



COMPASS

INTERNATIONAL INC.



2018

**Front-End / Conceptual
Estimating Yearbook**

17TH EDITION



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ABOUT THE FIRM



Compass International Consultants Inc. (C.I.C.I) was founded in 1992 and is a provider of Estimating Services, International Construction Cost Data, Location Factors, Estimating Training Seminars, Value Engineering, Production and Review of Claims, Estimating Support and a provider of Global Conceptual Construction Economic Cost Data. Compass International is backed by an excellent team of experienced Cost Engineers, Cost Estimators, Planners, Civil / Mechanical / Chemical Engineers and Economists.

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This data source is the result of more than 20+ year's research and data collection. The information contained in this data source was collected from more than 100 + completed CAPEX projects (Refinery, Chemical and Manufacturing facilities) located in North America, the UK, Mainland Europe, Asia, Africa and South America valued between \$0.30 million to over \$3 billion. The data is for the most part based on Compass International's cost library, augmented with latest cost and labor data from International Development Banks and Agencies, EU Commission Reports, various Country National Libraries and Bibliothèques from around the world, various Government Information Agencies, Global Quasi-Governance Organizations, an assortment of Government Trade Promotion Departments / Labor Departments, numerous trade magazines, hourly and annual salary rates from US / Overseas labor organizations and newspaper articles, professional society articles, an assortment of technical magazine articles, various international almanacs and directories, reference books, internet data and various cost – construction proposals and bids from contractors and engineering firms together with related journals, the cost models and tables have also been augmented by a number of personal estimating libraries (that in some cases are very recent), this information has been audited, expanded upon, modified and calibrated and refined to today's construction methods and installation applications. We would like to express our sincere thanks to the many engineers, contractors, vendors and other individuals (friends and colleagues) too many to mention who have given freely of their advice, input, time and knowledge so that this data source could be produced for the benefit of engineering and construction professionals that have an interest in this subject matter. We welcome any comments or data that could be used in future updates to make this database more complete and accurate.

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Compass International Consultants Inc.

Morrisville, Pennsylvania, USA



General Information: Introduction to CAPEX Estimating

Introduction to Front End / Conceptual Estimating: *"A Front End / Conceptual estimate is an estimation of the cost of a proposed CAPEX project based on initial conceptual engineering and design data, even though the specific details are not clearly revealed or specified at this early stage of the proposed CAPEX project. An all-inclusive value is required to determine the viability of the proposed undertaking."*

The completion of a front-end estimate / conceptual estimate is usually the first step in the CAPEX Budgeting / Estimating process. This publication has been compiled to assist all construction professionals with an annual reference guide that will help them with "quick" reasonably accurate construction prices for work associated with chemical plants, refineries, manufacturing facilities and other related industrial plants. A vast number of challenges and hurdles remain in place for "Process / Manufacturing / Chemical" companies (and their decisions to build new / revamped facilities): as we look into the future as of late 2017, the issues to be faced in 2018 and beyond include numerous issues (that have financial, construction and operating cost consequences) that will need to be gauged and planned for, if the decision is made to proceed with the EPC effort. The Process / Manufacturing / Chemical industry as the engineering / construction professionals knew it in the early years of the last decade will have changed dramatically in the next two or three decades. Emerging economies such as China, India, Brazil

and South Korea to name but a few will continue to forge ahead in developing their R & D and manufacturing bases, there is an increasing anxiety in some of the more developed nations as to how this will all play out and what impact this manufacturing / economic

"sea change" will have on the future employment opportunities, facility costs and engineering / construction activities in Western Europe, North America and around the world. Hopefully, this publication and its' future updates will assist the reader in navigating and understanding the dynamics of this situation, and the associated engineering / construction related costs specific to Process / Manufacturing / Chemical facilities. down all other legislation topics.

The more than one dozen industrial petro-chemical CAPEX projects valued between \$25 to \$50 billion currently under construction on the U.S. Gulf Coast have the need for over 25,000 to 40,000 imported welders, pipefitters, ironworkers and electricians etc.

THE GENERAL FORECAST FOR 2018 AND BEYOND

(Specific to the Process / Manufacturing / Chemical Industry and to the construction of these facilities).

- The more than one dozen industrial petro-chemical CAPEX projects valued between \$25 to \$50 billion currently under construction on the U.S.

