# APR Benchmark Polyethylene(PE) Films and Flexible Packaging Innovation Test Protocol

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**Concise title – "APR Benchmark Polyethylene(PE) Films and Flexible Packaging Innovation Test Protocol"**

**Introduction – Purpose and Scope**

This method presents the steps used in processing and testing for a laboratory to evaluate the compatibility of PE-based films and flexible packaging innovations with film reclamation systems sourcing post-consumer film from store drop-off collection points or, in some cases, curbside collection. The method also provides a report form for data and guidance from APR on evaluation of the results. For definitions, reference "Plastics Recycling Testing Terminology" at https://plasticsrecycling.org/apr-design-guide/resources/testing-terminology

Plastic film is generally defined as plastic items with a thickness of less than 10 mils (i.e., 0.010" or 0.25 mm) that are at least 85 percent (by weight) plastic with up to 15 percent other closely bonded or impregnated material, which may include printing, coatings, or fillers. Film, when used in packaging, is referred to as flexible packaging. The shape of flexible packaging typically changes when it is full of a product compared to when it is empty, whereas the shape of rigid packaging generally remains the same. In this test protocol, the term "film" is used to mean flexible packaging.

This test can be used to evaluate the impact of "innovative" PE film components. As examples: multi-layer constructions, coatings, additives, printing, labels, or new PE resin co-polymer or multi-material compositions. This test includes assessment of the effect of the innovation in both ASTM test parts and blown film. Both potential applications are included because postconsumer recovered film may end up in either a rigid application or a film application and the innovation must be shown to be compatible with both recycling processes.

**Purpose of PE Benchmark Test Protocol Development**

- Help innovators design products that are compatible with PE film recycling systems yet fully functional to protect package contents and facilitate marketing
- Assess the impact to plastic film reclaimers of film and flexible packaging components, such as carry-out bags, zipper storage bags, food wraps, pouch-style packaging, and other film products that may be candidates for store drop-off recovery & recycling and thus appear in the supply stream.
- Provide data to the Sustainable Packaging Coalition (SPC) so that they can identify what is suitable for store drop-off for those brands that participate in the How2Recycle(TM) label program
- Support Wrap Recycling Action Program (WRAP) goals of doubling store drop-off bag and wrap recycling
- Support existing end markets and encourage growth of new end markets per the "Circular Economy"

**Scope of Benchmark Test Protocol**

As specified in the current version of the PE Flexible Packaging Design® Guide, the following packaging attributes or innovations are covered by the scope of the current Film Benchmark Test Protocol.

1. Non-PE layers and coatings, including PET, nylon, EVOH, and others not specified.
2. Rigid PE and Non-PE attachments.
3. Mineral fillers and other additives that alter the density of the PE substrate.
4. Paper and PE labels.
5. Inks and pigments, including direct print, reverse print, laminated printing, and other printing technologies.

The following packaging attributes or technologies are conditionally in scope, if prior testing has been done with positive results.

1. Vacuum-deposited metalized layers, provided a metals-detection test has been done and the material passed through the detector without being identified and/or removed as a metal. APR's Evaluation of Sorting Potential for Plastic Articles Utilizing Metal, Metalized, or Metallic Printed Components can be referenced for guidance on the type of metal detection equipment to be used. https://plasticsrecycling.org/images/pdf/design-guide/test-methods/Metal_Sort_Protocol.pdf
2. "Oxo-degradable" and photo-degradable additives, as well as other additives identified as biodegradable, provided they have passed APR's PE Biodegradable Additives Test, or equivalent.

The following packaging attributes or technologies are out of scope of the Benchmark Test.

1. Metal foil layers, which are defined and deemed "non-recyclable" in APR's PE Flexible Packaging Design Guide due to the documented adverse effect on the recycling process and the quality of recycled goods produced. PE film recyclers universally separate such packages early in the process and discard them.
2. Polyvinylidene chloride (PVDC) films, layers, or coatings, which are deemed "non-recyclable" in APR's PE Flexible Packaging Design Guide due to the documented adverse effect on the recycling process and the quality of recycled goods produced. PE film recyclers universally separate such packages early in the process and discard them.

