

Methanol Fuel Blending In China

Tim Chan – Enmore 14th International MeOH Week Nanjing, China 9 -10 July 2019







History

- The Methanol Institute (MI) was established in 1989
- 29 years later, MI recognized as the trade association for the global methanol industry
- Facilitating methanol's expansion from our Singapore headquarters and regional offices in Washington DC, Brussels, and Beijing













Methanol's Evolving Global Demand

Methanol Demand vs Supply in 2018



Source: CNFIA Statistics



Fuel Application the Largest Downstream

•Methanol consumption increased to 69.5 MMTs in 2017

•Total Fuel Application (Direct Fuel, DME, MTBE) accounting for 25% of the total consumption in 2017

• Formaldehyde share dropped, MTBE share might decrease in 2020 when E10 promoted nationally.

•Methanol Direct Fuel in Industrial Boilers and Cookstoves increasingly contributed in the directive fuel blending

•Fuel blending is also suspected to contribute in "Others" in the official statistics

Source: CNFIA Statistics



China Methanol Production and Energy Security



- China methanol production capability: 84.32 MMTs, mainly dedicated coal to methanol projects
- New NG stock feed methanol project suspended, coking gas limited by steel industry
- Advanced coal gasification and world scale methanol production



China Domestic Energy Resources in Global Share

- China: coal reserve rich country (115bln tons) with scarce crude (2bln tons) and NG reserves
- Increasing concerns of energy security, mainly crude, over 70% oversea import
- Methanol imports ~8 MMTs in recent years, import only ~11%
- China Vehicle Population in 2018: 240 mln, consuming 100 MMTs gasoline and 140 MMTs diesel









Methanol Gasoline/Methanol Vehicle in China

M15-M25

- 7 MMT of methanol used for M15 blends in China
- ~75% of cars built by international automakers
- Under China's new policy on methanol as a transport fuel, lower blends (M15 -25) are not encouraged

Fuel and chemical Properties

- Octane
- Heat value
- Ignition/flame temperature
- RVP
- Burning speed
- Solubility between each other

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M85-M100

- Dedicated vehicles (e.g. Geely)
- Use of SI technologies in light duty vehicles
- Both SI and CI for heavy duty vehicles
- Few changes needed to existing vehicle technologies at low cost



Methanol Gasoline-General Information

- China trialed M15 from 1980s
- First official promotion of M15 in Shanxi from 2002, with Sinopec cooperation
- Shanxi's experience shared with other provinces in China, including Shannxi, Zhejiang, Guizhou, Gansu, etc.
- 2.5 MMTs of methanol blended with gasoline by CAAEFA official statistics in recent years
- Low levels of methanol officially in regular gasoline





CHINA EXPERIENCE-National Standards

Fuel Based

- The Additive of Methanol Gasoline for Vehicles
- Determination Method of Methanol Content in Methanol Gasoline for Motor Vehicles
- Methanol Gasoline (M85) for Motor Vehicles
- Fuel Methanol for Motor Vehicles
- Still on-hold: Methanol Gasoline (M15) for Motor Vehicles

Infrastructure and Management Guideline by MIIT

- Same for both M15 and M100
- Construction of Methanol Fuel Fueling Stations
- Guidelines for Safety Operation of Methanol Fuel

Standard	No.	Implemented Since
The Additive of Methanol Gasoline for Vehicles	GB/T 34548-2017	2018
Determination Method of Methanol Content in Methanol Gasoline for Motor Vehicles	GB/T31776-2015	2015
Methanol Gasoline (M85) for Motor Vehicles	GB/T 23799-2009	2009
Fuel Methanol for Motor Vehicles	GB/T23510-2009	2009



CHINA EXPERIENCE-Local Standards



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Local standards available, province-wide promotion of methanol gasoline

Local standards available, pilot program on methanol vehicles initiated in selective cities/districts

