DRAFT--NOT FOR PUBLICATION

PRECISION LIMITS OF SLURRY SEAL ASPHALT CONTENTS . . .

A DECADE OF EXPERIENCE

/C. Robert Benedict

An informal presentation to the ISSA Research and Development Committee Meeting, Newport Beach Marriott Hotel, Newport Beach, California, February 9, 1981 9:00 A.M.

User agency demand for quality construction is greater now than ever before. A variety of quality assurance programs for hot mixed asphaltic concrete have been adopted in many states. In at least two states, Virginia and Ohio, quality assurance specifications are in use for slurry seal. Under these specifications the contractor is required to submit his own laboratory design and job mix formula (JMF) and to meet the criteria he has established during construction or be severely penalized for his poor performance.

Inconsistent and poor extraction results baffled many contractors and buyers alike since, in many instances, the extraction results bore little or no relation to the appearance and field performance of the slurry seal. Among the many explanations for the variations and disparities were:

1. Poor sampling techniques
2. Sampling on start-up or shut down
3. Failure to completely dry the samples before extraction
4. Failure to account for ash loss on extraction by centrifuge
5. Failure to run reflux extractions long enough or to absolute clearness
6. Weight errors in the laboratory
7. Sloppy laboratory techniques
8. Impossibility to extract "fines" portion of the sample
9. Absorbtive aggregates would not release all the A.C.

During our technical panel at the 1975 Las Vegas meeting, considerable time was spent in a discussion of the problem. Personnel of Interstate Asphalt and Slurry Seal, Quakertown, Pa. presented a number of field observations and recommended procedures for more accuracy in asphalt extraction of slurry seals. The result was our committee's first Technical Bulletin #101, "Guide for Sampling of Slurry Mix or Extraction Tests."

the attainable precision tolerance of this group is estimated at about ±0.5% in more than 95% of the job samples with no radical outliers.

Your ISSA R & D Committee has produced a number of papers and bulletins relating to this problem such as Technical Bulletins #101, #107 and Operational Bulletins #127 and #128. We urge you to compare your own results with those presented here and then return to your shops determined to out-perform your own quality record.

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We wish to acknowledge the assistance of the Virginia, Kansas, Ohio, and Oklahoma Departments of Transportation and thank them for their cooperation in supplying data for this presentation.

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REFERENCES:

1. Raymond T. Young and Robert J. Province. Bituminous Slurry Surfaces Handbook. Revised Edition, 1980, Slurry Seal, Inc., Waco, Texas.

2. ISSA R & D Committee. Design Technical Bulletins--1980.
   Technical Bulletin #101, "Guide for Sampling of Slurry Mix for Extraction Tests," 1975, Revised 1978.
   Technical Bulletin #107, "A Method for Unit Field Control of Slurry Seal Qualities," 1976, Revised 1978.
   Operations Bulletin #127, "Field Control, Steady State Operations and Mill Sequencing," 1979.
   Operations Bulletin #128, "Calibration of Gate Metering Slurry Machines," 1980.

3. C. Robert Benedict. Design and Control of Slurry Seal Mixes. Proceedings of the Asphalt Emulsion Manufacturers Association, 1977/ISSA P-305.

4. C. Robert Benedict. An Introduction to Elements and Uses of Slurry Seal Systems. USAF/AFIT "Blue Book," ISSA, 1980 Edition #P5.

