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IN-PLACE 22A AGGREGATE ACCEPTANCE SAMPLING PROCEDURES

MICHIGAN DEPARTMENT OF TRANSPORTATION

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In-place 22A aggregate
acceptance sampling
procedures

IN-PLACE 22A AGGREGATE
ACCEPTANCE SAMPLING PROCEDURES

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Introduction and Conclusions

Prior to 1977, it was the practice of the Michigan Department of Transportation to inspect 22A aggregate at the production site (stockpile). Since stockpiled aggregate will undergo a 'remixing' when transported to the construction site, and a further remixing as it is spread over the roadbed by earthmoving and grading machines, the Department was concerned about the possibility of accepted stockpiled aggregate being unacceptable after placement. The possibility of this occurrence is closely related to the characteristics of the stockpiled aggregate inspection procedures, and was discussed in the report, "Aggregate Gradation Quality Control" (MDOT Research Report R-1024, 1976). Generally, this report favored the practice of inspecting aggregates at the construction site. This idea was also the prevailing trend in the aggregate industry in 1977. For these reasons, the End-Result Aggregate Committee was formed to develop in-place aggregate inspection procedures.

Based on information presented in Report R-1024, the committee adopted an inspection plan based on 'acceptance sampling by attribution' as a decision rule to accept or reject in-place aggregates. The procedures developed therein were used to inspect the following four construction projects:

1) Project FR-64015/11535A
2) Project M-36021/10139A
3) Project FR-23092/10729A
4) Project I-50062/00703A

The sampling, testing, and acceptance procedures used to inspect the above four construction projects are described in Section I, and the test results are analyzed in Section II. Based on these results, and comments from participating District Engineers as well as Aggregate Inspectors, we conclude that it is feasible and beneficial to implement in-place aggregate inspection procedures. To further reduce testing cost without substantially sacrificing the power to reject poor quality aggregate, we utilized sequential testing procedures to modify the in-place aggregate acceptance sampling procedures presented in Section I. These modified inspection procedures are discussed in Section III. In this section, we show that the modified inspection procedures can reduce testing cost by at least 29.21 percent, depending on the produced aggregate quality level. We mention in Section II that the lot size can be doubled if the in-place aggregate uniformity is high. If this option is also used, the testing cost reduction will be at least 64.63 percent. We demonstrate that this saving is large enough to justify the slight loss in statistical power to reject poor quality aggregate. We therefore recommend the use of the modified in-place aggregate acceptance sampling procedures for future in-place aggregate inspection.

I
IN-PLACE 22A AGGREGATE ACCEPTANCE SAMPLING PROCEDURES (SSFD Inspection Procedures)

The in-place aggregate inspection procedures presented in this section were used to inspect four construction projects: FR-64015/11535A, M-36021/10139A, FR-23092/10729A, and I-50062/00703A. The inspection procedures are derived from the so-called 'Single-Sample Fraction-Defective Plan.' For this reason, we shall refer to the inspection procedures as the SSFD inspection procedures for analysis purposes. We specify the sampling and testing methods, and the lot acceptance criteria of the SSFD inspection procedures as follows.

Lot Size

The aggregate base course is accepted by lots. Each lot is 18,000 sq yd. The last lot is 18,000 sq yd plus any fractional lot less than 9,000 sq yd; or is a fractional lot 9,000 sq yd or more. For example, if the width of a two-lane aggregate base course is 51 ft, and if only one lane is constructed at a time, then the lot size is 6,353 by 25.5 ft. That is, the width of the construction base is considered, from the sampling point of view, to be 25.5 ft because of the construction procedure.

When to Sample

The aggregate is sampled after it has been placed on the grade and shaped to the approximate final cross-section, but prior to the final compaction.

Sample Size

Each lot is equally divided into 12 strata as shown in Figure 1. One spot is randomly chosen from each stratum. From each spot, one aggregate sample of 20 to 30 lb is taken. Thus, we have 12 (stratified) random samples from each lot.

Sampling Layout

When a lot is ready for inspection, the Inspector randomly chooses 12 spots from which he takes 12 samples. In order to fulfill the randomness requirement, the Inspector would have to know how to use a table of random numbers to obtain sampling spots. This is time-consuming and is not recommended for field work. For this reason, we have provided a predesigned

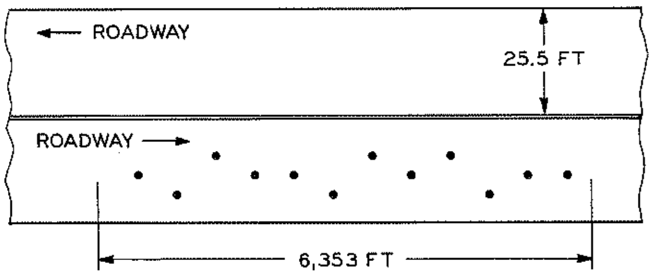
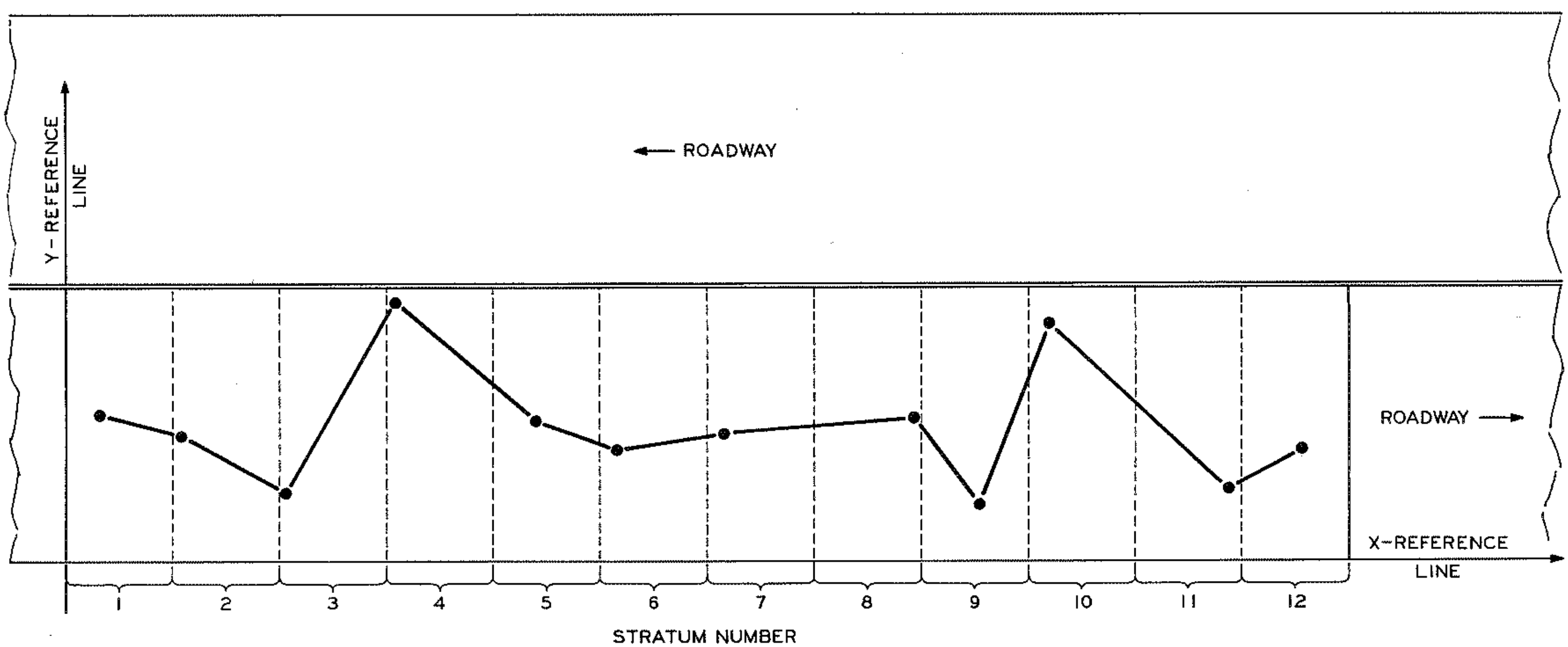


Figure 1. Lot stratification pattern.

Figure 2. Sampling layout No. 245 for lot size 6,353 by 25.5 ft.



package of sampling layouts for each lot size. Every sampling layout provides 12 random spots from each of which a sample is taken. With this predesigned package of sampling layouts, the Inspector need only use a simple method to randomly choose a sampling layout from the package. The format of sampling layouts is explained below.

As an example, the major lot sizes of Construction Project M-36021 are described in Table 1. For each of the two lot sizes, a package of 216 sampling layouts is designed by using a random number generated computer program. Each sampling layout provides 12 random spots from which samples are to be taken. The location of each spot is indicated by two numbers which are distances to the chosen Y-reference and X-reference lines, respectively. The Y-reference line is one of the two edges transverse to the roadway, while the X-reference line is one of the two construction edges of the roadway.

TABLE 1
Major Lot Sizes of Project M-36021

Base Width	25.2 ft	22 ft
Lot Length	6,353 ft	7,364 ft

To make the above explanations more understandable, the 216 sampling layouts for the lot size 6,353 by 25.5 ft are presented in Appendix A. The sampling layout No. 245 of this package is presented in Table 2 and, graphically, in Figure 2.

Sampling Procedure

When a lot is ready for inspection, the Inspector rolls a die three times. The three numbers shown determine which sampling layout in the package designed for that lot size should be used to sample aggregates. This constitutes the general sampling procedures for a regular lot (see Example 1, below). Occasionally, an irregular lot will be encountered. The sampling procedures for irregular lots are described in Examples 2 through 4.

Example 1 (regular lot) - Suppose that the base width is 25.5 ft. By definition, the length of a lot is 6,353 ft (= 18,000 x 9/25.5). When a regular lot is ready for inspection, the Inspector rolls a die three times.

Suppose that the three numbers are 2, 4, and 5, respectively. Then, the sampling layout No. 245 of the package of sampling layouts designed for the lot size of 6,353 by 25.5 ft is used to sample aggregates from that lot. This particular layout is shown in Figure 2.

TABLE 2
Sampling Layout No. 245
for Lot Size 6,353 ft by 25.5 ft

Stratum Number	Distances to Reference Lines	
	Y-Reference	X-Reference
1	161	13.8
2	536	11.9
3	1072	6.6
4	1612	24.8
5	2339	13.1
6	2726	10.7
7	3257	12.0
8	4220	13.8
9	4535	5.6
10	4857	22.3
11	5773	6.9
12	6118	10.7

Example 2 (last lot) - The base width is 25.5 ft. However, the length of a lot is not 6,353 ft, but L ft (a fractional lot). Usually, this lot is the last one to be inspected. The sampling procedures for this type of irregular lot are described below.

a) The Inspector rolls a die three times. Suppose that the three numbers are 2, 4, and 5, respectively.

b) The sampling layout No. 245 is identified from the package of sampling layouts designed for the regular lot (6,353 by 25.5 ft).

c) Every number corresponding to the distance to the Y-reference line is multiplied by the factor L/6,353.

d) The adjusted layout is then used to sample aggregates from that lot. For example, suppose that L = 4,764.75 ft (three-fourths of the regular length). The adjusted layout for this lot is obtained by multiplying every number in column Y-reference of Table 2 by the factor 0.75 (4,764.75/6,353). The adjusted layout for this lot is presented in Table 3.

TABLE 3
Adjusted Sampling Layout No. 245
for An Irregular Lot Size
(4764.75 ft by 25.5 ft)

Stratum Number	Distances to Reference Lines	
	Y-Reference	X-Reference
1	121	13.8
2	402	11.9
3	804	6.6
4	1209	24.8
5	1754	13.1
6	2045	10.7
7	2443	12.0
8	3165	13.8
9	3401	5.6
10	3643	22.3
11	4330	6.9
12	4589	10.7

Example 3 - Occasionally, the base width is not uniform throughout a lot. In this situation, distances to the X-reference line should be properly adjusted. Suppose that most of the base in this area for inspection has a width of W ft. Denote L to be the length of the regular lot determined according to this base width. We also denote W_i to be the base width of the i-th stratum of this lot. Then, the sampling procedures for this type of irregular lot pattern are described below.

a) The Inspector rolls a die three times. Suppose that the three numbers are 2, 4, and 5, respectively.

b) The sampling layout No. 245 is identified from the package of sampling layouts designed for lot size L ft by W ft.

c) The number corresponding to the distance to the X-reference line in the i-th stratum is multiplied by W_i/W, $i = 1, \ldots, 12$.

d) The adjusted layout is then used to sample aggregates from this lot. As an example, suppose that

$$W_i = \begin{cases} 25.5 \text{ ft}, & i = 1, \ldots, 11 \\ 22.0 \text{ ft}, & i = 12 \end{cases}$$

Since most of the base width is 25.5 ft, the size of the regular lot would be 6,353 by 25.5 ft. In this case, we need only to adjust the number corresponding to the distance to the X-reference line in the 12-th stratum. The adjustment factor is 22/25.5. The adjusted layout is presented in Table 4.

Example 4 (Combination of Examples 2 and 3) - The base width is not uniform throughout a fractional lot. In this situation, the regular sampling layout should be adjusted according to methods described in Examples 2 and 3.

TABLE 4
Adjusted Sampling Layout No. 245
for An Irregular Lot Size
(W_i = 25.5 ft , i=1,..,11 & W_{12} = 22 ft)

Stratum Number	Distances to Reference Lines	
	Y-Reference	X-Reference
1	161	13.8
2	536	11.9
3	1072	6.6
4	1612	24.8
5	2339	13.1
6	2726	10.7
7	3257	12.0
8	4220	13.8
9	4535	5.6
10	4857	22.3
11	5773	6.9
12	6118	9.2 (*)

(*) Adjusted Number (10.7 x 22 / 25.5)

Testing Procedure

When 12 samples are collected from a lot, they should be tested immediately by the specified testing method (conventional hand testing method or mechanical testing method). The test results should be immediately sent to the Inspector to facilitate lot acceptance.

We shall see later that the test results of each sample affect lot acceptance. Therefore, every sample should be properly marked for later reference. For example, if a sample of 20 to 30 lb is taken from the fifth stratum of lot 2, the bag containing this sample can be marked as 2-5. It is also advised that the Inspector prepares a list of lot locations prior to construction.

Aggregate Quality Classification

Each sample is defined as defective if it fails to meet any one of the specification limits given in Table 5. Based on the test results of the 12 samples from a lot, each lot is classified into one of the four lot quality categories specified in Table 6.

TABLE 5
Specification Limits for In-place 22A Aggregate

Specification Item		Lower Limit	Upper Limit
Aggregate Gradation (Percent Passing Various Sieves)	1-in.	100	100
	3/4-in.	88	100
	3/8-in.	63	87
	No. 8	28	52
	L. B. W.	3	9 (*)
Percent Crushed Aggregate		25	100
Deval Abration Value for Bituminious Pavement	Uncrushed Aggregate	0	20
	Crushed Aggregate	0	30
Deval Abrasion Value for Concrete Pavement	Uncrushed Aggregate	0	40
	Crushed Aggregate	0	50

(*) If the aggregate is produced entirely by crushing rock, boulders, cobbles, slag, or concrete, the maximum limit is increased to 11 percent. "L.B.W." stands for the loss-by-washing.

TABLE 6
Lot Quality Classification

Quality Category	Number of Samples with Loss-By-Washing Exceeding 10 Percent (*)	Number of Defective Samples
Q-1	None	0
Q-2	None	1 - 6
Q-3	None	Over 6
Q-4	At Least One	------

(*) If the aggregate is produced entirely by crushing rock, boulders, cobbles, slag, or concrete, the maximum limit is changed to 12 percent.

TABLE 7
Unit Price Reduction Scheduled for Each
Lot Quality Level

Number of Defective Samples in the Lot	Percent Decrease on The Contracted Price (Penalty Level)	
	Bituminous Pavement Surface	Concrete Pavement Surface
1	0	0
2	5	5
3	10	10
4	15	15
5	25	25
6	50	50
7 or more	50	pay as subbase (C.I.P.)

Action Rules

When the Inspector receives the test results of the 12 samples from a lot, he records the total number of defective samples and checks to see in which of the four quality categories (Table 6) the lot falls. The action to be taken for each lot quality category is described as follows:

(A1) The lot falling in the Q-1 category shall be accepted at 100 percent of the contract unit price.

(A2) For lots falling in the Q-2 category, the contractor may replace the substandard material or may correct the material by blending, provided that the blending method is accepted by the Project Engineer. When the contractor replaces or corrects the material, the entire lot will be resampled, tested, and categorized as if it were a new lot. If the contractor does not replace or correct the defective material, the unit price for the lot will be adjusted in accordance with Table 7.

(A3) For lots falling in the Q-3 category, in the case of concrete pavement surfaces, the procedures in (A2) will be followed; for bituminous pavement surfaces, the Project Engineer will make the decision as to whether the material can remain in place or if correction of the lot is required. If correction of the lot is allowed, the procedures in (A2) are then followed.

(A4) For lots falling in the Q-4 category, the substandard material must be replaced with new material. Then, the entire lot will be resampled, tested, and categorized as it is a new lot.

II

EVALUATION OF THE IMPLEMENTED SSFD IN-PLACE 22A AGGREGATE INSPECTION PROCEDURES

When a construction project was completed, we reviewed the in-place aggregate inspection procedures with the contractor, Aggregate Inspectors, project crew members, and Testing and Research Division personnel involved with the aggregate base inspection. The consensus was that the implemented SSFD inspection procedures worked well with no unusual problems. Some minor problems and suggestions were mentioned and these are discussed below.

One minor problem was completing the lots. This situation occurred because one contractor preferred to switch to another lot before completing the current lot. This resulted in missing samples. Consequently, a decision could not be reached on an incompleted lot. One way to take care of this problem is to form lots in accordance with the contractor's work schedule. Thus, a lot may be formed by many broken sections of the roadway. This results in extra bookkeeping effort. The inconvenience can be reduced by requesting that the contractor complete as many lots as possible.

Another problem is the determination of sampling locations on the non-mainline roadway sections such as turning lanes, temporary driveways and roadways. If this situation does not occur often, the Inspector can adjust sampling locations as suggested in Section I. However, if we know that this situation is going to occur frequently, the sampling layouts can be designed to fit the situation and, therefore, eliminate unnecessary sampling location adjustments during construction.

The end-result aggregate inspection procedures require rapid test result availability in order to facilitate lot acceptance and aggregate producer's (contractor's) quality control. This is to be done with limited overtime. Therefore, it was suggested that the lot size should be doubled so as to cut testing in half. This method is permissible if the in-place aggregate uniformity is high. This subject is examined in Section III where modifications to the SSFD inspection procedures are discussed.

The above discussion indicates that the SSFD inspection procedures presented in Section I are feasible from an administrative point of view. We now use the test results to discuss the performance of the implemented SSFD inspection procedures.

TABLE 8
Action on Each Lot of Project G (FR-64015/11535A)

LOT	Number of Defective Samples	Sample Failed to Meet Specification		Action on The Lot
		Sample Number	Sieve Size & Percent	
1	0			Accept The Lot
2	1	11	LBW (9.16)	Accept The Lot
3	0			Accept The Lot
4	0			Accept The Lot
5	0			Accept The Lot
6	0			Accept The Lot
7	1	6	LBW(11.11)	Replace Sublot Aggregates
8	0			Accept The Lot
9	0			Accept The Lot
10	0			Accept The Lot

Table 9
Action on Each Lot of Project U (M-36021/10139A)

LOT	Number of Defective Samples	Sample Failed to Meet Specification		Action on The Lot
		Sample Number	Sieve Size & Percent	
1	1	8	3/4"(62.76)	Accept The Lot
2	1	4	No.8(52.13)	Accept The Lot
3	0			Accept The Lot
4	0			Accept The Lot
5	1	9	No.8(52.60)	Accept The Lot
6	0			Accept The Lot

For discussion purposes, the four construction projects are abbreviated as Projects G, U, J, and D for their construction locations as follows:

Project	Project Number	Construction Location
G	FR-64015/11535A	Grand Rapids
U	M-36021/10139A	Upper Peninsula
J	FR-23092/10729A	Jackson
D	I-50062/00703A	Detroit

We note that aggregate for Project D was produced by crushing slag. As presented in Table 5, the upper limit for the loss-by-washing for this project is 11 percent (9 percent for the regular production – Projects G, U, and J). Also, as presented in Table 6, the critical limit for the loss-by-washing that requires the replacement of sub-lot aggregates is 12 percent for Project D and 10 percent for Projects G, U, and J.

The test results of the above four construction projects are presented in Appendix B. The number of samples which failed to meet specification limits and the corresponding decisions are summarized in Tables 8 through 11. We also graphically present the test results in Figures 3 through 6 for examination of the in-place aggregate uniformity and producers' aggregate quality control. These figures indicate that aggregate gradations of Projects G and U change from sample to sample much less than those of Projects J and D. In other words, Projects G and U have much higher aggregate uniformity than Projects J and D. The above statement is verified by Table 12 which is the sample variances of the percentage passing various sieve sizes and loss-by-washing. If aggregate gradations (percent passing various sieve sizes) of the four construction projects were the same, we would say that Projects G and U have better aggregate quality than Projects J and D. The sample aggregate gradations are presented in Table 13. We observe that aggregate gradations of the four projects are significantly different. This complicates the matter of comparing the aggregate quality among the four construction projects. This is discussed below.

