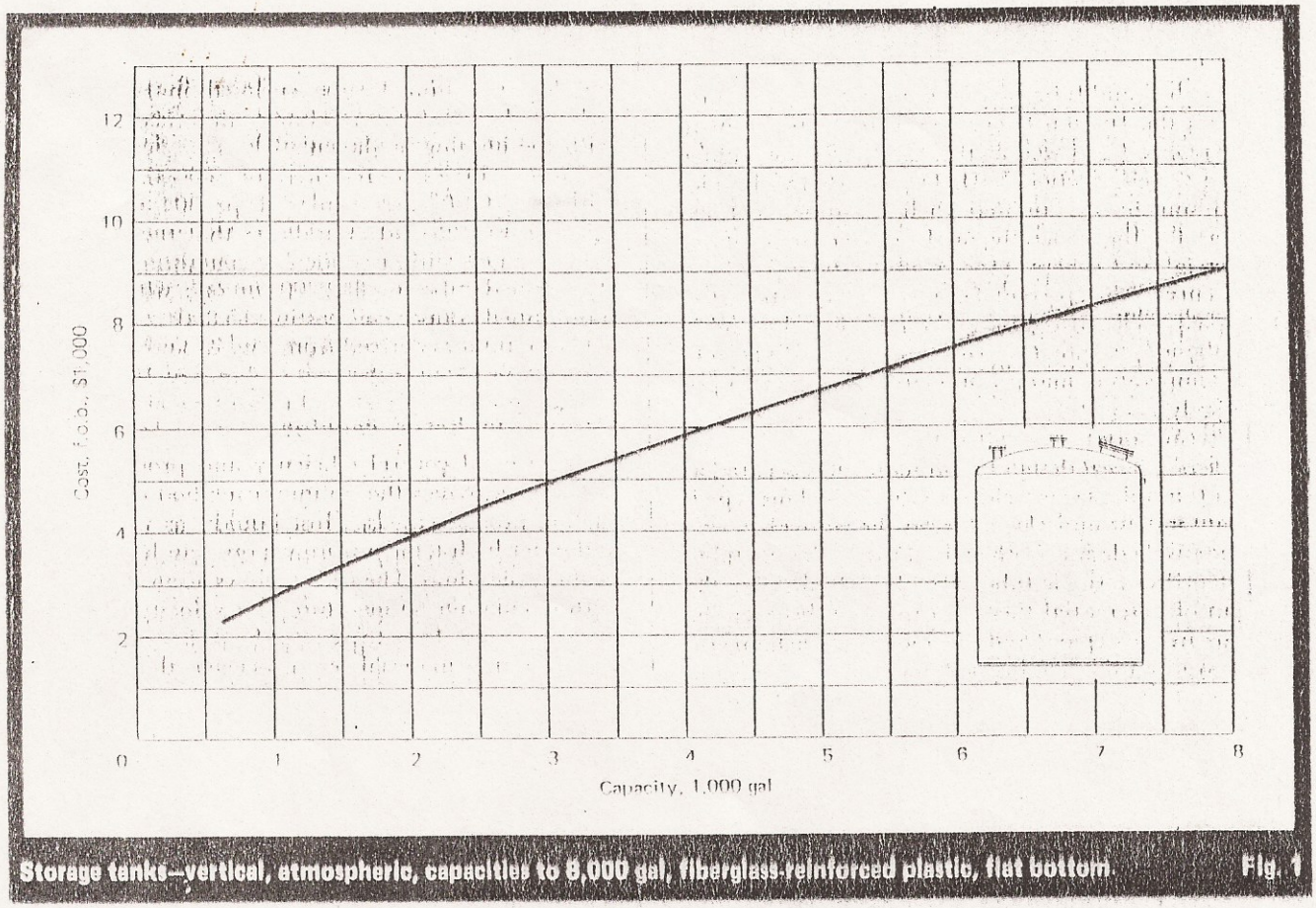
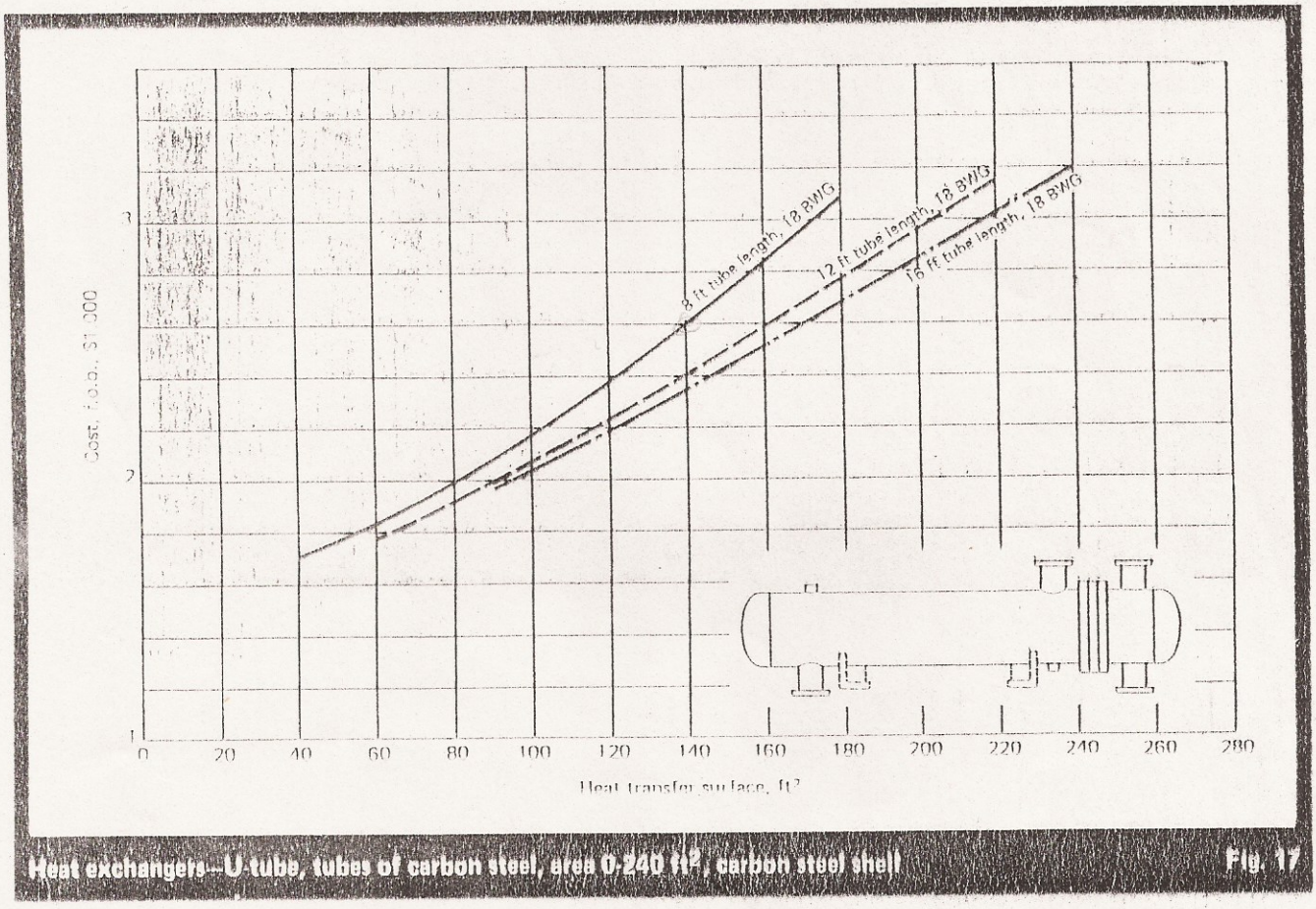



Storage tanks—vertical, atmospheric, capacities to 8,000 gal, fiberglass-reinforced plastic, flat bottom. Fig. 1





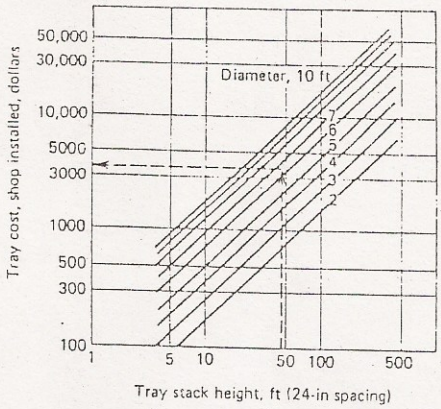

Heat exchangers—U-tube, tubes of carbon steel, area 0-240 ft², carbon steel shell Fig. 17

| Linings | Thickness, in | M & L, $/ft² |
|---|---|---|
| Acid brick | 3 | 3.80 |
| | 4 | 5.50 |
| | 6 | 8.25 |
| Firebrick | 4½ | 7.16 |
| | 9 | 10.79 |
| Rubber | 3/16 | 4.37 |
| | 1/4 | 4.75 |
| Refractory | 2 | 7.50 |
| | 4 | 10.52 |
| Gunite | 2 | 3.20 |
| | 4 | 4.55 |
| Chemical lead | 5 lb | 6.25 |
| | 10 | 7.13 |
| | 15 | 8.86 |

