Anime Cel Pigment References Preservation Project (v1.1)

Technical specifications for STAC / Taiyo-Shikisai /
USA-Cartoon Colour Cel-Vinyl colour charts
including sRGB / CMYK / PANTONE matching system.

Version 1.1 • August, 2025
European ICC Profile (ECI/FOGRA)
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Technical Colour Workflow for almost any classic Anime / Cel Pigment Charts

SUMMARY

This document consolidates sources, specifications, decisions,

and reference code to generate sRGB, CMYK samples

and identify closest Pantone tones from CIE L*a*b* values for:

* **スタック**（*STAC：Saito Tele-Anima Colors Co. Ltd.*）

* **太陽色彩**（*TAIYO-SHIKISAI/ 太陽色彩株式会社 ANIMATION. PAINT*）

* **Cartoon Cel-Vinyl** Colour Charts

Version: 1.1 • Date: 24/08/2025 • Scope: Europe (ICC ECI/FOGRA commercial printing profiles)

1. Sources (LAB, RGB, Hex sRGB, Hex ProPhoto, HSL)

The colour specifications originate from captures and measurements performed on pigment charts for cels (vinyl). Original dataset (with no Pantone nor CMYK conversions) was sourced from the Kanzenshuu community forum:

https://www.kanzenshuu.com/forum/viewtopic.php?t=19448

A large part of this work has been based on the complete spectrophotometry carried out for that document. Unfortunately, it has not yet been possible to locate and contact the person who performed those measurements.
This project, and this document, will be updated once contact is established.

– Original Measuring Details –

Measuring Device	Date Created	Notes
Epson Perfection v600	2021-12-27	48-bit scanning, ProPhoto RGB embedded ICC profile
ColourMunki Photo	2024-05-23	Spectrophotometric remeasurement D50/2° standard observer
X-Rite i1Pro 2	2025-04-09	Final wide-gamut capture addressing metamerism issues

– Technical scanning and conversion specifications notes –

• Many pigment Colours exceed sRGB gamut boundaries. Accurate display requires Rec.2020 compatible monitors (limited availability as of 2021).

• Original charts scanned at 48-bit depth, saved as TIFF with embedded ProPhoto RGB ICC profile for maximum Colour fidelity.

• Spectrophotometric remeasurement provided device-independent CIE L*a*b* values as ground truth references.

• Derived sRGB values computed from L*a*b* coordinates with gamut clipping applied when Colours fall outside sRGB boundaries.

• Neutral reference points standardized:Closest Pantone calculation from L*a*b* (ΔE00)

BLACK at LAB(6,0,0) sRGB(19,19,19), WHITE at LAB(95,0,0) sRGB(240,240,240)

• STAC <-> Taiyo-Shikisai **conversions implemented via Toei Animation in-house lookup table** (not physically equivalent Colours).

• Physical chart aging and yellowing affected low-saturation/high-lightness samples. Retrobright treatment applied to restore accuracy.

– Database evolution timeline –

Date	Update Description
2025-08-24	**Consolidation for STAC / TAIYO / USA CARTOON colour charts by including CMYK and closest Pantone values (using a PSOcoated V3 ICC colour profile).** **All the colour charts catalogued in one document (this one!) as faithfully as possible to the original values, both in print (CMYK) and digitally on screen (sRGB).**
From here backwards, it corresponds to the original Excel work provided in the forum	
2022-05-18	Integration of older STAC chart scan Colour code nomenclature updates Deprecated codes mapping established
2022-07-25	ProPhoto RGB hexadecimal values added for workflow convenience
2023-01-19	Complete X-Colour chart digitization

2023-01-20	STAC A-Colour (those created by TOEI for USA animes) chart integration
2023-01-27	sRGB HSL values computed and added for UI/web design applications
2023-02-21	STAC Taiyo-Shikisai conversion table implemented from Toei reference
2023-04-30	Taiyo-Shikisai 595-Colour edition 8-booklet comprehensive scan
2024-01-15	Extended STAC Taiyo-Shikisai mapping with additional missing entries
2024-05-13	STAC spectrophotometric recapture replacing scanner-based measurements
2024-05-15	Sun Colour spectrophotometric update scanner version retained as reference
2024-05-29	X-Colour and A-Colour post-retrobright recapture with enhanced accuracy
2025-02-01	Cel-Vinyl chart addition wide-gamut colours beyond instrument limits
2025-04-09	Comprehensive i1Pro2 recapture metamerism correction for violet/pink hues

2) ICC profiles and European selection (ECI/FOGRA)

For European commercial offset printing on coated substrates, the workflow employs **PSO Coated V3** (European Colour Initiative) as the primary CMYK destination profile.

This profile represents current industry standards for high-quality commercial printing and supersedes historical FOGRA39 in contemporary workflows.

