B20 Demonstration Project

Kansas City Area Transportation Authority (KCATA)

Report prepared for:

Federal Transit Authority

Report prepared by:

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Introduction

Environmental and energy security concerns have prompted many US transits to investigate or implement alternative fuel programs, primarily due to either regulatory requirements or regional consumer pressure. The adoption of alternative fuel technologies often results in a significant increase of capital and maintenance expenses, reduction in operating performance, and alteration or reduction of existing routes. In the past, fleet managers have mentioned one of the largest roadblocks to the use of alternative fuels is the change in performance noticed by drivers and users.

Biodiesel, a cleaner burning fuel for diesel engines produced from resources such as soybean oil, has many positive attributes associated with its use. The most noted attribute highlighted by fleet managers is the similar operating performance to conventional petroleum-based diesel fuel (petrodiesel) and the lack of changes required in facilities and maintenance procedures. Bus patrons notice the lack of black smoke and the reduction and/or change in exhaust odor from use of biodiesel compared to petrodiesel. Biodiesel blends function in the engine the same way as petrodiesel, but is a fuel that fulfills environmental and energy security needs without significantly affecting operating performance.

Biodiesel blends of 20% or less are a drop-in replacement for conventional petrodiesel. In the past, however, fuel costs for biodiesel blends such as B20 were higher than petrodiesel. This higher fuel cost was a barrier to transit use even though the total costs of B20 use were less than other alternative fuels due to the ability to use B20 in existing engines and fueling infrastructure. Recently, however, significantly higher prices for petrodiesel combined with a national tax incentive similar to that available for ethanol has allowed B20 blends to be priced more competitively with petrodiesel. Even with similar fuel costs, further data documenting impacts from long-term use of biodiesel is desired and many transits are unaware of the benefits of biodiesel and the ability to reduce pollution "overnight" by its use.

The recent Energy Independence and Security Act (EISA) of 2007 outlined requirements for use of 35 billion gallons of renewable fuels by 2017. Biodiesel can be used to meet this federal fuel usage requirement. When coupled with the federal tax incentive, EISA 2007 may drive increased use of biodiesel blends, and transits are a likely user. In addition, recent data released by the National Renewable Energy Laboratory and Cummins Engine Company suggests that—contrary to what has been largely reported for B20—the use of B20 in inner city buses does not increase NOx but is actually NOx neutral in these applications. All these factors are strong driving forces for increased use of B20 in transit buses.

This KCATA project was designed to augment a larger, more detailed program with the St. Louis Transit system and other 1000 hour durability testing of new engines equipped with particulate traps that will be common in transit bus engines from hence forward. The KCATA project goal is to document and track effects of using biodiesel (B20) in a number of select buses in an urban setting utilizing the Kansas City mass transit system. This project will generate data and information on impacts of B20 under normal operating conditions that can be used by urban transits as they evaluate the potential to switch to B20.

Project Objectives

The objectives of this project were to:

1) Document and track the effects of B20 use under normal operating conditions for as long a time as funding permitted (originally estimated at six months)
2) Track maintenance costs and impacts as they relate to operation of the buses on a "day-to-day" basis and compare to use of petrodiesel alone.

Due to the presence of the federal tax incentive, and the recent rise in petrodiesel price, the cost for B20 was lower than originally planned for this project. The price similarity between petrodiesel and biodiesel allowed the demonstration and data evaluation for an entire year of operation rather than six months - this was an unexpected benefit. For this report, differences between the period of time the buses were fueled with conventional petrodiesel (September 2005 to August 2006) and the period in which B20 (a 20% blend of biodiesel with conventional petrodiesel) was used (September 2006 through August 2007) were analyzed using data normally collected by KCATA as a part of their routine operations. Fuel economy (miles per gallon) and maintenance records for each bus during each time period were analyzed for differences (positive or negative) that may have occurred due to use of B20 versus the previous period of time when the bus ran on standard #2 petrodiesel.

The Kansas City Area Transportation Authority (KCATA)

The Kansas City Area Transportation Authority is an interstate agency of Missouri and Kansas with a seven-county jurisdiction - the counties of Cass, Clay, Jackson, and Platte in Missouri; and Johnson, Leavenworth, and Wyandotte in Kansas.

The KCATA's Metro Division is responsible for the provision of public transportation to an average of approximately 50,000 passengers per day. The Metro Division operates 70 bus routes that provide almost eight million miles of scheduled transit service per year with an operating budget of roughly $40.5 million. Approximately one-fifth of its income is derived from operations, mostly passenger revenue. Smaller amounts are obtained from stadium express operations and bus advertising. Around two-thirds of the operating cost is derived from local governmental subsidies, and the federal government provides the remaining 12 percent of Metro's operating funds. The Authority receives operating and capital assistance for its Metro Division from the Federal Transit Administration (FTA).