Notes on Food Residue

**Brands that choose to package food or any sticky or wet substance in a flexible package should be aware of "clean and dry" requirements for store drop-off recycling as well as prohibitions on food waste and residual liquids in bale specifications used by buyers and sellers.**

The wash systems typically operated by film recyclers use very mild conditions, with warm or room temperature water and no detergent or strong chemicals. In these circumstances, and given the increased surface area of granulated film compared to rigid container granulate, film recycling wash systems are less able to handle food and liquid contamination. It is beyond the scope of APR's Design® Guide to provide a determination of recyclability to a package based strictly on the impact of content residue.

Notes on Bale Specifications

APR's package design guidance and test methods are provided as a service to the entire recycling value chain. The data obtained from testing packaging innovations will encourage, but not guarantee, the actual fitness for these innovations in the recycling stream or their acceptance by individual recyclers. Buyers and sellers will

utilize their own bale specifications in determining the suitability of feedstocks, and prohibitions may exist that are out of APR's control.

**Hazards and Safety Statement**

APR practice, tests, and method can include the use of: electrically powered equipment, heated equipment and molten polymers, rotating motors and drive assemblies, hydraulic powered equipment, high pressure air, and hazardous laboratory chemicals. This document does not address the range of safety hazards associated with conducting the laboratory process and assessment steps that are presented. APR recommends that a trained safety professional review the laboratory equipment and materials employed in this test before beginning any lab work. APR also recommends that these practices and tests be conducted only by laboratory staff who have been trained in in safety procedures and equipment operation for laboratory work involving the preparation and evaluation of plastics.

**Control Selection**

| |
|---|
| Option #1 – If there is a PE film in the market place, similar to the Innovation and known to be recyclable, it can be selected as the control for this test, with the approval of the APR. |
| Option #2 – If there is a PE film article/resin known to be recyclable, consisting of the same base PE resin materials as Innovation, except the specific ingredient/feature being evaluated, it can be selected as the control for this test, with the approval of the APR. |

**Method Summary and Flow Diagram**

Control and two different sets of PE film blends are produced for evaluation in the laboratory. The test P-blends will be used to evaluate the innovation against a control in both pellets and ASTM Test Parts (which will simulate extruded composite lumber products).

The F-blends including the control will combine fractions of 50% P-blend with 50% virgin resin material to be used to test the innovation in blown film.

The tables below summarize the two blends and effective percentage of innovation material in each.

**P-blends (Pellet Production for Molding Parts)**

| Blend | Composition | Effective % Control Film | Effective % Innovation Film |
|---|---|---|---|
| P-0% | 100% Control film | 100 | 0 |
| P-25% | 75% Control film<br>25% Innovation film | 75 | 25 |
| P-50% | 50% Control film<br>50% Innovation film | 50 | 50 |

**F-blends (Film Production)**

| Blend | Composition | Effective % Virgin Resin | Effective % Control Film | Effective % Innovation Film |
|---|---|---|---|---|
| F-0% | 50% Virgin Pellet<br>50% P-0% Pellet | 50 | 50 | 0 |
| F-12.5% | 50% Virgin Pellet<br>50% P-25% Pellet | 50 | 37.5 | 12.5 |
| F-25% | 50% Virgin Pellet<br>50% P-50% Pellet | 50 | 25 | 25 |

