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NLK appliance

Manual

EN 459-2

(DIN 1060 part 3)

1. Unpacking and Installation

Please be careful in unpacking the appliance and check for any damages. It is important to immediately detect potential damages caused by transportation. As the case may be, a direct recording of facts is necessary. Therefore please contact the manufacturer.

- Observe technical data for information concerning permissible surrounding conditions.
- Before start-up, please check if your line voltage is 230 V - 50 Hz or 115 V - 60 Hz.
- Only licensed temperature probes may be used.

2. Installation and Start-up

Please observe the following succession in installing the system.

ATTENTION - SECURITY ADVICE

Unslaked lime is etching. The milk of lime is highly alkaline after slaking.
!! Implicitly wear safety glasses and protective gloves !!

1. Install the stand and insert the cross clamp.
2. Fix cross sleeve at the stand and mount the stirring device.
3. Insert stirring paddle into the clamping chuck and secure it.
4. Put the Dewar vessel onto the stand base and secure it with the Dewar clamp.
5. Justify the stirring device with the stirring paddle.
6. Regulate the stirring device at the lowest rotation speed and justify the Dewar vessel, so that the stirrer can rotate freely in the Dewar flask.
7. Put on the lid and justify stirring device and stirring paddle, so that the stirring paddle can rotate freely. Be sure that the blade agitator is not in direct contact with the glass. The Dewar flask is to be secured with the clamp.
8. Attention: Check the height of the stirring paddle.
9. Close lid, insert the temperature probe and secure it.
10. Connect the temperature probe and observe the manual of the temperature measuring device.

3. General Information

Examination of the reactivity of fine lime while slaking effects via measuring the incipient rise of temperature subject to the duration of reaction (wet slaking curve, NLK).

Basis of apparatus and measuring system is EN 459-2.

3.1. Theoretic basis and measurement system

According to standard, 150 +/- 0,5 g of unslaked lime are given into a Dewar vessel with 600 +/- 1g of distilled water at about 20°C.

The reaction of fine lime (CaO) with water in connection with the generation of calcium hydroxide (Ca(OH)2) effects exothermally (1160 kJ/kg).

The releasing heat energy heats the water and also parts of the device. The temperature rise is measured and assigned in a time curve. This creates the wet slaking curve (NLK)

From the wet slaking curve, the required data is acquired. (see chapter analysis)
The apparatus constitutes a reaction calorimeter of simple construction.

In consideration of the specific heat of the CaO (~ 0.84 J/g K), a theoretic heating of ~64°C is calculated from the reaction heat of 1160 kJ/K.
This figure is not reached in reality. This can be caused by impure lime, the inability to achieve a complete transformation and of course because the apparatus absorbs and conducts heat.

The maximum temperature T_{max} can be calculated from the measured figure T'_{max} , the initial temperature T_o and the water equivalent of the apparatus (see chapter analysis).

T'_{max} = measured maximum temperature
T_{max} = theoretic maximum temperature (reaction heat of 1160 kJ/K)
W = water equivalent (capacity of heat)
(m_h) = warm water in noted quantity
(T_h) = warm-water temperature in noted quantity
(m_k) = cold water in noted quantity
(T_k) = cold-water temperature in noted quantity
(T_m) = mixing temperature of cold and warm water
Q_x = quantity of heat
C_w = heat capacity of water
C_k = heat capacity of lime
L_f = slaking factor
T_o = initial temperature

Calculation of the water equivalent

The maximum temperature T'_{max}, measured in a test, is little too small because the apparatus absorbs heat. The maximum temperature T_{max} can be calculated if the water equivalent W (capacity of heat) is noted.

