

IHS Chemical

Process Economics Program

Report 29I

Ethylene from Naphtha

By Michael Arné

December 2014

ihs.com/chemical



IHS Chemical agrees to assign professionally qualified personnel to the preparation of the Process Economics Program's reports and will perform the work in conformance with generally accepted professional standards. No other warranties expressed or implied are made. Because the reports are of an advisory nature, neither IHS Chemical nor its employees will assume any liability for the special or consequential damages arising from the Client's use of the results contained in the reports. The Client agrees to indemnify, defend, and hold IHS Chemical, its officers, and employees harmless from any liability to any third party resulting directly or indirectly from the Client's use of the reports or other deliverables produced by IHS Chemical pursuant to this agreement.

For detailed marketing data and information, the reader is referred to one of the IHS Chemical programs specializing in marketing research. THE IHS CHEMICAL ECONOMICS HANDBOOK Program covers most major chemicals and chemical products produced throughout the world. In addition the IHS DIRECTORY OF CHEMICAL PRODUCERS services provide detailed lists of chemical producers by company, product, and plant for the United States, Europe, East Asia, China, India, South & Central America, the Middle East & Africa, Canada, and Mexico.

Report 29I

Ethylene from Naphtha

By Michael Arne

December 2014

Abstract

This report covers the technology and costs of manufacturing ethylene from naphtha via steam cracking. The three process configurations presented are:

- Front-end demethanizer
- Front-end depropanizer
- Front-end depropanizer with a gas turbine driver for the cracked gas compressor

For each process configuration, we have examined four design cases:

- Wide range naphtha feed for maximum propylene yield
- Wide range naphtha feed for maximum ethylene yield
- Light virgin naphtha feed for maximum propylene yield
- Light virgin naphtha feed for maximum ethylene yield

Each of the process configurations has been sized to allow production under all four design cases. We present capital cost estimates for each of the three process configurations. We also present operating cost estimates for all twelve of the process configuration/design case pairs.

Our goal in this project has been to present a set of designs that represent “typical” current practice. This report is intended to illustrate ethylene production economics as it is commercially practiced now, in late 2014.

Contents

1. Introduction.....	1
2. Summary	2
Front-end demethanizer.....	2
Front-end depropanizer	3
Front-end depropanizer with gas turbine driver	3
Process economics.....	4
3. Industry status	8
Characteristics of the market.....	9
4. Technology review	10
Cracking furnace yields.....	10
A brief survey of the literature	12
5. Front-end demethanizer.....	14
Process description.....	14
Pyrolysis and quench	33
Compression and drying.....	33
Subcooling and separation.....	34
Product separation	34
Refrigeration.....	35
Steam distribution.....	35
Process discussion.....	35
Cost estimates.....	37
Capital costs.....	37
Production costs.....	37
6. Front-end depropanizer	46
Process description.....	46
Pyrolysis and quench	65
Compression, drying, depropanizer.....	65
Subcooling and separation.....	66
Product separation	66
Refrigeration.....	67
Steam distribution.....	67
Process discussion.....	67
Two-stage front-end depropanizer.....	68
Cost estimates.....	69
Capital costs.....	69
Production costs.....	69

7. Front-end depropanizer with gas turbine driver	80
Process description	80
Pyrolysis and quench	100
Compression, drying, depropanizer	101
Subcooling and separation	110
Product separation	110
Refrigeration	110
Steam distribution	111
Gas turbine and HRSG	111
Process discussion	111
Two-stage front-end depropanizer	112
Gas turbine	113
Cost estimates	113
Capital costs	113
Production costs	113
Appendix A: Patent summaries	115
Appendix B: Design and cost bases	119
Design conditions	119
Cost bases	119
Capital investment	119
Production costs	120
Effect of operating level on production costs	121
Appendix C: Reference citations	122
Appendix D: Patent references by assignee	125
Appendix E: Process Flow Diagrams	126

Tables

Table 2.1: Summary of Ethylene Production Costs	5
Table 2.2: Summary of Ethylene Production Costs	6
Table 2.3: Summary of Ethylene Production Costs	7
Table 3.1: World Supply/Demand for Ethylene	8
Table 3.2: World Ethylene Consumption by End Use	9
Table 4.1: Naphtha Cracking Yields, Wt%	11
Table 4.2: Naphtha Cracking Yields, Mol%	12
Table 4.3: Gas Cracking Yields	13

Table 5.1: Ethylene from Naphtha Front-End Demethanizer Design Bases.....	14
Table 5.2: Ethylene from Wide Range Naphtha Maximum Propylene Case Front-End Demethanizer.....	16
Table 5.3: Ethylene from Naphtha with Front-End Demethanizer Major Equipment.....	29
Table 5.4: Ethylene from Naphtha with Front-End Demethanizer Total Capital Investment	32
Table 5.5: Butadiene & BTX Content	37
Table 5.6: Ethylene from Wide Range Naphtha Maximum Propylene Case Front-End Demethanizer.....	38
Table 5.7: Ethylene from Wide Range Naphtha Maximum Ethylene Case Front-End Demethanizer.....	40
Table 5.8: Ethylene from Light Virgin Naphtha Maximum Propylene Case Front-End Demethanizer.....	42
Table 5.9: Ethylene from Light Virgin Naphtha Maximum Ethylene Case Front-End Demethanizer.....	44
Table 6.1: Ethylene from Naphtha Front-End Depropanizer Design Bases	46
Table 6.2: Ethylene from Wide Range Naphtha Maximum Propylene Case Front-End Depropanizer	48
Table 6.3: Ethylene from Naphtha With Front-End Depropanizer Major Equipment.....	62
Table 6.4: Ethylene from Naphtha with Front-End Depropanizer Total Capital Investment	70
Table 6.5: Butadiene & BTX Content	71
Table 6.6: Ethylene from Wide Range Naphtha Maximum Propylene Case Front-End Depropanizer.....	72
Table 6.7: Ethylene from Wide Range Naphtha Maximum Ethylene Case Front-End Depropanizer.....	74
Table 6.8: Ethylene from Light Virgin Naphtha Maximum Propylene Case Front-End Depropanizer	76
Table 6.9: Ethylene from Light Virgin Naphtha Maximum Ethylene Case Front-End Depropanizer	78
Table 7.1: Ethylene from Naphtha Front-End Depropanizer with Gas Turbine Driver Design Bases.....	81
Table 7.2: Ethylene from Wide Range Naphtha Maximum Propylene Case Front-End Depropanizer with Gas Turbine Driver	83
Table 7.3: Ethylene from Naphtha with Front-End Depropanizer and Gas Turbine Driver Major Equipment.....	96
Table 7.4: Ethylene from Naphtha with Front-End Depropanizer & Gas Turbine Driver Total Capital Investment.....	99
Table 7.5: Butadiene & BTX Content	100
Table 7.6: Ethylene from Wide Range Naphtha Maximum Propylene Case Front-End Depropanizer with Gas Turbine Driver	102
Table 7.7: Ethylene from Wide Range Naphtha Maximum Ethylene Case Front-End Depropanizer with Gas Turbine Driver	104
Table 7.8: Ethylene from Light Virgin Naphtha Maximum Propylene Case Front-End Depropanizer with Gas Turbine Driver	106
Table 7.9: Ethylene from Light Virgin Naphtha Maximum Ethylene Case Front-End Depropanizer with Gas Turbine Driver	108
Table A.1: Ethylene from Naphtha Patent summaries.....	115