TRANSPORTATION OF POTATOES IN BULK

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The U. S. Department of Agriculture has conducted research for many years on the transit requirements for potatoes. Much effort has been devoted to developing and testing the performance of improved types of railroad refrigerator cars in cooperation with railroad, carlines, shippers, receiver, equipment builders, State experiment stations and others in the industry. In 1960, the Bangor and Aroostook Railroad put into operation the first of its bulk potatoe railroad cars. By 1963 Western Fruit Express had built 75 cars for the Great Northern Railroad for shipping chipping potatoes from the Red River Valley to Texas. In 1968, ACF Industries introduced an insulated air conditioned covered hopper car for bulk transport of potatoes and other perishables. The new car has a capacity of 1800 cwt. ACF Industries first tested the car in cooperation with the Northern Pacific Railway and Frito Lay, Inc. In 1969, the Northern Pacific Railway purchased 50 of these new cars. In 1969, Western Fruit Express built a proto-type 1670 cwt. mechanical car with dual parallel conveyors. By 1970, the Burlington Northern had some 950 bulk potato cars in operation. The Red River Valley potato movement by rail ending June 1971, showed that 183 Conditionaire and 7091 RS bulk carloads amounted to 44 percent of the Valley's total movement by rail, while rail movement counted for 63 percent of the Valley's total movement. There is no doubt that bulk shipping is here to stay.

During part of the shipping season in the Red River Valley, potatoes are transported in extremely cold weather and are loaded when temperatures are as low as 15 to 20 degrees below zero. Reduction in grade, loss of condition, wide ranges of temperatures in the cars, and excessive losses from decay in transit have been reported by shippers and receivers.

New types of rail cars are being tested to replace the RS or standard ice bunker refrigerator car which is no longer being built. The new cars are mechanically refrigerated and heated and have two to three times the load capacity of the RS cars. New equipment for loading and unloading these cars is also being developed.

Our studies which began in January 1969 were undertaken to evaluate the new concepts in bulk shipping of potatoes.

In most of our test shipments cars were paired either as RS to RS car, Conditionaire to RS car, or mechanical refrigerator car to RS car. There were a number of single car tests particularly when we were working with precut seed.

The paired car tests were made to compare the effectiveness of the different types of cars in maintaining temperature and quality of the potatoes. The paired cars were loaded with potatoes from the same storage and shipped to the same destination on the same train. When possible the paired cars were loaded the same day. However, in some tests with the Conditionaire car, the paired RS car was loaded on a different day.

For test shipments with chipping potatoes, where possible, random samples of potatoes were taken during the loading and unloading of each test car and checked for chip color to determine any change in quality which might occur during transit.

The center flow Conditionaire bulk potato car is basically a covered hopper car with 3 compartments. Each compartment has a full length hatch at the top and a gravity flow outlet at the bottom. A sliding gate at each outlet opens lengthwise and allows potatoes to flow onto a conveyor directly beneath the outlet. A self-contained diesel-electric generator system provides 230 volts to power the heating and cooling equipment. In the air circulation system fairly high pressure fans force air through the potatoes. The fans have a capacity to produce a minimum of 1 c.f.m. of air per hundredweight of potatoes. Air is drawn off the top of the car, it is then forced into the bottom of the hoppers and up through the potatoes. The air is heated,

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or cooled as it passes through the air conditioning unit depending on the thermostat setting and the temperature of the load. The exterior of the car is insulated with 2 inches of polyurethane foam.

The mechanical refrigerator cars used in these tests were converted for bulk shipping of potatoes by replacing the floor racks with a slatted floor that sloped toward a draper chain conveyor extending from each end of the car to a cross conveyor trough at the doorway of the car. The walls, roof, and floor have a 6-inch foamed-in-place insulation core. Ducts in the side walls and air diffusers from a plenum above the ceiling aid in the forced air circulation. As in the Conditionaire car a diesel-electric generator system provides the electrical power for the heating and cooling equipment.

TEMPERATURE

Tuber temperature at both loading and unloading was determined with metal pulp thermometers on potatoes taken at random from the conveyors.

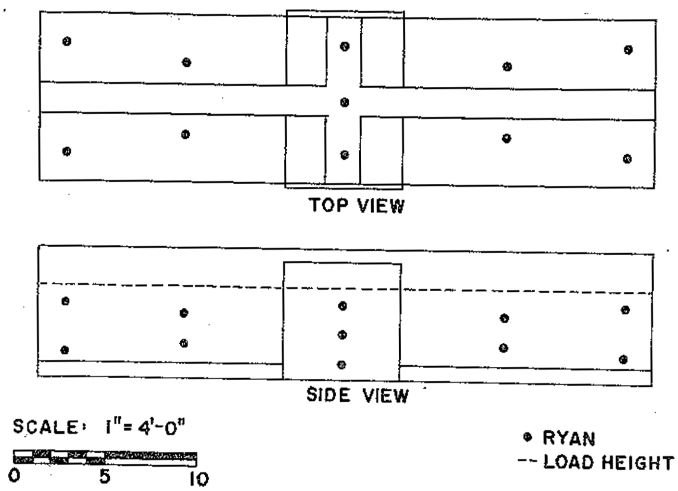

Figure 1: Points showing the location of Ryan recording thermometers in the RS bulk cars.

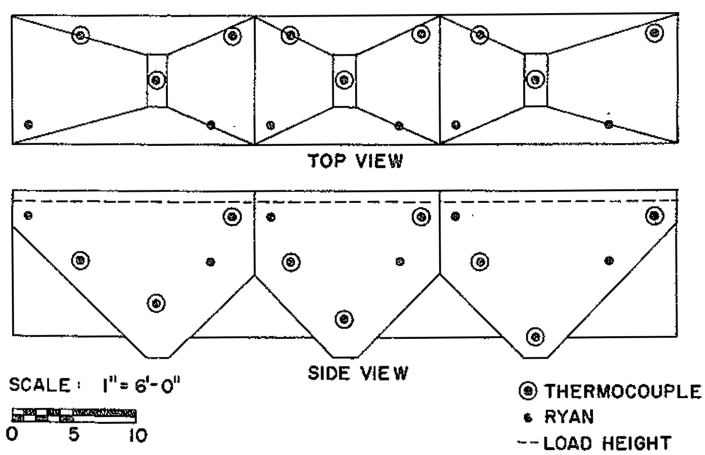

Figure 2: Points showing the locations of Ryan thermometers and thermocouples in the center flow Conditionaire car.

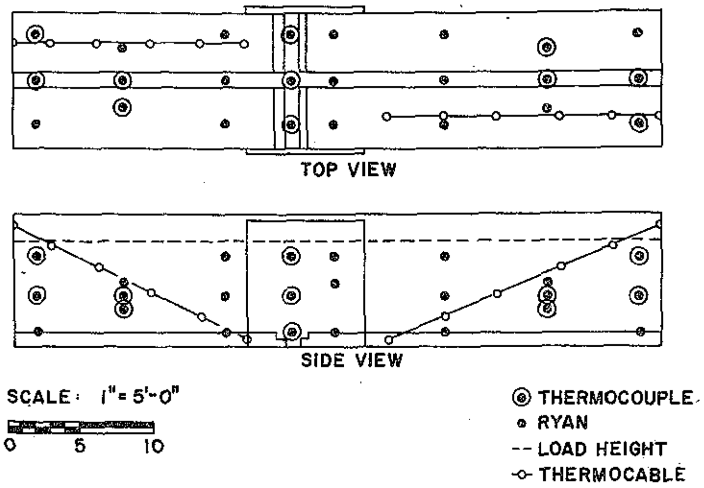

Figure 3: Points showing the location of Ryan thermometers and thermocouples in the mechanical refrigerator car.

Ryan recording thermometers and thermocouples (Figures 1, 2, 3) were used to record temperatures throughout the cars. Temperature was recorded at points indicated in the slides. Potatoes with thermocouples attached were placed at the indicated points during loading and a 24-point Brown Electronik recorder was used to record temperatures from the thermocouples.

