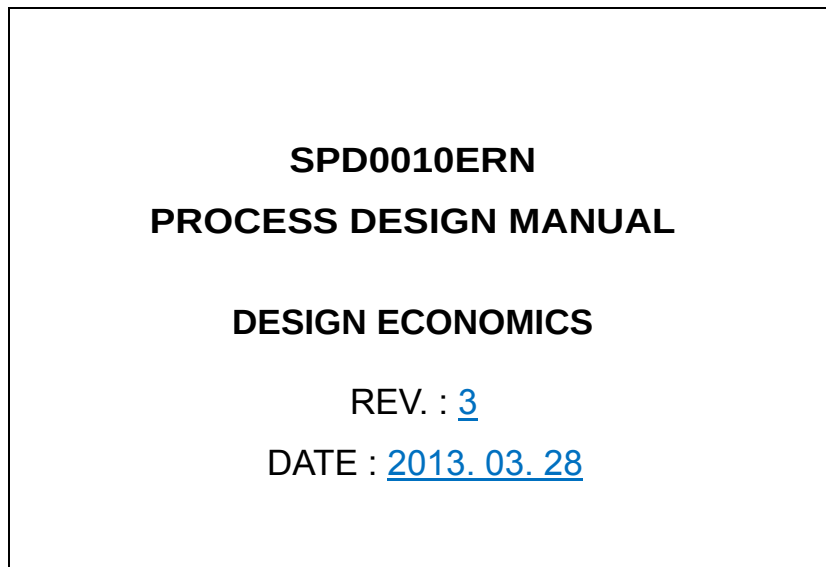


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1. SCOPE

This manual describes the basic considerations of design economics.

At the basic design stage, the design engineer must make selection, judgment or decision with respect to all basic design items based on some criteria or their design philosophy.

The design items include mechanical conditions, such as the types of equipment and process conditions, such as pressures and temperatures which are determinative to the plant operating conditions.

Many of the mechanical conditions can be selected almost easily based on the design code or equipment design manual.

On the other hand, the process conditions are highly interrelated and the results of their selection will have large effects not only on the plant cost but also on the operating cost.

Hence, in any case process conditions must be selected not on the unit operation basis but with consideration given to the effects on the overall plant economics.

This manual is intended to discuss the reference thoughts on plant design criteria, the components of the plant cost and operating cost, and appropriate balance between the plant cost and operating cost.

2. CRITERIA AND CONSTRAINTS

2.1. General

The target of the basic engineering is minimization of the life cycle cost; namely the sum of the plant cost and operating cost required throughout the plant life time.

The criteria to this are called IPF (Index of Performance Function) or objective function.

Meanwhile, the plant must satisfy numerous specifications, such as the required process performance and legal restrictions.

Such specifications are called constraints.

The term "Optimum Design" refers to the design in which the constraints are satisfied and the IPF is minimum.

2.2. Constraints

Constraints imposed on the plant engineering can be classified into three:

- (1) Process performance
- (2) Environmental requirements

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(3) Safety requirements.

The process performance is indicated as product specifications which are given by the clients in usual cases.

On the other hand, the environmental and safety requirements are imposed by law or as a result of the assessment.

In cases where they are imposed by law, the restrictions in the local law may be severer than those in the national law; the design engineer must be careful of this point.

Also, in cases where they are imposed as a result of the assessment, the assessment requirements take precedence over the legal restrictions.

Besides the above constraints, limitations are imposed on the types and/or quantities of utilities to be used, depending on the conditions of the surrounding areas. Consideration to operability is also a restrictive condition even if not specifically required.

2.3. Index of Performance Function

As mentioned above, the target of the basic engineering is minimization of the sum of the plant cost and operating cost required throughout the plant life time.

For convenience, this target is considered on the yearly basis in usual cases.

The index of performance function (IPF) can be formulated as follows:

$$IPF = U + \alpha I$$

Where, U = Annual utility cost

I = Plant cost

α = Plant cost factor (conversion rate to annual plant cost and annual fixed cost)

The relationship between the values U and I in the case of the optimum design (where the index of performance function is minimum) are as discussed below.

