EXHIBIT 46

Exhibit #-46

ENVIRONMENTAL PROTECTION AGENCY

BEFORE THE ADMINISTRATOR

In Re:

Proposed Toxic Pollutant Effluent Standards for Aldrin/Dieldrin et. al.	)	FWPCA (307) Docket No. 1

AFFIDAVIT OF SEBASTIAN C. CARUSO, Ph.D.
FOR OBJECTOR, AMERICAN IRON AND STEEL INSTITUTE

On behalf of Objector, American Iron and Steel Institute, Sebastian C. Caruso, being duly sworn, deposes and says:

(1) I am a Senior Fellow and Head of the Water Resources Fellowship in the Division of Sponsored Research of Carnegie-Mellon University. That in such position, I am responsible for directing research on the development and testing of analytical procedures for identifying pollutants in the environment, carrying out research on the chemistry and engineering aspects of processes suitable for the treatment of steel industry wastewaters, and the review of environmental standards as they apply to steel industry wastewaters. That I am completely familiar with the methods in general use for the detection and measurement of cyanides, cadmium, mercury and many other constituents.

(2) I am currently a member of the American Iron and Steel Institute's Environmental Quality Committee, Toxic Substances Task Force, and have reviewed information supplied by the Environmental Protection Agency to the American Iron and Steel Institute in preparing a study of the availability and applicability of analytical methods required to test

for compliance with the proposed toxic pollutant effluent standard for mercury.

(3) Attached is my statement entitled, "Proposed Toxic Pollutant Effluent Standards - Methods of Analysis for Mercury."

FURTHER AFFIANT SAITH NOT.

Sebastian C. Caruso, Ph.D.

Sworn to and subscribed before me
this 12th day of March, 1974.

Rena Baker Zeffer
Notary Public

RENA BAKER ZEFFER, Notary Public
Pittsburgh, Allegheny County, Pa.
My Commission Expires
August [illegible]

PROPOSED TOXIC POLLUTANT EFFLUENT STANDARDS -
METHODS OF ANALYSIS FOR MERCURY

The analytical methods recommended in the "Proposed Toxic Pollutant Effluent Standards" for mercury to test for compliance with the proposed standard are identified in the Federal Register of October 16, 1973, Volume 38, Number 199. The recommended method in the ASTM Manual (Method D 3223-73, Part 23 of Annual Book of ASTM Standards, 1973) is based on a flameless atomic absorption procedure. The precision of this method over the range of 0.2 to 10 μg/l is expressed as:

$$S_T = 0.174\ X + 0.170 \quad \text{(in natural waters)}$$

where: S_T = overall precision (average standard deviation)

and, X = the determined concentration of mercury in μg/l.

Thus, for $X = 10$ μg/l, $S_T = 1.91$ μg/l

and for $X = 2$ μg/l, $S_T = 0.518$ μg/l

Since the proposed standard for mercury is 20 μg/l, the analytical procedure will be required to measure concentrations at 20 and 2 μg/l (1/10 diffusion). Using the calculated average standard deviations at a concentration level of 10 μg/l, 95 percent of the measurements would be expected in the range of 10 ± 3.8 μg/l and at a concentration level of 2.0 μg/l, 95 percent of the measurements would be expected in the range of 2.0 ± 1.0 μg/l. The precision at the 20 μg/l level was not given, but is likely similar to that at 10 μg/l. If this is so, then at the 20 μg/l concentration level 95 percent of the measurements would be expected in the range of 20 ± 7.6 μg/l.

It is apparent that the reliability of an analytical method is an important consideration in setting standards and in testing for compliance. The results obtained from a method should be interpreted with suitable

precision and accuracy data at the indicated concentration levels.

Sebastian C. Caruso, Ph.D.
Carnegie-Mellon University

EXHIBIT 47

Exhibit # 47

ENVIRONMENTAL PROTECTION AGENCY

BEFORE THE ADMINISTRATOR

In Re:

Proposed Toxic Pollutant Effluent Standards for Aldrin/Dieldrin et. al.	)	FWPCA (307) Docket No. 1

AFFIDAVIT OF SEBASTIAN C. CARUSO, Ph.D.
FOR OBJECTOR, AMERICAN IRON AND STEEL INSTITUTE

On behalf of Objector, American Iron and Steel Institute, Sebastian C. Caruso, being duly sworn, deposes and says:

(1) I am a Senior Fellow and Head of the Water Resources Fellowship in the Division of Sponsored Research of Carnegie-Mellon University. That in such position, I am responsible for directing research on the development and testing of analytical procedures for identifying pollutants in the environment, carrying out research on the chemistry and engineering aspects of processes suitable for the treatment of steel industry wastewaters, and the review of environmental standards as they apply to steel industry wastewaters. That I am completely familiar with the methods in general use for the detection and measurement of cyanides, cadmium, mercury and many other constituents.

(2) I am currently a member of the American Iron and Steel Institute's Environmental Quality Committee, Toxic Substances Task Force, and have reviewed information supplied by the Environmental Protection Agency to the American Iron and Steel Institute in preparing a study of the availability and applicability of analytical methods required to test

for compliance with the proposed toxic pollutant effluent standard for cadmium.

(3) Attached is my statement entitled, "Proposed Toxic Pollutant Effluent Standards - Methods of Analysis for Cadmium."

FURTHER AFFIANT SAITH NOT.

Sebastian C. Caruso, Ph.D.

Sworn to and subscribed before me this 12th day of March, 1974.

Rena Baker Zeffer
Notary Public

RENA BAKER ZEFFER, Notary Public
Pittsburgh, Allegheny County, Pa.
My Commission Expires
August 1, 1976

PROPOSED TOXIC POLLUTANT EFFLUENT STANDARDS -
METHODS OF ANALYSIS FOR CADMIUM

The analytical methods recommended in the "Proposed Toxic Pollutant Effluent Standards" for cadmium to test for compliance with the proposed standard are identified in the Federal Register of October 16, 1973, Volume 38, Number 199. Analytical procedures vary greatly in their ability to accurately measure a required parameter. There are many sources of error possible in a given method. Some are due to faulty technique of the analyst; some are caused by reagents, equipment or laboratory facilities; and some are inherent in the procedure. In general, low concentrations are more difficult to analyze for accurately. Information concerning the reliability of an analytical procedure can be obtained by the use of statistical techniques applied to a large number of analyses on a sample of known concentration. From the values measured the precision and accuracy of the method are calculated. Other information useful to an analyst include the detection limit and the sensitivity of a method. The statistical information reported for the recommended cadmium method is shown in Table 1. This data was calculated from analysis performed by 59 laboratories.

Since the proposed standard for cadmium is 40 μg/l, the analytical method will be required to measure samples at 40 and 4 μg/l (1/10 diffusion) accurately. The precision and accuracy statements are not available at these concentrations, but are given for 50 and 10 μg/l. Thus, measurements made on a sample whose concentration is approximately 50 μg/l would have a 95 percent probability of falling between 29 and 71 μg/l. Similarly, measurements made on a sample whose concentration is about 10 μg/l would have a 95 percent probability of falling between zero and 24 μg/l. Measurements on a

sample with a concentration approximately 4 μg/l would be even less reliable, since the standard deviation is most likely higher at 4 μg/l than at 10 μg/l. From these observations, it is apparent that more reliable analytical procedures would be desirable to test for compliance with the proposed standard. In addition, the uncertainty of any recommended analytical procedures should be taken into account when testing for compliance with a standard.

Sebastian C. Caruso, Ph.D.
Carnegie-Mellon University

Table 1

PRECISION AND ACCURACY OF CADMIUM METHODS

Statistical Parameter	Cadmium
Detection Limit[1]	1.0 μg/l
Sensitivity[2]	4.0 μg/l
Relative Standard Deviation	
at 50 μg/l	21.6%
at 10 μg/l	72.8%
Relative Error	
at 50 μg/l	8.2%
at 10 μg/l	3.0%

[1]Detection Limit - The concentration that produces absorption equivalent to twice the magnitude of the fluctuation in the background.

[2]Sensitivity - The concentration of metal that produces an absorption of 1%.

EXHIBIT 48

EXHIBIT #48

ENVIRONMENTAL PROTECTION AGENCY

BEFORE THE ADMINISTRATOR

In Re:

Proposed Toxic Pollutant	)	
	)	
Effluent Standards for	)	FWPCA (307) Docket No. 1
	)	
Cyanide	)	

AFFIDAVIT OF WALTER E. JACKSON
FOR OBJECTOR, AMERICAN IRON AND STEEL INSTITUTE

On behalf of Objector, American Iron and Steel Institute, Walter E. Jackson, being duly sworn, deposes and says:

(1) I am Walter E. Jackson, Assistant Director of Environmental Control for United States Steel Corporation. That in such position, I am responsible for the review of environmental standards and the reviewing and recommending of proposed methods to obtain environmental standards and evaluating the cost and technology of the facilities to meet such standards. That I am familiar with the records of United States Steel Corporation and other information in the possession of the American Iron and Steel Institute involving the technology and cost of reducing toxic pollutant discharges.

(2) I am currently a member of the American Iron and Steel Institute's Environmental Quality Committee, Toxic Substances Task Force. I have reviewed information supplied by the Environmental Protection Agency to United States Steel Corporation and various members of the American Iron and Steel Institute in preparing a study of the

propriety of the proposed standards as well as the availability of technology and the economic impact of implementing it, which the proposed toxic pollutant effluent standards would have on the American iron and steel industry.

(3) Attached is my statement entitled, "Proposed Toxic Pollutant Effluent Standards for Cyanide - Technology and Economic Impact."

FURTHER AFFIANT SAITH NOT.

Walter E. Jackson

Walter E. Jackson

Sworn to and subscribed before me

this 13th day of March, 1974.

Lillian E. Bertram

Notary Public

My Commission Expires Mar 13, 1975

STATEMENT OF
WALTER E. JACKSON

Submitted on Behalf of
American Iron and Steel Institute

Proposed Toxic Pollutant Effluent Standards for Cyanide
Technology and Economic Impact

The proposed standards have been reviewed to evaluate their feasibility and impact on the American iron and steel industry. It is concluded that technology does not exist to achieve a "no detectable discharge" cyanide standard. A concentration of 10 micrograms per liter cannot be met in the foreseeable future, probably not before 1983, if then. No technology has been demonstrated for achievement of 100 micrograms per liter within one year and it is doubtful that this standard could be met by July, 1977. The effect of vigorous enforcement of these standards would be the loss of some or all of the iron and coke making capacity of the industry and all of the economic ramifications associated with that loss.

The Federal Register of Thursday, December 27, 1973 (Volume 38, Number 247) contains an introductory statement which comments on the economi impact of the proposed toxic pollutant effluent standards, noting that the proposed standards "are not based upon economic considerations or upon the availability of treatment technology. However, the impact of the standards upon the economy has been examined and does not appear to be great."

After publication of the Federal Register of December 27, 1973, AISI and several of the firms it represents requested from EPA copies of backgrou studies, reports and data on treatment technology and economic impact of the proposed standards. In response to these inquiries, EPA submitted a five-pa report entitled "Economic Impact of Toxic Standards" covering all toxic

substances, unsigned and undated, and a report of November, 1973 "Preliminar Analysis - Cost Effectiveness Relationships for the Removal of Cadmium, Mercury and Cyanide from Industrial Waste Streams," prepared by Associated Water and Air Resources Engineers, Incorporated of Nashville, Tennessee. Page 1 of the cost effectiveness report states that after reviewing only readily available literature and correspondence from unidentified researcher and equipment manufacturers, "the values used in this report cannot be taken as the most accurate estimates available." The report notes that "considera more time in evaluating data from all sources would be required to arrive at final judgments." Apparently, this time was not taken and data from other sources not evaluated because these reports were the only information the EPA supplied in response to inquiries for the data EPA examined.

It appears that the proposed standards were indeed "not based upon economic considerations or upon the availability of treatment technology." The AISI believes this to be an inappropriate basis for the establishment of standards, since the impact of the proposed cyanide standard on the American iron and steel industry is considerable.

