

AIR SPRING
FOR
ROLLING STOCK

 **SUMITOMO ELECTRIC INDUSTRIES, LTD.**

Introduction

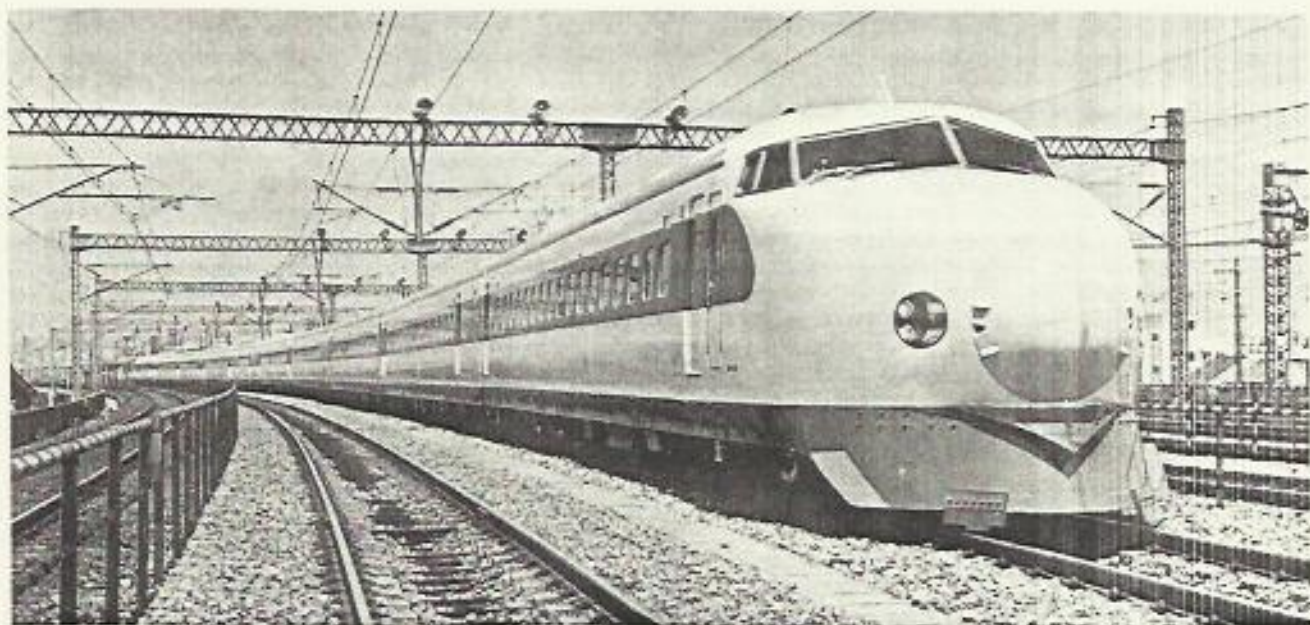
Rubber Products

Developing processing techniques and producing rubber materials have been an intimate part of Sumitomo's operations for many years. Recently, however, natural rubber in cable manufacturing has been replaced by such synthetics as butyl rubber, chloroprene rubber and silicone rubber, because of their excellent characteristics of resistance to heat, oils, chemicals and abrasion.

Industrial rubber products is a large part of this division's product line. They, include vibration-insulation products such as air suspensions for rail cars and industrial machines, and rubber-coated fabric products such as fuel tanks for aircraft, "Fabridams" for irrigation and prevention of floods, and inflatable life rafts for ships and aircraft.

The development of air springs has greatly improved the riding quality of railway vehicles in recent years. This is because it has become possible to employ air springs as suspension springs with a soft spring constant which was difficult to obtain with metallic springs in the past. This means that use of air springs makes it possible always to maintain a constant vehicle floor height, regardless of the number of passengers.

Sumitomo's Air Spring thus has been extensively used in Shinkansen (bullet train) cars of the Japanese National Railways as well as high-speed suburban cars. It also is being employed in high-speed inter-city and suburban train cars in more than 10 countries of the world, including Australia, and the U.S.A.



▲ Japan National Railway



▲ Chicago South Shore & South Bend (CSS & SB)

General Characteristics

1. Soft, Flexible Spring Characteristics in Vertical Direction

It is possible to obtain a soft spring constant in the vertical direction only by using a relatively small auxiliary air reservoir.

2. Ideal Lateral Spring Characteristics

Sumitomo's Air Spring shows a linear hysteresis loop and an adequately soft spring constant.

