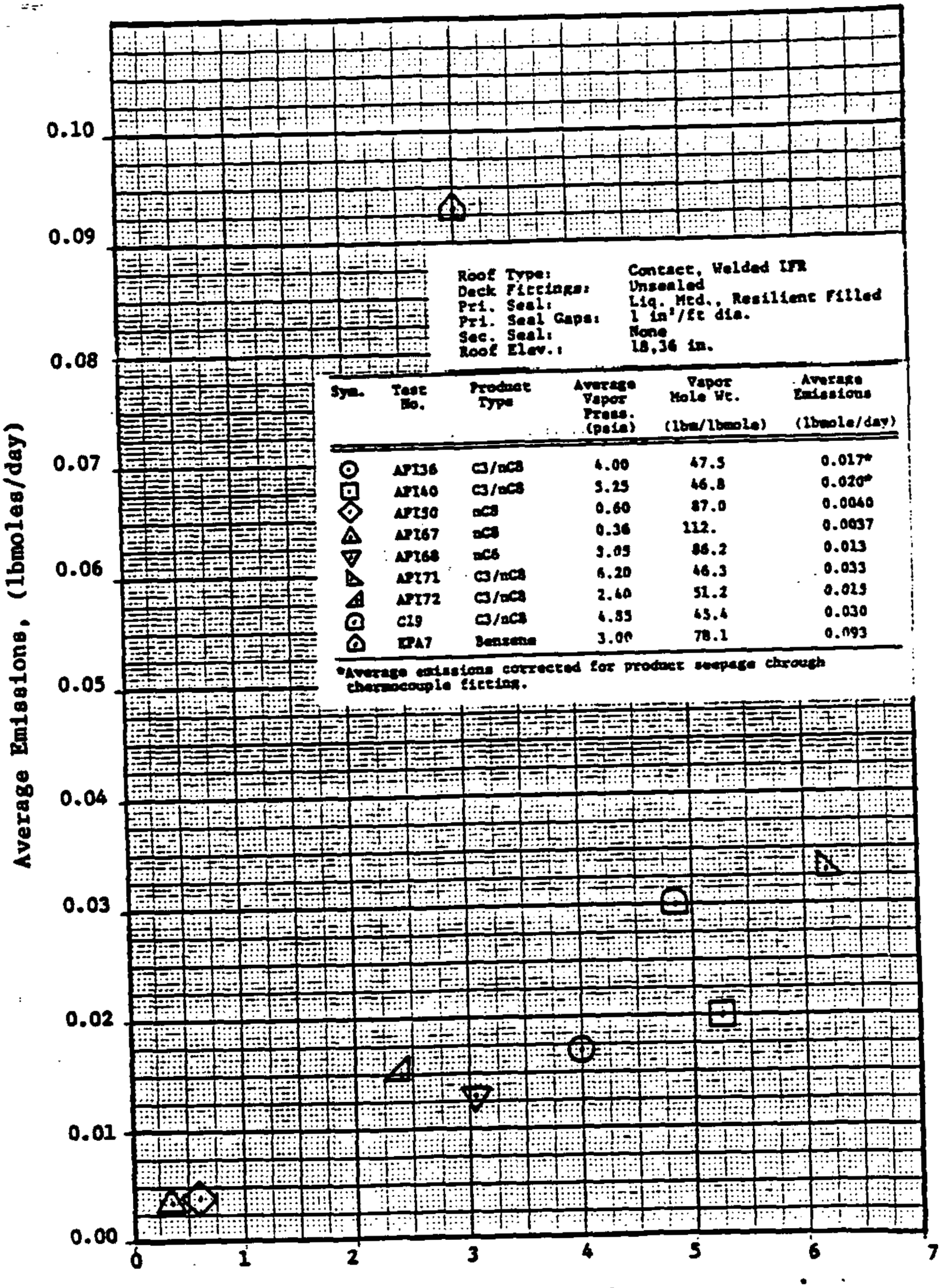


Figure 3.13 Effect of Vapor Pressure on Emissions



Sym.	Test No.	Product Type	Average Vapor Press. (psia)	Vapor Mole Wt. (lbm/lbmole)	Average Emissions (lbmole/day)
⊙	API36	C3/nC8	4.00	47.5	0.017*
⊡	API40	C3/nC8	5.25	46.8	0.020*
◇	API50	nC8	0.60	87.0	0.0040
△	API67	nC8	0.36	112.	0.0037
▽	API68	nC6	3.05	86.2	0.013
◺	API71	C3/nC8	6.20	46.3	0.033
◿	API72	C3/nC8	2.40	51.2	0.015
◠	C19	C3/nC8	4.85	45.4	0.030
⌂	EPA7	Benzene	3.00	78.1	0.093

*Average emissions corrected for product seepage through thermocouple fitting.

Figure 3.14 - Effect of Vapor Pressure and Product Type on Emissions

4.0 Bolted, Contact IFR Emission Tests

4.1 IFR Description

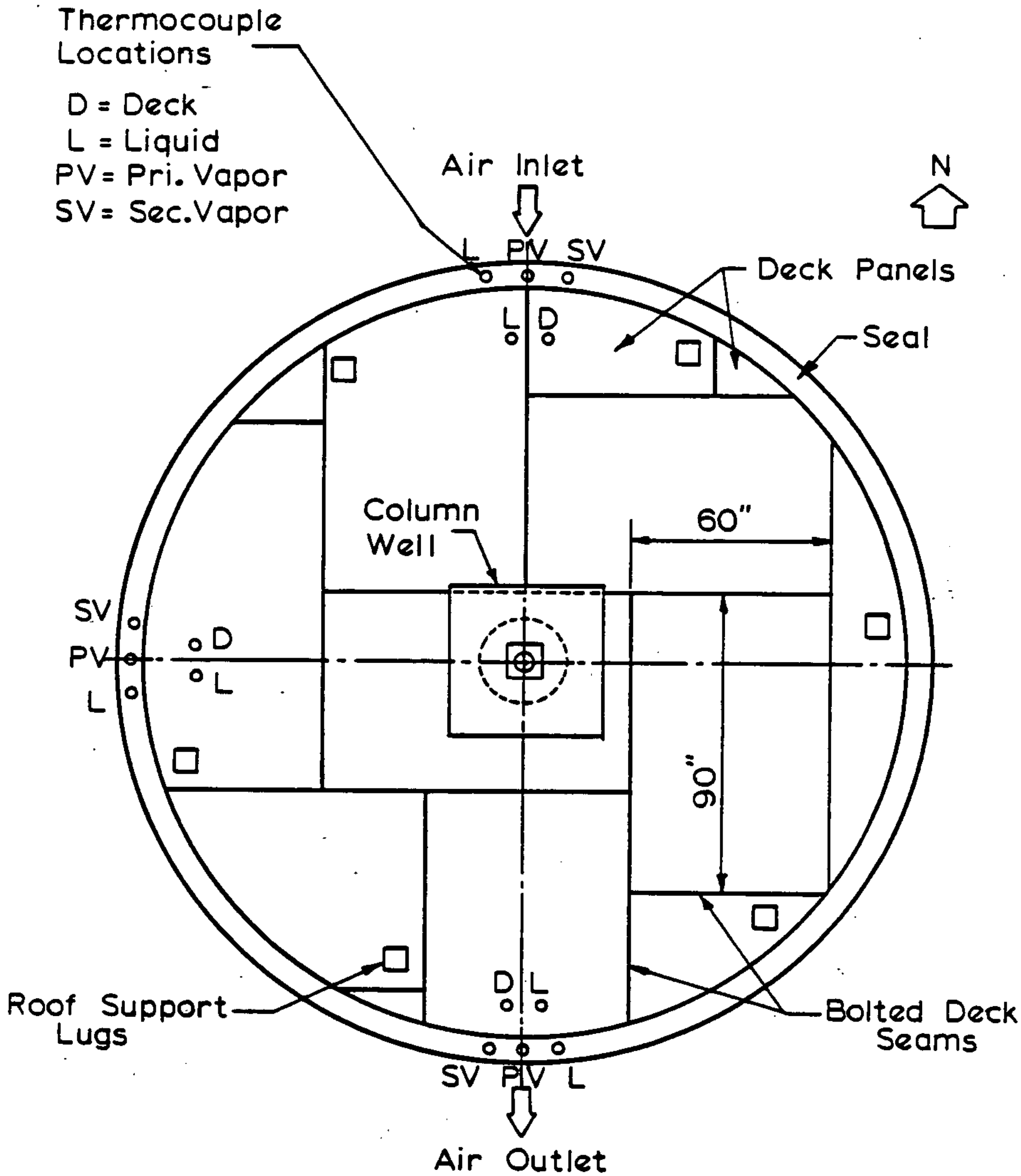
The bolted, contact IFR used during Phases 3 and 3R of the test program was supplied by Petrex, Incorporated.

Figure 4.1 is a plan view of the IFR. Since the roof is a contact type, floatation was provided by product displacement. The roof was 19 ft-0 in. diameter with a 6 in. wide rim space and was equipped with 6 fixed legs. The roof deck was constructed of 1-1/2 in. thick, aluminum honeycomb core panels, each 60 in. by 90 in. These panels were bolted together with clamping bars to form a rigid roof deck. The total length of clamped deck seams was 89 ft. The roof was equipped with only one deck fitting, a column well.

Figure 4.2 is an elevation view of the IFR, where it is shown floating at a 36 in. roof elevation position. At this elevation, the outer edge of the secondary seal extended to the top of the shell heating panel, and thus the temperature of the shell in the rim space was controlled by the temperature of the circulating liquid in the tank shell heating panels.

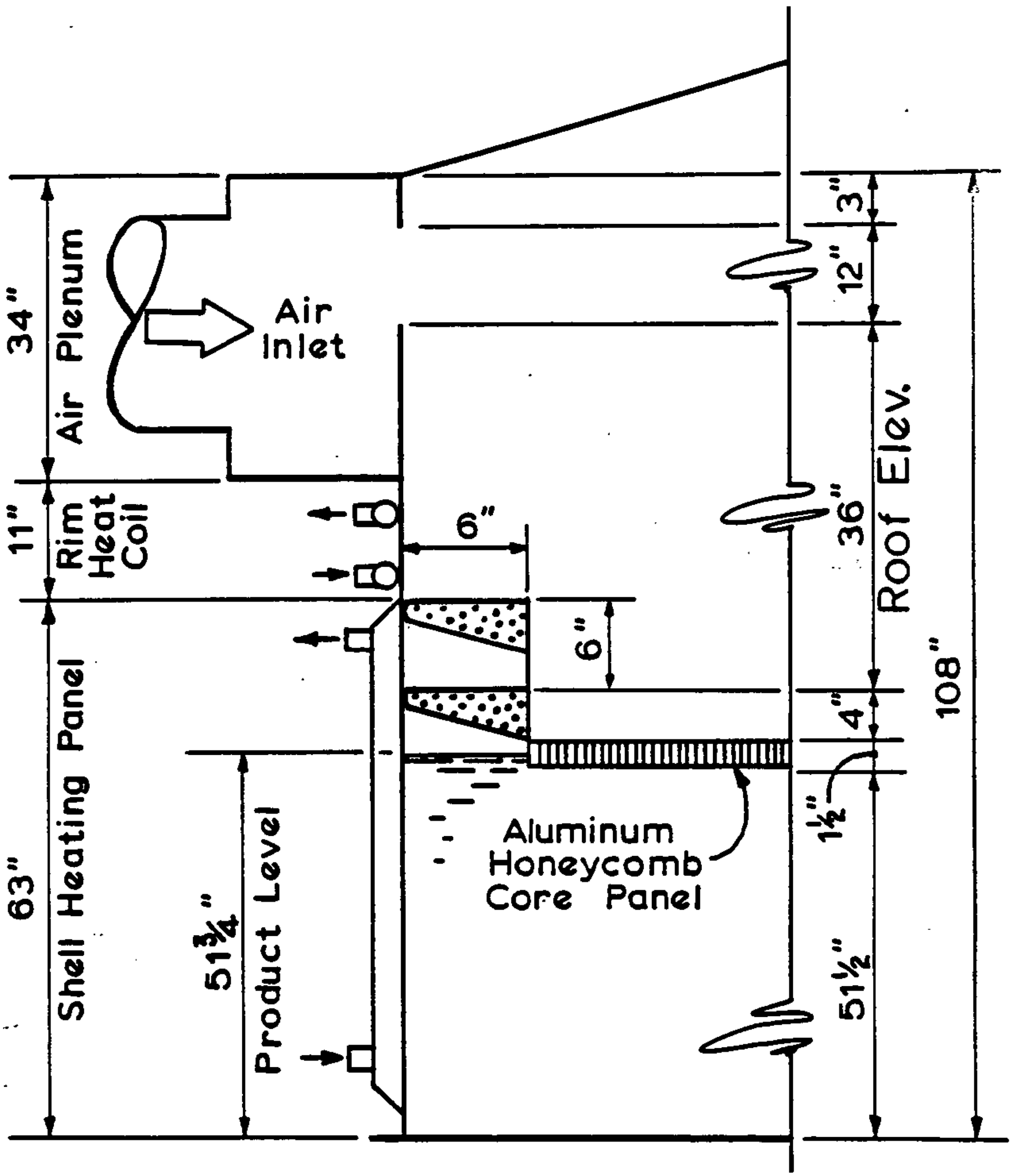
The roof was equipped with a vapor mounted, resilient foam filled primary seal and a resilient foam filled secondary seal (of identical construction to the primary seal), which was mounted 6 in. above the primary seal. The rim side face of these seals was attached to a series of aluminum clamping plates, which were clipped to the IFR rim.

Figure 4.1 also shows the thermocouple locations. Measurement of the liquid and deck temperatures were made on the North, South and West sides of the IFR. The liquid temperature was measured approximately 1 in. below the bottom of the roof deck. In the rim area of the IFR, measurements were made of the liquid temperature, the vapor temperature below the primary seal, and the vapor temperature between the primary and secondary seals on the North, South and West sides of the IFR.



PLAN VIEW OF CONTACT BOLTED IFR

Figure 4.1



Elevation View Of Contact
Bolted IFR In Test Tank
Figure 4.2

4.2 Test Conditions

Table 4.1 summarizes the test conditions used during Phase 3 (Test Nos. API52 through API65) and Phase 3R (Test Nos. API65R and 66. The chronological sequence of events is described in Appendix A.

Preliminary emission tests (Test Nos. API52A, B, C, D, E, API53A, B, C and API54A, B) indicated that during the tank filling operation, product had probably inadvertently gotten into the primary seal through the vertical gaps between the aluminum clamping plates on the rim face of the primary seal. This product was removed from the primary seal before commencing Test API52. The emission test data from these preliminary tests is not included in Table B3.

Since the IFR rim plate for use with a secondary seal was fabricated from two rolled aluminum extrusions joined in a circumferential seam, an attempt was made (Test Nos. 56 and 57) to determine the emission contribution of the seam.

TABLE 4.1 SUMMARY OF TEST CONDITIONS FOR PHASES 3 AND 3R [1]

Test No.	Product Type	Nominal Vap. Press (psia)	Gap Area (in^2/ft dia.) Pri.	Gap Area (in^2/ft dia.) Sec.	Roof Components Column Well	Roof Components Deck Seams	Roof Components Rim Plate	Notes
Phase 3:								
API 52A	C3/nC8	5.0	0	0	Unsealed	Unsealed	Unsealed	[2]
API 52B	C3/nC8	5.0	0	0	Unsealed	Unsealed	Unsealed	[2]
API 52C	C3/nC8	5.0	0	0	Unsealed	Unsealed	Unsealed	[2]
API 52D	C3/nC8	5.0	0	0	Unsealed	Unsealed	Unsealed	[2]
API 52E	C3/nC8	5.0	0	0	Unsealed	Unsealed	Unsealed	[2], [3]
API 53A	C3/nC8	5.0	1	0	Unsealed	Unsealed	Unsealed	[2]
API 53B	C3/nC8	5.0	1	0	Unsealed	Unsealed	Unsealed	[2]
API 53C	C3/nC8	5.0	1	0	Unsealed	Unsealed	Unsealed	[2]
API 54A	C3/nC8	5.0	3	1	Unsealed	Unsealed	Unsealed	[2]
API 54B	C3/nC8	5.0	3	1	Unsealed	Unsealed	Unsealed	[2]
Product Liquid Removed From Primary Seal								
API 52	C3/nC8	5.0	0	0	Unsealed	Unsealed	Unsealed	
API 52R	C3/nC8	5.0	0	0	Unsealed	Unsealed	Unsealed	
API 53	C3/nC8	5.0	1	0	Unsealed	Unsealed	Unsealed	
API 54	C3/nC8	5.0	3	1	Unsealed	Unsealed	Unsealed	
API 55A	C3/nC8	5.0	Sealed	Sealed	Sealed	Sealed	Sealed	
API 55	C3/nC8	5.0	Sealed	Sealed	Sealed	Sealed	Sealed	[4]
API 56	C3/nC8	5.0	Sealed	Sealed	Sealed	Unsealed	Sealed	[4]
API 57	C3/nC8	5.0	Sealed	Sealed	Sealed	Unsealed	Unsealed	[4]
API 58	C3/nC8	5.0	Sealed	Sealed	Unsealed	Unsealed	Unsealed	[4]

TABLE 4.1 SUMMARY OF TEST CONDITIONS FOR PHASES 3 AND 3R [1] (continued)

Test No.	Product Type	Nominal Vap. Press (psia)	Gap Area (in^2/ft dia.) Pri.	Sec.	Roof Components Column Well	Deck Seams	Rim Plate	Notes
API 59	C3/nC8	5.0	0	-	Unsealed	Unsealed	Unsealed	
API 60	C3/nC8	5.0	1	-	Unsealed	Unsealed	Unsealed	
API 61	C3/nC8	5.0	3	-	Unsealed	Unsealed	Unsealed	
API 62	C3/nC8	2.5	1	-	Unsealed	Unsealed	Unsealed	
API 63	C3/nC8	0.5	1	-	Unsealed	Unsealed	Unsealed	
API 64	nC8	0.5	1	-	Unsealed	Unsealed	Unsealed	
API 65	nC6	2.5	1	-	Unsealed	Unsealed	Unsealed	
Phase 3R:								
API 65R	nC6	2.5	1	-	Unsealed	Unsealed	Unsealed	
API 65A	nC6	2.5	1	-	Unsealed	Unsealed	Unsealed	[5]
API 66	nC6	2.5	1	0	Unsealed	Unsealed	Unsealed	[2]
API 66R	nC6	2.5	1	0	Unsealed	Unsealed	Unsealed	

Notes: [1]. During both Phases 3 and 3R, Type 1 air flow distribution was used, the nominal (air-product) temperature difference was kept at zero, and the roof elevation was kept at 36 in. below the air inlet.

[2]. Emission test data is of questionable value since liquid product was present in the primary seal.

[3]. Column well cover intentionally positioned off center with a gap.

[4]. All taped joints were also caulked during this test.

[5]. During this test the primary seal gap plates were intentionally extended down into the product.

4.3 Test Results

The measured test data for Phases 3 and 3R are tabulated in Table B3 in Appendix B, and are plotted on Figures 4.3 through 4.12. Table 4.2 is a summary of the average emissions for each test in Phases 3 and 3R for all data points with wind speeds less than or equal to 20 mi/hr.

The effect of primary seal gaps on emissions is shown in Figure 4.6, where again for small gaps (i.e. 1 in^2/ft dia.) the variation did not appear to significantly affect emissions.

The effect of primary and secondary seal gaps on emissions is shown in Figure 4.3. Comparing the results of Test API60 to those of Test API53 shows some reduction in emissions with the use of a secondary seal.

The effect of deck fittings and deck seams on emissions is shown in Figure 4.5. The deck seam emissions are summarized in Table 4.3 for both the Bolted, Noncontact IFR (which had 36 ft. of deck seam) and the Bolted, Contact IFR (which had 89 ft. of deck seam).

The effect of vapor pressure and product type on emissions is shown in Figures 4.7, 4.10, 4.11 and 4.12.

TABLE 4.2 SUMMARY OF EMISSION TEST RESULTS FOR BOLTED, CONTACT IFR

Test No.	Average Vap. Press. (psia)	Nominal Vap. Press. (psia)	Vapor Mole Wt. (lbm/lbmole)	Emissions [1] at Average Vap. Press. (lbm/day)	Emissions [1] at Average Vap. Press. (lbmole/day)	Emissions [1] at Nom. Vap. Press. (lbm/day)	Emissions [1] at Nom. Vap. Press. (lbmole/day)	Standard Deviation (%)
API52	5.55	5.00	48.0	1.94	0.0404	1.70	0.0354	8.28
API52R	5.55	5.00	48.0	2.24	0.0467	1.97	0.0410	1.08
API52, 52R	5.55	5.00	48.0	2.03	0.0423	1.78	0.0371	9.80
API53	5.45	5.00	48.0	1.89	0.0394	1.70	0.0354	8.94
API54	5.45	5.00	48.0	2.15	0.0448	1.93	0.0402	9.07
API55A	5.40	5.00	48.1	0.811	0.0169	0.737	0.0153	5.40
API55	5.40	5.00	48.1	0.727	0.0151	0.661	0.0137	4.06
API55,55A	5.40	5.00	48.1	0.777	0.0162	0.706	0.0147	7.34
API56	5.45	5.00	48.2	1.66	0.0344	1.49	0.0309	8.38
API57	5.50	5.00	48.2	1.86	0.0386	1.65	0.0342	6.96
API58	5.45	5.00	48.2	2.17	0.0450	1.95	0.0405	8.44
API59	4.95	5.00	48.6	2.11	0.0434	2.14	0.0440	6.77
API60	4.85	5.00	49.0	2.26	0.0461	2.35	0.0480	2.76
API61	4.80	5.00	49.0	2.68	0.0547	2.82	0.0576	14.2
API62	2.95	2.50	52.0	1.75	0.0337	1.46	0.0281	16.8
API63	0.88	0.50	75.5	1.23	0.0163	0.687	0.00910	9.35
API64	0.55	0.50	105.	0.955	0.00910	0.867	0.00826	8.41
API65	3.40	2.50	86.2	2.79	0.0324	1.98	0.0230	4.68
API65R	3.40	2.50	86.2	4.79	0.0556	3.40	0.0394	6.68
API65A	3.40	2.50	86.2	4.81	0.0558	3.41	0.0396	7.94
API65R,A	3.40	2.50	86.2	4.79	0.0556	3.40	0.0394	6.59
API66R	3.45	2.50	86.2	4.30	0.0499	3.00	0.0348	11.0

Notes: [1]. Emission values tabulated are the average emission value for all data points with wind speeds less than or equal to 20 mi/hr.

TABLE 4.3 BOLTED DECK SEAM EMISSIONS

Test No.	Product Type	Nominal Vapor Press. (psia)	Vapor Mole. Wt. (lbm/lbmole)	Deck Seams	Total Deck Seam Length (ft)	Emissions At Nom. Vap. Press. (lbm/day)	Emissions At Nom. Vap. Press. (lbmole/day)
Bolted, Contact IFR							
API55	C3/nC8	5.00	48.1	sealed	89	0.661	0.0137
API56	C3/nC8	5.00	48.2	unsealed	89	1.49	0.0309
Bolted, Noncontact IFR							
API76R	C3/nC8	5.00	46.8	unsealed	36	2.08	0.0444
API77	C3/nC8	5.00	47.1	sealed	36	1.69	0.0359

Pri. Seal: Sealed
Sec. Seal: None
Deck Fittings: Sealed

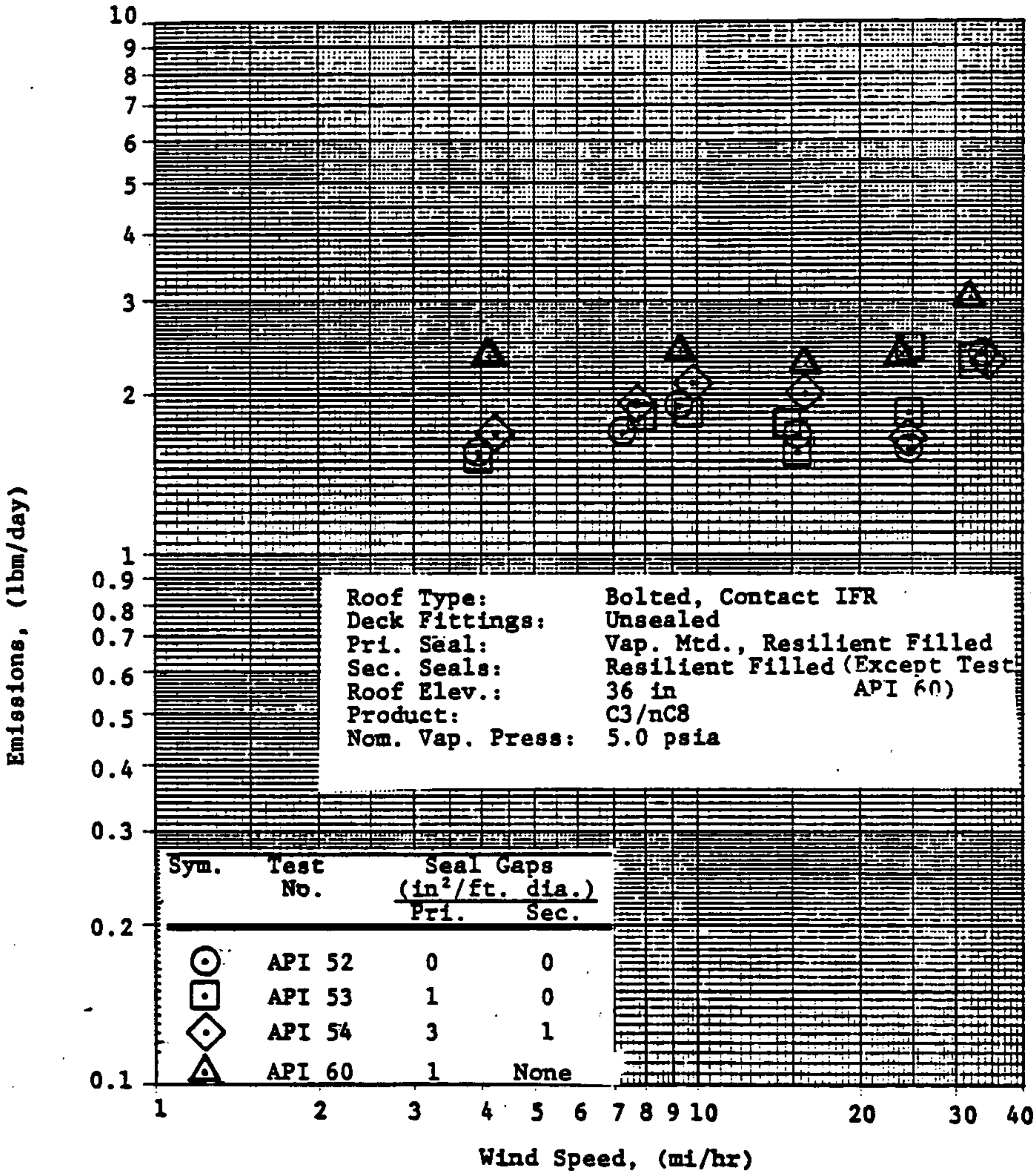


Figure 4.3 Effect of Primary and Secondary Seal Gaps on Emissions

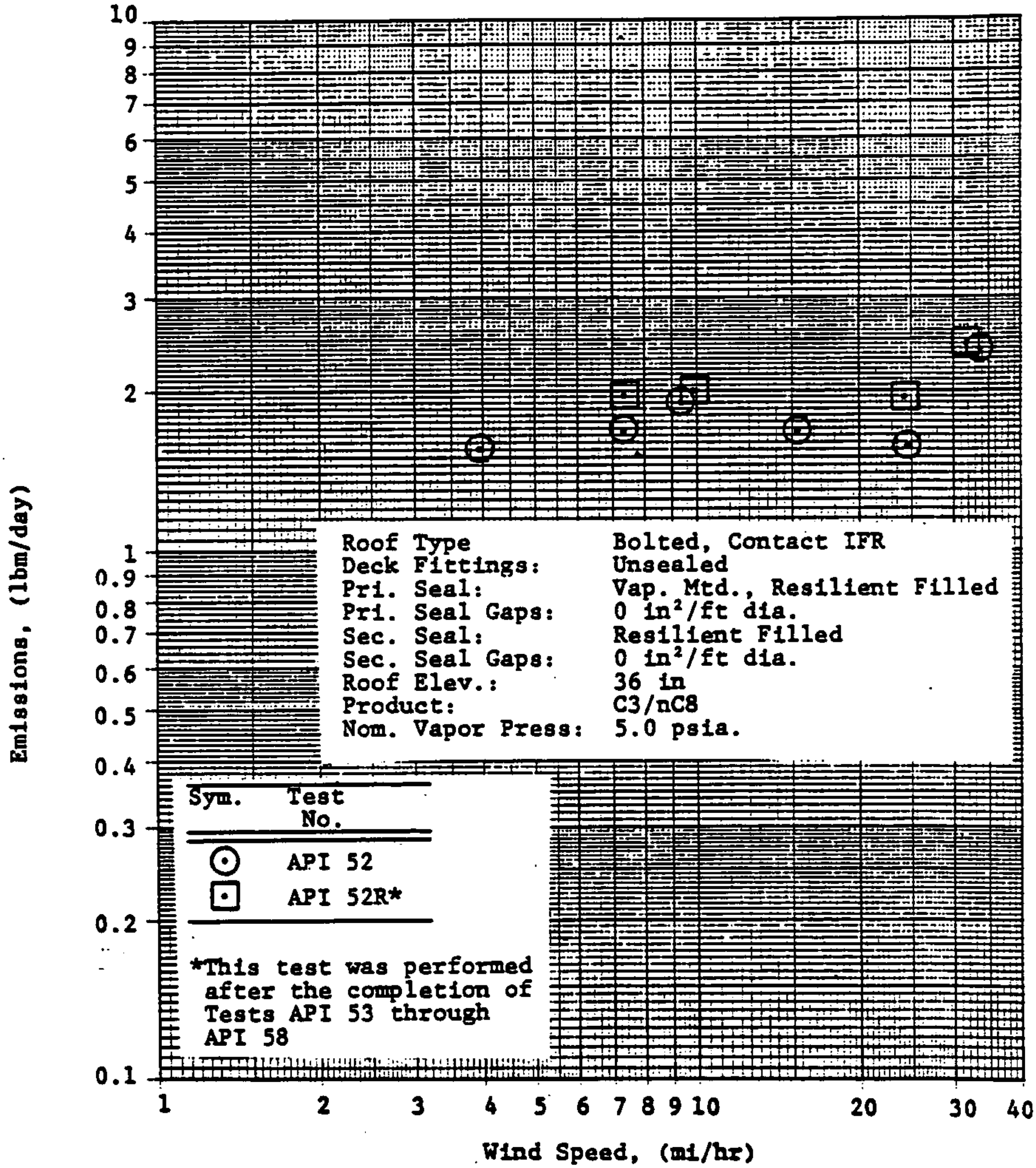


Figure 4.4 Repeatability of Emissions for Test API 52

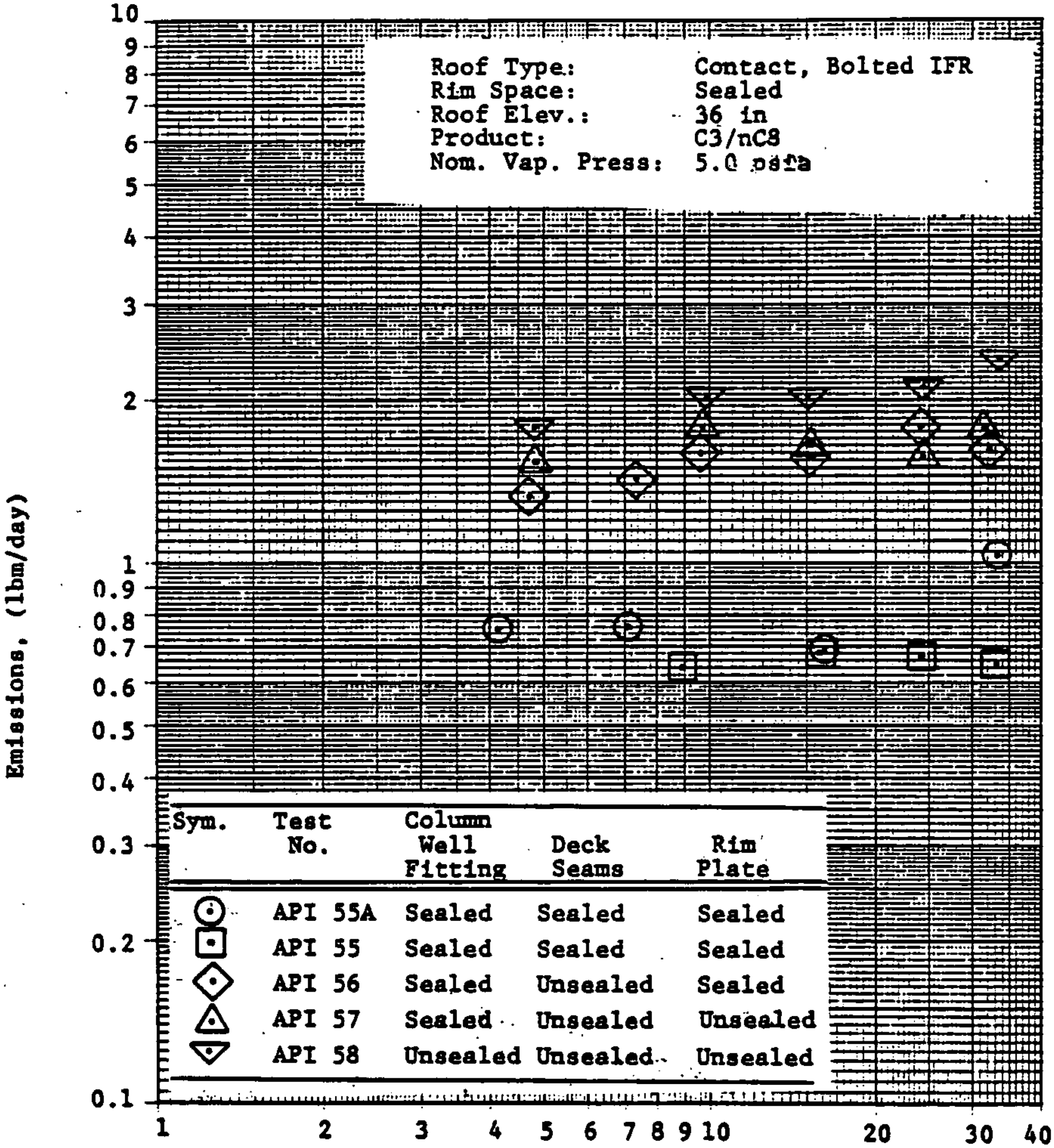


Figure 4.5 Effect of Deck Fittings and Deck Seams on Emissions

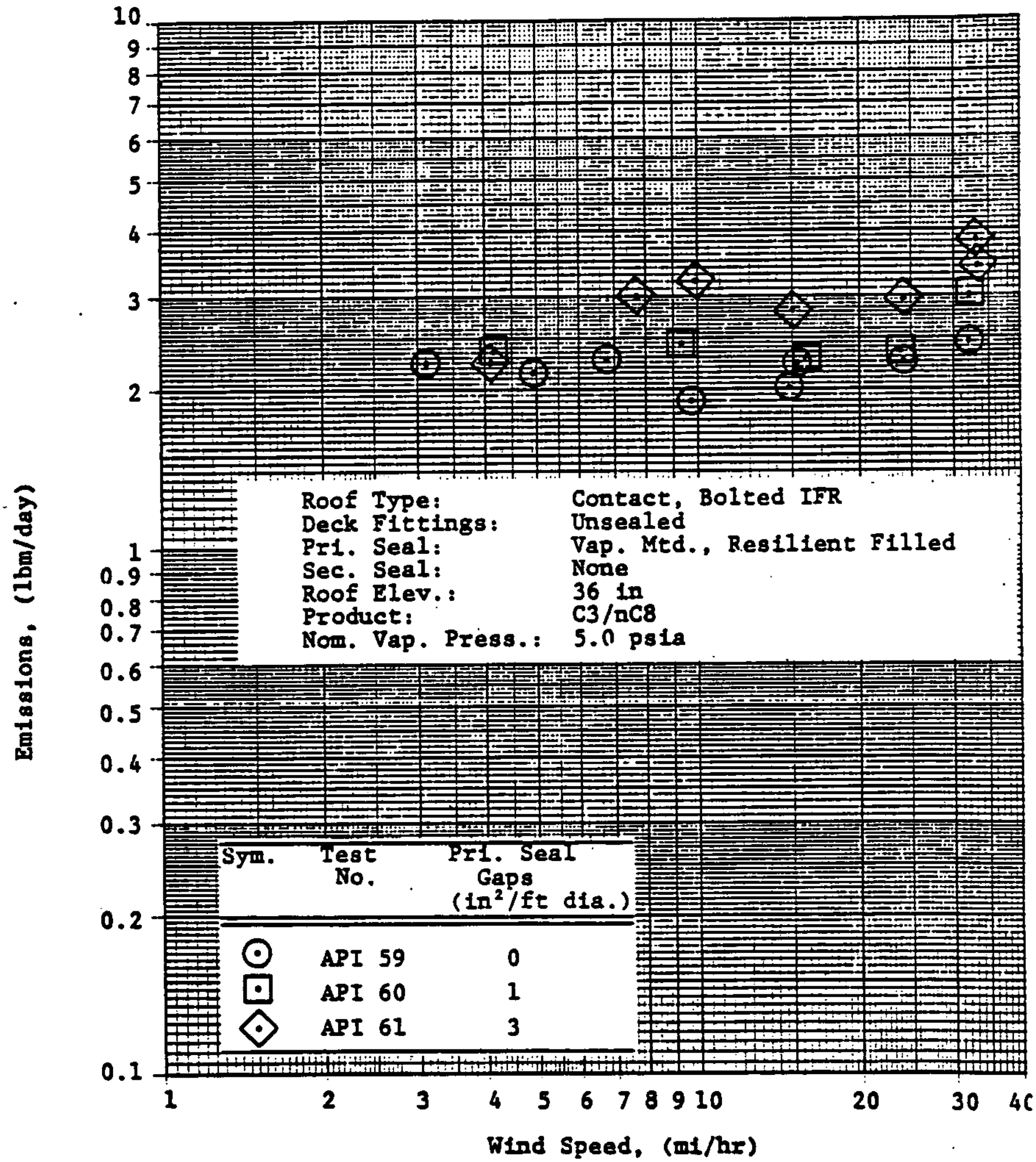


Figure 4.6 Effect of Primary Seal Gaps on Emissions

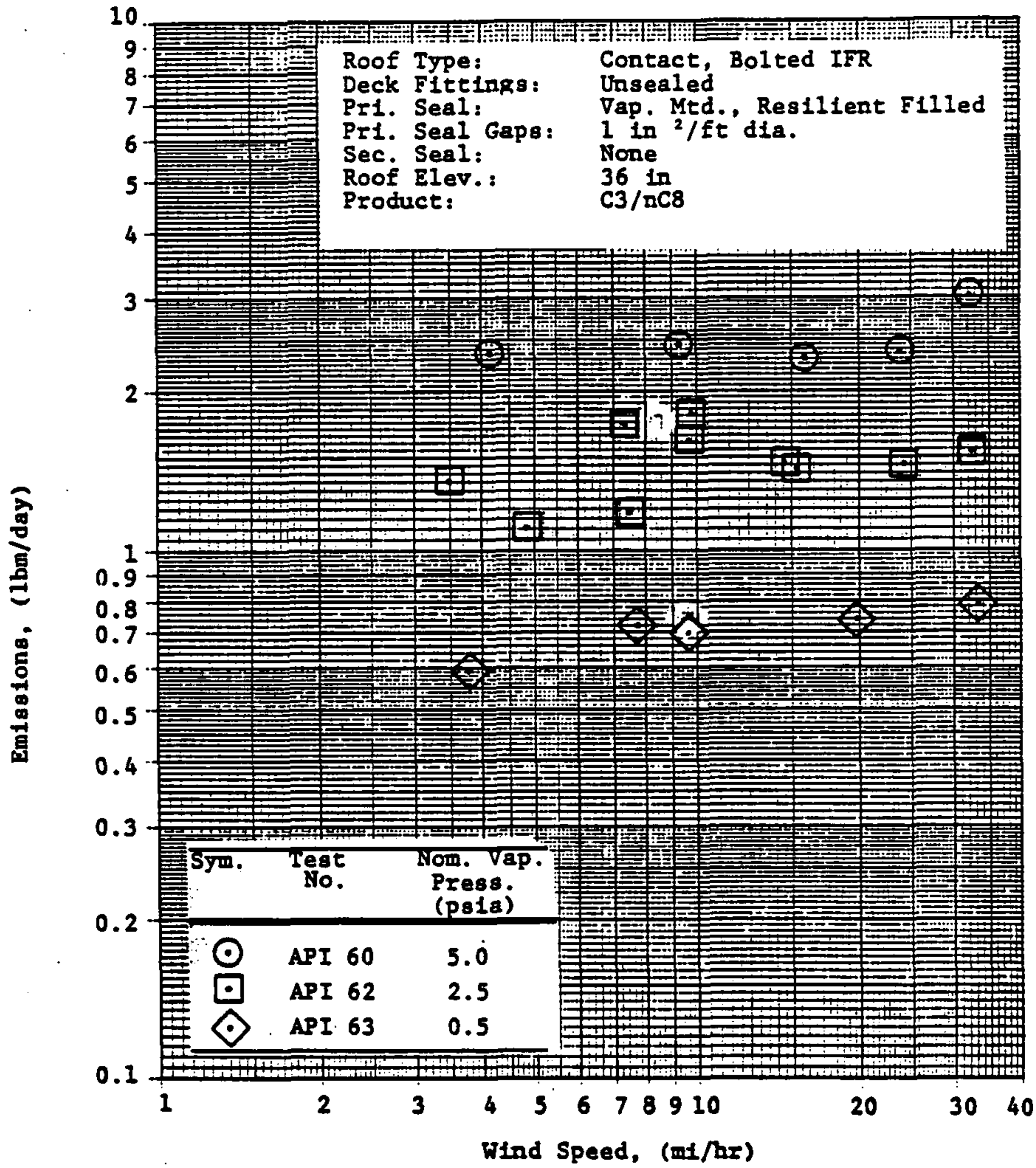


Figure 4.7 Effect of Vapor Pressure on Emissions

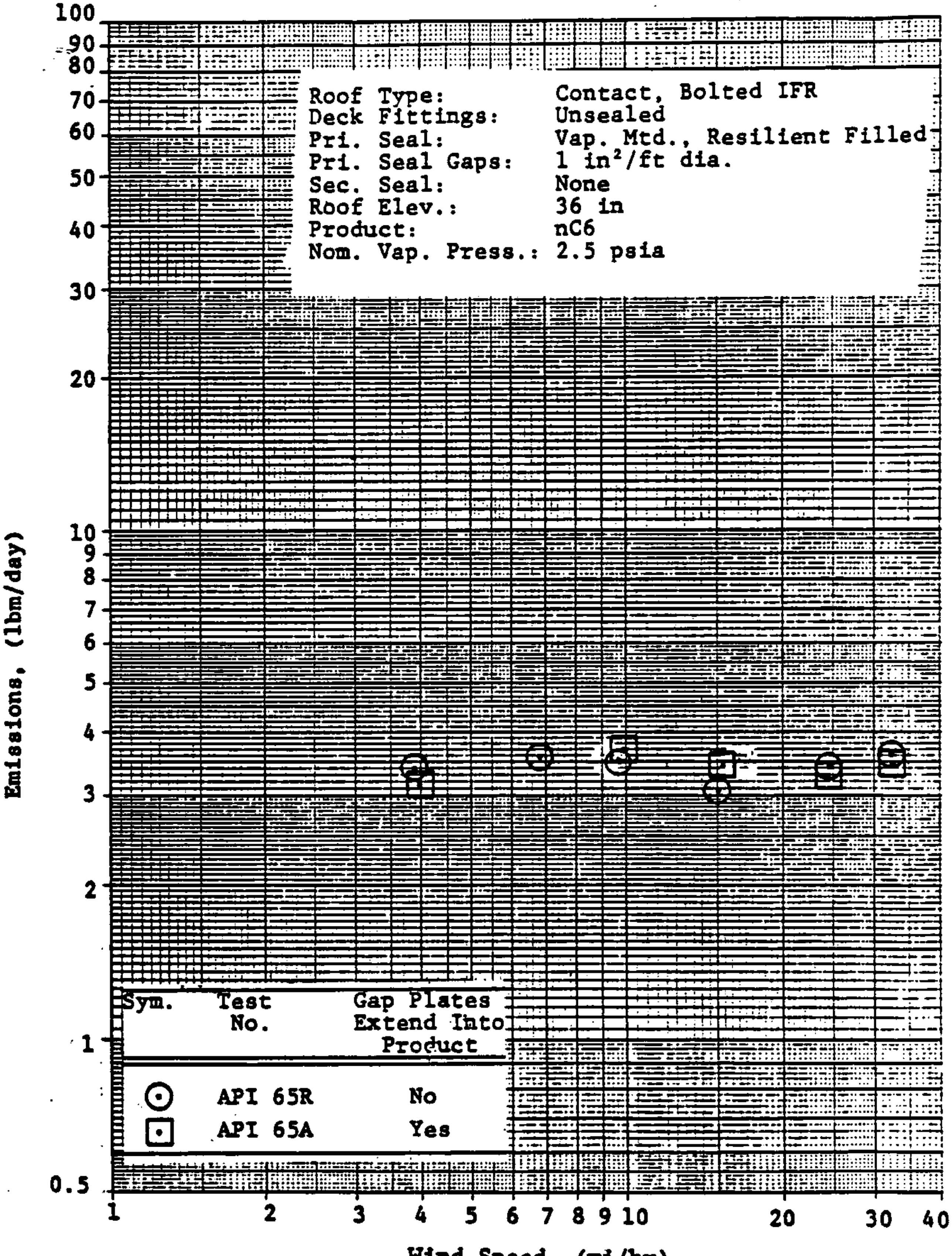


Figure 4.8 Effect on Emissions of Extending the Primary Seal Gap Plates Into the Product

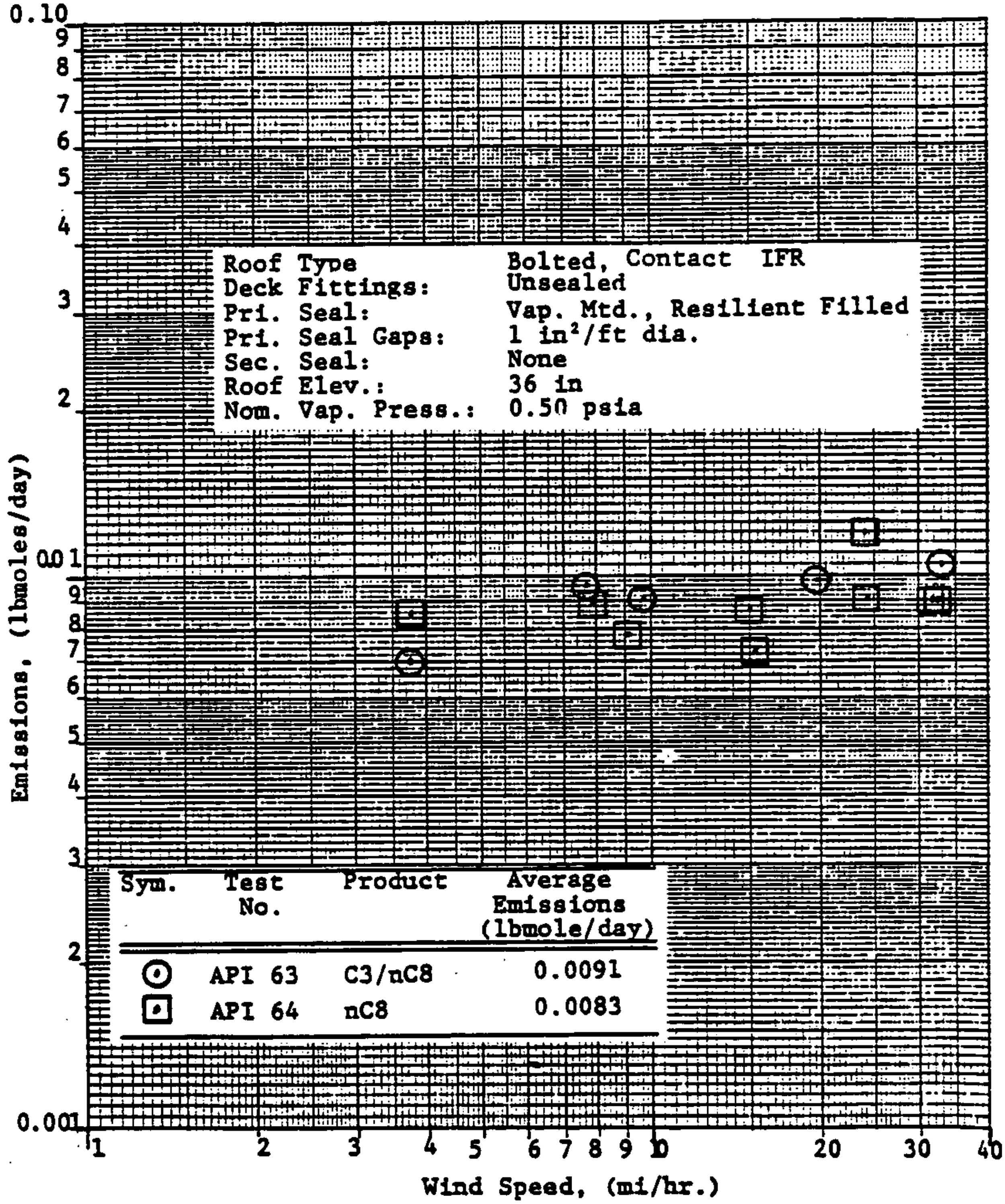


Figure 4.9 Effect of Product Type on Emissions at a Nominal Vapor Pressure of 0.50 psia.

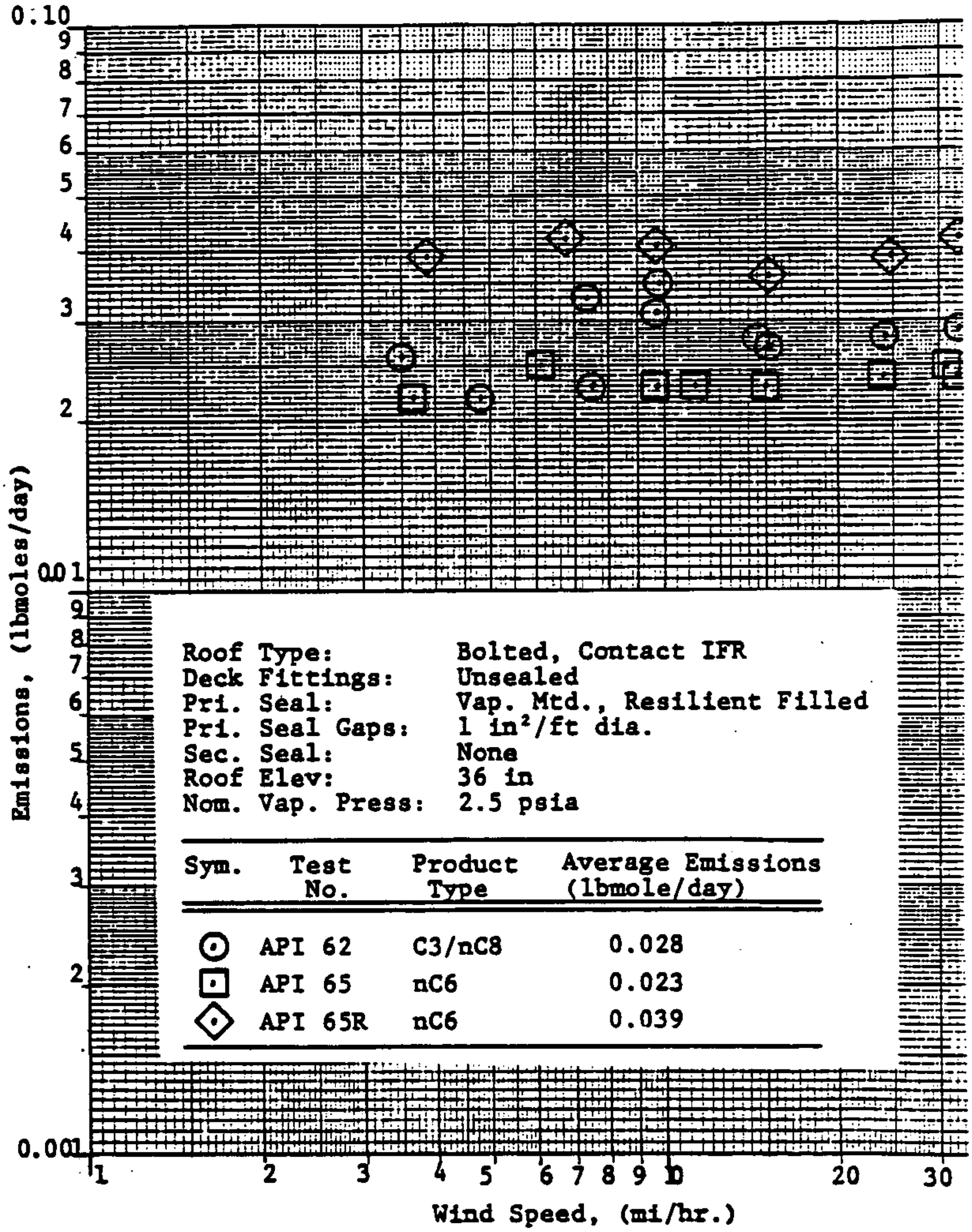


Figure 4.10 Effect of Product Type on Emissions at a Nominal Vapor Pressure of 2.5 psia.

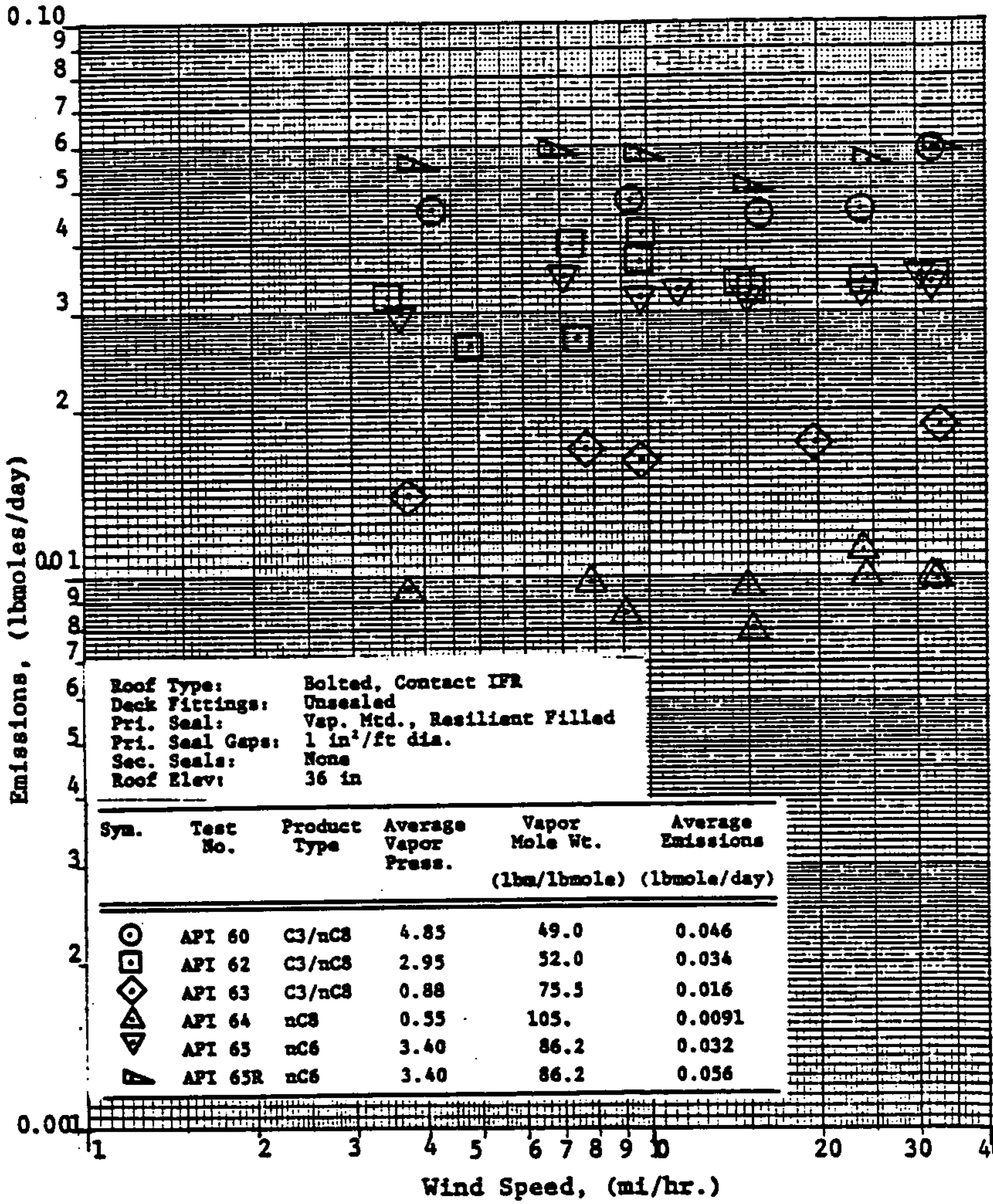


Figure 4.11 Effect of Product Type and Vapor Pressure on Emissions

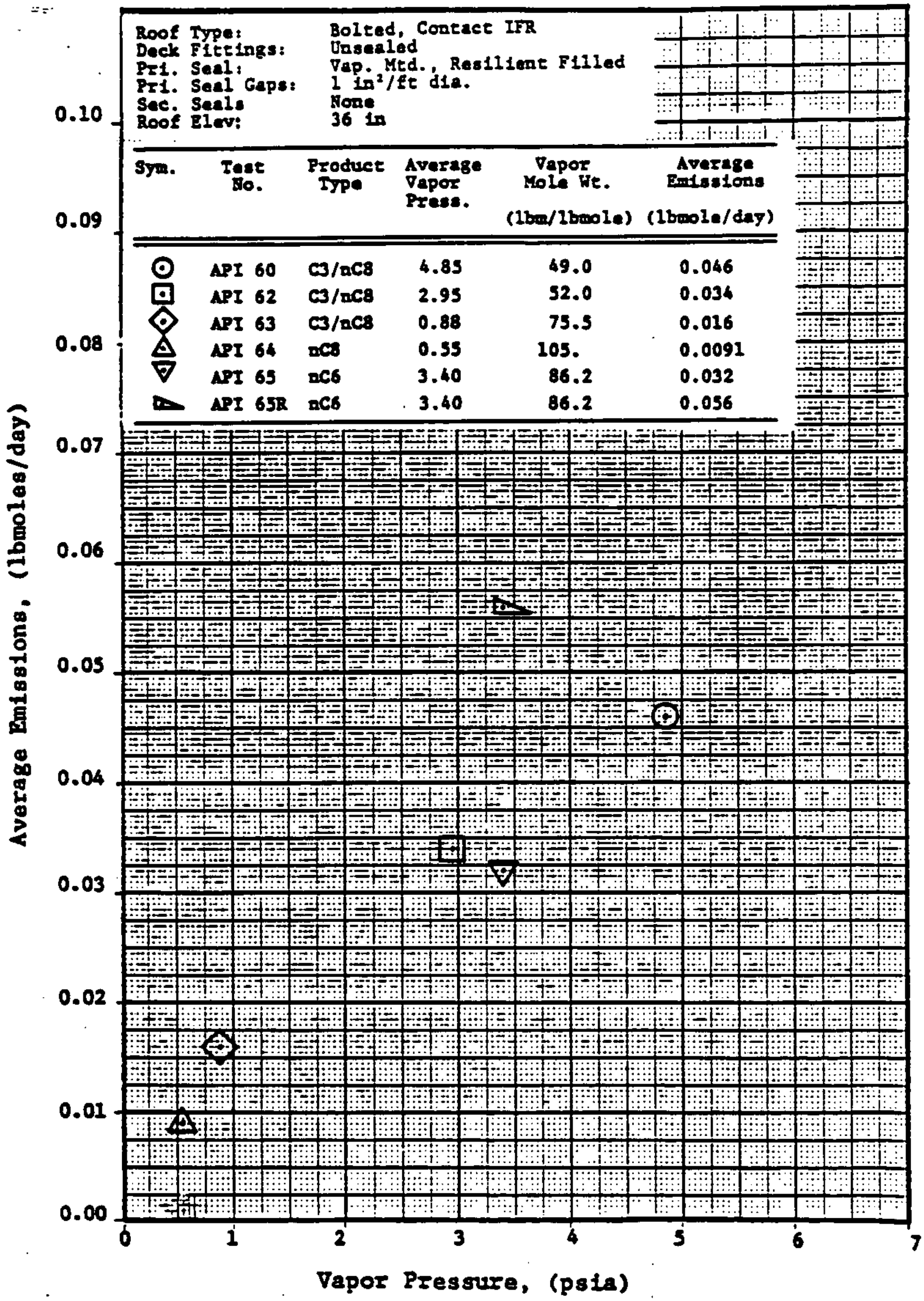


Figure 4.12 Effect of Product Type and Vapor Pressure on Emissions

5.0 IFR Component Tests

5.1 Deck Fitting Emission Tests

A series of bench scale deck fitting emission tests were performed in order to quantify the emissions from IFR deck fittings not tested in the 20 ft. dia. test tank. Also, the column well fittings used with each of the IFR's tested in the 20 ft. dia. test tank were also tested on the bench scale test apparatus in order to correlate the emission data from the bench scale tests with that obtained in the test tank.

Appendix E contains a schematic diagram for each of the deck fitting tests. The wooden pallet and test drum shown in each of the diagrams was placed on one of the five (5) scales, and a themocouple was installed in the product to monitor the test temperature.

The five scales used in the deck fitting tests were as follows:

Scale No.:	1, 2, 3	4, 5
Scale Type:	Electronic	Mechanical
Manufacturer:	Circuits & Systems, Inc.	Toledo Scale Corp.
Model No.:	SX-1000	4180
Range:	0 to 1000 lbm	0 to 1000 lbm
Readability:	± 0.2 lbm	± 0.5 lbm

The test apparatus remained on the scale for a period of about thirty days. Each day, the time, weight and product temperature were recorded. These data are tabulated in Appendix E, and the results of these tests are summarized in Table 5.1 The emission rates shown in this table were calculated by applying a linear least squares regression to the test data in Appendix E. Note that the weight change values listed in the tables in Appendix E are cumulative weight changes referenced to the initial weight measurement.

