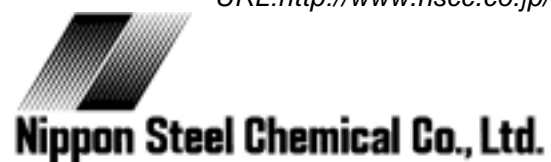


Transparent Styrene Resin

URL:<http://www.nsccl.co.jp/>



Technical Literature on ESTYRENE[®]MS

Prepared: October 30, 2001

Nippon Steel Chemical Co., Ltd.

Contents

1. Characteristics of ESTYRENE [®] MS	3
2. Grades of ESTYRENE [®] MS	4
3. Applications of ESTYRENE [®] MS	4
4. General Physical Properties of ESTYRENE [®] MS	5
5. Properties of ESTYRENE [®] MS	7
6. Blending Properties of ESTYRENE [®] MS	11
7. Molding Conditions for ESTYRENE [®] MS	14
8. Other Considerations	14
9. Inquiries	15

Notice

Your interest in ESTYRENE[®]MS of Nippon Steel Chemical is highly appreciated. Because of its outstanding transparency, high-grade textures, ease of molding and other excellent properties, ESTYRENE[®]MS is sure to fulfill your needs.

In order to promote an accurate understanding of ESTYRENE[®]MS, the technical literature has been prepared that gives an outline of its characteristics. It is hoped that you will find this literature useful as a basic source of information, as you examine its use in your own applications.

However, the various numerical values contained in this literature are not guaranteed values, but are given for reference purposes. Notably, it is recommended that the technical factors of special importance to your company be subjected to thorough examination and assessment by your company.

Please use this technical literature only for reference sake, and take note that the literature will be updated in the future at the discretion of our company.

Plastics Department, Chemicals Division
Nippon Steel Chemical Co., Ltd.

1. Characteristics of ESTYRENE[®]MS

ESTYRENE[®]MS is a styrene-methyl methacrylate copolymer—an excellent resin having a well-balanced combination of the good moldability, low water absorption coefficient and high refraction factor of polystyrene and the high transparency, good weather resistance, high hardness and other properties inherent in polymethyl methacrylate (acrylic resin or PMMA).

ESTYRENE[®]MS also shows distinctive features as an optical material because of the high transparency and optical properties specific to it.

Characteristics of ESTYRENE[®]MS

(1) Transparency and textures equal to those of acrylic resin (detailed on page 6)

- ESTYRENE[®]MS has extremely high transparency and excellent gloss and appearance comparable to those of acrylic resin over all wavelengths of visible ray. It also imparts high-grade textures equal to those of acrylic resin molded products.

(2) High surface hardness (on page 7)

- ESTYRENE[®]MS shows the highest surface hardness (in terms of pencil hardness) next to acrylic resin. It exhibits excellent resistance to the mar caused by nail scratching etc.

(3) Low water absorption coefficient (on page 7)

- ESTYRENE[®]MS shows lower water absorption than acrylic resin. This reduces changes in dimension due to water absorption in practical use, enabling ESTYRENE[®]MS to maintain high dimensional accuracy. This characteristic makes ESTYRENE[®]MS the material of choice for use in lenses and other precision optical parts.

(4) Good weather resistance (on page 8)

- ESTYRENE[®]MS is superior in weather resistance to polystyrene (GP) resin and AS resin. Its weather resistance is next to that of acrylic resin.

(5) High refraction factor (on page 9)

- ESTYRENE[®]MS shows a higher refraction factor than acrylic resin, enabling the downsizing and lighter weight of optical parts.
- Four refraction factors can be selected according to the grade of ESTYRENE[®]MS. This ensures more freedom of optical design.

(6) Good compatibility with HIPS resin (in the case of MS-200 and MS-300) (on page 10)

- MS-200 and MS-300 offer good compatibility with HIPS resin.
- When MS-200 and MS-300 that are used together with HIPS resin parts must be collected for recycling, they need not be separated from the HIPS resin parts. Thus, ESTYRENE[®]MS is more advantageous than acrylic resin in terms of recycling.

Note: MS-600 does not offer compatibility with PS resin.

(7) High compatibility with SBS resin (in the case of MS-200) (on page 11)

- MS-200 offers good compatibility with SBS resin (styrene- butadiene block copolymer resin)

(8) Good moldability (on page 13)

- ESTYRENE[®]MS offers good moldability comparable to that of ABS and PS resins.

