Oddy testing protocol based on procedures at the
Metropolitan Museum of Art

Dates of Use: 2019 to present

I. Introduction

This Oddy testing protocol is based on procedures developed at the Metropolitan Museum of Art by Isabella Busarino, Alayna Bone, Catherine Stephens, and Eric Breitung, which in turn derive from methods published by the British Museum[1], where test tubes are fitted with silicone stoppers holding three metal coupons, and the Met's original three in one jar version[2], where metals are hung from the rim of a beaker inside of a screw-top jar. In both cases, the corrosion states of the coupons after 28 days of aging at elevated temperatures and humidity in the presence of an unknown material are used to determine the appropriateness of a material for use in close proximity to cultural heritage materials.

After discussion at the Materials Working Group annual meetings in 2018 and 2019, minor modifications were made to the Met's protocol (20190226_OT) in advance of the 2020 MWG Round Robin Testing program to ensure all participating groups could obtain comparable results. Since 2020, further edits have been made to the protocol to incorporate MMA updates that replace 3D printed nylon coupon holders with reusable water-jet cut stainless steel coupon holders; and to update vendor information. This new method retains the repeatability improvements of the Met's previous method and reduces long-term costs and waste. However, based on some test results, the silver coupon is very slightly less sensitive to sulfides when using the stainless steel holder. The difference does not appear to be significant enough to warrant the continued use of nylon holders given the cost and reusability benefits provided by the steel holders. The nylon holders will remain available for purchase on Shapeways for those using the Oddy test to evaluate materials intended for use with silver collections, where the sensitivity of the silver coupon is paramount.

This document is currently maintained by the Materials Working Group, Testing and Standards committee, Oddy Testing Focus Group. Contributors include: Eric Breitung, Alayna Bone, Laura Resch, and Julia Sybalsky.

[1]Korenberg, C., Keable, M., Phippard, J., Doyle, A. "Refinements Introduced in the Oddy Test Methodology", Studies in Conservation, (August 2017), online article, 1-12.
[2]Bamberger, J. A., Howe, E. G., Wheeler, G., A Variant Oddy Test Procedure for Evaluating Materials Used in Storage and Display Cases, *Studies in Conservation* 44 (1999) 86-90.

II. General Overview of Test

a. The time estimate for execution of this test protocol as written is 112-130 minutes per test, including sample tests and control tests, photography and publishing of results in the online Test Results Table maintained on the AIC Wiki. Procedural choices, such as the use of different washing methodologies, could increase or decrease this time.

Cleaning:	8-26 minutes
Test Preparation:	17 minutes
Test Assembly:	24 minutes
Test Interpretation:	14 minutes
Recordkeeping:	12 minutes
Coupon Photography:	19 minutes
Uploading Results:	17 minutes

b. All tests are run in duplicate, i.e. a test consists of two jars containing sample material with associated lids, O-rings, coupon hangers, and glass vials. Each test is assigned a unique number, and replicates are labeled "A" and "B".

a. Negative controls, also in duplicate, are included with every group of materials tested. In other words, if 15 materials are being tested on Monday, one set of controls is required. A new set of controls is required for the next group of Oddy tests that are prepared on Tuesday. A unique number is assigned to each control, and replicates are labeled "A" and "B". For example, if two materials are being tested, jars in the batch might be numbered 1a, 1b, 2a, 2b, C1a, and C1b. A second batch of two materials might be 3a, 3b, 4a, 4b, C2a, and C2b.

b. For each material tested, it is recommended that at least one replicate should be run using a new lid and ring (or reused components from "permanent" tests) in the "A" replicate. The "B" replicates, including controls, may utilize reused lids. By following this practice, a mismatch between A and B replicates may reveal contamination associated with a reused "temporary" lid. However, doing so also significantly reduces the cost savings afforded by reuse. All reuse of lids/rings is clearly recorded in the test record.

c. Alongside each batch of materials and controls, it is recommended to test permanent, temporary, and unsuitable standard materials as a baseline for evaluation of tests. Ideally such standards should be agreed upon by the community. They may be commercial materials or chemicals prepared to a specified concentration. The Metropolitan Museum of Art has used Obomodulan 500 (OBO-Werke), Paper tape with

potato starch, #067-25/0 (Klug Conservation), and 100% Wool Flannel style 527 (Test Fabrics) for this purpose. Development of more universal chemical standards warrants further research.