Table 5.1 also lists the average emission rates in lbmole/yr normalized to a nominal vapor pressure of 5.00 psia. This normalization was performed using the same vapor pressure function ratio as was used to normalize the Test Tank Concentration change readings (see Page 10).

TABLE 5.1 SUMMARY OF IFR DECK FITTING EMISSION TESTS

Test No.	Description	Product Type	Average Product Temp. (°F)	Average Vap. Press. (psia)	Vapor Mole Wt. (lbm/lbmole)	Average Emission Rate (lbm/day)	Correlation Coefficient (-)	Average Emission Rate [2] (lbmole/yr)
1	Access Hatch Cover, Ungasketed	nC6	67.5	2.39	86.2	0.0206	0.681	0.204
2	Access Hatch Cover, Gasketed and Clamped	nC6	66.9	2.35	86.2	0.0157	0.689	0.158
3	1-1/2 in. Dia. Adjustable Roof Leg	nC6	68.4	2.44	86.2	0.101	0.914	0.977
4	8 in. Dia. Slotted Pipe Sample Well	nC6	68.4	2.44	86.2	0.485	0.996	[illegible]
5	8 in. Dia. Pipe Column Well	nC6	68.2	2.43	86.2	0.217	0.989	2.11
6	1 in. Dia. Stub Drain	nC6	75.7	2.91	86.2	0.0350	0.902	0.279
7	Phase 1 Column Well, Ungasketed	nC6	74.5	2.83	86.2	0.526	0.998	4.32
8	1/2 in. Gap Around Built-Up Column	nC6	72.5	2.70	86.2	0.626	0.998	5.42
9A	Phase 1 Column Well, Gasketed	C3/nC8	69.9	3.40	49.2	0.289	0.977	3.38
9B	Phase 1 Column Well, Ungasketed	C3/nC8	69.2	6.56	46.8	0.921	0.959	5.07
10	Phase 2 Column Well	C3/nC8	68.3	4.21	47.8	0.130	0.964	1.22
11	Phase 3 Column Well [1]	C3/nC8	68.3	3.60	48.5	0.202	0.986	2.25
12	1/8 in. Gap Around Built-Up Column	nC6	63.3	2.15	86.2	0.220	0.983	2.44
13	Access Hatch Cover With 1/8 in. Gap	nC6	62.4	2.10	86.2	0.493	0.997	5.61
14	Sample Well With 10% Gap Area	nC6	65.4	2.27	86.2	0.139	0.985	1.45
15	1/8 in. Gap Around Built-Up Column [1]	nC6	62.7	2.12	86.2	0.249	0.983	2.81

Notes: [1]. Test drum was 30 in. diameter.
[2]. Average emission rate normalized to a nominal vapor pressure of 5.00 psia.

5.2 Laboratory Evaporation Tests

5.2.1 Objective

The objective of the Laboratory Evaporation Tests was to determine the evaporation rates of flasks filled with various liquid hydrocarbons to determine if the evaporation rates followed a systematic pattern related to the vapor pressure and vapor molecular weights of the liquid hydrocarbons. Each of the flasks were to be fitted with stoppers equipped with vertical tubes through which the evaporated hydrocarbon could diffuse. In some flasks the tube was to terminate above the liquid surface, and in other flasks the tube was to extend below the liquid surface. Both single component and multicomponent hydrocarbon liquids were to be tested.

5.2.2 Test Description

Four separate series of tests were performed: Series 1, 2, 3 and 4. The basic differences among the tests involved apparatus modifications (see Figures 5.1 and 5.2). Series 1, 2 and 3 were performed with neoprene closures. Series 4 was performed with brass closures because it was discovered that neoprene was permeable to hydrocarbon vapors.

The hydrocarbons were allowed to diffuse upward through vertical tubes into the atmosphere. In all cases, the apparatus was maintained at 70°F. (21.1°C) in a constant temperature bath, and the ambient conditions were recorded daily. The average ambient conditions were as follows:

Series 1-3 (Neoprene Closures):

Temperature	76.9°F (24.9°C)
Relative Humidity	63.8%
Atmospheric Pressure	750.1 mm. Hg (29.52 in. Hg)

Series 4 (Brass Closures):

Temperature	75.8°F (24.3°C)
Relative Humidity	44.2%
Atmospheric Pressure	748.8 mm Hg (29.48 in. Hg)

Throughout the duration of the tests, periodic weighings were made to determine the rate of hydrocarbon loss due to evaporation (diffusion through the vertical tubes).

5.2.3 Test Apparatus

The apparatus used during Series 1-3 was as follows:

1. Aminco Water Bath (with heating, cooling, and circulating capabilities)
2. Erlenmeyer Flasks (125 ml. graduated capacity)
3. Neoprene Stoppers (#6 and #6½)
4. Zinc Granules For Flask Ballast (20 mesh)
5. Reagent Grade Hydrocarbons (n-Pentane, n-Hexane, n-Heptane, n-Octane; i-Octane, Benzene)
6. Stainless Steel Diffusion Tubes (2" x ¼" O.D. x 11/64" I.D. and 4" x ¼" O.D. x 11/64" I.D.)
7. Teflon Plugs and Vinyl Tubing Caps

The apparatus used during Series 4 was as follows:

1. Aminco Water Bath (same as above)
2. Erlenmeyer Flasks (24/40 Standard Taper Necks, 125 ml. graduated capacity)
3. Brass Stoppers (24/40 Standard Taper)
4. Zinc Granules for Flask Ballast (20 mesh)
5. Vinyl Tubing Caps
6. Stainless Steel Diffusion Tubes (2-1/2" x 1/4" O.D. x 0.180" I.D. and 5" x 1/4" O.D. x 0.180" I.D.)
7. Structural Weld Epoxy (Green), 3M Co.
8. Hydrocarbons (n-Hexane, Benzene, Regular Grade Unleaded Gasoline, Propane/n-Octane Mixture). The gasoline had an experimentally determined Reid Vapor Pressure of 11.45 at 100°F and the Propane/n-Octane mixture had an experimentally determined True Vapor Pressure of 4.854 psia at 70°F.

5.2.4 Test Results

The test results are summarized in Tables 5.2 and 5.3. with results from Series 1, 2 and 3 as follows:

Series 1: Apparatus Type I (n-Pentane, n-Hexane, n-Heptane, n-Octane, i-Octane, and Benzene)

Series 2: Apparatus Type II (n-Pentane, n-Hexane, n-Octane, and Benzene)

Series 3: Apparatus Types I and III (Equimolar n-Pentane/n-Octane Mixture)

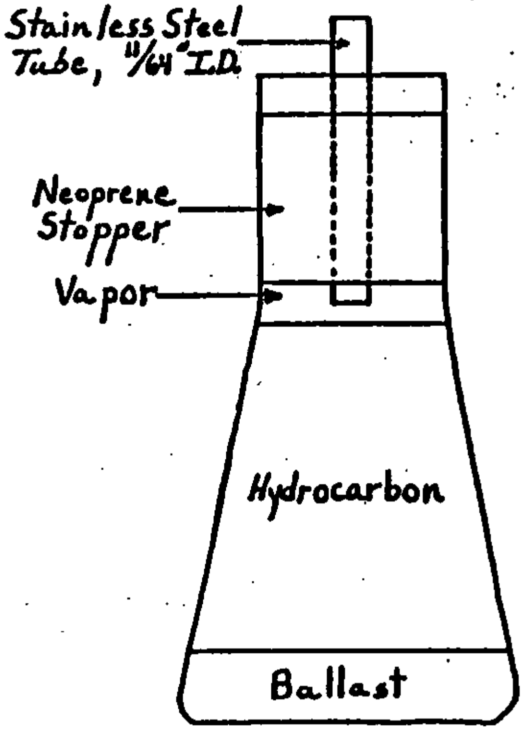
Series 4: Apparatus Types I and III (n-Hexane, Benzene, Regular-Unleaded Gasoline, and Propane/n-Octane Mixture)

The results for Series 1-3 include the measured correction for the permeability of the neoprene closures. No correction was necessary for the Series 4 results because solid brass closures were used.

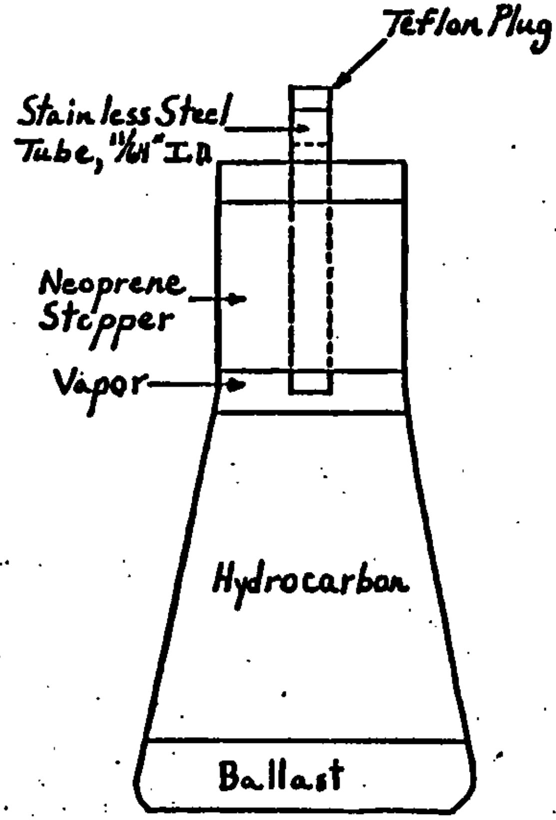
The measured test data for the Laboratory Evaporation Tests are tabulated in Appendix F as follows:

Table F1: Series 1 (Type I, Neoprene Closures)
Table F2: Series 2 (Type II, Neoprene Closures)
Table F3: Series 3 (Types I and III, Neoprene Closures)
Table F4: Series 4 (Types I and III, Brass Closures)
Note that the weight change values listed in these tables are cumulative weight changes referenced to the initial weight measurement.

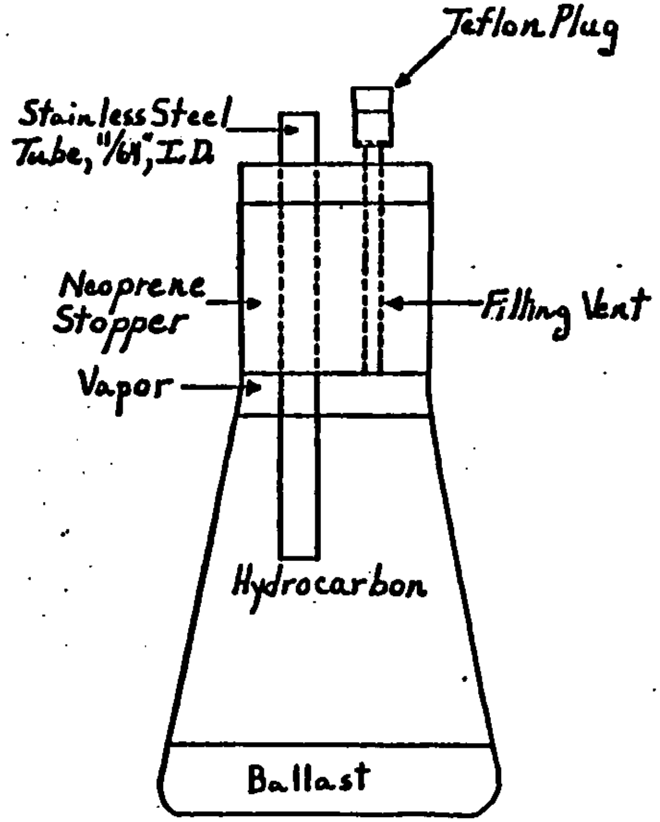
In general, the test results shown in Tables 5.2 and 5.3 agree in trend with what may be expected from evaporation and diffusion theory. As the vapor pressure decreases, and as vapor molecular weight increases, the rate of diffusion-controlled evaporation decreases. This confirms that evaporation rates generally vary in a systematic manner dependent on product vapor pressure and product vapor molecular weight.



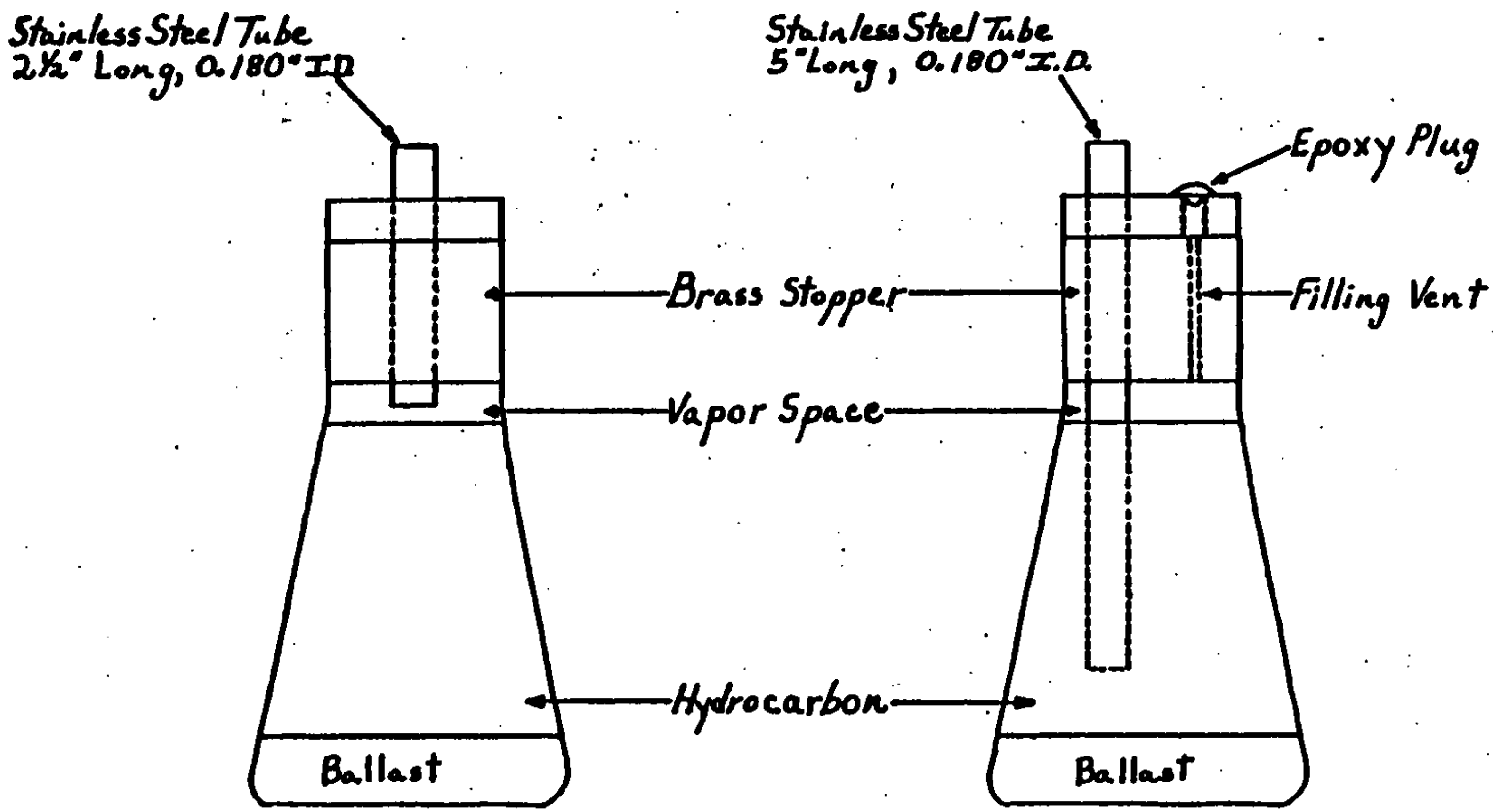
Type I
Diffusion Through
An Open Vertical
Tube



Type II
Neoprene Stopper
Permeability



Type III
Diffusion Through A
Partially Submerged
Vertical Tube



Type I
Diffusion Through
An Open Vertical
Tube

Type III
Diffusion Through A
Partially Submerged
Vertical Tube

Figure 5.2 Laboratory Evaporation Flask Used in Series 4

Table 5.2 - Laboratory Evaporation Test Results For Series 1, 2 and 3

Hydrocarbon	Apparatus Type	Cumulative Gross Diffusion, (Grams/Day)	Cumulative Stopper Permeability, (Grams/Day)	Cumulative Net Diffusion, (Grams/Day)
n-Pentane	I	0.6530	-	0.6263
n-Pentane	II	-	0.0267	-
n-Hexane	I	0.1762	-	0.1617
n-Hexane	II	-	0.0145	-
n-Heptane	I	0.0432	-	0.0332
n-Heptane	-	-	0.0100 (1)	-
n-Octane	I	0.0120	-	0.0065
n-Octane	II	-	0.0055	-
i-Octane	I	0.0482	-	N.D.
Benzene	I	0.1842	-	N.D.
Benzene	II	-	0.2011	-
n-Pentane/(2) n-Octane	I	0.2353	0.0267(3)	0.2086
n-Pentane/(2) n-Octane	III	0.1277	0.0267(3)	0.1010

(1) Calculated (2) Equi-Molar Mixture (3) Assumed n-Pentane Vapor

Table 5.3 Laboratory Evaporation Test Results For Series 4

Hydrocarbon	Apparatus Type	Diffusion Rate* (Ave. Cumulative), (Grams/Day) @70°F
n-Hexane	I	0.126 (28) σ = 0.0125
	III	0.144 (35) σ = 0.0084
Benzene	I	0.069 (28) σ = 0.0056
	III	0.087 (35) σ = 0.0100
Gasoline, Regular Unleaded (RVP = 11.45 at 100°F) (TVP=7.2 psia)	I	0.295 (21) σ = 0.0349
	III	0.228 (35) σ = 0.0419
Propane/Octane Mixture (TVP=4.854 at 70°F)	I	0.084 (28) σ = 0.0305
	III	0.089 (28) σ = 0.0141

* Evaporation Rate. Values enclosed by parentheses are the number of results contributing to the Average.

RVP: Reid Vapor Pressure, psig.

TVP: True Vapor Pressure, psia.

5.3 Laboratory Permeability Tests

A series of preliminary laboratory permeability tests were performed on samples of 0.020 in. thick polyurethane-coated nylon fabric to determine its permeability to normal hexane (nC6) vapor.

A modified version of test procedure ASTM-E96-66 ("Standard Test Method for Water Vapor Transmission of Materials in Sheet Form") was used. This modified procedure involved the use of an evaporation pan containing liquid nC6. The material be tested was sealed to the mouth of the pan. The assembly was placed in a controlled temperature and humidity environment and periodically weighed. To determine the loss rate through the sample edges seal to the pan, control samples were used consisting of sheet aluminum samples which were sealed to the mouth of the pan in the same fashion as the test material samples. The average measured loss rate of the control samples was subtracted from the average measured loss rate of the test material samples to determine the test material permeation rate to nC6 vapor.

Figure 5.3 shows the construction of a typical laboratory permeability test assembly. The materials used in this assembly consisted of:

1. Evaporation Pans

   Rectangular aluminum pans supplied by Chicago Metallic Co., Cat. No. C587, having a mouth area of 0.467 ft^2.

2. Test Material Samples

   Polyurethane-coated nylon fabric supplied by McMaster-Carr Co., Cat No. 86, Item No. 8809K14.

3. <u>Control Samples</u>

   Aluminum plates 1/32 in. thick cut to fit the mouth of the evaporation pan.

4. <u>Sample Edge Sealant</u>

   Polysulfide type sealant supplied by Petrex Inc.

5. <u>Product Liquid</u>

   Reagent grade normal hexane

6. <u>Sample Fill Opening Sealant</u>

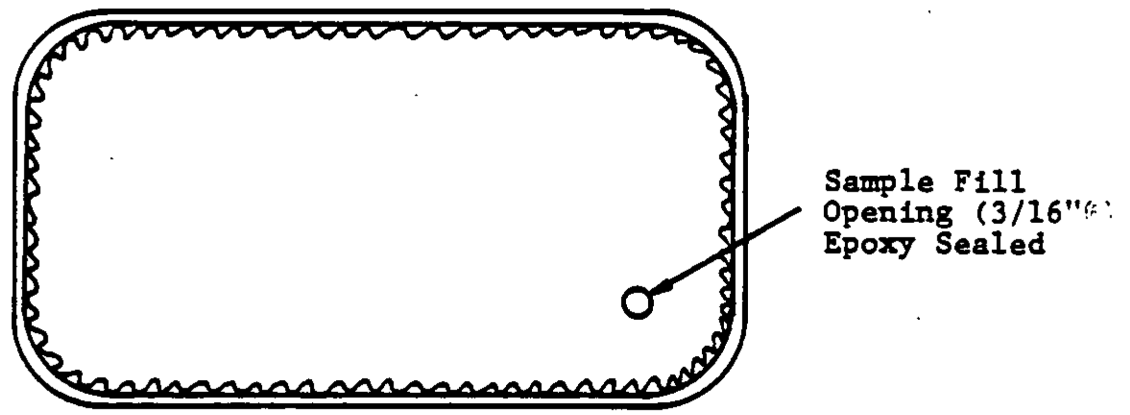
   The 3/16 in. dia. sample fill opening was sealed with a small cork stopper covered with structural weld epoxy supplied by 3M Co.

A total of 5 test material sample assemblies and 5 control sample assemblies were used.

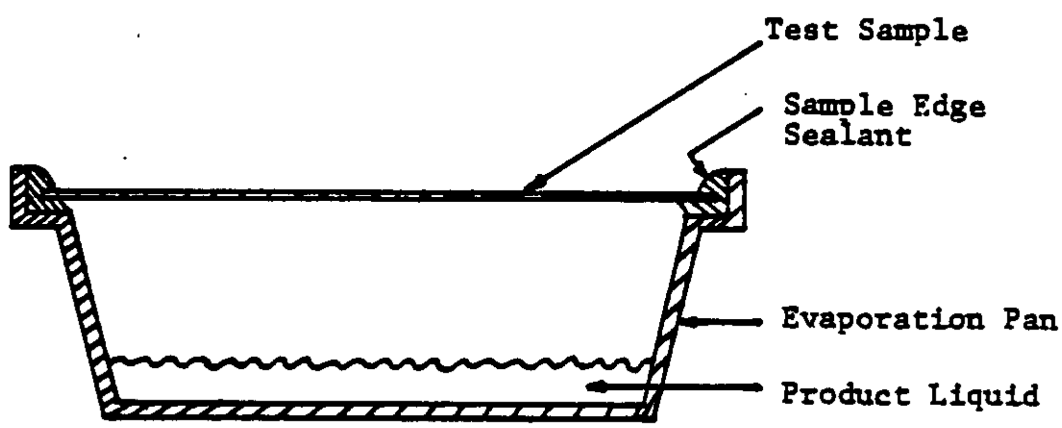
Each sample (fabric or aluminum) was sealed to the mouth of the evaporation pan with a 1/2 in. bead of polysulphide sealant and allowed to cure for 4 days. After the sealant had cured, each pan was filled with normal hexane liquid through the 3/16 in. dia. sample fill openings. These openings were then plugged with a small cork stopper and each stopper was completely covered with an epoxy seal. The completed assemblies were allowed to cure for 2 additional days before beginning the test.

The measured laboratory permeability test data is recorded in Tables G1 and G2 in Appendix G. Table 5.4 lists the test results, which gave an average net permeability rate of 0.0522 lbm/ft^2 day to nC6 vapor.

Although additional laboratory permeability tests were planned, it was decided to perform these permeability tests using the Deck Fitting Emission Test Apparatus, where larger permeability samples could be accommodated in the test apparatus. The results of these additional permeability tests are described in the next section.



Top View of Test Assembly



Cross-Sectional View of Test Assembly

Figure 5.3 Laboratory Permeability Test Assembly

Table 5.4 Laboratory Permeability Test Results For 0.020 in. Thick Polyurethane-Coated Nylon Fabric

Sample Nos.	Description	Average Gross Loss Rate [1] (gm/day)	Average Net Loss Rate (gm/day)	Average Net Loss Rate (lbm/ft^2day)	Notes
1-5	Aluminum Plate Control Samples	1.92 (25% S.D.)	0	0	[2]
6-10	Polyurethane-Coated Nylon Fabric	12.97 (5.3% S.D.)	11.05	0.0522	

Notes: [1]. Average Test Conditions:

Temperature:	74.8°F
Relative Humidity:	40.6%
Barometric Pressure:	29.59 in Hg
Hydrocarbon Liquid:	nC6

[2]. The test results from Samples Nos. 1 and 2 were not used because of suspected leaks.

5.4 Bench Permeability Tests

During certain emission tests performed in the test tank, some of the roof components (i.e. deck fittings, deck seams and floating roof rim area) were sealed using 0.020 in. thick polyurethane coated nylon fabric which was taped in place using aluminum backed duct tape. Typically, it required about 100 ft^2 of fabric to seal all of the roof components. During the tests where all of the roof components were sealed (i.e. Test API77 in Phase 1R, Test API45 in Phase 2, and Test API55 in Phase 3), there remained residual emissions which were suspected to be due to the hydrocarbon vapor permeation of the fabric used to seal the roof components.

To determine the permeation rate of this fabric to hydrocarbon vapor, a series of permeability tests were performed. In addition to testing the 0.020 in. thick polyurethane coated nylon fabric used to seal the roof components, it was also decided to test the 0.037 in. thick polyurethane coated nylon fabric, which was used as the primary seal envelope material in Phases 2 and 2R during this test program and during earlier tests [2,5]. Since these earlier tests included benzene product, the permeability of this material was also tested with benzene.

A preliminary laboratory permeability test was performed, and is described in Section 5.3. The rest of the permeability tests were performed using the Deck Fitting Emission Test Apparatus, since larger permeability samples could be accommodated in this test apparatus. This test apparatus is described in Section 5.1. Figures E14, E15 and E16 in Appendix E show the test apparatus assembly details as it was used during the bench permeability tests.

The bench permeability tests are identified as Bench Test Nos. 16 through 24. The measured test data is tabulated in Appendix E, and the test results are listed in Table 5.5. Note that the weight change values listed in the tables in Appendix E are cumulative weight changes referenced to the initial weight measurement.

The permeability test results confirm that the residual emissions measured when all roof components were sealed were probably due to hydrocarbon vapor permeation of the fabric used to seal the roof components. For example, Bench Permeability Test No. 20 indicates a permeation rate of about 0.03 lbm/ft^2 day, and for 100 ft^2 of sealing fabric this could result in residual emissions as high as 3 lbm/day if product saturation conditions were present under the sealing fabric. This compares, for example, with the measured residual emissions of about 2 lbm/day in Test API77.

TABLE 5.5 PERMEABILITY OF POLYURETHANE COATED NYLON FABRIC

Test No.	Fabric Thickness (in)	Fabric Area (ft^2)	Length of Taped Seams (in)	Product Type	Average Product Temp. (°F)	Average Vap. Press. (psia)	Vapor Mole. Wt. (lbm/lbmole)	Average Emission Rate (lbm/day)	Correlation Coefficient (-)	Average Permeation Rate ($lbm/ft^2 day$)	Notes
16	0.020	2.75	-	C3/nC8	59.2	7.13	45.8	0.0612	0.838	0.0222	
17	0.037	2.75	-	C6H6	60.5	1.22	78.1	0.159	0.996	0.0578	
18	0.037	2.75	-	nC6	60.1	1.98	86.2	0.0158	0.663	0.00578	
19	0.020	2.75	-	C3/nC8	53.8	3.86	46.6	0.0652	0.783	0.0237	
20	0.020	2.75	-	C3/nC8	48.1	3.56	46.3	0.0808	0.806	0.0294	
21	0.020	2.75	48	C3/nC8	50.9	4.68	45.9	0.0650	0.863	0.0236	[1]
22	0.020	2.75	-	C3/nC8	43.2	3.59	46.0	0.0344	0.805	0.0125	
23	1/16" thk.	alum.	60	C3/nC8	44.2	3.38	46.3	0.00273	0.096	-	[1]
Laboratory Permeability Test											
—	0.020	0.467	-	nC6	74.8	1.85	86.2	0.0244	—	0.0522	

Notes: [1]. Aluminum backed duct tape was used on all taped seams.

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(1). American Petroleum Institute, "Use of Internal Floating Covers and Covered Floating Roofs to Reduce Evaporation Loss", API Publication 2519, Second Edition, 1976.

(2). Cherniwchan, W. N. and R. J. Laverman, "Hydrocarbon Emission Loss Measurements On A 20 Foot Diameter Pilot Test Tank With An Ultraflote and a CBI Weathermaster Internal Floating Roof", Chicago Bridge & Iron Co., Final Report, Research Contracts R-0113 and R-0191, June 12, 1978.

(3). Cherniwchan, W. N., "Air Flow Characteristics of Roof and Shell Vents for a Weathermaster Floating Roof Tank", Chicago Bridge & Iron Co., Final Report, Research Contract R-0158, Jan. 5, 1978.

(4). Helm, N. C. and P. D. Giese "Wind Tunnel Tests of a 0.017 - Scale Model to Determine Pressure, Flow and Venting Characteristics of a Liquid Storage Tank", FluiDyne Engineering Corporation, Report No. 1114, (CBI Research Contract R-0150), June, 1977.

(5). Laverman, R.J. and W.N. Cherniwchan, "Measurement of Benzene Emissions from a Floating Roof Test Tank", U. S. Environmental Protection Agency, Report No. EPA-450/3-79-020, June, 1979.

(6). Purdy, D.M., F.J. Maher and D. Frederick, "Model Studies of Wind Loads on Flat-Top Cylinders", Journal of the Structural Division, ASCE, Vol. 93, No. ST2, Proceedings of Paper No. 5209, April, 1967, pp 379-395.

(7). Runchal, A.K., "The Influence of the Wind on Hydrocarbon Emissions From Internal Floating Roof Tanks", Analytic and Computational Research, Inc., Nov. 17, 1980.

(8). American Petroleum Institute, "Petrochemical Evaporation Loss From Storage Tanks", API Bulletin 2523, First Edition, November, 1969.

APPENDIX A

Chronological Sequence of Events

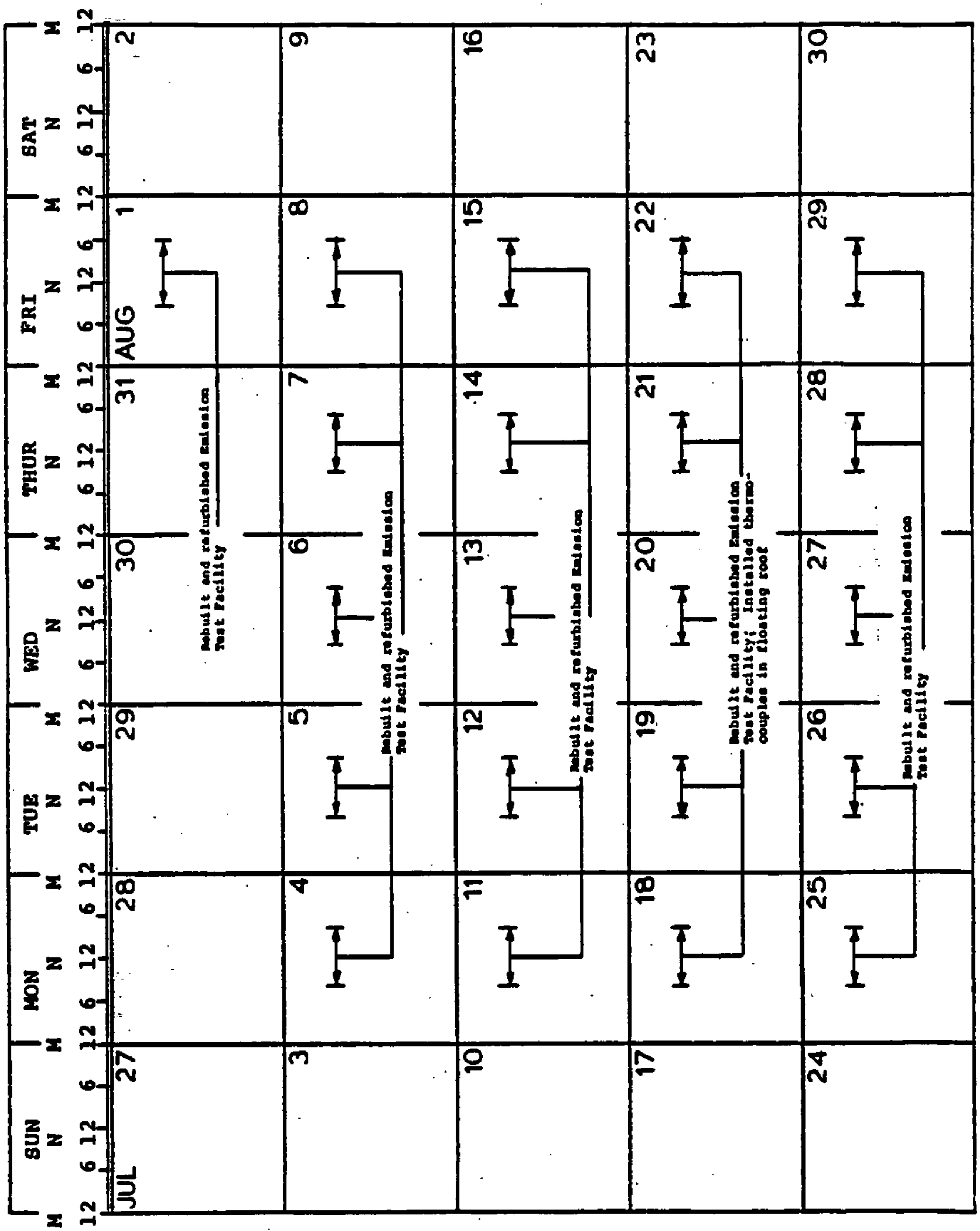


Figure A1 Calender of Events for August, 1980

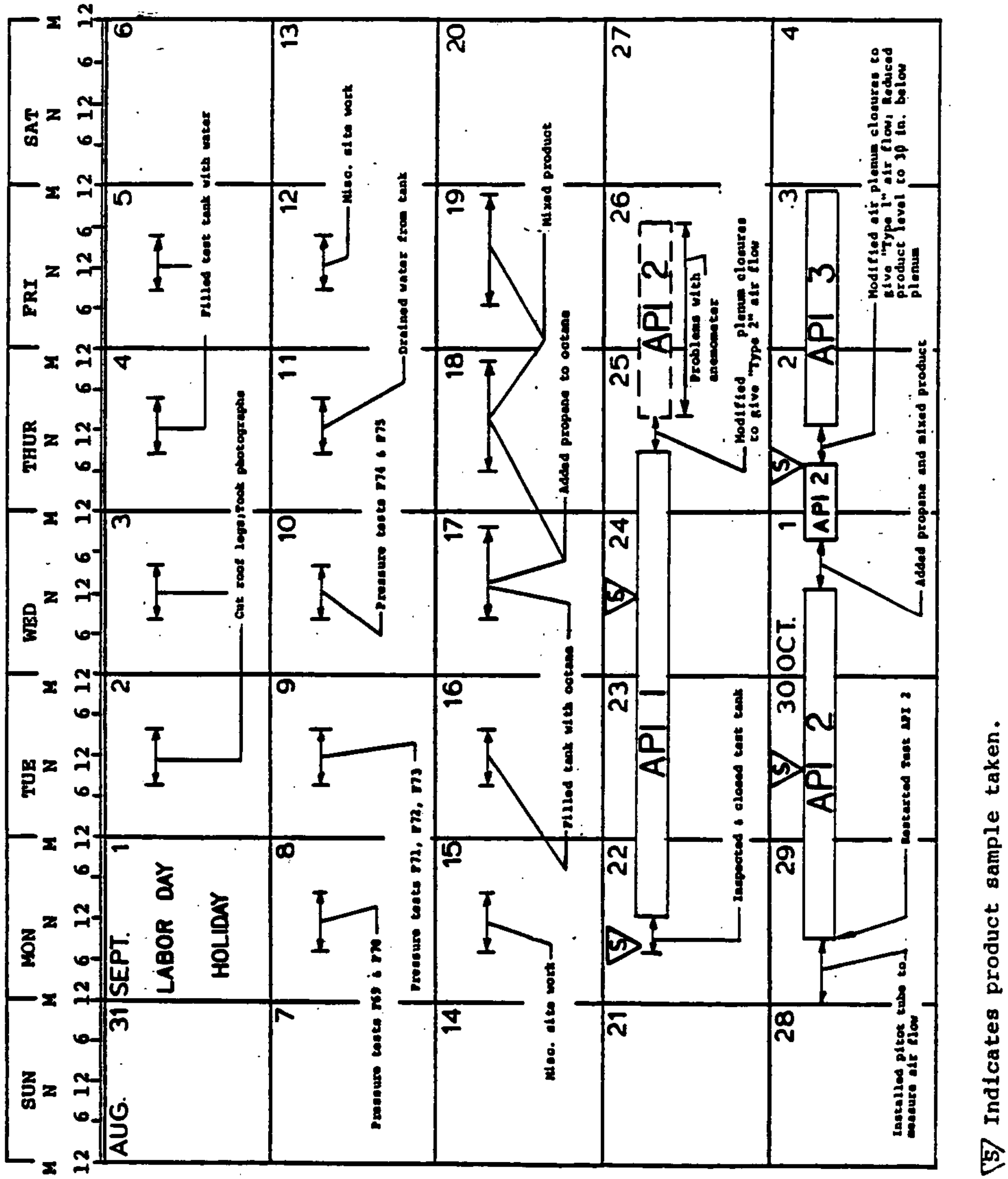


Figure A2 Calender of Events for September, 1980

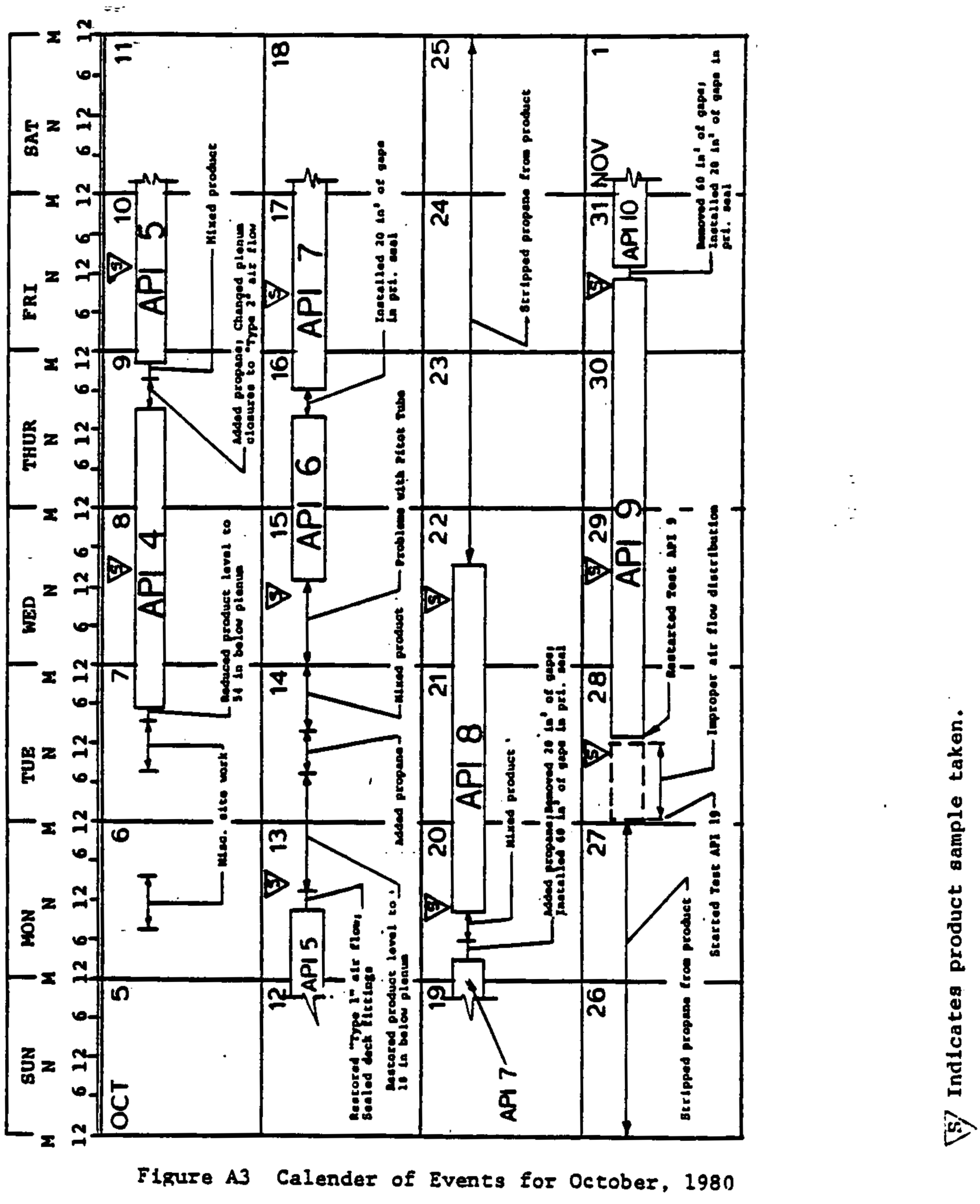


Figure A3 Calender of Events for October, 1980

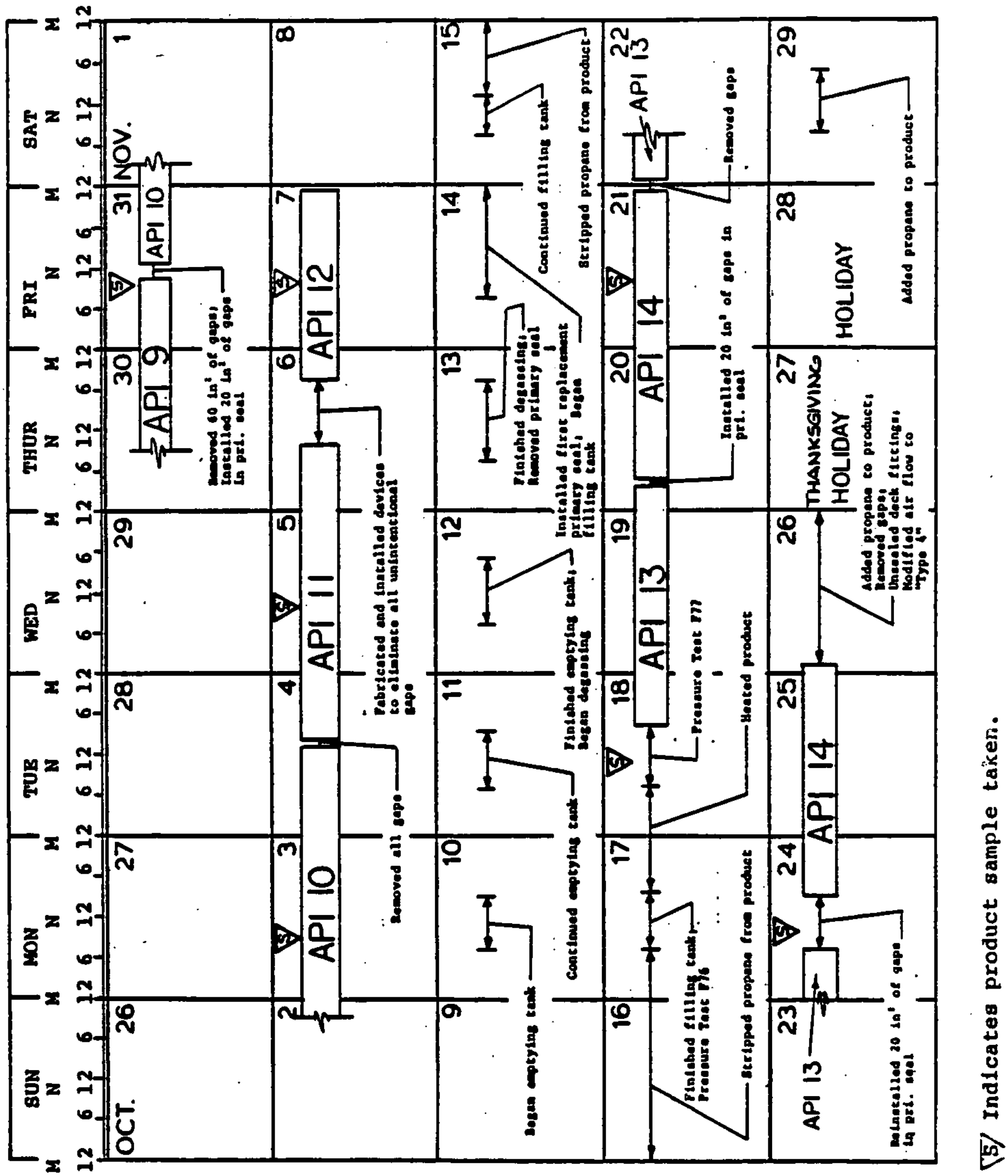


Figure A4 Calender of Events for November, 1980

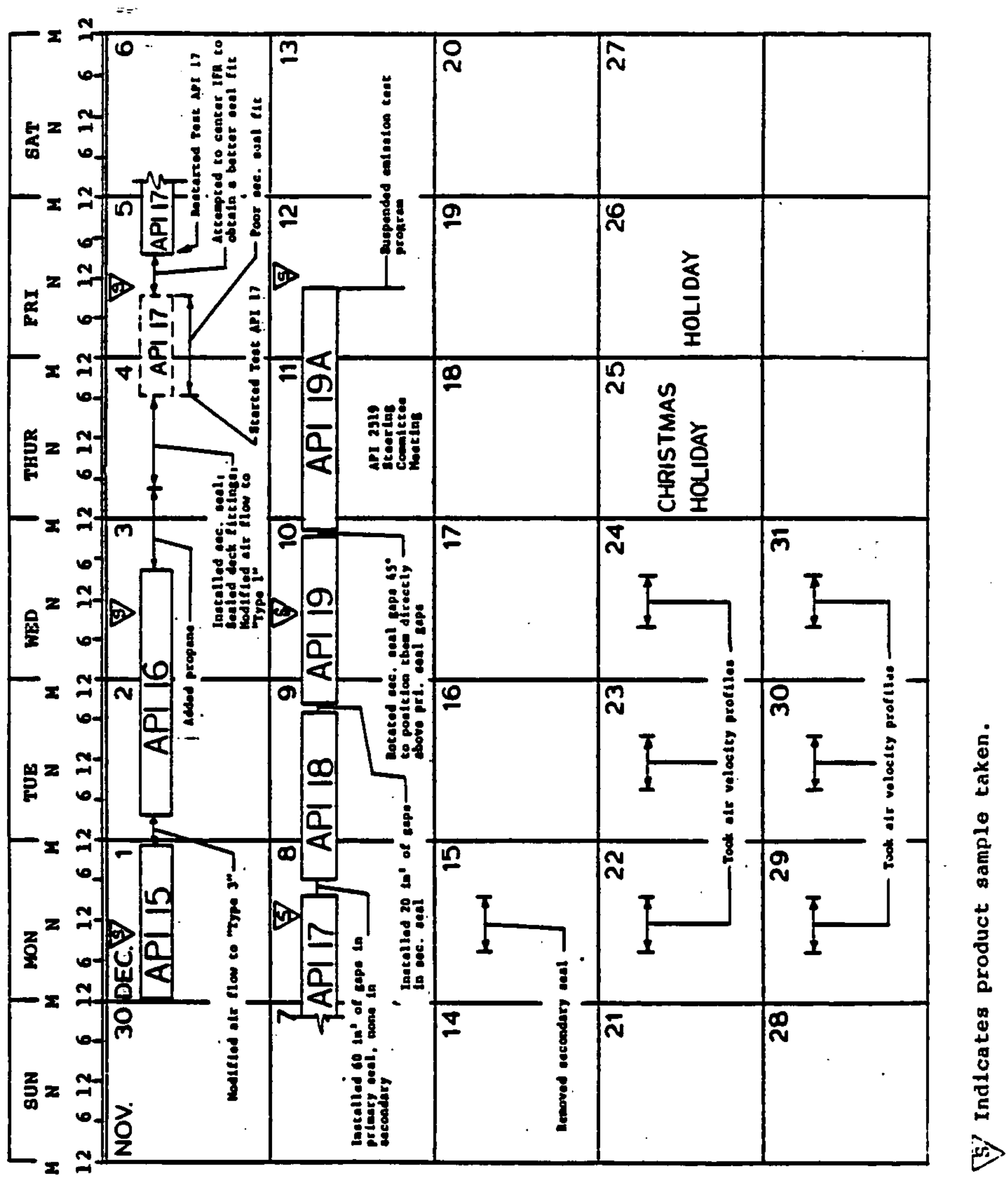


Figure A5 Calender of Events for December, 1980

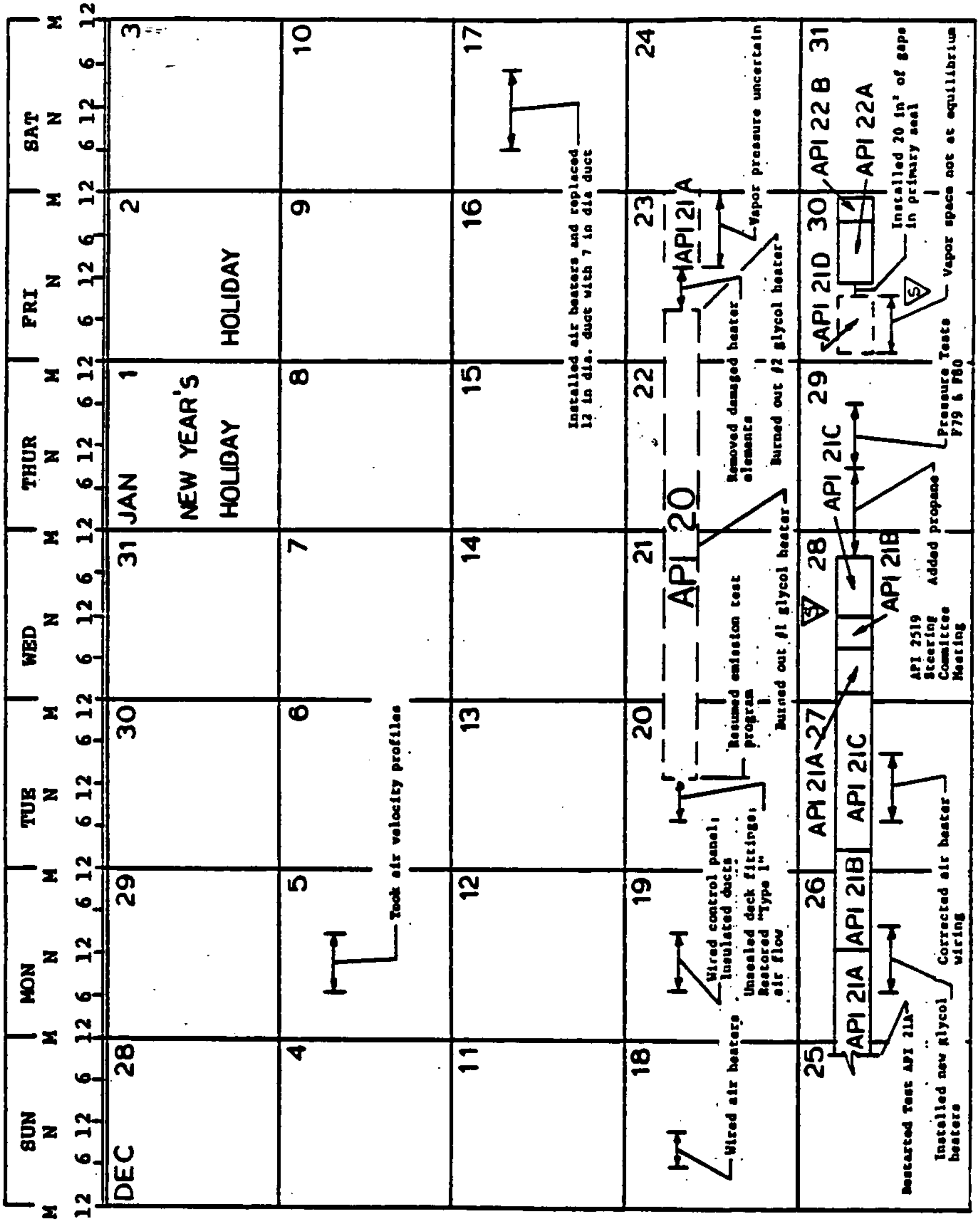
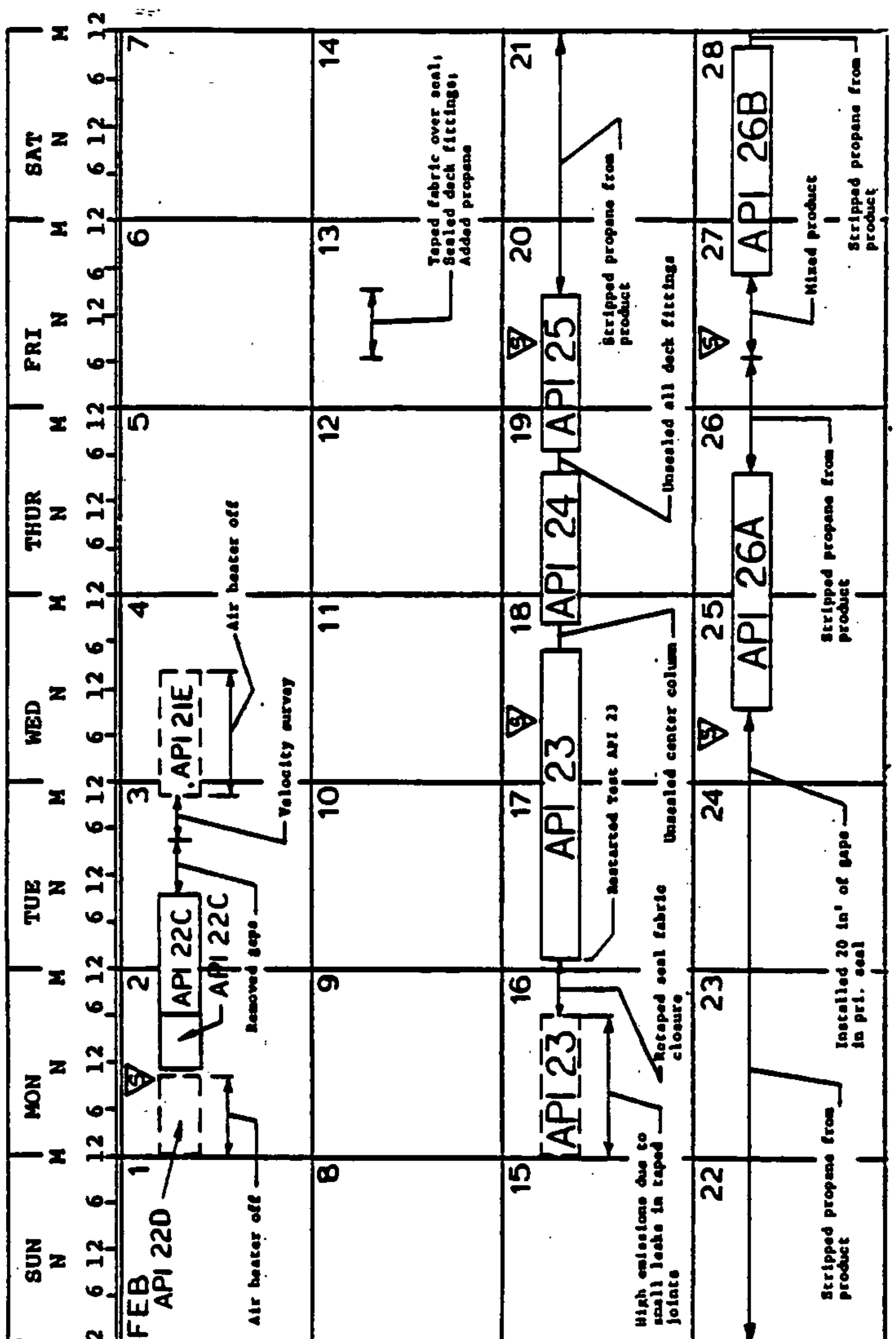


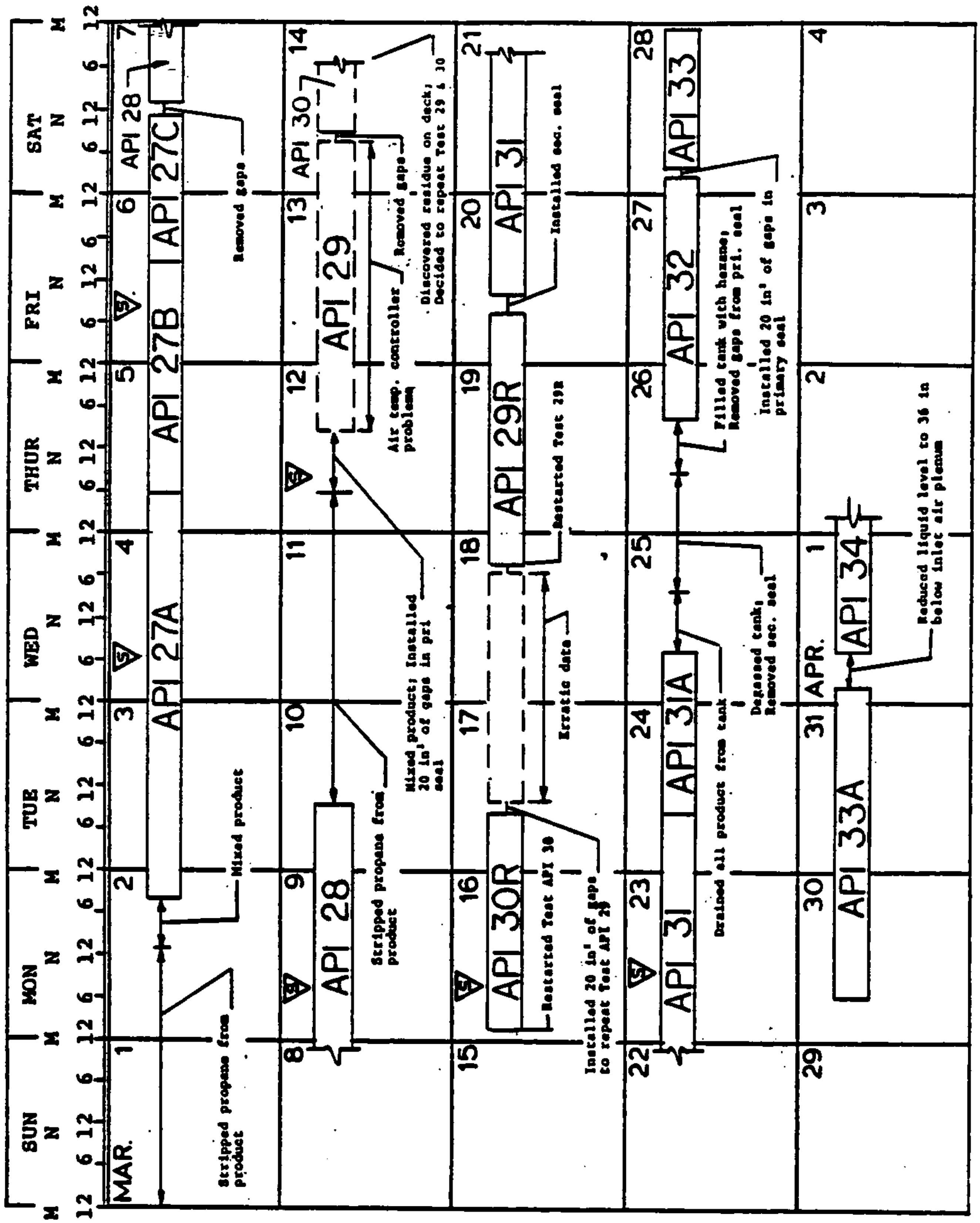
Figure A6 Calender of Events for January, 1981

S Indicates product sample taken.



. Figure A7 Calender of Events for February, 1981

5 Indicates product sample taken.



Indicates product sample taken.