省	份	地方甲醇汽油标准	生效时间	
Prov	vince	Local Methanol Gasoline Standards	Implemented Since	
甘肃	Gansu	M15 + M30	2009	
贵州	Guizhou	M15	2010	
河北	Hebei	M15 + M30	2010	
黑龙江	Heilongjiang	M15	2005	
江苏	Jiangsu	M45	2009	
辽宁	Liaoning	M15	2006	
陕西	Shaanxi	M15 + M25	2004	
山东	Shandong	M15	2012	
上海	Shanghai	M100	2013	
陕西	Shanxi	M5, M15, M85 + M100	2008	
四川	Sichuan	M10	2004	
新疆	Xinjiang	M15 + M30	2007	
浙江	Zhejiang	M15, M30 + M50	2009	
宁夏	Ningxia	M15 + M30	2014	

Methanol Gasoline Infrastructure Achievements

- 50 methanol gasoline blending terminal centers completed/under construction in 15 different provinces
- Over 1.2 million metric tons (400 million gallons/1.5 billion liters) of annual methanol fuel blending capacity
- Total number of over 1,200 refilling stations
- In 2013, 0.8 MMTs of M15 sold in Shanxi, accounting for 23% of the total gasoline market





M15 Emission Tests in China





 M15 emission test in Beijing Institute of Technology (BIT)

Methanol improves tailpipe emission of CO, HC and NOx

• For unconventional emissions:

- <u>NO</u> increase of HCHO by introducing methanol
- Significant reduction of BTEX and PM
- BTEX (benzene, ethylbenzene, toluene, xylene)
- PM major contributor to smog in cities and difficult to reduce, especially in high volumes



Other Technology Concerns on M15

Metal Corrosion and nonmetal swelling

- Methanol is corrosive to some metals, modern vehicles engineered to accommodate alcohol fuel like E10
- Proper corrosion inhibitor used in China
- Methanol small molecular structure causes swelling of rubber and plastic components
- Modern vehicles can working with low level of alcohol gasoline
- China national standard of GB/T 24141 requiring rubber tubes in the fuel piping MUST accommodate oxygen-contained gasoline
- High level methanol fuel like M100, must use swelling resistant technology
- Swelling inhibitor may be needed for old vehicle models

Phase Separation, Vapor lock, injector block...

	Corrosion rest	or a chinese wil	.5 Inhibitor t	inder US SA	SITAT Stand	laru			
J	Testing plate		Red copper	Steel	Stainless Steel	Cast aluminu m	Zinc	Tin	Brass
	Weight loss	Max	0.061	0.041	0.013	0.067	0.272	0.044	0.039
	per surface	Min	0.000	-0.047	-0.012	0.014	0.102	0.000	0.015
	(mg/cm ²)	Average	0.026	-0.011	0.001	0.027	0.208	0.019	0.023
	(<u>8</u> , e)	US Standard Limits	0~0.070	$\begin{array}{rl} \text{-0.050} & \sim \\ \text{0.050} & \end{array}$	-0.020 \sim 0.020	0~0.080	0~0.350	0 ~ 0.0450	$\begin{array}{c} 0 & \sim \ 0.050 \end{array}$

Comparison Test on Regular Rubber Fuel Tube in Methanol Gasoline of 3 Different Ratios and Standard Gasoline

Fuel	Tube size before immersion			Tube size after 4 weeks of immersion			Swelling scale		
	Diameter (mm)			Diameter (mm)			Diameter (mm)		
	lnner diameter	Outer diameter	Length (mm)	lnner diameteeter	Outer diameter	Length (mm)	lnner diameter	Outer diamete r	Length (mm)
93 [#] gasoline	4.52	10.66	21.22	5.2	12.66	23.48	15.04%	18.76%	2.26
M10	4.58	10.5	20.6	4.86	12.72	22.88	6.11%	21.14%	2.28
M15	4.76	10.62	20.26	5.36	12.58	22.26	12.61%	18.46%	2
M30	4.52	10.5	20.7	5.2	12.52	22.66	15.04%	19.24%	1.96

NO Difference!







