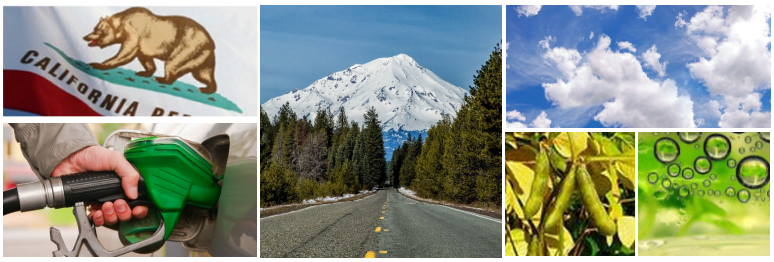
Potential Amendments to the Regulation on the Commercialization of Alternative Diesel Fuels



December 13, 2019
Sacramento, CA

Agenda

- ADF Regulation Background
- Overview and Results of ADF Additive Testing
- Purpose of Workshop – Potential Amendments
  - New Approved ADF Formulation
  - Reinforced Certification Test Requirements
  - New Certification Requirement
- Discussion

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ADF Regulation Background

- Establishes a comprehensive, multi-stage process for administering the commercialization of ADFs in California
- Governs introduction and use of innovative ADFs in California while preserving or enhancing the benefits of existing motor vehicle diesel-fuel regulations
- Includes process for certification of additives or ADF formulations that mitigate NO_x emissions to provide emission-equivalence with each California diesel fuel from which the ADF is blended

Certification of ADF Additives and ADF Formulations

- Biodiesel Additive Certification Fuel (B100) and Reference CARB Diesel (R) must meet specifications in Appendix 1
  - "Reference CARB Diesel" means "reference fuel" as defined in section 2282(g)(3)
- Additized or unadditized B100 is blended at 20 percent by volume with R and/or other ADF formulation components to produce the candidate fuel (C)
- Proposed emission test protocol is submitted for review

Certification Test Procedures

- The test protocol includes:
  - Candidate fuel formulation
  - Analyses of B100, Reference CARB Diesel, and B20 candidate fuel
  - Emission test facility, test engine, test sequence, etc.
- Test protocol must be approved by the Executive Officer before any emission testing begins
- Engine testing must be performed for NOx and PM emissions over a minimum of 20 Federal Test Procedure (FTP) cycles on each candidate and reference fuel

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Certified ADF Additives and Formulations

Executive Order	Company	Additive	Date Signed
EO G-714-ADF01	National Biodiesel Board	VESTA™ 1000	July 20, 2017
EO G-714-ADF02	Renewable Energy Group, Inc.	REG Proprietary Renewable Diesel	January 18, 2018
EO G-714-ADF03	California Fueling	VESTA™ 5000	January 26, 2018
EO G-714-ADF04	Targray Technology International Inc.	CATANOX	February 22, 2018
EO G-714-ADF05A	Best Corp.	BC-EC1c	March 29, 2019
EO G-714-ADF06	Renewable Energy Group, Inc.	REG Proprietary Renewable Diesel	June 1, 2018
EO G-714-ADF07	California Fueling	VESTA™ 5100	June 1, 2018
EO G-714-ADF08	California Fueling	VESTA™ 5115	December 19, 2018
EO G-714-ADF09	Renewable Energy Group, Inc.	REG Proprietary Renewable Diesel #2	April 29, 2019

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B20 Additive Treat Rate Comparison

Authority	Additive	Dosage (ppmv)	Test Facility
App. 1, (a)(1)(A)	DTBP	10,000	UCR
EO G-714-ADF01	VESTA™ 1000	3,000	SwRI
EO G-714-ADF05A	BC-EC1c	20	SwRI
EO G-714-ADF07	VESTA™ 5100	1,000	SwRI

General Concerns Regarding B20 ADF Certification Test Procedures

- Reproducibility of certification test results
- Applicability of certified ADF additives and formulations to broad range of California diesel fuel specifications
- How to reinforce the certification test procedures to:
  - Make the overall pass/fail results more reproducible
  - Broaden the applicability of the certified ADF additives and formulations to range of California diesel fuel specifications