Ryan recording thermometers were also attached to the underside of each car to record outside temperature.

LOADING AND UNLOADING

To load the RS bulk car and the mechanical refrigerator cars potatoes were conveyed from the grading table to a telescoping loading conveyor at the door on the side of the car. The conveyor extended into the car and could be directed toward either end. Filling began in one end with the conveyor lowered close to the floor. As the car filled, the conveyor was raised and directed from one side of the car to the other and gradually retracted to give a uniform fill. The center of the car was filled last as the conveyor was backed out the door.

When the RS and mechanical cars were unloaded the doors were opened and a conveyor was inserted in the cross conveyor trough. The first pick-out board was removed from over the cross conveyor to start the flow of potatoes. The potatoes were conveyed to a pallet box loader which raised automatically as the pallet boxes were filled.

To load the Conditionaire car potatoes were conveyed to a conveyor extending out of the storage over the car hatch opening. The potatoes were directed onto a hydraulically controlled, telescoping conveyor which was lowered through the hatch opening to the bottom of the compartment.

As loading progressed, the conveyor was raised. When loading was completed, the conveyor was removed, the hatch was closed and the car was moved to position the next compartment beneath the conveyor. In loading these cars under warmer conditions, a conveyor may be positioned and extended over the car and canvas chutes dropped from the end into the compartment for loading. The latter method was used to load bulk pre-cut seed for test shipments going from Colorado to Florida.

At unloading, the insulated gate cover was unlatched and swung to one side. As shown earlier, a belt conveyor was moved into position between the track and the gate and the potatoes unloaded.

RESULTS

In a paired car shipment of chipping potatoes going from Grand Forks, N.D. to River Grove, Ill., in 2 RS bulk cars, the increase in temperature change after the third day indicated that either heater control, air circulation, or both, in the car were poor. A drop of minimum temperature to the low 50's in the bottom of the load and a rise in maximum temperature to or near 70° F. indicated that poor air circulation did exist. Quality as determined by chip color improved during transit. The agtron reading for chip color increased from 50.5 to 59.0 in one car and from 50.0 to 56.6 in the other car. This increase in percent light transmitted indicated lighter colored chips at unloading than at loading.

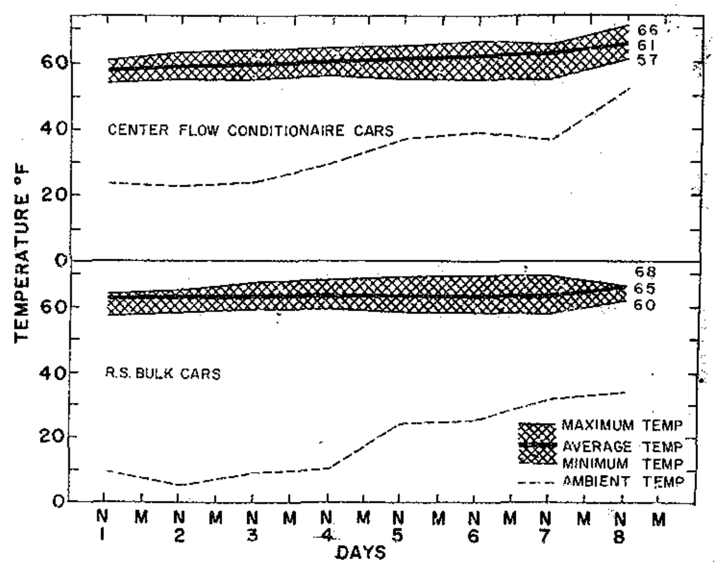

Figure 4: Temperature patterns in the 3 paired car tests involving center flow Conditionaire to RS cars going to Houston and Irving, Texas from Jan. 15 to February 11, 1969.

