Ontario

FIELD GUIDE

FOR THE ACCEPTANCE OF HOT MIX AND BRIDGE DECK WATERPROOFING

Prepared by:
Bituminous Section
Materials Engineering and Research Office
Ministry of Transportation Ontario

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To all users of this publication:

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Preface

The **2005** Field Guide has been prepared by the Bituminous Section of the Materials Engineering and Research Office to provide procedural guidelines to administer contract requirements on Ministry of Transportation projects in Ontario. The purpose of the Guide is to uniformly implement, across the Province, the acceptance procedures for Hot Mix and Bridge Deck Waterproofing. This year's Field Guide incorporates changes from last year's guide. These changes apply to new contracts advertised this year.

For carry-over contracts, specific sections in earlier field guides should be referred to.

The **2005** Field Guide is not a specification and does not form part of the contract between the Ministry and the Contractor. Neither the Ministry nor the Contractor are bound by the contents of this Guide unless agreed to in writing, in whole or in part, by both parties.

The **2005** Field Guide is primarily intended for use by Ministry of Transportation Regional and District Staff as well as Consultants administering Ministry contracts involving hot mix placement and bridge deck waterproofing. The guide outlines the required sampling, testing and recommended acceptance procedures, in accordance with the applicable Ontario Provincial Standard Specifications (OPSS) and current Ministry Special Provisions.

Major Changes and Highlights for 2005

Major Changes that have been made in this year's Field Guide are:

1) **<u>Tack Coat Specification</u>: Selected Ministry contracts may contain Special Provision No. 313F44, dated February 2005. This February, 2005 revision changes the basis of payment for tack coating of protection board to be included in the tack coating item. Application reates are also provioded for expanded asphalt and cold in place recycling of surfaces (in Chapter 1).**

2) **<u>Maximum Permitted Field Adjustments for JMF Properties</u>: 25.0mm and 12.5mm sieves now have been added in the list (in Chapter 2).**

3) **<u>Specification Limits for Air Voids</u>: For Superpave Mix, this shall be 4.0% as now mentioned in this guide (in Chapter 2).**

4) **<u>Special Provision 313F03</u>: Range of Percent Asphalt Cement for Bidding Purpose has also been added to this guide (in Chapter 4).**

There are a few proposed changes to the smoothness specification for this year as described in Chapter 6. The Tender Opening Date Reduction Factor (TODRF) will remain at 0.4 for tenders opened in 2005 with a single lift over Expanded Asphalt Pavement. A TODRF of 0.6 will apply for tenders opened in 2005 with SMA, single lift placed on a pulverized grade without Granular A provision, and matching existing curb and barrier wall within 1.5m of the lane being paved with the lane and shoulder being paved simultaneusly, if there is a shoulder.

The proposed 2005 version of SP 103F31 restricts diamond grinding on a single lift over expanded asphalt as previously stated for single lifts over granular surfaces or pulverized grades.

It is important to note that OPSS 313, 1150, 1101 and 1103 hot mix specifications, which were published in November 2002, have not been implemented on new Ministry contracts.

Contractors will be allowed to opt-into Standard Special Provision (SP), No. 103S38, entitled "Acceptance of Pavement Based on Visual Acceptance of Segregation", dated August 2003, under certain circumstances. The conditions for opting-into this SP are given in Chapter 5 and may be clarified, if necessary, by contacting the Ministry's Bituminous Section.

In addition to the form for JMF changes given in Appendix D and described previously, the **2005** Field Guide also includes a Random Number Table given in Appendix A as well as two relevent LS procedures, LS-100 and LS-101, which are respectively reproduced in Appendices B and C and give rules for rounding and Percent Within Limits calculations.

Chapter One

HOT MIX SAMPLING FOR ASPHALT CEMENT CONTENT AND GRADATION, MARSHALL PROPERTIES, RECOVERED PENETRATION AND COMPACTION / OTHER INITIATIVES AND CHANGES IN HOT MIX

1-1 General

Contracts without a Bituminous Quality Control (QC) plan, include a Special Provision (SP) No. 103F35, entitled "End Result Specification for Acceptance of Hot Mix (Aggregate Gradation, Asphalt Cement Content, Air Voids, Compaction) Based on Owner Testing". However, for those contracts with a Bituminous QC plan, a similarly-titled SP 103F34 ".....Based on Contractor Testing" is included.

Methods of sampling hot mix for aggregate gradation, asphalt cement content and air voids testing are included in Section 1-2, core sampling of hot mix for compaction is included in Section 1-3 and sampling of PGAC is included in Section 1-4.

Several years ago, a new hot mix item was created for Stone Mastic Asphalt (SMA) and several new additional hot mix items were created for Superpave mixes. Both Superpave and SMA mixes are designed using the gyratory compactor which requires larger (20 **-** 35 kg) samples for testing ERS attributes. **In 2004**, it was agreed that, for large samples of hot mix which are required for SMA and Superpave mixes, the Contractor will no longer be required to obtain permission to use an alternative sampling method. In addition, the samples may now be placed in a maximum of two receptacles and it won't be manditory to mix them once they are received at the testing laboratory.

In addition to the sampling requirements given in the body of this chapter, more details of the material and construction requirements of SMA and Superpave mixes are again included in Section 1-5 of this chapter along with descriptions of surface course thickness trials, an NSSP for tack coating and issues surrounding hot-in-place recycling.

1-2 Sampling For Aggregate Gradation, Asphalt Cement Content and Air Voids (and Recovered Penetration Testing for Hot-in-Place only)

1-2.1 Sample Size

The size of hot mix samples normally required for testing are as follows:

(a) For all mix types including premium hot-in-place recycling (but excluding regular hot-in-place recycled mix and hot-in-place with integral overlay):

A Set of Three Samples with a minimum mass of 10 kg for each of the three samples, {for SMA and Superpave mixes, 20**-**35 kg bulk samples **–** [see Table 1-3 i.e. 2 or more plates per sample will be required, if plate sampling is being carried out] shall be taken by the Contractor for each sublot [see Note 1]}. One sample will be retained by the Contractor for Quality Control (QC) testing and the other two from each set of three will be delivered to the Owner. The Owner may perform Quality Assurance (QA) testing on one sample and the other sample

will be stored for possible re-testing for outliers or for referee testing. For SMA, three additional 3 kg samples will also be required (possibly another plate, if plate samples are being taken) from one of the sublots in each lot which will be split for QA , QC and referee "draindown" testing (see Table 1-3 and Section 1-5.5).

Note: 1) Although plate sampling of SMA and Superpave mixes is described within this Chapter, the larger samples required for gyratory testing means that at least twice as many plates will be needed as required for conventional mixes. As a result of this, the Ministry agreed to allow the Contractor to propose alternative sampling methods, in lieu of plates for these mix types and a form letter had to be submitted for this purpose. However, the Ministry has agreed that Contractors will no longer be required to obtain permission, in order to use an alternative sampling method, as long as each sample is taken after its designated truckload has been unloaded at the site. In addition, it is permitted to place samples of SMA and Superpave mixes in a maximum of two receptacles and it won't be manditory to mix them once they are received at the testing laboratory.

(b) For hot-in-place recycled mix (excluding premium hot-in-place recycling) with and without integral overlays:

Individual samples with a minimum mass of 5 kg, will be taken for testing, in order to determine compliance for the penetration of asphalt cement recovered from hot mix (recovered penetration) and air voids for Owner Testing.

Note: 2) Penetration testing of asphalt material for all hot-in-place recycled mix is required by a laboratory which has participated in the Ministry's Penetration correlation testing.

1-2.2 Sampling Frequency

The sampling frequency is dependent on the lot size with the sublot size being set at the Contract Administrator's discretion in consultation with the Contractor within the parameters given in the Special Provision.

(a) For Hot-in-Place Recycled Mix and Hot in Place Recycled Mix With an Integral Overlay:

The special provisions in the Contract contain information on the requirements for these items. These mixes normally have a lot size of 4000 m^2 with five 5 kg samples taken for each lot (i.e. one sample for each 800 $m^{2)}$.

(b) For All Other Mixes :

10(to 35) kg Samples: When a lot is defined as 5000 t of any one type of hot mix produced, then the lot will normally be divided into 10 approximately equal sublots of 500 t each and a set of three samples with a minimum mass of 10kg [for SMA and Superpave mixes, 20-35 kg samples (see Table 1-3) will be required from each sublot (see Note 1)]. For SMA, 3 additional 3 kg samples (probably another plate, if plate samples are being taken) will also be required from one of the sublots in each lot for draindown testing (see Section 1-5.4). Note that an exception to these requirements may be made, if lightweight aggregates are used.

1-2.3 Sampling Methods and Random Sample Locations

Random samples are to be obtained by the methods permitted in the Contract. Refer to the Contract to determine which method is permitted for each hot mix type. The methods which may be permitted are (1) plate samples, (2) truck box samples, (3) coring, (4) from the screed auger chamber and (5) any acceptable alternative sampling method (to replace plates) proposed by the Contractor as long as each sample is taken after its designated truckload has been unloaded at the site.

The sampling locations and lot/sublot sizes should be determined on a daily basis. They cannot be determined at the start of a contract on a tonnage basis because there may be a need to terminate a lot prior to reaching a pre-determined tonnage.

Note: 3) FOR HOT IN-PLACE RECYCLED MIXES, THE SAME RANDOM NUMBERS CAN BE USED FOR THE 5 kg SAMPLES.

1-2.3.1 Quantity Method for Plate Samples

1. When production is expected to proceed with 5000 t lots with 10 sublots, divide each lot as follows:

   Example: HL 8 to have a set of three 10 kg samples obtained from each 500 t sublot within a 5000 t lot, i.e. Lot 3.

Lot 3	Sublot	1	0	-	≤ 500 t
		2	> 500	-	≤ 1000 t
		3	> 1000	-	≤ 1500 t
		4	> 1500	-	≤ 2000 t
		5	> 2000	-	≤ 2500 t
		6	> 2500	-	≤ 3000 t
		7	> 3000	-	≤ 3500 t
		8	> 3500	-	≤ 4000 t
		9	> 4000	-	≤ 4500 t
		10	> 4500	-	≤ 5000 t

2. For each sublot, select a random number either from a random number table or generated by a calculator or computer. A table of random numbers is given in Appendix A.

Lot 3	Sublot 1	0.750
	Sublot 2	0.446
	etc.	etc.

3. Using the random number determined for each sublot, identify the "tonne to be sampled". In reality, this number is only used to identify the truck load from which the sample is taken.

   Example: random number x lot or sublot size = tonne to be sampled
   0.750 x 500 = 375

4. Set up a table with each tonne to be sampled as follows:

HL 8: Sampling Locations (Set of Three 10 kg samples) - 5000 t Lots

HL 8 Lot/Sublot No.	Sublot Size	Random No. for Tonne	"Tonne to be Sampled" =(Random No. X 500) + start tonne for sublot
3/1	0 - ≤500 t	.750	375
3/2	>500 - ≤1000 t	.446	723
3/3	>1000 - ≤1500 t	etc.	etc.
3/4	>1500 - ≤2000 t	etc.	etc.
3/5	>2000 - ≤2500 t	etc.	etc.
3/6	>2500 - ≤3000 t	etc.	etc.
3/7	>3000 - ≤3500 t	etc.	etc.
3/8	>3500 - ≤4000 t	etc.	etc.
3/9	>4000 - ≤4500 t	etc.	etc.
3/10	>4500 - ≤5000 t	etc.	etc.

Note: 4) DO NOT PROVIDE THE SAMPLE TONNE INFORMATION TO THE CONTRACTOR PRIOR TO THE TRUCK BEING LOADED.

5. A copy of the sample table is provided to the employee, designated by the Contract Administrator, who will be responsible for identifying the truck load containing the sample tonne. A running total of hot mix production will have to be maintained for each item. A printing calculator or adding machine will minimize any chance of error. When the truck containing the "Tonne to be sampled" is identified, the person must:

   a. Mark the top of the weigh ticket "Load to be sampled".

   b. Write on the back of the ticket the mass of the sample (either 5 kg, 10 kg or 20-35 kg for SMA and Superpave), the lot number and sublot number (where applicable).

      Example: Mass 10 kg
      Lot 3
      Sublot 1 etc.

   c. Draw a diagonal line across the face of the ticket with a bright coloured marking pen. This will help draw attention to the fact that the load is to be sampled.

6. The road inspector must ensure that the Contractor's representative is fully aware of the load to be sampled.

7. The Contractor's representative is then required to take the set of three plate samples [for SMA and Superpave mixes, 2 or more plates per sample will be required, if plate samples are being taken – i.e. see Table 1-3 and Note 1)] anywhere within the load (but recommended within the middle third of the load).

8. All plate samples shall be taken at the same transverse offset.

9. The samples shall only be obtained from a machine laid mat, away from the wheelpaths of the paving equipment and far enough away from any pavement edge to ensure that the whole plate is covered by the mat.

10. After the sample has been taken, the Contractor is then required to properly label each sample with all relevant information (including its station and offset) and package the sample as designated in the contract. For each set of three plate samples, one plate sample should be designated as “QC” and the other two plates “QA” and “Referee” [for SMA and Superpave mixes, each of the samples will require two or more plates per sample – see Table 1-3 and Note 1)].

11. The packaged (i.e. bag, box etc.) “QA” and “Referee” samples, should be placed in heavy gauge plastic bags with an area on each bag in which a date and a code and all other relevent information (such as Contract number, lot, sublot, station and offset) can be written using a regular permanent magic marker. The bags and seals may be obtained from the appropriate Regional Quality Assurance Section. The Contract Administrator‘s representative may then seal the bag with a Bag Guard Seal (tie wrap) which has a customized MTO code. If the seal is applied he must then write the same code onto the bag along with the date the bag was sealed.

12. The samples should then be delivered to the designated location, as detailed in the Contract.

13. After the paver has passed over each plate, then examine the pavement surface. If the pavement surface is found to be homogeneous, then the set of samples is acceptable, providing that the samples on each of the three plates [6 or more plates for SMA and Superpave mixes – see Table 1-3 and Note 1)] have a minimum mass of 10 kg. However, if the pavement sample is disturbed, in some way, or if any one of the plate samples has less than 10 kg, then the Contractor must discard the set of plate samples and obtain a new set of three [i.e. 6 or more plates in total for SMA and Superpave mixes – see Table 1-3 and Note 1)] as soon as possible. In all cases, ensure that the full thickness of the pavement has been obtained on the plate.

Note: 5) The size of the plate used may be changed according to mat thickness, in order to yield a minimum of 10 kg. For example, for a lift 40 mm thick, a plate with minimum dimensions of 0.35 x 0.35 m (14 x 14 in.) is required to obtain 10 kg of mix. For different mat thicknesses, refer to Table 1-1 given below:

TABLE 1-1: APPROXIMATE MASS OF HL 4 ON PLATE (kg)

MAT THICKNESS (mm)	PLATE SIZE					
	.15 x .20	.25 x .25	.30 x .30	.35 x .35	.45 x .45	m
	6 x 8	10 x 10	12 x 12	14 x 14	18 x 18	in
100	6.7	14.0	20.2	27.5	45.5	
80	5.4	11.2	16.2	22.0	36.4	
70	4.7	9.8	14.1	19.3	31.8	
60	4.0	8.4	12.1	16.5	27.3	
50	3.3	7.0	10.1	13.7	22.7	
40	2.7	5.6	8.1	11.0	18.2	
30	2.0	4.2	6.0	8.2	13.6	
25	1.7	3.5	5.1	6.9	11.4	

1-2.3.2 Quantity Method for Coring Samples

1. Determine the sampling locations using steps 1 to 6 in the procedure for “Quantity Method for Plate Samples” for the 5 kg sampling locations.

2. The Contractor is required to obtain the cores, label, package and deliver them to the designated location, as detailed in the Contract.

1-2.3.3 Quantity Method for Screed Auger Chamber Samples

1. When production is expected to proceed with 5000 t lots with 10 sublots, divide each lot as follows:

   Example: OFC to have a set of three 10 kg samples obtained from each 500 t sublot within a 5000 t lot.

HL 4	Lot 3	Sublot	1	0	-	≤ 500 t
			2	> 500	-	≤1000 t
			3	>1000	-	≤1500 t
			4	>1500	-	≤2000 t
			5	>2000	-	≤2500 t
			6	>2500	-	≤3000 t
			7	>3000	-	≤3500 t
			8	>3500	-	≤4000 t
			9	>4000	-	≤4500 t
			10	>4500	-	≤5000 t

2. For each sublot, select a random number from the random number table.

Example :	Lot 3	Sublot 1	0.750	
	Lot 3	Sublot 2	0.446	etc.

3. Using the random number, identify the "tonne to be sampled". In reality, this number is only used to identify the truck load from which the sample is taken.

Example:	random number x lot size	=	tonne to be sampled
	0.750 x 500	=	375

4. Set up a sampling table with each tonne to be sampled, as illustrated below:

   OFC: Set of three 10 kg samples from each Sampling Location - 5000 t lot

OFC Lot/Sublot No.	Sublot Size	Random No. for Tonne	"Tonne to be Sampled" =(Random No. x 500) + start tonne for sublot
3/1	0 - ≤ 500 t	.750	375
3/2	> 500 - ≤1000 t	.446	723
3/3	>1000 - ≤1500 t	etc.	etc.
3/4	>1500 - ≤2000 t	etc.	etc.
3/5	>2000 - ≤2500 t	etc.	etc.
3/6	>2500 - ≤3000 t	etc.	etc.

3/7	>3000 - ≤3500 t	etc.	etc.
3/8	>3500 - ≤4000 t	etc.	etc.
3/9	>4000 - ≤4500 t	etc.	etc.
3/10	>4500 - ≤5000 t	etc.	etc.

Note: 6) DO NOT PROVIDE THE SAMPLE TONNE INFORMATION TO THE CONTRACTOR PRIOR TO THE TRUCK BEING LOADED.

5. A copy of the sample table is provided to the employee, designated by the Contract Administrator, who will be responsible for identifying the truck load containing the sample tonne. This will require the designated individual to maintain a running total of hot mix production for each mix. A printing calculator or adding machine will minimize any chance of error. When the truck containing the "Tonne to be sampled" is identified, the person must:

   a. Mark the top of the weigh ticket "Load to be sampled".

   b. Write on the back of the ticket the mass of the sample (either 5 kg, 10 kg or 20-35 kg for SMA and Superpave mixes), the lot and/or sublot number and the random number for the side of the screed for sampling.

Example:	Mass	10 kg
	Lot	3
	Sublot	1

   c. Draw a diagonal line across the face of the ticket with a bright coloured marking pen. This will help draw attention to the fact that this load is to be sampled.

6. When the load is received at the paver**,** the road inspector will inform the Contractor's representative that the sample is to be taken anywhere within the load.

7. The Contractor is required to obtain the sample, label each sample with all relevant information (including its station and offset), then package and deliver the samples to the designated location, as detailed in the Contract. For each set of three auger samples, one sample should be designated as “QC” and the other two “QA**”** and “Referee”.

8. The packaged (i.e. bag, box etc.) “QA**”** and “Referee” samples, should be placed in heavy gauge plastic bags with an area on each bag in which a date and a code and all other relevent information (such as Contract number, lot, sublot, station and offset) can be written using a regular permanent magic marker. The Contract Administrator‘s representative may then seal the bag with a Bag Guard Seal (tie wrap) which has a customized MTO code. If the seal is applied he must then write the same code onto the bag along with the date the bag was sealed.

1-3 Core Sampling For Compaction Testing

Core samples for compaction testing are based on the same lots and sublots defined for AC/gradation and air voids testing. For each 500 t sublot, a randomly-selected location will be chosen for a set of three cores taken by the Contractor.

1. The locations for the set of three cores are determined by selecting pairs of random numbers from random number tables. The first number will be used to calculate the distance into the sublot and the second for the offset of the core in accordance with the following example:

   Example: HL 8 to have a set of three cores obtained from each 500 t sublot within a 5000 t lot (Lot 3).

The HL 8 was placed between Sta. 22+245 and Sta. 30+195 over a 3.75 metres width (i.e. one lane).

Length of Lot 3:	22+245 - 35+495	=	13,250 metres
Length of sublots:	13250 ÷ 10	=	1,325 metres

Lot 3	Sublot	1	22 + 245 - 23 + 570
		2	23 + 570 - 24 + 895
		3	24 + 895 - 26 + 220
		4	26 + 220 - 27 + 545
		5	27 + 545 - 28 + 870
		6	28 + 870 - 30 + 195
		7	30 + 195 - 31 + 520
		8	31 + 520 - 32 + 845
		9	32 + 845 - 34 + 170
		10	34 + 170 - 35 + 495

2. From the random number tables, select pairs of numbers for each sublot.

Example:	Lot 3	Sublot	1 -	.235,	.713
			2 -	.732,	.030
			etc.	etc.	etc.

3. Using the first number of each pair, determine the longitudinal location of the cores, and using the second number from each pair, determine the transverse location.

Example:	Lot #3:	1st random # X length of sublot	=	Distance into lot.
	Sublot 1	.235 X 1325	=	311.4 m metres or
		Sta. 22+245 + 0+311.4	=	Sta. 22+556.4
		2nd random # x pavement lane width for the lot	=	offset Rt. E.P.
		.713 x 3.75	=	2.69

Lot 3, Set of three cores @ Sta. 22+556.4 offset 2.69 Rt. E.P.

4. Give the Contractor the location of the cores after rolling of the lot is complete [see Note 7)].

5. The Contractor must extract the cores no later than the next regular working day following the completion of the entire lot. However, if it is desired to obtain the cores immediately after the completion of the sublot, then the Contractor must demonstrate to the Contract Administrator that the pavement can be made sufficiently cool (by using dry ice, for example) prior to coring.

6. If the core location falls less than 250 mm from an unconfined pavement edge, then the cores are to be relocated a distance of 250mm from the edge of the lane. Coring on bridgedecks will not be allowed, unless permitted by the Contract Administrator and cores cannot be taken within 250 mm of a longitudinal or transverse joint, or the edge of pavement.

7. The set of three cores must be taken from the same lane, at the same transverse offset, and within a spacing of from 0.5 to 1.0 metre from one another.

8. The cores must have a minimum diameter of 150 mm and a maximum nominal diameter of 200 mm and must consist of the full layer being sampled and at least one underlying layer, if one is present. All cores (including those taken for possible re-testing), should be inspected

for defects. If a core is damaged, a replacement core must be extracted at a location adjacent to the orginal core.

9. Each core shall be clearly marked with all relevant information [See Note 7)] including its Contract number, lot and sublot number using a permanent metallic paint marker. Silver (or gold) markers appear to produce the best results and may be obtained at any well-stocked art supply store [see Note 9)]. For each set of three cores, one of the cores shall be for "QC" testing, one for "QA" testing and one for "Referee" testing, as designated by the Contract Administrator. However, the appropriate designation should be clearly marked only on the QC core which the Contractor will retain. The two remaining cores should be delivered to the Owner without marked designation or both could be marked "QA/Referee". The CA or the QA laboratory will choose one of the two for QA testing and retain the other for Referee testing, if required.

10. The integrity of all cores must be protected during transport and until the testing is carried out. One method that could be used to protect the cores is to first individually wrap each core in cellophane or similar material, place it in a metal or plastic cylinder (such as the type used for casting concrete cylinders and the void between the core and cylinder wall filled with fine sand to prevent movement or the core within the cylinder [see Note 8). Once again note that only the cylinder containing the QC core should be marked "QC".

11. The two QA/Referee cylinders, should be well-wrapped (in bubble wrap or newpaper for example) and placed in heavy gauge plastic bags with an area on each bag in which a date and a code and all other relevent information (such as Contract number, lot, sublot, station and offset) can be written using a regular permanent magic marker. The bags and seals may be obtained from the appropriate Regional Quality Assurance Section. The Contract Administrator's representative must then seal the bag with a Bag Guard Seal (tie wrap) which has a customized MTO code. If the seal is applied he must then write the same code onto the bag along with the date the bag was sealed. To provide additional protection to the cores, the heavy-gauge bags containing the cylinders could be placed in small cardboard or metal boxes and surrounded by appropriate packaging material (again more bubble wrap or newspaper could be used for this purpose).

12. Immediately after coring, the Contractor must clean out and sponge dry all core holes, fill them with hot mix and compact the hot mix according to clause 313.07.01.18 of OPSS 313. A mechanical compactor with a round foot slightly smaller than the diameter of the core hole must be used. The holes must be filled and compacted in such a way as to conform with the adjoining undisturbed pavement as per OPSS 313.17.01.06.03.

13. The Contract Administrator must ensure that all cores have been obtained at their proper locations [i.e. chosen from pairs of random numbers (as in 2 and 3) given above] and that all of the core holes have been properly filled.

14. Once any referee cores have been received, the Quality Assurance laboratory should inspect them for damage and any undamaged cores should then be carefully re-packaged. However, if any of the cores have been damaged, then the Contract Administrator should be immediately notified.

Notes: 7) When a core location coincides with a localized area which has been identified by the Contractor prior to paving and determined by the Contract Administrator to be unable to provide adequate support for the Contractor's compaction operations (and consequently result in lower compaction), then the core shall be moved to the nearest location outside of the area identified. It should be noted that these locations shall not be identified by the Contractor after the compaction core has been taken or after the compaction test result(s) have been received.

8) It should be noted that when a core contains more than one lift of hot mix and the bond between the lifts breaks during coring or at any time prior to being wrapped for transport, then each lift within the core shall be clearly marked with all appropriate information. In addition, the separated lifts should be individually wrapped before being placed in the plastic or metal container.

9) Two types of paint markers that the Bituminous Section have found to be suitable include the Sandford, silver coat, bold tip metallic from Basic Office Products and the Pilot Paint Marker, Bullet Tip from Grand and Toy. Both are about $6.00 each. Any well-stocked art suppy store should have similar products.

1-4 Sampling PGAC

To ensure that the PGAC being sampled and tested is representative of the material used in production, it is recommended that the Contract Administrator bag and apply security seals to the QA and Referee samples (cans) taken at the hot mix plant.

In accordance with the Contract requirements, the total tender quantities of hot mix items should be divided into lots and sublots for PGAC sampling purposes, in accordance with the following:

a) < 5,000 tonnes: One lot with one sublot

b) 5,000 to 10,000 tonnes: One lot with two sublots (each sublot with about half the total tonnage)

c) > 10,000 tonnes: Each 10,000 tonnes will be treated as one lot with two sublots. The last lot with less than 10,000 tonnes will be treated as one lot with one or two sublots as described in a or b above.

In the presence of the Contract Administrator or his representative, the Contractor is required to take three 1-litre samples (cans) of PGAC which are randomly chosen within each sublot. An example of random sampling for PGAC is given below:

1. When production is expected to proceed with 10000 t lots with 2 sublots, divide each lot as follows:

   Example: DFC to have a set of three 1-litre samples (cans) obtained from each 5000 t sublot within a 10000 t lot, i.e. Lot 2.

Lot 2	Sublot	1	0	-	$\leq$ 5000 t
		2	$>$5000	-	$\leq$ 10000 t

2. For each sublot, the Contract Administrator must select a random number either from a random number table or generated by a calculator or computer. A table of random numbers is given in Appendix A.

Lot 2	Sublot	1	0.872
	Sublot	2	0.125

3. Using the random number determined for each sublot, the Contract Administrator will identify the "tonne to be sampled".

Example:	random number x sublot size	= tonne to be sampled
	0.872 x 5000	= 4360

0.125 x 5000 = 625

4. The Contract Administrator will then set up a table with each tonne to be sampled as follows:

DFC: Sampling Locations (Set of Three 1-litre samples) - 10000 t Lots

DFC Lot/Sublot No.	Sublot Size	Random No. for Tonne	"Tonne to be Sampled" =(Random No. X 5000) + start tonne for sublot
2/1	0 - ≤5000 t	.872	4360
2/2	>5000 - ≤10000 t	.125	5625

5. The Contractor will then take three 1-litre sampling cans of the PGAC which will be used in the "tonne to be sampled". The samples are taken near the point of injection into the mix (usually a spigot on the PGAC supply line) in the presence of the Contract Administrator or his representative.

6. After the samples have been taken, the Contract Administrator must immediately take possession of the QA and referee samples (for testing by the QA laboratory). The Contractor will retain the QC sample (for testing by the QC laboratory). Since the samples will be hot, the Contract Administrator should take the QA and referee sample to a location (such as the Contract Administrator's office) which will allow them to cool sufficiently in order that they can be bagged.

7. Once they are cooled, both the QA and referee samples can be inserted into the same type of heavy gauge plastic bag that the Regional Quality Assurance Section provides for hot mix. Packing material should be placed around the cans to try to keep them upright and so that they don't knock against one another and become uncovered. Any relevent information (such as Contract number, PG grade, the plant that produced it, where it was sampled etc.) should be written on the bag using a regular permanent magic marker. Other relevent paperwork associated with the samples may be placed in the bag. The Contract Administrator's representative should seal the bag with a Bag Guard Seal (tie wrap) which has a customized MTO code (again the same type of ties being used for hot mix). When the seal is applied the Contract Administrator must then write the same code onto the bag along with the date the bag was sealed.

8. Once sealed, the samples can be given back to the Contractor for delivery to the QA laboratory or the Contract Administrator may retain and deliver them to the laboratory himself.

9. The QA laboratory will unseal the samples and note down the security number which must be reported along with the test result (if the sample is tested). The referee sample and any untested QA samples will be stored.

1-5 Other Initiatives and Changes in Hot Mix

There have been several new initiatives introduced over the last few years including a tack coat specification, a thickness specification, Superpave and SMA. These initiatives and other changes surrounding hot-in-place recycling are described below.

1-5.1 Tack Coat Specification

Selected Ministry contracts may contain **Special Provision No. 313F44, dated February 2005. This February, 2005 revision changes the basis of payment for tack coating of protection board to be included in the tack coating item. Application rates are also provided for expanded asphalt and cold in place recycling of surfaces.**

This section summarizes the contents of the Special Provision and provides guidance on items which require action on the part of the Contract Administrator. As with all specifications covered in this Field Guide, the Contract Administrator must always refer to the Contract documents for administering the specifications.

Products

The specified product for tack coating consists of SS-1 emulsion which is diluted 50:50 with water (usually by the Contractor rather than the supplier).

The use of products other than diluted SS-1 will be permissible. Such requests are likely to be made for late season paving or for paving situations when a "fast break" of the emulsion is desirable (e.g. night paving). The Contractor is required to give the Contract Administrator fourteen (14) calendar days notice of the proposed use of alternate products and the Contract Administrator will be required to respond within 7 calendar days by either agreeing to the proposal or not accepting it with reason(s). When such a request is received, the Contract Administrator must review it with the applicable Quality Assurance section, who in turn will contact Head Office if necessary.

Equipment

Tack coat for main lane paving must be done using pressure distributors capable of applying the product uniformly. Distributors must be equipped with volume determining devices. The use of pressure wands will be acceptable for irregularly shaped areas such as tapers.

Application

This Special Provision specifies which lifts of construction are to be tack coated and may vary from Region to Region. In general terms, all existing and milled surfaces will require tack coating. Depending upon the designer option selected, the final binder course lift may also require tack coating, but some Regions may specify it on the final binder course only if this lift has been left over the winter. You must determine for your contract which option has been selected. The surface to be tacked must be free of contamination and standing water.

There may be extenuating circumstances when the use of tack coat may be waived. For example, if the final binder course is specified to be tack coated but construction is carried out such that the surface course is placed on the new binder course within a day or so and the binder course surface is clean, tack coat may not be necessary. Another situation when the use of tack coat could be reviewed is if paving must proceed late in the year, and the Contract is experiencing severe traffic delays because of the time required for the emulsion to break. It should be noted, however, that any decision to waive the use of tack coat must be made by the Contract Administrator in consultation with the applicable Regional **Contract** Office (who may involve their Quality Assurance Section or Head Office).

Application Rates

There are **three** rates of application specified: **0.50 kg/m^2 for protection board,** 0.35 kg/m^2 for existing, milled surfaces, **expanded asphalt surfaces and the surfaces of any binder course**

travelled over the winter, and 0.20 kg/m^2 for **cold in place material** and binder course surfaces constructed in the same calendar year (when required). The Contractor's Quality Control (QC) plan usually specifies how the application rate is to be controlled by the Contractor. Reference should be made to the QC plan and conformance to it is required in the same manner as for other quality items. The Contract Administrator must ensure that the distribution is uniform both transversely and longitudinally and that the full lane width being paved is tack coated. Too much tack coat is not desirable as it can bleed through the mix and result in fat spots or, in extreme cases, pavement flushing.

If the specified application rate appears inappropriate (i.e. results in excessive runoff or does not appear to be create an asphalt film which is thick enough), please contact the **Regional Quality Assurance Section, who review the application rate in conjunction with the Bituminous Section.**

Lot/sublot sizes

The entire quantity of tack coat which will be applied at a specified application rate should be treated as a lot. Sublots have nominally been set at the quantity required to tack coat 40,000 square metres. Sublot sizes should be established in consultation with the Contractor, and some flexibility is recommended when this quantity is approached to include such variables as end of day or end of tanker load etc.

Acceptance of Tack Coat

Acceptance of tack coat is based on two criteria which are weighted equally: product quality and conformance to the specified application rate.

Product Acceptance

The product quality is assessed primarily on the basis of percent residue. Given that SS-1 emulsion has a minimum asphalt residue of 55 percent and the product is diluted 50:50, the minimum residue for field samples should be 27.5 percent. Acceptance testing to confirm this is the responsibility of the Contractor. Each sublot must be sampled in triplicate (one for QC, one for QA and one for possible Referee Testing). Results of all sublots with percent residue greater than or equal to 20 percent are analyzed to calculate the weighted mean (WM_{pro}) using the following equation:

$$WM_{pro} = \frac{(PR_{sub.1} \times A_{sub.1}) + (PR_{sub.2} \times A_{sub.2}) + \ldots\ldots + (PR_{sub.\,n} \times A_{sub.\,n})}{A_{sub.1} + A_{sub.2} \ldots\ldots + A_{sub.\,n}}$$

Where: $PR_{sub.n}$ = Percent Residue for sublot n and;
$A_{sub.n}$ = the area of sublot n

The specification provides pay factors of either full pay for a weighted mean of at least 27.5 or 0.75 for values between 20 and 27.4. Sublots with results less than 20 must not be included in this calculation.

The laboratory conducting the QC testing is required to participate in MTO correlation program for emulsion testing prior to and during the paving operation. Participation in an alternate program is acceptable. It is recommended that the CA confirm the acceptability of the QC lab with the applicable Regional Quality Assurance office. In the event that referee testing is invoked by the Contractor (in accordance with the specification), the applicable

Quality Assurance Office, in conjunction with Head Office, will designate the referee laboratory.

Acceptance of Application Rate

The acceptance of tack coat application rate will be based on quantity calculations supplied by the Contractor. For each sublot of tack coat, the Contractor is required to submit to the Contract Administrator a summary which includes, as a minimum:

- the total area tack coated (on a daily basis);
- the quantity of tack coat used (on a daily basis) and;
- the resulting mean application rate (both on a daily basis and for the sublot).

The actual product quantity used is determined by the Contractor using the equipment on the pressure distributors. Dip stick measurements or electronic printouts will be acceptable for this purpose. The Contract Administrator can, and frequently should, be present to confirm these measurements. The quantity summaries and the resulting application rate are required to be submitted to the Contract Administrator within seven calendar days of the date of application. Tack coat application results will be analyzed by the Contract Administrator using the results for each sublot. For calculation purposes, the maximum value of the application rate for any sublot shall be the specified rate for that lot. The weighted mean for the application rate ($WM_{app.}$) is calculated for each lot using the equation:

$$WM_{pro} = \frac{(AR_{sub.1} \times A_{sub.1}) + (AR_{sub.2} \times A_{sub.2}) + \ldots\ldots + (AR_{sub.\ n} \times A_{sub.\ n})}{A_{sub.1} + A_{sub.2} \ldots\ldots\ldots + A_{sub.\ n}}$$

Where: $AR_{sub.n}$ = Application Rate for sublot n and;
$A_{sub.n}$ = area of sublot n

For lots in which the application rate is specified at **0.50 kg/m^2**, **the application rate for each sublot must not be less than 0.30 kg/m^2 for the result to be included in the calculation of the weighted mean.** For lots with a specified application rate of 0.35 kg/m^2, the corresponding cut-off value is 0.20 kg/m^2. For lots with a specified application rate of 0.20 kg/m^2, the corresponding cut-off value is 0.15 kg/m^2. Sublots with an application rate of less than the cut-off values will be accepted into the work with no payment.

The results for the remaining sublots will be analyzed for the weighted mean application rate and the application rate payment factor determined from the table supplied in the specification. This is either 1.0 (full pay) or 0.75.

Payment for each lot of tack coat is calculated using the equation

Payment = Total area tack coated x Price x 0.5 (Product Payment Factor + Application Rate Payment Factor)

While the price is the bid price for the tender item, if an alternate product has been used, it should be set up as a separate lot and the negotiated price should be used in the equation.

Non-conformance of percent residue or application rate should be addressed through the Contractor's QC plan.

Feedback

Field staff are encouraged to provide feedback to the Ministry on the use of this specification in their contracts. Such information can be passed on to the applicable Regional Quality Assurance office who can transmit it to Head Office. Items such as application rate and construction impacts (e.g. traffic delays due to time required for emulsion to break, if any) are of particular interest.

1-5.2 Surface Course Lift Thickness Trial Contracts

A number of trial contracts with payment of hot mix surface course by square metres instead of tonnes **were** tendered **last year**. The hot mix surface course item requires lift thickness and pavement width as acceptance criteria. All associated standard special provisions have been modified to be compatible with payment in square metres.

An NSSP "Thickness of Hot Mix" was written with this in mind and is included on a trial basis on a limited number of Contracts. A Thickness Payment Adjustment is applied to the surface course based on the mean lift thickness determined from 50 mm diameter cores in relation to the design thickness specified for the surface course.

A Laboratory Standard LS-294 "Method for Measuring Pavement Lift Thickness" provides details on the apparatus used to take lift thickness measurements. The equipment required for measuring the core lift thickness will be provided on loan by MERO for each Trial.

In addition to the "Thickness and Width of Hot Mix" NSSP**,** the "Thickness Measurement Trial Section" NSSP is included on some trial contracts in Ontario. This NSSP specifies additional thickness testing carried out by the Ministry's designate using a Cover Meter that is followed by the Contractor obtaining 150 mm to 200 mm core samples at each Cover Meter Test location, over the metal delineator. The Contract Administrator must notify the Regional Quality Assurance Office 2 Business days before Cover Meter testing begins since Head Office Materials Engineering and Research Office and/or Head Office Construction Office staff intend on being on site while this testing is carried out.

Forms for reporting thickness measurements can be obtained from the Bituminous Section by contacting Pamela Marks at 416 235-3724.

1-5.3 Superpave

Three years ago, the Ministry created several new Superpave hot mix tender items. Superpave, which stands for Superior Performing Asphalt Pavements, represents an improved system for specifying asphalt binders and mineral aggregates, developing an asphalt mixture design and analyzing and establishing pavement performance prediction.

All of the designations for these new tender items use the prefex "Superpave" followed by "9.5", "12.5", "19", "25"and "37.5", depending upon the nominal maximum size (in mm) of the mix. There are two other tender items designated "Superpave 12.5FC1" and "Superpave 12.5FC2". These are similar to the "Superpave 12.5" item except that they are friction course (i.e. "FC") mixes in which the coarse aggregates only must be obtained from a source listed in the Designated Sources of Materials (DSM) list (designated "1") or both the coarse and fine aggregates must come from this list (designated "2").

The Superpave system includes an asphalt binder specification, a hot mix asphalt (HMA) mix design and analysis system, and computer software used to integrate the system components.

Table 1-2 lists the specifications which were modified to include both Superpave and SMA (see Section 1-5.4) mixes:

Table 1-2 – Superpave and SMA Specifications

Subject	Special Provision
PGAC	111S08, 313F02, 313F03(M)
Aggregates	110F12
Superpave Mixes	103F40
SMA Mixes	NSSP SMA
Moisture Susceptibility	103S15
ERS	103F34
Recycling	313F47, 313F42
Multiplier Factors	313S46

Superpave mixes are comprised of well-graded, high quality, rut and skid resistant aggregates bound by a PGAC binder. Superpave mixes will be designed using gyratory compactors, which require much larger samples (especially those coarser mixes designed at higher levels of gyrations). Table 1-3 gives the approximate minimum masses required for such samples.