First, we compare Project G with U. We see from Table 12 that Project G has slightly better aggregate uniformity than Project U in terms of percent passing 3/4-in., 3/8-in. and No. 8 sieves, but not in terms of the percent loss-by-washing. Similarly, we see from Table 13 that percentage passing the same three sieves in Project G are closer to the targeted values than those in Project U, but again, not in terms of the percent loss-by-washing. This means that aggregate samples in Project G have a better chance of meeting the specification limits of 3/4-in., 3/8-in., and No. 8

Table 10
Action on Each Lot of Project J (FR-23092/10729A)

LOT	Number of Defective Samples	Sample Failed to Meet Specification		Action on The Lot
		Sample Number	Sieve Size & Percent	
1	3	6	No.8(52.14)	10% Penalty for Not Replacing Sublot Aggregates
		8	No.8(52.34)	
		9	No.8(53.42)	
2	3	1	No.8(53.75)	10% Penalty for Not Replacing Sublot Aggregates
		6	No.8(52.68)	
		7	No.8(57.27)	
3	6	2	Crushed	50% Penalty for Not Replacing Sublot Aggregates
		5	No.8(52.85)	
		7	No.8(52.97)	
		8	No.8(53.05)	
		10	No.8(52.79)	
		11	No.8(54.16)	
4	6	2	No.8(53.19)	50% Penalty for Not Replacing Sublot Aggregates
		6	No.8(52.86)	
		7	No.8(54.37)	
		8	No.8(53.93)	
		9	No.8(54.18)	
		11	No.8(53.53)	
5	2	10	No.8(52.02)	50% Penalty for Not Replacing Sublot Aggregates
		12	No.8(53.83)	
6	8	1	No.8(54.36)	50% Penalty for Not Replacing Sublot Aggregates
		2	No.8(52.89)	
		3	LBW (9.08)	
		4	No.8(54.77)	
		7	No.8(52.36)	
		9	No.8(55.59)	
		10	3/8"(89.72)	
		10	No.8(56.50)	
		12	3/8"(87.41)	
		12	No.8(57.17)	
7	4	1	No.8(54.02)	15% Penalty for Not Replacing Sublot Aggregates
		1	LBW (9.80)	
		2	No.8(52.46)	
		3	No.8(53.68)	
		4	No.8(53.34)	
8	-	-	-	8 Missing Samples

Table 11
Action on Each Lot of Project D (I-50062/00703A)

LOT	Number of Defective Samples	Sample Failed to Meet Specification		Action on The Lot
		Sample Number	Sieve Size & Percent	
1	2	1 2	LBW(11.05) LBW(11.41)	5% Penalty for Not Replacing SublotaAggregates
2	1	8	LBW(11.11)	Accept The Lot
3	1	7	LBW(11.42)	Accept The Lot
4	0			Accept The Lot
5	0			Accept The Lot
6	0			Accept The Lot
7	4	1 1 2 2 8 10	3/8"(87.47) No.8(59.05) 3/8"(88.10) No.8(67.33) LBW(11.39) LBW(11.98)	15% Penalty for Not Replacing Sublot Aggregates
8	3	2 3 4	LBW(11.17) LBW(12.20) LBW(12.46)	Replace Sublot Aggregates for Re-inspection

(*) Aggregate for this project is produced by crushing slag. The upper specification limit for the loss-by-washing is 11 percent. The sublot aggregates must be replaced for re-inspection if the loss-by-washing exceeds 12 percent.

Table 12
Sample Variances of Percents Pssing Various
Sieve Sizes & Loss-by-Washing

Construction Project	Variance			
	3/4-in	3/8-in	No.8	L.B.W.
G	1.599	6.785	4.589	0.342
U	2.376	8.346	5.482	0.258
J	1.288	22.777	18.968	0.408
D	0.152	14.481	22.285	1.304

* The percent passing 1-In. sieve is 100 for every sample. Thus, the sample variance for this measurement is 0 .

Table 13
Sample Aggregate Gradations

Construction Project	Percent Passing				Percent L.B.W.
	1-in	3/4-in	3/8-in	No.8	
G	100	95.75	74.58	47.31	7.73
U	100	93.94	69.10	47.99	6.46
J	100	97.46	78.70	49.11	7.75
D	100	99.62	78.91	39.50	9.56
Upper Limit	100	100	87	52	9 (*1)
Target Value	100	94	75	40	6 (*2)
Lower Limit	100	88	63	28	3

(*1) This limit is 11 percent for Project D.
(*2) Thus, the target value for Project D is 7 percent.

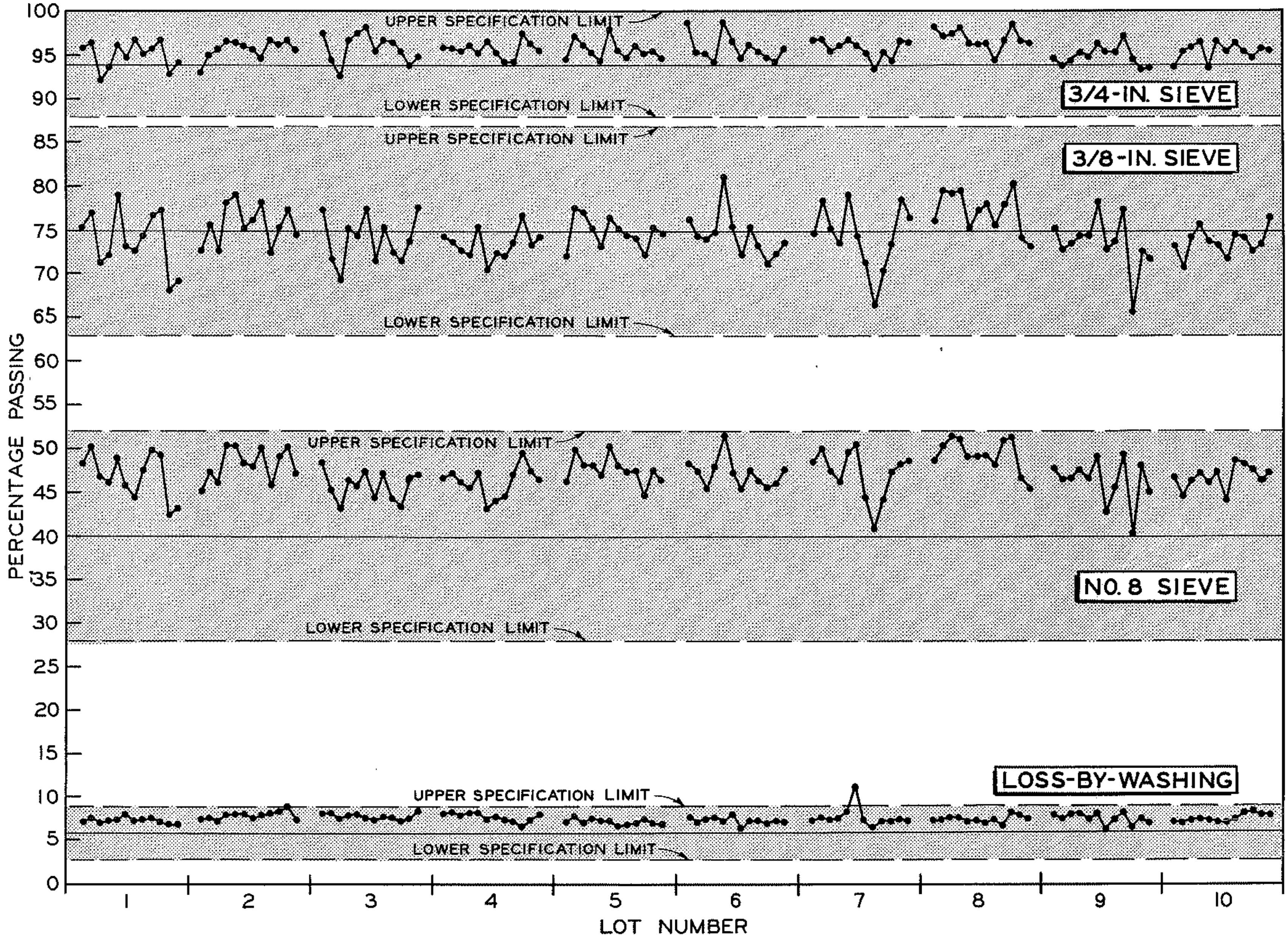


Figure 3. Test results of Project G (FR-64015/11535A).

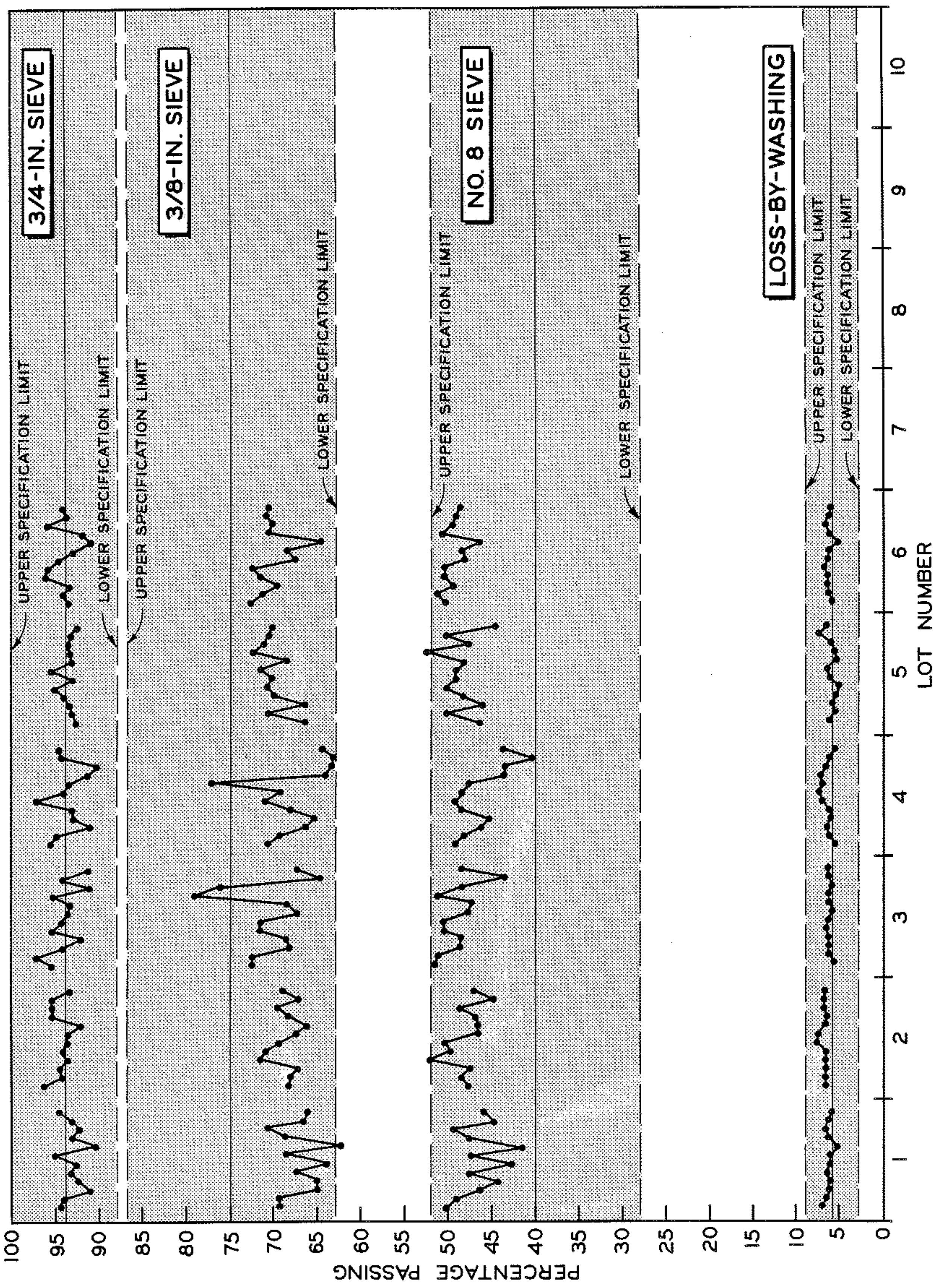


Figure 4. Test results of Project U (M-36021/10139A).

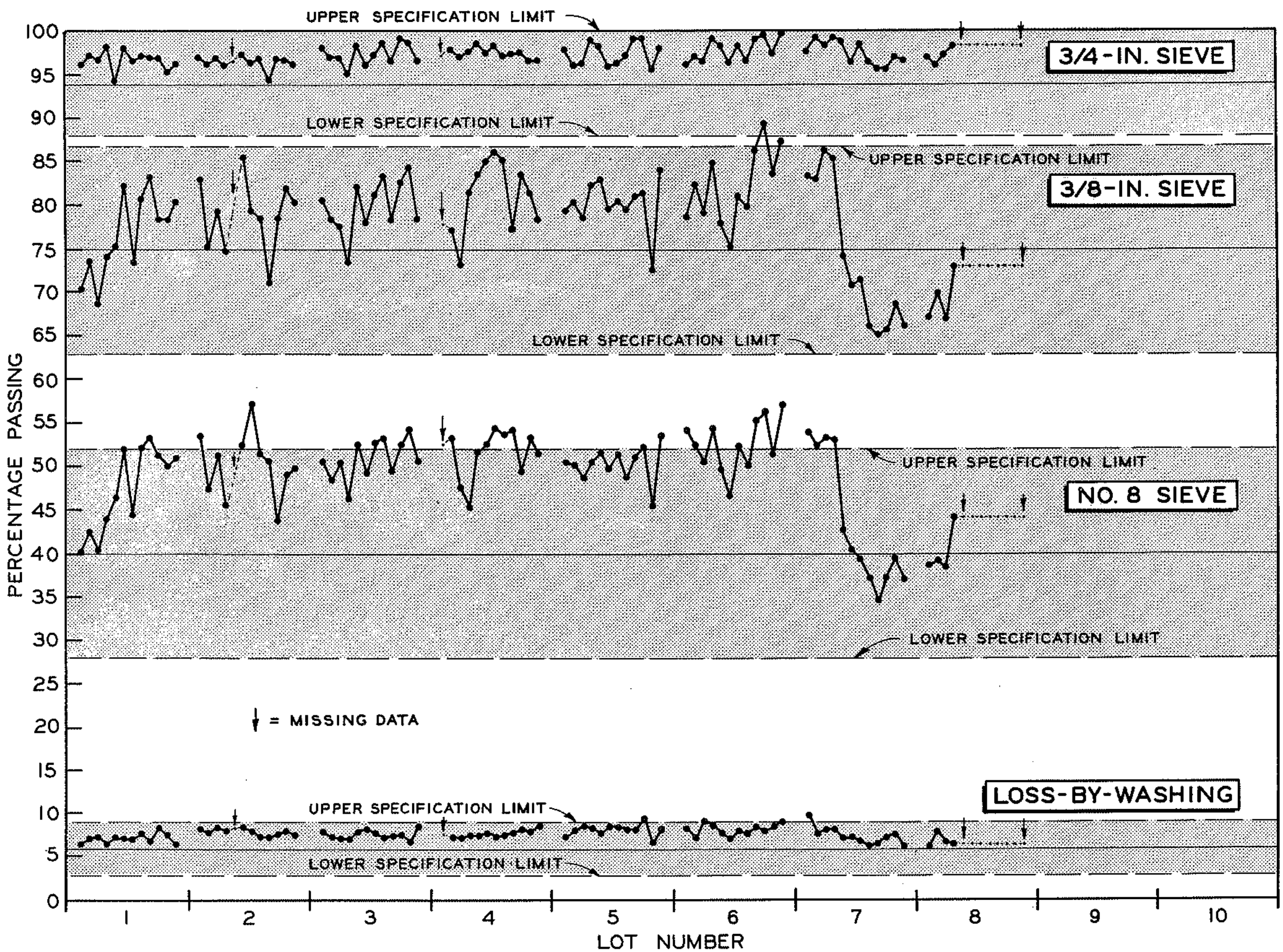


Figure 5. Test results of Project J (FR-23092/10729A).

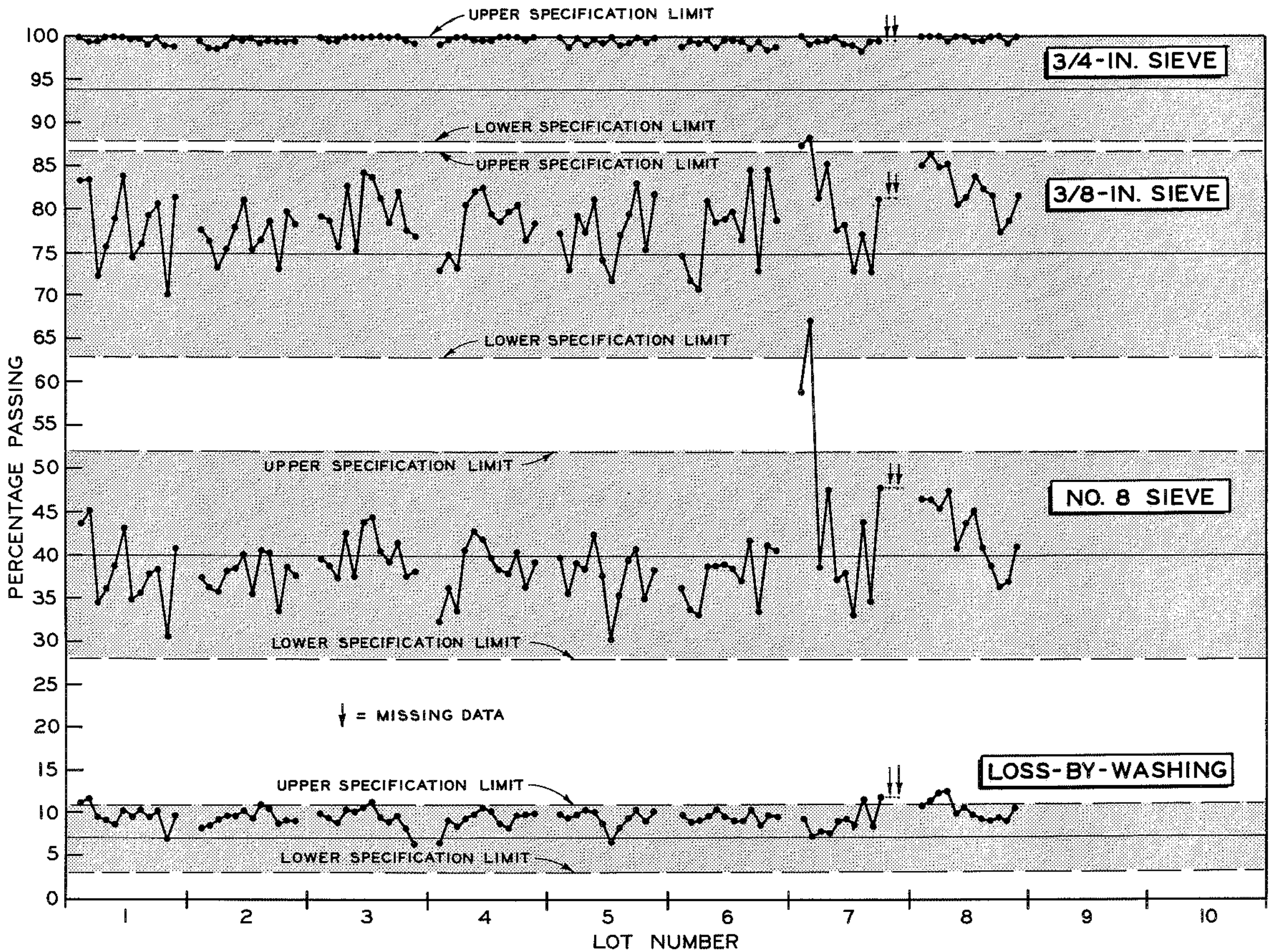


Figure 6. Test results of Project D (I-50062/00703A).

sieves than those of Project U. However, the reverse is true for the two projects regarding the specification limits for loss-by-washing. It normally takes two defective samples to reject a lot. However, a lot can be rejected by one defective sample if the percent loss-by-washing exceeds the critical limit that requires the replacement of sub-lot aggregates. This means that failing to control loss-by-washing is more crucial than failing to control sieve sizes. For this reason, we could not tell which project has the better chance for a lot to be accepted or rejected. For comparison purposes, we must compute the lot acceptance probability. To do so, we first define the following two aggregate quality levels:

P = percentage of aggregate that meets the specification limits specified in Table 5

and

Q = percentage of aggregate whose percent loss-by-washing does not exceed the critical limit that requires the replacement of sub-lot aggregates for reinspection.

It is clear that $P \leqslant Q$. For the SSFD inspection procedures presented in Section I, the lot acceptance probability (the chance for a lot to be accepted at the first inspection) is:

$$A(SSFD) = \left[P^{12} + 12(Q - P)\, P^{11} \right] \Big/ 100^{12} \qquad (1)$$

Therefore, for N lots inspected by the SSFD inspection procedures, the expected number of lots accepted at the first inspection is:

$$L(SSFD) = N \times A(SSFD) \qquad (2)$$

The estimated P and Q of the four construction projects are presented in Table 14. Substituting the estimated P and Q into Eqs. (1) and (2), we obtain the estimated lot acceptance probabilities and expected numbers of lots accepted at the first inspection in Table 15. This table indicates that lots in Project U have a slightly higher chance of acceptance than those in Project G. We therefore conclude that Project U has slightly better quality aggregate than Project G.

We have previously mentioned that Projects G and U have better aggregate uniformity than Projects J and D. We see from Table 13 that Projects G and U also have better control in aggregate gradation than Projects J and D. This immediately allows us to conclude that lots in Projects G and U have a better chance of acceptance than those in Projects J and D.

