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Please read this note !



Question and answer ! What is to do, when ...



Warning: Please read carefully this safety instruction !

1. Fundamentals

1.1 Introduction

For an assessment of the hazard situation in dust-processing installations, knowledge of the minimum ignition energy is indispensable. This value can possibly determine the extent and hence the cost of protective measures.

The minimum ignition energy (MIE) is understood to mean the lowest energy value of a high-voltage capacitor discharge required to ignite the most ignitable dust/air mixture. The dust concentration and the ignition delay time must be systematically varied until a minimum value of the ignition energy is found. All tests are performed at atmospheric pressure and room temperature.

1.2 Influencing quantities

Detailed investigations have shown that the minimum ignition energy of a combustible dust is influenced by the following parameters:

1.2.1 Inductance in the discharge circuit

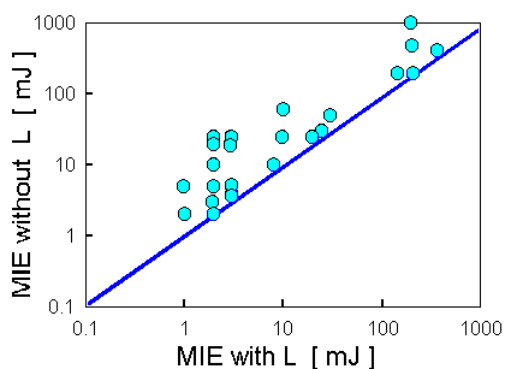


Fig. 1.2.1:
Influence of the Inductance on
the minimum ignition energy

By definition, minimum ignition energy data refer to protracted capacitor discharges. These are generally clearly more incentive than purely capacitive discharges. The results obtained under such conditions can be applied to operational conditions only if the capacitors occurring in plant installations are also discharged via an inductance. Hence, if the incentive of electrical discharges - especially of electrostatic discharges - with regard to dust/air mixtures is to be assessed, the minimum ignition energy must also be determined without an inductance in the discharge circuit. As Fig. 1.2.1 shows, the effect of this influencing factor is not straightforward, but varies and is dependent on the type of dust.

1.2.2 Turbulence, ignition delay time

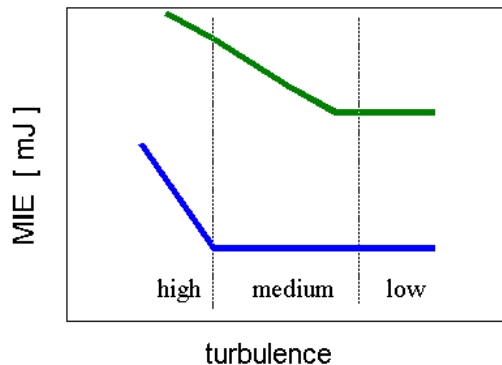


Fig. 1.2.2:
Influence of ignition delay time
on the minimum ignition energy

Easily the simplest measure of the turbulence of the dust/air mixtures is the ignition delay time t_v between actuation of the outlet valve and the sparkover. Short ignition delay times result in a high turbulence, long delay times in a low turbulence. The determination of the MIE should be performed with as low a turbulence as possible. If times are too long, separation of the dust can occur and the result is no longer meaningful.

The optimum ignition delay time which results in the lowest value of the MIE is not constant, but depends on the dust sample. The ignition delay time must therefore be varied step by step until the minimum value of the ignition energy is found.

1.2.3 Particle size, median value

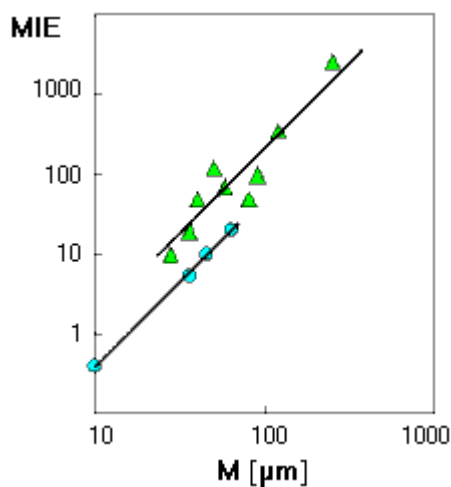


Fig. 1.2.3:
Influence of the median value on
the minimum ignition energy

The particle size or the median value can have an appreciable influence on the minimum ignition energy. This energy limit value increases with the cube of the median value of a dust. The finer a dust, the easier it can be ignited.

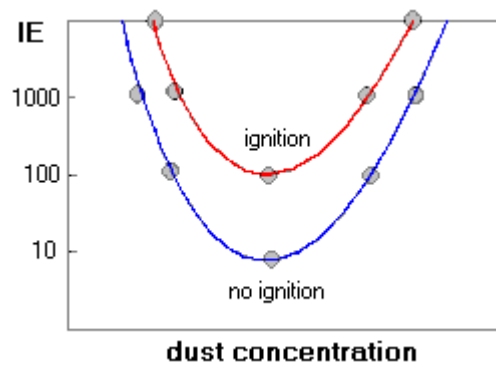
This model calculation has only limited applicability. The following estimation is more conservative and in practice produces a better agreement with the experimental results:

$$MIE_2 = MIE_1 \cdot (M_2 / M_1)^{2.5}$$

Index 1: measured

Index 2: estimated

1.2.4 Dust concentration



There is a parabolic relation between the dust concentration and the ignition energy. The MIE has therefore to be determined over a wide range of dust concentrations.

Fig. 1.2.4: Influence of the dust concentration on the ignition energy

1.2.5 Temperature

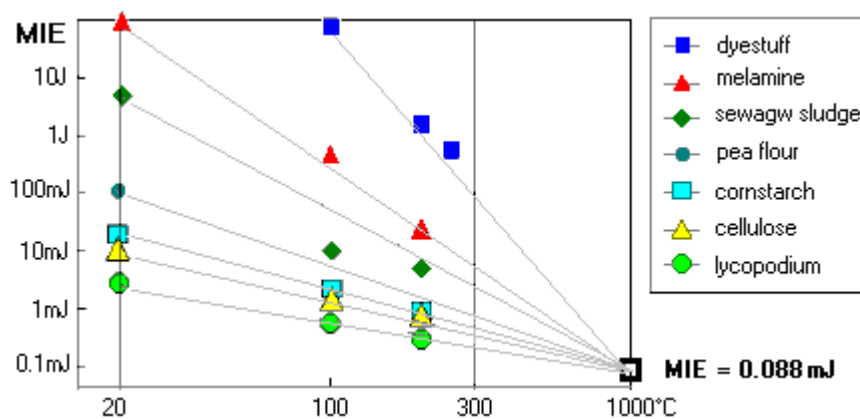


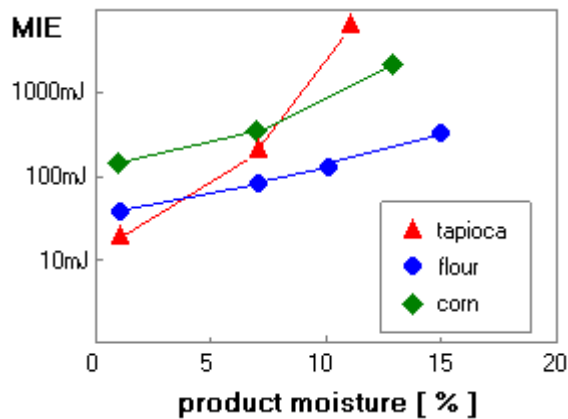
Fig. 1.2.5: Influence of the temperature on the minimum ignition energy

The minimum ignition energy is also influenced by temperature. It is lowered by an increase in temperature to an extent which depends on the ignitability of the dust. A dust which is difficult to ignite shows a more pronounced effect than one which is readily ignited. As a result, a log-log plot comprises straight lines which meet at a point (1000°C; 0.088 mJ). If the minimum ignition energy of a dust is known at room temperature, a straight line connecting this point with the intersection point mentioned above thus describes the temperature dependence of the minimum ignition energy of the dust up to temperatures of 300°. The following equation can be used to estimate the MIE in a temperature range from 25 to 300°C:

$$\text{MIE}(T) = 10^{-4.056 + (1.873 - 0.624 \log T) \cdot (\log \text{MIE}(25^\circ\text{C}) + 4.056)}$$

T [°C], MIE [J]

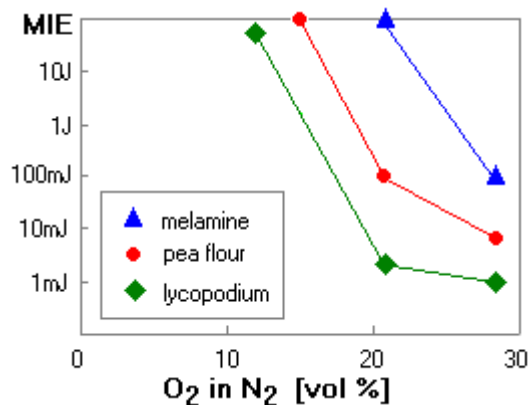
1.2.6 Product moisture (water content)



As the adjacent plot shows, the influence of the moisture content on the minimum ignition energy of a dust depends on the dust. In general, it appears that below 5% the influence is slight, whereas above 10% the value of the minimum ignition energy is increased by around 1 (one) power of ten or more.

Fig. 1.2.6: Influence of the moisture content on the minimum ignition energy

1.2.7 Oxygen concentration



The O₂ content of the combustion air has a decisive influence on the minimum ignition energy (see adjacent plot). In a semi logarithmic plot, the MIE rises linearly, especially at low oxygen concentrations. This rapid decrease in the ignitability or increase in the MIE is primarily due to the addition of nitrogen, which has an inerting effect. With increasing oxygen concentration, on the other hand, the curves tend to flatten out reflecting a lowering of the rate of decrease of the minimum ignition energy.

Fig. 1.2.7: Influence of the O₂ content of the combustion air on the MIE

1.2.8 Addition of flammable gases

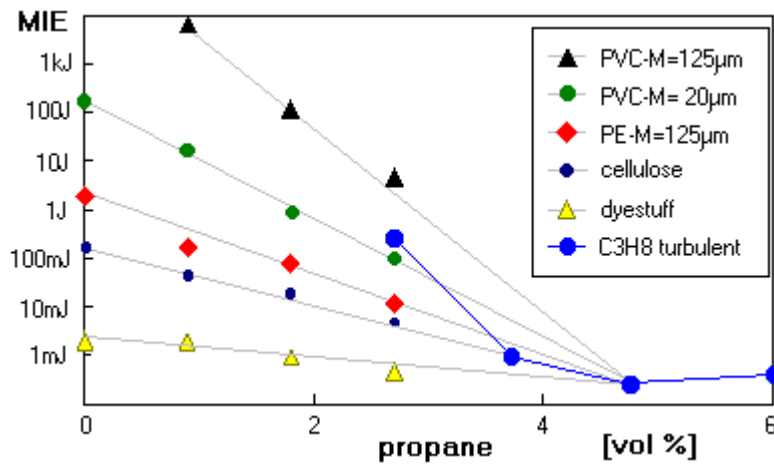


Fig. 1.2.8: Influence of the addition of flammable gas on the MIE

The addition of flammable gases (solvent vapours) to the combustion air lowers the minimum ignition energy of combustible dusts and this lowering is greater the more difficult they are to ignite. A semi logarithmic plot of the MIE against the added flammable gas content results in straight lines which meet at a point characteristic of the minimum ignition energy of the particular flammable gas.

