Ethylene Unit
Operation Management Concepts

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1. Current Views

Almost every aspect of life has a time cycle. The Chinese speak of twelve-year cycles and others speak of seven-year cycles. Your health, finances, employment, and relationships move in time cycles. Financial Markets, of which the ethylene market is a member, also move in time cycles. From 1992 to 1996 were good years, 1998 to the present have not been good. Projections are that 2002 onward may be good years.

Because our competitors are constantly improving, Titan must also constantly improve. There are several changes that are presently occurring in the Petrochemical Industry due to the fact that the products are becoming world-based commodities.

The first change is that technology is improving. The size of plants is increasing helping reduce unit cost. The current energy usage is 40% of original plants. New furnace technology has improved yields. A mature industry typically reduces production cost 3% per year, as shown in the energy reduction.

The second change is how we operate our plants. Today the requirements are that we maintain higher environmental and safety standards. Our operators are the keys to meeting the levels of consistency that are required to be competitive. Information Management is essential for the organization to have the "right" information to the "right" people at the "right" time.

The third change in the Petrochemical Industry is the Corporate Structural Changes. In the past two years we have seen many mergers and acquisitions resulting in improved Corporate Structural efficiency. Forty percent of the world ethylene capacity is now from 10 producers. This improves the experience curve of producers. If you have five ethylene plants; some of the majors may have twenty ethylene plants giving them an experience advantage.

The driving forces for these changes are that petrochemicals are now world commodities, therefore world competitive performance is required.

A. Market Outlook

Short Term Price Factors

- Inventory movement
- Plant outages
- Change in major feedstock price
- Anticipation of new capacity
- Seasonal expectations
- Market psychology

Long Term Price Factors

- Cost of production
- Economic cycle
- Technology
- Regional trade balances

Profitably is the Goal, not Price

- The goal of being in any business is to make a profit
- If a profit is not made, costs cannot be paid and eventually, in a free market, the business fails
- A measure of profitability in the petrochemicals business is the "cash margin"
- Cash margin is defined as the difference between price and cash costs

B. Current Expansions

To be based on current data

2. Ethylene Plant Economics

A. General Investment

A 300 KTA would cost on the order of US$300 Million. If this money were placed in a bank you could expect to receive about 6% interest with no risk. If an investment were at risk, normally you would expect a higher return, above 10%. Because the chemical business is cyclical, as are most things in life, some years are good and some years are not so good.

Year	At 6%	At 10%	Varies
1	1.8 Million	3.0 Million	1.8 Million
2	1.8 Million	3.0 Million	0.5 Million
3	1.8 Million	3.0 Million	2.4 Million
4	1.8 Million	3.0 Million	6.0 Million
Total	7.2 Million	12.0 Million	10.7 Million

Even with the good year of 6.0 Million the total is below the 10% return of 12 Million. This shows that when the market is good, you need to get very good returns because the lean times are comings. It is not sufficient to just make money in the good markets alone.

B. Plant Capacity

Each part of the plant has a guarantee of performance with an associated monetary penalty if the guarantee is not met. Therefore the vendors design their portion of the plant with a safety margin, typically of 10%. In some areas Process Designers only used 5%, but most other vendors used 10%.

This means that the pumps, compressors, towers, and heat exchangers are all rated for 115.5%. The cooling tower is rated for 10% above the heat exchangers and should be designed for 127%. Many plants can process 120% because the main vendor used a 10% safety factor.

3. Follow the Money

A. **Where is the Money Made?**
B. **Where is the Money Spent?**
C. **Where is the Money Lost?**

There is a saying in politics, “Follow the Money”, which is also true in most organizations. The first thing you should do, as a manager, is survey to see where the money is made, and where the money is spent. Many managers only look at where the money is spent and try to cut total cost. Reviewing cost is a major function of a manager. **Remember; if an expenditure is making money, it is not a cost.** A 10% cut in expenditures in all areas normally results in less money being generated.

