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PACKINGHOUSE NEWSLETTER

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CITRUS PACKINGHOUSE DAY
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IMPACT-CUSHIONING MATERIAL CONSIDERATIONS

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Cushioning materials are important to reduce impacts in handling all fresh produce commodities. A general definition for a cushioning material would be any material designed and installed to reduce impact, shock and vibration of a product thereby minimizing the product damage from such mechanical inputs. Shock is considered a pulse, transient or acceleration change in a relatively short period of time. Impact is typically characterized by a velocity change created by the collision between two objects. Vibration is considered as repetitive motion, either random or cyclic in the time domain. With respect to damage, these mechanical parameters may interact. For example, a trailer truck running over a curb (impact) may cause an initial shock to the truck's product which might be followed by vibrational motion. The vibrational motion would be dependent upon the truck and produce mass, the truck's spring and shock absorber system and the initial impact force.

Citrus is not as conducive to bruising from the dynamic force mentioned above as some fresh produce items such as apples. However, results conducted at Florida citrus packinghouses (Miller and Wagner, 1991) using an Instrumented Sphere (IS)[a] have shown that impacts at the dump, mechanical pregrading, mechanical final grading are greater than 100 Gs (1 G = 32.2 ft/s^2 = 9.8 m/s^2).

[a] The IS units used in these studies were developed initially through a program at the USDA-ARS Agricultural Engineering unit at Michigan State University. These units are now commercially manufactured by Techmark, West Mount Hope Hwy., Lansing, MI 48917.

Use of trade names for any product does not imply endorsement by IFAS-University of Florida.

To reduce impact levels, many cushioning materials are available commercially. For the general characteristics of G level, velocity change and coefficient of restitution, some materials are compared in Table 1. The coefficient of restitution (COR) represents the degree of elasticity of colliding bodies. A COR value of one would indicate total conservation of kinetic energy during impact. In the ideal condition, a ball dropped onto a rigid surface would rebound to its dropped height and the coefficient of restitution would be one.

Using the IS unit, the standard condition was a 12 in. (30 cm) drop onto a steel plate which is the last entry in Table 1. The G level reduction for any of the cushioning materials was greater than 58%, while other materials typically encountered in packinghouses yielded reduction of 25% (fiberboard) to 40% (belting). Higher velocity change and coefficient of restitution values would indicate the energy retained by the sphere as opposed to energy absorbed by the cushioning material. This factor on a packingline may not be important but would be significant in reducing the vibration in transit conditions. In selection of a cushioning material, the durability and cost of the material must be considered. Material thickness has a major effect on the G level reduction, e.g. Poron data of Table 1. Materials which accumulate dirt or debris may create a rough surface leading to abrasive or puncture wounds of the fruit. This type of damage may be more deleterious to citrus than the impact damage.

Table 1. Drop tests (30 cm) of instrumented sphere (IS) on typical Florida packingline equipment surfaces.

Surface[w]	G-level ($\bar{x} \pm$ s.d.)	% reduction G-level[x]	Velocity change,[z] m/s ($\bar{x} \pm$ s.d.)	Coefficient of restitution[y]
Belting, 0.8 cm (0.3 in.) rough-top Neoprene	180 ± 5	39.6	3.2 ± 0.21	0.44
Cushion, Nomad	67 ± 2	77.5	2.2 ± 0.03	0.37
Fiberboard (42-33-42)	221 ± 33	25.8	3.5 ± 0.12	0.56
Foam, 1.3 cm (0.5 in.) Ensolite	68 ± 1	77.2	3.2 ± 0.15	0.73
Urethane Foam, Poron 0.6 cm (0.25 in.)	125 ± 6	58.1	2.7 ± 0.04	0.46
Urethane Foam, Poron 1.0 cm (0.38 in.)	67 ± 2	77.5	2.8 ± 0.05	0.59
Urethane Foam, Poron 1.3 cm (0.50 in.)	59 ± 2	80.2	2.8 ± 0.05	0.57
PVC foam, NoBruze 1.3 cm (0.50 in.)	68 ± 2	77.2	3.7 ± 0.08	0.68
PVC foam, NoBruze 2.2 cm (0.88 in.)	47 ± 1	84.6	3.7 ± 0.12	0.58
Metal, steel	298 ± 24	0.0	3.6 ± 0.24	0.95

[z]Note: 1 m/s = 3.28 ft/s.
[y]With 5.7 cm diameter billiard ball.
[x]Relative to steel, 1 G = 32.2 ft/sec^2 = 9.8 m/sec^2.
[w]Note: All surfaces were supported by a steel plate.