2. Grades of ESTYRENE[®]MS

(1) Ordinary grade: MS-200, MS-300, MS600

Three ordinary grades are available depending on the ratio of co-polymerization between styrene and methyl methacrylate.

(2) Optical-specific grade: MS-200EL

Although this grade retains the characteristics of MS-200, it is destined exclusively for optical applications by greatly reducing foreign substances in the material. This grade is widely used in prisms for camera viewfinders and other areas where specifications for foreign substances provide extremely severe requirements.

(3) Long lasting anti-static grade*: NDM-600

This grade is a transparent resin, using MS-600 as a base, to which long lasting anti-static property is imparted. Cloth or water wiping does not impair the effectiveness of anti-static function.

*Individual technical literatures are prepared for optical-specific and long lasting anti-static grades. Call for them.

3. Applications of ESTYRENE[®]MS

ESTYRENE[®]MS is already in wide use to take full advantage of its excellent properties, primarily for areas where transparency is paramount, including lighting fixtures, displays, reflectors, carports, medical devices, cosmetics cases, OA machines and sundry goods, and for such optical parts as optical lenses/prisms and Fresnel lenses for projection TVs.

Application examples

(1) Uses related to home electric appliances and OA machines

Making use of high transparency/textures and surface hardness:

Push buttons for telephones etc., transparent exterior components for home electric appliances and OA machines*

*Because MS-200 and MS-300 offer good compatibility with HIPS resin, they are more advantageous in terms of recycling than acrylic resin transparent molded products that are in wide use in home electric appliances and OA machines.

Making use of high light fastness, transparency and surface hardness:

Lighting fixture covers

(2) Uses related to sundry goods, medical/cosmetics devices

Making use of high transparency/textures and surface hardness:

Tableware, kitchenware, medical devices, cosmetics cases

(3) Uses related to residential equipment

Making use of high transparency/textures and surface hardness:

Ceiling boards and partitions for carports etc., profiled decorative panels produced by extrusion

(4) Optical parts

Making use of high transparency, low water absorption property (high dimensional stability), high refraction factor and surface hardness:

Optical lenses/prisms, light panel of LCD display units, front panel, Fresnel and Lenticular lenses for projection TVs

4. General Physical Properties of ESTYRENE[®]MS

Table 1 General Physical Properties of ESTYRENE[®]MS Ordinary Grade

Test item	Test method	Condition	Unit	KS-10	MS-200	MS-300	MS-600
				For sheeting	For injection and extrusion		
1. Mechanical properties							
Tensile strength at break	JIS K 7133 【ISO 572-1】	5mm/min.	MPa	51.1	58.4	59.4	77.1
			(kgf/cm ²)	520	600	610	790
Tensile elongation at break			%	2.5	3.0	3.0	4.5
Flexural strength	JIS K 7171 【ISO 178】	3mm/min.	MPa	78	110	106	110
			(kgf/cm ²)	(800)	(1,120)	(1,090)	(1,120)
Flexural modulus			MPa	3,390	3,420	3,350	3,350
			(kgf/cm ²)	(34,600)	(34,900)	(34,200)	(34,200)
Charpy impact strength	JIS K 7111 【ISO 179】	80 × 10 × 4mm 1eA	kJ/m ²	1.3	2.2	1.4	1.5
Rockwell hardness	JIS K 7202 【ISO 2039-2】	M scale	-	62	62	63	74
		L scale	-	94	94	95	101
		R scale	-	120	120	120	122
2. Fluidity							
Melt mass-flow rate	JIS K 7210 【ISO 1133】	200 ,5kg	g/10min.	13	1.6	4.0	1.0
		220 ,10kg		>140	26	53	14
Melt volume-flow rate	JIS K 7210 【ISO 1133】	200 ,5kg	cm ³ /10min.	14	1.8	4.4	1.1
		220 ,10kg		>150	28	57	15
3. Thermal properties							
Vicat softening temperature	JIS K 7206 【ISO 306】	50 /h,50N		97	99	100	100
Temperature of deflection under load	JIS K 7191-2 【ISO 75-2】	120 /h, 1.80MPa		76	79	79	79
4. Optical properties							
Solar light transmittance	JIS K 7105	4.0 mm thick	%	90	90	90	92
Haze	JIS K 7105 【ISO 14782】	4.0 mm thick	%	2.1	0.1	1.6	0.1
Refraction factor	JIS K 7105 【ISO 489】	-	-	1.57	1.57	1.56	1.53
5. Other properties							
Density	JIS K 7112 【ISO 1183】	23 /23	kg/m ³	1.075	1.075	1.088	1.134
Water absorption coefficient	JIS K 7209 【ISO 62】	23 /24h immersion	%	0.10	0.10	0.15	0.15
Ball pressure registration temperature	Electrical Appliance and Material Control Law	-		-	90	90	90
Flammability	UL 94	-	-	-	HB	HB	HB
Voluntary control criteria by JHOPA*	-	-	-	Conforming	Conforming	Conforming	Conforming