1.3 Test procedures

1.3.1 Standards

- a) EN13821: Determination of minimum ignition energy of dust/air mixtures
- b) ASTM E2019: Standard test method for Minimum Ignition Energy of a dust cloud in air
- c) ISO/IEC 80079-20-2: Material characteristics. Combustible dusts test methods

Dust concentration [mg]:

ASTM E2019, EN13821	300	600	900	1200	1500	1800	2400	3000
ISO/IEC 80079		750		1200		2000		3000

Ignition delay time t_v [ms]:

ASTM E2019, EN13821	60	90	120	150	180
ISO/IEC 80079	60		120		180

The ISO/IEC 80079 standard is a subset of the ASTM E2019 and EN13821 standards with respect to dust concentration and ignition delay time.

Test procedures:

The test method according to ISO/IEC 80079 is a short form of the method according to ASTM E2019 and EN13821. Details, see: [1.3.4 Test procedures, example](#)

Calibration Round Robin CaRo:

In the test method according to ISO/IEC 80079, without consideration of the statistical energy E_s , the sole specification of the energy range (E_1 , E_2) is not precise enough. A comparison of the results of different apparatus and their calibration is not possible.

Recommendation:

Tests according to ASTM E2019, EN13821 are valid for ISO/IEC 80079. But not vice versa! Therefore we recommend:

- a) Test according to ASTM E2019, EN13821, or
- b) Test according to ISO/IEC 80079, however with E_s

History:

During the development of the minimum ignition energy apparatus "MIKE" in 1992 we have adopted the concentration levels from the 1m³ container and the 20L sphere:

g / m ³	250	500	750	1000	1250	1500	2000	2500
mg / 1.2L	300	600	900	1200	1500	1800	2400	3000

1.3.2 Test procedures, general

The energy just sufficient to ignite the dust under investigation is determined. This ignition energy is then successively halved with **variation** of the **dust concentration** and the **ignition delay time** (turbulence) in a series of tests until no ignition takes place in **at least 10** successive experiments. The minimum ignition energy MIE lies between the lowest energy value (E2) at which ignition occurred and the energy (E1) at which in at least 10 successive experiments no ignition was observed.

The energy range thus determined is called the minimum ignition energy of a combustible dust in admixture with air. However, for purposes of simplification often only the lower limit value (E1) is specified as the minimum ignition energy MIE.

$$E1 < MIE < E2$$



To assess the ignition hazard for dust/air mixtures due to operational spark discharges, especially electrostatic discharges, the minimum ignition energy MIE must be determined with a purely capacitive spark discharge (without inductance) by the method described above.

In the case of fuel gases, the inductance generally has no influence on the MIE. Highly flammable dusts often show the same behavior.

1.3.3 Statistic ignition energy (Es)

For the purpose of comparison between different apparatus, only one statistic MIE value (E_s) instead of the energy range (E_1 , E_2) should be used. This single value (E_s) can be estimated by the use of the probability of ignition as follows:

$$E_s = 10^{\log E_2 - I[E_2] \cdot (\log E_2 - \log E_1) / ((NI+I)[E_2] + 1)}$$

where is: $I[E_2]$ = number of tests with ignition at the energy E_2 .

$(NI+I)[E_2]$ = total number of tests at the energy E_2 .

e.g.

	IE \ mg	300	600	900	1200	1500		probability
$E_2 =$	30 mJ	NI	I	I	I	NI	→	3 of 5
$E_1 =$	10 mJ		NI	NI	NI			

$$E_s = 10^{\log E_2 - 3 \cdot (\log E_2 - \log E_1) / (5 + 1)} = 17 \text{ mJ}$$

where is: **I** = ignition of dust

NI = no ignition of dust in 10 trials

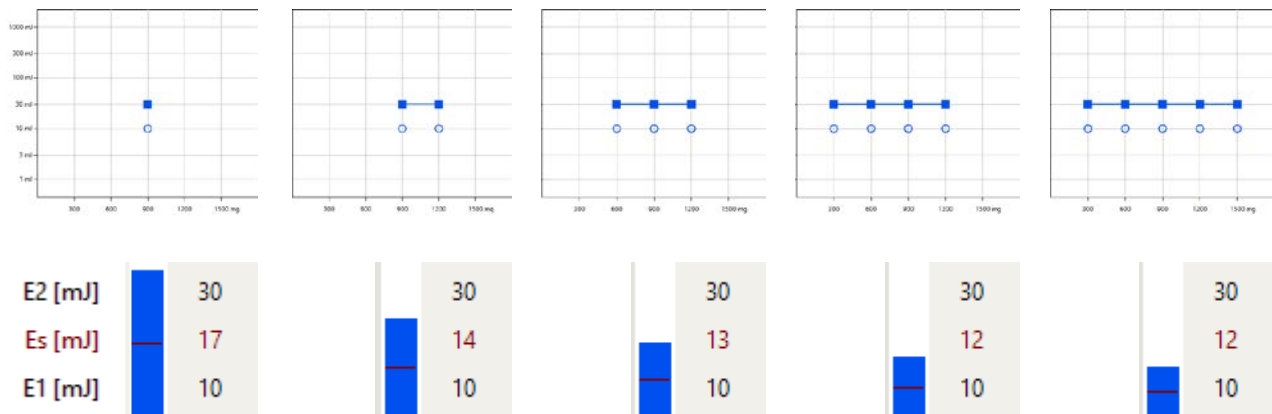
Accuracy of the E_s - estimation

From the number of tests, the accuracy of E_s can be estimated:

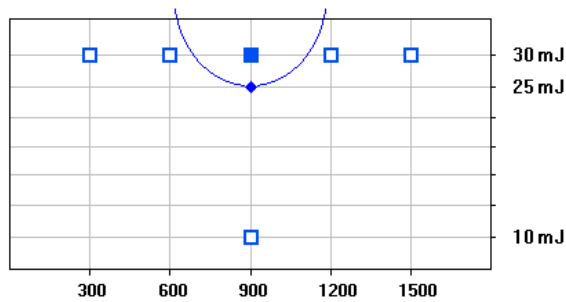
$$S_{\max} = 10^{\log E_s + I[E_2] \cdot (\log E_2 - \log E_1) / ((NI+I)[E_2] + 1)}$$

$$S_{\min} = 10^{\log E_s - I[E_2] \cdot (\log E_2 - \log E_1) / ((NI+I)[E_2] + 1)}$$

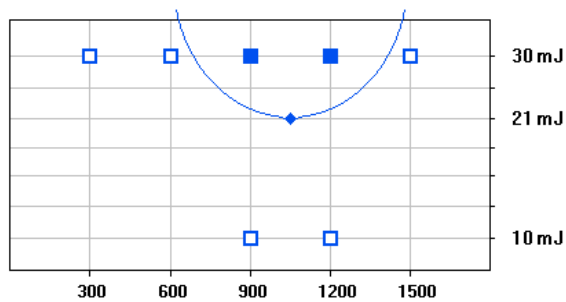
Examples of the accuracy of the E_s - estimation



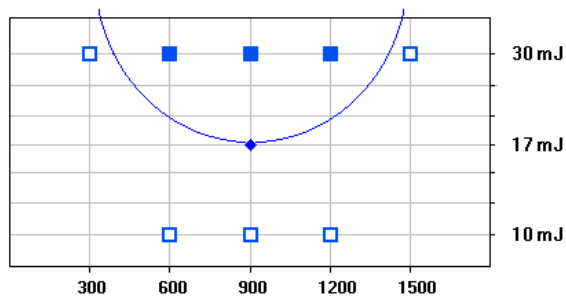
Examples for test procedures and statistic energy (Es)



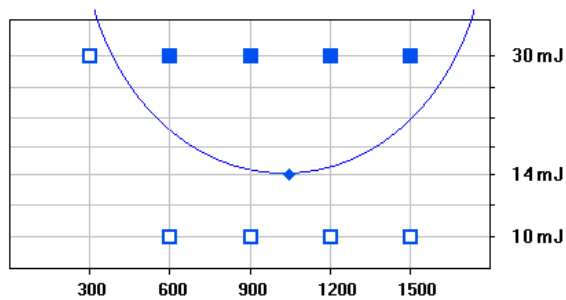
$E2 = 30\text{mJ} / E1 = 10\text{mJ}$
 probability of ignition = 1 of 5
 $E_s = 25\text{mJ}$



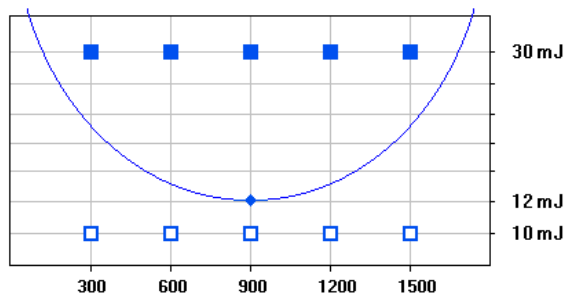
$E2 = 30\text{mJ} / E1 = 10\text{mJ}$
 probability of ignition = 2 of 5
 $E_s = 21\text{mJ}$



$E2 = 30\text{mJ} / E1 = 10\text{mJ}$
 probability of ignition = 3 of 5
 $E_s = 17\text{mJ}$



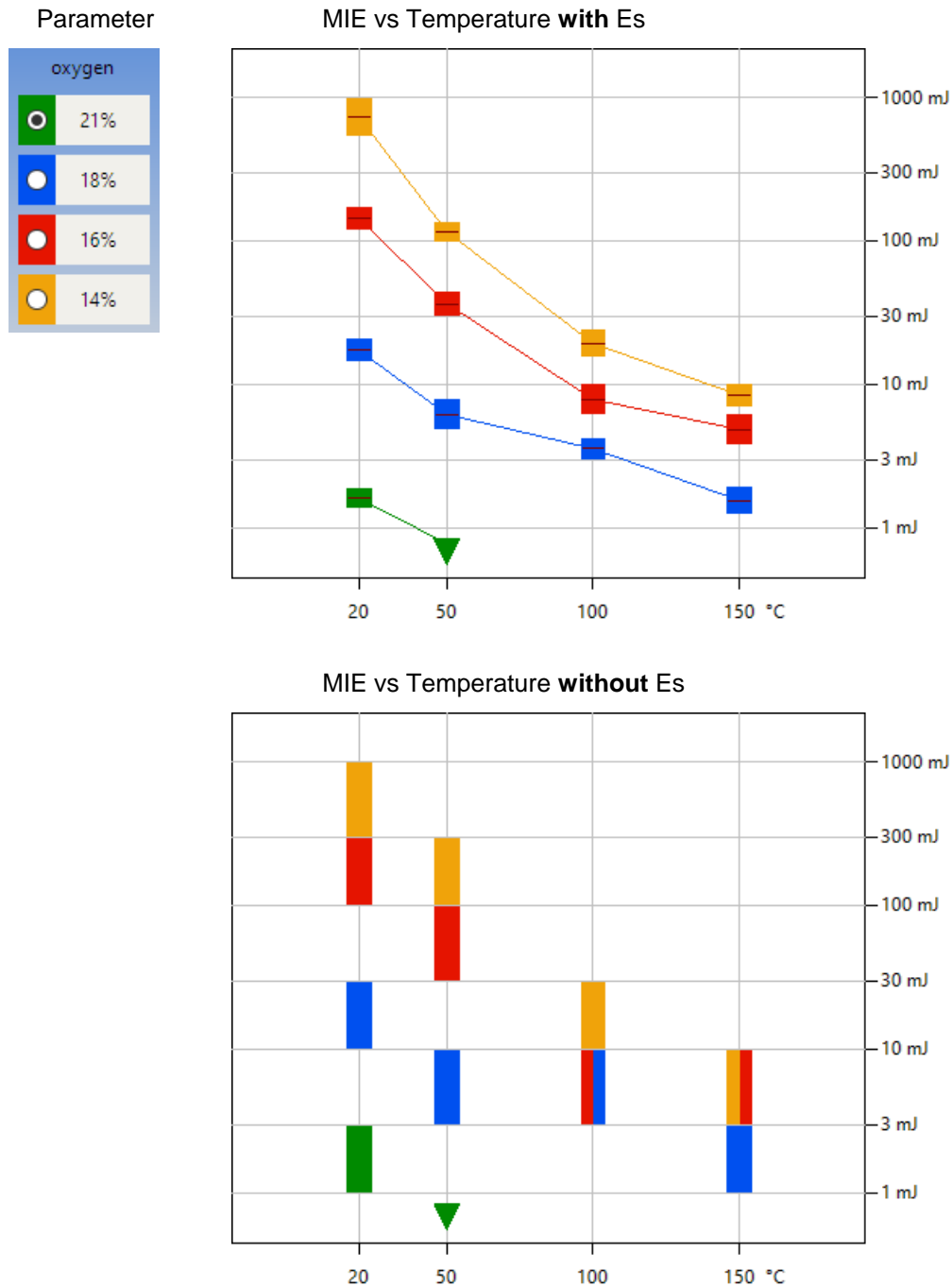
$E2 = 30\text{mJ} / E1 = 10\text{mJ}$
 probability of ignition = 4 of 5
 $E_s = 14\text{mJ}$



