

Evaluating color transforms in ICC profiles

ICC input and output profiles contain transforms between device data encodings and the ICC PCS. These transforms should provide either an accurate color match or a pleasing rendering, depending on the chosen rendering intent.

The following recommendations are provided to assist in the evaluation of the colorimetric and perceptual rendering intent transforms in ICC v4 profiles. Any tolerances provided are guidelines and may not be suitable for all applications.

Three types of test can be considered:

- Round trip tests determine the accuracy with which a given rendering intent within a profile can be inverted, such that when a PCS value is converted to the device encoding and back to the PCS the difference is minimized. Round trip tests are applicable to all intents.
- Device model tests can determine the accuracy with which the profile predicts the colorimetry of a given device encoding value, or the accuracy with which the profile predicts the device encoding value required to produce a given colorimetry. Device model tests are generally applicable to Colorimetric intents.
- Subjective tests evaluate how pleasing a rendering or re-rendering transform is. Such tests are generally applicable to Perceptual intents.

1. Preview tags shall not be used for testing round-tripping errors. [N. B. check situations where preview tags are required]

2. Round-tripping results may be affected by the device characteristics, the profile and the CMM. Profiles that will be used in open systems should be evaluated using several CMMs, preferably those that will be used in practice.

3. Determine if the profile AToB1 and BToA1 transforms and media white point tag accurately reflect the device characteristic (after chromatic adaptation from the actual adopted white to D50, if necessary). This is required for all v4 profiles. The AToB1 transform should be checked by comparing PCS values to device measurements obtained using the actual illumination, chromatically adapted to D50 using the chad tag. The BToA1 transform is checked by transforming device values to the PCS (using AToB1), back to device (using BToA1), and back to PCS (using AToB1), and comparing the first and second PCS values. If it is desired to show the difference between the value predicted by the profile and the measured data in 1976 CIELAB Δ^*_{ab} , the data should be scaled to be ICC-Absolute Colorimetry as described

in the ICC specification. Whether the comparison is in Media-Relative or ICC-Absolute colorimetry should be reported.

4. Determine if the profile media relative colorimetric and perceptual transforms are identical. If they are identical the profile contains no color rendering or re-rendering - proceed to step 5. If they are not identical, proceed to step 7.

5. Determine whether the transforms contain 3D CLUTs larger than 2x2x2 (2x2x2 CLUTs are used in some transforms like a matrix).

6a. If the transforms do contain CLUTs larger than 2x2x2, they should be tested by round-tripping colors by round-tripping test colors spanning the profile gamut, or the Perceptual Reference Medium Gamut (PRMG) if its use is indicated,. Round-tripping color differences in CIELAB E^*ab should be <1 mean and <3 maximum.

6b. If the transforms do not contain CLUTs larger than 2x2x2, they should be tested. The round-tripping should be very accurate, since the transforms are analytical and there is no need for color rendering or re-rendering tradeoffs. Round-tripping color differences (in CIELAB E^*ab) should be <0.5 mean and <1 max.

It should be noted that the gamut for a perceptual transform can be larger than the PRMG even when use of the PRMG is indicated. An image can be color rendered or re-rendered appropriately for the PRMG, but still be encoded in a color space which has a larger gamut than the PRMG.

7a. If the media relative colorimetric and perceptual transforms are not identical and the use of the PRMG is indicated, some additional leeway in the round-tripping accuracy should be granted to allow for reasonable tradeoffs between color rendering/re-rendering and spanning the PRMG. Transforms should be tested by round-tripping colors spanning the PRMG, but the round-tripping color differences within the PRMG should be <2 mean and <10 maximum.

7b. If the media relative colorimetric and perceptual transforms are not identical and the use of the PRMG is not indicated, knowledge of the the target gamut for the perceptual color rendering or re-rendering is necessary to apply the objective evaluation methods outlined above to the perceptual rendering intent transforms. However, subjective evaluation methods can be used even when such knowledge is not available.

V4 profiles with no color rendering or re-rendering indicate that the images to which they are assigned are to be interpreted as being already color rendered appropriately for the PRM. Such profiles can be evaluated objectively, so long as any errors are very small. However, visual evaluation is useful to determine the degree to which in-gamut colors match when produced using different printers. Very small CIELAB color differences can sometimes result in a visual mismatch, particularly for near-neutral colors. Visual evaluation can also help identify measurement or illumination errors.

V4 profiles that contain color rendering or re-rendering intentionally modify the output colorimetry and hence cannot be completely evaluated using only objective methods. Subjective evaluation using large numbers of real images is required to determine the quality of the color rendering or re-rendering.

To subjectively evaluate the AToB0 transform in a profile for use as a source profile, a collection of images that are judged to be of excellent quality when interpreted directly according to the source color encoding should be printed on a print medium with a color gamut similar to the PRMG using the perceptual rendering intent, and then viewed in the PRM viewing conditions.

To subjectively evaluate the BToA0 transform in a profile for use as a destination profile, a collection of images that are judged to be of excellent quality when printed and viewed using a print medium and viewing conditions similar to those of the PRM should be reproduced on the destination medium using the perceptual rendering intent, and then viewed in the intended destination viewing conditions.

Images suitable for subjective BToA0 transform evaluation are provided in ISO 12640-3, and can also be made from camera raw files by carefully color rendering into ROMM RGB and evaluating the results by printing colorimetrically on a print medium with a color gamut similar to the PRMG, and then viewing the prints in the PRM viewing conditions.

For improved interoperability with v2 source profiles, it may also be desirable to subjectively evaluate BToA0 transforms using images that are in color encodings with reference media different from the PRM (and have v2 profiles embedded). Such co-optimization is desirable when it can be achieved without sacrificing the subjective quality of the PRM image reproduction.