3. Good Self-Damping Characteristics

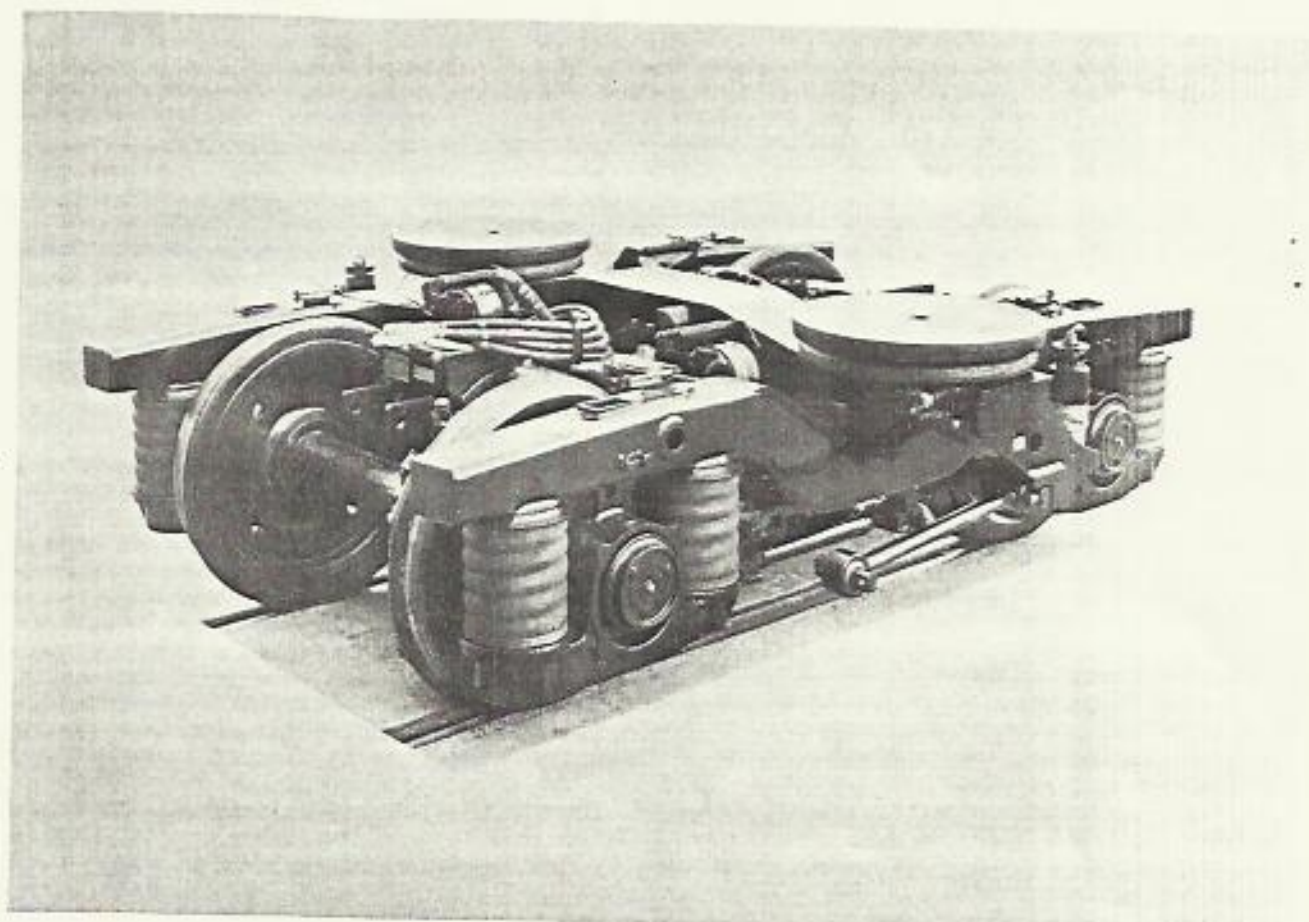
A proper self-damping action in the air spring can be achieved by placing an orifice between the air spring and the auxiliary air reservoir.

4. Possibility of Voluntarily Choosing Spring Characteristics

The vertical and lateral spring characteristics, and the vertical self-damping action can be designed to meet the track and running conditions so that passengers can enjoy comfortable riding.

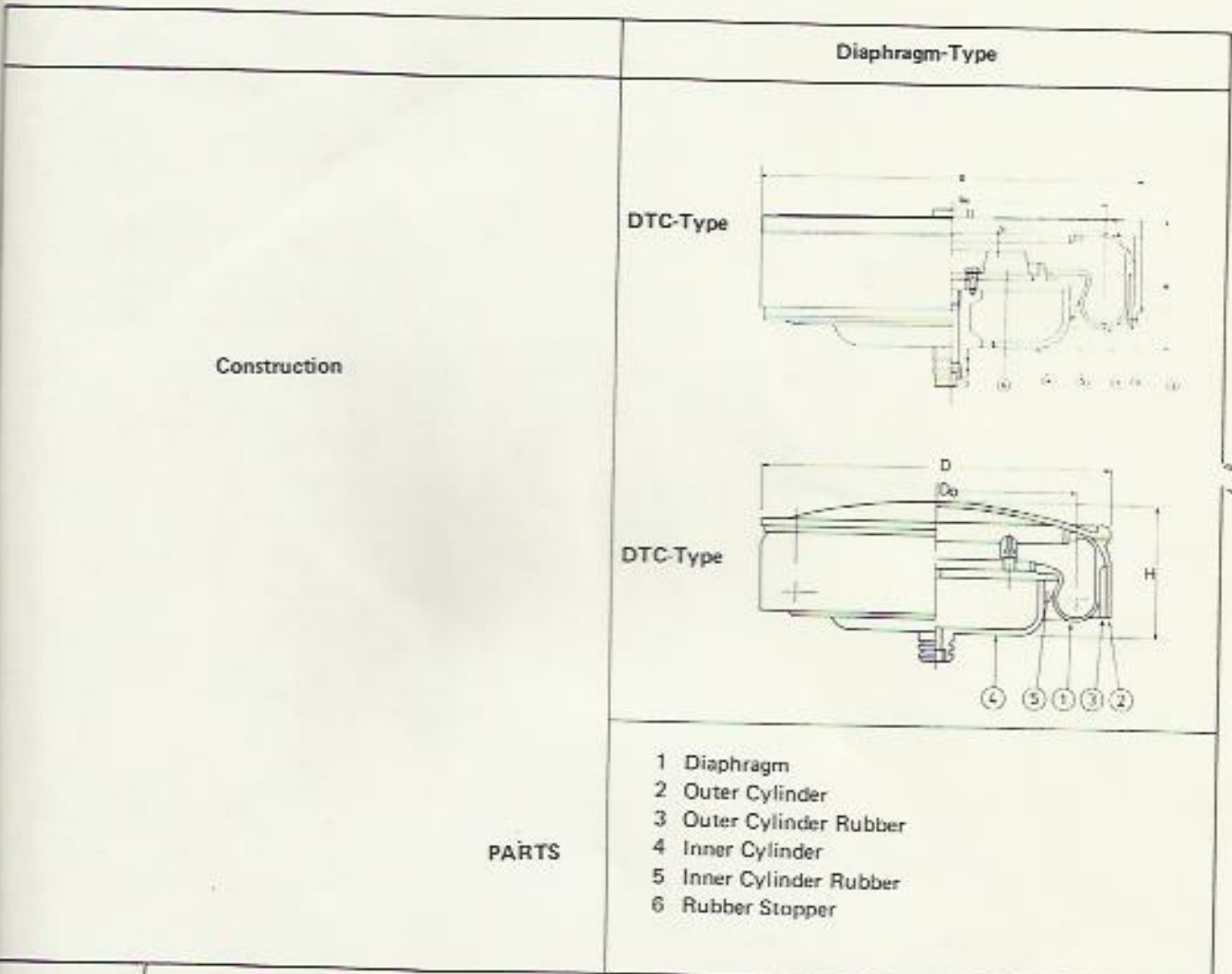
5. Great Durability

The vertical and lateral spring actions are made entirely by pneumatic pressure, thus reducing load on the diaphragm and eliminating the age variations in spring characteristics to increase the spring's durability.

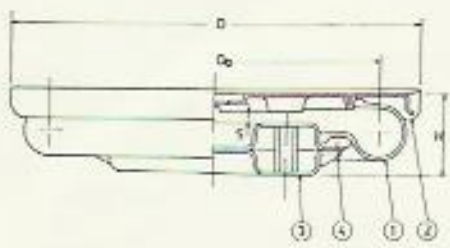
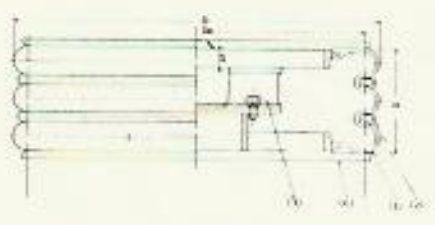
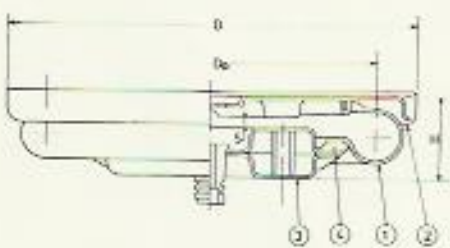
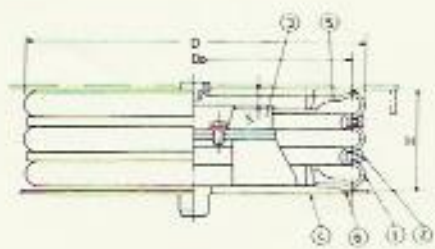



▲ Japan National Railway

Available Types of AIR SPRING



	Type No.		DTC500	DTC535
	Nominal diameter	: Do	(mm)	500
Outside diameter of outer cylinder	: D	(mm)	620	664
Nominal height	: H	(mm)	216	263
Space of stopper	: S	(mm)	30	—
Maximum displacement	: Vertical	(mm)	±40	
	: Lateral	(mm)	±40	
Recommended maximum pressure in service	:	(kg/cm ²)	about 5	

Bellow-Type			Triple-Convolution-Type			
<p>A-Type</p> 			<p>BL-Type</p> 			
<p>B-Type</p> 			<p>BT-Type</p> 			
<p>1 Bellow 2 Upper Seat 3 Under Seat 4 Rubber Seat</p> 			<p>1 Bellow 2 Girdle Ring 3 Rubber Stopper 4 Under Seat 5 Upper Seat Rubber 6 Under Seat Rubber</p>			
1B550	1B600-1	1B600-2	3BL500	3BL550	3BT550	3BT600
550	600	600	500	550	550	600
683	720	720	544	595	592	648
146	150	150	160	160	182	182
30	25	30	25	27	27	27
±40	+35 -30	+40 -30	+40		±40	
±40	±40	±40	±20		+40	
about 5			about 5			

Note: 1. In the strokes (+) is for compression and (-) is for expansion.
2. The stroke of compression side (+) includes deflection of rubber stopper.

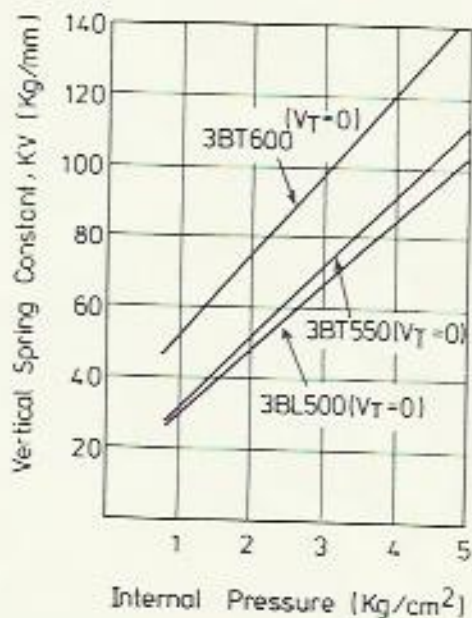
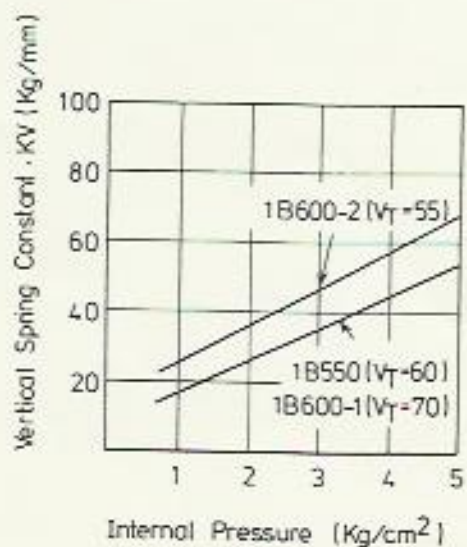
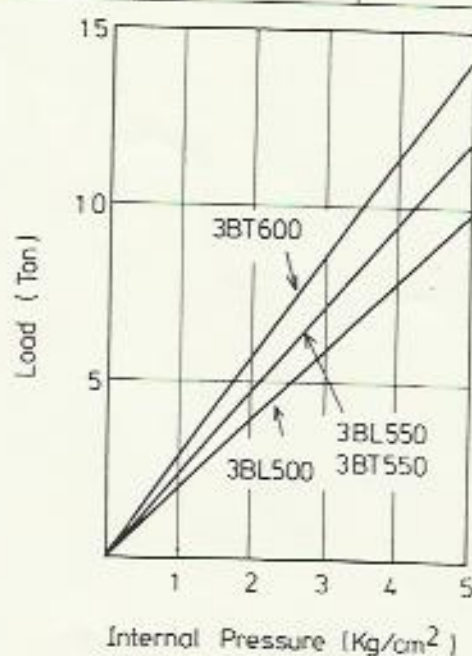
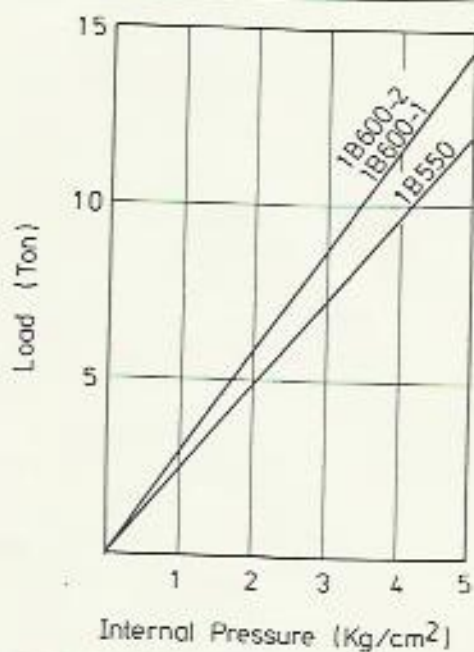
Properties