$E2 = 30\text{mJ} / E1 = 10\text{mJ}$
 probability of ignition = 5 of 5
 $E_s = 12\text{mJ}$

Statistic energy (Es) under non-atmospheric test conditions

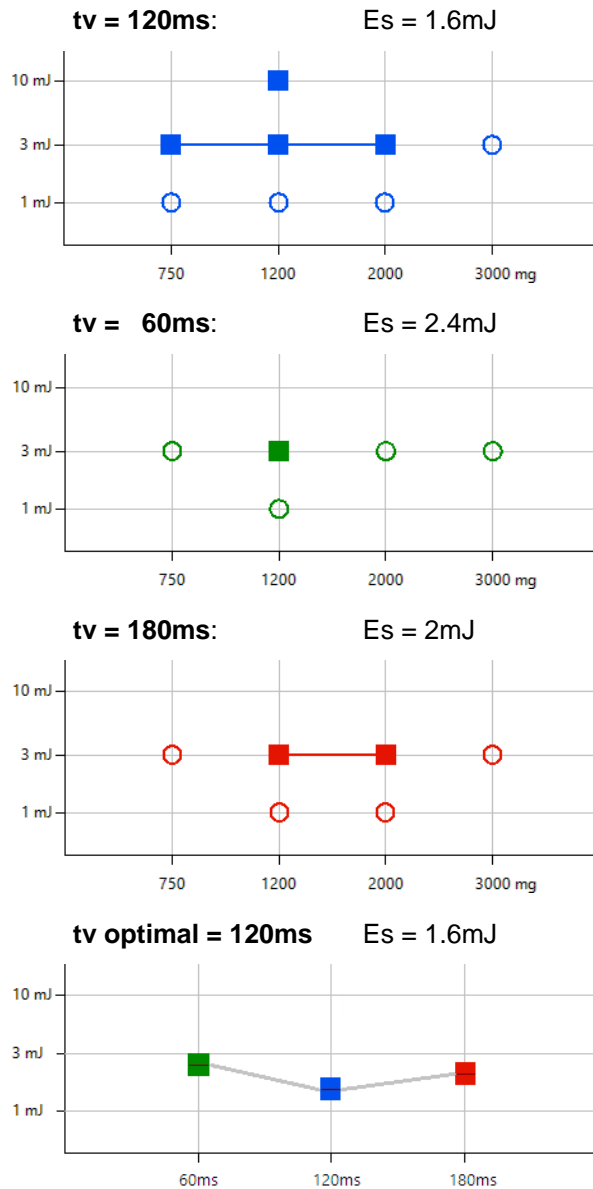
For tests with elevated temperature and/or reduced oxygen content, the specification of the ignition probability E_s is mandatory for a meaningful presentation.



1.3.4 Test procedures, example

ASTM E2019, EN13821

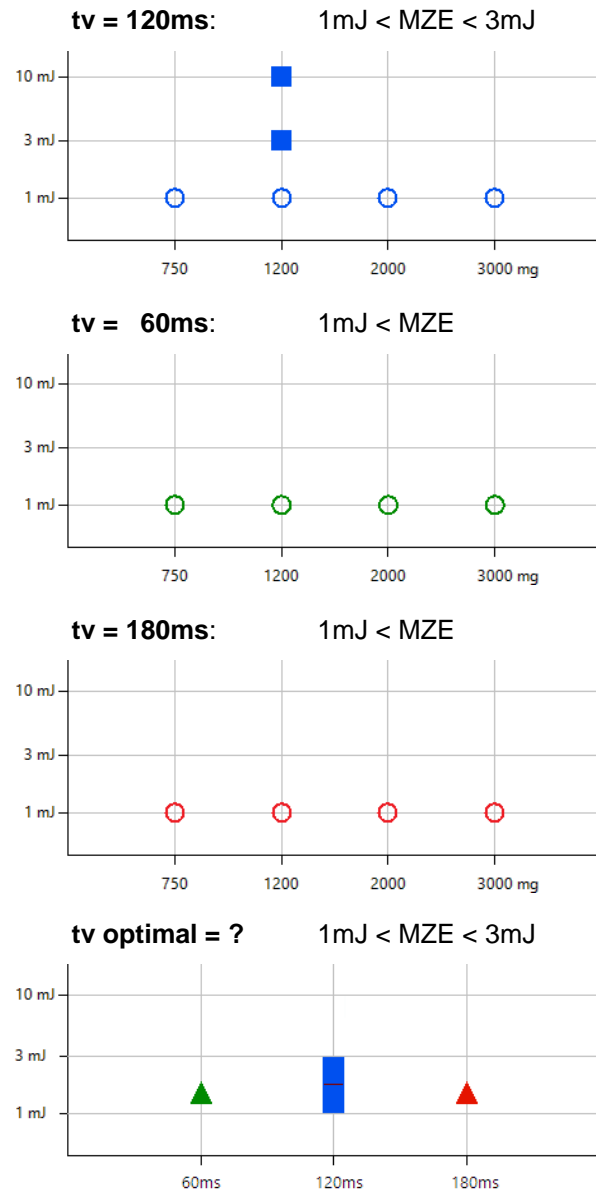
ISO/IEC 80079 with Es



Recommended test method.

All standards are taken into account.
The additional effort is small in relation to the more accurate result.

ISO/IEC 80079 without Es



With this method, $t_v=60\text{ms}$ and $t_v=180\text{ms}$ only confirm that no lower MIE values are present. No statement can be made about the optimum ignition delay time t_v .

1.4 Test apparatus MIKE 3

Based on the findings discussed in section 1.2, it has been internationally agreed that an apparatus for the determination of the minimum ignition energy of combustible dusts must fulfill the following minimum conditions:

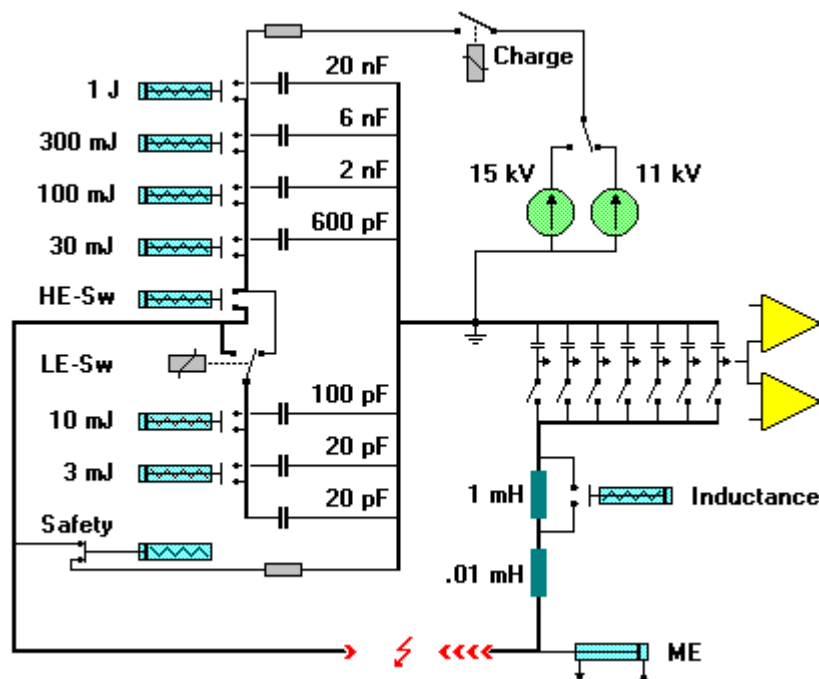
- with an inductance in the discharge circuit: $L = 1 \text{ mH} - 2 \text{ mH}$
- without an inductance in the discharge circuit: $L \leq 0.025 \text{ mH}$
- electrode material: tungsten or stainless steel
- electrode diameter: $d = 2 \text{ mm}$
- electrode spacing: at least 6 mm

A modified Hartmann tube made of glass with a volume of 1.2 liter is used as the explosion vessel. The dust dispersion system at the base of the tube is of the "mushroom-shaped" type around which the sample is loosely scattered. A blast of compressed air at 7 bar is used to disperse the dust in the glass cylinder where it is ignited by a spark between two electrodes.

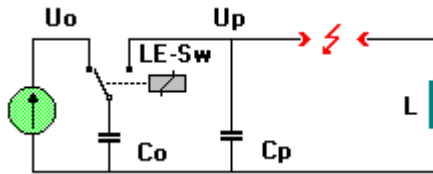
Experiments have shown that dust/air mixtures can easily have MIE values less than 10 mJ. The measurement range of the MIKE 3 has thus been specially designed for the lower energy values. Due to pneumatically actuated high-voltage switches, the parasitic capacitances have been reduced by an order of magnitude.

A further improvement of the test equipment has been achieved by direct assembly of the capacitor discharge apparatus with the modified Hartmann tube. Long supply leads are thus avoided. The high-voltage unit and the explosion vessel are arranged in the same Faraday cage.

1.4.1 Schematic circuit diagram



1.4.2 Discharge circuit for 1 mJ , 3 mJ - Triggering by high-voltage relay



U_o = charging voltage
 U_p = discharge voltage
 C_o = discharge capacitor
 C_p = parasitic capacitor (electrode holder)
 L = inductance (0.01mH / 1 mH)
 LE-Sw = high-voltage relay

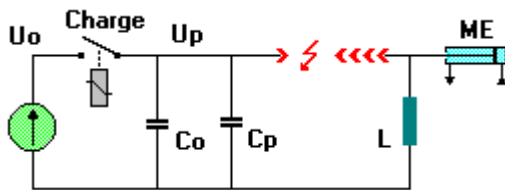
The discharge capacitor C_o is given the charge $Q_o = U_o \cdot C_o$. After switching of the relay "LE-Sw", the **charge** is retained, on the other hand the voltage U_o is lowered to U_p in accordance with the following equation:

$$U_p = U_o \cdot C_o / (C_o + C_p)$$

This results in a reduced spark **energy** E_p according to the MIE definition of:

$$E_p = 0.5 \cdot (C_o + C_p) \cdot U_p^2$$

1.4.3 Discharge circuit for 10 mJ ... 1 J - Triggering by moving electrode



U_o = charging voltage
 U_p = discharge voltage
 C_o = discharge capacitor
 C_p = parasitic capacitor
 L = inductance (0.01mH / 1 mH)
 ME = moving electrode
 Charge = charging relay

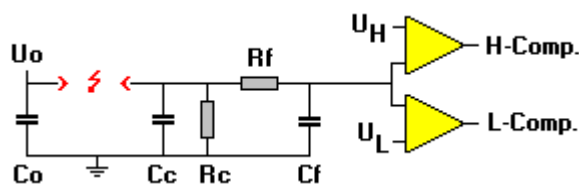
At the start, the moving ground electrode is in its home position. The electrode gap is then ca. 25 mm. Even with a charging voltage $U_o = 15$ kV, the breakdown voltage is by no means reached. After opening the charging relay "Charge", the electrode is moved rapidly by the pneumatic system to the set minimum electrode gap of 6 mm. Sparkover occurs before the end position is reached. The spark energy E_p is calculated according to the MIE definition by the following equation:

$$U_p = U_o$$

$$E_p = 0.5 \cdot (C_o + C_p) \cdot U_p^2$$

1.4.4 Spark monitoring

In the determination of the minimum ignition energy, tests are performed for the absence of ignition. It is therefore essential that reliance can be placed on the correctness of the energy value of the discharge spark which just fails to ignite the dust/air mixture. The charge transferred by the spark is measured in every ignition experiment and a check is made for compliance with limit values.



