

INDUSTRY GUIDELINES **POP208**

Specification and testing guidelines for recycled materials suitable for non-pressure plastic pipe applications.

Polyethylene, Polypropylene and Rigid PVC

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Specification and testing guidelines for recycled materials suitable for non-pressure plastic pipe applications

SCOPE

This guideline defines the specification and testing requirements for recycled post-consumer or pre-consumer polyethylene (PE), polypropylene (PP) and rigid PVC materials for incorporation into non-pressure pipe and fittings applications covered by the Standards listed below. Additional performance testing requirements for pipe and fittings incorporating recycled materials have also been defined and are detailed in the Appendix A. This is applicable to both plain and structured wall pipe and fittings.

AS/NZS 5065	Polyethylene and polypropylene pipes and fittings for drainage and sewerage applications
AS/NZS 4401	Plastics piping systems for soil and waste discharge (low and high temperature) inside buildings – Polyethylene (PE)
AS/NZS 2439	Perforated drainage pipe and associated fittings
AS/NZS 1254	PVC-U pipes and fittings for stormwater and surface water applications
AS/NZS 1260	PVC-U pipes and fittings for drain, waste, and vent applications
AS/NZS 2053	Conduits and fittings for electrical installations
AS/NZS 61386.21	Conduit systems for cable management

1.0 INTRODUCTION

Due to the critical role plastic pipes play in our everyday lives, delivering essential services and utilities, it is extremely important for them to be designed and manufactured to meet the required performance. The long-term performance of thermoplastic pipes is highly dependent upon using plastic materials that have the required physical, chemical, and rheological properties. These material properties along with correct pipe design will ensure that pipe performance criteria are met whether the pipe is made from 100% virgin material, or a combination of virgin and post-consumer or pre-consumer recycled thermoplastic materials.

Relevant AS/NZS Standards define material properties and pipe performance criteria. However, internationally a large amount of research and standard development has been undertaken on material characteristics and structured wall pipe performance criteria using recycled materials in non-pressure pipe and fittings

This guideline takes into consideration the work undertaken internationally and provides further guidance on the evaluation and use of post-consumer and pre-consumer recycled materials in non-pressure pipe applications, providing a pathway for future Standards development here in Australia.

The various recycled material characteristics in this guideline are based on specification and testing criteria defined in international standards - ISO, EN, ASTM and AASHTO listed in Appendix C.

2.0 MATERIAL DEFINITIONS

POST-CONSUMER^{1&2}

Plastics material generated by households or by commercial, industrial, and institutional facilities in their role as end-users of the product that have fulfilled their intended purpose or that can no longer be used.

PRE-CONSUMER^{1,2&3}

Plastics material diverted from the waste stream during a manufacturing process or from unused products. Excluding manufacturers own rework, regrind or scrap.

REWORKED MATERIAL²

Plastics scrap material which is generated from the manufacturers own production of pipes or fittings that has been retained within plants owned and operated by the same legal entity (also known as own re-processed material).

Note: Transportation from one plant to another of the same legal entity is considered as retained.

RECYCLED MATERIAL²

Plastics material resulting from the recycling of post-consumer and/or pre-consumer plastics products, reprocessed that can be made into pipes or fittings in accordance with the relevant product Standard.

VIRGIN MATERIAL²

Plastics material in a form such as granules or powder, which has not been previously processed other than for compounding, and to which no rework or recyclable materials have been added.

ROUGH-CUT REGRIND

Plastics material from post-consumer, pre-consumer or reworked sources that has gone through shredding and /or granulation size reduction processes producing an irregular shaped particle of varying size. This material may be washed or unwashed.

RE-PELLETISED MATERIAL

This is rough-cut regrind material that has gone through an extrusion process converting it into regular size and shaped pellets.

MICRONISED MATERIAL

Plastics material, typically PVC that has been finely ground into powder.

Notes:

1. Definition is based on AS 14021" Environmental labels and declarations – Self declared environmental claims (Type 2 Environmental Labelling) (ISO 14021:2016MOD)"
2. Definition is based on CEN/TS 14541.1 "Plastics pipes and fittings – Utilisation of thermoplastics recyclates Part 1 Terminology"
3. Previously defined as Post-Industrial.

