Whisky Losses during Aging

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Changes in warehousing procedures have been inaugurated in the storage of distilled liquors during aging which have resulted in a saving of approximately $750,000 over a period of three years. In brief, these changes involved lowering warehouse temperatures from 70° to 55° F., maintaining an equilibrium humidity of 65 to 70 per cent relative humidity in the warehouse atmosphere, specifying and inspecting new barrels to ensure the receipt of high-quality barrels, and intensifying the maintenance and care of barreled goods during the aging period.

ONE of the most important factors of warehousing operations is the maintenance of whisky goods intact during the aging period. This period may vary up to eight or ten years. During this time the whisky is stored in barrels under direct governmental supervision in Internal Revenue bonded warehouses.

From the standpoint of ordinary commonsense, wooden barrels are exceedingly poor containers. Their characteristics are such that losses cannot be avoided. These losses, inherent in the properties of a wooden barrel, comprise soakage and evaporation.

Wood, being porous and spongelike, literally soaks up whisky in the same way it soaks up water. This soakage amounts to 19 pounds of 100-proof whisky and is equivalent to 2.4 proof gallons per barrel. This amount is irretrievably lost, since Government regulation permits no recovery of this whisky, not even of the 1.2 gallons of alcohol which each barrel contains. This constitutes a sizable loss when it is realized that about 1,500,000 whisky barrels are dumped annually, each containing at least 1.0 proof gallon of recoverable alcohol.

Evaporation of whisky takes place directly through the wooden barrel. Although white oak is usually regarded as a dense and nonporous wood, whisky evaporates through it at rates varying from 0.80 to 1.5 pounds per month per barrel. This variation in rate depends on the texture of the wood, which may be very hard and tough down to very soft and light. An over-all average evaporation rate may be taken as 1.1 pounds per month per barrel or its equivalent of 1.7 proof gallons per barrel per year. This figure also includes a small loss from minor leaks caused by defects in the wood such as small knots, growth streaks, seasoning cracks, etc.

After five years the unavoidable losses, including evaporation and soakage, add up to $(5 \times 1.7) + 2.4 = 10.9$ proof gallons per barrel. Since barrels normally contain about 48 gallons, this loss approximates 22.7 per cent of the original entered contents after a normal aging period of five years.

For these reasons, therefore, the statement is made that barrels are exceedingly poor containers. It is nothing less than foolhardy to store one's belongings in packages which lose 22.7 per cent in five years. It is even more foolhardy when the cost of this loss of matured whisky, including tax and cost of production, is approximately $4.30 per gallon.

The Government makes certain allowances under the Carlisle Tables for nonpayment of tax for soakage and evaporation. These tables, however, are grossly inadequate. The Carlisle Tables were drawn up from average data compiled in the 80's and 90's, but are applied to individual barrels warehoused during recent times. It has been the general experience throughout the industry to pay tax on a certain amount of nonexistent whisky. This happens when the losses experienced during warehousing exceed those provided for under the Carlisle Tables.

In spite of the inherent faults in barrels as packages for whisky storage, their use is obligatory; by governmental definition American whisky must be aged in charred, new, white oak barrels. Therefore, the distilling industry must make the best of a bad situation. Every opportunity must be taken advantage of to reduce whisky losses during the warehousing period.

WITH this background a survey of losses was undertaken by the Seagram company some years ago. A total of 2500 barrels of various ages up to two years was weighed for gross weight. The barrels chosen for weighing were those judged to be most representative of the entire inventory. The centermost racks were chosen, and all the barrels in these racks were weighed. These racks consist of six tiers of barrels with thirty-one barrels per tier. The total number weighed per rack thus was 186 barrels. Representative floors throughout seven warehouses having six floors each were chosen until 2500 barrels were included in the survey.

