MWM MN Calculation Method

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Agenda

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2. History of MWM MN calculation
3. Adaption to modern lean burn engines
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5. Evaluation of the method for the calculation
6. Implementation of factors
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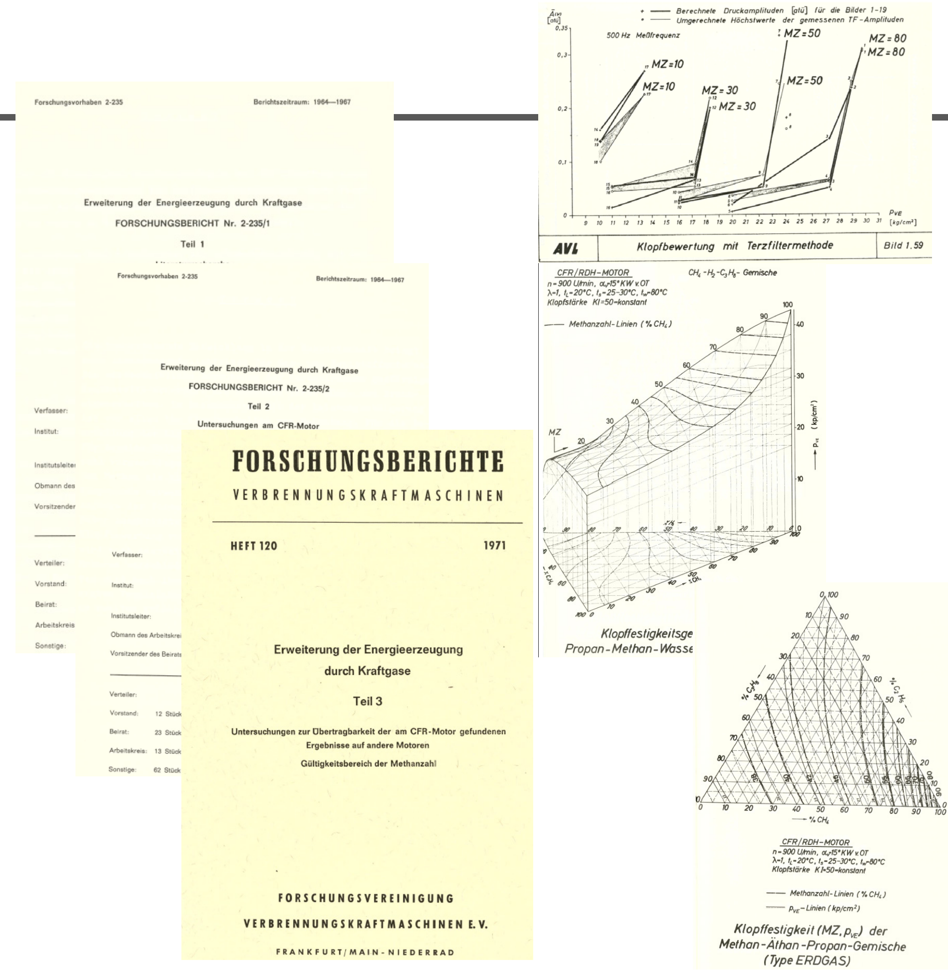
1 Basis for Calculations

- Beginning of the '60s, engineers saw the need to improve gas specification for engine use
- Drivers for this research program were MWM & KHD (DEUTZ)
- **FVV (German research association combustion engines) started a research program on MN**
  - Supported by a broad group of engine manufacturers
  - In 1964 , research work on this was started by Cartellieri at AVL Austria
- Results of work after 3 research programs in 1971:
  - New parameter MN for gases was born
  - Manual method for calculation of combustion behavior of gas compositions was shown.
  - Triangle diagrams are used to create compositions with nearly the same MN



These triangle diagrams are the basis for today's MN calculations

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2 History of MN calculation

- **MWM as a driver of the research program was deeply involved in the results.**
- **In the mid ‘80s, MWM started the work for a calculation program for computers based on AVL data from FVV funded research program**
- **End of the 80th the first computer calculation program based on the MWM algorithm was available for gas compositions.**
- **In the 90th the program was sold to other companies like Ruhrgas, today EON.**

→ **AVL has developed a similar program using the <u>same</u> data base. The AVL program is proprietary**

