State of California
AIR RESOURCES BOARD

**Response to Significant Environmental Issues**

Item: Public Hearing to Consider the Amendments to Regulations Regarding the Calculation and Use of Reactivity Adjustment Factors for Low-Emission Vehicles and the Adoption of Initial Reactivity Adjustment Factors for Passenger Cars and Light-Duty Trucks Certifying to Transitional Low-Emission Vehicle Exhaust Emission Standards

Agenda Item No.: 91-10-2

Public Hearing Date: November 14, 1991

Issuing Authority: Air Resources Board

Comment: Several comments were received identifying significant environmental issues pertaining to this item. These comments are summarized and responded to in the Final Statement of Reasons, which is incorporated by reference herein.

Resolution 91-53 is also incorporated herein and attached hereto. In the Resolution the Board made various findings pertaining to potential environmental impacts of the proposed regulations. The Board found that the proposed regulations would not have any significant adverse environmental impacts.

Response: See above.

Certified: Pat Hutchens
Pat Hutchens
Board Secretary

Date: Sept. 2, 1992

State of California
AIR RESOURCES BOARD

Resolution 91-53

November 14, 1991

Agenda Item No.: 91-10-2

WHEREAS, sections 39600 and 39601 of the Health and Safety Code authorize the Air Resources Board (the "Board") to adopt standards, rules and regulations and to do such acts as may be necessary for the proper execution of the powers and duties granted to and imposed upon the Board by law;

WHEREAS, in section 43000 of the Health and Safety Code the Legislature has declared that the emission of air contaminants from motor vehicles is the primary cause of air pollution in many parts of the state;

WHEREAS, section 43018(a) of the Health and Safety Code, enacted by the California Clean Air Act of 1988, directs the Board to endeavor to achieve the maximum degree of emission reduction possible from vehicular and other mobile sources in order to accomplish the attainment of the state ambient air quality standards at the earliest practicable date;

WHEREAS, section 43018(b) of the Health and Safety Code directs the Board no later than January 1, 1992 to take whatever actions are necessary, cost-effective, and technologically feasible in order to achieve, by December 31, 2000, a reduction of reactive organic gases ("ROG") of at least 55 percent and a 15 percent reduction in the emissions of oxides of nitrogen ("NOx") from motor vehicles, and the maximum feasible reductions in particulates ("PM"), carbon monoxide ("CO"), and toxic air contaminants from vehicular sources;

WHEREAS, section 43018(c) of the Health and Safety Code provides that in carrying out section 43018, the Board shall adopt standards and regulations which will result in the most cost-effective combination of control measures on all classes of motor vehicles and motor vehicle fuel, including but not limited to reductions in motor vehicle exhaust and evaporative emissions, reductions in in-use vehicular emissions through durability and performance improvements, requiring the purchase of low-emission vehicles by state fleet operators, and specification of vehicular fuel composition;

WHEREAS, section 43101 of the Health and Safety Code directs the Board to adopt and implement emission standards for new motor vehicles which the Board has found to be necessary and technologically feasible to carry out the purposes of Division 26 of the Health and Safety Code;

WHEREAS, section 43104 of the Health and Safety Code directs the Board to adopt test procedures for determining whether new motor vehicles are in compliance with the emission standards established by the Board;

WHEREAS, following a hearing on September 27-28, 1990, the Board in Resolution 90-58 approved the Low-Emission Vehicles and Clean Fuels regulations which require the production of low-emission light- and medium-duty vehicles and require that alternative fuels used by these vehicles be made reasonably available to motorists; at the direction of the Board these regulations were subsequently adopted by the Executive Officer in Executive Order G-604;

WHEREAS, the Low-Emission Vehicles and Clean Fuels regulations establish emission standards for low-emission vehicles which require the application of reactivity adjustment factors ("RAFs") to the non-methane organic gas exhaust mass emissions from transitional low-emission vehicles ("TLEVs"), low-emission vehicles, and ultra-low-emission vehicles operating on fuels other than conventional gasoline, to determine compliance with applicable emission standards;

WHEREAS, the Low-Emission Vehicles and Clean Fuels regulations include a protocol under which the Executive Officer can establish RAFs for representative vehicle/fuel combinations by applying a reactivity scale based on the maximum incremental reactivity ("MIR") of individual hydrocarbon species to hydrocarbon exhaust speciation profiles;