Process vessel cost, $ = Base cost x $F_m$ x $F_p$

Adjustment factors:

| Shell material | $F_m$ Clad | $F_m$ Solid | Pressure factor, psi | $F_p$ |
|---|---|---|---|---|
| Carbon steel | 1.00 | 1.00 | Up to 50 | 1.00 |
| Stainless 316 | 2.25 | 3.67 | 100 | 1.05 |
| Monel | 3.89 | 6.34 | 200 | 1.15 |
| Titanium | 4.23 | 7.89 | 300 | 1.20 |
| | | | 400 | 1.35 |
| | | | 500 | 1.45 |
| | | | 600 | 1.60 |
| | | | 700 | 1.80 |
| | | | 800 | 1.90 |
| | | | 900 | 2.30 |
| | | | 1000 | 2.50 |




Required:
- Tray stack height, ft
- Tray diameter, ft
- Tray spacing, in
- Tray type
- Material

Time base: mid-1968

Exponent size: 1.0

Included:
- Trays (as specified)
- Supports
- All fittings
- Shop fabrication
- Shop installation

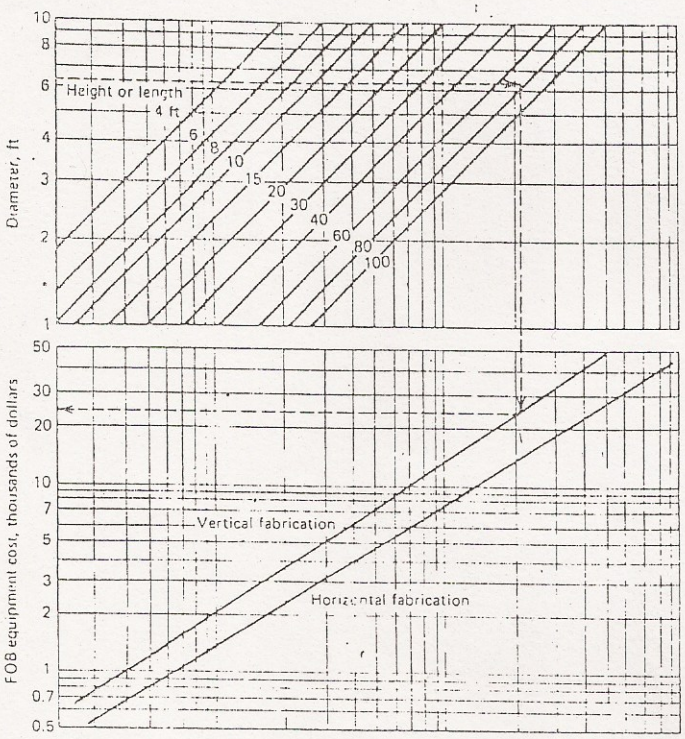
Tray cost, $ = Base cost ($F_t + F_f + F_m$)

Adjustment factors:

| Tray spacing, in | $F_t$ | Tray type | $F_f$* | Tray material | $F_m$* |
|---|---|---|---|---|---|
| 24 | 1.0 | Grid (no downcomer) | 0.0 | Carbon steel | 0.0 |
| 18 | 1.4 | Plate | 0.0 | Stainless | 1.7 |
| 12 | 2.2 | Sieve | 0.0 | Monel | 8.9 |
| | | Trough or valve | 0.4 | | |
| | | Bubble cap | 1.8 | | |
| | | Koch Kascade | 3.9 | | |

*If these factors are used individually, add 1.00 to the above values.

FIGURE 4.2.4
Add-on costs of typical vessel components. (*Guthrie, 1969, reproduced by permission of Chemical Engineering magazine.*)




Required:
- Diameter, ft
- Length, ft
- Design pressure, psig
- Shell material
- Fabrication (horiz. or vert.)

Time base: Mid-1968

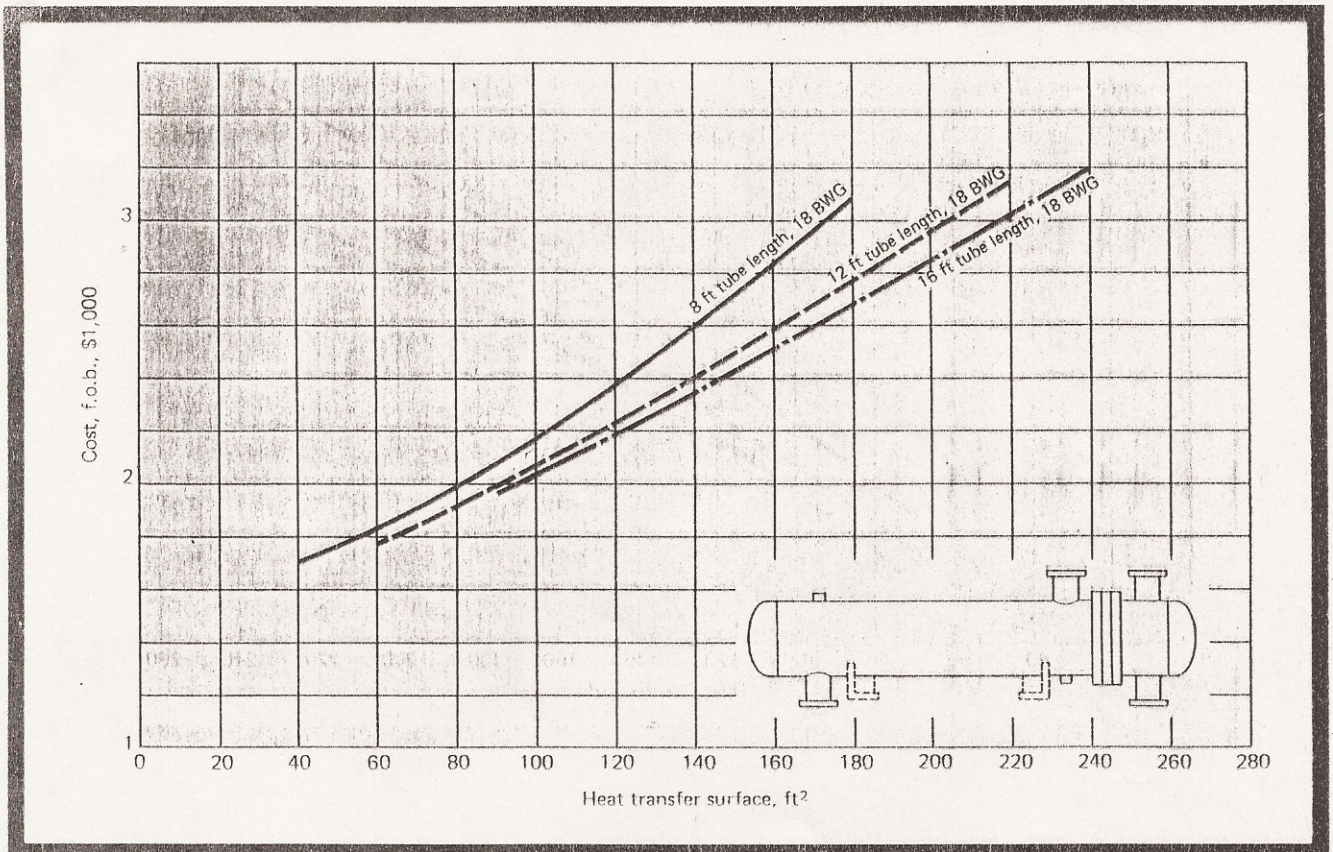
Exponent size:
- Vertical, 0.65
- Horizontal, 0.60

Included:
Vertical:
- Shell and 2 heads
- Nozzles and manways
- Skirt, bearing, and lugs
- Tray supports