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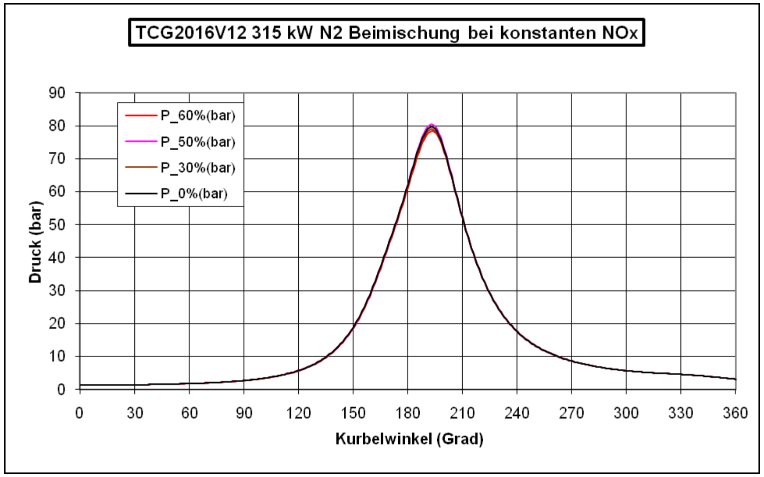
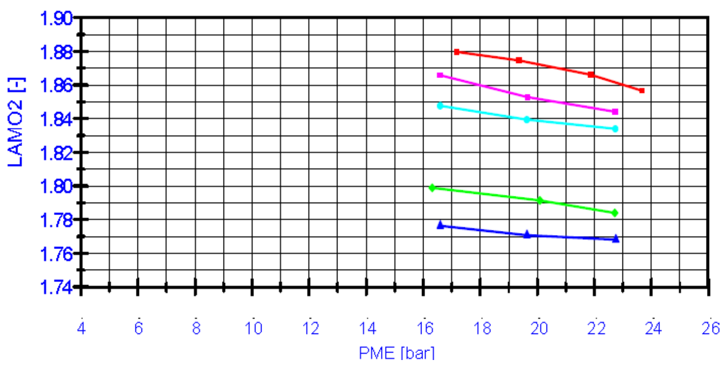
3 Adaption for modern lean-burn engines

- MWM (and other engine manufacturers) have done engine tests, mixing Nitrogen into natural gas. The results show that nitrogen in the gas has no impact on the knock resistance of lean-burn engines.
- For modern lean burn engines there is no influence of Nitrogen in the gas on the knock resistance due to the large amount of nitrogen in the final mixture.





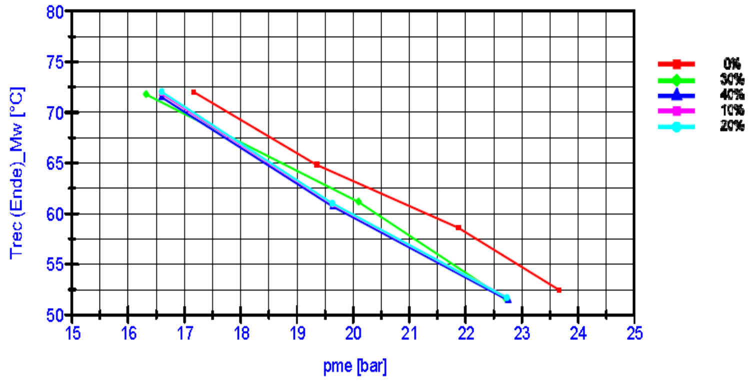


Abbildung 6.6: Klopfgrenze N2 Beimischung

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4 Adaption for C> C4

- The AVL MN program calculates only C< C5. These means that all components C> C4 are calculated as C4
  - The percentage of C4 content in the C4+ content of natural gas is very high (generally above 70%)
  - Nevertheless, if important amounts of C5, C6, C6+ are contained the calculated MN shows an unrealistic higher knock margin.

Strategy for improvement of calculation

- Content of C>C4 not calculated 1:1 as C_4H_{10}

- Use of factors to calculate the influence of C> C4, for example:
  - 1%C_5H_{12} influences the knock margin like 2%C_4H_{10}, factor = 2 (calculate 1% C5 as 2% C4)
  - 1%C_6H_{14} influences the knock margin like 5%C_4H_{10}, factor = 5 (calculate 1% C5 as 5% C4)

→ **The more detailed the gas composition is given the more accurate the knock resistance is determined**