**A flow diagram is provided on page 5 that outlines the testing steps**

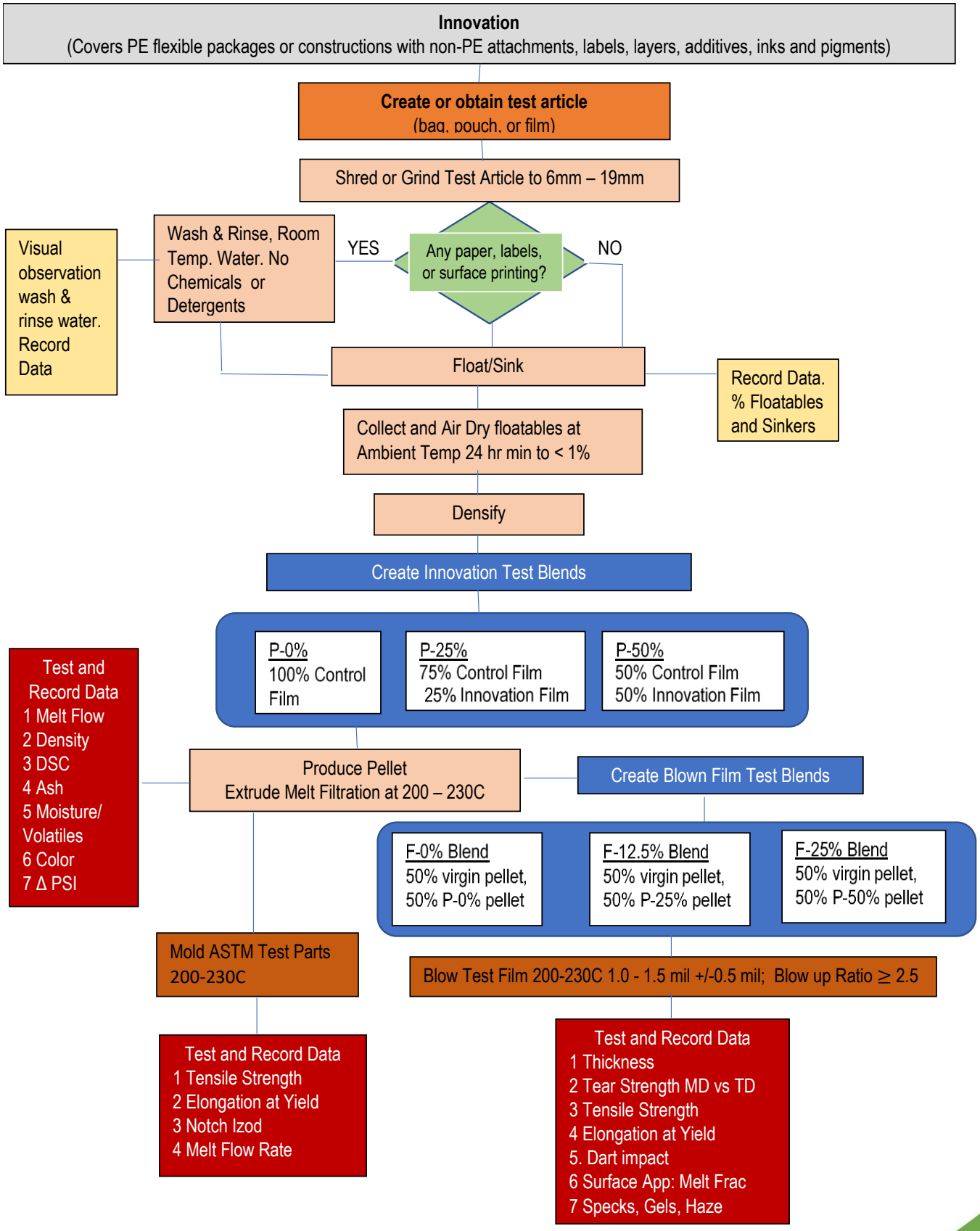
**Interpretation of Testing Results**

The Benchmark Test Protocol will evaluate blends at 50% innovation content. In choosing to use testing blends of 50% effective innovation content, APR has followed test protocol development precedents for PET and HDPE rigid containers.

APR understands that the nature of the recovery system for film materials is very different and that the overall composition of the supply stream is much less homogeneous. It is also understood that PCR feedstock is used in a number of diverse applications with very different needs and specifications. This test is designed to evaluate and document a single innovation type and its effect on the film recycling stream.

APR's test protocol will strive to accurately reflect the compatibility of any package submitted with the goal of encouraging innovation while continuing to ensure the integrity of the recycling supply stream and address the needs of the film recycling industry.

