# CAPCOST Illustration

## TBWS, Chapter 6, Problem 1

**Estimate the $COM_d$ (cost of manufacturing) for the light gas plant given in Problem 5.4. The duties of the four heat exchangers are given below:**

| | | |
|---|---|---|
| **E-201** | $Q$ | $= -3.80 \times 10^6$ kJ/h |
| **E-202** | $Q$ | $= 5.55 \times 10^6$ kJ/h |
| **E-203** | $Q$ | $= -4.20 \times 10^6$ kJ/h |
| **E-204** | $Q$ | $= 3.09 \times 10^6$ kJ/h |

**Assume a stream factor of 0.913 (8000 h/yr) for this process.**

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## Why are we doing this example?

**This particular problem features many elements common to manufacturing cost estimation.**

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## Comments

**Answer to be formula for $COM_d$ as a function of raw material cost ($C_{RM}$).**

**Assume pump efficiency of 80%.**

**Solution using CAPCOST is attached.**

**Copy of Problem 5.4 and its solution is also attached, for the reader's convenience.**

**Stream Factor**
**TBWS, 2nd Ed., page 212**

**A stream factor provides the expected "uptime" for a plant, i.e., the actual number of *operating* hours per year.**

**Maximum number of hours per year:**

$$365 \text{ days} \times (24 \text{ hours/day}) = 8760 \text{ hours}$$

**Actual number of operating hours per year:**

$$(\text{stream factor}) \times 8760 \text{ hours}$$

**Always state flow rates on PFD in terms of stream hours, i.e., the *operating* hours.**

| Unit Number | 200 |
|---|---|

| CEPCI | 397 |
|---|---|

***TBWS Problem 5.4***

## User Added Equipment

| Exchangers | Type of Exchanger | Shell Pressure (barg) | Tube Pressure (barg) | MOC | Area (square meters) | Equipment Cost | Bare Module Cost |
|---|---|---|---|---|---|---|---|
| E-201 | Floating Head | 15 | 4 | CS/CS | 155 | $ 31,300 | $ 105,000 |
| E-202 | Floating Head | 4 | 15 | CS/CS | 45 | $ 19,700 | $ 65,500 |
| E-203 | Floating Head | 5 | 4 | CS/CS | 85 | $ 23,700 | $ 78,100 |
| E-204 | Floating Head | 5 | 4 | CS/CS | 20 | $ 18,300 | $ 60,300 |

| Pumps (with drives) | Pump Type | Power (kilowatts) | # Spares | MOC | Discharge Pressure (barg) | Purchased Equipment Cost | Bare Module Cost |
|---|---|---|---|---|---|---|---|
| P-201 | Centrifugal | 1.3 | 1 | Carbon Steel | 16 | $ 4,990 | $ 22,000 |
| P-202 | Centrifugal | 1.2 | 1 | Carbon Steel | 6 | $ 4,960 | $ 19,800 |

| Towers | Tower Description | Height (meters) | Diameter (meters) | Tower MOC | Demister MOC | Pressure (barg) | Equipment Cost | Bare Module Cost |
|---|---|---|---|---|---|---|---|---|
| T-201 | 36 Stainless Steel Sieve Trays | 19 | 0.95 | Carbon Steel | | 15 | $ 45,000 | $ 137,000 |
| T-202 | 40 Stainless Steel Sieve Trays | 21 | 1.1 | Carbon Steel | | 5 | $ 56,900 | $ 149,000 |

| Vessels | Orientation | Length/Height (meters) | Diameter (meters) | MOC | Demister MOC | Pressure (barg) | Equipment Cost | Bare Module Cost |
|---|---|---|---|---|---|---|---|---|
| V-201 | Horizontal | 3.75 | 1.25 | Carbon Steel | | 15 | $ 7,020 | $ 36,000 |
| V-202 | Horizontal | 3.75 | 1.25 | Carbon Steel | | 5 | $ 7,020 | $ 23,300 |
| | | | | | | Sum | 218,890 | $ 696,000 |