Measuring principle

A mixed test is carried out, in which warm water in noted quantity (m_h) and temperature (T_h) are set and cold water of noted quantity (m_k) and temperature (T_k) are added. The upcoming mixtemperature (T_m) is measured. In doing so, the preset warm water and the apparatus yield a heat quantity Q_x and the cold water absorbs the same heat quantity Q_x.

$$Q_{x\,(release)} = m_h * C_w * (T_h - T_m) + W * (T_h - T_m)$$
$$Q_{x\,(absorb)} = m_k * C_w * (T_m - T_k) \text{ aus } Q_{x\,(release)} = Q_{x\,(absorb)} \text{ follows}$$
$$m_h * C_w * (T_h - T_m) + W * (T_h - T_m) = m_k * C_w * (T_m - T_k) \text{ and}$$

$$W = \frac{m_k * C_w * (T_m - T_k) - m_h * C_w * (T_h - T_m)}{T_h - T_m} \quad \text{in J/°C}$$

Example: If you set formula W =

m_h = 550 g and T_h = 50°C
m_k = 200 g and T_k = 20°C
T_m = 42,5°C and
C_w = 4,19 J/g °C

Then equivalent for W is:

W = 209,5 J/°C

By setting in the values:

T_h = 49,9°C and T_m = 42,6°C

it arises: W = 289,9 J/°C

This simple example shows that for the determination of the water equivalent, the temperature mesurement is to execute with a resolution of 0,01°C to avoid an imprecise measurement.

Useful details for the determination of a water equivalent

- Prepare hot water (50 +/- 1°C)
- Put Dewar vessel on a balance and reset balance (tare)
- Weigh in hot water (550 +/- 0,1g)
- Insert Dewar vessel with hot water into the apparatus, immerse stirring paddle, close lid, insert measuring sensor and switch on stirrer device (350 turns per minute)
- Weigh in cold water (200 +/- 0,1g, 20°C) into a beaker (250 ml, small model)
- Place beaker with cold water beside the working apparatus. Observe temperature indication of hot water. When temperature falls less than 0,1°C/min, remove the measuring sensor, immerse it into the cold water of the beaker and stirr it manually. After some seconds, the temperature indication remains stable so the figure can be noted (T_k)
- Remove measuring sensor from cold water and insert the sensor into the lid of the Dewar vessel. After some seconds, the temperature indication remains stable so the figure can be noted (T_h)
- Open lid, add cold water from the beaker. Close lid, observe temperature indication. It takes about 30 seconds, than the temperature should be stable and the figure can be noted. (T_m)
- Repeat the entire process 5 to 10 times, without counting the first one. Assess an average figure and calculate W.

Test preparation

For a test, prepare a sample quantity of about 0,5 kg. The temperature of the sample should be 20 +/- 1°C.

To assure a sample quality corresponding to the testproduct, the sample has to be stored in thight-sealed containers. Even a minor absorption of humidity can manipulate the course of the wet slaking curve.

For a single test, a sample quantity of 150 +/- 0,5g needs to be weighed into the filler.

Performance of a measurement

- Fill in 600 +/- 1g of distilled water (20 +/- 0.5°C) into the Dewar vessel and place it in the stand.
- Lower telescope with stirring paddle and stirring device to the preset stop position.
- Put lid on and close. Insert the measuring sensor, start the stirring device (rotation speed 350 +/- 1 t.p.m.)
- Wait for temperature stability (takes about 2 minutes). In the meantime, switch on the temperature measure with data logging.
- Regulate data logging at a spacing of 60 seconds.
  A data record of 30 seconds per equivalent shows a more differentiated temperature course.
- Open lid of the Dewar vessel and fill in the prepared sample quantity all at once (use a funnel or paper bag). Close lid, start paper feed of the recorder or a stopwatch. This point of time is regarded as the start of the test.

- **Remark according to DIN:**

  It has to be assured that the content of the vessel is completely stirred during the entire testphase. Using strongly thickening limes, an increase of the rotation speed can be necessary when a reaction temperature of about 60°C is reached.