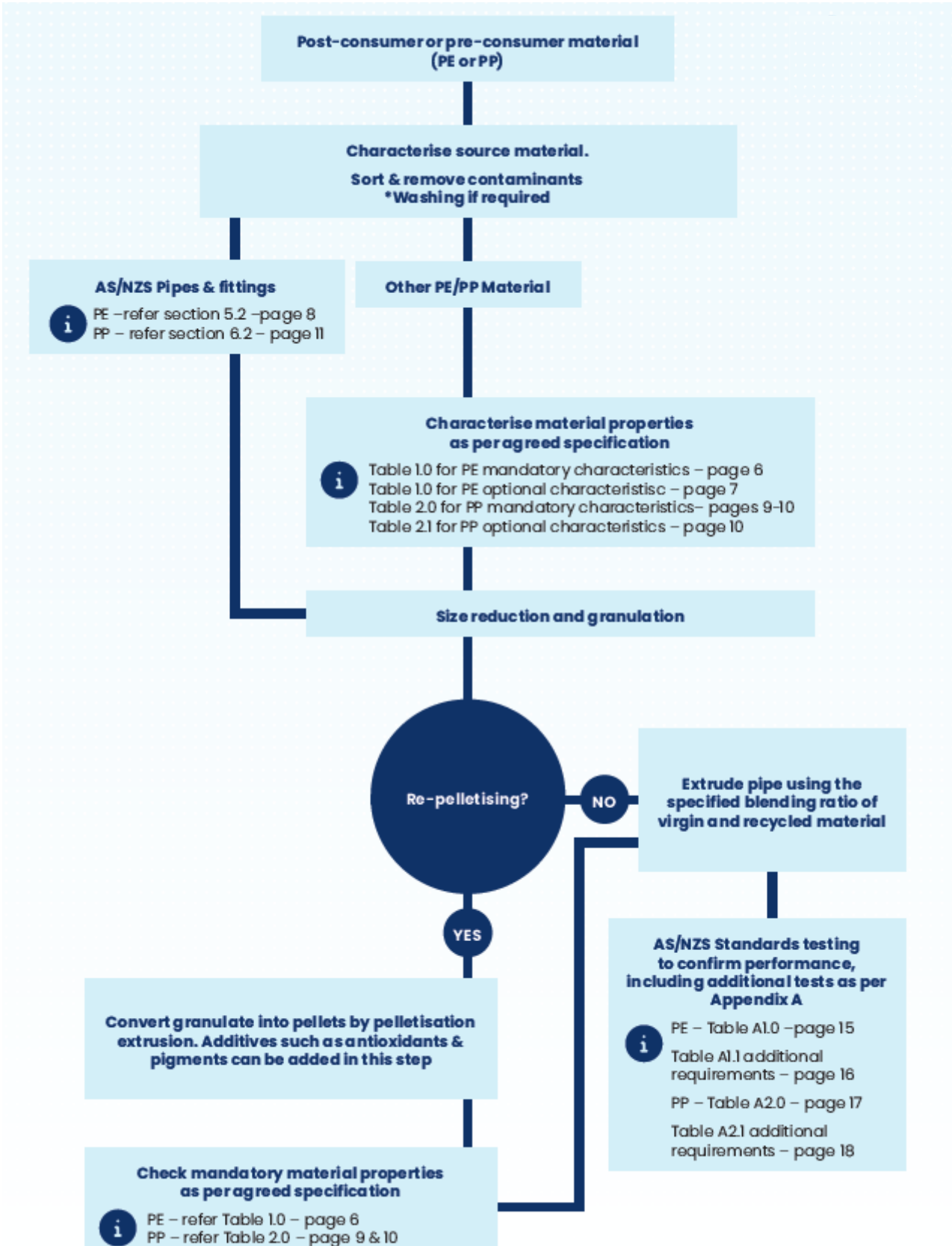
3.0 MATERIAL CHARACTERISTICS FOR RECYCLED MATERIALS

It is extremely important externally sourced recycled materials (post-consumer and pre-consumer) conforms with an agreed specification between the supplier and purchaser to ensure the material is fit for purpose. These materials shall be permitted to be used alone or added to virgin or manufacturers own rework or a combination for the production of polyethylene, polypropylene, and PVC-U pipes (and fittings, if relevant) for non-pressure applications.

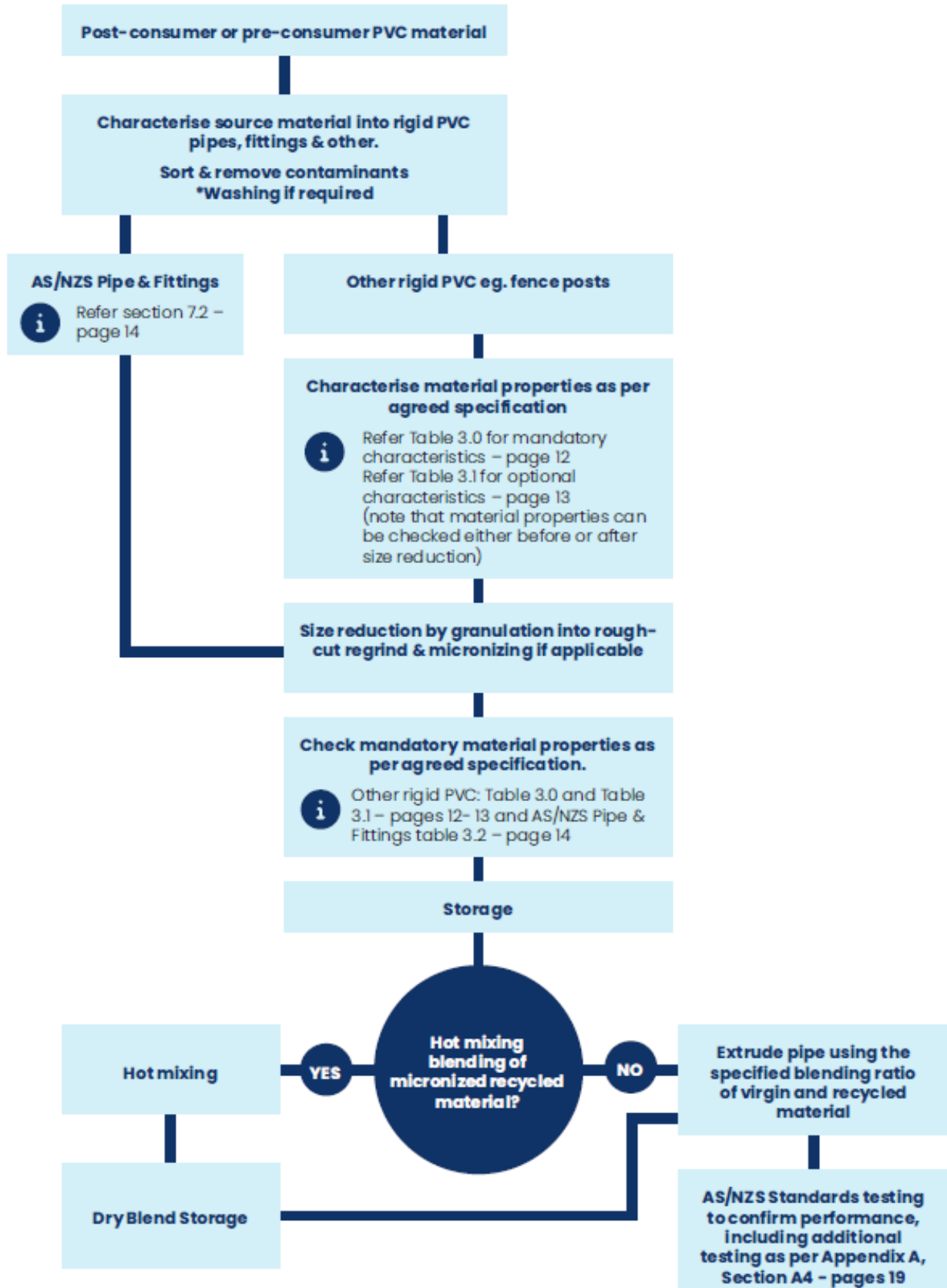
- a) A specification for each material type shall be agreed upon between the supplier of the external recycled material and pipe / fitting manufacturer. The specification shall cover at least the mandatory characteristics given in tables 1.0 and 1.1 for PE, tables 2.0 and 2.1 for PP and tables 3.0 and 3.1 for rigid PVC.
- b) The quality plan of the supplier of external recycled material shall not be less stringent than the relevant requirements of ISO 9001.
- c) The material shall be clean and free from visible contamination. Material filtering during pelletisation or extrusion shall be carried out.
- d) Each delivery of recycled material shall be covered by a certificate of conformity according to EN 10204:2004, 3.1 showing conformity to the agreed specification.
- e) Where a certificate of conformity is not provided with external recycled material, the pipe manufacturer shall conduct verification testing on all material to confirm that it conforms to the requirements.
- f) The maximum quantity of external recycled material that is intended to be added shall be specified by the manufacturer.
- g) The manufacturer will verify the performance of pipe and / or fitting incorporating recycled material of a known specification at the defined maximum addition level. Performance requirements are specified by the relevant AS/NZS Standard plus the additional requirements defined in Appendix A of this document.
- h) The quantity of recycled material that is added in each production batch shall be recorded by the manufacturer.