4.

1. Vertical Spring Characteristics

Type	Diaphragm-Type	
	DTC500	DTC535
Effective area : A_e (cm ²)	2050	2300
Variation of effective area : dA_e/dx (cm ² /cm)	-5	-7
Internal volume of air spring : V_o (ℓ)	22	36
<p>Relation Between Load and Internal Pressure</p> <p>$W = P_o \times A_e$</p> <p>Where,</p> <p>W : Load on air spring</p> <p>P_o : Internal pressure (gauge pressure)</p> <p>A_e : Effective area</p>		
<p>Vertical Spring Constant (Kv)</p> <p>$K_v = mA_e^2 \frac{P_o + 1}{V_o + V_T} + P_o \frac{dA_e}{dx}$</p> <p>m : Polytropic index</p> <p>A_e : Effective area</p> <p>P_o : Internal pressure (gauge pressure)</p> <p>V_o : Internal volume of air spring</p> <p>dA_e/dx : Variation of effective area</p> <p>V_T : Volume of auxiliary air reservoir</p>		

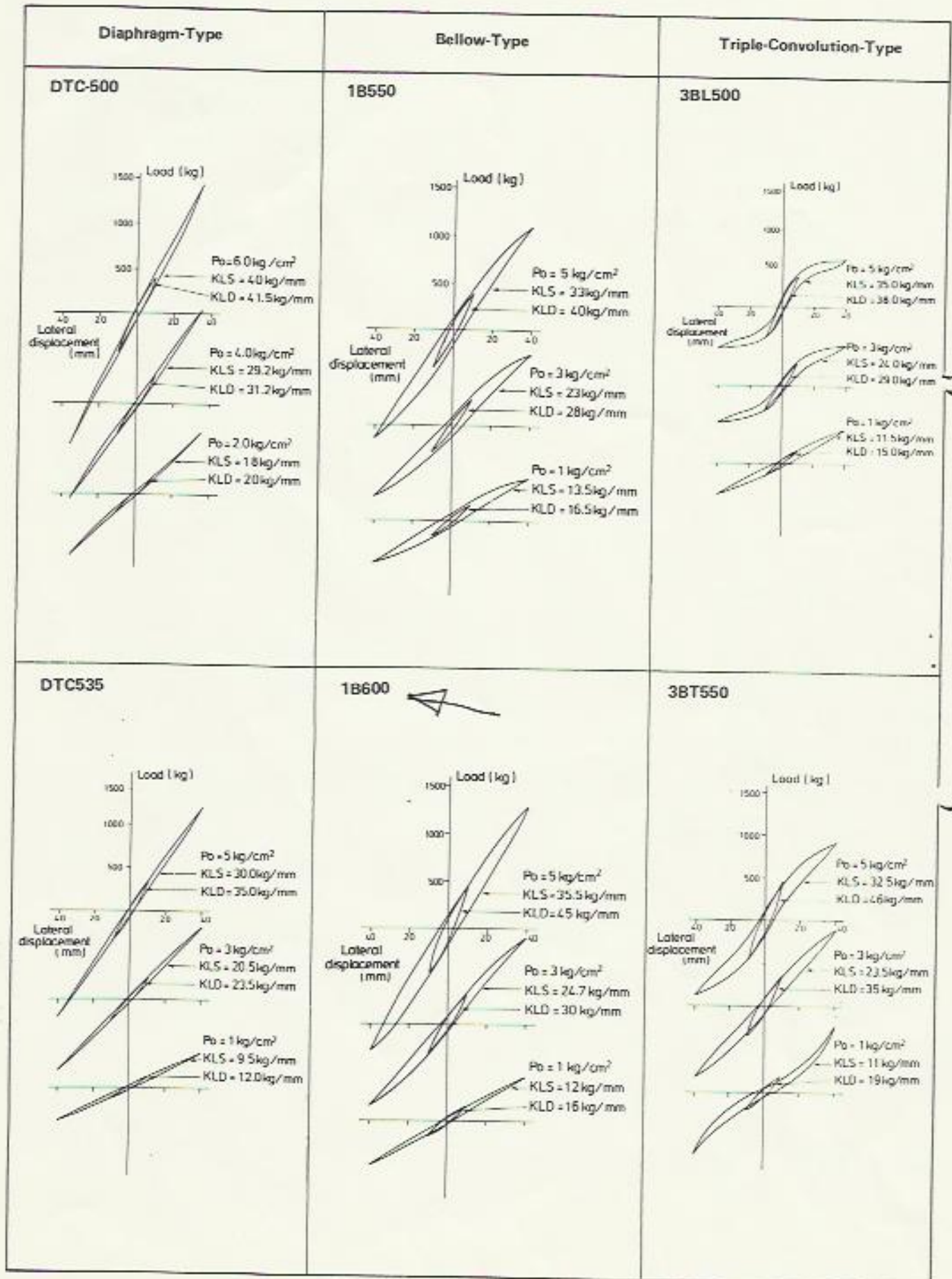
Bellow-Type			Triple-Convolution-Type		
1B550	1B600-1	1B600-2	3BL500	3BL550 3BT550	3BT600
2400	2920	2900	1960	2375	2830
27.5	7	20	31~51	30~57	33~61
21.5	30.5	25.6	28	32	40