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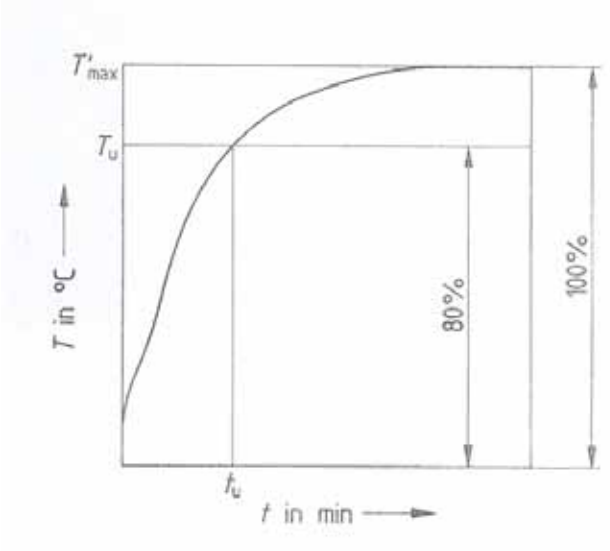
Analysis



The measured temperature equivalents are illustrated in a diagram, in relation to the course of time. This creates the wet slaking curve.

To mark the reaction rate, the time (t_u) needed for an 80% transformation of lime is indicated in minutes. During this process, the temperature (T_u) is reached.

The equivalent T_u is calculated of the measured maximum temperatur T_{max} and the initial temperature $T_{o.}$ The related time (t_u) is seen in the wet slaking curve.

$T_u = 0.8 \times T'_{max} + 0.2 \times T_o$ in °C

A complete transformation of 100% is effected when the maximum temperature T_{max} is observed (the related time t_{ges} can actually not be used as a test result due to the extremely flat course of the curve).

The measured maximum temperature T_{max} is not appropriate to compare different apparatuses due to differing heat consumption of the devices.

Determing the maximum temperature T_{max} , the water equivalent W of the apparatus is to be observed.

In order to simplify calculation, the formula for T_{max} contains:

Heat capacity of water:	C_m	= 4.19 J/g°C
Heat capacity of lime:	C_k	= 0.838 J/g°C
Water quantity:	m_w	= 600 g
Lime quantity:	m_k	= 150 g

Containing these specifications, the quite complex and theoretic formula becomes:

$$T_{max} = (2639.7 * T'_{max} + W \times T'_{max} W * T_o) / 2639{,}7 \text{ in °C}$$

The slaking factor LF results from the equivalents T'_{max}, T_o and t_{ges}.
Due to the always imprecise determination, this factor is to be censored critically.

$$LF = (T'_{max} \; T_o) / t_{ges} \quad \text{in °C / min.}$$

Order Numbers

NLK Complete mounting without measure-data logging

NLK Complete mounting, without stirring device without data logging and accessories without filling-device	Order No	11218

NLK spare parts

Dewar vessel with top flange F 9 C	Order No	1126
Folding lid	Order No	11217
Stirrig paddle	Order No	11219
Replacement Dewar vessel, glass refill only F 9 A	Order No	1116
Base plate with stand	Order No	11221
Cross clamp	Order No	11222
Dewar clamp	Order No	11223
Filling Device	Order No	11224

