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Preface

This booklet has been compiled for the occasion of the opening in Japan of the 17th General Meeting of the International Rubber Study Group in May 1964, with the object of helping those who will attend the General Meeting from many countries of the world all the more to deepen their recognition of the rubber industry in Japan.

In keeping with the development of Japanese economy, the rubber industry in recent years has shown such a remarkable growth that, as it may already be known, Japan at the present time ranks second among the free nations of the world in the output of rubber goods. This development has been possible not only by the own merits of the Japanese rubber industry, but also by the growth and development of industries correlative to the rubber industry, such as those of carbon black, organic rubber chemicals, fibers for rubber, reclaimed rubber, and the like.

Japan's rubber industry itself will be taken up for reports and discussions at the Plenary Session, a number of committees, symposia, and other interchanges of views at the General Meeting. This booklet, therefore, is meant for the elucidation of the present and the future of the correlative industries which have played, and will play an important and indispensable role in the favorable development of the rubber industry in Japan.

For carbon black, the principal subsidiary material for rubber products, Japan has almost relied upon its imports. The supplying capacity of the manufacturers, however, has been so much expanded, and the quality of carbon black has been so much improved, that they are, at the present time, able to stand for exporting the products. In organic rubber chemicals, except for special items, Japan today has almost attained self-sufficiency. At the same time, development of originally Japanese products is being undertaken.

Japanese fiber industry has always stood high in public evaluation all over the world. The excellent quality of the products, including tire-cords, has raised the position of the Japanese rubber industry in a world-wide sense. By developing an original manufacturing method, Japan is enabled to supply cheap and superior reclaimed rubber, and has raised her competitive position in rubber goods.

Detailed descriptions of these matters are contained in this booklet. In collecting and presenting all these materials in this form, we wish this booklet would be in any way useful for the promotion of the accurate understanding of the industries correlative to the rubber industry in Japan, and for the development of rubber industries and their correlative industries of the countries concerned.

May 1964.

I. Carbon Black

(1) General Situation

Japan did not carry out any domestic production of the carbon black before World War II with its entire demand being met by an importation from the United States, though, as early as in 1930's the Teikoku Oil Company had produced the channel black in Formosa and the Nippon Chisso Company the acetylene black in Korea.

Since immediately after the war, Japan's production had centered on the acetylene black for the rubber production and color making. Commencement of marketing of the oil furnace black, produced by the Tokai Electrode Mfg. Co., Ltd. in 1950, provided an impetus for development in succession of various manufacturing techniques for the furnace black, thus making Japan the world's only country who was able to produce the furnace black of high quality without introducing its manufacturing technique from the United States. However, even then, Japan found herself still compelled to import a sizable quantity of the furnace black to fill up the half of its domestic demand.

Since 1959, with domestic demand rapidly increasing, new enterprises concluded the technical agreements with the companies in the United States and started the carbon black production. The existing manufacturers, on their part, also raised their production capacity through an introduction of foreign techniques and improving the manufacturing processes. Japan's production capacity of the carbon black, thus, has attained a considerable increase and consequently Japan became self-sustaining nation in meeting all her domestic demand. In 1963, Japan's annual production capacity rose to 130,000 odd tons, far surpassing the 83,000-ton domestic demand, making it possible for Japan to become an exporter of fairly large quantity of the product.

(2) Enterprises and the Brands

At present, 10 Japanese manufacturers engage in the carbon black production in 12 factories. Out of the four companies operating under the technical agreements with the foreign companies, the Tokai Electrode Mfg. Co., Ltd., Mitsubishi Chemical Industries Ltd. and Showa Denko are all producers of several chemicals, including the carbon black, while the remaining one, Toyo Continental Carbon Ltd., is also an organization evenly invested by both Toyo Koatsu Company and Continental Carbon Company of the United States.

Asahi Carbon Mfg. Co., Ltd., Hokutan Carbon Co., Ltd. and Gastone Kasei Co., Ltd., all producing the carbon black with own-developed techniques, are the subsidiaries of an automobile tire manufacturing company, a coal mining company and a chemical industry company, respectively. The other companies, Denkikagaku Kogyo K.K., Mitsui Chemical Industrial Co., Ltd. and Nittetsu Chemical Industry Co., Ltd. are the enterprises also turning out other products with high percentages. As such, Japanese carbon black manufacturing enterprises are constituted either with the large business undertakings or with the companies closely affiliated with such large undertakings. Presently these companies produce various kinds of the carbon black as shown on the Table 1 with the number of their brands reaching over 40.

(3) Raw Materials and Manufacturing Processes

The raw materials used in the manufacturing of the carbon black in Japan are mainly the oil of the coal tar origin, particularly the creosote oil, since the coal tar oil contains in larger quantity, as compared with petroleum, the aromatic oil which has high yields of the carbon black. But if and when less expensive, and high quality, petroleum become available in future, such material situation may undergo different picture.

It is worthy of note that the carbon black produced in Japan from either the coal tar oil or the petroleum differs very little in quality, thanks to superb Japanese manufacturing techniques.

The coal tar oil stands high among the raw materials in producing the so-called furnace blacks such as ISAF, HAF, FF, FEF, GPF, SRF, etc. Only Asahi Carbon Mfg. Co., Ltd. and Toyo Continental Carbon Ltd. utilize the petroleum as the raw material for the production. As for the FT class product, one company uses the natural gas and the other the gas from the coke ovens, as the raw materials. The acetylene black is made from the acetylene gas from the carbide. All channel blacks also use the coal tar oil as the raw material.