Figure A8 Calender of Events for March, 1981

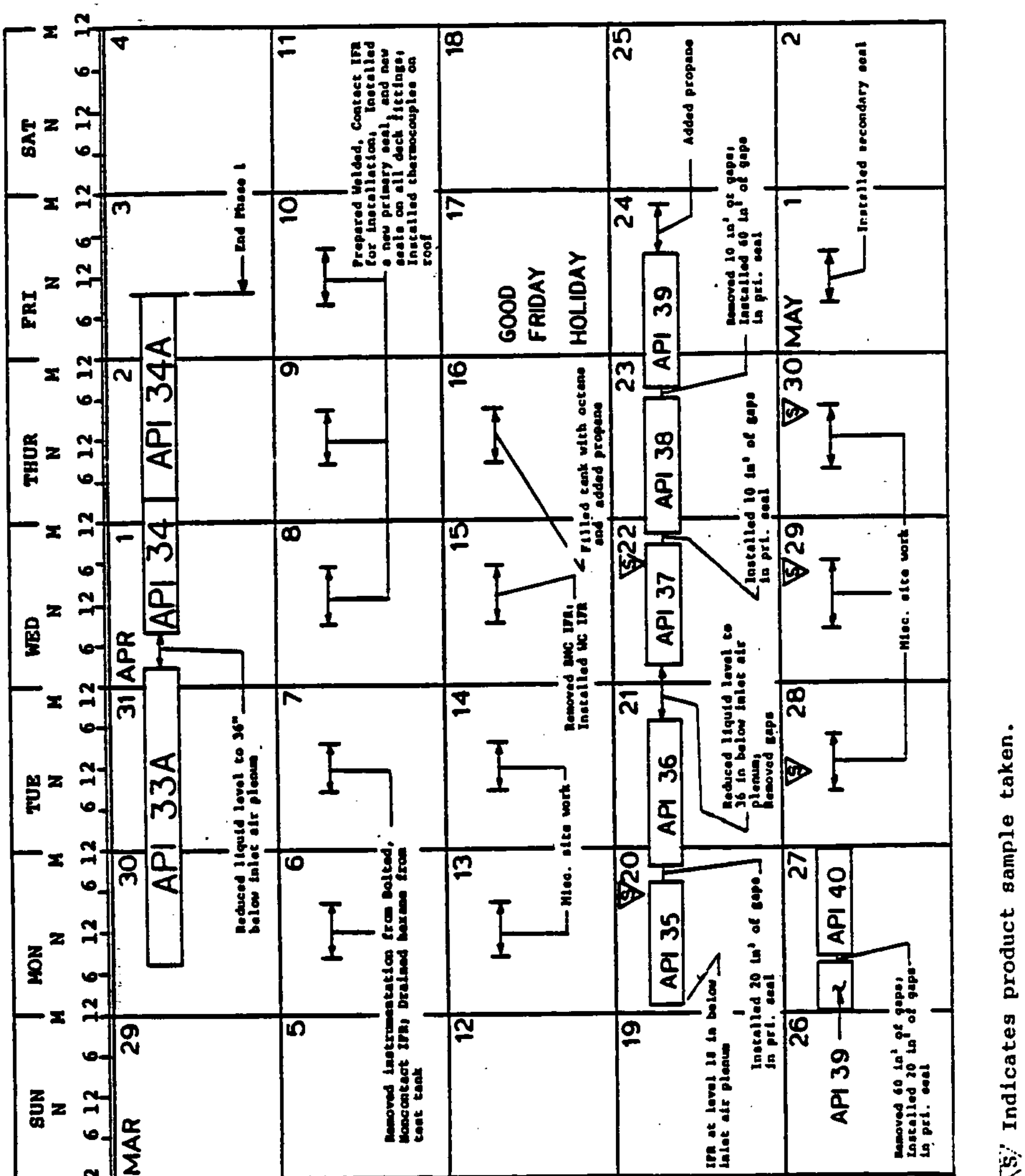


Figure A9 Calender of Events for April, 1981

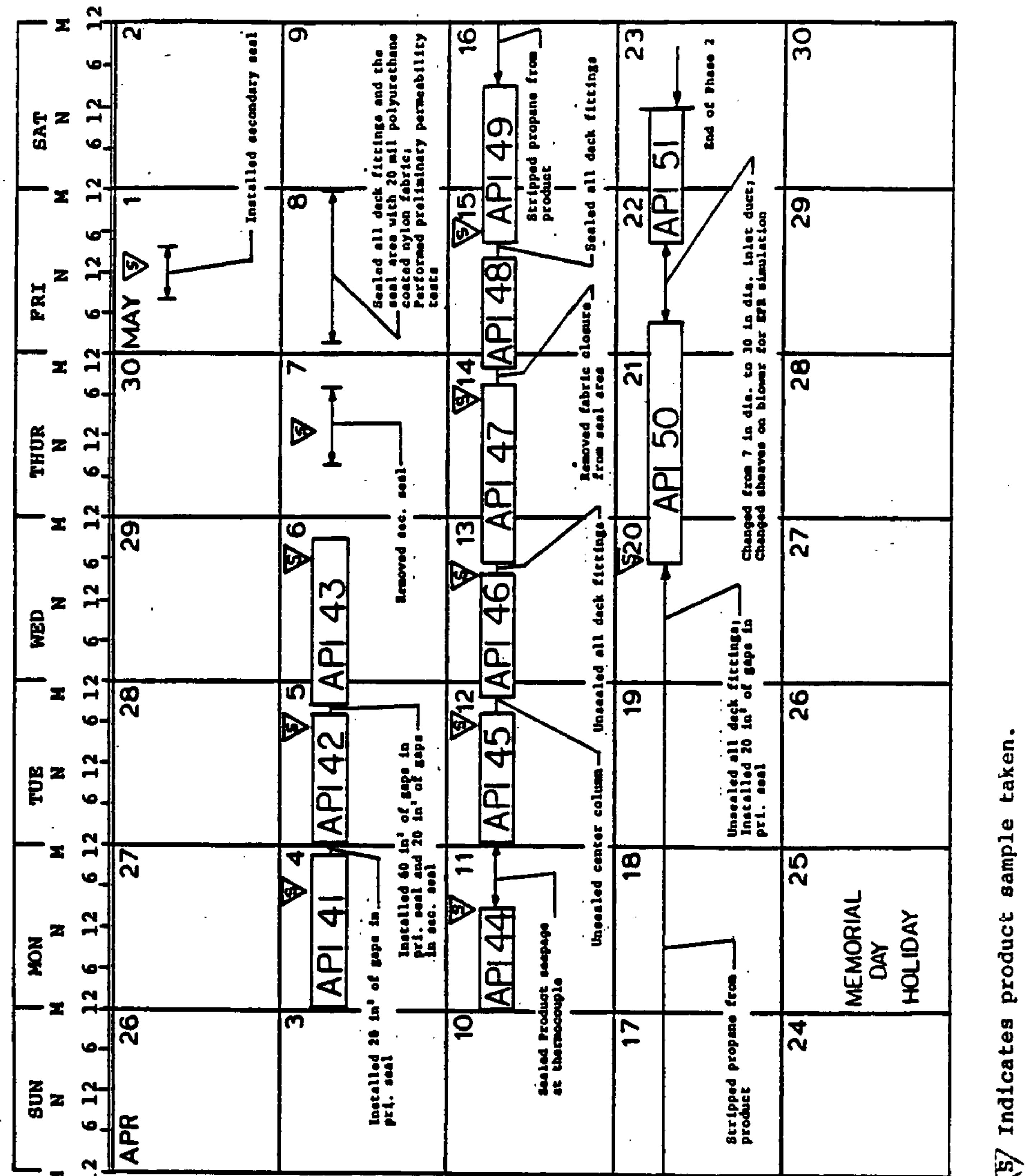
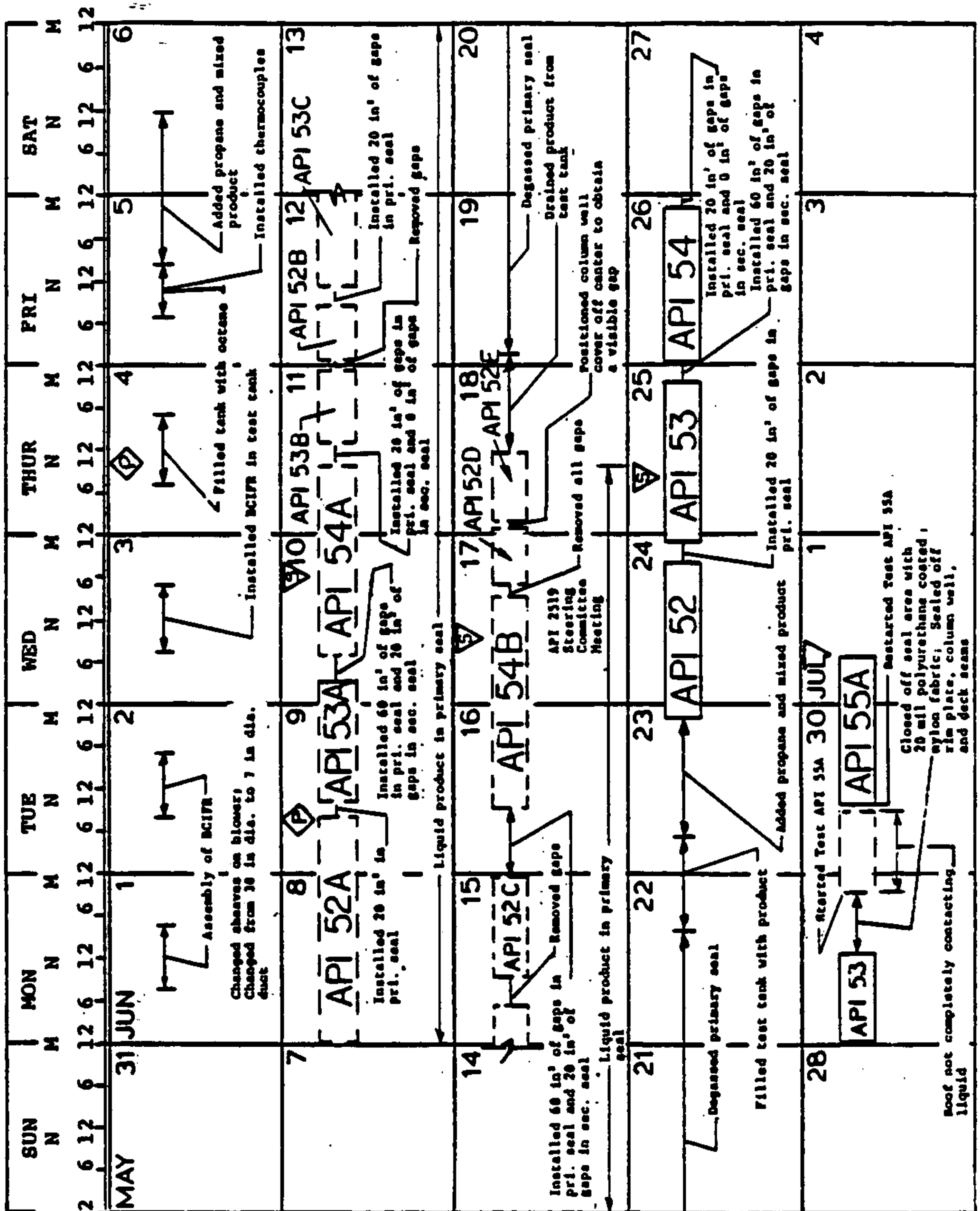
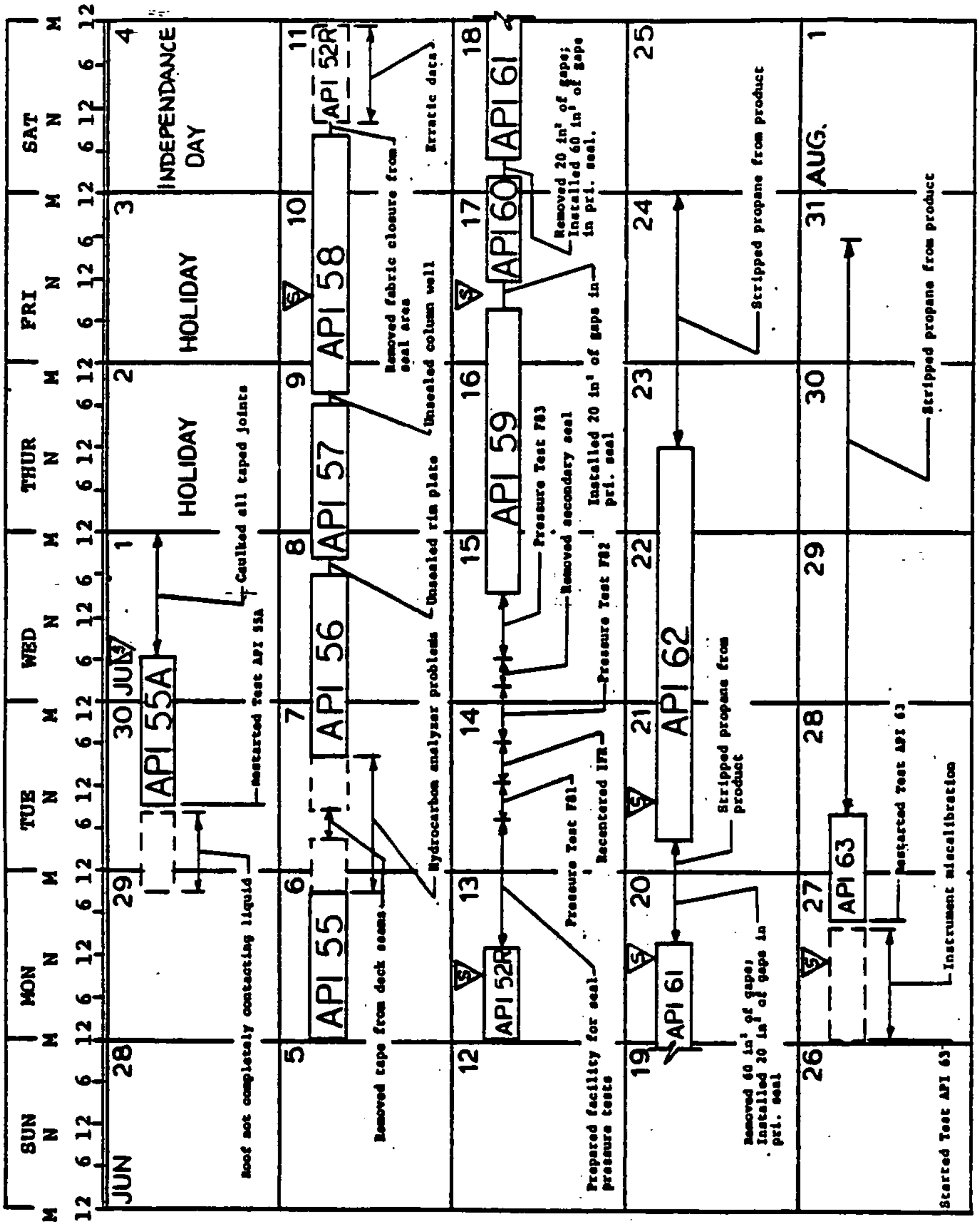


Figure A10 Calender of Events for May, 1981



Ⓟ Indicates liquid product observed on part of roof deck.
Ⓢ Indicates product sample taken.

Figure A11 Calender of Events for June, 1981



S Indicates product sample taken.

Figure A12 Calender of Events for July, 1981

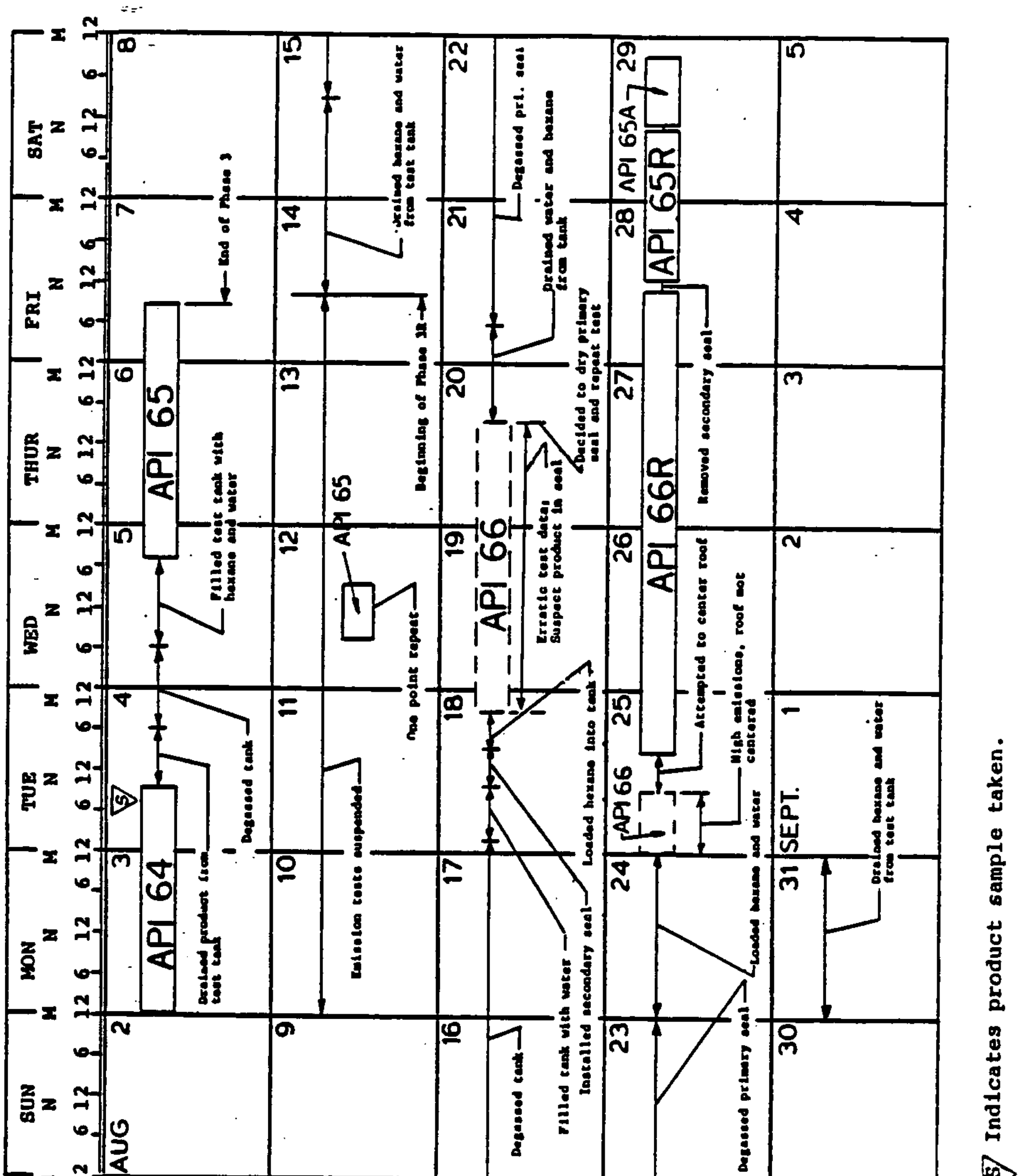


Figure A13 Calender of Events for August, 1981

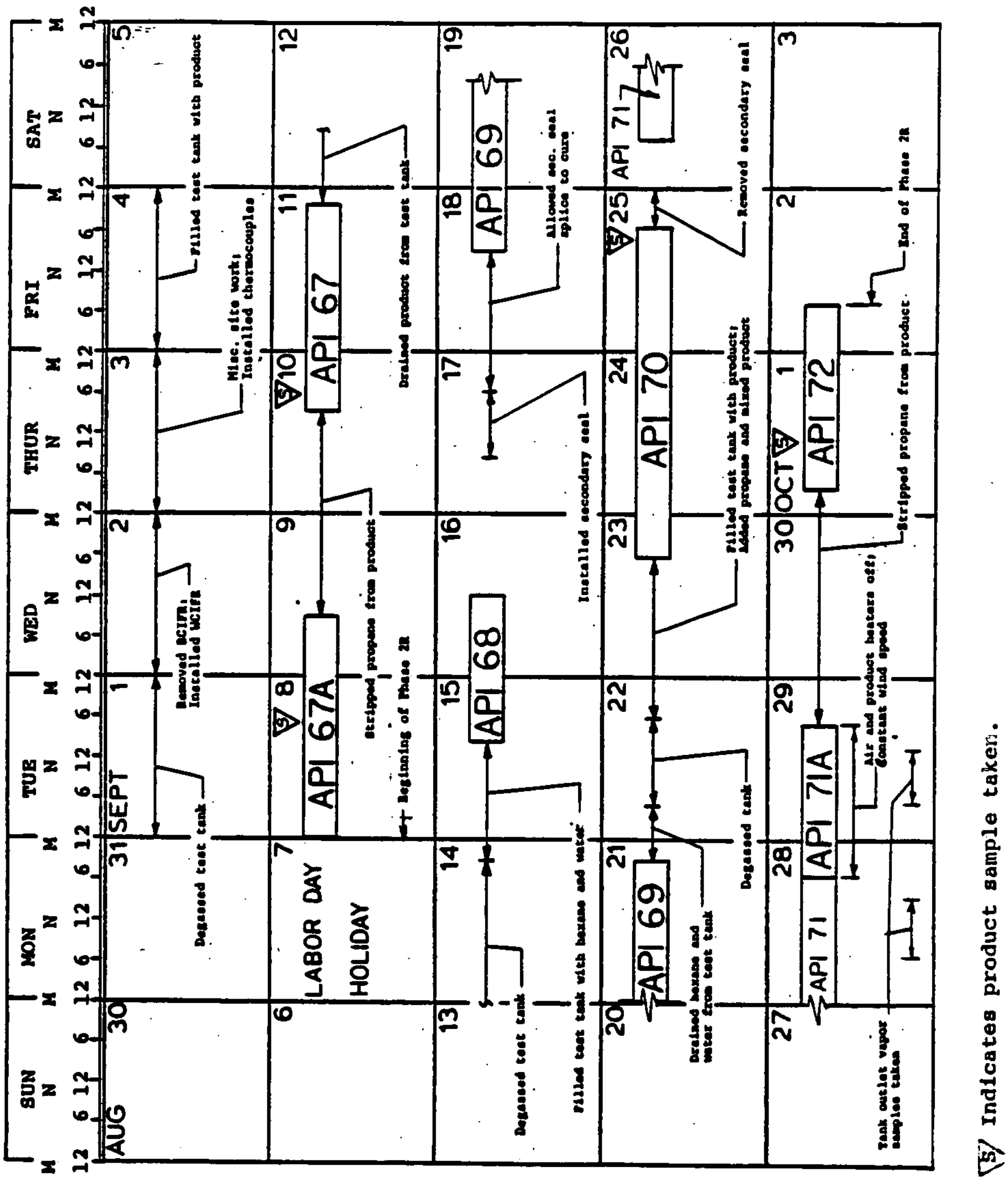


Figure A14 Calender of Events for September, 1981

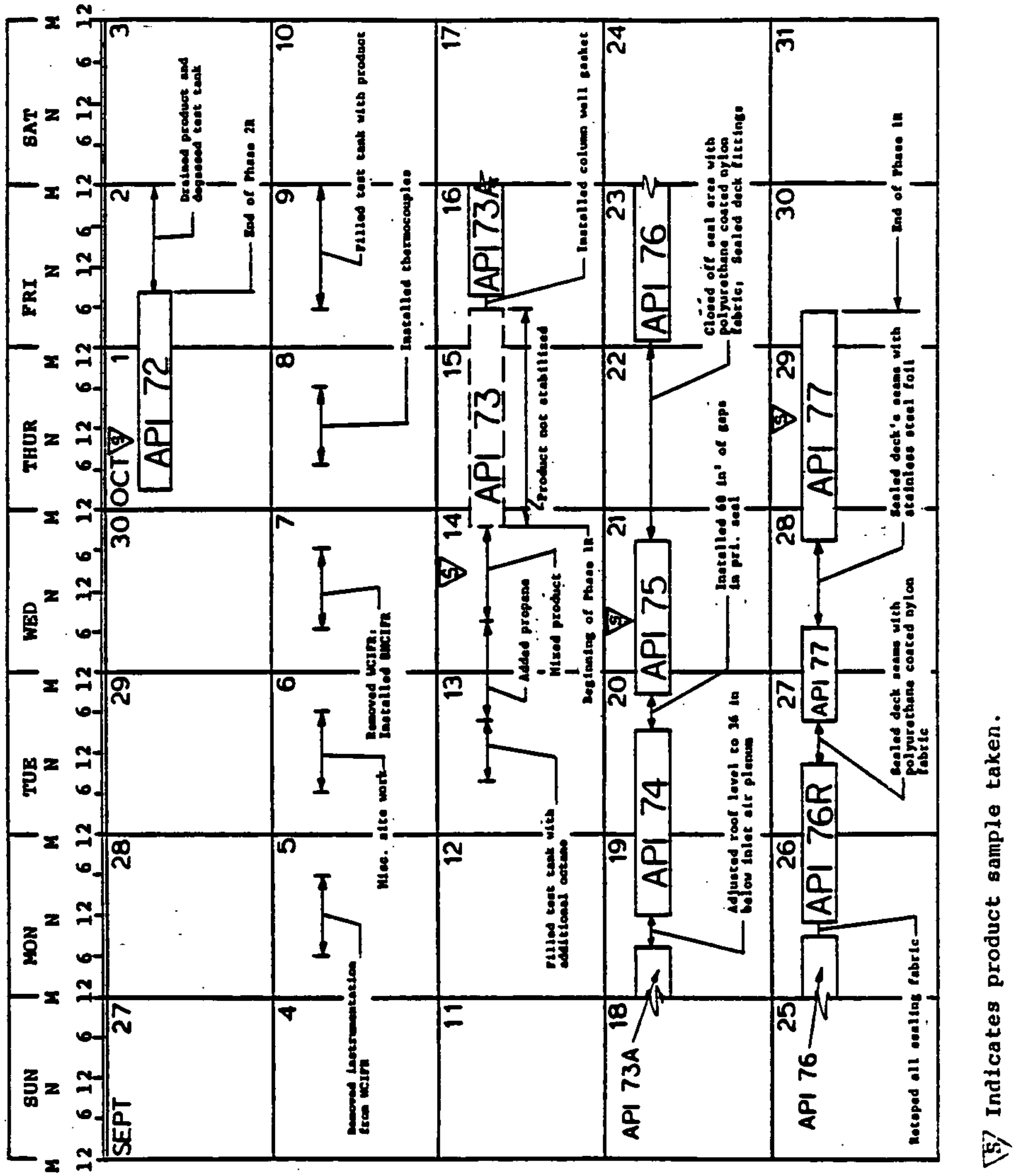


Figure A15 Calender of Events for October, 1981

APPENDIX B

IFR Emission Test Data

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR

Test No.	Air Flow Rate	Product Temp.	Vapor Press.	(Outlet-Inlet) Concentration (ppmv) (C3 Basis)		Emissions	Wind Speed	Date	Time	
	(scfm)	(°F)	(psia)	Meas.	Calc. [1]	(lbm/day)	(mi/hr)			
API 1	955	74.4	5.39	83.2	75.7	12.1	18.0	9-22-80	1930	
	1090	73.4	5.17	81.4	78.2	14.3	20.6	9-23	0800	
	710	73.8	5.14	105.	101.	12.0	13.4	9-23	1200	
	1490	71.9	4.94	79.8	81.0	20.2	28.1	9-23	1800	
	1365	71.8	4.84	89.6	93.2	21.3	25.8	9-24	0130	
	1095	71.2	4.77	77.6	82.1	15.1	20.7	9-24	0400	
	815	71.1	4.74	82.6	88.3	12.0	15.4	9-24	0630	
	465	70.8	4.67	119.	129.	10.1	8.77	9-24	1030	
	275	69.8	4.53	210.	237.	10.9	5.19	9-24	1700	
	205	71.2	4.57	238.	266.	9.12	3.88	9-24	2100	
	315	71.6	4.54	208.	234.	12.3	5.94	9-25	0100	
	595	72.3	4.52	101.	114.	11.4	11.2	9-25	0600	
API 2	2005	75.0	3.35	114.	183.	61.3	45.3	9-29	1530	
	1385	74.6	3.07	117.	207.	48.0	31.3	9-30	1200	
	1235	73.6	2.99	99.9	182.	37.6	27.9	9-30	1500	
	940	75.2	3.02	100.	180.	28.3	21.2	9-30	1800	
	650	75.4	2.98	111.	203.	22.1	14.7 [2]	9-30	2200	
	320	73.7	2.85	148.	285.	15.3	7.22	10-1	0300	
	220	73.6	2.80	167.	327.	12.0	4.97	10-1	0600	
	495	73.8	2.77	130.	258.	21.4	11.2	10-1	0930	
	1795	74.5	5.18	185.	177.	53.2	40.5	10-2	0400	
	1255	73.0	5.05	177.	175.	36.7	28.3	10-2	0800	

Notes: [1]. Normalized to 5.00 psia vapor pressure.
[2]. Wind speed calculated for "Type 2" air flow pattern.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc. [1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 3	1855	72.8	5.00	54.0	54.0	16.8	35.0	10-2-80	1530	
	1585	73.5	5.03	58.5	58.1	15.4	29.9	10-2	1930	
	1230	74.8	5.10	72.0	70.2	14.4	23.2	10-2	2200	
	1010	76.2	5.17	96.4	92.6	15.6	19.1	10-3	0400	
	600	74.5	5.03	139.	138.	13.9	11.3	10-3	0830	
	390	75.4	5.07	232.	228.	14.9	7.36	10-3	1130	
	225	75.2	5.04	347.	343.	12.9	4.25	10-3	1430	
API 4	1775	72.4	4.31	65.0	77.8	23.1	33.5	10-7	2230	
	1470	73.9	4.37	66.5	78.2	19.2	27.7	10-8	0300	
	1255	74.3	4.38	75.8	89.0	18.7	23.7	10-8	0630	
	960	74.4	4.36	92.4	109.	17.5	18.1	10-8	1130	
	620	76.9	4.46	116.	133.	13.8	11.7	10-8	2000	
	385	74.7	4.29	217.	261.	16.8	7.26	10-9	0400	
	310	72.6	4.13	233.	294.	15.2	5.85	10-9	1130	
API 5	1495	72.7	4.82	256.	268.	67.0	33.7	10-10	0600	
	1235	74.8	4.91	161.	165.	34.0	27.9 [2]	10-10	1430	
	965	74.8	4.88	159.	164.	26.5	21.8	10-10	2030	
	680	74.8	4.85	179.	186.	21.1	15.3	10-11	0000	
	325	73.6	4.44	262.	303.	16.5	7.34	10-13	1130	

Notes: [1]. Normalized to 5.00 psia vapor pressure.
[2]. Wind speed calculated for "Type 2" air flow pattern.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc. [1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 6	1940	77.2	4.83	89.0	92.8	30.1	36.6	10-15-80	1730	
	1500	77.8	4.87	87.3	90.1	22.6	28.3	10-15	2030	
	1240	77.3	4.84	98.2	102.	21.2	23.4	10-15	2330	
	880	78.4	4.91	107.	109.	16.1	16.6	10-16	0330	
	630	77.5	4.85	132.	137.	14.4	11.9	10-16	0630	
	440	76.6	4.79	196.	206.	15.2	8.30	10-16	1100	
	220	75.7	4.74	319.	341.	12.6	4.15	10-16	1430	
API 7	1810	77.9	4.88	92.5	95.3	28.9	34.2	10-17	0330	
	1420	77.0	4.82	86.4	90.4	21.5	26.8	10-17	0700	
	1220	75.8	4.74	85.5	91.2	18.6	23.0	10-17	1030	
	940	76.1	4.76	91.1	96.7	15.2	17.7	10-17	1400	
	615	76.6	4.79	126.	133.	13.7	11.6	10-17	1730	
	380	76.9	4.81	179.	188.	11.9	7.17	10-17	2030	
	280	74.3	4.65	248.	271.	12.7	5.28	10-20	0330	
API 8	2050	74.1	5.04	261.	258.	88.6	38.7	10-20	1400	
	1830	75.1	5.08	284.	278.	85.2	34.5	10-20	2000	
	1500	75.1	5.06	251.	247.	62.0	28.3	10-20	2330	
	1180	74.9	5.03	110.	109.	21.5	22.3	10-21	0300	
	970	75.1	5.03	109.	108.	17.6	18.3	10-21	0600	
	630	74.6	4.96	143.	144.	15.2	11.9	10-21	1330	
	380	75.0	4.97	224.	226.	14.4	7.17	10-21	1700	
	225	76.0	5.02	296.	295.	11.1	4.25	10-21	2100	
	390	75.6	4.98	221.	222.	14.5	7.36	10-22	0000	
	1235	75.2	4.93	108.	110.	22.7	23.3	10-22	0330	
	1335	73.3	4.76	94.2	99.9	22.3	25.2	10-22	1200	
	1860	74.3	4.81	240.	252.	78.3	35.1	10-22	1600	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc.[1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 9	1925	50.0	0.542	117.	107.	34.7	36.3	10-28-80	1900	
	1525	49.9	0.537	145.	135.	34.4	28.8	10-28	2200	
	1340	49.1	0.516	208.	201.	45.2	25.3	10-29	0600	
	1005	49.5	0.507	36.3	35.8	6.02	19.0	10-29	1430	
	700	50.2	0.508	276.	272.	31.8	13.2	10-29	2230	
	305	50.1	0.502	382.	381.	19.4	5.75	10-30	0530	
	245	50.3	0.495	26.2	26.4	1.08	4.62	10-30	1730	
	1000	50.8	0.495	149.	150.	25.2	18.9	10-31	0030	
	550	50.7	0.491	189.	192.	17.7	10.4	10-31	0500	
API 10	1900	51.2	0.484	24.1	24.9	7.93	35.8	10-31	1630	
	1495	51.8	0.484	31.6	32.7	8.17	28.2	10-31	2000	
	1250	52.0	0.481	45.3	47.1	9.85	23.6	10-31	2330	
	995	52.2	0.407	19.9	24.5	4.08	18.8	11-3	0330	
	660	52.5	0.406	17.0	21.0	2.32	12.5	11-3	0630	
	380	52.8	0.402	16.2	20.2	1.28	7.17	11-3	1030	
	195	53.1	0.403	20.0	24.9	0.812	3.68	11-3	1400	
	195	54.4	0.410	32.1	39.3	1.28	3.68	11-4	0100	
	385	54.7	0.410	28.7	35.1	2.26	7.26	11-4	0600	
	970	54.7	0.406	15.2	18.8	3.05	18.3	11-4	1430	

Notes: [1]. Normalized to 0.50 psia vapor pressure.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate	Product Temp.	Vapor Press.	(Outlet-Inlet) Concentration (ppmv) (C3 Basis)		Emissions	Wind Speed	Date	Time	
	(scfm)	(°F)	(psia)	Meas.	Calc. [1]	(lbm/day)	(mi/hr)			
API 11	1890	55.2	0.408	28.9	35.5	11.2	35.7	11-4-80	2000	
	1585	54.5	0.397	107.	135.	35.8	29.9	11-5	0630	
	1285	54.3	0.392	16.1	20.6	4.43	24.2	11-5	1400	
	975	54.4	0.389	97.8	126.	20.6	18.4	11-5	2300	
	635	53.8	0.382	79.8	105.	11.1	12.0	11-6	0230	
	390	53.6	0.379	45.4	60.1	3.92	7.36	11-6	0530	
	260	53.2	0.374	60.4	81.2	3.53	4.91	11-6	1030	
API 12	1800	56.1	0.393	4.80	6.13	1.85	34.0	11-6	2230	
	1490	56.9	0.397	5.68	7.17	1.79	28.1	11-7	0400	
	1150	57.4	0.400	7.22	9.07	1.75	21.7	11-7	0900	
	940	57.7	0.400	5.99	7.51	1.18	17.7	11-7	1330	
	650	58.3	0.404	4.54	5.64	0.614	12.3	11-7	1730	
	385	58.6	0.405	9.38	11.6	0.748	7.26	11-7	2030	
	220	58.8	0.405	19.2	23.8	0.875	4.15	11-7	2330	
API 13	1880	75.6	0.324	14.3	22.2	6.98	35.5	11-18	2000	
	1500	79.8	0.364	25.0	34.5	8.65	28.3	11-19	1100	
	1230	81.1	0.378	25.8	34.3	7.06	23.2	11-19	1430	
	990	82.2	0.389	26.8	34.6	5.72	18.7	11-19	1830	
	640	83.6	0.405	41.9	52.0	5.56	12.1	11-19	2200	
	420	84.6	0.416	70.5	85.0	5.98	7.92	11-20	0130	
	250	85.3	0.424	128.	151.	6.33	4.72	11-20	0430	
	305	89.3	0.471	108.	115.	5.85	5.75	11-22	0300	
	450	89.5	0.474	74.9	79.1	5.96	8.49	11-22	0730	
	670	91.2	0.495	46.6	47.0	5.27	12.6	11-24	0430	
	2000	90.0	0.479	22.1	23.1	7.72	37.7	11-24	0800	

Notes: [1]. Normalized to 0.50 psia vapor pressure.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc. [1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 14	1810	85.9	0.431	87.0	101.	30.7	34.2	11-20-80	0730	
	1445	87.8	0.453	30.2	33.4	8.06	27.3	11-20	1530	
	1245	88.5	0.462	36.1	39.1	8.15	23.5	11-20	1900	
	980	89.0	0.468	38.7	41.4	6.78	18.5	11-20	2230	
	640	89.2	0.471	48.4	51.4	5.51	12.1	11-21	0100	
	395	87.6	0.450	115.	128.	8.45	7.45	11-21	0500	
	1530	87.1	0.444	85.7	96.7	24.8	28.9	11-21	0730	
	1260	87.3	0.446	35.1	39.4	8.31	23.8	11-21	1500	
	390	88.4	0.460	99.4	108.	7.06	7.36	11-21	1930	
	1875	89.0	0.467	80.8	86.6	27.2	35.4	11-21	2330	
	1825	87.7	0.449	84.4	94.2	28.7	34.4	11-24	2230	
	730	87.9	0.451	100.	111.	13.6	13.8	11-25	0730	
	205	89.1	0.466	272.	292.	10.0	3.87	11-25	1400	
	1395	89.8	0.475	92.9	97.8	22.8	26.3	11-25	2000	
	440	90.0	0.478	118.	124.	9.10	8.30	11-26	0130	

Notes: [1]. Normalized to 0.50 psia vapor pressure.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate	Product Temp.	Vapor Press.	(Outlet-Inlet) Concentration (ppmv) (C3 Basis)		Emissions	Wind Speed	Date	Time	
	(scfm)	(°F)	(psia)	Meas.	Calc. [1]	(lbm/day)	(mi/hr)			
API 15	1830	57.4	3.87	119.	162.	49.4	34.5	12-1-80	0330	
	1500	56.8	3.82	137.	189.	47.4	28.2	12-1	0800	
	1250	56.7	3.80	110.	153.	31.9	23.5 [2]	12-1	1100	
	970	57.1	3.81	91.1	126.	20.5	18.3	12-1	1430	
	635	57.6	3.81	99.1	137.	14.6	12.0	12-1	1900	
	390	57.8	3.81	111.	154.	10.0	7.34	12-1	2230	
API 16	1810	58.0	3.78	208.	291.	88.0	32.7	12-2	0730	
	1440	57.6	3.74	198.	280.	67.4	26.0	12-2	1030	
	1265	57.5	3.70	219.	313.	66.3	22.9	12-2	1800	
	985	57.6	3.69	219.	314.	51.7	17.8	12-2	2100	
	655	57.9	3.70	219.	314.	34.4	11.8	12-3	0000	
	490	57.9	3.68	210.	302.	24.8	8.86 [3]	12-3	0330	
	255	58.1	3.68	194.	279.	11.9	4.61	12-3	0600	
	1715	57.9	3.66	236.	342.	98.2	31.0	12-3	0830	
	1355	58.2	3.65	168.	245.	53.8	24.5	12-3	1430	
	1190	58.2	3.64	167.	244.	48.6	21.5	12-3	1630	
API 17	1920	61.0	5.27	14.3	13.4	4.30	36.2	12-5	1900	
	1495	60.9	5.26	16.0	15.0	3.76	28.2	12-5	2200	
	1245	61.3	5.20	14.2	13.5	2.82	23.5	12-8	0230	
	960	61.2	5.19	17.3	16.5	2.65	18.1	12-8	0530	
	635	60.9	5.16	22.1	21.2	2.26	12.0	12-8	0900	
	375	59.9	5.08	38.7	37.9	2.38	7.08	12-8	1400	
	225	59.8	5.07	67.9	66.7	2.51	4.25	12-8	1630	

Notes: [1]. Normalized to 5.00 psia vapor pressure.
[2]. Wind speed calculated for "Type 4" air flow pattern.
[3]. Wind speed calculated for "Type 3" air flow pattern.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc. [1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 18	1915	59.6	5.05	16.7	16.5	5.28	36.1	12-8-80	2100	
	1015	59.5	5.03	30.7	30.4	5.17	19.2	12-9	0230	
	335	59.3	5.02	74.6	74.3	4.17	6.32	12-9	0530	
	1470	59.2	5.00	22.3	22.3	5.48	27.7	12-9	0830	
	640	59.0	4.98	37.9	38.0	4.07	12.1	12-9	1130	
	225	59.0	4.98	121.	122.	4.58	4.25	12-9	1500	
	1850	58.7	4.95	18.4	18.6	5.76	34.9	12-9	1930	
API 19	1860	58.6	4.94	19.3	19.6	6.10	35.1	12-10	0000	
	1115	58.6	4.93	33.8	34.4	6.41	21.0	12-10	0230	
	355	58.8	4.94	88.5	89.9	5.34	6.70	12-10	0800	
	820	59.0	4.95	37.3	37.8	5.19	15.5	12-10	1300	
	605	59.3	4.96	47.1	47.5	4.81	11.4	12-10	1600	
	230	59.6	4.98	199.	200.	7.69	4.34	12-10	1830	
	1895	59.7	4.99	21.7	21.8	6.90	35.8	12-10	2130	
API 19A	1860	59.5	4.97	35.6	35.9	11.2	35.1	12-11	0100	
	990	59.7	4.98	30.3	30.5	5.05	18.7	12-11	0500	
	290	59.7	4.97	167.	168.	8.16	5.47	12-11	0830	
	1535	59.7	4.96	30.6	30.9	7.94	29.0	12-11	2000	
	1270	59.8	4.96	31.8	32.1	6.82	24.0	12-11	2330	
	1000	59.9	4.97	34.1	34.4	5.75	18.9	12-12	0200	
	675	60.3	4.99	46.8	46.9	5.30	12.7	12-12	0430	
	405	60.3	4.99	78.2	78.4	5.31	7.64	12-12	0700	
	285	60.1	4.97	129.	130.	6.20	5.38	12-12	1030	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc. [1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 21A	770	60.0	2.81	21.3	41.6	5.36	14.5	1-26-81	0430	
	510	59.4	2.79	29.2	57.6	4.91	9.62	1-26	0830	
	240	57.9	2.73	51.7	104.	4.19	4.53	1-26	1400	
	1340	55.5	2.63	14.3	30.0	6.73	25.3	1-28	0330	
	1860	55.2	2.62	14.8	31.2	9.71	35.1	1-28	0600	
API 21B	820	57.6	2.72	16.3	33.1	4.54	15.5	1-26	2000	
	530	57.4	2.71	23.8	48.4	4.30	10.0	1-26	2230	
	225	56.9	2.69	49.1	101.	3.79	4.25	1-27	0300	
	1320	54.2	2.58	14.1	30.2	6.68	24.9	1-28	1230	
API 21C	820	56.3	2.67	16.5	34.2	4.69	15.5	1-27	1700	
	515	56.2	2.66	24.2	50.2	4.33	9.72	1-27	1930	
	220	55.8	2.65	51.7	108.	3.97	4.15	1-28	0100	
	1800	54.7	2.60	11.6	24.7	7.43	34.0	1-28	1800	
	1320	55.2	2.62	11.0	23.2	5.12	24.9	1-28	2100	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc. [1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 22A	855	51.1	3.83	38.4	52.8	7.55	16.1	1-30-81	1400	
	545	51.5	3.85	63.7	87.0	7.93	10.3	1-30	1630	
	230	51.9	3.87	119.	161.	6.21	4.34	1-30	2000	
API 22B	835	52.7	3.92	45.0	60.2	8.41	15.8	1-30	2330	
	830	50.5	3.80	45.4	63.1	8.76	15.7	2-2	1430	
	535	51.1	3.83	65.1	89.5	8.01	10.1	2-2	1730	
	220	51.4	3.85	140.	192.	7.05	4.15	2-2	2030	
API 22C	220	51.9	3.87	167.	227.	8.34	4.15	2-3	0300	
	525	51.9	3.87	81.2	110.	9.67	9.91	2-3	0700	
	820	51.8	3.87	52.7	71.6	9.82	15.5	2-3	1030	
API 23	1805	55.2	6.89	18.6	12.3	3.71	34.1	2-17	0400	
	1325	55.3	6.90	22.7	15.0	3.32	25.0	2-17	0700	
	835	54.9	6.86	35.0	23.3	3.25	15.8	2-17	1000	
	535	54.8	6.85	65.2	43.4	3.89	10.1	2-17	1330	
	225	55.1	6.88	132.	87.4	3.29	4.25	2-17	2030	
	1815	55.0	6.87	17.8	11.8	3.59	34.2	2-18	0630	
	1325	54.6	6.83	19.8	13.2	2.93	25.0	2-18	0930	
	540	54.6	6.83	59.0	39.4	3.56	10.2	2-18	1330	
	215	55.1	6.88	118.	78.1	2.81	4.06	2-18	1830	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc. [1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 24	1800	55.4	6.91	32.0	21.1	6.34	34.0	2-18-81	2230	
	1320	55.8	6.95	39.0	25.5	5.63	24.9	2-19	0200	
	825	56.5	7.01	56.4	36.3	5.02	15.6	2-19	0530	
	520	56.9	7.05	85.6	54.7	4.76	9.81	2-19	0900	
	375	57.1	7.07	119.	75.8	4.75	7.08	2-19	1130	
	225	57.6	7.12	166.	105.	3.94	4.25	2-19	1530	
API 25	1790	58.3	7.19	37.4	23.3	6.97	33.8	2-19	2000	
	1335	58.7	7.23	43.8	27.0	6.04	25.2	2-19	2230	
	810	58.8	7.24	53.5	33.0	4.47	15.1	2-20	0200	
	530	58.9	7.25	79.8	49.1	4.35	10.0	2-20	0500	
	390	58.3	7.19	98.9	61.5	4.01	7.36	2-20	1200	
	235	58.7	7.23	166.	102.	4.03	4.43	2-20	1500	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc.	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 26A	1825	60.5	3.85	17.6	15.8 [1]	4.82	34.4	2-25-81	1300	
	1320	61.6	3.91	15.2	13.4 [1]	2.96	24.9	2-25	1800	
	810	61.0	3.87	25.4	22.6 [1]	3.06	15.3	2-25	2200	
	530	60.2	3.83	43.2	38.9 [1]	3.45	10.0	2-26	0230	
	225	59.8	3.81	95.8	86.9 [1]	3.27	4.25	2-26	0600	
	370	59.1	3.77	59.9	55.0 [1]	3.41	6.98	2-26	0900	
	825	59.1	3.77	30.2	27.7 [1]	3.83	15.6	2-26	1200	
	1280	59.2	3.77	19.6	18.0 [1]	3.85	24.2	2-26	1500	
API 26B	1695	58.3	2.37	10.1	10.7 [2]	3.04	32.0	2-27	2200	
	1330	58.8	2.39	11.0	11.6 [2]	2.58	25.1	2-28	0130	
	845	59.0	2.39	17.6	18.5 [2]	2.61	15.9	2-28	0500	
	530	59.3	2.40	34.1	35.6 [2]	3.16	10.0	2-28	1000	
	740	59.2	2.40	19.3	20.2 [2]	2.50	14.0	2-28	1700	
	395	59.5	2.41	38.3	39.8 [2]	2.63	7.45	2-28	2030	
	225	59.5	2.41	69.6	72.4 [2]	2.73	4.25	2-28	2300	

Notes: [1]. Normalized to 3.50 psia vapor pressure.
[2]. Normalized to 2.50 psia vapor pressure.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate	Product Temp.	Vapor Press.	(Outlet-Inlet) Concentration (ppmv) (C3 Basis)		Emissions	Wind Speed	Date	Time	
	(scfm)	(°F)	(psia)	Meas.	Calc.[1]	(lbm/day)	(mi/hr)			
API 27A	1885	57.7	0.730	61.3	41.7	13.1	35.6	3-3-81	0230	
	1340	57.7	0.729	33.5	22.8	5.11	25.3	3-3	0500	
	540	57.4	0.724	32.6	22.3	2.02	10.2	3-3	1230	
	240	57.5	0.724	57.3	39.2	1.58	4.53	3-3	1530	
	1855	57.5	0.723	67.0	46.0	14.3	35.0	3-3	2030	
	1320	57.4	0.721	13.6	9.36	2.07	24.9	3-4	0100	
	835	57.6	0.723	18.2	12.5	1.74	15.8	3-4	0430	
	390	57.1	0.715	36.5	25.3	1.65	7.36	3-4	0800	
	1845	57.8	0.722	58.9	40.5	12.5	34.8	3-4	2030	
	1310	57.8	0.721	13.6	9.36	2.05	24.7	3-5	0100	
	830	57.9	0.721	17.8	12.2	1.70	15.7	3-5	0530	
API 27B	1815	58.0	0.721	25.5	17.5	5.33	34.2	3-5	0930	
	1315	58.1	0.722	8.53	5.86	1.29	24.8	3-5	1330	
	820	58.3	0.724	12.3	8.43	1.16	15.5	3-5	1600	
	540	58.3	0.723	16.5	11.3	1.02	10.2	3-5	1900	
	250	58.3	0.722	48.7	33.5	1.40	4.72	3-5	2300	
	395	58.3	0.721	36.3	25.0	1.65	7.45	3-6	0430	
	1060	58.0	0.715	13.0	9.02	1.60	20.0	3-6	1230	
	225	58.1	0.716	39.2	27.7	1.02	4.25	3-6	1500	
API 27C	1800	58.2	0.716	28.3	19.6	5.90	34.0	3-6	2000	
	1295	58.3	0.717	28.2	19.5	4.23	24.4	3-6	2300	
	810	58.5	0.718	19.4	13.4	1.79	15.3	3-7	0400	
	510	58.6	0.719	27.4	18.9	1.61	9.62	3-7	0800	
	210	58.6	0.718	64.9	44.9	1.58	3.96	3-7	1130	

Notes: [1]. Normalized to 0.50 psia vapor pressure.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc.[1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 28	1830	58.6	0.717	4.64	3.21	0.984	34.5	3-7-81	1730	
	1305	58.5	0.714	6.65	4.62	1.01	24.6	3-7	2100	
	825	58.5	0.714	11.2	7.79	1.08	15.6	3-8	0000	
	820	58.9	0.713	11.0	7.66	1.05	15.5	3-9	0230	
	520	58.8	0.711	19.9	13.9	1.21	9.81	3-9	0530	
	225	58.2	0.702	47.4	33.5	1.26	4.25	3-9	0900	
	1895	58.4	0.703	4.26	3.01	0.953	35.7	3-9	1600	
	825	58.7	0.706	8.90	6.26	0.863	15.6	3-9	2100	
	535	58.8	0.707	15.3	10.7	0.962	10.1	3-10	0000	
	390	58.7	0.705	23.9	16.8	1.10	7.36	3-10	0400	
	225	58.7	0.704	44.0	31.0	1.17	4.25	3-10	0800	
API 29R	1845	69.0	0.281	42.9	76.9	23.7	34.8	3-18	2300	
	1295	69.4	0.284	66.4	118.	25.5	24.4	3-19	0730	
	815	69.6	0.285	35.0	61.8	8.42	15.4	3-19	1330	
	525	69.6	0.285	40.3	71.2	6.25	9.91	3-19	1900	
	230	69.5	0.284	78.3	139.	5.34	4.34	3-19	2200	
	1045	69.7	0.286	50.2	88.5	15.5	19.7	3-20	0400	
	375	69.8	0.287	46.5	81.7	5.13	7.08	3-20	0800	

Notes: [1]. Normalized to 0.50 psia vapor pressure.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc. [1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 30	1320	70.0	0.291	9.25	16.0	3.53	24.9	3-16-81	0230	
	810	69.5	0.287	11.9	20.9	2.83	15.3	3-16	0500	
	1830	69.6	0.287	5.74	10.1	3.08	34.5	3-16	1830	
	1305	70.2	0.292	9.35	16.1	3.52	24.6	3-17	0030	
	805	70.4	0.294	15.1	25.9	3.49	15.2	3-17	0330	
	520	70.8	0.297	24.2	41.0	3.57	9.81	3-17	0600	
	205	70.9	0.298	60.4	102.	3.50	3.87	3-17	0900	
API 31	1825	69.7	0.285	4.53	7.99	2.44	34.4	3-20	1730	
	1330	69.9	0.287	9.03	15.9	3.53	25.1	3-20	2200	
	815	69.5	0.283	18.4	32.7	4.47	15.4	3-21	0800	
	515	69.1	0.280	16.4	29.5	2.54	9.72	3-21	1330	
	220	68.2	0.272	69.3	129.	4.73	4.15	3-23	0300	
	1810	67.9	0.269	9.10	17.0	5.16	34.2	3-23	0600	
	1270	67.5	0.266	9.68	18.3	3.90	24.0	3-23	0930	
	815	67.5	0.266	7.10	13.5	1.84	15.4	3-23	1400	
	525	68.4	0.273	24.8	45.8	4.02	9.91	3-24	0230	
	235	68.2	0.271	64.0	119.	4.68	4.43	3-24	0630	
API 31A	245	68.2	0.271	19.6	36.5	1.50	4.62	3-24	1400	
	520	68.6	0.274	7.80	14.4	1.25	9.81	3-24	1800	
	820	68.9	0.276	10.5	19.2	2.63	15.5	3-24	2200	
	1290	69.2	0.278	8.03	14.6	3.14	24.3	3-25	0200	
	1785	69.4	0.280	7.00	12.6	3.76	33.7	3-25	0600	

Notes: [1]. Normalized to 0.50 psia vapor pressure.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv)(C3 Basis) Meas.	Calc.[1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 32	1850	57.0	1.83	5.63	7.88	2.44	34.9	3-26-81	2130	
	1320	59.3	1.94	6.55	8.60	1.90	24.9	3-27	0100	
	820	60.5	2.01	11.4	14.5	1.99	15.5	3-27	0430	
	530	60.8	2.02	22.4	28.2	2.50	10.0	3-27	0830	
	215	61.4	2.05	50.7	62.9	2.26	4.06	3-27	1400	
	405	62.0	2.08	13.8	16.8	1.14	7.64	3-27	1900	
	1085	62.0	2.08	8.20	10.0	1.82	20.5	3-27	2130	
	385	61.6	2.06	29.0	35.8	2.30	7.26	3-28	0200	
API 33	1825	61.1	2.04	6.60	8.25	2.52	34.4	3-28	0600	
	1310	68.1	2.42	12.5	12.9	2.83	24.7	3-28	2130	
	815	68.5	2.45	16.3	16.7	2.27	15.4	3-28	2330	
API 33A	1770	67.0	2.36	9.30	9.91	2.93	33.4	3-30	1130	
	1270	67.1	2.37	7.70	8.18	1.74	24.0	3-30	1800	
	805	67.2	2.37	11.3	12.0	1.61	15.2	3-30	2030	
	520	67.3	2.38	19.6	20.7	1.80	9.81	3-31	0030	
	395	66.8	2.35	34.8	37.3	2.46	7.45	3-31	0530	
	220	66.4	2.33	84.2	91.2	3.35	4.15	3-31	0900	
	510	66.2	2.31	39.2	42.7	3.64	9.62	3-31	1200	
	820	67.6	2.39	13.2	13.8	1.90	15.5	3-31	1930	
	1280	67.9	2.41	8.00	8.32	1.78	24.2	3-31	2230	
	1770	68.1	2.42	8.20	8.48	2.51	33.4	4-1	0200	

Notes: [1]. Normalized to 2.50 psia vapor pressure.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate	Product Temp.	Vapor Press.	(Outlet-Inlet) Concentration (ppmv) (C3 Basis)		Emissions	Wind Speed	Date	Time	
	(scfm)	(°F)	(psia)	Meas.	Calc.[1]	(lbm/day)	(mi/hr)			
API 34	1770	68.2	2.43	9.43	9.73	2.88	33.4	4-1-81	0930	
	1280	68.2	2.43	13.0	13.4	2.87	24.2	4-1	1400	
	800	68.4	2.44	16.8	17.2	2.31	15.1	4-1	1700	
	510	68.4	2.44	24.5	25.1	2.14	9.62	4-1	1930	
	230	68.1	2.42	58.7	60.7	2.34	4.34	4-1	2330	
API 34A	1810	67.3	2.38	9.25	9.77	2.96	34.2	4-2	0600	
	805	66.8	2.35	26.0	27.8	3.75	15.2	4-2	1000	
	390	68.6	2.45	39.5	40.3	2.63	7.36	4-2	2130	
	1280	68.8	2.45	12.3	12.5	2.69	24.2	4-3	0030	
	525	69.1	2.48	31.9	32.1	2.82	9.91	4-3	0330	
	210	69.1	2.48	72.3	72.8	2.56	3.96	4-3	0600	

Notes: [1]. Normalized to 2.50 psia vapor pressure.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc.[1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 73A	1825	72.6	5.98	12.2	9.73	2.97	34.4	10-16-81	0830	
	805	72.6	5.95	24.8	19.9	2.68	15.2	10-16	1330	
	215	72.8	5.92	66.4	53.7	1.93	4.06	10-16	2230	
	375	71.2	5.52	53.2	47.1	2.95	7.08	10-19	0400	
	1300	71.1	5.49	16.3	14.5	3.16	24.5	10-19	0800	
API 74	1830	71.5	5.49	14.8	13.2	4.04	34.5	10-19	1400	
	145	71.4	5.44	113.	102.	2.46	2.74	10-19	2230	
	385	71.5	5.42	47.3	42.8	2.76	7.26	10-20	0330	
	515	71.6	5.40	36.2	32.9	2.83	9.72	10-20	0800	
	1300	71.5	5.38	19.5	17.8	3.88	24.5	10-20	1130	
	810	72.0	5.39	23.5	21.4	2.90	15.3	10-20	1500	
API 75	1790	72.5	5.39	15.5	14.1	4.22	33.8	10-20	2130	
	810	72.8	5.40	23.8	21.7	2.93	15.3	10-21	0130	
	195	72.8	5.37	99.0	90.6	2.96	3.68	10-21	0600	
	405	72.5	5.33	50.4	46.6	3.16	7.64	10-21	1000	
	525	72.2	5.29	42.5	39.7	3.48	9.91	10-21	1400	
	1230	72.2	5.25	21.5	20.2	4.17	23.2	10-21	2100	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-1 SUMMARY OF EMISSION TEST DATA FOR BOLTED, NONCONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc.[1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 76	1800	72.9	5.29	6.50	6.06	1.83	34.0	10-23-81	0400	
	810	72.4	5.25	17.7	16.7	2.26	15.3	10-23	0800	
	220	71.7	5.19	101.	96.4	3.55	4.15	10-23	1230	
	1300	71.8	5.19	10.6	10.1	2.20	24.5	10-23	1800	
	795	72.0	5.20	20.1	19.2	2.55	15.0	10-23	2200	
	510	74.1	5.26	30.1	28.3	2.41	9.62	10-26	0230	
	380	73.9	5.24	37.8	35.7	2.27	7.17	10-26	0600	
	195	73.8	5.23	76.9	72.8	2.37	3.68	10-26	0930	
API 76R	1785	74.5	5.26	6.64	6.23	1.86	33.7	10-26	1830	
	760	74.7	5.23	15.1	14.3	1.82	14.3	10-27	2330	
	180	74.5	5.25	77.1	72.6	2.19	3.40	10-27	0330	
	360	74.1	5.21	35.4	33.6	2.02	6.79	10-27	0730	
	515	73.8	5.19	27.7	26.5	2.28	9.72	10-27	1130	
API 77	1830	74.2	5.20	7.65	7.30	2.23	34.5	10-28	0000	
	790	74.3	5.20	13.0	12.4	1.64	14.9	10-28	0330	
	195	73.8	5.16	63.9	61.5	2.01	3.68	10-28	0730	
	1815	74.4	5.16	7.22	6.94	2.11	34.2	10-29	0400	
	800	74.2	5.15	12.5	12.1	1.61	15.1	10-29	0730	
	230	74.0	5.13	48.2	46.7	1.80	4.34	10-29	1100	
	395	74.2	5.13	25.7	24.9	1.64	7.45	10-29	1530	
	490	74.3	5.14	17.8	17.2	1.41	9.25	10-29	1800	
	1285	74.4	5.13	8.33	8.06	1.73	24.2	10-29	2230	
	1775	74.4	5.13	6.63	6.43	1.91	33.5	10-30	0330	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-2 SUMMARY OF EMISSION TEST DATA FOR WELDED, CONTACT IFR

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc.[1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 35	1815	71.3	4.14	5.12	6.42	1.94	34.2	4-20-81	0330	
	1285	70.2	4.08	6.90	8.82	1.90	24.2	4-20	0630	
	815	69.8	4.05	11.6	15.0	2.04	15.4	4-20	1030	
	515	70.1	4.06	16.8	21.6	1.86	9.72	4-20	1400	
	235	69.7	4.04	25.3	32.7	1.28	4.43	4-20	1730	
	395	68.9	3.99	17.2	22.6	1.49	7.45	4-20	2100	
API 36	1815	68.7	3.97	6.02	7.94	2.41	34.2	4-21	0100	
	1310	68.6	3.96	6.65	8.79	1.93	24.7	4-21	0330	
	820	69.0	3.98	9.60	12.6	1.73	15.5	4-21	0630	
	520	69.4	4.01	15.4	20.1	1.75	9.81	4-21	1000	
	225	70.1	4.04	26.2	34.0	1.28	4.24	4-21	1330	
	395	70.6	4.06	14.0	18.0	1.19	7.45	4-21	1900	
API 37	1805	70.2	4.02	4.45	5.78	1.74	34.1	4-22	0530	
	1305	70.2	4.02	4.68	6.08	1.33	24.6	4-22	0900	
	810	70.1	4.01	7.60	9.90	1.34	15.3	4-22	1230	
	515	70.1	4.01	12.4	16.2	1.39	9.72	4-22	1600	
	395	70.2	4.01	16.5	21.5	1.42	7.45	4-22	1830	
	205	69.5	3.97	28.6	37.8	1.29	3.87	4-22	2200	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-2 SUMMARY OF EMISSION TEST DATA FOR WELDED, CONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc.[1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 38	1790	69.9	3.98	4.92	6.46	1.93	33.8	4-23-81	0200	
	1295	69.9	3.98	4.65	6.11	1.32	24.4	4-23	0430	
	805	69.8	3.97	7.78	10.3	1.38	15.2	4-23	0700	
	515	69.7	3.96	14.5	19.2	1.65	9.72	4-23	1030	
	380	69.7	3.96	19.1	25.3	1.61	7.17	4-23	1400	
	215	69.6	3.95	34.8	46.2	1.66	4.06	4-23	1800	
API 39	1790	69.3	3.93	6.85	9.14	2.74	33.8	4-23	2230	
	1290	69.2	3.92	8.28	11.1	2.39	24.3	4-24	0130	
	805	69.1	3.91	14.0	18.8	2.53	15.2	4-24	0430	
	520	68.9	3.89	19.6	26.5	2.30	9.81	4-24	0700	
	385	68.7	3.88	25.8	34.9	2.25	7.26	4-24	0930	
	220	69.0	3.90	35.4	47.7	1.76	4.15	4-24	1300	
	1805	70.1	5.12	7.48	7.26	2.19	34.1	4-27	0330	
	810	70.0	5.11	13.8	13.4	1.82	15.3	4-27	0630	
API 40	1755	70.3	5.13	7.38	7.15	2.10	33.1	4-27	1430	
	1020	71.1	5.19	8.79	8.40	1.43	19.2	4-27	1700	
	685	71.7	5.23	12.6	11.9	1.37	12.9	4-27	1900	
	395	72.4	5.28	21.8	20.4	1.35	7.45	4-27	2130	
	230	72.7	5.30	33.3	31.0	1.19	4.33	4-27	2330	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-2 SUMMARY OF EMISSION TEST DATA FOR WELDED, CONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc. [1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 41	1795	71.7	5.23	2.55	2.41	0.724	33.9	5-4-81	0300	
	1300	71.6	5.22	3.30	3.13	0.680	24.5	5-4	0600	
	815	70.8	5.17	5.64	5.42	0.739	15.4	5-4	0930	
	525	71.8	5.24	9.79	9.24	0.812	9.90	5-4	1800	
	390	71.9	5.24	11.6	10.9	0.713	7.35	5-4	2030	
	225	71.9	5.24	19.0	17.9	0.674	4.25	5-4	2330	
API 42	1800	72.0	5.25	3.43	3.23	0.972	34.0	5-5	0300	
	1300	71.7	5.23	3.75	3.55	0.771	24.5	5-5	0600	
	810	71.9	5.24	6.20	5.84	0.792	15.3	5-5	0930	
	520	71.9	5.24	9.54	8.99	0.782	9.81	5-5	1300	
	395	71.5	5.22	13.8	13.1	0.866	7.45	5-5	1700	
	220	71.1	5.19	21.7	20.7	0.763	4.15	5-5	1930	
API 43	1805	70.4	5.14	4.28	4.14	1.25	34.1	5-5	2330	
	1305	70.0	5.11	6.70	6.52	1.42	24.6	5-6	0300	
	815	69.8	5.10	10.8	10.5	1.44	15.4	5-6	0530	
	525	69.3	5.06	14.4	14.2	1.25	9.91	5-6	0900	
	395	69.8	5.10	16.1	15.7	1.04	7.45	5-6	1730	
	220	69.5	5.08	27.1	26.6	0.979	4.15	5-6	2000	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-2 SUMMARY OF EMISSION TEST DATA FOR WELDED, CONTACT IFR (continued)

Test No.	Air Flow Rate	Product Temp.	Vapor Press.	(Outlet-Inlet) Concentration (ppmv) (C3 Basis)		Emissions	Wind Speed	Date	Time	
	(scfm)	(°F)	(psia)	Meas.	Calc. [1]	(lbm/day)	(mi/hr)			
API 44	1805	63.7	4.68	2.50	2.71	0.818	34.1	5-11-81	0330	
	1305	63.8	4.69	3.30	3.57	0.779	24.6	5-11	0600	
	815	64.1	4.71	5.62	6.05	0.824	15.4	5-11	0900	
	515	64.4	4.73	9.78	10.5	0.902	9.72	5-11	1230	
API 45	1810	65.0	4.77	1.13	1.20	0.363	34.2	5-12	0230	
	1310	65.1	4.78	1.28	1.35	0.297	24.7	5-12	0500	
	820	65.0	4.77	2.01	2.13	0.292	15.5	5-12	0730	
	525	65.6	4.81	4.82	5.06	0.444	9.91	5-12	1100	
	400	66.3	4.86	6.47	6.71	0.449	7.55	5-12	1330	
	225	66.8	4.89	8.29	8.52	0.321	4.24	5-12	1900	
	395	67.0	4.90	4.81	4.93	0.326	7.45	5-12	2130	
API 46	1810	67.1	4.91	1.83	1.87	0.567	34.2	5-13	0200	
	1310	67.2	4.92	2.08	2.12	0.465	24.7	5-13	0430	
	815	67.3	4.92	2.90	2.96	0.403	15.4	5-13	0700	
	520	67.4	4.93	5.11	5.20	0.452	9.81	5-13	1000	
	410	67.6	4.94	6.29	6.38	0.437	7.73	5-13	1300	
	235	67.9	4.97	10.2	10.3	0.405	4.43	5-13	1600	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-2 SUMMARY OF EMISSION TEST DATA FOR WELDED, CONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc.[1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 47	1810	67.3	4.92	2.96	3.02	0.913	34.2	5-13-81	2100	
	1310	67.5	4.94	2.90	2.95	0.645	24.7	5-13	2330	
	815	67.4	4.93	4.83	4.91	0.670	15.4	5-14	0230	
	525	67.4	4.93	7.48	7.61	0.668	9.91	5-14	0500	
	390	67.4	4.93	11.1	11.3	0.737	7.36	5-14	0730	
	210	67.0	4.90	25.6	26.2	0.921	3.96	5-14	1100	
	1300	67.0	4.90	3.77	3.86	0.840	24.5	5-14	1600	
	220	66.2	4.85	21.0	21.8	0.802	4.15	5-14	1930	
API 48	1805	66.6	4.88	4.88	5.03	1.52	34.1	5-15	0030	
	1305	67.1	4.91	4.85	4.96	1.08	24.6	5-15	0230	
	815	67.2	4.92	7.18	7.33	0.999	15.4	5-15	0530	
	525	67.6	4.94	10.7	10.8	0.953	9.91	5-15	0800	
	390	68.1	4.98	14.7	14.8	0.964	7.36	5-15	1030	
	210	68.8	5.03	24.6	24.4	0.859	3.96	5-15	1300	
API 49	1785	69.7	5.09	2.90	2.84	0.847	33.7	5-15	1830	
	1305	69.3	5.06	3.30	3.25	0.710	24.6	5-15	2100	
	815	69.0	5.04	5.04	4.99	0.680	15.4	5-15	2330	
	515	67.4	4.93	9.30	4.46	0.815	9.72	5-16	0900	
	390	68.2	4.99	11.8	11.8	0.773	7.36	5-16	1230	
	215	69.6	5.08	23.3	22.8	0.821	4.06	5-16	1630	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-2 SUMMARY OF EMISSION TEST DATA FOR WELDED, CONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc.[1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 50	1290	80.8	0.581	2.60	2.23	0.481	24.3	5-21-81	0630	
	810	81.0	0.584	2.73	2.33	0.316	15.3	5-21	0930	
	515	82.0	0.598	4.18	3.48	0.300	9.72	5-21	1430	
	395	82.5	0.604	4.14	3.41	0.226	7.45	5-21	1730	
	230	83.1	0.613	5.90	4.80	0.185	4.34	5-21	2130	
	1785	83.3	0.615	1.93	1.56	0.466	33.7	5-22	0100	
	520	83.1	0.613	6.03	4.90	0.426	9.81	5-22	0430	
API 51	3890	83.6	0.620	3.16	2.54	1.67	3.98	5-22	1930	
	6270	83.0	0.611	3.61	2.94	3.08	6.89	5-22	2200	
	8820	82.3	0.602	4.05	3.35	4.94	10.2 [2]	5-23	0130	
	9480	81.7	0.594	3.86	3.24	5.14	11.1	5-23	0630	
	7280	80.8	0.581	3.49	2.99	3.65	8.18	5-23	0930	
	5170	80.8	0.581	3.04	2.61	2.26	5.52	5-23	1200	

Notes: [1]. Normalized to 0.50 psia vapor pressure.
[2]. External Floating Roof simulation; Wind Speed (mi/hr) = $(2.96 \times 10^{-4})(Q, SCFM)^{1.15}$

TABLE B-2 SUMMARY OF EMISSION TEST DATA FOR WELDED, CONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C8 Basis) Meas.	Calc.[1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 67A	1725	77.1	0.423	1.20	1.42	1.06	32.6	9-8-81	0300	
	1290	77.0	0.421	1.63	1.94	1.08	24.3	9-8	0630	
	790	77.1	0.423	1.97	2.34	0.800	14.9	9-8	1130	
	520	78.1	0.434	2.32	2.68	0.604	9.81	9-8	1500	
	405	78.1	0.434	2.26	2.61	0.458	7.64	9-8	1830	
	215	78.1	0.434	3.76	4.35	0.405	4.06	9-8	2100	
	1785	77.7	0.429	0.72	0.84	0.650	33.7	9-9	0100	
	1310	77.5	0.427	1.15	1.35	0.766	24.7	9-9	0400	
	800	77.1	0.423	2.61	3.10	1.07	15.1	9-9	1000	
API 67	1720	80.8	0.363	0.60	0.83	0.618	32.5	9-10	1900	
	1320	80.7	0.362	0.63	0.87	0.500	24.9	9-10	2130	
	805	80.5	0.360	1.17	1.63	0.569	15.2	9-11	0130	
	520	80.1	0.356	1.76	2.48	0.560	9.81	9-11	0530	
	395	81.5	0.371	2.81	3.80	0.651	7.45	9-11	1800	
	215	81.3	0.369	4.12	5.61	0.523	4.06	9-11	2030	

Notes: [1]. Normalized to 0.50 psia vapor pressure.

