Molex, LLC.
Product Compliance

Substance Testing Requirements for Trace Analysis of Prohibited Substances

1.0 Purpose

The purpose of this standard is to ensure the consistency and accuracy of the substance test data reported to Molex and by Molex. This standard establishes the minimum requirements for the testing methods, standards, capable instrumentation, and reporting requirements when performing substance testing of materials to determine compliance to legislation, industry standards, or customer requirements.

2.0 Overview

Applicability to raw materials, components, and/or finished goods:	This standard establishes the minimum requirements for the substance testing of prohibited substances used globally either within Molex or on Molex's behalf. These requirements apply to testing of raw materials or components purchased by Molex, and/or finished goods that have been disassembled to homogeneous materials.

3.0 Revision History

This document supersedes all previous revisions.

Revised Date:	May 15th, 2020
Reviewed Date:	May 15th, 2020
Revision Details:	Updated document format Updated test methodologies and reference standards Removed MDLs as they are covered by reference standards

4.0 Definitions

4.1 Reference Documents

- IEC 62321 series of standards: Determination of certain substances in electrotechnical products.
- BS EN 14582: Characterization of waste. Halogen and sulfur content. Oxygen combustion.
- Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS).
- European Union Commission Delegated Directive EU 2015/863 amending Annex II of Directive 2011/65/EU, adopted on 31 December 2016.

4.2 Table of Abbreviations

AAS	Atomic Absorption Spectrometer
Be	Beryllium
Br	Bromine
Cd	Cadmium
Cr	Chromium (elemental)
Cr6+	Hexavalent chromium
CV-AAS	Cold-Vapor – Atomic Absorption Spectroscopy
CV-AFS	Cold-Vapor – Atomic Fluorescence Spectrometer
DI water	De-ionized water
DMA	Direct Mercury Analysis
g	grams
GC-MS	Gas Chromatograph – Mass Spectrometer
HBCDD	Hexabromocyclododecane
Hg	Mercury
HPLC	High-Performance Liquid Chromatograph
IC	Ion Chromatograph
ICP	Inductively Coupled Plasma
L	Liters
mL	Milliliters
Pb	Lead
PBB	Polybrominated biphenyl
PBDE	Polybrominated diphenyl ether
ppm	Parts per million by weight
Sb	Antimony
UV / VIS	Ultraviolet / Visible Spectrometer

4.3 Technical Definitions

4.3.1 Analysis Sample

The analysis sample is the material sample which has been prepared, stripped, and/or diluted and is ready for analysis.

4.3.2 Analyte

An analyte is the substance or chemical constituent that is being measured in an analytical procedure.

4.3.3 Brominated Flame Retardants

Brominated flame retardants are a group of chemicals added to materials, alone or in synergy with other compounds, in order to reduce flammability. These organic compounds, such as polybrominated biphenyl, polybrominated diphenyl ether, and hexabromocyclododecane contain the element bromine which has the atomic number 35.

4.3.4 Calibration Blank

A calibration blank is a sample which consists of reagent water and all reagents used during the entire analytical procedure. The calibration blank is used to determine the error in the measurement due to the contribution of the reagents and the preparative analytical steps.

4.3.5 Calibration Standard

A calibration standard is a certified reference material used in the determination, by measurement or comparison, of the nominal value of each reading on a measuring instrument. The calibration standard certification shall be obtained from a recognized, accredited test and measurement standard laboratory (e.g. NIST).

4.3.6 Diluent

The diluent is a solvent used to dilute or carry the sample so the analysis can be performed.

4.3.7 Duplicate Sample

A duplicate sample is a separate material sample analyzed for the same constituent at the same time as the analysis sample, under the same conditions.

4.3.8 Dynamic Instrument Range

The dynamic instrument range is the concentration range over which a standard measurement is within 10% of the true value.

4.3.9 Halogen

A halogen is an element in the VII column of the periodic table. The halogens are fluorine (atomic number 9), chlorine (atomic number 17), bromine (atomic number 35), iodine (atomic number 53), and astatine (atomic number 85).

4.3.10 Hexavalent Chromium

Hexavalent chromium is chromium in the oxidation state of 6+; it can bond with 6 other atoms. Chromium has an atomic number of 24.

4.3.11 Homogeneous Material

A homogeneous material is a material that is of uniform composition throughout and that cannot be mechanically disjointed from different materials. For example, in terminals plated with both a nickel and a tin layer, the base metal (copper alloy) and each plating layer is considered a homogeneous material and

therefore must be considered separately. As another example, a cable is constructed of wire, insulation, jacketing and may be marked with ink. Each of these materials is considered a homogeneous material.

4.3.12 Intentionally Added

Intentionally added elements or compounds are deliberately added to the analyte during any part of the analysis.

4.3.13 Interference Sample

An interference sample is a sample prepared to determine any negative or distorting effect on the analysis.

4.3.14 Material Sample

The material sample represents the homogeneous material to be analyzed.

4.3.15 Method Detection Limit

The method detection limit is the constituent concentration in solution that, when processed through the complete method, produces a signal with 99% probability that it is different from the blank.

4.3.16 Phthalates

Phthalates are the dialkyl or aryl esters of 1,2 benzenedicarboxylic acid. Phthalates are primarily used as a plasticizer in PVC.

4.3.17 Reporting Limit

The reporting limit is the minimum concentration of the element or compound being analyzed that can be accurately quantified.

4.3.18 Screen Testing

Screen testing is a method used to determine the necessity of further analytical testing of the material sample to gain an understanding of its chemical composition.

4.3.19 Sample Matrix

The sample matrix is the known elements or substances at the expected concentrations found in the analysis sample. The sample matrix includes the digestion reagents and all the elements or substances in the material sample.

4.3.20 Spike Sample

A spike sample is an additional portion of a sample to which a known amount of the analyte of interest is intentionally added before sample preparation.

4.3.21 Thermal Decomposition

Thermal decomposition is partial or complete degradation of sample components using convection and conduction heating mechanisms resulting in the release of volatile components.

