

PERP Report

NGL Extraction Technologies

06/07S10

December 2007



44 South Broadway, White Plains, New York 10601, USA

Tel: +1 914 609 0300 Fax: +1 914 609 0399

This report was prepared by Nexant, Inc ("Nexant") and is part of the Process Evaluation Research Planning Program (PERP). Except where specifically stated otherwise in this Report, the information contained herein is prepared on the basis of information that is publicly available, and contains no confidential third party technical information to the best knowledge of Nexant. Aforesaid information has not been independently verified or otherwise examined to determine its accuracy, completeness or financial feasibility.

Neither NEXANT, Subscriber nor any person acting on behalf of either assumes any liabilities with respect to the use of or for damages resulting from the use of any information contained in this Report. Nexant does not represent or warrant that any assumed conditions will come to pass.

The report is submitted on the understanding that the Subscriber will maintain the contents confidential except for the Subscriber's internal use. The Report should not be reproduced, distributed or used without first obtaining prior written consent by Nexant. Each Subscriber agrees to use reasonable effort to protect the confidential nature of the Report.

Contents

Section	Page
1 Executive Summary	1
1.1 INTRODUCTION.....	1
1.2 CURRENT COMMERCIAL TECHNOLOGY.....	2
1.2.1 Processing Requirements	2
1.2.2 NGL Extraction Technologies	2
1.3 LICENSED TECHNOLOGIES	4
1.4 EMERGING TECHNOLOGIES	6
1.4.1 Supersonic Technology.....	6
1.4.2 Membrane Technology	6
1.4.3 Integration of Cryogenic Technology	7
1.5 ECONOMIC ANALYSIS.....	8
1.6 MARKET REVIEW	9
1.6.1 United States	9
1.6.2 Western Europe.....	10
1.6.3 Asia Pacific	11
2 Introduction	12
2.1 INTRODUCTION.....	12
2.2 BACKGROUND.....	13
2.2.1 NGL Sources.....	13
2.2.2 NGL Uses.....	14
2.2.2.1 Ethane	14
2.2.2.2 Propane and Butane	14
2.2.2.3 Pentane and Heavier Hydrocarbons.....	14
2.2.3 Natural Gas Specifications.....	15
2.3 NGL EXTRACTION.....	16
2.3.1 Phase Envelope	16
2.3.2 Block Flow Diagram.....	17
2.3.3 Pre-Treatment.....	18
2.3.4 Degree of NGL Extraction.....	20
2.3.5 Technology Options.....	21
3 NGL Extraction Technologies	22
3.1 INTRODUCTION.....	22
3.2 COOLING BASED PROCESSES.....	23
3.2.1 Low Temperature Separation.....	23
3.2.2 Mechanical Refrigeration.....	28
3.2.3 Turbo-Expansion.....	32

3.3	OTHER PROCESSES	38
3.3.1	Lean Oil Absorption.....	38
3.3.2	Solvent Absorption	40
3.3.3	Adsorption.....	42
3.4	MAIN CONSIDERATIONS IN PROCESS CHOICE AND DESIGN	45
3.4.1	Impact of Feed Gas Pressure.....	45
3.4.2	Impact of Feed Gas Pressure Decline	45
3.4.3	Impact of Feed Gas Composition.....	47
3.4.4	Impact of NGL Recovery.....	48
3.5	NATURAL GAS LIQUIDS FRACTIONATION	49
4	Licensed Technologies	52
4.1	INTRODUCTION.....	52
4.2	ENGINEERING COMPANIES WITH TRACK RECORDS IN NGL EXTRACTION	53
4.3	COOLING BASED PROCESSES.....	55
4.3.1	ABB Lummus/Randall Gas Technologies.....	55
4.3.2	IPSI LLC	61
4.3.3	Ortloff Engineering Ltd.....	64
4.3.4	Costain	68
4.4	OTHER PROCESSES	70
4.4.1	Advanced Extraction Technologies – AET Process®	70
4.4.2	Prosernat/IFP – IFPEXOL	70
4.4.3	Shell Global Solutions – SORDECO®	74
4.5	SUMMARY OF NGL RECOVERY PROCESSES	76
5	Emerging Technologies.....	78
5.1	INTRODUCTION.....	78
5.2	SUPERSONIC TECHNOLOGIES	79
5.2.1	TWISTERTM Technology	81
5.2.2	3-S Technology	82
5.3	MEMBRANE TECHNOLOGIES	84
5.3.1	MTR Technology	85
5.3.2	BORSIG Technology	85
5.3.3	Other Developments	85
5.4	INTEGRATION OF CRYOGENIC TECHNOLOGY.....	87
6	Economic Analysis	89
6.1	INTRODUCTION.....	89
6.2	DESIGN BASIS.....	90
6.2.1	Raw Gas Composition	90

6.2.2	NGL Extraction Processes	91
6.2.3	Sales Gas Specification	92
6.3	COST OF PRODUCTION BASIS	93
6.3.1	Battery Limits	93
6.3.2	Production Costs	93
6.3.3	Product and Utility Pricing.....	95
6.3.4	Gas Shrinkage	95
6.4	COST OF PRODUCTION	98
6.4.1	Process Economics for Dew Point Control by Mechanical Refrigeration ...	98
6.4.2	Process Economics for NGL & Ethane Extraction by Turbo Expansion.....	100
6.4.3	Cost of NGL Production Summary	102
6.4.4	Sensitivity to Changes in Ethane Price	103
6.4.5	Sensitivity to Changes in Sales Gas Price.....	104
7	Commercial Analysis	105
7.1	INTRODUCTION.....	105
7.2	GENERAL MARKET CHARACTERISTICS	105
7.2.1	Ethane.....	105
7.2.2	LPG	105
7.2.3	Natural Gasoline/Condensate.....	106
7.3	UNITED STATES	107
7.3.1	Gas Resources	107
7.3.2	Consumption	107
7.3.3	Supply	107
7.3.4	Supply, Demand and Trade.....	109
7.4	WESTERN EUROPE	110
7.4.1	Gas Resources	110
7.4.2	Consumption	110
7.4.3	Supply	111
7.4.4	Supply, Demand and Trade.....	112
7.5	ASIA PACIFIC	113
7.5.1	Gas Resources	113
7.5.2	Consumption	113
7.5.3	Supply	114
7.5.4	Supply, Demand and Trade.....	115
8	Glossary of Terms	116
9	References	120