APPENDIX

AN ANALYSIS OF EXTRACTION DATA FROM (10) JOBS

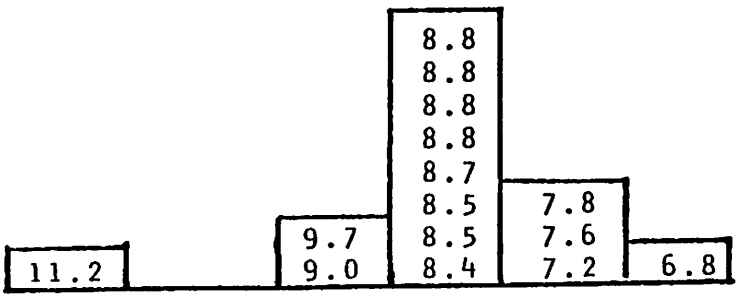
(1) CITY '74
2 MACHINES
AVERAGE---7.73%
SPAN---4.1, ± 2.05%
2/18 OUT AC
0/18 OUT AGG

		7.9		
		7.8		
	8.6	7.6		
	8.4	7.5		
	8.4	7.5		
	8.3	7.3		
9.3	8.0	7.0		
9.1	8.0	7.0	6.2	5.2

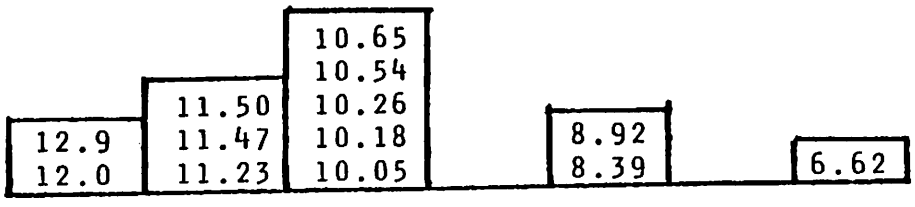
(2) HIGHWAY '75
1 MACHINE
AVERAGE---10.42%
SPAN---4.4, ± 2.2%

		10.9	9.7	
		10.9	9.7	
		10.5	9.5	8.9
		10.4	9.4	8.8
		10.4	9.4	8.7
		10.3	9.1	8.7
12.8	11.6	10.2	9.1	8.6
12.5	11.3	10.2	9.1	8.4

(3) HIGHWAY '75
2 MACHINES ?
AVERAGE---8.57%
SPAN---4.4, ± 2.2%

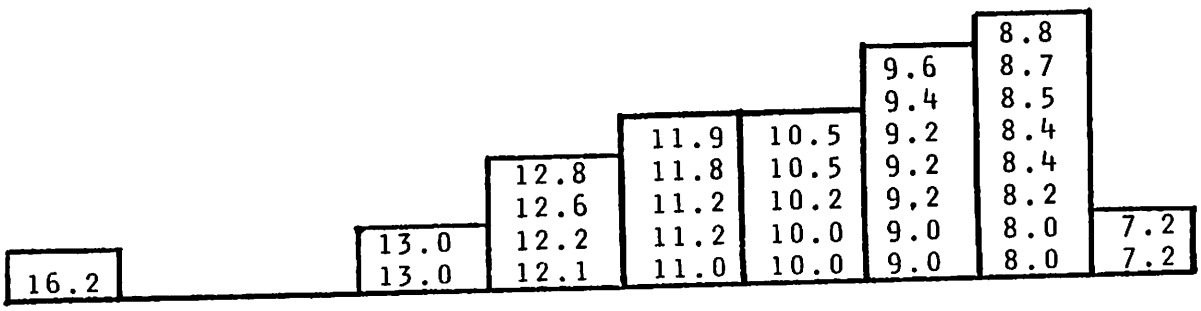


(4) HIGHWAY '75
3 MACHINES
AVERAGE---10.36%
SPAN---6.28, ± 3.14%



(5)CITY SPRING '73
2 MACHINES
AVERAGE---16.99%
SPAN---8.0, ± 4.0%

(6) CITY FALL '74
2 MACHINES
AVERAGE---10.18%
SPAN---9.0, ± 4.5%



The quantity assurance results of Ohio SR 42 and SR 35F - 1977 follow:

SR 42, Type "C," 20 lbs.