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Overview of ADF Additive Testing

- CARB staff designed an emissions testing program to determine whether certified additives are effective at mitigating NOx emissions, consistent with the certification procedures in the ADF regulation Appendix 1
- Testing was in response to stakeholder concerns and CARB's ongoing goal to ensure effectiveness of ADF regulation
- CARB contracted with UC Riverside (UCR) to perform additive testing

Additive Testing Procedures

- Testing employed a 1991 Detroit Diesel Corporation (DDC) Series 60 engine on an engine dynamometer at UCR
- Test was conducted using Federal Test Procedure (FTP) heavy-duty transient cycle and Alternative 1 (RCCR), which requires more fuel changes but gives more statistical reproducibility
- Certified additive formulations were tested 20 times each and compared to reference diesel, other formulations tested less
- Unadditized B20 also tested to provide point of reference

Test Fuels for Additive Testing

Property (test method)	Reference CARB diesel	Unadditized B100	Unadditized B20
Aromatics (D5186)	6.5 vol%	-	5.2 vol%*
PAH (D5186)	0.2 wt%	-	< 0.2 wt%*
Unadditized Cetane (D613, triplicate)	53.3 53.2 51.9	48.4 48.9 47.2	50.5 50.3 50.3
API Gravity (D287)	37.8	28.6	36.0
Kinematic Viscosity (D445)	2.76 mm^2/s	4.14 mm^2/s	2.93 mm^2/s
Sulfur (D5453)	<0.5 ppm	2.86 ppm	0.96 ppm
Nitrogen (D4629)	<1.0 ppm	4.5 ppm	<1.0 ppm

*Aromatics and PAH levels for Unadditized B20 estimated from Reference CARB Diesel results using linear interpolation.

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Summary of Emissions Results from ADF Additive Testing								
Fuel Blend (Exec. Order No.)	Additive Name	Dosage (ppmv)	Number of Tests	Reference NOx, X_R (g/bhp-hr)	Candidate NOx, X_C (g/bhp-hr)	NOx Increase (% of X_R)	Adjusted Tolerance (% of X_R)	Failed Em. Equiv. by (% of X_R)
B20 (G-714-ADF05A)	BEST Corp. BC-EC1c	20	20	4.536	4.709	3.82	0.78	3.04
B20	No Additive	0	8	4.564	4.742	3.90	0.67	3.23
B20 (G-714-ADF07)	VESTA™ 5100	1000	20	4.515	4.624	2.41	0.71	1.70
B20	VESTA™	2200	8	4.516	4.604	1.94	0.75	1.19
B20 (G-714-ADF01)	VESTA™ 1000	3000	20	4.602	4.705	2.25	0.74	1.51
B10	VESTA™	3000	4	4.586	4.616	0.66	0.57	0.09

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Results of ADF Additive Testing

- All tested additives failed statistical test for B20 NOx emission equivalence with Reference CARB Diesel
  - BEST additive showed effectively no NOx mitigation, VESTA additives showed partial NOx mitigation
- Certification testing of B20 formulations with these additives passed statistical test for NOx emission equivalence with a reference fuel, in many cases showing NOx reductions
- Staff is concerned that the UCR additive test program results did not align with certification test program results

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Factors Influencing Testing Results

- Staff identified many factors that could contribute to differences between certification testing and CARB's additive testing results:
  - Test facility and equipment, test fuels, blending practices, chain of custody for test fuels, and equipment operators
- Staff proposes to reinforce the ADF certification procedures by addressing factors listed above with additional certification requirements

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Potential Amendments

- Provide an additional approved B20 ADF formulation for public use
- Reinforce ADF certification test requirements
- Require all ADF additives and formulations to meet new reinforced certification requirements

New Approved ADF Formulation

(a)(1)(B)1. Blends consisting solely of renewable hydrocarbon diesel at not less than 75 percent by volume, biodiesel, and CARB diesel, where the total biodiesel content of the blend does not exceed 20 percent by volume.