WHEREAS, the portions of the Low-Emission Vehicles and Clean Fuels regulations pertaining to low-emission vehicle standards, the establishment and application of RAFs, and the certification of new motor vehicles to the low-emission standards are contained in Title 13, California Code of Regulations, section 1960.1 and the California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles (the "Standards and Test Procedures"), which is incorporated by reference in section 1960.1;

WHEREAS, the staff initially proposed regulatory amendments which would establish RAFs for TLEVs which operate on methanol ("M85"), compressed natural gas ("CNG"), and liquefied petroleum gas ("LPG"), to be used to determine compliance with the TLEV exhaust emission standards;

WHEREAS, the staff has also proposed regulatory amendments which would make various changes regarding the calculation and use of RAFs for low-emission vehicles; these changes include revisions to the MIRs of individual hydrocarbon species, revisions to the treatment and applicability of updated RAFs, and identification of a value for the gram ozone potential per gram non-methane organic gases for light-duty TLEVs operating on conventional gasoline;

WHEREAS, the proposal would be effected by amendments to Title 13, California Code of Regulations, section 1960.1, and the incorporated Standards and Test Procedures, as set forth in Attachments A and B hereto;

WHEREAS, the California Environmental Quality Act and Board regulations require that an action not be adopted as proposed where it will have significant adverse environmental impacts if feasible alternatives or mitigation measures are available which would substantially reduce or avoid such impacts;

WHEREAS, the Board has considered the impact of the proposed regulations on the economy of the state;

WHEREAS, a public hearing and other administrative proceedings have been held in accordance with the provisions of Chapter 3.5 (commencing with section 11340), Part 1, Division 3, Title 2 of the Government Code; and

WHEREAS, the Board finds that:

The RAF approved herein for light-duty TLEVs operating on M85 is appropriately based on application of the criteria in the regulatory protocol for setting RAFs as modified herein;

There are insufficient data available to establish technically sound RAFs for light-duty TLEVs operating on CNG or LPG at this time;

The revisions approved herein to the identification of the MIRs of individual hydrocarbon species in the Standards and Test Procedures appropriately reflect the peer review and compilation of new data that has occurred over the past year;

The regulatory amendments approved herein pertaining to the use of RAFs are necessary and appropriate to clarify the regulatory requirements and to specify how updated RAFs are to be used;

Use of an MIR scale in determining RAFs is appropriate because the scale reflects the conditions where hydrocarbon control has the greatest impact on ozone formation; the ten percent correction factor included in the modifications to the original proposal will eliminate any overcrediting of reactivity benefits for M85 and LPG in high ozone episodes due to application of the scale, and will provide a margin of safety against such overcrediting during moderate ozone episodes;

The modifications to the original proposal pertaining to the assignment of a RAF for a specific engine family at the

request of a manufacturer is necessary to assure that appropriate RAFs will be available on a timely basis for all vehicles; the modifications include additional elements which will minimize the possibility that the RAF will not accurately reflect the emissions of in-use higher mileage vehicles;

The amendments approved herein should contribute to a more cost-effective means of reducing motor vehicle emissions by adjusting emission standards to reflect the ozone-forming potential of clean fuel/vehicle systems;

The amendments approved herein will not have any significant adverse environmental impacts.

NOW, THEREFORE, BE IT RESOLVED that the Board hereby approves the amendments to section 1960.1, Title 13, California Code of Regulations, and the incorporated California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles, as set forth in Attachments A and B hereto, with the modifications described in Attachment C hereto, and with a further modification to eliminate the requirement that a vehicle manufacturer wishing to have a unique RAF assigned to a specific vehicle/fuel system must submit a speciated profile two years prior to certification of the vehicle.

BE IT FURTHER RESOLVED that the Board directs the Executive Officer (1) to incorporate into the approved amendments the modifications described in Attachment C hereto, with such other conforming modifications as may be appropriate; (2) to conduct an informal workshop on the modified language if warranted; and (3) to adopt the amendments approved herein, after making the modified regulatory language available for public comment for a period of 15 days, provided that the Executive Officer shall consider such written comments regarding the modifications as may be submitted during this period, shall make additional modifications if deemed appropriate after consideration of supplemental comments received, and shall present the regulations to the Board for further consideration if he determines that this is warranted.