Generally in chemical plants, if the degree of energy recovery is increased to reduce the utility cost, the plant cost will increase.

Hence, the utility cost, if expressed as the function of the plant cost - t, will show an inverse parabolic curve as shown in Fig. 2-1.

The index of performance function will also show an inverse parabolic curve on the same graph. On the curve, Point lo is the optimum point where the index of performance function is minimum.

At the optimum point, the differential coefficient of utility cost with respect to the plant cost corresponds with the plant cost factor α .

Namely, if the coefficient is large, the plant cost will be low and the utility cost will be high. If the coefficient is excessively small, the energy consumption will be low but the plant cost will be high. Hence, the selection of this coefficient is important.

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3. SELECTION OF PLANT COST FACTOR

The plant cost factor α may be or may not be indicated by the client. In cases where it is indicated by the client, of course, the data must be followed.

If not, it is recommended that the factor should be calculated by the following formula:

$$\alpha = \frac{r + 1 - \frac{(1+g)^m \cdot t - \frac{1}{m}}{g(1+g)^m}}{\frac{(1+g)^m - 1}{g(1+g)^m} + \frac{(1+g)^{n-m} - 1}{g(1+g)^m} \cdot (1-t)}$$

Where, m: Legal depreciation (years)

n: Plant life (years)

t: Income tax rate for gross profit

r: Allowable investment efficiency

g: Discount rate

f: Maintenance, insurance, labor, etc., cost rate per plant cost.

Normally, the above variables are to be indicated by the clients, but if not, the following values should be used:

$m = n = 8$, $t = 0.5$, $f = 0.05$, $g = 0.08$ and $r = 0.10$.

In cases where the above values are used, the factor α will amount to 0.308.

For reference, Table 3-1 shows the values of the factor in various cases where the variables g and r are parameter and all the other variables are fixed at respective values.

The discount rate is almost equivalent to the interest and the allowable investment efficiency means the lower limit of the profit rate.

This plant cost factor is important to standardize the design philosophy in the regions where the plant cost and utility cost are mutually affected, for instance, in the determination of the heat recovery rate, insulation thickness and the size of the air preheater for the heater.

4. COMPONENTS OF PLANT COST

Components of the plant cost [are](#) as shown in Table 4-1.

The total plant cost is affected to a large or small extent by the selection made by the design engineer in each individual item of design work.

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However, as the extents vary largely in individual cases, they cannot be shown generally. Of them, the factors which have large effects on the equipment cost, are as shown in Table 4-2.

The factors which have large effects on the erection cost are as shown in Table 4-3.

When equipment cost and erection cost are estimated, reference should be made to the major unit costs and cost curves in the cost engineering handbook.

5. COMPONENTS OF UTILITY COST

The utilities generally used shows in Table 5-1.

Unit costs of these utilities vary largely depending on the plant location and the conditions of the utility facilities. Hence, in cases where the utility facilities are outside the scope of service, the unit costs specified by the clients should be used.

If no unit costs are available from the clients, it is recommended that data in the case of similar plants or the reference data shown in Table 5-1 should be used.

When the utility facilities are included in the scope of service, recommendations given by the personnel in charge of the facilities should be followed.

