Asphalt Concrete Plant Inspection Manual

Highway Division
Materials Office

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Iowa Department of Transportation

Iowa Department of Transportation
Office of Materials

Asphalt Concrete Plant Inspection Manual

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SOURCE APPROVAL CON'T.

B. Acceptable Quality Control Program
An outline of the quality control program used by the terminal showing testing frequencies, tests performed, and a typical test report shall be submitted to the Office of Materials. A general guideline showing minimum testing is given in Appendix A.

C. Storage
Emulsions which are to be shipped to Iowa projects shall be held in storage tanks for a minimum of 24 hours. Certification shall be on the basis of tests made at the time of shipment.

D. Records and Documentation
Evidence of maintaining a satisfactory program for keeping testing and shipment records shall be provided. This program shall enable proper identification and documentation of all shipments made to projects and shall include a file of refinery test reports covering all asphalt cement and cutback asphalts received by the terminal.

Continued approval of a source will be based on the following:

A. Ability to consistently supply material meeting specifications.

B. Ability to meet precision limits for quality control testing.

C. Continuation of originally approved quality control program.

D. Maintenance of required records.

E. Proper documentation of shipments.

Approval to deliver certified material may be withdrawn for inadequate compliance with these requirements.

MONITORING APPROVED SOURCES

Monitoring activities at distribution terminals, including inspection of quality control records and procedures will be conducted by the appropriate District Materials Office. Approved refineries may be requested to submit a sample once per year of asphalt cement along with their complete analysis to the Central Laboratory in Ames. Similar samples will be required for cutback asphalts if supplied. Refinery monitoring samples may also be taken by District Materials personnel at time of incorporation into terminal or contrator's storage facilities.

All District Materials Office monitoring activities shall be reported to the Central Materials Office.

DOCUMENTATION

Each shipment invoice covering certified materials delivered to a project shall have a signed certification statement as to type and grade, specific gravity or weight per gallon, quantity in load, batch number or other identification, project number, and compliance with the appropriate Iowa DOT specifications. A copy of this invoice shall be furnished to the contracting authority at the time of delivery.

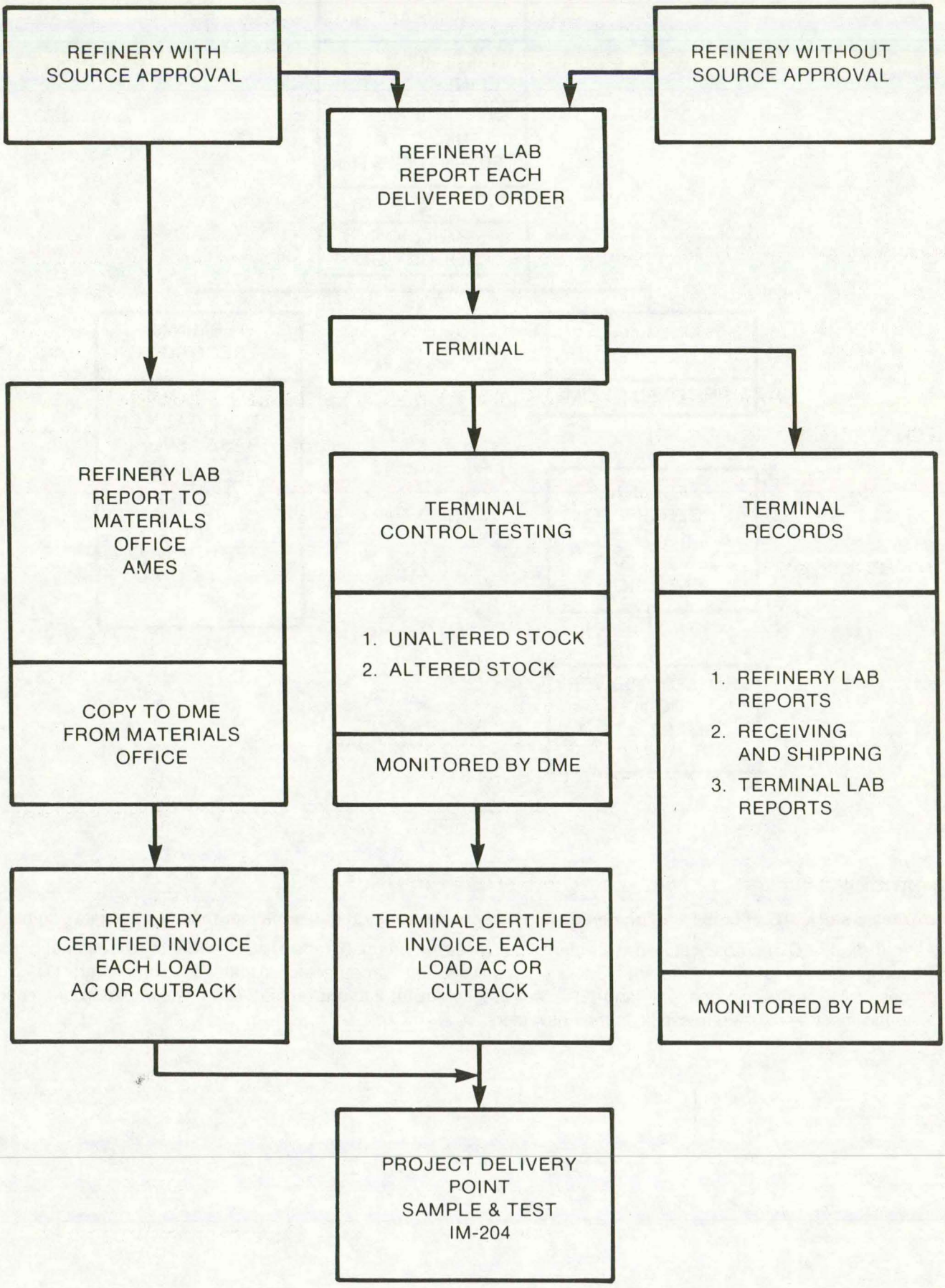
A distribution terminal receiving refinery material shall promptly obtain, from the refinery, a report of complete test analysis covering each batch or identifiable lot received.

A refinery delivering certified material to a project shall promptly forward a report of complete test analysis for each batch or identifiable lot to the Iowa Department of Transportation, Office of Materials, Ames, IA 50010.

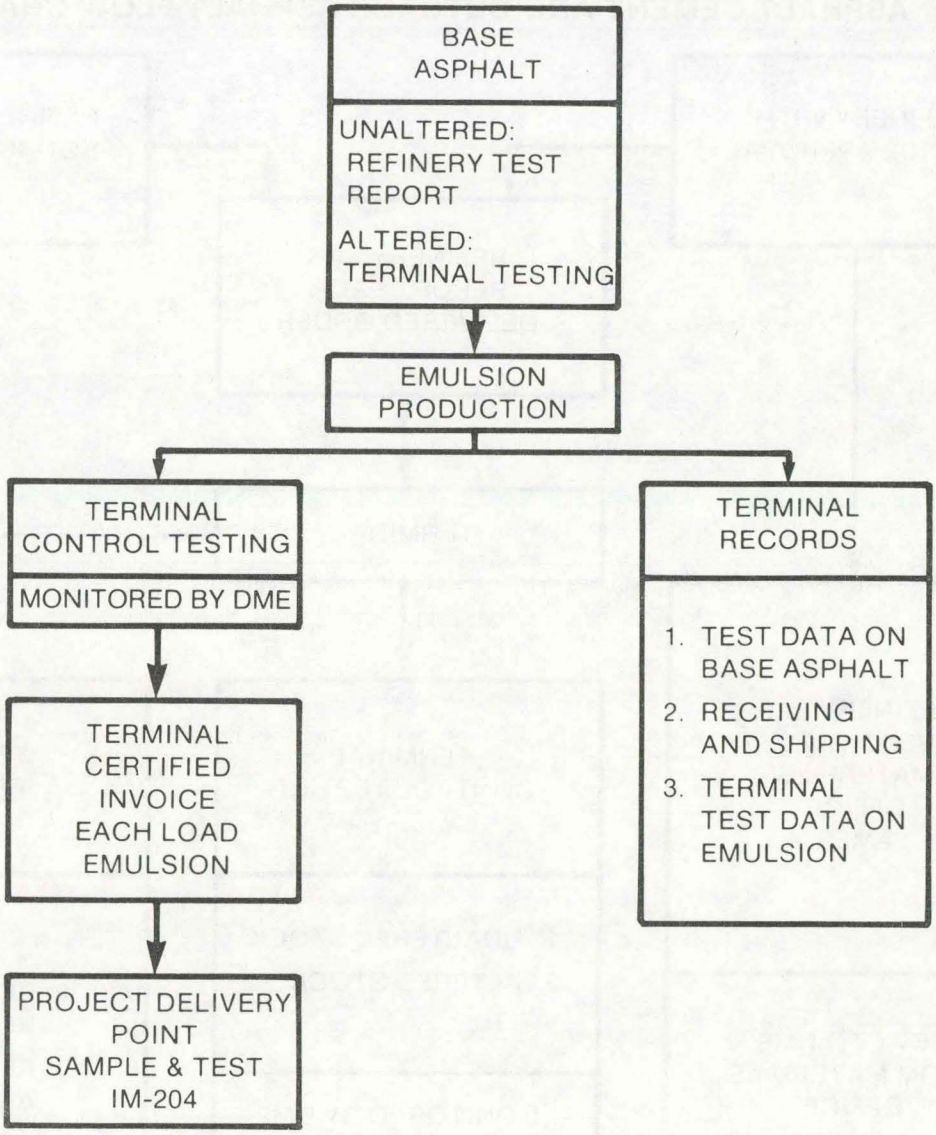
ACCEPTANCE

Properly identified and certified materials may be incorporated into a project. Final acceptance will be based on the certifications and the results of tests on project samples secured in accordance with Instructional Memorandum No. 204 or in accordance with special requirements when specified.

ASPHALT CEMENT AND CUTBACK ASPHALT FLOW CHART



ASPHALT EMULSION FLOW CHART



DEFINITIONS:

1. Unaltered stock: AC or cutback of one grade and refinery source, stored in a manner that maintains its original identity.
2. Altered stock: AC or cutback stored in a manner that loses the original grade or source identity. A material is considered altered any time a material of different grade or source is blended to another stored material. Examples are: (1) Two or more grades of AC blended in one tank, and (2) AC or cutback from different refinery sources blended in one tank. Altered materials must be retested to establish their new identity.

APPENDIX B

APPROVED SOURCES - ASPHALT CEMENT
General Revision

The following sources are approved to furnish asphalt cement on the basis of certification:

Supplier		Address
American Oil Co.	Terminal	Linwood, IA
American Oil Co.		Whiting, IN
Ashland Petroleum Co.		St. Paul Park, MN
Bituminous Materials & Supply Co.	Terminal	Algona, IA
Bituminous Materials & Supply Co.	Terminal	Tama, IA
Deal Petroleum Co.	Terminal	Tulsa, OK
Illinois Road Contractors Inc.	Terminal	Meredosia, IL
Jerbro,Inc.	Terminal	Sioux City, IA
Jerbro, Inc.	Terminal	Sioux Falls, SD
Koch Asphalt Co.	Terminal	Dubuque, IA
Koch Refining Co.		St. Paul, MN
Koch Asphalt Co.	Terminal	Omaha, NE
Midwest Industrial Fuel Co.	Terminal	La Crosse, WS
Pester Refining Co.		Eldorado, KS
Shell Oil Co.	Terminal	Kansas City, KS
Sinclair Refinery		Sinclair, WY
Vance Brothers, Inc.	Terminal	Kansas City, MO

APPENDIX C
APPROVED SOURCES - LIQUID ASPHALTS AND CUT-BACKS AND EMULSIONS
General Revision

The following sources are approved to furnish liquid asphalts and cut-backs on the basis of certificaiton:

IBM Code	Supplier		Address
06	American Oil Co.	Terminal	Linwood, IA
01	Bituminous Materials & Supply Co.	Terminal	Algona, IA
03	Bituminous Materials & Supply Co.	Terminal	Tama, IA
24	Illinois Road Contractors Inc.	Terminal	Meredosia, IL
04	Jebro, Inc.	Terminal	Sioux City, IA
29	Jebro, Inc.	Terminal	Sioux Falls,SD
05	Koch Asphalt Company	Terminal	Dubuque, IA
10	Koch Refining Co.		St. Paul, MN
19	Koch Asphalt Co.	Terminal	Omaha, NE
23	Pester Refining Co.		Eldorado, KS
14	Richards Oil Co.	Terminal	Savage, MN
27	Vance Brothers Inc.	Terminal	Kansas City,MO

The following sources are approved to furnish asphalt emulsion on the basis of certification:

IBM Code	Supplier	Address
12	Bitucote Products Co.	Alton, IA
13	Bitucote Products Co.	Des Moines, IA
01	Bituminous Materials & Supply Co.	Algona, IA
03	Bituminous Materials & Supply Co.	Tama, IA
15	Hiway Asphalt Products, Inc.	Henderson, NE
24	Illinois Road Contractors Inc.	Meredosia, IL
05	Koch Asphalt Co.	Dubuque, IA
17	Koch Asphalt C	Marshall, MN
18	Koch Asphalt Co.	Kansas City, MO
19	Koch Asphalt Co.	Omaha, NE
10	Koch Asphalt Co.	St. Paul, MN
	Koch Asphalt Co.	Chicago, IL
21	Monarch	Omaha, NE
14	Richards Oil Co.	Savage, MN
20	Utica Asphalt Terminal Inc.	Utica, IL
27	Vance Brothers Inc.	Kansas City, MO

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

MONITORING GUIDE

FOR
ASPHALT
REFINERIES AND TERMINALS

REFINERIES

Refinery monitoring samples will be taken on request by the Central Materials Office or when deemed necessary by the District Materials Engineer. These samples will be taken before the material is incorporated into terminal or contractor storage. All testing of these samples will be conducted by the Central Laboratory.

DISTRIBUTION TERMINALS

The appropriate District Materials Office will review terminal procedures and records related to Iowa D.O.T. work each time a terminal is visited for monitoring purposes. The minimum monitoring frequencies are:

1. Distribution terminals that regularly supply asphalt products to Iowa D.O.T. projects shall be monitored at least once a month.

2. Distribution terminals that are intermittent suppliers shall be monitored at least once a year.

Samples taken during monitor visits shall be tested by the District Laboratory except for problem situations.

Distribution terminals that are actively supplying asphalt products to State of Iowa projects will submit a sample/or samples once a month to the Central Laboratory, along with all required AASHTO and IDOT test results. One sample of asphalt cement and one sample of cutback and one sample of emulsion shall be submitted to the Central Laboratory each month.

All Iowa D.O.T. tests will be required on blended materials.

Anytime a source is changed, the blended materials loose their original identity, and a full compliment of AASHTO and IDOT tests will have to be run on the new blend, and accompany the sample to the Central Laboratory.

The sources of the various products shall be listed on the test reports, submitted with the samples.

This procedure will also apply to times of intermittent production.

CORRELATION TESTING

Monitor samples from a terminal submitted to the Central Laboratory will be used for correlation between the terminal control lab and the Central Laboratory. Test reports on these samples will be distributed to the monitoring District Office and the terminal.

District laboratories will also correlate their monitoring test results with the terminal lab and will submit the correlation results to the Central Materials Office and the terminal.

Highway Division

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

ASPHALT MATERIALS

GENERAL

Most asphalt materials used in highway construction are produced by the petroleum industry; a few natural deposits of lake asphalt and rock asphalt are worked although the quantity of these latter materials is relatively small. A variety of terms are associated with asphalt materials, some are used interchangeably. This often results in confusion, therefore, the following definitions have been listed:

1. Asphalt - "A dark brown to black cementitious material, solid, semi-solid or liquid in consistency; in which the predominating constituents are bitumens which occur in nature as such or which are obtained as residue in refining petroleum." (ASTM D-8)

2. Bitumen - A mixture of hydrocarbons of natural or pyrogenous origin, or a combination of both; frequently accompanied by non-metallic derivatives which may be gaseous, liquid, semi-solid or solid; and which is completely soluble in carbon disulfide.

3. Flux or Flux Oil - A thick, relatively nonvolatile fraction of petroleum which may be used to soften asphalt to a desired consistency.

4. Asphalt, Natural (Native) - Asphalt occuring in nature which has been derived from petroleum by natural processes of evaporation of volatile fractions leaving the asphalt fraction.

5. Asphalt, Petroleum - Asphalt refined from crude petroleum.

6. Asphalt, Rock - Porous rock such as sandstone or limestone that has become impregnated with natural asphalt through geologic process.

7. Diluent - Cutter stock such as gasoline, kerosene, and low volatile oils used to liquify asphalt cement in the manufacture of cutback asphalts.

The chemical elements commonly found in asphalts include: carbon, hydrogen, oxygen, nitrogen, sulphur and other trace minerals depending upon the source of the asphalt. These chemical elements are combined in complex compounds verying in composition, molecular weight and chemical properties. These compounds are believed to be polymers that tend to grow together and change their molecular weights and composition under varying exposure to heat,

sunlight, weather or simple aging. Such polymerization has a material affect upon the physical properties of the asphalt.

Asphalt Cement

Asphalt cements are thermoplastic materials that change in consistency or viscosity with changes in temperature. The relationship between temperature and viscosity, however, may not be the same for different sources or types and grades of asphaltic material. Grading of this material is accomplished by setting limits on the viscosity at specified temperatures; this is done by specifying minimum and maximum values for the empirical penetration test at $77^{o}F$ or the physically fundamental viscosity test at $140^{o}F$. The specifications list the types and grades of material to be used in each type of mixture.

Asphalt is a relatively strong cementing agent, readily adhesive, and resistent to the action of water, most acids, alkalies and salts. Since it is a plastic substance, it imparts flexibility within certain temperature ranges to mixtures of mineral aggregates with which it is usually combined. In view of these properties the asphalt cement content of asphalt aggregate mixtures should be as high as economic, stability, and durability requirements permit and warrant. The mineral aggregate void space (VMA), as defined by IM-321, in wearing course mixtures, and economics, additional cost of increased binder material, in base course mixtures normally control the quantity of asphalt incorporated in asphalt aggregate mixture systems.

In order to mix asphalt cement with aggregate, it is necessary to make the asphalt cement fluid by heating, emulsifying, or dilution. For high type surfacing the most practical approach is to heat and dry the aggregate and make the asphalt fluid by heating prior to mixing. The temperature must be carefully controlled at all times to prevent damage to the asphalt binder and aggregate. Minimum and maximum specification limits have been set for the various mixture types, and care should be taken to see that the requirements are met.

In the proportioning of asphalt, it is important to note that there are two methods of specifying asphalt cement content: "percent by weight of total mix", or "percent or parts by weight of dry aggregate".

> By Specification, the "percent by weight of total mix" is used on all hot mix work. This means that when a 6.0 percent asphalt content has been ordered, that each 100 lbs. of mix should contain 6 lbs. of asphalt cement and 94 lbs. of dry aggregate.

On cold mix work, the asphalt content is specified by "percent or parts by weight of dry aggregate." This means that when 5.0 percent or parts asphalt has been ordered, that 5 lbs. of asphalt cement residue is to be combined with 100 lbs. of dry aggregate. This method is utilized when cutback or emulsified asphalts are combined with aggregate mixtures. The quantity of diluent or water carried by the asphaltic material and aggregate must be kept separate in order to control the quantity of asphalt residue incorporated in the mixture.

Cutback Asphalt

Three types of cutback asphalt are currently being produced. The types and uses of this material are listed below:

(a) Rapid Curing (RC) - Liquid asphalt composed of asphalt cement and gasoline type diluent of high volatility. The lighter grades such as RC-70 are used for tack coats and light surface treatments. The heavy grades such as RC-800 are used for sealcoats and some aggregate mixtures. Since the diluent is highly volatile, flash point nil, extreme care must be used when this material is handled. A minimum amount of heat should be applied to this material.

(b) Medium Curing (MC) - Liquid asphalt composed of asphalt cement and kerosene type diluent of medium volatility. The lighter grades are used for prime coats, tack coats, and light surface treatments. The heavy grades are used for sealcoats and aggregate mixtures. Although the flash point of this material is considerably higher than the flash point of RC material, extreme care should be used when heating to minimize fire hazards.

(c) Slow Curing (SC) - Liquid asphalt composed of asphalt cement and oils of low volatility. This material is primarily used for dust alleviation treatment and soil or aggregate stabilization.

The application rates and curing periods are provided for in the specifications and on the plans. Typical application rates are as follows:

Tack Coats	RC-70, MC-70	0.02-0.05 gal/sy.
Prime Coats	MC-70	0.10-0.30 gal/sy.
Light Surface Treatments	RC-70, MC-70	0.10-0.20 gal/sy.
Seal Coats	RC-800,MC-800, MC-3000	0.25-0.35 gal/sy.
Dust Alleviation	SC-250, SC-800	0.10-0.30 gal/sy.

The asphalt content of aggregate mixtures used for base and surface courses should be based on the results of central laboratory tests unless other conditions or provisions govern. The asphalt content of maintenance patch mixtures is normally set by experience; this commonly results in asphalt contents ranging from 4% to 5% A.C. residue by weight of mix. In order for aggregate mixtures containing cutback asphalt to develop stability, it is absolutely necessary that a minimum of 50 percent of the diluent be aerated out of the mixture before it is spread and compacted. Since aggregates used in the mixtures are not dried before mixing, the aeration process must also reduce the moisture content to approximately 2 percent before compaction.

The curing properties of a cutback asphalt are determined by the quantity and type of diluent. Cutbacks containing small percentages of diluent and/or highly volatile diluent will cure more rapidly than cutbacks containing higher percentages of diluent or diluent of low volatility. Temperature and humidity also effect the rate of cure.

The measuring unit for the consistency of a cutback is the centistoke (abbreviated C.S.) and is measured in a device called a Kinematic Viscometer at $140^{O}F$. The maximum viscosity for each grade by specification is twice the minimum limit. For example, a RC-70 cutback has a viscosity range of 70 to 140 centistoke (CS). Specifications for the standard grades of cutback asphalt are provided by AASHO Specification Designations M-81, M-82 and M-141.

Emulsified Asphalt

Emulsified Asphalts are composed of asphalt cement and water, and a small quantity of emulsifying agent which is similar to detergent. They may be of either the Anionic, electro-negatively charged asphalt globules, or Cationic, electro-positivily charged asphalt globules types, depending upon the emulsifying agent.

Emulsified asphalts are produced in three grades:

1. Rapid Setting (RS)
2. Medium Setting (MS)
3. Slow Setting (SS)

The RS and MS grades are further broken down into subgrades (1 and 2); this is accomplished by changing the percentage of asphalt residue which in turn changes the consistency - viscosity. The MS and SS grades may be produced with either 100 to 200 penetration asphalt cement or 40 to 90 penetration asphalt cement; the latter type is designated (h) for hard residue. Special emulsions may be produced which contain a small percentage of high or medium volatile type diluent; these special emulsions are designed to improve or extend workability of the resultant asphalt-aggregate mixture.

Emulsified asphalts are normally used in the following manner:

Material	Usage
RS-1, CRS-1	Light Surface Treatments
RS-2, CRS-2	Seal Coats
MS-1 MS-2, MS-2h, CMS-1, CMS-2	Plant or Road mixtures with aggregates containing essentially no fine, minus No. 8, material.
SS-1, SS-1h, CSS-1, CSS-1h	Plant or Raod mixtures containing substantial fine aggregate, tack coats when diluted with 50± % water and Slurry Seals.

Application rates for surface treatments, and A.C. residue content for aggregate mixtures are designated on the plans and in the specifications. When A.C. determinations are made, moisture present in the aggregate and water contained by the emulsion must be taken into account in the calculations.

The consistency of emulsions is controlled by placing limitations on the viscosity as measured in the Saybolt Furol Viscometer at 77°F or 122°F depending on the grade. The measuring unit is "Saybolt Seconds" which is the time interval required for a given volume of material to flow through a specified orifice at the test temperature. Specifications for the standard anionic and cationic grades are provided by AASHO specification designations M-140 and M-208.

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

BITUMINOUS TREATED AGGREGATE BASE

General

Bituminous treated aggregate base mixtures are processed gravels, crushed stones, or blends gravel, sand and crushed stone stabilized with a specified percentage of asphalt. The asphalt may be incorporated by mixing emulsified asphalt or cutback asphalt with the moist aggregate blend or by mixing asphalt cement with aggregate which has been previously heated and dried. The contractor may select from specification options the binder material, mixing process, and placement procedure. Job mix formulae are not required.

These mixtures are placed as base course and stabilized shoulder surfacing although other uses may be assigned by special design. All designs should provide for a sealcoat or surface course to provide protection from traffic abrasion and weathering.

Procedures

Mixtures processed cold are mixed at or near optimum moisture content as determined by Matls. I.M. 309. This moisture content is a composite: combined aggregate moisture, water from the emulsified asphalt and water added at the mixer. When the contractor selects the option to incorporate asphalt cement as binder, conventional hot mix equipment and procedures are employed.

Mixtures containing the standard SS-1 emulsified asphalt or RC-70 cutback asphalt normally require aeration prior to final placement and compaction; the amount of aeration required is variable. Factors influencing aeration are: temperature, humidity, wind velocity, aggregate characteristics, moisture content, and aeration procedures. Aeration should be carried on until the asphalt in the windrow is uniformily tacky; in some cases it may be necessary for the contractor to place and compact special test sections to determine the proper mixture condition.

Contractors may incorporate CSS-1 emulsified asphalt or modified SS-1 emulsified asphalt as binder material to facilitate placement and compaction. The use of these materials may reduce or eliminate manipulation and aeration; this is particulary advantageous when the mixtures are placed in confined areas and on shoulders. Longer mixing times and higher moisture contents are often required to obtain adequate dispersion of the asphalt and to prevent premature break. In some cases pugmill production must be reduced by 25 to 50 percent.

Inspection

Plant calibration and inspection procedures are provided in Materials I.M. 508 and I.M. 509. Sampling and testing requirements are contained in Materials I.M. 204 and I.M. series 300. Additional information is provided by the Office of Construction.

It should be noted that the specifications do not provide for separate measurement for payment of the bituminous binder material. The bituminous binder material and moisture present following mixing are included in the pay quantities when payment is based on weight measurements.

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

ASPHALT TREATED BASE

General

Asphalt Treated Bases are composed of crushed and uncrushed aggregates stabilized with varying quantities of asphalt cement. Materials can normally be produced from local sources because quality limits reflect usage and economic requirements. Asphalt Treated Base mixtures may be placed: 1. directly on earth subgrades with minimal preparation, 2. below rigid pavements as subbase, 3. adjacent to flexible or rigid pavements as shoulders, 4. below surface courses 1 inch or more in thickness as base, leveling and strengthening courses, and 5. adjacent to rigid or flexible pavement for widening. All designs should provide for a seal coat or one inch or more of surface course before asphalt treated bases are placed in permanent service. Conventional hot mix equipment and procedures are employed to produce, place and compact asphalt treated base courses although more specialized equipment may be required for widening, shoulders, and subbases.

Job Mix Formula

When the specifications require a job mix formula, representative samples of the aggregate are to be obtained as directed by the District Materials Engineer and submitted to the Central Laboratory for analysis. A job mix formula will be set for each aggregate combination on the basis of gradation, stability, asphalt content and voids. The design criteria developed from laboratory studies and performance evaluations pertains specifically to base courses. This criteria places combined limitations on void percentage, (maximum) and effective asphalt content, (minimum). Factors influencing the resultant job mix formulae are: aggregate surface area based on gradation, aggregate absorption expressed as a function of the water absorption (50 percent), and mixture mechanical properties as determined from Marshall Stability tests. The final formula is comprised of the aggregate percentages and percent asphalt.

Inspection

Plant calibration and inspection procedures are provided in Materials I.M. 508 and I.M. 509. Sampling and testing requirements are contained in Materials I.M. 204 and I.M. series 300. Additional information and instructions are provided by the Office of Construction.

It should be noted that specifications may provide for separate measurement for payment of the asphalt cement for all asphalt treated base mixes subject to mix design. The tonnage of asphalt cement is not deducted from the tonnage of mixture incorporated and accepted in the work.

STORAGE OF RECLAIMED ASPHALT PAVEMENT

GENERAL

Reclaimed asphalt material may be stored with proper storage and certification procedures.

Stored material will not be considered for use on any project other than the one it came from or a tied project unless the storage and certification are met. It must have been salvaged from a project let by the Department of Transportation.

PROCESSING, SAMPLING, AND TESTING

Processing for use may be by means which result in a product acceptable to the Engineer. Processed material should be sampled and tested for gradation at the time of processing. Sampling and testing will be at the rate specified in the applicable contract documents. Samples shall be delivered to the District Materials Laboratory for testing.

STORAGE

Storage should be by individual sources as determined by quality of aggregate, type of asphalt cement, and size of processed material. Storage procedures must meet the specification requirements at the time of storing.

Stockpiles of RAP stored for future use should be placed on a prepared base.

CERTIFICATION

Information required for certification of RAP material into stockpile for future use shall include the following:

1. Project identification of where the material came from.
2. Mix data from original project as to type, class and size of mix, along with placement in the pavement structure (depth, surface or base, etc.), as set forth in the Special Provisions for the project from which the material was removed.
3. Identification of responsible parties including the contractor, processor, and warehouse firm.
4. Method of removal and stockpiling.
5. Description of stockpile location and quantity.
6. Extracted gradation information, if available.

A copy of the Form 820009 fully completed by the owner and verified by the contracting authority, shall be forwarded to the District Materials Office for the district in which the storage is located within 10 days of stockpile completion.

SUMMARY

Certified material on file will be considered for applicable recycled asphalt projects when meeting the source and quality requirements.

The engineer has the right to reject the use of or require additional testing of any certified stockpile for reasons of segregation, contamination, improper certification or questionable source and quality requirements.

Form 820009
10-86

Iowa Department of Transportation

HIGHWAY DIVISION

Reclaimed Asphalt Certified Report

Date _____

Owner of RAP _____

Material Description:

Salvaged from Highway No. _____ Dates of Removal _____

From _____ To _____

Original Project No. _____ Year Built _____

Surface Course: Size _____ Type _____ Class of Mix _____ Depth _____

Base or Binder: Size _____ Type _____ Class of Mix _____ Depth _____

Stockpile Description:

Location: _____

_____

Section _____ Township _____ Range _____ County _____

Lab. No.	Identification of Sample	% A.C. Extract	Gradation: 1/1000 T Minimum 3 Tests									
			¾	½	⅜	4	8	16	30	50	100	200
Average of Samples												

Note: Use additional sheets if necessary for complete gradation information.

Stockpile Photo *(Optional)*

Note: Stockpile photo will be used for future identification and should show stockpile size, shape, and relation to surroundings. Larger photos may be attached to the back of this form. All photos should have location printed on the back.

Tons in Stockpile _____ Weighed _____ Estimated _____

Type of Protection _____

Direction of Picture _____

Certified by _____

_____

Verified by _____
Iowa DOT Inspector

Copies to: Owner, District Materials, Area Inspector, Project Engineer

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

TYPE B ASPHALT CONCRETE

General

Type B Asphalt Concrete base, binder, leveling, strengthing, and surface course mixtures are composed of gravel, crushed stone or combinations of gravel, stone and sand produced from approved sources and formulated to provide service for roads carrying low to moderate traffic. The formulation procedure results in a job mix formula for each aggregate combination together with a recommended percentage of asphalt cement. Class 2 mixtures can often be prodcued utilizing a single processed aggregate such as pit run gravel because crushed particles are not specifically required. Class 1 and surface course mixes requirements include a minimum crushed particle percentage and additional controls.

Type B asphalt Concrete may be placed as base, binder, or surface course depending upon mix class and size. Class 2 mixtures may be placed full depth on virtually any roadway except those subjected to heavy traffic volumes. Class 1 mixtures may also be placed full depth; both classes of mix are commonly placed as upper base or surface on Bituminous Treated Aggregate Base and Asphalt Treated Base courses. Type B Base specifications are employed on the secondary road system and by special designs on the primary road system. The type B Surface specifications apply on primary projects unless otherwise provided. Because several options are available, care must be exercised in selecting the mix class, lift thickness, and mix size during the various stages of design and construction so that the appropriate requirements are met.

Job Mix Formula

Job mix formulae are required by the specifications for all aggregate combinations. In each case, representative samples are to be obtained as directed by the District Materials Engineer and submitted to the Central Laboratory for analysis. A job mix formula will be set for each aggregate combination on the bassis of gradation, stability, asphalt content and voids. The design criteria developed from laboratory studies and performance evaluations apply specifically to wearing courses; limiting values for the various characteristics for each mixture as actually produced are provided in Materials I.M. 511. The formulae are comprised of the aggregate percentages, percent asphalt, and gradation as limited by specification requirements. In the event satisfactory job mix formulae cannot be set within the limitations imposed by the specifications, they may be set by extra work order with the advance approval of the Construction Engineer. Formulae set in this manner may be outside of the standard limits and may incorporate material

percentages or material types other than specified. Adjustments in contract price may be required depending upon the type of changes ordered.

Special Requirements

The standard specifications for Type B aggregates and mixes permit usage of a broad range of aggregates and formulations. These requirements will provide the design level of service, light to moderate traffic, under average service conditions, although some aggregates or aggregate combinations may not exhibit satisfactory performance when incorporated in surface courses. Problems of this type will vary across the state and are to be monitored by the District Materialas Engineer. Special specifications will be prepared by the Central Office Materials staff on request or by recommendation by the District for specific projects. In some cases special provisions will be initiated by the Central Office staff for projects that will be subjected to unusual service conditions or contain special designs.

Inspection

Plant calibration and inspection procedures are provided in Materials I.M. 508 and I.M. 509. Sampling and testing requirements are contained in Materials I.M. 204 and I.M. series 300. Additional information and instructions are provided by the Office of Construction.

It should be noted that the specifications may provide for separate measurement for payment of the asphalt cement. The tonnage of asphalt cement is not deducted from the tonnage of mixture incorporated and accepted in the work.