Biodiesel Background

Biodiesel is a domestically-produced, renewable alternative fuel comprised of mono-alkyl esters of long chain fatty acids derived from triglycerides such as vegetable oils, animal fats, and/or waste greases designated B100, and meeting the requirements of the national fuel quality standard, ASTM D 6751[1]. Biodiesel can be used in concentrations up to 20% with petrodiesel (B20) in existing diesel engines with essentially no modification. Biodiesel has a higher cetane value than conventional US based petrodiesel, higher lubricity, and less emissions of unburnt hydrocarbons, carbon monoxide, and particulate matter. The BTU content of pure biodiesel, B100, is approximately 8% lower[2, 3] than average No. 2 petrodiesel, but is similar to No. 1 petrodiesel. When used in B20 blends, the BTU content is approximately 1.6% lower than that of average No. 2 petrodiesel, but many operators report they are unable to discern a fuel economy difference between B20 and petrodiesel alone.

Recent testing that mirrors more "real-world" operating experiences has shown that NO_x emissions with B20 and lower blends are not statistically different when compared to standard No. 2 petrodiesel using testing cycles representative of inner city buses[4]. In addition, in SAE Paper 2008-01-0078, "Effects of Methyl Ester Biodiesel Blends on NOx Production", Cummins Engine Company reported, 'At B20, the difference in NOx emissions between a biodiesel blend and its base diesel fuel is relatively small, and is less than the difference seen between two commercial diesel fuels within the normal range of aromatics content available in the marketplace.' Pure biodiesel (B100) has essentially no nitrogen, aromatics, or sulfur and is biodegradable, non-toxic, renewable and sustainable. Previous independent studies by the US Department of Agriculture (USDA) and the US Department of

[1] http://www.biodiesel.org/pdf_files/fuelfactsheets/BDSpec.PDF
[2] http://www.biodiesel.org/pdf_files/fuelfactsheets/emissions.pdf
[3] http://www.biodiesel.org/pdf_files/fuelfactsheets/BTU_Content_Final_Oct2005.pdf
[4] http://www.nrel.gov/docs/fy07osti/40554.pdf

Energy (USDOE) show that B100 has a 78% life cycle CO_2 reduction compared to petrodiesel and an extremely high fossil energy balance of 3.2 to 1[5, 6].

Test Buses and Bus Routes

In early 2005, the Kansas City Area Transportation Authority (KCATA) purchased 13 new buses (termed MAX – Metro Area eXpress) for their existing fleet with the sole purpose of using each of these buses on a specific route. MAX buses differ from KCATA's regular bus service fleet in length (they are 1½ feet longer), engine size, and transmission. Each bus has a Cummins engine and Voith transmission and cost approximately $330,000 at the time of purchase in July 2005. Figure 1 presents one of the actual MAX buses in service.

Figure 1. Kansas City Area Transportation Authority MAX bus.

MAX is a new form of bus transit providing faster, more convenient commutes than traditional bus service on existing Kansas City streets. MAX buses run seven days a week, 4:30 A.M. to Midnight. They use dedicated lanes during rush hour and have the ability to prolong green lights at intersections to remain on schedule. Operating along the Main Street corridor from the River Market in the north, through downtown, past Union Station, and Crown Center, and on to the Country Club Plaza, MAX connects an estimated 150,000 jobs and thousands of convention visitors with Kansas City. Appendix 'MAX Routes' provides a schematic of the MAX route. Each MAX bus generally operates both a short and long run on this route each day.

MAX has been created through a cooperative effort between KCATA and the City of Kansas City, Missouri. The budget for creating MAX was $21 million, with $16.8 million in federal funding and $4.2 million in local funding.

[5] http://www.biodiesel.org/pdf_files/fuelfactsheets/Benefits%20of%20Biodiesel.Pdf
[6] http://www.biodiesel.org/pdf_files/fuelfactsheets/Performance.PDF

Biodiesel Delivery, Fueling, and Storage at KCATA

Soy-based biodiesel (B100) was procured by Carter Energy in Kansas City from a number of national biodiesel producers and delivered as a B20 blend to the KCATA facility. The blended biodiesel was stored in a separate, dedicated 25,000 gallon underground storage tank. Carter Energy received valid Certificates of Analysis (COAs) with each B100 load to insure it met current ASTM specification at the time of delivery, and the B100 was blended with diesel fuel at their facility via a "splash" blending arrangement and transported to the KCATA fuel storage site. The dedicated storage tank at KCATA is underground, was cleaned before the project began, and was used only for this project.. MAX buses were fueled each night at an indoor facility on the KCATA grounds. KCATA fuel procurement and administrative personnel reported no problems with fuel handling or storage.

Documentation of the effects of B20 use in the field over a one year time period

Fuel economy (miles per gallon) for each of the 13 MAX buses (buses 3500 to 3512) was calculated from fuel consumption and mileage records kept by KCATA in their maintenance department. Table 1 presents a typical record of fuel consumption and mileage for each bus using petrodiesel only for September 2006. Even though these buses all ran similar routes, it is instructive to note the broad range of fuel economy values from a low of 2.88 mpg to a high of 3.60 mpg during the month. Fuel consumption and mileage records are kept for all buses for each month they were in use as a normal part of KCATA business practice.