Lot No.	Gals.	Lbs/SY	Gals/ton	SY
1	3618	*12.09 (a)	68.0 (a)	8,796
2	5570	28.09	29.35	13,517
3	8478	23.0	32.0	22,780
4	4953	20.0	32.0	15,118
5	7161	19.0	32.0	24,255
6	5050	19.49	28.21	18,376
7	2794	*18.93	27.0	10,936
8	3492	*18.63	27.28	13,760
9	3749	19.00	27.00	14,770
10	940	31.00 (a)	26.10	2,280
Average (valid)		20.77	28.99	
Design		20#	30.0 ± 5	

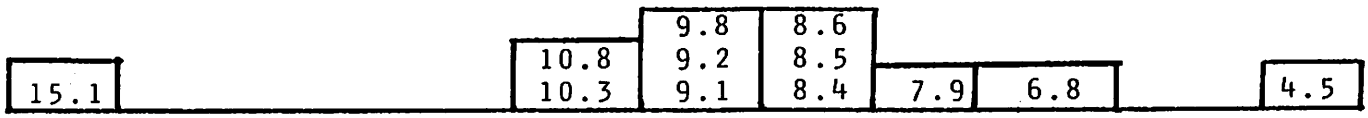
*Penalty

SR 35F, Type "B," 17 lbs.

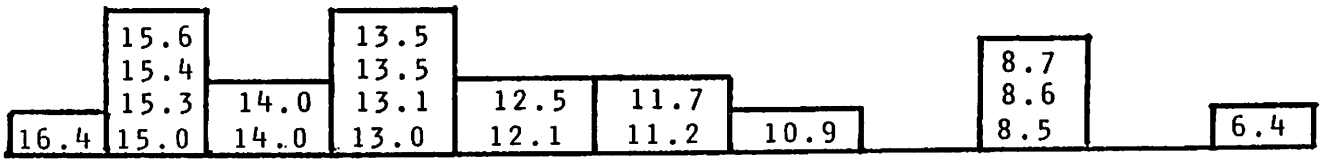
Lot No.	Gals.	Lbs/SY	Gals/ton	SY
1	4387	13.29	44.79	14,739
2	3685	15.81	44.79	10,010
3	5780	14.72	47.81	16,426
4	8813	24.27 (b)	45.09	16,239
5	8982	17.66	41.84	24,316
Average		17.75	44.86	
Design		17.0	43.8 ± 5	

(a) Vagary
(b) Base problem - re ran

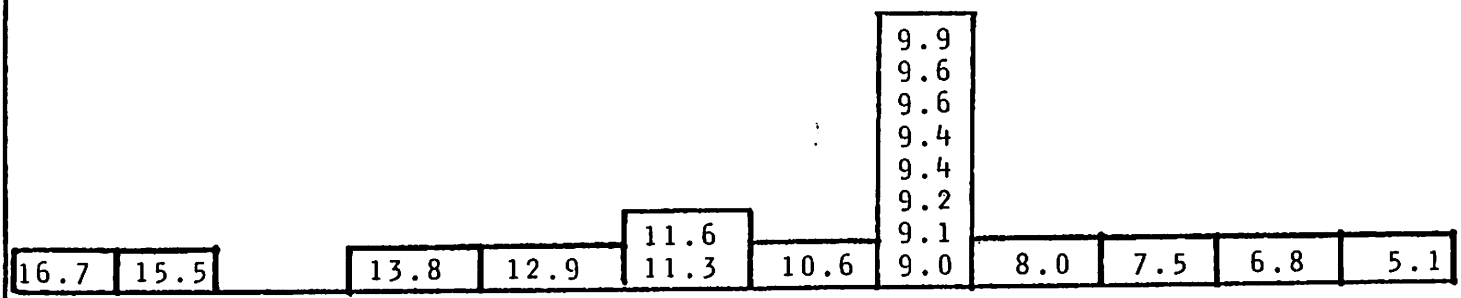
(7) AIRPORT FAI.I. '71
6 MACHINES
AVERAGE---9.083%
SPAN---10.6. ± 5.3%



