

# Centrifuge control ensures operational safety: state of the art



Dirk Spangenberg, Andreas Lehnberger, Eduardo Lima, Arend Wittenberg  
 Lehnberger.A@bma-worldwide.com  
 BMA Braunschweigische Maschinenbauanstalt GmbH, Germany

## Introduction

Occupational and operational safety are key issues in industry worldwide, also in sugar factories. Management is responsible for the safety of employees. While occupational safety is regulated only locally, operational safety also requires the manufacturers of equipment to act.

The rotational energy of a basket filled with sugar can exceed 10 MJ. This is equivalent to the kinetic energy of a mass in linear motion, e.g. a 40 t truck moving at a speed of 80 km/h.

With regard to the interaction between the rotating centrifugal basket, the drive unit and the control unit, this poster focuses on the use of fail-safe components and the implementation of safety-enhancing operating sequences.

## Risk and hazard classification

- Basis: severity  $S$  and probability (frequency  $F$  combined with possibility  $P$ ) (Fig. 1)
- Safety-related equipment parts and functions: Performance levels (PL) acc. ISO 13849-1
- Safety-related electrical functions: Safety integrity levels (SIL) acc. IEC 62061

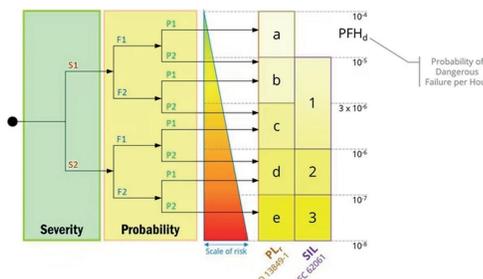


Fig. 1. Classification of performance levels (PL) and safety integrity levels (SIL) (Sick AG 2024)

## Fail-safe M&C components (2<sup>nd</sup> level)

- Electrical components for measurement and control (M&C) must reliably detect critical operating states.
- Sensors must have a suitable performance level (PL) for their hazard classification.
- Redundancy can ensure reliability.
- A fail-safe controller has integrated redundancy and safety functions.
- The 2<sup>nd</sup> level BMA safety concept requires only three sensors with a very high performance level and fail-safe controllers for the centrifugal and the frequency converter.

## BMA's 3-level safety concept

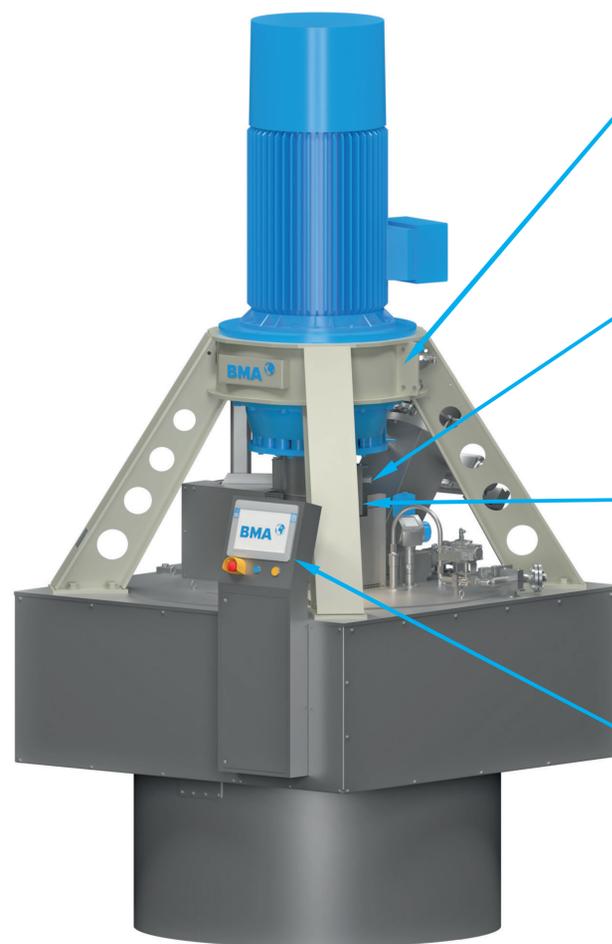
- 1<sup>st</sup> level: **Design measures** to improve passive safety (Spangenberg *et al.* 2024, Lehnberger *et al.* 2024)
  - ▶ Choice of basket material (duplex stainless steel)
  - ▶ Design of openings in basket (elliptical openings)
  - ▶ Basket design for finite life fatigue (min. 1,500,000 cycles service life)
  - ▶ Stability of rotating system (difference to resonant frequencies)
  - ▶ Structural strength of housing (absorbs energy of basket)
- 2<sup>nd</sup> level: **Fail-safe M&C components**
  - ▶ refer to the section on the right
- 3<sup>rd</sup> level: **Safety-enhancing operations**
  - ▶ refer to the sections below