4.0 MATERIAL RECYCLING AND CONVERSION PROCESS STEPS

4.1 PE&PP MATERIAL RECYCLING AND CONVERSION PROCESS STEPS



4.2 RIGID PVC MATERIAL RECYCLING AND CONVERSION PROCESS STEPS



5.0 MATERIAL CHARACTERISTICS FOR RECYCLED POLYETHYLENE (PE) MATERIALS

The following tables define both mandatory and optional characteristics for recycled polyethylene (PE) materials:

- Section 5.1 Table 1.0 defines mandatory characteristics and Table 1.1 defines optional characteristics for externally sourced PE recycled material.
- Section 5.2 Table 1.2 defines mandatory characteristics and Table 1.4 defines optional characteristics for externally sourced recycled PE pipes and fittings manufactured to applicable AS/NZS Standards.

Mandatory characteristics represent the minimum specification requirements to define a recycled material.

5.1 POLYETHYLENE (PE) RECYCLED MATERIAL CHARACTERISTICS TO BE COVERED BY AN AGREED SPECIFICATION FOR NON-PIPE AND FITTING SOURCES

Samples shall be taken from compounded and pelletised batches or from each individual material batch source. The frequency of sampling shall be agreed between the supplier and the product manufacturer.

Table 1.0 Mandatory Characteristics

CHARACTERISTIC	UNIT	TEST METHOD	REQUIREMENT
Density	kg/m ³	ISO 1183-1 ASTM D4883 Ultrasonic technique not impacted by colour	+/- 3 kg/m ³ of the agreed mean density
Melt mass-flow rate (MFR)	g/10 min	ISO 1131-1 Temp = 190°C Load = 5kg	≤1.6g/10min (190°C/5kg) and within +/-20% of the agreed mean MFR (190/5)
Oxidation Induction Time	min	ISO 11357-6 Temperature = 200°C	minimum = 20 minutes (granulate or pelletised material)
Carbon Black Content (black only)	%	ISO 6964	2 – 4 % carbon black
Carbon black dispersion		AS/NZS 1462.28	Shall not be worse than micrograph B in Annex B of AS/NZS 1462.28
Carbon black average particle size range (black only)	nm	ASTM D3849 or equivalent	Average particle size shall not exceed 40 nm
Elongation at Break	%	ISO 527-2 At 50mm/min Test type 1B Test samples = 5	≥150% for density ≥ 950kg/m ³ ≥250% for density < 950kg/m ³
Source of base recycled material		Declaration of source by recycle supplier/input material processor	% from PE pipe % from HDPE bottles % from other
Shape		Visual inspection	Rough-cut regrind or pellets

Table 1.1 Optional Characteristics

CHARACTERISTIC	UNIT	TEST METHOD	REQUIREMENT
Filler content assessment by ash residue or thermogravimetric analysis	%	ISO 3451-1 ASTM D5630 (2g, 800°C) or Thermogravimetric Analysis (TGA) as per ASTM E1131 or ISO 11358	Maximum percentage to be agreed between supplier and purchaser
Volatile Content	mg/kg g	ISO 4437	≤ 350 mg/kg
Extraneous Polymers		FTIR analysis – ASTM D7399 DSC - ISO 11357-3	Presence /no presence of PP contaminants
Non-meltable particles/impurities		Mesh filtering	Agreed mesh size for inline screen pack on pelletising extruder
Flexural Modulus	MPa	ISO 178	To be agreed between supplier and purchaser
Bulk Density	kg/m ³	ISO 60 or an alternative method agreed between the supplier and purchaser.	To be agreed between supplier and purchaser

