

Alternative Uses for MTBE Facilities
99/00-7

March 2001

Copyright © by Chem Systems 2001
All rights reserved

The information disclosed in this report shall be used and retained only by the Client for the sole and confidential use of Client and its majority-owned affiliates in its own research and commercial activities, including loaning the Report on a confidential basis to third parties for temporary and specific use for the sole benefit of Client.

Client shall use reasonable effort to protect the confidential nature of the information supplied herein and shall not reproduce any of this Report except within its own organization or that of its majority-owned affiliates, except those affiliates which are engaged in the business of market research, management consulting or publishing or are subsidiaries of such firms shall not receive copies of or have access to this Report.

Client shall refrain from any general publication of this Report, either directly or through its affiliates so as to constitute passing of title into the public domain or otherwise jeopardize the common law or statutory copyright in said Report. To the extent the Client copies or reproduces this Report, in whole or in part, for use in its own organization or that of its majority-owned affiliates, it shall mark such copies in the proper place with the notice set forth above and include the foregoing paragraphs.

TABLE OF CONTENTS

	Page
I SUMMARY	1
A. INTRODUCTION	1
B. ALTERNATIVE USES FOR MTBE FACILITIES – ISOOCTANE PRODUCTION	4
C. ECONOMIC EVALUATION	6
1. Retrofitting a Refinery MTBE Unit to an Isooctane Process	6
2. Simplified Return on Investment Analysis for Isooctane Production	8
D. GLOBAL MTBE SUPPLY/DEMAND BALANCE	9
1. Demand	9
2. Supply	11
II REGULATORY OVERVIEW	13
A. BACKGROUND	13
B. BLUE RIBBON PANEL FINDINGS	14
1. Overview	14
2. Specific Panel Recommendations	15
C. U.S. EPA POLICIES	16
D. STATE INITIATIVES IN THE U.S.	18
1. Background	18
2. California	18
3. Other States	20
E. NON U.S. REGULATORY DEVELOPMENTS	21
F. CONCLUSIONS	22
III COMMERCIAL MTBE TECHNOLOGY	23
A. RAW MATERIAL AND COPRODUCT VALUATIONS	23
1. Feedstocks	23
(a) Isobutylene from Steam Crackers	23
(b) Isobutylene from Refineries	25
(c) Isobutylene from TBA Dehydration	25
(d) Isobutane Dehydrogenation	25
2. Feedstock Valuation	26
(a) Isobutylene	26
(b) Field Butanes	26
(c) tertiary-Butyl Alcohol	28
(d) Other Raw Materials and Byproducts	28

TABLE OF CONTENTS
(Continued)

	Page
B. MTBE PRODUCTION CHEMISTRY	31
1. Chemistry	31
C. CONVENTIONAL MTBE PROCESS TECHNOLOGY	34
1. ABB Lummus Process	34
(a) Isomerization	34
(b) Dehydrogenation (Catofin Process)	37
(c) Etherification (CD Tech)	39
2. UOP Process	39
(a) Isomerization (Butamer Process)	41
(b) Dehydrogenation (Oleflex Process)	43
(c) Etherification (Ethermax Process)	45
(1) Reaction Section/C ₄ Column	45
3. Huntsman TBA/PO Process	47
4. Process Economics	48
(a) Plant Capacity Basis	48
(b) Raw Materials and Utility Pricing Basis	48
(c) MTBE From Field Butanes	49
5. MTBE From Steam Cracker Mixed Butylenes	51
6. MTBE From Refinery Mixed Butylenes	51
7. MTBE From tertiary-Butyl Alcohol	54
(a) Comparative Economics	56
IV ALTERNATIVE USES FOR MTBE FACILITIES	57
A. ISOCTANE PROCESS TECHNOLOGY OVERVIEW	57
1. Introduction	57
2. Physical Properties of Isooctane	58
3. Impact of MTBE Phaseout on Refinery Operations	59
(a) Gasoline Pool	59
(b) MTBE Associated Operations	59

TABLE OF CONTENTS
(Continued)

	Page
B. SNAMPROGETTI SP-ISOETHER PROCESS	61
1. Introduction	61
2. Process Description and Characteristics	61
3. Process Parameters	64
(a) Conversion	64
(b) Reaction Temperature	64
(c) Catalyst Life	64
(d) Product Properties	64
C. KBR-FORTUM NEXOCTANE PROCESS	65
1. Introduction	65
2. Process Description and Characteristics	65
3. Process Parameters	67
(a) Conversion	67
(b) Reaction Temperature	68
(c) Catalyst Life	68
D. UOP INALK PROCESS	68
1. Introduction	68
2. Process Description and Characteristics	68
E. IFP SELECTOPOL PROCESS	71
1. Introduction	71
2. Process Description and Characteristics	71
F. COMPARISON OF PROCESSES	72
G. RETROFITTING A REFINERY MTBE FACILITY TO PRODUCE ISOCTANE	73
1. MTBE Plant Basis	73
(a) Feedstock Basis	73
(b) Conventional MTBE Material Balance and Utility Consumption	73
(c) Process Equipment	74
2. Isooctane Process	77
(a) Material Balance	77
(b) Utility Consumption	80
(c) Product Properties	80