Table 1 Japanese Carbon Black Manufacturers and Their Brands

Use	Kind	Manufacturer	Brand*	Location of Factory
Rubber	ISAF	Tokai Electrode	Seast I Seast 6 (Vulcan 6)	Wakamatsu, Chita
		Mitsubishi Chemical	Daiablack I (Statex 125)	Kurosaki, Yokkaichi
		Showa Denko	Shoblack I (Philblack I)	Ichihara
		Toyo Continental Carbon	Continex ISAF (Same)	Yokoshiba
	HAF	Tokai Electrode	Seast H. 305 Seast 3 (Vulcan 3)	Wakamatsu, Chita
		Mitsubishi Chemical	Daiablack H (Statex R)	Kurosaki, Yokkaichi
		Showa Denko	Shoblack O (Philblack O)	Ichihara
		Nittetsu Chemical	Niteron 200	Tobata
		Toyo Continental Carbon	Continex HAF (Same)	Yokoshiba
	Low Modulus (ISAF, HAF)	Tokai Electrode	Seagal 600 (Regal 600) 〃 300 (〃 300)	Wakamatsu, Chita
		Mitsubishi Chemical	Daiablack LI (Neotex 100) 〃 LH (〃 130)	Kurosaki, Yokkaichi
	High Structure (ISAF, HAF)	Mitsubishi Chemical	Daiablack SI (Statex 125H) 〃 SH(〃 RH)	Kurosaki, Yokkaichi
		Tokai Electrode	Seast 6H (Vulcan 6H) 〃 3H (〃 3H)	Wakamatsu, Chita
	FF	Mitsubishi Chemical	Daiablack FF (Statex B)	Kurosaki, Yokkaichi
		Tokai Electrode	Seast 99 (Stealing 99)	Wakamatsu, Chita
	FEF (MAF)	Tokai Electrode	Seast 116 SO	Wakamatsu, Chita
		Asahi Carbon	60, 60L [low modulus]	Niigata
		Hokutan Carbon	100, 80	Shinhoronai
		Denki Kagaku	2000	Omuta
		Nittetsu Chemical	Niteron 10	Tobata
	GPF	Asahi Carbon	55	Niigata
		Hokutan Carbon	G	Shinhoronai
	SRF	Asahi Carbon	50, 35 [low modulus]	Niigata
		Hokutan Carbon	S	Shinhoronai
	FT	Mitsui Chemical	Miike Carbon 20	Omuta
		Gastone Kasei	Gastone	Niigata
Dry Cell	Acyetylene	Denki Kagaku	Acyetelene black	Omuta
Pigment Ink Paint Others	General Grade	Mitsubishi Chemical	100	Kurosaki
		Nittetsu Chemical	N-115	Tobata
	High Grade	Nittetsu Chemical	Nipel 100, S	Tobata

* Foreign brand of the same product that producer has technical tieups with Japanese manufacturer written in the parenthesis.

(4) Supply-Demand Situation and Import and Export

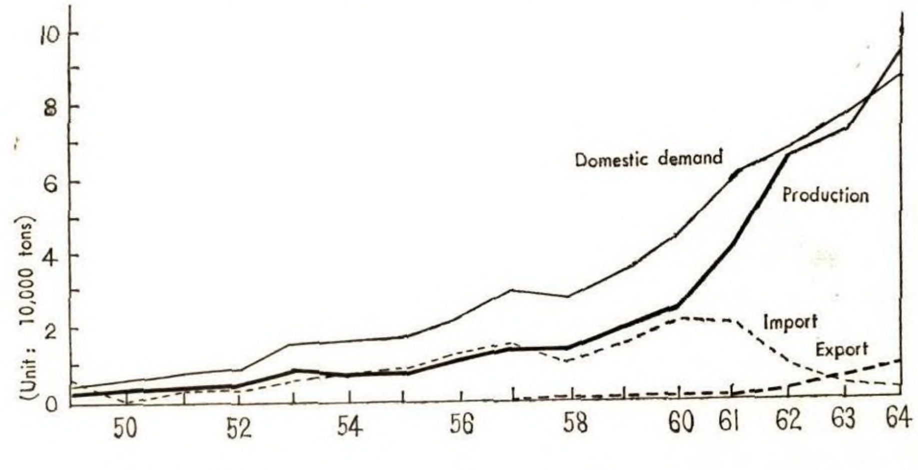
The supply and demand for the carbon black in Japan is undergoing a remarkable change of late as seen on the Table 2 and Figure 1, that is to say, Japan, which had been an importer of the carbon black for a long time, is now emerged as a self-sustaining country in the production after successfully establishing a modern mass production system, and furthermore she has superfluous capability to export it.

Table 2 Supply-Demand Situation of the Carbon Black in Japan

		Result					Future Prospect		
		1955	1960	1961	1962	1963	1964	1965	1967
Supply	Production	7, 870	24, 990	42, 609	66, 690	73, 445	96, 015	113, 474	151, 296
	Import	8, 411	21, 780	20, 941	9, 913	3, 965	2, 900	2, 000	2, 000
	Total	16, 281	46, 770	63, 550	76, 603	77, 410	98, 915	115, 474	153, 296
Demand	Domestic demand	16, 768	47, 171	60, 913	68, 872	77, 520	88, 915	100, 474	128, 296
	Export	10	491	567	3, 513	5, 490	10, 000	15, 000	25, 000
	Total	16, 778	47, 662	61, 481	72, 385	83, 010	98, 915	115, 474	153, 296

Sources: Production and domestic demand figures from The Ministry of International Trade and Industry: Import and Export figures from Finance Ministry.
Note: Figures for 1964 and after are business circle's estimate.

Figure 1 Supply-Demand Situation of the Carbon Black in Japan



The figure indicates up until 1960, Japan's demand for the carbon black had been heavily dependent on the import but since then the importation has drastically reduced with an introduction of foreign manufacturing techniques and modernization of equipment. It also indicates, since immediately after 1960, Japan has become an exporter of the carbon black to such countries as the Soviet Union and others in Asia, North and South America.

In 1963, Japan exported the carbon black to the Soviet Union, Hong Kong, the United States, Thailand, Formosa, Korea, India, Singapore, the Philippines, Burma, People's Republic of China, Vietnam, Cambodia, Indonesia, Malaya, Brazil, and other countries.

Japan's annual carbon black production capacity today stands at 134,000-ton mark finding it one of the free world's major producing nations following the United States and Britain. Japan also ranks second in the world in consumption of the new rubber by surpassing the Britain. Taking into account her growing export, however moderate in degree, of the carbon black, it is presumed, Japan's production will become the world's second in the near future.

The percentage-wise break down of the use of carbon black in Japan (approx. 95% of which being used for the rubber products) is as follows:

Consumption of the Carbon Black in Japan (1963)

For automobile tires	71.3%
For other rubber products	23.3%
(Total for rubber products)	(94.6%)
For Color use	5.4%
Grand total	100.0%

The compound rate of the carbon black is the highest in the field of automoible tire manufacturing, and in 1964, it is thought, the carbon black's ratio in the same manufacturing will mark as high as 42% against the new rubber. In addition, the general compound rate of the carbon black in the present Japanese rubber industry is about 25%.

(5) Future Prospect

The future production of the carbon black will be greatly influenced by the materials to be used in manufacturing the rubber products, especially of the synthetic rubber which uses the carbon black with a high percentage.

In Japan, the consumption of the synthetic rubber centering on SBR is on a yearly rise recording 127,500 tons in 1963 or 40% of the new rubber consumption. It is assumed such rising tendency will continue for some time to come and accordingly, demand for the carbon black will become larger.