d. It is recommended to prepare material samples for testing according to the Material Sample Preparation Guide provided on the AIC Wiki.
e. Details regarding the materials tested, the testing procedure used, the weight of the jars before and after testing, the test result, and its interpretation are recorded in a custom-built database or spreadsheet such as the Template for Recording Results presented on the AIC Wiki. It is recommended to enter information about the materials being tested into the test record prior to assembling tests.
f. Evaluation of metal coupons and the assignment of Permanent, Temporary, and Unsuitable ratings to sample materials is guided by the standardized Corrosion Vocabularies produced by The Metropolitan Museum of Art. This resource approximately represents the range of phenomena documented at The Metropolitan Museum of Art. Results not captured by this glossary should nevertheless be noted in the test record, and may be added to future versions of the Glossary.

III. Personal Protection Equipment (PPE)

a. Nitrile gloves, safety glasses, and a laboratory coat are worn throughout this procedure.
b. Hands are washed with soap and warm water prior to donning gloves to remove oils. Care is taken to always handle the metal coupons (copper [Cu], lead [Pb], or silver [Ag]) with tweezers while wearing clean nitrile gloves, as handling coupons with dirty or oily hands can cause coupon contamination. Out of a small range of gloves, Freeform ® SE blue powder-free nitrile gloves performed best in the Met's Oddy test, and are preferred.

IV. Materials and Equipment

This protocol specifies key equipment and supplies that are required and if possible, should not be substituted (**Appendix 1: Materials and Supplies**). Alternate vendors may be substituted as long as the product specification is met.

V. Washing Methods

One of two different washing methods (dishwasher, handwashing) is used to clean jars, lids, and Viton O-rings used in the test. KIMAX vials are always washed by hand. New components are always washed before using. New stainless steel holders should be hand washed before using the first time. Subsequently either the Hand Washing Method or the Dishwasher Method is acceptable.

a. Dishwasher Method (Lancer 815 LX Dishwasher)
   KIMAX Jars
   i. Mechanically remove all materials from jar.
   ii. Place each jar over a spindle jet.
   iii. The wash cycle includes the following steps:

- Prewash: Rinse for 2 min.* with 60°C water
- Wash (base): Rinse with 96 mL of NaOH in 12 L of water at 40°C for 2 min.*
- Rinse A: Rinse for 2 min. with unheated water. Rinse with 96 mL of Phosphoric Acid in 12 L of unheated water for 2 min.
- Rinse B: Rinse for 3 min. with unheated water.
- Rinse C: Rinse for 3 min. with unheated water.
- Purified Water Rinse A: Rinse for 3 min. with unheated 15 MΩ-deionized water.
- Purified Water Rinse B: Rinse for 1 min.* with 60°C 15 MΩ-deionized water.
- When water is being heated, it is recycled within the chamber until it reaches temperature making the times listed much shorter than the actual cycle time. After the washer reaches the prescribed temperature, it runs for the programmed amount of time. The full wash cycle requires approximately 1.75 hours. Detergents are not currently used.

iv. Washed glassware is placed in a 60°C oven for drying and storage.

Viton™ O-rings, stainless steel coupon holders, and lids

i. Place on flat stainless-steel mesh rack.
   - Place on flat stainless steel mesh rack.
   - Lids are placed upright with threads facing downward and are weighted with a stainless-steel mesh screen to inhibit flipping.

ii. The wash cycle includes the following steps:
   - Prewash: Rinse for 2 min.* with 80°C water
   - Rinse A: Rinse for 5 min. with unheated water.
   - Rinse B: Rinse for 1 min.* with 80°C water.
   - Purified Water Rinse A: Rinse for 1 min. with unheated 15 MΩ-deionized water.
   - Purified Water Rinse B: Rinse for 1 min.* with 60°C 15 MΩ-deionized water.
   - When water is being heated, it is recycled within the chamber until it reaches temperature making the times listed much shorter than the actual cycle time. After the washer reaches the prescribed temperature, it runs for the programmed amount of time. The full wash cycle requires approximately 2.5 hours. Detergents are not currently used.

iii. Washed Viton™ O-rings, stainless steel coupon holders, and lids are dried and stored in a 60°C oven. Once dry, they are removed and stored in clean glass beakers.