Two interesting conclusions were drawn from the survey. The first unsuspected fact was that the evaporation rate did not depend in any conclusive manner on the manufacturer of the barrels. Three reputable manufacturers, who build sound and well-made products, furnished the barrels for the survey. In no case did the data show conclusively that greater evaporation losses occurred from one company's barrels in comparison to another's barrels in the same quality class. These data are plotted in Figure 1. The variation in evaporation rate for any given company's barrels is nearly as much as the variation in the entire data. The solid black line is not meant to represent the data as a continuous line, but rather the Government allowance under the Carlisle Tables for leakage and evaporation. It is given merely for reference and was obtained by subtracting the Government allowance for a soakage of 14 pounds from the allowances in the Carlisle Tables, which include both soakage and evaporation. The data as well as the Government allowance were calculated to the same units—namely, evaporation in pounds per month per barrel.

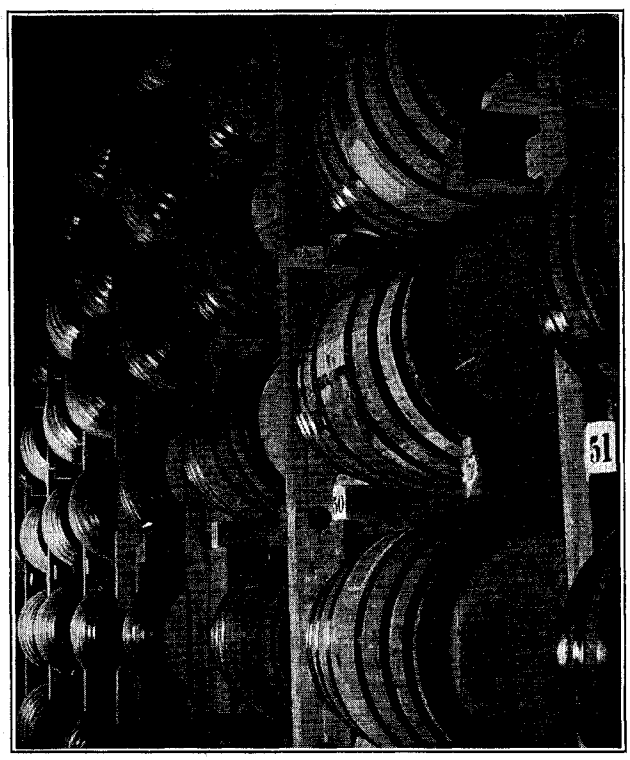
The second outstanding conclusion from this survey had to do with the location of the barrels in the warehouse racks. The evaporation rates were calculated and arranged to show variation with height above the floor—that is, in terms of tier level. The data are given in Table I and show that in every

TABLE I. EVAPORATION RATES FROM FIRST- AND SIXTH-TIER BARRELS

Storage Time, Days	Evapn., Lb./Mo./Bbl. First tier	Evapn., Lb./Mo./Bbl. Sixth tier	Per Cent Increase
69	0.68	0.92	35.3
231	0.86	1.09	26.7
242	0.83	0.88	6.0
319	0.86	1.03	19.8
343	1.00	1.33	33.0
357	1.01	1.25	23.8
390	0.97	1.32	36.1
530	1.23	1.44	17.1
534	0.87	1.46	67.8
542	1.25	1.41	12.8
548	1.14	1.32	15.8
590	1.00	1.15	15.0
642	1.32	1.49	12.9
670	1.14	1.38	21.1
730	1.04	1.38	32.7
		Average	25.0

case the evaporation rate on the top tier was higher than on the bottom tier in the same rack. In some cases the top-tier evaporation rate was 67.0 per cent more than the bottom rate. In other cases there was as little as 6.0 per cent increase from bottom to top. These data do not represent single barrels; rather, each figure is an average of thirty-one barrels. An over-all average per cent increase in evaporation rate based on all the barrels in the survey can be taken at 25.0 per cent. That is, on the average under conditions of the survey, loss by evaporation was 25.0 per cent more from the top tiers than from the bottom.

