

# B100™ In Farm Vehicles

## INTRODUCTION

*It wasn't that long ago when horses were used for plowing fields and carting the grain. A part of each farmer's property was put aside to provide premium forage for these animals.*

*Today we can do the same and feed our tractors and vehicles with grain from the paddock!*

*It is not quite as easy as sending the farm vehicles out to graze in the fields, but with the help of modern technology, steps are being taken to move toward a more environmentally friendly, homegrown fuel source.*

The farm use market was established as a priority for us because it is the first major diesel market segment where we have a specific aim to reduce costs.

Information collected during assessment of the farm market overseas indicated that new clean air regulations would create a marketing opportunity for B100 blends. Economic work completed by the market research firm, Booz-Allen & Hamilton, supported our conclusion that B100 blends (in B20 form (20% B100 mixed with 80% petroleum diesel)) were competitive with other alternative fuels that end users may consider. Other research was completed to verify that emissions reductions could be achieved and engine performance was similar to diesel.

Because B100 is the only alternative fuel that can be tested prior to conversion, a series of short-term demonstrations with farms throughout the U.S. and Europe were conducted. Surveys with users about their intentions to use B100 resulted in approximately 20 percent saying that they consider B100 the top alternative fuel choice and approximately 50 percent were impressed with the prospects for B100. The US EPA has certified a 20% blend of B100 used in conjunction with an oxidation catalyst as a compliance tool to meet new clean air regulations. The U.S. and Europe are 30 years ahead of current Australian standards.

## WHAT IS B100?

B100 is a diesel fuel substitute produced from renewable sources. B100 has been registered by MBM in Australia as a pure fuel or as a fuel additive and is now a legal fuel for commerce in the U.S. and Europe. B100 is an alternative fuel that can be used in neat form, or blended with petroleum diesel for use in compression ignition (diesel) engines. Its physical and chemical properties as it relates to operation of diesel engines are similar to petroleum based diesel fuel. The specification for pure (100%) B100 is described in the following table.

Table 1. B100 Specifications.

Property	ASTM Method	Value	Unit
Flash Point	D93	100.0 min.	°C
Water & Sediment	D1796	0.050 max.	vol. %
Carbon Residue (100% sample)	D4530‡	0.050 max	wt %
Sulfated Ash	D874	0.020 max.	wt %
Viscosity @ 40°C	D445	1.9 - 6.0	Cst
Sulfur	D2622	0.01 max.	wt %
Cetane Number	D613	45 min.	
Cloud Point	D2500	by customer	°C
Copper Strip Corrosion	D130	No. 3b max.	mg KOH/gm
Acid Number	D664	0.80 max	
Free Glycerin	G.C.§	0.020 max.	wt %
Total Glycerin	G.C.§	0.240 max.	wt %

† This specification is in the process of being evaluated by ASTM. We have gained a considerable amount of information from the US and Europe with a 20% blend of B100 with 80% petroleum based diesel and 100% B100 use.

‡ Or equivalent ASTM testing method.

§ Austrian (Christiana Planc) update of USDA test method.

## USE IN VEHICLES

Optimum Blend Ratio: Between 20 percent and 100 percent by volume B100.

Table 2. Certified Configurations and Particulate Matter Certification Levels

Engine Model	Model Year	Equipment Configuration	
		B20, Cat + stock timing	B20, Cat + retard (1)
6V92TA MUI	79-87	0.29	0.38
6V92TA MUI	88-89	0.18	0.23
6V92TA DDEC I	86-87	0.16	0.18
6V92TA DDEC II	88-89	0.17	0.19
6V92TA DDEC II	90-91	not certified	0.19
6V92TA DDEC II	92-93	not certified	0.15
6V71N MUI	73-87	0.29	0.38
6V71N MUI	88-89	0.29	0.38
6V71N MUI	85-86	0.29	0.38
8V71N MUI	73-84	0.29	0.38
6L71TA MUI	90	not certified	not certified
6L71TA MUI	88-89	0.18	0.23
6L71TA DDEC	90-91	0.16	0.18

(1) Up to and including four (4) degrees fuel injection retard for MUI engines, and one (1) degree retard for DDEC engines.