High Level Methanol Fuel Blending-General Information

- China R&D work from late 1980s with the US cooperation
- First official promotion of methanol vehicles using high level blends in 2000s in Shanxi
- National Pilot by Ministry Industry and Information Technology (MIIT) since 2012 in 5 regions with over 1,000 vehicles
- New Policy paper is introduced in 2019 for national promotion
- Roughly 100K retrofitted vehicles for M100 in China consuming over 1 MMTs of methanol each year
- OEMs Involved Geely Auto, FAW, Yu Tong, etc









MIIT Methanol Vehicle Pilot

- Over 1,000 vehicles received acceptance review
- Total pilot mileage over 184 million km
- The methanol fuel consumption over 24 kts.
- Health check to 1,199 people from a variety of occupations with potential methanol exposure like vehicle drivers & maintenance works, fueling station staff, operators in methanol fuel blending
- Taxi fuel cost saving around 30%
- Total number in operation over 7,000 now and projected to reach 15K-20K in 2019

methanol venicle operation in onina (by January 2013)

Province	City	Vehicle Type	Vehicle No.	
Shanyi	Jinzhong	Taxi	260	
Snanxi	Changzhi	HD Bus	96	
Shanghai	Shanghai Minhang		18	
	Xi'An	Taxi	1500	
	Paoli	Taxi	200	
	Dauji	Mini MPV	15	
Shannxi	Yulin	Self-Dumping Truck	5	
	Hanzhong	Taxi	20	
Guizhou	Guiyang	Taxi	4776	
Gancu	Lanzhou	Taxi	150	
Gansu	Pingliang	Taxi	50	
		Total	7090	



Environmental Benefits of Methanol Vehicles

- Methanol improves tail pipe emissions significantly
- Future Vehicles certified according to Euro 6 equivalent
- Other technology solution with same ^{Eu} emission level of Euro 6, requiring higher cost after treatment like Urea CAG Doping M
- No formaldehyde increase, even below US standard



CA6SH-ME4 HD SI M100 (GB17691-2005, Eqv. Euro 5, ESC) VS. China Emission Standards of Diesel Vehicle



Fueling Infrastructure for Methanol Vehicles

- 20 fueling infrastructures: 13 fixed stations and 7 skid mounted
- NO significant cost to change gasoline station to M100 (~30,000 RMB)
- Promotional plan targeting of 35 by 2020 and 45 by 2019 in Cities of Guiyang and Xi An
- Market fuel price according to gasoline and NG prices





China M100 Vehicle OEMs

Geely Auto

- SI M100 with key components improved on corrosion, lubrication, fuel injection
- 14 M100 cars demonstration in Iceland
- HD bus and trucks under development
- Engine Calibration by MI member Fuel Injection Tech
- 300,000 units/year production capacity

FAW Truck and Yu Tong Bus

 SI M100 HD engine for HD trucks and buses produced by FAWJY

Tianjin University

 CI, Diesel Methanol Compound-Combustion (DMCC)
HD trucks, marine and locomotives Applied to truck retrofitting







China's Policy for Methanol as a Transport Fuel

- Based on the positive results of the pilot, 8 ministries and agencies released a policy for methanol as a transportation fuel on 19 March 2019
 - To promote methanol vehicles among consumers
 - 5-year projection: **50,000 cars, trucks, and buses**
 - >500,000MT of methanol consumed/year
- Allows consumers free choice to purchase methanol fuelled vehicles
 - 32 models certified by MIIT
 - Previously only opened to licensed operators under the pilot project
- Central government will not give subsidies but local governments can
 - Shanxi Province, Gui Zhou, and Xi An City giving subsidies (RMB 5,000/passenger vehicle and RMB 10,000/commercial vehicle)
 - MIIT studying how to involve methanol vehicles in **Double Credit Scheme** will incentivise OEMs







M100-Geely Dakar Racing 2019



Geely "methanol power"



M100-Geely Dakar Racing 2019

- GEELY AUTO SHELL LUBRICANT COOPER TIRE Team
- M100 Fuel used in the racing
- M100 engine was calibrated in Spain and tested in Middle East
- Methanol originated from Trinidad and Tobago
- Fuel supply supported by Geely's car dealer in Peru
- Methanol quality instability discovered by Geely from color



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Methanol Engine for Electricity and Heat

- Methanol engine can be used for electricity and CHP (combined heat and power)
- High efficiency achieved from optimized engine speed and exhaust heat recover
- Even lower emission than road applications
- Distributed power and air-conditioning for remote areas and islands
- Engine size can be as large as 6MW, the same for Stena Germanica marine engine



A 4 cylinder engine SI for CHP on trial







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Methanol Boiler Basics - Structure