Screen display maintains sRGB IEC61966-2-1 ICC profile compliance for maximum device compatibility and consistent Colour reproduction across standard monitors.

– Technical Profile Specification –

- **CMYK Output Profile:** PSO Coated v3 (ECI) - European commercial coated paper standard
- **Colour Reference Space:** CIE L*a*b* D50/2° standard observer (device-independent ground truth)
- **RGB Working Space:** sRGB IEC61966-2-1 for display, ProPhoto RGB for archival/editing
- **Gamut Management:** Out-of-gamut Colours handled via ICC profile rendering intent (perceptual/relative Colourimetric)
- **Alternative Substrates:** FOGRA52 (uncoated), PSO Uncoated v3 (uncoated), FOGRA51 (newsprint)

Through the original script, using the Pantone-to-Lab CSV, it is possible to choose the ICC profile in use.

NOTE: This will positively affect the final colour displayed in CMYK; as an advantage, it allows adapting the document to any printing house in the world that may require any other type of ICC.

3) Colour Processing: Technical Decisions

The colour space conversion implements a two-stage transformation pipeline to ensure compatibility with standard imaging libraries:

(i) CIE L*a*b* □ sRGB intermediate conversion, followed by (ii) sRGB CMYK conversion by using **PSO Coated V3 ICC** profile.

– Data Preservation Strategy –

```
# Original data always preserved
original_data = {
    'L': 25.4,    # 1 decimal precision
    'a': -1.5,    # 1 decimal precision
    'b': -5.0,    # 1 decimal precision
    'R': 55, 'G': 61, 'B': 68  # Integer values
}

# Computed data maintains separate namespace
computed_data = {
    'C': 9.41,    # 2 decimal precision
    'M': 5.88,    # 2 decimal precision
    'Y': 14.12,   # 2 decimal precision
    'K': 0.00     # 2 decimal precision
}
```

– Colorimetric Conversion Chain –

```
def lab_to_cmyk(self, L, a, b):

    """
    Convert LAB to CMYK using ICC profile transformation

    Critical decisions:
    1. Relative Colorimetric rendering intent
    2. Black Point Compensation enabled
    3. PSOcoated_v3.icc for print accuracy
    """

    # Validate and clamp input values
    L_val = max(0, min(100, float(L)))
    a_val = max(-128, min(127, float(a)))
    b_val = max(-128, min(127, float(b)))

    # PIL LAB format conversion
    lab_image = Image.new("LAB", (1, 1))
    lab_image.putpixel((0, 0), (

        int(L_val * 2.55),      # L* 0-100 → 0-255
        int(a_val + 128),       # a* -128..127 → 0-255
        int(b_val + 128)        # b* -128..127 → 0-255

    ))

    # Transform using ICC profile
    cmyk_image = ImageCms.applyTransform(lab_image, self.transform)
    c, m, y, k = cmyk_image.getpixel((0, 0))

    return (c/255.0)*100, (m/255.0)*100, (y/255.0)*100, (k/255.0)*100
```

– Presicion Requeriments – Decimal precision standards –

Data Type	Precision	Rationale
LAB Values	1 decimal	Industry standard, adequate for visual discrimination
XYZ Tri-stimulus	1 decimal	Matches spectrophotometer output precision
RGB Values	Integer	8-bit color depth standard
CMYK Percentages	2 decimals	Print industry requirement for dot gain calculations
Delta E CIE2000	3 decimals	Critical for <1.0 imperceptible threshold detection
Hex Values	Standard	#RRGGBB format, uppercase

– Presicion Requeriments – Delta E Thresholds –

```
DELTA_E_THRESHOLDS = {

    'imperceptible': 1.0,      # JND (Just Noticeable Difference)
    'barely_perceptible': 3.0, # Trained observer threshold
    'perceptible': 6.0,        # Average observer threshold
    'clearly_visible': 10.0    # Obvious color difference

}
```

– Delta E CIE-2000 Implementation –

The colour space conversion also implements a two-stage transformation pipeline to ensure compatibility with standard imaging libraries:

```
def calculate_delta_e_cie2000(self, lab1, lab2):
    """
    CIE2000 Delta E calculation with complete implementation

    Key improvements over CIE76/CIE94:
    - Accounts for blue region distortions
    - Improved neutral color handling
    - Perceptually uniform chroma scaling
    """
    L1, a1, b1 = lab1
    L2, a2, b2 = lab2

    # Weighting factors (industry standard)
    kL = kC = kH = 1.0

    # Chroma calculation with G factor correction
    C1 = math.sqrt(a1**2 + b1**2)
    C2 = math.sqrt(a2**2 + b2**2)
    C_avg = (C1 + C2) / 2.0

    # G factor for improved chroma scaling
    G = 0.5 * (1 - math.sqrt(C_avg**7 / (C_avg**7 + 25**7)))

    # Prime values with G correction
    a1_prime = a1 * (1 + G)
    a2_prime = a2 * (1 + G)

    # Continue with CIE2000 algorithm...
    # [Full implementation in color_processor.py]
```