In some cases, the additional quantities required will be obtained by using double (or triple plate) sampling. However, the Contractor may use any alternative method of sampling Superpave (and SMA) mixes at the paving site, as long as each sample is taken after its designated truckload has been unloaded at the site [see Note 1)] and the Contractor is aware that he is fully responsible for any costs which are related to the use of any alternative method. Also now it is permitted to place samples in a maximum of two receptacles and it won't be manditory to mix them once they are received at the testing laboratory.

Generally, for many ERS purposes (e.g. air void payment factor curve and trigger values), Superpave mixes will be treated like DFC, except that, they will be designed at 4% air voids. In addition, the lower and upper tolerance limits for air voids will be 2.5 and 5.5%, respectively but the limits for compaction will depend on the particular gradation being used and the overall adjustment to the payment factor will be phased-in over a four-year period (full adjustments in 2005).

Table 1-3 - Sample Size and Frequency

Material	Minimum Mass of Field Samples (kg)	Frequency of Sampling
Mixes designed using the Marshall method	10	Every sublot
SMA, Superpave 9.5, 12.5, 12.5 FC1, 12.5 FC2, and 19.0	20 or 30 [See Notes 1 and 10]	Every sublot
Superpave 25.0 and 37.5	25 or 35 [See Notes 1 and 10]	Every sublot
SMA mixes for draindown testing	3	Once per lot

Note 10): The larger sample size will be applicable when samples are designated for testing to the maximum number of gyrations. The frequency of the

larger samples shall be two per lot, as designated by the Contract Adminstrator.

1-5.4 Stone Mastic Asphalt

SMA is comprised of a coarse crushed aggregate skeleton bound together by a mortar or glue (consisting of asphalt cement, the pass 75 μm and cellulose or mineral fibres).

AASHTO has developed three different gradation bands for various SMA mixes. MTO has essentially adopted their mid-range band but with 90 to 100% passing the 13.2 mm sieve (to replace 90 to 99% passing the 12.5 mm sieve). Since this gradation requires between 8 and 11% fines, a high quality commercial mineral filler (approximately 10%) is normally required to make up the shortfall. In addition, in order to prevent draindown of the A.C. during the hauling and placement of the mix, approximately 0.3% or more by mass of cellulose fibres must also be added.

Since the Ministry is moving towards Superpave, SMA is being designed using the gyratory compactor (at 4% air voids). All plant mixes will be tested in the same manner, which will require larger 20 kg (i.e. 2 plates of 10 kg each) samples, as already mentioned in this chapter plus another 10 kg sample (split in thirds) for “Draindown” testing in each lot (Table 1-3). As with Superpave mixes, the Contractor will be allowed to use a method other than plate sampling to obtain these larger samples [see Note 1)].

The minimum A.C. content that will be allowed in the SMA mixes is related to the bulk relative density of the combined aggregates and is likely to be about 6%.

Generally, for aggregate quality and for most ERS purposes, SMA will be treated like DFC. However, for payment purposes, the air void attribute will be taken out of the PWL calculation and an Air voids Administration Procedure will be in place based on lot averages and test results from individual sublots. The single 500 tonne lot will be replaced by 2 to 3 trials of SMA in the binder with a total tonnage of 1000 tonnes and the lower limit for the compaction PWL will be increased to 93.5. The Contractor will also be required to conduct a so-called "Draindown" test (which has been recently developed by AASHTO) for each lot of SMA. In addition, the adjustments to the payment factor will be phased-in over a period of **several** years (full adjustments in 2007 for ERS and Smoothness). Most of the changes mentioned for SMA are described in more detail in chapters 2.0 and 3.0.

The specifications which have been modified to include SMA have been listed in Table 1-2.

1-5.5 Hot-In-Place Recycled Mix Issues

There are three different hot in-place-recycling techniques:

1) Hot-in-place recycling,
2) Hot-in-place recycling with integral overlay, and
3) Premium hot-in-place recycling.

The third technique is **relatively a** new method, that has only been selected under special conditions.

Since the Ministry has now switched from penetration-graded asphalt cement to Performance Graded Asphalt Cement (PGAC), most laboratories are no longer performing Penetration of Bituminous Material Testing (LS-200) on a regular basis and the test is not included in any laboratory testing correlation programs regularly required by the Ministry.

Work involving hot-in-place recycling still requires “Penetration of Bituminous Material Testing” (LS-200). Therefore, in order to maintain confidence in their test results, all laboratories currently

carrying out such testing on Ministry contracts, are now required to participate in Penetration correlation testing.

Arrangements to undergo correlation testing for LS-200 should be made through the applicable Regional Quality Assurance Section with Jim Pretty [(416) 235-3688] or Pamela Marks [(416) 235-3724] at the Bituminous Section.

For electronic or hard copies of the Depth of Scarification Test form given on next page, or for assistance with any hot-in-place recycling, please contact Pamela Marks [(416) 235-3724] at the Bituminous Section.

ONTARIO TRANSPORTATION TRANSPORTS

Determination of Scarification Depth for Hot-In-Place Recycling

Contract No.		Highway		Lot No.		Date Measured	
Region		Item No.		Lot Size		Weather Conditions	

Test No.	Time	Location		Mass of Material, **M** (kg)	Mass per m^2 of Integral Overlay, **V** (kg/m^2)	Mass per m^2 of Benificating Hot Mix added, **B** (kg/m^2)	Mass per m^2 of Fine Aggregate added, **C** (kg/m^2)	Mass per m^3 of Existing Pavement, **E** (kg/m^3)	Scarification Depth (mm)
		Station	Offset from Centreline						

A = Area of test ring (m^2) = _____

Note: All entries must be in units specified.

$$\text{Scarification Depth (mm)} = \frac{1000 \times [(\mathbf{M} / \mathbf{A}) - \mathbf{V} - \mathbf{B} - \mathbf{C}]}{\mathbf{E}}$$

Comments: _____

_____

_____

_____

Submitted to the Contract Administrators Representative on
(date) _____ at (time) _____

Owner Rep. Signature _____

Contractor Rep. Signature _____

Chapter Two

"COMBINED" END-RESULT-SPECIFICATION FOR THE ACCEPTANCE OF ASPHALT CEMENT/GRADATION, COMPACTION AND AIR VOIDS

2-1 General

Since April 22, 1998, one of two similar Special Provisions (SP's) combining Percent Within Limits (PWL) criteria for aggregate gradation, asphalt cement content, air voids and compaction has been placed in all new contracts. SP No. 103F34 entitled "End Result Specification for Acceptance of Hot Mix (Aggregate Gradation, Asphalt Cement Content, Air Voids, Compaction) Based on Contractor Testing" and a similarly-titled SP No. 103F35 ".....Based on Owner Testing". In both of these SP's, price adjustments for the various attributes are being combined into a single payment factor using Percent Within Limits (PWL) analyses.

In 2004, VMA was added as an additional criteria for acceptance and the title of SP No. 103F34 was changed to "End Result Specification for Acceptance of Hot Mix (Aggregate Gradation, Asphalt Cement Content, Air Voids, VMA, Compaction) Based on Contractor Testing". Along with the addition of VMA, several other changes to the specification which were implemented **in 2004** are briefly listed below:

1) Mix Design Submissions:

   a. Volumetric Properties and Moisture Susceptibility: For Superpave mixes, in addition to the normal mix design, the Contractor **is** required to retain an independent, third party laboratory to check mix volumetric properties and moisture susceptibility and submit a conformance document which is signed and sealed by the laboratory's supervising engineer. The document must include a statement that the mix and aggregate properties listed in the "Table of Mix Check Requirements" included in Table 2-1 have met the stated requirements.

   b. Density Testing of Hot Mix Aggregates For Mix Design and Production: In addition to conducting aggregate density testing in the mix design stage, during HMA production, the Contractor **is** required to procure samples and conduct density tests for RAP and each of the aggregates identified in the mix design and submit the results to the Contract Administrator.

2) Field Adjustments to the Job Mix Formula:

   a. Situation 1 – For Marshall Mixes, the test results must show that the minimum design Marshall stability, flow and VMA have been achieved and there was no payment reduction for air voids. For Superpave Mixes, the test results must show that the design requirements for VMA, percent Gmm at Nmax, VFA and the dust proportion were met and there was no payment reduction for air voids.

   b. Situation 2 – The Contractor now has to show that any proposed changes will improve either the air voids or VMA or both. The air voids PWL must

also be at least 50 and the lot mean VMA must be no more than 0.5 percent below the design minimum.

Due to the additional complications involved in these field adjustments, a form has been developed (given in Appendix D), which is to be used for this purpose.

3) Sampling: For SMA and Superpave mixes, it **is** permitted to place samples in a maximum of two receptacles. However, it won't be mandatory to mix them once they are received at the testing laboratory.

4) Conditions for Referee Testing: Table 2-9 summarizes the requirements to invoke referee testing. For VMA, the conditions for referee testing will depend upon differences in QA and QC testing of the combined aggregate densities used in calculating VMA.

5) Specification Limit for AC: The lower limit (in %) is JMF-0.4.

6) Payment Adjustment for Minimum AC: **In 2004**, Superpave contracts included a minimum AC content for bidding purposes. If the AC content, as submitted by the Contractor in the mix design, is different than the minimum specified in SP 313F03, then a payment adjustment (or adjustments if more than one mix design or a JMF change is made during the contract) will be made for the tonnage represented by that difference.

More details regarding the above are given in this Chapter and the Special Provision "SP 103F34".

2-2 Contractor Mix Designation

2-2.1 General

The Ministry is no longer required to verify mix designs as a standard practice. Instead, the Contract Administrator will review the mix design and the Job Mix Formula (JMF) documents. At the Contract Administrator's discretion, the Ministry may conduct a duplicate mix design with the submitted samples. Until he receives a written confirmation from the Contract Administrator of the conformance of the submitted mix design documents and the JMF, the Contractor is not allowed to place any mix. A sample confirmation letter from the Contract Administrator is shown later in this Chapter, titled "Sample Letter to Contractor".

2-2.2 Superpave Mix Designs ("SP 103F34")

For Superpave mixes in contracts containing "SP 103F34", in addition to the mix design submission, the Contractor must retain an independent, third party laboratory to conduct a check of the mix volumetric properties and moisture susceptibility requirements listed in Table 2-1.

The details describing how the mix check is to be conducted are included in the specification.

Table 2-1 - Mix Check Requirements

Mix and Aggregate Property	Requirements[1]
Gradation of component aggregates	For information only
Aggregate densities	For information only
Bulk Relative Density and Maximum Relative Density of Mix	For information only
Air voids at N_{design}	+/- 0.7 % from submitted design
VMA	+/-1.0 % from submitted design and not more than 0.3% below design minimum
VFA	Within specified mix design range
$\%G_{mm}$ at $N_{initial}$	Not more than design maximum [2]
$\%G_{mm}$ at N_{max}	Not more than design maximum
Dust Proportion	Within specified mix design range
Tensile Strength Ratio	Not less than design minimum

Notes: 1) Design requirements specified elsewhere in the Contract

2) For mix check on plant produced mix, this shall not exceed the design requirement by more than 0.5%.

2-3 Field Adjustments to the Job Mix Formula

The criteria for making field adjustments to the job mix formula (JMF) is incorporated into the two SP's stated in Section 2-1.

Definition

A field adjustment to the JMF is defined as a change in the target gradation and/or asphalt cement content of a mix, within specified limits, without a redesign of the mixture.

Submission

The revised JMF must be supplied in writing, together with supporting documentation (as detailed herein) to the Contract Administrator. The revised JMF may be applied to the lot being placed at the time the confirmation of the receipt of the revised JMF is issued, and the previous lot, if requested by the Contractor as part of the written submission for a JMF change. If this request is not made, then the revised JMF will not apply to any mix placed prior to confirmation of receipt of the revised JMF.

A field adjustment will be permitted under three situations:

Situation 1

To more closely reflect the actual mix being produced when test results for the last lot produced to the submitted JMF accrued a negative payment adjustment for asphalt cement content and/or aggregate gradation but met all specified mix requirements.

In contracts containing "SP 103F34", for Marshall mixes, the test results (lot mean) must show that the minimum design Marshall stability, flow and VMA was achieved and there was no payment reduction for air voids and for Superpave mixes, the test results (lot mean) must show that the design requirements for VMA, percent G_{mm} at N_{max}, voids filled with asphalt (VFA) and dust proportion were met, and that there was no payment reduction for air voids.

This is to address situations when negative payment adjustments are being accrued on asphalt cement content and aggregate gradations but other mix properties have been proven to be satisfactory.

Situation 2

To permit minor changes in the constituent proportions [percentage of asphalt cement, coarse aggregate(s) and/or fine aggregate(s)] when the test results for the last lot produced to the submitted JMF indicated no negative price adjustment for asphalt cement or gradation, but changes are designed to improved either the air voids or the VMA or both. For this situation, the air voids must have a percent within limits (PWL) of 50 or greater and the lot mean VMA shall be no more than 0.5 percent below the design minimum. The changes related to VMA are required in contracts containing “SP 103F34”.

Situation 3

To permit minor changes in the submitted JMF before production starts on the contract.

Number of Permitted Changes

The number of field adjustments to the JMF is limited to two for each mix design submitted for a given item.

Maximum Permitted Change

Field adjustments must be limited in scope such that the net impact of all adjustments does not exceed any of the attributes shown in Table 2-2 in comparison to the original JMF submitted under the current mix design:

When the job mix formula is changed, it should be documented on the pertinent weigh ticket and/or inspector's diary.

Test Results to Support Request For Field Adjustment

The request for a field adjustment to a JMF, under all situations requires test results as supporting documentation. These test results may be those generated by the Ministry, if available, the Contractor’s QC (Quality Control) and/or test results provided by a laboratory with CCIL type B certification, totalling a minimum of four plant checks.

For Situation 1, in contracts containing “SP 103F34”, the test results must represent a minimum of one lot with all of its sublots. In addition, for Situation 2, the mean of the test results for a minimum of four samples of mix produced in support of an application for a field adjustment must be submitted which confirm that the proposed JMF will produce mix which will conform to the contract requirements for air voids and VMA, and that the proposed mix will continue to conform to or show no deterioration in Marshall stability and flow (for Marshall mixes), and percent G_{mm} at the initial and maximum number of gyrations, VFA, and dust proportion for Superpave mixes.

Table 2-2 - Maximum Permitted Field Adjustments for JMF Properties

Attribute	Maximum Field Adjustment
Asphalt cement content (all mixes except SMA)	± 0.2 %
Asphalt cement content - SMA only	± 0.4 **%**
Percent RAP	- 5.0 %
Percent passing 26.5mm, **25.0mm,** 19mm and 16mm sieves	± 5.0 %
Percent passing 13.2mm, **12.5mm** and 9.5mm sieves	± 4.0 %
Percent passing 4.75mm, 2.36mm and 1.18 mm sieves	± 3.0 %
Percent passing 600, 300 and 150µm sieves	No limits
Percent passing 75µm sieve (all mixes except SMA)	± 1.0 %
Percent passing 75µm sieve - SMA only	± 2.0 %

Notes: 3) The revised JMF shall meet the requirements of the contract for asphalt cement content and gradation on all sieves.

4) A full mix design is required whenever a material is added, deleted or when the blend proportions are changed such that the impact(s) exceed the above.

For Situation 2, in contracts containing "SP 103F34" and Situation 3, in lieu of plant check data, results of tests carried out on laboratory-mixed samples is acceptable. For mixes designed using the Marshall method, a minimum of 12 briquettes is required. For SMA and Superpave mixes, a minimum of six gyratory-compacted specimens (two compacted to the design number of gyrations and two compacted to the maximum number of gyrations) is required. For each mix design method, a minimum of two determinations for maximum theoretical density shall be performed.

When a second field adjustment is being requested (as allowed under these guidelines), the Contractor must submit samples which are duplicates of those used in the testing required to support the request. Samples are not required for tests which were performed by the Ministry.

The suggested guidelines have been drawn up to protect the Ministry's interests (i.e. purchasing a mix meeting our requirements), while giving the producer ample opportunity to supply the material and/or make the necessary adjustments to his operation to ensure that the specifications are met.

A form and its accompanying description, which is included in Appendix D, has been developed for the Contractor, in order to justify changes to the job mix formula. An electronic version of this form will be available from the appropriate Regional Quality Assurance Section.

SAMPLE LETTER TO CONTRACTOR

To: _____
(NAME OF CONTRACTOR)

CONTRACT NO.:_____

Re: Contractor Mix Designation as required by SP for Acceptance of Hot Mix by End Result Specification

Your submission of a mix design and job mix formula documents for item #_____, _____ (mix type), dated _____ has been received and reviewed by MTO.

OPTION #1

This letter is confirmation that the above submission conforms to the Contract requirements and placement of this mix may now commence on this Contract.

Confirmation of conformance to Contract requirements of the submitted Marshall or Superpave mix design, including the mix check by the Independent laboratory, does not constitute any guarantee that the mix can be produced and/or constructed to Contract requirements, and does not relieve the Contractor of the responsibility for ensuring the specified quality of materials and workmanship is achieved.

OPTION #2

The above information does not conform to the Contract requirements for the following reasons:

-

-

-

-

-

A new submission of the mix design and job mix formula documents is required.

The following points were noted in your submission.

-

_____ _____
Contract Administrator, MTO Date

cc: Head, Quality Assurance
Originator

2-4 Lot Size and Sampling

The lot sizes for hot mix will be set at the Contract Administrator's discretion, in consultation with the Contractor. However, when the tender item quantity is 5,000 tonnes or more, the lot size for Aggregate Gradation, Asphalt Cement Content, Air Voids**,** Compaction **and VMA** will normally be 5000 tonnes with 10 equal sublots of 500 tonnes in accordance with Table 2-3 given below. Interruptions during paving and tender items with smaller quantities than 5,000 tonnes will be dealt with as detailed in the SP and this Section.

Table 2-3 - Proposed Number of Lots Based on Tonnage of Item

Number of Tonnes for the Hot Mix Item	Number of Lots (Excluding Single 500 t lot Noted in Section 2-4.2 for Lot > 5000 tonnes)
< 5000	1
5000 to 10000	2
10000 to 12000	2 or 3 (as determined by the Contract Administrator)
> 12000	3 +

A set of three 10 kg samples {for SMA and Superpave mixes, 20-35 kg samples [see Table 1-3 and Note 1, of Chapter 1]} will be taken for each sublot. For all mixes, the Contractor and Owner will each receive one sample to determine compliance for aggregate gradation, asphalt cement content, air voids and voids in mineral aggregates. For all mixes designed using the Marshall Method, the same samples received by the Contractor and Owner will also be used to determine compliance for Marshall Flow and Marshall stability. The third 10 kg sample [for SMA and Superpave mixes, 20-35 kg sample (see Table 1-3, of Chapter 1) from the set of three will be saved by the Owner and designated as a referee sample. For SMA mixes, one additional 10 kg sample will also be taken from one of the sublots from each lot, which will be split into three (QA**,** QC and referee) portions for determining its draindown characteristics. For each sublot, all samples will be taken from the same truckload and at the same transverse offset. More details regarding this sampling procedure are given in Chapter 1, since it will be considered an alternative sampling procedure for all contracts whether or not they include this new ERS SP.

A set of three cores will also be taken from each sublot for compaction testing. All cores for each sublot will be taken at the same transverse offset and at a spacing of 0.5 to 1.0 m between each core (See Section 1-3 in Chapter 1). The Owner and the Contractor will each receive one core and the third core will be delivered to the Owner and saved for possible re-testing or referee testing.

If the item overruns, the planned lot size should be continued, taking random samples as required until the item is completed. After the samples for the last complete lot have been taken, the additional sublots should be treated in the same manner as for an interrupted lot, as shown in Section 2-4.2.

2-4.1 Paving on Bridge Decks and Staged Construction - All Item Quantities

The quality of hot mix on bridge decks is a major concern to the Ministry because of the severe consequences which can result from substandard material. To address this concern, the Contract Administrator, in conjunction with the Regional Quality Assurance Section, should treat hot mix placed on a bridge deck or staged construction as a separate lot. The Contract Administrator should also consider including paving of the approaches to the bridge as part of the lot. For these lots, the Contract Administrator has to determine the amount of testing that will be required for that lot. The following two options are available (only Option 1 will apply to SMA and Superpave mixes):

Option 1- Divide the lot into 3 approximately equal sublots; each with one set of. three 10 kg plate samples {for SMA and Superpave mixes, 20-35 kg samples [see Table 1-3 and Note 1 on Chapter 1]} at each sampling location. Test one of the 10 kg (or 20-35 kg for SMA or the Superpave mixes) portions from each of the three sublots and apply the results to the ERS system outlined in the new SP's and this Chapter.

Option 2 - Divide the lot into 3 approximately equal sublots, each with one random set of three, 10 kg samples. Test one of the 10 kg portions from any one of the three sublots and compare the results with the requirements listed in Tables 2-4 to 2-6. If the sample is non-rejectable, then the lot will be paid for at the full contract price and the remaining samples will be discarded. However, if the tested sample is rejectable, then one of the three 10 kg plates taken from each of the remaining sets of samples will be tested and the results for all three samples will be applied to the ERS system outlined in the new SP's and this Chapter.

To determine if the mix is rejectable for the lot, the aggregate gradation, asphalt cement content, air voids and compaction shall comply with the limits specified in Tables 2-4 to 2-6.

Table 2-4 - Specification Limits from Job Mix Formula

Test	LL	UL
Asphalt Cement Content	JMF - 0.4	JMF + 0.5
Designated Large Sieve	JMF - 5.0	JMF + 5.0
4.75 mm Sieve	JMF - 5.0	JMF + 5.0
600μm Sieve	JMF - 3.5	JMF + 3.5
75 μm Sieve	JMF - 2.0	JMF + 2.0

where: JMF = Job Mix Formula

Table 2-5 - Specification Limits for Air Voids

Mix Type	Mix Design Criteria	LL	UL
All Mixes Except Dense Friction Course	**Marshall Mixes:** 4.0 ± 0.5% **Superpave Mixes: 4.0 %**	2.5	5.5
Dense Friction Course	3.5 ± 0.3%	2.2	4.8

Table 2-6 - Tolerance Limits for Pavement Compaction

Mix Type	LL	UL
All Mixes Except For Dense Friction Course, Heavy Duty Binder Course, Superpave 12.5FC 2, Superpave 19.0, 25.0 and 37.5 and Stone Mastic Asphalt	91.5%	97.0%
Heavy Duty Binder Course, Superpave 19.0, 25.0, 37.5	90.5%	97.0%
Dense Friction Course, Superpave 12.5FC 2	91.5% [see Note 6) given below]	98.0%
Stone Mastic Asphalt	93.0%	98.0%

Note: 5) Dense Friction Course (DFC) and Superpave 12.5FC2 **compaction** must be analyzed using a lower limit of 90.5%. If the compaction PWL for DFC or 12.5FC2 using a Lower Limit of 90.5% is greater than 95, then the compaction PWL for DFC or 12.5FC2 must also be calculated using a lower compaction limit of 91.5% and the payment factor must be determined for each lower limit using Table 2-6.1 given below. The highest calculated payment factor shall be used.

Table 2-6.1 - Dense Friction Course / Superpave 12.5FC 2 Payment Factors For PWL>95%

PWL	LL = 90.5%	LL = 91.5%
100	1.015	1.030
99	1.012	1.024
98	1.009	1.018
97	1.006	1.012
96	1.003	1.006

When determining the amount of testing required for a lot, the Contract Administrator must consider the consequences of accepting substandard material, the amount of material to be placed and the constraints (location and work load) of the Acceptance Laboratory. The Contract Administrator may also want to consider the quality of mix that was produced to date using that particular job mix formula.

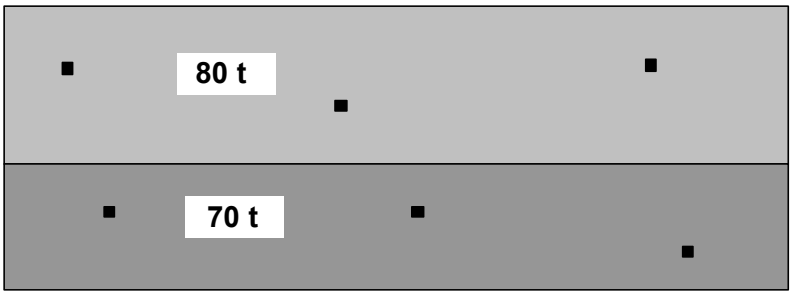
A suggested way for dealing with bridge deck paving or staged construction (under normal laboratory constraints) is as follows:

When bridge deck paving or any construction stage is greater than 100 tonnes, use Option 1 (mentioned earlier in this Chapter).

When bridge deck paving or any construction stage is less than 100 tonnes, use Option 2.

The following example illustrates the use of Option 2 applied to staged construction.

- **Example: Staged construction on a bridge deck - Option 2**



1. Take 3 sets of 3 plate samples (see Note 1 of Chapter 1) for a particular stage.
2. One of the 9 plate samples is tested for acceptance and compared to the rejection criteria outlined in Tables 2-3 to 2-5.
3. If non-rejectable - the Contract Administrator may recommend that all remaining samples be discarded. Full payment is given.
4. If rejectable - test one of the 3 plates for each of the remaining 2 samples and apply the combined ERS system using a separate lot for each stage

Note: 6) For contracts containing SP 103F34 (Contractor testing for acceptance), the Contractor shall perform the above testing and the Owner may perform QA testing on samples from any location.

2-4.2 Item Quantity Greater Than 5,000 Tonnes

When the hot mix tender item quantity is 5000 t or more (3000 t for Dense Friction Course, Open Friction Course, Heavy Duty Binder Course and HL 1), it will be permitted to have one lot not exceeding 500 t (this small lot may extend to up to 1000 t for DFC, in some carry over contracts) and consisting of one sublot. However, it should be noted that for SMA this single 500 t lot will be replaced by 2 to 3 trial lots (each divided into 3 sublots) with a total tonnage of up to 1000 t which will be placed in the binder.

This 500 t lot must be placed in a binder course (except for OFC or if the contract is single lift construction, where it must be placed in the surface course) and not in a critical location such as a bridge deck and may even be deferred to the next construction season. However, it must never be used to retroactively reduce price adjustments. To determine if the mix is rejectable for this 500 t lot, asphalt cement content, aggregate gradation, air voids and compaction must comply with the limits specified in Tables 2-4, 2-5 and 2-6. There must be one set of mix samples taken for the mix properties and three cores taken for compaction with n=3 being used to calculate the PWL. This lot will not be subjected to a payment adjustment unless the mix is rejectable. However, when the mix in that lot is rejectable, then the criteria for rejection, repair and payment reduction will apply.

The remaining quantity of the tender item, will normally be divided into 5,000 t lots, each with ten equal sublots of 500 t each. Various ways of planning the location of these lots are shown in the examples (in the following pages) .

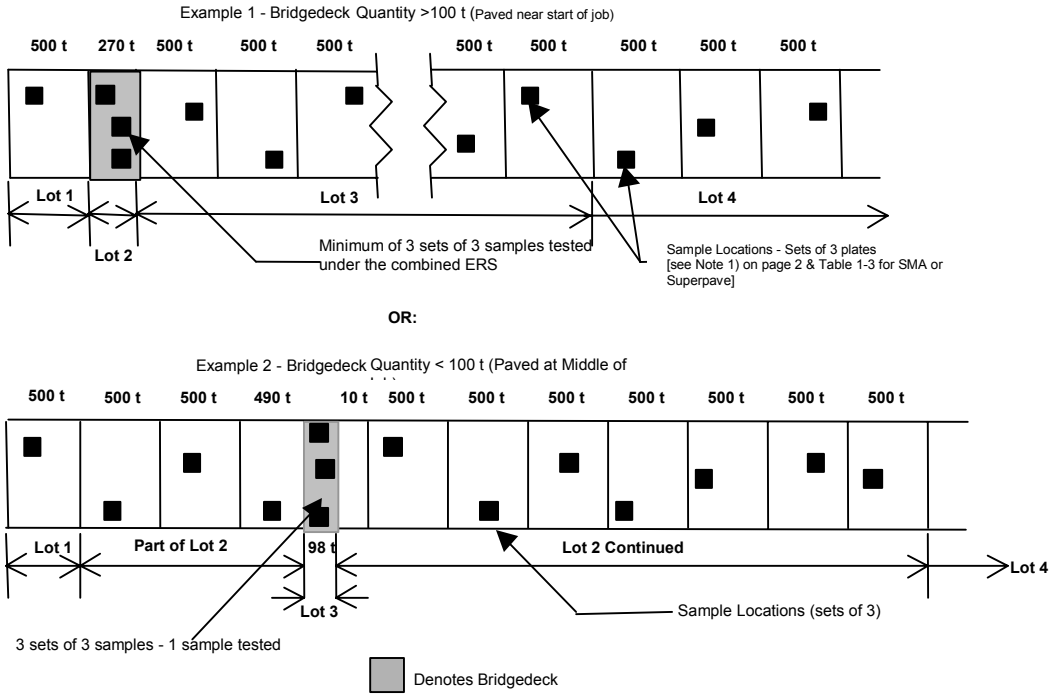
The quantity remaining after paving the last full lot will normally be treated as follows:

a) If the remaining quantity is expected to be less than 1000 t, consider it as part of the previous lot.

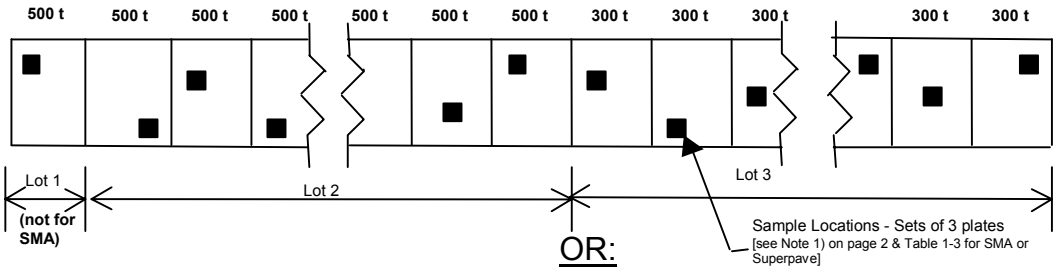
b) If the remaining quantity is expected to be greater than 1000 t, then the Contractor may request that the remaining quantity be considered as a separate lot with a minimum of three sublots.

Examples of the application of the ERS system when the item is greater than 5,000 t are as follows:

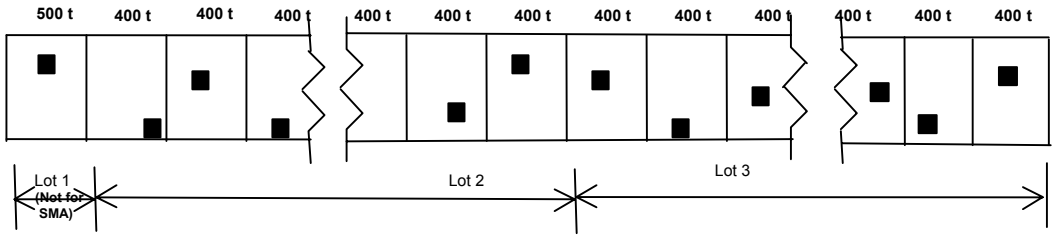
Paving of Bridgedecks - Item quantity = 15000 tonnes



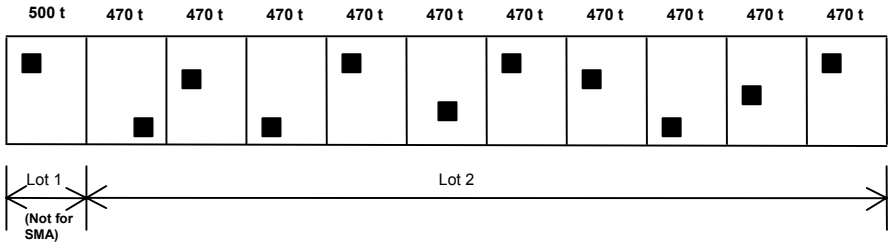
Example: Item quantity = 8500 tonnes



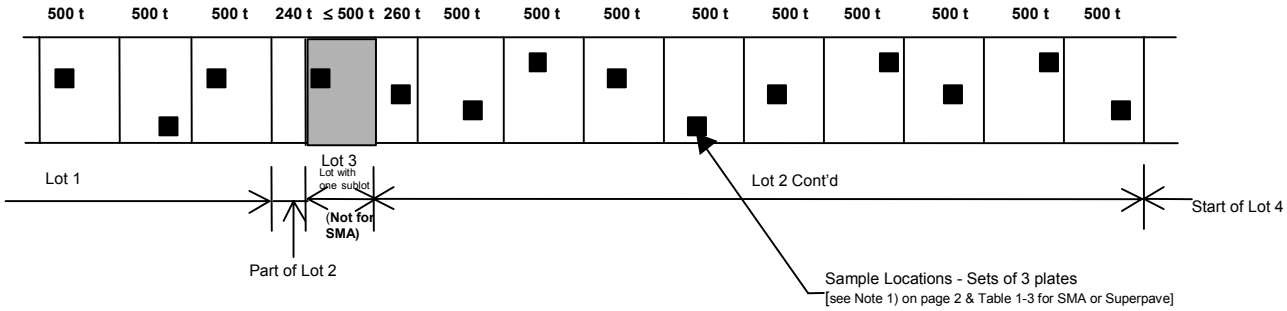
OR:



Example: Item quantity = 5200 tonnes

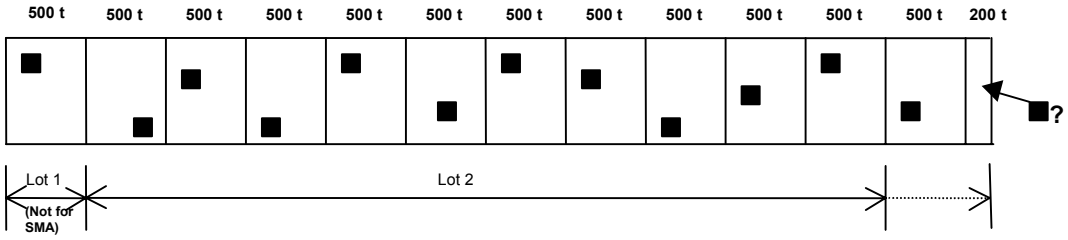


Example: Item quantity > 5000 tonnes



When only one or two sublots are completed at the end of the paving item, due to a change in the job mix formula or when a delay of more than 20 business days occurs in placing the complete lot, then the test results obtained for the one or two sublots will be considered as part of the previous lot and the previous lot will then have eleven or twelve sublots. When three to nine sublots are completed due to the above circumstances, then the three to nine sublots will be considered as a lot. However, when a delay of more than 20 business days occurs in placing the complete lot, prior to the end of the 20 business days, at the Contractor's request in writing to the Contract Administrator, the lot may be completed upon the resumption of paving for that item.

Example: Interrupted sequence of paving due to unforeseen stoppage or change in Job Mix Formula



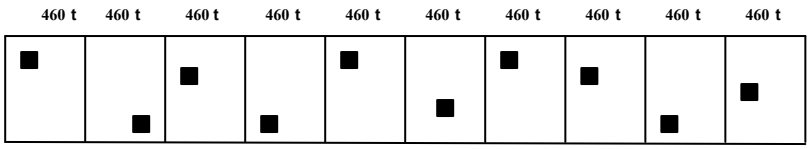
Note: 7) The last 200 t shown in the diagram (referred to by the "?") would be a sublot if, by random numbers, a sample was required to be taken. Regardless of whether or not a sample is to be taken, the 200 t is included in the total quantity of the previous lot.

2-4.3 Item Quantity 1,000 Tonnes to 5,000 Tonnes

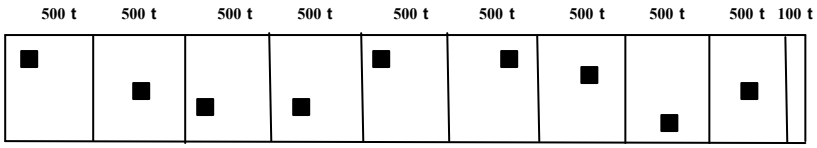
When the tender item quantity is between 1000 t and 5,000 t the quantity will normally be considered as one lot. The lot/sublot sizes can be reduced at the discretion of the Contract Administrator and after discussion with the Contractor. If possible, the sublot sizes should be of equal size. A minimum of three sublots have to be completed and tested to constitute a lot in order that the ERS system may be used.

An example of the use of the testing regime to be used is as follows:

Example: Item Quantity = 4600 tonnes



NOT



2-4.4 Item Quantity Less Than 1000 Tonnes

When the item quantity is less than 1000 t, the lot/sublot sizes will be determined by the Contract Administrator based on individual circumstances. For item quantities less than 1000 t, the hot mix may be accepted by the Contract Administrator based upon such testing as is deemed necessary by the Contract Administrator to determine substantial conformance with the contract. When three or more tests have been completed, for a lot, the material will be accepted at the full contract price, subjected to a payment reduction or rejected as detailed in the special provision.

The amount of testing to be performed on a lot will depend on the consequences of accepting substandard material, the amount of material to be placed and the constraints (location and work load) of the Acceptance Laboratory.

2-5 Density Testing and Reporting of Results

2-5.1 Density Testing of Hot Mix Aggregates and Calculating VMA ("SP 103F34")

For contracts containing the Special Provision "SP 103F34", the Contractor must report the QC density testing of aggregates and RAP which was done for the purpose of developing mix designs for each mix type in the Contract. The testing may be performed during the production of each aggregate and RAP (if RAP is included in the mix) or during the stockpiling of the materials at the hot mix plant.

During HMA production, the Contractor is required to procure samples, conduct density tests for RAP and each aggregate identified in the mix design for each mix type, and report the resulting combined aggregate densities.

The first set of aggregate samples must be taken in the first lot with more than one sublot and subsequent samples must be taken during the production of every alternate lot of hot mix. All sampling should be carried out when approximately half of the tonnage for the lot has been placed. The bulk relative density of each aggregate is measured and the combined aggregate density is calculated using the following formula:

i) $$G_{sb} = \frac{100}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + ... \frac{P_N}{G_N}}$$

where: G_{sb} is the bulk relative density for the combined aggregates;
P_1, P_2, and P_N are the percentages of each aggregate by mass;
G_1, G_2, and G_N are the bulk relative densities of the individual aggregates; and
N is the number of aggregates involved.

The VMA for each sublot is calculated from the bulk relative density for the combined aggregates as well as the bulk relative density of the mix and the %AC by mass determined from the plate samples in accordance with the following formula:

ii) $$VMA = 100\left(1 - \frac{Gmb(1 - \%AC)}{Gsb}\right)$$

where: G_{mb} is the bulk relative density for the mix determined from plate samples and;
%AC is the percent asphalt cement content by mass determined from plate samples.

The calculation of QC VMA shall be based on the process control bulk relative densities of aggregates obtained during the mix design process, or values submitted with the revised mix design as permitted in the specification, averaged with the determination of densities on the specified QC samples obtained during HMA production. For QA purposes, the calculation of VMA shall be based on testing carried out on samples submitted with the mix design, or the revised mix design if applicable, averaged with the determination of densities on the specified QA samples obtained during HMA production. For both QC and QA, results for aggregate density test results for samples taken during HMA production shall be applicable only to the lots subsequent to the lot during which they were taken.

2-5.2 Reporting Test Results

The ERS system requires that the test results from a number of sublots be used to determine the acceptability of a lot with the exception for the lot with one sublot (or for SMA, the 2 to 3 trial lots in the binder which replace the lot with one sublot) which is allowed for an item with greater than 5000 t.

The results of the extraction tests may be reported on form PH-CC-249, END RESULT SPECIFICATION - HOT MIX - EXTRACTION TEST RESULT FOR GRADATION AND AC (shown later in this Chapter). The BRD's, MRD's, % compaction and thickness measurements taken from each core sample may be reported on form PH-CC-255 98-05, HOT MIX - COMPACTION ACCEPTANCE AND PRICE ADJUSTMENT SHEET (shown later in this Chapter). It should be noted that computerized versions of either of the two forms are also acceptable.

As the QC tests are completed and received by the Contract Administrator, the QA test results for each sublot can be made available to the Contractor. However, no indication is to be made as to the acceptability or otherwise of the hot mix, based on these individual results.

The test results from the extraction tests, compaction testing and air voids from each sublot are used to determine a combined payment factor. **For lots with 3 or more sublots,** a computer program has been developed to calculate the combined payment adjustment based on all applicable attributes (see Chapter 3.0). An example of the form entitled "**ERS 2005 - HOT MIX QC/QA Comparison and Payment Factor Calculation**" generated from such calculations is shown later in this Capter.

END-RESULT SPECIFICATION
HOT MIX - EXTRACTION TEST RESULT FOR GRADATION AND AC

Contract No.		Highway	
Item No.		Station	
Mix Type		Offset	
Job Mix Formula No.		Lane	
Date Sampled		Lot Size	
Time Sampled		Lot No.	
		Sublot No.	

