MOLEX MATERIAL SPECIFICATION – C51100 ALLOY METAL STRIPS

1.0 SCOPE

This specification covers the comprehensive technical requirements, applicable reference documents, and quality requirements for metal strips. The values listed for acceptance criteria are in SI.

2.0 PURPOSE

The purpose of this specification is to comprehensively define the Molex requirements for the alloy's chemical composition, physical properties, mechanical properties, and reference other applicable documents related to quality requirements and dimensional tolerances.

This specification, when constructed, referenced the requirements cited in the primary regional norms typically referenced for copper alloy strip manufacture in UNS C51100 alloy; ASTM B888M-13, EN 1654 (CuSn4), JIS H 3110 and ultra-fine grain (UFG) supplier citations.

3.0 REFERENCE DOCUMENTS

This primary specification focuses on the physics of C51100 alloy and related mechanical properties to ensure Molex product performance. Other Molex documents are necessary to verify material characteristics that support high quality and manufacturability of products.

These reference documents are crucial to the Molex process / product and therefore all requirements contained within them must be attested to and demonstrate their conformance, within the supplier's process certification:

ASTM B888M / ASTM B103M and the associated reference documents listed under Section 2.1 *ASTM Standards*
ASTM B820 is specifically mentioned as critical to Molex formability requirements
JIS H3110 and UFG supplier citations (< 4µm)
2090580043 Geometric Conditions and Tolerances for Metal Strips
2090580044 Metal Strip Surface conditions and Requirements

4.0 ORDER OF PRECEDENCE

This defines the priority order that should be followed when reviewing attributes and requirements of metal strip:

1. Molex Purchase Order
2. Packaging Specifications
3. Molex (Individual) Metal Strip Specification (i.e. Part Number Specification)
4. Molex Material Alloy Specification (**This document –** 2090580051– Molex Material Specification – C51100 Alloy Metal Strips)
5. Surface (2090580044) and Geometric (2090580043) Global Engineering Specifications

5.0 DEFINITIONS

Ultrafine grain (UFG) – is defined as a “ready-to-finish” grain size of less than 0.004 mm (< 4µm).

6.0 TECHNICAL REQUIREMENTS

6.1 Chemical Composition

UNS #	Cu wt.%	Pb wt.%	Fe wt.%	P wt.%	Sn wt.%	Zn wt.%
C51100[2]	Remainder	≤ 0.05	≤ 0.10	0.03 – 0.35	3.5 – 4.9	≤ 0.30

2. Copper + Sum of Named Elements = 99.5% min.
Limits for unnamed elements may be established between Molex and the supplier to satisfy certain environmental or customer requirements.

6.2 Mechanical Properties (longitudinal direction)

Mechanical Properties Table C51100				
Designation	**Tensile Strength (1)**	**Yield Strength (1)**	**Elongation %**	**RTF Grain size (2)**
	(MPa)	0.2% offset (MPa)	in 50 mm	(mm)
061	315 - 370	≥ 110	≥ 45	N/A
H01	315 - 400	≥ 140	≥ 25	≤ 0.030
H02	380 - 485	≥ 290	≥ 12	≤ 0.010
H03	460 - 565	≥ 420	≥ 6	≤ 0.010
H04	495 - 600	≥ 465	≥ 2	≤ 0.010
H06	580 - 685	≥ 550	≥ 1	≤ 0.010
H06 UFG	580 - 680	≥ 530	≥ 13	< 0.004
H08	625 - 725	≥ 595	≥ 1	≤ 0.010
H08 UFG	660 - 760	≥ 630	≥ 7	< 0.004
H10	660 - 750	≥ 630	≥ 1	≤ 0.010
H10 UFG	700 - 800	≥ 690	≥ 3	< 0.004

Notes:

(1) Tensile requirements are longitudinal values in uniaxial tension in accordance with ASTM E8M

(2) Ready to Finish (RTF) grain size is measured before final rolling for the H tempers. The measurement of (RTF) grain size in the UFG tempers is typically verified by uniaxial tension values

(3) Temper Designations; 061, H01 and H02 are extracted from ASTM B888

(4) Temper Designations; H03, H04, H06, H08 and H10 are extracted from ASTM B888 Tensile values, with reduced yield strengths derived from the fine grain sizes

(5) Temper Designations; H06 UFG (ultrafine grain), H08 UFG and H10 UFG are derived from UFG supplier citations

6.3 Electrical Conductivity (SnP bronze conductivity is strongly influenced by chemical composition)

6.3.1 For annealed temper (“O” temper code) the minimum requirement shall be:
- Direct Chill (DC) cast and hot rolled: 12 MS/m (21% IACS) @ 20ºC
- Continuous Cast and cold rolled: 10.5 MS/m (18% IACS) @ 20ºC

6.3.2 For rolled tempers (“H”, “HR” temper codes) the minimum requirement shall be 10.3 MS/m (17.7% IACS) @ 20ºC

6.3.3 The test standard shall be ASTM E 1004 (eddy current) or ASTM B 193 (resistivity)

6.4 Bending properties

Bending of metal strip samples shall be in accordance with ASTM B820; Bend Test for Formability of Copper Alloy Spring Material. The requirement is that the supplier’s material when tested at finished thickness and temper shall achieve the inside bend radii as listed in the table below without observable cracking on the outside bend radius (reference 5.4.1.)