Table 14
Estimated Aggregate Quality Levels
of the Four Construction Projects

Project	Number of Samples			Estimated Aggregate Quality Levels	
	Total	Meeting The Specification	LBW $\leq$ C *	P	Q
G	120	118	118	98.33	98.33
U	72	69	72	95.83	100.00
J	86	54	84	62.79	97.67
D	94	83	92	88.30	97.87

(*) C is the critical limit for the loss-by-washing that requires the removal of sublot aggregates for re-inspection

Table 15
Lot Acceptance Probability and Expected Number of Lots Accepted under The SSFD Inspection Procedures

Project	Number of Lots	Actual No. of Lots Accepted	Lot Acceptance Probability	Expected Number of Lots Accepted
G	10	9	0.8170	8.17
U	6	6	0.9130	5.48
J	7	0	0.0288	0.20
D	8	5	0.5169	4.14

We also observe from Table 13 that the percent passing the No. 8 sieve in Project J is very close to the upper specification limit. This means that a high proportion of samples from this project will fail to meet the No. 8 sieve specification limits as shown in Table 10. Since the aggregate uniformity of this project is about the same as that of Project D, we can conclude that the aggregate quality of Project J is inferior to that of Project D.

As far as aggregate quality is concerned, we conclude from the above discussion that Projects G and U are about the same; these two projects are better than Project D, and the worst one is Project J. This ranking of the four construction projects is in line with the rank order of the percentage of lots actually accepted (Table 15). Moreover, Table 15 shows that the actual and expected numbers of lots accepted are very close. This indicates that the SSFD inspection procedures performed as expected.

When the contractor delivers poor quality aggregate, the SSFD inspection procedures would strongly reject the in-place aggregate as shown in the case of Project J. In fact, it rejected every lot of Project J at the first inspection. This should be compared with the inspection results of the traditional stockpiled aggregate inspection procedures. For this method, the lot acceptance probability is:

$$A(\text{STOCKPILE}) = P/100 + (100 - P)\, P/10{,}000$$

Thus, the estimated chance for accepting any lot of Project J is 86.15 percent. That is, we would expect to accept six lots of Project J. This clearly demonstrates that the implemented SSFD inspection procedures are much better than the stockpiled aggregate inspection procedures. The other advantage is that in-place aggregate gradation and uniformity information are available which may be valuable for future research on pavement performance. This leads us to conclude that the SSFD in-place 22A aggregate inspection procedures are feasible and beneficial.

TABLE 16

Decision Rules of A Truncated Sequential Probability Ratio Test
(A:Acceptance ; R:Rejection ; C:Continuation - No Decision)

Number of Samples Tested	Number of Samples Failed to Meet Specification Limits			
	0	1		2
		LBW ≤ C (*1)	LBW > C	
1	C	C	R (*2)	-
2	C	C	R	R
3	C	C	R	R
4	C	C	R	R
5	C	C	R	R
6	C	C	R	R
7	A	C	R	R
8	A	C	R	R
9	A	C	R	R
10	A	C	R	R
11	A	C	R	R
12	A	A	R	R

(*1) C is the critical limit for the loss-by-washing that requires the replacement of sublot aggregates for re-inspection.

(*2) R in this column means that sublot aggregates must be replaced for re-inspection.

III
REVISED IN-PLACE 22A AGGREGATE INSPECTION PROCEDURES
(TSPRT-1 and TSPRT-2 Inspection Procedures)

In this section, we shall present modified versions of the SSFD inspection procedures for the purpose of reducing testing cost. First, we discuss the alternative suggested by a District Engineer. This is to double the lot size to cut testing in half. When the aggregate uniformity is high, doubling the lot size has very little effect on the chance of accepting good and rejecting poor quality aggregate. However, the effect could be significant on low uniformity aggregate. For example, for a good lot followed by a bad lot, the SSFD inspection procedures would accept the good lot and reject the bad one. This is fair to both the contractor and the Department. When the lot size is doubled, these two lots become one lot. The chance of accepting this 'big' lot is less than that of accepting the original 'small' good lot. On the other hand, the chance of rejecting this 'big' lot is less than that of rejecting the original 'small' bad lot. This works against both the contractor and the Department. Thus, doubling the lot size should be used with caution.

An alternative is to use the decision rules of a 'Truncated Sequential Probability Ratio Test' (TSPRT) to determine whether an extra sample is needed for testing. This method was presented in MDOT Research Report R-1024. The rules of the TSPRT inspection procedures are presented in Table 16. We observe from this table that a lot is never accepted before seven samples are tested. However, a lot can be rejected after one sample is tested. Based on these rules, we modify the SSFD inspection procedures presented in Section I as follows.

TSPRT-1 Inspection Procedures

For each lot ready for inspection, 12 samples are obtained by the same method as the SSFD inspection procedures presented in Section I. These 12 samples are then randomly ordered, and tested one by one until conditions are met for accepting or rejecting the lot without further testing. These terminating conditions are specified below.

(C1) A lot is accepted without further testing if there is no defective sample in the first seven samples tested.

(C2) A lot is rejected without further testing if the loss-by-washing of the tested sample exceeds the critical limit that requires the replacement of sub-lot aggregates for reinspection. As previously stated, this critical limit is 10 percent. However, the limit is increased to 12 percent for aggregate produced by crushing rock, boulders, cobbles, slag, or concretes.

(C3) A lot is rejected when the second defective sample occurs. If the loss-by-washing of this sample does not exceed the critical limit stated in (C2), we continue testing until either the (C2) condition is met or all of the samples are tested. For the latter case, the penalty level on this lot is determined according to Table 17.

TABLE 17
Penalty Levels for The TSPRT-1 Inspection Procedures

Number of Defetive Samples in a Lot	TSPRT-1 Procedures		SSFD Procedures
	Probability of Rejecting The Lot	Penalty Level (Percent)	Penalty Level (Percent)
0	0	0.00	0
1	0	0.00	0
2	28 / 33	5.89	5
3	21 / 22	10.48	10
4	98 / 99	15.15	15
5	791 / 792	25.03	25
6 or More	1	50.00	50

Denote T to be the testing size (number of samples tested) under the TSPRT-1 procedures. Then, the percentage testing reduction of TSPRT-1 over SSFD inspection procedures is 100(12 - T)/12. For perfect quality aggregate (P = 100), we have T = 7 due to the first condition. Therefore, the percentage testing reduction is 41.67 percent. If the loss-by-washing always exceeds the critical limit that requires the replacement of sub-lot aggregates, i.e., Q = 0 and, consequently, P = 0, the sub-lot aggregates must be replaced for reinspection after one sample is tested according to the second condition. For this case, T = 1 and, therefore, the percentage testing reduction is 91.67 percent. If the aggregate always fails to meet the specification limits, but stays within the critical limit that requires the replacement of sub-lot aggregates, i.e., P = 0 and Q = 100, we will test all of the samples according to the third condition. In this case, there is no testing reduction at all. These three extreme cases indicate that the percentage testing reduction depends on the aggregate quality levels P and Q defined in the previous section. To highlight the potential testing reduction of the TSPRT-1 inspection procedures, we present the following equation for computing the expected testing size under the TSPRT-1 inspection procedures:

$$T = 1 - Q/100 + \sum_{i=2}^{6} i\,Q^{i-1}\,(100 - Q)/100^{i}$$

$$+ 7\,Q^{6}\,(100 - Q) + P^{7}/100^{7}$$

$$+ (Q^{7} - P^{7}) \sum_{i=8}^{11} i\,Q^{i-8}\,(100 - Q)/100^{i}$$

$$+ 12\,(Q^{7} - P^{7})\,Q^{4}/100^{11} \qquad (3)$$

The expected testing sizes and percentage testing reductions are presented in Figures 7 and 8, respectively, for selected values of Q. These two figures show that the TSPRT-1 inspection procedures could substantially reduce testing. This means that substantial savings on testing costs including overtime could be made. However, we must note that this benefit is achieved by reducing the probability of rejecting poor quality aggregate. To see this, we present the following equation for computing the lot acceptance probability under the TSPRT-1 inspection procedures:

$$A(\text{TSPRT-1}) = (P/100)^{7} + 7(Q - P)\,P^{11}/100^{12} \qquad (4)$$

It can be mathematically shown that

$$A(\text{TSPRT-1}) \geqslant A(\text{SSFD}) \qquad (5)$$

This means that the chance of rejecting excellent quality aggregate is reduced. This benefits both the contractor and, indirectly, the Department. However, the chance of rejecting poor quality aggregate is also reduced. This only benefits the contractor.

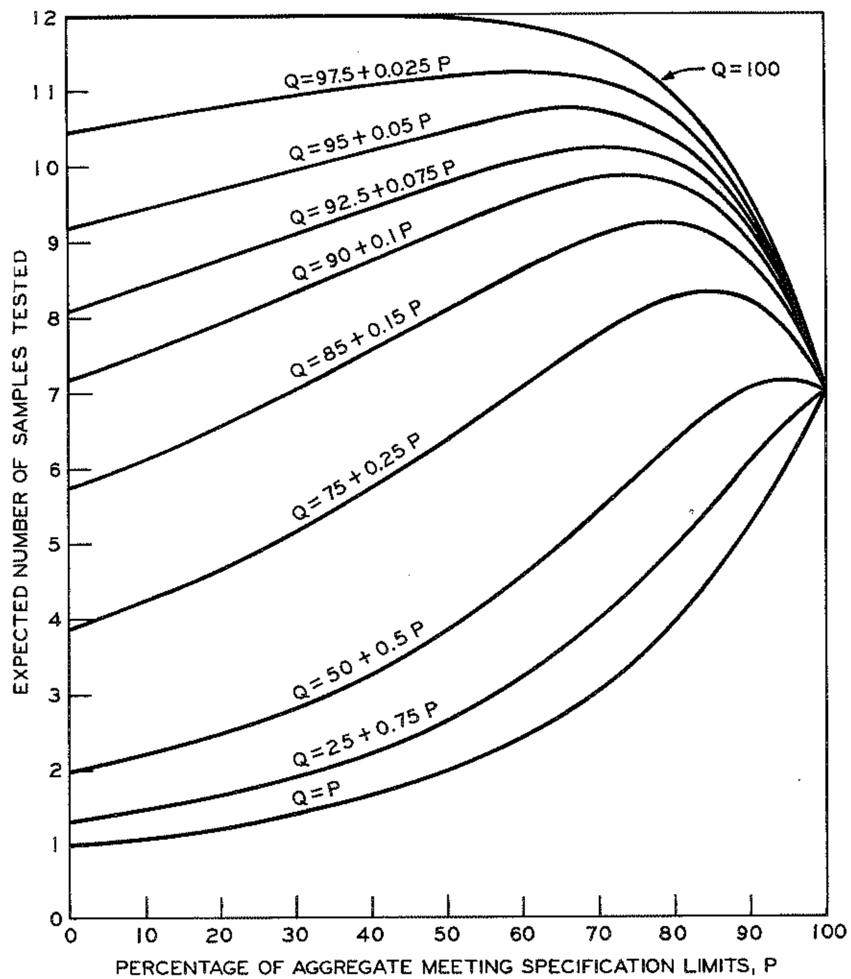


Figure 7. Expected testing size of the TSPRT-1 inspection procedures.

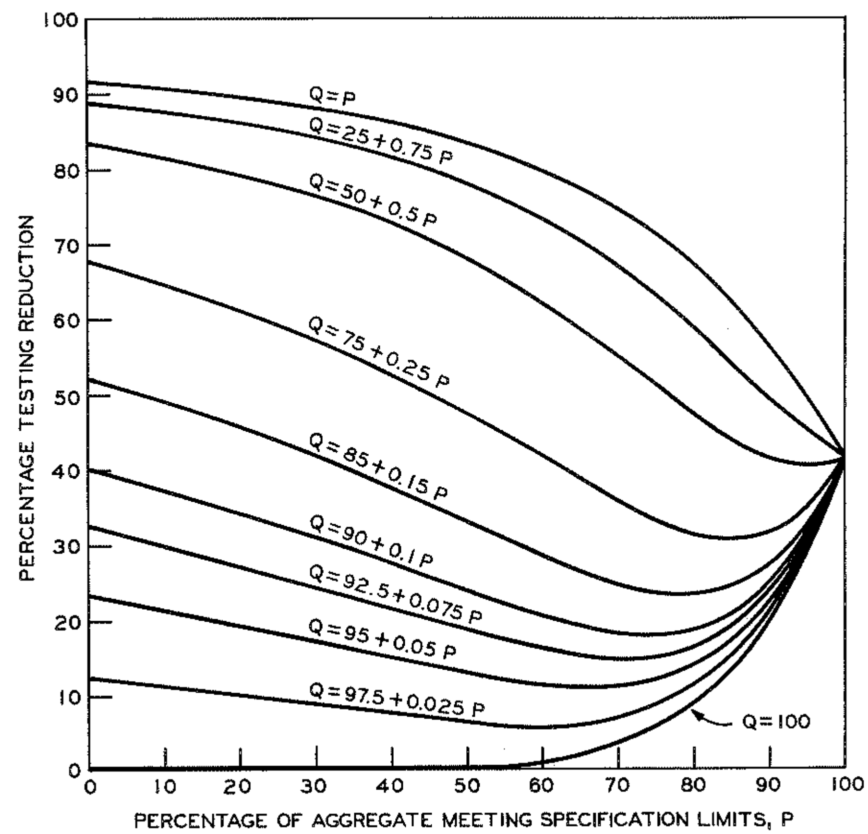


Figure 8. Percentage testing reduction of TSPRT-1 over SSFD inspection procedures.

We note that, for each aggregate quality level P, the difference between A(TSPRT-1) and A(SSFD) is largest when Q = P, and smallest when Q = 100. In general, when P is high, Q would be very close to 100. When P is low, Q may not be low. Thus, Q may not be equal to P frequently. Nevertheless, we present the lot acceptance probabilities of both cases in Figures 9 and 10, respectively. These figures indicate that the differences between A(TSPRT-1) and A(SSFD) are not noticeably large. This suggests that the power loss on rejecting poor quality aggregate may be small enough to justify the use of TSPRT-1 inspection procedures.

For demonstration purposes, we consider a lot that has two defective samples. This lot will be rejected by the SSFD inspection procedures. The action on this lot is either to replace the sub-lot aggregates or penalize the contractor at 5 percent of the aggregate cost, depending on the condition of the defective samples. However, the probability of rejecting this lot under the TSPRT-1 inspection procedures is only 28/33. When this lot is rejected, the action is the same as that of the SSFD inspection procedures. Thus, the expected penalty on this lot would be 5 percent x 28/33 under the TSPRT-1 inspection procedures. Similarly, for lots with three, four, or five defective samples, the expected penalty levels under the TSPRT-1 inspection procedures are 10 percent x 21/22, 15 percent x 98/99, and 25 percent x 791/792, respectively. For lots with six or more defective samples, the penalty levels of both TSPRT-1 and SSFD inspection procedures are 50 percent. The above analyses show that the TSPRT-1 inspection procedures penalize lots slightly less than the SSFD inspection procedures. To make both inspection procedures have the equivalent penalty levels, we set the penalty levels for the TSPRT-1 inspection procedures as follows:

$$\underset{(\text{TSPRT-1})}{\text{Penalty Level}} = \underset{(\text{SSFD})}{\text{Penalty Level}} / \underset{(\text{TSPRT-1})}{\text{Lot Rejection Probability}} \qquad (6)$$

The adjusted penalty levels for the TSPRT-1 inspection procedures are presented in Table 17. Using Table 17 to penalize lots inspected by the TSPRT-1 inspection procedures, we conclude that:

1) The TSPRT-1 inspection procedures have slightly less chance than the SSFD inspection procedures to reject poor quality aggregate.

2) For a lot rejected by both inspection procedures, the TSPRT-1 inspection procedures penalize this lot slightly more than the SSFD inspection procedures. However, the extra penalty is so designed that both inspection procedures have the same expected penalty level on a lot.

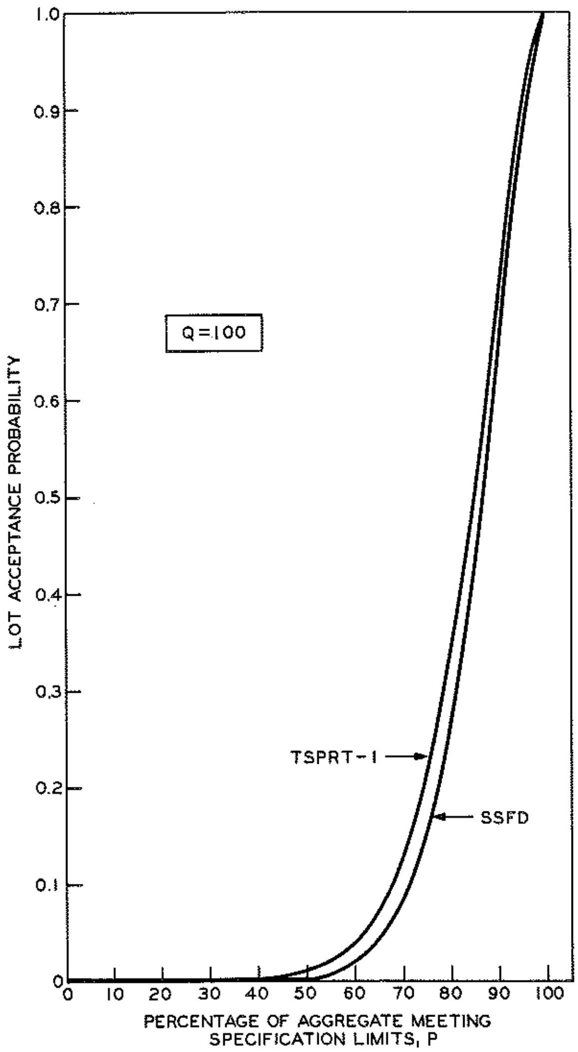


Figure 9. Lot acceptance probabilities of SSFD and TSPRT-1 inspection procedures when the loss-by-washing never exceeds the critical limit called for the replacement of sub-lot aggregates.

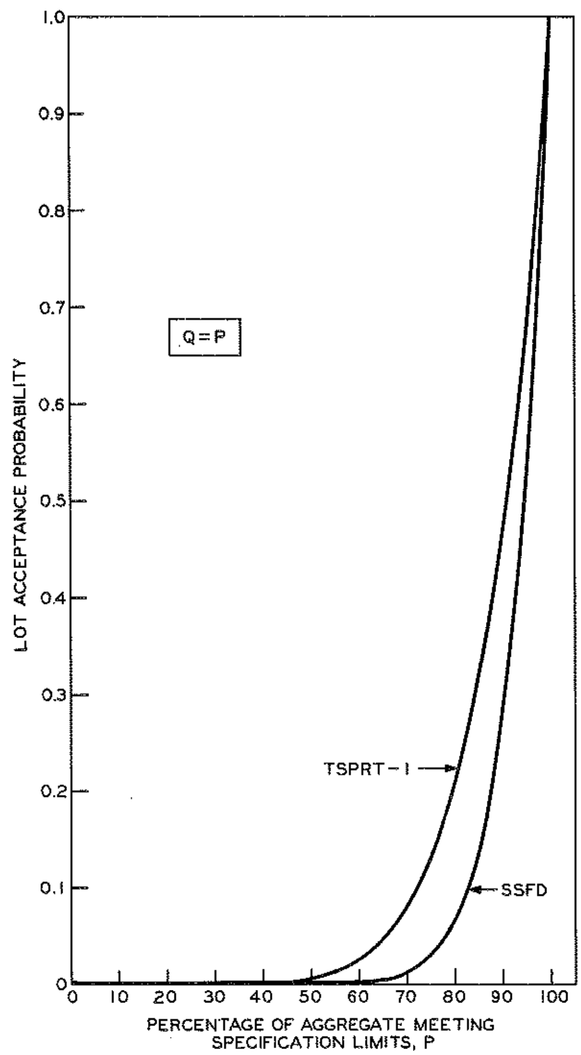


Figure 10. Lot acceptance probabilities of SSFD and TSPRT-1 inspection procedures when the loss-by-washing of every defective sample also exceeds the critical limit called for the replacement of sub-lot aggregates.

3) The TSPRT-1 procedures potentially require much less testing than the SSFD inspection procedures. This substantially reduces testing and other related costs.

4) If the consequence of not replacing sub-lot aggregates can be measured in terms of cost, both inspection procedures are then comparable. Unless this loss is so much more than the saving on testing cost, one can always design the penalty levels to offset this loss. In this regard, the TSPRT-1 inspection procedures are superior to the SSFD inspection procedures.

For the purpose of designing proper penalty levels to offset the loss due to the possibility of not replacing sub-lot aggregates, we provide the following equations for computing probabilities of declaring the replacement of sub-lot aggregates under the SSFD and TSPRT-1 inspection procedures.

$$R(SSFD) = 1 - (Q/100)^{12} \tag{7}$$

and

$$R(TSPRT\text{-}1) = R(SSFD) - (P/100)^{7} - P^{7} Q^{5}/100^{12} \tag{8}$$

The differences between R(SSFD) and R(TSPRT-1) are presented in Figure 11 for selected values of Q. This information is to be used for setting up penalty levels so that both inspection procedures have 'equivalent' penalty levels for a lot. Consequently, the TSPRT-1 inspection procedures are superior to the SSFD inspection procedures because of the testing reduction.

Applying TSPRT-1 Inspection Procedures to the Four Projects

We now demonstrate how the TSPRT-1 inspection procedures would have worked on the four construction projects. First of all, we assume that the sampling order in Appendix B is the testing order for the TSPRT-1 inspection procedures. For this case, the testing sizes and percentage testing reductions are presented in Table 18. As expected, projects of good quality aggregate show a larger testing reduction than projects of poor quality aggregate. The overall testing reduction is 29.57 percent. Both inspection procedures result in the same decision on every lot except lot No. 5 of Project J. This lot is penalized at 5 percent under the SSFD inspection procedures, but is accepted under the TSPRT-1 inspection procedures because both defective samples occur after the seventh tested sample. However, the TSPRT-1 inspection procedures levy a slightly larger penalty on lots 1, 2, and 7 of Project J, and lots 1 and 7 of Project D. The total extra penalty is 2.15 percent. Thus, the difference of aggregate costs

TABLE 18
Testing Size And Percentage Testing Reduction
Under The TSPRT-1 Inspection Procedures
(Testing order is the sampling order presented in Appendix B)

Project	Number of Lots	Number of Samples Tested			Percentage Testing Reduction (Over SSFD)	
		SSFD	TSPRT-1	TSPRT-2	TSPRT-1	TSPRT-2
G	10	120	69	69	42.50	42.50
U	6	72	47	47	34.72	34.72
J (*)	7	84	79	50	5.95	40.48
D	8	96	67	53	30.20	44.79
Total	31	372	262	219	29.57	41.13

(*) One lot is deleted from this project due to missing samples.

TABLE 19
Expected Testing Size And Percentage Testing Reduction
Under The TSPRT-1 Inspection Procedures
(Testing order is randomly determined)

Project	Number of Lots	Expected Number of Samples Tested			Percentage Testing Reduction (Over SSFD)	
		SSFD	TSPRT-1	TSPRT-2	TSPRT-1	TSPRT-2
G	10	120	71.17	68.83	40.67	42.64
U	6	72	50.76	43.74	29.50	39.25
J (*)	7	84	82.73	52.10	1.51	37.98
D	8	96	68.27	56.20	28.88	41.46
Total	31	372	272.93	220.87	26.63	40.62

(*) One lot is deleted from this project due to missing samples.

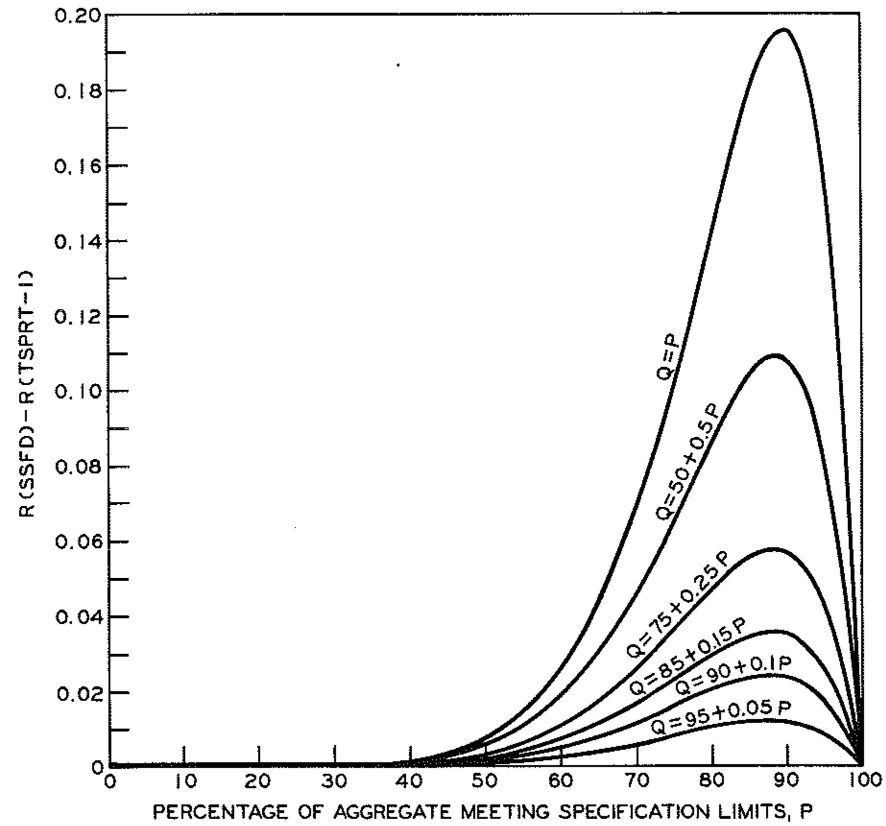


Figure 11. Differences of probabilities of replacing sub-lot aggregates between SSFD and TSPRT-1 inspection procedures for selected values of Q.

between two inspection procedures is 2.85 percent of the aggregate price of a lot. This cost should be compared with the 29.57 percent saving on testing cost to determine whether it is cost effective to use the TSPRT-1 inspection procedures.

We note that the above case is only one of the 479,001,600 possible testing orders that could be used for the comparison of the two inspection procedures. We now examine the general situation where the testing order is randomly determined as proposed. The expected testing sizes and percentage testing reductions are presented in Table 19. The expected overall testing reduction is 26.63 percent. We note that the TSPRT-1 inspection procedures could accept eight lots rejected by the SSFD inspection procedures. The chance of rejecting these eight lots under the TSPRT-1 inspection procedures are presented in Table 20. This table shows that the difference in numbers of lots rejected by the two inspection procedures is only

TABLE 20
Actions on Lots That Both SSFD And TSPRT-1 Inspection Procedures Could Have Different Decisions

Project And Lot Number	TSPRT-1 Procedures		SSFD Procedures	
	Rejection Probability	Action When The Lot Is Rejected	Rejection Probability	Action When The Lot Is Rejected
G - 7	7 / 12	R. S. A.	1	R. S. A.
J - 1	21 / 22	10.48% Pny.	1	10% Pny.
J - 2	21 / 22	10.48% Pny.	1	10% Pny.
J - 5	28 / 33	5.89% Pny.	1	5% Pny.
J - 7	98 / 99	15.15% Pny.	1	15% Pny.
D - 1	28 / 33	5.89% Pny.	1	5% Pny.
D - 7	98 / 99	15.15% Pny.	1	15% Pny.
D - 8	21 / 22	R. S. A.	1	R. S. A.
Total	7.12	--------	8	-------

(*) "R.S.A." stands for the replacement of sublot aggregates for re-inspection. "Pny." stands for the penalty on the lot.

TABLE 21
Penalty Levels for The TSPRT-2 Inspection Procedures

No. of Samples Tested	No. of Defective Samples	Estimated Number of Defective Samples	Penalty Level (Percent)
7	4 Or More	More Than 6	50
7	3	5.14	25
7	2	3.43	10
8	2	3.00	10
9 Or More	2	2.00 - 2.67	5

0.88 (8.00 - 7.12) of a lot. This table also shows that the TSPRT-1 inspection procedures have slightly higher penalty levels, but with less frequency, than the SSFD inspection procedures. As previously stated, the expected penalty levels are the same for both inspection procedures. For this reason, the only decision difference between the two inspection procedures is that the TSPRT-1 inspection could accept lot 7 of Project J and lot 8 of Project D. The probabilities of not replacing sub-lot aggregates of these two lots are 5/12 and 1/22, respectively. In order to make a fair comparison of the two inspection procedures, the consequence of not replacing sub-lot aggregates of these two lots must be converted to cost. If 5/12 + 1/22 of this cost is less than the 26.63 percent saving on testing and other related costs, we say that it is beneficial to use the TSPRT-1 inspection procedures to inspect in-place 22A aggregate. Even if it is not, we still have the option to adjust penalty levels so that the use of TSPRT-1 inspection procedures has no negative effect on the contractor, but remains beneficial to the Department.

TSPRT-2 Inspection Procedures

We have mentioned that the TSPRT-1 inspection procedures have insignificant testing reduction when P is very low and Q is very high (the upper left corner of Figure 7). To also reduce testing for lots with low P and high Q, we modify the third terminating condition of the TSPRT-1 inspection procedures as follows:

(C3) A lot is rejected without further testing if the second defective sample occurs after the seventh sample tested. However, if the second defective sample occurs before the seventh sample tested, we continue testing until either the second terminating condition is met or seven samples are tested.

Because of the above modified condition, we would rarely test all of the 12 samples before reaching a decision. Thus, when a lot is rejected under the situation that sub-lot aggregates are allowed to stay with a penalty, we must estimate the number of defective samples, D, in a lot to determine the penalty level. One way is to estimate:

$$D = 12 \times \frac{\text{Number of Defective Samples}}{\text{Number of Samples Tested}} \tag{9}$$

Using this estimate to check with Table 7, we present the penalty levels for the TSPRT-2 inspection procedures in Table 21.

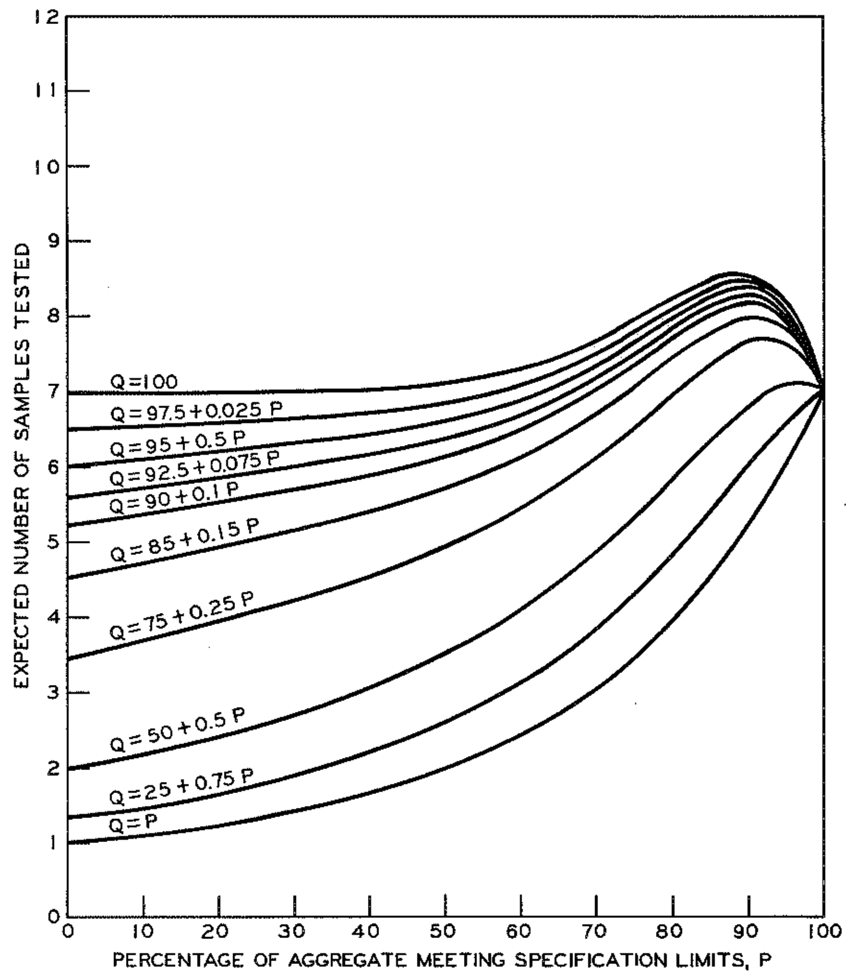


Figure 12. Expected testing size of the TSPRT-1 inspection procedures.

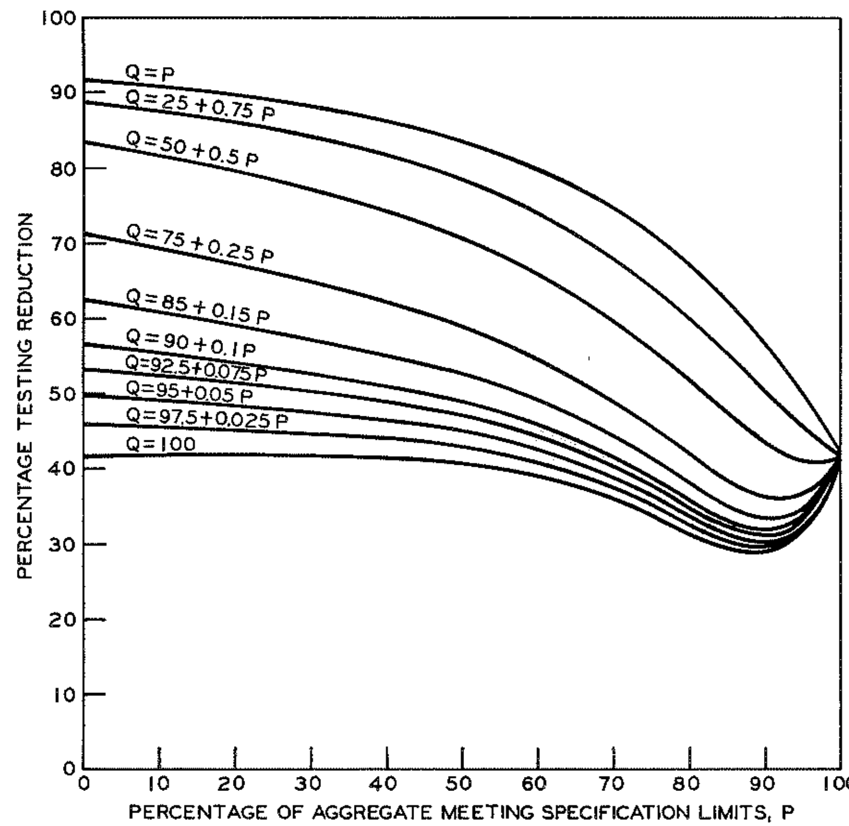


Figure 13. Percentage testing reduction of TSPRT-1 over SSFD inspection procedures.

Apparently, the modified (C3) condition allows us to only test seven samples for a lot with $P = 0$ and $Q = 100$. The equation for computing the expected testing size under the TSPRT-2 inspection procedures is:

$$T = 1 - Q/100 + \sum_{i=2}^{6} i\, Q^{i-1} (100 - Q)/100^{i}$$

$$+ 7\, Q^{6} (100 - Q) + Q^{7} - 7(Q - P)\, P^{6}/100^{7}$$

$$+ 7 \sum_{i=8}^{11} i\, (Q - P)\, (100 - P)\, P^{i-2}/100^{i}$$

$$+ 84\, (Q - P)\, P^{10}/100^{11} \qquad (10)$$

The expected testing size and percentage testing reduction, 100(12 - T)/12, are presented in Figures 12 and 13, respectively. Comparing Figures 12 and 13 with Figures 7 and 8, we see that substantial testing reduction is also made for lots with low P and high Q.

We note that the TSPRT-1 and TSPRT-2 inspection procedures have the same chance to reject poor quality aggregate lots. However, the modified (C3) condition slightly reduces the chance of declaring the replacement of sub-lot aggregates for reinspection. Consequently, the TSPRT-2 inspection procedures penalize lots slightly more often than the TSPRT-1 inspection procedures. As before, if the consequences of not replacing sub-lot aggregates can be measured in terms of cost, these two inspection procedures can be comparable. Under this circumstance, the penalty levels in Table 21 can be adjusted so that both TSPRT-1 and TSPRT-2 inspection procedures have the same 'expected' penalty systems. In this regard, we conclude that the TSPRT-2 inspection procedures are superior to the TSPRT-1 inspection procedures because of the extra saving of testing and other related costs.

The equation for computing the probabilities of declaring the replacement of sub-lot aggregates for reinspection is:

$$R(\text{TSPRT-2}) = 1 - (Q/100)^{7} + 7(Q - P)\,(100 - Q) \sum_{i=6}^{10} P^{i}/100^{i+2} \qquad (11)$$

It can be mathematically shown that R(TSPRT-2) $\leq$ R(TSPRT-1). The differences between R(TSPRT-1) and R(TSPRT-2) are presented in Figures 14 through 21 for selected values of Q. We see from these figures that the differences are not noticeably large. As a matter of fact, the differences are quite small for the likely values of aggregate quality levels (high P and Q - lower right corners of Figures 17 through 21).

For lots whose sub-lot aggregates are allowed to stay, the expected penalty levels are also presented in Figures 14 through 21. We observe from these figures that the TSPRT-2 inspection procedures penalize lots slightly more than the TSPRT-1 inspection procedures when the aggregate quality, P, is high. The above situation is reversed when P is low. We also observe that the maximal difference of expected penalty levels is less than 4 percent. We remark that the penalty levels are quite high when P is low. It is believed that the contractor would move to replace sub-lot aggregates, thereby avoiding large penalties. Therefore, practically speaking, the 4 percent difference in penalty is of little consequence. Thus, we may say that, on the average, the TSPRT-2 inspection procedures penalize lots slightly more than the TSPRT-1 inspection procedures. If this is not enough to offset the loss due to the possibility of not replacing sub-lot aggregates, the penalty levels can be adjusted so that the two procedures have the equivalent expected penalty levels. From this point of view, the two inspection procedures are the same to the contractor. But, as already discussed, the use of TSPRT-2 inspection procedures will be beneficial to the Department because of the testing reduction.

Applying TSPRT-2 Inspection Procedures to the Four Projects

As before, we first assume that the sampling order in Appendix B is the testing order for the TSPRT-2 inspection procedures. The expected testing sizes and percentage testing reductions are presented in Table 18. This table shows that substantial testing reductions are also made on projects of poor quality aggregate as expected. We note that the TSPRT-1 and TSPRT-2 inspection procedures have consistent decisions (acceptance, rejection with penalty, and replacement of sub-lot aggregates) on every lot. Penalty levels on lots whose sub-lot aggregates are allowed to stay are presented in Table 22. We observe that the difference of penalty levels between the two inspection procedures could be quite large on an individual lot. However, the difference becomes insignificant in the average sense.

We now examine the case of the testing order randomly determined as proposed. The expected testing sizes and percentage testing reductions are presented in Table 19. We see that the results in Table 19 are very close to those in Table 18. This merely indicates that the sampling order

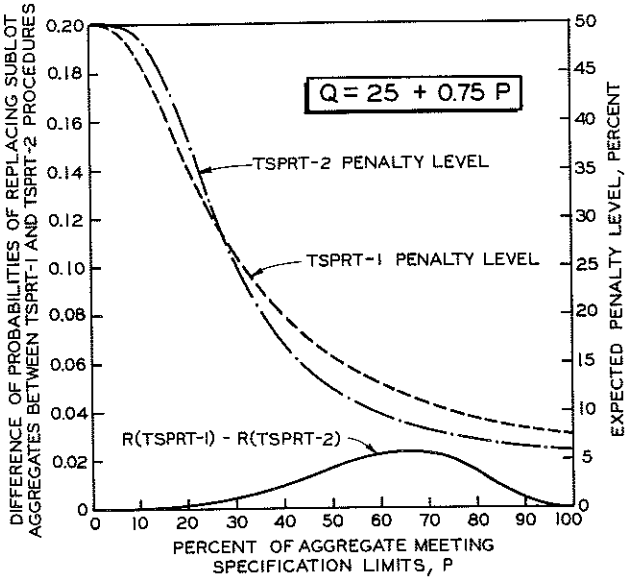


Figure 14.

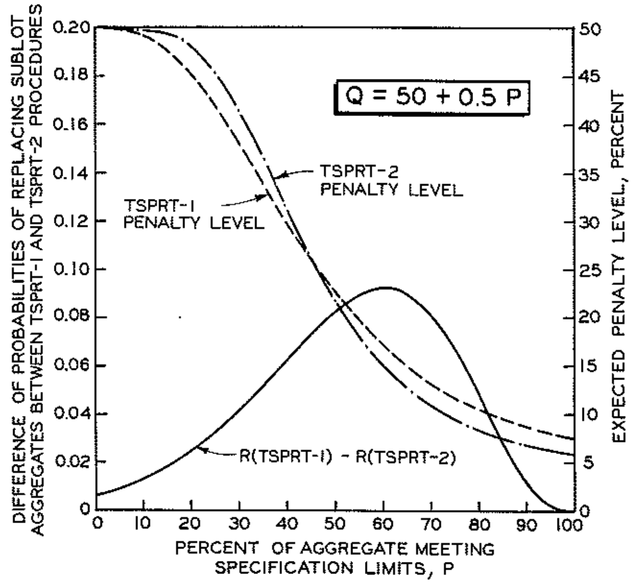


Figure 15.

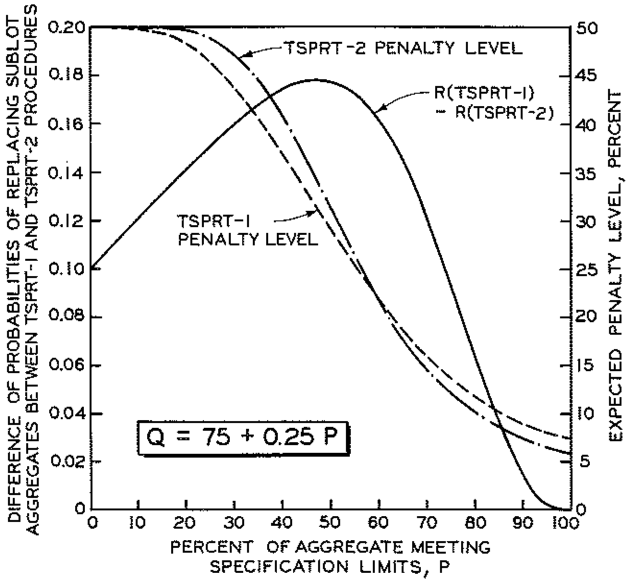


Figure 16.