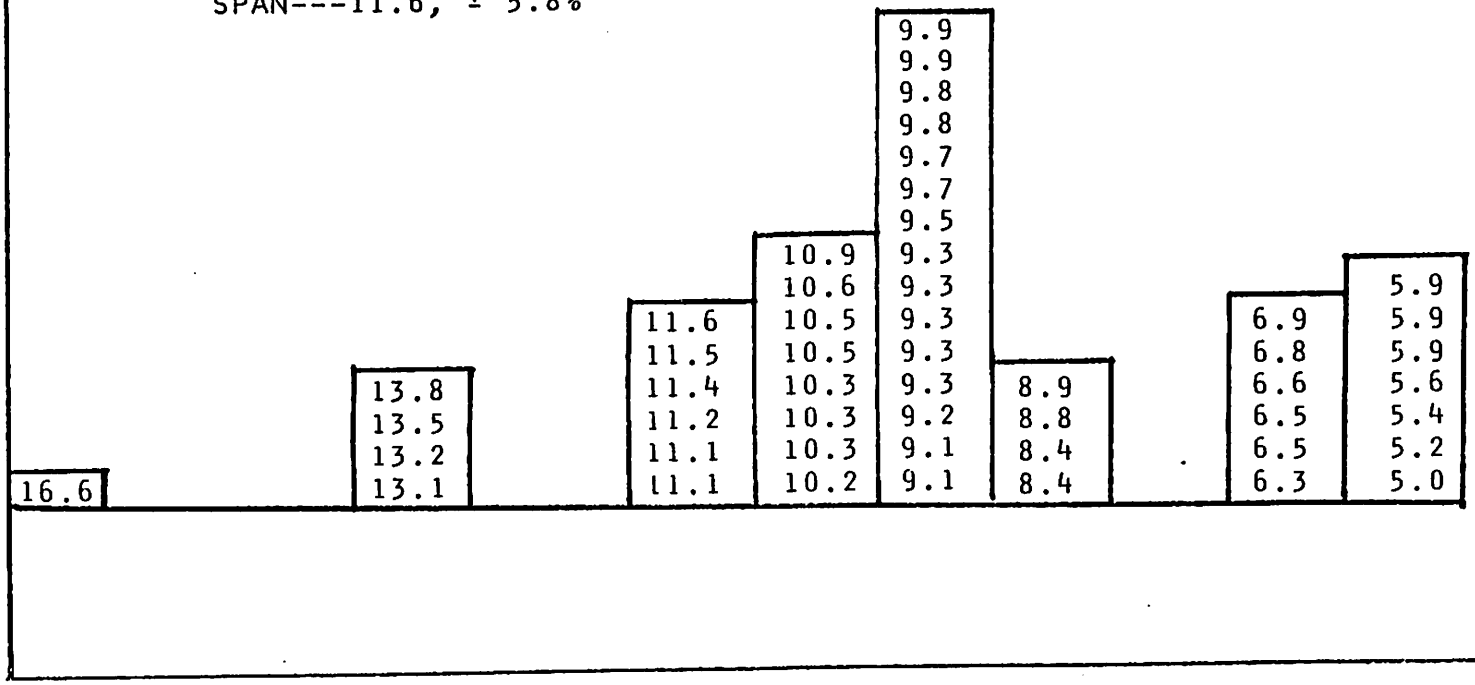
(8) SHOULDERS '71
1 MACHINE
AVERAGE---12.47%
SPAN---10.0, ± 5%