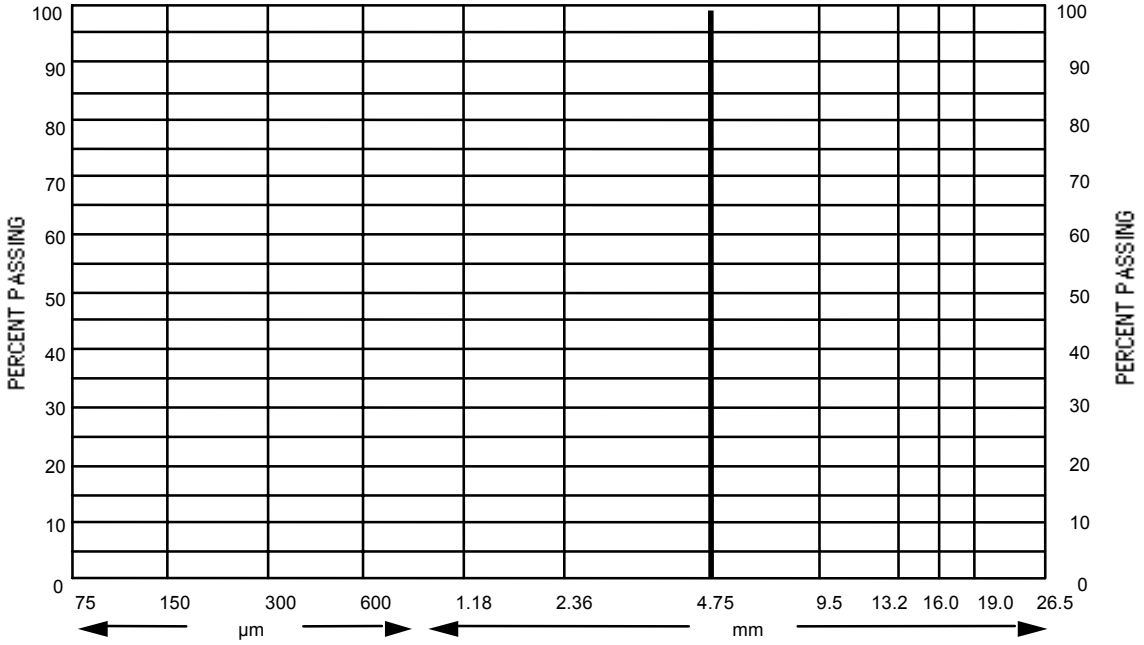
☐ Surface
☐ Binder, course number ____.
☐ Levelling

☐ Plate sample
☐ Screed auger sample
☐ Truckbox sample

☐ Core number ____.
(Core test result not for QUADB input)

Mass of Test Portion (Moisture Free)		Remarks
Total Mass of Extracted Aggregates (Dry)		
Mass of Extracted Aggregates After Washing (Dry)		

AC / Sieves	AC	26.5	19.0	16.0	13.2	9.5	4.75	2.36	1.18	600	300	150	75	Pan
Job-Mix Formula														
Cumulative Mass Retained														
% Passing														
% Swingback														



The sample was delivered to the laboratory on (date) _____ at (time) _____ .

The above information was telephoned to the Contractor's designated representative on (date) _____ at (time) _____.

Testing laboratory location and name _____

Testing technician's name (print please) _____

A copy was [faxed to / left with] the Contractor's designated representative on (date) _____ at (time) _____.

Laboratory Rep. Signature_____ Contractor Rep. Signature_____

White-Regional Quality Assurance; Canary-Contractor; Pink-Project Supervisor; Golden Rod-Const. Supervisor/Originator
PH-CC-249 91-02

HOT MIX - COMPACTION ACCEPTANCE AND PRICE ADJUSTMENT SHEET

Contract No.		Lot No.	
Item No.		Lot Size	
Mix Type		Number of Sublots	
Region			
Highway			

Original Test Results ☐
Retest Results ☐
☐ Surface
☐ Binder Course Num. _____
☐ Levelling / Padding

*Immediate Substrate : Granular - G / Hot Mix - HM ☐ / Concrete - C ☐ / ML (if Milled)

Sub-lot #	Station and Offset from Centreline For Each Sublot	Date Paved	Date Sampled	*Immediate Substrate	Lift Thickness (mm)	Correction Factor for Thickness	Bulk Relative Density (BRD)	Maximum Relative Density (MRD)	**Percent Compaction (Based on Individual MRD)
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

**Percent Compaction = $100 \times \frac{BRD}{MRD} + C$

Where: C = Thickness Correction Factor

(0.1% for each whole millimetre that the individual pavement course thickness is less than 40 mm)

Lot Mean Thickness ☐

Lot Mean MRD ☐

Lot Mean for Compaction ☐

Lot Standard Deviation for Compaction ☐

The Contractor's designated representative was informed of the above on (date) _____ at (time) _____ .

Ministry Rep. Signature _____ Contractor Rep. Signature _____

Comments: _____

White-Regional Quality Assurance; Canary-Contractor; Pink-Contract Administrator; Golden Rod-Const. Supervisor/Originator
PH-CC-255 98-05

2-6 Acceptance

The "Combined" ERS bases the acceptance of the hot mix on a lot-by-lot basis. Aggregate gradation of each sieve (see **Note 8)**, asphalt cement content, air voids**,** VMA and compaction are accepted based on the percent within limits (PWL) of the lot. An example is given later in this Chapter in Section 2-12.

For contracts which contain the SP entitled "End Result Specification.....Based on Owner Testing" [and do not contain a Bituminous Quality Control (QC) Plan], the Contract Administrator will determine the acceptability of the mix based on the Owner's test results. The Owner will test one (plate) sample for A.C. content, aggregate gradation, the percent air voids, Marshall Stability and Flow and the Voids in Mineral Aggregate. One core from each sublot will also be tested by the Owner to determine Percent Pavement Compaction.

For contracts which contain the SP entitled "End Result Specification.....Based on Contractor Testing", the Contract Administrator will determine the acceptability of the mix based on test results generated by the Contractor, provided that those test results meet the requirements for comparison of QA and QC results. The Contractor will test one plate sample [for SMA and Superpave mixes, 20-35 kg samples (see Table 1-3 of Chapter 1) - i.e. 2 or more plates per sample will be required – See Note 1) of Chapter 1] for A.C. content, aggregate gradation, the percent air voids, and voids in the mineral aggregate. In addition, for mixes designed using the Marshall Method, the Contractor will also test the same sample for Marshall Stability and Flow. One core from each sublot will also be tested by the Contractor to determine Percent Pavement Compaction.

It should be noted that Contractors will not be allowed to opt-in to the latest version of either SP 103F34 or 103F35.

The mean and standard deviations of the test results for each attribute measured from samples taken from each sublot are calculated according to the following formulae:

$$(1) \qquad \overline{X} = \frac{\sum x_i}{n}$$

$$(2) \qquad s = \sqrt{\frac{\sum \left(x_i - \overline{X}\right)^2}{n-1}}$$

Where: $\overline{X}$ = the lot mean, s = the sample standard deviation

x_i = the individual value or test result

and n = the number of samples in the lot

The Upper and Lower Quality Indices for each attribute are then used to determine the Percent Within Limits (PWL) for all four attributes using the following formulae (3) and (4) given below.

$$(3) \qquad Q_L = \frac{\overline{X} - LL}{s}$$

$$(4) \qquad Q_U = \frac{UL - \overline{X}}{s}$$

where: Q_L =Lower Quality Index, Q_U =Upper Quality Index, LL =Lower Limit, UL =Upper Limit

The upper and lower specification limits (LL and UL) for the four attributes are given in Tables 2-4 to 2-6. The percent within limits for each attribute is calculated using Equation (5) and a Payment Factor is assigned based on the PWL. A table showing percent within limits versus quality indices as well as examples of calculations using percent within limits are shown in Appendix C.

$$PWL = (P_L + P_U) - 100 \quad (5)$$

where: PWL = Percent Within Limits

P_L = Percent Within Lower Limit (From the table given in Appendix C)

P_U = Percent Within Upper Limit (From the table given in Appendix C)

The payment factors for the different attributes are combined for each lot to obtain the Total Payment Factor for each lot according to the method and equations outlined in Section 2-9. An example can be found at the end of this Chapter.

Notes: 8) It should be noted that the gradation attribute is based on four sieve sizes only, i.e. the "designated large sieve" as well as the 4.75mm, 600µm and 75µm sieves.

9) The designated large sieve is defined as follows for the mix types given below:

25.0 mm	Superpave 37.5
19.0	Superpave 25.0
16.0 mm	HL 8, Medium Duty Binder Course and Heavy Duty Binder Course
13.2 mm	HL 4 Binder and HL 4 Surface Courses
12.5	Superpave 19.0
9.5 mm	HL 1, HL 3, HL 3A, Open Friction Course, Dense Friction Course, Superpave 12.5, Superpave 12.5 FC 1 and 12.5 FC 2
4.75	Superpave 9.5
2.36 mm	HL 2

10) HL - Modified mixes and Recycled Hot mixes will be designed individually for the Designated Large Sieve.

<u>For SMA Only</u>

For SMA only, the percent within limits calculations for air voids will be carried out for information purposes only.

It has been agreed with Industry that, until more experience is gained with SMA, an interim Air Voids Administration Procedure will be in place. In this procedure, a lot will be considered acceptable with respect to air voids, if the mean of the test results for that lot is greater than or equal to 2.5% and less than or equal to 5.5%, as long as no individual test result for a sublot is less than 2.0% or greater than 6%. A lot will be considered rejectable, if the mean of all of the test results within that lot is either less than 2.5% or greater than 5.5%,

while an individual sublot will be considered rejectable, if its test result is less than 2.0 percent or greater than 6.0 percent air voids.
In addition for SMA, the Contractor will also be required to test one sample from each lot (i.e. the additional 10 kg sample chosen from one of the sublots) to determine its "Draindown" characteristics. If either the QC or QA samples are found to exceed the 0.3 percent requirement for this test, then the referee sample will also be tested for information purposes. Again this year, if the mix exceeds the 0.3 percent requirement but does not initially indicate the presence of "fat spots", the mix will not be removed but will be monitored for performance. However, if such fat spots begin to develop at a later time then they will be treated as any other visual deficiency (see Section 5-2).

2-7 Re-testing For Outliers / Referee Testing

Either the Contractor or the Ministry may challenge the validity of one of the results within a lot as an outlier.

For Contracts containing the SP "….Based on Owner Testing", the Contractor or the Owner may challenge one, two or all sublots from a lot through referee testing. However, for Contracts containing the SP "….Based on Contractor Testing", challenges may only be settled by referee testing of all sublots. Details of these mechanisms are included in the following subsections.

2-7.1 Challenging an Individual Test Result as an Outlier

The Contractor or the Contract Administrator may question an individual test result from the original (i.e. first) set of results only when the payment factor for that lot is less than 1.0. VMA is excluded from outlier challenges. The challenge must be made within three (3) business days of the Contractor and Contract Administrator having received all of the test results for that lot.

When the result from one of the tests is challenged as an outlier, the "T" test is used to determine whether the result is either typical of or is not typical of the population. If it is not typical of the population, then it is considered to be an "OUTLIER" and may be replaced with another test result. The identification of an outlier does not mean that the sampling or testing was performed incorrectly but only that it is not typical of the lot.

Outliers are identified through the principles of a normal distribution curve (i.e. values that are at the outside edges of the "bell curve" are unrepresentative of the group mean). A 10% significance level [see **Note 13** later in this Chapter] is used for the "T" test.

The precision that should be used for recording individual test results and the lot mean and standard deviation which are used to calculate the "T"-values used in the "T" test are shown in Table 2-7.

Table 2-7 - Precision to Be Used When Conducting a "T" Test

Parameter	Individual test results	Lot Mean	Lot Standard Deviation
Aggregate Gradation (%)	1 decimal place	3 decimal places	4 decimal places
Asphalt Cement Content (%)	2 decimal places	3 decimal places	4 decimal places
Air Voids	1 decimal place	3 decimal places	4 decimal places
Pavement Compaction (%)	1 decimal place	3 decimal places	4 decimal places

Final Calculation for "T"	3 decimal places	3 decimal places	3 decimal places

Note: 11) When conducting the "T" test, all rounding should conform to LS-100

Two examples illustrating the use of the "T" Test, Table 2-8 ("Critical Values for the "T" test) and the required precision (Table 2-7) are given below:

Examples from Extraction Test Results

Example 1

Contract 96-76
JMF No. 96-076-20
Lot No. 4

Sublot No.	AC content (%)
1	4.65
2	4.82
3	4.93
4	4.75
5	4.86
6	*5.18*
7	4.63
8	4.99
9	4.81
10	4.63

An inspection of the ten test results, shown in Example 1, might suggest that the asphalt cement content value of 5.18 % for sublot 6, may not come from the same population as the asphalt cement contents determined from the samples taken from the other nine sublots. In order to test this hypothesis, it is first necessary to determine the mean $\overline{X}$, and standard deviation, s for the ten values:

$$\overline{X} = 4.825; \qquad s = 0.1758$$

In order to avoid negative numbers, the absolute value of the difference between the value being tested and the mean of all of the test values is used in equation (6) for m=6:

$$(6) \qquad T_m = \frac{\left|X_m - \overline{X}\right|}{s}$$

$$T_6 = \frac{\left|5.18 - 4.825\right|}{0.1758} = 2.019$$

From Table 2-8, for n = 10 (i.e. for ten test results), we observe that the upper 5 % Significance Level is 2.176. Since 2.019 is less than or equal to 2.176, it is reasonable to conclude that the value of 5.18 is not significantly high and that there is a very good chance that it comes from the same population as the other nine values.

Table 2-8 - Critical Values for the "T" Test When the Standard Deviation is Calculated From the Same Sample

Number of Observations	10% Two-Sided Significance level (Upper or Lower 5% Significance Level)
3	1.153
4	1.463
5	1.672
6	1.822
7	1.938
8	2.032
9	2.110
10	2.176
11	2.234
12	2.285

Example 2

Contract 95-67
JMF No. 95-067-01
Lot No. 8

Sublot No.	% <4.75mm sieve
1	51.0
2	*62.8*
3	54.6
4	52.1
5	55.8
6	53.2
7	49.7
8	50.9
9	55.6
10	53.8

An inspection of the ten results, shown in Example 2, suggests that the value of 62.8 % for sublot 2 may not come from the same population as the other values. The mean of the ten values, $\overline{X}$ = 53.950 and the standard deviation, s = 3.7263 From these values, we therefore compute T for sublot 2:

$$T_2 = \frac{|62.8 - 53.950|}{3.7263} = 2.375$$

From Table 2-8 for n = 10, we observe that the lower 5 % Significance Level is 2.176. Since 2.375 is greater than 2.176, it is reasonable to conclude that the value 62.8 for sublot 2 is not likely to have come from the same population as the other nine values. Further investigation of the doubtful value is, therefore, warranted.

If the outlier test procedure indicates that the test result is not valid, then the result will be discarded, unless there is an obvious error in the calculations or in the transposing of the numbers. If there is no obvious error, then the third plate sample from the set of three samples (or third core from the set of three) will be tested. The sample will be tested by the Contract Administrator or the Contractor (depending upon whether the special provision for "Contractor Testing" or "Owner Testing" is in the Contract - See Subsection 2-7.2) and the results used in the calculations for payment adjustments will be binding on both the Contractor and the Owner.

Notes:12) There may be cases where the precision of intermediate steps (i.e mathematical operations on individual test results) required for final calculation of a "T" value may not be clearly stated either within the Contract or this Field Guide. As a result, the Contractor's calculations for the "T" test may be based on slightly different assumptions of precision for these intermediate steps than the calculations carried out by the Ministry's representative. Where this is the case, the Contractor's calculations should be accepted, provided that he has used the appropriate precision and rounding procedures wherever they have been specified.

13) The Ministry 's position is that outliers could occur on either side of the mean value but not on both sides simultaneously. The maximum risk of erroneously rejecting a result which comes from the same population as the other values (i.e. the significance level) is set at 10%. This means that values on the outside 10% of the population are considered to be outliers. This significance level (two-sided) is the same as a 5% significance level on the low side and a 5% significance level on the high side.

14) For contracts containing the SP "….Based on Owner Testing", the results from outlier testing will be used for any subsequent referee challenges involving the same sublot. Therefore, if the referee sample is tested for an outlier of Asphalt Cement, Gradation, or Air Voids, the sample will also be tested for the other two criteria in case the results are needed for a subsequent referee challenge.

15) For contracts containing the SP "…Based on Contractor Testing", the replacement result for the outlier may be obtained from the Owner's result for the affected sublot if the owner tested that sample, or the Contractor can test the referee sample and forgo referee privileges for the affected lot.

2-7.2 Referee Testing

2-7.2.1 Contracts Containing the SP Entitled "End Result Specification .....Based on Owner Testing"

For contracts containing the SP based on "Owner Testing", when the Contractor or the Contract Administrator questions the test results for one sublot per lot, two sublots per lot or an entire lot and shows evidence for justification of referee testing, then the sublot(s)/lot will be referee tested. Referee testing of an entire lot will be permitted, regardless of whether or not a sublot has been re-tested as an outlier. Before it is decided to go to referee testing, it is recommended that the **Regional Quality Assurance Section** be contacted.

The party questioning the results must deliver the "Evidence" to the other party within 3 business days of the Contractor receiving all the test results for that lot. The Contractor's "Evidence" in this context is defined as follows:

a) The Contractor has at least as many test results as the Owner for the sublot(s)/lot. For example, if 10 sublots were tested for a lot of 5300 t, then the Contractor must produce at least 10 test results from that same lot of material, and

b) There is at least a 0.02 improvement in the Compaction Payment Factor or the Composite Payment Factor for A.C. Content, Gradation and Air Voids based on the Contractor's results, and

c) The Contractor's results shall show that the lot is not rejectable.

Only one request per lot can be made for referee testing.

The party who questions the results will decide to have the referee sample(s) for the sublot/lot tested for:

a) Asphalt Cement Content, Aggregate Gradation, and Air Voids, and/or

b) Compaction, or

c) Air voids only for HDBC, DFC, SMA and Superpave mixes, if QA payment factors for asphalt cement content, 4.75 mm, 600 μm and 75 μm are all equal to or greater than 1.000,

by a referee laboratory selected by the Contract Administrator from a Roster Rotation List maintained by the Owner for this purpose. This list has Regional zones which allows local laboratories to participate in the process and reduce the transportation distance that some samples must traverse (particularly from contracts in the Ministry's Northeastern and Northwestern Regions).

The Contract Administrator will be responsible for the delivery of the referee samples to the selected laboratory. Both parties will be permitted to observe the testing. Most referee laboratories have specific protocols for observing their testing which should be adhered to.

The referee test results will be binding on both the Contractor and the Owner and no further testing will be done except that, when repairs are carried out, the lot will be re-evaluated as specified under "Repairing and Re-evaluating".

2-7.2.2 Contracts Containing the SP entitled "End Result Specification .....Based on Contractor Testing"

For contracts containing the SP "Based on Contractor Testing" and a Bituminous Quality Control Plan, testing by an independent third party referee is available to assess the quality of hot mix, regardless of the differences in the test results generated by the Quality Control and Quality Assurance laboratories. The Owner or Contractor may invoke referee testing of the entire lot.

If referee testing is requested, the referee laboratory will be designated by the Contract Administrator from the same Roster Rotation List described in clause 2-7.2.1.

For Contracts containing "SP 103F34", referee testing may be invoked under the conditions described in Table 2-9 and either party can request referee testing for draindown of SMA.

Table 2-9 - Referee Testing Categories

Referee testing For:	Conditions for Referee testing, based on QC and QA testing
AC content and gradation with or without air voids, with or without compaction	May be carried out on any mix. If air voids referee testing is not to be included, its PF shall be at least 1.00 and mean VMA shall not be less than design minimum.
Air Voids only, with or without compaction	May only be carried out on Marshall mixes and provided that the payment factors for AC, the 4.75 mm, 600 µm and 75 µm sieves are each at least 1.000 and the mean VMA is not less than design minimum.
Air Voids and VMA only, with or without compaction	May only be carried out on Superpave mixes and provided that the payment factors for AC, the 4.75 mm, 600 µm and 75 µm sieves are each at least 1.000.
Compaction Only	None

Referee Testing for VMA

For Contracts containing "SP 103F34", when the combined aggregate density determined by a QA laboratory is within 0.020 of the mean combined aggregate density used by the QC laboratory, the aggregate densities will be deemed to be in agreement and the referee laboratory must use the mean QC combined aggregate density in calculating the VMA. However, if the mean QC and QA combined densities are not in agreement, then the referee laboratory must conduct aggregate density testing on samples supplied to it for this purpose. These samples must be the last samples taken prior to the start of the lot being subjected to referee testing. The combined aggregate density result must be compared to the mean QC and QA combined aggregate density results, and the referee calculation of VMA must be based on the result which is closer to the referee result or the referee result itself, if it is exactly in between the QC and QA combined aggregate density test results.

2-7.2.3 Outliers in Referee Results

When an outlier is identified in referee test results, then the sublot containing the outlier will be treated as a lot with one sublot for both mix properties and compaction (or air voids, when only air voids is subject to referee testing, and compaction for DFC, HDBC and SMA). The remaining sublots will then form a separate lot. There will also be a 50/50 cost sharing between the Owner and the Contractor for referee outlier testing, as stated in the Special Provision.

2-8 Repairing and Re- Evaluating

When the Contract Administrator requires that a rejectable lot be repaired or the Contractor elects to carry out repairs in lieu of accepting a payment adjustment, then the Contractor must determine what areas of hot mix in a lot are to be repaired.

Prior to that repair, the Contractor must take a slab sample or clusters of cores to provide sufficient material for the testing that is required for A.C. content, Gradation and Air Voids and/or Compaction in the unrepaired area and within one metre of the limits of each end of the repair area.

Whenever repair work is to be carried out, the Contractor shall determine the area(s) to be repaired. However, the Ministry will determine where the original sublots actually started and ended using weigh ticket information and/or diary records. The Ministry should not give any advice regarding the areas to be repaired other than ensuring that all pertinent test information is available to the Contractor on request. The Contractor should be permitted to undertake additional testing at no cost to the Ministry, if the Contractor wishes, to verify the extent of the rejectable material.

The repair area selected by the Contractor must then be extended by one metre. These repair areas must be repaired by removal and replacement or an overlay where it is permitted by the Contract Administrator, prior to re-evaluating.

The minimum width of all repairs must be the width of the lane and/or shoulder being repaired (i.e. between existing longitudinal joints including any demarcations, which may be present). The minimum length of all repairs must be 3 metres. A paver must be used in carrying out all repairs.

When repairs are made to all or part(s) of a lot, the lot will be re-evaluated. If there is only one repair area in a lot, then the unrepaired area of the lot will form a lot and the repaired area will also form a lot (see the Case #1 example, given later in this Chapter). The samples for the unrepaired area must consist of the original unrepaired sublot samples and the two samples described above taken from within one metre of the limits of the repair area.

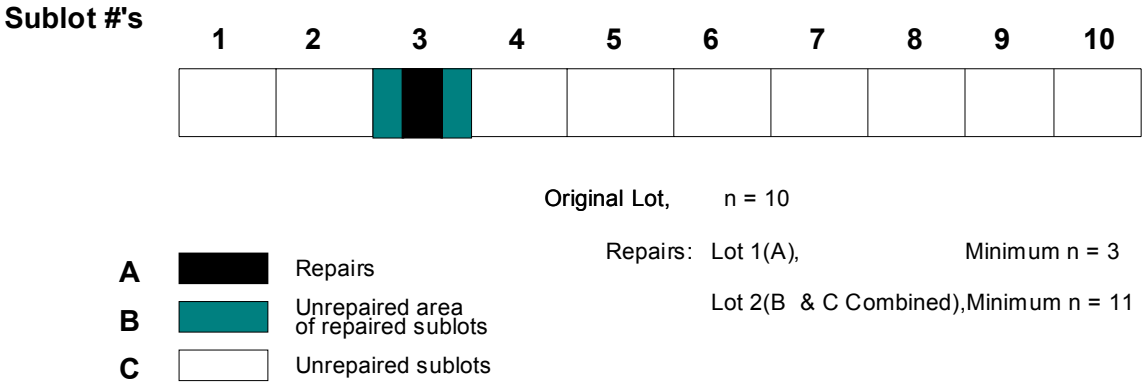
If there is more than one repair area in a lot, then the repaired locations will be considered as one lot, the unrepaired areas of the repaired sublots will be considered as one lot and the remaining sublots of the original lot which were not repaired will be considered as a third lot (see the Case #2 example, given later in this Chapter). The samples for the lot of the unrepaired areas of the repaired sublots will include the samples described above taken from within one metre of the limits of the repair area. The lot of the remaining unrepaired sublots will have the original test results re-evaluated using the new number of sublots.

If there are only one or two sublots in a lot which are not repaired, then the Contract Administrator will include those sublots as part of the previous or next lot. The Contract Administrator in conjunction with the Contractor will determine the number of sublots for the repair lot.

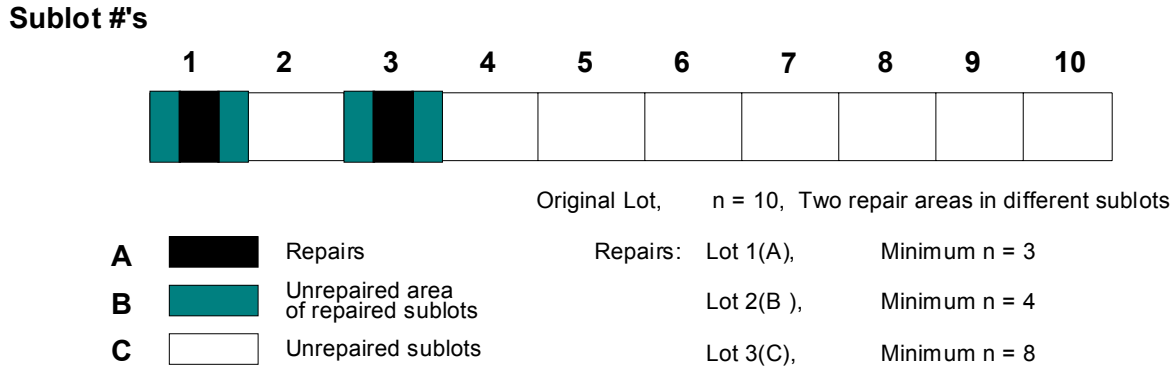
The re-evaluated lots will be accepted at the full contract price, subjected to a payment adjustment or rejected as detailed in clause 313.07.01.15 of OPSS 313, as amended by the SP. The Contractor must sample the re-evaluated lots as specified in clause 313.07.01.15.01 of OPSS 313 as amended by the SP, unless otherwise instructed by the Contract Administrator.

The repaired area must be tested for all criteria. The unrepaired areas of the repaired sublot(s) must be tested only for the criteria which were subject to penalties in the original test results. The lot of unrepaired sublots will be re-evaluated using the new number of sublots. If the repair location is less than 500 tonnes, the Contract Administrator in conjunction with the Contractor, may decide to include it as part of the current lot being produced.

Case # 1 - One Repair Area in the Lot



Case # 2 - More Than one Repair Area in the Lot



2-9 Basis of Payment

This section presents the various formulae used in determining a combined payment factor based on the individual payment factors for each attribute.

Gradation

To obtain the gradation payment factor, use the following formulae:

(7) $PF_{G(SUB)} = PF_{DLS} + PF_{4.75} + PF_{600} + PF_{75}$

(8) If $PF_{G(SUB)}$ is greater than or equal to 4, then: $PF_G = PF_{G(SUB)} - 3$

(9) If $PF_{G(SUB)}$ is less than 4, then: $PF_G = PF_{G(SUB)}/4$

where:

$PF_{xxx(SUB)}$	=	Sub-factor for calculation purposes.
PF_G	=	Payment Factor for Gradation
PF_{DLS}	=	Payment Factor for Designated Large Sieve
$PF_{4.75}$	=	Payment Factor for the 4.75mm sieve
PF_{600}	=	Payment Factor for the 600μm sieve
PF_{75}	=	Payment Factor for the 75μm sieve

PF values are obtained from Table 2-10 and using the method given in Appendix C.

Combined Asphalt Cement Content and Gradation

To obtain the combined payment factor for Asphalt cement content and gradation, use the following formulae:

(10) $PF_{GAC(SUB)} = PF_G + PF_{AC}$

(11) If $PF_{GAC(SUB)}$ is greater than or equal to 2, then: $PF_{GAC} = PF_{GAC(SUB)} - 1$

(12) If $PF_{GAC(SUB)}$ is less than 2, then: $PF_{GAC} = PF_{GAC(SUB)} / 2$

where: PF_{AC} = Payment Factor for Asphalt Cement Content
PF_{GAC} = Combined Payment Factor for AC Content and Gradation.

Payment Factor for VMA (Superpave Mixes in Contracts with "SP103F34" Only)

(13) If the lot mean VMA is not more than 0.5 percent below the minimum VMA specified for mix design purposes, then the payment factor for VMA is 1.000.

(14) If the lot mean VMA is more than 0.5 percent lower than the minimum VMA specified for mix design purposes, then the payment factor for the subject lot will be:

$$PF_{VMA} = 0.8000 - 0.4(VMA_{min} - 0.5\text{-}VMA_{mean})$$

where: PF_{VMA} = payment factor for VMA
VMA_{mean} = lot mean
VMA_{min} = minimum VMA specified for mix design

Comparing the Payment Factors of Air Voids and VMA ("SP103F34 " Only)

(15) For Superpave mixes, when the Payment Factor for VMA is less than 1.000, it will be compared to the payment factor for air voids and the lesser of the two will be the payment factor for voids, PF_{VOIDS}. However, if the Payment Factor for VMA is equal to 1.000 (it can't be greater), then the payment factor for voids, PF_{VOIDS} will be the same as the payment factor for air voids.

(16) For Marshall mixes, the payment factor for voids will be the same as the payment factor for air voids.

Combined Gradation, Asphalt Cement Content, And Voids - see Note 16) - (Mix Properties)

To obtain the composite payment factor for gradation, asphalt cement content and air voids, use the following formulae:

(17) $PF_{GAC/VOIDS(SUB)} = PF_{GAC} + PF_{VOIDS}$

(18) If $PF_{GAC/VOIDS}$ is greater than or equal to 2, then: $PF_{GAC/VOIDS} = PF_{GAC/VOIDS(SUB)} - 1$

(19) If $PF_{GAC/VOIDS(SUB)}$ is less than 2, then: $PF_{GAC/VOIDS} = PF_{GAC/VOIDS(SUB)} / 2$

where: $PF_{GAC/VOIDS}$ = Composite Payment Factor for Gradation, AC Content and Voids (mix properties payment factor)

For all Mixes, except SMA: PF_{VOIDS} = Payment Factor for Voids

For SMA [see Note 17)] PF_{VOIDS} = PF_{GAC}, if $PF_{GAC} < 1.000$ or;

PF_{VOIDS} = 1.000, if $PF_{GAC} \geq 1.000$

Notes: 16) For SMA, the payment Factor for air voids as determined by Table 2-10 (Payment Adjustment Factors based on PWL) will not be used in the combined payment factor.

17) For SMA, although sampling and testing for air voids are required, for the purposes of payment factor calculation, air voids will be treated as a mix attribute where sampling/testing has been waived by the Owner but the Owner must still be given all QC test results for air voids as well as all of the other attributes.

Total (AC, Gradation, AC, Voids and Compaction)

To obtain the total combined payment factor for asphalt cement content, gradation, air voids and compaction, use the following formulae:

(20) $PF_{TOTAL(SUB)} = PF_C + PF_{GAC/VOIDS}$

(21) If $PF_{TOTAL(SUB)}$ is greater than or equal to 2 then: $PF_{TOTAL} = PF_{TOTAL(SUB)} - 1$

(22) If $PF_{TOTAL(SUB)}$ is less than 2 then: $PF_{TOTAL} = PF_{TOTAL(SUB)} / 2$

where: PF_{TOTAL} = Total Payment Factor

PF_C = Compaction Payment Factor

For an **SMA mix** that is not rejectable:

(23) If $PF_{TOTAL} < 1.000$, then $PF_{TOTAL} = 1 - [TODRF \times (1 - PF_{TOTAL})]$

where: TODRF is the tender opening date reduction factor in accordance with the following table:

Tender Opening Date (Year)	TODRF for Non-Rejectable SMA Mix
2005	0.6
2006	0.8
2007	1.0

When there is no sampling/testing for a mix attribute [see **Note 17**)] or when the requirement for sampling/testing is waived by the Owner, the payment factor for that attribute will be equal to either:

a) The payment factor it is added to in formulae 10, 17 or 20, if that payment factor is less than 1.0; or
b) 1.0, if the payment factor it is added to in formulae 10, 17 or 20 is equal to or greater than 1.0.

Table 2-10: Payment Adjustment Factors based on PWL

PWL	Designated Large Sieve	4.75 mm Sieve	600 µm Sieve	75 µm Sieve	AC Content	% Air Voids		Compaction
						All Mixes except SMA,DFC,HDBC and Superpave	SMA,DFC,HDBC and Superpave	
100	1.0025	1.0025	1.0025	1.0025	1.010	1.020	1.020	1.030
99	1.002	1.002	1.002	1.002	1.008	1.016	1.013	1.024
98	1.0015	1.0015	1.0015	1.0015	1.006	1.012	1.007	1.018
97	1.001	1.001	1.001	1.001	1.004	1.008	1.000	1.012
96	1.0005	1.0005	1.0005	1.0005	1.002	1.004	1.000	1.006
95	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
94	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
93	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
92	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
91	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
90	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
89	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.991
88	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.983
87	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.974
86	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.965
85	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.956
84	0.997	0.997	0.997	0.997	0.992	1.000	1.000	0.948
83	0.994	0.994	0.994	0.994	0.984	1.000	1.000	0.939
82	0.992	0.992	0.992	0.992	0.976	1.000	1.000	0.930
81	0.989	0.989	0.989	0.989	0.968	1.000	1.000	0.921
80	0.986	0.986	0.986	0.986	0.960	1.000	1.000	0.913
79	0.983	0.983	0.983	0.983	0.952	0.984	0.999	0.904
78	0.980	0.980	0.980	0.980	0.944	0.968	0.998	0.895
77	0.977	0.977	0.977	0.977	0.936	0.952	0.995	0.886
76	0.974	0.974	0.974	0.974	0.928	0.936	0.991	0.878
75	0.972	0.972	0.972	0.972	0.920	0.920	0.986	0.869
74	0.969	0.969	0.969	0.969	0.912	0.904	0.980	0.860
73	0.966	0.966	0.966	0.966	0.904	0.888	0.973	0.851
72	0.963	0.963	0.963	0.963	0.896	0.872	0.964	0.843
71	0.960	0.960	0.960	0.960	0.888	0.856	0.955	0.834
70	0.957	0.957	0.957	0.957	0.880	0.840	0.944	0.825
69	0.954	0.954	0.954	0.954	0.872	0.823	0.933	0.816
68	0.951	0.951	0.951	0.951	0.864	0.806	0.920	0.808
67	0.949	0.949	0.949	0.949	0.856	0.789	0.906	0.799
66	0.946	0.946	0.946	0.946	0.848	0.772	0.891	0.790
65	0.943	0.943	0.943	0.943	0.840	0.755	0.875	0.781
64	0.940	0.940	0.940	0.940	0.832	0.738	0.858	0.773
63	0.937	0.937	0.937	0.937	0.824	0.721	0.839	0.764
62	0.934	0.934	0.934	0.934	0.816	0.704	0.820	0.755
61	0.931	0.931	0.931	0.931	0.808	0.687	0.799	0.746
60	0.929	0.929	0.929	0.929	0.800	0.670	0.778	0.738
59	0.926	0.926	0.926	0.926	0.790	0.653	0.755	0.729
58	0.923	0.923	0.923	0.923	0.780	0.636	0.731	0.720
57	0.920	0.920	0.920	0.920	0.770	0.619	0.706	0.711
56	0.917	0.917	0.917	0.917	0.760	0.602	0.680	0.703
55	0.914	0.914	0.914	0.914	0.750	0.585	0.653	0.694
54	0.911	0.911	0.911	0.911	0.740	0.568	0.624	0.685
53	0.909	0.909	0.909	0.909	0.730	0.551	0.595	0.676
52	0.906	0.906	0.906	0.906	0.720	0.534	0.564	0.668
51	0.903	0.903	0.903	0.903	0.710	0.517	0.533	0.659
50	0.900	0.900	0.900	0.900	0.700	0.500	0.500	0.650
49	0.882	0.882	0.882	0.882	0.686	0.490	0.490	0.637
48	0.864	0.864	0.864	0.864	0.672	0.480	0.480	0.624
47	0.846	0.846	0.846	0.846	0.658	0.470	0.470	0.611
46	0.828	0.828	0.828	0.828	0.644	0.460	0.460	0.598
45	0.810	0.810	0.810	0.810	0.630	0.450	0.450	0.585
44	0.792	0.792	0.792	0.792	0.616	0.440	0.440	0.572
43	0.774	0.774	0.774	0.774	0.602	0.430	0.430	0.559
42	0.756	0.756	0.756	0.756	0.588	0.420	0.420	0.546
41	0.738	0.738	0.738	0.738	0.574	0.410	0.410	0.533
40	0.720	0.720	0.720	0.720	0.560	0.400	0.400	0.520
39	0.702	0.702	0.702	0.702	0.546	0.390	0.390	0.507
38	0.684	0.684	0.684	0.684	0.532	0.380	0.380	0.494
37	0.666	0.666	0.666	0.666	0.518	0.370	0.370	0.481
36	0.648	0.648	0.648	0.648	0.504	0.360	0.360	0.468
35	0.630	0.630	0.630	0.630	0.490	0.350	0.350	0.455
34	0.612	0.612	0.612	0.612	0.476	0.340	0.340	0.442
33	0.594	0.594	0.594	0.594	0.462	0.330	0.330	0.429
32	0.576	0.576	0.576	0.576	0.448	0.320	0.320	0.416
31	0.558	0.558	0.558	0.558	0.434	0.310	0.310	0.403
30	0.540	0.540	0.540	0.540	0.420	0.300	0.300	0.390
29	0.522	0.522	0.522	0.522	0.406	0.290	0.290	0.377

Table 2-10: Payment Adjustment Factors based on PWL - Continued

PWL	Designated Large Sieve	4.75 mm Sieve	600 µm Sieve	75 µm Sieve	AC Content	% Air Voids		Compaction
						All Mixes except SMA,DFC,HDBC and Superpave	SMA,DFC,HDBC and Superpave	
28	0.504	0.504	0.504	0.504	0.392	0.280	0.280	0.364
27	0.486	0.486	0.486	0.486	0.378	0.270	0.270	0.351
26	0.468	0.468	0.468	0.468	0.364	0.260	0.260	0.338
25	0.450	0.450	0.450	0.450	0.350	0.250	0.250	0.325
24	0.432	0.432	0.432	0.432	0.336	0.240	0.240	0.312
23	0.414	0.414	0.414	0.414	0.322	0.230	0.230	0.299
22	0.396	0.396	0.396	0.396	0.308	0.220	0.220	0.286
21	0.378	0.378	0.378	0.378	0.294	0.210	0.210	0.273
20	0.360	0.360	0.360	0.360	0.280	0.200	0.200	0.260
19	0.342	0.342	0.342	0.342	0.266	0.190	0.190	0.247
18	0.324	0.324	0.324	0.324	0.252	0.180	0.180	0.234
17	0.306	0.306	0.306	0.306	0.238	0.170	0.170	0.221
16	0.288	0.288	0.288	0.288	0.224	0.160	0.160	0.208
15	0.270	0.270	0.270	0.270	0.210	0.150	0.150	0.195
14	0.252	0.252	0.252	0.252	0.196	0.140	0.140	0.182
13	0.234	0.234	0.234	0.234	0.182	0.130	0.130	0.169
12	0.216	0.216	0.216	0.216	0.168	0.120	0.120	0.156
11	0.198	0.198	0.198	0.198	0.154	0.110	0.110	0.143
10	0.180	0.180	0.180	0.180	0.140	0.100	0.100	0.130
9	0.162	0.162	0.162	0.162	0.126	0.090	0.090	0.117
8	0.144	0.144	0.144	0.144	0.112	0.080	0.080	0.104
7	0.126	0.126	0.126	0.126	0.098	0.070	0.070	0.091
6	0.108	0.108	0.108	0.108	0.084	0.060	0.060	0.078
5	0.090	0.090	0.090	0.090	0.070	0.050	0.050	0.065
4	0.072	0.072	0.072	0.072	0.056	0.040	0.040	0.052
3	0.054	0.054	0.054	0.054	0.042	0.030	0.030	0.039
2	0.036	0.036	0.036	0.036	0.028	0.020	0.020	0.026
1	0.018	0.018	0.018	0.018	0.014	0.010	0.010	0.013
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

A sample of the results from the EXCEL® computer program to calculate the payment factors is shown later in this Chapter .

