EPA-450/3-76-018-b
April 1977

DETERMINING INPUT VARIABLES FOR CALCULATION OF IMPACT OF NEW SOURCE PERFORMANCE STANDARDS: WORKSHEETS FOR CHEMICAL PROCESSING INDUSTRIES

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

EPA-450/3-76-018-b

DETERMINING INPUT VARIABLES FOR CALCULATION OF IMPACT OF NEW SOURCE PERFORMANCE STANDARDS: WORKSHEETS FOR CHEMICAL PROCESSING INDUSTRIES

by

The Research Corporation of New England
129 Silas Deane Highway
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Contract No. 68-02-1382

EPA Project Officer: Gary D. McCutchen

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

April 1977

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Publication No. EPA-450/3-76-018-b

FOREWORD

During 1974, two studies were initiated that ultimately resulted in the establishment of priorities for developing and promulgating New Source Performance Standards (NSPS). The procedures used to determine these priorities produced a great deal of information that is believed to be useful in the industries involved and, accordingly, is being published in this series of reports (EPA-450/3-76-017, EPA-450/3-76-018, EPA-450/3-76-019, and EPA-450/3-76-020). This information is organized as follows:

EPA-450/3-76-017 discusses (1) the mathematical model (Model IV) used to determine NSPS impacts over a 10-year period; (2) the methods used to attain input variables; and (3) the summary tables which are the heart of this study. Included in the summary tables are data related to (1) emission, growth, and replacement rates; (2) present and future production and capacity; (3) nationwide emissions; and (4) NSPS impact. These tables include information on 13 pollutants and nearly 200 stationary source categories.

EPA-450/3-3-76-018-a, -b, -c, -d, -e, and -f are the calculation sheets, showing how the input variables reported in EPA-450/3-76-017 were derived. All information sources, assumptions, and calculations are documented and explained. The appropriate worksheets are arranged alphabetically in the following volumes:

018-a - Stationary Combustion Sources

018-b - Chemical Processing Industries

018-c - Food and Agricultural Industries

018-d - Mineral Products Industries

018-e - Metallurgical Industries

018-f - Miscellaneous Sources (Evaporation Losses, Petroleum Industry, Wood Products Industry, and Assembly Plants

The 018-a -f series is of interest only to those concerned with the detailed calculations used to determine the Model IV input variables.

EPA-450/3-76-019-a provides additional results and information produced during the priority study. Its major purpose is to describe the computer program used to rank all the Model IV input and output variables by pollutant (these rankings are reported in 019-b and -c). In addition, it contains (1) summaries of the control systems considered "best" for each source, (2) equipment retirement ages, and (3) emission trends for each source category.

EPA-450/3-76-019-b and c present the computer-generated ranked data for each pollutant. Ranking is from highest to lowest for each of the 21 variables, e.g., A (nationwide capacity) and E_u (uncontrolled emission rate). Volume 019-b contains ranked data for particulate, nitrogen oxide (NO_x), and sulfur oxide (SO_x) sources. In Volume 019-c, the remaining pollutant sources are ranked: hydrocarbons, carbon monoxide (CO), fluorides, hazardous material, acid mist, lead, ammonia, sulfides, chlorine, and trace metals.

EPA-450/3-76-020, the final document in this series, takes the objective impact values from EPA-450/3-76-017, adds subjective judgements, and uses these combined criteria to produce a priority list for NSPS development. The report then calculates nationwide emission trends over the next 15 years for each criteria pollutant (particulate, SO_x, NO_x, hydrocarbons, and CO) based on a series of scenarios (e.g., no NSPS, 20 NSPS per year, etc.)

In summary, documents EPA-450/3-76-017 and 020 present the results of this study. Each stands alone, but they also complement each other, with 020 building on the results of 017. The remaining documents (018-a -f and 019-a -c) present additional and/or more detailed information derived from the impact and priority studies.

APPENDIX 4-B

DETERMINATION OF INPUT VARIABLES
FOR
THE CHEMICAL PROCESS INDUSTRY

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 7-19-74

Source Adipic Acid

K: Ref 096 Chem Profiles from Chemical Marketing 7-1-66

1966 Capacity = 910×10^6 lb/yr
1966 Demand = 930×10^6 lb/yr

based on 1963 production data (Ref 045 p 48) 645×10^6 lb/yr and 12% compound growth for the 1963 to 1966 period we calculate the 1966 production = 906×10^6 lb/yr

$$K = \frac{906}{910} = .995 \cong 1$$

We will assume that the K value for this industry is 1 especially in this instance where demand is high and growth is attempting to match demand, as indicated in the above reference

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 7-19-74

Source Adipic Acid

Ref: 076 Table AA-V

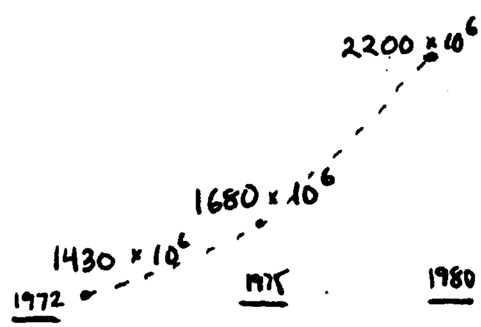
1972 Capacity = 1430×10^6 lb/yr

1980 Capacity = 2200×10^6 lb/yr

1972 Cap on stream in 1980 = 1270×10^6 lb/yr (160×10^6 lb/yr phased out)

New Cap added by 1980 = 770×10^6 lb/yr

Growth rate 5.5% compound, as noted in above source Table AA-V



using growth from 1972 to 1975 of 5.5% compound we calculate

1975 Cap = $1430 \times 10^6 (1+.055)^3$

1975 Cap = 1680×10^6 lb/yr

A: Using the 1975 Capacity calculated above;

$A = 1680 \times 10^6$ lb/yr or

or ∴ $A = .84 \times 10^6$ TON/yr

P_c: Growth rate $P_c = .055$ compound from above

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 7-19-74

Source Adipic Acid

P_B: Using the above data, 1972 Cap = 1430×10^6 lb/yr
1972 Cap onstream in 1980 = 1270×10^6 lb/yr

assuming that the obsolescence will occur as a compound function

$$1430 = 1270 (1 + P_B)^8 \qquad P_B = \sqrt[8]{\frac{1430}{1270}} - 1$$

$$P_B \cong .015 \text{ compound}$$

Adipic acid use is predominately (≈ 90%) for the production of nylon 66 Demand for adipic acid will therefore depend heavily on factors related to nylon production. Competition with other raw material sources for nylon manuf will definitely have effect.

Prediction of trends may be uncertain due to unforseen developments. The 5.5% compound growth we estimate for the 1975 to 1985 period is discernably lower than & the 1956 - 1965* growth of 15.8% /yr and the estimated 12% /yr for 1965 - 1980* which represented initial nylon growth

* Ref 096 7-1-66

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Computation Sheet For Emission Factors

Calculations Done By 2J Marrone Date 7-19-76

Source Adipic Acid

$COOH \cdot (CH_2)_4 \cdot COOH$ Dibasic acid used in manuf of synthetic fibers (nylon)

cyclohexane —(Cat Air Oxy)→ cyclohexanone / cyclohexanol —(O_2; HNO_3 cat)→ adipic acid

NO_x

NO_x

E_u : Ref 075 Table 5.1-1 pg 5.1-1

$$E_u = 12 \text{ lb/TON acid } (NO \,\&\, NO_2)$$

Based on info from ref 100 p 7-13 we find that the emission factor above (obtained from Table 7-4 on pg 7-14) represents the oxides of nitrogen emitted from the absorber - off gas stream. The absorber is considered an integral part of the adipic acid process; NO_x is converted to HNO_3 for reuse. The estimated efficiency for this system is 98-99%.

E_N: Ref 100 pg 7-5 to 7-9

Control systems are available (limited use so far) and more are being evaluated which are designed to treat the absorber tail gas from nitric acid plant.

We apply this technology to an Adipic Acid plant and use the highest efficiency mentioned in the reference 90% eff (CAUSTIC SCRUBBER)

$$E_N = .10 \times E_u = .1 \times 12 = 1.2$$

$$\therefore E_N = 1.2 \text{ lb/TON acid}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 7-30-74

Source Adipic Acid

Location of Major suppliers: Ref 095 Chem Eco Handbook 608.5030 D OCT 67

Dupont: W.Va & Tex

Monsanto: Fla

Others: Va, Tex, La, Fla (mostly Tex & Fla)

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Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10/9/74

Source Adipic Acid

NO_x :

~~State regulations of~~

Regulations in the states with adipic acid plants (see preceding page) do not restrict NO_x emissions from chemical processes (except nitric acid production).*

Therefore, for adipic acid plants, we can assume

$$E_s = E_u = 12 \text{ LB } NO_x/\text{TON AD. ACID}$$

*Ref. 84 & 148

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-27-74

Source Dimethylterephthalate - Terephthalic Acid (DMT - TPA) by Nitric Acid Oxidation

Currently there are 5 processes in use in the U.S. for producing TPA - DMT. Ref 127 pg DT2 to DT-4

	Process	Feed	Oxidation	Product
1.	Amoco	p-xylene	Air	TPA
2.	Mobil	p-xylene	O_2	TPA
3.	Dupont	p-xylene	HNO_3	DMT (TPA intermediate)
4.	Hercules	p-xylene	Air	DMT
5.	Tennessee Eastman	p-xylene	Air	DMT (TPA intermediate)

Only one process (Dupont) uses nitric acid oxidation of p-xylene and for this reason the suspected NO_x emissions will only be a function of the capacity by this particular process

The following list from Ref 127 pg DT-11 lists the producers, locations and capacity for DMT - TPA.

Plant	Location	Process	Capacity 10^6 lb/yr TPA	DMT
Amoco	Ill Ala	Amoco	150 412	
Dupont	Tenn N.J.	Dupont		360 300
Hercules	N.C. N.C.	Hercules		100 600
Hystron	S.C.	Hercules		100

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Computation Sheet For Industrial Factors

Calculations Done By 2J. Mannone Date 8-27-74

Source DMT - TPA (Nitric Acid Oxidation)

cont'd

Plant	Location	Process	Capacity TPA	10^6 lb/yr DMT
Mobil	Tex	Mobil	144	
Tennessee Eastman	Tenn	Tenn Eastman		580
			706	2040

converting TPA to DMT equivalent by Eq DMT = 1.17×TPA
Ref 127 DT-11

Total DMT = 2040 + 1.17 (706)
= 2040 + 826
Total DMT ≈ 2865 × 10^6 lb/yr

We see that of this 1973 capacity, approximately 23% is by the Dupont Nitric Acid oxidation process. $\frac{660}{2865} \cong .23$

P_c: Ref 127 pg DT-1 assumes an annual growth rate of 9.5%. This is in line with the growth rate of 9% (1970-1980) predicted for TPA-DMT demand. (Ref 095 I 695.4021 F)

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Computation Sheet For Industrial Factors

Calculations Done By W. Massone Date 8-27-74

Source DMT - TPA (Nitric Acid Oxidation)

P_c: cont'd

This growth however is for the DMT-TPA industry as a whole whereas we are intereste~~d~~ in the growth pertinent to the nitric acid oxidation process only.

Reference is made to the attached graph which was developed from the following information.

1973 Industry Capacity = $2,865 \times 10^6$ lb/yr } from above
1973 Dupont Capacity = 660×10^6 lb/yr }

1980 Industry Capacity = $5,900 \times 10^6$ lb/yr Ref 127 Table DT-V

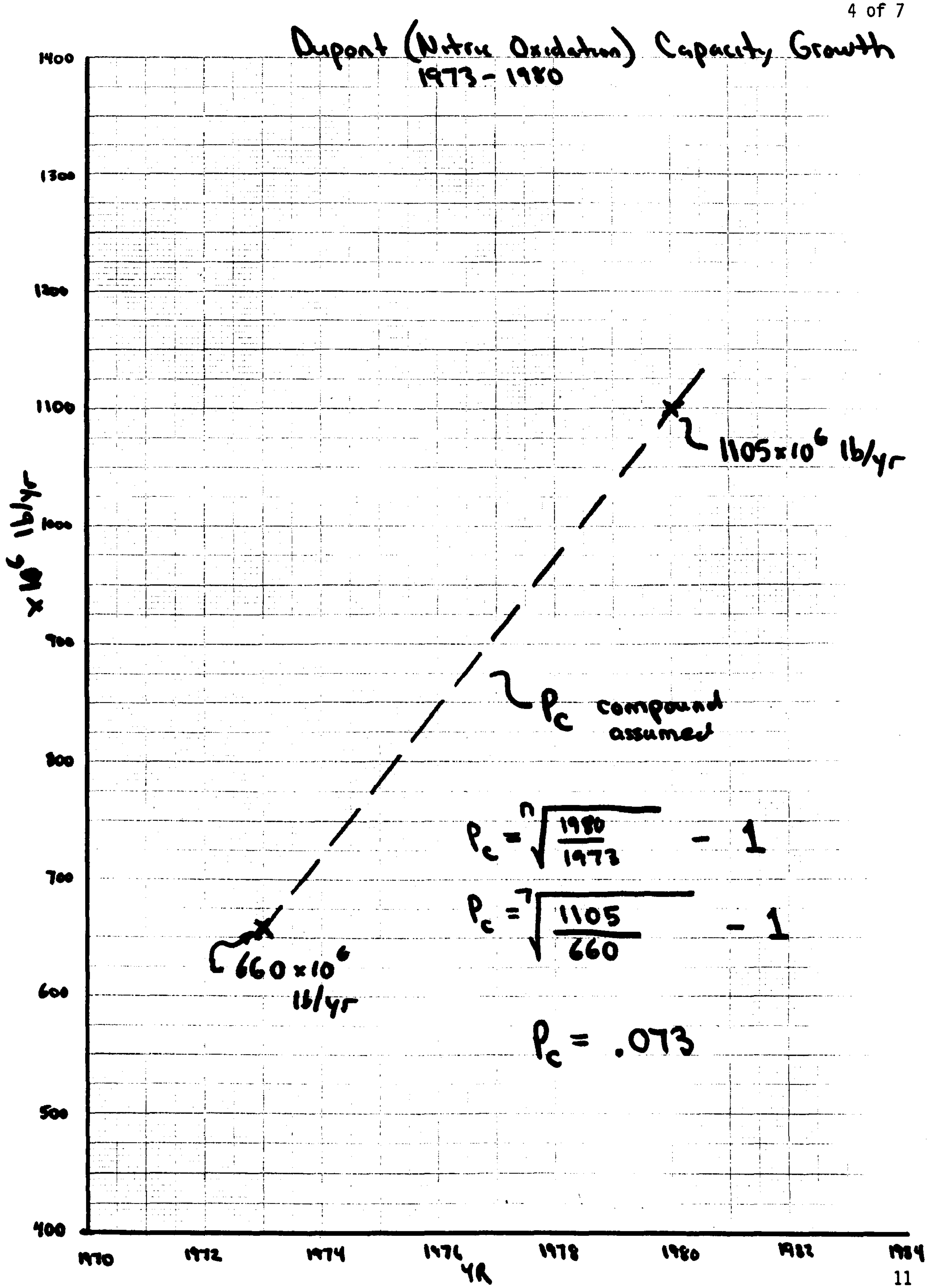
15% of added capacity to be attributable to the Dupont process (Ref 127 Table DT-VI)

New cap = $(5900 - 2865) \times 10^6$
= 3035×10^6 lb/yr

New Dupont Cap = $.15(3035 \times 10^6)$
= 455×10^6 lb/yr

Note! that Ref 127 Table DT-V and DT-VI reported the added capacity ([redacted] including the [redacted] 500×10^6 lb/yr Dupont replacement) as $2,335 \times 10^6$ lb/yr which is obviously a math error in light of the $5,900 \times 10^6$ capacity figure.

∴ 1973 Dupont Cap = 660×10^6 lb/yr
1980 Dupont Cap = $660 + 445 = 1105 \times 10^6$ lb/yr


Dupont (Nitric Oxidation) Capacity Growth
1973 - 1980
x 10^6 lb/yr
1400
1300
1200
1100
1000
900
800
700
600
500
400
1970
1972
1974
1976
1978
1980
1982
1984
YR
1105 x 10^6 lb/yr
660 x 10^6 lb/yr
Pc compound assumed
Pc = n√(1980/1973) - 1
Pc = 7√(1105/660) - 1
Pc = .073

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-27-74

Source DMT- TPA (Nitric Acid Oxidation)

P_c: cont'd

from this we determine the annual growth rate assumed to be compound to be 7.3%.

$\therefore$ $P_c = .073$ compound

(see attached graph)

A: The 1975 production capacity is estimated from the 1973 Dupont capacity and the 7.3% compound growth rate. n = 2 years

$$1975 \text{ cap} = 660(1+.073)^2$$

$$A = 760 \times 10^6 \text{ lb/yr}$$

or

$$A = \frac{760 \times 10^6}{2 \times 10^3} = 380{,}000 \text{ Ton/yr DMT}$$

by Nitric Acid Oxidation

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-27-74

Source DMT - TPA

K: Looking at the outlook for the DMT-TPA industry (Ref 095 I pg 695.4021 D) it is mentioned that new capacity being added for 1971 will meet demand at an average capacity utilization of 85%.

Ref 095	695.4021 B	1969	Prod	1,920 × 10^6 lb
"	695 4021	1970	Demand	1998 × 10^6 lb

These figures indicate production very close to demand at the 85% utilization factor.

We will use this factor as applicable to this industry and apply it equally to the Nitric acid oxidation Process

K = .85

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-26-74

Source DMT - TPA (Nitric Acid Oxidation)

P_B:

We assume that the obsolecence rate for this portion of the DMT-TPA industry may be approximated from IRS depreciation guidelines

Ref 037 pg 33 Section 28.0

Asset guideline life = 11 yrs

P_B est ≅ 2 × IRS = 22 yrs

100% Depreciation in 22 yrs = $\frac{100\%}{22 \text{ yrs}}$ = 4.5%/yr simple

$P_B = .045$ simple

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Computation Sheet For Emission Factors

Calculations Done By W. Monrone Date 8-27-74

Source OMT - TPA (Nitric Acid Oxidation)

NO_x

E_u: Ref 100 Table 7-4 pg 7-14

$$E_u = 13 \text{ lb/TON DMT-TPA}$$

E_N: Information on commercial systems and their achievable effeciencies is not extensive in the literature for this source. Similar to Adipic acid we will assume the control may be applied in 1975-1985 from technology being adapted to nitric acid tail gas processes.) We assume a 90% eff $E_N = .1 \times E_u = .1 \times 13 = 1.3$

$$\therefore E_N = 1.3 \text{ lb/TON DMT-TPA}$$

It is conceivable that nitric acid oxidation would give way completely to catalytic air oxidation in which case this soubce would no longer be of concern or applicable under NSPS.

It is important to Note that presently only one process (and one Company; Dupont) employs HNO_3 for Oxidation. Enforcing NSPS would impose reg on one Company!

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-14-74

Source DMT - TPA (Nitric Acid Oxidation

E_s :

Two plant in 1973 [New Jersey & Tennessee]

10^6 lb/yr	
360	Tenn
300	N.J.

The only state which has a general NO_x regulation is Illinois. It specifies a lb/hr limitation for existing and new plants when the HNO_3 usage exceeds 100 T/yr. Since there are no applicable NO_x regulations (NJ & Tenn) which may be applied to this industry we assume;

$$E_s = E_u = 13 \text{ lb/TON DMT-TPA}$$

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Computation Sheet For Industrial Factors

Calculations Done By HOPPER Date 8/27/74

Source Hydrochloric Acid

REF (95) 738.5030A

PRESENTS production data from 1940 → 1967

REF (42) P21 STATES (CURVE ATTACHED)

"1969 – 1,800,000 TONS" WHICH IS ALSO INCLUDED ON THE ATTACHED CURVE.

ASSUME COMPOUND GROWTH

$$P_c = \sqrt[29]{\frac{1800}{265}} - 1.0 = 0.0683$$

$$P_c = 0.0683$$

$$\text{PRODUCTION}_{1975} = (1,800 \times 10^3)(1.0683)^{75-69} = 2.676 \times 10^6 \text{ TONS}$$

REF (42)

P20 "MOST HCl IS PRODUCED AS A BY-PRODUCT FROM THE PRODUCTION OF CARBON TETRACHLORIDE AND OTHER CHLORINATED HYDROCARBONS, PVC, ETHYLENE OXIDE AND PHENOL."

P21 "THE MAJOR PORTION OF HCl CURRENTLY PRODUCED (85%) IS A BY-PRODUCT OF THE CHLORINATION OF HYDROCARBONS"

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Computation Sheet For Industrial Factors

Calculations Done By ______________ Date 8/28/74

Source Hydrochloric Acid

IT IS UNDERSTANDABLE, THEREFORE, THAT INFORMATION REGARDING CAPACITY COULD NOT BE FOUND IN THE LITERATURE.

SINCE 85% IS PRODUCED AS A BY-PRODUCT OF SEVERAL OTHER PROCESSES, WE WILL LOOK AT THE "K" FACTOR FOR THOSE PROCESSES AND USE THIS "K" FOR HCl. THIS ASSUMPTION IS VALID AS LONG AS THE EFFICIENCY OF THE ORIGINAL PROCESS DOES NOT CHANGE AS K CHANGES.

FOR PVC

REF: Calc's for PVC by W.A. Marrone, 8/30/74 AS PART OF THIS PROJECT

$K_{PVC} = 0.82$

FOR CCl_4

DATA FROM REFS (95) & (96) PER ATTACHED CURVE

$K_{CCl_4} = 0.94$

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Computation Sheet For Industrial Factors

Calculations Done By Homer Date 8/28/74

Source Hydrochloric Acid

FOR ETHYLENE OXIDE

1964 = 2,065 x 10^6 #
1964 = 2163 x 10^6 #
} REF (95) p 654.5030C FEB '66

$K_{EO} = 0.95$

FOR CHLOROBENZENE

REF 95 p 633.5030 FEB '67 {
1965 Production = 546.3 x 10^6 #
1965 Capacity = 720 x 10^6 #

$K_{CB} = 0.76$

FOR PERCHLOROETHYLENE

$$\frac{1964\ \text{Prod}}{1964\ \text{Cap}} = \frac{365.7}{422} = K_{PCE} = 0.87$$

FOR TRICHLOROETHYLENE

$$\frac{1964\ \text{Prod}}{1964\ \text{Cap}} = \frac{370.5}{475} = 0.78 = K_{TCE}$$

} REF (95) p 634.5030, 634.5031

ASSUME AVG OF VALUES = K_{HCL}

$K_{HCL} = 0.86$

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Computation Sheet For Industrial Factors

Calculations Done By Hopper Date 8/28/74

Source

$$A = \frac{2.676 \times 10^6 \text{ TONS}}{0.86}$$

$$A_{TOTAL} = 3.11 \times 10^6 \text{ TONS}$$

THERE ARE 3 BASIC SOURCES OF HCl
1. 84.5% BY-PRODUCT
2. 8.5% SALT/H₂SO₄
3. 7% SYNTHESIS

} REF (142) P1

EMISSIONS DIFFER FOR EACH PROCESS
REF 142 P3, P16, P19
THEREFORE, WE WILL USE A DIFFERENT A FOR EACH PROCESS. P_C, P_B & K WILL BE ASSUMED EQUAL FOR ALL PROCESSES

$$A_{BY\ PRODUCT} = 2.63 \times 10^6 \text{ TONS}$$

$$A_{SALT} = 0.26 \times 10^6 \text{ TONS}$$

$$A_{SYNTHESIS} = 0.22 \times 10^6 \text{ TONS}$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-26-74

Source Hydrochloric Acid

P_B: We assume that the obsolescence rate derived from IRS Tables will be identical for each process of HCl production.

Ref 037 pg 33 Section 28.0

Asset guideline life = 11 yrs

P_B est ≈ 2 × IRS = 22 yrs

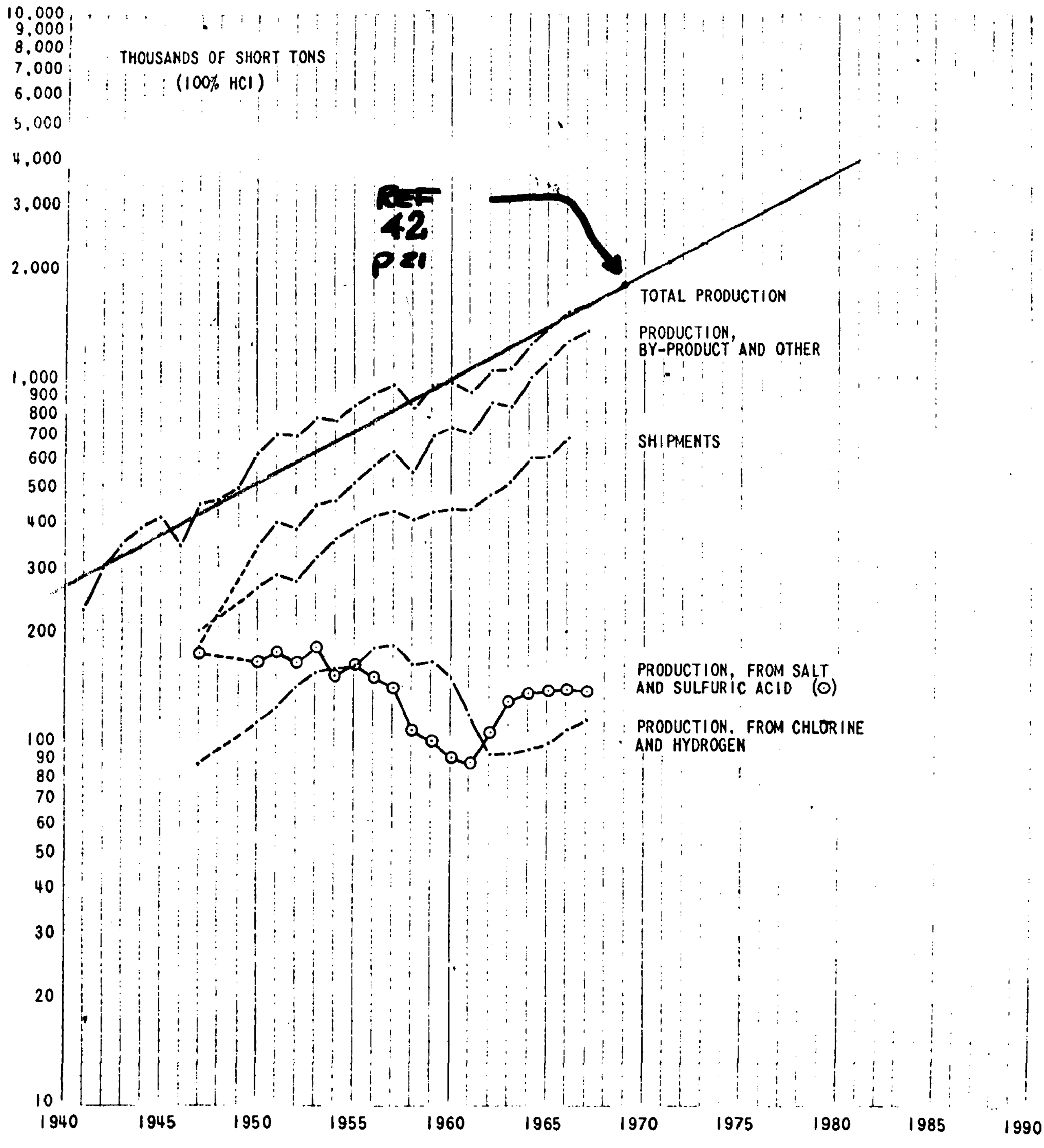
100% Depreciation in 22 yrs $\frac{100\%}{22 \text{ yrs}}$ = 4.5%/yr simple

P_B (Byproduct) = .045 simple

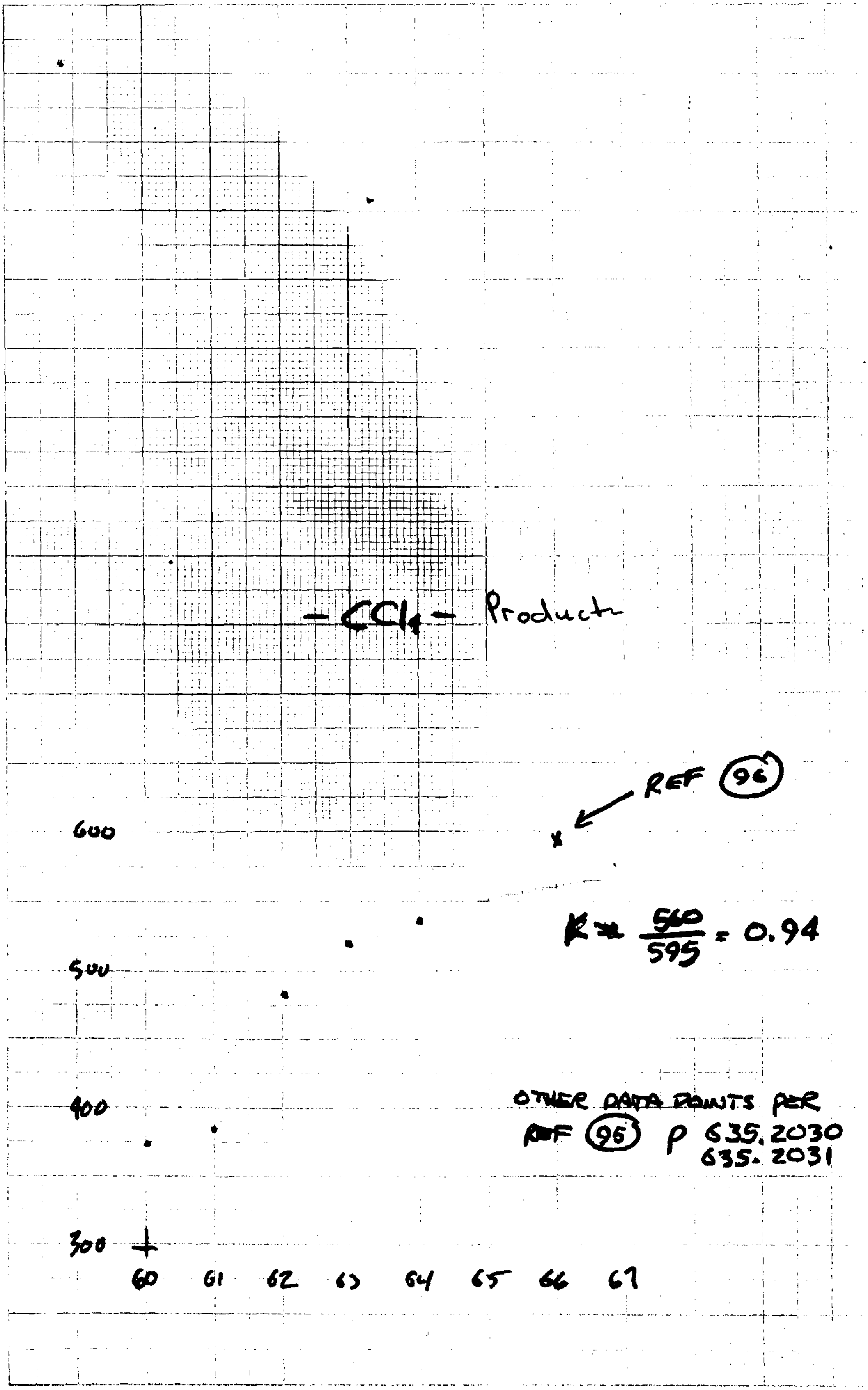
P_B (Salt) = .045 simple

P_B (Synthesis) = .045 simple

HYDROCHLORIC ACID - SALIENT STATISTICS



(1) ADDITIONAL CATEGORIES: IMPORTS AND EXPORTS ARE INCLUDED IN TABLE. DATA IN TABLE BEGIN WITH 1931.


-CCl4- Product
REF 96
K ≈ 560/595 = 0.94
OTHER DATA POINTS PER
REF 95 P 635.2030
635.2031
600
500
400
300
60
61
62
63
64
65
66
67

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 8/29/74

Source Hydrochloric Acid

ACID MIST

$E_{U\,BYPRODUCT}$ = ? #/TON ACID REF ( ) TAB 5.7-1

$E_{U\,SALT} = \frac{1.3+3.8}{2} = 2.55$ #/TON ACID REF (142) p 19

$E_{U\,SYNTHESIS} = 0$ REF (142) p 16

REF (142) p 13 CONTROL by wet scrubbing to 0.1 #/TON ACID

$\frac{3-.1}{3} = 96.7\%$

$E_N = 0.1$ #/TON FOR BYPRODUCT & SALT

$E_N = 0$ FOR SYNTHESIS

E111d

REF (142) p 3

"Adequate control equipment is available to prevent emissions of more than 0.5% hydrogen chloride, or about 0.5 pounds per ton of acid produced."

$E_{111d} = 0.5$ #/TON ACID

FOR by-product & salt

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-10-74

Source Hydrochloric Acid

E_S: Acid Mist with the exception of sulfuric acid plants is not regulated by any of the states. In this case the value of E_S is considered to be equivalent to E_u.

$$E_{S_{Byproduct}} = 3 \text{ lb/TON Acid}$$

$$E_{S_{Salt}} = 2.55 \text{ lb/TON Acid}$$

It should be noted that some state may interpret mist emissions as applicable to particulates (not considered here).

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-26-74

Source Hydrofluoric Acid

K: "Most production (75 percent) is in captive plants. Accordingly, temporary lulls in demand can effect merchant plants markedly." Ref 045 pg 432

Referring to the attached graph, which we developed from data in Ref 095 I 739.5030 A-G and Ref 042 p 21-22, "apparent" utilization factors may be determined.

$K_{62} = \frac{166.5}{210} = .79$

$K = \frac{Prod}{Cap}$

$K_{64} = \frac{197.3}{233} = .85$

$K_{66} = \frac{246.8}{278} = .89$

$K_{68} \cong \frac{290}{300} = .97$

A merging of production and capacity is evident during the period 1962 - 1968.
Ref 141 p 96 states that many inorganic chemicals were producing near capacity during 1973.

Lacking any recent production or capacity data (1970's) and sufficient trend predication after the 1975 base year, we must make the following predictions and conclusions until more information is assembled.

① Recent economic lulls have caused merchant plants to decrease their collective capacity.

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Marron Date 8-26-74

Source Hydrofluoric Acid

K: cont'd

② growth in the utilization factor (K) has occurred [.79 in 1962 to .97 in 1968]

③ Production near capacity in 1973 indicates a continuance of the mergence of production and capacity figures. (Ref 141 p76)

④ We assume this trend will level out so that production will remain essentially a small percentage below the capacity level.

We will assume a utilization factor of .98 and apply it for the period 1975-1985

K=.98

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-26-74

Source Hydrofluoric Acid

A: We have developed a graph of the production of 100% HF for the period 1962-1968 and added additional data for 1969 and 1974. Extrapolation, linearly, of this data has yielded a 1975 production figure.

$$P_{75} = 440 \times 10^3 \text{ TONS/yr of } 100\% \text{ HF}$$

The 1975 capacity is obtained from the production figure and the utilization factor K.

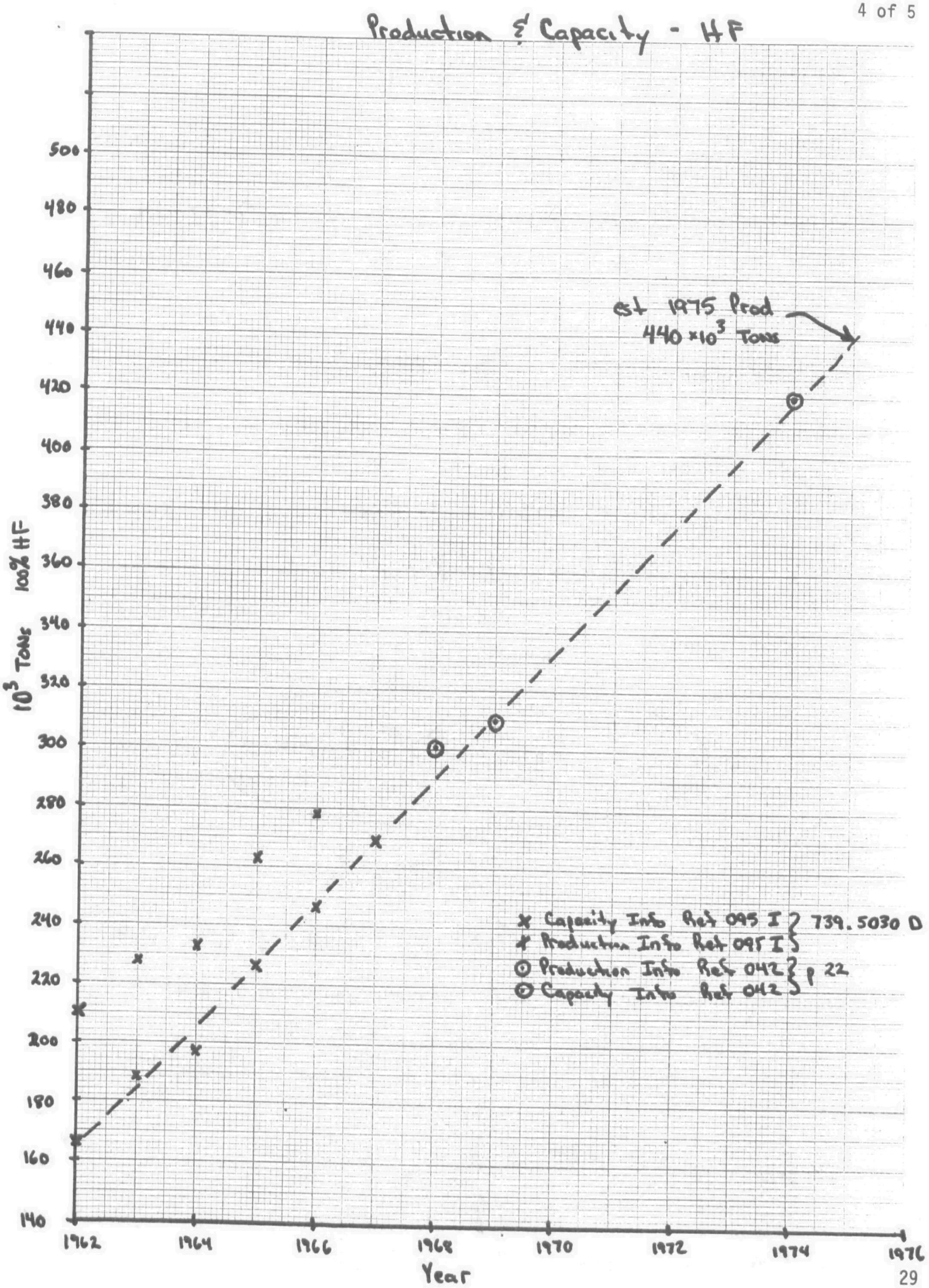
$$A = \frac{440 \times 10^3}{.98} = 449 \times 10^3 \text{ TONS/yr of } 100\% \text{ HF}$$

$$A \overset{or}{=} .449 \times 10^6 \text{ Tons/yr } 100\% \text{ HF}$$

P_c: Growth will be estimated by the slope of the production curve on the attached graph. Taking the growth from this slope and applying it to the simple growth above base year 1975 we obtain;

1975 Prod = 440×10^3
1969 Prod = 310×10^3 > 6 years $\Delta = \frac{440-310}{6} \times 10^3 = 21.7 \times 10^3$ Tons/yr growth

$$P_c = \frac{21.7 \times 10^3}{440 \times 10^3} = .049 \text{ simple}$$


Production & Capacity - HF
est 1975 Prod
440 ×10^3 Tons
× Capacity Info Ref 095 I
× Production Info Ref 095 I
739.5030 D
⊙ Production Info Ref 042
⊙ Capacity Info Ref 042
p 22
10^3 Tons 100% HF
Year
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
1962
1964
1966
1968
1970
1972
1974
1976

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-27-74

Source Hydrofluoric Acid

P_B :

Ref 037 pg 33 Sec 28.0

Asset guideline period 11 yrs

P_B est → 2×IRS = 22yrs

$\frac{100\%}{22 yrs}$ = 4.5 %/yr simple

∴ P_B = .045 simple

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-26-74

Source Hydrofluoric Acid

Process:
Ref 045
p 428-437

$$CaF_2 + H_2SO_4 \xrightarrow[\text{kiln}]{\Delta} H_2F_2 + CaSO_4$$

1 ton anhydrous HF requires: 3,500 lb Fluorspar (98% CaF_2)
6,400 lb H_2SO_4 (96% H_2SO_4)
7,000,000 BTU producer gas

Acid grade fluorspar - ≈98% CaF_2
.03% S

Acid Production - 40% Acid, 50% Acid, 80% Acid, 99% Acid } produced — also 70% acid tech grade

We will use the 70% acid figure as representative of the acid produced.

Fluorides

AP 42 (Ref 075 p 5.8-1 Table 5.8-1)

Fluoride emission from rotary kiln 50 lb/TON of acid

using 70% acid conversion we calculate the emission factor in terms of 100% HF

$$\frac{50\text{ lb}}{\text{TON acid}} \times \frac{\text{TON acid}}{.70\text{ HF}} = 71.4\text{ lb/TON } 100\%\text{ HF}$$

$$\therefore \quad E_u = 71.4\text{ lb/TON of } 100\%\text{ HF}$$

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Computation Sheet For Emission Factors

Calculations Done By William Marrone Date 8-26-74

Source Hydrofluoric Acid

Fluoride: cont'd

E_N: Ref 075 p5.8-1 Table 5.8-1

controlled emissions of fluoride .2 lb/ton acid

converting from 70% acid → $\frac{.2 \text{ lb}}{\text{Ton acid}} \times \frac{\text{Ton acid}}{.70 \text{ HF}}$ = .29 lb/ton 100% HF

(WATER SCRUBBER)

∴ E_N = .29 lb/ton 100% HF

Assume $E_{111d} = E_N$ ∴ E_{111d} = .29 lb/ton 100% HF

E_S: Fluorides

Ref 084 & 148

There are no Fluoride regulation applicable to Hydrofluoric Acid plants

∴ $E_S = E_u$

∴ E_S = 71.4 lb/ton 100% HF

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Computation Sheet For Emission Factors

Calculations Done By William Marrone Date 8-26-74

Source Hydrofluoric Acid

Sulfur Oxides

E_u: As reported in Ref 045 p 423 there is .03% S in fluorspar by weight and that 3,500 lbs of Fluorspar is required to produce 1 ton of 100% HF.

Assuming that all of the S is converted to SO_2 we calculate the resultant sulfur oxide emission factor from the kiln ~~due to~~ the fluorspar feed S content and in terms of 100% HF product

$$.0003 \frac{lb\ S}{lb\ Feed} \times 3{,}500 \frac{lb\ Fluorspar}{Ton\ HF\ 100\%} = \frac{1.05\ lb\ S}{TON\ 100\%\ HF}$$

$1\ lb\ S \rightarrow 2\ lb\ SO_2 \therefore$

$$E_{SO_2} = 2.1 \frac{lb\ SO_2}{TON\ 100\%\ HF}$$

Since producer gas is reported to be the fuel used in the kiln or some equivalent gas we would not expect a significant SO_2 contribution from the fuel.

$$\therefore E_u = 2.1\ lb/TON\ 100\%\ HF$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-26-74

Source Hydrofluoric Acid

Sulfur Oxide cont'd

E_N:

Control of sulfur oxide was not indicated as the state of the art in this industry

We will evaluate the full impact of SO_x emission from HF manuf. by assuming $E_N = 0$. The value of $T_S - T_N$ will be maximized and, depending on its value, indicate whether or not control technology is warranted.

$$\therefore E_N = 0$$

E_S: Ref 236 pg IV-19

range in plant capacity 275 - 1000 $\frac{TON}{day}$ and 5000 scfm for kiln $\Rightarrow$ Avg Plant ≈ 640 $\frac{T}{D}$ acid

Ref 096 July 1, 1967 Lists the HF producing states (plant location) and their capacities.

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 9-30-75

Source Hydrofluoric Acid

Sulfur Oxides cont'd

E_S:

State	Total Cap 1968 TON/yr
Tex	93,000
La	30,000
W Va	20,000
Del	25,000
Calif	12,000
N.J	26,000
Ohio	10,000
Ill	12,000
Ky	18,000
Ark	40,000
	286,000

From Ref 084 & 148 only La and Ill have regulations applicable to this source Both of which specify a limit of 2000 ppm of SO_2

$$\frac{30+12}{286} = \frac{42}{286} = .147$$ or 14.7% of cap in these two states

Calculating lb/hr allowable emission for 2000 ppm limit:

$$\frac{2000 \text{ ppm}}{10^6} \times 5000 \frac{\text{scf}}{\text{min}} \times 60 \frac{\text{min}}{\text{hr}} \times 64 \frac{\text{lb}}{\text{lb mole}} \times \frac{\text{lb mole}}{\text{SCF}\ (387)} \cong 99 \text{ lb/hr}$$

assuming $24 \frac{hr}{d}$ ⟹ 2380 lb SO_2/day allowable emissions

For an average plant size of 640 T/D acid this gives an allowable emissions of

$$\frac{2380}{640} \cong 3.72 \text{ lb } SO_2/\text{TON acid HF}$$

This limit is greater than E_u so that E_s for Ill and La is equal to E_u. The other states, not having a regulation are assumed $E_s = E_u$

$$E_S = 2.1 \text{ lb/TON } 100\% \text{ HF}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 1-30-75

Source Hydro Fluoric Acid

Particulate

E_N : Ref 075 pg 5.8-1 Table 5.8-1

Emissions from grinding and drying of fluorspar for well-controlled plant

$$E_p = 20 \text{ lb/TON Fluorspar}$$

using 3500 lb fluospar / TON 100% HF

$$E = \frac{20 \text{ lb}}{\text{TON Flu}} \times \frac{3500 \text{ lb Flu}}{\text{TON HF}} \times \frac{\text{TON}}{2000 \text{ lb}}$$

$$E_N = 35 \text{ lb/TON } 100\% \text{ HF}$$

E_u :

We don't now what the effective efficiency is of this system nor does the literature cite any values for achievable efficiencies.

