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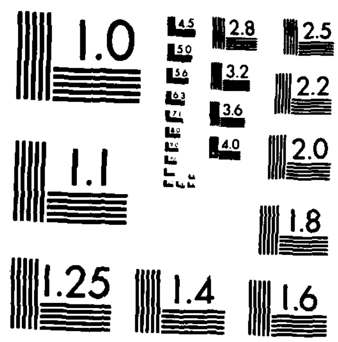

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USAF OEHL REPORT
83-075EA111AEB

VANDENBERG AIR FORCE BASE EMISSION SURVEY

JANUARY 1983

USAF Occupational and Environmental Health Laboratory
Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas 78235

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William E Mabson
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Commander

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The purpose of this report is to provide an air emissions inventory of Vandenberg AFB for calendar year 1981 in accordance with the format required by the California Air Resource Board (CARB). The report will also provide complete permit applications on some of the inventoried facilities in accordance with the rules and regulations of Santa Barbara County Air Pollution Control District (SBAPCD).

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REPORT NO. 83-075EA111AEB

USAF OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY

BROOKS AFB TX 78235

VANDENBERG AIR FORCE BASE EMISSION SURVEY

JANUARY 1983

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PREFACE

In June 1982, the USAF Occupational and Environmental Health Laboratory (USAF OEHL) and USAF Hospital Vandenberg, Office of Surgeon General Aerospace Medicine Bioenviromnental Engineering (SGPB) contracted Engineering-Science to prepare an Air Emissions Inventory under contract No. F33615-80-D-4001, order No. 32. The primary project monitor for Vandenberg AFB was Major Jerry Morford of the USAF Hospital Vandenberg/SGPB. The contract project monitor for the USAF OEHL was Captain Robart Bauer.

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SECTION 1.0

INTRODUCTION

SECTION 1.0

INTRODUCTION

Vandenberg Air Force Base (VAFB) in Santa Barbara County, California, has been required by the local air pollution regulating body (Santa Barbara County Air Pollution Control District [SBAPCD]) to prepare certain deliverables to update base activities that generate air pollutants. These deliverables are:

- Provide an air emissions inventory (point and area sources) r VAFB for calendar year 1981 in accordance with the format required by the California Air Resources Board (CARB). Ref ce is: "Instructions for Emission Data System Review and Upda Reporting (Emission Data Turnaround Document)," June 1981.

- Provide complete permit applications on some of the inventoried facilities in accordance with the rules and regulations of the SBAPCD.

To facilitate preparation and submittal of these requirements in a timely manner, Engineering-Science, Inc. (ES) was retained under USAF Contract Number F33615-80-D-4001, Call Order 32. All emission data requirements necessary to complete call order specifications were collected onsite by ES staff from pertinent sources on VAFB. These sources are tabularized in Section 2.0. Whenever appropriate or applicable, EPA Document AP-42, "Compilation of Air Pollutant Emission Factors," with Supplements 1-12, served as the primary sources of emission factors. In specific instances, other methodologies had to be employed. The alternate approaches have been discussed and approved by VAFB personnel prior to use and are identified in the appropriate portions of Section 2.0. No actual emission measurements or stack sampling were performed. Concurrent (and frequently identical in type) data acquisition for permit submittals was performed. All data collected were discussed with VAFB personnel to describe the type of information required, level of detail, and justification for data type selection.

The emission inventory was for the five primary pollutants as well as for hypergolic fuels and oxidizers. Hypergolic materials included:

hydrazine, unsymmetrical dimethyl hydrazine, monomethyl hydrazine, Aerozine-50 (UDMH/hydrazine), inhibited red fuming nitric acid, and nitrogen tetroxide.

The results of the inventory and data calculation efforts were used either to prepare a permit application document or to encode appropriate point and area source forms. The completed forms were routed through Vandenberg to the SBAPCD. All official submittals are available as an appendix under separate cover.

SECTION 2.0

METHODOLOGIES

SECTION 2.0

METHODOLOGIES

2.1 SOURCES EXAMINED

Tables 2.1-2.3 itemize the deliverables by category (area or point source, and permit application). This final listing was significantly different from the initial listing presented in the scope of work. The difference stems primarily from reinterpretation of the definition of a point source and redundancy in permit applications. The following portions of this section address each of the three deliverable categories separately. Focus of the discussions is on the sources of data along with the calculation procedures including assumptions and interpretations.

2.2 NON-HYPERGOLIC POINT SOURCES

Near project completion it was discovered that original SBAPCD point source requirements had been modified. Instead of the anticipated 48 non-hypergolic points sources, it was discovered that only sources with emission levels for any one pollutant in excess of 10 tons per year need be included in this portion of the emission inventory. This quickly reduced the point source inventory to:

Building 1856 - No. 2 diesel-fired boiler
Power Plant No. 1 - Building 1783
Power Plant No. 2 - Building 1856
Power Plant No. 6 - Building 535

Data concerning operational equipment sizing and throughputs for the power plants were obtained from "Installation Generator Data, 1 October 1981 Inventory" civilian staff of the power production shop. Primary contacts were Mr. Zoet and Mr. Briggs (866-3367). All boiler data were obtained from the Heating Shop's "Recurring Maintenance File List" prepared May 13, 1981. Primary contact was Mr. Carroll.

Based on consumption figures for each source supplied by Mr. Briggs and Mr. Carroll, emissions of criteria pollutants could be calculated.

TABLE 2.1

POINT SOURCES PREPARED FOR EMISSION INVENTORY

1. Boilers (1)

2. Power Plants (3)

3. Hypergolic sources (5)

   a. Space Launch Complex (SLC-2)

      1) Aerozine-50 Tank (880 gals)
      2) Nitrogen Tetroxide Tank (1,020 gals)

   b. SLC-3 Hydrazine Scrubber

   c. SLC-4

      1) West Pad

         - Two Aerozine-50 Tanks (11,000 gals each) (one emission point)

         - Unsymmetrical Dimethyl Hydrazine (UDMH) Tank (1,300 gals)

         - Nitrogen Tetroxide Tank (~28,000 gals)

         - Inhibited Red Fuming Nitric Acid (IRFNA) Tank (1,300 gals)

      2) East Pad

         - Aerozine-50 Tank (~28,000 gals)

         - Nitrogen Tetroxide Tank (~28,000 gals)

         - Hydrazine Tank (1,300 gals)

   d. Titan Tank Farm

      1) Aerozine-50 Tank (22,000 gals)
      2) Nitrogen Tetroxide Tank (22,000 gals)

   e. Agena Tank Farm

      1) Seven UDMH Tanks (1,100 gals each)
      2) Eight IRFNA Tanks (1,100 gals each)

TABLE 2.2

AREA SOURCES PREPARED FOR EMISSION INVENTORY

1. Rocket engine flushing (3 locations) (previously a point source)
2. Component cleaning facility (2 sources) (previously a point source)
3. Dry cleaning plant (previously a point source)
4. Petroleum product storage area (9 tanks) (previously a point source)
5. Paint spray boths (7) (previously a point source)
6. Boilers of or greater than 5 million Btu heat input (12) (previously a point source)
7. Power generating stations (5) (previously a point source)
8. Concrete batch plants (2) (previously a point source)
9. Sandblasting booths (2) (previously a point source)
10. Incinerators (3) (previously a point source)
11. Paint, adhesive, and solvent use
12. Household cleaner use (only what is purchased on-base)
13. Roofing and road surfacing
14. Small POL storage tanks serving boilers and fixed generators
15. Portable generators (flightline and others)
16. Service stations (6)
17. Aircraft operations (only 3 assigned helicopters but frequent transient aircraft)
18. Aircraft fuel throughputs
19. Pesticide use
20. Portable sandblasters (approximately 20)
21. Boilers of less than 5 million Btu heat input
22. Space heating
23. Fire Department fire-fighting training
24. Missile launches during 1981.
25. Fugitive dust from construction of the MX and STS facilities
26. Union Oil Company, Jesus Maria Field
27. POL Loading Rack Emissions

TABLE 2.3

VAFB PERMIT APPLICATIONS

1. Unconventional fuel storage facilities

    a. Space Launch Complex (SLC)-2

        1) Aerozine-50 Tank (880 gal)
        2) Nitrogen Tetroxide Tank (1,020 gal)

    b. SLC-3 Hydrazine Scrubber

    c. SLC-4

        1) <u>West Pad</u>

            - Two Aerozine-50 Tanks (11,000 gal each)
            - Unsymmetrical Dimethyl Hydrazine (UDMH) Tank (1,300 gal)
            - Nitrogen Tetroxide Tank (22,000 gal)
            - Inhibited Red Fuming Nitric Acid (IRFNA) Tank (1,300 gal)

        2) <u>East Pad</u>

            - Aerozine-50 Tank (22,000 gal)
            - Nitrogen Tetroxide Tank (22,000 gal)
            - Hydrazine Tank (1,300 gal)

    d. Titan Tank Farm

        1) Aerozine-50 Tank (22,000 gal)
        2) Nitrogen Tetroxide Tank (22,000 gal)

    e. Agena Tank Farm

        1) Seven UDMH Tanks (1,100 gal each)
        2) Eight IRFNA Tanks (1,100 gal each)

2. Engine Flushing

    a. SLC-2
    b. SLC-3, East and West

3. Conventional Fuel Storage Facilities

    a. Three gasoline storage tanks at POL facility near airport (one with 127,000 gal capacity, and two each with 20,000 gal capacity)

    b. CE Service Station with 5,000 gal tank

    c. Boeing Building (6523) Service Station with 5,000 gal tank

    d. Marshallia Ranch Golf Course Service Station with 2,500 gal tank

TABLE 2.3--Continued

VAFB PERMIT APPLICATIONS

4. Sandblasting Operations

5. Water Treatment Plant Baghouse to control particulate matter generated during soda ash and lime receiving

6. Hydrogen Sulfide Degasifiers at four water wells

7. Dry Cleaning Plant

Annual consumption and operating schedules for each point source have been coded into the format provided by the SBAPCD (refer to Figures 2-1 through 2-3). Completed forms for non-hypergolic point sources appear as Appendix 1 (under separate cover).

Emission factors applied to the various point sources were based on assignment of pertinent Source Classification Codes (SCC) obtained from Aeros Manual Series, Volume V, "Aeros Manual of Codes, Update Number 2," EPA-450/2-76-005-02, June 1979. For instance, the corresponding SCC for Power Plant No. 1 is 2-01-001-02. Page 3.7.0-13 of that document identifies the appropriate emission factors for different pollutants as a function of 1000 gallons burned. These factors were the basis of the emission estimates presented on the coded forms.

2.2.1 UTM Coordinate Assignments

Each point source is assigned a location to within 0.1 km accuracy using the Universal Transverse Mercator (UTM) coordinate system. Values are obtained using United States Department of the Interior Geological Survey maps. Under the UTM system, the earth is divided into a series of zones. Due to its geographical location in the extreme western portion of Santa Barbara County, VAFB is in zone 10 while the majority of the remainder of the County is in zone 11. To make VAFB coordinates consistent with other Santa Barbara County sources (coordinates differ from east to west in each zone), it became necessary to translate its zone 10 values into "rotated" zone 11 values. The translation formulas are:

$$X_{Z11} = -679.52 + 0.99868(X_{Z10}) + 0.008876(Y_{Z10}) + 6.653\text{x}10^{-6}(Y^2{}_{Z10})$$

$$X_{Z11} = 12.09-0.00725(X_{Z10}) + 1.008876(Y_{Z10}) - 1.3629\text{x}10^{-5}(X_{Z10}Y_{Z10})$$

2.3 HYPERGOLIC EMISSION SOURCES

An important objective of this inventory study is to characterize and quantify atmospheric emissions resulting from releases of hypergolic propellants (hypergolics) at Vandenberg Air Force Base (VAFB). Hypergolics by definition are components that ignite upon contact without

FIGURE 2-1

EMISSION DATA SYSTEM REVIEW AND UPDATE REPORT
FACILITY DESCRIPTION

AGENCY:
PERSON:
DATE :

	COUNTY ID :	
	FACILITY ID :	
	ACTION CODE :	( )
* 010 **	NAME & ADDRESS :	U.S. AIR FORCE, VANDENBERG AIR FORCE BASE
	CITY CODE :	8485
	ZIP CODE :	93437
	AIR BASIN CODE :	SCC
	NEDS AQCR :	032
	FAC. SIC CODE :	9711
	OWNERSHIP TYPE :	F
* 015 **	CONTACT PERSON :	MAJOR JERRY MORFORD
	TELEPHONE :	805 8667811
	NO OF EMPLOYEES:	13124
	PLANT AREA :	98400
** 018 **	COMPANY NAME :	4392 AEROSG/DE, VANDENBERG AFB
	ATTENTION :	MAJOR JERRY MORFORD
** 020 **	MAIL ADDRESS :	USAF HOSPITAL, VANDENBERG
	MAIL CITY :	VANDENBERG AFB
	ZIP CODE :	93437
** 030 **	UTM COORDINATE :	EAST: NORTH:

COUNTY ID: FACILITY ID:

EMISSION DATA SYSTEM REVIEW AND UPDATE REPORT
DEVICE AND STACK DESCRIPTION

AGENCY:

PERSON:

DATE :

DUNTY ID :
ACILITY ID:
EVICE ID :

* 150 **	ACTION CODE	STACK ID	UTM-EAST (KILOMETERS)	UTM-NORTH (KILOMETERS)	HEIGHT (FEET)	DIAMETER (FEET)

******************EXHAUST******************		
GAS TEMPERATURE (F)	GAS FLOW RATE (CFM)	GAS VELOCITY (FPM)

* 210 **	ACTION CODE	DEVICE NAME	DAILY CYCLE	WEEKLY CYCLE	ANNUAL CYCLE	WEEKS/ YEAR	PERMIT ID

CONFID	NEDS IPP	REL HGT (FEET)	VENT THRU STACK ID	*********FUEL BURNING DEVICES ONLY*********	
				% SPACE HEAT	BOILER CAPACITY (10**6 BTU)

** 215 **	ACTION CODE	ECAP CODE	**********COMPLIANCE**********			CONTROL REGULATION 1	CONTROL REGULATION 2	CONTROL REGULATION 3
			STATUS	SCHEDULE DATE	EFFECTIVE DATE			

** 160 **	ACTION CODE	DEVICE CONTROL 1	DEVICE CONTROL 2	DEVICE CONTROL 3
		DEVICE CONTROL 4	DEVICE CONTROL 5	

INVENTORY YEAR: COUNTY ID: FACILITY ID:

EMISSION DATA SYSTEM REVIEW AND UPDATE REPORT
PROCESS AND EMITTENTS

AGENCY:
PERSON:
DATE :

NTY ID :
ILITY ID:
ICE ID :
NO :

CATEGORY CODES (APED):

240 ** ACTION CODE	PROCESS DESCRIPTION	SCC	TOTAL YEARLY PROCESS RATE (CES UNITS/YR)	MAXIMUM PROCESS RATE (CES UNITS/HR)

************************FUEL BURNING DEVICES ONLY************************

NORMAL OPER % OF MAX	% SULFUR	% ASH	% NITRO	HEAT CONTENT	SPECIFIC GRAVITY

260 ** ACTION CODE	EMITTENT ID	UNCONTROLLED EMISSION FACTOR (LBS/CES UNIT)	ACTUAL EMISSION FACTOR (LBS/CES UN)	% REDUCED	EMISSIONS (TON/YR)	ALLOWABLE EMISSION (TON/YR)	EST METHOD

INVENTORY YEAR: COUNTY ID: FACILITY ID: FACILITY NAME:
DEVICE ID: CES NO:

external aid (as a spark) and consist of both fuels and oxidizers. Fuels include unsymmetrical dimethylhydrazine referred to as UDMH (N_2H_2 [CH_3]2); Aerozine-50 (50% hydrazine, 50% UDMH); and hydrazine (N_2H_4). Oxidizers include nitrogen tetroxide (N_2O_4) and inhibited red fuming nitric acid (IRFNA). The hypergolic fuels and oxidizers are used in combination to provide propulsion for rockets and missiles.

Due to the moderate vapor pressures of the propellants (especially N_2O_4), evaporation will take place to the surrounding gaseous medium until an equilibrium condition is reached. If a quantity of propellant was left exposed to ambient air then it would completely evaporate. Normally, however, the propellants are kept in pressurized storage tanks with an inert (i.e. nitrogen or helium) blanket. Propellant will evaporate into the blanket until an equilibrium is reached. When transferring fuel into a tank, vapor (N_2 + propellant) is displaced. This displaced vapor is normally vented to the atmosphere. At some of the VAFB sites the fuel vapors are put through a scrubber to reduce the amount of fuel vapor entering the atmosphere. Likewise, specific oxidizer vapors are disposed of by a scrubber or burner which utilizes propane as a fuel. At some of the sites, though, ventings of vapors are made directly into the atmosphere without using any control technology.

The lack of direct measurements at VAFB of effluent concentrations and flow rates precluded the direct computation of release amounts. This necessitated a search for data outside of VAFB. The data were assembled and carefully reviewed to determine applicability to this study. Appropriate data were then analyzed in order to help determine emission rates.

The following sections describe in more detail the ES effort. Section 2.3.1 describes the activities that result in releases of hypergolics at VAFB; Section 2.3.2 discusses the data base that was available for this study; Section 2.3.3 details the methodologies used to estimate the emissions; and Section 2.3.4 discusses the meteorological restrictions associated with any hypergolic movement on-base. The hypergolic calculations were used to complete point source submittals which appear as Appendix 2 under separate cover.

2.3.1 VAFB Hypergolic Activities

Hypergolic activities at VAFB consist of various propellant transfers which eventually transport the fuel from incoming tank trucks to its final launch area destination. Each launch area is formally known as a Space Launch Complex (SLC). Three SLCs are of interest to this study. SLC-2 contains Aerozine-50 (880 gallon) and nitrogen tetroxide (1,020 gallon) tanks. SLC-3 contains a small hydrazine tank. SLC-4 is separated into two launch areas designated SLC-4W and SLC-4E that are physically separated by several hundred feet. SLC-4W contains two Aerozine-50 tanks (11,000 gallons each), an unsymmetrical dimethyl hydrazine (UDMH) tank (1,300 gallons), a nitrogen tetroxide (N_2O_4) tank (28,000 gallons), and an inhibited red fuming nitric acid (IRFNA) tank (1,300 gallons). SLC-4E contains an aerozine-50 tank (28,000 gallons), an N_2O_4 tank (28,000 gallons), and a hydrazine tank (1,300 gallons).

There are two tank farms where hypergolic fuels are stored after being transported onto VAFB. The Titan Tank Farm contains an Aerozine-50 tank and an N_2O_4 tank (22,000 gallons each). The Agena Tank Farm contains seven UDMH and eight IRFNA tanks (1,100 gallons each).

SLC-2

SLC-2 is the launch complex which handles NASA operations. During 1981 there were two launches at this location. Associated with these launches were two hypergolic propellant transfer operations. An operation as defined here means the transfer of propellant from an Air Force tank truck to one of the storage tanks at SLC-2 and subsequent transfer to the launch vehicle.

When a tanker truck arrives at SLC-2, the existing pressure is between 10 and 25 psig. It is then pressurized with helium to 20-40 psig. Propellant is then forced into the tank with continuous venting of the displaced vapors through the tank. The vent gas from both fuel and oxidizer is fed into separate Peabody Engineering Company scrubbers. A typical off-loading duration is 45 minutes.

Propellant is transferred to the vehicle using helium at 150 psig. Vapors generated in the vehicle tanks and associated transfer system are vented through the corresponding scrubber. The vehicle tanks hold about 8,500 pounds of nitrogen tetroxide and 5,500 pounds of Aerozine-50. The vehicle loading and subsequent scrubber venting process duration is about 45 minutes for both fuel and oxidizer.

SLC-3

The operation services the NAVSTAR spacecraft with mission quantities of hydrazine (N_2H_4). The process involves the transfer, over an 8-hour period, of liquid N_2H_4 from a supply tank through flex hoses and interface panels into the spacecraft's two propellent tanks. As a consequence, a small amount of liquid hydrazine is trapped in the servicing hoses (approximately 0.3 pound). This small quantity of residual N_2H_4 is allowed to drain into a catch tank where its vapors are cleaned by a scrubber and then vented to the atmosphere. Presently the operation takes place once per year.

The control device is a Rockwell International Vapor Absorpti System Model G505-122306-001. Vapors are absorbed by a neutralizing solution of 54 gallons of water containing 5 pounds of a 20% solution of HCl. The device is located at the SLC-3 West tower, level 78.

SLC-4

The activities at SLC-4 are in support of Titan launches. The necessary propellants for the initial stages are provided through systems operated by the Martin Marietta Corporation (MMC). In addition, the launch vehicle (last stage and/or orbiter) requires a separate propellant capability. The Lockheed Missile and Space Company (LMSC) is responsible for the orbiter propellants. Each of these activities is discussed in more detail in the following paragraphs.

1. LMSC Activities

Orbiter propellants (hydrazine, UDMH, HDA [a high density IRFNA]) are transferred to 1,300 gallon weigh tanks called Propellant Transfer Units (PTUs). These tanks are used to provide a calibrated propellant weight for loading operations. Propellant vapors are vented to Peabody Scrubbers. These scrubbers employ a water spray to remove toxic or hazardous gases from contaminated nitrogen or helium gas from the vent system of the PTU. Facility water is supplied to the unit and discharged with venting gases to the drain area for the oxidizer or the retention basin for the fuel.

The 1,300 gallon IRFNA tank contains a form of IRFNA called High Density Acid (HDA). The HDA "vapor" (N_2O_4[1]) is vented through two scrubbers in series. LMSC-provided data on frequency of operations showed 6 hydrazine operations (2 hours each), 8 UDMH operations (30 minutes each), and 16 HDA operations (15 minutes each) during 1981. The flow rate for the hydrazine transfers was about 3 scfm and 3-5 scfm for UDMH and HDA.

When a transfer is completed, a purging operation is performed. Propellant is then transferred from storage to the launch vehicle when required.

There is also a water ejector in use in the SLC-4W fuel room. Its purpose is to assist during evacuation of the hydrazine loading system and to receive hydrazine liquid and vapors during fill line disconnect and equipment loading/flushing operations.

The ejector employs high volume water flow through a cavitating venturi to obtain suction into the mainstream by way of a vacuum port. Facility water is supplied to the unit and discharged with hydrazine and/or isopropanol liquid/vapors to the retention basin.

During 1981 this unit was used approximately four times. An estimated total of 15 pounds of hydrazine and 8 pounds of isopropanol were put through the unit and into the retention basin.

There also exists at SLC-4W a 140 gallon drain-back receiver tank which is used as a receiver for pickling HDA. On about two days per year there are 85 gallons of commodity in the tank.

2. MMC Activities

Propellant vapor emissions at ⁻C-4 all come from ventings that follow basic activity steps there. These are: filling of the Ready

1) Vapor species found above HDA consist mostly of N_2O_4, with very little acid vapor if any. This is due to the low vapor pressure of nitric acid compared to that of the N_2O_4 content in HDA.

Storage Vessels (RSV) by propellant transfer from both commercial delivery (CD) and Air Force tankers (AFT), calibration of flow meters used in loading of launch vehicles, vehicle stage testing after loading, and post-launch operations where the various propellant transfer/loading systems and lines are blown back and purged along with final RSV depressurization.

Titan Tank Farm

The Titan Tank Farm serves as one of two on-base depositories for propellants. Two types of propellant transfers occur at the farm. Commercial tank trucks unload to the tank farm and Air Force trucks load at the Farm to transport to the SLCs. The following paragraphs detail the transfer procedures involved.

When a commercial trailer arrives at the tank farm, it is pressurized with GN_2 to 25 psig which takes 2-5 minutes. The tank is bled down from its storage pressure of 15-17 psig to 5-10 psig by venting which takes 5-10 minutes. Fuel vapors are vented directly to the atmosphere, while oxidizer vapors are fed into a burner. The transfer is accomplished through a 100 gallon per minute pump while the tank is being continuously vented as described above. The transfer duration is approximately 30-45 minutes. When the transfer is complete, the lines are "blown out" into the tanks with a 48-50 psig GN_2 purge, with the tank venting during this process. This purge takes about 2 minutes. The trailer and tank are then adjusted to 10-15 psig. This takes about 2 minutes for the trailer and 5 minutes for the tank.

The commercial trailers normally transport a full load (with 10% ullage) to the tank farm. Approximately 38-40,000 pounds of oxidizer are transported while 40-42,000 pounds of fuel are transported during a typical operation.

The remaining type of operation that occurs is the transfer of propellant from the tank farm into an Air Force trailer. Before the transfer starts, the tank is pressurized to 20 psig which takes about 5 minutes, while the trailer is vented down to between 5 and 0 psig. This venting takes about 2 minutes. The transfer is done through the same 100 gallon per minute pump, however, it is assisted by a 9-10 psig pressure differential between the tank and the trailer. Venting is continuous during this operation. When the transfer is complete, the lines are "blown out" into the trailer for approximately 2 minutes using GN_2 at 48-50 psig. Pressure in both the trailer and tank settles to about 15 psig.

During 1981 there were an estimated ten Aerozine-50 and fifteen nitrogen tetroxide operations. An operation is defined for Titan Tank Farm as a complete cycle of unloading a commercial tanker truck to the tank farm and a subsequent transfer from the tank farm to an Air Force tanker truck.

Agena Tank Farm

Operations at the Agena Tank Farm are similar to the Titan Tank Farm. Trailers arrive at the tank farm at about 5 psig. The tank is at about 10 psig and is vented down to 0 psig. The trailer is then pressurized to 20 psig with GN_2. The transfer is then performed with a continuous venting. There is no pump. It is a pressurized transfer and vented directly to the atmosphere. A duration of approximately 20 minutes is required for each of the individual tanks. About 2-1/4 truck loads, each containing 40,000 pounds, are required to fill a set of tanks.

The procedure for transferring propellant from the tank to the trailer is the same procedure except it is done in reverse. The vapor is vented out through the tank.

In addition to these ventings, there are occasional releases of liquid propellants into a dump pond. An estimated 15 gallons of oxidizer and 60 gallons of fuel were dumped and subsequently neutralized during 1981. These liquids were exposed to the air for 2 to 3 minutes.

The information presented in this section was obtained exclusively from sources within VAFB. SLC-2 information was obtained from Mr. Till Moen of McDonnel Douglas. SLC-4 information was obtained from LMSC and MMC submittals. However, the MMC submittal was inadequate for this study and a request for more information has been made. Additional[1] information was obtained through Captain Mazur, Lieutenant Myers, and Sargeant Bruns at SLC-4. Tank farm information was obtained from Dan Hamel. Information concerning the Titan Tank Farm was obtained from Mr. Sceech, and further information on the Agena Tank Farm was provided by Mr. Hoffman and Mr. Rand.

2.3.2 Data Base

This section provides a brief description of the data base that was available to Engineering-Science for estimating emissions from hypergolic activities. Nine references were used in this study and are attached.

Reference 1 is information received verbally by ES from Dr. Takimoto of the Aerospace Corporation. The data are believed to be originally from a Martin Marietta Corporation study done seven to ten years ago. Data are presented concerning propellant ventings and purges for a Titan III operation. Information concerning flow rate, Aerozine-50 concentration, and release duration are presented (refer to appendix). Information or background as to how the values were derived were not available.

Reference 2 is a report entitled "Selection and Design of a Bubble Cap Scrubber for Hydrazine Removal from Vent Gases." The report was done by IIT Research Institute in May 1982. There is no information presented as to how the values used were derived. Also, there was no information as to how the vapors were generated. Several items emerged which were of interest to the present study and served to confirm previous understanding of operations. One was that purging practices deliver a low concentration of hydrazine at a high flow rate, and another was that tank loadings displace a high concentration at a low gaseous flow rate.

Reference 3 is entitled "Shuttle Payload Integration Facility (SPIF) Program." The report was prepared by MMC (MCR-81-016) in June 1981. It is an oxidizer (N_2O_4) burner evalaution study. Various inlet vapor flow conditions were tested to determine combustion products and burner operating characteristics.

Reference 4 is entitled "Launch Complex Safety Plan - Space Launch Complex Four" done by MMC (T3J-WLCSP-4C). This document provided some operating and blanketing pressures of various vehicle tanks.

Reference 5 is an ES report entitled "Air Pollution Testing of Hypergolic Fuel Vapor Scrubbers at Cape Canaveral Air Force Station, Florida," dated September 1981. The report presents data covering the efficiency of an MMC scrubber. Although this is not the same type of scrubber employed at VAFB, the report presents data concerning inlet concentrations to the scrubber during propellant transfer operations. The two hypergolic propellants under investigation were monomethyl hydrazine (MMH) and nitrogen tetroxide.

Reference 6 is comprised of the appendices (CP-S70S005) to an MMC report from March 1982 for a fuel vapor scrubber system (FVSS) to be used at VAFB. It contains design standards for the FVSS which tell what inlet conditions to expect during fuel venting situations at VAFB.

Reference 7 is entitled "Critical Item Product Function Specification for Oxidizer Vapor Scrubber System" done by MMC (VCP-82-308). This is similar to Reference 6 except here data are presented for oxidizers, especially nitrogen tetroxide. An interesting finding was that under two different design extremes (low flow rate, high concentration, and high flow rate, low concentration) the mass flow rate was about equal.

Reference 8 is an MMC final report entitled "VAFB Space Shuttle Oxidizer Effluent Analysis for Station Sets V19, V21, and V23." The purpose of this study was to collect "design-to-specification" data for VAFB vapor vent systems. This reference presents calculations of expected oxidizer vapor carry-off in STS, V19 OMS and RCS tank blowdown and purging operations, and likewise for V21 de-servicing and V23 servicing operations.

Reference 9 is an MMC report (Contract F09603-79-G-0364-QP12) entitled "Engineering Report - Fuel Vapor Emission Study." This is a report of actual fuel transfers at Little Rock Air Force Base and measurements made from them. The report documents how the emissions were calculated, but offers no information as to the amounts of fuel handled, etc. Also, there is no information concerning effluent concentration values.

The references given in this section come from a variety of sources and cover a wide spectrum of topics associated with hypergolics. Use of this variety of information type necessitated a very careful review of the data to determine exactly what is of interest to the current study at VAFB. Upon initial examination, a given piece of information may appear ideal, but after a more thorough review subtle differences in source of generation or measurement method may arise which make application of the data much more suspect. It should be pointed out here that in any future studies where screening of data is considered a requirement, creedance should not be put in any data set until it has been determined that it has application to the problem being studied.

References

1. Telephone conversation between Engineering-Science and Dr. Takimoto of the Aerospace Corporation on August 9, 1982. He stated that the data was off briefing charts made from an old (7-10 years). Martin-Marietta study and could give no further identification.

2. Selection and Design of a Bubble Cap Scruber for Hydrazine Removal from Vent Gases. Bassam Jody and Robert Chopp, IIT Research Institute, May 1982. IITRI·Project C6501. Contract No. DAFA 1875-A-0084TB2.

3. Shuttle Payload Integration Facility (SPIF) Program. MCR-81-016 Rev. A. Martin Marietta Corporation, June 1981. Contract F04701-78-C-0107.

4. Launch Complex Safety Plan - Space Launch Complex Four. Martin Marietta Aerospace, November 26, 1980. T3J-W1CSP-4C.

5. Air Pollution Testing of Hypergolic Fuel Vapor Scrubbers at Cape Canaveral Air Force Station, Florida. Engineering-Science, McLean, Virginia. Air Force Contract No. F-33615-80-D-4001 (September 1981).

6. Appendices to Martin Marietta Report CP-S705005. March 11, 1982.

7. Critical Item Product Function Specification for Oxidizer Vapor Scrubber System. Martin Marietta Corporation, June 18, 1982. VCP-82-308, 8401-WPC514.

8. VAFB Space Shuttle Oxidizer Effluent Analysis for Station Sets V19, V21, and V23. Martin Marietta Corporation (Denver Division). (Analysis performed during April 1982.)

9. Engineering Report - Fuel Vapor Emission Study. Martin Marietta Corporation (Denver Division), September 1980. Contract F09603-79-G-0364-QP12.

2.3.3 Vandenberg Air Force Base Hypergolic Propellant Emission Factor Development

The development of emission factors for hypergolic fuels and oxidizers began with the calculation of a "vapor weight factor." This factor is an expression of expected pounds of vapor of a specific propellant per cubic foot of vented volume. Unique values for each oxidizer and fuel were calculated. Following this exercise, an expected efficiency for the N_2O_4 burners was developed. With these two tools, emissions from specific activities could be calculated.

2.3.3.1 Vapor Weight Factors

1. Pounds Per Cubic Foot Expression:

   These factors can be derived from the Ideal Gas Law: PV = nRT, where P is pressure, V is volume, n is the number of moles of gas present in V, R is a proportionality constant whose value depends on the units used, and T is the absolute temperature.

   Using the metric system, the units are: P in atmospheres, V in liters, R is 0.082054 liter-atm/°Kelvin, and T is in degrees Kelvin (°C + 273.15). As most work at VAFB is in scfm (standard cubic feet per minute), "standard" used here is defined as one atmosphere and 68°F (20°C). Other pressures and temperatures likely to be encountered at VAFB should only effect the final value to a percent or two at most. This also applies to elevation differences as VAFB is close to sea level. Using these factors in other parts of the country should not change the final result as long as scf values are used as inputs.

   Deriving weight per unit volume, one first obtains the number of moles, n. The Ideal Gas Law becomes (for 1 scf):

   $$n = \frac{PV}{RT}, \text{ and } n = \frac{1 \text{ atm} \times 28.317 \text{ liters/ft}^3}{0.082054 \text{ liter-atm/°K} \times (20\text{°C} + 273.15)\text{°K}} = \frac{28.317}{24.054}$$

   which will give the number of moles of any vapor in one scf, or 1.1772 gram-moles. Multiplying this by the vapor molecular weight (M.W.) will give the number of grams per scf, and dividing this by

453.6 grams/lb will give the pounds per cubic foot for any vapor, or:

$$\text{Vapor lbs/scf} = \frac{1.1772 \text{ gram-moles} \times \text{M.W.}}{453.6 \text{ grams/lb}} = 2.595 \times 10^{-3} \times \text{M.W.}$$

If working with scfm values, this becomes the number of pounds of vapor per minute.

When working with ppm concentrations (which is a ratio of volumes value), first convert the ppm to a fraction value by dividing it by one million. Then using this to multiply the above vapor lbs/scf yields the weight of vapor. Since propellant work usually involves concentrations in tens and hundreds of thousands of ppm, the numerical value of "Kppm" or thousands of ppm will be used here. The expression of vapor weight per scf now becomes:

$$\frac{\text{ppm}}{1{,}000{,}000} = \text{vapor fraction ratio} = \frac{\text{Kppm} \times 1000}{1{,}000{,}000} = \frac{\text{Kppm}}{1000} = \text{Kppm} \times 10^{-3}$$

Using this fraction, vapor weight per scf now becomes:

$$\begin{aligned}\text{Vapor-lbs/scf} &= 2.595 \times 10^{-3} \times \text{M.W.} \times \text{Kppm} \times 10^{-3}\text{, or}\\ &= \underline{2.595 \times \text{M.W.} \times \text{Kppm} \times 10^{-6}}\end{aligned}$$

2. Factors for Specific Propellant Vapors and Gases:

These are obtained by multiplying the above general expression of vapor-lbs/scf by vapor molecular weights.

a. N_2O_4 - Here is a special case as this oxide of nitrogen exists in the liquid phase largely in the molecular form of N_2O_4 (M.W. = 92.012) and begins to dissociate into NO_2 molecules (M.W. = 46.006) when in the vapor phase according to the equilibrium reaction: $N_2O_4 \rightleftharpoons 2NO_2$. Depending upon temperature, pressure and concentrations, the degree of dissociation will shift the equation either to the right or left. Increasing the vapor temperature or extent of dilution drives the reaction to the right, i.e. increases the degree of dissociation and amounts of NO_2. Increasing the pressure or concentrations will drive the equation to the left and diminish the amounts of NO_2. Ultimately, once emitted into the atmosphere, virtually 100% of N_2O_4 emissions end up dissociated into the NO_2 form due to the extreme dilutions encountered. However, prior to and at the moment of emission (the situations of interest in making calculations), the vapor is still largely undissociated.