5.2 POLYETHYLENE RECYCLED MATERIAL CHARACTERISTICS TO BE TESTED FOR EXTERNALLY SOURCED RECYCLED PE PIPES AND FITTINGS MANUFACTURED TO APPLICABLE AS/NZS STANDARDS

If the source of the material is from pipes or fittings manufactured to the following listed AS/NZS Standards and produced under an ISO Type 5 product certification program, then only those characteristics given in Table 1.3 need to be tested and Table 1.4 are optional:

- AS/NZS 4130 Polyethylene (PE) pipes for pressure applications
- AS/NZS 5065 Polyethylene and polypropylene pipes and fittings for drainage and sewerage applications
- AS/NZS 4129 Fittings for polyethylene (PE) pipes for pressure applications (Note: removal of non-PE-100 material may be required)

Table 1.3 Mandatory Characteristics

CHARACTERISTIC	UNIT	TEST METHOD	REQUIREMENT
Melt mass-flowrate (MFR)	g/10 min	ISO 1131-1 Temp = 190°C Load = 5kg	Check MFR of pipe and fittings prior to reprocessing. MFR of reprocessed material shall not deviate from the initial MFR by more than $\pm 20\%$. Typical MFR (190/5) range for PE100 = 0.1 - 0.4 g/10 min
Oxidation Induction Time	min	ISO 11357-6 Temperature = 200°C	Minimum = 20min (post pelletisation)
Volatile content	mg/kg	ISO 4437	≤ 350 mg/kg

Table 1.4 Optional Characteristics

CHARACTERISTIC	UNIT	TEST METHOD	REQUIREMENT
Extraneous Polymers		IR analysis – ASTM D7399 DSC - ISO 11357-3	Presence /no presence of PP contaminants
Non-melttable Particles – detection during pelletising		Mesh filtering	Agreed mesh size for inline screen pack on pelletising extruder

6.0 MATERIAL CHARACTERISTICS FOR RECYCLED POLYPROPYLENE (PP) MATERIALS

The following tables define both mandatory and optional characteristics for polypropylene materials:

- Section 6.1 Table 2.0 defines the mandatory characteristics and Table 2.1 defines the optional characteristics for externally sourced PP recycled material.
- Section 6.2 Table 2.2 defines the mandatory characteristics and Table 2.4 defines the optional characteristics externally sourced recycled PP pipes and fittings manufactured to applicable AS/NZS Standards.

Mandatory characteristics represent the minimum specification requirements to define a recycled material.

6.1 POLYPROPYLENE RECYCLED MATERIAL CHARACTERISTICS TO BE COVERED BY AN AGREED SPECIFICATION FOR NON-PIPE AND FITTING SOURCES

Samples shall be taken from compounded and pelletised batches or from each individual material batch source. The frequency of sampling shall be agreed between the supplier and the product manufacturer.

- Only PP-B (block copolymer) or PP-MD (modified by minerals) material shall be used.
- PP recycle containing uncoated CaCO₃ (calcium carbonate) shall not be used.

Table 2.0 Mandatory Characteristics

CHARACTERISTIC	UNIT	TEST METHOD	REQUIREMENT
Density	kg/m ³	ISO 1183-1 ASTM D4883 Ultrasonic technique not impacted by colour	+/- 3 of the agreed mean density.
Melt mass-flow rate (MFR)	g/10 min	ISO 1131-1 Temp = 230°C Load = 2.16kg	≤1.6g/10min (190°C/5kg)
Volatile content	mg/kg	ISO 4437	≤350 mg/kg
Elongation at break	%	ISO 527-2 At 50mm/min Test type 1B At 50mm/min Test type 1B Test samples = 5	≥100% for all test samples
Oxidation Induction Time	min	ISO 11357-6 Temperature = 200°C	Minimum = 10 min
Carbon Black Content (black only)	%	ISO 6964	2 – 4 % carbon black
Carbon black dispersion		AS/NZS 1462.28	Shall not be worse than micrograph B in Annex B of AS/NZS 1462.28

Table 2.0 Mandatory Characteristics Continued

CHARACTERISTIC	UNIT	TEST METHOD	REQUIREMENT
Carbon black average particle size range (black only)	nm	ASTM D3849 or equivalent	Average particle size shall not exceed 40 nm
Source of base recycle material		Declaration of source by recycle supplier/input material processor	% from PP-B, PP-H or PP-MD pipe % from other PP-B, PP-H sources Declaration shall identify the original application of the material, level of cleanliness and colour
Shape		Visual inspection	Rough-cut regrind or pellets

Table 2.1 Optional Characteristics

CHARACTERISTIC	UNIT	TEST METHOD	REQUIREMENT
Flexural modulus	MPa	ISO 178	To be agreed between supplier and purchaser
Filler content assessment by ash residue or thermogravimetric analysis	%	ISO 3451-1 ASTM D5630 (2g, 800°C) or thermogravimetric Analysis (TGA) as per ASTM E1131 or ISO 11358	To be agreed between supplier and purchaser
Extraneous Polymers		FTIR analysis – ASTM D7399 DSC - ISO 11357-3	Presence of PE contaminants. PE content in PP must be less than 1% mass fraction
Non-melttable particles/impurities		Mesh filtering	Agreed mesh size for inline screen pack on pelletising extruder
Bulk Density	kg/m ³	ISO 60 or an alternative method agreed between the supplier and purchaser.	To be agreed between supplier and purchaser

6.2 POLYPROPYLENE RECYCLED MATERIAL CHARACTERISTICS TO BE TESTED FOR EXTERNALLY SOURCED RECYCLED PP PIPES AND FITTINGS MANUFACTURED TO APPLICABLE AS/NZS STANDARDS