**TABLE OF CONTENTS
(Continued)**

	Page
H. ECONOMIC EVALUATION	82
1. Retrofitting a Refinery MTBE Unit to an Isooctane Process	82
2. Simplified Return on Investment Analysis for Isooctane Production	83
V MTBE MARKET OUTLOOK	86
A. BACKGROUND	86
B. GLOBAL GASOLINE MARKET TRENDS	87
1. Gasoline Demand	87
2. Use of Lead Additives in Gasoline	87
3. MTBE Use in Gasoline	87
C. U.S. MTBE DEMAND	89
D. U.S. MTBE SUPPLY/DEMAND BALANCE	92
E. GLOBAL MTBE SUPPLY/DEMAND BALANCE	94
1. Demand	94
2. Supply	95
3. Global Supply/Demand Balance	101
APPENDIX	102
PERP TITLE INDEX	107

TABLES

		Page
Table I.B.1	Average Properties of Typical Gasoline Blendstocks	5
Table I.B.2	Isooctane Process Comparison Overview	6
Table I.C.1	Nexoctane Plant Retrofit ISBL Costs, Million Dollars	7
Table I.C.2	Nexoctane Plant Cost of Production Summary	7
Table I.C.3	Simple ROI Assessment for Isooctane Production	8
Table I.D.1	Global MTBE Demand	10
Table III.A.1	Typical Isomer Distribution in C ₄ Product Streams	24
Table III.A.2	Cost of Production Estimate for: <i>t</i> -Butyl Alcohol Process: TBA (Allocated Cost)	30
Table III.A.3	Raw Material and Byproduct Prices	31
Table III.C.1	MTBE Plant Capacity	48
Table III.C.2	Utility Pricing Basis	49
Table III.C.3	ISBL Capital Cost of MTBE from Field Butanes	49
Table III.C.4	Cost of Production Estimate for: MTBE Process: from Field Butanes	50
Table III.C.5	Cost of Production Estimate for: MTBE Process: from Steam Cracker Mixed Butylenes	52
Table III.C.6	Cost of Production Estimate for: MTBE Process: from Fluid Catalytic Cracker	53
Table III.C.7	ISBL Capital Cost of MTBE from TBA	54
Table III.C.8	Cost of Production Estimate for: MTBE Process: from TBA	55
Table III.C.9	Summary of MTBE Production Costs	56
Table IV.A.1	Average Properties of Typical Gasoline Blendstocks	58
Table IV.A.2	Isooctane Isomers and Characteristics	59
Table IV.A.3	Feedstock-to-Product Ratios	60
Table IV.B.1	SP-Isoether Product Properties	65
Table IV.D.1	Inalk Oligomerization Catalyst Comparison	70
Table IV.D.2	Inalk Feed and Product Quality	70
Table IV.E.1	IFP ISO-8 Gasoline Quality	72
Table IV.F.1	Isooctane Process Comparison Overview	72

TABLES
(Continued)

		Page
Table IV.G.1	FCC C ₄ Stream Composition	73
Table IV.G.2	MTBE Plant Material Balance	74
Table IV.G.3	MTBE Plant Utility Consumption	74
Table IV.G.4	MTBE Plant Equipment List	76
Table IV.G.5	Nexoctane Plant Material Balance	79
Table IV.G.6	Mixed C ₄ Raffinate Composition	79
Table IV.G.7	Nexoctane Plant Utility Consumption	80
Table IV.G.8	Nexoctane Product Properties (FCC derived C ₄ feed)	81
Table IV.G.9	Nexoctane Product Properties (dehydro derived C ₄ feed)	81
Table IV.H.1	Nexoctane Plant Retrofit ISBL Costs, \$Million	82
Table IV.H.2	Nexoctane Plant Cost of Production Summary	83
Table IV.H.3	Cost of Production Estimate for: Isooctane Gasoline Process: KBR-Fortum Nexoctane	84
Table IV.H.4	Simple ROI Assessment for Isooctane Production	85
Table V.C.1	U.S. Oxygenate Supply/Demand Balance	90
Table V.D.1	U.S. MTBE/TAME Supply/Demand Balance	93
Table V.E.1	Global MTBE Demand	94
Table V.E.2	Regional MTBE Capacity, 2000	97-101

FIGURES

		Page
Figure I.D.1	Global MTBE Demand	10
Figure I.D.2	Global MTBE Capacity by Region, 2000	12
Figure III.A.1	Isobutylene Supply Sources	24
Figure III.A.2	Factors Influencing MTBE Processing Route Selection	27
Figure III.A.3	Cost Assumptions of TBA Production via Propylene Oxide/ <i>tertiary</i> -Butyl Alcohol Plant Operations	29
Figure III.C.1	MTBE Production Processes	35
Figure III.C.2	Lummus Butane Isomerization Process Flow Diagram	36
Figure III.C.3	Catofin Process Isobutane Dehydrogenation	38
Figure III.C.4	CDTECH MTBE Process Flow Diagram	40
Figure III.C.5	UOP "Hot" Butamer Process Flow Diagram	42
Figure III.C.6	UOP Oleflex Process Flow Diagram	44
Figure III.C.7	Ethermax MTBE Process Flow Diagram	46
Figure IV.B.1	The Snamprogetti Water Cooled Tubular Reactor	62
Figure IV.G.1	Typical Refinery Based MTBE Plant	75
Figure IV.G.2	Isooctane Process Scheme	78
Figure V.E.1	Global MTBE Demand	95
Figure V.E.2	Global MTBE Capacity by Region, 2000	96
Figure V.E.3	Global MTBE Trade	101