The AISI believes that iron and coke manufacturing processes are the only significant sources of cyanide in the industry's discharges, and th other processes included under the definition of Section 129.01(a)(v) - "Ferrous Metal Production" and Section 129.05 - Applicability (Cyanide) shou not be considered as sources for the discharge of cyanide into navigable wat Based on this contention we have studied the technology proposed by EPA and the cost required to meet the proposed toxic pollutant effluent standards. What follows is a discussion of technology required to meet various cyanide concentrations, estimated capital costs, time requirements for installing

that technology, and the environmental impact of the technology considering estimated energy requirements, solid waste and sludge disposal, and related problems resulting from installation of that technology.

In evaluating treatment costs, "typical" facilities were selected and cost estimates were prepared for these facilities. These costs were reduced to doll per ton and this figure was multiplied by industry production figures to comput estimated total industry cost.

Control facilities for the treatment of steel industry waste waters have not been standardized. The EPA has proposed several treatment processes in the background document entitled "Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the Steel Making Segment of the Iron and Steel Manufacturing Point Source Category". The AISI does not support the conclusions reached in this document regarding the applicability of the proposed technology or the stipulated effluent concentrations attainable with this technology. However, AISI is presently reviewing the prop effluent limitations, guidelines and standards and intends to comment upon this material. In order to evaluate the potential impact of the proposed toxic effluent standards, EPA's proposal treatment methods were utilized. These treatment methods have been designated "Best practicable Control Technology Currently Available" (BPCTCA) and "Best Available Technology Economically Achievable", (BATEA).

The best practicable control technology currently available (BPCTCA) for overall treatment of blast furnace process water has been described by EPA as a recycle system with untreated blowdown. This technology is proposed by EPA for installation on or before July 1, 1977. Assuming a blowdown of 125 gallons per ton of iron produced (approximately 5%), EPA stipulates the maximum

concentration of cyanide in the discharge would be 30,000 micrograms per liter.

The best available technology economically achievable (BATEA) for blast furnace process water is proposed by EPA as a recycle system with treatment of the blowdown by alkaline chlorination, pressure filter and carbon adsorption. This technology has been proposed for all new sources and for installations on existing sources by July 1, 1983. Assuming a blowdown of 125 gallons per ton of iron produced, (approximately 5%), EPA stipulates the maximum concentration of cyanide in the discharge would be 500 micrograms per liter.

Under certain circumstances of stream flow, stream-discharge flow ratio and diffusion, the proposed toxic pollutant effluent standards would allow a cyanide concentration of 100 micrograms per liter in the discharges from blast furnaces. If all of these conditions are not met, then the allowable concentration would be 10 micrograms per liter, or no detectable discharge. Regardless of the allowable cyanide concentration, the technology required to meet the proposed "toxic pollutant" standard would have to be installed and operational within one year, unless the discharge is covered by a National Pollutant Discharge Elimination System (NPDES) permit and, in that case, after the term of the NPDES permit. As a practical matter, this cannot be done within one year or within five years (the maximum term of an NPDES permit). Therefore, the consequences of enforcement of these standards would be the loss of some or all of the iron production in the United States. EPA has proposed a cyanide concentration of 500 micrograms per liter to be achieved on or before July 1,

1983 using best available technology, and it is incomprehensible to think that a concentration of one-fifth this level could be achieved at an earlier date, if ever.

Once-through blast furnace process water has been treated in pilot tests to meet 100 micrograms of cyanide per liter. This limited experience indicates that once-through blast furnace water can be treated by alkaline chlorination to a level of 100 micrograms per liter if the water is first clarified to a high degree to remove most of the suspended solids and reduce the chlorine demand to a reasonable level. Clarified water is limed to a pH of approximately 9.5, treated with chlorine at a dosage rate o 7 pounds of chlorine per pound of cyanide, and allowed to react in a contact chamber for approximately 30 minutes for destruction of cyanide. The industry cost for this treatment, assuming the technology is transferable from experimental to actual conditions, on all blast furnaces would be $110 million plus annual operating and other related costs. This cost estimate assumes that some blast furnaces already have adequate clarifiers. It should be pointed out that a once-through water treatment system for cyanide destruction is not consistant with the attainment of standards for other contaminants such as suspended solids. It is estimated that this once-through chlorination treatment woule remove 2,800 tons of cyanide per year. This process would consume 20,000 tons per year of chlorine, 100,000 tons per year of lime and 47,000 tons per year of coal which would be needed to produce and supply the lime and chlorine. The coal consumed in power plants and in lime kilns would produce 1,300 tons per year of air pollutants and generate solid waste of over 14,000 tons per year. This treatment

system, if used on all blast furnaces within the industry, would consume 10^{12} BTU's of energy per year. Finally, alkaline chlorination of blast furnace waste water could produce chloroamines and residual chlorines in the final effluent, which in some cases (cyanogen chloride) can be more toxic than the cyanide for which the treatment is designed to remove. To our knowledge it has not been demonstrated that free cyanide in once-through blast furnace water can be reduced to the level of 10 micrograms per liter and/or a level of "no discharge."

The EPA proposed effluent limitation guidelines stipulate that recycling of blast furnace process water is the best technology for reducing environmental impact of water pollutants from iron production. The overall quality of a stream is determined mainly by the weight of contaminants discharged regardless of their concentration at the point of entry into the stream. Therefore, for contaminants such as suspended solids, the maximum reduction in the weight discharged from a blast furnace process water system will result from recycling the water to reduce the volume discharged. Recycling would involve processing the gas scrubbing and gas cooling water in a clarifier, piping this water through a cooling tower, and then recycling to the gas scrubber and cooler. To maintain dissolved solids at a low enough level to prevent scaling, a portion of the water (assumed to be approximately 5% of the total in circulation) would be bled off. This "blowdown" water would be taken off after the clarifier and would be low in suspended solids concentration. The weight of suspended solids in the effluent water would be only 5% of that discharged from a once-through system.

There would also be a removal of cyanide in the recirculation process

so that even through the concentration of cyanide in the blowdown stream would be higher than the concentration on a once-through water system, the total weight of cyanide discharged per unit of production would be less for the recycle system. EPA guidelines indicate that reduction of cyanide discharge as a result of recycling approximates 60%. Furthermore, there is evidence that in the process of recycling, some cyanides are converted to less toxic complex cyanides.

The estimated cost to the steel industry for recycling all blast furnaces would be $290 million, plus annual operating and other related costs, taking into account the fact that some blast furnaces have adequate clarifiers and other are already recycled. This treatment would remove 1,800 tons per year of total cyanide, somewhat lower than the reduction expected through alkaline chlorination of once-through water. Although the EPA indicates the effluent concentration of cyanide in the blowdown from the recycle system will exceed the proposed limit of 100 micrograms per liter, most of the cyanide present would be in the form of less toxic complexes. Recycling would discharge only 5% of suspended solids discharged from a once-through system.

Blast furnace recycling has been recommended by EPA as the BPCTCA required by July, 1977 to meet the proposed industry standard of 30,000 micrograms per liter for cyanide. It should be noted that achieving this date would be an enormous task for the steel industry. Construction times would be related to the availability of materials, skilled labor, equipment from independent suppliers, capital available to the industry and other limiting factors (such as scheduling to maintain iron capacity) that will determine the speed with which this can be done.

The EPA stipulates best available technology (1983) as blast furnace recycle with treatment of blowdown by means of alkaline chlorination, filtration and carbon adsorption. EPA estimates this treatment will achieve a cyanide concentration of 500 microgram per liter. It is also recognized that introduction of chlorine into this effluent could result in reaction products and residual chlorines that are environmentally undesirable. Howeve, if installation of this technology were required, the estimated cost to the steel industry would be an additional $87 million, plus additional annual operating and material costs. This does not include costs for facilities to heat the effluent water which may be required to make the cyanide amenable to chlorination.

The only other significant source of cyanide from the iron and steel industry is coke plant waste water. EPA has defined BPCTCA for coke product: as treatment of coke waste waters in free and fixed ammonia stills, dephenolization by biological oxidation (or solvent extraction) for treatment required on or before July, 1977. EPA estimates this treatment system will achieve cyanide concentrations in the discharge of coke production waste waters of 40,000 micrograms per liter, based on an assumed flow of 175 gallons of water per ton of coke produced. Industry costs for installing this treatment system are difficult to estimate because of wide variation in present conditions, but would be expected to be in the range of from $165 million to $290 million, plus annual operating and materials costs.

The BATEA defined by EPA adds recycle, aeration, chemical oxidation, neutralization, breakpoint chlorination, clarification and carbon adsorption to the treatment described for BPCTCA. Assuming a flow of 100 gallons of water discharged per ton of coke produced, EPA stipulates this would achieve a cyanide concentration of 500 micrograms per liter which would be

required to be met by July, 1983. Again, it is incomprehensible to understand how coke process waters could be expected to meet a cyanide concentration of 100 micrograms per liter or less within 1 to 5 years, when EPA has recently defined best technology as achieving a cyanide discharge concentration of five times that allowed under the the toxic standards. The estimated cost of this thechnology is an additional $90 million plus annual operating and materials costs. Should it be necessary to heat the effluent in order to make the cyanide amenable to chlorination, steam generating and effluent cooling capacity would be required, increasing the costs to a range of $120 to $255 million. The environmental impact of yet unproven technology is difficult to assess but would include energy consideration as well as sludge-solid waste disposal.

If the iron and steel industry was required to install the EPA's BATEA system, including chlorination for all blast furnace and coke plant waste waters, the total capital expenditure for the industry would be a minimum of $632 million plus annual operating and related expenses. As noted in the summary statement entitled "Economic Impact of Toxic standards" received from EPA, the iron and steel industry has difficulty in attracting capital funds and consideration should be given to the use of this limited capital for the control of pollution representing the greatest environmental impact. At the same time, the various treatment systems described above require chlorine which is now distributed under a priority system established by the EPA. If chlorine treatment were to be required to meet the proposed toxic pollutant effluent limits, EPA would be required to establish a priority for chlorine to the iron and steel industry.

The above analysis indicates that treatment technology has not been demonstrated to achieve proposed toxic effluent concentrations for cyanide. To achieve what has been defined by EPA as "best technology", would require considerable capital expenditures and construction programs that could not be concluded prior to 1983, if by that date. Total environmental impact of the proposed standards has not been adequately evaluated. All of these factors must be considered in determination of the final toxic pollutant effluent standard.

Walter E. Jackson

EXHIBIT 52

ORIGINAL

EPA Ex 52
4-18-74 C.R. Bloom

ENVIRONMENTAL PROTECTION AGENCY
BEFORE THE ADMINISTRATOR

In Re: Proposed Toxic Pollutant Effluent Standards for Aldrin-Dieldrin, et al.	FWPCA (307) Docket No. 1

AFFIDAVIT OF DAVIS L. FORD,
SUBMITTING DIRECT WRITTEN TESTIMONY ON BEHALF OF
THE AMERICAN PETROLEUM INSTITUTE

1. I, Davis L. Ford, was retained by the American Petroleum Institute to present written direct testimony regarding the economic impact and technological feasibility of the proposed toxic effluent standards for cadmium and cyanide as applicable to petroleum refining and for cadmium and mercury as applicable to oil and gas extraction.

2. My qualifications to testify as a witness regarding these matters are set forth in the attached statement of biographical data.

3. I will be available for oral cross-examination of my written direct testimony, which is incorporated herein and made a part of this affidavit, upon appropriate

notice following commencement of oral hearings before the Environmental Protection Agency in Washington on April 8, 1974.

Respectfully submitted,

Davis L. Ford

Davis L. Ford

Subscribed and sworn before me this
17th day of April, 1974.

Notary Public

My Commission Expires June 30, 1976

Biographical Data

DAVIS L. FORD, Ph.D.