Methanol Boiler Basics – Applications and Construction Layout

- Widely used for heating and industrial stream, new built and replacing coal
- Capacity ranged from 1 to 20 t/h
- Fuel: 100% methanol to methanol blends with methanol content over 60% in vol.
- One steam ton capacity consuming 110 kg of methanol, industrial use can be long hours
- Estimated more than 1000 units, consuming over 2 MMTs methanol in 2017

Source: Methanol New Energy Applications in China: Boilers and Cook Stoves



Underground Storage Tank

Methanol Boiler

Methanol Boiler Economics

Fuel	Methanol (Low Price)	Methanol (High Price)	NG (Low Price)	NG (High Price)	Diesel	Coal	Commerical and Industrial Electricity
Unit Price (RMB)	1.8/kg	4/kg	2.2/m3	10/m3	5.5/kg	0.4/kg	0.9/kwh
Unit Price/0.1cal (RMB)	3.8	8.4	2.6	11.8	5.5	0.5	10
Thermal Efficiency	90%	90%	90%	90%	90%	55%	96%
Actual Economics (RMB/0.1 cal)	4.2	9.3	2.9	13.1	6.1	1.45	11

- Methanol Opex comparable to NG depending on regions, helped to fill the clean fuel gap in last winter when NG was short of supply
- Methanol as liquid fuel has superior Capex benefit to NG
- Diesel being eliminated due to its emissions despite its price dropping quickly
- Coal is 100% off the market in most cities of China



Emission Tests in China



- Methanol Fuel Blends: Jin Jjing Da
- Neat Methanol: LinJing
- Methanol showing superior emission benefits to other hard fuels and diesel
- Methanol has no Sulphur and NOx emission is superior than NG boiler
- Methanol boiler easily fulfilling the latest Chinese emission standard even in Key Regions like Beijing, Shanghai etc.

Policy Initiative for Methanol Boilers

Chinese Ministry of Environment Protection Confirmed Methanol Fuel Emission Standard

中华人民共和国	生态环境部 re Perdie's Republic of China
素引号: 000014672/2015-01507	分类:环境科技及其管理信息、环境标准
发布机关:环境保护部	生成日期: 2015年12月24日
名 称:关于野基燃料锅炉执行标准有关问题的复函	十 四 河
× 2: 1982[2012]2122	土 返 词:
	环境保护部函
	环函[2015]319号
关	于醇基燃料锅炉执行标准有关问题的复函
河北省环境保护厅:	
你厅《关于醇基燃料锅炉执行标准有关	回题的请示》(冀环科〔2015〕178号)收悉。经研究,现必复如下: TF 工業教育工業研究にはないないないない。その教育での研究、現象のであり、「「「」」
野基燃料走一种以甲醇为土,混合有乙 () // / / / / / / / / / / / / / / / / /	群、内群寺梦元群尖和院佺的低怒泪液体燃料。 允分燃烧后会排放一氧化碳、碳氢化合物、二氧
化硫、氮氧化物和颗粒物。	
	份中醇、乙醇、沥青、燃料油油采为液体燃料采,拟行统一的标准限值,建议醇基燃料的锅炉奓 2014)中增达的地位的地位的扩展了2014
照ℕ物別大飞沙系初排版你/世》(GB 13271- 蛙山必須	-2014/ 中流/田纳/口的形形/ 2利姜水拟门。
行叱凶侵。	77 1年 /日 十九七日
地说 甘油冬少 白油灰 吉特主行场	2013年12月24日
抄选: 具他合有、日冱区、直辖中坏现	加水が圧く向ノ。

The Boiler Burner Authority on New Classification to include Methanol as Burner Fuel

- Burner Test Lab of China Special Equipment Inspection and Research Center
- Alcohol based fuel in liquid fuel category for boiler burners
- Standard will be in effective since 2018
- Original emission concentrations, designing specifications, etc.



