

# Summary of the Bare Module Method

<b>FOB</b>	free on board, cost of equipment ready for shipment from supplier
<b>Installed</b> = FOB + shipping + uncrate, inspect, and hook up	
<b>L+M</b> = (installed-shipping) + piping + instruments + electrical + insulation + foundation + structure + offsites	$L+M = FOB * (L+M \text{ Factor})$
Physical plant cost = L+M + shipping	Note that shipping cannot be correlated
<b>BM</b> = above + home engineering + field expense	BM = Bare module Home off = 9% of L+M Field = 10 to 15% L+M $BM = FOB * (BM \text{ Factor})$ Rough estimate $BM \text{ factor} = (L+M) * 1.4$
<b>TM</b> = Total fixed capital investment = BM + contractors fees + contingencies	TM = total module Contr = 3 to 5% of BM Conting = 10 to 15% of BM
<b>Total investment</b> = above + royalty + land + spare parts + legal + working capital + interest during construction	Working capital = 10+% of fixed capital invest. This could vary greatly.  Note: This is for isolated module, not grassroots plant.
<b>Turnkey cost</b> = total invest + Startup expenses	

**Notes:** 1. Total module (TM) does not account for site development, off-sites, utilities, etc. These costs would vary depending upon the equipment considered. Turton (pg. 68) suggests 35% of BM costs for this factor.



# Sample cost estimation data

Costs are for mid-1970

The base cost is \$8000 for an exchanger with  $A = 100 \text{ m}^2$

Define basic shell and tube

Corrections for pressure and material

ENERGY SYSTEMS & EXCHANGE: HEAT EXCHANGERS										MS = 300
Shell & Tube				Air Cooled		Tubes		Specialized		
Floating head				Kettle		single embossed		double embossed		Trickle, trombone, serpentine, Drip or Cascade Coolers
						Plate-coil				
Size	Unit	Cost $10^3 \$$	Range	n	Err-or %	L+M	L/M	BM	Comments	
<b>SHELL AND TUBE</b>										
Floating head, 1140 kPa, c/s in c/s shell, bare tube. Delivered cost: standard 4.85 m length, with either 2.5 or 1.9 cm O.D. tubes on square or triangular pitch.										
Pressure, MPa										
2.2 : x 1.15      7.0 : x 1.55										
2.9 : x 1.25      22. : x ~2.5										
4.2 : x 1.45      28. : x ~2.8										
5.6 : x 1.52      35. : x ~3.1										
tubes in c/s shell:										
Al x 1.2      s/s 316 x 2.4										
Cu x 1.35      s/s 304 x 2.0										
Brass x 1.3      Monel x 3.0										
Admiralty x 1.5      Ti x 9.0										
70-30 Cu-Ni x 1.7      Inconel x 2.4										
Ni x 2.8      Hastalloy C x 8.5										
tubes and shell:										
s/s 316 x 3.0      Monel x 4.0										
s/s 304 x 2.8      Ti x 13.0										
After cooler for compressor, c/s with water on shell side. excl: separator, integral piping, support stand and instrumentation.										
0.1	$\text{m}^3/\text{s}$	0.38	0.03 to 0.30	0.58						
Cross bore in c/s shell. Karbate. Delivered.										
10 108	Heat Transfer Area $\text{m}^2$ ( $1076 \text{ ft}^2$ )	4	0.7 to 70	0.69						
										5-2 Heat Exchange
										5-5
										Fixed tube x 0.85 U-tube x 0.87 Kettle re-boiler x 1.35 Tubes only x 0.3 Expansion joint on fixed tube x 1.25 23, 70, 91 123, 126, 127 128, 145, 150 170, 201, 203 212, 314, 318 344, 403, 494 498, 506, 531

The correlation is valid for  $A = 2-2000 \text{ m}^2$

Estimate uncertainty in  $\pm \%$