IAPMO UNIFORM ES
4755 East Philadelphia Street
Ontario, California – USA 91761-2816
Ph: 909.472.4100 | Fax: 909-472-4171
http://www.uniform-es.org

INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS
UNIFORM EVALUATION SERVICE

EVALUATION CRITERIA FOR HDPE AND FOAM COMPOSITE BUILDING MATERIAL EC 035-2018 (Adopted July 2018)

1.0 INTRODUCTION

1.1 PURPOSE: The intent of this criteria is to establish requirements for High Density Polyethylene (HDPE) composite shell with foam plastic core for use as building material to be recognized in an evaluation report independently reviewed and issued by a certification body under the 2018 and 2015 International Building Code (IBC), and the 2018 and 2015 International Resident Code (IRC).

This Evaluation Criteria (EC) is intended to provide a guideline for the evaluation of HDPE composite shell with foam plastic core as building material, since the IBC, IRC, and associated reference standards do not specify requirements for such usage.

1.2 SCOPE: This document describes the test procedures and analysis methods used to assess HDPE composite shell with foam plastic core as building material across six objectives: (1) Quality, (2) Strength, (3) Effectiveness, (4) Fire Resistance, (5) Durability and (6) Safety as set forth in for recognition in an Evaluation Service Report.

The HDPE composite shell with foam plastic core is used primarily as structural material with load bearing, shear and diaphragm capacity for a pre-fabricated integrated modular building system as an alternative to the requirements of Section 1403 of the IBC for walls and Section 1506 of the IBC for roofs. The HDPE facing will act as the exterior and interior finish material. Other product characteristics shall comply with the governing code provisions or certification body's evaluation criteria, as applicable.

This criteria establishes minimum standards and minimum test requirements to assess the performance of HDPE composite shell filled with PE or equal foam plastic as a building material, together with methods of marking and identification.

The certification body issuing the evaluation report shall be accredited as complying with ISO/IEC Standard 17065 by an accreditation body conforming to ISO/IEC 17011 that is a signatory to the International Accreditation Forum (IAF) Multilateral Recognition Agreement (MLA).

2.0 REFERENCED STANDARDS

2.1 GENERAL: The IAPMO Uniform ES criteria for HDPE composite shell with foam plastic core as building material are based on and comply with the following references. Standards referenced in this criteria shall be applied consistent with the specific edition of the code(s) for which the Evaluation Report is prepared unless otherwise approved by the certification body. Unless indicated otherwise, publications listed are current editions.

2.2 INTERNATIONAL CODE COUNCIL

2.1.1 International Building Code® (IBC), 2018 and 2015, International Code Council

2.1.2 International Residential Code® (IRC), 2018 and 2015, International Code Council

2.2 ASTM INTERNATIONAL

2.2.1 ASTM D695 – 15: Standard Test Method for Compressive Properties of Rigid Plastics

2.2.2 ASTM D638 – 14: Standard Test Method for Tensile Properties of Plastics

2.2.3 ASTM D732 – 17: Standard Test Method for Shear Strength of Plastics by Punch Tool

2.2.4 ASTM C518 – 17: Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus

2.2.5 ASTM D4976 – 12a: Standard Specification for Polyethylene Plastics Molding and Extrusion Materials

2.2.6 ASTM E72 – 15: Standard Test Methods of Conducting Strength Tests of Panels for Building Construction

2.2.7 ASTM E108 – 16: Standard Test Methods for Fire Tests of Roof Coverings

2.2.8 ASTM D4819 – 13: Standard Specification for Flexible Cellular Materials Made from Polyolefin Plastics

2.2.9 ASTM D570 – 98(2010): Standard Test Method for Water Absorption of Plastics

2.2.10 ASTM D6341 – 16: Standard Test Method for Determination of the Linear Coefficient of Thermal Expansion of Plastic Lumber and Plastic Lumber Shapes Between -30 and 140°F (-34.4 and 60°C)

2.2.11 ASTM D2990 – 17: Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics

2.2.12 ASTM C1427 – 16: Standard Specification for Extruded Preformed Flexible Cellular Polyolefin Thermal Insulation in Sheet and Tubular Form

2.13 ASTM E178 – 16a: Standard Practice for Dealing with Outlying Observations

2.14 ASTM E2322 – 03(2015): Standard Test Method for Conducting Transverse and Concentrated Load Tests on Panels used in Floor and Roof Construction