锅炉用液体和气体燃料燃烧器技术条件

Specification for liquid fuels and gaseous fuels burners of boilers

在提交反馈意见时,请将您知道的相关专利连同支持性文件一并附上。

(征求意见稿)



CPCIF Group Standards for Methanol Boilers

Methanol Based Fuel Group Standards Under CPCIF

- CAAEFA leading a research group on two Group Standards under CPCIF
- More than 12 cooperative companies from China including boiler manufacturers, fuel suppliers, storage/tanker producers
- MI and MI member Methanex also contributed
- Anticipated to be effective in NOV of 2018

1. Methanol Based Fuel for Boilers

- Burner and fuel composition tests conducted by National Lab of Coal Clean Utilization in Shan Dong University
- Methanol Boiler Fuel is classified into MF50, MF75 and MF100

Important Note: The table referred here is the draft by 5th of June, 2018. Detailed specification numbers may be changed.

No	Itom		Index		Test
NO.	item	MF50 MF75 MF100		MF100	method
1	Methanol content (volume fraction)/%	48-52	73-77	≥98	Appendix A
2	Density ^a (20°C)/(g/cm ³) no more than	0.86	0.84	0.81	GB/T 1884 、GB/T 611
3	Lower calorific value/(KJ/Kg) no less than	27170	22990	19228	GB/T 384
4	Ash content (mass fraction)/% no more than		0.01		GB 508
5	Condensation point/°C not higher than		-30		GB 510
6	рН		6~8		See 4.3.1
Sulfur content ^b (mass		0.02 (general area)			GB/T 11140、 SH/T 0253
		0.	、SH/T 0689		
8	Nitrogen content ^c (mass fraction)/% no more	rogen content ^c (mass 0.015 (general area) ction)/% no more			SH/T 0162 、SH/T 0657
	than	0.	0.01 (key area)		
9 Chlorine content/(mg/kg) 2				GB/T 18612	
10	Low-temperature anti- 10 phase separation (-20°C, 4h) Clear and transparent, without phase separation		See 4.3.2		
11	Copper sheet corrosion (50°C, 3h) class no more than	1		GB/T 5096	
otes:					
) In case of a	ny discrepancy, the determination res	sult as per the m	ethod in GB/T 1	884 shall prevai	l;
) In case of a	ny discrepancy, the determination re-	sult as per the m	ethod in SH/T 0	689 shall prevai	;
In case of an	ny discrepancy, the determination res	sult as per the m	ethod in SH/T 0	704 shall prevail	; pitrogon contor
hall be subject	t to the regulations in GB 13271-201	ea according to 4.	the inflication of	the sulfur and	nitrogen conten
				WWW.M	ETHANOL.OF



CPCIF Group Standards for Methanol Boilers

2. Technical requirements for storage and supply facilities of methanol based fuel for boilers

- Specifications in safe use and storage of fuel, on volume, safety distance, precautions, etc.
- Max. Storage capacity less than 150m3, less than 20m3 in the urban built-up area
- Skid Mounted storage allowed, which will facilitate promotion
- Safe distance based on aboveground/under-ground storage tank and different nature of buildings

Table 4.3 The fire protection spacing for the storage tank, unloading (fuel supply) pump, the vent pipe opening and other buildings (structures) (m)+

			Underground storage tank ${\scriptstyle e^{2}}$		Aboveground skid mounted	l storage tank, l storage tank∛	Unloading (fuel supply) pump,	
Building (structure)↔			90 < V≤150m3 ↔	V≤90m3+²	V > 20m3.₽	V≤20m3.₽	and the vent pipe opening of storage tank∻	÷
	Important public building +>		35₽	35₽	50₽	50₽	35.0	÷
	A place near open flame or spark.		17.5 +	12.5+2	25+2	25+2	12.5+	÷
	Protecti civi	Under Category I protection ↔	14.0	11 🖓	20 🕫	16₊⊃	11.0	÷
ion category of il buildings ↔	on catego l building	Under Category II protection ↔	11.0	8.5+	16+2	12+2	8.5 0	÷
	ory of	Under Category III protection ->	8.5₽	7.0	12*	10+7	7 🕫	÷
5	Worksho	n and warshouse for].

Important Note: The table referred here is the draft by 5th of June, 2018. Detailed specification numbers may be changed.



Other Form of Methanol Burners – Furnaces and Kilns

- Using methanol burner for ceramic sintering, metal alloying, tobacco drying, etc.
- Better ceramic surface finish: less flaws, brighter color due to the clean exhaust gas from methanol
- Better energy efficiency reported: less air intake comparing to NG
- Regular safety incidents with LPG, making methanol more appealing

Methanol kiln in Dehua County where each batch of ceramics takes 8 hours in the kiln and **500kg** of methanol burned.