Reinforced Certification Requirements

- Emissions testing at two different labs
- Additional testing with commercial California diesel fuel
- Presence of observers during fuel blending and emission testing
- More stringent "chain of custody" requirements
- Miscellaneous other improvements

Emissions Testing – Labs & Fuels

- Certification tests would be performed at two test facilities
  - Facility 1
    - B20 blended with Reference CARB Diesel v. Reference CARB Diesel
  - Facility 2
    - B20 blended with Reference CARB Diesel v. Reference CARB Diesel
    - B20 blended with Designated Equivalent Limits Diesel v. Designated Equivalent Limits Diesel, as specified in 13 CCR 2282(h)
- Each test at each facility would be required to pass statistical emission-equivalence for NOx and PM

Emissions Testing – New Fuel

- "Designated Equivalent Limits Diesel" means a commercial California diesel fuel or blend of commercial California diesel fuels, produced at a California refinery or refineries, that meets the requirements of 13 CCR 2282(h) and may contain 2-ethyl-hexyl nitrate. Designated Equivalent Limits Diesel does not contain biodiesel or DTBP.
- Triplicate analyses and demonstrations of specifications would be required for cetane number of Biodiesel Additive Certification Fuel; cetane number, aromatic hydrocarbon content, and PAH content of Reference CARB Diesel; and all specifications of Designated Equivalent Limits Diesel.

Specifications of Designated Equivalent Limits Diesel

Property	Equivalent Limit	Test Method
Aromatic Hydrocarbon Content (% by wt.)	≤ 21.0	ASTM D5186-03 (2009)
PAH Content (% by wt.)	≤ 3.5	ASTM D5186-03 (2009)
API Gravity	≥ 36.9	ASTM D287-82
Cetane Number	≥ 53	ASTM D613-84
Nitrogen Content (ppmw)	≤ 500	ASTM D4629-96
Sulfur Content (ppmw)	≤ 15	ASTM D5453-93

Observation

- Observation and verification of fuel blending at each emission test facility by an independent state-licensed professional engineer
- Observation and verification of certification emission testing at each emission test facility by an independent state-licensed professional engineer

Chain of Custody

- Diesel Test Fuels, the Biodiesel Additive Certification Fuel, additives, and other fuel blending components would be shipped directly from their sources to each emission test facility for blending and sampling
- Samples from each test facility would be sent to the same independent laboratory for analysis
- Duplicate samples would be retained and shipped to CARB

Comparison of Certification Requirements

Requirement	Current	Under Consideration
Number of Emission Test Facilities	1	2
Number of Diesel Test Fuels	1	2, Reference and Designated Equivalent Limits (DEL)
Number of Biodiesel (B100) Cert. Fuels	1	1
Number of Candidate Fuels	1	3
Number of Emission Test Programs	1	3
Number of Equivalence Demonstrations	1	3
Observation of Candidate Fuel Blending	Not Required	Independent, state-licensed professional engineers
Observation of Emission Testing	Not Required	Independent, state-licensed professional engineers
Direct Shipping of Fuels and Components	Not Required	Required, from sources to emission test facilities
Analysis of Fuels and Components	Not Additives	All, including additives, from each test facility
By the Same Independent Laboratory	Not Required	Required for all samples from each test facility
Retained Samples, Fuels and Components	Not Required	Shipped to CARB after test protocol approved

New Certification Requirement

(a)(2)(J) As of January 1, 2021, only biodiesel additives and ADF formulations that are approved under section (a)(1) of this appendix or certified according to the certification procedures in this appendix that became effective [the effective date of this subarticle] can be used to comply with the in-use requirements under section 2293.6.

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ADF Amendment Timeline

- December 13, 2019 workshop
- January 7, 2020 hearing notice and ISOR
- February 27, 2020 CARB hearing
- July 1, 2020 potential effective date for amendments
- January 1, 2021 certified ADF additives and formulations would be required to meet new reinforced certification procedures

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Discussion

Thank You

Please submit feedback by **December 20, 2019** @
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