



HAMMER-IMS

Paper

# High-coverage inline basis-weight measurement of nonwoven filtration media as a clean alternative to nuclear and X-Ray gauging



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This paper is based on the Hammer-IMS presentation given on:

**FILTECH 2018**  
March 13 - 15 • Cologne - Germany

## Abstract

Over the last years the basis-weight of nonwoven filtration media has mainly been measured by means of nuclear isotopes and high-power X-Rays. The reason why basis-weight measurement is so important for the nonwoven filtration-media converting industry is because of the high cost of mainly polymeric-based nonwoven filament material and the increasing demand for high product quality (e.g. basis-weight measurement can reveal information related to filter material porosity, permeability, etc.).

Depending on the basis-weight of the semi-finished product, a converting plant either uses Krypton or Strontium-based isotopes if nuclear sources are applied. Nowadays, electronics technology has evolved to a situation where frequencies of multiple tens of Gigahertz can be generated at an affordable price. The availability of these frequencies enables the creation of non-nuclear, and even non-radioactive gauges to measure basis-weight. These gauges come without any harmful side effects, both to humans and the environment, so no regulation applies. Moreover, they stand for a reduction of the total-cost-of-ownership for inline basis-weight measurement in a production plant for filtration media.

Hammer-IMS introduced this technology under the name M-Ray-technology. The inline basis-weight measurement can be installed in nonwoven production lines using the following formation processes: drylaid, spunlaid and meltblown. The technology and products support a high stand-off distance, which enables even uncompressed nonwovens of several centimeters thick to be measured reliably without touching or damaging the material. It can even be applied in wetlaid processes, after drying or thermal bonding has taken place.

The M-Ray based technology is incorporated into Hammer-IMS's multi-head measurement systems, realizing a high-coverage measurement system compared to a classical solution. This paper will discuss the M-Ray technology, its advantages, some M-Ray enabled products and some example cases useful for the filtration media converting industry.

## Introduction

Nonwoven materials are highly favored as it comes to filtration media. According to [EDANA17], 3.7% of nonwovens material deliveries (in 2015) have been used for filtration applications covering liquid, air & gas filtration. Although, the biggest application domain for nonwovens is still the hygiene market, which covers almost one third of the total market, filtration media is responsible for 85,000 tons of nonwoven material being produced each year.

Filtration, both wet and dry, is, according to [NWIndustry17], a fast-growing end-use market for nonwovens. And the increase is not expected to level off anytime soon as new market niches are uncovered almost daily for nonwoven filtration media. The growth in the filtration market varies depending on the market segment, but overall there is a 5-8% annual growth noted.

In past years, the filtration market has been seeing nonwovens take market share and applications from other types of media such as wovens and paper. Nonwovens have an advantage over other media thanks to increasing demands for: energy savings, low cost materials, recyclability and light-weight materials.

The facts mentioned above indicate a significant growing part of the nonwoven industry is taken by the filtration industry. Likewise, the entire nonwoven industry is growing thanks to increasing business in many other

markets. We can conclude that there is currently an increasing demand for nonwoven filtration media. This increasing demand has attracted – and is still attracting – many investments for the production and conversion of nonwoven materials. However, sooner or later it may occur that markets will get saturated and product quality as well as material & cost reduction will become more important to stay competitive. In particular the raw-material costs are highly dependent on the uncertainty related to the evolution of crude oil prices on worldwide markets. Installing automated inline basis-weight measurement (and control) systems is a good choice to increase product quality and reduce material costs. Such systems are developed to detect holes and flaws as well as continuous production outside grammage-tolerance levels in inline nonwoven production lines.

Luckily enough, technology innovations have turned the classical X-Ray and nuclear based basis-weight measuring systems into affordable and clean non-radioactive solutions. Solutions that make use of M-Ray technology are gaining popularity and market acceptance. Section 2 discusses the M-Ray technology in greater detail. Section 3 introduces the products of Hammer-IMS incorporating the M-Ray technology. Section 4 introduces and discusses interesting measurement results for nonwoven materials.