We assume that this well-controlled plant represents an efficiency of 95% such that $E_u = \frac{E_N}{.05}$

$$\therefore E_u = 700 \text{ lb/TON } 100\% \text{ HF}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 1-30-75

Source Hydrofluoric Acid

Particulate

E_s:

As mentioned above Average Plant size 640 T/D acid and using 3500 lb Fluorspar (through kiln) per ton acid produced

$$\text{Avg PWA} = 640 \frac{\text{T acid}}{\text{day}} \times \frac{3500 \text{ lb}}{\text{TON acid}} \times \frac{\text{TON}}{2000 \text{ lb}} = 1120 \frac{\text{TON}}{\text{day}}$$

for 24 hr/day, this gives a process weight rate of

$$\text{PWR} = 1120 \frac{\text{TON}}{\text{day}} \times 2000 \frac{\text{lb}}{\text{TON}} \times \frac{\text{day}}{24 \text{ hr}} = 93{,}330 \text{ lb/hr fluorspar}$$

Ref 084 & 148

Allowable emissions determined for each state based on this PWR and weighted according to fractional cap. occurrence for 1967 as presented on pg 5 of "Emission Factors"

State	A_i	Allowable lb/hr	A_i x Allow
Tex	.325	76.0	24.70
La	.105	53.5	5.62
W Va	.070	32.5	2.28
Del	.087	8.6 +	.75
Calif	.042	40.0	1.68
NJ	.091	30.0	2.73
Ohio	.035	53.5	1.87
Ill	.042	53.5	2.25
Ky	.063	53.5	3.37
Ark	.140	39.0	5.46
	$\Sigma = 1.000$		$\Sigma \cong 50.7$ lb/hr

+ based on .2 gr/scf and 5000 scfm

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 1-30-75

Source Hydrofluoric Acid

Particulate cont'd

E_S:

$$E_{allow} = 50.7 \text{ lb/hr}$$

and

$$E_S = \frac{50.7 \text{ lb/hr}}{640 \frac{\text{TON acid}}{\text{day}} \times \frac{\text{day}}{24 \text{ hr}}} = 1.9 \text{ lb/TON acid}$$

We see that E_S calculated is about $\frac{35}{1.9} \cong 18.5$ times less than E_N which implies that this industry may be asked to be controlled more stringently that is apparently technologically feasible

We make the assumption that $E_S = E_N$ to represent the condition that controls req can only be set as low as current technology will permit.

$$E_S = 35 \text{ lb/TON acid}$$

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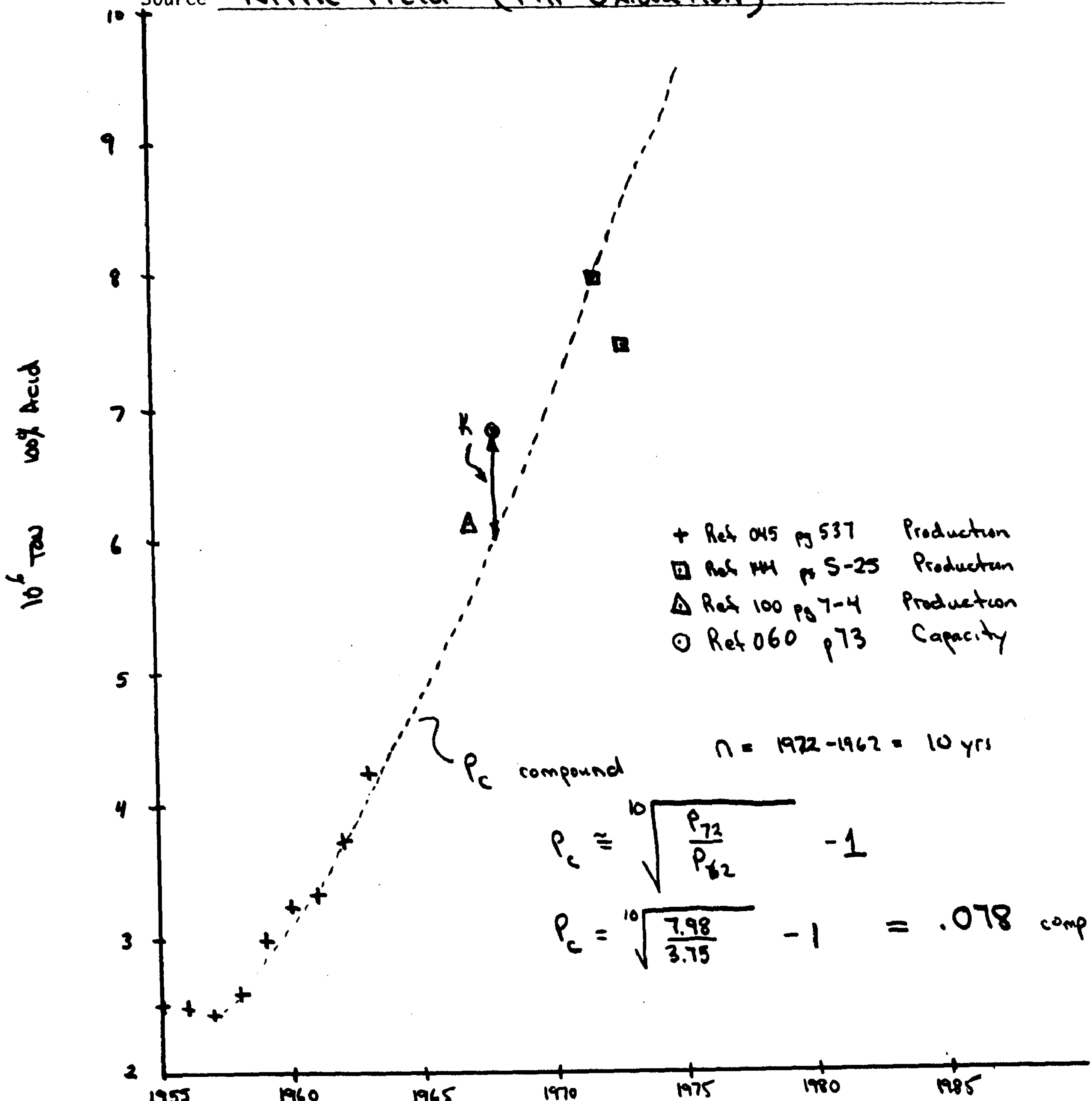
Computation Sheet For Industrial Factors

Calculations Done By W Marrone Date 12-27-74

Source Nitric Acid (Air Oxidation)



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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 12-27-74

Source Nitric Acid

K:

Our best estimate at this time will be based on a Capacity value in the year 1968 and a estimated production level in that year from the graph attached.

$$Cap_{68} = 6.82 \times 10^6 \text{ TON/yr}$$

$$Prod_{68} \cong 6.0 \times 10^6 \text{ TON/yr}$$

$$K = \frac{6.0}{6.82} \cong .88$$

$$\therefore K = .88$$

P_c: Ref to attach graph using production points in the years 1962 and 1972

$$P_c = .078 \text{ compound}$$

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Calculations Done By W. Marrone Date 12-27-74

Source Nitric Acid

A: Using the Production in 1972 of 7.98×10^6 TON/yr, K = .88 and a growth rate of 7.8% compound we may determine the value of A. (1975 Production Capacity)

$$P_{75} = P_{72}(1+.078)^3 = 7.98 \times 10^6 (1.078)^3$$

$$P_{75} = 9.99 \times 10^6 \text{ TON/yr}$$

$$A = \frac{P_{75}}{K} = \frac{9.99}{.88} \cong 11.4 \times 10^6 \text{ TON/yr}$$

$\therefore$

$$A = 11.4 \times 10^6 \frac{\text{TON}}{\text{Yr}}$$ 100% Acid produced

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 12-27-74

Source Nitric Acid

P_B:

Ref 037 pg 33 Class 28.0

Assett guideline period = 11 yrs

P_B est → 2×IRS = 22 yrs

$\frac{100\%}{22 \text{ yrs}}$ × 100 = 4.5% / yr simple

P_B = .045 simple

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-27-74

Source Nitric Acid (Air Oxidation)

NOx /

E_u :

Ref 075 Table 5.9-1

Uncontrolled Weak Acid Plant 50-55 lb/TON 100% acid

We will use the average 52.5 lb/TON 100% acid

∴ E_u = 52.5 lb/TON 100% acid

E_N : The most preferred means of control has been the employment of catalytic combustor units

Ref 075 Table 5.9-1

	lb/TON 100% Acid	Avg
Cat Comb (Hydrogen Fired)	0 - 1.5	.75
Cat Comb (75% H_2, 25% N.G.)	.8 - 1.1	.95
Cat Comb (Nat Gas Fired)	2 - 7	4.50

Avg 2.06

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Calculations Done By W. Marrone Date 12-27-74

Source Nitric Acid (Air Oxidation)

NO_x/ cont'd

E_N:

The actual system chosen is ultimately tide to an economic appraisal to determine feasibility. We will a that an approximate average value arrived at above is entirely achievable for HNO_3 plants.

$$\therefore E_N = 2 \text{ lb/TON} \quad \text{100\% Acid produced}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-27-74

Source Nitric Acid

NO_x/ cont'd

E_s: Ref 060 pg 70-73

gives 1966 capacity by state from which we may determine fractional total capacity distribution throughout the states in 1966. Assuming this breakdown is representative for 1975-1985 then the allowable emission (Ref 148 & 084) may be weighted for each state by A_i

State	Capacity	A_i	lb/TON Allowable Emission	A_i x Allow
Alabama	263,000	.0386	5.5	.0212
Arizona	35,000	.0051	5.5	.0281
Arkansas	255,000	.0374	*	1.9640
Calif	247,000	.0362	**	.0362 x $E_{S AVG}$
Colo.	20,000	.0029	+	.1523
Florida	347,000	.0509	3.0	.1527
Geo	330,000	.0484	10.0	.4840
Ill	396,500	.0581	5.5	.3196
Ind	162,000	.0238	*	1.2495
Iowa	197,000	.0289	5.5	.1590
Kansas	500,000	.0733	5.8	.4251
Kentucky	80,000	.0117	5.8	.0679
Louisiana	494,500	.0725	6.5	.4713
Maine	20,000	.0029	*	.1523
Minn	70,000	.0103	5.5	.0567
Miss.	340,000	.0498	*	2.6145
Mo	541,500	.0794	*	4.1685
Neb	248,500	.0364	5.5	.2002
N.J.	296,500	.0435	*	2.2838
N.Y.	25,500	.0037	3.0	.0111
N.C.	130,000	.0191	5.8	.1108
Ohio	380,000	.0557	5.5	.3064
Penn	82,500	.0121	5.5	.0665
Tenn	167,000	.0245	5.5	.1348
Texas	446,500	.0655	*	3.4388
Utah	59,500	.0087	*	.4568

cont'd

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-27-74

Source Nitric Acid

NO_x / E_s cont'd

State	Capacity	A_i	lb/TON Allowable Emission	A_i x Allow
Virginia	480,000	.0704	5.5	.3872
Wash	77,000	.0113	*	.5933
W Va	109,000	.0160	*	.8400
Wis	20,000	.0029	*	.1523
TOTAL	6,820,500			

$\Sigma = 21.4687 + .0362 E_{S_{AVG}}$

NOTES

* No reg $E_{S_i} = E_u = 52.5$ lb/TON

** reg by county $E_{S_i} = E_{S_{AVG}}$

+ only ground level specified E_{S_i} assumed = to E_u = 52.5 lb/TON

$$E_S = E_{S_{AVG}} = \Sigma = 21.4687 + .0362 E_{S_{AVG}}$$

$$E_{S_{AVG}} = \frac{21.4687}{1-.0362} = \frac{21.4687}{.9638} = 22.275$$

$$E_S \cong 22.3 \text{ lb/TON}$$ 100% Acid

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-27-74

Source Nitric Acid

NO_x/ E_s: cont'd

There are current NSPS regulation for new Nitric Acid Plants (Ref 147 pg 45) Ref 273 pg 24881 promulgated standard equivalent to proposed.

Since no state has a regulation for new source more stringent than this standard $E_s(new) = E_{stand} = 3.0$ lb/TON

For existing sources the value of E_s(existing) is taken as the value of E_s calculated above.

E_s (new) = 3.0 lb/TON 100% acid

E_s (existing) = 22.3 lb/TON 100% acid

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Computation Sheet For Industrial Factors

Calculations Done By HOPPER Date 2/4/75

Source Phosphoric Acid - Thermal Process

Ref (47) p 203 gives production of 1.02×10^6 tons P_2O_5 (1968)
Ref (95) p 761.5020 W gives production from 1940
The 1963 (most recent data) production is $.950 \times 10^6$ tons P_2O_5
Since the historical growth is compound

$$P_c = \sqrt[5]{\frac{1.02}{.950}} - 1.0 = 0.0143$$

$P_c = 0.0143$ compound

Ref (95) p 761.5020 W gives wet acid production & capacity info (Assume to be the same for thermal process)

1955 = 780/1000 = 0.78
1957 = 930/1200 = 0.78
1959 = 1150/1400 = 0.82
1961 = 1400/1650 = .85
1963 = 1950/2350 = 0.83

Assuming the Avg = .81

$K = 0.81$

$$A = \frac{(1.02 \times 10^6)(1 + .0143)^7}{0.81} = 1.391 \times 10^6$$

$A = 1.391 \times 10^6$ tons P_2O_5

From Ref (37) p 33 Section 28.0, the depreciation guideline for fertilizer plants and the mfg of chemicals and allied products is 11 yrs. Assuming twice the IRS guideline,

$$P_B = \frac{1}{(2)(11)} = 0.045$$

$P_B = 0.045$ simple

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Computation Sheet For Industrial Factors

Calculations Done By Hopper Date 2/4/75

Source Phosphoric Acid - Thermal Process

Several ref's treat the emissions of mist as a particulate; several others treat emissions as acid mist.

Since this industry would probably be regulated on the basis of gen'l process weight reg's, we will assume ~~that~~ the emissions are particulate.

Ref (47) p203

$E_{UP} = 134$ LB/TON P_2O_5

Several control alternatives are available, Ref (145) p141ff

Venturi scrubbers & cyclones - 99.9%
Glass fiber mist eliminators - 99.9%
ESP - 99.9%+

Assuming ~~that~~ 99.9% can be readily achieved,

$$E_{NP} = (1-.999)(134) = 0.134$$

$E_{NP} = 0.134$ LB/TON P_2O_5

From Ref (42) p 27, 28 The majority of PA plants are located in Cal., Ill, Texas, Pa & Ohio, Ind, NJ, Ala (61%) [Assume 1971 data - 1972 publication]

6.33x10⁶

Cal - 4/31 = 13% Penn - 2/31 6.5%
Tex - 2/31 = 6.5% Ohio - 2/31 (61%)
31 Ind - 2/31
NJ - 2/31
Ill - 3/31 = 10% Ala - 2/31

1971 Capacity

$$1.391 \times 10^6 = (1971\ Cap)\left[1 + .0143\right]^4$$ 1971 Cap. = 1.314×10^6

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Computation Sheet For Emission Factors

Calculations Done By Hoper Date 2/4/75

Source Phosphoric Acid — Thermal Process

$$\frac{1.314 \times 10^6 \text{ tons/yr}}{31 \text{ plants}} = 4.239 \times 10^4 \text{ TPY/plant}$$

Ref (53) p 12 states $\eta_{process} = 99.9\%$

Assuming 330 days/yr op'n @ 24 hrs/day

$$\frac{4.239 \times 10^4}{(330)(24)} = 5.352 \text{ TPH } (10,700 \text{ pph})$$

From Ref (84), (148) & gen'l pwr curve (156)

Allowable LB/HR

Cal - 10.0 ✓
Tex - 15.2 ✓
Ill - 6.00 ✓
Penn - Assume = to curve
Ohio - 12.00 ✓
Ind - 12.00 ✓
N.J. - 30.0
Alab. - 9.76
All others - 11.5

$$E_{sp} = \left[(10)(.13) + (15.2)(.065) + (6)(.10) + (12)(.065) + (12)(.065) + (30)(.065) + (9.76)(.065) + (11.5)(.445) \right]$$

$$= \left[1.3 + .988 + .6 + .78 + .78 + 1.95 + .634 + 5.12 \right] \div 5.352 = 2.271$$

$$E_{sp} = 2.27 \text{ LB/ton } P_2O_5$$

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Computation Sheet For Industrial Factors

Calculations Done By Hopper Date 2/4/75

Source Phosphoric Acid - Wet Process

Ref (234) p 3-142
1970 Production = 3.8×10^6 tons P_2O_5 (1968)

Ref (95) p 761.5020 W gives production from 1940
The 1963 (most recent data) production is 1.95×10^6 tons P_2O_5

Since the historical growth is compound

$$P_c = \sqrt[7]{\frac{3.80}{1.95}} - 1.0 = 0.10$$

$$P_c = 0.10$$ compound

Using the Avg K det'd for wet process acid in "Industrial Factors - Phosphoric Acid, Thermal Process"

$$K = 0.81$$

$$A = \frac{(3.8 \times 10^6)(1.10)^7}{.81} = 9.14 \times 10^6$$

$$A = 9.14 \times 10^6 \text{ Tons } P_2O_5$$

Ref (37) p33 gives the IRS depreciation guideline for fertilizer plants and the mfg of chemicals and allied products is 11 yrs. Assuming twice the IRS guideline,

$$P_B = \frac{1}{(2)(11)} = 0.045$$

$$P_B = 0.045$$ simple

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 2/4/75

Source Phosphoric Acid – Wet Process

From Ref (234) p 3-152

$$E_{UF^-} = 2.5 \text{ LB/TON } P_2O_5 \text{ produced}$$

Ref (159) p 5-11 indicates that a "well-controlled" plant will emit 0.01 LB/TON P_2O_5 INPUT

Ref (234) p 3-143 indicates the P_2O_5 input to output ratio of

.30 – .35 in
.28 – .32 out

Using avg's $\frac{.325}{.30} = 1.083 \frac{\text{LB in}}{\text{LB out}}$

$$0.01 \times 1.083 = E_{NF} = 0.0108$$

$$E_{NF^-} = 0.0108 \text{ LB/TON } P_2O_5 \text{ produced}$$

$$\eta = \frac{2.5 - .0108}{2.5} = 99.6\%$$

Ref (159) p 5-11 states that 0.02 LB/TON P_2O_5 IN would be the reg'd control for existing plants

$$0.02 \times 1.083 = 0.0217$$

$$E_{111dF^-} = 0.0217 \text{ LB/TON } P_2O_5 \text{ produced}$$

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 2/5/75

Source Phosphoric Acid - Wet Process

From Ref (42) p 28

There are 39 plants in the U.S.

Fla - 13/39

Ill - 5/39

Cal - 5/39

Tex - 3/39

Fla (Ref 148) has a reg of 0.02 lb/ton P_2O_5 in (0.0217 lb/ton P_2O_5 out)

Assume no reg's for others

$$E_{s_{F^-}} = \left(\frac{13}{39}\right)(.0217) + \left(\frac{26}{39}\right)\left(\frac{0.01+0.07}{2}\right) = .00723 + .02667$$

↑ Assumed avg of existing emissions since all plants have some control (Ref (159) p 5-11)

$$E_{s_{F^-}} = 0.0339 \text{ lb/ton } P_2O_5 \text{ output}$$

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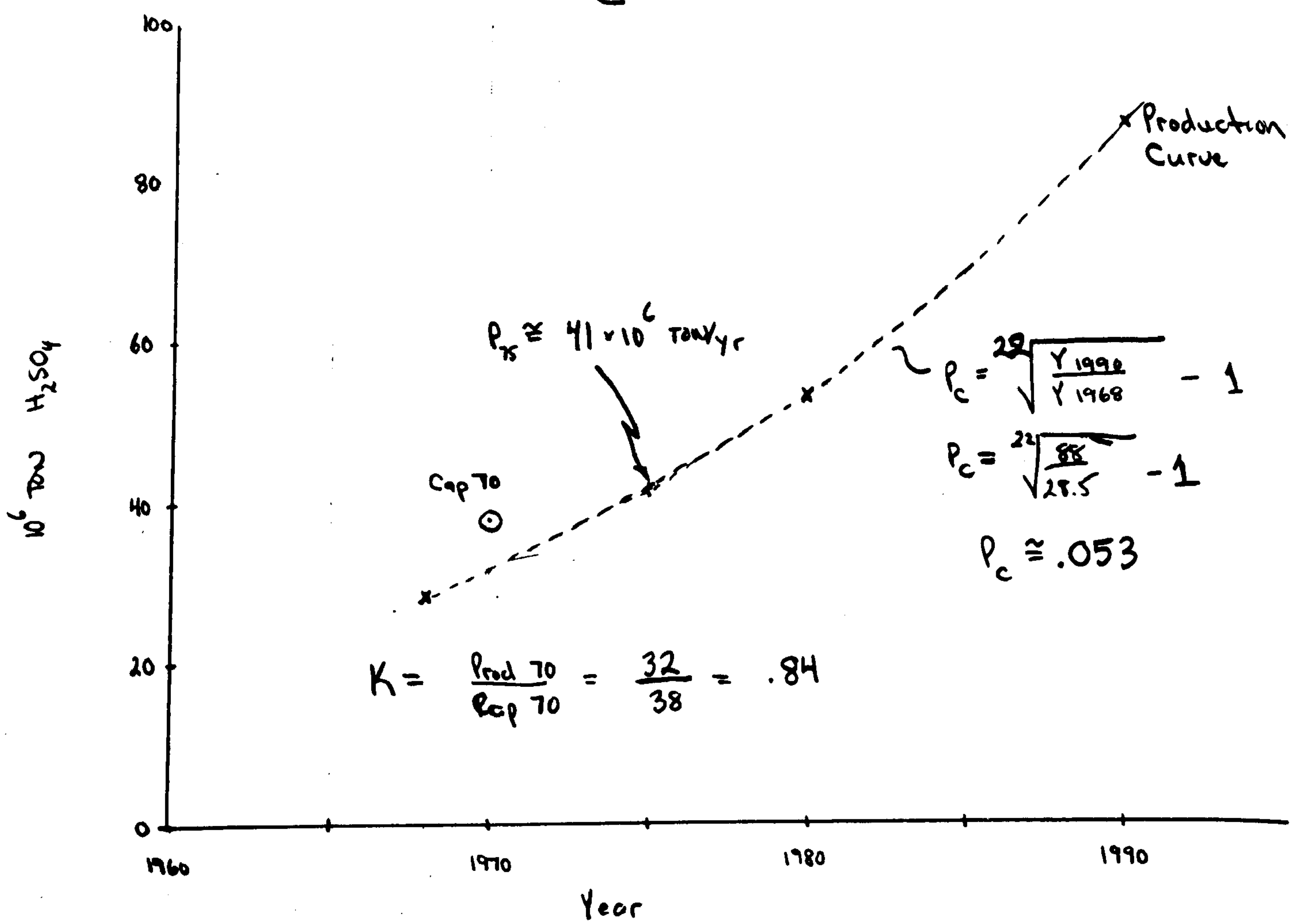
Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 12-17-74

Source Sulfuric Acid

Ref 020 pg 1

1970 production capacity 38×10^6 TONS sulfuric acid
from 250 plants { 215 · Contact Plants 97% of production
35 Chamber Plants 3% of production



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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 12-17-74

Source Sulfuric Acid

K: Based on data (graph) for 1970 K = .84 which we assume typical of this industry and applicable to 1975 to 1985

$\therefore K = .84$

P_c: - the growth rate determined for period 1968 - 1990 from attached graph was 5.3% compound

$\therefore P_c = .053$ compound

A: $P_{75} = 41 \times 10^6$ TON/yr $\qquad A = \frac{P_{75}}{K}$

$$A = \frac{41.0 \times 10^6}{.84} = 48.8 \times 10^6 \text{ TON/yr}$$

$\therefore A = 48.8 \times 10^6$ TON/yr 100% sulfuric acid

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 12-17-74

Source Sulfuric Acid

Presently, greater than 95% of the acid produced is by the contact process. Ref 020 pg 3 indicates that several factors (unattractive costs, low conc product, pollution concerns) are combining resulting in a disappearance of this process. No plants of this type have been built since 1956.

We make the assumption that in 1985 all the production and emissions will be attributable to the Contact Process.

P_B: Ref 037 Class 28.0 pg 33

Asset guideline period 11 yrs

P_B est → 2 × IRS = 22 yrs

$\frac{100\%}{22 \text{ yrs}}$ deprec = 4.5% simple

$\therefore P_B = .045$ simple

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-17-74

Source Sulfuric Acid

SO_2 /

E_u : Ref 020 pg 11

for plant before 1960 conversion efficiency range 95-96%
for plants after 1960 " " 96-98%

We assume 96% is typical of most existing plants

Ref 075 Table 5.17-1 @ 96% conversion

E = 55 lb/TON 100% Acid

∴ E_u = 55 lb/TON 100% Acid

E_N : Reference 075 pg 5.17-5

By going to a dual stage absorption process conversion efficiency of 99.7% and higher may be obtained (4 lb/TON)
with some tail gas processes emission may be ~~b~~ lower

2.7 lb/TON was quoted as average of ~~several~~ tests

We will assume that 3 lb/TON is achievable

∴ E_N = 3 lb/TON 100% Acid

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-17-74

Source Sulfuric Acid

SO_2/ cont'd

E_s : We assume that sulfuric acid production is relatively widely dispersed and that the value of E_s may be obtained by averaging the limits throughout the 50 states.

Ref 084 & 148

The Following States gave SO_2 limits for new and/or existing plants

State	New (lb/TON Acid)	Existing
Alabama	6.5	6.5
Conn	6.5	6.5
Delaware	6.5	13.0
Florida	4.0	10.0
Georgia	4.0	10.0
Illinois	4.0	no reg
Indiana*	6.5	6.5
Iowa	6.5	6.5
Kansas	30.0	30.0
Kentucky	4.0	27.0
Louisiana	6.5	6.5
Mass	4.0	27.0
Michigan*	6.5	6.5
Minnesota	4.0	6.5
New York	4.0	4.0
North Carolina	27.0	27.0
Ohio	6.5	6.5
Oklahoma	4.0	no reg
Penn	6.5	6.5
South Carolina	4.0	4.0
Tennessee	4.0	6.5
Utah	**	no reg
Virginia	33.0+	33.0+
Washington*	20.0	20.0
W. Virginia	33.0+	33.0+
Wisconsin	4.0	4.0
~~Wyoming~~	4.0	4.0

* one county of state only
** give 80% control for new plant
\+ based on 68% H_2SO_4 from elemental sulfur   Ref 075 5.17-1

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-17-74

Source Sulfuric Acid

SO_2/ cont'd

No state has emission limits less than the proposed limit of 4.0 lb/TON acid (Ref 147 pg 43) for new sulfuric acid plants. All states must set limits for new plants equal to this level

Ref 273 pg 24881 promulgated standard equivalent to proposed

$$\therefore E_s(\text{new}) = 4.0 \text{ lb/TON} \quad \text{100\% acid}$$

For existing plants:

24 states have specified limits, we assume the remaining 26 will essentially require $E_{s_i} = E_u$

$$E_s = \frac{\sum_{1}^{24} E_{s_i} + (26 \times E_u)}{50}$$

$$E_s = \frac{311 + 1430}{50} \cong 35 \text{ lb/TON}$$

$$\therefore E_s(\text{existing}) = 35 \text{ lb/TON} \quad \text{100\% acid}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-17-74

Source Sulfuric Acid

Acid Mist

E_u:

Ref 075 pg 5.17-1

68% of acid product : elemental sulfur
18.5% " spent acid & H_2S
13.5% " sulfide ores

Ref 075 Table 5.12-2

	Avg lb/TON acid
Recovered Sulfur	.58
Bright Virgin Sulfur	1.70
Dark Virgin Sulfur	3.31
Sulfide Ore	4.30
Spent Acid	2.45

$$E = .68\left(\frac{1.7 + .58 + 3.31}{3}\right) + .185(2.45) + .135(4.30)$$

$$E = 1.27 + .45 + .58$$

$$E_u = 2.3 \text{ lb/TON } 100\% \text{ acid}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-17-74

Source Sulfuric Acid

Acid Mist cont'd

E_N: Ref 075 Table 5.17-3

From this table, electrostatic precipitators or fiber mist eliminators we see that an emission level of .1 lb/TON is achievable.

∴ E_N = .10 lb/TON 100% acid

E_{IIId}: Ref 161 pg 1-9 to 1-10

.15 lb/TON (acid mist) 100% acid may be achieved easily at a good number of plants

.5 lb/TON 100% acid at the remainder (easily) and very expensive systems would be required but technically feasible to achieve .15 lb/TON

A level of .15 lb/TON is equivalent to new source performance standard

We assume E_{IIId} = .15 lb/TON 100% acid

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Computation Sheet For Emission Factors

Calculations Done By R.J. Marrone Date 12-17-74

Source Sulfuric Acid

Acid Mist: cont'd

E_s (new) Ref 147 pg 43 proposed standard for new source is .15 lb/TON 100% acid. Referring to Ref 148 & 084 we see that no states have regulation more stringent than this limit. Since all states must specify the NSPS level;

$E_s(\text{new}) = E_{\text{proposed}} = .15$ lb/TON

∴

$E_s(\text{new}) = .15$ lb/TON 100% acid

E_s: (existing)

Ref 084 & 148 The following States have acid mist regulations applicable to existing acid plants.

State	lb/TON acid
Alabama	.50
Georgia	.15
Illinois	.15
Indiana*	.50
Iowa	.50
Kansas	.50
Kentucky	.90
Mich	.70
Minn	1.70
Miss	.50
N.J.	1.90
N.Y.	.15
North Carolina	.50
Ohio	.50

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-17-74

Source Sulfuric Acid

Acid Mist cont'd

E_s : (existing)

State	lb/TON
Penn	.5
SC	.5
Tenn	.5
Virginia	.9
Wash	1.0

19 states have regs ∴ 31 state have $E_{si} = E_u$

$$E_s = \frac{\sum_{1}^{19} E_{si} + (31 \times E_u)}{50} = \frac{12.55 + 71.3}{50}$$

$$E_{s\,(existing)} = 1.68\ \text{lb/TON}\ 100\%\ \text{acid}$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-2-74

Source Acrylonitrile

Ref 031

K: Referring to Fig 12 which gives production and capacity data for acrylonitrile, we may calculate the K factor.

Taking 1970 as a point of reference

$$Cap_{70} = 1{,}500 \times 10^6 \text{ lb/yr}$$
$$Prod_{70} = 1{,}350 \times 10^6 \text{ lb/yr}$$

therefore

$$K = \frac{1{,}350}{1{,}500} = .9$$

P_c: Ref 031 pg 22 indicates that the demand for acrylonitrile is going to increase 9.5%/yr

From 096 July 1 1974 the following growth information is reported;

(1) 1963-1973 growth 11.5%/yr
(2) 1974 growth 7.5%/yr
(3) 1975-1978 est growth 10%/yr

nylon and plastic production is expected to be strong and therefore indicates good future of acrylonitrile (096). We will use the growth rate of 9.5%/yr as indicated in Ref 031

$$P_c = .095 \text{ compound}$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-2-74

Source Acrylonitrile

A: The previous report developing acrylonitrile industrial factors gave a 1975 production capacity value (A) of 1×10^6 Tons/yr, however looking at Fig 12 Ref. 031 we determine $P_{75} = 2000 \times 10^6$ lb/yr or 1×10^6 T/yr

applying the K-factor of .9 we estimate the 1975 prod. capacity as;

$$A = \frac{1 \times 10^6}{.9} = 1.1 \times 10^6 \text{ T/yr}$$

A more recent information source (Ref 096 July 1 1974) lists the capacity for acrylonitrile production as;

$$A = 1,650 \times 10^6 \text{ lb/yr}$$

or

$$A = .83 \times 10^6 \text{ T/yr}$$

We will use this more up-to-date number as indicative of the 1975 production capacity

$$\boxed{A = .83 \times 10^6 \text{ T/yr}}$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-25-74

Source Acrylonitrile

P_B:

Ref 037 pg 33 Sec 28.0

Asset guideline period for chemical manuf = 11 yrs

P_B is estimated by 2 × IRS = 22 yrs

100% Depreciation in 22 yrs $\Longrightarrow \frac{100\%}{22\ yrs} = 4.5\%/yr$ simple

$\therefore P_B = .045$ simple

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-2-74

Source Acrylonitrile

Hydrocarbons

E_u : Ref 050 Acrylonitrile pg 2

emissions after absorber (non control) Ton/Ton

Light HC	=	.150
Acrylonitrile	=	.010
Acetonitrile		.005
		.165 T/T

or E_u = 330 lb/Ton acrylonitrile produced

E_N : Ref 050 pg 2 suggests that use of thermal incineration could achieve nearly 100% control efficiency. We will assume a level of 99.95%

therefore

$$E_N = .0005 \times E_u$$

$$E_N = .165 \text{ lb/Ton}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-2-74

Source Acrylonitrile

Carbon Monoxide

E_u: Ref 050 Acrylonitrile pg 2

emission after absorber (no control)

CO - .180 Ton / TON acrylonitrile produced

or

E_u = 360 lb/TON acrylonitrile produced

E_N: Ref 050 pg 2 indicates an achievable control efficiency of 100% for CO reduction in a CO boiler.

We will use a value of 99.95%

E_N = .0005 × 360 lb/TON

E_N = .18 lb/TON acrylonitrile produced

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By R. Londergan Date 10/8/74

Source Acrylonitrile

HC :

As discussed in Vol #1,

$$E_S = E_S^u + E_S^P + E_S^A$$

Production capacity information has been obtained from Ref. 031, p. 24, which gives plant location & capacity.

(i) One acrylonitrile plant is located in Tenn., which has no stationary HC regulation*. The contribution to E_S is

$$E_S^u = \left(330 \text{ LB/TON}\right) \times \frac{180}{1025} = E_u \times A_i = 58.0 \text{ LB/TON}$$

where E_u is taken from a previous emission factor calc.

(ii) Texas, Louisiana, Kentucky, and Ohio have HC regulations which require specific emissions control efficiencies*. The table below lists fractional capacity and control efficiency for each state :

STATE	A_j	P_{cj} *
TEXAS	0.366	.90 **
LA.	0.122	.90
OHIO	0.293	.85
KY.	0.044	.85

* Ref 84 & 148

** Texas reg. requires incineration – we have assumed 90% efficiency.

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Computation Sheet For Emission Factors

Calculations Done By R. Londergan Date 10/8/74

Source Acrylonitrile

HC :

We then have

$$E_S^P = E_u \sum_{j=1}^{L} A_j (1 - P_{cj})$$

$$E_S^P = (330)[.488(.10) + .337(.15)] = 32.7 \text{ LB/TON}$$

The total result for E_S is then

$$E_S = E_S^u + E_S^P = 91 \text{ LB}^{HC}/\text{TON ACRYLONITRILE}$$

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Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10/9/74

Source Acrylonitrile

Carbon Monoxide:

None of the states with acrylonitrile plants have applicable CO regulations.* Therefore for carbon monoxide we have

$$E_s = E_u = \frac{360 \text{ LB CO}}{\text{TON ACRYLONITRILE}}.$$

* Ref. 84 & 148.

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-27-74

Source Ammonia

P_c :

Production data for synthetic ammonia was obtained as follows;

① 1951 - 1963 Ref 045 pg 79

② 1972 & 1973 Ref 144 pg S-25

These data were plotted and appear on the attached graph.

We calculated a compound growth rate a shown between the period 1967 - 1973. It is assumed that this growth rate will be applicable to the period 1975 - 1985.

$\therefore P_c = .09$ compound

K :

Sufficient data for ammonia production was not obtained so as to permit determination of an actual capacity utilization factor. We may obtain a representative value by referring to Ref 144 pg 48. We will use a K for the period 1965 - 1973 which is an average value derived ~~for the~~ chemical industry

$K = .83$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-27-74

Source Ammonia

A: Referring to the attached graph and reference 144 pg S-25 we may ~~at~~ estimate the ~~total~~ anhydrous ammonia production in 1975, and the 1975 production capacity.

$$P_c = .09 \text{ compound}$$
$$P_{1973} = 15.47 \times 10^6 \text{ TONS/yr}$$
$$K = .83$$

$$P_{75} = P_{73}(1+P_c)^2$$
$$P_{75} = 15.47(1.09)^2$$
$$P_{75} \cong 18.4 \times 10^6 \text{ TONS}$$

$$A_{75} = \frac{18.4}{.83} \times 10^6 \cong 22.2 \times 10^6 \text{ TONS}$$

Emission factors in Ref 075 (Table 5.2-1) specify two types of ammonia plants. Since these emission factors are different for each of the plants we must breakdown the capacity for the Ammonia Industry.

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-27-74

Source Ammonia

A: cont'd

A percentage breakdown for the Methanator nor the CO-absorber & Regeneration System could not be surmised from the available literature.

For the purpose of this study we will assume a 50-50 split between these two. ~~the~~ distinct processes.

$$A_{Methanator} = 11.1 \times 10^6 \text{ TON/yr}$$

$$A_{CO-Reg} = 11.1 \times 10^6 \text{ TON/yr}$$

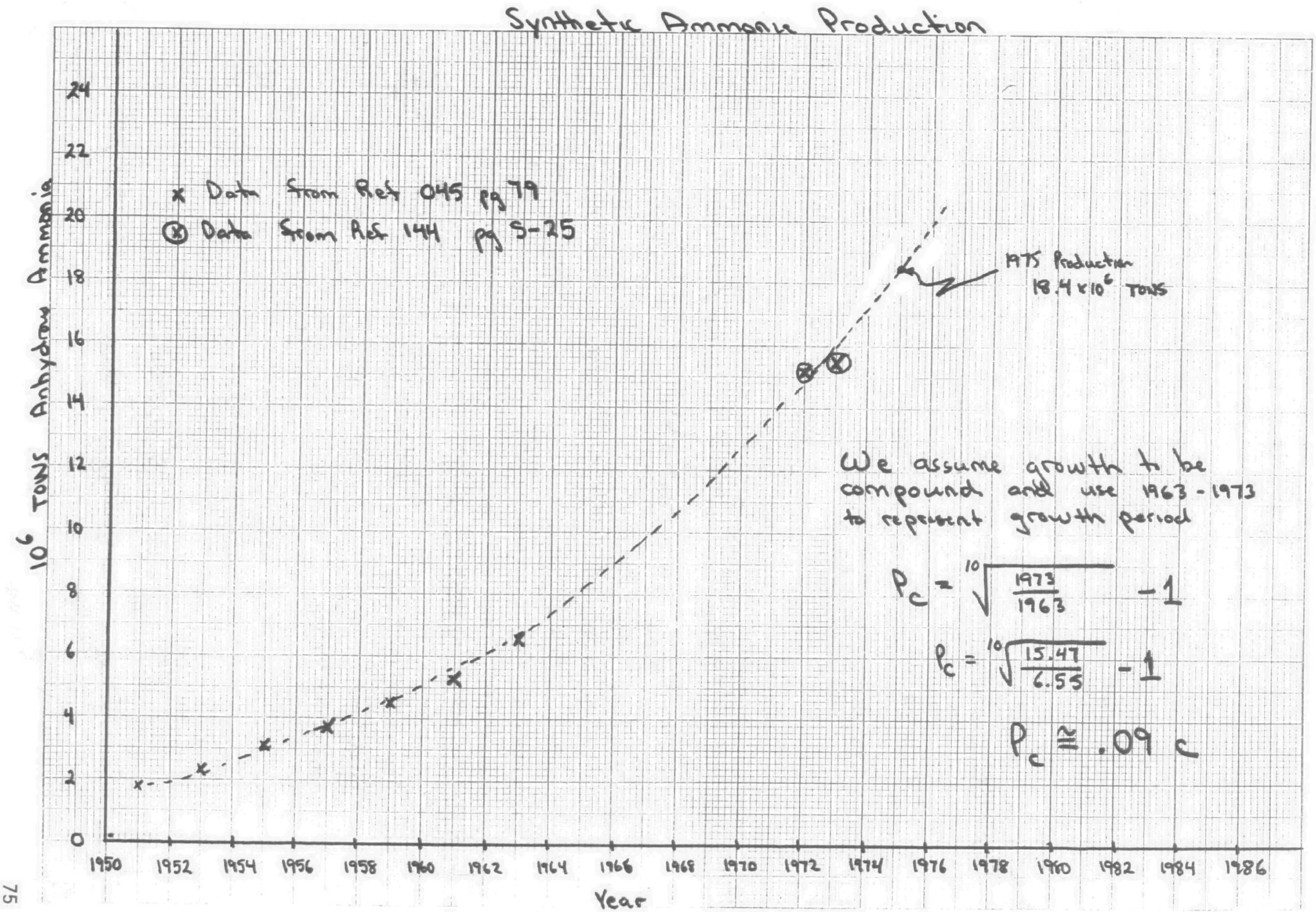
P_B: Ref 037 pg 33 Section 28.0

Asset guide line period 11 yrs

$P_B \rightarrow 2 \times IRS = 22$ yrs

$$\frac{100\%}{22 \text{ yrs}} = 4.5\%/\text{yr simple}$$

$$\therefore P_B = .045 \text{ simple}$$



We assume growth to be compound and use 1963 - 1973 to represent growth period

$$P_c = \sqrt[10]{\frac{1973}{1963}} - 1$$

$$P_c = \sqrt[10]{\frac{15.47}{6.55}} - 1$$

$$P_c \cong .09\ c$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 9-30-74

Source Ammonia

E_u:

Ref 075 Table 5.2-1

Methanator Plant

E_u lb/TON of NH_3 produced

	CO	HC	NH_3
Purge Gas	Negligible	90	3
Storage and Loading	–	–	200
Total	negligible	90	203

∴ $E_{u\,HC}$ = 90 lb/TON
$E_{u\,CO}$ = negligible
$E_{u\,NH_3}$ = 203 lb/TON
} methanator plant

CO absorber and regeneration system

E_u lb/TON NH_3 produced

	CO	HC	NH_3
Regenerator exit	200	–	7
Purge Gas	Neg	90	3
Storage and loading	–	–	200
Total	200	90	210

∴ $E_{u\,HC}$ = 90 lb/TON
$E_{u\,CO}$ = 200 lb/TON
$E_{u\,NH_3}$ = 210 lb/TON
} CO absorber & Regeneration system

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 9-30-74

Source Ammonia

E_N: Ref 075 Table 5.2-1 and associated comments addendum to the table.

Control capabilities for specific sources in ammonia manufacturing are reported as follows;

① The regenerator exhaust is stated as being controlled by a two-stage water scrubber and incineration system which may reduce NH_3 and CO emission to a negligible amount.

In this instance we assume negligible to mean 99.5% control

② 99% reduction in NH_3 emissions may be achieved for purge gas and storage-loading facilities through use of three-stage packed tower water scrubber. Hydrocarbons are not reduced

We assume that similar to the regenerator exhaust, we may include incineration to control HC and use an efficiency of 99.5% for HC.

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Computation Sheet For Emission Factors

Calculations Done By W Marrone Date 9-30-74

Source Ammonia

E_N cont'd

Methanator Plant

$E_{N\,HC} = .005 \times E_u = .005 \times 90 = .45$ lb/TON

$E_{N\,CO}$ = Negligible emission – no control imposed

$E_{N\,NH_3} = .01 \times 3$ (Purge) $+ .01 \times 200$ (Storage & Loading) $= 2.03$ lb/TON

∴ E_N HC = .45 lb/TON
E_N NH_3 = 2.03 lb/TON
E_N CO = negligible emission – no control

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 9-30-74

Source Ammonia

E_N: cont'd

CO absorber & Regeneration system

E_N CO = .005 × 200 (Regenerator, E_u) = 1 lb/TON

E_N NH_3 = .005 × 7 (Regenerator) + .01 × 3 (Purge) + .01 × 200 (Storage & Loading)

E_{NH_3} = .035 + .03 + 2

E_N NH_3 = 2.065 ≈ 2.07 lb/TON

E_N HC = .005 × 90 (Purge Gas) = .45 lb/TON

∴

E_N CO = 1.0 lb/TON NH_3 produced.

E_N NH_3 = 2.07 lb/TON NH_3 prod.

E_N HC = .45 lb/TON NH_3 prod.

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Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10/8/74

Source Ammonia

HC:

The HC emissions in the ammonia manufacturing process* consist predominantly of methane, which is a non-reactive hydrocarbon in the sense of air pollution regulations*. Non-reactive hydrocarbons emissions are in general not restricted by state regulations;** and therefore we would estimate that controls would not be required on HC emissions from ammonia plants. This assumption leads to the conclusion $E_S = E_u$, or

$$E_S = E_u = 90 \text{ LB/TON } NH_3$$

where E_u is taken from a previous ~~stack~~ emission factor calculation.

** Ref. 84 & 148

*** Certain states and local regulations do ~~prohibit~~ specify limits on non-reactive organic materials, but these are few and far between. In the absence of a geographic distribution of NH_3 production, we can assume that HC emissions are uncontrolled.