***TBWS Problem 5.4***

| Name | Total Module Cost | Grass Roots Cost |
|---|---|---|
| E-201 | $ 124,397 | $ 176,000 |
| E-202 | $ 77,000 | $ 110,000 |
| E-203 | $ 92,100 | $ 131,000 |
| E-204 | $ 71,100 | $ 101,000 |
| P-201 | $ 25,900 | $ 34,000 |
| P-202 | $ 23,300 | $ 31,300 |
| T-201 | $ 161,000 | $ 205,000 |
| T-202 | $ 176,000 | $ 232,000 |
| V-201 | $ 42,400 | $ 53,000 |
| V-202 | $ 27,500 | $ 38,100 |
| Totals | $ 821,000 | $ 1,110,000 |

***TBWS Problem 6.1***

| Utility Used | Efficiency | Actual Usage | Annual Utility Cost |
|---|---|---|---|
| **Cooling Water** | | 3800 MJ/h | $ 10,800 |
| **Low-Pressure Steam** | | 5550 MJ/h | $ 270,000 |
| **Cooling Water** | | 4200 MJ/h | $ 11,900 |
| **Low-Pressure Steam** | | 3090 MJ/h | $ 150,000 |
| Electricity | 0.8 | 1.63 kilowatts | $ 786 |
| Electricity | 0.8 | 1.5 kilowatts | $ 726 |
| NA | | | |
| NA | | | |
| NA | | | |
| NA | | | |
| | | | $ 444,210 |

| Material | Classification | Price ($/kg) | Consumption (kg/h) | Material Costs ($/y) |
|---|---|---|---|---|

**Economic Options**

| | | |
|---|---|---|
| Cost of Land | | |
| Taxation Rate | 42% | |
| Annual Interest Rate | 10% | |
| Salvage Value | $ | 82,100 |
| Working Capital | $ | 82,100 |
| $FCI_L$ | $ | 821,000 |
| Total Module Factor | 1.18 | |
| Grass Roots Factor | 0.50 | |

**Economic Information Calculated From Given Information**

| | | |
|---|---|---|
| Revenue From Sales | $ | - |
| $C_{RM}$ (Raw Materials Costs) | $ | - |
| $C_{UT}$ (Cost of Utilities) | $ | 461,080 |
| $C_{WT}$ (Waste Treatment Costs) | $ | - |
| $C_{OL}$ (Cost of Operating Labor) | $ | 650,000 |

**Factors Used in Calculation of Cost of Manufacturing ($COM_d$)**

Comd = 0.18*FCIL + 2.73*COL + 1.23*(CUT + CWT + CRM)

| | | |
|---|---|---|
| Multiplying factor for FCIL | 0.18 | |
| Multiplying factor for $C_{OL}$ | 2.73 | |
| Facotrs for $C_{UT}$, $C_{WT}$, and $C_{RM}$ | 1.23 | |
| $COM_d$ | $ | 2,489,408 |

⇐ for CRM = 0

***TBWS Problem 6.1***

For CRM ≠ 0: COMd = 2,489,000 + 1.23*CRM

**Factors Used in Calculation of Working Capital**

Working Capital = $A*C_{RM} + B*FCI_L + C*C_{OL}$

| | |
|---|---|
| A | 0.10 |
| B | 0.10 |
| C | 0.10 |

| | |
|---|---|
| Project Life (Years after Startup) | 10 |

| | |
|---|---|
| Construction period | 2 |

**Distribution of Fixed Capital Investment (must sum to one)**

| | |
|---|---|
| End of year One | 60% |
| End of year Two | 40% |
| End of year Three | |
| End of year Four | |
| End of year Five | |

# CAPCOST Illustration

**TBWS, Chapter 5, Problem 4**

**The light gas separations unit of a certain refinery consists of two columns in series that are fed a mixture of propane, butanes, and higher hydrocarbons.**

**The first column, the depropanizer, separates the propane (and small amounts of propylene) from the heavier material.**

**The second column, the debutanizer, separates the butanes from the remaining hydrocarbons.**

**A PFD and equipment summary table are given in Figure P5 and Table P5.4, respectively.**

**Using the CAPCOST program, estimate the total module cost and grass roots cost of this process unit.**

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## Why are we doing this example?