Appendix 'Fuel Economy' presents fuel consumption (gallons) and associated mileage by month for 12 buses for the 14 months in which the buses ran on just standard #2 petrodiesel (combination of S500 and the new Ultra Low Sulfur Diesel—ULSD, grade S15) and the 13 months they ran on B20 exclusively blended with the S15 ULSD. Normal data collected by KCATA did not track sulfur or BTU content, so the amount of petrodiesel run on S500 vs. S15 or any BTU differences between the two are unknown. Some operators reported lower fuel economy with S15 ULSD than with the previous S500 grade, but this is anecdotal and not able to be confirmed by the data available. Bus 3512 began operations in January 2006 instead of July 2005. This data was used to determine the overall fuel mileage differences (+/-) of B20.

Table 2 presents the mileage and fuel consumption summation for all 13 buses for the full 12 month period covered in this report. Fuel economy differences for the 12 month average with the petrodiesel only buses ranged from a low of 3.15 mpg to a high of 3.53 mpg (total range 0.38 mpg) while the B20 buses ranged from a low of 3.07 mpg to a high of 3.39 mpg (total range of 0.32). The summary averages from the two groups yielded overall fuel economy of the petrodiesel buses of 3.36 mpg while the B20 buses averaged 3.26 mpg, a difference of 0.10 mpg. This difference is well within the variability experienced from bus to bus for both the petrodiesel and the B20 groups.

Table 1. Fuel consumption and mileage for KCATA MAX buses – September 2006.

Bus #	Month Miles	Fuel Consumption (gallons - B20)	Fuel Economy (miles per gallon
3500	3,121.1	1,085.5	2.88
3501	3,509.0	974.1	3.60
3502	3,307.9	963.3	3.43
3503	3,408.2	1,134.8	3.00
3504	2,522.1	732.4	3.44
3505	2,986.7	913.8	3.27
3506	2,846.8	867.5	3.28
3507	3,284.3	974.4	3.37
3508	3,575.8	1,020.1	3.51
3509	2,990.2	907.7	3.29
3510	2,687.8	781.8	3.44
3511	2,962.1	883.2	3.35
3512	3,609.1	1,088.4	3.32

Table 2. Total mileage and fuel consumption for all 13 KCATA MAX buses over the period of study.

	September 2005 - August 2006			September 2006 to August 2007			
	Standard #2 Diesel			**B20 w/ ULSD**			
Bus #	total miles	gallons	composite D2 mpg	total miles	gallons	composite B20 mpg	Difference with B20, mpg
3500	37,642.2	11,250.7	3.35	38,754.6	12,628.0	3.07	-0.28
3501	40,959.7	11,842.5	3.46	37,706.1	11,382.8	3.31	-0.15
3502	40,948.3	12,259.2	3.34	40,787.7	12,600.6	3.24	-0.10
3503	39,836.3	11,810.3	3.37	38,431.9	12,122.9	3.17	-0.20
3504	38,086.3	11,197.7	3.40	38,859.3	11,644.2	3.34	-0.06
3505	40,247.1	12,017.5	3.35	38,071.4	11,853.7	3.21	-0.14
3506	39,845.9	11,323.8	3.52	38,404.9	11,912.4	3.22	-0.30
3507	39,939.3	11,825.8	3.38	39,984.5	12,275.1	3.26	-0.12
3508	40,643.1	11,508.9	3.53	37,702.5	11,117.3	3.39	-0.14
3509	41,289.7	12,557.8	3.29	37,910.0	11,950.9	3.17	-0.12
3510	39,859.6	11,789.7	3.38	38,504.9	11,357.3	3.39	0.01
3511	39,392.7	12,458.5	3.16	39,746.8	12,066.9	3.29	0.13
3512	24,586.8	7,804.6	3.15	41,036.5	12,478.7	3.29	0.14
	503,277.0	**149,647.0**	**3.36**	**505,901.1**	**155,390.8**	**3.26**	-0.10

For these two groups, the miles and gallons consumed between #2 diesel and B20 throughout the study period were similar, the routes were similar (negating any topography affects), and the drivers of these 13 buses drove their buses for identical periods of time (three month shifts on a single bus each). During this period of time the fleet did, however, switch from S500 petrodiesel to S15 ULSD. Given the wide variety of fuel economy values from bus to bus over the 12 month average (range of 0.32 to 0.38 mpg from bus to bus within the B20 and petrodiesel only groups respectively), the even wider range of fuel economy on a month by month basis (range of 0.72 mpg from bus to bus in September 2006 for instance), and the unknown effects of the impact of the switch to ULSD which was used by all the B20 buses, this data set demonstrates similar fuel economy for petrodiesel and B20 in actual field use.

Impacts on maintenance and driver satisfaction

Detailed maintenance records are kept for all 13 MAX buses during their time of operation and are reported by month. Maintenance operations include repair to bus structure (broken lights, inoperable doors, etc.), brakes, steering, and fluid levels associated with the transmission, etc. Once a defect is reported by the bus driver or other KCATA maintenance staff, an individual work order is prepared for each malfunction noted. Typical scheduled maintenance occurs every 6,000 miles for the MAX buses.

