

USIFI Mil Spec Conference

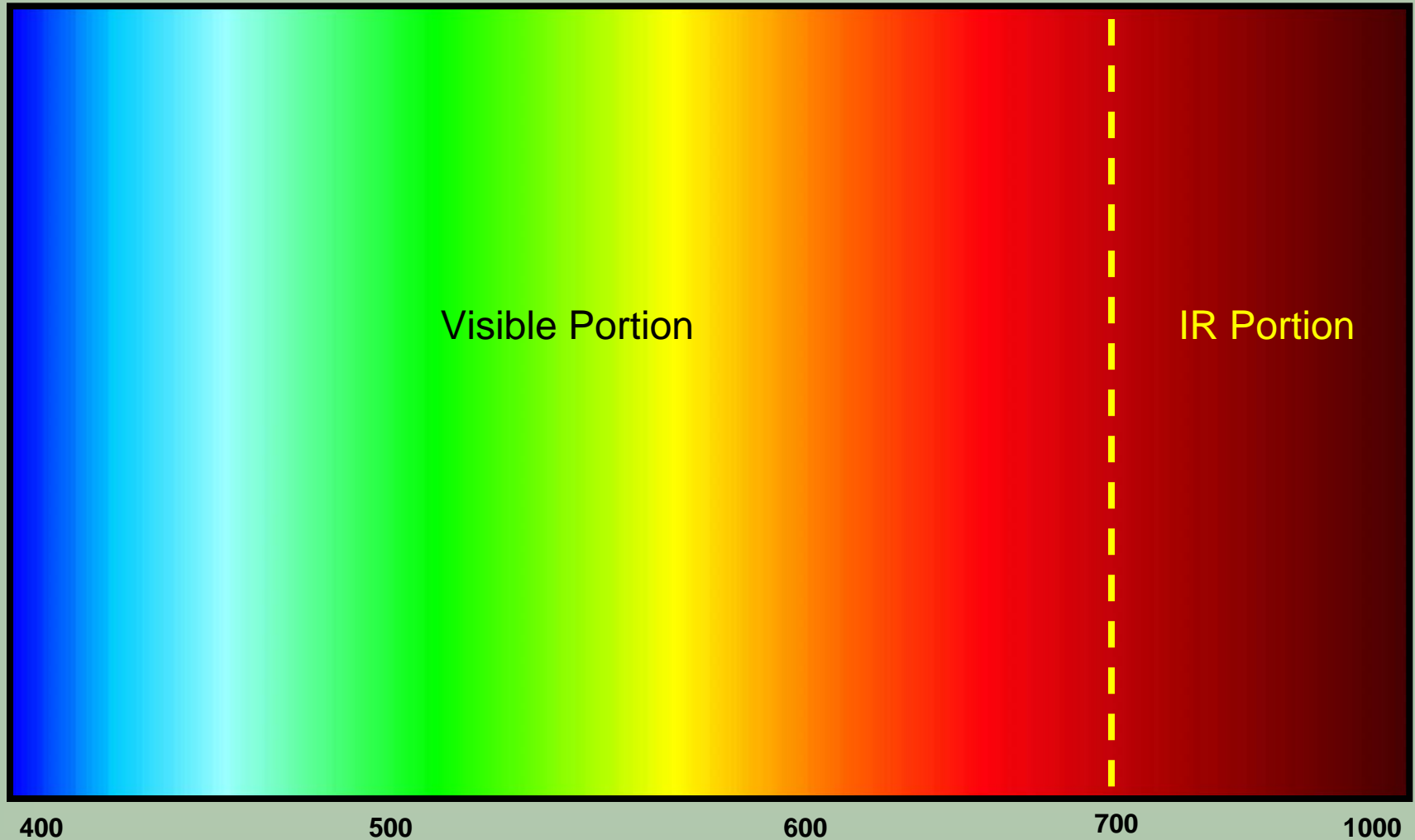
Natick, MA
February, 2006



Ferro – Background on Military Applications

- **Leader in Infrared Camouflage for 50+ Years**
- **Started as visual camouflage**
- **Matched IR Reflective properties of Chlorophyll**
- **Worked with all Military Branches**
- **Work continues on advanced camouflage**
- **Cool Colors® & Eclipse® Solar Reflective Pigments**
- **Technology is an offshoot of Military Camouflage**

Camouflage Spectrum Visible to Near Infrared



Military Specifications (1)

- **MIL C 53039B (June 2005) Moisture Cure**
 - Coating, Aliphatic Polyurethane (CARC)*

Primary Colors (Green 383 & Tan 686)

- **Green 383 (Fed Std 34094) – Approved pigments**

- Acid Insoluble Green
- Chrome Oxide Green
- Light Stable Organic Yellows & Oranges
- Carbazole Violet (PV-23)
- Iron Oxide
- Zinc/Magnesium Ferrite
- Other CACP pigments

* CARC = Chemical Agent Resistant Coating

NOTE: NO LEAD OR CHROMATE PIGMENTS SHALL BE USED

Military Specifications (2)

- **MIL C 53039B (June 2005)**
 - Coating, Aliphatic Polyurethane (CARC)*

Primary Colors (Green 383 & Tan 686)

- **Tan 686 (Fed Std 33446) – Approved Pigments**

- Titanium Dioxide
- Chrome Oxide Green
- Red &/or Yellow Iron Oxide
- Zinc/Magnesium Ferrite
- Other CACP pigments