Cushioning materials may be arranged in layers. Two possibilities using either Teflon or belting are diagramed in Figure 1. Teflon, although relatively expensive, does provide a much lower coefficient of friction. Minor differences are noted among other plastics, metal and plywood (Table 2). The belting wave arrangement allows more flexibility than a rigidly mounted side belt surface.

Cushioning materials have a role in mitigating damage in field harvesting, in transit to the packinghouse, on the packing line and in transport to the marketplace. Each step requires analysis to determine the impact, shock and vibration encountered. Based on those measurements and the associated materials' properties and costs, the most appropriate cushioning material and thickness can be selected.

Table 2. Coefficient of friction (μ) for citrus varieties on various surfaces, non-rolling condition.

	Surface					
Variety	Unpainted plywood	PVC	Sheet metal	Teflon	UHMW-PE	Mean
Dancy tangerine	0.42	0.59	0.67	0.22	0.36	0.45 a
Marsh grapefruit	0.41	0.53	0.39	0.23	0.38	0.39 a
Hamlin orange	0.45	0.46	0.43	0.20	0.33	0.37 a
Pineapple orange	0.40	0.43	0.38	0.19	0.42	0.36 a
Valencia orange	0.36	0.38	0.43	0.23	0.36	0.35 a
Mean	0.41 bc[z]	0.48 c	0.46 bc	0.21 a	0.37 b	

[z]Means with same letters within columns do not differ significantly at 5% level for Duncan's multiple range test.

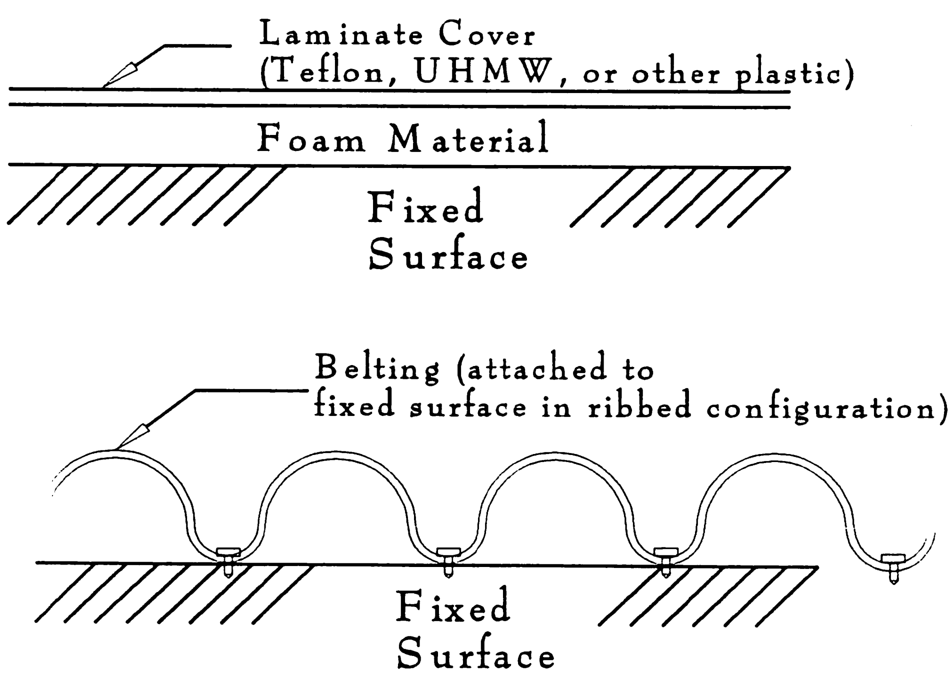

Figure 1. Cushioning alternatives to provide durable wear surface.

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THIRTY-SEVENTH ANNUAL CITRUS PACKINGHOUSE DAY
THURSDAY, AUGUST 20, 1998
CITRUS RESEARCH AND EDUCATION CENTER
700 EXPERIMENT STATION ROAD, LAKE ALFRED, FL 33850

Mark your calendar for Citrus Packinghouse Day. Registration begins at 8:30 AM and the program begins at 9:30 AM. Tickets for lunch may be purchased at registration. There is no meeting registration fee and reservations are not required.

AVAILABLE PUBLICATIONS

Available from Dr. W. F. Wardowski, Citrus REC, 700 Experiment Station Road, Lake Alfred, Florida 33850

References above.

Available from Dr. B. L. Wild, P. O. Box 581, Gosford NSW 2250 AUSTRALIA

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