
Demonstration and Driveability Project to Determine the Feasibility of Using E20 as a Motor Fuel

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Outline

- Minnesota Fuel Policies
- E20 Program
 - Drivability - UMN
 - Materials Compatibility - MSUM
 - Emissions - RFA
- Lab Ethanol Research
- Related Studies
- Future Work

Status of Minnesota Fuel Policies

- State Policy on Ethanol
 - Current Standard: 10% Ethanol blend in gasoline
 - Future Goal: 20% blend by 2013 with 5% from cellulosic
 - The Next Generation Energy Initiative increases E85 gas stations from 287 end of 2006 to 1800 by the year 2010
 - » Today there are 348
 - Minnesota Statute 239.791 Subd.1a requires that on August 30, 2013, gasoline sold in the State of Minnesota shall contain at least 20% denatured ethanol by volume. If on December 31, 2010, however, it is determined that 20% of the State's gasoline volume is ethanol, then this provision expires. If 20% volume replacement is not achieved by 2010, then the 2013 requirement becomes effective provided the United States Environmental Protection Agency (US EPA) certifies E20 by December 31, 2010. In order to use E20 in non-Flex-Fuel vehicles, it will be necessary that the US EPA certify E20 as a motor fuel through a waiver under section 211(f) (4) of the Clean Air Act.

Status of Minnesota Fuel Policies

- State Policy on Biodiesel
 - Current Standard: 2% Biodiesel blend
 - 5 percent biodiesel fuel blend by 2008, 10 percent by 2011, 15 percent by 2013 and ultimately 20 percent by 2015

E20 Drivability Program

- Primary funding by the State of Minnesota and the Council of Great Lakes Governors
- Funding provided in support of the E20 Mandate
- Supplemental Funding by the MN Corn Growers Association
- In-kind support by the RFA

E20 Drivability Program

- Thirteen month field test program with matched fleet of UM light and medium duty gasoline vehicles
 - 40 running E0
 - 40 running E20
- The selection of vehicles included a wide cross section of model year 2000 through 2006 Chrysler, Ford,
- General Motors, and Toyota vehicles; all vehicles were fuel-injected and included hybrid models. Complementary programs

E20 Drivability Program

- Test data
 - Daily driveability survey by lay drivers
 - Quarterly driveability tests by professional raters
 - Maintenance, fuel economy records
 - Fuel Analysis
 - » Distillation
 - » Vapor Pressure
 - » Vapor-Liquid Ratio (TVL20)
 - » Driveability Index (Calculated)

E20 Drivability Program – Daily Log Sheet

		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Cold Start Ambient Temperature								
Odometer Reading								
Engine Block Heater used?(Oct-Apr)	Yes/No							
Cold Crank Start Time (sec)								
Cold Start	# attempts/sec							
Cold Engine Idle Quality (P/N)	G - 1 -2 - 3 - S							
Cold Engine Idle Quality (D)	G - 1 -2 - 3 - S							
Cold Engine Drivewayway	Stall ^{1 a}							
(Check One when applicable)	^b							
	Hesitation ²							
	Stumble ³							
	Surge ⁴							
	Backfire ^b							
Warm Engine Start Time (sec)								
Warm Start	# attempts/sec							
Warm Engine Idle Quality (P/N)	G - 1 -2 - 3 - S							
Warm Engine Idle Quality (D)	G - 1 -2 - 3 - S							
Warm Engine Drivewayway	Stall ^{1 a}							
(Check One when applicable)	^b							
	Hesitation ²							
	Stumble ³							
	Surge ⁴							
	Backfire ⁵							
Road Condition	Wet							
(Check One)	Dry							
	Ice/Snow							
Fuel obtained away from Fleet HQ	Yes/No							
	Quantity							

Driver Comments:

- 1a-Stall while accelerating; 1b-Stall while decelerating
- 2 Temporary lack of vehicle response while accelerating
- 3 A short, sharp reduction in speed while accelerating
- 4 Repeated power fluctuations
- 5 A popping/backfire noise in the intake or exhaust systems



Center for Diesel Research

E20 Drivability Program –Lay Driver Results

Table 10a – Average and 95% Confidence Intervals of Lay Driver

Demerit Scores: *Results are weighted by total number of reports.*

Results shown only for paired vehicles, both reporting. Shaded results are statistically different at a 95% confidence level.

Fuel	E0		E20	
Season	Ave. demerits	95% CI	Ave. demerits	95% CI
Summer	5.84	0.51	5.89	0.46
Fall	5.29	0.59	6.49	0.58
Winter	4.59	0.49	5.13	0.58
Spring	2.95	0.41	4.97	0.56

- Count-weighted method.
- May be biased in that the drivers of some vehicles reported the same problems over and over, while for other vehicles which may have had similar problems, reports were not submitted as often.
- Vehicles in which the drivers were more diligent in completing reports will be more heavily weighted.