NOTE: NO LEAD OR CHROMATE PIGMENTS SHALL BE USED

Military Specifications (3)

- **MIL C 53039B (June 2005)**
 - Coating, Aliphatic Polyurethane Single Component, CARC
Primary Colors – Same as MIL C 46168
(Green 383 Fed Std 34094 & Tan 686 Fed Std 33446)
- **MIL-DTL-64159 (January 2002)**
 - Coating, Water Dispersible Aliphatic Polyurethane, **CARC***

NOTE: NO LEAD OR CHROMATE PIGMENTS SHALL BE USED

Military Specification (4)

- **MIL PRF 24635C**

- Performance Specification
 - Enamel, Silicone Alkyd Copolymer
 - Primary Colors
 - » Haze Gray Fed Std 26270
 - » Deck Gray Fed Std 26008



- **MIL PRF 53134D**

- Performance Specification
 - Ultra-lightweight Camouflage Net System (ULCANS)

- **STANAG 2338 NATO Green**

Military Specifications (5)

- **MIL PRF 44103D (November 1996)**
 - Performance Specification
 - Cloth, Waterproof, Weather Resistant
 - Primary Colors
 - » Green 483
 - » Tan 459
- **MIL PRF 32002C (August 2000)**
 - Performance Specification
 - Cover Material, Vehicle, Coated Tactical and Combat Heavy-Duty, Waterproof
- **MIL PRF 20696F (September 1997)**
 - Performance Specification
 - Cloth, Waterproof, Weather Resistant



Federal Standard 595B Camouflage Colors

Green 383	34094
Brown 383	30051
Tan 686	33446
Black	37030
Dark Green	34082
Field Drab	33105

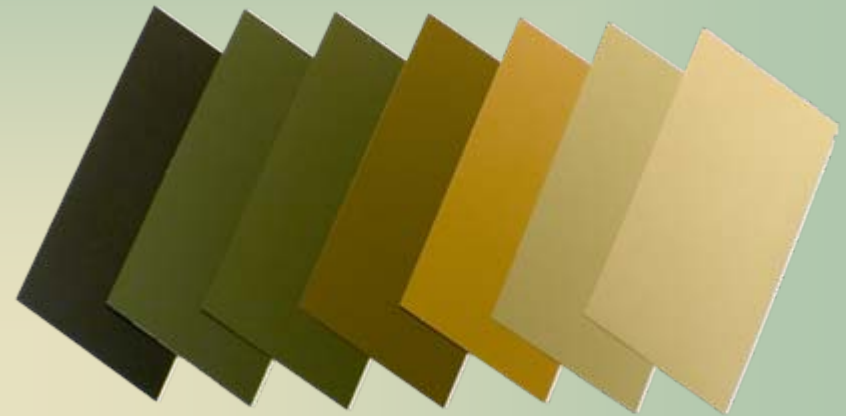


Sand	33303
Sandstone	33510
Earth Yellow	33245
Aircraft Green	34031
Aircraft gray	36300
Aircraft Black	37031

Federal Standard 595B Numbering System

Five Digit Number (ex: 595B30494)

- First Digit = Finish
 - 1- High Gloss
 - 2- Semi-Gloss
 - 3- Flat or Lusterless
- Second Digit = Color
 - 0 = Brown
 - 1 = Red
 - 2 = Orange
 - 3 = Yellow
 - 4 = Green



- 5 = Blue
- 6 = Gray
- 7 = White, Black, Miscellaneous
- 8 = Fluorescent
- xxx = last 3 digits refer to reflectance

Federal Standard 595B Pigments

NOTE: The Fed Std 595 A&B sets are used for Color Matching for various applications. They are “ink” pigments and do not possess IR reflectivity for the Military applications.

- Pigments used to **match** Federal Standard Specs **MUST** be chosen for Stability, Compatibility & IR Specifications of the final system.
- IR Requirements should be obtained from the appropriate specification.
 - **Example - Fed Std Color Chip 34094 contains**
 - » Rutile Titanium Dioxide
 - » Phthalocyanine Blue (Red Shade)
 - » Natural Raw Umber
 - » Chrome Yellow Medium (Red Shade)

The combination of the above pigments will not match the IR requirements for military specifications

Color Reflectance Requirements

MIL C 53039B

<u>Color #</u>	<u>Lightness</u>	<u>Center of 2 NBS Ellipse</u>	
	<u>Visual Y</u>	<u>x</u>	<u>y</u>
• Green 383 (34094)	0.063-0.083	0.328	0.365
• Tan 686 (33446)	0.360-0.400	0.368	0.364
• Brown 383 (30051)	0.060-0.080	0.357	0.342
• Dk Green (34082)	0.071-0.091	0.339	0.390

MIL PRF 44103D No Federal Standard Number

• Green 483*	9.16	0.318	0.344
• Tan 459*	46.99	0.371	0.363

*Color varies – obtain chips from customer for matching purposes

MIL C 53039B IR Requirements

<u>Color #</u>	<u>Infrared Avg.</u>		
	<u>Min.</u>	<u>Max.</u>	<u>Ratio</u>
• 383 Green	---	60.0	5.2
• Tan 686	62.0	72.0	---
• Brown 383	8.0	20.0	---
• Dark Green	---	60.0	5.2

MIL C 53039B Red plus IR Average Calculation

Red Region (Nanometers)

620-1

630-1

640-2 Red Average

650-3

660-3

I

Infrared Region (Nanometers)