BE IT FURTHER RESOLVED that the Board hereby determines that the amendments approved herein will not cause California motor vehicle emission standards, in the aggregate, to be less protective of public health and welfare than applicable federal standards.

BE IT FURTHER RESOLVED that the Board hereby finds that separate California emission standards and test procedures are necessary to meet compelling and extraordinary conditions.

BE IT FURTHER RESOLVED that the Board finds that the California emission standards and test procedures as amended herein will not cause the California requirements to be inconsistent with section 202(a) of the Clean

Air Act and raise no new issues affecting previous waiver determinations of the Administrator of the Environmental Protection Agency pursuant to section 209(b) of the Clean Air Act.

BE IT FURTHER RESOLVED that the Executive Officer shall, upon adoption, forward the amendments to the Environmental Protection Agency with a request for a waiver or confirmation that the amendments are within the scope of an existing waiver of federal preemption pursuant to section 209(b) of the Clean Air Act, as appropriate.

BE IT FURTHER RESOLVED, that the Board directs the Executive Officer to identify and propose correction factors for RAFs for fuels other than M85 and LPG to eliminate potential overcrediting of reactivity benefits when adequate data become available.

I hereby certify that the above is a true and correct copy of Resolution 91-53, as adopted by the Air Resources Board.

Pat Hutchens

Pat Hutchens, Board Secretary

**Resolution 91-53**

November 14, 1991

Identification of Attachments to the Resolution

**Attachment A:** Amendments to Title 13, California Code of Regulations, section 1960.1, as set forth in Appendix B to the Staff Report.

**Attachment B:** Amendments to the California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles, as set forth in Appendix C to the Staff Report.

**Attachment C:** Staff's Suggested Changes to the Proposed RAF Amendments (Distributed at the hearing on November 14, 1991).

**PUBLIC HEARING ON REACTIVITY ADJUSTMENT FACTORS**

**NOVEMBER 14, 1991**

STAFF'S SUGGESTED CHANGES TO THE PROPOSAL

The staff report and technical support document on the proposed regulations regarding the calculation and use of reactivity adjustment factors for low-emission vehicles and the adoption of initial reactivity adjustment factors for transitional low-emission vehicles were released to the public on September 27, 1991. Based on further analyses conducted by the Air Resources Board staff and comments received on these documents and the regulations contained therein, the staff is recommending that the following modifications to the proposed regulations be considered by the Air Resources Board at this hearing.

1. Withdrawal of Proposed RAFs for CNG and LPG

Upon further evaluation of the CNG and LPG data, the staff recommends that reactivity adjustment factors (RAFs) for these fuels not be adopted at this time. For CNG, the staff has conducted additional exhaust emission testing after the release of the staff report. Because of the high uncertainty of the new CNG data, the staff cannot propose a RAF for CNG with any confidence. Because the LPG database consists of only two vehicles, the staff also recommends that the Board not adopt a RAF for LPG at this time. Therefore, the staff recommends that no RAFs be adopted for LPG and CNG at this hearing.

2. Engine Family Specific RAFs

Section Affected: "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles", which is incorporated by reference in Title 13, California Code of Regulations, section 1960.1.

Because the staff is unable to propose generic RAFs for all potential TLEV technologies at this hearing, the staff is proposing that the regulations be amended to facilitate the development of engine family specific RAFs. Previously adopted regulations allow vehicle manufacturers to apply for RAFs specific to their vehicle/fuel system. The Executive

Officer would approve such requests provided that appropriate supporting data are submitted and that there is at least a 25 percent difference between the requested factor and the one already established for the same or similar vehicle/fuel system.