* Japan Hygienic Olefin and Styrene Plastics Association

The numerical values shown in the table are typical values based on the specified test methods and are not guaranteed values.

- These values may be revised based on improvements.
- The UL file No. for each grade is E52433.
- ESTYRENE[®] is the registered trademark of Nippon Steel Chemical.

5. Properties of ESTYRENE[®]MS

(1) Transparency

ESTYRENE[®]MS has extremely high transparency and gloss comparable to those of polymethyl methacrylate (PMMA or acrylic resin) over all wavelengths of visible light. Table 2 and Fig. 1 show the wavelength dependency of light transmittance.

Particularly in the range of short wavelengths, while PC (polycarbonate) and GPPS resins experience a reduction in light transmittance, ESTYRENE[®]MS retains a high light transmittance.

Table 2 Light Transmittance Measured by Spectrophotometer (%)

Wavelength measured (nm)	Optical path (mm)	ESTYRENE [®] MS			Reference		
		MS-200	MS-300	MS-600	GPPS	PC	PMMA
350	3	84	86	87	78	55	90
450	3	91	91	91	89	89	92
450	32	83	84	86	-	78	91

The numerical values shown are only typical, not guaranteed values.

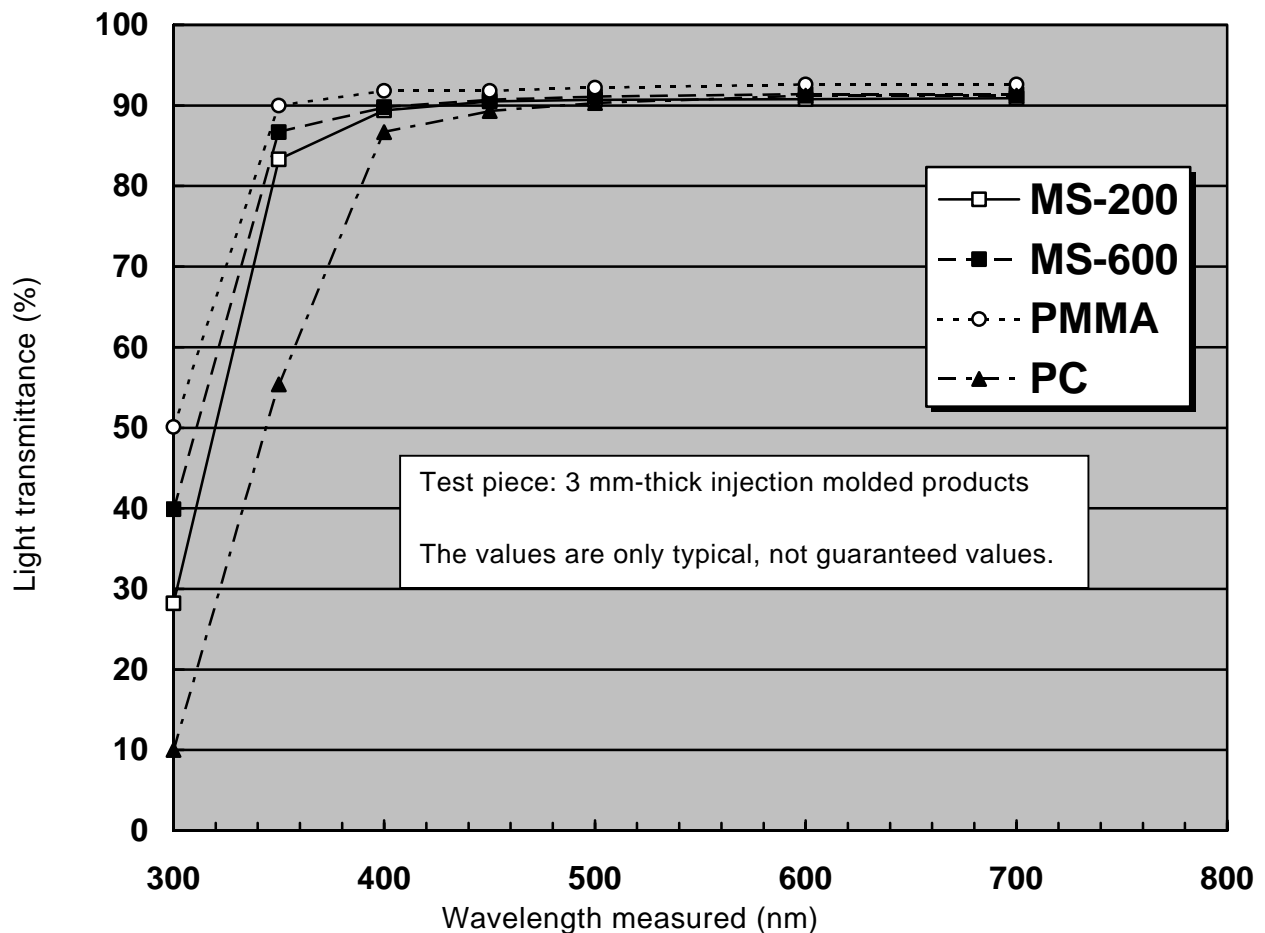