Sanitary Engineer

Personal Data

Date of Birth: 18 May 1937

Education

B. S. in Civil Engineering, Texas A & M University, 1959
M. S. in Environmental Health Engineering, The University of Texas at Austin, 1964
Ph.D. in Environmental Health Engineering, The University of Texas at Austin, 1966

Military Service

First Lieutenant, U. S. Ordnance Corps, Inactive Reserve

Professional Affiliations

American Society of Civil Engineers
Texas Society of Professional Engineers
Water Pollution Control Federation
American Water Works Association
Texas Section, American Society of Civil Engineers
IAWPR Continuing Education Committee
Registered Professional Engineer:

- State of Louisiana - No. 12656
- State of Oklahoma - No. 9231
- State of Colorado - No. 11171
- State of New Jersey - No. 17767R
- State of Texas - No. 24326
- State of Illinois - 62-30775
- State of Idaho - No. 2545
- State of Tennessee - No. 8788

Honorary Affiliations

Sigma Xi
Chi Epsilon
Phi Kappa Phi
National Register of Prominent Americans and International Notables

Experience Record

1956-59 Hasie and Green & Associates. Consulting Engineers, Lubbock, Texas. Civil engineer on design of wastewater treatment systems; master planning; water quality studies; comprehensive fallout shelter surveys; design and construction of runways, USAF; storm drainage studies.

1960-61 U. S. Corps of Engineers, Fort Worth District, Civil engineer on design of dams and supervision of construction; cost estimating; general surveys; supervision of construction; Atlas Missile facilities specification writing.

1961-63 Hasie and Green & Associates. Consulting Engineers, Lubbock, Texas. Civil engineer.

March 1974

Davis L. Ford, Ph.D.

Teaching Experience (cont'd.)

Pan American Health Organization, Sanitary Engineering Course in Industrial Water Pollution Control, University of Nuevo Leon, Monterrey, Mexico (1972).

The University of Texas, Sanitary Engineering Graduate Course, "Design of Water and Wastewater Treatment Facilities," (1970 - present)

Pan American Health Organization, Environmental Engineering Course in Industrial Pollution Control, Sao Paulo, Brazil (1974)

IAWPR Water Quality Control Short Course, Birmingham, England (1974)

Publications

Two books, 20 reports, and over 50 publications in the field of environmental engineering (refer to separate list for publications).

Davis L. Ford, Ph.D.

Experience Record (cont'd.)

1966-68 Center for Research in Water Resources, The University of Texas, Austin, Texas. Assistant Director. Supervision and administration of University sponsored research programs related to water resources -- industrial, State and Federal; preparation of research programs and reports for industry in conjunction with pollution control programs; general administrative and budgeting matters.

1968-Present Engineering-Science, Inc. Senior Vice President and Member of Board of Directors.

Engineering-Science of Texas. Manager responsible for administration and conduct of all civil, sanitary, and environmental health engineering projects conducted at this office.

Consultant for over 50 industries, United Nations (WHO & PAHO), U. S. Government (Environmental Protection Agency), various State Agencies and municipalities, and the Governments of Mexico and Venezuela.

Teaching Experience

Manufacturing Chemists' Association, Sanitary Engineering Short Course, Title I, Higher Education Act (1967-68)

Water Pollution Control Sanitary Engineering Training Course, Six-weeks Course, Warsaw, Poland (1967)

The University of Texas, Sanitary Engineering Graduate Classes (1968)

University del Valle, Sanitary Engineering Laboratory Short Course, Cali, Colombia (1969)

Water Pollution Control, Two-weeks Course, Wroclaw, Poland (1969)

Water Pollution Control, Sanitary Engineering Short Course, Maracaibo, Venezuela (1968)

The University of Texas, Sanitary Engineering Graduate Course, "Unit Operations in Water & Wastewater Treatment," (1969)

Pan American Health Organization, Sanitary Engineering Course in Industrial Water Pollution Control, Mexico City, Mexico (1971)

Publications

"Expanded Design Charts for Concrete Pavements," Civil Engineering, January (1960).

"Kinetics of Aerobic Oxidation in the Thermophilic Range," Masters Thesis, The University of Texas, Austin, Texas, January (1965).

"Aerobic Oxidation in the Thermophilic Range," Proceedings of the Fifth Industrial Water and Waste Conference, Texas, Water Pollution Control Association, Dallas, Texas, June (1965).

A formal discussion of the "Role of Enzymes in the Contact Stabilization Process," 3rd International Conference on Water Pollution Research, Munich, Germany, 1966.

"New Concepts in Oxygen Transfer and Aeration," Special Lecture Series on Advances in Water Quality Improvement, The University of Texas, Austin, Texas, April 4-7, 1966.

"Dehydrogenzse Enzyme as a Parameter of Activated Sludge Activities," 21st Annual Purdue Conference, Purdue University, 1966.

"The Effects of Process Variables on Sludge Floc Formation and Settling Characteristics," Proceedings of the 39th Annual Conference, Water Pollution Control Federation, Kansas City, 1966, Journal WPCF, November (1967).

"Reuse Can Be Cheaper Than Disposal," with Louis Koenig, Symposium on Water Reuse, 16th AIChE Meeting, Houston, 1966.

"Laboratory Development of Biological Treatment Data for a Chemical Waste," 22nd Purdue Industrial Waste Conference, Purdue University, 1967.

"Engineering Aspects of Surface Aeration Design," 22nd Purdue Industrial Waste Conference, Purdue University, 1967.

Co-Author of a set of volumes prepared for a training course in Warsaw, Poland, August, 1967, under the sponsorship of the United Nations World Health Organization:

Volume I : "Analytical Procedures and Methods"
Volume III : "Physical, Chemical, and Biological Processes"
Volume IV : "Waste Treatment Plant Design and Operational Control"

Report on Biological Waste Treatment with E. F. Gloyna, Report to Thompson Chemical Company, St. Louis, Missouri (January, 1967)

Report on Biological Waste Treatment, with E. F. Gloyna, for Jefferson Chemical Company, Conroe, Texas (February, 1967).

Report on Biological Waste Treatment, with E. F. Gloyna, for Pure Oil Company, Smiths Bluff Refinery, Nederland, Texas (March, 1967).

Report on Biological Waste Treatment, with E. F. Gloyna, for Atlantic-Richfield Company, Atreco Refinery, Port Arthur, Texas (May, 1967).

Report on Biological Waste Treatment, with E. F. Gloyna, for Enjay Chemical Company, Baytown, Texas (July, 1967).

Report on Biological Waste Treatment, with W. W. Eckenfelder and E. M. Davis, for Petro-Tex Chemical Company, Houston, Texas (March, 1968).

Report on Biological Waste Treatment, with E. F. Gloyna, for Merichem Company, Houston, Texas (April, 1968).

"Total Organic Carbon as a Parameter in Wastewater Evaluation," Public Works Journal, April (1968).

Report on Biological Waste Treatment, with E. F. Gloyna and W. W. Eckenfelder, for El Paso Products Company, Odessa, Texas (May, 1968).

"Application of the Total Carbon Analyzer for Industrial Waste Water Evaluation," 23rd Annual Purdue Conference, Purdue University, 1968.

A formal discussion of "Energy and Hydraulic Tests on Mechanical Aeration Systems," 4th International Conference on Water Pollution Research, Prague, Czechoslavakia, 1968.

"Injection of Wastewaters into Disposal Wells," with Earnest F. Gloyna, Unpublished report (1967).

"Effluent Quality and Treatment Economics for Industrial Wastewaters," with W. Wesley Eckenfelder and C. S. Chow, 23rd Annual Purdue Conference, Purdue University, 1968.

Report on Trickling Filter Media Evaluation, with W. Wesley Eckenfelder and S. Balakrishnan, for Koch Engineering Company, Wichita, Kansas (July, 1968).

Report on Biological Waste Treatment, with W. Wesley Eckenfelder and N. Burleson, for Reichhold Chemical Company, Tuscaloosa, Alabama (September, 1968)

"Evaluation of Waste Treatment Plant Operation," with W. Wesley Eckenfelder, Pacific Northwest Pollution Control Association, Penticton, B. C., Canada, October 1968.

"Biodegradability Tests as a Basis of Industrial Wastewater Treatment Plant Design," Proceedings, Minnesota Water Pollution Control Association, Minneapolis, Minnesota, December 1968.

"Protection of River Waters Against Pollution," with W. Wesley Eckenfelder and Joseph F. Malina, Prepared for the World Health Organization for Poland Project-26, The University of Texas, Austin, Texas, 1968.

"General Sludge Characteristics," Special Lecture Series - Physical and Chemical Treatment, The University of Texas, Austin, Texas, April 1968.

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"Treatment of Complex Petrochemicals by Incineration and Waste Stabilization Ponds," Purdue, with E. F. Gloyna and Marvin Herring, May 1970.

"Preliminary Investigative Studies for the Design of a Petrochemical Waste Treatment Facility," presented at the 54th Texas Water Utility Association, Texas A & M University, with M. E. Stiver, April, 1972.

"Measurement and Analysis of Water Effluents," with J. C. Martin, Gulf Coast Measurement Short Course, Houston, Texas, September 14-16, 1971.

"Predicting Thermal Balances in Mechanically Aerated Activated Sludge Systems," with E. C. Sebesta and Dr. C. S. Shih, 27th Annual Purdue Industrial Waste Conference, May, 1972.

"Biological Treatment of Industrial Wastes," 23rd Industrial Waste and Advanced Water Conference, Purdue University, April, 1972.

"Biological Treatment of Industrial Wastes," presented at the 11th Annual Environmental & Water Resources Engineering Conference, Vanderbilt University, Nashville, Tennessee, June, 1972.

"The Interrelationship of Biological-Carbon Adsorption Systems for the Treatment of Refinery and Petrochemical Wastewaters," with Marion A. Buercklin, presented at the Sixth Conference International Association of Water Pollution Research, Jerusalem, Israel, June, 1972.

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Davis L. Ford

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PART I

A REVIEW OF THE PROCESS APPLICABILITY AND ECONOMIC IMPACT OF THE PROPOSED TOXIC POLLUTANT EFFLUENT STANDARDS

on the

PETROLEUM REFINING INDUSTRY

prepared for the
AMERICAN PETROLEUM INSTITUTE

by

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INTRODUCTION

The information presented in this statement is developed pursuant to the "Proposed Toxic Pollutant Effluent Standards" as published by the Environmental Protection Agency (EPA) in the Federal Register, December 27, 1973. Specifically, this statement considers the proposed effluent standards for cadmium and cyanide discharged in the refining of petroleum and focuses especially on current discharge levels of these pollutants, the concomitant impact on refining operations, possible treatment processes, and the economic effectiveness of applying such processes.

To develop the information presented in this statement, questionnaires were completed by refineries representing approximately sixty-five (65) percent of the total U. S. refining capacity. The cadmium and total cyanide levels reported in these questionnaires, as well as the flow and diffusion factors predicted to segregate the reporting refineries into the concentration categories proposed in the standards, provide a base for analysis of the impact of the proposed standards and represent the best data which could be prepared in the brief time frame available. The results of this API survey, set forth in Appendix A, together with an extensive review of pertinent case histories and literature citations, constitutes the data base used in the development of this statement.

The analyses contained in this statement begin with consideration of the sources of cadmium and cyanide in petroleum refining effluents followed by a statistical analysis of current discharge levels based on the API survey results. Process applicability for removal of these constituents is then evaluated, using results from refinery treatability programs and treatment experience from other industrial categories as a basis. An economic impact assessment based on these studies and case histories is then applied to the petroleum refining industry, using appropriate crude processing, flow, process cost, and economy-in-scale factors.

SOURCE DEFINITION

Both cadmium and cyanides are present in most refinery effluents, although their concentrations in the combined effluent discharged from a refinery are in the part per billion (ppb) range.

Cadmium is not present in most crudes; therefore, the source is attributable to either intake water or cadmium addition in processing. The presence of cadmium is generally traced back to intake water, corrosion products, the addition of cadmium compounds for distillate

desulfurizing, or as lube oil additive to prevent oxidation (1).[1/] Consequently, the source of cadmium in refinery effluents generally cannot be isolated to a specific location and stream segregation of cadmium-bearing waters appears impractical.