H-Comp = upper limit value

L-Comp = lower limit value

Co = discharge capacitor

Cc = measuring capacitor

Rc = leakage resistance

Cf, Rf = filter

The charge of the discharge capacitor Co is transferred to the measuring capacitor Cc. The slowly increasing corona current occurring before the sparkover is also collected in the measuring capacitor Co, but is discharged by resistor Rc. Only the charge transfer of the actual spark with its high transient current is recorded by this circuit.

The voltage characteristic across Cc corresponds, like the spark current, to a damped oscillation. The subsequent filter (Cf, Rf) now uses this to calculate the mean value for the spark monitoring. The peak value of this charge measurement must lie within the limits UL and UH to be recognized as a valid value.

1.4.5 Energy range

By definition, the MIE is represented by the energy stored in a capacitor. However, the charge of the capacitor and hence the spark energy is lowered not only by the corona current flowing before the sparkover; dirty insulators and possibly conductive dusts can also result in the dissipation of considerable charge.

Energy data which refer only to the initial charge of the capacitor are misleading. The actual energy value of the spark is **always less than** this theoretical maximum value and is thus unfortunately on the wrong side from the viewpoint of safety considerations. For example, a spark which just ignited a dust would actually have a lower energy than that specified !

Nominal	Maximum	Minimum	Triggering	Voltage
1 mJ	1.8 mJ	0.7 mJ	relay	15 kV
3 mJ	4 mJ	1.8 mJ	relay	15 kV
(10 mJ)	13 mJ	7 mJ	relay	15 kV
10 mJ	* 18 mJ	7 mJ	moving electrode	15 kV
30 mJ	40 mJ	18 mJ	moving electrode	11 kV
100 mJ	133 mJ	70 mJ	moving electrode	11 kV
300 mJ	400 mJ	230 mJ	moving electrode	11 kV
1 J	1.33 J	650 mJ	moving electrode	11 kV

Maximum = theoretical maximum value (worst case)

Minimum = lower limit of spark monitoring

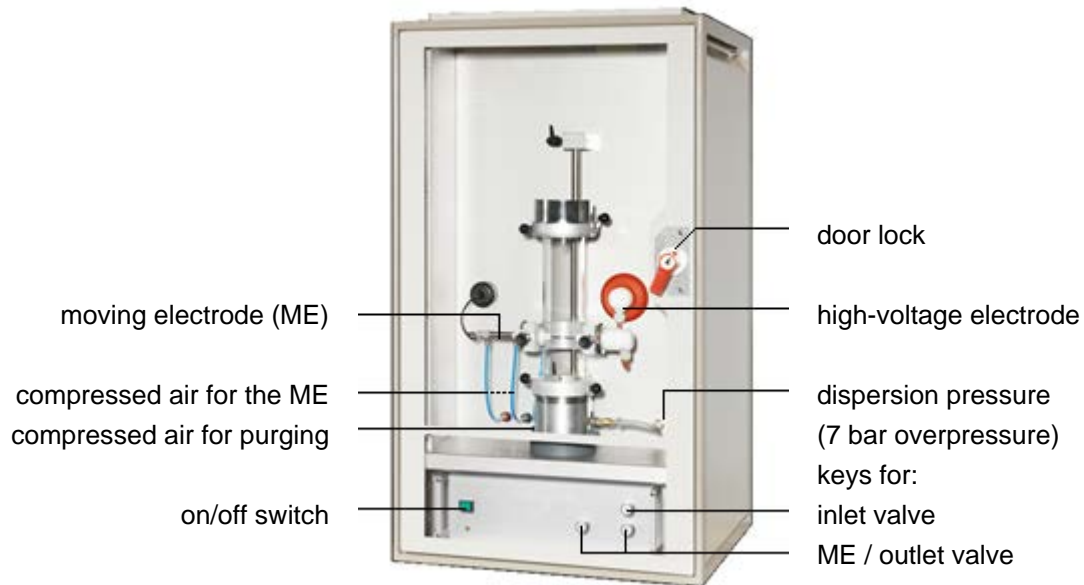


10 mJ (ex-factory = moving electrode)

* relatively large corona losses must be anticipated.

2. Apparatus

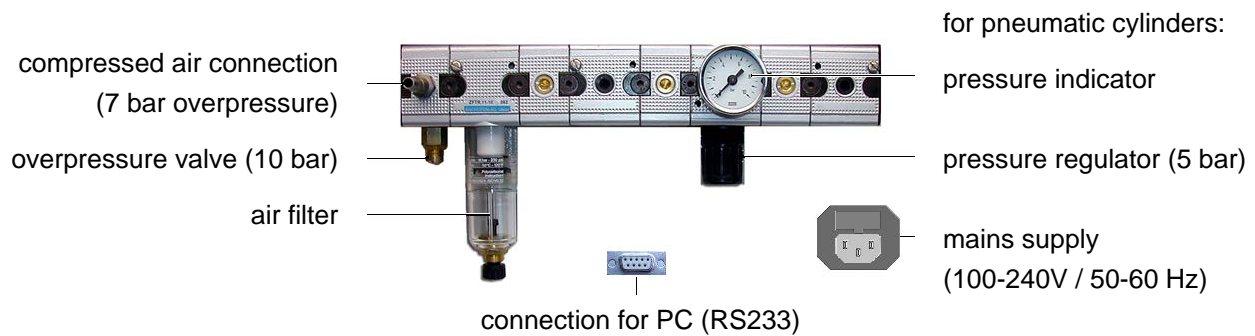
2.1 Controls (front side)



Functions of the **door lock** with 3 positions:

1. Door open (electrode adjustment and cleaning):
The high voltage is switched **off** and the keys are **enabled**.
2. Door closed (purging with air after test)
The high voltage is switched **off** and the keys are **enabled**.
3. Door closed (MIKE is ready for a test)
The high voltage is switched **on** and the keys are **disabled**.

2.2 Connections (back side)



Compressed air supply:

Compressed air is used to power the pneumatics and the dust dispersion.
Nominal value = **7 bar overpressure = 8 bar absolute**.

Only **normal compressor compressed air** may be used. With the use of synthetic compressed air MIE-values which are clearly different were obtained.

2.3 Safety instructions



Usually the MIKE is set up in a ventilated laboratory hood. When connecting the exhaust directly to the ventilation, the pressure of the blast as well as flames have to be considered.



For safety reasons, when manipulating with the electrodes, the plug of the high voltage electrode (on the right-hand side) must be **unplugged**.
The moving electrode (left-hand side) is always grounded and therefore safe.



Before making the electrical connections, please compare the information on the rating label with the data of your mains supply.

3. Software

3.1 Installation

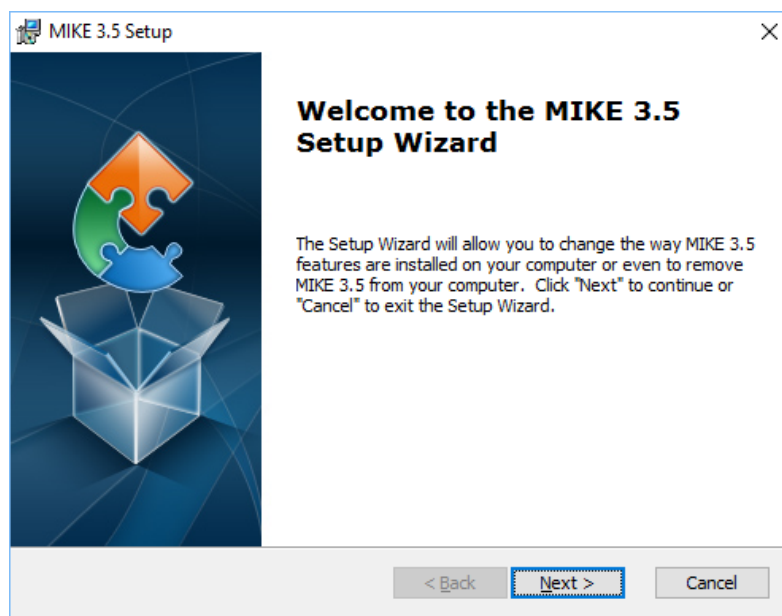
3.1.1 System requirements

Any personal computer with "Microsoft Windows" 7 ... 11 (32 and 64 bit) is suitable.

Graphics card, monitor:	resolution at least 1024 x 768 with at least 16 bit color depth.
Interface:	USB (USB - RS232 adapter is included) or RS232 (COMx)

3.1.2 Installing the MIKE - Software

Please execute the following setup file: [*MIKE35_setup.msi*](#)



3.2 Configuration



Start MIKE now ...

3.2.1 User management

When first starting MIKE, the administrator has to define the users:

System Users Rights					
no	username	signature	authorization	active	status
1	New	Cesana AG	Setup	✓	activated
2	JS	John Smith	Administrator	✓	activated
3	SE	my Service	Service	✓	new
4	SU	my Supervisor	Supervisor	✓	new
5	OP	my Operator	Operator	✓	new

username A sensible short form.

signature: Full name. Will be inserted into the protocol.

authorization: "Administrator" for the administration of the users.
 "Service" for calibration and maintenance.
 "Supervisor" for supervision of processing.
 "Operator" for all other users.
 see: [3.2.2 Rights](#)

active: The administrator can also withdraw an access right ...

status: "new" or "activated"



The account of the administrator in row 2 never expires.

3.2.2 Rights

The administrator can freely define the rights for all accounts:

<div> <div>System</div> <div>Users</div> <div>Rights</div> </div>					
no	can do ...	Administrator	Service	Supervisor	Operator
1	New tests	✓	✓	✓	✓
2	Filemanager (new, save)	✓	✓	✓	✓
3	Table modification	✓	✓	✓	✓
4	Test conditions	✓	✓	✓	
5	System - Settings	✓	✓		
6	Software Update	✓	✓		
7	User Management (see: Users)	✓			
8	Set Access Rights (this table)	✓			



Save all entries and exit "Settings".

3.2.3 Choice of user

Insert user name and password. New users will be requested to confirm the password.

Note: MIKE doesn't distinguish between upper and lower case characters.



automatic start:

After a renewed start of MIKE, the last user will be displayed and with a delay of one minute the system will automatically change to the main program.



For further configuration of MIKE please log in with rights for "System - Settings" i.e. as "Administrator".