**This particular problem features many elements common to capital cost estimation.**

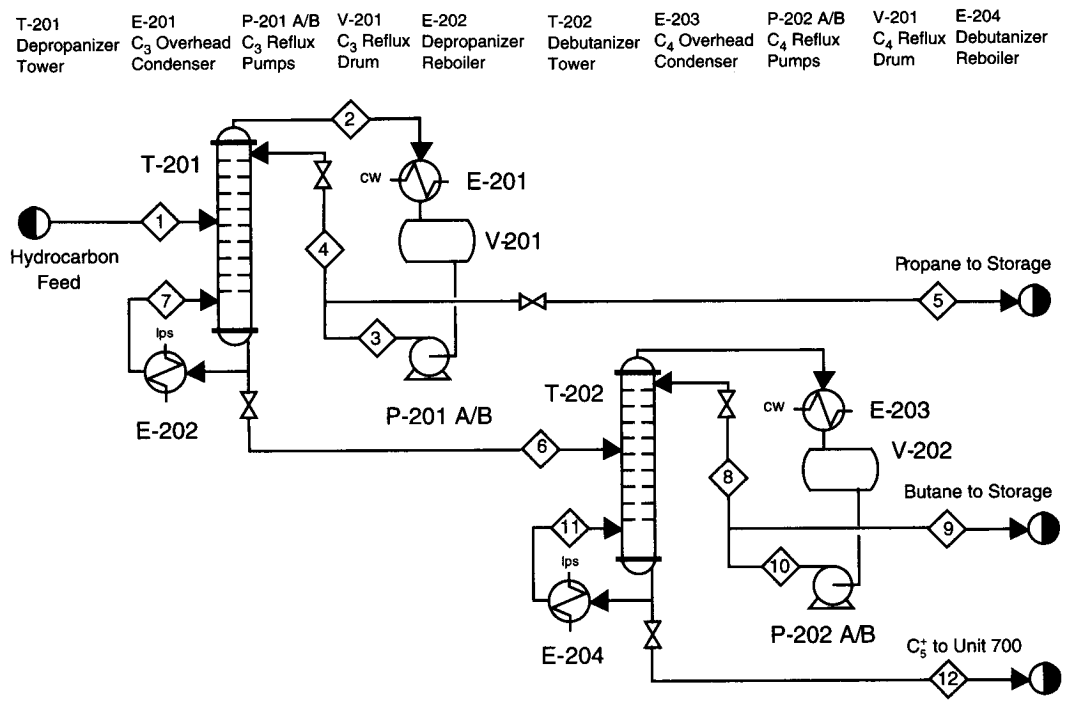


**Figure P5.4** PFD for Unit 200—Light Gas Separations Plant

**Table P5.4 Equipment Summaries for Problem 4**

| Equipment | E-201 | E-202 | E-203 | E-204 | T-201 | T-202 | P-201A/B | P-202A/B | V-201 | V-202 |
|---|---|---|---|---|---|---|---|---|---|---|
| Type | Floating head | Floating head | Floating head | Floating head | Tower | Tower | Centrifugal pump | Centrifugal pump | Horizontal vessel | Horizontal vessel |
| Area | 155 $m^2$ | 45 $m^2$ | 85 $m^2$ | 20 $m^2$ | - | - | - | - | - | - |
| Shell pressure* | 15 barg | 4 barg | 5 barg | 4 barg | - | - | - | - | - | - |
| Tube pressure* | 4 barg | 15 barg | 4 barg | 5 barg | - | - | - | - | - | - |
| MOC | Carbon steel | Carbon steel | Carbon steel | Carbon steel | Carbon steel | Carbon steel | Carbon steel | Carbon steel | Carbon steel | Carbon steel |
| Diameter | - | - | - | - | 0.95 m | 1.00 m | - | - | 1.25 m | 1.25 m |
| Length or height | - | - | - | - | 19.0 m | 21.0 m | - | - | 3.75 m | 3.75 m |
| Design pressure* | - | - | - | - | 15 barg | 5 barg | - | - | 15 barg | 5 barg |
| Internals | - | - | - | - | 36 sieve trays | 40 sieve trays | - | - | - | - |
| MOC | - | - | - | - | Stainless steel | Stainless steel | - | - | - | - |
| Power | - | - | - | - | - | - | 1.3 kW | 1.2 kW | - | - |
| Discharge pressure* | - | - | - | - | - | - | 16 barg | 6 barg | - | - |

*all pressures are entered as bar gauge, 0.0 barg = 1.0 bar.