The degree of dissociation is important as the average M.W. of the mixture will shift between the values of 92 and 46 and this in turn impacts upon the vapor weights (and therefore emissions) in lbs/scf. In order to establish the degree of dissociation (with its impact on average M.W.) under emission conditions to be expected at VAFB, a calculational effort was made and resulted in Graph 1. The "Zone of VAFB Highest Probability and Impact" was defined as the temperature range of 59 to 95°F (15 to 35°C) and most probable concentrations from 250 Kppm (i.e. 25%) to pure material, these being most likely to be of significance in VAFB emission calculations. It can be seen that the NO_2 weight percents in this zone range from approximately 5 to 17%, with a most probable value about 9 to 10% or less. As these percentages impact the mixture M.W. value by just one-half (because they only change the difference between 92 and 46 when affecting the M.W. value -- mathematically equivalent to a halved percentage value reduction in the N_2O_4 M.W. of 92.012), this means the average mixture M.W. is only reduced by approximately 2 to 8% and most likely by less than 5%. Taking into account the many, many times greater uncertainties involved in calculating emissions*, the conservative choice will be to not adjust the N_2O_4 M.W. for NO_2 dissociation, leaving it at 92.012.

$$N_2O_4 \text{ vapor lbs/scf} = 2.595 \times 92.012 \times \text{Kppm} \times 10^{-6}$$
$$= \underline{2.388 \times 10^{-4} \times \text{Kppm}}$$

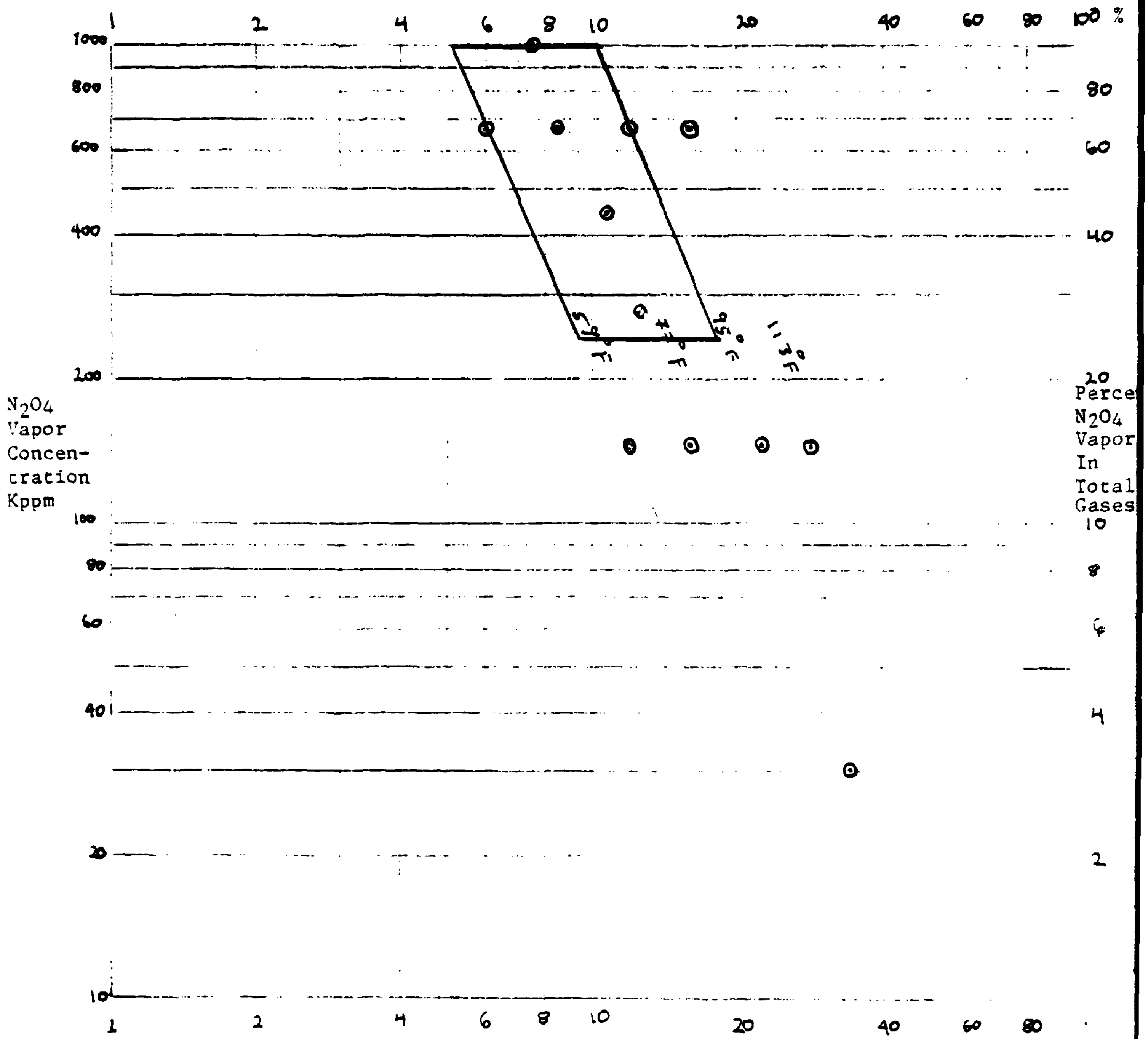
*This is a reflection of the many assumptions that must be made and frequent unavailability of decent input data. Notwithstanding the presence and use of multi-significant-place values, a realistic practice on the part of all users would be to mentally round off the final emission calculation value to just one significant figure, unless input data quality justifies additional significant digits.

GRAPH 2-1

ZONE OF VAFB HIGHEST PROBABILITY AND IMPACT

N_2O_4/NO_2 EQUILIBRIUM PERCENTAGES CHART

Weight Percent of Total $N_2O_4 + NO_2$ as NO_2



Weight Percent of Total $N_2O_4 + NO_2$ as NO_2

b. "IRFNA Vapor" - Due to the great difference in vapor pressures between N_2O_4 (the ingredient dissolved into nitric acid that makes it Inhibited "Red Fuming" Nitric Acid) and the nitric acid, which is very much less; the vapor above IRFNA can be considered to be essentially just N_2O_4. For purposes of calculations, the weight factor developed for N_2O_4 above should be used for IRFNA emission estimates.

c. Hydrazine, N_2H_4, M.W. = 32.045

$$N_2H_4 \text{ vapor lbs/scf} = 2.595 \times 32.045 \times \text{Kppm} \times 10^{-6} = \underline{8.316 \times 10^{-5} \times \text{Kppm}}$$

d. UDMH, M.W. = 60.099

$$\text{UDMH vapor lbs/scf} = 2.595 \times 60.099 \times \text{Kppm} \times 10^{-6} = \underline{1.560 \times 10^{-4} \times \text{Kppm}}$$

e. Aerozine-50 (A-50) - Being a mixture of hydrazine and UDMH which have greatly differing vapor pressures, the vapor above A-50 would not have the same composition as the liquid. From data in Reference 9, the ullage vapor above A-50 has a high preponderance of UDMH, mostly on the order of 96-99 wt %. As in the N_2O_4 case above, a conservative choice would be to adopt the UDMH vapor weight-value above for the A-50 value. While an adjustment can be made for the content of hydrazine vapor, it would only lower the vapor weight per scf by a percent or so at most -- a trivial amount in light of uncertainties commonly encountered in emission calculations.

$$\text{A-50 vapor lbs/scf} = \underline{1.56 \times 10^{-4} \times \text{Kppm}}$$

2.3.3.2 N_2O_4 Burner Efficiency

Direct data were not found for the efficiency or operating parameters of the VAFB burners used to destroy N_2O_4 vapors. Reference 3 had the only actual measured burner-effluent data located during the data survey. Unfortunately, the test conditions and data did not cover what might be expected at VAFB.

The Reference 3 study used a Titan Site-Martin Marietta ten lb/min burner head. However, testing constraints limited the actual flow to a maximum of 1.6 lbs/min of N_2O_4. Also, the study purpose was to evaluate burner operating and flame parameters and was not addressed to efficiency of N_2O_4 vapor destruction. A single value of "96 mole percent consumption of the N_2O_4 feed" was presented, however, the source and background for this value was not located within the report.

As the study data were for tests ranging between where black smoke (propane-rich) or reddish-brown fumes (N_2O_4-rich) were visible, the report values inbetween these conditions were reviewed. This was based on the assumption that VAFB oxidizer burners are operated so that neither black smoke or visible N_2O_4 fumes are emitted.

In the parts of Reference 3 where it was possible to (sometimes with intermediate calculations needed) directly compare weights of input N_2O_4 and output NO_x,* the following efficiencies (in percent) were obtained:

From Figure 11 - "Nitrogen Oxide Emitted at Low Propane Flows"

94.7, 95.4%

From Figure 16 - "NO_x Emitted from the Burner at Different Input Rates" (If vertical axis scale is a typo error and really is 0.01, 0.02, etc. lb/min)

93.0, 98.0, 97.5%

From Figure 18 - "Flow Rate Vs. NO_x Emissions for Tank Blowdown"

98.8, 95.0, 91.6, 87.8%

From Table in Appendix C - "Flame Chemistry Test Data"

54.7, 82.4, 95.6, 80.6, 75.8%
74.3, 97.3, 95.6, 95.2, 85.9%
and 79.1%

*NO_x is defined as NO and NO_2 combined -- this being the forms of nitrogen oxides seen after passage through a flame. Burner effluents were usually about 40-43% NO_2 with NO as the balance.

(For the Appendix C Table, with the two most extreme values at each end deleted, the average of the remaining 9 values is 85%.)

This is a most difficult situation from which to make a judgment since both the Reference 3 operating conditions are not always clear, while those of the VAFB burner are unknown in this case. Also, it is unknown if the above values can or cannot be given equal weight when comparing one to another. As it appears that values below 90% (along with their magnitudes) approximate those above 90%, a balanced and conservative choice (until better information is available) is to adopt a burner efficiency value of 90%. Since the value is based on so little data, it is suggested that this 90% efficiency factor be used -- and understood -- only as an interim value pending better information being obtained.

2.3.3.3 Titan Tank Farm Transferrings

A. Two operations take place at the tank farm: delivery by truck/tanker to Titan storage tank and then from storage to Air Force truck. Emission factors will be developed for each emitting step and combined together to yield one emission factor per transfer operation (venting, transfer and purging will be combined). N_2O_4 and Aerozine-50 (A-50) are the propellants.

B. For Titan Tank Farm "Givens" (mostly from phone calls to VAFB Titan Tank Farm personnel), see Table 2.4.

2.3.3.3.1 Emission-Relevant Activities: Incoming Load Transfer to Storage Tank:

A. Vent Storage Tank Blanket Pressure (16 psig to 5 psig)

During this activity, the method is the same for both oxidizer and fuel storage tanks. As the ullage in the storage tank varies during the filling process (taking 6 commercial deliveries of oxidizer and from 3 to 4 (3.6 average) loads of fuel to fill a tank), the assumption will be made that on the average, the tank is half full. This assumes that half the time the tank level is below the midpoint and the rest of the time it

TABLE 2.4

TITAN TANK FARM "GIVENS"

Item	Oxidizer (= O_x)	Fuel (=F)
Propellants Handled:	N_2O_4	A-50
Density	12.1 lb/gal	7.5 lbs/gal
Storage tank (=ST) volume	22,000 gals (2,941 ft^3)	22,000 gals (2,941 ft^3)
ST propellant capacity (with 10% ullage)	≈240, [illegible]0 lbs (≈ 20,000 gals)	≈ 150,000 lbs (≈20,000 gals)
Commercial Delivery (=CD)		
Incoming tanker capacity (with 10% ullage)	38-40,000 lbs/load (≈3,300 gals)	40-42,000 lbs/load (≈5,500 gals)
CD Tanker volume (total)	≈ 3,700 gals (≈ 492 ft^3)	≈6,200 gals (≈830 ft^3)
Air Force Tanker (trailer) (=AFT)		
Total volume (incl. ullage)	2,500 gals (≈ 334 ft^3)	≈4,500 gals (≈602 ft^3)
Load capacity - volume (w. 10% ullage)	2,250 gals (≈ 301 ft^3)	4,000 gals (≈535 ft^3)
Load capacity - weight	27,180 lbs	30,000 lbs
Controls:	All N_2O_4 vented through burner*	All fuel vapor vented to atmosphere
Vapor Weight Factors:	lbs N_2O_4 vapor/ft^3 = 2.388** x 10^{-4} x Kppm lbs/scf	lbs A-50 vapor/ft^3 = 1.56** x 10^{-4} x Kppm lbs/scf

* Burner efficiency assumed to be 90% (see section on N_2O_4 Burner Efficiency for discussion).
** Values from section on Vapor Weight Factors.

is above that point. This concept is based on the idea that starting at near empty (90% ullage), it takes several transfers to fill (with 10% ullage), with each succeeding load starting with a fuller tank than the one before. Half the storage tank volume is 11,000 gallons or 1,470 ft^3. With a venting pressure drop of from 16 to 5 psig (11 psig), this will correspond to a scf volume of:

$$\frac{11 \text{ psi}}{14.7 \text{ psi/atm}} \times 1{,}470 \text{ ft}^3 = 1{,}100 \text{ scf vented } \underline{\text{per}}\ \underline{\text{average}} \text{ transfer}$$

(1) Oxidizer Emissions from Step A

This is dependent on the N_2O_4 vapor concentration within the storage tank ullage upon venting. While Reference 8 has calculations showing concentrations expected during venting of N_2O_4 tanks, Reference 5 was the only one that had actual measured concentrations -- though it was for gases vented during propellant transfers rather than a simple venting. A review of the Reference 5 data showed initial concentration values (the ones one would expect to be first out and typical of ullage values) at start of transfers showed higher end (in 5 out of 9 runs selected) concentrations of about 300 to 350 Kppm N_2O_4 with an average value of 325 Kppm.

Taking this as a typical N_2O_4 vapor combination in the ST ullage while venting, this represents:

lbs NO_x (NO, NO_2, N_2O_4 emitted after going through the burner is counted as NO_x) emitted/average venting in Step A =

1,100 scf vented x 2.388 N_2O_4 factor x 10^{-4} x 325 Kppm lbs/scf x 0.1 burner efficiency factor = 8.5 lb NO_x emitted/avg. ST venting

(2) Fuel Emissions from Step A

With A-50, expected emissions would be in the form of saturation concentrations from fuel evaporating into the ullage. No direct data for A-50 were located in the data survey. The closest reference is Reference 1 which, however, has no background information available on how the values were derived. For A-50, the highest values (presumably saturated) were 24-25% (or 250,000 ppm). That this figure is "ball park" accurate comes from use of the vapor pressure/ppm formula:* ppm = vapor pressure (in atmospheres) x 10^6 applied to an A-50 vapor pressure value of 3.1 psi at 80°F. Assuming that this is a saturated situation, the ppm will be: (3.1 psi ÷ 14.7 psi/atm) x 10^6 = 211,000 ppm. As the average ambient temperature at VAFB is usually in the 60's (°F) and vapor pressure drops rapidly with relatively small temperature reductions, a conservative (i.e. in the direction of increased emission

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*Converting vapor pressure into ppm: The approach is to calculate wt. of a unit volume at the vapor pressure, then the volume of that wt. if P = 1 atm, then take the ratio of the 2 volumes to get a ppm value.

Let vapor pressure = P_{vap} (expressed in atmospheres)

Total wt. (leave as number of moles) in unit value V_{unit} at P_{vap} is:

$$P_{vap} \cdot V_{unit} = nRT, \quad n = \frac{P_{vap} \cdot V_{unit}}{RT}$$

and the new volume; V^1 for the same n at a new P^1 (= 1 atm) will be (in equation form):

$$\frac{P_{vap} \cdot V_{unit}}{RT} = n = \frac{P^1 V^1}{RT}, \text{ which reduces to } P_{vap} \cdot V_{unit} = P^1 V^1 \qquad (1)$$

For ppm, we want the ratio: $\frac{V^1}{V_{unit}}$ which is multiplied by 1,000,000 to get ppm.

So, taking the Equation (1), we get $\frac{V^1}{V_{unit}} = \frac{P_{vap}}{P^1}$, which becomes: ppm = $\frac{P_{vap}}{P^1}$ x 10

which reduces farther (since we set P^1 = 1 atm and can now express the vapor pressure in atm) as: ppm = vapor pressure (in atm) x 10^6

estimates) choice of 210,000 ppm or 210 Kppm will be used in calculations as the saturated vapor concentration for A-50.

Taking this value as typical of saturated ST ullage, this represents (as above):

lbs A-50 vapor emitted/avg. Step A venting = 1,100 scf x 1.56 x 10^{-4} x 210 Kppm lbs/scf = <u>36 lbs</u>

As this was directly vented to the atmosphere, this is the emission.

B. <u>Actual Propellant Transfer Step</u>

Propellants are transferred from the CD using a 100 gpm pump, with the ST continuously venting ullage from displacement by incoming propellant. Thus, the ullage vented equals volume of propellant delivered.

(1) Oxidizers: 40,000 lbs/load delivered ÷ 12.1 lbs/gal ÷ 7.481 gal/ft^3 = <u>442 ft^3/load</u>

lbs NO_x emitted = 442 ft^3 x 2.388 x 10^{-4}

x 325 kppm lbs/scf x 0.1 = <u>3.4 lbs NO_x</u>

(2) Fuel: 42,000 lb/load delivered ÷ 7.5 lbs/gal ÷

7.481 gal/ft^3 = <u>749 ft^3/load</u>

lbs A-50 vapor emitted = 749 ft^3 x 1.56 x 10^{-4} x 210 Kppm lbs/scf

= <u>24.5 lbs A-50 vapor</u>

C. <u>Line Purging After Transfer</u>

After the transfer is completed, the lines (at the CD tanker) are purged by being "blown out" with 50 psig GN_2 into the storage tank while the latter continues venting. Note: this is not a simple "through-and-out" flushing of just the "plumbing" associated with propellant transfer, it is a purge flow also flushing out the ST ullage -- this having remained essentially saturated with propellant vapor. So the emissions are not just whatever propellant (liquid and vapor) remains in the lines, it also includes whatever ST ullage vapors are blown out.

Appropriate and applicable data for this filling-line purge step could not be located in the available data base. The closest values found were in References 1 and 7. The "tanker purge" in Ref 1 shows an equivalent purge flow of 145 scfm for an estimated duration of 15 minutes. However, no details or other information is given as to what physical situation this applies to or how these values were arrived at. Reference 1 also has for the "system purge" on the RSV (a much larger system) an equivalent purge flow of 560 scfm, also for an estimated duration of 15 minutes. One design extreme (for scrubber inlet use) given in Reference 7 can be assumed to refer to a purge condition -- it is given as 270 scfm with an oxidizer concentration of 33,000 ppm. Regarding this, no duration value is given or any other information to describe the situation or setup to which these values apply. The 33,000 ppm figure was originally calculated in, and taken from Reference 8 and is based on amounts of propellant evaporated when hot (150°F) GN_2 is used. Reference 7 also mentions values of 32 lbs of oxidizer vented for each GN_2 purge. Besides this value appearing rather high compared to a tank line purge situation, no information was given as to the applicable situation and how this value was derived.

From the above values, a purge flow of 300 scfm appears reasonable as a "higher end" selection for a line purge estimate. Since the flow duration at Titan Tank Farm is two minutes, we are talking about an estimated total purge flow of 600 scf. As this also represents the amount of ullage that will be vented by displacement from the ST during the purge, the emissions are equal to that amount of ullage displaced -- i.e. 600 scf of ullage vapors. With this volume being only a small part of the total average ullage, this means (again, as above in B) that the ullage vapor concentration is still essentially saturated.

The emission estimates can now be calculated for the line purge step as:

(a) Oxidizers:

$600 \text{ scf} \times 2.388 \times 10^{-4} \times 325 \text{ Kppm lbs/scf} \times 0.1$

$= \underline{4.7 \text{ lbs of } NO_x \text{ emitted}}$

(b) Fuel:

$600 \text{ scf} \times 1.56 \times 10^{-4} \times 210 \text{ Kppm lb/scf} = \underline{19.7 \text{ lbs of A-50 vapor emitted}}$

D. Summary of Emissions Per Load Transferred From Commercial Tanker to Titan Tank Farm Storage Tank

Emitting Step		Oxidizer (lbs)	Fuel (lbs)
A	Vent storage tank from storage blanket	8.5	36
B	Actual transfer operation	3.4	24.5
C	Line purge operation	4.7	19.7
Total Emissions per propellant load transferred		16.6	80.2

1981 emissions, based on 15 load transfers, are 249 lbs of NO_x, and based on 10 load transfers, are 802 lbs of A-50.

2.3.3.3.2 Emission-Relevant Activity - Loading of Air Force Tanker (AFT) From Storage Tank

A. Vent AFT From Blanket Pressure to Just Above Ambient (15 psig to 1 psig)

Since the AFTs are in fully dedicated use and not cleaned out between loads, the maximum emissions would be those of essentially saturated vapor within the AFT ullage. Using the same values and reasoning approaches as presented in 3.1.A, the AFT venting emissions can be calculated (assuming the AFT is essentially empty to start with) as:

(1) Oxidizer:

$$\underset{\substack{\text{(converting pressure}\\ \text{change to atmospheres)}}}{\frac{15 - 1 \text{ psig}}{14.7 \text{ psi/atm}}} \times \underset{\substack{\text{(AFT volume}\\ \text{[empty])}}}{\frac{2{,}500 \text{ gals}}{7.481 \text{ gals/ft}^3}} \times \underset{(N_2O_4 \text{ factor})}{2.388 \times 10^{-4}}$$

$$\times \underset{\substack{\text{(vapor}\\ \text{conc.)}}}{325 \text{ Kppm lb/ft}^3} \times \underset{\substack{\text{(burner}\\ \text{effic.}\\ \text{factor)}}}{0.1} = \underline{2.5 \text{ lbs } NO_x \text{ emitted}}$$

(2) Fuel:

$$\frac{15 - 1 \text{ psig}}{14.7 \text{ psi/atm}} \times \frac{4{,}500 \text{ gals}}{7.481 \text{ gals/ft}^3} \times 1.56 \times 10^{-4} \times 210 \text{ Kppm lbs/scf}$$

$$= \underline{18.8 \text{ lbs of A-50 vapor emitted}}$$

B. Actual Propellant Transfer Step

Here again, as in the transfer step into the storage tank, a 100 gpm pump is used to fill the AFT to about 90% of volume (10% ullage) while continuously venting from the AFT as the propellant is received. Using the same reasoning as in 3.1.B, the emissions are in that volume of saturated ullage displaced by the propellant transferred.

(1) Oxidizer:

$$\frac{2{,}250 \text{ gals (vol. of load)}}{7.481 \text{ gal/ft}^3} \times 2.388 \times 10^{-4} \times 325 \text{ Kppm lbs/scf}$$

$$\times 0.1 = \underline{2.3 \text{ lbs } NO_x \text{ emitted}}$$

(2) Fuel:

$$\frac{4{,}000 \text{ gals (vol. of load)}}{7.481 \text{ gals/ft}^3} \times 1.56 \times 10^{-4} \times 210 \text{ Kppm lbs/scf}$$

$$= \underline{17.5 \text{ lbs of A-50 vapor emitted}}$$

C. Line Purging After Transfer

After the transfer is completed, the lines (at the ST) are purged by being blown out with 50 psig GN_2 into the AFT which continues to be vented. As with 3.1.C reasoning, the same approach will be used here, however, with one difference. The purge volume of 600 scf is now several times the ullage volume in the much smaller (and loaded) AFTs. These ullages are: 250 gals (33.4 ft^3) for the oxidizer AFT and 500 gals (66.8 ft^3) for the fuel AFT.

So the emissions here will not only be whatever saturated vapor is initially in the AFT ullage, they will also come from whatever evaporates into the purge flow as it passes over the propellant liquid surface on its way to the vent. As the purge flow rate (300 scfm) represents 9 turnovers of ullage per minute for the oxidizer AFT and 5 turnovers for the fuel AFT over a duration of two minutes, it is apparent that the time is not there for any degree of vapor saturation per turnover to be achieved by evaporation into the purge flow. As some evaporation will take place due to continually fresh purge gas impinging on the liquid surface, one estimate would be to make the total amount evaporated over the two minutes equal to the amount of vapor initially present before purging.* This in effect would make the final emissions equal to double the amount of saturated ullage vapor originally present. Note that this estimate would probably not change much if different purge rates were used. This is due to the evaporation rate (lbs/min/ft^2 surface) into fresh gas being nearly constant plus its being a function of temperature rather than flow.

*The true amount over two minutes would probably be far less, however, using a conservative approach (i.e. to move towards worst case with emissions calculated) has been chosen here as a guide.

The calculations would be:

(1) Oxidizer

$$2^* \times \frac{250 \text{ gal}}{7.481 \text{ gal/ft}^3} \times 2.388 \times 10^{-4} \times 325 \text{ Kppm lbs/scf}$$

$$\times\ 0.1 = \underline{0.5 \text{ lbs } NO_x}$$

(2) Fuel

$$2^* \times \frac{500 \text{ gal}}{7.481 \text{ gal/ft}} \times 1.56 \times 10^{-4} \times 210 \text{ Kppm lbs/scf}$$

$$= \underline{4.4 \text{ lbs A-50 vapor}}$$

D. Summing Up Emissions Per Load Transferred From ST to AFT

Emitting Step		Oxidizer (lb)	Fuel (lb)
A	Vent AFT from storage blanket	2.5	18.8
B	Actual transfer operation	2.3	17.5
C	Line purge operation	0.5	4.4
Total Emissions per load transferred		5.3	40.7

1981 emissions of NO_x based on 15 load transfers are 80 lbs.

1981 emissions of A-50 based on 10 load transfers are 407 lbs.

2.3.3.4 Agena Tank Farm Transferrings

The steps of propellant handling are similar at Agena as those at Titan though the propellants and physical scales are different. Because of this, the same approach as for Titan Tank Farm will be used here. Unfortunately, there is considerably less information available on Agena and therefore Titan will have to be used as a model of both the physical setup as well as for the approach. More assumptions, extrapolations, etc. will also have to be made.

2.3.3.4.1 Agena Tank Farm "Givens"

(See Table 2.5)

*Volume of ullage doubling factor as discussed above.

TABLE 2.5

AGENA TANK FARM "GIVENS"

Item	Oxidizer ($=0_x$)	Fuel (=F)
Propellants Handled:	IRFNA (Type III A)	UDMH
Density	12.64 lbs/gal	6.55 lbs/gal
Storage Tanks:		
Propellant capacity Total volume (with 10% ullage)	8 x 1,100 gals, total - 8,800 gal - 9,778 gal[a]	7 x 1,100 gals, total - 7,700 gal - 8,555 gal[a]
Trailers (both delivery & removal)	40,000 lbs = 3,165 gals/load	40,000 lbs = 6,107 gals/load
Trailer volume (with 10% ullage[b])	3,516 gals	6,785 gals
Vapor Weight Factor:	= 0.041 lbs/ft^3 (IRFNA saturated vapor[c] @ 25°C)	lbs UDMH vapor/ft^3 = 1.56[d] x 10^{-4} Kppm 1

a. Total volume equals propellant capacity plus 10% ullage and is calculated by dividing propellant capacity by 0.9.
b. Assumed value.
c. The vapor above IRFNA is assumed to be all N_2O_4 as the nitric acid-base vapor pressure is very low in comparison. The value shown is that calculated from the only vapor pressure value found for IRFNA -- 133 mm Hg @ 25°C, and assuming this is all N_2O_4 for one cubic foot given volume. Using Ideal Gas Law: PV = nRT.

$$n\ (\#\ \text{of moles}) = \frac{\frac{133\ \text{mm Hg}}{760\ \text{mm Hg/atm}} \times 28.317\ \text{l/ft}^3}{0.082054\ \text{l-atm/°K} \times 298.15\text{°K}} = 0.20256\ \text{moles};\ \times 92.012\ (N_2O_4\ \text{M.W.}) = 18.6\ \text{grams}$$

18.6 grams ÷ 453.6 g/lb = 0.041 lbs N_2O_4 or "IRFNA vapor" per ft^3.

d. Value from section on Vapor Weight Factors.

2.3.3.4.2 Incoming Load Transfer to Storage Tanks

A. Vent Storage Tank Blanket Pressure (10 psig - 0 psig)

Since an incoming load is slightly less than 3 Agena IRFNA tanks in volume, will assume that three tanks are nearly empty (90% ullage) and that therefore 3 x 1,100 gals volume will be venting (either together or one at a time -- it makes no difference). Applying the same approach to the UDMH tanks will mean 6 tanks will vent per truckload arrival.

The scf volume being vented is:

(1) Oxidizer:

$$\frac{10 - 0 \text{ psig}}{14.7 \text{ psi/atm}} \times 3 \text{ tank vols.} \times \frac{1{,}100 \text{ gals}}{7.481 \text{ gals/ft}^3} = 300 \text{ scf vented}$$

(2) Fuel:

$$\frac{10 - 0 \text{ psig}}{14.7 \text{ psi/atm}} \times 6 \text{ trailers} \times \frac{1{,}100 \text{ gals}}{7.481 \text{ gals/ft}^3} = 600 \text{ scf vented}$$

Total emissions: (no controls at Agena - all emissions direct to atmosphere)

(3) Oxidizer: Using vapor weight factor developed for IRFNA in Table 2.5.

300 scf x 0.041 lbs vapor/ft^3 = $\underline{\text{12.3 lbs IRFNA vapor/load}}$

(4) Fuel: No direct or applicable data were found with saturation concentrations for UDMH. Since the vapor above Aerozine-50 (A-50, 50% UDMH/50% N_2H_4), is about 96-98% UDMH (because of its higher vapor pressure compared to N_2H_4), the saturated vapor concentrations used for A-50 in the Titan Tank Farm section of this report will be used. This is 210,000 ppm and becomes:

600 scf x 1.56 x 10^{-4} x 210 Kppm lbs/ft^3 = $\underline{\text{19.7 lbs UDMH vapor/load}}$

B. Actual Propellant Transfer Step

As with Titan, the tanks being filled are venting to the atmosphere as the propellant moves into the vessel. Thus, the volume vented is equal to the propellant volume by displacement.

(1) Oxidizer:

$$\frac{3165 \text{ gals/load}}{7.481 \text{ gals/ft}^3} \times 0.041 \text{ lbs vapor/ft}^3 = \frac{17.3 \text{ lbs IRFNA}}{\text{vapor/load}}$$

(2) Fuel:

$$\frac{6107 \text{ gals/load}}{7.481 \text{ gals/ft}^3} \times 1.56 \times 10^{-4} \times 210 \text{ Kppm lbs/scf} = \frac{26.7 \text{ lbs UDMH}}{\text{vapor/load}}$$

C. Truck Venting Following Transfer

Unlike the Titan operation, Agena propellants are transferred by pressure rather than by pumping. So at the end of the transfer, one has a large trailer ullage at 20 psig which is vented down to 5 psig before leaving the Agena Tank Farm. Since the transfer takes about one hour per oxidizer load and two hours per fuel load, this becomes the time available for propellant to evaporate into the ullage. A reasonable assumption will be made that only about half of the amount needed for full vapor saturation actually evaporates and ends up being vented. These calculate to:

(1) Oxidizer:

$$0.5 \text{ (evap. factor)} \times \frac{20 - 5 \text{ psig}}{14.7 \text{ psi/atm}} \times \frac{3516 \text{ gal (trailer empty vol)}}{7.481 \text{ gal/ft}^3}$$

$$\times\ 0.041 \text{ lbs vapor/ft}^3 = \frac{9.8 \text{ lbs vapor vented}}{\text{from trailer}}$$

(2) Fuel:

$$0.5 \text{ (evap. factor)} \times \frac{20 - 5 \text{ psig}}{14.7 \text{ psi/atm}} \times \frac{6785 \text{ gal}}{7.481 \text{ gal/ft}^3}$$

$$\times\ 1.56 \times 10^{-4} \times 210 \text{ Kppm lbs/scf} = \frac{15.2 \text{ lbs UDMH vapor vented}}{\text{from trailer}}$$

D. Line Purging After Transfer

No information was known about this phase of Agena Tank Farm operation. Therefore, since the trailers and loads are approximately the same as used for Titan, the assumption is made that the procedure and operation are the same (lines purged @ 300 scfm nitrogen for 2 minutes through the tanks which remain vented). Since the ullage atop a full Agena tank is small compared to the purge flow, the same assumption will be made as was for Section 3.1.C, in Titan -- i.e. the loss is twice that of the ullage volume alone, which is assumed to be at saturation.

(1) Oxidizer:

$$2^* \times \frac{3 \text{ tanks} \times (1222^{**} - 1100 \text{ gals})}{7.481 \text{ gals/ft}^3} \times 0.041 \text{ lbs vapor/ft}^3$$

$$= \underline{4.0 \text{ lbs vapor purged}}$$

(2) Fuel:

$$2^* \times \frac{6 \text{ tanks} \times (1222^{**} - 1100 \text{ gals})}{7.481 \text{ gals/ft}^3} \times 1.56 \times 10^{-4}$$

$$\times 210 \text{ Kppm lbs/scf} = \underline{6.4 \text{ lbs vapor purged}}$$

E. Summing Up Emissions Per Load Delivered to Agena Tank Farm

Emitting Step		Oxidizer (lbs)	Fuel (lbs)
A	Vent storage tank from storage blanket	12.3	19.7
B	Actual propellant transfer step	17.3	26.7
C	Trailer venting following transfer	9.8	15.2
D	Line purging after transfer	4.0	6.4
Total Emissions per load delivered		43.4	68.0

1981 emissions, based on three transfers, are 130 lbs of N_2O_4 and 204 lbs of UDMH.

*Ullage doubling factor as discussed above.
**Total calculated volume of one tank.

2.3.3.4.3 Trailer Loading From Agena Tank Farm

A. Vent Trailer Blanket Pressure - 5 psig to 0 psig

The assumption is made here that the trailer is essentially empty and saturated with propellant vapor.

(1) Oxidizer:

$$\frac{5 - 0 \text{ psig}}{14.7 \text{ psi/atm}} \times \frac{3{,}516 \text{ gals}}{7.481 \text{ gals/ft}^3} \times 0.041 \text{ lbs vapor/ft}^3$$

= 6.6 lbs vapor of IRFNA

(2) Fuel:

$$\frac{5 - 0 \text{ psig}}{14.7 \text{ psi/atm}} \times \frac{6{,}785 \text{ gals}}{7.481 \text{ gals/ft}^3} \times 1.56 \times 10^{-4}$$

x 210 Kppm lbs/scf = 10.1 lbs UDMH vapor

B. Actual Propellant Transfer Step

As before, the receiving vessel (the trailer) is venting by displacement from the incoming propellant. Meanwhile, the storage tanks have been pressurized to 20 psig to push the propellant over into the trailer. The values here are identical to those calculated in 4.2.B: 17.3 lb IRFNA vapor/load, 26.7 lbs UDMH vapor/load.