Fig. 1 Wavelength Dependency of Light Transmittance

(2) Surface hardness

The surface hardness of plastic materials is expressed, in many cases, in a Rockwell hardness value. But the use of a pencil hardness value is a more practical means of evaluating the susceptibility of plastic materials to mar (or the extent of their mar resistance). Table 3 compares the mar resistance of different types of resin. It reveals that ESTYRENE[®]MS shows the second highest mar resistance next to PMMA (acrylic resin).

Table 3 Pencil Hardness* of ESTYRENE[®]MS

Material	MS-200	MS-600	PMMA	PC	GPPS	ABS	HIPS
Pencil hardness	H	2H	4H	B	F	Around HB	2B or less

*Harder >4H>3H>2H>H>F>HB>B>2B softer, as indicated by the pencil hardness comparison.

(3) Moisture absorption property and dimensional stability of ESTYRENE[®]MS

ESTYRENE[®]MS shows lower water absorption property than PMMA (acrylic resin). Because of the far reduced dimensional change due to water or moisture, ESTYRENE[®]MS makes available molded products with high dimensional stability.

Fig. 2 Dimensional Change due to Moisture (at the temperature of 60 and the humidity of 90%)

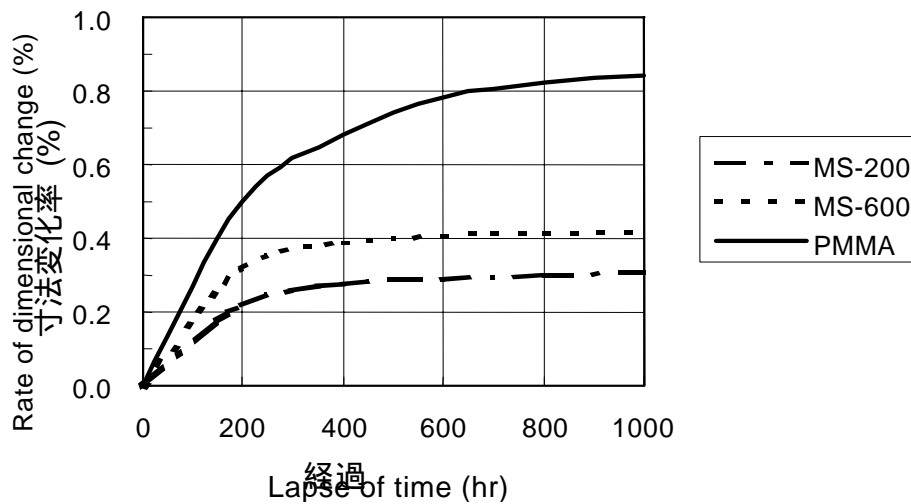
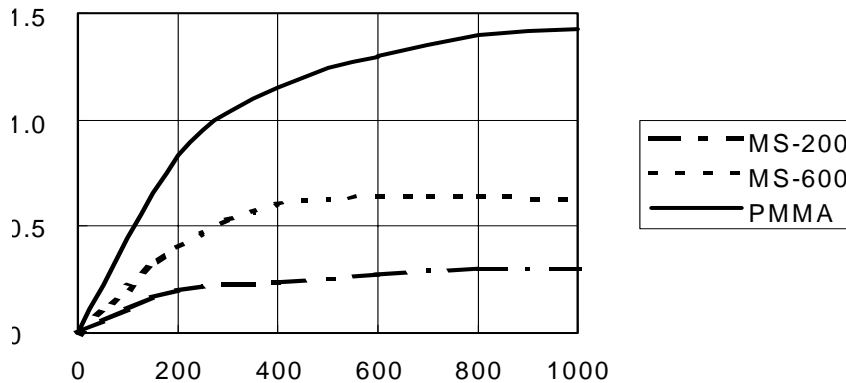


