Layout of a filter apparatus with slide rule

One of the most important parameter of a filter apparatus is the ***filter area***. Mostly the filter area differs from the total filter area. The real filter area is the quotient from the volume stream and the rate of filtration.

At most applications rate of filtration lies between 0,5 and 2,5 m/min.
The extreme application lies between 0,2 and 0,5 m/min or 2,5 and 4 m/min.
The normal pressure drop at the filter apparatus lies between 50 and 200 mmWG.

Variables influencing the operation [T(x) and Δp] of the filter units:

⇒ ***filter media***
- physical characteristics
  - bursting pressure
  - air permeability
  - pore size
  - area basis weight
- chemical characteristics

⇒ ***dust, bulk material***
- dirty air loading
- particle size distribution
- bulk density
- agglomerate characteristics
- electro-static characteristics
- chemical compound

⇒ ***carrier gas***
- air quantity
- temperature
- pressure
- humidity
- chemical compound

⇒ ***filter apparatus construction***
- system of regeneration
- dirty air conduct
- geometry of the filter unit
- filter media and filter arrangement
- star filter geometry

⇒ ***way of operation***
- type of regeneration
- dirty air carry in
- dirty air carry out
- waste air emission

⇒ ***operating costs***

⇒ ***investments***

The separation of dust works mostly at the surface of the filter media. A filter accessory layer and a filter cake are formed. The filter accessory layer, also called dust layer, is the real higly-effective filter layer. Hereby total separation grades of about 99,9 % are often obtained. These filter units are called "surface filter units". As a result of the thickening of the filter aid layer [Fi_{hi}] and the filter cake [Fi_{ku}] the pressure drop [Δp] increases. Because of this the star filters will be cleaned periodically by means of compressed air. As filter media fleece is predominantly used. Because of the good separation of dust this type of filter is used in a lot of different industries. In spite of the high tech, filter units with compressed air regeneration are still based on experience. At the moment there is no standard calculation for layout possible, which can help to dimension a filter unit in advance. Difficulties at model calculations are caused above all by the instationary operation mode of the filter apparatus as well as the high number of influencing variables.

Slide rule
On the front side you can see *14 scales*. Scales 9, 10 and 11 refer to our filter apparatus. The ascending rate (scale 9) is indicated in relation to the chosen serie, type of filter elements and the set parameters.

Examples

1st example: At **scale 2** you choose the pipe-speed **25 m/s** at a pipe diameter of **120 mm (at scale 3)**.

⇒ Verticallly, below scale 3 you can read the pipe-cross section **112 cm²** at **scale 4**.
⇒ Vertically above the green triangle at **scale 5** you can read the air-volume of **17 m³/min** and at **scale 6 – 1000 m³/h**.
⇒ At **scale 13** you now fix the speed of filtration for this operation to
⇒ **1 m/min**
⇒ and read now vertically above the value of 1m/min at **scale 12** the required filter area of **17 m²**.
⇒ From *product sheet »PM-TS-01«* you have chosen the filter apparatus serie **R** 05 and star filter-type **ts-e** 104/…-50 with a filter area of 18 m²
⇒ For star filter type **ts-e** you now follow the symbol ▲ at **serie 05** on **scale 11** and read now vertically above at **scale 9** the **ascending rate** of **245 cm/s**. In case your bulk material is light and its agglomeration and speed of vertical descend are low it is important to put more weight on the **ascending rate**.
⇒ **Scale 10** shows the free area cross section A_c of **11,5 dm²**.

2nd example: Bulk material is transported with an **air volume of 2.000 m^3/h.**

⇒ At **scale 6** you put the green triangle to the air volume of **2.000 m^3/h.**

⇒ Now you can see at **scale 12,** (rate of filtration **1 m/min at scale 13);** the required filter area of **33 m^2**.

⇒ If for example a suction canal with a **pipe speed of 25m/s (scale 2)** is planned, you can read the necessary pipe diameter of **170 mm** on **scale 3**.

⇒ for a rectangle connection pipe see at **scale 4** the cross section of **230 cm^2**.