... further settings (i.e. selection of interface)

3.2.4 Settings

Interface

1. The MIKE-apparatus is connected or will be simulated.
2. *RS-232 port on computer.* This setting is irrelevant if MIKE is simulated.

User

1. *Name of company:* will be used for the report
2. *Name of lab/site:* will be used for the report
3. *Identity:* automatic generated filenames starts always with the here defined identity.
Thus, enter an abbreviation specific for your laboratory.
4. *Language for help:* The MIKE program always uses English.
However, both English and German is available for the integral help texts

Standard

Recommended setting: ASTM E2019, EN13821.

The ISO/IEC 80079 standard is a subset of the ASTM E2019 and EN13821 standards in terms of dust concentration and ignition delay time. (see: [1.3.1 Standards](#))

Directory

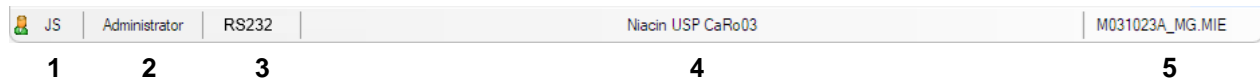
1. *MIKE-files:* The directory of the last MIKE-file is stored automatically.
Therefore you can leave the preset directory.
2. *Report-files:* The directory of the last report mask is stored automatically.
Therefore you can leave the preset directory.



Save all entries and exit "Settings".

3.3 Operation

3.3.1 Status bar



- | | |
|--|--|
| <ol style="list-style-type: none"> 1. The actual user, 2. The authorization of this user, 3. Interface, 4. The actual product 5. Filename | <p>see: 3.2.3 choice of user</p> <p>see: 3.2.2 rights</p> <p>see: 3.2.4 settings</p> |
|--|--|

3.3.2 Files

New file



At the start of a test with new dust, a new file is opened. The file name is automatically allocated by the program **(A)** or given by you **(B)**:

- A:** Automatic generated filenames starts always with identity (see: [3.2.4 settings](#)), followed by the date when the file is opened. The subsequent letter distinguishes files which are generated on the same day.

example 1: Identity_221115A.MIE

example 2: Identity_221115B.MIE (generated on the same day as example 1)

- B:** example 3: my_Product.MIE (maximum length of filename = 126 characters)



In the past the filename was limited by the operating system to only 8 characters. An assignment filename - product was difficult. Therefore the MIKE-program contains its own file manager and shows beside the filename the designation of the product. This has been very useful in the past so we decided to keep this feature in the actual software release.

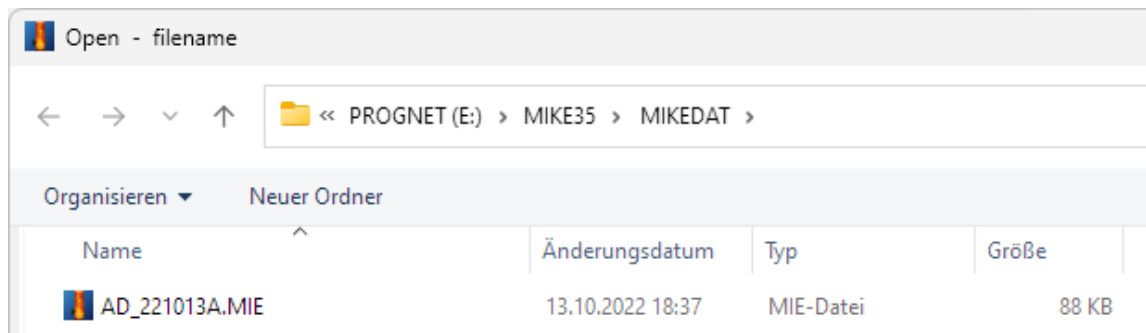
With modern operating systems this restriction becomes unnecessary. The filename can be much longer and can also contain the designation of the product. For which version (A or B) you decide is up to you.

Our recommendation: B is state of the art.

Open file - by filename



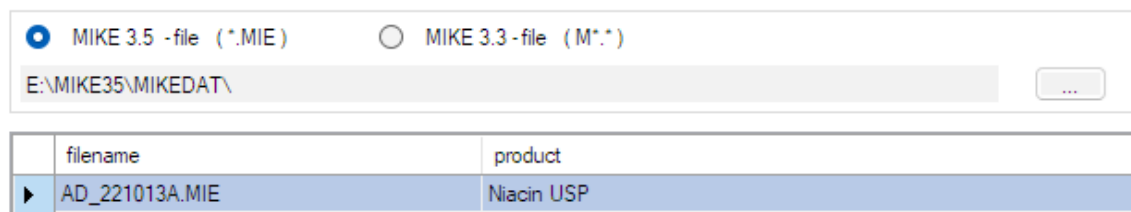
An index of MIKE-files is shown according to the Windows-Standard:



Open file - by product (.MIE - files)



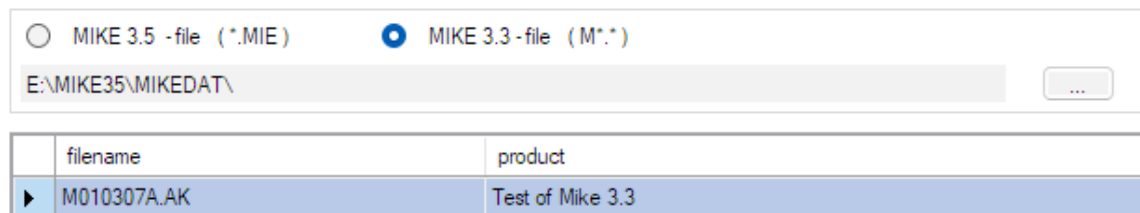
An index of MIKE-files is shown with filename and product. You can sort the fields (ascending or descending, "filename" or "product") by a click on the corresponding field.



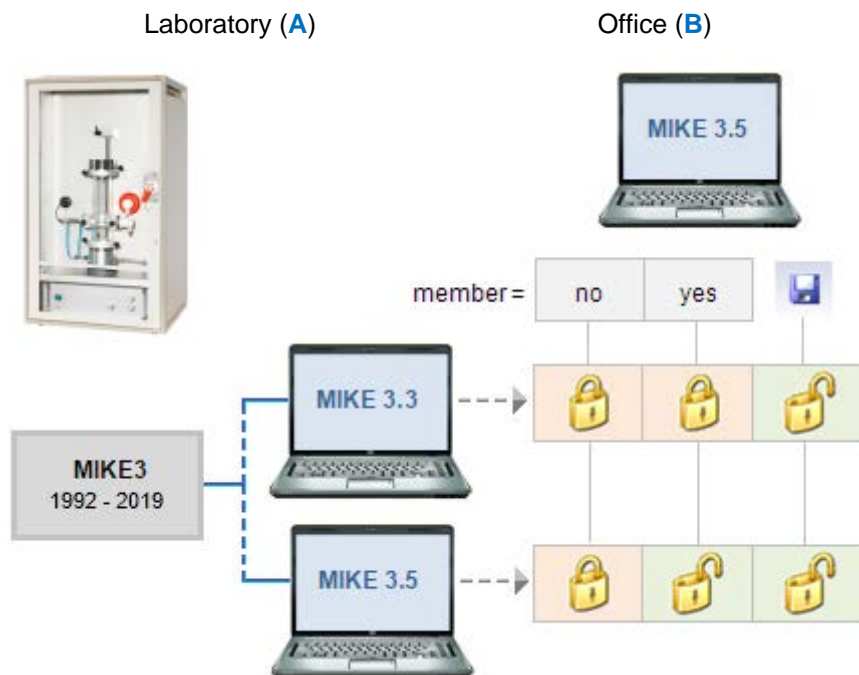
Open file - by product (MIKE 3.3 - files)



An index of old MIKE-files is shown with filename and product. You can sort the fields (ascending or descending, "filename" or "product") by a click on the corresponding field.



3.3.3 Access rights



When transferring files to other computers, e.g. from the laboratory (A) to the office (B), the list of users must be observed. The user (B) must be a **member** of the laboratory (A).



locked

All manipulations of data are locked, except view, export and printout..



unlocked

You have full access: you can add series, manipulate data and add comments.



MIKE3.3 files do not have user administration and the file format is different.

Therefore, the **MIKE3.3** file must be saved in **MIKE3.5** format for manipulations.

A new file name is generated: e.g. M0103007A.AK becomes M0103007A_**i3**.MIE

Locked **MIKE3.5** files must be imported for free access. A new file name is generated for differentiation: e.g. AD_221013A.MIE becomes AD_221013A_**i3**.MIE

For the user management, the import of data is registered in the audit:

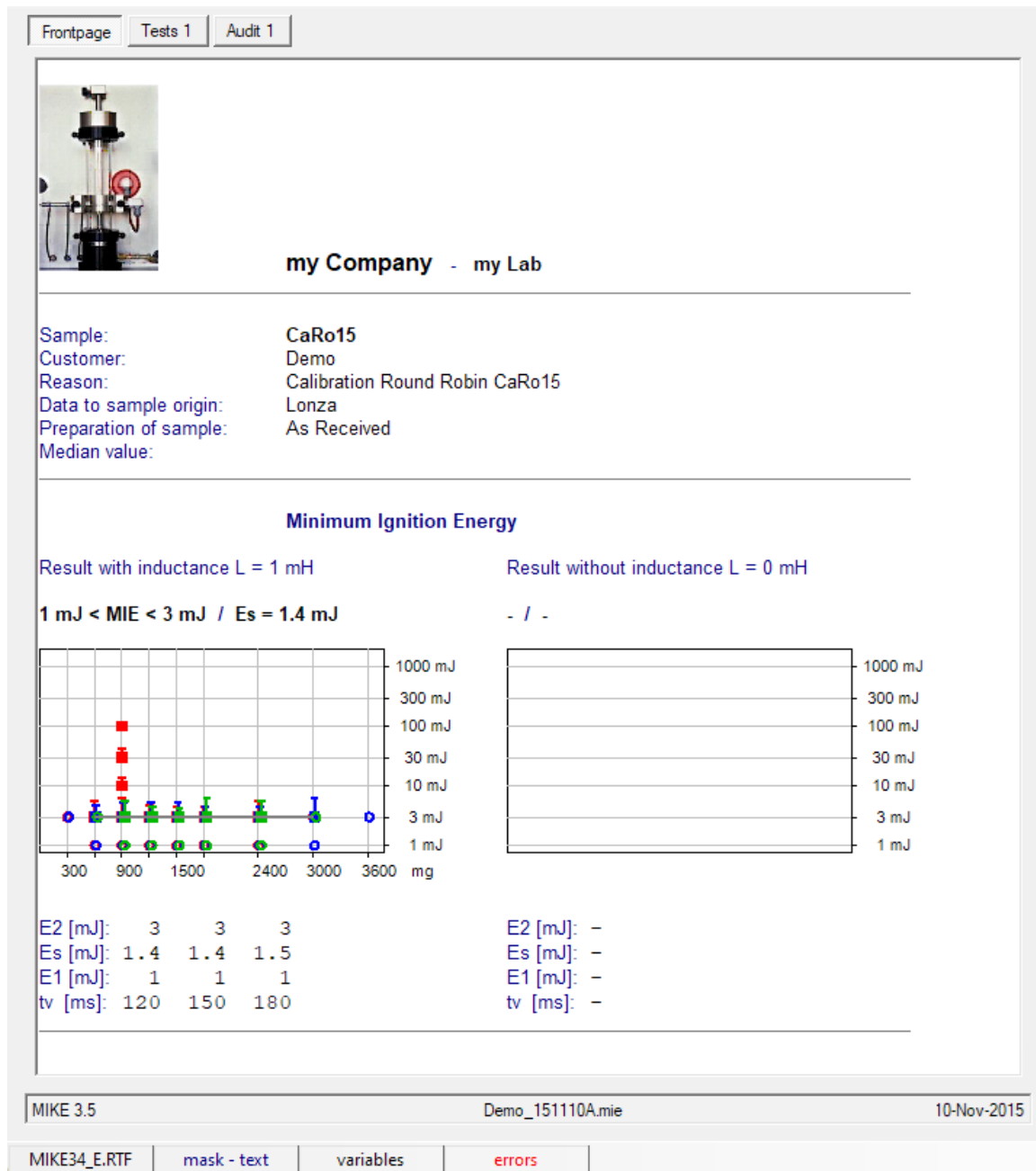


no	date	time	cause	event	username	signature
95	27.03.2025	10:19	OP1	MIKE data imported (3.5)	JS	John Smith
					OP1	my Operator 1

3.3.4 Test report



Select a mask. The test results and graphics are then inserted automatically by the program in the mask and a report is produced. This can be edited as a whole and then printed out.

