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DEFINITION OF FLOW PROCESSES AND TROUBLES IN THE OPERATION OF STORAGE SILOS

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CONTENTS

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1 - PRELIMINARY NOTE

This document aims to define the main concepts in the design of storage silos with regard to the flow behaviour of materials stored in silos and the problems which may occur on discharge. It is meant to assist a common understanding and the use of common concepts amongst silo designers, users and manufacturers, as well as amongst experts from various countries.

2 - FOREWORD

Knowlegde of the problems related to the storage, flow and discharge of bulk materials is necessary for designing a silo or for correcting defective silos.

Correct silo design can be achieved following for example Jenike's method. This method defines the measurement of the main characteristics of a bulk material, i.e. its flow properties (see document FEM 2 381). On the basis of these properties silo dimensions can be determined, and defects of defective silos can be eliminated. In practice problems can arise from various causes, e.g. changes in operating conditions, or variations on temperature, storage time, moisture, wall material roughness, and in many cases from changes in the properties of the stored material.

As silos should always be suited to the materials to be stored, it is recommended to describe as precisely as possible bulk materials accordingly (see document FEM 2 581/2 582).

According to this document, a description and identification of the bulk material is possible, which can prove beneficial when looking for causes of problems (see also document FEM 2 321 : "Influence of the characteristics of bulk materials on the design and dimensioning of silos").

3 - FLOW PROFILES

Occurence of the flow or discharge problems described below depends on the type of flow profile within the silo.

The flow profile defines the way in which the material flows in the silo. There are essentially two main types - mass flow and funnel flow.

3.1 Mass flow

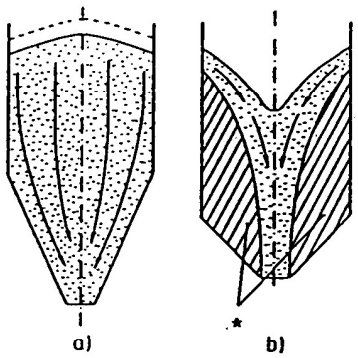
Mass flow is characterized in that all of the bulk material contained in the silo is in motion during discharge of the silo. With mass flow, silos empty completely (figure 1a).

3.2 Funnel flow

In the case of funnel flow only the central core of the bulk material is initially in motion on discharge. The dormant zones (*) first remain motionless, then collapse from the top as material discharge progresses, or flow from the sides into the funnel that is being formed (figure 1b).

When the wall slope of the discharge hopper is sufficiently steep, funnel flow silos empty totally. If the discharge hopper is too flat, large quantities of bulk material may sometimes remain dormant in the silo.

Figure 1 : Flow profiles
a) mass flow
b) funnel flow
* dormant zones



By definition, these are the only flow profiles, i.e. mass flow in which the whole bulk material starts moving when discharging the silo, and funnel flow in which dormant zones exist.

Subcategories are sometimes defined to distinguish between special forms of funnel flow, in which there are dormant zones of different sizes locally limited, or locally limited flow zones, e.g. central flow pipes or asymmetric flow channels. All these flow profiles are special forms of funnel flow, and the terms "partial mass flow" or "virtual mass flow" may be misleading.

The silo active volume, also called "silo activity", means the amount of bulk material in relation to the silo volume which moves at the beginning of the silo discharge in the case of a full silo.

$$S_a = \frac{V_S - V_t}{V_S} \cdot 100\ \%$$

where : V_S = total volume of stored bulk material
V_t = volume of dormant zones with the stored material at the beginning of discharge with a full silo
S_a = silo activity in %

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