If special forming requirements are necessary, those will be listed separately on the part number document.

H04	90° GW	180° GW	90° BW	180° BW
Thickness	10:1 w/t		10:1 w/t	
0.51-1.0 mm	-	-	-	-
0.3-0.5 mm	0.5 r/t	0.5 r/t	0.5 r/t	2.0 r/t
0.15-0.29 mm	0.5 r/t	0.5 r/t	0.5 r/t	2.0 r/t
≤0.149 mm	0.5 r/t	0.5 r/t	0.5 r/t	2.0 r/t

HR04	90° GW	180° GW	90° BW	180° BW
Thickness	10:1 w/t		10:1 w/t	
0.51-1.0 mm	-	-	-	-
0.3-0.5 mm	0.5 r/t	0.5 r/t	0.5 r/t	2.0 r/t
0.15-0.29 mm	0.5 r/t	0.5 r/t	0.5 r/t	2.0 r/t
≤0.149 mm	0.5 r/t	0.5 r/t	0.5 r/t	1.5 r/t

H06	90° GW	180° GW	90° BW	180° BW
Thickness	10:1 w/t		10:1 w/t	
0.51-1.0 mm	-	-	-	-
0.3-0.5 mm	0.5 r/t	1.5 r/t	2.0 r/t	3.5 r/t
0.15-0.29 mm	0.5 r/t	1.5 r/t	2.0 r/t	3.5 r/t
≤0.149 mm	0.5 r/t	1.5 r/t	2.0 r/t	3.5 r/t

HR06	90° GW	180° GW	90° BW	180° BW
Thickness	10:1 w/t		10:1 w/t	
0.51-1.0 mm	-	-	-	-
0.3-0.5 mm	0.5 r/t	1.0 r/t	1.0 r/t	3.0 r/t
0.15-0.29 mm	0.5 r/t	1.0 r/t	1.0 r/t	2.5 r/t
≤0.149 mm	0.5 r/t	0.8 r/t	0.8 r/t	2.0 r/t

H08	90° GW	180° GW	90° BW	180° BW
Thickness	10:1 w/t		10:1 w/t	
0.51-1.0 mm	-	-	-	-
0.3-0.5 mm	2.0 r/t	3.0 r/t	6.0 r/t	9.0 r/t
0.15-0.29 mm	2.0 r/t	3.0 r/t	6.0 r/t	9.0 r/t
≤0.149 mm	2.0 r/t	3.0 r/t	6.0 r/t	9.0 r/t

HR08	90° GW	180° GW	90° BW	180° BW
Thickness	10:1 w/t		10:1 w/t	
0.51-1.0 mm	-	-	-	-
0.3-0.5 mm	1.5 r/t	2.5 r/t	2.5 r/t	5.0 r/t
0.15-0.29 mm	1.5 r/t	2.5 r/t	2.5 r/t	5.0 r/t
≤0.149 mm	1.5 r/t	2.0 r/t	2.0 r/t	4.0 r/t

H06 UFG	90° GW	180° GW	90° BW	180° BW
Thickness	10:1 w/t		10:1 w/t	
0.51-1.0 mm	-	-	-	-
0.3-0.5 mm	0.5 r/t	0.5 r/t	0.5 r/t	1.5 r/t
0.15-0.29 mm	0.5 r/t	0.5 r/t	0.5 r/t	1.5 r/t
≤0.149 mm	0.5 r/t	0.5 r/t	0.5 r/t	1.0 r/t

H08 UFG	90° GW	180° GW	90° BW	180° BW
Thickness	10:1 w/t		10:1 w/t	
0.51-1.0 mm	-	-	-	-
0.3-0.5 mm	1.0 r/t	2.0 r/t	2.5 r/t	4.0 r/t
0.15-0.29 mm	1.0 r/t	2.0 r/t	2.0 r/t	4.0 r/t
≤0.149 mm	1.0 r/t	1.5 r/t	1.5 r/t	3.5 r/t

H10 UFG	90° GW	180° GW	90° BW	180° BW
Thickness	10:1 w/t		10:1 w/t	
0.51-1.0 mm	-	-	-	-
0.3-0.5 mm	1.0 r/t	4.0 r/t	4.0 r/t	-
0.15-0.29 mm	1.0 r/t	3.5 r/t	3.5 r/t	-
≤0.149 mm	1.0 r/t	3.5 r/t	3.5 r/t	-

Notes:

(1) W/t = width to thickness ratio (defining bending width). r/t = inside bend radius to thickness ratio

(2) It is the expectation that tempers lower than H04 will possess bend formability that is as good (or better) than the values listed for the H04 temper.

