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Natural gas — Calculation of methane number

Gaz naturel — Calcul de l'indice de méthane

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Foreword

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The committee responsible for this document is ISO/TC 193, *Natural Gas*.

Natural gas — Calculation of methane number

1 Scope

This Technical Report describes methods for the calculation of the methane number (*MN*) of dry natural gas when the composition of the gas by mole fraction is known.

If the difference of *MN* between two calculation methods is more than 6, it is recommended to use a test method to determine *MN* for the gas.

The Gas Research Institute (GRI) methods are used to calculate methane number, *MN*, and motor octane number, *MON*, of gas; the linear relation is useful in determining and comparing the knock resistance of high methane content natural gas.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
methane number
MN
measure of resistance of a gas fuel to knock, which is assigned to a test fuel based upon operation in knock testing unit at the same standard knock intensity

Note 1 to entry: It is assigned that pure methane is used as the knock resistant reference fuel, that is, methane number of pure methane is 100, and pure hydrogen is used as the knock sensitive reference fuel, methane number of pure hydrogen is 0.

2.2
motor octane number
MON
numerical rating of knock resistance obtained by comparison of its knock intensity with that of primary reference fuels when both are tested in a standardized CFR engine operating under the specified conditions

3 Calculation methods of methane number

3.1 GRI methods

The GRI has applied the ASTM octane rating method to various natural gas fuels (see Annex A) to measure *MON*. Two mathematical relations were developed to estimate the *MON* rating of a natural gas fuel. The limitation of each component is shown in Table A.2.

3.1.1 Linear coefficient relation

$$MON = 137{,}78_{x1} + 29{,}948_{x2} - 18{,}193_{x3} - 167{,}062_{x4} + 181{,}233_{x5} + 26{,}994_{x6} \quad (1)$$

where

x is the mole fraction of corresponding component.

The number of subscripts for each corresponding component is given as follow:

number	1	2	3	4	5	6
component	CH_4	C_2H_6	C_3H_8	C_4H_{10}	CO_2	N_2

3.1.2 Hydrogen/carbon ratio relation

$$MON = -406{,}14 + 508{,}04\,R - 173{,}55\,R^2 + 20{,}17\,R^3 \qquad (2)$$

where

R is ratio of hydrogen atoms to carbon atoms.

NOTE In the original GRI composition data of gas fuels for octane test, the heaviest hydrocarbon is butane. In fact, real gas can contain C6+ even C8 hydrocarbons. If the gas contains hydrocarbons heavier than butane, take into account that the ratio of hydrogen atoms to carbon atoms could be different. All hydrocarbons are to be considered, not only those that are lighter than butane.

3.1.3 Correlation between *MON* and *MN*

$$MN = 1{,}445\,MON - 103{,}42 \qquad (3)$$

$$MON = 0{,}679\,MN + 72{,}3 \qquad (4)$$

NOTE The correlation is not quite linear, and as a result the formulae are not the inverse of each other.

3.2 AVL method

AVL Inc. also developed a method to calculate the methane number, but the exact algorithm is confidential and property of AVL Inc.

NOTE The AVL method is to be published in a CEN standard developed by CEN/TC 234/WG 11.

4 Express calculated *MN*

4.1 Mole fraction

If the mole fraction of a natural gas fuel is known, *MN* can be calculated. Since there are two formulae for *MON*, two *MN*s of the gas can be calculated. The two results should both be reported in the calculation report.

For the same gas, if the difference between the two *MN*s is more than 10, this is extraordinary. It means the composition of the gas is unusual. For example, the gas can be diluted by LPG gas, or the gas can contain more nitrogen or CO_2.

According to Reference [1], most European gases are in the *MN* range between 65 and 100. For the engines used in the tests, as a rule of thumb, a 10-point decrease in *MN* roughly results in a 1-point decrease in the knock-limited compression ratio. Also, a 10-point decrease in *MN* roughly results in a reduction in the knock-limited bmep.

If the difference between the two *MN* results is more than 6, the user should consider that the two *MN*s are in doubt, then, a test method rather than the calculations of this technical report should be used.