<u>b. Hand-washing Method</u>

KIMAX Jars (alternative to dishwasher method)

i. Wash with Micro-90 Lab Cleaner (1% solution in tap water) using a laboratory cleaning brush.

ii. Rinse 3 times with hot tap water.

iii. Soak in room temperature aqueous sodium hydroxide (NaOH) bath with a pH of 12 for at least 15 hours (overnight). Use stainless steel tongs or large tweezers for delivering and retrieving items from the baths. Thick nitrile gloves, safety glasses, and a laboratory coat are required.
    - *Base bath preparation (yields 7.5 L): Add 3.0 g NaOH pellets to 7.5 L of deionized H 2 O. Check that the pH reads 12 on the pH indicator strip. The base bath is contained in a lidded polypropylene container within a secondary polypropylene drip container.*

iv. Rinse once with hot tap water.

v. Soak in a hydrochloric acid (HCl) bath with a pH of 2 for at least 15 hours (overnight). Use stainless steel tongs for delivering and retrieving items from the baths. Thick nitrile gloves, safety glasses, and a laboratory coat are required.
    - *Acid bath preparation (yields 7 L): Slowly add ~6 mL HCl (37% w/w; 1.2 g/mL density) to 2 L of deionized H 2 O. Add the remaining 5 L of deionized H 2 O. Check that the pH reads 2 on the pH indicator strip. The acid bath is contained in a lidded polypropylene container within a secondary polypropylene drip container.*

vi. Rinse three times with hot tap water then rinse three times with 18.2 mΩ-deionized water.

vii. Dry in an oven, right side up, at 60°C.

KIMAX vials

i. Place dirty vials in a 50 mL Pyrex beaker.

ii. Soak vials with Micro 90 Lab cleaner for at least 24 hours (1% solution in tap water). Use a pipette to deliver the solution into the small vials.

iii. Rinse 3 times with tap water. Use a pipette to deliver the rinse water into the small vials. Rinse water may be more quickly removed from the vials by upending the vials onto absorbent paper.

iv. Soak in room temperature aqueous sodium hydroxide (NaOH) bath with a pH of 12 for at least 15 hours (overnight). Contain vials within a small beaker while in the bath. The beaker is contained in a polypropylene drip container during the soak. Thick nitrile gloves, safety glasses, and a laboratory coat are required.
    - *If not preparing a larger volume of base bath for jars, to prepare 1 L of base: Add 0.40 g NaOH pellets to 1 L of deionized H 2 O. Check that the pH reads 12 on the pH indicator strip.*

v. Still contained within the beaker, rinse vials with hot tap water.

vi. Place in a hydrochloric acid (HCl) bath with a pH of 2 for at least 15 hours (overnight). The beaker is contained in a polypropylene drip container during the soak. Thick nitrile gloves, safety glasses, and a laboratory coat are required.
    - *If not preparing a larger volume of acid bath for jars, to prepare 1 L of acid: Slowly add 0.8 mL HCl (37% w/w; 1.2 g/mL density) to 250 mL of deionized H 2 O. Add the remaining 750 mL of deionized H 2 O. Check that the pH reads 2 on the pH indicator strip.*

vii. Rinse three times with hot tap water then rinse three times with 18.2 mΩ-deionized water.
viii. Dry and store in an oven, right side up, at 60°C until use.

Viton™ O-rings, lids, and coupon holders

i. Wash lids, Viton O-rings, and coupon holders in a Micro-90 Lab Cleaner solution (1% in tap water) by dipping in cleaning solution and rubbing with gloved hands or a clean sponge. Do NOT soak for any length of time in Micro-90 Lab Cleaner solution.
ii. Rinse 3 times with hot tap water and 3 times with 18.2 MΩ-deionized water.
iii. Store in oven at 60°C until use.

