UPDATE ON POTATO HANDLING AND THE INSTRUMENTED SPHERE [1,2]

by
G. M. Hyde, R. Mathew and R. W. Bajema [3]

The Problem and Some Solutions

Washington's 1990 potato crop was worth $333 million[4]. Each 1% of that crop that was thrown away because of bruise cost the growers $3.3 million. Since impacts in the harvesting and handling equipment cause the tuber bruise problem, the solutions to that problem are to:

1. Reduce the number of impacts, 2. Reduce the severity of the impacts, 3. Increase the bruise resistance of the tubers, or 4. All of the above.

Approach

Our approach to solving the bruise problem is four-fold.

1. We use the Instrumented Sphere (I.S.) 5 and a video camera to characterize the impacts that occur in harvesting and handling equipment, and to tell us where they occur and what causes them.

2. We do laboratory experiments to tell us the bruise resistance of the tubers.

3. The I.S. and bruise resistance information tell us which impacts will cause tuber damage in the harvesting and handling equipment, and where to make improvements.

4. Finally, we do more lab. and field experiments to determine how to grow and/or condition the tubers so that they are more bruise resistant.

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[1] Proceedings of the 31st Annual Washington State Potato Conference & Trade Fair, Moses Lake, Wa. Feb., 1992.

[2] This research is funded in part by the Washington State Potato Commission.

[3] Agricultural Engineering Department, Washington State University.

[4] Hasslen, D. A. and J. McCall. 1990-91. Washington Agricultural Statistics. Washington State Dept. of Agriculture and the USDA. Washington Agricultural Statistics Service, 6128 Capitol Blvd., Tumwater, Wa. 98501.

[5] Zapp, H.R., S.H. Ehlert, G.K. Brown, P.R. Armstrong and S.S. Sober. 1990. Advanced Instrumentation Sphere (I.S. for Impact Measurement. Transactions of the ASAE 33(3):955-960.

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I.S. and Video Evaluation

Figure 1 shows the equipment involved in I.S. and video evaluation of handling equipment. The impact evaluation procedure is as follows: First we synchronize the I.S. and video camera clocks so that the time on the video tape matches the time in the I.S. data. Then we pass the I.S. three times through each transfer point in the equipment while tracking it with the video camera. After a run, the data from the I.S. are dumped to the computer and printed out. We mark high-g impacts, and play back the video tape to the time of each large impact to see where and how it occurred.

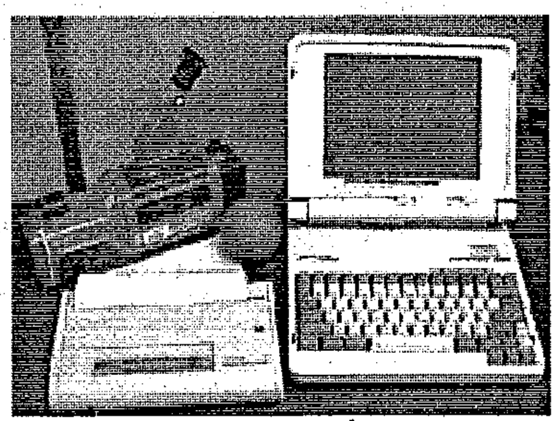

Figure 1. Handling equipment evaluation tools: Dust-tight video camera, Instrumented Sphere, computer, and printer.

What the I.S. Tells Us

The I.S. gives us both the severity of the impact (in g's) and the amount of cushioning involved (as velocity change, ΔV). Figure 2 is a graph of the impacts measured in one potato harvester, plotted with g's on the horizontal axis and ΔV on the vertical axis. Impacts (the circles) further to the right are the more severe; those higher up are more cushioned.

When we add cushioning reference lines to the graph (Figure 3), we can tell what kind of impacts they were (how much cushioning). The bottom sloping line is for impacts on steel; the top curved line is for impacts on 1/4"Poron™ or equivalent.

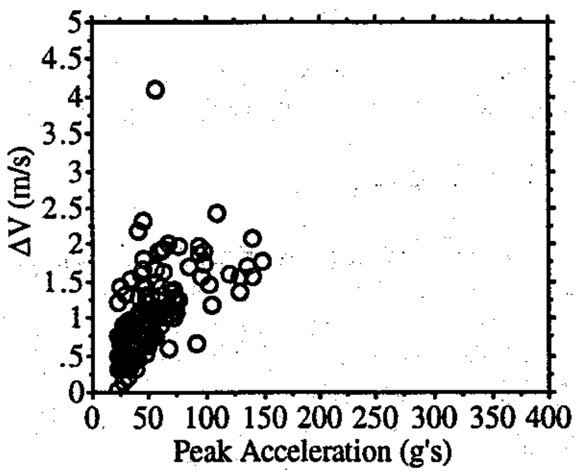

Figure 2. Impacts recorded with the I.S. on one potato harvester.