The recent worldwide tendency of seeking a development and usableness of new synthetic rubber necessitate Japan to develop new carbon black in meeting such challenge. As such, Japan, on her part will endeavor to raise the present production of the carbon black and, at the same time, will seek a development of the new carbon black to cope with such world's trend.

As for the stereo rubber (PBR) (the production of which Japan is to initiate at the end of this year) the United States, as a consequence of experimental use of such rubber, is said to have found that the carbon black of high structure is most useful in kneading as well as in mixing the rubber. As for Japan, she has already successfully developed a technique for such carbon black production.

As has been mentioned earlier the present capacity in the Japanese carbon black manufacturing facilities is enabling Japan to export the products in relatively large quantity to other countries while meeting all the necessary domestic demand. Furthermore, with the completion of scheduled mass production system, Japan will be able to supply the products in larger quantity to more wider overseas areas. Japan's export target of the products during the 1964 fiscal year is set at 10,000 tons.

II. Organic Rubber Chemicals

(1) General Situation

Organic rubber chemicals were successfully manufactured in Japan for the first time in 1931. In keeping with the development of the Japanese rubber industry, their production, since then, has gradually increased up to the present time. Upon looking back, we see that, owing to the suspension of the importation of rubber chemicals and a rapid increase in demand for domestic products during the war, facilities for their manufacture were expanded and their quality improved, and that, in this way, the foundation of today's rubber chemical industry was laid. Subsequent to the war, both domestic demand and exports of rubber products were increased, and side by side therewith, the production of organic rubber chemicals grew by strides, so that the greater part of domestic demand was met by products of home make.

At the present time, as many as fifty different kinds of rubber chemicals are produced in Japan, including vulcanization accelerators, antioxidants, vulcanizing agents, and other organic rubber chemicals.

(2) Kinds of Products and Principal Enterprises

There are seven following organic rubber chemical enterprises in Japan:

Daitō Chemical Co., Ltd.
Kawaguchi Chemical Industrial Co., Ltd.
Kōei Chemical Industrial Co., Ltd.
Ōuchi Shinkō Chemical Industrial Co., Ltd.
Sanshin Chemical Industrial Co., Ltd.
Seikō Chemical Co., Ltd.
Sumitomo Chemical Industrial Co., Ltd.

Except for the Sumitomo Chemical Industrial Co., Ltd., they are mostly medium and small enterprises. The breakdown by item of the 1963 output of organic rubbber chemicals is given in Table 1.

Table 1. Output of Organic Rubber Chemicals by Kind in 1963

Classification	Item	Annual Output (in tons)	Manufacturer
1. Vulcanization accelerators			
Aldehyde-ammonia type	(AC. AA) Acetaldehyde-ammonia	4	Ouchi Shinko
	(H) Hexamethylene tetramine (Hexa)	10	Ouchi Sinko Sumitomo Chemical
Aldehyde-amine type	(K) Acetaldelyde-aniline reaction product	4	Ouchi Sinko
	(8) Butyraldehyde-aniline reaction production	22	Ouchi Shinko
Guanidine type	(D) Diphenylguanidine (DPG)	544	Ouchi Shinko Sumitomo Chemical Sanshin Chemical
	(DT) Diorthotolylguanidine (DOTG)	17	Ouchi Shinko
	(BG) o-Tolylbiguanide	12	Ouchi Shinko
	(PR) DOTG Salt of dicatechol borate	1	Ouchi Shinko
Thiazole type	(M) 2-Mercaptobenzothiazole (MBT)	1, 325	Ouchi Shinko Sumitomo Chemical Sanshin Chemical Kawaguchi Chemical Daito Chemical
	(DM) Dibenzothiazyl disulfide (DBTDS)	1, 575	Ouchi Shinko Daito Chemical Sumitomo Chemical Kawaguchi Chemical Sanshin Chemical
	(ME) Zn-Salt of mercaptobenzothiazole	56	Ouchi Shinko Sumitomo Chemical
	(CZ) N-Cyclohexylbenzothiazole sulfenamide	707	Ouchi Shinko Sumitomo Chemical Kawaguchi Chemical Sanshin Chemical
	(MSA) N-Oxydiethylenebenzothiazole sulfenamide	128	Ouchi Shinko Kawaguchi Chemical
	(64) N, N′-Diethylthiocarbamoyl-benzothiazole sulfenamide	0	Ouchi Shinko
	(HM) Cyclohexylamine salt of 2-mercaptobenzothiazole	2	Sanshin Chemical
Imidazoline type	(22) Z, Z′ (2-Mercaptoimidezoline)	66	Ouchi Shinko Sumitomo Chemical Kawaguchi Chemical
Thiuram type	(TS) Tetramethylthiuram monosulfide	49	Ouchi Shinko Sanshin Chemical Kawaguchi Chemical
	(TT) Tetramethylthiuram disulfide	348	Ouchi Shinko Sanshin Chemical Sumitomo Chemical Kawaguchi Chemical
	(TRA / TP) Dipentemethylenethiuram tetrasulfide	20	Ouchi Shinko Koei Chemical
Dithiocarbamate	(P) Pipecoline pipecolyl dithiocarbamate	4	Ouchi Shinko

