

TOYOTA ENGINEERING STANDARD

NO. : **TSM5514G** _____

TITLE : POLYPROPYLENE RESIN MOLDING MATERIALS

CLASS : **C2** _____

Established/Revised : **Rev.9 (Aug.2005)** _____

This standard has been revised in consequence of the following changes:

- (1) ISO-compliant test methods and property requirements when tested under such methods have been added.
- (2) terms and explanations have been modified.

Engineering Information
Planning Dept.
Engineering Administration Div.
TOYOTA MOTOR CORPORATION

TOYOTA ENGINEERING STANDARD	TSM5514G	CLASS
		C2

POLYPROPYLENE RESIN MOLDING MATERIALS

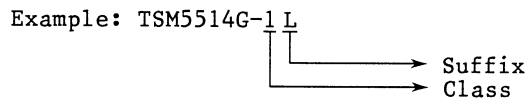
1. Scope

This standard covers the general properties of polypropylene resin molding materials. The polypropylene resin molding materials dealt with herein shall basically be defined as those obtained via direct polymerization, and then added with coloring agents or additives as required (hereinafter referred to as "molding materials"). (If polymer blend is necessary in putting into practical use a material procured in a foreign country, the standard may be applied to this material.) The molding materials shall meet a part performance criteria and material specifications which are specified in separate standards. The parts made of materials provided by this standard shall conform to prohibitions and restrictions for substances of environmental concern in TSZ0001G. Exempt uses specified by EU ELV Directive shall conform to the latest version of the Directive.

2. Classification and Designation

The classification and designation of molding materials are specified in Table 1. When a molding material requires special performance, the following suffixed letters are added to the material codes.

- "L": Light resistance
- "W": Weatherability
- "H": Heat aging resistance



Prepared and Written by: Organic Material Dept. Material Engineering Div. 2	Engineering Administration Div. © TOYOTA MOTOR CORPORATION
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TOYOTA ENGINEERING STANDARD

TSM5514G

Table 1

Class	Materials code	Composition	Major application
Class 1	TSM5514G-1	Homopolymer polymerizing of propylene.	Suitable for the production of parts not requiring impact resistance.
Class 2	TSM5514G-2	High flow type of copolymer consisting of propylene and ethylene.	suitable for parts requiring medium impact resistance.
Class 3A	TSM5514G-3A	High flow type of highly crystal copolymer consisting of propylene and ethylene, which contains relatively more ethylene than propylene.	Suitable for large or thin parts requiring high impact resistance.
Class 3B	TSM5514G-3B		Suitable for large or thin parts requiring high impact resistance, especially at low temperature.
Class 4	TSM5514G-4	Highly crystal copolymer, which has relatively high melt viscosity, consisting of propylene and ethylene.	suitable for parts by blow molding and extrusion, also including vacuum forming with extruded sheet.
Class 5	TSM5514G-5	Highly crystal copolymer consisting of propylene and ethylene.	Especially suitable for parts requiring better characteristic of integral hinge use.

3. Quality

The properties of the molding materials shall be tested in accordance with either of the standards shown below.

TSM0506G (for the new JIS standard, or ISO standard)

TSM0501G (for the old JIS standard, or ASTM standard)

In either case, material quality shall be checked for the fulfillment of requirements shown in Table 2 or 3, and Table 4, under test conditions specified in Section 4. Test results shall be evaluated according to the criteria described in Section 5. However, TSM0506G shall be used if the standard to be used is not specified.

Table 2 General Mechanical Property Requirement (Under ISO-Compliant Test Method)

Test item		Class 1	Class 2	Class 3A	Class 3B	Class 4	Class 5	
Specific gravity		0.90 to 0.92	0.89 to 0.93	0.89 to 0.92	0.89 to 0.91	0.89 to 0.92	0.89 to 0.91	
Tensile test	Yield stress (MPa)	26 min.	21 min.	19 min.		22 min.		
	Deformation at break (%)	Report						
	Tensile modulus (MPa)	1020 min.	1040 min.	815 min.	940 min.	610 min.		
Charpy impact strength	23 °C notched (kJ/m ²)	1.9 min.	5.8 min.	6.0 min.	10 min.	4.5 min.		
	-30 °C notched (kJ/m ²)	---		2.8 min.	3.5 min.	---		
Brittle temperature (°C)		---	10 max.	0 max.	-15 max.	5 max.		
Deflection temperature under load	1.8 MPa (°C)	48 min.	43 min.			33 min.		
	0.45 MPa (°C)	92 min.	80 min.	72 min.	78 min.	73 min.		
Rockwell hardness	R Scale	82 min.	75 min.	70 min.		72 min.	70 min.	
Melt flow rate (g/10 min)		---		Report			---	

