Cost Effectiveness Analysis of Effluent Limitations and Standards for the Pharmaceutical Industry

Prepared for:

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Washington, DC 20460

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Under Contract No.
68-01-6162

November 1982

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Chapter 1

Background Methodology on Cost Effectiveness

Cost-effectiveness (CE) is defined as the incremental annualized cost of a pollution control option in an industry or industry subcategory per incremental pound equivalent of pollutant removed by that control option. CE offers a useful way of quantifying comparisons among alternative pollution control options.

Cost effectiveness analyses account for differences in toxicity among the pollutants by computing toxic weighting factors. These factors are necessary because different pollutants have different potential effects on human and aquatic life. For example, a pound of zinc in an effluent stream has a significantly different potential effect than a pound of PCBs. Toxic weighting factors for pollutants are derived using ambient water quality criteria and toxicity values. In the majority of cases, toxic weighting factors are derived using chronic freshwater aquatic criteria. However, in cases where a human health criterion has also been established for the consumption of fish, then the sum of both the human and aquatic criteria are used in deriving toxic weighting factors. These factors are then standardized by relating them to a particular pollutant.

Copper is selected as the standard pollutant for developing weighting factors since it is a toxic metal pollutant and is commonly detected and removed from industrial effluents. Some examples of the effects of different aquatic and human health criteria on weighting factors are shown in Table 1.

Table 1. Weighting Factors Based on Copper Freshwater Chronic Criteria

Pollutant	Human* Health Criteria (ug/l)	Aquatic Chronic Criteria (ug/l)	Weighting Calculation	Final Weight
Copper	--	5.6	5.6/5.6	1.00
Hexvalent Chromium	--	.29	5.6/.29	19.30
Nickel	100	96.00	5.6/100 + 5.6/96	0.114
Cadmium	--	.025	5.6/.025	224.0
Benzene	400	--	5.6/400	0.014

*Based on ingestion of 6.5 grams of fish products/day.

As indicated in Table 1, 224 pounds of copper pose the same relative hazard in surface waters as one pound of cadmium since cadmium has a toxic weight 224 times as large as the toxic weight of copper. Benzene, on the

other hand, is less potentially toxic than copper, as 71 pounds (1/.014) of benzene would pose the same hazard as one pound of copper.

The final weights are then used to calculated the "pound equivalent" unit: a standard measure of toxicity. Pound equivalents are calculated as the number of pounds of pollutant multiplied by the weighting factor. Thus, in CE analyses, the amount of pollutant removed by a control option is weighted by its relative toxicity. Cost-effectiveness is calculated as the ratio of incremental annual cost of an option to the incremental pound equivalents removed by the option.

Indirect dischargers are treated differently from direct dischargers in the CE analyses since the POTW removal efficiency of a pollutant is reflected in the incremental pounds removed to surface waters. For example, if a plant is discharging 100 pounds of cadmium in its effluent stream to a POTW and the POTW has a removal efficiency for cadmium of 38 percent, then the cadmium discharged to surface waters is only 62 pounds. If the regula- tion results in a reduction of cadmium in the effluent stream to 50 pounds, then the amount discharged to surface waters is calculated as 50 pounds multiplied by the POTW removal efficiency factor (1 - .38 = .62), i.e., 31 pounds (50 x 62 percent). Cost-effectiveness calculations reflect the fact that the reduction of pollutant discharge to surface waters is not 50 pounds (the change in the amount discharged to the POTW), but 31 pounds (the change in the amount actually discharged to surface waters).

The pollutants include in CE analyses are the regulated pollutants and selected non-regulated ones. Non-regulated pollutants are included because they can be removed incidentally as a result of a particular treatment technology, even though they are not specifically limited. Some of the factors considered in selected non-regulated pollutants include toxicity, frequency of occurence, and amount of pollutant in the wastestream.

Data sources for CE analyses include development documents from the Effluent Guidelines Division, economic impact analyses from the Office of Analysis and Evaluation, ambient water quality criteria documents from the Criteria and Standards Division, and POTW removal efficiency data from the Monitoring and Data Support Division.

The data set for an industry specific CE analysis contains the following information for each subcategory within the industry:

- Wastewater pollutants;
- The pollution control options identified by EGD;
- Annual volume of loadings by pollutant--currently, and at each BAT or PSES control level;
- Toxic weighting factor for each pollutant;

- POTW removal efficiencies (applicable to indirect dischargers only); and

- Annualized costs for each control option (where results are adjusted to 1981 dollars for all industries).