Example - A cost cutting program in an ethylene plant of a multi-national corporation in Baton Rouge, Louisiana resulted in the plant going from US$10 million per month in profit to break even. They decided to raise the suction pressure of the cracked gas machine to save steam cost. The yield of ethylene went down and plant lost money. **Any time we do not make the money that we are capable of – that is money lost.**

Many managers are confused in what is the objective of an operating plant. Many think that the object of the plant is to produce “x” tons of plant product. The true objective of the plant is to make money. We are only using the plant as a vehicle to obtain our true objective. This knowledge will often change how we will run the plant. Not every time is maximum rate of product equal to the maximum profit.

The two largest expenditures in an Ethylene Plant are the feed and fuel. These two items account for 90% of the total operating cost. Therefore the main way to reduce cost in an ethylene plant is to reduce these two items. Improve the recovery of products from your feed at a lower fuel cost.

A. Where the money is made in an Ethylene Plant?

Where the money is made in an ethylene plant is the production of ethylene and propylene. Generally, these two high value products should be maximized. Sometimes energy savings and profit are inversely related.

On a simple basis product yield is; $C_2H_6 = C_2H_4 + H_2$, and remember the reaction can go each way.

An overall correlation of how the plant is performing is the olefin to naphtha ratio. The lower this number the lower feed stock cost.

Things that effect the yield of ethylene and propylene are;

A. Proper Feedstock Selection

Feed stocks are chosen based on the ratio of their components. The better-feed stocks have a high paraffin composition. Each feedstock has a landed cost, which is the cost to reach the dock, and has a yield profile from which a dollar value of each feedstock can be generated. The landed cost minus the yield value is called the Net Feedstock Cost.

B. Proper Reaction Temperature – COT

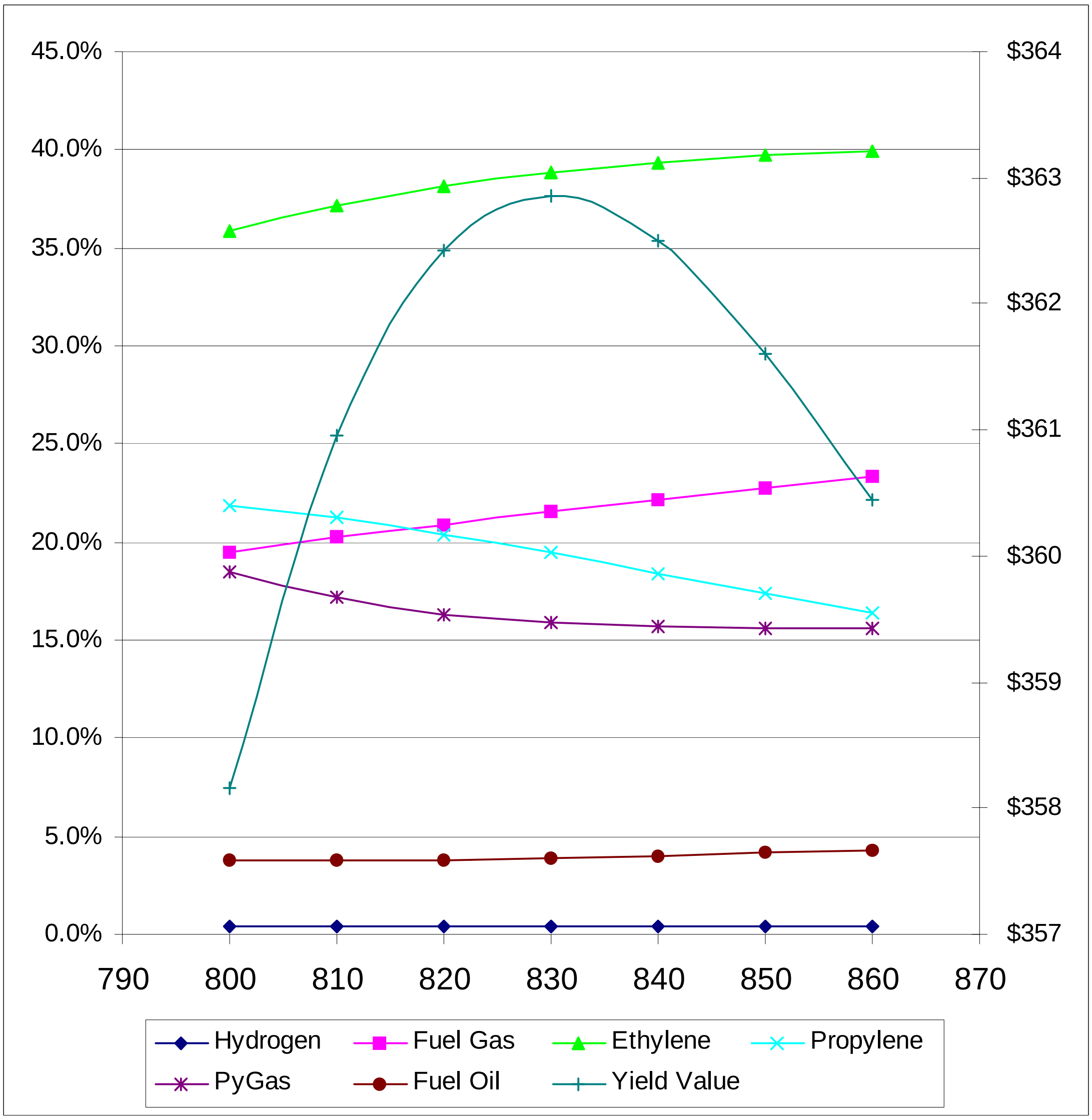
Reaction Temperature should be chosen on the basis of high value products. Low reaction temperature lead to low yields. High reaction temperatures lead to low yields due to the recombination of ethylene and propylene to by products such as Py Gas and Fuel Oil.