Issues and Factors

IMPACTING THE BOTTOM LINE OF A CAPEX ESTIMATE ENGINEERING

#	ISSUES AND FACTORS
1	Production of design deliverables / specifications (who produces Owner or EPC firm / when).
2	C / S / A design deliverables (who produces / when).
3	Process Flow Diagrams (who produces – Owner or EPC firm / when).
4	E/I design deliverables / Control Philosophy / Classification (does owner have a preferred vendor who produces outline spec / when).
5	Piping design and detailing (who produces – does this exist – has Owners Engineering group produced the first draft of this document / when).
6	Relevant codes to be utilized.
7	Other Engineering issues.
PROCUREMENT	
1	Long lead items (M.E. items) some complex items such as a multi-stage compressor could take as long as twelve months to design and produce.
2	Freight issues.
3	Import duties.
4	Bulk material purchasing.
5	Expediting.
6	Inspection / trafficking / performance testing.
7	Warehousing.
8	Early delivery bonuses / payments.
9	Other Procurement issues i.e. spare parts, vendor assistance.
CONSTRUCTION	
1	Location of facility (USA or Overseas).
2	Weather issues (cold or hot climate).
3	Productivity expectations of workforce.
4	Union / Non union / Merit Shop construction approach.
5	Plant start up activities.
6	Labor availability and possible overtime / shift work requirements.
7	Protection of the completed work.
8	General Conditions / Preliminaries.
9	Construction equipment usage.
10	Establish camp / Establish concrete batch plant.
11	All required permits.
12	Small tools / Consumables.
13	Guards / Security.
14	Special safety issues.
15	Cleaning protocols / special requirements.
PROJECT SPECIFIC ITEMS	
1	Completion date (Normal schedule or fast track schedule).
2	Escalation / Taxes.
3	Operator Training issues.
4	Owner costs / Owner provided items.
5	Contractual issues / Type of contract.
6	Warranty issues (procure extended warranty period).
7	Payment terms / Financing costs.
8	Currency impact issues.
9	Insurance issues (BAR / Umbrella / Bonds).
10	Liquidated damages / Consequential damages clauses.
11	Bonus / Penalty clause for early or delayed completion.
12	Contingency issues (technical and general contingency).

PROCESS UNIT / MAJOR EQUIPMENT / CONSTRUCTION RELATED COST - CAPACITY EQUATIONS / EXPONENTS

Formaldehyde facility	0.60
Furnace box	0.75
Furnace cylindrical	0.80
Gas-recycling unit	0.73
Gas dehydration unit	0.65
Glycol unit	0.70
Hammer mill	0.81
Heaters, gas fired	0.45
Heat Exchanger u tube	0.55
Heat Exchanger S/T, floating head c.s. 200SF	0.62
Heat Exchanger S/T fixed sheet c.s. 200 SF	0.48
Hopper / Silo conical	0.65
Hydrochloric acid facility	0.70
Hydrogen production facility	0.67
Hydrogen Peroxide	0.72
Hydrofluoric Acid plant	0.71
Hydrogen sulfide stripping unit	0.61
Hydro treating unit (desulfurization)	0.68
Isomerization unit	0.65
Isoprene	0.59
Kettle, glass line 500 gallon and above	0.40
Jacketed reactor	0.55
Liquefied Petroleum-gas recovery plant	0.66
Lube oil plant	0.68
Methanol plant	0.66
MTBE facility	0.65
Natural gas facility	0.63
Nitric acid	0.65
Nylon facility	0.63
Oxo – Alcohols unit	0.73
Oxygen production plant	0.68
Paraffins facility	0.65
Paraxylene facility	0.60
PET facility	0.58
Phenol plant (High Purity)	0.70
Phthalic Anhydride facility	0.68
Phosphoric Acid plant	0.64
Polyethylene plant (High Density)	0.62
Polymer plant, large unit	0.66
Polymerization	0.55
Polymer plant, small unit	0.75
Polyvinyl Chloride facility	0.63
Power Plant Coal 150 – 1,500 MW	0.85
Power Plant Gas 150 – 1,500 MW	0.82
Power Plant Oil 150 – 1,500 MW	0.85