6.4.1 Acceptance Criteria for Bending

Bending Observations	Acceptance Criteria	Rank
	"Accepted", smooth, no orange peel, no cracks	1
	"Accepted", small orange peel, no cracks	2
	"Accepted", heavy orange peel, no cracks	3
	"Rejected", heavy orange peel, shallow cracks	4
	"Rejected", heavy orange peel, deep cracks	5

6.5 Stress Relaxation Resistance (in accordance with ASTM E 328)*

C51100 Alloy (10µ grain) Stress Relaxation in Percent Retained @ 1000 Hours						
Temp °C	50% $R_{p0.2}$∥	80% $R_{p0.2}$∥	100% $R_{p0.2}$∥	50% $R_{p0.2}$⊢	80% $R_{p0.2}$⊢	100% $R_{p0.2}$⊢
75	98%	97%	76%	97%	96%	75%
100	94%	93%	71%	93%	92%	70%
125	83%	82%	59%	82%	81%	58%
150	68%	67%	43%	67%	66%	42%

C51100 Alloy (< 4µ grain) Stress Relaxation in Percent Retained @ 1000 Hours						
Temp °C	50% $R_{p0.2}$∥	80% $R_{p0.2}$∥	100% $R_{p0.2}$∥	50% $R_{p0.2}$⊢	80% $R_{p0.2}$⊢	100% $R_{p0.2}$⊢
75	97%	96%	75%	96%	95%	74%
100	94%	93%	71%	93%	92%	70%
125	79%	78%	55%	78%	77%	54%
150	60%	59%	35%	59%	58%	34%

*Annual test data certification required

7.0 CERTIFICATION REQUIREMENTS

Certification at P.O. Level	Supplied Data at P.O. Level	Annual Capability Statement	Engineering Data by Request
Chemical Compostion (data)		Chemical Capability	
Tensile (data)		Tensile Capability	Transverse properties
Yield (data)		Yield Capability	Spring Bending Limit
Elongation (data)			
Grain size (data)			
			Elastic Modulus (data)
Thickness (data)		Thickness Capability	
Width (data)		Width Capability	
Camber (pass/fail)			
Surface Roughness (data)			
		Stress Relaxation Verification	
Burr (pass/fail)			
Bend Formability (pass/fail)			ASTM B820 Appendix narrow beam reporting table, or other
Electrical Conductivity (data)			
			Other Physical Properties
Reference Documents (pass/fail)			

7.1 Requirements for "Annual Capability Assessment" of critical characteristics

7.1.1 Chemical composition requires a statistical assessment on an annual basis to verify capability. This assessment be on file and available to Molex when requested.

7.1.2 Mechanical properties requires a statistical assessment on an annual basis to verify capability. This assessment be on file and available to Molex when requested.

7.1.3 Dimensional tolerances, requires a statistical assessment on an annual basis to verify capability. This assessment be on file and available to Molex when requested.

7.1.4 Stress relaxation resistance is to be verified for a temper and a process in the H04 to H08 designation range at 80% of yield strength for 1000 hours at 75ºC and 125ºC. The supplier shall select and active Molex item to fulfill this requirement. It is acceptable to utilize Larson Miller Parameters to facilitate this annual verification audit.

7.2 Engineering Data

Acceptance of this material specification and the requirements include the supplier's commitment to provide other engineering data when requested. These types of data may include transverse properties, spring bending limits or other physical properties of this material.

7.3 Recent Change Summary

Document ID# Change from **400005026-ES** → **2090580051**.

Updated **Section 3: Reference Documents** to reflect new **2090580043** and **2090580044** titles and content.

Removed **ES-40000-5006: Mechanical Tool-Wear Test Standard** from **Section 3: Reference Documents** due to obsolescence.

Added **Section 4: Order of Precedence**.

Removal of what was previous **Section 6: Dimensional Requirements**

- All current Geometric and Dimensional Requirements are contained in **2090580043: GEOMETRIC CONDITIONS AND TOLERANCES FOR METAL STRIPS**. Including:
  - Strip Thickness
  - Strip Width
  - Burr
  - Camber
- All current Surface Condition Requirements are contained in **2090580044: METAL STRIP SURFACE CONDITIONS AND REQUIREMENTS**. Including:
  - Surface Roughness