VI. Metal Coupon Preparation

a. Upon receipt from the supplier, all metals are immediately removed from the clear plastic film sleeve, placed back into the hard plastic box, and stored in at least one Corrosion Intercept® Ziploc® -style bag. Ideally both sides of the bag are composed of the Intercept material rather than using the style with a transparent window.
b. A dedicated tool (scalpel, pair of scissors) is used to cut each metal.
c. Copper and Silver Coupons
    i. Without touching the metal, even with gloved hands, measure and cut Ag and Cu metal foils into coupons measuring 0.8 cm x 2.5 cm.
    ii. Soak copper and silver coupons in separate beakers of HPLC grade acetone.
    iii. After removing each coupon from the solvent, place it on a clean piece of aluminum foil. While holding one edge with a glove finger wrapped in a Kimwipe, wipe the exposed side dry with another Kimwipe. Flip the coupon over and repeat on the opposite side.
    iv. Soak the coupons in separate beakers of fresh HPLC grade isopropanol.
    v. After removing each coupon from the solvent, place it on a clean piece of aluminum foil. While holding one edge with a glove finger wrapped in a Kimwipe, wipe the exposed side dry with another Kimwipe. Flip the coupon over and repeat on the opposite side.
    vi. Collect solvents and dispose of as hazardous waste.
d. Lead Coupons
    i. Prepare only as much Pb foil as you will use in one batch. Sand lead coupons immediately before inserting into jars to minimize re-oxidation of the surface.
    ii. Cutting large strips of lead before sanding and then cutting them down after sanding makes the sanding process more efficient. The Pb foil is cut into one or more pieces 10 cm long by 0.8(x) cm wide, with x being the number of skinny strips you want to prepare for sanding. After sanding, the foil is cut into coupons measuring 0.8 cm x 2.5 cm.
    iii. The sanding process is completed in a homemade 'filtration box' with ULPA filtration.
    iv. Place a 12 inch by 12 inch flat glass plate inside the filtration box, and place the un-sanded lead strip(s) on top of the glass plate. The strip(s) should be made as

flat as possible before sanding. The metal is very soft and flexible, so it folds and creases easily. Any folds or creases will make it more difficult to achieve an even texture after sanding.

v. Cut a 2 in square piece of 3200 grit Micromesh™ sand paper, and fold it in half twice so that it forms a 1 in square with grit on both sides. To sand, use a gloved finger to hold the closer end of one lead strip. While sanding, hold the Micromesh™ under one thumb so that pad of the thumb is flat when applying pressure and covers the entire width of the lead strip. Sand from the center of the strip to the end away from the user using even light pressure. Avoid using the tip of the thumb or pressing part of the thumbnail into the Micromesh™. Change the position of the Micromesh™ every 15-20 strokes to an unused portion of the Micromesh™. Every stroke should be straight and run all the way from the middle of the strip to the far end. Approximately 45 strokes will properly sand one half of a 10 cm by 0.8 cm lead strip. Once the first half is sanded, rotate the strip 180 degrees and sand the second half of the same side. Then flip the strip over and sand the other side using the same technique. If the lead strip elongates or stretches, too much pressure is being applied while sanding. The goal is to remove the native oxide, leaving a surface with uniform roughness, applying minimal pressure. Hanging large images of over-sanded and correctly sanded lead coupons in the preparation area is recommended for reference. A correctly sanded lead coupon is lighter in shade than the un-sanded lead, and has a consistent overall texture with no shiny patches of specular reflection.

vi. After sanding lead strips, wipe with a Kimwipe® dipped in acetone, or rinse each side with acetone from a wash bottle, followed by wiping with a Kimwipe®. Repeat until the Kimwipe® wipes clean.

vii. Next, repeat with isopropanol.

viii. Cut larger lead strips into skinny 0.8 cm x 10 cm strips. Then cut each skinny lead strip into 0.8 cm x 2.5 cm coupons.

ix. After polishing and rinsing, dispose of Kimwipe®, Pb-contaminated gloves, and sandpaper as lead-contaminated hazardous waste.