* HC emissions are the same for both NH_3 manufacturing processes, the methanator process and the CO absorber process.

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Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10/8/74

Source Ammonia

CO:

The CO absorber and regeneration system for NH_3 production results in CO emissions. State regulations for carbon monoxide* do not pertain to chemical industry processes, so CO emissions for this case are uncontrolled. Consequently,

$$E_S = E_u = 200 \frac{LB\ CO}{TON}\ NH_3$$

for the CO absorber system,

while $E_S = E_u$ = negligible for the methanator system.

The E_u factors are obtained from previous emission factor calculations.

NH_3 :

No ammonia emissions regulations are listed in our documentation.* Therefore, we assume that emissions are uncontrolled in all states, so that $E_S = E_u$. For the two NH_3 processes, this gives

(i) $E_S = E_u = 203 \frac{LB\ NH_3}{TON\ NH_3}$ (methanator)

(ii) $E_S = E_u = 210\ LB\ NH_3/TON\ NH_3$ (CO absorber)

* Ref 84 & 148.

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 11-1-74

Source Ammonia

E_{IIId} : NH_3

Applicable controls for the distinct manufacturing steps in the ammonia process are assumed equally feasible for new and existing plants. This is true for both types of Ammonia Plants $\therefore E_{IIId} = E_N$

$\therefore$

E_{IIId} [Methanator Plant] = 2.03 lb/TON NH_3 produced

E_{IIId} [CO absorber & Regenerator Plant] = 2.07 lb/TON NH_3 produced

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Computation Sheet For Industrial Factors

Calculations Done By HOPPER Date 8-2-74

Source CARBON BLACK - CHANNEL PROCESS

REF (45) p 211

"Before WW II, ABOUT 80% OF THE CARBON BLACK MANUFACTURED WAS CHANNEL BLACK . . . ."

"THESE FIGURES CHANGED IN 1946 TO ABOUT 51% . . . ."

"Since that time the popularity of furnace black has increased to 88% (1962)." IE 12% CHANNEL BLACK

REF (50)

"THE CHANNEL PROCESS IS ON THE WAY OUT (3% U.S. PRODUCTION 1970)

∴ P_C = NEGATIVE

WE WILL ASSUME THAT OBSOLETE PLANTS ARE NOT BEING REPLACED DUE TO THE LACK OF ECONOMIC INCENTIVE

$P_B = 0$

Since P_C is negative & P_B is zero, there is no capacity upon which to set standards for criteria pollutants

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 5/1/75

Source Carbon Black - Channel Process

Ref (75) p 5.3-2 TAB 5.3-1

$EU_P = 2300$ #/ton CB

$EU_{CO} = 33,500$ LB/ton CB

$EU_{HC} = 11,500$ LB/ton CB

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-2-74

Source Carbon Black - Furnace Process

K: Referring to the graph attached we may estimate the K factor for the Carbon Black - Furnace Process

Total Carbon Black produced (est for 1985) was given in reference 050 Carbon Black pg 1. With an assumption of 85% of production from Furnace (Ref 050 gives 83% Furnace, 14% Thermal, and 3% Channel) the production curve for the Furnace process is estimated.

The Furnace Prod Capacity as well as the Total for the industry is shown in Ref 096 July 1 1974. Calculation of the K factor is obtained by dividing the 1974 Capacity of 3.80×10^9 lb/yr into the 1974 production of 2.95×10^9 lb/yr gotten from the attached graph

We see that K = .77 (Furnace) and interestingly that K for the industry is about .83

We will use a utilization factor of;

K = .77

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-2-74

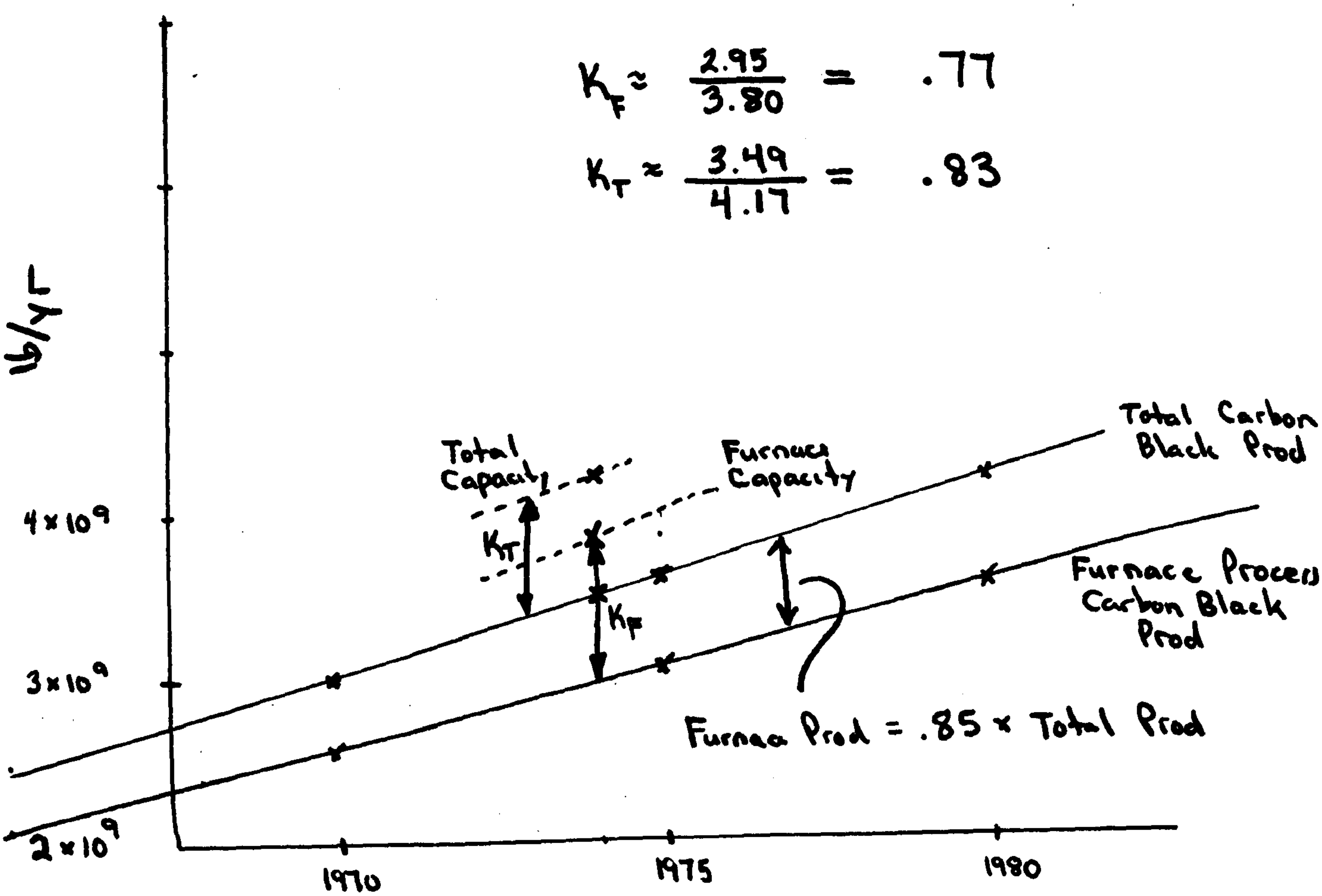
Source Carbon Black - Furnace Process

K: Support for calc of K value

Furnace Process Only

$$K_F \approx \frac{2.95}{3.80} = .77$$

$$K_T \approx \frac{3.49}{4.17} = .83$$



Capacity values in 1974 obtained from Ref 096 July 1 1974

Total Carbon Black Prod obtained from Ref 050 Carbon Black pg 1.

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-2-74

Source Carbon Black - Furnace Process

A: The estimated production (Ref 050 Carbon Black pg 1) for 1975 is;

$$P_{75} = 1,800,000 \times .85$$

$$P_{75} = 1,530,000 \text{ T/yr}$$ Furnace Process

$$A = \frac{P_{75}}{K} = \frac{1,530,000}{.77} = 1,987,000 \text{ T/yr}$$

∴

$$A = 1,987,000 \text{ T/yr}$$ Carbon Black by Furnace only

P_c : Ref 096 July 1 1974

A predicted growth of 2-3 %/yr is indicated for the period 1975 to 1978.

We will use a growth rate of 2.5%/yr assumed to be compound. For the 1975 to 1985 period.

∴ $P_c = .025$ compound

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-26-74

Source Carbon Black - Furnace Process

P_B :

Ref 037 pg 33 Section 28.0

Carbon Black is assumed to be covered under this section of the IRS Table.

Asset guideline life 11 yrs
P_B est ≈ 2×IRS = 22 yrs

100% Depreciation in 22 yrs $\frac{100\%}{22 yrs} \approx 4.5\%/yr$ simple

$\therefore P_B = .045$ simple

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-6-74

Source Carbon Black - Furnace

Data from Ref 049 (Table 21-1 pg 472) for 1968 gives a breakdown of fuel use for the Furnace Process in Carbon Black Manuf.

1,180,000 Ton with Oil
156,000 Ton with Gas

1,336,000 Tons Total

$$\% \text{ by oil} = \frac{1,180,000}{1,336,000} = .88 \text{ or } 88\%$$

Since the overwhelming majority of carbon black produced (according to 1968 data and assumed to hold true in 1975) is by oil fuel we will use this as our basis for emission factor determination

As an integral part of the Furnace Process some collection system is required for carbon black product collection. Electrostatic precipitators, Baghouse Filters, cyclone scrubbers etc are used singularly or at times in series. 85-90% efficiency has been cited by Ref 049 p474; and Ref 075 Tab 5.3-1 pg 5.3-2, as the minimum collection (recovery) efficiency for this manufacturing process

Calculation of E_u factors will therefore be done on the basis of oil-fuel usage and 90% carbon recovery.

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Computation Sheet For Emission Factors

Calculations Done By RJ Marrone Date 8-6-74

Source Carbon Black - Furnace

Particulate

E_u: Ref 075 Table 5.3-1 pg 5.3-2 gives an emission factor for 90% carbon recovery (use of a cyclone) which as we discussed is assumed to be the "uncontrolled" emission factor.

E_u = 220 lb/TON of carbon black

E_N: Control systems have ranged from three-unit series arrangements using precipitators, baghouses, and cyclones to single baghouse collection systems. Ref 075 cites a 99.5% overall eff using the fabric system. (see above Table ref) Ref 049 p 475 even goes as far as saying that bag systems are replacing other collection devices

We assume an overall efficiency for these systems of 99.9% as attainable in 1975-1985

$$E_N = .001 \times \frac{220}{.10}$$

E_N = 2.[illegible] lb/TON carbon produced

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-6-74

Source Carbon Black - Furnace

Carbon Monoxide

E_u: Carbon monoxide emissions are obtained from Table 5.3-1 Ref 075, using Furnace - oil category

E_u = 4,500 lb/TON of carbon Black

Note: It is stated that for every 32 lbs of carbon theoretically available in 1000 ft³ gas 1.0 to 1.5 lbs of carbon is produced and the remainder is emitted as CO, CO_2, and uncaptured carbon

E_N: Ref 050 Carbon Black pg 2 indicates that complete control can be achieved by utilizing a CO boiler or incinerator. We will assume 99.9% efficiency

$$E_N = .001 \times E_u$$

E_N = 4.5 lb/TON

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-6-74

Source Carbon Black - Furnace

Hydrocarbons

E_u:

Assuming the use of oil fuel to be predominant then the uncontrolled emission factor will be based on this fuel. Ref 075 pg 5.3-2 give E = 400 lb/TON for oil in the Furnace Process,

$$E_u = 400 \text{ lb/TON carbon Black}$$

If we were to prorate this factor by the % we we would have, using Ref 075 emission data

oil - 400 lb/Ton
Gas 1800 lb/Ton

$$E = .88(400) + .12(1800)$$
$$E = 352 + 216$$
$$E \cong 570 \text{ lb/TON}$$

Since this figure is significantly higher and better represents the picture of the industry we will use this factor,

$$\therefore E_u = 570 \text{ lb/TON of carbon black}$$

E_N: Ref 050 indicates that complete removal of hydrocarbons by thermal or catalytic incineration. We assume 99.9% eff $E_N = .001 \times E_u$

$$E_N = .57$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-5-74

Source Carbon Black - Furnace

Sulfides

E_u: Sulfide emissions are released in the form of hydrogen sulfide. The emission is dependent on the type and sulfur content of the fuel. Natural gas should have negligible sulfide emissions. According to Ref 075 p 5.3-2 the factor may be approximated by the relationship

$E = 38\,S$ where S is the sulfur content.

Perry Handbook Ref 101 pg 9-6 sets the limit for No. 2 distillate fuel at 1% S and No1 at .5% S. We will assume the maximum sulfur content of 1% for this calculation

$E_u = 38$ lb / TON of carbon black from oil

By weighting the emissions for fuel usage we obtain;

$$E = .12 \times 0 + .88 \times 38$$
$$= 0 + 33$$

$E_u = 33$ lb / TON

*This is a weighted factor representative of the whole Furnace industry.

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-6-74

Source Carbon Black - Furnace

Sulfides - cont'd

E_N: Ref 050 indicates complete removal of H_2S (sulfides) by either thermal or catalytic incineration. We will assume 99.9% eff

$$E_N = .001 \times E_u$$

E_N = .033 lb/TON carbon produced represented in terms of H_2S

E_{IIId}: Transfer of this control technology to existing plants is assumed to be as effective as for new plants.

$\therefore E_{IIId} = E_N$

E_{IIId} = .033 lb/TON carbon

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-6-74

Source Carbon Black - Furnace

Plants sizes vary 3,000 - 50,000 T/yr Ref 045
Modern Plants 25,000 - 35,000 T/yr p212

Most of carbon black plants are located in Texas and Louisiana with some others in California*, New Mexico, Arkansas, North Carolina, and Ohio.

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-17-74

Source Carbon Black (Furnace)

E_S: cont'd

Taking the production capacity in 1963 and the total industry plants in 1963 we may estimate an average typical carbon black plant capacity

$$\text{Typical Plant} = \frac{2{,}662 \times 10^6 \ \frac{lb}{yr}}{37 \text{ plants}} \times \frac{TON}{2000\ lb} \cong 3.6 \times 10^4$$

36,000 T/yr carbon production capacity

With an efficiency of 90% the carbon input may be calculated from 36,000 T/yr carbon produced as;

$$\frac{36{,}000\ T/yr}{.90} = 40{,}000\ T/yr$$ carbon feed (process weight) for typical plant

Assuming an operating schedule of $350\ \frac{d}{yr} \times 24\ \frac{hr}{d} = 8400\ \frac{hr}{yr}$

$$40{,}000\ \frac{Ton}{yr} \times \frac{yr}{8400\ hr} \times 2000\ \frac{lb}{TON} = 9{,}524\ lb/hr$$

typical process weight rate

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Calculations Done By W. Marrone Date 10-17-74

Source Carbon Black (Furnace)

E_S:

In this process, the carbon produced in the furnace ~~to~~ ~~by~~ sub-stoichiometric combustion is collected by a product collection device which we have already stated is on the average 90% efficient.

Ref 050 "Carbon Black" pg 3 industry is presently only 10% controlled

We make the assumption that the industry is essentially uncontrolled and that the production of carbon black is obtained by an average product collection system which is 90% efficient.

Ref 045 p 210 Production 1963 ≅ 2050×10^6 lb/yr

Using K = .77 $A_{63} = 2662 \times 10^6$ lb/yr

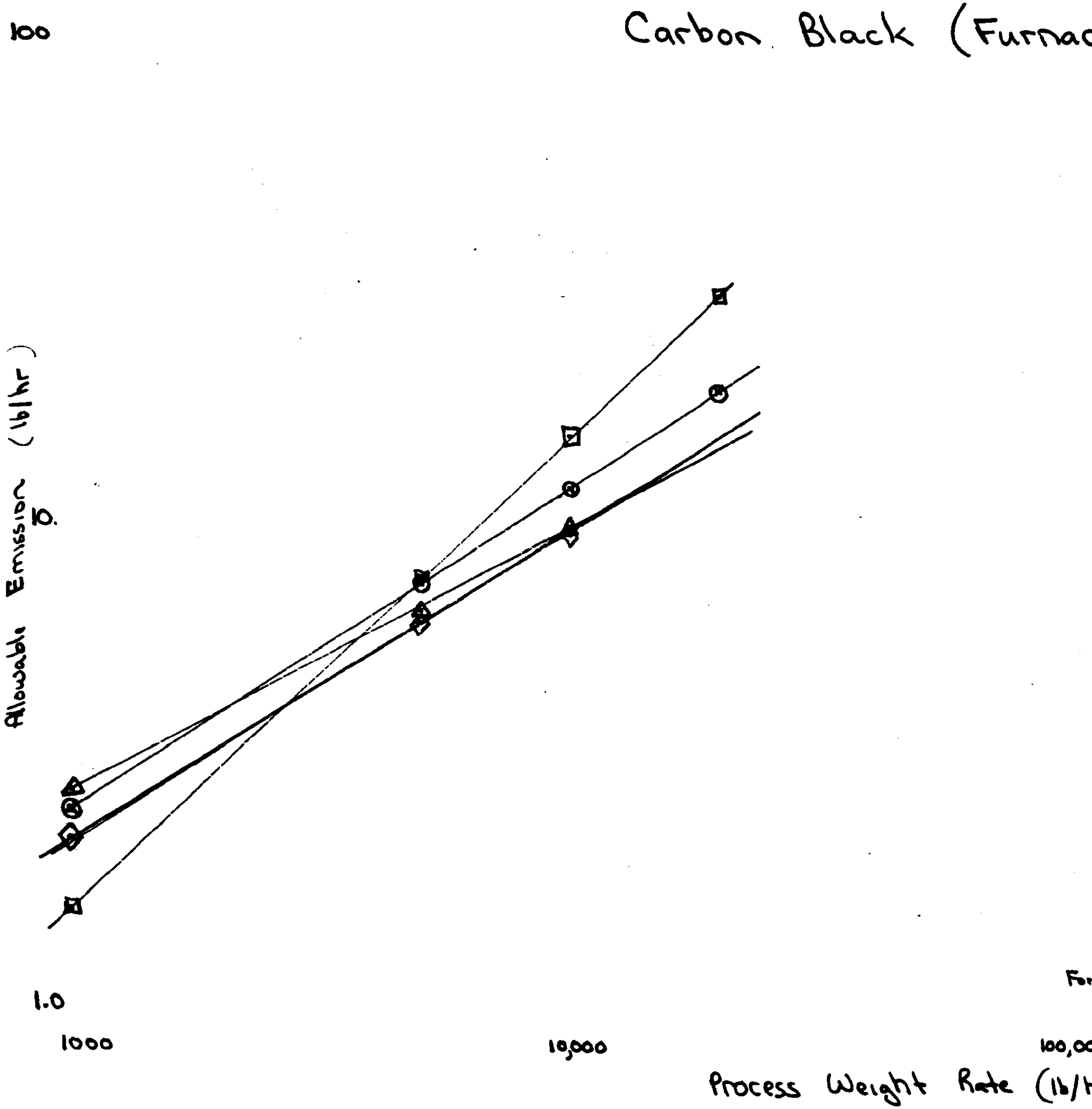
Ref 045 pg 212-213

A list of carbon black plants in 1963 is given which indicates the following breakdown

37 plants

State	No. of Plants	% of Total Plants (A_i)
Texas	18	.48
La	7	.19
N.M.	3	.07
Calif	4	.11
Pa	1	.03
Ark	1	.03
Kansas	1	.03
Okla	1	.03
North Carolina	1	.03

Carbon Black (Furnace)



California - no state wide Regulation Table

Penn $A = .76\ E^{.42}$

A - lb/hr allowable PT

$E = F \times W$

For Carbon Black $F = 500$ lb/TON product

$W = \frac{.9 \times 9524}{2000} = 4.29$ T/hr

$A \cong 19.1$ lb/hr

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-17-74

Source Carbon Black (Furnace)

E_S : cont'd

Ref 148 & Ref 084 Table III — From SIP's obtain allowable emissions for this process weight.

State	E_{si} Allowable Emission lb/hr	$A_i \times E_{si}$
Oklahoma	11.5	.345
North Carolina	11.5	.345
Louisiana	11.5	2.185
Kansas	11.5	.345
Texas	14.5	6.960
New Mexico	9.6	.672
Arkansas	9.5	.285
Penn	19.1	.573
California	Avg (E_S^A)	$.11 \times E_S^A$

assume Calif has avg of other states

$$E_S^A = .11 E_S^A + 11.71$$

$$(1 - .11) E_S^A = 11.71$$

$$E_S^A = \frac{11.71}{.89} \cong 13.16 \text{ lb/hr}$$

$$13.16 \frac{\text{lb}}{\text{hr}} \times 8400 \frac{\text{hr}}{\text{yr}} = 110,545 \text{ lb/yr} \quad \text{emissions}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-17-74

Source Carbon Black (Furnace)

E_s: cont'd Particulates

Using the allowable emissions of 110,545 lb/yr and the production capacity of 36,000 T/yr we may evaluate E_s;

$$E_s = \frac{110,545 \text{ lb/yr}}{36,000 \text{ T/yr}} = 3.07 \text{ lb/TON} \approx 3.1 \text{ lb/TON}$$

$\therefore$ $E_s = 3.1$ lb/TON carbon produced

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Computation Sheet For Emission Factors

Calculations Done By 2) Marrone Date 10-17-74

Source Carbon Black (Furnace)

E_s: cont'd CO, HC, H_2S

There are no specific nor general ~~state~~ regulations which may applied to the carbon black industry with respect to CO, HC, or H_2S so that we assume $E_s = E_u$

$\therefore$

E_s CO = 4,500 lb/TON carbon black

E_s HC = 570 lb/TON carbon black

E_s H_2S = 33 lb/TON carbon black

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 12-16-74

Source Charcoal Manufacturing

K: Little information was obtained to access the utilization of capacity for this industry. We will estimate the value of K by using Ref 144 Table 1 pg 48

For chemical process industries K avg 1965-1973 = .83

For primary processed goods K avg 1965-1973 = .85

Until more specific information appears relative to charcoal manufacture we will use a figure of K = .85 for charcoal manufacture capacity utilization ratio.

∴ K = .85

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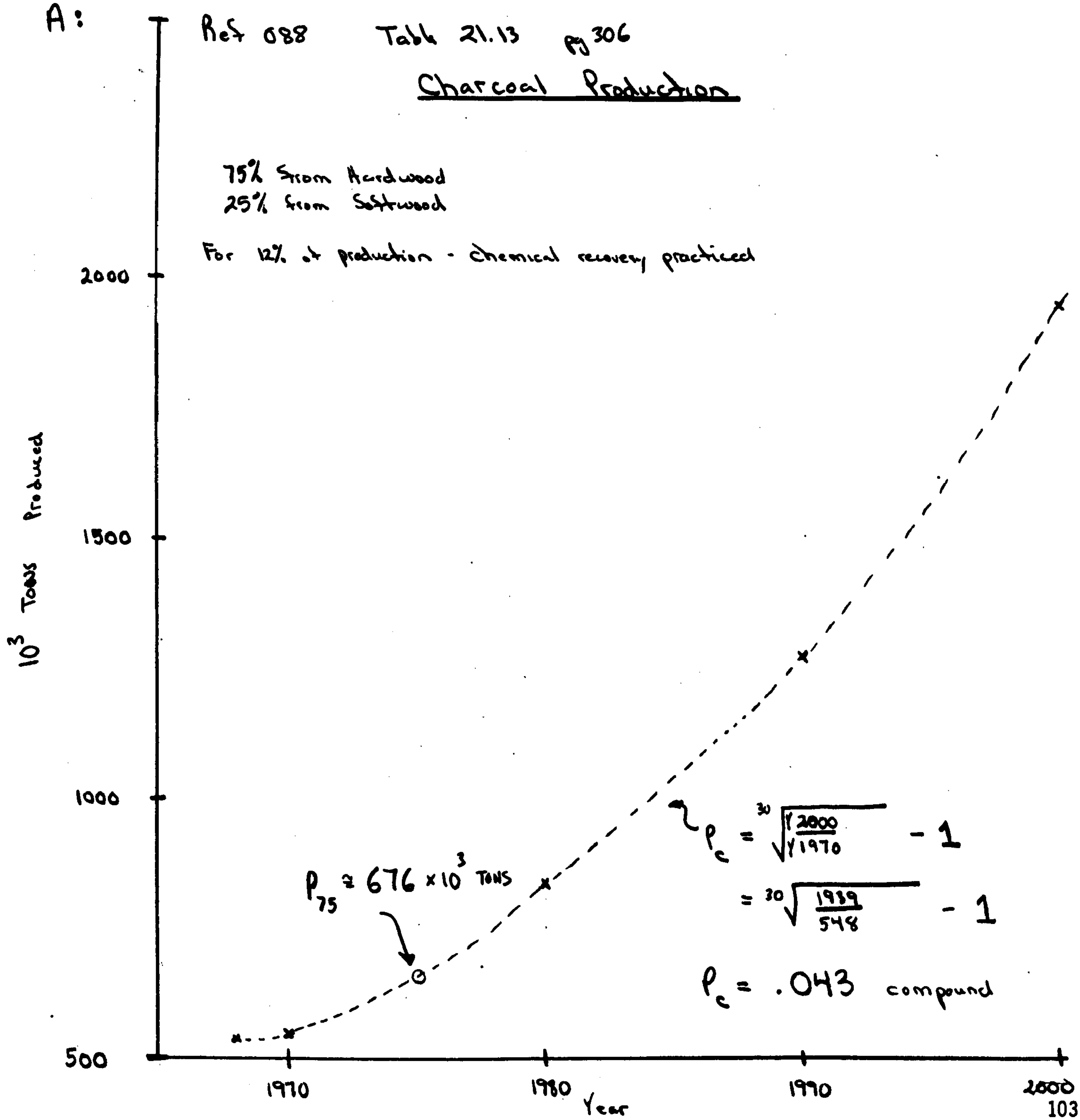
Computation Sheet For Industrial Factors

Calculations Done By W. Massone Date 12-16-74

Source Charcoal Manufacture

A:



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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 12-16-74

Source Charcoal Manufacturing

A: cont'd

$P_{75} = 676 \times 10^3$ TONS

$K = .85$

$\therefore \quad A = \frac{P_{75}}{K} = \frac{676 \times 10^3 \text{ TONS}}{.85} \cong 795 \times 10^3$ TONS

$\therefore$ $A = 795 \times 10^3$ TONS/yr
or $.795 \times 10^6$ TON/yr

P_c:

From curve of production we estimate a compound growth rate by

$$P_c = \sqrt[30]{\frac{Y_{2000}}{Y_{1970}}} - 1$$

$P_c = .043$ compound

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 12-16-74

Source Charcoal Manufacturing

P_B:

Ref 037 Class 28.0

Asset Guideline Period 11 yrs

P_B est → 2 × IRS 22 yrs

$\frac{100\%}{22 \text{yrs}}$ = 4.5% /yr simple

∴ P_B = .045 simple

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-16-74

Source Charcoal Manufacturing

E_u: Particulate Ref 075 pg 5.4-1

Charcoal from pyrolysis of wood

24 hr distillation cycle (batch) in retort

4 units hard wood → 1 unit charcoal

Plants may operate with chemical plant recovery or without.

As stated in Ref 088 pg 306 12% of production was assumed to utilize chemical recovery of methanol and acetic acid.

We will weight emission factor from Ref 075 Table 5.4-1 (lb/TON charcoal was verified from ref 093, 619)

E = .12 (with recovery) + .88 (without recovery)

Particulate

E = .12 (0) + .88 (400)

E = 0 + 352 ∴ E_u = 352 lb/TON charcoal

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-16-74

Source Charcoal Manufacturing

E_u: cont'd

Carbon Monoxide

$$E = .12(320) + .88(320) = 1.0(320) = 320 \text{ lb/ton}$$

$$\therefore E_{u_{CO}} = 320 \text{ lb/ton charcoal}$$

Hydrocarbons

lb/ton

	with Recovery	without Recovery
HC	100	100
Methanol	—	152
Acetic Acid	—	232
	100	484

$$E = .12(100) + .88(484) \approx 12 + 426 \cong 438$$

$$\therefore E_{u_{HC}} = 438 \text{ lb/ton charcoal}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-16-74

Source Charcoal Manufacturing

E_N : Ref 075 pg 5.4-1

"Gaseous emissions can be controlled by means of an afterburner because the byproducts are combustible. If an afterburner operates efficiently, no "organic pollutants should escape into the atmosphere."

Since this same source identifies the particulate as tars and oils, we suspect this material to be adequately control in an incinerator/afterburner.

An efficiency of 99% is assumed for Part, HC, & CO

Particulate:

$E_N = .01 \times 352 = 3.5$ lb/TON charcoal

Hydrocarbon

$E_N = .01 \times 438 \approx 4.4$ lb/TON charcoal

CO

$E_N = .01 \times 320 = 3.2$ lb/TON charcoal

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-16-74

Source Charcoal Manufacturing

E_s : hydrocarbon - co

There are no specific hydrocarbon or carbon monoxide regulations applicable to this source. We assume the $E_s = E_u$

$$E_s\,(co) = 320 \text{ lb/TON charcoal}$$

$$E_s\,(HC) = 438 \text{ lb/TON charcoal}$$

Particulates:

Ref 236 pg IV-10

emission occur 7 days out of 25 days for a typical Missouri kiln charged with 50 cords of wood.

$$4000 \frac{lb}{cord} \times 50 \text{ cord} \times \frac{1}{7 \text{ day}} \times \frac{day}{24 \text{ hr}} = 1190 \text{ lb/day}$$ avg process weight rate

From the Generalized Process Table for this weight rate the allowable emissions are 2.9 lb/hr

$$E_s' = \frac{2.9 \text{ lb/hr}}{1190 \text{ lb/hr input}} \times 2000 \frac{lb}{T} = 4.87 \frac{lb}{\text{TON input}}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-16-74

Source Charcoal Manuf.

E_s: cont'd

Particulate

Using 4 TONS input → 1 TON charcoal

$$E_s = 4.87 \frac{lb}{TON\ input} \times \frac{4\ TON\ input}{TON\ charcoal}$$

$$E_s \cong 19.5\ lb/TON\ charcoal$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-13-74

Source Chlor - Alkali

K:

Ref 146 pg 93

"The chlor-alkali industry's growth and recovery continued during 1973 from the low level posted in 1970-1971. The output gain brought the chlorine operating rate to 97-98 percent of recorded capacity in 1973, compared to 92 percent in 1972."

Using the utilization during a slow period (92%) and the peak level (97-98%) we estimate the capacity utilization factor for the period 1975-1985 as the average between these two figures.

$$K = \frac{97.5 + 92}{2} = 94.75 \div 100 \cong .95$$

$$\therefore K = .95$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-13-74

Source Chlor-Alkali

A: This industry comprises the chlorine, caustic, soda ash, and potash production. We are concerned here with the production of chlorine-caustic or chlorine-alkali. According to Ref 045 pg 253-254 and pg 697; approximately 7% of chlorine in 1963 came from sources ~~other~~ other than electrolytic and that by 1965, 98% of all caustic derived from these same electrolytic processes.

There, fore most of the chlorine and caustic produced in the US comes from the electrolytic process as co-products.

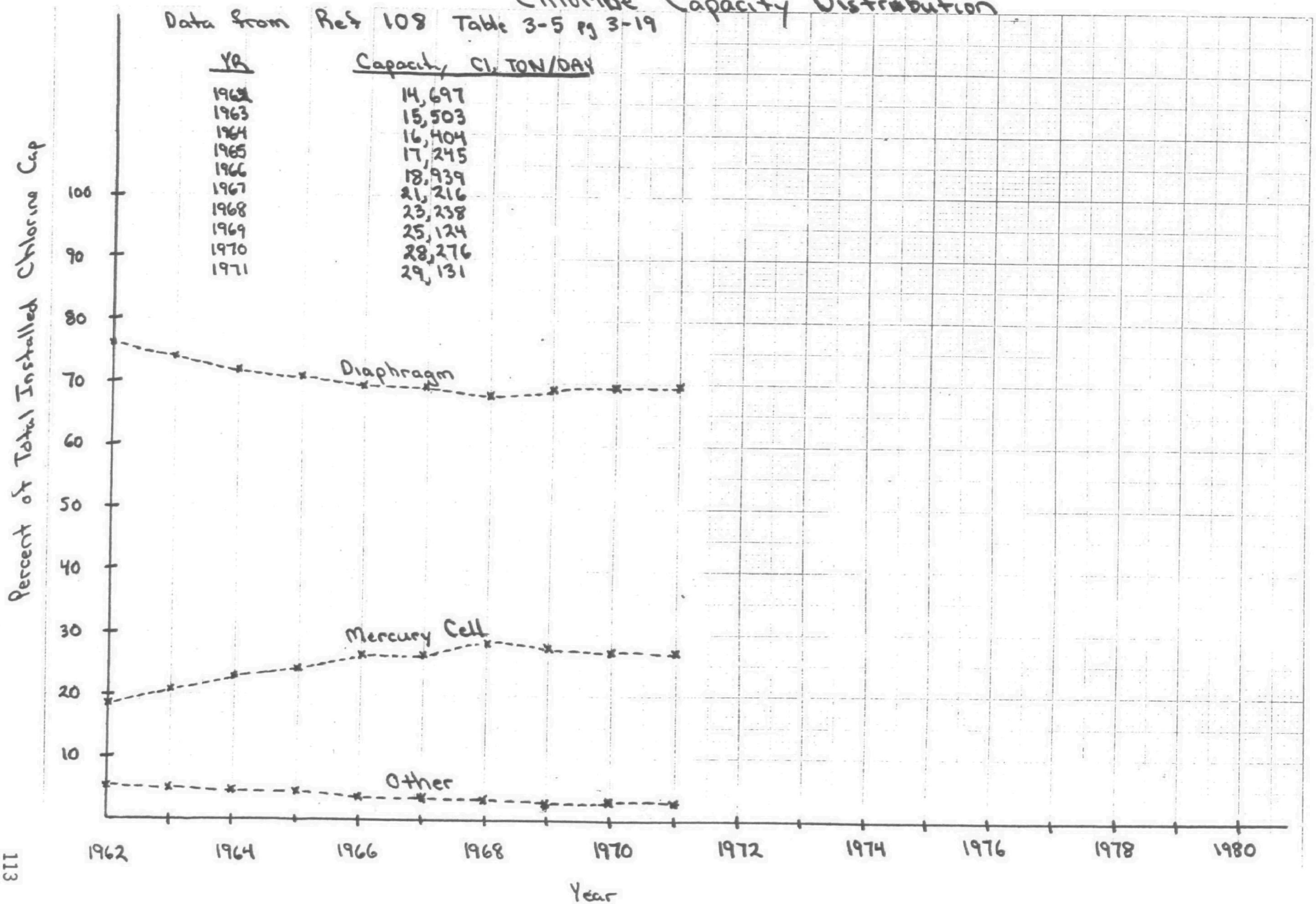
The attached graph illustrates the breakdown between the two electrolytic process and "other" sources in the total installed chlorine capacity for the chlori-alkali industry. We also present the growth in the total daily chlorine capacity from 1962 to 1971 with a projection of the curve to 1975.

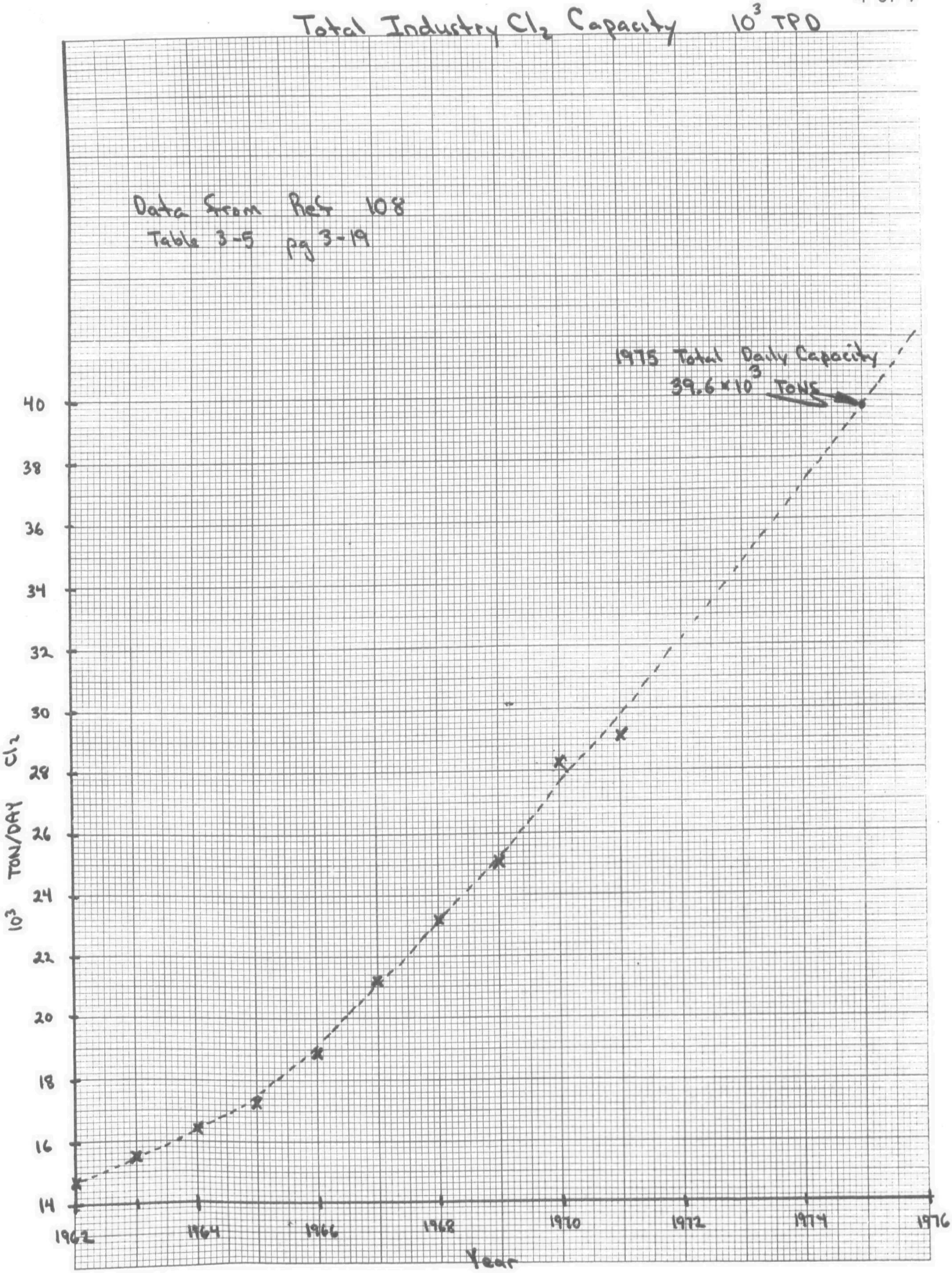
Total 1975 Daily Production Capacity
39.6×10^3 TON/DAY

Chlorine Capacity Distribution

Data from Ref 108 Table 3-5 pg 3-19

YR	Capacity, Cl, TON/DAY
1962	14,697
1963	15,503
1964	16,404
1965	17,245
1966	18,939
1967	21,216
1968	23,238
1969	25,124
1970	28,276
1971	29,131




Total Industry Cl_2 Capacity 10^3 TPD
Data from Ref 108
Table 3-5 pg 3-19
1975 Total Daily Capacity
39.6×10^3 TONS
10^3 TON/DAY Cl_2
40
38
36
34
32
30
28
26
24
22
20
18
16
14
1962
1964
1966
1968
1970
1972
1974
1976
Year

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-13-74

Source Chlor - Alkali

A: cont'd

The approximate breakdown in 1971 was;

69.8% for Diaphragm Cells
27.2% for Mercury Cells
3.0% for Other Sources

We were unable to ascertain future trends for this capacity breakdown interms of quantitative numbers. For our estimate we will assume that 97% of ~~the~~ chlorine capacity is derived from electrolytic cells. (70% for diaphragm and 27% for mercury cell)

For an assumed operating schedulec of 350 d/yr and a total Cl_2 capacity (daily) of 39.6×10^3 T/D we may estimate the 1975 Prod Capacity (in terms of chlorine) for diaphragm and mercury electrolytic cells as;

Diaphragm Cells

$$A_D = .7 \times 39.6 \times 10^3 \frac{T}{D} \times 350 \frac{D}{yr}$$

$$A_D = 9.7 \times 10^6 \text{ TON/YR chlorine}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-13-74

Source Chlor- Alkali

A: cont'd

Mercury Cells $A_m = .27 \times 39.6 \times 10^3 \frac{T}{D} \times 350 \frac{D}{yr}$

$A_m = 3.74 \times 10^6$ TON/yr Chlorine

P_c :

We assume that growth in the chlor-alkali is the same for the diaphragm and the mercury cell plants

Ref 146 pg 95 indicates that production and use of chlorine and caustic soda is expected to grow at ~~6~~ to 7 percent through 1980. We will estimate the average growth rate for the period 1975 -1985 as 6.5% annually

$\therefore P_c = .065$ compound

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-25-74

Source Chlori - Alkali

P_B:

Mercury Cells and Diaphragm Cells:

We will estimate the obsolescence rate for both plant types from IRS guidelines

Asset Guideline Period = 11 yrs
P_B estimate by 2 x IRS = 22 yrs

100% Depreciation in 22 yrs

$\frac{100\%}{22 \text{ yrs}} \cong 4.5\% / yr$

$\therefore P_B = .045$ simple

Ref 108 pg A10 - A11
Ref 052 pg 88-91 } give plant Info and location of Chlori-Alkali producers.

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 9-16-74

Source Chlor - Alkali

Chlorine:

E_u: Ref 075 Table 5.5-1

Diaphragm Cells

E = 2,000 to 10,000 lb / 100 tons chlorine

use average value $\frac{12,000}{2}$ = 6000 lb/ TON

or E = 60 lb/TON from blow gas

Other sources; Tank cars 450 lb/100 TON
Storage Tanks 1200 lb/100 TON
[illegible] B. 1650. lb/100 TON or 16.5 lb/TON

∴ $E_{u\ \text{Diaphragm}}$ ≅ 77 lb/TON chlorine produced

Diaphragm Cells

E_N: above reference indicates that a caustic or lime scrubbing system can achieve an emission level of 1 lb/100 TONS or .01 lb/TON chlorine produced

Control of tank cars and storage tanks can be achieved according to Ref 052 pg 20 by treatment in water or caustic scrubbers. We assume that the minor contribution of chlorine emissions from these sources in comparison with the blow gas will not appreciably change the blow gas control efficiency.

∴ $E_{N\ \text{diaphragm}}$ = .01 lb/TON Cl_2 produced

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 9-16-74

Source Chlor - Alkali

Chlorine cont'd

E_u: Ref 075 Table 5.5-1

Mercury Cells

$E = 4{,}000 \rightarrow 16{,}000$ lb/100 TON Cl_2

we will use an average value

$\frac{4000 + 16000}{2} = 10{,}000$ lb/100 TON

or $E = 100$ lb/TON Cl_2 from blow gas

Other sources as in Diaphragm Cell

Tank Cars 450 lb/100 TON

Storage Tanks 1200 lb/100 TON

1650 lb/100 TON or 16.5 lb/TON Cl_2

$\therefore E_{u\,(mercury)} \cong 117$ lb/TON Clorin produced

E_N: Mercury Cells

We will use the control assumption used for the diaphragm cells.

$\therefore E_{N\,(mercury)} = .01$ lb/TON Clorine produced

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 11-1-74

Source Chlor - Alkali

E_{IIId} : Chlorine

Caustic Scrubbing of blow tank emissions and other miscellaneous sources is assumed feasible on existing plant as well as on new plant both for Diaphragm and Mercury Cell Facilities. $\therefore E_{IIId} = E_V$

$\therefore E_{IIId}$ (Diaphragm) = .01 lb/TON Cl_2 produced

E_{IIId} (Mercury) = .01 lb/TON Cl_2 produced

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 9-16-74

Source Chlor - Alkali

Mercury

Mercury emissions are attributable to Mercury Cell Plants only

Sources: (1) hydrogen by-product stream
(2) end-box ventilation
(3) cell-room ventilation

Mercury Cell Plants

E_u:

Ref 108 pg 3-22 to 3-23 and p 3-24 to 3-30

The hydrogen by-product stream would emit 220 lb/100 TONS if completely uncontrolled. All plants have a minimum treatment to recover the valuable mercury. The estimated emission of mercury vapor and mist after minimum treatment is about 50 lb/100 TONS or E = .5 lb/TON chlorine produced

Estimated emission from end-box ventilation uncontrolled range from 2 to 15 lb/100 TONS. We will use $\frac{2+15}{2} = 8.5 \cong 9$ lb/100 TON

or E = .09 lb/TON chlorine produced.

Cell room ventilation emission estimate range .5 to 5 lb/100 TON Cl_2

We use $\frac{.5+5}{2} = 2.75 \cong 2.8$ lb/100 TONS

or E = .028 lb/TON chlorine produced

$\therefore E_u = .5 + .09 + .028 = .618$ or $\approx .62$ lb/TON

$\therefore E_u = .62$ lb/TON chlorine produced

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Computation Sheet For Emission Factors

Calculations Done By ______________________ Date ____________

Source ____

Mercury Cont'd.