4.4 Instrumentation Definitions

4.4.1 Atomic Absorption Spectrometer (AAS)

AAS is an instrument that measures volatile metal complexes by measuring the amount of light absorbed. A sample is aspirated into a flame and atomized.

4.4.2 Cold Vapor – Atomic Absorption (CV-AAS)

CV-AAS is a subset of AAS. The sample is aspirated directly into an absorption cell where the amount of light absorbed is measured.

4.4.3 Cold Vapor – Atomic Fluorescence Spectrometer (CV-AFS)

CV-AFS is a subset of atomic fluorescence spectrometry (AFS). The sample is aspirated directly into an absorption cell where the amount of light that fluoresces is measured.

4.4.4 Direct Mercury Analysis (DMA)

DMA is an instrument for the determination of mercury using thermal decomposition for sample preparation and atomic absorption detection.

4.4.5 Gas Chromatograph – Mass Spectrometer (GC-MS)

GC is an instrument in which a chemical mixture is carried by a gas mobile phase through a stationary phase. The interaction of the vaporized sample traveling through the stationary phase separates into different components depending on differences in partition coefficients. MS is an instrument used along with GC which acts as the instrument detector. It is used as a technique for separating ions by their mass-to-charge (m/z) ratios.

4.4.6 High-Performance Liquid Chromatograph (HPLC)

HPLC is an instrument in which a chemical mixture is carried by a liquid mobile phase through a column containing a stationary phase. The interaction of the sample with the stationary phase selectively retains individual compounds thereby separating it into its components.

4.4.7 Ion Chromatograph (IC)

IC is an instrument in which a chemical mixture is carried into a stream of eluent onto a column of ion exchangers. The chemical mixture is separated into its component anions based on their relative affinities for a low capacity, strongly basic anion exchanger.

4.4.8 Inductively Coupled Plasma (ICP)

ICP is emission spectroscopy using a flowing stream of argon gas ionized by an applied radio frequency field used to determine metals in solution.

4.4.9 Ultraviolet / Visible Spectrometer (UV / VIS)

UV / VIS is an optical instrument for measuring properties of light in the visible or ultraviolet portion of the electromagnetic spectrum.

5.0 Procedures

The requestor shall provide the laboratory with this standard, supply adequate sample (as specified by the laboratory) for the test, and indicate the substances required to be tested. The requestor shall also indicate the type of material and intentionally added substances contained (if known) and if any special sample preparation steps are necessary (e.g. removal of plating from terminal). Many laboratories provide rush services; this shall be requested when necessary.

5.1 General Laboratory Practices and Demonstration of Capability

All laboratories shall be ISO 17025 accredited and shall follow the procedures of the IEC 62321 series of test methods to determine the levels of certain prohibited substances. In the event of conflicts between this standard and IEC 62321, this standard shall take precedence.

5.1.1 Instrument Maintenance

The instruments used for analysis shall be maintained per locally controlled work instructions.

5.1.2 Method Detection Limit Determination

The method detection limit shall be determined for each analyte of interest before data from any sample is reported. The detection limit shall be established as five standard deviations above the noise signal of the instrument. The standard deviation of the noise signal shall be determined per locally controlled work instructions.

5.1.3 Spike Sample

A spike sample shall be prepared by adding a known concentration of analyte to an analysis sample. The concentration of the addition should double the concentration of the analyte in the original analysis sample. The spike recovery shall be reported as % recovery. The % recovery shall be 80% to 120% of the expected recovery. A spike sample shall be analyzed with each set of 20 or fewer samples.

5.1.4 Duplicate Sample

A duplicate sample shall be processed independently throughout the entire sample preparation and analytical process. The duplicate results shall be reported as % difference between the two samples. The allowable % difference shall be determined from control charts that are locally controlled and documented in laboratory work instructions. A duplicate sample shall be analyzed with each set of 20 or fewer samples.

5.1.5 Dynamic Instrument Range

The concentration range over which a method has a linear or second order response shall be determined for each analyte of interest before data from any samples are reported. The dynamic instrument range shall be determined per locally controlled work instructions.

5.2 Collection of Material Sample

The material sample to be analyzed for prohibited substances shall be representative of the homogeneous material as manifested in the Molex final product. For example, each plating layer/finish and brass base of a plated terminal shall be tested separately as a homogeneous material. Acid stripping may be used to test plating layer/finish and brass base of a plated terminal. The material sample shall contain no more than 0.05% by weight of any materials other than the homogeneous material of interest. The method for collection of the material sample shall be defined per locally controlled work instructions.

In the case of material having multiple plating layers, each individual layer is not required to be separated. Layers that could not be cleanly separated shall be treated as a single homogeneous material per RoHS definition. However, if Molex customers have stricter requirements and requested in-depth analysis of each individual layer, Molex in turn may also request such testing be done. In those instances, Molex will communicate this requirement directly to the supplier. Upon such request only, test samples can be prepared using the method described in Appendix B.

Samples should be thoroughly dried prior to testing. For example, inks and adhesives should be dried before being sent for testing. Solder paste and wire must be reflowed prior to testing.

5.3 Analysis Method Minimum Requirements

All analytical methods used for determining prohibited substances shall be defined per locally controlled work instructions and shall satisfy the minimum requirements established below.

5.3.1 Brominated Flame Retardant (Including PBB/PBDE/HBCDD)

If bromine is intentionally added to the material, then GC-MS or HPLC analysis of brominated flame retardant shall be performed. If bromine is not intentionally added, then analysis time and costs may be reduced by doing a screen testing for bromine concentration using IC. When conducting bromine screen testing, if the elemental bromine concentration is equal to or exceeds 35% of the prohibited limit for brominated flame retardant, then GC-MS or HPLC analysis for brominated flame retardant shall be performed. Test methodology may be referenced per IEC 62321-6:2015 or newer.