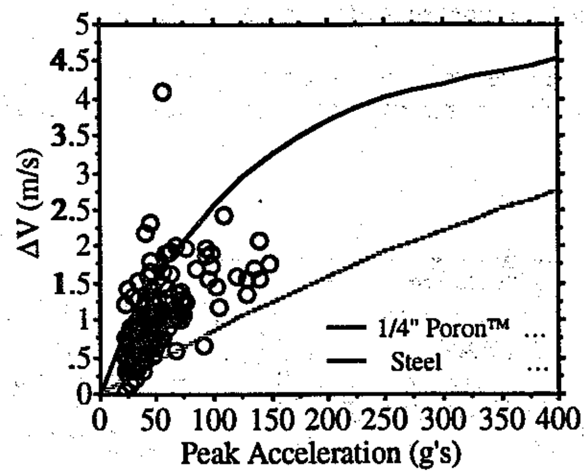

Figure 3. Harvester impacts with cushion reference lines.

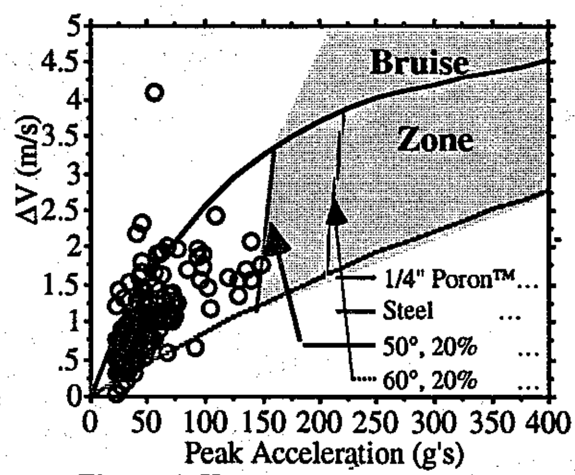

Figure 4. Harvester impacts with cushioning and bruise threshold lines plus bruise zone.

Adding bruise threshold lines to the graph (Figure 4, the two nearly vertical lines near the center) tells us whether the impacts would bruise tubers and how much. Those lines are the 20% damage thresholds for 50°F (left) and 60°F (right) for fairly bruise resistant, 8-10 oz. Russet Burbank tubers. Any impacts falling on the 50°F line will bruise 20% of tubers at that temperature; impacts farther to the right of that line will damage more and more tubers. Thus, the 20% or more bruise zone is the shaded area in the graph. Any impacts in the bruise zone can be a problem. Note that, for this harvester, all but one of the impacts fell to the left of the 50°F, 20% damage line, out of the bruise zone. So bruise damage on this harvester should be small if the crop is fairly bruise resistant. Note also that the 60°F bruise threshold line is to the right of the 50°F bruise threshold line, indicating that the warmer tubers are more bruise resistant than the colder ones.

Some Sidecaster and Harvester Results

Figure 5 shows the impacts on a second harvester. Two sidecasters served both this harvester and the one in Figures 2-4. Figure 6 shows the sidecaster impacts.

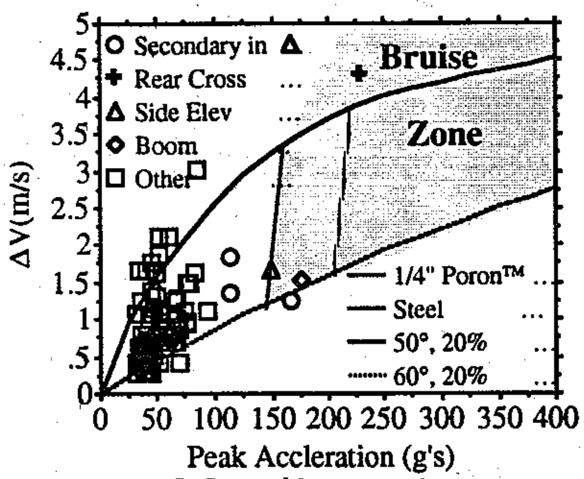

Figure 5. Second harvester impacts.