A parallel study was made of temperature and relative humidity in the warehouse areas involved. The average warehouse temperature at the time was approximately 70° F. However, the temperatures from the first to the sixth tier ranged through 10° from 65° to 75° F. These were the extremes while the average was approximately 4° F. The relative humidities were likewise determined in the same areas with a sling psychrometer. As was expected, the relative humidities varied widely, in the range 42 to 62 per cent. The average variation from first to sixth tier was approximately 7 per cent. Therefore, on the average the evaporation rate of barrels on the sixth tier was 25 per cent greater than barrels on the first tier, and this increase was accompanied by an average increase in temperature of 4° F. and an average decrease in relative humidity of 7 per cent.



MANNER OF RACKING WHISKY BARRELS DURING AGING; BARRELS IN FOREGROUND SHOW HOW CRACKED STAVES ARE REPAIRED WITH DUCK AND CASEIN GLUE

The evaporation rates are plotted in Figure 2, which shows the spread of evaporation rates from the first to the sixth tier and how these losses proceed with time of storage in the warehouses. The Government allowance for leakage and evapora-

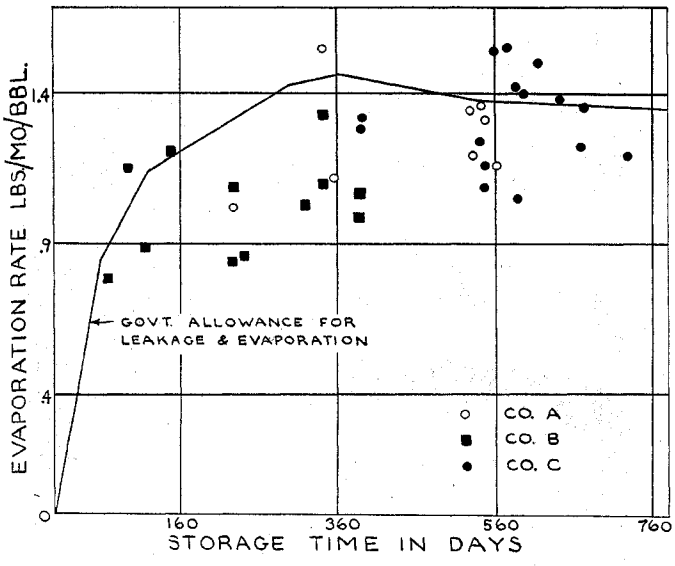


FIGURE 1. EVAPORATION RATES FROM BARRELS OF THREE COMPANIES

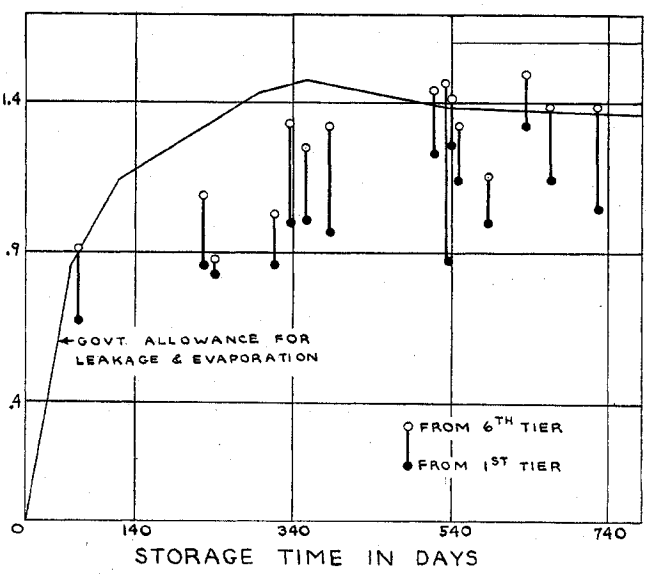


FIGURE 2. EVAPORATION RATE FROM FIRST AND SIXTH TIERS

tion is shown as the solid curve. In about half the cases the loss from the top tier is above the Goverment allowance. This means that on these barrels the Government would require payment of tax for whisky which was no longer in the barrels.