Criteria for toxicity values have been developed for all of the priority pollutants and were taken from data in the 1980 Ambient Water Quality Criteria Document (EPA-440/5-80 Series). Criteria for a few of the non-conventional pollutants were taken from the Quality Criteria for Water, EPA-440/9-76-023, EPA 1976 (the Red Book).

Chapter II

Cost Effectiveness for the Pharmaceutical Industry

The proposed regulations control the discharge of COD, BOD_5, TSS, and the priority pollutant cyanide. The control of total toxic organic chemicals was also considered under the PSES regulation but was not proposed.

Cost effectiveness analyses cover non-conventionals and priority pollutants only; thus, for the pharmaceutical industry, the cost effectiveness analysis will focus on cyanide and total toxic volatile organics only.

Proposed BPT Regulation

The proposed revision in the BPT regulation requires direct dischargers to limit cyanide concentrations to 207 ug per liter of effluent (long-term average).

The estimation procedure used for this CE is as follows:

1) Find total number of pounds of priority pollutants (cyanide) removed from pharmaceutical effluent streams per year due to regulatory compliance (provided by EPA);

2) Convert the value for (1) to pounds-equivalent using the copper-based weighting factors (for cyanide: Pounds Equivalent = 1.6 x (1's value));

3) Calculate the annualized costs of compliance using total capital costs, annual operation and maintenance costs, and a capital recovery factor:

$$\text{Annualized Costs} = 0.22\ (\text{Capital Costs}) + \text{O\&M}.$$

4) Divide the annualized cost of compliance by pounds-equivalent of priority pollutants removed per year to get CE of proposed regulation.

Table 2. Cost-Effectiveness of Effluent Regulations+ for Cyanide Removal from Direct Dischargers in the Pharmaceuticals Industry

Proposed Regulations	lbs. equiv. currently discharged annually	lbs. equiv. removed annually	total extimated annualized cost (1979$)	CE (1979$) lbs. equiv.	CE (1982$) lbs. equiv.
BPT	32,184	27,149	557,000	$20.52	$26.64

+Regulation standards set at 207 ug/liter for cyanide (long-term average).

Note: Conversion factors for dollars:

1979 to 1980 = 1.127 (from technical contractor).

1980 to 1982 = 1.152 (from ENR Construction Cost Index).

The proposed BPT regulation for cyanide requires the installation of treatment facilities at six pharmaceuticals plants. Together these plants must spend an estimated $685,000* annually to comply with the regulation, including amortization of capital. An effect of this expenditure is the removal of 16,968 pounds of cyanide (or 27,149 pounds equivalent of pollutant) each year from the wastestreams of these plants. The unit removal cost of cyanide--or the cost effectiveness of the regulation--is $26.64* per pound equivalent of cyanide removed (see Table 2).

Proposed PSES Regulation

Two options were considered for the proposed PSES regulation. The proposed regulation requires indirect dischargers to limit cyanide concentrations to 207 ug per liter of effluent (long-term average). The other option considered, but not proposed, added a limitation on total toxic volatile organics to the cyanide limit.

The CE estimation procedure for indirect dischargers is the same as that described for direct dischargers, with the addition of one step. The pounds-equivalent removed is multiplied by (1- POTW removal efficiency) to obtain the reduction in pollutants discharged to surface waters.

*In 1982 dollars.

It is estimated that nine plants will bear costs under the proposed regulation, for a total annualized treatment cost of $379,000*. Associated with this expenditure is an annual removal of 2828** pounds of cyanide (or 4525 pounds-equivalent). The unit cost of removal--or the cost effectiveness of the regulation--is $83.78 per pound-equivalent of cyanide removed (see Table 3).

The removal of toxic organic chemicals, as required by the second PSES option, would impose additional costs on an estimated 47 plants. The footnote to Table 3 lists the pollutants involved. The incremental annualized cost for the removal of toxic organic chemicals is estimated at $5,453,000*, with an annual incremental pollutant removal of 179,303 pounds-equivalent. The incremental cost effectiveness of removing toxic organics would be $30.41 per pound-equivalent (see Table 3).

Cost Effectiveness Comparison of Industrial Effluent Regulations

The CEs of effluent regulations for a variety of industries have been calculated and are presented in the tables at the end of this report. The 1981 dollar values range from less than one dollar to $420.00 per pound equivalent of pollutant removed. Of the industries with CEs for PSES, there are only three industries with higher CEs than the pharmaceutical industry.

Proposed BCT, BAT, and NSPS Regulations

There is no incremental removal of non-conventional or priority pollutants under the proposed regulations listed above. Therefore, no cost effectiveness analysis was performed.

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*In 1982 dollars.

** The total amount of cyanide removed from the effluent of indirect dischargers is 5892 pounds. Allowing for the POTW removal efficiency results in a reduction in cyanide discharged to surface waters of 2828 pounds.