ERS 2005 – Hot Mix QC/CA Comparison and Pay Factor Calculation

QC LOT PAY FACTOR CALCULATION

CONTRACT	2005-xxx	Lot No.	4		
HIGHWAY	x	Lot Size (t)	5000		
REGION	Eastern	No. Sublots	10	Layer	Surface
MIX TYPE	**SUP125**	Date Paved	15-Jul-05		
ITEM No.	3	Date Tested	19-Jul-05	The Mean Combined Aggregate Density	2.655

Sublot Data Input

JMF Id.	DLS	4.75 mm	600 µm	75 µm	AC	Air Voids	Compaction	VMA
2005-xxx-xx	**73.5**	**51.8**	**22.1**	**3.8**	**4.60**			**14.0**
Sublot 1	78.9	54.5	24.4	3.9	4.37	4.2	94.6	15.05
Sublot 2	76.3	55.9	25.1	4.1	4.27	4.0	92.8	14.84
Sublot 3	76.3	54.1	24.6	1.9	4.37	4.0	93.0	14.56
Sublot 4	69.9	45.3	21.4	3.7	4.15	4.3	93.5	14.90
Sublot 5	77.7	54.7	24.8	4.2	4.39	3.8	92.3	14.75
Sublot 6	73.1	50.7	23.3	4.1	4.30	3.8	92.8	13.90
Sublot 7	78.7	55.1	24.3	2.8	4.79	3.7	92.3	13.85
Sublot 8	78.0	57.3	25.3	4.4	4.39	2.8	92.6	14.45
Sublot 9	76.1	54.8	24.6	4.4	4.43	3.7	92.5	14.70
Sublot 10	68.8	46.9	21.4	3.1	4.11	4.6	94.5	14.22
Sublot 11								
Sublot 12								

Lot Calculation Results

COUNT	10	10	10	10	10	10	10	10
Lot Mean	75.4	52.9	23.9	3.7	4.36	3.9	93.1	14.52
Std Dev	3.60	3.98	1.43	0.82	0.19	0.48	0.85	0.41
LL	68.5	46.8	18.6	1.8	4.2	2.5	91.5	
UL	78.5	56.8	25.6	5.8	5.1	5.5	97.0	
QL	1.91	1.54	3.72	2.28	0.85	2.90	1.88	
QU	0.87	0.97	1.17	2.62	4.00	3.36	4.62	
PL	99	95	100	100	80	100	99	
PU	81	84	89	100	100	100	100	
PWL	80	79	89	100	80	100	99	
PF	0.9860	0.9830	1.0000	1.0025	0.960	1.020	1.024	1.000

Calculation of Total Pay Factor @ Applicable TODRF = **1.0**

PF_g(sub) =	3.9715
PF_g =	0.9929
PF_{gac}(sub) =	1.9529
PF_{gac} =	0.9764
PF_{voids} =	1.0200

$PF_{gac/voids}$(sub) =	1.9964
$PF_{gac/voids}$ =	0.9982
PF_{total}(sub) =	2.0222
PF_{total} =	**1.0222**

Ministry Rep. Signature _____ Contractor Rep. Signature _____

Date: _____ Date: _____

Comments: _____

Acceptance based on QC results is subject to review of QA results by Owner.

Copy to: Regional Quality Assurance Contract Administrator Contractor Originator

2-10 Mixes That Are Difficult to Compact due to "Unmanageable Factors":

In the past, the ORBA have presented concerns to the MTO related to a Contractor's ability to deal with "Unmanageable Factors" which may effect compaction but are beyond the Contractor's control during the paving operation. Unmanageable factors include such things as:

- areas that are unable to provide adequate support for the compaction operations (possibly due to poor subgrade conditions) or;

- changes in substrate conditions within the same lot (e.g. granular base, unmilled hot mix, milled hot mix), that cause an increase in the lot standard deviation

Note that the weather is uncontrollable but not unmanageable because Contractors are able to reschedule work/change operations accordingly.

The following interim procedure was developed by the Bituminous Section to determine if there are "Unmanageable Factors" and then, if they are found to be unmanageable, to waive the payment reduction on the affected lots. The procedure was included in a memorandum, dated February 20, 1996 to the Managers of Construction.

1.0 Initial Notification

The Contractor shall notify the Contract Administrator with supporting Process Control test results immediately upon becoming aware of an apparent unmanageable factor(s) but no later than 1 business day of receiving MTO test results for the lot. The Contractor may also request that the lot be re-tested and he shall be notified when re-testing will take place.

2.0 Quality Control Documentation Submission Review

The Contractor shall submit a report within 2 days of the initial notification containing the following:

- the production rates and mix temperatures (discharge and road) for each day of paving;

- all process control results with corresponding MTO results for all lots placed prior to the lot(s) in question;

- the details of the rolling patterns, weights, types and OPS classification of the compaction equipment that was used for all lots;

- details of the daily weather during paving;

- the type and condition of the substrate(s) on which all the lots were placed;

- any other relevant mix, aggregate, or production and placement information and;

- a clear and concise statement of the Contractor's opinion on what factor(s) was unmanageable and how this affected the test results.

The report shall be a well-organized document with charts or other data summaries to illustrate the Contractor's position and shall clearly lay out the steps that he has taken to improve and detail the results achieved.

The Ministry will review the submission for completeness and advise the Contractor if the submission is incomplete. If the submission is incomplete, then the Contractor can resubmit the report with additional documentation to continue the appeal or he can abandon the appeal.

The report will be made available to a mutually agreed upon advisor, if one is needed.

3.0 Independent Compaction Advisor

The Contractor or the Contract Administrator, in conjunction with the Quality Assurance Section and the Bituminous Section, shall determine whether a mutually agreed upon independent compaction advisor will be needed to help with the review. The fees for the advisor shall be equally shared by the Contractor and the MTO.

The advisor shall assist by reviewing and recommending changes to the Contractor's operation and/or mix design and discuss the probable reason(s) for the poor compaction. The MTO decision will be as outlined in Section 5.0.

4.0 Field Demonstration Review

When the Contractor notifies the Contract Administrator that there is an apparent unmanageable factor, the MTO will arrange to review the paving and compaction operations of the mix.

Prior to the review, a meeting shall be held to discuss how, what, when and where the demonstration and review will be done. The purpose is to agree on production rates, mix temperatures, equipment options, etc. The meeting shall be attended by representatives of the Contractor (with his Subcontractors as desired), the Contract Administrator, the Quality Assurance Section, the Bituminous Section, and the independent compaction advisor, if applicable.

The Contractor shall demonstrate the use of different equipment, rolling patterns, mix temperatures and production rates for a period not to exceed the lessor of 1 day or a quantity of 1500 t.

The demonstration shall attempt to duplicate as closely as possible the weather, substrate and all other conditions that existed when the poor results were achieved provided these conditions met the Contract requirements.

The Contractor shall co-operate with MTO, or a mutually agreed upon advisor, to try different rolling patterns, mix temperatures, production rates or equipment recommended by the MTO or the advisor. The contractor is not expected to provide compaction equipment beyond that outlined in Table V of OPSS 313 for the demonstration.

The MTO will accept the Contractor's process control results for the demonstration only if the results have been comparable to MTO's results on the previous lots. Otherwise MTO will require that the Contractor take cores and pay for MTO testing. The Contractor shall submit the process control results to the Ministry and the advisor (if involved) within one business day of completion of the field demonstration.

The application of the ERS for compaction will be suspended for the demonstration. It shall be applied for lots prior to and after the demonstration, if no unmanageable factor is proven.

The advisor (if applicable) shall submit a brief report on the details and findings of the field demonstration to all representatives who attended the field demonstration review meeting within 3 business days of completion of the field demonstration.

5.0 MTO Decision

The MTO will review the information submitted by the Contractor, together with the MTO's own records and the report of the advisor, if applicable. The MTO will give its decision and reasons within 10 business days of receipt of a complete submission of the documentation from the Contractor. During this period, the Contractor has the option to continue paving at his own risk.

An unattributed brief summary of the findings of each appeal is to be distributed to ORBA and the Regional Managers of **Contracts** by the Bituminous Section within three months of the decision. It is expected that this information will be shared by ORBA throughout the industry and communicated at the MTO/Contractor prework/prepave meeting.

Note: 18) The MTO considers it critical that the Contractor provide "Evidence" in the form of both documentation and a field demonstration, in order for the appeal to be successful. In the event that a field demonstration is not possible on MTO work, the MTO may accept a demonstration on work done for others with the same mix. If this is not possible, the documentation alone may be deemed inconclusive or insufficient and the price reduction will not be waived.

2-11 Calcium Chloride

When a Contractor suspects that the placement of calcium chloride prior to hot mix paving will prevent the placement of durable hot mix, the Contractor can submit a written request for the Ministry to review the problem on a site-specific basis.

2-12 Examples of Calculations for Percent Within Limits and Combined Payment Factors

This section presents an example of how to calculate a payment factor based on a percent within limits calculation using compaction data from the example for Superpave 12.5 shown earlier in this Chapter (Excel spreadsheet). The payment factor based on that data is then used with the data for the other attributes to calculate the combined payment factor.

1) Percent Within Limits Calculation

Data For Compaction of Superpave 12.5 Mix (From Example Shown Earlier)

94.6	92.8	93.0	93.5	92.3
92.8	92.3	92.6	92.5	94.5

(A) Calculate Mean; $\overline{X}$ and Standard Deviation; S of above data using Equations (1) and (2), respectively:

(1) $$\overline{X} = \frac{\sum x_i}{n}$$

(2) $$s = \sqrt{\frac{\sum \left(x_i - \overline{X}\right)^2}{n-1}}$$

Where: $\overline{X}$ = the individual compaction value
and n = the number of samples in the lot

$$\text{Mean, } \overline{X} = \frac{94.6 + 92.8 + ... + 94.5}{10} = 93.1$$

$$\text{Standard Deviatiion, } s = \sqrt{\frac{(94.6-93.1)^2 + (92.8-93.1)^2 + ... + (94.5-93.1)^2}{9}}$$

$$= 0.85$$

(B) Calculate the Quality Indices From Equations (3) and (4) Using the Lower Quality Limit LL and Upper Quality Limit UL From Table 2-6 for Superpave 12.5 :

(3) $$Q_L = \frac{\overline{X} - LL}{s}$$

$$= \frac{93.1 - 91.5}{0.85} = 1.88$$

(4) $$Q_U = \frac{UL - \overline{X}}{s}$$

$$= \frac{97.0 - 93.1}{0.85} = 4.59$$

where: Q_L = Lower Quality Index Q_U = Upper Quality Index

LL = Lower Limit UL = Upper Limit

(C) From the Table in Appendix C , Determine P_L and P_U :

P_L = 99 From Q_L = 1.88

P_U = 100 From Q_U = 4.59

(D) From Equation 5, Determine the Percent Within Limits (PWL):

(5) $$PWL = (P_L + P_U) - 100 = 99$$

(E) From Table 2-10 for Compaction, the Payment Factor is determined to be 1.024

2) <u>Determining Combined Payment Factor</u>

Data For Superpave 12.5 Mix (From Example Shown Earlier in the Excel Spreadsheet)

PF_{AC}	=	Payment Factor for Asphalt Cement	=	0.9600
PF_{DLS}	=	Payment Factor for Designated Large Sieve	=	0.9860
$PF_{4.75}$	=	Payment Factor for the 4.75mm sieve	=	0.9830
PF_{600}	=	Payment Factor for the 600μm sieve	=	1.0000
PF_{75}	=	Payment Factor for the 75μm sieve	=	1.0025
PF_{AV}	=	Payment Factor for Air Voids	=	1.0200
PF_C	=	Payment Factor for Compaction	=	1.0240
PF_{VMA}	=	Payment Factor for Voids in the Mineral Aggregate	=	1.0000

(A) From Equation (7), Calculate $PF_{G(SUB)}$

(7) $PF_{G(SUB)} = PF_{DLS} + PF_{4.75} + PF_{600} + PF_{75}$

$= 0.9860+0.9830 + 1.0000+ 1.0025$

$= 3.9715$

(B) From Equation (9), Calculate PF_G:

(9) If $PF_{G(SUB)}$ is less than 4, then, $PF_G = PF_{G(SUB)}/4$

$= 3.9715/4 = 0.9929$

If $PF_{G(SUB)}$ is greater than or equal to 4, then use equation (8)

(C) From Equation (10), Calculate $PF_{GAC(SUB)}$:

(10) $PF_{GAC(SUB)} = PF_G + PF_{AC}$

$= 0.9929 + 0.9600 = 1.9529$

(D) From Equation (12), Calculate PF_{GAC}:

(12) If $PF_{GAC(SUB)}$ is less than 2, then: $PF_{GAC} = PF_{GAC(SUB)}/ 2$

$= 1.9529/2 = 0.9764$

If $PF_{GAC(SUB)}$ is greater than or equal to 2, then use equation (11)

(E) From (13), $PF_{VMA} = 1.000$, From (15), $PF_{VOIDS} = 1.0200$

(F) From Equation (17), Calculate $PF_{GAC/VOIDS(SUB)}$:

(17) $PF_{GAC/VOIDS(SUB)} = PF_{GAC} + PF_{VOIDS}$

$= 0.9764 + 1.0200 = 1.9964$

(G) From Equation (19), Calculate $PF_{GAC/VOIDS}$:

(19) If $PF_{GAC/VOIDS(SUB)}$ is less than 2, then: $PF_{GAC/VOIDS} = PF_{GAC/VOIDS(SUB)}/2$

$= 1.9964/2$

$= 0.9982$

If $PF_{GAC/VOIDS(SUB)}$ is greater than or equal than 2, Use Equation (18)

(H) Calculate $PF_{TOTAL(SUB)}$ Using Equation (20)

(20) $PF_{TOTAL(SUB)} = PF_C + PF_{GAC/VOIDS}$

$= 1.0240 + 0.9982 = 2.0222$

(I) Calculate The Total Combined Payment Factor, PF_{TOTAL} Using Equation (21):

(21) If $PF_{TOTAL(SUB)}$ is greater than or equal to 2 then $PF_{TOTAL} = PF_{TOTAL(SUB)} - 1$

$= 2.0222 - 1.0000 = 1.0222$

If $PF_{TOTAL(SUB)}$ is less than 2 then use equation (22)

Chapter Three

STATISTICAL COMPARISON OF QUALITY CONTROL VERSUS QUALITY ASSURANCE TESTING

3-1 General

This chapter has been prepared for contracts which contain Special Provision No. 103F34 entitled "End Result Specification for Acceptance of Hot Mix (Aggregate Gradation, Asphalt Cement Content, Air Voids, **VMA** and Compaction) Based on Contractor Testing". This chapter will assist the Contract Administrator in comparing the Contractor's QC test results with the Owner's QA results, in order to assess the conformance of hot mix to the contract specifications for the required attributes (i.e. aggregate gradation, asphalt cement content, air voids and compaction).

Statistical comparison of the Contractor's QC and the Owner's QA test results for each attribute is performed to determine whether the two sets of test data are deemed to be in agreement. Examples of this comparison and a description of the computer program designed to make this comparison are described in this chapter.

Last year there **were** several modifications to the computer program resulting from the following changes to SP 103F34 including:

1) The addition of VMA as an attribute;
2) A revision of the lower limit for AC (in %) from JMF-0.5 to JMF-0.4; and
3) Changes in the conditions for referee testing (now includes AC content and gradation with or without air voids for any mix, air voids only with or without compaction for all Marshall mixes and air voids and VMA only for Superpave mixes. These and additional conditions are summarized in Table 2-9, Chapter 2.0.

3-2 Sampling for QC / QA

For each QC sample that the Contractor takes, the Contractor must also take additional (replicate) samples for the Owner's QA testing and for referee testing (See Chapters 1 and 2).

Loose Hot Mix: Three plate samples of at least 10 kg (at least 20 kg for SMA or Superpave) at each sample location are taken from the same truckload and at the same transverse offset.

Cores: Three cores, at a spacing of 0.5 to 1.0 metres between one another are taken at the same transverse offset.

3-3 Hot Mix ERS Payment and QC/QA Comparison Microsoft® Excel Spreadsheet

In order to automate the calculations for QC/QA comparison, the Bituminous Section has developed a Microsoft® Excel spreadsheet computer program to compare QC and QA results, **for lots with 3 or more sublots**. The following tab names are used to navigate among the various worksheets:

TAB NAME	SHEET
Guide	**Basic User Information**
QC	QC Pay Factor Calculation Sheet,
QA	QA Pay Factor Calculation Sheet,
QCvQA	Lot Pay Factor Comparison Sheet (QC vs. QA),
REF	Referee Pay Factor Calculation Sheet,
OutC	Outlier Test Calculation Sheet
FIN	Final Composite Pay Factor Calculation Sheet,
AddData	Additional Attributes/Requirements Record Sheet
App	Appendix (supporting statistical tables etc.)

To *Move* within any individual worksheet, you can use the scroll bars shown or the arrow keys (←↑→↓). The PgDn, PgUp, Alt+PgDn, Alt+PgUp, may also be used to move one screen down, up, to the right or to the left.

To *Print* the currently displayed page, the user may click on the 'Print' button located at the top left 'or highlight the area to print and simply print using the print selection process.

DATA INPUT:

The workbook and all individual sheets are password protected so that the formulae cannot be accidentally altered or erased. Areas where data are to be input are unprotected and shaded green or yellow for better clarity. Although the cells are fully editable (including the format), the format of the cells should not be edited or changed by the user. For partial QA, the data is simply entered in the appropriate numbered sublot row on the QA sheet.

The following number of significant digits should be used for data entry and rounded in accordance with LS-100:

To the Nearest Whole Number:	Thickness, Stability
To One Decimal Place:	Individual (% passing) gradation results, Individual percent compaction values, Air void values, Lower and upper limits, VCA_{drc}, VCA_{mix} (for SMA), VFA, VMA, Dust Proportion, Flow, G_{mm} at N_{ini} and N_{max}, Tensile Strength Ratio (for SMA and Superpave)
To Two Decimal Places:	Asphalt cement content, Lower and upper quality indices, Draindown
To Three Decimal Places:	Core MRD, Plate MRD

If any technical difficulties are encountered with the program, please contact:

Richard Raciborski,
Ministry of Transportation,
Bituminous Section,
Materials Engineering and Research Office,
Room 238, Building "C",
1201 Wilson Avenue,
Downsview, Ontario, M3M 1J8

Telephone: **(416) 235-3544**

It is strongly recommended that the lot data file name be established (i.e. rename the file with the mix type and lot number as detailed in Section 3-3.3 before entering data) and that all input data be saved frequently.

The rest of this section includes general instructions for the use of the Microsoft® Excel Program, depending upon whether SP 103F34 or SP 103F35 has been included in the contract.

3-3.1 Owner Testing for Acceptance (i.e. SP 103F35)

1. **'**QC' Sheet: The general contract information should be input into the top of the 'QC' sheet as described in Section 3-3.2. This information will be automatically repeated on the 'QA', 'QCvQA', 'REF' and 'FIN' sheets.

2. 'QA' Sheet: The QA test data is input into the 'QA' sheet. The test data for each sublot should be input into cells B14 to I25 of the 'QA' sheet, for the Designated Large Sieve, 4.75mm sieve, 600 micron sieve, 75 micron sieve, Asphalt Cement Content, Air Voids, VMA and Compaction. The rest of the 'QA' sheet displays lot calculation results and calculates the intermediate and final pay factors. The final calculations shown are for the Total Pay Factor (PFtotal). The number of sublots and date tested should also be input into this sheet.

3. If Referee testing is invoked, then the referee results should be inserted into the 'REF' sheet described in Section 3-3.2.

4. The instructions for using the final composite pay factor (i.e. 'FIN') sheet and the recommended conventions for saving and naming of files are given in Sections 3.3-2 and 3-3.3, respectively.

5. To determine if a sublot result within a lot is an outlier, a statistical test is available in the 'OutC' sheet described in Section 3-3.2.

3-3.2 Contractor Testing with QC results used for Acceptance (i.e. SP 103F34).

1. The 'QC', 'QA', 'QCvQA' , 'AddData' and 'FIN' sheets are used in this case. The 'REF' sheet should only be used if Referee testing has been invoked. The 'QC', 'QA', and 'REF' sheets are almost identical except they are used for QC, QA, and Referee results, respectively.

   The 'QC' sheet is used to enter the general contract information and QC test results. The general contract information is input at the top of the sheet and will automatically

be repeated on the 'QA', 'QCvQA', 'REF' and 'FIN' sheets. The Region, Mix type and layer can be selected from drop-down menus. To the right of "MIX TYPE", one of the following recommended codes should be used (or click on cell B8, and choose the mix type from the drop down menu):

Mix Type	Recommended Code
SMA	SMA
Superpave 37.5	SUP375
Superpave 25.0	SUP250
Superpave 19.0	SUP190
Superpave12.5	SUP125
Superpave12.5FC 1	SUP125FC1
Superpave12.5FC 2	SUP125FC2
Superpave 9.5	SUP095
HL1	HL1
HL2	HL2
HL3	HL3
HL3A	HL3A
HL4	HL4
HL8	HL8
HL1 modified	HL1Mod
MDBC	MDBC
HDBC	HDBC
DFC	DFC
OFC	OFC
RHM	RHM

The Job Mix Formula (JMF) designation number is placed in cell A13 and the JMF data in cells B13 to F13 and I13. The QC test data should be input into the green-shaded areas of the 'Sublot Data Input' table. The sublot test results are to be entered in cells B14 to I25, for the Designated Large Sieve, 4.75 mm sieve, 600 μm sieve, 75 μm sieve, Asphalt Cement Content, Air Voids, Compaction and VMA. In addition, the mean combined aggregate density should be entered in cell I9. For SMA only, one more column will be created at the end of the table (i.e. cells J14 to J25) which will be used to display air voids acceptance for SMA based on an Interim Air Voids Administration Procedure (See Section 2-6 in Chapter 2). In any case, the rest of the sheet displays the lot calculation results and the intermediate and final pay factors. The Total Pay Factor (PF_{total}) represents the final calculation.

2. The 'QA' Sheet is used to enter the QA test data. The number of sublots is entered in cell D7, the date of testing in cell D9 and the combined aggregate density in cell I9. Ensure that the results for the all of the sublots are entered in their correctly numbered sublot rows (i.e. between rows 14 and 25). The rest of the sheet displays the lot calculation results and the intermediate and final pay factors. The Total Pay Factor (PF_{total}) represents the final calculation.

3. The 'QCvQA' Sheet does not require any input. It automatically uses the information from the 'QC' and 'QA' sheets for the QC/QA comparison of Pay Factors. At the bottom of the 'QC & QA Comparison' sheet (Cells F42 and F43), there will be a comment with a suggested action for each of the mix properties and the compaction in the 'Action' column. The list of suggested actions is as follows:

   "Contractor to consider Referee testing. Air Voids may be excluded from the testing";
   "CA to consider Referee testing. Air Voids may be excluded from the testing";
   "Use QC results for acceptance of mix properties";
   "Use QC results for acceptance of compaction";

"Contractor to consider Referee testing for %AV only";
"CA to consider Referee testing for %AV only";
"Contractor to consider Referee testing for %AV and VMA only";
"CA to consider Referee testing for %AV and VMA only";
"Either party may request Referee testing. %AV must be included in the testing";
"Contractor to consider Referee testing for compaction";
"CA to consider Referee testing for compaction".

It should be noted that when the cursor is positioned in cell J41, there is a note reminding the user that Referee testing of the entire lot may be invoked by either party, regardless of the difference in QC and QA payment factors.

4. The 'REF' Sheet should be used only to input Referee test results when Referee testing has been invoked. The name of the Referee lab should be entered in cell H7 and the date of referee testing in cell D9. Sublot referee results for mix attributes (gradation, AC content, air voids and VMA) and/or the results for compaction are to be entered in some or all of the cells B14 to I25, depending on which properties were referee-tested. If the Referee is instructed in cell G9 to conduct the Combined Aggregate Density (CAD) testing, then its value should be entered in cell G11. Comparison of QC and QA results for CAD is included right below the lot calculation results. The rest of the sheet displays lot calculation results and calculates the intermediate and final pay factors. The final calculations are for the total pay factor "PF_{total}".

5. The 'OutC' Sheet is used to check any group of sublot test results for outliers. Enter the number of sublots in cell D3, the suspected result in cell D4 and the other sublot results for the specific characteristic/property in the cells below cell D4. The outcome of the statistical test will be displayed in cell H5. For comparison, answers for three different significance levels (0.5%, 1.0% and 2.5%) are provided.

6. The 'FIN' Sheet is to be used to confirm the "FINAL COMPOSITE LOT PAY FACTOR". The input that is required in this sheet is the selection of 'QC' or 'REF' from the drop-down boxes activated when clicking on the shaded cells; I8 for % AC, gradation, VOIDS and for Superpave mixes only, VMA as well; I9 for compaction; I10 for Air Voids only and I11 for VMA only (Superpave mixes only). ONLY input 'QC' or 'REF' in cell I10 (for air voids) when the mix type is HDBC or DFC, SMA and all Superpave (SUP) mixes. Cell I10 must be blank for all other mix types. Once the options are selected for payment purposes, the program will import the appropriate data from the 'QC' and/or 'REF' sheets and calculate the final pay factor at the bottom of the page in the cell beside Pf_{total}.

7. An 'AddData' Sheet includes other contractual information such as thicknesses and additional test results such as stability and flow. The Contract requirements for layer thicknesses, core and plate MRD's and BRD's, VMA, Stability, flow, G_{mm} at N_{ini} and G_{mm} at N_{max} are input in the appropriate cells in row 15. The QC and QA test results (and REF for draindown) are input into the appropriate cells E17 to AA28 as required. Appropriate columns are displayed for data entry when a specific mix type is selected on the "QC" page.

8. Section 3-3.3 gives the recommended conventions for saving and naming of files.

3-3.3 Conventions for Saving and Naming of Files

It is suggested that the original copy of the template be kept as a backup file and a template-based separate data file be created for each lot and saved under an appropriate unique

name. A separate folder should be created for each mix type, containing the files of all lots of that mix type. Another folder should be created for each paving contract which contains all of the folders for the individual mix types.

A typical file name should consist of up to 11 characters followed by the standard ®Excel extension of xls (i.e. *HL801.xls or SUP125FC215.xls*). The first three to nine characters (i.e. HL8 or SUP125FC2) represent the mix type designated in accordance with the recommended codes given in 3-3.2 and the last two characters before the extension identify the lot number (i.e. 01 for lot one, 15 for lot 15).

The use of this convention for the naming of files will assist MTO staff when tracking results from many different contracts. ALL files/folders must be forwarded to the applicable MTO Regional Quality Assurance Office at the completion of paving on each contract.

For all lots which are referee tested, as soon as the referee results are received, all relevant information should be forwarded to MTO's Bituminous Section by facsimile [(416) 235-3996], by clicking on the live link located on the "**Guide**" sheet or by E-mail to the attention of:

Anil Virani – E-mail address: **Anil.Virani@mto.gov.on.ca**

Questions regarding the program or the inputting of data can be addressed to **Richard Raciborski** at the Ministry's Bituminous Section by phone at (416)-235-3544 or by E-mail at: **Richard.Raciborski@mto.gov.on.ca**.

3-4 Consequences of Test Results

The Contractor's QC results and the Owner's QA results will be compared by the Contract Administrator on a lot-by-lot basis to determine if they agree. The determination of the "agreement" of both sets of results (i.e. a minimum of one QA for every two QC results) will be made as follows:

1) If the difference between the compaction payment factor and the mix properties payment factor [AC content/gradation, with or without *voids* (i.e. the lower of the payment factors for air voids and VMA for Superpave mixes or air voids for the other mixes)] calculated using the QA and QC test results are both less than 0.020 (0.025 for HDBC, DFC, SMA and all Superpave mixes), then the QC results shall be deemed to agree.
.
2) If the difference in either the compaction payment factor or mix properties payment factor [AC content/gradation, with or without *voids* (i.e. the lower of the payment factors for air voids and VMA for Superpave mixes or air voids for the other mixes)] calculated for the QA and QC test results are equal to or more than 0.020 (0.025 for HDBC, DFC, SMA and all Superpave mixes), then the results shall be deemed to disagree.

In either case, the Contractor or the Owner will both have an opportunity to engage a third party Referee laboratory to test the samples. The results of the referee testing will be used to determine the payment factors for the acceptance of the disputed properties for the disputed lots of hot mix and will be binding on both the Owner and Contractor. The costs to do the referee testing will be as follows:

1) If the QC and QA results agree, then the cost of the referee testing will be borne by the party making the request for referee testing.

2) If the QC and QA tests don't agree, then the cost of referee testing will be borne by the party whose payment factor is further removed from that generated by the Referee laboratory.

3) If the QC and QA tests don't agree and the payment factor determined by referee testing is exactly between the payment factors from the QC and QA tests, then the cost of the Referee services must be split between the Owner and Contractor.

3-5 Example

The example shown in next page from the Microsoft® Excel spreadsheet program shows a comparison between 5 QA and 10 QC test results for compaction. As the example shows, the difference in total pay factor between QC versus QA test results for Superpave 12.5 is greater than 2.5% [see **Note 1**)] as shown by bolded total on last line i.e. **0.0348**. Therefore referee testing must be considered.

Note: 1) For mixes other than HDBC, DFC**,** SMA and the Superpave mixes, the tolerance for comparison will be 2.0%.

ERS 2005 – Hot Mix QC/CA Comparison and Pay Factor Calculation

LOT PAY FACTOR COMPARISON (QC vs QA)

CONTRACT	2005-xxx	Lot No.	4
HIGHWAY	x	Lot Size (t)	5000
REGION	Eastern	No. Sublots	10
MIX TYPE	**SUP125**	Date Paved	15-Jul-05
ITEM No.	3	Tested (QC)	19-Jul-05

Layer: Surface

Sublot Data	DLS		4.75 mm		600 µm		75 µm		AC		Air Voids		Compaction		VMA	
JMF Id.	QC	QA	QC	QA	QC	QA	QC	QA	QC	QA	QC	QA	QC	QA	QC	QA
2005-xxx-xx	73.5		51.8		22.1		3.8		4.6						14.0	
Sublot 1	78.9	82.7	54.5	57.4	24.4	25.7	3.9	4.5	4.37	4.55	4.2	3.7	94.6	94.6	15.05	13.75
Sublot 2	76.3		55.9		25.1		4.1		4.27		4.0		92.8		14.84	
Sublot 3	76.3	80.9	54.1	58.2	24.6	26.2	1.9	4.5	4.37	4.80	4.0	3.5	93.0	92.4	14.56	15.12
Sublot 4	69.9		45.3		21.4		3.7		4.15		4.3		93.5		14.90	
Sublot 5	77.7	79.2	54.7	58.9	24.8	26.1	4.2	4.4	4.39	4.83	3.8	3.1	92.3	92.6	14.75	14.56
Sublot 6	73.1		50.7		23.3		4.1		4.30		3.8		92.8		13.90	
Sublot 7	78.7	76.8	55.1	48.8	24.3	22.8	2.8	4.3	4.79	4.37	3.7	3.7	92.3	94.2	13.85	14.80
Sublot 8	78.0		57.3		25.3		4.4		4.39		2.8		92.6		14.45	
Sublot 9	76.1	80.4	54.8	57.5	24.6	26.2	4.4	4.7	4.43	4.41	3.7	3.0	92.5	92.1	14.70	14.24
Sublot10	68.8		46.9		21.4		3.1		4.11		4.6		94.5		14.22	
Sublot11																
Sublot12																

Combined Lot Calculation Results

COUNT	10	5	10	5	10	5	10	5	10	5	10	5	10	5	10	5
Lot Mean	75.4	80.0	52.9	56.2	23.9	25.4	3.7	4.5	4.36	4.59	3.9	3.4	93.1	93.2	14.52	14.49
Std Dev	3.60	2.19	3.98	4.16	1.43	1.47	0.82	0.15	0.19	0.21	0.48	0.33	0.85	1.14	0.41	0.53
LL	68.5	68.5	46.8	46.8	18.6	18.6	1.8	1.8	4.2	4.2	2.5	2.5	91.5	91.5		
UL	78.5	78.5	56.8	56.8	25.6	25.6	5.8	5.8	5.1	5.1	5.5	5.5	97.0	97.0		
QL	1.91	5.26	1.54	2.25	3.72	4.63	2.28	18.07	0.85	1.83	2.90	2.71	1.88	1.48		
QU	0.87	-0.69	0.97	0.15	1.17	0.14	2.62	8.90	4.00	2.37	3.36	6.33	4.62	3.36		
PL	99	100	95	100	100	100	100	100	80	100	100	100	99	96		
PU	81	26	84	56	89	55	100	100	100	100	100	100	100	100		
PWL	80	26	79	56	89	55	100	100	80	100	100	100	99	96		
PF	0.9860	0.4680	0.9830	0.9170	1.0000	0.9140	1.0025	1.0025	0.960	1.010	1.020	1.020	1.024	1.006	1.000	1.000

Pay Factor Comparison

Attribute	QC	QA	Difference
Mix Properties	0.9982	0.9688	**0.0294**
Compaction	1.0240	1.0060	**0.0180**
Total	1.0222	0.9874	**0.0348**

ACTION - Subject to Applicability Please Read the Attached Note!

CA to consider Referee testing. Air Voids may be excluded from the testing.
Use QC results for acceptance of compaction.

Chapter Four

PERFORMANCE-GRADED ASPHALT CEMENT (PGAC)

This chapter has been adapted from the document entitled "*1998 Guide For the Use of Performance Graded Asphalt Cement (PGAC) in MTO Contracts".* Information regarding compaction and recompaction of mixtures containing PGAC has been modified since then.

4-1 Introduction

The Ministry of Transportation of Ontario (MTO) adopted the use of Performance Graded Asphalt Cement (PGAC) in 1997 and interim PGAC guidelines and specifications were released in May of that year. Since 1999, Ontario has been divided into three geographical zones, with appropriate PGAC upgrades for highways with heavier traffic. The MTO modifies the specified PGAC grades in each zone for mixes with more than 20% RAP. For MTO rural freeway/urban arterials and urban freeways, there is an automatic increase of one or two grades to the high temperature side.

4-2 Superpave

Superpave is the main product of the asphalt portion of the Strategic Highway Research Program (SHRP). Superpave is a system comprising the binder (asphalt cement) specification, the new volumetric mix design procedure (using the Superpave Gyratory Compactor) and mix performance prediction system. Superpave is being implemented by most agencies in stages, with the adoption of binder specifications being the first phase.

In Superpave, asphalt cements are designated as PG XX-YY, where XX and YY are the summer and winter design pavement temperatures, in °C, a range within which the asphalt cement is expected to perform. Grades are in 6 degree increments. The design high and low performance temperatures are related in part to the climatic conditions for the locale, the traffic loading anticipated on the pavement structure and the position of the hot mix layer within the pavement structure. The presence and percentage of RAP also impacts on the appropriate PGAC grade. With pavement temperatures, the concept of reliability must also be appreciated, i.e. the probability that a given range limit may be exceeded.

Numerous publications provide in-depth treatment of Superpave and related specifications. For example, the Asphalt Institute publication titled *"Superpave- Performance Graded Asphalt Binder Specification and Testing"*, Superpave Series No. 1 (SP-1) is an excellent source of information.

4-3 Geographical Zones for PGAC

For PGAC use, Ontario has been divided into the following three zones:

Zone 1: is the area north of the boundary formed by the French River, Lake Nipissing, and the Mattawa River (unchanged from 1997).

Zone 2: is the area south of Zone 1, and north of a line from Honey Harbour, to Longford, Taylor Corners, Cavan, Cambellford, and Mallorytown.

Zone 3: is the area south of Zone 2.

The zones are illustrated in Figure 4-1. They are delineated on the basis of temperature contours at a 98% reliability level from available weather data and with due regard to the relationship between pavement and air temperatures, as established by the Long Term Pavement Performance (LTPP) studies. Where available, the major towns closest to the temperature contours are selected as the boundary between zones. Some generalisation of the zone mapping is necessary**,** in order to avoid the creation of mini-zones due to localised variations in climatic data.

For design purposes:

- Towns located along a zone boundary line are to be included in the zone south of the boundary line.
- Projects located within 10 km of the zone boundary lines may be included in either zone, at the discretion of the designer, so that they may be considered as being a single zone.

4-3.1 Zones for MTO Administration

The Ontario-wide zones can be modified for MTO purposes using the flexibility allowed in the previous section and any other administrative criteria at the discretion of the applicable Regional Geotechnical Section. For example:

- the Regional boundary between Owen Sound and Huntsville can be used as the northern boundary between Zones 2 and 3.
- the Regional boundary between Bancroft and Central Region (approximately the Huntsville District boundary to Highway 7) can be used by Central Region as a Zone 3 boundary.

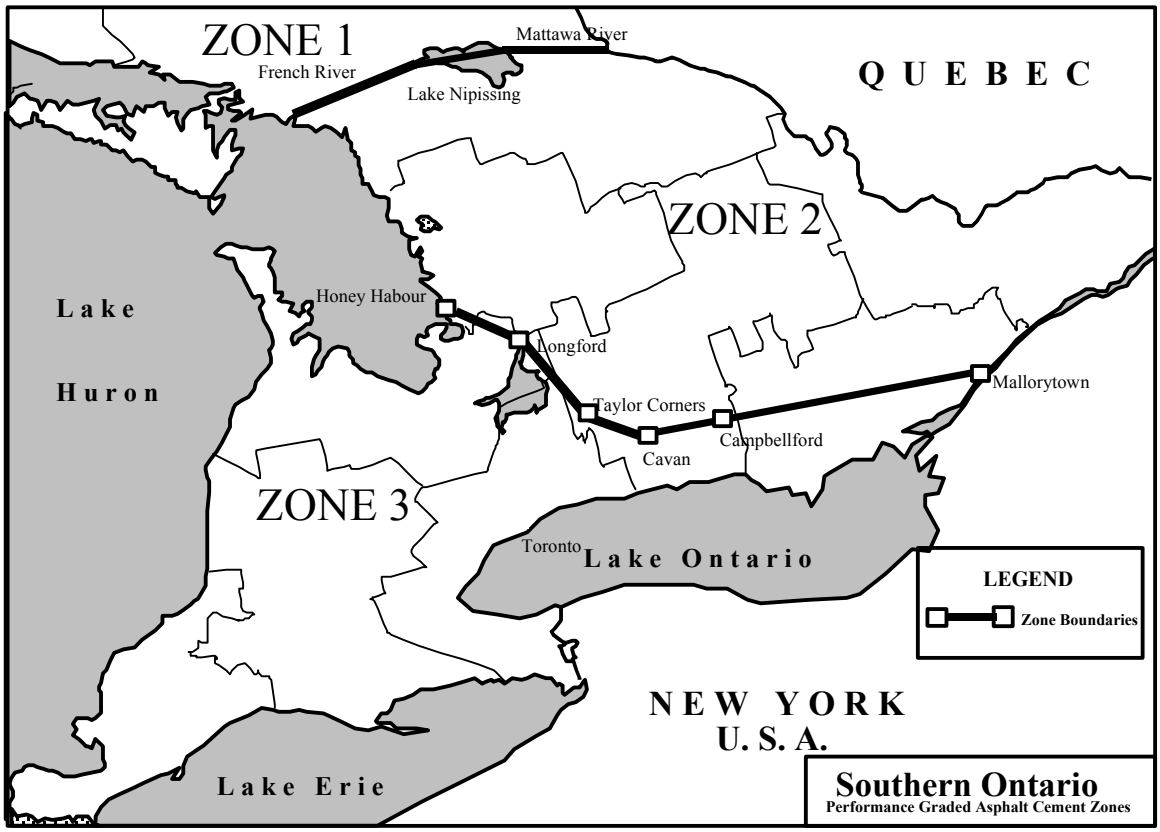


Figure 4-1: PGAC Zones for Ontario

4-4 Grade Selection For MTO Contracts

Performance graded asphalt cements are selected on the basis of:

- the location of the contract, i.e. the geographical zone in which it is located, noting that some discretion is allowed;
- the type of hot mix (new versus recycled hot mix); and
- upgrades for highways with heavier traffic as appropriate.

