

# CH402 Chemical Engineering Process Design

## Class Notes L15

### Cost Components of Capital Investments

Templates for today's lesson is found in Canvas Lesson 15

## L15/16 Learning Objectives

- L15:
1. Use cost components to estimate capital costs for chemical processing facilities.
  2. Estimate capital costs using Lang factors.
- L16:
1. Estimate capital costs using scaling factors.
  2. Estimate capital costs based on turnover ratio.

# Problem 6-3

The purchase and installation costs of some pieces of equipment are given as a function of weight rather than capacity. An example of this is the installed costs of large tanks. The 1990 cost for an installed aluminum tank weighing 45,000 kg was \$640,000. For a size range from 10,000 to 450,000 kg, the installed cost weight exponent for aluminum tanks is 0.93. If an aluminum tank weighing 300,000 kg is required, what capital investment is needed in the year 2000?

# Problem 6-4

The 1990 cost for an installed 304 stainless steel tank weighing 135,000 kg was \$1,100,000. The installed cost weight exponent for stainless steel tanks is 0.88 for a size range from 100,000 to 300,000 kg. What weight of installed stainless steel tank could have been obtained for the same capital investment as in Problem 6-3?

# Plant Costs - Methods A-G

- A - Detailed item estimate
- B - Unit cost estimate – based on records
- C - Percentage of delivered-equipment cost
- D - Lang factors
- E - Power factors with plant/capacity ratio
- F - Cost per unit capacity
- G - Turnover ratio

# Percentage of Delivered-Equipment Cost

[FE Ref. Manual pages 257](#)

**Method C**

Component	Range
<i>Direct costs</i>	
Purchased equipment-delivered (including fabricated equipment and process machinery such as pumps and compressors)	100
Purchased-equipment installation	39–47
Instrumentation and controls (installed)	9–18
Piping (installed)	16–66
Electrical (installed)	10–11
Buildings (including services)	18–29
Yard improvements	10–13
Service facilities (installed)	40–70
Land (if purchase is required)	6
Total direct plant cost	264–346
<i>Indirect costs</i>	
Engineering and supervision	32–33
Construction expenses	34–41
Total direct and indirect plant costs	336–420
Contractor's fee (about 5% of direct and indirect plant costs)	17–21
Contingency (about 10% of direct and indirect plant costs)	36–42
Fixed-capital investment	387–483
Working capital (about 15% of total capital investment)	68–86
Total capital investment	455–569

# Example 6-1

p. 240

Estimate the fixed capital investment for a process plant if the purchased-equipment cost is \$100,000. Use the ranges of process-plant component cost outlined in Table 6-3, for a process plant handling both solids and fluids, with a high degree of automatic controls, and essentially outdoor operation. Do not include land.

*Very Important Example – Needed for PS8 Problem 6-8*

example 6-1 cadet - Excel

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	A	B	C	D	E	F	G	H
1	<b>Checklist for Fixed Capital Investment in a New Facility or Large Addition</b>							
2	<i>(Percentage of FCI Method)</i>							
3								
4	<b>Component</b>		<b>% of FCI</b>	<b>Estimated %</b>	<b>Estimated %</b>	<b>Estimated Cost</b>		
5			<i>T6.3 values</i>		<i>(normalized)</i>	<i>(component costs)</i>		
6	<i>Direct (includes delivery)</i>							
7	Purchased Equipment		15 to 40					
8	Purchased Equipment Installation		6 to 14					
9	Instrumentation and Controls		2 to 12					
10	Piping		4 to 17					
11	Electrical Systems		2 to 10					
12	Buildings		2 to 18					
13	Yard Improvements		2 to 5					
14	Service Facilities		8 to 30					
15	Land		1 to 2					
16								
17	<i>Indirect</i>							
18	Engineering and Supervision		4 to 20					
19	Construction Expenses		4 to 17					
20	Legal Expenses		1 to 3					
21	Contractor's Fee		2 to 6					
22	Contingency		5 to 15					
23								
24	Totals							