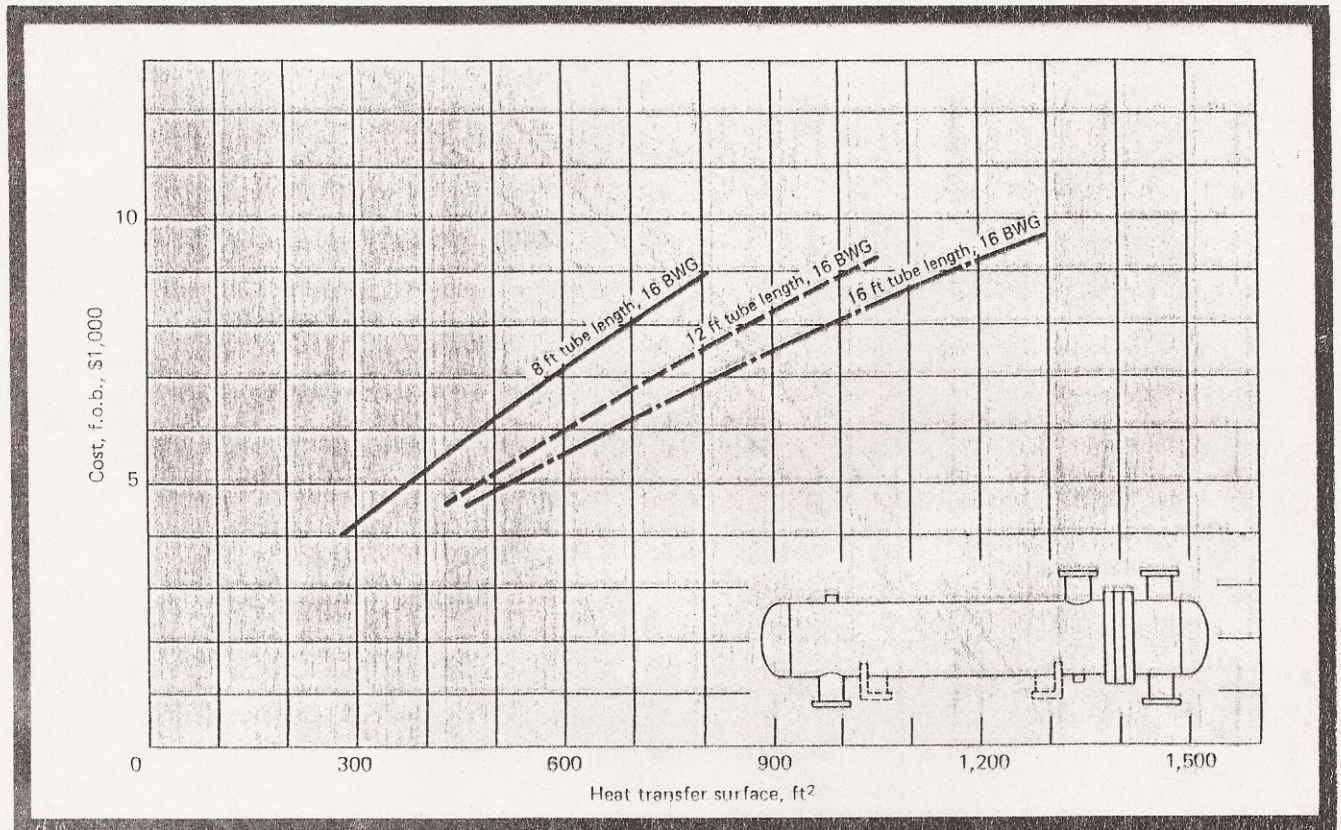
Horizontal:
- Shell and 2 heads
- Nozzles and manways
- Saddles, 2

Basis of chart:
- Carbon steel material
- 50-psi design pressure
- Average nozzles and manways
- ASME code construction
- Shop fabrication

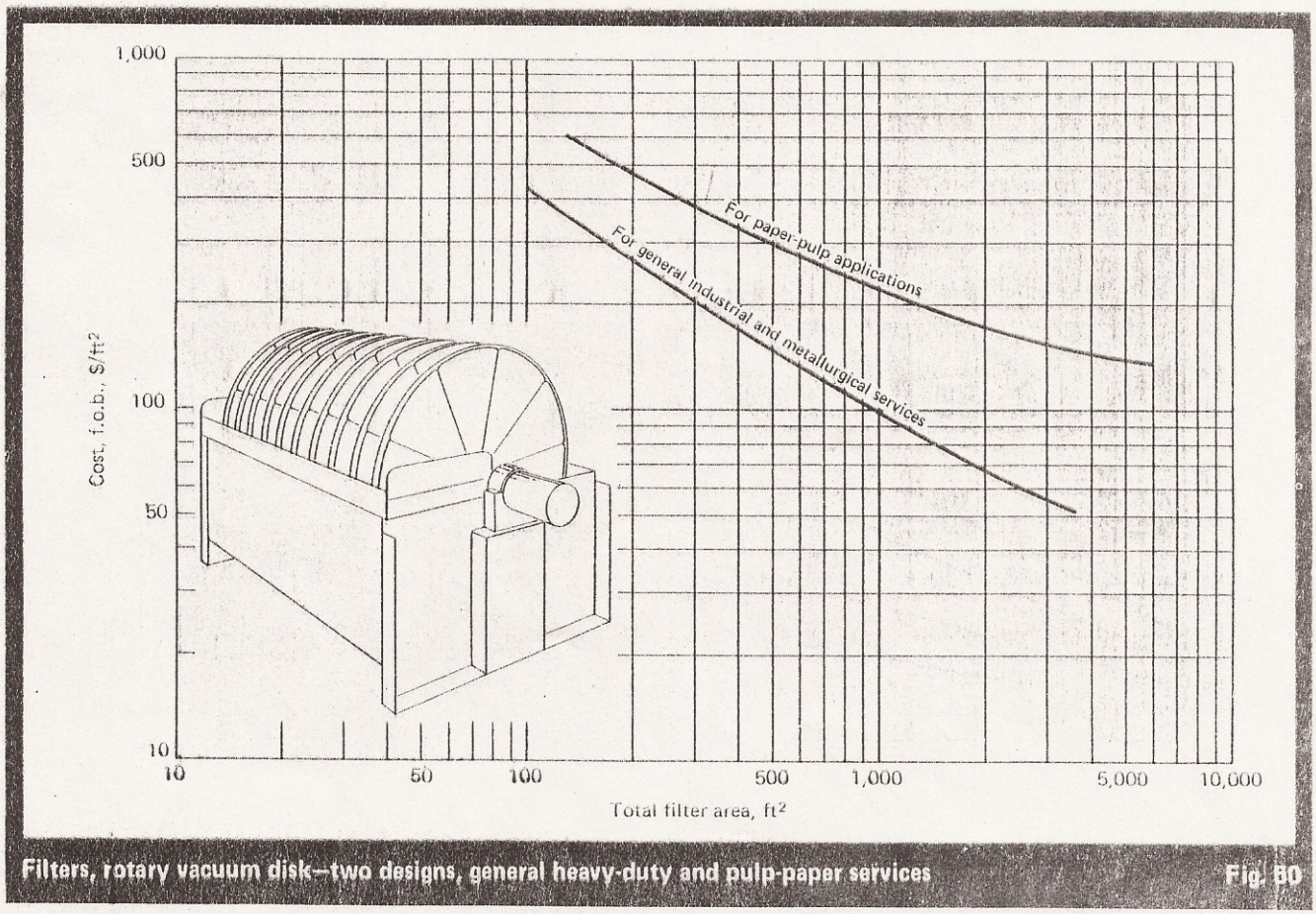
FIGURE 4.2.2
Purchased cost of pressure vessels. (*Guthrie, 1969, reproduced by permission of Chemical Engineering magazine.*)