Properties

6

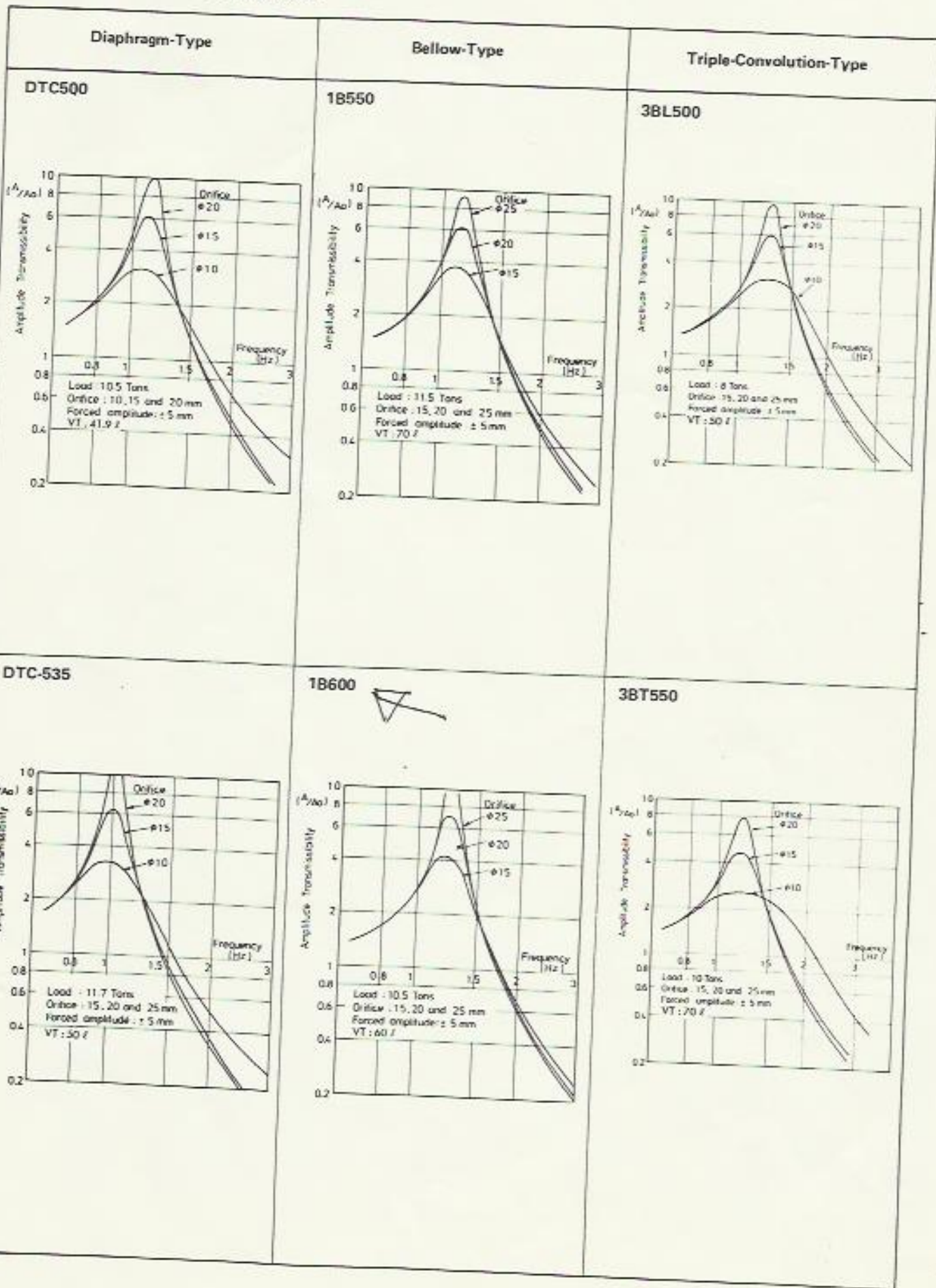
2. Lateral Spring Characteristics



Properties

7.