720

740

760

770

780 IR Average

800

810

830

840

860

Ratio = IR Avg / Red Avg

Spectral Reflectance Limits for 383 Green 34094 Mil C 53039B

<u>Wavelength</u>		<u>Min.</u>	<u>Max</u>	<u>Wavelength</u>	<u>Min.</u>	<u>Max.</u>
600	----	10.2		700	11.0	28.0
610	----	9.8		710	15.0	35.8
620	----	9.8		720	19.0*	41.0
630	----	9.8		730	25.0*	48.5
640	----	9.5		740	30.0*	51.8
650	----	9.5*		750	36.3*	56.0
660	----	10.0*		760	40.0*	59.5
670	4.0	10.5*		770	42.0	61.5
680	5.8	13.0		780-900	42.0	-----
690	8.5	21.5				

* Note- Red Numbers are problem areas





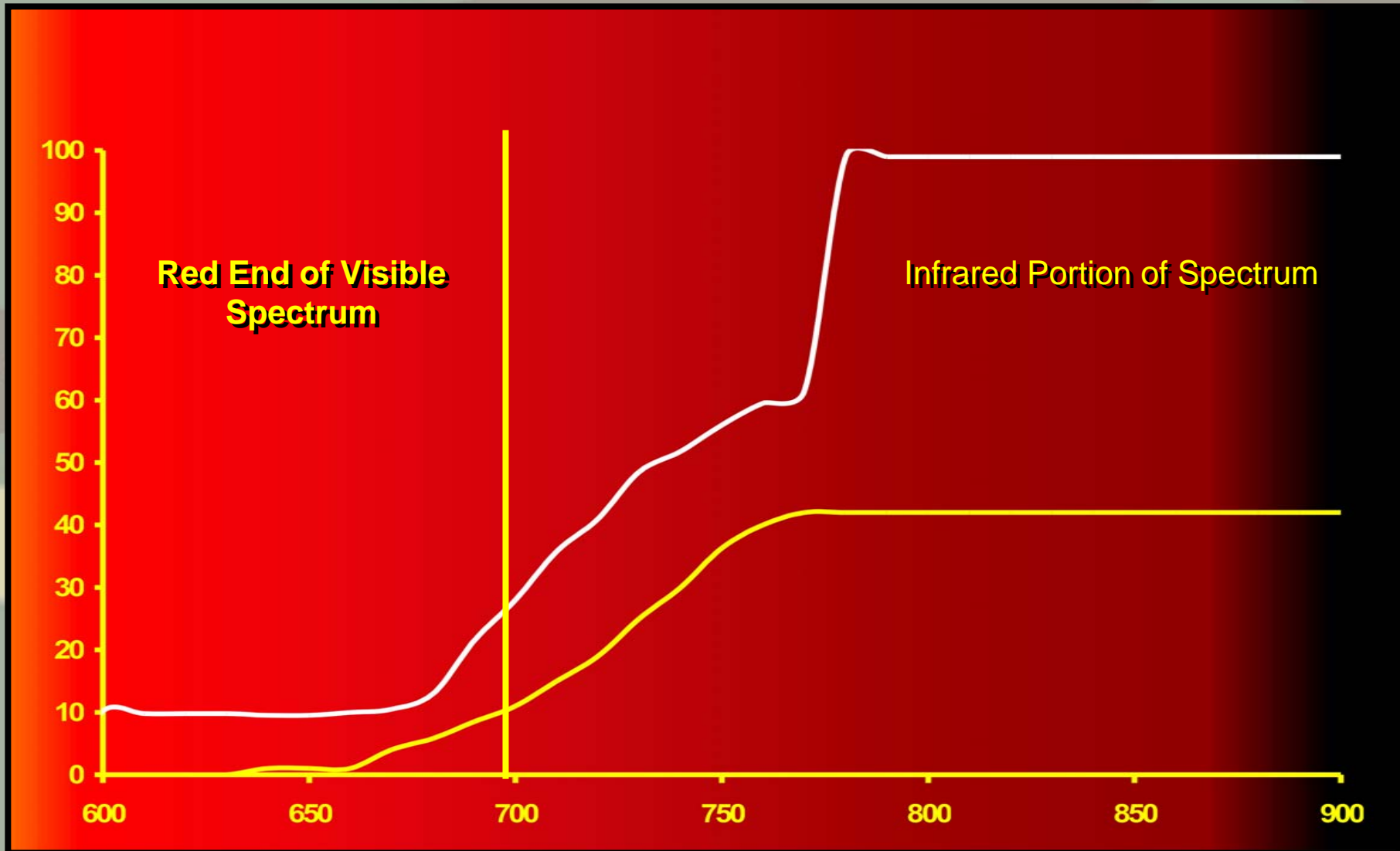




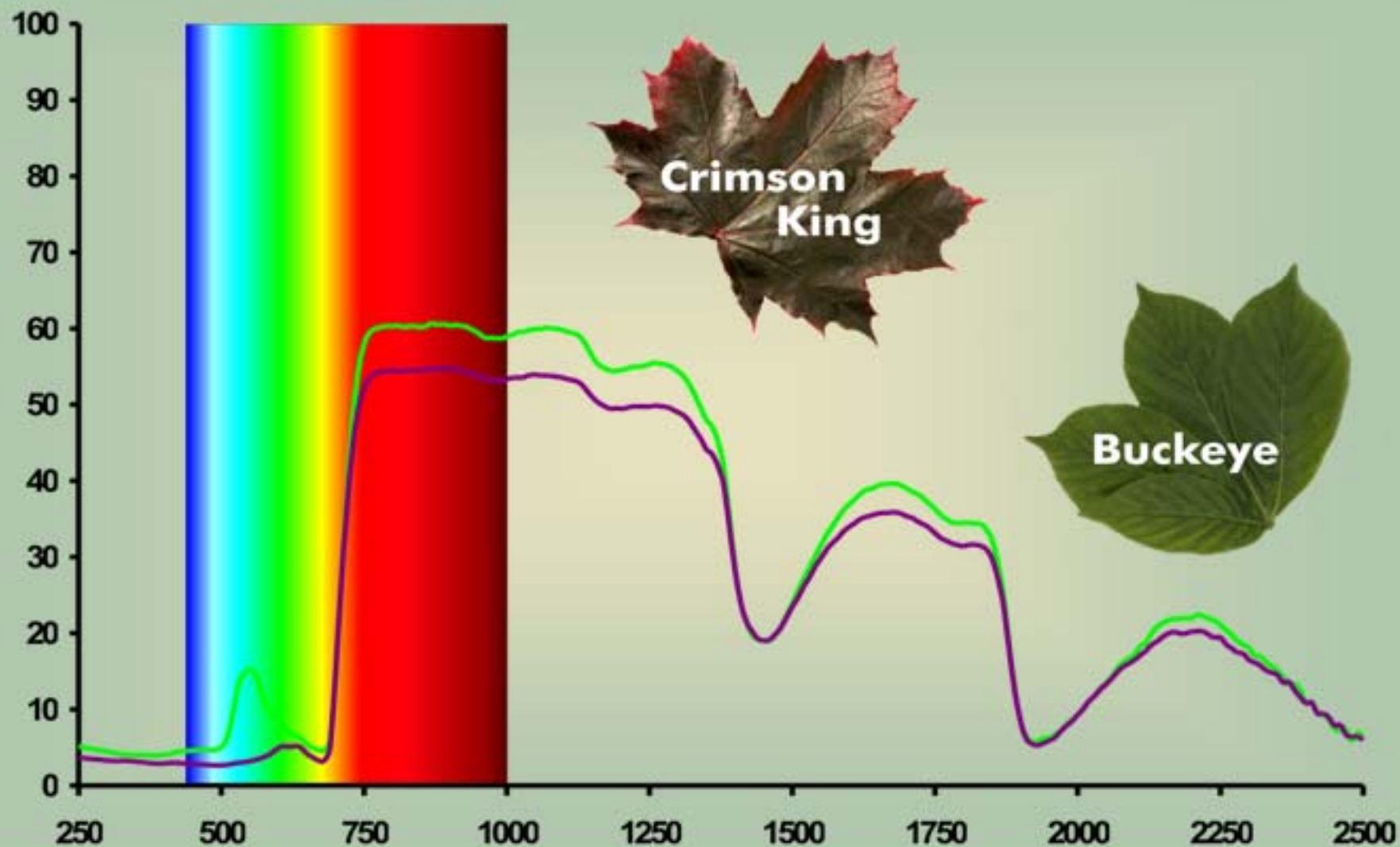




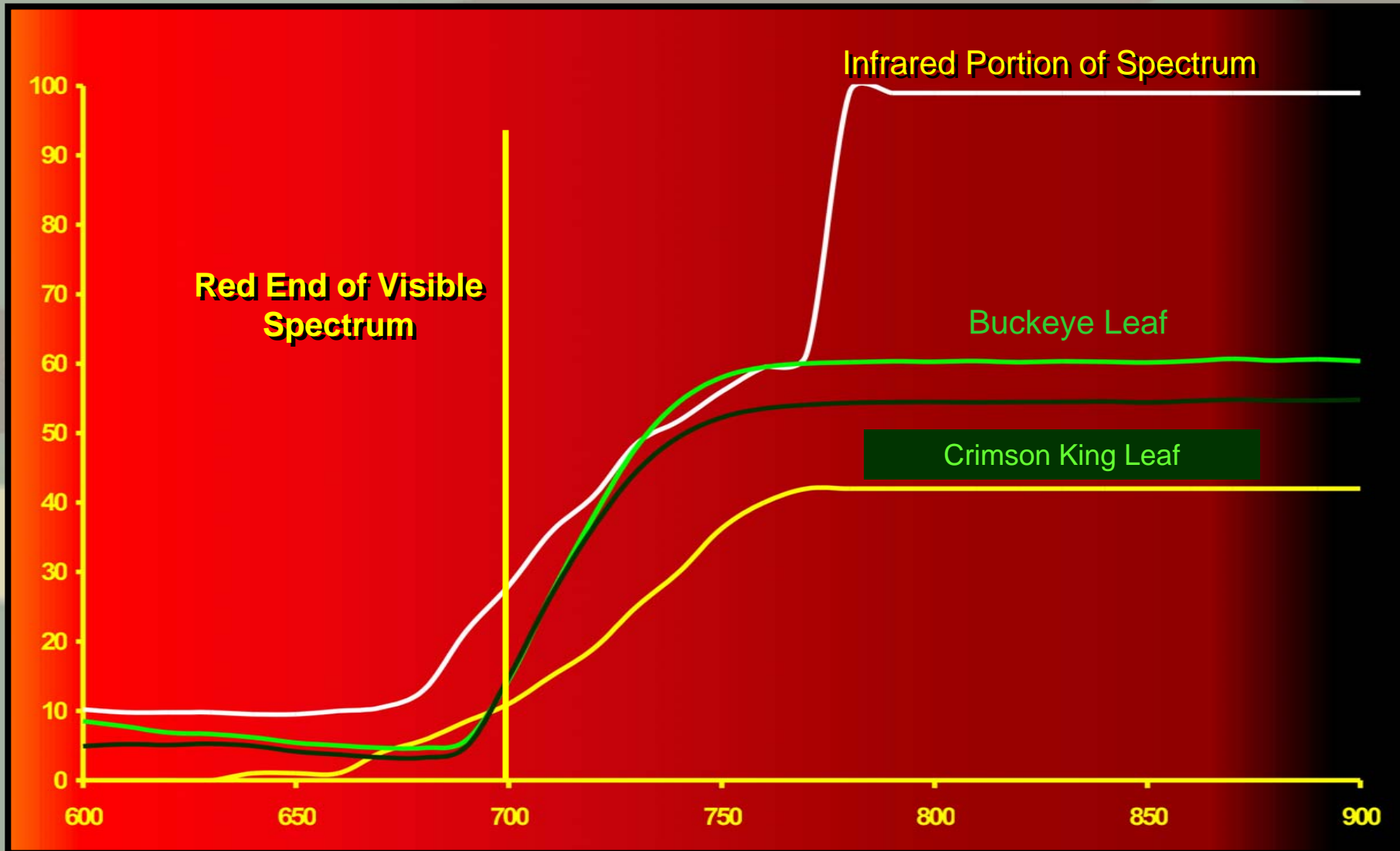
Spectral Reflectance Limits for 383 Green 34094 Mil C 53039B (1)