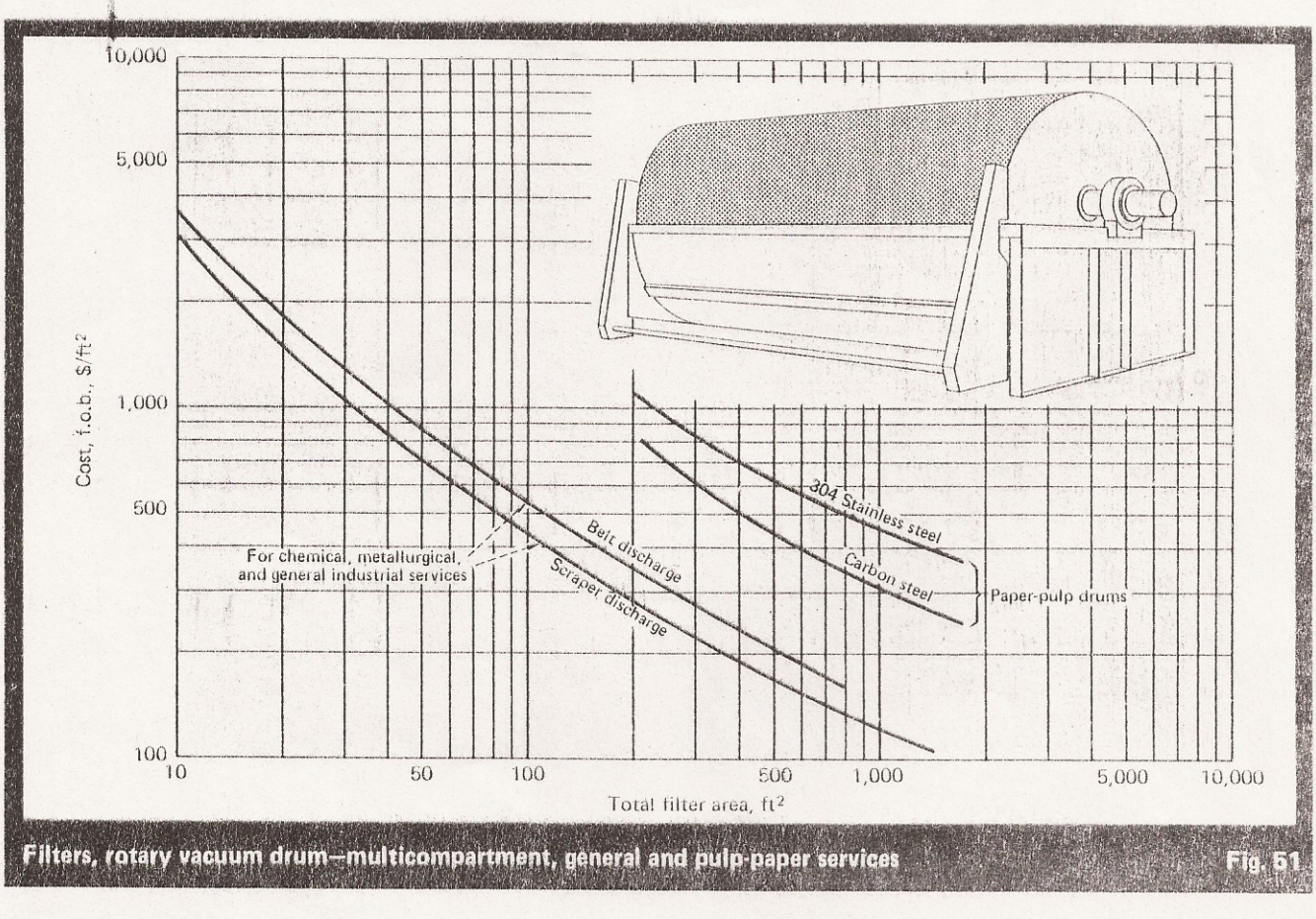

**Heat exchangers—U-tube, tubes of carbon steel, area 0-240 ft², carbon steel shell** **Fig. 17**



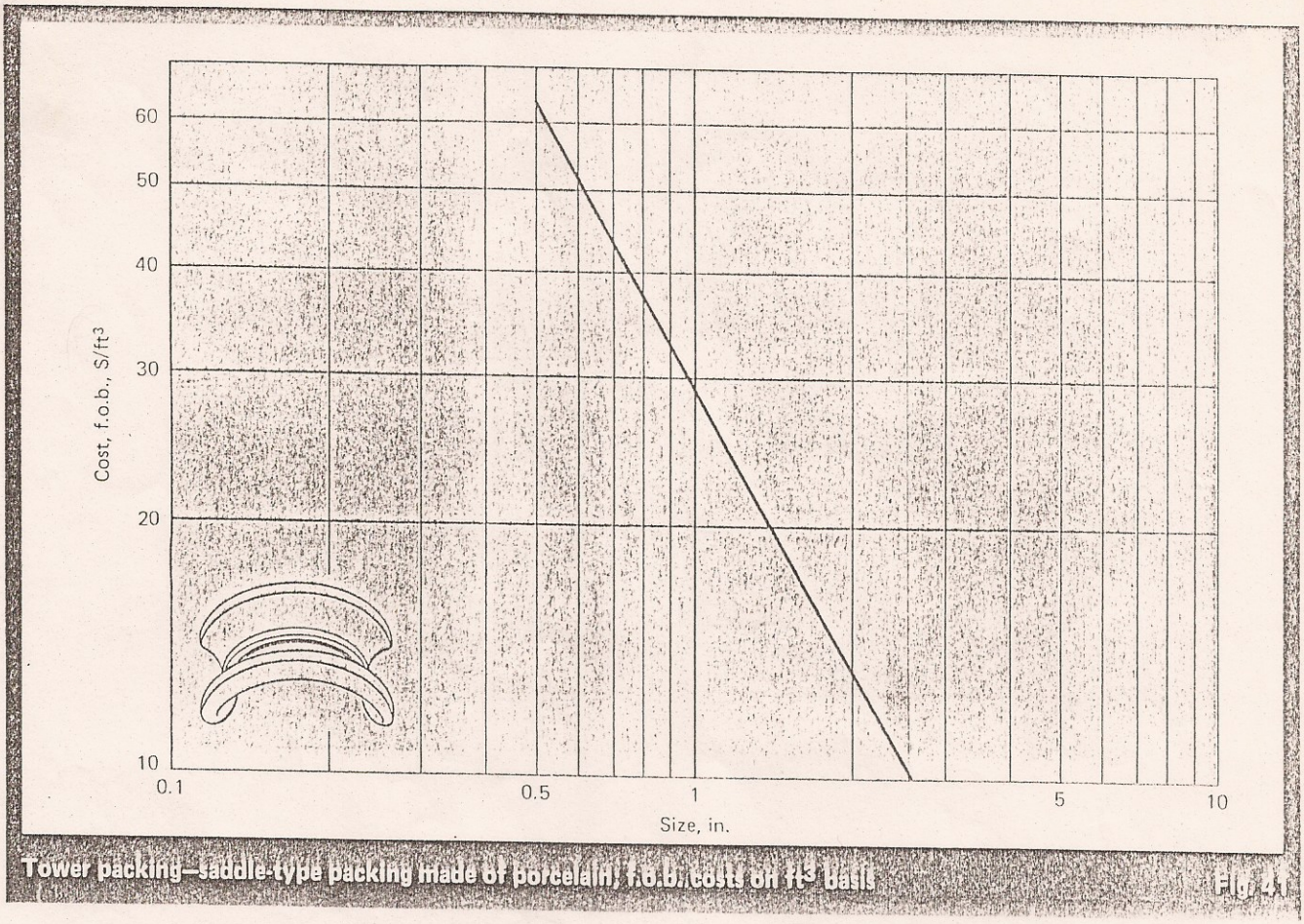

**Heat exchangers—U-tube, tubes of carbon steel, area 300-1,500 ft², carbon steel shell** **Fig. 18**



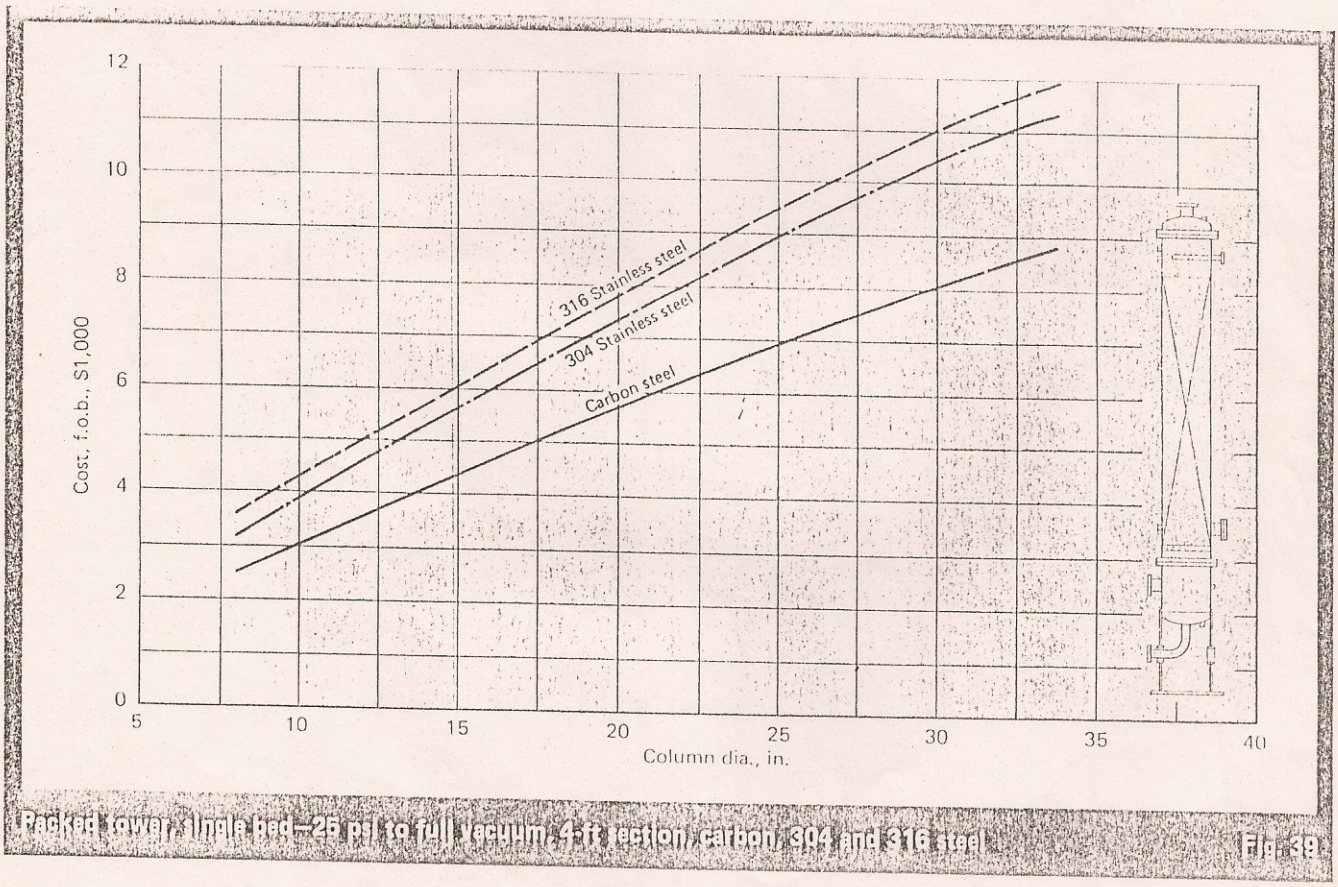

**Filters, rotary vacuum disk—two designs, general heavy-duty and pulp-paper services** **Fig. 50**



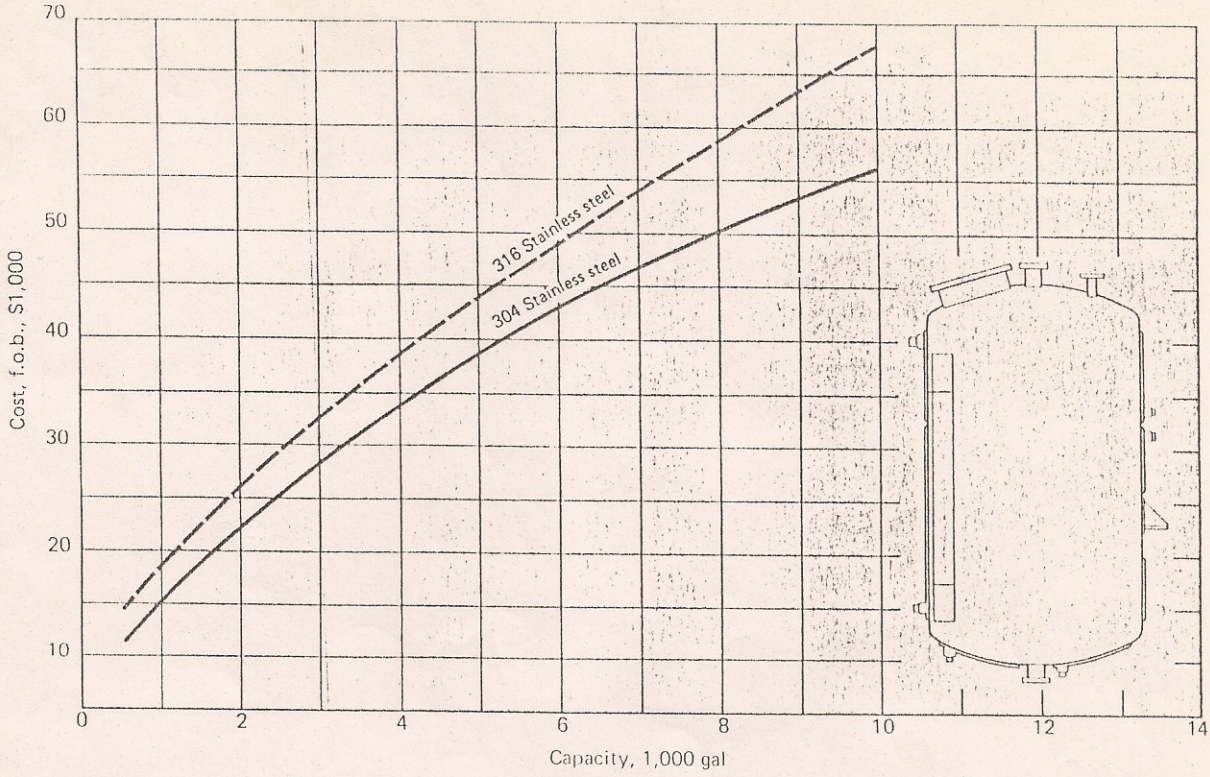