PROCESS UNIT / MAJOR EQUIPMENT / CONSTRUCTION RELATED COST - CAPACITY EQUATIONS / EXPONENTS

Power Plant Nuclear 150 – 1,500 MW	0.77
Precipitator dust collector	0.75
Pressure Vessel (CS)	0.60
Pressure Vessel (SS)	0.65
Propane Deasphalting plant	0.60
Propane Dewaxing plant	0.54
Propylene unit	0.72
Pulverizer mill	0.37
Pump centrifugal 400 GPM and above	0.37
Reactor, C.S. or S.S. 1,000 gallon and above	0.50
Reactor SS glass lined 1,000 gallon and above	0.55
Refineries, 50,000 barrels / day & above and larger	0.63
Refineries, 50,000 barrels / day & smaller	0.65
Reforming, catalysts units	0.60
Refrigeration plant	0.65
Rotary Drum Filter	0.66
Roller mill	0.63
Scrubber	0.70
Separator centrifugal	0.55
Soda bicarbonate facility	0.68
Solvent extraction plant	0.88
Solvent dewaxing unit	0.72
Soybean extraction plant	0.73
Sphere storage tank	0.72
Styrene plant	0.77
Steam Boiler / Production 100 psi	0.63
Steam Boiler / Production 500 psi	0.77
Sulfur production / recovery unit (Clause / Amine)	0.63
Sulfuric acid plant	0.67
Tanks C.S. Floating head 10,000 gallon and above	0.54
Tank C.S. Glass lined	0.51
Topping Unit	0.66
Tower C.S. W/o trays	0.60
Toluene facility	0.67
Transformer	0.58
Tray sieve type	0.83
Turbine	0.66
Urea plant	0.75
Vacuum Distillation unit	0.62
Vacuum Flash unit	0.64
Vibrating screen	0.65
Vinyl acetate	0.68
Vinyl chloride unit	0.83
Visbreaker	0.63
NON EQUIPMENT – FACILITY ITEMS:	
Civil works	0.67
Construction Labor	0.45
Piping	0.87
Structural steel	0.67
Engineering / Drafting work	0.47

Construction Cost Range per SCFD

2018 COST BASIS

LOCATION	FACILITY SIZE SCFD	\$ CONSTRUCTION COST (LOW) EXCLUDES, MAJOR EQUIPMENT, TAGGED ITEMS, ELECTRICAL EQUIPMENT, PIPE / STRUCTURAL STEEL MATERIALS , OFFSITE FABRICATION & CONSTRUCTION MANAGEMENT, INCLUDES CIVIL / CONCRETE, FIELD RUN PIPING, E & I, INSULATION, REFRACTORY & PAINTING	\$ CONSTRUCTION COST (HIGH) EXCLUDES, MAJOR EQUIPMENT, TAGGED ITEMS, ELECTRICAL EQUIPMENT, PIPE / STRUCTURAL STEEL MATERIALS , OFFSITE FABRICATION & CONSTRUCTION MANAGEMENT, INCLUDES CIVIL / CONCRETE, FIELD RUN PIPING, E & I, INSULATION, REFRACTORY & PAINTING	\$ COST PER SCFD (LOW)	\$ COST PER SCFD (HIGH)
N.W. USA (Merit Shop)	20,000,000	12,600,000	18,270,000	0.63	0.91
Mid-West USA (Merit Shop)	30,000,000	18,000,000	26,100,000	0.60	0.87
N.W. USA (Merit Shop)	40,000,000	22,800,000	33,060,000	0.57	0.83
Mid-West USA (Union)	50,000,000	28,750,000	41,687,500	0.58	0.83
Gulf Coast USA (Open Shop)	60,000,000	32,700,000	47,415,000	0.55	0.79

Table 23

CAPEX & OPEX 50,000 B/D OIL PROCESSING REFINERY USA GULF COAST 2018 BASED ON (3) SIMILAR SIZED COMPLETED REFINERIES. OPEN SHOP LABOR (I.E. NON-UNION)