Fig. 3 Secular Changes in Water Absorption (when materials are kept left in the water of 23)

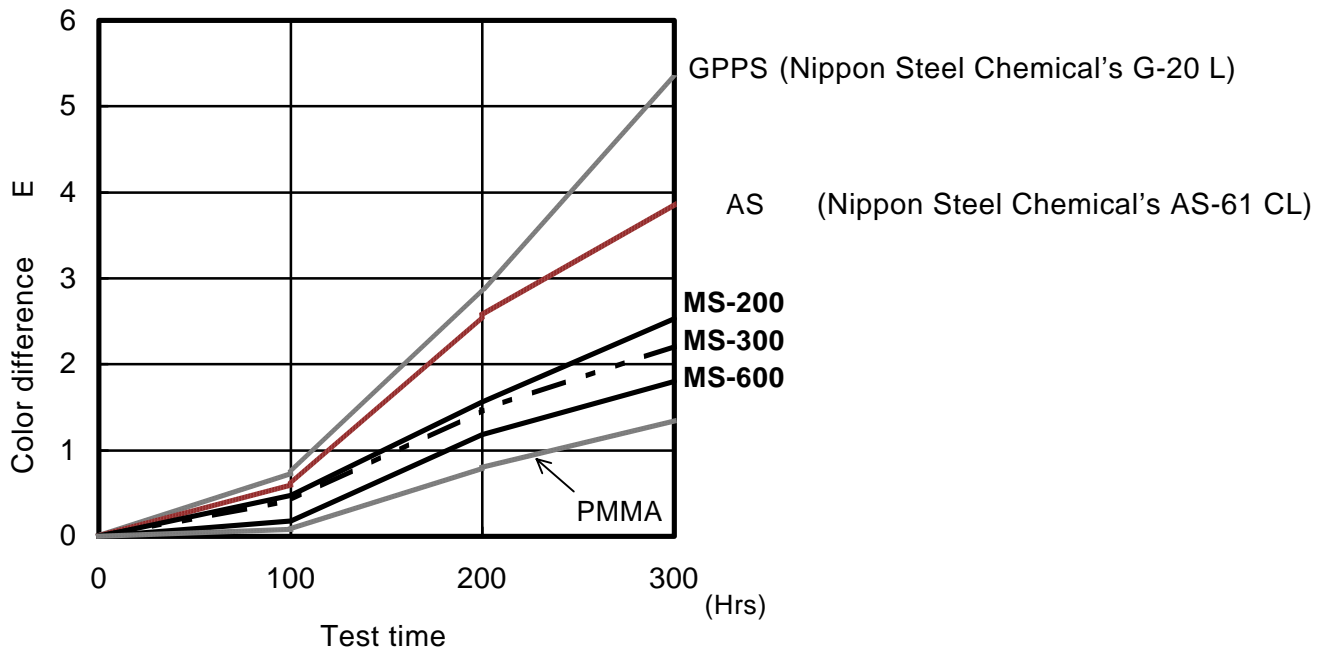


(4) Weather resistance of ESTYRENE® MS

Fig. 4 gives the weather resistance of ESTYRENE® MS. The weather resistance of ESTYRENE® MS far excels that of GPPS and AS resins. Some grades of ESTYRENE® MS offer the weather resistance comparable to acrylic resin (PMMA), a resin prominent for its excellent weather resistance.

The values given in Fig. 4 are based on the results of test on unpainted materials. Since test results regarding weather resistance may vary depending on the color tone used and the adoption of appropriate measures for weather resistance, consult us beforehand.

