Fitness Guidelines

for

Federal Reserve Notes (FRNs)

1 INTRODUCTION

The Federal Reserve uses detection equipment in its high-speed, currency processing operations to verify the acceptability of Federal Reserve Note (FRN) deposits for redistribution to the depository institutions and, subsequently, to the public. The Federal Reserve defines fit and unfit currency in Operating Circular # 2. Fit currency is defined as: "a note that is suitable for continued circulation and is sufficiently clean to allow its genuineness and denomination to be readily ascertained;" and unfit currency is defined as: "a note that is not suitable for further circulation because of its physical condition, such as torn, dirty, limp, worn or defaced." This document is intended to more precisely define what is considered by the Federal Reserve to be fit and unfit notes. Banks and other depository institutions may use this document to facilitate conversations with equipment manufactures, third party service providers and branch operations concerning the Federal Reserve's Recirculation Initiative. An FRN is acceptable for redistribution if it meets the following criteria:

- Is the correct denomination designated for the deposit being processed;
- Is genuine, not a counterfeit note;
- Is a series-design approved for recirculation (old series-design notes are considered unfit after a certain period of time in circulation);
- Is free from excessive holes, tears, tape or missing or folded note portions and has acceptable area dimensions;
- Has uniform brightness and is free from excessive soiling; and,
- Is free from excessive print wear, particularly in the portrait area.

All of the fitness measurements are evaluated against fit/unfit parameters individually. An FRN must fail at least one fitness measurement to be considered unfit. Conversely, if an FRN marginally passes multiple fitness measurements the FRN is still considered fit.

This document describes the criteria that the Federal Reserve uses to determine the fitness of FRNs. Not all of these measures are required to meet the fitness requirements of the Federal Reserve's Recirculation Policy. Pictures have been included for reference purposes for twenties and tens in accordance with the Recirculation Policy.

2 FRN SURFACE QUALITY

2.1 Soiling

Soiling is a measure of the loss of reflectivity from the unprinted areas and the subtle background printing of the 2004 series design, on the portrait side and reverse side of an FRN. This includes soiling due to dirt, aging (yellowing), wear and extraneous markings. The soil level is a measure of the average amount of soiling on the portrait and reverse side of FRNs. When the amount of soiling on an FRN equals or exceeds the measurement criteria listed in the chart in Section 2.3 the FRN is considered unfit.

2.2   Ink Wear

Ink Wear is a measure of the improper reflectivity of the printed areas on the portrait side of an FRN. This includes ink wear due to aging, excessive folding wear and other wearing. Ink Wear level is determined by the percentage of printed pixels that are more than 2 % reflectance lighter than the nominal reflective value. The ink wear level is a measure of the average amount of ink wear on the portrait side of the FRN. When the amount of ink wear on an FRN equals or exceeds the measurement criteria listed in the chart in Section 2.4 the FRN is considered unfit.

2.3   Surface Fitness Measurement Criteria Chart

Unfit Measurement Criteria

Currency	Soil Level Front	Soil Level Back	Ink Wear Front
	Density [1]	Density [1]	% Worn Pixels
$5 Series 1996	≥ 0.210	≥ 0.225	≥ 25 %
$5 Series 2006	≥ 0.280	≥ 0.340	≥ 25 %
$10 Series 1996	≥ 0.220	≥ 0.240	≥ 25 %
$10 Series 2004	≥ 0.250	≥ 0.290	≥ 25 %
$20 Series 1996	≥ 0.200	≥ 0.240	≥ 25 %
$20 Series 2004	≥ 0.290	≥ 0.315	≥ 25 %

[1] See detailed explanation of density and % reflectance measurements in Section 7.

3   FRN SUBSTRATE DEFECTS

3.1   Length, Width, Holes, Tears, Corners, Tape

A genuine Federal Reserve Note is considered <u>unfit</u> for redistribution if it has any one of these measured defects:

- length < 151mm (with greater than 50% of the note present)
- width < 63mm (with greater than 50% of the note present)
- total holes area > 19mm^2, includes open tears on the short edges
  (the hole areas are additive)
- total tear depth > 4mm, along the long edges
  (tears with a minimum length of 3mm and a minimum width of 2mm are detectable, the tear depths are additive)
- at least one missing corner > 72mm^2
  (missing corners with a minimum area of 26mm^2 and a minimum horizontal or vertical dimension of 5mm are detectable)
- at least one folded corner > 182mm^2 or 4 folded corners regardless of area
  (folded corners with a minimum area of 26mm^2 and a minimum horizontal or vertical dimension of 5mm are detectable)
- tape length > 9mm, with minimum thickness of 0.05mm
  (this is the length along the long dimension of the note, a specific width along the short edge dimension is not used)