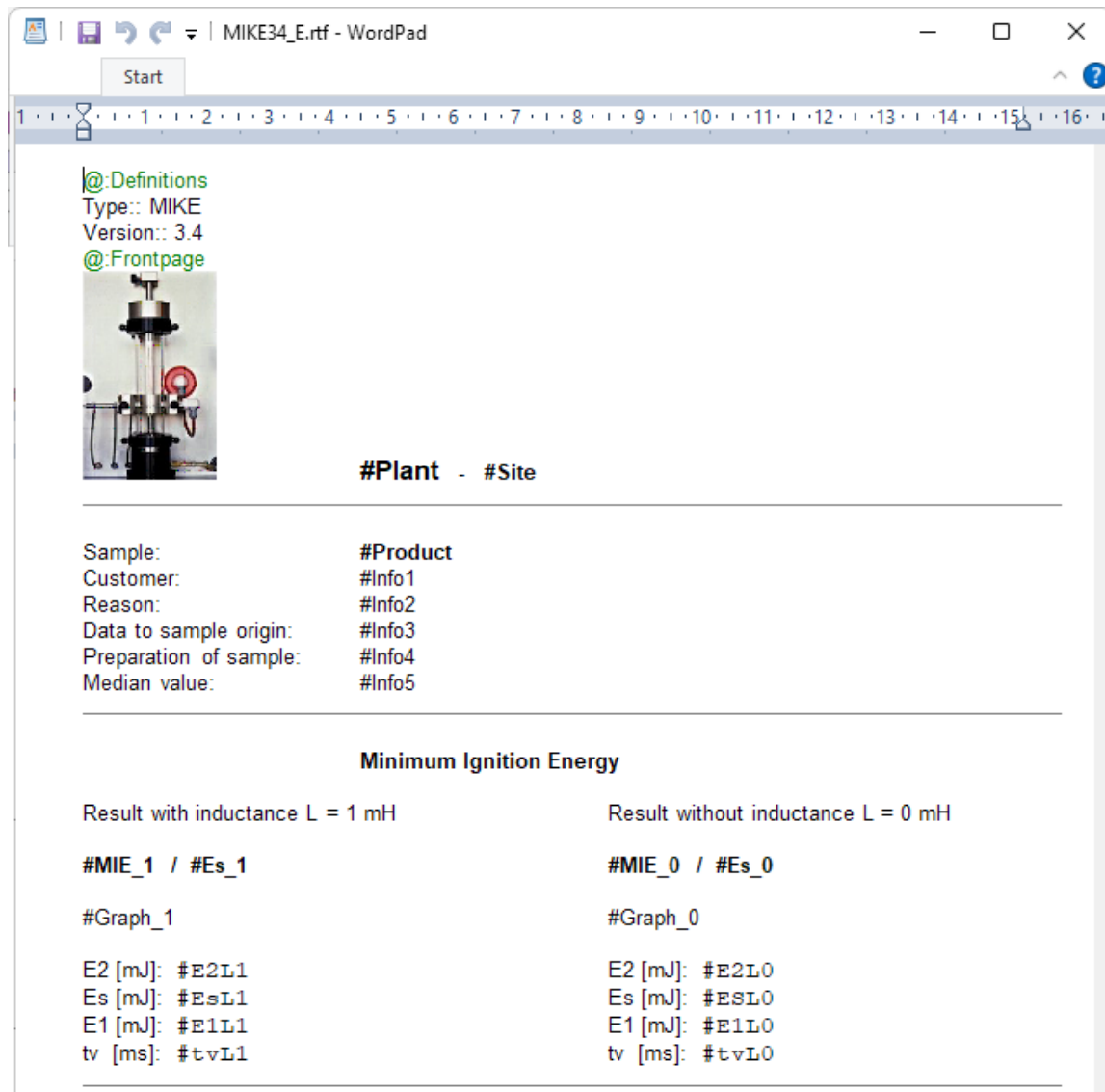


We recommend to enter all comments and other information's (customer, reason, sample preparation, median value etc.) in the corresponding fields in the window „info“ rather than to edit the report. Changes in the report, e.g. added comment, would be lost !

3.3.5 Report - Mask

Report-mask: edit / design

Aim and object of the mask is to enter repetitive text and to define all those fields in which variables (e.g. test results) should be entered automatically for the report.



The MIKE-software contains sample masks in English and German. These masks can be easily adapted to your requirements. We recommend to use the Editor-program "**WordPad**" from Microsoft.

If you intend to generate your own mask without changing the available masks, simply modify one of the these masks and store it under a new name (save as ...).

These masks are split into several sections. Each section starts with a "@:"-code. Please do never modify this codes. All fields for variables are marked by "#"-code.

While the use of fonts designed for proportional character spacing is possible, formatting of the results table will be difficult. Therefore we recommend to use fonts with fixed character spacing (e.g. Courier New) for tables.

Report-mask: sections, variables

@:definitions	section for contents and printout
Type::	MIKE
Version::	3.4
@:frontpage	section for product, final results, graphs and notes
@:tests_header	section for header of tests-table
@:tests_table	section for contents of tests-table
@:tests_footer	section for footer of tests-table
@:audit_header	section for header of audit- table
@:audit_table	section for contents of audit -table
@:audit_footer	section for footer of audit -table
@:curve	section for header of curve
@:end	end of report

global data:	
#Plant	name of your company
#Name	your lab. / your name
#Product	product
#File	filename
#ADate	actual date
#Graph_X	graph 0 & 1
#Info1	customer
#Info2	reason
#Info3	data to sample origin
#Info4	preparation of sample
#Info5	median value
#Notes	comments
individual series:	
#SSnr	series-number
#SCmg	dust concentration (mg)
#SIE	ignition energy
#SInd	inductance
#Stvs	ignition delay, set value
#Stve	ignition delay, effective
#Slat	ignition at / (no ignitions)
#SNote	comments on tests

final results:	
#E_I1	MIE - with ignition, 1 mH
#E_I0	MIE - with ignition, 0 mH
#E_NI1	MIE - without ignition, 1 mH
#E_NI0	MIE - without ignition, 0 mH
#E2L1	E2 / 1 mH
#E2L0	E2 / 0 mH
#E1L1	E1 / 1 mH
#E1L0	E1 / 0 mH
#EsL1	Es / 1 mH
#EsL0	Es / 0 mH
#tvL1	tv / 1 mH
#tvL0	tv / 0 mH
#MIE_1	Min. ignition energy / 1 mH
#MIE_0	Min. ignition energy / 0 mH
#ES_1	Statistic energy / 1 mH
#ES_0	Statistic energy / 0 mH
audit:	
#ANr	test number
#ADate	date
#ATime	time
#ACaus	reason
#AEVT	event
#AVAL	value

3.3.6 Audit

Info	Table	Graph	Audit
------	-------	-------	-------

no	date	time	cause	event	value
1	10.11.2015	10:27	wpsl	New file created	
2	10.11.2015	10:27	System	M3 - 9633	21001.14
3	10.11.2015	11:09	wpsl	Series added	1
4	10.11.2015	11:15	wpsl	Series added	2
5	10.11.2015	11:26	wpsl	Series added	3
6	10.11.2015	11:43	wpsl	Series added	4
7	10.11.2015	13:08	wpsl	Series added	5
8	10.11.2015	13:20	wpsl	Series added	6
9	10.11.2015	13:35	wpsl	Series added	7
10	10.11.2015	13:44	wpsl	Series added	8
11	10.11.2015	13:56	wpsl	Series added	9
12	10.11.2015	14:23	wpsl	Series added	10
13	11.11.2015	07:49	wpsl	Series added	11
14	11.11.2015	08:26	wpsl	Series added	12
15	11.11.2015	08:37	wpsl	Series added	13

username	signature	authorization
wpsl	wpsl	Administrator
JS	John Smith	Administrator

All activities are automatically recorded. An example:

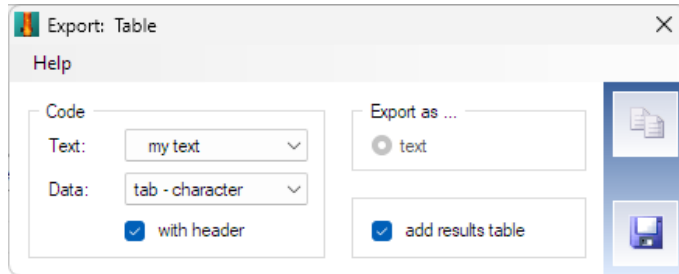
- 1 wpsl starts a new file and with it a new audit.
- 2 Firmware and serial number of the MIKE-apparatus are included.
- 3 ... Each added series will be recorded.



The data of the audit are stored manipulation proof in the MIKE-file.

3.3.7 Export

You can easily export data to other software.
Select first a page (*Info, Table, Graph, Audit*).
The Export-Menu is in "*File / Export*".



Text: Text with or without quotation marks.

Data: Define here the character which separates numbers.

with header: Shall a header be added to the columns ?

add results table: Shall we add the results-table (E1, Es, E2 as a function of tv) ?



The data are copied according to your instructions directly in the Windows-clipboard. From there you can paste it into any other program i.e. Excel, Word.



The data is written into a text file (*.txt).

3.4 Checking the MIKE

3.4.1 Serial interface (Tools / Check: Interface)

This program checks the serial connection between the PC and MIKE. Data is sent to the MIKE (write), read by the MIKE and compared with the transmitted data (failures). If problems are found, check the entry in "Interface", see: [3.2.4 Settings](#).

Write:	72	Read:	71
repeated	0	repeated	0

is:	failures	0
should be:		

Problem with communication?

Check cables and connectors

Check in [Settings](#) Com-Port Correct?

3.4.2 Ignition sparks (Tools / Check: Ignition)

In the next step, check the sparkover, without dust, at different ignition energies and with and without an inductance:

<input checked="" type="checkbox"/> single tests <input checked="" type="checkbox"/> energy fixed <input checked="" type="checkbox"/> dust dispersion <input checked="" type="checkbox"/> check of cylinders	energy <input type="text" value="10 mJ"/> delay tv <input type="text" value="120 ms"/> inductance <input type="text" value="1 mH"/>	correct: <input type="text" value="0"/> no spark: <input type="text" value="0"/> other failures: <input type="text" value="0"/> <hr/> eff. ignition delay: <input type="text" value="-"/> <div></div>
---	---	---

moving electrode	15 kV
------------------	-------

As in the performance of the actual experiment, a distinction is made between the set ignition delay time (delay tv = **tv set**) and the time measured at sparkover (eff. ignition delay = **tv eff**). The bottom field shows you the type of triggering selected and the charging voltage of the capacitors.