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

TYPE A ASPHALT CONCRETE

General

Type A Asphalt Concrete binder, leveling, strengthening, and surface course mixtures are composed of combinations of high quality gravel, crushed stone, and sand produced from approved sources and formulated for service on road surfaces carrying high traffic volumes. Mixtures designated a 1 inch and 3/4 inch may also be placed full depth as base or widening although economic considerations will normally favor usage of lower mixture classes except when small quantities are required. Because four mix sizes are available, care must be exercised in selecting the lift thicknesses and mix sizes during the various stages of design and construction so that the appropriate requirements are met.

Job Mix Formula

Job mix formulae are required by the specification for all aggregate combinations. In each case, representative samples are to be obtained as directed by the District Materials Engineer and submitted to the Central Laboratory for analysis. A job mix formula will be set for each aggregate combination on the basis of gradation, stability, asphalt content and voids. The design criteria developed from laboratory studies and performance evaluations apply specifically to wearing courses; limiting values for the various characteristics for each mixture as actually produced are provided in Materials I.M. 511. The formulae are comprised of the aggregate percentages, percent asphalt, and gradation as limited by specified tolerances for each controlling sieve size.

In the event satisfactory job mix formulae cannot be set within the limitations imposed by the specifications, they may be set by extra work order with the advance approval of the Construction Engineer. Formulae set in this manner may be outside of the standard limits and may incorporate materials percentages or material types other than specified. Adjustments in contract unit price may be required depending upon the type of changes ordered.

Special Requirements

The standard specifications for Type A aggregates and mixes provide for usage of a restricted range of aggregates and formulations. These requirements will provide the design level of service, moderate to heavy traffic, under average service conditions, although some aggregates or aggregate combinations may not exhibit satisfactory performance when incorporated in surface courses. Problems of this type will vary across the state and are to be monitored by the District Materials Engineer. Special specifications will be prepared by the Central Office Materials staff on request or by recommendation by the District for specific projects. In some cases special provisions will be initiated by the Central Office staff for projects that will be subjected to unusual service conditions or contain special designs.

Inspection

Plant calibration and inspection procedures are provided in Materials I.M. 508 and I.M. 509. Sampling and testing requirements are contained in Materials I.M. 204 and I.M. series 300. Additional information and instructions are provided by the Office of Construction.

It should be noted that the specifications may provide for separate measurement for payment of the asphalt cement. The tonnage of asphalt cement is not deducted from the tonnage of mixture incorporated and accepted in the work.

ASPHALTIC CONCRETE PLANT INSPECTION

General

The certified plant inspector should witness the contractor's operations, from the initial plant set up to the final shutdown. The contractor's plant and method of operations should be examined thoroughly before work begins. Any deficiencies which are observed with regard to specification compliance should be reported to the contractor and the engineer. The certified plant Inspector's diary should include all pertinent information regarding the plant, plant set up and calibration, as well as the project data required for contract and specification compliance documentation.

On most projects an assistant plant inspector will be assigned to assist in performing the various tests and inspection function. The overall responsibility for plant inspection remains with the certified plant inspector assigned to the plant. This section of the manual deals primarily with this overall responsibility, therefore, no guidelines will be presented regarding division of duties and functions. The assignment of duties and functions of the inspection monitors remain the responsibility of the Resident Construction engineer.

PLANT INSPECTOR'S DUTIES

A. Preliminary

The first phase of the contractor's operations consists of preparing the plant site and building stockpiles. The certified plant inspector should be assigned to the project prior to this phase of the work so that those procedures which are governed by the specifications may be observed and properly controlled.

The general areas or procedures requiring attention are:

1. Construction of Stockpiles to:
   (a) Minimize segregation, and
   (b) eliminate contamination and intermingling.

   This is accomplished by construction stockpile in lifts, controlling stockpile height, controlling drifting and rolling of material, constructing partitions or bulkheads, and stabilizing the stockpile work area. Refer to the specifications for specific requirements.

2. Plant Erection Which Provides:

(a) Safe working conditions, and
(b) reliable operation.

This is accomplished by proper site preparation, placement of adequate foundations for bins and mixing equipment and constructing safeguards such as berms and drainage ways.

B. Job Mix Formula

The job mix formula together with the specifications provide the initial basis for setting up and starting the job, therefore, the plant inspector must be thoroughly familiar with the information provided by the job mix formula report.

Before a job mix formula can be developed by the laboratory, numerous arrangements must be made in the field by the contractor, material producers, and District Materials Engineer. The contractor must first select his material sources and estimate, in cooperation with the producers, the tentative proportions and gradations of each of the materials. A stockpile of at least 500 tons or project amount if less must be produced so that representative samples of the processed material can be obtained. After the contractor has selected his materials, representatives of the District Materials Office obtain samples and attempt to combine them as requested by the contractor. Adjustments may be necessary in these proposed proportions since the exact gradations may not be known in advance.

The following example demonstrates how two materials are combined to arrive at a composite gradation.

Gradations of Individual Aggregates-Percent Passing

	1"	3/4"	1/2"	3/8"	#3	#5	#16	#30	#50	#100	#200
A) 1/2 Crushed Stone		100	99	80	47	29	21	17	13	11	9.2
B) Sand				100	96	84	66	42	9.7	1.4	0.7

Example 57.5% Cr. Lmst. and 42.5% Sand

Line A x 57.5%	57.5	56.9	46.0	27.0	16.7	12.1	9.8	7.5	6.3	5.3
Line B x 42.5%	42.5	42.5	42.5	40.8	35.7	28.0	17.8	4.1	0.6	0.3
Composite Gradation	100.0	99.4	88.5	67.8	52.4	40.1	27.6	11.6	6.9	5.6

If the composite gradation complies with the limits specified for the job mix formula, production limits are set for the individual aggregates and samples are submitted to the Central Laboratory for the Job Mix Design Analysis.

Aggregate production and inspection are covered in detail by Matls. I.M. 204 and I.M. 209. The acceptance of mixture gradation is outlined in section 2.53 of the Construction Procedures and Instructions Manual.

If the materials as first analyzed do not consistently meet the specified limits, it may be necessary to adjust the proportion percentages or production limits. Familiarity with the material sources and production methods facilitates setting realistic limits. This reduces the number of trial and error steps and subsequent adjustments. It is advantageous to maintain records of this type for each material source and type.

After the preliminary proportions and limits have been established (refer to page 4) samples of the aggregates are analyzed in the laboratory to determine the characteristics of the proposed asphalt-aggregate mixture. Certain characteristics are subject to specification limitations. Occasionally changes are required in the material proportions or material sources because mixture characteristics cannot be controlled within the specification limits or design criteria. When changes are made during the design stage, they will be incorporated in the job mix formula report. If changes are found necessary after production begins, they are to be made as provided for in Materials I.M. 511 unless a complete new job mix formula is required. The report shown on Page 6, together with a description of test results, is typical of reports of this type.

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Supersedes Jan. 1986

FORM 955

IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION
OFFICE OF MATERIALS
PROPORTIONS & PRODUCTION LIMITS FOR AGGREGATES

COUNTY: MUSCATINE PROJECT NO.: SEE BELOW DATE: 08/13/86

PROJECT LOCATION: FROM E.C.L. MUSCATINE TO NEAR Y40

TYPE OF MIX: B CLASS OF MIX: 1 COURSE: SURFACE MIX SIZE: 1/2"

CONTRACTOR: RIVER CITY PAVING TRAFFIC: 4040 A.D.T.

MATERIAL	IDENT #	% IN MIX	PRODUCER & LOCATION
1/2" CR. STONE	5TH6-27	42.5	WENDLING- MOSCOW- NW1/4 8-78-2
1/2" CR. CHIPS	5TH6-28	22.5	WENDLING- MOSCOW- NW1/4 8-78-2
SAND	5TH6-29	35.0	WENDLING- ATALISSA- NW1/4 20-78-2
TYPE AND SOURCE OF ASPHALT CEMENT: AC-10 AMOCO- LINWOOD TERMINAL			

GRADATION OF INDIVIDUAL AGGREGATE SAMPLES (Typical, Target, or Average)

MATERIAL	SIEVE ANALYSIS -% PASSING 1-1/2	1	3/4	1/2	3/8	4	8	16	30	50	100	200
1/2" CR. STONE	100	100	100	99	86	56	40	30	25	20	16	12
1/2" CR. CHIPS	100	100	100	100	93	15	2.1	1.7	1.5	1.3	1.1	0.8
SAND	100	100	100	100	100	95	86	70	45	15	1.9	0.4

PRELIMINARY JOB MIX FORMULA TARGET GRADATION

TOLERANCE				98/100	7	7	6		5			3
COMB GRADING	100	100	100	100	92	60	48	38	27	14	7.7	5.4
SURFACE AREA C.	TOTAL					0.02	0.04	0.08	0.14	0.30	0.60	1.60
S.A. SQ. FT./LB.	29.37				+2.0	1.2	1.9	3.0	3.7	4.2	4.6	8.7

PRODUCTION LIMITS FOR AGGREGATES APPROVED BY THE CONTRACTOR/PRODUCER

SIEVE SIZE	42.5% 1/2" CR. STONE		22.5% 1/2" CR. CHIPS		35.0% SAND					
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
1"	100.0	100.0	100.0	100.0	100.0	100.0				
3/4"	100.0	100.0	100.0	100.0	100.0	100.0				
1/2"	98.0	100.0	98.0	100.0	100.0	100.0				
3/8"	79.0	91.0	89.0	100.0	100.0	100.0				
#4	49.0	60.0	8.0	19.0	90.0	100.0				
#8	35.0	43.0	1.0	5.0	81.0	89.0				
#30	20.0	28.0	1.0	4.0	41.0	47.0				
#200	8.0	13.0	0.0	2.0	0.0	1.5				

COMMENTS: PROJECT NO.: FN-22-4(36)--21-70 FN-22-4(44)--21-70

The above data is furnished for informational purposes only. The Contracting Authority makes no representations as to accuracy, either expressed or implied, which are to be construed to relieve the Contractor from the responsibility to comply with the specifications.

Signed_____ Signed_____
Contractor/Producer Dist. Matls. Engr.

c: Materials
Dist. 1 Materials
R. Monroe
Const. Dept.

D. Heins — D.M. Asphalt — Harold Smith-City of D.M. — Hallett Const. — Weavers — Martin Marietta D.M. Lab — C. Berry — M. Trueblood

FORM 955
3-75

Matls IM 508
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IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION
Office of Materials

PROPORTIONS & PRODUCTION LIMITS FOR AGGREGATES

COUNTY: Polk PROJECT NO.: W.O. 0206-85-009 DATE: 6-19-86

PROJ LOCATION: On Fleur Drive from R.R. Viaduct to McKinley Avenue

TYPE AND CLASS OF MIX: Type A COURSE: Binder and Surface MIX SIZE: 1/2"

CONTRACTOR: Des Moines Asphalt TRAFFIC: 29,000 VPD ~~XXXX~~

MATERIAL	SAMPLE INDENT.	PROP. % IN MIX	PRODUCER & LOCATION
1/2" Quartzite	1MT6-58	55.0	Weaver Const. 28-12N-5E Sauk Co. Wisc.
1/2" Washed Chips	1MT6-59	12.5	Mar. Marietta, Ames SW-24-84-24 Story
Sand	1MT6-60	32.5	Hallett (EDM) SE-18-78-23 Polk
Asph. Cement	PAC-30	Polymerized Asph. Cement	Bitucote Prod. - Des Moines, Iowa

GRADATION OF INDIVIDUAL AGGREGATE SAMPLES (Typical, Target, or Average)

MATERIAL	SIEVE ANALYSIS -% PASSING											SILT
	1	3/4	½	3/8	4	8	16	30	50	100	200	
1/2" Quartzite			100	93	58	38	26	19	15	11	8.0	
1/2" Washed Chips		100	99	87	30	6.5	3.5	3.0	2.5	2.0	1.8	
Sand				100	99	92	78	46	16	1.9	1.0	

PRELIMINARY JOB MIX FORMULA TARGET GRADATION

TOLERANCE ±			100	98/100	7	7	5		4			2	
COMBINED GRADING				100	95	68	52	40	26	14	6.9	4.9	
SURFACE AREA C.						.02	.04	.08	.14	.30	.60	1.60	TOTAL
S. A. SQ. FT. /LB.					+2.0	1.36	2.04	3.2	3.64	4.2	4.14	7.84	28.42

PRODUCTION LIMITS FOR AGGREGATES APPROVED BY THE CONTRACTOR/PRODUCER

SIEVE SIZE	1/2" Quartzite		1/2" Washed Chips		Sand					
	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
1										
3/4	100		100							
½	98	100	98	100						
3/8	86	98	80	94	100					
4	51	63	23	35	92	100				
8	33	42	1.5	11	87	96				
30	15	22	0	6.0	42	49				
50										
200	6.0	10	0	3.5	0	2.0				

COMMENTS:
(Spec. No. etc.)

1010

The above data is furnished for informational purposes only. The Contracting Authority makes no representations as to accuracy, either express or implied, which are to be construed to relieve the Contractor from the responsibility to comply with the specifications.

Signed George D. Seward
Contractor ~~Producer~~

Signed for Kirk F. Brannaman
Dist. Matls. Engr.

January 1987
Supersedes Jan. 1986

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
ASPHALT CONCRETE MIX DESIGN
LAB LOCATION AMES

MIX, TYPE AND CLASS: TYPE B LAB NO. ABD6-173

INTENDED USE: SURFACE

SIZE 1/2" SPEC. NO. 1000 DATE REPORTED 8-20-86
FN-22-4(36)--21-70
(A) COUNTY MUSCATINE PROJECT FN-22-4(44)--21-70

CONTRACTOR RIVER CITY PAVING

PROJ. LOCATION FROM E.C.L. MUSCATINE TO NEAR Y-40

AGG. SOURCES CR. LST. & CHIPS - WENDLING, MOSCOW QRY, MUSCATINE CO.;
SAND - WENDLING, ATALISSA, MUSCATINE CO.

(B) JOB MIX FORMULA AGGREGATE PROPORTIONS: 42.5% AAT6-776; 22.5% AAT6-777; 35% AAT6-778

JOB MIX FORMULA - COMBINED GRADATION

	1-1/2"	1"	3/4"	1/2"	3/8"	NO.4	NO.8	NO.16	NO.30	NO.50	NO.100	NO.200
(C)				100	92	60	48	38	27	14	7.7	5.4
TOLERANCE:				98/100	7	7	6		5			3*

(D)	ASPHALT SOURCE AND APPROXIMATE VISCOSITY	AMOCO - 1070 POISES		
	PLASTICITY INDEX			
(E)	% ASPH. IN MIX	4.5	5.5	6.5
(F)	NUMBER OF MARSHALL BLOWS	50	50	50
	MARSHALL STABILITY - LBS.	2538	2468	1953
	FLOW - 0.01 IN.	7	8	13
(G)	SP.GR. BY DISPLACEMENT(LAB DENS.)	2.368	2.400	2.401
(H)	BULK SP. GR. COMB. DRY AGG.	2.704	2.704	2.704
(I)	SP. GR. ASPH. @ 77 F.	1.029	1.029	1.029
(J)	CALC. SOLID SP.GR.	2.548	2.509	2.471
(K)	% VOIDS - CALC.	7.06	4.34	2.85
(J)	RICE SP. GR.	2.541	2.489	2.451
(K)	% VOIDS - RICE	6.81	3.58	2.04
(L)	% WATER ABSORPTION - AGGREGATE	0.95	0.95	0.95
(M)	% VOIDS IN THE MINERAL AGGREGATE	16.37	16.12	16.98
(N)	% V.M.A. FILLED WITH ASPHALT	56.89	73.06	83.23
(O)	CALCULATED ASPH.FILM THICKNESS(MICRONS)	6.98	8.81	10.67
(P)	FILLER/BITUMEN RATIO		1.02	

(Q) A CONTENT OF 5.3% ASPHALT IS RECOMMENDED TO START THE JOB.
* ALSO CONTROLLED BY FILLER/BITUMEN RATIO

COPIES:
ASPH. MIX DESIGN
PROJ. LISTED ABOVE
DISTRICT ENGINEER
RESIDENT ENGINEER
BITUMINOUS ENGINEER
BIT. FIELD ENGINEER
MIX DESIGN ENGINEER
CONTRACTOR

ASPHALT CONCRETE MIX DESIGN

Refer to:

Section A. Project Information.

Line B. Job Mix Formula aggregate proportions set as specified. Aggregates listed by lab. no. in sequence as identified on source line in section A.

Line C. Job Mix Formula target and design gradation with tolerances.

Line D. Source and grade of the asphalt used in the job mix formula.

Line E. Asphalt percentages used to establish asphalt content for formula.

Line F. Marshall Stability and Flow test data, refer to I.M. 511 for recommended minimum stability values.

Line G. The specific gravity by displacement of the (2 1/2 by 4 in. dia.) specimens before being tested for stability. The specimens are compacted in a mold by a mechanical Marshall compactor. These lab density values are used to compute void percentages line K, per I.M. 510.

Line H. The bulk specific gravity of the combined aggregate used in the trial mixtures.

Line I. The specific gravity of the asphalt used in the laboratory trial mixtures.

Line J. The calculated solid specific gravity as determined per I.M. 510 and Rice Specific Gravity as determined per I.M. 340.

Line K. The percent total voids in the compacted specimens.

Refer to Matls. I.M. 510 for the recommended methods of measurement and calculation for results shown in lines J, K, M and N.

Line L. The percent by weight of water absorption for the combined aggregate used in these trial mixtures.

Line M. The voids in the mineral aggregate expressed as percent of the bulk volume of the compacted mixture. This void space is defined as the intergranular void space between the particles of aggregate in a compacted mixture.

Line N. The percentage listed in line M filled with asphalt, design range 65-80 percent.

Line O. Average asphalt coating film thickness, the ratio of effective asphalt, adjusted for absorption, to the aggregate surface area as determined from the job mix formula gradation.

Line P. The ratio between the -200 material and the asphalt cement.

Line Q. The target asphalt content recommended to start the job set as specified as part of the job mix formula.

C. Sampling and Testing

There are a number of sampling and testing procedures that a plant inspector must be familiar with and perform in order to establish and maintain acceptable quality construction. A number of these tests, measurements, and calculations, in addition to documenting specification compliance, also provide the basis for determining contract pay quantities.

Sampling frequencies are provided for in Materials Department I.M. 204 and the Standard Specifications. Sampling and testing methods are provided for in the Materials Department I.M. 300 series. Testing equipment may be obtained from the District Office and the Central Laboratory; other supplies may be obtained from the Central Storerooms. Each of the measurements and tests which are the responsibility of the plant inspector are discussed in subsequent sections of this instruction.

D. Plant Equipment

Items of equipment to be checked for specification compliance prior to beginning operations are listed below:

1. Truck Scales
2. Cold Aggregate Feeders
3. Dryer
4. Dust Collector and Feeder
5. Hot Aggregate Storage Bins and Feeders
6. Revolution Counters, and/or Scales
7. Thermometer Equipment.
8. Equipment for Heating, Storing and Measuring Asphalt Cement
9. Asphalt Pump, Surge Tank, and/or Scales
10. Testing Laboratory
11. Safety Requirements

Refer to the following plant diagrams and descriptions.

In addition to determining if all of the required equipment is available and functioning properly, the plant inspector should look for potential sources of difficulty. One of the most troublesome difficulties encountered during production is mixture segregation which may be caused by plant equipment or operation. Segregation at the plant may be caused by:

1. Pugmill discharge being too high above the truck bodies.

2. Depositing into very large truck bodies, causing the mixture to cone and roll. In this case trucks should be moved back and forth during loading.

3. Pugmill or storage gates opening improperly. They may not open or close quickly or to the full extent of the opening.

4. Inadequate mixing. This may be caused by short mixing cycle, improper mixer paddle positioning, worn paddles, or low level in the mixing chamber.

5. Improperly designed, maintained, and operated surge and storage bins and conveyors. Example - material discharge into conveyor must be centered into the bucket or belt.

6. Failure to provide near level truck charging platform.

Coarse - lean mixtures are more subject to segregation than fine-rich mixtures, therefore more care must be exercised when the former type of mixtures are being produced. Undue segregation of the mix results in non-uniform distribution of the material in the pavement. This can lead to a patchy appearance as well as early structural distress.

Another troublesome problem encountered during production is contamination of the asphalt cement. This may be caused by:

1. Allowing fuel oil used for cleaning pumps and lines to enter the storage tanks.

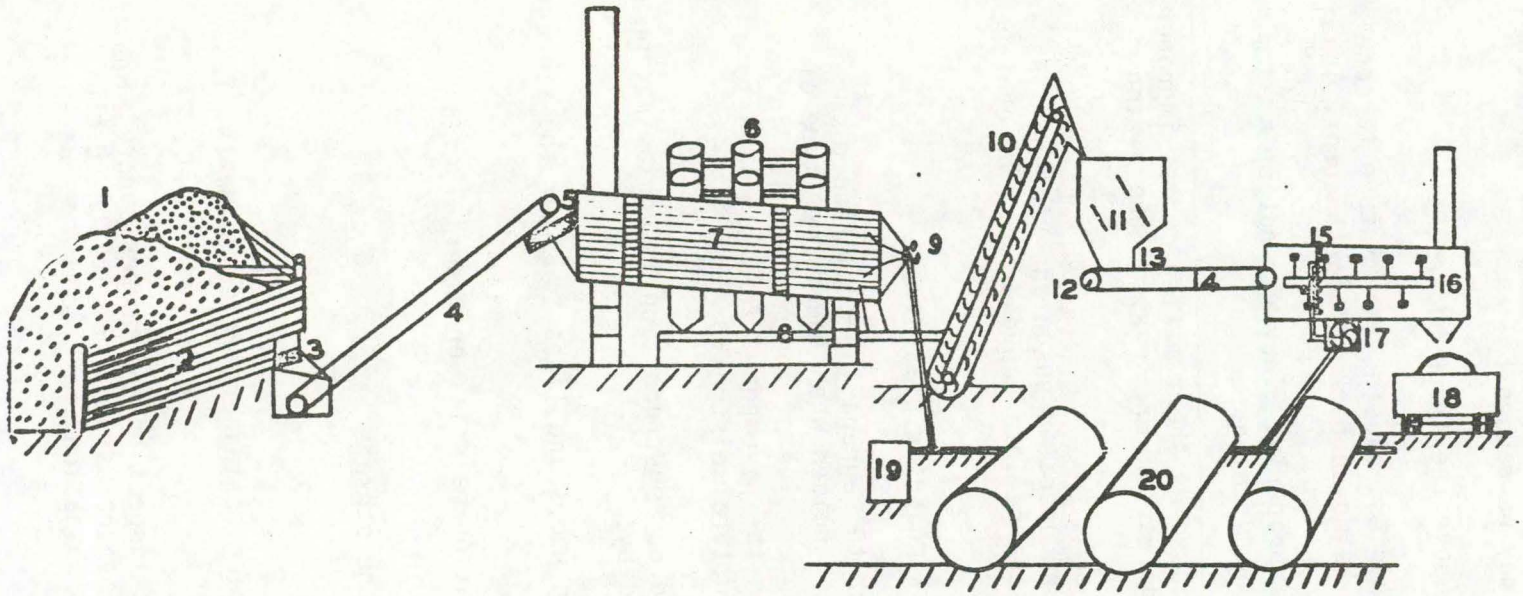
2. Accepting delivery of non-specification material or material of a different grade.

3. Leakage of plant heating oil into the storage tanks.

4. Contaminated delivery tanks.

5. Improper sampling, and sample catching container, refer to Matls. I.M. 323.

Contamination can be prevented by alert inspection and proper supervision by the contractor since most of the problems are associated with the use of cleaning fluids and improper material combination.



CONTINUOUS PLANT

Material Flow Diagram

1. Aggregate Stockpiles
2. Separating Bulkheads
3. Proportioning Feeder
4. Cold Aggregate Conveyor
5. Dryer Intake, Screen
6. Dust Collector
7. Dryer Drum
8. Dust Return
9. Burner
10. Hot Aggregate Elevator
11. Hot Aggregate Storage Bin
12. Approximate Location of Revolution Counter
13. Bin Gate Control
14. Feeder Belt
15. Asphalt Spray Bars
16. Mixer and Holding Hopper
17. Asphalt Pump
18. Truck Position
19. Fuel Line to Burner
20. Asphalt Storage Tanks

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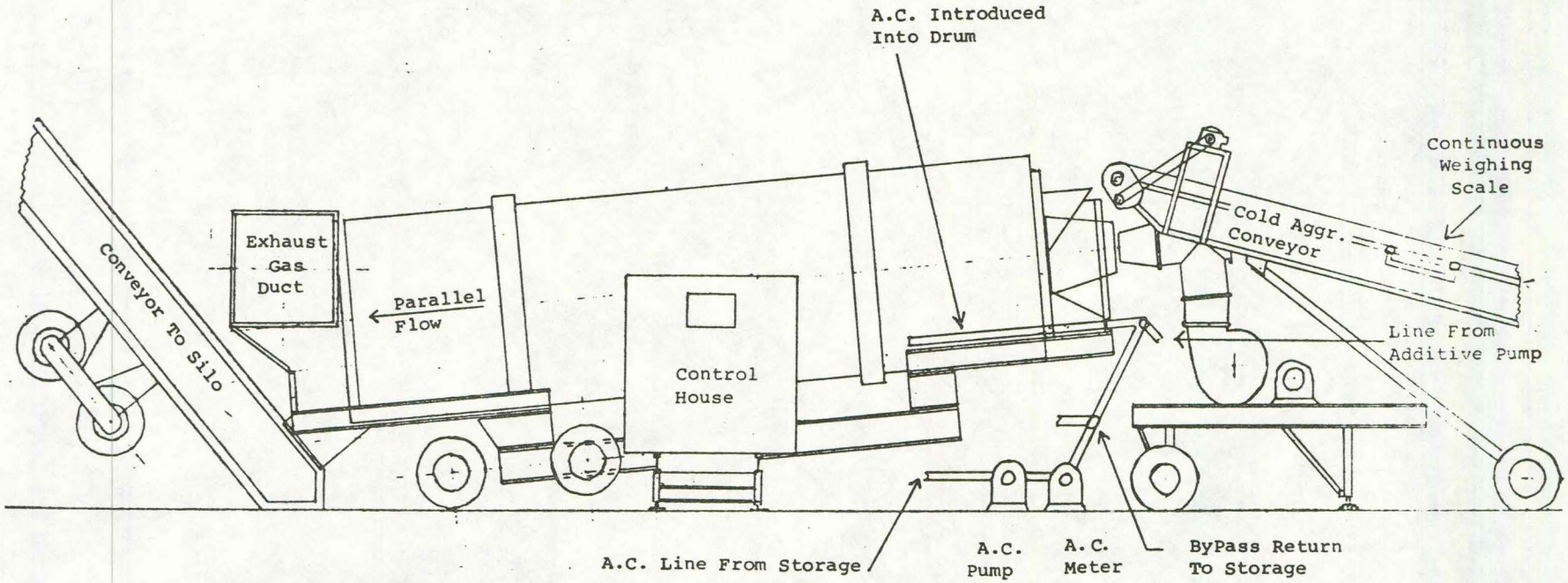
DRIER DRUM MIXER



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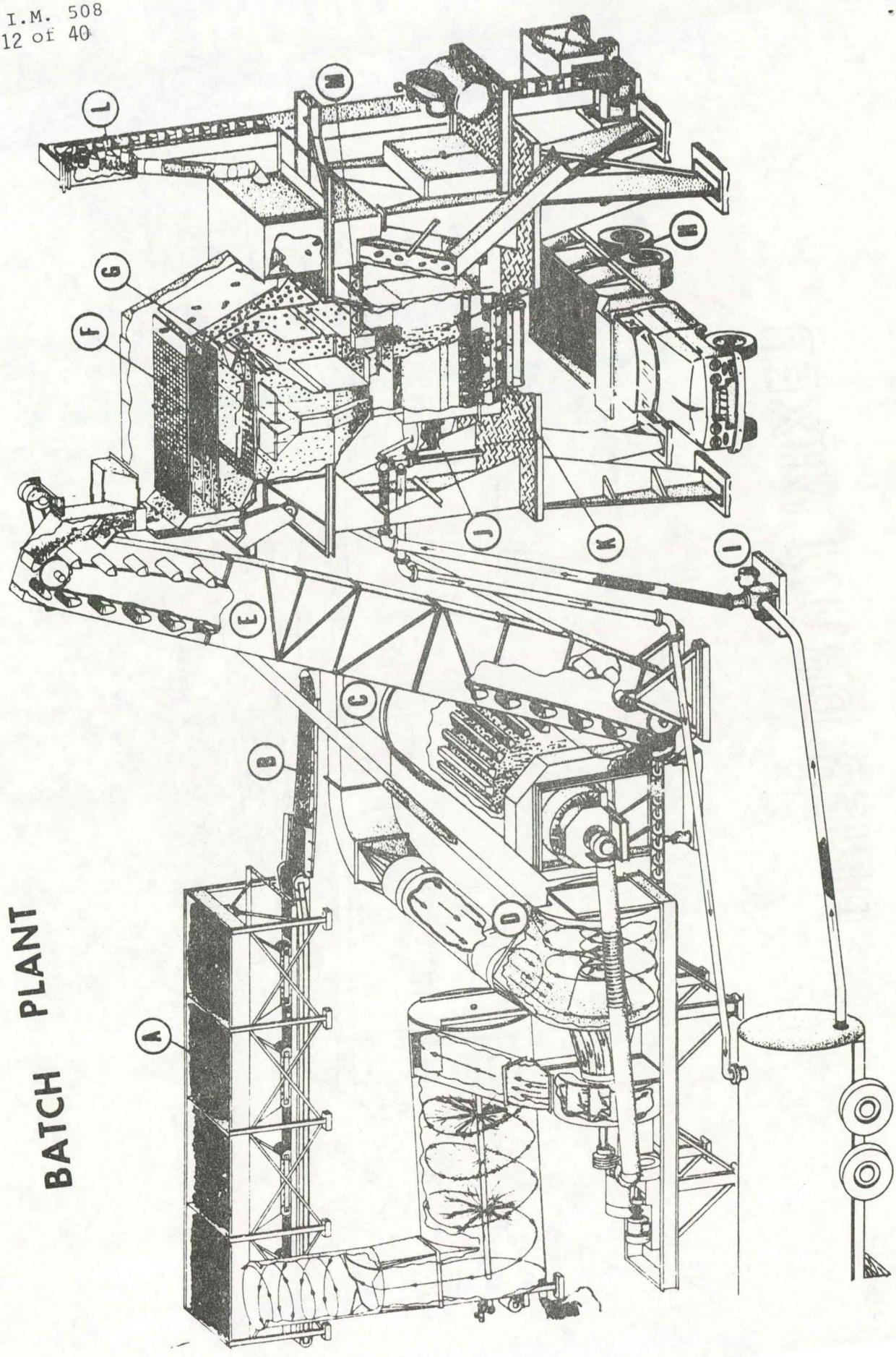

BATCH PLANT

BATCH PLANT
MATERIAL FLOW DIAGRAM

A. Multiple Compartment Cold Feeder
B. Cold Elevator
C. Drier
D. Horizontal Cyclone Dust Collector & Exhaust Washer
E. Hot Aggregate Elevator & Dust Return
F. Screening Unit
G. Hot Aggregate Storage Bins
H. Aggregate Batcher & Scale
I. Asphalt Transfer Pump
J. Asphalt Batcher & Scale
K. Pugmill Mixer
L. Optional Mineral Filler Elevator
M. Optional Mineral Filler Feeder

E. Plant Calibration

The specifications require that all material proportioning equipment be calibrated and checked for accuracy. The job mix formula provides the basis for the calibrations.

When specifications require that the contractor provide the personnel, scales, test weights, and equipment for calibrating each delivery component, the plant inspector shall determine moisture contents of the various materials. The calibration operations will be monitored by and subject to the approval of the District Materials Engineer or his authorized representative. The plant inspector should be present and observe all procedures. The District Materials Engineer will furnish the plant inspector with copies of the calibration results, so that adequate information is available for making adjustments when indicated. Should difficulty be experienced during operations, the District Materials Engineer should be contacted for assistance. Normally the District Materials Engineer will assign one or more experienced inspectors to monitor the calibration of proportioning and mixing plants. The plant inspector should be thoroughly acquainted with plant operations, so that problems are recognized and corrected as early as possible.

A sample calibration has been included as a guide in this section (pages 18 to 26). Due to the wide variation in plant equipment, this example will not cover all situations, but it should provide the basis for understanding the overall procedure.

1. Cold Aggregate Feeders

The first step in calibrating a proportioning plant is the calibration of the cold aggregate feeders. These units determine the final gradation of the mixture.

(a) Fixed Speed-Variable Gate Opening Cold Feeders
These feeders are controlled by gates which meter the flow volumetrically. They are calibrated by weighing the quantity of material which passes through a given gate opening during a measured time interval. The interval is determined by counting the number of revolutions that the feeder makes while the material is delivered. From the RPM of the feeder and the weight of the material, the deliver rate in pounds per minute is calculated (corrected for moisture). The calibration is graphed by plotting the pounds of dry aggregate delivered per minute at the gate openings used in the calibration.

(b) Fixed Gate Opening-Variable Speed Cold Feeders
With this system, a gate opening is selected for each cold feeder. This gate opening must be maintained throughout the calibration and the job. They are calibrated by weighing the amount of material delivered at several different speeds of the cold feeder motor over a measured time interval.

The calibration is graphed by plotting the pounds of dry aggregate delivered per minute at the speeds of the cold feeder motor used in the calibration.

These cold feeders are equipped with a master control, which may be used to adjust the production rate. Changing the master control setting changes the speed of all the cold feeders proportionately.

(c) With either type of cold feed, the gate setting is very important and should be checked regularly.

(d) Refer to the following table and graphs A, B and C.