E_N: Mercury Cell Plants

cell room emission represent only 4-5% of the total mercury discharge $\left(\frac{.028}{.618} \cong .045 \text{ or } 4.5\%\right)$

Control according to Ref 108 pg 3-30-3-31, is normally achieved by improved housekeeping and maintanence. Other than reporting "sizeable reductions" this source gave no quantitative estimate. We estimate a conservative 85% attainable efficiency ∴ E = .15 × .028

E ≅ .004 lb/TON

Table 3-6 of Ref 108 indicates the following estimated emission rates for control systems on combined H_2 and End Box streams:

① chemical scrubbing .02→.6 lb/100 TON
② Activated Carbon .3 lb/100 TON
③ Molecular Sieve .1 lb/100 TON

We will use .1 lb/100 TON the highest estimated

∴ E = .001 lb/TON

E_N = .004 + .001 = .005 lb/TON chlorine produced

This corresponds to an overall eff of $\frac{.618 - .005}{.618} \times 100$ = 99.2%

(∴ E_N = .005 lb/TON chlorine)

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 9-16-74

Source Chlor - Alkali

Carbon Monoxide

Ref 052 pg 23 estimates that the carbon monoxide concentration in diaphragm and mercury blow gas after chlorine liquification is about .4% by volume.

Actual emission factors nor volume exhaust rates were not found in the literature. We may however, estimate the emissions as follows:

Ref 052 Table 4 pg 19

E_4: Cl_2 emission from liquification blow gas 20 - 50% by vol
2,000 - 16,000 lb/100 TONS

Using 20% and 2000 lb/100 TONS and ratioing this data along with MW factor we may crudely estimate the CO emission

$MW_{Cl_2} = 71$
$MW_{CO} = 28$

$$\frac{.20 \times 71}{2000} = \frac{.004 \times 28}{x}$$

$$x = \frac{.004 \times 28 (2000)}{.20 \times 71} = 15.8 \text{ lb}/100 \text{ TONS}$$

$\therefore E_4 = .158$ lb/TON Cl_2 produced

Mercury & Diaphragm

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 9-16-74

Source Chlor - Alkali

Carbon Monoxide cont'd

E_N :

Control of CO has not be indicated

Since the emission factor is relatively small we will evaluate the full impact of CO emission from this industry by assuming, at this point, $E_N = 0$.

The impact will relate therefore to a pollutant which is presently not controlled within this industry and, depending on the value of $T_S - T_N$, guide management decisions on relative importance of implementing studies aimed at seeking state-of-the-art control technology.

$$\therefore E_N = 0$$

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Computation Sheet For Emission Factors

Calculations Done By U.F. Russo Date 10/8/74

Source Chlor-Alkali

Mercury Emissions:

Ref. 146, pg 94 states that there are 44 total plants.

Assuming the number of plants for each of the process (diaphragm cell and mercury cells) is in the proportion of the respective capacity

$$N_{plant}^{Hg\ cell} = \left(\frac{3.74 \times 10^6 \text{ TON/YR FOR Hg cell}}{13.86 \times 10^6 \text{ TON/YR Total Cap}} \right) 44 \text{ plants}$$

$\cong 12$ plants

$$N_{Plant}^{Dia.\ cell} \cong 31 \text{ plants}$$

$$\therefore N_{Plant}^{other} \cong 44 - (31 + 12) = 1 \text{ plant}$$

Only Hg cells contribute Hg emissions. Assuming a 365 day operation (see calculations for HC for explanation of following equation)

$$E_S = \frac{365}{A(\text{TONS/YEAR})} \sum_{i=1}^{M} E_S^i N_{P_i}$$

where E_S units lbs/TON
E_S^i is reg. for i^{th} state in lbs/day

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Computation Sheet For Emission Factors

Calculations Done By U.F. Russo Date 10/8/74

Source Chlor - Alkali

Mercury Emissions (Cont.):

N_p^i is the number of plants in the i^{th} state.

For mercury, the national standard (Ref. 148) is 2,300 gms/day or

$$E_S^i = \frac{2{,}300 \text{ gms/day-plant}}{454 \text{ gm/lb}} = 5.066 \text{ lbs/day-plant}$$

Since all states have this regulation, the above equation reduces to

$$E_S = \frac{365}{A(\text{TONS/YEAR})} (E_S^i) N_p^{Hg\ cell}$$

where the A represents the total production capacity of Chlor-Alkali Industry plants using Hg. cell production method.

$$E_S = \frac{365 \text{ (days/YR)}}{3.74 \times 10^6 (\text{TON/YR})} 5.066 \frac{\text{lbs}}{\text{day-Plant}} (12 \text{ plants})$$

$$E_S = 5933 \times 10^{-6} \text{ lbs/TON}$$

$$E_S^{Hg} = .006 \text{ lbs/TON}$$ MERCURY Emissions

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Computation Sheet For Emission Factors

Calculations Done By U.F. Russo Date 10/10/74

Source Chlor-Alkali

Carbon Monoxide Emissions

There are no regs on CO from Chlor Alkali plants

Assuming the plant using neither diaphragm or Hg cell has same CO emissions

$E_S^{CO} = .158$ lbs/TON BOTH DIAPHRAGM & Hg Cells

Chlorine Gas Emissions:

There are no applicable standards

For diaphragm cells.

$E_S = 77$ lb/TON

For Mercury cells

$E_S = 117$ lb/TON

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 10-7-74

Source Sulfur Recovery - Oil and Nat Gas Production

K:

Ref 149 pg 42

It is reported that for 1972 the actual production was 50% of design capacity in Sulfur Recovery Claus Plants. We assume this factor typical of Sulfur Recovery Plants at Oil & Nat Gas Processing Facilities for the period 1975 to 1985.

$\therefore K = .5$

P_c:

Specific growth information on natural gas processing was not found in the literature however, we may make the approximation that the long term growth in crude oil production of 4.22%/yr obtained from Ref 095 and used in (a) Petroleum Storage - Tanks
(b) Sulfur Recovery - Refinery Fuel Gas
will be equally applicable to the growth in Crude Oil and Nat Gas Production. It is also implied that the proportion of sour gas treated in gas processing remain constant

$\therefore P_c = .042$ compound

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 10-7-74

Source Sulfur Recovery - Oil & Nat Gas Production

A: Ref 149 pg 42

1973 design capacity = 6,250 metric Ton/day sulfur recovered

Using 1.1023 Ton = 1 metric ton Ref 143 p F-234
365 Day/yr

$$A_{73} = 6250 \frac{MT}{Day} \times 1.1023 \frac{T}{MT} \times 365 \frac{Day}{Yr} = 2.51 \times 10^6 \frac{T}{Yr}$$

Using a 4.2% compound growth, we may calculate the 1975 production capacity from this 1973 estimate

$$A = A_{73} (1 + .042)^2 = 2.51 (1.042)^2$$

$$A \approx 2.73 \times 10^6 \text{ Ton/yr sulfur produced}$$

We convert this capacity figure into a value based on sulfur **feed**. The reasoning here (similar to "Sulfur Recovery - Refinery Fuel Gas") is that the true production level for the industry is a function of the overall efficiency or sulfur recovery. This implies an artifical change in the value of "A" if the emission limits (system efficiency) are changed.

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Computation Sheet For Industrial Factors

Calculations Done By ______________________ Date __________

Source Sulfur Recovery - Oil & Nat Gas Recovery

A: cont'd

Ref 149 pg 59 Table 17

Average Claus Plant sulfur removal eff = 95%

$$\text{Sulfur Feed} = \frac{\text{Sulfur Removal}}{.95} = \frac{2.73 \times 10^6}{.95} = 2.87 \times 10^6$$

∴

$$A = 2.87 \times 10^6 \text{ TON/yr Sulfur Feed}$$

P_B: Ref 037 p30 Section 13.2

We assume that this category is applicable to sulfur recovery plants at Natural Gas Processing Facility

Asset Guideline period × 14 yrs

P_B est → 2 × IRS = 28 yrs

$$\frac{100\%}{28\text{yr}} \cong 3.5\% / \text{yr} \text{ simple}$$ 100% depreciation in 28 yrs

∴

$$P_B = .035 \text{ simple}$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 10-7-74

Source Sulfur Recovery - Oil and Nat Gas Production

Ref 149 p 52-55

24 state process natural gas; however only seven practice sulfur recovery from "sour gas".

Arkansas
Florida
Mississippi
New Mexico
North Dakota
Texas
Wyoming

Table 14 & 15 deal with the 31 plants > 50 metric Ton/Day. Appendix I gives full breakdown by state.

Note: In actuality this study recieved information from 31 plants representing 7 states when in fact there are 84 plants practicing sulfur Recovery

1973 Data pg 42 Ref 149 & (Appendix I)

Total Plants = 84 (31 plants > 50 metric TON/DAY)
Total Capacity = 6,250 MTD (660 MTD of this is standby)
Useful Capacity = 5,590 MTD

pg 52 Sour Gas represents ≈ 5% of total Gas

2% of Total gas is processed for sulfur recovery (1162×10^6 scfd) in 1973

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-7-74

Source Sulfur Recovery - Oil & Nat Gas Production

The bulk of information on this industry was taken from Ref 149.

Oil and Nat Gas production generally occur together in as much that, crude oil and gas will normally be taken in both forms from the same well. All wells will vary in the relative ratio of oil and gas.

The overall process involves the following basic steps

1. Obtaining crude from well (oil & gas)
2. Separating oil from gas fraction
3. Storage of crude oil
4. Processing of Gas (sulfur recovery & refining if necessary)

This study concerns itself with emissions from the sulfur recovery operation in gas processing. Hydrocarbon emissions, identified with oil storage, are not covered here. Crude petroleum storage at the well-head is covered under

"Petroleum Storage - Tanks" by T. Hopper

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-7-74

Source Sulfur Recovery - Oil & Nat Gas Production

E_u:

We make the assumption that the exhaust from a Claus plant on a gas processing plant will have nearly the same sulfur compound composition as for a Recovery plant on a Refinery Fuel Gas processor.

From Emission Factor on "Sulfur Recovery - Refinery Fuel Gas"[4]

Compound	%S of Total Exhaust attributable to this compound
H_2S	47.2
SO_2	23.3
COS	2.7
CS_2	4.5
S_8	22.3
	100.0 ✓

Using the 95% Claus sulfur removal efficiency detailed above we find;

100 lb S Feed to Claus → 5 lb of S emitted

or 2000 lb S (1 TON) Feed → 100 lb of S emitted

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-7-74

Source Sulfur Recovery - Oil & Nat Gas Production

E_u: cont'd

Using 100 lb S emitted / TON S Feed and the weight breakdown we get

			lb S attributable to:
H_2S	.472 × 100	=	47.2
SO_2	.233 × 100	=	23.3
COS	.027 × 100	=	2.7
CS_2	.045 × 100	=	4.5
S_8	.223 × 100	=	22.3
			100.0 ✓

Emission Factors are developed in terms of SO_2 and Sulfides (H_2S)

$23.3 \frac{\text{lb S}}{\text{TON S Feed}}$ in SO_2 and $76.7 \frac{\text{lb S}}{\text{TON S Feed}}$ in sulfides

$\frac{\text{MW } SO_2}{\text{MW S}} = \frac{64}{32} = 2$ $\frac{\text{MW } H_2S}{\text{MW S}} = \frac{34}{32} = 1.06$

$46.6 \frac{\text{lb } SO_2}{\text{TON Sulfur Feed}}$ $81.3 \frac{\text{lb } H_2S}{\text{TON Sulfur Feed}}$

or

47 lb SO_2/TON S Feed 81 lb H_2S/TON Su Feed

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-7-74

Source Sulfur Recovery - Oil & Nat Gas Production

E_u: cont'd

Summary

SO_x	47 lb	/TON Sulfur Feed to Claus Plant
Sulfides as H_2S	81 lb	/TON Sulfur Feed to Claus Plant

E_N:

Ref 149 pg 59 Table 17

Attainable overall sulfur efficiency 99.5%

Assume all sulfur in final tail gas in form of SO_2

$\therefore E_N \; H_2S = 0$

SO_x emission $2000 \text{ lbs S Feed} \times .005 = 10 \text{ lb S/TON Feed S to Claus}$

$$\frac{MW\ SO_2}{MW\ S} = \frac{64}{32} = 2$$

$$E_N = 20 \text{ lb } SO_2/\text{TON S Feed}$$

Summary

	E_N	
H_2S	0	lb H_2S /TON S Feed to Claus Plant
SO_x	20	lb SO_2 /TON S Feed to Claus Plant

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Computation Sheet For Emission Factors

Calculations Done By D. Marrone Date 11-1-74

Source Oil & Nat Gas Production

E_{111d}: H_2S (sulfides)

Add-on tail gas processes are assumed suitable (will attain compreable overall S. reduction efficiency) for existing Claus Plants at Oil & Nat Gas Facilities as for new plants

$\therefore E_{111d} = E_N$

$\therefore E_{111d} = 0$ H_2S

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-8-74

Source Sulfur Recovery - Oil & Nat Gas Production

E_S:

Ref 149 Appendix I details the sulfur capacity by state for Claus Plants in Nat Gas Processing

State	No of Plants	Total Design Capacity (MT/D)
Alabama	2	386
Arkansas	2	130
California	(1) Not Reported →	(83 est)
Florida	4	664
Mississippi	3	1297
New Mexico	6	117
North Dakota	1	20
Oklahoma	2	23
Texas	42	2683
Utah	1	10
Wyoming	12	919
	75	6249 (not including California)
	76	6332 including Calif

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Calculations Done By W. Marrone Date 10-8-74

Source Sulfur Recovery - Oil & Nat Gas Production

E_s: cont'd

We note that design capacity was not reported for Calif. Only one plant is indicated and it is not expected that any approximation to its capacity will greatly have an effect on the E_s determination

$$\text{Avg Plant size for the industry without Calif.} \cong \frac{6249}{75} \cong 83 \text{ MTD/plant}$$

California is assumed to have therefore $1 \times 83 = 83$ MTD capacity

$$Cap_{IND} = 6249 + 83 = 6332 \text{ MTD}$$

Computing the typical Plant size and fractional state capacity;

State	Cap/No Plants Typical Plant Size (MTD)	Capstate/cap Ind (A_i) Fractional Ind. Capacity
Alabama	193	.0609
Arkansas	65	.0205
California	83	.0131
Florida	166	.1048
Mississippi	432	.2048
New Mexico	19.5	.0185
North Dakota	20	.0032
Oklahoma	11.5	.0036
Texas	64.	.4237

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Source Sulfur Recovery - Oil & Nat Gas Production

E_s: cont'd

State	Cap/No Plants Typical Plant Size (MTD)	Cap state /Cap Ind Fractional Ind Capacity
Utah	10	.0016
Wyoming	76.5	.1451
		Σ .9998
		OK! rounding error

We note that there is a wide variance in the typical capacity of a sulfur recovery plant between all the states. It ranges from a low of 10 to a high of 432 MTD. One explanation may be that some states have relatively few but new plants which tend to have larger capacity whereas other states may have a higher percentage of older (smaller capacity) plants.

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Computation Sheet For Emission Factors

Calculations Done By William Marrone Date 10-9-74

Source Sulfur Recovery - Oil & Nat Gas Production

E_s : cont'd

We outline the applicable state regulations obtained from Ref 84 Table XVII and updated by Ref 148. Since both old and new plants are identified we will evaluate E_s for both types.

$$E_S^A = \sum_{i=1}^{m} E_S^i A_i$$

① Arkansas specifies only a ground level SO_2 reg - We assume E_S for Arkansas to be comparable to the average $E_{si} = E_S^A$ (old & new)

② Regulation does not exist state wide - We assume average E_S (country) to be applicable to Calif $E_{si} = E_S^A$ (old & new)

③ Florida, New Mexico, North Dakota, Wyoming, and Oklahoma (old plants only) do not have applicable regulations in which case E_s is assumed equal to E_u; $E_{si} = E_u = .05$ lbS / lbS input
(reported in terms of total sulfur)

④ Texas specifies a SO_2 emission limitation obtained from a Table and Equation [lb SO_2/hr vs SCFM exhaust flow]
Ref 149 Table 16 states that Texas & Louisiana both require Claus eff of 74-97%. Rather than obtain an estimate via the scfm route we assume the Louisiana limitation of .01 lbS / lbS input applicable to Texas

$$E_{si} = .01 \text{ lbS / lbS input (old \& new)}$$

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Computation Sheet For Emission Factors

Calculations Done By ____________ Date 10-9-74

Source Sulfur Recovery

E_s: cont'd

(5) Utah requires 80% control for new sources with emissions greater than 250 Ton/yr

Typical Plant 10 MTD and 95% Sulfur Recovery

$$E = \left(\frac{10\ MT}{.95\ D}\times 1.1023\ \frac{Ton}{MT}\right)\times 365\ \frac{D}{yr}\times\frac{100\ lb\ S}{Ton\ S\ input}\times\frac{Ton}{2000\ lb} = \frac{T}{yr}$$

(sulfur input) (emitted)

$$E \cong 212\ T/yr$$

Since $E < 250$ T/yr ~~on the~~ average the required control of 80% would not be required for old & new. This calc is based on the fact that Utah has only one plant (1973) with a small capacity; 10 MTD. If any new plant was installed it would necessarily be greater than 10 MTD, in which case the 80% would apply. With this in mind we assume

$$E_{old} = E_{Si_{old}} = E_u = .05\ lb\ S / lb\ S\ input$$

$$E_{new} = E_{Si_{new}} = .2E_u = .01\ lb\ S / lb\ S\ input$$

	OLD	NEW
(6) Alabama	.16 lb S / lb S input	.08 lb S / lb S input
Mississippi	.06 lb S / lb S input	.06 lb S / lb S input
Oklahoma	[see (3) above]	.01 lb S / lb S input

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Calculations Done By W. Marrone Date 10-9-74

Source Sulfur Recovery - Oil & Nat Gas Production

E_S: cont'd

E_{Si} Summary of Regulations lbS/lbS input

	Old Plant	New Plant
Alabama	.16	.08
Arkansas	E_S^A	E_S^A
California	E_S^A	E_S^A
Florida	.05	.05
Mississippi	.06	.06
New Mexico	.05	.05
North Dakota	.05	.05
Oklahoma	.05	.01
Texas	.01	.01
Utah	.05	.01
Wyoming	.05	.05

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-9-74

Source Sulfur Recovery - Oil & Nat Gas Production

E_s : cont'd

State	Old Plant $E_{si} \times A_i$	New Plant $E_{si} \times A_i$
Alabama	.0097	.0049
Arkansas	$.0205 E_s^A$	$.0205 E_s^A$
California	$.0131 E_s^A$	$.0131 E_s^A$
Florida	.0052	.0052
Mississippi	.0123	.0123
New Mexico	.0009	.0009
North Dakota	.0002	.0002
Oklahoma	.0002	.00004
Texas	.0042	.0042
Utah	.00008	.00002
Wyoming	.0073	.0073

$$E_s^A = .04008 + .0336 E_s^A \qquad E_s^A = .03506 + .0336 E_s^A$$

$$(1 - .0336) E_s^A = .04008 \qquad (1 - .0336) E_s^A = .03506$$

$$.9664 E_s^A = .04008 \qquad .9664 E_s^A = .03506$$

$$E^A_{s_{old}} \cong .041 \text{ lbs/lbs input} \qquad E^A_{s_{new}} = .036 \text{ lbs/lbs input}$$

We assume a value of E_s to be the average of these or $E_s \cong .039$ lbS/lbS input

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-9-74

Source Sulfur Recovery - 0.1 ¢ Nat Gas Production

E_S: cont'd

$$E_S = .039 \text{ lb S / lb S input}$$

If we assume the same ratio of Sulfides and SO_2 in the exhaust (wt %) then;

$\frac{23.3 \text{ lb S}}{100 \text{ lb S input}}$ in SO_2

$\frac{76.7 \text{ lb S}}{100 \text{ lb S input}}$ in H_2S

$.039 \times .233 = .0091$ lb S/lb S input in SO_2

$.039 \times .767 = .0299$ lb S/lb S input in H_2S

Using $\frac{MW\ SO_2}{MW\ S} = \frac{64}{32} = 2:1$ $\frac{MW\ H_2S}{MW\ S} = \frac{34}{32} = 1.06 : 1$

$2 \times .0091 = .0182$ lb SO_2/lb S input [redacted]

$1.06 \times .0299 = .0317$ lb H_2S/ lb S input [redacted]

Converting to lb/TON by 2000 lb/TON

$$E_S \cong 36.\ \text{lb } SO_2 \text{ / TON S Input}$$

$$E_S = 63 \text{ lb } H_2S \text{ / TON S Input}$$

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Computation Sheet For Industrial Factors

Calculations Done By K. Tower Date 12/23/74

Source Detergent

Ref 005, p. 1 states that production in the detergent industry was running at about 90% capacity in 1970.

$K = .90$

Ref 050 states that production in the detergent industry has increased 3-4% for the past 10 years. We assumed an average of 3.5%.

$P_c = .035$ compound

Ref 005 states that particulate from the spray dryer, and to a much smaller extent, odors, are the only significant emissions from detergent manufacture.

Ref 050 states that spray dryed product represents 75% of total detergent production.

Ref 050

1970 Total detergent production 5.2×10^9 lbs

$(5.2 \times 10^9 \text{ lbs})(.75) = 3.9 \times 10^9$ lbs spray dryed product

1977 Estimated spray dryed product $= 4.7 \times 10^9$ lbs

The attached graph shows the growth of spray dryed detergent.

$$A = \frac{4.5 \times 10^9 \frac{\text{lbs}}{\text{yr}}}{(.9)(2000 \frac{\text{lbs}}{\text{ton}})} = 2.5 \times 10^6 \frac{\text{TONS}}{\text{YR}}$$

$A = 2.5 \times 10^6 \frac{\text{TONS SPRAY DRYED DETERGENT}}{\text{YR}}$

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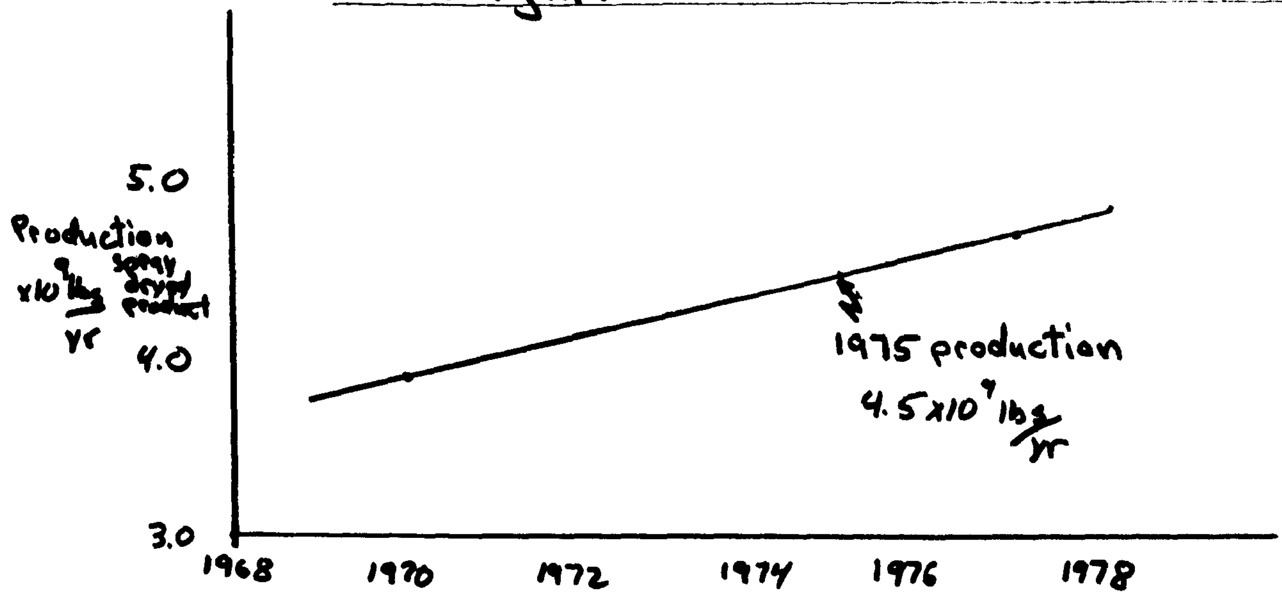
Computation Sheet For Industrial Factors

Calculations Done By K. Tower Date 12/23/74

Source Detergent



Ref 050 states that no plants are expected to be replaced since the industry is only 20 yrs. old.

$P_B = .00$

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Computation Sheet For Emission Factors

Calculations Done By K. Tower Date 12/23/74

Source Detergent

Ref 075 gives the uncontrolled particulate emissions from a detergent spray dryer as 90 lbs/TON Product.

$$\bar{E}_u = 90 \text{ lbs/TON Product}$$

Ref 050 states that the best available control is 99.5% efficiency ⟶ an emission rate of .45 lb/TON.

$$\bar{E}_N = .45 \text{ lbs/TON Product}$$

E_s Ref 050 estimates 37 spray dryed detergent plants. Although there are only 37 s/d detergent plants we assumed that their geographical distribution was identical to that for the 700 soap and detergent establishments – Ref 005, p1

State	% of Total Detergent
California	17.8
Texas	9.0
New York	18.6
Ohio	10.3
Illinois	12.7
Maryland	9.3
All Others	22.3

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Computation Sheet For Emission Factors

Calculations Done By K. Tower Date 12/24/74

Source Detergent

Ref. 050, p. 1, indicates that the average detergent plant production is 35,000 lbs/hr.; 12 hrs/day

This we assumed to be the Process Weight Rate (PWR)

From Ref 84, 148 & theoretical PWR curve

Allowable, lbs/hr.

Ohio - 28.0

New York 23.5

California 25.5* Ref 156 Assume L.A county representative of state

Texas 51.0

Illinois 12.0

Maryland 25.5

All others 27.0 (Gen'l PWR Curve)

$$E_s = f[(28.0)(.103) + (23.5)(.186) + (25.5)(.178) + (51.0)(.09) + (12.0)(.127) + (25.5)(.093) + (27.0)(.223)$$

$$= f[2.88 + 4.37 + 4.54 + 4.59 + 1.52 + 2.37 + 6.02]$$

$$= 26.29 \text{ lbs/HR}$$

$$E_{s_{Part}} = \frac{26.29 \text{ lbs/HR}}{17.5 \frac{\text{TONS}}{\text{HR}}} = 1.50 \frac{\text{lbs}}{\text{TON}}$$

$$\boxed{E_{s_{Part}} = 1.50 \frac{\text{lbs}}{\text{TON Product}}}$$

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Computation Sheet For Industrial Factors

Calculations Done By HOPPER Date 8/2/74

Source ETHYLENE DICHLORIDE (Oxychlorination Process)

REF (80) STATES THE 1970 ANNUAL PRODUCTION TO BE

7.46×10^9 lb/yr

REF (50) STATES 5.0×10^9 FOR THE SAME YEAR.

IN ORDER TO DET'N WHICH IS "CORRECT", THIS & ADDITIONAL DATA IS PLOTTED ON THE ACCOMPANYING GRAPH. DATA POINTS FROM REF 96 ARE DEMAND NOT PRODUCTION — WHICH AREN'T NECESSARILY THE SAME. AS A RESULT OF A "BEST FIT" CURVE THRU THE DATA, A 1970 PRODUCTION RATE IS DET'D TO BE

6.2×10^9 #/YR

THIS # MUST BE UPDATED IF NEW INFORMATION IS MADE AVAILABLE SINCE THE VALUE HAS BEEN DET'D BY QUESTIONABLE MEANS.

REF (96) STATES:

(a) 1967 CAPACITY @ 7.1×10^9 #/YR

(b) GROWTH = 12% (ASSUME COMPOUND)

$$(7.1 \times 10^9)(1.12)^3 = 1970 \text{ CAPACITY} = 9.97 \times 10^9$$

$$K = \frac{6.2 \times 10^9}{9.97 \times 10^9} = 0.62 = K$$

More recent info from Ref (96) Oct 1, 1974 gives 1974 capacity @ 11.025×10^9 LBS & an estimated growth of 9%

$P_c = 0.09$ CUPD

$$A = (11.025 \times 10^9)(1.09)^1 = 12.0 \times 10^9 \text{ \#/YR} = A$$

HOWEVER, THE OXYCHLORINATION PROCESS IS THE ONLY ONE (CHLORINATION OF ETHYLENE IS THE OTHER) WHICH IS RELATED TO A POLLUTION PROBLEM — REF (50). IN 1970, ABOUT 55% OF

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Computation Sheet For Industrial Factors

Calculations Done By HOPPER Date 8/2/74

Source ETHYLENE DICHLORIDE (Oxychlorination)

ETHYLENE DICHLORIDE WAS MADE BY THIS PROCESS. AS A RESULT A MUST BE IN TERMS OF THIS PROCESS ONLY.

$$A = (12.0 \times 10^9)(.55) = 6.6 \times 10^9 \text{ \#/YR} = A$$

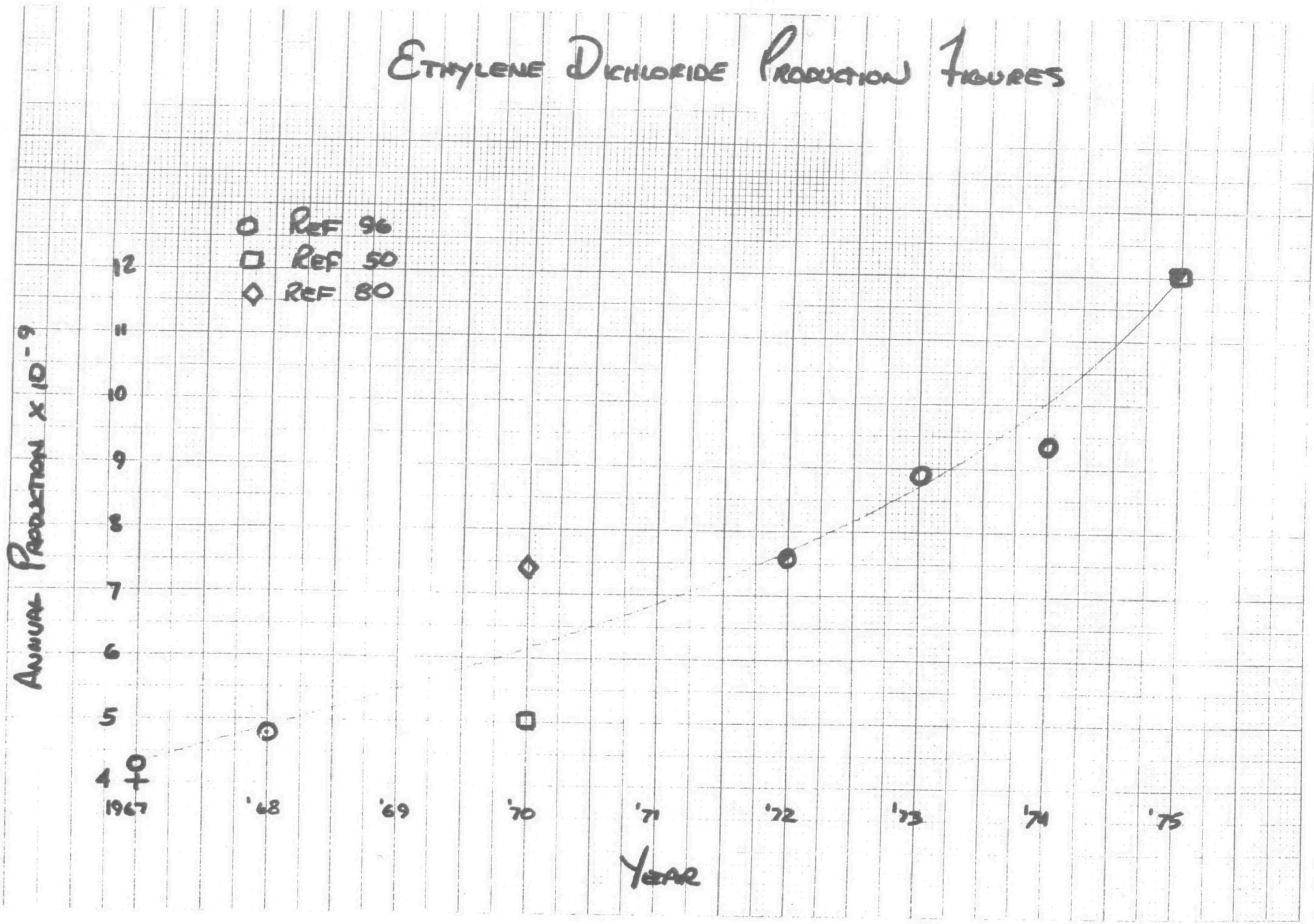
$$= 3.3 \times 10^6 \frac{\text{TONS}}{\text{YR}}$$

TYPICAL PLANT Ref (50) 1970

$$\frac{2.5 \times 10^6 \text{ TONS}}{12} = 2.083 \times 10^5 \frac{\text{TONS}}{\text{PLANT} \cdot \text{YR}}$$

FROM REF (95)
SEC 651.5030E
June 1967 Plant Loc'n's

Calif - 11%
Ky - 22%
Tex - 32%
La - 30%
Ky - 2.5%
W Va - 2.5%


ETHYLENE DICHLORIDE PRODUCTION FIGURES
REF 96
REF 50
REF 80
ANNUAL PRODUCTION X 10^-9
4
5
6
7
8
9
10
11
12
1967
'68
'69
'70
'71
'72
'73
'74
'75
YEAR

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-23-74

Source Ethylene Dichloride (Oxychlorination)

P_B :

Ref 037 pg 33 Sec 28.0

IRS Depreciation and Asset Guideline = 11 yrs

2 × IRS ≈ P_B = 22 yrs for 100% simple depreciation

$$\frac{100}{22} \cong 4.5\%$$

$$\therefore P_B = .045 \text{ simple}$$

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Computation Sheet For Emission Factors

Calculations Done By HOPPER Date 8/2/74

Source ETHYLENE DICHLORIDE (oxychlorination)

REF (50) STATES EMISSIONS AS

CO 0.008 TONS CO / TON EDC ⇒ 16 #/TON

H/C .05 + .012 + .008
= 0.07 TONS/TON ⇒ 140 #/TON

THESE EMISSIONS ARE FROM "A TYPICAL MODERN PLANT" REF (50)

"the industry is presently uncontrolled" REF (50)

∴ THESE EMISSIONS COULD BE ASSUMED AS UNCONTROLLED.

So

$E_{CO} = 16$ #/TON

$EU_{HC} = 140$ #/TON

REF (50) INCINERATION + WET SCRUBBING

$\eta \approx 100\%$ ASSUME $\eta = 99.9\%$

∴

$EN_{CO} = .016$ #/TON

$EN_{H/C} = .14$ #/TON

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Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10/8/74

Source Ethylene Dichloride

HC:

As discussed in Vol #1,

$$E_S = E_S^u + E_S^P + E_S^A$$

Production capacity by plant location (as of 1967) is obtained from Ref. 95, Sec. 651.5030 E. Assuming the same distribution still applies, we can proceed to calculate the components of E_S.

(i) HC emissions are uncontrolled in W. Va.*, which accounts for ~2.5% of production capacity. Thus

$$E_S^u = (.025)\, E_u = (.025)(140) = 3.5 \text{ LB/TON}$$

(ii) The remaining states have HC regulations which require specific levels of emissions control efficiency*. The table below gives the relevant data:

STATE	FRAC. CAPACITY A_i	CONTROL EFFIC. P_c *
CAL.	0.110	.85 **
KY.	0.245	.85
TEX.	0.320	.90 ***
LA.	0.300	.90

* Ref 84 & 148: Emissions are reactive HC.
** L.A. County Reg assumed for whole state
*** Incineration requirement assumed equivalent to 90% efficiency

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Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10/9/74

Source Ethylene Dichloride

HC (cont).

For E_s^P, we obtain

$$E_s^P = E_u \sum_j A_j (1 - P_{cj}) = (140)[(.15)(.355) + (.10)(.620)]$$

$$E_s^P = 16.1 \text{ LB/TON}$$

where E_u is obtained from a previous emission factor calc.

The total for E_s is then

$$E_s = E_s^u + E_s^P = 19.6 \text{ LB HC/TON Ethylene Dichloride}$$

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Computation Sheet For Emission Factors

Calculations Done By RJ Londergan Date 10/9/74

Source Ethylene Dichloride

CO:

State regulations for CO* do not pertain to chemical production sources, so in this case

$$E_s = E_u = 16 \text{ LB CO/TON Eth. Dichl.}$$

* Ref 84 & 148.

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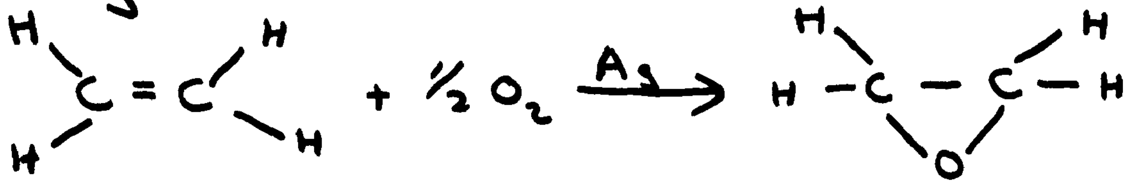
Computation Sheet For Industrial Factors

Calculations Done By K. Tower Date 12/27/74

Source Ethylene Oxide (by air oxidation)

The manufacture of ethylene oxide is done by the direct oxidation of ethylene according to the following reaction:



ethylene oxygen ethylene oxide

Ref. 210, p 106

This direct oxidation is presently being carried out using either air or high purity oxygen.

Ref 050, p. 1 states that the oxygen process pollutes less than the air process. We made the assumption that is was negligible and based our factors only on ethylene oxide produced by air oxidation.

Ref 206, p.10, states that ethylene oxide producers operated close to 87% of year-end name plate capacity in 1972.

K = .87

Ref 050, p.1 gives the estimated 1975 production rate of ethylene oxide by air oxidation as 2.95×10^9 lbs/yr.

$$A = \frac{2.95 \times 10^9 \frac{\text{lbs}}{\text{yr}}}{.87} = 3.39 \times 10^9 \frac{\text{lbs}}{\text{yr}}$$

$$A = \frac{3.39 \times 10^9 \frac{\text{lbs}}{\text{yr}}}{2000 \frac{\text{lbs}}{\text{TON}}} = 1.695 \times 10^6 \frac{\text{TONS}}{\text{YR}}$$

$A = 1.70 \times 10^6 \frac{\text{TONS EO}}{\text{YR}}$ by air oxidation

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Calculations Done By K. Tower Date 12/27/74

Source Ethylene Oxide (by air oxidation)

Ref 206 states that ethylene oxide production should increase an average of 7.5% annually. We assumed this to be at a compound rate.

$P_c = .075$ compound

We assume that the obsolescence rate will be that of the general industry of the manufacture of chemicals and allied products.

From Ref 037, p. 33 section 28.0:

Asset guideline period for the manufacture of chemicals and allied chemicals = 11 yrs.

$P_{B_{est}} = 2 \times IRS = 22$ yrs.

$$\frac{100\%}{22 \text{ yrs}} = 4.5\%/\text{yr}$$

$P_B = .045$ simple

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Computation Sheet For Emission Factors

Calculations Done By K. Tower Date 12/27/74

Source Ethylene Oxide (by air oxidation)

Ref. 050, p.2, gives the following table of emissions produced by the manufacture of ethylene oxide by air oxidation:

Chemical	TONS Emissions / TON EO produced
Ethylene	0.100
Ethane	0.010
Methane	0.080
Ethylene Oxide	0.006
	0.196

$$E_u = \left(.196 \frac{\text{TONS Hydracarbons}}{\text{TON EO}}\right) \times \left(2000 \frac{\text{lbs}}{\text{TON}}\right) = 392 \frac{\text{lbs}}{\text{TON EO produced}}$$

$$\boxed{E_u = 392 \frac{\text{lbs. Hydracarbons}}{\text{TON EO produced by air oxidation}}}$$

Ref 050 states that 99+% efficiency can be expected on ethylene oxide production emissions with the use of a catalytic converter.

$$E_N = \left(392 \frac{\text{lbs HC}}{\text{TON EO}}\right) \times (.01) = 3.92 \frac{\text{lbs HC}}{\text{TON EO}}$$

$$\boxed{E_N = 3.92 \frac{\text{lbs Hydracarbons}}{\text{TON EO produced by air oxidation}}}$$

Ref 050, p. 3 indicates that there are no state emission control regulations for the ethylene oxide industry. We assume that $E_s = E_u$

$$\boxed{E_s = 392 \frac{\text{lbs Hydracarbons}}{\text{TON EO produced by air oxidation}}}$$

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Computation Sheet For Industrial Factors

Calculations Done By Hopper Date 1/24/75

Source Explosives

Explosives are categorized as follows:

1. High explosives
2. Low explosives

High explosives will be represented by TNT
Low explosives will be represented by nitrocellulose (NC)

Ref (221) p 13 Tab II gives the 1967 production of explosives as 953,000 tons. No mention of high or low is given, however.

Ref (93) p 388 indicates that nitrocellulose is pulling black powder out of use. (Both are low explosives)

Ref (95) p 530.5020 shows that between 1930 & 1935 black powder constituted about 22% of the total market. After 1935, the % continued to drop to practically zero. If we assume that the drop in black powder was compensated for by NC, then

$$1967 \text{ Prod. High} = (1-.22)(953{,}000) = 0.743 \times 10^6 \text{ tons}$$

$$1967 \text{ Prod Low} = (0.22)(953{,}000) = 0.210 \times 10^6 \text{ tons}$$

Ref (95) p 530.5020 gives the 1958 production of exp. @ 961.6×10^6 lbs & the 1966 value of 1970.2×10^6 lbs. The growth (from the curve presented on p 530.5010) is compound.

$$P_c = \sqrt[8]{\frac{1970.2}{961.6}} - 1.0 = 0.094$$

$$P_c = 0.094$$ compound (Assume valid for high + low)

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Computation Sheet For Industrial Factors

Calculations Done By Hopper Date 1/24/75

Source Explosives

No specific value of K could be det'd, so we will use that for the chemical industry in general. From Ref (44) p48 the avg K for the chemical industry between 1965 & 1973 is 83%

$$K = 0.83$$

Assume valid for high & low

$$A_{\text{HIGH EXP.}} = \frac{(0.743 \times 10^6)(1.094)^8}{0.83} = 1.837 \times 10^6$$

$$A_{\text{HIGH EXP.}} = 1.837 \times 10^6 \text{ TONS}$$

$$A_{\text{LOW EXP.}} = \frac{(.210 \times 10^6)(1.094)^8}{0.83} = 0.519 \times 10^6$$

$$A_{\text{LOW EXP.}} = 0.519 \times 10^6 \text{ TONS}$$

From Ref (37) p 33, the allowable IRS guideline for "Manufacture of Chemicals and Allied Products ..... explosives ..." is 11 yrs.

Assuming twice the allowable

$$P_B = \frac{1}{2(11)} = 0.045$$

$$P_B = 0.045$$ simple

Assume valid for high & low

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 1/24/75

Source Explosives

High explosives will be represented by TNT & low explosives by NITROCELLULOSE

PARTICULATE — High only

Ref (221) p18 TAB VI

Eu for the sulfuric acid concentrator & Red water incinerator

$$E_{UP_{High}} = 50.4 \ \text{LB/TON PRODUCT}$$

(Utilizing a transfer of technology from sewage sludge incineration, (Ref (44) p57) a high energy wet scrubber could be used to control particulate emissions to 96.6 - 99.6%. Assuming the avg,

$$E_N = \left[1 - \frac{.966 + .996}{2}\right]\left[50.0\right] + .4 = 1.35 \ \#/\text{TON}$$

$$E_{NP_{HIGH}} = 1.35 \ \text{LB/TON PRODUCT}$$

Since there are no specific regs for industrial incineration, we will use the process weight rate regs.

Ref (221) p18 gives a plant size of 400 TPD of TNT

Assuming 24 hrs/day & using the gen'l PWR curve generated from Ref (84) & (148)

$$\frac{400}{24}(2000) = 33{,}333 \ \text{LB/HR}$$

Allowable = 25.8 #/HR

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Calculations Done By Hopper Date 1/24/75

Source Explosives

$$E_{SP} = \frac{25.8(24)}{400} = 1.55$$

$$E_{SP_{HIGH}} = 1.55 \text{ LB/TON PRODUCT}$$

NOx - High Expl.

Ref (221) p 18 gives NO_x emissions (uncontrolled). The total is

$$E_{U_{NO_x \, HIGH}} = 169 \text{ LB/TON PRODUCT}$$

By using a 95% efficient bubble cap absorption system (Ref (221) p 18) on the nitration reactor line, emissions can be reduced to 2.5 LB/ton

$$E_N = 2.5 + 1 + 2 + 6 = 11.5 \text{ LB/ton}$$

$\frac{169 - 11.5}{169}$ = 93% overall

$$E_{N_{NO_x \, HIGH}} = 11.5 \text{ LB/TON PRODUCT}$$

Since there are essentially no NO_x emission regs for explosives mfg, $E_S = E_U$

$$E_{S_{NO_x \, HIGH}} = 169 \text{ LB/TON PRODUCT}$$

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 1/24/75

Source Explosives

NOx - Low Expl

Ref 221 p18 gives EU (12.5 - Reactor Pots, 29.0 H_2SO_4 concentrator)

$$EU_{NO_x\,low} = 41.5 \text{ LB/TON PRODUCT}$$

Assuming a transfer of technology from the control of NO_x emissions from HNO_3 mfg. (Ref (117) p 38, 39) an $\eta = 93\%$ could be achieved with a catalytic decomposition system

$$EN_{NO_x\,low} = (1-.93)(41.5) = 2.91$$

$$EN_{NO_x\,low} = 2.91 \text{ LB/TON PRODUCT}$$

Since there are essentially no regs for NO_x emissions from explosives mfg., $E_S = E_U$

$$ES_{NO_x\,low} = 41.5 \text{ LB/TON PRODUCT}$$

SOx - High

Ref (221) p18 gives uncontrolled emission factors (18.0 from sulfuric acid concentrator & 13.0 from red H_2O incinerator

$$EU_{SO_x\,high} = 31.0 \text{ LB/TON PRODUCT}$$

Same Ref & page indicate that a reduction in SO_x emissions to 4.2 LB/TON can be realized with a spray chamber on the H_2SO_4 concentrator. This corresponds to ~76% η. We feel that a transfer of techology from H_2SO_4 mfg could be attained.

