A COMPARISON OF RAW SUGAR BOILING SCHEMES

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ABSTRACT

This paper presents a rigorous method for calculating the material and steam balance for various sugar boiling schemes. Examples are given for:

1. The conventional three boiling system

2. The two boiling (A-C) system

3. The double einwurf system

The results from the material and steam balance can be used to compare these systems with regard to:

1. The pan requirement

2. The centrifugal station requirement

3. The exhaust (or vapor) requirement

4. The condenser water requirement

5. The controllability of purities

6. The ease of graining

ASSUMPTIONS

These are listed in Table 1.

DISCUSSION OF RESULTS

Pan Requirement: From a knowledge of the massecuite volumes and the strike boiling times, the pan capacity requirements can be calculated. The massecuite volumes are presented in Figures 1, 2 and 3 are summarized in Figure 4. The boiling times for the strikes for the different schemes will vary somewhat. The A strikes for the double einwurf massecuites will take less time to boil because of the large footings used.

The pan capacity requirements for the three boiling and two boiling systems are approximately equal, while the pan requirements for the double einwurf are about 10% greater.

Centrifugal Requirement: The production of "C" massecuite is constant for all boiling systems. The production of high grade massecuite is lowest for the two boiling system. The high grade massecuite production in the case of the three boiling system is about 6% greater than that of the two boiling. The quantity of high grade massecuite produced by the double einwurf system is about 50% greater than that from the two boiling, and about 45% greater than that from the three boiling system. This is a result of the double centrifugalling of the "B" sugar.

Exhaust Steam Requirement: The steam requirements for the various boiling schemes is shown in Figure 5. The steam requirement is lowest for the two boiling system, followed by the three boiling system where steam requirement is 7% greater than that of the two boiling, followed by the double einwurf system's steam requirement which is 23% greater than that of the two boiling system.

Condenser Cooling Water Requirement: The pan condenser water requirement closely parralels the steam requirements. The double einwurf system requires about 20% more water than that of the other two systems.

Control of Purities: In the two boiling system the "A" molasses purity must be controlled so that the C massecuite can be maintained at its optimum level. This necessitates close control of the "A" massecuite purity by recycle of "A" molasses to the "A" strike.