Operational maintenance records were obtained from KCATA maintenance staff for each bus and analyzed for any additional maintenance and associated costs that may have occurred due to use of B20 versus the previous period of time when the bus ran on standard #2 diesel. In all maintenance records or work orders no mention or breakout is made of defects or repairs specifically attributable to use of biodiesel. Of the possible work orders and associated defects common to KCATA bus maintenance, anything involving the engine, fuel tank, or fuel delivery system was noted and in particular repairs dealing with filter change-outs, or leaking oil or fuel were singled out. Of the approximately 2,150 work orders assigned during the two-plus years of this project, only 135 of them (~6%) fell within these categories and in discussions with KCATA maintenance and management personnel they felt no additional maintenance was required on the 13 buses due to use of biodiesel within the parameters of the defects that occurred in the approximate 2,150 work orders. Table 3 presents a typical work order for one MAX bus that details specific types of maintenance needed.

In vehicles that have run petrodiesel for long periods of time, it is possible for the use of B20 to remove the petrodiesel gums and deposits collected in the fuel system when first changing over to B20 and in about 2% of the cases an increase in the need to change fuel filters can occur. Once the petrodiesel deposits have been cleaned, the filter changes revert to normal frequencies. This phenomenon was specifically checked for this project. Maintenance personnel indicated fuel filter change-outs were no more frequent with B20 than before for this project. This validates that the need for fuel filters changes is relatively rare, even when first switching. The relatively short use of petrodiesel in these newer buses could have also contributed to the lack of filter changes observed with B20 in this project.

During the time that B20 was in operation with the 13 MAX buses, some injector failures (six) occurred on six different MAX buses that did not occur on other KCATA buses fueled by standard #2 diesel or on the other seven MAX buses during this period of time. All

six injector failures were covered by Cummins under warranty. These failures occurred during a period of October 2006 through March 2007 and have not occurred since. Neither Cummins nor KCATA could attribute the need to replace these injectors to the use of B20.

Drivers were not told the buses they were driving over the study period were fueled with B20 and none of the drivers, according to KCATA administrative personnel, expressed any dissatisfaction with the daily operation of their bus or remarked about any power differences related to the use of B20.

Project Summary and Conclusions

The Kansas City Area Transportation Authority (KCATA) was tasked by the Federal Highway Administration to investigate the use of a 20% blend of soy-based biodiesel in 13 dedicated buses (MAX – Metro Area eXpress) that ran on a single route in the Kansas City Metro area for a period of approximately two years. In the first 12 months the buses were fueled with standard S500 #2 petrodiesel and the following 12 months on a B20 blend with Ultra Low Sulfur Diesel (ULSD), S15 grade. Fuel economy data (miles per gallon) and operational maintenance data were recorded for all 13 buses to help investigate the effect of a B20 blend versus standard No. 2 petrodiesel. For the period of time in which the buses ran on the B20 blend, fuel economy was well within bus to bus variation (B20 vs. petrodiesel difference of 0.1 mpg). No specific "day-to-day" maintenance problems were observed due to use of B20. Some injectors were replaced with the B20 buses, but their replacement was covered by Cummins and could not be attributed to the use of B20.

Fuel economy is certainly a factor in the transit business, as is the cost of engine and fuel system maintenance. This project demonstrated similar fuel economy and maintenance between B20 use and petrodiesel alone in actual transit daily use over the period of one year. This was the case even though all the B20 use was with 15 ppm sulfur diesel fuel (S15 grade ULSD) and the petrodiesel use was with conventional 500 ppm S500 grade petrodiesel.