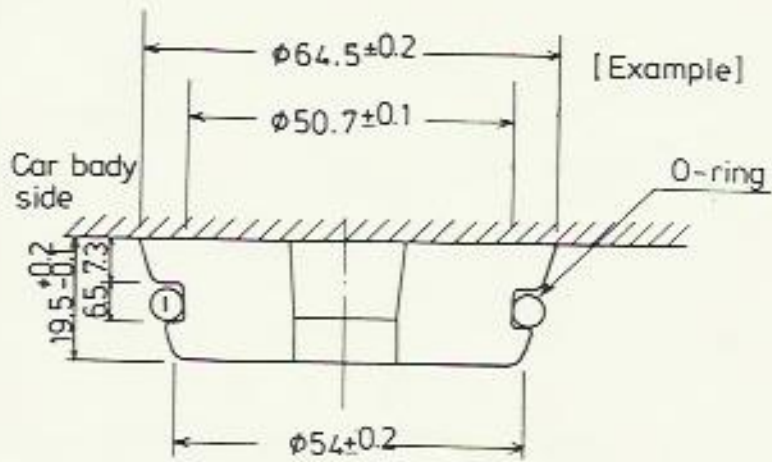
3. Vibration Characteristics



Installation Method

1. Body Side (Bellow-Type)

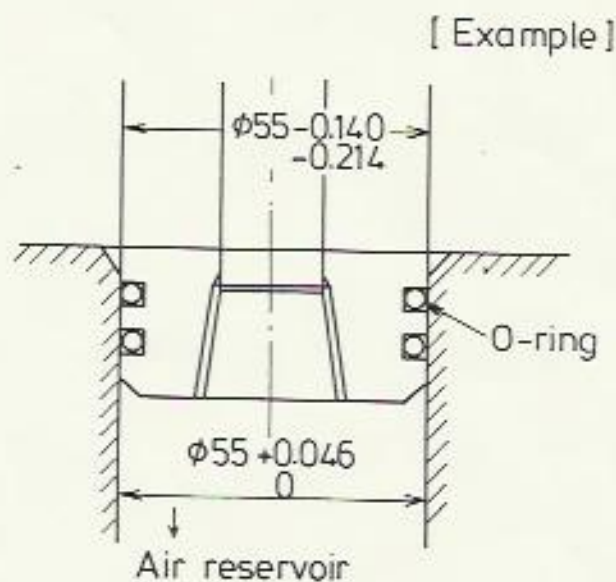
The recommended dimensions of the fitting to be attached to car body side is shown, when the upper hole is used.



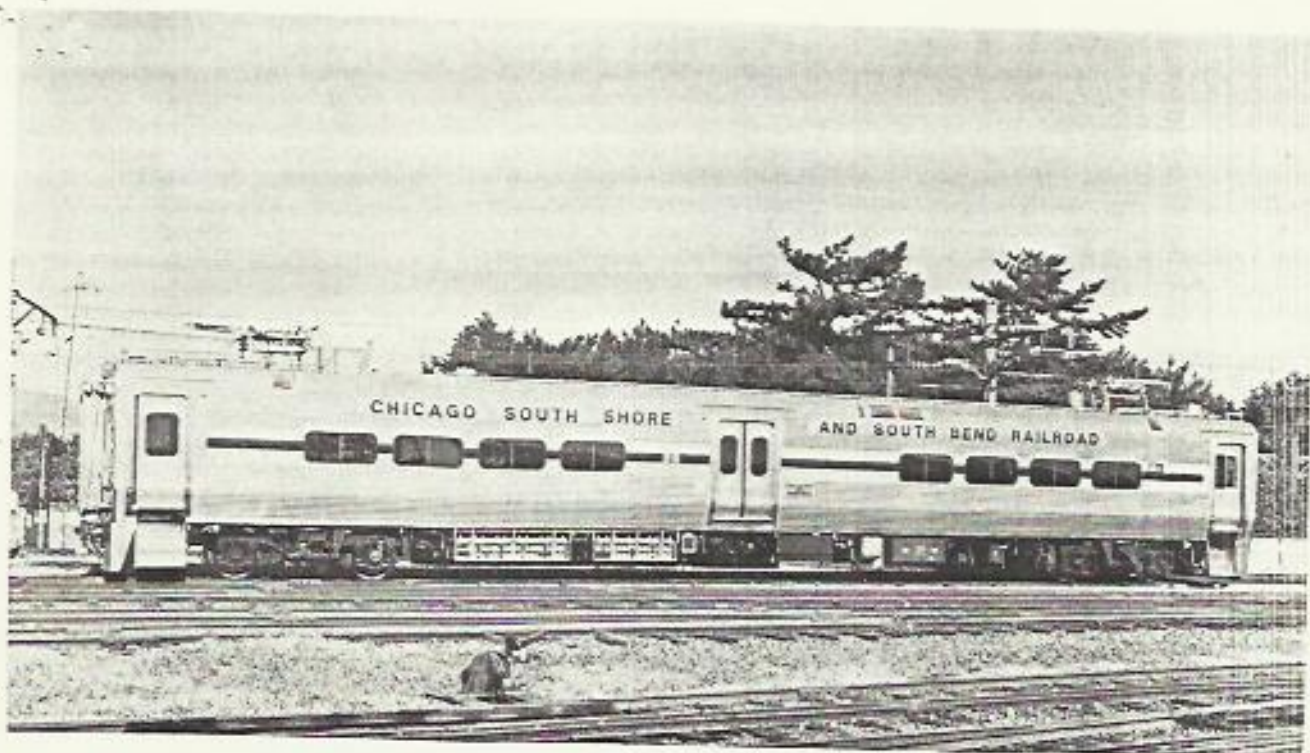
Unit = mm

2. Bogie/truck Side (Diaphragm-Type) (Bellow-Type)

The recommended dimensions of the hole to be provided on bogie/truck bolster or on bogie/truck frame is shown, when the lower nozzle is used.