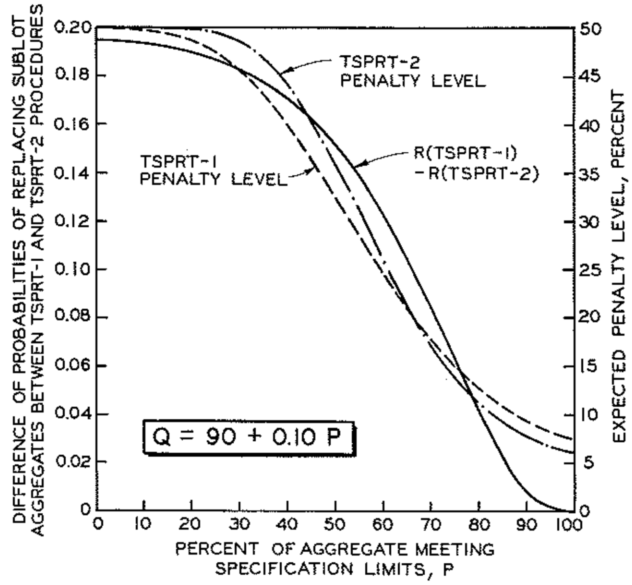


Figure 17.

Figures 14 – 17. Expected penalty levels of TSPRT-1 and TSPRT-2 inspection procedures when a lot is rejected. Also, the difference of probabilities of replacing sub-lot aggregates between TSPRT-1 and TSPRT-2 inspection procedures.

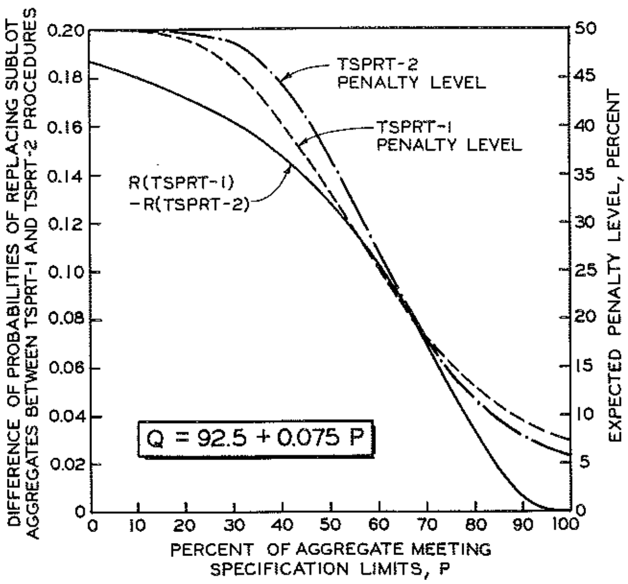
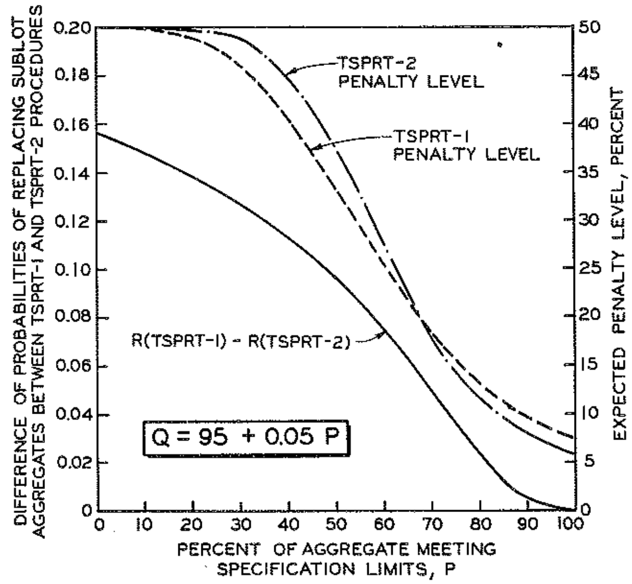


Figure 18.

Figure 19.



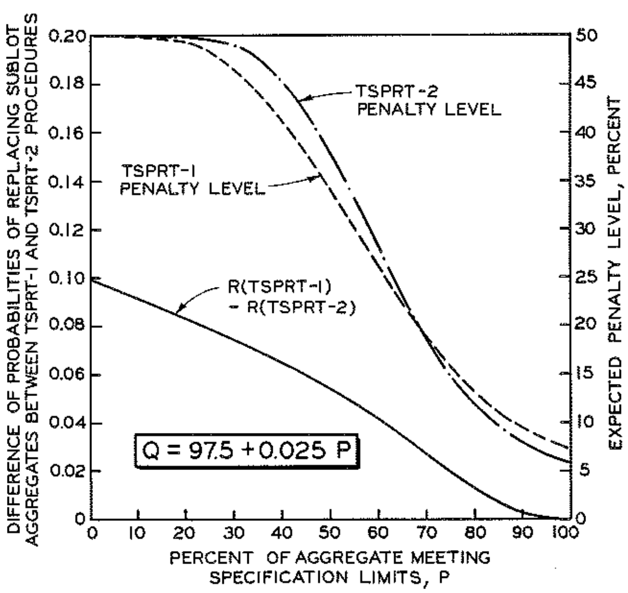
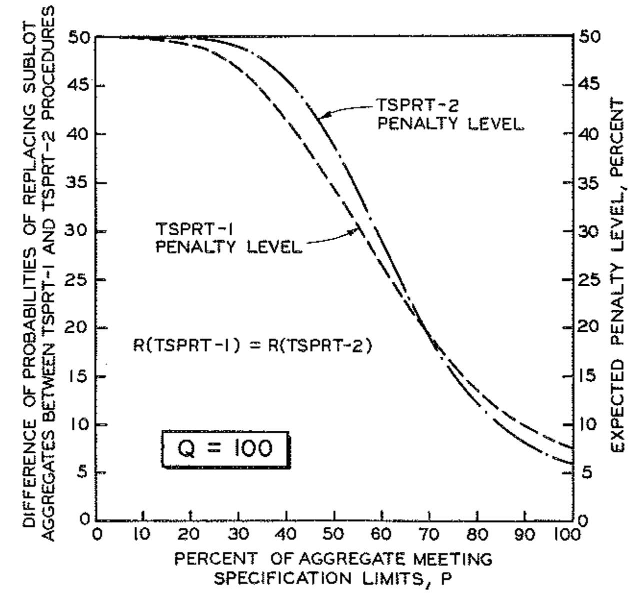


Figure 20.

Figure 21.



Figures 18 – 21. Expected penalty levels of TSPRT-1 and TSPRT-2 inspection procedures when a lot is rejected. Also, the difference of probabilities of replacing sub-lot aggregates between TSPRT-1 and TSPRT-2 inspection procedures.

TABLE 22

Penalty Levels on Lots That Sublot Aggregates Are Allowed to Stay Under Both TSPRT-1 And TSPRT-2 Inspection Procedures (Testing order is the sampling order in Appendix B)

Project And Lot Number	TSPRT-2 Inspection Procedures		TSPRT-1
	Number of Samples Tested	Penalty Level (Percent)	Penalty Level (Percent)
J - 1	8	10	10.48
J - 2	7	25	10.48
J - 3	7	25	50.00
J - 4	7	25	50.00
J - 6	7	50	50.00
J - 7	7	50	25.03
D - 1	7	10	5.89
D - 7	7	10	15.15
Average		25.63	27.18

in Appendix B happened to be one of the 'typical' testing orders obtained by randomization. Actions on lots that could be rejected by both TSPRT-1 and TSPRT-2 inspection procedures are presented in Table 23. This table indicates that the TSPRT-2 inspection procedures penalize lots 3 and 4 of Project J much less than the TSPRT-1 inspection procedures. This is why the average penalty level of eight lots under the TSPRT-2 inspection procedures is slightly less than that under the TSPRT-1 inspection procedures. This result is in line with the theoretical presentation on the differences of penalty levels between TSPRT-1 and TSPRT-2 inspection procedures (see Figure 19 for P = 63 which is the estimated aggregate quality level of Project J).

We note that the 35.68 percent price reduction is a significant penalty. It is likely that the contractor would replace sub-lot aggregates to avoid such a large penalty. Therefore, penalty levels of lots 3, 4, and 6 are unlikely to be entered into Table 23 for computing the average penalty levels.

This means that the average penalty level of the TSPRT-2 inspection procedures is slightly larger than that of the TSPRT-1 inspection procedures in the practical sense. Based on the tested results of the four construction projects presented in Appendix B, we conclude that the TSPRT-2 inspection procedures are superior to the TSPRT-1 inspection procedures.

TABLE 23
Actions on Lots That Could Be Rejected by Both
TSPRT-1 And TSPRT-2 Inspection Procedures
(Testing Order Is Randomly Determined)

Project And Lot Number	Number of Defetive Samples		Action When The Lot Is Rejected	
	LBW ≤ C	LBW > C	TSPRT-1	TSPRT-2
G - 7	0	1	R. S. A.	R. S. A.
J - 1	3	0	10.48% Pny.	11.50% Pny.
J - 2	3	0	10.48% Pny.	11.50% Pny.
J - 3	6	0	50.00% Pny.	35.68% Pny.
J - 4	6	0	50.00% Pny.	35.68% Pny.
J - 5	2	0	5.89% Pny.	7.50% Pny.
J - 6	8	0	50.00% Pny.	48.23% Pny.
J - 7	4	0	15.15% Pny.	17.93% Pny.
D - 1	2	0	5.89% Pny.	7.50% Pny.
D - 7	4	0	15.15% Pny.	17.93% Pny.
D - 8	1	2	R. S. A.	R. S. A.
Average			23.67%	21.49%

(*) "C" is the critical limit the loss-by-washing that requires the replacement of sublot aggregates. "R.S.A." stands for the removal of sublot aggregates. "Pny." stands for the penalty on the lot.

APPENDIX A

A Package of 216 Sampling Layouts
for Lot Size 6,353 ft by 25.5 ft

SAMPLE LAYOUT NUMBER	DISTANCES TO Y- AND X-REFERENCE LINES FOR EACH OF 12 SAMPLES IN A LOT											
	X(1) Y(1)	X(2) Y(2)	X(3) Y(3)	X(4) Y(4)	X(5) Y(5)	X(6) Y(6)	X(7) Y(7)	X(8) Y(8)	X(9) Y(9)	X(10) Y(10)	X(11) Y(11)	X(12) Y(12)
111	91 24.6	1026 7.0	1401 3.0	2063 1.6	2327 15.5	2816 16.9	3263 4.1	3761 15.4	4613 9.4	4914 0.1	5593 21.5	5893 1.4
112	231 15.9	713 16.0	1412 23.9	1859 2.9	2240 21.2	2775 22.5	3425 7.7	4054 24.8	4654 16.2	4875 24.7	5769 8.5	6071 6.6
113	25 13.5	661 9.2	1066 4.5	1708 7.1	2175 7.6	2848 6.9	3509 13.7	4033 25.0	4573 21.3	5026 5.7	5684 13.9	5927 7.6
114	458 12.7	1000 6.8	1470 13.0	1649 4.5	2618 16.1	2672 19.9	3252 25.4	3960 1.6	4685 10.6	5157 10.9	5766 2.4	5884 3.0
115	276 16.1	559 7.9	1127 6.3	1638 22.1	2365 14.4	2857 18.9	3705 15.6	4166 16.6	4509 15.9	4790 18.8	5688 5.4	5977 13.6
116	486 20.5	736 18.7	1476 23.5	1801 1.1	2393 18.7	2819 12.3	3332 13.9	3854 10.4	4338 7.6	4769 18.3	5368 24.3	6242 15.8
121	123 15.9	766 14.5	1480 16.8	1887 1.9	2608 11.8	2684 5.9	3179 17.6	3722 1.3	4759 17.0	5194 23.8	5706 5.1	6270 20.0
122	47 22.4	962 18.1	1383 16.6	1855 10.8	2185 2.2	2824 24.6	3394 0.2	3990 15.6	4516 4.4	5227 10.0	5316 20.6	5839 24.9
123	103 2.4	641 6.1	1586 13.0	2051 7.6	2305 22.0	2815 10.5	3237 25.5	3983 14.9	4237 23.8	5180 12.7	5713 16.4	6145 22.2
124	77 4.3	971 3.5	1408 20.5	1711 24.5	2395 24.8	2908 21.5	3272 4.6	3858 23.5	4259 20.7	5282 18.3	5342 22.2	6131 14.1
125	333 17.6	1020 3.3	1156 14.4	1673 16.4	2461 19.3	2912 21.5	3360 18.8	4025 5.4	4596 17.5	5276 15.4	5467 5.5	6165 14.7
126	412 24.0	961 18.8	1152 2.5	2097 12.6	2622 16.0	2660 18.8	3615 6.9	3919 1.5	4275 24.7	5035 9.2	5693 14.4	6125 19.8
131	478 4.6	726 7.5	1141 21.1	2117 10.6	2349 19.4	3169 21.0	3523 22.2	4137 0.7	4391 23.2	5061 15.6	5777 16.5	5918 21.5
132	170 5.0	621 0.9	1143 14.3	1774 7.9	2196 3.1	3147 2.8	3211 7.8	4076 1.4	4692 17.9	4949 14.4	5777 3.3	6091 0.6
133	292 18.5	687 25.4	1338 21.9	2017 14.9	2572 21.1	2671 18.2	3663 17.1	3853 21.2	4398 0.4	5033 5.4	5335 23.4	5956 22.1
134	304 19.8	557 21.0	1529 24.0	2077 8.7	2336 11.3	2848 14.9	3504 6.3	4194 25.5	4459 23.1	5036 19.8	5781 23.9	5894 12.4
135	215 9.2	812 5.3	1481 20.3	1641 6.0	2360 5.2	2706 18.9	3457 23.2	4139 15.8	4522 18.6	4971 1.0	5793 5.5	5963 5.2
136	386 18.9	721 3.2	1075 22.2	1837 8.5	2546 20.1	2776 17.8	3371 21.3	3972 21.0	4488 1.6	5285 19.1	5423 14.1	5893 0.4
141	423 18.0	764 13.1	1064 3.0	1876 24.8	2206 14.8	2841 5.9	3473 21.5	4206 2.1	4457 5.0	5116 19.6	5513 14.7	6000 21.3
142	197 23.4	607 15.3	1244 17.7	1755 25.2	2348 2.4	2783 4.2	3204 3.9	3842 0.1	4502 5.9	5219 3.2	5667 12.3	6163 22.6
143	466 23.0	909 13.3	1061 2.5	2072 7.2	2314 12.2	3010 9.3	3460 22.0	4060 1.7	4390 8.5	4884 17.0	5805 6.6	6094 5.1
144	315 17.8	693 10.9	1061 1.5	1803 2.2	2536 19.7	2804 14.8	3495 23.1	4152 6.6	4700 5.6	5216 11.7	5457 17.0	6175 15.4
145	7 19.0	799 18.5	1199 25.1	2042 23.1	2161 21.6	3127 9.0	3598 22.5	3795 25.0	4706 9.2	4947 15.7	5304 21.3	6263 4.9
146	102 0.9	882 16.8	1294 5.4	1733 13.9	2248 17.0	2702 15.3	3199 10.5	3767 5.0	4284 0.3	4837 18.9	5646 17.3	5967 15.6
151	146 1.6	1023 21.8	1249 23.6	1859 3.1	2224 22.4	2896 2.9	3417 11.7	3862 5.1	4678 14.9	5254 15.6	5778 0.4	5931 3.7
152	502 17.1	718 1.4	1535 0.1	2015 12.7	2435 6.3	2824 15.2	3701 8.1	3862 24.4	4282 10.2	5045 9.3	5304 16.2	6187 0.1
153	21 7.1	993 17.0	1577 14.6	2097 1.5	2577 1.4	2844 10.4	3677 15.4	4196 10.9	4380 10.0	4824 18.4	5548 3.7	5912 18.9
154	16 14.9	845 8.9	1300 15.9	2059 7.1	2502 24.7	3145 19.5	3581 1.2	4231 20.1	4589 20.8	4778 14.9	5745 21.5	5925 5.2
155	354 6.2	626 5.9	1354 10.7	1876 23.6	2600 10.0	2904 11.1	3266 8.7	3790 0.2	4540 11.4	4896 13.2	5394 12.3	6075 24.3
156	248 16.4	933 0.8	1449 1.3	2057 10.9	2292 23.7	3128 18.7	3210 23.9	3748 16.0	4242 10.6	5119 10.8	5345 3.9	6294 15.2
161	150 5.7	613 17.0	1326 22.6	2117 6.0	2327 23.4	2760 23.0	3298 24.4	3889 6.5	4319 3.1	4853 24.9	5774 3.9	6092 23.0
162	384 12.6	973 14.4	1149 6.1	2087 16.4	2526 17.1	2826 15.1	3315 3.3	3916 15.9	4383 9.2	5176 1.5	5785 1.2	5980 4.0
163	337 4.4	760 9.1	1066 1.7	1832 25.5	2251 9.4	2905 14.8	3583 25.2	4227 17.5	4436 3.8	5208 21.5	5429 21.2	6122 17.8
164	193 16.7	629 2.1	1508 24.7	1676 17.7	2127 6.4	3102 11.3	3325 3.6	3868 16.3	4397 8.3	5025 17.3	5382 10.3	6246 0.0
165	39 4.2	623 16.1	1309 6.5	1742 22.6	2124 2.3	2708 7.7	3646 23.5	3935 7.3	4518 12.2	4946 12.3	5576 4.1	6337 6.9
166	431 21.3	894 14.2	1582 12.4	1920 8.5	2464 12.8	2862 9.4	3208 4.8	3755 18.5	4446 5.5	5135 20.3	5434 1.2	6318 24.6

SAMPLE LAYOUT NUMBER	DISTANCES TO Y- AND X-REFERENCE LINES FOR EACH OF 12 SAMPLES IN A LOT											
	X(1) Y(1)	X(2) Y(2)	X(3) Y(3)	X(4) Y(4)	X(5) Y(5)	X(6) Y(6)	X(7) Y(7)	X(8) Y(8)	X(9) Y(9)	X(10) Y(10)	X(11) Y(11)	X(12) Y(12)
211	317 2.1	855 23.5	1308 3.5	1990 8.7	2451 4.6	2886 11.0	3528 15.7	3966 17.7	4736 9.3	4874 4.3	5434 21.5	5843 3.6
212	116 12.1	628 10.8	1578 20.9	1697 3.5	2122 13.5	2814 23.5	3509 5.4	3814 14.4	4353 2.9	4906 1.3	5760 24.3	6101 2.5
213	10 13.1	1032 9.3	1267 19.1	1888 17.6	2328 21.3	2892 21.2	3321 11.2	4134 9.6	4314 17.0	4804 22.2	5465 13.3	6286 4.3
214	206 12.5	699 18.1	1077 21.0	1744 8.8	2316 10.6	3063 0.8	3580 16.0	3882 21.9	4649 11.3	5108 11.7	5328 5.2	6169 4.2
215	101 22.0	837 23.0	1383 2.7	1699 5.0	2625 23.2	2682 6.7	3541 3.1	3779 20.1	4320 9.6	5144 12.5	5642 7.9	5837 7.4
216	450 6.8	887 14.6	1278 23.9	1764 16.7	2280 3.7	3001 10.6	3303 20.1	3892 18.6	4492 8.9	5191 3.6	5303 17.3	6080 2.3
221	194 17.5	889 21.4	1203 15.1	1691 2.2	2338 18.2	3105 7.1	3695 8.6	3941 11.6	4691 8.8	4974 14.7	5610 2.0	6337 4.8
222	510 21.1	674 9.3	1201 17.0	1687 25.3	2135 19.2	2974 11.6	3536 4.2	3750 1.3	4409 7.6	5032 13.4	5539 10.3	6315 9.9
223	326 6.2	591 21.8	1413 1.5	1636 14.7	2396 0.2	2758 14.6	3290 0.0	4154 2.0	4473 6.5	5064 13.1	5703 11.9	6066 24.3
224	93 6.8	758 3.4	1093 20.4	1790 6.3	2616 17.8	2944 13.1	3704 6.6	4193 19.4	4309 22.4	5259 0.4	5610 17.9	5899 14.0
225	193 6.9	913 13.0	1175 15.4	1813 20.6	2641 6.2	2964 20.3	3673 6.7	3917 14.5	4240 20.1	5251 3.9	5621 14.6	6183 18.5
226	172 9.3	1024 15.1	1373 7.8	1676 24.9	2211 10.9	2932 19.6	3399 5.8	3852 4.1	4736 22.2	5117 2.8	5634 24.9	6297 10.4
231	2 24.8	1011 5.2	1075 3.5	1815 21.5	2565 25.1	2877 21.8	3314 6.7	4097 1.9	4316 0.8	5174 24.3	5538 10.7	5982 6.9
232	37 11.5	832 15.1	1374 25.2	1816 2.0	2288 5.1	3107 11.5	3251 5.3	4182 3.5	4454 12.1	5285 0.6	5817 7.6	6217 11.8
233	327 5.5	847 15.5	1088 15.3	1916 12.2	2617 14.8	2707 17.2	3456 14.5	3995 24.2	4643 1.8	5196 14.1	5410 1.9	5991 14.1
234	210 11.7	539 0.1	1567 21.2	1830 11.1	2207 2.2	2998 16.1	3448 10.1	3718 10.5	4445 20.2	5040 18.8	5789 16.0	5869 4.6
235	412 24.9	817 14.1	1509 24.1	1710 5.6	2394 1.3	2890 10.4	3493 9.1	4169 18.4	4695 21.8	4853 21.3	5658 14.2	6237 6.8
236	118 5.4	550 3.3	1339 2.2	1868 13.1	2435 5.9	3011 10.1	3647 20.9	3887 18.3	4539 13.4	4909 14.5	5304 21.0	5845 6.8
241	241 24.9	1032 10.9	1547 21.0	1844 1.8	2582 4.5	2916 4.1	3544 7.1	3872 0.7	4505 5.7	5193 11.2	5510 10.3	6002 8.7
242	53 24.3	563 13.7	1316 1.3	1785 24.7	2405 7.5	2946 14.0	3182 21.1	4165 24.3	4327 22.5	5261 3.8	5791 8.7	5912 22.8
243	4 13.8	779 24.9	1410 25.0	1964 9.3	2177 20.9	2985 3.4	3635 2.3	4229 12.0	4672 4.8	4953 19.8	5374 25.1	6161 10.2
244	529 0.8	573 10.2	1244 15.4	1820 4.2	2134 3.3	2816 19.2	3192 8.0	4017 8.0	4657 17.9	5081 23.6	5337 16.3	5846 23.3
245	146 17.9	813 16.4	1531 9.6	1749 13.8	2125 11.9	2661 6.6	3200 24.8	3927 13.1	4314 10.7	4845 12.0	5809 13.8	6123 5.6
246	110 22.3	1008 6.9	1353 10.7	1615 18.1	2308 17.5	2788 3.9	3227 16.8	3709 9.8	4417 20.9	5165 2.4	5624 8.4	6178 0.6
251	405 12.1	535 8.0	1580 1.1	1871 23.0	2635 24.8	2893 8.1	3535 14.4	3817 7.6	4356 24.4	5152 7.7	5761 23.6	6003 2.9
252	158 3.5	924 8.8	1389 23.4	1781 23.9	2291 3.4	2779 11.7	3467 9.2	3971 5.5	4243 15.8	5140 0.7	5426 0.6	6214 23.2
253	487 10.3	648 14.8	1367 15.9	1685 8.4	2153 13.6	2924 12.7	3691 18.8	4021 10.9	4514 3.5	5089 15.4	5342 1.7	6049 6.3
254	112 2.2	616 5.0	1554 24.2	1692 9.1	2423 4.2	2761 13.0	3548 11.1	3988 8.5	4457 21.2	4903 3.7	5527 23.6	6206 9.3
255	262 7.3	699 11.7	1550 17.1	1614 25.0	2194 23.1	2668 11.4	3560 1.8	4137 19.5	4569 18.8	4997 3.3	5750 4.2	5997 9.5
256	219 5.0	714 24.7	1109 4.3	1951 2.1	2130 14.8	2720 7.2	3295 12.6	4081 19.2	4647 13.5	5187 6.9	5495 2.8	6263 9.1
261	12 3.5	1040 13.8	1459 16.0	1732 23.6	2169 19.8	3159 19.5	3574 1.6	3887 3.6	4632 8.6	5009 10.1	5795 14.7	5922 8.7
262	90 24.8	919 1.0	1525 3.8	2013 5.7	2325 1.1	2795 10.4	3234 14.1	4060 24.6	4347 9.1	5122 11.9	5522 13.6	6241 2.3
263	194 9.2	735 17.3	1488 14.1	1862 20.5	2207 11.1	2945 25.4	3652 1.0	4210 1.9	4389 23.3	4959 12.1	5624 11.7	5956 5.3
264	472 24.9	1047 3.9	1485 5.1	1958 6.2	2557 1.8	3072 3.0	3305 14.2	4147 21.4	4301 24.8	5285 7.7	5414 20.0	6077 0.2
265	199 3.9	942 2.0	1553 14.3	1590 10.2	2314 15.1	3132 1.8	3526 20.2	4044 11.1	4531 16.1	5003 7.3	5468 2.5	5920 1.2
266	308 2.5	669 1.0	1190 23.6	2065 7.3	2447 6.2	3030 17.1	3474 16.4	4231 14.4	4601 18.0	5100 16.1	5473 13.2	6038 20.1

