Table of Contents

Chapter Three – Aggregate Properties

Chapter Four – Aggregate Specifications and Requirements

Chapter Five – Aggregate Production

Chapter Six - Statistical Quality Control for Aggregate Processing

Chapter Seven – Quality Control Plan

Chapter Eight – Testing Equipment

Chapter Nine – Sampling

Chapter Ten – Testing

Appendix B

AASHTO Guide Test Methods (Not official documents)

T 2	Sampling of Aggregates
T 11	Materials Finer than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing
T 27	Sieve Analysis of Fine and Coarse Aggregates
T 84	Specific Gravity and Absorption of Fine Aggregate
T 85	Specific Gravity and Absorption of Coarse Aggregate
T 112	Clay Lumps and Friable Particles in Aggregate
R 76	Reducing Field Samples of Aggregate to Testing Size
T 304	Uncompacted Void Content of Fine Aggregate

ASTM Guide Test Methods (Not official documents)

D 4791	Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
D 5821	Determining Percent of Fractured Particles in Coarse Aggregates

Appendix C

Quality Control Plans

Limerock Quarries, Inc.
Indiana Quality Sand & Gravel, Inc.

Appendix D

Audits

Certified Aggregate Producer Program Audit Checklist
Certified Aggregate Producer Program Partial Audit Checklist
Sampling, Sample Reduction, and Testing Procedures

PROGRAM INSTRUCTORS

Industry Representatives

John Berscheit	Quality Control Rieth-Riley Construction Co.	
Kelly Cook	Levy Technical Laboratories	219-462-2924
Deana Jones	Quality Control I.M.I.	765-473-5578
Robert Jones	Executive Director I.M.A.A.	317- 580-9100
Bob Lingerfelt	Quality Assurance Manager Mulzer Crushed Stone	812- 424-5594
James Schultz	Geologist Hanson Aggregates	502-553-0249
George Williams	Quality Control Manager Rogers Group	812-332-6341

University Representatives

Nelson Shaffer	I.U.P.U.I.

INDOT Representatives

Matt Beeson	Manager Office of Materials Management	317-610-7251 Ext: 204
Bob Dahman	Testing Engineer Ft. Wayne District	260-969-8238
Bob Rees	Geologist Supervisor Office of Materials Management	317-610-7251 Ext: 232
Kurt Sommer	Testing Engineer Crawfordsville District	765-361-5625
Bart Williamson	Materials Technician Office of Materials Management	317-610-7251 Ext: 259

CERTIFIED AGGREGATE TECHNICIAN TRAINING COURSE AGENDA

Title – Time	Subjects	Instructor	Reference
	Monday Morning Moderator: Bob Rees		
Introduction			
10:00 to 10:30	Opening Comments Agenda/Manual Update	Matt Beeson (Bob Rees)	
CAPP Technician Program Responsibilities			
10:30 to 10:45	Industry Perspective	Robert Jones	
Math for Aggregates			
10:45 to 11:15	Round-Off Rules Calculator Operation Mean Standard Deviation Moving Average	Bob Rees	Chp 1
Geology			
11:15 to 12:00	Origin	Nelson Shaffer	Chp 2
12:00 to 1:00	** LUNCH **		

Monday Afternoon
Moderator: Bob Rees

Aggregate Quality

1:00 to 2:00	Aggregate Types & Terms	Bob Rees (Mike Bramblett)	Chp 2
	Properties		Chp 3
	Quality Requirements		Chp 4
2:00 to 2:15	** BREAK **		

Tests for Quality Rating

2:15 to 3:00	Absorption	Bob Rees	Chp 4/Chp 10
	Abrasion Resistance		
	Soundness		
	Deleterious Materials		
	Special Requirements		
3:00 to 3:15	**BREAK**		

Test for Quality Rating (continued)

3:15 to 4:30		Bob Rees	
5:00	**DINNER**		

Help Session

7:30 Holiday Inn Express: Bob Lingerfelt/George Williams/Deana Jones/Mike Blackwell