Table 4-1 provides the basic performance grades for each zone in MTO contracts. Two basic PGAC grades are specified for each zone, one for new hot mix or mix containing up to 20 percent recycled asphalt pavement (i.e. RAP), and the other for mixes containing 21 to 40 percent RAP. Since 1998, for recycled mixes containing up to 40 percent RAP, the required PGAC is specified for each zone, (i.e. a design based on recovered penetration is not required). Recycling ratios in excess of 40 percent should be addressed on a contract specific basis, in consultation with the appropriate Regional and Head Office units.

It should be noted that PG 52-40 is not widely used in large quantities. As such, the price and availability of this product may result in “value engineering” type proposals from contractors wishing to substitute PG 52-34 for PG 52-40 during construction, especially for recycled mixes. Such proposals should be discussed with the applicable Regional and Head Office units.

Table 4-1: Grade Selection for MTO Contracts

	PGAC		
	Zone 1	**Zone 2**	**Zone 3**
New Hot Mix Or up to 20% RAP	52-34	58-34	58-28
21% to 40% RAP	52-40	52-40	52-34

4-4.1 Upgrades for Heavy Traffic

Superpave specifications recommend upgrades of the high temperature performance grade when the pavement is expected to experience heavy traffic loading. For Ontario use, Superpave guidelines have been interpreted in terms of highway classification and/or commercial truck traffic. The guidelines are presented in Table 4-2. It is recommended that the applicable Regional Geotechnical office be consulted for the application of these guidelines.

As shown in Table 4-2, for MTO rural freeway/urban arterials and urban freeways, there will be an automatic increase of one or two grades to the high temperature side, respectively which will provide an additional margin of safety against premature rutting.

4-5 Contract Documents

There have been a number of changes to several standard special provisions since 1997 which deal with PGAC in MTO contracts. Most of these are dated March 1998. A brief description of the documents and the changes from 1997 are summarised in the following paragraphs. The actual documents must be referred to for contract administration purposes.

4-5.1 Special Provision 103S33

Minor changes were made to the 1997 version (NSSP PGAC 313) of this document. Mix design submissions now include information related to mixing, compaction and recompaction temperatures. The subsections of OPSS 313 and 1149 related to viscosity and penetration have also been amended.

4-5.2 Special Provision 111S08

This document removed all references to OPSS 1101 in 1149 and, as such, is now considered the main specification for PGAC. It details the physical requirements of the products and contract-specific requirements such as quality control plans. Quality control/Quality assurance (QC/QA) protocols are also described. The lot size for PGAC is based on the quantity of the product incorporated into hot mix. QC testing for acceptance on a lot-by-lot basis by the Contractor is mandatory.

Quality assurance testing by MTO is recommended at the same frequency as QC testing, i.e. one sample per lot. When test results are classified as major borderline or rejectable (as defined in the document), the Regional Quality Assurance Section should be involved in determining the appropriate action.

Table 4-2: Guidelines for the Modification of PGAC High Temperature Grade Based on Highway Classification and Traffic Conditions

Roadway Classification		Changes in PGAC Grade	
		Increase From Standard Grade	**Optional Additional Increase in Grade**
MTO Highways	Urban Freeway	2 grades	N/A
	Rural Freeway Urban Arterial	1 Grade	1 Grade
	Rural Arterial Urban Collector	Consider increasing by 1 grade if heavy truck traffic > 20%	1 Grade
	Rural Collector Rural Local Urban / Suburban Local	No Change	1 or 2 grades
Municipal Roadways	Upper Tier - Expressway Type - Arterial Large Lower Tier Arterial	1 grade	
	Large Lower Tier - collector - rural - local urban - local suburban Small Lower Tier - all categories	No Change	

Notes: 1) Upgrading of the high temperature grade is recommended for use in both surface and top binder courses (i.e. the top 80 mm to 100 mm of hot mix).

2) For roadways which experience a high percentage of heavy truck traffic and/or bus traffic at slow operating speeds with frequent stops/starts and/or historical concerns with instability rutting, consideration should be given to an increase in the high temperature grade.

Table 4-3: Range of Percent Asphalt Cement for Bidding

Hot Mix Asphalt Type	% for Bid
Superpave 25.0	**4.0**
Rich Bottom Mix	**4.4**
Superpave 19.0	**4.5 – 4.8**
Superpave 12.5, 12.5FC1, 12.5FC2	**4.6 – 5.2**

4-5.3 Special Provision 313F02

The warrant for this special provision **has changed to include SMA**. The use of this SP requires a "fill-in" which should be obtained from Tables 4-1 and 4-2.

4-5.4 Special Provision 313F03

This special provision governs, amongst other issues, the selection of PGAC for RHM**, and a percentage by mass of asphalt cement for bidding purposes**. The required grades for two ranges of recycling ratios (0 to 20 % and 21 to 40 %) in the different geographical zones are specified. It should be noted that mix designs based on target recovered penetration are not required. The use of this SP requires a "fill-in" which should be obtained from Tables 4-1, 4-2 **and 4-3.**

4-5.5 Special Provision 313F42

This document governs the selection of PGAC for optional recycling. The use of this SP requires a "fill-in" which should be obtained from Tables 4-1 and 4-2. For recycling ratios in excess of 40 percent, it is recommended that the required Contractor's proposal be reviewed by the applicable Regional Geotechnical Office and the Bituminous Section.

4-6 Supply of PGAC

The MTO has created a separate listing in the Designated Sources for Materials (DSM) for PGAC.

4-7 Determination of the Laboratory Mixing and Compaction Temperatures of Hot Mix for Design of Pavement Mixtures

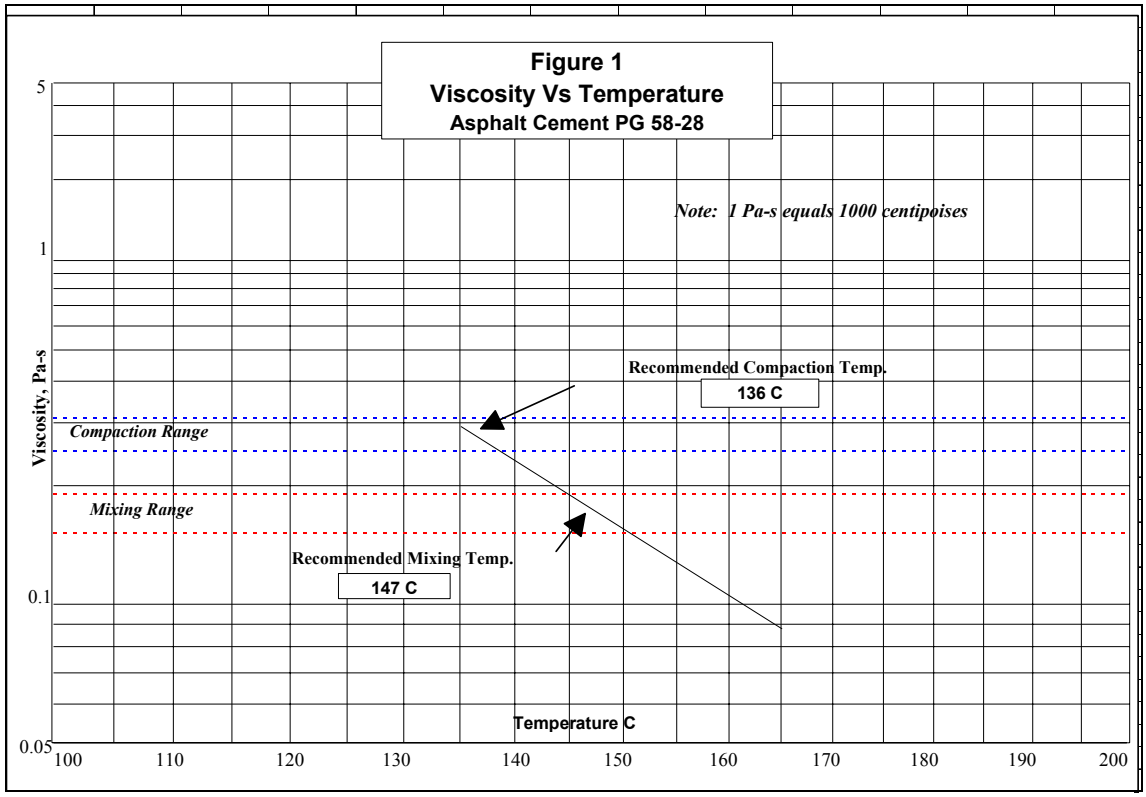
The viscosity-temperature relationship of an asphalt cement is used as a guide for establishing the mixing and compaction temperature in the laboratory. The temperature to which the asphalt cement must be heated in order to produce a viscosity of 0.17 ± 0.02 Pa.s is the mixing temperature. The temperature to which the asphalt cement must be heated to produce a viscosity of 0.28 ± 0.03 Pa.s is the compaction temperature. This has been the guide for Marshall mix design criteria and the relationship continues to be valid for laboratory purposes within Superpave. In Ontario, the mixing and compaction temperatures are the temperatures where the asphalt cement has a viscosity of 0.17 and 0.28 Pa.s respectively.

The Brookfield Viscometer is a rotational device (ASTM D 4402) which is used to determine the mixing, compaction and pumping temperatures in the Superpave system. Viscosity measurements at 135° C and 165° C are plotted on a log viscosity vs. temperature chart which is used to interpolate the mixing and compaction temperatures.

The procedure for establishing the mixing and compaction temperatures from the laboratory is valid for refinery-produced asphalt cements but may not be valid for some polymer-modified asphalt cements. The supplier of these asphalt cements must be consulted for their recommendations regarding the mixing and compaction temperatures.

The relationship between temperature and viscosity given in Figure 4-2 shows the idealised laboratory mixing and compaction ranges. The asphalt cement acts as a "super lubricant" within the mixing temperature range and a "super glue" within the compaction temperature range.

Figure 4-2 – Viscosity Versus Temperature (PG 58-28)



4-8 Compaction Temperatures at Design and for Reheated Mix

The appropriate compaction temperatures for hot mix are important in determining the void properties of the mix at the design stage and during construction.

For new hot mix incorporating refinery-produced asphalt cement, the compaction temperature is typically obtained from a Temperature Viscosity Chart for the specific product. However, the use of temperature viscosity charts may not be valid for some polymer-modified asphalt cements and the suppliers of such products will need to specify the compaction temperature to be used with their products.

The appropriate compaction temperature for reheated mixtures has been the subject of considerable study and discussion by the Superpave Implementation Committee. Since 2000, it has been agreed with industry that, for all asphalt mixtures (including recycled mixes), the Contractor will now specify the compaction temperature for reheated mix. This may be the same but can never be less than the compaction temperature employed during mix design.

4-9 Compaction Temperatures of Hot Mix Containing Recycled Asphalt Pavement (RAP)

4-9.1 Compaction of Hot Mix Containing Up to 20% RAP

The direction provided in Section 4-8 for new hot mix will also be applicable for hot mix containing up to 20% RAP. This means that the compaction temperature for the reheated mix may be the same but can never be less than the compaction temperature employed in the design of these mixtures.

4-9.2 Compaction Temperatures For Mixes Which Contain 21 to 40% RAP

Such mixes incorporate a "softer" grade of PGAC which is either specified in the contract (for RHM items) or is selected by the Contractor in accordance with guidelines available elsewhere.

a) For mixes containing 21 to 30 % RAP, the compaction temperature must be 3°C higher than the compaction temperature stipulated by the proprietor of the PGAC for the product specified/used.

b) For mixes containing 31 to 40 % RAP, the compaction temperature must be 6°C higher than the compaction temperature stipulated by the proprietor of the PGAC for the product specified/used.

These proposals make a number of assumptions, including:

- that all RAP materials are similar in terms of the properties of the residual asphalt cement; and
- that all PGAC products "harden" similarly when mixed with RAP and when subjected to plant conditions.

While the assumptions given above may not be valid, it is important to adopt this uniform approach for the testing of recycled asphalt mixes.

4-9.3 Examples of Compaction Temperature Determinations

Situation A (Up to 20% RAP): Supplier X, PG 58-28

	New Hot Mix*
Mix Design Temperature	140° C
Compaction Temperature for Reheated Hot Mix Asphalt (HMA)**	≥140° C

* Supplied with mix design submission

Situation B (21 to 40% RAP): Supplier Y, PG 52-34

New hot mix specifies the use of PG 58-28, the Contractor elects to supply mix with RAP (percentage in the range of 21 to 40 %) which requires the use of PG 52-34 to be provided by Supplier Y.

	Data for PG 52-34 *	**21 - 30 % RAP**	**31 – 40 % RAP**
Mix Design Temperature	142° C	145° C	148° C
Compaction Temperature for Reheated Hot Mix Asphalt (HMA)**	≥142° C	≥145° C	≥148° C

* Supplied with mix design submission

** Specified by Contractor

Chapter Five

ACCEPTANCE OF PAVEMENT BASED ON VISUAL OBSERVATION

5-1 General

The purpose of this section is to provide guidelines for the acceptance of bituminous pavement on the basis of its surface appearance, as specified in Subsection 313.07.01.17 of OPSS 313.

A Standard Special Provision (SP), No. 103S38, entitled "Acceptance of Pavement Based on Visual Assessment of Segregation" is being included in all new contracts containing DFC, HL1 Modified, or for Highways 11 and 69, HL3 Modified surface courses.

Visual deficiencies other than segregation will be dealt with as "Other Pavement Surface Defects", as described in Section 5-4.

5-2 Visual Inspection

The Bituminous Contractor Quality Control Plan (if applicable) requires that the Contractor visually inspect the pavement. The Contractor has the primary responsibility to check for deficiencies, notify the Contract Administrator and propose corrective measures. However, the Contract Administrator will perform visual inspections for acceptance purposes.

After final compaction and before the construction season has ended, each bituminous pavement course must be thoroughly inspected by the Contract Administrator to ensure that the surface texture of the mat is of uniform texture and free of segregation, fat spots, flushing, oil spills, paver and roller marks and any other surface defects. The Contract Administrator will inform the Contractor of the inspection at least 24 hours prior to the time the inspection is carried out.

It should be noted that paver and/or roller marks may also result in low-amplitude waves in the pavement which can manifest themselves as vibrations in ride (commonly known as "chatter"). If the Contract contains a smoothness specification (SP 103F31), such low-amplitude waves may not be reflected in surface smoothness measurements (i.e. a high profile index) but may be detected in ride quality. Since these waves in the pavement can usually be detected visually, they should be treated the same as any other surface defects (see Section 6-5.3 – Effects of Chatter, Chapter 6) would be treated.

All Consultant Inspectors must be experienced in segregation assessment, prior to carrying out any visual inspection of the compacted hot mix. It is recommended that, at the beginning of the contract, the Contract Administrator's Inspector work closely with the applicable Quality Assurance Officer so that consistent assessments are being made throughout the Province.

All visually defective areas should be marked out by the Contract Administrator on the pavement surface and the marks must remain in place until the pavement has been properly assessed and repaired, if necessary. The Inspector will be required to prepare a detailed list which identifies each discrete area of defective pavement with its defect(s) and area in square metres. This may be done on a form similar to that shown in this Chapter.

VISUAL ASSESSMENT OF HOT MIX DEFICIENCIES

Region: **Inspector / Contract Admin.:**

Contract No.: **Company / MTO:**

Highway No.: **Date of Inspection:**

Contractor: **Page:** **of**

General Information			Visual Deficiencies						Dates (Year/Month/Day)	
Direction	Lane No.	Hot Mix Details Surface S), Binder (B) Padding (P) / Lift No. (First Binder Lift Placed is 1) / Hot Mix Type	Location - From/To: (Note Stations, if Possible)	Segregation Type: Midlane (ML) Other (O)	Segregation Degree: Slight (SL, Medium (M), Severe (SEV)	Other Deficiencies (Give Details)	Lane Width (m)	Area (m^2)	Date Deficient Section of Hot Mix Was Placed	Date Contractor Was Officially Notified of Deficiency (in Writing)

Pavement may be deemed defective on the basis of visual observation, at any time before the end of the construction season in which the mix was placed. Such pavement must not be paved over until a decision is made as to its disposition. However, if the Contract Administrator deems that the pavement constitutes a hazard to the travelling public, then the hazard must be immediately eliminated.

All pavement deemed defective, on the basis of visual inspection, must be brought to the Contractor's attention, in writing, as soon as it becomes evident.

A "Draindown" test has been developed by AASHTO to indicate the likelihood that open-graded mixes like Stone Mastic Asphalt (i.e. SMA) will form "fat spots". Any mix which has failed the 0.3 percent requirement for the Draindown test (see Section 2-6) and has not yet developed such spots at the time construction has been completed, should be marked out in the field. Such areas should be monitored during the one-year warranty period by the appropriate Regional Quality Assurance Section and if "fat spots" develop later, then the Contractor may be required to remove and replace such material.

5-3 Segregation

Segregation consists of areas with predominantly coarser texture than that of the surrounding pavement and is classed into two main types:

"Mid-Lane" Segregation:
[See Note 1]: consists of a continuous or discontinuous longitudinal "streak" which is typically no greater than 300 mm in width. Such segregation is often found in the middle of the lane, in the vicinity of the gearbox of the paver [see Note 2]; and

"Other" Segregation: consists of discrete areas or patches of regular, irregular or chevron shape.

The degree of severity of segregation is categorised as either slight, medium or severe, in accordance with the following criteria:

Slight Segregation: The pavement matrix is in place between the coarse aggregate particles but there is slightly more coarse aggregate particles in comparison with the surrounding acceptable mix.

Medium Segregation: The pavement has significantly more coarse aggregate particles than the surrounding acceptable mat and usually exhibits some lack of surface matrix.

Severe Segregation: The pavement appears very coarse, with coarse aggregate particle against coarse aggregate particle and the pavement has little or no matrix.

A dispute settlement mechanism has been developed which may be used for defining the degree of segregation, in the event of a dispute. The procedure, which is discussed in Section 5-3.4, will be available to the Contractor in any contract which includes the SP's described in Section 5-1. Contractors will not be allowed to opt-in to this new procedure [although under some circumstances, the Contractor may be able to opt-into the SP itself (see last paragraph of Section 5-3.4.2)].

Notes: 1) The administration of paving operations, in which mid-lane segregation has been found and stated in this Field Guide is based on a memorandum written by the Bituminous Section to the Regional Managers and dated June 14, 1995.

2) Longitudinal streaks located in areas other than within the vicinity of the gearbox of the paver (such as those at the ends of the fixed main screed on a paver with extendible screeds) will be treated as “Other Pavement Surface Defects”. However, they will be price-adjusted/repaired in the same way as mid-lane segregation (see Section 5-4).

5-3.1 Initial Notification / Corrective Action For Segregation

If the Contract requires a Bituminous Quality Control Plan, then the Contractor is required to inspect the pavement, report deficiencies to the Contract Administrator and propose corrective measures. Any corrective measures that the Contractor proposes which differ from this Field Guide will require Ministry approval.

When the Contract Administrator first notices a segregation problem (i.e. if the Contractor has not already identified the problem and has proposed corrective action) then the Contract Administrator or his designated representative must bring the problem to the Contractor's attention verbally and then immediately follow this up in writing with a letter to the Contractor (similar to the one shown on Page 80). The Contractor must be instructed to take immediate preventative action, in order to preclude any reoccurrence of such segregation. The Contract Administrator may also assess a QC compliance deviation in accordance with Ministry guidelines for administering Contractor QC compliance requirements.

The Contractor will then be required to propose, in writing, the corrective action which he plans to take for medium segregation in surface courses or severe segregation in any pavement course.

The severity and extent of the segregation must be determined as soon as it is practical to do so. However, for the last 3 days of paving, the determination of the severity should be made within five working days after paving is completed, weather permitting.

5-3.2 Disposition of Segregated Mix

Segregation occurring in hot mix shall be dealt with as detailed below.

Slight Segregation: Slightly segregated mix will be accepted into the work with no payment reduction.

Medium Segregation: Binder Courses and Levelling/Padding Courses With a Total Thickness of Not Less Than 40 mm [see Note 3)]:

Medium segregated binder courses will normally be left in place with no payment reduction [see Notes 4 and 5].

However, any areas of medium segregation that deteriorate prior to being overlaid by another pavement course, including pavement left to traffic over the winter, must be repaired at no cost to the Ministry.

Surface Courses:

Areas of medium segregation will be price-adjusted or at the discretion of the Contract Administrator, either removed and replaced or covered with an overlay of the same mix type.

The Contractor may undertake remedial action, which has been approved by the Contract Administrator, in lieu of a payment reduction for medium segregation.

Severe Segregation: All severely segregated mix must be removed and replaced.

All cases of severe segregation in any pavement laid and all cases of medium segregation in surface courses are to be reviewed by the Regional Quality Assurance Office. In many cases, this will be reviewed with the Bituminous Section as well.

Notes: 3) Textural problems in levelling/padding courses with thicknesses less than a normal lift of hot mix (i.e. less than 40 mm, in most cases), any bullnose or tapers that were not machine-laid and any areas of "handwork" will be dealt with solely on the basis of their workmanship and not on segregation assessment.

4) It has been reported that Open Friction Course (OFC) underlain by a medium-segregated binder course tends to cause "pop outs" due to the accumulation of moisture in the segregated binder. Therefore, such areas should be very carefully evaluated before allowing them to be left in place.

5) When a binder course with medium segregation will be open to traffic over the winter, the Contractor should be notified that the cost of any emergency repairs during the winter will be charged to the Contractor.

5-3.3 Continuing Segregation

When the Contractor has continuing problems with medium or severe segregation and after notification that such segregation is present has been provided, then the matter should be brought to the attention of the Construction Supervisor and/or Area Construction Engineer. The Ministry will consider the possibility that factors beyond the Contractor's control such as experimental equipment or mix may be contributing to the problem. The Ministry will then determine whether or not to instruct the Contractor to stop paving. If the Contractor is instructed to stop paving, the Owner will not be held responsible for any additional costs that the Contractor may incur as a result of the shutdown.

After instructing the Contractor to stop but before paving restarts, a special meeting should be held with the Contractor to emphasise the seriousness of the matter and potential for further stoppages regardless of the Contractor's proposals to make repairs and/or agreement to payment reductions. The intent of the meeting is to prevent further placement of new pavement that will not perform as well as pavement placed without segregation. The meeting should be attended by the next level of management higher than the on-site supervisors for both the Ministry and the Contractor, wherever possible. In some cases, these individuals should observe the pavement after restarting operations for themselves.

SAMPLE LETTER TO CONTRACTOR
(Version 1.0)

TO: _____
(NAME OF CONTRACTOR)

CONTRACT NO.:_____ HIGHWAY NO.:_____

Re: **Notice of (General/Mid-Lane) Segregation for _____**(Hot Mix type)

Segregation has been observed in the mat, contrary to the requirements of OPSS 313.07.01.17 on _____ . The (general) area(s) where this segregation has been noted is as follows:

Lift No.:_____ Lane No.: _____ From Station:_____to Station:_____

Lift No.:_____ Lane No.: _____ From Station:_____to Station:_____

Lift No.:_____ Lane No.: _____ From Station:_____to Station:_____

etc.

It should be noted that there may also be other areas of segregation than those identified above.

While a formal assessment and the disposition of this mix will be determined at a later date, the Contractor is hereby informed that action is immediately required to eliminate any further incidences of segregation.

_____ _____
Contract Administrator, MTO Date

_____ _____
Contractor's Representative Date

cc: Head, Regional Quality Assurance

5-3.4 Challenging the Degree of Severity

This section applies only to those Contracts which contain Special Provision No. 103S38, entitled "Acceptance of Pavement Based on Visual Assessment of Segregation" which include the following mechanism for resolving disputes arising from differences in the assessment of the degree of severity:

1) The Contractor will be allowed to challenge, in writing, the degree of severity of any segregated areas which have been assessed as either medium or severe by the Contract Administrator. The Contractor must list each disputed area, its dimensions and his own assessment of its severity.

2) The Contractor will normally be allowed a maximum of four separate written challenges for each Contract item, where the item has at least 30000 tonnes of hot mix. The Contractor will be allowed only up to two written challenges where the item has less than 30000 tonnes of hot mix.

3) Another representative of the Owner, who is qualified in segregation assessment, will make a second visual assessment of each of the areas that were disputed by the Contractor. That assessment will be made under our current guidelines (see Section 5-3.2).and must be carried out within five working days after the Contract Administrator has received the Contractor's written challenge. This second assessment will normally be carried out by the appropriate Regional Quality Assurance Officer or a representative of the Bituminous Section

4) If the segregation has occurred in any HL mix types, RHM or DFC, the Contractor may further challenge the second visual assessment by the Owner's Regional or Head Office representative. In this case, textural depth testing using ASTM procedure E 965 - 87, "Standard Test Method for Measuring Surface Macrotexture Depth Using a Volumetric Technique", will be normally be carried out by "the Owner's Designated Representative" (i.e. the appropriate Regional Quality Assurance Officer or any other representative of the Owner who has been properly trained to carry out the test procedure). The test procedure used to determine the severity of a segregated area is described in this Section and the results of the testing will be binding on both the Owner and Contractor.

5-3.4.1 Macrotexture Test

The macrotexture test involves the following procedure:

a) Once the testing location is thoroughly dry, it must be brushed clean using a soft bristle brush to remove any dirt and loose material.

b) A known volume of graded glass beads is measured out. A small flush-filled penetration cup containing a volume of about 28 cm^3 is suitable for this purpose.

c) The beads are dumped out of the cup into the middle of the testing location and then spread out in a circular fashion with a hard rubber disk (a hockey puck). The beads are spread out until they cannot be spread out any further and only the uppermost points of the aggregate protrude through. At that point, the hockey puck will be able to glide freely over the “circle of beads”.

d) Four separate measurements of the diameter of the "circle of beads" are taken and then averaged together.

e) The following equation is used to determine the average macrotexture depth for the area covered by the glass beads:

$$M_d = \frac{4 \times V}{(\pi \times D^2)}$$

where: M_d = Average macrotexture depth in mm

V = Volume of graded glass beads $\geq$ 25,000 mm^3

D = Average diameter of the "circle of beads" after spreading in mm

π = 3.141592654.....

5-3.4.2 Severity Procedure

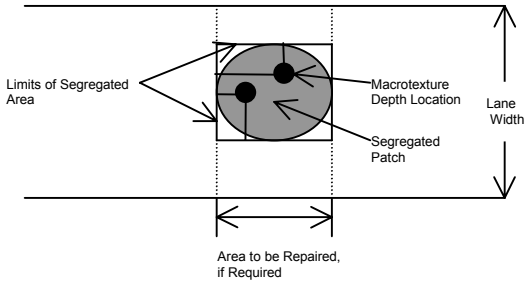
The macrotexture depth procedure will only be used for challenging the mix types shown in Table 5-1 and if the circle of glass beads can comfortably fit within the segregated area being tested. The procedure for evaluating a disputed segregated area is as follows:

a) The Owner's Designated Representative will choose four non-segregated locations, adjacent to the disputed area, to act as a control for the unsegregated mix.

b) A macrotexture test will be conducted at each control location by the Owner's Designated Representative. The average macrotexture depth at any control location must not be more than the maximum allowable average macrotexture depth noted in Table 5-1. If the macrotexture depth determination, at any control location, is found to be more than the maximum allowable average macrotexture depth, then the area tested is not suitable to be used as a control area and another area should be chosen to do the test. The four average acceptable macrotexture depth determinations are themselves averaged together to determine the average control macrotexture depth, M_C.

c) The limits of the disputed segregated area both parallel to and perpendicular to the pavement lane will be determined visually by the Owner's Designated Representative (See Figure 5-1).

Figure 5-1



d) Two to four representative testing locations within the disputed area for macrotexture depth determinations are chosen by the Owner's Designated Representative using random numbers from Appendix A and determining the distances along the limits of segregation (See Figure 5-1). The choice of two to four will depend upon the repeatability of the first two locations but four tests is recommended since it is more representative than two.

e) One macrotexture test will be conducted at each of the segregated locations by the Owner's Designated Representative. The average macrotexture depth determinations from these areas will themselves be averaged together to determine the macrotexture depth, M_S, which will deemed to be representative of the entire disputed area.

f) The ratio M_S/M_C will determine the degree of segregation of the disputed area, in accordance with the standard ratios shown in Table 5-1.

g) Individual average macrotexture depth determinations must be rounded to two decimal places and the macrotexture ratios rounded to one decimal place in accordance with LS 100.

h) The results should be filled out in calculation forms similar to that shown at the end of this Chapter .

The Contractor will be given a penalty, as determined in Section 5-6, for any disputed area where the macrotexture ratio (M_S/M_C) is found to be greater than the maximum macrotexture ratio for the severity of the area which was assessed by the Contractor and stated in his written challenge.

For contracts containing DFC**,** HL 1 Modified, or for Highways 11 and 69, HL 3 Modified, as part of the Ministry's premium surface course initiative, the Contractor will be allowed to opt-in to the most recent version of the segregation specification. A copy of the opt-in agreement is given later in this Chapter .

Table 5-1

Mix Type	Non-Segregated (i.e. Control Areas) Maximum Allowable Macrotexture Depth (mm)	Macrotexture Ratio M_s/M_c Degree of Segregation		
		Slight	Medium	Severe
HI Mixes [except HL 1 – see Note 6], RHM	0.65	< 1.9	1.9 to 2.5	> 2.5
DFC/HL1*	0.80	< 1.6	1.6 to 2.2	> 2.2

***Note 6)**: For modified mixes of HL 3 with ≥ 80% crushed stone, use the ratios for HL1

5-4 Disposition of "Other Pavement Surface Defects"

The following additional guidelines will apply to the disposition of defective pavement due to causes other than segregation (i.e. "other pavement surface defects"):

- The Contract Administrator will review the defective pavement, determine the quantity of hot mix involved, the severity of the problem, the disposition of the area in question and the responsibility for the cost for any remedial work, if required. For longitudinal streaks located in the lane at locations other than within the vicinity of the gearbox of the paver (see Note 2).

- The Contract Administrator will review his/her findings and recommendations with the Ministry prior to informing the Contractor.

- The Contractor will then be advised, in writing, of the disposition of the work.

5-5 Repairs

Repairs will either consist of removal and replacement with new hot mix or a hot mix overlay, where it is permitted.

For some defects, overlays on traffic lanes beneath structures may be allowed on open roadways or beneath structures, if clearances between the pavement surface and the underside of the structure after overlay do not exceed the tolerable limit. Overlays on traffic lanes beneath posted structures, adjacent to curb-and-gutter or on bridge decks will not be permitted.

The method(s) of repair chosen by the Contractor will always be subject to the approval of the Contract Administrator, after first consulting with the applicable Regional Quality Assurance Section.

Repairs for defective hot mix must be full lane or shoulder width (i.e. between existing longitudinal joints including any lane markings which may be present). However, localised repairs may be permissible for mid-lane segregation in binder courses, where defects other than segregation are located on a paved shoulder or where the defect is so small that it can be removed with a single core. However, it should be noted that localised repairs will not be permitted for longitudinal streaks located anywhere within the vicinity of the wheelpaths.

A paver must be used for all repairs except for those where localised repairs are allowed.

Where localised repairs are allowed for mid-lane segregation, these repairs must:

- Not exceed 300 mm in width
- Be to the full depth of the subject lift; and
- Be entirely tack-coated.

When a defect is located on a paved shoulder, the Contract Administrator may allow an isolated repair of the paved shoulder only.

In some cases, the Contract Administrator may allow a defect with a maximum dimension of 150 mm to be removed by a single core. Where removal by core is allowed, the replacement of the pavement must be consistent with the repairs required for cored holes taken for sampling purposes. The Contractor must clean out and sponge dry the cored hole. The hole is then filled with hot mix and compacted using a mechanical compactor with a round foot slightly smaller than the diameter of the cored hole. The holes are then filled to conform with the adjoining undisturbed pavement.

Hot mix used in all repairs must meet the requirements specified for the tender item in the Contract. All repairs must be done in a sightly and workmanlike manner complying with all requirements for placing hot mix stated in the Contract. All repaired areas must be entirely tack-coated and all transverse joints in surface course repairs must butt up to the vertical face.

5-6 Payment for Defective Work

Where, the Contract contains the SP, entitled "Acceptance of Pavement Based on Visual Assessment of Segregation" the Contractor will be given a bonus of $1.50 per tonne for DFC, HL1 Modified mixes or for Highways 11 and 69, HL3 Modified or $0.50 per tonne for all other mixes for each continuous lane-kilometre of mainlane surface course (i.e. where the stations start and end with whole kilometre multiples) including the contiguous partially-paved shoulder up to 0.3 m in width and in the two areas less than one lane-kilometre in length at the beginning of the Contract which do not have:

- Mid-lane segregation;
- More than one area of slight "Other" segregation of up to 8m^2 in size;
- Medium or severe "Other" segregation; and
- Other significant visual defects;

before any repairs are made. Transfer lanes on freeways and freeway-to-freeway interchange ramps, excluding any hand-laid areas at the ends of these areas, which meet the above-listed restrictions, are also eligible for bonuses. After repairs are made for visual defect(s) in any area, the repaired lane-kilometres of mainlane surface course will not be eligible for a bonus.

The Contract Administrator will calculate the theoretical tonnage of surface course which will receive such a bonus using the design widths and depths for each lane-kilometre of mainline paving including the contiguous partially-paved shoulder and for HL mixes (including RHM) and DFC mixes, 97.5 and 96.0%, respectively, of the Bulk Relative Density determined from the mix design. The theoretical tonnage of surface course in the portions of the pavement that may receive such a bonus at the beginning and end of the Contract which are less than one-kilometre in length shall also be similarly calculated.

Any visually-defective areas that have been repaired or overlaid will not be eligible for a bonus.

LETTER TO CONTRACTOR (Version 4.0)

TO: _____
(NAME OF CONTRACTOR)

CONTRACT NO.:_____

Re: MUTUAL AGREEMENT FOR OPTING-INTO THE SEGREGATION SPECIFICATION

The Standard Special Provision**, SP 103F38**, entitled "Acceptance of Pavement Based on Visual Assessment of Segregation", dated August 2003**,** which has been attached to this Agreement, shall be included in the above-captioned contract under the following conditions:

1. The Contract does not already include the Standard Special Provision entitled "Acceptance of Pavement Based on Visual Acceptance of Segregation", dated August 2003 or earlier;

2. The surface course which is to be constructed on this contract essentially consists of DFC, HL1 Modified or for Highways 11 and 69, HL3 Modified and none of it has been placed at the time this Agreement is signed;

3. The Contractor shall carry out macrotexture ratio determinations (i.e. at least three macrotexture depth determinations at each control area and adjacent segregated area), in the presence of the Contract Administrator or his representative using the method described in Chapter 5 of the most recent "Field Guide For the Acceptance of Hot Mix and Bridge Deck Waterproofing", for several separate segregated patches designated by the Contract Administrator for each mix type remaining to be constructed on the Contract at the time this Agreement is signed by both parties, in accordance with the following:

   a. The Contract Administrator will designate which segregated patches that are present (if there are any, preferably at least 10 but not more than 15) in which the Contractor will conduct macrotexture ratio determinations for each mix type, in order to cover the range of severity encountered.

   b. The measurements taken from the macrotexture tests carried out by the Contractor shall be filled out in forms similar to the one attached to this Agreement and given to the Contract Administrator. The testing shall be done in the presence of the Contract Administrator or his designated representative.

   c. Either the Contract Administrator or his representative, if either is qualified in segregation assessment, or a Regional Quality Assurance Officer, will assess the degree of segregation at each location and complete that portion of the form. A copy of all completed forms should then be sent to:

      Bituminous Section
      1201 Wilson Avenue
      Room 238, Building 'C'
      Downsview, Ontario
      M3M 1J8

      Facsimile: (416) 235-3996

   d. The outcome of the macrotexture testing will have no positive or negative impact on the Contractor unless the Contractor requests that the testing be used to challenge the second visual assessment, referred to in the SP before the testing begins.

   e. The Contractor will provide a Quality Control Technician who will perform the tests to the Ministry's satisfaction which do not involve challenges to the second visual assessment. Testing will be scheduled to be done when traffic control has been set up for other purposes (eg. QC and QA coring, etc.) whenever possible.

   f. The Ministry will bear the costs of traffic control when required only for the macrotexture testing of segregated patches in which the Contractor has not challenged the second visual assessment. The Ministry will pay for these costs, in accordance with Section GC 3.11 of the General Conditions of the Contract. However, if the Contractor has challenged the second visual assessment for a specific segregated patch, then the responsibility for the cost of traffic control will be in accordance with the revised SP dated March 2001 or later attached to this Agreement. The Contractor shall bear all other costs associated with the macrotexture testing.

4. The Contractor shall provide a written proposal, which is acceptable to the Ministry, explaining how the Contractor intends to modify his normal paving equipment and/or operation, in order to prevent segregation;

5. If the Contractor does not fully implement his accepted modifications to his normal paving equipment and/or operation referred to in clause 2, then the maximum bonus available to the Contractor for DFC, HL 1 Modified or for Highways 11 and 69, HL 3 Modified will be limited to $0.50 per tonne;

6. The Ministry may cancel this Agreement at any time with 24 hours written notice to the Contractor;

7. Once this Agreement has been signed, the Contractor will not be allowed to opt-out, without approval from the appropriate Regional Quality Assurance Section;

8. If this Agreement has been cancelled, for the hot mix placed after the date of cancellation, all of the conditions revert to those that existed prior to the time this Agreement was signed;

By signing this letter, both the Contractor and the Contract Administrator agree to the conditions listed above.

Contractor	Contract Administrator
Date: _____	Date: _____

For surface and binder courses, all repairs for remedial work due to visually-defective mix, including pavement which has been removed and replaced, additional shouldering, traffic control and any other work which has to be redone such as zone painting or bridge deck waterproofing shall be made entirely at the Contractor's expense.

The Contractor will not be charged for the reclaimed asphalt pavement (RAP) used in the repairs. However, should a shortfall in RAP quantity occur on the Contract, the additional RAP used in the remedial work will be taken into consideration**,** in addressing the shortfall.

Where payment reductions for segregation in surface courses are allowed in lieu of repairs, the Contractor will be assessed a payment reduction of $2000 once to each applicable surface course tender item regardless of the existence of bonuses and for:

Mid-Lane Segregation: an additional payment reduction of $2.50 per linear metre will be applied.

Other Segregation: an additional payment reduction of $2.00 per square meter will be applied to Contracts that do not contain SP 103F38, "Acceptance of Pavement Based on Visual Assessment of Segregation". However for contracts that contain this SP, an additional payment reduction of $15.00 per square metre will be applied. The area of each patch shall be computed by multiplying the full lane width by the length of the patch and rounding to the next whole square metre.

The Contractor will be charged $50 for each disputed segregated area where the macrotexture ratio is found to be greater than the maximum macrotexture ratio given in **Table 5-1** for the severity assessed by the Contractor.

5-7 Construction Office (St. Catharines) Involvement

With the above stated policies, it will only be necessary to refer cases to the Construction Office (St. Catharines) when, in the opinion of either the Bituminous Section or the Region, they are not fully covered herein and/or there are reasons why some variation of the policy should be applied.

MACROTEXTURE RATIO CALCULATION FORM

Region: **Contract No.:** **Highway No.:** **Lane Description:** **Mix Type:**

Volume (V) of Glass Beads in mm^3 = **Mass of Constant Sample of Glass Beads Used (if Balance Available) =**

Macrotexture Test of Control (i.e. Unsegregated Areas)							Macrotexture Test of Segregated Area							Macrotexture Ratio = M_S/M_C	Severity
Location: (Station)	Measured Diameters of Sand Patch (mm)					Macrotexture Depth = $4V/(\pi D_C^2)$	Location: (Station)	Measured Diameters of Sand Patch (mm)					Macrotexture Depth= $4V/(\pi D_S^2)$		
	D1	D2	D3	D4	Average (D_C)			D1	D2	D3	D4	Average (D_S)			
Average Macrotexture Depth, M_C:							Average Macrotexture Depth, M_S:								
Average Macrotexture Depth, M_C:							Average Macrotexture Depth, M_S:								
Average Macrotexture Depth, M_C:							Average Macrotexture Depth, M_S:								
Average Macrotexture Depth, M_C:							Average Macrotexture Depth, M_S:								

Chapter Six

MEASUREMENT AND ACCEPTANCE OF PAVEMENT BASED ON SMOOTHNESS

6-1 General

The purpose of this section is to provide guidelines for the acceptance of bituminous pavement on the basis of its surface smoothness, measured using both a profile measuring device and a straight edge.

Special Provision (SP) No. 103F31, entitled "Asphaltic Concrete Surface Tolerance and Payment Adjustment for Surface Smoothness", is being applied in all new contracts which involve the construction of at least one lift of hot mix.