SAMPLE LAYOUT NUMBER	DISTANCES TO Y- AND X-REFERENCE LINES FOR EACH OF 12 SAMPLES IN A LOT											
	X(1) Y(1)	X(2) Y(2)	X(3) Y(3)	X(4) Y(4)	X(5) Y(5)	X(6) Y(6)	X(7) Y(7)	X(8) Y(8)	X(9) Y(9)	X(10) Y(10)	X(11) Y(11)	X(12) Y(12)
311	334 3.0	538 22.8	1463 24.5	1777 5.1	2645 11.7	3081 5.7	3381 24.0	3904 2.5	4511 22.2	4834 8.6	5755 24.6	5927 7.2
312	206 0.4	1038 11.7	1166 12.0	1772 12.5	2646 16.1	2753 7.0	3605 2.4	4089 12.9	4459 11.6	5185 20.8	5585 16.2	5837 7.8
313	150 2.3	923 7.5	1064 3.5	1763 24.4	2234 0.9	3175 9.4	3218 0.3	4076 13.8	4598 11.7	5191 23.3	5427 13.0	5855 22.0
314	124 22.8	864 19.4	1376 13.3	1735 6.0	2140 11.5	2748 11.0	3642 0.8	4066 1.5	4683 19.4	5123 10.6	5674 4.1	6303 13.4
315	523 5.0	953 24.8	1239 3.9	1780 3.8	2546 15.6	2995 24.7	3594 5.7	3801 11.1	4268 3.6	4795 20.4	5335 16.6	6312 10.8
316	286 7.5	720 22.8	1187 25.1	2092 9.9	2477 23.2	2866 20.1	3577 20.5	4074 11.8	4366 3.5	5112 9.3	5413 21.9	6211 11.1
321	491 3.3	1046 4.0	1509 0.8	2097 12.5	2595 12.7	2860 8.8	3497 0.1	4070 4.9	4349 6.4	4871 10.1	5589 25.1	5826 10.4
322	35 8.1	768 22.3	1226 11.0	1706 13.1	2522 7.6	3016 11.3	3206 3.4	4099 14.8	4524 15.6	5155 15.1	5315 14.1	5910 22.2
323	497 15.9	595 1.1	1127 20.7	2094 8.6	2596 24.4	2900 11.8	3299 5.6	3992 11.9	4463 15.3	4854 8.8	5349 18.6	5879 4.2
324	428 23.5	768 18.9	1328 5.3	2091 0.7	2263 7.9	2983 18.2	3255 23.8	4105 16.6	4355 12.2	4961 3.5	5478 4.6	6099 9.5
325	382 4.6	855 19.6	1544 7.4	1896 3.1	2361 9.7	2840 5.2	3264 3.6	3955 16.9	4734 15.4	5162 16.1	5572 9.7	6342 0.6
326	15 13.5	812 24.6	1433 8.1	1725 9.3	2424 13.4	2970 9.8	3643 22.6	3839 0.1	4444 6.7	5088 18.3	5720 13.8	5997 24.6
331	79 25.0	598 19.8	1249 12.0	1804 18.0	2400 16.7	3027 2.5	3423 2.2	3941 9.6	4386 15.7	4854 3.1	5720 1.9	6115 7.9
332	182 20.0	640 8.7	1223 25.1	1923 1.8	2546 5.0	2727 10.6	3652 18.3	4154 19.5	4715 23.6	5086 19.6	5480 20.1	6191 23.7
333	357 1.1	956 17.7	1513 19.7	1646 19.0	2423 19.6	2989 12.5	3238 21.2	3883 21.0	4620 11.9	5291 15.2	5550 17.5	6330 9.0
334	498 14.5	735 8.3	1120 24.1	2050 22.7	2291 4.2	2982 3.3	3464 4.6	4011 12.5	4551 7.0	5005 24.3	5640 16.0	6113 14.0
335	429 14.8	908 17.5	1328 23.4	1631 25.4	2531 16.0	2823 6.3	3696 16.1	3928 5.8	4651 6.2	4989 6.5	5630 16.4	6063 11.8
336	452 5.9	949 22.6	1485 12.0	2050 20.7	2267 1.5	2820 22.0	3372 20.2	3749 21.0	4558 15.0	4965 3.4	5352 6.1	6187 20.3
341	393 15.0	897 5.9	1131 14.2	2069 14.9	2352 2.3	2655 21.8	3367 11.0	4095 4.7	4692 7.2	5227 16.6	5516 11.2	5904 21.9
342	189 0.5	898 19.3	1075 2.4	1724 2.1	2254 17.6	3064 1.9	3302 6.5	4037 1.3	4664 11.6	4904 21.3	5543 23.2	6202 0.6
343	525 16.3	801 11.0	1546 15.9	1937 7.4	2333 5.9	2798 1.3	3242 16.2	3852 25.3	4737 9.5	5267 3.9	5433 23.0	6147 15.0
344	237 19.1	545 5.8	1109 1.5	2042 5.3	2131 17.0	2960 24.0	3704 15.9	4218 17.9	4392 22.8	5046 3.7	5319 10.0	6238 15.0
345	107 23.4	738 16.3	1389 9.4	1609 18.5	2441 20.5	3042 22.4	3418 3.9	3718 24.0	4464 4.8	5147 21.0	5605 3.5	5962 9.8
346	220 17.4	955 9.0	1166 12.3	1607 22.6	2318 5.7	2861 10.6	3589 3.9	3742 1.8	4240 13.9	4954 2.5	5560 25.2	5929 12.4
351	3 11.5	990 2.7	1273 4.4	1790 14.5	2498 23.9	2658 5.8	3277 25.1	4149 15.3	4238 23.6	4973 20.3	5389 6.1	6181 13.8
352	270 16.0	1007 16.9	1241 6.9	2031 24.1	2153 6.9	2868 18.8	3641 23.5	4049 17.8	4459 7.0	4888 13.8	5428 8.4	6282 23.1
353	526 14.2	1051 21.2	1177 0.1	1844 17.3	2570 1.4	2693 21.7	3559 0.3	3799 0.6	4585 4.5	4898 2.7	5355 17.0	6190 17.8
354	374 6.4	634 8.0	1449 17.7	1592 5.9	2555 17.2	2700 11.5	3289 2.9	4015 22.2	4417 21.4	5224 11.3	5535 23.0	6129 20.3
355	405 13.9	975 13.8	1509 17.2	1737 6.5	2342 25.4	3158 21.5	3466 10.0	4063 25.2	4645 0.2	4777 0.5	5456 10.1	6021 16.3
356	292 16.0	544 18.9	1529 18.4	2033 11.8	2378 18.9	2813 21.4	3389 1.7	3781 1.2	4657 21.4	5001 17.7	5604 6.9	5898 9.3
361	48 15.2	790 22.5	1305 19.0	1789 23.2	2133 9.3	3046 14.8	3363 18.6	3994 3.5	4388 6.7	5045 19.6	5621 18.6	6250 1.1
362	66 25.1	1057 18.7	1176 2.2	2050 2.0	2234 23.7	3052 22.4	3398 0.3	3749 6.5	4764 23.0	4879 9.2	5620 0.9	6018 15.0
363	76 22.5	619 15.4	1503 5.0	1807 19.2	2376 2.7	3175 3.5	3568 23.1	4152 3.8	4764 2.3	5140 21.3	5614 22.5	6220 4.8
364	37 17.0	606 1.2	1237 0.3	1811 0.5	2538 19.7	3072 16.0	3624 13.7	4006 12.7	4470 0.9	4989 10.5	5709 12.8	6288 16.6
365	453 22.7	989 2.8	1127 20.1	1727 10.3	2610 7.3	2864 4.6	3450 17.1	4008 21.0	4719 17.0	5279 16.2	5722 6.4	5895 17.1
366	390 9.2	758 10.1	1495 18.6	2102 12.5	2130 0.5	2939 2.4	3559 19.8	4207 1.4	4264 6.1	5082 23.3	5799 1.5	6232 9.2

SAMPLE LAYOUT NUMBER	DISTANCES TO Y- AND X-REFERENCE LINES FOR EACH OF 12 SAMPLES IN A LOT											
	X(1) Y(1)	X(2) Y(2)	X(3) Y(3)	X(4) Y(4)	X(5) Y(5)	X(6) Y(6)	X(7) Y(7)	X(8) Y(8)	X(9) Y(9)	X(10) Y(10)	X(11) Y(11)	X(12) Y(12)
411	178 25.5	670 12.4	1190 4.3	1641 0.1	2118 2.6	3143 7.7	3493 23.5	4032 4.5	4620 4.6	5243 18.3	5657 10.4	6032 0.8
412	217 12.2	845 0.3	1426 16.6	1795 18.4	2246 0.6	2863 14.8	3699 8.0	3905 21.6	4479 8.2	4862 18.0	5599 7.6	5896 14.4
413	215 5.6	1051 25.1	1506 16.9	1744 5.0	2199 2.4	2730 22.2	3433 19.0	3991 12.4	4431 24.9	4933 10.1	5346 21.0	6161 10.3
414	334 20.1	705 14.7	1271 8.1	1596 16.6	2594 7.5	3098 12.3	3446 20.6	3847 17.1	4415 24.0	5022 13.5	5418 21.1	6035 12.5
415	113 5.3	637 0.1	1515 21.0	1668 0.9	2134 15.4	2665 7.3	3363 2.8	3820 7.8	4585 25.1	5100 22.7	5516 7.5	6185 2.7
416	329 7.2	964 18.0	1299 0.0	1879 15.2	2244 8.1	2984 14.5	3556 8.2	4024 12.4	4700 21.7	4767 16.0	5713 21.3	6095 2.0
421	506 11.6	851 12.7	1431 16.7	1851 23.7	2623 11.0	2852 19.7	3558 8.9	3864 11.7	4270 8.1	5094 22.7	5410 2.6	6310 4.8
422	417 5.9	853 21.3	1387 2.5	2027 23.4	2158 14.9	2798 18.5	3614 10.3	3744 15.8	4394 9.8	4807 20.9	5360 8.3	5828 7.3
423	365 18.9	895 22.8	1579 15.5	1645 12.5	2376 18.0	2882 15.0	3563 8.0	3998 24.9	4509 2.6	5018 16.3	5584 22.7	5830 25.1
424	172 12.1	968 16.0	1442 4.4	1812 15.5	2475 20.5	3158 4.0	3519 21.4	3747 24.4	4510 3.4	5240 0.9	5539 3.3	6281 9.2
425	110 19.0	735 11.7	1520 5.9	2111 10.2	2176 0.1	2853 18.3	3706 7.0	3707 1.0	4427 13.8	4892 10.8	5729 6.3	6071 15.5
426	490 23.4	924 20.7	1086 19.9	1629 22.6	2489 9.8	3007 2.2	3705 4.6	4003 2.4	4686 22.5	5201 8.7	5456 14.7	5950 1.3
431	36 24.1	565 3.2	1079 15.5	1840 5.1	2635 16.4	3029 1.4	3220 13.0	4211 21.9	4438 4.4	5060 15.3	5445 0.4	5837 10.7
432	297 7.0	891 13.1	1230 24.5	2116 18.6	2273 2.8	3084 22.5	3554 23.7	4068 12.3	4689 18.1	4817 10.3	5795 23.9	5846 21.6
433	353 17.2	977 20.5	1160 11.5	1702 2.5	2527 6.2	2967 0.5	3450 16.3	4150 13.9	4723 9.5	5190 1.1	5341 8.6	6298 12.0
434	198 25.3	670 0.9	1213 12.1	2115 10.5	2226 0.7	2682 18.1	3299 12.6	3892 12.7	4364 9.4	5225 11.0	5602 14.2	6006 2.9
435	222 11.3	676 4.3	1161 24.6	2094 18.0	2468 11.7	2806 17.3	3428 17.5	4186 23.5	4281 1.5	5039 1.7	5790 9.5	6277 22.9
436	348 10.7	530 3.2	1535 19.4	1827 24.9	2145 14.1	2957 14.7	3597 21.5	4010 13.4	4702 21.1	5059 15.7	5305 17.9	6161 6.9
441	23 11.3	715 22.4	1482 10.1	1692 19.4	2293 24.9	2822 7.6	3704 20.6	4114 8.7	4272 15.5	4877 21.5	5479 20.3	5913 8.3
442	490 4.9	655 17.9	1093 15.3	1661 17.4	2464 21.3	2991 23.6	3297 22.1	4072 25.2	4718 1.7	5069 25.0	5816 3.7	6317 22.4
443	489 7.7	985 8.1	1566 8.0	1949 21.0	2184 17.5	3162 10.2	3609 20.4	4121 11.5	4522 0.5	5033 6.7	5561 24.4	6015 4.6
444	45 21.0	753 1.3	1077 12.8	2059 11.5	2366 7.1	2931 16.3	3346 12.0	3924 8.6	4736 2.5	4977 19.5	5297 11.5	6196 18.4
445	310 0.8	586 18.9	1446 15.3	1981 23.5	2263 2.8	2702 6.6	3600 7.6	3848 23.4	4317 6.8	5091 6.8	5655 20.4	6267 0.7
446	368 13.4	924 12.4	1238 20.9	1641 6.1	2179 8.2	3070 13.9	3596 10.1	4085 0.9	4420 4.1	5281 5.9	5770 0.1	6188 22.2
451	128 5.5	1027 24.7	1480 4.6	1830 4.7	2237 0.3	2851 22.7	3680 17.5	4015 3.5	4300 22.5	4856 17.0	5450 12.5	6007 21.5
452	169 6.3	580 12.7	1246 14.2	1632 10.4	2647 11.3	3110 9.1	3637 18.8	4025 12.5	4572 4.9	5002 24.4	5751 18.7	6088 17.4
453	239 9.9	607 11.7	1341 11.5	1958 11.3	2143 7.0	3070 12.6	3195 16.6	3727 23.2	4716 19.6	4977 10.2	5570 18.6	5970 7.0
454	518 23.7	730 8.5	1283 23.9	1725 1.2	2128 8.7	2686 3.6	3408 5.0	4059 24.6	4738 11.9	4913 15.0	5370 14.0	5888 20.2
455	458 17.0	632 23.8	1446 11.0	2107 19.9	2624 24.2	2919 9.2	3589 24.6	4054 2.1	4239 5.4	5101 7.5	5574 21.5	6254 21.6
456	368 24.9	620 2.3	1393 16.8	1693 7.1	2322 9.8	3011 4.6	3598 1.0	3989 11.5	4569 12.6	5120 2.1	5458 13.7	5939 2.0
461	33 14.7	687 10.3	1517 16.1	1684 2.1	2599 13.7	2707 7.1	3532 18.5	4113 4.0	4661 2.9	4855 6.7	5443 14.1	6310 4.1
462	63 24.4	909 6.4	1109 21.9	1854 13.3	2388 6.6	2653 9.4	3179 20.3	3777 12.9	4703 2.7	4948 10.1	5352 21.1	5980 14.4
463	256 2.6	980 18.4	1572 16.9	1635 13.1	2281 13.1	2727 9.1	3367 25.2	3947 22.3	4527 12.1	5017 25.4	5800 11.7	5920 1.4
464	144 12.7	676 17.3	1544 21.5	1870 18.6	2125 20.7	3145 0.8	3615 16.7	4135 2.4	4526 19.8	5127 16.4	5787 5.5	6204 8.4
465	245 24.7	627 14.1	1122 13.5	2015 0.5	2538 0.8	2678 9.5	3514 21.4	4154 19.1	4455 1.2	5152 2.8	5794 7.1	6081 18.4
466	189 11.2	958 2.9	1424 12.2	2102 15.0	2546 3.7	2911 6.3	3316 14.9	3858 8.4	4736 4.4	4856 19.1	5746 11.9	6118 9.3