**Filters, rotary vacuum drum—multicompartment, general and pulp-paper services** **Fig. 51**



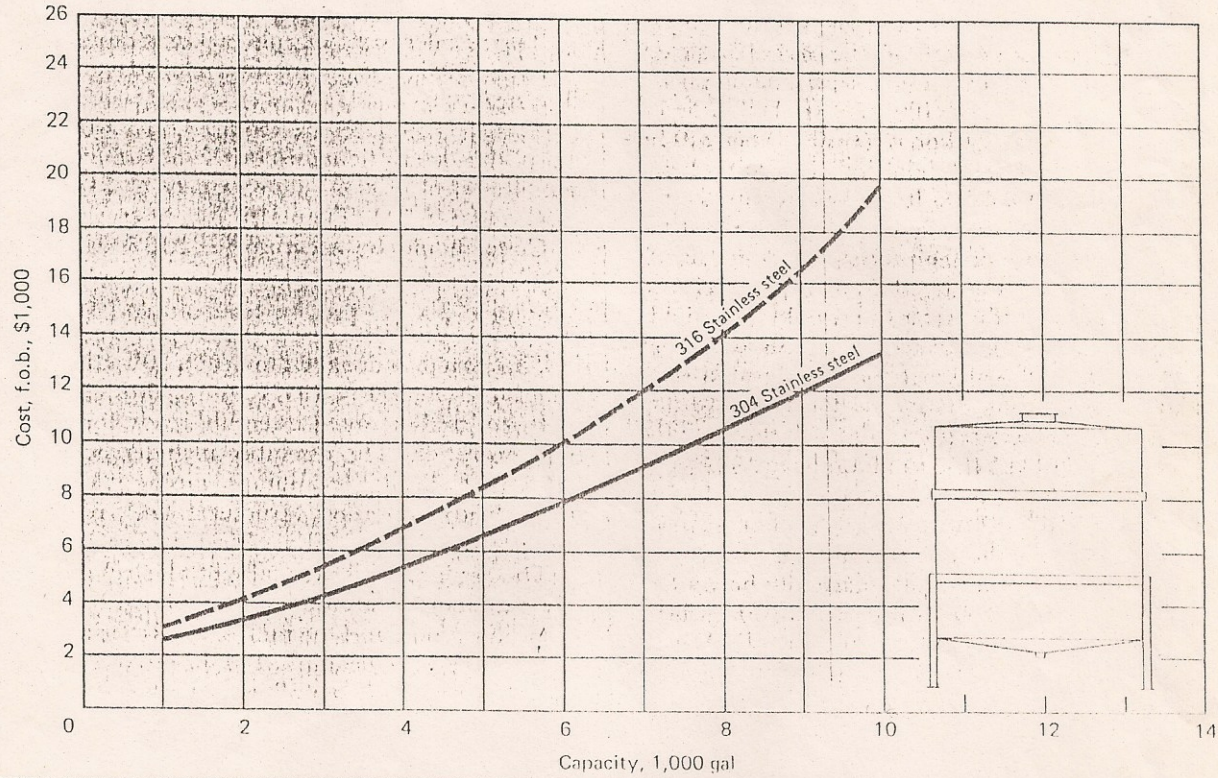

Tower packing—saddle-type packing made of porcelain; f.o.b. costs on ft³ basis Fig. 41



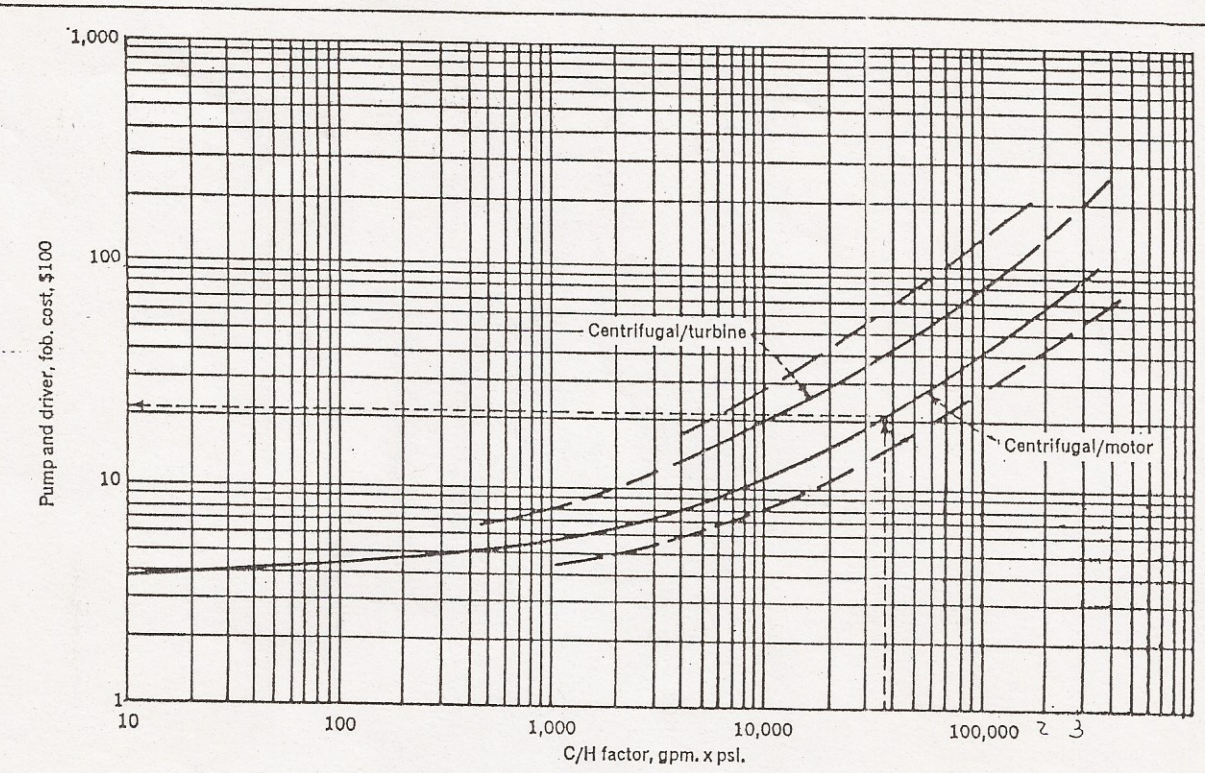

Packed tower, single bed—25 psi to full vacuum, 4-ft section, carbon, 304, and 316 steel Fig. 39