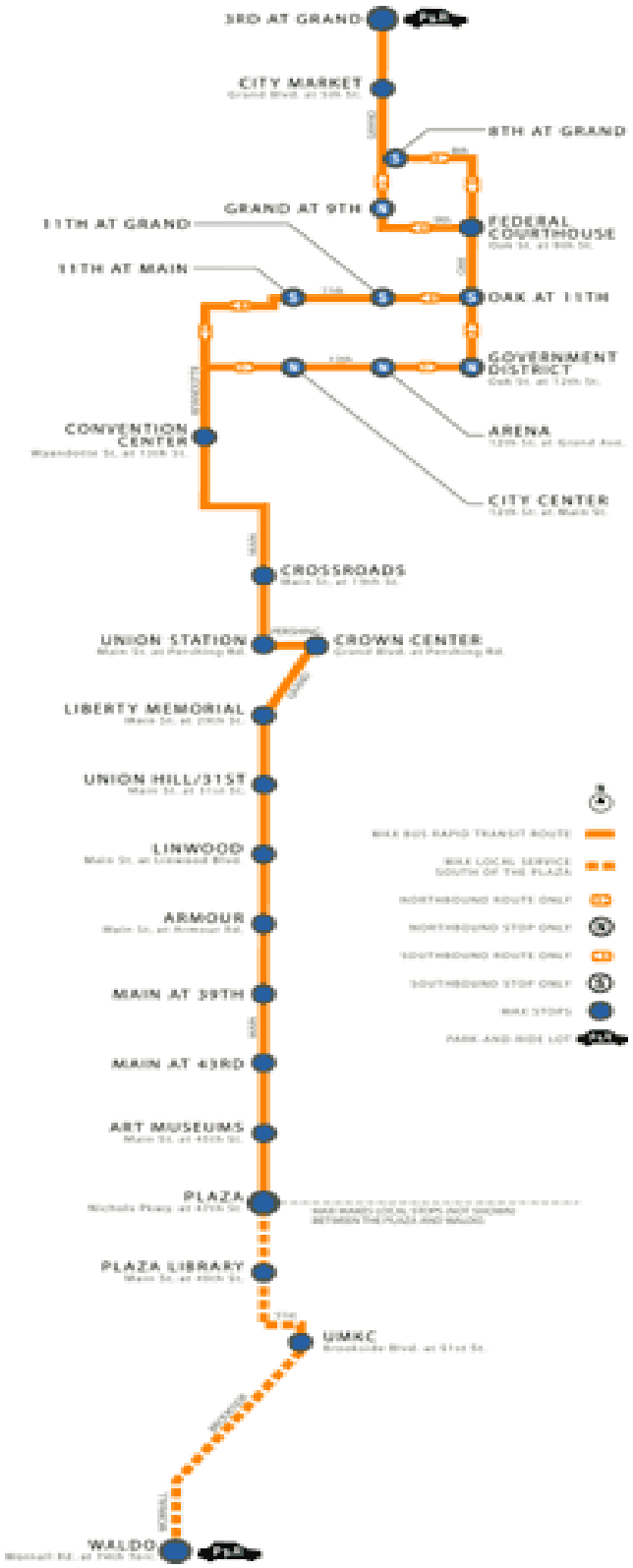
KCATA administrative personnel who oversaw this project stated they were essentially pleased with the use of B20 especially from the standpoint of improving emissions in an urban setting, as well as the improvement in lubricity imparted by biodiesel as they switched to S15 grade ULSD.

Table 3. Typical KCATA maintenance record for a MAX bus.

Work Order	Work Order Title	Defect	Repair	Repair Employee	Last Task End
73919	FAST IDLE	Loose	Torque	7269	09/27/06
73919	FAST IDLE	Inoperative	Removed & Replaced	7269	09/27/06
71472	KCATA VEHICLE MINI INSPECTION				10/20/06
74170	Brake Reline, S-Cam Rear				10/02/06
74386	R.S. mirror loose	Broken	Removed & Replaced	7871	10/03/06
75068	coolant leak in defrost area	Not Working	Replace Coil	7830	10/13/06
74700	BRAKES	No Defect	Inspected	7038	10/09/06
74700	BRAKES	Not Working	Replace bulbs	7038	10/09/06
75542	OPERATOR REPORTED ENGINE WON'T START.				11/17/06
76732	Loose floor rubber left side rear	Loose	Tightened / Secured	7105	11/09/06
77483	CHECK BATTERY'S + CHARGING	Required Maint.	Removed & Replaced	7224	11/23/06
77483	CHECK BATTERY'S + CHARGING	Not Working	Replace bulbs	7224	11/23/06
77203	RETARDER				11/17/06
75505	RTS & GILLIG BUS INSPECTION-B Inspection				12/14/06
78724	Body Inspection Repair.				12/14/06
79153	rotten egg smell on bus				12/21/06
78750	Inspection Repair	Not Working	Replace bulbs	7059	12/15/06
78750	Inspection Repair	No Defect	Inspected	7188	12/15/06
78750	Inspection Repair	Loose	Tightened / Secured	7188	12/15/06
78750	Inspection Repair	Leaking	Repaired	7188	12/15/06
78750	Inspection Repair	Cracked	Replace Belt's	7188	12/15/06
81229	RIGHT HEADLIGHT	Broken	Removed & Replaced	7278	01/26/07
80829	no start	Dead	Replaced	7222	01/22/07
81313	HEADLIGHT OUT	Burnt Out	Removed & Replaced	7330	01/27/07
78737	KCATA VEHICLE MINI INSPECTION				02/05/07
81505	BRAKES	Worn	Rebuilt	7224	02/05/07

Appendix

MAX Routes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CITY MARKET
8TH AT GRAND
GRAND AT 9TH
11TH AT GRAND
FEDERAL COURTHOUSE
11TH AT MAIN
OAK AT 11TH
GOVERNMENT DISTRICT
CONVENTION CENTER
ARENA
CITY CENTER
CROSSROADS
UNION STATION
CROWN CENTER
LIBERTY MEMORIAL
UNION HILL/31ST
LINWOOD
ARMOUR
MAIN AT 39TH
MAIN AT 43RD
ART MUSEUMS
PLAZA
PLAZA LIBRARY
UMKC
WALDO