For each one degree C we are away from the optimum Coil Outlet Temperature we lose opportunity dollars. The further we are away the larger the difference. For each ton of feed, if we are 5 degrees away from the optimum we lose US $1.00 per hour and US $8,000 per year. For our feed rates, which are 191 tons per hour, this is US $1,528,000 per year.

Effect Of Coil Outlet Temperature

Severity	1.42	1.31	1.20	1.09	0.99	0.90	0.82
COT	800.00	810.00	820.00	830.00	840.00	850.00	860.00
Hydrogen	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Gas	0.20	0.20	0.21	0.22	0.22	0.23	0.23
Ethylene	0.36	0.37	0.38	0.39	0.39	0.40	0.40
Propylene	0.22	0.21	0.20	0.19	0.18	0.17	0.16
Py Gas	0.19	0.17	0.16	0.16	0.16	0.16	0.16
Fuel Oil	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Yield Value	**358.16**	**360.95**	**362.43**	**362.86**	**362.50**	**361.61**	**360.44**

Effect Of Coil Outlet Temperature



C. Reduce Reaction Pressure – CGC Suction Pressure

Because we are going from one feed to two products, reaction pressure should be low to favor the production of the two products. When we wish to go from two feeds to one product, as in the Acetylene Converters, high pressure is wanted to shift the process to the smaller volume.

For each 0.1 kg/cm2 we lower the suction pressure the yield of the high value products improves. This 0.1 kg/cm2 drop equates to US $113.10 per hour and US $904,800 per year. There is more energy required in the compressor by lowering the suction pressure, but it is a small debit compared to the increase in yields.