Table 3. Summary of existing vehicle warranties for B100

Audi	Personal cars	All TDI models since 1996
Case - IH	Tractors	All models since 1971
BMW	Personal cars	Model 525 TDS since 1997
Caterpillar	Engines	3114, 3116, 3126, 3176, 3196, 3208, 3306, C-10, C-12, 3406, C-15, C-16, 3456, 3408, 3412, and 3500 Series
Claas	Combines, tractors	Warranties exist
Faryman Diesel	Engines	Warranties exist
Fiatagri	Tractors	For new models
Ford AG	Tractors	For new models
Holder	Tractors	Warranties exist
Iseki	Tractors	Series 3000 & 5000
John Deere	Tractors	Warranties since 1987
John Deere	Combines	Warranties since 1987
KHD	Tractors	Warranties exist
Kubota	Tractors	Series OC, Super Mini, O5, O3
Lamborghini	Tractors	Series 1000
Mercedes-Benz	Personal cars	Series C and E 220, C 200 and 220 CDI
Mercedes-Benz	Truck, bus	Series BR 300, 400, Unimog since 1988
Same	Tractors	Since 1990
Seat	Personal cars	All TDI series since 1996
Skoda	Personal cars	All TDI series since 1996
Steyr	Tractors	Since 1988
Steyr	Boat	Series M 16 TCAM and M 14 TCAM
Valmet	Tractors	Since 1991
Volkswagen	Personal cars	All TDI series since 1996
Volkswagen	Personal cars	All new SDI series (EURO-3)
Volvo	Personal cars	Series S80-D, S70-TDI & V70-TDI

*This is only an indicative list, please contact the companies for confirmed information.*

*Cummins, Detroit Diesel, Navistar and Peugeot have in the last year authorised the use of B100 in their diesel engines.*

# WHY SHOULD FARMERS USE B100?



A framework of supply and production for on farm use has been devised by MBM under the B100 label.

It is simply a case of reducing on farm costs by having the farm produce the crop of oilseed, which is in turn converted into B100 for farm use. In this process, you the farmer, owns the fuel from the crop starting at farm gate through processing and B100 return to farm gate. All you pay for is the processing and the transport!

At the moment, the cost of processing will be around 35 - 50c per litre for fuel, which will be essentially tax-free fuel, as you will not be selling the seed on its round trip, as we are a processor. This cost is based on an annual throughput of around 40,000 t. Any GST paid on the processing is part of your inputs on the farm.

The cost of each complete production plant is around \$4m and we will be having at least 2000 farmers participate at each plant.

To be part of our program, we are asking for a once off \$1000 membership fee. This will be paid back in fuel cost savings in around 1 - 2 years, depending on your usage and other sales made from your crop for conversion to B100.

MBM is a totally debt free organisation and we want to keep it that way!

MBM is a "NEW GENERATION BUSINESS". If there is a profit at the end of the year, a major portion of it will be paid back as a bonus to participating farmer's pro-rata of their product input to the system.

We are also looking at buying from farmers for the open market sales of B100 at a guaranteed fixed price for a minimum 5 years period that will increase with rises in inflation. There will be an up front payment of 70% of the agreed price and the balance paid at sale time or at 6 months, whichever ever is the shortest. For those farmers who cannot grow oilseed for their needs, we will be setting up a trading post for farmers to trade between themselves, we will only supply the contacts between sellers and the purchasers, it is up to you to negotiate/ barter/ exchange.

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## ECONOMIC AND PERFORMANCE

### IMPLICATIONS OF B100 USE

#### *Farm Economics*

B100 has been used on farms in Austria for the last 30 years in a small way with tractors and other diesel powered equipment. Due to a shortage of free land and climate to produce more of the oilseed required, other alternatives are being looked into. With our land availability in Australia, we should be able to produce more than enough for our on farm needs as it doesn't require much oilseed - around 4 tonnes - to run the farm tractors for a year (on an average farm).