Appendix

Fuel Economy

Month Year	BUS #	MPG	month miles		Month Year	BUS #	MPG	month miles
July, 2005	3500	4.29	1,609		July, 2005	3501	3.15	1,190
August, 2005	3500	3.04	3,448		August, 2005	3501	2.47	3,016
September, 2005	3500	3.17	3,549		September, 2005	3501	3.26	3,924
October, 2005	3500	3.32	3,319		October, 2005	3501	3.57	3,297
November, 2005	3500	3.55	2,404		November, 2005	3501	3.56	3,471
December, 2005	3500	4.22	3,458		December, 2005	3501	3.60	3,248
January, 2006	3500	2.84	2,594		January, 2006	3501	3.61	3,607
February, 2006	3500	3.38	2,768		February, 2006	3501	3.66	3,081
March,2006	3500	3.54	3,016		March,2006	3501	3.67	3,618
April, 2006	3500	4.00	3,718		April, 2006	3501	3.44	3,072
May, 2006	3500	3.80	3,602		May, 2006	3501	3.63	3,743
June, 2006	3500	3.20	3,260		June, 2006	3501	3.11	3,029
July, 2006	3500	2.77	2,571		July, 2006	3501	3.12	3,128
August, 2006	3500	2.76	3,383		August, 2006	3501	3.37	3,741
September, 2006	3500	2.88	3,121		September, 2006	3501	3.60	3,509
October, 2006	3500	2.94	3,641		October, 2006	3501	3.63	3,702
November, 2006	3500	2.86	3,070		November, 2006	3501	3.60	3,151
December, 2006	3500	2.83	3,126		December, 2006	3501	3.63	2,780
January, 2007	3500	3.31	3,868		January, 2007	3501	3.59	2,931
February, 2007	3500	3.24	2,657		February, 2007	3501	3.52	3,573
March, 2007	3500	3.41	3,667		March, 2007	3501	3.46	3,523
April, 2007	3500	3.39	2,901		April, 2007	3501	3.24	3,117
May, 2007	3500	3.20	3,484		May, 2007	3501	3.01	3,080
June, 2007	3500	2.91	2,765		June, 2007	3501	2.89	3,116
July, 2007	3500	3.00	3,581		July, 2007	3501	2.88	2,936
August, 2007	3500	2.97	2,873		August, 2007	3501	2.80	2,290
September, 2007	3500	3.17	3,349		September, 2007	3501	3.31	3,316

Month Year	BUS #	MPG	month miles		Month Year	BUS #	MPG	month miles
July, 2005	3502	3.11	1,155		July, 2005	3503	2.76	1,157
August, 2005	3502	2.95	3,329		August, 2005	3503	2.64	3,528
September, 2005	3502	3.15	3,616		September, 2005	3503	3.09	3,376
October, 2005	3502	3.48	3,562		October, 2005	3503	3.41	3,398
November, 2005	3502	3.56	3,270		November, 2005	3503	3.50	3,570
December, 2005	3502	3.58	3,780		December, 2005	3503	3.56	3,225
January, 2006	3502	3.53	2,885		January, 2006	3503	3.46	3,270
February, 2006	3502	3.32	3,040		February, 2006	3503	3.63	2,877
March,2006	3502	3.53	3,454		March,2006	3503	3.62	3,832
April, 2006	3502	3.45	3,080		April, 2006	3503	3.47	3,530
May, 2006	3502	3.26	3,510		May, 2006	3503	3.44	3,024
June, 2006	3502	3.22	3,566		June, 2006	3503	3.31	2,585
July, 2006	3502	3.09	3,173		July, 2006	3503	3.06	3,266
August, 2006	3502	3.10	4,014		August, 2006	3503	3.09	3,883
September, 2006	3502	3.43	3,308		September, 2006	3503	3.00	3,408
October, 2006	3502	3.33	3,458		October, 2006	3503	2.99	2,658
November, 2006	3502	3.63	3,425		November, 2006	3503	3.07	3,136
December, 2006	3502	3.57	3,699		December, 2006	3503	3.11	3,003
January, 2007	3502	3.51	3,549		January, 2007	3503	3.45	3,252
February, 2007	3502	2.86	3,119		February, 2007	3503	3.55	3,364
March, 2007	3502	3.06	3,396		March, 2007	3503	3.53	3,413
April, 2007	3502	3.39	3,580		April, 2007	3503	3.32	2,866
May, 2007	3502	3.16	2,945		May, 2007	3503	3.17	3,098
June, 2007	3502	3.02	3,435		June, 2007	3503	2.94	2,865
July, 2007	3502	3.01	2,868		July, 2007	3503	3.03	3,786
August, 2007	3502	3.00	4,006		August, 2007	3503	2.99	3,584
September, 2007	3502	3.19	2,678		September, 2007	3503	3.08	3,275