If the source of the material is from pipes or fittings manufactured to the following listed AS/NZS Standards and produced under an ISO Type 5 product certification program, then only the following characteristics given in Table 2.2 need to be tested and Table 2.3 are optional:

- AS/NZS 5065 Non pressure Polypropylene pipes
- AS/NZS 4129 PP Pressure fittings (Note: removal of non-PP material may be required)

Table 2.2 Mandatory Characteristics

CHARACTERISTIC	UNIT	TEST METHOD	REQUIREMENT
Melt mass-flow rate (MFR)	g/10 min	ISO 1131-1 Temp = 190°C Load = 5kg	Check MFR of pipe and fittings prior to reprocessing. MFR of reprocessed material shall not deviate from the initial MFR by more than ± 30%
Oxidation Induction Time	min	ISO 11357-6 Temperature = 200°C	Minimum = 20 min To be measured after recycling processing e.g., granulation and pelletizing
Volatile content	mg/kg	ISO 4437	≤ 350 mg/kg

Table 2.3 Optional Characteristics

CHARACTERISTIC	UNIT	TEST METHOD	REQUIREMENT
Extraneous Polymers	%	FTIR analysis – ASTM D7399 DSC - ISO 11357-3	Presence of PE contaminants. PE content in PP must be less than 1% mass fraction.
Non-melttable Particles		Mesh filtering	Agreed mesh size

7.0 MATERIAL CHARACTERISTICS FOR RECYCLED RIGID PVC MATERIALS

The following tables define both mandatory and optional characteristics for rigid PVC materials:

- Section 7.1 Table 3.0 defines the mandatory characteristics and Table 3.1 defines the optional characteristics for externally sourced rigid PVC recycled material.
- Section 7.2 Table 3.2 defines the optional characteristics for externally sourced recycled rigid PVC pipes and fittings manufactured to applicable AS/NZS Standards for non-pressure applications.

Mandatory characteristics represent the minimum specification requirements to define a recycle material.

7.1 RIGID PVC RECYCLED MATERIAL CHARACTERISTICS TO BE COVERED BY AN AGREED SPECIFICATION FOR NON-PIPE AND FITTING SOURCES

Table 3.0 Mandatory Characteristics

CHARACTERISTIC	UNIT	TEST METHOD	REQUIREMENT
Source of base recycled material		Declaration of source by recycle supplier/input material processor	Declaration shall identify the original application of the material, level of cleanliness and colour
Stabiliser Type		Declaration of stabiliser type by recycle supplier/input material processor	Heavy metal stabilisers such as lead, and cadmium must be declared. These materials shall only be used in the core of sandwich construction pipes.
PVC Content	%	Refer to PIPA Guideline POP107 <i>Measuring the PVC content in PVC pipes and fittings</i>	AS/NZS 1260 minimum PVC content by mass = 80% AS/NZS 1254 minimum PVC content by mass = 75% AS/NZS 2053.2 or AS/NZS 61386 Electrical / Communications conduits minimum PVC content by mass = not defined
Vicat softening temperature	°C	ISO 2507-1 or ISO 306	For use into AS/NZS 1260 pipes minimum VST = 76°C fittings minimum VST = 74°C

Table 3.1 Optional Characteristics

CHARACTERISTIC	UNIT	TEST METHOD	REQUIREMENT
Density	kg/m ³	ISO 1183-1 ISO 1183-2	To be agreed between supplier and purchaser
Particle size distribution		Sieve analysis or other particle size analysis methodology	Method and specification to be agreed between supplier and purchaser
Impurities – solid contaminates		EN 15346 Annex C – Determination of tetrahydrofuran insoluble impurities, or visual evaluation of sheets or evaluation of sieved micronised material	Method and specification to be agreed between supplier and purchaser
Extraneous Polymers		FTIR analysis	Method and specification to be agreed between supplier and purchaser
Bulk Density	kg/m ³	ISO 60 or an alternative method agreed between the supplier and purchaser	Applies to micronised (powered) or granulated PVC
Fitness of processing		Torque rheometer	Test conditions to be agreed between supplier and purchaser: - Peak Torque - Fusion time Heat and shear stability

7.2 RIGID PVC RECYCLED MATERIAL CHARACTERISTICS TO BE TESTING FOR EXTERNALLY SOURCED RECYCLED RIGID PVC PIPES AND FITTINGS MANUFACTURED TO APPLICABLE AS/NZS STANDARDS

If the source of the material is from pipes or fittings manufactured to the AS/NZS Standards listed below and produced under an ISO Type 5 product certification program and is used in the core of sandwich construction stormwater pipes, DWV pipes, electrical or communications conduits there is no mandatory testing to characterise the recycled PVC material.

It should be noted that where PVC-U stormwater pipes and /or fittings are being reprocessed the minimum PVC content should be checked if the recycled material is to be used in the core of AS/NZS 1260 DWV pipes.

- AS/NZS 1254 PVC-U pipes and fittings for stormwater and surface water applications
- AS/NZS 1260 PVC-U pipes and fittings for drain, waste, and vent applications
- AS/NZS 2053 Conduits and fittings for electrical installations
- AS/NZS 61386.21 Conduit systems for cable management
- AS/NZS 1477 PVC-U pipes and fittings for pressure applications
- AS/NZS 4441 Oriented PVC (PVC-O) pipes for pressure applications
- AS/NZS 4765 Modified PVC (PVC-M) pipes for pressure applications

Table 3.2 Optional Characteristics

CHARACTERISTIC	UNIT	TEST METHOD	REQUIREMENT
PVC Content	%	Refer to PIPA Guideline POP107 <i>Measuring the PVC content in PVC pipes and fittings</i>	<p>Minimum PVC content requirements for DWV and Stormwater pipes and fittings must be taken into account when manufacturers incorporate recycled PVC material back into pipe or fittings.</p> <p>AS/NZS 1260 pipes and fittings require a minimum PVC content by mass = 80%</p> <p>AS/NZS 1254 pipes and fittings require a minimum PVC content by mass = 75%</p>
Fitness of processing		Torque rheometer	<p>Test conditions to be agreed between supplier and purchaser:</p> <ul style="list-style-type: none"> - Peak Torque - Fusion time - Heat and shear stability

APPENDIX A – PERFORMANCE TESTING REQUIREMENTS FOR PLASTIC PIPES AND FITTINGS CONTAINING RECYCLED MATERIALS

Outlined in the following tables are the performance testing requirements for pipe and fittings incorporating recycled materials. These testing requirements are based on existing product standards plus additional requirements to assess the performance impacts of recycled materials incorporated into the product.