– Quality Assesment Framework –

```
def categorize_delta_e(self, delta_e):

    """Categorize conversion quality based on Delta E"""
    if delta_e < 1.0:

        return 'excellent'      # Imperceptible difference
    elif delta_e < 3.0:

        return 'good'           # Barely perceptible
    elif delta_e < 6.0:
        return 'acceptable'     # Noticeable but usable

    elif delta_e < 10.0:

        return 'problematic'    # Clearly visible

    else:
        return 'unacceptable'   # Significant color shift
```

4) Closest Pantone calculation from L*a*b* (ΔDE00)

Pantone Colour matching employs CIE ΔDE00 (CIEDE2000) Colour difference formula to quantify perceptual Colour differences between target CIE *L*a*b** coordinates and Pantone Solid Coated (C) reference library.

The algorithm identifies the Pantone Colour with minimumΔDE00 value, providing the closest perceptual match.

CIEDE2000 (ΔDE00) represents the most advanced Colour difference formula, incorporating corrections for lightness, chroma, and hue perception non-linearities, particularly in blue and gray regions where human visual system exhibits reduced discrimination sensitivity.

– Euclidean Distance in Perceptual Space –

```
def find_closest_pantone(self, L, a, b, max_delta_e=None):
    """
    Pantone matching using CIE2000 in LAB space

    Decision rationale:
    - LAB space provides perceptual uniformity
    - CIE2000 handles edge cases better than CIE76
    - Database of 2000+ Pantone colors with LAB values
    """

    input_lab = (float(L), float(a), float(b))
    best_match = None
    min_delta = float('inf')

    for pantone in self.pantone_database:
        pantone_lab = (pantone['L'], pantone['a'], pantone['b'])
        delta_e = self.calculate_delta_e_cie2000(input_lab, pantone_lab)
```

```
        if delta_e < min_delta:
            min_delta = delta_e
            best_match = pantone

    return best_match['name'], best_match['code'], min_delta
```

– ΔE00 interpretation –

- **ΔDE00 < 1.0:** Imperceptible difference under standard viewing conditions
- **ΔDE00 1.0-2.0:** Barely perceptible to trained observers under optimal conditions
- **ΔDE00 2.0-5.0:** Noticeable difference but acceptable for commercial applications
- **ΔDE00 5.0-10.0:** Clear colour difference, requires attention in critical applications
- **ΔDE00 > 10.0:** Distinctly different colours, unsuitable for colour matching.

– Technical limitations / Accuracy considerations –

- Some colours may exceed Pantone gamut boundaries, resulting in ΔE00 > 5.0
- Colour matches under D50º illuminant may vary under different light sources
- Pantone physical standards have ±1.5 ΔDE00 manufacturing tolerance.
- Fluorescent or metallic pigments cannot be accurately matched.
- Individual Colour perception differences may affect the results.

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5) Conversion Quality Metrics

For professional Colour documentation r**equiring both screen display and print reproduction**, the recommended format presents dual Colour visor (sRGB and real CMYK simulation) accompanied by comprehensive technical data tables, by ensuring accurate colour communication across digital and print media workflows.

Future EPUB implementation should embed RGB Colour swatches with sRGB ICC profile metadata while maintaining numeric Colour data in accessible text format.

PDF/X standards are reserved for pre-press applications requiring embedded CMYK Colour spaces.

```
class QualityMetrics:
    def __init__(self, conversion_results):
        self.cmyk_deltas = [r['cmyk_delta_e00'] for r in conversion_results]
        self.pantone_deltas = [r['pantone_delta_e00'] for r in conversion_results
                              if r['pantone_delta_e00'] is not None]

    def calculate_statistics(self):
        return {
            'cmyk_mean_delta': statistics.mean(self.cmyk_deltas),
            'cmyk_median_delta': statistics.median(self.cmyk_deltas),
            'pantone_mean_delta': statistics.mean(self.pantone_deltas),
            'excellent_rate': self.count_by_quality('excellent') / len(self.cmyk_deltas),
            'problematic_rate': self.count_by_quality('problematic') / len(self.cmyk_deltas)
        }
```

– Expected Quality Benchmarks –

Metric	Target	Rationale
CMYK Mean ΔE	< 3.0	Acceptable for print production
Excellent Rate	> 60%	Majority of colors imperceptible difference
Problematic Rate	< 10%	Minimize clearly visible color shifts
Pantone Match Rate	> 80%	Industry database completeness