TABLE B-2 SUMMARY OF EMISSION TEST DATA FOR WELDED, CONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C6 Basis) Meas.	Calc.[1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 68	1760	78.0	3.08	1.86	1.48	0.850	33.2	9-15-81	1630	
	800	78.0	3.08	3.75	2.98	0.779	15.1	9-15	1930	
	215	77.8	3.06	15.7	12.5	0.880	4.06	9-15	2200	
	360	77.5	3.04	9.82	7.90	0.931	6.79	9-16	0200	
	520	77.2	3.02	6.40	5.20	0.883	9.81	9-16	0630	
	1290	77.1	3.01	2.70	2.19	0.926	24.3	9-16	1000	
API 69	1790	77.4	3.03	1.10	0.89	0.520	33.8	9-18	1800	
	800	77.2	3.02	1.86	1.51	0.395	15.1	9-18	2030	
	225	77.1	3.01	8.49	6.90	0.508	4.25	9-18	2300	
	390	76.5	2.97	6.14	5.07	0.645	7.36	9-19	0900	
	510	76.8	2.99	5.32	4.36	0.726	9.62	9-19	1230	
	1265	77.5	3.04	2.40	1.93	0.800	23.9	9-19	1500	
	380	77.6	3.05	4.81	3.86	0.480	7.17	9-19	2030	
	1285	77.6	3.05	1.86	1.49	0.628	24.2	9-21	0330	
	515	77.5	3.04	4.85	3.90	0.657	9.72	9-21	0800	
	800	77.6	3.05	3.56	2.86	0.748	15.1	9-21	1130	
	1735	78.4	3.11	1.79	1.40	0.800	32.7	9-21	1530	
	230	78.0	3.08	7.80	6.19	0.466	4.34	9-21	1900	
	810	78.0	3.08	2.45	1.94	0.515	15.3	9-21	2130	

Notes: [1]. Normalized to 2.50 psia vapor pressure.

TABLE B-2 SUMMARY OF EMISSION TEST DATA FOR WELDED, CONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc.[1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 70	815	70.7	6.19	10.1	7.70	1.05	15.4	9-24-81	0400	
	215	70.3	6.16	32.8	25.2	0.905	4.06	9-24	0800	
	405	71.4	6.25	12.1	9.11	0.617	7.64	9-24	2030	
	520	71.4	6.25	11.2	8.43	0.733	9.81	9-24	2300	
	1305	71.2	6.24	4.43	3.34	0.729	24.6	9-25	0430	
	1795	70.6	6.19	3.54	2.70	0.811	33.9	9-25	1000	
	1305	70.6	6.19	5.64	4.31	0.940	24.6	9-25	1300	
	390	70.8	6.20	17.7	13.5	0.878	7.35	9-25	1700	
	805	70.9	6.21	9.06	6.88	0.926	15.2	9-25	2000	
	520	71.0	6.22	13.1	9.93	0.864	9.81	9-25	2230	
API 71	1770	71.1	6.23	5.98	4.53	1.34	33.4	9-26	1000	
	795	71.1	6.23	11.9	9.00	1.20	15.0	9-26	1300	
	215	71.7	6.28	44.8	33.5	1.21	4.06	9-26	1900	
	395	70.2	6.15	22.8	17.5	1.16	7.45	9-28	0400	
	525	69.5	6.10	18.5	14.4	1.26	9.90	9-28	0800	
	1310	69.4	6.09	6.64	5.18	1.13	24.7	9-28	1100	
	520	70.7	6.19	13.9	10.6	0.921	9.81	9-28	1800	
API 71A	540	70.2	6.15	12.5	9.61	0.868	10.2	9-28	2200	
	540	68.8	6.04	15.4	12.1	1.10	10.2	9-29	0200	
	540	67.6	5.94	16.3	13.1	1.18	10.2	9-29	0600	
	535	66.5	5.85	15.6	12.8	1.14	10.1	9-29	1000	
	530	65.9	5.81	13.2	10.9	0.970	10.0	9-29	1400	
	530	65.8	5.80	11.3	9.38	0.832	10.0	9-29	1800	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-2 SUMMARY OF EMISSION TEST DATA FOR WELDED, CONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc. [1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API 72	1800	72.1	2.42	2.65	2.75	0.828	34.0	10-1-81	0400	
	810	71.6	2.40	6.09	6.37	0.863	15.3	10-1	0900	
	235	71.2	2.39	17.5	18.4	0.724	4.43	10-1	1230	
	390	71.3	2.39	12.3	12.9	0.843	7.36	10-1	1600	
	525	70.8	2.37	8.38	8.88	0.780	9.91	10-1	1900	
	1275	70.4	2.36	4.13	4.40	0.939	24.1	10-1	2300	
	1800	70.4	2.36	3.10	3.30	0.995	34.0	10-2	0230	

Notes: [1]. Normalized to 2.50 psia vapor pressure.

TABLE B-3 SUMMARY OF EMISSION TEST DATA FOR BOLTED, CONTACT IFR

Test No.	Air Flow Rate	Product Temp.	Vapor Press.	(Outlet-Inlet) Concentration (ppmv) (C3 Basis)		Emissions	Wind Speed	Date	Time	
	(scfm)	(°F)	(psia)	Meas.	Calc. [1]	(lbm/day)	(mi/hr)			
API52	1790	84.9	5.54	8.98	7.89	2.37	33.8	6-24-81	0200	
	1305	84.7	5.53	8.20	7.24	1.58	24.6	6-24	0500	
	805	84.0	5.47	14.0	12.5	1.68	15.2	6-24	0830	
	495	84.0	5.47	25.5	22.8	1.89	9.34	6-24	1230	
	385	85.0	5.54	29.7	26.1	1.68	7.26	6-24	1800	
	210	85.1	5.54	50.3	44.2	1.55	3.96	6-24	2030	
API52R	1290	88.3	5.61	10.4	9.01	1.94	24.3	7-13	0200	
	520	88.2	5.59	26.2	22.8	1.98	9.81	7-13	0500	
	390	87.9	5.55	34.0	29.8	1.95	7.36	7-13	0800	
	1685	87.1	5.47	9.73	8.70	2.45	31.8	7-13	1300	
API53	1735	85.5	5.57	9.20	8.04	2.33	32.7	6-25	0000	
	1305	85.3	5.55	12.7	11.1	2.43	24.6	6-25	0430	
	810	84.3	5.48	12.8	11.4	1.55	15.3	6-25	1000	
	510	84.3	5.48	24.3	21.7	1.85	9.62	6-25	1300	
	415	84.7	5.50	29.4	26.1	1.81	7.83	6-25	1630	
	210	85.0	5.52	48.9	43.2	1.52	3.96	6-25	1930	
	1740	85.4	5.55	8.73	7.67	2.23	32.8	6-25	2200	
	1300	83.0	5.33	9.23	8.53	1.86	24.5	6-29	0300	
	780	82.6	5.29	14.4	13.4	1.75	14.7	6-29	1230	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-3 SUMMARY OF EMISSION TEST DATA FOR BOLTED, CONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc.[1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API54	1805	84.9	5.51	8.55	7.58	2.29	34.1	6-26-81	0330	
	1300	84.4	5.47	8.55	7.64	1.66	24.5	6-26	0600	
	835	83.5	5.40	15.9	14.4	2.02	15.8	6-26	1300	
	520	83.9	5.43	26.6	24.0	2.09	9.81	6-26	1630	
	390	84.1	5.44	32.5	29.3	1.91	7.36	6-26	1900	
	225	84.3	5.45	50.0	44.9	1.69	4.25	6-26	2130	
API55A	1770	85.1	5.45	4.02	3.61	1.07	33.4	6-30	2200	
	805	85.0	5.44	5.70	5.13	0.691	15.2	7-1	0100	
	220	84.3	5.39	22.5	20.5	0.755	4.16	7-1	0400	
	375	83.6	5.34	13.2	12.2	0.764	7.08	7-1	0730	
API55	1760	84.3	5.34	2.43	2.24	0.659	33.2	7-6	0430	
	1285	83.2	5.26	3.31	3.11	0.668	24.3	7-6	1130	
	830	84.6	5.36	5.34	4.90	0.680	15.7	7-6	1800	
	475	85.3	5.41	8.90	8.07	0.642	8.96	7-6	2130	
API56	1275	85.4	5.41	9.15	8.30	1.77	24.1	7-7	1900	
	805	85.8	5.43	12.9	11.6	1.57	15.2	7-7	2130	
	510	86.5	5.48	21.0	18.7	1.60	9.62	7-8	0330	
	390	86.2	5.46	24.7	22.1	1.44	7.36	7-8	0700	
	250	86.8	5.50	35.8	31.8	1.33	4.72	7-8	1800	
	1700	87.1	5.52	6.43	5.68	1.62	32.1	7-8	2100	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-3 SUMMARY OF EMISSION TEST DATA FOR BOLTED, CONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc.[1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API57	1670	86.9	5.50	7.08	6.28	1.76	31.5	7-9-81	0230	
	1295	86.6	5.48	8.20	7.32	1.58	24.4	7-9	0600	
	800	86.5	5.47	13.8	12.3	1.65	15.1	7-9	1000	
	515	87.0	5.50	23.1	20.5	1.77	9.72	7-9	1430	
	255	87.6	5.55	41.2	36.2	1.54	4.81	7-9	1830	
API58	1780	87.3	5.52	9.10	8.04	2.39	33.6	7-10	0300	
	1300	85.6	5.40	10.7	9.73	2.12	24.5	7-10	0900	
	795	85.7	5.40	16.9	15.3	2.04	15.0	7-10	1230	
	525	87.2	5.51	26.4	23.4	2.05	9.91	7-10	2130	
	255	85.9	5.41	45.4	41.2	1.76	4.81	7-11	0830	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-3 SUMMARY OF EMISSION TEST DATA FOR BOLTED, CONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (C3 Basis) Meas.	Calc.[1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API59	1275	84.3	5.02	10.6	10.6	2.25	24.1	7-15-81	2200	
	790	84.2	4.99	15.3	15.4	2.03	14.9	7-16	0330	
	515	84.0	4.96	21.8	22.0	1.90	9.72	7-16	0630	
	360	83.5	4.91	36.8	37.7	2.27	6.79	7-16	1100	
	260	83.7	5.15	48.3	49.4	2.15	4.91	7-16	1300	
	165	84.5	4.90	79.1	81.2	2.24	3.11	7-17	0330	
	810	83.8	4.84	15.8	16.5	2.23	15.3	7-17	0700	
	1700	83.4	4.78	8.19	8.65	2.46	32.1	7-17	1300	
API60	1695	84.0	4.81	10.1	10.6	3.01	32.0	7-17	1600	
	1265	84.6	4.83	10.7	11.2	2.36	23.9	7-17	1830	
	835	85.0	4.85	15.8	16.4	2.29	15.8	7-17	2100	
	495	85.1	4.84	28.1	29.2	2.42	9.34	7-17	2330	
	220	85.2	4.84	61.3	63.9	2.35	4.15	7-18	0230	
API61	1755	84.8	4.79	12.4	13.1	3.83	33.1	7-18	0630	
	1280	85.0	4.79	13.1	13.8	2.96	24.2	7-18	1000	
	795	85.4	4.80	20.2	21.2	2.83	15.0	7-18	1330	
	525	86.3	4.83	34.8	36.3	3.19	9.91	7-18	1830	
	405	86.6	4.84	42.5	44.3	3.00	7.64	7-18	2130	
	220	86.5	4.69	56.9	61.5	2.26	4.15	7-20	0400	
	1765	86.2	4.66	10.6	11.6	3.41	33.3	7-20	0700	

Notes: [1]. Normalized to 5.00 psia vapor pressure.

TABLE B-3 SUMMARY OF EMISSION TEST DATA FOR BOLTED, CONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv)(C3 Basis) Meas.	Calc.	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API62	1730	81.0	2.95	6.33	5.27 [1]	1.53	32.6	7-21-81	1230	
	1285	81.6	2.97	8.26	6.81	1.46	24.2	7-21	1900	
	770	81.7	2.98	13.8	11.4	1.46	14.5	7-21	2300	
	510	81.5	2.97	22.8	18.8	1.61	9.62	7-22	0200	
	390	80.8	2.94	31.9	26.6	1.74	7.36	7-22	0500	
	395	81.2	2.96	21.5	17.8	1.18	7.45	7-22	1930	
	185	81.5	2.97	53.6	44.3	1.37	3.49	7-22	2300	
	520	81.3	2.96	24.9	20.6	1.80	9.81	7-23	0330	
	805	81.1	2.95	12.7	10.6	1.42	15.2	7-23	0730	
	255	81.1	2.95	31.7	26.3	1.12	4.81	7-23	1130	
API63	200	84.4	0.873	31.5	17.8 [2]	0.596	3.77	7-27	2000	
	1755	84.6	0.877	4.78	2.69	0.790	33.1	7-28	0000	
	1045	84.7	0.879	7.53	4.23	0.739	19.7	7-28	0400	
	515	84.7	0.879	14.2	7.97	0.687	9.72	7-28	0630	
	410	84.7	0.879	18.8	10.6	0.724	7.74	7-28	0930	

Notes: [1]. Normalized to 2.50 psia vapor pressure.
[2]. Normalized to 0.50 psia vapor pressure.

TABLE B-3 SUMMARY OF EMISSION TEST DATA FOR BOLTED, CONTACT IFR (continued)

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) Meas.	(Outlet-Inlet) Concentration (ppmv) Calc.	Emissions (lbm/day)	Wind Speed (mi/hr)	Date	Time	
API64	1720	94.3	0.527	1.33	1.26	0.940	32.4	8-3-81	0300	
	1290	94.7	0.532	1.82	1.71	0.955	24.3	8-3	0630	
	810	95.1	0.538	2.34	2.17	0.762	15.3	8-3	1230	
	480	95.7	0.546	4.31	3.94 [1]	0.819	9.06	8-3	1730	
	415	96.0	0.551	5.71 (nC8 Basis)	5.17	0.930	7.83	8-3	2200	
	200	95.9	0.549	11.5	10.4	0.905	3.77	8-4	0000	
	1695	95.8	0.548	1.42	1.29	0.950	32.0	8-4	0330	
	1270	95.8	0.548	2.13	1.94	1.07	24.0	8-4	0700	
	795	95.4	0.542	2.89	2.66	0.917	15.0	8-4	0930	
API65	1700	81.2	3.32	5.15	3.76	2.09	32.1	8-5	2200	
	1270	81.4	3.33	6.75	4.90	2.04	24.0	8-6	0130	
	795	81.4	3.33	10.4	7.55	1.96	15.0	8-6	0500	
	515	81.5	3.34	16.2 (nC6 Basis)	11.7 [2]	1.98	9.72	8-6	0730	
	375	82.4	3.41	24.5	17.3	2.12	7.08	8-6	2000	
	195	82.4	3.41	41.3	29.2	1.86	3.68	8-6	2300	
	1650	82.6	3.42	5.73	4.03	2.17	31.1	8-7	0300	
	600	82.6	3.42	14.4	10.1	1.99	11.3	8-12	1130	

Notes: [1]. Normalized to 0.50 psia vapor pressure.
[2]. Normalized to 2.50 psia vapor pressure.

TABLE B-3 SUMMARY OF EMISSION TEST DATA FOR BOLTED, CONTACT IFR (continued)

Test No.	Air Flow Rate	Product Temp.	Vapor Press.	(Outlet-Inlet) Concentration (ppmv) (C6 Basis)		Emissions	Wind Speed	Date	Time	
	(scfm)	(°F)	(psia)	Meas.	Calc.[1]	(lbm/day)	(mi/hr)			
API65R	1720	82.4	3.41	9.08	6.42	3.61	32.5	8-28-81	1130	
	1305	82.5	3.42	11.3	7.97	3.40	24.6	8-28	1400	
	800	82.5	3.42	16.7	11.8	3.08	15.1	8-28	1630	
	515	82.6	3.42	29.9	21.0	3.54	9.72	8-28	1900	
	360	82.7	3.43	43.4	30.5	3.58	6.79	8-28	2130	
	205	82.3	3.40	71.3	50.6	3.39	3.87	8-29	0830	
API65A	1720	82.0	3.38	8.55	6.10	3.44	32.5	8-29	1200	
	1305	82.1	3.39	10.8	7.70	3.28	24.6	8-29	1430	
	520	82.2	3.39	30.4	21.6	3.67	9.81	8-29	1700	
	210	82.2	3.39	64.2	45.6	3.13	3.96	8-29	1900	
	810	82.3	3.40	18.3	13.0	3.44	15.3	8-29	2130	
API66R	1730	82.4	3.41	6.56	4.64	2.63	32.6	8-25	2230	
	1290	82.5	3.42	8.10	5.71	2.41	24.3	8-26	0130	
	805	82.7	3.43	13.8	9.69	2.55	15.2	8-26	0430	
	520	83.1	3.46	22.3	15.5	2.63	9.81	8-26	0730	
	1720	83.3	3.48	6.47	4.47	2.51	32.5	8-26	1800	
	1290	83.3	3.48	8.00	5.53	2.33	24.3	8-26	2130	
	800	83.2	3.47	18.7	12.9	3.38	15.1	8-27	0230	
	515	82.8	3.44	29.2	20.4	3.44	9.72	8-27	0630	
	380	82.8	3.44	36.8	25.8	3.20	7.17	8-27	1000	
	1720	83.0	3.46	6.33	4.41	2.48	32.5	8-27	1930	
	785	82.9	3.45	16.6	11.6	2.98	14.8	8-27	2230	
	510	82.8	3.44	24.0	16.8	2.80	9.62	8-28	0300	
	375	82.7	3.43	35.5	24.9	3.05	7.08	8-28	0730	

Notes: [1]. Normalized to 2.50 psia vapor pressure.

TABLE B4 SUMMARY OF EMISSION TEST DATA FOR A WELDED, CONTACT IFR [Ref. 2]

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (Propane Basis) Meas.	Calc. [1]	Emissions (lbm/day)	Wind Speed (mi/hr)	Emissions (lbmoles/day)		
C19	2001	52.2	4.73	7.56	7.79	2.60	37.8	0.0573		
	1569	53.5	4.82	8.06	8.12	2.13	29.6	0.0469		
	1128	53.8	4.85	8.51	8.51	1.61	21.3	0.0355		
	829	54.1	4.86	10.9	10.9	1.51	15.6	0.0333		
	406	53.7	4.85	20.6	20.6	1.40	7.7	0.0308		
	252	49.5	4.55	21.2	22.9	0.96	4.8	0.0211		

Product: C3/nC8
Vapor Molecular Weight: 45.4 lbm/lbmole
Average Emissions: 0.0375 lbmoles/day

Notes: [1]. Normalized to 4.85 psia vapor pressure.

TABLE B5 SUMMARY OF EMISSION TEST DATA FOR A WELDED, CONTACT IFR [Ref. 5]

Test No.	Air Flow Rate (scfm)	Product Temp. (°F)	Vapor Press. (psia)	(Outlet-Inlet) Concentration (ppmv) (Benzene Basis)		Emissions (lbm/day)	Wind Speed (mi/hr)	Emissions (lbmoles/day)		
				Meas.	Calc.[1]					
EPA 7	1081	97.3	3.02	27.8	27.6	8.84	20.4	0.1133		
	733	97.1	3.01	39.1	39.0	8.46	13.8	0.1084		
	625	97.2	3.01	43.8	43.7	8.08	11.8	0.1035		
	541	97.3	3.02	46.7	46.4	7.44	10.2	0.0952		
	437	94.8	2.85	53.0	55.8	7.22	8.2	0.0925		
	318	95.1	2.88	77.6	80.8	7.62	6.0	0.0975		
	220	96.1	2.94	105	109	7.12	4.2	0.0911		
	128	96.9	3.00	155	155	5.88	2.4	0.0753		
	190	96.8	2.99	111	111	6.27	3.6	0.0803		

Product: Benzene
Vapor Molecular Weight: 78.1 lbm/lbmole
Average Emissions: 0.0952 lbmole/day

Notes: [1]. Normalized to 3.00 psia vapor pressure.

APPENDIX C

Vapor Space Velocity Surveys

Appendix C

Vapor Space Velocity Surveys

This appendix summarizes the results of velocity surveys which were performed in the vapor space (the ventilated space above the internal floating roof) of the 20 ft. diameter test tank to determine the air flow patterns and local velocities for air flow distribution Types 1 through 4. It was the purpose of these surveys to better understand the air flow patterns caused by each of the types of air flow distribution. Also, it was intended to compare these air flow patterns and local velocities with those measured on field tanks to help relate the test tank results to field tanks.

Test Procedure

For each velocity survey, the air flow rate into the test tank was kept constant at 525 scfm (corresponding to an ambient wind speed equivalent of 10 mi/hr for the Type 1 air flow distribution).

The velocity surveys were performed at essentially two elevations: (1) at the level of the center of the air plenum, and (2) at the level just above the top of the IFR seal.

As shown on Figure C1, a position grid was established inside the test tank at the level of the center of the air plenum. This grid consisted of points located at a radius of 4 ft., 6 ft, and 8 ft. from the center of the tank. A series of eighty radial lines were utilized in establishing the locations of the measurement point positions. Utilizing this method, positions were located on four rings, identified as Rings A, B, C, and D on Figure C1.

It was decided, however, to perform air speed and direction measurements at only half of these positions, with the thought that additional air speed and direction measurements could be performed at the other locations later, if necessary.

To determine the air speed at a particular location, an air speed probe was mounted on a special stand, which was placed at the measurement position. Also mounted on this stand was a protractor and a vertically hanging fine thread which was positioned by the air flow in the direction of air movement at the measurement location. For each measurement, the air speed probe was rotated until a maximum reading was obtained, which occurred in the direction indicated by the deflected thread. The direction of air movement was referenced to due North, which was identified as 0 degrees.

Air Speed Instrumentation

The instrument which was utilized to sense the air speed was an Alnor Type 8500 Thermo-Anemometer air speed measuring instrument. This instrument is especially designed to measure the speed of slowly moving air or gas.

The instrument utilizes a heated thermocouple in a Type 1520 Probe. The probe is attached to a battery powered indicator through a five foot long extension cable. The indicator has two scales: 10 through 300 ft/min (0.114 through 3.41 mi/hr) and 100 through 2,000 ft/min (1.14 through 22.7 mi/hr).

Test Results

Tables C1 through C5 contain the tabulated measurements, where both the air speed and direction at each location are listed.

Figures C2 through C5 indicate the air flow pattern for each of the four air distribution types. At some locations, it was not possible to determine the exact direction of air movement since at that particular measuring location the reading of air movement direction appeared to be too variable. This probably indicated the presence of a local turbulence eddy at the measuring location. Figures C2 through C5 also indicate the air inlet and outlet plenum opening conditions which were present during each of the velocity surveys.

Figures C6 through C9 show the velocity profile on both the inlet and outlet side of the tank for air distribution Types 1 and 2 at the measuring locations which were 4 ft, 6 ft, and 8 ft from the center of the tank.

Observations

The lowest velocity which could be measured with the anemometer was approximately 0.1 mi/hr. At this air velocity, the air movement is so low that it does not even disturb the vertically hanging fine thread which was used to indicate air flow direction.

It should be noted, that when measurements were taken above the seal for air distribution Type 1, all measurements were less than 0.1 mi/hr.

In air distribution Types 2 through 4, where the air was forced to flow through only a few of the plenum openings, it was possible to measure an air speed at the locations above the seal.

It should be noted, however, that in these air distribution types the air speed at which the air exited the inlet air plenum openings were significantly higher than those measured in Type 1. With these higher inlet air speeds, it should be expected that more disturbance of the air present in the vapor space above the internal floating roof would take place. Also, this level of turbulence might be expected to affect the air speed just above the seal.

Although for an actual 20 ft. diameter IFR tank one would probably have only four shell vents, it should be noted that one should be trying to simulate the type of air distribution which would be expected to occur in the broad population of IFR tanks, where for larger tank diameters a more uniform distribution of inlet air flow takes place. It would thus seem that the air distribution pattern which occurs in Type 1 is more indicative of this broad population of IFR tanks.

TABLE C1 AIR SPEED AND DIRECTION DATA FOR AIR FLOW TYPE 1

Radial Line No.	Locations A		Locations B		Locations C		Locations D	
	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)
0	-	-	15	180	28	170	35	170
1	-	-	10	275	12	185	38	185
2	-	-	<10	280	12	190	35	190
3	-	-	<10	225	15	215	30	195
4	-	-	10	230	12	215	15	190
5	-	-	20	240	22	225	12	205
6	-	-	40	215	35	215	15	205
7	-	-	25	230	25	220	25	210
8	-	-	40	240	17	225	28	225
9	-	-	12	270	14	265	18	210
10	-	-	12	315	<10	285	15	205
30	-	-	40	95	15	150	12	155
31	-	-	15	120	12	160	12	185
32	-	-	20	145	18	165	20	175
33	-	-	<10	160	35	170	25	180
34	-	-	12	155	25	155	20	195
35	-	-	17	180	30	190	20	190
36	-	-	20	180	25	190	25	205
37	-	-	18	175	22	190	23	210
38	-	-	12	180	30	190	20	190
39	-	-	14	165	30	185	25	185
40	-	-	22	195	25	180	30	180

TABLE C1 AIR SPEED AND DIRECTION DATA FOR AIR FLOW TYPE 1(continued)

Radial Line No.	Locations A		Locations B		Locations C		Locations D	
	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)
41	-	-	12	195	25	200	25	185
42	-	-	15	200	30	190	30	190
43	-	-	22	185	28	190	25	185
44	-	-	30	180	18	190	25	190
45	-	-	15	185	25	210	38	185
46	-	-	15	195	22	195	30	185
47	-	-	20	210	30	210	23	190
48	-	-	11	215	30	205	25	195
49	-	-	18	220	45	200	17	190
50	-	-	<10	225	40	180	15	195
70	-	-	15	35	12	45	30	170
71	-	-	30	130	<10	140	35	170
72	-	-	65	135	15	140	35	165
73	-	-	38	130	25	140	38	165
74	-	-	25	140	38	155	40	165
75	-	-	45	155	35	150	40	170
76	-	-	20	135	23	145	35	160
77	-	-	15	140	25	155	30	165
78	-	-	30	145	45	170	28	170
79	-	-	60	160	40	175	25	170

Notes: [1]. All air speed and direction measurements listed here are at the elevation of the center of the air inlet openings. The inlet air flow rate was kept constant at 525 acfm, and this corresponds to an external wind speed of about 9.9 mi/hr for Type 1 air flow distribution.

TABLE C2 AIR SPEED AND DIRECTION DATA FOR AIR FLOW TYPE 2

Radial Line No.	Locations A		Locations B		Locations C		Locations D	
	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)
0	-	-	11	95	13	230	35	270
1	-	-	10	105	16	225	25	265
2	-	-	14	130	15	220	30	240
3	-	-	12	205	17	215	35	235
4	-	-	16	210	15	210	50	230
5	-	-	25	225	25	200	65	230
6	-	-	17	185	25	185	110	225
7	-	-	28	200	70	190	125	220
8	-	-	85	190	80	205	130	215
9	240	220	240	220	100	220	150	220
10	-	-	95	225	100	225	120	220
30	-	-	15	75	20	115	20	135
31	160	185	35	80	24	110	28	140
32	-	-	37	125	25	145	27	145
33	-	-	15	100	30	130	20	140
34	-	-	15	65	50	125	27	145
35	-	-	17	90	40	140	28	140
36	-	-	12	120	50	130	35	150
37	-	-	25	95	55	145	50	165
38	-	-	20	140	50	160	35	160
39	-	-	20	145	40	175	25	165
40	-	-	20	135	25	180	60	180

TABLE C2 AIR SPEED AND DIRECTION DATA FOR AIR FLOW TYPE 2 (continued)

Radial Line No.	Locations A Speed (ft/min)	Locations A Direction (deg)	Locations B Speed (ft/min)	Locations B Direction (deg)	Locations C Speed (ft/min)	Locations C Direction (deg)	Locations D Speed (ft/min)	Locations D Direction (deg)
41	-	-	30	185	35	185	45	185
42	-	-	20	190	25	235	30	180
43	-	-	40	195	25	240	30	175
44	-	-	40	210	45	245	35	170
45	-	-	30	235	30	225	20	165
46	-	-	35	225	35	255	17	135
47	-	-	25	230	17	240	17	160
48	-	-	30	235	25	215	15	155
49	160	175	30	230	25	230	12	130
50	-	-	40	245	25	225	15	235
70	-	-	180	115	160	130	100	130
71	240	140	210	130	160	145	120	130
72	-	-	80	135	175	145	115	135
73	-	-	45	130	130	150	115	150
74	-	-	22	125	110	145	80	155
75	-	-	20	120	50	160	70	145
76	-	-	19	90	20	250	70	145
77	-	-	16	85	28	235	40	155
78	-	-	16	85	16	260	33	170
79	-	-	<10	85	12	260	21	265

Notes: [1]. All air speed and direction measurements listed here are at the elevation of the center of the air inlet openings. The inlet air flow rate was kept constant at 525 scfm, and this corresponds to an external wind speed of about 11.9 mi/hr for Type 2 air flow distribution.

TABLE C3 AIR SPEED AND DIRECTION DATA FOR AIR FLOW TYPE 3

Radial Line No.	Locations A		Locations B		Locations C		Locations D	
	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)
0	-	-	220	180	100	180	130	180
1	230	185	50	195	48	195	110	185
2	-	-	22	260	37	210	80	190
3	-	-	17	240	33	235	75	185
4	-	-	15	245	50	250	60	210
5	-	-	22	295	43	260	25	215
6	-	-	20	275	55	255	22	220
7	-	-	50	275	42	270	22	230
8	-	-	30	260	48	265	25	235
9	-	-	60	300	48	280	22	245
10	-	-	45	285	53	300	20	245
30	-	-	48	115	12	0	15	270
31	130	140	55	130	12	5	18	320
32	-	-	60	130	25	325	15	10
33	25	150	42	125	25	195	20	285
34	-	-	45	110	30	335	25	315
35	-	-	55	145	25	25	20	295
36	-	-	35	140	30	50	15	205
37	-	-	51	150	20	5	30	210
38	-	-	57	130	25	varies	15	170
39	150	175	75	150	25	varies	25	220
40	-	-	70	160	40	135	35	180

TABLE C3 AIR SPEED AND DIRECTION DATA FOR AIR FLOW TYPE 3 (continued)

Radial Line No.	Locations A Speed (ft/min)	Locations A Direction (deg)	Locations B Speed (ft/min)	Locations B Direction (deg)	Locations C Speed (ft/min)	Locations C Direction (deg)	Locations D Speed (ft/min)	Locations D Direction (deg)
41	190	185	73	150	45	140	90	185
42	-	-	100	140	50	190	120	190
43	-	-	95	140	140	180	140	175
44	-	-	85	140	150	185	160	180
45	-	-	25	215	120	185	190	160
46	-	-	30	205	100	195	170	185
47	150	210	26	180	100	215	150	180
48	-	-	28	170	110	210	150	170
49	190	220	50	220	85	225	140	175
50	-	-	70	220	85	225	90	180
70	-	-	20	45	16	120	30	155
71	-	-	27	50	25	115	35	160
72	-	-	25	65	20	110	35	165
73	-	-	40	80	17	125	60	170
74	-	-	40	80	17	145	85	170
75	-	-	35	100	25	175	95	180
76	-	-	30	115	28	170	120	170
77	-	-	35	115	75	170	130	180
78	-	-	50	150	145	165	160	185
79	230	175	240	175	250	180	160	185

Notes: [1]. All air speed and direction measurements listed here are at the elevation of the center of the air inlet openings. The inlet air flow rate was kept constant at 525 acfm, and this corresponds to an external wind speed of about 9.5 mi/hr for Type 3 air flow distribution.

TABLE C4 AIR SPEED AND DIRECTION DATA FOR AIR FLOW TYPE 4

Radial Line No.	Locations A		Locations B		Locations C		Locations D	
	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)
0	-	-	45	180	120	180	100	180
1	250	185	125	175	65	185	60	185
2	-	-	22	280	20	190	55	180
3	-	-	15	285	varies	varies	30	195
4	-	-	15	270	12	260	40	210
5	-	-	12	250	35	250	35	205
6	-	-	18	250	30	250	60	195
7	-	-	25	255	35	255	20	200
8	-	-	125	225	90	235	18	215
9	250	220	100	230	170	230	15	220
10	-	-	35	315	75	225	15	225
30	-	-	13	90	15	180	15	0
31	120	140	varies	varies	15	95	15	50
32	-	-	varies	varies	15	145	15	325
33	-	-	15	105	15	330	15	330
34	-	-	30	110	15	20	15	110
35	-	-	15	115	<10	varies	15	25
36	-	-	15	160	50	115	15	varies
37	-	-	30	120	20	120	40	120
38	-	-	10	170	15	varies	15	varies
39	150	175	15	130	25	varies	15	varies
40	-	-	20	180	20	180	15	135

TABLE C4 AIR SPEED AND DIRECTION DATA FOR AIR FLOW TYPE 4 (continued)

Radial Line No.	Locations A Speed (ft/min)	Locations A Direction (deg)	Locations B Speed (ft/min)	Locations B Direction (deg)	Locations C Speed (ft/min)	Locations C Direction (deg)	Locations D Speed (ft/min)	Locations D Direction (deg)
41	150	185	25	205	15	185	25	varies
42	-	-	20	235	15	190	15	varies
43	-	-	15	285	15	195	65	195
44	-	-	25	245	15	200	20	200
45	-	-	25	250	15	70	45	185
46	-	-	15	250	45	160	50	205
47	-	-	20	255	15	varies	35	190
48	-	-	30	305	15	varies	50	215
49	120	220	30	220	15	265	50	175
50	-	-	35	225	<10	225	45	270
70	-	-	20	135	55	135	40	155
71	250	140	220	140	100	140	60	160
72	-	-	100	135	120	145	110	145
73	-	-	15	130	80	150	75	150
74	-	-	12	110	50	135	40	155
75	-	-	12	70	25	115	35	160
76	-	-	22	70	15	115	60	180
77	-	-	30	75	varies	varies	35	185
78	-	-	20	125	varies	varies	40	190
79	250	175	210	175	160	175	90	185

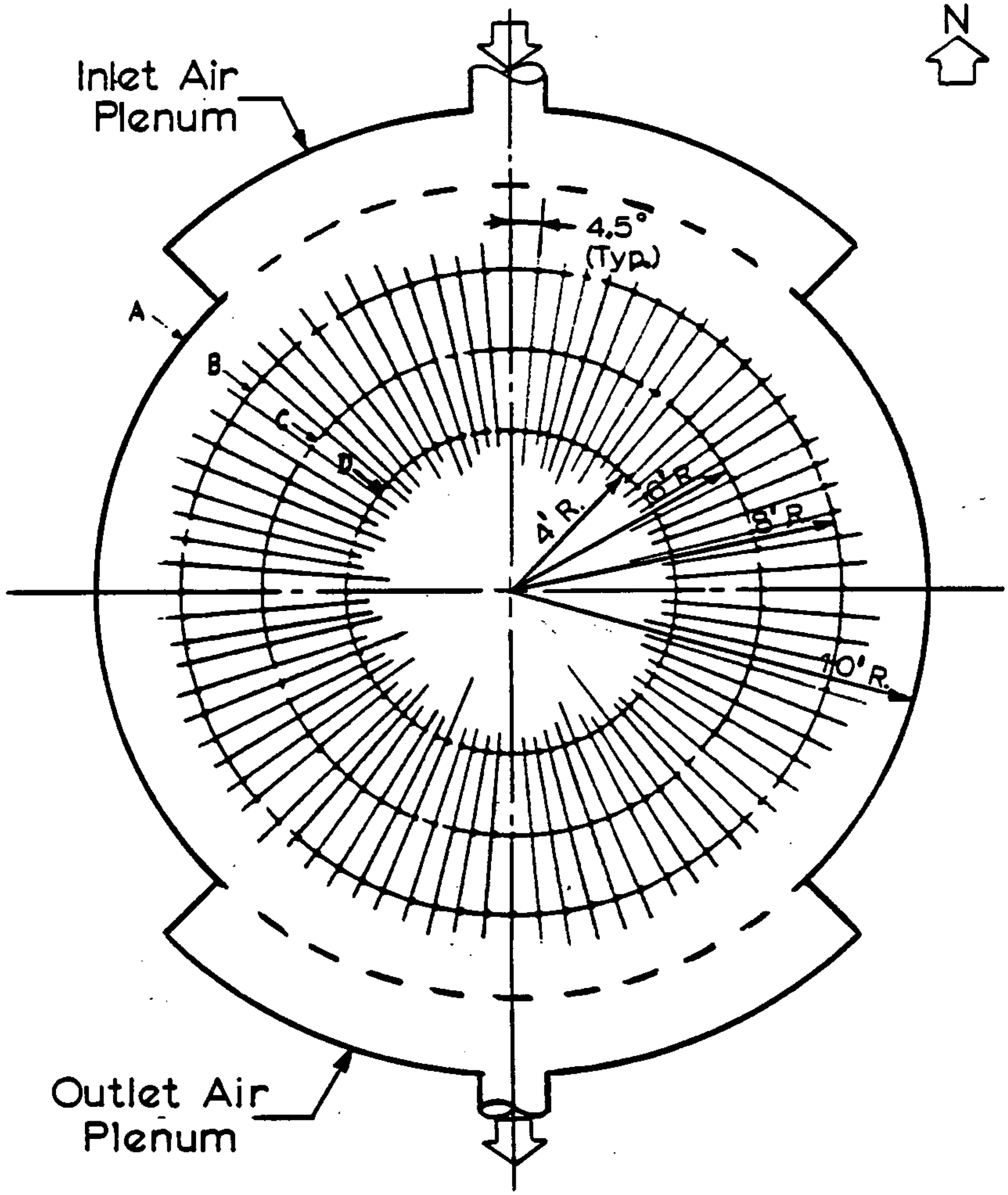
Notes: [1]. All air speed and direction measurements listed here are at the elevation of the center of the air inlet openings. The inlet air flow rate was kept constant at 525 acfm and this corresponds to an external wind speed of about 9.9 mi/hr for Type 4 air flow distribution.

TABLE C5 AIR SPEED AND DIRECTION DATA FOR AIR FLOW DISTRIBUTION TYPES 1, 2, 3 AND 4 AT VARIOUS LOCATIONS DIRECTLY ABOVE THE PRIMARY SEAL

Location	Type 1		Type 2		Type 3		Type 4	
	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)	Speed (ft/min)	Direction (deg)
A 0	<10 [2]	[3]	15	varies	40	180	25	180
A 5	<10	[3]	20	295	60	295	35	295
A10	<10	[3]	55	315	50	315	60	315
A15	<10	[3]	45	340	50	340	60	340
A20	<10	[3]	60	0	75	0	35	0
A25	<10	[3]	35	25	45	25	25	25
A30	<10	[3]	50	45	50	45	15	25
A35	<10	[3]	50	70	90	70	40	250
A40	<10	[3]	25	90	75	90	20	270
A45	<10	[3]	50	295	90	295	20	25
A50	<10	[3]	24	135	65	315	25	315
A55	<10	[3]	50	160	80	335	25	340
A60	<10	[3]	45	180	75	360	20	0
A65	<10	[3]	17	205	45	25	35	25
A70	<10	[3]	27	225	60	45	50	45
A75	<10	[3]	<10	70	70	70	25	70

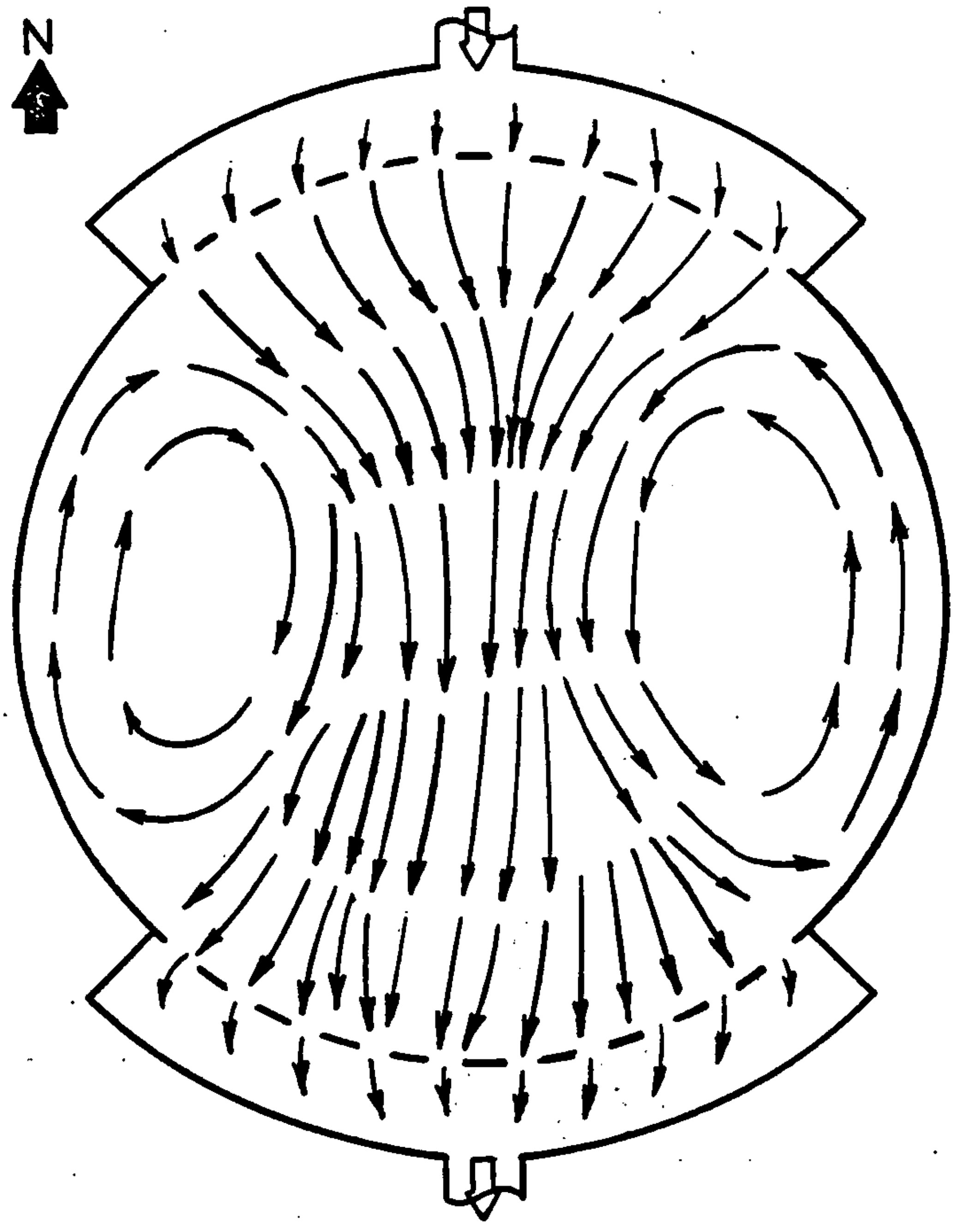
Notes: [1]. The roof was kept at an elevation of 18 in. below the air openings, and the air flow was kept constant at 525 acfm.
[2]. The sensitivity of the hot wire anemometer was limited to air speeds >10 ft/min (0.114 mi/hr)
[3]. The air speed was so small that its direction could not be determined.

Figure C1
Velocity Survey
Measurement Locations



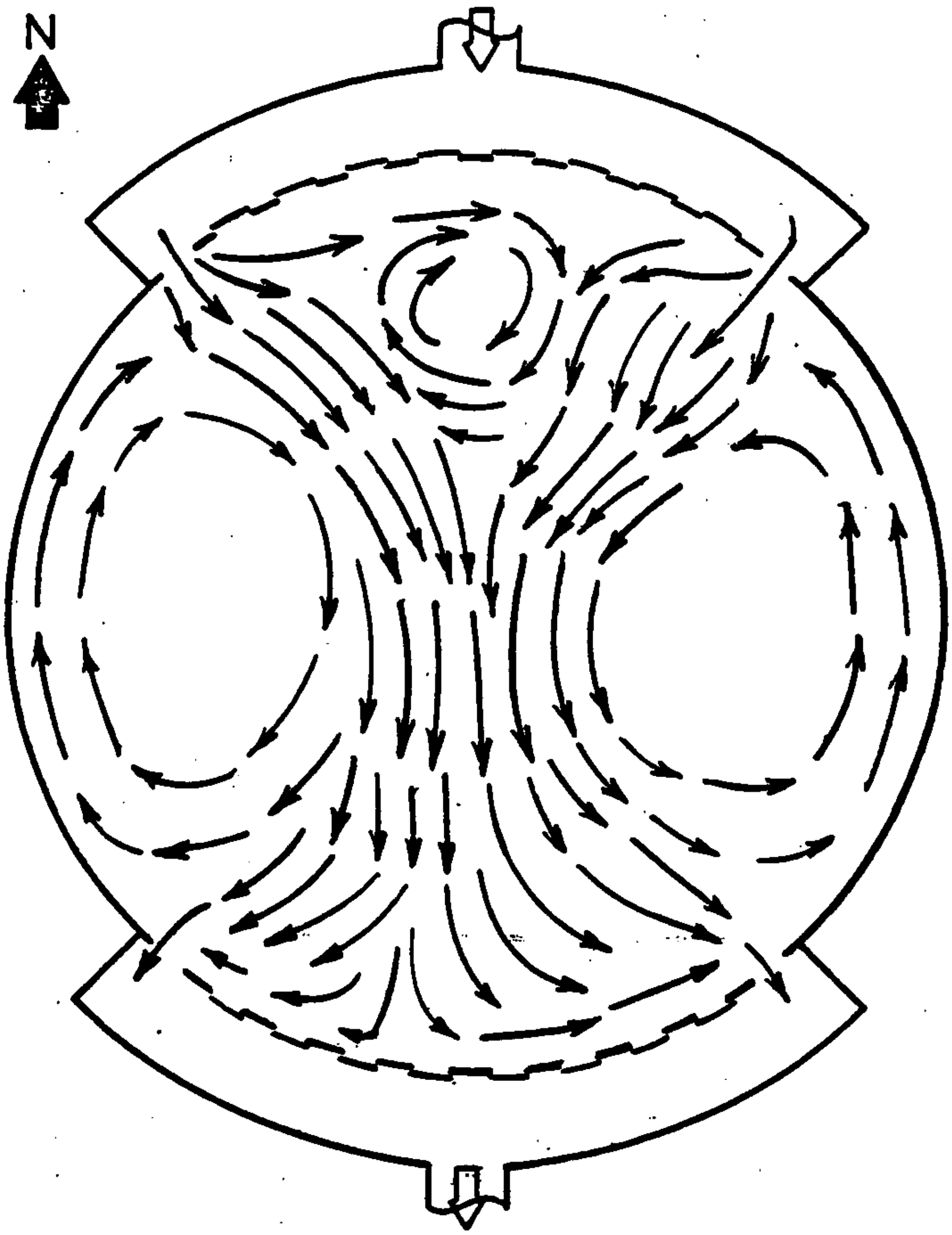
Plan View Of I F R

Figure C2
Velocity Survey For
Air Distribution – Type 1



Plan View Of IFR
Air Flow Rate = 525 scfm

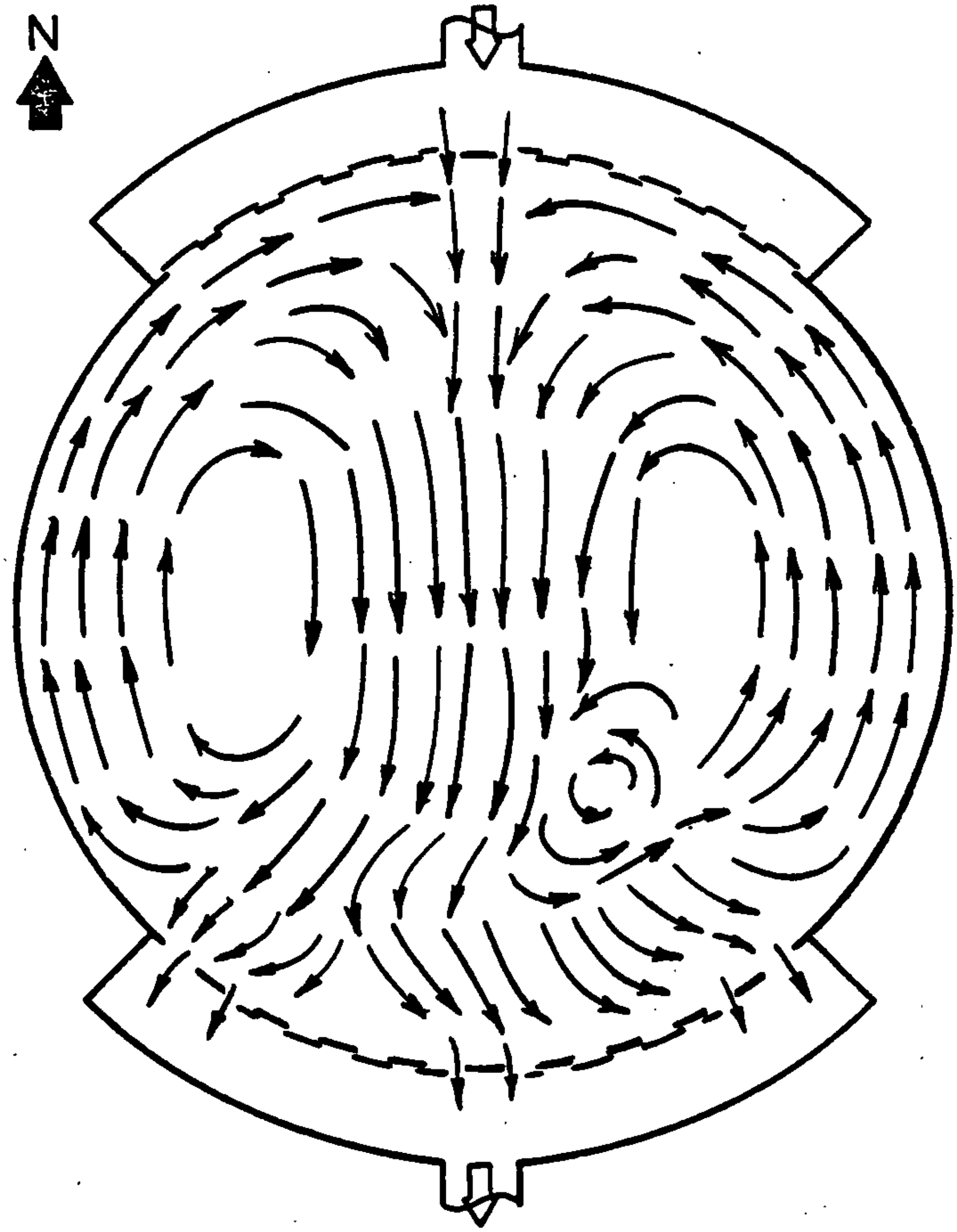
Figure C3
Velocity Survey For
Air Distribution - Type 2