Source: Da Wei Energy



Other Form of Methanol Burners – Tobacco Drying

- Tobacco drying rooms can be retrofitted to burn methanol to produce exhaust gas for tobacco drying
- Methanol burns clean with high concentration of CO2 which retains the quality of tobacco leaves
- Coal and natural gas do not burn as cleanly, coal is also banned in some regions
- Each room is equipped with sensors for CO, NOx, SOx, CO2, temperature etc.
- Each room consumes 2 tons of methanol per season; there are 1.2 million drying rooms in China



Source: Da Wei Energy







Different Methanol Cook Stoves

- A methanol cook stove composed of a methanol fuel storage tank, supply pump, tank, and the stove itself.
- Different forms methanol Cook Stoves: Single stove, dual stoves for stir frying, steaming
- Fuel: 100% methanol to methanol blends (emulsified with water), stored in day tank/cylinder for small amount in the kitchen, and large amount stored outside the kitchen
- Widely used in restaurants, central kitchens: mainly cost driven, to replace LPG and NG (due to safety and cost concerns)







Basic Conditions of Methanol Cook Stoves

- Usually called "Alcohol Based Fuel", complying with two Standards: Alcohol Based Liquid Fuel and Stove for Alcohol based domestic fuel NY312-1997
- Market for Cooking Application estimated over 5 MMTs in China in 2017.

ICS 75. 160. 20 F 19



中华人民共和国国家标准

GB 16663-1996

醇基液体燃料

Alcohol base liquid fuel



1997-07-01 实施

国家技术监督局 发布



Economics and Status

Fuel	Methanol	Natural Gas	Liquefied Petroleum Gas	Diesel	Coal	Electricity
Price per unit mass	¥3.4/kg	¥1.85/m³	¥9.2/kg	¥8.7/kg	¥0.4/kg	¥0.78/kWh
Price per kcal (¥0.0001/kcal)	6.4	2.2	8.1	8.6	0.8	9.1
Thermal Efficiency	56%	75%	50%	40%	30%	80%
Actual Economics (¥0.0001/kcal)	11.4	2.9	16.2	21.5	2.7	11.4

- The prices used are the consumer received prices in the field investigation
- Methanol is cheaper than LPG
- Chinese kitchens (large capacity for hundreds people) and restaurants have very limited connection to NG pipelines due to high infrastructure cost
- Methanol as liquid fuel has superior Capex benefit to NG
- Diesel and coal are banned to be used in China



Different Attitude at Local Government Level

- Regions like Tianjin, Gansu, Shanxi, Shannxi, Guilin and Gansu supportive
- Regions like Xiamen, do not allow
- Difference dependent on how safely methanol fuel distributed, local cooking fuel supply conditions, companygovernment engagement, etc.

中华人民共和国农业行业标准

醇基民用燃料灶!

NY 312-1997

Stove for alcohol-based domestic fuel

1 范围

本标准规定了醇基民用燃料灶具的型号编制、基本参数、技术要求、试验方法、安全事项、抽样和检 验、标志、包装、运输、贮存。

本标准适用于使用醇基液体燃料的家用炊事灶,其主要燃烧器的额定热负荷为 16 700 kJ/h 的灶具。

2 引用标准

下列标准所包含的条文,通过在本标准中引用而构成为本标准的条文。本标准出版时,所示版本均 为有效。所有标准都会被修订,使用本标准的各方应探讨使用下列标准最新版本的可能性。 GB/T 384-81 石油产品热值测定法 GB 8913-88 居住区大气中二氧化硫卫生标准检验方法 四氟汞盐盐酸副玫瑰苯胺分光光度法 GB 11738-89 居住区大气中甲醇,丙酮卫生检验标准方法 气相色谱法 GB 12372-90 居住区大气中二氧化氯检验标准方法 改进的 Saltzman 法 CJ 4-83 家用煤气灶

3 型号编制及参数

306

3.1 型号编制
型号编制用汉语拼音及数字表示。











Contacts