Table 3. Cost-Effectiveness of Effluent Regulatory Options for Indirect Dischargers in the Pharmaceuticals Industry

Proposed Regulations	lbs. equiv. currently discharged annually	lbs. equiv. removed+ annually	total extimated annualized cost (1979$)	CE (1979$) lbs. equiv.	CE (1982$) lbs. equiv.
PSES*	6,539	4,525	292,000	$64.53	$83.78
PSES++	---	179,303	4,200,000	$23.42	$30.41

Note: Conversion factors for dollars:
1979 to 1980 = 1.127 (from technical contractor.)
1980 to 1982 = 1.152 (from ENR Construction Cost Index).

*Proposed regulation setting cyanide limit at 207 ug/liter (long-term average). Reflects POTW removal efficiency of 52 percent for cyanide.

+ From discharge to surface waters.

++ Incremental cost and removals of total toxic organic chemicals** over the cost of cyanide destruction. The CE numbers refer to this increment only.

**Effluent of 47 plants before regulation = 19.7 million lbs/yr.
Effluent of 47 plants after regulation = 236,000 lbs/yrs.
Incremental removal of effluent to POTW = 19.5 million lbs/yrs.
Specific pollutants included are:

Chemical	% of 19,500,000 lbs.	X	1 - POTW Removal Efficiency	X	Toxic Weighting Factor	=	Pounds Equivalent
Methylene Chloride	59.3		.42		.03566		173,189
1,1,1 trichloroethane	23.2		.13		.0000054		3
Toluene	8.9		.10		.000013		2
Chlorobenzene	4.2		.33		.00037		100
Chloroform	1.8		.39		.04017		5,499
Ethylbenzene	1.2		.16		.00170		64
1,2 Dichloroethane	0.9		.09		.00258		41
Benzene	0.3		.29		.014		238
Methyl Chloride	0.3		.08		.03566		167
							179,303

Industry Comparison
Cost Effectiveness for
Direct Dischargers
(Toxic and Nonconventional Pollutants Only)
Copper Based Weights
(1981 Dollars)

Industry	Pounds Equivalent Currently Discharged (000's)	Pounds Equivalent Remaining at Selected Option (000's)	Cost Effectiveness of Selected Option(s) ($/pound equivalent)
Aluminum Forming	1,319	90	107
Battery Manufacturing	4,134	7	21
Coil Coating	2,289	9	49
Coal Mining	BAT=BPT	BAT=BPT	BAT=BPT
Copper Forming	70	8	126
Electronics	9	3	406
Foundries			
Inorganic Chemicals	32,503	1,290	++
Iron & Steel	40,746	1,040	2
Leather Tanning			
Metal Finishing	2,012	2,012	NA
Nonferrous Metals			
Organic Chemicals, & Plastics and Synthetics			
Pesticides	148,386	4,448	++
Pharmaceuticals	BAT=BPT	BAT=BPT	BAT=BPT
Porcelain Enameling			6
Petroleum Refining	BAT=BPT	BAT=BPT	BAT=BPT
Pulp & Paper*	1,330	748	18
Steam Electric			
Textile Mills	BAT=BPT	BAT=BPT	BAT=BPT
Timber			

++ Less than a dollar.
* PCB control for Deink subcategory only.

Industry Comparison
Cost Effectiveness for
Indirect Dischargers
(Toxic and Nonconventional Pollutants Only)
Copper Based Weights
(1981 Dollars)

Industry	Pounds Equivalent Currently Discharged (To Surface Waters) (000's)	Pounds Equivalent Remaining at Selected Option (To Surface Waters) (000's)	Cost Effectiveness of Selected Option(s) ($/pounds equivalent)
Aluminum Forming	1,434	24	8
Battery Manufacturing	1,159	10	149
Coal Mining**	N/A	N/A	N/A *
Coil Coating	2,503	10	10
Copper Forming	34	4	420
Electronics	23	22	10
Inorganic Chemicals	3,971	3,004	9
Iron & Steel	5,599	1,404	6
Leather Tanning			152
Metal Finishing	11,680	675	7
Nonferrous Metals			
Foundries			
Organic Chemicals,			
& Plastics and Synthetics			
Pesticides	105,754	2,196	++
Petroleum Refining			
Pharmaceuticals	7	2	79
Porcelain Enameling			14
Pulp & Paper	N/A	N/A	N/A
Steam Electric			
Textiles*	N/A	N/A	N/A
Timber			

* N/A: Pretreatment Standards not promulgated, or no incremental costs will be incurred.
** Coal mining has no known or expected indirect dischargers.
++ Less than a dollar.