Sparkover:

With the lowest ignition energies (1 mJ, 3 mJ) and triggering by the high-voltage relay, the energy of the spark may occasionally be too low (message: charge too low ? No spark ?). Excessive charge has been lost owing to the corona current. Or, even in the absence of any disturbing influences, the spark energy was actually too low and the emitted error message has correctly reported this. In the practical application of the MIKE - with dust - this appears much less frequently as sparkover is facilitated by the dust/air mixture. With higher ignition energies, 100% sparkover may be expected.



Error messages:

- | | |
|------------------------------|---|
| • Door open: | Door is not shut properly. |
| • Pressure too low: | Check the compressed air connection (7 bar ?) |
| • Charge too high ? | Upper limit of spark monitoring exceeded. |
| • Charge too low ? | Are the electrodes and insulators clean ? |
| • Deviation of tv | Triggering by high-voltage relay:
If tv eff is too large, the delayed sparkover was probably caused by electrostatic charge on the surface of the glass tube. Clean the glass tube with water (this lowers the resistance of the surface). |
| • Deviation of tv | Triggering by moving electrode:
If tv eff is too large, the cause usually lies in the movement of the ME cylinder being too slow. Clean piston rod and if need be lubricate with a little oil. |
| • Check: Cylinder ... | The position of the cylinder is monitored. The specified cylinder is not in the correct position. Check compressed air for the cylinders (5 bar). |

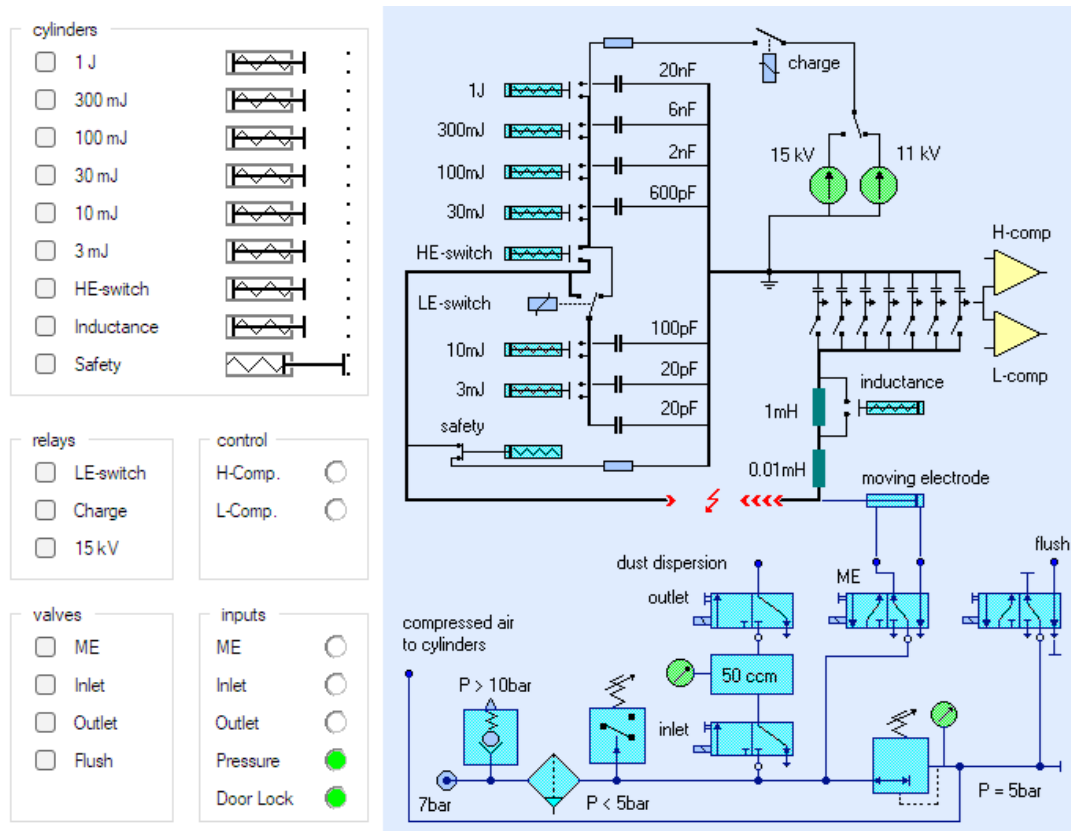


Options:

- | | |
|------------------------------|--|
| • Single tests: | Select between single or continuous testing.. |
| • Energy fixed: | Energy and inductance are as specified. |
| • Dust dispersion: | Select between with or without dust dispersion. |
| • Check of cylinders: | The position of the pneumatic cylinders is monitored. |
| • Recording: | Protocol in a text-file "ignition.txt". |
| • Change Triggering: | In principle, the type of triggering can be changed at low energy |
| • Change Voltage: | values (1...10 mJ). But retention of the pre-set values is advisable |

3.4.3 IO - Port (Tools / Check: IO - Port)

With this test program for detailed troubleshooting, you have direct access to all cylinders, valves and relays of the MIKE.



Group "cylinders"

Safety:	Inverse cylinder: In the home position, the HV output is grounded.
Induct.:	High-voltage switch to short the 1 mH inductance.
HE-Sw.:	High-voltage switch: 30mJ...1J busbar / HV output.
3 mJ....1 J:	High-voltage switch for the particular energy level.
(The capacitor for the 1 mJ spark is always connected)	

Group "relays"

LE-Switch:	High-voltage relay
Charge:	Charging relay
15 kV:	Switch: 11 / 15 kV

Group "control"

H-Comp.:	Upper limit
L-Comp.:	Lower limit

Group "valves"

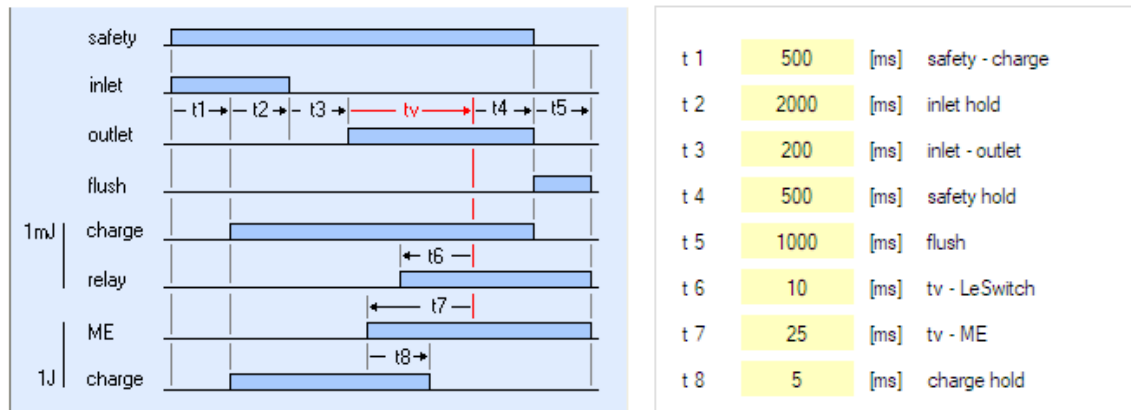
ME:	Moving electrode
Inlet:	Inlet valve
Outlet:	Outlet valve
Flush:	Purging

Group "inputs"

ME:	Moving electrode
Inlet:	Inlet valve
Outlet:	Outlet valve
Pressure:	Pressure monitoring
Door Lock:	Door locking

3.4.4 Timing (System / Timing)

The times in the test sequence of the MIKE are freely definable over a wide range. Under normal circumstances, there is no necessity to change these times as optimum settings have already been selected. Use the "Default" button to reset all the time settings to their default values.



- t 1** Start of cycle: After this time has elapsed, all pneumatic cylinders must have reached their correct position.
- t 2** Opening time for the inlet valve (Inlet): At the same time, charging time of the capacitors. This time must be sufficient to allow filling of the pressure vessel and also ensure reliable charging of the largest capacitor.
- t 3** Delay time inlet-outlet valve (Inlet-Outlet): The inlet valve must be completely closed before the outlet valve opens.
- t 4** Hold time of the outlet valve .
- t 5** Purging (Flush): The holder of the moving electrode is cleaned with compressed air.
- t 6** Triggering by high-voltage relay: This time-entry compensates the switching time of the relay so that sparkover occurs at the desired tv-time.
- t 7** Triggering by moving electrode: This time-entry compensates the mechanical movement time of the electrode so that sparkover occurs at the desired tv-time.
- t 8** Charge relay hold: This time-entry compensates the delay in the mechanical movement of the electrode so that the loss of charge due to corona current is reduced.

4. Calibration / Test procedures

According to international standards (e.g. ISO 9000, GLP), test equipment must be calibrated at intervals by comparison with a standard or a calibrated testing apparatus. This calibration also applies to the MIKE-apparatus for the determination of the minimum ignition energy.

Therefore we deliver with the equipment a test dust with reference results. We highly recommend to follow all the instructions step by step and to determine the minimum ignition energy of the test dust.

4.1 Preparation

4.1.1 New File



At the start of a test with a new dust, a new file is opened. The file name is automatically allocated by the program (Identity and date) or given by you. See: [3.3.2 Files](#).

The screenshot shows the 'Info' tab of the MIKE software interface. The form is organized as follows:

- product:** Niacin USP
- tested by:** Cesana AG
- filename:** CAG_250318A.MIE
- created:** 18-Mrz-2025
- status:** unlocked
- customer:** (empty field)
- reason:** CaRo25
- origin:** Arxada
- preparation:** tel quel
- median:** 22um
- comment:** (empty text area)

A yellow padlock icon indicates the file is unlocked.

We recommend to enter all information related to the product (customer, reason, sample preparation, median value etc.) in the corresponding fields. This text will be stored together with the test results in the MIKE-file.

4.1.2 Sample preparation for the calibration

The results can only be compared when the sample preparation is the same. Therefore the test dust has been milled, homogenized and tightly packed.

Please keep the container closed whenever possible.



For the calibration: please test the sample „**as delivered**“.
By no means, prepare the sample additionally.



For the calibration, only tests **with** inductance ($L = 1\text{mH}$) must be carried out.

4.1.3 Test conditions



Electrode spacing = 6 mm

Move the moving electrode using the „ME“ (moving electrode) key to the working position and adjust the gap between the moving and fixed electrode with the gauge supplied to 6 mm (screw adjustment of the fixed electrode).

International guidelines require an electrode gap of at least 6 mm.



Dispersion pressure $P_z = 7$ bar (over pressure)

The compressed air for dispersion of the dust and for the pneumatic system of the moving electrode must be set to 7 bar ± 0.5 bar (manometer gauge = 7 bar).

4.2 Procedures

4.2.1 Test procedures



Open the window „Next Series“ by a click on this button or by pressing the „enter“-key.

1. Enter the parameters of the new series on the screen. The values of the series previously selected are used as default values.
2. Take out the base and distribute the dust evenly around the mushroom-shaped nozzle
Alternative: Add the dust from above to the tube. However, it is necessary to ensure that the amount of dust adhering to the electrodes is kept at a minimum.
3. Close the door and lock.
4. Start the series by clicking „OK“ or pressing the „Enter“ key.
5. Observe the test.

The dust was ignited:

6. Inform the computer of this by clicking „Yes“ or press the „Y“-key.
7. Release the door lock of the MIKE (this enables the keys for manual operation).
8. Roughly pre-clean the apparatus with compressed air through repeated, alternate opening of the inlet (I) and outlet (O) valves.
9. Open the door. Vacuum off the residues and clean the tube, the mushroom-shaped nozzle and the electrodes.

The dust was not ignited:

6. Start the next test by clicking „No“ or pressing the „Enter“ key. The remaining dust is again dispersed and possibly ignited.



