European materials handling federation	Whitepaper **FEM 9.222 and VDI 4486**	**FEM 9.201**

1 Object and Purpose

This whitepaper addresses automated material handling systems and availability testing for such systems.

Both FEM9.222 and VDI4486 target the assessment of availability of material handling systems. As both FEM9.222 and VDI4486 address seemingly the same the obvious question is: **which one to apply?**

This whitepaper provides you with the answer and

- An overview of the scope of the standards FEM9.222 and VDI4486
- The approaches / methods defined
- Recommendations which approach and hence which standard to use when

Issued: 2025/08

2 Introduction and General Remarks

Both standards, FEM9.222 and VDI4486, use a different approach to define availability. The following will describe where they overlap and where they are different.

2.1 The correlation of availability and performance

Before we get deeper into these two standards it is important to understand the correlation of availability and performance. Especially as these standards make reference to both, availability and performance.

FEM9.222 defines availability as the measure of the useful operating / service time of an installation. While it does not provide a definition of the term performance, FEM9.222 recognizes that the non-availability of the system or of a part thereof also influences the performance of the system. Which in layman's terms translates to "a machine or a conveyor which is broken is not producing any part or conveying any carton".

VDI4486 introduces the combined term "performance availability". It is defined as indicating the degree of fulfilment of processes agreed between contract parties (manufacturer and user) in accordance with the requirements and in compliance with the agreed basic conditions. Obviously, the fulfilment of a process or its performance requires that the needed resources for the process fulfilment are available. The joint determination of availability and performance is core to the new calculation method proposed by VDI4486.

3 FEM9.222

The objective of this standard goes way beyond the determination of availability and also provides recommendations for the commissioning, hand-over and testing of installations with storage/retrieval machines, material-handling facilities and other machinery and their controls.

In the following we will only focus on the aspects of FEM9.222 related to the determination of availability.

3.1 Definition of Availability according to FEM9.222

FEM9.222 actually provides different definitions of availability, including or excluding the standby time of the system. As most contracts refer to the operational use of the system and also VDI4486 focusses on the fulfilment of processes this whitepaper will also concentrate on the part of the operational definition by FEM9.222:

Availability during the total operating time

$$\eta_{Btr} = \frac{t_{Btr} - t_{ABtr}}{t_{Btr}}$$

with

t_{Btr} = ***Total operating time***

and

t_{ABtr} = ***Portion of the downtime which falls within the operating time***.

To illustrate the usage of above formula we assume a system which is switched on at 6 a.m., with actual operations starting at 6:30 a.m., operations completed at 4 p.m. and the system switched off at 5 p.m. e.g., with power left on for an additional hour to allow for some maintenance checks after operations. Unfortunately, a lift was interrupted mid-day for 20 min due to a mis-aligned light sensor. This translates into a total operating time t_{Btr} of 570 min (from 6:30 a.m. to 4 p.m.), a downtime t_{ABtr} of 20 min and hence an availability η_{Btr} of 0,965 or 96,5 %.

Real systems include parallel components and parts of the system (sub-systems) which are not directly coupled. Think of several parallel AS/RS stacker crane aisles or the operation of the shipping sub-system which is not directly linked to the operations of the goods-in sub-system. The break-down of one stacker crane typically does not affect the other cranes. Also, you will normally not be forced to stop the shipping operations when a weighing scale at goods-in has a malfunction.

Therefore FEM9.222 proposes to distinguish between

a) Components or modules which are directly linked to each other in a serial way

   This could be a series of conveyors forming a conveying line or an AS/RS sub-system directly linked to a goods-to-person picking area.

   For linked, serial components or modules the total availability is

   $$\eta_{total} = \eta_1 \cdot \eta_2 \cdot \eta_3 \cdot \ldots\ldots\ldots \eta_n$$

b) Components or modules which operate in parallel

   Think of alternative, parallel conveying paths allowing to reach the same target location or several parallel AS/RS stacker crane aisles.

   For parallel components or modules, the total availability is

   $$\eta_{total} = 1 - [(1-\eta_1) \cdot (1-\eta_2) \cdot (1-\eta_3) \cdot \ldots\ldots\ldots (1-\eta_n)]$$

c) Components or modules which are independent of each other

   This could be sub-systems operating basically independently from each other like goods-in and shipping. Or think of system components which do not directly interact like a system visualization screen and an algorithm for replenishment optimization.

Although systems engineering does not provide a calculation formula for independent modules, FEM9.222 proposes for these cases and also to reflect parallel components or modules to introduce a weighting factor **k**. This leads to the generalized, recommended formula: