



OFFICE MEMORANDUM

DATE: November 29, 1978

TO: J. W. Burge
Engineer of Materials

FROM: L. T. Oehler

SUBJECT: "Salt Degradation Study," Research Project 77 TI-427, Research Report No. R-1100.

This report contains some statistics obtained from the data sent to us on November 2, 1978. The Aggregate Sampling forms are included as an appendix for your reference.

The following is Mr. Wen-Hou Kuo's report on the analysis of these data.

Thirty samples were taken from the salt shipment (Purchase Order No. 10022) loaded at Goderich, Ontario on September 12, 1978. This shipment was unloaded and resampled at Alpena for the purpose of studying the effect of transshipment on salt gradation. Thirty samples were also taken from the salt shipment (Purchase Order No. 10025) loaded at Goderich, Ontario on September 25, 1978; this shipment was unloaded and resampled at Holland, Michigan.

A multivariate statistical analysis of variance program was used to analyze the data of these two shipments. The results are:

- 1) The average salt gradations of 30 samples obtained before and after transshipment for each purchase order are presented in Tables 1 and 2.

TABLE 1
ESTIMATES OF SALT GRADATION OF THE
SHIPMENT (PURCHASE ORDER 10022)
BEFORE AND AFTER TRANSSHIPMENT

Sieve Size	Total Percent Passing Each Sieve		Difference	Significant at the 0.05 Level
	Before Shipment	After Shipment		
3/8 in.	99.20	100.00	-0.80	No
No. 4	72.97	76.03	-3.06	No
No. 8	29.43	29.97	-0.54	No
No. 30	3.73	3.93	-0.20	No

TABLE 2
ESTIMATES OF SALT GRADATION OF THE
SHIPMENT (PURCHASE ORDER 10025)
BEFORE AND AFTER TRANSSHIPMENT

Sieve Size	Total Percent Passing Each Sieve		Difference	Significant at the 0.05 Level
	Before Shipment	After Shipment		
3/8 in.	99.23	99.32	-0.09	No
No. 4	71.00	61.19	9.81	Yes
No. 8	28.93	13.23	15.70	Yes
No. 30	4.70	1.87	2.83	Yes

2) At the 0.05 significance level, the transshipment had no significant effect on the salt gradation of the shipment from Goderich to Alpena (Purchase Order 10022). However, for the shipment from Goderich to Holland (Purchase Order 10025) transshipment has significantly changed the total percent passing the No. 4, No. 8, and No. 30 sieves.

3) The loading, hydrating, and unloading processes are probably the major factors changing the gradation of the salt shipment. The loading process presumably degrades salt because of abrasion. After salts are loaded onto the ship, the hydrating process probably takes place. The hydrating process presumably makes the salt coarser. Finally, the unloading process degrades the salt again. Thus, these three processes occur in order with opposite effects on the salt gradation. If the loading and unloading processes are the dominating factors, the total percent passing each sieve after transportation should be greater than or equal to the percent passing before transportation. This is the case for the shipment shown in Table 1 (Purchase Order 10022), but not the case for the shipment shown in Table 2 (Purchase Order 10025).

4) Based on the argument presented in (3) and the statistical conclusions presented in (2), we can make the following observations.

a) The net result of the loading-unloading process and the hydrating process resulted in no significant change in the salt gradation of the Goderich-Alpena shipment.

b) For the shipment from Goderich to Holland, converting the figures in Table 2 into the percentages retained on each sieve as shown in Table 3, we see that the total percent retained on the No. 4 and No. 8 sieves increased by 15.79. This is the net result of the loading-unloading and hydrating processes. We conclude that the hydrating process is the dominating factor in this shipment.

TABLE 3
ESTIMATES OF THE PERCENT RETAINED ON EACH
SIEVE OF THE SHIPMENT (PURCHASE ORDER 10025)
BEFORE AND AFTER TRANSSHIPMENT

Sieve Size	Percent Retained on Each Sieve		Difference
	Before Transshipment	After Transshipment	
3/8 in.	0.77	0.68	0.09
No. 4	28.23	38.13	-9.90
No. 8	42.07	47.96	-5.89
No. 30	24.23	11.36	12.87
Passing No. 30	4.70	1.87	2.83

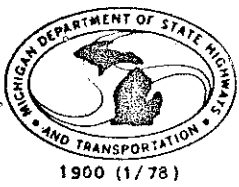
TESTING AND RESEARCH DIVISION

Le Roy T. Oshley

Engineer of Research

LTO:WHK:bf

APPENDIX



AGGREGATE INSPECTION DAILY REPORT

Job No. Maintenance M. D. S. H. & T.	Page of
Control Section Identity Purchase Order #10022	
Report No. 1	Date Tested 9/12/78

Source of Material: Pit Name Sifto Salt Co. - Goderich, Ontario Pit No. _____
 Producer Domtar Industries, Inc. Contractor Boat name: E. B. Barber (Algoma Central Railways)

Test No.	Specification	Sampled from: Car Initial and Truck Number or Stock Pile Bins	CUMULATIVE PER CENT PASSING												Loss by Woody ring	Fineness Modulus Base =	Crushed Material	Organic Plate No.	Thin or Elongated Pieces	Incusted Particles More than 1/3 Area	Incusted Particles Total	Soft Particles	Chert	Sum of Soft Particles and Chert
			Specification Requirements																					
			Sieve Openings - Inches or Sieve Number																					
			2 1/2	2	1 1/2	1	3/4	1/2	3/8	4	8	16	30	50										
13								100	(86)	41		4											0.1	
14								100	(85)	30		3											---	
15								100	(90)	(55)		6											---	
16								100	81	39		5											---	
17								100	79	43		5											---	
18	Salt							(97)	76	26		1											---	
19								(99)	50	6		1											---	
20								100	77	32		5											---	
21									100	(83)	38		7											---
22								(96)	46	4		1											---	
23								(99)	64	21		1											---	
24								100	52	13		2											---	
Average of Daily tests																								

Material (specification)	Salt	Kit No. K.D.
Cubic yards or tons tested today *		Hours of Plant Operation _____
Previous cumulative total *		
Cumulative total tested to date *		

* Quantities based on Contractor's estimate.

Remarks: Boat en route to Alpena

Copies: District Materials Supervisor (original and one copy)

District Materials Supervisor - Using District (when applicable)

Project Engineer Maintenance Dept.
M. D. S. H. & T.
Lansing, Michigan

THIS MATERIAL _____ SPECIFICATION REQUIREMENTS. IT IS Accepted

(Signed) /s/ L. C. Woodyard
Plant Inspector

Metro 569-3993
 Field Address Phone No.



1900 (1/78)

AGGREGATE INSPECTION DAILY REPORT

Job No.

Control Section Identity

P.O. #10022

Report No.

1

Date Tested

Oct. 78

Page
2
of
3

Source of Material: Pit Name _____

Pit No. _____

Producer Domtar Co.

Contractor

Tri-County Enterprises Co.

Test No.	Specification	Sampled from: Car Initial and Number, Truck Number or (Stock Pile)	CUMULATIVE PER CENT PASSING													Moisture	Fineness Modulus Base =	Crushed Material	Organic Plate No.	Thin or Elongated Pieces	Incusted Particles More than 1/3 Area	Incusted Particles Total	Soft Particles	Chert	Sum of Soft Particles and Chert															
			Specification Requirements																																					
			Sieve Openings - Inches or Sieve Number																																					
			2 1/2	2	1 1/2	1	3/4	1/2	3/8	4	8	16	30	50	100	200																								
11	NaCl								100	77	38		(8)																											
12	NaCl								100	(83)	39		5																											
13	NaCl								100	68	22		2																											
14	NaCl	Dock at Alpena							100	70	25		3																											
15	NaCl								100	73	28		3																											
16	NaCl								100	69	30		6																											
17	NaCl								100	70	27		5																											
18	NaCl								100	(86)	43		6																											
19	NaCl								100	79	33		4				(2.1)																							
20	NaCl								100	76	29		3																											
Average of Daily tests																																								

Material (specification)	NaCl	(Rock Salt)	Kit No.
Cubic yards or tons tested today *	See Page #3		Hours of Plant Operation
Previous cumulative total *			
Cumulative total tested to date *			
* Quantities based on Contractor's estimate.			