Ref (147) indicates that a sodium sulfite-bisulfite scrubbing process

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 1/24/75

Source Explosives

could be used. From p44 of Ref (14), a typical η can be calculated

$$\frac{\left(\frac{85.0+21.5}{2}\right)-4.0}{\left(\frac{85.0+21.5}{2}\right)} = \frac{53.25-4}{53.25} = 92\%$$

$$E_{N_{SO_x\ high}} = (1-.92)(31.0) = 2.48$$

$$E_{N_{SO_x\ high}} = 2.48 \text{ LB/TON PRODUCT}$$

Since there are no regs, $E_S = E_U$

$$E_{S_{SO_x\ high}} = 31.0 \text{ LB/TON PRODUCT}$$

SOx - low

Ref (221) p 18

$$E_{U_{SO_x\ low}} = 65 \text{ LB/TON PRODUCT}$$

Assuming similar control techniques & η as for the high exp. mfg

$$E_N = (1-.92)(65) = 5.2$$

$$E_{N_{SO_x\ low}} = 5.2 \text{ LB/TON PRODUCT}$$

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 1/24/75

Source Explosives

Since there are no eggs, $E_S = E_U$

$$E_{S_{SO_x \, low}} = 65.0 \text{ LB/TON PRODUCT}$$

Summary

	PART.			NO_x			SO_x		
	E_U	E_N	E_S	E_U	E_N	E_S	E_U	E_N	E_S
High Expl.	50.4	1.35	1.55	169	11.5	169	31.0	2.48	31.0
Low Expl.	—	—	—	41.5	2.91	41.5	65.0	5.2	65.0

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Computation Sheet For Industrial Factors

Calculations Done By HOPPER Date 8/7/74

Source FORMALDEHYDE

FROM REF (50)

1970 PRODUCTION = 3.87×10^9 #/YR

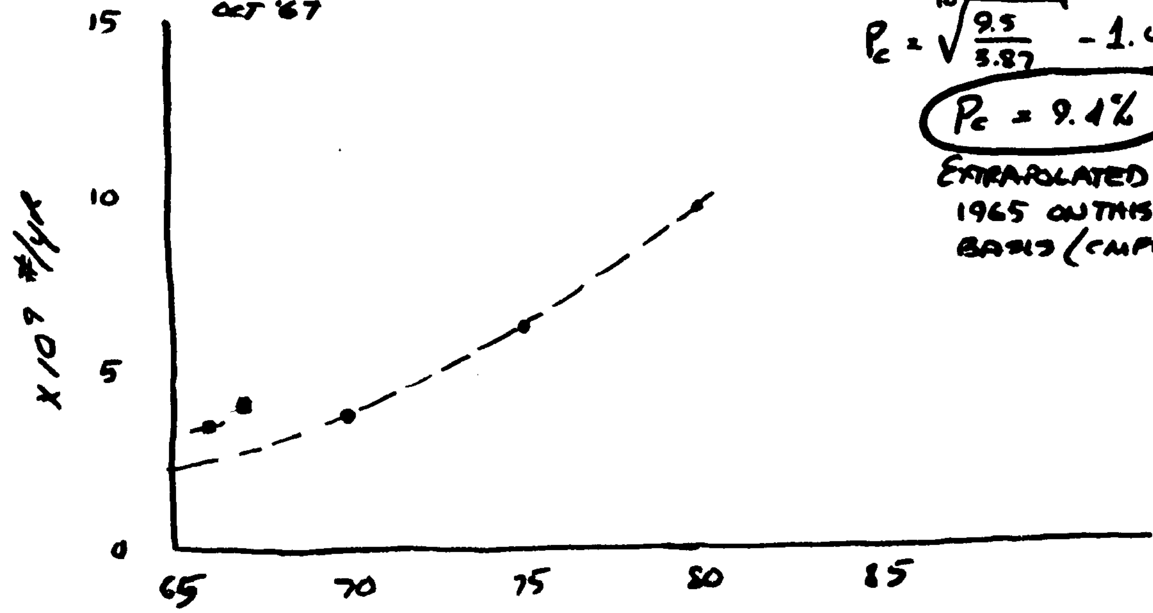
1975 } ESTIMATES 6.27×10^9
1980 } 9.5×10^9

REF (96)

CAPACITY 1966 3.557×10^9

REF (95) 1967 4.[illegible]7 $\times 10^9$

SEC 658.5030B
OCT '67



$$P_c = \sqrt[10]{\frac{9.5}{3.87}} - 1.0$$

$P_c = 9.4\%$

EXTRAPOLATED TO 1965 ON THIS BASIS (CMPD)

$$K_{1966} = \frac{2.55}{3.557} = 72\%$$

$$K_{1967} = \frac{2.9}{4.067} = 71\%$$

$\therefore$ K = 0.72

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By HOPPER Date 8/7/74

Source Formaldehyde

$$\text{PROD } 1975 = \text{PROD } 1970 \left(1+P_c\right)^5$$
$$= \left(3.87\times10^9\right)\left(1.094\right)^5 = 6.06\times10^9 \ \#/\text{YR}$$

$$A = \frac{6.06\times10^9}{0.72} = 8.42\times10^9 \ \#/\text{YR} = A \qquad 4.21\times10^6 \ \frac{\text{TONS}}{\text{YR}}$$

PREVIOUS WORK USED PRODUCTION NOT CAPACITY &
K = 0.9 (TYP. OF INDUSTRY)

From Ref (50) Typical plant =

$$\frac{3.87\times10^9}{57} = 67.9\times10^6 \ \#/\text{YR}\cdot\text{PLANT}$$

From Ref (95) MAJOR LOC'NS IN 1967

TEXAS	14%
W.VA	10%
OHIO	8%
NC	5%
MO.	5%
	42%

REMAINDER IN
NC, OREG., MO, MASS. NJ (3)

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-23-74

Source Formaldehyde

P_B:

Ref. 037 pg 33

Sec 28.0

Asset guideline period = 11 yrs

2 × IRS = 22 yrs for 100% Depreciation (simple)

est $P_B \approx \frac{100\%}{22 \text{ yrs}} \doteq 4.5\%$

$P_B = .045$ simple

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Computation Sheet For Emission Factors

Calculations Done By ______________________ Date ______________

Source Formaldehyde

Assume all formaldehyde mfg'd from methanol REF (50)

Two methods using [redacted] methanol:
(a) Iron oxide catalyst - 50% of capacity
(b) Silver catalyst - 50% of capacity
REF (50)

For CO, $Eu_a = 0.13$ #CO/ton form.
For H/C $Eu_a = .006 + .005 + .012$
$= .023$ #HC/ton form.
REF (50) p2

For CO $Eu_b = .005$ #CO/ton form.
For H/C $Eu_b = .001 + .0035 = 0.0045$
REF (50) p3

We will det'n an integrated Eu for each pollutant

$$Eu_{CO} = [.5(.13) + .5(.005)][2000] =$$

$$Eu_{CO} = 135 \text{ \#CO/ton form.}$$

$$Eu_{HC} = [.5(.023) + .5(.0045)][2000]$$

$$Eu_{HC} = 27.5 \text{ \#HC/ton form}$$

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 8/7/74

Source Formaldehyde

PREVIOUS WORK INDICATED

$EU_{H/C}$ = 18 #/TON AS DET'D FROM REF (76)

OUR VALUE OF 27.5 #/TON WAS DERIVED FROM REF (50)

BOTH OF THESE REFERENCES BASED THEIR INFO ON THE SAME SOURCE - "PETROCHEMICAL INDUSTRIAL QUESTIONAIRE"

Analysis of both values indicates that:

① 18#/TON is BASED ON CAPACITY

② 27.5#/ton is BASED ON PRODUCTION

In ORDER TO BE COMPATIBLE WITH THE MODEL THE 27.5 #/ton VALUE MUST BE USED.

These #'s ALSO give us A CHECK on K

$K' = \frac{18}{27.5} = 65.5\%$ which is good agreement with 72%

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Computation Sheet For Emission Factors

Calculations Done By ______________________ Date ____________

Source Formaldehyde

Since wet scrubbing does not remove CO & is not highly efficient for H/C removal, incineration would represent the BACT. The method would remove nearly 100% (Ref (50)) of pollutants.

So Assume $\eta = 99\%$

$E_{N_{CO}} = 1.35$ #/ton

$E_{N_{HC}} = 0.28$ #/ton

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10/9/74

Source Formaldehyde

HC :

~~Thus~~ As discussed in Vol #1,

$$E_S = E_S^u + E_S^P + E_S^A .$$

Distribution of production capacity (1967) is given on page 2 of the industrial factor calculations.

(i) According to the 1967 production distribution, 78% of the plants are located in states with no applicable HC regulations.* (All except Ohio, Texas)

Thus

$$E_S^u = (.78)(27.5) = 21.5 \text{ LB/TON}$$

where E_u is calculated in previous emission factor work.

(ii) For Ohio & Texas**, the state regulations require specific emissions control efficiency. For E_S^P we have

$$E_S^P = E_u \sum_j A_j(1-P_{cj}) = 27.5\left[\underbrace{(.15)(.08)}_{\text{OHIO}} + \underbrace{(.10)(.14)}_{\text{TEXAS}}\right]$$

$$E_S^P = 0.7 \text{ LB/TON}$$

Then we obtain

$$\boxed{E_S = E_S^u + E_S^P = 22.2 \text{ LB HC/TON FORM.}}$$

*Ref 84 & 148

**Emissions reg. requires incineration; we have assumed 90% efficiency.

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Computation Sheet For Emission Factors

Calculations Done By RJ Londergan Date 10/9/74

Source Formaldehyde

CO:

Carbon monoxide emissions regulations only apply for specific types of sources,* which do not include chemicals plants. Therefore, in this case

$$E_p = E_u = 135 \text{ LB CO/TON FORM.}$$

---

*Ref 84 & 148.

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 1-17-75

Source Fuel Conversion - Coal Gasification

There are presently no full-production commercial coal gasification units in the United States and the prospects are not very good that any will be on-line operation prior to 1980. This goes for low-BTU and high BTU gas. Ref 256, 257, and 258 present a complete analysis for nearly 40 fuel conversion processes.

Ref 256 pg 7

of 39 processes 21 are for low BTU gas
18 for SNG

As discussed in the above reference the Lurgi process is planned to be the first US SNG process for commercial use. (Texas).

It is not know at this time, how much gas will be produced or is planned to be produced from coal in the year 1985. Project Independence and foreign oil supplies are putting external non-technical pressure on current development. Most processes are in the developing - process design stage. Some are only at the bench or pilot stage. Most could not be expect to be in operation commercially by 1985. Ref 258 pg I-13 Table I-3 presents the types of plants required to meet Project Independence. and as can be surmised this is a mighty task.

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Computation Sheet For Industrial Factors

Calculations Done By 2J. Marrone Date 1-17-75

Source Fuel Conversion - Coal Gasification

It is difficult then, to predict the production of gas in 1985 and equally difficult is guessing exactly which processes will be employed. Factors which influence process selection are the characteristics of the feed (caking, sulfur content etc)

One major assessment that may be made is that this industry is at a stage that if NSPS are imposed then it will encompass all sources since existing capacity is not within the U.S. Imposition of NSPS would be incorporated in the "Process Design and Development" so that the final commercial unit will be installed environmentally acceptable and by route of the most effective economics.

Since there is no existing capacity in 1975 we may state that $A = 0$.
In attempting to define this industry we make the appraisal that most of the installed capacity will occur close to the year 1985 so that defining a growth (P_C & P_B) rate after 1975 on some hypothetical capacity is unreasonable. Our judgment leads us to define just a value for C and treat this 1985 production capacity according to the

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 1-17-75

Source Fuel Conversion - Coal Gasification

following equations;

A = 0 no existing capacity P_c & P_B undefined
B = 0

C to be defined (1985 capacity)

$$T_S = K E_S C$$

$$T_N = K E_N C$$

impact

$$T_S - T_N = KC[E_S - E_N]$$

This study is developed according to the following;

(1) Ref 258 p I-13 gives the number of plants need for High-BTU gas and Low-BTU gas production from coal to meet Project Independence
We see that 12 High BTU and 16 Low-BTU plants (Total of 28) represent approx 68% of the synthetic fuel plants

(2) This study is restricted to these two coal gasification routes and it is assumed the Project Indepence will be meet such that in 1985 there are
12 High BTU
16 Low BTU
> gasification plants.

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 1-17-75

Source Fuel Conversion - Coal Gasification

(3) For High-BTU (SNG) Gas we will assume that the Lurgi Process will be the system

(4) For the Low-BTU (utility application) gas we will assume that the Koppers-Totzek will be the system.

(5) Since the requirements of coal gasification are in terms of production capacity these values may be used to develop C.

(6) SNG plants are run continuously and product may be stored and in light of non information we assume $K = 1.0_{H\text{-}BTU}$

(7) Low-BTU (utility) plants are run in conjunction with power utility systems and would have turndown to accomonodate peak-demand situation assume $K = .50_{L\text{-}BTU}$

Ref 259 p 22

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 1-17-75

Source Fuel Conversion - Coal Gasification

Ref 257 pg 2 and Ref 258 pg I-13

SNG High BTU plant size $= 250 \times 10^9$ BTU/day

Low BTU Plant (utility) size $= 130 \times 10^9$ BTU/day

365 day/yr

We may now estimate the value of C using these average plant sizes and the expected number of plants for each coal gasification route.

High BTU production : $12 \text{ plant} \times 250 \times 10^9 \frac{\text{BTU}}{\text{day plant}} \times 365 \frac{\text{day}}{\text{yr}} \cong 1.1 \times 10^{15} \frac{\text{BTU}}{\text{yr}}$

Low BTU production : $16 \text{ plant} \times 130 \times 10^9 \frac{\text{BTU}}{\text{day plant}} \times 365 \frac{\text{day}}{\text{yr}} \approx .76 \times 10^{15} \frac{\text{BTU}}{\text{yr}}$

$C_{H\text{-}BTU} = 1.1 \times 10^{15}$ BTU/yr SNG gas produced

$C_{L\text{-}BTU} = \frac{.76}{.5} \times 10^{15}$ BTU/yr $\cong 1.52 \times 10^{15}$ BTU/yr gas produced

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 1-17-75

Source Fuel Conversion – Coal Gasification

All references reviewed [256, 257, 258, 259, 260] discuss fully the current state of technology for this industry with respect to process development. Most systems have not gotten fully to the points where atmospheric emissions could be determined. Emissions are discussed however, the treatment given is in terms of sulfur compounds and not the other pollutants. We judge that since sulfur compounds have been treated primarily that they represent the most significant and prominent pollutant. Information on other pollutants may have to wait until emissions are investigated more fully on the larger pilot plant systems and after "Process" concerns have been taken care of first.

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 1-17-75

Source Fuel Conversion - Coal Gasification

High-BTU Gasification (Lurgi Process)

Ref 256 p 10

We assume that the flowsheet describe the best system design such that the sulfur emissions would represent an indication of E_N:

Emission Σ stream ③, ⑦, ⑧ pg H & 16

③ 18 kg/hr
⑦ 12 kg/hr
⑧ 49 kg/hr

79 kg/hr × 2.2 lb/kg ≈ 174 lb/hr × 24 hr/day = 4171 lbS/day

Sulfur Compounds

$$E_N : \frac{4171 \text{ lb/day}}{250{,}000 \times 10^6 \text{ BTU/day}} = .0167 \text{ lb}/10^6 \text{ BTU}$$ SNG gas produced

The uncontrolled emissions are considered to result when stream ⑦ is not incinerated ~~off~~ assum 90% ⟹ E_u ⑦ = 12/.01 = 1200

E_u' = 1200 + 18 + 49 = 187 kg/hr × 2.2 lb/kg = 411 lb/hr × 24 h/day ≅ 9874 lb/day

Sulfur Compounds

$$E_u = \frac{9874 \text{ lb/day}}{250{,}000 \times 10^6 \text{ BTU/day}} = .039 \text{ lb}/10^6 \text{ BTU}$$ SNG gas produced

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 1-17-75

Source Fuel Conversion - Coal Gasification

Ref 084 & 148

There are no sulfur regulations which may be applied to coal gasification plants so that $E_s = E_u$

$E_s = .039$ lb/10^6 BTU SNG gas produced

Low BTU Coal Gasification Kopper - Totzek

Ref 256 pg 64 Figure 6

The process design which provide for Claus sulfur recovery and Tail gas (Beavon) cleanup will be assumed to represent the most advanced system in estimating E_N

Plant design 130×10^9 BTU/day

Pg 70 Table 36

stream ⑥ 3.9 Kg/hr "controlled"

$$\frac{3.9 \text{ Kg/hr} \times \frac{2.2 \text{ lb}}{\text{kg}} \times \frac{24 \text{ hr}}{\text{day}}}{130 \times 10^9 \text{ BTU/day}} = \frac{206 \text{ lb/day}}{130{,}000 \times 10^6 \text{ BTU/day}}$$

sulfure compounds

$E_N = .0016$ lb/10^6 BTU gas produced

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 1-17-75

Source Fuel Conversion - Coal Gasification

Low BTU Coal Gasification cont'd

E_u:

Uncontrolled emissions are assumed to be with no tail-gas cleanup
Ref 256 pg 69 Table 35

Stream ④ 181 kg/hr

sulfur compounds

$$E_u \quad \frac{181 \frac{kg}{hr} \times 24 \frac{hr}{day} \times 2.2 \frac{lb}{kg}}{130{,}000 \times 10^6 \ BTU/day} = .074 \ lb/10^6 \ BTU \text{ gas produced}$$

E_s:

We assume as for SNG production that $E_s = E_u$

$$E_s = .074 \ lb/10^6 \ BTU \text{ gas produced}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 1-17-75

Source Fuel Conversion - Coal Gasification

Impact Calculation

High BTU Coal Gasification

$C = 1{,}100 \times 10^{12}$ BTU/yr

$K = 1.0$

$E_N = .0167$ lb/10^6 BTU

$E_S = .039$ lb/10^6 BTU

$T_S = KCE_S$

$T_N = KCE_N$

$$T_S = (1.0)(1{,}100 \times 10^{12} \frac{BTU}{yr})(\frac{.039 \text{ lb}}{10^6 \text{ BTU}}) = 42.9 \times 10^6 \frac{lb}{yr}$$

$T_S = 21{,}450$ TON/yr sulfur compounds

$$T_N = (1.0)(1{,}100 \times 10^{12} \frac{BTU}{yr})(\frac{.0167 \text{ lb}}{10^6 \text{ BTU}}) \cong 18.4 \times 10^6 \frac{lb}{yr}$$

$T_N = 9{,}135$ TON/yr

IMPACT $T_S - T_N \cong 12{,}300$ TON/yr

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 1-17-75

Source Fuel Conversion - Coal Gasification

Low-BTU Coal Gasification

$C = 1.52 \times 10^{15}$ BTU/yr

$K = .50$

$E_N = .0016$ lb/10^6 BTU

$E_S = .074$ lb/10^6 BTU

$T_S = KCE_S$

$T_N = KCE_N$

$$T_S = (.5)(1.52 \times 10^{15} \frac{BTU}{yr})(.074 \frac{lb}{10^6 BTU}) = 56.24 \times 10^6 \text{ lb/yr}$$

$T_S = 28,120$ TON/yr sulfur compounds

$$T_N = (.5)(1.52 \times 10^{15} \frac{BTU}{yr})(.0016 \frac{lb}{10^6 BTU}) = 1.22 \times 10^6 \text{ lb/yr}$$

$T_N = 610$

Impact $T_S - T_N \cong 27,500$ TON/yr

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Computation Sheet For Industrial Factors

Calculations Done By HOPPER Date 6/3/75

Source LEAD PIGMENT Mfg.

Ref (276) p 8

1966 Pb consumption = 119.9×10^3 TONS (MAX YEAR)
1971 Pb " = 81.3×10^3 "

$$P_c = \sqrt[5]{\frac{81.3}{119.9}} - 1 = -0.075$$

$$P_c = -0.075$$ COMPOUND

Ref (276) p 8

$$1975\ P_{ROD} = (1 - .075)^4 (81.3 \times 10^3) = 0.0595 \times 10^6 \text{ TONS}$$

$$= 0.0595 \times 10^6 \text{ TONS}$$

We will assume K equal to that det'd for the paint industry. (See "INDUSTRIAL FACTORS - PAINT MFG")

$$K = 0.83$$

$$A = \frac{0.0595 \times 10^6}{.83} = 0.0717 \times 10^6$$

$$A = 0.0717 \times 10^6 \text{ TONS LEAD}$$

Since production is declining @ a 7.5% rate & twice the allowable IRS depreciation rate is only ~ 4.5% (Ref 37), we assume no economic incentive to replace obsolete plants. $\therefore$ $P_B = 0.0$

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 6/3/75

Source Lead Pigment Mfg

Ref (278) p 71

$$E_{U_{Pb}} = 9.5 \text{ LB/TON Pb IN PRODUCT}$$

Ref (276) p33 indicates ~~that~~ a baghouse could achieve 99.9% η

$$E_{111d_{Pb}} = (1-.999)(9.5) = 0.0095$$

$$E_{111d_{Pb}} = 0.0095 \text{ LB/TON Pb IN PRODUCT}$$

Ref (276) p 33 indicates typical plant size of 60 TPD
Assuming 24 hr op'n

$$\frac{60 \text{ TPD}}{24} = 2.5 \text{ TPH} = 5000 \text{ pph}$$

From the gen'l PWR curve (Ref (84) + (148)), the allowable emissions are 7.8 LB/HR

$$E_S = \frac{7.8}{2.5} = 3.12$$

$$E_S = 3.12 \text{ LB/TON Pb IN PRODUCT}$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 6-5-75

Source Maleic Anhydride (Benzene Oxidation)

K: Ref 096 Oct 1966

discussion offered that mentioned the over-capacity which plagued this industry in the past (1950's) however, maleic anhydride producers have learned from mistakes and have gauged more closely expansion programs so that demand and capacity were nearly equal.

Certainly K will be large (close to 1) based on this. We make the assumption that K will be high enough in the .9 - 1.0 range to be considered equal to 1.0

$$K = 1.0$$

P_c: Ref 096 Oct 1966

growth trend 1955-1965 - 10.9% /yr
est trend 1966-1970 - 12% /yr

Ref 128 pg MA-8 indicates a capacity growth from 1972-1973 of 9%

about 50% of the production of MA. goes to polyester resin which was shown by Hopper - "Synthetic Resins : Polyester" to have a growth of 17% /yr. This gives good backup to M.A. high growth rate.

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Computation Sheet For Industrial Factors

Calculations Done By William Morrone Date 6-5-75

Source Maleic Anhydride by Benzene Oxidation

P_c: We will use a growth of 9%/yr for the industry.

$$P_c = .09\ c$$

A: ref 128 pg MA-8

$$\text{Cap}_{1973} = 391 \times 10^6 \text{ lb/yr}$$

$$\text{Cap}_{1975} = 391\,(1+.09)^2 = 465 \times 10^6 \text{ lb/yr}$$

$$A = 465 \times 10^6 \frac{\text{lb}}{\text{yr}} \times \frac{\text{TON}}{2000 \text{ lb}} = 233{,}000 \text{ TON/yr}$$

$$A = .23 \times 10^6 \text{ T/yr}$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 6-5-75

Source Maleic Anhydride by Benzene Oxidation

P_B:

Ref 037 pg 33

Class 28

IRS guideline period 11 yrs

P_B est → 2 × IRS = 22 yrs

$\frac{100\% \text{ deprec}}{22 \text{ yrs}} = 4.5\%$

P_B = .045 simple

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 6-5-75

Source Maleic Anhydride (Benzene Oxidation)

E_u: hydrocarbon & carbon monoxide

Ref 128 Table MA-VI and pg MA-3

single and significant source of emissions (HC & CO) is scrubber vent in recovery system. This scrubber is integral with process therefore, emission are considered uncontrolled.

$$E_{u_{CO}} = .67 \frac{T}{T} \times 2000 \frac{lb}{T} = 1340 \text{ lb/TON maleic anhydride}$$

$$E_{u_{HC}} = .086 \frac{T}{T} \times 2000 \frac{lb}{T} = 172 \text{ lb/TON maleic anhydride}$$

E_N: Ref 128 pg MA-5

indicates that appreciable control of CO & HC might be achieved by coupling a combustion device with the product recovery scrubber. One plant plans such a unit but data on efficiency is not reported. We assume that a degree of control of 99.9% can be obtained $E_N = .001 \times E_u$

$$E_{N_{HC}} = .172 \text{ lb/TON maleic anhydride}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 6-5-75

Source Maleic Anhydride (Benzene Oxidation)

E_u: cont'd

$$E_{u_{CO}} = 1.34 \text{ lb/TON maleic anhydride}$$

E_s: Ref 084 & 148

CO/ There are no specific CO regulations so that E_s is assumed equal to E_u

$$E_{s_{CO}} = 1340 \text{ lb/TON maleic anhydride}$$

HC/ The largest hydrocarbon emission is attributable to benzene which is believed to be considered photochemically unreactive.

The state locations and capacity breakdown shown on pg MA-8 of ref 128 used to develop E_s factor

$$A_i = \frac{\text{Prod State}}{\text{Prod Total}}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 6-5-75

Source Maleic Anhydride (Benzene Oxidation)

State	A_i	Allowable lb/TON*	
W Va	.056	N.R	
Pa	.206	N.R	
Mo	.292	N.R	
Tex	.139	N.R	
NJ	.139	N.R	
Ill	.167	26	based on 85% control

$\Sigma = .999$ OK rounding error

* average plant - 359/8 ≅ 45 ×10⁶ lb/yr × $\frac{1}{2000}$ × $\frac{1 yr}{350 d}$ = 64 $\frac{TON}{day}$ MA.

N.R. = No reg ∴ $E_{s_i} = E_u$

$$E_s = .833 \times E_u + .167 \times 26 = .833(172) + .167(26)$$

$$E_s = 143 + 4.$$

$E_{s_{HC}}$ = 147 lb/TON maleic anhydride

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Computation Sheet For Industrial Factors

Calculations Done By HOPPER Date 12/16/74

Source PAINT

REF (50) "PAINT & VARNISH Mfg"

P1

1970 PRODUCTION of SURFACE COATINGS = 830 x10^6 GALLONS

FROM REF (50) P 9 THERE WERE 1930 x10^6 # of VARNISH & RESIN PRODUCED (ASSUME 1970)

FROM REF (75) P 4.2-1 WEIGHT of VARNISH = 7 #/GAL

$$\text{SO} \quad \frac{1930 \times 10^6 \text{ LB}}{7 \text{ LB/GAL}} = 276 \times 10^6 \text{ GALLONS}$$

$$1970 \text{ PAINT PRODUCTION} = 830 \times 10^6 - 276 \times 10^6 \text{ GALLONS}$$
$$= 554 \times 10^6 \text{ GALLONS}$$

REF (135) P 157 INDICATES A GROWTH of PAINT & VARNISH = 2.63% (CMPD)

$$\therefore P_c = 0.0263$$

COMPOUND

$$1975 \text{ PRODUCTION} = (554 \times 10^6)(1.0263)^5 = 631 \times 10^6 \text{ GALLONS}$$

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Calculations Done By Hoper Date 12/16/74

Source Paint

Ref (235) p K6, Assuming the Avg of 80-90%

$K = 0.85$

Also, Ref (25) p17 Tab 2-6 indicates $\frac{1975\ Prod}{1975\ Cap} = \frac{1060}{1247} = .85$

$$A = \frac{631 \times 10^6}{.80} = 789 \times 10^6 \text{ gals}$$

$A = 789 \times 10^6$ gallons ← See bottom of page

Ref (235) p 169 indicates that the average life of equipment is 10 to 20 yrs. Assuming an avg of 15 yrs,

$$P_B = \frac{100\%}{15\text{ yrs}} = 6.67\%$$

$P_B = 0.0667$ simple

12/17/74 Since emission factors are on a "per ton" basis

$$A = 789 \times 10^6 \text{ gallons } \left(12.5 \frac{\text{lb}}{\text{gal}}\right) / 2000 = 4.93 \times 10^6 \text{ tons}$$

↑ See p2 - Emission factors

$A = 4.93 \times 10^6$ tons

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By Homer Date 12/16/74

Source Paint

REF (75) p 5.10-2 TAB 5.10-1

$$EU_{PART} = 2 \text{ \#/TON OF PIGMENT}$$

REF (222) STATES "The volatile portion of most common surface coatings averages approximately 50% ....."

SO,

$$EU_{PART} = 2 \frac{\#}{\text{TON PIG}} \times \frac{\text{1 TON PIG}}{\text{2 TON PAINT}} = 1 \text{ \#/TON of PAINT}$$

$$E_{UP} = 1 \text{ \#/TON of PAINT}$$

REF (75) p 5.10-2
TAB 5.10-1

$$EU_{HC} = 30 \text{ \#/TON of PAINT}$$

$$EU_{HC} = 30 \text{ \#/TON of PAINT}$$

From REF (25) p35; We can use a fabric filter on the pigment handling operation & control to an efficiency exceeding 99.9%
Assume 99.9%

$$E_{N} = (1 - .999)(1) = 0.001$$

$$E_{N_P} = 0.001 \text{ \#/TON of PAINT}$$

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Computation Sheet For Emission Factors

Calculations Done By HOPPER Date 12/16/74

Source PAINT

For HC, the most effective control technique is incineration

From Ref (30) p 7 $\eta = 99\%^{+}$. Assume 99%

$$E_{N_{HC}} = (1-.99)(30) = 0.3$$

$$E_{N_{HC}} = 0.3 \text{ \#/TON OF PAINT}$$

ES DET'N

PARTICULATE

From Ref (25) p 7-8 TAB 2-1

✓	ILL	124/826.3 =	15%
NR	NJ	103.3/826.3 =	12.5%
✓	CAL	99.2/826.3 =	12.0%
✓	OHIO	84.3/826.3 =	10%
NR	MICH	56.1/826.3 =	7%
NR	PA	47.0/826.3 =	6%
NR	TEX	44.6/826.3 =	5.5%
	OTHERS	=	32%

REF (235) p 82 TAB 21 "typical plant size = 1.9×10^6 gallons of paint per year. From Ref (75) p 4.2-1, "Paint weighs 10-15 #/gal

Assuming the av's = 12.5 #/gal

$$(1.9 \times 10^6 \text{ gals})(12.5 \text{ \#/gal}) = 23.75 \times 10^6 \text{ \# paint}$$

$$\frac{23.75 \times 10^6}{(8760)} = 2711 \text{ \#/HR} = 1.36 \text{ TPH}$$

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Calculations Done By Homer Date 12/17/74

Source Paint

This is paint. The quantity of pigment handled would be ~50% of this, or

1356 lb/hr ≡ 0.678 TPH of pigment

From Refs (84), (148) & (156) & the gen'l PWR curve, the allowable emissions are

Ill - 2.05 lb/hr
NJ - 14.20
Cal - 3.33 (Assume LAAPCD Rule 54)
Ohio - 3.15
Mich - 3.15
PA - consider as part of gen'l PWR curve
Tex - 2.15

All States - 3.18

$$E_{s_p} = f\left[.15(2.05) + (.125)(14.2) + (.12)(3.33) + (.10)(3.15) + (.07)(3.15) + (.055)(2.15) + (.38)(3.18)\right]$$

$$= .3075 + 1.775 + .3996 + .3150 + .2205 + .1183 + 1.2084$$

$$= 4.34 \text{ lb/hr}$$

$$E_{s_p} = \frac{4.34 \text{ lb/hr}}{1.36 \text{ TPH paint}} = 3.19$$

$$E_{s_{part}} = 3.19 \text{ \#/ton of paint}$$

Since this is greater than E_u

$$E_{s_{part}} = 1 \text{ \#/ton paint}$$

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 12/17/74

Source PAINT

HYDROCARBONS

REF (235) p 5d TAB 7 STATES that . . .

46.0% REACTIVE SOLVENTS
31.6% UNREACTIVE "
22.4% UNKNOWN

Ref (25) p43ff INDICATES that AS MORE STATES ENACT H/C REG'S, PAINT REFORMULATION WILL become MORE & MORE PREVALENT. WE WILL ASSUME that by 1985, ALL PAINT SOLVENTS WILL be CONSIDERED "EXEMPT" OR UNREACTIVE.

OF the 7 STATES LISTED ON p2 of these calcs, only 3 have regs & none of these have regs dealing with the limitation of exempt solvent emissions.

$$\therefore E_{S_{HC}} = E_U = 30$$

$$E_{S_{HC}} = 30 \text{ \#/TON PAINT}$$

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Computation Sheet For Industrial Factors

Calculations Done By HOPPER Date 7/30/74

Source PHTHALIC ANHYDRIDE ~~(O- xylene Process)~~ (NAPHTHALENE PROCESS)

PHTHALIC ANHYDRIDE IS CURRENTLY MFG'D BY TWO PROCESS

O - XYLENE
NAPHTHALENE REF (50)

FEW IF ANY NEW PLANTS USING THE NAPHTHALENE PROCESS WILL BE BUILT IN THE FUTURE REF (50)

CURRENT CAPACITY FOR NAPHTHALENE PROCESS PLANTS WILL BE DECREASING FROM 603 MM#/YR IN 1973 TO 538 MM#/YR IN 1980. THIS TREND INDICATES THAT CAPACITY LOST THRU OBSOLESCENCE IS NOT BEING REPLACED. The estimated number of newplants is zero. REF (76) TABLE I

∴ ALL PHTHALIC ANHYDRIDE PLANTS USING THE NAPHTHALENE PROCESS WOULD NOT BE SUBJECT TO NSPS & ONLY THE O-XYLENE PROCESS MUST BE CONSIDERED

FROM REF (76) CAPACITY IN 1973 BY THE O- XYLENE PROCESS WAS 720 MM#/YR. THIS REFERENCE ALSO STATES AN ESTIMATED 1985 CAPACITY OF 1800 MM#/YR

ASSUMING COMPOUND GROWTH

$$CAP\ 1985 = CAP\ 1973\,(1+P_c)^n$$

$$1800 = 720\,(1+P_c)^{12}$$

$$\boxed{P_c = 7.9\%}$$ (COMPOUND)

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Computation Sheet For Industrial Factors

Calculations Done By HOPPER Date 7/30/74

Source PHTHALIC ANHYDRIDE

REF (50)

(a) 1972 PRODUCTION = 870 MM#/YR
(b) 1971 PRODUCTION = 46% BY NAPTHALENE 54% O-OXYLENE

ASSUME NO CHANGE FROM '71 TO '72

$(870 \times 10^6)(.54) = 470$ IN 1972

USING P_c = 7.9% & 1973 CAPACITY OF 720 MM#/YR
CALCULATE 1972 CAPACITY

$720 = X(1.079)^1$

$X = 667$

$K = \frac{470}{667} = .705 = 0.70$

BASED ON TYPICAL UTILIZATION RATES IN THE CHEMICAL PROCESS INDUSTRY, THIS K WOULD APPEAR TO BE LOW

REF (50)

TYP PLANT SIZE IN 1972 $= \frac{870 \times 10^6}{21} = 41.4 \times 10^6$

REF (78) TYPICAL NEW PLANT $= 134 \times 10^6$

THIS INFORMATION WOULD INDICATE THAT THE NEW, LARGE PLANTS ARE BEING BUILT IN ANTICIPATION OF FUTURE DEMANDS & PRODUCTION WILL APPROACH CAPACITY IN A PERIOD

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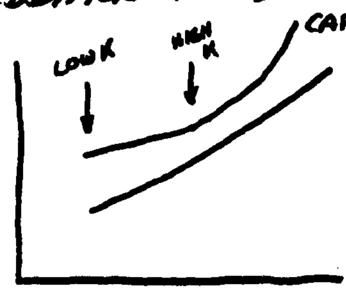
Computation Sheet For Industrial Factors

Calculations Done By Hopper Date 7/30/79

Source Phthalic Anhydride

OF TIME. THIS CAN BE DEMONSTRATED ON THE SKETCH BELOW FOR THIS INDUSTRY, WHICH IN 1972 HAD ONLY 21 PLANTS. EACH NEW ADDITION WOULD HAVE A HIGH PERCENTAGE EFFECT.



WE WILL DETERMINE AN AVERAGE K BASED ON AN ARITHMETIC AVERAGE OF HIGH & LOW

REF (95)

SEC 687.5030 FEB '66

IN 1964 $\frac{PROD}{CAP} = \frac{560}{630} = 89\%$

IN 1961 $\frac{PROD}{CAP} = \frac{380}{520} = 73\%$ ← AGREES WITH K AS CALC'D ON P2

$\Delta \div 2 = \frac{89-73}{2} = 8\%$

EST 6 NEW PLANTS 1973 - 1985 REF (76) TAB I p3 of 3

$\therefore K = 70 + 8 = 78\%$

$K = 0.78$

IT IS POSSIBLE THAT A K CAN BE DET'D FOR BOTH NEW & EXISTING PLANTS - BUT IT WOULD BE QUITE SUBJECTIVE. IF $(T_S - T_N)$ IS CONSIDERABLE, WE CAN GO BACK & DO THIS

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Computation Sheet For Industrial Factors

Calculations Done By HOPPER Date 7/30/74

Source PHTHALIC ANHYDRIDE

$A_{1975} = 720 \times 10^6 (1.079)^2 = 838 \times 10^6$ #/YR

$A = 838 \times 10^6$ #/YR = 0.419×10^6 TONS/YR

REF (76)

TABLE I p 3 of 3

CURRENT (1973) CAPACITY OF NAPTHALENE PROCESS PLANTS = 603×10^6 #/YR

ESTIMATED 1980 CAPACITY = 528 #/YR

(1) ASSUME SIMPLE DETERIORATION

$\frac{603}{528} = 1 + 7i \qquad i = P_B = 2.0\%$

(2) ASSUME this obsolescence RATE APPLIES EQUALLY TO THE O-XYLENE PROCESS

$\therefore P_B = 0.02$

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Computation Sheet For Emission Factors

Calculations Done By HOPPER Date 7/31/74

Source PHTHALIC ANHYDRIDE

CARBON MONOXIDE

$$E_U = 0.140 \frac{\text{TONS CO}}{\text{TON PH. AN.}} = 280 \text{ LB/TON PH.AN.}$$

$$E_M = 0.0001 \frac{\text{"}}{\text{"}}$$ BY INCINERATION REF (050)

$$E_N = 0.2 \text{ LB/TON}$$

HYDROCARBONS

$$E_U = 0.065 \frac{\text{TONS HC}}{\text{TON PH. AN.}} = 130 \text{ LB/TON PH.AN.}$$

$$E_M = 0.0025 \frac{\text{"}}{\text{"}}$$ BY INCINERATION REF (50)

$$E_N = 5.0 \text{ LB/TON}$$

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Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10/8/74

Source Phthalic Anhydride

HC

As discussed in Vol #1,

$$E_S = E_S^{a} + E_S^{P} + E_S^{A}$$

No detailed breakdown of phthalic anhydride production into individual plant location and capacity was found. From Ref. 045, p. 623 we have a listing of plant locations, ~~We will therefore assume that production~~ as of 1963. We will assume that current production capacity is distributed among states in ~~the same~~ proportion to the number of plants located there in 1963. The table below lists the fractional capacity ~~estimated~~ within each state on this basis

STATE	A_i	Control regulation* (percent)
CAL	0.11	.85 **
PENN.	0.18	— ***
OHIO	0.06	.85
N.J.	0.39	— ***
TEX.	0.06	.90 ****
PUERTO RICO	0.06	— ***
ILL.	0.18	.85

* REF. 84 & 148

** L.A. COUNTY REGS. ASSUMED FOR WHOLE STATE

*** NO STATIONARY H.C. REG. GIVEN IN REF. 148

**** TEXAS REGULATION REQUIRING "INCINERATION" IS ESTIMATED AS A REQUIREMENT OF 90% EMISSIONS CONTROL.

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Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10/8/74

Source Phthalic Anhydride

HC (cont.)

(a) $E_S^u = E_u \sum_{i=1}^{k} A_i$

$= (130)\left(\frac{11}{18}\right) = 79.4$ LB/TON

where $E_u = 130$ LB/TON from previous emissions factor calculation.

(b) $E_S^p = E_u \sum_{j=1}^{4} A_j (1 - P_{cj}) = 130\left[(.15)\left(\frac{6}{18}\right) + (.10)\left(\frac{1}{18}\right)\right]$

$= 6.5 + .7 = 7.2$ LB/TON

The total estimated E_S is then

$E_S = E_S^u + E_S^p = 86.6$ LB/TON

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Computation Sheet For Emission Factors

Calculations Done By R.J. Londergan Date 10/8/74

Source Phthalic Anhydride

CO.

Carbon monoxide emissions from Phthalic anhydride production are not ~~regulated~~ restricted by current state regulations.* Therefore, E_S for CO will in this case be equal to E_{u}.

$$E_S = E_{u} = 280 \text{ LB/TON PH. AN.}$$

using E_u from a previous emission factor calculation.

* Ref. 84 & 148.

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Computation Sheet For Industrial Factors

Calculations Done By K. Tower Date 1/20/75

Source Printing Ink

The printing ink industry supplies the graphic arts industry with the ink necessary to make their various prints. Because these two industries are so closely related we assume their growth rates are the same. From ref. 050, p. 2

$$P_c = .050 \text{ compound}$$

Since there was no data relating production to capacity for the printing ink industry we assumed the fractional utilization rate to be the same as that given by ref. 144 for all chemicals manufacturers ⟶ 0.83. This value represented an average value for the years 1965-1973.

$$K = 0.83$$

Ref 050 states that the total production of printing ink in 1968 was 504.5×10^6 lbs. The printing ink capacity in 1975 will therefore be equal to the following:

$$A = \frac{Prod_{1968}}{K}\left(1+P_c\right)^{1975-1968}$$

$$= \frac{\left(504.5 \times 10^6 \frac{lbs}{YR}\right)\left(1+.050\right)^7}{(.83)\left(2000 \frac{lbs}{TON}\right)} = .427 \times 10^6 \frac{TONS}{YR}$$

$$A = .427 \times 10^6 \frac{TONS}{YR} \text{ INK}$$

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Computation Sheet For Industrial Factors

Calculations Done By K. Tower Date 1/21/75

Source Printing Ink

Ref 037, p.33, section 28.0 states that the asset guideline period for the manufacture of chemicals and allied products is 11 years. Assuming twice the IRS allowable

$$P_B = \frac{1}{(2)(11)} = .045$$

$P_B = .045$ simple

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Computation Sheet For Emission Factors

Calculations Done By K.Tower Date 1/21/75

Source Printing Ink

Printing ink is a mixture of coloring matter dispersed or dissolved in a vehicle or carrier, which forms a fluid or paste which can then be printed on a substrate and dried. The vehicle used acts as a carrier for the colorant during the printing operation. Vehicle preparation by heating is by far the largest source of ink manufacturing emissions. There are three types of vehicle cooking processes → those which cook oils, oleoresinous, and alkyds. The emissions are organic in nature. There is no specific data giving the percentage breakdown of the amount of cooking done by each of these processes. However ref. 075 (p. 5.14-2, Table 5.14-1) gives an emission factor for a general vehicle cooking process as 120 lbs/TON Prod.! We assume this to be the general uncontrolled emission factor for the printing ink industry.

$$E_u = 120 \frac{\text{lbs HC}}{\text{TON INK Produced}}$$

Ref 075, 5.14-1 states the emissions from the cooking phase can be reduced by more than 90% with the use of scrubbers or condensers followed by afterburners.

$$E_N = 120 \frac{\text{lbs}}{\text{TON}} \times .10 = 12 \frac{\text{lbs}}{\text{TON}}$$

$$E_N = 12 \frac{\text{lbs HC}}{\text{TON of INK}}$$

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Computation Sheet For Emission Factors

Calculations Done By K. Tower Date 1/21/75

Source Printing Ink

Ref 158 (Printing Ink) gives the following table (summarized) concerning the geographical distribution of printing ink manufacture establishments.

Geographic Area	Total Number of Establishments	% of Total	* Hydrocarbon Regulations
United States	398	—	
Massachusetts	16	4.0	No Reg.
Ohio	33	8.3	15 lbs/day or 85% control
Indiana	4	1.0	15 lbs/day or 85% control
Illinois	44	11.1	8 lbs/day or 85% control
Michigan	7	1.8	No. Reg.
Wisconsin	12	3.0	15 lbs/day or 85% control
Minnesota	7	1.8	No Reg.
Missouri	15	3.8	No Reg.
Georgia	14	3.5	No. Reg.
California	49	12.3	15 lbs/day or 85% control
		50.6	

* Ref 084 & Ref 148

In order to compute E_s for the printing ink industry, we made the following assumptions:

1) For those states which have no hydrocarbon regulations $E_s = E_u$. ($120 \frac{lbs}{TON}$)
2) The % of the total number of printing ink establishments for each state is equal the % of the total volume of ink produced.
3) For those states (49.4%) where the % of total is not known, we assume their hydrocarbon regulation is equal to E_s

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Computation Sheet For Emission Factors

Calculations Done By K. Tower Date 1/21/75

Source Printing Ink

4) The average printing ink plant operates 16 hrs/day, 5 day/wk, 50 $\frac{wks}{YR}$ 4000 hrs/yr.