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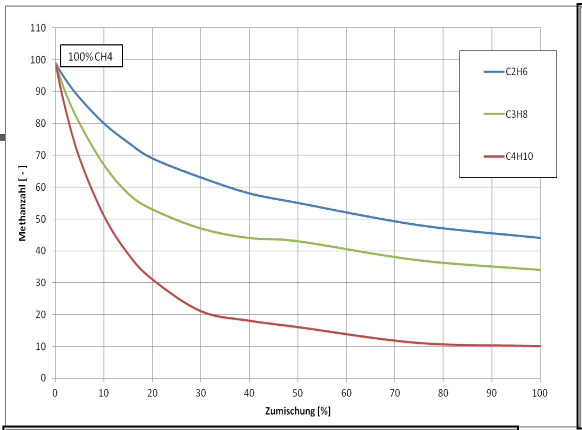
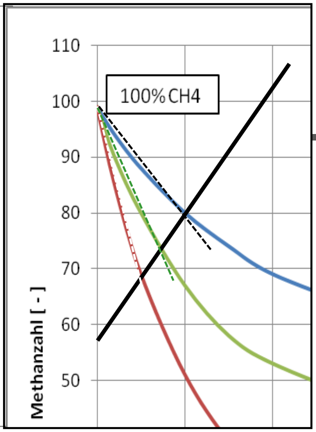
5 Evaluation of the method using factors





- Typical trend for MN is shown in the diagram:
- – Admission of small amounts of higher hydrocarbons reduces the MN “quasi linear”

- Factors for different gases calculated by change of MN:

  C4H10 to C2H6: -MN5,2/-MN1,7 = 3,1

  C3H8 to C2H6: -MN3,1/-MN1,7 = 1,8

- Reverse calculation / Example:

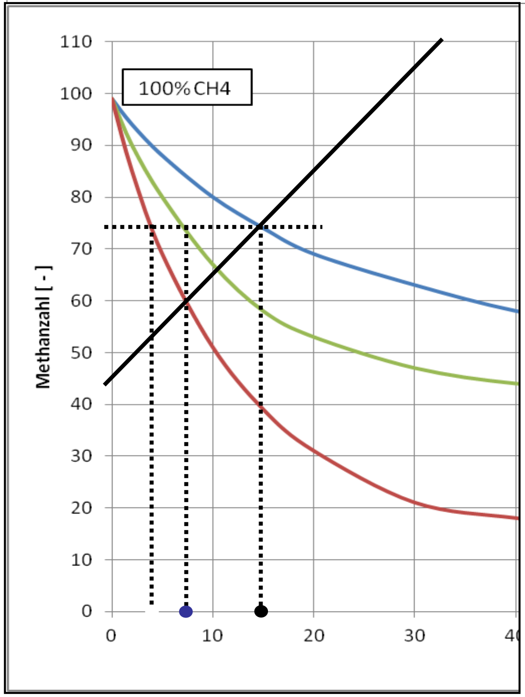
  5%C4H10 ➔ -MZ26

  5%C2H6*3,1 = 15,5%C2H6 ➔ -MN26

  8,4%C3H8 ➔ -MN26

  8,4%C2H6*1,8 = 15,1%C2H6 ➔ -MN26

→ **For the “quasi linear” part factors can be used for calculation for MN**



5 Evaluation of the factors for C5, C6, C7

- **For evaluation of the influence on MN different fuels were tested on a gas engine.**
- **The base MN of the pipeline gas was 80.**
- **The knock margin was measured with admission of the following components :**
  - N-Pentane (0-4.3%)
  - Hexane (0-5.5%)
  - Heptanes (0-3.3%)
- **Results:**
  - C5: 1% admission reduces the MN 11,6 points
  - C6: 1% admission reduces the MN 19,4 points
  - C7: 1% admission reduces the MN 26,5 points

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6 Implementation of factors

- **Base for implementation:**
- **1% C4H10 reduces the MN: 5 points**
  - $\Delta MZ(1\%C5H12) = \Delta MZ(1\%C4H10) * 11{,}6/5 = \Delta MZ(\mathbf{2{,}3}\%C4H10)$
  - $\Delta MZ(1\%C6H14) = \Delta MZ(1\%C4H10) * 19{,}4/5 = \Delta MZ(\mathbf{3{,}9}\%C4H10)$
  - $\Delta MZ(1\%C7H16) = \Delta MZ(1\%C4H10) * 26{,}5/5 = \Delta MZ(\mathbf{5{,}3}\%C4H10)$
- **This calculation is valid for amounts up to 3% of each component of C5, C6, C7.**