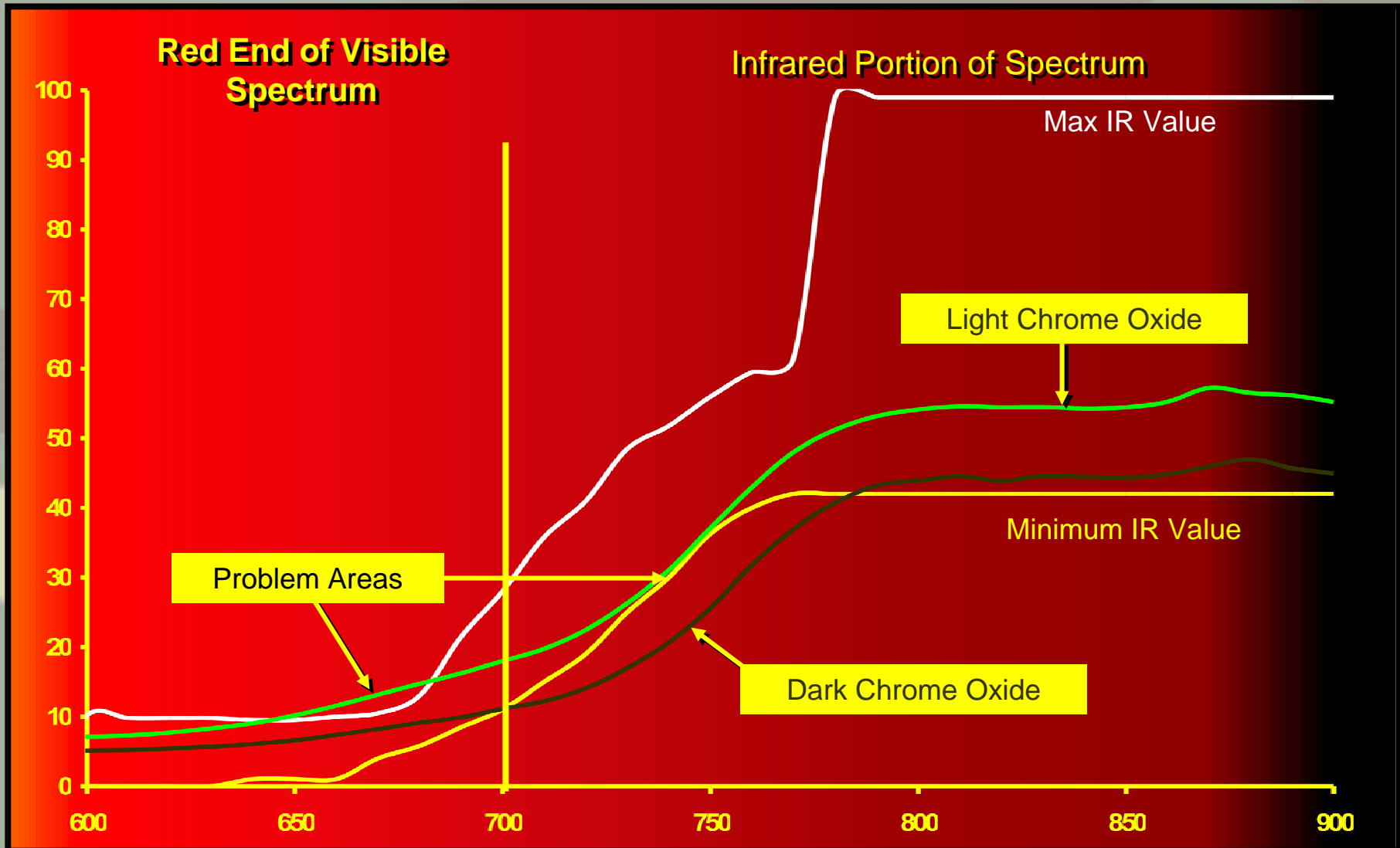
Spectral Reflectance of Natural Foliage



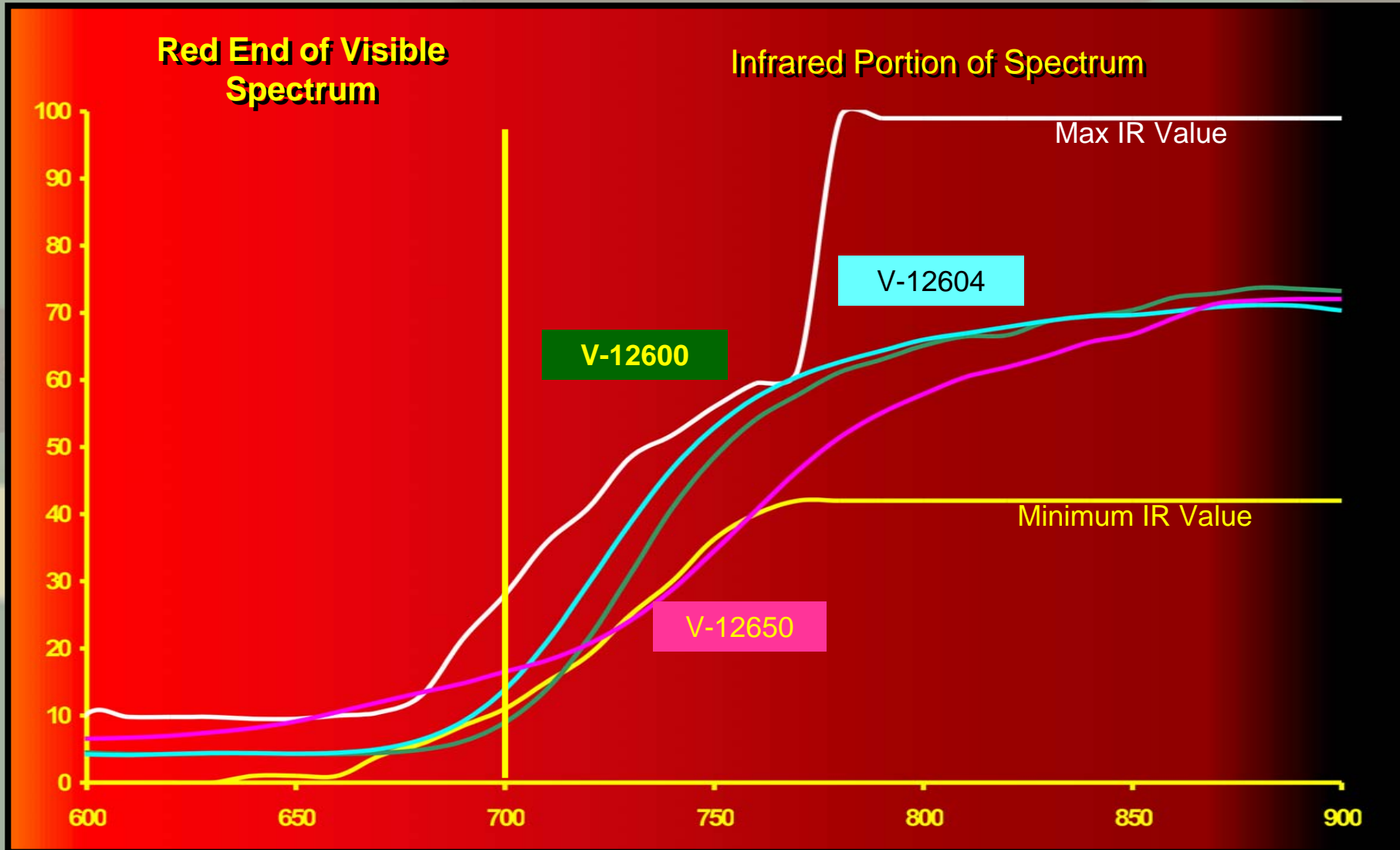
Spectral Reflectance Limits for 383 Green 34094 Mil C 53039B (2)



Spectral Reflectance Limits for 383 Green 34094 Mil C 53039B (3)