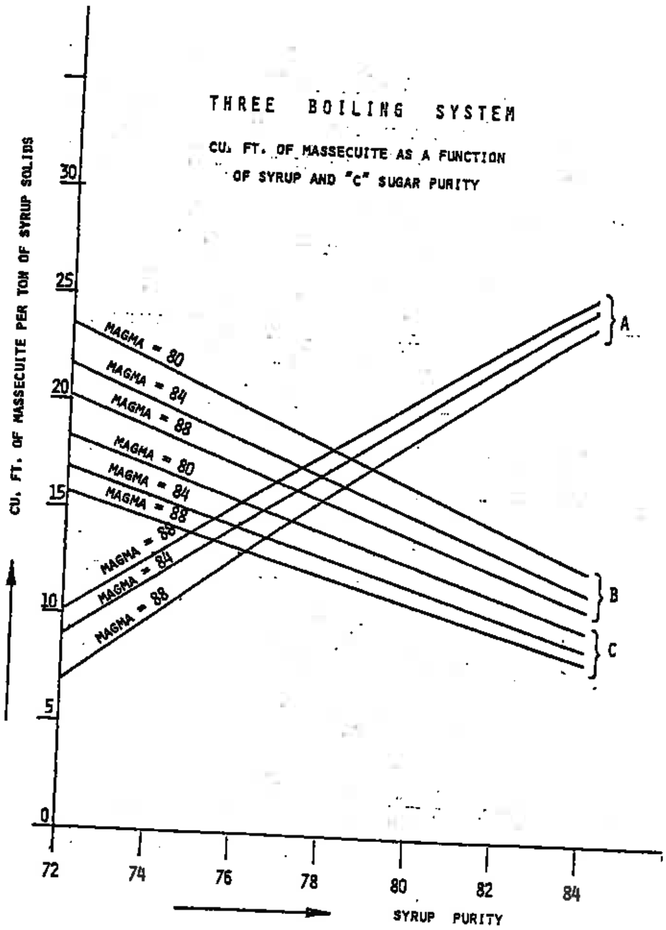


Figure 1

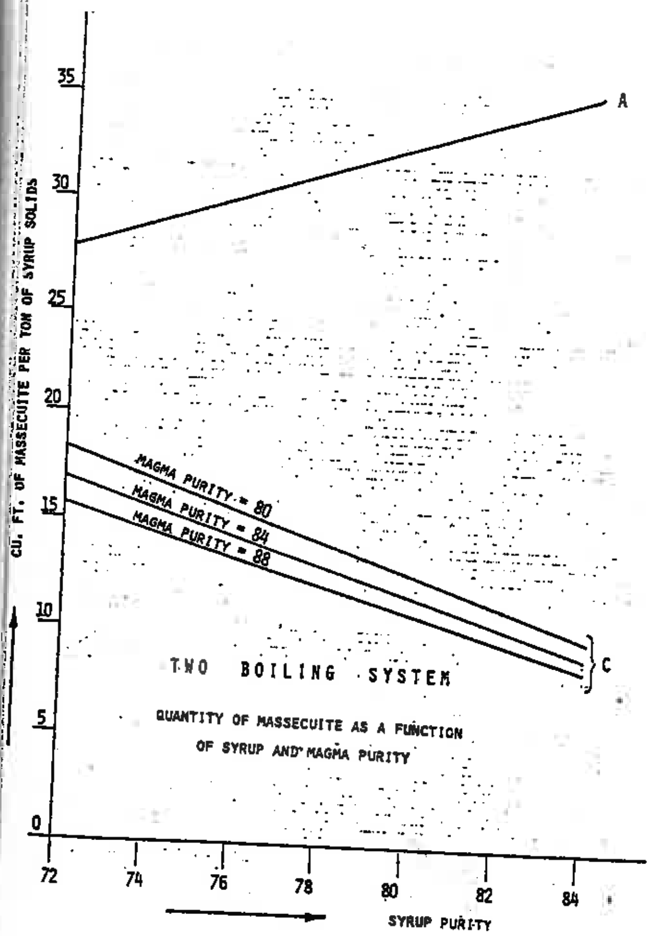


Figure 2

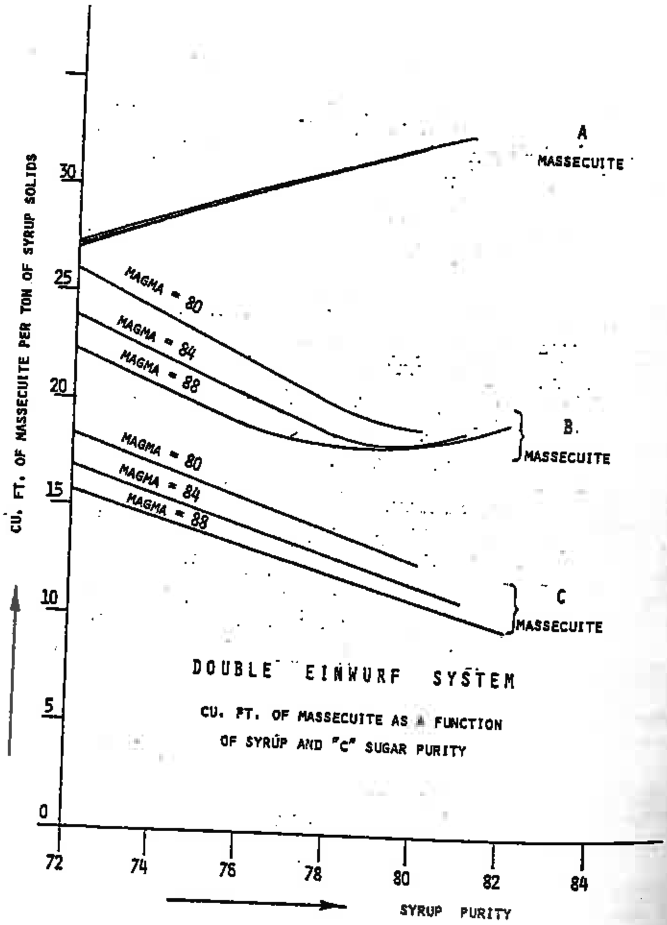


Figure 3

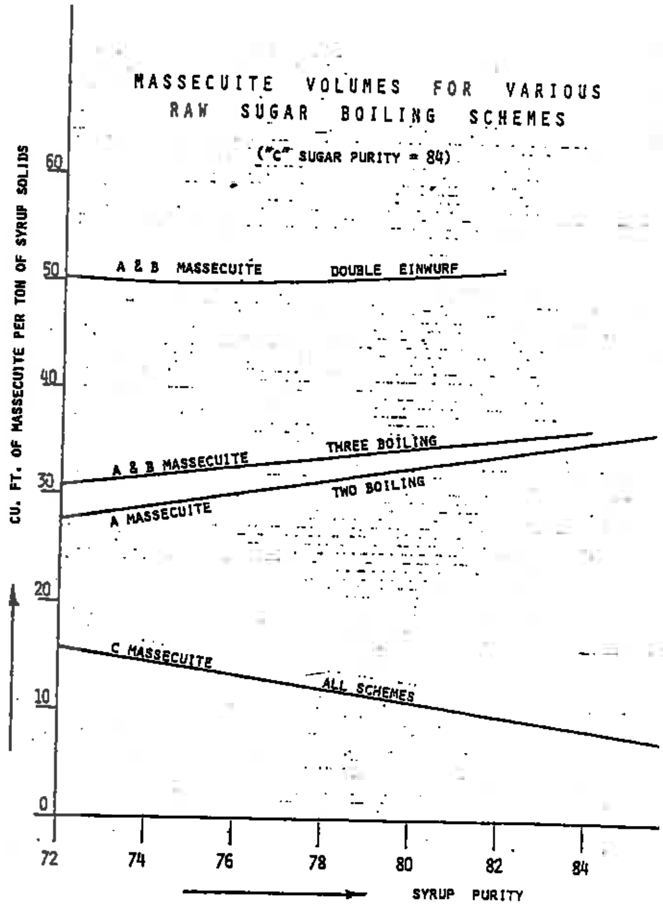


Figure 4

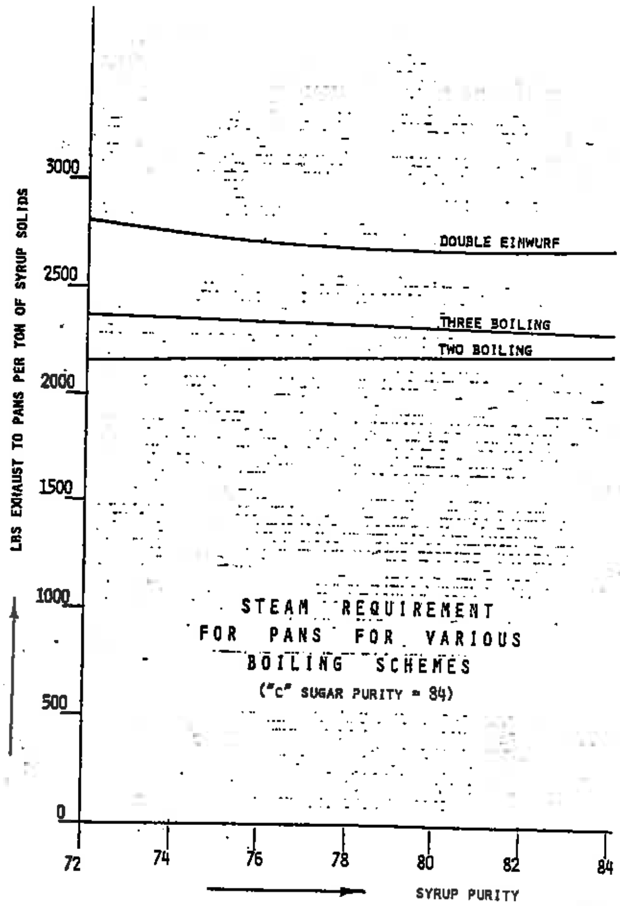


Figure 5

In the three boiling system less control of the "A" strike purity is required since the grain strike purity can be varied as required. B massecuite purities are readily controllable.

In the double einwurf system the control of strike purities is more difficult than that of the three boiling system. The large volume of the "B" sugar going to the "A" strikes makes the "A" massecuite purity increase rapidly as the syrup purity increases. The large quantity of "C" sugar going to the "B" strike also makes the "B" strike purity increase rapidly at high syrup purities.

<u>Ease of Graining:</u> Graining in the three boiling and double einwurf schemes on a 70 purity material is quite easy. Graining "A" molasses at under 60 purity as is required for the two boiling system can be difficult.

<u>Range of Application:</u> The two boiling system can operate on syrup purities up to 78-80 before the recycle of "A" molasses to the "A" strike is necessary.