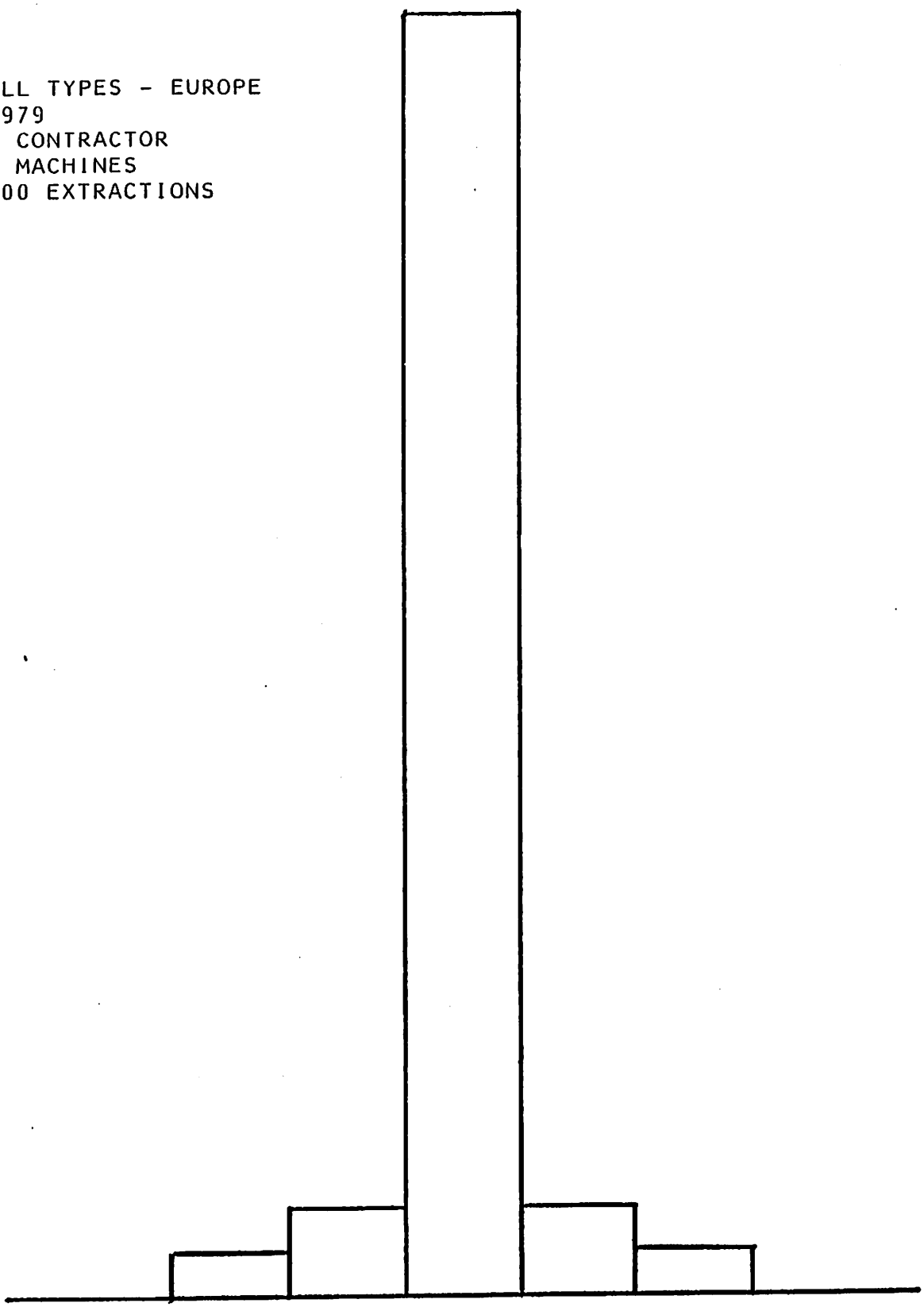
(9) SHOULDERS '73
2 MACHINES
AVERAGE---9.941%
SPAN---11.6, ± 5.8%



(10) SHOULDERS '74
3 MACHINES
AVERAGE---9.298%
SPAN---11.6, ± 5.8%



(11) ALL TYPES - EUROPE
1979
1 CONTRACTOR
8 MACHINES
900 EXTRACTIONS



Continued field observations have yielded a variety of subtle and not-so-subtle variations in slurry seal jobs (as well as many hot mix and chip seal jobs). No concensus is yet reached, but it seems clear to many observers that there is a great deal of room for improvement in the precision of asphalt content proportioning for all the paving arts, especially slurry seal.