5) The average printing ink plant produces 2.53 $\frac{\text{TONS INK}}{\text{DAY}}$

$$\frac{504 \times 10^6 \frac{lbs}{YR}}{\left(250 \frac{DAYS}{YR}\right)\left(2000 \frac{lbs}{TON}\right)(398 \text{ plants})} = 2.53 \frac{\text{TONS INK}}{\text{Day}}$$

6) Since an 85% reduction of the emissions from an average plant gives a value greater than 15 lbs/day, the applicable regulation for those states which operate under L.A rule 66 or its equivalent is the 85% reduction of emissions

$$\left(120 \frac{\text{lbs emissions}}{\text{TON INK}}\right)\left(2.53 \frac{\text{TONS INK}}{\text{DAY}}\right) \times .15 = 45.5 \text{ lbs/day or}$$

$$\left(45.5 \frac{lbs}{day}\right) \Big/ 2.53 \frac{\text{TONS INK}}{\text{DAY}} = 18.0 \frac{\text{lbs Emissions}}{\text{TON INK}}$$

$$E_s = (.040) E_{All \atop Mass} + (.083) E_{Allowable \atop Ohio} + (.01) E_{Allowable \atop Ind.} + (.111) E_{All \atop Ill.} + (.018) E_{All \atop Mich} +$$
$$(.030) E_{All \atop Wisc} + (.018) E_{All \atop Minn.} + (.038) E_{All \atop Missouri} + (.035) E_{All \atop Georgia} + (.123) E_{All \atop Calif} + (.494) E_s$$

$$E_s = (.040)\left(120 \tfrac{lbs}{TON}\right) + (.083)\left(18.0 \tfrac{lbs}{TON}\right) + (.01)\left(18.0 \tfrac{lbs}{TON}\right) + (.111)\left(18.0 \tfrac{lbs}{TON}\right) + (.018)\left(120 \tfrac{lbs}{TON}\right) +$$
$$(.030)\left(18.0 \tfrac{lbs}{TON}\right) + (.018)\left(120 \tfrac{lbs}{TON}\right) + (.038)\left(120 \tfrac{lbs}{TON}\right) + (.035)\left(120 \tfrac{lbs}{TON}\right) +$$
$$(.123)\left(18.0 \tfrac{lbs}{TON}\right) + .494 E_s$$

$$E_s = \frac{4.8 + 1.49 + .18 + 2.00 + 2.16 + .54 + 2.16 + 4.56 + 4.2 + 2.21}{.506} = 48.0 \frac{lbs}{TON}$$

$$\boxed{E_s = 48.0 \frac{\text{lbs emissions}}{\text{TON INK}}}$$

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Computation Sheet For Industrial Factors

Calculations Done By HOPPER Date 8/1/74

Source SOAP MANUFACTURING

$P_C = 0$ REF (5) P 38
REF (6) P 738 FIG 569

HOWEVER, "INCREASED CONCERN FOR ECOLOGY PROBLEMS MAY CAUSE A RISE IN SOAP SALES IN THE NEAR FUTURE" REF (5)

THEREFORE, THIS INDUSTRY SHOULD BE REVIEWED PERIODICALLY FOR AN SURGE IN GROWTH

$A_{PROD} = 1 \times 10^9$ #/YR (1970 BASIS SAME AS 1975 SINCE $P_C = 0$ REF (5))

$K = 0.9$ REF (005)
ASSUME TO BE SAME AS DETERGENTS INDUSTRY

$A = 1.11 \times 10^9$ #/YR 0.555×10^6 TONS/YR

SINCE $P_C = 0$ & $(T_S - T_N)$ IS ONLY AFFECTED BY P_B, THE VALUE OF $(T_S - T_N)$ FOR THIS INDUSTRY SHOULD BE FAIRLY LOW (THIS WILL BE DET'D ONCE THE CALC'N IS MADE

HOWEVER, SINCE THE INDUSTRY PRODUCTION IS SO GREAT (REF 77 P 429), EVEN A SLIGHT INCREASE IN P_C COULD HAVE A SIGNIFICANT EFFECT ON EMISSIONS. IN THE EVENT OF AN UPSWING IN PRODUCTION, $(T_S - T_N)$ COULD INCREASE DRASTICALLY. THEREFORE, THIS INDUSTRY SHOULD BE WATCHED CAREFULLY. SEE COMMENTS REG. EMISSIONS ON EMISSION FACTORS CALC'N SHEET.

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Computation Sheet For Industrial Factors

Calculations Done By W. Morrone Date 9-26-74

Source Soap Manufacturing

P_B:

Ref 037 pg 33 Sec 28.0

Soap manuf comes under the manuf of chemicals and allied products. The asset guideline period is 11 yrs

We estimate P_B from 2 × IRS = 22 yrs

100% Depreciation in 22 yrs (simple)

$$\frac{100\%}{22 \text{ yrs}} = 4.5\%/\text{yr}$$

$$\therefore P_B = .045 \text{ simple}$$

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Computation Sheet For Emission Factors

Calculations Done By HOPPER Date 8/2/74

Source SOAP MANUFACTURING

E_U = 13 #/TON REF (005) p 16

AVG OF RANGE 10 #/TON - 15 #/TON

THIS EMISSION IS DET'D AFTER A CYCLONE COLLECTOR ON A SPRAY DRYER. THE CYCLONE IS AN INTEGRAL PART OF THE PROCESS. ALTHOUGH THE SPRAY DRIER IS NOT ALWAYS USED IN THE MFG OF ALL SOAPS, IT WILL BE TREATED AS THOUGH IT IS. THE EFFECT WOULD BE A MAXIMIZATION OF $(T_S - T_N)$. IN THE EVENT THAT P_E CHANGES, THIS ASSUMPTION WOULD HAVE TO BE MODIFIED TO OBTAIN ~~AN~~ A MORE REALISTIC ESTIMATE OF $(T_S - T_N)$.

ONE METHOD OF DEALING WITH THIS INDUSTRY IS TO COMBINE IT WITH DETERGENT MFG & CONTROL EMISSIONS FROM SPRAY DRIERS.

REF (5) GIVES SOME INFO ON ODORS

REF (77) p 453 η = 99.8% FOR WET SCRUBBER SYSTEM

13 #/TON (1 - .998) = E_N = 0.026 #/TON

REF (005) HAS MAP SHOWING LOCATIONS FOR USE IN DETERMINING E_S.

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Computation Sheet For Emission Factors

Calculations Done By V. F. Russo Date 10/17/74

Source Soap Manufacturing

Particulates:

Ref. 005 Pg. 2 gives distribution of Soap and Detergent plants in the 50 states. Page 1 states there are 700 total plants. We assume 350 plants are in the soap manufacturing industry

1975 Production Capicity = A = 1.11 x 10^9 lbs/YR

Assuming 8760 HR/YR Operation

Average Process Weight Rate = 1.27 x 10^5 lbs/HR

Employing the 50 State numerical average process weight rate curve,

Allowable Emissions = 46 lbs/HR

Thus

$$E_S = \frac{46 \text{ lbs/HR}}{1.27 \times 10^5 \text{ lbs/HR}} \; 2000 \text{ lbs/TON} = 0.724 \text{ lbs Part/TON Soap}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By William Marrone Date 8-15-74

Source Sodium Carbonate (Solvay Process)

Soda Ash

K:

Capacity Information:

Ref 095 p670 Ammonia Soda Plants:

Note * 1962-1964 information

9 plants

Allied - Syr, N.Y.
Det, Mich
Bat. Roug, La

Diamond - Plains, Ohio

Olin - Saltville, Va
L. Charle, La

PPG - Barberton, Ohio
- Corpus Christi, Texas

Wyandotte - W. Mich

Ammonia Soda plants range in size from 550 - 2,600 T/d cap

No Ammonia Plants have been built since 1935.

Using this information to ascertain Solvay plants and their respective capacities we determine from the following source:

Ref 096
July 1966

Plant		T/yr Cap
Allied	NY	1,100,000
	Mich	450,000
	LA	875,000
Diamond	Ohio	800,000
Olin	Va	360,000
	La	375,000
PPG	Ohio	600,000
	Tex	240,000
Wyandotte	Mich	800,000
		5,600,000 T/yr by Solvay

From Ref 095 June 1966 772.3030A Synthetic Prod = 5×10^6 T/yr 1964

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By William Marron Date 8-15-74

Source Sodium Carbonate (Solvay Process)

Using this 1964 production data

$$P_{64} = 5 \times 10^6 \text{ T/yr}$$

and the capacity of 1966 of 5.6×10^6 T/yr

$$K = \frac{5}{5.6} = .89$$

This value is valid in 1966 using the 1964 production since new plant production is non-existant. We will assume this K factor as representative of this industry.

$$K = .89$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-16-74

Source Sodium Carbonate (Solvay Process)

A:

We have determined above that the 1966 capacity for this industry was 5.6×10^6 Ton/yr

A more recent source of information Ref 042 p 38-39 gives a listing of Solvay plants which is almost identical to that from ref 045 and 096. The exception is that one synthetic plant is no longer listed (Allied - Det, Mich).

1968-1970 information

Synthetic Plants		T/yr Capacity
Allied	La	785,000
Allied	Syracuse NY.	1,000,000
Diamond	Ohio	800,000
Olin	La	375,000
Olin	Va	400,000
PPG	Ohio	600,000
PPG	Texas	240,000
Wyandotte	Mich	800,000
		5,000,000 T/yr Total capacity

(Note: ref lists 3,750,000 which is obviously an error as it would produce a capacity to large for this industry) ← 375,000

There is a synthetic plant located in Freeport, Texas (Dow) which is indicated by reference 045 pg 670 to be a carbonation of caustic and not a Solvay process plant.

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-16-74

Source Sodium Carbonate

A: There has been an obvious reduction in production capacity for the Solvay process. We use this Capacity, obtained from Ref 042 pg 38, as the value of A in 1975, until more recent information on these plant is obtained

$$A = 5 \times 10^6 \ T/yr$$

Note: K is assumed to remain the same industry-wide even though one of the nine plants has ceased operation

P_c: Since reference 045 p669 states that no Ammonia-soda (solvay) plants have been constructed since 1935 and we have found no evidence to indicate any recent construction of these plants we must assume at this time that the growth in this industry (solvay) is non-existant

$$P_c = 0$$

Growth in overall Sodium Carbonate production comes from natural plants (Trona Domes)

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-14-74

Source Sodium Carbonate (Soda Ash)

Ref 146 p95

"While production and use of chlorine & caustic soda is expected to grow at 6 to 7 percent through 1980, synthetic soda ash is expected to decline gradually.

Evidence supports the assumption that there is negative or zero growth in this industry. Natural production growth is occurring at 8-9% (Ref 146 pg 95). It is obvious that replacement of obsolete synthetic capacity would not occur

$\therefore P_B = 0$

$\therefore P_C = 0$ or neg

$P_B = 0$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 5-9-75

Source Sodium Carbonate (Solvay Process)

Ref 075 pg 5.16-1

Table 5.16-1 gives uncontrolled emission factors for particulate and ammonia from Solvay soda Ash plants.

E_u (Pt) = 6 lb/TON soda ash

E_u (Ammonia) = 7 lb/TON soda ash

These ammonia emissions are after ammonia recovery in brine absorbers.

Since this industry has a values for $P_C \leq 0$ and $P_B = 0$ then it would not appear likely that this source would be a candidate for NSPS. Ammonia, being a non-designated pollutant may be regulated by section 111(d). We will develop the factors E_N, E_{111d}, and E_S for ammonia at this time and forgo these factors for particulate.

Ref 084 & 148 there are no specific regulations limiting the discharge of ammonia to the atmosphere so that we may state $E_S = E_u$

E_S = 7 lb/TON soda ash

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Mascone Date 5-9-75

Source Sodium Carbonate (Solvay Process)

Ammonia

E_N: As discussed on pg 230 of ref 093;
the recovery of ammonia in the Solvay process is essential due to the high cost of ammonia and its relative worth with respect to the product.

We have found no information defining the degree of control achieved however we make the judgement that some additional efficiency may be achieved through improved design or operating procedures. It is probable that an additional 50% reduction from the already control level would be the maximum to expect

$E_N = .5 \times E_u = .5 \times 7 = 3.5$ lb/TON soda ash

$E_N = 3.5$ lb/TON soda ash (NH_3)

E_{IIId}: We assume that existing plants are amenable to design and operating improvements as discussed above and we equate $E_N = E_{IIId}$

$E_{IIId} = 3.5$ lb/TON soda ash

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Computation Sheet For Industrial Factors

Calculations Done By William Marrone Date 6-5-75

Source Sodium Carbonate /Soda Ash - Natural

K: Ref 096 July 1966

The capacity figures given are taken to represent 1965

$$\text{Capacity}_{1965} = 1{,}720{,}000 \text{ T/yr}$$

Ref 095 Sept 1971 772.3030 A

$$1965 \text{ Prod Natural} \cong 1{,}500{,}000 \text{ T/yr}$$

therefore $K_{65} = \frac{1.5\times10^6}{1.72\times10^6} \cong .87$

We assume this to be typical

$$\therefore K = .87$$

A: Ref 095 as above

extrapolation of the trend from 1965 to 1970 yields a production level in 1975 of about 5×10^6 T/yr and utilizing a K = .87 this gives a production capacity in 1975 of:

$$A = \frac{5\times10^6}{.87} = 5.75\times10^6 \text{ T/yr}$$

$$A = 5.75\times10^6 \text{ T/yr soda ash}$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 6-5-75

Source Sodium Carbonate/Soda Ash - Natural

P_c: A compound compound rate between 1965 and 1975 is assumed so that;

$$P_c = \sqrt[10]{\frac{P_{75}}{P_{65}}} - 1$$

$$P_c = \sqrt[10]{\frac{5\times10^6}{1.5\times10^6}} - 1$$

$$P_c = 1.128 - 1 = .128 \text{ c}$$

$$P_c = .128 \text{ compound}$$

P_B: Ref 1037 pg 33

Class 28

Assest Guideline period 11yrs

P_B est → 2×IRS = 22yrs

$$P_B = \frac{100\%}{22\,yr} \approx 4.5\%$$

$$P_B = .045 \text{ simple}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 6-5-75

Source Sodium Carbonate / Soda Ash - Natural

Little in the way of emission factors could be found for natural soda ash plants.

Based on a general presentation in Ref 045 pg 666 we see that most of the processing steps deal with handling and processing a liquid or slurry. It appears that the only significant emissions would come from product driers. We make the judgement that emission characteristics from the Detergent Industry spray dryer can be applied to Soda Ash dryers.

Particulate

$E_u = 90$ lb/TON soda ash

$E_N = .45$ lb/TON soda ash

E_s will be determined by using the PWR curve for those states with Natural production. From Ref 096 we see the capacity in 1966 is distributed in Calif, and Wyoming,

Calif - 150,000 + 70,000 + 200,000 = 420,000 ≈ 25%
Wyo - 900,000 + 400,000 = 1,300,000 ≈ 75%

$$\text{Avg plant size} = \frac{1{,}720{,}000 \text{ T/yr}}{5 \text{ plants}} \times 2000 \frac{\text{lb}}{\text{TON}} \times \frac{\text{yr}}{8400 \text{ hr}} = 81{,}900 \frac{\text{lb}}{\text{hr}}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 6-5-75

Source Sodium Carbonate / Soda Ash - Natural

Ref 084, 148, 156

State	A_i	Allow Pt lb/hr	Allow Pt lb/ton	Allow × A_i
Calif	.25	40	.97	.24
Wyo	.75	50	1.22	.92

$E_s = \Sigma = 1.16$ lb/ton

$E_s = 1.16$ lb/ton
part

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Computation Sheet For Industrial Factors

Calculations Done By Hopper Date 2/7/75

Source Synthetic Fibers — Acetate

Ref (95) p 543.1130

1970 Production = 0.6832×10⁹ LBS

The avg growth between 1964 & 1970 has been steady & compound in nature.

$$P_c = \sqrt[6]{\frac{.6832}{.5799}} - 1.0 = 0.0277$$

$P_c = 0.0277$ compound

Ref (209) gives production & capacity values for 4 companies making up 80% of the total production

$$K = 498/535 = 0.93$$

$K = 0.93$

$$A = \frac{(.6832)(10^9)(1.0277)^5}{(.93)(2000)} = 0.421 \times 10^6$$

$A = 0.426 \times 10^6$ tons

Ref (37) gives the IRS depreciation guideline of 11 yrs for "... assets used in the mfg of ... synthetic fibers ..." Assuming twice the avg,

$$P_B = \frac{1}{(2)(11)} = 0.045$$

$P_B = 0.045$ simple

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 2/7/75

Source Synthetic Fibers — Acetate

Since no emission factors for acetate fiber mfg could be located, we will assume HC emissions equal to ~~that~~ for nylon production.

Ref (95) pS: 19-1 TAB 5.19-1

$$E_{U_{HC}} = 7 \ \text{LB/TON ACETATE}$$

We will assume ~~that~~ 95% control could be achieved using carbon absorption

$$E_N = (1-.95)(7.0) = 0.35$$

$$E_{N_{HC}} = 0.35 \ \text{LB/TON ACETATE}$$

Since State regs apply only to the use of solvents, there would be no reg'n of HC emissions from the drying of the fiber. So $E_S = E_U$

$$E_{S_{HC}} = 7.0 \ \text{LB/TON ACETATE}$$

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Computation Sheet For Industrial Factors

Calculations Done By Hopper Date 2/7/75

Source Synthetic Fibers - Dacron (Polyester)

Ref (95) p 543.1130

1970 Production = 1.461×10^9 LBS

The avg growth rate between 1960 & 1970 is cmpd

1960 Production = 0.0752×10^9 LBS

$$P_c = \sqrt[10]{\frac{1.461}{.0752}} - 1.0 = 0.345$$

19.4282

Same Ref & page indicates a slight dropping off trend from 1963. We will use this new value rather than 0.345 which appears to be unrealistically high.

$$P_c = \sqrt{\frac{1.461}{1.078}} - 1.0 = 0.164$$

$P_c = 0.164$ compound

Ref (209) gives production & capacity values for 9 companies making up 80% of the total production

$$K = \frac{1465}{2163} = 0.68$$

$K = 0.68$

$$A = \frac{(1.461 \times 10^9)(1.164)^5}{(0.68)(2000)} = 2.295 \times 10^6$$

$A = 2.295 \times 10^6$ TONS DACRON

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Computation Sheet For Industrial Factors

Calculations Done By Hopper Date 2/7/75

Source Synthetic Fibers - Dacron

From Ref (37) The IRS depreciation guideline for "Mfg of chemicals and allied products .... includes assets used in the mfg of ... synthetic fibers ..." is 11 yrs. Assuming twice the avg,

$$P_B = \frac{1}{(2)(11)} = 0.045$$

$$\boxed{P_B = 0.045} \text{ simple}$$

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 2/7/75

Source Synthetic Fibers - Dacron

Ref (75) p 5.19-1 TAB 5.19-1

$E_{U_P} = 7.0$ LB/TON DACRON

OIL MIST

ESP's have been used successfully to control oil mists.
Assuming an $\eta = 95\%$

$E_{N_P} = (1-.95)(7.0) = 0.35$

$E_{N_P} = 0.35$ LB/TON DACRON

Ref (209) p13

9 Plants have capacity = 2163×10^6 LBS/YR
Assuming 330 days/yr & 24 hr/day

$$\frac{2163 \times 10^6 \text{ LB/YR}}{(9)(330)(24)} = 30,345 \text{ LB/HR}$$

From the gen'l PWR curve generated from Refs (84) + (48), the allowable emission rate is 24 pph

$$E_S = \frac{24(2000)}{30345} = 1.58$$

$E_{S_P} = 1.58$ LB/TON DACRON

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Computation Sheet For Industrial Factors

Calculations Done By Hoppe Date 2/7/75

Source Synthetic Fibers - Nylon

Ref (95) p 543.1130

1970 Production = 1.358×10^9 lbs

The avg growth between 1960 & 1970 is compound

1960 Production = 0.412×10^9 lbs

$$P_c = \sqrt[10]{\frac{1.358}{.412}} - 1.0 = 0.127$$

3,2961

$P_c = 0.127$ compound

Ref (209) p13 states that "Eight Companies account for 80% of U.S. Man-Made Fiber Capacity"

For Nylon $K = 1358/1823 = 0.72$ $K = 0.72$

$$A = \frac{(1.358 \times 10^9)(1.127)^5}{(0.72)(2000)} = 1.715 \times 10^6 \text{ tons}$$

$A = 1.715 \times 10^6$ tons

From Ref (37) The IRS guideline depreciation for "Mfg of chemicals and allied products . . . includes assets used in the mfg of . . . synthetic fibers" is 11 yrs. Assuming twice the avg,

$P_B = \frac{1}{(2)(11)} = 0.045$ $P_B = 0.045$ simple

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Computation Sheet For Emission Factors

Calculations Done By Homer Date 2/7/75

Source Synthetic Fibers - Nylon

Ref (75) p 5.19-1 TAB 5.19-1

$$E_{U_{HC}} = 7.0 \text{ LB/TON nylon}$$

We will assume ~~that~~ 95% control could be achieved using carbon absorption.

$$E_N = (1-.95)(7.0) = 0.35$$

$$E_{N_{HC}} = 0.35 \text{ LB/TON Nylon}$$

Since State regs apply only to the use of solvents, there would be no reg'n of HC emissions from the drying of the finished fiber. So $E_S = E_U$

$$E_{S_{HC}} = 7.0 \text{ LB/TON Nylon}$$

Ref (75) p 5.19-1
TAB 5.19-1

$$E_{U_P} = 15.0 \text{ LB/TON nylon}$$

OIL MIST

ESP's have been used successfully to control oil mists.

Assuming an efficiency of 95%,

$$E_{N_P} = (1-.95)(15.0) = 0.75 \text{ LB/TON}$$

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 2/7/75

Source Synthetic Fibers - Nylon

$E_{N_P} = 0.75$ LB/ton nylon

134,500 TPY

From Ref (209) p 13

7 plants have capacity = 1883×10^6 LBS/YR

Assuming 330 day/YR & 24 hr/day operation

$$\frac{(1883 \times 10^6)}{(7)(330)(24)} = 33965 \text{ LB/HR}$$

From the gen'l PWR curve generated from Refs (84) & (148) the allowable emission rate is 26 LB/HR

$$E_{S_P} = \frac{26\,(2000)}{33965} = 1.53$$

$E_{S_P} = 1.53$ LB/ton nylon

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-16-74

Source Viscose Rayon

K: Ref 146 pg 202

Operating rates of 90-95% were reached in 1972-1973 which was stated to be the maximum feasible rate.

We will assume that rayon demand will continue such that capacity utilization will follow this current trend.

Assume K=.90 (lower range of max feasible limit)

∴ K = .90

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-16-74

Source Viscose Rayon

A: The long range (1950-1969) rayon production appears on the attached graph. We have calculated the gross long term yearly growth from 1950-1969 as

$$\frac{1969-1950}{19\text{ years}} \cong 13.8 \times 10^6 \text{ lb/yr /yr}$$

Extrapolating the 1969 production through to 1975 by using the growth of 13.8×10^6 lb/yr /yr we may estimate the 1975 production. (see attached graph)

$$P_{75} = 1161 \times 10^6 \text{ lb/yr}$$

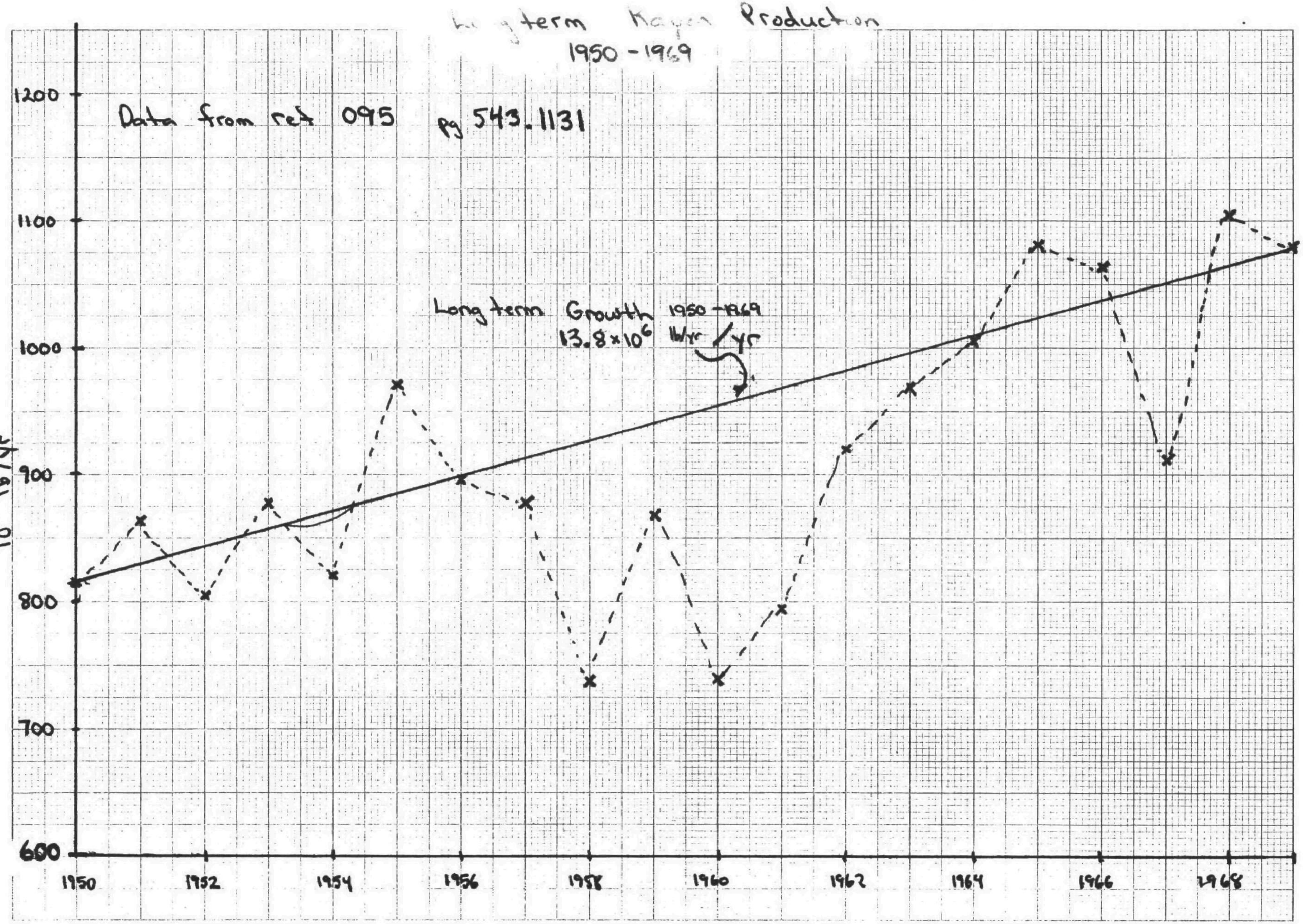
By applying K = .9 we obtain

$$A = \frac{P_{75}}{K} = \frac{1161 \times 10^6}{.9} = 1290 \times 10^6 \text{ lb/yr}$$

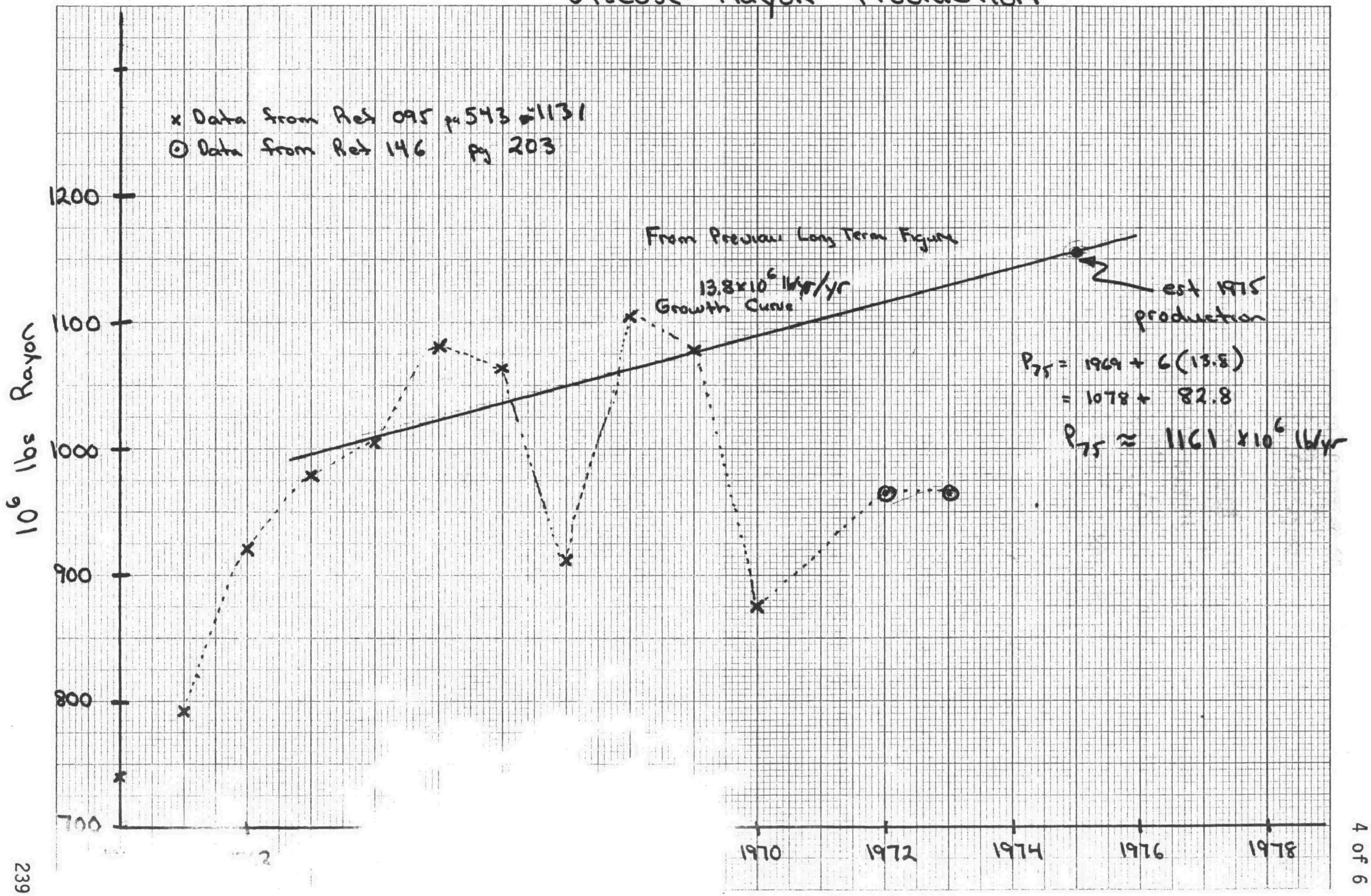
$$\therefore A = 1290 \times 10^6 \text{ lb/yr}$$

or

$$A = .645 \times 10^6 \text{ TON/yr}$$


term Production
1950 - 1969
Data from ref 095 pg 543.1131
Long term Growth 1950-1969
13.8 x 10^6 lb/yr /yr
10^6 lb/yr
1200
1100
1000
900
800
700
600
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968

Viscose Rayon Production



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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-16-74

Source Viscose Rayon

P_c:

Growth estimates for rayon were not obtainable in our literature. The production data appearing on the attached graphs clearly indicate a sizeable fluctuation from year-to-year. Note that the 1972 & 1973 production figure obtained from Ref 146 pg 203 are a good deal below the predicted trend (extrapolation of 1969 production using longterm growth factor).

Using the long term growth information may not be unrealistic for the rayon industry and it may even be better than using a short-term growth prediction.

With 13.8×10^6 lb/yr/yr growth and a 1975 production of 1161×10^6 lb/yr as a base line we may estimate a simple growth rate and assume it applicable to the period 1975-1985

$$\frac{13.8 \times 10^6}{1161 \times 10^6} \cong .012 \qquad 1.2\%/\text{yr simple}$$

$$\therefore P_c = .012 \text{ simple}$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-26-74

Source Viscose Rayon

P_B :

Ref 037 pg 33 Section 28.0

Asset guideline period - 11 yrs

P_B est ≈ 2 × IRS = 22 yrs

$\frac{100\%}{22 \text{ yrs}} = 4.5\% / \text{yr}$ simple

∴ $P_B = .045$ simple

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 9-16-74

Source Viscose Rayon

Sulfides:

E_u: Reference 075 Table 5.19-1

CS_2 55 lb/TON
H_2S 6 lb/TON

we convert CS_2 weight to H_2S: $\frac{55 \text{ lb } CS_2}{TON} \times \frac{34 \text{ lb } H_2S}{76 \text{ lb } CS_2} \times 2 = H_2S \frac{lb}{TON}$
$= 49.2$

or

$\frac{55 \text{ lb}}{TON} CS_2 \times \frac{64 \text{ lb S}}{76 \text{ lb } CS_2} = 46.3 \text{ lb S}$

check

then $46.3 \text{ lb S} \times \frac{34 \text{ lb } H_2S}{32 \text{ lb S}} = 49.2$ lb/TON as H_2S

Total $E_u = 49 + 6 = 55$ lb/TON rayon as H_2S

E_N: Above reference indicates that carbon adsorption may achieve a 80-95% reduction.

$\text{Avg} = \frac{80+95}{2} \cong 88\%$

We will assume an efficiency of 85% $\therefore E_N = .15 \times E_u$
$= .15 \times 55$ lb/TON

$\therefore E_N = 8.3$ lb/TON rayon as H_2S

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Computation Sheet For Emission Factors

Calculations Done By D. Marrone Date 10-11-74

Source Viscose Rayon

E_S: Sulfides as H_2S

Ref 084 and update in Ref 148

There are no specific regulations for H_2S emissions from this industry or any general process source. There are also no general regulation applying to H_2S with the exception of its association with odors.

We assume that $E_s = E_u$

$$E_S = 55 \text{ lb/TON rayon as } H_2S$$

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Computation Sheet For Emission Factors

Calculations Done By W Marrone Date 11-1-74

Source Viscose Rayon

E_{111d} : H_2S

Carbon Adsorption is assumed feasible in being applied (retrofitted) to an existing plant such that $E_{111d} = E_N$

$$\therefore E_{111d} = 8.3 \text{ lb/TON rayon as } H_2S$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-29-74

Source High Density Polyethylene

A: Refer to attached graph which was developed from capacity data Ref 128 Table VIII and Production/sales data in Ref 116 Jan. 1972 pg 42

Ref 128 { 1972 Capacity = 2,315 × 10^6 lb/yr
1980 Capacity = 8,500 × 10^6 lb/yr

Ref 116 { 1970 Sales 1646 × 10^6 lb/yr
1971 Prod 1900 × 10^6 lb/yr
1971 Sales 1885 × 10^6 lb/yr

$\frac{Sales}{Prod} = \frac{1885}{1900} = .99 \approx 1.0$

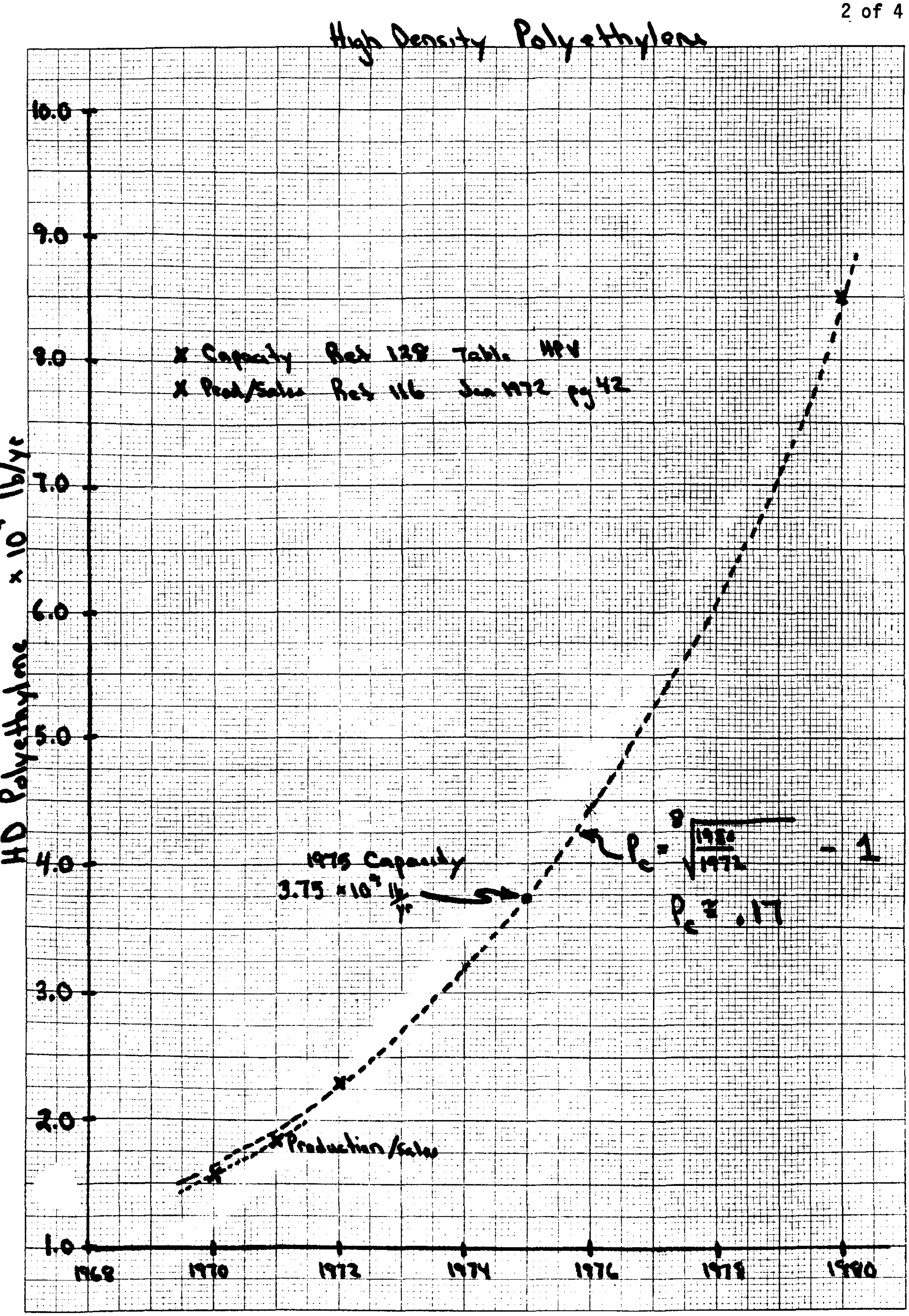
We will assume sales identical with production and therefore 1970 Prod = 1646 × 10^6 lb/yr

Interpolation between 1972 to 1980 yields ~~and~~ an estimate of the 1975 production capacity of

$$A = 3.75 \times 10^9 \text{ lb/yr}$$

converting to tons/yr ;

∴ $A = 1.88 \times 10^6$ Ton/yr HD Polyethylene


High Density Polyethylene
x Capacity Ref 128 Table
x Prod/Sales Ref 116 Jan 1972 pg 42
HD Polyethylene x 10^9 lb/yr
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
1968
1970
1972
1974
1976
1978
1980
1975 Capacity
3.75 x 10^9 lb/yr
Production/Sales
ρc = 8√(1980/1972) − 1
ρc ≅ .17

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-30-74

Source High Density Polyethylene

K: Using the above 1970-1971 "Production" figures and estimating 1970-1971 capacities from the attached curve we are able to determine utilization factors.

1970 Production	$1,646 \times 10^6$ lb/yr
1970 est Capacity	$1,650 \times 10^6$ lb/yr
1971 Production	1900×10^6 lb/yr
1971 Capacity	1920×10^6 lb/yr

$$K_{70} = \frac{1646}{1650} = .998 \quad \text{and} \quad K_{71} = \frac{1900}{1920} = .989$$

average ≅ .994

We assume this to be essentially 1

$$\therefore K = 1$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Moscone Date 8-30-74

Source High Density Polyethylene

P_c: Growth is obtained by assuming a compound rate between the 1972 and 1975 capacity figures given in reference 128, and using the following;

$$P_c = \sqrt[8]{\frac{1980 \text{ Cap}}{1972 \text{ Cap}}} - 1$$

$$P_c = \sqrt[8]{\frac{8500 \times 10^6}{2315 \times 10^6}} - 1$$

$$\therefore P_c \cong .176 \text{ compound}$$

P_B: Ref 128 Table HP-V

Current Cap = $2,315 \times 10^6$ lb/yr

Current Capacity on-line in 1980 = $2,315 \times 10^6$ lb/yr

This indicates that replacement of obsolete is not expect to 1980 and we assume this true to 1985

$$\therefore P_B = 0$$

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Computation Sheet For Emission Factors

Calculations Done By William Marrow Date 9-4-74

Source High Density Polyethylene

Hydrocarbons

E_u: Ref 034 Table 1 pg 10

$$E_u = 50 \text{ lb/TON HDPE}$$

E_N: Above source lists control alternatives as waste gas collection and incineration with an efficiency range achievable of 80-100%

We will assume an efficiency of 99%

$$E_N = .01 \times E_u = .01 \times 50 = .5 \text{ lb/TON}$$

$$E_N = .5 \text{ lb/TON HDPE}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By R.J. Londergan Date 10/7/74

Source H. D. Polyethylene

HC

As discussed in Vol #1,

$$E_S = E_S^u + E_S^P + E_S^A$$

Plant locations and production capacity are obtained from Ref. 128, p. HP-9.

(a) One plant is located in Iowa, which has no relevant HC regulation*. This plant has a fractional capacity of .054.

This gives $E_S^u = (.054)(50) = 2.70$ LB/TON

where $E_u = 50$ LB/TON from an earlier emission factor calculation.

(b) Texas and Louisiana have percentage emission control efficiency regulations* (Texas requires incineration as a control method if emissions exceed 100 lb/day. We have assumed that this method is 90% efficient in controlling emissions.) Since Louisiana and Texas represent ~~.946~~ fractional capacity of 0.946, and both states require 90% control efficiency, we have

$$E_S^P = (0.946)(.10)(50) = 4.73 \text{ LB/TON}$$

For total E_S we obtain

$$E_S = 2.70 + 4.73 \simeq 7.4 \text{ LB/TON HDPE}$$

* Ref 84 and 148.