2.15 ASTM E2126 – 11: Standard Test Methods for Cyclic (Reversed) Load Test for Shear Resistance of Vertical Elements of the Lateral Force Resisting Systems for Buildings
2.16 ASTM D1435 – 13: Standard Practice for Outdoor Weathering of Plastics
2.17 ASTM G154 – 12a: Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials
2.18 ASTM D7989 – 15: Standard Practice for Demonstrating Equivalent In-Plane Lateral Seismic Performance to Wood-Frame Shear Walls Sheathed with Wood Structural Panels

2.3 INTERNATIONAL STANDARDS ORGANIZATION

2.3.1 ISO/TR 10358:1993: Plastics pipes and fittings -- Combined chemical-resistance classification table
2.3.2 ISO/IEC 17011:2004: Conformity assessment -- Requirements for accreditation bodies accrediting conformity assessment bodies
2.3.3 ISO/IEC 17020:2012: Conformity assessment -- Requirements for the operation of various types of bodies performing inspection
2.3.4 ISO/IEC 17025:2005: General requirements for the competence of testing and calibration laboratories
2.3.5 ISO/IEC 17065:2012: Conformity assessment -- Requirements for bodies certifying products, processes and services

2.4 NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

2.4.1 NFPA 286-15: Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth

2.5 UNDERWRITERS LABORATORIES

2.5.1 UL 790-2014, Revised July 29, 2014: Standard for Standard Test Methods for Fire Tests of Roof Coverings

3.0 DEFINITIONS

3.1 High Density Polyethylene (HDPE): Thermoplastic material with specific gravity of 58.7 pcf (922.7 kg/m^3) and greater.

3.2 HDPE Composite Shell with Foam Plastic Core: Material consisting of HDPE foamed to form a high density outer layer and low density core. As an alternative, the foam plastic core may consist of another foamed-in-place polymer, such as polyurethane.

4.0 BASIC INFORMATION AND TEST REPORTS

4.1 DESCRIPTION: The following information and data shall be submitted for review and evaluation for recognition of HDPE composite shell filled with PE or equivalent foam plastic as a building material in an evaluation report:

4.1.1 PRODUCT DESCRIPTION: Complete information pertaining to components, material specifications, and manufacturing processes. Materials shall comply with an appropriate recognized national standard(s).

4.1.1.1 COMPONENTS:

4.1.1.1.2 COMPOSITE SHELL WITH FOAM PLASTIC CORE: Rotationally-molded High Density Polyethylene (HDPE) includes fire-retardant additives and is exposed on one side to a foaming agent to create a shell-like outer layer and foam plastic core. Alternatively, the core may consist of a polymer that is foamed in place against the outer HDPE shells.

4.1.1.1.3 HARDWARE: Fastening system using steel bolts, plates, connectors and brackets shall be used to tie and connect the HDPE composite shell filled with PE or equal foam plastic building components.

4.1.1.2 MATERIAL SPECIFICATIONS:

4.1.1.2.1 FLAME RETARDANT HIGH DENSITY POLYETHYLENE: The material shall comply with requirements in Section 5.2 and 5.3 of this criteria.

4.1.1.2.2 FOAMED-IN-PLACE POLYMER: The material is intended for the core only and shall comply with requirements in Section 5.3 of this criteria.

4.2 MANUFACTURING PROCESS: Either of the following processes may apply:

4.2.1 All parts shall be manufactured using rotational molding technology. Rotational molding involves a heated hollow steel mold filled with resin powder. The mold shall be made with a double-wall shell cavity construction and the resin shall be expanded to fill the cavity.

4.2.2 The exterior shells shall be manufactured using rotational molding, involves a heated hollow steel mold filled with resin powder. The inner core shall be a polymer that is foamed into place against the inside face of the HDPE shells, forming a sandwich type construction.

4.3 INSTALLATION INSTRUCTIONS: Installation details and drawings, noting installation requirements and/or limitations.

4.4 IDENTIFICATION: Each part shall bear an imprint which clearly identifies the manufacturer or a registered trademark, model number or name of the product, and size. Packaging shall include the evaluation report number and certification body logo.

4.5 TEST REPORTS: The test reports shall be in accordance with specified procedures and standards (ASTM, ISO, NFPA). In additional to reporting content specified in the applicable standard, the reports shall include:

4.5.1 A description of the test procedures, test results, observations, tested assemblies, load measurements, and photographs of specimens and typical failures.