Fig. 4 Weather Resistance of ESTYRENE® MS



The values above are based on experiments at Nippon Steel Chemical's Polymer Research Center and are not guaranteed values.

- Test method: Conforming to ASTM D4459
- Test piece thickness: 3 mm
- Light source at the time of measuring color difference: D65/10

(5) Refraction factor of ESTYRENE® MS

Table 4 compares the refraction factor between ESTYRENE® MS and other plastic materials.

Table 4 Refraction Factor of ESTYRENE® MS

Material	MS-200	MS-300	MS-600	PMMA	PC	GPPS
Refraction factor	1.57	1.56	1.53	1.49	1.58	1.59

(6) Chemical resistance of ESTYRENE® MS

Table 5 shows the chemical resistance of ESTYRENE® MS for reference purposes. When using chemicals other than those given in the table, consult us.

Table 5 Chemical Resistance of ESTYRENE® MS

Chemicals used for evaluation	MS-200	MS-600	Reference		
			PMMA	GPPS	AS
Distilled water					
10% hydrochloric acid					
10% acetic acid					
10% oxalic acid					
10% lactic acid					
Saturated boric acid					
10% caustic soda					
Methanol		x	x	x	x
Ethanol		x	x		x
Isopropanol		x	x		
n-butanol	x	x	x		
n-octyl alcohol		x			
Naphthalene	x			x	
Kerosene	x			x	
Ethylene glycol					
Glycerin					
Bean oil					
Olive oil					
Peanut oil					
Lecithin					
Lanolin					
Vaseline					
10% neutral cleanser					
Liquid paraffin					

Condition for measurement: After 14-day immersion at 40

Visual observation: No change Hazing, discoloring Slightly cracked x Melted

6. Blending Properties of ESTYRENE® MS

(1) The compatibility of MS-200 and MS-300 with HIPS

ESTYRENE® MS-200 and MS-300 offer good compatibility with HIPS (impact-resistant polystyrene resin). When these MS-200 and MS-300 are used in combination with HIPS-molded products, they need not be separated from HIPS-molded products for collection. This means that ESTYRENE® MS-200 and MS-300 are more advantageous in recycling than acrylic resin.

- 1) The properties of MS-200, when blended with HIPS, are virtually the same as those of HIPS blended with GPPS. In this case, no deterioration in properties occurs due to the blending of different resins.
- 2) The physical properties of MS-300, when blended with HIPS, are the same as those of MS-300 which is blended with MS-200 or GPPS, with the only exception of Izod impact strength which shows a decrease. No scaling occurs due to phase separation.
- 3) When acrylic resin is blended with HIPS, a substantial decrease occurs in tensile stress (elongation) at break and Izod impact strength, due to the lack of compatibility between the two. Their molded products also show scaling partially.

Table 6 Properties*¹ of MS-200, MS-300, G-20*³ and PMMA, When Blended with H-65*²

Item	Unit	H-65	MS-200 blend		MS-300 blend		G-20 blend		PMMA blend	
			5%	10%	5%	10%	5%	10%	5%	10%
Tensile strength	MPa (kgf/cm ²)	30 (310)	31 (320)	32 (330)	30 (310)	32 (330)	30 (310)	31 (320)	27 (280)	28 (290)
Tensile stress at break	%	35	28	23	34	24	29	26	16	13
Flexural strength	MPa (kgf/cm ²)	49 (500)	53 (540)	55 (560)	50 (510)	53 (540)	51 (520)	53 (540)	47 (480)	50 (510)
Flexural modulus	MPa (kgf/cm ²)	2,050 (20,900)	2210 (22,600)	2,280 (23,300)	2,180 (22,300)	2,240 (22,900)	2,180 (22,300)	2,240 (22,900)	2,180 (22,700)	2,270 (23,200)
Izod impact strength	kJ/m ² (kgf/cm ²)	9.0 (9.2)	8.6 (8.8)	8.0 (8.2)	6.8 (6.9)	5.8 (5.9)	8.5 (8.7)	8.1 (8.3)	5.1 (5.2)	4.0 (4.1)
Vicat softening temperature		98	98	98	98	98	98	98	-	-
Scaling in molded product	-	-	No scaling	No scaling	No scaling	No scaling	No scaling	No scaling	Scaling	Scaling

*¹ Test method: H-65 is dry-blended individually with 5% and 10% of each MS-200, MS-300, G-20 and PMMA and is then mounted directly onto a molding machine to produce each test specimen.