Cyanides are generated in cracking and coking operations as reaction products, and enter the effluent from overhead receivers and through washing operations. Most or all of the cyanide generation in a refinery occurs in these two operations, so the cyanide-bearing water can generally be isolated from other waste streams within the refinery complex. As shown in Figure 1(2) for one such stream, the cyanide concentration in refinery effluents is related to the nitrogen content of the crude feedstock. It is therefore apparent that the cyanide concentration in refinery effluents will vary according to the type of crude and the extent of cracking and coking operations within the refinery complex. Specific petrochemical operations in an integrated refinery may produce cyanide-bearing water, but these too normally can be identified and isolated from combined streams.

CADMIUM AND CYANIDE LEVELS IN PETROLEUM REFINERY EFFLUENTS

If the proposed toxic effluent standards for cadmium and cyanide were enacted, any refinery not in compliance

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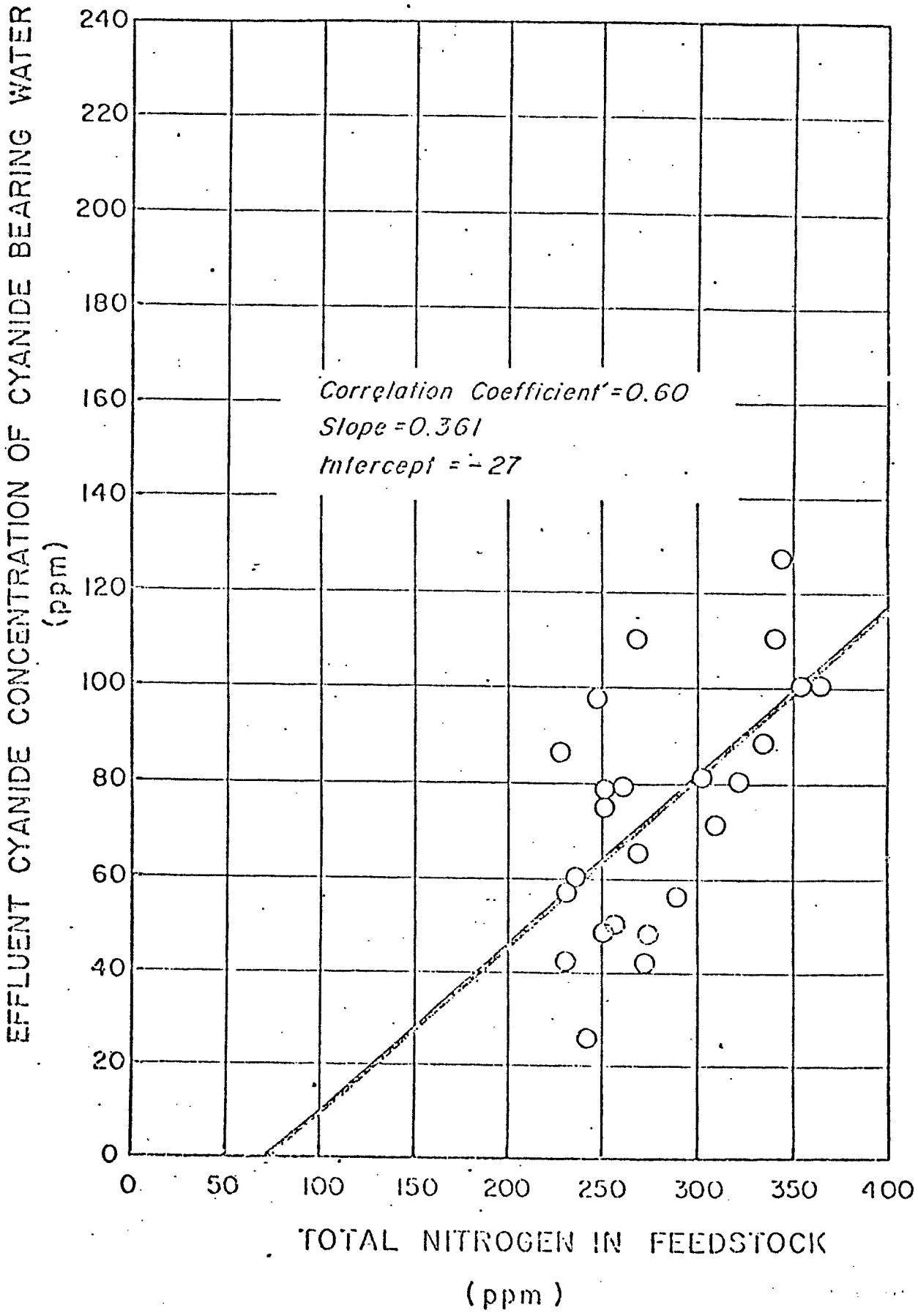
1/ Citations to literature references set forth as an attachment to this statement are designated by the literature reference number in parentheses.


EFFLUENT CYANIDE CONCENTRATION OF CYANIDE BEARING WATER
(ppm)
240
220
200
180
160
140
120
100
80
60
40
20
0
Correlation Coefficient = 0.60
Slope = 0.361
Intercept = -27
0
50
100
150
200
250
300
350
400
TOTAL NITROGEN IN FEEDSTOCK
(ppm)

by the effective date of the final regulations would be forced to cease its refining operations.

The number of refineries currently meeting the proposed standards for cadmium and cyanide can be evaluated from the API survey results set forth in Appendix A. The cadmium concentration in the effluents of reporting refineries is statistically presented in Figure 2.

These survey data show that less than 5 percent of the reporting refineries can currently satisfy the no discharge provision for streams with a low flow of less than 10 cfs and only 25 percent can satisfy the four ppb concentration limit applicable to streams of more than 10 cfs flow and less than 10:1 diffusion, whereas 91 percent of the reporting refineries might meet the 40 ppb limit applicable to streams with greater than a 10:1 diffusion as defined in the proposed toxic effluent standards.

The same results are also resolved in terms of crude capacity as tabulated in Table 1 and plotted in Figure 3. These data indicate that refineries representing less than 3 percent of the crude capacity could comply with the proposed no discharge provision and only 34 percent of the crude capacity could comply with the four ppb provision although 97 percent of the crude refining

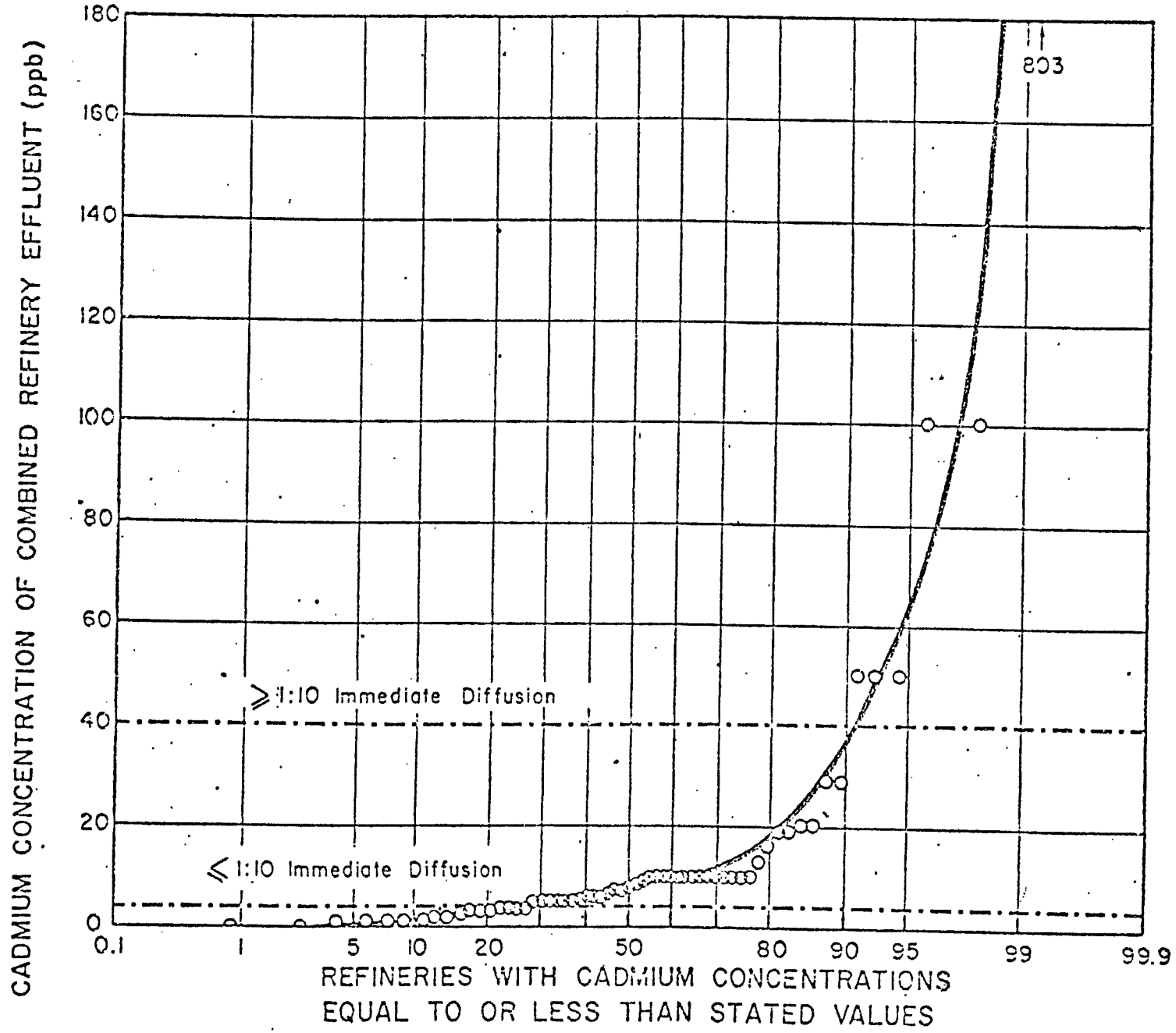


FIGURE 2. CADMIUM CONCENTRATIONS OF REPORTING REFINERIES (1974)

TABLE 1

EFFLUENT CADMIUM CONCENTRATION AS A FUNCTION OF CUMULATIVE CRUDE THROUGHPUT

Cadmium Concentration (ppb)	MBBL Crude Capacity per day equal to or less than stated concentration from reporting refineries	Percent of Total Crude Capacity from reporting refineries
≤ 1	679	9
≤ 5	2,525	33.4
≤ 10	6,013	79.6
≤ 20	6,546	86.7
≤ 50	7,422	98.3
≤ 100	7,494	99.2
≤1,000	7,552	