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-30-74

Source Low-Density Polyethylene

P_c: Capacity data for 1971 and 1980 were obtained from Table LPV of Ref 128 also pg LP-1

Cap 1971 $5,269 \times 10^6$ lb/yr

Cap 1980 $21,100 \times 10^6$ lb/yr

Assuming a compound growth rate between the period we may calculate P_c

$$P_c = \sqrt[9]{\frac{\text{1980 Cap}}{\text{1971 Cap}}} - 1$$

$$P_c = \sqrt[9]{\frac{21,100}{5,269}} - 1$$

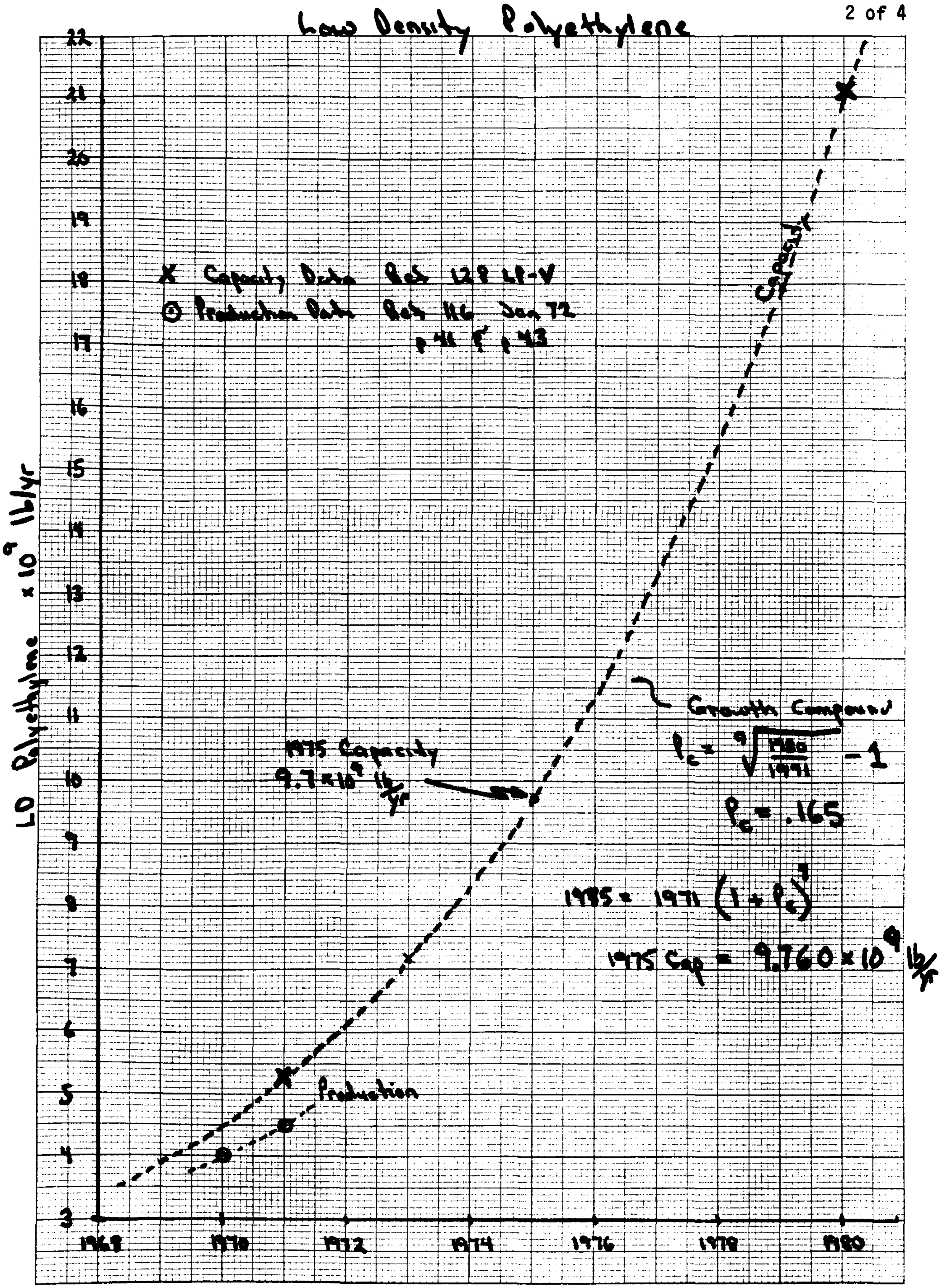
$$\therefore P_c \cong .165 \text{ compound}$$

A: Interpolation on the attached graph using the relationship

$$1975 = 1971\,(1+P_c)^4$$

$$\underset{\text{Cap}}{1975} = 5,269\,(1+.165)^4 \times 10^6 \cong 9,700 \times 10^6 \text{ lb/yr}$$

$$\therefore A = 9.7 \times 10^9 \text{ lb/yr} \text{ or } 4.85 \times 10^6 \text{ Ton LDPE/yr}$$


Low Density Polyethylene
LD Polyethylene x 10^9 lb/yr
X Capacity Data Ref 129 LP-V
⊙ Production Data Ref 116 Jan 72
p 41 & p 43
Capacity
Growth Compound
1975 Capacity
9.7 x 10^9 lb/yr
Pc = 9√(1980/1971) - 1
Pc = .165
1975 = 1971 (1 + Pc)^3
1975 Cap = 9.760 x 10^9 lb/yr
Production
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
1968
1970
1972
1974
1976
1978
1980

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-30-74

Source Low Density Polyethylene

K: Production/Sales information was obtained from ref 116 Jan 72 pg 41 & 43

		10^6 lb/yr
1971	Sales	4480
1971	Prod	4500
1970	Sales	4050

$\frac{Sale}{Prod} = \frac{4480}{4500} \cong .995 \cong 1.$

∴ Sale ≅ Prod

we assume 1970 Sale = 1970 Prod

∴ 1970 Prod = 4050×10^6 lb/yr
1971 Prod = 4500×10^6 lb/yr

From the attached graph we obtain 1970 and 1971 capacities.

$$1970 \text{ Cap} = \frac{1971 \text{ Cap}}{(1.165)^1} = 4{,}520 \times 10^6 \text{ lb/yr}$$

$$1971 \text{ Cap} = 5{,}269 \times 10^6 \text{ lb/yr}$$

$$K_{70} = \frac{4050}{4520} = .896 \quad \text{and} \quad K_{71} = \frac{4500}{5{,}269} = .854$$

$$\text{avg } K = .875 \Rightarrow .88$$

We will use this average value for the period 1975 - 1985

$$K = .88$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-30-74

Source Low Density Polyethylene

P_B: Ref 128 Table LP-V gives the following information

1971 Current Capacity = $5,269 \times 10^6$ lb/yr

Current Capacity on-line in 1980 = $4,705 \times 10^6$ lb/yr

564×10^6 lb/yr obsolete capacity 1971-1980

We assume that of the $16,395 \times 10^6$ lb/yr to be added by 1980; $16,395 - 564 = 15,831 \times 10^6$ lb/yr will be new capacity and the 564×10^6 lb/yr will be replacement of obsolete capacity.

Assuming a simple replacement rate between 1971 and 1980 and comparing this yearly rate with the 1975 base year capacity we may obtain a value for P_B.

$$\frac{564 \times 10^6 \text{ lb/yr}}{9 \text{yrs}} = 62.7 \times 10^6 \text{ lb/yr/yr}$$

$$P_B = \frac{62.7 \times 10^6}{9.7 \times 10^9} \cong .006$$

$\therefore P_B = .006$ simple

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By William Marrone Date 8-30-74

Source Low Density Polyethylene

Hydrocarbons

E_u: Ref 034 Table 1 pg 10

$E_u = 25$ lb/TON LDPE

E_N: From above ref - control alternative is waste gas collection and incineration with achievable efficiency of 80-100%

We assume 99% eff ∴ $E_N = .01 \times E_u$

$E_N = .01 \times 25 = .25$ lb/TON

∴ $E_N = .25$ lb/TON LDPE

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Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10/7/74

Source LD Polyethylene

Hydrocarbons

As discussed in Vol. #1,

$$E_S = E_S^u + E_S^P + E_S^A$$

Plant location and capacity information is obtained from Ref. 128, p. LP-7.

(a) Two plants are located in states with no relevant HC emissions regulations*. These plants represent a fractional capacity of .080.

Using E_u from a previous emissions factor calculation,

$$E_S^u = E_u \sum_{i=1}^{k} A_i = 25(.08) = 2.0 \text{ LB/TON}$$

(b) Percentage emissions control regulations apply to all of the remaining plants* (We have assumed that the Texas regulation, which requires incineration if emissions exceed 100 lbs/day, corresponds to a 90% control efficiency regulation). The fractional capacity located in Texas and Louisiana is 0.82, and control for these states is 90%. The remaining capacity (0.10) is located in states requiring 85% control.*

Then

$$E_S^P = E_u \sum_{j=1}^{M} A_j(1 - P_{cj}) = [(0.10)(0.82) + (0.15)(0.10)](25) = 2.175 \text{ LB/TON}$$

Total E_S is then

$$E_S \cong 2.0 + 2.2 = 4.2 \text{ LB/TON LDPE.}$$

*Ref 84 & 148.

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-29-74

Source Poly propylene

A: Capacity data for the years 1969 and 1972 as well as an estimate for 1980 are presented in reference 129. Table PP-V

Current Cap (1969)	$1{,}160 \times 10^6$ lb/yr
Capacity 1972	$2{,}050 \times 10^6$ lb/yr
Capacity 1980 est	$5{,}800 \times 10^6$ lb/yr

This data appear on the attached graph

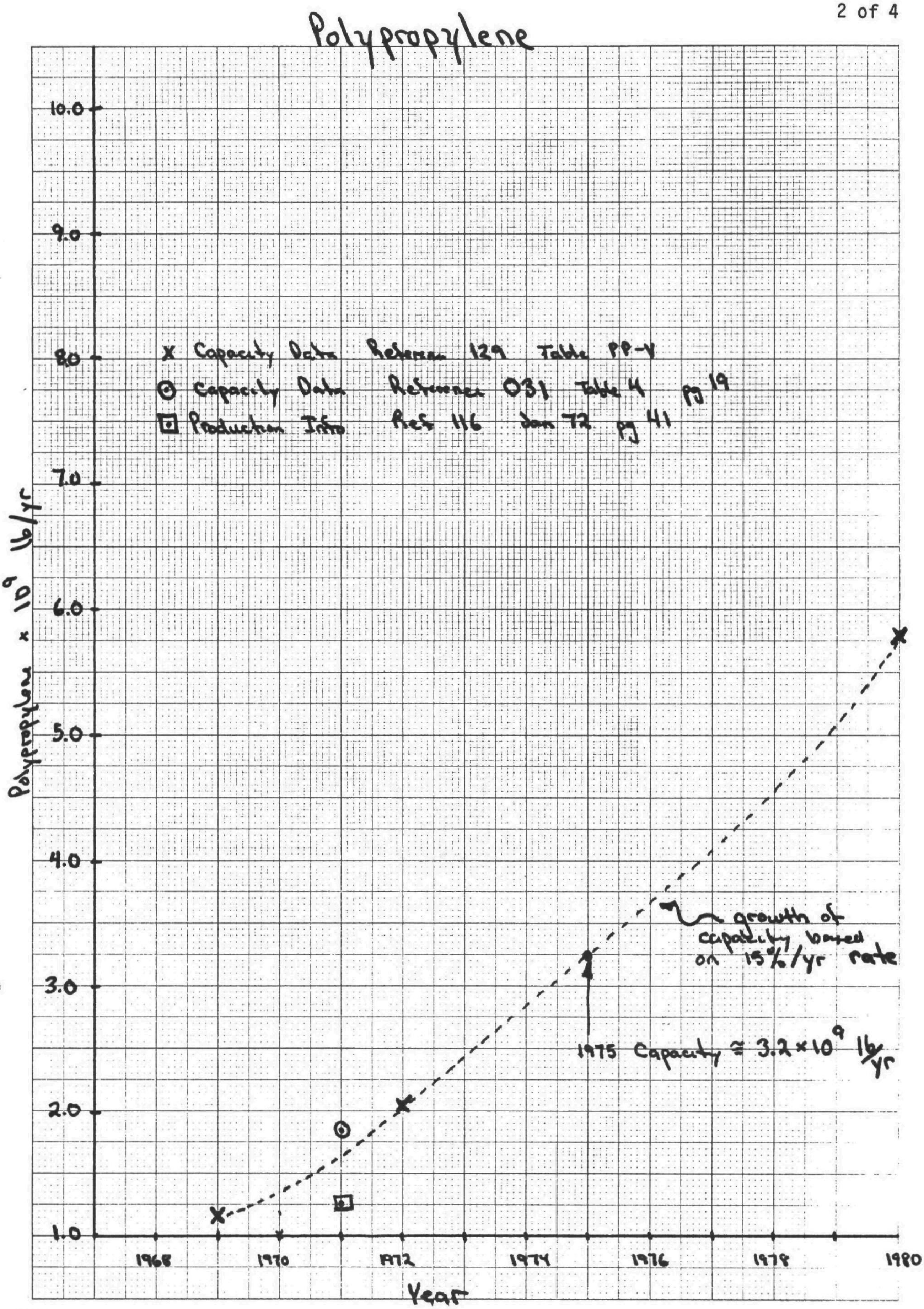
Interpolation yields an estimate of the 1975 capacity which we determine to be 3.2×10^9 lb/yr

Converting lb/yr → Ton/yr $\Rightarrow A = \frac{3.2 \times 10^9 \text{ lb}}{2 \times 10^3 \frac{\text{lb}}{\text{Ton}}} = 1.6 \times 10^6 \frac{\text{Ton}}{\text{yr}}$

$\therefore A = 1.6 \times 10^6$ Ton/yr polypropylene

P_c: The growth used in Ref 129 to develop the 1980 estimated Capacity from the 1969 and 1972 data was 15%/yr compound (pg PP-10). It is admitted by this source that this growth rate is below the recent trend. We will use this value, however unseen market opportunities or continued growth at the present rate may mean a higher value than assumed.

$P_c = .15$ compound


Polypropylene
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
Polypropylene x 10⁹ lb/yr
X Capacity Data Reference 129 Table PP-V
⊙ Capacity Data Reference 031 Table 4 pg 19
⊡ Production Info Ref 116 Jan 72 pg 41
growth of capacity based on 15%/yr rate
1975 Capacity ≅ 3.2×10⁹ lb/yr
1968
1970
1972
1974
1976
1978
1980
Year

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Computation Sheet For Industrial Factors

Calculations Done By RJ Marron Date 8-29-74

Source Polypropylene

K: A production value for polypropylene for 1971 was obtained from Ref 116 Jan 72 p41

$$P_{71} = 1{,}260 \times 10^6 \text{ lb/yr}$$

From our attached graph we estimate a 1971 capacity as 1.62×10^9 lb/yr.

A utilization factor is obtained from a Prod/cap. ratio

$$K = \frac{1.26 \times 10^9}{1.62 \times 10^9} \cong .78$$

We will use this utilization factor until more production info is assembled

$$\therefore \quad K = .78$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-29-74

Source Polypropylene

P_B: We are able to estimate the replacement rate of obsolescent capacity from Table PP-V of Ref 129

Current (1969) Capacity = $1,160 \times 10^6$ lb/yr

Current Capacity on Stream in 1980 = $1,040 \times 10^6$ lb/yr

Obsolete Capacity 120×10^6 lb/yr

We assume that of the added capacity to 1980 of 4,760,

$(4760 - 120)^{\times 10^6} = 4640 \times 10^6$ Net New Capacity

120×10^6 = Obsolete Cap replaced.

Assume this capacity to be replaced annually on a simple basis, so that; 1969 → 1980 = 11 years

$$\frac{120 \times 10^6 \text{ lb/yr}}{11 \text{ yr}} = 10.91 \times 10^6 \text{ lb/yr/yr}$$

Baseline year 1975 Cap = 3.2×10^9 lb/yr

$$P_B = \frac{10.91 \times 10^6}{3.2 \times 10^9} = .003$$

$\therefore P_B = .003$ simple

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-30-74

Source Polypropylene

Particulates:

E_u: Ref 075 Table 5.13-1

E_u = 3 lb/TON

E_N: As indicated in Ref 129 pg PP-5, material handling and drying are the preliminary sources of particulate emissions. Baghouses alone or in combination with cyclones are suitable for control.

We will assume an overall efficiency of particulate collection of 99.0%.

$E_N = .01 \times E_u = .01 \times 3$ lb/TON

$\therefore$ E_N = .03 lb/TON

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Computation Sheet For Emission Factors

Calculations Done By W. Masone Date 8-30-74

Source Polypropylene

Hydrocarbons:

E_u: Ref 075 Table 5.13-1

$$E_u = .7 \text{ lb/TON}$$

E_N: Ref 129 specifies purification/recovery vents as prime sources of hydrocarbon emissions and propylene in particular. It is also stated on pg PP-8 that flare systems or incinerators will be used for new plants with efficiencies nearing 100% based on combustion and 99.5% on pollutant mass basis

$$\therefore E_N = .005 \times E_u = .005 \times .7$$

$$\therefore E_N = .0035 \text{ lb/TON}$$

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Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10/7/74

Source Polypropylene

HC

As discussed in Vol. # 1,

$$E_S = E_S^u + E_S^P + E_S^A$$

(a) $E_S^u = E_u \sum_{i=1}^{K} A_i$

E_u = 0.7 LB/TON from previous emissions factor calculation. States with ~~[illegible]~~ no applicable HC regulations (Ref. 84) which have polypropylene sources (Ref. 129, p. PP11) contribute to E_S according to the following table:

State	A_i*
DEL	.172
N.J.	.289**
W.VA.	.069

*Computed from Ref. 129, p. PP11

**Computed by dividing total Hercules, Inc. contribution equally between two plants (only total is given in Ref. 129)

Then $E_S^u = (0.7)(0.53) = 0.37$ LB/TON

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Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10/7/74

Source Polypropylene

HC (cont)

(b) The only state with a relevant percentage control regulation (Ref. 148) and polypropylene sources is Louisiana, which requires 90% emissions control efficiency. From Ref. 129, p. PP11, the fractional capacity for Louisiana is .159 (see previous note concerning Hercules, Inc. contribution).

Then $E_S^P = (0.7)(~~.9~~\ 0.1)(.159) = .011$ LB/TON

(c) The relevant emission control regulation for Texas is an absolute limit of 100 lb/day per source. From Ref. 129, p. PP-11, 4 sources (plants) in Texas are given; using E_u as given above, only 1 would emit more than 100 lb/day. The remaining 3 are treated as in section (a) for E_S^{u}.

Then we have

$$E_S^A = (0.7)(.18) + \frac{365}{A}(100)$$

where ~~A = 580 TON/YR~~ $A = 580 \times 10^3$ TON/YR = TOTAL CAPACITY (1969)

Then $E_S^A = .126 + .063 = .189$ LB/TON

Total for E_S is then

$$E_S = 0.37 + .011 + .189 = 0.59 \text{ LB/TON Polypropylene}$$

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Computation Sheet For Emission Factors

Calculations Done By VM Russo Date 10/10/74

Source Poly propylene

Particulate Emissions:

Ref. 129, page PP-11 breaks out capacity by state

State	Plant Capacity	(Output) Process Weight Rate (lb/HR) **	(Input) *** Allowable Emissions
✓ Texas	50×10^6 lb/YR	5,723	9.5 lbs/HR
	70×10^6	8,022	13.0 "
	90×10^6	10,302	17.0 "
	150×10^6	17,170	28.0 "
Del.	200×10^6	22,890	23.0 " ****
✓ W.Va.	80×10^6	9,150	18 "
✓ La.*	185×10^6	21,180	21.0 "
N.J.*	185×10^6	21,180	26.0 "
	150×10^6	17,170	22.0 "

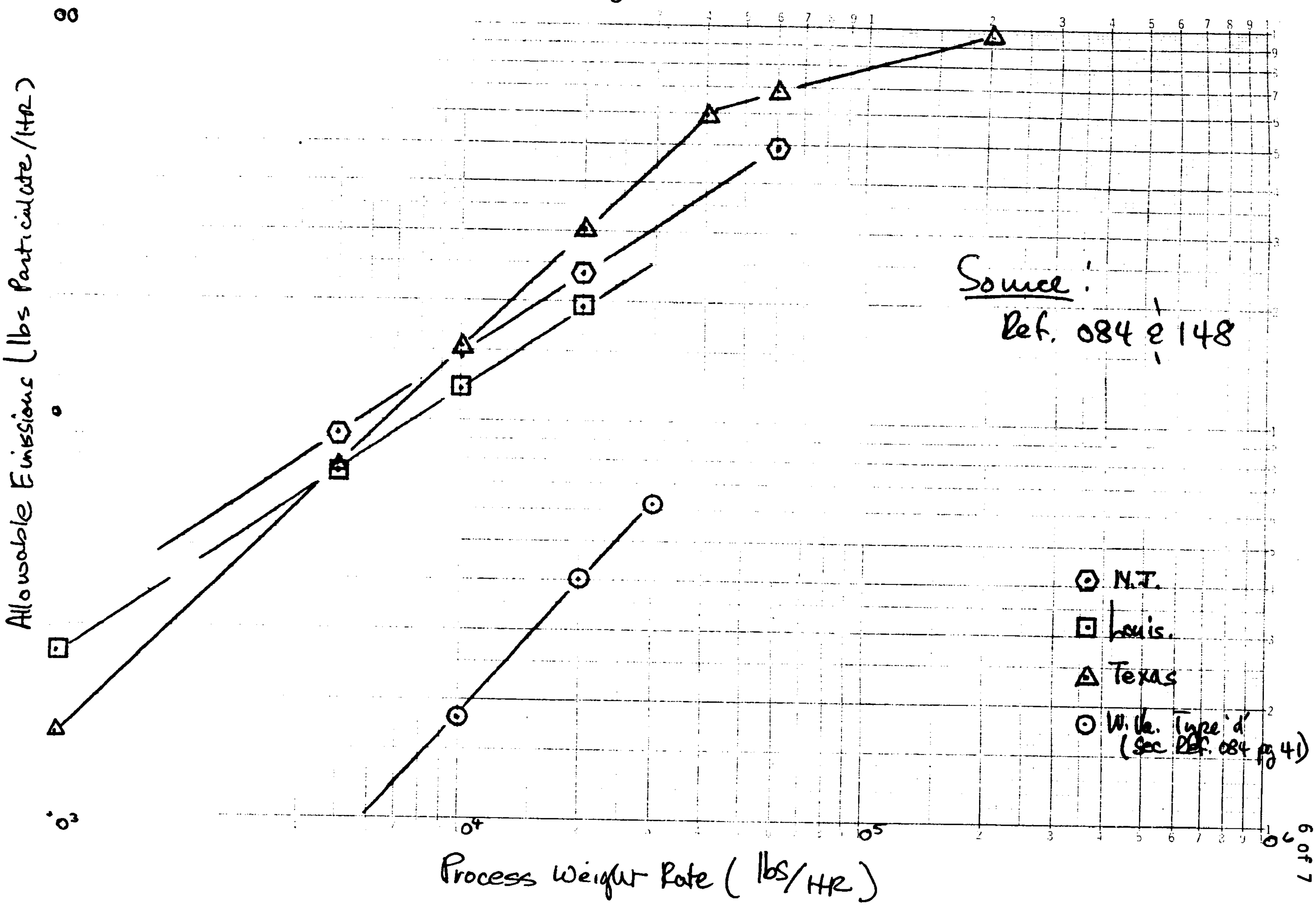
* Hercules, Inc. total capacity divided equally between two plants

** Assuming 24 HR/DAY, 7 DAY/WK OPERATION FOR 52 WKS.

*** (See next page) In determining emissions, Process Wgt. Rate multiplied by 1.08 to take into account input process wgt. (See Ref. 129 Table PP1)

**** Delaware regs taken as average of other 4 states' regs (see Ref. 084 p32)

Process Weight Rates



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Computation Sheet For Emission Factors

Calculations Done By V F Russo Date 10/10/74

Source Polypropylene.

Sum of the allowable emissions is

$$E_S^{o} = 177.5 \text{ lbs Part./HR}$$

$$E_S\left(\text{lbs Part./TON PP}\right) = \frac{\left(177.5 \frac{\text{lbs}}{\text{HR}}\right)\left(24 \frac{\text{HR}}{\text{DAY}}\right)\left(7 \frac{\text{DAY}}{\text{WK}}\right)\left(52 \left(\frac{\text{WKS}}{\text{YR}}\right)\right)}{1160 \times 10^{6} \text{ lbs/YR} \left(\frac{1}{2000} \text{ TON/lbs}\right)}$$

$$E_S = 2673.5 \times 10^{-3} \text{ lbs Part./TON PP}$$

$$E_S = 2.674 \text{ lbs Part/TON PP}$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-29-74

Source Polystyrene

A: The following capacity data was assembled;

Ref 129 PS-1 { 1971 capacity = 3.5×10^9 lb/yr
1980 Cap est = 6.7×10^9 lb/yr }

Ref 116 Aug 1972 pg 14 1972 Capacity = 3.6×10^9 lb/yr

Plotting this data and drawing a best-fit line through the values we may estimate by interpolation the 1975 production capacity for polystyrene.

$A \cong 4.7 \times 10^9$ lb/yr

The best-fit line is obtained by assuming compound growth between 1971 and 1980
$$P_c = \sqrt[9]{\frac{1980}{1971}} - 1$$

converting to tons/yr,

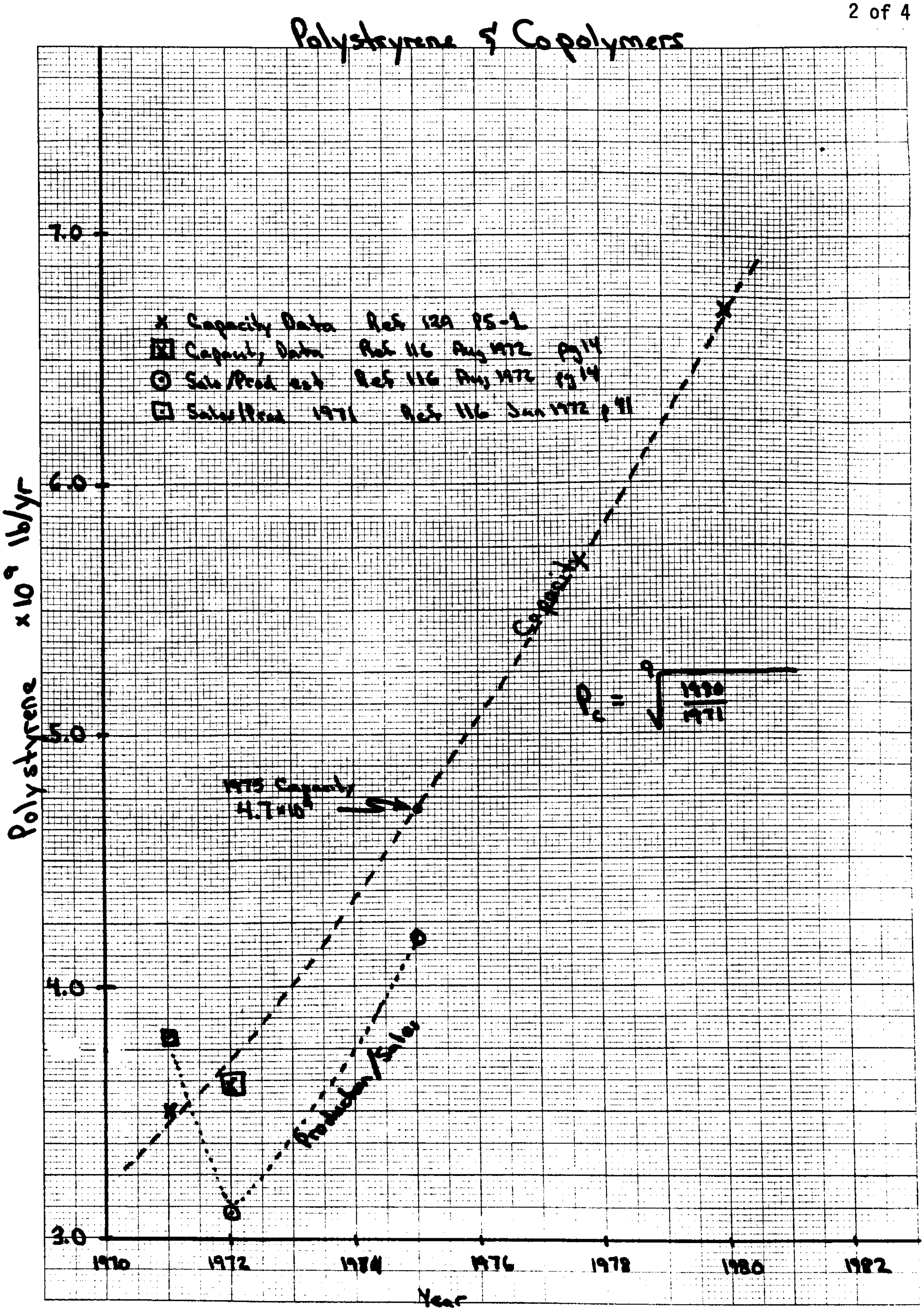
∴ $A = 2.35 \times 10^6$ TON/yr polystyrene

P_c: The growth during this period is assumed to be compound and is estimated by the relationship

$$P_c = \sqrt[n]{\frac{1980}{1971}} - 1 \qquad n = 9 \text{ yrs}$$

$$P_c = \sqrt[9]{\frac{6.7}{3.5}} - 1 = .075$$

∴ $P_c = .075$ compound


Polystyrene & Copolymers
X Capacity Data Ref 129 PS-1
Capacity Data Ref 116 Aug 1972 pg 14
Sale/Prod est Ref 116 Aug 1972 pg 14
Sales/Prod 1971 Ref 116 Jan 1972 p 41
Capacity
Production/Sales
1975 Capacity
7.0
6.0
5.0
4.0
3.0
1970
1972
1976
1978
1980
1982
Year
Polystyrene ×10⁹ lb/yr

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-29-74

Source Polystyrene

K: We may estimate a capacity utilization factor by comparing prod/sale data with capacity data.

From Ref 116 Jan 72, p 41

1971 Sales $3{,}816 \times 10^6$ lb/yr
1971 Prod $3{,}840 \times 10^6$ lb/yr

$$\frac{\text{Sale}}{\text{Prod}} = \frac{3816}{3840} = .993 \quad \text{or} \approx 1$$

We will assume that sales and production figures are identical and use all sale estimates for production estimates, when the latter is not available for this industry

Sales Forecasts: Ref 116 Aug 72

1972: $3{,}100 \times 10^6$ lb/yr
1975: $4{,}200 \times 10^6$ lb/yr

From above:

1972 Cap = $3{,}600 \times 10^6$ lb/yr
1975 Cap = $4{,}700 \times 10^6$ lb/yr

$$K_{72} = \frac{3100}{3600} = .86 \quad \text{and} \quad K_{75} = \frac{4200}{4700} = .89$$

the average will be used

$\therefore$ K = .88

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-29-74

Source Polystyrene

P_B :

Current Capacity 1971 = $3{,}500 \times 10^6$ lb/yr

Current Capacity on-line in 1980 = $3{,}275 \times 10^6$ lb/yr

225×10^6 lb/yr obsolete capacity

We will assume that of the $3{,}425 \times 10^6$ lb/yr total capacity to be added by 1980 $(3{,}425 - 225) \times 10^6$ or 3200×10^6 lb/yr will be new capacity and the 225×10^6 lb/yr obsolete capacity will be replaced.

Assuming a simple replacement rate for the period 1971 to 1980;

$$\frac{225 \times 10^6 \text{ lb/yr}}{9 \text{ yrs}} = 25 \times 10^6 \text{ lb/yr/yr}$$

Applying this simple decay rate to the 1975 base year capacity of 4.7×10^9 lb/yr we may estimate P_B.

$$P_B = \frac{25 \times 10^6}{4.7 \times 10^9} = .005$$

$\therefore$ $P_B = .005$ simple

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-3-74

Source Polystyrene

Hydrocarbons:

E_u: Ref 129 Table PS- VI

Total hydrocarbon emissions are shown to be attributable to the feed preparation section, the reactor vent and the solvent recovery section. The ~~total~~, which we assume to be an uncontrolled amount, is ~~[illegible]~~ .00583 TON/TON or about;

$$.00583\frac{T}{T} \times 2000\frac{lb}{T} = 11.7 \text{ lb/TON}$$

This "uncontrolled" assumption is somewhat confirmed by the statement on pg PS-7 of the above ref which states that based on questionnaire the polystyrene industry employs few if any air pollution control devices.

$\therefore E_u = 11.7$ lb/TON polystyrene

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Computation Sheet For Emission Factors

Calculations Done By RJ Marrone Date 9-3-74

Source Polystyrene

Hydrocarbons cont'd

E_N: Control in this industry is not extensive, however if we assume that polystyrene may be controlled in a manner similar to polypropylene HC emissions then incineration or flares could be used. We assume an efficiency of 99% as for polypropylene.

$$E_N = .01 \times E_u = .01 \times 11.7 \cong .12 \frac{lb}{ton}$$

$\therefore$ E_N = .12 lb/ton polystyrene

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Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10/7/74

Source Polystyrene

HC

As discussed in Vol. #1,

$$E_S = E_S^u + E_S^A + E_S^P$$

All information regarding plant location and production capacity used for computing E_S has been obtained from Ref. 129, p. PS-9. For those plants with no capacity given, the unattributed capacity ($A_{total} - A_{attributed}$) has been divided equally among the plants, with a net result of

$$\frac{.37 \times 10^9 \text{ lbs/yr}}{24 \text{ plants}} = 15.4 \times 10^6 \text{ lbs/yr / plant. } (1971)$$

(a) $E_S^u = E_u \sum_{i=1}^{k} A_i$

For those states without applicable HC regulations, fractional capacity is listed below:

STATE	A_i
MASS	.014
MICH	.071
MO.	.003
N.J.	.059
N.Y.	.008
PENN.	.094
$\sum_{i=1}^{k} A_i$	= .249

Then

$$E_S^u = (11.7)(.249) = 2.91 \text{ LB/TON}$$

where $E_u = 11.7$ LB/TON from previous emission factor calculation.

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Computation Sheet For Emission Factors

Calculations Done By R.J. Londergan Date 10/7/74

Source Polystyrene

HC

(b) All remaining states have a HC regulation which requires 85% emission control efficiency for plants of the size we are considering.

Then $E_S^P = \sum_{j=1}^{L} A_j E_u (1 - P_{cj}) = E_u (.85)\left(\sum_{j=1}^{L} A_j\right)$

Since the sum of those sources considered in (a) and those considered here represent 100% of capacity, we must have

$$\sum_{j=1}^{L} A_j = 1 - \sum_{i=1}^{K} A_i = .751$$

Therefore $E_S^P = (11.7)(.85)(.751) = 1.32$ LB/TON

The final result for E_S is then

$E_S = E_S^u + E_S^P = 4.2$ LB/TON Polystyrene

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-30-74

Source Polyvinyl Chloride

P_c: The growth rate was obtained from assuming a compound rate occuring between 1972 and 1980 for the data present in table PV-V Ref 129

$$1972 \text{ Cap} = 4,375 \times 10^6 \text{ lb/yr}$$
$$1980 \text{ Cap} = 8,000 \times 10^6 \text{ lb/yr}$$

$$P_c = \sqrt[8]{\frac{1980}{1972}} - 1 \cong .078 \text{ compound}$$

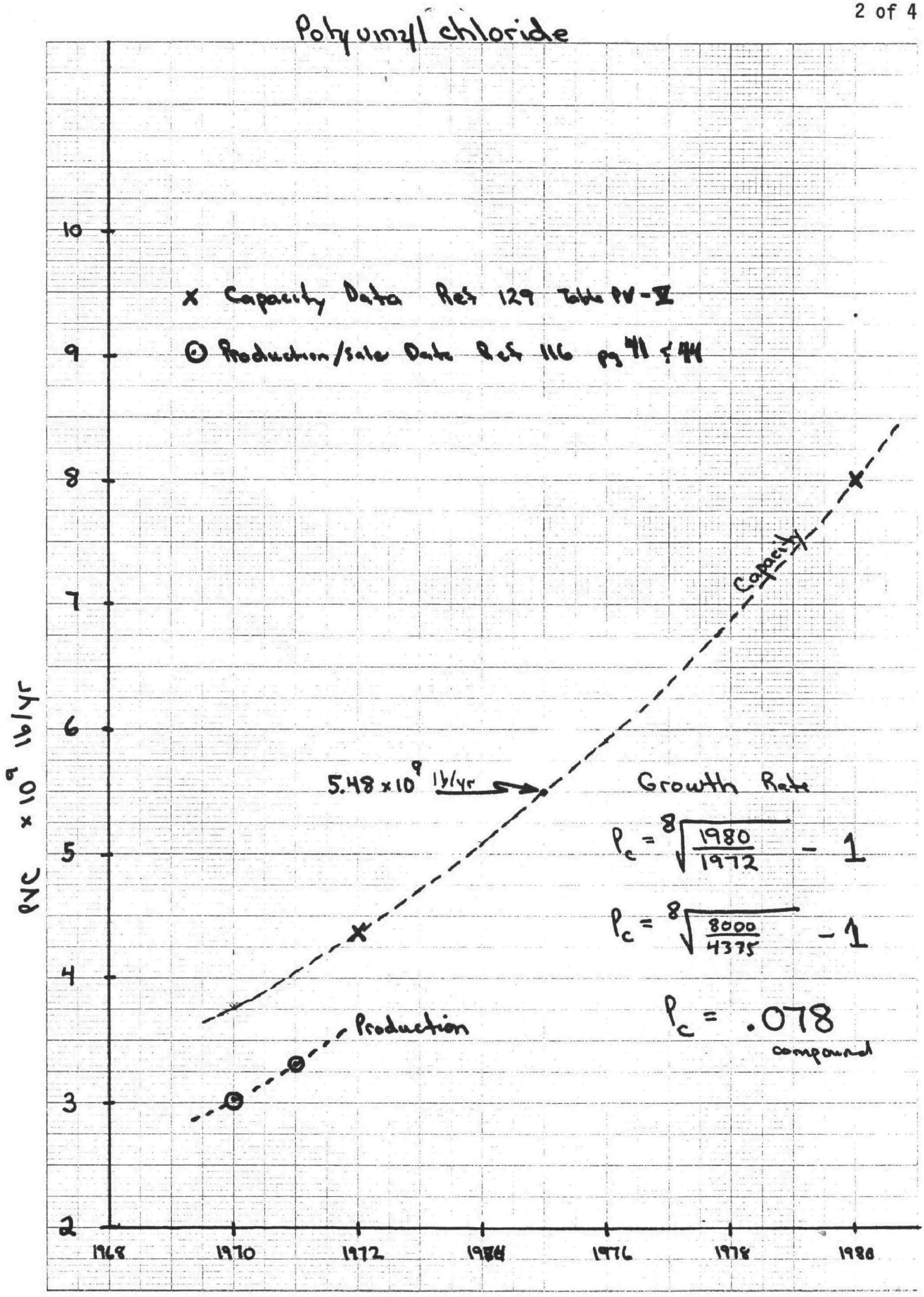
$$\therefore P_c = .078 \text{ compound}$$

A: The 1972 and 1980 Capacity figures are plotted on the attached graph with the curve generated by the growth rate function. We estimate by interpolation the 1975 Production capacity by;

$$1975 \text{ cap} = 1972 \text{ Cap } (1 + P_c)^3$$
$$1975 = 4,375 \times 10^6 \ (1.078)^3$$
$$1975 = 5,480 \times 10^6 \text{ lb/yr}$$

converting to Ton/yr

$$\therefore A = 2.74 \times 10^6 \text{ Ton/yr PVC}$$


Polyvinyl chloride
× Capacity Data Ref 129 Table IV-V
⊙ Production/sales Data Ref 116 pg 41 & 44
5.48 × 10⁹ lb/yr
Capacity
Production
Growth Rate
$P_c = \sqrt[8]{\frac{1980}{1972}} - 1$
$P_c = \sqrt[8]{\frac{8000}{4375}} - 1$
$P_c = .078$
compound
PVC × 10⁹ lb/yr
10
9
8
7
6
5
4
3
2
1968
1970
1972
1974
1976
1978
1980

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-30-74

Source Polyvinyl chloride

K: The following Production/Sales information was obtained from Ref 116 p 41 and p 44

1970	Sales	$3,022 \times 10^6$	lb/yr
1971	Sales	$3,286 \times 10^6$	lb/yr
1971	Production	$3,320 \times 10^6$	lb/yr

$$\frac{\text{Sales}}{\text{Prod}} = \frac{3286}{3320} \cong .99$$

$$1970 \text{ Prod} = \frac{1970 \text{ Sales}}{.99} = 3053 \times 10^6 \text{ lb/yr}$$

Capacities in 1970 and 1971 are estimated by 1972 capacity and the $P_c = .078$

$$1971_{cap} = \frac{1972}{(1.078)^1} = 4,058 \times 10^6 \text{ lb/yr}$$

$$1970_{cap} = \frac{1972}{(1.078)^2} = 3,765 \times 10^6 \text{ lb/yr}$$

$$K_{70} = \frac{3053}{3765} \cong .81 \quad \text{and} \quad K_{71} = \frac{3,320}{4058} \cong .82$$

We will use a utilization factor of .82 and assume it applicable over the period 1975-1985

$$\therefore K = .82$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-30-74

Source Polyvinylchloride

P_B: The capacity in (current) 1972 for PVC = $4,375 \times 10^6$ lb/yr

The current capacity that is estimated to be on-line in 1980 will be $4,280 \times 10^6$ lb/yr

$$4,375 - 4,280 = 95 \times 10^6 \text{ lb/yr}$$ obsolete capacity to 1980

We assume that of the 3,720 $\times 10^6$ lb/yr total capacity added $3720 - 95 = 3625 \times 10^6$ lb/yr will be for **new** capacity and the 95×10^6 lb/yr will be replacement of obsolete capacity

1972-1980 = 8 yrs

$$\frac{95 \times 10^6 \text{ lb/yr}}{8 \text{ yr}} = 1.19 \times 10^6 \text{ lb/yr /yr}$$

P_B is estimated by assuming a simple replacement rate based on the 1975 base-line capacity

$$P_B = \frac{1.19 \times 10^6}{5.48 \times 10^9} = .0002$$

$\therefore P_B = .0002$ simple

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-30-74

Source Polyvinyl Chloride

Particulates:

E_u: Ref 075 Table 5.13-1

$E_u = 35$ lb/TON

E_N: Ref 075 note on Table 5.13-1 indicates that control of these particulate emissions can be achieved as best as 99% by fabric filter systems (baghouses)

we use 99% eff $E_N = .01 \times E_u = .01 \times 35$ lb/TON

$\therefore E_N = .35$ lb/TON

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-30-74

Source Polyvinyl Chloride

Hydrocarbons :

E_u : Reference 075 Table 5.13-1

$$E_u = 17 \text{ lb/TON PVC}$$

E_N : We assume that, similar to the other synthetic plastics, hydrocarbon emission may be controlled by waste gas collection and incineration. Using an efficiency of 99.5%

$$E_N = .005 \times E_u = .005 \times 17 = .085 \text{ lb/TON}$$

$$\therefore E_N = .085 \text{ lb/TON PVC}$$

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Computation Sheet For Emission Factors

Calculations Done By U.F. Rosso Date 10/10/74

Source Poly Vinyl Chloride

Ref. 129 Breaks out cap. by state (pg. PV-11)

State	Number Plants	Ave. Plant Capacity*	Process Wgt. Rate**	Allowable Emiss***
Texas	2	162.5×10^6 lbs/yr	18,600 lbs/hr	29 lbs/hr
N.J.	5	120	13,735	19
Louis	2	140	16,025	20
Calif	3	95	10,875	12****
Ohio	4	146.25	16,740	21
Ky	2	197.5	22,600	25
Flor	1	50	5,780	7
Miss.	1	220	25,175	22
Mass.	4	115	13,160	13
Okla.	1	80	9150	11
Del.	2	155	17,730	16****
Pa	1	140	16,010	15.5****
N.Y.	2	55	6290	7.9

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Computation Sheet For Emission Factors

Calculations Done By V.F. Russo Date 10/10/74

Source Poly Vinyl Chloride

PVC Part. Emissions (Cont.)

State	# Plants	Ave Pl. Capacity*	Process Wgt Rate**	Allowable Emis
Ill	3	85x10^6 lbs/YR	9720 lbs/HR	5.9
Maryland	1	130	14870	14.0
W. Va.	2	90	10,290	*****

* When capacity is given for 2 plants, both are assumed equal.

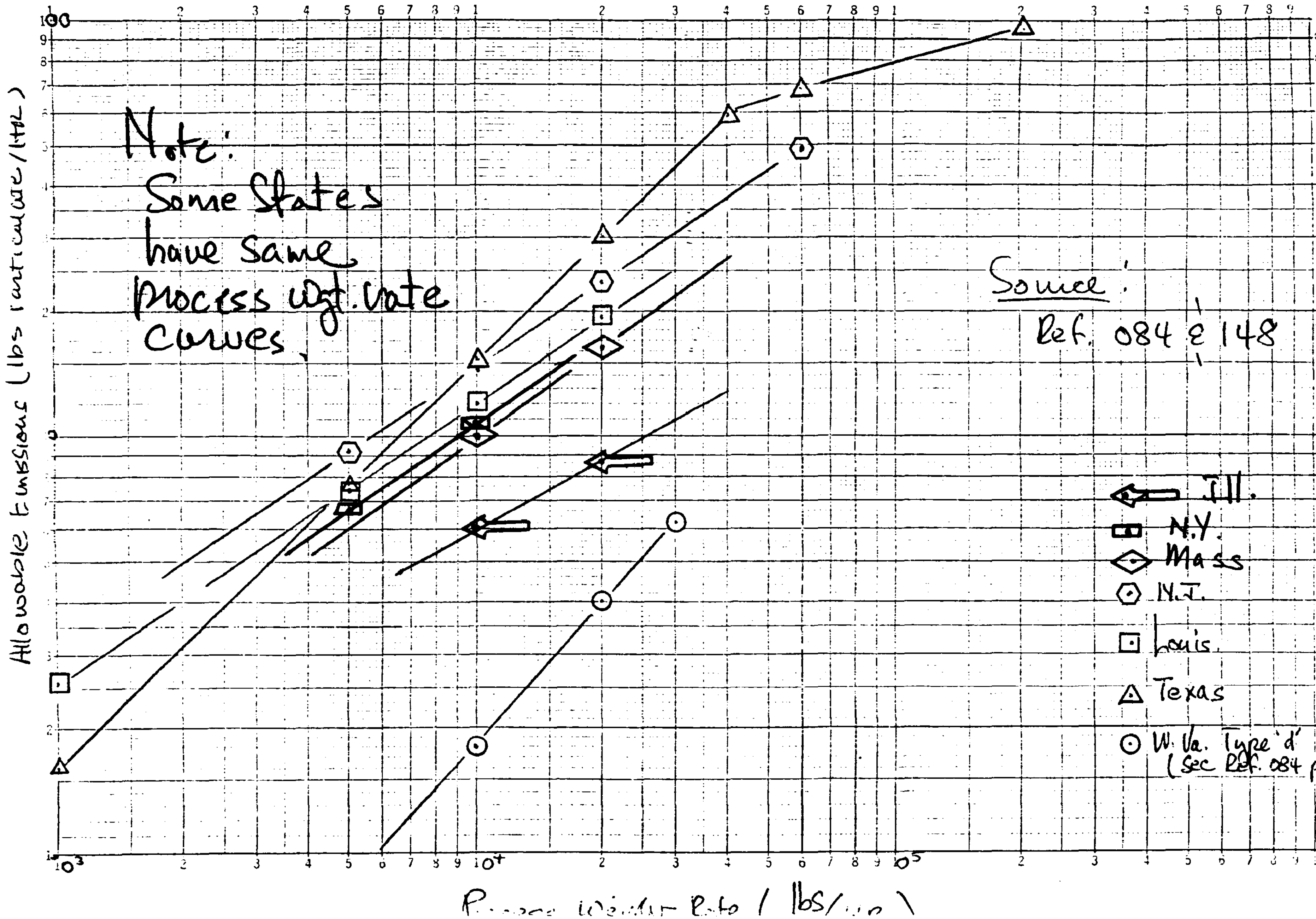
** Assuming 24 HR/day, 7 day/WK, 52 WK/YR operation.