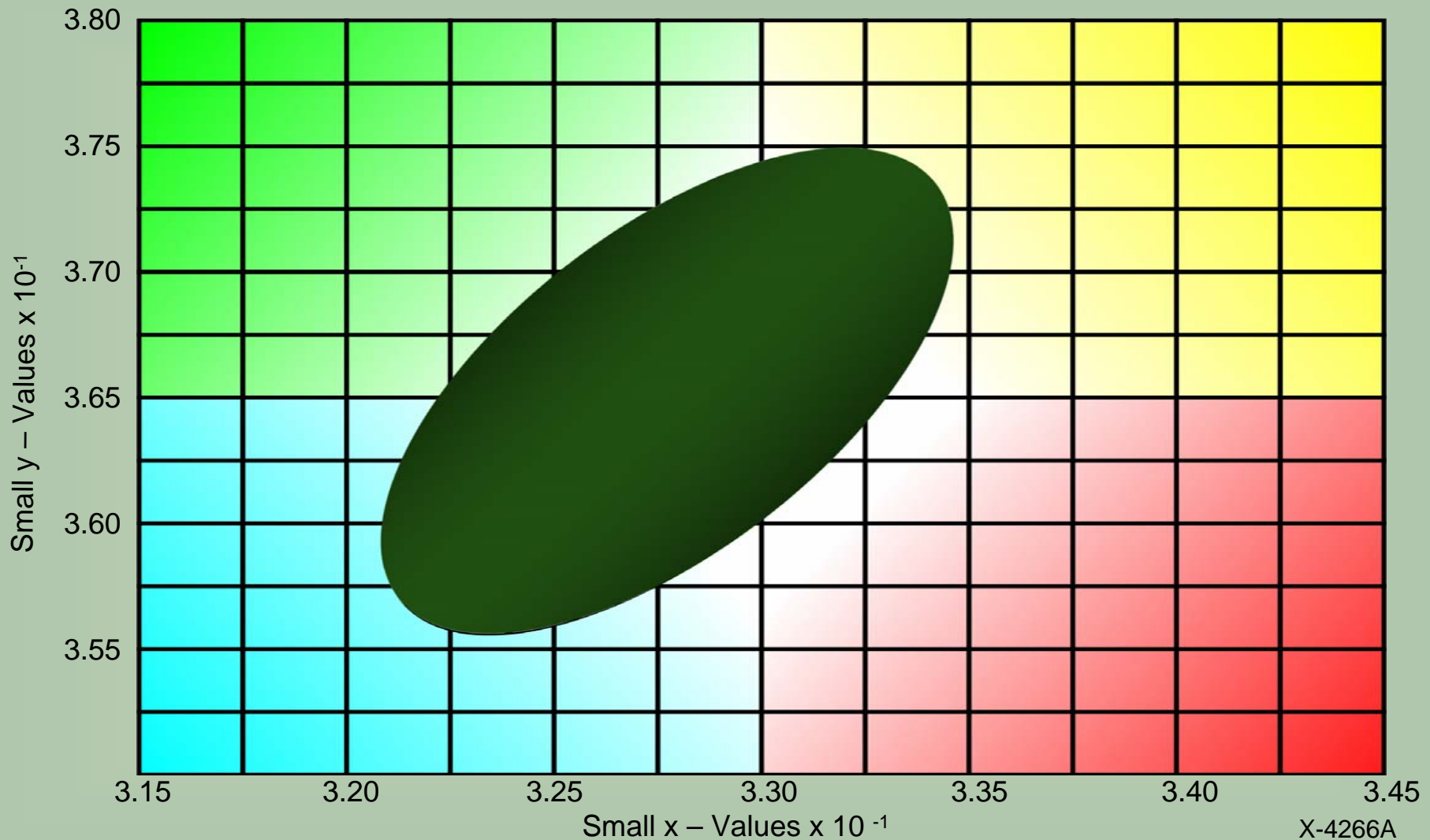
Spectral Reflectance Limits for 383 Green 34094 Mil C 53039B (4)



MIL C 53039B Color Ellipse

Chromaticity Diagram for Green 383 (Fed Std 34094)