The staff is proposing that the 25 percent criterion be deleted. Vehicle manufacturers would thus be permitted to develop engine family specific RAFs by following the procedure outlined in the test procedures and the additional requirements described below. The staff envisions that durability vehicles for each of the families would have to be emission tested at regular intervals, in accordance with current practice or other approved accelerated durability programs, to generate a deterioration factor for NMOG mass changes and one for changes in the RAF. Neither deterioration factor would be allowed to be less than 1.00. The NMOG mass and RAF deterioration factors would be multiplied together to come up with an overall adjustment factor to apply to in-use vehicle NMOG levels for determining compliance with applicable NMOG emission standards. To confirm that the results from the durability vehicle(s) are reliable, at least 4 emission data vehicles and/or similar qualifying vehicles would also have to be tested using the FTP cycle to determine speciated NMOG emission profiles and attendant RAFs. A statistical process would be used to demonstrate that the data vehicles as a group exhibit similar profiles. In the future, the staff intends to examine further measures to verify that vehicles in-use comply with the intent of the reactivity adjustment process.

3. Correction of Bias in Protocol for Determining RAFs

Section Affected: "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles", which is incorporated by reference in Title 13, California Code of Regulations, section 1960.1.

Following the release of the staff report, airshed modeling analyses conducted by Carnegie Mellon University for the ARB have been completed. The results suggest that there may be a bias in the maximum incremental reactivity scale (MIR) which results in RAFs which are numerically higher than they should be. This bias was found to be 10 percent for M85 and LPG under worst case conditions. Therefore, the staff is recommending that any RAFs developed for M85 or LPG, either by the ARB or by manfacturers, be adjusted upward by 10 percent. Accordingly, the staff recommends that the RAF for M85 be revised from the originally proposed value of 0.36 to 0.41. This adjustment should address any potential biases in the MIR scale as well as other uncertainties in protocol. The staff will determine whether a bias

correction is needed for CNG once more representative vehicle emission data become available.

4. Revised MIR Scale

Section Affected: "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles", which is incorporated by reference in Title 13, California Code of Regulations, section 1960.1.

Subsequent to the release of the staff report, Dr. W.P.L. Carter has made additional updates to the maximum incremental reactivity (MIR) scale. Furthermore, the staff has included the MIRs of compounds which were previously omitted from the regulations. The updated MIR scale which the staff is recommending for Board adoption is included as an attachment to this document. Additions to the originally proposed scale are shown in double-underline, and deletions are shown in strike-out. The revised MIR scale is reflected in the proposed RAF for M85.

| NMOG Constituent | Maximum Incremental Reactivity (g $O_3$/g NMOG) | |
|---|---|---|
| **ALKANES** | | |
| **Normal Alkanes** | | |
| Methane | 0.0148 | |
| Ethane | ~~0.26~~ | 0.25 |
| Propane | 0.48 | |
| n-Butane | 1.02 | |
| n-Pentane | ~~1.03~~ | 1.04 |
| n-Hexane | 0.98 | |
| n-Heptane | 0.81 | |
| n-Octane | 0.61 | |
| n-Nonane | 0.54 | |
| n-Decane | 0.47 | |
| n-Undecane | 0.42 | |
| n-Dodecane | 0.38 | |
| n-Tridecane | 0.35 | |
| n-Tetradecane | 0.32 | |
| n-Pentadecane | 0.29 | |
| **Branched Alkanes** | | |
| 2-Methylpropane | 1.21 | |
| 2,2-Dimethylpropane | 0.37 | |
| 2-Methylbutane | 1.38 | |
| 2,2-Dimethylbutane | 0.82 | |
| 2,3-Dimethylbutane | 1.07 | |
| 2-Methylpentane | 1.53 | |
| 3-Methylpentane | 1.52 | |
| 2,2,3-Trimethylbutane | 1.32 | |
| 2,2-Dimethylpentane | 1.40 | |
| 2,3-Dimethylpentane | 1.51 | |
| 2,4-Dimethylpentane | 1.78 | |
| 3,3-Dimethylpentane | 0.71 | |
| 2-Methylhexane | 1.08 | |
| 3-Methylhexane | 1.40 | |
| 2,2,4-Trimethylpentane | ~~0.87~~ | 0.93 |
| 2,3,3-Trimethylpentane | 1.20 | |
| 2,3,4-Trimethylpentane | 1.60 | |