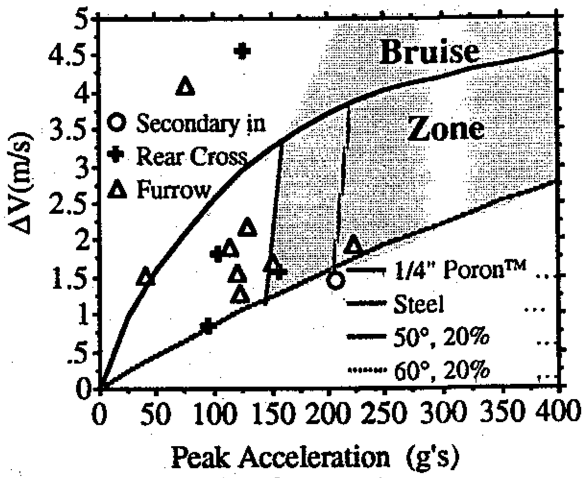

Figure 6. Sidecaster impacts.

The second harvester shows some hard impacts at the input to the secondary, mostly where tubers from the sidecasters fall onto the steel framing between the two halves of the secondary. There was also a cushioned, but still damaging, impact on the rear cross. The sidecasters show some severe impacts at the input to the secondary (we could hear the I.S. "clunk" when it went through that area), and several in the furrow.

Some Packing Line Results

Two subtle areas in packing lines that can cause bruise are the drops to the output cross conveyors under roll sizers and weigh sizers. The problem is the steel support under the conveyor belt. Remember that belting over steel offers little cushioning. The solution is to remove the steel support under the belt at the points where the tubers drop.

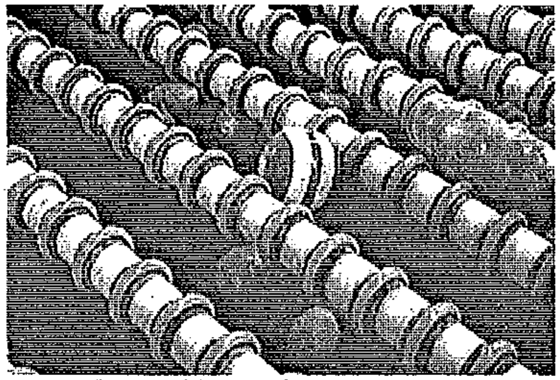

Figure 7. I.S. about to drop to output conveyor in roll sizer.

Figure 8. I.S. just dropped to weigh sizer output conveyor with 500-g impact!

Figure 9 shows impacts in one packing line, the one with the roll sizer shown in Figure 7. Note the hard, severe impacts (the +'s) in the bruise zone. There is also a severe box impact and one on the singulator shaker, another common problem area.

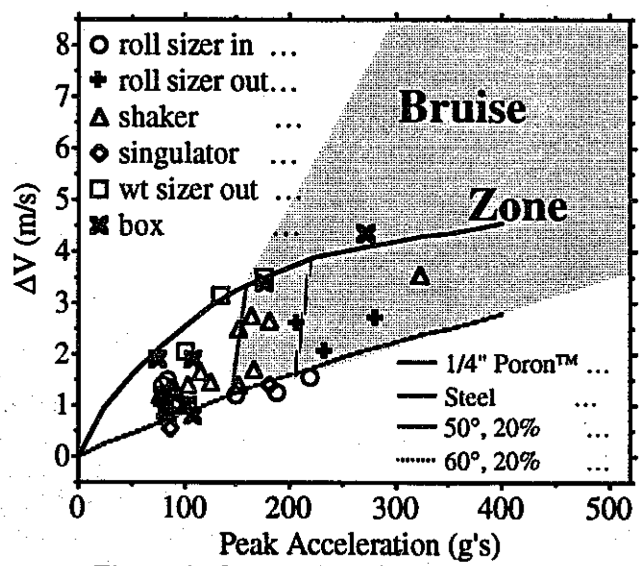

Figure 9. One packing line's impacts.

Figure 10 shows a second packing line, the one with the weigh sizer output shown in Figure 8. There were two very severe impacts at that point out of the three I.S. runs through it, plus some other impacts in the bruise zone from that device. The roll sizer in this line showed only a moderate problem, but the drop off a roller-type sorting table (the Δ's) showed some problem.