[FE Ref. Manual page 257](#)

Sheet1 Sheet2 Sheet3

READY 120%



# Use cost & evaluation spreadsheet from course webpage.

Slide 9

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7	Project Identifier: Illustration 101			Fraction of delivered equipment			User: copy	Calculated		
8				Solid-	Solid-fluid	Fluid	from values	values,		
9				processing	processing	processing	at left or	million \$		
10				plant	plant	plant	insert			
11	Direct Costs									
12	Purchased equipment, E'							0.100		
13	Delivery, fraction of E'	0.10	0.10	0.10	0.00			0.000		
14	Subtotal: delivered equipment							0.100		
15	Purchased equipment installation	0.45	0.39	0.47	0.36			0.036		
16	Instrumentation&Controls(installed)	0.18	0.26	0.36	0.40			0.040		
17	Piping (installed)	0.16	0.31	0.68	0.32			0.032		
18	Electrical systems (installed)	0.10	0.10	0.11	0.20			0.020		
19	Buildings (including services)	0.25	0.29	0.18	0.20			0.020		
20	Yard improvements	0.15	0.12	0.10	0.08			0.008		
21	Service facilities (installed)	0.40	0.55	0.70	0.60			0.060		
22	Total direct costs	1.69	2.02	2.60	2.16			0.316		
23	Indirect Costs									
24	Engineering and supervision	0.33	0.32	0.33	0.32			0.032		
25	Construction expenses	0.39	0.34	0.41	0.40			0.040		
26	Legal expenses	0.04	0.04	0.04	0.08			0.008		
27	Contractor's fee	0.17	0.19	0.22	0.08			0.008		
28	Contingency	0.35	0.37	0.44	0.32			0.032		
29	Total indirect costs	1.28	1.26	1.44	1.20			0.120		
30	Fixed capital investment (FCI)									
31								0.436		
32	Working capital (WC)									
33		0.70	0.75	0.89	0.89			0.089		
34	Total capital investment (TCI)									
35								0.525		
36										

Instructions Capital Inv. Materials&Labor Utilities

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# Lang Factors

**Method D**

[FE Ref. Manual pages 257](#)

PTW, Page 254

Table 6-10. Revised Lang factors for estimation of fixed-capital investment (FCI) or total capital investment (TCI)

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Factor  $\times$  delivered-equipment cost = FCI or TCI

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Type of Plant	Lang factors	
	FCI	TCI
Solid	4.0	4.7
Solid-fluid	4.3	5.0
Fluid	5.0	6.0

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H.J. Lang, *Chem. Eng.*, 54 (10) 1947, page 117 and *Chem. Eng.*, 55 (6) 1948, page 112

Example 1: **Delivered** equipment cost (DEC) for a fluid processing plant is \$110,000

$$\text{FCI} = 5.0 \times \$110,000 = \$550,000, \text{TCI} = 6.0 \times \$110,000 = \$660,000 \text{ and WC} = \$110,000$$

Example 2: **Purchased** equipment cost for a solid processing plant is \$100,000

$$\text{DEC} = \$100,000 + .1 \times \$100,000 = \$110,000 \quad (\text{assume delivery} = 10\% \text{ of PEC, slide 9})$$

$$\text{FCI} = 4.0 \times \$110,000 = \$440,000, \text{TCI} = 4.7 \times \$110,000 = \$517,000, \text{ and WC} = \$77,000$$

## Problem 6-8.

The purchased-equipment cost for a plant which produces pentaerythritol (solid-fluid processing plant) is \$300,000. The plant is to be an addition to an existing formaldehyde plant. The major part of the building cost will be for indoor construction. The contractor's fee will be 7% of the direct plant cost. All other costs are close to the average values found for typical chemical plants. On the basis of this information, estimate the total direct plant cost, the fixed capital investment, and the total capital investment.