| NMOG Constituent | Maximum Incremental Reactivity (g $O_3$/g NMOG) | |
|---|---|---|
| **Branched Alkanes** | | |
| 2,2-Dimethylhexane | 1.20 | |
| 2,3-Dimethylhexane | ~~1.31~~ | 1.32 |
| 2,4-Dimethylhexane | 1.50 | |
| 2,5-Dimethylhexane | 1.63 | |
| 3,3-Dimethylhexane | 1.20 | |
| 2-Methylheptane | 0.96 | |
| 3-Methylheptane | 0.99 | |
| 4-Methylheptane | 1.20 | |
| 2,4-Dimethylheptane | ~~1.33~~ | 1.34 |
| 2,2,5-Trimethylhexane | 0.97 | |
| Other Branched C9H20 Alkanes | ~~1.13~~ | 1.14 |
| Branched C10H22 Alkanes | 1.01 | |
| Branched C11 Alkanes | 1.17 | |
| Branched C12 Alkanes | 1.23 | |
| **Cyclo Alkanes** | | |
| Cyclopentane | ~~2.37~~ | 2.38 |
| Methylcyclopentane | 2.82 | |
| Cyclohexane | 1.28 | |
| t-1,2-Dimethylcyclopentane | 1.85 | |
| 1,3-Dimethylcyclopentanes | ~~2.64~~ | 2.55 |
| Methylcyclohexane | ~~1.84~~ | 1.85 |
| Ethylcyclopentane | 2.31 | |
| Ethylmethylcyclopentane | 1.94 | |
| 1c,2t-3-Trimethylcyclopentane | 1.94 | |
| 1,2,4-Trimethylcyclopentane | 1.94 | |
| Dimethylcyclohexanes | 1.94 | |
| Ethylcyclohexane | 1.94 | |
| Ethylmethylcyclohexane | 2.30 | |
| Trimethylcyclohexane | 2.30 | |
| C10 Cycloalkanes | 1.78 | |
| C11 Cycloalkanes | 1.91 | |
| C12 Cycloalkanes | 1.68 | |

| NMOG Constituent | Maximum Incremental Reactivity ($g\ O_3/g$ NMOG) | |
|---|---|---|
| **ALKENES** | | |
| Ethene | 7.28 | 7.29 |
| Propene | 9.39 | 9.40 |
| 1-Butene | 8.90 | 8.91 |
| 2-Butenes | 9.93 | 9.94 |
| 2-Methylpropene | 5.29 | 5.31 |
| 1-Pentene | 6.22 | |
| 2-Pentenes | 8.79 | 8.80 |
| 2-Methyl-1-Butene | 4.89 | 4.90 |
| 3-Methyl-1-Butene | 6.22 | |
| 2-Methyl-2-Butene | 6.40 | 6.41 |
| 1-Hexene | 4.41 | 4.42 |
| 2-Hexenes | 6.67 | 6.69 |
| 3-Hexenes | 6.67 | 6.69 |
| Methyl-1-Pentenes | 4.41 | 4.42 |
| Methyl-2-Pentenes | 6.67 | 6.69 |
| 3,3-Dimethyl-1-Butene | 4.41 | 4.42 |
| 1-Heptene | 3.48 | |
| 2-Heptenes | 5.52 | 5.53 |
| 3-Heptenes | 5.52 | 5.53 |
| 3-Ethyl-2-Pentenes | 5.52 | 5.53 |
| 2,3-Dimethyl-2-Pentene | 5.52 | 5.53 |
| 3-Methyl-1-Hexene | 3.48 | |
| 2-Methyl-2-Hexenes | 5.52 | 5.53 |
| 4-Methyl-2-Hexene | 5.53 | |
| 2-Methyl-3-Hexene | 5.53 | |
| 3-Methyl-3-Hexenes | 5.52 | 5.53 |
| 1-Octene | 2.68 | 2.69 |
| 2-Octenes | 5.27 | 5.29 |
| 3-Octenes | 5.27 | 5.29 |
| 4-Octenes | 5.27 | 5.29 |
| 2,4,4-Trimethyl-1-Pentene | 2.68 | 2.69 |
| 2,4,4-Trimethyl-2-Pentene | 5.29 | |
| 1-Nonene | 2.22 | 2.23 |