E20 Drivability Program –Lay Driver Results

Table 10b – Average and 95% Confidence Intervals of Lay Driver

Demerit Scores: *Results are weighted by averages for individual vehicles. Results shown only for paired vehicles, both reporting. None of the differences between E0 and E20 are statistically significant.*

Fuel	E0		E20	
Season	Ave. demerits	95% CI	Ave. demerits	95% CI
Summer	7.09	3.36	7.15	3.23
Fall	5.94	3.72	5.40	3.30
Winter	5.70	3.35	5.48	2.80
Spring	3.28	2.84	5.76	3.42

- Vehicle-weighted method.
- Average demerits for each vehicle are calculated.
- Statistics are based upon performance of individual vehicles.
- The inconsistency and lack of statistical significance suggests that differences in performance of the two fuels were not great.

E20 Drivability Program –Trained Rater Results

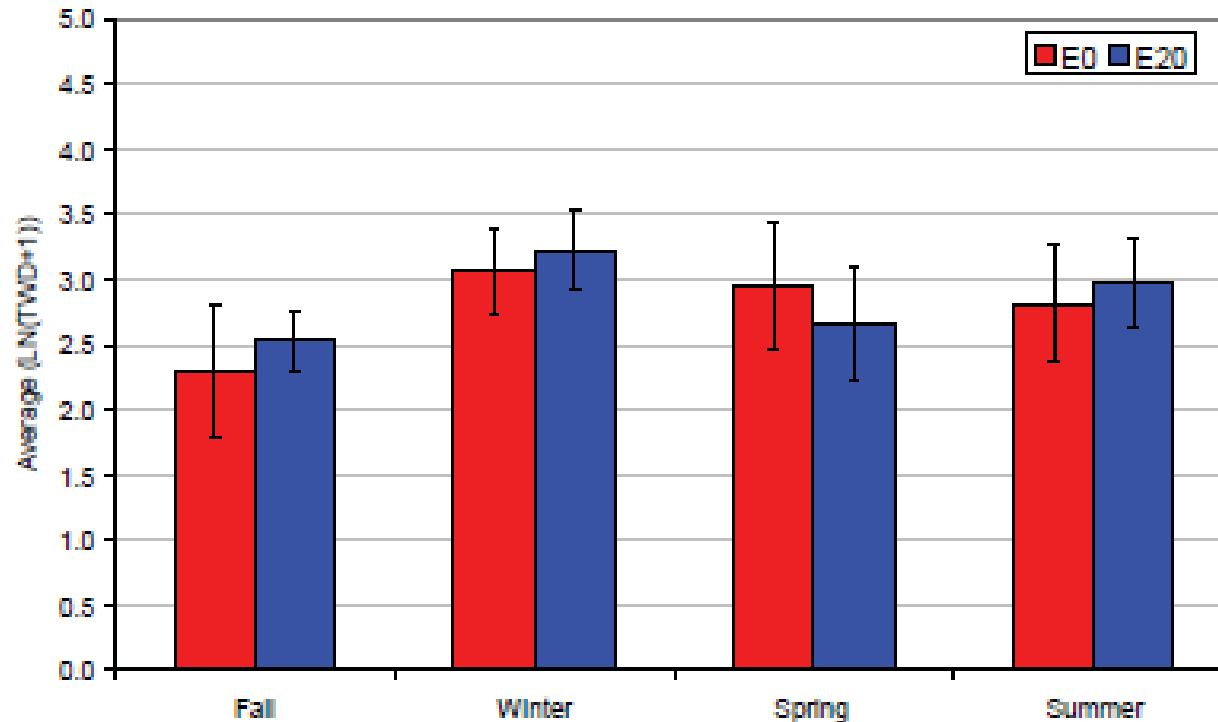


Figure 6a - **Average Trained Raters' Log Transformed Weighted Average Demerits.** Error bars show 95% confidence intervals. Results shown only for paired vehicles both reporting. None of the differences between E0 and E20 are statistically different at a 95% confidence level.

E20 Drivability Program – Fuel Economy Results

- This study was not designed to examine fuel economy.
- The average fuel economy for the test fleet over the course of the project was relatively low: 11.9 mpg for the vehicles operating on E0, and 11.8 mpg for the vehicles operating on E20.
- For individual pairs of vehicles the fuel economy is 1.7% higher for the E20 vehicles.
- When two outlier vehicles were removed, the E20 vehicles show an average fuel economy decrease of 1.4%.
- The statistical uncertainty is large and the driving patterns were not matched such that this data should be used carefully.

E20 Drivability Program –Test Result

- The drivability study showed that **E20 provided similar power and performance to 10 percent ethanol blended fuel throughout the entire calendar year**, which included a broad range of ambient weather conditions.
- There were two vehicle issues, check-engine lights, raised during the fleet testing that were not fuel related.