Dimple-jacketed reactors—stainless steel, 0-10,000 gal; reactor 75 psi, jacket 125 psi — Fig. 27




Storage tanks—Vertical, atmospheric, capacities to 10,000 gal, stainless steel, flat top and cone bottom — Fig. 6




**Required**
Capacity, gpm.
Differential pressure, psi.
Suction pressure, psig.
System temp., °F.
Casing material

**Exponent**
Average exponent 0.52

**Included**
Pumping unit
Driver and coupling
Base plate

$C/H = Q \cdot \Delta p$

Centrifugal pumps and drivers—Fig. 6

Centrifugal Pump Cost, $ = [Base cost × $F_m$ × $F_o$]Index

Adjustment factors

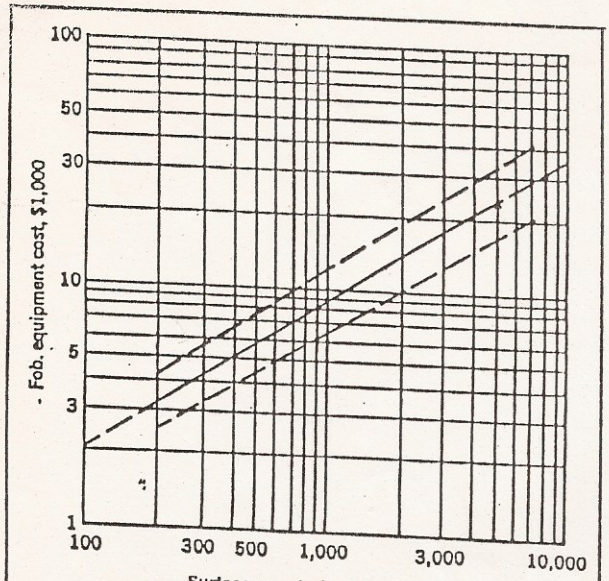
| Material | $F_m$ |
|---|---|
| Cast iron | 1.00 |
| Bronze | 1.28 |
| Cast steel | 1.32 |
| Stainless | 1.93 |
| Carpenter 20 | 2.10 |
| Worthite | 2.44 |
| Hastelloy C | 2.89 |
| Monel | 3.23 |
| Nickel | 3.48 |
| Titanium | 8.98 |

| Operating Limits | Max. value | | |
|---|---|---|---|
| Suction pressure, psig. | 150 | 500 | 1,000 |
| System temperature, °F. | 250 | 550 | 850 |
| Factor $F_o$ | 1.0 | 1.5 | 1.9 |

Field installation modules

| Module | 6A | 6B | 6C | 6D | 6E |
|---|---|---|---|---|---|
| Base dollar magnitude, $100,000 | Up to 2 | 2 to 4 | 4 to 6 | 6 to 8 | 8 to 10 |
| Equipment fob. cost, $E$ | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Piping | 30.2 | 29.8 | 29.6 | 29.5 | 29.4 |
| Concrete | 4.0 | 3.9 | 3.9 | 3.9 | 3.9 |
| Steel | — | — | — | — | — |
| Instruments | 3.0 | 2.9 | 2.9 | 2.9 | 2.9 |
| Electrical | 31.0 | 30.5 | 30.3 | 30.3 | 30.2 |
| Insulation | 2.5 | 2.5 | 2.5 | 2.4 | 2.4 |
| Paint | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| Field materials, $m$ | 71.5 | 70.4 | 70.0 | 69.8 | 69.6 |
| Direct material, $E + m \equiv M$ | 171.5 | 170.4 | 170.0 | 169.8 | 169.6 |
| Material erection | 60.0 | 59.2 | 59.0 | 58.6 | 58.5 |
| Equipment setting | 9.7 | 9.2 | 8.9 | 8.7 | 8.6 |
| Direct field labor, $L$ | 69.7 | 68.4 | 67.9 | 67.3 | 67.1 |
| Direct $M$ & $L$ cost | 241.2 | 238.8 | 237.9 | 237.1 | 236.7 |
| Freight, insurance, taxes | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 |
| Indirect cost | 89.2 | 81.2 | 78.5 | 78.2 | 75.7 |
| Bare module cost | 338.4 | 328.0 | 324.4 | 323.3 | 320.4 |
| $L/M$ ratios | 0.41 | 0.40 | 0.40 | 0.40 | 0.40 |
| Material factor, $E + m$ | 1.72 | 1.70 | 1.70 | 1.70 | 1.69 |
| Direct cost factor, $M$ & $L$ | 2.41 | 2.39 | 2.38 | 2.37 | 2.36 |
| Indirect factor | 0.37 | 0.34 | 0.33 | 0.33 | 0.32 |
| Module factor (norm) | 3.38 | 3.28 | 3.24 | 3.23 | 3.20 |

Note: All data are based on 100 for equipment, $E$.
Dollar magnitudes are based on carbon steel.




Required
Surface area, sq. ft.
Design type
Tube, shell material
Design pressure
Design temperature

Exponent
Size component 0.65

Basis of chart
Floating head
Carbon steel construction
Design pressure, 150 psi.

Included
Complete fabrication

Exchanger Cost, $ = [Base cost ($F_d + F_p$) × $F_m$] Index

Adjustment factors

| Design Type | $F_d$ |
|---|---|
| Kettle, reboiler | 1.35 |
| Floating head | 1.00 |
| U tube | 0.85 |
| Fixed tube sheet | 0.80 |

| Design Pressure, Psi. | $F_p$* |
|---|---|
| Up to 150 | 0.00 |
| 300 | 0.10 |
| 400 | 0.25 |
| 800 | 0.52 |
| 1,000 | 0.55 |

*If these factors are used individually, add 1.00 to these values.

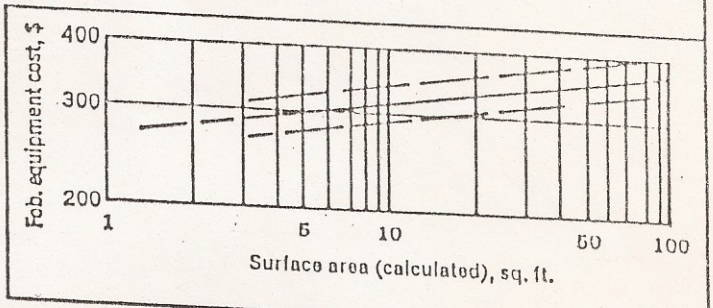
Shell/Tube Materials, $F_m$

| Surface Area, Sq. Ft. | CS/ CS | CS/ Brass | CS/ Mo | CS/ SS | SS/ SS | CS/ Monel | Monel /Monel | CS/ Ti | Ti/ Ti |
|---|---|---|---|---|---|---|---|---|---|
| Up to 100 | 1.00 | 1.05 | 1.60 | 1.54 | 2.30 | 2.00 | 3.20 | 4.10 | 10.28 |
| 100 to 500 | 1.00 | 1.10 | 1.75 | 1.78 | 3.10 | 2.30 | 3.50 | 5.20 | 10.60 |
| 500 to 1,000 | 1.00 | 1.15 | 1.82 | 2.25 | 3.26 | 2.50 | 3.6 | 6.15 | 10.75 |
| 1,000 to 5,000 | 1.00 | 1.30 | 2.15 | 2.81 | 3.75 | 3.[illegible] | 4.25 | 8.95 | 13.05 |
| 5,000 to 10,000 | 1.00 | 1.52 | 2.50 | 3.52 | 4.50 | 3.75 | 4.95 | 11.10 | 16.60 |