#	DESCRIPTION / OPERATING UNIT	M.E. / TAGGED ITEMS / BULK MATERIAL % SPLIT	LABOR % SPLIT INCL IN-DIRECTS	LOW \$ COST MILLIONS	HIGH \$ COST MILLIONS
1	Atmospheric / Vacuum Condensate Distillation Unit including Piping, E&I, Isulation, painting & field indirects	62	38	102.6	200.1
2	Isomerisation ditto	65	35	44.3	86.4
3	FCC / Cat Cracker / Catalytic Reformer ditto	62	38	116.2	226.6
4	Alkylolation Unit ditto	65	35	2.9	5.7
5	Kerosene Unit ditto	65	35	2.4	4.7
6	Diesel Hydrotreater ditto	62	38	5.5	10.7
7	Amine Unit ditto	65	35	10.7	20.8
8	Saturated Gas Unit ditto	65	35	15.3	29.9
9	Naphtha Hydrotreater ditto	65	35	57.8	112.6
10	Lube Oil Unit ditto	65	35	6.9	13.5
11	Delayed Coker Unit ditto	65	35	4.3	8.4
12	Sour Water Stripper Unit ditto	62	38	10.0	19.5
13	Dewaxing Unit ditto	60	40	3.5	6.9
14	Caustic Unit ditto	60	40	6.1	11.9
15	LPG Unit ditto	65	35	3.3	6.4
16	Sulphur Recovery Unit ditto	60	40	12.2	23.8
17	Claus / Tail Gas Unit ditto	60	40	1.9	3.8
18	Desalter Unit ditto	60	40	1.2	2.3
19	Hydrogen / Pressure Swing Absorption Unit ditto	65	35	3.9	7.5
20	Waste Water Treatment Unit ditto	50	50	9.3	18.1

NO. OF M.E. ITEMS	CUBIC YARDS / PER M.E. ITEM
25	515 / 20.6
50	788 / 15.76
100	1,137 / 11.37
200	2,269 / 11.34
300	3,331 / 11.10

Tons of Structural Steel per piece of Major Equipment (I.S.B.L.): For applications where the M.E. count is less than 25 use 3.0 tons per M.E. item.

NO. OF M.E. ITEMS	TONS OF S.S. / PER M.E. ITEM
25	69 / 2.76
50	117 / 2.34
100	221 / 2.21
200	423 / 2.11
300	689 / 2.2

LF of pipe per piece of Major Equipment (I.S.B.L.): For applications where the M.E. count is less than 25 use 650 LF per M.E. item.

NO. OF M.E. ITEMS	LF OF PIPE / PER M.E. ITEM
25	14,370 / 575
50	26,370 / 527
100	48,760 / 488
200	73,830 / 369
300	94,167 / 313

Heat Exchanger (S & T) C.S.:

AREA	COST PER SF
100	\$82 - \$128
500	\$56 - \$97
1,000	\$35 - \$65

Heat Exchanger (S & T) Polished S.S.:

AREA	COST PER SF
100	\$403 - \$740
500	\$168 - \$303
1,000	\$139 - \$185

Vessel Atmosphere / Pressure, C.S.

GALLONS	COST PER GALLON
100	\$56 - \$92
500	\$25 - \$45
1,000	\$13 - \$20
5,000	\$4.10 - \$9.20
10,000	\$2.80 - \$4.60

Tower (Distillation) with 20 – 30 trays 60' to 70' high

DIA. / INCHES	100 PSI MATERIAL ONLY \$ COST	250 PSI MATERIAL ONLY \$ COST
24	\$64,870	\$85,850
36	\$82,365	\$94,333
48	\$86,671	\$113,892
60	\$96,217	\$134,777
72	\$132,677	\$190,715

Direct Field Construction Hours per piece of M.E. (I.S.B.L.): For applications where the M.E. count is less than 25 use 1,750 M.H. s per M.E. item.

NO. OF M.E. ITEMS	NO. OF PIPING LINES PER M.E.
25	189 / 7.9
50	346 / 6.9
100	678 / 6.8
200	873 / 4.4
300	1,065 / 3.5

Concrete Cost Per Major Equipment Cost per item (I.S.B.L.)

DATA TABLE

NUMBER OF M.E. ITEMS	TOTAL COST / PER M.E. ITEM	COST PER ITEM
25	\$3,164,180	\$126,567
50	\$4,974,693	\$99,494
100	\$9,439,578	\$94,396
200	\$18,356,986	\$91,785
300	\$27,177,095	\$90,590

CONCRETE GENERAL ESTIMATING DATA

TYPE	PER SF	PER M2
Bush hammer concrete	\$0.62 - \$1.30	\$6.67 - \$14.00
Acid wash concrete	\$0.23 - \$0.40	\$2.47 - \$4.30
Pattern concrete slabs	\$0.50 - \$0.84	\$5.38 - \$9.04
Colorize concrete slab	\$0.57 - \$1.05	\$6.13 - \$11.30
Bag / Dress concrete walls	\$0.30 - \$0.75	\$3.23 - \$8.07

Estimating Thoughts for Structural Steel and Miscellaneous Steel

Obtain and review any available engineering deliverables / drawings or sketches. Take off lengths of steel section and multiply by appropriate weight in pounds per LF, determine pounds / tons of steel that is depicted on the drawings. Structural steel is usually fabricated in a vendors shop, and delivered to the site for eventual erection. Structural steel has a number of differing specifications / materials of construction, that have differing cost consequences the most widely used is A36.