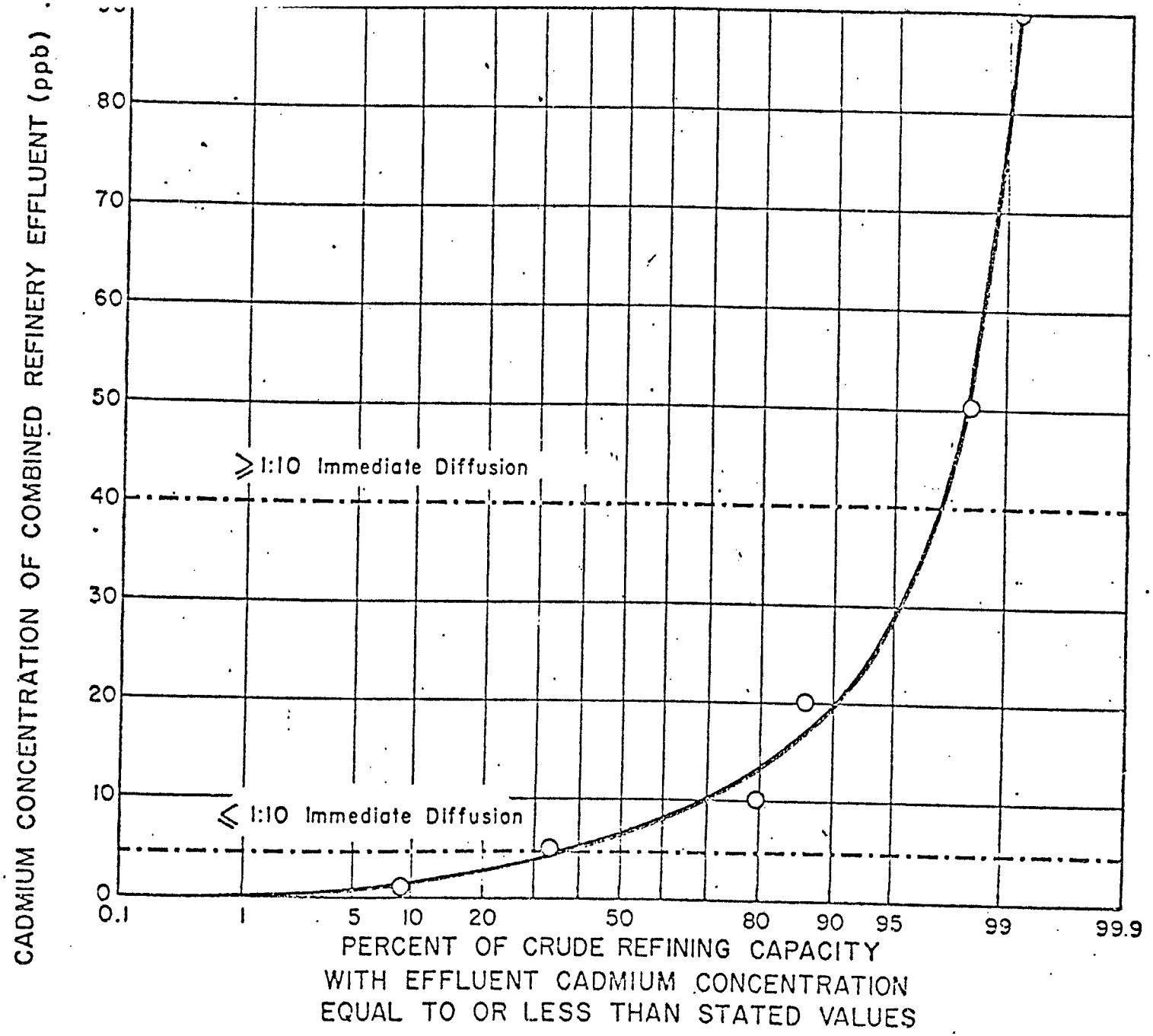


FIGURE 3. CADMIUM CONCENTRATION AS A FUNCTION OF CRUDE CAPACITY

capacity would not be affected by the 40 ppb concentration limit.[2/]

The potentially disastrous impact of proposed concentration limits on the refining industry is even more apparent for cyanides. As shown in Figure 4, less than 5 percent of the reporting refineries can satisfy the no discharge provision, less than 20 percent can currently conform to the 10 ppb concentration limit at less than 10:1 diffusion, and only 65 percent can conform to the most lax concentration requirement of 100 ppb. When resolved in terms of crude refining capacity as tabulated in Table 2 and plotted in Figure 5, similar percentages of current U. S. crude capacity are currently affected by these proposed standards.[3/]

2/ Municipalities and sanitation districts are not covered by the proposed toxic effluent standards. Yet if the characterization data tabulated in Table 3 are representative, average cadmium concentration levels in treated municipal effluents are considerably higher than cadmium discharge levels from petroleum refineries.

3/ The few, scattered discharge data for cadmium and mercury effluents from oil and gas extraction reported in response to the API questionnaire tend to confirm EPA's conclusion that these "discharges are less than the proposed Standards." However, more data are required before a definitive conclusion can be readied.

Nevertheless, in view of these data, and in light of the serious problems with reproducibility at the ppb level for the analytical procedures specified by the proposed standards (discussed in detail in the testimony of D. B. Bruss, Part II, infra) significant questions are raised concerning the need for inclusion of petroleum extraction in the list of industries covered by the proposed standards. Accordingly, further consideration should be given to removing petroleum extraction from the list following receipt of further test results

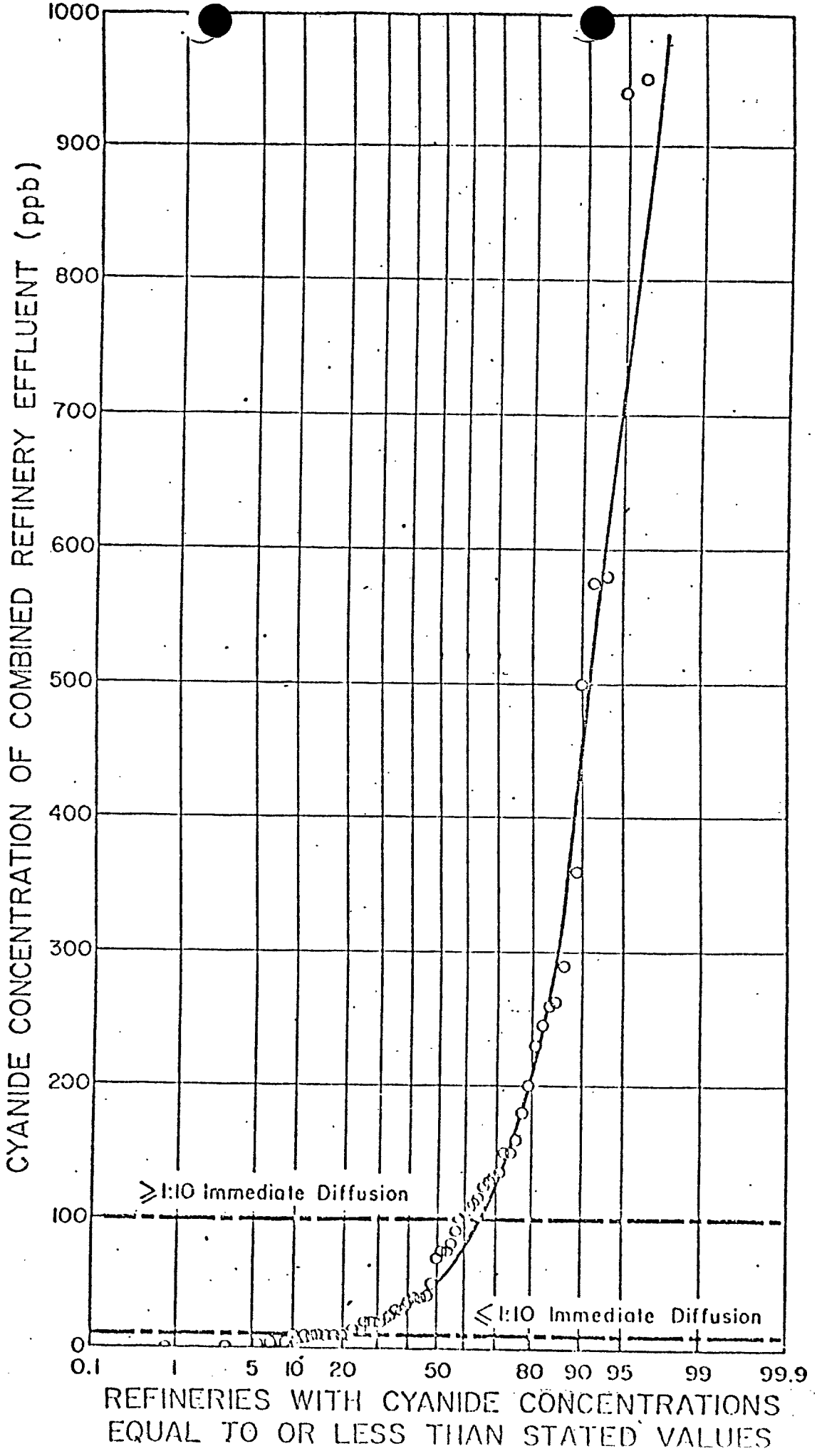


FIGURE 4. CYANIDE CONCENTRATIONS OF REPORTING REFINERIES (1974)

TABLE 2

EFFLUENT CYANIDE CONCENTRATION AS A FUNCTION OF CUMULATIVE CRUDE THROUGHPUT

Cyanide Concentration (ppb)	MBBL Crude Capacity per day equal to or less than stated concentration from reporting refineries	Percent of Total Crude Capacity from Reporting Refineries
≤ 10	1,481	19.44
≤ 50	3,941	51.7
≤ 100	4,324	56.8
≤ 150	5,705	74.9
≤ 200	6,234	81.9
≤ 300	6,762	88.9
≤ 500	7,069	92.8
≤1,000	7,454	97.9
≤1,500	7,615	100

TABLE 3

CADMIUM CONCENTRATIONS TREATED MUNICIPAL EFFLUENTS

DISCHARGER	Cadmium (ppb)	Reference
Oxnard, California	20	3
Hyperion	50	3
Orange County San. Dist.	60	3
L.A. Sanitation Dist.	38	4

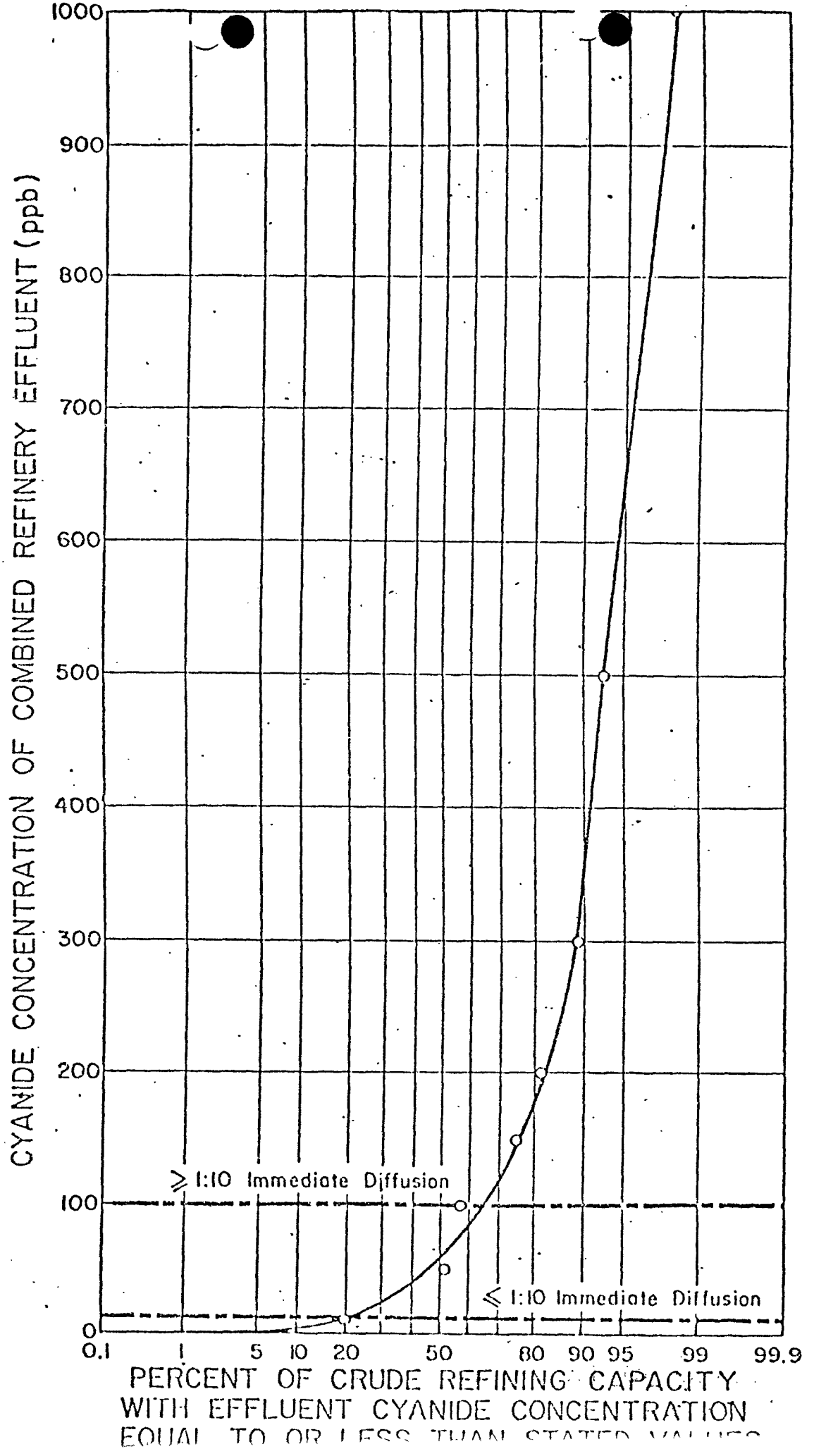


FIGURE 5. CYANIDE CONCENTRATION AS A FUNCTION OF CRUDE CAPACITY

Taken together, the proposed cadmium and cyanide levels could have a far-reaching impact on the petroleum refining industry since as much as 60 percent of the nation's refining capacity would face cessation of operations if effective treatment processes are not developed and incorporated by June, 1975, the planned effective date of the toxic effluent standards. Consequently, it is necessary to analyze in detail the applicability of treatment processes for cadmium and cyanide to the petroleum industry.