The Ministry is phasing-in penalties [using a Tender Opening Date Reduction Factor (TODRF)] for sublots located in areas where:

a) SMA is used;
b) A single lift is placed over pulverized grade, if a Granular "A" 'Sweetener' is not included in the contract;
c) Areas on resurfacing contracts where the Contractor is required to match pavement elevations to a permanent barrier wall or curb, which was not constructed on the Contract, is within 1.5 m of the lane being paved and the paver has simultaneously paved both the lane and shoulder, if there is a shoulder; and
d) where the construction consists of a single lift of hot mix placed over expanded asphalt.

The proposed 2005 version of SP 103F31 is still under development in consultation with industry. The changes proposed in the new specification include restricting diamond grinding on a single lift over expanded asphalt as previously required for single lifts over granular surfaces or pulverized grades. The proposed version of special provision also outlines the requirements for Smoothness Correction of Pavement Surface(s) Beneath the Surface Course. At no additional cost to the Owner, the Contractor may place hot mix padding on the existing pavement or any other pavement(s) underlying the surface course, as the Contractor deems necessary, in order to meet the surface smoothness requirements specified for the surface course. Diamond grinding (or micro-milling) will also be allowed for such corrections on existing pavements or hot mix binder courses, but only if the thickness of these pavements after grinding (or micro-milling) is not reduced by more than 5 mm below the general profile of the surrounding unground (or unmilled) pavement surface.

Areas where a single lift is placed on an existing surface or on a milled surface in Northeastern or Northwestern Regions or on resurfacing contracts where the Contractor must match a lane to an existing pavement surface, will once again be exempt from surface smoothness measurements.

Sublots located in areas of hot-in-place recycling, when used as a surface course (including hot-in-place with an integral overlay and hot-in-place recycled premium mix), will be able to receive a bonus but they will not be subjected to payment reductions based on profile index or penalties for scallops. However, they will still have to be repaired if the profile index exceeds 600 mm/km or if the amplitude of a scallop exceeds 14.5 mm.

6-2 Definitions

The following terms need to be defined for the purposes of this section:

Blanking band: a band of uniform height "B" in mm (0 mm for asphaltic concrete) with a length equal to the sublot length, which is positioned optimally between the highs and the lows of the profile trace to "blank out" as much of the profile trace as possible.

Existing Surface: means the original pavement surface prior to construction under the Contract.

Filter factor: an input parameter which can be used to electronically modify the surface trace.

Final profile index: the profile index used for acceptance purposes.

Initial profile index: the first profile index measured for a given sublot, as soon as it is feasible to do so after final rolling.

Mircomilling: means the use of a specialized milling machine with very close tooth spacing, which allows for the restoration of the riding characteristics of existing AC roadways.

Paving Thickness: the total thickness of hot mix placed at the same location during the life of the contract.

Profile index: the rate of smoothness averaged over both wheelpaths for a given sublot of surface course or any given corresponding pavement section.

Profile Measuring Device (PMD): a device used for measuring the pavement profile.

PMD Operator: means the Ministry-approved person who actually operates the PMD or the Ministry-approved Quality Control Technician (QCT) or the Paving Control Technician (PCT) who provides on-site direct supervision during the operation of the PMD.

Pulverized Grade: means a grade that has undergone in-place full depth reclamation of bituminous pavement and underlying granular.

Quality Assurance (QA): means a system or series of sampling, testing or other activities carried out by the Owner to ensure that materials/products received from the Contractor meet the specified requirementsMeasurements or other activities performed by the Owner or the Owner's representative to monitor quality.

Quality Control (QC): means a system or series of sampling, testing or other activities carried out by the Contractor to ensure that materials/products supplied to the Owner meet the specified requirements. Measurements or other activities performed by the Contractor to monitor quality.

Rate of smoothness: the amplitudes of all of the individual bumps and depressions outside of a blanking band which are greater than 0.8 mm and which also extend at least 0.6 m, as measured by a PMD along the profile length, are all added

together and then divided by the sublot length or the length of any given pavement section; expressed in mm/km.

Reduction length: an input parameter which is equal to the sublot length, normally set at 100m.

Sublot: a continuous traffic lane of pavement; including partially-paved shoulder (up to 0.3 m in width), if present; which has been measured by PMD for purposes of repairs/payment adjustments and normally having a length of 100 m measured horizontally for highway survey purposes.

Scallop: a bump or depression in the pavement surface, at a location which is automatically determined by the PMD's computer as either a line through the profile trace for McCracken profilographs or a shaded mark above the trace for Cox profilographs (see Note 8) which is at least "S" mm ("S" **=** 10 mm shall be the upper limit for acceptability for asphaltic concrete) above or below a 7.5 m long baseline which is constantly changing in elevation due to the surrounding pavement.

Subsequent profile index: any profile index measured after the initial profile index.

Tolerance(s): shall refer to measurements of deviations which are taken using a rigid metal straight edge.

Total Repair Area Limit: means the limit for all surface smoothness related repairs represented by the area represented by all measured sublots of surface course constructed within the same construction season.

Wheelpaths: means 1.0 m on each side of the centreline of the actual trafficked lane. The trafficked lane does not include adjacent paved areas such as paved shoulders or tapers.

6-3 Tolerances and Surface Smoothness

6-3.1 Tolerances Measured by Straight Edge:

The requirements for tolerances apply to all hot mix, regardless of whether or not surface smoothness measurements using a profile measuring device also apply [see Note 1), below]. The requirements for tolerances are included in SP 103F31. When required, the tolerances must be measured using a rigid metal straight edge, 3 m in length, which has been approved by the Contract Administrator.

For all binder courses and their joints and all padding, the tolerances of the pavement surface must be such that when tested with a 3 m long straight edge placed anywhere, including the edge of the pavement, in any direction on the surface, except across the crown or drainage gutters, there must not be a gap greater than 6 mm between the bottom of the straightedge and the surface of the pavement.

For all surface courses, the tolerances of the pavement surface must be such that when tested with a 3 m straight edge placed anywhere including the edge of the pavement, in any direction on the surface, except across the crown or drainage gutters, there must not be a gap greater than 3 mm between the bottom of the straightedge and the surface of the pavement.

Tolerance measurements should be carried out by the Contractor for quality control. In addition, at any time, the Contractor may be required to take additional tolerance

measurements at the direction of and in the presence of the Contract Administrator. In some instances, Ministry representatives may take the measurements as well [see Note 1), below].

Note: 1) Where sublots have been measured by profilograph, tolerance measurements using a 3 m straight edge can be used to check longitudinal joints and the transverse profile across a lane. The straight edge may also be used to confirm the locations of transverse bumps (scallops) shown on the traces, but it should not be used to replace profilograph results if the amplitudes of the bumps (scallops) shown on the profile traces indicate them to be acceptable, but the straight edge indicates a failure (unless the area being measured is exempt from surface smoothness-related payment adjustments and repairs). Since the baseline of a profilograph is not the same as a 3 m straight edge, different results should be expected. Therefore, if a question arises regarding the reliability of the profile traces, then the Contract Administrator can, at any time, ask the Contractor to re-run any area in the Contract Administrator's presence or hire another profilograph to do audit testing.

6-3.2 Surface Smoothness

For contracts which contain the 2003 or later versions of SP 103F31, where the posted speed limit is greater than 60 km/hr and the pavement consists of at least one lift of hot mix (excluding padding or levelling) consisting of at least 5000 tonnes, all surface courses must be measured for surface smoothness using the profilometer described in the special provision and in Section 6-4, except in the situations **outlined in 313.07.01.16 of the specification. Minor revisions to the excemptions are planned for the 2005 version of the special provision.**

6-4 Profile Measuring Device (PMD) & Approval of Paving Control Technicians/Operators

6-4.1 Profile Measuring Device / Calibration and Correlation

For all contracts containing a special provision for surface smoothness measurements, the Contractor must provide a computerized California profilograph or another equivalent Profile Measuring Device (PMD). Such a device has to be approved by the Ministry to measure the surface smoothness of the pavement and all scallops. For the purposes of this Field Guide, any PMD provided by the Contractor for surface smoothness measurements will be referred to as the "Contractor's PMD", regardless of who owns and/or operates it.

California profilographs must conform to ASTM E 1274–88, "Standard Test Method for Measuring Pavement Smoothness Using a Profilograph". The details of what is considered acceptable are included in LS 293.

The calibration of the Contractor's PMD must be verified for both height and distance recording. The accuracy of the height recording must be ±0.5 mm and the accuracy of the distance recording must be ± 0.3 m in 30 m at all times.

The height calibration must be checked on a daily basis, and the distance calibration checked on a monthly basis. Both calibrations must be carried out in accordance with LS 293.

In addition, the vertical calibration of the Contractor's PMD must be verified each time the PMD is re-assembled or whenever the Contract Administrator requires.

The Contractor must also ensure that, at all times during testing, the air pressure of the measuring wheel is within the equipment manufacturer's allowance.

The Contract Administrator should occasionally check and record the air pressure of the profilograph's measuring wheel [25 p.s.i. ± 1 p.s.i. (or 170 kPa)]. He should also

occasionally be present when the Operator is verifying the height and distance calibrations of his profilograph. In addition, if the Contract Administrator feels the measurements taken by the Contractor do not accurately reflect the perceived roughness of the pavement, he or she can ask the Operator to verify the height or distance calibrations in the Contract Administrator's presence at any time.

The Contractor's PMD must be correlated on an annual basis and prior to use on any of the Ministry's contracts**,** in accordance with LS 293.

In the past, all PMD's were only pushed manually during the correlation. However, since most companies are now adapting motors behind the PMD or using small garden tractors or similar vehicles to power them, the PMD's must also be approved for powered operation. The Contract Administrator must ensure that the Ministry has approved the PMD to be used for such operation. This is to ensure that the Operator is not using methods which can distort the PMD's frame or make it difficult for him to control the PMD's speed or offset. In addition, it should be noted that the Ministry has been engraving the rim of each measuring wheel with an **identification letter. Some measuring wheels also have a signature ("John A. Blair")**. The Contract Administrator must check with the appropriate Regional Quality Assurance Office to determine if the measuring wheel has been approved for use in the current construction season under the mode of operation (i.e. manually or powered) that the Contractor is using.

The appropriate Regional Office or the Bituminous Section may be contacted for a listing of each PMD that has been approved for powered operation and the measuring wheels that have been approved for use in the current construction season. No profilograph can use any combination of mode of operation (i.e. manually or powered) and measuring wheel that has not been approved. If there is any question of this, please contact the appropriate Regional Quality Assurance Section or the Bituminous Section. Any change in the measuring wheel or changes to the device or how it is powered will require re-correlation at our Correlation Site.

6-4.2 Approval of Paving Control Technicians / Operators

The Ministry requires that all companies operating profilographs must have at least one different person approved by the Ministry to supervise each profilograph that the company owns. The Ministry can approve both Operators and/or Quality Control Technicians (QCT's) or equivalents to provide direct supervision during the operation of each profilograph. In any case, regardless of who has been approved, the Ministry wants to ensure that there is at least one approved person at the site from the company that owns or operates the profilograph, while it is being run.

Every approved person must be familiar with the most current smoothness specifications, Field Guide, LS 101, LS 293 and ASTM E1274-88 and be experienced using the equipment and interpreting the data. As a result, a written test as well as a hands-on demonstration is required for all candidates. Each successful candidate receives a signed card which must be carried when taking profilograph measurements. The Contract Administrator may ask to see the card at any time.

6-5 Surface Smoothness Measurements

6-5.1 Lot and Sublot Size

For surface smoothness measurements, a lot will be defined as all pavement in a given surface course contract item that has been measured by PMD. Each lot will generally be divided into 100 m sublots, upon which corrective work and individual pay adjustments for surface smoothness will be evaluated.

Prior to the pre-pave meeting, the Contractor must present a sketch of the proposed locations for each sublot to the Contract Administrator, in accordance with the guidelines presented in this Section. The sketch should show each lane with all of it's sublots, any areas that will be excluded from being measured by the PMD, any other areas that are to be measured for information purposes (i.e. will not have surface smoothness-related payment reductions or repairs) and any areas which will be exempt from smoothness-related payment reductions only. It is not required that the sketch be drawn to scale. The stations covered by each sublot should be readily apparent from the sketch.

Each sublot will be assumed to be 100 m long, unless it is otherwise indicated on the sketch. In order to maintain 100 m sublots on steep grades or superelevations with even stations, the stations of the sublots may have to be slightly adjusted, in order to compensate for the actual measurements taken along the profile. Slightly shorter or longer sublots may be designed at the end of the steep grade or superelevation, in order to go back to even stations for any sublots that follow.

It is recommended that, for each traffic lane, all included sublots should be numbered sequentially in the direction of traffic, *no sublot should have the same sublot number as any other* (unless one of them is from a pavement surface beneath the other) and no sublot should be carried over from one lane to the next. If only one direction is involved, then the numbering should be in the chainage direction, if at all possible. A sublot should not be broken by any area that will not be measured. Therefore, if there is an area such as a bridge in which payment reductions may apply to part of it (such as the bridgedeck itself) but there are other parts where they may not apply (such as in the abutment areas), three or more sublots may be necessary to completely define the bridge (see Section 6-5.1.3).

The Contract Administrator will evaluate the validity of all of the areas which the Contractor has shown on the sketch which are not to be measured or which are claimed to be exempt from surface smoothness-related payment reductions or repairs.

There may also be some other areas where the Contractor claims he cannot sufficiently control truck traffic before the hot mix is likely to sufficiently cool, areas over rigid structures where the design profile over such structures may not permit the correction of pavement distortions or any other areas where the Contractor believes that circumstances beyond his control may prevent him from obtaining acceptable smoothness (see Section 6-5.1.4). After discussion with the appropriate Regional Quality Assurance Section and the Bituminous Section, the Contract Administrator may or may not decide to modify the Contractor's sketch. In any case, once these "Excluded Areas" have been accepted by the Contract Administrator, they will not be payment-adjusted, even if they receive a bonus and such areas will not be included in the tonnage calculation for the lot.

The Contract Administrator should mark an "X" through each accepted sublot on his or her copy of the sketch, to show that it has been completed and accepted.

The Contractor must fill out all of the applicable information in a form similar to the one shown later in this chapter. Note that the form shows that *at least, the initial and final PI measurements are placed in consecutive vertical cells*. This is critical in Excel spreadsheets so that the information can be easily transferred from file-to-file.

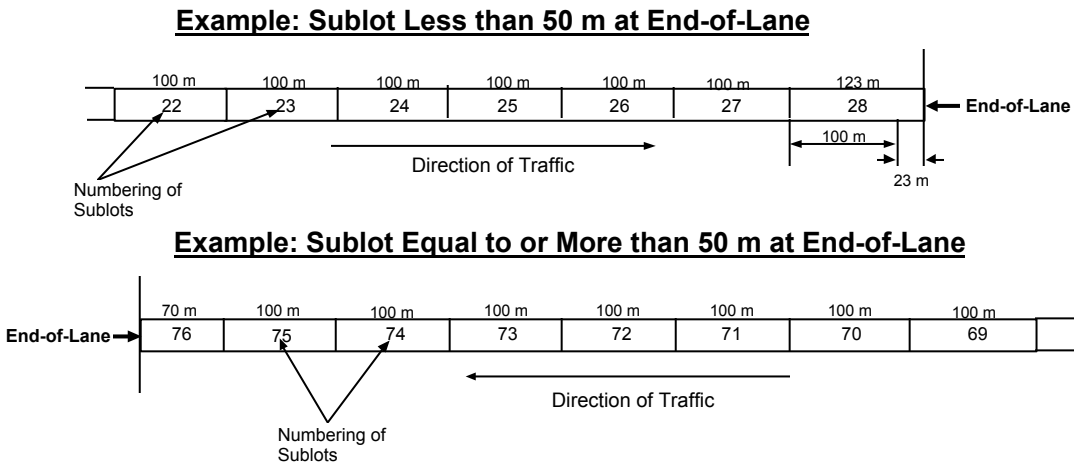
It should be noted that on grades, if the surveyed stations are horizontally-projected they will not match the actual distances travelled along the profile. Such differences should be taken into account by the Contractor when drawing the sketch, since all sublots must be 100 m along the actual measured profile (except at the end of a lane etc.). The PMD must not deviate from the stated stations by more than 1%. To avoid this, the PMD Operator should be aware that LS 293 requires that no individual profile run can be more than 500 m in length. Therefore, when each profile run has been completed, the Operator should set up at the beginning of the first sublot following the last one that was completed.

6-5.1.1 Sublots at End-of-Lane

If, after the last complete sublot within a lane, the remaining portion of the lane is greater than or equal to 50 m in length, then that remaining portion of the lane will be considered to be the last sublot in the lane and the reduction length (i.e. the input parameter which sets the sublot length) must be reduced by the Operator to the smaller sublot length. If the portion left at the end of the lane is less than 50 m in length, then it will be added to the previous sublot in the lane and the reduction length of the larger sublot must be increased by the Operator to the larger sublot length.

In either case, the profile index of the affected sublot will be averaged over the increased/reduced sublot length and the sublot will be considered equally with all other sublots when calculating the overall pavement factor.

Figure 6-1: End-of-Lane Sublots



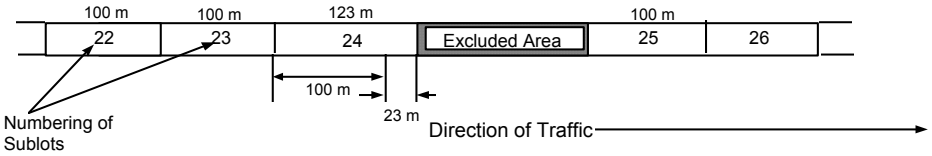
6-5.1.2 Sublots Before Excluded Areas

If an area is encountered that is excluded from smoothness measurements by profilograph, then the portion of the lane encountered prior to that area may either be added to the previous sublot or a new sublot created in the same manner as described for end-of-lane sublots in Subsection 6-5.1.1.

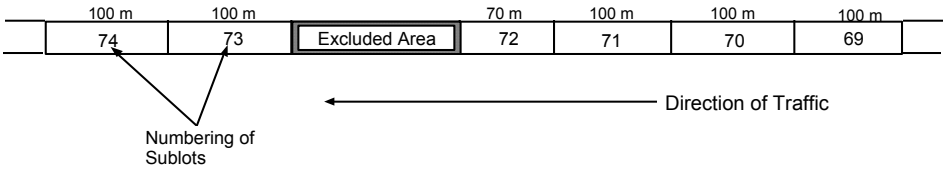
The sequential numbering of the sublots should resume after excluded areas.

Figure 6-2: Sublots Before Excluded Areas

Example: Sublot Less than 50 m Before Excluded Area



Example: Sublot Equal to or More than 50 m Before Excluded Area



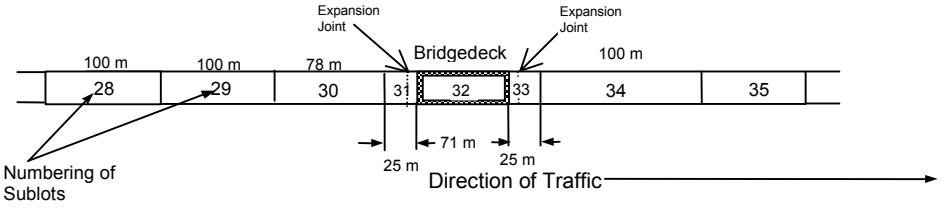
Where sublots have been changed in size by the Operator, the Contract Administrator must always ensure that the new reduction length has been recorded on the header accompanying the trace.

6-5.1.3 Sublots Before and After Areas Which are Measured but Not Payment-Reduced or Repaired

If an area is encountered that is to be measured but not payment-reduced or repaired such as the abutment areas adjacent to a long bridge which might be included in contracts containing versions of SP 103F31 prior to June 2002, then two or more small sublots may be required. The example shown in Figure 6-3 below includes a bridgedeck more than 50 m long between two expansion joints. At each abutment, within 15 m on the roadway side and 10 m on the bridgedeck side of the abutment**,** there should be small sublots (i.e. sublots 31 and 33) that will be measured but not payment-reduced or repaired and another sublot (sublot 32) comprised of the bridgedeck itself that would be fully payment-adjusted. For bridges shorter than 50 m with expansion joints being installed prior to paving, the abutment areas and bridgedeck can usually be combined into a single sublot.

Figure 6-3: Sublots Surrounding Bridgedecks

Example: Bridgedeck (>50 m) and Abutment Areas



6-5.1.4 Additional Excluded Areas

At the pre-pave meeting, the Contract Administrator will discuss the Contractor's sketch with the Contractor. At that time, the Contractor will be required to defend any additional areas

shown on the sketch, (other than those noted in Section 6-3.2), that the Contractor believes should be excluded from measurements. Such areas may include certain intersections where the Contractor feels that the truck traffic cannot be sufficiently controlled before the hot mix has sufficiently cooled, areas over rigid structures where the design profile over such structures may not permit the correction of pavement distortions or any other areas where the Contractor expresses concern that circumstances beyond his or her control may prevent him from obtaining acceptable smoothness. The Contract Administrator will evaluate the Contractor's concerns and, after discussing with the appropriate Regional Quality Assurance Section and the Bituminous Section, the Contract Administrator may either leave the sketch the same or he may choose to modify it. In any case, any such additional areas will only be able to receive a maximum payment factor of 1.0 (i.e. no bonuses will be allowed).

The decision of the Contract Administrator regarding any additional excluded areas will be binding on both the Ministry and Contractor and the Contractor should be aware that no other areas may be excluded from the requirements for surface smoothness measurements (unless damage occurs due to circumstances beyond the Contractor's control) once paving of the surface course begins.

6-5.2 Measurement of Surface Smoothness

The Contractor must clearly mark out each sublot on the pavement surface or shoulder prior to testing. All such marks (or stakes) for the surface course must remain visible and unobtrusive until any measurements taken for payment purposes (or for the purposes of identifying scallops) are completed and accepted.

The Contractor is required to do smoothness testing within 10 business days of a sublot being constructed. However, on bridge decks, the testing should take place prior to the installation of the expansion joints.

Under no circumstances whatsoever should surface smoothness measurements be taken on any asphalt that is so warm that the bogey wheels of the PMD are sinking into the mat or particles of soft hot mix are sticking to the measuring wheel.

The Contractor must give the Contract Administrator or his representative a minimum of 48 hours notice prior to the first smoothness testing carried out on each surface course item within the contract. For any other smoothness testing, the Contractor must give the Contract Administrator or his representative at least 24 hours notice prior to testing.

Initial and subsequent profile indices for a given sublot should be averaged over both wheelpaths and then rounded to the nearest whole number in accordance with the rounding procedure, LS 100, given in Appendix B.

The wheelpaths for measuring surface smoothness, are located at a distance of 1.0 m on either side of the centreline of the actual trafficked lane and these are the locations that will be measured in the event of a dispute. However, it is likely that lane painting will not be completed at the time the surface smoothness measurements are being carried out. In this case, the centreline of the lane may be approximated from the design dimensions for the lane and shoulders and suitable reference points as long as the 150 mm tolerance requirements for the wheelpath measurements will be maintained.

Where the Contractor cannot ensure that the measurements are within the required tolerances or the proposed reference line will not remain intact until the sublot has been accepted for payment by the Contract Administrator, then the Contract Administrator will have the right to require changes to the Contractor's proposed reference line or offset or, if necessary, he can require that the Contractor establish a permanent surveyed reference line for the affected sublot(s) at no additional cost to the Owner. In any case, the Contract Administrator must agree to the reference line and offset that the PMD Operator is intending to use each day.

All smoothness measurements must be done in the direction of traffic. This likely means that, after one wheelpath in a lane is measured, then the PMD must be pulled back to the beginning of the pavement section before the other wheelpath is measured.

For California-type profilographs, the testing must be carried out as per ASTM E1274-88 (LS 293 will take precedence where conflicts arise), with a blanking band height "B", set at 0 mm; i.e. a *Zero Blanking Band*.

The individual payment adjustment for a sublot can only be based on the initial profile indices, unless the sublot has either been repaired or it has been re-tested at the request of the Contract Administrator. Normally this means that the Contractor's PMD is only allowed to measure a sublot's wheelpath once.

Figure 6-4: Summary Sheet For Profilograph Measurements

Hot Mix - Smoothness Acceptance and Price Adjustment Sheet

☐ Daily Working Sheet ☐ Final Summary Sheet (for Payment)

Contract No.:		Mix Type:		Page		of	
PMD Type / Manufacturer		PMD Serial No:		Wheel Designation:			
Contractor/Owner-Operator:		Completed by:		Date:			
Highway No.:		Lane No. and Direction:		Sublots		to	

Notes: *Areas that are superelevated or on curves should be designated as "(S)" or "(C)", re † If a scallop is left unrepaired, write "(U)" after its height

Sublot Information				Surface Smoothness Measurements (mm/km)						Sublot Payment Factor	Scallop Locations and Heights							
											Initial Measurements				Final Measurements †			
											Left Wheelpath		Right Wheelpath		Left Wheelpath		Right Wheelpath	
SubLot #	Stations* (Start / End)	Length (m)	Date of Measurement	Initial/ Subsequent Measurements (Mark "F" for Final Payment)	Wheelpath Left	Wheelpath Right	Mean (PI)	Initial PI	Final PI	(Based on Final run)	Stations	Heights (mm)	Stations	Heights (mm)	Stations	Heights (mm)	Stations	Heights (mm)
				Initial														
				Sub#1														
				Sub#2														
				Sub#3														
				Initial														
				Sub#1														
				Sub#2														
				Sub#3														
				Initial														
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				Sub#2														
				Sub#3														
				Initial														
				Sub#1														
				Sub#2														
				Sub#3														

The Contractor must ensure that the surface to be tested is clear of any loose stones, debris etc. which could significantly affect the results. Running the PMD over such debris will not be considered as a valid excuse for re-testing a sublot.

The Contractor will always be expected to make a reasonable effort to prevent vehicles at intersections & private entrances & exits from crossing newly-placed hot mix before it has been sufficiently compacted & allowed to cool. This will involve contacting any & all affected businesses & homeowners & the placement of tapes, flagging and/or temporary barricades.

If any area has still suffered damage, due to circumstances beyond the Contractor's reasonable control, prior to being measured, then the Contractor must inform the Contract Administrator, in writing, within one working day of the damage occurring. The Contract Administrator will then decide if the area should be excluded from the requirements for surface smoothness.

The Contract Administrator must receive one continuous, unbroken, *original* profile record for all measurements conducted that same day from the Contractor. However, if the Contractor made prior arrangements to hand over the profile record to the Contract Administrator or his/her representative, yet neither were on site at the agreed-upon time, then the Contract Administrator or his/her representative must make sure that it is received the next day that one or the other is on site. The Contract Administrator should not accept either a broken daily profile record or a paper spool which has been signed on any other day except the day that the measurements were taken, for any other reason without a valid explanation from the Contractor.

It should be noted that, recently it has come to the Ministry's attention that duplicates of profile records which are produced from electronic files on Cox Brothers profilographs sometimes neglect to include the amplitudes of one or more bumps/dips close to the ends of a sublot (thus producing a slightly reduced rate of smoothness). According to the manufacturer, such discrepancies have been known to occur only when metric units are being used and that the trace produced while the profilograph is being pushed is always the correct one. Since the Ministry has always maintained that the original trace produced at the site and handed to the Contract Administrator is the one which is used for payment purposes, it is imperative that companies operating Cox profilographs note down the profile indices for all sublots prior to handing over the daily profile record.

The daily profile record may have profile traces representing various sublots from different mix types, lifts, lanes, etc., depending on what was measured. Specific details of the notations which are required both within and on the outside of the daily profile record are included in LS 293.

Prior to doing any testing, the daily record must be signed by both the Ministry-approved PMD Operator or the Contractor's Quality Control Technician and the Contract Administrator or his representative.

When a series of sublots does not show a header with all applicable input parameters or if there is any discrepancy in the numbering of lots, stations, etc., then the Contract Administrator has the right to refuse payment for the affected sublots (i.e. they will have to be re-tested to determine the appropriate payment factors for those sublots).

Areas of special conditions, such as superelevations or curves and any additional information such as joints or major intersections should be clearly marked on the profile traces and the summary sheets.

Sublots with traces that are incomplete, of improper format, or missing shall be deemed incomplete and unacceptable for payment purposes.

After the initial profile trace is made, all areas where scallops with "S"-values greater than 10 mm, must be marked on the pavement surface by the Contractor prior to doing any corrective work. The Contract Administrator should review these areas prior to repair.

The *original profile traces* for pavement surfaces being measured for surface smoothness must be available to the Contract Administrator**,** at any time for inspection. The Contract Administrator must be given all of the *original profile traces* for all surface courses and all binder courses (when measured beneath OFC or on carry-over contracts), prior to acceptance.

The Contractor must fill out all required information for the surface course(s) and the existing or binder surface**,** where either has been measured, on summary forms similar to those shown on Page 101. The forms must be submitted to the Contract Administrator no later than five business days following the date when the measurements were taken and prior to any corrective action taking place. Separate summary sheets shall be filled out for all of the sublots measured for payment purposes and the existing or binder surfaces where they have been measured.

The amplitudes of all scallops, shall be measured in accordance with LS 293 and recorded in the summary sheets, along with all other relevant information.

The Contractor must also provide summaries of all rate of smoothness measurements taken in both wheelpaths from each sublot in Microsoft® Excel spreadsheet file(s) on 3.5" floppy disks or CD's for IBM-compatible PC's. The Excel spreadsheets should be set up so that, at the very least, the individual rate of smoothness measurements for the initial and final PI's for consecutive sublots fall in consecutive vertical cells so that the data can be easily transferred from one file to another. One copy of all completed summary forms and the disks must be sent to:

Bituminous Section
1201 Wilson Avenue
Room 238, Building "C"
Downsview, Ontario
Attention: M. Ahmed

The Contract Administrator must ensure that the summary sheets and all *original profile traces* are received from the Contractor, in accordance with the requirements of the specification. This will avoid conflicts which could arise later.

6-5.3 Effects of Chatter

It is possible for the driver of a vehicle to experience a vibration commonly known as "chatter" in a pavement where the profile indices indicated an acceptable ride. Limited experience with this phenomenon indicates that it appears to occur when a series of small amplitude regularly-spaced waves have been constructed into the pavement surface. These waves appear to have amplitudes of 0.8 to 2.0 mm and wavelengths of about 1.5 to 2.0 m, as indicated by the profile traces. Although they are numerous, the amplitudes of these waves are small enough so that they do not produce a profile index greater than the acceptable range (generally, at the upper end of the range). Such small waves would not normally be a problem, except that they are regularly-spaced and appear to set up a vibration in certain vehicles passing over them.

Since these waves appear to be caused by problems with the paver (e.g. a defective screed), the Contract Administrator should treat this phenomenon as he would with any other problem associated with a defective paver, since there is often a definite visual textural deficiency associated with it (see Section 5-2,).

6-5.4 Carry-Over Contracts

In contracts containing versions of SP 10F31 released before June 2002, if the Ministry had not allowed the Contractor to construct a portion of the surface course in the same construction season as the immediately preceding binder course, then**,** the Contractor was allowed to take measurements of the uppermost binder course in the fall and in the following spring at the Ministry's cost. If the binder course was found to increase in roughness by more than 5% over the winter, then the profile indices of each sublot of overlying surface course was reduced by the difference recorded between the two sets of measurements. The details regarding this have been presented in several previous Field Guides.

However, for contracts containing the June 2002 or later versions of SP 10F31, regardless of who's at fault for the carry-over, the Contractor will be now allowed to either:

1) Reduce the profile indices of the sublots of surface course which will be constructed over the binder course by 15 mm/km or;
2) Take surface smoothness measurements on the upper binder course both in the Fall and in the next Spring at his own cost.

Where the Contractor decides to carry out the surface smoothness measurements on the preceding (i.e. upper) binder course, then the (fall) measurements must be taken immediately prior to halting construction for the season. The Contractor will then be required to re-measure the surface smoothness of that preceding binder course in the same season that the surface course is constructed immediately after the frost has come out of the ground**.**

To ensure that the two sets of measurements taken on the upper binder course for payment purposes are coincident with one another, the Contractor must clearly and permanently mark the sublot stations at regular intervals of no more than 100 m and the reference lines and offsets used for each wheelpath on the pavement surface at the edge of the lane before the end of the season in which the binder is constructed. In addition, the Contractor must conduct all smoothness measurements on the binder using profile runs of not more than 500 m long. At the end of each run, the Operator should set up at the beginning of the first sublot following the last one that was completed.

Since such measurements are extremely important to the final payment factor for the surface course, the Contact Administrator must provide the same degree of inspection for these measurements as he is required to do for the measurements taken on the surface course.

If, in the Spring, the average profile index for all of the measured upper binder course is more than 5% greater than the measurements which were taken in the fall, then the profile index for each sublot of surface course overlying the measured upper binder course will be reduced by the difference in average profile index recorded for the measured upper binder course**,** in accordance with the following equation:

$$PI_{ASL} = PI_{MASL} - (PI_{AverageMBS} - PI_{AverageMBF})$$

Where: PI_{ASL} is the Adjusted Profile Index for the affected sublot of surface course,

PI_{MASL} is the Profile Index for the affected sublot of surface course,

$PI_{AverageMBF}$ is the average Profile Index for all of the upper binder course which was measured at the end of the season in which it was constructed.

$PI_{AverageMBS}$ is the average Profile Index for all of the upper binder course which was measured at the beginning of the same season (i.e. in the Spring) in which the affected overlying sublot of surface course is constructed.

However, if in the Spring, the average profile index for the measured upper binder course is not more than 5% greater than the average profile index for the measured upper binder in the fall of the same season in which the binder was constructed (or the following season, if the binder is left open for a second winter), then the profile indices for the surface course in all of the affected sublots will remain the same for payment purposes.

It should be noted that the surface course will not be adjusted in any area where the severity of ravelling in the binder course is found to be any worse than very slight in accordance with SP 004, entitled "Manual for Condition Rating of Flexible Pavements – Distress Manifestations".

The Ministry will no longer be responsible for any of the costs required for the Contractor to measure the surface of the upper binder course.

It should be noted that, although the profile indices for the surface course will be corrected for carry-over contracts, there will be no such corrections for scallops with "S"-values greater than 10 mm.

Copies of the summary sheets for the measurements taken in the Fall and Spring on the binder courses should be provided to the Bituminous Section.

6-5.5 Damage to Surface Course

If an area of the existing pavement surface after milling and/or padding which underlies a sublot or an area of surface course within a sublot has been damaged**,** due to circumstances beyond the Contractor's control prior to being measured for payment purposes, then the Contractor must inform the Contract Administrator, in writing, within one business day of the damage occurring.

If such damage has occurred to the existing surface after milling and/or padding, then the Contractor shall not cover the affected area until a decision has been made by the Contract Administrator.

The Contract Administrator will evaluate the Contractor's submission and decide if such damage could not have been foreseen by the Contractor, prior to construction. The Contract Administrator will then decide if such an area should be excluded in the final calculation for the payment factor and that decision will be binding on both the Ministry and the Contractor.

6-5.6 QA Testing

The Owner is required to conduct QA testing on a minimum of 10% of the QC (i.e. Contractor) measurements of the surface course which the Contractor will be constructing in a given construction season.

The Contract Administrator is required to choose the number and the locations of a series of randomly-chosen independent QA sections of pavement, from 300 to 1000 m long, which will be measured for QA purposes. Each independent QA section must comprise only complete QC sublots (i.e. the stations at the beginning and end of the sublots should be in multiples of 100 m as in the QC sublots).

Before choosing where these sections are to be located, the Contract Administrator must be given the sketch of sublots (see Section 6-5.1) and also be familiar with the Contractor's plan for the construction of the surface course, especially if it will be done in several phases.

The Contract Administrator must first decide on the number and length of the randomly-chosen independent QA sections which he intends to have measured, assuming that only 10% will be measured. The following guidelines may be used for this purpose:

Table 6-1

# of QC Sublots of Surface Course Constructed Within a Construction Season	Length of Independent QA Sections (m)	# of Independent QA Sections
< 100	300 to 500	2 to 3
100 to <200	300 to 500	3 to 5
200 to < 300	500 to 750	3 to 5
300 to < 500	500 to 750	5 to 7
500 to < 1000	750 to 1000	5 to 13
≥ 1000	1000	≥ 10

Once the length and number of sections has been decided, the Contract Administrator will choose a list of random numbers from Appendix A. Those numbers, which are then ranked from the lowest to the highest, are multiplied by the total number of QC sublots, determined from the Contractor's sketch (note that every sublot on the Contractor's sketch MUST have a unique number). The results are rounded to the nearest whole number using LS-100 (given in Appendix B) to identify the QC sublots which are closest to the midpoint of each independent QA section.

The following example is given below:

Example 1 Contract: 2005-####
# of QC Sublots Constructed in a Season: 254

Step 1: Calculate 10% of # of QC Sublots: 25.4
Step 2: From Table 6-1, choose: 5 QC sections @ 500m each
Step 3: Select 5 random numbers from Appendix A and calculate the sublot closest to the midpoint of the section as follows:

Random#	Ranked Random #	QC Sublot Closest to Midpoint of Randomly-Chosen Section	
0.318	0.202	0.202 x 254 = 51.31	(51)
0.801	0.318	0.318 x 254 = 80.77	(81)
0.435	0.435	0.435 x 254 = 110.49	(110)
0.202	0.745	0.745 x 254 = 189.23	(189)
0.745	0.801	0.801 x 254 = 203.45	(203)

Each randomly-chosen QA section must include one of the QC sublots which has been determined by random numbers. That sublot should be as close to the midpoint of the section as possible.

A number of scenarios may occur. For instance, if the calculation causes more than one sublot to fall within the same section, then, another random number (and QA section) should be chosen. Also if the calculation causes two adjacent sections to overlap, then the two sections may be combined and the length of the combined section extended by the length

that the two sections overlap. Alternatively, another random number may be chosen for a completely new section, at the discretion of the Contract Administrator.

It has been agreed that all QA sections must be measured within 15 business days of their construction. Therefore, if a QC sublot falls within a section where all of the sublots within that section are not likely to be constructed within, say, two business days of one another, then it would be prudent to shorten that section (to include the most sublots which are likely to be constructed within two days of another) and then an additional random number (and QA section) chosen to represent the excluded sublots. In any case, the pavement sections should be chosen in such a way that the Contractor Administrator can be reasonably assured that the 15 business day requirement for the QA measurements can be easily met.

After a QA section has been constructed, the Contractor should be informed of its location at least 48 hours prior to taking the QA measurements for that section.

The Contract Administrator will designate a third party, to operate an approved, i.e. correlated, PMD, on behalf of the Owner, which will be deemed to be the "Owner's PMD" for such testing.

The disposition of all QA sections resulting from a comparison between the average QA and QC profile index measurements has been summarized in Table 6-2.

Depending upon the outcome of the first couple of independent QA sections, the Contract Administrator might decide to increase the number of measurements beyond the initial 10%.

Although, the intent is to choose a minimum of 10% of the independent QA sections as randomly as possible, specific circumstances may result in more sections being selected using other criteria. For instance, if the Contract Administrator is driving over a section of pavement and the ride does not appear to reflect the numbers that the Contractor is presenting in the profile traces or summary sheets, then the Contract Administrator can have the Owner's PMD measure any other independent QA section as well. Another example may be when a significant difference exists between the QC and QA measurments for a particular section and the Contract Adminstrator decides to measure adjacent section(s) using the Owner's PMD to determine the extent of the problem.

As part of the QA/QC comparison of the QA sections, the Contract Administrator will also be verifying that the QC summaries and profile traces have correctly identified the number and amplitude of all scallops which have been identified by the QA measurements.

In any single sublot, if the Contract Administrator finds at least one scallop(s) present in the QA trace with an amplitude greater than 11.0 mm that is not identified in the applicable QC trace or the amplitude of at least one of the scallops within that sublot is at least 1.5 mm larger than the amplitude of the same scallop identified on the applicable QC trace and that difference affects how that scallop will be treated (i.e. the QA measurements indicate that the size of its payment reduction increases or that it now must be repaired) then:

a) The QA profile traces and/or summary sheets for the affected sublot will be given to the Contractor,

b) The QA measurements for that sublot will be used for the disposition of any scallops measured by the Owner's PMD within the affected sublot,

c) The QA profile index will be used for the acceptance of the affected sublot, and will take precedence over any adjustment of that sublot based on the QC/QA outcome outlined in Table 6-2, and

d) The Contractor, may request referee testing (see Section 6-5.7).

For any of the QC/QA comparisons described in this Chapter, the Contractor will be providing all required traffic control, protection and lane closures for up to three separate visits to the site by the Owner's PMD for a combined total of up to 20 hours of measurements (excluding any waiting time in which the Owner's PMD was delayed by the Contractor). For additional QA measurements beyond 20 hours, a change order for additional traffic control, protection and lane closures should be issued.