## References

Lehnberger A., Spangenberg D., Wittenberg A., Geyer I. (2024): Centrifugeuse discontinue : sécurité du panier. *IAA Industries Alimentaires et Agricoles 141*, 26-29

Sick AG (2024): <https://www.sick.com/us/en/what-are-performance-levels/w/blog-safety-standard-performance-levels/>, 25.03.2024

Spangenberg D., Lehnberger A., Wittenberg A. (2024): Centrifugal safety by design and during operation: The state of the art. *S.I.T. Conference Vancouver 83*, #1282



## Speed monitoring

- Hazard classification
  - ▶ Failure can lead to serious accidents
  - ▶ S2 (severe, irreversible injury/death)
  - ▶ F1 (rare to less frequent)
  - ▶ P2 (scarcely possible)
  - = Performance level **PL = d**



## Vibration monitoring

- Hazard classification
  - ▶ Failure can lead to serious accidents
  - ▶ S2 (severe, irreversible injury/death)
  - ▶ F1 (rare to less frequent)
  - ▶ P2 (scarcely possible)
  - = Performance level **PL = d**



## Oscillation monitoring

- Hazard classification
  - ▶ Failure can lead to serious accidents
  - ▶ S2 (severe, irreversible injury/death)
  - ▶ F1 (rare to less frequent)
  - ▶ P1 (possible under certain conditions – only at low speed)
  - = Performance level **PL = c**



## Control logic systems

- Hazard classification
  - ▶ Failure can lead to serious accidents
  - ▶ S2 (severe, irreversible injury/death)
  - ▶ F1 (rare to less frequent)
  - ▶ P2 (scarcely possible)
  - = Performance level **PL = d**
- Preferred: fail-safe controllers

## Safety-enhancing operations (3<sup>rd</sup> level) – Procedure

- If a **critical operating state** is detected: machine must be immediately brought to an uncritical operating state!
- Critical operating states are e.g.
  - ▶ Unbalance (vibration or oscillation) due to inadequate distribution of masecuite during filling process, incorrect application of wash water, low-grade masecuite (fine grain, low purity), sugar deposits in the basket (incrustations), damaged basket, shaft or bearing
  - ▶ Interruption or lack of instrument air
  - ▶ Interruption of the power supply

## Safety-enhancing operations (3<sup>rd</sup> level) – Measures compliant with stop category 1 (ISO 13850)

- Minor malfunction
  - ▶ Deceleration to a safe speed (100 min<sup>-1</sup>)
- Major malfunction
  - ▶ Deceleration to standstill
- Redundant measures
  - ▶ Braking via frequency converter
  - ▶ Braking via mechanical brake
- Braking of the rotating system
  - ▶ Fail-safe-monitored deceleration ramp: mechanical braking in case of unexpected braking curve

## Summary and outlook

- Although batch centrifugals have a considerable hazard potential, they are only very rarely the cause of accidents.
- To minimise risks at all times, BMA has a 3-level safety concept for its current batch centrifugals:
  - ▶ Passive safety
  - ▶ Fail-safe M&C components
  - ▶ Safety-enhancing operations
- With the introduction of new technologies and functions, the rules and standards for centrifugal safety will continue to be updated in order to supply safe batch centrifugals at all times.