C. Tank Ventings After Transfer Completed

This is the same situation as in 4.2.C, except it is the emptied tanks (with 90% ullage) that have to be vented. This calculates as below and makes the same assumptions as in 4.2.C.

(1) Oxidizer:

$$0.5 \text{ (evap. factor)} \times \frac{20 - 10 \text{ psig}}{14.7 \text{ psi/atm}} \times 3 \text{ tanks} \times \frac{(1222 - 122 \text{ gals})^*}{7.481 \text{ gals/ft}^3}$$

x 0.041 lbs vapor/ft^3 = 6.2 lbs. vapor

*Total volume of tank (100% ullage) minus 10% ullage = 90% ullage.

(2) Fuel:

$$0.5 \text{ (evap. factor)} \times \frac{20 - 10 \text{ psi}}{14.7 \text{ psi/atm}} \times 6 \text{ tanks} \times \frac{(1222 - 122 \text{ gal})^*}{7.481 \text{ gals/ft}^3}$$

$$\times 1.56 \times 10^{-4} \times 210 \text{ Kppm lbs/scf} = \underline{9.8 \text{ lbs vented}}$$

D. Line Purging After Transfer

The same approach is used as in 4.2.D, especially with the ullage volume above the loaded trailers about equal to the tanks in 4.2.D.

(1) Oxidizer:

$$2^{**} \times \frac{(3516 - 3165 \text{ gals}) \text{ [trailer ullage volume]}}{7.481 \text{ gal/ft}^3}$$

$$\times 0.041 \text{ lbs vapor/ft}^3 = \underline{3.8 \text{ lbs vapor purged}}$$

(2) Fuel:

$$2^{**} \times \frac{(6785 - 6107 \text{ gals}) \text{ [trailer ullage volume]}}{7.481 \text{ gal/ft}^3}$$

$$\times 1.56 \times 10^{-4} \times 210 \text{ Kppm lbs/scf} = \underline{5.9 \text{ lbs vapor purged}}$$

E. Summing Up Emissions Per Load From Agena Tank Farm

Emitting Step		Oxidizer (lbs)	Fuel (lbs)
A	Vent trailer from storage blanket	6.6	10.1
B	Actual propellant transfer step	17.3	26.7
C	Tank ventings following transfer	6.2	9.8
D	Line purging after transfer	3.8	5.9
Total Emissions per Agena propellant trailer loaded		33.9	52.5

1981 emissions, based on three transfers, are 102 lbs of N_2O_4 and 158 lbs of UDMH.

*Total volume of tank (100% ullage) minus 10% ullage = 90% ullage.
**Volume of ullage doubling factor as discussed in 4.2.D.

2.3.3.5 SLC-4 Propellant Emission Activities

Propellant vapor emissions at SLC-4 all come from ventings that follow basic activity steps there. These are: filling of the Ready Storage Vessels (RSV) by propellant transfer from both commercial delivery (CD) and Air Force tankers (AFT), calibration of flow meters used in loading of launch vehicles, vehicle stage testing after loading, and post-launch operations where the various propellant transfer/loading systems and lines are blown back and purged along with final RSV depressurization.

The SLC-4 emission calculations will be done in two steps: determination of a vapor-equivalent-volume (VEV), followed by the actual emission calculation where the VEV (and its associated propellant vapor concentrations) is multiplied by the vapor weight factor and (if applicable) the burner efficiency factor, or:

$$\text{lbs emissions} = \text{VEV} \times \text{vapor weight factor lbs/scf} \times \text{burner efficiency}$$

Calculation of a VEV reduces all the differences (volumes, pressure drops, etc.) found between the various activities to one common (equivalent) unit -- a scf value. The VEV scf takes into account not only the physical parameters of a given situation, it also incorporates whatever assumptions have been made to permit unknown factors to be quantified and then included. A general "venting formula" (per venting) would take the form of:

$$\frac{\text{(initial psig - final psig)}}{\text{14.7 psi/atmosphere}} \times \text{ullage (volume) being vented}$$

= equivalent volume (under standard conditions) being vented and will usually give the VEV value directly.

2.3.3.5.1 SLC-4 "Givens"

The "givens" for SLC-4 are summarized in Table 2.6. The values shown were taken from excerpts out of a set of Martin Marietta Aerospace Titan III WTR Test Procedures and discussion with SLC-4 personnel.

TABLE 2.6

SLC-4 "GIVENS"

Item		Oxidizer	Fuel
Propellants handled:		N_2O_4	Aerozine-50 (A-50)
Propellant density:		12.1 lb/gal[a]	7.5 lbs/gal[a]
Vapor weight factors		2.388×10^{-4} x kppm lbs/scf[b]	1.56×10^{-4} x kppm lbs/scf[b]
RSV (ready storage vessel) propellant capacity		25,000 gallons (3342 ft^3)	20,500 gallons (2740 ft^3)
RSV total volume		27,778 gallons (3713 ft^3)[c]	22,778 gallons (3045 ft^3)[c]
Commercial propellant tanker	- capacity	3,500 gallons (468 ft^3)	5,500 gallons (735 ft^3)
	- total volume[d]	3,700 gallons (492 ft^3)	6,200 gallons (829 ft^3)
Air Force tanker	- capacity	2,250 gallons (301 ft^3)	4,000 gallons (535 ft^3)
	- total volume[d]	2,500 gallons (334 ft^3)	4,500 gallons (602 ft^3)

a At 68°F.
b All calculations assume standard conditions of 68°F and one atmosphere.
c Obtained by dividing RSV propellant capacity by 0.9.
d Total volume = full propellant capacity volume plus 10% ullage.

2.3.3.5.2 SLC-4 Venting Activities

A. RSV LOADING

1. RSV Venting as Part of Propellant Filling Process

a. Oxidizer - The RSV blanket pressure (14 to 15 psig) is vented to approximately 4 to 6 psig (initially necessary prior to trailer off-load) This occurs approximately 1-1/2 times per trailer off-load due to vessel repressurization. To fill the RSV (defined as 10% ullage) requires about 21,000 gallons of oxidizer (the RSV starts with about 4,000 gallons) -- the equivalent of six commercial trailer loads or nine full AFT loads (the latter totaling about 20,250 gallons as the AFT load capacity of 2,250 gallons does not divide evenly into 21,000 gallons).

The 4,000 gallons in the RSV at start of filling represents an 85.6% ullage (100% - 100 [4,000 ÷ 27,778]). The assumption will be made here (similar in reasoning to that used for the Titan Tank Farm storage tank loadings) that the average ullage per load transferred is half way between the starting and next-to-the-final ullage (as the RSV is separately vented after the final load -- see Section 3. below). For CD loading of the RSV, the average ullage is 54.1%,* and multiplying this value by 27,778 gallons (the total RSV volume) equals 15,028 gallons as the average ullage during CD loadings. For AFT loadings of oxidizer, the same approach given an average ullage of 53.2%,** multiplying this by 27,778 gallons (total RSV volume) equals 14,778 gallons as the average ullage during AFT off-loadings.

* 85.6-10% ullage differences divided by 6 = 12.6% ullage change/load; and next to full ullage of 10% + 12.6% = 22.6%; therefore total ullage change during RSV loading is 85.6-22.6% = 63%; half of which is 31.5% and 85.6-31.5 = 54.1%.

**Since nine AFT loads only go to 20,250 gallons plus the original 4,000, this is 24,250 gallons total, or 24,250 ÷ 27,778 = 0.873. This from 100% is 12.7% ullage when full. Now: 85.6-12.7% = 72.9% difference on filling, dividing this by 9 loads gives 8.1% ullage change/load; and next-to-full ullage of 12.7 + 8.1% gives 20.8%; and 85.6 - 20.8 = 64.8% difference; half of which is 32.4% and 85.6 - 32.4 = 53.2%.

The oxidizer venting of the RSV during filling occurs approximately 1-1/2 times per trailer off-load. This is (6 off-loads per RSV filling) x (1-1/2 venting per off-load) = 9 times per RSV filling from CDs and 13.5 for AFTs, and the general formula presented in 2.3.3.5 above will be used as part of the VEV calculation. The ullage is assumed to start out being "saturated" with N_2O_4 vapors at 325 kppm (as in the Titan Tank Farm case) and should remain reasonably constant as the RSV continues to fill by displacement. Additional pressurization between fillings should not change the vapor concentration significantly.

So an averaœe VEV per oxidizer filling of the RSV (this includes the initial and subsequent ventings that occur with each tanker off-load) would be:

For CD loadings; the VEV_{CD} =

$$9 \times \frac{15\ \text{psig} - 4\ \text{psig}}{14.7\ \text{psi/atm}} \times 54.1\%\ \text{of}\ \frac{27{,}778\ \text{gals}}{7.481\ \text{gals/ft}^3}$$

$$= 13{,}529\ \text{scf}$$

For AFT loadings; the VEV_{AFT} =

$$13.5 \times \frac{15\ \text{psig} - 4\ \text{psig}}{14.7\ \text{psi/atm}} \times 53.2\%\ \text{of}\ \frac{27{,}778\ \text{gals}}{7.481\ \text{gals/ft}^3}$$

$$= 19{,}955\ \text{scf}$$

The oxidizer emissions are calculated using the general equation presented in 2.3.3.5, namely: VEV x vapor weight factor x burner efficiency factor = lbs emitted.

For CD loadings: 13,529 scf x 2.388 x 10^{-4} x 325 kppm lbs/scf x (1.0-0.9) = 105 lbs CD

For AFT loadings: 19,955 SCF x 2.388 x 10^{-4} x 325 kppm lbs/scf x 0.1 = 155 lbs AFT

b. Fuel - This case is different from the oxidizer situation in that the RSV is first vented from nominal blanket pressure (15 psig) to ambient pressure and then continuously vented at ambient as fuel is pumped in. Thus the total volume vented (assumed to be saturated with fuel vapors) is the volume from initial depressurization plus the subsequent ullage volume displaced by incoming fuel.

The total VEV would be:

$$\frac{15\ \text{psig} - \emptyset\ \text{psig}}{14.7\ \text{psi/atm}} \times \frac{(22{,}778 - 4{,}000\ \text{gals})}{7.481\ \text{gals/ft}^3}$$

$$+ \frac{(20{,}500 - 4{,}000\ \text{gals})}{7.481\ \text{gals/ft}^3} = 4{,}767\ \text{scf}$$

The fuel emissions (per RSV loading) are calculated as VEV times vapor-weight factor and will use the saturated concentration (same as Titan section) of 210 kppm.

$4{,}767$ scf x 1.56×10^{-4} x 210 kppm lbs/scf
= 156 lbs fuel emitted per full loading of RSV

2. Final Venting of Emptied Propellant Carrier

a. Oxidizer - Here the essentially emptied (of liquid) trailer is vented from 52 to 10 psig prior to leaving the SLC-4 facility. The key assumption has to do with degree of vapor saturation in the ullage upon venting. The probability is that the nitrogen gas blanket is likely to be saturated or close to it. As the degree is difficult to determine, the assumption will be made of a saturated ullage being vented.

The VEVs will be calculated first for both (single) CD and AFT carriers.

$$VEV^1_{CD} = \frac{52\text{-}10 \text{ psig}}{14.7 \text{ psi/atm}} \times 492 \text{ ft}^3 \text{ (the tanker total volume)}$$

$$= 1406 \text{ scf/CD trailer}$$

$$VEV^1_{AFT} = \frac{52\text{-}10 \text{ psig}}{14.7 \text{ psi/atm}} \times 334 \text{ ft}^3 \text{ (the tanker total volume)}$$

$$= 954 \text{ scf/AFT trailer}$$

The oxidizer emissions calculate as:

$$1406 \text{ scf/CD load} \times 2.388 \times 10^{-4} \times 325 \text{ kppm lbs/scf} \times 0.1 = 10.9 \text{ lbs/CD}$$

$$954 \text{ scf/AFT load} \times 2.388 \times 10^{-4} \times 325 \text{ kppm lbs/scf} \times 0.1 = 7.4 \text{ lbs/AFT}$$

Since the full loading of the oxidizer RSV takes 6 CD loads or 9 AFT loads, the final emissions per RSV loading are:

If CDs are used: emissions are 6 x 10.9 lbs/CD = <u>65 lbs per full RSV loading</u>

If AFTs are used: emissions are 9 x 7.4 lbs/AFT = <u>67 lbs per full RSV loading</u>

b. <u>Fuel</u> - The same approach and assumptions will be used here as for the oxidizer situation above. In the case of fuel transfer, a pressure of 30 psig in the trailer is used.

$$VEV^1_{CD} = \frac{30\text{-}10 \text{ psig}}{14.7} \times 829 \text{ ft}^3 = 1128 \text{ scf/CD trailer}$$

$$VEV^1_{AFT} = \frac{30\text{-}10 \text{ psig}}{14.7} \times 602 \text{ ft}^3 = 819 \text{ scf/AFT trailer}$$

The fuel emissions calculate as:

$$1128 \text{ scf/CD load} \times 1.56 \times 10^{-4} \times 210 \text{ kppm lbs/scf}$$
$$= 37 \text{ lbs/CD venting}$$

$$819 \text{ scf/AFT load} \times 1.56 \times 10^{-4} \times 210 \text{ kppm lbs/scf}$$
$$= 27 \text{ lbs/AFT venting}$$

Since the full loading of the fuel RSV takes 3 CD or 4 AFT loads, the final fuel emisions per RSV loading are:

If CDs are used: emissions are 3 x 37 lbs/CD = 111 lbs per full RSV loading

If AFTs are used: emissions are 4 x 27 lbs/AFT = 108 lbs per full RSV loading

3. Final Venting of Filled Oxidizer RSV (Note: the filled fuel RSV is not vented)

To calculate the VEV, this represents the 10% ullage in the filled RSV being vented (through the burner) from 48 to 15 psig. Vapor saturation/concentration is assumed to be 325 kppm.

$$VEV_{OxRSV} = \frac{48-15 \text{ psig}}{14.7 \text{ psi/atm}} \times 371.3^{*} \text{ ft}^3 = 833.5 \text{ scf}$$

The oxidizer emission is:

$$833.5 \text{ scf} \times 2.388 \times 10^{-4} \times 325 \text{ kppm lbs/scf} \times 0.1$$
$$= 6.5 \text{ lbs/final Ox RSV venting}$$

B. RSV Venting in "Prover" Operation

The "prover" operation precedes launch vehicle loading and consists of the (closed system) filling of the prover tank, followed by flow meter calibrations with propellant flowing back into the RSV. Venting only occurs when the RSV pressure builds up and is to prevent RSV over-pressurization. On the

*10% of oxidizer RSV total volume, i.e. 10% ullage when filled.

average, there are two operational and one final RSV ventings per full calibration run prior to vehicle loading. The emissions will be calculated and totalled per full calibration operation. The RSV is assumed to be full (i.e. 10% ullage) during all prover operations and the ullage is at saturation levels (i.e. oxidizer = 325 kppm and fuel = 210 kppm).

1. Oxidizer

The two oxidizer RSV operational ventings are from 32 to 24 psig, while the final venting is from 32 to 14 psig blanket pressure. The VEV for these three ventings is:

$$2 \text{ ventings} \times \frac{32-24 \text{ psig}}{14.7 \text{ psi/atm}} \times 371.3 \text{ ft}^3 \text{ (same as in Section A(3) above)}$$

$$= 404 \text{ scf, plus}$$

$$\frac{32-14 \text{ psig}}{14.7 \text{ psi/atm}} \times 371.3 \text{ ft}^3 = 455 \text{ scf totalling 859 scf as the OxVEV}$$

The prover oxidizer emission is:

$$859 \text{ scf} \times 2.388 \times 10^{-4} \times 325 \text{ kppm lbs/scf} \times 0.1$$

$$= \underline{6.6 \text{ lbs oxidizer per full prover operation}}$$

2. Fuel

With fuel, the two operational RSV ventings and the final venting are all from 28 to 14 psig. The fuel VEV will be:

$$\frac{3 \text{ ventings} \times 28-14 \text{ psig}}{14.7 \text{ psi/atm}} \times [3045 \text{ ft}^3 \text{ (fuel RSV total vol)}$$

$$- 2740 \text{ ft}^3 \text{ (fuel RSV loaded vol)}]$$

$$= 3 \times 0.9524 \times 305 \text{ ft}^3 = 871 \text{ scf fuel vapor vented}$$

The prover fuel emission is:

$$871 \text{ scf} \times 1.56 \times 10^{-4} \times 210 \text{ kppm lbs/scf}$$
$$= \underline{29 \text{ lbs fuel per full prover operation}}$$

C. Post-Vehicle Loading Operations

1. RSV Venting After Line Blow-backs

This step consists of a one-time RSV venting following loading-line blow-backs into the RSV (after the vehicle has been loaded and prior to launch). The RSVs each have 4,000 gallons of propellant left at this point and the ullage being vented is assumed to be at usual ullage values of 325 kppm for oxidizer and 210 kppm for fuel.

a. Oxidizer - The pressure drop in the oxidizer RSV venting is from 32 to 14 psig. The VEV will be:

$$\frac{32\text{-}14 \text{ psig}}{14.7 \text{ psi/atm}} \times$$

$$\frac{(\text{total RSV vol. of } 27{,}778 \text{ gals} - 4{,}000 \text{ gals remaining oxidizer})}{7.481 \text{ gals/ft}^3}$$

$$= \frac{24 \text{ psig}}{14.7 \text{ psi/atm}} \times \frac{23{,}778 \text{ gals}}{7.481 \text{ gals/ft}^3} = 3{,}892 \text{ scf}$$

The emissions will be:

$$3{,}892 \text{ scf} \times 2.388 \times 10^{-4} \times 325 \text{ kppm lbs/scf}$$

$$\times\ 0.1 = \underline{30 \text{ lbs}} \text{ per oxidizer post vehicle loading operations}$$

b. Fuel - With fuel, the RSV pressure drop is from 40 to 15 psig and the ullage vented will be 22,778 gals (total volume of fuel RSV) minus 4,000 gals of remaining propellant = 18,778 gals. The VEV will be:

$$\frac{40\text{-}15 \text{ psig}}{14.7 \text{ psi/atm}} \times \frac{18{,}778 \text{ gals}}{7.481 \text{ gals/ft}^3} = 4{,}269 \text{ scf}$$

The emissions will be:

$4,269 \text{ scf} \times 1.56 \times 10^{-4} \times 210 \text{ kppm lbs/scf}$
$= \underline{140 \text{ lbs}}$ per fuel post vehicle loading operations

2. <u>Purging of Lines (After Testing) On Vehicle Stages I and II</u>

The lines involved here are all approximately the same volume each -- 3" dia. by an estimated run of 400 feet. This represents a calculated volume of about 20 ft^3 per line. As each vehicle stage has two lines per propellant (a line for liquid transfer and one for pressurization/venting) and there are two stages per vehicle, this makes a total of 4 lines (80 ft^3) per propellant per vehicle.

As gases venting from these lines (after previous purging) are primarily N_2 with, at most, small amounts of propellant vapor residue, the conservative (in direction of increased emissions) assumption will be made that concentrations are 1% of that normally encountered (the oxidizer 325 kppm and fuel 210 kppm).

a. <u>Oxidizer</u> - Two lines involved are vented to ambient from 48 psig and do not go through the usual burner control -- the only SLC-4 oxidizer ventings that do not. These emissions are (combining the VEV and emission calculations):

$$\frac{48-\emptyset \text{ psig}}{14.7 \text{ psi/atm}} \times 40 \text{ ft}^3 \times 2.388 \times 10^{-4} \times 325 \text{ kppm} \times (0.01)$$

$= \underline{0.01 \text{ lbs}}$ combined ventings from two lines <u>not</u> using burners

This value, even as a worst-case, is a small amount when compared to emissions from other SLC-4 activities. Therefore, calculations will not be performed for the other lines, both oxidizer and fuel. This decision comes from the probability that all such emissions combined in reality amount to less than one pound.

D. Post-Launch Operations

1. Blow-back and Vent Lines

This is a procedure used as a final purge, leak-check, or depressurization of liquid transfer or pressurization/venting lines after a launch or for change-out of major components. Since these are the same lines and situation as the preceding sections, calculations will not be made as any possible emissions would be trivial at most.

2. Final Depressurization of RSVs

This venting is the last on the RSVs to bring them down to a storage blanket condition. The RSV ullage volumes are the same as presented above in Section C(1)(a) and (b) and vapor concentrations are assumed to be the same.

a. Oxidizer - The pressure drop in the oxidizer RSV venting is from 32 to 15 psig. The VEV will be:

$$\frac{32\text{-}15 \text{ psig}}{14.7 \text{ psi/atm}} \times \frac{23{,}778 \text{ gals}}{7.481 \text{ gal/ft}^3} = 3{,}676 \text{ scf}$$

The emissions will be:

$$3{,}676 \text{ scf} \times 2.388 \times 10^{-4} \times 325 \text{ kppm lbs/scf} \times 0.1 = \underline{29 \text{ lbs}} \text{ oxidizer in final RSV venting}$$

b. Fuel - The pressure drop here is from 28 to 14 psig. The VEV is:

$$\frac{28\text{-}14 \text{ psig}}{14.7 \text{ psi/atm}} \times \frac{18{,}778 \text{ gals}}{7.481 \text{ gal/ft}^3} = 2{,}391 \text{ scf}$$

The emissions will be:

$$2{,}391 \text{ scf} \times 1.56 \times 10^{-4} \times 210 \text{ Kppm lbs/scf} = \underline{78 \text{ lbs}} \text{ fuel in final RSV venting}$$

E. Summary of Calculated Emissions From SLC-4 Activities

Emitting Step	Oxidizer (lb)	Fuel (lb)	1981 Emissions[1)] Oxidizer (lb)	1981 Emissions[1)] Fuel (lb)
A. RSV Loading:				
1. RSV propellant filling process:				
If CDs used	105	156	---	---
If AFTs used	155	156	---	---
2. Final Venting of Emptied Propellant Carriers - For CDs	65	111	---	---
- For AFTs	67	108	---	---
3. Final Venting of Loaded RSV	6.5	(not vented)	---	---
Total emissions per total RSV loading operation:				
If CDs used	176.5	267	---	---
If AFTs used	228.5	264	686[2)]	792
B. RSV Venting in "Prover" Operation:	6.6	29	20	87
C. Post-Vehicle Loading Operations:				
1. RSV Venting After Line Blow-backs	30	140		
2. Purging of Lines (After Testing) on Vehicle Stages I and II	(negl.)[3)]	(negl.)[3)]	---	---
Total emissions per vehicle	30	140	90	420
D. Post-Launch Operations:				
1. Blow-back and Lines Venting	(negl.)[3)]	(negl.)[3)]	---	---
2. Final Depressurization of RSV's	29	78		
Total emissions per vehicle	29	78	87	234
E. Total 1981 Emissions			883	1,533

1) Based on three operations per year.
2) Worst-case.
3) See 2.3.3.5.2.C2 above.

2.3.3.6 SLC-4 West Pad Fuel Room Inhibited Red Fuming Nitric Acid (IRFNA) Propellant Tank

Operation

The mission of Space Launch Complex 4 (SLC-4) is the launching of orbital satellites and other payloads using Titan rockets. The west pad of SLC-4 is committed to the preparation and staging of Titan III B/Agena D systems. The necessary propellants for the initial stages (RSV operations) are provided through systems operated by the Martin Marietta Corporation. In addition, the orbiter vehicle (Agena D) requires its own propellant capability so that upon achieving orbit, it can be positioned into desired location. Responsi[illegible] for the orbiter and related propellants is the Lockheed Missile and Space Company (LMSC).

Orbiter oxidizer used at SLC-4W is a variation of inhibited red fuming nitric acid (IRFNA), termed HDA (high density IRFNA). Since this oxidizer is used only in Agena D payloads, all onsite movement and storage is launch related and primarily involves travel and delivery from the Agena tank farm. As scheduled launch time approaches, IRFNA moves onto SLC-4W by truck and is delivered into a 1,300 gallon tank in the Oxidizer Room. This tank is positioned on a scale and designed to provide a calibrated oxidizer weight to Agena vehicles.

The IRFNA tank during a typical year will contain 150 gallons of oxidizer three days and 900 gallons for a 15 day period. During the remainder of the year, the tank is empty. Normal tank operating pressure is 8 psig with nitrogen gas blanketing in place.

Vapors are generated during several operations: truck transfer into the tank and purging of the tank/vehicle filling system. Emissions from these two operations are vented through two Peabody Engineering Company scrubbers arranged in series. The system utilizes facility water in spray form to achieve removal and has a reported capture rate of 99 percent (each unit reported as 90 percent efficient by Captain Mazur, Chief, Titan III Mechanical Engineering Section) at a flow rate of 5 scfm. Usage of the IRFNA tank generates emissions through the two scrubber systems due to tank loadings occurs 16 times per year. Each activity period is approximately 15 minutes, for a total of 4 hours per year.

Emission Estimate

Data Input:

1) Inlet gas flow rate: 5 scfm (maximum reported rate)

2) Duration of flow: 4 hours/year

3) Inlet gas: A combination of N_2O_4 and blanketing nitrogen gas. The saturated HDA vapor will have 0.041 lbs N_2O_4*/ft^3 at 25°C.

4) Peabody scrubber efficiency: 99% (two 90% units arranged in series)

Use conversion formula of:

(flow rate in scfm) (IRFNA vapor weight factor)(60 min/hr)

($5\ ft^3/min$) (0.041 lb "IRFNA vapor"/ft^3) (60 min/hr)

= 12.3 lb of N_2O_4/hr uncontrolled

Controlled Emissions in this examination are:

(12.3 lb of N_2O_4/hr) (1-0.99) = 0.12 lb/hr

Annual emissions can be expected to be:

(0.12 lb/hr) (4 hr/yr) = 0.48 lb N_2O_4/yr

2.3.3.7 SLC-4 East Pad Fuel Room Hydrazine Propellant Tank

Operation

The mission of Space Launch Complex 4 (SLC-4) is the launching of orbital satellites and other payloads using Titan Rockets. The east pad of SLC-4 is committed to the preparation and staging of Titan III-D systems. The necessary propellants for the initial stages are provided

*Reference footnote c. of Table 2.5 - Agena Tank Farm "Givens".

through systems operated by the Martin Marietta Corporation. In addition, the launch vehicle (last stage and/ or orbiter) requires its own propellant capability so that upon achieving orbit, can be positioned in its desired location. Responsible for the orbiter and its related propellant is the Lockheed Missile and Space Company (LMSC).

Orbiter fuel used at SLC-4E is hydrazine (N_2H_4). Since the fuel is used only in launch payloads, all onsite movement and storage is launch related. As scheduled launch time approaches, hydrazine moves onto SLC-4E by truck and is delivered into a 1,300 gallon tank in the Fuel Room. This tank is positioned on a scale and designed to provide calibrated propellant weights to launch vehicles.

The hydrazine tank in normal operation is loaded to 50 percent of capacity and blanketed with nitrogen at 10 psig. Transfer from storage to launch vehicle is performed at 50 psig. LMSC estimates that during a typical year, 45 days out of the year, the tank will contain 600 gallons of hydrazine. During the remainder of the year, the tank is empty.

Vapors are generated during several operations: truck transfer into the tank and purging of the tank/vehicle filling system. Emissions from these two operations are vented into a Peabody Engineering Company scrubber for capture. The system utilizes facility water in sprays to achieve removal and has a reported capture rate of 90 percent (Captain Mazur, Chief, Titan III Mechanical Engineering Section) at 5 scfm.

Emission Estimate

Data Input:

1) Inlet gas flow rate:	5 scfm (maximum reported rate)
2) Duration of flow:	4 hours/year
3) Inlet gas:	A combination of hydrazine (N_2H_4 - molecular weight 32) and blanketing nitrogen gas. Saturated N_2H_4 vapor at about 100°F will be about 35,000 ppm in concentration.

4) Peabody Scrubber efficiency: 90%

Use conversion formula of:

(flow rate in scfm) (N_2H_4 vapor weight factor) (60 min/hr)

(5 ft^3/min) ($8.316 \times 10^{-5} \times 35$ Kppm lbs/ft^3) (60 min/hr)
= 0.87 lb/hr uncontrolled N_2H_4 vapor

Controlled Emissions in this examination are:

(0.87 lb of N_2H_4/hr) (1-0.90) = 0.087 lb/hr

Annual emissions can be expected to be:

(0.087 lb/hr) (12 hr/yr) = 1.04 lb N_2H_4/yr

2.3.3.8 SLC-4 West Pad Fuel Room Unsymmetrical Dimethyl Hydrazine (UDMH) Propellant Tank

Operation

The mission of Space Launch Complex 4 (SLC-4) is the launching of orbital satellites and other payloads using Titan rockets. The west pad of SLC-4 is committed to the preparation and staging of Titan III B/Agena D systems. The necessary propellants for the initial stages are provided through systems operated by the Martin Marietta Corporation. In addition, the launch vehicle (last stage and/or orbiter) requires its own propellant capability so that upon achieving orbit, can be positioned in its desired location. Responsible for the orbiter and its related propellant is the Lockheed Missile and Space Company (LMSC).

Orbiter fuel used at SLC-4W is unsymmetrical dimethyl hydrazine (UDMH). Since the fuel is used only in launch payloads, all onsite movement and storage is launch related and primarily involves travel and delivery from the Agena tank farm. As scheduled launch time approaches, UDMH moves onto SLC-4W by truck and is delivered into a 1,300 gallon tank in the Fuel Room. This tank is positioned on a scale and is designed to provide calibrated propellant weights to launch vehicles.

The UDMH tank in normal operations contains 700 gallons of fuel for an annual total of 18 days. During the remainder of the year, the tank is empty. Normal tank operating pressure is 15 psig, including nitrogen gas blanketing.

Vapors are generated during several operations: truck transfer into the tank and purging of the tank vehicle filling system. Emissions from these two operations are vented into a Peabody Engineering Company scrubber for capture. The system utilizes facility water/water sprays to achieve removal and has a reported capture efficiency of 90 percent (Captain Mazur, Chief, Titan III Mechanical Engineering Section) at 5 scfm. Usage of the UDMH tank to generate emissions through the Peabody scrubber due to tank loadings occur eight times per year. Each activity period is approximately 30 minutes, for a total of 4 hours per year.

Emission Estimate

Data Inputs:

1) Inlet gas flow rate: 5 scfm (maximum reported rate)

2) Duration of flow: 4 hours/year

3) Inlet gas: A combination of UDMH vapor and blanketing nitrogen gas.

4) Peabody scrubber efficiency: 90%

Use conversion formula of:

(flow rate in scfm) (UDMH vapor weight factor) (60 min/hr) = lb/hr

$(5\ ft^3/min)\ (1.56 \times 10^{-4} \times 210\ Kppm\ lb/ft^3)\ (60\ min/hr)$
= 9.8 lb of UDMH/hr uncontrolled

Controlled Emissions in this examination are:

(9.8 lb UDMH/hr) (1-0.90) = 0.98 lb/hr

Annual emissions can be expected to be:

(0.98 lb/hr) (4 hr/yr) = 3.9 lb of UDMH/yr

2.3.3.9 SLC-3 NAVSTAR Hydrazine Servicing Operations

Operation

The operation services the NAVSTAR spacecraft with mission quantities of hydrazine (N_2H_4). The process involves the transfer, over an 8-hour period, of liquid N_2H_4 from a supply tank through flex hoses and interface panels into the spacraft's two propellent tanks. As a consequence, a small amount of liquid hydrazine is trapped in the servicing hoses (approximately 0.3 pound). This small quantity of residual N_2H_4 is allowed to drain into a catch tank where its vapors are cleaned by a scrubber and then vented to the atmosphere. Presently the operation takes place once per year.

Control Equipment

The control device is a Rockwell International Vapor Absorption System Model G505-122306-001. Vapors are absorbed by a neutralizing solution of 54 gallons of water containing 5 pounds of a 20% solution of HCl. The device is located at the SLC-3 West tower, level 78.

Emission Estimate

Emission tests of the hydrazine scrubber were performed by Rockwell International (refer to Appendix). The result was an outlet concentration of 1.75 ppm by volume. For the SLC-3 process, inlet and outlet flow rates of 30 cfm have been estimated by Sgt. Ashby (April 22, 1982).

Emissions are estimated using the formula:

(flow rate in scfm) (N_2H_4 vapor weight factor) (60 min/hr) = lb/hr

$$(30\ ft^3/min)\ (8.316 \times 10^{-5} \times 0.00175\ \text{Kppm lbs/min})\ (60\ min/hr) = \underline{2.6 \times 10^{-4}\ lb/hr}$$

Emittance over the 8-hour period of loading will be $\underline{2.1 \times 10^{-3}\ lb}$

Point of discharge is approximately 130 feet above ground at level 78 of the SLC-3W missile service tower.

2.3.3.10 SLC-2 National Aeronautic and Space Administration (NASA) Nitrogen Tetroxide (N_2O_4) Storage Tank

The mission of Space Launch Complex 2 (SLC-2) is to launch orbiter payloads. SLC-2 is run by NASA, not the Air Force. Associated with vehicle operations is the use of propellant so that once orbit is achieved, desired payload positioning can be obtained. The oxidizer propellant is nitrogen tetroxide (N_2O_4). Preparatory for each launch (two were performed during 1981), a delivery of N_2O_4 is made to SLC-2 by tank truck. The arriving oxidizer is under a helium blanket at a pressure of from 10 to 25 psig. To move the N_2O_4 into storage (1,020 gallon vessel), the tank truck pressure is increased to 40 psig using helium and forced into the tank. Tank loading takes approximately 45 minutes. During loading, the tank is in continuous vent to the atmosphere through a Peabody Engineering Company Scrubber for capture. The system utilizes facility water in a spray application to achieve a reported capture efficiency of 90 percent (Peabody Scrubber efficiency obtained from Captain Mazur, Chief, Titan III Mechanical Engineering Section, SLC-4).

During vehicle loading the N_2O_4 storage tank is pressurized using helium to 150 psig and then metered into the orbiter storage tank. Loading progress is monitored through a sight glass and when oxidizer is "seen", the procedure is stopped. Any excess liquid N_2O_4 is drawn off and returned to storage. Vehicle loading takes approximately 45 minutes with continuous venting through return lines back to the Peabody Scrubber.

After vehicle loading has been accomplished, the system is pressurized with helium at 20 to 25 psig and then purged for 2 to 3 minutes, with vent gases generated during this process routed through the Peabody Scrubber. Vent gases discharge at a height of 15 feet above grade.

