MASTER

CLEAN ROOM WIPING CLOTHS

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The Bendix Corporation
Kansas City Division

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Introduction

Wiping cloths are used in clean rooms to wipe down equipment and work surfaces. To improve its effectivity, a wiping cloth may be dampened with water or a solvent. To do its job, the cloth must leave behind a surface that is cleaner than it was before it was wiped. So a suitable cloth is one that does not inherently produce particles, lint, or films and that can be laundered to remove contaminants introduced into it through manufacture and use. There is no industry specification for clean room wiping cloths to guide the user. (There is a Military Specification, MIL-C-85093A, which will be discussed.) So a search for suitable cloths was undertaken.

Requests for information on clean room wiping cloths were sent to approximately 80 organizations consisting of textile firms, distributors, trade associations, research institutions, libraries, and museums. The trade associations and other information sources had no information on clean room wiping cloths. Many manufacturers offered products for test, a few of which were claimed to be lint free and absorbent.

The information from manufacturers and suppliers was reviewed and approximately 80 cloths were obtained for evaluation. About half of these were rejected as clearly unsuitable. The rest were tested. The plan was to test at least one of each promising combination of fiber and construction. Some cloths that were expected to be unsuitable were tested to provide a datum against which others could be compared.

Activity

The tests and measurements used were:

1. Dry weight in g/m^2,

2. Amount of material in mass percent, extractable by water, isopropyl alcohol, 1,1,2-trichlorotrifluorethane, and trichloroethylene,

3. Identity of extractable material,

4. Absorptivity for each of the liquids in #2 in mL/m^2, and

5. Content of lint and particles 5 μm and larger per square meter.

The dry weights were determined on cloths after drying in an air oven at 105 to 110°C. The extractions were done in a Soxhlet extractor. The extractable material was analyzed by infrared spectrophotometry. Absorptivity was determined by immersing a dried cloth in a measured amount of solvent, allowing it to saturate, withdrawing it and allowing it to drain, and measuring the solvent remaining. At the same time the speed of wetting was observed.

The amount of particles and lint was measured in two ways. One, referred here as the detachable particle test, was a modification of ASTM F 51. In this method, filtered air is drawn through a 0.01 ft^2 piece of the fabric and then through a membrane filter. The particles and fibers, 5 μm and larger on the filter, are counted by microscopic examination. This examination is tedious so to avoid it the number of particles was determined by a particle counter, an instrument that measures and counts particles in a gas stream as it passes through an optical detector.

The equipment was set up in this way. An approximately 4-foot length of flexible PVC tubing was attached to the inlet port of the particle counter. A polypropylene "T" was attached to the other end of the tube. To the side-arm of the "T," by means of a short piece of tubing, was attached an 0.8-μm filter. An approximately 2-foot length of tubing was attached to the remaining arm of the "T." To the other end of this tube was attached the 0.01 ft^2 filter assembly called for in ASTM F 51. A spring-loaded pinch cock was clamped on the tube between the filter assembly and the "T."

In a series of tests air was continuously pumped through the particle counter. When the pinch cock was closed the air was drawn in through the side arm and the 0.8-μm filter. In running a test, the pinch cock was closed and the cloth was clamped in the filter assembly. The pinch cock was removed and a finger was placed over the side arm. The air was then drawn through the filter assembly and the cloth that was clamped in it. Testing was done in a clean bench where there were essentially no particles 5 μm and larger. For this reason the 5-μm prefilter specified by ASTM F 51 was not used in the filter assembly. The final filter was left out also to permit the particles to pass on and be counted in the meter.

The military specification contains a similar test and places a limit on the number of particles and fibers that are 5 μm and larger at $2x10^4/m^2$.

The other particle content test is called the shake test. A wiper was put into a 1.2-L Mason-type jar that had a glass lid with a gasket. The standard rubber gasket produced particles, and therefore was replaced with a urethane gasket. Six-hundred millilitres of filtered, demineralized water were added. The jar was closed and shaken for one minute in a Red Devil paint shaker in which the standard 3-inch drive pulley was replaced by a 1 3/4-inch pulley. The pulley change reduced the vigorousness of the agitation to a level that seemed more appropriate. The water was then examined for particles and lint. If the water was obviously dirty a sample was filtered, and the particulate residue was examined under a low power binocular microscope. If the water appeared at least relatively clean a sample was passed through a liquid borne particle counter where the number of particles per 100 mL in the ranges 2, 5, 15, 25, and 50 μm and larger were counted.

This test is similar to one in MIL-C-85043A. The military specification uses a hydraulic oil and shakes for 15 minutes. The military specification limit for 5-μm particles and lint by the shake test is $1.8x10^7/m^2$.

The cloths tested represented three kinds of construction, woven, knit, and nonwoven (similar to felt). The materials of which the cloths were made were cotton, rayon, nylon, polyester, polyethylene, polypropylene, and a rayon-polyester blend. Also tested was a urethane foam which in effect, is a very thin, approximately 1/8-inch thick sponge.

Some of the cloths were clearly remnants from runs of fabrics produced for other purposes. Fabric weights in a single lot varied considerably and some of the cloths without hems were mixtures of irregular sizes and shapes. Such inconsistency is undesirable in cloths intended for such critical use.

Results and Discussions

The detachable particle test detects only a small amount of the lint and particles of a cloth. This is illustrated by Table 1 where the results of some of the detachable particle tests and the shake tests are compared.