The comparison of temperatures from 3 paired car tests show some of the temperature differences. The first pair is a Conditionaire to RS bulk car test shipment (Figure 4) from East Grand Forks, Minn. to Houston, Texas in January 1969. The second pair is the River Grove, Ill. test shipment mentioned earlier. Note the wide range in temperature. The third pair was the mechanical refrigerator - RS bulk car shipment from Grand Forks, N. D. to San Jose, Calif. in March 1969. The range of temperature in this test shipment was also quite wide.

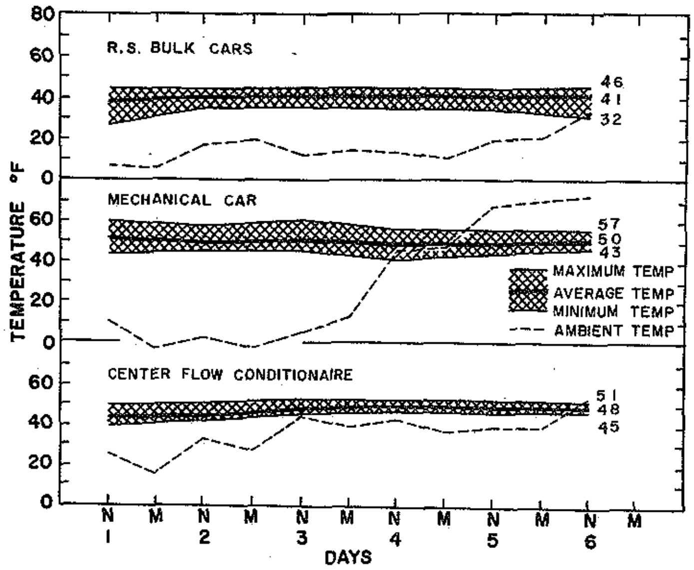

Figure 5: The temperature patterns in table stock potatoes shipped bulk by rail from the Red River Valley to Burlington, Iowa and Garland, Texas February 8 to March 27, 1969.

In 3 paired car tests (Figure 5) of Conditionaire to RS cars of chipping potatoes, during the period from January 15 to February 21, 1969, the RS car temperature averaged higher than the thermostat setting, whereas the temperature in the Conditionaire car averaged very close to the thermostat setting. Comparing the total change in temperature from loading to unloading, the temperature in the Conditionaire cars remained closer to the original tuber temperature than the temperatures in the RS cars. Less change in temperature in the Conditionaire cars apparently proved beneficial to quality as determined by chip color. The color intensity of chips from potatoes in the RS cars averaged 6 percent darker in agtron readings than the chips from potatoes in the Conditionaire car.

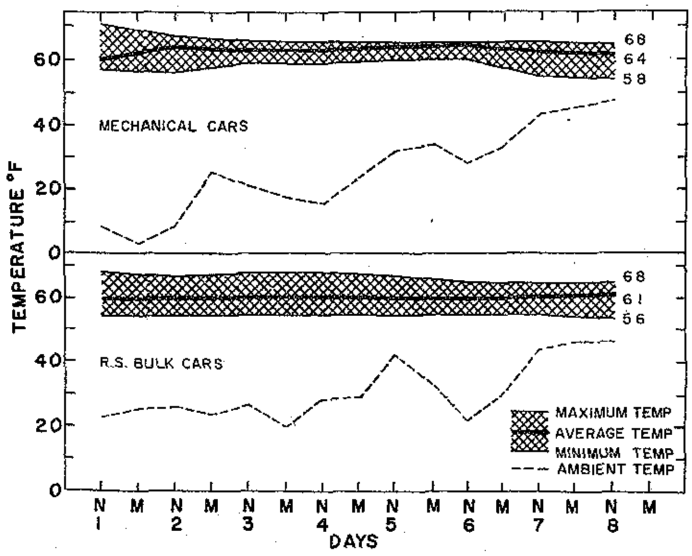

Figure 6: Temperatures in the paired car tests involving mechanical refrigerator cars to RS cars from February 13, to March 14, 1969.