2. Conveyor Scales

The specifications require Drier Drum Mixing Plants be equipped with continuous weighing central conveyor scales that are interlocked with the asphalt deliver system. These scales are checked for accuracy by two methods as follows:

1. The scale is first zeroed while the conveyor is operating at normal operating speed but unloaded. It is then adjusted to readout a predetermined total weight using the special scale beam weights and a standard operating time interval. Both of the foregoing procedures are to be performed in accordance with the scale manufacturer's instructions.

2. The second accuracy check requires the comparison of the weight shown on the totalizing meter, with the weight actually delivered as determined by running material over the conveyor into a tared truck. The truck tare and loaded weights must be obtained by weighings over certified commercial truck scales, or plant scales that have been checked against certified scales and approved by the engineer. The conveyor scales should be checked at several delivery rates representing the proposed operating range. The contractor shall adjust the weighing system so that when the plant is operating, the final mixture is uniform and consistently within the specified job mix formula tolerances.

3. Asphalt Pump

Some batch plants, all continuous and drum mixing plants deliver asphalt material to the mixer through volumetric pumps. The pumps are adjusted by changing drive sprockets or movement of a vernier dial control. These volumetric systems must be calibrated throughout the proposed operating range at the normal operating temperature. Refer to graph D. When totalizing meters are required, they must be adjusted to readout the quantity delivered within the specified deliver tolerance.

4. Hot Aggregate Feeders

After the various aggregates have been proportioned and dried, they are fed to the mixer unit in one of two ways:

(a) On continuous flow plants the hot aggregate is fed through adjustable calibrated gates to the mixer by elevator or belt. These feeders are calibrated in the same manner that cold feeders are calibrated, but in relation to the plant revolution counter. Refer to tables and graphs E and F.

(b) On batch plants the hot aggregates are weighed in batches over calibrated scales as described in the following paragraphs and examples.

The dust collected by the dust collector is fed from a calibrated bin or returned directly to the hot aggregate, depending on the type of plant equipment and the specifications requirements. If the dust is returned separately, the feeder should be calibrated to feed the required quantity of dust in a uniform manner. If the dust is returned directly to the hot aggregate, the weight or volume of dust collected and returned is taken into account automatically in the calibration of the hot aggregate delivery system or batch weights.

If the plant is equipped with a gradation unit which divides the aggregate after drying by screening into size fractions, it will be necessary to determine the percentage of each size fraction that must be fed or weighed into the mixer or weigh box. This may be done by one of two methods. In the first method the plant screen sizes must be known such that the percentage passing (adjusted for carry over) each screen can estimated from the estimated average composite gradation curve. These percentages are then used to compute the delivery rate (gate openings) or batch weight for each size fraction. The second method which can be only used for setting up batch plants is based on the actual weights of material accumulated in each individual hot bin after a short period of plant operation. The bin weights are totaled and the individual bin weights converted to percentages of the total. These percentages are multiplied by the size of the aggregate batch, this results in individual batch weights for the various size fractions. Either of the previously mentioned methods of determining proportions are subject to adjustment as work progresses since the estimates are subject to error and

variation will be encountered in the gradation of the aggregates being fed to the plant. When gradation units are used, they should be balanced, to deliver material which has a gradation similar to the composite gradation being delivered by the cold feed system.

5. Batch Plant Scales

Calibration of batch plant scales as required by the specifications is performed by incrementally loading the scales with standard test weights and partial batches through the operating range of the scales. As each increment of load is applied, the actual observed weight and the required weight are compared. The differences, plus or minus, are determined and converted to percentages of the required weight. If the percentage deviations are less than the tolerance allowed by the specifications and the scales are sensitive to the test loads, the scales will be considered in calibration. If the scales do not meet the various requirements, the contractor should be notified immediately and required to make the necessary repairs or adjustments. Recalibration may be ordered by the engineer if the scale equipment malfunctions or if required material quantities do not agree with actual material quantities.

6. Initial Plant Settings

Three examples of initial plant settings have been provided: one for a continuous plant with a vernier type A.C. pump control, one for continuous plant with a sprocket type asphalt pump, and one for a 6000 pound batch plant with a scale bucket for asphalt measurement.

The plant inspector is at this point cautioned not to make adjustments or effect settings of plant equipment, and in no way manipulate or operate any equipment at any time. All operations connected with the contractor's plant or other equipment are by specification the strict and total responsibility of the contractor.

7. Mixing Rate

The specifications contain requirements regarding the quality and duration of mixing for the various types of mixes and plants. The design, condition, speed and loading of the mixer unit together with the characteristics of the materials being mixed will vary from job to job and need to be taken into account when evaluations are made.

Mixing times are determined in the following manner:

(a) Continuous Plants. Mixing time in a continuous plant is the interval between the entrance of the aggregate into the mixer and the discharge of the same aggregate, coated with asphalt, from the mixing chamber. The mixing time in "seconds" is determined by the following formula:

$$\frac{\text{Pugmill Content (Pounds)}}{\text{Pugmill Output (Pounds per second)}} = \text{Mixing Time (Seconds)}$$

The pugmill content in pounds is determined under operating conditions by stopping the mixer, emptying hopper, cutting off the feed and running the material in the mixer into a separate truck to be weighed. The weight of the material adhering to the walls and paddles of the mixer is estimated and added to the quantity in the truck. The pugmill output equals the pugmill input and is determined from the bitumen pump and hot aggregate calibration data. Mixing times may be increased by: 1. reversing the mixer paddles to retard the flow of material through the mixer, 2. by reducing the material input rate, 3. raising the dam gate at the end of the mixer.

(b) Batch Plants. The mixing rate of batch plants is controlled by the batch size and the dry and wet mixing timer settings. The batch size should not exceed the manufacturers rated capacity and the timer should be set to provide the specified mixing time unless more or less time is authorized by the engineer. The accuracy of the timer may be checked with a stop watch if necessary.

January 1987
Supersedes Jan. 1986

Form 820916
3-86

Iowa Department of Transportation
CALIBRATION OF PLANT EQUIPMENT
Cold Feed and Asphalt Cement Delivery
(Continuous - Batch - Drum)

County Tama
Project FR-30-6(44)--2G-86
Date 8-4-86
Proj. Eng. John Peters

Contractor Cessford Const. Plant Location Montour Quarry Material Ident. & % 3/4" Cr. Lmst 58% Moisture 2.6 %

Plant Type and Name Cedar Rapids - Drum Mix ADM-1 Pollution Control ____ Material Ident. & % Sand 30% Moisture 4.0 %

Mix Type B Binder Recycled Class I Mix Size 3/4" Gate ____ Material Ident. & % RAP 12% Moisture 5.1 %

Asphalt Type and Grade AC-10 Temperature °F ____ RPM Feeder/RPM Plant/Master Maximum Plant Set for 300 TPH

Bin Number	#1 SAND			#2 and 3 3/4" Cr. Lmst.						#5 R.A.P.		
~~Pump vernier setting/gate opening in inches~~/Dial setting	Dial - 8.2			Dial - 5.9			Dial - 5.9			Dial - 6.1		
Run number	1	2	3	1	2	3	1	2	3	1	2	3
Revolutions delivered/Time delivered												
Total wet weight aggregate delivered/TPH wet	93.6			178.5 →			→			37.8		
Total weight A.C. delivered Total dry weight aggregate delivered/TPH Dry	90.0			174.0 →			→			36.0		
Dry weight per revolution												
Dry weight per minute												
~~Average dry weight per (Minute-Rev.)~~/Tach set point	88.0			48.0			28.0			79.0		
	Gate 6"			Gate 6"			Gate 6"			Gate 4"		

Date scale was certified 8-4-86

The above data is furnished as set forth in the Standard Specifications for plant operations, for informational purposes only. The Contracting Authority makes no representations as to accuracy, either expressed or implied, which are to be construed to relieve the Contractor from the responsibiity to comply with the specifications.

Distribution:
White Copy - Plant Inspector
Canary Copy - Contractor
Pink Copy - District Materials Engineer
Goldenrod Copy - Project Engineer

Calibrated by Theodore Huisman (Name) monitored ~~Witnessed~~ by Mark Trueblood (Name)

Contractor Cessford Construction Title Asphalt Tech. - Dist. 1 Materials

January 1987
Supersedes Jan. 1986

Form 820915
9-85

CALIBRATION OF PLANT EQUIPMENT
(DRUM MIX PLANT)

Tama County
Project FR-30-6(44)--2G-86
Date 8-4-86
Report No.

Contractor Cessford Construction Plant Location Montour Quarry Res. Eng./Co. Eng. John Peters

Plant Type and Name Cedar Rapids - Drum Mix Material Ident. & % Moisture %

Mix Type B Binder (Recycled) Class I Mix Size 3/4"

Asphalt Type and Grade AC-10 Temperature °F A.C.#/Gal. 8.55

WEIGH BELT	Virgin Weigh Belt			Recycled Weigh Belt			A.C. PUMP						
Run Number	1	2	3	1	2	3	Run Number	1	2	3	1	2	3
Span	2541	2578	2578	2124	2124		Meter Er. Gals.	299	300				
Fine Zero	5524	5524	5524	4800	4800		Corrected Gals.						
Total weight aggregate lbs.	17,640	17,460	17,500	11,390	10,660		Metered lbs.	2556	2565				
Truck total weight aggregate lbs.	17,900	17,440	17,490	11,420	10,720		Truck lbs.	2560	2568				
Difference	-260	+20	+10	-30	-60			4	3				
% Error	1.45	0.1	0.06	0.26	0.6		% Error	0.16	0.12				

Scales comply ☒ Yes ☐ No

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Distribution:
White Copy - Plant Inspector
Canary Copy - Contractor
Pink Copy - District Materials Engineer
Goldenrod Copy - Resident Engineer

Calibrated by Theodore Huisman (Name)
Contractor Cessford Construction

monitored ~~Received~~ by Mark Trueblood (Name)
Title Asphalt Tech - Dist. 1 Materials

Iowa Department of Transportation

CALIBRATION OF PLANT EQUIPMENT

County: MADISON
Project: BR-30-5(24)
Date: 4-13-1987
Report No: 1

Contractor: CESSFORD CONSTRUCTION CO. Plant Location: Winterset
Res. Engr./Co. Engr.
Plant Type and Name: Batch - Cedar Rapids Material: 3/4" Cr. Stone Moisture: 2.0 %
Mix Type: Type A Class: Mix Size: 3/4" Surface E.P.M. Feeder: 28.5 E.P.M. Plant:
Asphalt Type and Grade: PG-100 Temperature °F: 300°

See Graph 'A'

Pump vernier setting, gate opening in inches	3"			4"			5"					
Run number	1	2	3	1	2	3	1	2	3	1	2	3
Revolutions delivered	125.0	145.5		58.3	58.4		42.5	41.8				
Total wet weight aggregate delivered	7500	9190		4910	4930		4460	4390				
Total dry weight aggregate delivered	7353	9010		4814	4833		4373	4304				
Dry weight per revolution	58.8	61.9		82.6	82.8		102.9	103.0				
Dry weight per minute	1700	1790		2386	2392		2973	2976				
Average dry weight per (Minute Rev.)	1745 ⊙			⊙ 2389			⊙ 2974					

E.P.M. Feeder: 28.5
Material: 3/8 inch cr. stone - 25% Moisture: 4.5 %

See Graph 'B'

Pump vernier setting, gate opening in inches	2"			3"			4"					
Run number	1	2	3	1	2	3	1	2	3	1	2	3
Revolutions delivered	125.0	145.5		58.3	58.4		42.5	41.8				
Total wet weight aggregate delivered	7500	9190		4910	4930		4460	4390				
Total dry weight aggregate delivered	7177	8794		4699	4718		4268	4201				
Dry weight per revolution	57.4	60.4		80.6	80.8		100.4	100.5				
Dry weight per minute	1659	1747		2329	2335		2902	2904				
Average dry weight per (Minute Rev.)	1703 ⊙			2332 ⊙			2903 ⊙					

E.P.M. Feeder: 28.5
Material: Sand - 30% Moisture: 4.0 %

See Graph 'C'

Pump vernier setting, gate opening in inches	3"			4"			5"					
Run number	1	2	3	1	2	3	1	2	3	1	2	3
Revolutions delivered	140.0	141.5		88.1	83.1	88.1	66.5	69.5				
Total wet weight aggregate delivered	8220	8500		8910	7450	7910	7800	8310				
Total dry weight aggregate delivered	7904	8173		8567	7163	7606	7500	7990				
Dry weight per revolution	56.5	57.8		97.2	86.2	86.3	112.8	115.0				
Dry weight per minute	1632	1669		2810	2491	2495	3259	3323				
Average dry weight per (Minute Rev.)	1650 ⊙			★ ⊙ 2493			3291 ⊙					

Scales certified: ☒ Yes ☐ No

* Run # 1 & 2 are too far apart need a 3rd run. (eliminate run #1, use avg. of #2 & #3).

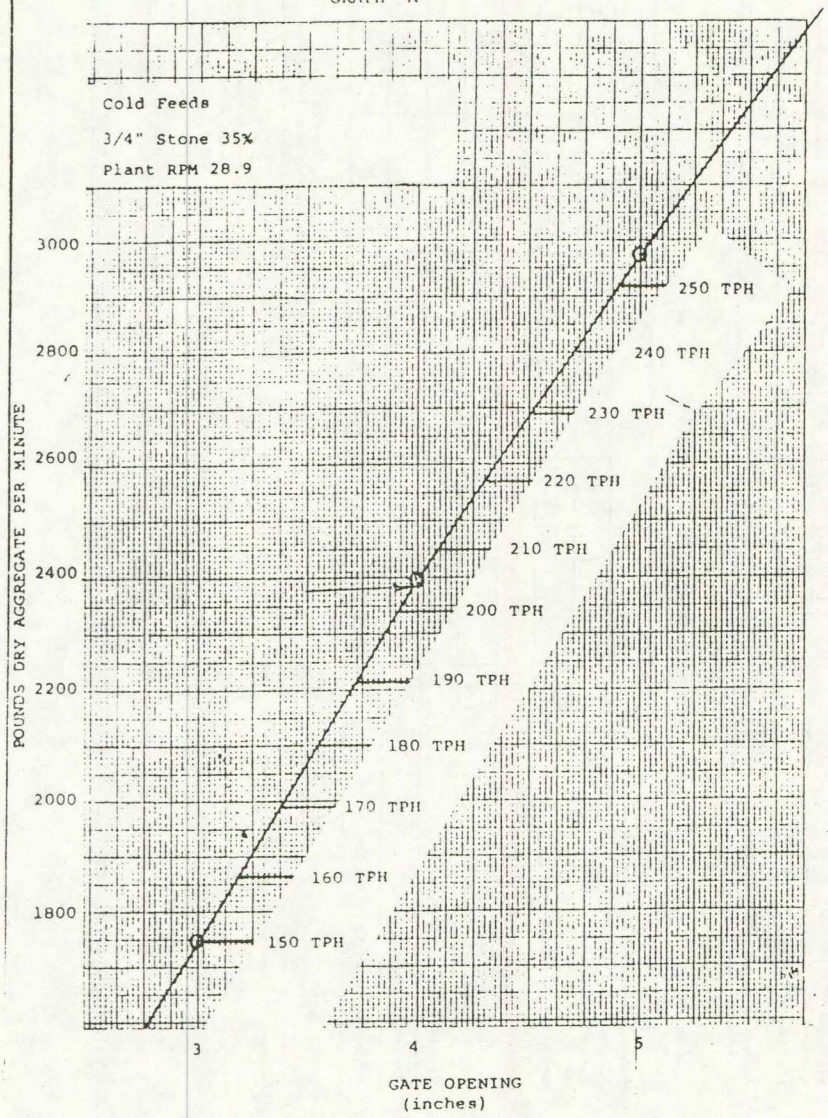
The above data is furnished as set forth in the Standard Specifications for plant inspection for informational purposes only. The Contracting Authority makes no representations as to accuracy, either express or implied, which are to be construed to relieve the Contractor from the responsibility to comply with the specifications.

Distribution
Copy 1 - Plant Inspector
Copy 2 - Contractor
Copy 3 - District Materials Engineer
Copy 4 - Resident Engineer

Calibrated by: Bill Brown
M.I.S. 1
Title

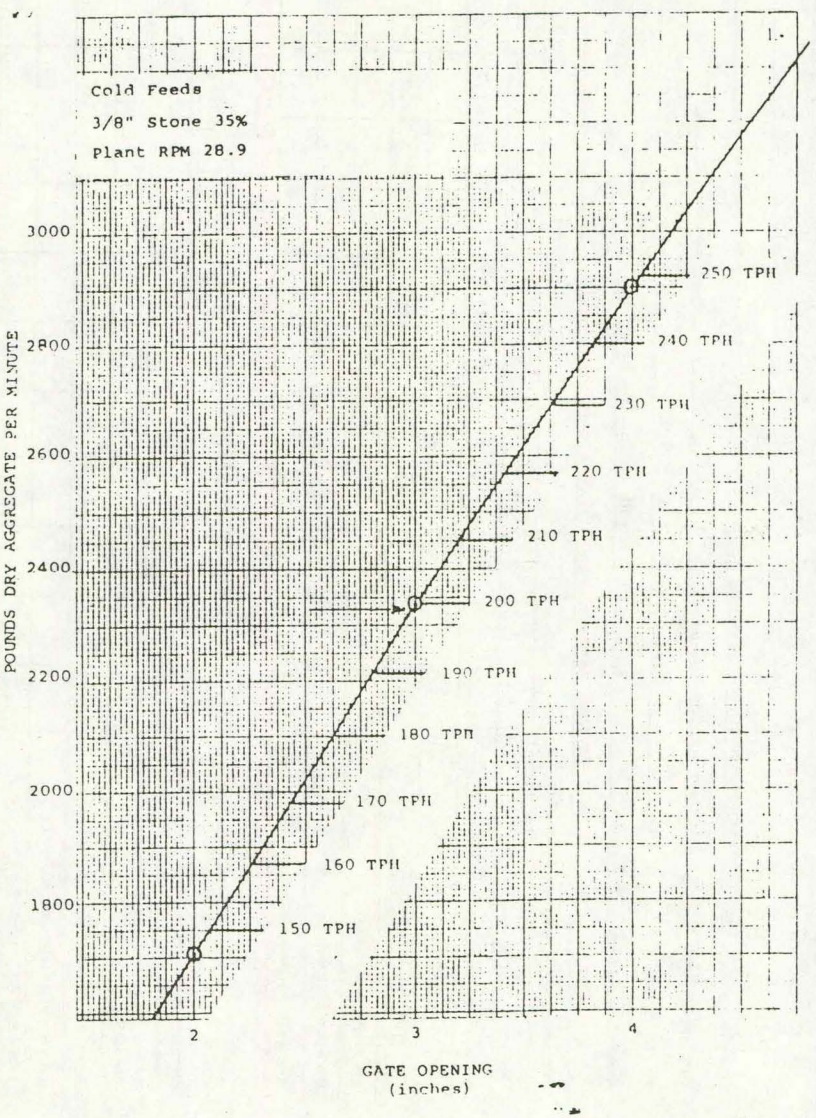
Received by: John Jones
Supt.
Title

GRAPH "A"



GRAPH "B"

508



January 1987
Supersedes Jan. 1986

FORM 916
10/71

IOWA DEPARTMENT OF TRANSPORTATION

CALIBRATION OF PLANT EQUIPMENT

County Marshall
Project FN-30-5(24)
Date 4/13/72
Report No. 1

Contractor Cessford Construction Co. Plant Location LeGrand Res. Eng./Co. Eng.
Plant Type and Name Batch - Cedar Rapids Material Moisture %
Mix Type Type A Class Mix Size 3/4" Surface R.P.M. Feeder 28.9
R.P.M. Plant
Asphalt Type and Grade 85-100 Temperature °F 300

Asphalt Pump Calibration

See Graph 'D'

~~Pump vernier setting, gate opening in inches~~	30			40			50			60		
Run number	1	2	3	1	2	3	1	2	3	1	2	3
Revolutions delivered	165.05			94.91			43.82			35.00		
Total wet weight aggregate delivered												
Total weight A.C. delivered Total dry weight aggregate delivered	429			350.5			210.5			210.5		
Dry weight per revolution												
Dry weight per minute												
Average dry weight per (Minute-Rev.)	2.6 ⊙			3.7 ⊙			4.8 ⊙			6.0 ⊙		

Hot Bin Calibration

See Graph 'E'

~~Pump vernier setting~~ gate opening in inches	4"			5"			6"					
Run number	1	2	3	1	2	3	1	2	3	1	2	3
Revolutions delivered	299.5			275.0			251.3					
Total wet weight aggregate delivered												
Total weight A.C. delivered Total dry weight aggregate delivered	16700			19150			20180					
Dry weight per revolution												
Dry weight per minute												
Average dry weight per (Minute-Rev.)	55.8 ⊙			69.7 ⊙			83.0 ⊙					

Dust Feeder Calibration

See Graph 'F'

~~Pump vernier setting, gate opening in inches~~	5			10			15					
Run number	1	2	3	1	2	3	1	2	3	1	2	3
Revolutions delivered	18.00			9.85			11.10					
Total wet weight aggregate delivered												
Total weight A.C. delivered Total dry weight aggregate delivered	57.5			73.8			122.0					
Dry weight per revolution												
Dry weight per minute												
Average dry weight per (Minute-Rev.)	3.2 ⊙			7.5 ⊙			11.0 ⊙					

Scales comply [X] Yes [ ] No

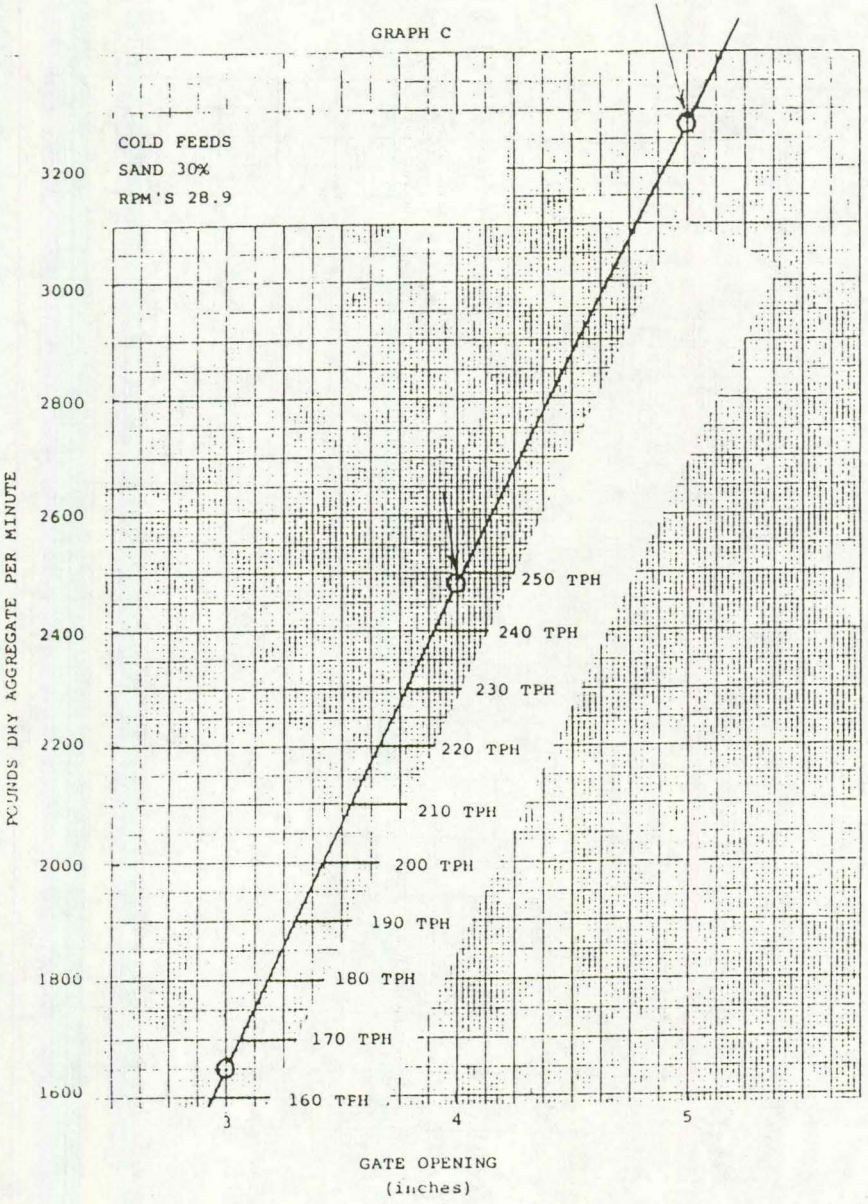
The above data is furnished as set forth in the Standard Specifications for plant operations, for informational purposes only. The Contracting Authority makes no representations as to accuracy, either express or implied, which are to be construed to relieve the Contractor from the responsibility to comply with the specifications.

Distribution:
Copy 1 - Plant Inspector
Copy 2 - Contractor
Copy 3 - District Materials Engineer
Copy 4 - Resident Engineer

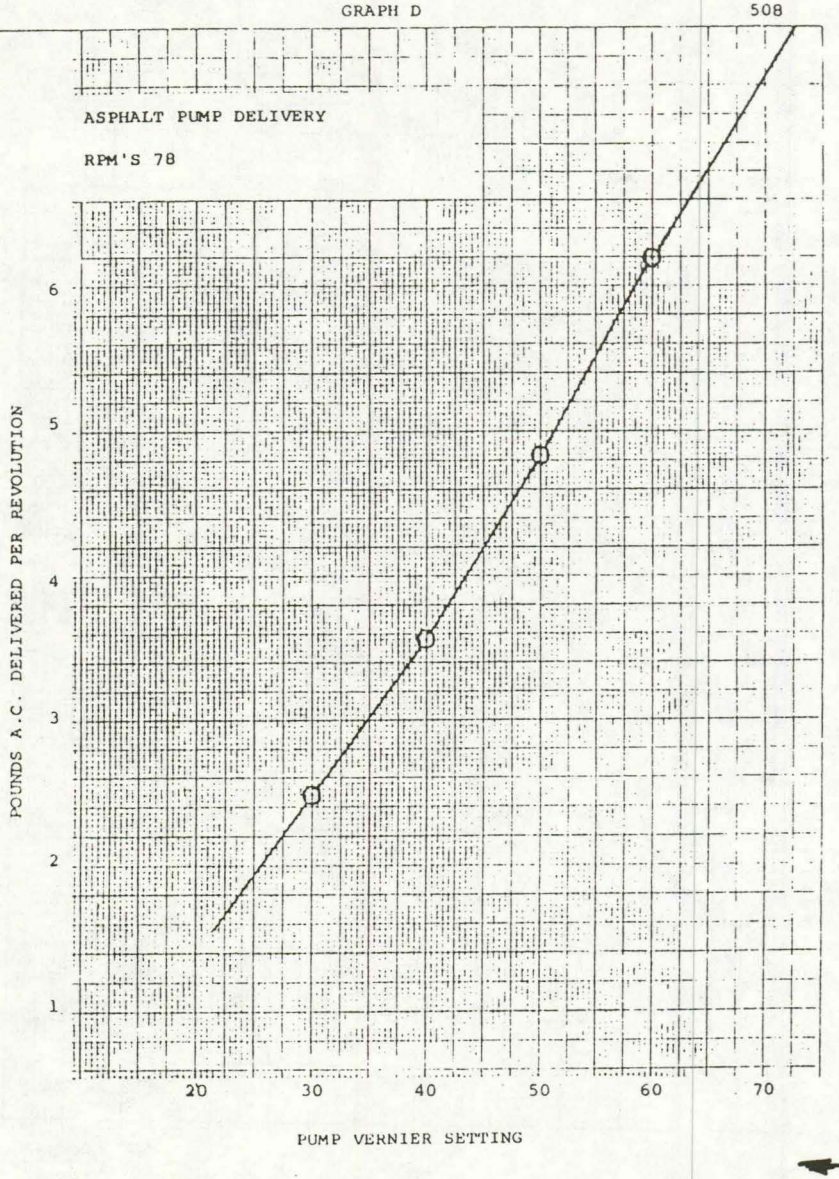
Calibrated by Bill Brown (Name)
M.I.S. 1 (Title)

Received by John Jones (Name)
Title Supt. (Contractor)

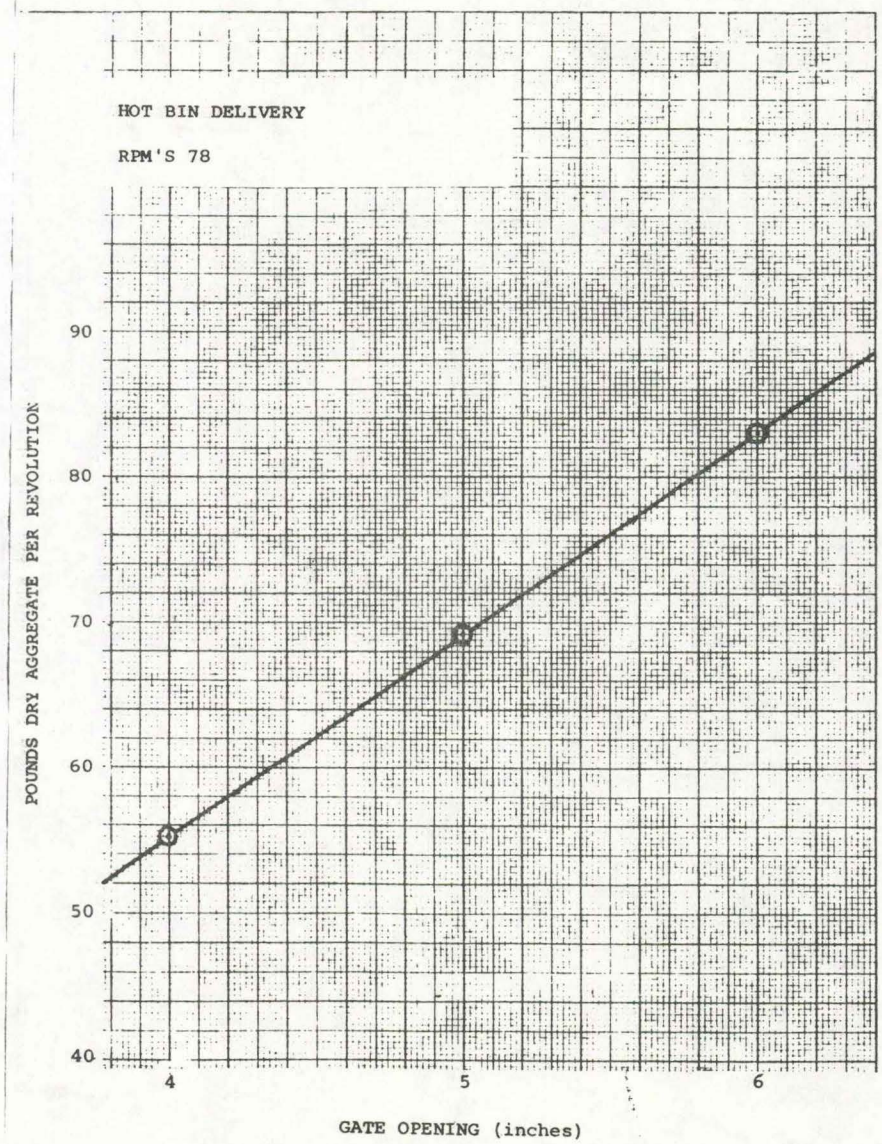
GRAPH C



GRAPH D 508

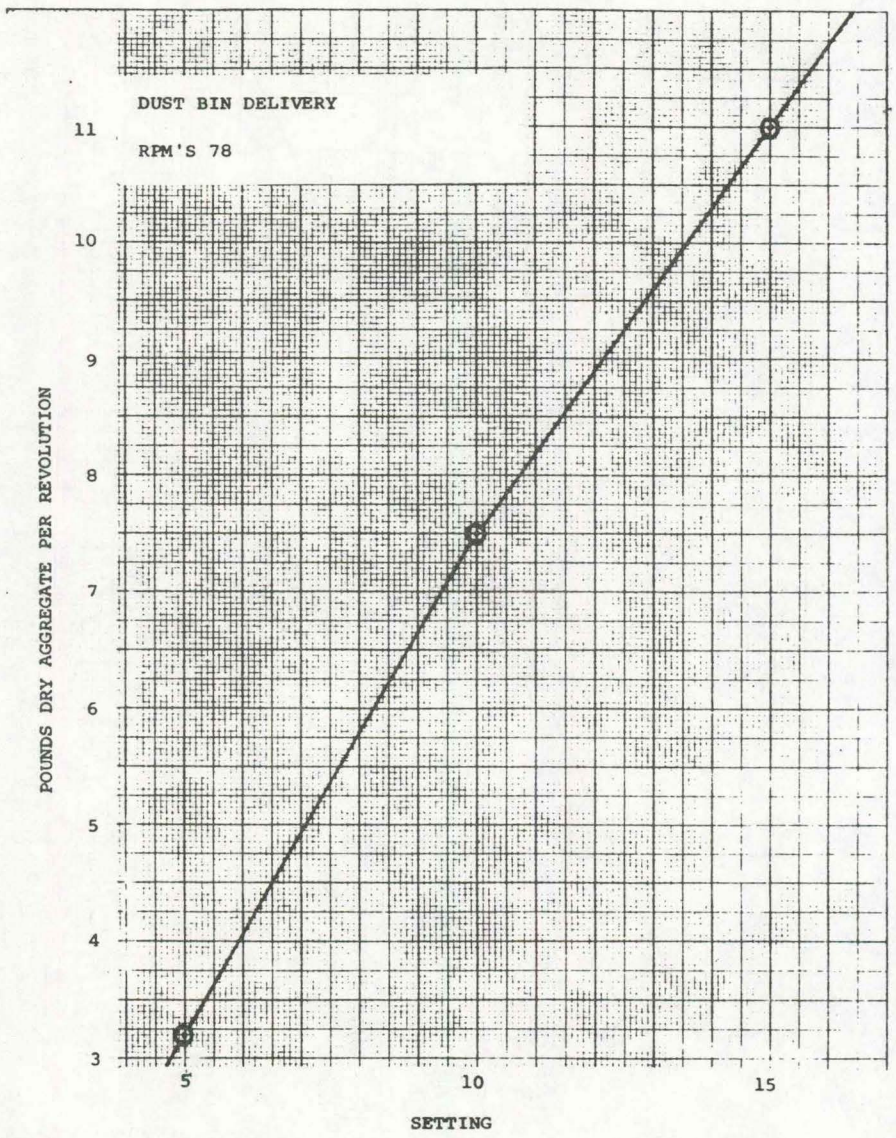


GRAPH E



GRAPH F

508



INITIAL PLANT SETTING

The following examples are based on initial plant output of 200 TPH of mix and an intended asphalt content 5.0% by weight of mix.