VII. Jar Preparation and Assembly

a. It is recommended, but not required, to prepare material samples for testing according to the Material Sample Preparation Guide presented on the AIC Wiki.

b. Label sample and control jars with sample and control numbers, with duplicate pairs labeled “A” and “B” using permanent marker. Record the Control # in the test record of each sample material to be tested.

c. To prepare one sample jar, place a sheet of weighing paper on the scale and tare. Weigh 2.0 +/- 0.1g of test sample material on the paper and load into a 100 mL KIMAX borosilicate jar. Record each sample weight in the test record.

d. Dose a KIMAX borosilicate mini-test tube with 0.5mL 18.2 MΩ-deionized water using a recently calibrated micropipette. (Calibration can be checked using a precision balance

and a thermometer; if recalibration is needed, it is usually sent out for service.) Load the mini-test tube into the jar alongside the sample.

e. To prepare one control jar, load only a KIMAX borosilicate mini-test tube containing 0.5mL 18.2 MΩ-deionized water. No other material is placed in the jar.
f. To a pre-washed stainless steel coupon holder or new 3D printed nylon coupon holder, attach the metal coupons by bending the coupon 5-7mm from one end and crimping it onto the holder. Insert the coupon holder into the mouth of each jar (including controls). Make sure coupons do not contact each other, the jar, or the test material.
g. Insert a Viton o-ring into each lid and lightly screw the lids onto the jars. Tighten lids to a torque of 4 Nm using a torque wrench fitted with the custom socket.
h. Weigh sample and control jars and record values in the test record.
i. Place in the oven at 60°C, leaving as much space between jars as possible for air circulation, standing upright.
j. Leave jars in the oven at 60°C for 60 minutes. Remove jars and re-tighten lids to a torque of 4 Nm while warm using a torque wrench fitted with the custom socket.
k. Record the date that the jars were placed in the oven in the test record.
l. Return jars to the oven and age at 60 ± 1.5 °C for 28 days.

VIII. Coupon Assessment

a. After 28 days in the oven, remove jars and allow to cool to room temperature. Record the date that the jars were removed from the oven in the test record.
b. Record weights of each jar in the test record.
c. For each jar, compare the weight before and after aging to determine whether each vessel was sealed during the experiment. A loss greater than 25% of the water mass (0.13 grams) one or both jars in a duplicate pair is considered a system failure and the experiment is repeated. The overall test rating is recorded as “Retest” (R). If one or both control jars fail, the corrosion phenomena present on the controls is still recorded in the test record, and coupons for each sample test are rated according to the corrosion phenomena observed, but overall ratings for all sample tests in the batch are recorded as “Retest” (R).
d. Open each jar and lift the coupon holder out. Remove coupons from the coupon holder using tweezers.
e. Unfold each coupon where it was crimped over the coupon holder. Press the coupons flat using two blocks of polished flat stainless steel, aluminum, or glass. Place the coupons on a fresh piece of aluminum foil or a petri dish. Be sure that the surface used the flatten the coupons is clean and dry before using it on the next coupon.
f. Dogear or inscribe the control coupons in the folded area over to avoid mixing samples during coupon evaluation.
g. Coupons are ideally examined by three separate individuals independently recording results and ratings in isolation. If this is not feasible, individuals may examine the coupons collectively, but should record results and ratings without consulting one another. Results and ratings are then shared within the group. If all members agree, they are recorded in the test record. If all members do not agree, the coupons are reviewed collectively, using a microscope if needed, until arriving at a consensus.

h. In general, the ratings below are used to assess non-control coupons. Please see refer to the Corrosion Libraries produced by The Metropolitan Museum of Art for more detail. These illustrated glossaries describe commonly-observed corrosion phenomena, and will be used as reference to rate test results. They can be downloaded using the links below:

Copper Corrosion Library
Silver Corrosion Library
Lead Corrosion Library

"Permanent" rating: The material tested may be used indefinitely in the presence of art.

- Coupons look similar to the controls.
- Copper: Very slight reddening
- Silver: Light white haze. Remnants of polishing compounds from some manufacturers can develop or appear as white splotches. This stock is generally returned to the manufacturer, however, if it makes it into a test, the white splotches are ignored.
- Lead: Very slight darkening

"Temporary" rating: The material is safe for use near but not in contact with art for up to six months.

- Copper: Slight-to-extreme reddening, rainbow-like color change, or a light haze.
- Silver: Development of a heavy white haze, yellow tarnish or orange haze, or very slight purpling.
- Lead: Slight-to-extreme darkening, blue or rainbow tarnish, or thin yellow/olive, orange, blue, or white compacted corrosion, haze from slight crystal formation over the entire coupon.