Field installation modules

| Module | 3A | 3B | 3C | 3D | 3E |
|---|---|---|---|---|---|
| Base dollar magnitude, $100,000 | Up to 2 | 2 to 4 | 4 to 6 | 6 to 8 | 8 to 10 |
| Equipment fob. cost, $B$ | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Piping | 45.6 | 45.1 | 44.7 | 44.4 | 44.3 |
| Concrete | 5.1 | 5.0 | 5.0 | 5.0 | 5.0 |
| Steel | 5.1 | 5.0 | 5.0 | 5.0 | 5.0 |
| Instruments | 10.2 | 10.1 | 10.0 | 9.9 | 9.8 |
| Electrical | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Insulation | 4.9 | 4.8 | 4.7 | 4.7 | 4.7 |
| Paint | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Field materials, $m$ | 71.4 | 70.5 | 69.9 | 69.5 | 69.3 |
| Direct material, $B + m = M$ | 171.4 | 170.5 | 169.9 | 169.5 | 169.3 |
| Material erection | 55.4 | 54.7 | 54.2 | 53.9 | 53.8 |
| Equipment setting | 7.6 | 6.5 | 5.9 | 5.5 | 5.2 |
| Direct field labor, $L$ | 63.0 | 61.2 | 60.1 | 59.4 | 59.0 |
| Direct $M$ & $L$ cost | 234.4 | 231.7 | 230.0 | 228.9 | 228.3 |
| Freight, insurance, taxes | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 |
| Indirect cost | 86.7 | 78.8 | 75.9 | 75.5 | 73.0 |
| Bare module cost | 329.1 | 318.5 | 313.9 | 312.4 | 309.5 |
| $L/M$ ratios | 0.37 | 0.36 | 0.35 | 0.35 | 0.35 |
| Material factor, $B + M$ | 1.71 | 1.70 | 1.70 | 1.69 | 1.69 |
| Direct cost factor, $M$ & $L$ | 2.34 | 2.32 | 2.30 | 2.29 | 2.28 |
| Indirect factor | 0.37 | 0.34 | 0.33 | 0.33 | 0.32 |
| Module factor (norm) | 3.29 | 3.18 | 3.14 | 3.12 | 3.09 |

Note: All data are based on 100 for equipment, $B$.
Dollar magnitudes are based on carbon steel.




Double-pipe exchanger costs (for process requirements less than 100 sq. ft. Specify double pipe units).

Adjustment factors

Material: CS/CS = 1.0, CS/SS = 1.85

| Pressure: | | |
|---|---|---|
| up to | 600 psi. | 1.00 |
| | 900 | 1.10 |
| | 1000 | 1.25 |

Module factors

| | |
|---|---|
| Field Installation | 1.35 |
| Module factor (norm) | 1.83 |

Shell-and-tube exchangers—Fig. 3

**Tabla 17. Factores relativos para la estimación de la inversión de capital para los diversos rubros, basados en el costo de los equipos entregados**

Los valores que figuran en esta Tabla se basan en plantas de procesos construidas durante los últimos diez años, como grandes ampliaciones de una planta en un terreno preexistente, donde el terreno necesario se encuentra disponible por compra o por ser de propiedad de la compañía. † Los valores se basan en inversiones de capital fijo desde menos de $ 1millón hasta más de $ 10 millones.

| *Rubro* | *Porcentaje del costo del equipo entregado para* | | |
|---|---|---|---|
| | *Planta que procesa sólidos* ‡ | *Planta que procesa sólidos y fluidos* ‡ | *Planta que procesa fluidos* ‡ |
| **Costos directos** | | | |
| Equipo adquirido y entregado (incluyendo equipo fabricado y maquinaria para el proceso) § | 100 | 100 | 100 |
| Instalación del equipo adquirido | 45 | 39 | 47 |
| Instrumentación y controles (instalados) | 9 | 13 | 18 |
| Cañerías y tuberías (instaladas) | 16 | 31 | 66 |
| Instalaciones eléctricas (colocada) | 10 | 10 | 11 |
| Obras civiles (incluyendo servicios) | 25 | 29 | 18 |
| Mejoras del terreno | 13 | 10 | 10 |
| Instalaciones de servicios (montadas) | 40 | 55 | 70 |
| Terreno (si es necesario adquirirlo) | 6 | 6 | 6 |
| Costo directo total de la planta | 264 | 293 | 346 |
| **Costos indirectos** | | | |
| Ingeniería y supervisión | 33 | 32 | 33 |
| Gastos de construcción | 39 | 34 | 41 |
| Total de costos directos e indirectos de la planta | 336 | 359 | 420 |
| Honorarios del contratista (aproximadamente el 5%de los costos directos e indirectos de la planta) | 17 | 18 | 21 |
| Eventuales (alrededor del 10% de los costos directos e indirectos de la planta) | 34 | 36 | 42 |
| Inversiones de capital fijo | 387 | 413 | 483 |
| Capital de trabajo (alrededor del 15% de la inversión total de capital) | 68 | 74 | 86 |
| Inversión total de capital | 455 | 487 | 569 |

# Economic Indicators

2009 2008

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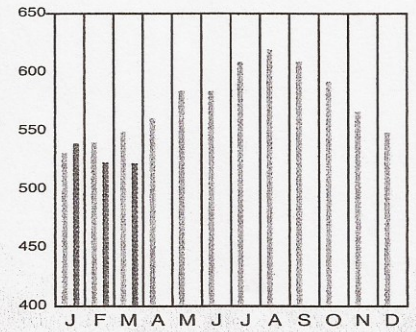
## CHEMICAL ENGINEERING PLANT COST INDEX (CEPCI)

| (1957-59 = 100) | Mar. '09 Prelim. | Feb. '09 Final | Mar. '08 Final |
|---|---|---|---|
| ***CE* Index** | 522.6 | 532.3 | 549.2 |
| Equipment | 616.6 | 631.9 | 659.5 |
| Heat exchangers & tanks | 563.2 | 587.0 | 631.5 |
| Process machinery | 597.2 | 615.2 | 616.4 |
| Pipe, valves & fittings | 761.0 | 770.6 | 795.7 |
| Process instruments | 385.2 | 384.6 | 431.0 |
| Pumps & compressors | 898.0 | 897.0 | 857.6 |
| Electrical equipment | 459.6 | 458.7 | 452.2 |
| Structural supports & misc | 636.1 | 660.9 | 694.7 |
| Construction labor | 325.7 | 323.7 | 317.1 |
| Buildings | 494.8 | 495.5 | 486.8 |
| Engineering & supervision | 349.0 | 349.8 | 354.9 |

**Annual Index:**
**2001 = 394.3**
**2002 = 395.6**
**2003 = 402.0**
**2004 = 444.2**
**2005 = 468.2**
**2006 = 499.6**
**2007 = 525.4**
**2008 = 575.4**

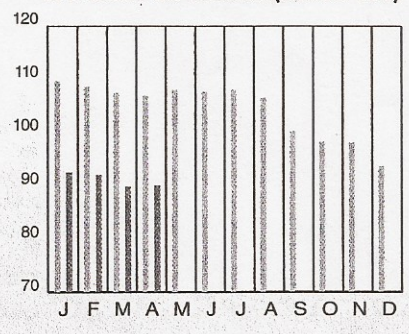



Starting with the April 2007 Final numbers, several of the data series for labor and compressors have been converted to accommodate series IDs that were discontinued by the U.S. Bureau of Labor Statistics

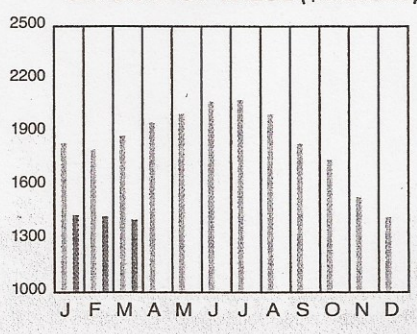
## CURRENT BUSINESS INDICATORS

| | LATEST | | PREVIOUS | | | YEAR AGO | | |
|---|---|---|---|---|---|---|---|---|
| CPI output index (2000 = 100) | Apr. '09 = | 90.0 | Mar. '09 = | 89.8 | Feb. '09 = | 92.0 | Apr. '08 = | 106.7 |
| CPI value of output, $ billions | Mar. '09 = | 1,411.5 | Feb. '09 = | 1,430.2 | Jan. '09 = | 1,436.7 | Mar. '08 = | 1,877.6 |
| CPI operating rate, % | Apr. '09 = | 65.6 | Mar. '09 = | 65.4 | Feb. '09 = | 67.0 | Apr. '08 = | 78.3 |
| Producer prices, industrial chemicals (1982 = 100) | Apr. '09 = | 218.3 | Mar. '09 = | 224.0 | Feb. '09 = | 224.1 | Apr. '08 = | 270.7 |
| Industrial Production in Manufacturing (2002=100)* | Apr. '09 = | 95.5 | Mar. '09 = | 95.8 | Feb. '09 = | 97.9 | Apr. '08 = | 111.7 |
| Hourly earnings index, chemical & allied products (1992 = 100) | Apr. '09 = | 145.5 | Mar. '09 = | 145.5 | Feb. '09 = | 145.7 | Apr. '08 = | 141.2 |
| Productivity index, chemicals & allied products (1992 = 100) | Apr. '09 = | 129.7 | Mar. '09 = | 128.5 | Feb. '09 = | 128.2 | Apr. '08 = | 133.9 |

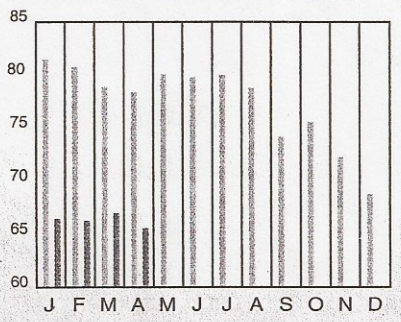
### CPI OUTPUT INDEX (2000 = 100)




### CPI OUTPUT VALUE ($ BILLIONS)




### CPI OPERATING RATE (%)



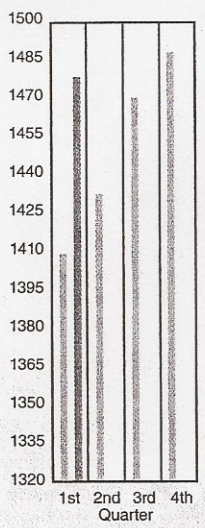

*Due to discontinuance, the Index of Industrial Activity has been replaced by the Industrial Production in Manufacturing index from the U.S. Federal Reserve Board.
Current business indicators provided by Global insight, Inc., Lexington, Mass.

