C26 Deformation Mechanisms of Walk-Off Mats

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After attending this presentation, attendees will understand the deformation mechanisms of contemporary floor mats (also called walk- off mats). Attendees will comprehend the nomenclature used to describe mat deformations. Attendees will also become aware of the various forces present in use, laundering, and delivery, which may contribute to

deformation. In addition, attendees will understand how these principles were applied in defense of a trip and fall injury case.

This presentation will impact the forensic science community by providing a tutorial of failure mechanism of materials as related to walk- off mats.

Floor mats, also called dust mats or walk off mats, are ubiquitous in our society. They may be encountered many times during a day; at the coffee shop, grocery store, office building, and school. Sizes vary; typical dimensions are 2 feet by 3 feet, 4 feet by 6 feet or 4 feet by 10 feet. Frequently placed at the transition from outdoors to indoors, the mats appear as a safety device to prevent tracking water onto surfaces with low coefficients of friction, i.e., floors which are slippery when wet. But, an additonal rationale behind their widespread placement is that they remove and trap dirt, debris, and moisture at the building entryway, reducing building cleaning costs. Mats are typically rented from a company that services the mats periodically, by removing and laundering a soiled mat, and replacing with a clean mat.

Contemporary floor mats are composites made of a rubber base with a fiber carpet pile. While specific material formulations vary, a typical rental mat consists of a nitrile rubber backing and a nylon pile. The pile may be attached to the rubber backing by various mechanisms, depending on manufacturer. For example, individual tufts of the pile may be directly bonded to the rubber by thermomechanical means, or may be bonded by means of a woven or non-woven pile substrate. Due to the nature of the materials they are made of, mats can fail by several mechanisms:

- Delamination – separation of the pile from the substrate;
- Substrate Degradation – changing the properties of the rubber substrate through exposure to chemicals, UV light, or heat; or
- Rippling – permanent deformation of the mat caused by unequal stretching the polymer bonds of the substrate past their limit of plastic deformation.

These mechanisms, which degrade the properties of the mat, occur with time, and depending on the exact conditions of use and care. The floor-mat manufacturing and rental industries recognize that mats have a finite lifetime, and that they must be periodically removed from service and replaced.

During duty, cleaning and placement, the mat is subjected to various forces. The forces can result in elastic or plastic deformation of the mat substrate, depending on their magnitude. During use, frictional forces hold the mat to the floor; tensile and compressive forces are generated by people walking on the mat; and torsional forces are generated if the mat is not lying flat on the floor. These forces are generally small enough to cause only elastic, or non-permanent deformation. During laundering, the mats are agitated with soap and water, rinsed, and spun dry, in industrial washing machines. During water extraction by spinning, the mats experience the largest forces. For a mat lying flat against the wall of the washer barrel, the centripetal spinning force becomes a simple compressive force through the thickness of the mat, similar to that created by placing a weight on it during use. However, if the mat became twisted or rolled over during washing, a bending force is experienced during spinning, which is maximized on the outer surface of the bend. Centripetal force, coupled with the weight of additional wet mats, can exceed the elastic strength of the material, break polymer bonds and cause permanent deformation. Ripples that prevent the mat from lying flat can thus develop over multiple laundering cycles. Standards for laundering are specified by the mat manufacturer. Care is taken to specify parameters such as laundering temperature, soap formulation and amount, the weight of mats to be placed in each pocket of the washing machine, and the spin speed.

In one case, a rental company placed a mat at the doorway of a county museum. An 80-year-old woman tripped on a ripple in the mat, fell, and broke her hip. It was found that although the mat rental company observed the manufacturer instructions regarding laundering of its mats, they failed to have a formal inspection program in place to ensure that rippled mats were removed from service.

Walk-Off Mats, Deformation, Rubber

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