## M-Ray technology: what?

M-Rays are the result of physics, and more specifically, it is referring to electromagnetic waves. Physicists prefer to call the sine-shaped M-Rays 'millimeter waves'. Unlike the waves of the sea and the acoustic waves produced when you speak, the millimeter waves do not use a medium (water in the case of the sea waves, air for speech waves). Millimeter waves are electromagnetic waves that are comparable to the signal transmission waves used

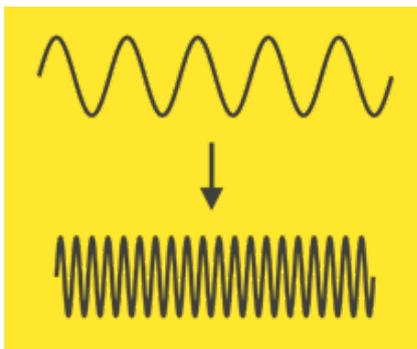


Figure: Top: typical waves used by cell phones. Bottom: millimeter waves are much higher in frequency, resulting in a shorter wavelength than typically used today.

in FM-radio, WiFi, GPS, cell phone communication. Millimeter waves have much higher frequencies than those of these technologies, which means a shorter wavelength. Millimeter waves have frequencies between 30 GHz and 300 GHz, which are ten to hundred times higher than the operating frequencies of your cell phone. Millimeter waves have wavelengths of only a few millimeters.

Millimeter waves are commercially viable thanks to recent advances in electronics. It is known that our smart phones today have more computing power than our first desktop PCs many years back. Similarly, technological evolutions in electronics have taken place in the field of radio frequencies used for communication including millimeter wave frequencies. Gordon Moore, founder and former chairman of Intel, predicted in the 1960s [Moore65] that the capabilities of electronics would grow exponentially. Gordon Moore's prediction was extremely accurate, and therefore the phenomenon that the electronics technology capabilities is increasing at this mindboggling rate is generally referred to as Moore's Law. Today we have come to a situation that electronic chip technology enables us to generate millimeter waves, which can be applied for industrial sensing and measuring applications. Hammer-IMS incorporates the use of these waves in its solutions for inline thickness and basis-weight measurement.

Today the use of millimeter waves is mainstream, largely applied for communication purposes. A typical example is point-to-point links connecting a cellular network's communication poles, servicing multiple simultaneous phone calls and providing a high-bandwidth connection between the poles. The name of the application is 'cell phone's backhaul connection'. Millimeter waves are also applied in applications that stream HD movies from your cell phone or tablet to your TV system, allowing for smooth lossless HD movie streaming from your cell phone, tablet, etc. to your TV system. These applications are key enablers for the activities of Hammer-IMS, since it is using the same building blocks as part of its measurement equipment.

Hammer-IMS offers contactless industrial basis-weight measurement for nonwoven filtration media based on its specialized millimeter wave technology. For these nonwoven applications, there are a range of advantages intrinsically related to the choice of millimeter waves (M-Rays). First of all, M-Rays are non-nuclear, neither radioactive. This sets them apart from classic solutions based on X-Rays or nuclear, beta-particle radiation, which are harmful for both people and environment. European Basic Safety

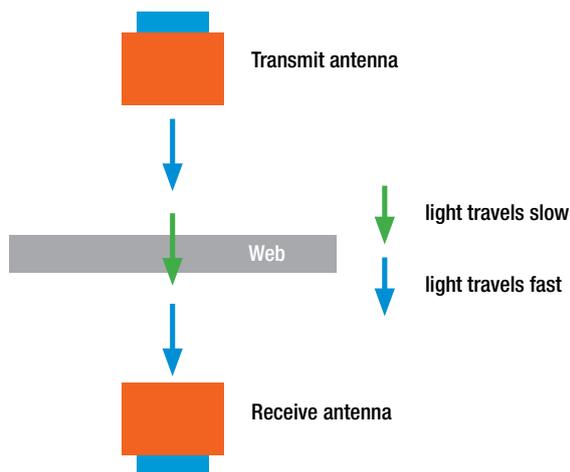


Figure: The measurement principle is non-conventional. Instead of measuring absorption properties, Hammer-IMS measures the M-Rays' time delays. Measuring time-delays has the additional feature of maintaining measurement precisions even for materials having basis-weight of more than 1,000 gsm.

Standards [Europe13] force European member states to implement a restrictive policy on granting licenses for nuclear installations, among which these nuclear basis-weight measurement sensors. In Belgium, FANC [FANC15] controls these licenses and confirms this tendency.

Secondly, M-Rays can penetrate through most non-metallic materials, both opaque (irrespective of color) and transparent, covering both rough and shiny material surfaces. M-Ray-based measurement systems are robust when facing fog, dust or changing environmental light conditions, because they do not get influenced by the environment in the same way as with regular light.