METHOD FOR MATERIAL BALANCE SOLUTION

The method of solution will be described in detail for the three boiling system. The principles used in the solution of the three boiling scheme can be readily applied in the solution of other boiling schemes:

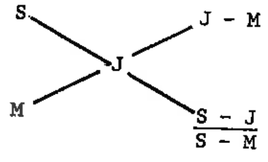
The data required is as follows:

	Brix	Purity
Syrup	X	X
Sugar	X	X
"A" Massecuite	X	not required
"B" Massecuite	X	X
"C" Massecuite	X	X
Grain	X	X
Magma	X	X
A Molasses (Diluted)	X	X
B Molasses (Diluted)	X	X
Final Molasses (Diluted)	X	X
Total pounds of syrup solids handled.		

Before describing how the calculations are performed, a thorough understanding of the SJM formula is required. Expressed in words, the formula says that given a juice (or initial material) of J purity and producing a sugar of S purity with a molasses of M purity, the percentage of the total pol in the original material which will go into the sugar will be

$$100 \times \frac{S(J - M)}{J(S - M)}$$

The above formula does not take into account any losses. Another useful formula is the Cobenze Diagram for calculating mixtures:



Here the quantities S, J, and M have the same meaning as in the SJM formula. In this formula, the ratio of sugar solids to molasses to juice solids are in the ratio of J - M to S - J to S - M. The Cobenze Diagram can thus be used to solve for the ratio of solids in streams given the purities.

In solving the three boiling system the following calculations are performed.

1. The syrup entering the pan floor is ultimately separated into sugar and final molasses. The SJM formula can be applied to these streams to find the pol in final molasses by applying the SJM formula to the pol in syrup.

2. The solids (Brix) in final molasses can be obtained by dividing the pol in final molasses by the final molasses purity.

3. Knowing the purities of the "C" Massecuite, "C" Sugar, and final molasses and the quantity of final molasses, the Cobenze Diagram can be applied to find the solids in the "C" massecuite, and the "C" Sugar. The pol in the "C" Sugar and "C" massecuite can be obtained by multiplying the solids by the purity.

4. Knowing the Grain, "B" Molasses, and "C" Massecuite purities together with the solids in the "C" Massecuite, the solids in the Grain and "B" molasses can be obtained using the Cobenze Diagram. From the solids in the Grain and "B" molasses and their respective purities the pol in the Grain and "B" molasses can be obtained.

5. The grain strike is composed of syrup and "A" molasses. Knowing all the purities and the solids in the grain strike the solids in syrup and "A" molasses can be obtained using the Cobenze Diagram, while the pol can be obtained from the solids and the respective purities.

6. The "B" massecuite and "B" sugar solids (from the B strike) can be calculated knowing the purities and the "B" molasses solids. The pol in the "B" sugar and "B" massecuite can be obtained from the respective solids and purities.

7. In steps 1 and 2 the final molasses pol and solids were determined. The total pol and brix in the "A" and "B" sugars can be obtained by subtracting the final molasses pol and solids from the pol and solids in the syrup. The pol and solids in the "A" sugar can be obtained by subtracting the pol and solids in the "B" sugar from the pol and solids in the total "A" and "B" sugars.

8. If it is desired to make the same size sugar crystal from the A and B sugars, then the magma produced from the "C" strike should be divided between the "A" and "B" strikes in proportion to the quantity of A and B sugar.

9. The total of syrup and "A" molasses solids and pol used on the "B" strike is obtained by subtracting the solids and pol in the magma used on the "B" strike from the solids and the pol in the "B" massecuite. The average purity of the syrup and "A" molasses fed to the "B" strike is calculated, and then using the Cobenze mixing diagram the quantity of solids in the syrup and "A" molasses feed to the "B" strike are calculated individually. The pol in the syrup and "A" molasses feeds to the "B" strike are calculated individually.

10. The pol and solids in the "A" molasses produced in the "A" strike is obtained by adding up the "A" molasses pol and strikes used in the "B" and grain strikes.

11. The pol and solids in the "A" strike is obtained by adding up the "A"sugar and "A" molasses.

12. The syrup required for the A strike is obtained by subtracting the syrup used in the "B" and grain strikes from the total syrup. This completes the pol and solids balance for the boiling system.