	(PZ) Zn-Dimethyl dithiocarbamate	14	Ouchi Shinko Kawaguchi Chemical
	(EZ) Zn-Diethyl dithiocarbamate	126	Ouchi Shinko Kawaguchi Chemical Sumitomo Chemical
	(PX) Zn-Ethylphenyl dithiocar-bamate	52	Ouchi Shinko Sumitomo Chemical Kawaguchi Chemical Sanshin Chemical
Mixed type	(F) DBTDS+Hexa+DPG	131	Ouchi Shinko Sumitomo Chemical Kawaguchi Chemical Sanshin Chemical
	(MX-1) MBT+Hexa	14	Sanshin Chemical
	(MX-2 / MX-3) DBTDS+Hexa	28	Sanshin Chemical
Total		5, 259	
2. Antioxidants			
Aldehyde-amine type	(AC) Aldol-1-naphthylamine	382	Ouchi Shinko Kawaguchi Chemical
Ketone-amine type	(224 / RD) Polymerized trimethydihydro-quinoline	146	Ouchi Shinko Sumitomo Chemical Seiko Chemical
	(AW) Ethoxy-trimethyldihydro-quinoline	259 259	Ouchi Shinko Seiko Chemical
	(BA) Diphenylamine-acetone reaction product	190	Ouchi Shinko Seiko Chemical
Aryl secondary	(PA) Phenyl-1-naphthylamie (PAN)	80	Ouchi Shinko
Amine type	(D) Phenyl-2-naphthylamine (PBN)	1, 196	Ouchi Shinko Sumitomo Chemical Koei Chemical Kawaguchi Chemical Seiko Chemical
	(F) Dinaphthyl-p-phenylenedia-mine (DNPD)	11	Sumitomo Chemical Seiko Chemical
	(H) Diphenyl-p-phenylenediamine (DPPD)	112	Seiko Chemical
	(810-NA) Isopropyl-phenyl-p-phenylenediamine (PPPD)	444	Ouchi Sinko Seiko Chemical Sumitomo Chemical
Phenol type	(200 / BHT) Dibutyl-p-cresol	141	Ouchi Shinko Seiko Chemical
	(SP) Styrenated phenol	695	Ouchi Shinko Sumitomo Chemical Kawaguchi Chemical Seiko Chemical
	(W) Dihydroxy-diphenylcyclohexane	25	Sumitomo Chemical
	(alba) Dibutyl hydroquinone	17	Seiko Chemical
Benjimidazole type	(MB) 2-Mercaptobenzimidazole	86	Ouchi Shinko Sumitomo Chemical
Mixed type	(HP / P) DPPD PBN	282	Ouchi Shinko Seiko Chemical Sumitomo Chemical
	(K / E) DPPD DNPD PBN	30	Seiko Chemical
Other type	(NBC) Ni-dibutyl dithiocabamate	10	Kawaguchi Chemical
	Special Wax	1, 068	Ouchi Shinko Seiko Chemical
Total		5, 174	

(Continued on next page)→

3. Others			
Vulcomizing agents	(Q / GM) Quinove dioxime	28	Ouchi Shinko Kawaguchi Chemical
	(DQ / DGH) Dibenyoyl quinone dioxime	38	Ouchi Shinko Kawaguchi Chemical
	(R) Morpholine disulfide	5	Kawaguchi Cnemical
Scorch retarder	N-Nitrosodiphenylamine	57	Ouchi Shinko
Peptizers	(SS) Dibenyamidodiphenyl disulfide	49	Ouchi Shinko
	(SZ) Zn-Benzamidothiophenate	33	Ouchi Shinko
Total		210	
Grand Total		10, 643	

Source: Statistics; The Ministry of International Trade and Industry.

(3) Demand and Supply and Future Prospects

The production of organic rubber chemicals in Japan up to about 1959 had natural rubber in view, and the ratio of production between vulcanization accelerators and antioxidants was approximately six to four. At the same time, the variety of products as compared with that of today was smaller. As the domestic production of synthetic rubbers, however, was well launched about 1960, the production of organic rubber chemicals for synthetic rubbers also was started; the produced items and their output were rapidly increased, and vulcanization accelerators and antioxidants became almost equal in their output. In 1963, organic rubber chemicals produced at home amounted approximately to 10,000 tons, while the small quantity of approximately 200 tons (2% of the total output) was imported. Domestic demand may be said to have been met almost by home products. (See Table 2.)

On the other hand, the excellent quality of Japanese organic rubber chemicals has attracted attention abroad, and has, particularly in recent years, stimulated orders from foreign countries for exports. Since 1961 nearly 5% of the domestic production has been exported. (See Table 3.) A sharp rise in demand from Communist bloc countries has opened up a bright future for the exportation of the products, and the industry concerned has set the goal at exporting 1,500 tons (10% of the total output) during 1964. Thus the organic rubber chemical industry is establishing itself as an export industry.

The headway made in recent years by synthetic rubbers has opened up new fields of demand for rubber chemicals as well as their utilization ratio. At the same time, new types of organic rubber chemicals have been developed for the production and processing of plastics, or for the

Table 2. Demand and Supply of Organic Rubber Chemicals

(in Tons)

Year	Classification	Supply		Demand	
		Output	Imports	Consumption	Exports
1955	Vulcanization Accelerators	1, 254		1, 254	
	Antioxidants	840		793	
	Vulcanizing Agents	4		4	
	Others	55		52	
	Total	2, 153	68. 2	2, 103	25. 8
1960	Vulcanization Accelerators	3, 501		3. 260	
	Antioxidants	2, 536		2, 248	
	Vulcanizing Agents	64		58	
	Others	379		381	
	Total	6, 480	441. 7	5, 947	89. 7
1961	Vulcanization Accelerators	4, 353		3, 983	
	Antioxidants	3, 399		3, 202	
	Vulcanizing Agents	85		73	
	Others	755		752	
	Total	8, 592	294. 6	8, 010	403. 8
1962	Vulcanization Accelerators	4, 879		4, 402	213. 1
	Antioxidants	4, 126		3, 613	116. 2
	Vulcanizing Agents	57		51	
	Others	966		979	
	Total	10, 058	164. 3	9, 045	329. 3
1963	Vulcanization Accelerators	5, 257	30. 1	4, 541	645. 1
	Antioxidants	4, 153	169. 7	3, 936	96. 9
	Vulcanizing Agents	72		63	
	Others	1, 207		1, 200	
	Total	10, 689	198. 8	9, 740	742. 0

Source: Statistics; Ministry of Finance.

Table 3. Export and Import of Organic Rubber Chemicals

(in Tons)

Export

	1955	1960	1961	1962	1963
Taiwan	3. 4	59. 2	77. 6	61. 1	42. 8
Ryukyu Islands	0. 8	1. 3	2. 5	2. 0	1. 2
Philippines		4. 4	11. 8	48. 8	44. 3
Hong Kong		10. 6	0. 3	14. 1	38. 4
Korea			95. 1	44. 3	100. 1
Australia	10. 0		1. 5		5. 0
Argentine	5. 4				2. 0
United States			137. 3	1. 3	16. 4
U. S. S. R.				80. 0	263. 0
Others	6. 2	14. 2	78. 7	77, 7	228. 8
Total	25. 8	89. 7	403. 8	329. 3	742. 0

(Continued on next page)→

Import

	1955	1960	1961	1962	1963
Great Britain	2.4	36.0	13.8	0.9	0.2
West Germany	35.6	84.5	106.9	2.8	2.1
United States	30.2	321.2	173.9	160.6	197.5
Total	*68.2*	*441.7*	*294.6*	*164.3*	*199.8*

Source: Statistics; Ministry of Finance.

mixed uses of plastics and rubbers. The new products are cross-linking agents, such as chemicals like organic peroxide; the deterioration retarders including non-staining type retarder which is as effective as the staining one, and the like. It is expected that the production of these new types of organic rubber chemicals, together with the existing ones, will greatly increase in the future.