→ **The MWM method is accurate for all possible C4+ contents!**

7 Conclusion

- **MWM offers an algorithm to calculate the Methane Number based on the same data as the AVL method**
- **MWM accurately reflects knocking behaviour of gas engines as it makes corrections for:**
  - Higher hydrocarbons (C4+)
  - Nitrogen
- **The MWM calculation method is offered for inclusion in the gas standard and the algorithm would than be open for inclusion in stakeholders systems (SCADA)**

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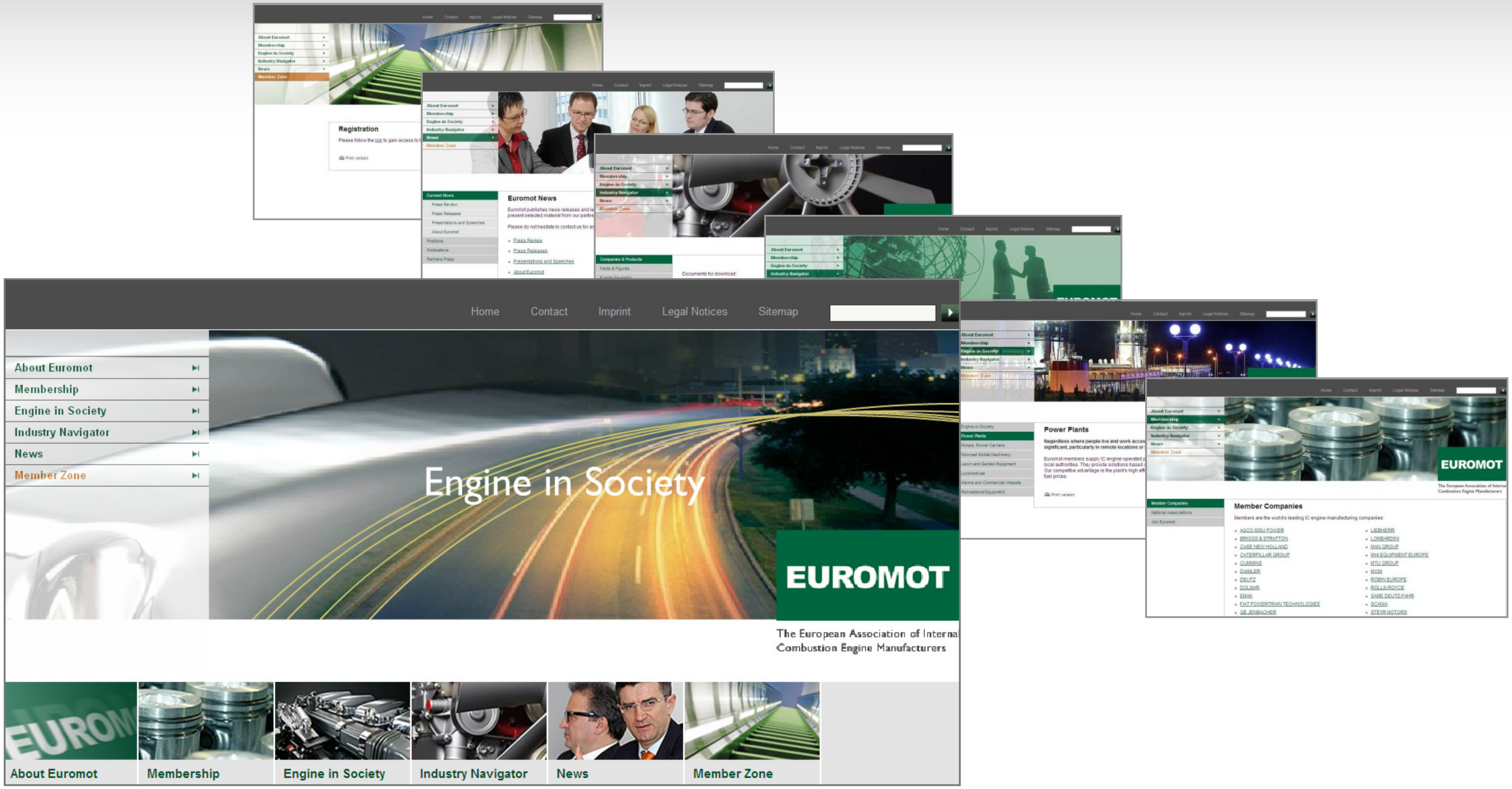

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