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Established/ 9 Revised:
 Aug.2005

TOYOTA ENGINEERING STANDARD

TSM5514G

Table 3 General Mechanical Property Requirement (Under Old-JIS-Compliant Test Method)

Test item		Class 1	Class 2	Class 3A	Class 3B	Class 4	Class 5	
Specific gravity		0.90 to 0.92	0.89 to 0.91			0.89 to 0.92	0.89 to 0.91	
Tensile test	Yield stress (MPa)	25 min.	20 min.					
	Elongation at break (%)	100 min.	50 min.	100 min.		200 min.		
Flexural test	Flexural strength (MPa)	33 min.	25 min.			18 min.		
	Flexural modulus (MPa)	980 min.	1000 min.	900 min.		580 min.		
Izod impact strength	23 °C notched (J/m)	20 min.	65 min.	115 min.	145 min.	49 min.		
	-30 °C notched (J/m)	---		40 min.	45 min.	---		
Brittle temperature (°C)		---	5 max.	0 max.	-20 max.	5 max.		
Heat deflection temperature	1820 kPa (°C)	55 min.	50 min.			40 min.		
	455 kPa (°C)	100 min.	95 min.	85 min.		80 min.		
Rockwell hardness	R Scale	85 min.	80 min.	70 min.	75 min.		70 min.	
Melt flow rate (g/10 min)		---	Report				---	

Table 4 Other Required Properties

Items		TSM standard	Class 1	Class 2	Class 3A	Class 3B	Class 4	Class 5
Weatherability (with "W"-molding materials)	Retention of tensile yield strength (%)	TSM0501G	90 min.					
	Gray scale		Discoloration shall be better than grade-4 and color fading shall be better than grade-3.					
Appearance	$\Delta E^* \leq 3.0$							
Light resistance (with "L"-molding materials)	Color and chromaticity meter Microscope (magnification: 50)		No micro-cracks etc.					
Heat aging resistance (with "H"-molding materials)		---	Retention of tensile yield strength shall be 90% min.					
Glass haziness	Method A	TSM0503G	10% max.					
	Method B		90% min.					
Odor	Intensity	TSM0505G	3.0 max.					
	Degree of unpleasantness		-1.5 min.					
	Fishiness		1.0 max.					
	Pungency							
Flammability (mm/min)		TSM0500G	100 max.					

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Established/ 9 Revised:
 Aug.2005

TOYOTA ENGINEERING STANDARD

TSM5514G

4. Test Method

4.1 Test According to the ISO Standard or New JIS Standard

4.1.1 Molding of Test Specimens

As a rule, mold test specimens according to Section 2, TSM0506G. Regarding the injection molding of test specimens, or detailed conditions of the compression molding of the plate for punching test specimens, refer to Section 3.2 and TABLE 1, ISO 1873-2; or Section 3.3 and TABLE 2, ISO 1873-2. For injection molding, use a die specified in TSM0506G.

4.1.2 Conditioning

Condition the test samples and/or specimens in accordance with Section 2.4, TSM0506G. Conditioning time shall be 40 h or longer, as specified in Section 4, ISO 1873-2.

4.1.3 Atmosphere

According to Section 2.4, TSM0506G.

4.1.4 Sampling

According to Section 2.5, TSM0506G. Be sure to report molding conditions etc. along with test results.

4.1.5 Number of Test Specimens

The number of test specimens, for each property, shall be 10 or more, unless otherwise specified.

4.1.6 Specific Gravity Test

According to Section 3.1, TSM0506G.

4.1.7 Tensile Test

Use the test method specified in Section 3.2, TSM0506G. As for detailed conditions (stretching speed etc.), use the conditions specified in TABLE 3 of ISO 1873-2. These conditions are shown in Table 5.

Table 5

Item		Crosshead speed (mm/min)	Remarks
Tensile test	Yield stress (MPa)	50	---
	Deformation at break (%)		However, use 5 mm/min. if deformation is 10% or less.
	Tensile modulus (MPa)	1	---

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Established/ 9 Revised:
 Aug.2005

TOYOTA ENGINEERING STANDARD**TSM5514G**

4.1.8 Charpy Impact Test

According to Section 3.3, TSM0506G.