5.3.1.1 Analysis Sample

To ensure the accuracy of the results, the analysis sample concentration shall be a minimum of 1.0000 grams / liter of homogeneous material in the diluent. The mass of the homogeneous material sample shall be determined by using an analytical balance capable of measuring 0.0002 grams.

5.3.1.2 Calibration Blank

A calibration blank shall be analyzed along with the analysis sample to determine the contribution of contamination from the reagents and the analysis sample preparation process. The calibration blank shall be prepared using the same concentrations of solutions used to digest, extract, and prepare the analysis sample and treated exactly as the analysis sample, including exposure to all equipment, glassware, procedures, as well as reagents. No bromine or brominated flame retardant shall be intentionally added.

5.3.1.3 Interference Sample

An interference sample shall be analyzed along with the analysis sample to determine retention time interferences with the bromine or brominated flame retardant and shall produce less than a 5% contribution to the bromine or brominated flame-retardant reading. The interference sample shall be created by dissolving all the substances intentionally comprising the composition

of the homogeneous material sample into a solution prepared in the same manner as the calibration blank. The concentrations of the substances present in the interference sample shall be equivalent to the concentrations of those same substances expected in the analysis sample.

5.3.1.4 Calibration Standard

The instrument shall be calibrated with a minimum of three calibration standards and a calibration blank. The standards shall be created by diluting bromine or brominated flame retardant certified standard to the needed concentration in the expected sample matrix and the calibration blank shall be prepared in the same reagents as the standards. The calibration standards shall have concentrations of bromine or brominated flame retardant that bracket the expected concentration of the analysis sample and that are within the method dynamic range. One concentration of the bromine or brominated flame-retardant calibration standard shall be at or below the method detection limit. The second bromine or brominated flame-retardant calibration standard shall be at or near the mid-range of the method's dynamic range and the third calibration standard shall be at or near the upper limit of the dynamic range of the method.

5.3.1.5 Analysis Instrumentation

Screen testing for bromine shall be performed using IC. Testing for brominated flame retardant shall be performed using GC-MS or HPLC.

5.3.1.6 Reporting of Results

The results shall be reported as ppm by weight of bromine or brominated flame retardant in the homogeneous material. The reported amount of bromine or brominated flame retardant shall be determined by subtracting the analytical result for the calibration blank from the analytical result for the analysis sample. All results shall be from the dynamic range of the method. The reporting limit shall be 10 ppm for brominated flame retardant or 50 ppm for bromine.

5.3.2 Hexavalent Chromium

If chromium is intentionally added to the material, then analysis of hexavalent chromium shall be performed. If chromium is not intentionally added, then analysis time and costs may be reduced by doing a screen testing for elemental chromium concentration. When conducting chromium screen testing, if the elemental chromium concentration is equal to or exceeds the prohibited limit for hexavalent chromium, then analysis for hexavalent chromium shall be performed. Test methodology may be referenced per IEC 62321-7-1:2015 or newer for hexavalent chromium in plating / metal, or IEC 62321-7-2:2017 or newer for hexavalent chromium in polymers / electronics.

5.3.2.1 Analysis Sample

To ensure the accuracy of the results, the analysis sample concentration shall be a minimum of 1.0000 grams / liter of homogeneous material in the diluent. The mass of the homogeneous material sample shall be determined using an analytical balance capable of measuring 0.0002 grams.

5.3.2.2 Calibration Blank

A calibration blank shall be analyzed along with the analysis sample to determine the contribution of contamination from the reagents and the analysis sample preparation process. The calibration blank shall be prepared using the same concentrations of solutions used to digest, extract, and prepare the analysis sample and treated exactly as the analysis sample, including exposure to all equipment, glassware, procedures, as well as reagents. No chromium shall be intentionally added.

5.3.2.3 Interference Sample

An interference sample shall be analyzed along with the analysis sample to determine spectral line overlaps, broadened wings of intense spectral lines, scattered light from high concentrations of elements, turbidity, and chemical interferences. This interference sample shall produce less than a 5% contribution to the chromium or hexavalent chromium reading. The interference sample shall be created by dissolving all the substances intentionally comprising the composition of the homogeneous material sample into a solution prepared in the same manner as the calibration blank. The concentrations of the substances present in the interference sample shall be equivalent to the concentrations of those same substances expected in the analysis sample.

5.3.2.4 Calibration Standard

The instrument shall be calibrated with a minimum of three calibration standards and a calibration blank. The standards shall be created by diluting chromium or hexavalent chromium certified standard to the needed concentration in the expected sample matrix and the calibration blank shall be prepared in the same reagents as the standards. The calibration standards shall have concentrations of chromium or hexavalent chromium that bracket the expected concentration of the analysis sample and that are within the method dynamic range. One concentration of the chromium or hexavalent chromium calibration standard shall be at or below the method detection limit. The second chromium or hexavalent chromium calibration standard shall be at or near the mid-range of the method's dynamic range and the third calibration standard shall be at or near the upper limit of the dynamic range of the method.

5.3.2.5 Analysis Instrumentation

Screen testing for chromium shall be performed using ICP. Testing for hexavalent chromium shall be performed using UV / VIS.

5.3.2.6 Reporting of Results

The results shall be reported as ppm by weight of chromium or hexavalent chromium in the homogeneous material. The reported amount of chromium or hexavalent chromium shall be determined by subtracting the analytical result for the calibration blank from the analytical result for the analysis sample. All results shall be from the dynamic range of the method. The reporting limit shall be 10 ppm for chromium or hexavalent chromium.

5.3.3 Mercury

Test methodology may be referenced per IEC 62321-4:2013 or newer.

5.3.3.1 Analysis Sample

To ensure the accuracy of the results, the analysis sample concentration shall be a minimum of 1.0000 grams / liter of homogeneous material in the diluent. The mass of the homogeneous material sample shall be determined using an analytical balance capable of measuring 0.0002 grams.