The principle behind the measurement technology of Hammer-IMS refers to the effect that these waves are 'slowed down' by the presence of material. The thicker (or the heavier) the material, the more the wave is slowed down in speed.

The measurement principle is shown in the figure on the right. The signal transmitted by an antenna travels through the material, which introduces a time delay, due to the decreased speed. After receiving the signal by the other antenna, state-of-the-art processing electronics measure and analyze this delay and deduct the basis-weight of the material from it. M-Rays are typically not absorbed by most dry and non-conductive materials, which enables the technique to be applied even for very heavy materials (more than 1,000 grams per square meter), while still maintaining its best noise-related behavior. The M-Ray technology can be used to measure the basis-weight of many materials including PE, PET and PP based nonwovens.

## CURTAIN: multi-head M-Ray technology in an industrial scanner

For M-Rays to be successfully applied for inline quality control, the technology has been incorporated into intuitive industrial solutions, such as the Hammer-IMS Marveloc 602-CURTAIN solution (shown on the right). The inline scanner system contains multiple sensors, executing inline basis-weight measurements at precision levels down to 1 gsm at a high stand-off distance of about 30 centimeters.

The non-nuclear and non-radioactive M-Rays enable nonwoven manufacturers to downsize operational costs. Typically they realize total-cost-of-ownership reductions of 40,000 Euros up to even 150,000 Euros. These gains typically relate to eliminated need to replace a nuclear isotope (e.g. Kr-85 needs to be replaced every 10.7 years), the eliminated expenses related to nuclear safety inspection, contributions to regulatory offices and operator safety training. The M-Ray based measurement systems are innovative, yet, the operator is still able to work in a well-known familiar software environment as shown below.



Figure: The Marveloc 602-CURTAIN scanning frame containing 4 M-Ray sensors, scanning basis-weight of nonwoven converting lines in real time.

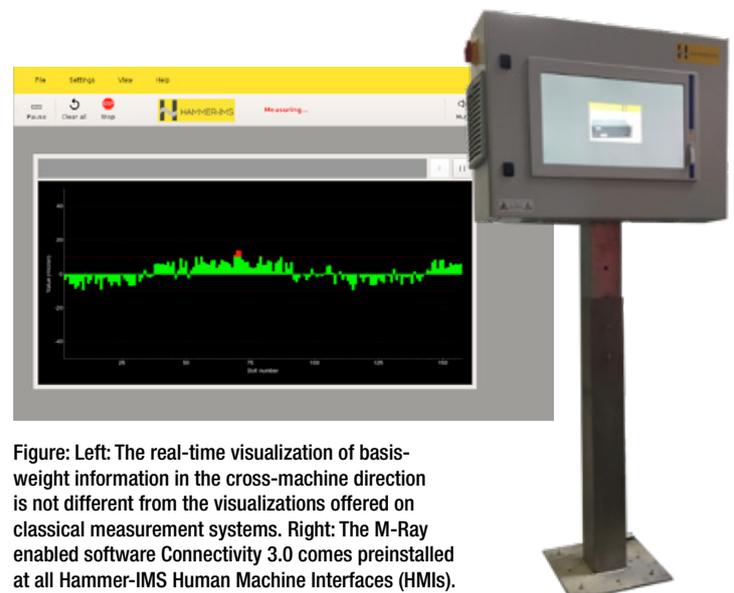


Figure: Left: The real-time visualization of basis-weight information in the cross-machine direction is not different from the visualizations offered on classical measurement systems. Right: The M-Ray enabled software Connectivity 3.0 comes preinstalled at all Hammer-IMS Human Machine Interfaces (HMIs).