"Unsuitable" rating: The material should not be used in contact with or near art and another material should be found.

- Copper: Severe blackening or heavy haze.
- Silver: Slight-to-extreme purple, rainbow, or black tarnish.
- Lead: thick yellow, orange, blue, or white compacted corrosion, or white fluffy crystal formation of any size.

i. For each test, results are assessed and recorded separately for each type of metal and for "A" and "B" replicates.
j. To assess each coupon, lift it using tweezers only. Examine the surface of the coupon at different angles under a consistent indoor light source (ex. Brightech LightView Pro LED Magnifying Glass). If the light source is adjustable, a standard color temperature and/or light level is selected that will be used for all coupons. Examination under the standard lighting may be supplemented by other lighting conditions.

k. Examine coupons from the control jars. If coupons in both jars are minimally corroded, meaning that the corrosion phenomena observed are at or below the threshold of those rated “P” in the Corrosion Libraries, the control test is considered valid. If corrosion phenomena observed on any metal coupon in one or both control jars are rated “T”, the control test is not valid. The corrosion phenomena present on the controls is still recorded in the test record, and individual metals for each associated sample test are described and rated according to the corrosion phenomena observed, but overall ratings for all sample tests in the batch are recorded as “Retest” (R).
l. Examine coupons from the sample jars. The corrosion phenomena observed on each coupon below the fold are compared to the Corrosion Libraries and described separately for replicates “A” and “B” in the test record. Corrosion phenomena not present in the glossary should nevertheless be described and may be added to the glossary at a later date. Ratings are assigned to each coupon as instructed in the Glossary. The lowest of the ratings assigned to the three metals in the test is also the overall rating assigned to the material.
m. In the event that there are moderate differences in the same corrosion phenomenon on “A” and “B” replicates, as long as the rating for both levels is still the same, the result is valid. However, if the more extreme corrosion pushes one coupon into the next rating category, or if the replicates exhibit different types of corrosion phenomena, then the rating for the metal and the material overall is “Retest” (R).

IX. Disassembly and Reuse of Test Materials

a. **R**euse
    i. Used components are not always reused. Sort lids and O-rings, separating those from jars that tested “permanent”, “temporary”, and “unsuitable”.
    ii. Used components from “unsuitable” tests are not reused.
    iii. Lids and O-rings from “permanent” tests may be reused indefinitely.
    iv. O-rings from temporary tests are not reused.
    v. Lids from “temporary” tests may be reused. They are marked for each “T” test by scoring or using permanent marker. Additional research is needed to understand whether reuse after 4 marks is associated with irregularities in test outcomes.
    vi. Nylon coupon holders are never reused. Steel holders can be reused regardless of prior test results.
    vii. These practices were established to avoid the possibility of contamination from one test to another.
b. Disassembly
    i. Using a spatula, remove the O-rings from the lids.
    ii. If not immediately photographing coupons, package them in a small polyethylene bag for storage.

X. Photography/Documentation of Coupons

a. After evaluation, Oddy test coupons with matching duplicate results and passing control jars are photographed with a color reference using two different types of lighting: diffuse lighting and glancing-angle lighting. Guidelines for Coupon Photography are provided on the AIC Wiki, here.
b. Test results and images are uploaded to the AIC Wiki Test Results Table. Instructions are published here.

Appendix I. Materials and Supplies

This protocol requires that materials marked with an asterisk (*) be sourced according to the product specification noted here.

Test Assembly

Kimble™ KIMAX™ GL 45 Media/Storage Bottles, 100mL (Product # 02-542A)
Viton™ O-ring; size 323, 75 durometer, black (Product #V75323)
Kimble™ KIMAX™ Reusable Borosilicate Glass Tubes with Plain End, 0.7mL (Product #14-925B)
Shapeways Oddy Test Hanger – Triangular, laser sintered nylon coupon holder in white natural versatile plastic
Water-jet stainless steel coupon holders – 'Met Oddy part' in 0.5mm 316 stainless steel; Order from Peter Hotkowski of Asterisk Incorporated, 50-3 River Street, Old Saybrook CT 0647, 860-388-3811, peteh@asteriskinc.com
Extra caps: Kimble™ Blue Polypropylene Cap (Product #02-542-1)