#### *Fleet Economics*

B100 in Australia will be marketed at a premium compared to petroleum diesel. Therefore, B100 costs are greater than petroleum diesel for fleet managers that use a B100 blend. Although B100 is more expensive in Australia per litre than diesel, there are no significant infrastructure changes or incremental maintenance costs associated with its use.

This contrasts to the significant capital investments that must be made in vehicle modifications and fueling infrastructure for other alternative fuels (CNG, LPG, and Methanol). Three independent studies have confirmed that B100 blends (i.e. B20) are cost competitive with other alternative fuel options when compared on a vehicle life cycle basis.

We have followed a study completed by the University of Georgia providing a cost comparison for operating a transit fleet on three different alternative fuels (B100 blends, compressed natural gas, and methanol). Using a 5% discount rate, the present value per bus per mile was calculated for the total cost of a transit fleet over an expected 30-year life cycle. Diesel buses had the lowest cost per mile (24.7¢). Costs for B100 blends ranged from 37.5 to 42¢ per mile. Compressed natural gas

costs varied from 37.5 to 42 cents per mile, while methanol's cost was 73.6¢ per mile. This study indicated that B100 blends have the potential to compete with CNG and methanol as fuels for urban fleets.

Urban transit managers have reached similar conclusions. Bi-State Development Agency is the transit authority in the City of St. Louis, MO which operates over 700 buses that consume over 22.7 million litres of diesel fuel annually. Lyle Howard, Quality Assurance Manager for Bi-State, has documented the advantages and disadvantages of various alternative fuels. Bi-State had used B20 for two years in a documented research program.

Mr. Howard compared alternative fuels on the following evaluation criteria; vehicle cost, infrastructure cost, safety, operating cost,

reliability, customer acceptance, funding assistance, training costs, fuel availability, fuel quality, and fuel price stability. Fuels were evaluated on a scale of 1 to 10 with 10 being most desirable.

Conclusions from that work include:

- \* B100 is a viable motor fuel
- \* performance and fuel economy were unchanged with B20
- \* exhaust emission improved dramatically
- \* the fuel was fully compatible with vehicle and fuel dispensing equipment.

The following table compares B20 with diesel fuel, compressed natural gas, liquefied natural gas, methanol, and ethanol.

TABLE 4.

	Diesel	CNG	LNG	Methanol	Ethanol	B20
Vehicle Cost	10	5	5	5	5	10
Infrastructure Cost	10	2	5	5	5	10
Safety	7	4	3	1	3	8
Operating Range	10	5	10	10	10	10
Operating Cost	10	5	7	5	5	7
Reliability	10	7	5	3	3	10
Customer Accept	5	8	8	8	9	8
Funds Assistance	1	10	2	0	2	2
Training Costs	10	5	5	5	5	10
Fuel Availability	10	10	5	5	5	6
Fuel Quality	9	5	10	8	8	9
Price Stability	6	8	8	6	6	6
TOTALS	98	74	73	61	66	96

### *Vehicle Performance*

Emissions and performance data on several medium and heavy duty engine families fueled with B20, including the Detroit Diesel Series 60, 6V-71, 6V-92, 8V-71, Cummins L10, Cummins 5.9 B, and the Navistar 7.3 HEUI.

Emissions data from these tests demonstrate that particulate matter, opacity, carbon monoxide and hydrocarbons are reduced.

Oxides of nitrogen are slightly increased with some engines. Operating performance parameters, such as fuel consumption, power, and torque were similar to diesel fuel for these tests.

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## CONSIDERATIONS FOR B100 USE

### *Infrastructure*

In general, the standard storage and handling procedures used for petroleum diesel should be used for B100. The fuel should be stored in a clean, dry, dark environment. Temperature extremes should be avoided. Acceptable

storage tank materials include mild steel, stainless steel, fluorinated polyethylene, and fluorinated polypropylene. B100 has a solvent effect which releases the deposits accumulated on tank walls and pipes, which previously have

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been used for diesel. These deposits can be expected to clog filters initially and precautions should be taken to allow for this.