TREATMENT PROCESS APPLICABILITY

There are presently no treatment systems in petroleum refineries designed specifically for cyanide or cadmium removal. To assess possible treatment processes, it is therefore necessary to develop process data from laboratory and field investigations conducted within the industry and to extrapolate applicable information from other industrial categories. The former approach is preferred to the latter, however, as there are inherent limitations in translating process information between industrial categories. A brief discussion of the candidate processes for cadmium and cyanide removal in refineries is presented as follows:

Cadmium

Lime Precipitation and Filtration

This is probably the most effective method of treating cadmium which might be applied to petroleum effluents. Although the total refinery effluent would have to be treated as cadmium bearing waters are difficult to segregate, the feasibility of treating refinery discharges by lime precipitation and filtration is reasonably well documented. Cadmium forms an insoluble and highly stable hydroxide precipitate at an alkaline pH and in the absence of appreciable complexing agents, precipitation and filtration provides effective removal. The completeness of the reaction, however, is a function of pH, and lime addition to a pH value of 10 or above would be required to meet the proposed concentration limits (5). Unless this step were already included in a refinery treatment system for removal of other constituents, the cadmium removal process would require provisions for lime addition, rapid mix, flocculation, sedimentation, filtration, and possible additional neutralization. Comprehensive treatability studies would be required before designing such a system to insure process effectiveness and develop design criteria.

Ion Exchange

Ion exchange, although more expensive than lime precipitation for cadmium removal, could effect cadmium

removals of 99 to 99.9 percent using selected resins (5). The applicability of this process to petroleum refining is limited, however, based on the large volumes of flow which would require treatment, the non-selectivity of ion exchange resins, and regenerant water treating requirements.

Miscellaneous Processes

Other potential processes for cadmium removal, such as evaporation, carbon treatment, and reverse osmosis are impractical for petroleum refining based both on flow and cost-effective considerations.

Cyanide

As previously indicated, cyanides emanate from cracking and coking operations in the refining of petroleum. The cyanide-bearing water can be limited to these sources (exclusive of acrylonitrile production and other selected petrochemical processing), segregated, and treated separately. An analysis of effluent flow discharged from catalytic cracking and coking units for selected refineries indicates that such flow can be related to crude throughput as shown in Figure 6 (6). It is on this basis that process and economic considerations for the following cyanide removal processes can be formulated.

Alkaline Chlorination

Based on recent studies, alkaline chlorination of the cyanide-bearing waters within a refinery did not promote complete

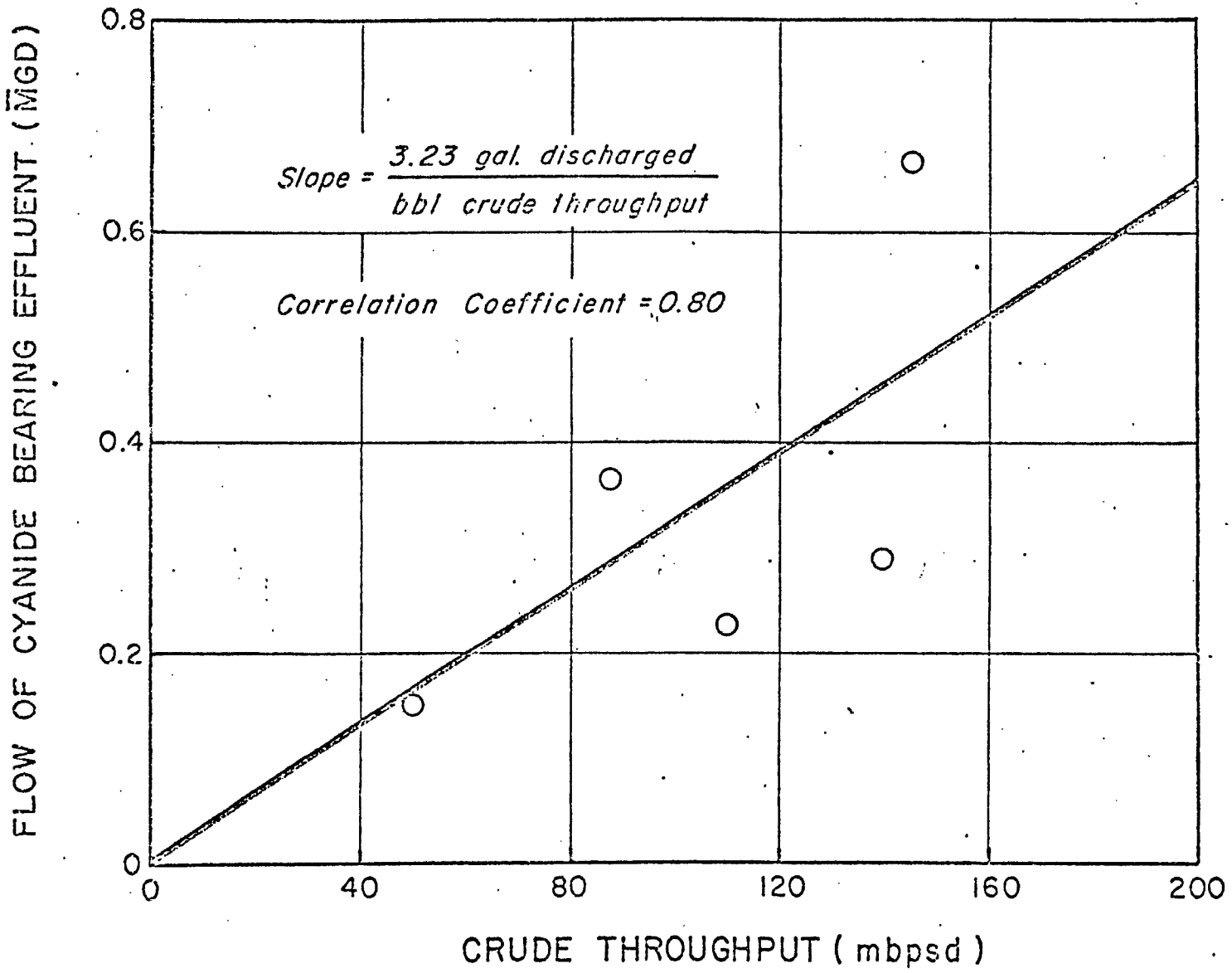


FIGURE 6. CYANIDE-BEARING FLOW FROM A REFINERY AS A FUNCTION OF CRUDE THROUGHPUT

oxidation of cyanide. Observed residuals in the combined flow exceeded 100 ppb, thereby raising questions as to the applicability of this process (2). Moreover, the chlorination of refinery sour waters leads to many problems. The high chlorine demand due to phenols, sulfides and ammonia adversely affects the applicability of this approach, and production of such substances as cyanigen chloride, chlorophenols, and other chlorinated hydrocarbons could actually magnify the toxicity potential.

Electrolysis

This process is primarily applicable in treating wastewaters with high concentrations of cyanide (approximately 100 ppm); however, some experimental work with selected refinery wastewaters has been performed (2). These results indicate that the cyanide concentration could be reduced to 28 ppb, although there were high associated power requirements.

Activated Sludge

Some cyanide removal is noted through activated sludge systems, either through biochemical utilization, complexing, or stripping. Effluent levels below 100 ppb are rarely achieved, however, so this approach has no applicability under the proposed standards for limiting cyanide concentrations.

Cyanides were reduced from 930 to 285 ppb in the Union Oil Company Lemont refinery activated sludge plant, with slightly lower levels obtainable using bench scale reactors (2). Other refinery activated sludge plants operating under optimum conditions have not been able to produce consistently effluents with cyanide concentrations of less than 100 ppb.

Carbon Adsorption

Cyanide can be removed via carbon adsorption by adding cupric sulfate and oxygen to the cyanide-bearing water, forming a cupric cyanide complex which can then be sorbed on granular carbon. Extensive carbon isotherm work on refinery cyanide water, however, indicated residual cyanide levels of 400 ppb with unrealistic carbon capacities of one pound cyanide removed per 1600 pounds of carbon utilized. Additional column testing was performed, obtaining lower values of effluent cyanide, but at the expense of carbon capacity. There is no observed removal of cyanide from an existing carbon system treating refinery wastewater as recently analyzed, and, in fact, the concentrations increased across the column in certain observations. For these reasons, carbon adsorption was not further considered as a candidate process.

Miscellaneous Processes

Other possible modes of cyanide removal have been tested using the refinery cyanide-bearing waters. These

included precipitation using the metallic ions of iron, copper, and zinc; incineration; ozonation, polysulfide injection to form a stable thiocyanate complex; ion exchange, wet oxidation; and steam stripping (2). These systems were relatively unsuccessful in terms of process effectiveness and were not further considered.

Implementation Time Considerations

Another critical factor to be considered in assessing the applicability of treatment processes for both cadmium and cyanide removal is the limited time remaining before the contemplated effective date for the toxic standards implementation in June, 1975. Even assuming effective treatment processes were available for cadmium and cyanide removal in petroleum refining and ignoring economic considerations, the time required for treatability studies, process design, equipment delivery, and start-up far exceeds that allowed for implementation under the proposed standards.

ECONOMIC IMPACT

Assuming that treatment processes could eventually be developed and implemented, although after the scheduled effective date of the proposed standards, determination of the economic impact on the refinery industry depends on a cost analysis of vendor estimates for bench and pilot work performed within the industry and on installation

and operating cost experience of existing plants in other industrial categories. This is necessitated by the scarcity of cost information related directly to process removal of cadmium and cyanide in petroleum refining. The similarity of the basic equipment for most of the systems described herein, however, does provide a generalized basis for predicting economic impact.