SAMPLE LAYOUT NUMBER	DISTANCES TO Y- AND X-REFERENCE LINES FOR EACH OF 12 SAMPLES IN A LOT											
	X(1) Y(1)	X(2) Y(2)	X(3) Y(3)	X(4) Y(4)	X(5) Y(5)	X(6) Y(6)	X(7) Y(7)	X(8) Y(8)	X(9) Y(9)	X(10) Y(10)	X(11) Y(11)	X(12) Y(12)
511	180 2.9	887 21.6	1319 16.8	2111 18.9	2185 22.6	2855 14.1	3190 19.0	3837 15.6	4572 6.0	5149 19.4	5535 19.4	6109 20.5
512	366 4.0	534 2.9	1388 9.0	1719 18.0	2267 23.9	2889 15.4	3535 4.5	3957 6.9	4673 22.4	4889 13.7	5444 10.1	5968 10.1
513	361 10.4	637 19.8	1072 16.8	2080 10.9	2209 16.8	2876 20.9	3676 12.2	3766 1.8	4645 5.7	4808 18.8	5660 9.2	5946 12.1
514	370 4.1	883 11.7	1180 15.7	2004 18.7	2422 23.7	2841 11.7	3452 5.5	3765 15.5	4457 10.5	4964 7.6	5404 15.0	5969 17.6
515	312 15.0	1028 3.0	1415 19.9	1847 20.9	2632 2.7	2708 13.8	3434 20.4	4167 24.9	4256 7.6	5210 0.1	5640 15.2	6276 11.3
516	17 21.6	746 1.5	1400 14.4	1646 12.4	2622 17.7	3126 16.5	3521 23.8	3843 9.1	4532 9.5	5128 21.5	5296 23.4	5974 20.8
521	50 9.8	797 3.7	1194 2.5	2050 25.3	2599 19.1	2815 18.4	3590 21.2	4014 21.6	4625 10.2	4988 19.2	5557 3.5	5908 24.9
522	405 13.6	921 7.2	1329 23.9	2003 0.8	2259 14.6	2953 16.6	3301 1.0	4044 13.9	4729 22.7	5125 0.3	5769 16.6	6129 9.9
523	350 23.0	755 24.0	1531 10.6	1714 16.9	2634 18.1	2897 16.7	3677 4.7	3946 6.6	4649 22.9	5133 22.2	5573 16.1	5948 22.0
524	359 16.9	771 20.2	1308 23.4	1700 18.3	2390 22.2	3058 7.0	3315 10.3	4134 20.2	4436 5.9	5026 16.4	5789 19.1	5842 19.5
525	410 5.1	1053 5.7	1081 22.7	1676 12.3	2181 18.6	2939 1.8	3514 19.7	3802 5.0	4411 14.9	5277 23.2	5688 5.7	5969 9.2
526	349 6.7	742 21.2	1185 22.4	1724 5.3	2378 6.2	2731 18.6	3509 13.3	3806 24.0	4408 17.0	4977 0.5	5634 19.3	5866 18.4
531	327 2.2	737 15.6	1129 9.6	2095 7.0	2489 11.1	2840 18.7	3283 9.1	3788 10.4	4497 22.2	5062 13.4	5303 20.5	5899 2.0
532	90 15.0	820 25.1	1212 21.0	1971 11.9	2403 7.9	2851 6.6	3620 16.4	4194 15.7	4390 13.2	5135 20.2	5401 23.0	6042 2.4
533	454 3.7	676 9.3	1472 12.3	2002 7.1	2135 20.6	2766 13.2	3390 20.6	3963 17.1	4306 5.7	4921 9.4	5734 24.7	6254 22.7
534	438 0.6	763 10.3	1121 14.3	1947 17.7	2318 12.5	2750 4.0	3327 17.0	4021 18.8	4500 11.8	5254 9.3	5437 20.6	6155 10.0
535	270 25.1	832 15.6	1379 8.7	1945 7.9	2123 22.3	3143 23.9	3580 2.3	4182 2.3	4647 20.8	4813 11.7	5630 18.2	6161 19.0
536	36 4.1	1049 13.1	1112 15.1	1912 6.9	2143 1.5	3088 8.3	3244 18.0	4119 1.1	4532 0.7	4982 18.8	5483 9.1	6166 9.6
541	478 17.3	902 0.3	1399 3.2	1780 23.8	2568 16.0	2729 4.5	3431 24.8	3945 7.8	4559 9.4	5271 0.5	5709 21.6	6071 12.9
542	482 3.4	816 3.9	1569 18.4	1825 16.4	2609 10.5	3076 6.2	3583 11.0	3941 14.0	4384 8.5	4870 21.4	5730 5.1	5833 15.6
543	392 11.4	606 23.4	1242 6.6	2095 15.3	2601 3.7	2676 13.9	3683 10.8	3762 18.5	4533 6.9	4929 19.9	5333 2.0	6146 18.3
544	428 3.6	764 6.3	1493 9.3	1792 4.7	2574 14.3	2653 11.3	3659 1.7	3804 25.2	4523 25.4	4915 7.8	5540 25.4	5846 24.7
545	132 14.6	688 25.1	1156 8.4	1833 18.2	2440 24.3	2846 11.1	3653 19.7	3784 17.1	4495 21.7	5111 19.4	5753 22.9	6159 9.4
546	320 5.6	933 22.2	1494 15.9	1912 0.4	2316 21.2	2727 11.4	3299 4.0	3872 5.6	4386 8.7	4878 19.2	5651 8.9	6221 3.4
551	226 12.5	921 7.0	1499 20.0	1668 18.5	2343 14.8	3065 18.9	3196 14.2	3935 13.7	4479 23.0	5078 13.0	5726 3.0	5831 15.2
552	301 4.9	789 21.7	1268 0.5	2023 20.8	2631 20.6	2950 3.7	3504 0.9	4125 15.6	4537 19.0	4774 12.6	5412 12.8	6205 1.0
553	200 3.2	941 20.2	1563 6.5	1998 3.7	2132 8.8	2976 18.7	3396 2.5	3969 23.1	4295 11.2	4861 20.8	5392 3.8	6159 10.2
554	281 22.7	545 20.2	1096 25.3	1913 15.0	2406 11.9	2846 17.4	3190 25.3	4234 9.6	4640 6.1	5025 18.9	5623 17.8	6219 7.7
555	397 11.8	739 13.2	1368 17.7	1912 14.1	2353 9.6	3127 10.7	3331 20.3	3970 15.4	4305 16.5	5106 22.5	5689 0.2	5880 7.0
556	63 13.9	549 15.0	1541 2.5	1962 9.9	2582 13.6	3133 20.2	3663 4.9	3889 22.6	4653 9.0	5201 7.0	5332 7.8	6004 15.8
561	139 7.6	798 23.2	1112 3.8	1786 14.3	2320 20.8	3074 9.3	3508 3.7	3708 19.9	4658 1.1	4982 0.1	5452 0.7	6334 21.7
562	43 10.8	854 10.1	1338 23.6	1596 0.9	2234 2.4	2981 15.2	3337 7.7	4101 24.6	4489 3.0	5062 14.5	5304 16.3	5872 2.8
563	171 6.0	829 21.7	1474 8.0	2085 19.6	2430 7.2	2831 25.0	3260 11.6	4038 22.8	4576 22.9	5031 16.4	5694 7.3	6181 12.3
564	367 17.2	971 2.4	1428 18.8	1886 19.8	2635 9.4	2748 22.8	3363 20.5	4188 3.2	4253 8.8	5252 10.1	5451 12.6	6272 16.8
565	394 22.9	803 2.4	1583 19.4	2088 16.5	2308 13.1	2923 7.2	3221 8.4	3968 18.6	4341 21.5	4912 1.5	5736 19.9	6096 20.9
566	151 10.4	859 4.9	1358 21.0	1714 24.2	2377 18.9	2669 22.6	3512 2.5	3970 20.4	4528 2.5	5003 23.2	5752 11.0	6230 5.6

SAMPLE LAYOUT NUMBER	DISTANCES TO Y- AND X-REFERENCE LINES FOR EACH OF 12 SAMPLES IN A LOT											
	X(1) Y(1)	X(2) Y(2)	X(3) Y(3)	X(4) Y(4)	X(5) Y(5)	X(6) Y(6)	X(7) Y(7)	X(8) Y(8)	X(9) Y(9)	X(10) Y(10)	X(11) Y(11)	X(12) Y(12)
611	290 9.0	579 4.0	1527 23.7	1699 11.3	2155 6.7	3025 3.2	3350 20.3	4012 8.3	4674 17.6	5031 8.5	5481 7.1	5968 8.6
612	441 24.7	1040 5.2	1294 14.8	1797 14.3	2595 0.3	2777 10.2	3665 6.2	3765 13.5	4596 9.2	4773 4.3	5369 18.7	5927 1.7
613	463 19.3	774 17.3	1487 19.8	1597 25.4	2595 9.9	2912 22.6	3387 5.9	4154 23.3	4588 12.8	5171 23.5	5343 23.3	6254 21.1
614	353 11.3	782 13.4	1173 7.8	1744 23.0	2182 21.3	3015 14.6	3501 12.0	3771 2.9	4410 25.3	4851 4.0	5785 3.2	6030 1.0
615	515 5.7	633 7.2	1169 5.5	1703 14.6	2408 4.5	3045 16.6	3629 23.9	3855 20.5	4575 21.7	4906 15.6	5442 13.0	6068 22.6
616	137 10.1	694 18.5	1221 17.9	1804 1.7	2587 10.6	2989 25.3	3557 10.3	3898 19.0	4504 20.7	5183 6.7	5781 4.7	5872 19.2
621	154 22.9	855 21.8	1150 5.6	1695 16.3	2170 22.3	2710 21.0	3360 12.5	4089 6.4	4554 7.9	5238 0.7	5638 15.2	5960 8.7
622	58 20.3	741 9.4	1208 3.3	1867 12.4	2598 9.9	2977 8.2	3426 25.2	4045 2.7	4360 25.0	4859 5.7	5739 12.3	6320 19.4
623	347 7.0	767 8.7	1358 17.0	1958 15.9	2640 11.3	3090 6.4	3319 19.8	4007 7.1	4512 4.4	5134 13.4	5352 3.9	5842 16.8
624	385 4.9	558 6.2	1066 13.5	1989 10.6	2182 24.1	2986 9.8	3448 3.6	3762 10.5	4528 14.3	4965 13.4	5359 11.2	6206 17.7
625	295 18.0	982 25.0	1450 22.8	1814 15.7	2128 13.9	3112 20.0	3700 19.2	3870 12.1	4670 9.4	5128 15.6	5814 2.2	6009 8.5
626	374 2.0	1006 3.1	1297 3.1	1764 9.5	2134 4.2	3064 18.4	3536 3.5	3954 12.2	4571 7.4	5250 8.1	5413 23.0	6084 9.9
631	274 3.6	940 0.4	1515 25.4	1894 2.0	2395 18.3	2889 8.1	3539 23.7	4191 19.7	4634 15.5	5269 20.8	5753 10.7	5960 5.4
632	469 13.1	612 23.6	1579 19.6	1734 14.6	2184 14.4	2726 15.8	3376 17.4	3728 17.8	4752 15.4	5221 19.0	5571 11.1	6084 24.3
633	289 2.5	870 22.5	1490 20.3	1675 12.6	2422 20.4	3111 7.7	3583 14.5	3734 4.3	4719 19.3	4857 0.3	5328 4.3	6315 21.1
634	330 23.5	666 10.5	1268 2.4	2069 8.4	2342 22.0	2683 15.2	3474 18.8	4049 0.1	4603 21.6	4888 19.6	5714 8.6	6333 20.7
635	374 21.1	754 21.6	1433 14.8	1689 25.3	2286 14.1	3019 18.4	3656 15.8	3795 11.5	4670 10.6	4993 5.8	5627 25.5	5879 17.1
636	72 3.3	970 7.8	1282 8.0	1697 10.1	2164 25.2	3046 9.5	3332 1.0	3898 21.5	4720 18.5	5159 12.0	5450 9.6	6225 19.0
641	409 18.0	536 3.5	1569 13.6	1946 24.0	2324 13.4	2810 13.8	3510 8.6	3910 21.3	4554 18.1	4965 24.0	5813 13.9	6039 11.4
642	510 16.1	531 22.6	1528 19.6	2108 7.8	2188 6.8	2772 7.4	3658 9.2	3753 1.3	4364 24.6	5244 20.4	5534 5.8	6265 21.5
643	508 22.2	1037 13.4	1072 22.2	1866 13.3	2340 2.4	3039 16.0	3463 16.3	3853 16.6	4643 8.7	5168 20.2	5368 12.3	6080 7.3
644	262 1.7	557 2.1	1294 4.9	2085 17.2	2245 22.1	3001 5.8	3579 11.6	4233 18.7	4419 4.8	5000 20.5	5356 16.7	6121 12.3
645	411 0.8	821 9.7	1389 19.1	1713 6.4	2461 19.8	3145 2.9	3241 5.2	3951 23.5	4286 20.1	4913 20.8	5577 7.4	5825 24.2
646	328 22.8	747 0.0	1539 17.6	1874 11.6	2469 11.1	3152 24.6	3483 19.5	4124 3.4	4565 0.4	4823 8.5	5521 10.1	6296 6.3
651	504 13.6	655 5.2	1411 20.8	1829 12.5	2446 18.5	2810 7.1	3236 6.1	3730 24.1	4538 20.3	5178 3.0	5515 19.7	6079 24.7
652	236 8.0	535 23.8	1152 11.6	1983 4.7	2231 24.6	3039 0.1	3388 20.5	4144 10.7	4739 9.9	5173 5.0	5441 19.7	6018 20.8
653	248 16.1	735 15.4	1432 14.1	1787 23.1	2630 11.4	2966 21.7	3448 0.2	4186 22.1	4480 1.1	5197 0.7	5751 6.4	6340 20.1
654	72 10.3	1044 21.3	1459 4.2	1891 4.8	2306 22.3	3042 23.1	3236 7.6	3749 12.1	4531 2.4	5247 20.4	5483 0.2	6333 21.0
655	355 24.6	743 20.0	1062 7.2	2105 23.6	2285 19.3	2749 20.4	3259 1.6	4151 4.3	4485 0.6	5043 18.0	5488 13.2	6138 21.7
656	429 11.7	860 7.3	1519 3.4	1861 18.6	2325 8.0	2872 0.7	3479 0.4	4205 17.0	4744 13.6	4986 6.2	5716 6.9	6241 17.6
661	261 7.2	621 11.4	1169 23.6	1648 3.0	2246 23.7	2996 15.6	3649 4.7	3985 4.3	4751 4.9	5224 6.5	5314 12.1	6282 16.9
662	301 14.6	1001 22.4	1144 4.3	2012 5.1	2507 17.6	3171 20.6	3356 8.5	4163 13.8	4240 17.6	5160 23.1	5511 11.6	6160 10.6
663	401 9.3	987 5.5	1360 12.1	1817 15.4	2313 2.2	3028 25.4	3359 1.8	3891 12.2	4427 6.8	4875 6.2	5496 13.3	6329 20.9
664	314 10.2	531 3.3	1059 3.4	1845 4.8	2266 10.1	3054 11.2	3696 13.0	4160 13.4	4250 8.2	4993 12.2	5570 16.3	6002 9.4
665	311 4.1	565 12.5	1497 4.2	1680 9.5	2391 20.4	2918 2.3	3329 17.8	3739 10.5	4487 20.4	4886 19.3	5655 16.2	6202 0.9
666	183 4.7	826 20.9	1260 6.7	1805 14.6	2578 20.0	3125 2.1	3701 17.5	4145 14.9	4254 9.5	5245 11.9	5502 7.8	5831 25.2

APPENDIX B

TEST RESULTS OF THE FOUR CONSTRUCTION PROJECTS

Project G (FR-64015/11535A)
Project U (M–36021/10139A)
Project J (FR-23092/10729A)
Project D (I-50062/00703A)

Sample ID such as "G-5-8" means that this sample is obtained from the eighth sub-lot of lot No. 5 of Project G. In the 'remark' column, 'FAILED' means that the aggregate gradation of this sample does not meet the specification limits.

SAMPLE ID	PERCENT PASSING 1-IN	3/4-IN	3/8-IN	NO. 8	PERCENT L.B.W.	PERCENT CRUSHED	REMARK
G- 1- 1	100	96.05	75.51	48.33	7.32	37.80	
G- 1- 2	100	96.65	77.01	50.22	7.79	33.38	
G- 1- 3	100	92.37	71.39	46.86	7.30	42.05	
G- 1- 4	100	93.86	72.21	46.12	7.34	48.78	
G- 1- 5	100	96.27	79.08	49.20	7.38	37.58	
G- 1- 6	100	94.96	73.16	45.71	8.11	40.10	
G- 1- 7	100	96.93	72.96	44.47	7.63	47.92	
G- 1- 8	100	95.38	74.60	47.77	7.77	46.45	
G- 1- 9	100	95.73	76.92	50.07	7.83	40.74	
G- 1-10	100	96.84	77.11	49.67	7.44	34.88	
G- 1-11	100	92.84	68.15	42.41	7.13	38.81	
G- 1-12	100	94.02	69.19	43.19	7.13	39.71	
G- 2- 1	100	93.02	72.79	45.37	7.54	36.90	
G- 2- 2	100	95.11	75.79	47.59	7.79	31.65	
G- 2- 3	100	95.81	72.71	46.32	7.54	40.85	
G- 2- 4	100	96.82	78.03	50.71	8.17	32.21	
G- 2- 5	100	96.69	79.04	50.65	8.37	50.19	
G- 2- 6	100	96.33	75.04	48.44	8.10	43.88	
G- 2- 7	100	95.81	76.09	48.18	7.93	31.56	
G- 2- 8	100	94.67	78.13	50.31	8.07	31.83	
G- 2- 9	100	96.87	72.37	45.99	8.20	35.55	
G- 2-10	100	96.36	75.48	49.33	8.53	48.75	
G- 2-11	100	96.80	77.29	50.25	9.16	51.68	FAILED
G- 2-12	100	95.67	74.63	47.24	7.39	36.24	
G- 3- 1	100	97.41	77.50	48.55	8.16	35.65	
G- 3- 2	100	94.50	71.78	45.24	8.30	40.14	
G- 3- 3	100	92.80	69.35	43.15	7.93	43.36	
G- 3- 4	100	96.84	75.18	46.63	8.00	40.46	
G- 3- 5	100	97.34	74.62	45.83	8.14	34.54	
G- 3- 6	100	98.00	77.40	47.50	7.92	32.14	
G- 3- 7	100	95.32	71.55	44.29	7.49	40.33	
G- 3- 8	100	96.98	75.33	47.21	7.97	38.22	
G- 3- 9	100	96.55	72.47	44.40	7.72	36.23	
G- 3-10	100	95.43	71.45	43.55	7.39	44.58	
G- 3-11	100	93.80	73.85	46.91	7.68	43.83	
G- 3-12	100	94.98	77.75	51.06	8.92	42.20	
G- 4- 1	100	95.98	74.31	46.91	8.27	40.45	
G- 4- 2	100	95.94	73.86	47.25	8.51	46.81	
G- 4- 3	100	95.58	72.87	46.34	8.09	43.43	
G- 4- 4	100	96.29	72.11	45.94	8.65	35.78	
G- 4- 5	100	95.19	75.55	47.51	8.46	44.30	
G- 4- 6	100	96.55	70.61	43.22	7.70	43.02	
G- 4- 7	100	95.33	72.58	44.16	7.83	34.08	
G- 4- 8	100	94.20	72.00	44.76	7.69	41.18	
G- 4- 9	100	94.19	73.94	47.10	7.37	38.69	
G- 4-10	100	97.64	76.89	49.85	6.87	40.81	
G- 4-11	100	96.33	73.45	47.78	7.60	37.80	
G- 4-12	100	95.62	74.29	46.87	8.12	40.22	

SAMPLE ID	PERCENT PASSING 1-IN	3/4-IN	3/8-IN	NO. 8	PERCENT L.B.W.	PERCENT CRUSHED	REMARK
G- 5- 1	100	94.64	72.09	46.67	7.38	38.62	
G- 5- 2	100	97.21	77.89	50.22	8.02	41.52	
G- 5- 3	100	96.13	77.08	48.42	7.19	37.87	
G- 5- 4	100	95.34	75.21	48.06	7.72	47.36	
G- 5- 5	100	94.30	73.09	47.02	7.58	38.99	
G- 5- 6	100	98.03	76.47	50.55	7.44	38.12	
G- 5- 7	100	95.75	76.08	48.47	6.98	45.58	
G- 5- 8	100	94.96	74.69	47.79	6.99	42.13	
G- 5- 9	100	96.20	74.10	47.86	7.02	39.44	
G- 5-10	100	95.32	72.11	44.84	7.86	47.73	
G- 5-11	100	95.41	75.57	47.93	7.08	36.28	
G- 5-12	100	94.87	74.74	46.73	7.07	38.91	
G- 6- 1	100	98.88	76.43	48.54	7.92	46.11	
G- 6- 2	100	95.50	74.69	47.81	7.57	31.76	
G- 6- 3	100	95.33	74.18	45.50	7.78	39.24	
G- 6- 4	100	94.09	74.93	48.05	7.85	38.63	
G- 6- 5	100	98.92	81.42	51.98	7.61	39.89	
G- 6- 6	100	96.74	75.69	47.34	8.15	37.76	
G- 6- 7	100	94.71	72.01	45.69	6.77	45.05	
G- 6- 8	100	96.32	75.56	47.85	7.31	35.05	
G- 6- 9	100	95.56	73.40	46.65	7.39	42.98	
G- 6-10	100	94.82	71.22	45.88	7.06	42.21	
G- 6-11	100	94.19	72.37	46.12	7.26	39.81	
G- 6-12	100	95.99	74.75	47.85	7.24	33.77	
G- 7- 1	100	96.98	74.81	48.46	7.33	34.32	
G- 7- 2	100	96.93	78.57	50.07	7.69	41.97	
G- 7- 3	100	95.61	75.26	47.28	7.58	40.95	
G- 7- 4	100	96.00	73.51	46.06	7.50	39.39	
G- 7- 5	100	96.99	79.15	49.92	8.55	38.54	
G- 7- 6	100	96.23	74.45	50.43	11.11	54.44	FAILED
G- 7- 7	100	95.25	71.46	44.67	7.48	36.09	
G- 7- 8	100	93.41	66.55	40.74	6.59	35.74	
G- 7- 9	100	95.67	70.54	44.26	7.18	42.90	
G- 7-10	100	94.38	73.34	47.80	7.29	38.04	
G- 7-11	100	96.92	78.38	48.31	7.35	39.54	
G- 7-12	100	96.82	76.67	48.73	7.24	33.43	
G- 8- 1	100	98.65	76.07	48.78	7.38	29.89	
G- 8- 2	100	97.08	79.78	50.38	7.54	36.47	
G- 8- 3	100	97.52	79.30	51.99	7.90	33.67	
G- 8- 4	100	98.16	79.69	51.20	7.74	34.15	
G- 8- 5	100	96.64	75.42	49.11	7.38	46.94	
G- 8- 6	100	96.31	77.21	49.24	7.40	42.47	
G- 8- 7	100	96.48	78.11	49.25	7.10	35.86	
G- 8- 8	100	94.52	75.79	48.06	7.45	33.47	
G- 8- 9	100	96.84	78.25	51.26	6.81	49.08	
G- 8-10	100	98.82	80.12	51.43	8.65	46.87	
G- 8-11	100	96.91	74.19	46.67	8.13	40.52	
G- 8-12	100	96.51	73.20	45.40	7.79	41.99	