Furnace – Effect of CGC Suction Pressure

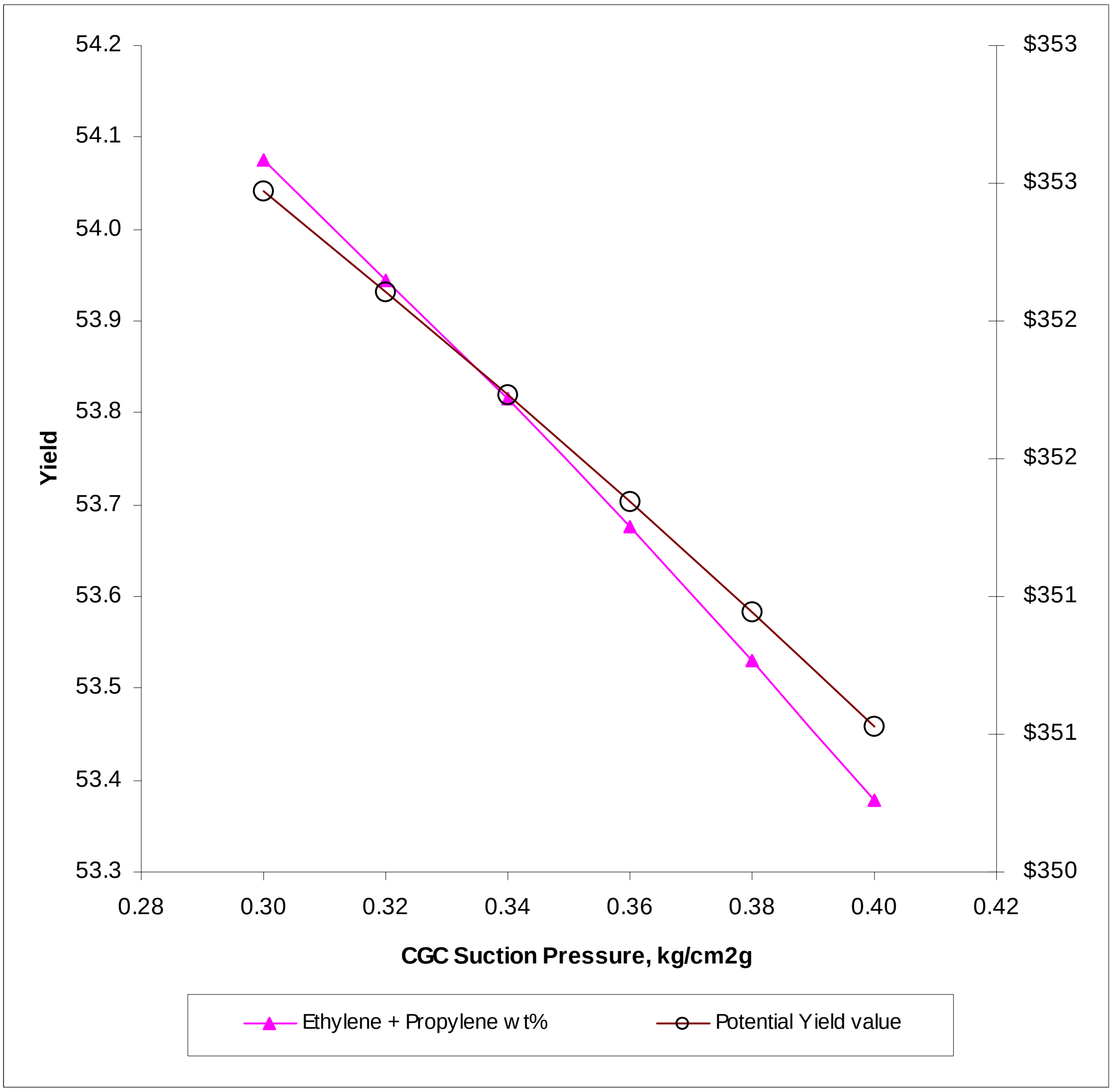
CGC Suction Pressure	**0.40**	**0.38**	**0.36**	**0.34**	**0.32**	**0.30**
Ethylene Yield (%)	34.5	34.6	34.6	34.7	34.7	34.8
Propylene Yield (%)	18.9	18.9	19.0	19.1	19.2	19.3
HPG Yield (%)	19.4	19.4	19.5	19.5	19.6	19.7
Fuel Gas Yield (%)	19.1	19.0	18.9	18.8	18.7	18.6
Fuel Oil Yield (%)	8.2	8.1	8.0	7.9	7.8	7.7

Ethylene + Propylene wt%	**53.4**	**53.5**	**53.7**	**53.8**	**53.9**	**54.1**

Per ton of naphtha

Potential Yield value	**$350.53**	**$350.94**	**$351.35**	**$351.74**	**$352.11**	**$352.47**
Yield Value Loss USMM /yr	**-$1.76**	**-$1.39**	**-$1.02**	**-$0.67**	**-$0.33**	