<u>Emission Estimate</u>

1. <u>Oxidizer Transfer Step</u>

   Emissions are estimated using methodologies developed for the Titan and Agena Tank Farms. The volume of the SLC-2 nitrogen tetroxide tank is 1,020 gallons. Normal "empty" conditions are assumed to mean 90% ullage and "full" to mean 10% ullage. So, when a load is delivered and the tank filled, the following volume of vapor is displaced:

$$\frac{(1{,}020 \text{ gal/tank})\ (0.8)}{(7.481 \text{ gal/ft}^3)} = 109.1 \text{ ft}^3$$

The following information is utilized to calculate emissions:

a. N_2O_4 vapor weight factor: (2.388×10^{-4} x Kppm lbs/ft^3) = lbs vapor/ft^3 (refer to vapor weight factor section. paragraph 2.3.3.1 for derivation).

b. Measured N_2O_4 saturation concentration: 325,000 ppm (Ref. 5 - Air Pollution Testing of Hypergolic Fuel Vapor Scrubbers at Cape Canaveral Air Force Station, Florida. Engineering-Science, McLean, VA. Air Force Contract No. F-33615-80-D-4001).

c. Scrubber efficiency: 90%

Therefore, emissions per tank loading are:

$$(109.1 \text{ ft}^3)\ (2.388 \times 10^{-4} \times 325 \text{ Kppm lb/scf})\ (0.1) = \underline{0.85 \text{ lb as } N_2O_4}$$

2. Vehicle Loading

Considering that vapor displacement from loading of a vehicle is equivalent to an 80% ullage change in the storage vessel at saturation concentration of 325 Kppm N_2O_4, emissions from a vehicle loading are the same as calculated above, i.e. the emissions are:

= <u>0.85 lb/N_2O_4 per vehicle load</u>

With two launches in 1981, this totals (two tank fillings, followed by two vehicle loadings); 4 x 0.85 lb (N_2O_4) = <u>3.4 lbs N_2O_4 in 1981</u>

3. Line Purging

The process is the same whether fuel or oxidizer is involved. Line purging takes place in two different steps. The 3/4 inch fill line to the rocket is purged with GN_2 back through the storage tank and then through the scrubber. The 1/2 inch vent line from the rocket is purged using GN_2 directly to the scrubber. At no steps in the procedure are any fumes vented directly to atmosphere.

No information was available concerning the amount of GN_2 utilized in the purging procedure. In the case of the purging of the fill lines, this issue is of importance as the purge gas enters the tank and displaces ullage vapors through the scrubber.

To estimate GN_2 volume, data from the Titan Tank Farm calculations were applied to the fill line purge situation. Inside cross-sectional diameter of the Titan Tank Farm piping is 3 inches. If flow velocity is considered the same between purge systems, the volume flow through a fill line will be proportional to the Titan Tank Farm rate of 300 scfm as a function of cross-sectional areas. The relationship becomes:

$$(300 \text{ scfm at Titan purge}) \frac{\pi/4\ (3/4\text{" SLC-2 fill line diameter})^2}{\pi/4\ (3\text{" Titan line diameter})^2} = 19 \text{ scfm}$$

If the same 3 minute purge duration is performed, purging operations of the N_2O_4 fill line will be:

$$(19 \text{ scfm})\ (3 \text{ min/purge})\ (2.388 \times 10^{-4} \times 325 \text{ Kppm lb/scf})\ (0.1) = \underline{0.44 \text{ lb/launch}}$$

For the purging of the 1/2 inch vent line, ullage and saturation concentrations of N_2O_4 are not involved as the line is purged directly to the scrubber and does not pass through the tank and it ullage. Two assumptions are made to estimate emissions from this system:

1) total N_2O_4 in the vent line is equivalent to one quart liquid;

2) all liquid is vaporized during purging and routed through the scrubber.

Emissions are therefore:

$(12.1 \text{ lb/gal of } N_2O_4)\ (0.25 \text{ gal})\ (0.1) = \underline{0.3 \text{ lb/launch}}$

With two launches in 1981, total purging emissions are:

$(0.44 + 0.3) \text{ lb/launch} \times 2 \text{ launch/yr} = \underline{1.48 \text{ lb/yr } N_2O_4 \text{ emissions in 1981}}$

2.3.3.11 SLC-2 National Aeronautic and Space Administration (NASA) Aerozine-50 Storage Tank

The mission of Space Launch Complex 2 (SLC-2) is to launch orbiter payloads with SLC-2 run by NASA, not the Air Force. Associated with vehicle operations is the use of on-board propellant so that once orbit is achieved, desired payload positioning can be obtained. The fuel used is Aerozine-50 (A-50), a combination of unsymmetrical dimethylhydrazine (UDMH) 50 percent, and 50 percent hydrazine. Preparatory for each launch (two were performed during 1981), a delivery of A-50 is made to SLC-2 by tank truck. The arriving fuel is under a helium blanket at a pressure of from 10 to 25 psig. To move the A-50 into storage (an 880 gallon vessel), the tank truck pressure is increased to 40 psig using helium and this forces the A-50 into the tank. Tank loading takes approximately 45 minutes. During loading, the tank is in continuous vent to the atmosphere through a Peabody Engineering Company Scrubber for capture. The system utilizes facility water in a spray application to achieve a reported capture efficiency of 90 percent (Peabody Scrubber efficiency obtained from Captain Mazur, Chief, Titan III Mechanical Engineering Section, SLC-4).

During vehicle loading the A-50 storage tank is pressurized using helium to 150 psig and then metered into the orbiter storage tank. Loading progress is monitored through a sight glass and when fuel is "seen", the procedure is stopped. Any excess liquid A-50 is drawn off and returned to storage. Vehicle loading takes approximately 45 minutes with continuous venting through return lines back to the Peabody Scrubber.

After vehicle loading has been accomplished, the system is pressurized with helium at 20 to 25 psig and purged for 2 to 3 minutes, with vent gases generated during this process routed through the Peabody Scrubber. Vent gases are discharged at 15 feet above grade. Scrubber wastes are discharged into the evaporation pond for subsequent neutralization.

Emission Estimate

1. Fuel Transfer Step

Emissions are estimated using methodologies developed for the Titan and Agena Tank Farms. The capacity of the SLC-2 Aerozine-50 tank is 880 gallons. Normal "empty" conditions are assumed to mean 90% ullage and "full" to mean 10% ullage. So, when a load is delivered and the tank is filled, the following volume of vapor is displaced:

$$\frac{(880 \text{ gal/tank})\ (0.8)}{(7.481 \text{ gal/ft}^3)} = 94.1 \text{ ft}^3$$

The following information is utilized to calculate emissions:

a. Vapor weight factor: $(1.56 \times 10^{-4} \times \text{Kppm}) = \text{lb A-50 vapor/ft}^3$ (refer to vapor weight factor calculations in paragraph 2.3.3.1 for derivation).

b. A-50 vapor concentration: 210,000 ppm (refer to Titan Tank Farm discussion for concentration justification).

c. Scrubber efficiency: 90%

Emissions per tank loading are from the amount of vapor displaced (as in above discussion for N_2O_4), or:

$$(94.1 \text{ ft}^3)(1.56 \times 10^{-4} \times 210 \text{ Kppm lbs/ft}^3)(0.1) = \underline{0.31 \text{ lb}}$$

2. Vehicle Loading

Considering that vapor displacement from loading of vehicle is equivalent to an 80% ullage change in the storage vessel at saturation concentration of 210 Kppm A-50 vapor, the emissions are (same as calculated above for tank-filling):

= 0.31 lb A-50 vapor per vehicle load

With two launches in 1981 (two tank fillings, followed by two vehicle loadings): 4 x 0.31 lbs = 1.24 lbs A-50 vapor emitted in 1981

3. Line Purging

The situation, arguments, and parameters presented above for the N_2O_4 line purging process are also applicable to the Aerozine-50 procedures. Fill line emissions are therefore:

$$(19 \text{ scfm}) (3 \text{ min/purge}) (1.56 \times 10^{-4} \times 210 \text{ Kppm lb/scf}) (0.1) = \underline{0.19 \text{ lb/launch}}$$

For the vent line system, emissions based on vaporization of one quart of fuel are:

$$(7.5 \text{ lb/gal of A-50} (0.25 \text{ gal}) (0.1) = \underline{0.19 \text{ lb/launch}}$$

With two launches in 1981, total purging emissions are:

$$(0.19 + 0.19) \text{ lb/launch} \times 2 \text{ launch/yr} = \underline{0.76 \text{ lb/yr A-50 emissions in 1981}}$$

2.3.4 Meteorological Restrictions

Due to the toxic nature of hypergolic fuels and the population density at VAFB, it is of major importance to have safety criteria designed to eliminate hazards from planned ventings and to minimize the hazards involved should an accidental spillage occur. Complete documentation, which covers all safety aspects can be found in the 1st Strategic Aerospace Division Missile Mishap Prevention Plan (1STRADM 127-200). It provides guidance for the prevention, investigation, and reporting of missile accidents and incidents at VAFB.

A prime concern is the meteorological conditions existing and forecast to exist during hazardous operations. Procedures have been developed which restrict operations during unfavorable meteorological conditions. These procedures are described in the following sections.

The Toxic Hazard Corridor (THC) forecast is the method by which operational personnel determine whether the meteorological conditions are unfavorable for the proposed operation. Toxic corridors represent the evacuation areas downwind of planned vents and possible accidental spills of toxic chemicals.

A THC forecast must be requested from Base Weather immediately prior to the start of the operations for which the THC is needed. A THC must be computed for the following operations:

(1) Transfer of toxic propellants from one storage or missile tank to another, at tank farms and launch complexes

(2) Mechanical installation/removal of destruct ordnance on a missile containing toxic propellants.

(3) Electrical connection/disconnection of destruct ordnance on a missile containing toxic propellants.

(4) Peacetime launch.

(5) Disposal of toxic propellants as authorized by Bio-Environmental Engineering.

(6) Whenever toxic propellant tanks are vented to atmosphere.

The following conditions will normally impose a "hold" or "no-go" for all operations involving the use of a toxic hazard corridor:

(1) Whenever the weather forecaster is unable to predict a clearly defined toxic hazard corridor.

(2) Whenever the toxic hazard corridor is predicted to actually overlay any portion of a noncontrolled inhabited area, i.e. a nonoperational area that cannot be rapidly evacuated. (All cantonment areas, housing areas, hospital areas and all off-base areas fall in this category.)

(3) Whenever an inversion exists below 800 ft. mean sea level (MSL) and the wind direction is toward any noncontrolled inhabited areas. (Presence of weather inversion will be as determined by the weather forecaster only.)

(4) When any thunderstorm is approaching the area and within an estimated three miles. (A thunderstorm is defined as a storm in which lightning is visible or which the meteorologist describes as a thunderstorm.)

(5) When the toxic hazard corridor is predicted to be a nonmoving circular area over the operation and visibility is such that the plume cannot be detected visually (i.e., during the hours of darkness combined with heavy fog).

(6) When heavy rain is present which seriously restricts the visibility of personnel.

Venting will not be started, or will be discontined if started, when the following conditions exist:

(1) Vapors shift from the toxic hazard corridor. (Reevaluation of THC with weather forecaster must be accomplished before venting can continue.)

(2) Wind speed is insufficient to dissipate vapors from the area (normally 3 knots or less).

(3) The toxic hazard corridor overlays any portion of a noncontrolled inhabited area.

(4) Rapid communication capability is lost to personnel in the toxic hazard corridor.

A THC forecast is prepared around the clock by the duty forecaster using information gathered primarily by the Weather Information Network and Display System (WINDS). The forecast is continuously monitored by the forecaster and modified when necessary (immediately in the event of a toxic propellant spill). The forecasts are valid for not more than two hours. The actual THC forecast contains the meteorological data on which the forecast is based (wind speed and direction, ΔT and wind direction variability), an arc which will enclose a toxic spill, and a distance which is the limit of the hazardous concentrations downwind.

The THC is calculated by using a program on a TI-59 Calculator. Complete information and documentation of this program can be found in AWS/TR-80/003 entitled "Calculating Toxic Corridors."

The procedures outlined above provide specific guidance about meteorological restrictions on hypergolic activities. The safety of personnel at the site and in the surrounding area is the prime concern and the reason for these procedures.

2.4 AREA SOURCES

Non-hypergolic pollutant sources that emit quantities less than 10 tons per year are considered to be area sources. Once quantified (using criteria and methodologies described in the following section), these emissions were assigned to grid squares for reporting purposes. The reporting format consists of three page types (examples are provided as Figures 2-4 through 2-6). Codes used in reporting were taken from "Emission Data System Review and Update Report Manual - Appendix II,"

AIR BASI	COUNT	REGI ID	ACTIVI NAM	YEA	CELL COLU	CELL ROW	ACTIVI LEVE
SCC	42		SANBLAST	1981	001	046	T.S.P.=17.7%
					009	050	T.S.P.=1.4%
					007	055	T.S.P.=1%
					008	049	T.S.P.=1%
					006	056	T.S.P.=9.1%
					003	059	T.S.P.=9.1%
					006	045	T.S.P.=9.1%
					007	045	T.S.P.=9.1%
					005	045	T.S.P.=9.1%
					004	044	T.S.P.=9.1%
					006	053	T.S.P.=9.1%
					005	051	T.S.P.=2.1%
S.C.C.	42				008	050	T.S.P.=3.6%
S.C.C.	42			1981	005	051	TOG=100%

AIR BASI	COU	ACTIVI		YEA	ACTIVI LEVE
SCC	42	MLTY	JET	1981	TSP- 25 TPY
					SOX- 8.6 TPY
					NOX- 59 TPY
					TOG- 70 TPY
					CO- 116 TPY
		CIVIL	GAS	1981	TSP- 0.0 TPY
					SOX- 0.1 TPY
					NOX- 0.1 TPY
					TOG- 0.3 TPY
					CO- 7.3 TPY
		CIVIL	JET	1981	TSP- 0.0 TPY
					SOX- 0.8 TPY
					NOX- 0.4 TPY
					TOG- 0.4 TPY
					CO- 13.6 TPY
		P.OL.	TSFR		TOG- 0.8 TPY
		FIRE	TRN		TSP- 3.5 TPY
					CO- 4.5 TPY
					TOG- 1.1 TPY
					NOX- 0.2 TPY
		MSSLE	LN		CO- 96.4 TPY
					NOX- 2.2 TPY
					TSP- 61.3 TPY
					4250 2-40.7 TPY
		SOLVE	NTC		TOG- 0.9 TPY
		SOLVE	NTR		TOG- 16.4 TPY
		SOLVE	NTP		TOG- 81.5 TPY
		ASPRO	DEG		TOG- 43.9 TPY
		ASPHP	AVG		TOG- 16.0 TPY
		PAINT	OIL		TOG- 35.3 TPY
		PAINT	WTR		TOG- 4.0 TPY
		FUGDU	STB		TSP- 138 TPY
		FUGDU	STR		TSP- 176 TPY
		SPACE	NTR		TSP- 1.4 TPY
					SOX- 0.05 TPY
					CO- 1.8 TPY
					TOG- 0.7 TPY

AIR DATA	COUNTY	ACTIVITY	CES #
SCC	42	MLTY JET	47571
SCC	42	CIVILJET	47589
SCC	42	CIVILGAS	57331
SCC	42	POL TRSE	46482
SCC	42	FIRE TRN	47290
SCC	42	MSSLE LN	47084
SCC	42	SOLVENTC	46847
SCC	42	SOLVENTR	58693
SCC	42	SOLVENTP	46771
SCC	42	ASPRODES	66720
SCC	42	ASPHPAVG	46870
SCC	42	PAINTOIL	46763
SCC	42	PAINTWTR	46755
SCC	42	FUGDUSTB	42373
SCC	42	FUGDUSTR	47381
SCC	42	NTGASCMB	47191
SCC	42	DOMCLEAN	46912
SCC	42	DOMPSTCD	47100
SCC	42	SERSTAWL	46532
SCC	42	SERSTAVD	46540
SCC	42	SERSTAAL	46557
SCC	42	SERSTASP	46565
SCC	42	UNIONOIL	46425
SCC	42	COMBDESL	47159
SCC	42	COMONTGB	47167
SCC	42	COMDFRPN	58727
SCC	42	POLGDLN	46466
SCC	42	FECPNTAN	46748
SCC	42	COMPCLEN	46789
SCC	42	CNCRTBTH	47035
SCC	42	SANBLAST	47027
SCC	42	SLCYSOLV	47839

April 1980. The grid pattern used was supplied by SBCAPCD and consisted of 2 km squares aligned based on the translated coordinate system. Provided to VAFB under separate cover is an itemization and inventory of all area sources by grid.

2.4.1 Rocket Engine Flushing and Line Purging

2.4.1.1 SLC-3 Atlas Missile Flushing

A 200 gallon trichloroethylene (TCE) storage tank, a 500 gallon waste TCE-water mixture storage tank and associated funnels, piping, and pumps necessary to flush Atlas engines (three engines per missile) are used prior to missile launch. An operation consists of pumping liquid oxygen compatible grade TCE through the feed lines and ducts of the Atlas engine for a period of 60 seconds after the start of discharge from the engine. The engine lines and ducts are then purged with dry nitrogen gas until all traces of TCE have been eliminated. The waste TCE is collected in a funnel, equipped with a water spray ring, closely fitted around the engine exhaust bell and piped to a 500 gallon waste tank. The TCE-water mixture is then pumped to 55 gallon drums and subsequently sold to a commercial reprocessing facility under the auspices of the Defense Property Disposal Office.

The quantity of TCE lost through evaporation is reduced by the use of the water spray ring system. It is expected that this water spray system will have a vapor control efficiency of only about 10% because of the low solubility (4%) of TCE in water. This system will, however, act as a cover or curtain to slow down the evaporation rate.

Approximately one ton of TCE is used per missile flush (all three engines). The operation is accomplished over a period of approximately four hours with one engine flush per launch.

The Atlas vehicle launch rate will vary from two to six per calendar year. There were two in 1981.

Weight quantities of TCE are measured before and after each flushing operation. The resultant difference in solvent weight is assumed to evaporate to the atmosphere. The last four engine flushes at SLC-3 are considered to be representative of normal operations. Data measured during these flushes are presented in Table 2.7.

2.4.1.2 SLC-2 Engine Flushing and Line Purging

2.4.1.2.1 Engine Flushing

Engine flushing equipment consists of a portable trichloroethylene (TCE) tank cart, waste TCE collection drum and associated funnels, piping, and pumps necessary to flush engines prior to missile launch. Operation consists of pumping NASA rocket liquid oxygen compatible grade TCE through the feed lines and ducts of the rocket engine (one engine per missile). The engine lines and ducts are then purged with dry nitrogen gas until all traces of TCE have been eliminated. The waste TCE is collected in a funnel, closely fitted around the engine exhaust bell and run down into a waste drum.

Past experience by NASA at SLC-2 has shown that during a representative operation, 746 pounds of TCE are put through the engine. Of this total, 725 pounds are eventually recovered, reflecting a net TCE vapor loss of 21 pounds. With the flushing operation requiring four hours, this represents an average 5.3 lb/hr loss during activity. Frequency of engine flush operations are launch related and occur from 2 to 4 times per year.

2.4.1.2.2 Line Purging

The final post-launch procedures at the SLC-2 Aerozine-50 and N_2O_4 storage tanks involve solvent flushing of the transfer lines.

In each case, the transfer system consists of approximately 200 running feet of 3/4 inch line for the fill line and 200 feet of 1/2 inch line for the return system. Flushing of these systems is achieved by use of a centrifugal pump and one of two solvents: Freon for the N_2O_4 system and isopropyl alcohol for the A-50 system.

The contaminated A-50 and N_2O_4 lines contain not only the hypergolic propellant but GN_2 purge gas. During purging, 50 gallons of the appropriate solvent is passed through the fill lines up to a height

TABLE 2.7

SLC-3 ENGINE FLUSH DATA

Flush Date	TCE Input (lb)	TCE Output (lb)	Loss (lb)
May 24, 1980	2,388.5	2,292.75	95.75
December 4, 1980	2,417.0	2,332.75	84.25
May 26, 1981	2,318.25 2,330.0[a)]	2,271.25 2,239.0[a)]	47.0 91.0[a)]
December 9, 1981	2,041.5[a)]	1,945.0[a)]	96.5[a)]
AVERAGE VALUES	2,299.0	2,216.0	83.0

a) Calculation based on volume differences, translated into weight.

Since the engine flush occurs over a four-hour period, hourly emissions during operation are:

$$\frac{(83\ \text{lb/flush})}{(4\ \text{hr/flush})} = 20.8\ \text{lb/hr}$$

of 85 feet above the launch pad and then back to ground level where all flushing materials are recovered in a container. The solvent flushing rate is 4 to 6 gallons per minute. Solvent losses to the atmosphere during this process are considered to be negligible.

2.4.2 Component Cleaning Facility

Operations at Component Cleaning that generate TOG emissions are a vapor degreaser and a paint stripper. Contact: Mr. Carpenter.

1. Vapor Degreaser

Process uses 111-trichloroethane at the annual consumption (loss) rate of 1,566 gallons. Given a density of 10.9 lb/gal, losses (emissions) are:

(1,566 gal/yr) (10.9 lb/gal) = 17,069 lb/yr = 8.5 tou/yr

Hours of operation are: 8 hrs/day, 5 days/week, 52 weeks/yr

Emissions levels generated are lower through use of a vapor condenser.

2. Paint Stripping

Process uses methylene chloride and phenol in a 3 ft x 3 ft x 8 ft bath to clean parts associated with Minuteman launches. Exact consumption figures are not given, therefore emissions are estimated as follows:

Tank capacity:	300 gals
Tank refill rate:	additions to reobtain desired level performed 6 times per year
Tank refill quantity:	10% of capacity, or 30 gals
Density of methylene chloride:	50% of total - 11.14 lb/gal
Density of phenol:	50% of total - 8.93 lb/gal
Average density:	10.04 lb/gal

Emission rate: (30 gal/refill) (6 refills/yr) (10.04 lb/gal) = 1,807 lb/yr

2.4.3 Base Exchange Dry Cleaner (Bldg. 11193)

Dry cleaning operations take place at Base Exchange (Building 11193) and consist of one 100-pound load washer/extractor in conjunction with two 50-pound load dryers. Clothing is transferred manually from the washer/extractor to the drying operation. Heat for the drying cycle is supplied by a 50 horsepower boiler (electrically powered).

Typical processing is nine loads per day with operations 6 hours per day, 5 days per week. Annual perchloroethylene consumption is 1,200 gallons per year. Contact is Mr. Ebright.

The perchloroethylene emissions from the dryer are captured in carbon adsorption units that vent to the atmosphere through a common 12-inch diameter duct, approximately 25 feet high. The carbon units are steam stripped in a closed system with the perchloroethylene returned to the holding tank.

Emissions are calculated based on Table 4.1.1 on page 4.1-5 of AP-42, which states that it can be assumed that the amount of solvent consumed is evaporated and that consumption equals solvent loss. Calculation uses the density of perchloroethylene of 13.5 pounds per gallon and the assumption that 100% of the perchloroethylene is evaporated.

$$\frac{(1{,}200\ \text{gal/yr})\ (13.5\ \text{lb/gal})}{(1{,}560\ \text{hr/yr})} = \underline{10.4\ \text{lb/hr}} \text{ or } \underline{8.1\ \text{ton/yr}}$$

2.4.4 Paint Spray Booths

The following information was utilized to develop emission estimates. Emission factors employed are the same as presented in Section 2.4.7. As each booth created special circumstances, they are discussed separately.

2.4.4.1 4392 Transportion, Building 10726 - Contact T Sgt. Harrison

Activities involve auto touchup painting with enamel. Average operation is two vehicles per week, 50 weeks per year. Emissions of TOG are based on use of factor of 7.5 lb per vehicle taken from a report, prepared for the California Air Resources Board by the consulting firm of KVB, entitled: "Control of Hydrocarbon Emissions from Stationary Sources in the California South Coast Air Basin," June 1978.

(100 vehicles/yr) (7.5 lb/vehicle) = 750 lb/yr

2.4.4.2 Mopic Laboratory, Building 9340 - Contact M Sgt. Carbone

Small article painting (high speed camera motors, counter balance weights, etc.). Use mostly lacquer with some enamel and zinc chromate primer. Used 216 12-oz. spray cans of approximately 50% enamel and 50% lacquer.

(216 cans) (12 oz./can) = 10.13 gal <u>each</u> of lacquer and enamel

(10.13 gal enamel) (4.5 lb/gal) = 45.6 lb/yr

(10.13 gal lacquer) (5.5 lb/gal) = 55.7 lb/yr

101.3 lb/yr

4.4.4.3 CES paints, Building 11439 - Contact Mr. Curtis

Small article painting (plaques and nameplates, etc.). Use laytex lacquer enamel, epoxy (seldom). Do not always spray. Do brush and roller work as well. Quantities used in calculations are based on 7 months of purchase data prorated over the entire year.

Enamel: (270 gal/yr) (4.5 lb/gal) = 1,215 lb/yr

Acrylic: (511 gal/yr) (1.3 lb/gal) = 664 lb/yr

1,879 lb/yr

2.4.4.4 Auto Hobby, Building 6438 - Contact J.R. Flemens

This activity paints cars and trucks with an operation schedule of 50 weeks per year. Currently use 3 to 4 gallons per week of both enamel and auto primer plus 1 to 2 gallons per year of lacquer. In 1983 they plan to replace this booth with a new facility equipped with a waterfall curtain.

Enamel: (3.5 gal/wk) (50 wk/yr) (4.5 lb/gal) = 788 lb/yr

Primer: (3.5 gal/wk) (50 wk/yr) (5.0 lb/gal) = 875 lb/yr

Lacquer: (1.5 gal/wk) (5.5 lb/gal) = 8 lb/yr

1,671 lb/yr

2.4.4.5 AFLC, Building 9327 - Contact Mr. Hifill

Paint both large and small items using an air gun. Use lacquers and enamels at a combined quantity of 250 gallons per year.

Mixture: (250 gal/yr) (5 lb/gal) = 1,250 lb/yr

2.4.4.6 First Training Aid, Building 6436 - Contact: T Sgt. Williams

Painting schedule varies greatly with all size items using enamel, lacquers, polyurethane, and lacquer thinner. Use 60 to 70 gallons of paint per year.

Mixture: (65 gal/yr) (5 lb/gal) = 325 lb/yr

2.4.5 <u>Concrete Batch Plants</u>

Two concrete batch plants were in operation in 1981, one associated with MX activities in the northern part of the base and the other in association with STS activities at SLC-6. The SLC-6 batch plant has been dismantled. The northern facility will continue to operate in conjunction with the airfield expansion.

Quantitites of concrete prepared in 1981 were reported as:

MX: 31,826 yd^3 (Contact: Mr. Bottroff-Lompoc Transmir)
STS: 37,500 yd^3 (Contact: Mr. O'Gorman)

For units controlled by fabric filters, the AP-42 emission factor is:

0.02 lb TSP/yd^3 (Table 8.10-1)

This yields emissions of:

MX: 637 lb/yr
STS: 750 lb/yr

2.4.6 <u>Incinerators</u>

Data were taken from previous permit submittals and confirmed by telephone conversations.

There were three small incinerators in operation at VAFB.

2.4.6.1 Hospital Incinerator

Certified Environmental Incinerator, Model P-50, with a combustion chamber cross sectional area of 8 ft^2 (2 x 4). About 12,500 lb/yr of 90% combustible pathological material is burned each year using natural gas as an auxiliary fuel. The average burning rate is about 15 lb/hr, maximum about 25 lb/hr. This incinerator was installed in 1973.

To estimate emissions, use AP-42 pathological incinerator factors and an annual consumption rate of 6.5 tons.

Result: TSP: 50 lb/yr
NO_x: 19 lb/yr

2.4.6.2 Building 10577, 1 Strad HQ

Pacific Coast Incinerator, Model CSN 300, with a combustion chamber cross sectional area of 13 ft^2 (2'6" x 5'1"). About 750 lb/yr of 95% combustible Class I material is burned each year using natural gas as an auxiliary fuel. The average burning rate is about 15 lb/hr, maximum about 50 lb/hr. This incinerator was installed in 1969.

To estimate emissions from this unit, use 1981 process weight rate of 750 lb/yr and AP-42 refuse incinerator emission factors.

Result: TSP - 6 lb/yr
CO - 8 lb/yr
TOG - 6 lb/yr
NO_x - 1 lb/yr
SO_2 - 1 lb/yr

2.4.6.3 Building 23225

Pacific Coast Incinerator, Model CSN 300, with a combustion chamber cross sectional area of 13 ft^2 (2'6" x 5'1"), about 2,400 lb/yr of 95% combustible Class I material is burned each year using LPG auxiliary fuel. The average burning rate is about 25 lb/hr, maximum about 50 lb/hr. This incinerator was installed in 1967.

Emissions estimated using same factors as in previous unit and a one-time 1981 burn of 2,400 lb.

Result: TSP - 18 lb/yr
CO - 3 lb/yr
TOG - 24 lb/yr
NO_x - 18 lb/yr
SO_2 - 2 lb/yr

2.4.7 Adhesive, Paint, and Solvent Usage

Total organic gas (TOG) emissions from paint, adhesive and solvent use have been estimated using emission factors from two South Coast Air Quality Management District (SCAQMD) forms entitled "Emission Factor Table for Specific Organics," Form G-3, and "Emission Factor Table for Common Organics," (Table 2.8). The latter form provides generalized emission categories of organic materials for which specific organic commodities may be assigned. The former SCAQMD form was used in cases where a given commodity may not be correctly assigned to an emission category. For isolated cases where commodities cannot be directly assigned an emission factor from either of the two forms, engineering judgement was utilized to determine the most representative emission factor. This judgement was based on an assessment of organic properties of the commodity in question. It should be noted that these commodities constitute only a very small fraction of the total commodity usage and organic emissions.

COCESS, Base Supply, and Civil Engineering Contracts were the major contacts for organic commodity use. Corresponding individuals were: COCESS - T Sgt. Witherspoon; Base Supply Sgt. Funn and M Sgt. Trenholm; CE Contracts Mr. Magalong. The data were provided primarily on computer sheets with commodity type, quantity, and in the case of Base Supply, commodity delivery destination listed.

TABLE 2.8

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

EMISSIONS FROM BURNING OF FUELS -- GENERAL
(DO NOT USE FOR I.C. ENGINES OR TURBINES)

Fuel	Annual Usage for Year 1979	Emissions (lbs/yr)				
		Organic Gases	Nitrogen Oxides	Sulfur Oxides	Carbon Monoxide	Part. Matter
Natural Gas	(Millions of cu. ft.)	7.0†	213†	0.83†	4.8†	17.5†
LPG Propane Butane	(Thousands of gals.)	0.3*	11.6*	4.6*	1.55*	1.75*
Refinery Gas	(Millions of cu. ft)	7.0†	249†	to be reported on sulfur balance	4.1†	17.5†
Diesel Oil or Light dist. (0.1%S)	(Thousands of gals.)	2.7*	75*	14*	0.6*	3.6*
Fuel Oil (0.25% S)	(Thousands of gals.)	2.7*	75*	32.3*	0.6*	4.9*
Fuel Oil (0.50% S)	(Thousands of gals.)	2.7*	75*	77.6*	0.6*	7.1*
Total Emissions, lbs/yr						

† Emission factors in lbs per million cu. ft.
* Emission factors in lbs per thousand gallons.

EMISSION FACTOR TABLE FOR COMMON ORGANICS

Coatings	Lbs. of Orgs/Gal.
Adhesives	5.5
Enamel	4.5
Lacquer	5.5
Primers	5.0
Sealer	5.5
Solvents	7.0
Stains (spirit)	6.0
Varnish	4.5
Water Based	1.3
Water Soluble	0.0

Printing Industry	Lbs. of Orgs/Gal.
Litho inks & ltr Press inks	3.0
flexo inks	5.5
Water soluble inks	0.0
Gravure inks	5.5

Degreasers and Dry Cleaners	Lbs. of Orgs/Gal.
111 Trichloroethane	11.1
Perchloroethylene	13.5
Methylene Chloride	11.2
Petroleum (Stoddard, 140°F)	6.5

TABLE 2.8 --Continued

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

FORM G-3: EMISSION FACTOR TABLE FOR SPECIFIC ORGANICS

Solvent	Lbs. of Orgs/Gal.
Acetone	6.6
Benzene	7.3
Butyl Cellosolve	7.5
Cellosolve Acetate	8.1
Chevron 1100	6.7
Chevron 1200	6.5
Diamine	8.4
Dimethyl Formamide	7.9
Dowanol EE	7.7
Dowanol EB	7.5
Electro Solvent	11.5
Epoxy Thinner	7.0
Ethyl Alcohol (Commercial)	6.3
Freon 113	13.0
Furfuryl Alcohol	9.4
Hexylene Glycol	7.7
Hexane	5.5
Isopropyl Alcohol	6.6
Kerosine	7.0
Lactol Spirits	6.3
Methanol	6.6
MEK	6.7
Mineral spirits	6.5
Naphtha	6.3
Pemsol	6.4
Rho-Chem 231	13.3
Rho-chem 47	12.6
Rho-thane	11.0
Rho-Tri	12.5
Shell 360	6.4
Toluene	7.2
Turco Cleaning Solvent	7.3
VM & P Naphtha	6.3

Solvent	Lbs. of Orgs/Gal
Var Sol #1	6.5
West Chem Solvent #3	7.6
Xylene	7.2
Materials	
Charis Black Asphalt	5.0
Contact Cement	5.5
Epoxy Paint	5.5
Fuel Oil	3.7
Glaze	5.5
Lining, Cans	5.0
Lining, Drum	4.5
Paint Remover	5.2
Polyurethanes	5.2
Quench Oil	7.5
Shellac	5.5
Toner	6.0
Treating Oil	7.5
Urethane	5.0
Wash Coat	5.5
Wax	6.2

Fiberglass Products	Lb of Orgs/ Lb of Material
Epoxy (2 component)	0.05
Fiberglass Resin	0.05
Gel Coal	0.10
Plasticizer	0.05
Resins	0.05

In some cases the quantities were provided in units of kits, tubes, pails, cans, ounces, or simply designated "each". The following assumptions were applied to these units:

1. One kit, tube, and in most cases the "each" unit designation is equal to one pint.
2. For enamel paints, the "each" unit designation is equal to one gallon.
3. One pail is equal to 5 gallons.
4. One can is equal to 1 gallon.

Sample Calculations

Emission factors are presented in pounds of organics per gallon of material. A sample calculation is provided below:

Base supply - 240.88 gals of lacquer allocated for 1981

$$\text{Emission factor} = \frac{\text{5.5 lb of organic}}{\text{gal of lacquer}}$$

5.5 lb/gal x 240.88 gals = <u>1324.84 lb/yr (TOG)</u>

See Tables 2.9, 2.10, and 2.11 for a complete summary of organic commodity usage and emissions.

Allocation of Organic Materials

Organic emissions from materials supplied though COCESS, Base Supply, and CE Contracts were allocated as follows:

1. COCESS - 75% to living quarters
   25% to cantonment area
2. CE Contracts - See table
3. Base Supply - 100% to cantonment area

TABLE 2.9

COCESS
ORGANIC COMMODITY USAGE AND ORGANIC EMISSIONS
(Oct. 1, 1981-May 31, 1982)

Category	COCESS Usage Rate (gals)	Emission Factor (lb/gal)	Multiplier	Emission Rate (lb/yr)
A	2562.07	5.5	1.5	21137
B	1102.6	5.2	1.5	8600
C	5767	1.3	1.5	11246
D	1346	4.5	1.5	9086
E	956	5.0	1.5	7170
F	16	4.5	1.5	108
G	106	6.0	1.5	954
H	1123	7.0	1.5	11796
I	16.4	6.2	1.5	153
J	8.0	0.05	1.5	1
K	0.31	3.7	1.5	2
			Total =	70253 lb/yr or 35.13 t/yr (TOG)

Category A = sealers, glaze, contact cement, lacquer, shellac, adhesives, and epoxy paint.
Category B = polyurethane an' 'aint remover.
Category C = water based pai... (acrylic and latex)
Category D = enamel paint
Category E = primer
Category F = varnish
Category G = stains
Category H = epoxy thinner
Category I = wax
Category J = resin
Category K = fuel oil or lubricant

Note: The above data are compiled for 8 months, therefore a 1.5 multiplier was used to extrapolate to 12 months.