*² H-65: Nippon Steel Chemical's standard highly impact-resistant grade of HIPS

*³ G-20: Nippon Steel Chemical's standard highly impact-resistant grade of GPPS

(2) The compatibility of MS-200 with SBS resin (styrene-butadiene block copolymer resin)

ESTYRENE[®] MS-200 has good compatibility with SBS resin (styrene-butadiene block copolymer), thereby allowing the blend of the two resins to form a transparent polymer alloy. The use of this nature makes possible:

- 1) The increase of rigidity on the side of SBS resin
- 2) The increase of impact resistance on the side of MS-200.

Cautions:

- 1) Neither MS-200 nor MS-600 have compatibility with SBS resin.
- 2) SBS resin's compatibility with MS-200 varies depending on grade. Inquire about details.
- 3) Direct molding through dry blending is also possible, but higher-quality molded product can be obtained by kneading and pelletizing beforehand in an extruder. Contact us for details.

Table 7 Blending Properties of ESTYRENE[®] MS and SBS Resin

Test item	Test method	Unit	MS-200	MS-200/SBS blending ratio			SBS resin
				70/30	50/50	30/70	
Tensile strength	ASTM D 638	MPa (kgf/cm ²)	60 (610)	49 (500)	32 (330)	26 (270)	22 (220)
Tensile stress at break		%	3.1	3.7	35.4	65.7	156.0
Flexural strength	ASTM D 790	MPa (kgf/cm ²)	85 (870)	76 (780)	54 (550)	40 (410)	35 (360)
Flexural modulus		MPa (kgf/cm ²)	3,160 (32,200)	2,450 (25,000)	2,020 (20,600)	1,680 (17,100)	1,650 (16,800)
Izod impact strength	ASTM D 256	kJ/m ² (kgf·cm/cm ²)	2.3 (2.3)	2.3 (2.3)	3.4 (3.4)	5.8 (5.8)	2.7 (2.7)
Melt flow rate	JIS K 7210	g/10min	1.6	3.2	4.3	3.2	7.0
Temperature of deflection under load	ASTM D 648		90	86	79	73	75
Solar light transmittance	JIS K 7105	%	91	90	90	90	90
Haze	JIS K 7105	-	0.9	1.2	1.6	2.6	4.2

The values above are based on experiments at Nippon Steel Chemical's Polymer Research Center and are not guaranteed values.

(3) Scrap-return of ESTYRENE® MS

- 1) The scrap-return of ESTYRENE® MS shows no substantial deterioration in general physical properties, but its yellowness tends to slightly increase at each scrap-return.
- 2) Scrap-returns are not recommended for optical parts and other similar applications where specifications for foreign substances provide extremely severe requirements.

Table 8 Properties of Scrap-returned MS-600

Test item	Test method	Condition	Unit	Number of returns			
				0	1	3	5
Tensile strength	ASTM D 638	5mm/min.	MPa (kgf/cm ²)	71 (730)	71 (720)	71 (720)	71 (720)
Tensile stress at break			%	5.8	5.5	6.0	5.3
Flexural strength	ASTM D 790	3mm/min.	MPa (kgf/cm ²)	118 (1,200)	116 (1,240)	116 (1,390)	116 (1,480)
Flexural modulus			MPa (kgf/cm ²)	3,340 (34,100)	3,330 (34,000)	3,330 (34,000)	3,380 (34,500)
Izod impact strength	ASTM D 256	6.4 mm thick, notched	kJ/m ² (kgf·cm/cm ²)	2.5 (2.5)	2.5 (2.5)	2.5 (2.5)	2.4 (2.4)
Melt flow rate	JIS K 7210	200 ,49N(5kgf)	g/10min.	1.0	1.0	1.1	1.1
		230 ,37N(3.8kgf)		5.2	5.2	5.3	5.3
Temperature of deflection under load	ASTM D 648	6.4 mm thick 1.82MPa		91	92	92	92
Color difference (E)		Permeation method			0.3	0.5	0.8
YI	Nippon Steel Chemical's own method	Permeation method			0.4	0.5	1.1
Solar light transmittance	JIS K 7105	4.0mm thick	%	92	92	91	91

- The values above are based on experiments at Nippon Steel Chemical's Polymer Research Center and are not guaranteed values. Measurement values may vary according to injection and molding conditions. Here, both the injection and molding temperatures are set at 230 .
- The values above do not guarantee the performance of actually molded products from scrapped materials.