Effect of CGC Suction Pressure



54.2
54.1
54.0
53.9
53.8
53.7
53.6
53.5
53.4
53.3
Yield
$353
$353
$352
$352
$351
$351
$350
0.28
0.30
0.32
0.34
0.36
0.38
0.40
0.42
CGC Suction Pressure, kg/cm2g
Ethylene + Propylene w t%
Potential Yield value

D. Reduce Concentration of Products – Steam to Oil Ratio

Because the reaction can go each way, one way to shift the products is to reduce the ratio of products by adding an inert to dilute the system. In an ethylene plant the inert that is added is steam. By raising the steam to oil ratio the high value product yield can be increased.

From the high load test data the increased value of going from 0.4 to 0.5 on was worth US $567.00 per hour and US $4,536,000 per year. Design SOR is 0.50

Furnace – Effect of Steam to Oil Ratio from High Load Test Data

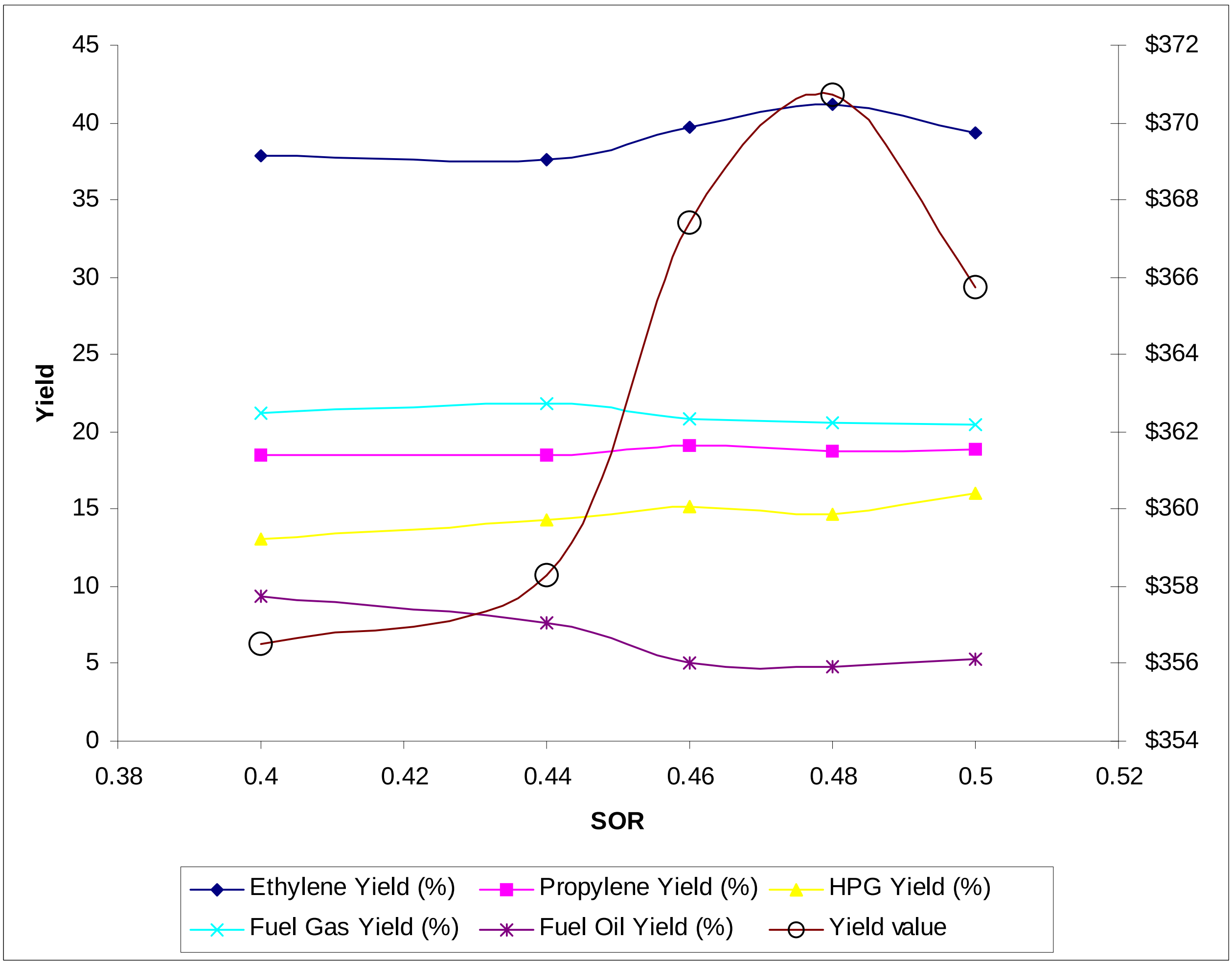
SOR	**0.4**	**0.44**	**0.46**	**0.48**	**0.5**
Ethylene Yield (%)	37.9	37.66	39.7	41.15	39.35
Propylene Yield (%)	18.48	18.54	19.17	18.79	18.82
HPG Yield (%)	13.06	14.36	15.19	14.7	16.02
Fuel Gas Yield (%)	21.19	21.84	20.83	20.57	20.48
Fuel Oil Yield (%)	9.37	7.6	5.11	4.79	5.33