3rd example: You know that you need for an application **10 m^2 filter area** with a **filtration speed of 2 m/min.**

⇒ At **scale 12 you fix** the filter area by adjusting **10 m^2** over the **2 m/min** filter rate on **scale 13.**

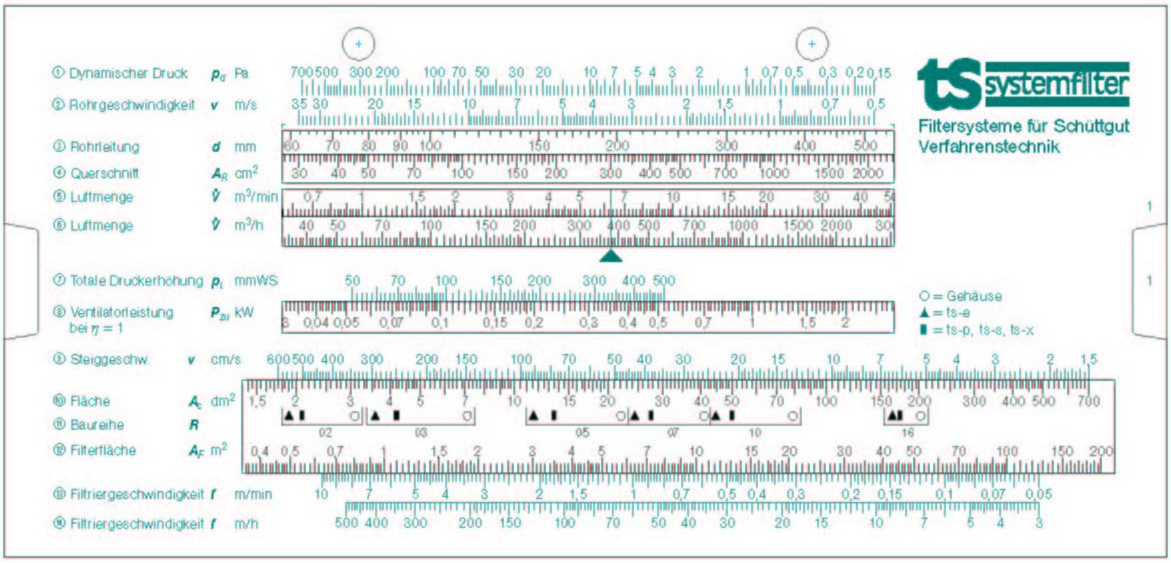
⇒ Now you can read at **scale 6** the air quantity of **1200m^3/h.**

⇒ If your pipe diameter is **160 mm (scale 3)** you can read at scale 2 that you will have a pipe speed of **16,5 m/s**. For most of the bulk materials this pipe speed as suction speed is sufficient without any rest of dust in the pipe system.

⇒ To determine the suction power of the fan you need the total pressure-increase in mmWG and the efficiency. The **total pressure increase** is calculated by adding the dynamic pressure and the assumed pressure drop at the filter (usually between 50 and 200 mmWG) and other resistances of the plant. At our example the dynamic pressure with a pipe diameter of **160 mm (scale 3)** is **160 Pa (scale1)**, this means **16 mmWG**. To this pressure the assumed pressure drop of **150 mmWG** and other resistances of the plant of **34 mmWG** are added. The total calculated pressure increase is **200 mmWG**.

⇒ The total pressure increase of **200 mmWG** (scale 7) is the required power of the fan at η=1 of **0,66 kW (scale 8).**

⇒ With help of the logarithmic **scale x^2** on the back side of the slide rule the power can be converted to the expected efficiency of 70 %. You put the value **66** and **70** on top of each other and now you can read over the value **100** the value **94**. If you consider the position of the decimal point, the value is 0,94. The power of 0,94 kW is required to put the fan into operation.



1 = dynamic pressure Pa
2 = pipe-speed m/s
3 = pipe-diameter mm
4 = cross-section cm^2
5 = air-quantity m^3/min
6 = air-quantity m^3/h
7= total pressure increase mmWG

8 = power of the fan
9 = ascending rate cm/s
10 = area dm^2
11 = serie R
12 = filter area m^2
13 = rate of filtration m/min
14 = rate of filtration m/h