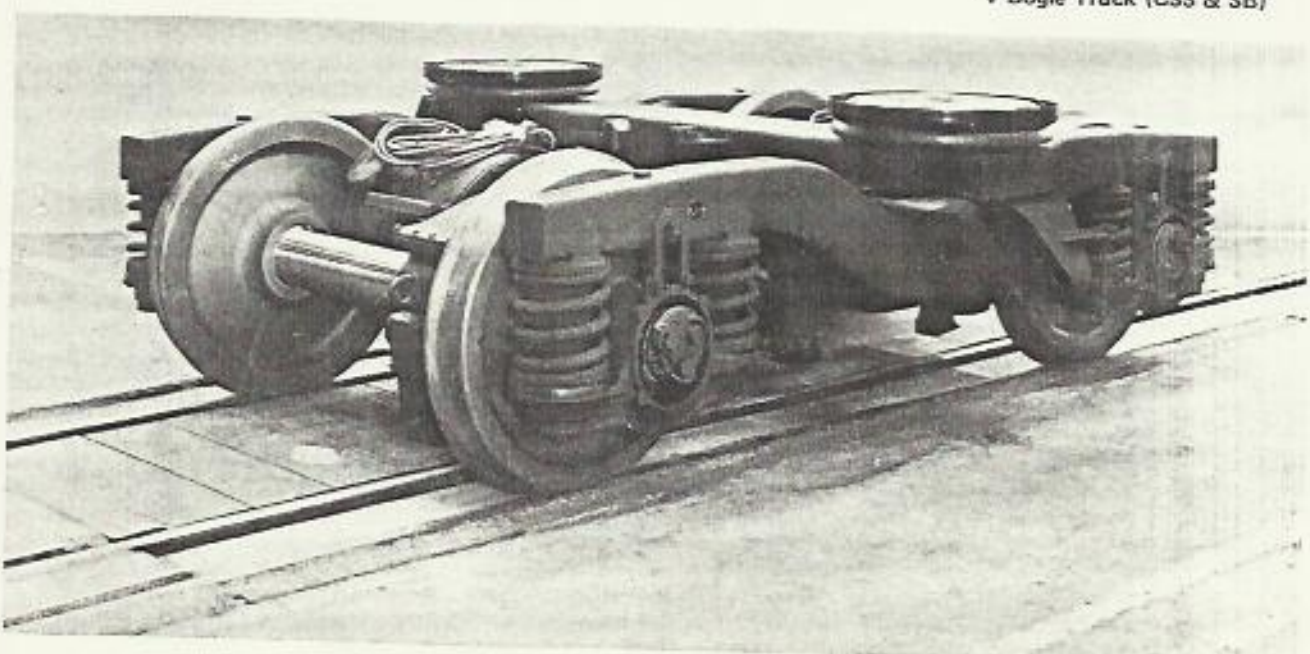
Air reservoir



▲ Train (CSS & SB)



◀ SUMITOMO'S AIR SPRING
Type: 1B600-1



▼ Bogie Truck (CSS & SB)

Methods of the inspection

1. The inspections of air leakage

- 1. Pressure gages are fitted on each air reservoirs.
- 2. The pin of the height control rod of the Leveling Valve is taken off.
- 3. Inner pressure of the air reservoir shall be 5 kg/cm^2 .
- 4. After maintaining above condition for 3 minutes, if a decline in the pressure is less than 0.2 kg/cm^2 , this air spring should be come up to the standard.
- 5. If not, air leakage of each screws of the air pipe line is checked by soapy water. Coming up to the standard, the rubber diaphragm should be replaced.
- 6. When cars are put into the carport, cut the power supply of cars. It is not necessary to inspect as aforesaid, if inner pressure shall remain in the air spring next morning.
- 7. The air spring shall be inspected after using for 3 years, and after that it shall be inspected at the whole inspection of cars in every 1.5 years.

2. Visual inspections

The height of the air spring shall be extended and the outside appearance of the rubber diaphragm shall be inspected or the standard established another. Deal with the air spring on the standard of replacement.

3. Daily inspections

- 1. Being put into the carport, inspect the outside appearance of the rubber diaphragm by visual check.
- 2. Being put into the carport, inspect the air leakage by a sound like "SHU".
- 3. If anything is wrong with the air spring, deal with it on Clause 1 and 2.



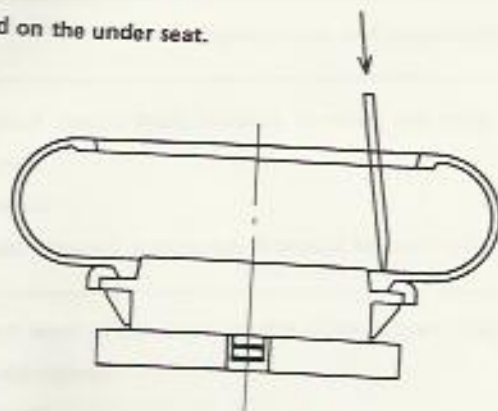
Judgements for condemning

1. Diaphragm

Defects	Explanations and judgements for condemning
Ply separation	<p>The separation of the stratum between rubber (especially outer rubber layer) and fiber cord.</p> <p>— This defect happens at the initial stage in use and the surface raises to comparatively wide range like hernia. In case of using still more, the surface of raised rubber is torn as if it was cut by a knife. But the escape of air is a little.</p> <p>(judgement)</p> <ul style="list-style-type: none"> -1. When the cord is exposed, it should be replaced. -2. When the separation becomes 30 x 20mm and over, it should be replaced, even if the separation happens only on the cuticle and the cord is protected enough.
Crack	<p>The scale-like and comparatively sharp crack which occurs in circumferential direction near to the contact area or rubber (especially outer rubber layer) with upper seat or rubber seat.</p> <p>— At the initial stage, those are separated hair cracks and thereafter those become continuous separation.</p> <p>(judgement)</p> <ul style="list-style-type: none"> -1. When the cord is exposed, it should be replaced. -2. When the depth of crack becomes 1.5mm over, it should be replaced. -3. When the depth of crack is under 1.5mm, it can be used, even if the length of crack comes up to full circle.
Crack	<p>The separated crack which occurs in circumferential direction near the small bead (rubber seat, side) of rubber (especially inner rubber layer), and the crack which occurs in meridian direction in outer rubber stratum.</p> <p>— Those occur at the portions of no uniform thickness and overlapping portions of rubber.</p> <p>(judgement)</p> <ul style="list-style-type: none"> -1. When the cord is exposed, it should be replaced. -2. When the depth of crack becomes 1.5mm over, it should be replaced. -3. When the length of crack becomes 50mm over, it should be replaced.

Assembling

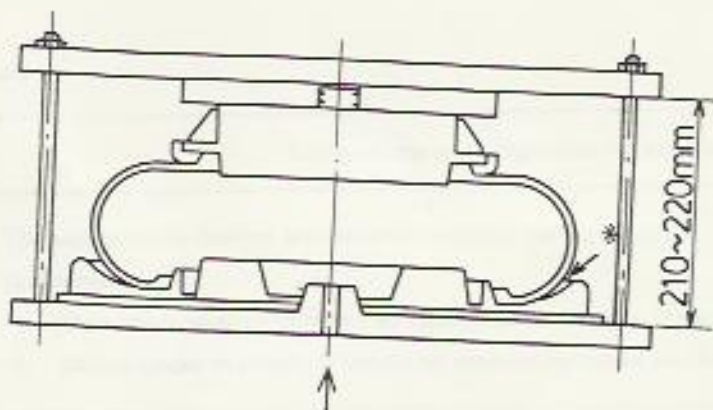
1. A rubber diaphragm is fitted on the under seat.