SEV (kcal/kg-C2H4)	5340	5516	5656	5610	5658

Per ton of naphtha

Yield value	**$ 356.50**	**$ 358.31**	**$ 367.39**	**$ 370.72**	**$ 365.74**

Effect of Steam to Oil Ratio



B. Where the money is spent in an Ethylene Plant?

The two largest expenditures in an Ethylene Plant are the feed and fuel. These two items account for 90% of the total operating cost. Therefore the main way to reduce cost in an ethylene plant is to reduce these two items. Improve the recovery of products from your feed at a lower fuel cost.

There are several ways to reduce fuel cost.

A. Proper Fuel Air Ratios in Furnaces and Boilers

The proper fuel to air ratio in furnaces and boilers can reduce fuel consumption. Any excess air that is in the furnace has to be heated to the reaction temperature and them a portion of that heat is then vent out the stack. Typically furnaces should have about 4% excess O_2, which could be based on a Nox limit, and boilers should have about 2% O_2 air.

Because air is 21% oxygen and 79% nitrogen for each 1% excess O_2 that is introduced to the furnace there is 4% excess N_2. Both of excess components the are vented via the stack at 200 degrees C, greatly reducing the efficiency of the furnace.

In our furnaces each 1% of excess air results in an energy loss of US $1.56 per hour or US $12,500.00 per year for each furnace. If we are running 6% high this equates to $75,000.00.

B. Reduce Recycles

1. C2 And C3 Recycles

Any excess C2 or C3 Recycles causes additional fuel to be utilized in the furnace, additional steam to be required in each of the three compressors along with loss of unit capacity. Not counting the unit capacity loss, the per ton energy loss is US$ 41.82 per hour or US$ 334,560.00 per year.

2. C4 Recycle

Any excess C4 Recycle causes additional fuel to be utilized in the furnace, additional steam to be required in the CGC compressor along with loss of unit capacity. Not counting the unit capacity loss, the per ton energy loss is US $33.36 per hour or US $266,876 per year.

3. **Off Test Re-treatment**

Any off test re-treatment causes additional steam to be required in each of the three compressors along with loss of unit capacity. Not counting the unit capacity loss, the per ton energy loss is US $10.29 per hour or US $83,000.00 per year. For year 2000 at 700 tons this was approximately US $5,800,000.00.

4. **BOG Re-treatment**

Any Boil Off Gas re-treatment from the Ethylene Storage Tanks causes additional steam to be required in each of the three compressors along with loss of unit capacity. Not counting the unit capacity loss, the per ton energy loss is US$ 10.29 per hour or US $83,000.00 per year. For year 2000 at two tons per hour, this was approximately US $166,000.00.