In the first paired car test with the mechanical refrigerator car and RS car, there was less total change in tuber temperature in the mechanical car (Figure 6) and the average temperature did not drop as much in the mechanical cars as it did in the RS cars. There was less total change in temperature in the mechanical refrigerator cars than in the accompanying RS cars. As with the Conditionaire cars chip color was lighter from potatoes shipped in the mechanical refrigerator cars than from the potatoes shipped in the RS cars. It is apparent that the two new types of mechanical cars give a more uniform air flow throughout the load and therefore less fluctuation in temperature than is found in the RS cars.

TUBER DAMAGE AND DISEASE DEVELOPMENT

Injury to potatoes was determined by a combination of chemical treatment and visual analysis. Samples for injury were immersed in a catechol solution and allowed to dry before being visually rated for bruising. Injured areas turned dark red to black after treating with catechol. Discoloration was found in any fresh injury in which the skin was broken. Serious damage, that in which more than 10 percent of the surface area was injured, averaged about 15 percent during loading and unloading. Damage to the potatoes during the actual transport is negligible. During the transit period, symptoms appear from damage occurring earlier as the potatoes were being handled. Although disease development in transit was minor in these tests, excessive tuber damage that occurred during loading could cause disease losses in transit. Potatoes are often treated as hardware with not enough consideration for careful handling and optimum temperature. As a result, losses are heavy from decay, overheating, sprouting, and freezing. Although temperature is not as critical in the development of decay in sound mature potatoes, decay originating at bruises, cuts, or skinned areas, or induced by heat injury before, or during harvest is serious. Potatoes with unbroken skins are substantially protected against the invasion of decay-producing organisms, are resistant to moisture loss, and are not susceptible to surface browning. Potato tubers produce suberin and wound periderm, and skinned or feathered surfaces may be healed if provided the optimum environment. Optimum temperature for healing is 60° -- 70°F. Higher temperatures favor the development of decay. Below 50°F. healing proceeds slowly, and no wound periderm formation develops below 40°F.

Protection against freezing in transit is the greatest problem in moving table stock and seed potatoes to market. One test car of our winter test shipments in 1969 had minimum temperatures which averaged 32°F. It was necessary to hold this car at destination for several days to allow frozen tubers to begin to decay so they could be graded out. Freezing can become a problem with winter shipments if cars are not warmed up properly prior to loading or if held up in transit for too long a period without the fans running.

Lack of proper or sufficient ventilation can cause a buildup of carbon dioxide and a reduction of oxygen in transit. This could cause the loss of market quality. High carbon dioxide - low oxygen conditions are associated with black heart which is the discoloration and breakdown of the inner tissues of the potato, it can also stimulate sprouting, and may be responsible for increasing the amount of soft rot decay found at destination. In the second test shipment in the mechanical refrigerator car carbon dioxide increased to 11.5 percent and the oxygen was reduced to 7.5 percent in a 6-day period. In a later shipment in the same car carbon dioxide increased to about 15 percent in 12 days. After 2 days in transit in an RS bulk car of chipping potatoes the carbon dioxide increased to 9.5 percent. The mechanical refrigerator car paired in this test had a CO_2 content of 4.6 percent at the same check point, but the oxygen content had decreased to 11.5 percent. By the third day, the CO_2 content in the mechanical car had increased to 7.8 percent. Removing heaters from the bunkers in the RS bulk car the third day in transit, lowered the CO_2 content almost to normal. The atmosphere of a Conditionaire car loaded with table stock was samples of periodically enroute, and the maximum content of CO_2 was 1 percent.

In summary, all types of cars tested maintained potatoes at moderate temperatures. Temperature variations ranged from 5 - 14 degrees. Temperatures were lowest in the bottom of RS cars, indicating that air circulation should be improved. Fluctuations of conditioned chipping potatoes in transit caused a change in quality as determined by chip color, and it was concluded that the less fluctuation from that of the conditioned potatoes, the less detrimental the change in chip color. Moisture condensation in the cars was detrimental in that it made the potatoes on the top of the load more susceptible to decay. More careful handling would reduce the incidence of damage, and reduce decay in transit.