III. Fibers

(1) General Situation

In recent years, fibers have not only been consumed in larger quantity all over the world, but also have greatly developed their quality.

The concrete manifestation of this is visible in the development of chemical fibers. During the past ten years, a series of new chemical fibers suitable for various uses have made their appearance. Year after year, therefore, these fibers have increased their importance in all kinds of fibers. At present, chemical fibers represent only 25% of the total output of fibers. Naturally, their further developments in the future are anticipated.

Figures showing the consumption of fibers in Japan are given in Table 1, reflecting an increase of approximately 50%, from 887,000 tons in 1955 to 1,318,000 tons in 1963. Natural fibers reached a peak in 1961, followed by a gradual downward trend. Their increase between 1955 and 1963 was only 127,000 tons, while that of chemical fibers during the same period was 305,000 tons. Most conspicuous was the increase in

Table 1. Changes in Demand on Fibers

(Yarns in Tons)

Item \ Colum	1955	1960	1961	1962	1963
Natural Fibers					
Cotton Yarn	397, 984	523, 211	533, 225	497, 243	487, 300
Others	192. 488	212, 714	214, 792	226, 994	229, 367
Total	590, 472	735, 925	748, 017	724, 237	716, 667
Chemical Fiber					
Rayon Yarn	88, 866	127, 691	121, 543	125, 503	114, 245
Synthetic Yarn (C)	18, 589	140, 246	169, 588	204, 769	281, 084
Others	188, 867	225, 551	218, 381	208, 176	205, 580
Total (B)	296, 331	493, 488	509, 512	538, 448	600, 909
Grand Total (A)	886, 803	1, 229, 413	1, 257, 529	1, 262, 685	1, 317, 576
B/A (%)	33. 4	40. 1	40. 5	42. 6	45. 6
C/A (%)	2. 0	11. 4	13. 4	16. 2	21. 3

Source: Statistics; The Ministry of International Trade and Industry.
Note: The colum of 1963 shows the figures in the fiscal year, so, these figures mean some estimated ones.

synthetic fibers, such as nylon and others.

Synthetic fibers, which in 1955 occupied only 2% of all the fibers, made such rapid strides that the percentage in 1963 was as high as 21. Causes greatly contributory to this advancement of synthetic fibers are various, namely, their excellent qualities, rapid increase in demand as materials for clothing, due to the superior quality of itself, the recent progress of processing techniques, and successive discovery of their uses for industries such as fishing, belts, tirecords, and the like.

It is hardly necessary to remark that cotton, wool, as well as hemp, are natural products, the production of which naturally depends heavily upon climatic conditions. Consequently, their prices are always subject to fluctuations.

On the other hand, chemical fibers are products of large-scale equipment industries, fit for mass production according to plans. Hence their aptitude as industrial materials.

The quantity of fibers supplied to Japanese industries amounted in 1955 to 55,000 tons, and in 1963 to 109,000 tons, or almost twice as many. The quantity of natural fibers, of which cotton is the main item, being nearly the same for both years, the increase was entirely due to that in chemical fibers.

In view of this rapid change, from natural to chemical fibers, in the use of fibers for industrial purposes, especially in the principal fibers used for rubber products, which are now mostly chemical fibers, mention will be made in the following of the chemical fibers connected with the rubber industry.

(2) Kinds of Chemical Fibers and Main Enterprises

The chemical fibers produced in large quantities in Japan at the present time are rayon, the synthetic fibers of polyamide (nylon) and polyvinyl (vinylon), the polyester fiber (polyester), and the polyacrylic fiber (acrylic). The polypropylene fiber (polypropylene) is also expected as the fiber of tomorrow. The polyurethane fiber (spandex), which has been suitable for the field of rubber yarn, has already been taken up for production. (See Table 2: Kinds of Chemical Fibers.)

Table 2. Kinds of Chemical Fibers

- Chemical Fibre
  - Inorganic Fibre
    - Metallic Fibre
    - Glass Fibre
  - Regenerated Fibre — Cellulose
    - Rayon (Viscose Rayon)
    - Cuprammonium Cuprammonium (Rayon)
  - Semi-synthetic Fibre — Cellulose — Acetate
  - Synthetic Fibre
    - Polyamide — Nylon 6
    - Polyvinyl Alcohol fibre — Vinylon
    - Polyvinylidene Chloride fibre — Vinylidene
    - Polyviuyl Chloride fibre — Polyvinyl Chloride
    - Polyester fibre — Polyester
    - Polyacrylonitrile fibre — Acrilic
    - Polyethylene fibre — Polyethylene
    - Polypropylene fibre — Polypropylene
    - Polyurethane fibre — Spandex

The leading enterprises in Japan at present number three for high tenacity viscose rayon, six for nylon, three for vinylon, five for polyester, six for acrylic, and seven for polypropylene. (See Table 3.)

(3) Productive Capacity of Facilities and Methods of Production

The productive capacity of the facilities for high tenacity viscose rayon had rapidly been expanded until 1961, when it exceeded 100 tons per day. In 1963, however, the daily output showed a decrease to 83 tons. On the other hand, thanks partly to an increase in items, facilities for synthetic fibers were expanded between 1955 and 1963 to be ten times as large. (See Table 4.) The daily output increased with great strides from 76 tons in 1955 to 764 tons in 1963. The increase of nylon was from 36 to 241 tons, and that of vinylon from 30 to 145 tons. In 1955, neither polyester nor acrylic was produced in Japan, but in 1963 the former scored a daily output of 173 tons, and the latter 109 tons. As vinylidene and polyvinyl chloride have their particularly limited usage, no change was marked in their tonnage of production. Polypropylene and polyethylene are regarded as fibers with bright prospects.

In this way, eight different kinds of synthetic fibers are now being produced in Japan, and efforts will be continued in the future for the development of new fibers and their commercial production. At the same time, as a result of the development of the petrochemical industry, new manufacturing methods of raw materials have come to be adopted, enabling the enterprises to reduce cost sharply. Rationalization of cost, therefore, will be positively carried out in the future.