In order to assign costs on a uniform basis, several factors must be taken into account. For purposes of this evaluation, reported capital costs were amortized over a 20-year plant life at 10 percent interest. This would give the same capital recovery factor as recently used by API in the current economic evaluation of refinery wastewater treatment (7). Costs were also adjusted to reflect an Engineering New Record (ENR) Index of 1800. Another significant adjustment is for economy-in-scale. In order to establish a rational basis for this adjustment so that all costs can be compared at the same hydraulic flow rate, cost information for various processes and plant sizes were obtained (7)(8)(9). The relationships for the three selected processes were similar, as shown in Figure 7, with correlation coefficients higher than 0.70 in all cases. An average of these relationships was then used, as shown in Figure 8, to scale costs up or down to the plant size selected for cost analysis. The hydraulic flow used for

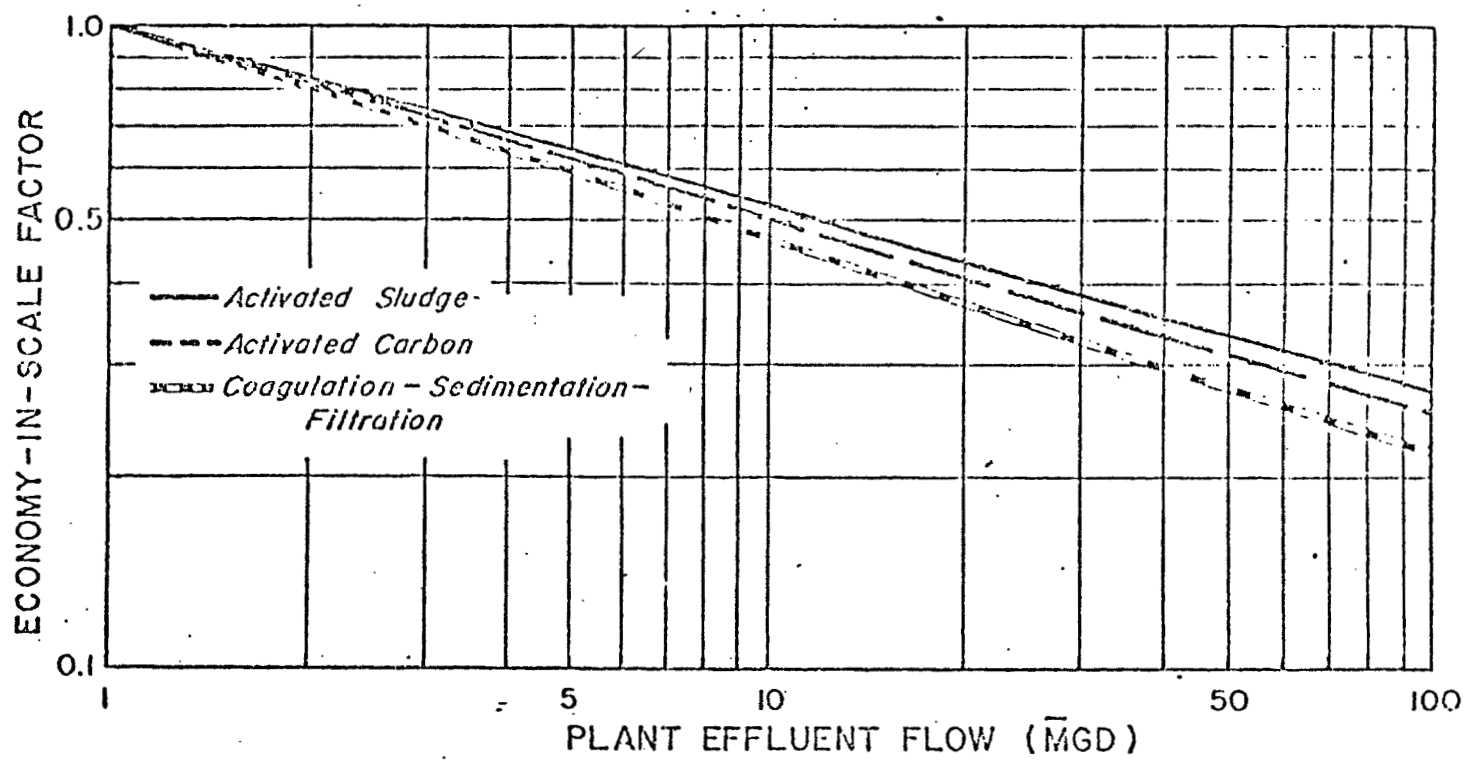


FIGURE 7. ECONOMY-IN-SCALE RELATIONSHIPS - THREE THREATMENT PROCESSES

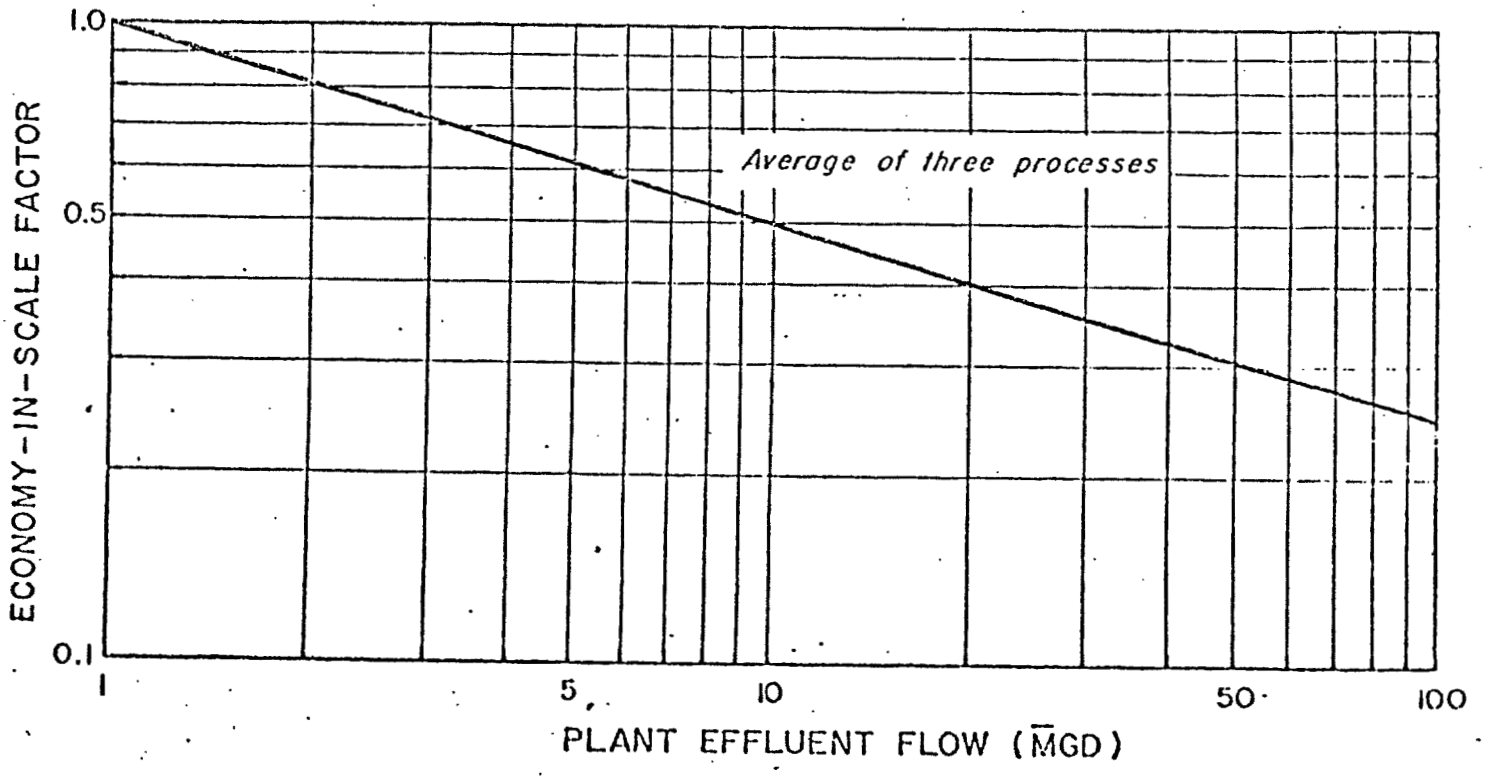


FIGURE 8. ECONOMY-IN-SCALE RELATIONSHIP - AVERAGE OF THREE PROCESSES

cost comparison of cadmium treatment was 3.0 MGD which was the value used in the contractor's report to EPA evaluating cost-effectiveness in removal of these constituents (10). As shown in Figure 6, a realistic cyanide-bearing flow in a refinery would be approximately 300 gpm (0.43 MGD), and the economy-in-scale function indicated in Figure 8 was used in translating costs to a plant designed for this hydraulic capacity.

As both cadmium and cyanide concentrations in petroleum refinery effluents are low -- as shown in Figures 2 and 4 -- costs are presented on a volume treated rather than a poundage removed basis. These costs include amortization, operation, maintenance, and other fixed costs, and represent the average of the best estimates possible based on case histories and cited literature values. The cost-effluent concentration curves for the two most appropriate processes in treating cadmium contained in refinery wastewaters are as shown in Figure 9. Similar curves for selected processes in treating cyanides are shown in Figure 10.

The economic impact of cadmium treatment is first estimated using the approach as calculated in Table 4. Assuming all refineries must treat to a level of 40 ppb, an annual cost of only $1,261,000 based on 1972 refining capacity is predicted. Based on a four ppb requirement, however, an annual cost of $27,745,000 is required, while

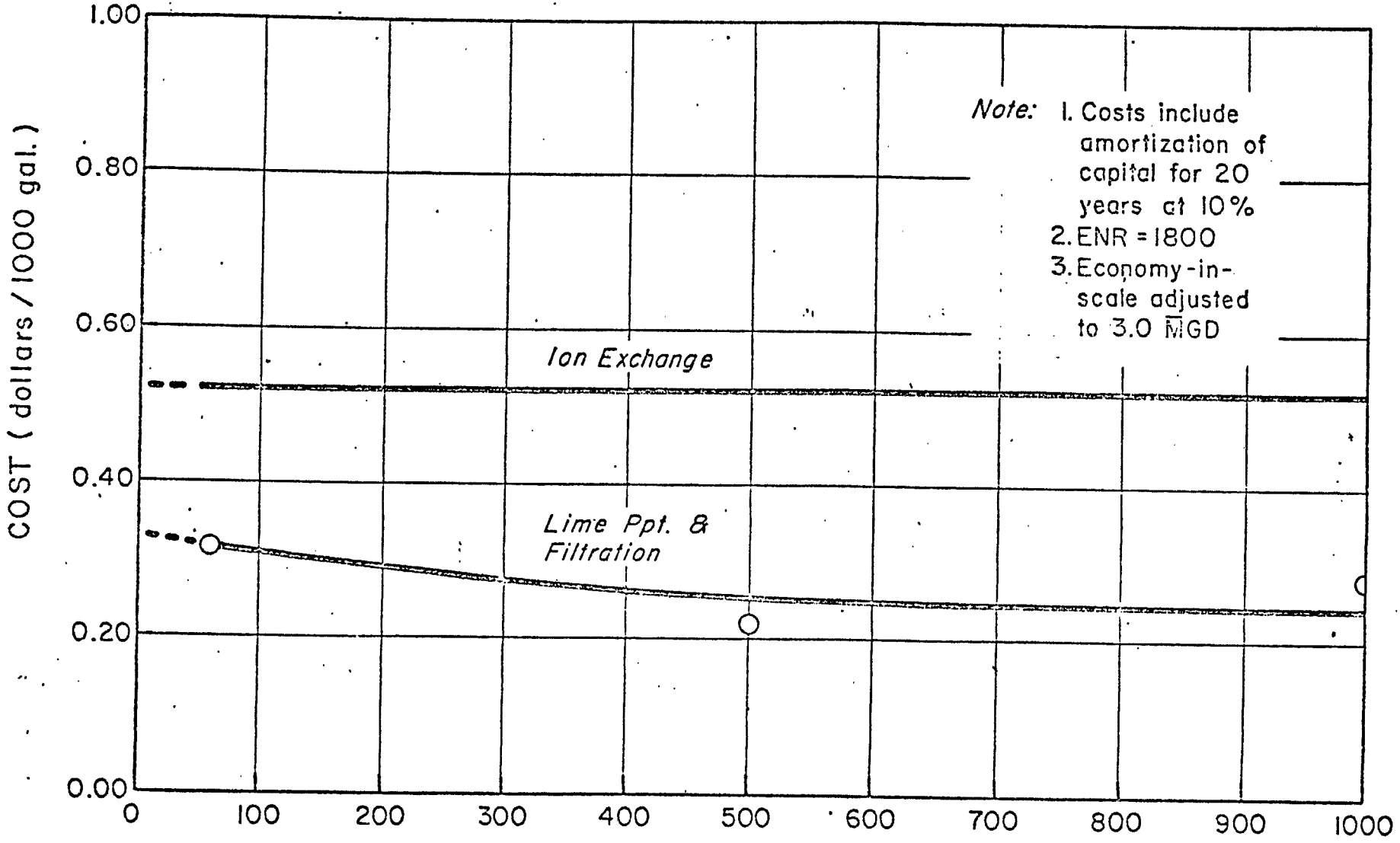

COST (dollars / 1000 gal.)
1.00
0.80
0.60
0.40
0.20
0.00
0
100
200
300
400
500
600
700
800
900
1000
CADMIUM CONCENTRATION (ppb)
Ion Exchange
Lime Ppt. & Filtration
Note: 1. Costs include amortization of capital for 20 years at 10%
2. ENR = 1800
3. Economy-in-scale adjusted to 3.0 MGD

Figure 9.