Typical Plant Cold Feed Settings

Set for 190 TPH total Cold Aggregate (Dry Weight)

Material	% in Mix	lbs/Min	Gate Setting
3/4" Cr. Stone	35%	2217	3-3/4" (Graph A)
3/8" Cr. Stone	35%	2217	2-13/16" (Graph B)
Sand	30%	1900	3-5/16" (Graph C)

Drum Mixing Plant

Set Cold Feed Proportions as shown above.

Set aggregate delivery control on plant control console to deliver 190 tons per hour of dry aggregate (95% of 200).

Set asphalt delivery control on Control Console to deliver 10 tons per hour of asphalt cement (5% of 200).

Continuous Plant
Hot Feed and A.C. Pump Calculations and Settings
"Vernier Pump Control"

$$\frac{200 \text{ TPH} \times 2000 \text{ lbs/Ton}}{60/\text{Min/Hr}} = 6667 \text{ lbs/Min of Mix}$$

$$\frac{6667 \text{ lbs/Min of Mix}}{78 \text{ RPM Plant}} = 85.5 \text{ lbs/Rev of Mix}$$

85.5 lbs/Rev Mix x 5.0% A.C. = 4.3 lbs/Rev of A.C.
85.5 - 4.3 = 81.2 lbs/Rev Total Hot Aggregate
81.2 x 5.0% Dust = 4.1 lbs/Rev of Dust
81.2 x 95.0% Hot Aggregate = 77.1 lbs/Rev of Hot Aggregate

Asphalt pump = 4.3 lbs/Rev = 44.2 (Graph D)
Hot Aggr Gate = 77.1 lbs/Rev = 5.5" (Graph E)
Dust Feeder = 4.1 lbs/Rev = 6.0 (Graph F)

If the dust is returned directly to the hot aggregate, separate computations are not required for the dust being fed since it is automatically included in the hot aggregate delivery.

Continuous Plant
Hot Feed and A.C. Pump Calculations and Settings
"Sprocket Drive A.C. Pump"

Assume Asphalt Pump Calibrated with 43T x 43T
Sprockets and delivers 4.5 lbs A.C./Rev
Assume RPM Plant = 78.0

$$\frac{4.5 \text{ lbs A.C./Rev}}{5.0\% \text{ A.C.}} = \frac{4.5}{0.05} = 90.0 \text{ lbs. Mix/Rev}$$

$$90.0 \text{ lbs Mix/Rev} \times 78.0 \text{ RPM} \times \frac{60 \text{ Min/Hr}}{2000 \text{ lbs/Ton}} = 210 \text{ TPH Mix}$$

$$4.5 \text{ lbs A.C./Rev} \times 78.0 \text{ RPM} \times \frac{60 \text{ Min/Hr}}{2000 \text{ lbs/Ton}} = 10.5 \text{ TPH A.C.}$$

$$85.5 \text{ lbs Hot Aggr/Rev} \times 78.0 \text{ RPM} \times \frac{60 \text{ Min/Hr}}{2000 \text{ lbs/Ton}} = 199.5 \text{ TPH Hot Aggr}$$

85.5 x 5.0% Dust = 4.3 lbs Dust/Rev
85.5 x 95.0% Hot Aggr = 81.2 lbs Hot Aggr/Rev

Hot Aggr Gate	= 81.2 lbs/Rev	= 5.9"	(Graph E)
Dust Feeder	= 4.3 lbs/Rev	= 6.3	(Graph F)

Batch Plant
Initial Plant Setting

After the aggregate scales and asphalt scale have been checked for accuracy, the batch weights are set and mixing operations are begun. The scales are checked by adding weights to the hopper and observing the scale dial indicators. Some batch plants are equipped with volumetric asphalt pumps rather than scale buckets; these devices are calibrated the same way that asphalt pumps are calibrated on continuous plants, but operated on a batch basis:

Assume 6000 lb batch plant, cold feeds as cited previously.

Scale Settings

Asphalt: 5% A.C. x 6000 lbs = 300 lbs

Combined Hot Aggr: 6000 - 300 = 5700 lbs

Dust: Returned to hot aggr bin directly.

All gate and scale settings, and weighing controls shall be set to target on the required quantities. Offsetting shall not be permitted except to correct calibration errors.

F. Production Inspection Duties

1. Temperature Control

It is necessary to observe and control the temperature of the various material components to document specification compliance, to prevent damage to the material, and to produce uniform workable mixtures. The specifications contain the ranges and tolerances for each type and class of mixture. It has been found that base mixtures which are to be placed in thick lifts can be produced at 240 F, where as fine mix surface courses must be produced at, or above 300 F. The specification limits for mix temperature are the same for all plant types. Production above or below these limits must be approved in advance by the engineer, and documented as set out in section 1108.04 of the standard specifications.

	Point of Test (Temperature)	
(a)	Asphalt Cement	Deliver units and storage tanks
(b)	Aggregate	Dryer Pyrometer
(c)	Final Mixture	Truck body at plant
(d)	Final Mixture (on road)	Behind Paver

2. Gradation Control

A. By cold feed advisory and extraction tests.

The contractor is responsible for insuring that the gradation of the final mixture as shown by extraction tests consistently complies with the requirements of the job mix formula. Advisory sampling and testing will be performed at the aggregate sources and after cold feed combination at the plant site. The sampling and testing frequencies are outlined in Materials I.M. 204. Cold feed proportioning will also be observed and verified as part of the overall plant inspection activity.

Cold feed check samples will be taken daily to verify the accuracy of proportioning and to provide guidance to the contractor with regard to mixture gradation. The samples are obtained by incrementally cutting the stream of combined aggregate or by taking several sections from the belt feeding the drier. Samples must be secured in a safe and reliable manner as provided in Sections 1106 and 2001 of the Standard Specifications. Testing procedures shall be in accordance with Materials I.M.-Series 300.

B. By cold feed gradation control

The final acceptance gradation will be based on the cold feed gradation. Additional quality tests above the minimum specified may be run at the option of the District Materials Engineer.

The sampling and testing frequencies are outlined in Matls. I.M. 204. Cold feed proportioning will be monitored and verified as part of the overall plant inspection activity. The samples are to be obtained by incrementally cutting the stream or belt flow of combined aggregate. The contractor must be responsible for furnishing a plant set-up so that representative samples can be obtained. This may require equipment modification.

Samples must be secured in a safe and reliable manner as provided in Sections 1106 and 2001 of the Standard Specifications. Testing procedures shall be in accordance with Materials I.M.-Series 300

C. Cold feed gradation and other completed mix irregularities may result from the following causes:

(a) Sample not representative of lot
(b) Test errors, weights, calculations, etc.
(c) Stockpile segregation
(d) Storage bin segregation
(e) Incorrect dust adjustment
(f) Wet - non-uniform stockpiles
(g) Improper bin balance (Multiple hot bins)
(h) Incorrect cold feed settings
(i) Non-uniform cold feed delivery
(j) Stockpile contamination
(k) Intermingling of aggregates in stockpiles and/or feeders
(l) Degradation

When the cold feed sieve analysis tests indicates that the combined material does not comply with the gradations requirements, the following steps are taken by the plant inspector.

(a) Recheck test procedures and computations
(b) Check gate settings and feeder operations
(c) Check the materials and material handling procedures
(d) Notify Resident Construction Engineer, District Materials Engineer and the Contractor of the results
(e) Obtain a second sample and test promptly.

If the cold feed tests and/or inspection observations indicate that proportioning irregularities are occurring, the contractor is required to take corrective action immediately. Adjustments in proportions and other job mix formula changes must be approved in writing in accordance with Materials I.M. 511.

Several alternatives are normally available to the contractor when difficulties are encountered:

(a) Change material handling procedures
(b) Change proportions (Job Mix Formula change)
(c) Change materials (New Job Mix Formula required)
(d) Change processing procedures at the source.
(e) Correct proportioning irregularities
(f) Waste fines collected by dust collection systems
(g) Reset Job Mix Formula target gradation

In most cases, operations will not be interrupted more than a few hours. If a change is made affecting the materials or proportions, a mix sample should be rushed to the laboratory for density-void analysis. Also an extraction test may be run, at the option of the District Materials Engineer. Major proportion changes and source changes normally require central laboratory analyses; these tests must be performed before a new job mix formula can be approved and used. All changes must be documented and reported immediately. Changes in materials or proportions are to be reported on Form 908. On projects where the cold feed gradation is the basis for acceptance, the filler bitumen ratio will be based on the cold feed gradations.

3. Asphalt Content Control (also refer to Materials I.M. 509)

The control of this material component is the most important plant inspection responsibility because the performance of the finished pavement is directly related to the quantity of binder incorporated in the mix. Separate check systems are used for continuous and batch plants as follows:

(a) Continuous and Drum Mixing Type Plants

During the first day or two of operation and during periods when asphalt or aggregate delivery is questionable, it is advisable to perform proportioning verifications in addition to the measurements required by I.M. 204. The verification methods are listed below:

(1) Compare asphalt delivered by metering pump with outage shown by 2 or 4 hour tank measurements.

Tank Measured A.C. -- (NPR) x(lbs AC/Rev)
Outage (lbs) from calibration data.

(2) Compare total mix produced including waste to asphalt and aggregate delivered by plant for a given period of time or number of plant revolutions.

Tons of Mix Weighed --- (NPR) x(lbs/Rev A.C.)+
Over truck scale (NPR x (lbs/Rev Aggr)

(3) Compare: percent A.C. by 2 hour tank measurement and percent A.C. by delivery.

$$\text{Tank Measured A.C. Content\%} \quad ------ \quad \frac{(\text{NPR}) \times (\text{lbs/Rev AC}) \times 100}{(\text{lbs of mix produced})} \quad ---- \quad \text{Intended A.C. Content \%}$$

NPR = Net Plant Revolutions = Final Counter Reading minus Initial Counter Reading

The specifications require drum mixing plants to be equipped with totalizing asphalt meters and aggregate scales. This equipment should be utilized for making continuing checks; total asphalt delivered as indicated by the meter should be periodically compared with quantities used as determined by tank measurements.

(b) Batch Type Plants

The operation of batch type plants should also be verified when work begins on a project. This is done by making intermediate tank measurements at 2 or 4 hour intervals and by checking the operation and sensitivity of the scale equipment.

If the measurements indicate that uniform control is not being maintained, the contractor is required by the specifications to adjust and correct his operations to obtain specification compliance. Such actions may include but not be limited to cleaning, repair, or replacement of equipment, recalibration of pumps and feeders, and training of personnel. In some cases it may be necessary for the contractor to obtain assistance from equipment manufacturers or distributors. Refer to the check list on page 29 for possible causes of difficulty.

The inspectors should be aware of the fact that the specifications provide for establishing mutual agreements for determining asphalt quantities on projects involving small quantities, or intermittent or diversified operations.

The illustration on page 33 shows how a control chart may be used to monitor asphalt content control and detect operating trends. The chart is a plot of the difference between the intended asphalt content and the actual as determined by tank measurements. Charts of this type are recommended for all projects and are particularly significant when continuous plants are employed.

4. Specification Compliance

All materials shall be inspected prior to being incorporated in a pavement structure. Some materials such as asphaltic materials are being shipped to projects under the certification program, in either case, it is necessary to check and file the reports such that each material component is properly identified and is incorporated under the proper documentation. This is accomplished by obtaining material reports or certification documents for each lot of material before the material is incorporated in the work. All shipments of Bituminous Material incorporated in the work shall be logged on Form 7 as they are received.

A Non-Compliance Notice (Form 225) shall be immediately delivered to the acting representative of the Contractor for the area of construction involved whenever tests results on acceptance samples representing material to be incorporated or incorporated in the work indicate non-compliance with the specifications and plans. Appropriate action in accordance with the applicable specifications and Instructional Memorandums shall be taken.

INSPECTORS CHECK LIST FOR ASPHALT CONTROL

I. Before Calibration

1. Check capacity of storage tanks
2. Check tank sticks
   (a) To be sure they fit the tanks
   (b) To determine how they are to be used (touch stick or dip stick, percent of diameter or inches, etc.)
   (c) To be sure tanks are level
3. Check piping and type of pumping system
4. Learn contractor's method of operating the system
5. Check truck scales

II During Operation

1. Determine percent A.C. by tank stick measurement method as required.
2. Determine percent A.C. by verification as required
3. Check batch scales for sensitivity
4. Check truck scales for sensitivity

III. If Computed Percent A.C. is High

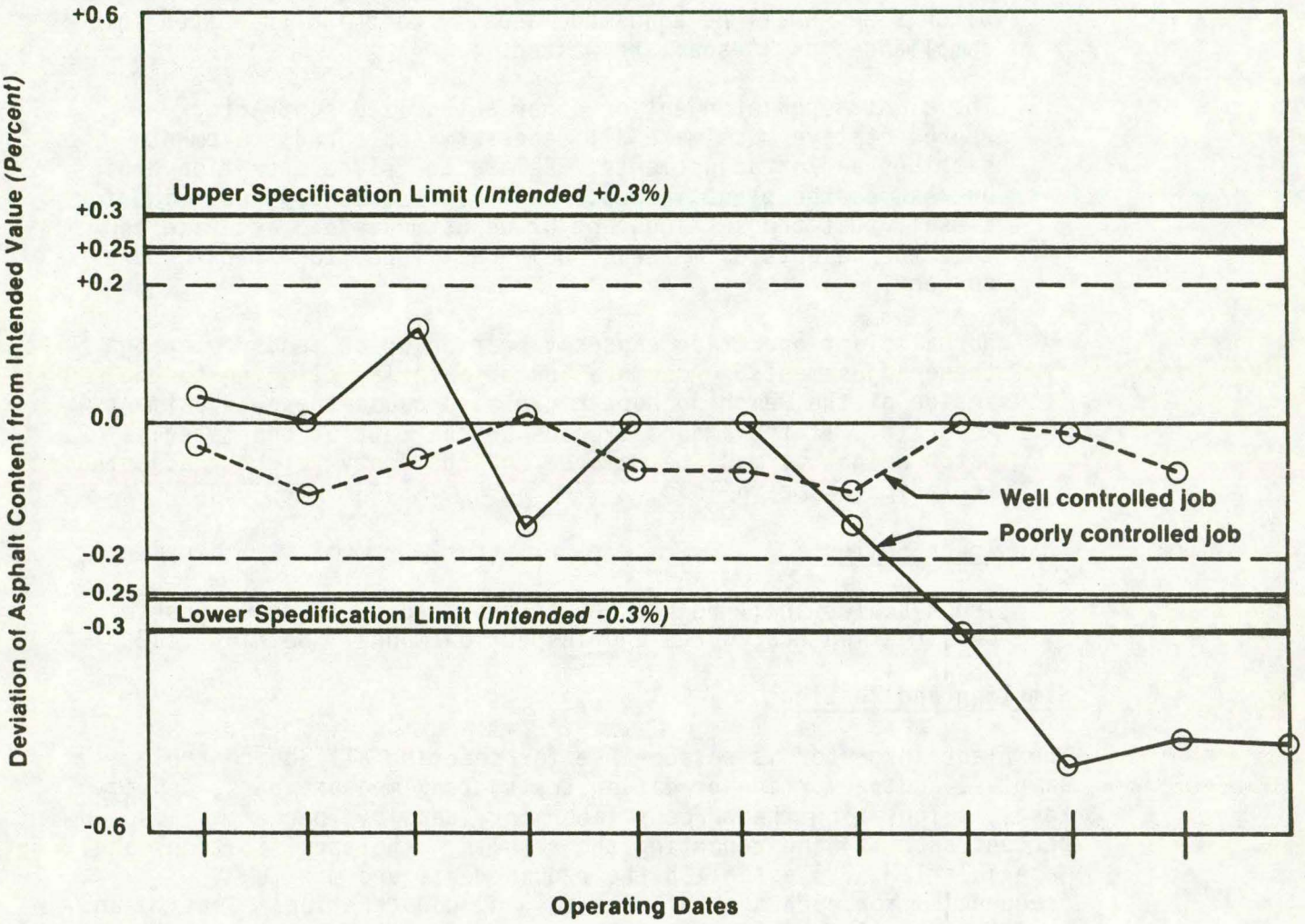
1. Check tank stick readings and computations
2. Check to be sure that all mix produced was included in the computations.
3. Check for spilled, wasted, or otherwise used asphalt cement
4. Check to be sure all asphalt listed as "added" during the period should be included.
5. Check truck scales and total mix made
6. Check hot feeder gates and pump setting
7. Check aggregate delivery level for uniformity

IV. If Computed Percent A.C. is Low

1. Check tank stick readings and computations
2. Check total mix made
3. Check to be sure that all asphalt added during the period is included.
4. Check hot feeder gate and pump setting
5. Check for plugged nozzle
6. Check pumping pressures
7. Check strainer screen
8. Check truck scales

Materials Instructional Memorandum 509 provides the detail procedure for making tank measurements and determining asphalt content.

Comparison of Tank Measurement Determinations with Specification Requirements



5. Checking Scales

(a) Batch Scales

Batch scale sensitivity shall be checked once per day during a normal working day by placing a weight equal to 1/10 percent of the batch weight on the fully loaded scales and observing the movement of the indicator. A properly sensitive scale will exhibit a visible indicator movement when so tested. If no indicator movement is visible, immediate corrective action must be taken by the contractor.

The specified scale delivery tolerance limits should be checked by periodically witnessing the batch weighing operations. Each scale indicator should consistently indicate the required weight within the specified delivery tolerance, and return to zero when unloaded within the specified 0.5 percent tolerance.

When automatic batch weighing equipment is used, the interlock system shall be set at the 1.0 percent limit as specified. They may be manually over-ridden to continue plant operation if the specified delivery tolerance is not exceeded. When the delivery tolerances are exceeded, the asphalt or aggregate batch sizes shall be adjusted manually to bring the batch into compliance, or it shall be wasted.

The plant superintendent or other authorized contractor representative must make all necessary scale and equipment settings and/or adjustments. Before the plant operation begins or resumes the plant inspector will independently determine for himself that the settings and/or adjustments are accurate and that the weights of material being delivered to the batch are correct.

Normal plant operation causes vibration which tends to change these adjustments. Accumulation of material clinging to the inside of the weighing hopper can also cause these adjustments to drift. If the amount exceeds one percent of the material batch weight it must be removed and the empty weight readjusted to indicate a zero load.

(b) Truck Scales

Truck scales shall be checked as provided by Instructions to Construction Procedures and Inspection Manual, Section 3.42.

6. Sampling and Testing

The plant inspector is responsible for securing all job control samples, and performing gradation tests, tank measurements, density tests, calculating the percent laboratory density, percent voids, percent asphalt, and reporting the results. The specifications and Materials I.M. 204 establish the requirements and minimum frequencies for each type of material and construction. Density and gradation testing are to be given prompt and careful attention and the contractor and Resident Engineer are to be kept advised at all times. The Construction Procedures and Inspection Manual provide instructions and examples pertaining to documentation requirements.

When granular base courses, subbases and soils are being compacted to a specified level of density, the laboratory density, Standard Proctor or Modified Proctor will be determined in the field. Representative samples should be obtained as early as possible so that immediate evaluations can be made of the contractor's compaction procedures.

(a) Lot Sampling

For construction operations that are carried on continuously, a "lot" is defined as a day's run or major portion of a day's run. Intermittent construction operations involving small quantities shall be grouped to establish a lot; the time period shall normally not be longer than one week or working days. For further explanation and definition of "lots," see Section 2303.14 of the Standard Specifications.

Laboratory density of hot asphalt mixtures, due to equipment limitations and requirements can only be determined by the Central Laboratory, and the District Laboratories. It is, therefore, necessary that arrangements be made to collect and forward the samples to the nearest laboratory. In order to prevent confusion and delays, these arrangements should be made before work begins on the project. Hot mix samples are to be obtained in accordance with I.M. 322 on all types of work.

7. Calculation of Percent of Laboratory Density

The core density, expressed as percent of laboratory density, is calculated as follows:

$$\text{Percent Lab. Density} = \frac{\text{Core Density} \times 100}{\text{Lab. Density}}$$

8. Calculation of Percent Voids

The percent voids in the sample is calculated as follows:

$$\text{Percent voids} = \frac{\text{Solid Density} - \text{Sample Density}}{\text{Solid Density}} \times 100$$

Where:

Solid Density = maximum density (Rice or High Pressure)

9. Calculating results for a lot.

1. Calculation of the average field density of the lot =

$$\frac{\text{Sum of field densities}}{\text{Number of Samples}}$$

2. $$\text{Average \% Lab Density} = \frac{\text{Average field density} \times 100}{\text{Lab Density}}$$

3. $$\text{Average \% Voids} = 100 - \frac{100 \times \text{average field density}}{\text{Solid Density}}$$

EXAMPLE

Assume Lab Density is 2.354

Assume Solid Density is 2.503

Assume field densities of individual cores to be 2.303, 2.289, 2.311, 2.290 and 2.284

Average field density of the lot =

$$\frac{2.303 + 2.289 + 2.311 + 2.290 + 2.284}{5} = 2.295$$

$$\text{Average \% Lab Density} = \frac{2.295 \times 100}{2.354} = 97.5\%$$

$$\text{Average \% voids} = 100 - \frac{100 \times 2.295}{2.503} = 8.3\%$$

10. Determining gradation on recycle projects:

The average RAP gradation available will be combined mathematically with the daily virgin aggregate cold feed gradation to determine the mix control and acceptance gradation.

Samples of completed mix will be taken to the District or Central Laboratory for analysis.

11. Completed Project

When a project is completed, the plant inspector should again check all records and documentation for accuracy and completeness. It is also necessary to determine at this time the net quantity of materials incorporated in the project. The field records and plant records should be compared and final determinations made. Detailed instructions are provided in the Construction Procedures and Inspection Manual.

12. Diary and Report Requirements

(a) Diary, refer to Construction Procedures and Inspection Manual.

(b) Report Forms. Two forms are used to document plant operations and provide sample identification. They are:

Form 7 "Asphaltic Concrete Plant Daily Report". This form is submitted daily to document plant operations, job control testing, and material placement on all hot mix and cold mix construction. A completed sample form has been included.

Form 193 "Identification of Sample for Test". This form must accompany all samples submitted to the Central Laboratory and District Laboratories. Examples of completed forms have been included in this instruction.

(c) Testing Worksheets. All worksheets and other original documents used by inspection personnel are to include identification of: 1. individuals associated with sampling and testing, 2. County and Project No., 3. Material and sampling point, 4. date and time of sampling and testing and, 5. source, producer or contractor. All documents other than field notebooks are to filed with the appropriate report and retained per the file retention schedule.

Refer to Construction Procedures and Inspection Manual.

Iowa Department of Transportation

Report 1 of 2 — January 1987

DAILY PLANT REPORT

BITUMINOUS TREATED BASE, ASPHALT TREATED BASE, ASPHALT CONCRETE

County Delaware
Project FR-3-B(15)-2G--28
Date 10-22-85
Report No. 37

Contractor Mathy Const. — Plant Location Edgewood West
Plant Type Drum Mixer — Make B.B. Green — Resident Engineer WM. Crawford
Mix Type B — Class 1 — Size ½ — Crushed Aggr. Sources Edgewood East & West — Recycle Source 22 %
Asphalt Source Koch, Dubuque — Sand Sources Littleport Pit — Plant Operated 7:15 A.M. to 5:15 P.M.

SIEVE ANALYSIS OF COMBINED AGGREGATES

SAMPLE No.	Time	Compliance	1½	1	¾	½	⅜	4	8	16	30	50	100	200
JOB MIX FORMULA					98/100		81/95	59/73	47/59		24/34			30/9.0
Lab-37		Yes			100	99	91	71	57	45	32	17	10	6.8

SAMPLES SUBMITTED

Materials	Senders No.	Materials	Senders No.
Type B	37A	AC-5	JT-127
Type B	37B		
Type B	37C		
AC-5	JT-125		
AC-5	JT-126		

Asphalt Cement AC-5 — Grade — Total Aggregate Per Batch or Rev. — Lb.
Intended Added 5.29 % A.C. — Added 5.43
Intended Total 6.20 % A.C. — Tank Meas. 6.34 % A.C.

Lab. Den. 2.402 — **DENSITY RECORD** — SOLID DEN. 2.447

Course Laid	Station	¢ Refer	Date Laid	* (1)	Density	% Density	% Voids
Surface	855+21	3.0 Rt.	10-22-85	1 3/8	2.303	95.878	5.9
Surface	1301+03	7.7 Rt.	10-22-85	1 3/8	2.324	96.753	5.0
Surface	1345+35	2.1 Rt.	10-22-85	1 1/4	2.332	97.086	4.7
Surface	1366+34	2.9 Rt.	10-22-85	1 1/4	2.301	95.795	6.0
Surface	1397+41	7.5 Rt.	10-22-85	1 1/4	2.341	97.460	4.3
Shlds	138+99	1.9 Lt.	10-22-85	7 7/8	2.354	98.002	3.8
Shlds	141+44	3.6 Lt.	10-22-85	8	2.333	97.127	4.7
Shlds	144+24	4.2 Lt.	10-22-85	7 7/8	2.292	95.420	6.3
Shlds	148+44	1.5 Lt.	10-22-85	8	2.353	97.960	3.8
Shlds	155+73	1.8 Lt.	10-22-85	8 1/4	2.300	95.754	6.0

ASPHALT MATERIALS AND AGGREGATE DELIVERIES

Grade	Car Or Tr. No.	Ticket No.	Time Unloaded	Quantity
AC-5	T-144	6744	AM	25.73
AC-5	T-144	6761	AM	25.74
AC-5	9119	6767	AM	24.36
AC-5	T-144	6772	PM	25.73
AC-5	R-47346	6774	PM	24.64

TEMPERATURE RECORD — Avg Surf. Den. = 2.320 — Avg Shld Den. = 2.326

Time	7	9	11	1	3	5
Air	45	46	55	60	65	64
A.C.	300	300	300	300	300	300
Aggregate						
Mix	325	320	315	310	310	310
Mat Surface		295	300	285	285	280
Mat Shlds			300	285	285	

PRODUCTION AND PLACEMENT RECORD

* (2)	Side	Course Laid	From Station to Station	Tons Today	Tons To Date
1½	Rt.	Surface	831+20 — 869+06 (4)		
1½	Rt.	Surface	1277+36 (5) — 1425+20 (8)		
1½	Rt.	Surface	1425+20 (8) — 1428+25	2013.725	24,223.135
		Sprinkle			

1	¾	½	⅜	4	8	16	30	50	100	200

Comments:

Fines/Bitumen Ratio = $\frac{6.8}{6.34}$ = 1.07

Ave % Field Voids = Surface = 5.2 Shlds = 4.9

Lab % Voids = 2.0

QI (Density) = (Show Calculation)

Surface $\frac{96.586 - 95.000}{97.460 - 95.795} = \frac{1.586}{1.665} = 0.95$

Shlds $\frac{96.836 - 94.000}{98.002 - 95.420} = \frac{2.836}{2.582} = 1.10$

COMMENTS: Delays, Breakdowns, Corrective Action etc.
* Thickness: (1) Actual, (2) Intended
Bituminous Treated Base: Enter % Moisture in % Voids Column

SIGNED J. C. Thomas
Inspector

DISTRIBUTION White Copy - Materials Office/Records Center. Green Copy - Construction Office. Canary Copy - District Materials/Engineer. Pink Copy - Resident Construction Engineer or County Engineer. Goldenrod Copy - Plant Inspector

FORM 193
3-75 H-3575

January 1987

IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION
OFFICE OF MATERIALS
Ames, Iowa

IDENTIFICATION OF SAMPLE FOR TEST

(Read Instructions on back before taking sample and filling out form)

Material Type "A" Asphalt Conc. 3/8" Mix 5.75% AC Sender's Sample No. 4

Intended Use Surface Course Contract Number

County Wapello Project FN-34-4(6) Road No. US 34

Design No. Specification No. Std.

Contractor Morris Const. Co., (Name) Ottumwa, Iowa (Address)

Producer Brand

Location of ~~Producing~~ Paving Plant Johnson Quarry 1 mile N. of Podunk Center

Sec. Twp. Range Co.

Unit of Material Represented 1 - day's run 9-4-70

Quantity Represented 1200 Tons

Sampled by John Smith (Name) Ottumwa, Iowa (Address)

Date Sampled 9-4-70 Sample Shipped by (Frt.) (P.P.) (Express)

Report to xxxxxxxxxxxx (Name) Materials Engr. (Title) Ames, Iowa (Address)

Report to xxxxxxxxxxxx (Name) District Engr. (Title) xxxxxxxxxxxx (Address)

Report to xxxxxxxxxxxx (Name) Resident Engr. (Title) xxxxxxxxxxxx (Address)

Additional Detailed Information:

(For paint give analysis printed on container. For tile give grade specified, etc.)

40 lb. Mix sample per Materials Dept. IM-204.

(NOTE: A representative of the Department of Transportation shall select the sample.)

FORM 193
3-75 H-3575

January 1987

IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION
OFFICE OF MATERIALS
Ames, Iowa

IDENTIFICATION OF SAMPLE FOR TEST

(Read Instructions on back before taking sample and filling out form)

Material AC-10 Asphalt Cement **Sender's Sample No.** 1

Intended Use Type B Asphalt Concrete Surface Course **Contract Number** _____

County O'Brien **Project** FN-10-5(2) **Road No.** Ia. 10

Design No. ---------- **Specification No.** Std.

Contractor Midwest Surfacing Co., Humboldt, Iowa
(Name) (Address)

Producer American Oil Company **Brand** _____

Location of Producing Plant Sugar Creek, Mo.

_____ **Sec.** _____ **Twp.** _____ **Range** _____ **Co.** _____

Unit of Material Represented 10,000 gallons used on 10-1-70

Quantity Represented 10,000 gallons

Sampled by Tom Brown (Name) Cherokee, Iowa (Address)

Date Sampled 10-1-70 **Sample Shipped by (Frt.) (P.P.) (Express)**

Report to xxxxxxxxxxxx (Name) Materials Engr. (Title) Ames, Iowa (Address)

Report to xxxxxxxxxxxx (Name) District Engr. (Title) xxxxxxxxxxxx (Address)

Report to xxxxxxxxxxxx (Name) Resident Engr. (Title) xxxxxxxxxxxx (Address)

Additional Detailed Information:

(For paint give analysis printed on container. For tile give grade specified, etc.)

1-3 oz. sample per Matls. IM-204 for viscosity

(NOTE: A representative of the Department of Transportation shall select the sample.)

ASPHALTIC CONCRETE EQUIPMENT

Mfg. Code	Stock No.	Quan. Needed	Description
		1 ea.	Box Sieves - 1-1/2", 1.06", 3/4", .530",3/8", #4
		1 Ea.	8" Round Sieves - #4, #8, #16, #30, #50, #100, #200, #300 Wash, Pan and Cover.
		1	Box Shaker w/pans
		1	Sample Splitter (w/Pans, Scoop & Brush)
		1	O'Haus Balance w/pan and weights
		1	O'Haus Balance Wood Stand
012	532165	1	1-Gal. Dunking Can.
		1	Surface Checker w/Parts Box
003	059500	25	2-Gal. Cardboard Box (14"x9"x6")
020	015500	1	Roll 3" Tape (Paper-Stickum Type)
012	733100	24	3 Oz. Ointment Tins
016	009400	3	12-Qt. Pails
012	660225	6	4-Qt. Round Pans
012	660250	6	6-Qt. Round Pans
012	527000	1	Short Handle Round Point Shovel
		1	Pointing Trowel
012	702100	1	Candy Scoop
012	717725	1	Large Spoon
012	530155	6	1-Qt. Cans w/Lids

Mfg. Code	Stock No.	Quan. Needed	Description
		1	-30 to 120°F. General Purpose Thermometer
		2	200 to 400°F. Maximum Registering Thermometers
		2	100 to 400°F. Asphalt Thermometers
		1	Electric Sieve Shaker
		1	Electric Sieve Shaker Timer (Switch)
020	491500	1	Putty Knife
		1	Sieve Cleaning Brush (cropped paint brush)
	The following items stocked by the Office Supply Storeroom		
370	820007	1 Pad	Form 7
370	820193	1 Pad	Form 193
370	830252	1 Pad	Form 52
000	352700	1 Box	Pencil Carbon Paper
000	319200	1 Box	Tag Envelopes
000	480300	1 Box	5EC Shipping Tags
No Numbers		30	Combined Aggregate Grading Curves

Uncoded Items Stocked by Ames Laboratory
Coded Items Available Through Ames Storeroom

INSTRUCTIONAL MEMORANDUM
WEIGHING EQUIPMENT

General

Section 2001.07 of the Standard Specifications covers weighing equipment and procedures. Under certain conditions equipment used to determine true net weights must be fully automatic or semi-automatic. Fully automatic systems are those that perform all required functions and print then on a ticket automatically. Semi-automatic systems must, as a minimum, be capable of determining the gross weight and print it on a ticket automatically. The remaining functions must be entered on the ticket manually by a weighmaster.

Except for asphalt batch type plants, each load ticket is to contain all weight calculations necessary to arrive at a true net weight. This includes a printed gross weight, a printed or manually entered tare weight and a resultant printed or manually entered net weight.