Table 3. Products of Chemical Fiber Enterprises

	High Tenacity Viscose Rayon Yarn	Nylon	Vinylon	Polyester	Acrylic	Polypro-pylene	Vinylidene	Polyvinyl Chloride	Poly-ethlene	Spandex
Teijin, Limited	○	○		○				○		○
Toyo Rayon Co., Ltd.		○		○	○	○				○
Kurashiki Rayon Co., Ltd.			○	○						
Nippon Rayon Co., Ltd.	○	○		○						
Asahi Chemical Industry		○			○					
Toyo Spinning Co., Ltd.	○			○		○				○
Mitsubishi Rayon Co., Ltd.						○				
Toho Beslon Co., Ltd.					○					
Nichibo Co., Ltd.			○							
Kanegafuchi Spinning Co., Ltd.		○							○	
Kureha Spinning Co., Ltd.		○								
Kanegafuchi Chemical Industry Co., Ltd.					○					
Japan Exlan Co., Ltd.					○					
Asahi-Dow Limited							○		○	
Mitsubishi Vonnel Co., Ltd.					○					
Shin Nippon Chisso Hiryo Co., Ltd.						○				
Kureha Chemical Industry Co., Ltd.							○		○	
Nitto Boseki Co., Ltd.						○			○	
Mitsui Chemical Industry Co., Ltd.									○	
Toyo Chemical Co., Ltd.								○	○	
Nihon Vinylon Co., Ltd.			○							
Nichiay Plastic Co., Ltd.								○		
Daiwa Spinning Co., Ltd.						○				
Toa Wool Spinning and Weaving Co., Ltd.						○				
Fuji Spinning Co., Ltd										○
Total	3	6	3	5	6	7	2	3	6	4

Table 4. Productive Capacity of Equipment and Plants

	High Tenacity Viscose Rayon Yarn	Synthetic Fibers								Total
		Nylon	Vinylon	Poly-ester	Acrylic	Polypro-pylene	Vinyli-dene	Poly-vinyl Chloride	Poly-ethylene	
1955	39	36	30	0	0	0	10	0	0	76
1960	87	124	80	66	82	0	14	28	7	401
1961	102	137	117	114	97	0	14	29	14	516
1962	102	171	126	135	91	12	14	29	18	598
1963	83	241	145	173	109	26	14	29	26	764

Source: Statistics; The Ministry of International Trade and Industry.

(a) High tenacity viscose rayon yarn

With high alpha pulp as raw material, this yarn, like usual rayon yarns, is produced by wet spinning. In response to the rapid growth of demand on motorcar tires in 1960, the productive capacity was increased in 1961 for 102 tons daily (35 tons for Teijin, 28 tons for Nippon Rayon, 20 tons for Toyo Spinning, and 19 tons for Toyo Rayon). In 1963, however, the daily output was reduced to 83 tons, as Toyo Rayon, owing to the commercial production of nylon as a fiber for the purpose of motorcar tires, gave up its facilities for high tenacity viscose rayon.

(b) Nylon

The nylon manufactured in Japan is the kind using ε-Caprolactum as raw material. The prevailing method for caprolactum manufacturing has two processes, namely, the phenol method to manufacture cyclohexanone from benzol by way of phenol, and the other method of direct oxidation of cyclohexane. Recently, Toyo Rayon has by itself invented the PNC method by inducting photo synthesis into chemical reaction. This is an epoch-making method, and the facilities applying this technique have been in operation since 1963. The technique has been exported to Firestone Tire and Rubber (U.S.A.).

Two methods are employed in spinning, namely, chip spinning and non-chipping, continuous polymerization spinning. Both are melt-spinning methods.

Purchasing the patent from Du Pont (U.S.A.), Toyo Rayon is spinning by the chip spinning process with facilities for a daily output of 147 tons. Nippon Rayon is equipped with the continuous polymerization spinning technique of Inventa (Switzerland), and the plant has a daily capacity of 72 tons. In 1963, Kanegafuchi Spinning and Kureha Spinning commenced production by the continuous polymerization method, while Teijin and Asahi Chemical Industry adopted the chip spinning method.

(c) Vinylon

Vinylon is obtained by dint of firstly, dissolving polyvinyl alcohol (Poval) in water, secondly spinning with wet or dry method, and lastly by applying after-treatment so as to make the fiber insoluble. Kurashiki Rayon and Nichibo are mainly using the wet-spinning method in their facilities respectively for a daily production of 92 tons and 52 tons. Nihon Vinylon began to produce filament by the dry-spinning method.

Until recent years, supply of poval, the raw material, had entirely been dependent upon carbide acetylene. In 1962, however, the Kurashiki Rayon began to produce poval from natural gas acetylene, and Nichibo is planning to produce it with waste gas of petroleum as the starting material.

(d) Polyester

With the technique of I.C.I. (Britain), Toyo Rayon and Teijin began in 1957 to produce a fiber by applying the chip spinning method to the polymer obtained by condensation of dimethyl terephthalate (D.M.T.) and ethylene glycol (polyethylene terephthalate). The capacity of each firm has already reached 100 tons a day.

In 1962, patents and knowhow of polyester fibers were obtained by Toyo Spinning from Goodyear (U.S.A.), by Kurashiki Rayon from Chemstrand (U.S.A.), and by Nippon Rayon from Inventa (Switzerland), and production on a commercial basis was started. These fibers are improvements obtained by the addition of a third ingredient to the said polymer.

Terephthalic acid, the raw material for D.M.T., which was the main raw material for fibers, was formerly produced by two methods, one of which was the scientific design process using paraxylene as raw material, and the other the Henkel process based on phthalic anhydride. In 1962, however, the toluene-Henkel process was introduced, and in 1963 the Hercules process, and production was started by these processes. The advantages of the first of these methods are twofold: the possibility of using the low cost toluel and the possibility of shortening the process. The Hercules process is a new method to convert paraxylene into D.M.T.

(e) Acrylic

This is a fiber produced by the wet-spinning method with acrylonitrile as the main ingredient. Several firms are in operation for a daily output of 40 tons each by Asahi Chemical, Mitsubishi Vonnel, and Japan Exlan, and 20 tons by Kanegafuchi Chemical Industry, 10 tons by Toho Beslon, and 8 tons by Toyo Rayon.

Acrylonitrile, the raw material, is obtained by the cyanamic acid process or the Sohio process. This Sohio method is the technique of the Standard of Ohio (U.S.A.) using propylene and ammonia as raw materials, and is more advantageous in cost than the acetylene process.

The acrylic fiber containing more than 85% of acrylonitrile is mainly used for clothing, and that containing approximately 60% is partly for industrial uses.

(f) Polypropylene

This fiber is obtained by melt-spinning polypropylene resin, and is being produced by Toyo Rayon, Mitsubishi Rayon, Toyo Spinning, and Shin Nippon Chisso.

(g) Polyethylene

By melt-spinning medium- and high-density polyethylene resins, polyethylene is produced by Mitsui Chemical, Kanegafuchi Spinning, Nitto Boseki, and others.