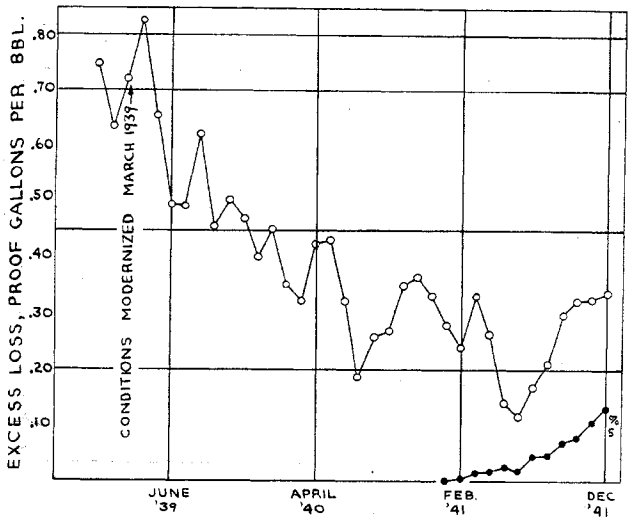


FIGURE 3. EXCESS LOSS

WITH these results at hand, the Seagram company began in March, 1939, to modernize the warehousing procedures and conditions in an attempt to reduce these losses. Not only would the production cost of whisky be saved by lowering the evaporation rate, but also the major item (the loss in tax over the Government allowance) would be reduced. At present any loss over the Government allowance is taxed at the rate of $4.00 per proof gallon, literally, for nonexistent whisky. The steps of warehousing subject to revision were temperature of the warehouses, humidity control, specifications for new barrels, and care of barreled goods during storage.

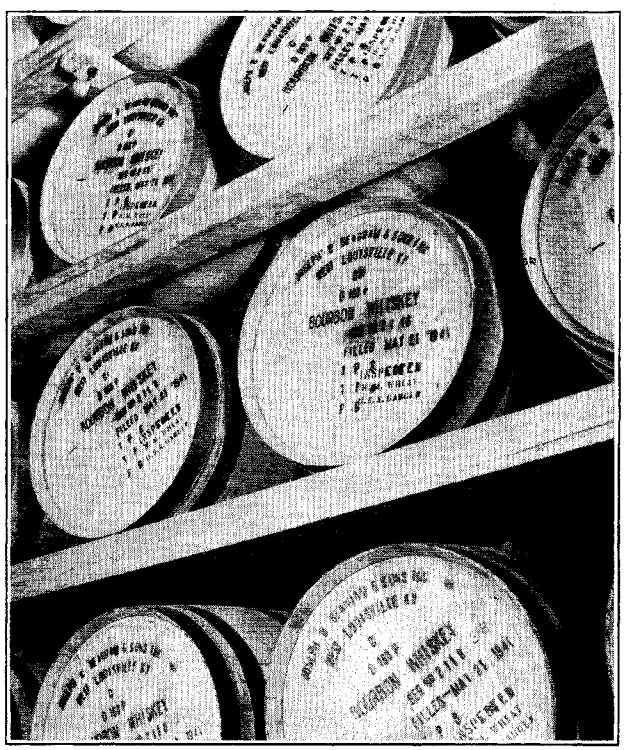
The warehouse temperatures had been kept at approximately 70° F. during the winter months. During the summer months when regulation of temperature was beyond our control, the warehouse temperatures in some places rose to 80° F. In the light of the survey which indicated that a 25 per cent increase in evaporation may be caused by a temperature increase of 4° F., it was decided to lower warehouse temperatures to 55° F. during the winter months. During the summer every effort was made to keep the temperature as low as possible. The summer temperatures under the new operation, however, still ranged between 70° and 80° F.