| NMOG Constituent | Maximum Incremental Reactivity ($g\ O_3/g$ NMOG) | |
|---|---|---|
| Propadiene | 7.28 | 7.29 |
| 1,3-Butadiene | 10.88 | 10.89 |
| 2-Methyl-1,3-Butadiene | 9.07 | 9.08 |
| Cyclopentadiene | 7.65 | 7.66 |
| Cyclopentene | 7.65 | 7.66 |
| 1-Methylcyclopentene | 5.67 | |
| 3-Methylcyclopentene | 5.65 | 5.67 |
| Cyclohexene | 5.65 | 5.67 |
| a-Pinene | 3.28 | |
| b-Pinene | 4.41 | |
| **ALKYNES** | | |
| Ethyne | 0.51 | 0.50 |
| Propyne | 4.10 | |
| 1-Butyne | 9.23 | 9.24 |
| 2-Butyne | 9.23 | 9.24 |

| NMOG Constituent | Maximum Incremental Reactivity (g $O_3$/g NMOG) | |
|---|---|---|
| **AROMATIC HYDROCARBONS** | | |
| Benzene | 0.42 | |
| Toluene | 2.72 | 2.73 |
| Ethylbenzene | 2.99 | 2.70 |
| o-Xylene | 6.68 | 6.46 |
| m&p-Xylenes | 8.15 | |
| m-Xylene | 8.16 | |
| p-Xylene | 6.60 | |
| n-Propylbenzene | 2.27 | 2.12 |
| i-Propylbenzene | 2.41 | 2.24 |
| Methylethylbenzenes | 7.20 | |
| 1,2,3-Trimethylbenzene | 8.61 | 8.85 |
| 1,2,4-Trimethylbenzene | 8.69 | 8.83 |
| 1,3,5-Trimethylbenzene | 10.11 | 10.12 |
| n-Butylbenzene | 1.87 | |
| s-Butylbenzene | 2.04 | 1.89 |
| Diethylbenzenes | 6.44 | 6.45 |
| 1-Methyl-2-Propylbenzene | 6.45 | |
| 1-Methyl-3-Propylbenzene | 6.45 | |
| C10 Trialkyl Benzenes | 9.07 | |
| Tetramethylbenzenes | 9.06 | 9.07 |
| C11 Monoalkyl Benzenes | 1.70 | |
| 1-Methyl-4-Isobutylbenzene | 5.83 | 5.84 |
| C11 Dialkyl Benzenes | 5.84 | |
| C11 Trialkyl Benzenes | 8.21 | |
| C12 Monoalkyl Benzenes | 1.55 | |
| C12 Dialkyl Benzenes | 5.34 | |
| C12 Trialkyl Benzenes | 7.50 | |
| Indan (C9H10) | 1.04 | 1.06 |
| Methyl Indan | 1.06 | |
| Napthalene | 1.16 | 1.18 |
| Tetralin | 0.96 | |
| Methyl Naphthalenes | 3.27 | |
| 2,3-Dimethyl Naphthalene | 5.13 | |
| Styrene | 2.20 | 2.22 |
| **AROMATIC OXYGENATES** | | |
| Phenol | 1.13 | |
| Cresols | 2.31 | |
| Benzaldehyde | -0.56 | -0.55 |
| p-Tolualdehyde | -0.56 | 3.32 |

| NMOG Constituent | Maximum Incremental Reactivity (g $O_3$/g NMOG) | |
|---|---|---|
| **OXYGENATES** | | |
| **Alcohols** | | |
| Methanol | 0.56 | |
| Ethanol | 1.33 | 1.34 |
| n-Propyl Alcohol | 2.26 | |
| Isopropyl Alcohol | 0.54 | |
| n-Butyl Alcohol | 2.69 | |
| Isobutyl Alcohol | 1.92 | |
| t-Butyl Alcohol | 0.42 | |
| **Aldehydes** | | |
| Formaldehyde | 7.14 | 7.15 |
| Acetaldehyde | 5.51 | 5.52 |
| Propionaldyde | 6.53 | |
| Acrolein | 6.76 | 6.77 |
| n-Butyraldehyde | 5.26 | |
| Crotonaldehyde | 5.41 | 5.42 |
| Pentanaldehyde | 4.40 | 4.41 |
| Hexanaldehyde | 3.79 | |
| C7 Aldehydes | 3.32 | |
| **Ethers** | | |
| Methyl t-Butyl Ether | 0.62 | |
| Ethyl t-Butyl Ether | 1.98 | |
| **Ketones** | | |
| Acetone | 0.56 | |
| Butanone | 1.18 | |