Use Cost and Evaluation Worksheet (colorful worksheet).

## New Definitions - Important Grass-Roots Plant

- A complete plant including infrastructure erected on a new area or site.
- Investment includes all costs of land, site development, battery-limit facilities, and auxiliary facilities.

### Battery Limit

- The design of most process units includes a pipe rack on one side of the unit that contains all the piping entering and exiting the unit. The battery limit is where the piping crosses the defined boundary between the unit and the area outside of the unit.
- Battery limits typically exclude storage facilities, administrative buildings, utilities, or auxiliary facilities unless otherwise specified.
- The operational principle is primarily safety but is commonly applied in process design as well. In preparing for major maintenance of a unit, it is cleared of hazardous materials and isolated from the rest of the plant. A chief operator can go to the battery limits and determine whether all the necessary blinds have been properly installed. He or she signs off on a blind list confirming full unit isolation before work begins.

# Plant Costs - Methods A-G

- A - Detailed item estimate
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- G - Turnover ratio

## Method G: Turnover Ratio

- Use existing data to calculate turnover ratio.
- Assume turnover ratio is constant.

$$\text{Turnover Ratio} = \frac{\text{gross annual sales}}{\text{fixed capital investment}}$$

Eq. 6-11, p. 258

0.2 to 4 y<sup>-1</sup>

± 30 % accuracy.

Use in PS8, problem 6-9

## Problem 6-9.

Estimate by the turnover ratio method the fixed-capital investment required in 2000 for a proposed sulfuric acid plant (battery-limit) which has an annual capacity of  $1.3 \times 10^8$  kg/yr of 100% sulfuric acid (contact catalytic process), using the data from Table 6-11, when the selling price of sulfuric acid is \$86 per metric ton. The plant will operate 325 days/year. Repeat the calculation, using the cost capacity exponent (scaling) method with data from Table 6-11

## Problem 6-9.

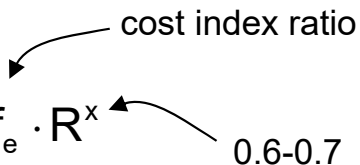
Estimate by the turnover ratio method the fixed-capital investment required in 2000 for a proposed sulfuric acid plant (battery-limit) which has an annual capacity of  $1.3 \times 10^8$  kg/yr of 100% sulfuric acid (contact catalytic process), using the data from Table 6-11, when the selling price of sulfuric acid is \$86 per metric ton. The plant will operate 325 days/year. Repeat the calculation, using the cost capacity exponent (scaling) method with data from Table 6-11



## Method E: Power Factors and Plant Capacity Ratio

Similar to what we have been doing for single pieces of equipment.

$$C_n = C \cdot f_e \cdot R^x$$



Eq. 6-9, p. 254

$$C_n = f \cdot (D \cdot R^x + I)$$

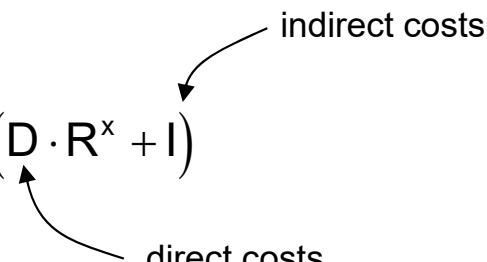


Table 6-11, p. 255

Eq. 6-10

± 20 % accuracy.

$$\text{Cost of Plant A} = \text{Cost of Plant B} \cdot \left( \frac{\text{Capacity of Plant A}}{\text{Capacity of Plant B}} \right)^n$$

## Problem 6-10.

The total capital investment for a chemical plant is \$1 million, and the working capital is \$100,000. If the plant can produce an average of 8000 kg of final product per day during a 365-day year, what selling price in dollars per kilogram of product would be necessary to give a turnover ratio of 1.0?

# Questions?