If the dust was not ignited a little dust has escaped through the hinged cover. In addition some dust adheres to the tube wall and the electrodes. As a result, the dust concentration gradually decreases. Experience has shown that with the same dust filling up to 4 tests can be done. The dust concentration in the MIKE-apparatus is just a relative parameter. We recommend, independent from the dust concentration, to proceed as follows:

3	tests	(see 6.)
-	cleaning	(see 7. - 9.)
-	fresh dust sample	(see 2.)

3	tests	(see 6.)
-	cleaning	(see 7. - 9.)
-	fresh dust sample	(see 2.)

4	tests	(see 6.)
----------	-------	----------

Error messages:

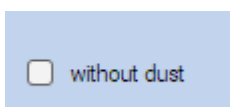
Charge too low ? No spark ?

No sparkover occurred or the spark energy was too low. Clean the electrodes and insulators thoroughly and check the electrode gap if need be. Electrostatic charged dust can also influence the sparkover with its electric field. The sparkover occurs too late and the energy is too low due to the corona current. Clean the glass tube with water (this lowers the resistance of the surface). Then start the next test with a new dust filling.

Deviation of $t_v > 10 \text{ ms}$

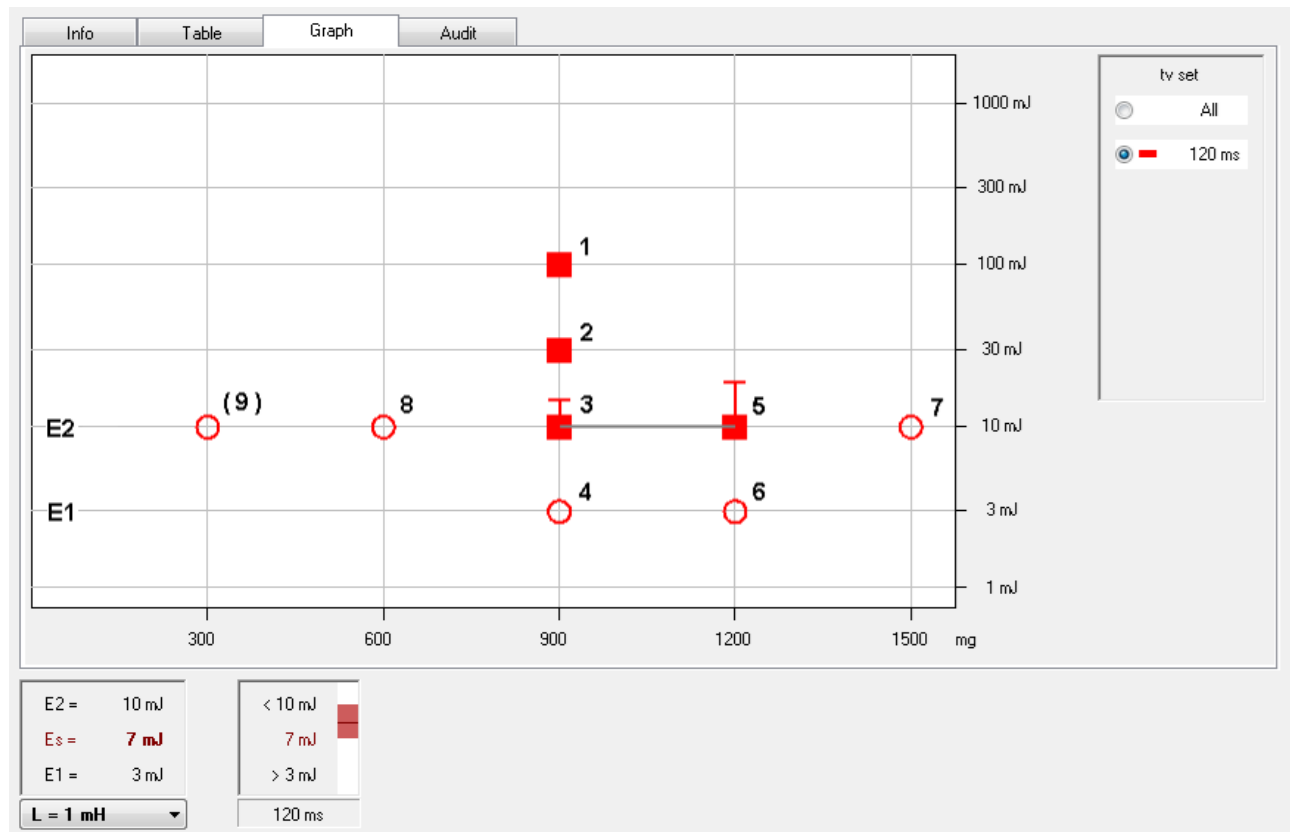
In triggering by the moving electrode, the mechanical system is probably dirty and stuck. Clean the piston rods and apply a little oil if necessary. Actuate the piston several times with the „ME“ key. In triggering by the high-voltage relay, electrostatic charges are probably the cause of the delayed sparkover. Clean the glass tube with **water** (this lowers the resistance of the surface). Then start the next test with a new dust filling.

Checking the sparkover:



To test the sparkover, you can interrupt the normal test procedure at any time by selecting „spark only“. The dust is then not dispersed - and need not be vacuumed off. Select „with dust“ to return to the normal test procedure.

4.2.2 Graphics of results



The series **with ignition** of the dust (**solid squares**) and the series **without ignition** of the dust (**outline circles**) are displayed each time. The vertical pointers (T-shaped) indicate how many single tests were necessary until the dust was ignited (low ignition probability). If the dust was ignited in the first test (high ignition probability), no vertical pointer appears.

Example for the test procedures

- 1 Start with a dust sample weight of 900 mg, an ignition delay time of 120 ms and an ignition energy with a high ignition probability e.g. 100mJ.
- 2,3,4 Lower the energy until the dust no longer ignites in **10** successive tests.
- 5,7,8 At energy (**E2**), where an **ignition** occurs, continue testing with higher and lower dust concentrations.
- 4,6 All dust concentrations with an ignition at an energy (**E2**) must be confirmed by „**10 no ignitions**“ at an energy level (**E1**).
- <9> For the calibration, **at least 5** different dust concentrations are required to calculate the ignition probability.



The entire procedure must then be repeated with different ignition delay times (in steps of 30ms) to find the actual lowest ignition energy at the optimum ignition delay time for the dust under test.

4.2.3 Table of results

Info	Table	Graph	Audit					
	sn	conc.	IE (mJ)	tv set	tv eff	L(mH)	I (NI)	comment
<input checked="" type="checkbox"/>	1	900	3	120	120	1	3	
<input checked="" type="checkbox"/>	2	600	3	120	120	1	3	
<input checked="" type="checkbox"/>	3	300	3	120	121	1	1	
<input checked="" type="checkbox"/>	4	150	3	120	120	1	(10)	
<input checked="" type="checkbox"/>	5	1200	3	120	120	1	1	
<input checked="" type="checkbox"/>	6	1500	3	120	120	1	3	
<input checked="" type="checkbox"/>	7	1800	3	120	120	1	5	
<input checked="" type="checkbox"/>	8	2400	3	120	120	1	4	
<input checked="" type="checkbox"/>	9	300	1	120	120	1	(10)	
<input checked="" type="checkbox"/>	10	600	1	120	120	1	(10)	
<input checked="" type="checkbox"/>	11	900	1	120	120	1	(10)	
<input checked="" type="checkbox"/>	12	900	1	120	120	1	(10)	
<input checked="" type="checkbox"/>	13	1200	1	120	121	1	(10)	
<input checked="" type="checkbox"/>	14	1500	1	120	120	1	(10)	
<input checked="" type="checkbox"/>	15	1800	1	120	120	1	(10)	
<input checked="" type="checkbox"/>	16	2400	1	120	121	1	(10)	

E2 = 3 mJ
Es = 1.3 mJ
E1 = 1 mJ
L = 1 mH

< 3 mJ
1.3 mJ
> 1 mJ
120 ms

Designations:

sn	= consecutive numbering of the test series
conc.	= weight of dust sample in mg
IE [mJ]	= ignition energy
tv set	= set ignition delay time (set value)
tv eff	= measured ignition delay time (actual value)
L [mH]	= inductance (0 mH or 1 mH)
I	= ignition in specified experiment
(NI)	= no ignition of the dust after: (Number of Non-ignitions)

Editing the table:



this series are valid and will be evaluated. (to change, click on this field).

4.2.4 Conformity with reference values

Compare finally your value of the statistic energy (Es) with the reference value delivered with the test dust. Your result must be within the given tolerance range.

4.3 General test procedures

4.3.1 Sample preparation

The lowest values of the MIE of a product are obtained if the sample is tested when it is dry and containing a fine particle size fraction. The product preparation is thus immensely important.

The product should be carefully dried by one of the following methods:

- a) 24 h at 50°C under vacuum
- b) 24 h at 75°C under atmospheric pressure



The sample must be prepared so that the median value **M** is less than **63 µm**.

Due to the big influence of the particle size distribution on the MIE (see 1.2.3) the particle size distribution and the corresponding median value **M** must be measured and indicated in the report.

In justified exceptional cases the dust can also be tested as supplied.

4.3.2 Test procedures

1. Start with a dust sample weight of 900mg (1200mg), an ignition delay time of 120ms and an ignition energy with a high ignition probability e.g. 100mJ.
2. Lower the energy until the dust no longer ignites in **10** successive tests.
3. At energy (**E2**), where an **ignition** occurs, continue testing with higher and lower dust concentrations.
4. All dust concentrations with an ignition at an energy (**E2**) must be confirmed by „**10 no ignitions**“ at an energy level (**E1**).



The entire procedure must then be repeated with different ignition delay times (in steps of 30ms) to find the actual lowest ignition energy at the optimum ignition delay time for the dust under test.



The entire test sequence is performed twice for every dust: Once **with** an inductance, where the spark is protracted, and once **without** an inductance.

5. Troubleshooting



5.1 Error message: Charge too low? No spark?

Thoroughly clean the electrodes and insulators and, if necessary, check the electrode spacing. If electrostatically charged dust adheres to the glass tube, the resulting electrical field makes the spark more difficult. The spark jumps with a delay and its energy is often too low due to corona losses. The glass tube must be rinsed with water (to reduce surface resistance). Then repeat the experiment with a fresh dust filling.



5.2 Error message: Charge too high?

The internal spark monitoring system reports that the charge transferred by the spark and thus the energy was too high. If this error occurs repeatedly and with only one energy value, there is a suspicion of a defective high-voltage capacitor!



5.3 Error message: Deviation of $t_v > 10 \text{ ms}$

When triggered by moving electrodes (10mJ ... 1J), the mechanism is probably dirty and stuck together. Clean the piston rod and, if necessary, oil them a little. Press the "ME" key several times..

When triggered by the high-voltage relay (1mJ, 3mJ), the cause of the delayed spark jump must be sought in the electrical field that has built up. The glass tube should be rinsed out with water (to reduce surface resistance). Then repeat the experiment with a fresh dust filling.



5.4 Error message: Check: Cylinder ...

Each cylinder has a position sensor and the position of the cylinder is monitored. For further diagnosis use the program [3.4.3 Tools / Check: IO - Port](#) activate and deactivate the cylinder in question. Does the position display change?

- a) The position sensor is misaligned or defective.
- b) The cylinder does not reach the required position.

A visual inspection is recommended for further diagnosis. See: [Service - Manual](#)



5.5 The MIE is higher than expected

Do you use synthetic compressed air? This is not allowed!

Has the dust sample become agglomerated or moist? See: [4.3.1 Sample preparation](#)

6. References

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