4.1.9 Brittle Temperature Test

For evaluation, use B type specimens, specified in Section 9.5, TSM0501G. Use, however, the flat test pieces specified in Section 2, TSM0506G.

4.1.10 Deflection Temperature under Load Test

According to Section 3.4, TSM0506G. Conduct the test at the flexural stresses of 1.8 MPa and 0.45 MPa.

4.1.11 Melt Flow Rate Test

According to Method A specified in Section 3.5, TSM0506G. Conduct the test at a temperature of 230 °C, and with a load of 21.18 N.

4.1.12 Rockwell Hardness Test

According to Section 3.8, TSM0506G. Conduct the test at a temperature of 23±2 °C, using an "R" scale.

4.2 General Mechanical Property Test According to TSM0501G (ASTM or Old JIS)

Useless otherwise specified in the part and material standards, the test shall be conducted under the conditions specified in Section 4.2.1 to 4.2.4 inclusive.

4.2.1 Conditioning

Condition the test samples and/or specimens in accordance with Section 4, TSM0501G for not less than 24 h.

4.2.2 Atmosphere

According to Section 5, TSM0501G.

4.2.3 Preparation of Test Specimens

According to Section 3.1, TSM0501G.

4.2.4 Number of Test Specimens

According to Section 6, TSM0501G.

4.2.5 Specific Gravity Test

According to Section 9.1, TSM0501G.

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Established/ 9 Revised:
Aug.2005

TOYOTA ENGINEERING STANDARD

TSM5514G

4.2.6 Tensile Test

According to Section 9.2, TSM0501G. Conduct the test in the atmosphere of 23 ± 2 °C. Crosshead speed shall be as shown in Table 6.

Table 6

Type	Crosshead speed (mm/min)
Classes 2, 3A, 3B	50
Classes 1, 4, 5	10

4.2.7 Flexural Test

According to Section 9.3, TSM0501G. Conduct the test in the atmosphere of 23 ± 2 °C with 2.0 mm/min of crosshead speed.

4.2.8 Izod Impact Test

According to Section 9.4, TSM0501G. Conduct the test in the atmosphere of 23 ± 2 °C for notched specimens, and -30 ± 2 °C for unnotched specimens.

4.2.9 Hardness Test

According to Section 9.9, TSM0501G. Conduct the test in the atmosphere of 23 ± 2 °C and measure on R-Scale with Rockwell hardness.

4.2.10 Heat Deflection Temperature Test

According to Section 9.6, TSM0501G. Conduct the test at 1820 kPa and 455 kPa of flexural stress.

4.2.11 Brittle Temperature Test

According to Section 9.5, TSM0501G.

4.2.12 Melt Flow Rate Test

According to Section 9.10, TSM0501G. Conduct the test at 230 ± 1 °C of set temperature and 21.18 N of load.

4.3 Other Property Tests

4.3.1 Weathering (Light Resistance) Test

(1) Test method

This test is performed on weatherable materials identified by a letter suffix of "L." The test shall be conducted using the method shown in Section 9.20, TSM0501G. As test equipment, use one of the light resistance test units shown in Table 7, specified in detail in Section 9.20, TSM0501G. Apply radiation at quantities shown in Table 7.

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Established/ 9 Revised:
 Aug.2005

TOYOTA ENGINEERING STANDARD

TSM5514G

Table 7

Suffix	Test equipment	Min. required quantity of radiation
W	Sunshine Weather-O-Meter	1500 h
L	Carbon arc Fade-O-Meter	1000 h
	Xenon	300 MJ/m ²
	Suga SC-700FP	
	Suga SX-75	
	Atlas Ci65AW	2065 kJ/m ²
	Atlas Ci4000	

(2) Method of judging test results

Regarding test pieces for which evaluation has been completed in accordance with the above test method, judge test results via the following method.

(a) Visual judgment

Determine the grade of test piece discoloration/color fading using the gray scale for discoloration/color fading specified in ISO 105-A02 or JIS L 0804.

(b) Color difference measurement

Measure color difference ΔE* and lightness difference ΔL* between the initial piece and the piece at test completion; using the color/chromaticity meter specified in Section 9.20, TSM0501G and the CIELAB (L*a*b*) color system.

(c) Judgment using a microscope

Check, for cracks, the exposed surface of the test piece at test completion, using a microscope with a magnification of 50.