Month Year	BUS #	MPG	month miles		Month Year	BUS #	MPG	month miles
July, 2005	3504	2.48	1,028		July, 2005	3505	2.86	932
August, 2005	3504	2.50	2,758		August, 2005	3505	2.43	2,106
September, 2005	3504	3.01	3,479		September, 2005	3505	3.06	3,816
October, 2005	3504	3.40	3,607		October, 2005	3505	3.36	3,427
November, 2005	3504	3.72	3,440		November, 2005	3505	3.50	3,548
December, 2005	3504	3.56	3,532		December, 2005	3505	3.60	3,823
January, 2006	3504	4.08	2,834		January, 2006	3505	3.59	3,568
February, 2006	3504	3.61	3,163		February, 2006	3505	3.46	2,674
March,2006	3504	3.63	3,453		March,2006	3505	3.35	3,178
April, 2006	3504	3.37	3,044		April, 2006	3505	3.47	3,140
May, 2006	3504	3.40	3,712		May, 2006	3505	3.32	3,107
June, 2006	3504	3.13	3,299		June, 2006	3505	3.22	2,862
July, 2006	3504	3.02	3,328		July, 2006	3505	3.02	3,553
August, 2006	3504	3.09	1,196		August, 2006	3505	3.36	3,552
September, 2006	3504	3.44	2,522		September, 2006	3505	3.27	2,987
October, 2006	3504	3.55	3,929		October, 2006	3505	3.42	3,302
November, 2006	3504	3.58	3,101		November, 2006	3505	3.47	3,130
December, 2006	3504	3.47	3,209		December, 2006	3505	3.35	2,787
January, 2007	3504	3.37	2,923		January, 2007	3505	3.53	3,148
February, 2007	3504	3.44	3,426		February, 2007	3505	3.03	2,367
March, 2007	3504	3.51	3,206		March, 2007	3505	3.49	3,389
April, 2007	3504	3.39	3,090		April, 2007	3505	3.28	3,209
May, 2007	3504	3.23	3,238		May, 2007	3505	3.16	3,298
June, 2007	3504	3.17	3,299		June, 2007	3505	2.91	3,618
July, 2007	3504	3.07	3,606		July, 2007	3505	2.93	3,390
August, 2007	3504	2.99	3,312		August, 2007	3505	2.95	3,448
September, 2007	3504	3.28	2,680		September, 2007	3505	3.17	3,485

Diesel Fuel Only

B20

Month Year	BUS #	MPG	month miles		Month Year	BUS #	MPG	month miles
July, 2005	3506	3.06	1,214		July, 2005	3507	3.13	1,063
August, 2005	3506	2.60	3,330		August, 2005	3507	2.85	3,677
September, 2005	3506	3.18	3,307		September, 2005	3507	3.01	3,224
October, 2005	3506	3.71	4,344		October, 2005	3507	3.66	3,505
November, 2005	3506	3.72	3,640		November, 2005	3507	3.37	3,404
December, 2005	3506	3.67	3,755		December, 2005	3507	3.50	3,630
January, 2006	3506	3.86	3,528		January, 2006	3507	3.64	3,434
February, 2006	3506	3.60	2,950		February, 2006	3507	3.56	2,681
March,2006	3506	3.57	3,100		March,2006	3507	3.59	3,492
April, 2006	3506	3.67	3,025		April, 2006	3507	3.50	3,314
May, 2006	3506	3.22	2,201		May, 2006	3507	3.50	3,487
June, 2006	3506	3.35	3,092		June, 2006	3507	3.18	3,216
July, 2006	3506	3.14	3,333		July, 2006	3507	3.13	3,394
August, 2006	3506	3.50	3,571		August, 2006	3507	3.04	3,160
September, 2006	3506	3.28	2,847		September, 2006	3507	3.37	3,284
October, 2006	3506	3.58	3,191		October, 2006	3507	3.48	3,254
November, 2006	3506	3.67	3,607		November, 2006	3507	3.61	3,593
December, 2006	3506	3.59	3,205		December, 2006	3507	3.47	3,869
January, 2007	3506	3.55	3,458		January, 2007	3507	3.47	3,430
February, 2007	3506	3.48	3,267		February, 2007	3507	3.17	2,500
March, 2007	3506	3.54	3,595		March, 2007	3507	3.41	3,173
April, 2007	3506	3.29	3,371		April, 2007	3507	3.34	2,921
May, 2007	3506	2.89	2,801		May, 2007	3507	3.18	3,553
June, 2007	3506	2.70	2,817		June, 2007	3507	2.99	3,416
July, 2007	3506	2.64	2,788		July, 2007	3507	2.86	2,975
August, 2007	3506	2.76	3,459		August, 2007	3507	2.91	4,016
September, 2007	3506	3.05	3,053		September, 2007	3507	3.25	3,693