5.3.3.2 Calibration Blank

A calibration blank shall be analyzed along with the analysis sample to determine the contribution of contamination from the reagents and the analysis sample preparation process. The calibration blank shall be prepared using the same concentrations of solutions used to digest, extract, and prepare the analysis sample and treated exactly as the analysis sample, including exposure to all equipment, glassware, procedures, as well as reagents. No mercury shall be intentionally added.

5.3.3.3 Interference Sample

An interference sample shall be analyzed along with the analysis sample to determine spectral line overlaps, broadened wings of intense spectral lines, scattered light from high concentrations of elements, and chemical interferences. This interference sample shall produce less than a 5% contribution to the mercury reading. An interference sample shall be created by dissolving all of the substances intentionally comprising the composition of the homogeneous material sample into a solution prepared in the same manner as the calibration blank. The concentrations of the substances present in the interference sample shall be equivalent to the concentrations of those same substances expected in the analysis sample.

5.3.3.4 Calibration Standard

The instrument shall be calibrated with a minimum of three calibration standards and a calibration blank. The standards shall be created by diluting a mercury certified standard to the needed concentration in the expected sample matrix and the calibration blank shall be prepared in the same reagents as the standards. The calibration standards shall have concentrations of mercury that bracket the expected concentration of the analysis sample and that are within the method dynamic range. One concentration of the mercury calibration standard shall be at or below the method detection limit. The second mercury calibration standard shall be at or near the mid-range of the method's dynamic range and the third calibration standard shall be at or near the upper limit of the dynamic range of the method.

5.3.3.5 Analysis Instrumentation

Analysis for mercury should be performed using CV-AFS, DMA, or ICP. If there is spectral interference in ICP, analysis using CV-AAS is acceptable. No other instrumentation is acceptable for analysis of mercury.

5.3.3.6 Reporting of Results

The results shall be reported as ppm by weight of mercury in the homogeneous material. The reported amount of mercury shall be determined by subtracting the analytical result for the calibration blank from the analytical result for the analysis sample. All results shall be from the dynamic range of the method. The reporting limit shall be 10 ppm for mercury.

5.3.4 Cadmium

Test methodology may be referenced per IEC 62321-5:2013 or newer.

5.3.4.1 Analysis Sample

To ensure the accuracy of the results, the analysis sample concentration shall be a minimum of 1.0000 grams / liter of homogeneous material in the diluent. The mass of the homogeneous material sample shall be determined using an analytical balance capable of measuring 0.0002 grams.

5.3.4.2 Calibration Blank

A calibration blank shall be analyzed along with the analysis sample to determine the contribution of contamination from the reagents and the analysis sample preparation process. The calibration blank shall be prepared using the same concentrations of solutions used to digest, extract, and prepare the analysis sample and treated exactly as the analysis sample, including exposure to all equipment, glassware, procedures, as well as reagents. No cadmium shall be intentionally added.

5.3.4.3 Interference Sample

An interference sample shall be analyzed along with the analysis sample to determine spectral line overlaps, broadened wings of intense spectral lines, scattered light from high concentrations

of elements, and chemical interferences. This interference sample shall produce less than a 5% contribution to the cadmium reading. The interference sample shall be created by dissolving all the substances intentionally comprising the composition of the homogeneous material sample into a solution prepared in the same manner as the calibration blank. The concentrations of the substances present in the interference sample shall be equivalent to the concentrations of those same substances expected in the analysis sample.

5.3.4.4 Calibration Standard

The instrument shall be calibrated with a minimum of three calibration standards and a calibration blank. The standards shall be created by diluting a cadmium certified standard to the needed concentration in the expected sample matrix and the calibration blank shall be prepared in the same reagents as the standards. The calibration standards shall have concentrations of cadmium that bracket the expected concentration of the analysis sample and that are within the method dynamic range. One concentration of the cadmium calibration standard shall be at or below the method detection limit. The second cadmium calibration standard shall be at or near the mid-range of the method's dynamic range and the third calibration standard shall be at or near the upper limit of the dynamic range of the method.

5.3.4.5 Analysis Instrumentation

Analysis of cadmium shall be performed using ICP. If there is spectral interference in ICP, analysis using AAS is acceptable.

5.3.4.6 Reporting of Results

The results shall be reported as ppm by weight of cadmium in the homogeneous material. The reported amount of cadmium shall be determined by subtracting the analytical result for the calibration blank from the analytical result for the analysis sample. All results shall be from the dynamic range of the method. The reporting limit shall be 5 ppm for cadmium in resins and 10 ppm for cadmium in all other materials.

5.3.5 Lead

Test methodology may be referenced by IEC 62321-5:2013 or newer.

5.3.5.1 Analysis Sample

To ensure the accuracy of the results, the analysis sample concentration shall be a minimum of 1.0000 grams / liter of homogeneous material in the diluent. The mass of the homogeneous material sample shall be determined using an analytical balance capable of measuring 0.0002 grams.

5.3.5.2 Calibration Blank

The calibration blank shall be analyzed along with the analysis sample to determine the contribution of contamination from the reagents and the analysis sample preparation process. The calibration blank shall be prepared using the same concentrations of solutions used to digest, extract, and prepare the analysis sample and treated exactly as the analysis sample, including exposure to all equipment, glassware, procedures, as well as reagents. No lead shall be intentionally added.

5.3.5.3 Interference Sample

An interference sample shall be analyzed along with the analysis sample to determine spectral line overlaps, broadened wings of intense spectral lines, scattered light from high concentrations of elements, and chemical interferences. This interference sample shall produce less than a 5% contribution to the lead reading. The interference sample shall be created by dissolving all the

substances intentionally comprising the composition of the homogeneous material sample into a solution prepared in the same manner as the calibration blank. The concentrations of the substances present in the interference sample shall be equivalent to the concentrations of those same substances expected in the analysis sample.