13. The lbs. material for each stream are obtained by dividing the solids by the Brix.

14. The evaporation in each strike is obtained by the difference of the total feed and the quantity of massecuite.

15. The exhaust requirement for each strike is obtained by multiplying the evaporation for each strike by the assumed pan factor.

Note: If crystal yield from each strike rather than molasses purity is the desired criterion, then the molasses purities required to achieve these yields should be recalculated and used as the starting purity assumptions for a second iteration. This process can be repeated until the desired accuracy is achieved.

Table 1

ASSUMPTIONS

1.	SYRUP BRIX	60
2.	DILUTED A & B MOLASSES	65
3.	SUGAR POL	97.6
4.	FINAL MOLASSES PURITY	30
5.	GRAIN PURITY	
	TWO BOILING	57.5
	THREE BOILING	70
	DOUBLE EINWURF	70
6.	CRYSTAL YIELD, %	
	A STRIKES	50
	B STRIKES	42
	C STRIKES	39
7.	B MAGMA PURITY (DOUBLE EINWURF ONLY)	93

Table 2

STRIKE COMPONENTS FOR VARIOUS BOILING SCHEMES

BOILING SCHEME	A	B	C	GRAIN
Two Boiling	C Sugar Magma Syrup A Molasses	-	Grain A Molasses	Syrup A Molasses
Three Boiling	C Sugar Magma Syrup	C Sugar Magma Syrup A Molasses	Grain B Molasses	Syrup A Molasses
Double Einwurf	B Sugar Magma Syrup	C Sugar Magma Syrup A Molasses	Grain B Molasses	Syrup A Molasses

Table 3

COMPARISON OF BOILING SCHEMES

Boiling System	Advantages	Disadvantages
Two Boiling	Good up to Syrup Purities of 78-80	Difficult to Control C Massecuite Purity Requires Boiling Back A Molasses at Normal Syrup Purities Difficult to Grain at Low Purity
Three Boiling	Easy Control of Strike Purities Handles High Syrup Purities Without Boiling Back	
Double Einwurf	Produces Better Quality High Grade Sugar B Strikes Easier to Boil	Cannot Handle High Syrup Purities Without Boil Back Requires About 40% More High Grade Centrifugals Requires About 15% More Exhaust Steam Than Three Boiling Scheme

TWO BOILING SYSTEM

Basis: 100,000 lb. Syrup Solids

Stream	Pol lb.	Brix lb.	Material lb.	Purity	°Brix	Cu. Ft.
"A" Strike						
Magma	23,074	27,469	31,215	84.00	88.00	
Syrup	80,000	100,000	166,667	80.00	60.00	
"A" Molasses	7,285	12,669	19,491	57.50	65.00	
Total	110,359	140,138	217,373	78.75	64.47	
Evaporation	0	0	65,048	-	-	
"A" Massecuite	110,359	140,138	152,324	78.75	92.00	1,634
"A" Sugar	72,058	73,529	73,824	98.00	99.60	
"A" Molasses (Diluted)	38,300	66,609	102,475	57.50	65.00	
"C" Strike						
Grain	10,338	17,979	20,431	57.50	88.00	
"A" Molasses	20,678	35,961	55,325	57.50	65.00	
Total	31,016	53,940	75,756	57.50	71.20	
Evaporation	0	0	20,148	-	-	
"C" Massecuite	31,016	53,940	55,608	57.50	97.00	583
"C" Sugar (Diluted)-Magma	23,074	27,469	31,215	84.00	88.00	
Final Molasses	7,941	26,471	33,089	30.00	80.00	
Grain						
"A" Molasses	10,338	17,979	27,660	57.50	65.00	
Evaporation	0	0	7,229	-	-	
Grain	10,338	17,979	20,431	57.50	88.00	223

Exhaust or Vapor Required for Sugar Boiling

Strike	Evaporation	Pan Factor	Exhaust
A	65,048	1.15	74,805
B	-	-	-
C	20,148	1.25	25,185
Grain	7,229	1.25	9,036
Total	92,425		109,026