A1. PERFORMANCE CHARACTERISTICS OF POLYETHYLENE (PE) PIPE CONTAINING RECYCLED MATERIAL - AS/NZS 5065 & AS/NZS 4401

- Applies to both structured and solid wall pipes containing recycled PE materials at any percentage.
- Type tests shall be carried out on pipe containing the maximum specified amount of externally sourced recycled material for each form with an agreed specification.
- Successful conformance tests to the specified percentage of recycled material will also prove conformance for lower percentages of the specified recycled material.

Table A1.0

CHARACTERISTIC	TEST METHOD	TEST PARAMETERS	REQUIREMENTS	FREQUENCY
Thermal Stability¹	ISO 11357-6	Temp = 200°C Sample = pipe bore	Minimum = 20 minutes	BRT once/production batch
Ring Stiffness^{1&2}	AS/NZS 1462.22	As per test method	≥relevant SN	BRT once/production batch
Ring Flexibility¹	AS/NZS 1462.23	As per test method	30% deflection Pipes must remain elliptical without cracking, rupture, buckling or exhibition permanent deformation	BRT once/production shift
Melt mass flow rate – pipe MFR	ISO 1133-1	Temp = 190°C Load = 5kg	≤1.6g/10min	Type test – any new material formulation or design or once per 5 years whichever occurs first

Notes:

¹Increased testing frequency versus current standard.

² Test does not apply to AS/NZS 4401 pipe

Table A1.1 Additional requirements: only applies to AS/NZS 5065 Corrugated pipe containing post or pre-consumer recycled PE material

CHARACTERISTIC	TEST METHOD	TEST PARAMETERS	REQUIREMENTS	FREQUENCY
Creep Ratio¹	ISO 9967	Temp = 20°C	≤4 at 2-year extrapolation	Type test – any new material formulation or design or once per 5 years whichever occurs first
Un-notched Constant Ligament Stress Crack Test (UCLS) slow crack growth resistance	ASTM F3181	Temperature = 80°C Stress = 4.48MPa	For service life = 100 years at 23°C and factored tensile design stress = 3.45MPa Average failure time for five specimens shall not be less than 34 hours, with no single specimen failing in less than 18 hours.	Type test – any new material formulation or design or once per 5 years whichever occurs first

Notes:

¹ Test does not apply to AS/NZS 4401 pipe

A2. PERFORMANCE CHARACTERISTICS OF POLYPROPYLENE (PP) PIPE CONTAINING RECYCLED MATERIAL – AS/NZS 5065

- Applies to both structured and solid wall pipes containing recycled PP materials at any percentage.
- Type tests shall be carried out on pipe containing the maximum specified amount of externally sourced recycled material for each form with an agreed specification.
- Successful conformance tests to the specified percentage of recycled material will also prove conformance for lower percentages of the specified recycled material.

Table A2.0

CHARACTERISTIC	TEST METHOD	TEST PARAMETERS	REQUIREMENTS	FREQUENCY
Thermal Stability¹	ISO 11357-6	Temp = 200°C Sample = pipe bore	Minimum = 10 minutes	BRT once/production batch
Ring Stiffness¹	AS/NZS 1462.22	As per test method	≥relevant SN	BRT once/production batch
Ring Flexibility¹	AS/NZS 1462.23	As per test method	30% deflection Pipes must remain elliptical without cracking, rupture, buckling or exhibition permanent deformation	BRT once/production shift
Melt mass flow rate – pipe MFR	ISO 1133-1	Temp = 230°C Load = 2.16kg	≤1.5g/10min	Type test – any new material formulation or design or once per 5 years whichever occurs first

Notes:

¹Increased testing frequency versus current standard.

Table A2.1 Additional requirements: only applies to AS/NZS 5065 Corrugated pipe containing post or pre-consumer recycled PP material

CHARACTERISTIC	TEST METHOD	TEST PARAMETERS	REQUIREMENTS	FREQUENCY
Creep Ratio	ISO 9967	Temp = 20°C	≤4 at 2-year extrapolation	Type test – any new material formulation or design or once per 5 years whichever occurs first
Resistance to internal pressure 1000 hrs¹	ISO 1167-1	Temp = 95°C Hoop stress = 2.5 MPa Time = 1000 hrs Water in water No: test pieces = 3	No failure during the test period.	Type test – any new material formulation or design or once per 5 years whichever occurs first
Elongation at break	ISO 527-2	At 50mm/min Test type 1B At 50mm/min Test type 1B No: test pieces = 5, taken from the pipe liner area.	≥150% for all test samples	Type test – any new material formulation or design or once per 5 years whichever occurs first

Notes:

¹Test shall be carried out on extruded solid-wall pipe made from the defined mass percentage blend of virgin and externally sourced recycled material.

A3. PERFORMANCE CHARACTERISTICS OF PERFORATED DRAINAGE PIPE CONTAINING RECYCLED MATERIAL – AS/NZS 2439.1

Performance testing requirements for pipe and fittings incorporating recycled materials for perforated drainage pipe are those defined in AS/NZS 2439.1. There are no additional testing requirements.