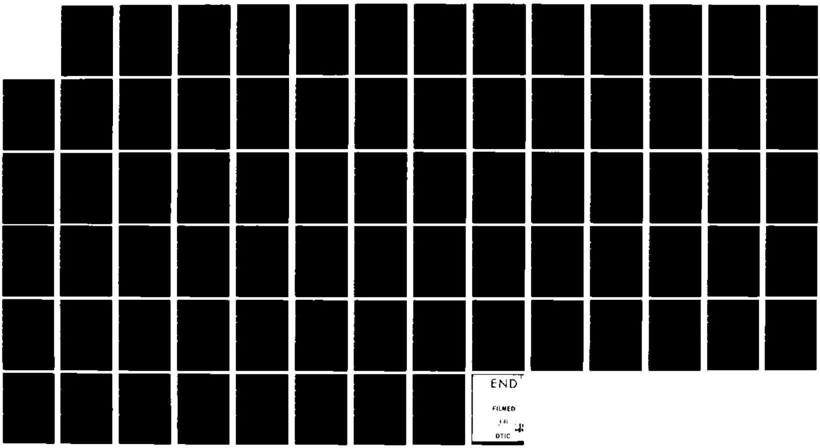
TABLE 2.10

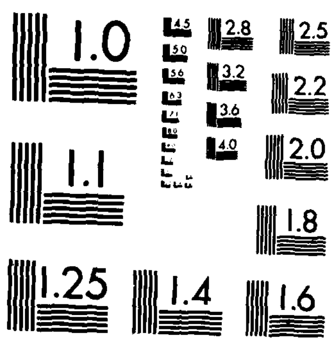
BASE SUPPLY 1981
ORGANIC COMMODITY USAGE AND ORGANIC EMISSIONS

Commodity Type	Commodity Usage (gals)	Emission Factor (lb/gal)	Emission Rate (lb/yr)
Paint remover	2579.07	5.2	13411
Coating compound	5.00	4.5	23
Dichlorodifluoroethane	251.89	10.8	2720
Trichlorotrifluoroethane	1496.68	13.0	19457
Propane	132.00	4.9	647
Latex	68.00	1.3	88
Petroleum naptha	9.00	6.3	57
Tetrachloroethylene	166.00	13.6	2258
Petroleum thinner	254.00	6.5	16541
Petrolatum	7.00	0	0
Ethylacitat	0.88	7.5	7
Diesel fuel	29.00	0.5	15
Dyelayoutblue	2.25	5.5	12
Bromochlorodifluoroethane	40.00	12.9	516
Sealing compound	23.81	1.0	24
PVC solvent cement	0.25	7.0	2
Corrosion compound	0.63	4.5	3
Epoxy spray	20.00	5.5	110
Rinsing solution	1.00	6.5	7
Chloroform spetran	2.00	12.4	25
Freon	55.00	11.3	622
Freon-22	203.13	9.8	1991
Freon-11	25.00	12.2	305
Lacquer	240.88	5.5	1325
Paint	63[illegible]5.72	4.5	28601
Paint thinner	700.66	7.0	4905
Lacquer thinner	1475.00	7.6	11210
adhesive	434.13	5.5	2388
Cleaning compound	4820.60	6.5	31334
Dichloromethane	31.85	11.1	354
Litho ink	7.25	3.0	22
Armorall	24.99	4.5	112
Urethane	25.50	5.0	128
Engine oil lube	2250.75	0.5	1125
Acetone	34.00	6.6	224
Chloroform	30.00	12.4	372
Ethylene diamine	128.00	1.3	129
Stain	85.25	6.0	512
Polyurethane	83.50	5.2	434
Varnish	35.50	4.5	160
Linseed oil	162.00	5.0	810

AD-A125 442 VANDENBERG AIR FORCE BASE EMISSION SURVEY(U) 2/2
ENGINEERING-SCIENCE INC ARCADIA CALIF JAN 83
OEHL-TR-83-075EA111AEB F33615-80-D-4001

UNCLASSIFIED F/G 6/6 NL

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5.0
5.6
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

TABLE 2.10--Continued

BASE SUPPLY 1981
ORGANIC COMMODITY USAGE AND ORGANIC EMISSIONS

Commodity Type	Commodity Usage (gals)	Emission Factor (lb/gal)	Emission Rate (lb/yr)
Trichloroethane	2061.64	11.2	23090
Sealant/sealer	332.71	5.5	1830
ether	267.11	5.9	1576
coating	16.32	4.5	73
Vinyl Coating	6.00	1.0	6
Coating organic	240.00	4.5	1080
MEK	817.00	6.7	5474
Toluene	249.50	7.2	1796

Total = 163017 lb/yr or
81.5 t/yr (TOG)

TABLE 2.11

CE CONTRACTS - 1981
PAINT USAGE AND ORGANIC EMISSIONS

Paint Type	Commodity Usage (gals per bldg.)	Emission Factor (lb/gal)	Emission Rate (lb/yr per bldg.)
Rust inhibitive primer/barrier	25	5.0	125
Chlorinated rubber intermediate coat	25	4.5	112.5
Chlorinated rubber top coat	25	4.5	112.5

Total = 350 lb/yr/bldg. (TOG)

x 33 bldgs. = 11550 lb/yr
= <u>5.78 t/yr (TOG)</u>

Note: 75 gallons of paint are allocated to each of 33 base buildings listed below. It is assumed that this quantity is equally distributed among the three types of paint.

Buildings painted:

Bldg. No's.		
702	510 *	6420
21153	510A*	6206
1995	475	5432
1801	460	1810
1627	1704	1768
1602	1703	1053
1288	1702	980
1278	22107	874
1274	21200	872
1273	8430	657
909	8312	500
		70

*Bldgs 510 & 510A count as one bldg..

2.4.8 Household Goods - Consumer Use of Organic Compounds and Resultant TOG Emissions

The commissary and the base exchange are the primary outlets for organic compounds used by consumers at Vandenberg Air Force Base. The U.S. EPA document titled "Procedures for the Preparation of Emission Inventories for VOCs," Second Edition, Volume 1, 1977, provides a consumer emission factor of 6.3 pounds of reactive volatile organic compounds (RVOC) per capita per year. To utilize this emission factor the following assumptions were made:

1) Consumer consumption of organic materials primarily takes place in the 2,080 housing units.

2) Typically there are 2.5 people per housing unit.

3) RVOC emissions by consumers constitute the vast majority of the TOG emissions and therefore RVOC is approximately equal to TOG.

Emission Calculation

$$6.3 \text{ lb/capita/yr TOG} \times 2{,}080 \text{ units} \times \frac{2.5 \text{ people}}{\text{unit}} = 32{,}760 \text{ lb/yr TOG}$$
$$= 16.4 \text{ t/yr TOG}$$

These emissions are allocated to each of the five housing increments.

2.4.9 Asphalt Roofing and Paving Emissions - Overall Coordination: Captain Leppert

CE Contracts (Asphalt Pavement Emissions) - Contact: Mr. Bert Johnson (CE Contracts)

Use U.S. EPA AP-42, page 4.5-2,3, Table 4.5-1. Table A-4, AP-42, gives asphalt density at 8.57 lb/gal. Emission factor (Table 4.5-1) =

$$\frac{0.2 \text{ lb VOC}}{\text{lb asphalt}} \quad \text{(i.e. 20\% of asphalt evaporated)}$$

This factor is for the medium cure cutback used by the contractors.

Location	Asphalt (gal used)	VOC Emissions (lb/yr)
Near Bldg. 761 (SLC-3W)	1345	2305.3
Arguello Road	4711	8074.7
Utah Road	2621	4492.4
Iceland Road	3969	6802.9
Near Bldg. 7315	78	133.7
Washington Ave.	5065	8681.4
North Utah Ave.	2377	4074.2
Tranquillon Mt. Road	860	1474.0

Total = 36,038.6 lb/yr
or 18.02 t/yr VOCs

Sample Calculation

Bldg. 761 (SLC-3W)

$$\frac{1345 \text{ gal asphalt}}{\text{yr}} \times \frac{0.2 \text{ lb VOC}}{\text{lb asphalt}} \times \frac{8.57 \text{ lb asphalt}}{\text{gal asphalt}} = 2305.3 \text{ lb/yr}$$

All of the above paving locations were strictly overlay operations with the exception of Washington Avenue which was a heat/remix operation followed by an overlay.

The pavement was heated with a diesel combustion unit rated at 11,000 Btu/hr. The heat/remix operation took approximately 18 hrs (16-20 hrs).

Heating Unit Combustion Emission Calculations

Diesel Heating Value = $\frac{140{,}000 \text{ Btu}}{\text{gal}}$, 0.5% sulfur content

Use U.S. EPA AP-42 Table 1.3-1 to obtain emissions factors.

Gallons of diesel consumed = 11,000 Btu/hr x 18 hrs

$$\times \frac{1 \text{ gal}}{140{,}000 \text{ Btu}} = 1.4 \text{ gal of diesel}$$

1)	Particulate:	2.5 lb/10^3 gal x 1.4 gal	=	negligible emissions
2)	SO_2 :	142 lb/10^3 gal x 0.5% S x 1.4 gal	=	" "
3)	SO_3 :	2 lb/10^3 gal x 0.5% S x 1.4 gal	=	" "
4)	CO :	5 lb/10^3 gal x 1.4 gal	=	" "
5)	HC :	1 lb/10^3 gal x 1.4 gal	=	" "
6)	NO_x :	18 lb/10^3 gal x 1.4 gal	=	" "

CE Contracts - Asphalt Roofing 1981 (Oil based - medium cure)
Contact: Leartis Hicks (CE Contracts)

Use U.S. EPA AP-42, pages 4.5-2,3, Table 4.5-1.

Assume typical depth of asphalt to be 1/4 inch (1/48 or 0.021 ft)

Asphalt density = 8.57 lb/gal (Table A-4 AP-42)

= 64 lb/ft^3 asphalt

Data:

Bldg. No.	Asphalt (ft^2)	Asphalt (ft^3) (ft^2 x 0.021 ft depth)	VOC Emissions (lb/yr)
10726 A & B	20,100	422	5,401.6
INC 1 & 2	180,000	3,780	48,384
10363	7,500	157.5	2,016.0
11432	6,900	145	1,856.0
21200	2,600	55	704
21150	15,100	317	4,057.6
16158	12,000	252	3,225.6
8339	8,300	174	2,227.2
6523	12,500	262.5	3,360.0

Total = 71,232 lb/yr VOCs
or 35.62 t/yr VOCs

Table 4.5-1 indicates a typical percentage by weight of asphalt evaporated = 20% or VOC emissions = $\frac{0.2 \text{ lb VOCs}}{\text{lb asphalt}}$

Sample Calculation

Bldg. 10726 A & B

$$\frac{0.2 \text{ lb VOC}}{\text{lb asphalt}} \times \frac{422 \text{ ft}^3 \text{ asphalt}}{\text{yr}} \times \frac{64 \text{ lb asphalt}}{\text{ft}^3} = \underline{5401.6 \text{ lb/yr VOC}}$$

2.4.10 POL Storage Tank Data

1. Diesel and Fuel Oil Storage - Contact: Mr. Ward

Small storage tanks used at the Vandenberg Air Force Base to store quantities of petroleum, oils, and lubricants (POLs) were identified using map sequences obtained from the Base master plan. The two map sequences (tabs) utilized were:

- G-7, liquid fuel system
- K-2, technical site utilities

Tanks were identified by material stored and located by nearest building number. The results are presented in Table 2.12.

Emissions from these tanks will be the result of saturated or equilibrium concentration vapors being displaced during filling. These emissions, termed working losses, are therefore a function of product throughput. Individual tank throughputs could not be obtained. Instead, the POL inventory figures for 1981 were employed (an example sheet is attached). Two columns were used, D and F. Column D reflects shipments to power plants directly and column F indicates diesel shipments from bulk storage to the small tanks.

A combination of these values provides a picture of diesel movement on the base and methodolodgy for averaging throughput and calculating emissions. POL records indicate for 1981 combined column D and F values of 1,182,145 gallons (see Table 2.13). The following ratio:

$$\frac{1{,}182{,}145 \text{ gallons throughput}}{606{,}075 \text{ gallons capacity}} = 1.95$$

is an expected average annual throughput for any tank as a function of capacity. Using this value and the emission factor for diesel calculated from AP-42 formula (2) on page 4.3-8 (updated April 1981):

$$Lw = 2.40 \times 10^2 \; MPK_nK_c$$

where M = molecular weight (130)
P = true vapor pressure (use 0.011 psia for kerosene at 75°F)
K_n = turnover factor = 1
K_c = product factor = 1
LW = TOG working loss emissions

Using this emission factor results in extremely small TOG values. Table 2.14 shows calculated emission values by grid square assignment for all sources except the POL storage facility near the airport (discussed separately in the next section). Due to the low total quantity involved (41.55 lb/yr), these sources were not placed in the area source inventory.

TABLE 2.12

POL STORAGE TANK INVENTORY - DIESEL

Bldg. or Location	Grid	Tank Capacity (gals)	Comments
Oak Mountain Telemetry Station	41 x 10	2,000	Underground
Oak Mountain Telemetry Station	41 x 10	15,000	Underground
Oak Mountain Telemetry Station	41 x 10	15,000	Underground
Oak Mountain Telemetry Station	41 x 10	500	
Tranquillon Peak Radar	42 x 7	6,000	
SLC-3	45 x 6	6,500	RP-1 (calculated based on thru-put of 43,000 gals in 1981)
SLC-3	45 x 6	15,000	
SLC-3	45 x 6	15,000	
South Vandenberg	46 x 7	2,000	
South Vandenberg	46 x 7	500	
South Vandenberg	46 x 7	1,000	
South Vandenberg	46 x 7	2,500	
South Vandenberg	46 x 8	500	
South Vandenberg	46 x 8	2,000	
South Vandenberg	46 x 8	6,000	
South Vandenberg	47 x 8	3,000	
Complex 395-D	49 x 6	8,000	Underground
Complex 395-C	50 x 6	8,000	Underground
MM/LCFOO-EO	50 x 7	15,000	Underground
Complex 576-E	51 x 5	15,000	Underground
SLC-10	51 x 6	4,000	Above ground
SLC-10	51 x 6	4,000	Underground
MM/LCFOO-DO	51 x 8	15,000	Underground
Cantonment	51 x 9	1,000	Underground
Cantonment	51 x 9	10,000	Underground
Cantonment	51 x 9	10,000	Underground
ICC area	52 x 9	280	Underground
ICC area	52 x 9	800	Underground
ICC area	52 x 9	1,000	Underground
ICC area	52 x 9	2,000	Underground
CDT Bldg.	52 x 10	500	Underground
CDT Bldg.	52 x 10	800	Underground
Complex 395-B	53 x 5	8,000	Underground
ABRES-A	53 x 6	47,670	Above ground Tank M1780
ABRES-A	53 x 6	72,400	Above ground Tank M1779
ABRES-A	53 x 6	72,400	Above ground Tank M1778

TABLE 2.12--Continued

POL STORAGE TANK INVENTORY - DIESEL

Bldg. or Location	Grid	Tank Capacity (gals)	Comments
COTAR No. 1	53 x 9	280	Underground
MM/LCFOO-CO	53 x 9	15,000	Underground
COTAR No. 2	54 x 6	280	Underground
COTAR No. 2	54 x 6	800	Underground
Guidance Station and 395 A	54 x 8	550	Underground
Guidance Station and 395 A	54 x 8	20,000	Underground Tank 1855
Tracking station	54 x 10	215	Underground
Complex 576 G	55 x 7	15,300	Underground
Complex 576 D	55 x 8	15,000	Underground
MM/LCFOO-01E	55 x 8	14,500	Underground
Tracking station	55 x 10	2,600	Above ground
MM/LFOO-03	56 x 6	1,500	Underground
MM/LFOO-02	56 x 6	1,500	Underground
MM/LFOO-05	57 x 5	1,500	Underground
MM/LF50-04	57 x 5	1,500	Underground
MM/LFOO-24	57 x 5	11,000	Underground
MM/LFOO-08	57 x 6	14,500	Underground
Destruct Bldg.	57 x 6	200	Underground
MM/LCFOO-01A&B	57 x 6	1,000	Underground
MM/LCFOO-01A&B	57 x 6	1,000	Underground
MM/LFOO-21	57 x 6	11,000	Underground
MM/LFOO-22	57 x 6	11,000	Underground
MM/LFOO-23	57 x 6	11,000	Underground
MM/LFOO-25	58 x 4	11,000	Underground
MM/LFOO-09	58 x 4	14,500	Underground
MM/LFOO-26	59 x 3	11,000	Underground
MM/LFOO-06	59 x 3	11,000*	Underground
MM/LFOO-07	59 x 3	11,000*	Underground
Bldg. 488	43 x 7	10,000	
Bldg. 676	45 x 7	15,000	
Bldg. 535	43 x 4	20,000	
TOTAL1)		606,075	

*Assumed.

TABLE 2.13

1981 DIESEL FUEL SUMMARY FROM POL INVENTORY

(Date) A	(Input) B or C	(Output) D	(Output) E	(Output) F	(D&E&F) G	(B or C-6) Storage
Jan	77588	31026	2957	41758	75741	1847
Feb	85648	62308	2369	47554	112231	26583
Mar	115341	46286	3304	59873	109463	5878
Apr	115691	46506	2566	61501	110573	5118
May	123550	70625	3866	55481	129972	6422
Jan	77247	38692	2722	32518	73932	3315
Jul	30840	30840	1540	61512	93892	63052
Aug	23207	23207	2092	105996	131295	108088
Sep	122910	92310	3423	37900	133633	10723
Oct	76659	45961	2180	25014	73155	3504
Nov	77289	30949	2578	38852	72379	4910
Dec	85257	46498	2479	48978	97955	12698
Total	1011227	565208	32076	616937	1214221	202994

TABLE 2.14

DIESEL AND FUEL OIL EMISSIONS BY
GRID SQUARE ASSIGNMENT
(lb/yr)

Grid	Emission Rate
41 x 10	2.21
42 x 7	0.41
43 x 4	1.36
43 x 7	0.68
45 x 6	1.46
45 x 7	1.02
46 x 7	0.41
46 x 8	0.58
47 x 8	0.20
49 x 6	0.54
50 x 6	0.54
51 x 5	1.02
51 x 6	0.54
51 x 8	1.02
51 x 9	1.43
52 x 9	0.14
52 x 10	0.09
53 x 5	0.54
53 x 6	13.09
53 x 9	1.04
54 x 6	0.07
54 x 8	1.40
54 x 10	0.01
55 x 7	1.04
55 x 8	2.01
55 x 10	0.18
56 x 6	0.20
57 x 5	0.95
57 x 6	3.40
58 x 4	1.73
59 x 3	2.24
Total	41.55

2. POL Storage Facility

There are nine storage tanks located at the POL facility near the airport, with pertinent data for each tank presented in Table 2.15. Estimation of emissions were made using factors appearing in: "Aeros Manual of Codes," Aeros Manual Series, Vol. V, EPA-450/2-76-005-2. Emissions from aboveground storage can be attributed to two basic sources: breathing losses associated with temperature and pressure fluctuations and working losses, which are the result of volume displacement of saturated or equilibrium TOG vapors during vessel loading. For underground tanks, usually only the working loss contribution is considered. In the case of gasoline tanks, emissions were calculated for the purpose of permit submittal. These values as well as emission factors applicable to the other tank situations are presented in Table 2.16.

2.4.11 Generator Emission Calculation Methodology

According to AP-42, the best methodology for calculating emissions from such sources is to aggregate and compute. However, this does not suit well the gridded area source format required for this project, therefore we will employ the AP-42 methodology for natural gas fired compressor engines for Vandenberg sources utilizing natural gas and the Vandenberg operators' "rule of thumb" value for quantities of diesel fired in appropriate units.

As mentioned in Section 2.2, generator size and location are taken from "Installation Generator Data, 1 October 1981 Inventory." Power production shop coordinators are Mr. Zoet and Mr. Briggs.

Assumptions

1. If no plant or normal firing rate is given, unit is exercised or utilized at maximum rating.

2. Pickled or not-in-service units were not considered in operation in 1981.

3. For gaseous units, hours of exercise operation were (0.5 hr/mo) (12 mo/yr) = 6 hr/yr (representing 75% of operation)

TABLE 2.15

POL STORAGE TANK INFORMATION

Material	Storage Tank Capacity (gal)	Storage Tank Throughput (gal)	Storage Tank Characteristics
RP-1	50,000	43,043	Underground
JP-4	50,000	828,606 (comb.)	Underground
	50,000		Underground
Leaded gasoline	20,000	42,445 (comb.)	Above ground 1704, #1
	20,000		Above ground 1704, #2
Unleaded gasoline	126,000	48,402	Above ground, fixed-roof, 1701
Diesel	420,000	390,600	Above ground, floating-roof tank with double seal
	210,000	195,300	Above ground, floating-roof tank with double seal
	50,000	46,677	Underground

TABLE 2.16

POL EMISSION FACTORS AND ESTIMATES

Material	Tank Type	Emission Factors	Pertinent Data	Emission Estimate (lb/yr)
Leaded gasoline	Above ground	(1)	(2,3)	5,182
Unleaded gasoline	Above ground (2 tanks)	(1)	(2,3)	3,392
RP-1	Underground	0.03 lb/10^3 gal	43.043 x 10^3 gal/yr	1.3
JP-4	Underground (2 tanks)	2.5 lb/10^3 gal	828.606 x 10^3 gal/yr	2,072
Diesel	Above ground	1.6 lb/10^3 gal	630 x 10^3 gal/yr	1,008
	Above ground	0.03 lb/10^3 gal	585.9 x 10^3 gal/yr	17.6
	Underground	0.03 lb/10^3 gal	46.677 x 10^3 gal/yr	1.4
TOTAL				11,674.3

(1) For above ground tank: loss from breathing =

$$2.26 \times 10^{-2} M \left(\frac{P}{14.7-P}\right)^{0.68} (D)^{1.73} (H)^{0.51} (\Delta T)^{0.5} F_p C K_c \text{ (lb/yr)}$$

For both above and below ground tanks: loss from working =

$$2.4 \times 10^{-2} M P K_n K_c \text{ (lb/}10^3\text{ gal throughput)}$$

(2) Physical characteristics of POL gasoline storage vessels:

	Tank 1701	Tanks 1704 (#1, 2)
Fuel stored	Unleaded	Leaded
Diameter	26' 1"	31' 1/2"
Height	33' 7"	30' 5"(long)
Shell color	White	White
Vapor controls	None	None
Capacity (gal)	126,000	20,000
Roof type	Fixed	Cylindrical

(3) Emission loss equation parameters and values:

Symbol	Description	Tank 1701 Value	Tanks 1704, #1, 2 Value
M	Molecular weight	66[a]	66[a]
P	True vapor pressure	5.8 psia[b]	5.8 psia[b]
D	Diameter	26.08 ft	20.6[c]
H	Average vapor space height	16 ft	4.33 ft[d]
T	Average ambient diurnal temperature change	14°F[e]	14°F[e]
F_p	Paint factor	1.0	1.0
C	Adjustment factor for small diameter tanks	0.98	0.91
K_c	Product factor	1.0	1.0
K_n	Turnover factor	1.0	1.0

[a] Based on RVP 10 gasoline in AP-42 Table 4.3-1 (revised 4/81).
[b] Calculated from AP-42 Figure 4.3-6 (revised 4/81) using ambient temperature of 68°F.
[c] Diameter based on maximum surface area inside cylindrical tank of 30.4 ft by 11 ft. Calculated to convert surface area to equation input parameters.
[d] Assumes cylinders to be half full on average, height multiplied by the equivalent diameter equals half the cylinder volume (cylinder has radius of 5.5 ft.
[e] Base weather at Vandenberg.

when adding in power outages, then normal hours of operation are $\frac{6}{0.75} = 8$ hr/yr.

Appropriate emission factors were not available for gasoline and diesel industrial engines, so use factor for natural gas fired pipeline compressor engines (reciprocating and not turbine) (Table 3.3.2-1).

Emission Factors:

NO_x $\frac{(15 \text{ g/KW hr}) (\text{rated KW}) (\text{load factor}) (8 \text{ hr/yr})}{(454 \text{ g/lb})}$

CO: $\frac{(1.9 \text{ g/KW hr}) (\text{rated KW}) (\text{load factor}) (8 \text{ hr/yr})}{(454 \text{ g/lb})}$

HC: $\frac{(5.9 \text{ g/KW hr}) (\text{rated KW}) (\text{load factor}) (8 \text{ hr/yr})}{(454 \text{ g/lb})}$

SO_2: $\frac{(0.003 \text{ g/KW hr}) (\text{rated KW}) (\text{load factor}) (8 \text{ hr/yr})}{(454 \text{ g/lb})}$

4. For diesel fired units, use Table 3.3.3-1, and Vandenberg "rule of thumb" for rate of fuel consumption of 1 gal/ 10 KW hr.

   for units equal to or above 200 KW (rated), exercising is 2 hr/mo or 24 hr/yr. Assuming this to represent only 75% of usage yields output of $\frac{24}{0.75} = 32$ hr/yr.

   for units below 200 KW, exercising is 1 hr/mo = 12 hr/yr. Again, with this only 75% of usage, yield is output of $\frac{12}{0.75} = 16$ hr/yr.

   fuel consumption rate is calculated as:

   $\underline{(\text{hr/yr}) (\text{rated KW}) (\text{load factor})} = \text{KW hr/yr}$

   $\frac{(\text{KW hr/yr}) (1 \text{ gal})}{(10 \text{ KW hr}) 1{,}000} = 10^3 \text{ gal/yr}$

   Emission Factors:

   CO: $(10^3 \text{ gal/yr}) (102 \text{ lb}/10^3 \text{ gal})$
   HC: $(10^3 \text{ gal/yr}) (37.5 \text{ lb}/10^3 \text{ gal})$
   NO_x: $(10^3 \text{ gal/yr}) (469 \text{ lb}/10^3 \text{ gal})$
   SO_2: $(10^3 \text{ gal/yr}) (31.2 \text{ lb}/10^3 \text{ gal})$
   Part: $(10^3 \text{ gal/yr}) (33.5 \text{ lb}/10^3 \text{ gal})$

TABLE 2.17

GAS FIRED UNITS

Building	KW Rating	Plant or Normal KW Load	Load Factor	Emissions (lb/yr) NO_x	CO	TOG	SO_2
8425	5	5*	1	1.32	0.17	0.52	NEG.
8425	10	10*	1	2.64	0.33	1.04	NEG.
853	5	5*	1	1.32	0.17	0.52	NEG.
1555	25	10	0.4	2.64	0.33	1.04	NEG.
1737	5	1	0.2	0.26	0.03	0.10	NEG.
1740	10	2	0.2	0.53	0.07	0.21	NEG.
6601	10	2.5	0.25	0.66	0.08	0.26	NEG.
10004	5	1	0.2	0.26	0.03	0.10	NEG.
11477	20	5	0.25	1.32	0.17	0.52	NEG.
22114	15	11	(Butane)				
13405	25	10	0.4	2.64	0.33	1.04	NEG.
9320	10	10*	1.0	2.64	0.33	1.04	NEG.
9320	10	10*	1.0	2.64	0.33	1.04	NEG.
1987	10	10*	1.0	2.64	0.33	1.04	NEG.
1987	10	10*	1.0	2.64	0.33	1.04	NEG.
21100	125	75	0.6	19.82	2.51	7.80	NEG.
RF Lab	6.5	6.5*	1	1.72	0.22	0.68	NEG.
Beacon Test	6.5	6.5*	1	1.72	0.22	0.68	NEG.
Beacon Test	6.5	6.5*	1	1.72	0.22	0.68	NEG.
Test Van	6.5	6.5*	1	1.72	0.22	0.68	NEG.
T.V. Van	6.5	6.5*	1	1.72	0.22	0.68	NEG.
T.V. Van	6.5	6.5*	1	1.72	0.22	0.68	NEG.
RFMV	5	5*	1	1.32	0.17	0.52	NEG.
Base wide	5	3	0.6	0.79	0.10	0.31	NEG.
Base wide	5	3	0.6	0.79	0.10	0.31	NEG.

*Assumed

TABLE 2.18

DIESEL FIRED UNITS

Building	KW Rating	Plant or Normal KW Load	Load Factor	Emissions (lb/yr) CO	TOG	NO_x	SO_2	Part.
8425	15	15*	1	2.45	0.9	11.26	0.75	0.80
8425	15	15*	1	2.45	0.9	11.26	0.75	0.80
8425	15	15*	1	2.45	0.9	11.26	0.75	0.80
8425	30	30*	1	4.90	1.8	22.51	1.50	1.61
8425	15	15*	1	2.45	0.9	11.26	0.75	0.80
8425	30	30*	1	4.90	1.8	22.51	1.50	1.61
8425	30	30*	1	4.90	1.8	22.51	1.50	1.61
8425	60	60*	1	9.79	3.6	45.02	3.00	3.22
8425	60	60*	1	9.79	3.6	45.02	3.00	3.22
8425	60	60*	1	9.79	3.6	45.02	3.00	3.22
8425	60	60*	1	9.79	3.6	45.02	3.00	3.22
8425	60	60*	1	9.79	3.6	45.02	3.00	3.22
8425	60	60*	1	9.79	3.6	45.02	3.00	3.22
8425	60	60*	1	9.79	3.6	45.02	3.00	3.22
8425	100	100*	1	16.32	6.0	75.04	4.99	5.36
8425	100	100*	1	16.32	6.0	75.04	4.99	5.36
8425	150	150*	1	24.48	9.0	112.56	7.49	8.04
8425	150	150*	1	24.48	9.0	112.56	7.49	8.04
8425	150	150*	1	24.48	9.0	112.56	7.49	8.04
64	650	300	0.462	97.92	36.0	450.24	29.95	32.16
185	500	206	0.412	67.24	24.72	309.16	20.57	22.08
185	500	206	0.412	67.24	24.72	309.16	20.57	22.08
188	15	2	0.133	0.33	0.12	1.50	0.10	0.11
442	125	20	0.16	3.26	1.2	15.01	1.00	1.07
475	200	90	0.45	29.38	10.8	135.07	8.99	9.65
475	200	86	0.43	28.07	10.32	129.07	8.59	9.22
501	250	80	0.32	26.11	9.6	120.06	7.99	8.58
511	250	97	0.388	31.66	11.64	145.58	9.68	10.40
590	40	40*	1.00	6.53	2.4	30.02	2.00	2.14
1743	60	50	0.833	8.16	3.0	37.52	2.50	2.68
643	100	40	0.400	6.53	2.4	30.02	2.00	2.14
661	100	50	0.50	8.16	3.0	37.52	2.50	2.68
1972	150	75	0.50	12.24	4.5	56.28	3.74	4.02

*Assumed

TABLE 2.18

DIESEL FIRED UNITS--Continued

Building	KW Rating	Plant or Normal KW Load	Load Factor	Emissions (lb/yr) CO	TOG	NO_x	SO_2	Part.
810	60	40	0.667	6.53	2.4	30.02	2.00	2.14
830	300	80	0.267	26.11	9.6	120.06	7.99	8.58
830	300	200	0.667	65.28	24.0	300.16	19.97	21.44
676	60	55	0.917	8.98	3.3	41.27	2.75	2.95
1280	650	300	0.462	97.92	36.0	450.24	29.95	32.16
1544	100	24	0.24	3.92	1.44	18.01	1.20	1.29
1559	75	13	0.173	2.12	0.78	9.76	0.65	0.70
1575	100	65	0.65	10.61	3.9	48.78	3.24	3.48
1577	40	20	0.50	3.26	1.2	15.01	1.00	1.07
1579	30	15	0.50	2.45	0.9	11.26	0.75	0.80
1581	30	12	0.40	1.96	0.72	9.00	0.60	0.64
8427	250	250*	1.0	81.60	30.00	375.20	24.96	26.8
1748	30	5	0.167	0.82	0.3	3.75	0.25	0.27
1753	200	120	0.6	39.17	14.4	180.10	11.98	12.86
1801	100	75	0.75	12.24	4.5	56.28	3.74	4.02
1905	40	15	0.375	2.45	0.9	11.26	0.75	0.80
1937	75	30	0.4	4.90	1.8	22.51	1.50	1.61
1937	75	30	0.4	4.90	1.8	22.51	1.50	1.61
1988	60	20	0.33	3.26	1.2	15.01	1.00	1.07
6512	100	95	0.95	15.50	5.7	71.29	4.74	5.09
7422	15	4.5	0.3	0.73	0.27	3.38	0.22	0.24
1764	45	45*	1.0	7.34	2.7	33.77	2.25	2.41
9340	100	20	0.2	3.26	1.2	15.01	1.00	1.07
952	60	45	0.75	7.34	2.7	33.77	2.25	2.41
10525	150	125	0.833	20.4	7.5	93.8	6.24	6.7
10577	100	46	0.46	7.51	2.76	34.52	2.30	2.47
11439	30	10	0.33	1.63	0.6	7.50	0.50	0.54
13850	75	25	0.33	4.08	1.5	18.76	1.25	1.34
13850	350	150	0.429	48.96	18.0	225.12	14.98	16.08
21101	75	60	0.8	9.79	3.6	45.02	3.00	3.22
21150	350	165	0.471	53.86	19.8	247.63	16.47	17.69
1762	30	15	0.5	2.45	0.9	11.26	0.75	0.80

*Assumed

TABLE 2.18

DIESEL FIRED UNITS--Continued

Building	KW Rating	Plant or Normal KW Load	Load Factor	Emissions (lb/yr)				
				CO	TOG	NO_x	SO_2	Part.
21101	100	29	0.29	4.73	1.74	21.76	1.45	1.55
907	250	130	0.52	42.43	15.6	195.10	12.98	13.94
907	100	100*	1.0	16.32	6.0	75.04	4.99	5.36
21203	150	120	0.8	19.58	7.2	90.05	5.99	6.43
1980	150	80	0.533	13.06	4.8	60.03	3.99	4.29
21100	125	75	0.6	12.24	4.5	56.28	3.74	4.02
SLC-3	150	150*	1.0	24.48	9.0	112.56	7.49	8.04
SLC-3	150	150*	1.0	24.48	9.0	112.56	7.49	8.04
Base wide	60	45	0.75	7.34	2.7	33.77	2.25	2.41
Base wide	60	45	0.75	7.34	2.7	33.77	2.25	2.41
Base wide	60	45	0.75	7.34	2.7	33.77	2.25	2.41
Base wide	60	45	0.75	7.34	2.7	33.77	2.25	2.41
LF-02	60	25	0.417	4.08	1.5	18.76	1.25	1.34
LF-03	60	25	0.417	4.08	1.5	18.76	1.25	1.34
LF-04	60	25	0.417	4.08	1.5	18.76	1.25	1.34
LF-05	60	25	0.417	4.08	1.5	18.76	1.25	1.34
LF-06	60	25	0.417	4.08	1.5	18.76	1.25	1.34
LF-07	60	25	0.417	4.08	1.5	18.76	1.25	1.34
LF-08	75	30	0.4	4.90	1.8	22.51	1.50	1.61
LF-09	75	30	0.4	4.90	1.8	22.51	1.50	1.61
LCF-01A	150	30	0.2	4.90	1.8	22.51	1.50	1.61
LCF-01B	100	45	0.45	7.34	2.7	33.77	2.25	2.41
LCF-01E	75	35	0.467	5.71	2.1	26.26	1.75	1.88
LF-21	75	45	0.6	7.34	2.7	33.77	2.25	2.41