Plan View Of IFR

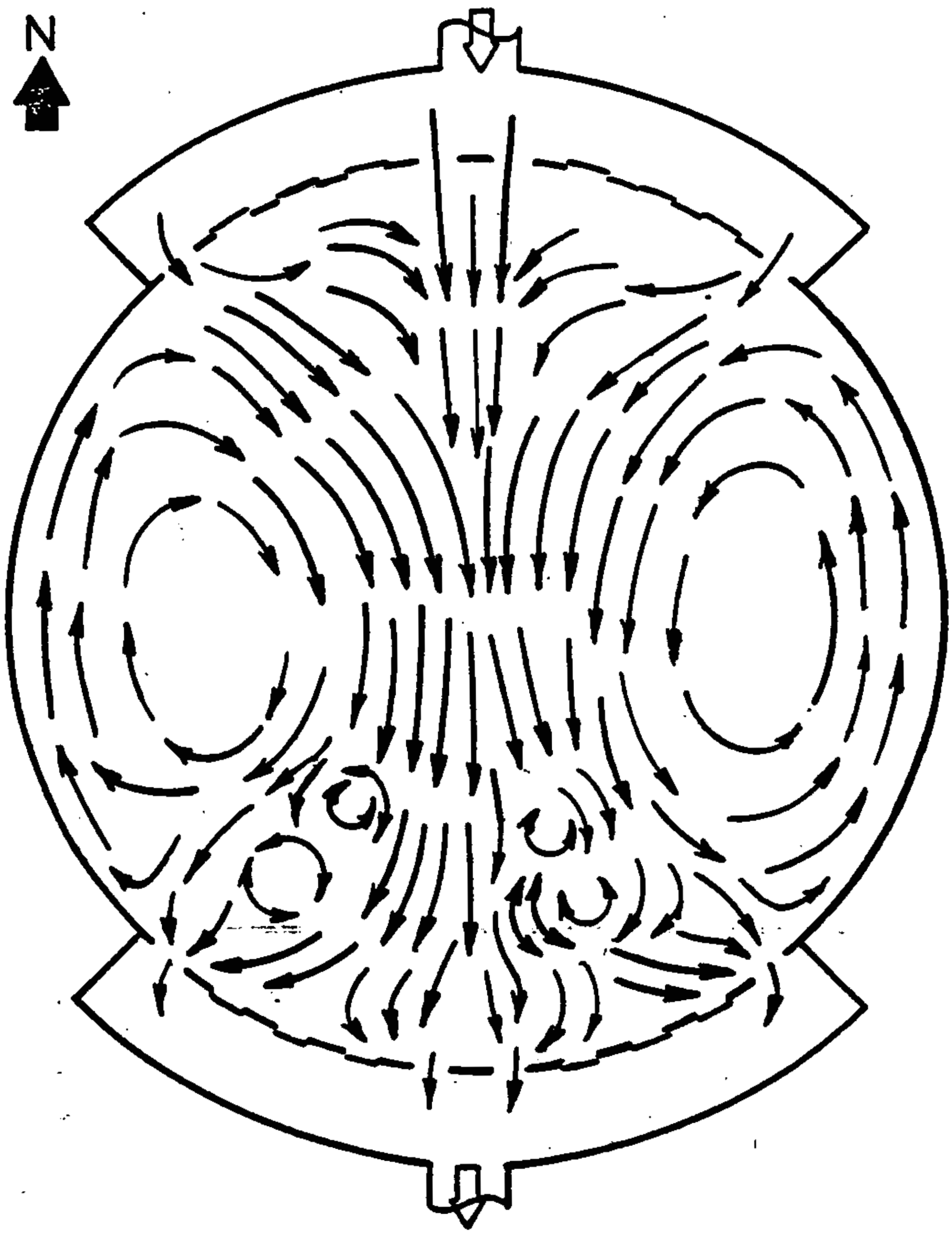
Air Flow Rate = 525 scfm

Figure C4
Velocity Survey For
Air Distribution - Type 3

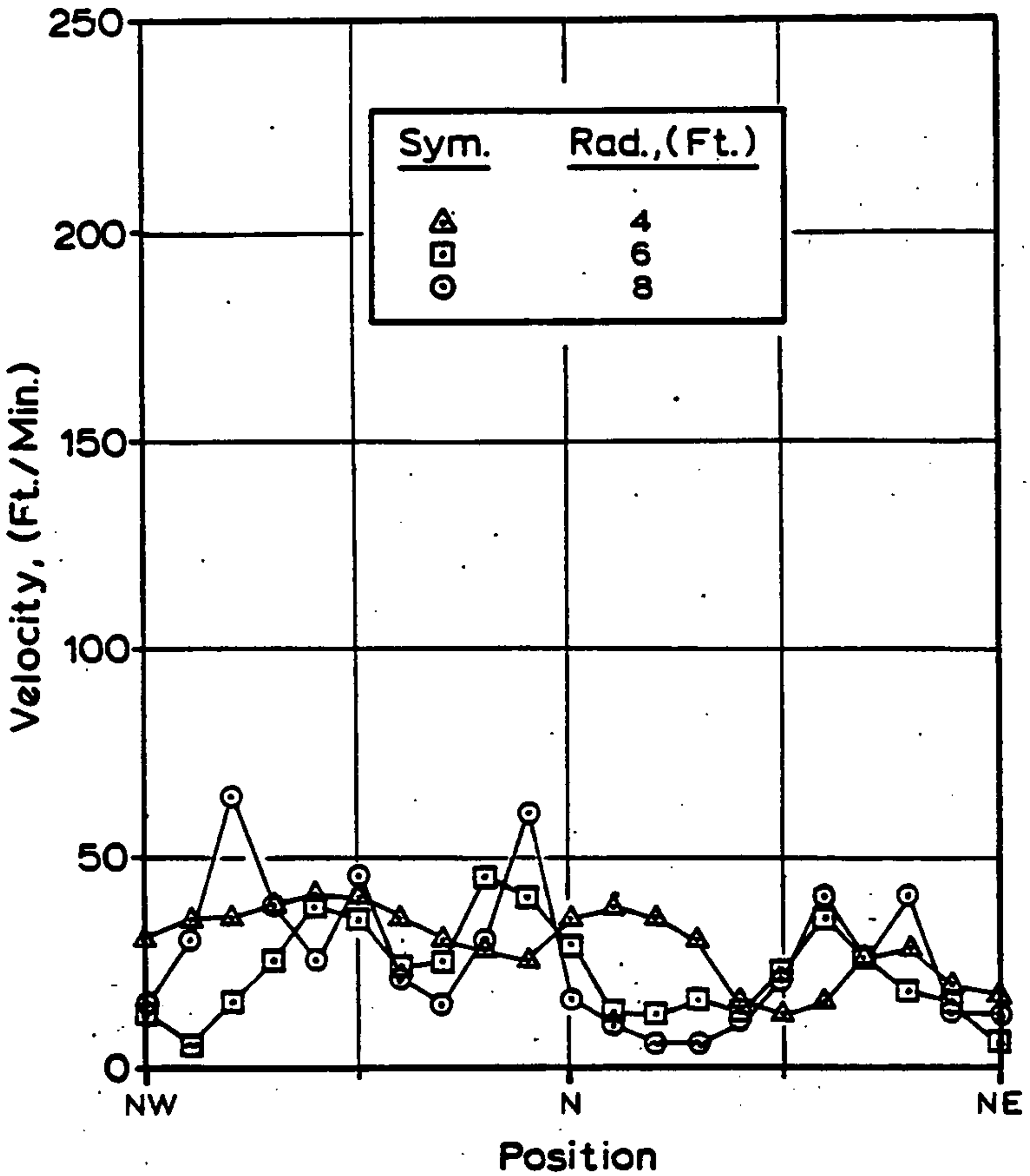


Plan View Of IFR
Air Flow Rate = 525 scfm

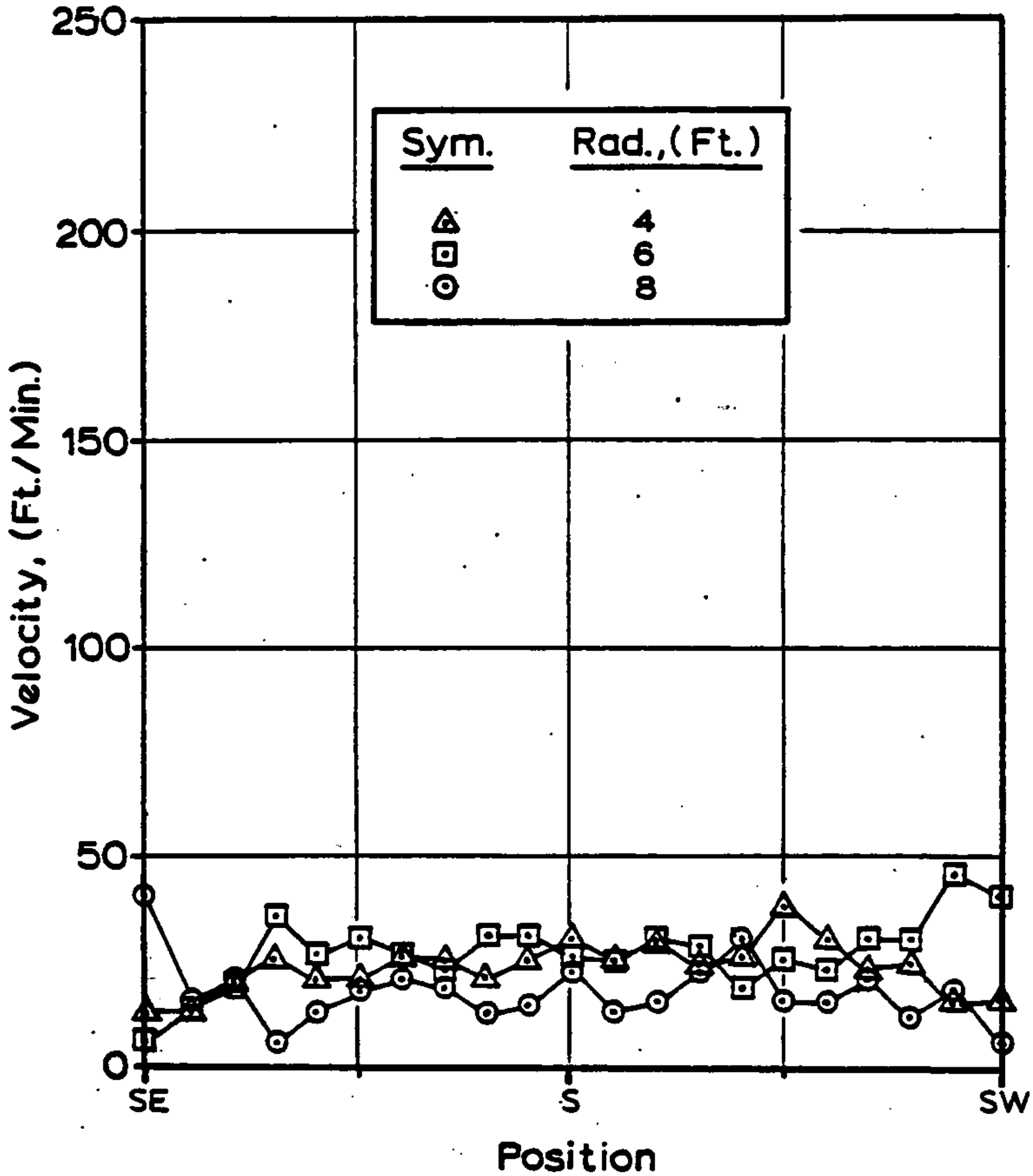
Figure C5
Velocity Survey For
Air Distribution - Type 4



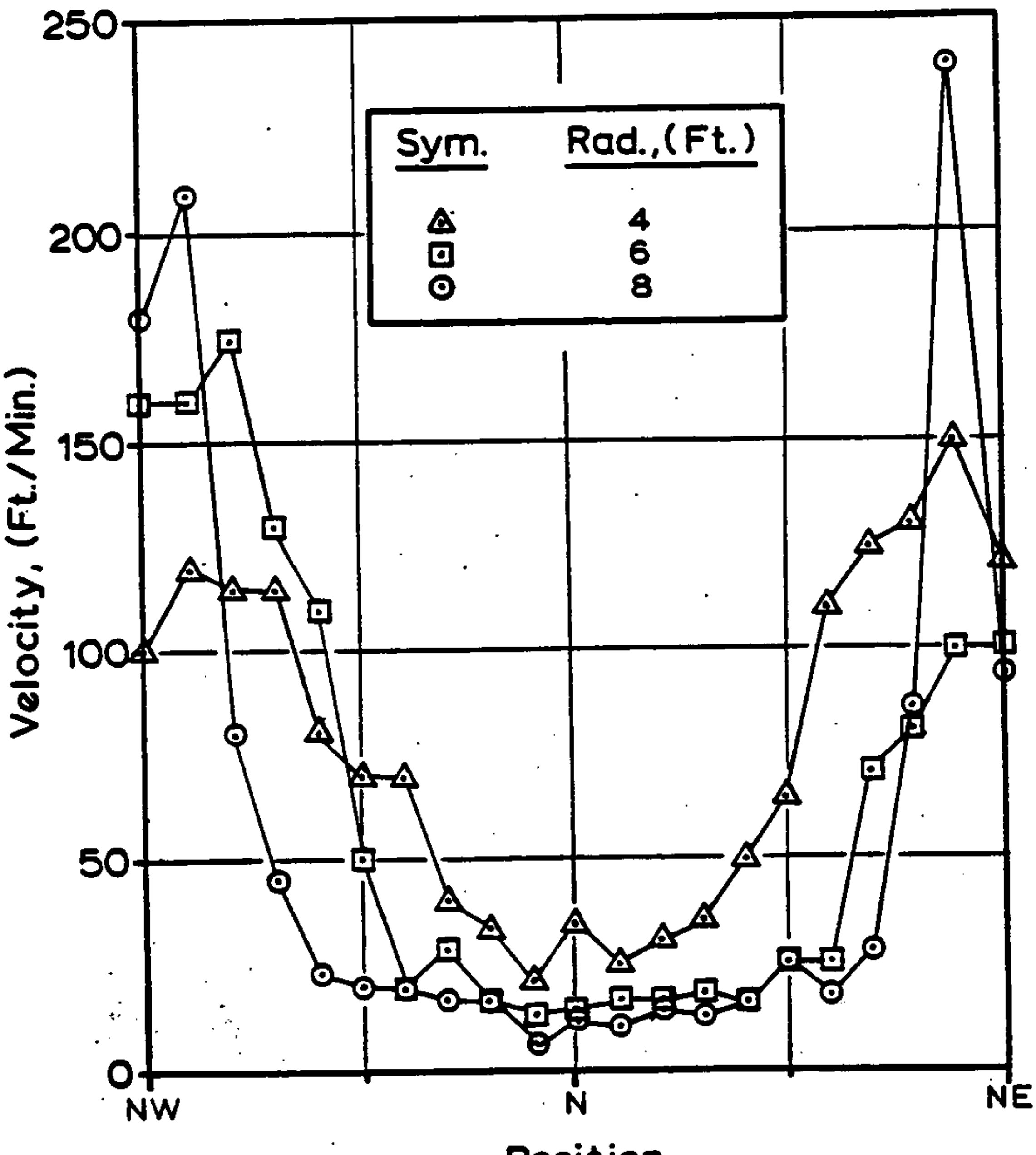
Plan View Of IFR
Air Flow Rate=525 scfm



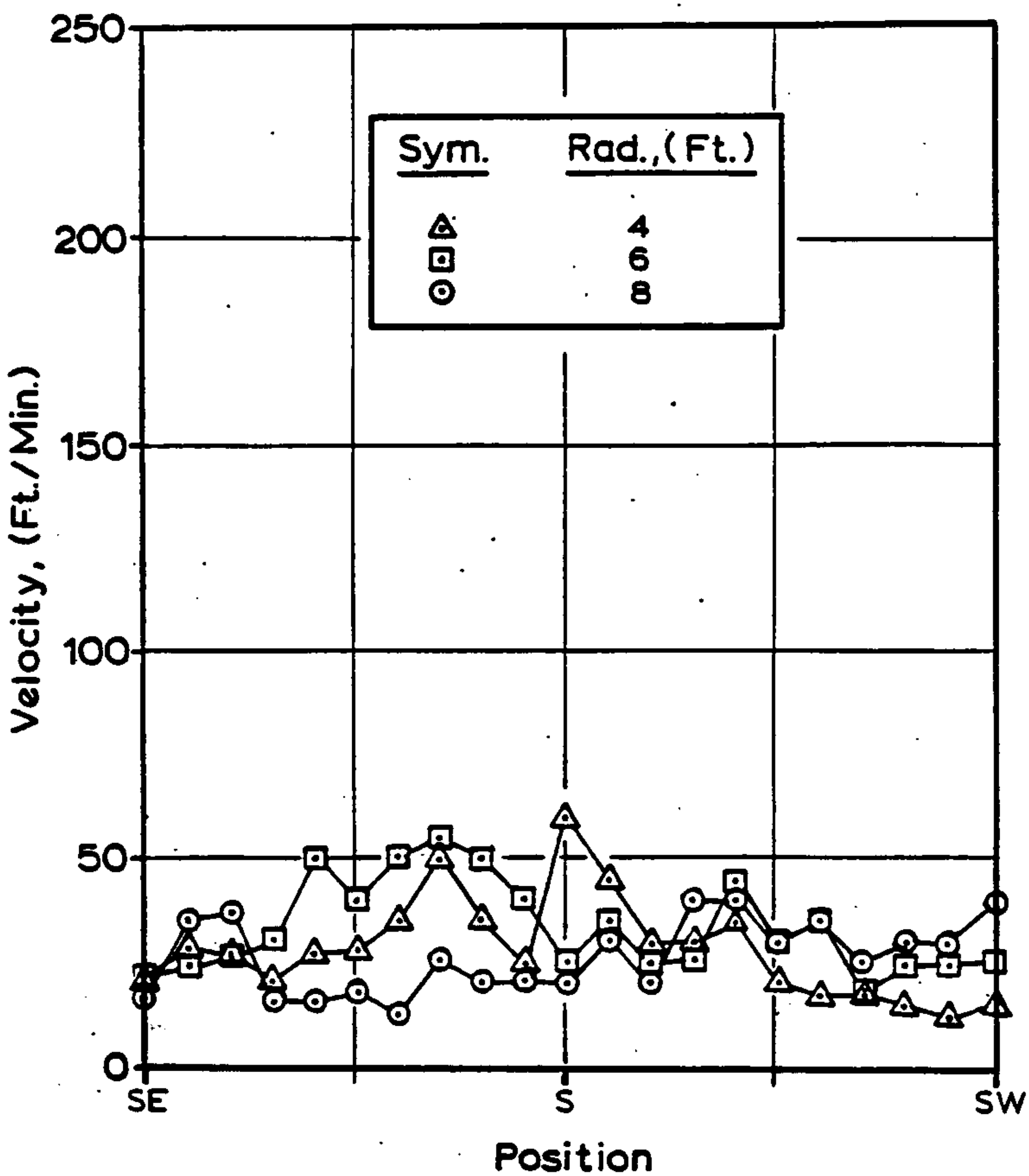
Inlet Side Velocity Versus Position
For Air Distribution Type 1
Figure C6



Outlet Side Velocity Versus Position
For Air Distribution Type 1
Figure C7



Inlet Side Velocity Versus Position
For Air Distribution Type 2
Figure C8



Outlet Side Velocity Versus Position
For Air Distribution Type 2
Figure C9

APPENDIX D

Product Composition and Vapor Pressure Data

TABLE D-1 SUMMARY OF PRODUCT COMPOSITION AND VAPOR PRESSURE

Sample Date Sample Time	9-22-80 0730	9-24-80 0800	9-30-80 1430	10-02-80 0900	10-08-80 1500
Component	**Measured Product Vapor Composition, (mole %)**				
Methane	0.0214	0.0149	0.0000	0.0086	0.0000
Ethane	2.0328	1.8774	0.6090	1.5656	1.0560
Propane	17.5543	16.8137	11.3025	17.4649	16.6248
i-Butane	0.1014	0.0898	0.0770	0.1067	0.0969
n-Butane	0.0266	0.0206	0.0184	0.0343	0.0279
n-Octane	0.6001	0.5439	0.6657	0.5102	0.6749
Oxygen	15.8552	15.4477	17.2479	15.4245	15.9849
Nitrogen	63.8082	65.1920	70.0795	64.8852	65.5345
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Component	**Calculated Product Liquid Composition, (mole %)**				
Methane	0.0001	0.0001	0.0000	0.0000	0.0000
Ethane	0.0923	0.0882	0.0268	0.0747	0.0467
Propane	3.2912	3.3003	2.0363	3.5096	2.9855
i-Butane	0.0610	0.0571	0.0442	0.0698	0.0552
n-Butane	0.0246	0.0202	0.0162	0.0347	0.0243
n-Octane	96.5308	96.5340	97.8765	96.3112	96.8883
Total	100.0000	100.0000	100.0000	100.0000	100.0000
	Calculated Product Vapor Pressure, (psia)				
Temp., (°F)					
30	2.590	2.583	1.539	2.687	2.245
40	3.026	3.018	1.810	3.143	2.631
50	3.513	3.504	2.116	3.652	3.063
60	4.056	4.047	2.461	4.218	3.546
70	4.658	4.648	2.847	4.848	4.084
80	5.325	5.315	3.282	5.544	4.682
90	6.061	6.050	3.769	6.313	5.345
100	6.873	6.861	4.313	7.159	6.078
Test No: Notes:	API 1,2 [1]	API 1,2	API 1,2	API 3,4	API 3,4

TABLE D-1 SUMMARY OF PRODUCT COMPOSITION AND VAPOR PRESSURE (continued)

Sample Date Sample Time	10-10-80 1245	10-13-80 1430	10-15-80 1025	10-17-80 1045	10-20-80 1125
Component	Measured Product Vapor Composition, (mole %)				
Methane	0.0054	0.0000	0.0014	0.0000	0.0009
Ethane	1.4538	0.9520	1.1119	1.0250	1.2768
Propane	20.8684	18.0539	17.6800	17.7748	19.1074
i-Butane	0.1169	0.1062	0.1054	0.1049	0.1041
n-Butane	0.0326	0.0286	0.0297	0.0277	0.0293
n-Octane	0.8561	0.7442	0.6509	0.5419	0.6298
Oxygen	14.7393	14.9765	15.4173	15.3064	14.5467
Nitrogen	61.9275	65.1386	65.0034	65.2193	64.3050
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Component	Calculated Product Liquid Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	0.0594	0.0408	0.0496	0.0479	0.0574
Propane	3.3725	3.1086	3.2177	3.4721	3.5197
i-Butane	0.0586	0.0574	0.0610	0.0664	0.0612
n-Butane	0.0248	0.0236	0.0264	0.0271	0.0293
n-Octane	96.4847	96.7696	96.6453	96.3865	96.3323
Total	100.0000	100.0000	100.0000	100.0000	100.0000
	Calculated Product Vapor Pressure, (psia)				
Temp., (°F)					
30	2.546	2.312	2.413	2.582	2.642
40	2.980	2.709	2.826	3.023	3.092
50	3.466	3.155	3.289	3.518	3.596
60	4.007	3.653	3.805	4.069	4.157
70	4.608	4.208	4.380	4.681	4.780
80	5.275	4.823	5.018	5.360	5.471
90	6.011	5.505	5.723	6.110	6.233
100	6.823	6.259	6.502	6.936	7.072
Test No: Notes:	API 5	API 5	API 6,7	API 6,7 [1]	API 8

TABLE D-1 SUMMARY OF PRODUCT COMPOSITION AND VAPOR PRESSURE (continued)

Sample Date / Sample Time	10-22-80 1000	10-28-80 1040	10-29-80 1500	10-31-80 1030	11-03-80 1020
Component	**Measured Product Vapor Composition, (mole %)**				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	1.2071	0.0593	0.0505	0.0573	0.0441
Propane	16.7321	2.0649	1.8000	1.5819	1.4257
i-Butane	0.0822	0.0295	0.0241	0.0259	0.0253
n-Butane	0.0249	0.0115	0.0121	0.0128	0.0112
n-Octane	0.5279	0.4686	0.4418	0.4096	0.7064
Oxygen	15.0265	19.4209	20.0213	19.9152	19.7056
Nitrogen	66.3993	77.9453	77.6502	77.9973	78.0817
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Component	**Calculated Product Liquid Composition, (mole %)**				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	0.0576	0.0029	0.0025	0.0030	0.0019
Propane	3.3438	0.4377	0.3904	0.3545	0.2519
i-Butane	0.0533	0.0206	0.0173	0.0193	0.0142
n-Butane	0.0249	0.0125	0.0136	0.0150	0.0096
n-Octane	96.5204	99.5262	99.5761	99.6082	99.7224
Total	100.0000	100.0000	100.0000	100.0000	100.0000
	Calculated Product Vapor Pressure, (psia)				
Temp., (°F)					
30	2.520	0.378	0.345	0.322	0.248
40	2.950	0.459	0.420	0.394	0.307
50	3.431	0.556	0.510	0.480	0.379
60	3.967	0.671	0.619	0.584	0.468
70	4.563	0.809	0.749	0.709	0.577
80	5.224	0.973	0.905	0.860	0.711
90	5.954	1.169	1.093	1.042	0.873
100	6.760	1.401	1.316	1.259	1.071
Test No: Notes:	API 8	API 9-12	API 9-12	API 9-12	API 9-12

TABLE D-1 SUMMARY OF PRODUCT COMPOSITION AND VAPOR PRESSURE (continued)

Sample Date Sample Time	11-05-80 1100	11-07-80 0900	11-18-80 1155	11-21-80 1015	11-24-80 1245
Component	Measured Product Vapor Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	0.0368	0.0391	0.0363	0.0348	0.0269
Propane	1.3004	1.2577	0.0499	0.0282	0.0285
i-Butane	0.0070	0.0240	0.0000	0.0000	0.0000
n-Butane	0.0032	0.0094	0.0000	0.0000	0.0000
n-Octane	0.6702	0.5599	0.6675	0.5569	0.6886
Oxygen	19.6943	19.6497	19.8208	19.8930	19.1496
Nitrogen	78.2881	78.4602	79.4255	79.4871	80.1064
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Component	Calculated Product Liquid Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	0.0016	0.0018	0.0016	0.0016	0.0012
Propane	0.2358	0.2433	0.0091	0.0056	0.0051
i-Butane	0.0040	0.0151	0.0000	0.0000	0.0000
n-Butane	0.0028	0.0091	0.0000	0.0000	0.0000
n-Octane	99.7558	99.7307	99.9893	99.9928	99.9937
Total	100.0000	100.0000	100.0000	100.0000	100.0000
	Calculated Product Vapor Pressure, (psia)				
Temp., (°F)					
30	0.233	0.242	0.078	0.075	0.074
40	0.289	0.300	0.108	0.105	0.104
50	0.359	0.371	0.149	0.146	0.144
60	0.445	0.459	0.204	0.200	0.198
70	0.551	0.567	0.276	0.271	0.269
80	0.680	0.699	0.368	0.363	0.361
90	0.839	0.860	0.487	0.481	0.479
100	1.032	1.056	0.637	0.631	0.628
Test No: Notes:	API 9-12	API 9-12 [1]	API 13,14	API 13,14	API 13,14

TABLE D-1 SUMMARY OF PRODUCT COMPOSITION AND VAPOR PRESSURE D6
(continued)

Sample Date Sample Time	12-01-80 0930	12-03-80 0930	12-05-80 0940	12-08-80 1225	12-10-80 0900
Component	Measured Product Vapor Composition, (mole %)				
Methane	0.0044	0.0000	0.0000	0.0000	0.0000
Ethane	1.9631	1.6521	1.9555	1.8527	1.8912
Propane	18.9462	18.0954	23.4113	22.1691	22.3659
i-Butane	0.0570	0.0575	0.0790	0.0761	0.0718
n-Butane	0.0059	0.0111	0.0152	0.0145	0.0103
n-Octane	0.7312	0.7614	0.5973	0.6375	0.5906
Oxygen	15.1109	15.3239	14.5092	16.7969	14.6282
Nitrogen	63.1813	64.0986	59.4352	58.4532	60.4420
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Component	Calculated Product Liquid Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	0.0842	0.0710	0.0893	0.0828	0.0868
Propane	3.2760	3.1120	4.4078	4.0583	4.2386
i-Butane	0.0310	0.0309	0.0476	0.0444	0.0436
n-Butane	0.0049	0.0091	0.0141	0.0130	0.0096
n-Octane	96.6039	96.7770	95.4412	95.8015	95.6214
Total	100.0000	100.0000	100.0000	100.0000	100.0000
	Calculated Product Vapor Pressure, (psia)				
Temp., (°F)					
30	2.545	2.395	3.332	3.075	3.209
40	2.975	2.802	3.893	3.594	3.749
50	3.455	3.257	4.518	4.173	4.352
60	3.990	3.764	5.212	4.816	5.021
70	4.584	4.329	5.980	5.528	5.762
80	5.242	4.955	6.827	6.315	6.579
90	5.969	5.648	7.757	7.180	7.478
100	6.770	6.412	8.776	8.130	8.463
Test No: Notes:	API 15,16	API 15,16	API 17-19A	API 17-19A [1]	API 17-19A

TABLE D-1 SUMMARY OF PRODUCT COMPOSITION AND VAPOR PRESSURE (continued)

Sample Date Sample Time	12-12-80 1200	1-28-81 1000	1-30-81 0945	2-02-81 0950	2-18-81 0900
Component	Measured Product Vapor Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	1.7702	1.6008	1.1630	1.2636	2.1664
Propane	22.4517	11.9935	25.4810	22.3220	35.6394
i-Butane	0.0851	0.0826	0.0962	0.0962	0.1620
n-Butane	0.0213	0.0136	0.0166	0.0172	0.0230
n-Octane	0.5987	0.6399	0.8535	0.7900	0.6554
Oxygen	14.8906	16.3980	14.7123	17.4473	12.2886
Nitrogen	60.1824	69.2716	57.6774	58.0637	49.0652
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Component	Calculated Product Liquid Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	0.0803	0.0717	0.0484	0.0530	0.0957
Propane	4.2023	2.2012	4.1746	3.7322	6.4068
i-Butane	0.0511	0.0484	0.0487	0.0502	0.0921
n-Butane	0.0196	0.0122	0.0127	0.0137	0.0200
n-Octane	95.6467	97.6665	95.7156	96.1509	93.3854
Total	100.0000	100.0000	100.0000	100.0000	100.0000
	Calculated Product Vapor Pressure, (psia)				
Temp., (°F)					
30	3.168	1.783	3.055	2.768	4.717
40	3.703	2.087	3.575	3.240	5.510
50	4.300	2.430	4.157	3.768	6.391
60	4.962	2.813	4.803	4.355	7.367
70	5.696	3.243	5.519	5.007	8.442
80	6.505	3.722	6.311	5.728	9.622
90	7.396	4.257	7.182	6.524	10.912
100	8.373	4.852	8.139	7.400	12.319
Test No: Notes:	API 17-19A	API 21	API 22 [2]	API 22	API 23-25

TABLE D-1 SUMMARY OF PRODUCT COMPOSITION AND VAPOR PRESSURE (continued)

Sample Date Sample Time	2-20-81 0900	2-25-81 0700	2-27-81 0755	3-04-81 0735	3-06-81 0930
Component	Measured Product Vapor Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	2.1961	0.1595	0.0336	0.0144	0.0193
Propane	32.2253	18.2265	10.9705	2.7642	2.7859
i-Butane	0.1700	0.1157	0.0881	0.0490	0.0561
n-Butane	0.0243	0.0167	0.0096	0.0058	0.0105
n-Octane	0.6040	0.6204	0.5843	0.6003	0.6494
Oxygen	12.9818	17.0330	20.5853	20.1337	20.7094
Nitrogen	51.7982	63.8282	67.7286	76.4326	75.7694
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Component	Calculated Product Liquid Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	0.0994	0.0072	0.0016	0.0007	0.0009
Propane	5.9982	3.3896	2.1011	0.5229	0.5106
i-Butane	0.1011	0.0687	0.0543	0.0298	0.0329
n-Butane	0.0222	0.0152	0.0091	0.0054	0.0094
n-Octane	93.7791	96.5193	97.8339	99.4412	99.4462
Total	100.0000	100.0000	100.0000	100.0000	100.0000
	Calculated Product Vapor Pressure, (psia)				
Temp., (°F)					
30	4.453	2.406	1.511	0.431	0.424
40	5.201	2.824	1.781	0.521	0.513
50	6.032	3.294	2.086	0.627	0.618
60	6.953	3.818	2.430	0.754	0.743
70	7.969	4.402	2.817	0.903	0.892
80	9.084	5.050	3.252	1.081	1.068
90	10.304	5.767	3.740	1.291	1.276
100	11.635	6.560	4.286	1.539	1.532
Test No: Notes:	API 23-25 [2]	API 26A	API 26B	API 27-28	API 27-28

TABLE D-1 SUMMARY OF PRODUCT COMPOSITION AND VAPOR PRESSURE (continued)

Sample Date / Sample Time	3-09-81 0920	3-12-81 0900	3-16-81 0905	3-23-81 1000	3-26-81 to 4-03-81
Component	Measured Product Vapor Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	------
Ethane	0.0126	0.0132	0.0176	0.0251	------
Propane	2.7162	0.1438	0.1116	0.0965	------
i-Butane	0.0530	0.0132	0.0118	0.0065	------
n-Butane	0.0067	0.0048	0.0032	0.0008	------
n-Octane	0.6669	0.5189	0.5580	0.5498	------
Oxygen	20.4902	21.3368	20.7711	20.1181	------
Nitrogen	76.0544	77.9693	78.5267	79.2032	------
Total	100.0000	100.0000	100.0000	100.0000	----------
Component	Calculated Product Liquid Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	
Ethane	0.0006	0.0006	0.0008	0.0012	n-Hexane
Propane	0.4970	0.0290	0.0219	0.0190	100.0000
i-Butane	0.0308	0.0087	0.0075	0.0042	
n-Butane	0.0060	0.0049	0.0032	0.0008	
n-Octane	99.4655	99.9567	99.9666	99.9748	
Total	100.0000	100.0000	100.0000	100.0000	100.0000
	Calculated Product Vapor Pressure, (psia)				
Temp., (°F)					
30	0.413	0.091	0.086	0.083	0.873
40	0.500	0.124	0.118	0.115	1.162
50	0.603	0.168	0.161	0.157	1.527
60	0.726	0.225	0.218	0.213	1.980
70	0.872	0.300	0.291	0.286	2.540
80	1.046	0.396	0.387	0.380	3.224
90	1.252	0.519	0.508	0.501	4.051
100	1.494	0.673	0.661	0.653	5.047
Test No: / Notes:	API 27,28	API 29-31A	API 29-31A	API 29-31A	API 32-34A [3]

TABLE D-1 SUMMARY OF PRODUCT COMPOSITION AND VAPOR PRESSURE (continued)

Sample Date Sample Time	4-20-81 2030	4-22-81 2030	4-28-81 1200	4-29-81 1900	4-30-81 1930
Component	Measured Product Vapor Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0037
Ethane	0.7795	0.8340	1.4533	1.3569	1.4454
Propane	15.5691	15.9358	21.7928	20.7359	21.0132
i-Butane	0.0790	0.0887	0.1075	0.1119	0.1054
n-Butane	0.0487	0.0603	0.0550	0.0622	0.575
n-Octane	0.5714	0.6210	0.7755	0.5914	0.5600
Oxygen	17.4508	17.6060	15.2738	16.3982	14.4532
Nitrogen	65.5015	64.8542	60.5421	60.7435	62.3616
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Component	Calculated Product Liquid Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	0.0360	0.0374	0.0610	0.0619	0.0670
Propane	2.9919	2.9401	3.6565	3.9102	4.0533
i-Butane	0.0490	0.0524	0.0565	0.0677	0.0656
n-Butane	0.0466	0.0548	0.0441	0.0580	0.0552
n-Octane	96.8766	96.9155	96.1820	95.9023	95.7590
Total	100.0000	100.0000	100.0000	100.0000	100.0000
	Calculated Product Vapor Pressure, (psia)				
Temp., (°F)					
30	2.220	2.191	2.745	2.393	3.059
40	2.603	2.569	3.212	2.801	3.578
50	3.033	2.993	3.735	3.258	4.157
60	3.513	3.467	4.316	3.768	4.801
70	4.049	3.996	4.962	4.335	5.515
80	4.645	4.584	5.676	4.965	6.303
90	5.305	5.237	6.464	5.662	7.171
100	6.035	5.959	7.331	6.431	8.124
Test No: Notes:	API 35-39	API 35-39	API 39-49 [4]	API 39-49 [4]	API 39-49 [4]

TABLE D-1 SUMMARY OF PRODUCT COMPOSITION AND VAPOR PRESSURE (continued)

Sample Date Sample Time	5-01-81 1445	5-04-81 1600	5-05-81 1700	5-06-81 1730	5-07-81 1500
Component	Measured Product Vapor Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	1.4484	1.3548	1.3570	1.4355	1.4357
Propane	20.9201	20.5292	20.2459	20.8412	20.3589
i-Butane	0.1090	0.1075	0.1077	0.1110	0.1093
n-Butane	0.0567	0.0561	0.0631	0.0542	0.0620
n-Octane	0.5702	0.7909	0.6477	0.7126	0.5827
Oxygen	15.6789	15.7921	15.5844	15.0131	15.4376
Nitrogen	61.2167	61.3694	61.9942	61.8324	62.0138
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Component	Calculated Product Liquid Composition, (mole %)				
Methane	0.0000.	0.0000	0.0000	0.0000	0.0000
Ethane	0.0671	0.0557	0.0605	0.0624	0.0663
Propane	4.0194	3.4257	3.6851	3.6546	3.8877
i-Butane	0.0674	0.0560	0.0624	0.0613	0.0670
n-Butane	0.0541	0.0446	0.0561	0.0458	0.0586
n-Octane	95.7920	96.4181	96.1360	96.1760	95.9205
Total	100.0000	100.0000	100.0000	100.0000	100.0000
	Calculated Product Vapor Pressure, (psia)				
Temp., (°F)					
30	3.013	2.576	2.766	2.749	2.922
40	3.524	3.015	3.237	3.217	3.418
50	4.096	3.508	3.764	3.740	3.973
60	4.730	4.055	4.349	4.322	4.588
70	5.434	4.665	5.000	4.968	5.272
80	6.211	5.339	5.720	5.683	6.028
90	7.067	6.085	6.514	6.472	6.681
100	8.007	6.097	7.387	7.340	7.776
Test No: Notes:	API 39-49 [4]	API 39-49 [4]	API 39-49 [4]	API 39-49 [4]	API 39-40 [4]

TABLE D-1 SUMMARY OF PRODUCT COMPOSITION AND VAPOR PRESSURE
(continued)

Sample Date Sample Time	5-11-81 1700	5-12-81 1700	5-13-81 2000	5-14-81 1945	5-15-81 1845
Component	Measured Product Vapor Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	1.4359	1.4292	1.3691	1.3545	1.3430
Propane	20.8368	20.9769	20.1396	20.2730	19.9480
i-Butane	0.1083	0.1104	0.1086	0.1100	0.1071
n-Butane	0.0535	0.0654	0.0575	0.0622	0.0564
n-Octane	0.5134	0.5216	0.5753	0.7457	0.7314
Oxygen	14.8258	14.3533	15.5691	15.5880	15.9400
Nitrogen	62.2263	62.5441	62.1808	61.8666	61.8740
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Component	Calculated Product Liquid Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	0.0687	0.0681	0.0632	0.0577	0.0577
Propane	4.1866	4.1881	3.8512	3.4719	3.4513
i-Butane	0.0707	0.0715	0.0668	0.0592	0.0583
n-Butane	0.0541	0.0656	0.0546	0.0511	0.0469
n-Octane	95.6200	95.6067	95.9642	96.3602	96.3859
Total	100.0000	100.0000	100.0000	100.0000	100.0000
	Calculated Product Vapor Pressure, (psia)				
Temp., (°F)					
30	3.132	3.133	2.877	2.612	2.597
40	3.663	3.664	3.365	3.057	3.040
50	4.256	4.258	3.912	3.556	3.536
60	4.914	4.916	4.518	4.111	4.088
70	5.644	5.646	5.192	4.728	4.702
80	6.449	6.452	5.936	5.411	5.381
90	7.335	7.340	6.756	6.166	6.132
100	8.308	8.313	7.658	6.998	6.959
Test No: Notes:	API 39-49 [4]	API 39-49 [4]	API 39-49 [4]	API 39-49 [4]	API 39-49 [4]

TABLE D-1 SUMMARY OF PRODUCT COMPOSITION AND VAPOR PRESSURE (continued)

Sample Date Sample Time	5-16-81 1500	4-27-81 to 5-16-81	5-20-81 1930	6-25-81 0840	7-01-81 1045
Component	Measured Product Vapor Composition, (mole %)				
Methane	0.0000	0.0003	0.0000	0.0000	0.0000
Ethane	1.3290	1.3961	0.0400	1.2517	1.1461
Propane	19.9698	20.6129	0.8085	16.3649	16.0835
i-Butane	0.1092	0.1087	0.0168	0.0808	0.0753
n-Butane	0.0630	0.0589	0.0189	0.0298	0.0303
n-Octane	0.8355	0.6539	0.6416	0.5141	0.5108
Oxygen	16.2065	15.4367	20.3448	17.1281	16.8956
Nitrogen	61.4870	61.7324	78.1294	64.6306	65.2584
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Component	Calculated Product Liquid Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	0.0550	0.0627	0.0018	0.0601	0.0551
Propane	3.2736	3.7690	0.1497	3.2986	3.2517
i-Butane	0.0556	0.0631	0.0099	0.0530	0.0496
n-Butane	0.0488	0.0524	0.0172	0.0302	0.0309
n-Octane	96.5671	96.0529	99.8213	96.5581	96.6127
Total	100.0000	100.0000	100.0000	100.0000	100.0000
	Calculated Product Vapor Pressure, (psia)				
Temp., (°F)					
30	2.468	2.829	0.178	2.497	2.450
40	2.890	3.310	0.225	2.923	2.869
50	3.363	3.848	0.285	3.400	3.338
60	3.889	4.446	0.360	3.930	3.860
70	4.475	5.110	0.454	4.521	4.441
80	5.124	5.844	0.571	5.176	5.086
90	5.843	6.654	0.716	5.899	5.799
100	6.635	7.544	0.895	6.697	6.586
Test No: Notes:	API 39-49 [4]	API 39-49 [5]	API 50,51	API 52-61	API 52-61

TABLE D-1 SUMMARY OF PRODUCT COMPOSITION AND VAPOR PRESSURE (continued)

Sample Date Sample Time	7-10-81 0930	7-13-81 0920	7-17-81 0920	7-20-81 1235	7-21-81 1000
Component	Measured Product Vapor Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	1.1016	1.1158	0.7732	0.7634	0.3723
Propane	15.8834	15.8143	13.4051	13.2884	8.7380
i-Butane	0.0818	0.0797	0.0708	0.0690	0.0543
n-Butane	0.0317	0.0247	0.0260	0.0214	0.0161
n-Octane	0.5131	0.5077	0.6119	0.4902	0.4931
Oxygen	16.8470	16.6485	17.7995	17.6359	18.5499
Nitrogen	65.5414	65.8093	67.3135	67.7317	71.7763
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Component	Calculated Product Liquid Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	0.0529	0.0535	0.0351	0.0369	0.0180
Propane	3.2044	3.1941	2.5130	2.7166	1.7961
i-Butane	0.0537	0.0525	0.0425	0.0462	0.0366
n-Butane	0.0322	0.0252	0.0240	0.0222	0.0168
n-Octane	96.6568	96.6747	97.3854	97.1781	98.1325
Total	100.0000	100.0000	100.0000	100.0000	100.0000
	Calculated Product Vapor Pressure, (psia)				
Temp., (°F)					
30	2.413	2.406	1.888	2.032	1.349
40	2.825	2.818	2.216	2.383	1.589
50	3.288	2.279	2.584	2.778	1.861
60	3.803	3.792	2.997	3.219	2.170
70	4.377	4.365	3.459	3.713	2.517
80	5.013	4.999	3.975	4.262	2.908
90	5.718	5.701	4.549	4.873	3.349
100	6.495	6.476	5.187	5.550	3.844
Test No: Notes:	API 52-61	API 52-61	API 52-61 [1]	API 52-61	API 62

TABLE D-1 SUMMARY OF PRODUCT COMPOSITION AND VAPOR PRESSURE (continued)

Sample Date Sample Time	7-27-81 1155	8-04-81 1030	8-05-81 to 8-29-81	9-08-81 2145	9-10-81 1700
Component	Measured Product Vapor Composition, (mole %)				
Methane	0.0000	0.00000	------	0.0000	0.0000
Ethane	0.0176	0.01836	------	0.0612	0.0030
Propane	1.5226	0.00244	------	0.3275	0.0227
i-Butane	0.0254	0.00086	------	0.0024	0.0000
n-Butane	0.0121	0.00056	------	0.0007	0.0000
n-Octane	0.4836	0.47361	------	0.5093	0.5643
Oxygen	20.4884	21.03528	------	18.0558	20.7637
Nitrogen	77.4503	78.46889	------	81.0431	78.6463
Total	100.0000	100.0000	--------	100.0000	100.0000
Component	Calculated Product Liquid Composition, (mole %)				
Methane	0.0000	0.0000	------	0.0000	0.0000
Ethane	0.0009	0.0009	n-Hexane	0.0030	0.0001
Propane	0.3186	0.0005	100.0000	0.0668	0.0044
i-Butane	0.0174	0.0006	------	0.0016	0.0000
n-Butane	0.0129	0.0006	------	0.0007	0.0000
n-Octane	99.6501	99.9974	------	99.9279	99.9955
Total	100.0000	100.0000	100.0000	100.0000	100.0000
	Calculated Product Vapor Pressure, (psia)				
Temp., (°F)					
30	0.291	0.070	0.873	0.121	0.070
40	0.358	0.099	1.162	0.159	0.100
50	0.438	0.139	1.527	0.208	0.140
60	0.536	0.192	1.980	0.271	0.193
70	0.655	0.263	2.540	0.352	0.263
80	0.800	0.354	3.224	0.455	0.355
90	0.974	0.471	4.051	0.584	0.472
100	1.184	0.619	5.047	0.746	0.620
Test No: Notes:	API 63	API 64	API 65,66 [3]	API 67A	API 67

TABLE D-1 SUMMARY OF PRODUCT COMPOSITION AND VAPOR PRESSURE (continued)

Sample Date Sample Time	9-16-81 to 9-21-81	9-25-81 1715	10-1-81 1010	10-14-81 1800	10-21-81 1030
Component	**Measured Product Vapor Composition, (mole %)**				
Methane	------	0.0033	0.0000	0.0036	0.0000
Ethane	------	2.7953	0.6159	2.7117	2.4093
Propane	------	22.1621	8.3489	19.0345	17.5126
i-Butane	------	0.0801	0.0466	0.0808	0.0725
n-Butane	------	0.0172	0.0114	0.0172	0.0170
n-Octane	------	0.5276	0.5644	0.4073	0.4884
Oxygen	------	15.9322	19.1826	16.2730	16.8337
Nitrogen	------	58.4822	71.2302	61.4719	62.6665
Total	------	100.0000	100.0000	100.0000	100.0000
Component	**Calculated Product Liquid Composition, (mole %)**				
Methane	------	0.0000	0.0000	0.0000	0.0000
Ethane	n-Hexane	0.1319	0.0286	0.1390	0.1177
Propane	100.0000	4.3805	1.6180	4.2165	3.6150
i-Butane	------	0.0513	0.0292	0.0595	0.0489
n-Butane	------	0.0170	0.0110	0.0198	0.0178
n-Octane	------	95.4193	98.3131	95.5653	96.2006
Total	-------	100.0000	100.0000	100.0000	100.0000
	Calculated Product Vapor Pressure, (psia)				
Temp., (°F)					
30	0.873	3.439	1.257	3.351	2.878
40	1.162	4.012	1.480	3.907	3.358
50	1.527	4.648	1.733	4.526	3.894
60	1.980	5.355	2.020	5.214	4.490
70	2.540	6.136	2.344	5.973	5.150
80	3.224	6.996	2.710	6.810	5.878
90	4.051	7.940	3.123	7.729	6.681
100	5.047	8.973	3.588	8.735	7.563
Test No: Notes:	API 68,69 [3]	API 70-71A	API 72	API 73-77	API 73-77

TABLE D-1 SUMMARY OF PRODUCT COMPOSITION AND VAPOR PRESSURE (continued)

Sample Date Sample Time	10-29-81 1300				
Component	Measured Product Vapor Composition, (mole %)				
Methane	0.0000				
Ethane	2.1300				
Propane	16.3446				
i-Butane	0.0680				
n-Butane	0.0163				
n-Octane	0.4721				
Oxygen	16.6690				
Nitrogen	64.3000				
Total	100.0000				
Component	Calculated Product Liquid Composition, (mole %)				
Methane	0.0000				
Ethane	0.1048				
Propane	3.4178				
i-Butane	0.0466				
n-Butane	0.0173				
n-Octane	96.4135				
Total	100.0000				
	Calculated Product Vapor Pressure, (psia)				
Temp., (°F)					
30	2.706				
40	3.159				
50	3.666				
60	4.229				
70	4.854				
80	5.546				
90	6.308				
100	7.147				
Test No: Notes:	API 73-77				

Notes for Table D1

[1]. Sample was not used by the contractor to reduce the emission test data. The vapor pressure data from this sample does not follow the normal pattern of decay with respect to time when compared with other samples in the same time period.

[2]. Sample was not used by the contractor to reduce the emission test data. This sample indicates an excessively high propane loss.

Example:

Sample Date	Time	Total lbmoles In Tank	% C3 In Liquid	lbmoles of C3	lbm of C3
1-30-81	0945	$\approx$ 703	4.17	29.3	1293
2-02-81	0950	$\approx$ 703	3.73	26.2	1156

Loss of C3 indicated by Samples = 1293-1156 = 137 lbm
Loss of C3 indicated by Emission Test API22
$\approx$ 8 lbm/day X 3 days = 24 lbm
(excluding non-equilibrium points)

In general, a sample was not used if;
(loss indicated by sample) $\geq$ 3X (loss indicated by emission Testing)

[3]. Product was purchased as high purity n-Hexane. A gas chromatograph analysis was not performed.

[4]. The decay of vapor pressure with respect to time was not detectable due to the normal scatter in the vapor pressure data. The low emission levels throughout this time period made it possible to use an average vapor pressure curve without introducing any appreciable error.

[5]. The vapor composition shown is the average vapor composition for all samples in the time period from 4-27-81 to 5-16-81. The liquid composition and vapor pressure were calculated in the usual manner.

FIGURE D-1 Vapor Pressure Map, September Through December, 1980

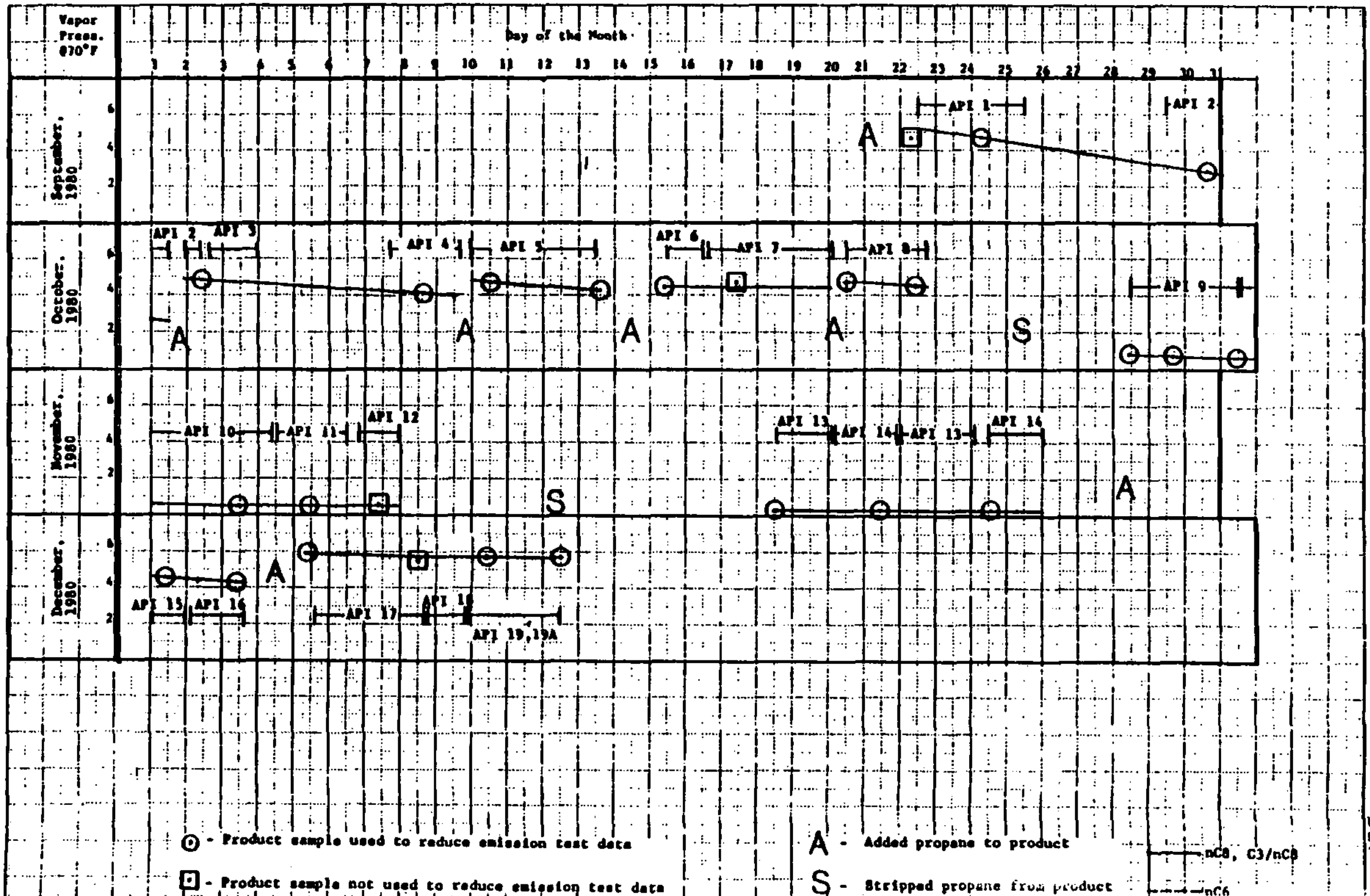


FIGURE D-2 Vapor Pressure Map, January Through May, 1981

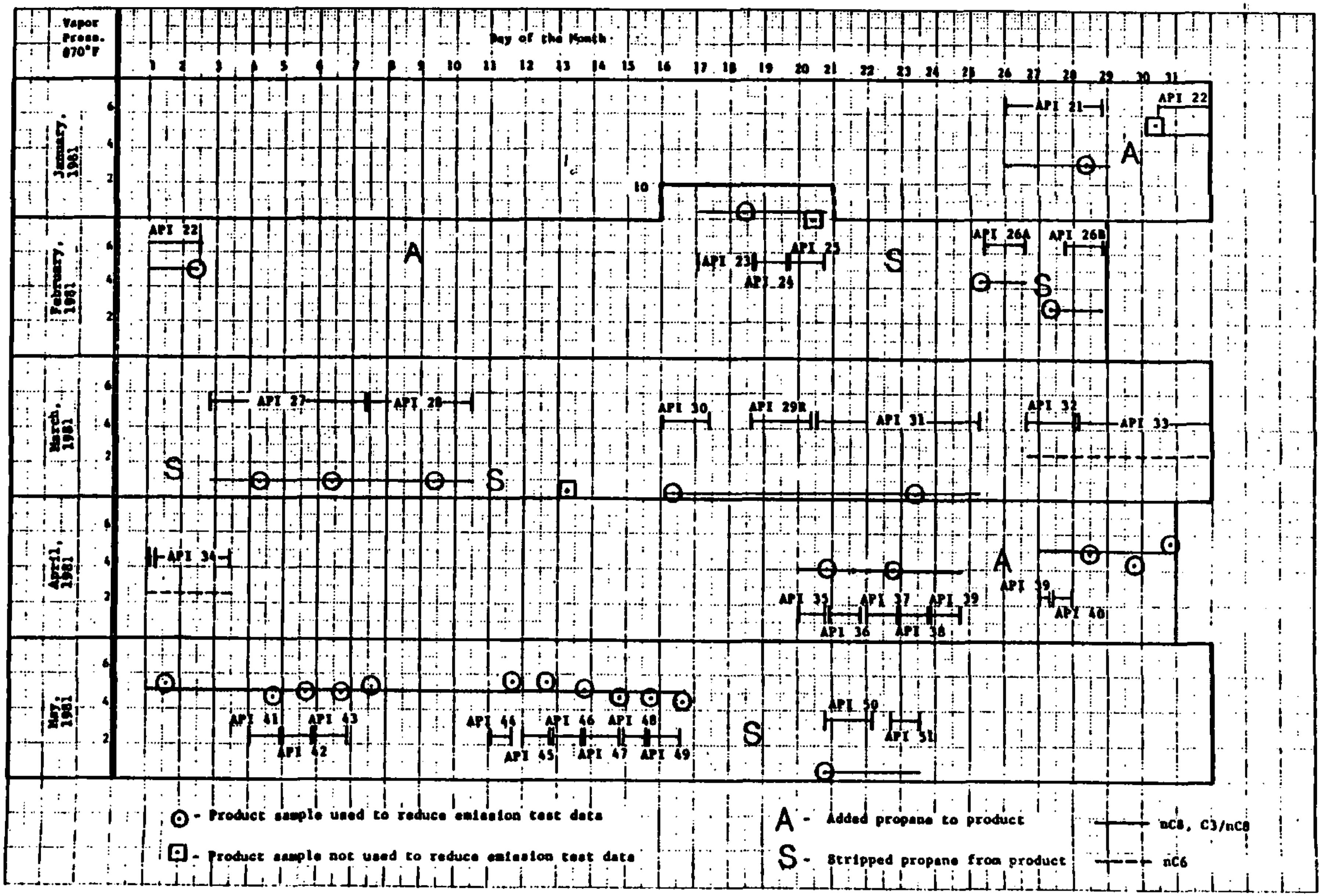
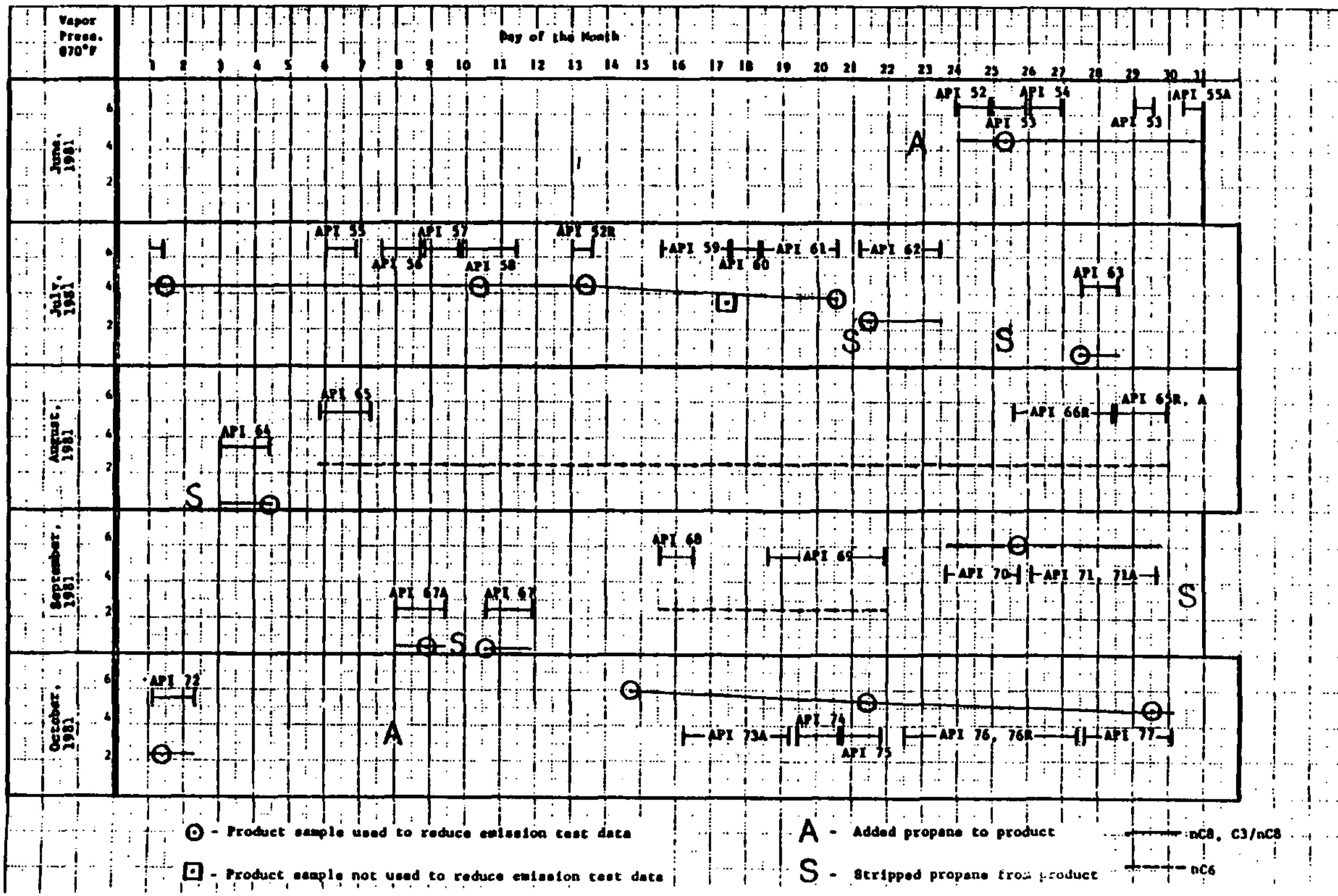


FIGURE D-3 Vapor Pressure Map, June Through October, 1981



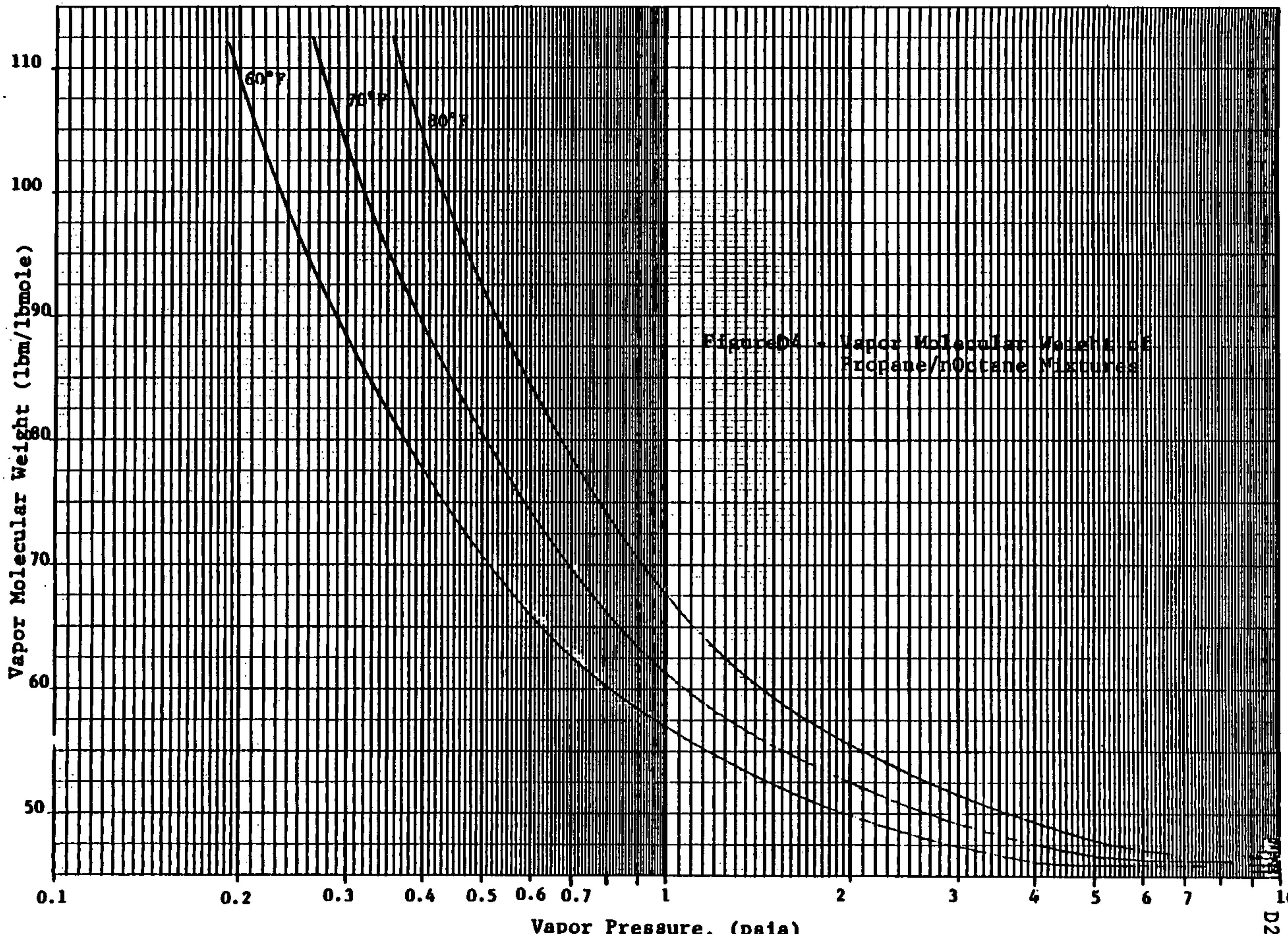


Figure D4 - Vapor Molecular Weight of Propane/nOctane Mixtures

TABLE D2 PRODUCT COMPOSITION AND VAPOR PRESSURE FOR IFR DECK FITTING AND PERMEABILITY TESTS

Sample Date Sample Time	9-2-81 2310	9-10-81 2130	9-24-81 1720	9-28-81 2230	9-2-81 2320
Component	**Measured Product Vapor Composition, (mole %)**				
Methane	0.0000	0.0000	0.0004	0.0000	0.0000
Ethane	0.6530	0.1943	0.4347	0.1077	0.8939
Propane	15.1953	10.9305	34.2872	21.1243	16.8290
i-Butane	0.0816	0.0705	0.1613	0.1404	0.0857
n-Butane	0.0173	0.0145	0.0202	0.0275	0.0202
n-Octane	0.6034	0.5271	0.5756	0.6163	0.5108
Oxygen	17.5486	18.7198	13.9761	16.4360	17.0151
Nitrogen	65.9008	69.5433	50.5446	61.5477	64.6453
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Component	**Calculated Product Liquid Composition, (mole %)**				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	0.0297	0.0092	0.0199	0.0049	0.0428
Propane	2.8574	2.1800	6.4873	3.9291	3.3879
i-Butane	0.0492	0.0457	0.0978	0.0834	0.0562
n-Butane	0.0160	0.0145	0.0188	0.0252	0.0205
n-Octane	97.0477	97.7506	93.3762	95.9573	96.4926
Total	100.000	100.0000	100.0000	100.0000	100.0000
Average Product Temp. (°F)	69.9	69.9	69.2	69.2	68.3
Vapor Press. at Avg. Prod. Temp. (psia)	3.85	2.94	8.12	5.00	4.45
Vapor Molecular Wt. at Avg. Prod. Temp. (lbm/lbmole)	48.3	50.1	46.1	47.6	47.4
Test No.	9A	9A	9B	9B	10
Notes:	Initial Sample	Final Sample	Initial Sample	Final Sample	Initial Sample

TABLE D2 PRODUCT COMPOSITION AND VAPOR PRESSURE FOR IFR DECK FITTING AND PERMEABILITY TESTS (continued)