Tuesday Morning
Moderator: Bob Rees

Math Homework Review

8:00 to 8:10	Answers & Discussion	Bob Rees	

Processing

8:10 to 8:45	Extraction	Bob Lingerfelt Jim Schultz George Williams	Chp 5
	Crushing		
	Other Benefaction		
	Screening		
	Sand Production		
	Segregation		
	Stockpiling and Handling		
	Degradation		
	Contamination		
	Retrieval		

Segregation

8:45 to 9:00	Video	George Williams	

Test Equipment

9:00 to 9:30	Suggestions	Bob Lingerfelt (Kelly Cook)	Chp 8
	Manufacturers & Cost		Handout

9:30 to 9:45 ** BREAK **

Lab Layout

9:45 to 10:15	Suggestions	Bob Lingerfelt Jim Schultz George Williams	

Tuesday Morning (continued)

Test Equipment Verification

10:15 to 10:45	Procedures	Kelly Cook (Bob Rees)	Chp 8 ITM 211-9.0 Appendix A

Production Sampling

10:45 to 11:15	Sampling Techniques	Bob Lingerfelt Jim Schultz George Williams	Chp 9

Stockpile Sampling

11:15 to 11:45	Safety	Bob Dahman Kurt Sommer	Chp 9
	Sampling Technique		Chp 9/Video
	Sample Reduction & Sample Size		Chp 9/Video

Aggregate Testing

11:45 to 12:00	Decant	Bob Dahman Kurt Sommer	Chp 10/Video
	Sieve Analysis		Chp 10/Video
	Sieve Analysis (Dense Graded)		Chp 10/Video
	Fineness Modulus		Chp 10
	Moisture		Chp 10
	Coarse Aggregate Angularity		Chp 10
	Non-Durable Particles		Chp 10
	Flat and Elongated Particles		Chp 10
	Frequency		Chp 11
	Homework Problems		Handouts

12:00 to 1:00 ** LUNCH **

Tuesday Afternoon
Moderator: Bob Rees

Aggregate Testing (continued)

1:00 to 2:30		Bob Dahman Kurt Sommer	Chp 10/Chp 11
2:30 to 2:45	** BREAK		

Aggregate Testing (continued)

2:45 to 3:45		Bob Dahman Kurt Sommer	Chp 10/Chp11

Diary

3:45 to 4:00	CAPP Requirements Typical Diary Examples	Bob Lingerfelt Jim Schultz George Williams	ITM 211 (10.0) Chp 11

Help Session

7:30 Holiday Inn Express: Bob Lingerfelt/Deana Jones/George Williams/Kelly Cook/Jon Havens/Mike Blackwell

Wednesday Morning
Moderator: Bob Rees

Aggregate Testing Homework Review

8:00 to 8:15	Answers & Discussion Math Revue	Matt Beeson (Bob Rees)	Handout

Quality Control Plans

8:15 to 8:45	CAPP QCP Requirements INDOT QCP Checklist QCP Addenda	Matt Beeson (Bob Rees)	Chp 7
8:45 To 9:15	Producer QCP	Bob Lingerfelt George Williams Jim Schultz	Chp 7

Aggregate Production Statistical Control

9:15 to 9:30	CAPP Requirements	Matt Beeson (Bob Rees)	ITM 211

9:30 to 9:45 ** BREAK **

Aggregate Production Statistical Control (continued)

9:45 to 12:00	Statistical Quality Control Statistical Concepts Z Value Percent Compliance	Bob Rees (George Williams)	Chp 6

12:00 to 1:00 ** LUNCH **

Wednesday Afternoon
Moderator: Bob Rees

Aggregate Production Statistical Control (continued)