TABLE 6-2 – QA Versus QC testing For Each Independent QA Section

Average QA Versus QC Profile Index [see Note 2)]	Outcome
$QA_{avgPI} \leq 1.10 \times QC_{avgPI}$	- The Contractor's QC measurements for all of sublots measured by the Owner's PMD will be used for acceptance purposes.
$QA_{avgPI} > 1.10 \times QC_{avgPI}$	- The Contract Administrator will give one original copy of all of the Owner's QA traces and/or summary sheets for the measured sublots which were used to determine QA_{avgPI} to the Contractor within 20 business days of the construction of the sublots; - Either the Owner's QA measurements will be used for acceptance of the sublots measured by the Owner's PMD or - The Contractor may request referee testing (see Section 6-5.7).

Note 2): QA_{avgPI} = average QA profile index for each independent QA section
QC_{avgPI} = average QC profile index for each independent QA section

6-5.7 RefereeTesting

The Contractor must request "Referee Testing" for any individual QA section (based on average profile index measurements) or an individual sublot (for scallops only), in writing, within 5 business days of receiving all of the Owner's QA profile traces.

If the Contractor's written request is received within the specified time period, then the Contract Administrator will select a company to conduct Referee testing from a list of consultants. The measurements will be repeated using a "Referee PMD", within 10 business days of receiving the Contractor's written request which will be binding on both the Contractor and the Owner.

Differences Based on Profile Indices:

In all cases, when Referee testing is carried out due to differences of average profile indices between QA and QC test results then:

1) The Referee profile indices will be used for the acceptance of all sublots measured by the Referee PMD and;

2) The measurements by the "Referee PMD" will be used for the disposition of any scallops included in all sublots measured by the Referee PMD.

Differences Based on Scallops:

When the Referee testing is carried out on a sublot due to differences between QA and QC test results that affect the disposition of one or more scallops, then:

1) The test results from the “Referee PMD” will be used for the disposition of all scallop(s) within the disputed sublots and;

2) The Referee profile index will be used for the acceptance (based on profile index) of any sublot(s) that contained the disputed scallop(s).

6-6 Repairs and Redecisioning

Before any repairs are carried out, the Contractor will be required to submit a written proposal which has to be agreed to by the Contract Administrator.

Repairs may consist of one or more of the following corrective measures:

1) Remove and replace,

2) Diamond grinding, but not milling, or

3) A hot mix overlay where it is permitted

4) Other methods of repair, if approved by the Contract Administrator, in consultation with the appriopriate Regional Office.

Hot-in-place recycling may only be used to repair hot-in-place contract items only. Where there is an integral overlay, the integral overlay must be replaced with a new integral overlay of the same specified thickness as the original integral overlay.

Diamond grinding is no longer allowed for single lifts placed directly on a granular surface, or on pulverized grade and it will be limited to 3 separate locations of no more than 20% of the area within a particular sublot. In addition, as always, diamond grinding will only be allowed, if the pavement design thickness is not significantly reduced after the repair. **For contracts with the 2005 version of the special provision, it has been proposed that diamond grinding be no longer allowed for single lifts placed directly on expanded asphalt.**

If the Contractor wishes to grind down more than 5 mm below the general profile of the surrounding pavement surface, then the Contractor may be required by the Contract Administrator to prove by coring that the design thickness of the surface course will not be reduced by more than 5 mm after the repair.

The slurry that is created by the diamond grinder must be completely removed from the site (i.e. it cannot be simply pumped onto the shoulder or over the shoulder into a drainage ditch) and it must disposed of in accordance with all applicable environmental regulations.

There can be no more than one remove and replace or a hot mix overlay repair area allowed in any individual sublot and all such individual repair areas must be at least 50 m apart.

Overlays on traffic lanes beneath structures may be allowed for open sections of pavement or beneath structures, if clearances between the pavement surface and the underside of the structure after overlay do not exceed the tolerable limit. Overlays on traffic lanes beneath posted structures, adjacent to curb-and-gutter or on bridge decks will not be permitted.

A paver must be used where corrective measures include remove/replace or the construction of a hot mix overlay. Hot mix used in such repairs must meet the requirements specified for the item in the Contract.

The minimum width of all repairs will be the width of the lane being repaired (i.e. between existing longitudinal joints including any lane markings which may be present).

For repairs to individual scallops, the bump or depression after repair cannot exceed 14.5 mm in 7.5 m (10 mm in versions of SP 103F31 before June 2002). However, financial penalties will still apply if that bump or depression is at least 10 mm in 7.5 m.

When repairs are made to all or part(s) of any sublot due to high initial readings of smoothness and/or due to rejectable individual scallops, then the entire sublot must be re-tested by PMD in conformance with the Contract. Subsequent profile indices measured after such repairs will be used in the final calculations for the payment adjustment to the lot.

If an overlay is constructed, then it must be re-tested by PMD. If the overlay does not meet the tolerances and/or surface smoothness requirements, then a second overlay will not be permitted.

When repairs are made to a sublot for any other reasons such as oil spills, segregation etc. then, at the discretion of the Contract Administrator, the Contractor will be required to re-test the sublot by PMD. Any such readings will be included in the final calculations for payment adjustment to the lot.

When repairs are made to pavement courses, due to unacceptable tolerances measured by straight edge or for any other reasons, the pavement may be re-tested by straight edge, at the discretion of the Contract Administrator.

The total repair area limit ed area for all surface smoothness related repairs within a given construction season shall be limited to 5% of the area represented by all measured sublots of surface course constructed within the same construction season.

It has come to the attention of the Bituminous Section that some Contractors are using steel drum rollers after the pavement has cooled. Cold rolling or any other compaction method which has the potential to cause checking will never be considered an acceptable method of repair and should not be accepted by the Contract Administrator.

6-7 Payment / Repair Costs

6-7.1 Penalties Based on Profile Index

The payment factor for the surface smoothness for each sublot of asphaltic concrete pavement will be based on the initial profile index only**,** unless it has been re-tested or a QA or Referee profile index has been substituted, in accordance with the requirements of the Contract.

If the profile index for a sublot is greater than 550 mm/km [see Notes **7** and **8**], then at least a portion of that sublot must be repaired as described in Section 6-6, unless it is located in an area which is exempt from surface smoothness-related payment reductions/repairs.

If the profile index for a sublot is greater than or equal to 430 mm/km but less than or equal to 550 mm/km [see Notes **6** and **7**], then the Contractor may either choose to repair the sublot or to accept the inclusion of its payment factor in the calculation for the lot.

After a sublot has been repaired/overlaid due to high initial profile indices or scallops, the repaired sublot must have no scallops with amplitudes greater than 14.5 mm in 7.5 m (10 mm in 7.5 m in versions of SP 103F31 prior to June 2002) and its subsequent profile index must be less than or equal to 550 mm/km.

A subsequent profile index must never be used to increase a payment factor to greater than 1.0 for any sublot, if the sublot has been repaired for surface smoothness-related

deficiencies. A subsequent profile index must never be used to increase a payment factor, unless the sublot has been repaired.

The individual payment factors for each sublot are determined by substituting the profile indices into the applicable formula shown in Table 6-3 and rounding to 3 decimal places, in accordance with LS 100. The payment for the entire lot will be the average of the individual payment factors for all sublots within the lot, rounded to 3 decimal places, in accordance with LS 100 up to a maximum of 1.050 times the contract payment of the hot mix surface course tender item.

For all mixes, if the average payment factor for the lot is less than 1.000, then:

the payment reduction per tonne will be = $(1.000 - PF_S)$ X Price

If the average payment factor for the lot is equal to 1.000, then:

the payment adjustment per tonne will be zero.

If the average payment factor for the lot is greater than 1.000, then:

the payment increase per tonne will be: $(PF_S - 1.000)$ X Price

where PF_S = the average payment factor for smoothness for the lot.

The term “Price” means the contract price of the hot mix surface course tender item. However, when the Contract specifies that the contract price will be adjusted due to a change in asphalt cement content from that specified for bidding purposes, then “Price” will mean the contract price after adjusting for the change in asphalt cement content, if applicable.

The payment reduction or increase per tonne will be multiplied by the theoretical tonnage of surface course in the lot (i.e. the pavement that was actually measured) to determine the decrease or increase in payment.

The Contract Administrator will calculate the theoretical tonnage of surface course in any sublot using the length of pavement on which PMD measurements were made, design widths [including its continguous partially-paved shoulder up to 0.3 m in width - see Note **3**] and thicknesses of the finished lane from the drawings and the mean lot average bulk relative density calculated from all of the values obtained from compaction testing of the core samples obtained on the contract.

Note: 3) A paved shoulder of up to 0.5 m will only be included, if it is being paved at the same time as the adjacent lane. However, if the Contractor is able to pave a wider shoulder with an extendible screed, only the first 0.5 m adjacent to the lane will be included in the tonnage calculation for payment adjustments

The Contractor is required to leave all scallops with amplitudes from 10 to 14.5 mm (rounded to the nearest 0.5 mm) unrepaired and apply penalties of $1500 and $3000 respectively, when their amplitudes are from 10 to 11.5 mm inclusive and from 12.0 to 14.5 mm inclusive and they have been constructed on multi-lane freeways, or apply respective penalties of $1250 and $2500 when their amplitudes are from 10 to 11.5 mm inclusive and from 12.0 to 14.5 mm [see Note **12**)], inclusive and they have been constructed on all other highways, unless:

A) The scallop is located within one of the "Excluded Areas" that the Contractor has requested and the Contract Administrator agreed to exempt from surface smoothness-related payment reductions and repairs (see Section 6-5.1.4);

B) The Contract Administrator has deemed that the Contractor could not have prevented the creation of the scallop; or

C) The scallop is located in a rejectable sublot and the Contractor elects to repair it [see Note **12**].

Figure **6.5** presents a few different scenarios in which bumps/dips may be counted either as single scallops or as two separate scallops for payment adjustment purposes. For instance, where two scallops have been recorded in adjacent wheelpaths in the same lane at stations which are within 3 m of one another and they are both left unrepaired, then the two scallops will be treated as a single scallop when being assessed a penalty. In addition, where the profile trace crosses the same "excessive height" line [see Note **4**)], where it is printed on the profile traces, more than once within the same baseline distance of 7.5 m and these bumps are recorded as separate scallops, then these "multiple-peaked" scallops will be treated as a single scallop for penalty assessment purposes.

Note: **4**) It should be noted that McCracken California profilographs actually print out the "excessive height" lines on the traces but Cox profilographs do not, making it much more difficult to define some of these different scenarios. However, this can always be done on any trace by using a bump template to define the maximum amplitude and then by manually drawing the "excessive height" line.

The payment adjustment for a sublot which includes any unrepaired scallops will remain unaffected by any penalties given for such scallops.

Table 6-3 - Payment Factors Based on Profile Indices

Initial and Subsequent Profile Indices (PI) in mm/km per Sublot	Payment Factor
Equal to or less than 150	1.200 - Subject to Note **5**) given below
150 to 230	$1.575 - \frac{PI}{400}$ - Subject to Note **5**) given below
230 to 430	1.000
430 to 550	$1.358 - \frac{PI}{1200}$ - Subject to Notes **6**) and **7**)
551 or greater	REJECTABLE [Requires Repairs – Subject to Notes **7**) and **8**]

Notes: **5**) The payment factor will be equal to 1.000 for subsequent profile index measurements which are taken after repairs, regardless of the reason for the repairs or if the sublot is located in any measured additional "Excluded Areas".

6) For sublots with profile indices between 430 and 550 mm/km and located:

a) where the surface course consists of SMA; or

b) where the construction consists of a single lift of hot mix (with of without leveling and/or padding) placed placed on pulverized grade where provision for Granular "A" placed on the pulverized grade is not included in the Contract; or

c) on resurfacing contracts where the Contractor is required to match pavement elevations to a permanent barrier wall or curb which was not constructed on the Contact, is within 1.5 m of the lane being paved and the paver has simultaneously paved both the lane and shoulder, if there is a shoulder; or

d) where a single lift is being placed on expanded asphalt;

then the payment factor shall be:

$$1 - \frac{TODRF\ (PI-430)}{1200}$$

Where: TODRF is the Tender Opening Date Reduction Factor given by Table C and PI is the profile index for the applicable sublot in mm/km.

7) Sublots, with profile indices between 430 and 600 mm/km and located in areas of hot-in-place being used as a surface course (including hot-in-place with an integral overlay and hot in-place recycled premium mix), shall receive a payment factor of 1.00. Sublots with profile indices greater than 600 mm/km and located in areas of hot-in-place recycling being used as a surface course (including hot-in-place with an integral overlay and hot in-place recycled premium mix) shall be repaired.

8) Repairs to a sublot will only be allowed provided that the total area for all surface smoothness-related repairs has not exceeded 5% of the area represented by all measured sublots of surface course constructed in the same construction season. Any additional rejectable sublot that is not allowed to be repaired because of the 5% limit will receive a payment factor of 0.500, in addition to any other penalties assessed for scallops within that sublot that are also not allowed to be repaired.

Table C – Tender Opening Date Reduction Factor (TODRF)

Situation	Tender Opening Date Reduction Factor (TODRF)
Tenders opened in 2005 with a single lift over Expanded Asphalt Pavement	**0.4**
Tenders opened in 2005 with SMA, single lift over pulverized grade without Granular A provision, and matching existing curb or barrier wall within 1.5 m of the lane being paved with the lane and shoulder being paved simultaneously paved, if there is a shoulder	**0.6**
Tenders opened in 2006 with single lift over Expanded Asphalt Pavement, SMA, single lift over pulverized grade without Granular A provision, and matching existing curb or barrier wall within 1.5 m with lane with the lane and shoulder being paved simultaneously paved, if there is a shoulder	**0.8**

6-7.2 Penalties for Scallops

The Contractor will be given penalties for all scallops**,** in accordance with Table 6-4.

Where two scallops on the same side of the blanking band have been recorded in adjacent wheelpaths in the same lane at stations which are within 3 m of one another and they are both left unrepaired, then the two scallops shall be treated as a single scallop for penalty assessment purposes. In addition, where the profile trace crosses the same "excessive height line", where it is printed on the profile traces more than once within the same baseline distance of 7.5 m and these bumps or dips are recorded as separate scallops, then these "multiple-peaked" scallops shall be treated as a single scallop for penalty assessment purposes (see Figure **6-5**).

The payment adjustment for a sublot which includes any unrepaired scallops shall be unaffected by any penalties given for such scallops.

TABLE 6-4 - Penalties for Scallops- see Note 9)

Amplitude of Scallops (rounded to nearest 0.5 mm)	Penalty
10.0 to 11.5	The Contractor will receive a penalty of $1,500 for each scallop located in multi-lane freeways and $1250 for each scallop located in all other highway types [see Notes **10**) and **11**)]. No repairs will be allowed for any scallop in this amplitude range [see Note **12**)].
12 to 14.5	The Contractor will receive a penalty of $ 3,000 for ea scallop located in multi-lane freeways and $2500 for ea scallop located in all other highway types [see Notes and **11**)]. No repairs will be allowed for any scallop in amplitude range. [see Note **12**)]
> 14.5	All scallops must be repaired in this amplitude ra [subject to Note **13**)]

NOTES: **9)** In contracts containing versions of SP 103F31 before June 2002, the disposition (i.e. penalties/repairs) of scallops will be quite different than those presented in this table. The version included in the contract will apply.

10) For scallops located in sublots in the areas listed under Note **10)**, the financial penalties shown in this table shall be multiplied by the applicable tender opening date reduction factor shown in Table C.

11) For scallops with amplitudes between 10.0 and 14.5 mm which are located in areas where hot-in-place recycling is used as a surface course (including hot-in-place recycling with an integral overlay and hot in-place recycled premium mix), shall not receive a penalty.

12) Subject to Note **13**) given below, the Contractor may repair a scallop with an amplitude between 10.0 and 14.5 mm inclusive, if at least one other scallop with an amplitude greater than 14.5 mm is less than 5.0 m away from it and the Contractor wishes to repair both scallops as part of the same repair area. Subject to

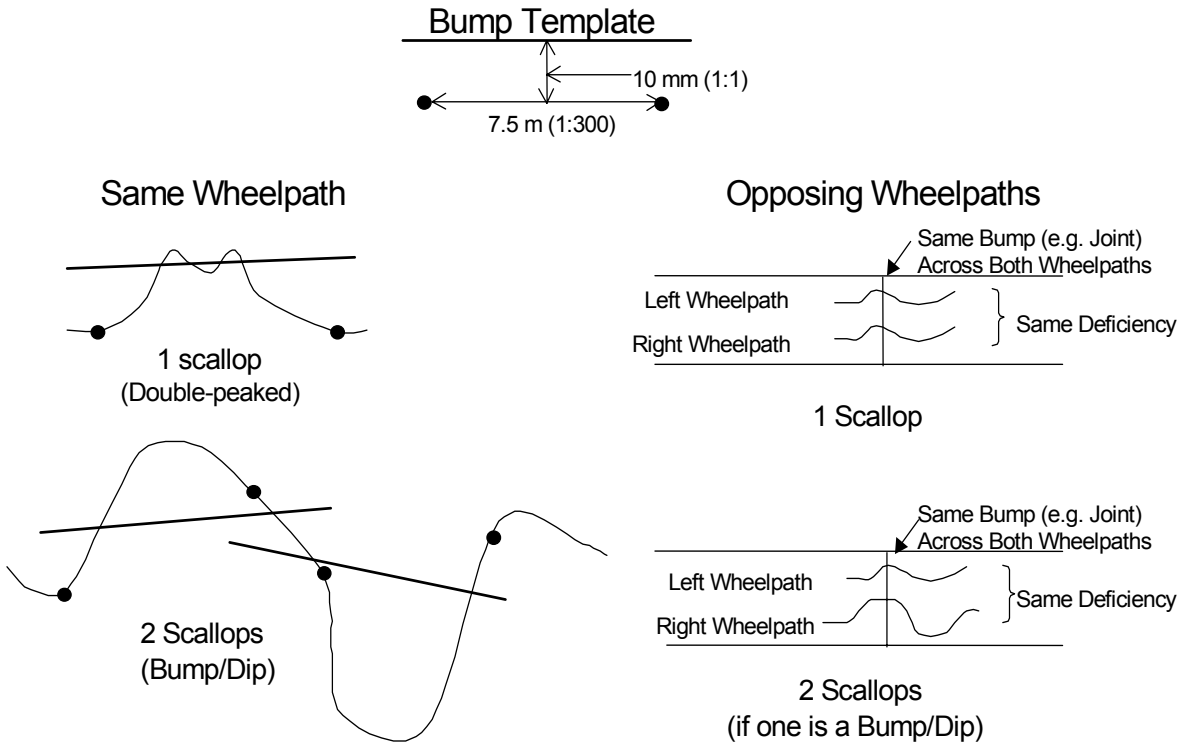
the restrictions on repairs stated in Note 13), the Contractor may repair a scallop in this amplitude range when repairing a sublot that has a profile index greater than 550 mm/km. However, if the repair removes that scallop, then the penalty for that scallop will be waived.

13) Scallop repairs will be allowed, provided that the total area for all surface smoothness-related repairs does not exceed 5% of the area represented by all measured sublots of surface course constructed in the same season as the rejected scallop. Any additional scallop with an amplitude greater than 14.5 mm that is not allowed to be repaired because of the 5% limit, will receive a $3000 penalty if it is located in a multi-lane freeway or $2500 if it is located in any other highway type.

6-7.3 Repair Costs

All repairs are made entirely at the Contractor's expense. Where overlays are allowed, any other associated costs such as additional granular materials for shoulders etc., must also be borne by the Contractor.

Figure 6-5 : Comparison of One Scallop Versus Two



6-8 Responsibilities of Contract Administrator

6-8.1 At the Beginning of the Contract

Smoothness is now being included as part of the Inspection Task Manual and the Contract Administrator has a few added responsibilities related to the administration of the smoothness specification.

1) Review Contractor's Sketch:

At the beginning of the Contract, the Contract Administrator is responsible for reviewing the Contractor's sketch of the sublots in detail. The Contract Administrator must check that the sketch shows all relevent stations, sublot sizes, reference lines and offsets, major intersections, all areas to be measured and areas which are to be measured but not subject to payment reductions. It is also important that no two sublots have the same number. Too often the Contractor is using the same sublot number in different lanes which can become extremely confusing when the stations or the lane which is involved are either not included or they turn out to be wrong. Details regarding changes in sublot size near the end-of-lane or adjacent to areas exempt from surface smoothness measurements are given in Section 6-5.1.

It is important to determine if the Contractor has legitimately claimed areas which are to be exempt from measurements and/or penalties. Prior to paving, the Contractor may also ask that other areas be exempt from smoothness measurements. After discussing with the appropriate Region (and the Bituminous Section, if necessary), the sketch may be further modified, if necessary.

2) Hire a Second Profilograph to Do QA Testing:

The Contract Adminstrator must hire a second profilograph to do QA. QA testing must be carried out within 15 business days of the construction of each independent QA section of pavement. The amount tested must be at least 10% of the Contractor's QC sublots.

The consequences of differences between QC and QA results are given in Section 6-5.6. For other versions of the specification, the specification itself and the applicable previous Field Guides should be consulted.

Under no circumstances should the QA (or audit) PMD be allowed to follow behind the Contractor's PMD, even if it means the Region has to hire separate traffic protection to accompany the audit PMD at another location (or at a later date).

There may be some cases, however, where representatives of the applicable Regional Quality Assurance Office decide that it may just be too costly or inconvenient to do the QA testing or auditing at some other location (such as projects constructed on limited access highways). If this is the case, then, in addition to the audit measurements, it is recommended that significantly more inspection ($\geq$50%) be provided by a person fully familiar with the operation of a profilograph and the specification at the time the Contractor's PMD is taking the measurements.

The Contractor is required to provide traffic protection, lane closures etc. for up to 3 separate visits representing a combined total of no more than 20 hours of measurements by the Owner's PMD.

6-8.2 Prior to Taking Surface Smoothness Measurements Each Day

1) The Contract Administrator must check that at least one person on site from the company that owns the PMD has been approved by the Ministry. The Operator of the PMD**,** the Contractor's Quality Control Technician (QCT) or the Contractor's Pavement Control Technician (PCT) or their equivalents must have a valid approval card issued by the Ministry which is initialled by Masud Ahmed/John Blair [of the Bituminous Section] and Chris Wojcik [or Hannah Schell of the Concrete Section] and signed by the candidate. If there is any question on the validity of the card, the Contract Administrator should contact the applicable Regional Quality Assurance Section (or the Bituminous Section). A list of approved operators will reside with them.

2) The Contract Administrator must note down the make and serial number of the PMD and the engraved letter, serial # and signature on the measuring wheel for the PMD that the Contractor (or Operator) is using, then check with the applicable Regional Quality Assurance Section (or the Bituminous Section) whether that particular PMD and measuring wheel as well as its mode of operation (manual or powered) has been approved for use on Ministry contracts. Of course if the same PMD is being used each day, then there is only a need to check it once.

3) The Contract Administrator must ask and then observe while the Operator checks that the tire pressure of the "bicycle" wheel used for measuring **(**i.e. the "measuring wheel") is within the allowable limits (i.e 25 +/- 2 p.s.i.).

4) The Contract Administrator must also observe the Operator during the height calibration and occasionally during the distance calibration as well (see Section 6-4.1).

5) Before the PMD Operator begins taking measurements each day, the Contract Administrator must discuss all of the areas to be measured and the reference lines and offsets that the Operator is planning to use that day. If the Contract Administrator does not feel that the reference line is sufficient or that it is not likely to remain in place until the job is completed, then the Contract Administrator can even require that the Contractor mark out the reference line using surveyed nails or some other more permanent method. This also applies to binder courses that are to be measured during the following spring, since those measurements can significantly affect the payment factor for the overlying surface course

6) The Contract Administrator and either the Operator, QCT or PCT (i.e whoever on site has a valid approval care issued by the Ministry) must sign and date (along with the time) the beginning of the profile record.

6-8.3 Each Hour During Surface Smoothness Measurements

The Contract Administrator should make sure that:

1) The PMD is only taking measurements in the direction of traffic.

2) Any particular sublot and wheelpath is only being measured once (i.e. initial measurements). It should be noted that additional, i.e. subsequent, measurements may only be taken after repairs or at the request of the Contract Administrator.

   It should be noted that some Contractors have expressed concern that they are not able to carry out their own QC testing on the surface course because the first measurements taken must always be reported to the Contract Administrator for acceptance. The Ministry takes the position that if the Contractor requires QC testing, then such testing should be done on the binder course.

3) Both sets of bogey wheels supporting the device, follow the same path exactly. If these wheels do not follow the same path, then the device is out of alignment and it "crabs" along the wheelpath. The Operator can adjust this fairly easily by loosening a special bolt at the back bogey wheels. It should be stressed that it is the responsibility of the Operator to ensure that the device is always tracking properly. Therefore any measurements taken while the machine is out of alignment are suspect and must be repeated.

When the Operator has finished a run, the Contract Administrator should:

4) Ask and then observe while the Operator checks that the tire pressure of the "measuring wheel" is within allowable limits (i.e 25 +/- 2 p.s.i.) and that the device has been properly calibrated for height (using the calibration blocks).

5) Occasionally sign the profile trace with the date and time. This will allow the Contract Administrator to recall where the Operator was when he made the visit, if there are questions later regarding any suspected inconsistencies.

6-8.4 At the End of Each Day (Before Operator Leaves)

The Contract Administrator should make sure that:

1) The same single, continuous, profile record which the Contract Administrator has signed at the beginning of the day has been received before the PMD Operator leaves the site. Contractually, it is the Contractor's responsibility to ensure that the profile record is given to the Contract Administrator, but the Contract Administrator must do all that is reasonable to make sure that he/she is on site to receive it.

2) The profile record should have enough information on both the outside and inside of the roll so that the results for each wheelpath in every sublot for the surface course and any other surfaces measured can be easily found. The Contract Administrator should not accept any traces without all of the required information.

6-8.5 At the End of Each Day (Back at the Trailer)

The Contract Administrator should:

1) Check again that the daily profile record has enough information so that the rate of smoothness measurements and scallops in every wheelpath and sublot can be easily found.

2) Keep a running summary of the rate of smoothness measurements in both wheelpaths and the heights and locations of all scallops. This is suggested in order to save the Contract Administrator a lot of grief later. If this is not done, the Contract Administrator will be looking through several different daily profile records when he/she has to confirm the results on the summary sheets (which will probably be given to the Contract Administrator at the end of paving). In addition, if the Contract Administrator has a running summary, it makes it much easier to determine if the profile indices being produced by the Contractor appear to be correct. For instance, when the Contract Administrator drives over a section of pavement, he/she can use the running summary to gauge whether the ride he/she experiences reflects the numbers that the Contractor is presenting before the final summary sheets have been given to the Contract Administrator.

6-8.6 After Measurements Are Taken

The Contract Administrator must:

1) Make sure that all relevant summary sheets and profile traces have been received and that all of the required information has been included (see Section 6-5.2) and LS 293.

2) Check that the profile indices from the traces for each wheelpath match those given in the summary sheets.

3) Make sure that all scallops shown on the profile traces have been recorded on the summary sheets and that the Contractor has recorded their amplitudes.

   It should be noted that the amplitudes required are not the numbers given on the traces above the bumps, but must be measured using a bump template and millimetre scale.

4) Determine the overall payment adjustment for the surface course using the average BRD from the cores taken of the applicable mix and the design widths and depths from all measured sublots.

5) If the QA measurements taken by the Owner's PMD (see Section 6-5.6) indicate that, for an independent pavement section, $QA_{avgPI} > 1.10 \times QC_{avgPI}$, then the QA measurements must be given to the Contractor within 20 business days of the construction of the affected sublots.

6) Where the contract is a carry-over, review the Contractor's profile traces, summary sheets and calculations related to the adjustments of the surface course based on changes in the upper binder course over the winter, when the Contractor elects to measure the upper binder both in the fall and in the following spring.

Chapter Seven

ACCEPTANCE OF BRIDGE DECK WATERPROOFING

NOTE: 1) EACH LOT MUST BE DECISIONED FOR WATERPROOFING MEMBRANE THICKNESS BEFORE THE BRIDGE IS PAVED. THE CONTRACTOR MUST SIGN FORM PH-CC-129A PRIOR TO PAVING

7-1 General

The acceptance/rejection criteria for bridge deck waterproofing are covered by OPSS 914 and by special provision.

This section of the guide has been prepared to assist field staff with the implementation of a statistically-based acceptance procedure for waterproofing membrane which includes a thickness component and a membrane-quality component.

The thickness acceptance/rejection criteria are based on membrane thickness measurements taken in the field, while the quality criteria are based on test results obtained in the Downsview laboratory. The two components or criteria are combined to determine the acceptability of the waterproofing membrane.

Rounding-off should be carried out according to LS-100 given in Appendix B.

When a deck surface not constructed as part of the Contract is to be waterproofed, this acceptance system may be inequitable, if the deck surface is uneven or rough. The Bridge Management Section, Head Office, has prepared guidelines for restoring existing decks to an acceptable surface for waterproofing and acceptance, under this system. Upon mutual agreement of the Regional Area **Contract** Engineer, Head Structural Section and Head Quality Assurance, this acceptance procedure may be waived if the deck is considered too rough or uneven. The Engineering Materials Office, Concrete Section, should then be consulted to develop an alternative acceptance method. The Contractor must be advised in writing of changes to the acceptance criteria.

NOTES:

2) Process control is the Contractor's responsibility. Do not take thickness measurements of the membrane, as work progresses.

3) Measure membrane thickness for acceptance/rejection after the complete construction of a lot (which includes the placement of protection boards, where appropriate). A lot for bridge deck waterproofing is a deck or part of a deck with an area of 600 m^2 or less (see special provision and OPSS 914 September 1988, whichever governs).

4) The test locations shall be calculated prior to the completion of the lot so that they may be laid out & measurements taken immediately after construction is completed. A second set of locations should also be calculated in case a re-test is required.

5) All rounding of numbers to the required number of significant figures shall follow the appropriate convention shown in Appendix B.

6) Acceptance/rejection of the membrane thickness will be based on the mean thickness and standard deviation within a lot.

7) Acceptance/rejection of the membrane quality will be based on a set of adjustment points for each failed test.

7-2 Sampling and Testing of Membrane Thickness

Membrane Thickness Acceptance Procedure will be discussed by working through the following example:

Step:
1. Compute the area of the deck (by stages)
2. Determine lot size(s) to the closest 0.1 m^2 and assign lot numbers.
   Number lots consecutively per structure through all stages of construction. No structure (site) number should have any duplicate lot numbers.
3. Select random numbers
4. Determine test locations to the closest 0.1 m
5. Measure and record the membrane thickness at each test location
6. Computations
7. Acceptance determination
8. Re-testing
9. Basis of payment

Example

A bridge deck 110 metres long by 11 metres wide is to be waterproofed in two stages in order to maintain traffic on one side. The Contractor wishes to waterproof 6 metres wide on the first side.

Step 1 Compute area of deck (by stages)

Stage 1: 6 x 110 = 660 m^2
Stage 2: 5 x 110 = 550 m^2

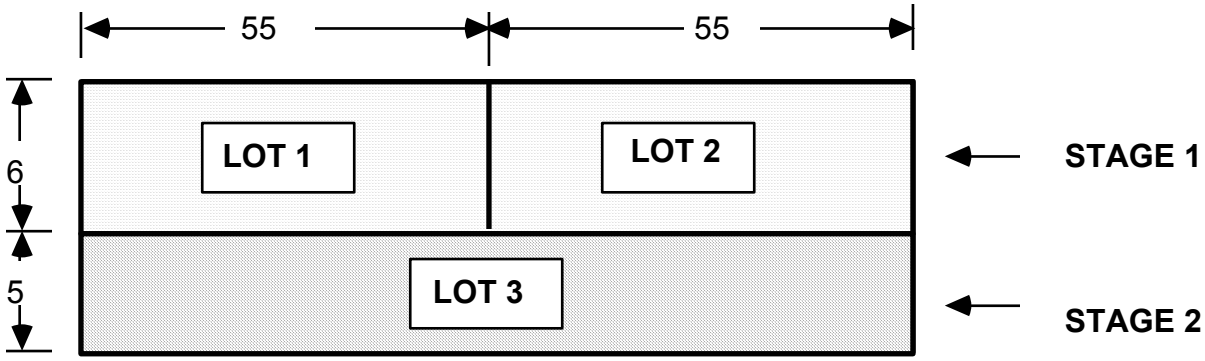
Total = 1210 m^2

Step 2 Determine lot sizes to the closest 0.1 m^2 and assign lot numbers

Since the first stage will have in excess of 600 m^2, it must be divided into two equal lots, each 55 metres long.

The second stage, which has an area under 600 m^2 (i.e. criteria 2), is considered to be a single lot which is numbered lot 3, not lot 1 stage 2.

Note: 8) If the deck is of irregular shape, the lot sizes should be roughly equal in area.



Step 3 Select random numbers

The test locations are obtained by using random numbers.

From a Random Number Table select two sets of ten random numbers from a vertical column or horizontal row. See Sample Random Number Table.

.958	.863	.912	.012	.219	.201	.384	.291	.661	.633
.142	.784	.288	.910	.049	.644	.327	.345	.535	.310
.433	.412	.427	.996	.174	.318	.931	.006	.345	.263
.717	.976	.232	.083	.936	.094	.092	.391	.953	.688
.919	.370	.939	.575	.765	.539	.619	.308	.705	.829
.324	.637	.533	.659	.026	.617	.348	.218	.935	.463
.015	.004	.485	.594	.102	.942	.726	.295	.328	.489
.870	.204	.854	.547	.527	.552	.958	.454	.024	.689
.433	.152	.722	.656	.224	.358	.385	.667	.156	.647
.082	.502	.347	.393	.303	.295	.637	.307	.507	.689
.119	.057	.188	.474	.713	.138	.689	.004	.255	.903
.297	.713	.871	.658	.215	.353	.876	.045	.765	.864

Sample Random Number Table

The numbers in the rows/columns will be used to determine the distance from the end of the lot and the offset location from one edge of the lot.

Note: 9) Avoid using the same rows/columns when calculating a second set of test locations.

Step 4 Determine test locations to the closest 0.1 m

To determine the length (Ls) of each sub-lot, divide the length of the lot by ten. The Distance into each sub-lot is then determined by multiplying Ls by a random number.

The Offset from one side of the lot is determined by multiplying a random number by the width of the lot.

Example: Sample Locations for Lot No. 1

Ls = 55 ÷ 10 = 5.5 m; Length of each sublot is therefore 5.5 m.

Sample No.	Start Sub-lot	+	(Ls x Random No.)	=	Dist. (m)	Width	x	Random No.	=	Offset (m)
1	0.0	+	(5.5 x .919)	=	5.1	6	x	.661	=	4.0
2	5.5	+	(5.5 x .370)	=	7.1	6	x	.535	=	3.2
3	11.0	+	(5.5 x .939)	=	16.2	6	x	.345	=	2.1
4	16.5	+	(5.5 x .575)	=	19.7	6	x	.953	=	5.7
5	22.0	+	(5.5 x .765)	=	26.2	6	x	.705	=	4.2
6	27.5	+	(5.5 x .539)	=	30.5	6	x	.935	=	5.6
7	33.0	+	(5.5 x .619)	=	36.4	6	x	.328	=	2.0
8	38.5	+	(5.5 x .308)	=	40.2	6	x	.024	=	0.1
9	44.0	+	(5.5 x .705)	=	47.9	6	x	.156	=	0.9
10	49.5	+	(5.5 x .829)	=	54.1	6	x	.507	=	3.0

The computed distances and offsets are then copied into the appropriate columns on Form PH-CC-129A.

Step 5 Measure and record membrane thickness at each test location

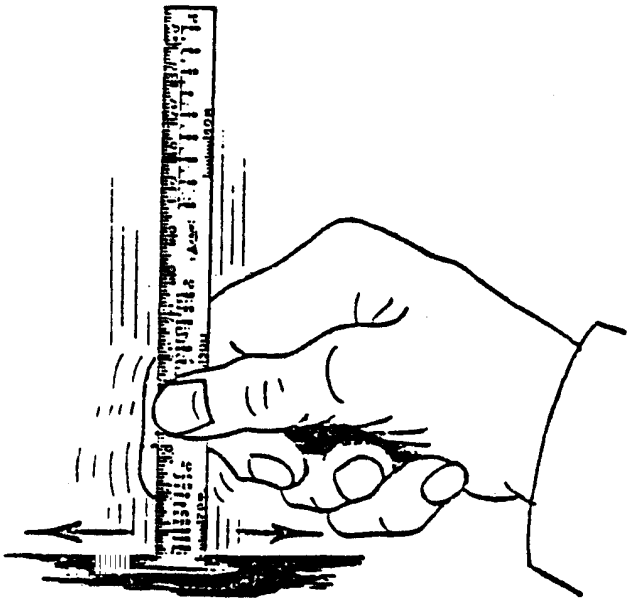
Mark out each computed test location on the deck as soon as construction of the lot is completed.

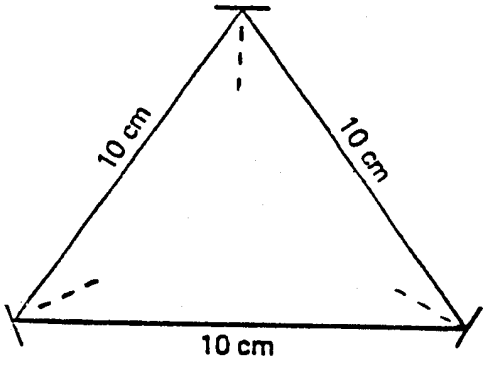
With the asphalt membrane system employing protection boards, you must select the closest upper corner of a protection board to your sample location. Lift up the corner of the board to expose a triangle of membrane approximately 15 cm per side.

With mastic membrane, measure the thickness at the computed distance and offset.

If a test location coincides with the placement of membrane reinforcement, a new random location must be determined for that sub-lot, to avoid the reinforced area.

The measurement is made with a thin steel scale, such as that supplied with a surveyor's chain for temperature correction or a machinist scale obtained at most hardware stores. The zero end of the scale is worked back and forth in a sawing action until it is in contact with the concrete deck. The thickness of the membrane may then be read directly off the scale. Take three readings, at each location, at the points of an imaginary equilateral triangle with approximate sides of 10 cm. These measurements should be made perpendicular to the bisector of the interior angle, as shown in the diagram below. Average the results of the three readings and round to the closest millimetre using the method shown in APPENDIX B. Record the result on Form PH-CC–129A. (See Figure 7-1).





Note: 10) The end of the Scale must be equal to zero.

Step 6 Computations

1. Add the 10 thickness measurements (T) and record in the box $\sum T$.
2. Square the sum ($\sum T$) and record in the Sum ^{2} box ($\sum T)^2$.
3. Divide the sum ($\sum T$) by 10 and enter the result, accurate to one decimal place in the Mean box.
4. Square each thickness (T) and enter in the thickness ^{2} column T^2.
5. Add the 10 thickness ^{2} (T^2) and enter in the sum of thickness ^{2} box ($\sum T^2$).
6. Enter the information from the appropriate boxes into the formula for standard deviation and calculate to four decimal places and then round off to the closest 0.05 using the appropriate rounding procedure shown in see Appendix B.
7. From Table 7-1, determine the pay factor from the intersection of the mean in the vertical columns and the standard deviation in the horizontal rows and enter on the appropriate line.

Step 7 Acceptance determination

7.1 Case 1 - Lot mean is less than 4.0 mm

The entire lot is considered unacceptable. In such cases, the Contractor must make whatever repairs he deems necessary to upgrade the lot. Where applicable, the Contractor should be advised that removed protection boards must be discarded and replaced with new boards. After the repairs are made, the entire lot is to be re-measured and evaluated starting at Step 3 of these instructions.

7.2 Case 2 - Lot mean is greater than or equal to 4.0 mm and less than or equal to 6.0 mm

If the lot is within the acceptable range of Table 7-1, the Contractor will be paid the full contract price.

If the lot is within the unacceptable range of Table 7-1, the Contractor shall be required to repair the lot, as outlined in 7.1. Once repaired, the entire lot will be re-measured and re-evaluated starting at Step 3 of these instructions (i.e. using new test locations).

If the lot is within the borderline range of Table 7-1, the Contractor may repair the lot or he may request that the lot be accepted as is, with a reduced payment, as outlined in Step 9.

7.3 Case 3 - Lot mean is greater than 6.0 mm

If the lot mean is greater than 6.0 mm, regardless of the standard deviation, a review of the conditions that the bridge deck will be exposed to (geometrics, traffic volume, % trucks, etc.) will be made and then the lot will be designated as acceptable, or unacceptable. The reasons for designating the deck acceptable or unacceptable will be discussed with the Contractor. In cases when the lot is designated unacceptable, the Contractor shall be required to repair the lot, as outlined in 7.1. Once repaired, the entire lot will be re-measured and re-evaluated for acceptance starting at Step 3 of these instructions.

Note: 11) Prior to a decision on the disposition of the lot, the Regional Quality Assurance Section must be consulted.

Step 8 Re-testing

The Contractor may request re-testing, if any or all of the ten sub-lot test values are challenged. If this occurs, the original evaluation will be set aside and 10 new thickness measurements shall be taken in the presence of the Contractor. THE NEW TEST VALUES WILL THEN BE USED TO DETERMINE ACCEPTANCE AND THE RESULTS WILL BE BINDING ON BOTH PARTIES.

REPAIR OF WORK

Whenever the Authority identifies an unacceptable lot, or whenever the Contractor chooses to improve a borderline lot, the Contractor shall make whatever repairs he deems necessary to upgrade the lot. Any protection boards that are removed shall be replaced with new ones. Once repairs have been completed, the Authority will determine a new set of random locations and will re-measure and re-evaluate the entire lot for acceptance, as described in these instructions.

Step 9 Basis of payment

If the lot is considered acceptable, the Contractor will be paid the contract price for the lot as bid. If the lot is borderline, the lot mean and the lot standard deviation will be applied to Table 1 of the special provision, in order to determine the thickness adjustment factor. Such thickness adjustment factor will then be multiplied by the contract price for the area of the lot, in order to determine payment. In the case of lump sum price, the price of the lot must be prorated before applying the thickness adjustment factor.

FIGURE 7-1 WATERPROOFING MEMBRANE THICKNESS REPORT

Ministry of Transportation Ontario

WATERPROOFING MEMBRANE THICKNESS REPORT

Report 1 of 3

Cont. No. 91-01 Region SWR Hwy. No. 7 Site No. 00-000

Area of Deck 1210.0 m^2 Membrane Manufacturer / Type SUPERPLASTIC II

Waterproofing Contractor TORRID WATERPROOFING

Lot No 1 Of 3 Area of Lot 330.0 m^2 ☒ First Test ☐ Re - Test

Sublot No.	Distance (m)	Offset (m)	Thickness (mm)	T^2 (mm^2)
1	5.1	4.0	4	16
2	7.1	3.2	4	16
3	16.2	2.1	5	25
4	19.7	5.7	4	16
5	26.2	4.2	5	25
6	30.5	5.6	4	16
7	36.4	2.0	5	25
8	40.2	0.1	5	25
9	47.9	0.9	6	36
10	54.1	3.0	5	25
		Sum	ΣT 47	(ΣT^2) 225
		Sum^2	$(\Sigma T)^2$ 2209	
		Mean = Sum /10	4.7	

St. Dev. = $\sqrt{\frac{n_o (\Sigma T^2) - (\Sigma T)^2}{n_o (n-1)}}$

$= \sqrt{\frac{10 \cdot 225 - 2209}{90}} = \sqrt{0.4555} = 0.6749 \rightarrow 0.65$

ADJUSTMENT FACTOR 1.00

This lot is
- ☒ Acceptable and will be paid at contract price.
- ☐ Borderline, may be left in place at the adjusted price.
- ☐ Unacceptable. It must be repaired.

Project Supervisor Steve Olanon

Acknowledged by Contractor _____

Date 91 00 00

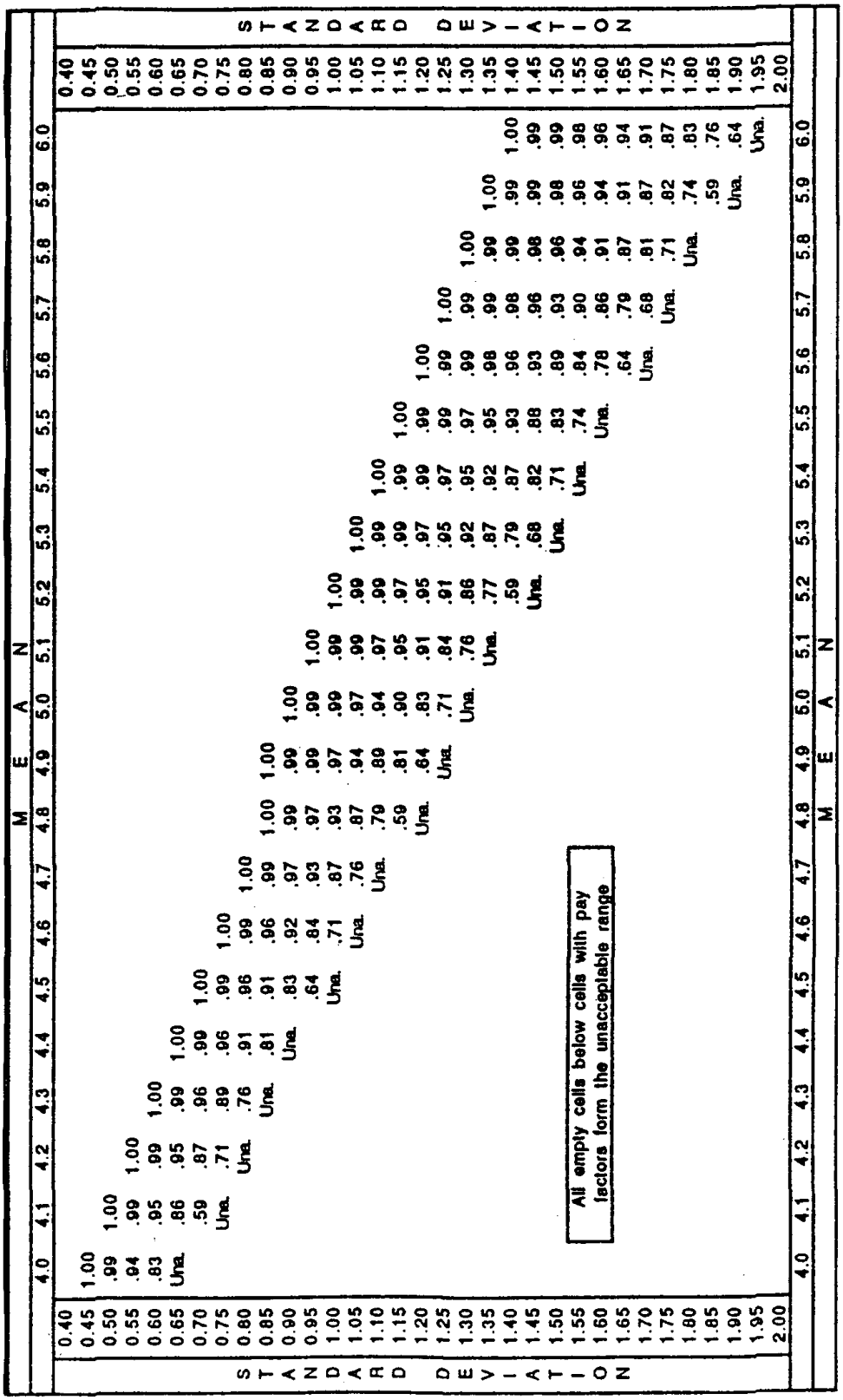
- ☐ This lot falls in the Borderline zone. I request the above adjustment factor be applied to the payment of this lot.
- ☐ I will repair this lot prior to retesting.
- ☐ I request re - Testing.

Contractor _____ Date _____

DISTRIBUTION: White-Proj. Super., Canary-Cont'r., Pink-Reg. Qual. Assur., Golden Rod-H.O. Bit. Sect.

PH-CC-129A 88-09

TABLE 7-1 PAYMENT ADJUSTMENT FACTORS FOR BRIDGE DECK WATERPROOFING MEMBRANE THICKNESS



7-3 Sampling and Testing of Membrane Quality

Summary of Membrane Quality Acceptance Procedure

The decision to accept the quality component of the waterproofing membrane will be based on the results of tests performed in accordance with OPSS 1213.

Any lot will be considered acceptable, if all specification requirements are met. Any lot will be considered borderline, if the total number of points resulting from Table 7-2 are less than or equal to 25; or will be considered rejectable, if the total number of adjustment points are greater than 25.

TABLE 7-2 PAYMENT ADJUSTMENT POINTS FOR BRIDGE DECK WATERPROOFING MEMBRANE QUALITY

Test	Specification Limits	Adjustment Points
Cone Penetration at 25 °C	Max 110	0.4 per 1
Cone Penetration at 50 °C	Max 160	0.4 per 1
Flow at 60 °C	Max 3	0.5 per 1
Low temperature flexibility at - 25 °C	Pass	5.0 for Failure
Toughness	Min 5.5	0.5 per 0.1
Toughness/Peak Load	Min 0.040	0.5 per 0.001

Below are the steps to be followed in the field:

Step:
1. Determine when to obtain the sample
2. Obtain the sample
3. Label the sample
4. Ship the sample
5. Compute the quality adjustment factor
6. Compute final payment for the lot

Payment Adjustment for Quality

Example

Step 1 Determine when to obtain the sample

Take the first random number used in determining the distance into the first sub-lot for the determination of the membrane thickness and calculate when to obtain the sample as follows:

In the previous example, this number was 0.919.

The first digit is used to identify in which sub-lot the sample will be taken and the second digit is used to identify how far into the sub-lot it will be taken.

e.g. .919 - 9th Sub-lot
10% into sub-lot

.370 - 3rd Sub-lot
70% into sub-lot

.024 - 10th Sub-lot
20% into sub-lot

Step 2 Obtain the sample

A full 4 L of material is required for laboratory testing. Suitable containers are 4 L "Paint Cans" with double tight lids or standard concrete cylinder moulds. The "Paint Cans" must be full and the cylinder moulds must be filled to within 50 mm of the top. "Paint Cans" should be used, if possible, because they can be handled hot; whereas the material has to cool in a cylinder mould before it can be moved about.

When the Contractor reaches the desired sub-lot and has waterproofed the approximate percentage of it; provide him with the container and have him draw off the sample and set it out of the way. The Contractor is not to be advised ahead of time, when the sample is to be taken.

Step 3 Label the sample

It is very important that the sample be completely and clearly identified. Use the concrete products field sample sheet (PH-CC-340) and make sure it contains the following information:

1. Contract number,
2. Region,
3. Name of membrane manufacturer,
4. Membrane product name,
5. Date the material was delivered to site,
6. Batch number(s) from manufacturers containers,
7. Temp. of material when sampled from melter,
8. Inspector's name,
9. Date sampled,
10. Field Sample Number,
11. What lot the sample is from and the total number of lots on the deck,
12. Name of waterproofing Contractor,
13. Structure site number.

Place the sample sheet in a brown waterproof envelope (SB-OS-31) and fasten it securely to the sample.

Step 4 Ship the sample

In order to get timely results, it is important to ship the sample quickly to Downsview - certainly within 24 hours of sampling.

Send the sample to: Concrete Products Laboratory
Ministry of Transportation
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8

Note: 12) If the test results are required very quickly, in order to facilitate the finalising of a Contract, a letter should be enclosed with the sample indicating by what date the results are required. Testing requires a minimum of 5 laboratory working days. Sending samples by courier will expedite urgent work.

Step 5 Compute the quality adjustment factor

Quality Pay Adjustment Factors are calculated as follows:

1. If the sample meets all of the test criteria outlined in Table 2 of special provision, then assign a quality adjustment factor of 1.00.

2. If the sample fails one or more test criteria, then total the adjustment points outlined in Table 2. The quality adjustment factor is then determined by subtracting the total of all of the adjustment points from 100 and then dividing the result by 100.

3. If the adjustment points exceed 25, then the lot is considered rejectable and the Contractor will not be paid for the lot, regardless of the adjustment factor for thickness.

Re-testing for Quality

The Contractor may request re-testing of any sample which results in price adjustment or rejection of a lot, within 30 calendar days of him receiving notification of such. This request must be in writing and a copy of the request must be forwarded to the concrete products laboratory. The results of the re-test shall be used for acceptance and they shall be binding on both parties. If the re-test results in either a price reduction or rejection of the lot, then the Contractor shall be charged $800.00 for the re-testing. If the re-test results for the material meet all test criteria (i.e. there is no payment adjustments), then no charge will be levied against the Contractor.

e.g. Sample of Superlastic II from Lot 1

Test		Result	Spec.
Cone Pen.	@ 25 °C	105	Max. 110
	@ 50 °C	184*	Max. 160
Flow	@ 60 °C	4*	Max. 3
Low Temp. Flex.	@ -25 °C	Pass	Pass
Toughness/Peak Load		0.038*	Min. 0.040

In this example, the material failed 3 tests:

1. Cone Pen. @ 50°C by 24 units
2. Flow @ 60°C by 1 unit
3. Toughness/Peak Force by 2 units

The total adjustment per test is determined by multiplying the number of units the test is outside specification by the adjustment points. (From Table 7 - 2).

Cone Pen. @ 50°C	24 x 0.4	=	9.6
Flow @ 60°C	1 x 0.5	=	0.5
Toughness/Peak Force	2 x 0.5	=	1.0
Total:			11.1

The total adjustment points for material quality is equal to the total of the individual test adjustments - in this case 11.1.

The quality adjustment factor is equal to:

$$(100 - 11.1) \div 100 = 88.9 \div 100 = 0.889$$

See example Field Sample Test Report form on Page 133.

Step 6 Compute final payment for the lot

The final payment for the lot will be based on the thickness and on the quality of the waterproofing membrane. The contract price for the lot shall be multiplied by the thickness adjustment factor and the result shall then be multiplied by the quality adjustment factor.

For this example, we will assume that the contract price for the waterproofing is \$12.40/m^2.

Area Lot	=	330.0 m^2		
Contract price	=	330.0 X \$12.40	=	\$4,092.00
Thickness Adjustment Factor	=	1.00		
Adjusted price for thickness	=	4,092.00 X 1.00	=	\$4,092.00
Quality Adjustment Factor	=	0.889		
Adjusted price for quality	=	\$4,092.00 X 0.889	=	\$3,637.79
Credit to the Ministry	=	4,092.00 -3,637.79	=	\$454.21

FIELD SAMPLE TEST REPORT

HOT APPLIED RUBBERIZED ASPHALT WATERPROOFING MEMBRANE

CONT. NO.	92-01	**REGION**	SWR	**SITE NO.**	00-000	**LOT NO.**	1
MATERIAL NAME		Superlastic II		**FIELD NO.**	92-1	**LAB NO.**	01/92
DATE SAMPLED		92 05 16	**DATE RECEIVED**		92 05 25	**DATE COMPLETED**	92 06 04
WATERPROOFER		Torrid Waterproofing					

TEST	SPECIFICATION LIMITS	*TEST VALUES*	DIFF. OUTSIDE SPEC. LIMIT	ADJUSTMENT POINTS	TOTAL ADJUSTMENT PER TEST
CONE PENETRATION @ 25°C (0.1 mm)	Max. 110	*105*		0.4 per 1	
CONE PENETRATION @ 50°C (0.1 mm)	Max. 160	*184*	24	0.4 per 1	9.6
FLOW @ 60°C (mm)	Max. 3	*4*	1	0.5 per 1	0.5
LOW TEMPERATURE FLEXIBILITY @-25°C	Pass	*PASS*		5.0 for failure	
TOUGHNESS (Joules)	Min. 5.5	*7.1*		0.5 per 0.1	
TOUGHNESS/PEAK FORCE (Joules/Newton)	Min. 0.040	*0.038*	2	0.5 per 0.001	1.0
MASS DENSITY	-	*1.21*	TOTAL ADJUSTMENT POINTS		11.1

QUALITY ADJUSTMENT FACTOR = $\frac{100 - \text{TOTAL ADJUSTMENT POINTS}}{100}$ = 0.889

PROTECTION BOARD THICKNESS (mm)	Min 3.20 mm	*3.31*
MEMBRANE REINFORCEMENT THICKNESS (mm)	-	*1.22*

APPENDICES

APPENDIX A:

RANDOM NUMBER TABLE

.318	.801	.435	.202	.745	.489	.900	.027	.827	.279
.922	.683	.847	.320	.476	.421	.893	.826	.444	.619
.726	.473	.854	.662	.381	.761	.661	.868	.174	.799
.711	.341	.219	.228	.466	.683	.676	.327	.502	.469
.978	.631	.469	.885	.267	.510	.601	.135	.290	.025
.689	.152	.703	.533	.742	.335	.670	.521	.007	.590
.521	.351	.824	.854	.347	.792	.542	.590	.051	.713
.960	.690	.343	.019	.917	.876	.365	.271	.942	.355
.991	.530	.165	.042	.448	.626	.526	.926	.607	.827
.713	.765	.812	.496	.626	.770	.331	.770	.662	.200
.141	.266	.141	.919	.199	.520	.332	.526	.752	.991
.966	.697	.704	.305	.831	.842	.740	.050	.925	.239
.681	.637	.035	.023	.335	.799	.623	.673	.509	.480
.106	.702	.879	.408	.519	.929	.416	.584	.486	.818
.635	.427	.554	.288	.318	.983	.844	.858	.059	.851
.507	.673	.434	.163	.060	.375	.025	.514	.848	.637
.297	.057	.951	.411	.441	.564	.171	.693	.052	.063
.817	.663	.369	.038	.653	.001	.321	.506	.886	.920
.763	.580	.967	.071	.368	.351	.950	.098	.529	.793
.496	.290	.698	.183	.504	.687	.005	.814	.954	.356
.314	.490	.174	.925	.886	.170	.496	.453	.835	.546
.306	.360	.103	.152	.234	.654	.941	.108	.980	.439
.444	.097	.321	.233	.725	.434	.416	.919	.578	.493
.178	.245	.433	.486	.622	.175	.238	.108	.637	.215
.984	.396	.434	.416	.101	.104	.597	.875	.543	.576
.574	.639	.116	.101	.754	.982	.358	.444	.856	.269
.648	.264	.090	.088	.176	.867	.485	.794	.388	.790
.764	.412	.018	.018	.523	.060	.329	.655	.313	.135
.899	.070	.117	.270	.914	.048	.048	.584	.566	.209
.792	.356	.793	.143	.640	.582	.267	.216	.824	.437
.489	.886	.430	.327	.315	.988	.426	.805	.934	.717
.238	.089	.246	.485	.958	.600	.253	.142	.082	.320
.635	.122	.911	.217	.136	.907	.322	.090	.216	.392
.557	.997	.727	.181	.510	.704	.349	.505	.863	.872
.244	.180	.057	.721	.359	.643	.432	.780	.052	.125
.546	.478	.347	.550	.471	.608	.325	.426	.002	.398
.593	.238	.636	.852	.030	.196	.939	.804	.453	.222
.660	.685	.385	.749	.813	.926	.004	.225	.115	.425
.339	.388	.357	.853	.634	.170	.448	.564	.383	.310
.755	.918	.791	.359	.414	.149	.799	.173	.156	.482

.511	.455	.333	.085	.021	.048	.265	.797	.430	.371
.941	.656	.523	.385	.994	.813	.012	.823	.502	.839
.673	.721	.637	.123	.748	.661	.372	.018	.243	.837
.623	.125	.748	.141	.648	.765	.933	.514	.969	.321
.498	.162	.692	.878	.474	.159	.751	.130	.691	.831
.731	.909	.171	.055	.139	.911	.113	.100	.178	.526
.556	.031	.853	.660	.417	.154	.051	.984	.881	.607
.652	.347	.261	.626	.778	.667	.321	.987	.404	.102
.815	.058	.984	.893	.741	.420	.400	.853	.715	.406
.567	.607	.476	.847	.120	.358	.313	.226	.091	.065
.651	.121	.116	.531	.112	.952	.329	.659	.328	.426
.380	.119	.809	.074	.450	.294	.254	.992	.543	.468
.117	.790	.119	.214	.858	.563	.163	.630	.185	.112
.689	.342	.174	.450	.134	.503	.421	.835	.607	.458
.871	.947	.688	.521	.923	.904	.436	.405	.400	.370
.976	.402	.486	.070	.999	.912	.375	.307	.134	.183
.530	.153	.153	.665	.521	.673	.595	.136	.507	.350
.433	.142	.067	.485	.816	.919	.963	.090	.751	.109
.247	.575	.220	.881	.124	.531	.012	.304	.165	.532
.985	.274	.841	.514	.476	.054	.371	.445	.131	.143
.153	.225	.585	.818	.598	.942	.333	.875	.250	.343
.091	.363	.923	.765	.005	.723	.899	.040	.114	.329
.491	.031	.258	.483	.518	.486	.840	.473	.544	.420
.231	.641	.742	.545	.179	.239	.142	.285	.170	.939
.931	.282	.138	.982	.406	.460	.059	.632	.239	.478
.587	.524	.683	.925	.145	.942	.385	.789	.371	.284
.580	.031	.961	.573	.009	.041	.992	.477	.556	.334
.334	.334	.106	.583	.892	.252	.111	.046	.604	.406
.967	.493	.221	.596	.314	.105	.328	.298	.385	.056
.367	.069	.941	.022	.162	.689	.959	.192	.896	.887
.980	.035	.631	.863	.234	.175	.946	.286	.678	.269
.673	.050	.559	.199	.416	.973	.543	.284	.157	.683
.356	.760	.248	.205	.054	.122	.160	.689	.197	.248
.578	.991	.208	.348	.259	.215	.946	.718	.795	.626
.589	.082	.788	.836	.125	.718	.733	.158	.493	.834
.358	.241	.973	.766	.790	.027	.703	.111	.136	.417
.369	.227	.963	.801	.718	.581	.254	.753	.451	.029
.379	.696	.880	.955	.858	.861	.443	.131	.858	.861
.327	.443	.131	.858	.619	.604	.277	.663	.156	.058
.567	.356	.247	.001	.124	.458	.646	.894	.576	.893

APPENDIX B:

LS-100

METHOD FOR ROUNDING-OFF OF TEST DATA AND OTHER NUMBERS

1. SCOPE

1.1 This method describes the procedure to be used for the rounding-off of all numbers.

2. GENERAL

Test values and calculated values are to be rounded in accordance with the criteria prescribed in Section 3.0.

3. CRITERIA

3.1 When the digit beyond the last place to be retained is less than 5, then the digit in the last place retained will remain (see Examples 1 & 2).

3.2 When the digit beyond the last place to be retained is greater than or equal to 5, then the digit in the last place to be retained will be increased by 1 (see Examples 1 & 2).

3.3 When a number is to be rounded, it will be rounded in one step only to the precision required and not rounded in two or more consecutive steps. For example: the number 1.347 can be rounded to 1.35 (to two decimal places). However, it is not acceptable to subsequently take 1.35 and then round it to the value of 1.4 to obtain a precision to one decimal place. In the method described herein, 1.347, rounded to one decimal place would have a value of 1.3.

NOTE 1: The requirement of rounding in one step does not refer to a rounded result which may have been obtained from a formula that may itself consist of rounded numbers. For example, it is perfectly acceptable to use % passing results which are themselves rounded to produce a rounded fineness modulus.

3.4 If, in special cases, it is desired to round off a number to the nearest 5, 0.5,0.05, 0.005 etc., then the observed or calculated value (with any number of significant digits) will be doubled, then respectively rounded to the nearest 10, 1, 0.1, 0.01 etc., in accordance with 3.1 to 3.3. The rounded result will then be divided by 2 (see Example 3).

Examples:

Example #1
Rounding to the closest whole number:

4.49	= 4	7.49	= 7
4.50	= 5	7.50	= 8
4.5	= 5	7.5	= 8
4.51	= 5	7.51	= 8

Example #2
Rounding to the closest 0.1:

7.649	=7.6	7.349	=7.3
7.650	=7.7	7.350	=7.4
7.65	=7.7	7.35	=7.4
7.651	=7.7	7.351	=7.4

Example #3
Rounding to the closest 0.05:

1.1249	x 2 = 2.2498	: 2.2 / 2 = 1.10
1.1250	x 2 = 2.2500	: 2.3 / 2 = 1.15
1.125	x 2 = 2.250	: 2.3 / 2 = 1.15
1.126	x 2 = 2.252	: 2.3 / 2 = 1.15

APPENDIX C:

METHOD FOR CALCULATION OF PER CENT WITHIN LIMITS

1. SCOPE

1.1 This method describes the procedure to be used for calculation of Per cent Within Limits.

2. RELEVANT DOCUMENTS

2.1 MTO Test Methods LS-100

3. DEFINITIONS

3.1 Per cent Within Limits (PWL) is an estimate of the percentage of the population (lot) that is within specification limits, determined by using the mean and standard deviation of the lot.

3.2 Mean ($\overline{X}$) is the arithmetic average of a set of test results.

3.3 Lot Standard Deviation (s) is the square root of the value found by summing the squares of the difference between each test result and the mean of the test results divided by the number of test results minus one ($n-1$).

3.4 Quality Index (Q_i) is a statistic which, when used with appropriate tables, provides an estimate of PWL of a lot. It can be based on an Upper or Lower Specification Limit, yielding Q_U or Q_L respectively.

4. GENERAL

4.1 All test results for a lot will be combined to calculate the Mean and Standard Deviation of the lot which will then be used to determine the Per cent Within Limits (PWL), according to the procedures in Section 5.

4.2 Any necessary rounding-off of test results or calculations will be in accordance with LS-100.

4.3 The lot mean will be reported to one decimal place. The Lot Standard Deviation, Lower Quality Index, and Upper Quality Index will be reported to two decimal places.

5. CALCULATIONS

5.1 The Quality Index, $Q_{i,}$ for the lower and upper specification limits shall be as determined from the following formulae:

$$Q_L = \frac{\overline{X} - LL}{s} \qquad Q_U = \frac{UL - \overline{X}}{s}$$

where:

Q_L	=	Lower Quality Index Value
Q_U	=	Upper Quality Index Value
LL	=	Lower Specification Limit
UL	=	Upper Specification Limit
$\overline{X}$	=	lot mean
s	=	lot standard deviation

5.2 PWL shall be determined from the following formula: $PWL = (P_L + P_U) - 100$

where: PWL = Per cent Within Limits
P_L = Per cent Within Lower Limit
P_U = Per cent Within Upper Limit

P_L and P_U are each determined from Table 1 based on Q_L and Q_U and the number of test results (n).

Where a lower limit is not specified, P_L will be 100. Where an upper limit is 100% or is not specified, P_U will be 100.

5.3 Notes for Table 1:

1. Enter the table using the number of test results and Q value.
2. If the value of Q_L or Q_U does not correspond exactly to a value in Table 1, use the next highest value of Q_L or Q_U from the table. The maximum P_L or P_U is 100.
3. Move across the table horizontally from the appropriate Q value to get P_L or P_U.
4. For negative values of Q_L or Q_U, enter the table using the absolute value of Q. P_L or P_U is equal to 100 minus the value from Table 1 for P_L or P_U.

6. EXAMPLES

6.1 Mean ($\overline{X}$) = 35.4 Lower Specification Limit (LL) = 30
Standard Deviation (s) = 3.22 Number of Test Results (n) = 42

$$Q_L = \frac{\overline{X} - LL}{s} = \frac{35.4 - 30}{3.22}$$

$$Q_L = 1.68$$

Look in Table 1 under n = 42 (see column n = 38 to n = 69).

As $Q_L = 1.68$ does not correspond exactly to a value in the table, use the next highest value in the column, 1.73.

Look across the table to the corresponding value of $P_L = 96$.

$P_U = 100$ (no upper limit is specified).

$$PWL = (P_L + P_U) - 100$$
$$= (96 + 100) - 100$$
$$= 96$$

6.2 Mean ($\overline{X}$) = 95.3 Lower Specification Limit (LL) = 91.5
Standard Deviation (s)= 2.87 Upper Specification Limit (UL) = 97.0
Number of Test Results (n) = 12

$$Q_L = \frac{\overline{X} - LL}{s} = \frac{95.3 - 91.5}{2.87} \qquad Q_U = \frac{UL - \overline{X}}{s} = \frac{97.0 - 95.3}{2.87}$$

$Q_L = 1.32$ $Q_U = 0.59$

From Table 1: $P_L = 91$
$P_U = 72$

$$PWL = (P_L + P_U) - 100$$
$$= (91 + 72) - 100$$
$$= 63$$

6.3 Mean ($\overline{X}$) = 222.4 Upper Specification Limit (UL) = 220
Standard Deviation (s) = 8.72 Number of Test Results (n) = 61

$$Q_U = \frac{UL - \overline{X}}{s} = \frac{220 - 222.4}{8.72}$$

$Q_U = -0.28$

From Table 1, a Q_i of 0.28 gives a P_i of 61, however, as Q_U is negative.

$P_U = 100 - 61 = 39$

P_L = 100 (no lower limit is specified)

$$PWL = (P_L + P_U) - 100$$
$$= (100 + 39) - 100$$
$$= 39$$

TABLE 1: Values for P_L and P_U for a Given Quality Index and Number of Tests

P_L or P_U	Quality Index (Q_L or Q_U)														
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=18	n=19 to n=25	n=26 to n=37	n=38 to n=69	n=70 to n=200	n>200
100	1.16	1.50	1.79	2.03	2.23	2.39	2.53	2.65	2.83	3.03	3.20	3.38	3.54	3.70	3.83
99	1.16	1.47	1.67	1.80	1.89	1.95	2.00	2.04	2.09	2.14	2.18	2.22	2.26	2.29	2.31
98	1.15	1.44	1.60	1.70	1.76	1.81	1.84	1.86	1.91	1.93	1.96	1.99	2.01	2.03	2.05
97	1.15	1.41	1.54	1.62	1.67	1.70	1.72	1.74	1.77	1.79	1.81	1.83	1.85	1.86	1.87
96	1.14	1.38	1.49	1.55	1.59	1.61	1.63	1.65	1.67	1.68	1.70	1.71	1.73	1.74	1.75
95	1.14	1.35	1.44	1.49	1.52	1.54	1.55	1.56	1.58	1.59	1.61	1.62	1.63	1.63	1.64
94	1.13	1.32	1.39	1.43	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.55
93	1.13	1.29	1.35	1.38	1.40	1.41	1.42	1.43	1.44	1.44	1.45	1.46	1.46	1.47	1.47
92	1.12	1.26	1.31	1.33	1.35	1.36	1.36	1.37	1.37	1.38	1.39	1.39	1.40	1.40	1.40
91	1.11	1.23	1.27	1.29	1.30	1.30	1.31	1.31	1.32	1.32	1.33	1.33	1.33	1.34	1.34
90	1.10	1.20	1.23	1.24	1.25	1.25	1.26	1.26	1.26	1.27	1.27	1.27	1.28	1.28	1.28
89	1.09	1.17	1.19	1.20	1.20	1.21	1.21	1.21	1.21	1.22	1.22	1.22	1.22	1.22	1.23
88	1.07	1.14	1.15	1.16	1.16	1.16	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
87	1.06	1.11	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.13
86	1.04	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
85	1.03	1.05	1.05	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
84	1.01	1.02	1.01	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99
83	1.00	0.99	0.98	0.97	0.97	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.95	0.95	0.95
82	0.97	0.96	0.95	0.94	0.93	0.93	0.93	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
81	0.96	0.93	0.91	0.90	0.89	0.89	0.89	0.89	0.89	0.88	0.88	0.88	0.88	0.88	0.88
80	0.93	0.90	0.88	0.87	0.86	0.86	0.86	0.85	0.85	0.85	0.85	0.84	0.84	0.84	0.84
79	0.91	0.87	0.85	0.84	0.83	0.82	0.82	0.82	0.82	0.81	0.81	0.81	0.81	0.81	0.81
78	0.89	0.84	0.82	0.80	0.80	0.79	0.79	0.79	0.78	0.78	0.78	0.78	0.77	0.77	0.77
77	0.87	0.81	0.78	0.77	0.76	0.76	0.76	0.75	0.75	0.75	0.75	0.74	0.74	0.74	0.74
76	0.84	0.78	0.75	0.74	0.73	0.73	0.72	0.72	0.72	0.71	0.71	0.71	0.71	0.71	0.71
75	0.82	0.75	0.72	0.71	0.70	0.70	0.69	0.69	0.69	0.68	0.68	0.68	0.68	0.68	0.67
74	0.79	0.72	0.69	0.68	0.67	0.66	0.66	0.66	0.66	0.65	0.65	0.65	0.65	0.64	0.64
73	0.76	0.69	0.66	0.65	0.64	0.63	0.63	0.63	0.62	0.62	0.62	0.62	0.62	0.61	0.61
72	0.74	0.66	0.63	0.62	0.61	0.60	0.60	0.60	0.59	0.59	0.59	0.59	0.59	0.58	0.58
71	0.71	0.63	0.60	0.59	0.58	0.57	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.55	0.55
70	0.68	0.60	0.57	0.56	0.55	0.55	0.54	0.54	0.54	0.53	0.53	0.53	0.53	0.53	0.52
69	0.65	0.57	0.54	0.53	0.52	0.52	0.51	0.51	0.51	0.50	0.50	0.50	0.50	0.50	0.50
68	0.62	0.54	0.51	0.50	0.49	0.49	0.48	0.48	0.48	0.48	0.47	0.47	0.47	0.47	0.47
67	0.59	0.51	0.47	0.47	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.44	0.44	0.44	0.44
66	0.56	0.48	0.45	0.44	0.44	0.43	0.43	0.43	0.42	0.42	0.42	0.42	0.41	0.41	0.41
65	0.52	0.45	0.43	0.41	0.41	0.40	0.40	0.40	0.40	0.39	0.39	0.39	0.39	0.39	0.39
64	0.49	0.42	0.40	0.39	0.38	0.38	0.37	0.37	0.37	0.37	0.36	0.36	0.36	0.36	0.36
63	0.46	0.39	0.37	0.36	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33
62	0.43	0.36	0.34	0.33	0.32	0.32	0.32	0.32	0.31	0.31	0.31	0.31	0.31	0.31	0.31
61	0.39	0.33	0.31	0.30	0.30	0.29	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.28
60	0.36	0.30	0.28	0.27	0.27	0.27	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.25
59	0.32	0.27	0.25	0.25	0.24	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23
58	0.29	0.24	0.23	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0.20
57	0.25	0.21	0.20	0.19	0.19	0.19	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
56	0.22	0.18	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.15
55	0.18	0.15	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
54	0.14	0.12	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
53	0.11	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
52	0.07	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
51	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D:

APPLICATION FOR FIELD ADJUSTMENT TO JMF

FROM: _____ **DATE:** _____
CONTRACTOR

TO: _____ **CONTRACT:** _____
CONTRACT ADMINISTRATOR

Re: Field Adjustment To JMF, **Special Provision 103F34** entitled "End Result Specification for Acceptance of Hot Mix (Aggregate Gradation, Asphalt Cement Content, Air Voids, VMA, Compaction) Based on Contractor Testing"

In accordance with the terms of this special provision, _____ (Contractor) proposes to change the Job Mix Formula on this Contract for Tender Item No._____, _____(type of mix). It is requested that the change become effective _____(date) starting with Lot _____ of this item.

This change is being made in conformance with Situation ____ (Insert 1, 2 or 3 here) identified below:

1. To more closely reflect the actual mix being produced when test results for the last lot produced to the submitted JMF accrued a payment reduction for asphalt cement content and/or aggregate gradation but met all other specified mix requirements. Table 1 confirms that
   - for Marshall mixes, the test results (lot mean) meet the minimum design requirements for Marshall stability, flow and VMA, and there was no payment reduction for air voids.
   - for Superpave mixes, the test results (lot mean) meet the design requirements for VMA, percent G_{mm} at N_{max}., voids filled with asphalt (VFA) and dust proportion, and that there was no payment reduction for air voids.

2. To permit minor changes in the constituent proportions when test results for the last lot produced to the submitted JMF indicated no negative price adjustments for asphalt cement or gradation, but changes are designed to improve either the air voids or the VMA or both. Table 2 confirms that the air voids PWL is presently at least 50 and the lot mean VMA is no more than 0.5 percent below the design minimum. Test results summarized in this table confirm improvements in these attributes, without any deterioration in the remainder of mix properties.

3. To permit minor changes in the submitted JMF before production starts. Table 3 confirms that the revised JMF will provide a mix meeting all design criteria.

Revised JMF:
The original and revised JMF, and the changes in the target AC content and gradation, are summarized below:

	JMF from Mix Design	**Revised JMF #1**	**Revised JMF #2**	**Change from Mix Design JMF**	**Max. Permitted Change**
AC Content--all mixes except SMA					**± 0.2 %**
AC Content --SMA only					**± 0.4 %**
Sieve	**% Passing**				
26.5/25.0 mm					± 5.0 %
19.0 mm					± 5.0 %
16.0 mm					± 5.0 %
13.2/12.5 mm					± 4.0 %
9.5 mm					± 4.0 %
4.75 mm					± 3.0 %
2.36 mm					± 3.0 %
1.18 mm					± 3.0 %
600 µm					No limit
300 µm					
150 µm					
75 µm -- all mixes except SMA					**± 1.0 %**
75 µm -- SMA only					**± 2.0 %**

CONTRACTOR'S REPRESENTATIVE

Contract Administrator's Response

☐ Your revised JMF outlined above (and the submitted documentation) have been reviewed and confirmed to conform to contract requirements. The revision will be applied to Lot _____ and to subsequent lots. Confirmation of conformance to Contract requirements of the revised JMF does not constitute any guarantee that the mix can be produced and/or constructed to Contract requirements, and does not relieve the Contractor of the responsibility for ensuring the specified quality of materials and workmanship is achieved.

☐ Your revised JMF outlined above (and the submitted documentation) have been reviewed. Permission to use the revised JMF is denied for the following reason(s).

CONTRACT ADMINISTRATOR **Date**

Supporting Documentation

(Contractor to complete Tables 1, 2 or 3 corresponding to Situations 1, 2 or 3 identified previously)

Situation 1: For Marshall mixes, the test results (lot mean) must show that the minimum design Marshall stability, flow and VMA were achieved and there was no payment reduction for air voids. For Superpave mixes, the test results (lot mean) shall show that the design requirements for VMA, percent G_{mm} at N_{max}., voids filled with asphalt (VFA) and dust proportion were met, and that there was no payment reduction for air voids. The following table confirms that these conditions have been satisfied.

Table 1: Confirmatory Information For Situation 1

	Original Properties (from Lot _____) Note 1	**Conditions**
PF for AC and/or gradation		< 1.000
PF for Air Voids		≥ 1.000
		Design Requirements
VMA		
Marshall Mixes:		
Marshall Stability		
Marshall flow		
Superpave Mixes:		
Percent G_{mm} at N_{ini}		
Percent G_{mm} at N_{max}		
VFA		
Dust Proportion		

Note 1: From QC testing (uncontested lot) or referee testing.

Situation 2: To permit minor changes in the constituent proportions when test results for the last lot produced to the submitted JMF indicated no negative price adjustments for asphalt cement or gradation, but changes are designed to improve either the air voids or the VMA or both. For this situation, based on the constructed lot, the air voids PWL shall be at least 50 and the lot mean VMA shall be no more than 0.5 percent below the design minimum. The proposed JMF shall yield a mix which improves on this, and shows no deterioration in the remainder of the mix properties.

Table 2: Mix Properties of Constructed Lot and Proposed JMF

	Based on constructed Lot ____ (Note 2)	**Conditions**	**Based on proposed JMF (Note 3)**
PF for AC and grading		≥ 1.000	N/A
PWL for Air Voids		≥ 50	N/A
VMA		≤ 0.5 % below design minimum	
		Requirements	
Marshall Mixes:			
Marshall Stability			
Marshall flow			
Superpave Mixes:			
Percent G_{mm} at N_{ini}		N/A	
Percent G_{mm} at N_{max}		N/A	
VFA		N/A	
Dust Proportion		N/A	

Note 2: From QC testing (uncontested lot) or referee testing.
Note 3: Attach results (mean of 4 plant checks or testing of laboratory constituted mix)
Note 4: The properties resulting from this revised JMF must continue to conform to design requirements or show no deterioration thereof.

Situation 3: To permit minor changes in the submitted JMF before production starts.

Table 3: Mix Properties - Mix Design and Proposed JMF

Properties	**From Submitted Mix Design**	**From Proposed JMF (Note 5)**	**Design Requirements**
Air Voids			
VMA			
Marshall Mixes:			
Marshall Stability			
Marshall flow			
Superpave Mixes:			
Percent G_{mm} at N_{ini}			
Percent G_{mm} at N_{max}			
VFA			
Dust Proportion			

Note 5: Attach laboratory test results (mean of 4 plant checks or testing of laboratory constituted mix)

Materials Engineering and Research Office
Bituminous Section
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8