4   OLDER SERIES DESIGNS

The Federal Reserve may determine that older series-designs of FRNs are unfit for circulation and destroy them when processed. The following is a list of all series-designs by denomination that are considered unfit no matter their physical condition:

$ 20	Before 1996 series
$ 10	Before 1996 series
$ 5	Before 1996 series

5   DOCUMENT REVIEW AND UPDATES

This document will be reviewed and updated on a periodic basis by the Federal Reserve. Depository institutions should direct any questions regarding the implementation of these guidelines to their respective equipment manufacturer or supplier. Equipment manufacturers may submit requests for clarification or changes to this document in writing to the Currency Technology Office, Attention: Systems Engineering and Analysis Group, P. O. Box 27622, Richmond, VA 23261.

6 FIT/UNFIT NOTE IMAGES

The following images represent Federal Reserve Notes that are fit and unfit. These notes are close to the decision point of fit versus unfit.

6.1 Twenties: Soil Level Front[1]

Series 1996	Series 2004
Fit	**Fit**
Marginally Fit	**Marginally Fit**
Marginally Unfit	**Marginally Unfit**
Unfit	**Unfit**

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[1] The pictures in this document are intended for visual and reference purposes only. Because of variances in electronic and hard copy appearances of these pictures, densitometer values can not be accurately reproduced.

6.2 Twenties: Soil Level Back

Series 1996	Series 2004
Fit	**Fit**
Marginally Fit	**Marginally Fit**
Marginally Unfit	**Marginally Unfit**
Unfit	**Unfit**

6.3 Tens: Soil Level Front

Series 1996	Series 2004

Fit

Fit

Marginally Fit

Marginally Fit

Marginally Unfit

Marginally Unfit

Unfit

Unfit

6.4 Tens: Soil Level Back

Series 1996	**Series 2004**

Fit

Fit

Marginally Fit

Marginally Fit

Marginally Unfit

Marginally Unfit

Unfit

Unfit

6.5 Ink Wear

Marginally Unfit

Unfit

Very Unfit

7 DENSITY AND REFLECTANCE MEASUREMENTS

The density measurements are based on a reflection densitometer, e.g., X-Rite 404G, with ANSI Status T response. The densitometer calibration is based on a T-Ref calibration plaque and a calibrated black backstop. The T-Ref calibration is traceable to the National Institute of Standards and Technology (NIST). The conversion from density to reflectance is: Reflectance = $10^{-density}$.

Density / Reflectance Conversion Chart

Average Density	Average % Reflectance	Average Density	Average % Reflectance
0.170	67.61%	0.275	53.09%
0.175	66.83%	0.280	52.48%
0.180	66.07%	0.285	51.88%
0.185	65.31%	0.290	51.29%
0.190	64.57%	0.295	50.70%
0.195	63.83%	0.300	50.12%
0.200	63.10%	0.305	49.55%
0.205	62.37%	0.310	48.98%
0.210	61.66%	0.315	48.42%
0.215	60.95%	0.320	47.86%
0.220	60.26%	0.325	47.32%
0.225	59.57%	0.330	46.77%
0.230	58.88%	0.335	46.24%
0.235	58.21%	0.340	45.71%
0.240	57.54%	0.345	45.19%
0.245	56.89%	0.350	44.67%
0.250	56.23%	0.355	44.16%
0.255	55.59%	0.360	43.65%
0.260	54.95%	0.365	43.15%
0.265	54.33%	0.370	42.66%
0.270	53.70%	0.375	42.17%

The fitness measurements provided by the Federal Reserve fitness sensors are correlated with densitometer evaluations of the reflectivity of each note. The average density of notes is calculated by taking readings at ten different reference points on each note. The average of the ten readings is used to provide an average density of the note. The average density values are used to correlate the density of notes to the soil levels used by the Federal Reserve sorting equipment. The following image shows the reference points used on the 2004 $20 where the readings are taken. Other denomination and series of notes use similar locations for density calculations. This methodology is used for each denomination and series.

8   GENERAL DETECTION METHODOLOGY

The Federal Reserve uses imaging technology to detect and quantify FRN substrate defects such as holes, tears, and missing or folded note portions. The general methodology involves taking a normal image and a backlighted image (producing a silhouette) of the FRN and comparing it to reference images. The Federal Reserve uses a like methodology with the normal image of the front and back of each FRN to detect and quantify soiling effects. Ink wear measurements are also made relative to the reference images. The Federal Reserve uses a separate technology for tape detection.