Remarks: *** "For Information Only - Salt Study"**

Copies: District Materials Supervisor (original and one copy)

District Materials Supervisor - Using District (when applicable)

Project Engineer _____

Maint. Div.

E. Wolf

THIS MATERIAL _____ SPECIFICATION

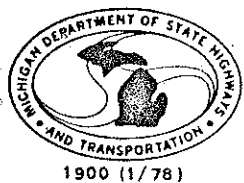
REQUIREMENTS. IT IS _____ *

(Signed) /s/ Ed Ayers - G. Tomasek

Plant Inspector

Alpena Lab

Field Address _____ Phone No. _____



1900 (1/78)

AGGREGATE INSPECTION DAILY REPORT

Job No. Maintenance M.D.S.H. &T.	Page 1 of 3
Control Section Identity Purchase Order #10025	
Report No. 1	Date Tested 9/25/78

Source of Material: Pit Name Sifto Salt Co. - Goderich, Ontario Pit No. _____
 Producer Domtar Industries, Inc. Contractor Boat name: Ago Canyon (Algoma Central)

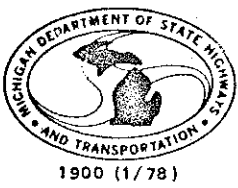
Test No.	Specification	Sampled from: Car Initial and Number, Truck Number or Stack File Bins	CUMULATIVE PER CENT PASSING													Loss by Wash- ing	Fineness Modulus Base =	Crushed Material Organic Plate No.	Thin or Elongated Pieces	Increased Particles More than 1/3 Area	Increased Particles Total	Soft Particles	Chert	Sum of Soft Particles and Chert						
			Specification Requirements																											
			Sieve Openings - Inches or Sieve Number																											
			2 1/2	2	1 1/2	1	3/4	1/2	3/8	4	8	16	30	50	100	200														
1									99	64	26		4			0.1														
2									100	80	40		7																	
3									100	73	30		4																	
4									100	72	32		3																	
5									100	76	31		5																	
6									94	70	36		6																	
7	Salt								99	48	8		1																	
8									94	69	40		9																	
9									100	75	24		5																	
10									99	70	29		5																	
11									100	75	34		7																	
12									99	72	32		6																	
Average of Daily tests																														

Material (specification)	Salt	Kit No.	K.D.
Cubic yards or tons tested today *		Hours of Plant Operation	
Previous cumulative total *			
Cumulative total tested to date *			

* Quantities based on Contractor's estimate.

Remarks: Boat en route to Holland, Mich.

Copies: District Materials Supervisor (original and one copy)	THIS MATERIAL _____ SPECIFICATION REQUIREMENTS. IT IS <u>Accepted</u> (Signed) <u>/s/ L. C. Woodyard</u> <i>Plant Inspector</i> <u>Metro 569-3993</u> <i>Field Address</i> _____ <i>Phone No.</i> _____
District Materials Supervisor - Using District (when applicable)	
Project Engineer <u>Maintenance Dept.</u>	
<u>M.D.S.H. &T.</u> <u>Lansing, Mich.</u>	



1900 (1/78)

AGGREGATE INSPECTION DAILY REPORT

Job No.	Maintenance M.D.S.H.&T.	Page 2 of 3
Control Section Identity	Purchase Order #10025	
Report No.	1	Date Tested 9/25/78

Source of Material: Pit Name Sifto Salt Co. - Goderich, Ontario Pit No. _____
 Producer Domtar Industries, Inc. Contractor Boat name: Ago Canyon (Algoma Central)