(d) Retention rate

Use tensile test specimens defined in Section 9.2, TSM0501G for this test. Expose the specimens to the accelerated weathering machine for 1500 h. After the exposure, carry out the tensile test to calculate the retention rate by equation (1).

Retention of tensile yield strength

$$S (\%) = \frac{S_1}{S_0} \times 100 \dots \dots \dots (1)$$

where,

S₀: tensile yield strength before weathering exposure

S₁: tensile yield strength after weathering exposure

4.3.2 Heat Aging Test

This test is applied to materials requiring heat aging performance (H suffixed).

(1) The specimens are defined in Section 4.2.4 and aged at 150 °C for 240 h in a Geer's oven.

(2) Tensile test speed is 10 mm/min.

(3) The retention is calculated by equation (2). Retention of tensile yield strength

$$S (\%) = \frac{S_h}{S_0} \times 100 \dots \dots \dots (2)$$

where,

S₀: tensile yield strength before aging

S_h: tensile yield strength after aging

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 Aug.2005

TOYOTA ENGINEERING STANDARD**TSM5514G****4.3.3 Glass Haziness Test**

According to Method A or B specified in TSM0503G. For the test, the heating temperatures shall be 80 and 100 °C, and the heating times shall be 20 h.

4.3.4 Odor Test

According to TSM0505G. For the test, prepare specimens of 10 cm in length, 10 cm in width, and 2 mm in thickness. Testing temperature shall be 80 °C.

4.3.5 Flammability Test

According to TSM0500G. For the test, prepare specimens having a length of 350 to 355 mm, a width of 100 mm and a thickness of finished product.

5. Evaluation of the Test Result**5.1 Numerical Value of Test Result**

Calculate the mean value (\bar{X}) and the standard deviation (S) from the data obtained from the procedures given in Section 4. Rounding of the numbers is defined in Section 6, TSM0501G.

5.2 Evaluation of Test Result

The judgment for qualification is determined in accordance with the followings by applying the values obtained from Section 5.1.

(1) For lower limit values specified in Tables 2, 3, 4

Accept: ($S_L \leq \bar{X} - 2.00 \times S$)

Reject: ($S_L > \bar{X} - 2.00 \times S$)

S_L : lower limit value of specification

(2) For upper limit values specified in Tables 2, 3, 4

Accept: ($S_u \geq \bar{X} + 2.00 \times S$)

Reject: ($S_u < \bar{X} + 2.00 \times S$)

S_u : upper limit value of specification

Where,

Mean value of test specimen: $\bar{X} = \frac{T}{n}$

$$T = (X_1 + X_2 + X_3 + \dots + X_n)$$

Standard deviation of test specimen: $S = \sqrt{V}$

$$V = \frac{S}{(n-1)}$$

$$S = (X_1 - \bar{X})^2 + (X_2 - \bar{X})^2 + \dots + (X_n - \bar{X})^2$$

$$= \sum Xi^2 - \frac{(\sum Xi)^2}{n}$$

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TOYOTA ENGINEERING STANDARD

TSM5514G

6. Marking of Material Code on Part

Parts made of materials complying with this standard are marked in accordance with TSZ6005G. Examples of marking are shown in Table 8.

Table 8

Material	Material Code	Marking
polypropylene resin molding materials	TSM5514G-1	>PP<
	TSM5514G-2	>PP/PE<
	TSM5514G-3A	
	TSM5514G-3B	
	TSM5514G-4	
	TSM5514G-5	

Applicable Standards

TSM0500G	Flammability Test Method for Interior Non-Metallic Materials
TSM0501G	Standard Test Methods for Plastic Molding Materials
TSM0503G	Fogging Test Method for Non-Metallic Materials
TSM0505G	Smell Quality of Non-Metallic Materials
TSM0506G	Standard Test Methods for Plastic Molding Materials for Compliance with ISO
TSZ0001G	Control Method for Substances of Environmental Concern
TSZ6005G	Indication Method of Material Marking for Plastic Parts and Rubber Parts
ISO 105-A02	Textiles--Tests for Colour Fastness--Part A02: Grey Scale for Assessing Change in Colour
ISO 1873-2	Plastics--Polypropylene (PP) Moulding and Extrusion Materials--Part 2: Preparation of Test Specimens and Determination of Properties
JIS L 0804	Grey Scale for Assessing Change in Colour

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