For batch plants quantities may be determined from batch counts and individual batch weights. The ticket shall indicate the batch weights, the number of batches and a net weight of the batches in each load. The ticket information may be entered by automatic printers or by a weighmaster. No tare weights are required when a batch plant is used.

Types of Systems

A. Batch Plants:
Batch plants may operate with or withour automatic printing. Automatic printing is required for optional payment. Tickets automatically printed must contain, as a minimum, the total weight of material used in each batch, the number of batches and a total weight of material in each load. Most printing systems will show the aggregates and asphalt separately (see example 1).

B. Storage Silo with Separate Weighing Hopper:
Tickets prepared automatically for this system shall contain, as a minimum, the gross weight of each drop weighed, a tare weight as a measure of any material left in the weighing hopper and a net weight of the material dropped. Also included shall be a true net weight of the total numer of drops in each load (see examples 2 and 3).

C. Storage Silo/Weigh Hopper Combination:
Tickets prepared automatically for this system shall contain, as a minimum, the gross weight of material in the bin at the beginning of each weighing increment, the weight of material remaining in the bin at the end of each weighing increment as a tare weight and a resultant net weight of each increment. If weighing is in more than one increment, the ticket shall show the total net weight of all increments included in the load (see example 4).

D. Truck Scales:
For Automatic Truck Scales - The scale must print the gross weight, tare weight of the truck, and net weight of the load. The tare weight of the truck is to be stored in the system, not necessarily a reweighing for each trip. The operator would have to identify the truck to the recorder (see example 5).

For Semi-Automatic Truck Scales - The scale must print the gross weight. The tare weight and net weight shall be on the ticket, and this may be done by the weighmaster by hand.

Many of the automatic systems are capable of printing much more information than that which as been specified as being minimum. These are good features that may be beneficial to the contracting authority and the contractor, however, no features may be substituted for those specified.

Batch plant (Example 1)

ASPRO INC.
Asphalt Products

P.O. BOX 2620
2261 LAPORTE RD.
WATERLOO, IOWA 50702
319—232-6537

Aspro

PROJECT FN20-6(31)--21--09

MIX 1/2 Surface TYPE 8208

9 TRUCK

R OPERATOR

DRIVER

RECEIVED BY

DATE	TIME	TOTAL WEIGHT	AGGREGATE 4	AGGREGATE 3	AGGREGATE 2	AGGREGATE 1	ASPHALT	BATCH WEIGHT
						9,480	561	10,041
						9,440	561	10,001
						9,470	561	10,031
OCT 1 82	9:09	30,073						

CASH ☐ C.O.D. ☐ CHARGE ☐

COLOR CODE: WHITE—ORIGINAL
PINK—CUSTOMER COPY
BLUE—FILE COPY
CANARY—TRUCKER COPY
GREEN—OFFICE COPY

TONS	PRICE/TON	AMOUNT

35

SI10 WITH WEIGH HOPPER (Example 2)

ASPHALT CONCRETE SCALE TICKET

CESSFORD CONSTRUCTION COMPANY
PLANT 1
P.O. Box 160
LeGrand, Iowa 50142
Telephone 515/479-2695

PROJECT NO. & COUNTY SR-3560 (2)

TRUCK OWNER Cessford TRUCK NO. 21

TIME & DATE									WEIGHT (TONS)						
9	:1	5	AM	Jn	0	9	83	SI	0	0	1	5	.1	5
9	:1	5	AM	Jn	0	9	83	N	0	0	1	5	.1	5
9	:1	5	AM	Jn	0	9	83	−	0	0	0	0	.7	1
9	:1	4	AM	Jn	0	9	83	+	0	0	0	7	.6	3
9	:1	4	AM	Jn	0	9	83	−	0	0	0	0	.7	1
9	:1	4	AM	Jn	0	9	83	+	0	0	0	8	.9	4

TYPE OF MIX ☐ ATB 1 ☐ B 1/2 ☐ A 2

CLASS OF MIX ☐ 1 ☐ 2 ☐ OTHER _____

WEIGHED BY K.C. Keith Carlson

13168

ASPHALT CONCRETE SCALE TICKET

CESSFORD CONSTRUCTION COMPANY
PLANT 1
P.O. Box 160
LeGrand, Iowa 50142
Telephone 515/479-2695

PROJECT NO. & COUNTY SR-3560 (2)

TRUCK OWNER Nielsen TRUCK NO. 66

TIME & DATE									WEIGHT (TONS)						
9	:1	8	AM	Jn	0	9	83	SI	0	0	3	0	.5	8
9	:1	8	AM	Jn	0	9	83	N	0	0	1	5	.4	3
9	:1	8	AM	Jn	0	9	83	−	0	0	0	0	.7	2
9	:1	8	AM	Jn	0	9	83	+	0	0	0	8	.5	7
9	:1	7	AM	Jn	0	9	83	−	0	0	0	0	.7	2
9	:1	6	AM	Jn	0	9	83	+	0	0	0	8	.3	0

TYPE OF MIX ☐ ATB 1 ☐ B 1/2 ☐ A 2

CLASS OF MIX ☐ 1 ☐ 2 ☐ OTHER _____

WEIGHED BY K.C.

13169

STORAGE SILO WITH
WEIGH HOPPER
(Example 3)

4.27

MANATTS

SOLD TO _____

TRUCK CUSTO...
0002 #57 ...

TRUCKER _____

LOAD NO. _____

CERTIFICATION STATEMENT

As ... herein described is from ... to as-
wi... and
ta... on
w...
qu... merits

Signed _____

DATE TIME TK
09/09/83 1130 FINE...

TARE+NETWT=GROSS
00000 15030 15030
00000 14940 14940

LOADWT TOTALTONS TICKET
29970 00000.20 0002

5.9K

TONS	PRICE	SUB TOTAL	TAX	AMOUNT

C.O.D. ☐ CHARGE ☐

RECEIVED BY _____ CHECKED BY _____

Self erecting System (Example 4)

01136

NORRIS CONSTRUCTION CO.
113 S. Wapello P.O. Box 130
Phone 515-682-3427
Ottumwa, Iowa 52501

B/G Drum

SOLD TO

IDOT

TRUCKER _____

FR-92-6(12)--26-54
TYPE A

LOAD NO. _____

CUST	TRUCK	MIX	DESCRIPTION
1	180	A	BASE

GROSS	TARE	NET WT.
35,210	24,010	11,200
23,970	12,380	11,590
12,370	1,230	11,140

LOADWT	SUBTOTAL	LOAD	TICKET	TIME/DATE
38,930	930.91	62	1,136	17:06:10 06/24/83

Cash ☐ C.O.D. ☐ Charge ☐

TONS	PRICE	SUB TOTAL	TAX	AMOUNT

RECEIVED BY _____

CHECKED BY _____

Truck Scale (Example 5)

ROHLIN CONSTRUCTION CO., INC.
1814 7th Ave. So.
ESTHERVILLE, IOWA 51334

AGGREGATE SCALE TICKET

Project No. FM-95-(10)

Date 5-6 19 83

County WINNEBAGO Truck No. H-22

12:55 05/06
G 048240LB

12:56 05/06
T 018100LB

12:56 05/06
N 030140LB

TIME & DATE

WEIGHT (TONS)

☑ BASE ☐ BINDER ☐ SHLD. ☐ FOB

☐ LEVEL ☐ WEAR ☐ RED ROCK ☐ TYPE _____

Weighed by BP

Truck Loading Point Kirschbaum

Remarks C/R Drum Mixer Plant #5

9112

METHOD TO DETERMINE NEW ASPHALT CEMENT QUANTITY TO ADD TO RECYCLED ASPHALT MIXES

BASIC FORMULA

$$X = D-(A \times B)$$

X = percent of A.C. to be added. Expressed as a whole number. Percent of total mix.
D = percent of A.C. intended. Expressed as a whole number. Percent of total mix.
A = percent of A.C. in R.A.P. Expressed as whole number.
B = percent of R.A.P. in mix. Expressed as a decimal.

EXAMPLE

A. C. Intended = 5.75%
A. C. in R.A.P. = 4.50%
% R.A.P. in Mix = 30%

X = D-(A x B)
X = 5.75-(4.50x.30)
X = 5.75-(1.35)
X = 4.40% A.C. to be added by wt. of total mix.

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

TANK MEASUREMENT AND ASPHALT CONTENT DETERMINATION

General

Unless otherwise specified this Instructional Memorandum covers the procedures used by the contracting authority to determine: 1. the quantity of asphalt incorporated in a project, and 2. the asphalt content of individual production runs of asphalt mixtures. The plant inspector is referred to the applicable specifications and instructions for the specified tolerances and measurement frequencies.

Tables are furnished for computing quantities of materials stored in standard horizontal cylindrical tanks, and for correcting volumes to standard temperature. The plant inspector is responsible for checking to see that appropriate gauging tables and calibrated sticks are available prior to beginning work on a project. The contractor is required to furnish the calibrated measuring sticks, and gauging tables for all storage tanks.

Procedures -(Refer to example, Form 904)

Column 1 & 2 - Date and Time

These columns provide space for the dates and time intervals for each production run.

Column 3 - Tank Identification

Each asphalt storage tank shall be identified by a number or letter and listed on the tabulation sheet. If a separate working tank or surge tank is provided, it will be necessary to establish a uniform procedure for determining the quantity or level of material in the tank. It is recommended that the plant inspector arrange with the contractor to maintain a uniform storage level in the surge tank.

Column 4 - Temperature (Degrees)

The temperature of the asphalt in each tank must be determined at the time the measurements are made. This is done by lowering a maximum registering thermometer to the approximate center of the asphalt stored. The thermometer

must be shook down to a temperature less than that of the asphalt in the storage tank and must be allowed to adjust to the temperature of the stored material. From 3 to 5 minutes should be allowed for this adjustment. Thermometers mounted permanently in the storage tanks by the manufacturers may be used if they agree with the thermometers checked by the Central Laboratory.

Column 5 - Measurement of Outage (Percent of diameter)

The number entered in this column is obtained from the actual tank measurement using the calibrated stick provided for each tank. The measurement is made by placing the stick through the designated tank hatch down to the level of the stored material. The percent outage is read from the stick at the reference elevation, which is normally the inside shell wall. The full elevation and checking to see that the zero percentage line and the top of the tank coincide. When the tank shell is full, the outage percentage is zero, and when the tank is empty the outage is 100%.

When non-standard tanks are used, the manufacturers tables, measuring sticks, and instructions must be followed.

Column 6 - Percentage Inage (Percent of Capacity)

The guaging table is used to convert the outage percentage from Column 5 to percent of capacity. Refer to the manufacturers tables for non-standard tanks.

Column 7 - Tank Capacity

The capacity of each tank depends upon its dimensions. The capacity of standard cylindrical tanks may be computed by determining the length and radius from actual measurements. All dimensions must be inside measurements. The volume of a cylindrical tank is obtained by multiplying the constant 7.48 x the constant pi 3.141116 x the length x the radius squared. The contractor is required to furnish the manufacturers data for non-standard tanks. The contractor should not be permitted to allow the level of the asphalt to drop below the level of the heating coils, because accurate measurements cannot be made when the cross section of the storage area varies.

Column 8 - Temperature Correction Factor

The volume of asphalt in the tank at the time of measurement must be corrected to 60^{o} (^{o}F.). Refer to tables T-102 or T103 to obtain the appropriate correction factor.

Column 9 - Corrected Gallons

The corrected gallons (at 60°F.) in the tank previously measured is the product obtained by multiplying columns 6, 7 and 8. This is the standard temperature at which pay quantities are determined.

Column 10 - Total Corrected Gallons on Hand

This is the sum of the corrected gallons in each tank at a given date and time.

Columns 11 & 12 - Total Asphalt Added

These columns provide space for entering the total quantity of asphalt added during the production run. Care must be exercised to insure that weight tickets are obtained for each load placed in the storage tank during the production run. Each shipment ticket should be logged in the plant field book with the appropriate date and unloading time. The weight figure in Column 11 is converted to corrected gallons (at 60°F.) by dividing by the weight per gallon coefficient provided by the supplier. Quantities added shall be certified or determined at the job site.

Columns 13 thru 19

These columns correspond to Columns 4 thru 10 except that they are used when determinations are made at the end of a work day or production run. Column 19 provides the number of corrected gallons remaining in the tank at the end of the production run.

Column 20 - Total Corrected Gallons Used

Column 20 value is obtained by adding Columns 10 and 12 and subtracting the gallons on hand, Column 19.

Columns 21 & 22 - Average Weight Per Gallon

The average weight per gallon is provided by the asphalt supplier. The total corrected gallons listed in Column 20 is multiplied by the average weight per gallon, Column 21. The total is listed in Column 22. If asphalt from different sources has been used during the production run, it is necessary to compute a weighted average weight-per-gallon for the total quantity used. If emulsified asphalt or cutback asphalt is being used, it is necessary to reduce the weight of the diluted material to asphalt residue. The quantity of asphalt residue incorporated is determined by multiplying the total weight of emulsion or cutback by the percent residue value furnished by the supplier.

Column 23 - Total Pounds of Mixture Produced

The total pounds of mixture produced is determined by adding the net weights of all the scale tickets. This total includes all mixture produced, including rejected, wasted, or commercial loads. Mixtures such as cold mixes which contain moisture must be corrected for the moisture content.

Column 24 - Total Pounds of Mix Wasted

This column provides space to record the total number of pounds of mix which was wasted, sold, rejected or otherwise disposed of. All mix so wasted should be weighed, if at all possible. It may be necessary to estimate small quantities of waste in some cases.

Column 25 - Total Pounds of Asphalt Wasted

This is determined by multiplying the percent asphalt from Column 28 by the total pounds of mix wasted from Column 24. <u>This quantity will not be included in the project pay quantity total.</u>

Column 26 - Net Quantity of Asphalt Incorporated in the Project

This is the net quantity of asphalt for which the contractor will be eligible to be paid. This total is obtained by subtracting Column 25 from Column 22.

Column 27 - Net Pounds of Mix Incorporated in the Project

This quantity is obtained by subtracting Column 24 from Column 23, and is the net quantity eligible for payment.

Column 28 - Percent Asphalt (by tank measurement)

This percentage is obtained by dividing the total net pounds of asphalt used by the total net pounds of mix produced. The plant inspector is at this point directed to refer to appropriate specifications to determine if this percentage is within the allowable tolerance, and to furnish the contractor with the information.

Column 29 - Percent Asphalt (Extraction)

This column is provided to record the extraction test results obtained from the District and Central Laboratories. This is provided for comparison purposes only.

ALL COMPUTATIONS SHOULD BE CHECKED THOROUGHLY AND PROMPTLY; ANY CORRECTIONS SHOULD BE REPORTED TO THE CONTRACTOR AND RECORDED ON THE DAILY REPORT FORMS. UPON COMPLETION OF THE PROJECT THE COMPLETED FORM 904 SHALL BE INCORPORATED IN THE RESIDENT OR COUNTY ENGINEERS PROJECT FILE.

FORM 904

IOWA DEPARTMENT OF TRANSPORTATION

TANK MEASUREMENT & ASPHALT DETERMINATION

PROJECT

COUNTY

CONTR.

TYPE MIX

			START OF PERIOD							ADDED		END OF PERIOD															
1 DATE	2 TIME	3 TANK NO.	4 TEMP (°F)	5 Tank Stick OUTAGE (PERCENT OF DIA.)	6 T-104 GAUGE (PERCENT OF CAPACITY)	7 TANK CAPACITY	8 T-102 TEMP CORR FACTOR	9 6X7=8=9 CORRECT GALLONS	10 TOTAL CORRECT GALLONS ON HAND	11 TOTAL A.C. ADDED WEIGHT	12 CORR GAL	13 TEMP (°F.)	14 Tank Stick OUTAGE (PERCENT OF DIA.)	15 T-104 GAUGE (PERCENT OF CAPACITY)	16 TANK CAPACITY	17 T-102 TEMP CORR FACTOR	18 15x16=17=18 CORRECT GALLONS	19 TOTAL CORRECT GALLONS ON HAND	20 10+12-19 TOTAL CORRECT GALLONS USED	21 AVERAGE WEIGHT PER GAL	22 20x21=22 TOTAL POUNDS OF A.C. USED	23 Tickets TOTAL POUNDS OF MIX MADE	24 TOTAL POUNDS OF MIX WASTED	25 20&24=25 TOTAL POUNDS OF A.C. WASTED	26 22-25=26 NET LBS. OF A.C. USED ON ROAD	27 23-24=27 NET LBS. OF MIX USED ON ROAD	28 22&23=28 PERCENT A.C. (TANK)	29 PERCENT A.C. (EXTR.)
6-20-68	10:00	1	270°	86.2	8.3330	10,000	.9286	774																			
6-20-68	10:00	2	315°	86.2	8.3330	10,000	.9069	709	1,563		15,613	310°	39.5	63.268	10,000	.9154	5792	9,201	7975	8.389	66,902	1,971,100	12,000	887	66,495	1,958,188	3.39	
6-21-68	6:30	1	300°	68.2	37.106	10,000	.9187	3408				300°	47.7	52.926	10,000	.9187	4863											
6-21-68	6:30	2	310°	39.5	63.268	10,000	.9154	5792	9,201		16,855	295°	39.0	63.890	10,000	.9204	5880	10,743	15,333	8.388	128,645	3,447,500	2,000	75	128,570	3,485,500	3.73	
6-22-68	6:30	1	300°	47.7	52.926	10,000	.9187	4863				295°	80.5	13.733	10,000	.9204	1264											
6-22-68	6:30	2	295°	39.0	63.890	10,000	.9204	5880	10,743		9,674	270°	98.0	0.6773	10,000	.9286	64	1,308	19,109	8.388	160,296	3,935,200	4,000	163	160,133	3,931,300	4.07	

METHOD OF DESIGN OF ASPHALTIC CONCRETE MIXES

GENERAL

The design of asphaltic concrete mixes involves determining an economical blend of aggregates that provides a combined gradation within the limits of the specifications and a determination of the percent asphalt to mix with the aggregate blend. Trial mixes prepared with different asphalt contents are tested for mix properties and the results analyzed to select the asphalt content that is judged to be most satisfactory for the intended use of the mix.

RAW MATERIALS

The aggregate sources, proposed aggregate blend proportions, and the source of asphalt are selected by the contractor. This information is submitted to the District Materials Engineer on Form 955 for approval. Material source approval, gradations, crushed particle amount and type, asphalt grade, and other specific requirements are checked prior to submitting materials and Form 955 to the laboratory.

TRIAL MIXES

A. Preparation of Aggregates

Aggregates must be air dried to a surface dried condition prior to further preparation. The individual aggregates are combined in the proportions proposed on the Form 955 in accordance with Test Method Iowa 504. About 100 lbs. of this combined aggregate is required for the design work.

B. Asphalt Cement

The asphalt cement used for trial mixes shall be of the same grade as indicated on the Form 955 and shall also be from the same source when possible.

C. Selecting Trial Asphalt Contents

Three trial mixes of different asphalt contents are made to assure close bracketing of the final recommended design asphalt content. Two trial mixes may be adequate for this purpose if recent results have been obtained with aggregate of the same or slightly adjusted composition.

The trial mix asphalt contents are best guess estimations that are one percent apart. They may be based on past experience, analysis of the aggregate gradation, calculated surface area of the aggregate, or trial and error.

The gradation plotted on the 0.45 power gradation chart indicates the void space available for asphalt. Gradations that closely follow the maximum density line indicate low void space.

The surface area of the aggregate is related to the film thickness of asphalt obtained by a given asphalt content. A higher surface area will almost always require a higher asphalt content.

D. Mix Preparation

Preparation of trial mixes is in accordance with Test Method Iowa 504.

TESTING RAW MATERIALS

Test procedures for the asphalt and combined aggregate are as follows:

Test	Cent. Lab Test No.	I.M. No.
Specific Gravity of Asphalt*	617	369
Bulk Sp.G. of Combined Aggregate	203	---
Water Absorption of Combined Aggregate	203	308**

*The sp.g. of the asphalt may be obtained from certifying documents or a lab test report.
**Procedure "C"

TESTING TRIAL MIXES

Test procedures for A.C. mixes are as follows:

	Cent. Lab Test No.	I.M. No.
Maximum Specific Gravity*	507	340 or 363
Compacting Marshall Specimens	502	325
Density of Compacted Mixes (Lab Density)	503	321
Marshall Stability and Flow	506	---

*The Rice sp.g. procedure, Test Method Iowa 507 or I.M. 340, is the referee method. The high pressure air meter procedure, I.M. 363, should only be used if results have previously been shown to correlate with Rice results.)

Four Marshall specimens are made from each trial mix. An extra specimen of the first mix compacted is usually made to determine the amount of mix necessary to produce the proper specimen thickness. The four specimens of each A.C. content are checked for lab density and on the following day (after the required cooling period) the three specimens with the closest densities are tested for stability and flow.

If a District Lab is not equipped for Marshall Stability, the selected three specimens are shipped to the Central Lab for testing. The specimens must be fully identified and packaged to prevent damage.

DESIGN CALCULATIONS

A. Calculation Basis and Nomenclature

The derivation of the formulas used for calculations is based on an assumed 100 grams of mix so that mix percentages are numerically equal to weights. Following is a list of nomenclature symbols used and their definitions:

%AC = % of asphalt cement in the trial mix
%Ag = % of combined aggregate in the trial mix = 100 - %AC
%Abs = % water absorption of the combined aggregate
Abs = fraction of water absorption of the combined aggregate = %Abs/100. This quantity is always used in the calculations rather than %Abs.
Gag = bulk specific gravity of the combined aggregate. This quantity may be by test or by calculation.
Gac = specific gravity of the asphalt
Gmx = maximum specific gravity of trial mix by test. This quantity may be referred to as the solid sp.g. or solid density. A calculated max. sp.g. should be designated as Gmx (calc.).
Gcm = density of compacted mix or lab density
%V = calculated % air voids in the compacted mix
%VMA = calculated % voids in the mineral aggregate

B. Calculated Maximum Specific Gravity

A theoretical maximum specific gravity may be calculated when the bulk sp.g. and water absorption of the aggregate is known. This calculated maximum specific gravity is used to check the results determined by test and is not intended for calculating other design quantities. A Rice specific gravity should not be considered suspect unless the calculated specific gravity differs by more than 0.030. Calculate the maximum sp.g. using the following steps and report the results to three decimal places.

1. Wt. of AC absorbed = 0.5 x Abs x %Ag
2. Wt. of effective AC = %AC - line 1
3. Volume of Aggregate = %Ag/Gag
4. Volume of effective AC = line 2/Gac
5. Gmx (calc.) = 100/(line 3 + line 4)

C. Calculated Bulk Specific Gravity of the Combined Aggregate

The bulk sp.g. of the combined aggregate (Gag) may be calculated from the maximum specific gravity of the mix determined by test. It is calculated with the following line steps and reported to three decimal places:

1. Gmx x %Ag x Gac
2. Gac x 100
3. 0.5 x Abs x %Ag x Gmx
4. Gmx x %AC
5. line 2 + line 3 - line 4
6. Gag (calc.) = line 1/line 5

D. Void Calculations

Quantities used to calculate void results shall be determined by test except Gag(calc.) may be used to calculate %VMA. The following formulas are used to calculate the indicated quantities that are reported to one decimal place.

$$\%V, \text{ air voids in the compacted mix} = 100 - \frac{100 \times Gcm}{Gmx}$$

$$\%VMA, \text{ voids in the aggregate} = 100 - \frac{Gcm \times \%Ag}{Gag}$$

$$\%VMA \text{ filled with asphalt} = \frac{\%VMA - \%V}{\%VMA} \times 100$$

E. Filler/Bitumen Ratio

Calculate the ratio as follows and report to two decimal places:

$$\text{Filler/Bitumen Ratio} = \frac{\%\text{Passing \#200}}{\%AC}$$

F. Asphalt Film Thickness

Calculations of asphalt film thickness are described in I.M. 511. It is reported to two decimal places.

EXAMPLE CALCULATIONS

Given data:

%AC = 5.75	Gag (test) = 2.667
%Ag = 100 - 5.75 = 94.25	Gac = 1.031
%Abs = 0.30	Gmx (test) = 2.438
Abs = 0.30/100 = 0.003	Gcm (lab dens.) = 2.347

A. Calculated Maximum Sp.G.

1. Wt. of AC absorbed = 0.003 x 94.25 x 0.5 = 0.141
2. Wt. of effective AC = 5.75 - 0.141 = 5.609
3. Volume of aggregate = 94.25/2.667 = 35.339
4. Volume of effective AC = 5.609/1.031 = 5.440
5. Gmx (calc.) - 100/(35.339 + 5.440) = 2.452

This calculated sp.g. compares favorably with the 2.438 obtained by test.

B. Calculated Bulk Sp.G. of Combined Aggregate

1. 2.438 x 94.25 x 1.031 = 236.905
2. 1.031 x 100 = 103.1
3. 0.5 x 0.003 x 94.25 x 2.438 = 0.345
4. 2.438 x 5.75 = 14.019
5. 103.1 + 0.345 - 14.019 = 89.426
6. Gag (calc.) = 236.905/89.426 = 2.649

C. Void Calculations

$$\%V = 100 - \frac{100 \times 2.347}{2.438} = 100 - 96.3 = 3.7$$

$$\%VMA \text{ using Gag (test)} = 100 - \frac{2.347 \times 94.25}{2.667} = 17.0$$

$$\%VMA \text{ using Gag (calc.)} = 100 - \frac{2.347 \times 94.25}{2.649} = 16.5$$

$$\%VMA \text{ filled with asphalt} = \frac{17.0 - 3.7}{17.0} \times 100 = 78.2$$

EVALUATING RESULTS

The test data and calculated results are compared to the criteria given in the appropriate table shown in I.M. 511 corresponding to the type and use of the mix. An asphalt content is selected that will produce a percent air voids in the compacted mix that is near or slightly above the minimum void values in Table F of I.M. 511 for the course and traffic count involved with the intended use of the mix. Interpolation may be necessary.

REPORTING RESULTS

The test and calculated results along with the % asphalt recommended to start the project is reported on Form 820956. Distribution of the report:

District Engineer
Resident or County Engineer
Bituminous Engineer (R. Monroe)
Asphalt Construction Engineer (J. Smythe)
Asphalt Mix Engineer (D. Heins)
Contractor
Bituminous Lab (W. Oppedal)
Asphalt Mix Design file

CONTROL OF ASPHALTIC CONCRETE MIXTURES

A. General

The job mix formulas are established on the basis of the results of tests performed on samples obtained during the initial stages of material production. Since these samples may not be truly representative of the material produced, and since materials do change with time and through handling, the plant produced mixtures may not develop test characteristics that meet design criteria. Therefore, each mixture shall be re-evaluated after paving operations have begun. Because material and mixture characteristics may change at any time, they must be monitored continuously throughout the course of the work. The re-evaluation procedures outlined herein are to be carefully followed so that all mix characteristics will conform with the appropriate requirements contained in tables A, B, C, D, E and F.

B. Job Mix Formula Definition

The specifications define the job mix formula as the percentage passing each specified sieve (target gradation), and the percentage of each material including asphalt, (aggregate and asphalt proportions). The original job mix formula and subsequent adjustments are set after consultation with the contractor on the basis of gradation, stability, skid resistance, film thickness, asphalt and void analysis. Design criteria for setting the original formula and subsequent adjustments are provided by the attached tables for the various mix types and service requirements.

C Sampling and Testing

The initial plant calibrations will, in virtually all cases, be based on the formula established by the Central Laboratory. Samples of the combined aggregate and plant produced mixture should be obtained and analyzed as soon as the operations of the plant stabilize. The first samples can normally be obtained after the plant has operated an hour or so. Sampling and testing should be performed promptly so that production and proportion changes, if required, can be effected before large quantities of mix are produced. If adjustments are made in the proportions, the entire procedure must be repeated.

Laboratory density per I.M. 325 shall be furnished to each project as set out in the sampling and testing guides contained in I.M. 204.

For interstate and high traffic urban projects the 75 blow Marshall density values are to be used for density-void control as outlined in this Instructional Memorandum and for determining the density of compacted pavements as required by the specifications (high traffic urban situations shall be those exceeding 10,000 vehicles per day).

The 50 blow Mashalll values shall be used for all other projects. Sand Mix Surface Courses. (Pen. or Visc. Graded Binder, and Emulsion Residue Binder). Density-void control is to be based on the special one (1) inch Marshall specimens compacted with 75 blows on one (1) specimen face.

D. Job Mix Formula Changes

1. Changes in Mix Characteristics.

As soon as the test data are available they should be compared with ranges of values found in the attached tables and with the original job mix data. In the event that the plant produced mixtures do not exhibit test characteristics which fall within the ranges found in the tables, the District Materials Engineer will order appropriate changes in the Job Mix Formula.

The District Materials Engineer may order changes even though the test results are within the ranges given providing that the quality of the mix will be improved with respect to durability or friction properties.

When changes are ordered for the foregoing reasons, the magnitude of the changes are to be limited such that adjusted mixtures will continue to exhibit test characteristics which fall within the ranges found in the tables. In each case, the properties of the aggregate and asphalt, projected traffic loadings and volumes, layer thickness, and service conditions shall be taken into account.

The tables contain two sets of design void ranges, one based on the Job Mix calculated solid specific gravity, and one based on the measured solid specific gravity using the procedure outlines in I.M. 340. Since the latter procedure utilizes tests on the actual plant mix rather than tests on preliminary aggregate samples, adjustments can be made on a rational basis. This approach should also be utilized when changes are noted in aggregate characteristics resulting from production adjustments or variation.

Each days percent of road density is determined daily comparing the densities of the road cores to the laboratory density of the first uncompacted mix box sample taken for the day's production from which the cores were taken.

Variations in compacted laboratory density and/or measured solid specific gravity of more than 0.020 shall be investigated promptly since these tests reflect changes in asphalt content, and aggregate properties and gradation. In some cases variations may be attributed to segregation, thoroughness of mixing, sampling procedure, and changes in aggregate production.

For a given mix proportion, if the density variation exceeds ± 0.020 from the average of previous day's tests the investigation shall include the testing of the back up samples for that particular day's run. The average density of all samples tested for that day shall be used in determining roadway density compliance. If no backup sample is available, the density determination shall be averaged with the density of the previous day's run to determine density compliance.

If the second day's density variation exceeds ± 0.020 from the first day's test then the backup samples shall be tested for the first day also, and averaged for each day.

2. Proportion Changes

The contractor must occasionally adjust aggregate proportions in order to consistently comply with the job mix formula target gradation tolerances and to correct for calibration errors. Proportion changes of 10 percent or less, for each material, may be approved without delaying operations for qualifying tests. Adjustments or interchanges exceeding 10 percent shall be evaluated before they are approved. Changes will be subject to the crushed particle and sand limitations, and mix design criteria.

3. Aggregate Changes

(a) The addition of new materials to job mix formula may be approved without central laboratory tests providing the materials are produced from geologically comparable sources, do not constitute more than 15 percent of the aggregate, meet quality requirements, and produce mixes that meet design criteria and specifications.

(b) When aggregates are introduced from sources that are not geologically comparable or otherwise differ significantly complete central laboratory testing is required.

4. Target Gradation Changes

Unusual aggregate gradation variation or degradation may cause the contractor to request that a new job mix formula target gradation be set using materials already on hand. Target gradation changes shall not be considered or approved until options under 2 and 3 above have been evaluated.

Resetting the target may also involve proportion interchanges and the introduction of a new aggregate. New target gradations together with proportion changes may be approved for future production when all design criteria and specifications limitations can be satisfied. Except for stability and A.C. film thickness, mixture characteristics can be predicted from tests on previous production; changes that may adversely affect stability should not be approved without central laboratory consultation. Compliance with film thickness criteria shall be determined by the following procedure:

Determination of Surface Area
(Refer to form 955)

PROPOSED TARGET	SIEVE ANALYSIS -% PASSING												
	1½	1	3/4	½	3/8	4	8	16	30	50	100	200	SILT
COMBINED GRADING			100	93	81	65	48	38	27	13	8.1	6.8	
SURFACE AREA C.						.02	.04	.08	.14	.30	.60	1.60	TOTAL
S. A. SQ. FT. /LB.					+2.0	1.30	1.92	3.04	3.78	3.90	4.86	10.88	31.68

Effective A.C. Content - Aggregate Basis

$$\text{Effective A.C. \%} = 100\ \frac{\text{(A.C. \% Mix)} - 1/2\ \text{(\% Water Absorption*)}}{\text{(\% Aggregate/Mix)}}$$

*Refer to Job Mix Report.

Bitumen Index

$$\text{Bitumen Index} = \frac{\text{(Effective A.C. \%)}}{100\ \text{(Surface Area)}}$$

Film Thickness

Film Thickness (Microns) = (Bitumen Index) (4870)

When significant aggregate characteristics change, e.g. Specific Gravity, and Absorption, or other variations are encountered, complete central laboratory tests are required. Field adjustments in job mix formulas must be supported by complete district laboratory testing. Modification of job mix formulas that exhibit borderline test characteristics, e.g. stability, voids, and film thickness, shall be approached with caution because some types of adjustments may result in unsatisfactory mixes.