Annex A
(informative)

GRI original composition data of gas fuels for octane test

Table A.1 — GRI original composition data of gas fuels for octane test

Blend %	Metane %	Ethane %	Propane %	Butane %	CO_2 %	Nitrogen %	H/C %
1	100	-	-	-	-	-	4,0
2	95,0	3,0	0,5	0,5	0,2	0,8	3,89
3	90,1	6,0	0,7	0,8	0,7	1,7	3,82
4	85,0	6,5	3,0	1,0	1,0	3,5	3,72
5	88,3	7,8	1,2	0,3	1,8	0,6	3,80
6	84,2	8,5	3,7	-	1,0	2,5	3,72
7	84,2	8,6	3,7	-	1,0	2,5	3,72
8	82,1	14,0	1,2	-	0,7	2,0	3,71
9	75,0	-	25,0	-	-	-	3,33
10	82,5	-	17,5	-	-	-	3,48
11	88,9	-	11,1	-	-	-	3,64
12	92,5	3,5	1,0	0,5	1,0	1,5	3,87

From John Kubesh[2].

Table A.2 — The concentration limitation of each component for octane test of GRI

No.	Component	Limitation, mole fraction %
1	Methane	≥75
2	Ethane	≤14
3	Propane	≤25
4	Butane+	≤1,0
5	CO_2	≤1,8
6	Nitrogen	≤3,5

Annex B
(informative)

The calculated *MN*s of some typical natural gas mixtures

There are 36 European and 30 Chinese and Thai natural gas mixtures, the calculated *MN*s are listed in Tables B.1 and B.2. The causes for *MN* difference of more than 6 are listed in Tables B.3 and B.4, and the composition of the gas is listed in Tables B.5 and B.6.

Table B.1 — Calculated *MN* of 36 Euro natural gas mixtures by two GRI methods

No.	Content method	HC ratio method	Difference (absolute)
1	84,18	85,90	1,72
2	71,48	79,39	7,91
3	85,08	86,83	1,75
4	78,10	74,74	3,36
5	73,23	70,04	3,19
6	81,50	83,36	1,86
7	66,05	66,61	0,56
8	74,78	73,29	1,49
9	78,81	80,52	1,71
10	80,58	80,01	0,57
11	70,56	84,60	14,04
12	91,03	92,38	1,35
13	89,53	93,13	3,60
14	68,20	66,77	1,43
15	67,83	66,97	0,86
16	66,97	87,72	20,75
17	75,24	77,26	2,02
18	69,81	80,54	10,73
19	95,06	98,57	3,51
20	92,73	96,21	3,48
21	84,48	86,08	1,60
22	66,66	71,86	5,20
23	74,41	71,24	3,17
24	77,35	76,07	1,28
25	83,11	83,40	0,29
26	75,78	74,56	1,22
27	91,05	92,77	1,72
28	66,00	71,32	5,32
29	80,34	96,62	16,28
30	72,07	83,88	11,81
31	74,26	72,15	2,11

Table B.1 *(continued)*

No.	Content method	HC ratio method	Difference (absolute)
32	92,54	95,68	3,14
33	74,99	75,90	0,91
34	18,04	53,15	35,11
35	40,14	59,89	19,75
36	21,84	54,67	32,83

Table B.2 — Calculated *MN* of 24 Chinese natural gas mixtures by two GRI methods

No.	Content method	HC ratio method	Differences (absolute)
1	82,01	80,71	1,30
2	74,53	72,38	2,15
3	78,16	75,76	2,40
4	82,00	80,89	1,11
5	91,46	92,65	1,19
6	93,73	95,77	2,04
7	93,87	96,03	2,16
8	90,58	90,76	0,18
9	93,07	96,06	2,99
10	78,33	76,30	2,03
11	87,24	98,74	11,50
12	95,43	98,67	3,24
13	72,88	75,03	2,15
14	77,87	78,46	0,59
15	77,35	77,81	0,46
16	52,20	73,11	20,91
17	81,93	80,63	1,30
18	81,13	79,77	1,36
19	65,12	64,48	0,64
20	45,34	55,08	9,74
21	82,31	78,33	3,98
22	94,37	98,01	3,64
23	94,57	97,91	3,34
24	94,49	98,11	3,62
25	61,56	56,36	5,20
26	71,68	55,38	16,30
27	65,32	52,84	12,48
28	90,89	96,47	5,58
29	25,87	49,30	23,43
30	92,46	96,77	4,31