Sample Date Sample Time	9-10-81 1730	9-24-81 1530	9-3-81 1430	9-11-81 1430	9-23-81 1500
Component	Measured Product Vapor Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	0.6677	0.4704	0.7441	0.5129	0.3321
Propane	15.9082	14.2366	14.9626	12.9359	12.3846
i-Butane	0.0785	0.0832	0.0769	0.0672	0.0759
n-Butane	0.0131	0.0129	0.0171	0.0127	0.01478
n-Octane	0.4846	0.4693	0.4777	0.5069	0.5333
Oxygen	17.1347	17.3089	17.2314	17.4411	18.1950
Nitrogen	65.7132	67.4187	66.4902	68.5233	68.4642
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Component	Calculated Product Liquid Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	0.0324	0.0233	0.0363	0.0247	0.0158
Propane	3.2802	2.9991	3.1024	2.6258	2.4746
i-Butane	0.0530	0.0575	0.0523	0.0445	0.0492
n-Butane	0.0137	0.0138	0.0180	0.0130	0.0148
n-Octane	96.6207	96.9063	96.7910	97.2920	97.4456
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Average Product Temp. (°F)	68.3	68.3	68.3	68.3	68.3
Vapor Press. at Avg. Prod.Temp. (psia)	4.27	3.90	4.08	3.46	3.25
Vapor Molecular Wt. at Avg. Prod. Temp. (lbm/lbmole)	47.7	48.2	47.8	48.6	49.1
Test No.	10	10	11	11	11
Notes:	Intermediate Sample	Final Sample	Initial Sample	Intermediate Sample	Final Sample

TABLE D2 PRODUCT COMPOSITION AND VAPOR PRESSURE FOR IFR DECK FITTING AND PERMEABILITY TESTS (continued)

Sample Date Sample Time	10-5-81 2230	10-21-81 2100	12-22-81 2100	12-22-81 2100	12-22-81 2130
Component	Measured Product Vapor Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	0.1913	0.1736	0.4028	0.4330	0.4724
Propane	31.8965	30.1565	19.0887	17.9150	21.9871
i-Butane	0.1839	0.1718	0.0779	0.0706	0.0939
n-Butane	0.0320	0.0204	0.0103	0.0103	0.0102
n-Octane	0.4632	0.4337	0.5488	0.4697	0.4278
Oxygen	13.6292	13.8483	17.0054	17.0581	16.2778
Nitrogen	53.6039	55.1957	62.8661	64.0433	60.7308
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Component	Calculated Product Liquid Composition, (mole %)				
Methane	0.0000	0.0000	0.0000	0.0000	0.0000
Ethane	0.0094	0.0087	0.0189	0.0213	0.0238
Propane	6.6385	6.4981	3.7361	3.7470	4.7677
i-Butane	0.1251	0.1216	0.0493	0.0484	0.0673
n-Butane	0.0338	0.0225	0.0100	0.0110	0.0114
n-Octane	93.1931	93.3491	96.1857	96.1723	95.1297
Total	100.0000	100.0000	100.0000	100.0000	100.0000
Average Product Temp. (°F)	59.2	59.2	53.8	48.1	50.9
Vapor Press. at Avg. Prod.Temp. (psia)	7.20	7.05	3.86	3.56	4.68
Vapor Molecular Wt. at Avg. Prod. Temp. (lbm/lbmole)	45.8	45.9	46.6	46.3	45.9
Test No.	16	16	19	20	21
Notes:	Initial Sample	Final Sample	Initial Sample	Initial Sample	Initial Sample

APPENDIX E

Bench Scale Deck Fitting Emission Test Data and Permeability Test Data

IFR Deck Fitting Emission Data Sheet

Scale No.: 1 Sheet No.: 1

Test No.: 1

Test Description: Access Hatch Cover, Ungasketed

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
5-20-81	1530	0.0	64.7	299.8	0.0	Begin test
5-21	0930	18.0	62.4	299.8	0.0	
5-21	1530	24.0	65.6	299.6	-0.2	
5-22	0930	42.0	63.5	299.8	0.0	
5-22	1530	48.0	66.2	299.8	0.0	
5-23	0630	63.0	65.8	299.8	0.0	
5-26	0900	137.5	65.2	300.0	+0.2	
5-26	1600	144.5	67.7	300.0	+0.2	
5-27	0900	161.5	64.3	299.8	0.0	
5-28	0930	186.0	60.5	299.6	-0.2	
5-28	1600	192.5	63.9	299.8	0.0	
5-29	0900	209.5	66.2	299.8	0.0	
5-29	1600	216.5	68.2	300.0	+0.2	
6-1	0900	281.5	61.5	299.4	-0.4	
6-1	1600	288.5	64.0	299.4	-0.4	
6-2	0900	305.5	66.1	299.8	0.0	
6-2	1600	312.5	67.6	300.0	+0.2	
6-3	0900	329.5	67.4	300.0	+0.2	
6-3	1600	336.5	69.5	299.8	0.0	
6-4	0900	353.5	67.1	299.8	0.0	
6-4	1600	360.5	69.2	299.8	0.0	
6-5	0900	377.5	67.0	299.8	0.0	
6-5	1600	384.5	69.6	300.0	+0.2	
6-8	0900	449.5	73.0	299.4	-0.4	
6-8	1600	456.5	74.8	299.6	-0.2	
6-9	0900	473.5	67.6	299.6	-0.2	
6-9	1600	480.5	68.0	299.6	-0.2	
6-10	0900	497.5	65.2	299.6	-0.2	
6-10	1600	504.5	66.8	299.6	-0.2	
6-11	0900	521.5	65.5	299.4	-0.4	
6-12	0900	545.5	67.8	299.4	-0.4	
6-12	1600	552.5	69.4	299.6	-0.2	
6-15	1600	624.5	77.1	300.2	+0.4	
6-16	0900	641.5	72.3	300.0	+0.2	
6-16	1600	648.5	70.9	299.8	0.0	
6-17	0900	665.5	64.1	299.6	-0.2	
6-17	1600	672.5	67.5	299.6	-0.2	
6-18	0900	689.5	66.8	299.6	-0.2	
6-18	1600	696.5	70.3	299.6	-0.2	
6-19	1600	720.5	70.3	299.2	-0.6	

IFR Deck Fitting Emission Data Sheet

Scale No.: 1 Sheet No.: 2

Test No.: 1

Test Description: Access Hatch Cover, Ungasketed

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
6-22-81	0900	785.5	64.2	299.4	-0.4	
6-22	1600	792.5	66.3	299.2	-0.6	
6-23	0900	809.5	64.7	299.2	-0.6	
6-23	1600	816.5	66.4	299.2	-0.6	
6-24	0900	833.5	67.9	299.2	-0.6	
6-24	1600	840.5	70.8	299.4	-0.4	
6-25	0900	857.5	69.9	299.4	-0.4	
7-1	2100	1013.5	74.7	298.6	-1.2	
7-6	0900	1121.5	70.7	298.2	-1.6	End test

IFR Deck Fitting Emission Data Sheet

Scale No.: 2 Sheet No.: 1

Test No.: 2

Test Description: Access Hatch Cover, Gasketed and Clamped

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
5-20-81	1530	0.0	63.9	293.6	0.0	Begin test
5-21	0930	18.0	62.0	293.4	-0.2	
5-21	1530	24.0	64.9	293.6	0.0	
5-22	0930	42.0	63.1	293.4	-0.2	
5-22	1530	48.0	65.8	293.4	-0.2	
5-23	0630	63.0	65.6	293.2	-0.4	
5-26	0900	137.5	65.0	293.6	0.0	
5-26	1600	144.5	67.4	293.6	0.0	
5-27	0900	161.5	64.0	293.4	-0.2	
5-28	0930	186.0	60.0	293.4	-0.2	
5-28	1600	192.5	63.4	293.6	0.0	
5-29	0900	209.5	66.2	293.6	0.0	
5-29	1600	216.5	68.0	293.8	+0.2	
6-1	0900	281.5	61.2	293.0	-0.6	
6-1	1600	288.5	63.6	293.4	-0.2	
6-2	0900	305.5	66.0	293.4	-0.2	
6-2	1600	312.5	67.3	293.6	0.0	
6-3	0900	329.5	67.3	293.6	0.0	
6-3	1600	336.5	69.1	293.4	-0.2	
6-4	0900	353.5	67.0	293.4	-0.2	
6-4	1600	360.5	68.8	293.4	-0.2	
6-5	0900	377.5	66.7	293.4	-0.2	
6-5	1600	384.5	69.0	293.6	0.0	
6-8	0900	449.5	73.0	293.2	-0.4	
6-8	1600	456.5	74.4	293.4	-0.2	
6-9	0900	473.5	67.2	293.2	-0.4	
6-9	1600	480.5	67.7	293.2	-0.4	
6-10	0900	497.5	64.8	293.2	-0.4	
6-10	1600	504.5	66.5	293.2	-0.4	
6-11	0900	521.5	65.2	293.2	-0.4	
6-12	0900	545.5	67.8	293.2	-0.4	
6-12	1600	552.5	69.1	293.4	-0.2	
6-15	1600	624.5	76.9	293.6	0.0	
6-16	0900	641.5	71.9	293.2	-0.4	
6-16	1600	648.5	70.8	293.2	-0.4	
6-17	0900	665.5	63.6	293.0	-0.6	
6-17	1600	672.5	66.7	293.0	-0.6	
6-18	0900	689.5	66.4	293.0	-0.6	
6-18	1600	696.5	69.8	293.2	-0.4	
6-19	1600	720.5	70.1	292.8	-0.8	

IFR Deck Fitting Emission Data Sheet

Scale No.: 2

Sheet No.: 2

Test No.: 2

Test Description: Access Hatch Cover, Gasketed and Clamped

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
6-22-81	0900	785.5	63.9	293.0	-0.6	
6-22	1600	792.5	65.8	293.0	-0.6	
6-23	0900	809.5	64.2	292.8	-0.8	
6-23	1600	816.5	66.0	293.0	-0.6	
6-24	0900	833.5	68.0	293.0	-0.6	
6-24	1600	840.5	70.4	293.4	-0.2	End Test

IFR Deck Fitting Emission Data Sheet

Scale No.: 3 Sheet No.: 1

Test No.: 3

Test Description: 1-1/2 in. Dia. Adjustable Roof Leg

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
6-5-81	1600	0.0	69.2	327.8	0.0	Begin Test
6-8	0900	65.0	73.0	327.4	-0.4	
6-8	1600	72.0	74.7	327.6	-0.2	
6-9	0900	89.0	67.4	327.4	-0.4	
6-9	1600	96.0	67.9	327.4	-0.4	
6-10	0900	113.0	64.9	327.4	-0.4	
6-10	1600	120.0	66.7	327.4	-0.4	
6-11	0900	137.0	65.0	327.4	-0.4	
6-12	0900	161.0	67.8	327.4	-0.4	
6-12	1600	168.0	69.4	327.6	-0.2	
6-15	1600	240.0	77.0	327.0	-0.8	
6-16	0900	257.0	71.9	326.6	-1.2	
6-16	1600	264.0	70.8	326.4	-1.4	
6-17	0900	281.0	63.5	326.2	-1.6	
6-17	1600	288.0	67.0	326.2	-1.6	
6-18	0900	305.0	66.4	326.2	-1.6	
6-18	1600	312.0	70.0	326.2	-1.6	
6-19	1600	336.0	70.2	326.0	-1.8	
6-22	0900	401.0	64.1	326.2	-1.6	
6-22	1600	408.0	66.2	326.2	-1.6	
6-23	0900	425.0	64.2	326.0	-1.8	
6-23	1600	432.0	66.2	326.0	-1.8	
6-24	0900	449.0	68.0	326.2	-1.6	
6-24	1600	456.0	70.6	326.4	-1.4	End Test

IFR Deck Fitting Emission Data Sheet

Scale No.: 4 Sheet No.: 1

Test No.: 4

Test Description: 8 in. Dia. Slotted Pipe Sample Well

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
5-20-81	1530	0	65.7	339.5	0	Begin Test
5-21	0930	18.0	61.6	339.0	-0.5	
5-21	1530	24.0	66.0	339.0	-0.5	
5-22	0930	42.0	62.6	338.5	-1.0	
5-23	0630	63.0	65.6	338.0	-1.5	
5-26	0900	137.5	64.6	338.0	-1.5	
5-26	1600	144.5	68.2	337.5	-2.0	
5-27	0900	161.5	63.0	336.5	-3.0	
5-28	0930	186.0	58.5	336.5	-3.0	
5-28	1600	192.5	64.0	336.5	-3.0	
5-29	0900	209.5	66.3	336.5	-3.0	
5-29	1600	216.5	68.9	336.5	-3.0	
6-1	0900	281.5	60.4	335.0	-4.5	
6-1	1600	288.5	64.4	335.0	-4.5	
6-2	0900	305.5	66.2	334.5	-5.0	
6-2	1600	312.5	68.0	334.5	-5.0	
6-3	0900	329.5	67.3	334.5	-5.0	
6-3	1600	336.5	70.0	333.5	-6.0	
6-4	0900	353.5	66.8	333.0	-6.5	
6-4	1600	360.5	69.6	333.0	-6.5	
6-5	0900	377.5	66.4	333.0	-6.5	
6-5	1600	384.5	69.9	333.5	-6.0	
6-8	0900	449.5	73.5	330.5	-9.0	
6-8	1600	456.5	75.7	330.5	-9.0	
6-9	0900	473.5	66.4	330.5	-9.0	
6-9	1600	480.5	67.2	330.5	-9.0	
6-10	0900	497.5	64.0	330.5	-9.0	
6-10	1600	504.5	66.8	330.5	-9.0	
6-11	0900	521.5	64.4	329.5	-10.0	
6-12	0900	545.5	67.6	329.5	-10.0	
6-12	1600	552.5	69.0	329.5	-10.0	
6-15	1600	624.5	78.4	327.5	-12.0	
6-16	0900	641.5	71.4	327.5	-12.0	
6-16	1600	648.5	70.0	327.5	-12.0	
6-17	0900	665.5	62.0	326.5	-13.0	
6-17	1600	672.5	67.3	326.5	-13.0	
6-18	0900	689.5	65.8	326.5	-13.0	
6-18	1600	696.5	71.0	326.5	-13.0	
6-19	1600	720.5	70.5	325.5	-14.0	

IFR Deck Fitting Emission Data Sheet

Scale No.: 4 Sheet No.: 2

Test No.: 4

Test Description: 8 in. Dia. Slotted Pipe Sample Well

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
6-22-81	0900	785.5	63.0	324.0	-15.5	
6-22	1600	792.5	66.1	324.0	-15.5	
6-23	0900	809.5	63.4	324.0	-15.5	
6-23	1600	816.5	66.3	324.0	-15.5	
6-24	0900	833.5	67.9	323.0	-16.5	
6-24	1600	840.5	71.4	323.0	-16.5	
6-25	0900	857.5	69.8	324.5	-15.0	
7-1	2100	1013.5	75.2	319.5	-20.0	
7-6	0900	1121.5	70.4	316.5	-23.0	
7-16	1600	1368.5	77.0	311.5	-28.0	End Test

IFR Deck Fitting Emission Data Sheet

Scale No.: 5 Sheet No.: 1

Test No.: 5

Test Description: 8 in. Dia. Pipe Column Well

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
5-20-81	1530	0.0	65.2	340.5	0.0	Begin test
5-21	0930	18.0	61.3	340.5	0.0	
5-21	1530	24.0	65.6	340.5	0.0	
5-22	0930	42.0	62.3	340.5	0.0	
5-22	1530	48.0	66.7	340.0	-0.5	
5-23	0630	63.0	65.4	340.0	-0.5	
5-26	0900	137.5	64.4	340.0	-0.5	
5-26	1600	144.5	67.9	340.0	-0.5	
5-27	0900	161.5	62.6	340.0	-0.5	
5-28	0930	186.0	58.2	340.0	-0.5	
5-28	1600	192.5	63.5	340.0	-0.5	
5-29	0900	209.5	66.2	340.0	-0.5	
5-29	1600	216.5	68.8	340.0	-0.5	
6-1	0900	281.5	60.3	339.5	-1.0	
6-1	1600	288.5	64.2	339.5	-1.0	
6-2	0900	305.5	66.2	339.0	-1.5	
6-2	1600	312.5	68.0	338.5	-2.0	
6-3	0900	329.5	67.5	339.0	-1.5	
6-3	1600	336.5	70.1	338.5	-2.0	
6-4	0900	353.5	66.8	338.5	-2.0	
6-4	1600	360.5	69.6	338.0	-2.5	
6-5	0900	377.5	66.4	338.0	-2.5	
6-5	1600	384.5	69.9	338.0	-2.5	
6-8	0900	449.5	73.8	337.0	-3.5	
6-8	1600	456.5	75.8	337.0	-3.5	
6-9	0900	473.5	66.0	337.0	-3.5	
6-9	1600	480.5	65.0	337.0	-3.5	
6-10	0900	497.5	63.8	337.0	-3.5	
6-10	1600	504.5	66.6	337.0	-3.5	
6-11	0900	521.5	64.4	336.5	-4.0	
6-12	0900	545.5	67.6	336.5	-4.0	
6-12	1600	552.5	70.0	336.5	-4.0	
6-15	1600	624.5	78.6	335.5	-5.0	
6-16	0900	641.5	71.3	335.5	-5.0	
6-16	1600	648.5	70.2	335.5	-5.0	
6-17	0900	665.5	61.8	335.0	-5.5	
6-17	1600	672.5	66.8	335.0	-5.5	
6-18	0900	689.5	66.0	335.0	-5.5	
6-18	1600	696.5	70.9	335.0	-5.5	
6-19	1600	720.5	70.3	335.0	-5.5	

IFR Deck Fitting Emission Data Sheet

Scale No.: 5 Sheet No.: 2

Test No.: 5

Test Description: 8 in. Dia. Pipe Column Well

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
6-22-81	0900	785.5	62.8	334.5	-6.0	
6-22	1600	792.5	65.8	334.5	-6.0	
6-23	0900	809.5	63.4	334.0	-6.5	
6-23	1600	816.5	66.0	334.0	-6.5	
6-24	0900	833.5	67.9	334.0	-6.5	
6-24	1600	840.5	71.3	334.0	-6.5	
6-25	0900	857.5	69.8	334.0	-6.5	
7-1	2100	1013.5	75.2	331.5	-9.0	
7-6	0900	1121.5	70.3	331.0	-9.5	
7-16	1600	1368.5	76.7	328.0	-12.5	End test

IFR Deck Fitting Emission Data Sheet

Scale No.: 1 Sheet No.: 1

Test No.: 6

Test Description: 1 in. Dia. Stub Drain

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
7-7-81	0900	0.0	75.8	385.6	0.0	Begin Test
7-8	0900	24.0	81.6	385.6	0.0	
7-9	0900	48.0	83.3	385.6	0.0	
7-10	0900	72.0	76.3	385.2	-0.4	
7-13	0900	144.0	83.8	385.2	-0.4	
7-16	1600	223.0	76.4	384.8	-0.8	
7-21	0900	336.0	75.8	385.6	ø	
7-22	0900	360.0	70.6	385.6	ø	
7-23	0900	384.0	70.6	385.4	-0.2	
7-24	0900	408.0	70.8	385.4	-0.2	
7-27	1700	488.0	-	385.4	-0.2	No temp. indicator
7-28	1700	512.0	-	385.2	-0.4	
7-29	0930	528.5	-	385.2	-0.4	
7-30	1700	560.0	71.0	385.0	-0.6	
7-31	1700	584.0	73.2	385.0	-0.6	
8-3	1600	655.0	77.6	385.2	-0.4	
8-4	1600	679.0	78.4	385.2	-0.4	
8-5	1600	703.0	78.4	385.0	-0.6	
8-6	1600	727.0	77.0	385.0	-0.6	
8-13	0830	887.5	75.4	384.6	-1.0	
8-14	1000	913.0	77.4	384.6	-1.0	
8-17	900	984.0	67.9	384.0	-1.6	
8-20	1830	1065.5	-	383.8	-1.8	
8-21	1600	1087.0	71.1	383.8	-1.8	
8-26	900	1200.0	75.8	383.8	-1.8	
8-27	900	1224.0	75.1	383.8	-1.8	
8-28	900	1248.0	74.9	384.0	-1.6	
8-31	1700	1328.0	78.0	383.8	-1.8	
9-1	1330	1348.5	75.8	383.8	-1.8	End Test

IFR Deck Fitting Emission Data Sheet

Sheet No.: 1

Scale No.: 4
Test No.: 7
Test Description: Phase 1 Column Well, Ungasketed

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
7-24-81	0900	0.0	70.0	420.0	0.0	Begin Test
7-27	1700	80.0	-	418.0	-2.0	
7-28	1700	104.0	-	417.5	-2.5	
7-29	0930	120.5	-	417.5	-2.5	
7-30	1700	152.0	71.5	416.5	-3.5	
7-31	1700	176.0	74.2	415.5	-4.5	
8-3	1600	247.0	77.7	413.8	-6.5	
8-4	1600	271.0	78.5	413.5	-6.5	
8-5	1600	295.0	78.1	412.0	-8.0	
8-6	1600	319.0	77.0	412.0	-8.0	
8-13	0830	479.5	74.9	408.5	-11.5	
8-14	1000	505.0	77.0	408.0	-12.0	
8-17	900	576.0	65.5	406.0	-14.0	
8-20	1830	657.5	-	405.0	-15.0	
8-21	1600	679.0	71.6	405.0	-15.0	
8-26	900	792.0	75.3	402.0	-18.0	
8-27	900	816.0	74.3	401.5	-18.5	
8-28	900	840.0	74.1	401.0	-19.0	
8-31	1700	920.0	78.4	399.5	-20.5	
9-1	1330	940.5	75.4	399.0	-21.0	
9-2	1500	966.0	72.2	399.0	-21.0	End Test

Contract 05000

IFR Deck Fitting Emission Data Sheet

Scale No.: 5 Sheet No.: 1

Test No.: 8

Test Description: ½" Gap Around Built-Up Column

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
7-24-81	0900	0.0	70.6	480.0	0.0	Begin Test
7-27	1700	80.0	-	478.5	-1.5	
7-28	1700	104.0	-	478.5	-1.5	
7-29	0930	120.5	-	478.5	-1.5	
7-30	1700	152.0	71.2	477.5	-2.5	
7-31	1700	176.0	73.8	476.5	-3.5	
8-3	1600	247.0	77.8	475.0	-5.0	
8-4	1600	271.0	78.6	474.5	-5.5	
8-5	1600	295.0	78.4	474.5	-5.5	
8-6	1600	319.0	77.1	473.5	-6.5	
8-13	0830	479.5	74.9	469.0	-11.0	
8-14	1000	505.0	77.0	468.5	-11.5	
8-17	0900	576.0	65.6	466.0	-14.0	
8-20	1830	657.5	-	464.0	-16.0	
8-21	1600	679.0	71.4	464.0	-16.0	
8-26	900	792.0	75.3	460.0	-20.0	
8-27	900	816.0	74.4	459.5	-20.5	
8-28	900	840.0	74.1	459.0	-21.0	
8-31	1700	920.0	78.4	457.5	-22.5	
9-1	1330	940.5	75.4	457.5	-22.5	
9-2	1500	966.0	71.9	455.5	-24.5	
9-2	2330	974.5	72.1	455.5	-24.5	
9-3	1430	989.5	-	454.5	-25.5	
9-3	2330	998.5	66.3	454.5	-25.5	
9-4	930	1008.5	69.2	454.5	-25.5	
9-5	1130	1034.5	68.3	454.5	-25.5	
9-6	1130	1058.5	66.4	454.0	-26.0	
9-7	1130	1082.5	68.9	454.0	-26.0	
9-8	1600	1111.0	68.2	452.5	-27.5	
9-9	1600	1135.0	67.2	451.5	-28.5	End Test

IFR Deck Fitting Emission Data Sheet

Sheet No.: 1

Scale No.: 1

Test No.: 9A

Test Description: Phase 1 Column Well, Gasketed

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
9-2-81	2310	-	72.5	-	-	Product sample taken
9-2	2330	0.0	72.5	451.0	0.0	Begin Test
9-3	930	10.0	69.9	450.8	-0.2	
9-3	1430	15.0	-	450.8	-0.2	
9-3	2330	24.0	66.8	450.6	-0.4	
9-4	930	34.0	70.5	450.4	-0.6	
9-4	1600	40.5	71.1	450.2	-0.8	
9-4	2330	48.0	72.1	450.0	-1.0	
9-5	1130	60.0	69.4	450.0	-1.0	
9-6	1130	84.0	67.7	449.6	-1.4	
9-7	1130	108.0	69.6	449.6	-1.4	
9-8	1600	136.5	68.7	449.0	-2.0	
9-8	2330	144.0	67.5	448.8	-2.2	
9-9	1600	160.5	67.4	448.8	-2.2	
9-9	2300	167.5	70.0	448.6	-2.4	
9-10	1300	181.5	70.0	448.8	-2.2	
9-10	1700	185.5	72.0	448.8	-2.2	
9-10	2130	190.0	70.9	448.8	-2.2	End Test Product Sample Taken

Contract 05000

IFR Deck Fitting Emission Data Sheet

Scale No.: 1 Sheet No.: 1

Test No.: 9B

Test Description: Phase 1 Column Well, Ungasketed

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
9/24/81	1720					Product Sample Taken
9/24	1730	0.0	68.6	450.0	0	Begin test
9/24	1900	1.5	67.6	449.7	-0.3	
9/24	2100	3.5	65.8	-	-	
9/25	0300	9.5	-	449.5	-0.5	
9/25	0700	13.5	-	449.3	-0.7	
9/25	1100	17.5	-	449.5	-0.5	
9/25	1500	21.5	74.3	449.1	-0.9	
9/25	1920	26.0	71.4	449.1	-0.9	
9/25	2315	29.75	69.2	449.1	-0.9	
9/26	0600	36.5	64.2	449.3	-0.7	
9/26	1000	40.5	75.8	448.9	-1.1	
9/26	1400	44.5	73.5	448.6	-1.4	
9/26	1800	48.5	72.9	448.6	-1.4	
9/28	1100	89.5	63.0	446.2	-3.8	
9/28	2230	101.0	64.4	446.0	-4.0	End test Product Sample Taken

IFR Deck Fitting Emission Data Sheet

Sheet No.: 1

Scale No.: 2

Test No.: 10

Test Description: Phase 2 Column Well

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
			72.7	-	-	Product Sample Taken.
9-2-81	2320	-				Begin Test
9-9	2330	0.0	72.7	125.6	0.0	
9-3	830	9.0	69.8	125.4	-0.2	
9-3	1430	15.0	-	125.4	-0.2	
9-3	2330	24.0	66.8	125.4	-0.2	
9-4	930	34.0	70.4	125.2	-0.4	
9-4	1600	40.5	71.0	125.2	-0.4	
9-4	2330	48.0	72.0	125.0	-0.6	
9-5	1130	60.0	69.3	125.0	-0.6	
9-6	1130	84.0	67.6	124.8	-0.8	
9-7	1130	108.0	69.4	124.8	-0.8	
9-8	1600	136.5	68.6	124.4	-1.2	
9-8	2330	144.0	67.5	124.2	-1.4	
9-9	1600	160.5	67.2	124.2	-1.4	
9-9	2300	167.5	69.6	124.2	-1.4	
9-10	1700	185.5	71.4	124.4	-1.2	
9-10	1730	186.0	70.4	124.4	-1.2	Product Sample Taken (1.6 lbs)
9-10	1730	186.0	70.4	-	-	
9-10	1735	186.1	70.4	122.8	-1.2	
9-11	1430	207.0	72.2	123.0	-1.0	
9-14	1100	275.5	74.2	122.8	-1.2	
9-15	2100	309.5	68.9	121.8	-2.2	
9-17	1730	354.0	60.7	121.6	-2.4	
9-18	1630	377.0	59.3	121.4	-2.6	
9-22	1800	474.5	63.0	121.2	-2.8	
9-23	1500	495.5	56.9	121.0	-3.0	End Test
9-24	1530	520.0	62.3	121.4	-2.6	Product Sample Taken.

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IFR Deck Fitting Emission Data Sheet

Scale No.: 3 Sheet No.: 1

Test No.: 11

Test Description: Phase 3 Column Well, 30 in Dia. Test Drum

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
9-3-81	1430	-	-	-	-	Product Sample Taken
9-3	1430	0.0	-	845.8	0.0	Begin Test
9-3	2330	9.0	67.0	845.8	0.0	
9-4	930	19.0	71.0	845.4	-0.4	
9-4	1600	25.5	71.0	845.4	-0.4	
9-4	2330	33.0	71.7	845.2	-0.6	
9-5	1130	45.0	70.1	845.2	-0.6	
9-6	1130	69.0	68.4	845.0	-0.8	
9-7	1130	93.0	69.6	844.8	-1.0	
9-8	1600	121.5	68.8	844.4	-1.4	
9-8	2330	129.0	67.6	844.2	-1.6	
9-9	1600	145.0	67.4	844.2	-1.6	
9-9	2300	152.0	69.3	844.2	-1.6	
9-10	1300	166.5	69.4	844.2	-1.6	
9-10	1700	170.5	70.9	844.4	-1.4	
9-11	1430	192.0	71.9	844.2	-1.6	
9-11	1430	192.0	71.9	-	-	Product Sample Taken (1.8 lbs)
9-11	1435	192.1	71.9	842.4	-1.6	
9-14	1100	260.5	74.4	842.2	-1.8	
9-15	2100	294.5	69.4	841.2	-2.8	
9-17	1730	339.0	61.2	840.8	-3.2	
9-18	1630	362.0	59.3	840.6	-3.4	
9-22	1800	459.5	63.2	840.0	-4.0	
9-23	1500	480.5	57.6	839.8	-4.2	End Test Product Sample Taken

IFR Deck Fitting Emission Data Sheet

Sheet No.: 1

Scale No.: No. 5

Test No.: 12

Test Description: 1/8" Gap Around Built-Up Column

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
9-9-81	2300	0.0	70.3	470.5	0	Begin test
9-10	1700	18.0	72.6	470.5	0	
9-11	1430	39.5	72.6	470.0	-0.5	
9-14	1100	108.0	74.2	469.0	-1.5	
9-15	2100	142.0	70.3	468.0	-2.5	
9-17	1700	186.0	59.0	467.5	-3.0	
9-18	1630	209.5	58.2	467.5	-3.0	
9-22	1800	307.0	62.5	467.5	-3.0	
9-24	1500	352.0	63.0	465.5	-5.0	
9-25	1920	380.3	72.0	465.5	-5.0	
9-26	1800	403.0	73.3	465.5	-5.0	
9-28	1100	444.0	60.8	464.5	-6.0	
9-28	2230	455.5	63.4	464.5	-6.0	
9-28	1645	449.8	62.9	464.5	-6.0	
9-30	1645	497.8	67.1	464.5	-6.0	
10-02	2300	552.0	52.5	464.5	-6.0	
10-05	0900	610.0	59.2	464.0	-6.5	
10-05	2300	624.0	71.2	464.0	-6.5	
10-06	0900	634.0	65.2	464.0	-6.5	
10-07	0900	658.0	51.0	463.5	-7.0	
10-08	0900	682.0	49.3	463.5	-7.0	
10-09	1000	707.0	50.4	463.0	-7.5	
10-12	1030	779.5	54.6	463.5	-7.0	
10-13	1600	809.0	60.8	463.5	-7.0	
10-14	1630	833.5	63.4	462.0	-8.5	
10-15	1615	857.3	62.3	462.0	-8.5	
10-19	1130	948.5	46.2	461.0	-9.5	
10-20	1730	978.5	55.4	461.0	-9.5	
10-21	2100	1006.0	53.5	461.0	-9.5	
10-27	0900	1138.0	60.8	459.6	-11.5	
10-28	1600	1169.0	67.0	459.0	-11.5	
10-30	1500	1216.0	71.1	459.0	-11.5	
11-2	1400	1287.0	77.8	457.0	-13.5	End test

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IFR Deck Fitting Emission Data Sheet

Scale No.: 4 Sheet No.: 1

Test No.: 13

Test Description: Access Hatch Cover With 1/8 in Gap

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
9-24-81	1830	0.0	-	310.5	0.0	Begin Test
9-25	1920	25.0	71.9	310.0	-0.5	
9-26	1800	47.5	73.2	309.5	-1.0	
9-28	1100	88.5	61.2	308.5	-2.0	
9-28	1645	94.3	63.2	308.0	-2.5	
9-30	1645	142.3	67.2	308.0	-2.5	
10-1	1830	168.0	68.2	-	-	
10-02	2300	196.5	52.9	306.0	-4.5	
10-05	0900	254.5	59.2	304.5	-6.0	
10-05	2300	268.5	71.4	304.0	-6.5	
10-06	0900	278.5	65.2	304.0	-6.5	
10-07	0900	302.5	51.4	303.0	-7.5	
10-08	0900	326.5	49.9	302.5	-8.0	
10-09	1000	351.5	50.6	302.5	-8.0	
10-12	1030	424.0	54.7	302.0	-8.5	
10-13	1600	453.5	61.2	300.5	-10.0	
10-14	1630	478.0	63.4	300.0	-10.5	
10-15	1615	501.8	62.4	299.5	-11.0	
10-19	1130	593.0	46.4	798.0	-12.5	
10-20	1730	623.0	56.0	297.0	-13.5	
10-21	2100	650.5	53.6	297.0	-13.5	
10-27	0900	782.5	60.9	294.5	-16.0	
10-28	1600	813.5	67.4	293.5	-17.0	
10-30	1500	860.5	71.4	293.0	-17.5	
11-2	1400	931.5	78.5	290.5	-20.0	End of Test

IFR Deck Fitting Emission Data Sheet

Sheet No.: 1

Scale No.: 3

Test No.: 14

Test Description: Sample Well With 10% Gap Area

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
10-6-81	0930	0.0	65.5	387.6	0.0	Begin test
10-7	0900	23.5	52.9	386.8	-0.6	
10-8	0900	47.5	51.4	386.6	-1.0	
10-9	1000	72.5	52.2	386.8	-0.8	
10-12	1030	145.0	56.0	386.6	-1.0	
10-13	1600	174.5	62.4	386.8	-0.8	
10-14	1630	199.0	63.9	386.6	-1.0	
10-15	1615	223.0	63.4	386.8	-0.8	
10-19	1130	315.0	48.4	385.6	-2.0	
10-20	1730	345.0	57.9	386.0	-1.6	
10-21	2100	373.5	54.8	385.8	-1.8	
10-27	0900	405.5	62.4	385.4	-2.2	
10-28	1600	436.5	69.8	385.2	-2.4	
10-30	1500	483.5	72.8	385.0	-2.6	
11-2	1200	552.5	80.8	-	-	
11-2	1400	554.5	80.9	384.6	-3.0	
11-3	1515	580.0	77.7	384.4	-3.2	
11-5	1130	624.0	77.8	384.0	-3.6	
11-6	930	646.0	71.0	383.6	-4.0	
11-10	1800	750.5	67.7	382.8	-4.8	
11-11	1630	773.0	67.9	382.8	-4.8	
11-13	1630	821.0	-	382.6	-5.0	
11-16	0900	882.5	70.9	382.4	-5.2	
11-17	1400	911.5	68.9	382.2	-5.4	
11-19	1600	961.5	71.9	382.0	-5.6	End Test

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IFR Deck Fitting Emission Data Sheet

Scale No.: 2 Sheet No.: 1

Test No.: 15

Test Description: 1/8" Gap Around Built-Up Column, 30 in dia. Test Drum

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
9-25-81	2330	0	65.4	778.4	0.0	Begin test
9-26	1800	18.5	73.9	778.2	-0.2	
9-28	1100	59.5	63.0	776.8	-1.6	
9-28	2230	71.0	64.3	776.6	-1.8	
9-28	1645	65.3	65.0	776.8	-1.6	
9-30	1645	113.3	69.6	777.4	-1.0	
10-1	0800	128.5	-	776.8	-1.6	
10-1	1830	139.0	68.3	-	-	
10-2	2300	167.5	54.2	775.0	-3.4	
10-5	0900	225.5	59.3	775.4	-3.0	
10-5	2300	239.5	72.6	775.8	-2.6	
10-6	0900	249.5	64.7	775.2	-3.2	
10-7	0900	273.5	52.8	774.2	-4.2	
10-8	0900	297.5	51.8	774.0	-4.4	
10-9	1000	322.5	52.6	774.0	-4.4	
10-12	1030	395.0	56.3	773.8	-4.6	
10-13	1600	424.5	63.0	773.6	-4.8	
10-14	1630	449.0	63.5	773.6	-4.8	
10-15	1630	473.0	63.4	773.6	-4.8	
10-19	1130	564.0	49.2	771.0	-7.4	
10-20	1730	594.0	58.2	771.6	-6.8	
10-21	2100	621.5	54.4	771.0	-7.4	
10-27	0900	753.5	61.2	770.0	-8.4	
10-28	1600	784.5	69.8	770.0	-8.4	
10-30	1500	831.5	72.0	769.0	-9.4	
11-2	1400	902.5	79.7	768.6	-9.8	End test

Permeability Data Sheet

Scale No.: 1 Sheet No.: 1

Test No.: 16

Test Description: Permeability of 0.020 in Thick Fabric

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
10-5-81	2230	-	-	-	-	Sample taken
10-5	2300	0	73.6	364.6	0.0	Begin test
10-6	0900	10.0	63.6	364.4	-0.2	
10-6	1630	17.5	65.1	364.2	-0.4	
10-7	0900	34.0	50.5	363.8	-0.8	
10-8	0900	58.0	51.0	363.8	-0.8	
10-9	1000	83.0	53.6	363.8	-0.8	
10-12	1030	155.5	57.4	363.8	-0.8	
10-13	1600	185.0	65.0	363.8	-0.8	
10-14	1630	209.5	64.0	363.8	-0.8	
10-15	1630	233.5	64.0	364.0	-0.6	
10-19	1130	324.5	48.3	363.2	-1.4	
10-20	1730	354.5	60.8	363.4	-1.2	
10-21	2100	382.0	53.4	363.2	-1.4	End test Sample taken

Permeability Data Sheet

Scale No.: 1 Sheet No.: 1

Test No.: 17

Test Description: Permeability of 0.037 in. Thick Fabric

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
11-20-81	1400	0.0	62.4	542.2	0.0	Begin test
11-23	0800	66.0	56.6	541.6	-0.6	
11-24	0800	90.0	64.0	541.6	-0.6	
11-25	1100	117.0	64.0	541.4	-0.8	
11-30	1645	243.0	-	540.4	-1.8	
12-1	1600	266.0	-	540.4	-1.8	
12-2	0900	283.0	66.0	540.2	-2.0	
12-3	0800	306.0	62.8	540.0	-2.2	
12-4	0930	331.5	59.8	540.0	-2.2	
12-7	1000	404.0	67.0	539.6	-2.6	
12-9	1300	455.0	58.6	539.0	-3.2	
12-10	1630	482.5	56.6	538.8	-3.4	
12-11	1630	506.5	57.0	538.6	-3.6	
12-14	1730	579.5	63.1	538.4	-3.8	
12-15	1300	599.0	55.3	538.0	-4.2	
12-16	0900	619.0	53.9	537.8	-4.4	
12-21	0900	739.0	-	537.6	-4.6	End test

Permeability Data Sheet

Sheet No.: 1

Scale No.: 3

Test No.: 18

Test Description: Permeability of 0.037 in. Thick Fabric

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
11-20-81	1400	0.0	62.4	418.8	0.0	Begin test
11-23	0800	66.0	56.6	418.8	0.0	
11-24	0800	90.0	64.0	418.8	0.0	
11-25	1100	117.0	64.1	418.8	0.0	
11-30	1645	243.0	60.1	418.8	0.0	
12-1	1600	266.0	62.5	419.0	+0.2	
12-2	0900	283.0	66.0	418.8	0.0	
12-3	0800	306.0	62.9	418.8	0.0	
12-4	0930	331.5	59.9	418.8	0.0	
12-7	1000	404.0	66.9	419.0	+0.2	
12-9	1300	455.0	58.5	418.6	-0.2	
12-10	1630	482.5	56.7	418.6	-0.2	
12-11	1700	506.5	57.0	418.8	-0.2	
12-14	1730	579.5	63.1	418.8	0.0	
12-15	1300	599.0	55.3	418.4	-0.4	
12-16	0900	619.0	53.9	418.2	-0.6	
12-21	0900	739.0	52.0	418.4	-0.4	End test

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Permeability Data Sheet

Scale No.: 1 Sheet No.: 1

Test No.: 19

Test Description: Permeability of 0.020 in. Thick Fabric

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
12-22-81	2100	-	52.2	411.6	-	Sample taken
12-22	2100	0	52.2	410.4	0	Begin test
12-23	1330	16.5	55.2	409.8	-0.6	
12-24	0930	36.5	52.0	409.6	-0.8	
12-24	2115	48.5	52.9	409.6	-0.8	
12-25	1140	63.0	54.0	409.6	-0.8	
12-26	1120	87.0	56.9	409.6	-0.8	
12-27	945	109.5	57.0	409.6	-0.8	
12-28	1000	133.5	58.5	409.6	-0.8	
12-29	1700	164.5	-	409.2	-1.2	
12-30	1700	188.5	51.7	409.2	-1.2	
12-31	1600	211.5	56.8	409.6	-1.4	
1-1	1100	230.5	50.1	409.2	-1.2	
1-2	0830	252.0	52.4	409.2	-1.2	
1-3	1200	280.5	57.9	409.4	-1.2	
1-4	0900	301.5	47.9	409.4	-1.0	End test

Permeability Data Sheet

Sheet No.: 1

Scale No.: 2

Test No.: 20

Test Description: Permeability of 0.020 in. Thick Fabric

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
12-22-81	2100	-	47.8	430.6	-	Sample taken
12-22	2100	0	47.8	429.0	0.0	Begin test
12-23	1300	16.0	-	428.6	-0.4	
12-24	0930	36.0	45.5	428.6	-0.4	
12-24	2115	48.0	45.6	428.4	-0.6	
12-25	1140	62.5	49.8	428.4	-0.6	
12-26	1130	86.5	52.3	428.4	-0.6	
12-28	1000	133.0	52.9	428.2	-0.8	
12-29	1700	164.0	-	427.6	-1.4	
12-30	1700	188.0	46.3	427.8	-1.2	
12-31	1600	211.0	52.3	428.2	-0.8	
1-1	1100	230.0	43.9	427.6	-1.4	
1-2	0830	251.5	46.5	427.6	-1.4	
1-3	1200	280.0	54.1	428.0	-1.0	
1-4	0900	301.0	40.3	428.0	-1.0	End test

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Permeability Data Sheet

Scale No.: 3 Sheet No.: 1

Test No.: 21

Test Description: Permeability of 0.020 in Thick Fabric, With Aluminum Duck Tape Seams

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
12-22-81	2130	-	49.6	424.8	-	Sample taken
12-22	2130	0	49.6	423.6	0.0	Begin test
12-23	1300	16.0	-	423.2	-0.4	
12-24	0930	36.0	48.4	423.2	-0.4	
12-24	2115	48.0	49.0	423.2	-0.4	
12-25	1140	62.5	51.6	423.2	-0.4	
12-26	1120	86.5	54.7	423.2	-0.4	
12-27	945	109.0	54.4	423.2	-0.4	
12-28	1000	133.0	54.3	423.2	-0.4	
12-29	1700	164.0	-	422.6	-1.0	
12-30	1700	188.0	49.2	422.8	-0.8	
12-31	1600	211.0	55.1	423.0	-0.6	
1-1-82	1100	230.0	46.8	422.6	-1.0	
1-2	0830	251.5	50.0	422.6	-1.0	
1-3	1200	280.0	54.0	422.8	-0.8	
1-4	0400	301.0	46.5	422.6	-1.0	End test

PERMEABILITY DATA SHEET

Sheet No.: 1

Scale No.: 1
Test No.: 22
Test Description: Permeability of 0.020 in. Thick Fabric

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
						Sample Taken
1-29-82	1600	-	-	-	-	Begin Test
2-1	1530	0.0	39.4	417.0	0.0	
2-3	1700	49.5	42.1	416.6	-0.4	
2-4	1430	71.0	36.1	416.4	-0.6	
2-5	1700	97.5	-	416.4	-0.6	
2-6	1100	115.5	24.7	416.4	-0.6	
2-8	1400	166.5	36.9	416.2	-0.8	
2-10	1630	217.0	36.2	416.2	-0.8	
2-11	0830	233.0	35.9	416.2	-0.8	
2-15	0930	330.0	50.9	416.6	-0.4	
2-16	0930	354.0	-	416.6	-0.4	
2-18	1700	409.5	51.4	416.4	-0.6	
2-22	1730	506.0	54.8	416.2	-0.8	
2-24	1030	547.0	46.8	415.8	-1.2	
2-25	1630	577.0	45.5	415.8	-1.4	
3-1	1130	668.0	54.1	415.8	-1.2	End Test
3-3	1500	719.5	50.1	415.4	-1.6	

Contract 05000

PERMEABILITY DATA SHEET

Scale No.: 3 Sheet No.: 1

Test No.: 23

Test Description: Permeability of Taped Joints in Sheet Aluminum

Date	Time	Elapsed Time (hrs.)	Temp. (°F)	Weight (lbm)	Weight Change (lbm)	Notes
1-24-82	1600	-	-	-		Sample Taken
2-1	1530	0.0	40.2	435.2	0.0	Begin Test
2-3	1700	49.5	42.6	435.4	+0.2	
2-4	1430	71.0	37.8	535.0	-0.2	
2-5	1700	97.5	-	435.0	-0.2	
7-6	1100	115.5	24.4	434.4	+0.2	
2-8	1400	166.5	36.3	435.0	-0.2	
2-10	1630	217.0	37.8	434.8	-0.4	
2-11	0830	233.0	37.0	434.8	-0.4	
2-15	0930	330.0	52.8	435.4	+0.2	
2-16	0930	354.0	-	435.6	+0.4	
2-18	1700	409.5	53.4	435.6	+0.4	
2-22	1730	506.0	56.2	435.6	+0.4	
2-24	1030	547.0	47.1	435.0	-0.2	
2-25	1630	577.0	47.3	435.2	0.0	
3-1	1130	668.0	55.4	435.2	0.0	
3-3	1500	719.5	49.8	435.0	-0.2	End Test