4.5.2 A description of the test specimens.

4.5.3 Information as set forth in the referenced test standard.

4.6 TESTING LABORATORIES: Testing laboratories shall be recognized by the certification body as suitable prior to testing. Testing laboratories shall be accredited for the applicable testing procedures, in accordance with ISO/IEC 17025, by a recognized accreditation body conforming to ISO/IEC 17011 that is a signatory to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement (MRA). Testing at a non-accredited laboratory may be permitted by the certification body, provided the testing is conducted under the supervision of an accredited laboratory and the supervising laboratory issues the test report.

5.0 TESTING & PERFORMANCE REQUIREMENTS

5.1 GENERAL: The HDPE composite shell with foam plastic core building material submitted to the laboratory for testing shall be representative samples of the manufactured product. Test procedures, equipment and materials shall be in compliance with international testing procedures and standards.

5.2 HDPE SHELL

5.2.1 General: The plastic shall comply with ASTM D4976, as Group 2, Class 3 or 4. Tensile properties shall be evaluated at four or more strain rates. Properties in ASTM D4976 and Sections 5.2.3, 5.2.4, 5.2.7, 5.2.8, and 5.2.9 of this criteria shall be evaluated at 73°F (23°C), or as specified in the test procedure; optionally, testing at elevated temperatures and low temperatures may be added.

5.2.2 Fire-Retardancy: The fire-retardant characteristics shall comply with IBC Section 2606.4 as CC1 or CC2.

5.2.3 Shear Strength:

5.2.3.1 Test Description: This test will assess HDPE shell's shear strength by the use of punch-type tooling in accordance with ASTM D732 procedures and will determine shear strength.

5.2.3.2 Performance Requirement: The values obtained from ASTM D732 will be used as a standard to determine applicability and limitations of the HDPE shell as building material.

5.2.4 Compressive Strength

5.2.4.1 Test Description: This test will assess HDPE shell's performance under compressive loads. Testing will be conducted in accordance with ASTM D695 and will determine the compressive properties.

5.2.4.2 Performance Requirement: The values obtained from ASTM D695 will be used as a standard to determine applicability and limitations of the HDPE component as building material.

5.2.5 Chemical Exposure: An evaluation of the chemical resistance of HDPE shall be provided. The HDPE shall comply with ISO/TR 10358. The evaluation report shall report chemicals rated S.

5.2.6 Moisture Absorption: ASTM D570. Tests shall be conducted at 73°F (23°C).

5.2.7 Coefficient of Thermal Expansion: ASTM D6341.

5.2.8 Creep: ASTM D2990. Tests shall be conducted for 1,000 hours minimum and at least three stress levels. The creep modulus shall be reported.

5.3 HDPE FOAM PLASTIC AND FOAMED-IN-PLACE POLYMER: The HDPE foam plastic or foamed-in-place polymer shall comply as Type II in accordance with ASTM C1427 and Type I/II in accordance with ASTM D4819. The results of surface burning characteristics shall comply with IBC Section 2603.3.

5.4 STRUCTURAL TESTS

5.4.1 In-Plane Shear Wall Tests in Seismic Design Categories A, B and C:

5.4.1.1 In-plane Testing: In-plane shear load tests on walls shall be conducted in accordance with ASTM E72 or ASTM E564 on three or more replicate specimens. The mean results of all tests are permitted for analysis provided the coefficient of variation is 15 percent or less. Otherwise, additional tests are required until the COV converges. No test shall be excluded unless determined as an outlier in accordance with ASTM E178. As alternative, the lowest individual result may be used in analysis.

5.4.1.2 Analysis: The allowable stress design (ASD) strength of each test series shall be the lesser of:

- Average peak load divided by a safety factor of three.
- Average load at initial failure modes that compromise the load-bearing capacity in compression.
- Average load at a net horizontal deflection of 0.2 inch (5.1 mm).

5.4.2 In-Plane Cyclic Shear Wall Tests in Seismic Design Categories A to F:

5.4.2.1 In-Plane Testing: In-plane shear load tests on walls shall be conducted in accordance with ASTM E2126 on three or more replicate specimens. The mean results of all tests are permitted for analysis provided the coefficient of variation is 15 percent or less. Otherwise, additional tests are required until the COV converges. No test shall be excluded unless

determined as an outlier in accordance with ASTM E178. As alternative, the lowest individual result may be used in analysis.