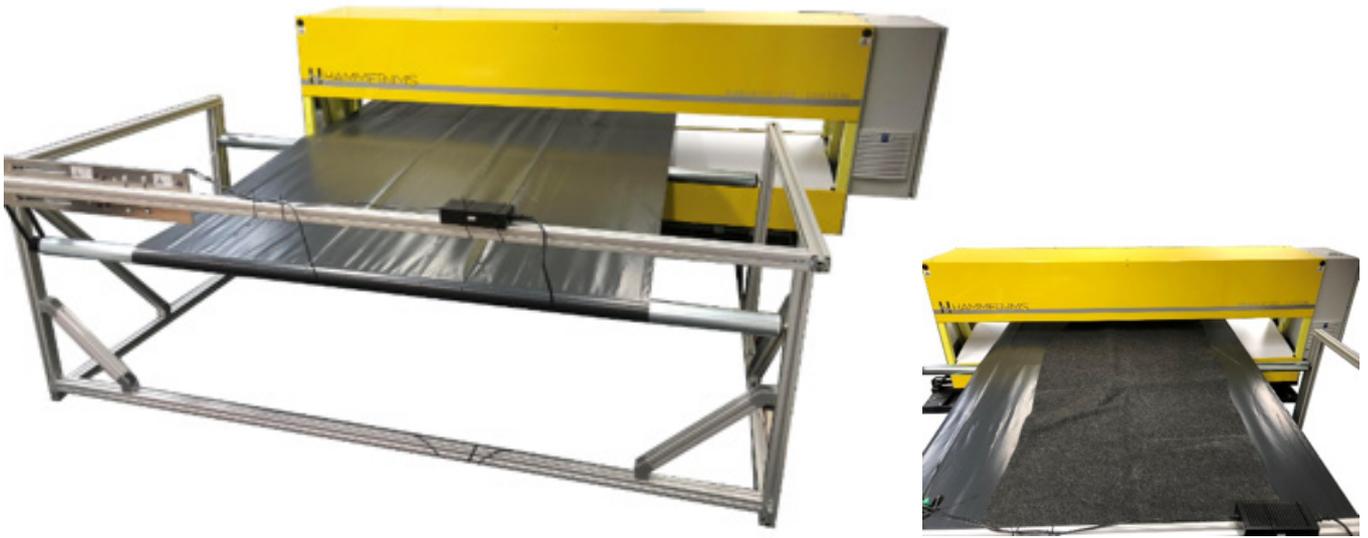


Figure: Left: A 200 micron PVC film is used as a carrier material to convey a non-woven material through the scanner, making a laboratory-device scanner system setup. Right: When applying a nonwoven material on the film, 100 % quality control is enabled in an offline setting.

## Measurements

The result of the experiment of this specific nonwoven material is shown in the figure below. The color map clearly reveals areas of different densities.

The curve below shows Marveloc 602's measured linearity by plotting the measured weight against the values taken from an off-the-shelf weighing scale used as reference. The figure shows that the output of the Marveloc 602 is comfortably within the tolerances of the weighing scale (the area between the red-dotted lines).

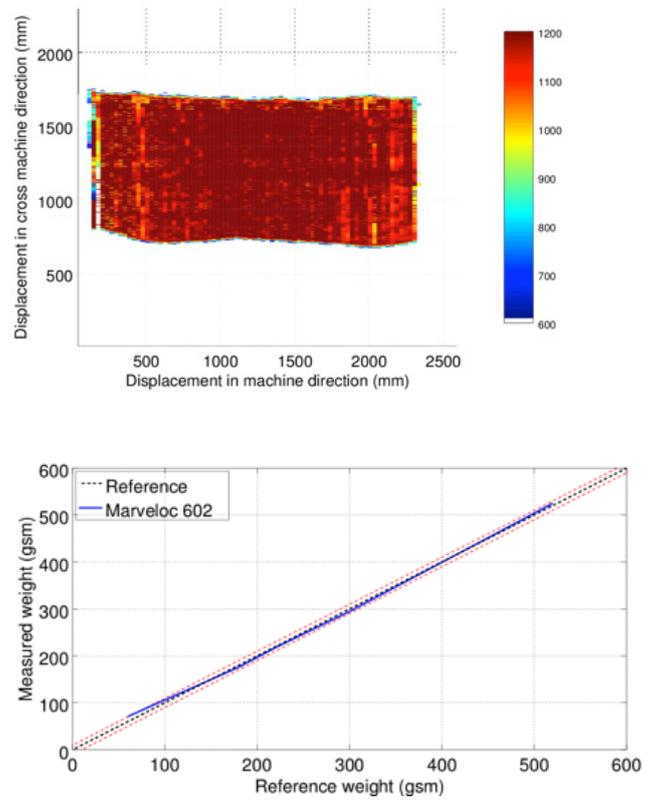


Figure: Curve showing the linearity of the Marveloc 602.

## Conclusion

M-Rays stand for clean inline basis-weight measurements for various flat materials including nonwoven filtration materials. The Marveloc 602-CURTAIN solution offers advantages in terms of cost savings and improved material coverage. Moreover the solution can serve as a clean one-to-one replacement for nuclear and radioactive measuring systems. The high stand-off distance is very useful for thick nonwoven materials.

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