Section	Page
A Nexant’s <i>ChemSystems</i> Capital Cost Estimates	A-1
B PERP Program Title Index	B-1

Figure	Page
1.1 United States LPG Supply/Demand Balance	9
1.2 Western Europe LPG Supply/Demand Balance.....	10
1.3 Asia Pacific LPG Supply/Demand Balance	11
2.1 Natural Gas Liquids	13
2.2 Typical Gas Phase Envelope for a Multi Component Mixture	16
2.3 Phase Diagram for a Fixed Composition Well Fluid	17
2.4 Gas Processing and NGL Extraction - Block Flow Diagram.....	18
3.1 Joule Thomson Effect Shown on a Phase Diagram	23
3.2 Joule-Thomson Plant without Glycol Injection	25
3.3 Joule-Thomson Plant with Glycol Injection.....	26
3.4 Joule-Thomson Process with Stabilization of NGL Products	27
3.5 Inability of Mechanical Refrigeration to Enter Two Phase Region for NGL Extraction from High Pressure Feed Gas	29
3.6 Mechanical Refrigeration Process.....	30
3.7 Turbo Expander and Joule Thomson Expansion.....	32
3.8 Turbo Expander Plant Propane Recovery	34
3.9 Categorizing Expander Based Processes.....	35
3.10 Turbo Expander Plant for Ethane Recovery.....	36
3.11 Lean Oil Absorption Process	39
3.12 Solvent Absorption Process	41
3.13 Bed Saturation with Single Component Adsorption	42
3.14 Solid Adsorption Process	44
3.15 Effect of Wellhead Pressure Decline and Remedial Measure.....	46
3.16 Effect of Feed Gas Composition on Total Compression Power	47
3.17 Effect of NGL Recovery Levels on Total Compression Power	48
3.18 NGL Fractionation Flow Scheme	50
4.1 ABB - Randall Process for High Ethane Recovery	57
4.2 ABB - Randall HPA Process - Propane Recovery Mode.....	58
4.3 ABB - Randall HPA Process - Ethane Recovery Mode.....	59
4.4 ABB - Randall HPA Process - High Ethane Recovery Mode.....	60
4.5 IPSI Enhanced NGL Recovery Process SM	62

4.6	IPSI Split Feed Compression Process	63
4.7	Gas Sub-cooled Process (GSP)	65
4.8	Single Column Overhead Recycle (SCORE).....	66
4.9	Costain - PETROFLUX Process for NGL Recovery	69
4.10	AET Process [®] NGL Recovery Unit	71
4.11	IFPEX-1 Process for Dehydration and NGL Removal	72
4.12	IFPEX-1 Process with Water Wash Column	73
4.13	SHELL - SORDECO [®]	75
5.1	Supersonic Gas Separator	80
5.2	C ₃ + Extraction.....	83
5.3	Example of an Integrated NGL and LNG Process	88
6.1	NGL Production Costs Breakdown.....	102
6.2	Cost of NGL Production with Varying Ethane Price	103
6.3	Cost of NGL Production with Varying Sales Gas Price	104
7.1	U.S. LPG End-Use Pattern, 2006.....	108
7.2	U.S. NGL Production Breakdown from Gas Processing Plants.....	108
7.3	U.S. LPG Supply/Demand Balance	109
7.4	Western Europe LPG End-Use Pattern, 2006	111
7.5	Western Europe NGL Production Breakdown from Gas Processing Plants.....	111
7.6	Western Europe LPG Supply/Demand Balance.....	112
7.7	Asia Pacific LPG End-Use Pattern, 2006.....	113
7.8	Asia Pacific NGL Production Breakdown from Gas Processing Plants	114
7.9	Asia Pacific LPG Supply/Demand Balance	115

Table	Page
1.1 Technologies Under Review	4
1.2 Ethane and Propane Recovery by Process	5
1.3 Recovery Factors and Gas Shrinkage Values.....	8
2.1 Typical Sales Gas Specifications	15
2.2 Main Pre-Treatment Options.....	19
2.3 Properties of Natural Gas Components.....	20
2.4 Main Processes for NGL Extraction	21
3.1 Advantages and Disadvantages of J-T Expansion	28
3.2 Advantages and Disadvantages of Mechanical Refrigeration.....	31
3.3 Advantages and Disadvantages of Turbo Expansion	37
3.4 Typical Fractionator Parameters	51
4.1 Technologies Under Review	54
4.2 Ethane and Propane Recovery by Process	77
6.1 Raw Gas Composition.....	90
6.2 Sales Gas Compositions.....	92
6.3 Assumptions for Cost of Production Analyses	94
6.4 Summary of Product and Utility Prices.....	95
6.5 Gas Shrinkage Calculation - Mechanical Refrigeration Case	96
6.6 Gas Shrinkage Calculation - Turbo Expansion Case	97
6.7 Cost of Gas Processing Estimate - Mechanical Refrigeration	99
6.8 Cost of Gas Processing Estimate - Turbo Expansion.....	101