Month Year	BUS #	MPG	month miles		Month Year	BUS #	MPG	month miles
July, 2005	3508	3.50	1,384		July, 2005	3509	2.69	1,441
August, 2005	3508	4.12	4,682		August, 2005	3509	2.41	2,890
September, 2005	3508	3.19	3,481		September, 2005	3509	3.15	4,183
October, 2005	3508	3.53	3,356		October, 2005	3509	3.36	3,493
November, 2005	3508	3.80	3,741		November, 2005	3509	3.35	3,633
December, 2005	3508	3.56	3,432		December, 2005	3509	3.44	3,456
January, 2006	3508	3.86	3,370		January, 2006	3509	3.70	3,450
February, 2006	3508	3.70	3,364		February, 2006	3509	3.37	3,163
March,2006	3508	3.61	2,948		March,2006	3509	3.52	3,665
April, 2006	3508	3.83	2,907		April, 2006	3509	3.34	3,065
May, 2006	3508	3.70	3,559		May, 2006	3509	3.14	2,909
June, 2006	3508	3.28	3,557		June, 2006	3509	3.21	3,606
July, 2006	3508	3.22	3,436		July, 2006	3509	2.93	3,119
August, 2006	3508	3.33	3,492		August, 2006	3509	3.08	3,548
September, 2006	3508	3.51	3,576		September, 2006	3509	3.29	2,990
October, 2006	3508	3.50	2,812		October, 2006	3509	3.51	3,317
November, 2006	3508	3.61	2,987		November, 2006	3509	3.48	3,144
December, 2006	3508	3.63	3,686		December, 2006	3509	3.19	3,017
January, 2007	3508	3.57	2,703		January, 2007	3509	3.26	3,125
February, 2007	3508	3.35	1,906		February, 2007	3509	3.16	2,893
March, 2007	3508	3.63	3,652		March, 2007	3509	3.40	3,590
April, 2007	3508	3.39	2,835		April, 2007	3509	3.18	2,768
May, 2007	3508	3.35	3,548		May, 2007	3509	3.15	3,611
June, 2007	3508	3.13	3,243		June, 2007	3509	2.91	3,433
July, 2007	3508	3.12	2,991		July, 2007	3509	2.87	3,370
August, 2007	3508	3.06	3,764		August, 2007	3509	2.82	2,651
September, 2007	3508	3.40	3,653		September, 2007	3509	3.29	3,191

Month Year	BUS #	MPG	month miles		Month Year	BUS #	MPG	month miles
July, 2005	3510	2.78	1,043		July, 2005	3511	2.66	1,077
August, 2005	3510	1.85	2,565		August, 2005	3511	2.51	3,383
September, 2005	3510	2.87	3,313		September, 2005	3511	3.15	1,903
October, 2005	3510	3.44	3,389		October, 2005	3511	3.31	3,520
November, 2005	3510	3.48	3,484		November, 2005	3511	3.52	3,606
December, 2005	3510	3.56	3,471		December, 2005	3511	3.18	3,814
January, 2006	3510	3.68	3,496		January, 2006	3511	3.39	2,857
February, 2006	3510	3.86	3,001		February, 2006	3511	3.42	3,140
March,2006	3510	3.56	3,115		March,2006	3511	3.53	3,325
April, 2006	3510	3.53	2,920		April, 2006	3511	3.43	3,690
May, 2006	3510	3.45	3,099		May, 2006	3511	2.85	3,520
June, 2006	3510	3.20	3,231		June, 2006	3511	2.84	3,342
July, 2006	3510	3.10	3,165		July, 2006	3511	2.66	3,179
August, 2006	3510	3.17	4,177		August, 2006	3511	2.95	3,496
September, 2006	3510	3.44	2,688		September, 2006	3511	3.35	2,962
October, 2006	3510	3.40	3,295		October, 2006	3511	3.31	2,670
November, 2006	3510	3.56	2,661		November, 2006	3511	3.50	3,406
December, 2006	3510	3.75	3,534		December, 2006	3511	3.39	2,924
January, 2007	3510	3.64	3,908		January, 2007	3511	3.47	2,792
February, 2007	3510	3.61	3,240		February, 2007	3511	3.50	3,354
March, 2007	3510	3.48	3,044		March, 2007	3511	3.49	3,582
April, 2007	3510	3.42	2,941		April, 2007	3511	3.47	3,198
May, 2007	3510	3.28	3,447		May, 2007	3511	3.31	4,034
June, 2007	3510	3.15	3,067		June, 2007	3511	3.07	3,187
July, 2007	3510	3.07	3,015		July, 2007	3511	3.00	3,876
August, 2007	3510	3.05	3,664		August, 2007	3511	2.94	3,763
September, 2007	3510	3.29	3,152		September, 2007	3511	3.14	3,216

Month Year	BUS #	MPG	month miles
January, 2006	3512	3.23	2,588
February, 2006	3512	3.31	2,872
March,2006	3512	3.33	2,981
April, 2006	3512	3.15	2,286
May, 2006	3512	3.24	3,315
June, 2006	3512	3.10	3,960
July, 2006	3512	2.87	3,118
August, 2006	3512	3.07	3,467
September, 2006	3512	3.32	3,609
October, 2006	3512	3.39	3,603
November, 2006	3512	3.50	3,236
December, 2006	3512	3.44	3,620
January, 2007	3512	3.50	3,172
February, 2007	3512	3.53	3,391
March, 2007	3512	3.41	3,624
April, 2007	3512	3.45	3,276
May, 2007	3512	3.18	3,278
June, 2007	3512	3.09	3,778
July, 2007	3512	2.90	2,829
August, 2007	3512	2.92	3,619
September, 2007	3512	3.18	3,168