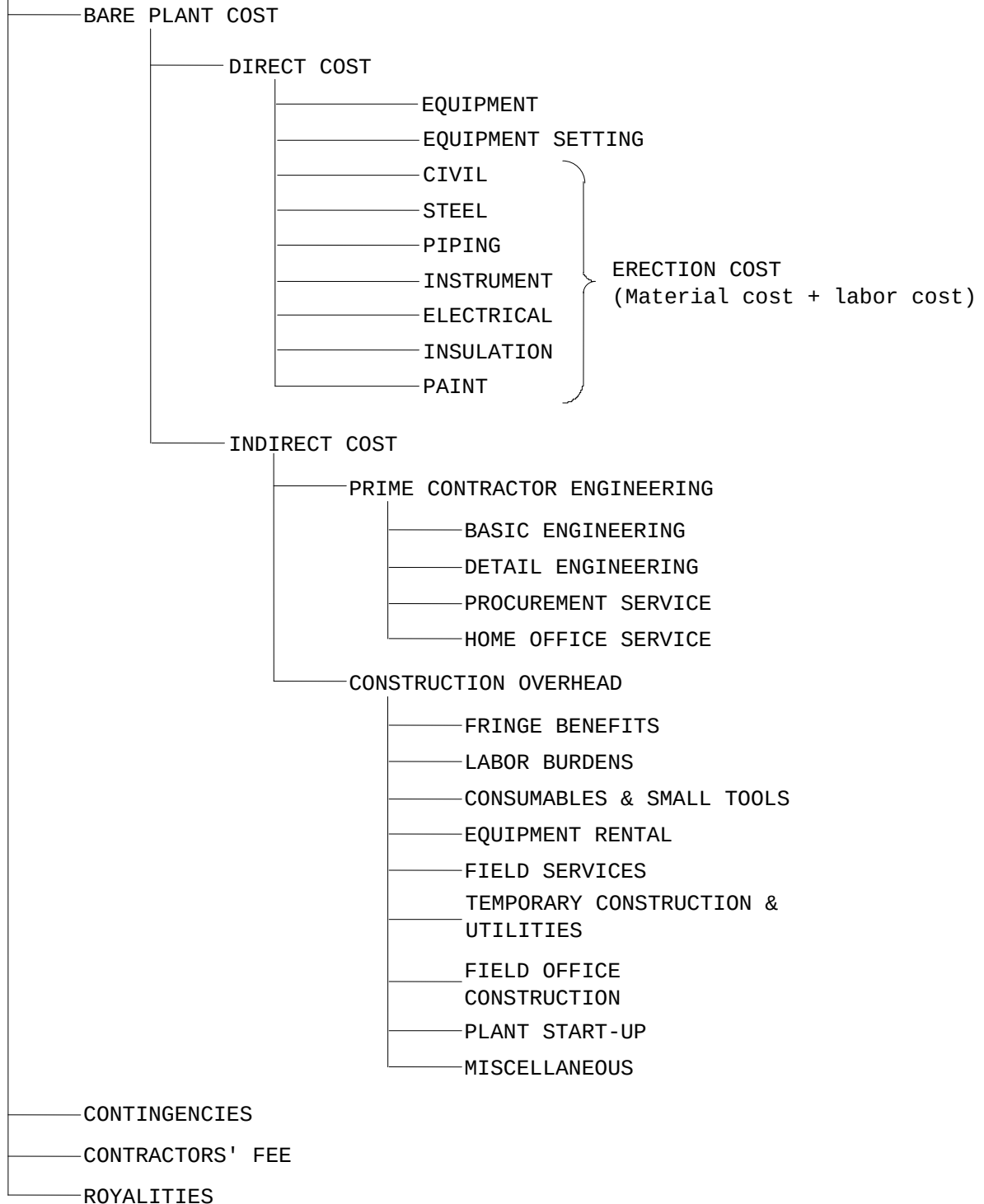
Table 3-1. Plant Cost Factor α in IPF for Option Design
($m=n=8$, $t=0.5$, $f=0.05$)

$\begin{matrix} g \\ r \end{matrix}$	0.07	0.08	0.1	0.12	0.15
0	0.25	0.273	0.3	0.328	0.317
0.05	0.277	0.29	0.319	0.348	0.393
0.1	0.293	0.308	0.337	0.368	0.415
0.15	0.31	0.325	0.356	0.388	0.438

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Table 4-1 Components of Plant Cost

TOTAL PLANT COST



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Table 4-2. Factor Affecting Cost In Major Equipment

Equipment Categories	Heat Exchangers	Tower	Vertical Vessels	Horizontal Vessels	Furnaces	Centrifugal Pumps
Design Parameters	Tube material Heat transfer area	Shell material Tower diameter	Shell material Capacity	Shell material Capacity	Tube material Capacity	Material Capacity
	Design Pressure Shell material	Tray number or packing height Tray space Design pressure	Design pressure Design temp.	Design pressure Design temp.	Design pressure Design temp.	Head Design temp.
Flare Stacks	Gas Compressors	Stack	Electric Generated	Centrifuges	Ejector	
Material	Material	Material	Material	Material	Material	
Gas flowrate	Capacity	Diameter	Power generated	Diameter	Capacity	
Diameter	Suction Pressure	Height		Capacity	Pressure	
Height	Discharge Pressure					
Design temp.	Inlet temp.					