5.3.5.4 Calibration Standard

The instrument shall be calibrated with a minimum of three calibration standards and a calibration blank. The standards shall be created by diluting a lead certified standard to the needed concentration in the expected sample matrix and the calibration blank shall be prepared in the same reagents as the standards. The calibration standards shall have concentrations of lead that bracket the expected concentration of the analysis sample and that are within the method dynamic range. One concentration of the lead calibration standard shall be at or below the method detection limit. The second lead calibration standard shall be at or near the mid-range of the method's dynamic range and the third calibration standard shall be at or near the upper limit of the dynamic range of the method.

5.3.5.5 Analysis Instrumentation

Analysis of lead shall be performed using ICP. If there is spectral interference in ICP, analysis using AAS is acceptable.

5.3.5.6 Reporting of Results

The results shall be reported as ppm by weight of lead in the homogeneous material. The reported amount of lead shall be determined by subtracting the analytical result for the calibration blank from the analytical result for the analysis sample. All results shall be from the dynamic range of the method. The reporting limit shall be 30 ppm for lead.

5.3.6 Halogen

Test methodology may be referenced per EN 14582, or per IEC 62321-3-2:2013 or newer.

5.3.6.1 Analysis Sample

To ensure the accuracy of the results, the analysis sample concentration shall be a minimum of 1.0000 grams / liter of homogeneous material in the diluent. The mass of the homogeneous material sample shall be determined by using an analytical balance capable of measuring 0.0002 grams.

5.3.6.2 Calibration Blank

A calibration blank shall be analyzed along with the analysis sample to determine the contribution of contamination from the reagents and the analysis sample preparation process. The calibration blank shall be prepared using the same concentrations of solutions used to digest, extract, and prepare the analysis sample and treated exactly as the analysis sample, including exposure to all equipment, glassware, procedures, as well as reagents. No halogen shall be intentionally added.

5.3.6.3 Interference Sample

An interference sample shall be analyzed along with the analysis sample to determine retention time interferences. The interferences shall produce less than a 5% contribution to the halogen reading. The interference sample shall be created by dissolving all the substances intentionally comprising the composition of the homogeneous material sample into a solution prepared in the same manner as the calibration blank. The concentrations of the substances present in the interference sample shall be equivalent to the concentrations of those same substances expected in the analysis sample.

5.3.6.4 Calibration Standard

The instrument shall be calibrated with a minimum of three calibration standards and a calibration blank. The standards shall be created by diluting a halogen certified standard to the needed concentration in the expected sample matrix and the calibration blank shall be prepared in the same reagents as the standards. The calibration standards shall have concentrations of the halogen that bracket the expected concentration of the analysis sample and that are within the method dynamic range. One concentration of the halogen calibration standard shall be at or below the method detection limit. The second halogen calibration standard shall be at or near the mid-range of the method's dynamic range and the third calibration standard shall be at or near the upper limit of the dynamic range of the method.

5.3.6.5 Analysis Instrumentation

Analysis of halogen shall be performed using IC.

5.3.6.6 Reporting of Results

The results shall be reported as ppm by weight of halogen in the homogeneous material. The reported amount of halogen shall be determined by subtracting the analytical result for the calibration blank from the analytical result for the analysis sample. All results shall be from the dynamic range of the method. The reporting limit shall be 50 ppm for halogen.

5.3.7 Beryllium

5.3.7.1 Analysis Sample

To ensure the accuracy of the results, the analysis sample concentration shall be a minimum of 1.0000 grams / liter of homogeneous material in the diluent. The mass of the homogeneous material sample shall be determined using an analytical balance capable of measuring 0.0002 grams.

5.3.7.2 Calibration Blank

The calibration blank shall be analyzed along with the analysis sample to determine the contribution of contamination from the reagents and the analysis sample preparation process. The calibration blank shall be prepared using the same concentrations of solutions used to digest, extract, and prepare the analysis sample and treated exactly as the analysis sample, including exposure to all equipment, glassware, procedures, as well as reagents. No beryllium shall be intentionally added.

5.3.7.3 Interference Sample

An interference sample shall be analyzed along with the analysis sample to determine spectral line overlaps, broadened wings of intense spectral lines, scattered light from high concentrations of elements, and chemical interferences. This interference sample shall produce less than a 5% contribution to the beryllium reading. The interference sample shall be created by dissolving all the substances intentionally comprising the composition of the homogeneous material sample into a solution prepared in the same manner as the calibration blank. The concentrations of the substances present in the interference sample shall be equivalent to the concentrations of those same substances expected in the analysis sample.

5.3.7.4 Calibration Standard

The instrument shall be calibrated with a minimum of three calibration standards and a calibration blank. The standards shall be created by diluting a beryllium certified standard to the needed concentration in the expected sample matrix and the calibration blank shall be prepared in the same reagents as the standards. The calibration standards shall have concentrations of

beryllium that bracket the expected concentration of the analysis sample and that are within the method dynamic range. One concentration of the beryllium calibration standard shall be at or below the method detection limit. The second beryllium calibration standard shall be at or near the mid-range of the method's dynamic range and the third calibration standard shall be at or near the upper limit of the dynamic range of the method.

5.3.7.5 Analysis Instrumentation

Analysis of beryllium shall be performed using ICP.

5.3.7.6 Reporting of Results

The results shall be reported as ppm by weight of beryllium in the homogeneous material. The reported amount of beryllium shall be determined by subtracting the analytical result for the calibration blank from the analytical result for the analysis sample. All results shall be from the dynamic range of the method. The reporting limit shall be 10 ppm for beryllium.

5.3.8 Antimony

5.3.8.1 Analysis Sample

To ensure the accuracy of the results, the analysis sample concentration shall be a minimum of 1.0000 grams / liter of homogeneous material in the diluent. The mass of the homogeneous material sample shall be determined using an analytical balance capable of measuring 0.0002 grams.

5.3.8.2 Calibration Blank

The calibration blank shall be analyzed along with the analysis sample to determine the contribution of contamination from the reagents and the analysis sample preparation process. The calibration blank shall be prepared using the same concentrations of solutions used to digest, extract, and prepare the analysis sample and treated exactly as the analysis sample, including exposure to all equipment, glassware, procedures, as well as reagents. No antimony shall be intentionally added.