(4) Demand and Supply

Results of the production of synthetic fibers are given in Table 5. In 1955, only three items of nylon, vinylon, and vinylidene were produced to the amount of 16,000 tons. In 1963, however, the output of 239,000 of eight items was the result, which was an increase of fifteen times in eight years. However, the output of high tenacity viscose rayon, which amounted in 1962 to 29,000 tons, was reduced in 1963 to 24,000 tons. This was due to a decline in exports and the use of nylon as a substitute to meet the demand for tirecords.

Table 6 shows demand on fibers for industrial uses (mainly for fishing nets and ropes, and also for rubber materials). Natural fibers have been in more or less steady annual demand for a volume between 41,000 and 43,000 tons. But it decreased to 37,000 tons in 1963. Demand for high tenacity viscose rayon has extremely decreased, while that for synthetic fibers has shown an increase of 15 times, from aobut 4,000 tons in 1955 to nearly 62,000 tons in 1963.

Table 5. Results of Production

	High Tenacity Viscose Rayon Yarn	Synthetic Fibers								Total
		Nylon	Vinylon	Poly-ester	Acrylic	Polypro-pylene	Vinyli-dene	Poly-vinyl Chloride	Poly-ethylene	
1955	10	8	6	0	0	0	2	0	0	16
1960	27	40	23	22	22	0	3	6	1	118
1961	26	50	30	37	23	0	3	7	3	153
1962	29	58	35	47	27	2	3	7	3	183
1963	24	80	37	62	36	6	4	8	6	239

Source: Statistics; The Ministry of International Trade and Industry.

Table 6. Demand for Domestic Industrial Purposes

(Yarn in Tons)

	1955	1960	1961	1962	1963
Natural Fibers					
Cotton Yarn	38, 447	40, 390	38, 073	39, 488	34, 100
Others	3, 074	2, 859	3, 429	3, 024	2, 784
Total	41, 521	43, 249	41, 502	42, 512	36, 884
Chemical Fibers					
Rayon Yarn	9, 539	22, 332	20, 826	19, 539	13, 462
Synthetic Yarn (C)	4, 110	23, 803	33, 387	44, 079	62, 064
Others	0	1, 013	2, 830	2, 909	7, 861
Total (B)	13, 649	47, 148	57, 043	66, 527	83, 387
Grand Total (A)	55, 170	90, 397	98, 545	109, 039	120, 271
C/A (%)	24. 7	52. 2	57. 9	61. 0	69. 3
B/A (%)	7. 4	26. 3	33. 9	40. 4	51. 6

Source: Statistics; The Ministry of International Trade and Induftry.
Note: The colum of 1963 shows the figures in the fiscal year, so, these figures mean some estimated ones.

(a) High tenacity viscose

Between 1951 and 1954, high tenacity viscose rayon drove out cotton completely from the field of tirecords for motorcars, and exclusively met demands for them. Recent trends, however, show a decline in demand, owing to inroads made by nylon.

As for uses of high tenacity viscose rayon, the overwhelmingly high percentage of approximately 90 is for tires of motorcars, and nearly 10% for tires of two-wheeled vehicles and belts.

(b) Nylon

In Japan, the study of the use of nylon for motorcar tirecords was successfully accomplished in 1960. In the three following years, nylon grew so rapidly as to share the market for motorcar tirecords with high tenacity viscose rayon. Nylon was consumed for tirecords to the amount of 1,000 tons in 1960, 3,500 tons in 1961, 9,700 tons in 1962, and 14,000 tons in 1963.

All the manufacturers of nylon are planning to go into the field of motorcar tirecords. Certain manufacturers of high tenacity viscose rayon, therefore, have begun to produce nylon in commercial volume, in order to maintain the shares they had enjoyed by the production of their speciality.

At the present time, 30% of nylon are for industrial uses. Of this percentage, 60% are for tirecords, and 30% for fishing nets and ropes. In 1964 new manufacturers will begin to produce on a commercial basis, and the total output will be remarkably increased. As a result, of all the uses of nylon, the proportion of industrial uses will grow in 1965 to be 40%. Half the volume of supplies to industries, or approximately 25,000 tons, will go to tirecord manufacturers.

(c) Vinylon

The rate of vinylon consumed for industrial purposes is 50%. In view of its quality, vinylon is mostly used for fishing nets and ropes. But no small quantity is wanted for belts of nylon and vinylon mixtures. For the past four or five years, vinylon has been used also for bicycle tirecords, though not in any large quantity. It is more suitable for rubber footwear and rubber cloth, and also for hoses.

(d) Polyester

Polyester is used almost entirely for clothing, and its consumption in the fields of industry is only about 5%. A study of its use for motorcar tirecords has recently been conducted with success, and experiments have just been commenced in its practical use for this purpose. For fishing nets and ropes, belts, and hoses, though in small quantities, polyester finds steady demand, which, in keeping with a reduction in cost, is expected to grow in the future.

(e) Others

Polypropylene, which is now in quest of fields for its use, has promising prospects. It may be used for belts, insulators, as well as fishing nets and ropes. Other fibers, such as polyethylene, vinylidene, and polyvinyl chloride are used for fishing nets and ropes, sewing threads, and miscellaneous articles. Acrylic is almost exclusively used for clothing.

(5) Future Prospects

No remarkable change is foreseen in demand on natural fibers and rayon in the future. It may tend rather to decline. According to the Ministry of International Trade and Industry, demand on synthetic fibers in 1965 is anticipated to show an increase of 50% over 1963, and to amount in different fields as follows:

Industries	85,700 tons
Clothing	237,500
Exports	78,600
Total	401,800 tons

Having these prospective demands in view, the manufacturers are expanding their present equipment and plants for synthetic fibers. When their plans are carried out, the facilities will have the following capacities:

Nylon	338 tons per day
Vinylon	161
Polyester	298
Acrylic	180
Polypropylene	64
Vinylidene	14
Polyvinyl Chloride	32
Polyethylene	42
Total	1,129

As has been stated above, the manufacturers of synthetic fibers are adopting new processes of manufacturing raw materials for synthetic fibers and the continuous polymerization spinning method, thereby to continue their efforts to reduce the cost of the products and to develop fresh fields for demand. It is anticipated, therefore, that demand for synthetic fibers will become stronger year after year.

IV. *Reclaimed Rubber*

(1) General Situation

It was approximately 50 years ago that the first reclaimed rubber was produced in Japan. Today, there are nine companies that engage in the production and marketing of the reclaimed rubber and their total production accounts for almost 90% of all production. Other companies, smaller in number, manufacture the reclaimed rubber for their own consumption but their production only reaches 10% of the total output.