## APR BENCHMARK PE FILMS AND FLEXIBLE PACKAGING TEST PROTOCOL: FLOW DIAGRAM



**Method steps**

- Before producing film for testing, review the APR Design® Guide and confirm that the innovation film will meet the requirements outlined therein.
- The innovator is responsible for providing the required amount of film material made from each of the innovation material and control PE resin. The amount of film required can be determined per from the table below describing the amount of washed flake required.
- Innovation and control film are each granulated to flake and stored in separate containers.
- Size Reduction - Shred and/or Grind to 6mm – 19mm size reduction for lab extruder feed throats
- Flake from each of the innovation and control film are separately converted to washed flake to evaluate impact on wet wash reclaiming systems. Wash is performed ONLY if paper, labels or surface printing is present.
- Room Temperature Water Only, No Added Detergents or Caustic Wash Chemistry Temperature range (20-35C)
    a. Wash Ratio 24/1 (example 1g flake to 24ml water) at 1000RPM for 10 minutes
    b. Rinse Ratio 24/1 (example 1g flake to 24ml water) at 5 minutes with mild agitation
    c. Sink Float ratio TBD for 5 minutes with manual agitation
- Wash water and rinse water are saved for individual visual observation. The presence of suspended paper fibers and particles of PE film with attached non water-soluble adhesives will be noted. Wash and rinse water discoloration will be noted.
- Material Float/Sink required for density separation by float/sink post wash. This step is for data collection only with no requirement. Data collected will be grams of sinking and floating materials. Calculated % is reported.
- Dry with ambient air for 24 hours minimum to release surface moisture to less than 1% before densifying
- Densify with appropriate densification equipment or equivalent laboratory time and temperature conditions to achieve the bulk density required for extrusion. Temperature of 190C for 15 minutes suggested; modify if needed.
- Blends to be 0% innovation, 50% innovation and suggested 25% innovation for testing to document curves until protocol has historical data trends. Produce the following blends of size reduced or washed densified flake by physically blending the flake. Additional grinding is acceptable if further size reduction is needed.

**Pellet and ASTM Test Bar Production Blends**

| Flake Compositions | Kg of blend required | Purpose of blend |
|---|---|---|
| P-0%<br>100% Control flake | Per lab requirement for a 30-minute run time | All tests compared to control values |
| P-50%<br>50% control with 50% innovation | Per lab requirement for a 30-minute run time | Required for comparison to control values |
| P-25%<br>75% control with 25% innovation | Per lab requirement for a 30-minute run time | Optional sample innovators may run for information on the impact of concentration of the innovation on recycling |

- Extrude (Melt Filtration)
    a. Filtration suggested at 40/150/40 mesh filtration screens
    b. Extrusion run time per variable, no less than 30 minutes
    c. Minimum throughput 500 gm/cm$^2$ per hour
    d. Less than 25% pressure increase from control is sought over a stable 15 minute run time.
    e. Preferred melt temperature range to be 200-230C. In the event that the range is not optimal, record temperature and state reasons for alteration.
    f. Bulk density will be no less than 500 kg/m$^3$
    g. Visual inspection of pellets will note surface appearance and any elongation

- ASTM Pellet Testing
    a. Melt flow ASTM D1238 (g/10mins)
    b. Density ASTM D792 or ASTM D1505 (g/cm$^3$)
    c. DSC ASTM D3418 (°C)
    d. Ash Content ASTM D5630 (%)
    e. Volatiles (%) air dried pellets to be exposed to 160°C for 10 minutes
    f. Reflection color (L*, b*, a*)
    g. Δ PSI APR test for PE: less than 25% higher Δ pressure after extruding through 150 mesh for the stable 15 minute run time, compared to 100% control. No buildup on screen.

- Injection Mold ASTM test specimens for Tensile and Impact Tests
    a. Preferred melt temperature range to be 200-230C. In the event that the range is not optimal, record temperature and state reasons for alteration.