Metal Coupons

Pb: Alfa Aesar™ Lead foil, 99.998% (metals basis), 0.1mm thick, Puratronic™ (Product #AA12051GH)
Ag: Silver foil, 99.998% (metals basis), annealed, 0.1 mm x 100 mm x 100 mm; Fine Metals Corporation
Cu: Copper foil, 99.999% (metals basis), annealed, 0.1 mm x 100 mm x 100 mm; Fine Metals Corporation

Metal Preparation

Micro-Mesh, Regular 3200, sheet or roll
Acetone, HPLC grade (Product # A949-1)
Isopropanol, HPLC grade (Product # BP26324)
Kimberly-Clark Kimwipes disposable delicate task wipers, 1-ply, 4½ x 8½ inches (Product #06-666A)
Beakers (50ml, 100ml, 250ml, 600ml, 1L)
Menda pump bottles, glass, 4oz.
Small watch glasses, 90mm or petri dishes

Sample Preparation

Mylar A (25 micron)
Weighing paper

Precision balance – Veritas S303
End Cutting Nippers,6-1/4" Overall Length
Razor scraper

Tools

Accupet 100-1000 ul Micropipette (Product #AP-1000)
Tweezers (flat tip)
Tweezers (blunt tip)
Metal ruler
Spatula & Packer Double Ended - SurgicalExcel 81-12191
12” Stainless Steel Forceps
Wooden handled straight point teasing needle, (Product #19010)
CDI 1502MRMH-QR torque wrench (2.8-16.4 Nm range)
Shapeways Oddy Torque_8 Socket
Small HEPA Vacuum cleaner
Tempered glass fermentation weights

Washing Supplies - Hand

Sodium hydroxide (NaOH) pellets, certified ACS (Product # S318-100)
Hydrochloric acid (HCl), HPLC grade (Product # A949-1)
Micro-90 Concentrated Lab Cleaner Detergent (Product #VV-18100-05)
EMD Millipore 109535 MColorpHast™ pH-indicator strips (non-bleeding), pH 0-14
12L Gasketed storage containers
Rubbermaid 11.4 QT Dish Pan (2-Pack)
Bell-Art SP Scienceware dispensing jug (for de-ionized water)
Spilltray and Drying Rack

Washing Supplies - Machine

Lancer 815 LX Dishwasher
LancerClean Sodium Hydroxide (NaOH) Detergent – LCD-S
LancerAcid Phosphoric Acid Rinse – LCA-P
Custom Stainless Steel Mesh Screen used to hold down lids:
Round Hole Stainless Perforated Sheet 304 (Part#: 13523); Dimensions: 17.1” x 18.1”

Other Equipment

Brightech LightView PRO - LED Magnifying Glass Desk Lamp
Brightech LightView PRO - LED Magnifying Glass Floor Lamp

Other Consumables

Freeform ® SE blue powder-free examination gloves (Microflex Product FFS-700-S)
Corrosion intercept bags, 3 x 5”
Hazardous waste disposal labels

Appendix II. Changes to this Protocol

In March 2024 this protocol was updated by the Materials Working Group to:

- Add Appendix II.
- Add the estimated time needed to complete the protocol.
- Replace several appendices with links to resources outside the protocol: Material Sample Preparation Guidelines, standardized Corrosion Libraries, Template for Recording Results, and Guidelines for Coupon Photography.
- Add further background to the Introduction.
- Change language describing use of new lid components in the A replicate from a requirement to a recommendation, and add option to reuse “permanent” lids in the A replicate.
- Add a requirement to remove metal from plastic film sleeve upon receipt from the manufacturer.
- Add links to video tutorials developed by the Metropolitan Museum of Art.
- Update language about coupon holders to include stainless steel option, and describe conditions in which one might opt instead for 3-D printed nylon.
- Add a +/- range to the sample size specified.
- Adjust the coupon assessment language to more closely match the Corrosion Libraries.
- Add language describing photography of coupons and upload of results to the AIC Wiki.
- Update Appendix I. Materials and Supplies to:
    - Provide alternate vendors for specific items;
    - Include 2024 pricing.