- 1. The under seat fitted on the rubber seat is placed flatly.
- 2. The sealed portion of the rubber diaphragm shall be uniformly mounted on the under seat.
- 3. The hard-wood stick which was formed into the shape with an end of about 30mm wide and 5mm thick shall be applied and be struck with a hammer.

Notes: (a) Flat bed, under the seat, is placed so that the said fitting may not clatter.
 (b) Lubricant is not applied to the sealed portion.

2. Fitting of the sealed portion of the upper seat.



- 1. The upper seat turned upside down is placed on the frame for assembling.
- 2. Keeping the rubber diaphragm stretched, as to the sealed portion of the rubber diaphragm and the seal of the upper seat, the whole circumference shall be uniformly fitted.
- 3. Inner pressure shall gradually be raised till it reaches 3 kg/cm^2 . It is necessary to check the asterisk of the (*) portion touched.

Notes: (a) The height of the frame for assembling can be as high as $210 \sim 220 \text{ mm}$.
 (b) A little water for Lubricant is applied to the seal.
 (c) It is necessary to check the seal of the upper seat set in uniformly. If the seal isn't partially set in, it is easy to be removed.
 (d) Use the flat beds of the upper seat and the under seat of which the diameter is larger than each one.
 (e) O-ring should be fitted.

Disassembling

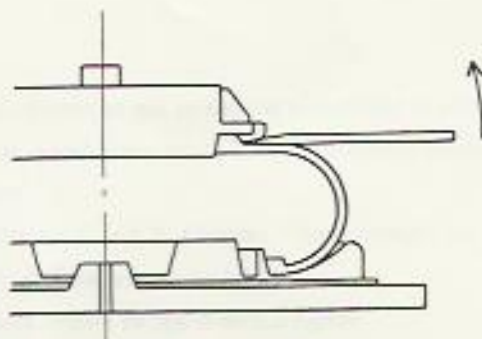
Defects	Explanations and judgements for condemning
Wear	Wear which results from rubbing between the outer rubber stratum of diaphragm and upper seat rubber seat. (judgement) When the cord is exposed, it should be replaced.
External hurt	Hurt and wear which occur in the outer rubber stratum as the result of ingress and/or rubbing of foreign substances. (judgement) The same as the ones in case of crack.
Air leakage	Air leakage which occurs in service. (judgement) It should be replaced. But if air leakage in assembling occurs enforce the decided inspection separately.

2. Other rubber parts

Defects	Explanations and judgements for condemning
Separation in contact area	The separation in contact area between metallic parts and rubber. (judgement) -1. When the separation becomes to 100mm over in length, it should be replaced. -2. 100mm under in length, it should be repaired by cyano acrylate adhesives.
Wear	Wear which occurs to the contact area with diaphragm. (judgement) When rubber wears off 1.5mm in depth partially, it should be replaced.
Crack	Crack which occurs on lapping portion of material. (judgement) When the crack becomes to 50mm over in length and 3mm over in depth or 5mm over in width, it should be replaced.

Disassembling

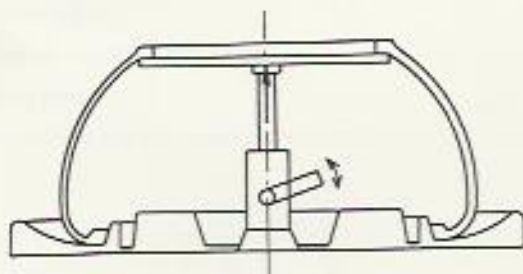
1. The seal of the under seat shall be removed.



Inner pressure shall be $0.1 \sim 0.2 \text{ kg/cm}^2$. If the seal of the under seat is gouged at a point of it by a hard wood stick with smooth ends, it will easily be taken off.

Notes: If inner pressure is sealed up at $0.5 \sim 0.7 \text{ kg/cm}^2$, even though a rubber diaphragm is not taken off by gouging with a stick, it is taken off in itself accompanied by a sound like "PON", but, as it is dangerous, this shall be as afore said.

2. The seal of the upper seat shall be removed.



The cross-shaped jig of which dimensions are 30mm bigger than the inside diameter of the rubber diaphragm is to be inserted into. The jig is pulled out by using an oil pressure jack and by pushing the center of it.

Notes: It is so easy to do without the handle of a jack.

3. Other notes:

- 1. After assembling, inner pressure is supplied till the seal shall be dried and adapt itself.
- 2. When inner pressure is 0 kg/cm^2 , the upper seat should not be taken up. Because it is so easily to remove the seal that inner pressure is negative.

Storage

1. Storage of rubber parts

- 1. Products are packed in cardboard cases as not to deform and stored in a dark and cool room.
- 2. The time for storage is 3 years under since producing. If products storing 3 years over are used, use them after due to confirming the following.
 - (a) After assembling under Clause 1 and 2, Chapter "Assembling", air spring of which the nominal height and inner pressure is 7 kg/cm^2 , shall be left for an hour.
 - (b) The decline in inner pressure should be less than 0.2 kg/cm^2 .
 - (c) The surface of rubber should be satisfied with the standard of Chapter "Judgements for condemning".
 - (d) Nothing should be deformational with all parts.

2. Keeping of metal parts

- 1. Products are packed in corrugated cardboard cases as not to force them to hurt and stored to pile up less than 3 steps.
- 2. The time for storage is 3 years under since producing. If products storing 3 years over are used, use them after due to confirm the following.
 - (a) No bruise and warp of anything bad to use
 - (b) No crack of welding parts
 - (c) No inferiority of painting and no corrosion of metal.