A4. PERFORMANCE CHARACTERISTICS OF RIGID PVC CONTAINING RECYCLED MATERIAL

A4.1 Non-pressure DWV and Stormwater pipes and fittings containing recycled material – AS/NZS 1254 and AS/NZS1260

Performance testing requirements for pipe and fittings incorporating recycled materials for rigid PVC are those defined in AS/NZS 1254 and AS/NZS 1260. There are no additional testing requirements.

A4.2 Rigid PVC electrical and communication conduits containing recycled material – AS/NZS 2053 and AS/NZS 61386.21

- Type tests as defined in the relevant conduit standard plus those defined in table 3A shall be carried out on conduits containing the maximum specified amount of recycled material for each recycled material with an agreed specification.
- Successful conformance tests to the specified percentage of recycled material will also prove conformance for lower percentages of the specified recycled material.

Table A3

CHARACTERISTIC	TEST METHOD	TEST PARAMETERS	REQUIREMENTS	FREQUENCY
Ring Flexibility¹	AS/NZS 1462.23	As per test method	30% deflection Pipes must remain elliptical without cracking, rupture, buckling or exhibition permanent deformation	BRT once/production shift
Flattening²	AS/NZS 1462.2	AS per test method	There shall be no evidence of splitting, cracking, or breaking	BRT once/production shift

Notes:

¹Applies only to structured wall pipe

²Applies only to single layer solid wall pipe

APPENDIX B – MATERIAL PROPERTY OVERVIEW FOR PE, PP AND PVC

The following tables provide examples of key pipe performance and raw material properties that apply in the case of non-pressure plastic pipes.

B1. NON-PRESSURE PIPE PERFORMANCE PROPERTIES CRITICAL TO LONG-TERM PERFORMANCE

Ring Flexibility

PVC, PE and PP pipes are required to be capable of handling high levels of bending strain. This is demonstrated by subjecting pipe to diametral deflections beyond 30%, pipes must remain elliptical without cracking, rupture, buckling or exhibiting permanent deformation.

Test Method:	AS/NZS 1462.23 Method for Determination of ring flexibility.
Application:	PVC, PE, and PP plain walled pipes and structured wall pipes e.g., corrugated twin wall pipes, sandwich construction pipes.

Ring Stiffness

Pipes are required to have adequate ring stiffness to ensure that they can be handled and installed in both above ground and buried installations without buckling or kinking for the applied loads.

Ring stiffness testing measures the pipe's ability to resist a nominated deflection by application of a short-term continuous load. A higher stiffness indicates that a higher load is required to achieve the defined deflection.

A pipe's stiffness rating (SN) is an important design parameter for buried flexible pipes. Standard SN ratings are 2, 4, 8, 10, 16 and 20.

Test Method:	AS/NZS 1462.22 Method for Determination of pipe stiffness.
Application:	PVC, PE and PP non-pressure pipes, all construction types.

Flattening Test Properties

This test checks that the incorporation of post-consumer recycle material has not introduced faults into the pipe.

Post-consumer materials have a higher likelihood of containing contaminants that may act as stress raisers that could lead to premature brittle failure. In addition, the inhomogeneous incorporation and / or poor processing of materials during pipe manufacture can also lead to premature brittle failure.

The flattening test requires a ring section of pipe to be compressed to 100% of the pipe's internal diameter without brittle splitting, cracking, or delamination.

Test Method:	AS/NZS 1462.2 Method for determining the flattening properties of plastics pipes and fittings.
Application:	Currently applies to PVC non-pressure pipe containing post-consumer recycle material.

B2. RAW MATERIAL PERFORMANCE PROPERTIES CRITICAL TO PIPE LONG-TERM PERFORMANCE

Thermal Stability

Polyolefins such as PE and PP can lose mechanical properties due to exposure to oxygen, heat, light, and mechanical stress, known as oxidation. Therefore, polyolefins need to be protected from thermal degradation by the incorporation of stabilisers / antioxidants during material manufacture.

A polyolefin material's thermal stability is assessed by measuring oxidation induction time (OIT).

Test Method: ISO 11357-6 Plastics - differential scanning calorimetry (DSC) - Part 6: Determination of oxidation induction time (Isothermal OIT).

Application: PE and PP raw materials and finished pipe.

UV/Solar Radiation Protection

Pipes exposed to sunlight must be protected by the incorporation of pigments such as carbon black or UV stabilisers in the case of non-black colours. The type and level of these additives is typically defined by the relevant AS/NZS product standards.

PVC pipes typically require the addition of 1.5 parts of rutile titanium dioxide per 100 parts by mass of PVC content to provide protection from solar radiation when in storage.

Test Method: Test for correct dispersion of additives AS/NZS 1462.28
 Test for average particle size of carbon black.
 Weathering resistance tests for non-black PE or PP compounds where the minimum percentage of hindered amine light stabiliser (HALS) has not been incorporated.

Application: PE and PP raw materials and finished pipe.
 PVC pipes.

Slow Crack Growth (SCG)

PE materials used in pipe applications must have good resistance to the slow crack growth (brittle) failure mechanism which can occur at lower stresses over longer periods of time.

The SCG failure mechanism is being the primary service limiting failure mode of concern for plain walled and corrugated PE drainage and sewerage pipes, particularly where recycled materials are used

Test Method: AS/NZS 1462.25 Determination of slow-crack-growth of PE resins - Notched, constant ligament-stress (NLCS) method.

Note: an alternate method using an unnotched test sample should be used for the assessment of recycled PE resins i.e., ASTM F3181-16

Application: PE materials that do not conform to AS/NZS4131 that are used in AS/NZS 5065 Drainage and Sewerage pipes.