5.3.8.3 Interference Sample

An interference sample shall be analyzed along with the analysis sample to determine spectral line overlaps, broadened wings of intense spectral lines, scattered light from high concentrations of elements, and chemical interferences. This interference sample shall produce less than a 5% contribution to the antimony reading. The interference sample shall be created by dissolving all the substances intentionally comprising the composition of the homogeneous material sample into a solution prepared in the same manner as the calibration blank. The concentrations of the substances present in the interference sample shall be equivalent to the concentrations of those same substances expected in the analysis sample.

5.3.8.4 Calibration Standard

The instrument shall be calibrated with a minimum of three calibration standards and a calibration blank. The standards shall be created by diluting an antimony certified standard to the needed concentration in the expected sample matrix and the calibration blank shall be prepared in the same reagents as the standards. The calibration standards shall have concentrations of antimony that bracket the expected concentration of the analysis sample and that are within the method dynamic range. One concentration of the antimony calibration standard shall be at or below the method detection limit. The second antimony calibration standard shall be at or near the mid-range of the method's dynamic range and the third calibration standard shall be at or near the upper limit of the dynamic range of the method.

5.3.8.5 Analysis Instrumentation

Analysis of antimony shall be performed using ICP.

5.3.8.6 Reporting of Results

The results shall be reported as ppm by weight of antimony in the homogeneous material. The reported amount of antimony shall be determined by subtracting the analytical result for the calibration blank from the analytical result for the analysis sample. All results shall be from the dynamic range of the method. The reporting limit shall be 10 ppm for antimony.

5.3.9 Phthalate

The phthalates of interest shall be: DEHP, DIBP, BBP, and DBP. The test methodology may be referenced per IEC 62321-8:2017 or newer.

5.3.9.1 Analysis Sample

To ensure the accuracy of the results, the analysis sample concentration shall be a minimum of 1.0000 grams / liter of homogeneous material in the diluent. The mass of the homogeneous material sample shall be determined by using an analytical balance capable of measuring 0.0002 grams.

5.3.9.2 Calibration Blank

A calibration blank shall be analyzed along with the analysis sample to determine the contribution of contamination from the reagents and the analysis sample preparation process. The calibration blank shall be prepared using the same concentrations of solutions used to digest, extract, and prepare the analysis sample and treated exactly as the analysis sample, including exposure to all equipment, glassware, procedures, as well as reagents. No phthalate shall be intentionally added.

5.3.9.3 Interference Sample

An interference sample shall be analyzed along with the analysis sample to determine retention time interferences with the phthalate and shall produce less than a 5% contribution to the phthalate reading. The interference sample shall be created by dissolving all the substances intentionally comprising the composition of the homogeneous material sample into a solution prepared in the same manner as the calibration blank. The concentrations of the substances present in the interference sample shall be equivalent to the concentrations of those same substances expected in the analysis sample.

5.3.9.4 Calibration Standard

The instrument shall be calibrated with a minimum of three calibration standards and a calibration blank. The standards shall be created by diluting phthalate certified standard to the needed concentration in the expected sample matrix and the calibration blank shall be prepared in the same reagents as the standards. The calibration standards shall have concentrations of phthalate that bracket the expected concentration of the analysis sample and that are within the method dynamic range. One concentration of the phthalate calibration standard shall be at or below the method detection limit. The second phthalate calibration standard shall be at or near the mid-range of the method's dynamic range and the third calibration standard shall be at or near the upper limit of the dynamic range of the method.

5.3.9.5 Analysis Instrumentation

Testing for phthalate shall be performed using GC-MS.

5.3.9.6 Reporting of Results

The results shall be reported as ppm by weight of phthalate in the homogeneous material. The reported amount of phthalate shall be determined by subtracting the analytical result for the calibration blank from the analytical result for the analysis sample. All results shall be from the dynamic range of the method. The reporting limit shall be 50 ppm for phthalates.

5.3.10 Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonates (PFOS)

The test methodology may be referenced per DIN CEN/TS 15968.

5.3.10.1 Analysis Sample

To ensure the accuracy of the results, the analysis sample concentration shall be a minimum of 1.0000 grams / liter of homogeneous material in the diluent. The mass of the homogeneous material sample shall be determined by using an analytical balance capable of measuring 0.0002 grams.

5.3.10.2 Calibration Blank

A calibration blank shall be analyzed along with the analysis sample to determine the contribution of contamination from the reagents and the analysis sample preparation process. The calibration blank shall be prepared using the same concentrations of solutions used to digest, extract, and prepare the analysis sample and treated exactly as the analysis sample, including exposure to all equipment, glassware, procedures, as well as reagents. No PFOA or PFOS shall be intentionally added.

5.3.10.3 Interference Sample

An interference sample shall be analyzed along with the analysis sample to determine retention time interferences with the PFOA or PFOS and shall produce less than a 5% contribution to the concentration reading. The interference sample shall be created by dissolving all the substances intentionally comprising the composition of the homogeneous material sample into a solution prepared in the same manner as the calibration blank. The concentrations of the substances present in the interference sample shall be equivalent to the concentrations of those same substances expected in the analysis sample.

5.3.10.4 Calibration Standard

The instrument shall be calibrated with a minimum of three calibration standards and a calibration blank. The standards shall be created by diluting a PFOA or PFOS certified standard to the needed concentration in the expected sample matrix and the calibration blank shall be prepared in the same reagents as the standards. The calibration standards shall have concentrations of PFOA or PFOS that bracket the expected concentration of the analysis sample and that are within the method dynamic range. One concentration of the PFOA or PFOS calibration standard shall be at or below the method detection limit. The second calibration standard shall be at or near the mid-range of the method's dynamic range and the third shall be at or near the upper limit of the dynamic range of the method.