1:00 to 2:00	Control Chart Concepts Control Chart Construction Control Chart Interpretation	Bob Rees (George Williams)	Chp 6 ITM 211 (13.4)
2:00 to 2:15	** BREAK **		
2:15 to 4:00	Product Set Up Process Control Understanding the Process & Steps for Managing Quality	George Williams	Chp 6

Help Session

7:30 Holiday Inn Express: Bob Lingerfelt/George Williams

Thursday
Moderator: Bob Rees

Lab Demonstration at INDOT Materials Management
(Bus leaves at 7:30)

8:00 to 12:00		Bob Rees Jim Schultz, Mike Blackwell Eric Woodings, Scott Woodard Bart Williamson, Chris Bell	
12:30 to 1:30	** LUNCH **		

Statistical Homework Review

1:30 to 1:45	Answers & Discussion	Bob Rees	Handout

Audits

1:45 to 2:00	INDOT Audits	Bob Rees	Appendix D
2:00 to 2:15	** BREAK **		

Customer Expectations

2:15 to 3:30	Producer Perspective/ Contracotr Perspective	George Williams/John Berscheit	

Review Session (Voluntary)

3:30 to 5:00		Bob Rees	

Help Session

6:30	Holiday Inn Express:	Bob Lingerfelt/George Williams/Mike Blackwell Eric Woodings/Jon Havens/Kelly Cook

Friday Morning
Moderator: Bob Rees

Course Exam

8:00
to
12:00

CERTIFIED AGGREGATE TECHNICIAN PROGRAM

PROCEDURES and POLICIES

MANUAL

SEPTEMBER, 2016

INDOT
CERTIFIED AGGREGATE TECHNICIAN PROGRAM

Objectives

The Indiana Department of Transportation (INDOT) has established a Quality Control/Quality Assurance (QC/QA) program for aggregates for the purpose of properly assigning the responsibility of manufacturing and overall improving the consistency of aggregates. The QC/QA program for aggregates requires that all aggregates supplied for INDOT use be supplied by a Certified Aggregate Producer. The Certified Aggregate Producer Program (CAPP) is a program whereby a qualified mineral aggregate Producer requesting to supply material to INDOT assumes all of the Plant site controls, and INDOT monitors the Producers production, sampling, and testing procedures. The CAPP requires that a Certified Aggregate Technician supervise all sampling and testing for process control.

The principal objective of the Certified Aggregate Technician Program is to provide the necessary training to Producer personnel so that they may administer the Quality Control requirements of the CAPP. Knowledge of aggregate production, materials, sampling, testing, statistics, and documentation are provided.

Administration

The training program is administered by INDOT, the Indiana Mineral Aggregates Association (IMAA). Specific duties of each agency include:

INDOT

1. Writing and Maintenance of the Training Manual
2. Proctoring Examination
3. Notification to Students of Examination Results
4. Mailing Certificates
5. Maintenance of Certified Aggregate Technician List
6. Retesting
7. Recertification

IMAA

1. Course Announcement
2. Student Registration
3. Manual Printing
4. Training Facility Arrangements
5. Meal and Refreshment Arrangements
6. Providing Training Course Materials
7. Certificate Preparation
8. Miscellaneous Administrative Tasks

INDOT - Research

1. Grading the Examination

Program Committee

The Program Committee acts as the steering committee which establishes the needs for the certification program and provides technical assistance for course materials and examinations. The committee is composed of representatives from INDOT, FHWA, IMAA.

Certification Committee

The Certification Committee is responsible for revocation or suspension of certifications for technicians. Their tasks include reviewing the violations of standard policies, rendering judgement of the seriousness of the violation, and hearing any subsequent appeal. The committee is composed of the following members:

Manager, Office of Materials Management
1 Aggregate Producer Certified Technician appointed by the IMAA Technical Committee

Certification Requirements

A technician is required to pass a written examination to become certified. Participation in the certification training course is required for the technician to take the examination.

Training Course Announcement

The announcement for the training course will be made on August 1 of each year that the course is offered.