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Table 4-3. Design Parameters Affecting Erection Cost

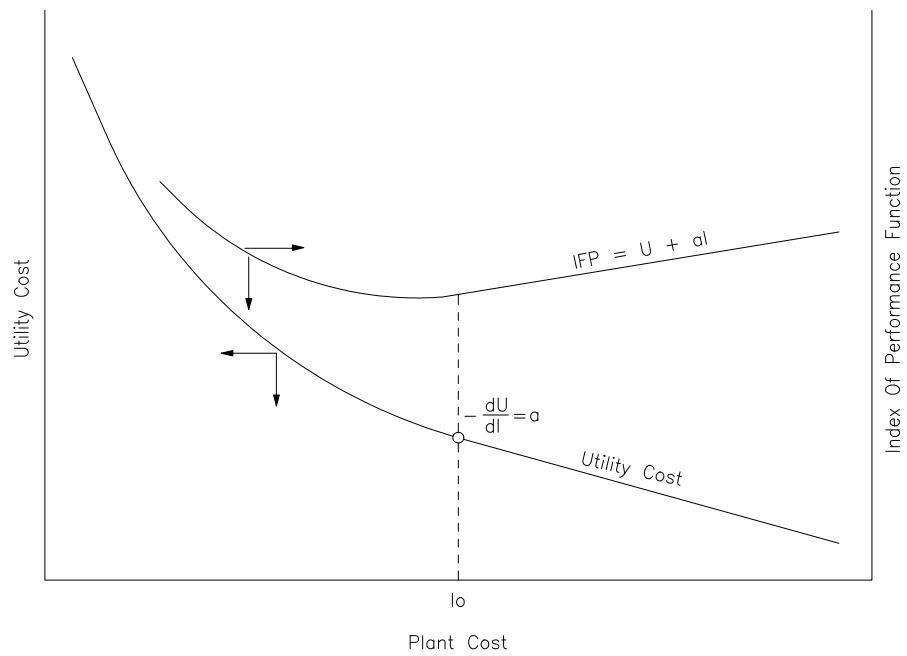
Equipment Design Parameters Cost Affected	Design Temp.	Design Temp.	Weight	Towers and Vessel		Rotary Machines	
				Diameter height length	Skirt height	Capacity	Horse- Power
Installation			○	○	○	○	
Civil			○	○	○		○
Steel structural			○	○	○		
Piping	○	○		○		○	
Instrument							
Electrical							○
Painting	○						

Table 5-1. Components of Utility Cost

	Korea	Oil producing Countries	Non-oil producing Countries
-Electricity	/KWH		
-Industrial water	/ton		
-Cooling water(sea water)	/ton		
-Boiler feed water	/ton		
-Steam (High pressure) (Middle pressure) (Low pressure)	/ton /ton /ton		
-Fuel oil	/k1		
-Fuel gas	kcal		
-Nitrogen	/Nm3		

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Fig. 2-1 Relationship of Utility Cost and Investment Cost



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6. REVISION HISTORY

Rev. No.	Date	Scope	Description
0	98. 4. 17	All pages	- First Edition - Team : Process Eng'g Team - Made by : J.H.Park J.E.Lim - Checked by : B.I.Lee S.B.Jo J.C.Ro - Approved by : S.G.Oh
1	2003. 10	5 Pages	Equation added - Made by : P.M.Hur - Checked by : J.H.Park - Approved by : C.S.Jung
2	2010.11.20	All pages	Document number revision - Prepared by : T.H. Lee - Reviewed by : H. Sung, J.C. Ro, H.H. Kwak, M.H. Oh, S.U. Hong - Approved by : E.D. Lee
3	2013.03.28	All pages	Typo is corrected (page 5 of 12) Table 5-1 is revised (Electricity was duplicated) Table 5-1 is updated (Nitrogen is added) - Prepared by : S.M.Lee - Reviewed by : L.J.Jung - Approved by : S.B.Lee