- ASTM Test Bar Testing
    a. Tensile Strength ASTM D638 (psi)
    b. Elongation at Yield ASTM D638 (%)
    c. Notched Izod ASTM D256 (ft/lbs$^3$)
    d. Melt flow ASTM D1238 (g/10mins)

**Film Testing Blends**

Blends to be 0% innovation, 12.5% innovation and suggested 25% innovation for testing to document curves until protocol has historical data trends. Produce the following blends of size reduced or washed flake by physically blending the flake:

**Film Production Blends**

| Flake Compositions | Kg of blend required | Purpose of blend |
|---|---|---|
| F-0%<br>50% P-0 Pellet and 50% Virgin Pellet | Per lab requirement for a 30-minute run time | All tests compared to control values |
| F-50%<br>50% P-50 Pellet and 50% Virgin Pellet | Per lab requirement for a 30-minute run time | Required for comparison to control values |
| F-25%<br>50% P-25 Pellet and 50% Virgin Pellet | Per lab requirement for a 30-minute run time | Optional sample innovators may run for information on the impact of concentration of the innovation on recycling |

Slip additive and/or antilock can be added only if for all virgin pellet blend equally for all control and test blends

- Film Production
    a. This is a data collection step. There will not be guidance requirements to meet for benchmark testing. production observation to be recorded and reported (structure/holes/stability). Films will be produced with the following specifications.
        1. Melt Temperature 200-230 C
        2. Thickness 1.0 mil to 1.5mil
        3. Blow up ratio > 2.5 (example: 10 cm die diameter to 25 cm bubble diameter)
    b. Blown film is the most stringent application and the preferred way to test innovations. If a party proposes testing a cast film innovation into cast film, they should contact APR for a consultation on the required procedures.

- Film Testing
    a. Thickness Testing ASTM D6988 (mil)
    b. Tear Strength ASTM D1922 (MD/TD) (g)
    c. Tensile Strength ASTM D882 (MD/TD) (psi)
    d. Elongation at Yield ASTM D882 (MD/TD) (%)
    e. Dart Impact ASTM D1709 (g)
    f. Haze ASTM D1003 (%)
    g. Gels and Specks: 5 samples of 10cm x 10cm for a gel and specks count greater than 0.38mm seen by the naked eye at 30cm from sample. The number will be recorded but no standard required
    h. Surface appearance for melt fracture

**Report Form and Assessment (Including Any Guidance Values)**

**Test Pellets**

| Assessment | Result | APR Benchmark Recommendation |
|---|---|---|
| Melt Flow Rate | | < 0.5 g/10min delta to control value |
| Density | | < 1 g/cc |
| DSC | | Melt Temperature < 150C |
| Ash | | Record, no requirement |
| Moisture/Volatiles | | < 1.0% |
| Color | | Record, no requirements |
| Delta Pressure | | No more than 25% delta to control |
| Bulk Density | | No less than 500 $kg/m^3$ |
| Surface Appearance | | Record via visual inspection, no requirement |

**Test ASTM Parts**

| Assessment | Result | APR Benchmark Recommendation |
|---|---|---|
| Tensile Strength | | No more than 25% delta to control |
| Elongation at Yield | | No more than 25% delta to control |
| Notch Izod | | No more than 25% delta to control |
| Melt Flow Rate | | < 0.5 g/10min delta to control value |

**Test Film**

| Assessment | Result | APR Benchmark Recommendation |
|---|---|---|
| Thickness (in.) | | 1.0 - 1.5mil |
| Tear Strength (TD) | | No more than 25% delta to control |
| Tear Strength (MD) | | No more than 25% delta to control |
| Tensile Strength (TD) | | No more than 25% delta to control |
| Tensile Strength (MD) | | No more than 25% delta to control |
| Elongation at Yield (TD) | | No more than 25% delta to control |
| Elongation at Yield (MD) | | No more than 25% delta to control |
| Dart Impact | | No more than 25% delta to control |
| Haze | | Record, no requirements |
| Gels and Specks | | Record, no requirements |
| Surface Appearance/ Melt Fracture | | Record via visual inspection, no requirements |

*Film testing results are minimum conditions. Historical data over time may require adjustments for specification change. and requirements for specific applications.

DOCUMENT VERSION HISTORY

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| 1 | April 20, 2018 |
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