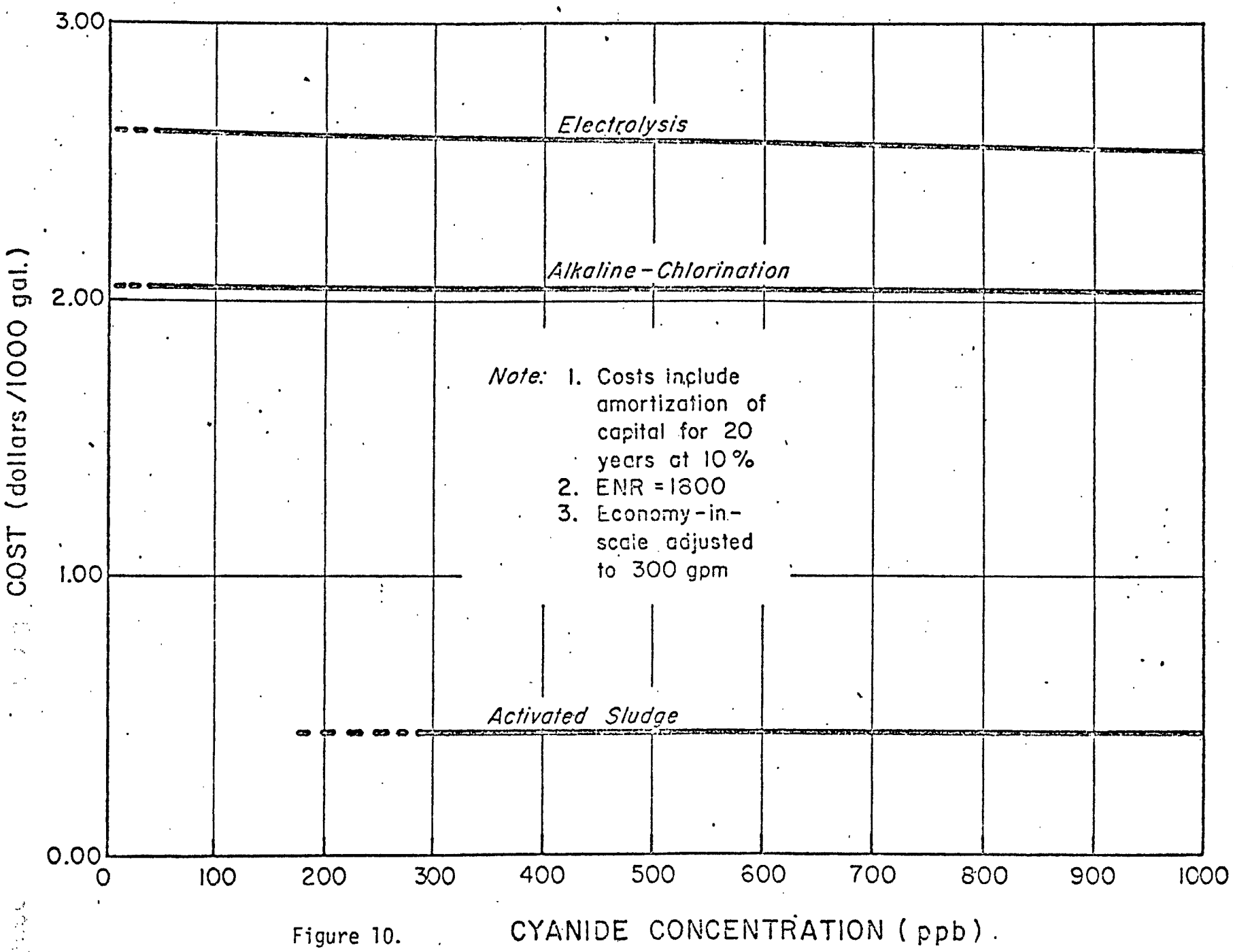

3.00
2.00
1.00
0.00
COST (dollars/1000 gal.)
Electrolysis
Alkaline-Chlorination
Activated Sludge
Note: 1. Costs include amortization of capital for 20 years at 10%
2. ENR = 1800
3. Economy-in-scale adjusted to 300 gpm
0
100
200
300
400
500
600
700
800
900
1000
CYANIDE CONCENTRATION (ppb).

Figure 10.

TABLE 4

CALCULATIONS FOR ESTIMATING
ECONOMIC IMPACT OF CADMIUM TREATMENT

PETROLEUM REFINERY EFFLUENTS

Reference & Basis of Calculation

1. Unit Cost = $0.32/1,000 gal — Fig. 9 - Lime ppt & Filtration

2. Gallons to be treated (assume total process flow to be treated - excludes ballast and storm water contribution)

Refinery Class	Crude Capacity* mbpsd	Wastewater Flow** gal/bbl	Wastewater Flow** total gal x 10^3
A	384	11	4,224
B	3,702	24	88,848
C	3,839	23	88,297
D	1,124	42	47,208
E	3,358	35	117,530
	12,407		346,107 x 10^3 gpd

* Ref. 7, p. IV-2
** Ref. 7, p. V-2

Weighted Average - all refinery classes

$$\frac{346{,}107 \times 10^3 \text{ gpd}}{12{,}407 \times 10^3 \text{ bpd}} = 27.9 \text{ gal/bbl}$$ See Figure 3

(a) Impact to 40 ppb Level - Cd Treatment

(12,900 x 10^3bpd)(.03 requiring treatment)(27.9 gal/bbl)

($0.32/1,000 gal)(365 days/year) = $1,261,000

(b) Impact to 4 ppb Level - Cd Treatment

(12,900 x 10^3 bpd)(.66 requiring treatment)(27.9 gal/bbl)

($0.32/1,000 gal)(365 days/year) = $27,745,000

(c) Impact to 0 Level - Cd Treatment

(12,900 x 10^3 bpd)(.95 requiring treatment)(27.9 gal/bbl)

($0.32/1,000 gal)(365 days/year) = $39,936,000

$39,936,000 is necessary to remove all cadmium if this is in fact obtainable at all from a process viewpoint. A delineation of refineries within the three levels of effluent requirements cannot be predicted until diffusion factor questions are answered with certainty, but as presently interpreted, and using information cited in Appendix A, the economic impact of the proposed cadmium standards would be approximately $20,000,000 yearly.

The economic impact of cyanide treatment is estimated using the calculations shown in Table 5, although as previously discussed, there are questions as to the applicability of alkaline chlorination in terms of process effectiveness. This notwithstanding if all refineries are to treat to a level of 100 ppb and assuming the cyanide-bearing waters are limited to cracking and coking operations, an annual cost of $10,912,000 is predicted. A 10 ppb requirement for all refineries would cost $24,942,000, and no pollutant discharge, if technically obtainable at all, would have an annual estimated cost of $29,618,000. Again, depending on a final definition of diffusion factors, the pro-rated economic impact of meeting the proposed standards for cyanide removal would be approximately $20,000,000 annually.

The cadmium and cyanide treatment costs would not be cumulative, as certain chemical and equipment requirements

TABLE 5

CALCULATIONS FOR ESTIMATING
ECONOMIC IMPACT OF CYANIDE TREATMENT
PETROLEUM REFINERY EFFLUENTS

	Reference & Basis of Calculation
1. Unit Cost = $2.05/1,000 gal	Fig. 10 - Alkaline Chlorination
2. Cost for treating only cyanide-bearing flow	
Gallons to be treated (assume only cyanide-bearing flow to be treated 3.23 gal/bbl crude)	See Figure 6
(a) Impact to 100 ppb Level - Cn Treatment	
($12,900 \times 10^3$ bpd)(.35 requiring treatment)(3.23 gal/bbl crude) ($2.05/1,000 gal)(365 days/year) = $10,912,000	
(b) Impact to 10 ppb Level - Cn Treatment	
($12,900 \times 10^3$ bpd)(.80 requiring treatment)(3.23 gal/bbl crude) ($2.05/1,000 gal)(365 days/year) = $24,942,000	
(c) Impact to 0 Level - Cn Treatment	
($12,900 \times 10^3$ bpd)(.95 requiring treatment)(3.23 gal/bbl crude) ($2.05/1,000 gal)(365 days/year) = $29,618,000	
3. Cost for treating total flow	
(a) Impact to 100 ppb Level - Cn Treatment	
($12,900 \times 10^3$ bpd)(.35 requiring treatment)(27.9 gal/bbl crude) ($2.05/1,000 gal)(365 days/year) = $94,500,000	
(b) Impact to 10 ppb Level - Cn Treatment	
($12,900 \times 10^3$ bpd)(.80 requiring treatment)(27.9 gal/bbl crude) ($2.05/1,000 gal)(365 days/year) = $214,000,000	
(c) Impact to 0 Level - Cn Treatment	
($12,900 \times 10^3$ bpd)(.95 requiring treatment)(27.9 gal/bbl crude) ($2.05/1,000 gal)(365 days/year) = $256,000,000	

for treating one constitutent can be credited in treating the other. However, equipment redundancy would be required based on process idiosyncrasies, and the estimated cost to the industry just for treating these two constitutents is estimated in the range of $30,000,000 to $35,000,000 per year and this excludes costs for sludge disposal and rerouting and segregating effluents requiring treatment under these proposed standards. It should be underscored at this point that alteration costs for changing conveyance lines for many refineries would be prohibitive. Therefore, removing cyanides in the total stream would be required and this could add as much as $165,000,000 annually based on the range of estimated costs as shown in Table 5. In perspective, the range of costs for removing these two constituents stated in the proposed guidelines is from ten to sixty percent of the total annualized cost estimated by API to obtain a level of "best practicable control technology currently available" for the entire refining industry (7).

Moreover, even this presupposes that required concentration levels can be achieved using available technology, which has clearly not been established for the refining industry. Currently, incineration is the only method which assures total removal of cyanides, and the operational costs <u>alone</u> for treating only cyanide-bearing waters are estimated to exceed one billion dollars annually.

SUMMARY

In summary, the proposed toxic pollutant standards as specifically related to the presence of cadmium and cyanides in petroleum refinery effluents could have a profound effect both on the petroleum industry and U. S. petroleum refining capacity. Unless treatment processes for cadmium and cyanide removal in petroleum refining effluents can be developed and fully implemented by June 1975, the scheduled effective date for the proposed toxic standards, refineries representing as much as 60 percent of the nation's refinery capacity might be forced to cease operations.

Yet, there are presently no treatment systems with proven process-effectiveness for removing cadmium and cyanides from petroleum refinery effluents. Treatment technology does exist for reducing cadmium and cyanides in selected industrial wastewaters, although residual concentration levels which are obtainable may not be compatible with the limitations imposed in the proposed standards and the state of the art is not defined in the petroleum refining industry. Moreover, any assessment of the applicability of such technology is dependent upon extrapolation from the experience from other industrial categories, a circumstance which inevitably limits a precise evaluation. Moreover, even assuming effective treatment processes were available for cadmium and cyanide removal in petroleum

refining, the time required for treatability studies, process design, equipment delivery, and start-up far exceeds that allowed for implementation under the proposed standards.

Finally, even if effective treatment processes were available and could be implemented, the economic impact of the proposed standards as defined in this presentation, ranging from $35,000,000 to $165,000,000 annually for the petroleum industry alone, is at variance with EPA's statement that "the impact of the standards upon the economy has been examined and does not appear to be great" (11). The final version of the toxic pollutant effluent standards under Section 307(a) of the Federal Water Pollution Control Act should reflect and incorporate analytical capability, environmental effect, process applicability, and economic impact in addition to water quality and toxicological factors. The purpose of this statement has been to consider fully both process applicability and economic impact as applied to petroleum refining so that the true effects which these factors will have can be taken into account.

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