Color fading and alteration can be caused by the reaction between dyes on garments and the constituents of human perspiration, such as skin waste. It varies for different individuals and conditions. Methods for testing fastness levels of dyed materials against perspiration have been established by ISO, AATCC and various other standards. There are cases where more color fading and alteration is caused by depending on the conditions under which garments are worn. Coupled with the eventual accumulation and concentration of perspiration, the reaction with sunlight is regarded as the cause for such occurrences, casting an influence on certain elements in the dye structure. To forecast such occurrences, methods for examining the components of perspiration under different conditions (acid and alkaline pH values) have been suggested by these standards.

**Colour fastness to Perspiration - Standard Test Methods:**

This test is designed for use in assessing the fastness of the dyed, printed, or otherwise colored textile yarns and fabrics of all kinds to the effects of human perspiration. The following standard methods are generally employed to assess the perspiration fastness.

- ISO 105 – EO4 1994 (Acid and Alkaline perspiration)
- AATCC 15:2002 (only Acid perspiration)

**Summary:**

Specimens of the textile in contact with the standard multifibre fabric (for colour transfer) are immersed in simulated alkaline and acid solution (see table below for liquor composition), drained and placed between two plates under a specific pressure, temperature and time in a testing device (perspirometer). Any change in colour of the specimens and staining of the multifibre is then assessed with the corresponding Grey scales for colour change and staining.
### Chemical composition

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alkaline solution</td>
<td>Acid solution</td>
</tr>
<tr>
<td>L-histidine monohydrochloride monohydrate (C₆H₉O₂N₃.HCl.H₂O)</td>
<td>0.5 g</td>
<td>0.5 g</td>
</tr>
<tr>
<td>Sodium chloride (NaCl)</td>
<td>5.0 g</td>
<td>5.0 g</td>
</tr>
<tr>
<td>Disodium hydrogen orthophosphate dodecahydrate (Na₂HPO₄.12H₂O) or Disodium hydrogen orthophosphate dihydrate (Na₂HPO₄.2 H₂O)</td>
<td>5.0 g</td>
<td>-</td>
</tr>
<tr>
<td>Sodium dihydrogen orthophosphate, anhydrous (Na₂HPO₄)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lactic acid (85%)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total volume</td>
<td>1 litre</td>
<td>1 litre</td>
</tr>
<tr>
<td>pH</td>
<td>8.0</td>
<td>5.5</td>
</tr>
<tr>
<td>Specimen size</td>
<td>100 x 40 mm</td>
<td>60 x 60 mm</td>
</tr>
<tr>
<td>Test conditions</td>
<td>37 ± 2º C for 4 hours under a pressure of 5 kg</td>
<td>38 ± 1º C for 6 hours under a pressure of 4.54 kg</td>
</tr>
</tbody>
</table>

### Procedure in brief:

**Reagents:**
- Alkaline Solution - Freshly prepared, composition as given in Table above
- Acid Solution - Freshly prepared, composition as given in Table above

**Test Specimens**
- Cut two specimens 100mm x 40mm (one specimen of 60 x 60 cm in AATCC method) along the length or width direction. For multi-coloured fabrics, prints or stripes, all colours of the design should be in contact with all components of the multifibre.
- Where it is not possible for all colours to be in contact with all components, more than one test specimen may need to be prepared.
- For fabrics of different shade or fibre composition on face and back, both sides should be tested.
- Avoid samples within 50 mm of the selvedge.
- Cut two pieces of multifibre 40mm wide. The multifibre has selvedges and is approximately 100mm long. For AATCC method 60 x 60 cm size multifibre fabric is cut.
Align the test specimens and multifibre and sew together along one short edge to form a composite specimen.

Test Procedure

- Weigh each specimen. Calculate the amount of test solution according to a liquor ratio of 50:1, i.e. 50 ml test solution per 1g of specimen.

- Immerse one composite specimen in the alkaline solution and the other in the Acid solution for 30 minutes at room temperature to ensure that the specimens are thoroughly wetted out. (In AATCC method, place the test specimen in a 9 cm diameter and 2 cm deep Petri dish. Add only acid perspiration solution to a depth of 1.5 cm and soak for 30 min.)

- Place each specimen onto a resin plate and draw across with the stirring rod to remove any air bubbles. Place another resin plate on top of the specimen to fully enclose it. Place a maximum of ten specimens into the perspirometer ensuring that each specimen is separated by one resin plate. Use a separate perspirometer for each solution.

- (In AATCC method, pass the specimen through the wringer so that it weighs 2.25 ± 0.05 times the original weigh. To obtain consistent results all specimens of a given construction in a test series should have identical pickup, as the degree of staining increases with the amount of retained solution. Assemble the plates in the perspirometer with the specimens evenly distributed between the plates. Place all 21 plates into the unit regardless of the number of specimens)

- Bring the upper pressure plate of the perspirometer down to rest on top of the resin plates and place the weight onto the pressure plate and tighten the securing screws. This is equal to a pressure of 12.5 KPa (5 kg) in between being applied on the specimens.

- Drain off any excess solution.

- Place the specimens into the oven at 37 ± 2°C, for 4 hours (38 ± 1°C, for 6 hours in AATCC method), set a timer for this.

- On completion of the test remove the specimens from the oven and separate them from the resin plates.

- Open out the specimens, so that they are only in contact at the line of stitching.

- Dry the specimens in an incubator or by laying on a screen at a temperature not exceeding 60°C.
Evaluation of results

- After drying, assess the specimens in a colour matching cabinet under D65, artificial daylight.

- Assess colour staining of all components on the multifibre using the grey scale for assessing staining.

- For multi-coloured prints only assess the worst area of staining on each component.

- Assess the change of shade on the original specimen compared to the tested specimen, using the grey scales for assessing change.

Some notes on testing

- It is sometimes advised that a complete different set of Perspirometers / plates be used for alkaline and acidic perspiration tests. This is recommended so that there is no contamination between the two.

- Some laboratories use different sets of equipment for ISO and AATCC testing for the same reasons.

Case studies:

Case 1

Gold coloured printing is quite popular due to the unique effects that it can offer to garments. Typically, gold prints are done using inorganic metallic pigments. There was a case where a woven shirt with gold coloured motif print was exported to Europe for a summer season. This article had passed the normal colourfastness tests as specified by the buyer.
Unfortunately, the garments were returned by customers with a complaint that the gold motif changed colour to green after use in areas such as the armhole, back where perspiration is excessive. The colour change was irreversible. This problem was investigated and it was found that the print was sensitive to perspiration, possibly because it was a copper based compound. On testing, the print failed colourfastness to perspiration – a test that was not performed as part of the quality control protocol.

Investigation revealed the use of a poor quality cheap gold powder which was sensitive to perspiration and turned green. The problem was solved only when the goods were redone using standard gold paste for the printing.

**Other cases**

Colourfastness to perspiration is often a problem for sportswear. There have been cases where articles for use in sports with poor colourfastness to perspiration have led to staining of undergarments.

Similar issues have been seen for industrial work wear where the users often work in conditions where perspiration is a natural occurrence, especially in hot environments such as India.

We have also seen problems with ladies undergarments such as brassieres being stained due to poor colourfastness to perspiration of outer garments.

These cases show that Colourfastness to perspiration is an important criterion in garment quality evaluation.
Squeezing excess liquor from sample

Loading the perspirometer

Loaded Perspirometer