5.4.2.2 Load-Bearing Walls: Load bearing walls may to subject to simultaneous axial compression and in-plane lateral loads acting on the facings. Additional tests shall be done to determine the effectiveness of load-bearing shear wall in areas of high seismicity. Testing shall conform to the following requirements:

5.4.2.2.1 Testing in accordance with ASTM E2126 and Section 5.4.2.1 of this criteria, modified to include axial compression loads on the test assemblies. The axial compression loads are applied statically and need not exceed maximum allowable axial load for the panel configuration.

5.4.2.2.2 The axial compression loads shall be constant and not vary during the in-plane displacement cycles and at completion. Verification of axial loading shall be by measurement and recording.

5.4.2.2.3 The axial compression loads shall occur over the load beam shown in Figure 5 of ASTM E2126 or with a similar placement such that facings are fully stressed to the expected axial and shear forces during the testing.

5.4.2.3 Analysis: The allowable strength design (ASD) strength of each test series in Sections 5.4.2.1 and 5.4.2.2 of this criteria shall be determined in accordance with IAPMO UES EC-003, The Testing Analysis of Steel Sheet Sheathing for Wood and Cold Formed Steel Light Framed Structure Shear Walls. The seismic design coefficients, factors, and system limitations may be taken from ASCE 7 Table 12-2-1, System A-15, provided compliance with ASTM D7989 is established. Otherwise seismic design coefficients, factors, and system limitations shall be taken from ASCE 7 Table 12-2-1, System A-17.

5.4.3 Axial Compression Load Tests:

5.4.3.1 Testing: Axial compression load tests on walls shall be conducted in accordance with ASTM E72 on three or more replicate specimens. The mean results of all tests are permitted for analysis provided the coefficient of variation is 15 percent or less. Otherwise, additional tests are required until the COV converges. No test shall be excluded unless determined as an outlier in accordance with ASTM E178. As alternative, the lowest individual result may be used in analysis.

5.4.3.2 Analysis: The allowable stress design (ASD) strength of each test series shall be the lesser of:

- Average peak load divided by a factor of safety of three.
- Average load at a net axial deflection of 0.125 inch (3.2 mm).
- Average load recorded at first cracking of plastic material.

5.4.4 Transverse Uniform Load Tests:

5.4.4.1 Testing: Transverse uniform load tests on walls, floors, and roofs shall be conducted in accordance with ASTM E2322 on three or more replicate specimens. The mean results of all tests are permitted for analysis provided the coefficient of

variation is 15 percent or less. Otherwise, additional tests are required until the COV converges. No test shall be excluded unless determined as an outlier in accordance with ASTM E178. As alternative, the lowest individual result may be used in analysis.

5.4.4.2 Analysis:

- The allowable stress design (ASD) strength of each test series shall be the average peak load divided by a factor of safety of three or greater.
- Load-deflection relationships shall be developed, up to the limits in IBC Section 1604.3.1.

5.4.5: CONNECTIONS: Connections to the units used in the testing shall be described in detail along with installation procedures and location.

5.4.6 DESIGN: Except as stated in Section 5.4.2.3 of this criteria, the strength properties determined in Section 5.2 of this criteria shall include a factor of safety of 2.5 or greater to the yield stress and three or greater to the breaking stress for use in ASD analysis. Structural analysis and engineered design of structures shall consider basic material properties driven from tests described in Sections 5.2, 5.3, and 5.4 of this criteria. The design methodologies shall include provisions for load interactions.

5.5 FIRE EXPOSURE TESTS

5.5.1 ROOF CLASIFICATION: Roof classification tests described in ASTM E 108 or UL 790 for compliance under the IBC and IRC, are required. The roof assembly shall comply as Class A, B or C roof assembly classification**.** ASTM E108 or UL 790 tests HDPE/HDPU component's performance as roof covering, measuring the surface spread of flame and the ability of the material to resist fire penetration from the exterior to the underside. Tests shall be conducted with the maximum roof load intended for inclusion in the evaluation report, unless the component is fully supported by code complying structural deck. Test parameters will vary depending on which class is being specified for the evaluation.

5.5.2 INTERIOR EXPOSURE: A room corner fire test shall be conducted in accordance with NFPA 286 as set forth in IBC Section 803.9. The test results shall comply with IBC Section 803.1.1.1 for acceptance. The test assembly shall include the systems with wall and ceiling of maximum component thickness for which recognition is desired and shall simulate the actual field application condition. Panels intended to support superimposed loads shall be fire-resistance tested in accordance with Section 4.5, except when use is limited to non-fire-resistance-rated construction. Panels shall be loaded in a manner resulting in conditions of maximum allowable stress in floors or walls.