*Assumed

TABLE 2.18

DIESEL FIRED UNITS--Continued

Building	KW Rating	Plant or Normal KW Load	Load Factor	Emissions (lb/yr) CO	TOG	NO_x	SO_2	Part.
LF-22	75	45	0.6	7.34	2.7	33.77	2.25	2.41
LF-25	75	45	0.6	7.34	2.7	33.77	2.25	2.41
LF-26	75	45	0.6	7.34	2.7	33.77	2.25	2.41
LCF-CO	75	45	0.6	7.34	2.7	33.77	2.25	2.41
LCF-DO	75	45	0.6	7.34	2.7	33.77	2.25	2.41
LCF-EO	100	45	0.45	7.34	2.7	33.77	2.25	2.41
Power Plant #1		66.1×10^3 gal/yr		6,742	2,479	31,001	4,759	2,214
Power Plant #2		478.5×10^3 gal/yr		48,807	17,944	224,417	34,452	16,030
Power Plant #3		4.0×10^3 gal/yr		408	150	1,876	288	134
Power Plant #4		5.1×10^3 gal/yr		520	191	2,392	367	171
Power Plant #5		0.5×10^3 gal/yr		51	19	235	36	17
Power Plant #6		134.4×10^3 gal/yr		13,709	5,040	63,034	9,677	4,502
Power Plant #7		0.69×10^3 gal/yr		70	26	324	50	23
Power Plant #8		0.27×10^3 gal/yr		28	10	127	19	9

2.4.12 Service Station Calculations

1. BX Service Station Emissions (TOG)

Reference: U.S. EPA AP-42, Table 4.4-4
Contact: Mr. Geyser

4 Underground Gasoline Tanks (10,000 gals. each)
Throughput 3,550,533 gals.

a. Balanced filling of underground tanks (assume submerged filling)

0.3 lb/10^3 gal x 3,550,533 = 1065 lb/hr TOG filling storage tank

= 0.53 t/yr TOG filling loss

b. Storage tank breathing loss

1.0 lb/10^3 gal x 3,550,533 gals = 3,551 lb/yr

= 1.8 t/yr TOG breathing loss

c. Displacement loss during refueling

9 lb/10^3 gal x 3,550,533 gals = 31,955 lb/yr

= 16.0 t/yr TOG

d. Spillage during refueling

0.7 lb/10^3 gal x 3,550,533 gals = 2485 lb/yr

= 1.2 t/yr TOG

e. Solvent usage

Shell 365 solvent - 4 bbls in 1981

Use 6.5 lb/gal (TOG) emission factor

(Reference: South Coast Air Quality Management District [SCAQMD] Organic Emission Factor Sheet)

Note: 6.5 lb/gal is provided for Stoddard solvent and Chevron 1200 solvent in the SCAQMD reference

6.5 lb/gal x 4 bbls x 55 gal/bbl = 1430 lb/yr = 0.72 t/yr TOG

Total BX emissions: 20.3 ton/yr

2. Vandenberg Motor Pool Service Stations (Military Vehicles)

Reference: U.S. EPA AP-42, Table 4.4-4 and Equation 2, page 4.3-8
Contact: Mr. Ward

North Vandenberg Tanks:

3 underground gasoline tanks, each with 10,000 gals capacity
1 underground diesel tank

South Vendenberg Tanks:

2 underground gasoline tanks (10,000 gas capacity each)

Emission Calculations (1981)

North Vandenberg:

Total gasoline throughput = 545,081 gal (monthly fuel inventory, calendar year 1981)*

a. Assume submerged filling of underground gasoline tanks (TOG loss)

$7.3\ lb/10^3\ gal \times (545,081\ gal) = 3,979\ lb/yr$ total (TOG)

b. Breathing loss

$1\ lb/10^3\ gal \times 545,081\ gals = 545\ lb/yr$ total (TOG)

c. Refueling Loss (uncontrolled)

$9\ lb/10^3\ gal \times 545,081\ gals = 4,906\ lb/yr$ (TOG) total

d. Spillage Loss

$0.7\ lb/10^3\ gal \times 545,081\ gals = 382\ lb/yr$ (TOG) total

e. Working loss diesel

Throughput total = 32,076 gals

$L_w = 0.034\ lb/10^3\ gal$ diesel from POL tank discussion

$0.034\ lb/10^3\ gal \times 32,076\ gals = 1.1\ lb/yr$ TOG (total)

*Approximately 90% of the gasoline received by POL is distributed to the North and South Vandenberg motor pool service stations. The North Vandenberg station received twice the quantity of gasoline received by South Vandenberg with remaining gasoline stored primarily at the POL bulk storage facility

Emission Calculations (1981)

South Vandenberg:

Total gasoline throughput = 272,541 gal (monthly fuel inventory, calendar year 1981)*

a. Assume submerged filling of underground gasoline tanks (TOG loss)

7.3 lb/10^3 gal x 272,541 gals = 1,990 lb/yr total (TOG)

b. Breathing loss

1 lb/10^3 gal x 272,541 gals = 273 lb/yr total (TOG)

c. Uncontrolled refueling loss

9 lb/10^3 gal x 272,541 gals = 2,453 lb/yr (TOG) total

d. Spillage loss

0.7 lb/10^3 gal x 272,541 gal = 191 lb/yr total (TOG)

Allocation (by tankage)

(1) North Vandenberg Motor Pool

(gasoline) 3,979 lb/yr + 545 lb/yr + 4,906 + 382 lb/yr = 9,812 lb/yr (TOG)

(diesel) 1.1 lb/yr (TOG)

North Vandenberg total = 9,813 lb/yr = 4.9 t/yr (TOG)

(2) South Vandenberg Motor Pool (Gasoline storage only)

1,990 lb/yr + 273 lb/yr + 2,453 lb/yr +

191 lb/yr = 4,907 lb/yr = 2.45 t/yr (TOG)

3. Boeing Refueling Station, Building 6523

Reference: U.S. EPA AP-42, Table 4.4-4
Contact: Mr. Woodin

Tankage:

1 underground gasoline tank, capacity of 5,000 gallons
Throughput: 1,650 gallons (seldom used)

Emission Calculations (1981)

a. Submerged filling of underground tank

$(7.3 \text{ lb TOG}/10^3 \text{ gal}) (1.65 \times 10^3 \text{ gal/yr}) = 12.0 \text{ lb/yr}$

b. Breathing Loss

$(1 \text{ lb TOG}/10^3 \text{ gal}) (1.65 \times 10^3 \text{ gal/yr}) = 1.7 \text{ lb/yr}$

c. Uncontrolled Refueling Losses

$(9 \text{ lb}/10^3 \text{ gal}) (1.65 \times 10^3 \text{ gal/yr}) = 14.9 \text{ lb/yr}$

d. Spillage Loss

$(0.7 \text{ lb}/10^3 \text{ gal}) (1.65 \times 10^3 \text{ gal/yr}) = 1.2 \text{ lb/yr}$

Total Boeing emissions: 29.8 lb TOG/yr

4. Civil Engineering (CE) Service Station

Reference: U.S. EPA AP-42, Table 4.4-4 and Equation 2, page 4.3-8
Contact: Sgt. Jake Felts

1 Underground gasoline tank, capacity of 5,000 gallons.
Throughput estimated to be 12 turnovers/yr or 60,000 gallons.

Delivery to service area is 70% from offsite using vapor balance and 30% from POL without vapor balance.

1 Underground diesel tank, capacity of 5,000 gallons.
Throughput estimated to be 12 turnovers/yr or 60,000 gallons.

Emission Calculations (1981)

a. Submerged fill delivery

(1) Without vapor balance:

$(7.3 \text{ lb TOG}/10^3 \text{ gal}) (60 \times 10^3 \text{ gal/yr}) (0.3) = 131 \text{ lb/yr}$

(2) With vapor balance:

$(0.3 \text{ lb TOB}/10^3 \text{ gal}) (60 \times 10^3 \text{ gal/yr}) (0.7) = 13 \text{ lb/yr}$

b. Breathing loss

$(1 \text{ lb TOG}/10^3 \text{ gal}) (60 \times 10^3 \text{ gal/yr}) = 60 \text{ lb/yr}$

c. Refueling loss (uncontrolled)

(9 lb TOG/10^3 gal) (60 x 10^3 gal/yr) = 540 lb/yr

d. Spillage loss

(0.7 TOG lb/10^3 gal) (60 x 10^3 gal/yr) = 42 lb/yr

e. Working loss diesel

Throughput total = 60,000 gal/yr

Lw = 0.034 lb/10^3 gal of diesel, calculated in small tank POL discussion

(0.034 lb TOG/10^3 gal) (60 x 10^3 gal/yr) = 2.0 lb TOG/yr

Total CE Service emissions: 788 lb TOG/yr

5. Marshallia Ranch Golf Course Service Station

Reference: U.S. EPA AP-42, Table 4.4-4 and Equation 2, page 4.3-8
Contact: Mr. Bennett

1 Underground gasoline tank, capacity of 2,500 gallons.
Throughput estimated to be 12 turnovers/yr or 30,000 gallons.

1 Underground diesel tank, capacity of 2,500 gallons.
Throughput estimated to be 12 turnovers/yr or 30,000 gallons.

Emission Calculations (1981)

a. Submerged fill delivery

(1) Without vapor balance:

(7.3 lb TOG/10^3 gal) (30 x 10^3 gal/yr) (0.3) = 219 lb/yr

b. Breathing loss

(1 lb TOG/10^3 gal) (30 x 10^3 gal/yr) = 30 lb/yr

c. Refueling loss (uncontrolled)

(9 lb TOG/10^3 gal) (30 x 10^3 gal/yr) = 270 lb/yr

d. Spillage loss

(0.7 TOG lb/10^3 gal) (30 x 10^3 gal/yr) = 21 lb/yr

e. Working loss diesel

Throughput total = 30,000 gal/yr

Lw = 0.034 $lb/10^3$ gal of diesel, calculated in small tank POL discussion

$(0.034 \text{ lb TOG}/10^3 \text{ gal}) (30 \times 10^3 \text{ gal/yr}) = 1.0 \text{ lb TOG/yr}$

Total Marshallia Ranch Golf Course: 541 lb TOG/yr

2.4.13 Aircraft Operation Emissions 1981 - Contact: Captain Kovach

Takeoffs and Landings

Initial planning called for addressing aircraft activities as line sources. Such an approach is necessary when multiple runways cover an extensive area and traffic control generates unique time-in-mode scenarios and alternating flight paths. To handle the information complexity with this activity requires the utilization of automated data handling procedures.

In interviews with Vandenberg staff at the airfield, it was learned that the level of data detail necessary to warrant this approach was not available from the base. The only aircraft stationed at the base are three helicopters. All other craft (outside of the small engine Aero Club) are transient.

Therefore, emissions from aircraft operations have been estimated using factors appearing in AP-42, specifically Tables 3.2.1-1,2,3,4,7,8. For calculation purposes, the summation of 1981 takeoffs plus landings shown in Table 2.19 was used. Values were presented in a memorandum dated January 13, 1982.

All time-in-mode scenarios presented in AP-42 were shown to Vandenberg personnel for review and comment. Based upon their response, the idle mode time durations were reduced by 1 minute, both in and out (for a total of 2 minutes reduction). In addition, 85% of the takeoffs and landings reflect touch-and-go activities, with no associated idle times. Table 2.20 summarizes data used in calculations.

TABLE 2.19

1981 VANDENBERG TAKEOFFS PLUS LANDINGS

Aircraft	Number
° Military	
KC-135	6,500
P-3	6,504
C-141	1,086
T-38	2,167
T-37	1,083
F-4	1,080
Other	3,256
° Civilian	
Small aircraft (one engine)	2,700
Two or more engines	2,408

TABLE 2.20

TIME-IN-MODE VALUES BY AIRCRAFT

Aircraft Type	Number of Engines	Landings Plus Takeoffs	Idle Mode (Min)	Take-off (Min)	Climb-out Mode (Min)	Approach Mode (Min)
KC-135	4	6,500	45.7	0.7	1.6	5.2
P-3	4	6,504	24	0.5	2.5	4.5
C-141	4	1,086	13.9	0.4	1.2	5.1
T-38	2	2,167	17.5	0.4	0.9	3.8
F-4 (Navy)	2	972[1)]	11	0.4	0.5	1.6
F-4 (Air Force)	2	108[1)]				
Helicopters	2	1,890[2)]	15	6.8	---[3)]	6.8
T-37	2	1,083	16.3	1.3	1.3	4.0
Other military	4	1,366[2)]	20.9	0.4	1.0	4.3
Small Aircraft						
Aero Club						
Cessna 172	1	1,796[4)]	14.0	0.3	5.0	6.0
Mooney 201	1	94	14.0	0.3	5.0	6.0
Contractor	1	810[5)]	14.0	0.3	5.0	6.0
Two or more engines	2	2,408	16.3[6)]	0.4[6)]	2.7	4 0

1) 486 LTO's (90%) Navy, 54 LTO's Air Force.
2) Values combine for 3,256 number presented in Table A-1.
3) Not applicable to helicopters.
4) Reported that of 1,350 LTO's; 70% Aero Club, 30% contractor; 95% of Aero Club Cessna 172, 5% Mooney. $\frac{(2700)}{2}(0.7)(0.95) = 898$ LTO's for Cessna 172.
5) $\frac{(2,700)}{2}(0.3) = 405$ LTO's.

Note: One LTO cycle = landings plus takeoffs divided by 2.

Sample Calculations

Unless otherwise indicated, emission factors utilized were taken from AP-42. Emission factors presented are in pounds per hour per engine. Therefore, estimates have to include adjustments for time-in-mode and number of engines. A sample calculation to demonstrate the methodology is shown below. A summation of emission factors and estimates appear as Table 2.21.

KC-135, Idle Mode: Total time-in-mode - 45.7 minutes
LTO's in mode - $\frac{(6,500)}{2}$ (0.15) = 487.5 (85% of LTO's are touch and go, without idle activities)

CO: $\frac{(64.4 \text{ lb/hr/eng})(45.7 \text{ min/mode})(487.5 \text{ mode/yr})(4 \text{ eng})}{(60 \text{ min/hr})(2{,}000 \text{ lb/ton})} = 47.9 \text{ ton/yr}$

NO_x: $\frac{(2.7 \text{ lb/hr/eng})(45.7 \text{ min/mode})(487.5 \text{ mode/yr})(4 \text{ eng})}{(60 \text{ min/hr})(2{,}000 \text{ lb/ton})} = 2.0 \text{ ton/yr}$

TOG: $\frac{(55.8 \text{ lb/hr/eng})(45.7 \text{ min/mode})(487.5 \text{ mode/yr})(4 \text{ eng})}{(60 \text{ min/hr})(2{,}000 \text{ lb/ton})} = 41.5 \text{ ton/yr}$

SO_x: $\frac{(1.1 \text{ lb/hr/eng})(45.7 \text{ min/mode})(487.5 \text{ mode/yr})(4 \text{ eng})}{(60 \text{ min/hr})(2{,}000 \text{ lb/ton})} = 0.8 \text{ ton/yr}$

Part: $\frac{(8.3 \text{ lb/hr/eng})(45.7 \text{ min/mode})(487.5 \text{ mode/yr})(4 \text{ eng})}{(60 \text{ min/hr})(2{,}000 \text{ lb/ton})} = 6.2 \text{ ton/yr}$

2.4.14 Aircraft Servicing Emissions - Contact: Mr. Kelly

The majority of organic emission losses from servicing operations are from refueling of aircraft. Other minor sources would include fuel combustion from ground support power units. Oil and lubricant emissions are considered to be negligible as compared to the other organic emissions.

1. Military and Civilian Contractor Aircraft

832,106 gallons JP-4 throughput from POL storage in 1981.

For calculation purposes assume JP-4 losses are a direct function of the vapor molecular weight and the true vapor pressure of the fuel.

Use U.S. EPA AP-42 Table 4.4-3 and 4.4-4.

TABLE 2.21

VANDENBERG AIR FORCE BASE EMISSION FACTORS AND ESTIMATES

Aircraft	Landings Plus Takeoffs	Time-In-Mode (Min)	Pollutant (factor in lb/hr/eng) (estimate in ton/yr) CO Fac.	CO Est.	NO_x (NO_2) Fac.	NO_x (NO_2) Est.	TOG Fac.	TOG Est.	SO_x (SO_2) Fac.	SO_x (SO_2) Est.	Part. Fac.	Part. Est.
KC-135												
Idle	975	45.7	64.4	47.9	2.7	2.0	55.8	41.5	1.1	0.8	8.3	6.2
Takeoff	6,500	0.7	14.9	1.2	93.3	7.1	5.4	0.4	8.4	0.7	12.0	0.9
Climbout	6,500	1.6	14.9	2.6	93.3	16.2	5.4	1.0	8.4	1.5	12.0	2.1
Approach	6,500	5.2	39.8	22.4	5.0	2.8	21.0	11.9	1.7	1.7	--	--
P-3												
Idle	976	24.0	17.5	6.9	2.1	0.8	11.5	4.5	0.5	0.2	1.6	0.6
Takeoff	6,504	0.5	4.4	0.3	19.3	1.1	0.8	0.1	2.1	0.1	3.7	0.2
Climbout	6,504	2.5	4.6	1.3	17.6	4.8	0.9	0.3	0.9	0.3	3.0	0.8
Approach	6,504	4.5	3.7	1.8	7.8	3.8	0.5	0.3	1.1	0.6	3.0	1.5
C-141												
Idle	163	13.9	74.9	2.9	1.5	0.1	77.8	3.0	0.8	0.1	4.4	0.2
Takeoff	1,086	0.4	13.0	0.1	109.8	0.8	3.0	0.1	10.0	0.1	79.8	0.6
Climbout	1,086	1.2	13.2	0.3	65.9	1.5	2.9	0.1	7.3	0.2	102.5	2.3
Approach	1,086	5.1	34.2	3.2	27.7	2.6	14.4	1.4	3.8	0.4	53.1	4.9
T-38												
Idle	325	17.5	93.3	4.4	0.7	0.1	15.7	0.8	0.5	0.1	NA	NA
Takeoff	2,167	0.4	245.6	1.8	22.0	0.2	6.8	0.1	8.5	0.1	NA	NA
Climbout	2,167	0.9	55.8	0.9	3.0	0.1	4.5	0.1	1.3	0.1	NA	NA
Approach	2,167	3.8	63.7	4.4	3.0	0.2	1.3	0.1	1.1	0.1	NA	NA
F-4 (Navy)												
Idle	146	11.0	48.0	0.7	3.2	0.1	9.8	0.2	1.1	0.1	57.8	0.8
Takeoff	972	0.4	611.9	2.0	241.3	0.8	17.2	0.1	35.4	0.1	299.7	1.0
Climbout	972	0.5	52.0	0.2	151.8	0.6	16.0	0.1	9.9	0.1	77.7	0.3
Approach	972	1.6	45.6	0.6	69.9	0.9	4.1	0.1	6.2	0.1	67.0	0.9

TABLE 2.21--Continued

VANDENBERG AIR FORCE BASE EMISSION FACTORS AND ESTIMATES

Aircraft	Landings Plus Takeoffs	Time-In-Mode (Min)	CO Fac.	CO Est.	NO_x (NO_2) Fac.	NO_x (NO_2) Est.	TOG Fac.	TOG Est.	SO_x (SO_2) Fac.	SO_x (SO_2) Est.	Part. Fac.	Part. Est.
			Pollutant (factor in lb/hr/eng) (estimate in ton/yr)									
F-4 (Air Force)												
Idle	16	27.8	48.0	0.2	3.2	0.1	9.8	0.1	1.1	NEG.	57.8	0.2
Takeoff	108	0.4	611.9	0.2	241.3	0.1	17.2	NEG.	35.4	NEG.	299.7	0.1
Climbout	108	0.8	52.0	0.1	151.8	0.1	16.0	NEG.	9.9	NEG.	77.7	0.1
Approach	108	3.5	45.6	0.2	69.9	0.2	4.1	NEG.	6.2	NEG.	67.0	0.2
Helicopters1)												
Idle	567 2)	15.0	42.0	0.2	0.2	NEG.	9.0	0.4	0.14	NEG.	NA	NA
Climbout	1,890	6.8	2.0	0.2	5.0	0.4	0.2	NEG.	0.68	0.1	NA	NA
Approach	1,890	6.8	2.0	0.2	5.0	0.4	0.2	NEG.	0.68	0.1	NA	NA
T-37 3)												
Idle	162	16.3	48.2	1.1	1.5	0.1	3.6	0.1	0.4	NEG.	NA	NA
Climbout	1,083	4.0	50.0	1.8	5.5	0.2	0.04	NEG.	1.05	0.1	NA	NA
Approach	1,083	1.3	39.3	0.5	13.2	0.2	0.04	NEG	1.05	NEG.	NA	NA
Other Military 4)												
Idle	205	20.9	63.7	4.6	2.0	0.2	30.3	2.2	0.9	0.1	1.0	0.1
Takeoff	1,366	0.4	12.0	0.1	155.6	1.4	3.8	0.1	7.3	0.1	10.4	0.1
Climbout	1,366	1.0	11.0	0.3	115.5	2.7	3.6	0.1	5.6	0.2	5.5	0.2
Approach	1,366	4.3	14.4	1.4	62.2	6.1	6.3	0.6	3.9	0.4	5.5	0.6
Small Aircraft												
Cessna 172												
Idle	269	14.0	10.2	0.2	NEG.	NEG.	0.35	NEG.	--	--	NA	NA
Takeoff	1,796	0.3	96.0	0.2	0.195	NEG.	1.05	NEG.	0.02	NEG.	NA	NA
Climbout	1,796	5.0	66.0	2.5	0.265	NEG.	0.826	0.1	0.01	NEG.	NA	NA
Approach	1,796	6.0	56.8	2.6	0.044	NEG.	0.895	0.1	0.01	NEG.	NA	NA

TABLE 2.21 --Continued

VANDENBERG AIR FORCE BASE EMISSION FACTORS AND ESTIMATES

Aircraft	Landings Plus Takeoffs	Time-In-Mode (Min)	Pollutant (factor in lb/hr/eng) (estimate in ton/yr) CO Fac.	CO Est.	NO_x (NO_2) Fac.	NO_x (NO_2) Est.	TOG Fac.	TOG Est.	SO_x (SO_2) Fac.	SO_x (SO_2) Est.	Part. Fac.	Part. Est.
Mooney 201												
Idle	14	14	7.26	NEG.	0.0094	NEG.	0.398	NEG.	0.0	--	NA	NA
Take-off	95	0.3	123.5	NEG.	0.205	NEG.	1.03	NEG.	0.02	NEG.	NA	NA
Climb-out	95	5.0	70.5	0.2	0.329	NEG.	0.585	NEG.	0.01	NEG.	NA	NA
Approach	95	6.0	25.3	0.1	0.372	NEG.	0.355	NEG.	0.01	NEG.	NA	NA
Contractor Planes												
Idle	122	14.0	13.7	0.1	0.008	NEG.	0.7	NEG.	0.002	NEG.	NA	NA
Takeoff	810	0.3	175.8	0.2	0.17	NEG.	1.58	NEG.	0.03	NEG.	NA	NA
Climbout	810	5.0	123.0	2.1	0.25	NEG.	1.35	NEG.	0.02	NEG.	NA	NA
Approach	810	6.0	60.77	1.3	0.17	NEG.	0.76	NEG.	0.01	NEG.	NA	NA
Two or More Engines												
Idle	361	16.3	19.8	1.0	0.3	NEG.	5.0	0.3	0.1	NEG.	NA	NA
Takeoff	2,408	0.4	125.4	1.0	5.9	0.1	1.1	NEG.	0.6	NEG.	NA	NA
Climbout	2,408	2.7	100.8	5.5	4.7	0.3	1.1	0.1	0.6	NEG.	NA	NA
Approach	2,408	4.0	47.3	3.9	1.5	0.1	1.1	0.1	0.2	NEG.	NA	NA
TOTALS				137.9		59.3		70.5		8.6		24.9

NA = Not Available.

NEG = Negligible.

1) Emission factors available only for T-53 engines. Vandenberg uses T-400 engines. Prorated emission factors for T-53 engines based on horsepower relative to T-400 engines. T-53 has horsepower rating of 1,400, with T-400 horsepower rating of 900.

2) Number represents 90% of 630 missions.

3) No emission factors in AP-42, values taken from: AFWL-TR-303, USAF Aircraft Pollution Emission Factors and Landing and Takeoff Cycles

4) Average emissions calculated from as many applicable aircraft as listed in AP-42 (C130-T56; C5-TF39; AT-TF41 and TF30). Parameter emission factors from similar modes of all four engines were averaged. Aircraft were assumed to have 4 engines since 98% of other military listed in AP-42 are similarly equipped.

5) Emission factors are average values for business jet, turboprop, and piston aircraft under civil aviation in AP-42.

For gasoline with a Reid Vapor Pressure of 10, the vapor molecular weight and true vapor pressure at 60°F will be 66 and 5.2 psia, respectively. JP-4 at the same temperature will have a vapor molecular weight of 80 and a true vapor pressure of 1.3 psia.

a. Uncontrolled Refueling (Displacement) Loss

Uncontrolled displacement loss for gasoline = 9 lb/10^3 throughput

$$9 \text{ lb}/10^3 \text{ gal (gasoline)} \times \frac{(80 \text{ vapor molecular wt.})\ (1.3 \text{ psia})\ \text{JP-4}}{(66 \text{ vapor molecular wt.})\ (5.2 \text{ psia})\ \text{gasoline}}$$

= 9 lb/10^3 gal gas x 0.3 multiplier

= 2.7 lb/10^3 gal JP-4 displacement loss factor

2.7 lb/10^3 gal x 832,106 gal JP-4 = <u>2246.7 lb TOG/yr</u>

= <u>1.12 tons TOG/yr</u>

b. Spillage Loss

Spillage loss gasoline = 0.7 lb/10^3 gal

Spillage loss JP-4 = 0.7 lb/10^3 gal x 0.3 multiplier
= 0.21 lb/10^3 gal JP-4

0.21 lb/10^3 x 832,106 gal = 174.7 lb TOG/yr
= 0.09 tons TOG/yr

c. Support Power Unit Combustion Emissions

Use U.S. EPA AP-42, Table 3.3.3-1

Fuel consumption:	Diesel	- 90 gallons
	JP-4	- 70 gallons
	Gasoline	- 140 gallons

Due to the small quantity of JP-4 used, for calculation purposes assume JP-4 emission factors similar to gasoline.

Diesel -	CO	:	102 lb/10^3 gal x 90 gal = 9.2 lb/yr
	TOG (HC exhaust)	:	37.5 lb/10^3 gal x 90 gal = 3.4 lb/yr
	NO_x	:	469 lb/10^3 gal x 90 gal = 42.2 lb/yr
	SO_x	:	31.2 lb/10^3 gal x 90 gal = 2.8 lb/yr
	Particulate	:	33.5 lb/10^3 gal x 90 gal = 3.0 lb/yr

JP-4 + Gasoline -

CO	:	3940 $lb/10^3$ gal x 210 gal = 827.4 lb/yr
TOG (HC exhaust)	:	132 $lb/10^3$ gal x 210 gal = 27.7 lb/yr
NO_x	:	102 $lb/10^3$ gal x 210 gal = 21.4 lb/yr
SO_x	:	5.31 $lb/10^3$ gal x 210 gal = 1.1 lb/yr
Particulate	:	6.47 $lb/10^3$ gal x 210 gal = 1.4 lb/yr

2. Aeroclub Aircraft

Data:

8-1/2 gal of AVGAS per flying hour

170 flying hrs per mo.

55 gal cleaning solvent

AVGAS is a 100 octane low lead gasoline

AVGAS throughput = 170 hrs/mo x 12 mo. x 8.5 gal/hr
= 17,340 gal/yr

Use U.S. EPA AP-42 Table 4.4-4 and SCAQMD Solvent Emission Factors

a. Uncontrolled Refueling (Displacement) Loss

9 $lb/10^3$ gal gas x 17340 gal = 156.1 lb TOG/yr

c. Spillage Loss (Fuel)

0.7 $lb/10^3$ gal x 17340 gal = 12.1 lb TOG/yr

d. Solvent Usage

Assume complete evaporation

55 gal solvent x 7.0 lb/gal solvent = 385 lb TOG/yr
= 0.19 tons TOG/yr

e. Storage Tank Emissions

Two underground 1000 gallon AVGAS (gasoline) tanks

Use AP-42 Table 4.4-4 (assume submerged filling of tank

(1) Filling underground tanks (TOG loss)

7.3 $lb/10^3$ gal x 17,340 gal AVGAS = 126.6 lb TOG/yr

(2) Underground tank breathing and emptying loss

1 $lb/10^3$ gal x 17,340 gal AVGAS = 17.3 lb TOG/yr

2.4.15 <u>Pesticide Use - 1981 Total</u>

Procedure: Pesticide supply data were provided by base personnel.

Method: Total active ingredient - 90% volatilization.
Inert ingredient - 10% volatilization.

Reference: Procedures for the Preparation of Emission Inventories for Volatile Organic Compounds, U.S. EPA, December 1977.

Allocation: Housing area - 68%
Cantonment area - 23%
Miscellaneous - 9%
(Source: Sgt. Jenkins, Pesticides Group)

		Active Ingredients (lb)		Inert Ingredients (lb)	
Substance	Application	Total	TOG Emissions	Total	TOG Emissions
Diazinon	Emulsion	52	46.8	57.5	5.8
Diazinon	Oil solution	2	1.8	198	19.8
Baygon	Emulsion	25	22.5	145.1	14.5
Malathion	Emulsion	5	4.5	3.8	0.4
Dursban	Emulsion	40	36	58	5.8
Fenthion	Granular	10	9	3.9	0.4
Strychnine		1.2	1.1	400	40
Sulfur Gas Cartridges		165	148.5	585	58.5
Diuron	Suspension	96	86.4	24	2.4
Ureabore	Granular	65	58.5	433	43.3
Chlordane	Emulsion	24	21.6	9.3	0.9
Chlorodi-phacinone	Anticoagulant	2	1.8	398	39.8
Carbonyl		2	1.8	0.5	--
Diazinon		2	1.8	98	9.8
Phenothrin	Aerosol	1	0.9	49	4.9
Phentachloro-phenol	Wood preservative	1	0.9	99	9.9
TOTALS		493.2	443.9	2,562.4	256.2

Pesticide TOG Allocation

700.1 lb/yr of TOG

Allocation: a) Housing - 68% = 476 lb
b) Cantonment - 23% = 161 lb
c) Miscellaneous - 9% = 63 lb

a) Housing emissions (476 lb/yr) distributed among following grid squares

50% in (51 x 9) = 238 lb
30% in (51 x 10) = 143 lb
20% in (52 x 9) = 95 lb

b) Cantonment area emissions (161 lb/yr) distributed among following grid squares

50% in (50 x 8) = 81 lb
30% in (50 x 9) = 48 lb
20% in (49 x 8) = 32 lb

c) Miscellaneous emissions (63 lb/yr) assumed distributed at the airfield to keep runways clear.

63 lb/yr in (50 x 7)

2.4.16 Sandblast Operations for 1981

Sandblast operations at Vandenberg Air Force Base (VAFB) can be divided into two basic activity groups. The first group is the units owned and operated by Air Force personnel. The second is the units operated by on-base contractors. A summary of both activity groups is presented in Tables 2.22 and 2.23.

Emissions factors for sandblast operations were unavailable through standard EPA reference documents. After investigation, staff located an estimation method developed by the California Air Resources Board (CARB). This method assumes that 3.9 percent of the circulated abrasive escapes to the atmosphere as TSP emissions. Using this emission factor and values from Tables 2.22 and 2.23, emissions from each unit can be estimated. The results are presented in Table 2.24. A sample calculation for DET 41, AFLC, Building 9327 stationary "steel shot" unit is presented below.

TABLE 2.22

AIR FORCE SANDBLAST OPERATIONS AT VAFB

Location	Model Type	Operation Description	Quantities Consumed
1. Civil Engineering Squadron Building 825	Kelco Company	Fixed booth, 20 hr/wk	Maximum consumption rate on an annual basis: 2,000 100-lb bags. Normally 500 100-lb bags of Monterey sand are ordered 4 times per year. 85% of this quantity is utilized in the fixed booth.
2. Civil Engineering Squadron Building 825	Kelco Company	Portable unit, 1 to 2 days per month	Utilizes remaining 15% of the Monterey sand ordered quarterly.
3. DET 41, AFLC Building 9327	MaCleod Company	Stationary "steel shot" unit	Maximum abrasive consumption rate is 2,000 lb of coarse steel grit; avg. rate consumed in 1981 was 1,500 lbs.
4. DET 41, AFLC Building 9350	MaCleod Company	Portable "steel shot" unit	Maximum and avg. abrasive consumption rates are the same: 1,000 lbs of fine steel grit in 1981.
5. 394 TMS Building 1930	Parkside Services Systems, Inc. Model No. 1020 G	Portable unit using water curtain	Maximum and avg. abrasive consumption rates are the same: 90 100-lb bags of "Clean Blast" in 1981.
6. 4392 AEROSG/Auto Hobby Shop Building 6437	Easy Sandblaster, Model No. 1000B, manufactured by D.S.M. Company, West Palm Beach, FL	Portable unit	Maximum abrasive consumption rate highly variable; avg. consumption rate is 50 94-lb bags of abrasives in 1981. Material used ranges from regular beach sand to Monterey sand.

TABLE 2.23

CONTRACTOR SANDBLAST OPERATIONS AT VAFB

Company and Contact	Operation Location	Operation Description	Quantities Consumed
Stearns-Roger Chet Rawson, X69766	Distributed equally among eight locations: LF-3, LF-06, SLC-3, SLC-3 fallback, SLC-4, SLC-5, ABRES, and Building 1795.	7 portable units operating 2 hr/day each for a total of 303 hr/month.	Total abrasive utilized is 692 100-lb bags per month.
Federal Electric Bob Hull, X68377	Building 9320	Fixed booth	1,100 lbs of abrasives in 1981.
	Building 9320	Glove Box	100 lbs of abrasives in 1981.
Boeing Cliff Scholes, X64865	Corner of 13th and New Mexico Streets	Portable unit	45 94-lb bags of abrasives utilized in 1981.
Lockheed Don Lee, X66295	Building 7436	Portable unit	40,800 lbs of abrasives utilized in 1981.
	Building 8310	Glove box	7,200 lbs of abrasives utilized in 1981.
Convair Jay Shah	Building 8305	Portable unit operating 10 days/yr, 8 hrs/day	280 lbs/hr of 20 to 30 mesh Monterey sand utilized.
	Building 8305	Portable unit operating 7 days/yr, 8 hrs/day	30 lbs/hr of 20 to 30 mesh Monterey sand utilized.

TABLE 2.23--Continued

CONTRACTOR SANDBLAST OPERATIONS AT VAFB

Company and Contact	Operation Location	Operation Description	Quantities Consumed
McDonald Douglas Mr. Conlon, X64034	SLC-2	Two sandblasters (only one operating at a time); schedule is 15 days/yr, 5 hrs/day.	400 lbs/hr of abrasives utilized during operation.
	SLC-2	One sandblaster operating 6 days/yr, 1 hr/day.	Between 60-90 (average 75) lbs/hr of abrasived utilized during operation.