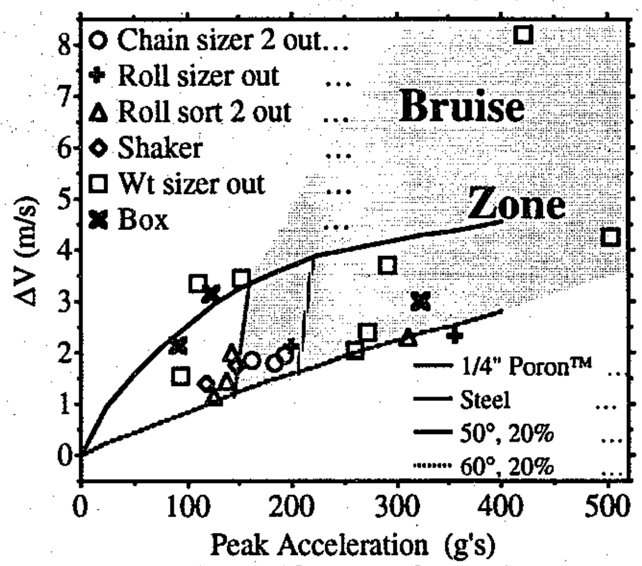

Figure 10. A second packing line with severe impacts, especially at output of weigh sizer.

Bruise Thresholds and Susceptibility or:
How Far Can You Drop a Tuber Anyway?

Figure 11 shows the results of extensive impact tests onto steel and 1/4" Poron ™ cushioning material for the stem end of fairly bruise resistant, 8-10 oz. Russet Burbank tubers at 50°, 60° and 70°F. Dropping these tubers onto steel from a height of up to 2" caused no blackspot bruise damage at 70°F. At 60°F, the allowable drop height is about 1", and at 50°F the distance is even less. Notice that we reached 100% damaged tubers at 16-to-20" drop heights onto steel for the three temperatures. With cushioning equivalent to 1/4" Poron ™, the allowable drop heights for 20% damage increased to about 10", 9" and 8" for tubers at 70°, 60°, and 50°F, respectively.

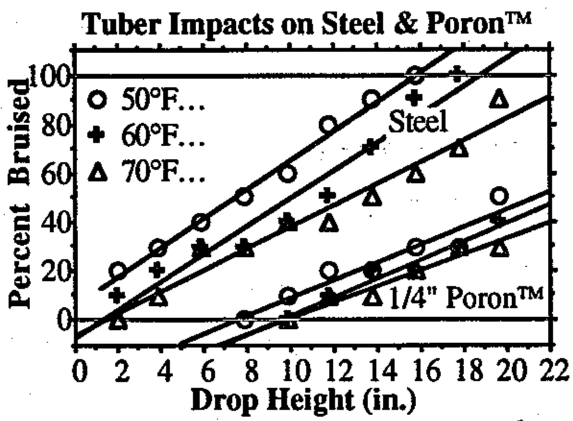

Figure 11. Preliminary, percentage of tubers bruised at 50, 60 and 70°F by drop height onto steel (upper three lines) and 1/4" Poron™ (lower three lines).

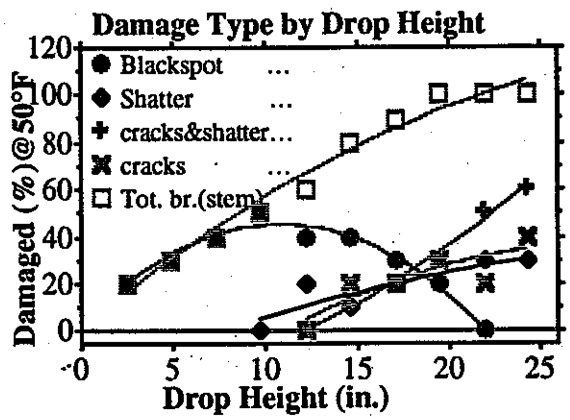

Figure 12. Percentage of tubers damaged by type and drop height at 50°F onto steel.

Figure 12 shows the percentage of tubers damaged and type of damage that resulted for 50°F tubers as drop height onto steel increased. Blackspot first increased, then decreased as shatter bruise and then cracking became the predominant types of damage. These results are consistent with the fact that materials such as potato tubers are visco-elastic in nature and tend to flow at slow loading rates, but to be more brittle at faster loading rates.

In a Nutshell

The main points to remember are that:

- Drops onto steel must be less than 2"
- Rubber belting over steel offers little cushioning
- Even a quarter of an inch of really good cushioning can make a big difference
- Stay out of the bruise zone!