## MARSHALL & SWIFT EQUIPMENT COST INDEX

| (1926 = 100) | 1st Q 2009 | 4th Q 2008 | 3rd Q 2008 | 2nd Q 2008 | 1st Q 2008 |
|---|---|---|---|---|---|
| **M & S INDEX** | 1,477.7 | 1,487.2 | 1,469.5 | 1,431.7 | 1,408.6 |
| Process industries, average | 1,553.2 | 1,561.2 | 1,538.2 | 1,491.7 | 1,463.2 |
| Cement | 1,551.1 | 1,553.4 | 1,522.2 | 1,473.5 | 1,448.1 |
| Chemicals | 1,523.8 | 1,533.7 | 1,511.5 | 1,464.8 | 1,438.5 |
| Clay products | 1,526.4 | 1,524.4 | 1,495.6 | 1,453.5 | 1,429.1 |
| Glass | 1,439.8 | 1,448.1 | 1,432.4 | 1,385.1 | 1,359.7 |
| Paint | 1,554.1 | 1,564.2 | 1,543.9 | 1,494.8 | 1,467.6 |
| Paper | 1,453.3 | 1,462.9 | 1,443.1 | 1,400.0 | 1,377.7 |
| Petroleum products | 1,663.6 | 1,668.9 | 1,644.4 | 1,594.4 | 1,555.8 |
| Rubber | 1,600.3 | 1,604.6 | 1,575.6 | 1,537.5 | 1,512.3 |
| Related industries | | | | | |
| Electrical power | 1,425.0 | 1,454.2 | 1,454.4 | 1,412.8 | 1,380.4 |
| Mining, milling | 1,573.0 | 1,567.5 | 1,546.2 | 1,498.9 | 1,473.3 |
| Refrigeration | 1,807.3 | 1,818.1 | 1,793.1 | 1,741.4 | 1,711.9 |
| Steam power | 1,509.3 | 1,521.9 | 1,499.3 | 1,453.2 | 1,426.8 |

**Annual Index:**

| | | | |
|---|---|---|---|
| **2001 = 1,093.9** | **2003 = 1,123.6** | **2005 = 1,244.5** | **2007 = 1,373.3** |
| **2002 = 1,104.2** | **2004 = 1,178.5** | **2006 = 1,302.3** | **2008 = 1,449.3** |

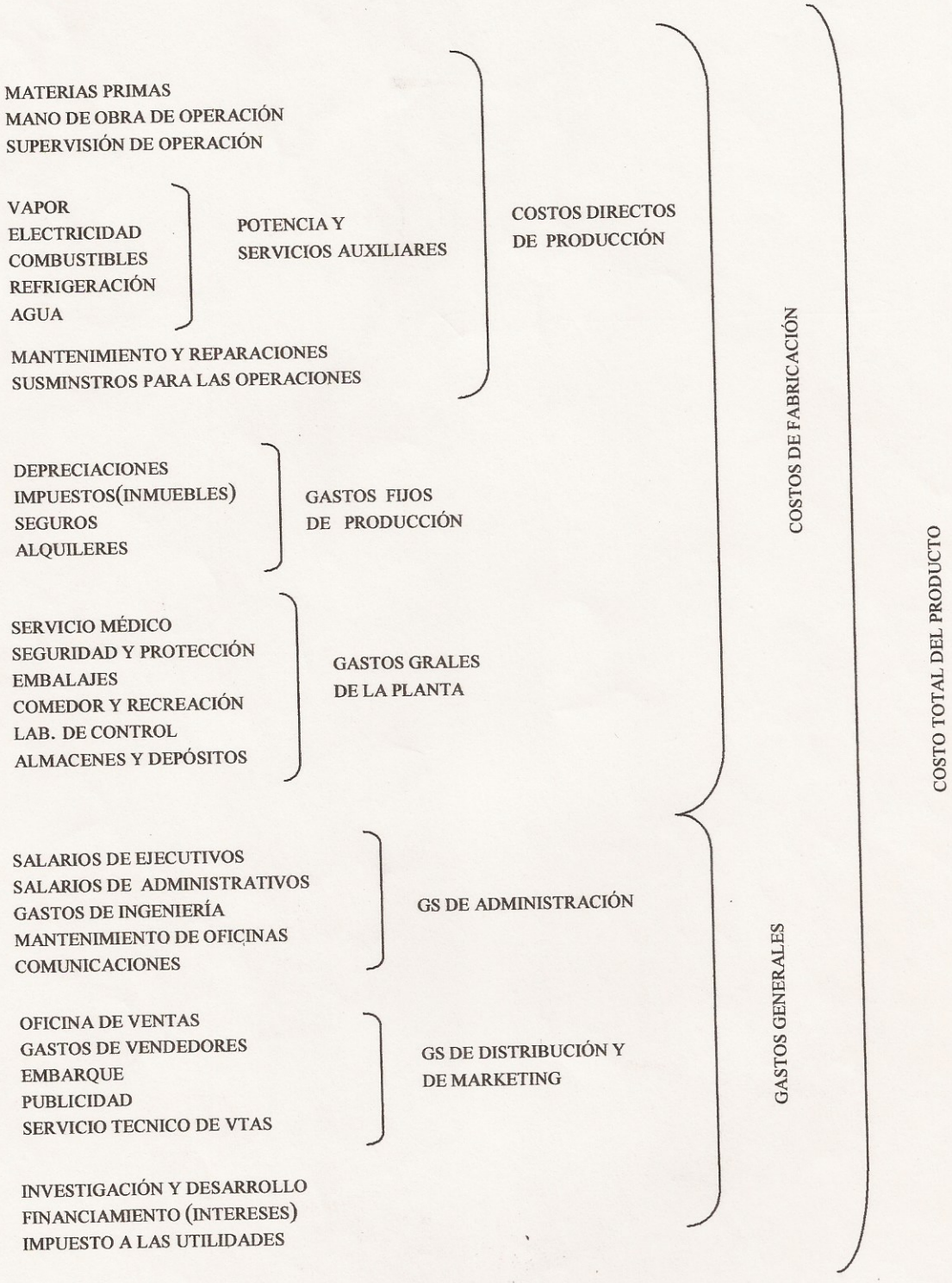



## CURRENT TRENDS

Although previous trends suggested that the month-over-month decline in equipment prices might be waning, preliminary estimates for the April CEPCI show that slightly sharper declines in equipment prices returned. Meanwhile, as expected, the operating rate edged up slightly in April — an indication that the U.S. has reached the bottom of widespread overcapacity.

Visit www.che.com/pci for more on capital cost trends and methodology. ■

## ESTIMACION DEL COSTO TOTAL DEL PRODUCTO



# Economic Indicators

2013 2014 2015

**Download the CEPCI two weeks sooner at www.chemengonline.com/pci**

## CHEMICAL ENGINEERING PLANT COST INDEX (CEPCI)

| (1957-59 = 100) | Nov. '15 Prelim. | Oct. '15 Final | Nov. '14 Final |
|---|---|---|---|
| CE Index | 543.0 | 547.2 | 578.4 |
| Equipment | 648.9 | 654.9 | 702.5 |
| Heat exchangers & tanks | 566.6 | 575.4 | 649.3 |
| Process machinery | 652.3 | 655.0 | 662.9 |
| Pipe, valves & fittings | 803.4 | 808.6 | 875.4 |
| Process instruments | 386.6 | 390.1 | 411.7 |
| Pumps & compressors | 956.5 | 956.4 | 942.9 |
| Electrical equipment | 508.4 | 508.2 | 516.2 |
| Structural supports & misc | 713.4 | 723.6 | 769.9 |
| Construction labor | 324.3 | 325.8 | 322.4 |
| Buildings | 539.3 | 540.4 | 546.9 |
| Engineering & supervision | 318.2 | 317.7 | 320.1 |

Starting with the April 2007 Final numbers, several of the data series for labor and compressors have been converted to accommodate series IDs that were discontinued by the U.S. Bureau of Labor Statistics

Annual Index:
2007 = 525.4
2008 = 575.4
2009 = 521.9
2010 = 550.8
2011 = 585.7
2012 = 584.6
2013 = 567.3
2014 = 576.1