Temperature measuring device with data logging

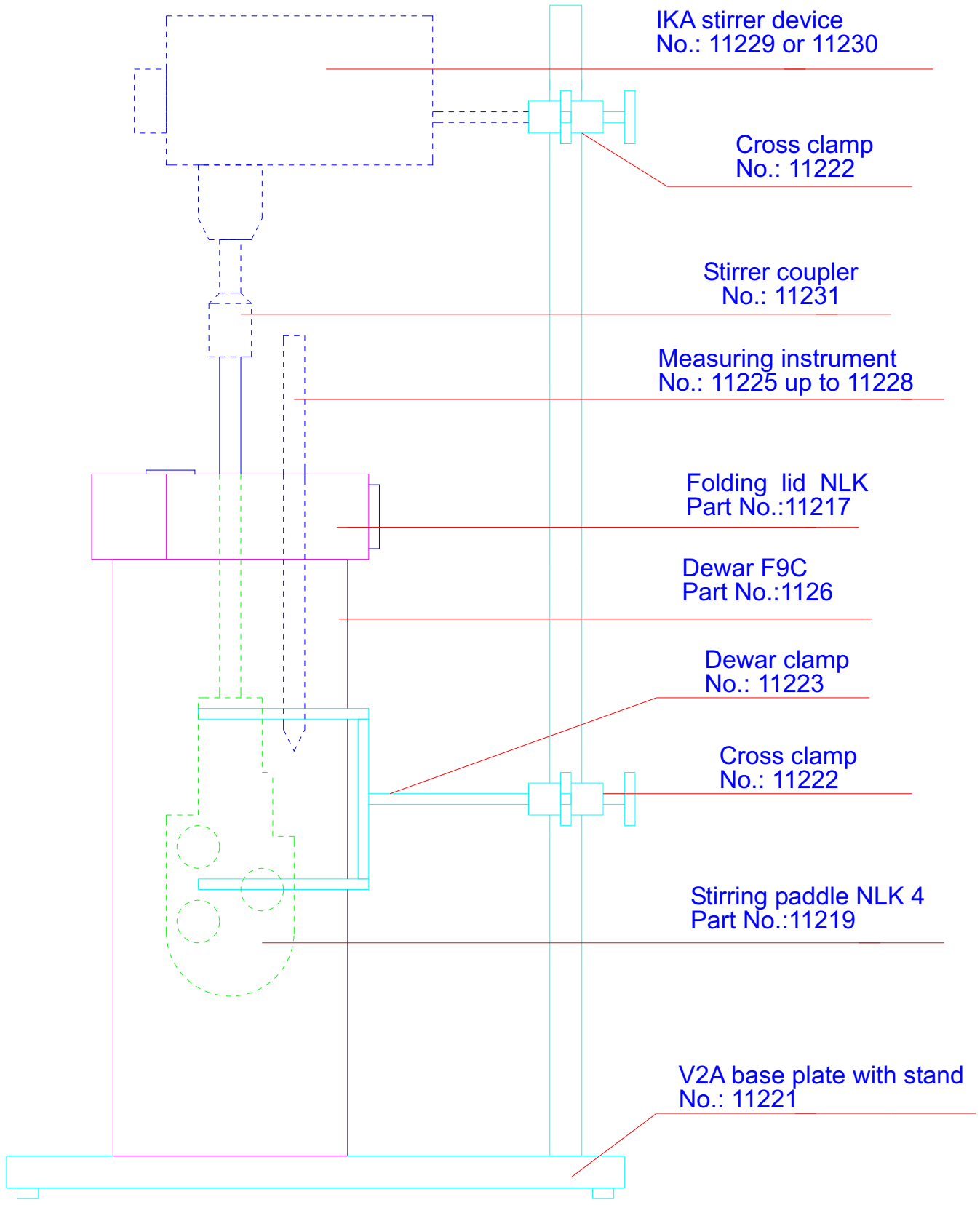
Data logger type 735-2	Order No	11225
Mains supply unit	Order No	11226
Record printer	Order No	11227
Measuring sensor	Order No	11228

Stirring device (accessory)

Eurostar digital	Order No	11229
Eurostar power basic	Order No	11230
Stirring coupler	Order No	11231

Warranty

In case of appropriate handling, we grant a warranty period of 12 months on our products. The warranty comprehends the wholesale price at most. In case of a warranty claim, please contact the manufacturer.



geändert Datum	Name
-	

Maße und Toleranzen, wenn nicht näher spezifiziert, unterliegen den Eigenarten und Besonderheiten der Glasverarbeitung und werden dem Stand der Technik entsprechend realisiert.

