# ExTools

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## Software for Explosion Protection

**E**x**T**ools is a software tools box for experts, which allows conversion, estimation, calculation and classification of several fuel and equipment related parameters. It contains also an extensive data-bank of safety indices of liquids and gases. The information gained from **E**x**T**ools helps experts to judge the risk in the plant. The application and function of the software toolbox are reported and the possibilities demonstrated with examples.

## 1. Goal of ExTools

**E**x**T**ools is a software toolbox for experts, which allows the:

- conversion of the safety indices (e.g., *LEL*, *Pmax*, *Kmax*, *LOC*, *MIE*, *MIT*), determined under ambient conditions into real process conditions for the plant.
- estimation of ignition hazards (friction, grinding und impact sparks),
- calculation (equipment volumes, maximum gap width for rotary air locks, *MESG* for fuels) or classification (type of flexible intermediate bulk container (FIBC) of different equipment requirements.

The above-mentioned conversion, estimation, calculation and classification are based on several research works /5...7/ and publications /8...13/. The development team disclaims any liability arising out of the use of this software.

## 2. Application of ExTools

With the help of the simplified example shown in Figure 1 the application of **E**x**T**ools is briefly described..

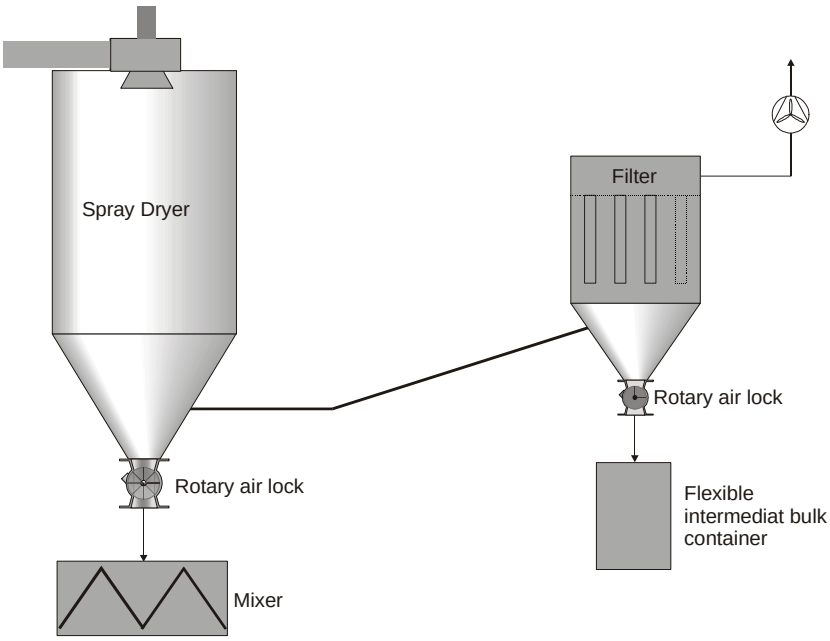



**Figure 1.** Simplified plant unit consisting of spray dryer, mixer, filter and FIBC

## 2.1 Ignitability Indices: MIE, MIT

With the ignitability indices, minimum ignition energy *MIE*, and minimum ignition temperature *MIT*, several process influences can be estimated, such as:

| | | | |
|---|---|---|---|
| **1** | MIE: influence of temperature | **5** | MIT: conversion of BAM - GG |
| **2** | MIE: influence of median value | **6** | Ignition hazard of friction sparks |
| **3** | MIE: influence of gas | **7** | Ignition hazard of grinding sparks |
| **4** | MIT: conversion of GG - BAM | **8** | Ignition hazard of impact sparks |

For the spray dryer (Fig. 1) the knowledge of the temperate influence on the *MIE* is very important to know, because the risk assessment is based on the temperature related minimum ignition energy. Knowing the *MIE* at ambient temperature (e.g., 10 mJ), the *MIE* at e.g. 200°C can be estimated (Fig. 2). In the calculation windows, **E**x**T**ools makes always some remarks. In the case shown in Figure 2 the remarks are:

note: This is an estimation!
Insert MIE-values measured with induction.


**Figure 2.** Estimation of the temperature influence on the minimum ignition energy *MIE*

In addition the ignition hazard of sparks can also be estimated with the *MIE* in combination with the minimum ignition temperature *MIT*. In spray dryers with disk atomizers the rotary disk can be an ignition source in the event of mechanical defects. Therefore, an ignition hazard of friction or impact sparks is given if the estimated equivalent energy of the spark *Ee* is equal or higher than the estimated temperature related *MIE* (Fig. 3).


note: This estimation is only a function of MIT!
Insert MIE-values measured with inductance.
Insert MIT-values measured with the BAM-oven.