Table 1. Comparison of Results From Particle Tests

Particles and Fibers per Square Meter, 5 µm and Larger		
Material	Detachable Particle Test	Shake Test
Polyester, Knit	$5x10^3$	$1x10^5$
Nylon, Knit	$1x10^4$	Plugged filter
Urethane Foam	$5x10^3$	$5x10^5$
Cotton, Woven	$7x10^4$	Too many to count
Polyester, Nonwoven	0	Many fibers
Rayon, Nonwoven	$8x10^3$	Many fibers
Rayon/Polyester Nonwoven	$2x10^3$	Tangled mat of fibers
MIL-C-85043A	$2x10^4$ max	$2x10^7$ max

The detachable particle test yielded particle counts on all but one cloth. In every case the amount of lint and particles found in the shake test was substantially more. In all but two, the quantities were too high to be measured. In the two cases where measurement was possible, the shake test results were 20 to 100 times the detachable particle results.

The lint and particle count limit that MIL-C-85043A places on the shake test, $2x10^7/m^2$ is too high. Unlaundered, as-received cloths met this requirement and yet the test water from their shake test was so laden with lint and particles that they were turbid. A better value would be $2x10^6/m^2$ which most of the knit cloths met. And the particle counts of these could be lowered to approximately $5x10^4/m^2$ by rinsing in filtered demineralized water.

The cotton cloths were judged to be unsuitable. The cloths were expected to have undesirably high levels of lint, but they were tested because there are cotton cloths which are offered as lint-free or low-linting. Three of four different cotton cloths tested failed the detachable particle test with values 3 1/2 to 20 times that permitted by MIL-C-85043A. The one that passed, surprisingly, was cheesecloth. Its low value, about half of the allowable, was probably because of its very open, lightweight construction. Folded over and used as a pad, as it is typically used, it would yield substantially more lint. In the shake tests of cotton wipers, the test water was so full of lint it was impractical to measure the amount.

The cotton cloths contained about 0.8 mass percent of oil, both hydrocarbon and silicone, which might form contaminating films on wiped surfaces.

The rayon cloths were nonwoven. None were satisfactory because either they deteriorated in the shake test or had a high extractable level, probably from a binder.

Nonwoven polyethylene and polypropylene cloths were unsatisfactory. The polyethylene cloths that were tested were supplied clean-room laundered. All contained considerable extractable material, up to 16 percent, which was surfactant and oil. The polypropylene cloth passed the shake test but shed some large particles. When examined at low power magnification, the polypropylene was seen to be fuzzy indicating that it probably would shed fibers in use.

Nylon cloths, both woven and knitted, were satisfactory provided they were made from filament yarn, hemmed, and properly laundered. Some clean-room laundered cloths, although they met the MIL-C-85043A limit, were quite dirty. Simple rinsing easily reduced the particle counts to below $1x10^5/m^2$. The tested cloths ranged widely in weight, approximately 64 g/m^2 to 274 g/m^2. As expected, the heavier weights absorbed more liquid. The heavier cloths were knitted from crimped multifilament yarn. The cloths had low to moderate extractable materials, approximately 0.03 to 1.0 percent which were surfactants and oils, in some cases, silicone oils. A nonwoven nylon had a higher extractable content, 1 to 3 percent, that was probably an acrylic binder.

One polyester knit, made from crimped multifilamentary yarn, was tested and found to be satisfactory. It was the cleanest of all the fabrics tested with respect to particles and lint, but was somewhat dirtier than a well rinsed nylon. Rinsing reduced its particle and lint content to that of rinsed nylon. The extractable material content was moderate to low and was a low molecular weight polyester. Of two nonwoven polyesters, one had very high solvent extractable material, and the other failed the shake test. Neither was suitable.

The urethane foam wipers are marginally suitable. They all had high extractable contents ranging from 0.3 to 3 percent. The extractables were polyesters, oils, and aromatic phosphates. The cloths swelled and distorted in trichloroethylene. They absorbed large quantities of liquid as might be expected of a sponge. In the shake test the cloths proved to be as clean as a clean as-received nylon cloth. The cloths were improved by rinsing but not as much as the nylon and polyester cloths.

Urethane foam can be either open or closed cell. In two instances separate shipments of cloths with the same commercial designation were found in one shipment to be open cell, and in another to be closed cell.

The conclusion about these urethane wipers is mixed. In applications where organic contamination is a concern, they probably are not suitable. The switching, in some cases, between open and closed cell foam is a concern. Probably the open cell form is capable of being cleaned to lower particle and lint levels. It is difficult to understand why laundered wipers have as much extractable material as they do.

Recommendations

Well-laundered nylon and polyester cloths knitted from filamentary yarn, with hems, are suitable. Woven nylon is suitable too if the lower fabric weight is acceptable.

Urethane foam wipers may be suitable if the moderately high solvent extractable material is not of concern.

Cotton fabrics are unsuitable because they are inherently high-linting.

Nonwoven cloths are unsuitable because they have high solvent extractable material or they produce excessive lint.

The detachable particle test is not suitable for evaluating the cleanliness of wiping cloths. The shake test is the preferred way. Using water as the test liquid is preferred because it is cheap, readily produced in high purity, easy to clean up after, and free from safety and environmental problems.

The lint and particle content limit of MIL-C-85043A is much too high. It should be lowered two to three orders of magnitude.

Users should write specifications on the wiping cloths they use. Each shipment of cloths that have been cleaned in a clean room laundry, whether it is a captive or independent laundry, should be inspected on a sampling basis.

In this work no study was made of the static properties of the cloths. The use of antistatic additives may be inconsistent with the desire for low extractables.