Test No.	Specification	Sampled from: Car Initial and Number, Truck Number or Stock Pile Bins	CUMULATIVE PER CENT PASSING													Weekly Weight Tons	Fineness Modulus Base =	Crushed Material Organic Plate No.	Thin or Elongated Pieces	Incrustrated Particles More than 1/3 Area	Incrustrated Particles Total	Soft Particles	Chert	Sum of Soft Particles and Chert												
			Specification Requirements																																	
			Sieve Openings - Inches or Sieve Number																																	
			2 1/2	2	1 1/2	1	3/4	1/2	3/8	4	8	16	30	50	100										200											
13							100	61	21		3				0.1																					
14							99	73	30		4				---																					
15							100	83	42		9				---																					
16							100	89	49		8				---																					
17							100	79	27		3				---																					
18							100	63	20		3				---																					
19	Salt						100	76	37		6				---																					
20							100	77	28		3				---																					
21							99	44	8		1				---																					
22							99	57	13		2				---																					
23							99	72	32		6				---																					
24							100	72	29		6				---																					
Average of Daily tests																																				

Material (specification)	Salt	Kit No.
Cubic yards or tons tested today *		Hours of Plant Operation
Previous cumulative total *		
Cumulative total tested to date *		

* Quantities based on Contractor's estimate.

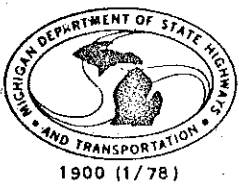
Remarks: Boat en route to Holland, Mich.

Copies: District Materials Supervisor (original and one copy)

District Materials Supervisor - Using District (when applicable)

Project Engineer Maintenance Dept.
M.D.S.H. & T.
Lansing, Mich.

THIS MATERIAL _____ SPECIFICATION
 REQUIREMENTS. IT IS Accepted
 (Signed) /s/ L. C. Woodyard
Plant Inspector
Metro 569-3993
 Field Address Phone No.



AGGREGATE INSPECTION DAILY REPORT

Job No.	Maintenance M.D.S.H. &T.	Page 3 of 3
Control Section Identity	Purchase Order #10025	
Report No.	1	Date Tested 9/25/78

Source of Material: Pit Name Sifto Salt Co. - Goderich, Ontario Pit No. _____
 Producer Domtar Industries, Inc. Contractor Boat name: Ago Canyon (Algoma Central)

Test No.	Specification	Sampled from: Car Initial and Number, Truck Number or Stock Pile Bins	CUMULATIVE PER CENT PASSING													Loss by Washing % 0.5	Fineness Modulus Base =	Crushed Material Organic Plate No.	Thin or Elongated Pieces	Incusted Particles More than 1/3 Area	Incusted Particles Total	Soft Particles	Chert	Sum of Soft Particles and Chert																
			Specification Requirements																																					
			Sieve Openings - Inches or Sieve Number																																					
			2 1/2	2	1 1/2	1	3/4	1/2	3/8	4	8	16	30	50	100										200															
25							100	(85)	47		(8)			0.1																										
26							(99)	70	27		4																													
27	Salt						100	73	27		4																													
28							100	74	30		5																													
29							(99)	76	18		1																													
30							(99)	62	21		3																													
Average of Daily tests					c	c			99	71	29		5																											

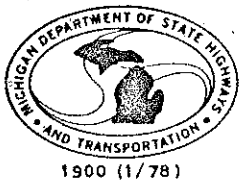
Material (specification)	Salt	Kit No.	K.D.
xxxxxxx tons tested today *ap.	14,700	Hours of Plant Operation	
Previous cumulative total *	0		
Cumulative total tested to date *	14,700		

* Quantities based on Contractor's estimate.

Remarks: Boat en route to Holland

Copies: District Materials Supervisor (original and one copy)
 District Materials Supervisor - Using District (when applicable)
 Project Engineer Maintenance Dept.
M.D.S.H. &T.
Lansing, Mich.

THIS MATERIAL _____ SPECIFICATION
 REQUIREMENTS. IT IS Accepted
 (Signed) /s/ L. C. Woodyard
Plant Inspector
Metro 569-3993
 Field Address Phone No.