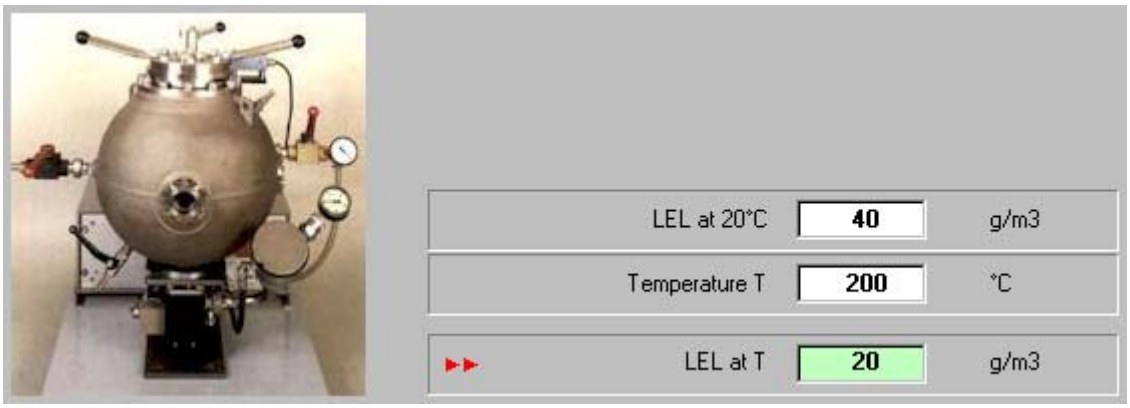
**Figure 3.** Estimation of the equivalent energy of friction sparks with MIE and MIT and assessment of ignition hazard given by this spark

## 2.2 Explosion Indices: LEL, Pmax, Kmax, LOC

With the explosion indices, lower explosion limit *LEL*, maximum explosion overpressure *Pmax*, maximum explosion constant *Kmax* and limiting oxygen concentration *LOC*, several process influences can be estimated. With the ignitability indices, minimum ignition energy *MIE*, and minimum ignition temperature *MIT*, several process influences can be estimated or the LOC-value measured in nitrogen (N2) can be converted to a LOC-value in carbon dioxide (CO2) and visa versa:

| | | | |
|---|---|---|---|
| **1** | LEL: influence of temperature | **5** | LOC: influence of temperature |
| **2** | Pmax: influence of temperature | **6** | LOC: conversion N2 - CO2 |
| **3** | Pmax: influence of initial pressure | **7** | LOC: conversion CO2 - N2 |
| **4** | Kmax: influence of initial pressure | **8** | LOC: estimation with MIE and MIT |

For the estimation of the explosive atmosphere in the spray dryers, the knowledge of the temperature related lower explosion limit *LEL* is necessary. Figure 4 shows that in the spray dryer the lower explosion limit measured under standard condition of *LEL* = 40g/m³ will be reduced to *LEL* = 20 g/m³ if the dryer temperature is for example 200°C.




note: This is an estimation!
The result is rounded down to the next lower integer value.

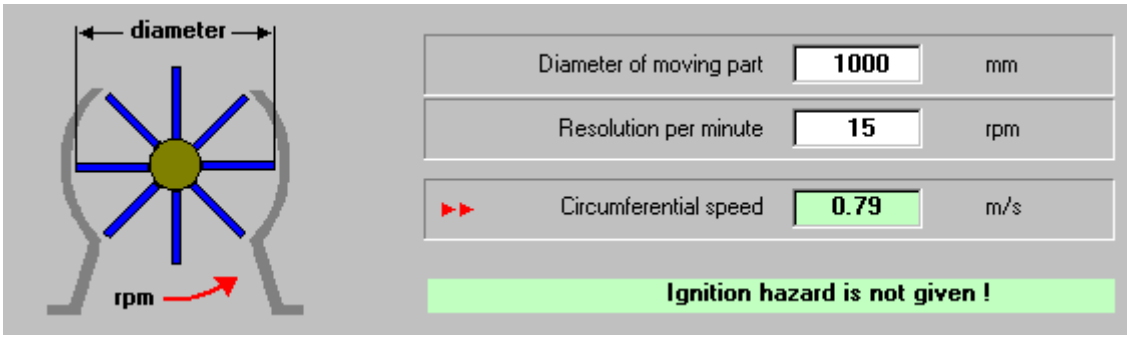
**Figure 4.** Estimation of the temperature influence on the lower explosion limit *LEL*

## 2.3 Equipment: Requirements

In this part several relevant requirements of equipments, which are important for the experts, can be derived.