5.3.10.5 Analysis Instrumentation

Testing for PFOA or PFOS shall be performed using HPLC / mass spectrometry as specified in DIN CEN/TS 15968.

5.3.10.6 Reporting of Results

The results shall be reported as ppm by weight of PFOA or PFOS in the homogeneous material. The reported amount shall be determined by subtracting the analytical result for the calibration blank from the analytical result for the analysis sample. All results shall be from the dynamic range of the method. The reporting limit shall be 25 ppb for PFOA or PFOS.

5.4 Analysis Report Requirements

When reporting the results of substance testing, the following information shall be disclosed on the written report:

- Primary language shall be English.
- Identification of the material sample as specified by Molex (such as metal alloy type (e.g. C510), resin (grade/color), or Molex Part Number).
- The method used to collect the analysis sample, including a specific disclosure of the methods used to ensure that the analysis sample was representative of the homogeneous material.
- The analysis method used, including a specific disclosure of the type of analysis instrumentation used (e.g. ICP).
- Results of the analyses of substances of interest as mg/kg or parts per million by weight.
- The reporting limit for each substance tested.
- Process flowcharts (similar with the general process flowcharts of Appendix A).
- The date the sample was received.
- The date the analysis was performed.
- Unique identification of the report.
- Each page and total number of pages in the report.
- The signature of the laboratory supervisor or comparable laboratory authority.
- Name, address, and location of any laboratory involved in the analysis and name of the operator.
- Specific reference to this standard.
- Photo of test sample specimen

6.0 Implementation

The ownership and administrative responsibility for this standard shall reside with Global Product Stewardship. The implementation date of these procedures shall be immediate. All data collected or reported with respect to substance testing of materials used in Molex's products shall comply this document.

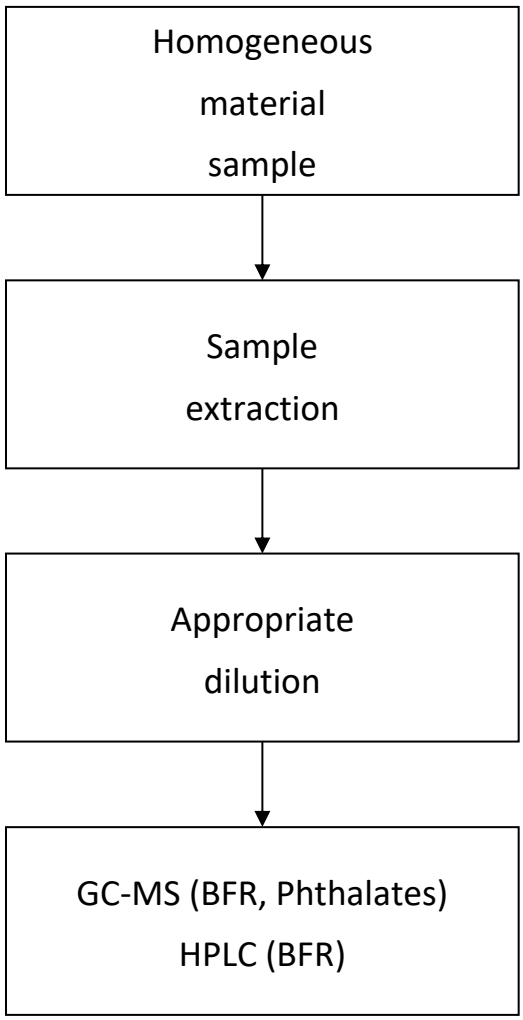
7.0 Exceptions

The objective of this standard is to ensure accurate and consistent results when performing substance testing of materials used in Molex's products; therefore, any requests for exceptions to or deviations from these requirements shall require the written approval of Global Product Stewardship team.

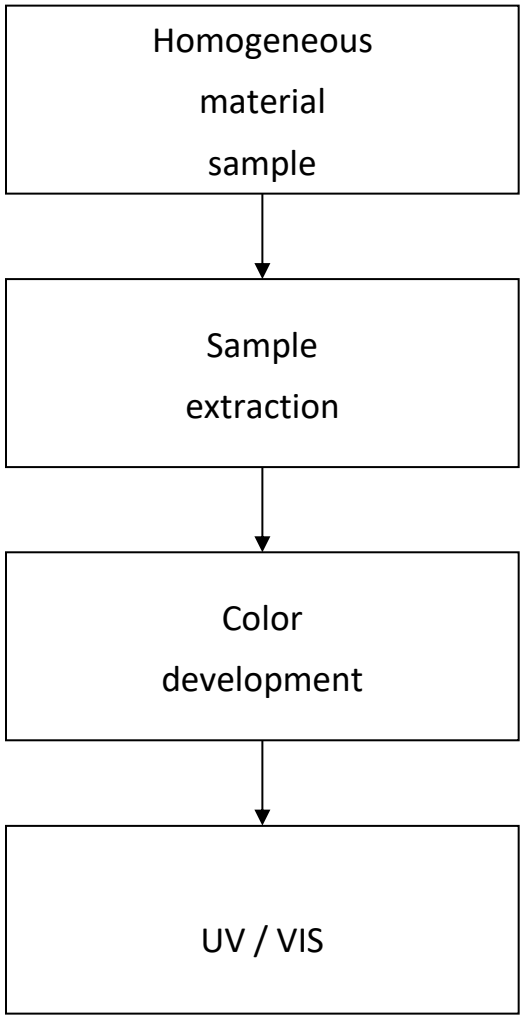
Appendix A: General Process Flowcharts

The specific processes of all analytical methods used for determining prohibited substances shall be defined per locally controlled work instructions