TYPE A ASPHALTIC CONCRETE
LEVELING, BINDER, AND SURFACE COURSES
TABLE A

Test Value Guides for Plant Produced Mixtures

Mix Size	1"Mix	3/4" Mix	1/2" Mix	3/8" Mix
	Mix Compacted in Laboratory		Average Values	
%Lab Air Voids (Min)		See Table F		
(Max)	6	6	6	6
(1) (2) (Calculated) Per I.M. 510				
%Lab Air Voids (Min)		See Table F		
(Max)	6	6	6	6
(1) (2) (Rice) Per I.M. 510				
%Voids in Mineral Aggr. VMA (Min) (1)	14	14.5	15	15.5
%VMA Filled with A.C. (Min-Max) (1)	65-80	65-80	65-80	65-80
A.C. Film Thickness (Min) (3)	7.0M	7.0M	7.0M	7.0M
A.C. Film Thickness (Min) (4)	6.5M	6.5M	6.5M	6.5M
Marshall Stability (lbs.) (Min)	1750	1750	1750	1750
Filler/Bitumen (5)				
Ratio (Max) Cold feed	1.20	1.20	1.20	1.20
Extraction (7)	1.30	1.30	1.30	1.30
	Mix Compacted on Roadway			
%Lab Density (Min)			As Specified	
%Voids (Min-Max) (1) (2) avg. (6)	4-8	4-8	4-8	4-8

(1) Except when otherwise specified, mix proportions should be adjusted to exhibit test values in the ranges given. When conflicts develop, void criteria based on Rice Procedure shall govern.
(2) Extreme caution should be exercised when mixtures exhibited average values near the lower limits and ADT exceeds 3000 VPD. (See Table F)
(3) Applies to wearing courses only, refer to job mix report for data. M=Microns)
(4) Applies to binder courses only, refer to job mix report for data. (M=Microns)
(5) Filler bitumen is the ratio of material passing the 200 mesh screen divided by percent of asphalt in the mix.
(6) Target lab voids prevail. Density may have to be increased to be within maximum field voids. General Specifications 2303.14 and Table "G." If conflicts develop between lab and field voids, see Table F.
(7) Only on projects where F/B is based on extractions.

TYPE B ASPHALTIC CONCRETE
LEVELING, BINDER, AND SURFACE COURSES
TABLE B

Test value Guides for Plant Produced Mixtures

Mix Size	1"Mix	3/4"Mix	1/2"Mix	3/8"Mix
	Mix Compacted in Laboratory		Average Values	
%Lab Air Voids (Min)		See Table F		
(Max)	6	6	6	6
(1) (2) (Calculated)	Per I.M. 510			
%Lab Air Voids (Min)		See Table F		
(Max)	6	6	6	6
(1) (2) (Rice)	Per I.M. 510			
%Voids in Mineral Aggr. VMA (Min) (1)	14	14.5	15	15.5
%VMA Filled with A.C. (Min-Max) (1)	65-85	65-85	65-85	65-85
A.C. Film Thickness (Min) (3)	7.0M	7.0M	7.0M	7.0M
A.C. Film Thickness (Min) (4) 6.5M	6.5M	6.5M	6.5M	
Marshall Stability (lbs.)	1500	1500	1500	1500
Filler/Bitumen (5) Ratio (max) Cold feed	1.20	1.20	1.20	1.20
Extraction (7)	1.30	1.30	1.30	1.30
Mix Compacted on Roadway				
%Lab Density (Min)			As Specified	
%Voids (Min-Max) (1) (2) Avg. (6)	3-8	3-8	3-8	3-8

(1) Except when otherwise specified, mix proportions should be adjusted to exhibit test values in the ranges given. When conflicts develop, void criteria based on Rice Procedure shall govern.
(2) Extreme caution should be exercised when mixtures exhibit average values near the lower limits and ADT exceeds 2000 VPD. (See Table F.)
(3) Applies to wearing courses only, refer to job mix report for date, (M=Microns)
(4) Applies to binder courses only, refer to lab mix report data. M=Microns.
(5) Filler/bitumen is the ratio of material passing the 200 mesh screen divided by percent of asphalt in the mix.
(6) Target lab voids prevail. Density may have to be increased to be within maximum field voids. General Specifications 2303.14 and Table "G." If conflicts develop between lab and field voids, see Table F.
(7) Any projects where F/B is based on extractions.

TYPE B ASPHALTIC CONCRETE
CLASS I AND II BASE COURSES
TABLE C

Test Value Guides for Plant Produced Mixtures

Class of Mixture		I	II
Mix Compacted in Laboratory		Average Values	
%Lab Air Voids (1) (2) (Calculated) Per I.M. 510	(Min)	See Table F	
	(Max)	6	6
%Lab Air Voids (1) (2) (Rice) Per I.M. 510	(Min)	See Table F	
	(Max)	6	6
%Voids in Miner Aggregate VMA (Min) (1)		14.5	14.5
%VMA Filled with A.C. (Min-Max) (1)		65-85	65-85
A.C. Film Thickness (Min) (3)		7.0M	7.0M
A.C. Film Thickness (Min) (4)		6.5M	6.5M
Marshall Stability (Lbs.) (Min)		1500	1000
Filler/Bitumen Ratio (5) (Max.)	Cold feed	1.20	1.20
	Extraction (7)	1.30	1.30
Mix Compacted on Roadway			
%Lab Density (Min)		As Specified	
%Voids (Min-Max) (1) (2) Avg. (6)		3-8	3-8

(1) Except when otherwise specified, mix proportions should be adjusted to exhibit test values in the ranges given. When conflicts develop, void criteria based on Rice Procedure should be given prime consideration.
(2) Extreme cautions should be exercised when mixtures exhibit average values near the lower limits and ADT exceeds 500 VPD (see Table F).
(3) Applies to wearing courses only, refer to job mix report for data. (M=Microns)
(4) Applies to lower courses only, refer to job mix report for data. (M=Microns)
(5) Filler bitumen is the ratio of material passing the 200 mesh screen divided by percent of asphalt in the mix.
(6) Target lab voids prevail. Density may have to be increased to be within maximum field voids. General Specifications 2303.14 and Table "G." If conflicts develop between lab and field voids, see Table F.
(7) Only on projects where F/B is based on extractions.

ASPHALT - SAND SURFACE COURSES
Table D

Test Value Guides for Plant Produced Mixtures Mix compacted in laboratory	Average Values
%Lab Air Voids (Min-Max) (1), (2) (Calculated) Per I.M. 510	6.5 - 9.5
%Lab Air Voids (Min-Max) (1) (2) (Rice) Per I.M. 510	6.5 - 9.5
Marshall Stability (lbs.) Min.	200

(1) Except when otherwise specified, mix proportions should be adjusted to exhibit test values in the ranges given. When conflicts develop, void criteria based on Rice Procedure shall govern.

(2) Extreme caution should be exercised when mixtures exhibited average values near the lower limits and ADT exceeds 2000 VPD.

ASPHALT TREATED BASE
Table E

Test Value Guides for Plant Produced Mixtures Class of Mixture (2)	1	2
Filler/Bitumen Ratio (1) (Max.)		
Cold Feed	1.4	1.4
Extraction	1.5	1.5
A.C. Film Thickness (min.)	6.0M	6.0M

(1) The filler/bitumen ratio is the ratio of material passing the 200 mesh screen divided by percent of asphalt in the mix.

(2) Class I compaction max. field voids 8.0%

Iowa Department of Transportation
Office of Materials
Table F

Laboratory voids shall be controlled on the basis of traffic volumes. The following minimums are specified for field control and shall prevail unless a conflict develops between laboratory voids, pavement voids and the specified density. If conflicts do develop, a test strip shall be constructed to determine whether or not the compactive effort required is within reason. Any relief granted in the laboratory voids will be subject to a review of the test strip results and characteristics of the mix by the central office. The minimum voids, as determined by the laboratory job mix, will be targeted at 0.50% higher.

After October 1, except for Interstate mainline paving, the District Materials Engineer may adjust the minimum Laboratory Void Limit downward by as much as 0.25%. This authorization is contingent upon a thorough review of all mix characteristics and placement and compaction efforts. Any such change shall be documented and a copy of such documentation shall be copied to the Materials Engineer immediately.

Course Position	Traffic Volumes				
	75 Blow	50 Blow Marshall			
	≥ 10,000	5000-10,000	2000-5000	1000-2000	≤ 1000
Surface Course	3.5%	3.5%	3.5%	3.0%	2.5%
Binder Course	3.5%	3.5%	3.0%	3.0%	2.5%
Base Course (Upper 1/2+)	3.5%	3.5%	3.0%	3.0%	2.5%
Base Course (Lower 1/2+)	3.5%	3.5%	3.0%	3.0%	2.5%

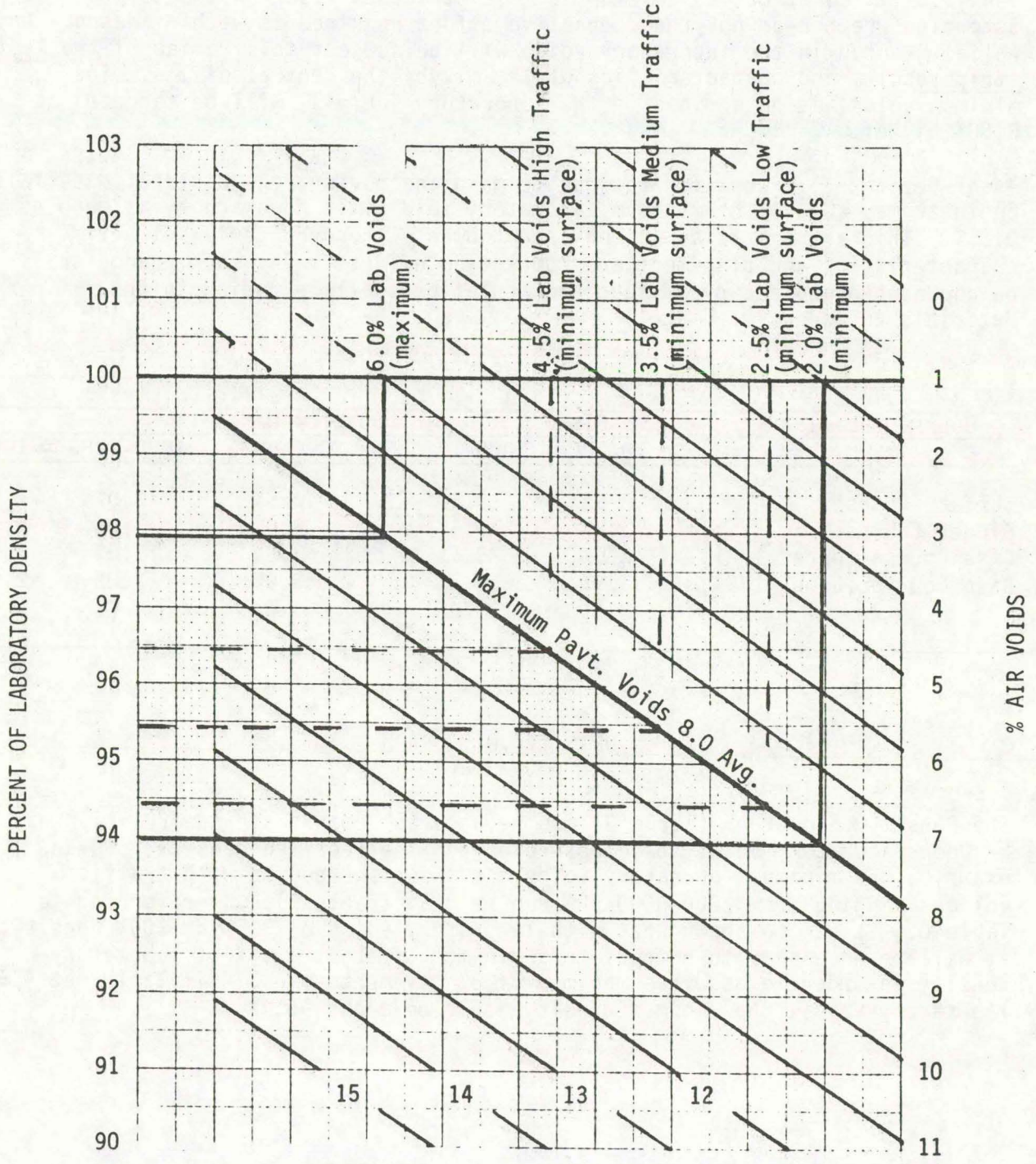
DENSITY VOID GRAPH
TABLE G

The Density Void Graph (Table G) can be used to demonstrate the relationship between laboratory voids, pavement voids and the required density. As an example, the minimum laboratory voids for a surface course with traffic volumes ranging from 2000-5000 VPD can be 3.5% (Table F). By referring to Table G., it can be shown what with laboratory voids of 3.5% at 100% density, it will be necessary to compact to a minimum of about 95.4% of laboratory density in order to assure a maximum of 8% pavement voids. Similarly, at 4.5% laboratory voids, the minimum density would be about 96.4%.

January 1987
Supersedes Jan. 1986

Iowa Department of Transportation
Office of Materials

DENSITY-VOIDS GRAPH
TABLE G



SPRINKLE TREATMENT

GENERAL

Sprinkle treatment is the process of placing a high quality, precoated one size aggregate on the surface of freshly placed asphalt cement concrete surface course and rolling it in conjunction with normal compaction procedures. The sprinkle treatment process is intended to improve the skid resistant characteristics and surface texture of asphalt pavements.

Sprinkle treatment of asphalt cement concrete surfaces is to be in accordance with the current standard specifications and amendments as applicable.

The District Materials Engineer will assign an experienced inspector to witness the calibration of the proportioning and mixing plant that will be used for the precoating of the sprinkle aggregate. Should difficulty be experienced during operations, the District Materials Engineer should be contacted for assistance.

AGGREGATE SELECTION

Aggregates selected for sprinkle treatment are to be composed of Type III crushed gravel or a Type IV crushed stone as classified in I.M. T-203. More skid resistant aggregates may be specified in particular situations or projects.

ASPHALT DETERMINATION

Prior to the beginning of a sprinkle treatment project, a sample of the aggregate is to be sent to the Ames Laboratory for determination of the percentage of asphalt required to properly coat the aggregate.

PRE-COATING

Pre-coating of the sprinkle treatment aggregate can be accomplished by use of the same types of equipment used to produce hot mix asphaltic concrete. The specifications require that the asphalt cement used be the same as used in the job mix.

The specifications require that the aggregate be pre-coated at a temperature between 240^{o}F and 275^{o}F. Attempts should be made to keep within this range, however, some increase in mix temperatures to a maximum of 330^{o} may be considered if it does not cause a detectable increase in the degradation or drainage of asphalt cement from the aggregate.

It is vitally important that the sprinkle treatment aggregate be thoroughly dried before it is coated. If not dried completely there may be some stripping or displacement of the asphalt coating as the moisture escapes. Time required for drying of the aggregate is associated with the length of time available from its introduction to the drier to the coating process. It therefore stands to reason that batch plants may not be as critical as drum mix plants.

It is suggested that in the initial calibration process, smaller quantities should be produced initially to determine the best procedure for drying and coating a particular aggregate.

If a problem occurs in obtaining and maintaining the required coating, it will be necessary that special handling procedures be undertaken. Methods which have been successfully used have consisted of (1) super heating the aggregate then holding it long enough for it to dry completely and to cool to the specified mixing temperature and (2) using a lower drying temperature, run the aggregate through the drier once without coating then run it through again and coat it. This will give the internal moisture a longer time to escape.

Other methods may be considered and evaluated for the required end result.

Many aggregates have a tendency to degrade somewhat in the drying process. For this reason, initial coating operations must be closely observed to assure there is sufficient asphalt cement available to completely coat the aggregate. If visual inspection indicates the coverage is not adequate, the mixing time should be increased and/or the asphalt cement should be increased to provide for the additional demand caused by the increase in fines.

In order that the minus 200 increase can be held to a minimum, it is necessary that all material intercepted by the dust collection system be kept out of the sprinkle treatment mix.

STOCKPILING

The freshly coated aggregate is to be piled on a clean, hard surface of sufficient size to permit some manipulation of the aggregate without contamination during the cooling process. Experience has indicated it is best if the freshly coated material is kept in piles less than 4 feet in height.

Experience has also indicated that water added to the freshly coated aggregate during the manipulation and cooling process causes a stripping of the asphalt from the aggregate. The best results have been obtained by manipulating and wetting the aggregate just prior to loading.

If stockpiles are in an area exposed to any possibility of contamination from dust, etc., they should be covered. The infiltration of this foreign material can cause a buildup of material on the spreader flutes causing unnecessary problems in the placement of the aggregate on the roadway.

SAMPLING AND TESTING

Aggregate for sprinkle treatment is sampled at the cold feed and checked for compliance with the specifications. Samples of the coated aggregate are taken from the roadway as a check of application rates. A 3'x3' sample cloth is recommended. It can be placed beneath the spreader to catch the aggregate distributed over one square yard. The weight can be checked and computed for application rates.

REPORTING

Daily totals of sprinkle aggregate used, a running total and cold feed gradation shall be reported on Form 820007. See page 34 of I.M. 508.

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

METHOD FOR VERIFICATION OF FIELD DENSITY FOR ASPHALTIC CONCRETE PAVING

GENERAL

Verification of the field density test result insures that testing equipment is operating properly and the results are within the range of accuracy. Investigations are conducted and corrections made when results can not be verified.

SAMPLE

A sample consists of all the cored specimens of one day's paving production.

SAMPLING FREQUENCY

A minimum of one sample per week, per project will be selected by the District Materials Office, on a random basis for verification. For projects that will be completed in less than a week, a minimum of one sample per project will be obtained.

HANDLING, STORING AND SHIPPING SAMPLES

The field technician, not knowing which samples will be selected for verification, will be required to retain all the specimens for at least one week. These specimens must be identified and stored in a manner which will not effect their densities. The field technician will submit the samples requested by the District Materials Office along with identification as to the location, the test results and calculations.

VERIFYING THE RESULT

The District Laboratory shall test each specimen of the submitted sample in accordance with IM 321. The test results of each specimen will be compared to each corresponding field test result for correlation. Results that do not correlate to within 0.02 will be considered suspect. Other information gained through this verfication testing, such as trends developing, will also give cause to suspect the results. Immediate investigations must be conducted and corrections made on all suspect test results.

Note: Each District Laboratory's procedure and equipment is verified through the established correlation program with the Central Laboratory.

REPORTING

The District Materials Office shall submit reports of the verification of field density tests to the Central Materials Office along with the documentation of what action that was taken for suspect results.

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

INSPECTION AND ACCEPTANCE OF RELEASE AGENTS FOR BITUMINOUS MATERIALS

GENERAL

Acceptance of release agents used to prevent bituminous materials from adhering to interior surfaces of truck bodies (Section 2001.03 of Standard Specifications) shall be on the basis of approved brands and use in accordance with manufacturer's recommendations. Brand names must be identifiable on the containers. Approved brands are listed in Appendix A.

BRAND NAME APPROVAL

Product approval will be base on information supplied by the producer and the results of tests showing the effect on asphalt cement. The producer shall submit, to the Office of Materials in Ames, a sample of the material together with product information including brand name and instructions for use. Brand name approval will remain in effect indefinitely, unless withdrawn because of unsatisfactory field results traceable to the release agent or a change in formulation. Changes in formulation must be reported immediately to the Office of Materials in Ames.

MONITOR SAMPLING AND TESTING

The Office of Materials may sample and test release agents to verify results of the original approval.

APPENDIX A
APPROVED BRANDS OF RELEASE AGENTS FOR BITUMINOUS MATERIALS

Producer	Brand Name
NCC Inc. Marietta, GA	Release Plus Release Plus #33
Du Bois Chemicals Cincinnati, OH	Liqui-Slip
Spartan Chemical Co. Toledo, OH	Spartan SD-20
Dial Chemical Co. Atlanta, GA	Release All
Huntington Laboratories Huntington, IN	Avalanche
Rochester Midland Rochester, NY	Release Agent SE-380
West Chemical Products, Inc. Long Island City, NY	Superlode
Texas Refinery Ft. Worth, TX	Big Red ←

Highway Division

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

AGGREGATE DELIVERY CONVERSION TABLE

Tons/Hour	50	60	70	80	90	100	110	120	130	140	150
Percent	#/Min	#/Min	#/Min	#/Min	#/Min	#/Min	#/Min	#/Min	#/Min	#/Min	#/Min
2.5	42	50	58	67	75	83	92	100	108	117	125
5.0	83	100	117	133	150	167	183	200	217	233	250
7.5	125	150	175	200	225	250	275	300	325	350	375
10.0	167	200	233	267	300	333	367	400	433	467	500
12.5	208	250	292	334	375	417	459	500	541	583	625
15.0	250	300	350	400	450	500	550	600	650	700	750
17.5	292	350	408	467	525	583	642	700	758	817	875
20.0	333	400	467	533	600	677	733	800	867	933	1000
22.5	375	450	525	600	675	750	825	900	975	1050	1125
25.0	417	500	583	667	750	833	917	1000	1083	1167	1250
27.5	458	550	642	733	825	917	1008	1100	1192	1283	1375
30.0	500	600	700	800	900	1000	1100	1200	1300	1400	1500
32.5	542	650	758	867	975	1083	1192	1300	1408	1517	1625
35.0	583	700	817	933	1050	1167	1283	1400	1517	1633	1750
37.5	625	750	875	1000	1125	1250	1375	1500	1625	1750	1875
40.0	667	800	933	1067	1200	1333	1467	1600	1733	1867	2000
42.5	708	850	992	1133	1275	1417	1558	1700	1842	1983	2125
45.0	750	900	1050	1200	1350	1500	1650	1800	1950	2100	2250
47.5	792	950	1108	1267	1425	1583	1742	1900	2058	2217	2375
50.0	833	1000	1167	1333	1500	1667	1833	2000	2167	2333	2500
52.5	875	1050	1225	1400	1575	1750	1925	2100	2275	2450	2625
55.0	917	1100	1283	1467	1650	1833	2017	2200	2383	2567	2750
57.5	959	1150	1341	1534	1725	1916	2109	2300	2491	2684	2875
60.0	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000
62.5	1042	1250	1458	1667	1875	2083	2292	2500	2708	2917	3125
65.0	1083	1300	1517	1733	1950	2167	2383	2600	2817	3033	3250
67.5	1125	1350	1575	1800	2025	2250	2475	2700	2925	3150	3375
70.0	1167	1400	1633	1867	2100	2333	2567	2800	3033	3267	3500
72.5	1209	1450	1691	1934	2175	2416	2659	2900	3141	3384	3625
75.0	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750
77.5	1292	1550	1808	2067	2325	2583	2842	3100	3358	3617	3875
80.0	1333	1600	1867	2133	2400	2667	2933	3200	3467	3733	4000
82.5	1375	1650	1925	2200	2475	2750	3025	3300	3575	3850	4125
85.0	1417	1700	1983	2267	2550	2833	3117	3400	3683	3967	4250
87.5	1459	1750	2041	2334	2625	2916	3209	3500	3791	4084	4375
90.0	1500	1800	2100	2400	2700	3000	3300	3600	3900	4200	4500
92.5	1542	1850	2158	2467	2775	3083	3392	3700	4008	4317	4625
95.0	1583	1900	2217	2533	2850	3167	3483	3800	4117	4433	4750
97.5	1625	1950	2275	2600	2925	3250	3575	3900	4225	4550	4875
100.0	1667	2000	2333	2667	3000	3333	3667	4000	4333	4667	5000

January 1970

Highway Division

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

Tons/Hour	150	160	170	180	190	200	210	220	230	240	250
Percent	#/Min	#/Min	#/Min	#/Min	#/Min	#/Min	#/Min	#/Min	#/Min	#/Min	#/Min
2.5	125	133	142	150	158	167	175	183	192	200	208
5.0	250	267	283	300	317	333	350	367	383	400	417
7.5	375	400	425	450	475	500	525	550	575	600	625
10.0	500	533	567	600	633	667	700	733	767	800	833
12.5	625	667	708	750	792	833	875	917	958	1000	1042
15.0	750	800	850	900	950	1000	1050	1100	1150	1200	1250
17.5	875	933	992	1050	1108	1167	1225	1283	1342	1400	1458
20.0	1000	1067	1133	1200	1267	1333	1400	1467	1533	1600	1667
22.5	1125	1200	1275	1350	1425	1500	1575	1650	1725	1800	1875
25.0	1250	1333	1417	1500	1583	1667	1750	1833	1917	2000	2083
27.5	1375	1467	1558	1650	1742	1833	1925	2017	2108	2200	2292
30.0	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500
32.5	1625	1733	1842	1950	2058	2167	2275	2383	2492	2600	2708
35.0	1750	1867	1983	2100	2217	2333	2450	2567	2683	2800	2917
37.5	1875	2000	2125	2250	2375	2500	2625	2750	2875	3000	3125
40.0	2000	2133	2267	2400	2533	2667	2800	2933	3067	3200	3333
42.5	2125	2267	2408	2550	2692	2833	2975	3117	3258	3400	3542
45.0	2250	2400	2550	2700	2850	3000	3150	3300	3450	3600	3750
47.5	2375	2533	2692	2850	3008	3167	3325	3483	3642	3800	3958
50.0	2500	2667	2833	3000	3167	3333	3500	3667	3833	4000	4167
52.5	2625	2800	2975	3150	3325	3500	3675	3850	4025	4200	4375
55.0	2750	2933	3117	3300	3483	3667	3850	4033	4217	4400	4583
57.5	2875	3067	3259	3450	3641	3834	4025	4216	4409	4600	4791
60.0	3000	3200	3400	3600	3800	4000	4200	4400	4600	4800	5000
62.5	3125	3333	3542	3750	3958	4167	4375	4583	4792	5000	5208
65.0	3250	3467	3683	3900	4117	4333	4550	4767	4983	5200	5417
67.5	3375	3600	3825	4050	4275	4500	4725	4950	5175	5400	5625
70.0	3500	3733	3967	4200	4433	4667	4900	5133	5367	5600	5833
72.5	3625	3867	4109	4350	4591	4834	5075	5316	5559	5800	6041
75.0	3750	4000	4250	4500	4750	5000	5250	5500	5750	6000	6250
77.5	3875	4033	4392	4650	4908	5167	5425	5683	5942	6200	6458
80.0	4000	4267	4533	4800	5067	5333	5600	5867	6133	6400	6667
82.5	4125	4400	4675	4950	5225	5500	5775	6050	6325	6600	6875
85.0	4250	4533	4817	5100	5383	5667	5950	6233	6517	6800	7083
87.0	4375	4666	4959	5250	5541	5833	6125	6416	6709	7000	7291
90.0	4500	4800	5100	5400	5700	6000	6300	6600	6900	7200	7500
92.5	4625	4933	5242	5550	5858	6167	6475	6783	7092	7400	7708
95.0	4750	5067	5383	5700	6017	6333	6650	6967	7283	7600	7917
97.5	4875	5200	5525	5850	6175	6500	6825	7150	7475	7800	8125
100.0	5000	5333	5667	6000	6333	6667	7000	7333	7667	8000	8333

Highway Division

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

TONS/HOUR	230	240	250	260	270	280	290	300	310
Percent	#/Min.	#/Min.	#/Min.	#/Min.	#/Min.	#/Min.	#/Min.	#/Min.	#/Min
2.5	192	200	208	217	225	233	242	250	258
5.0	383	400	417	433	450	467	484	500	517
7.5	575	600	625	650	675	700	725	750	775
10.0	767	800	833	867	900	933	967	1000	1033
12.5	958	1000	1042	1083	1125	1167	1208	1250	1292
15.0	1150	1200	1250	1300	1350	1400	1450	1500	1550
17.5	1342	1400	1458	1517	1575	1633	1692	1750	1808
20.0	1533	1600	1667	1733	1800	1867	1933	2000	2067
22.5	1725	1800	1875	1950	2025	2100	2175	2250	2325
25.0	1917	2000	2083	2167	2250	2333	2417	2500	2583
27.5	2108	2200	2292	2383	2475	2567	2658	2750	2842
30.0	2300	2400	2500	2600	2700	2800	2900	3000	3100
32.5	2492	2600	2708	2817	2925	3033	3142	3250	3358
35.0	2683	2800	2917	3033	3150	3267	3383	3500	3617
37.5	2875	3000	3125	3250	3375	3500	3625	3750	3875
40.0	3067	3200	3333	3467	3600	3733	3867	4000	4133
42.5	3258	3400	3542	3683	3825	3967	4108	4250	4392
45.0	3450	3600	3750	3900	4050	4200	4350	4500	4650
47.5	3642	3800	3958	4117	4275	4433	4592	4750	4908
50.0	3833	4000	4167	4333	4500	4667	4833	5000	5167
52.5	4025	4200	4375	4550	4725	4900	5075	5250	5425
55.0	5217	4400	4583	4767	4950	5133	4317	5500	5683
57.5	4409	4600	4791	4983	5174	5366	5559	5750	5942
60.0	4600	4800	5000	5200	5400	5600	5800	6000	6200
62.5	4792	5000	5208	5417	5625	5833	6042	6250	6458
65.0	4983	5200	5417	5633	5850	6067	6283	6500	6717
67.5	5175	5400	5625	5850	6075	6300	6525	6750	6975
70.0	5367	5600	5833	6067	6300	6533	6767	7000	7233
72.5	5559	5800	6041	6283	6525	6766	7007	7250	7491
75.0	5750	6000	6250	6500	6750	7000	7250	7500	7750
77.5	5942	6200	6458	6717	6975	7233	7492	7750	8008
80.0	6133	6400	6667	6933	7200	7467	7733	8000	8267
82.5	6325	6600	6875	7150	7425	7700	7975	8250	8525
85.0	6517	6800	7083	7367	7650	7933	8217	8500	8783
87.5	6709	7000	7291	7582	7875	8166	8457	8750	9042
90.0	6900	7200	7500	7800	8100	8400	8700	9000	9300
92.5	7092	7400	7708	8017	8325	8633	8942	9250	9558
95.0	7283	7600	7917	8233	8550	8867	9183	9500	9817
97.5	7475	7800	8125	8450	8775	9100	9425	9750	10075
100.0	7667	8000	8333	8667	9000	9333	9667	10000	10333

January 1970

Highway Division

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

TONS/HOUR	320	330	340	350	360	370	380	390	400
Percent	#/Min.	#/Min.	#/Min.	#/Min.	#/Min.	#/Min.	#/Min.	#/Min.	#/Min.
2.5	267	275	283	292	300	308	317	325	333
5.0	534	550	567	584	600	617	634	650	667
7.5	800	825	850	875	900	925	950	975	1000
10.0	1067	1100	1133	1167	1200	1233	1267	1300	1333
12.5	1333	1375	1417	1458	1500	1542	1583	1625	1667
15.0	1500	1650	1700	1750	1800	1850	1900	1950	2000
17.5	1867	1925	1983	2042	2100	2158	2217	2275	2333
20.0	2133	2200	2267	2333	2400	2467	2533	2600	2667
22.5	2400	2475	2550	2625	2700	2775	2850	2925	3000
25.0	2667	2750	2833	2917	3000	3083	3167	3250	3333
27.5	2933	3025	3117	3208	3300	3392	3483	3575	3667
30.0	3200	3300	3400	3500	3600	3700	3800	3900	4000
32.5	3467	3575	3683	3792	3900	4008	4117	4225	4333
35.0	3733	3850	3967	4083	4200	4317	4433	4550	4667
37.5	4000	4125	4250	4375	4500	4625	4750	4875	5000
40.0	4267	4400	4533	4667	4800	4933	5067	5200	5333
42.5	4533	4675	4817	4958	5100	5242	5383	5525	5667
45.0	4800	4950	5100	5250	5400	5550	5700	5850	6000
47.5	5067	5225	5383	5542	5700	5858	6017	6175	6333
50.0	5333	5500	5667	5733	6000	6167	6333	6500	6667
52.5	5600	5775	5950	6125	6330	6475	6650	6825	7000
55.0	5867	6050	6233	6417	6600	6783	6967	7150	7333
57.5	6134	6325	6517	6709	6900	7092	7284	7475	7667
60.0	6400	6600	6800	7000	7200	7400	7600	7800	8000
62.5	6667	6875	7083	7292	7500	7708	7917	8125	8333
65.0	6933	7150	7367	7583	7800	8017	8233	8450	8667
67.5	7200	7425	7650	7875	8100	8325	8550	8775	9000
70.0	7467	7700	7933	8167	8400	8633	8867	9100	9333
72.5	7732	7975	8216	8457	8700	8941	9182	9424	9667
75.0	8000	8250	8500	8750	9000	9250	9500	9750	10000
77.5	8267	8525	8783	9042	9300	9558	9817	10075	10333
80.0	8533	8800	9067	9333	9600	9867	10133	10400	10667
82.5	8800	9075	9350	9625	9900	10175	10450	10725	11000
85.0	9067	9350	9633	9917	10200	10483	10767	11050	11333
87.5	9333	9625	9916	10207	10500	10791	11082	11373	11667
90.0	9600	9900	10200	10500	10800	11100	11400	11700	12000
92.5	9867	10175	10483	10792	11100	11408	11717	12025	12333
95.0	10133	10450	10767	11083	11400	11717	12033	12350	12667
97.5	10400	10725	11050	11375	11700	12025	12350	12675	13000
100.0	10667	11000	11333	11667	12000	12333	12667	13000	13333