THREE BOILING SYSTEM

Basis: 100,000 Lb. Syrup Solids

Stream	Pol lb.	Brix lb.	Material lb.	Purity	°Brix	Cu. Ft.
"A" Strike						
Magma	14,032	16,704	18,982	84.00	88.00	
Syrup	54,456	68,070	113,451	80.00	60.00	
Total	68,488	84,775	132,433	80.78	64.01	
Evaporation	0	0	40,286	-	-	
"A" Massecuite	68,488	84,775	92,147	80.78	92.00	988
"A" Sugar	43,820	44,715	44,894	98.00	99.60	
"A" Molasses (Diluted)	24,667	40,060	61,631	61.57	65.00	
"B" Strike						
Magma	9,042	10,764	12,232	84.00	88.00	
Syrup	19,514	24,393	40,656	80.00	60.00	
"A" Molasses (Diluted)	19,159	31,114	47,868	61.57	65.00	
Total	47,716	66,272	100,756	72.00	65.77	
Evaporation	0	0	30,254	-	-	
"B" Massecuite	47,716	66,272	70,502	72.00	94.00	749
"B" Sugar	28,237	28,814	28,929	98.00	99.60	
"B" Molasses	19,478	37,458	57,628	52.00	65.00	
"C" Strike						
Grain	11,537	16,481	18,729	70.00	88.00	
"B" Molasses	19,478	37,458	57,628	52.00	65.00	
Total	31,015	53,940	76,357	57.50	70.64	
Evaporation	0	0	20,749	-	-	
"C" Massecuite	31,015	53,940	55,608	57.50	97.00	582
"C" Sugar (Diluted) -Magma	23,074	27,469	31,215	84.00	88.00	
Final Molasses	7,941	26,470	33,088	30.00	80.00	
Grain						
Syrup	6,028	7,535	12,559	80.00	60.00	
"A" Molasses	5,508	8,945	13,763	61.57	65.00	
Total	11,537	16,841	26,322	70.00	62.61	
Evaporation	0	0	7,593	-	-	
Grain	11,537	16,481	18,729	70.00	88.00	204

Exhaust or Vapor Required for Sugar Boiling

Strike	Evaporation	Pan Factor	Exhaust
A	40,286	1.15	46,329
B	30,254	1.15	34,792
C	20,749	1.25	25,936
Grain	7,593	1.25	9,491
Total	98,882		116,548

DOUBLE EINWURF BOILING SYSTEM

Basis: 100,000 Lb. Syrup Solids

Stream	Pol. lb.	Brix lb.	Material lb.	Purity	°Brix	Cu. Ft.
"A" Strike						
"B" Sugar Magma	37,510	40,334	45,834	93.00	88.00	
Syrup	78,117	97,646	162,744	80.00	60.00	
Total	115,628	137,980	208,578	83.80	66.15	
Evaporation	0	0	58,599	-	-	
"A" Massecuite	115,628	137,980	149,979	83.80	92.00	1,609
"A" Sugar	72,058	73,529	73,824	98.00	99.60	
"A" Molasses (Diluted)	43,569	64,451	99,156	67.60	65.00	
"B" Strike						
"C" Sugar Magma	23,074	27,469	31,215	84.00	88.00	
Syrup	0	0	0	-	-	
"A" Molasses	36,940	54,645	84,070	67.60	65.00	
Total	60,014	82,115	115,285	73.08	71.22	
Evaporation	0	0	27,928	-	-	
"B" Massecuite	60,014	82,115	87,356	73.08	94.00	928
"B" Sugar Magma (Diluted)	37,510	40,334	45,834	93.00	88.00	
"B" Molasses (Diluted)	22,504	41,780	64,278	53.86	65.00	
"C" Strike						
Grain	8,511	12,159	13,817	70.00	88.00	
"B" Molasses	22,504	41,780	64,278	53.86	65.00	
Total	31,015	53,940	78,095	57.50	69.06	
Evaporation	0	0	22,487	-	-	
"C" Massecuite	31,015	53,940	55,608	57.50	97.00	582
Magma ("C" Sugar Diluted)	23,074	27,469	31,215	84.00	88.00	
Final Molasses (as produced)	7,941	26,470	33,088	30.00	80.00	
Grain						
Syrup	1,882	2,353	3,922	80.00	60.00	
"A" Molasses	6,628	9,805	15,085	67.60	65.00	
Total	8,511	12,159	19,007	70.00	63.96	
Evaporation	0	0	5,190	-	-	
Grain	8,511	12,159	13,817	70.00	88.00	151

Exhaust or Vapor Required for Sugar Boiling

Strike	Evaporation	Pan Factor	Exhaust
A	58,599	1.15	67,389
B	27,928	1.15	32,117
C	22,487	1.25	28,109
Grain	5,190	1.25	6,488
Total	114,204		134,103