Certification Examination

The certification examination is given upon completion of the training course. The examination time is limited to a maximum duration of four hours and the examination is open book/open note. There are two parts of the examination. Part I consists of multiple choice, and fill in the blank questions, and Part II consists of word problems. A minimum score of 70 percent is required on each part to pass the examination.

A technician that has failed the certification examination will be allowed one retake of the exam. Only the part(s) failed are required to be retaken. A duration of 1 ½ hours for Part I and 2 ½ hours for Part II are allowed. The retake examination will be open book/open note and consist of a format similar to the original examination. The retake examination will be given at the INDOT Office of Materials Management within 30 days of notification of the technician's results of the original examination. A minimum score of 70 percent on each part is required to pass the retake examination. Technicians failing either part of the retake examination will be required to participate in the training course and pass the examination to become certified.

The examinations will be retained by INDOT Division of Research for a period of one year after such time the examinations will be destroyed. Technicians may review their examinations in the presence of an INDOT representative within one year of the examination date. Arrangements for review of the examination shall be made with INDOT.

Recertification Requirements

The certification is valid for three years as determined from the date of initial issuance. A technician is required to pass a written examination to become recertified. If the technician does not renew the certification, the certification will expire. Renewal of the certification may be made within the subsequent year after expiration by passing the recertification examination or retake examination, if required. If the technician requests to become recertified after one year but less than two years from the expiration of the certification, renewal of the certification may be made by passing both parts of the certification exam or retake examination, if required. If the technician requests to become recertified after two years from the expiration of the certification, the Certification Committee will review the request and render a decision on the certification requirements.

Technicians that have successfully demonstrated the proficiency of the tests required for the CAPP source they are assigned to will become recertified and are not required to take a written examination. The proficiency check will be required each of the three years since the latest certification date for the technician and will be conducted through the INDOT Independent Assurance Program.

The certified technician will be notified of the recertification procedures prior to the expiration of the certification. The technician is responsible for applying for certification renewal. A current address is required to be on file with INDOT. Address revisions are required to be sent to:

Geologist Supervisor
Indiana Department of Transportation
Office of Materials Management
120 S. Shortridge Rd.
Indianapolis, IN 46219
317-610-7251, ext: 232
Fax: 317-356-9351

A recertification refresher course will be offered prior to the examination. Course attendance is on a voluntary basis for the technician.

Recertification Examination

The recertification examination may be taken in an INDOT District or at the site of the refresher course upon completion of the training. The examination is limited to a duration of two hours, and is open book/open note. The examination consists of word problems, and a minimum score of 70 percent is required to pass the examination. Notification of the examination results will be made within 10 days of the examination date.

A technician that has failed the recertification examination will be allowed one retake of the examination. Two hours is allowed for the examination. The retake examination will be open book/open note and consist of a format similar to the original recertification examination. The retake will be given at the INDOT Office of Materials Management within 30 days of notification of the technician's results of the original recertification examination. A minimum score of 70 percent is required to pass the retake examination. Technicians failing the retake examination will be required to participate in the certification training course and pass the certification examination to become certified.

The examinations will be retained by INDOT Division of Research for a period of one year. After that period the examinations will be destroyed. Technicians may review their examinations in the presence of an INDOT representative within one year of the examination date. Arrangements for review of the examination are required to be made with INDOT.

Fees

The fee for attending the certification training course will be established by the Program Committee. The fee will cover a training manual, course materials, refreshments, and several meals.

The refund policy for the certification course fees is as follows:

1. An administration fee of $100 will be charged for cancellation by the technician within 7 days of the course.

2. Lack of attendance of the course will result in no refund of fees.

3. Unforeseen emergencies that result in absences during the course will result in a refund of the course fee.

The fee for attending the refresher recertification course will be established by the Program Committee. The fee will cover a training manual, course materials, refreshments, and one lunch. No refunds will be given for the recertification course; however, unforeseen emergencies that result in absence of the course will result in a refund of the course fee.