*** To put the process wgt. rate in terms of input rate, the process wgt rate listed was multiplied by 1.05 (See Ref. 129 Table PV-1).

**** State was assumed equal to the 50 State numerical average

***** No process wgt. curve, Eu is substituted

Process Weight Rates



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Computation Sheet For Emission Factors

Calculations Done By V.F. Russo Date 10/10/74

Source Polyvinyl Chloride

Part. Emissions (Cont.)

$$\therefore E_s = \sum_i \frac{E_A^i N_p^i}{A} + E_u A_i \text{ (with correct units)}$$

where A (A_i) is the (relative) production capacity

$$\sum_i E_A^i N_p^i = 546 \text{ lbs/HR} \left(24 \text{ HR/DAY}\right)\left(7 \text{ day/WK}\right)\left(52 \text{ WK/YR}\right)$$

$$= 4769856 \text{ lbs/YR} = 4.77 \times 10^6 \text{ lbs/YR}$$

~~= 2385 TONS/YR~~

$$\frac{\sum E_A^i N_p^i}{A} = \frac{4.77 \times 10^6 \text{ lbs/YR}}{2.74 \times 10^6 \text{ TON/YR}} = 1.74 \text{ lbs/TON}$$

$$E_u A_i \text{ for W.V}_u = 35 \text{ lbs/TON} \ \frac{180 \times 10^6 \text{ lbs/YR}}{4375 \times 10^6}$$

$$= 1.44 \text{ lbs/TON}$$

$$E_s = 1.44 + 1.74 = 3.18 \text{ lbs PART/TON PVC}$$

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Computation Sheet For Emission Factors

Calculations Done By R.J. Londergan Date 10/7/74

Source Polyvinylchloride

HC.

As discussed in Vol #1,

$E_S = E_S^u + E_S^P + E_S^A$.

Plant location and capacity information is obtained from Ref. 128, p. PV-11-12.

a) States with no applicable HC regulations, but with PVC plants, are Florida, Mass., Miss., Delaware, Maryland, Penna., N.J., N.Y., and W. Va.* These states represent a fractional capacity** of .496. Using E_u = 17 LB/TON from previous emissions factor calculation, we obtain

$$E_S^u = (.496)(17) = 8.43 \text{ LB/TON}$$

b) The remaining state regulations contain percent control regulations which apply to these plants. The regulations* require 90% control in Louisiana and Texas (we have assumed the 90% figure for Texas, which requires incineration for emissions exceeding 100 lb/day) and 85% for all remaining states. Fractional capacity in Texas and Louisiana is 0.138,** and for the remaining states it is .366

Then $E_S^P = [(0.1)(.138) + (.15)(.366)] \times 17 = 1.17$ LB/TON

and

$$E_S = (8.43 + 1.17) = 9.6 \text{ LB/TON PVC}$$

* Ref. 84 and 148

** Where an aggregate capacity is given, we have divided it equally among plants.

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Computation Sheet For Industrial Factors

Calculations Done By K. Tower Date 2/7/75

Source Synthetic Resins

Ref 103, p.758 makes this statement regarding synthetic resins:

"A man-made high polymer resulting from a chemical reaction between two (or more) substances, usually with heat or a catalyst. This definition includes synthetic rubbers, siloxanes, and silicones, but excludes modified, water soluble polymers (often called resins). Distinction should be made between a synthetic resin and a plastic: the former is the polymer itself, whereas the latter is the polymer plus such additives as fillers, colorants, plasticizers, etc."

We have previously covered such resins as polyethylene, polypropylene, polypropylene and SBR rubber. For this general category we were able to find little specific information. From the information we were able to find we found it best to define synthetic resins in three categories:

1) Phenolic resins
2) Urea - Melamine resins
3) Acrylonitrile - butadiene - styrene (ABS) & styrene - acrylonitrile (SAN) resins.

We do not assume that these resins cover the remaining resin industry. Rather we defined the industry in terms of the information we found.

Ref 204, p.7 gives the following production information for phenolic & urea - melamine resins. We present the information in graph form for the years 1963 - 1973

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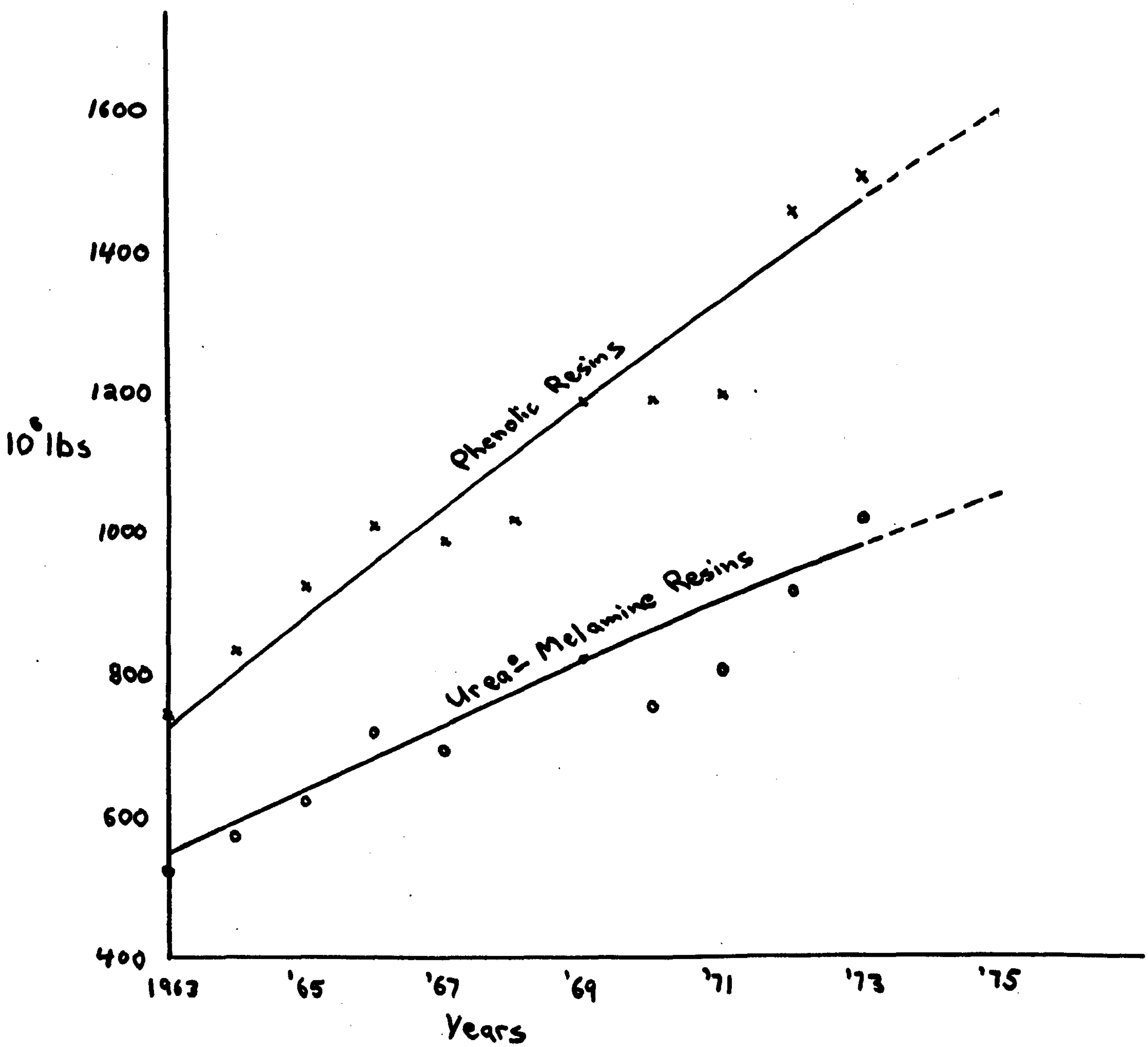
Computation Sheet For Industrial Factors

Calculations Done By K. Tower Date 2/7/75

Source Synthetic Resins

Phenolic & Urea-Melamine Resins Production 1963-1973



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Computation Sheet For Industrial Factors

Calculations Done By K. Tower Date 2/7/75

Source Synthetic Resins

Assuming a compound growth rate for both Phenolic & Urea-Melamine resins we calculate P_c as follows

$$P_{c_{\text{Phenolic}}} = \sqrt[1973-1963]{\frac{\text{Prod. } 1973}{\text{Prod } 1963}} - 1.0$$

$$= \sqrt[10]{\frac{1500 \times 10^6 \text{ lbs}}{741 \times 10^6 \text{ lbs}}} - 1.0$$

$$= 1.07 - 1.0 = .070$$

$$\boxed{P_{c_{\text{Phenolic}}} = 0.070 \text{ compound}}$$

$$P_{c_{\text{Urea-Mel.}}} = \sqrt[1973-1963]{\frac{\text{Prod. } 1973}{\text{Prod } 1963}} - 1.0$$

$$= \sqrt[10]{\frac{1022 \times 10^6 \text{ lbs.}}{518 \times 10^6 \text{ lbs}}} - 1.0$$

$$= 1.07 - 1.0 = .073$$

$$\boxed{P_{c_{\text{Urea-Mel}}} = .073 \text{ com'd}}$$

We could find no reliable information concerning the growth rate of SAN & ABS. We will assume it parallels that of the phenolic and Urea-melamine growth rates and take the average of the two similar growth rates. $\frac{.070 + .073}{2} \approx .072$

$$\boxed{P_{c_{\text{SAN,ABS}}} = .072 \text{ comp'd}}$$

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Computation Sheet For Industrial Factors

Calculations Done By K. Tower Date 2/7/75

Source Synthetic Resins

Ref. 207, p. 25 states that ABS & SAN producers operate at about 80% of their capacity. We will assume the same for Urea-melamine and phenolic producers.

$$K_{Phenolic} = 0.80$$

$$K_{Urea\text{-}Mel.} = 0.80$$

$$K_{SAN,ABS} = 0.80$$

Ref 204, p.7 states the 1973 production of phenolic resins as 1500×10^6 lbs.

$$Prod_{1975} = Prod._{1973}(1 + P_c)^{1975-1973}$$

$$= (1500 \times 10^6)(1.070)^2 = 1.72 \times 10^9 \text{ lbs}$$

$$A_{Phenolic} = \frac{1.72 \times 10^9 \text{ lbs}}{(2000 \frac{lbs}{TON})(0.80)} = 1.07 \times 10^6 \frac{TONS}{YR}$$

$$A_{Phenolic} = 1.07 \times 10^6 \frac{Tons}{YR}$$

Ref 204, p.7 states the 1973 production of Urea-Melamine as 1022×10^6 lbs.

$$Prod_{1975} = (1.022 \times 10^6)(1.073)^2 = 1.18 \times 10^9 \frac{lbs.}{yr.}$$

$$A_{urea\text{-}Mel} = \frac{1.18 \times 10^9 \frac{Tons}{yr.}}{(2000 \frac{lbs}{TON})(0.80)} = 0.74 \times 10^6 \frac{Tons}{yr.}$$

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Source Synthetic Resins

$$A_{Urea-Mel} = 0.74 \times 10^6 \frac{TONS}{YR}$$

Ref. 207, p. 75 gives the 1968 production of SAN & ABS resins as 464×10^6 lbs.

$$Prod_{1975} = (464 \times 10^6 \text{ lbs})(1.072)^7 = 7.55 \times 10^8 \text{ lbs}$$

$$A_{SAN,ABS} = \frac{7.55 \times 10^8 \frac{lbs}{YR}}{\left(2000 \frac{lbs}{TON}\right)(0.80)} = 0.47 \times 10^6 \frac{Tons}{YR.}$$

$$A_{SAN,ABS} = 0.47 \times 10^6 \frac{Tons}{YR}$$

Since no specific information could be found concerning the replacement rate of obsolete production capacity we assume that all three categories have replacement rates similar to the polystyrene industry ⟶ $.005_{simple}$

$$P_{B_{Phenolic}} = 0.005_{simple}$$

$$P_{B_{Urea-Mel.}} = 0.005_{simple}$$

$$P_{B_{SAN,ABS}} = 0.005_{simple}$$

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Computation Sheet For Industrial Factors

Calculations Done By K. Tower Date 2/7/75

Source Synthetic Resins

Summary of Industrial Factors

Category	A	K	P_C	P_B
Phenolic Resins	1.07×10^6 TONS/YR	0.80	0.070c	0.005s
Urea-Melamine Resins	0.74×10^6 TONS/YR	0.80	0.073c	0.005s
SAN, ABS Resins	0.47×10^6 TONS/YR	0.80	0.072c	0.005s

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Computation Sheet For Emission Factors

Calculations Done By K. Tower Date 2/7/75

Source Synthetic Resins

We were unable to find any information concerning the emission factors from these categories. We assume the uncontrolled emissions from these categories to be equal and the average of two simular industries poly-styrene and polypropylene.

$$E_u = \frac{E_{u\,poly\text{-}st.} + E_{u\,poly\text{-}prop}}{2} = \frac{11.7 + 3}{2} \approx 7.5 \text{ lbs/Ton}$$

Hydrocarbons

$$E_{u_{Phenolic}} = 7.5 \text{ lbs/Ton}$$

$$E_{u_{Urea\text{-}Mel.}} = 7.5 \text{ lbs/Ton}$$

$$E_{u_{SAN,\,ABS}} = 7.5 \text{ lbs/Ton}$$

These values are substantied by ref 222, p.4-54 which gives the uncontrolled emissions from a plastics plant (which they synonymize with synthetic resins) as 5-10 lbs/Ton.

If we assume that this industry can be controlled in a similar manner to the polypropylene and polystyrene industries, one can expect a 99% reduction of hydrocarbon emissions with the use of incineration or flares:

$$E_N = .01 \times E_u = .01 \times 7.5 = .075 \text{ lbs/Ton}$$

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Computation Sheet For ~~Industrial~~ Emission Factors

Calculations Done By K. Tower Date 2/7/75

Source Synthetic Resins

$$E_{N_{Phenolic}} = .075 \text{ lbs/Ton}$$

$$E_{N_{Urea\text{-}Mel.}} = .075 \text{ lbs/Ton}$$

$$E_{N_{SAN,ABS}} = .075 \text{ lbs/Ton}$$

Hydrocarbons

From ref236, pIV-58 we find an average plastic plant operates at an input rate of approx. 12×10^3 lbs/hr. Assuming this to be typical of these three industrial categories the 85% HC reduction regulation (from those 15 states with hydrocarbon regulations) is applicable. We will assume the emission regulation to be the same for all three categories and that their production facilities to be equally distributed throughout the US.

Allowable Emissions for States with HC regs $= 0.15 \times E_u = 0.15 \times 7.5 = 1.125 \frac{\text{lbs}}{\text{Ton}}$

Allowable Emissions For States without regs $= E_u$.

From ref 084 we find there are 15 state regulatory areas (of 55) with the 85% reduction regulation.

$$E_S = \left(\frac{15}{55}\right)(1.125) + \left(\frac{40}{55}\right)(7.5) = .307 + 5.455 = 5.762 \text{ lbs/Ton}$$

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Computation Sheet For ~~Industrial~~ Emission Factors

Calculations Done By K. Tower Date 2/7/75

Source Synthetic Resins

$$E_{s_{Phenolic}} = 5.76 \ lbs/Ton$$

$$E_{s_{Urea\text{-}Mel.}} = 5.76 \ lbs/Ton$$ Hydrocarbons

$$E_{s_{SAN,\,ABS}} = 5.76 \ lbs/Ton$$

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Computation Sheet For Industrial Factors

Calculations Done By Homer Date 5/8/75

Source ACRYLIC RESINS

Ref (272) p V-3 TAB V-1

1972 PROD = 660×10^6 LBS
EST 1977 PROD = 1350×10^6 LBS

$$P_c = \sqrt[5]{\frac{1350}{660}} - 1.0 = 0.154$$

$P_c = 0.154$ COMP'D.

1975 PROD = $(660 \times 10^6)(1.154)^3 = 1014 \times 10^6$ LBS

1974 PROD = $(660 \times 10^6)(1.154)^2 = 879 \times 10^6$ LBS

Ref (272) p V-40 gives 1974 capacity of 1015×10^6 LBS

$$K = \frac{879}{1015} = 0.87$$

$K = 0.87$

$$A = \frac{(1014 \times 10^6)}{(.87)(2000)} = 0.583 \times 10^6 \text{ tons}$$

$A = 0.583 \times 10^6$ TONS RESIN

Ref (37) The IRS depreciation guideline for "Mfg of chemicals AND ALLIED PRODUCTS . . " is 11 YEARS. Assuming twice the Avg

$$P_R = \frac{1}{2(11)} = 0.045$$

$P_R = 0.045$ simple

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 5/8/75

Source Acrylic Resins

Ref (272) p VIII-14, 15, 16 gives emissions from 3 typical well controlled plants

11.2×10^{-4} lb/lb resin — Case I
2×10^{-3} lb/lb resin — Case II
4.9×10^{-4} lb/lb resin — Case III

$$Avg = 1.2 \times 10^{-3} \equiv 2.4 \text{ lb/ton resin}$$

$$E_{N_{HC}} = 2.4 \text{ lb/ton resin}$$

The emission control methods used by the larger, more sophisticated producers of acrylic resins, appear to be relatively efficient. The use of closed liquid systems, conservation vents and nonregenerative water scrubbers removes over 99% of the vapors from these processes.

$$E_U = \frac{2.4}{(1-.99)} = 240 \text{ lb/ton} - E_{U_{HC}}$$

Ref (272) p V-10

Tex – 300 + 40 + 400 = 740×10^6 lbs/yr =
Ky – 5×10^6 lbs/yr
W.Va. – 70×10^6 lbs/yr
La – 200×10^6 lbs/yr

Neglecting the Ky. plant, & assuming 16 hrs/day, 250 days/yr

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Computation Sheet For Emission Factors

Calculations Done By Homer Date 5/8/75

Source Acrylic Resins

$$\frac{(740+70+200)\times 10^6}{6} = \text{Avg plant size} = 168\times 10^6 \text{ LB/YR} = 8.4\times 10^4 \frac{\text{TONS}}{\text{YR}}$$

$$\frac{(8.4\times 10^4)(240)}{250} = 80{,}640 \text{ LB/DAY}$$

$$\frac{80{,}640 \text{ LB/day}}{16} = 5040 \text{ LB/HR}$$

Using 85% control Ref (156)

$$(80\,640)(1-.85) = 12{,}096 \text{ LB/day}$$

$$(5040)(1-.85) = 756 \text{ LB/HR}$$

$$\frac{(12096 \text{ LB/day})(250 \frac{\text{day}}{\text{YR}})}{8.4\times 10^4 \frac{\text{TONS}}{\text{YR}}} = 36 \frac{\text{LB}}{\text{TON}}$$

for those STATES WITH H/C Regs

Of the 4 STATES with Acrylic production, none have H/C solvent regs (Ref (84)). However, we can assume that some control will be required by odor regs. For the purpose of this analysis, we will set Es equal to 36 LB/ton — the value representing 85% control

$$Es_{HC} = 36 \text{ LB/TON RESIN}$$

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Computation Sheet For Industrial Factors

Calculations Done By Homer Date 5/8/75

Source Alkyd Resins

Ref (272) p II-3 TAB II-1

1972 Prod = 695×10⁶ LB/YR
EST 1977 Prod = 750×10⁶ LB/YR

$$P_c = \sqrt[5]{\frac{750}{695}} - 1 = 0.015$$

$$\boxed{P_c = 0.015} \text{ cmpd.}$$

We will assume K equal to the other resin mfg processes (SEE "INDUSTRIAL FACTORS - POLYESTER RESIN")

$$\boxed{K = 0.68}$$

$$A = \frac{(695 \times 10^6)(1.015)^3}{(.68)(2000)} = 0.53 \times 10^6 \text{ tons}$$

$$\boxed{A = 0.53 \times 10^6 \text{ TONS RESIN}}$$

Ref (37) The IRS depreciation guideline for "Mfg of CHEMICALS AND ALLIED PRODUCTS ...." is 11 YEARS. Assuming twice the average

$$P_B = \frac{1}{2(11)} = 0.045$$

$$\boxed{P_B = 0.045} \text{ simple}$$

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Computation Sheet For Emission Factors

Calculations Done By Hoover Date 5/8/75

Source Alkyd Resins

Ref (272) p VIII-23 gives emission factors for HC's.

The total EF = 0.0076 (avg) LB/LB RESIN

This, however, includes fugitive emissions which would not be amenable to control using A/B's or carbon abs.

Prorating the factor for source emissions only

$$\left(\frac{2026}{18{,}026}\right)(0.0076)(2000) = 1.71 \text{ LB/TON RESIN}$$

$$E_{U_{HC}} = 1.71 \text{ LB/TON RESIN}$$

Ref (272) p VIII-25 indicates that vent gas combustion would be a better control alternative than carbon adsorption.

Assume $\eta_{A/B} = 99\%$

$$E_{N_{HC}} = 1.71(1-.99) = 0.017$$

$$E_{N_{HC}} = 0.017 \text{ LB/TON RESIN}$$

Ref (272) p VIII-23 The emission factor presented is for a 2.2 MM - 2.4 MM LB/YR alkyd plant which (Ref (272) p VIII-19) operates 250 days/yr - 2 shifts per day.

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Computation Sheet For Emission Factors

Calculations Done By Homer Date 5/8/75

Source Alkyd Resin

Using the uncontrolled value of 1.71

$$\frac{(1.71)(2.3 \times 10^6)}{2000} = 1967 \text{ lb/yr}$$

$$\frac{1967}{250} = 7.9 \text{ lb/day}$$

$$\frac{7.9}{16} = 0.5 \text{ lb/hr}$$

This is less than any State HC emission req (Ref (84) + (118) + (152))

$\therefore E_S = E_U$

$$E_{S_{HC}} = 1.71 \text{ lb/ton resin}$$

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Computation Sheet For Industrial Factors

Calculations Done By *Hopper* Date *5/7/75*

Source *Polyester Resin*

Ref 272 p II-3 TAB II-1

1972 Production = 862×10^6 LBS

1977 Est. Prod = 1900×10^6 LBS

$$P_c = \sqrt[5]{\frac{1900}{862}} = 0.17$$

$$P_c = 0.17$$ COMP'D

$$1975 \text{ Prod} = (862 \times 10^6)(1+.17)^3 = 1381 \times 10^6 \text{ LBS}$$

Ref (209) p13, gives prod & cap data for polyester fibre mfg. We will assume this same value

$$K = 1465/2163 = 0.68 = K$$

$$A = \frac{1381 \times 10^6}{(0.68)(2000)} = 1.02 \times 10^6 \text{ TONS}$$

$$A = 1.02 \times 10^6 \text{ TONS RESIN}$$

Ref (37) The IRS, depreciation guideline for "Mfg of chemicals and allied products ...." is 11 yrs. Assuming twice the avg

$$P_B = \frac{1}{2(11)} = 0.045$$

$$P_B = 0.045$$ simple

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Computation Sheet For Emission Factors

Calculations Done By HOPPER Date 5/8/75

Source Polyester Resin

Since the mfg of polyester (Dacron) fibers is basically (from the chemical standpoint) the same as polyester resin, we will use emission factors for polyester fibers mfg.

Ref (75) p 5.19-1 TAB 5.19-1

$$E_{UP} = 7.0 \text{ LB/TON RESIN}$$

← OIL MIST

Generally, ESP's have been used successfully to control oil mists. Assuming $\eta = 95\%$

$$E_{NP} = (1-.95)(7.0) = 0.35$$

$$E_{NP} = 0.35 \text{ LB/TON RESIN}$$

Ref (272) p II-27

"... 33 companies at over 80 locations ..."

We will use the gen'l PWR curve generated from Ref's (81) + (145) from Ref (272) p II-28, 29, 81 plants (Assume 1972 based on other info within the ref.

$$1972 \text{ CAPACITY} = \frac{862 \times 10^6 \text{ LBS}}{0.68} = 1268 \times 10^6 \frac{\text{LBS}}{\text{YR}}$$

Assume 24 hrs/day (Ref (272) p V-30) & 330 days/yr op'n

$$\frac{1268 \times 10^6}{(81)(24)(330)} = 1977 \text{ LB/HR}$$

Ref (272) p V-30 states that plant capacities could vary between 1 + 70 MM LB/YR

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Computation Sheet For Emission Factors

Calculations Done By Homer Date 5/8/75

Source Polyester Resin

(1977)(24)(330) = 15.7 MM LB/YR

From the gen'l PWR curve, the allowable emission is 4.1 LB/HR

$$\frac{(4.1)(2000)}{1977} = 4.1 \text{ LB/ton}$$

E_{SP} = 4.1 LB/ton resin

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-28-74

Source Styrene - Butadiene Rubber (SBR)

Synthetic Rubber is made up of a good variety of elastomer formulations. By far the largest group is the styrene-butadiene product. Distribution by type was obtained from Ref 095 pg 525.3230 B and enables us to estimate the % of SBR to total production of synthetic rubber

	Long Tons x 10^6 SBR	Total	SBR Fraction
1964	1.255	1.768	.71
1966	1.336	1.975	.68
1968	1.389	2.139	.65
1970	1.330	2.211	.60

We see that presently about 60% of the total synthetic rubber produced is styrene-butadiene. We see a decline or slowering in the growth rate of SBR and emergence of other rubbers.

⟹ This report will discuss styrene-butadiene rubbers only.

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-28-74

Source Styrene-Butadiene Rubber (SBR)

A: Ref 129 SB-1 gave the Current (1973) capacity of SBR as 4.5×10^9 lb/yr and an estimated 5.2×10^9 lb/yr for the 1980 production capacity.

In listing the SBR producers on pg SB-11 it gave a 1971 capacity of 1,954,000 Long tons/yr. This is converted to lb/yr by multiplying by 2240 lb/L Ton obtained from Ref 143 F-234.

$\therefore$ 1971 Cap = 1,954,000 × 2240 = 4.38×10^9 lb/yr

These three capacity figures are plotted on the attached graph. We estimate the 1975 production capacity from the straight line fitted between these values.

$$A = 4.7 \times 10^9 \text{ lb/yr}$$

converting this to Ton/yr

$$A = 2.35 \times 10^6 \text{ T/yr}$$ SBR

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-28-74

Source Styrene - Butadiene Rubber (SBR)

P_c: Ref 129 SB-10;

forecasts a 1980 capacity from a 1971 production capacity of 1,954,000 LT/yr by using an annual growth rate of 2%/yr. We will use this growth rate of 2% to represent the 1975-1985 period.

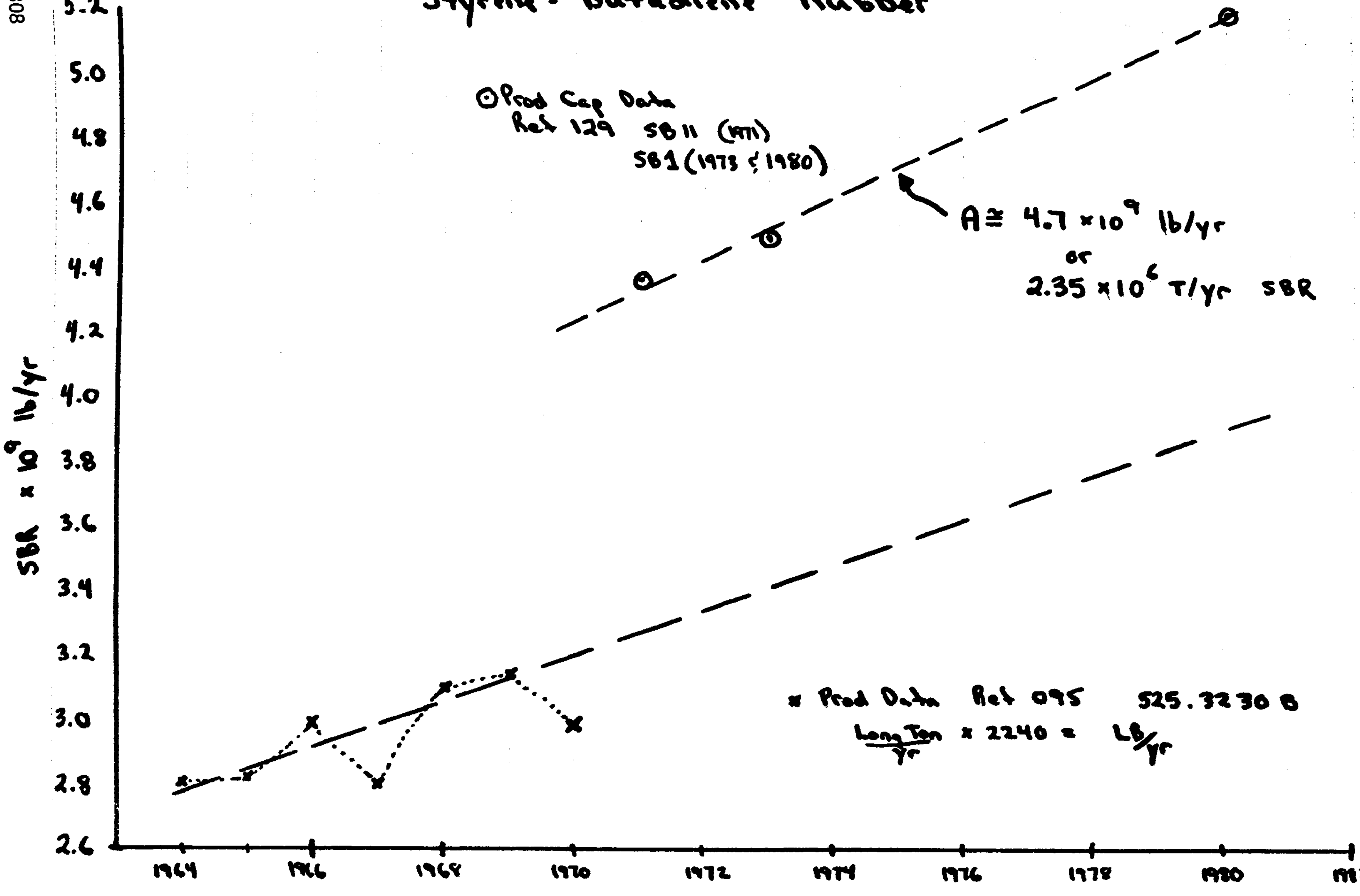
$$P_c = .02 \text{ compound}$$

K: Production data (SBR) for the period 1964-1970 was extracted from the table on Ref 095 pg 525.3230 B

YR	SBR 10^6 LONG TONS	10^9 lb/yr
1964	1.255	2.8
1965	1.261	2.82
1966	1.336	2.99
1967	1.243	2.8
1968	1.389	3.1
1969	1.403	3.14
1970	1.330	2.98

lb/yr = 2240 × Long Ton/yr

Styrene - Butadiene Rubber



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Computation Sheet For Industrial Factors

Calculations Done By William Marrone Date 8-28-74

Source Styrene - Butadiene Rubber (SBR)

K: cont'd

This production data is plotted along with the capacity on the attached graph. A "best fit" line was drawn through the data eliminating the two low years (1967 and 1970)

Utilization factors were developed for several years by ratioing the production values to the corresponding capacity value.

$K_{70} = \frac{3.2}{4.23} = .756$

$K_{72} = \frac{3.34}{4.42} = .755$

$K_{74} = \frac{3.48}{4.62} = .753$

$K_{75} = \frac{3.55}{4.71} = .754$

$K_{76} = \frac{3.61}{4.81} = .751$

$K_{78} = \frac{3.76}{5.0} = .752$

$K_{80} = \frac{3.9}{5.2} = .750$

From this data we surmise that a utilization factor of .75 would be satisfactory and representative

$K = .75$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-28-74

Source Styrene-Butadiene Rubber (SBR)

P_B: The obsolescence rate may be obtained from Table SB-V of Ref 129.

Current (1973) Capacity = $4{,}464 \times 10^6$ lb/yr

Current Capacity on-stream in 1980 = $4{,}352 \times 10^6$ lb/yr

112×10^6 lb/yr

The difference of 112×10^6 lb/yr represents the obsolete capacity which we assume will be replaced by 1980.

112×10^6 lb/yr obsolete capacity to be replaced

879×10^6 lb/yr total capacity added

767×10^6 lb/yr new capacity added

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 8-28-74

Source Styrene-Butadiene Rubber (SBR

P_B: cont'd

We will assume a simple obsolescence rate taking the 112×10^6 lb/yr and depreciating it over the period 1973 to 1980

$$\frac{112 \times 10^6 \text{ lb/yr}}{7 \text{ yrs}} = 16 \times 10^6 \text{ lb/yr / yr}$$ yearly obsolescence capacity

comparing this obsolescence rate to 1975 product capacity we calculate the value of P_B;

$$P_B = \frac{16 \times 10^6 \text{ lb/yr}}{4.7 \times 10^9 \text{ lb/yr}}$$

$$P_B \cong .003 \text{ simple}$$

$$\therefore \quad P_B = .003 \text{ simple}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Morrone Date 8-28-74

Source Styrene - Butadiene Rubber (SBR)

The emission sources which are identified in Ref 129 pg SB-4 to SB-6A were used as the basis for emission estimates from the styrene-butadience rubber process

Process Source	Pollutant
① butadience absorber	HC
② Dryer Vent	HC, Particulate
③ Carbon Black Handling	Particulate
④ Talc Dusting during Packaging	Particulate
⑤ Fugitive Emissions	HC, Particulate

A summary of emissions by pollutant for these sources is presented in Table SB-VI of the above reference source.

	Ton/TON		Calculated lb/TON product	
[redacted]	HC	PT	HC	PT
Dryer Vent	.001	.00002	2	.04
Butadiene Recovery	.0001	—	.2	—
Carbon Black	—	.0001	—	.20
Talc (Packaging)	—	.00002	—	.04
Fugitive Emissions	.001	.00021	2	.42
Total	.0021	.00035	4.2	.7

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-28-74

Source Styrene - Butadiene Rubber (SBR)

E_u: Using the above values we assign uncontrolled emission factors for HC and Pt from styrene - butadiene rubber manuf.

Note!! butadiene emissions from the absorber/recovery are considered uncontrolled even though a collector does absorb butadiene for recycle back into the process.
Ref 129 pg SB-7 indicates an average efficiency of the collector as $\frac{96.5+98}{2} \cong 97\%$

Particulates

$$E_u = .7 \text{ lb/TON SBR}$$

Hydrocarbons

$$E_u = 4.2 \text{ lb/TON SBR}$$

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Computation Sheet For Emission Factors

Calculations Done By William Marrone Date 8-28-74

Source Styrene - Butadiene Rubber

E_N:

Control techniques at existing plants are discussed on pg 5B-7 to 5B-9 of Ref 129.

Average absorber efficiency for butadiene recovery = 96.5 + 98 = 97.3% for HC

Carbon Black Handling - 95% eff reported
Report suggest 99% eff attainable for PT

Talc Handling - 75% max eff expected by employing cyclone

Ref 031 pg 39 - vapor loss from the dryer may be best controlled by more efficient stripping in the monomer-recovery operation.

Reference 075 Pg 5.20-1 indicates that fabric filters are sometimes used to control dryer particulate emissions.

The following assumptions are made in proposing a reasonable assessment of attainable pollutant control strategies;

1. monomer absorber efficiency would be increased to 99% and would simultaneously mean a reduction in the dryer vent hydrocarbon emissions. We assume a conservative 25% reduction
2. control of Carbon Black Part could be achieved 99% eff
3. Talc handling could be controlled by at least by 75%

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Computation Sheet For Emission Factors

Calculations Done By 2J Sh... Marrone Date 8-28-74

Source Styrene - Butadiene Rubber

E_N : cont'd

(4) Fabric Filters on the dryer would be 99% eff for particulate collection

(5) Fugitive emissions could be reduced through better house keeping, use of flares, improved process design, etc. We assume a 25% reduction in both hydrocarbon and particulate emissions.

	HC lb/TON	Part lb/TON
(1) Dryer:	.75 × 2 = 1.5	.01 × .04 = .0004
(2) Butadiene Recovery:	.01/.03 × .2 = .07	—
(3) Carbon Black:	—	.01 × .2 = .002
(4) Talc	—	.25 × .04 = .01
(5) Fugitive Emission:	.75 × 2 = 1.5	.25 × .42 = .105
Total	3.07	.117

Hydrocarbon E_N = 3.1 lb/TON SBR
Particulate E_N = .12 lb/TON SBR

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-28-74

Source Styrene - Butadiene Rubber SBR

Odors

Quote: Ref 129 pg SB-6

"In general, questionnaire responses seem to indicate that the production of SBR is not a process that has an odor problem.

No respondent reported any odor complaints in the past year. Most, however, did report that odors are occasionally detectable at the plant site. Although the odoriferous materials were not identified, the odor itself is described as the "typical rubber plant smell". This odor is most commonly associated with the rubber drying operation. Lack of community complaints implies that odor control is currently adequate."

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Computation Sheet For Emission Factors

Calculations Done By W Marrone Date 2-3-75

Source Styrene - Butadiene - Rubber (SBR)

Particulates :

Ref 151 pg 381

From data in table we calculate the simple average plant size

$$\frac{1550 \times 10^3 \ LT/yr}{20 \ plants} = 77.5 \times 10^3 \ LT/yr \text{ per plant}$$

$$LT = 2240 \ lb \cong 1.12 \ TON \quad \therefore \quad 77.5 \times 10^3 \ LT/yr \times 1.12 \ \frac{TON}{LT} \cong 86.8 \times 10^3 \ TON/yr$$

Assuming an operating schedule of 24 hr/day × 5 d/wk × 50 wk/yr we have 6000 hr/yr

$$\text{Avg PWR} = 86.8 \times 10^3 \ \frac{TON}{yr} \times \frac{yr}{6000 \ hr} \times 2000 \ \frac{lb}{TON} \cong 28.9 \times 10^3 \ \frac{lb}{hr}$$

We develop fractional capacity occurrence values (A_i) for each state (Ref 151 pg 381) based on 1965 data. It is assumed that this occurrence will not change appreciably and that we may apply this average process weight rate in determining a "weighted" allowable emission rate.

Ref 084 & 148 for allowable state regulations

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 2-3-75

Source Styrene - Butadiene Rubber (SBR)

Particulate cont'd E_s:

State	Ai	Allowable lb/hr	Ai x Allow
Ky	.082	24.5	2.009
La	.218	24.5	5.341
Mass	.002	22.0	.044
Ohio	.048	24.5	1.176
Tex	.485	43.0	20.855
W. Va.	.066	22.0	1.452
Conn	.029	18.5	.537
Del	.005	*	.005 x E_{Avg}
Calif	.063	21.5+	1.355
Tenn	neg	——	——
N.C.	neg	——	——

$$E_{Avg} = \Sigma = 32.769 + .005\, E_{Avg}$$

+ ref 156 pg 37
* gr/scf reg assume equivalent to average

$$E_{Avg} = 32.769 + .005\, E_{Avg}$$

$$.995\, E_{Avg} = 32.769$$

$$E_{Avg} \cong 32.9 \text{ lb/hr}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 2-3-75

Source Styrene - Butadiene Rubber (SBR)

Particulate cont'd

E_s:

Avg Plant = $86.8 \times 10^3 \frac{TON}{yr}$ and $6000 \frac{hr}{yr}$

$$E_s = \frac{32.9 \text{ lb/hr}}{86.8 \times 10^3 \frac{TON}{yr} \times \frac{yr}{6000 hr}} = 2.27 \frac{lb}{TON\ SBR}$$

Since $E_s >> E_u$ which is .7 lb/TON SBR then we may write

$$E_s = E_u = .7 \text{ lb/TON SBR}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 2-3-75

Source Styrene - Butadiene Rubber (SBR)

Hydrocarbons

E_s: Ref 084 and 148

Hydrocarbon emissions from this source do not come under any applicable state regulations so that we assume $E_s = E_u$

$$E_s = 4.2 \text{ lb/TON SBR}$$

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Computation Sheet For Industrial Factors

Calculations Done By Hopper Date 12/17/74

Source Varnish

From Ref (50) p9

1970 Production of Varnish & Resin = 1930×10^6 LBS = 0.965×10^6 TONS

From Ref (235) p157

Growth in Paint & Varnish Industry = 2.63% CMPD

$\therefore$ $P_C = 0.0263$ CMPD

1975 Production = $(0.965 \times 10^6)(1.0263)^5 = 1.099 \times 10^6$ TONS

Ref (235) p166, Assuming the avg of 80-90%

$K = 0.85$

$$A = \frac{1.099 \times 10^6 \text{ TONS}}{0.85} = 1.293 \times 10^6 \text{ TONS}$$

$A = 1.293 \times 10^6$ TONS

Ref (235) p169 indicates that the avg life of equipment is 10-20 YRS. Assuming an avg of 15 YRS,

$$P_B = \frac{100\%}{15 \text{ YRS}} = 6.67\%$$

$\therefore$ $P_B = 0.0667$ simple

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 12/17/74

Source Varnish

REF (75) p 5.10-2 TAB 5.10-1 gives H/C emission factors for Varnish mfg as follows:

Bodying oil - 40 #/ton
Oleoresinous - 150 #/ton
Alkyd — 160 #/ton
Acrylic - 20 #/ton

REF (50) p 9 indicates emissions from

Natural resins (oleoresinous)
Oils
Alkyd
Vinyl
Acrylics
Others

Vinyl process emissions appear to be about 1/4 that of oils or 1/3 that of acrylics
Emissions from "other" resins appear to be about 10% of acrylics

1/4 (40) = 10 #/ton
1/3 (20) = 7 #/ton } Assume 9 #/ton for vinyl

(.10)(20) = 2 #/ton for "others"

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 12/17/74

Source Varnish

Ref (50) p9 gives industry breakdowns in usage for these mat'ls

Nat. Resins	—	30/1930 = 1.6%
Oils	—	240/1930 = 12.4%
Alkyd	—	680/1930 = 35.2%
Vinyl	—	300/1930 = 15.5%
Acrylics	—	220/1930 = 11.4%
others	—	460/1930 = 23.9%

$$EU_{HC} = (150)(.016) + (40)(.124) + (160)(.352) + (9.0)(.155) + (20.0)(.114) + (2.0)(.239)$$

$$= 2.4 + 4.96 + 56.3 + 1.4 + 2.3 + .5 = 67.9$$

$$EU_{HC} = 67.9 \ \#/\text{ton varnish}$$

For H/C, the most effective control technique is incineration from. Ref (50) p7 $\eta = 99\%^+$. Assume 99%

$$EN_{HC} = (1 - .99)(67.9) = 0.679$$

$$EN_{HC} = 0.679 \ \#/\text{ton varnish}$$

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 12/17/74

Source Varnish

E_6 DETERMINATION — REF (84), (148) & (56)

REF (50) p2 indicates typical kettle size is between 1000 & 5000 gals. Assume 3000 gals as the avg

REF (75) p 5.10-1 states that typical cooking times are from 4-16 hours. Assume 10 hours as the avg.

Ref (75) p 4.2-1 Wt of varnish = 7 LB/GAL

$$\frac{\left(\frac{3000 \text{ GALS}}{10 \text{ hours}}\right)\left(7 \frac{\text{LB}}{\text{GAL}}\right)}{2000 \text{ LB/TON}} = 1.05 \text{ TONS/HR of varnish (typical)}$$

Uncontrolled emission factor = 67.9 LB/TON varnish

$$\text{LOSS} = (1.05)(67.9) = 71.3 \text{ LB/HR}$$

Referencing the "Paint" calculations (Hopper 12/16/74) p2 emission factors

68% of production occurs in 7 states, the remaining 32% being distributed throughout the U.S.

Only Ill, Ohio & Cal have regs (of the 7 states) for reactive H/C emissions

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 12/17/74

Source Varnish

Ref (235) p54 Tab 7 states that, of the solvents used,

46.0% are reactive
31.6% are unreactive
22.4% unknown

Assuming the 22.4% to be 50/50 reactive/unreactive

57.2% reactive
42.8% unreactive

There are no regs for unreactive emissions from the States of concern

For the reactive emissions, we will use LAAPCD Rule 66 as being representative

(c) 15 lb/day or 85% control

So, from p3 of these calc's $(71.3 \text{ lb/hr})\left(\frac{16 \text{ hrs}}{\text{day}}\right)(1-.85) = 171$ #/day

↑ Assumed max cooking time

$$\frac{171 \text{ \#/day}}{(16 \text{ hr/day})(1.05 \text{ tons varnish/hr})} = 10.2 \text{ \#/ton}$$

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 12/17/74

Source Varnish

$$E_{S_{HC}} = (0.428)(67.9) + (.572)(10.2) = 29.06 + 5.83$$

$$E_{S_{HC}} = 34.9 \text{ \#/ton of varnish}$$

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

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15. SUPPLEMENTARY NOTES

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16. ABSTRACT

The purpose of this document is to present the results of a study to determine the impact of new source performance standards on nationwide emissions. The work presented covers 14 potential pollutants from approximately 200 source categories for the year 1985. The results are being used by EPA as input to the development of an overall standard setting strategy. The report contains information regarding controlled and uncontrolled emission factors, State emission limitations, industrial capacity, utilization, growth and retirement rates. The results of this study have been published as three volumes which encompass ten separate documents. This document contains Appendix 4B of Volume II - Calculation Sheets for the Chemical Process Industry.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS		c. COSATI Field/Group
Air Pollution Air Pollution Control Industrial Processes Combustion Regulations Economic Factors	Priorities Chemical Industry Paper Industry Petroleum Industry	Metal Industry Agricultural Mineral Flyash Exhaust Gases	

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