Contract 05000

Figures E1 thru E13 - IFR Deck Fitting Emission Tests

Figures E14 thru E16 - Bench Scale Permeability Tests

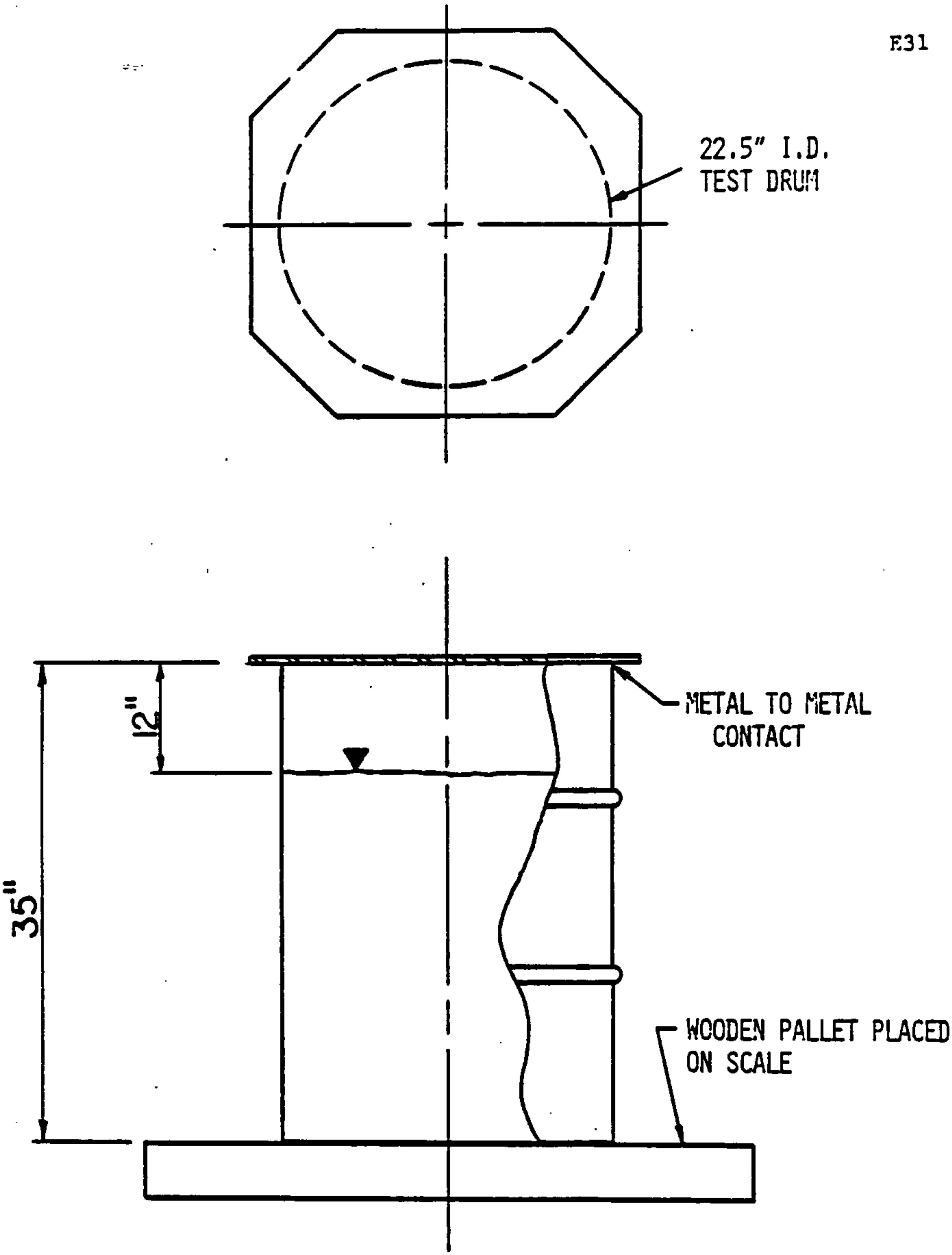


FIGURE E1 IFR DECK FITTING EMISSION TEST NO. 1, ACCESS HATCH COVER, UNGASKETED

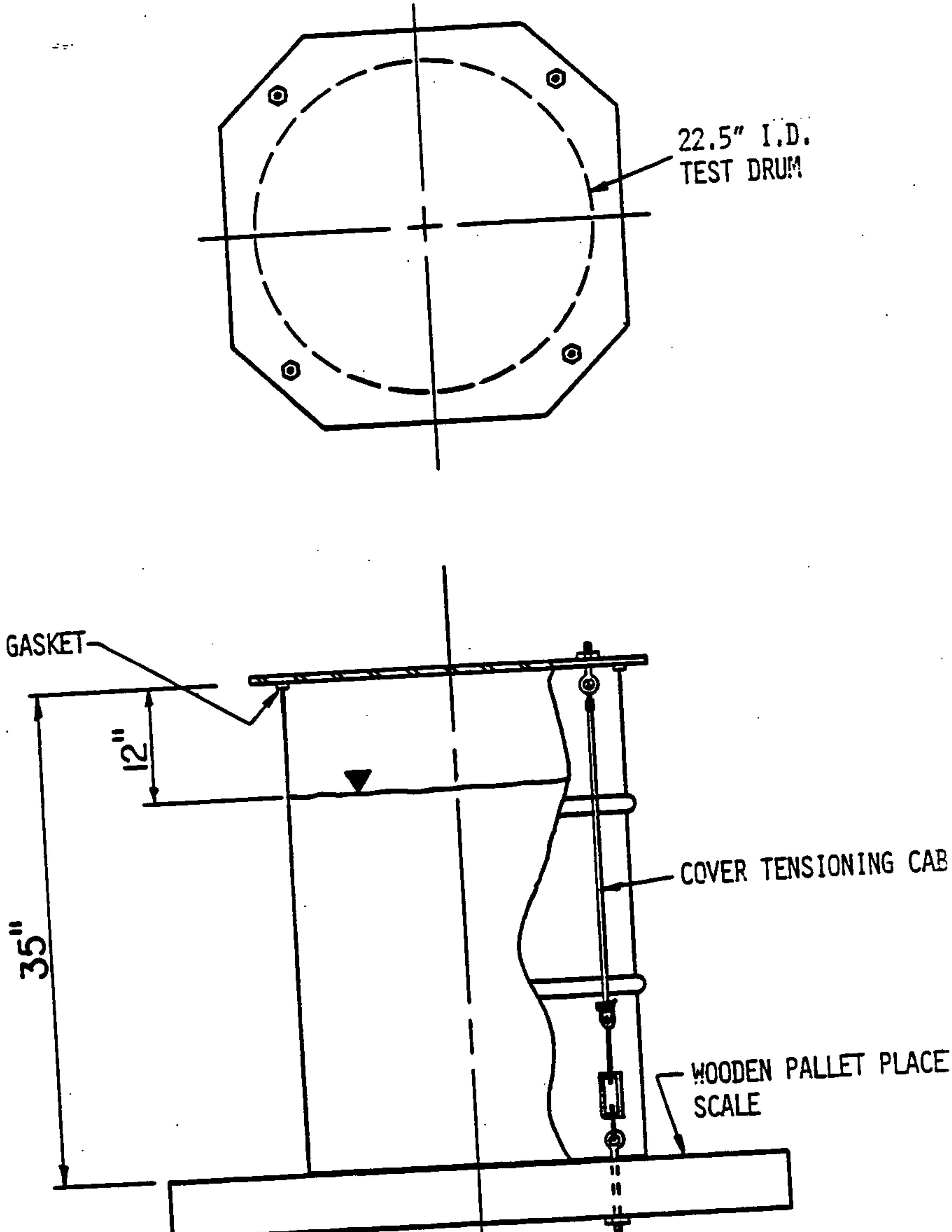


FIGURE E2 IFR DECK FITTING EMISSION TEST NO. 2, ACCESS HATCH CO
GASKETED AND CLAMPED

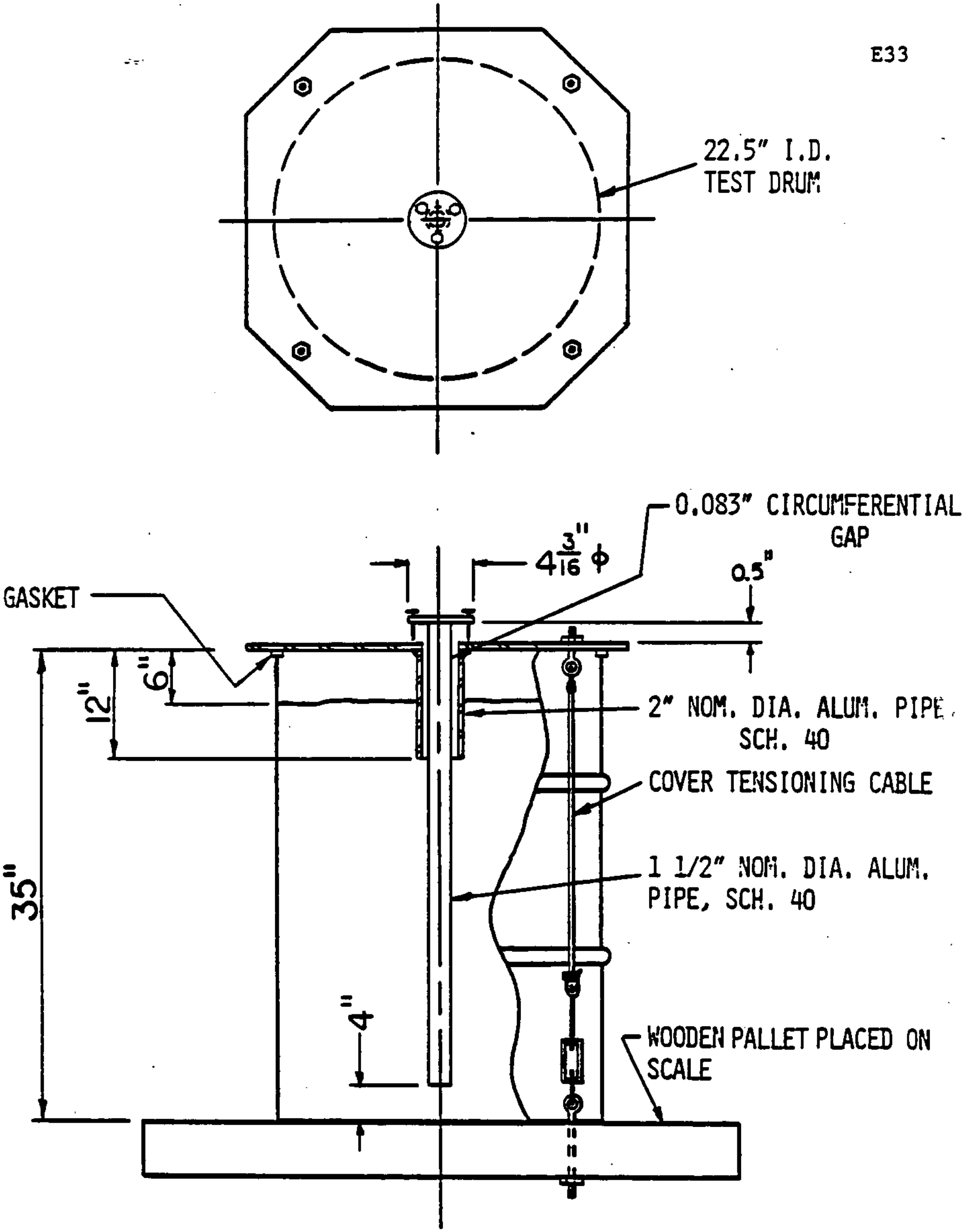


FIGURE E3 IFR DECK FITTING EMISSION TEST NO. 3, 1 1/2" DIAMETER ADJUSTABLE ROOF LEG

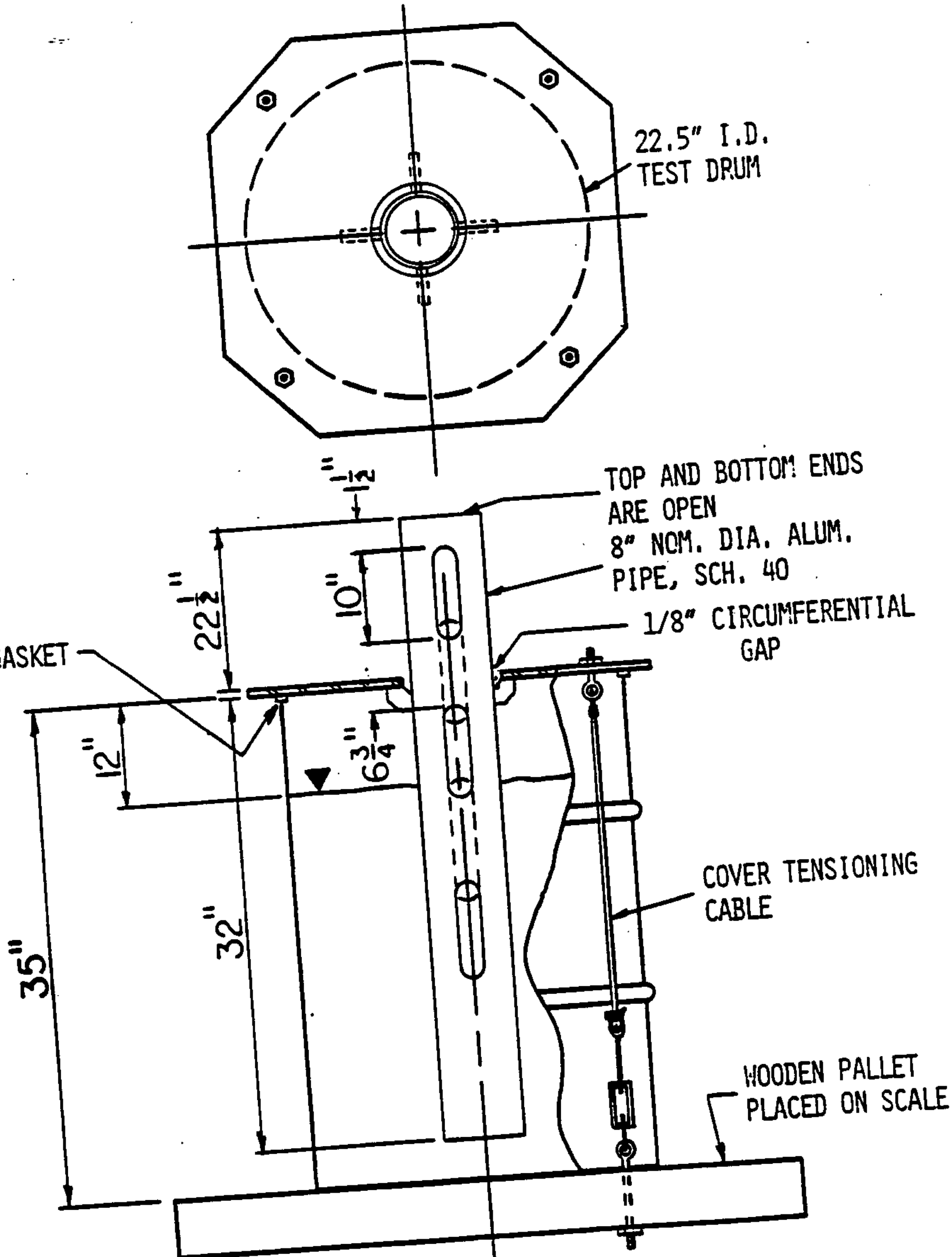


FIGURE E4 IFR DECK FITTING EMISSIONS TEST NO. 4,
8 IN. DIA. SLOTTED PIPE SAMPLE WELL

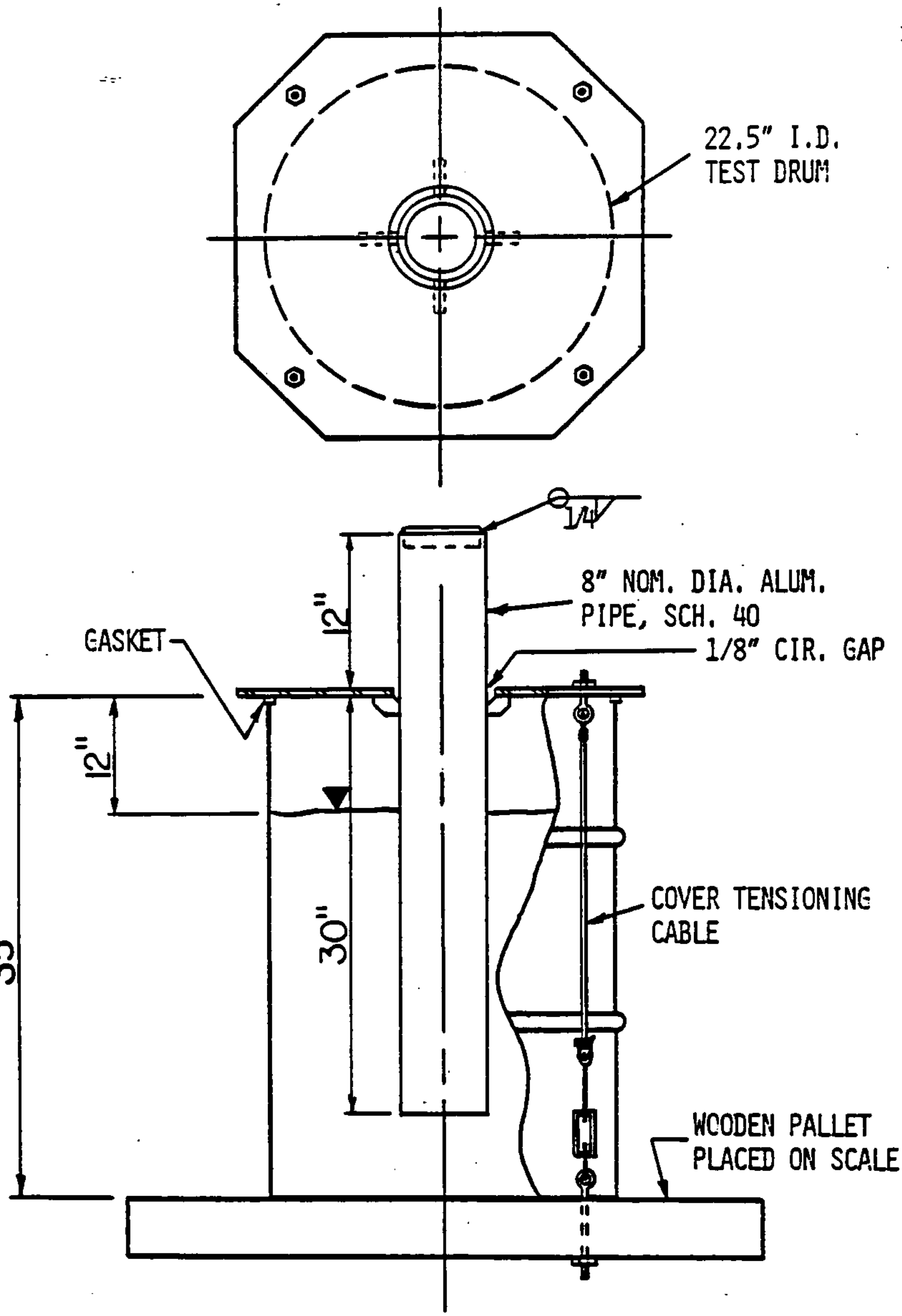


FIGURE E5 IFR DECK FITTING EMISSION TEST NO. 5,
8 IN. DIA. PIPE COLUMN WELL

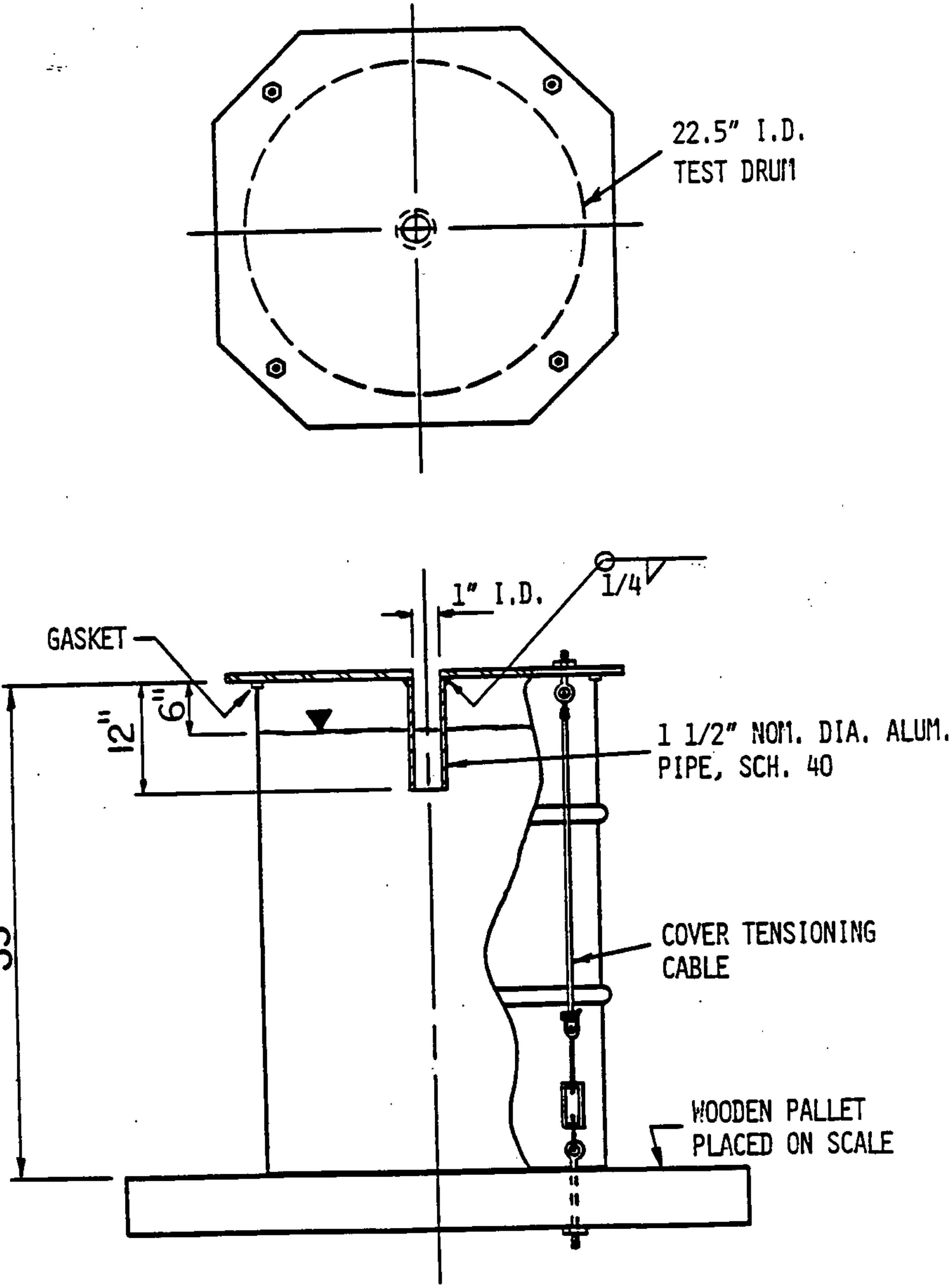


FIGURE E6 IFR DECK FITTING EMISSION TEST NO. 6,
1 IN. DIA. STUB DRAIN

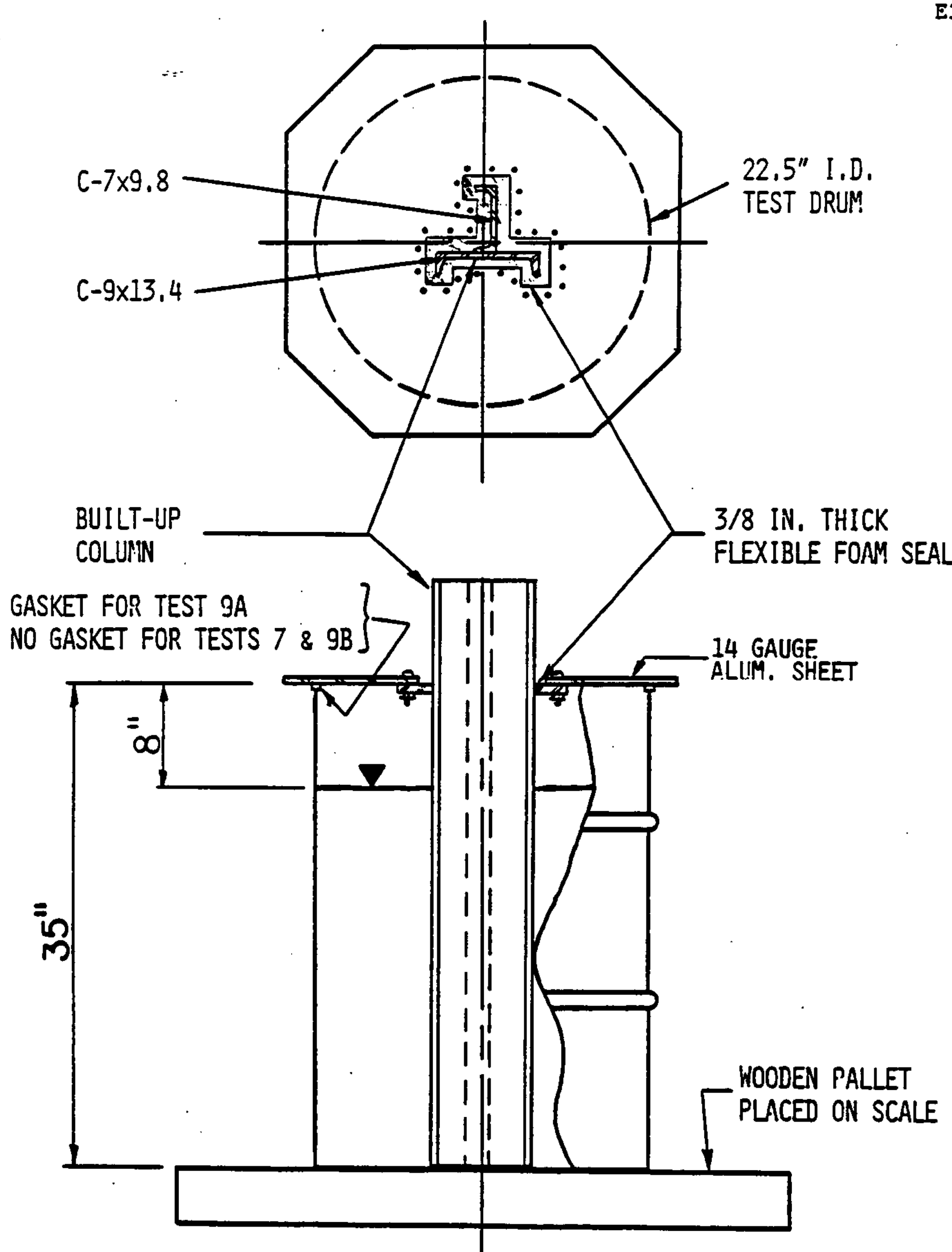


FIGURE E7 IFR DECK FITTING EMISSION TEST NOS. 7, 9A, AND 9B
PHASE 1 COLUMN WELL

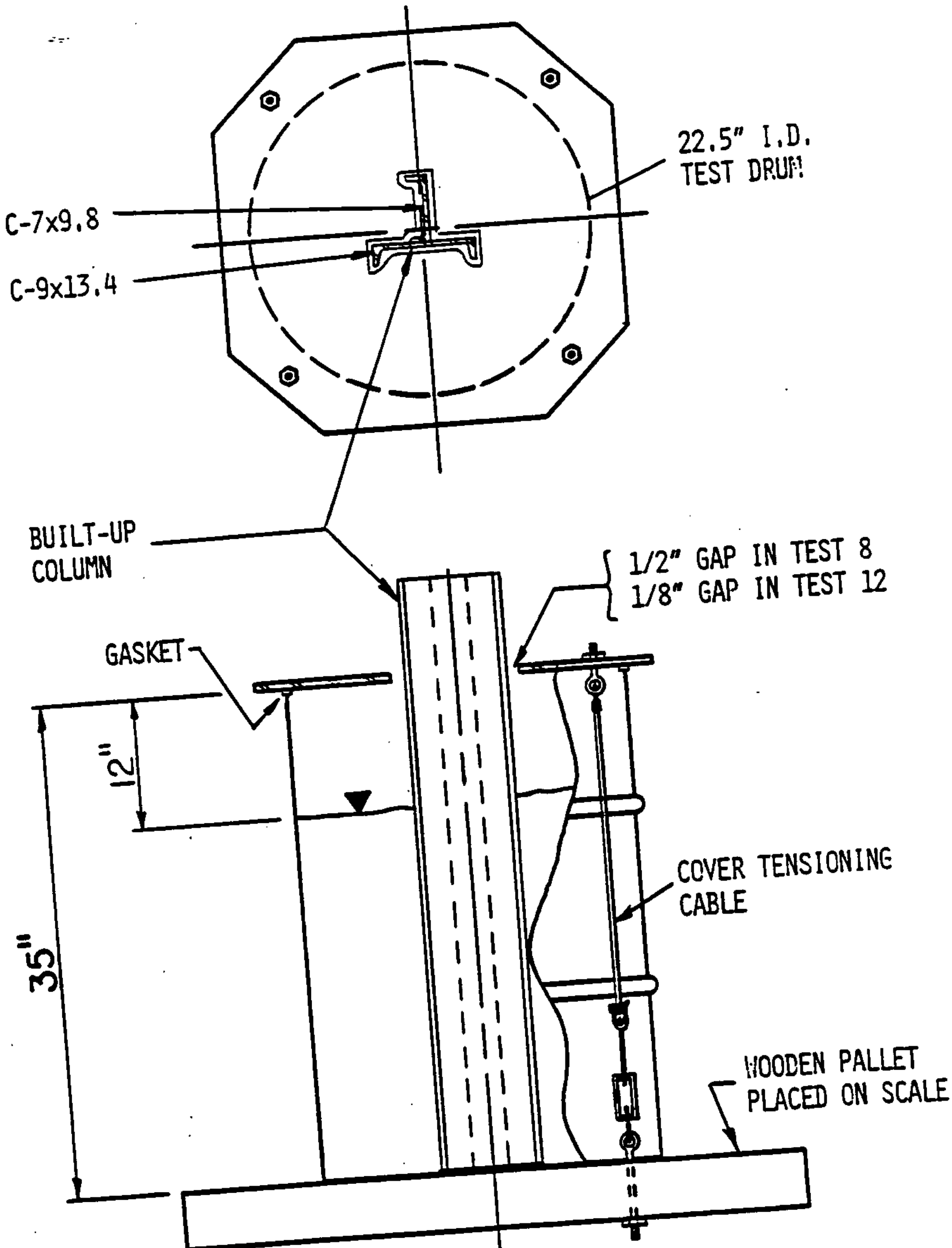


FIGURE E8 IFR DECK FITTING EMISSION TEST NOS. 8 AND 12, GAP AROUND BUILT-UP COLUMN

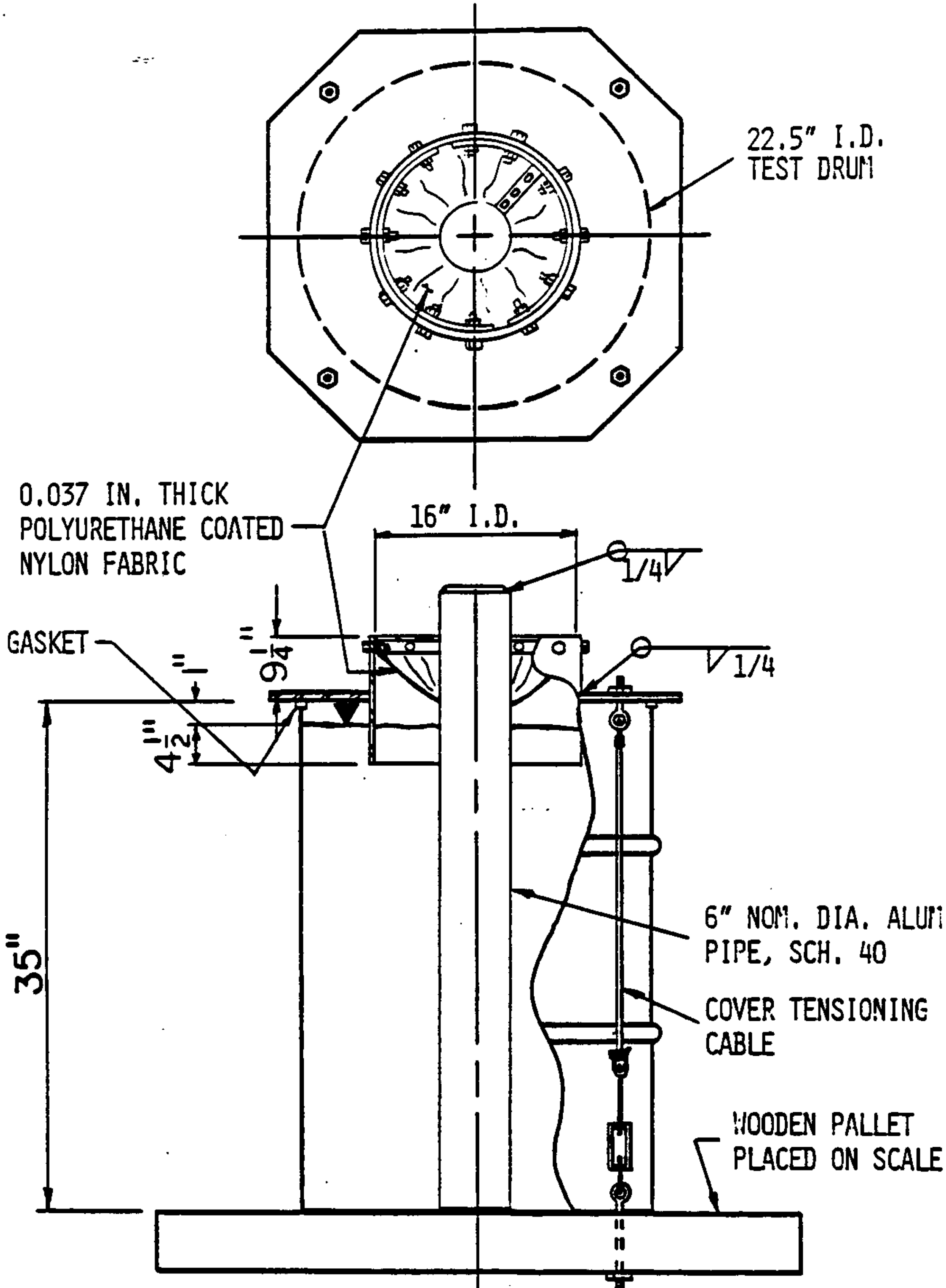


FIGURE E9 IFR DECK FITTING EMISSION TEST NO. 10,
PHASE 2 COLUMN WELL

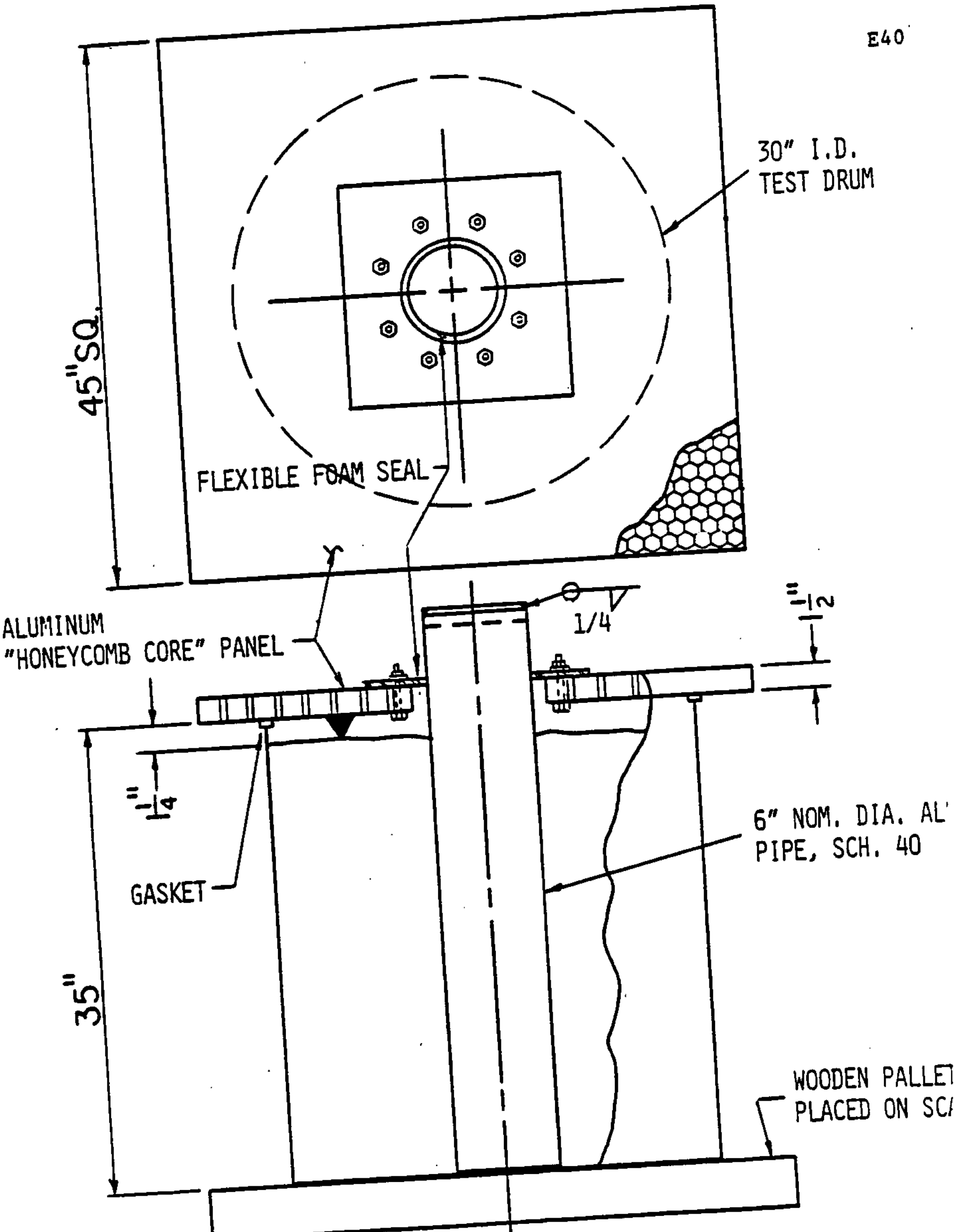
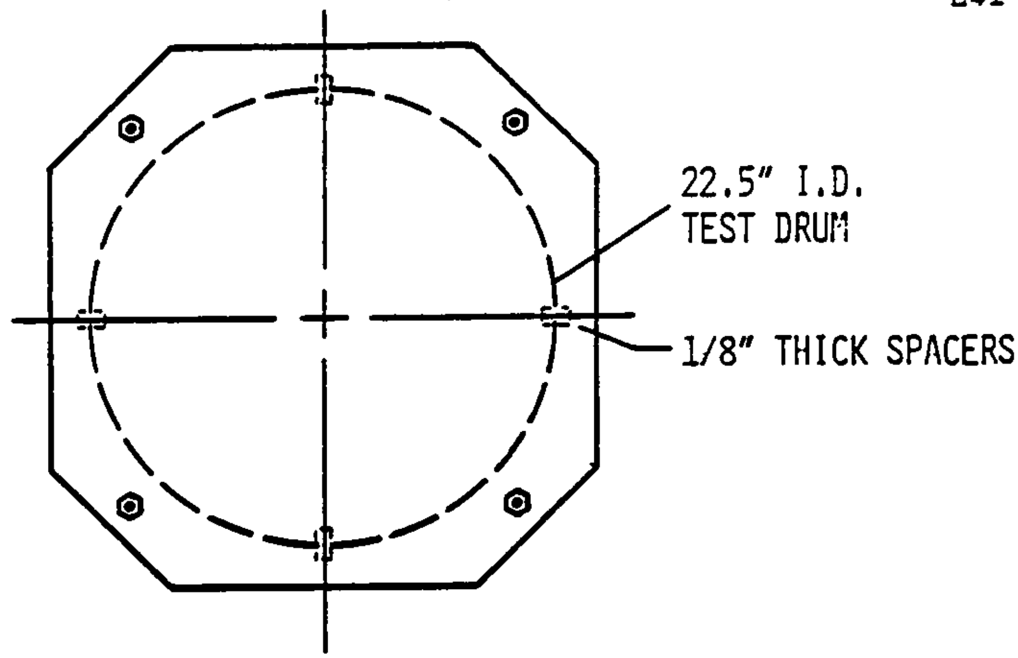


FIGURE E10 IFR DECK FITTING EMISSION TEST NO. 11, PHASE 3 COLUMN WELL



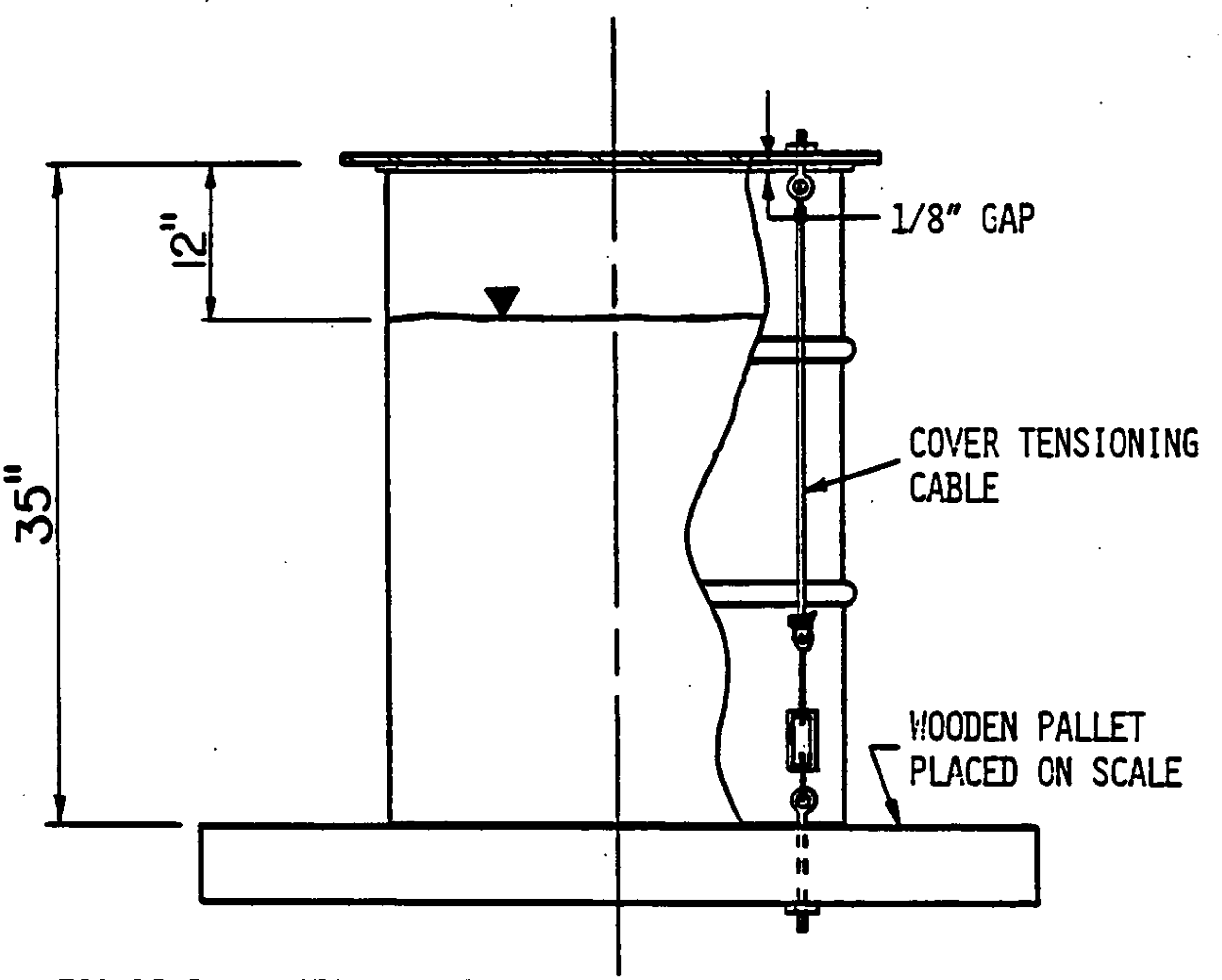


FIGURE E11 IFR DECK FITTING EMMISSION TEST NO. 13, ACCESS HATCH COVER WITH 1/8 IN. GAP

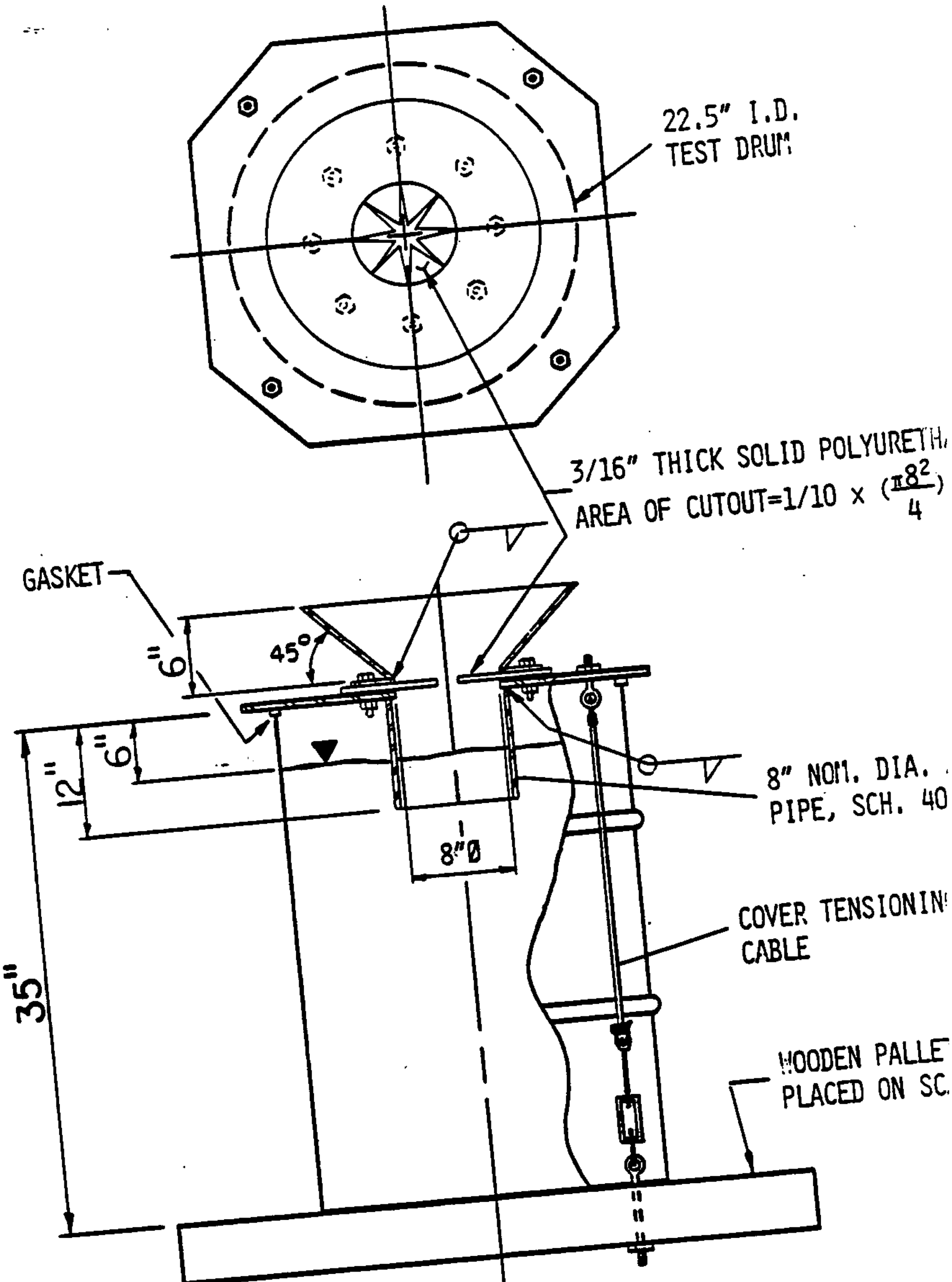


FIGURE E12 IFR DECK FITTING EMISSION TEST NO. 14, SAMPLE WELL WITH 10% GAP AREA

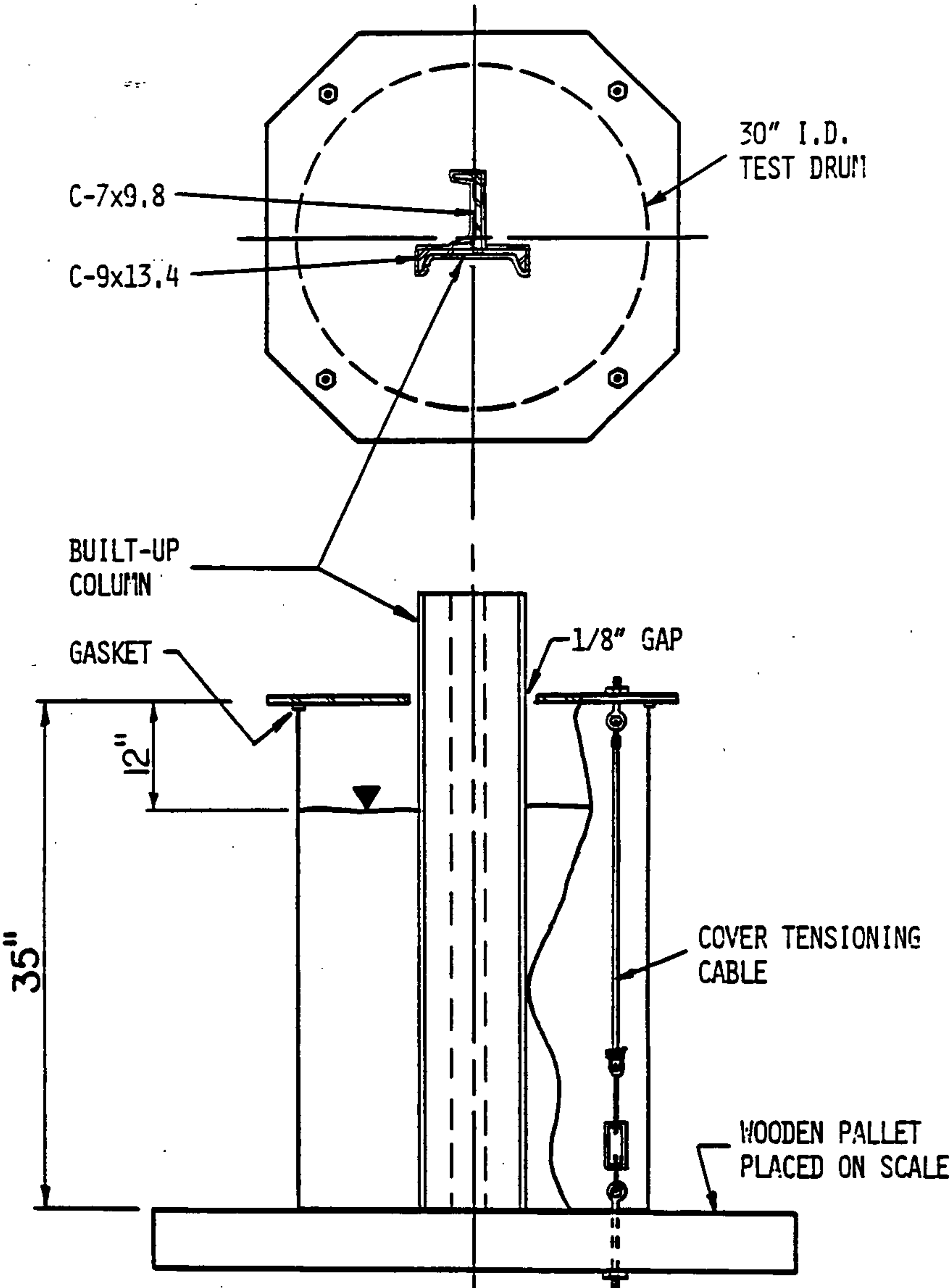


FIGURE E13 IFR DECK FITTING EMISSION TEST NO. 15, 1/8 IN. GAP AROUND BUILT-UP COLUMN WITH 30 IN. DIA. COLUMN WELL

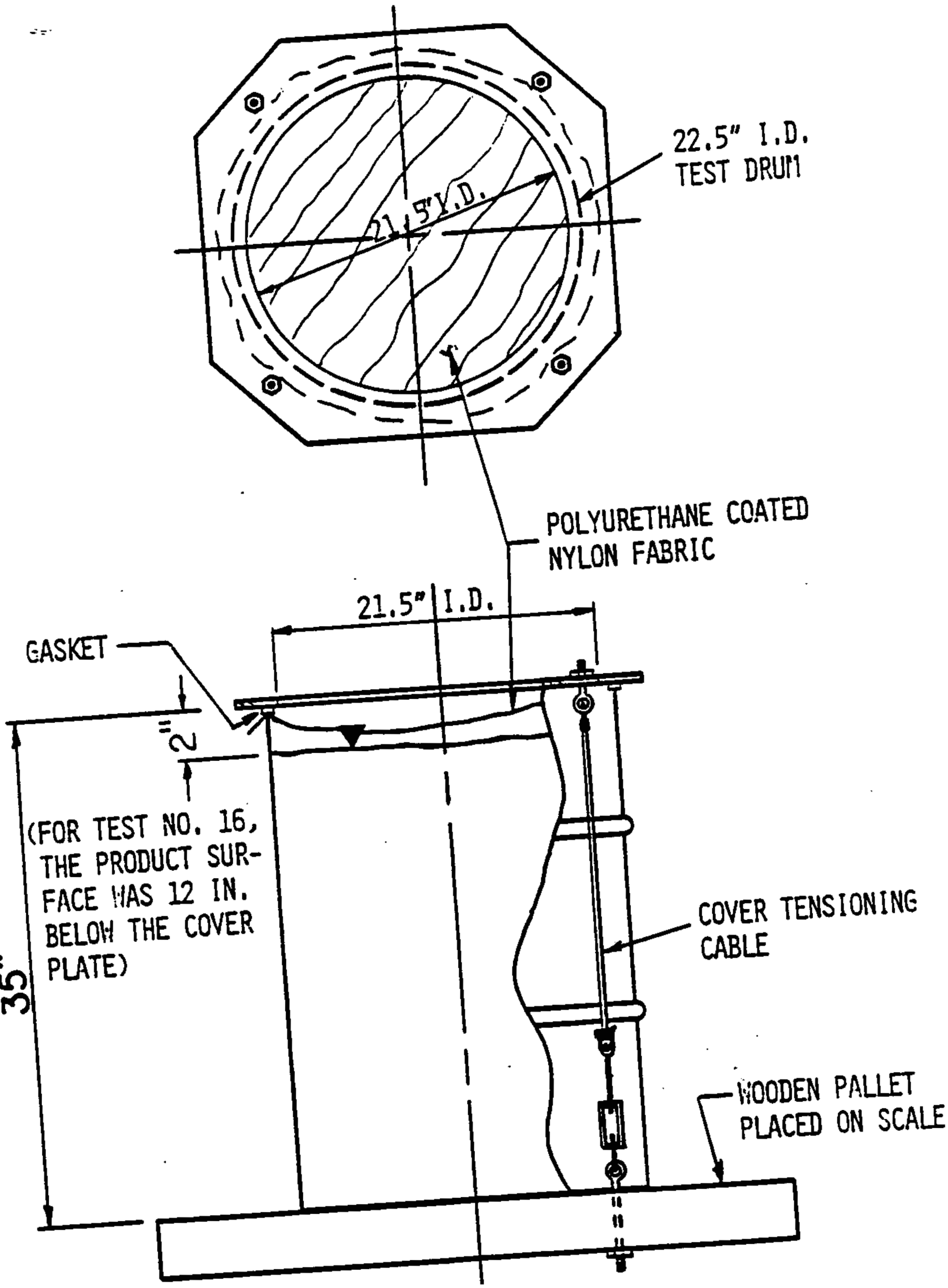


FIGURE E14 BENCH SCALE PERMEABILITY TEST NOS. 16,17,18,19,20
PERMEABILITY OF POLYURETHANE COATED NYLON FABRIC

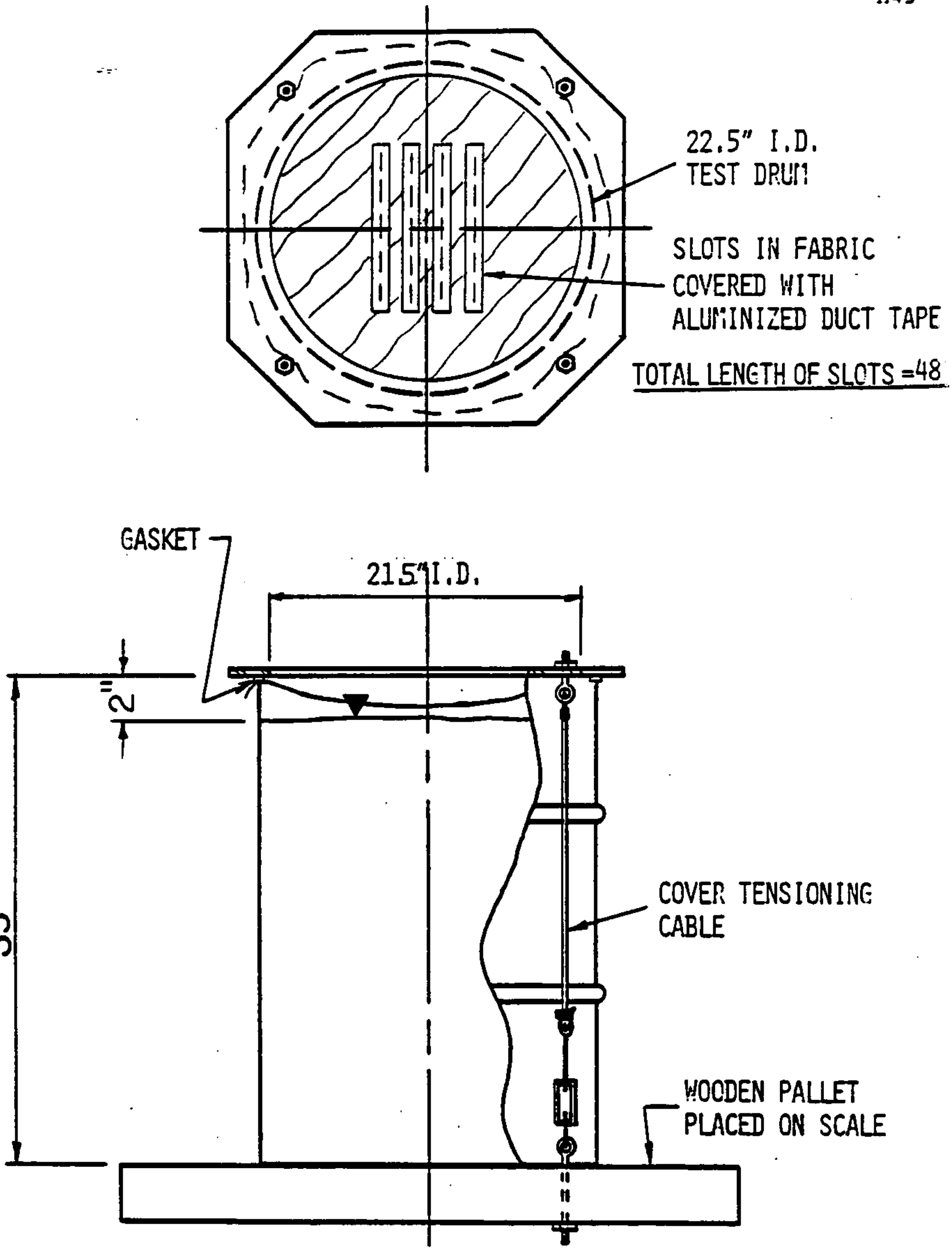


FIGURE E15 BENCH SCALE PERMEABILITY TEST NO . 21, PERMEABILITY OF POLYUREATHANE COATED NYLON FABRIC WITH TAPED SEAMS

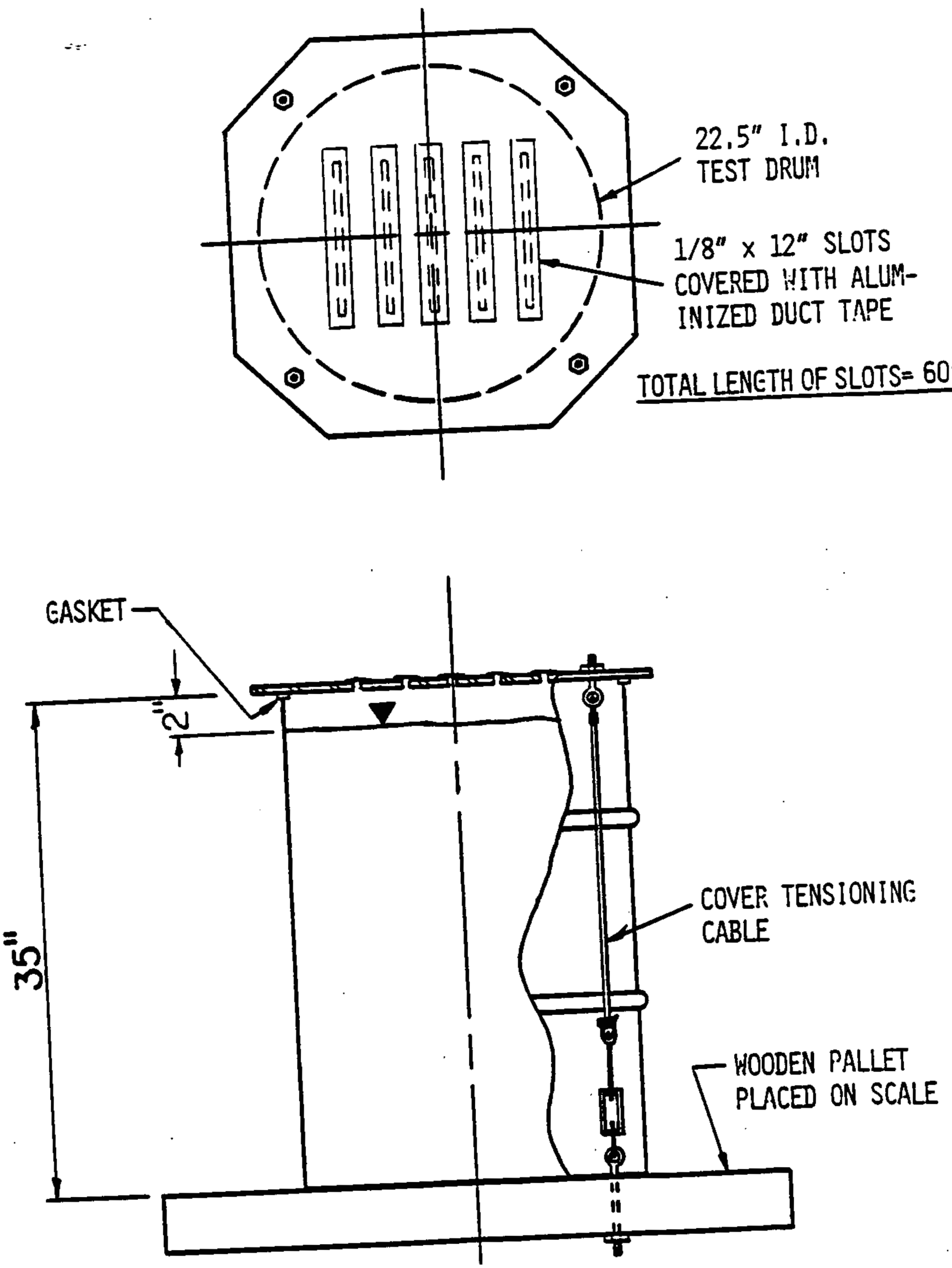


FIGURE E16 BENCH SCALE PERMEABILITY TEST NO. 23, PERMEABILITY OF TAPED JOINTS IN SHEET ALUMINUM

APPENDIX F

Laboratory Evaporation Test Data

Table F1 Laboratory Evaporation Test Data, Series 1

Flask No.	Test Duration (Days)	Weight (gm)	Weight Change (gm)	Loss Rate (gm/day)	Notes
1	0	234.53	0	0	n-Pentane, Type I
	5	231.12	3.41	0.682	
	12	226.33	8.20	0.684	
	19	221.50	13.03	0.686	
	26	216.52	18.01	0.694	Final
2	0	238.58	0	0	n-Pentane, Type I
	5	235.58	3.00	0.600	
	12	231.29	7.29	0.607	
	19	226.87	11.71	0.617	
	26	222.43	16.15	0.622	Final
3	0	236.73	0	0	n-Pentane, Type I
	5	233.65	3.08	0.617	
	12	229.32	7.41	0.617	
	19	224.80	11.93	0.629	
	26	220.32	16.41	0.631	Final
4	0	244.09	0	0	n-Pentane, Type I
	5	240.78	3.31	0.662	
	12	236.07	8.02	0.667	
	19	231.24	12.85	0.677	
	26	226.38	17.71	0.682	Final
5	0	242.77	0	0	n-Pentane, Type I
	5	239.67	3.10	0.619	
	12	235.32	7.45	0.622	
	19	230.76	12.01	0.631	
	26	226.16	16.61	0.641	Final

Table F1 Laboratory Evaporation Test Data, Series 1

Flask No.	Test Duration (Days)	Weight (gm)	Weight Change (gm)	Loss Rate (gm/day)	Notes
6	0	229.39	0	0	n-Hexane, Type I
	5	228.53	0.860	0.172	
	12	227.28	2.11	0.176	
	19	226.00	3.39	0.178	
	26	224.72	4.67	0.180	Final
7	0	243.80	0	0	n-Hexane, Type I
	5	242.95	0.850	0.170	
	12	241.72	2.08	0.173	
	19	240.44	3.36	0.177	
	26	239.17	4.63	0.178	Final
8	0	242.95	0	0	n-Hexane, Type I
	5	242.08	0.870	0.174	
	12	240.85	2.10	0.175	
	19	239.58	3.37	0.177	
	26	238.32	4.63	0.178	Final
9	0	240.69	0	0	n-Hexane, Type I
	5	239.93	0.76	0.152	
	12	238.77	1.92	0.160	
	19	237.58	3.11	0.164	
	26	236.37	4.32	0.166	Final
10	0	239.26	0	0	n-Hexane, Type I
	5	238.40	0.860	0.172	
	12	237.18	2.08	0.173	
	19	235.89	3.37	0.177	
	26	234.60	4.66	0.179	Final

Table F1 Laboratory Evaporation Test Data, Series 1

Flask No.	Test Duration (Days)	Weight (gm)	Weight Change (gm)	Loss Rate (gm/day)	Notes
11	0	243.51	0	0	n-Heptane, Type I
	5	243.34	0.170	0.034	
	12	243.04	0.470	0.039	
	19	242.68	0.830	0.044	
	26	242.30	1.21	0.046	Final
12	0	246.54	0	0	n-Heptane, Type I
	5	246.37	0.170	0.034	
	12	246.07	0.470	0.039	
	19	245.74	0.800	0.042	
	26	245.40	1.14	0.044	Final
13	0	246.31	0	0	n-Heptane, Type I
	5	246.15	0.160	0.032	
	12	245.86	0.450	0.037	
	19	245.53	0.780	0.041	
	26	245.18	1.13	0.043	Final
14	0	247.14	0	0	n-Heptane, Type I
	5	246.98	0.160	0.032	
	12	246.70	0.440	0.037	
	19	246.39	0.750	0.039	
	26	246.06	1.08	0.042	Final
15	0	247.55	0	0	n-Heptane, Type I
	5	247.39	0.160	0.032	
	12	247.12	0.430	0.036	
	19	246.79	0.760	0.040	
	26	246.50	1.05	0.040	Final

Table F1 Laboratory Evaporation Test Data, Series 1

Flask No.	Test Duration (Days)	Weight (gm)	Weight Change (gm)	Loss Rate (gm/day)	Notes
16	0	247.26	0	0	n-Octane, Type I
	5	246.24	0.020	0.004	
	12	247.15	0.110	0.009	
	19	247.02	0.240	0.013	
	26	246.91	0.350	0.013	Final
17	0	247.08	0	0	n-Octane, Type I
	5	247.07	0.010	0.002	
	12	246.99	0.090	0.008	
	19	246.88	0.200	0.011	
	26	246.78	0.300	0.012	Final
18	0	245.76	0	0	n-Octane, Type I
	5	245.73	0.030	0.006	
	12	245.66	0.100	0.008	
	19	245.55	0.210	0.011	
	26	245.43	0.330	0.013	Final
19	0	248.26	0	0	n-Octane, Type I
	5	248.24	0.020	0.004	
	12	248.17	0.090	0.008	
	19	248.07	0.190	0.010	
	26	247.97	0.290	0.011	Final
20	0	247.43	0	0	n-Octane, Type I
	5	247.41	0.020	0.004	
	12	247.34	0.090	0.008	
	19	247.23	0.200	0.011	
	26	247.14	0.290	0.011	Final

Table F1 Laboratory Evaporation Test Data, Series 1

Flask No.	Test Duration (Days)	Weight (gm)	Weight Change (gm)	Loss Rate (gm/day)	Notes
21	0	244.15	0	0	i-Octane, Type I
	5	243.92	0.230	0.046	
	12	243.55	0.600	0.050	
	19	243.15	1.00	0.053	
	26	242.79	1.36	0.052	Final
22	0	241.54	0	0	i-Octane, Type I
	5	241.33	0.210	0.042	
	12	240.95	0.590	0.049	
	19	240.57	0.970	0.051	
	26	240.19	1.35	0.052	Final
23	0	247.21	0	0	i-Octane, Type I
	5	247.02	0.190	0.038	
	12	246.69	0.520	0.043	
	19	246.35	0.860	0.045	
	26	246.01	1.20	0.046	Final
24	0	247.95	0	0	i-Octane, Type I
	5	247.77	0.180	0.036	
	12	247.45	0.500	0.042	
	19	247.10	0.850	0.045	
	26	246.77	1.18	0.045	Final
25	0	247.15	0	0	i-Octane, Type I
	5	246.95	0.200	0.040	
	12	246.63	0.520	0.043	
	19	246.30	0.850	0.045	
	26	245.97	1.18	0.045	Final

Table F1 Laboratory Evaporation Test Data, Series 1

Flask No.	Test Duration (Days)	Weight (gm)	Weight Change (gm)	Loss Rate (gm/day)	Notes
26	0	275.66	0	0	Benzene, Type I
	5	275.20	0.460	0.092	
	12	273.96	1.70	0.142	
	19	272.45	3.21	0.169	
	26	270.75	4.91	0.189	Final
27	0	274.23	0	0	Benzene, Type I
	5	273.81	0.420	0.084	
	12	272.62	1.61	0.134	
	19	271.18	3.05	0.161	
	26	269.59	4.64	0.179	Final
28	0	270.09	0	0	Benzene, Type I
	5	269.71	0.380	0.076	
	12	268.55	1.54	0.128	
	19	266.99	3.10	0.163	
	26	265.15	4.94	0.190	Final
29	0	269.68	0	0	Benzene, Type I
	5	269.28	0.400	0.080	
	12	268.17	1.51	0.126	
	19	266.69	2.99	0.157	
	26	264.96	4.72	0.181	Final
30	0	267.41	0	0	Benzene, Type I
	5	267.00	0.410	0.082	
	12	265.87	1.54	0.128	
	19	264.42	2.99	0.157	
	26	262.68	4.73	0.182	Final

Table F2 Laboratory Evaporation Test Data, Series 2

Flask No.	Test Duration (Days)	Weight (gm)	Weight Change (gm)	Loss Rate (gm/day)	Notes
1	0	216.27	0	0	n-Pentane, Type II
	7	216.15	0.120	0.017	
	14	215.95	0.320	0.023	
	21	215.69	0.580	0.028	
	28	215.42	0.850	0.030	Final
2	0	222.20	0	0	n-Pentane, Type II
	7	222.14	0.060	0.009	
	14	222.02	0.180	0.013	
	21	221.84	0.360	0.017	
	28	221.62	0.580	0.021	Final
3	0	220.08	0	0	n-Pentane, Type II
	7	219.94	0.140	0.020	
	14	219.78	0.300	0.021	
	21	219.57	0.510	0.024	
	28	219.34	0.740	0.026	Final
4	0	226.16	0	0	n-Pentane, Type II
	7	226.05	0.110	0.016	
	14	225.89	0.270	0.019	
	21	225.67	0.490	0.023	
	28	225.43	0.730	0.026	Final
5	0	225.90	0	0	n-Pentane, Type II
	7	225.78	0.120	0.017	
	14	225.59	0.310	0.022	
	21	225.35	0.550	0.026	
	28	225.06	0.840	0.030	Final

Table F2 Laboratory Evaporation Test Data, Series 2

Flask No.	Test Duration (Days)	Weight (gm)	Weight Change (gm)	Loss Rate (gm/day)	Notes
6	0	224.56	0	0	n-Hexane Type II
	7	224.51	0.050	0.007	
	14	224.44	0.120	0.009	
	21	224.34	0.220	0.011	
	28	224.21	0.350	0.013	Final
7	0	239.00	0	0	n-Hexane, Type II
	7	238.95	0.050	0.007	
	14	238.91	0.090	0.006	
	21	238.81	0.190	0.009	
	28	238.68	0.320	0.011	Final
8	0	238.16	0	0	n-Hexane, Type II
	7	238.11	0.050	0.007	
	14	238.04	0.120	0.009	
	21	237.93	0.230	0.011	
	28	237.78	0.380	0.014	Final
9	0	236.19	0	0	n-Hexane, Type II
	7	236.13	0.060	0.009	
	14	236.05	0.140	0.010	
	21	235.93	0.260	0.012	
	28	235.78	0.410	0.015	Final
10	0	234.43	0	0	n-Hexane, Type II
	7	234.31	0.120	0.017	
	14	234.19	0.240	0.017	
	21	234.04	0.390	0.019	
	28	233.88	0.550	0.020	Final

Table F2 Laboratory Evaporation Test Data, Series 2

Flask No.	Test Duration (Days)	Weight (gm)	Weight Change (gm)	Loss Rate (gm/day)	Notes
16	0	246.74	0	0	n-Octane, Type II
	7	246.71	0.030	0.004	
	14	246.68	0.060	0.004	
	21	246.62	0.120	0.006	
	28	246.55	0.190	0.007	Final
17	0	246.62	0	0	n-Octane, Type II
	7	246.57	0.050	0.007	
	14	246.54	0.080	0.006	
	21	246.46	0.160	0.008	
	28	246.39	0.230	0.008	Final
18	0	245.27	0	0	n-Octane, Type II
	7	245.23	0.040	0.006	
	14	245.23	0.040	0.003	
	21	245.19	0.080	0.004	
	28	245.12	0.150	0.005	Final
19	0	247.80	0	0	n-Octane, Type II
	7	247.78	0.020	0.003	
	14	247.78	0.020	0.001	
	21	247.75	0.050	0.002	
	28	247.69	0.110	0.004	Final
20	0	246.99	0	0	n-Octane, Type II
	7	246.97	0.020	0.003	
	14	246.97	0.020	0.001	
	21	246.95	0.040	0.002	
	28	246.90	0.090	0.003	Final

Table F2 Laboratory Evaporation Test Data, Series 2

Flask No.	Test Duration (Days)	Weight (gm)	Weight Change (gm)	Loss Rate (gm/day)	Notes
26	0	270.57	0	0	Benzene, Type II
	7	269.54	1.03	0.147	
	14	268.29	2.28	0.163	
	21	266.83	3.74	0.178	
	28	265.30	5.27	0.188	Final
27	0	269.43	0	0	Benzene, Type II
	7	268.48	0.950	0.136	
	14	267.24	2.19	0.156	
	21	265.79	3.64	0.173	
	28	264.27	5.16	0.184	Final
28	0	264.98	0	0	Benzene, Type II
	7	263.68	1.30	0.186	
	14	262.15	2.83	0.202	
	21	260.48	4.50	0.214	
	28	258.75	6.23	0.223	Final
29	0	264.78	0	0	Benzene, Type II
	7	263.56	1.22	0.174	
	14	262.16	2.62	0.187	
	21	260.70	4.08	0.194	
	28	259.19	5.59	0.200	Final
30	0	262.50	0	0	Benzene, Type II
	7	261.24	1.26	0.180	
	14	259.83	2.67	0.191	
	21	258.24	4.26	0.203	
	28	256.60	5.90	0.211	Final

Table F3 Laboratory Evaporation Test Data, Series 3

Flask No.	Test Duration (Days)	Weight (gm)	Weight Change (gm)	Loss Rate (gm/day)	Notes
31	0	247.96	0	0	n-Pentane/n-Octane, Type I
	6	246.48	1.48	0.247	
	13	244.75	3.21	0.247	
	20	243.02	4.94	0.247	
	27	241.33	6.63	0.246	Final
32	0	247.53	0	0	n-Pentane/n-Octane, Type I
	6	246.14	1.39	0.232	
	13	244.55	2.98	0.229	
	20	242.94	4.59	0.230	
	27	241.37	6.16	0.228	Final
33	0	246.11	0	0	n-Pentane/n-Octane, Type I
	6	244.63	1.48	0.247	
	13	242.91	3.20	0.246	
	20	241.21	4.90	0.245	
	27	239.56	6.55	0.243	Final
34	0	243.42	0	0	n-Pentane/n-Octane, Type I
	6	241.98	1.44	0.240	
	13	240.32	3.10	0.239	
	20	238.68	4.74	0.237	
	27	237.09	6.33	0.234	Final
35	0	245.98	0	0	n-Pentane/n-Octane, Type I
	6	244.62	1.36	0.227	
	13	243.00	2.98	0.229	
	20	241.43	4.55	0.228	
	27	239.89	6.09	0.226	Final

Table F3 Laboratory Evaporation Test Data, Series 3

Flask No.	Test Duration (Days)	Weight (gm)	Weight Change (gm)	Loss Rate (gm/day)	Notes
36	0	257.64	0	0	n-Pentane/n-Octane, Type III
	6	256.88	0.76	0.127	
	13	256.00	1.74	0.134	
	20	255.11	2.63	0.132	
	27	254.15	3.59	0.133	Final
37	0	260.03	0	0	n-Pentane/n-Octane, Type III
	6	259.25	0.78	0.130	
	13	258.38	1.65	0.127	
	20	257.50	2.53	0.127	
	27	256.60	3.43	0.127	Final
38	0	259.84	0	0	n-Pentane/n-Octane, Type III
	6	259.10	0.74	0.123	
	13	258.23	1.61	0.124	
	20	257.34	2.50	0.125	
	27	256.46	3.38	0.125	Final
39	0	255.84	0	0	n-Pentane/n-Octane, Type III
	6	255.07	0.77	0.128	
	13	254.22	1.62	0.125	
	20	253.36	2.48	0.124	
	27	252.52	3.32	0.123	Final
40	0	259.48	0	0	n-Pentane/n-Octane, Type III
	6	258.69	0.79	0.132	
	13	257.79	1.69	0.130	
	20	256.88	2.60	0.130	
	27	255.96	3.52	0.130	Final