| | | | |
|---|---|---|---|
| **1** | Volumes | **3** | Maximum experimental safe gap (MESG) |
| **2** | Rotary air lock | **4** | Flexible intermediate bulk containers (FIBC) |
| | | **5** | Circumferential speed and ignition hazard |

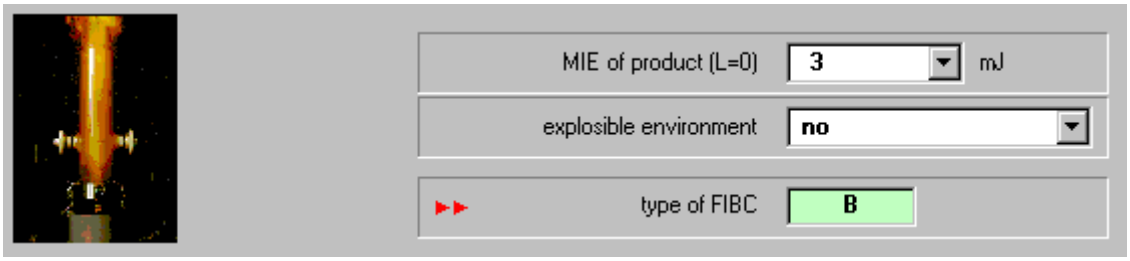
The mixer below the spray dryer in Figure 1 has an agitator. To estimate the ignition capability of sparks, derived from these rotating agitator blades in dust-air-mixtures, the circumferential speed of components must be known. As can be seen from Figure 5, with a circumferential speed of 0.79 m/s, no ignition hazard is given for mechanical generated sparks and hot surfaces, because it is known that neither ignition source appears in industrial practice when the circumferential speeds are less than or equal to 1 m/s.




note: For rotating steel parts in dust air mixtures.

**Figure 5.** Calculation of the circumferential speed of moving components and estimation of ignition hazard caused by moving parts

Below the filter (Fig. 1) a flexible intermediate bulk container (FIBC) is installed. Depending on their hazard situation at the location where the flexible bulk container is used, it must meet different requirements in order to avoid ignition hazards caused by electrostatic charging. **E**x**T**ools helps again in this case by choosing the right FIBC (Fig. 6).




note: FIBC type A: no special requirements.
FIBC type B: breakdown voltage of the FIBC wall < 4 kV.
FIBC type B: earth leakage resistance of all points of the FIBC (including hangers) < 100 MOhm.

**Figure 6.** Requirements of FIBCs relative to the usage with *MIE* and environment (*MIE* measured without inductance (L=0))

## 2.4 Safety Indices of Liquids and Gases

**E**x**T**ools contains also an extensive databank of liquids and gases, which enables experts responsible for assessing the explosive potential of fuels and evaluating the risk associated with handling liquids and/or gases.

| | | | |
|---|---|---|---|
| **1** | Safety Indices for Gases | **3** | Sicherheits-Kenngrössen für Gase |
| **2** | Safety Indices for Liquids | **4** | Sicherheits-Kenngrössen für Flüssigkeiten |

The databank of safety indices for gases (125 products) and for liquids (126 products) exists in English and German. An example is given in Figure 7.