**TBWS Problem 5.4 - Summary**

**Total Module Cost = $821,000**
**Grass Roots Cost = $1,110,000**

## User Added Equipment

| Compressors | Compressor Type | Power (kilowatts) | # Spares | MOC | Purchased Equipment Cost | Bare Module Cost |
|---|---|---|---|---|---|---|

| Drives | Drive Type | Power (kilowatts) | # Spares | Purchased Equipment Cost | Bare Module Cost |
|---|---|---|---|---|---|

| Evaporators | Type | Area (square meters) | Pressure (barg) | MOC | Volume (cubic meters) | Purchased Equipment Cost | Bare Module Cost |
|---|---|---|---|---|---|---|---|

| Exchangers | Type of Exchanger | Shell Pressure (barg) | Tube Pressure (barg) | MOC | Area (square meters) | Purchased Equipment Cost | Bare Module Cost |
|---|---|---|---|---|---|---|---|
| E-201 | Floating Head | 15 | 4 | Carbon Steel / Carbon Steel | 155 | $ 31,300 | $ 105,000 |
| E-202 | Floating Head | 4 | 15 | Carbon Steel / Carbon Steel | 45 | $ 19,700 | $ 65,500 |
| E-203 | Floating Head | 5 | 4 | Carbon Steel / Carbon Steel | 85 | $ 23,700 | $ 78,100 |
| E-204 | Floating Head | 5 | 4 | Carbon Steel / Carbon Steel | 20 | $ 18,300 | $ 60,300 |

| Fans / Blowers | Type | Gas Flowrate (cubic meters/s) | # Spares | MOC | Pressure Rise Across Fan (barg) | Purchased Equipment Cost | Bare Module Cost |
|---|---|---|---|---|---|---|---|

| Fired Heaters | Type | Heat Duty (MJ/h) | Steam Superheat (°C) | MOC | Pressure (barg) | Purchased Equipment Cost | Bare Module Cost |
|---|---|---|---|---|---|---|---|

| Pumps (with drives) | Pump Type | Power (kilowatts) | # Spares | MOC | Discharge Pressure (barg) | Purchased Equipment Cost | Bare Module Cost |
|---|---|---|---|---|---|---|---|
| P-201 | Centrifugal | 1.3 | 1 | Carbon Steel | 16 | $ 4,990 | $ 22,000 |
| P-202 | Centrifugal | 1.2 | 1 | Carbon Steel | 6 | $ 4,960 | $ 19,800 |

| Storage Tanks | Tank Type | Volume (cubic meters) | Volume (gallons) | Purchased Equipment Cost | Bare Module Cost |
|---|---|---|---|---|---|

| Towers | Tower Description | Height (meters) | Diameter (meters) | Tower MOC | Demister MOC | Pressure (barg) | Purchased Equipment Cost | Bare Module Cost |
|---|---|---|---|---|---|---|---|---|
| T-201 | 36 Stainless Steel Sieve Trays | 19 | 0.95 | Carbon Steel | | 15 | $ 45,000 | $ 137,000 |
| T-202 | 40 Stainless Steel Sieve Trays | 21 | 1.1 | Carbon Steel | | 5 | $ 56,900 | $ 149,000 |

| Turbines | Type of Turbine | Power (kilowatts) | # Spares | MOC | Purchased Equipment Cost | Bare Module Cost |
|---|---|---|---|---|---|---|

| Vessels | Orientation | Length/Height (meters) | Diameter (meters) | MOC | Demister MOC | Pressure (barg) | Purchased Equipment Cost | Bare Module Cost |
|---|---|---|---|---|---|---|---|---|
| V-201 | Horizontal | 3.75 | 1.25 | Carbon Steel | | 15 | $ 7,020 | $ 36,000 |
| V-202 | Horizontal | 3.75 | 1.25 | Carbon Steel | | 5 | $ 7,020 | $ 23,300 |
| | | | | | | | Sum Bare Module Cost | $ 696,000 |