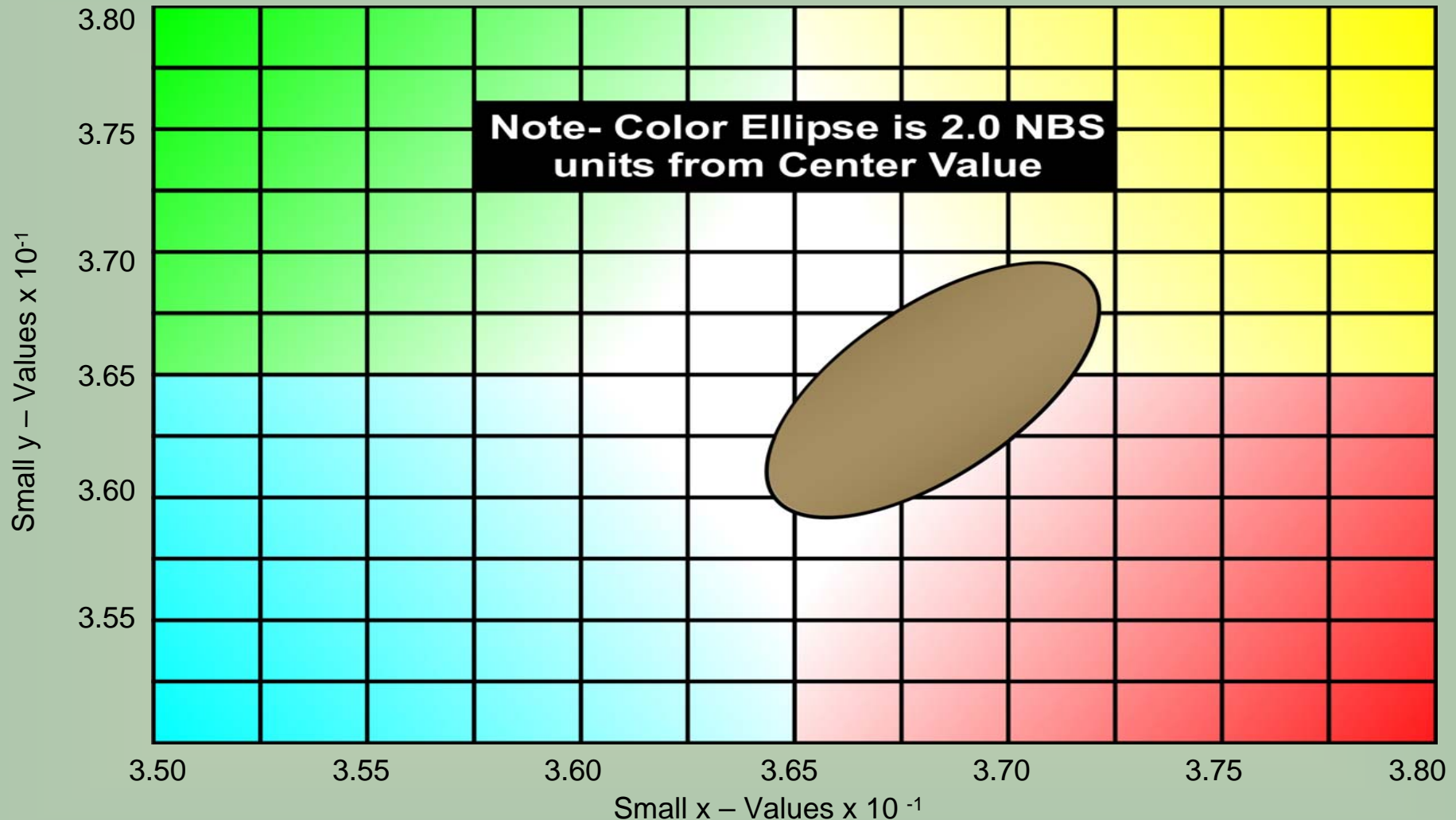
Cap Y Brightness = 0.063-0.083



MIL C 53039B Color Ellipse

Chromaticity Diagram for Tan 686 (Fed Std 33446)

Cap Y Brightness = 0.36-0.40



MIL PRF 44103 Reflectance Requirements 483 Green & 459 Tan

<u>Wavelength</u>	<u>Min.</u>	<u>Max.</u>	<u>Wavelength</u>	<u>Min.</u>	<u>Max.</u>
<u>483 Green</u>			<u>459 Tan</u>		
600	5	12	600	----	----
620	5	12	620	----	----
640	5	12	640	----	----
660	5	13	660	----	----
680	6	15	680	45	65
700	9	21	700	45	65
720	15	30	720	45	65
760	32	50	760	45	65
780	38	56	780	45	65
800	41	60	800	45	65
820	43	63	820	45	65
840	45	65	840	45	65
860	46	66	860	45	65

MIL PRF 24635C Specifications

- Navy Haze Gray 27270

Color Values

L +56.00

a -1.83

b -1.37

Color Deviation

DL +/-0.3

Da +/-0.3

Db +/-0.3

DE +/-0.5

IR Specifications

800nm Min. 65.0%

1000nm Min. 70.0%

- Deck Gray 26008



DL +/-0.5 800nm Min. 50.0%

Da +/-0.5 1000nm Min. 55.0%

Db +/-0.5

DE +/-1.0

Affects of the addition of TiO₂ & Black Iron Oxide to 383 Green Formulation

<u>Sample</u>	<u>Y</u>	<u>x</u>	<u>y</u>	<u>IR Avg.</u>	<u>Red</u>	<u>Ratio</u>
383 Green	7.88	0.328	0.360	45.91	8.33	5.51
+ 1% TiO ₂	7.93	0.328	0.360	47.56	8.35	5.69
+ 1% Black Fe	7.39	0.328	0.360	37.53	7.76	4.84

<u>WL</u>	<u>383</u>	<u>+1% TiO₂</u>	<u>+1%Fe</u>	<u>WL</u>	<u>383</u>	<u>+1%TiO₂</u>	<u>+1% Fe</u>
600	7.11	7.16	6.65	740	32.95	32.84	28.11
610	7.12	7.14	6.64	750	38.52	38.67	32.22
620	7.32	7.36	6.83	760	43.58	44.27	35.84
630	7.69	7.73	7.18	770	47.44	48.76	38.61
640	8.13	8.16	7.58	780	49.71	51.55	40.26
650	8.45	8.45	7.86	790	51.09	53.32	41.28
660	8.90	8.92	8.27	800	51.92	54.32	41.93
670	9.58	9.59	8.91	810	52.32	54.84	42.22
680	10.69	10.69	9.89	820	52.51	55.13	42.43
690	12.49	12.47	11.50	830	52.74	55.35	42.63
700	15.03	15.01	13.72	840	52.81	55.50	42.72
710	18.38	18.31	16.60	850	52.88	55.56	42.75
720	22.68	22.55	20.13	860	52.94	55.63	42.86
730	27.52	27.34	23.95				

Ferro Corporation Contacts

- **Terry Sliwinski 216-750-7390 Fax 216-750-6351 Email: sliwinski@ferro.com**
- **Ken Loye 216-750-7511 Fax 216-750-6536 Email: loyek@ferro.com**
- **Robert Blonski 216-750-6959 Fax 216-750-6351 Email: blonskib@ferro.com**

- **Spectrophotometers**

- **Perkin-Elmer Lambda 19 250-2500nm**
- **Match Scan II Diano Hardy 400-1000nm**
- **Cary Varian 500 UV/Vis 250-2500nm**

- **Mailing Address**

**Ferro Corporation
4150 E. 56th Street
Cleveland, OH 44105
Dock #4**

Information Sources

- Specifications:
 - www.dodssp.daps.dla.mil
 - Click Assist
 - Click Assist Quick Search
 - Click Quick Search
 - Type in 5 Digit Document number
- Federal Standard Color Chips
 - www.ipmsusa.org/Links/FS595Purchase.html