The statistics vividly speak of a continuous yearly increase in recent reclaimed rubber production in Japan and in 1963, it finally reached 40,428 tons against 14,501 tons in 1955. (See Table 1 below.)

Table 1. Production of the Reclaimed Rubber

(Unit: Ton)

Year	Production
1955	14, 501
1960	37, 825
1961	38, 699
1962	40, 121
1963	40, 428

Source: Statistics; The Ministry of International Trade and Industry.

In the meantime, the consumption of the reclaimed rubber is also on rise in line with the increase of the new rubber consumption and it saw almost three-fold increase during the last eight years since 1955. (See Table 2 below.)

Table 2. Consumption of the Reclaimed Rubber

(Unit: Ton)

Year	*Consumption* of the new rubber (A)	*Consumption* of reclaimed rubber (B)	B/A (%)
1955	93, 433	14, 186	15. 2
1960	218, 107	32, 953	15. 1
1961	254, 590	35, 637	14. 0
1962	282, 339	39, 689	14. 0
1963	310, 102	43, 433	14. 0

Source: Statistics; The Ministry of International Trade and Industry.

The reclaimed rubber, up until recently, had been used primarily to increase the quantity of the natural rubber and its demand had strongly been influenced by the fluctuative prices of the natural rubber. However, the fact that the reclaimed rubber has been maintaining, even today, 14-15% consumption ratio against the new rubber, is the actual proof of its contribution not only to lowering the rubber production cost and rationalizing the production process, but also to raising the quality of the rubber products. The fact is also due to the wide recognition of its nature as an effective compounding filler together with the carbon black and other rubber chemicals. No accurate ratio is known between the tire manufacturing and non-tire rubber product manufacturing in this use of the reclaimed rubber. The reclaimed rubber produced from the tires is mostly used for making various kinds of the tires and the general rubber products, whereas the one from the tubes is used for producing the tires and other rubber products of high grade. And the mixed reclaimed rubber is utilized for the automobile parts, floor matt, hose and others.

In the international scene of the reclaimed rubber consumption, the United States holds an undisputed lead over other countries followed by West Germany, Japan, England, France, Canada, in that order. (See Table 3 below.)

Table 3. Reclaimed Rubber Consumption in the Major Countries

(Unit: 1,000 long ton)

Year	U.S.	W. Germany	Japan	Britain	France	Canada
1960	277	46	33	36	30	16
1961	250	42	36	33	31	16
1962	260	43	40	36	34	18

Source: Statistics; The International Rubber Study Group.

(2) Manufacturing Processes

There were two processes in manufacturing the reclaimed rubber in Japan—the pan process and the alkalic process. The alkalic process had gradually lost its ground to the pan process resulting in the latter's dominating the present way of the processing. On the other hand, the neutral digesting process is most popular in both Europe and the United States while the continuous devulcanizing processes through the use of the reclamator is being adopted in lesser degree.

The digester process has generally been favored since it can remove completely the fibers from the waste rubber. Of late, Japan, whose pan process is making a remarkable progress, is successfully turning out the reclaimed rubber of high grade, comparable with the one made through the digester reclaiming process.

For instance, a fiber removing equipment utilizing the static electricity is in operation at a certain company which holds the patents in Japan and the United States for the equipment. The equipment is capable of removing and reducing the fiber coponents to less than 0.3%.

Japanese reclaimed rubber is being featured by less aceton extract comparing with that of the U.S., that is, much hydro carbon in quantity. The reclaiming oil of the petroleum origin has been in use in the United States but the use of the oil of botanical origin is more advisable in case the reclaimed rubber of high physical properties is sought after as in Japan.

The pine tar has hitherto been used as the oil of botanical origin but is being replaced of late by the tall oil and the dipemtene, due to the declining in the extracted amount of the pine tar. The tall oil, separated and refined from the waste liquid from the sulphite pulp, contains a considerably large amount of the resin acid and the fatty acid. Prepared with special alkalic chemicals, the tall oil has become popular in many ways of the use and it even prevents the delay of the curing in the SBR reclamation which has often occurred in the past. It also enables the manufacturing of the reclaimed rubber with high plasticity.

The tires and tubes have been used as the raw material for production of the reclaimed rubber which accounts for 70% of the total. The remaining 30% are obtained from the rubber footwear, water-pillow, rubber factory wastes, rubber toys and others.

The majority of raw materials for Japanese reclaimed rubber production is being supplied domestically by 76 specialized wholesale dealers who collect the wastes throughout the country and offer them to the manufacturers.

(3) The Kinds and Classifications

The Japan Industrial Standards regulate the materials and the quality to be used in the specified kinds of the reclaimed rubber as follows:

Reclaimed rubber of tube

Made from the automobile tube wastes or from the materials of equivalent quality.

Reclaimed rubber of tire

Made from tread rubber of automobile tire wastes or from the materials of equivalent quality.

Miscellaneous reclaimed rubber

1st grade: Made from the bicycle tube wastes or the rubber shoes excluding their soles or from the materials of the equivalent quality.
2nd grade: Made from the rubber footwear soles or the industrial rubber products wastes or the materials of the equivalent quality.

The classification of the reclaimed rubber are regulated in the Japanese Industrial Standards as follows:

Classification of Reclaimed Rubber

Items \ Kinds		Reclaimed rubber from tubes			Reclaimed rubber from tires	Miscellaneous reclaimed rubber	
		Raw rubber		GR-1			
		Black tube	Red tube	Reclaimed rubber		1st grade	2nd grade
Specifie gravity		Under 120	Under 125	Under 120	Under 120	Under 135	Under 155
Ash (%)		〃 20	〃 15	〃 20	〃 15	〃 40	〃 45
Acetone extract (%)		〃 15	〃 15	〃 10	〃 20	〃 17	〃 17
Tensile Test	Tensile strength (kg/cm^2)	Over 65	Over 55	Over 60	Over 60	Over 40	Over 35
	Expansibility (%)	〃 350	〃 300	〃 400	〃 250	〃 150	〃 150
Aging Test	Remnants ratio of tensile strength (%)	〃 70	〃 70	〃 70	〃 70	〃 70	〃 70
	Remnants ratio of tensibility (%)	〃 50	〃 50	〃 50	〃 50	〃 50	〃 50
Blending Test of Raw rubber	Keeping ratio of tensibility (%)	〃 70	〃 60	—	〃 60	〃 45	〃 40