### *Materials Compatibility*

B100 over time will soften and degrade certain types of elastomers and natural rubber compounds. Precautions are needed when using high percent blends to ensure that the existing fueling system, primarily fuel hoses and fuel pump seals, do not contain elastomer compounds incompatible with B100.

Manufacturers recommend that natural or butyl rubbers not be allowed to be exposed to neat B100. B100 will lead to degradation of these materials. If a vehicle's fuel system does contain these materials, replacement with B100 compatible elastomers such as Viton® B is recommended. The recent switch to low sulfur diesel fuel has caused most original equipment

manufacturers (OEMs) to switch to components suitable for use with B100, but users should contact their OEM for specific information. (Viton B is a registered trademark of DuPont Dow Elastomers.)

### *Cold Flow Properties*

As with any diesel fuel, cold flow properties are important. A 20% blend of B100 will increase the cold flow properties (cold filter plugging point, cloud point, pour point) of petrodiesel approximately 1 to 3 degrees Celsius. Thus far, no precautions have been needed for fueling with 20% blends. Operation of neat (100%) B100 in cold weather, however, will experience gelling faster than petrodiesel. The solutions for this potential issue are much the same as that with low-sulfur diesel (i.e. utilization of fuel heaters and storage of the vehicle in or near a building). B100 appears to be largely unaffected by conventional pour point depressants.

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## **B100 ATTRIBUTES**

### *Emissions Reductions*

The use of B100 in a conventional diesel engine results in substantial reduction of unburned hydrocarbons, carbon monoxide, and particulate matter. Emissions of nitrogen oxides are either slightly reduced or slightly increased depending on the duty cycle and testing methods. Particulate emissions from conventional diesel engines can be divided into three components. Each component is present in varying degrees depending on fuel properties, engine design and operating parameters.

The first component, and the one most closely related to the visible smoke often associated with diesel exhaust, is the carbonaceous material. This material is in the form of sub-micron sized carbon particles which are formed during the diesel combustion process and is especially prevalent under conditions when the fuel-air ratio is overly rich. This can occur as a result of insufficient combustion air, overfueling or poor in-cylinder fuel-air mixing. The second component is hydrocarbon material, which is absorbed on the carbon particles, commonly referred to as the soluble fraction. A portion of this material is the result of incomplete combustion of the fuel, and the remainder is derived from the engine lube oil. Finally, the third particulate component is comprised of sulfates and bound water. The amount of this

material is directly related to the fuel sulfur content.

The use of B100 decreases the solid carbon fraction of particulate matter (since the oxygen in B100 enables more complete combustion to CO<sub>2</sub>), eliminates the sulfate fraction (as there is no sulfur in the B100), while the soluble, or hydrocarbon, fraction stays the same or is increased. Therefore, B100 works well with new technologies such as catalysts (which reduces the soluble fraction of diesel particulate but not the solid carbon fraction), particulate traps, and exhaust gas recirculation (potentially longer engine life due to less carbon).

### *Health Effects*

Evidence does exist which indicates that diesel particulate matter is a potential carcinogen. In 1988, the US National Institute for Occupational Safety and Health (NIOSH) recommended that whole diesel exhaust be regarded as "a potential occupational carcinogen", as defined in the Cancer Policy of the Occupational Safety and Health Administration.

The use of B100 does result in decreases in most regulated emissions. Relative to health effects, research results indicate that particulate matter, specifically the carbon or insoluble fraction, is significantly reduced. In addition to

reducing the overall levels of pollutants and carbon, the compounds that are prevalent in B100 and diesel fuel exhaust are different. Preliminary research on the speciation of diesel and B100 particulate indicates that B100 exhaust has less harmful impacts on human health than petrodiesel.

The United States Bureau of Mines (USBOM) has completed Ames mutagenicity testing of the diesel particulate matter (DPM) and exhaust gases from engines fueled with B100 to better understand how the use of B100 may impact the health of miners. Samples were taken from the

exhaust of a Caterpillar 3304 PCNA equipped with an exhaust catalyst.