– ICC Profile Integration Method –

```
# Profile Selection Rationale

ICC_PROFILE_DECISIONS = {
    'primary': 'PSOcoated_v3.icc',
    'reason': 'ISO 12647-2 standard for offset printing',
    'characteristics': {
        'gamut': 'Optimized for coated paper printing',
        'black_generation': 'GCR (Gray Component Replacement)',
        'rendering_intent': 'Relative Colorimetric',
        'black_point_compensation': True
    }
}
```

– Rendering Intent Analysis –

```
RENDERING_INTENTS = {
    'perceptual': {
        'use_case': 'Photographic images',
        'gamut_mapping': 'Compresses entire gamut proportionally',
        'decision': 'Not chosen - too much color shift for spot colors'
    },
    'relative_colorimetric': {
        'use_case': 'Spot colors and logos',
        'gamut_mapping': 'Clips out-of-gamut colors to nearest equivalent',
        'decision': 'CHOSEN - Preserves in-gamut colors exactly',
        'black_point': 'Compensated to avoid gray shifts'
    }
}
```

– Batch Processing Strategy Adopted –

```
class BatchProcessor:

    def __init__(self, chunk_size=100):
        self.chunk_size = chunk_size

    def process_colors_batch(self, color_data):
        """
        Process colors in chunks to optimize memory usage
```

```
        and provide progress feedback
        """

        total_colors = len(color_data)
        processed = 0

        for chunk_start in range(0, total_colors, self.chunk_size):

            chunk_end = min(chunk_start + self.chunk_size, total_colors)
            chunk = list(color_data.items())[chunk_start:chunk_end]



            # Process chunk with single ICC transform initialization

            for color_id, data in chunk:


                self.process_single_color(color_id, data)
                processed += 1

                if processed % 50 == 0:

                    progress = (processed / total_colors) * 100
                    print(f"Progress: {progress:.1f}% ({processed}/{total_colors})")
```

– Valitations & Testings –

```
def validate_conversion_quality(self, results):
    """
    Automated validation of conversion results

    Fails pipeline if quality thresholds not met
    """

    quality_checks = {
        'cmyk_extreme_delta': len([r for r in results if r['cmyk_delta_e00'] > 15]),
        'missing_pantone_rate': len([r for r in results if r['pantone_name'] == 'N/A']) /
len(results),
        'invalid_rgb_count': len([r for r in results if not r['has_valid_rgb']]),
        'color_space_violations': self.check_color_space_violations(results)
    }

    # Quality gates
    assert quality_checks['cmyk_extreme_delta'] < len(results) * 0.05, "Too many extreme CMYK
deltas"
    assert quality_checks['missing_pantone_rate'] < 0.3, "Pantone match rate too low"

    return quality_checks
```

6. Considerations

1. Wide Gamut Support

- Rec2020 color space integration for future displays
- Extended gamut Pantone colors

2. Machine Learning Enhancement

- Trained models for better Pantone matching
- Metameric color prediction

3. Real-time Processing

- GPU acceleration for ICC transformations
- Streaming pipeline for large datasets

– Quality Assurance and Validation Requirements –

- Verify sRGB display under D65º illuminant, validate CMYK proofs under D50º.
- Document out-of-gamut colours are noticed with indications.
- Check the colour reproduction across different operating systems and displays.
- Include textual Colour descriptions and num. values for vision-impaired users.
- Colours exceeding sRGB/CMYK gamut boundaries undergo automatic clipping with potential Colour shift.
- Results are computational approximations; physical verification with Pantone Colour Bridge required.
- Colour appearance depends on illuminant and observer; maintain D50/2° reference standard.
- Commercial printing introduces ±2-3 ΔE00 variation; specify acceptable tolerance ranges.

– Final Notes –

While the data capture has been carried out under the best possible technical conditions, this document cannot exactly substitute the precise colorimetric compositions used by the manufacturers. In fact, not even the manufacturers themselves could maintain 100% colorimetric accuracy when producing their pigments.

In any case, the aim of this project is to faithfully preserve the composition of each of the pigments that the animation industry presented to us.

If you want to preserve these colour charts in printed form, you can use your own ICC profiles (Remember to explain to your printer that the colours must not be converted, but rather the embedded ICC profile in the document must be used).

7. References

- https://www.kanzenshuu.com/forum/viewtopic.php?t=19448
- http://www.style.fm/as/05_column/tsujita/tsujita_bn.shtml
- https://animestyle.jp/column/
- https://www.nekomataya.info/

- **CIE Publication 15:2004** - Colorimetry, 3rd Edition
- **ISO 12647-2:2013** - Process control for offset lithographic processes
- **CIE Technical Report 224:2017** - Colour fidelity index for accurate scientific use
- **ICC.1:2010** - Image technology colour management — Architecture, profile format and data structure

— End of Technical Documentation —

Work done out of love for colour

and preservation of hand-made

anime material and techniques !