B2. RAW MATERIAL PERFORMANCE PROPERTIES CRITICAL TO PIPE LONG-TERM PERFORMANCE CONTINUED

Melt Flow Rate (MFR)

A change in the MFR value measured on re-processed / re-pelletised compounds relative to the MFR value of the starting base polymer indicates a change in the average molecular weight and therefore a change in performance properties. This can lead to the quality of the final pipe product being adversely affected where incorrectly reworked PE or PE materials have been used in pipe production.

Test Method: ISO 1133-1 Plastics - Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics - Part 1: Standard method,

MFR change of +/-20% is considered best practice, based on current industry experience to ensure the quality and integrity of the reworked compounds.

Application: PE and PP raw materials and finished pipe.

Elongation at break (strain at break)

Elongation at break, also known as strain at break, is the ratio between changed length and initial length after breakage of the test specimen. It expresses the capability of a polymer to resist changes of shape without crack formation and is an indication of ductility. In the case of recycled plastics, the elongation at break is highly dependent upon the level of contamination present in the material.

Test Method: ISO 527-2 Plastics Determination of Tensile Properties Part 2: Test conditions for moulding and extrusion plastics

Filler content by Ash Test or Thermogravimetric analysis

An Ash test is used to determine if a material is filled. The test will identify the total filler content. It cannot identify individual percentages in multi-filled materials without additional test procedures being performed. An ash test cannot be used to determine the percent carbon fibre or percent carbon black since carbon burns off during the Ash test.

The Ash test result is expressed as % ash. A magnified optical examination of the ash residue is performed to determine if the ash is glass, mineral, or a combination of both. The total ash content equals the weight of the ash divided by the weight of the original sample multiplied by 100%.

Ash residue remaining in the crucible is considered filler unless the residue is less than 1%. Residues of less than 1% are typically the result of additives that did not burn off.

Thermogravimetric Analysis measures the percent weight loss of a test sample while the sample is heated at a uniform rate in an appropriate environment. The loss in weight over specific temperature ranges provides an indication of the composition of the sample, including volatiles and inert filler, as well as indications of thermal stability.

Test Method: ISO 3451-1
ASTM D5630 (2g, 800°C) or thermogravimetric Analysis (TGA) as per ASTM E1131 or ISO 11358

Application: Post-consumer or pre-consumer PE and PP materials

APPENDIX C – INTERNATIONAL STANDARDS

AASHTO M 294-18	Standard Specification for Corrugated Polyethylene Pipe, 300-to 1500-mm (12-to 60-in.) Diameter
ASTM D3849	Standard Test Method for Carbon Black-Morphological Characterization of Carbon Black Using Electron Microscopy
ASTM D4883	Standard Test Method for Density of Polyethylene by The Ultrasound Technique
ASTM D5630	Standard Test Method for Ash Content in Plastics
ASTM D7399	Standard Test Method for Determination of the Amount of Polypropylene in Polypropylene/Low Density Polyethylene Mixtures Using Infrared Spectrophotometry
ASTM E1131	Standard Test Method for Compositional Analysis by Thermogravimetry
ASTM F3181-16	Standard Test Method for The Un-notched, Constant Ligament Stress Crack Test (UCLS) for HDPE Materials Containing Post-Consumer Recycled HDPE
CEN/TS 14541	Plastic pipes and fittings – Characteristics for utilisation of non-virgin PVC-U, PP and PE materials
CEN/TS 17627:2021	Plastics – Recycled plastics – Determination of solid contaminants content
EN 10204:2004	Metallic Products – Types of Inspection Documents
EN 15346	Plastics – Recycled Plastics – Characterisation of Poly (Vinyl Chloride) (PVC) Recyclates
ISO 60	Plastics – Determination of Apparent Density of Material that can be Poured from a Specified Funnel
ISO 178	Plastics Determination of Flexural Properties
ISO 306	Plastics Thermoplastic materials Determination of Vicat Softening Temperature
ISO 527-1	Plastics - Determination of Tensile Properties Part 1: General principles
ISO 527-2	Plastics Determination of Tensile Properties Part 2: Test conditions for moulding and extrusion plastics
ISO 4437	Plastics Piping Systems for the supply of Gaseous Fuels – Polyethylene
ISO 6964	Polyolefin Pipes and Fittings Determination of Carbon Black Content by Calcination and Pyrolysis Test Method
ISO 1133-1	Plastics - Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics - Part 1: Standard method

ISO 1167-1	Thermoplastics pipes, fittings and assemblies for the conveyance of fluids Determination of the resistance to internal pressure Part 1: General method
ISO 1183-1	Plastics Methods for determining the density of non-cellular plastics Part 1: Immersion method, liquid pycnometer method and titration method
ISO 1183-2	Plastics Methods for determining the density of non-cellular plastics Part 2: Density gradient column method
ISO 2507-1	Thermoplastics pipes and fittings – Vicat Softening Temperature – Part 1: General Test Method
ISO 3451-1	Plastics Determination of ash Part 1: General Methods
ISO 9967	Thermoplastics pipes Determination of creep ratio
ISO 11357-3	Plastics Differential scanning calorimetry (DSC) – Part 3: Determination of Temperature and Enthalpy of Melting and Crystallization
ISO 11357-6	Plastics Differential scanning calorimetry (DSC) – Part 6: Determination of oxidation induction time (isothermal OIT) and oxidation induction temperature (dynamic OIT)
ISO 11358	Plastics Thermogravimetry (TG) of polymers
ISO 21138-3	Plastics piping systems for non-pressure underground drainage and sewerage – Structured-wall piping systems of PVC-U, PP and PE – Part 3: Pipes and fittings with non-smooth external surface, Type B



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