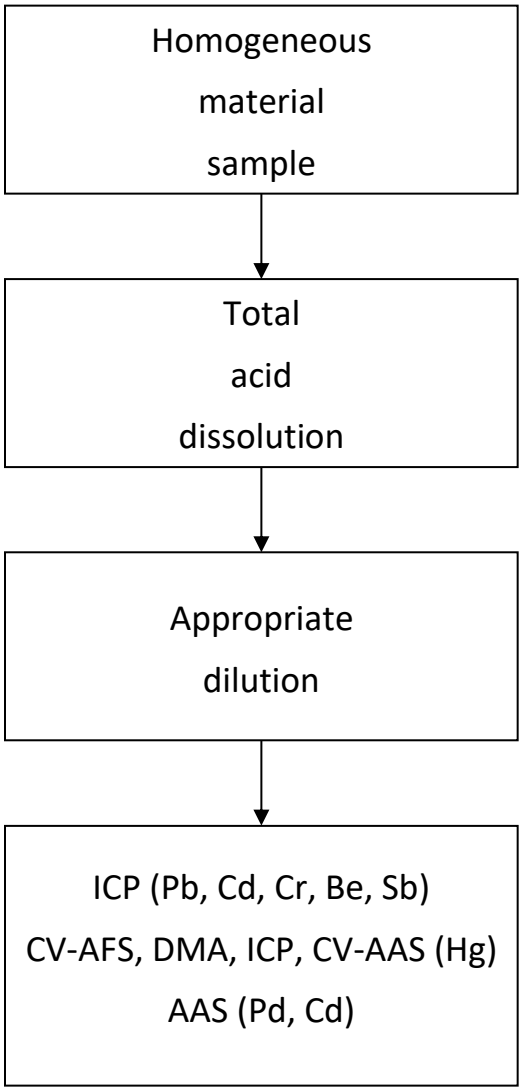
General process flowchart for brominated flame retardant and phthalate



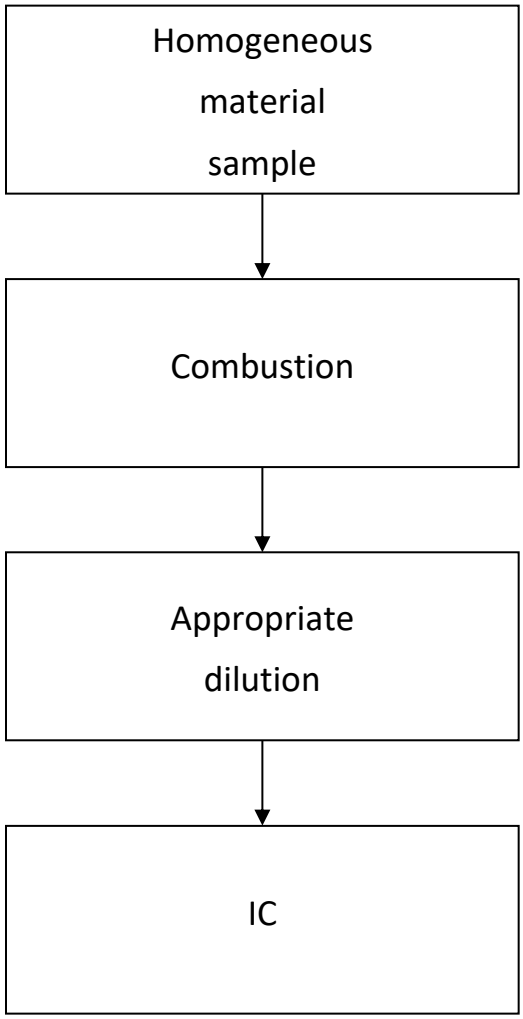
General process flowchart for hexavalent chromium



General process flowchart for lead, cadmium, chromium, mercury, beryllium, and antimony



General process flowchart for halogen



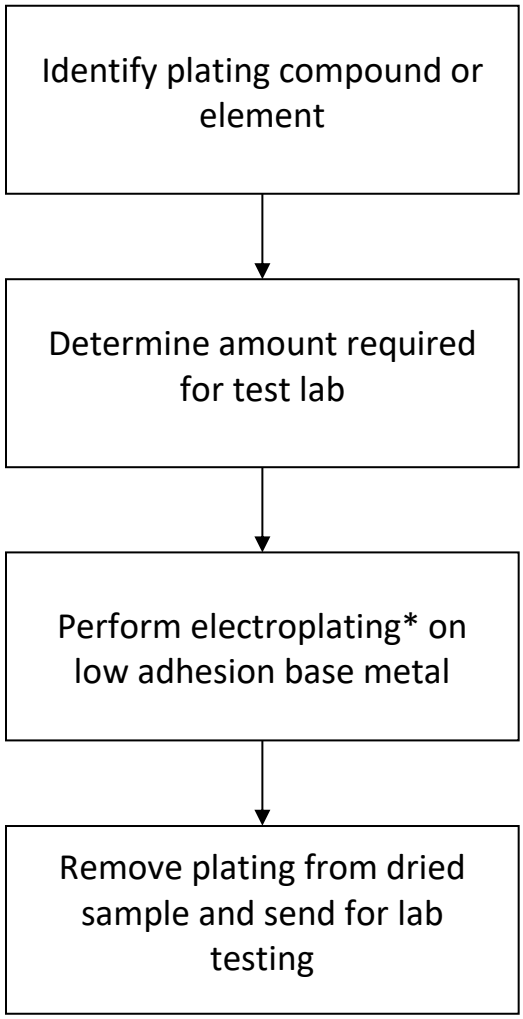
Appendix B: Sample Preparation for Multiple Plating Analysis

In most cases, multiple plating layers that could not be cleanly separated shall be treated as a single homogeneous material per RoHS definition, and therefore do not require analysis of each layer.

However, some Molex customers may have stricter requirements requiring in-depth analysis of each individual layer. In only those instances, Molex will promptly ensure this requirement is communicated directly to the supplier. At a high level, such samples can be prepared using method below.

Method

Prepare each individual plating layer separately on low adhesion base metal strips such as SUS304. In doing so, the resulted plating film can be easily peeled off for lab analysis.



* Electroplating can be done using equipment such as Hull Cell.

Repeat the process above for each plating layer.