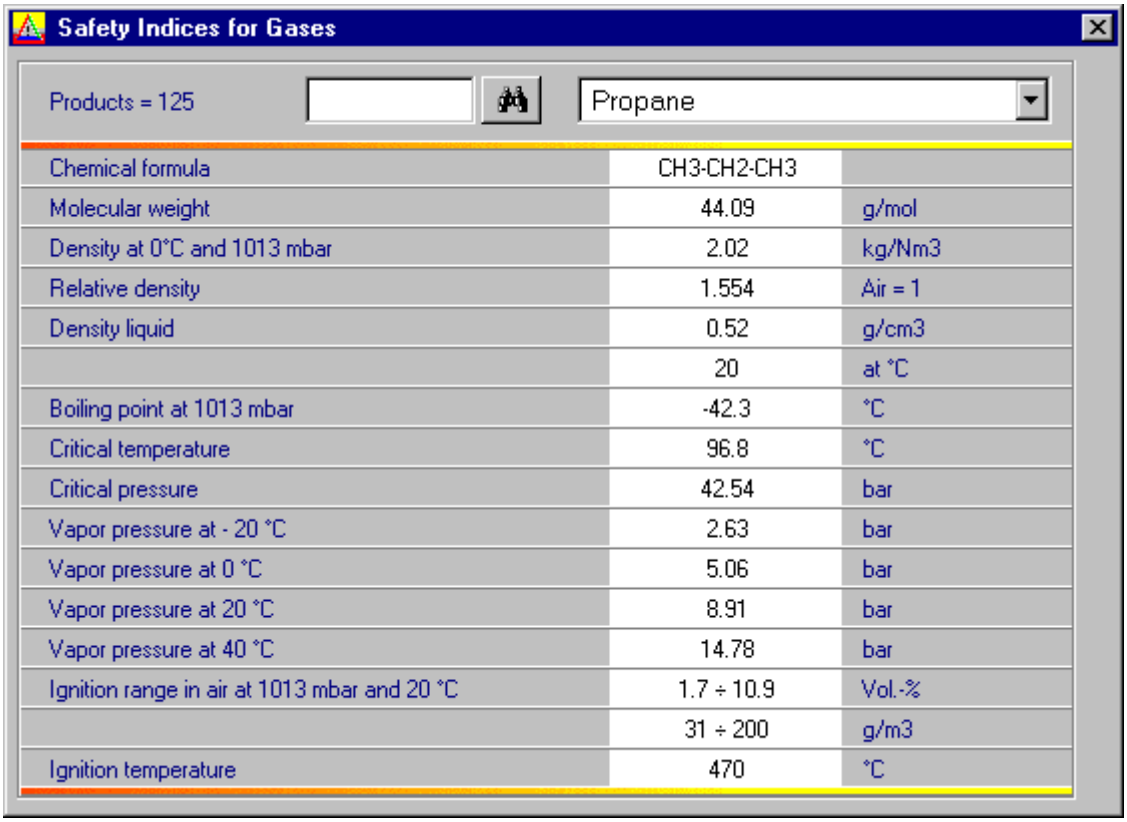



**Figure 7.** Example for safety indices for the gas Propane

## 3 Acknowledgement

Thanks to the sponsoring of several companies (Fig. 8) **E**x**T**ools is a freeware and can be passed on to any interested person.

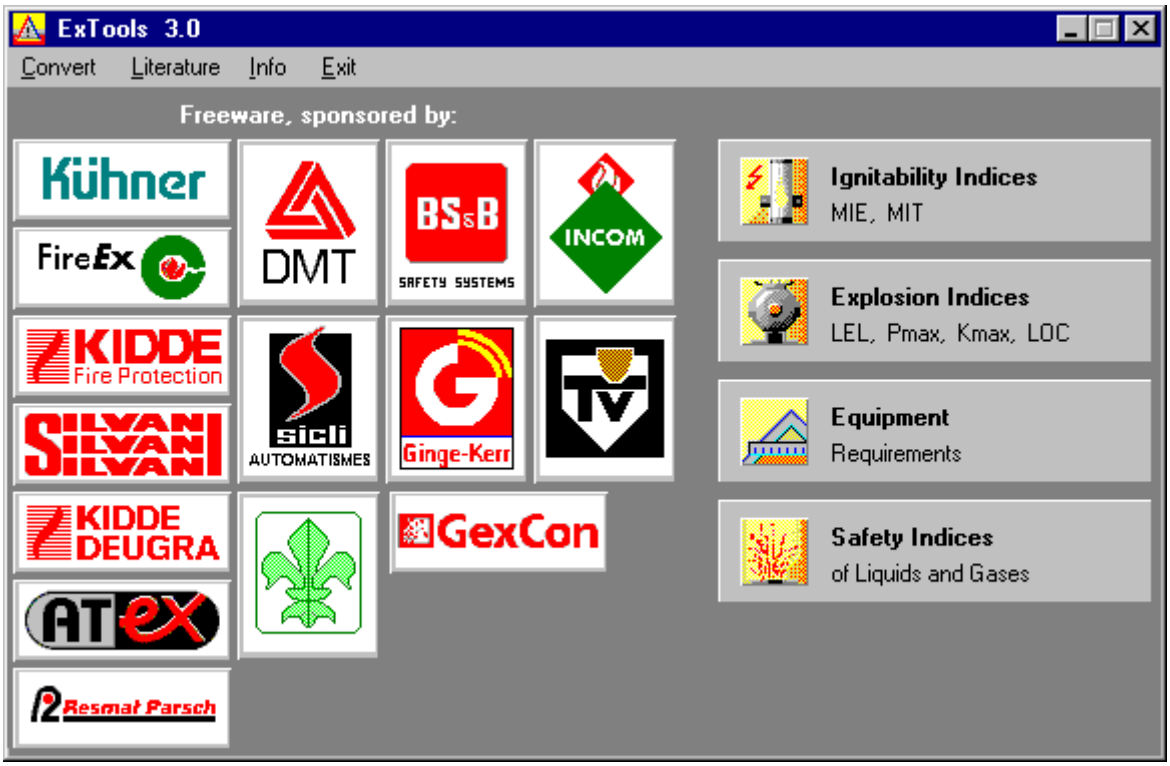



**Figure 8.** Main Picture of **E**x**T**ools

# 4 Literature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