Issues that may perhaps impact the erection activity of new structural steel are:

- Lifting equipment / cranes / hoists
- Mobilization / de-mobilization of crane (crane are typically rented by the day or week)
- Crane reach
- Lifting capacity

- Number of floors
- Bolted connections
- Welded connections
- Painting / touch up painting

Platforms, ladders, handrails, stair risers and other miscellaneous: perform take off and establish pounds / tons of material and assign appropriate installation man-hours. Checker plate, grating and floor plate and metal decking: perform take off and establish square feet of material and assign appropriate installation man-hours, allow at least 5% for waste in the cutting / fit up activity.

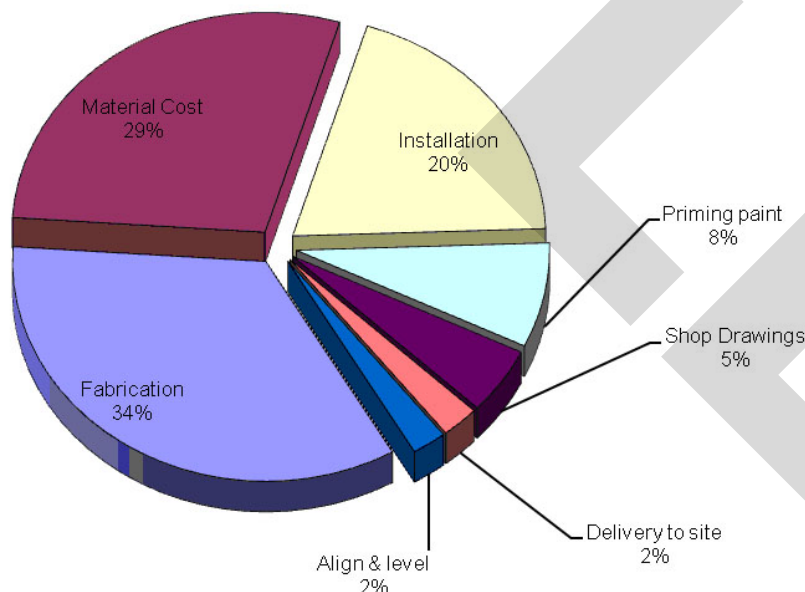
Order of Magnitude Structural Steel Estimating Data

Structural Steel weights per SF:

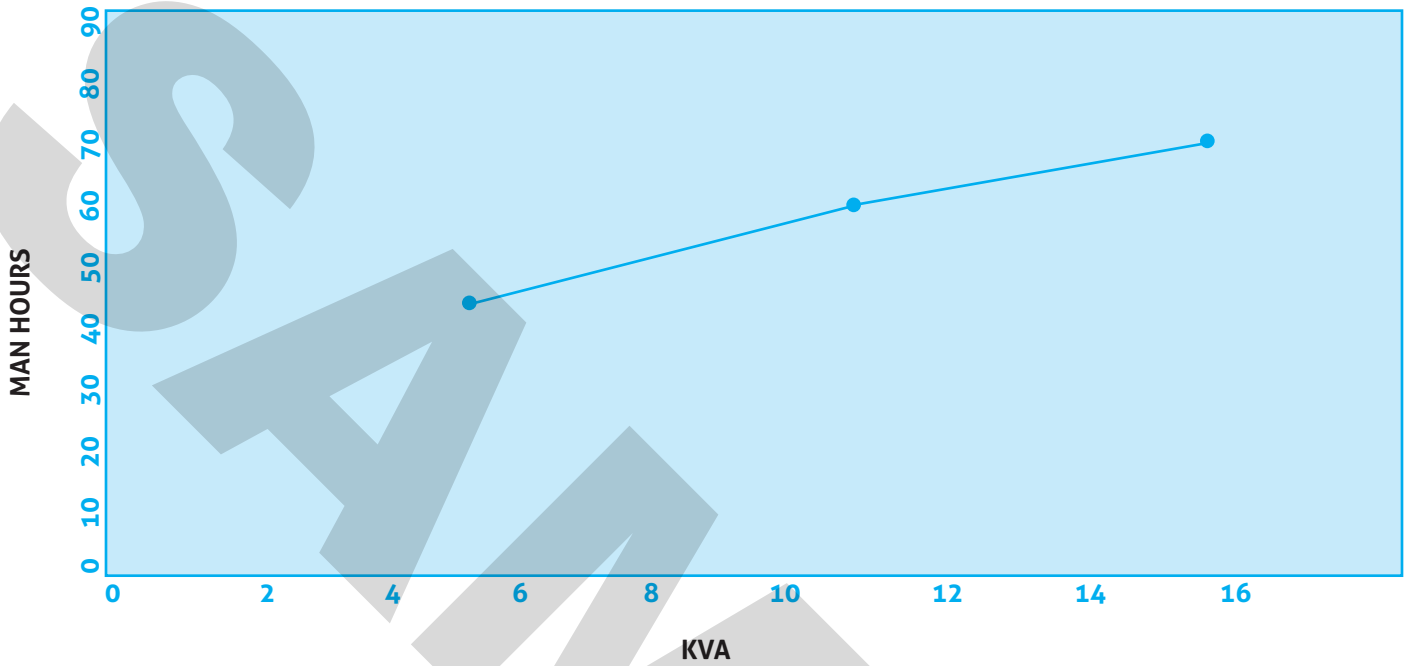
- Manufacturing Building = 10 - 15 lb / S.F.
- 5 Floor Office Building = 15 - 25 lb / S.F.
- Heavy industrial Facility = 25 - 75 lb / S.F.
- Process Structures: Preliminary weights of structures can vary from 1.5 lb to 3.5 lb (Cubic Foot of enclosed area).

Structural Steel as percentage of major equipment cost: usually falls in the 5% to 8% of major equipment cost. The following pie chart delineates the various cost / fabrication and installation activities associated with structural steel.

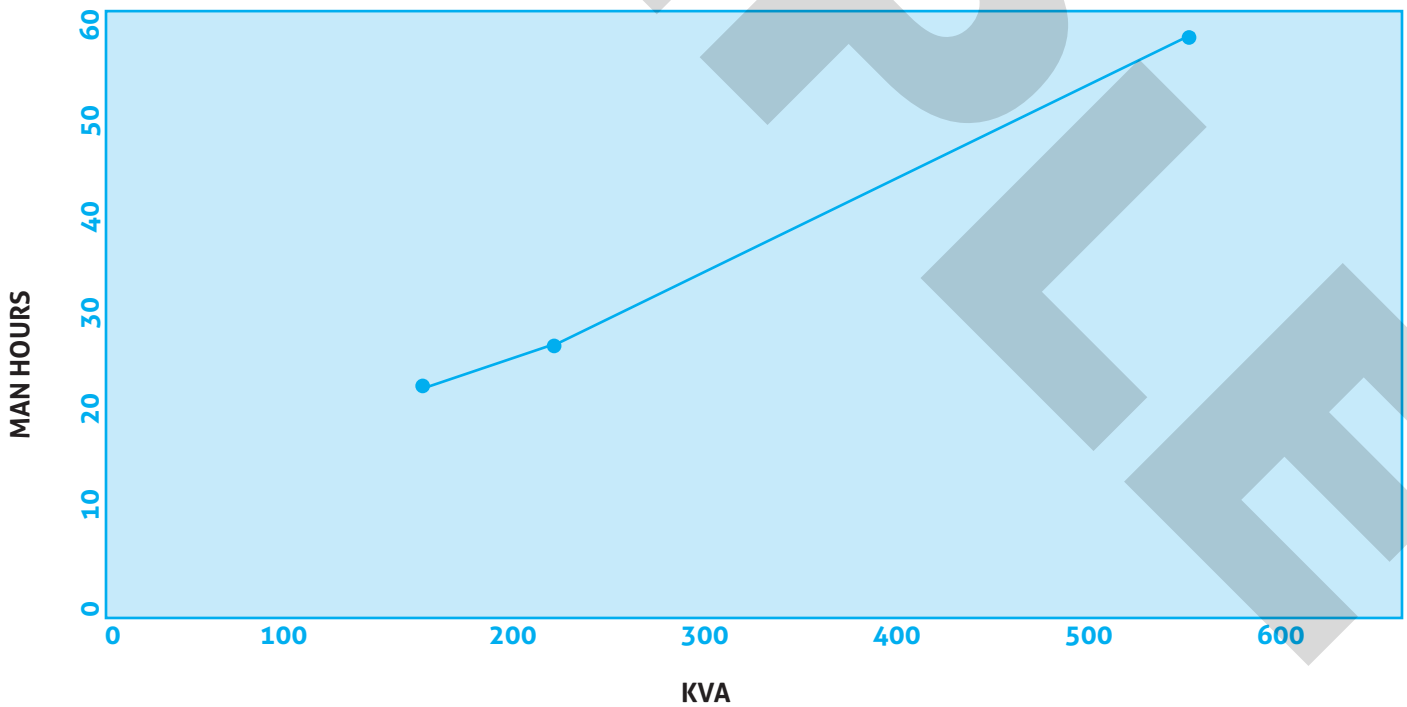
PERCENTAGE BREAKDOWN OF STRUCTURAL STEEL BASED ON 500-TON, 3-STORY BUILDING:



SEWAGE EJECTORS (DUPLEX – 1,800 GPM)



SUB STATION



check out. Includes installation of motor and drives, control.. Assume unit is mounted on a skid unit the hook-up piping and electrical between tank and pump is included, typically trim is shipped loose. Assumed that equipment is shipped in one piece: Excludes cranes, foundations, setting holding down bolts, grouting, brackets, supports, piping, cable, conduit and electrical hook-up, refer to productivity adjustments on earlier page to calibrate installation man-hours.

(D) TANK HEATERS (immersion / electrical): Installation man-hours include unloading, temporary warehousing, site transportation n/e 0.50 miles – 0.80 km, unpacking, lifting into position, setting, leveling, aligning, and system check out. Includes installation of motor and drives, controls: Assume unit is mounted on a skid unit the hook-up piping and electrical between tank and pump is included, typically trim is shipped loose: Assumed that equipment is shipped in one piece: Excludes cranes, foundations, setting holding down bolts, grouting, brackets, supports, piping, cable, conduit and electrical hook-up:

(E) BOX TYPE FIRED HEATER C.S. TUBES 250 PSI TUBE PRESSURE: Installation man-hours include unloading, temporary warehousing, site transportation n/e 0.50 miles – 0.80 km, unpacking, lifting into position, setting, leveling, aligning, and system check out. Includes installation of motor and drives, controls: Assume unit is mounted on a skid unit the hook-up piping and electrical between tank and pump is included: typically trim is shipped loose. Assumed that equipment is shipped in one piece: Excludes cranes, foundations, setting holding down bolts, grouting, brackets, supports, piping, cable, conduit and electrical hook-up: See chart previous page.

(F) BOX TYPE FIRED HEATER S.S. 304. TUBES 250-PSI TUBE PRESSURE: Installation man-hours include unloading, temporary warehousing, site transportation n/e 0.50 miles – 0.80 km, unpacking, lifting into position, setting, leveling, aligning, and system check out. Includes installa-

Table 53B

S.F / M2 EDR	NO. OF PIECES	LBS. WEIGHTS	M.H.' S
50 / 4.65	4-6	75	5
100 / 9.30	4-6	125	5
250 / 23.23	12	420	22
500 / 46.46	12/15	780	38

Table 53C

BOILER H.P	WEIGHTS LBS. # OF PIECES	MAN-HOURS	M.H. PER HP
50 / 4.65	4-6	75	5
100 / 9.30	4-6	125	5
250 / 23.23	12	420	22
500 / 46.46	12/15	780	38

Table 53D

M.W.	EQUIPMENT COST	INSTALLATION M.H.' S
10	\$1,500	2.5
25	\$3,536	4.5
50	\$6,769	8
100	\$13,070	14.5

Table 53E

DUTY / MILLION BTU' S	MATERIAL COST (REFER TO PREVIOUS TABLES FOR INSTALLATION WORK)
5	\$273,426
10	\$451,954
25	\$859,282
50	\$1,395,313
100	\$2,285,814

Table 53F

DUTY / MILLION BTU' S	MATERIAL COST (REFER TO PREVIOUS TABLES FOR INSTALLATION WORK)
5	\$416,426
10	\$691,475
25	\$1,306,175
50	\$2,138,708
100	\$3,523,396