SAMPLE ID	PERCENT PASSING 1-IN	3/4-IN	3/8-IN	NO. 8	PERCENT L.B.W.	PERCENT CRUSHED	REMARK
G- 9- 1	100	94.66	75.08	47.81	8.14	42.78	
G- 9- 2	100	93.91	72.81	46.66	7.87	42.94	
G- 9- 3	100	94.33	73.34	46.62	8.11	39.68	
G- 9- 4	100	95.24	74.41	47.64	8.49	42.47	
G- 9- 5	100	94.90	74.28	46.75	7.86	39.79	
G- 9- 6	100	96.39	78.44	49.19	8.67	30.40	
G- 9- 7	100	95.34	72.81	42.85	6.42	46.26	
G- 9- 8	100	95.27	73.71	45.68	7.83	44.77	
G- 9- 9	100	97.35	77.56	49.59	8.60	50.26	
G- 9-10	100	94.43	65.81	40.04	6.53	53.25	
G- 9-11	100	93.28	72.86	48.07	7.81	47.65	
G- 9-12	100	93.55	71.93	45.21	7.22	41.63	
G-10- 1	100	93.76	73.20	46.84	7.29	40.37	
G-10- 2	100	95.38	71.91	44.64	7.26	47.16	
G-10- 3	100	95.93	74.12	46.58	7.64	44.88	
G-10- 4	100	96.66	75.89	47.17	7.73	38.15	
G-10- 5	100	93.64	73.95	46.18	7.61	37.64	
G-10- 6	100	96.68	73.34	47.39	7.40	46.38	
G-10- 7	100	95.34	71.82	44.26	7.35	43.48	
G-10- 8	100	96.24	74.60	48.89	7.74	37.72	
G-10- 9	100	95.33	74.18	48.58	8.49	37.51	
G-10-10	100	94.70	72.87	47.85	8.92	48.60	
G-10-11	100	95.98	73.37	46.19	8.07	45.15	
G-10-12	100	95.64	76.59	47.26	8.03	37.66	
U- 1- 1	100	94.71	69.47	50.10	7.12	67.99	
U- 1- 2	100	94.16	69.69	49.21	6.89	66.25	
U- 1- 3	100	91.19	65.19	46.16	6.59	69.38	
U- 1- 4	100	92.66	65.21	44.32	6.03	73.02	
U- 1- 5	100	93.76	67.63	47.55	6.69	66.96	
U- 1- 6	100	92.72	64.13	42.72	6.26	69.97	
U- 1- 7	100	95.21	68.72	47.65	6.14	66.97	
U- 1- 8	100	90.49	62.76	41.33	5.27	78.02	FAILED
U- 1- 9	100	93.00	68.97	47.56	6.49	70.04	
U- 1-10	100	92.54	70.83	49.60	6.71	75.02	
U- 1-11	100	93.28	66.72	44.99	6.45	68.03	
U- 1-12	100	94.89	66.46	45.93	6.14	64.04	
U- 2- 1	100	96.58	68.45	47.51	6.69	76.02	
U- 2- 2	100	94.34	68.10	48.63	6.79	68.01	
U- 2- 3	100	94.68	67.50	47.39	6.42	62.99	
U- 2- 4	100	93.82	71.67	52.13	6.57	71.99	FAILED
U- 2- 5	100	94.10	71.02	49.95	6.56	71.02	
U- 2- 6	100	93.91	69.48	50.59	7.72	71.03	
U- 2- 7	100	93.73	67.59	46.51	7.54	70.02	
U- 2- 8	100	92.09	66.58	46.51	6.56	66.97	
U- 2- 9	100	95.06	68.50	46.99	6.26	64.72	
U- 2-10	100	95.34	69.81	48.84	6.73	72.42	
U- 2-11	100	95.57	67.23	44.93	6.85	68.35	
U- 2-12	100	93.56	69.01	47.15	6.72	77.91	

SAMPLE ID	PERCENT PASSING 1-IN	3/4-IN	3/8-IN	NO. 8	PERCENT L.B.W.	PERCENT CRUSHED	REMARK
U- 3- 1	100	95.76	72.72	51.73	5.97	66.01	
U- 3- 2	100	97.64	72.70	51.26	6.35	77.02	
U- 3- 3	100	94.34	68.35	47.81	6.22	74.04	
U- 3- 4	100	92.29	68.72	47.63	6.68	76.01	
U- 3- 5	100	95.69	71.96	50.35	6.81	66.04	
U- 3- 6	100	94.59	71.71	50.43	6.55	69.99	
U- 3- 7	100	93.83	67.50	47.57	6.08	71.03	
U- 3- 8	100	93.70	68.56	47.22	6.38	72.04	
U- 3- 9	100	95.40	79.18	51.09	6.20	66.95	
U- 3-10	100	91.20	76.29	48.27	6.08	67.01	
U- 3-11	100	94.18	64.76	43.13	6.45	62.97	
U- 3-12	100	91.60	67.49	48.41	6.60	68.99	
U- 4- 1	100	95.89	70.82	49.27	5.69	65.99	
U- 4- 2	100	95.20	69.51	48.31	6.42	69.99	
U- 4- 3	100	91.49	66.34	46.21	6.54	72.98	
U- 4- 4	100	93.28	65.53	45.41	6.07	66.01	
U- 4- 5	100	93.36	68.26	48.73	6.19	69.00	
U- 4- 6	100	97.31	71.03	49.52	7.15	71.03	
U- 4- 7	100	94.14	69.20	48.54	7.64	75.02	
U- 4- 8	100	93.76	77.13	47.89	7.10	70.95	
U- 4- 9	100	91.63	64.23	43.81	7.17	70.98	
U- 4-10	100	90.67	63.66	43.47	6.82	69.97	
U- 4-11	100	94.80	63.16	40.08	6.05	66.99	
U- 4-12	100	94.86	64.45	43.89	5.72	67.99	
U- 5- 1	100	92.99	66.88	46.74	6.35	78.83	
U- 5- 2	100	93.34	70.86	51.22	5.80	62.07	
U- 5- 3	100	93.52	66.24	46.26	6.00	63.49	
U- 5- 4	100	94.33	70.09	48.49	5.77	66.28	
U- 5- 5	100	95.39	70.93	50.06	5.37	71.63	
U- 5- 6	100	93.29	70.27	49.35	6.40	65.25	
U- 5- 7	100	95.89	71.63	49.31	6.76	70.55	
U- 5- 8	100	93.31	68.46	48.23	5.86	68.96	
U- 5- 9	100	93.39	72.49	52.60	5.90	72.88	FAILED
U- 5-10	100	93.90	71.01	47.93	6.29	70.93	
U- 5-11	100	93.39	70.68	50.48	7.89	70.82	
U- 5-12	100	92.89	70.21	44.81	6.81	67.47	
U- 6- 1	100	93.72	72.18	50.39	6.06	64.21	
U- 6- 2	100	94.03	71.40	51.54	6.48	65.24	
U- 6- 3	100	93.45	69.79	49.74	6.68	67.64	
U- 6- 4	100	96.60	71.81	50.77	6.65	68.06	
U- 6- 5	100	96.39	72.45	50.59	6.99	68.82	
U- 6- 6	100	94.80	67.44	48.08	6.57	67.74	
U- 6- 7	100	93.30	68.67	48.68	6.32	73.45	
U- 6- 8	100	91.06	64.76	46.52	5.21	68.28	
U- 6- 9	100	92.24	70.62	50.96	6.53	67.51	
U- 6-10	100	96.23	70.39	49.91	6.90	71.54	
U- 6-11	100	93.83	70.84	49.33	6.36	69.47	
U- 6-12	100	94.31	70.69	48.81	6.03	68.90	

SAMPLE ID	PERCENT PASSING 1-IN	3/4-IN	3/8-IN	NO. 8	PERCENT L.B.W.	PERCENT CRUSHED	REMARK
D- 1- 1	100	100.00	83.42	43.44	11.05		FAILED
D- 1- 2	100	99.46	83.64	45.10	11.41		FAILED
D- 1- 3	100	99.58	72.35	34.41	9.36		
D- 1- 4	100	100.00	75.90	36.09	9.19		
D- 1- 5	100	100.00	79.06	38.73	8.64		
D- 1- 6	100	100.00	84.09	43.07	10.06		
D- 1- 7	100	99.75	74.64	34.95	9.55		
D- 1- 8	100	99.71	76.06	35.50	10.33		
D- 1- 9	100	99.06	79.42	37.84	9.58		
D- 1-10	100	100.00	80.84	38.31	10.22		
D- 1-11	100	98.91	70.13	30.51	6.93		
D- 1-12	100	98.93	81.65	40.78	9.78		
D- 2- 1	100	99.70	77.79	37.42	8.22		
D- 2- 2	100	98.86	76.61	36.27	8.52		
D- 2- 3	100	98.68	73.47	35.99	9.20		
D- 2- 4	100	99.02	75.44	38.20	9.72		
D- 2- 5	100	100.00	78.05	38.58	9.70		
D- 2- 6	100	99.72	81.23	40.08	10.46		
D- 2- 7	100	100.00	75.36	35.56	9.50		
D- 2- 8	100	99.37	76.56	40.44	11.11		FAILED
D- 2- 9	100	99.69	78.81	40.16	10.93		
D- 2-10	100	99.44	73.19	33.55	8.83		
D- 2-11	100	99.56	79.98	38.78	9.21		
D- 2-12	100	99.66	78.35	37.78	9.11		
D- 3- 1	100	100.00	79.23	39.44	9.99		
D- 3- 2	100	99.64	78.77	38.71	9.52		
D- 3- 3	100	99.70	75.72	37.22	8.88		
D- 3- 4	100	100.00	82.75	42.58	10.57		
D- 3- 5	100	100.00	75.18	37.51	10.28		
D- 3- 6	100	100.00	84.27	43.90	10.86		
D- 3- 7	100	100.00	83.70	44.28	11.42		FAILED
D- 3- 8	100	100.00	81.27	40.26	9.64		
D- 3- 9	100	100.00	78.56	39.01	9.04		
D- 3-10	100	100.00	82.03	41.59	9.69		
D- 3-11	100	99.65	77.65	37.49	8.27		
D- 3-12	100	99.16	76.93	38.02	6.58		
D- 4- 1	100	99.04	72.99	32.27	6.46		
D- 4- 2	100	99.70	74.80	36.15	9.32		
D- 4- 3	100	100.00	73.10	33.54	8.55		
D- 4- 4	100	100.00	80.40	40.44	9.54		
D- 4- 5	100	99.70	82.12	42.70	9.93		
D- 4- 6	100	99.67	82.47	41.80	10.73		
D- 4- 7	100	99.64	79.45	39.78	10.32		
D- 4- 8	100	100.00	78.64	38.24	8.86		
D- 4- 9	100	100.00	79.67	37.84	8.28		
D- 4-10	100	100.00	80.39	40.23	9.74		
D- 4-11	100	99.76	76.49	36.23	9.79		
D- 4-12	100	100.00	77.29	39.10	10.00		

SAMPLE ID	PERCENT PASSING 1-IN	3/4-IN	3/8-IN	NO. 8	PERCENT L.B.W.	PERCENT CRUSHED	REMARK
D- 5- 1	100	100.00	77.42	39.92	9.96		
D- 5- 2	100	98.84	73.05	35.53	9.44		
D- 5- 3	100	100.00	79.33	39.12	9.96		
D- 5- 4	100	99.11	77.69	38.39	10.51		
D- 5- 5	100	99.74	81.27	42.38	10.18		
D- 5- 6	100	99.42	74.11	37.70	8.76		
D- 5- 7	100	100.00	71.98	30.24	6.40		
D- 5- 8	100	99.15	77.21	35.60	8.39		
D- 5- 9	100	99.39	79.67	39.52	9.59		
D- 5-10	100	100.00	83.16	41.02	10.63		
D- 5-11	100	99.56	75.41	35.05	9.00		
D- 5-12	100	100.00	81.93	38.59	10.22		
D- 6- 1	100	98.95	74.80	36.27	9.73		
D- 6- 2	100	99.48	71.82	33.75	8.82		
D- 6- 3	100	99.37	70.97	33.11	9.01		
D- 6- 4	100	99.75	81.07	38.77	9.62		
D- 6- 5	100	98.88	78.56	38.83	10.46		
D- 6- 6	100	99.76	78.95	38.99	9.60		
D- 6- 7	100	99.73	79.84	38.57	9.03		
D- 6- 8	100	99.59	76.51	36.94	8.99		
D- 6- 9	100	98.71	84.69	41.84	10.36		
D- 6-10	100	99.66	72.95	33.58	8.46		
D- 6-11	100	98.55	84.61	41.03	9.76		
D- 6-12	100	98.96	78.96	40.43	9.63		
D- 7- 1	100	100.00	87.47	59.05	9.33		FAILED
D- 7- 2	100	99.07	88.10	67.33	7.14		FAILED
D- 7- 3	100	99.69	81.31	38.82	7.87		
D- 7- 4	100	99.74	85.44	47.72	7.54		
D- 7- 5	100	100.00	77.69	37.28	9.00		
D- 7- 6	100	99.25	78.34	38.03	9.12		
D- 7- 7	100	99.13	73.00	33.15	8.51		
D- 7- 8	100	98.22	77.11	43.89	11.39		FAILED
D- 7- 9	100	99.56	72.94	34.78	8.43		
D- 7-10	100	99.62	81.21	48.05	11.98		FAILED
D- 7-11	MISSING DATA		-----	MISSING DATA			
D- 7-12	MISSING DATA		-----	MISSING DATA			
D- 8- 1	100	100.00	85.19	46.63	10.96		
D- 8- 2	100	100.00	86.64	46.57	11.17		FAILED
D- 8- 3	100	100.00	85.01	45.41	12.20		FAILED
D- 8- 4	100	99.65	85.26	47.45	12.46		FAILED
D- 8- 5	100	100.00	80.73	40.77	9.79		
D- 8- 6	100	100.00	81.41	43.70	10.81		
D- 8- 7	100	99.68	83.72	45.27	9.77		
D- 8- 8	100	99.69	82.34	40.82	9.37		
D- 8- 9	100	100.00	81.68	38.79	9.22		
D- 8-10	100	100.00	77.23	36.35	9.49		
D- 8-11	100	99.22	78.64	36.78	9.10		
D- 8-12	100	100.00	81.61	40.98	10.77		

SAMPLE ID	PERCENT PASSING 1-IN	3/4-IN	3/8-IN	NO. 8	PERCENT L.B.W.	PERCENT CRUSHED	REMARK
J- 1- 1	100	96.27	70.57	40.40	6.50	42.36	
J- 1- 2	100	97.16	73.88	42.77	7.03	44.41	
J- 1- 3	100	96.99	68.71	40.65	7.22	54.50	
J- 1- 4	100	98.52	74.32	44.05	6.61	47.34	
J- 1- 5	100	94.55	75.60	46.72	7.45	28.46	
J- 1- 6	100	98.11	82.29	52.14	7.35	36.42	FAILED
J- 1- 7	100	96.73	73.68	44.64	7.24	33.92	
J- 1- 8	100	97.17	80.99	52.34	7.88	38.41	FAILED
J- 1- 9	100	97.10	83.42	53.42	6.96	28.72	FAILED
J- 1-10	100	97.06	78.46	51.34	8.51	39.38	
J- 1-11	100	95.67	78.42	50.07	7.61	38.32	
J- 1-12	100	96.74	80.64	51.07	6.64	43.29	
J- 2- 1	100	97.62	83.03	53.75	8.12	46.95	FAILED
J- 2- 2	100	96.91	75.54	47.24	7.96	42.84	
J- 2- 3	100	97.27	79.58	51.25	8.57	41.87	
J- 2- 4	100	96.57	74.98	45.40	8.04	41.34	
J- 2- 5	MISSING DATA		-----	-----	MISSING DATA		
J- 2- 6	100	96.88	81.37	52.68	7.92	37.34	FAILED
J- 2- 7	100	97.81	86.58	57.27	8.51	100.00	FAILED
J- 2- 8	100	96.99	79.51	51.94	8.09	26.36	
J- 2- 9	100	97.13	78.70	50.68	7.19	30.10	
J- 2-10	100	94.57	71.31	43.93	7.16	32.36	
J- 2-11	100	97.04	78.87	49.04	7.62	29.11	
J- 2-12	100	97.08	82.01	49.97	7.94	38.08	
J- 3- 1	100	98.03	80.85	50.70	8.08	33.18	
J- 3- 2	100	97.11	78.46	48.30	7.49	23.48	FAILED
J- 3- 3	100	97.10	77.90	50.48	7.36	25.97	
J- 3- 4	100	95.21	73.61	46.19	7.25	35.08	
J- 3- 5	100	98.61	82.25	52.85	8.02	26.95	FAILED
J- 3- 6	100	96.06	78.01	49.18	8.15	48.77	
J- 3- 7	100	97.27	81.36	52.97	7.93	30.25	FAILED
J- 3- 8	100	98.89	83.57	53.05	7.39	33.07	FAILED
J- 3- 9	100	96.71	78.22	49.44	7.60	30.52	
J- 3-10	100	99.25	82.98	52.79	7.80	36.80	FAILED
J- 3-11	100	98.83	84.49	54.16	6.74	26.41	FAILED
J- 3-12	100	96.97	78.47	50.41	8.71	41.29	
J- 4- 1	MISSING DATA		-----	-----	MISSING DATA		
J- 4- 2	100	97.24	81.79	53.19	7.60	42.03	FAILED
J- 4- 3	100	98.07	77.24	47.76	7.36	39.70	
J- 4- 4	100	97.15	73.26	45.34	7.15	39.81	
J- 4- 5	100	97.93	81.65	51.97	7.34	41.84	
J- 4- 6	100	98.94	83.77	52.86	7.47	32.84	FAILED
J- 4- 7	100	97.73	85.06	54.37	7.79	33.57	FAILED
J- 4- 8	100	98.60	86.38	53.93	7.30	37.15	FAILED
J- 4- 9	100	97.26	85.12	54.18	7.65	38.25	FAILED
J- 4-10	100	97.41	77.44	49.38	7.89	44.19	
J- 4-11	100	97.63	83.70	53.53	8.26	48.28	FAILED
J- 4-12	100	96.96	81.40	51.82	7.95	42.19	

SAMPLE ID	PERCENT PASSING 1-IN	3/4-IN	3/8-IN	NO. 8	PERCENT L.B.W.	PERCENT CRUSHED	REMARK
J- 5- 1	100	98.13	79.68	50.53	7.66	41.94	
J- 5- 2	100	96.28	80.54	50.24	8.29	44.16	
J- 5- 3	100	96.47	78.91	48.76	8.75	37.69	
J- 5- 4	100	99.16	82.47	50.74	8.51	38.70	
J- 5- 5	100	98.52	83.15	51.97	8.03	46.55	
J- 5- 6	100	96.10	79.85	49.97	8.85	42.40	
J- 5- 7	100	96.63	80.76	51.41	8.70	47.41	
J- 5- 8	100	97.53	79.88	48.89	8.36	51.39	
J- 5- 9	100	99.39	81.36	51.03	8.32	39.41	
J- 5-10	100	99.52	81.68	52.02	9.47	52.72	FAILED
J- 5-11	100	95.91	72.81	45.54	6.69	47.13	
J- 5-12	100	98.27	84.34	53.83	8.14	39.05	FAILED
J- 6- 1	100	96.34	78.74	54.36	8.38	28.16	FAILED
J- 6- 2	100	97.27	82.61	52.89	7.17	37.43	FAILED
J- 6- 3	100	96.88	79.21	50.90	9.08	47.78	FAILED
J- 6- 4	100	99.06	85.00	54.77	8.79	44.18	FAILED
J- 6- 5	100	98.47	78.07	49.79	7.78	41.57	
J- 6- 6	100	96.24	75.27	46.83	7.23	38.72	
J- 6- 7	100	98.57	81.16	52.36	8.01	41.41	FAILED
J- 6- 8	100	96.87	80.00	50.07	7.78	37.38	
J- 6- 9	100	99.34	86.58	55.59	8.80	47.16	FAILED
J- 6-10	100	100.00	89.72	56.50	8.07	32.02	FAILED
J- 6-11	100	97.22	83.87	51.49	8.63	38.29	
J- 6-12	100	100.00	87.41	57.17	9.05	38.29	FAILED
J- 7- 1	100	97.89	83.44	54.02	9.80	36.98	FAILED
J- 7- 2	100	99.42	83.24	52.46	7.77	45.85	FAILED
J- 7- 3	100	98.25	86.54	53.68	8.06	42.83	FAILED
J- 7- 4	100	99.34	85.49	53.34	8.20	44.00	FAILED
J- 7- 5	100	98.89	74.18	42.96	7.17	54.16	
J- 7- 6	100	96.40	70.97	40.60	7.25	52.65	
J- 7- 7	100	97.78	71.55	39.64	6.92	45.73	
J- 7- 8	100	96.65	66.12	37.37	6.38	51.54	
J- 7- 9	100	95.96	65.20	34.71	6.69	59.33	
J- 7-10	100	95.88	65.99	37.35	7.31	53.34	
J- 7-11	100	97.12	68.91	39.83	7.62	49.91	
J- 7-12	100	96.87	66.17	37.07	6.11	49.22	
J- 8- 1	100	97.16	67.39	38.89	6.31	58.98	
J- 8- 2	100	96.29	70.05	39.38	8.02	46.38	
J- 8- 3	100	97.66	67.08	38.72	6.86	55.88	
J- 8- 4	100	98.55	73.17	44.29	6.75	47.98	
J- 8- 5	MISSING DATA		-----	-----	MISSING DATA		
J- 8- 6	MISSING DATA		-----	-----	MISSING DATA		
J- 8- 7	MISSING DATA		-----	-----	MISSING DATA		
J- 8- 8	MISSING DATA		-----	-----	MISSING DATA		
J- 8- 9	MISSING DATA		-----	-----	MISSING DATA		
J- 8-10	MISSING DATA		-----	-----	MISSING DATA		
J- 8-11	MISSING DATA		-----	-----	MISSING DATA		
J- 8-12	MISSING DATA		-----	-----	MISSING DATA		