7. Molding Conditions for ESTYRENE® MS

(1) Precautions in molding

Compared with ordinary HIPS resin, ESTYRENE® MS is high in moisture absorption property, requiring pre-drying before molding. For pre-drying conditions, refer to Table 9.

(2) Molding conditions

ESTYRENE® MS lends itself to molding under the same molding conditions as those for conventional PS.

Table 9 Example of Molding Conditions for ESTYRENE® MS*

Item	Example of conditions	Remarks
Pre-drying condition	70-80°C × 3 hrs or more	• In ordinary cases
	70°C × 6 hrs or 80°C × 4 hrs or more	• In the case of saturated water absorption
Molding temperature setting	200 ~ 250°V	• Should be set at temperatures to prevent nozzle clogging and sniveling
	• Nozzle section	
	• Intermediate section	200 ~ 250°C
• Hopper section	170 ~ 200°C	• Should be set at a temperature somewhat lower than the temperature set at midpoint
Mold temperature	Around 30-60°C	• Use of a mold temperature controller is recommended.
Injection speed	Medium speed	
Plasticizing conditions		• The setting of plasticizing conditions differs considerably depending on the type of the injection molding machine used and the required cooling time. (The plasticizing conditions at left are shown by way of example.)
Screw speed	50 ~ 100 rpm	
Back pressure	Around 10 kgf/cm ² . G	

*The above conditions are an example of general molding conditions. Some molds may require the setting of other items than those shown above.

(3) Thermal stability

ESTYRENE® MS is superior in thermal stability to acrylic resin.

8. Other Considerations

• Precautions in use and storage

- ESTYRENE® MS is an inflammable material. For fire prevention, it should be kept away from heat or flame. It should also be stored at a place some distance from heat or flame.
- ESTYRENE® MS is in the form of pellets. If the pellets are scattered on floors, roads etc., those floors and roads should promptly be cleaned up, because they are slippery.
- ESTYRENE® MS, when heated, generates the gas which may be irritant to human bodies. During heating, prevent humans from inhaling the gas by forced ventilation. If the human body gets closer to or comes into contact with molten resin, the body may suffer burns. Adequate disaster prevention measures should be taken.
- While ESTYRENE® MS is in storage, special care has to be paid to the prevention of moisture, discoloration and dust.

- 5) When disposing of ESTYRENE[®] MS, follow the national law regulating the disposal and cleaning of wastes and each municipal law.
- 6) When using ESTYRENE[®] MS, also refer to MSDS (Material Safety Data Sheet).
- 7) These precautions take ordinary use and handling into consideration. In the case of special use and handling, safety measures that correspond to the case should be taken.
- 8) These precautions are only for information purposes, not intended for guaranteeing.

• Notes to this Technical Literature

- 1) The numerical values given in this Technical Literature are typical values, not guaranteed values. These values should be used with extreme care. In addition, for important items, it is recommended that experiments using practical products be conducted in advance.
- 2) The contents of this literature were prepared based on the presently available information and, whenever necessary, may be revised by referring to the most up-to-date information.
- 3) The values for other types of resin than ESTYRENE[®] MS shown in this Technical Literature are quoted from those given in related catalogues and documents.

• Expression of ESTYRENE[®] MS pursuant to ISO

- 1) In accordance with ISO 1043-1 (JIS K6899-1) (Plastics and abbreviated terms – Part 1: Basic polymers and their special characteristics), it is recommended that ESTYRENE[®] MS be expressed as follows:

Grade	Abbreviation pursuant to ISO 1043-1	(Reference)
MS - 200 , MS - 200NT	SMMA	Styrene-methyl methacrylate
MS - 300	SMMA	Styrene-methyl methacrylate
MS - 600 , MS - 600XG	MMAS	Methyl methacrylate –styrene

9. For inquiries, contact:

MS Resin Marketing & Sales Team, Plastics Department, Chemicals Division

Nippon Steel Chemical Co., Ltd.

No. 2 TOC Bldg., 7-21-11 Nishi-Gotanda, Shinagawa-ku, Tokyo 141-0031, Japan

Tel: 81-5759-2733 Fax: 81-3-5759-2789

URL:<http://www.nsccl.co.jp/>