The temperature of 55° F. was arrived at from two considerations. One was the fact that men in the warehouses do not work effectively or with any degree of comfort if the room temperature is much below 55° F. Another consideration was the possible decrease in the aging rate at the low temperature. The effect of temperature on rate of aging has always been the subject of discussion in the distilling industry. It seems logical to believe that aging proceeds faster at somewhat higher temperatures. Yet no controlled experiment has yielded conclusive data.

AT PRESENT an experiment comprising 2500 barrels is under way in which various types of distillates are kept at a constant year-round temperature of 50° F. by mechanical refrigeration. Samples of these barrels after a year's storage when compared to those subjected to a year-round variation between 55° and 75° F. are indistinguishable from one another. Therefore, we believe that our low winter temperature of 55° F. is causing no delay in the normal rate of aging.

The relative humidity as well as the temperature was subject to yearly variation. The winter humidities had been kept close to 55 per cent which rose during the summer to about 80 per cent. It was realized that water vapor as such would have little or no effect on the diffusion and evaporation of alcohol through the woody membranes of the barrel. The chief effect of water vapor in the warehouse atmosphere is, no doubt, to control the swelling and shrinking of the barrel. That is, the function of atmospheric water vapor should be to keep the barrel tight and free from leaks. New barrels enter the warehouse containing 12 to 15 per cent moisture and in this condition are tight. A loss of moisture caused by a low relative humidity in the atmosphere causes the wood to shrink and results in open joints in the barrels. A high relative humidity (that is, above 85 per cent) results in proof reduction, mold growth, and generally unsanitary conditions in the warehouses. Moreover, unless this high relative humidity is maintained, any subsequent decrease in relative humidity will cause the wood to shrink and the barrels to leak.

The only logical relative humidity to maintain in warehouse atmosphere is that which is in equilibrium with the moisture in the barrels. At this equilibrium humidity, barring temperature changes, the wood of the barrels will neither shrink nor swell. From communications with the U. S. Forest Products Laboratory it was established that wood containing 12 to 15 per cent relative humidity was in equilibrium with an atmosphere having 65 to 70 per cent. This, then, was the basis for establishing under our revised procedures that the warehouse atmosphere should be maintained at 65 to 70 per cent relative humidity.



WHISKY BARRELS IN INTERNAL REVENUE BONDED WAREHOUSES, WITH GOVERNMENT MARKINGS ON THE HEADS OF EACH BARREL

TABLE II. SUMMARY OF EXCESS LOSSES FROM JANUARY, 1939 TO DECEMBER, 1941

	1939			1940			1941		
		Excess Loss			Excess Loss			Excess Loss	
	Barrels Taxpaid	Proof gal.	Proof gal./bbl.	Barrels Taxpaid	Proof gal.	Proof gal./bbl.	Barrels Taxpaid	Proof gal.	Proof gal./bbl.
January	9,928	7,188	0.7240	8,553	3,875	0.4530	10,933	3,046	0.2786
February	14,116	9,024	0.6393	14,539	5,126	0.3526	14,239	3,400	0.2387
March	20,832	15,073	0.7236	13,395	4,341	0.3241	19,649	6,506	0.3311
April	18,420	15,232	0.8269	15,614	6,636	0.4250	17,871	4,657	0.2606
May	15,261	10,038	0.6578	16,931	7,350	0.4341	25,657	3,568	0.1391
June	9,509	4,742	0.4987	29,589	9,570	0.3234	20,835	2,414	0.1159
July	12,142	6,027	0.4964	23,237	4,361	0.1877	25,065	4,187	0.1670
August	14,843	9,232	0.6220	9,798	2,515	0.2567	31,061	6,519	0.2099
September	20,877	9,544	0.6572	18,482	4,957	0.2682	24,372	7,184	0.2948
October	27,714	14,011	0.5056	35,113	12,254	0.3490	30,411	9,798	0.3222
November	37,858	17,841	0.4713	36,395	13,235	0.3636	38,699	12,533	0.3238
December	15,245	6,143	0.4030	17,464	5,798	0.3320	14,889	4,922	0.3353