Highway Division

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

TONS/HOUR	410	420	430	440	450	460	470	480	490
Percent	#/Min.	#/Min.	#/Min.	#/Min.	#/Min.	#/Min.	#/Min.	#/Min.	#/Mi
2.5	342	350	358	367	373	383	392	400	408
5.0	684	700	717	734	750	767	784	800	817
7.5	1025	1050	1075	1100	1125	1150	1175	1200	1225
10.0	1367	1400	1433	1467	1500	1533	1567	1600	1633
12.5	1708	1750	1792	1833	1875	1917	1958	2000	2042
15.0	2050	2100	2150	2200	2250	2300	2350	2400	2450
17.5	2392	2450	2508	2567	2625	2683	2742	2800	2858
20.0	2733	2800	2867	2933	3000	3067	3133	3200	3267
22.5	3075	3150	3225	3300	3375	3450	3525	3600	3675
25.0	3417	3500	3583	3667	3750	3833	3917	4000	4083
27.5	3758	3850	3942	4033	4125	4217	4308	4400	4492
30.0	4100	4200	4300	4400	4500	4600	4700	4800	4900
32.5	4442	4550	4658	4767	4875	4983	5092	5200	5308
35.0	4783	4900	5017	5133	5250	5367	5483	5600	5717
37.5	5125	5250	5375	5500	5625	5750	5875	6000	6125
40.0	5467	5600	5733	5867	6000	6133	6267	6400	6533
42.5	5808	5950	6092	6233	6375	6517	6658	6800	6942
45.0	6150	6300	6450	6600	6750	6900	7050	7200	7350
47.5	6492	6650	6808	6967	7125	7283	7442	7600	7758
50.0	6833	7000	7167	7333	7500	7667	7833	8000	8167
52.5	7175	7350	7525	7700	7875	8050	8225	8400	8575
55.0	7517	7700	7883	8067	8250	8433	8617	8800	8983
57.5	7859	8050	8242	8434	8625	8817	9009	9200	9392
60.0	8200	8400	8600	8800	9000	9200	9400	9600	9800
62.5	8542	8750	8958	9167	9375	9583	9792	10000	10208
65.0	8883	9100	9317	9533	9750	9967	10183	10400	10617
67.5	9225	9450	9675	9900	10125	10350	10575	10800	11025
70.0	9567	9800	10033	10267	10500	10733	10967	11200	11433
72.5	9907	10148	10391	10632	10873	11116	11358	11600	11841
75.0	10250	10500	10750	11000	11250	11500	11750	12000	12250
77.5	10592	10850	11108	11367	11625	11883	12142	12400	12658
80.0	10933	11200	11467	11733	12000	12267	12533	12800	13067
82.5	11275	11550	11825	12100	12375	12650	12925	13200	13475
85.0	11617	11900	12183	12467	12750	13033	13317	13600	13883
87.5	11957	12248	12540	12832	13123	13416	13707	14000	14291
90.0	12300	12600	12900	13200	13500	13800	14100	14400	14700
92.5	12642	12950	13258	13567	13875	14183	14492	14800	15108
95.0	12983	13300	13617	13933	14250	14567	14883	15200	15517
97.5	13325	13650	13975	14300	14625	14950	15275	15600	15925
100.0	13667	14000	14333	14667	15000	15333	15667	16000	16333

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Highway Division

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

TONS/HOUR	500	510	520
Percent	#/Min.	#/Min.	#/Min.
2.5	417	425	433
5.0	834	850	867
7.5	1250	1275	1300
10.0	1167	1700	1733
12.5	2083	2125	2167
15.0	2500	2550	2600
17.5	2917	2975	3033
20.0	3333	3400	3467
22.5	3750	3825	3900
25.0	4167	4250	4333
27.5	4583	4675	4767
30.0	5000	5100	5200
32.5	5417	5525	5633
35.0	5833	5950	6967
37.5	6250	6375	6500
40.0	6667	6800	6933
42.5	7083	7225	7367
45.0	7500	7650	7800
47.5	7917	8075	8733
50.0	8333	8500	8667
52.5	8750	8925	9100
55.0	9167	9350	9533
57.5	9584	9775	9967
60.0	10000	10200	10400
62.5	10417	10675	10833
65.0	10833	11050	11267
67.5	11250	11475	11700
70.0	11667	11900	12133
72.5	12082	12324	12566
75.0	12500	12750	13000
77.5	12917	13175	13433
80.0	13333	13600	13867
82.5	13750	14025	14300
85.0	14167	14450	14733
87.5	14582	14874	15166
90.0	15000	15300	15600
92.5	15417	15725	16033
95.0	15833	16150	16467
97.5	16250	16575	16900
100.0	16667	17000	17333

Highway Division

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

VOLUME CORRECTIONS FOR ASPHALTIC MATERIALS

GROUP 0—SPECIFIC GRAVITY AT 60°F ABOVE 0.966

LEGEND: t = observed temperature in degrees Fahrenheit
M = multiplier for correcting oil volumes to the basis of 60°F

t	M	t	M	t	M	t	M	t	M
0	1.0211	50	1.0035	100	0.9861	150	0.9689	200	0.9520
1	1.0208	51	1.0031	101	0.9857	151	0.9686	201	0.9516
2	1.0204	52	1.0028	102	0.9854	152	0.9682	202	0.9513
3	1.0201	53	1.0024	103	0.9851	153	0.9679	203	0.9509
4	1.0197	54	1.0021	104	0.9847	154	0.9675	204	0.9506
5	1.0194	55	1.0017	105	0.9844	155	0.9672	205	0.9503
6	1.0190	56	1.0014	106	0.9840	156	0.9669	206	0.9499
7	1.0186	57	1.0010	107	0.9837	157	0.9665	207	0.9496
8	1.0183	58	1.0007	108	0.9833	158	0.9662	208	0.9493
9	1.0179	59	1.0003	109	0.9830	159	0.9658	209	0.9489
10	1.0176	60	1.0000	110	0.9826	160	0.9655	210	0.9486
11	1.0172	61	0.9997	111	0.9823	161	0.9652	211	0.9483
12	1.0169	62	0.9993	112	0.9819	162	0.9648	212	0.9479
13	1.0165	63	0.9990	113	0.9816	163	0.9645	213	0.9476
14	1.0162	64	0.9986	114	0.9813	164	0.9641	214	0.9472
15	1.0158	65	0.9983	115	0.9809	165	0.9638	215	0.9469
16	1.0155	66	0.9979	116	0.9806	166	0.9635	216	0.9466
17	1.0151	67	0.9976	117	0.9802	167	0.9631	217	0.9462
18	1.0148	68	0.9972	118	0.9799	168	0.9628	218	0.9459
19	1.0144	69	0.9969	119	0.9795	169	0.9624	219	0.9456
20	1.0141	70	0.9965	120	0.9792	170	0.9621	220	0.9452
21	1.0137	71	0.9962	121	0.9788	171	0.9618	221	0.9449
22	1.0133	72	0.9958	122	0.9785	172	0.9614	222	0.9446
23	1.0130	73	0.9955	123	0.9782	173	0.9611	223	0.9442
24	1.0126	74	0.9951	124	0.9778	174	0.9607	224	0.9439
25	1.0123	75	0.9948	125	0.9775	175	0.9604	225	0.9436
26	1.0119	76	0.9944	126	0.9771	176	0.9601	226	0.9432
27	1.0116	77	0.9941	127	0.9768	177	0.9597	227	0.9429
28	1.0112	78	0.9937	128	0.9764	178	0.9594	228	0.9426
29	1.0109	79	0.9934	129	0.9761	179	0.9590	229	0.9422
30	1.0105	80	0.9930	130	0.9758	180	0.9587	230	0.9419
31	1.0102	81	0.9927	131	0.9754	181	0.9584	231	0.9416
32	1.0098	82	0.9923	132	0.9751	182	0.9580	232	0.9412
33	1.0095	83	0.9920	133	0.9747	183	0.9577	233	0.9409
34	1.0091	84	0.9916	134	0.9744	184	0.9574	234	0.9405
35	1.0088	85	0.9913	135	0.9740	185	0.9570	235	0.9402
36	1.0084	86	0.9909	136	0.9737	186	0.9567	236	0.9399
37	1.0081	87	0.9906	137	0.9734	187	0.9563	237	0.9395
38	1.0077	88	0.9902	138	0.9730	188	0.9560	238	0.9392
39	1.0074	89	0.9899	139	0.9727	189	0.9557	239	0.9389
40	1.0070	90	0.9896	140	0.9723	190	0.9553	240	0.9385
41	1.0067	91	0.9892	141	0.9720	191	0.9550	241	0.9382
42	1.0063	92	0.9889	142	0.9716	192	0.9547	242	0.9379
43	1.0060	93	0.9885	143	0.9713	193	0.9543	243	0.9375
44	1.0056	94	0.9882	144	0.9710	194	0.9540	244	0.9372
45	1.0053	95	0.9878	145	0.9706	195	0.9536	245	0.9369
46	1.0049	96	0.9875	146	0.9703	196	0.9533	246	0.9365
47	1.0046	97	0.9871	147	0.9699	197	0.9530	247	0.9362
48	1.0042	98	0.9868	148	0.9696	198	0.9526	248	0.9359
49	1.0038	99	0.9864	149	0.9693	199	0.9523	249	0.9356

VOLUME CORRECTION FOR ASPHALTIC MATERIALS

GROUP 0—SPECIFIC GRAVITY AT 60°F ABOVE 0.966

LEGEND: t = observed temperature in degrees Fahrenheit
M = multiplier for correcting oil volumes to the basis of 60°F

t	M	t	M	t	M	t	M	t	M
250	0.9352	300	0.9187	350	0.9024	400	0.8864	450	0.8705
251	0.9349	301	0.9184	351	0.9021	401	0.8861	451	0.8702
252	0.9346	302	0.9181	352	0.9018	402	0.8857	452	0.8699
253	0.9342	303	0.9177	353	0.9015	403	0.8854	453	0.8696
254	0.9339	304	0.9174	354	0.9011	404	0.8851	454	0.8693
255	0.9336	305	0.9171	355	0.9008	405	0.8848	455	0.8690
256	0.9332	306	0.9167	356	0.9005	406	0.8845	456	0.8687
257	0.9329	307	0.9164	357	0.9002	407	0.8841	457	0.8683
258	0.9326	308	0.9161	358	0.8998	408	0.8838	458	0.8680
259	0.9322	309	0.9158	359	0.8995	409	0.8835	459	0.8677
260	0.9319	310	0.9154	360	0.8992	410	0.8832	460	0.8674
261	0.9316	311	0.9151	361	0.8989	411	0.8829	461	0.8671
262	0.9312	312	0.9148	362	0.8986	412	0.8826	462	0.8668
263	0.9309	313	0.9145	363	0.8982	413	0.8822	463	0.8665
264	0.9306	314	0.9141	364	0.8979	414	0.8819	464	0.8661
265	0.9302	315	0.9138	365	0.8976	415	0.8816	465	0.8658
266	0.9299	316	0.9135	366	0.8973	416	0.8813	466	0.8655
267	0.9296	317	0.9132	367	0.8969	417	0.8810	467	0.8652
268	0.9293	318	0.9128	368	0.8966	418	0.8806	468	0.8649
269	0.9289	319	0.9125	369	0.8963	419	0.8803	469	0.8646
270	0.9286	320	0.9122	370	0.8960	420	0.8800	470	0.8643
271	0.9283	321	0.9118	371	0.8957	421	0.8797	471	0.8640
272	0.9279	322	0.9115	372	0.8953	422	0.8794	472	0.8636
273	0.9276	323	0.9112	373	0.8950	423	0.8791	473	0.8633
274	0.9273	324	0.9109	374	0.8947	424	0.8787	474	0.8630
275	0.9269	325	0.9105	375	0.8944	425	0.8784	475	0.8627
276	0.9266	326	0.9102	376	0.8941	426	0.8781	476	0.8624
277	0.9263	327	0.9099	377	0.8937	427	0.8778	477	0.8621
278	0.9259	328	0.9096	378	0.8934	428	0.8775	478	0.8618
279	0.9256	329	0.9092	379	0.8931	429	0.8772	479	0.8615
280	0.9253	330	0.9089	380	0.8928	430	0.8768	480	0.8611
281	0.9250	331	0.9086	381	0.8924	431	0.8765	481	0.8608
282	0.9246	332	0.9083	382	0.8921	432	0.8762	482	0.8605
283	0.9243	333	0.9079	383	0.8918	433	0.8759	483	0.8602
284	0.9240	334	0.9076	384	0.8915	434	0.8756	484	0.8599
285	0.9236	335	0.9073	385	0.8912	435	0.8753	485	0.8596
286	0.9233	336	0.9070	386	0.8908	436	0.8749	486	0.8593
287	0.9230	337	0.9066	387	0.8905	437	0.8746	487	0.8590
288	0.9227	338	0.9063	388	0.8902	438	0.8743	488	0.8587
289	0.9223	339	0.9060	389	0.8899	439	0.8740	489	0.8583
290	0.9220	340	0.9057	390	0.8896	440	0.8737	490	0.8580
291	0.9217	341	0.9053	391	0.8892	441	0.8734	491	0.8577
292	0.9213	342	0.9050	392	0.8889	442	0.8731	492	0.8574
293	0.9210	343	0.9047	393	0.8886	443	0.8727	493	0.8571
294	0.9207	344	0.9044	394	0.8883	444	0.8724	494	0.8568
295	0.9204	345	0.9040	395	0.8880	445	0.8721	495	0.8565
296	0.9200	346	0.9037	396	0.8876	446	0.8718	496	0.8562
297	0.9197	347	0.9034	397	0.8873	447	0.8715	497	0.8559
298	0.9194	348	0.9031	398	0.8870	448	0.8712	498	0.8556
299	0.9190	349	0.9028	399	0.8867	449	0.8709	499	0.8552

Highway Division

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

VOLUME CORRECTION FOR ASPHALTIC MATERIALS

GROUP 1—SPECIFIC GRAVITY AT 60°F OF 0.850 TO 0.966

LEGEND: t = observed temperature in degrees Fahrenheit
M = multiplier for correcting oil volumes to the basis of 60°F

t	M	t	M	t	M	t	M	t	M
0	1.0241	50	1.0040	100	0.9842	150	0.9647	200	0.9456
1	1.0237	51	1.0036	101	0.9838	151	0.9643	201	0.9452
2	1.0233	52	1.0032	102	0.9834	152	0.9639	202	0.9448
3	1.0229	53	1.0028	103	0.9830	153	0.9635	203	0.9444
4	1.0225	54	1.0024	104	0.9826	154	0.9632	204	0.9441
5	1.0221	55	1.0020	105	0.9822	155	0.9628	205	0.9437
6	1.0217	56	1.0016	106	0.9818	156	0.9624	206	0.9433
7	1.0213	57	1.0012	107	0.9814	157	0.9620	207	0.9429
8	1.0209	58	1.0008	108	0.9810	158	0.9616	208	0.9425
9	1.0205	59	1.0004	109	0.9806	159	0.9612	209	0.9422
10	1.0201	60	1.0000	110	0.9803	160	0.9609	210	0.9418
11	1.0197	61	0.9996	111	0.9799	161	0.9605	211	0.9414
12	1.0193	62	0.9992	112	0.9795	162	0.9601	212	0.9410
13	1.0189	63	0.9988	113	0.9791	163	0.9597	213	0.9407
14	1.0185	64	0.9984	114	0.9787	164	0.9593	214	0.9403
15	1.0181	65	0.9980	115	0.9783	165	0.9589	215	0.9399
16	1.0177	66	0.9976	116	0.9779	166	0.9585	216	0.9395
17	1.0173	67	0.9972	117	0.9775	167	0.9582	217	0.9391
18	1.0168	68	0.9968	118	0.9771	168	0.9578	218	0.9388
19	1.0164	69	0.9964	119	0.9767	169	0.9574	219	0.9384
20	1.0160	70	0.9960	120	0.9763	170	0.9570	220	0.9380
21	1.0156	71	0.9956	121	0.9760	171	0.9566	221	0.9376
22	1.0152	72	0.9952	122	0.9756	172	0.9562	222	0.9373
23	1.0148	73	0.9948	123	0.9752	173	0.9559	223	0.9369
24	1.0144	74	0.9944	124	0.9748	174	0.9555	224	0.9365
25	1.0140	75	0.9940	125	0.9744	175	0.9551	225	0.9361
26	1.0136	76	0.9936	126	0.9740	176	0.9547	226	0.9358
27	1.0132	77	0.9932	127	0.9736	177	0.9543	227	0.9354
28	1.0128	78	0.9929	128	0.9732	178	0.9539	228	0.9350
29	1.0124	79	0.9925	129	0.9728	179	0.9536	229	0.9346
30	1.0120	80	0.9921	130	0.9725	180	0.9532	230	0.9343
31	1.0116	81	0.9917	131	0.9721	181	0.9528	231	0.9339
32	1.0112	82	0.9913	132	0.9717	182	0.9524	232	0.9335
33	1.0108	83	0.9909	133	0.9713	183	0.9520	233	0.9331
34	1.0104	84	0.9905	134	0.9709	184	0.9517	234	0.9328
35	1.0100	85	0.9901	135	0.9705	185	0.9513	235	0.9324
36	1.0096	86	0.9897	136	0.9701	186	0.9509	236	0.9320
37	1.0092	87	0.9893	137	0.9697	187	0.9505	237	0.9316
38	1.0088	88	0.9889	138	0.9693	188	0.9501	238	0.9313
39	1.0084	89	0.9885	139	0.9690	189	0.9498	239	0.9309
40	1.0080	90	0.9881	140	0.9686	190	0.9494	240	0.9305
41	1.0076	91	0.9877	141	0.9682	191	0.9490	241	0.9301
42	1.0072	92	0.9873	142	0.9678	192	0.9486	242	0.9298
43	1.0068	93	0.9869	143	0.9674	193	0.9482	243	0.9294
44	1.0064	94	0.9865	144	0.9670	194	0.9478	244	0.9290
45	1.0060	95	0.9861	145	0.9666	195	0.9475	245	0.9286
46	1.0056	96	0.9857	146	0.9662	196	0.9471	246	0.9283
47	1.0052	97	0.9854	147	0.9659	197	0.9467	247	0.9279
48	1.0048	98	0.9850	148	0.9655	198	0.9463	248	0.9275
49	1.0044	99	0.9846	149	0.9651	199	0.9460	249	0.9272

Highway Division

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

GAGING TABLE FOR HORIZONTAL CYLINDRICAL TANKS

Outage: % of Diam.:	Filled % of Cap.	:Outage: % of Diam.:	Filled % of Cap.	:Outage: % of Diam.:	Filled % of Cap.	:Outage: % of Diam.:	Filled % of Cap.	:Outage: % of Diam.:	Filled % of Cap.
0.0	100.0000	11.0	94.0152	18.0	87.760	22.0	83.688	26.0	79.339
0.5	99.9400	.2	93.8555	.1	87.662	.1	83.582	.1	79.227
1.0	99.8308	.4	93.6940	.2	87.563	.2	83.476	.2	79.114
1.5	99.6896	.6	93.5315	.3	87.465	.3	83.370	.3	79.002
2.0	99.5227	.8	93.3680	.4	87.367	.4	83.263	.4	78.890
2.5	99.3340	12.0	93.2030	.5	87.268	.5	83.158	.5	78.778
3.0	99.1258	.2	93.0370	.6	87.169	.6	83.051	.6	78.666
3.5	98.9002	.4	92.8695	.7	87.070	.7	82.945	.7	78.553
4.0	98.6582	.6	92.7010	.8	86.970	.8	82.839	.8	78.440
4.5	98.4014	.8	92.5320	.9	86.870	.9	82.731	.9	78.328
5.0	98.1307	13.0	92.3610	19.0	86.771	23.0	82.624	27.0	78.215
5.2	98.0186	.2	92.1890	.1	86.671	.1	82.517	.1	78.102
5.4	97.9044	.4	92.0160	.2	86.571	.2	82.410	.2	77.989
5.6	97.7884	.6	91.8420	.3	86.471	.3	82.302	.3	77.875
5.8	97.6703	.8	91.6670	.4	86.370	.4	82.194	.4	77.761
6.0	97.5503	14.0	91.4910	.5	86.269	.5	82.087	.5	77.647
6.2	97.4285	.2	91.3140	.6	86.168	.6	81.978	.6	77.533
6.4	97.3048	.4	91.1355	.7	86.066	.7	81.870	.7	77.419
6.6	97.1789	.6	90.9560	.8	85.965	.8	81.760	.8	77.305
6.8	97.0517	.8	90.7760	.9	85.854	.9	81.652	.9	77.190
7.0	96.9229	15.0	90.5940	20.0	85.762	24.0	81.543	28.0	77.077
7.2	96.8918	.2	90.412	.1	85.659	.1	81.434	.1	76.962
7.4	96.6591	.4	90.229	.2	85.556	.2	81.325	.2	76.848
7.6	96.5251	.6	90.044	.3	85.453	.3	81.216	.3	76.734
7.8	96.3894	.8	89.858	.4	85.351	.4	81.108	.4	76.620
8.0	96.2520	16.0	89.673	.5	85.249	.5	80.990	.5	76.506
8.2	96.1131	.2	89.485	.6	85.146	.6	80.890	.6	76.389
8.4	95.9724	.4	89.397	.7	85.043	.7	80.780	.7	76.272
8.6	95.8304	.6	89.107	.8	84.940	.8	80.670	.8	76.158
8.8	95.6869	.8	88.918	.9	84.837	.9	80.560	.9	76.043
9.0	95.5418	17.0	88.727	21.0	84.733	25.0	80.449	29.0	75.928
9.2	95.3955	.1	88.631	.1	84.629	.1	80.338	.1	75.813
9.4	95.2475	.2	88.535	.2	84.525	.2	80.227	.2	75.698
9.6	95.0985	.3	88.439	.3	84.421	.3	80.116	.3	75.582
9.8	94.9477	.4	88.343	.4	84.317	.4	80.005	.4	75.465
10.0	94.7960	.5	88.246	.5	84.213	.5	79.894	.5	75.349
10.2	94.6420	.6	88.149	.6	84.108	.6	79.783	.6	75.231
10.4	94.4878	.7	88.051	.7	84.002	.7	79.672	.7	75.116
10.6	94.3310	.8	87.954	.8	83.899	.8	79.561	.8	75.000
10.8	94.1742	.9	87.857	.9	83.794	.9	79.450	.9	74.884

February 1968

Highway Division

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

GAGING TABLE FOR HORIZONTAL CYLINDRICAL TANKS

Outage: % of Diam.	Filled % of Cap.	Outage: % of Diam.	Filled % of Cap.	Outage: % of Diam.	Filled % of Cap.	Outage: % of Diam.	Filled % of Cap.	Outage: % of Diam.	Filled % of Cap.
30.0	74.767	34.0	70.019	38.0	65.127	42.0	60.138	46.0	55.082
.1	74.650	.1	69.898	.1	65.004	.1	60.012	.1	54.957
.2	74.533	.2	69.777	.2	64.881	.2	59.886	.2	54.829
.3	74.416	.3	69.565	.3	64.758	.3	59.760	.3	54.704
.4	74.299	.4	69.535	.4	64.632	.4	59.635	.4	54.576
.5	74.182	.5	69.413	.5	64.571	.5	59.510	.5	54.450
.6	74.065	.6	69.292	.6	64.385	.6	59.385	.6	54.322
.7	73.947	.7	69.171	.7	64.261	.7	59.259	.7	54.197
.8	73.830	.8	69.050	.8	64.135	.8	59.131	.8	54.070
.9	73.712	.9	68.929	.9	64.012	.9	59.006	.9	53.942
31.0	73.593	35.0	68.808	39.0	63.890	43.0	58.880	47.0	53.817
.1	73.476	.1	68.686	.1	63.766	.1	58.754	.1	53.689
.2	73.358	.2	68.564	.2	63.641	.2	58.628	.2	53.562
.3	73.240	.3	68.442	.3	63.517	.3	58.501	.3	53.435
.4	73.122	.4	68.320	.4	63.392	.4	58.372	.4	53.307
.5	73.004	.5	68.198	.5	63.268	.5	58.251	.5	53.181
.6	72.886	.6	68.076	.6	63.144	.6	58.124	.6	53.053
.7	72.768	.7	67.954	.7	63.019	.7	57.998	.7	52.926
.8	72.649	.8	67.832	.8	62.894	.8	57.871	.8	52.799
.9	72.530	.9	67.710	.9	62.770	.9	57.743	.9	52.671
32.0	72.411	36.0	67.588	40.0	62.645	44.0	57.617	48.0	52.543
.1	72.292	.1	67.466	.1	62.520	.1	57.490	.1	52.417
.2	72.173	.2	67.343	.2	62.394	.2	57.363	.2	52.290
.3	72.054	.3	67.220	.3	62.269	.3	57.238	.3	52.163
.4	71.935	.4	67.098	.4	62.144	.4	57.110	.4	52.035
.5	71.816	.5	66.975	.5	62.019	.5	56.982	.5	51.907
.6	71.698	.6	66.853	.6	61.894	.6	56.858	.6	51.780
.7	71.578	.7	66.731	.7	61.769	.7	56.732	.7	51.652
.8	71.457	.8	66.608	.8	61.645	.8	56.603	.8	51.525
.9	71.340	.9	66.485	.9	61.521	.9	56.479	.9	51.397
33.0	71.219	37.0	66.382	41.0	61.396	45.0	56.352	49.0	51.271
.1	71.101	.1	66.238	.1	61.270	.1	56.225	.1	51.143
.2	70.980	.2	66.115	.2	61.144	.2	56.098	.2	51.017
.3	70.860	.3	65.992	.3	61.018	.3	55.972	.3	50.888
.4	70.740	.4	65.869	.4	60.892	.4	55.845	.4	50.761
.5	70.620	.5	65.746	.5	60.767	.5	55.718	.5	50.634
.6	70.500	.6	65.623	.6	60.642	.6	55.591	.6	50.506
.7	70.380	.7	65.499	.7	60.518	.7	55.462	.7	50.379
.8	70.260	.8	65.375	.8	60.392	.8	55.337	.8	50.252
.9	70.140	.9	65.251	.9	60.265	.9	55.210	.9	50.123

Highway Division

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

GAGING TABLE FOR HORIZONTAL CYLINDRICAL TANKS

Outage: % of Diam.	Filled: % of Diam.	Outage: % of Diam.	Filled: % of Diam.	Outage: % of Diam.	Filled: % of Diam.	Outage: % of Diam.	Filled: % of Diam.	Outage: % of Diam.	Filled: % of Diam.
50.0	50.000	54.0	44.918	58.0	39.862	62.0	34.873	66.0	29.981
.1	49.877	.1	44.790	.1	39.735	.1	34.749	.1	29.860
.2	49.748	.2	44.663	.2	39.608	.2	34.625	.2	29.740
.3	49.621	.3	44.538	.3	39.482	.3	34.501	.3	29.620
.4	49.494	.4	44.409	.4	39.358	.4	34.377	.4	29.500
.5	49.366	.5	44.282	.5	39.233	.5	34.254	.5	29.380
.6	49.239	.6	44.155	.6	39.108	.6	34.131	.6	29.260
.7	49.112	.7	44.028	.7	38.982	.7	34.008	.7	29.140
.8	48.983	.8	43.902	.8	38.856	.8	33.885	.8	29.020
.9	48.857	.9	43.775	.9	38.730	.9	33.762	.9	28.899
51.0	48.729	55.0	43.648	59.0	38.604	63.0	33.638	67.0	28.781
.1	48.603	.1	43.521	.1	38.479	.1	33.515	.1	28.660
.2	48.475	.2	43.397	.2	38.355	.2	33.392	.2	28.543
.3	48.348	.3	43.268	.3	38.231	.3	33.269	.3	28.422
.4	48.220	.4	43.142	.4	38.106	.4	33.147	.4	28.302
.5	48.093	.5	43.018	.5	37.981	.5	33.025	.5	28.184
.6	47.965	.6	42.890	.6	37.856	.6	32.902	.6	28.065
.7	47.837	.7	42.762	.7	37.731	.7	32.780	.7	27.946
.8	47.710	.8	42.637	.8	37.606	.8	32.657	.8	27.827
.9	47.583	.9	42.510	.9	37.480	.9	32.534	.9	27.708
52.0	47.457	56.0	42.383	60.0	37.355	64.0	32.412	68.0	27.589
.1	47.329	.1	42.257	.1	37.230	.1	32.290	.1	27.470
.2	47.201	.2	42.129	.2	37.106	.2	32.168	.2	27.351
.3	47.074	.3	42.002	.3	36.981	.3	32.046	.3	27.232
.4	46.947	.4	41.876	.4	36.856	.4	31.924	.4	27.114
.5	46.819	.5	41.749	.5	36.732	.5	31.802	.5	26.996
.6	46.693	.6	41.628	.6	36.608	.6	31.680	.6	26.878
.7	46.565	.7	41.499	.7	36.483	.7	31.558	.7	26.760
.8	46.438	.8	41.372	.8	36.359	.8	31.436	.8	26.642
.9	46.311	.9	41.246	.9	36.234	.9	31.314	.9	26.524
53.0	46.183	57.0	41.120	61.0	36.110	65.0	31.192	69.0	26.407
.1	46.058	.1	40.994	.1	35.988	.1	31.071	.1	26.288
.2	45.930	.2	40.869	.2	35.865	.2	30.950	.2	26.170
.3	45.805	.3	40.741	.3	35.739	.3	30.829	.3	26.052
.4	45.678	.4	40.615	.4	35.615	.4	30.708	.4	25.935
.5	45.550	.5	40.490	.5	35.491	.5	30.587	.5	25.818
.6	45.424	.6	40.365	.6	35.368	.6	30.465	.6	25.701
.7	45.298	.7	40.240	.7	35.242	.7	30.344	.7	25.584
.8	45.171	.8	40.114	.8	35.119	.8	30.223	.8	25.467
.9	45.043	.9	39.988	.9	34.996	.9	30.102	.9	25.350

February 1968

Highway Division

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

GAGING TABLE FOR HORIZONTAL CYLINDRICAL TANKS

Outage: % of Diam.	Filled % of Cap.	Outage: % of Diam.	Filled % of Cap.	Outage: % of Diam.	Filled % of Cap.	Outage: % of Diam.	Filled % of Cap.	Outage: % of Diam.	Filled % of Cap.
70.0	25.233	74.0	20.661	78.0	16.312	82.0	12.240	89.0	5.9848
.1	25.116	.1	20.550	.1	16.206	.1	12.143	.2	5.8258
.2	25.000	.2	20.439	.2	16.101	.2	12.046	.4	5.6690
.3	24.884	.3	20.328	.3	15.998	.3	11.949	.6	5.5122
.4	24.769	.4	20.217	.4	15.892	.4	11.851	.8	5.3580
.5	24.651	.5	20.106	.5	15.787	.5	11.754	90.0	5.2040
.6	24.535	.6	19.995	.6	15.683	.6	11.657	.2	5.0523
.7	24.418	.7	19.884	.7	15.579	.7	11.561	.4	4.9015
.8	24.302	.8	19.773	.8	15.475	.8	11.465	.6	4.7525
.9	24.187	.9	19.662	.9	15.371	.9	11.369	.8	4.6045
71.0	24.072	75.0	19.551	79.0	15.267	83.0	11.273	91.0	4.4582
.1	23.957	.1	19.440	.1	15.163	.2	11.082	.2	4.3131
.2	23.842	.2	19.330	.2	15.060	.4	10.893	.4	4.1696
.3	23.728	.3	19.220	.3	14.957	.6	10.703	.6	4.0276
.4	23.611	.4	19.110	.4	14.854	.8	10.515	.8	3.8869
.5	23.494	.5	19.010	.5	14.751	84.0	10.327	92.0	3.7480
.6	23.380	.6	18.892	.6	14.649	.2	10.142	.2	3.6106
.7	23.266	.7	18.784	.7	14.547	.4	9.956	.4	3.4749
.8	23.152	.8	18.675	.8	14.444	.6	9.771	.6	3.3408
.9	23.038	.9	18.566	.9	14.341	.8	9.588	.8	3.2082
72.0	22.923	76.0	18.457	80.0	14.238	85.0	9.406	93.0	3.0771
.1	22.810	.1	18.348	.1	14.146	.2	9.2240	.2	2.9483
.2	22.695	.2	18.240	.2	14.035	.4	9.0440	.4	2.8211
.3	22.581	.3	18.130	.3	13.934	.6	8.8645	.6	2.6952
.4	22.467	.4	18.022	.4	13.832	.8	8.6860	.8	2.5715
.5	22.353	.5	17.913	.5	13.731	86.0	8.5090	94.0	2.4497
.6	22.239	.6	17.806	.6	13.630	.2	8.3330	.2	2.3297
.7	22.125	.7	17.698	.7	13.529	.4	8.1580	.4	2.2116
.8	22.011	.8	17.590	.8	13.429	.6	7.9840	.6	2.0956
.9	21.898	.9	17.483	.9	13.329	.8	7.8110	.8	1.9814
73.0	21.785	77.0	17.376	81.0	13.229	87.0	7.6390	95.0	1.8693
.1	21.672	.1	17.269	.1	13.130	.2	7.4680	.5	1.5986
.2	21.560	.2	17.161	.2	13.030	.4	7.2990	96.0	1.3418
.3	21.447	.3	17.055	.3	12.930	.6	7.1305	.5	1.0998
.4	21.334	.4	16.949	.4	12.831	.8	6.9630	97.0	0.8742
.5	21.222	.5	16.842	.5	12.732	88.0	6.7970	.5	0.6660
.6	21.110	.6	16.737	.6	12.633	.2	6.6320	98.0	0.4773
.7	20.998	.7	16.630	.7	12.535	.4	6.4685	.5	0.3104
.8	20.886	.8	16.524	.8	12.437	.6	6.3060	99.0	0.1692
.9	20.773	.9	16.418	.9	12.338	.8	6.1445	.5	0.0600