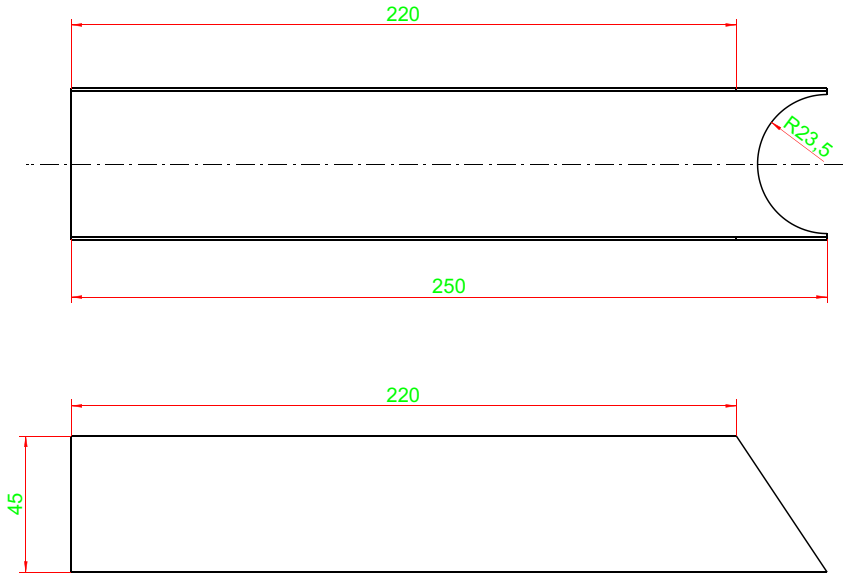
Tag: 19.03.2007	Name: Schieder
Maße: mm	M 1 : 1
Werkstoff:	Z.Nr:NLK E/ISOTHERM

KGW-ISOTHERM 76185 Karlsruhe
Tel.0721/958970 Fax.0721/9589777

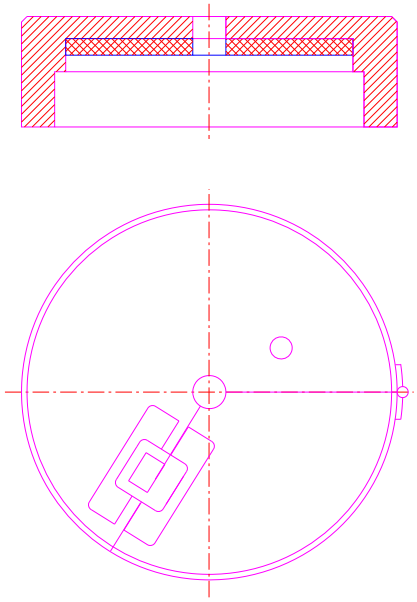
Apparatus with Dewar for "Wet Slaking Curve" to EN 459-2

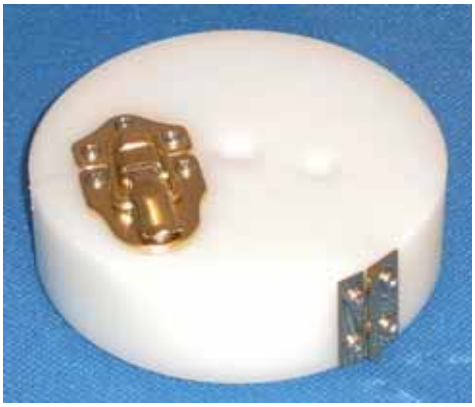
Accessory and spare parts

Filling Device No: 11224

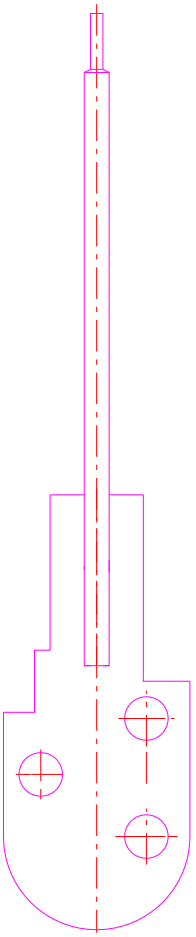


Folding lid No: 11217





Stirring paddle No: 11219



Order Numbers