TABLE 2.24

VAFB SANDBLAST EMISSION ESTIMATES*

Unit	Estimated Emissions (lb/yr)
Air Force	
Civil Engineering Squadron, Bldg. 825, fixed booth	6,630
Civil Engineering Squadron, Bldg. 825, portable unit	1,170
DET 41, AFLC, Bldg. 9327, fixed booth	59
DET 41, AFLC, Bldg. 9350, portable unit	39
394 TMS, Bldg. 1930, portable unit	351
4392 AEROSG/Auto Hobby Shop, portable unit	183
Contractors	
Stearns-Roger, 7 portable units	32,386
Federal Electric, fixed booth	43
Federal Electric, glove box	4
Boeing Company, portable unit	165
Lockheed, portable unit	1,590
Lockheed, glove box	281
Convair, portable unit	87
Convair, portable unit	66
McDonald Douglas, SLC-2	1,186
TOTAL	44,240

*1981 Data.

Given: unit utilized 1,500 lb of abrasives in 1981
Emission factor: 0.039 of abrasives utilized

Estimated emissions are:

$$(1{,}500 \text{ lb/yr})\ (0.039) = \underline{58.5 \text{ lb of TSP/yr}}$$

2.4.17 Heating Unit Emissions Calculations Methodology

Contact: Mr. Carroll

The emissions were made based on emission factors listed in AP-42 tables. The tables used were 1.3-1 for fuel oil combustion, Table 1.4-1 for natural gas combustion and Table 1.5-1 for LPG combustion. The emissions of the oil burning heaters were based on the domestic heater factors. The emissions of the natural gas and LPG units were based on the small commercial heater factors. The sulfur oxides emissions from the natural gas and LPG units were assumed to be negligible and were not calculated.

The sulfur oxide emissions of the oil burning units are based on a 0.5% sulfur content of the fuel oil. The following additional assumptions were also made:

1. Btu content of fuel

   a. #2 fuel oil = 140,000 Btu/gal
   b. natural gas = 1,050 Btu/ft^3
   c. LPG (propane) = 90,050 Btu/gal

2. 24 hour continuous operation of all units: 8,760 hr/yr

3. Average operating conditions = 45% of maximum

   a. winter mode: 60% of maximum - 4,380 hr/yr
   b. summer mode: 30% of maximum - 4,380 hr/hr

The fuel rates are reported on a per hour basis at full load. The emission rates are on a per year basis at an average of 45% maximum input. Copies of the tables used in the calculations are included.

TABLE 2.25

LIQUID PETROLEUM (PROPANE)

				Emission Rates in lb/yr				
Btu	Type	Bldg. No.	Gal.	Particulate	SO_x (as SO_2)	CO	TOG	NO_x (as NO_2)
240,000	F	00051	2.65	18.80	---	19.85	7.31	114.91
130,000	S	00900	1.44	10.22	---	10.79	3.97	62.44
675,000	W	00390	7.46	52.93	---	55.87	20.59	323.48
350,000	B	00394	3.87	27.46	---	28.99	10.68	167.81
495,000	B/H	00178	5.47	38.81	---	40.97	15.09	237.19
142,000	F	00530	1.57	11.14	---	11.76	4.33	68.08
750,000	B/H	00398	8.29	58.82	---	62.09	22.88	359.47
675,000	B/H	00520	7.46	52.93	---	55.87	20.59	323.48
250,000	B/H	00390	2.76	19.58	---	20.67	7.62	119.68
675,000	B/H	00390	7.46	52.93	---	55.87	20.59	323.48
675,000	B/H	00390	7.46	52.93	---	55.87	20.59	323.48
2,000,000	B/H	00392	22.10	156.81	---	165.52	60.98	958.30

TABLE 2. 26

NATURAL GAS

Btu	Type	Bldg. No.	ft^3	Emission Rates in lb/yr: Particu-late	SO_x (as SO_2)	CO	TOG (as CH_4)	NO_x (as NO_2)
250,000	F	01317	238.10	14.08	---	18.77	7.51	112.63
180,000	S	01341	171.43	10.14	---	13.52	5.41	81.09
8,000	F	01530	7.62	0.45	---	0.60	0.24	3.60
488,000	F	01648	464.76	27.48	---	36.64	14.66	219.85
185,000	F	01750	176.19	10.42	---	13.89	5.56	83.34
250,000	F	01766	238.10	14.08	---	18.77	7.51	112.63
80,000	F	02501	76.19	4.51	---	6.01	2.40	36.04
270,000	S	04412	257.14	15.20	---	20.27	8.11	121.64
160,000	S	05432	152.38	9.01	---	12.01	4.81	72.08
500,000	F	06105	476.19	28.16	---	37.54	15.02	225.26
250,000	F	06335	238.10	14.08	---	18.77	7.51	112.63
450,000	S	06418	428.57	25.34	---	33.79	13.52	202.73
100,000	S	06438	95.24	5.63	---	7.51	3.00	45.05
75,000	S	06442	71.43	4.22	---	5.63	2.25	33.79
40,000	S	06443	38.10	2.25	---	3.00	1.20	18.02
110,000	F	06444	104.76	6.19	---	8.26	3.30	49.56
250,000	F	07001	238.10	14.08	---	18.77	7.51	112.63
125,000	F	07008	119.05	7.04	---	9.39	3.75	56.32
180,000	F	07304	171.43	10.14	---	13.52	5.41	81.09
180,000	F	07306	171.43	10.14	---	13.52	5.41	81.09
180,000	F	07307	171.43	10.14	---	13.52	5.41	81.09
250,000	B	07430	238.10	14.08	---	18.77	7.51	112.63
250,000	F	08111	238.10	14.08	---	18.77	7.51	112.63
250,000	F	08114	238.10	14.08	---	18.77	7.51	112.63
250,000	F	08115	238.10	14.08	---	18.77	7.51	112.63
250,000	F	08117	238.10	14.08	---	18.77	7.51	112.63
250,000	F	08118	238.10	14.08	---	18.77	7.51	112.63
105,000	F	10706	100.00	5.91	---	7.88	3.15	47.30
080,000	S	10710	76.19	4.51	---	6.01	2.40	36.04
500,000	F	10715	476.19	28.16	---	37.54	15.02	225.26
115,000	S	10717	109.52	6.48	---	8.63	3.45	51.81
10,000	E	10719	9.52	0.56	---	0.75	0.30	4.50
8,000	S	10720	7.62	0.45	---	0.60	0.24	3.60

TABLE 2.26

NATURAL GAS--Continued

Btu	Type	Bldg. No.	ft^3	Emission Rates in lb/yr: Particulate	SO_x (as SO_2)	CO	TOG (as CH_4)	NO_x (as NO_2)
80,000	W&S	10721	76.19	4.51	---	6.01	2.40	36.04
235,000	F	11003	223.81	13.23	---	17.65	7.06	105.87
250,000	F	11004	238.10	14.08	---	18.77	7.51	112.63
250,000	F	11026	238.10	14.08	---	18.77	7.51	112.63
130,000	F	11032	123.81	7.32	---	9.76	3.90	58.57
560,000	S	11153	533.33	31.54	---	42.05	16.82	252.29
625,000	S	11153	595.24	35.20	---	46.93	18.77	281.57
170,000	S	11153	161.90	9.57	---	12.76	5.11	76.59
270,000	S	11156	257.14	15.20	---	20.27	8.11	121.64
350,000	B&W	11162	333.33	19.71	---	26.28	10.51	157.68
120,000	S	11165	114.29	6.76	---	9.01	3.60	54.06
405,000	S	11167	385.71	22.81	---	30.41	12.16	182.46
1,445,000	F	11167	1376.19	81.37	---	108.50	43.40	650.99
1,445,000	F	11168	1376.19	81.37	---	108.50	43.40	650.99
1,445,000	F	11168	1376.19	81.37	---	108.50	43.40	650.99
150,000	S	11177	142.86	8.45	---	11.26	4.51	67.58
235,000	F	11190	223.81	13.23	---	17.65	7.06	105.87
1,540,000	F	11195	1466.67	86.22	---	115.63	46.25	693.79
250,000	F	11238	238.10	14.08	---	18.77	7.51	112.63
150,000	S	11345	142.86	8.45	---	11.26	4.51	67.58
420,000	F	11432	400.00	23.65	---	31.54	12.61	189.22
350,000	S	11434	333.33	19.71	---	26.28	10.51	157.68
250,000	F	11442	238.10	14.08	---	18.77	7.51	112.63
160,000	S	11510	152.38	9.01	---	12.01	4.81	72.08
45,000	S	11511	42.86	2.53	---	3.38	1.35	20.27
150,000	S	1241[illegible]	142.86	8.45	---	11.26	4.51	67.58
250,000	F	1300[illegible]	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13005	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13010	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13016	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13017	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13019	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13020	238.10	14.08	---	18.77	7.51	112.63

TABLE 2.26

NATURAL GAS--Continued

				Emission Rates in lb/yr				
Btu	Type	Bldg. No.	ft^3	Particu- late	SO_x (as SO_2)	CO	TOG (as CH_4)	NO_x (as NO_2)
250,000	F	13021	238.10	14.08	---	18.77	7.51	112.63
940,000	F	13022	895.24	52.94	---	70.58	28.23	423.48
250,000	F	13024	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13025	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13027	238.10	14.08	---	18.77	7.51	112.63
125,000	F	13028	119.05	7.04	---	9.39	3.75	56.32
250,000	F	13104	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13106	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13213	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13215	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13219	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13221	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13222	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13401	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13404	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13405	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13408	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13409	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13412	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13516	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13521	238.10	14.08	---	18.77	7.51	112.63
250,000	F	13522	238.10	14.08	---	18.77	7.51	112.63
660,000	F	16109	628.57	37.17	---	49.56	19.82	297.34
250,000	F	16197	238.10	14.08	---	18.77	7.51	112.63
80,000	F	17596	76.19	4.51	---	6.01	2.40	36.04
250,000	W	06008	238.10	14.08	---	18.77	7.51	112.63
250,000	W	06011	238.10	14.08	---	18.77	7.51	112.63
500,000	W	06015	476.19	28.16	---	37.54	15.02	225.26
250,000	W	06206	238.10	14.08	---	18.77	7.51	112.63
50,000	W	06437	47.62	2.82	---	3.75	1.50	22.53
200,000	W	06612	190.48	11.26	---	15.02	6.01	90.10
130,000	W	07002	123.81	7.32	---	9.76	3.90	58.57
250,000	W	07004	238.10	14.08	---	18.77	7.51	112.63
290,000	B	01746	276.19	16.33	---	21.77	8.71	130.65

TABLE 2.26

NATURAL GAS--Continued

				Emission Rates in lb/yr				
Btu	Type	Bldg. No.	ft^3	Particulate	SO_x (as SO_2)	CO	TOG (as CH_4)	NO_x (as NO_2)
260,000	W	08312	247.61	14.64	---	19.52	7.81	117.13
70,000	W	09341	66.67	3.94	---	5.26	2.10	31.54
270,000	W	09351	257.14	15.20	---	20.27	8.11	121.64
500,000	W	11008	476.19	28.16	---	37.54	15.02	225.26
35,000	Wall heater	11146	33.33	1.97	---	2.63	1.05	15.77
465,000	Unit heater	11154	442.86	26.19	---	34.93	13.97	209.49
160,000	W	11441	152.39	9.01	---	12.01	4.81	72.09
160,000	W	12205	152.39	9.01	---	12.01	4.81	72.09
160,000	W	12406	152.39	9.01	---	12.01	4.81	72.09
160,000	W	12408	152.39	9.01	---	12.01	4.81	72.09
3,000,000	Combo unit on roof	13700	2857.14	168.94	---	225.26	90.10	1351.54
250,000	W	13512	238.10	14.08	---	18.77	7.51	112.63
250,000	F	09216	238.10	14.08	---	18.77	7.51	112.63
100,000	S	01203	95.24	5.63	---	7.51	3.00	45.05
250,000	F	01705	238.10	14.08	---	18.77	7.51	112.63
290,000	B	01746	276.19	16.33	---	21.88	8.71	130.65
340,000	S	04415	323.81	19.15	---	25.53	10.21	153.18
500,000	B&F	08110	476.19	28.16	---	37.54	15.02	225.26
500,000	B&F	08220	476.19	28.16	---	37.54	15.02	225.26
500,000	B&F	08221	476.19	28.16	---	37.54	15.02	225.26
250,000	F	08222	238.10	14.08	---	18.77	7.51	112.63
500,000	B&F	08225	476.19	28.16	---	37.54	15.02	225.26
500,000	B&F	08226	476.19	28.16	---	37.54	15.02	225.26
500,000	B&F	08227	476.19	28.16	---	37.59	15.02	225.26
500,000	B&F	08229	476.19	28.16	---	37.54	15.02	225.26
500,000	B&F	08230	476.19	28.16	---	37.54	15.02	225.26
500,000	B&F	09101	476.19	28.16	---	37.54	15.02	225.26
250,000	F	09102	238.10	14.08	---	18.77	7.51	112.63
500,000	B&F	09103	476.19	28.16	---	37.54	15.02	225.26
500,000	B&F	09106	476.19	28.16	---	37.54	15.02	225.26
250,000	F	09107	238.10	14.08	---	18.77	7.51	112.63
500,000	B&F	09108	476.19	28.16	---	37.54	15.02	225.26

TABLE 2.26

NATURAL GAS--Continued

Btu	Type	Bldg. No.	ft^3	Emission Rates in lb/yr: Particulate	SO_x (as SO_2)	CO	TOG (as CH_4)	NO_x (as NO_2)
325,000	S	09327	309.52	18.30	---	24.40	9.76	146.42
250,000	F	10396	276.19	16.33	---	21.77	8.71	130.65
500,000	F	11219	476.19	28.16	---	37.54	15.02	225.26
330,000	B&F	11443	314.29	18.58	---	24.78	9.91	148.67
160,000	F	12206	152.38	9.01	---	12.01	4.81	72.08
160,000	F	12207	152.38	9.01	---	12.01	4.81	72.08
160,000	F	12306	152.38	9.01	---	12.01	4.81	72.08
160,000	F	12307	152.38	9.01	---	12.01	4.81	72.08
160,000	F	13313	152.38	9.01	---	12.01	4.81	72.08
160,000	F	12314	152.38	9.01	---	12.01	4.81	72.08
160,000	F	12409	152.38	9.01	---	12.01	4.81	72.08
160,000	F	12901	152.38	9.01	---	12.01	4.81	72.08
160,000	F	12903	152.38	9.01	---	12.01	4.81	72.08
160,000	F	12905	152.38	9.01	---	12.01	4.81	72.08
160,000	F	12907	152.38	9.01	---	12.01	4.81	72.08
160,000	F	12911	152.38	9.01	---	12.01	4.81	72.08
160,000	F	12913	152.38	9.01	---	12.01	4.81	72.08
160,000	F	12915	152.38	9.01	---	12.01	4.81	72.08
500,000	B&F	13420	476.19	28.16	---	37.54	15.02	225.26
500,000	B&F	13421	476.19	28.16	---	37.54	15.02	225.26
500,000	B&F	13423	476.19	28.16	---	37.54	15.02	225.26
500,000	B&F	13424	476.19	28.16	---	37.54	15.02	225.26
250,000	F	13511	238.10	14.08	---	18.77	7.51	112.63
164,000	F	13851	156.19	9.24	---	12.31	4.93	73.88
164,000	F	13852	156.19	9.24	---	12.31	4.93	73.88
164,000	F	13853	156.19	9.24	---	12.31	4.93	73.88
164,000	F	13854	156.19	9.24	---	12.31	4.93	73.88
164,000	F	13855	156.19	9.24	---	12.31	4.93	73.88
164,000	F	13856	156.19	9.24	---	12.31	4.93	73.88
164,000	F	13857	156.19	9.24	---	12.31	4.93	73.88
164,000	F	13858	156.19	9.24	---	12.31	4.93	73.88
164,000	F	13859	156.19	9.24	---	12.31	4.93	73.88
164,000	F	13860	156.19	9.24	---	12.31	4.93	73.88

TABLE 2.26

NATURAL GAS--Continued

				Emission Rates in lb/yr				
Btu	Type	Bldg. No.	ft^3	Particulate	SO_x (as SO_2)	CO	TOG (as CH_4)	NO_x (as NO_2)
164,000	F	13861	156.19	9.24	---	12.31	4.93	73.88
164,000	F	13862	156.19	9.24	---	12.31	4.93	73.88
164,000	F	13863	156.19	9.24	---	12.31	4.93	73.88
164,000	F	13864	156.19	9.24	---	12.31	4.93	73.88
164,000	F	13865	156.19	9.24	---	12.31	4.93	73.88
164,000	F	13866	156.19	9.24	---	12.31	4.93	73.88
500,000	F	16104	476.19	28.16	---	37.54	15.02	225.26
250,000	F	16133	238.10	14.08	---	18.77	7.51	112.63
265,000	S	16153	252.38	14.92	---	19.90	7.96	119.39
60,000	F	16154	57.14	3.38	---	4.50	1.80	27.03
300,000	S	16162	285.71	16.89	---	22.53	9.01	135.15
250,000	F	16164	238.10	14.08	---	18.77	7.51	112.63
250,000	F	16191	238.10	14.08	---	18.77	7.51	112.63
300,000	B/H	6527	285.20	16.89	---	22.53	9.01	135.15
250,000	B/H	6816	238.10	14.08	---	18.77	7.51	112.63
580,000	B/H	6817	552.39	32.66	---	43.55	17.42	261.30
300,000	B/H	07422	285.71	16.89	---	22.53	9.01	135.15
375,000	S	09310	357.14	21.12	---	28.16	11.26	168.94
1,410,000	S	11352	1342.86	79.40	---	105.87	42.35	635.23
1,000,000	B/H	11433	952.38	56.31	---	4.44	30.03	450.51
349,000	B/H	11477	327.62	19.37	---	1.53	10.33	154.98
168,000	B/H	11559	160.00	9.46	---	0.75	0.30	75.69
240,000	F	12209	228.57	13.52	---	18.03	7.21	108.12
240,000	F	12210	228.57	13.52	---	18.03	7.21	108.12
240,000	F	12309	228.57	13.52	---	18.03	7.21	108.12
240,000	F	12310	228.57	13.52	---	18.03	7.21	108.12
250,000	B&F	14019	238.10	14.08	---	18.77	7.51	112.63
250,000	Hot H_2O & WAF	14026	238.10	14.08	---	18.77	7.51	112.63
500,000	B/H	11433	476.19	28.16	---	37.54	15.02	225.26
870,000	B/H	01735	828.57	48.99	---	65.32	26.13	391.95
1,712,500	B&F	01783	1630.45	96.44	---	128.58	51.43	771.50
540,000	B/H	06420	514.29	30.41	---	40.55	16.22	243.28
443,000	W&EU	06436	421.90	24.95	---	33.26	13.31	199.58

TABLE 2.26

NATURAL GAS--Continued

				Emission Rates in lb/yr				
Btu	Type	Bldg. No.	ft^3	Particulate	SO_x (as SO_2)	CO	TOG (as CH_4)	NO_x (as NO_2)
960,000	B/H	06440	914.29	54.06	---	72.08	28.83	432.50
1,275,000	B/H	06510	1214.29	71.80	---	95.73	38.29	574.41
400,000	B/H	06710	380.95	22.53	---	30.03	12.01	180.20
633,300	S&EU	08425	603.14	35.66	---	47.55	19.02	285.31
860,000	B/H	09307	819.05	48.43	---	64.57	25.83	387.44
2,675,000	B/H	10145	2547.62	150.64	---	200.85	80.34	1205.13
600,000	B/H	10503	571.43	33.79	---	45.05	18.02	270.31
1,050,000	B&F	10525	1000.00	59.13	---	78.84	31.54	473.04
705,000	F	13007	671.43	39.70	---	52.94	21.17	317.61
1,750,000	B	16200	1666.67	98.55	---	131.40	52.56	788.40
85,000	Heat sys.	01707	80.95	4.79	---	6.38	2.55	38.29
235,000	F	10501	223.81	13.23	---	17.65	7.06	105.87
250,000	F	10600	238.10	14.08	---	18.77	7.51	112.63
160,000	F	12313	152.38	9.01	---	12.01	4.81	72.08
160,000	F	12407	152.38	9.01	---	12.01	4.81	72.08
1,258,000	B&SH	01728	1198.10	70.84	---	94.46	37.78	566.75
750,000	B/H	01731	714.29	42.42	---	56.31	22.53	337.84
1,200,000	B/H	01743	1142.86	67.58	---	90.10	36.04	540.62
950,000	B/H	01795	904.76	53.50	---	71.33	28.53	427.99
2,400,000	S	06525	2285.71	135.15	---	180.21	72.08	1081.23
780,000	B/H	07403	742.86	43.93	---	58.57	23.43	351.40
2,420,000	S	07420	2304.76	136.28	---	181.71	72.68	1090.24
750,000	B/H	07501	714.29	42.24	---	56.31	22.53	337.84
634,000	B/H	08004	603.81	39.25	---	52.33	19.04	285.63
634,000	B/H	08005	603.81	39.25	---	52.33	19.04	285.63
250,000	B/H	08006	238.10	14.08	---	18.77	7.51	112.63
634,000	B/H	08007	603.81	39.25	---	52.33	19.04	285.63
500,000	B/H	08008	476.19	28.16	---	37.54	15.02	225.26
384,000	B/H	08009	365.71	21.62	---	28.83	11.53	173.00
500,000	B/H	08010	476.19	28.16	---	37.54	15.02	225.26
250,000	B/H	08110	238.10	14.08	---	18.77	7.51	112.63
1,346,000	F	08150	1281.90	75.80	---	101.05	40.43	606.39
1,086,000	B/H	08305	1034.29	61.16	---	81.54	32.62	489.26

TABLE 2.26

NATURAL GAS--Continued

				Emission Rates in lb/yr				
Btu	Type	Bldg. No.	ft^3	Particulate	SO_x (as SO_2)	CO	TOG (as CH_4)	NO_x (as NO_2)
3,350,000	S	08317	3190.40	188.65	---	251.53	100.61	1509.19
1,750,000	B/H	08339	1666.67	98.55	---	131.40	52.56	788.40
1,750,000	B/H	08415	1666.67	98.55	---	131.40	52.56	788.40
2,050,150	S	09325	1952.52	115.45	---	153.94	61.57	923.62
480,000	B/H	09334	457.14	27.02	---	36.04	14.42	216.25
400,000	B&S	09360	1333.33	78.84	---	105.12	42.05	630.72
920,000	F	10122	876.19	51.81	---	69.08	27.63	414.47
710,000	F	10366	676.19	39.98	---	53.31	21.32	319.86
2,400,000	F	10726	2285.91	135.15	---	180.21	72.08	1081.23
950,000	B/H	11013	904.76	53.50	---	71.33	28.53	427.99
25,000	S	11248	23.81	1.41	---	1.88	0.75	11.26
250,000	B/H	13002	238.10	14.08	---	18.77	7.51	112.63
250,000	B/H	13004	238.10	14.08	---	18.77	7.51	112.63
550,000	B/H	13009	523.81	30.97	---	41.30	16.52	247.78
250,000	B/H	13011	238.10	14.08	---	18.77	7.51	112.63
500,000	B/HG	13012	476.19	28.16	---	37.54	15.02	225.26
250,000	B/H	13013	238.10	14.08	---	18.77	7.51	112.63
250,000	B/H	13014	238.10	14.08	---	18.77	7.51	112.63
500,000	B/H	13015	476.19	28.16	---	37.54	15.02	225.26
2,500,000	B/steam	13607	2380.95	140.78	---	187.71	75.08	1126.28
2,310,000	B/F	16158	2200.00	130.09	---	173.45	69.38	1040.69
2,000,000	B/H	07011	1904.76	112.63	---	150.17	60.07	901.03
400,000	B/H	09113	380.95	22.53	---	30.03	12.01	180.20
750,000	F	09345	714.29	42.24	---	56.31	22.53	337.84
175,000	B/H	13320	166.67	9.86	---	13.14	5.26	78.84
175,000	B/H	13322	166.67	9.86	---	13.14	5.26	78.84
250,000	F	13513	238.10	14.08	---	18.77	7.51	112.63
825,000	B/H	01737	785.71	46.46	---	61.95	24.78	371.67
5,805,000	B/H	08310	5528.57	326.90	---	435.87	174.35	2615.23
5,500,000	B/H	06523	5238.10	309.73	---	412.97	165.19	2477.83
2,250,000	B/H	06601	2142.86	126.71	---	168.44	67.58	1013.66
4,200,000	B/H	07425	4000.00	236.52	---	315.36	126.14	1892.16
3,120,000	B/H	08314	2971.43	175.70	---	234.27	93.71	1405.61

TABLE 2. 26

NATURAL GAS--Continued

				Emission Rates in lb/yr				
Btu	Type	Bldg. No.	ft^3	Particulate	SO_x (as SO_2)	CO	TOG (as CH_4)	NO_x (as NO_2)
1,050,000	B/H	08337	1000.00	59.13	---	78.84	31.54	473.04
8,500,000	B/steam	08430	8095.24	478.67	---	638.23	255.29	3829.37
3,000,000	B/H	08500	2857.14	168.94	---	225.26	90.10	1351.54
8,500,000	B/H	08505	8095.24	478.67	---	638.23	255.29	3829.37
2,725,000	B/H	09005	2595.24	153.46	---	204.61	81.84	1227.65
4,407,000	B/steam	09113	4197.14	248.18	---	330.09	132.36	1985.42
4,085,000	B/H	09340	3890.48	230.04	---	306.73	122.69	1840.35
525,000	B/F	10343	500.00	29.57	---	39.42	15.77	236.52
4,185,000	B/steam	11439	3985.71	235.68	---	314.23	125.79	1885.40
1,855,000	B/H	11777	1766.67	104.46	---	139.28	55.71	835.71
4,341,250	B/H	13330	4134.52	244.47	---	325.97	130.39	1955.79
1,750,000	B/H	13321	1666.67	98.55	---	131.40	52.56	788.40
1,750,000	B/H	13323	1666.67	98.55	---	131.40	52.56	788.40
1,750,000	B/H	13121	1666.67	98.55	---	131.40	52.56	788.40
1,750,000	B/H	13123	1666.67	98.55	---	131.40	52.56	788.40
5,830,000	B/steam	07233	5552.38	328.31	---	437.75	176.10	2626.50
1,050,000	B/steam	11012	1000.00	59.13	---	78.84	31.54	473.04
675,000	B/H	00390	642.86	38.01	---	50.68	20.27	304.10
351,000	B/H	00864	334.29	19.77	---	26.36	10.54	158.13
1,622,000	B/H	07437	1544.76	91.34	---	121.79	48.72	730.73
3,074,000	B/H	13138	1975.24	116.80	---	155.73	62.29	934.37
2,592,000	B/H	13140	2468.57	145.97	---	194.62	77.84	1167.73
1,500,000	B/H	13750	1428.57	84.47	---	112.63	45.05	675.77
8,240,400	B/H	13120	7848.00	464.05	---	618.74	247.49	3712.42
8,530,000	B/H	07000	8123.81	480.36	---	640.48	256.19	3842.89
3,750,000	B/H	10577	3571.43	211.18	---	281.57	112.63	1689.43
6,270,000	B/H	07525	5971.43	353.09	---	470.79	188.32	2824.73
5,750,000	B/H	08401	5476.19	323.81	---	431.74	172.70	2590.46
1,682,000	B/H	08510	1601.90	94.72	---	126.29	50.52	757.76
9,350,000	B/H	09320	8904.76	526.54	---	702.05	280.82	4212.31
5,670,000	B/H	10252	5400.00	319.30	---	425.74	170.29	2554.42
4,670,000	B/H	11070	4447.62	262.99	---	350.65	140.26	2103.90

TABLE 2. 26

NATURAL GAS--Continued

				Emission Rates in lb/yr				
Btu	Type	Bldg. No.	ft^3	Particu-late	SO_x (as SO_2)	CO	TOG (as CH_4)	NO_x (as NO_2)
250,000	F	08119	238.10	14.08	---	18.77	7.51	112.63
23,500	F	08140	22.38	1.32	---	1.76	0.71	10.59
250,000	F	08140	238.10	14.08	---	18.77	7.51	112.63
60,000	S	08204	57.14	3.38	---	4.50	1.80	27.03
235,000	F	08216	223.81	13.23	---	17.65	7.06	105.87
235,000	F	08217	223.81	13.23	---	17.65	7.06	105.87
250,000	F	08224	238.10	14.08	---	18.77	7.51	112.63
125,000	F	09001	119.05	7.04	---	9.39	3.75	56.32
400,000	F	09003	380.95	22.53	---	30.03	12.01	180.20
250,000	F	09104	238.10	14.08	---	18.77	7.51	112.63
250,000	F	09105	238.10	14.08	---	18.77	7.51	112.63
250,000	F	09109	238.10	14.08	---	18.77	7.51	112.63
250,000	F	09116	238.10	14.08	---	18.77	7.51	112.63
250,000	F	09117	238.10	14.08	---	18.77	7.51	112.63
130,000	S	09350	123.81	7.32	---	9.76	3.90	58.57
250,000	F	10003	238.10	14.08	---	18.77	7.51	112.63
250,000	F	10004	238.10	14.08	---	18.77	7.51	112.63
250,000	F	10005	238.10	14.08	---	18.77	7.51	112.63
90,000	S	10312	85.21	5.07	---	6.76	2.70	40.54
30,000	S	10314	28.57	1.69	---	2.25	0.90	13.51
200,000	F	10317	190.48	11.26	---	15.02	6.01	90.10
500,000	F	10363	476.19	28.16	---	37.54	15.02	225.26
180,000	F	10364	171.43	10.14	---	13.52	5.41	81.09
250,000	F	10373	238.10	14.08	---	18.77	7.51	112.63
375,000	F	10375	357.14	21.12	---	28.16	11.26	168.94
105,000	F	10702	100.00	5.91	---	7.88	3.15	47.30
125,000	F	10704	119.05	7.04	---	9.39	3.75	56.32

TABLE 2.27

NO. 2 FUEL OIL

				Emission Rates in lb/yr					
Btu	Type	Bldg. No.	Gal.	Particulate	SO_2	SO_3	CO	TOG (as CH_4)	NO_x (as NO_2)
484,000	B/H	01930	3.46	34.10	968.39	13.64	68.20	13.64	245.51
750,000	S	16195	5.36	52.82	1500.19	21.13	105.65	21.13	380.32
800,000	B/H	21150	5.71	56.27	1598.13	22.51	112.54	22.51	405.16
990,000	B/H	21155	7.07	69.67	1978.77	27.87	139.35	27.87	501.66
1,170,000	B/H	00075	8.36	82.39	2339.81	32.96	164.78	32.96	593.19
1,590,000	B/H	00475	11.36	111.95	3179.46	44.78	223.91	44.78	806.06
3,875,000	B/H	00488	27.68	272.79	7747.13	109.11	545.57	109.11	1964.06
1,800,000	B/H	00852	12.86	126.74	3599.28	50.69	253.47	50.69	912.49
1,330,000	B/H	00875	9.50	93.62	2658.88	37.45	187.25	37.45	674.08
652,000	B/H	01545	4.66	45.92	1304.25	18.37	91.85	18.37	330.65
938,000	B/H	00731	6.70	66.03	1875.21	26.41	132.06	26.41	475.41
1,700,000	B/H	00870	12.14	119.64	3397.77	47.86	239.28	47.86	861.41
995,000	B/H	00871	7.11	70.07	1989.96	28.03	140.14	28.03	504.50
1,620,000	B/H	00960	11.56	113.92	3235.44	45.57	227.85	45.57	820.25
1,620,000	B/H	00980	11.56	113.92	3235.44	45.57	227.85	45.57	820.56
2,050,000	B/H	01546	14.64	144.28	4097.47	57.71	288.55	57.71	1038.79
1,730,000	B/H	01555	12.36	121.81	3459.34	48.72	243.62	48.72	877.02
12,568,000	B/steam	01856	89.77	884.68	25125.01	353.87	1769.37	353.87	6369.72
327,000	B/H	23201	2.34	23.06	654.92	9.22	46.12	9.22	166.04
525,000	B/H	01610	3.75	36.96	1049.56	14.78	73.91	14.78	286.09
140,000	F	0174	1.00	9.86	279.88	3.94	19.71	3.94	70.96
324,000	B/H	01978	2.31	22.77	646.53	9.11	45.53	9.11	163.91
8,728,000	B/H	0836	62.34	614.36	17453.44	245.74	1228.72	245.74	4423.40
170,000	F	00840	1.21	11.92	338.66	4.77	23.85	4.77	85.86
7,500	S	01028	0.05	0.49	13.99	0.20	0.99	0.20	3.55
100,000	F	00421	0.71	7.00	198.72	2.80	13.99	2.80	50.38
250,000	F	01970	1.79	17.64	500.99	7.06	35.28	7.06	127.01
130,000	S	01989	0.93	9.16	260.29	3.67	18.33	3.67	65.99
227,000	B	22112	1.62	15.96	453.41	6.39	31.93	6.39	114.95
227,000	B	23205	1.62	15.96	453.41	6.39	31.93	6.39	114.95
15,000	F	21101	0.11	1.08	30.79	0.43	2.17	0.43	7.81
125,000	F	21160	0.89	8.77	249.09	3.51	17.54	3.51	63.15

TABLE 2.27

NO. 2 FUEL OIL--Continued

Btu	Type	Bldg. No.	Gal.	Emission Rates in lb/yr: Particulate	SO_2	SO_3	CO	TOG (as CH_4)	NO_x (as NO_2)
105,000	F	22107	0.75	7.39	209.91	2.96	14.78	2.96	53.22
250,000	F	01052	1.79	17.64	500.99	7.06	35.28	7.06	127.01
250,000	F	01521	1.79	17.64	500.99	7.06	35.28	7.06	127.01
80,000	F	02501	0.57	5.62	159.53	2.25	11.23	2.25	40.44
405,000	B	00490	2.89	28.48	808.86	11.39	56.96	11.39	205.06
563,000	B	00535	4.02	39.62	1125.13	15.85	79.23	15.85	285.24
426,000	B	00660	3.04	29.96	850.84	11.98	59.92	11.98	215.71
1,577,200	HE	00738	11.27	111.07	3154.27	44.43	222.13	44.43	799.67
28,3000	B	00762	2.02	19.91	565.36	7.96	39.81	7.96	143.33
497,000	F	00765	3.55	34.98	993.58	13.99	69.97	13.99	251.89
303,000	F	00831	2.16	21.29	604.55	8.51	42.57	8.51	153.26
100,000	S	00853	0.71	6.70	198.72	2.80	13.99	2.80	50.38
250,000	F	01577	1.79	17.64	500.99	7.06	35.28	7.06	127.01
168,000	F	01579	1.20	11.83	335.86	4.73	233.17	4.73	85.15
576,000	B/SH	01610	4.11	40.50	1150.32	16.20	81.01	16.20	291.63
411,000	Air HD unit sys.	01850	2.94	28.97	822.85	11.59	228.44	11.59	208.61
380,000	Air HD unit & sys	01853	2.71	26.71	758.48	10.68	53.41	10.68	192.29
70 KW	SH & Gen	01865	---	---	---	---	---	---	---
805 KW	SH & Gen	01781	---	---	---	---	---	---	---
797,000	B	01905	1.41	13.80	394.63	5.56	27.79	5.56	100.05
227,000	B/H	23100	1.62	15.97	453.41	6.39	31.93	6.39	114.95
350,000	F	23228	2.50	24.64	699.71	9.85	49.28	9.86	177.39
8 KW	Hot H_2O & SH	23229	---	---	---	---	---	---	---
306,000	S & SH	00529	2.19	21.58	612.94	8.63	43.16	8.63	155.39
1,413,000	B/H	00715	10.09	99.44	2824.01	39.77	198.87	39.77	715.95
375,000	W & SH	00866	2.68	26.41	750.08	10.56	52.82	10.56	190.16
776,000	Hot H_2O & SH	00988	5.54	54.60	1550.55	21.84	109.19	21.84	393.10
1,000,000	B/H	01559	7.14	70.36	1998.36	28.15	140.73	28.15	506.63
820,000	W & Elec. Units	01628	5.80	57.16	1623.32	22.86	114.32	22.86	411.54
495,000	B/H	01740	3.54	34.89	990.78	13.95	69.77	13.95	251.14

TABLE 2.27

NO. 2 FUEL OIL--Continued

				Emission Rates in lb/yr					
Btu	Type	Bldg. No.	Gal.	Particu-late	SO_2	SO_3	CO	TOG (as CH_4)	NO_x (as NO_2)
200,000	F	01749	1.43	14.09	400.23	5.64	28.19	5.64	101.47
830,700	B	01801	5.93	58.44	1659.70	23.38	116.88	23.38	420.77
515,000	B & Elec. Units	21180	3.68	36.27	1029.97	14.51	72.53	14.51	261.12
145,000	B&F	23206	1.04	10.25	291.08	4.10	20.50	4.10	73.79
681,000	B & Elec Units	23235	4.86	47.90	1360.23	19.16	95.79	19.16	344.85
396,000	B/H	000175	2.83	27.89	792.07	11.16	55.78	11.16	200.81
396,000	B/H	00725	2.83	27.89	792.07	11.16	55.78	11.16	200.81
810,000	B/H	00761	5.79	57.06	1620.52	22.82	114.12	22.82	410.84
585,000	B/H	00839	4.18	41.19	1169.91	16.48	82.39	16.48	296.60
1,192,800	B/H	00840	8.52	83.96	2384.59	33.59	167.93	33.59	604.55
788,000	Hot H_2O & S	00861	5.63	55.48	1575.74	22.19	110.97	22.19	399.48
902,000	B/W	01544	6.44	63.47	1802.44	25.39	126.93	25.39	456.96

Following is a sample calculation demonstrating the procedure for a boiler in Building 13861 burning natural gas.