May 1986
Supersedes April 1974

Iowa Department of Transportation

Highway Division

OFFICE OF MATERIALS—INSTRUCTIONAL MEMORANDUM

TABLE C-1 TEMPERATURE-VOLUME CORRECTIONS FOR EMULSIFIED ASPHALTS

°C[t]	°F	M*	°C[t]	°F	M*	°C[t]	°F	M*
10.0	50	1.00250	35.0	95	0.99125	60.0	140	0.98000
10.6	51	1.00225	35.6	96	0.99100	60.6	141	0.97975
11.1	52	1.00200	36.1	97	0.99075	61.1	142	0.97950
11.7	53	1.00175	36.7	98	0.99050	61.7	143	0.97925
12.2	54	1.00150	37.2	99	0.99025	62.2	144	0.97900
12.8	55	1.00125	37.8	100	0.99000	62.8	145	0.97875
13.3	56	1.00100	38.3	101	0.98975	63.3	146	0.97850
13.9	57	1.00075	38.9	102	0.98950	63.9	147	0.97825
14.4	58	1.00050	39.4	103	0.98925	64.4	148	0.97800
15.0	59	1.00025	40.0	104	0.98900	65.0	149	0.97775
15.6	60	1.00000	40.6	105	0.98875	65.6	150	0.97750
16.1	61	0.99975	41.1	106	0.98850	66.1	151	0.97725
16.7	62	0.99950	41.7	107	0.98825	66.7	152	0.97700
17.2	63	0.99925	42.2	108	0.98800	67.2	153	0.97675
17.8	64	0.99900	42.8	109	0.98775	67.8	154	0.97650
18.3	65	0.99875	43.3	110	0.98750	68.3	155	0.97625
18.9	66	0.99850	43.9	111	0.98725	68.9	156	0.97600
19.4	67	0.99825	44.4	112	0.98700	69.4	157	0.97575
20.0	68	0.99800	45.0	113	0.98675	70.0	158	0.97550
20.6	69	0.99775	45.6	114	0.98650	70.6	159	0.97525
21.1	70	0.99750	46.1	115	0.98625	71.1	160	0.97500
21.7	71	0.99725	46.7	116	0.98600	71.7	161	0.97475
22.2	72	0.99700	47.2	117	0.98575	72.2	162	0.97450
22.8	73	0.99675	47.8	118	0.98550	72.8	163	0.97425
23.3	74	0.99650	48.3	119	0.98525	73.3	164	0.97400
23.9	75	0.99625	48.9	120	0.98500	73.9	165	0.97375
24.4	76	0.99600	49.4	121	0.98475	74.4	166	0.97350
25.0	77	0.99575	50.0	122	0.98450	75.0	167	0.97325
25.6	78	0.99550	50.6	123	0.98425	75.6	168	0.97300
26.1	79	0.99525	51.1	124	0.98400	76.1	169	0.97275
26.7	80	0.99500	51.7	125	0.98375	76.7	170	0.97250
27.2	81	0.99475	52.2	126	0.98350	77.2	171	0.97225
27.8	82	0.99450	52.8	127	0.98325	77.8	172	0.97200
28.3	83	0.99425	53.3	128	0.98300	78.3	173	0.97175
28.9	84	0.99400	53.9	129	0.98275	78.9	174	0.97150
29.4	85	0.99375	54.4	130	0.98250	79.4	175	0.97125
30.0	86	0.99350	55.0	131	0.98225	80.0	176	0.97100
30.6	87	0.99325	55.6	132	0.98200	80.6	177	0.97075
31.1	88	0.99300	56.1	133	0.98175	81.1	178	0.97050
31.7	89	0.99275	56.7	134	0.98150	81.7	179	0.97025
32.2	90	0.99250	57.2	135	0.98125	82.2	180	0.97000
32.8	91	0.99225	57.8	136	0.98100	82.8	181	0.96975
33.3	92	0.99200	58.3	137	0.98075	83.3	182	0.96950
33.9	93	0.99175	58.9	138	0.98050	83.9	183	0.96925
34.4	94	0.99150	59.4	139	0.98025	84.4	184	0.96900
						85.0	185	0.96875

Legend: *t = observed temperature in degrees Celsius (Fahrenheit)*
M = multiplier for correcting volumes to the basis of 15.6°C (60°F)

**Multiplier (M) for °C is a close approximation.*

OFFICE OF MATERIALS - INSTRUCTIONAL MEMORANDUM

TEMPERATURE---VOLUME

CORRECTIONS FOR DILUTED EMULSIFIED ASPHALT

Applies only for 1 to 1 dilution

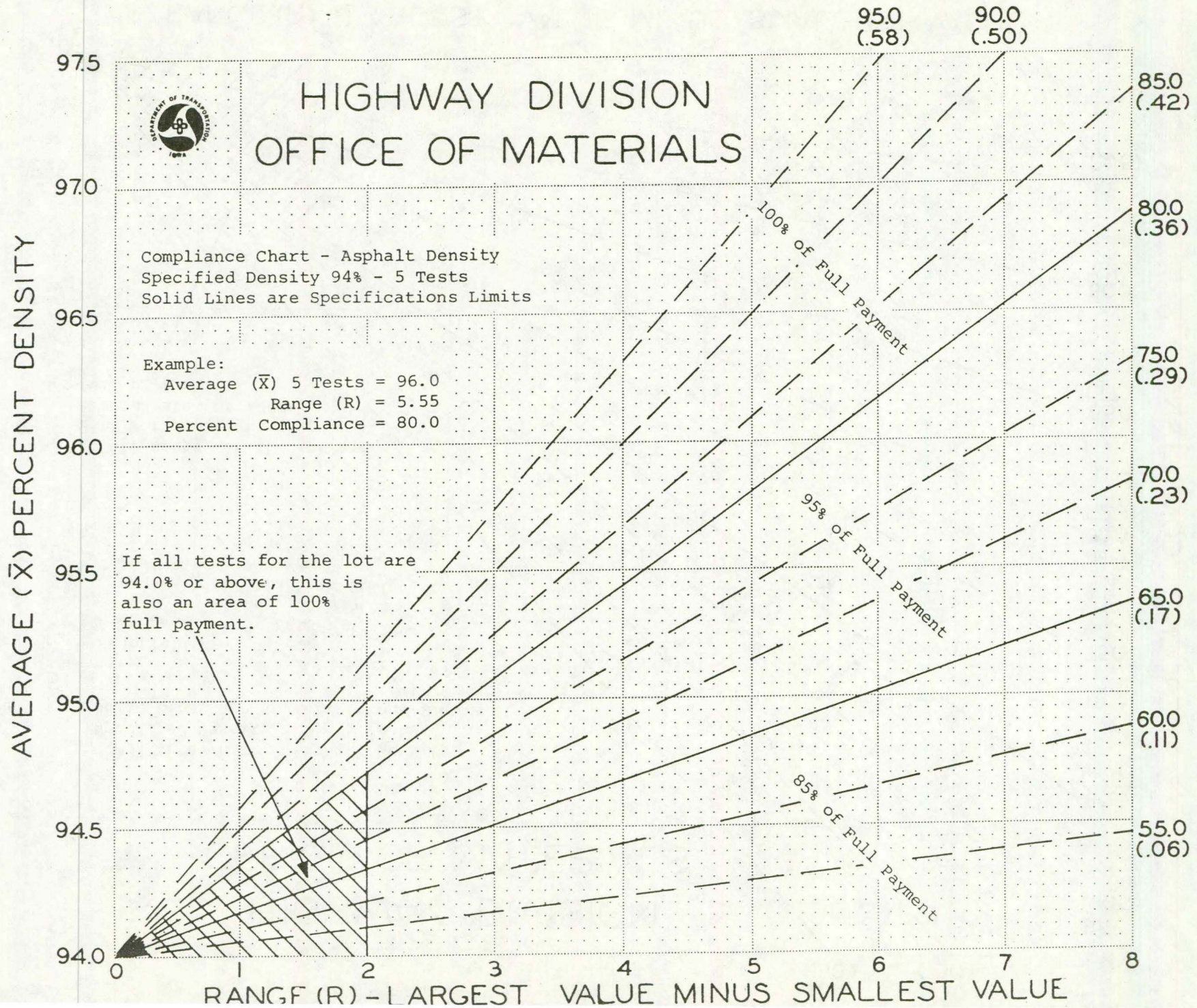
LEGEND: t = observed temperature in degrees Fahrenheit
m = multiplier for correcting volumes to the basis of 60°F

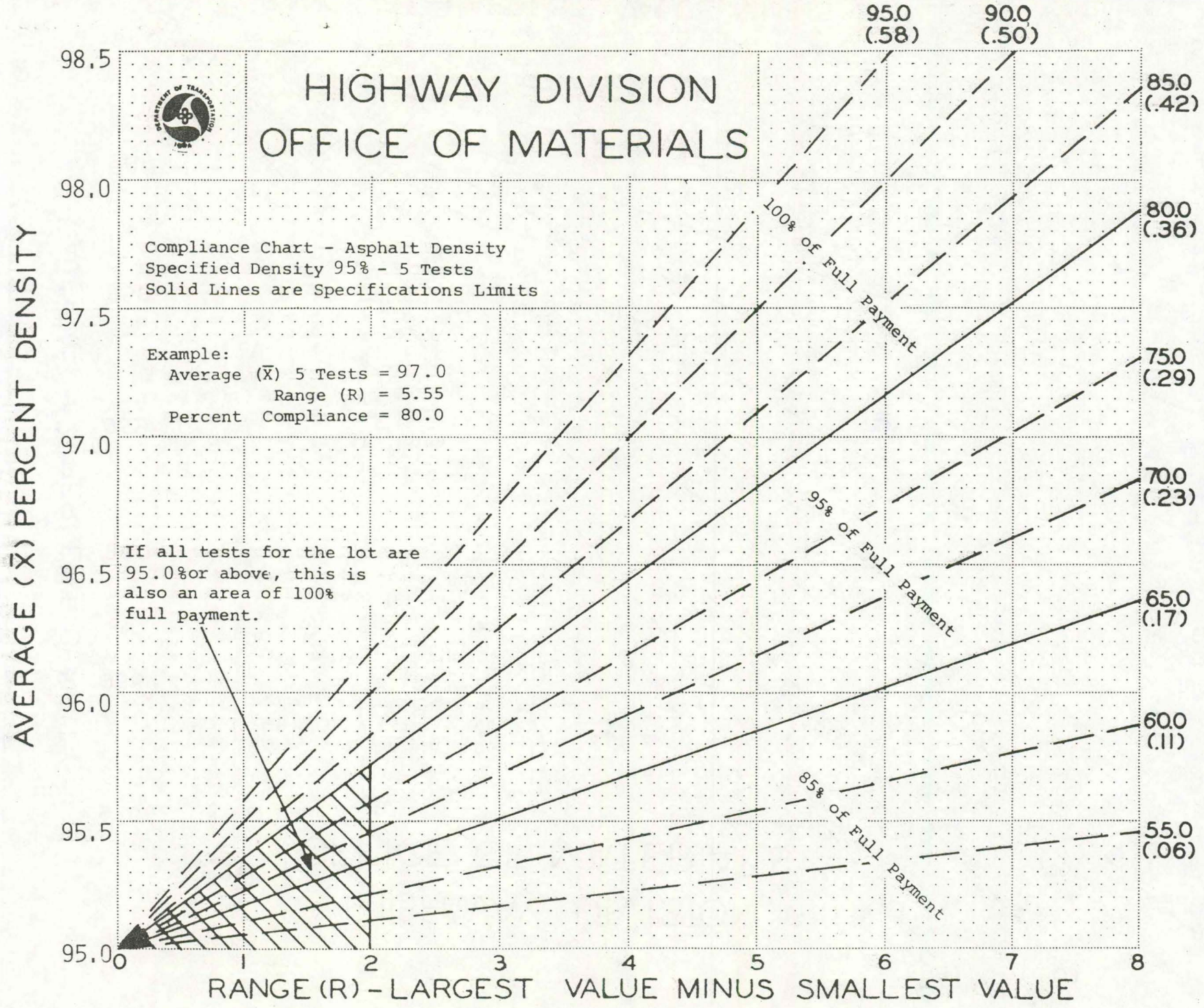
t	M	t	M	t	M
60	1.00000	90	.99422	121	.98700
61	.99982	91	.99400	122	.98675
62	.99964	92	.99378	123	.98650
63	.99948	93	.99356	124	.98625
64	.99930	94	.99334	125	.98600
65	.99912	95	.99312	126	.98575
66	.99894	96	.99290	127	.98550
67	.99877	97	.99268	128	.98524
68	.99858	98	.99245	129	.98498
69	.99840	99	.99222	130	.98473
70	.99822	100	.99200	131	.98447
71	.99802	101	.99177	132	.98420
72	.99783	102	.99154	133	.98394
73	.99764	103	.99131	134	.98368
74	.99744	104	.99108	135	.98341
75	.99725	105	.99085	136	.98314
76	.99706	106	.99062	137	.98288
77	.99686	107	.99039	138	.98262
78	.99666	108	.99016	139	.98235
79	.99647	109	.98992	140	.98208
80	.99628	110	.98969	141	.98182
81	.99608	111	.98945	142	.98154
82	.99587	112	.98921	143	.98126
83	.99566	113	.98896	144	.98099
84	.99546	114	.98872	145	.98072
85	.99526	115	.98848	146	.98044
86	.99505	116	.98823	147	.98016
87	.99484	117	.98798	148	.97989
88	.99464	118	.98774	149	.97962
89	.99942	119	.98750	150	.97934
		120	.98725		

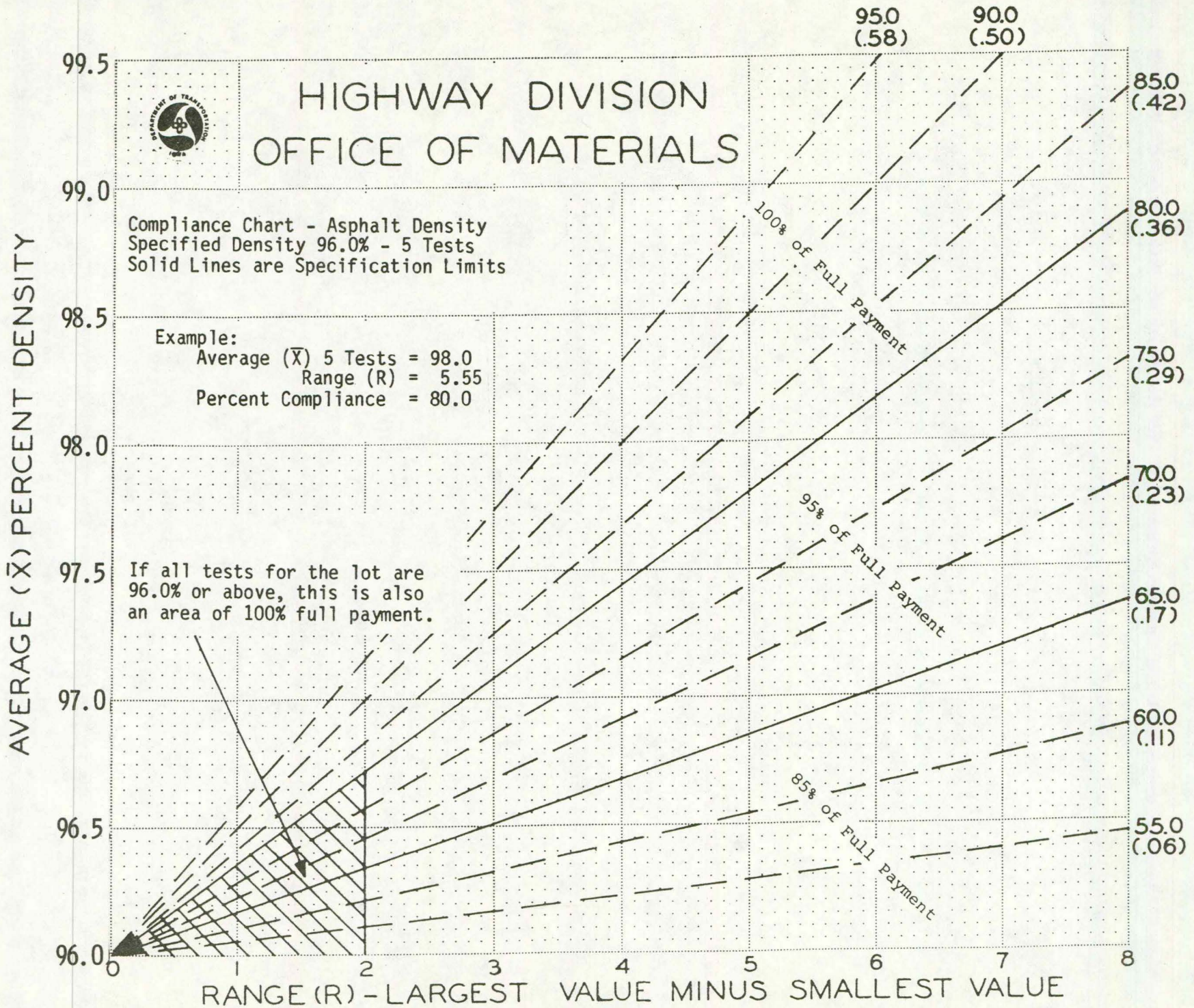
OFFICE OF MATERIALS - INSTRUCTIONAL MEMORANDUM

TABLE FOR ESTIMATING PERCENT OF LOT WITHIN TOLERANCE
(RANGE METHOD)

Percent Within Tolerance	NEGATIVE VALUES OF Q_U OR Q_L n=5	n=7	Percent Within Tolerance	POSITIVE VALUES OF Q_U OR Q_L n=5	n=7
50	0.00	0.00	99	0.66	0.65
			98	0.65	0.61
45	0.06	0.05	97	0.62	0.58
			96	0.60	0.55
40	0.11	0.09	95	0.58	0.53
39	0.13	0.10			
38	0.14	0.11	94	0.57	0.51
37	0.15	0.12	93	0.55	0.49
36	0.16	0.13	92	0.53	0.47
			91	0.51	0.46
35	0.17	0.14	90	0.50	0.44
34	0.18	0.15			
33	0.19	0.16	89	0.48	0.43
32	0.21	0.17	88	0.46	0.41
31	0.22	0.18	87	0.45	0.40
			86	0.44	0.38
30	0.23	0.19	85	0.42	0.37
29	0.24	0.20			
28	0.25	0.21	84	0.41	0.36
27	0.27	0.23	83	0.40	0.34
26	0.28	0.24	82	0.38	0.33
			81	0.37	0.32
25	0.29	0.25	80	0.36	0.31
24	0.30	0.26			
23	0.32	0.27	79	0.34	0.29
22	0.33	0.28	78	0.33	0.28
21	0.34	0.29	77	0.32	0.27
			76	0.30	0.26
20	0.36	0.31	75	0.29	0.25
19	0.37	0.32			
18	0.38	0.33	74	0.28	0.24
17	0.40	0.34	73	0.27	0.23
16	0.41	0.36	72	0.25	0.22
			71	0.24	0.20
15	0.42	0.37	70	0.23	0.19
14	0.44	0.38			
13	0.45	0.40	69	0.22	0.18
12	0.46	0.41	68	0.21	0.17
11	0.48	0.43	67	0.19	0.16
			66	0.18	0.15
10	0.50	0.44	65	0.17	0.14
9	0.51	0.46			
8	0.53	0.47	64	0.16	0.13
7	0.55	0.49	63	0.15	0.12
6	0.57	0.51	62	0.14	0.11
			61	0.13	0.10
5	0.58	0.53	60	0.11	0.09
4	0.60	0.55			
3	0.62	0.58	55	0.06	0.05
2	0.65	0.61			
1	0.66	0.65	50	0.00	0.00


HIGHWAY DIVISION
OFFICE OF MATERIALS
Compliance Chart - Asphalt Density
Specified Density 94% - 5 Tests
Solid Lines are Specifications Limits
Example:
Average ($\bar{X}$) 5 Tests = 96.0
Range (R) = 5.55
Percent Compliance = 80.0
If all tests for the lot are 94.0% or above, this is also an area of 100% full payment.
100% of Full Payment
95% of Full Payment
85% of Full Payment
95.0 (.58)
90.0 (.50)
85.0 (.42)
80.0 (.36)
75.0 (.29)
70.0 (.23)
65.0 (.17)
60.0 (.11)
55.0 (.06)
PERCENT COMPLIANCE
AVERAGE ($\bar{X}$) PERCENT DENSITY
97.5
97.0
96.5
96.0
95.5
95.0
94.5
94.0
0
1
2
3
4
5
6
7
8
RANGE (R) - LARGEST VALUE MINUS SMALLEST VALUE


HIGHWAY DIVISION
OFFICE OF MATERIALS
Compliance Chart - Asphalt Density
Specified Density 95% - 5 Tests
Solid Lines are Specifications Limits
Example:
Average (X̄) 5 Tests = 97.0
Range (R) = 5.55
Percent Compliance = 80.0
If all tests for the lot are 95.0%or above, this is also an area of 100% full payment.
100% of Full Payment
95% of Full Payment
85% of Full Payment
95.0 (.58)
90.0 (.50)
85.0 (.42)
80.0 (.36)
75.0 (.29)
70.0 (.23)
65.0 (.17)
60.0 (.11)
55.0 (.06)
PERCENT COMPLIANCE
AVERAGE (X̄) PERCENT DENSITY
98.5
98.0
97.5
97.0
96.5
96.0
95.5
95.0
0
1
2
3
4
5
6
7
8
RANGE (R) - LARGEST VALUE MINUS SMALLEST VALUE


HIGHWAY DIVISION
OFFICE OF MATERIALS
PERCENT COMPLIANCE
Compliance Chart - Asphalt Density
Specified Density 96.0% - 5 Tests
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85% of Full Payment
95.0 (.58)
90.0 (.50)
85.0 (.42)
80.0 (.36)
75.0 (.29)
70.0 (.23)
65.0 (.17)
60.0 (.11)
55.0 (.06)
AVERAGE (X̄) PERCENT DENSITY
99.5
99.0
98.5
98.0
97.5
97.0
96.5
96.0
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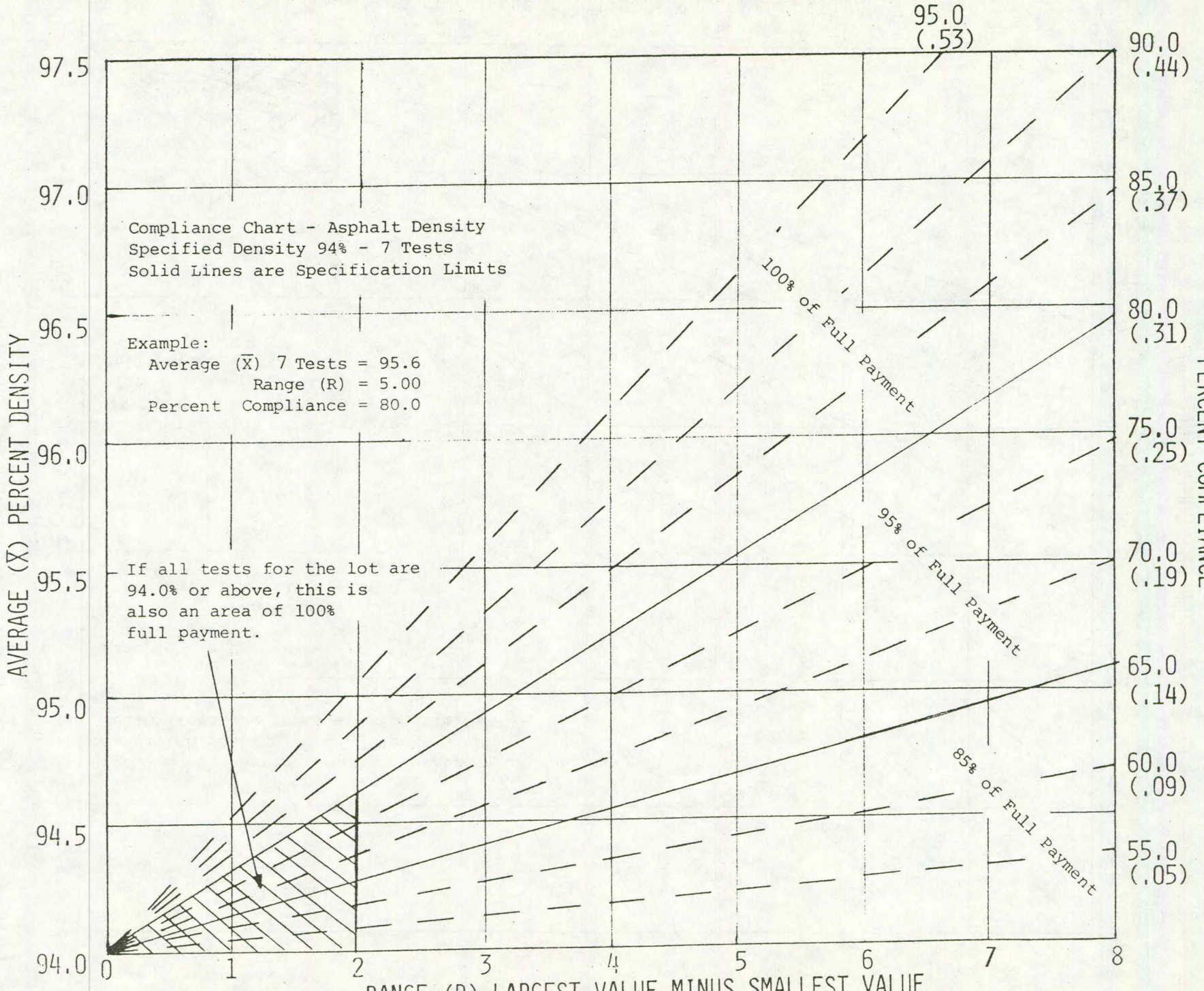
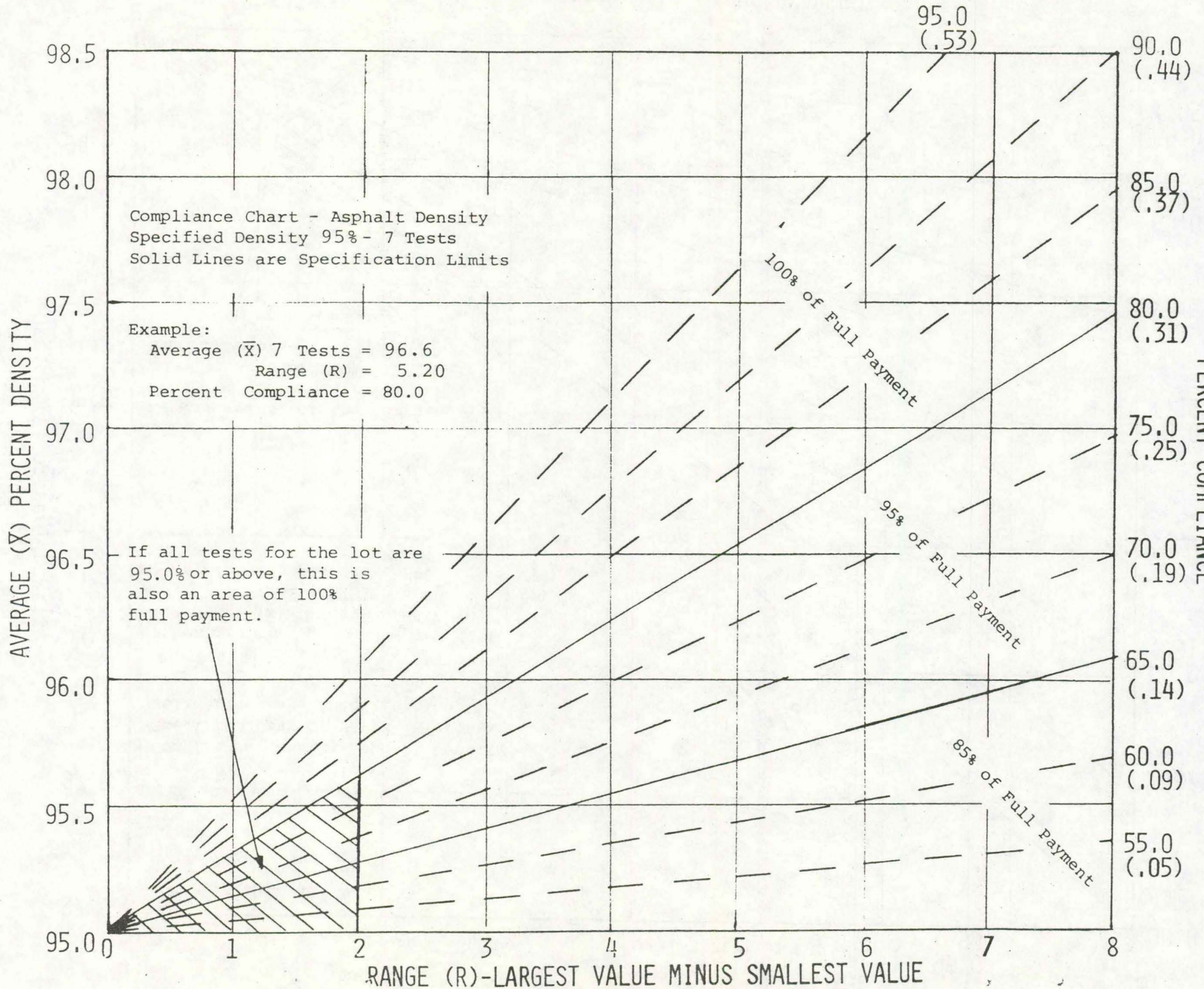
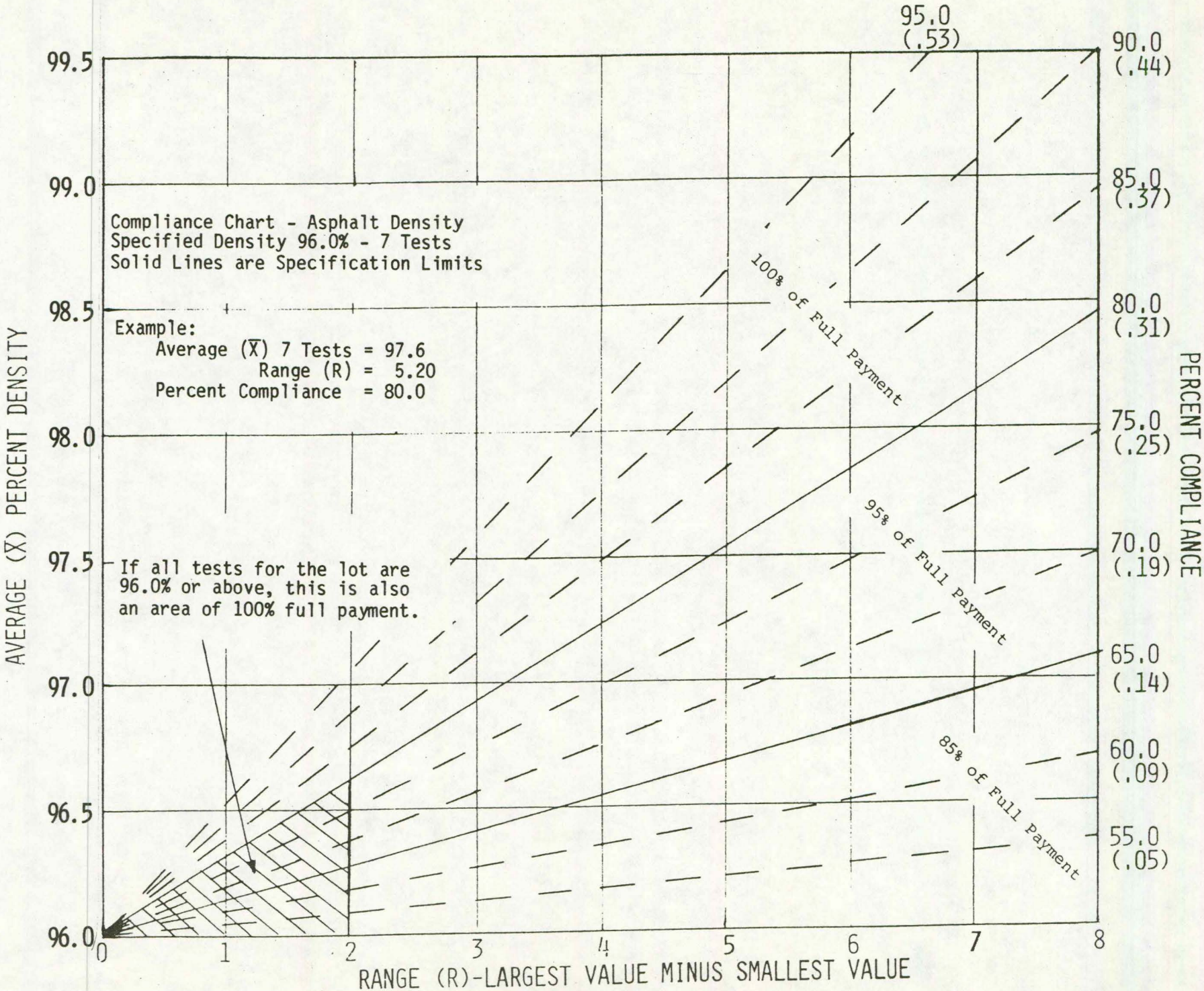
RANGE (R) - LARGEST VALUE MINUS SMALLEST VALUE


Compliance Chart - Asphalt Density
Specified Density 94% - 7 Tests
Solid Lines are Specification Limits
Example:
Average (X̄) 7 Tests = 95.6
Range (R) = 5.00
Percent Compliance = 80.0
If all tests for the lot are 94.0% or above, this is also an area of 100% full payment.
100% of Full Payment
95% of Full payment
85% of Full payment
AVERAGE (X̄) PERCENT DENSITY
97.5
97.0
96.5
96.0
95.5
95.0
94.5
94.0
RANGE (R)-LARGEST VALUE MINUS SMALLEST VALUE
0
1
2
3
4
5
6
7
8
PERCENT COMPLIANCE
95.0 (.53)
90.0 (.44)
85.0 (.37)
80.0 (.31)
75.0 (.25)
70.0 (.19)
65.0 (.14)
60.0 (.09)
55.0 (.05)


Compliance Chart - Asphalt Density
Specified Density 95% - 7 Tests
Solid Lines are Specification Limits
Example:
Average (X̄) 7 Tests = 96.6
Range (R) = 5.20
Percent Compliance = 80.0
If all tests for the lot are 95.0% or above, this is also an area of 100% full payment.
100% of Full Payment
95% of Full Payment
85% of Full Payment
AVERAGE (X̄) PERCENT DENSITY
98.5
98.0
97.5
97.0
96.5
96.0
95.5
95.0
PERCENT COMPLIANCE
95.0 (.53)
90.0 (.44)
85.0 (.37)
80.0 (.31)
75.0 (.25)
70.0 (.19)
65.0 (.14)
60.0 (.09)
55.0 (.05)
0 1 2 3 4 5 6 7 8
RANGE (R)-LARGEST VALUE MINUS SMALLEST VALUE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Specified Density 96.0% - 7 Tests
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99.0
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97.0
96.5
96.0
RANGE (R)-LARGEST VALUE MINUS SMALLEST VALUE
0
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PERCENT COMPLIANCE
95.0 (.53)
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