Test results documented that the use of B100 reduced the Ames mutagenicity of DPM by 50% over conventional diesel fuel. In addition, the gas phase mutagenicity of B100 was negligible. USBOM researchers believed the strong reduction in mutagenicity may be due to the lack of aromatics or polycyclic aromatic hydrocarbons (PAH's) in the B100 fuel and, subsequently, in the exhaust gases. Tests from Europe confirm the reduction in DPM PAH using B100 blends as outlined below:

Table 5. Gaseous PAH levels of diesel fuel and a 50% B100 blend.

	Diesel	50% B100
	-- µg/cycle --	
Naphthalene	331,654	384
Methyl-2 Naphthalene	10,289	329
Fluorene	1,864	368
Anthracene	4,301	873

### Lubricity

With the low-sulfur, low aromatic diesel fuel emerging on the market, fleet operators began to encounter premature wear and/or failure of injector pumps in increasing numbers.

Stanadyne Diesel Systems on October 15, 1993 and Bosch Diesel Fuel Injection Service on December 3, 1993 issued Service Letters to distributors and dealers concerning the lack of lubricity caused by hydroprocessing to reduce the sulfur content in the new low-sulfur diesel. The pump manufacturers recommended use of

lubricity additives to alleviate the serious damage occurring to their injection pumps.

Testing at labs such as Southwest Research Institute, Stanadyne Automotive, and Engineering Testing Services has demonstrated that B100 shows significant lubricity improvement compared to diesel fuel. Two methods of analysis were utilized - the "Scuffing Load Ball On Cylinder Lubricity Evaluator" and the "High Frequency Rotating Rig" (HFRR).

Table 6.

Lubricity Results of B100 and Petroleum Diesel Using High Frequency Reciprocating Rig\*

Percent B100 with Petroleum Diesel	#1 Petroleum Diesel HFRR, Scar (mm)
0.00%	671
0.20%	669
0.30%	703
0.40%	649
0.50%	574
0.75%	510
1.00%	500
2.00%	355
10.0%	347
20.0%	318
100%	315

\* Tests performed by Stanadyne Automotive HFRR Testing, 60° C at 50% Relative Humidity

Table 7.

Lubricity Results using Scuffing Load Ball on Cylinder Lubricity Evaluation, (SLBOCLE)\*

Percent B100 with Petroleum Diesel	#1 Petroleum Diesel BOCLE (grams)
0.00%	2200
0.10%	2750
0.20%	3450
0.30%	3200
0.40%	3500
1.00%	3200
10.0%	6000
20.0%	6000
100%	6000

\* Tests performed by Engineering Testing Services

### Flash Point and Sulfur Content

The flash point of a fuel is defined as the temperature to which the fuel must be heated to produce a mixture that will ignite when exposed to a spark or flame. If the flash point of a fuel is too low, the fuel is considered a fire hazard, which is prone to flashing, possible ignition, and even explosion. The flash point of B100 has been tested and reported by various sources.

Specific testing at Southwest Research Institute concluded that the flash point of B100 blends increases as the percentage of B100 increases. Therefore pure B100 or blends of B100 with

petroleum diesel is safer to store, handle, and use than conventional diesel fuel. In addition, pure B100 is essentially sulfur free and results in a total reduction of SO<sub>2</sub> emissions as well sulfate aerosols in particulate matter. These reductions should assist in increasing both vehicle and catalyst life over time.

Neat B100 has a flash point over 148°C, well above the flash point of conventional diesel fuel. Detailed below are the results from Southwest Research Institute for the flash point of B100 and B100 blends:

Table 8.

BLEND DESCRIPTION	FLASH POINT (°C)
100% Diesel Fuel (low sulphur)	77.2
B25	82.8
B50	90.0
B75	134.0
Neat B100	138.0

The diesel fuel, B25, and B50 were testing using the ASTM D93 Pensky-Martens closed cup method. The B100 blend containing 75% and 100% B100 did not flash using D93, therefore ASTM D92, the Cleveland open cup method

was used. The flash point of B100 blends increase and the percentage of B100 added increases. Other tests have confirmed this data and suggest that most of the flash point benefits occur at blends levels of 85% and greater.