1900 (1/78)

AGGREGATE INSPECTION DAILY REPORT

Job No.	P. O. 10025	Page 1 of 3
Control Section Identity		
Report No.	1	Date Tested 9/28, 29/78

Source of Material: Pit Name _____ Pit No. _____
 Producer **Domtar Industries** Contractor **MDSH&T**

Test No.	Specification	Sampled from: Car Initial and Number, Truck Number or Stock Pile	CUMULATIVE PER CENT PASSING													Loss by Washing	Fineness Modulus Base =	Crushed Material	Organic Plate No.	Thin or Elongated Pieces	Incrusted Particles More than 1/3 Area	Incrusted Particles Total	Soft Particles	Chert	Sum of Soft Particles and Chert							
			Specification Requirements																													
			Sieve Openings - Inches or Sieve Number																													
			2 1/2	2	1 1/2	1	3/4	1/2	3/8	4	8	16	30	50	100	200																
1									100	60	9		1																			
2									99	73	24		2																			
3									99	40	3		1																			
4									99	45	3		1																			
5	Rock Salt Stock Pile at Verplank Dock Holland								100	69	12		2																			
6									99	43	3		1																			
7										100	82	33		4																		
8										100	72	21		2																		
9										100	67	18		1																		
10										100	76	30		4																		
11										99	59	16		2																		
12										100	47	5		1																		
Average of Daily tests																																

Material (specification)		Kit No.	
Cubic yards or tons tested today *		Hours of Plant Operation	
Previous cumulative total *			
Cumulative total tested to date *			

* Quantities based on Contractor's estimate.

Remarks: **"For Information Only - Salt Study"**

Tests run by **A. Hagen**

Copies: District Materials Supervisor (original and one copy)

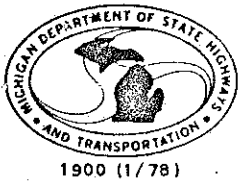
District Materials Supervisor - Using District (when applicable)

Project Engineer **Maint. Div., Lansing**

THIS MATERIAL _____ SPECIFICATION REQUIREMENTS, IT IS _____

(Signed) **/s/ A. Branham**
 Plant Inspector

Grand Rapids
 Field Address _____ Phone No. _____



1900 (1/78)

AGGREGATE INSPECTION DAILY REPORT

Job No. P. O. 10025	Page 3 of 3
Control Section Identity	
Report No. 1	Date Tested 9/28, 29/78

Source of Material: Pit Name _____ Pit No. _____
 Producer **Domtar Industries** Contractor **MDSH&T**

Test No.	Specification	Sampled from: Car, Initial and Number, Truck Number or Stock Pile	CUMULATIVE PER CENT PASSING												Moisture	Loss by Wash- ing	Fineness Modulus Base =	Crushed Material	Organic Plate No.	Thin or Elongated Pieces	Incrustrated Particles More than 1/3 Area	Incrustrated Particles Total	Soft Particles	Chert	Sum of Soft Particles and Chert
			Specification Requirements																						
			Sieve Openings - Inches or Sieve Number																						
			2 1/2	2	1 1/2	1	3/4	1/2	3/8	4	8	16	30	50											
25							100	78	22		3			0.0											
26							99	65	12		2														
27							99	60	14		2														
28							100	69	14		2														
29							99	66	15		2														
30							99	50	7		2														
31							100	57	11		1														
Average of Daily tests							99	63	14		2														

Material (specification)		Kit No.	
Cubic yards or tons tested today *		Hours of Plant Operation	
Previous cumulative total *			
Cumulative total tested to date *			

* Quantities based on Contractor's estimate.

Remarks: **"For Information Only - Salt Study"**
Big Rapids 800 tons, White Cloud 1500 tons, Newaygo 500 tons, Morley 300 tons,
Hart 500 tons, Coopersville 90 tons
Tests run by A. Hagen

Copies: District Materials Supervisor (original and one copy)
 District Materials Supervisor - Using District (when applicable)
 Project Engineer **Maint. Div., Lansing**

THIS MATERIAL _____ SPECIFICATION
 REQUIREMENTS. IT IS _____
 (Signed) **/s/ A. Branham**
Plant Inspector
Grand Rapids
 Field Address _____ Phone No. _____