E20 Program – Companion Studies

- Material Compatibility: Minnesota State University, Mankato
 - Automotive Fuel Pumps and Sending Unit
 - » All of the fuel pumps passed the validation criteria outlined in SAE J1537 in all three fuels
 - Plastics
 - Metals
 - » No issues that would cause a failure within a 20-year life cycle
 - Elastomers
 - » Some property changes, but not of a magnitude great enough to represent a concern
 - The study concludes that the effects of 20 percent ethanol blended fuels **do not** present problems for current automotive or fuel dispensing equipment.
- Emissions: RFA Sponsored - Automotive Testing Laboratories
 - Evaporative and Exhaust Emissions Study
 - » 1981 Buick Riviera
 - » 1999 Ford Taurus
 - » 2007 Dodge Caliber



E20 Program Results

- The vehicle fuel system materials study used both hydrocarbon-only fuel (gasoline) and 10 percent ethanol blended fuel to compare to 20 percent ethanol blended fuels. The year-long project culminated in four (4) separate and distinct material compatibility documents which conclude that the effects of 20 percent ethanol blended fuels do not present problems for current automotive or fuel dispensing equipment.
- The drivability study showed that E20 provided similar power and performance to 10 percent ethanol blended fuel throughout the entire calendar year, which included a broad range of ambient weather conditions.
- Based on the materials compatibility and drivability testing results of this scoping report, there are no issues that would prevent moving forward with the comprehensive testing required to certify E20 as a federally-approved motor fuel.
- Final recommendations on how to proceed with respect to E20 must be withheld until the ongoing emissions testing is complete.

Center for Diesel Research and Combustion

Lab Ethanol Research

- Ethanol (E85) performance and particle emissions in Otto (gasoline) engine
- Ethanol (E100) combustion in Diesel engine enhanced with hydrogen injection
- Ethanol (E100) as fuel in homogeneous charge compression ignition (HCCI) engine
- Hydrogen from reformed ethanol as a Diesel combustion modifier

Fundamental studies of ethanol blends in SI engine (E0 –E85)

Drayton, Marcus K.; Henry M. Ajo, Jeffrey T. Roberts, and David B. Kittelson, 2008. “The Influence of Fuel Ethanol Content on Spark Ignition Engine Nano-Particulate Emissions and Black Carbon Composition,” in preparation for submission to SAE.

Ajo, Henry M.; Marcus K. Drayton, David B. Kittelson, and Jeffrey T. Roberts, 2008. “The Effects of Ethanol as an Oxygenate Additive on Soot Nanoparticulate Matter Oxidation Kinetics, in preparation for submission to EST.

Dutcher, Dabrina D.; Marcus Drayton, Mark R. Stolzenburg, Juan M. Medrano, Deborah S. Gross, David B. Kittelson, and Peter H. McMurry, 2008. “Bio-Fuel Combustion: a Single Particle Perspective, Part 1: Ethanol” submitted to Environmental Science and Technology.

Drayton, Marcus K.; Henry M. Ajo, Jeffrey T. Roberts, and David B. Kittelson, 2008. “The Influence of Fuel Ethanol Content on Spark Ignition Engine Nano-Particulate Emissions and Black Carbon Composition,” in preparation for submission to SAE.



E20 Small Engine Review Study - UMN

- **Issues**
 - **Engine Performance**
 - **Cold Start**
 - **Enleanment**
 - **Vapor Lock**
 - **Engine Wear**
 - **Emissions**
 - **Engine and Fuel System Deposits**
 - **Material Compatibility**
 - **Phase Separation (of fuel)**

UMN GHG Study

Reducing Greenhouse Gas Emissions from Transportation Sources in Minnesota

A Study for the Minnesota Legislature

University of Minnesota Center for Transportation Studies

Objective - Evaluate strategies that can be implemented through state-level policies to reduce greenhouse gas (GHG) emissions from Minnesota's transportation sector.



UMN GHG Study

- Reduction targets for total GHG emissions established by the 2007 Minnesota Next Generation Energy Act. Percent reductions referenced to 2005 total emissions:
 - 15% by 2015
 - 30% by 2025
 - 80% by 2050
- Study assumed transportation's reduction target proportional to transportation's share of total GHG emissions (~24%)

UMN GHG Study – One Conclusion

- **Additional research: Biofuels are one of the areas important to Minnesota**
 - How to develop better biofuels along with producing more biofuel
 - Well-to-wheel life cycle fuel carbon analysis
 - Need common performance standards and assessment methods

Other Related Studies

- **Technical Issues Associated with the Use of Intermediate Ethanol Blends (>E10) in the U.S. Legacy Fleet** – Oak Ridge National Lab
- <http://www.osti.gov/bridge>
 - Does not appear to be available yet

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? Questions or Comments ?

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Study Links

- Drivability Study Link:
www.mda.state.mn.us/renewable/ethanol/default.htm
- E20 use in small spark-ignited engines:
 - www.state.mn.us/portal/mn/jsp/content.do?subchannel=-536881511&programid=536885395&sc3=null&sc2=null&id=-536881350&agency=Commerce
- UMN GHG Study
 - www.cts.umn.edu/Research/Featured/GreenhouseGas/