Table F4 Laboratory Evaporation Test Data, Series 4

Flask No.	Test Duration (days)	Weight (gm)	Weight Change (gm)	Loss Rate (gm/day)	Notes
1	0	341.51	0	0	n-Hexane, Type I
	1	341.35	0.160	0.160	
	4	341.00	0.510	0.128	
	8	340.55	0.960	0.120	
	12	340.06	1.45	0.121	
	18	339.31	2.20	0.122	
	25	338.48	3.03	0.121	
	32	337.62	3.89	0.122	
	42	336.43	5.08	0.121	Final
2	0	327.67	0	0	n-Hexane, Type I
	1	327.52	0.150	0.150	
	4	327.16	0.510	0.128	
	8	326.72	0.950	0.119	
	12	326.26	1.41	0.118	
	18	325.51	2.16	0.120	
	25	324.68	2.99	0.120	
	32	323.83	3.84	0.120	
	42	322.62	5.05	0.120	Final
3	0	329.40	0	0	n-Hexane, Type I
	1	329.24	0.160	0.160	
	4	328.90	0.500	0.125	
	8	328.45	0.950	0.119	
	12	327.97	1.43	0.119	
	18	327.22	2.18	0.121	
	25	326.40	3.00	0.120	
	32	325.55	3.85	0.120	
	42	324.35	5.05	0.120	Final
4	0	329.26	0	0	n-Hexane, Type I
	1	329.12	0.140	0.140	
	4	328.76	0.500	0.125	
	8	328.31	0.950	0.119	
	12	327.85	1.41	0.118	
	18	327.11	2.15	0.119	
	25	326.29	2.97	0.119	
	32	325.45	3.81	0.119	
	42	324.25	4.01	0.119	Final
	0				
	1				
	4				
	8				
	12				
	18				
	25				
	32				
	42				

Table F4 Laboratory Evaporation Test Data, Series 4

Flask No.	Test Duration (days)	Weight (gms)	Weight Change (gm)	Loss Rate (gm/day)	Notes
6	0	348.57	0	0	n-Hexane, Type III
	1	348.42	0.150	0.150	
	4	348.02	0.550	0.138	
	8	347.42	1.15	0.144	
	12	346.90	1.67	0.139	
	18	346.01	2.56	0.142	
	25	345.01	3.56	0.142	
	32	343.97	4.60	0.144	
	42	342.19	6.38	0.152	Final
7	0	335.18	0	0	n-Hexane, Type III
	1	335.02	0.160	0.160	
	4	334.65	0.530	0.133	
	8	334.08	1.10	0.138	
	12	333.54	1.64	0.137	
	18	332.65	2.53	0.141	
	25	331.66	3.52	0.141	
	32	330.61	4.57	0.143	
	42	328.87	6.31	0.150	Final
8	0	333.12	0	0	n-Hexane, Type III
	1	332.95	0.170	0.170	
	4	332.57	0.550	0.138	
	8	331.95	1.17	0.146	
	12	331.47	1.65	0.138	
	18	330.62	2.50	0.139	
	25	329.66	3.46	0.138	
	32	328.69	4.43	0.138	
	42	326.90	6.22	0.148	Final
9	0	345.37	0	0	n-Hexane, Type III
	1	345.21	0.160	0.160	
	4	344.83	0.540	0.135	
	8	344.19	1.18	0.148	
	12	343.63	1.74	0.145	
	18	342.70	2.67	0.148	
	25	341.66	3.71	0.148	
	32	340.62	4.75	0.148	
	42	338.76	6.61	0.157	Final
10	0	327.40	0	0	n-Hexane, Type III
	1	327.24	0.160	0.160	
	4	326.88	0.520	0.130	
	8	326.28	1.12	0.140	
	12	325.63	1.77	0.148	
	18	324.72	2.68	0.149	
	25	323.69	3.71	0.148	
	32	322.63	4.77	0.149	
	42	320.73	6.67	0.159	Final

Table F4 Laboratory Evaporation Test Data, Series 4

Flask No.	Test Duration (days)	Weight (gms)	Weight Change (gm)	Loss Rate (gm/day)	Notes
11	0	354.24	0	0	Benzene,
	1	354.15	0.090	0.090	Type I
	4	353.96	0.280	0.070	
	8	353.68	0.560	0.070	
	12	353.44	0.800	0.067	
	18	353.04	1.20	0.067	
	25	352.59	1.65	0.066	
	32	352.12	2.12	0.066	
	42	351.44	2.80	0.067	Final
12	0	363.26	0	0	Benzene,
	1	363.18	0.080	0.080	Type I
	4	362.97	0.290	0.073	
	8	362.71	0.550	0.069	
	12	362.44	0.820	0.068	
	18	362.03	1.23	0.068	
	25	361.58	1.68	0.067	
	32	361.10	2.16	0.068	
	42	360.40	2.86	0.068	Final
13	0	366.70	0	0	Benzene,
	1	366.63	0.070	0.070	Type I
	4	366.45	0.250	0.063	
	8	366.17	0.530	0.067	
	12	365.93	0.770	0.064	
	18	365.53	1.17	0.065	
	25	365.08	1.62	0.065	
	32	364.60	2.10	0.066	
	42	363.93	2.77	0.066	Final
14	0	355.40	0	0	Benzene,
	1	355.32	0.080	0.080	Type I
	4	355.13	0.270	0.068	
	8	354.86	0.540	0.068	
	12	354.59	0.810	0.068	
	18	354.18	1.22	0.068	
	25	353.73	1.67	0.068	
	32	353.26	2.14	0.067	
	42	352.57	2.83	0.067	Final
	0				
	1				
	4				
	8				
	12				
	18				
	25				
	32				
	42				

Table F4 Laboratory Evaporation Test Data, Series 4

Flask No.	Test Duration (days)	Weight (gms)	Weight Change (gm)	Loss Rate (gm/day)	Notes
16	0	363.42	0	0	Benzene,
	1	363.31	0.110	0.110	Type III
	4	363.02	0.400	0.100	
	8	362.72	0.700	0.088	
	12	362.18	1.24	0.103	
	18	361.58	1.84	0.102	
	25	360.90	2.52	0.101	
	32	360.22	3.20	0.100	
	42	359.21	4.21	0.100	Final
17	0	378.38	0	0	Benzene,
	1	378.29	0.090	0.090	Type III
	4	378.01	0.370	0.093	
	8	377.65	0.730	0.091	
	12	377.31	1.07	0.089	
	18	376.85	1.53	0.085	
	25	376.31	2.07	0.083	
	32	375.77	2.61	0.082	
	42	374.93	3.45	0.082	Final
18	0	368.93	0	0	Benzene,
	1	368.85	0.080	0.080	Type III
	4	368.59	0.340	0.085	
	8	368.25	0.680	0.085	
	12	368.01	0.920	0.077	
	18	367.60	1.33	0.074	
	25	367.15	1.78	0.071	
	32	366.69	2.24	0.070	
	42	366.02	2.91	0.069	Final
19	0	361.66	0	0	Benzene,
	1	361.57	0.090	0.090	Type III
	4	361.32	0.340	0.085	
	8	361.00	0.660	0.083	
	12	360.72	0.940	0.078	
	18	360.29	1.37	0.076	
	25	359.82	1.84	0.074	
	32	359.35	2.31	0.072	
	42	358.68	2.98	0.071	Final
20	0	378.44	0	0	Benzene,
	1	378.36	0.080	0.080	Type III
	4	378.09	0.350	0.088	
	8	377.79	0.650	0.081	
	12	377.26	1.18	0.098	
	18	376.74	1.70	0.094	
	25	376.19	2.25	0.090	
	32	375.64	2.80	0.088	
	42	374.80	3.64	0.087	Final

Table F4 Laboratory Evaporation Test Data, Series 4

Flask No.	Test Duration (days)	Weight (gms)	Weight Change (gm)	Loss Rate (gm/day)	Notes
21	0	339.72	0	0	Gasoline, Type I
	1	339.37	0.350	0.350	
	4	338.42	1.30	0.325	
	8	337.30	2.42	0.303	
	12	336.18	3.54	0.295	
	18	334.71	5.01	0.278	
	25	333.18	6.54	0.262	
	32	331.78	7.94	0.248	
	42	329.99	9.73	0.232	Final
24	0	337.62	0	0	Gasoline, Type I
	1	337.26	0.360	0.360	
	4	336.32	1.30	0.325	
	8	335.16	2.46	0.308	
	12	334.09	3.53	0.294	
	18	332.61	5.01	0.278	
	25	331.07	6.55	0.262	
	32	329.66	7.96	0.249	
	42	327.82	9.80	0.233	Final
25	0	340.85	0	0	Gasoline, Type I
	1	340.50	0.350	0.350	
	4	339.54	1.31	0.328	
	8	338.39	2.46	0.308	
	12	337.31	3.54	0.295	
	18	335.85	5.00	0.278	
	25	334.32	6.53	0.261	
	32	332.95	7.90	0.247	
	42	331.17	9.68	0.230	Final
	0				
	1				
	4				
	8				
	12				
	18				
	25				
	32				
	42				
	0				
	1				
	4				
	8				
	12				
	18				
	25				
	32				
	42				

Table F4 Laboratory Evaporation Test Data, Series 4

Flask No.	Test Duration (days)	Weight (gms)	Weight Change (gm)	Loss Rate (gm/day)	Notes
26	0	346.81	0	0	Gasoline, Type III
	1	346.51	0.300	0.300	
	4	345.72	1.09	0.273	
	8	345.09	1.72	0.215	
	12	343.99	2.82	0.235	
	18	342.87	3.94	0.219	
	25	341.68	5.13	0.205	
	32	340.50	6.31	0.197	
	42	338.65	8.16	0.194	Final
27	0	342.89	0	0	Gasoline, Type III
	1	342.58	0.310	0.310	
	4	341.85	1.04	0.260	
	8	341.11	1.78	0.223	
	12	340.32	2.57	0.214	
	18	339.23	3.66	0.203	
	25	338.10	4.79	0.192	
	32	337.03	5.86	0.183	
	42	335.35	7.54	0.180	Final
28	0	340.66	0	0	Gasoline, Type III
	1	340.33	0.330	0.330	
	4	339.59	1.07	0.268	
	8	338.93	1.73	0.216	
	12	338.02	2.64	0.220	
	18	336.95	3.71	0.206	
	25	335.81	4.85	0.194	
	32	334.74	5.92	0.185	
	42	333.08	7.58	0.180	Final
29	0	342.22	0	0	Gasoline, Type III
	1	341.91	0.310	0.310	
	4	341.18	1.04	0.260	
	8	340.54	1.68	0.210	
	12	339.80	2.42	0.202	
	18	338.76	3.46	0.192	
	25	337.69	4.53	0.181	
	32	336.68	5.54	0.173	
	42	335.12	7.10	0.169	Final
30	0	347.42	0	0	Gasoline, Type III
	1	347.12	0.300	0.300	
	4	346.41	1.01	0.253	
	8	345.68	1.74	0.218	
	12	344.74	2.68	0.223	
	18	343.55	3.87	0.215	
	25	342.33	5.09	0.205	
	32	341.15	6.27	0.196	
	42	339.19	8.23	0.196	Final

Table F4 Laboratory Evaporation Test Data, Series 4

Flask No.	Test Duration (days)	Weight (gms)	Weight Change (gm)	Loss Rate (gm/day)	Notes
31	0	352.08	0	0	Propane/n-Octane, Type I
	1	351.95	0.130	0.130	
	4	351.64	0.440	0.110	
	8	351.34	0.740	0.093	
	12	351.12	0.960	0.080	
	18	350.90	1.18	0.066	
	25	350.74	1.34	0.054	
	32	350.60	1.48	0.046	
	42	350.46	1.62	0.039	Final
32	0	341.17	0	0	Propane/n-Octane, Type I
	1	341.02	0.150	0.150	
	4	340.72	0.450	0.113	
	8	340.43	0.740	0.093	
	12	340.20	0.970	0.081	
	18	339.99	1.18	0.066	
	25	339.84	1.33	0.053	
	32	339.71	1.46	0.046	
	42	339.58	1.59	0.038	Final
34	0	335.47	0	0	Propane/n-Octane, Type I
	1	335.34	0.130	0.130	
	4	335.02	0.450	0.113	
	8	334.72	0.750	0.094	
	12	334.51	0.960	0.080	
	18	334.30	1.17	0.065	
	25	334.13	1.34	0.054	
	32	333.99	1.48	0.046	
	42	333.85	1.62	0.039	Final
35	0	335.87	0	0	Propane/n-Octane, Type I
	1	335.74	0.130	0.130	
	4	335.41	0.460	0.115	
	8	335.12	0.750	0.094	
	12	334.88	0.990	0.083	
	18	334.67	1.20	0.067	
	25	334.51	1.36	0.054	
	32	334.38	1.49	0.047	
	42	334.25	1.62	0.039	Final
	0				
	1				
	4				
	8				
	12				
	18				
	25				
	32				
	42				

Table F4 Laboratory Evaporation Test Data, Series 4

Flask No.	Test Duration (days)	Weight (gms)	Weight Change (gm)	Loss Rate (gm/day)	Notes
36	0	338.71	0	0	Propane/n-Octane, Type III
	1	338.61	0.100	0.100	
	4	338.28	0.430	0.108	
	8	337.98	0.730	0.091	
	12	337.57	1.14	0.095	
	18	337.15	1.56	0.087	
	25	336.74	1.97	0.079	
	32	336.37	2.34	0.073	
	42	335.85	2.86	0.068	Final
38	0	340.14	0	0	Propane/n-Octane, Type III
	1	340.03	0.110	0.110	
	4	339.74	0.400	0.100	
	8	339.39	0.750	0.094	
	12	339.11	1.03	0.086	
	18	338.73	1.41	0.078	
	25	338.37	1.77	0.071	
	32	338.05	2.09	0.065	
	42	337.59	2.55	0.061	Final
39	0	340.42	0	0	Propane/n-Octane, Type III
	1	340.32	0.100	0.100	
	4	340.02	0.400	0.100	
	8	339.66	0.760	0.095	
	12	339.32	1.10	0.092	
	18	338.94	1.48	0.082	
	25	338.55	1.87	0.075	
	32	338.20	2.22	0.069	
	42	337.71	2.71	0.065	Final
40	0	340.09	0	0	Propane/n-Octane, Type III
	1	339.97	0.120	0.120	
	4	339.70	0.390	0.098	
	8	339.30	0.790	0.099	
	12	338.99	1.10	0.092	
	18	338.61	1.48	0.082	
	25	338.26	1.83	0.073	
	32	337.94	2.15	0.067	
	42	337.46	2.63	0.063	Final
	0				
	1				
	4				
	8				
	12				
	18				
	25				
	32				
	42				

APPENDIX G

Laboratory Permeability Test Data

Table G1 Laboratory Permeability Test Data For Aluminum Plate Control Samples

Sample No.	Test Duration (days)	Weight (gm)	Weight Change (gm)	Loss Rate (gm/day)	Notes
3	0	282.20	-	-	
	1	279.64	2.56	2.56	
	2	276.91	5.29	2.65	
	5	269.72	12.48	2.50	
	6	267.40	14.80	2.47	Final Value
4	0	270.69	-	-	
	1	268.62	2.07	2.07	
	2	266.46	4.23	2.12	
	5	262.01	8.68	1.74	
	6	260.48	10.21	1.70	Final Value
5	0	277.21	-	-	
	1	275.50	1.71	1.71	
	2	273.68	3.53	1.77	
	5	269.09	8.12	1.62	
	6	267.66	9.55	1.59	Final Value

Average Loss Rate = 1.92 gm/day

Standard Deviation = 25%

Table G2 Laboratory Permeability Test Data For Polyurethane Coated Nylon Fabric

Sample No.	Test Duration (days)	Weight (gm)	Weight Change (gm)	Loss Rate (gm/day)	Notes
6	0	189.53	-	-	
	1	172.92	16.61	16.61	
	2	157.78	31.75	15.88	
	5	122.57	66.96	13.39	
	6	113.42	76.11	12.69	Final Value
7	0	192.78	-	-	
	1	175.36	17.42	17.42	
	2	159.72	33.06	16.53	
	5	122.38	70.40	14.08	Final Value
8	0	216.12	-	-	
	1	197.19	18.93	18.93	
	2	182.18	33.94	16.97	
	5	146.76	69.36	13.87	
	6	137.60	78.52	13.09	Final Value
9	0	217.27	-	-	
	1	200.57	16.70	16.70	
	2	185.87	31.40	15.70	
	5	152.29	64.98	13.00	
	6	143.63	73.64	12.27	Final Value
10	0	240.79	-	-	
	1	223.97	16.82	16.82	
	2	209.14	31.65	15.83	
	5	174.00	66.79	13.36	
	6	164.51	76.28	12.71	Final Value

Average Loss Rate = 12.97 gm/day

Standard Deviation = 5.3%

APPENDIX H

Wind Speed Calibration of Test Tank

Nomenclature for Appendix H

Symbol	Description	Units
C_D	Vent Discharge Flow Coefficient	-
C_P	Pressure Coefficient at a Shell Vent Location	-
C_{PL}	Pressure Coefficient at θ = 0 rad.	-
C_{PM}	Pressure Coefficient of the Tank Vapor Space	-
C_{PO}	Pressure Coefficient at θ = 0 rad.	-
D	Diameter of Tank	ft
g_C	Gravitational Constant (32.2 lbm ft/lbf sec^2)	$\left(\frac{\text{lbm ft}}{\text{lbf sec}^2}\right)$
H	Height of Tank Shell	ft
h	Vertical Position on Tank Shell	ft
N_{RE}	Reynolds Number of Tank	-
P	Pressure at a Shell Vent Location	lbf/ft^2
P_M	Pressure of the Tank Vapor Space	lbf/ft^2
P_R	Reference Pressure	lbf/ft^2
P_O	Pressure at θ = 0 rad.	lbf/ft^2
q	Volumetric Flow Rate	ft^3/sec
q_{IN}	Total Volumetric Air Flow Rate Into the Tank Vapor Space	ft^3/sec
q_{OUT}	Total Volumetric Air Flow Rate Out of the Tank Vapor Space	ft^3/sec
W	Width of Circumferential Opening in the Tank Shell Having an Area Equivalent to 0.20 ft^2/ft dia.	ft
ρ	Density of Air	lbm/ft^3
θ	Angle Measured From the Windward Side of the Tank	deg. or rad.
θ_M	Angle at Which the Pressure at a Shell Vent Location Equals the Pressure of the Tank Vapor Space.	deg. or rad.

Appendix H

Wind Speed Calibration of Test Tank

This appendix shows the development of the wind speed calibration of the test tank. The calibration consists of a mathematical relationship between the air flow rate, q, which is passed through the vapor space of the test tank when simulating an internal floating roof tank (IFRT), and the equivalent ambient wind speed, V, which would cause this air flow rate. Since the air flow rate through the vapor space of the test tank can be systematically varied, it is thus possible to simulate different ambient wind speeds and measure their affect on emissions.

An IFRT has both shell vents and a roof vent to permit the tank vapor space to be ventilated. API Std. 650, Appendix H, Paragraph H.3.8 requires that the tank shell vents shall be at least 0.20 ft^2/ft dia., that there be at least four shell vents on each tank, and that the maximum shell vent spacing be 32 ft. The API further specifies that there be an outer roof vent with a minimum flow area of 50 in^2.

As the wind flows over the exterior of the tank, air will flow into the vapor space through some of the vents and out of the vapor space through the rest of the vents. Normally, the amount of air flow through the roof vent is small in comparison to the sum of the air flows through the shell vents, and will thus be neglected in the following analysis.

Based on wind tunnel tests, it has been possible to determine the pressure coefficient, C_p, variation over the exterior surface of the tank. In particular, pressure coefficients have been measured at the location of the shell vents. Figure H1 shows the results of wind tunnel tests reported by Purdy, et al [6] for the case where $D/H = 2$ and where $h/H = 0.85$ and 1.00. Figure H2 shows some of the results of the wind tunnel tests performed by FluiDyne Engineering Corporation under CBI Research Contract R-0150 [4]. Each data point shown on Figure H2 is based on the average of four tests, as shown in Table H1. The smoothed curve shown in this figure is believed to be a reasonable average of the test data.

The number of shell vents varies with the diameter of the tank. On large diameter tanks the number of shell vents is considerable, and the vapor space air flow pattern caused by these shell vents can be approximated by a continuous circumferential shell opening of the same equivalent shell vent area.

Consider the case where the shell vent consists of a continuous circumferential opening around the top of the shell of some width, W, which meets the API shell vent area requirement of 0.20 ft^2/ft dia. Thus,

$$W = \frac{(0.20 ft^2/ft.dia.)(\emptyset)}{(\pi)\quad(\emptyset)} = \frac{0.20}{\pi} = 0.0637 \text{ ft.}$$

Note that the API criteria would require the same width of continuous circumferential vent opening, regardless of tank diameter.

The following figure describes the shell vent case under consideration.

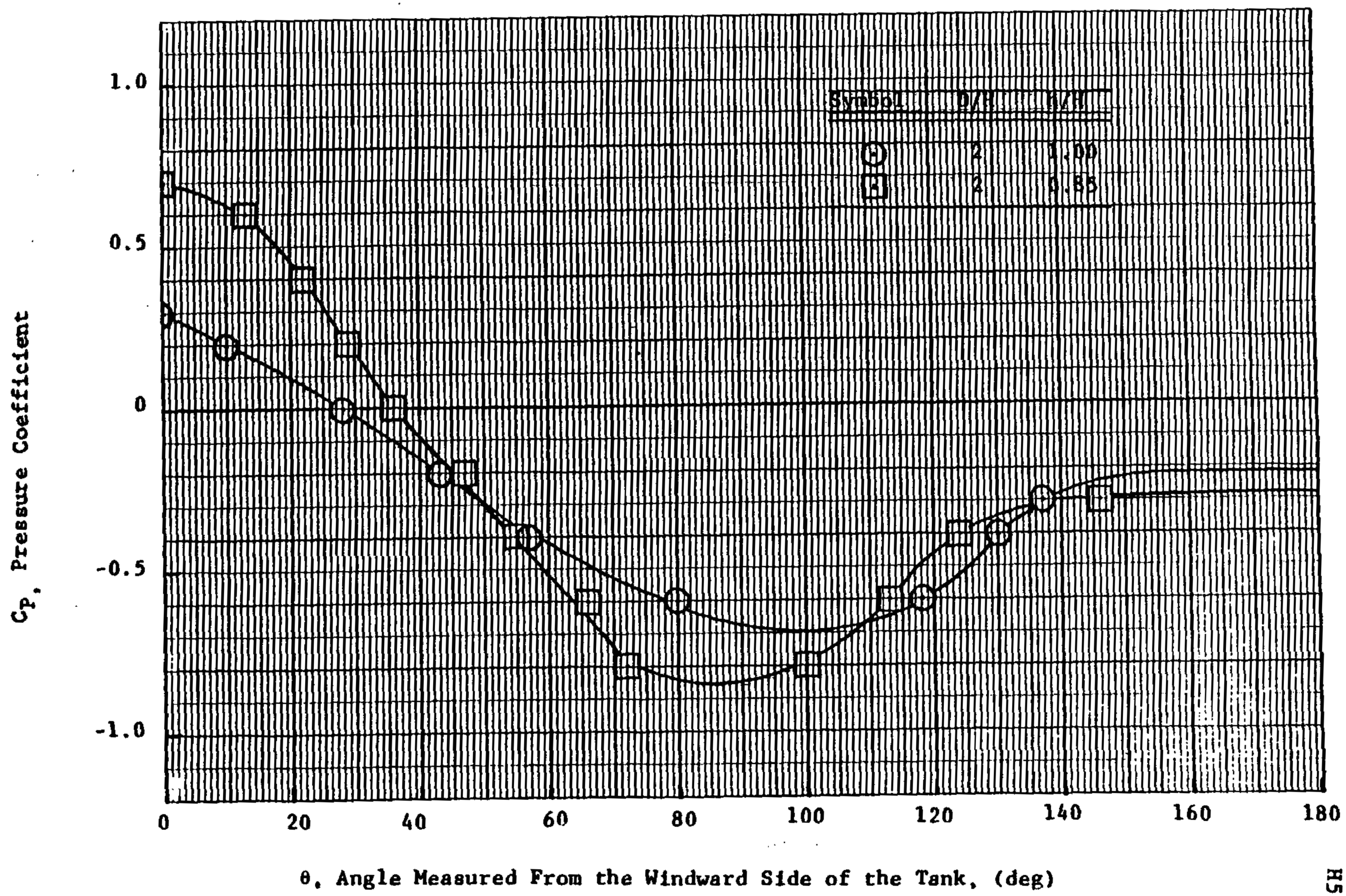
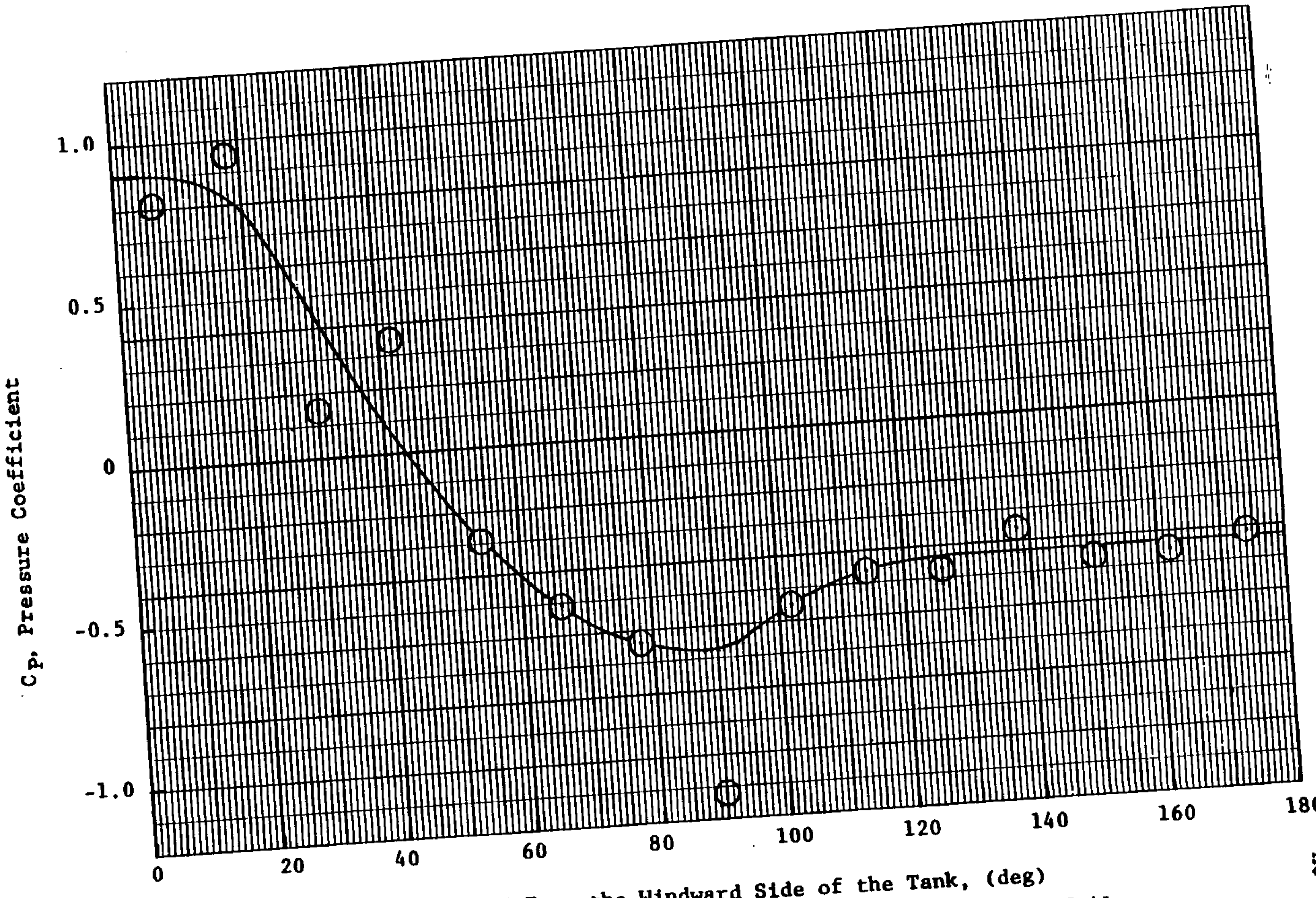


Figure H1 Shell Pressure Coefficient Versus Angle, Data of Purdey [Ref.6]

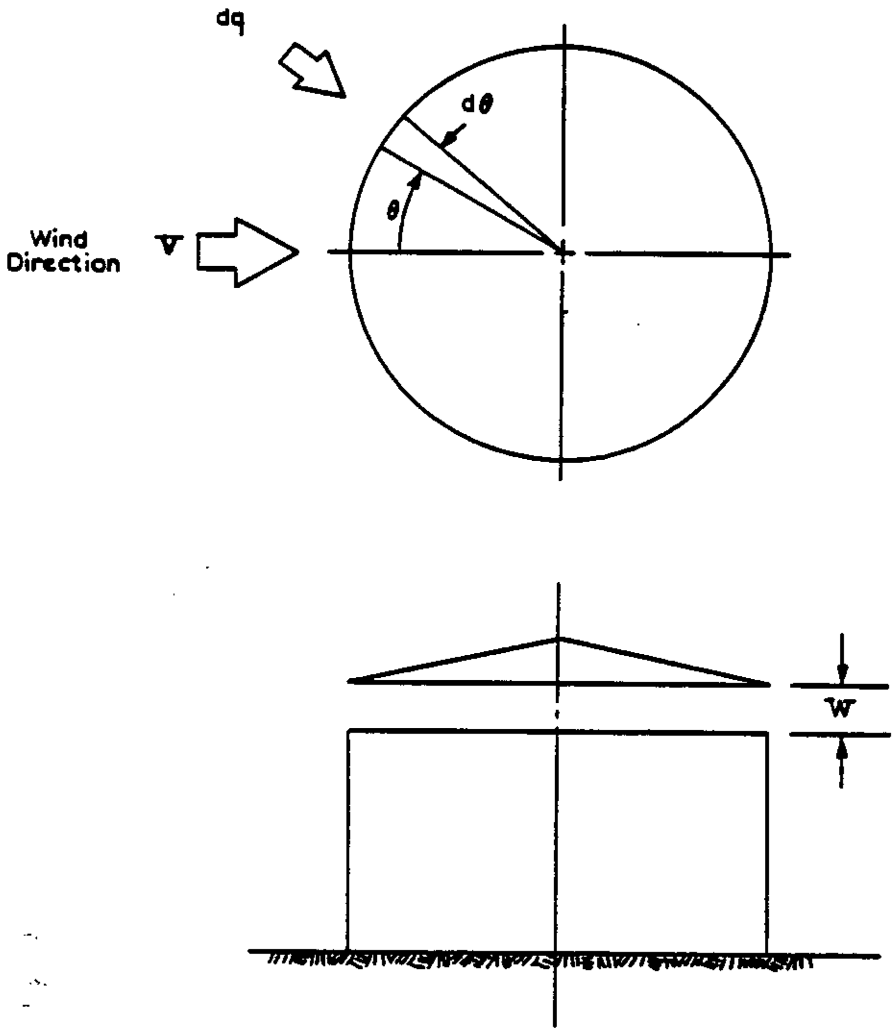


Versus Angle. Data of Helm [Ref.4]

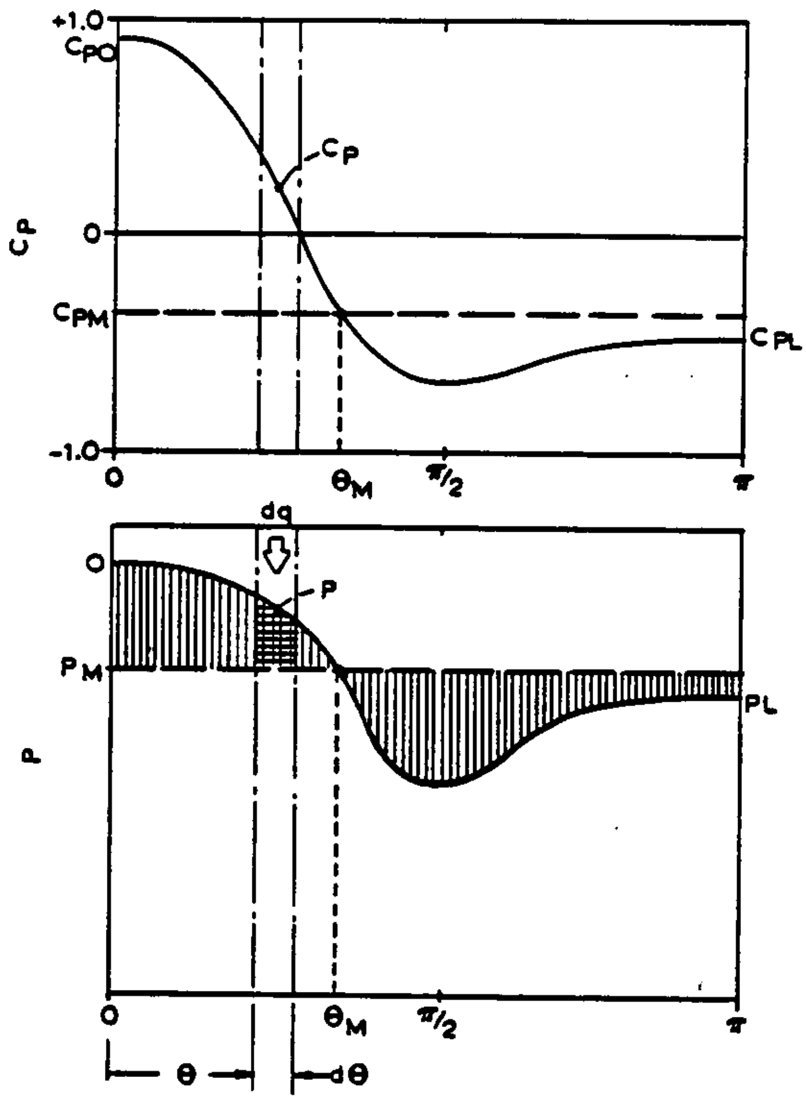
H6

Table H1 Measured Pressure Coefficients C_p
At Shell Vent Locations [Ref.4]

θ (deg)	Test No. 1.004	Test No. 2.002	Test No. 3.030	Test No. 4.002	Average Value
6	0.5726	1.0529	0.8296	0.8107	0.8164
18	0.9627	0.9643	0.9561	0.9450	0.9570
30	0.1691	0.1614	0.1566	0.1125	0.1499
42	0.4594	0.4458	0.2519	0.2609	0.3545
54	-0.3342	-0.3968	-0.2218	-0.2353	-0.2970
66	-0.5073	-0.5780	-0.4599	-0.5038	-0.5122
78	-0.7683	-0.7024	-0.5802	-0.5294	-0.6451
90	-0.9987	-1.1230	-1.2569	-1.1074	-1.1215
102	-0.5273	-0.6521	-0.5163	-0.5269	-0.5556
114	-0.4674	-0.5807	-0.4524	-0.3581	-0.4646
126	-0.4061	-0.5780	-0.5213	-0.4092	-0.4786
138	-0.3635	-0.4683	-0.3421	-0.2890	-0.3657
150	-0.4141	-0.5040	-0.4937	-0.4233	-0.4588
162	-0.4381	-0.5106	-0.4850	-0.3913	-0.4562
174	-0.3968	-0.4153	-0.4624	-0.3811	-0.4139
D/H	2	2	2	3	
N_{RE}	$2.82X10^6$	$2.76X10^6$	$2.87X10^6$	$2.83X10^6$	
IFR Level	Low	Mid	High	High	


dq
dθ
θ
Wind
Direction
V
W

The variation of shell pressure coefficient, C_P, and external pressure, P, with angle, θ, measured from the windward side of the tank can be depicted as follows:



Note that C_{PM} and P_M refer to the pressure coefficient and pressure, respectively, of the tank vapor space. Thus, from $\theta = 0$ to $\theta = \theta_M$ air will flow into the vapor space, and from $\theta = \theta_M$ to $\theta = \pi$ air will flow out of the vapor space.

At location θ, where $0 \leq \theta \leq \theta_M$, the differential volumetric flow rate or air into the tank vapor space is:

$$dq = C_D W \frac{D}{2} \left[\frac{2g_c \ (P-P_M)}{\rho}\right]^{\frac{1}{2}} d\theta \tag{H1}$$

Note that:

$$C_P \equiv \frac{\left(P-P_R\right)}{\left(\frac{\rho V^2}{2g_c}\right)} \tag{H2}$$

$$C_{PM} \equiv \frac{\left(P_M-P_R\right)}{\left(\frac{\rho V^2}{2g_c}\right)} \tag{H3}$$

Solving Equation (H2) for P, solving Equation (H3) for P_M, and forming the difference $(P-P_M)$, we obtain:

$$(P-P_M) = (C_P-C_{PM}) \left(\frac{\rho V^2}{2g_c}\right) \tag{H4}$$

Combining Equations (H1) and (H4), we get:

$$dq = C_D W \frac{D}{2} V \left[C_P - C_{PM}\right]^{\frac{1}{2}} d\theta \tag{H5}$$

The total flow into the tank vapor space through the shell vents, q_{IN}, is:

$$q_{IN} \equiv 2\int_{\theta=0}^{\theta=\theta_M} dq$$

Using Equation (H5) we obtain:

$$q_{IN} = C_D W\ D\ V\int_{\theta=0}^{\theta=\theta_M} \left[C_P - C_{PM}\right]^{\frac{1}{2}} d\theta \qquad \text{(H6)}$$

Similarly, the total flow out of the tank vapor space through the shell vents, q_{OUT}, is:

$$q_{OUT} = C_D WDV\int_{\theta=\theta_M}^{\theta=\pi} \left[C_{PM} - C_P\right]^{\frac{1}{2}} d\theta \qquad \text{(H7)}$$

Conservation of mass (neglecting the small amount of hydrocarbon vapor in the air flowing out of the shell vents) requires that:

$$q_{IN} = q_{OUT} \qquad \text{(H8)}$$

Substituting Equations (H6) and (H7) into Equation (H8) we get the following result which allows us to determine C_{PM} and θ_M.

$$\int_{\theta=0}^{\theta=\theta_M} \left[C_P - C_{PM}\right]^{\frac{1}{2}} d\theta = \int_{\theta=\theta_M}^{\theta=\pi} \left[C_{PM} - C_P\right]^{\frac{1}{2}} d\theta \qquad \text{(H9)}$$

Utilizing the relationship between C_P and θ shown by the curve in Figure H2, a numerical integration was performed and resulted in:

$C_{PM} = -0.342$

$\theta_M = 56.3$ deg.

$$\int_{\theta=0}^{\theta=\theta_M} \left[C_P - C_{PM}\right]^{\frac{1}{2}} d\theta = 0.830$$

Putting these results back into Equation (H6), we have the air flow through the tank vapor space.

$$\boxed{q = 0.830 C_D W D V} \qquad \text{(H10)}$$

From tests performed on a CBI standard, screened, hooded shell vent [3], it was found that $C_D = 0.570$. This may be compared to the value for ideal flow through a slot.
C_D, ideal $= \pi / (\pi+2) = 0.611$

Applying the above Equation (H10) to the 20 ft. diameter test tank, and using the API shell vent area criteria for vent opening height, we get:

$$q = (0.830)\,(0.570)\,(0.0637\text{ft})\,(20\text{ft})\,V$$

$$\left(q,\ \frac{\text{ft}^3}{\text{sec}}\right) = 0.602\ \left(V,\ \frac{\text{ft}}{\text{sec}}\right) \qquad \text{(H11)}$$

Or, changing units, we can write:

$$\boxed{(q,\ \text{scfm}\quad) = 53.0\ (V,\ \text{mi/hr})} \qquad \text{(H12)}$$

Equation (H12) is the wind speed calibration equation for the 20 ft. diameter test tank which relates air flow rate, q, in scfm to equivalent ambient wind speed, V, in mi/hr for an internal floating roof tank.

APPENDIX I

Pressure Tightness Tests

Nomenclature for Appendix I

Symbol	Description	Units
D	Tank Diameter	ft
F	Rotameter Correction Factor	-
M	Molecular Weight	lbm/lbmole
P	Pressure	psia
q	Volumetric Flow Rate	scfm
q'	Volumetric Flow Rate Per Foot of Tank Diameter	scfm/ft.dia.
T	Temperature	°F

Subscripts

A	Indicates Air	
H	Indicates Hydrocarbon	
AH	Indicates Air and Hydrocarbon Mixture	
N	Indicates Nitrogen	
M	Indicates Measured Conditions of Rotameter	
C	Indicates Calibration Conditions of Rotameter	

APPENDIX I

Pressure Tightness Tests

During the course of the emission test program performed in the 20 ft. diameter test tank, a number of pressure tightness tests were performed on both primary and secondary seals, and on roof decks. Table I1 summarizes the conditions for each pressure tightness test and Table I2 summarizes the test data. The dates and times when these pressure tightness tests were performed is also indicated on the Calendar of Events (Tables A1 through A15 in Appendix A).

The procedure used in performing a pressure tightness test was essentially the same for use with either a vapor mounted primary seal, a secondary seal or a roof deck. During a test, the IFR was floating on either product or water. The inlet air blower was shut off, and one of the two outer roof man holes was opened to provide access to the inside of the test tank. A controlled flow rate of compressed "house" air was passed through a rotameter outside of the test tank and then introduced beneath the IFR component being tested. Rotameters of different flow ranges were used to cover a wide range of pressure tightness. Pressure taps were located both beneath and above the IFR component being tested. In the case where a vapor mounted primary seal or a secondary seal was being tested, the pressure taps were located 180 degrees from the location of the air supply. An MKS Baratron, Type 77, Pressure Meter was used to read the pressure differences across the IFR component.

In reducing the flow data of a pressure tightness test, it was assumed that the air inlet flow became saturated with product vapor before it passed out of the IFR component. The outlet leakage rate (Column 7 in Table I2) is thus the measured inlet air flow rate (Column 6 in Table I2) corrected to product saturation conditions.

For purposes of comparison, the corrected outlet leakage rate was converted to a nitrogen equivalent leakage rate (Column 8 in Table I2). The pressure tightness test results presented in Table I2 were determined using the following flow data reduction equations.

Flow Data Reduction

The measured volumetric air flow rate through the rotameter, q_M, was first corrected to standard conditions using Eqs. (I1) and (I2).

$$q_A = F\ q_{AM} \tag{I1}$$

$$F = \left[\left(\frac{S_C}{S_M}\right)\left(\frac{T_C}{T_M}\right)\left(\frac{P_M}{P_C}\right)\right]^{\frac{1}{2}} \tag{I2}$$

The outlet leakage flow rate of air and hydrocarbon, q_{AH}, was determined by assuming that the outlet air flow rate, q_A, was saturated with product hydrocarbon vapor using Eq. (I3).

$$q_{AH} = \frac{q_A}{\left(1 - \frac{P_H}{P}\right)} \tag{I3}$$

Assuming that the openings through which the leakage flow passes act like small orifices, the nitrogen equivalent leakage flow rate, q_N, may be determined using Eq (I4).

$$q_N = q_{AH}\left(\frac{M_{AH}}{M_N}\right)^{\frac{1}{2}} \tag{I4}$$

But,

$$M_{AH} = \left(1 - \frac{P_H}{P}\right) M_A + \left(\frac{P_H}{P}\right) M_H \tag{I5}$$

Combining Eqs. (I4) and (I5), we have:

$$q_N = q_{AH} \left[\left(1 - \frac{P_H}{P}\right)\left(\frac{M_A}{M_N}\right) + \left(\frac{P_H}{P}\right)\left(\frac{M_H}{M_N}\right)\right]^{\frac{1}{2}} \tag{I6}$$

Finally, the nitrogen equivalent leakage rate per foot of tank diameter, q_N', may be determined using Eq (I7).

$$q_N' = \frac{q_N}{D} \tag{I7}$$

Test Results

The pressure tightness test results of Table I2 are plotted on Figure I1 and I2 as pressure drop (in H_2O) versus nitrogen equivalent leak rate (scfm/ft. dia.).

Figure I1 shows that a significant improvement in primary seal pressure tightness occurred when the first replacement primary seal was installed on the bolted, contact IFR. Pressure tightness Tests F79 and 80 show that after the inlet air duct heater was installed, an additional improvement in primary seal tightness was evident.

No pressure tightness tests were performed on the second replacement primary seal, but visual observations of the contact area between the tank shell and second replacement primary seal indicate that it appeared to fit better than both the original and first replacement primary seals.

Since the primary seal used with the welded, contact IFR was liquid mounted, it was not possible or necessary to perform a primary seal tightness test. Also, since the roof deck was welded and in contact with the liquid, it was not possible or necessary to perform a deck tightness test.

Figure I2 shows the results of pressure tightness Test F83 performed on the vapor mounted primary seal used with the bolted, contact IFR. A similar tightness Test F82 performed on the secondary seal (which was identical in construction to the primary seal) showed that the primary and seconday seals were of comparable leak tightness.

TABLE I1 - SUMMARY OF PRESSURE TIGHTNESS TEST CONDITIONS

Pressure Tightness Test No.	Date	Description of IFR Component Being Tested
Bolted, Noncontact IFR		
F69	9-9-80	Orig. Pri. Seal
F70	9-8-80	Orig. Pri. Seal
F71	9-9-80	Orig. Pri. Seal
F72	9-9-80	Deck With Bleeder Vent Unsealed
F73	9-9-80	Deck With Bleeder Vent Sealed
F74	9-10-80	Deck With Bleeder Vent Sealed
F75	9-10-80	Orig. Pri. Seal
F76	11-17-80	First Replacement Pri. Seal
F77	11-18-80	First Replacement Pri. Seal
F78	11-18-80	First Replacement Pri. Seal With 30 in^2 Gaps
F79	1-29-81	First Replacement Pri. Seal, After Duct Heater Installation
F80	1-29-81	First Replacement Pri. Seal, After Duct Heater Installation
Bolted, Contact IFR		
F81	7-14-81	Pri. and Sec. Seals in Combination
F82	7-15-81	Sec. Seal
F83	7-16-81	Pri. Seal

Table I2 - Summary of Pressure Tightness Test Data -

Pressure Tightness Test No.	Date	Product Type	Product Temp. (°F)	Product Vapor Pressure (psia)	Measured Inlet Flow Rate (scfm)	Corrected Outlet Leakage Rate (scfm)	Nitrogen Equivalent Leakage Rate $\left(\frac{scfm}{ft.dia.}\right)$	Pressure Difference (in. H_2O)
F69	9-8-80	Water	71.0 71.1 71.1 71.1 71.3 71.4 71.2	0.380 0.380 0.380 0.380 0.380 0.380 0.380	10.8 8.81 7.82 6.24 5.18 4.05 2.88	11.1 9.04 8.02 6.41 5.31 4.16 2.96	0.561 0.458 0.406 0.325 0.269 0.216 0.150	0.0015 0.0010 0.0007 0.0005 0.0006 0.0007 0.0004
F70	9-8-80	Water	72.8 73.7 73.5 72.9	0.409 0.409 0.409 0.409	42.9 29.9 19.0 9.10	44.1 30.8 19.5 9.36	2.23 1.56 0.988 0.474	0.016 0.0083 0.0043 0.0014
F71	9-9-80	Water	64.6 64.7 65.0 65.2 65.2 65.1	0.310 0.310 0.310 0.310 0.310 0.310	85.5 61.5 51.7 37.4 25.4 14.9	87.3 68.8 52.9 38.2 29.9 15.3	4.43 3.18 2.68 1.94 1.31 0.774	0.028 0.015 0.011 0.0070 0.0040 0.0020

Table I2 - Summary of Pressure Tightness Test Data - Continued

Pressure Tightness Test No.	Date	Product Type	Product Temp. (°F)	Product Vapor Pressure (psia)	Measured Inlet Flow Rate (scfm)	Corrected Outlet Leakage Rate (scfm)	Nitrogen Equivalent Leakage Rate $\left(\frac{scfm}{ft.dia.}\right)$	Pressure Difference (in. H_2O)
F72	9-9-80	Water	63.0	0.289	15.8	16.2	0.819	0.203
			63.1	0.289	11.5	11.7	0.595	0.134
			63.1	0.289	8.85	9.02	0.457	0.096
			64.0	0.297	7.15	7.30	0.370	0.075
			63.9	0.297	5.70	5.82	0.295	0.048
			63.7	0.297	4.32	4.40	0.223	0.032
			63.8	0.297	2.97	3.03	0.153	0.021
			64.4	0.303	1.92	1.96	0.099	0.013
F73	9-9-80	Water	63.0	0.291	16.9	17.2	0.872	0.209
			63.2	0.291	11.2	11.4	0.579	0.142
			63.3	0.291	8.47	8.65	0.438	0.102
			63.3	0.291	6.75	6.88	0.349	0.080
			63.6	0.299	5.34	5.47	0.276	0.056
			64.1	0.299	4.11	4.20	0.213	0.037
			64.3	0.299	3.08	3.14	0.159	0.025
			64.5	0.304	2.02	2.07	0.104	0.014
			64.8	0.308	0.995	1.02	0.051	0.005
F74	9-10-80	Water	64.5	0.304	15.4	15.7	0.795	0.198
			64.4	0.304	12.1	12.4	0.629	0.144
			64.7	0.304	8.49	8.67	0.439	0.094
			64.5	0.304	5.53	5.64	0.286	0.043

Table I2 - Summary of Pressure Tightness Test Data - Continued

Pressure Tightness Test No.	Date	Product Type	Product Temp. (°F)	Product Vapor Pressure (psia)	Measured Inlet Flow Rate (scfm)	Corrected Outlet Leakage Rate (scfm)	Nitrogen Equivalent Leakage Rate $\left(\frac{scfm}{ft.dia.}\right)$	Pressure Difference (in. H_2O)
F75	9-10-80	Water	70.6	0.363	77.2	79.2	4.01	0.033
			70.1	0.363	43.0	44.1	2.23	0.012
			69.0	0.363	20.9	21.5	1.09	0.004
F76	11-17-80	n-Octane	62.2	0.217	96.4	97.8	5.08	0.214
			62.2	0.217	76.1	77.2	4.01	0.144
			62.2	0.217	61.5	62.4	3.24	0.091
			62.2	0.217	43.2	43.9	2.28	0.064
			62.2	0.217	31.1	31.5	1.64	0.035
			62.2	0.217	19.4	19.7	1.02	0.017
F77	11-18-80	n-Octane	66.3	0.248	55.9	56.9	2.96	0.099
			66.5	0.248	41.9	42.7	2.22	0.064
			66.8	0.251	30.0	30.5	1.59	0.038
			67.4	0.256	19.3	19.6	1.02	0.019
			67.6	0.256	9.45	9.62	0.501	0.0075

Table I2 - Summary of Pressure Tightness Test Data - Continued

Pressure Tightness Test No.	Date	Product Type	Product Temp. (°F)	Product Vapor Pressure (psia)	Measured Inlet Flow Rate (scfm)	Corrected Outlet Leakage Rate (scfm)	Nitrogen Equivalent Leakage Rate $\left(\frac{scfm}{ft.dia.}\right)$	Pressure Difference (in. H_2O)
F78	11-18-80	n-Octane	67.7	0.258	55.3	56.3	2.93	0.0075
			68.2	0.262	41.8	42.6	2.22	0.0040
			68.7	0.265	30.0	30.5	1.59	0.0013
F79	1-29-81	Propane/ n-Octane	45.7	3.90	11.9	16.2	0.883	0.11
			45.8	3.90	16.3	22.1	1.20	0.16
			45.3	3.88	20.3	27.5	1.50	0.22
			45.0	3.86	24.8	33.6	1.83	0.35
			43.7	3.77	30.3	40.8	2.22	0.49
F80	1-29-81	Propane/ n-Octane	45.2	3.87	14.2	19.2	1.05	0.091
			45.4	3.88	11.4	15.5	0.845	0.064
			45.8	3.91	8.73	11.9	0.648	0.040
			45.5	3.89	5.67	7.71	0.420	0.016
			46.0	3.92	9.48	12.9	0.704	0.039
			45.8	3.91	14.4	19.6	1.07	0.080

Table I2 - Summary of Pressure Tightness Test Data - Continued

Pressure Tightness Test No.	Date	Product Type	Product Temp. (°F)	Product Vapor Pressure (psia)	Measured Inlet Flow Rate (scfm)	Corrected Outlet Leakage Rate (scfm)	Nitrogen Equivalent Leakage Rate $\left(\frac{scfm}{ft.dia.}\right)$	Pressure Difference (in. H_2O)
F81	7-14-81	Propane/ n-Octane	89.7	5.70	10.4	17.0	0.971	0.075
			89.7	5.70	7.87	12.8	0.731	0.051
			89.7	5.70	6.43	10.5	0.601	0.038
			89.7	5.70	4.84	7.90	0.452	0.027
			89.6	5.70	3.34	5.46	0.313	0.014
			89.4	5.63	1.62	2.63	0.150	0.0075
			89.3	5.63	4.54	7.35	0.420	0.023
			89.4	5.63	5.94	9.63	0.551	0.036
			89.6	5.70	8.24	13.5	0.770	0.053
			89.7	5.70	10.7	17.5	1.00	0.080
F82 [1]	7-15-81	Propane/ n-Octane	-	-	3.27	3.27	0.166	0.0043
					4.62	4.62	0.235	0.0075
					6.20	6.20	0.316	0.012
					8.11	8.11	0.413	0.017
					10.9	10.9	0.552	0.026
					14.2	14.2	0.722	0.038
					12.3	12.3	0.625	0.033
					9.38	9.38	0.477	0.022
F82 [1]	7-15-81	Propane/ n-Octane	-	-	7.11	7.11	0.362	0.015
					5.33	5.33	0.271	0.0094
					3.90	3.90	0.198	0.0061
					3.25	3.25	0.165	0.0043
					4.59	4.59	0.234	0.0077
					6.20	6.20	0.315	0.012
					8.04	8.04	0.409	0.017
					10.8	10.8	0.548	0.027
					14.1	14.1	0.717	0.039

did not affect the outlet leakage rate since the

Table I2 - Summary of Pressure Tightness Test Data - Continued

Pressure Tightness Test No.	Date	Product Type	Product Temp. (°F)	Product Vapor Pressure (psia)	Measured Inlet Flow Rate (scfm)	Corrected Outlet Leakage Rate (scfm)	Nitrogen Equivalent Leakage Rate $\left(\frac{scfm}{ft.dia.}\right)$	Pressure Difference (in. H_2O)
F83	7-15-81	Propane/ n-Octane	81.9	5.13	2.18	3.35	0.190	0.0096
			82.6	5.17	3.63	5.60	0.316	0.018
			82.9	5.20	6.04	9.35	0.528	0.036
			83.1	5.20	8.13	12.6	0.711	0.053
			83.5	5.24	11.7	18.2	1.03	0.096
			83.6	5.24	8.35	13.0	0.733	0.053
			83.5	5.24	6.17	9.58	0.541	0.039
			83.6	5.24	4.75	7.39	0.417	0.027
F83	7-15-81	Propane/ n-Octane	83.4	5.23	3.38	5.24	0.296	0.017
			83.4	5.23	2.53	3.93	0.222	0.012
			82.8	5.20	1.21	1.87	0.106	0.0048
			83.0	5.20	2.07	3.31	0.181	0.0091
			83.3	5.22	3.25	5.05	0.285	0.017
			83.3	5.22	4.75	7.36	0.416	0.026
			83.2	5.22	6.12	9.48	0.536	0.037
			83.2	5.22	7.93	12.3	0.695	0.053
			83.3	5.22	11.5	17.9	1.01	0.091

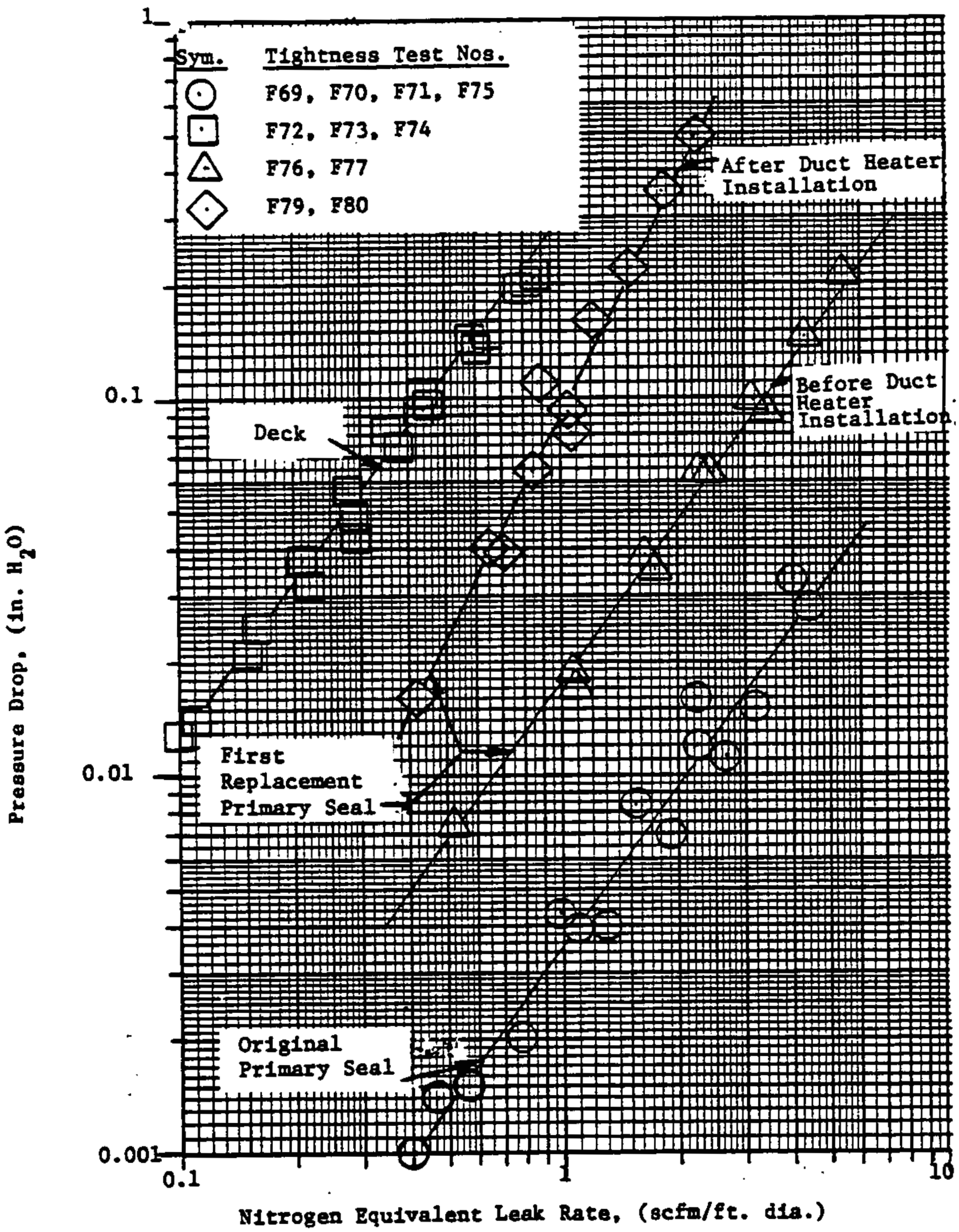


FIGURE I1 Leak Tightness of Noncontact, Bolted IFR

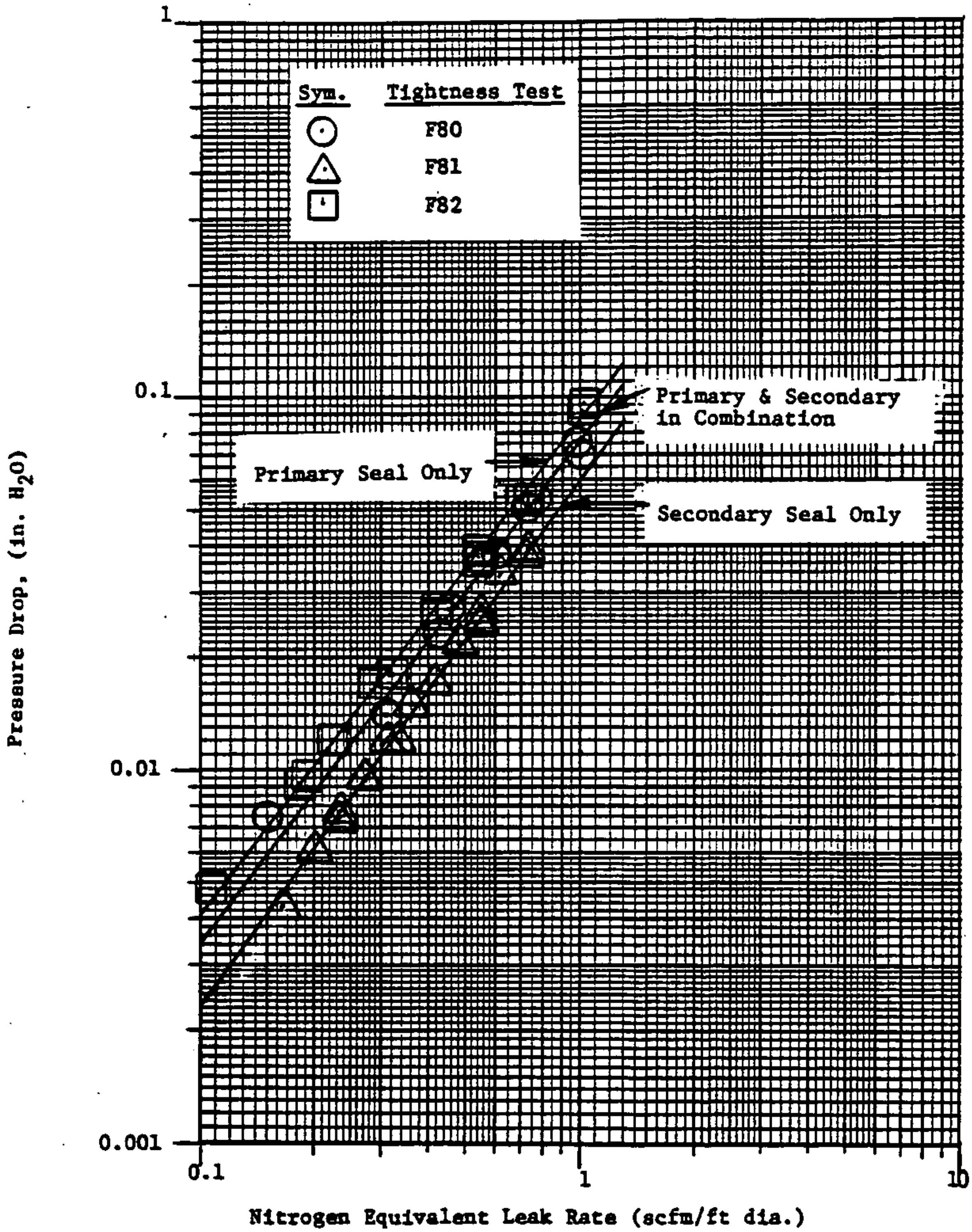


FIGURE I2 Leak Tightness of Contact, Bolted IFR