5.6 THERMAL RESISTANCE TESTS:

5.6.1 Steady-State Thermal Transmission Properties: In accordance with ASTM C518-15, this test method covers the measurement of steady state thermal

transmission through flat slab specimens using a heat flow meter apparatus. This test method may be used to characterize material properties, which may or may not be representative of actual conditions of use.

5.7 EXTERIOR EXPOSURE TESTS:

5.7.1 Weather Protection of Walls: Weather protection of the wall system shall be demonstrated as complying with IBC Section 1402.2, Exception 2. The specimens shall consist of the HDPE composite wall system and any exterior wall coverings. The specimen thickness shall represent the minimum combination of coating and foam plastic. Additional tests for different combinations of joints, openings, sills, and interface with roofs may be required.

5.7.2 Water-penetration Test of Roof Panels: A 6-inch square sample of facing shall be sealed to a suitable frame with putty, mastic or other compound to provide a watertight seal. The frame extends from the bottom of the sample to a minimum height of 5 inches (127 mm) above the top of the sample. The head of water shall be maintained on the sample for a minimum of 24 hours. The head of water shall be 2 inches (50.8 mm) or equivalent water depth determined from the water penetration test, Section 6.5, whichever is greater.

5.7.2.1 Conditions of Acceptance: At the end of 24 hours, there shall be no indication that water has dripped from the underside of the specimens.

5.7.3 Weathering: Effects of weathering shall conform to either Section 5.7.3.1 or 5.7.3.2 of this criteria. Samples shall be the thickness(es) representative of end use and as large as possible to facilitate both physical property and optical appearance evaluation. Physical property testing in accordance with ASTM D4976 and optical tests shall be conducted on exposed samples. Examination under by minimum 5× magnification shall report any cracking, checking, crazing, erosion or other visible damage that might affect performance of the material. The results of physical tests shall be compared to control specimens. Any adverse variance exceeding 10 percent shall be result in adjustments to the design loads.

5.7.3.1 Outdoor Exposure: The producers or users, or both, of new compounds for exterior building applications shall conduct weathering studies on all colors of each compound produced for at least two years in at least three widely different climatic areas. A dry, hot climate, such as Phoenix, AZ; a hot, humid climate, such as Miami, FL; and a temperate northern climate, such as Northern Ohio, Kentucky, or New Jersey are suggested sites. Records of color change, physical appearance, and property change shall be maintained for reference by purchaser.

- Samples shall be exposed in accordance with Practice D1435.
- Samples shall face south at a 45° angle of elevation for exposure periods of 6 months, 1 year, and 2 years at each exposure site selected.

5.7.3.2 Accelerated Weathering: Specimens shall be tested in accordance with ASTM G154 at approximately 315, 630, 1260, 1890, and 2520 kJ/m^2 with following parameters: UVB bulbs; 0.71 W/(m^2 • nm) irradiance; 310 nm wavelength; Exposure cycle is 4 hours UV at 60 (±3) °C Black Panel Temperature and 4 hours Condensation at 50 (±3) °C Black Panel Temperature.

6.0 QUALITY CONTROL

6.1 Quality documentation complying with the UES Minimum Requirements for Listee's Quality Assurance System (UES-010) shall be submitted. A complete description shall be provided of the quality management system used in the factory to manufacture the HDPE composite shell with foam plastic core for the building system.

6.2 Inspections of manufacturing facilities are required for this product. The inspections shall be conducted by the certification body or an inspection body accredited in accordance with ISO/IEC 17020 by an accreditation body conforming to ISO/IEC 17011 that is a signatory to the International Accreditation Forum (IAF) Multilateral Recognition Agreement (MLA).

7.0 EVALUATION REPORT RECOGNITION

7.1 The product identification label shall include the manufacturer's name and address, the evaluation report number, as required by the certification body. The product identification number shall be visible on the product.

7.2 The final evaluation report shall indicate that HDPE composite shell with foam plastic core is applicable for use as building material and set appropriate parameters to comply with the IBC or IRC, along with any other pertinent information to the satisfaction of the certification body. These parameters include structural strengths and stiffnesses, durability, weather protection, and fire exposure.