Three-year total	729,536 bbl.	272,917 proof gal. excess
Tax rate of $2.25	315,371	160,993
Tax rate of $3.00	330,171	84,601
Tax rate of $4.00	83,994	27,323

In practice this range can be maintained with fair success. For most atmospheric conditions regulation of the intake of outside air suffices. The warehouses are equipped with air circulation units which contain means of introducing moisture in the form of steam if the desired effect cannot be obtained from the outside air. On the other hand, only a start has been made in dehumidifying warehouse atmosphere.

In addition to the above changes in temperature and relative humidity, purchase specifications for new barrels were drawn up based on our experience and that of the barrel manufacturers. Specifications were written to provide barrels of uniformly high quality. Inspection procedures were inaugurated to serve as a check that the specifications for new barrels were being met[1].

The care which barreled goods receive during warehousing was intensified. The practice in the distilling industry is to inspect every barrel of whisky periodically throughout the storage period. This inspection period was shortened so that each barrel is inspected every ten calendar days. Inspectors on these ten-day cycles repair minor leaks, patch cracked staves, and generally perform preventive maintenance. In cases where the leak is too large to repair in passing or a head is badly buckled or a cracked stave shows probability of leaking, these barrels are removed from the racks and the defective parts are replaced with sound staves or heads. In addition, newly filled barrels are inspected for leaks daily until they have been stored for two months. From then on they are cared for in the ten-day inspection cycle.

THE CURVE of Figure 3 shows what results have been obtained by the changes described above. Before the changes were inaugurated in 1939, the excess loss was approximately 0.70 proof gallon per barrel. Since that time the excess loss has gradually decreased until at present it is in the vicinity of 0.30 proof gallon per barrel. These data were obtained directly from Government figures determined when the barrels were dumped and regaged for tax collection and represent actual operating conditions; they are summarized in Table II.

Figure 3 shows that the excess losses over the last six months have increased somewhat. This is probably caused by the fact that an increasing percentage of our goods is reaching an age of eighty months or more. The Government allowances under the Carlisle Tables arbitrarily provide for no further allowance after eighty-month storage. Hence, any percentage of our goods taxpaid at an age of eighty months or over will increase the over-all average excess loss per barrel. The percentage of taxpaid goods over eighty months is plotted in the lower right-hand corner of Figure 3, showing a rise from zero to about 5 per cent in the past year.

To get an idea of the monetary saving represented by this decrease in excess loss, a calculation was made to show what the excess taxes would have been if the rate of excess loss had remained at 0.70 proof gallon per barrel. During this three-year period 729,536 barrels were taxpaid. If these had each been 0.70 proof gallon excessive, the quantity of nonexistent whisky subject to tax would have been 510,675 proof gallons. Over this period the rate of tax varied from $2.25 to $4.00 per proof gallon. Thus, the tax collected on nonexistent whisky would have been $1,425,256. From actual figures during this period the excess loss was only 272,917 proof gallons. Figured at the same rate of tax, this quantity of loss was taxed $725,328. Thus the saving of excess tax was $699,928. In addition, the actual whisky saved was 237,757 proof gallons. Figured conservatively at $0.30 per proof gallon, this saving was worth $71,327. Thus, it can be said that the value of the change amounted to $771,255, roughly three quarters of a million dollars, over the past three years.

Acknowledgment

The authors gratefully acknowledge their indebtedness to A. F. Novak for the preparation of the illustrations.

[1] Gallagher, Milton, and Seibel, H. W., *Spirits*, June, July, Aug., Sept., and Oct., 1941.

PRESENTED before the Division of Industrial and Engineering Chemistry at the 103rd Meeting of the AMERICAN CHEMICAL SOCIETY, Memphis, Tenn.