Fuel input: $\dfrac{(164{,}000 \text{ Btu/hr})}{1{,}050 \text{ Btu/ft}^3} = 156.19 \text{ ft}^3\text{/hr}$

Annual consumption: $(156.19 \text{ ft}^3\text{/hr})\ (8{,}760 \text{ hr/yr})\ (0.45)$
$= 615.7 \times 10^3 \text{ ft}^3\text{/yr}$

Based on this value, emissions are estimated.

2.4.18 Natural Gas Usage and Associated Emissions for Housing Space Heating - 1981

The following procedures were employed to calculate emissions from natural gas usage.

Fiscal Year 1981 - 1,912,270 therms (increments 1-5)

Assume fiscal year is representative of calendar year.

$1{,}912{,}270 \text{ therms} \times \dfrac{100{,}000 \text{ Btu}}{\text{therm}} \times \dfrac{\text{ft}^3 \text{ (natural gas)}}{1050 \text{ Btu}} = 182.12 \times 10^6 \text{ ft}^3$ consumption

Reference: U.S. EPA AP-42, Table 1.4-1.

Emission Rates

Particulate: $15 \text{ lb}/10^6 \text{ ft}^3$ (large value for domestic heating)
$\times\ 182.12 \times 10^6 \text{ ft}^6 = 2{,}732 \text{ lb/yr} = 1.4$

SO_x: $0.6 \text{ lb}/10^6 \text{ ft}^3 \times 182.12 \times 10^6 \text{ ft}^3 = 109 \text{ lb/yr}$

CO : $20 \text{ lb}/10^6 \text{ ft}^3 \times 182.12 \times 10^6 \text{ ft}^3 = 3642 \text{ lb/yr} = 1.8 \text{ t/yr}$

TOG: $8 \text{ lb}/10^6 \text{ ft}^3 \times 182.12 \times 10^6 \text{ ft}^3 = 1457.0 \text{ lb/yr}$

NO_x: $80 \text{ lb}/10^6 \text{ ft}^3 \times 182.12 \times 10^6 \text{ ft}^3 = 14570 \text{ lb/yr} = 7.3 \text{ t/yr}$
(recommended value for domestic units)

Allocation - Assume equivalent housing density for increments 1-5. Therefore emission allocations are proportioned by housing area acreage.

2.4.19 Fire-Fighting Training Emissions

Contact: Sgt. Doyle

Activity Level

Use JP-4 and diesel to practice aircraft fire fighting. Consumption rates are:

13,951 gallons JP-4 burned in 1981
7,641 gallons diesel burned in 1981

Training takes place at a location 50 yards west of Building 1500.

Emission Factor Development

Attempts were made to identify emission factors specific to the open burning of JP-4 and diesel. None were found in U.S. EPA publications AP-40 and AP-42. Staff then contacted sources at Ventura County Air Pollution Control District, California Air Resources Board (Russ Tate and Chuck Larson) and U.S. EPA (Jim Southerland). Results of these conversations were negative.

In light of this development, Engineering-Science proposes to use AP-42 emission factors for open burning of automobile components (Table 2.4-1). When compared to corresponding emission factors for external combustion of fuel oils, the open burning factors are significantly lower in NO_x and much higher in CO and hydrocarbons. This compares favorably with impressions held by both ES and CARB staff.

Emission Estimation

To utilize automobile component emission factor data, the reported volumes must be converted. Conversions are based on product densities of 6.4 lb/gal for JP-4 and 7.0 lb/gal for jet kerosene (diesel).

$$\frac{(6.4\ \text{lb/gal})\ (13{,}951\ \text{gal/yr})}{(2{,}000\ \text{lb/ton})} = 44.64 \text{ ton of JP-4 during 1981}$$

$$\frac{(7.0\ \text{lb/gal})\ (7{,}641\ \text{gal/yr})}{(2{,}000\ \text{lb/ton})} = 26.74 \text{ ton of diesel during 1981}$$

Emissions are presented in Table 2.28.

TABLE 2.28

EMISSIONS FROM FIRE FIGHTING TRAINING

Pollutant	Emission Factor (lb/ton)	JP-4 (ton/yr) (44.64 ton)	Diesel (ton/yr) (26.74 ton)	Total
Particulates	100	2.2	1.3	3.5
Sulfur Oxides	Neg.	---	---	---
Carbon Monoxide	125	2.8	1.7	4.5
Organics (CH_4)	30	0.7	0.4	1.1
Nitrogen Oxides	4	0.1	0.1	0.2

Neg. = Negligible

2.4.20 Emissions From Missile Launches During 1981

Contact: Major Morford

1981 Vandenberg missile launch activities were supplied by base personnel. Emission factors used were a proration of data taken from a May 1981 Tetra Tech report. That reference table is presented as Figure 2.7. The results are summarized in Table 2.29. Allocation of emissions to grid squares was based on actual launch location.

2.4.21 MX Construction Emissions - 1981

Contact: Mr. Yingtz

Primary Assumptions:

1) Fugitive dust occurs primarily during excavation.

2) Excavation activities take place during the first 20% of the project duration.

3) Water applications (twice daily) will result in a 50% reduction in dusting.

4) A fugitive dust emission factor of 0.6 tons/acre/month used by SCAQMD is applicable to the Vandenberg area. This takes into account the 50% control from water applications.

5) Emulsified asphalt is used for asphalt pavement and therefore TOG emissions are considered negligible.

References: U.S. EPA AP-42, pp. 11.2.4-1, Table 4.5-1.

Notes: 1) No exterior painting in 1981.
2) Water-based (latex) paint used on interior.
3) MAB, STF, and MMF buildings - interior entirely painted.
4) ICF building - interior of high bay painted.
5) All office interiors painted.

1. Rail Transfer Facility (RTF)

a. Fugitive Dust

Seven acres disturbed. Project duration 8 months; 1.6 months excavation duration.

FIGURE 2-7

TABLE 5. EMISSIONS INVENTORY FOR MISSILES LAUNCHED FROM VANDENBERG AFB--1976

MISSILE TYPE	EMISSIONS (tons/yr)[a]			
	Carbon Monoxide[b] (CO)	Oxides of Nitrogen (NO_x)	Particulates[c] (TSP)	Hydrogen Chloride (HCl)
Atlas F, 1 launches[1]	11.1	0	0	0
Bomarc, 6 launch[2]	0.7	0	0	0
Minuteman I, 3 launches[2]	8.3	0.2	9.0	6.0
Minuteman II, 8 launches[3]	10.2	0	12.8	9.0
Minuteman III, 11 launches[4]	16.1	0	20.3	14.4
Scout, 2 launches[1]	0.7	0	3.0	0.4
Thor, 4 launches[2]	37.6	0	0	0
Titan II, 1 launch[2]	0.8	0.6	0	0
Titan III B, 5 launches[1]	4.2	3.2	0	0
Titan III D, 3 launches[1]	83.4	1.8	90.0	60.0
TOTAL, 44 launches	173.1	5.8	135.1	89.8

[a] Estimated quantities released below 5,000 ft altitude.

[b] Exhaust CO is not detectable in significant quantities because of effects of afterburning on conversion of CO to CO_2.

[c] Particulates are released as aluminum oxide (Al_2O_3)

References: 1. U.S. Air Force, 1975. (48)
2. Science Application, 1974. (43)
3. U.S. Air Force, 1973. (49)

TABLE 2.29

EMISSIONS FROM MISSILE LAUNCHES DURING 1981

Missile Type	Emission Factors[1] (ton/launch)				No. of Launches in 1981	Emissions (ton/yr)			
	CO	NO_x	TSP	HCl		CO	NO_x	TSP	HCl
Atlas F	11.1	---	---	---	1	11.1	---	---	---
Bomarc	0.12	---	---	---	0	0	---	---	---
Minuteman I	2.77	0.07	3.0	2.0	5	13.85	0.35	15.0	10.0
Minuteman II	1.28	---	1.6	1.13	0	0	---	---	---
Minuteman III	1.46	---	1.85	1.31	8	11.68	---	14.8	10.48
Scout	0.35	---	1.5	0.2	1	0.35	---	1.5	0.2
Thor/Delta	9.4	---	---	---	2	18.8	---	---	---
Titan II	0.8	0.6	---	---	0	0	---	---	---
Titan III B	0.84	0.64	---	---	2	1.68	1.28	---	---
Titan III D	27.8	0.6	30.0	20.0	1	27.8	0.6	30.0	20.0
Atlas E[2]	11.1	---	---	---	1	11.1	---	---	---
TOTAL					22	96.36	2.23	61.3	40.68

1) Taken from Table 2-4, "Emissions Inventory for Missiles Launches from Vandenberg Air Force Base - 1976," Air Quality Impact Analysis for MX Test Facilities at Vandenberg Air Force Base, TetraTech, May 1981 (attached).

2) Assume same as Atlas F.

Emission Factor = 0.6 tons/acre/month

0.6 tons/acre/mo. x 7 acres x 1.6 mo. = 6.7 tons particulate

2. Roads and Utilities

Twenty-one month construction duration beginning September 1980.

Overlay existing roads, approximately 44,400 ft.

New roads approximately 19,400 ft.

Assume: 1) 50 ft width disturbed during road construction.

2) 80% of construction duration allocated to road grating, excavation (i.e. 12 months for 1981).

New roads: 19,400 ft x 50 ft wide = $\frac{970,000 \text{ ft}^2}{43,560 \text{ ft}^2\text{/acre}}$ = 22.3 acres

0.6 tons/acre/mo. x 22.3 acres x 12 mo. = 161.0 tons particulate

3. ITF Integrated Test Facility

a. Fugitive Dust

21-1/2 months construction duration.

20% grading and excavation = 4.3 months.

Construction start March 19, 1980 - 20% allocation for excavation completed prior to 1981. Therefore, dust emissions for 1981 are insignificant.

b. VOC Emissions (assume to be TOG)

99,000 ft^2 total building (2 levels) or 49,500 ft^2 roof.

Roofing - Assume 1/4 inch thick = 0.021 feet thick asphalt.
Assume all roofing done in 1981.

Use AP-42 Table 4.5-1. Assume medium cure cutback asphalt: emission factor = $\frac{0.2 \text{ lb VOC}}{\text{lb asphalt}}$

AP-42 Table A-4, asphalt density = 8.57 lb/gal x 7.48 gal/ft^3

= 64.1 lb/ft^3

$\frac{0.2 \text{ lb VOC}}{\text{lb asphalt}} \times \frac{45,000 \text{ ft}^2 \times 0.021 \text{ ft depth}}{\text{year}} \times 64.1 \text{ lb/ft}^3 \text{ asphalt}$

= 12,114.9 lb/yr max. or 6.1 t/yr VOC

c. Paint Emissions

Latex paint: 1 gal/600 ft^2 paint coverage

1.3 lb/gal TOG emission factor (SCAQMD emission factor) (water-base paint)

For calculation purposes, the building offices and conference room dimensions are estimated as follows:

1) 7 offices - 19 ft x 27 ft each
2) conference room - 27 ft x 52 ft

Assume typical office room height of 10 ft. Total square footage painted =

[(19 ft x 10 ft) 2 + (27 ft x 10ft)2] 7 + (27 ft x 10 ft)2

+ (52 ft x 10 ft) 2 = 8,020 ft^2

$$8{,}020\ ft^2 \times \frac{1\ gal\ paint}{600\ ft^2} \times 2\ coats = 26.7\ gal\ of\ paint$$

26.7 gal x 1.3 lb TOG/gal = <u>35 lb TOG</u>

4. <u>SPF-B Stage Processing Facility</u>

a. Fugitive Dust

12 month duration (construction) beginning February 12, 1981. 20% excavation = 2.4 months in 1981. 5 acres disturbed. 0.6 t/acre/mo. x 5 acres x 24 mo. = <u>7.2 t/yr. particulates</u>

5. <u>SPF-A Stage Processing Facility</u>

2 acres land disturbed. 10-1/2 month construction duration beginning February 1981.

1.5 mo. x 0.2 = 2.1 mo. for excavation in 1981.

a. Fugitive Dust

0.6 tons/acre/mo. x 2.1 mo. x 2 acres = <u>2.52 t/yr. particulates</u>

b. Paint Emissions SPF - A & B

Latex paint - 1 gal/600 ft^2 paint coverage

1.3 lb/gal (TOG) emission factor (water-based paint)

Office dimensions (approximate for calculations): 26 ft x 14 ft x 10 ft high (typical height)

b. Paint Emissions SPF - A & B (Continued)

Total square footage painted = (26 ft x 10 ft)2 + (14 ft x 10 ft)2
= 800 ft^2

800 ft^2 x 1 gal/600 ft^2 x 1.3 lb TOG/gal x 2 coats = <u>3.5 lb TOG</u>

6. <u>SSF - Stage Storage Facility</u>

10 month construction duration beginning March 1981. 2 month excavation (20% of total duration). 30 acres disturbed.

a. Fugitive Dust

0.6 tons/acre/mo. x 30 acres x 2 mo. = 36 tons/yr

7. <u>ICF - Installation and Check-out Facility</u>

10-1/2 mo. construction duration beginning February 1981. 2.1 mo. excavation (20% of construction duration). 7 acres land disturbed.

a. Fugitive Dust

0.6 tons/acre/mo. x 7 acres x 2.1 mo. = <u>8.8 tons/yr particulate</u>

b. Roofing Asphalt

0.2 lb/lb asphalt x 15,300 ft^3 roofing x 0.021 ft depth

x 8.57 lb/gal asphalt (AP-42 Table A-4) x $\frac{7.48 \text{ gal}}{ft^3}$ asphalt

= <u>4,119 lb or 2.1 tons VOC emissions</u>

c. Paint Emissions

Latex paint - 1 gal/600 ft^2 paint coverage

1.3 lb/gal TOG emission factor

Dimensions (approximated for calculation purposes only):

1) Office - 10 ft x 27 ft x 10 ft high with middle divider wall
2) High bay - 47 ft x 101 ft x 41 ft high

Total square footage painted = (10 ft x 10 ft)4 + (27 ft x 10 ft) 2
+ (47 ft x 41 ft) 2 + (101 ft x
41 ft)2 = <u>13,076 ft^2</u>

13,076 ft^2 x 1 gal/600 ft^2 x $\frac{1.3 \text{ lb TOG}}{\text{gal}}$ x 2 coats = <u>57 lb TOG</u>

8. MAB Missile Building

18-1/2 month construction duration beginning May 1980.

Fugitive dust is considered insignificant for 1981 since the 20% construction period allocation for excavation activities occurred during 1980.

a. Paint Emissions

$59{,}892\ ft^2 \times 143$ ft high.

For calculation purposes assume equal building sides (i.e. 245 ft x 245 ft x 143 ft high).

$$\text{Total square footage painted} = (245\ ft \times 143\ ft)\ 4$$

$$= 140{,}140\ ft^2$$

$$140{,}140\ ft^2 \times 1\ gal/600\ ft^2 \times \frac{1.3\ lb\ TOG}{gal} \times 2\ coats = \underline{607\ lb\ TOG}$$

9. MMF Mechanical Maintenance Facility

17-1/2 month construction beginning June 1980.

Fugitive dust is considered insignificant for 1981 since the 20% construction period allocation for excavation activities occurred during 1980.

a. Paint Emissions

Assuming building volume approximates a rectangular cube.

$28{,}400\ ft^2$ of building, approximate height of rectangular cube = 35 ft.

$$\text{Dimensions} = 169\ ft \times 169\ ft \times 35\ ft\ high\ (28{,}400\ ft^2)$$

$$\text{Total square footage painted} = (169\ ft \times 35\ ft)\ 4 = 23{,}660\ ft^2$$

$$23{,}660\ ft^2 \times 1\ gal/600\ ft^2 \times \frac{1.3\ lb\ TOG}{gal} \times 2\ coats = \underline{103\ lb\ TOG}$$

2.4.22 STS Construction Emissions - 1981

Contact: Mr. Jay Shah and Mr. O'Gorman

For calculation purposes assume roofing is medium cure oil-based asphalt.

Fugitive dust reference: U.S. EPA AP-42, page 11.2.4-1.
Asphalt roofing reference: U.S. EPA AP-42, Tables A-4 and 4.5-1.

Note: The fugitive dust emission rates calculated on subsequent pages are conservative or worst-case estimates. The emission factor used in 1.2 tons/acre/mo. x 50% reduction (from applications of water twice daily) = 0.6 tons/acre/mo.

1. V88 Logistics Support Facilities

a. Fugitive Dust

Area disturbed = approximately 537,920 ft^2.

Three month disturbance duration.

$$0.6 \text{ tons/acre/mo} \times \frac{537{,}920 \text{ ft}^2}{43{,}560 \text{ ft}^2\text{/acre}} \times 3 \text{ mo.} = \underline{37.1 \text{ tons particulate}}$$

2. V21 Hypergolic Maintenance and Check-out Facility

Negligible emissions during 1981.

3. V18 Mate/Demate Facility

a. Fugitive Dust

42,785 ft^2 disturbed for 90 days.

$$0.6 \text{ tons/acre/mo} \times \frac{42{,}785 \text{ ft}^2}{43{,}560 \text{ ft}^2\text{/acre}} \times 3 \text{ mo.} = \underline{1.8 \text{ tons particulate}}$$

4. V19 Orbiter Maintenance and Check-out Facility

Emissions negligible for 1981.

5. <u>Administration Building</u>

Emissions negligible for 1981.

6. <u>V23 Space Lauch Complex 6</u>

a. Fugitive Dust (1981)

<u>Footage and Duration of Land Disturbed</u>

960,000 ft^2 for 2 mo. (22.0 acres)
75,000 ft^2 for 1 mo. (1.7 acres)
280,000 ft^2 for 2 mo. (6.4 acres)
60,000 ft^2 for 0.5 mo. (1.4 acres)
80,000 ft^2 for 0.5 mo. (1.8 acres)

Fugitive Dust = 0.6 tons/acre/mo. x
[(22.0 acres x 2 mo.)
+ (1.7 acres x 1 mo.)
+ (6.4 acres x 2 mo.)
+ (1.4 acres x 0.5 mo.)
+ (1.8 acres x 0.5 mo.)
= <u>36.1 tons particulate</u>

b. *Asphalt Roofing of Launch Control Center*

Assume medium cure oil-based asphalt (or tar) used with a 1/4 inch (0.021 ft) asphalt depth.

Roof footage - 17,500 ft^2

17500 ft^2 x 0.021 ft x 7.48 gal/ft^3 = 49.13 gal asphalt

49.13 gal x 8.57 lb/gal asphalt (AP-42 Table A-4) = 421 lb of asphalt

$\frac{0.2 \text{ lb TOG}}{\text{lb asphalt}}$ (AP-42 Table 4.5-1) x 421 lb asphalt = <u>84 lb TOG</u>

7. <u>V33 External Tank Storage and Marine Landing Facility</u>

a. Fugitive Dust

0.6 tons/acre/mo. x 1.5 acres land disturbed x 2 mo. disturbance duration = <u>1.8 tons particulate</u>

8. Tow Route - V33 to SLC 6

Use emulsified asphalt - negligible TOG emissions.

a. Fugitive Dust

Assume land disturbance width for road is 50 ft. Tow route is 4,300 ft. long.

0.6 tons/acre/mo. x 5 mo. of land disturbance

$$\times \frac{4{,}300 \text{ ft} \times 50 \text{ ft wide}}{43{,}560 \text{ ft}^2/\text{acre}} \text{ land disturbed} = \underline{14.8 \text{ tons particulate}}$$

2.4.23 Emissions From the Union Oil Company Jesus Maria Field

Contact: Zenis Walley, Jr. (805) 937-6376

Activities consist of three production wells with the following designations and pumping rates:

°45-3 produces 43-50 bbl/day (on-line April 1981)
°46-3 produces 20 bbl/day (on-line April 1981)
°36-3 produces 5 bbl/day (on-line Dec. 30, 1981)

Production is primarily by electric engine. Extracted oil is pumped directly to pipe and to tank and then trucked out through the loading rack. One truck load goes out per day.

The high viscosity oil is maintained at elevated temperature to facilitate product movement. Heat is supplied by steam circulating through coils in the storage tank. The steam is produced by a boiler which burns a combination of propane and field gas. Some fire in the boiler is always present.

Emissions from the facility have been estimated in permit submittals to San Barbara County.

Tankage Emissions
(Assume operates 8 months in 1981)

Permit No.	Description	TOG lb/hr	TOG ton/yr
4390	500 bbl diluent tank	0.54	1.77
4392	1000 bbl stock tank	1.68	5.52
4393	2000 bbl wash tank	0.60	1.97

Boiler, assume 24 hours per day continuous 8,760 hrs/yr

NO_x	0.36 lb/hr = 1.58 ton/yr	located in grid 54 x 6
SO_2	0.41 lb/hr = 1.80 ton/yr	
CO	0.05 lb/hr = 0.22 ton/yr	
Part.	0.03 lb/hr = 0.13 ton/yr	

2.4.24 POL Loading Rack Emissions Calculations

Contact: Mr. Ward

The data presented in Table 2.30 were obtained through a combination of conversations with Mr. McBride, Fuel Distribution Systems Worker and operator of the POL loading facility, and review of POL records for 1981.

No vapor balance or other means of vapor control are practiced at any of the loading racks. All top loading activities include submerged fill.

Emission Estimates

Reference: U.S. EPA AP-42, Table 4.4-3

Sample Calculation:

Loading rack #1: Use emission factor of 5 lb/10^3 gal transferred for submerged loading - normal service.

$$\frac{(5 \text{ lb}/10^3 \text{ gal})\ (42.4446 \times 10^3 \text{ gal/yr})}{(2{,}000 \text{ lb/ton})} = 0.11 \text{ ton/yr}$$

Estimates for all loading racks are presented in Table 2.31.

2.4.25 Water Well Degasifiers, Designations 22396, 22397, 22404, 22406

Operation

Base water demands are served primarily by 4 water wells located east of the cantonment area, approximately 4 miles from the main gate. The wells are located on a dirt road with restricted access through a locked gate. The groundwater contains a quantity of hydrogen sulfide

TABLE 2.30

SUMMARY OF POL LOADING RACK PRACTICES

Loading Rack Designation	Method of Loading	Fuel Handled	Tank Service	Throughput (gal/yr)
#1	Bottom	Regular gasoline	1704 #1, #2	42,445*
#3, #5 (combined)	Bottom	JP-4	---	832,106
#4	Bottom	RP-1	---	43,043
#6	Top (submerged)	Diesel	1702, 1703	649,013
#9	top (submerged)	Unleaded gasoline	1701	48,402*

*Assumed value of 10% of monthly fuels inventory, calendar year 1981. Remaining 90% of inventory moved from offbase directly to service stations.

TABLE 2.31

LOADING RACK EMISSION RATES

Loading Rack Designation	1981 Throughput (10^3 gal/yr)	AP-42 Emission Factor (lb/10^3 gal)	1981 Emissions (ton of TOG/yr)
#1	42.444	5	0.11
#3, #5 (combined)	832.106	1.5	0.6
#4	43.043	0.02	Neg.
#6	649.013	0.01	Neg.
#9	48.402	5	0.12

Neg. = Negligible

(H_2S) which must be removed prior to use. The removal is achieved in a unit termed a degasifier, with one associated with each well. The degasifier consists of three beds of plastic saddles (to increase surface area) positioned atop a water collection tank. Well water is pumped into the top of the degasifier and allowed to cascade down through the three beds. During this process the H_2S in the water is released and vented through open screens in the degasifier sides directly to the atmosphere.

Emission Estimation

Normal Base water requirements are 4 million gallons per day (per plant personnel). This demand can be met by the operation of 3 wells with one as a backup. Inlet and outlet water H_2S concentration were measured by the Air Force using a Hach Water Monitoring kit during July 1982. The results of two measurements at different wells were:

Inlet Concentration	Outlet Concentration
2.0 mg/liter	0.0-0.1 mg/liter
0.5 mg/liter	0.0-0.1 mg/liter

Using the average inlet H_2S concentration of 1.25 mg/liter and an outlet concentration of negligible assumes that 1.25 mg of H_2S is emitted to the atmosphere for each liter of water passed through the degasifier.

$$\frac{(4 \times 10^6 \text{ gal/day})\ (3.7854 \text{ liter/gal})\ (1.25 \times 10^{-3} \text{ g/liter})}{(453.6 \text{ g/lb})\ (24 \text{ hr/day})} = 1.74 \text{ lb of } H_2S\text{/hr}$$

Annual emissions would be:

$$(1.74 \text{ lb of } H_2S\text{/hr})\ (8{,}760 \text{ hr/yr}) = 15{,}242 \text{ lb of } H_2S\text{/yr}$$

2.5 PERMIT APPLICATIONS

For those sources identified in Table 2.3, the SBCAPCD Application for Authority to Construct and Permit to Operate (copy attached) was completed. Included with each submittal was a plot plan showing source location within VAFB boundaries. In addition, a brief operational description and emission estimation justification accompanied each submittal.

SANTA BARBARA COUNTY AIR POLLUTION CONTROL DISTRICT
315 Camino del Remedio, Santa Barbara, CA 93110 - (805) 964-8658

APPLICATION FOR AUTHORITY TO CONSTRUCT AND PERMIT TO OPERATE

INSTRUCTIONS

A. This application form must be filled out COMPLETELY and must be filed in DUPLICATE.
B. Copy of all plans, specifications and drawings must accompany this application form.
C. SEPARATE application forms must be submitted for EACH article, machine, equipment or other contrivance requiring a permit.
D. A FILING FEE OF $20.00 paid by check, or money order must accompany EACH application.
E. INCOMPLETE applications will be returned.

1. PERMIT TO BE ISSUED TO:

(Business license name of Corporation, Company, Individual Owner, or Governmental Agency that is to operate the equipment.)

2. MAILING ADDRESS:

Number Street City Zip Phone

3. TYPE OF ORGANIZATION: ☐ Corporation ☐ Partnership ☐ Individual Owner ☐ Governmental Agency

4. GENERAL NATURE OF BUSINESS:

5a. EQUIPMENT DESCRIPTION: Pursuant to the provisions of the Health and Safety Code of the State of California and the Rules and Regulations of the Santa Barbara County Air Pollution Control District, application is hereby made for AUTHORITY TO CONSTRUCT and PERMIT TO OPERATE the following equipment:

5b. Attachments: (Check applicable items)
1. Plot Plan (Points of emissions and structures within 200 feet of boundary). . . . . ☐
2. Summary of polluntant emissions (Use APCD Form No. 29) . . . . ☐
3. Brief description of operation: Working hours, flows, quantities, horsepower, btu ratings, capacities . . . . ☐
(For equipment other than unit operation include schematic and parts list)

NOTE: When added emissions of any pollutant exceed 5 lbs/hr see Rule 205.C for additional requirements.

6. ADDRESS AT WHICH THE ABOVE DESCRIBED EQUIPMENT IS TO BE OPERATED:

Number Street City Nearest Intersection

7. ESTIMATED COST OF EQUIPMENT OR OF ALTERATION:

Air Pollution Control Equipment: $ Basic Equipment: $

8. STATUS OF EQUIPMENT:
☐ New Construction ☐ Alteration ☐ Change of Ownership ☐ Change of Location

Estimated Starting Date Estimated Completion Date Old Permit No. if any

9. SIGNATURE OF RESPONSIBLE CORPORATE OFFICER, PARTNER OR SOLE PROPRIETOR:

10. DATE OF APPLICATION

1. TYPE OR PRINT NAME OF SIGNER: Title of Signer

DO NOT WRITE BELOW (A.P.C.D. USE ONLY)

DATE STAMP

Fee Schedule	Previous Permit
Calculated Rating	Filing Receipt
Permit Fee	Permit Receipt
A/C Fee	A/C Receipt
ACTION TAKEN:	

Page ____ of ____

Initials & Date ________

Santa Barbara APCD
SUMMARY OF AIR POLLUTANTS EMISSION

Company ____________________

Eqpt. Loc. (St. Add. or Lease) ____________________

Equipment or Permit Unit.	Hourly Feed Rate Max. & Average	Operating Hrs/Day & Days/Yr	Number of Stacks	Stack Ht. & Diam.	Pollutant Lbs/Hr						Remarks
					HC	NOx	SO_2	CO	PM*	Other	

1. Attach detailed calculations for each permit unit. Should include rated capacity of equipment, feed rates, assumptions and references (EPA-42 or test data).
2. When emissions go into an air pollution control device, use brackets, () to identify th
3. List first all items covered by permits or application made before October 12, 1976, and total them. Then list chronologically subsequent units applied for, added or altered. Total these.

SECTION 3.0

EMISSION SUMMARY

SECTION 3.0

EMISSION SUMMARY

The results of the emission inventory effort has been summarized into Tables 3.1 and 3.2. Table 3.1 addresses criteria pollutants as well as HCl from missile launches and H_2S associated with water-well degasification. Table 3.2 quantifies emissions from hypergolic propellant activities.

As shown, hypergolics represent only a small fraction of total base emissions. Several other observations are of note:

- Largest TSP sources are fugitive dust from MX and STS construction.
- Burning of diesel with 0.5 percent sulfur by weight results in largest SO_2 emission contributions.
- Burning of fuel (boilers, aircraft, generators) is the largest source of NO_x.
- After aircraft operations, missile launches resulted in largest sources of CO.
- Evaporative sources are largest contributors to TOG emission rates.

TABLE 3.1

CRITERIA POLLUTANT 1981 EMISSION SUMMARY - VAFB (lbs/yr)

	TSP	SO_x	NO_x	CO	TOG	Other
1. Adhesive, Paint and Solvent Usage						
Cocess	---	---	---	---	70,247	---
Base Supply	---	---	---	---	163,017	---
CE Contracts	---	---	---	---	11,550	---
2. Household Goods Usage	---	---	---	---	32,760	---
3. Asphalt Paving	---	---	---	---	36,039	---
4. Asphalt Roofing	---	---	---	---	71,232	---
5. Diesel and Fuel Oil Storage	---	---	---	---	42	---
6. POL Airfield Storage	---	---	---	---	11,674	---
7. Generator Emissions	23,615	50,130	330,688	71,915	26,456	---
8. Service Stations	---	---	---	---	56,565	---
9. Aircraft Servicing	4	4	64	837	3,150	---
10. Aircraft Operations	49,800	17,200	118,600	275,800	141,000	---
11. Pesticides	---	---	---	---	700	---
12. Sandblasting	44,240	---	---	---	---	---
13. Heating Units	20,311	135,886	157,618	30,117	10,115	---
14. Space Heating	2,732	109	14,570	3,642	1,457	---
15. Fire-Fighting Training	7,000	---	400	9,000	2,200	---
16. Missile Launches	122,600	---	4,460	192,720	---	81,360 (HCl)
17. MX Construction	444,440	---	---	---	17,125	---
18. STS Construction	183,200	---	---	---	84	---
19. Union Oil Company	344	3,600	3,160	440	18,520	---
20. POL Loading Rack	---	---	---	---	1,660	---
21. Water Well Degasifiers	---	---	---	---	---	15,242 (H_2S)
22. Component Cleaning	---	---	---	---	18,876	---
23. Base Dry Cleaning	---	---	---	---	16,200	---
24. Paint Spray Booths	---	---	---	---	5,976	---
25. Rocket Engine Flushing (SLC-3)	---	---	---	---	166	---
26. Rocket Engine Flushing (SLC-2)	---	---	---	---	84	---
27. Concrete Batch Plants	1,387	---	---	---	---	---
28. Incinerators	74	3	38	11	30	---
Total (lb/yr)	899,747	206,932	629,598	584,482	716,925	
Total (ton/yr	449.9	103.5	314.8	292.2	358.5	
HCl						81,360 (40.7 tpy)
H_2S						15,242 (7.6 tpy)

TABLE 3.2

HYPERGOLIC POLLUTANT 1981 EMISSION SUMMARY

(All values in lb/yr)

	NO_x*	N_2O_4	A-50	UDMH	N_2H_4
Titan Tank Farm					
Transfer to Storage (15 operations for N_2O_4, 10 for A-50)	249	---	802	---	---
Transfer to Tanker (15 operations for N_2O_4, 10 for A-50)	80	---	407	---	---
Agena Tank Farm					
Transfer to Storage (3 operations/yr)	---	130	---	204	---
Transfer to Tank (3 operations/yr)	---	102	---	158	---
SLC-4					
RSV Loading (3 operations/yr)	686	---	792	---	---
RSV Venting (3 operations/yr)	20	---	87	---	---
Post-Vehicle Loading (3 operations/yr)	90	---	420	---	---
Post-Launch Operation (3 operations/yr)	87	---	234	---	---
IRFNA Orbiter - SLC-4W	---	1	---	---	---
Hydrazine Orbiter - SLC-4E	---	---	---	---	1
UDMH Orbiter - SLC-4W	---	---	---	4	---
SLC-3					
Hydrazine Scrubber	---	---	---	---	neg.**
SLC-2					
N_2O_4 Storage	---	5	---	---	---
A-50 Storage	---	---	2	---	---
Totals	1,212	238	2,744	366	1

* Form of N_2O_4 emissions after passing through a burner-type control device.

**Annual emissions 2.11×10^{-3} lb.

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DT