During 1975 available extraction data from 10 slurry seal jobs were gathered from Oklahoma to Virginia and are graphically presented in the appendix as an example of the state-of-the-art 5 to 10 years ago. A summary of these extraction results is shown in the following table.

	AVERAGE %	RANGE	TOLERANCE FROM MEAN	% VARIATION FROM MEAN	ELIMINATE OUTLIERS	% VARIATION FROM AVERAGE
1.	7.73%	4.1%	±2.05%	±26.5%	±1.15%	±14.9%
2.	10.42%	4.4%	±2.2%	±21.1%	±1.75%	±16.8%
3.	8.57%	4.4%	±2.2%	±25.7%	±1.25%	±14.6%
4.	10.36%	6.38%	±3.14%	±30.3%	±1.80%	±17.4%
5.	16.99%	8.0%	±4.0%	±23.5%	±1.60%	± 9.4%
6.	10.18%	9.0%	±4.5%	±44.2%	±2.5%	±24.6%
7.	9.08%	10.6%	±5.3%	±58.4%	±2.0%	±22.0%
8.	12.47%	10.0%	±5.0%	±40.1%	±3.35%	±26.9%
9.	9.94%	11.6%	±5.8%	±58.3%	±3.15%	±31.7%
10.	9.29%	11.6%	±5.8%	±62.4%	±4.4%	±47.3%

TABLE 1. SUMMARY OF U.S. SLURRY SEAL ASPHALT EXTRACTION RESULTS, 1970-1975

Based on the above data it seems that precision limits of less than ±2.0% (10.0% ± 2.0%) of the Job Mix Formula were generally unattainable 5 to 10 years ago. By discarding the outliers. this figure is reduced to ±1.5%, which coincidentally is the current Virginia DOT specification tolerance.

For comparison, the following table shows generally accepted tolerances in the U.S. for hot mixed asphaltic concrete, chip seal, and slurry seal.

	JMF	JMF TOLERANCES
HMAC	5.0-8.0% ± .5%	6.2-10.0%
CHIP SEAL	.3-.4 gal/SY ± .05	12.5-16.7%
SLURRY SEAL (Field)	10.5% ± 1.5%	12.5-18.0%
ISSA GUIDE RANGE	7.5-13.5% ± 3.0%	22.0-40.0%

TABLE 2. COMPARATIVE TOLERANCES

Based on the above data and considering the use of continuous self-loading machines, the control methods and experiences of the Kansas and Virginia DOT's, the Ohio DOT adopted a new quality assurance specification based on acceptance lots of typical emulsion transport quantities of 5,000-6,000 gallons in 1977. The field results of the Ohio method are shown in Table 3 for both spread rate and emulsion content based on weighed quantities rather than laboratory extraction results.

	JMF	TOLERANCE	FIELD RESULTS
SR 42	30 gal/ton	±5 (16.7%)	28.99 ± 3.01 (10.4%)
SR 35	43.8 gal/ton	±5 (11.4%)	44.86 ± 3.02 (6.7%)

TABLE 3. OHIO DOT 1977 QUALITY ASSURANCE JOB RESULTS

Careful calibration, attention to detail, use of continuously self-loading machinery and experienced contractors combine here to gain greater precision than previously experienced. Precision comparable to the sophisticated computerized machinery of the hot mix industry is now possible for us to attain under these conditions.

Before complacency sets in, the millinea (attainable precision) has not yet been reached. Last year, the writer observed a series of nearly 900 extractions from 8 single machines used on some 500 jobs during the 1979 season in Europe. Nearly all extractions were well within ±.5% of the JMF and most within ±.3%. In comparison with typical American practice and performance shown in Table 2