Failure to pay the training course or examination fees will result in suspension of the certification.

Cancellation Policy

If a scheduled certification or recertification refresher course is cancelled because of insufficient class size, the technicians will be notified one week prior to the start of the course. The technicians will be reimbursed the course fee.

Revocation or Suspension of Certification

Certifications awarded may be revoked or suspended at any time by the Certification Committee for just cause. The procedure that will be taken to revoke or suspend a technician's certification is as follows:

1. The technician will be sent written notification of the revocation or suspension of certification by a registered letter. A copy of the written notification will be sent to the technician's employer. The letter will state the grounds for the revocation or suspension, request a written response, and establish a hearing date.

2. The technician will be allowed 60 days from the date of the notification to respond by letter. The response shall include an explanation of why the technician disagrees with the decision to revoke or suspend the certification.

3. After the 60 day time period has elapsed or upon receipt of the response, the case will be reviewed by the Certification Committee on the hearing date. The technician's response letter will be considered and the technician may appear before the Certification Committee.

4. The Certification Committee will issue a decision within one week of the hearing.

5. If the technician does not send a response letter, or fails to appear before the Certification Committee, a default judgement will be issued by the Certification Committee based on the evidence available. The revocation or suspension may be affirmed, modified, or vacated following the hearing.

The reasons that a technician's certification may be revoked or suspended include:

1. Cheating on recertification examinations

2. Falsification of quality control test results and/or records

The Certification Committee may decide to revoke or suspend the certification depending upon the seriousness of the violation. Violations deemed as unintentional will result in a penalty of a letter of reprimand to the technician and the technician's employer. Subsequent violations will result in suspension of certification for a designated period as determined by the Certification Committee. The certification will return to good standing after the period of suspension expires.

Intentional violations will result in a one year suspension of the certification. Subsequent violations will result in permanent revocation of the certification. If the technician wishes to become recertified after the period of suspension, the technician will be required to participate in the certification training course and pass the certification examination.

1 Introduction

Rounding

The Mean

Standard Deviation

Five-Point Moving Average

Terms Related to Aggregates

Internet Connection

CHAPTER ONE:
INTRODUCTION

Quality Control/Quality Assurance (QC/QA) is often used synonymously with the term Quality Assurance (QA). AAS HTO defines Quality Assurance as "All those planned and systematic actions necessary to provide confidence that a product will perform satisfactorily in service." This definition considers QA to be an all encompassing concept which includes quality control (QC), acceptance, and independent assurance (IA). A better understanding of the QC/QA concept may be made if the characteristics of the specifications are considered. These include:

1) QC/QA recognizes the variation in materials and test methods.

2) QC/QA uses a statistical basis that is applied and modified with experience and sound engineering judgement.

3) QC/QA places primary responsibility on the Producer for production control.

The procedure used by INDOT in the past to accept aggregates required that a stockpile of aggregates be tested to verify compliance with specifications, and the stockpile subsequently approved or disapproved prior to shipment. This pass/fail specification became very confrontational with Producers when failing tests were obtained and shipments delayed or stopped to active contracts. Even when eventually resolved, project delays were inevitable in many cases. A QC/QA procedure whereby Producer's tests could be used for acceptance, and shipments of aggregates made on demand was needed. The Certified Aggregate Producer Program (CAPP) was introduced as the procedure to accomplish both needs.

The CAPP designates specific quantities of material to be tested, material test values, test equipment calibrations, and statistical concepts to be applied to control aggregate products. A s such, a standard method for rounding values is required to be established and basic statistical rules be presented. This chapter discusses the procedures for rounding numbers, and the basic statistical calculations.

ROUNDING

When calculations are conducted, rounding is required to be in accordance with 109.01(a) using the standard "5" up procedure. There are two rules for rounding numbers:

1. When the first digit discarded is less than 5, the last digit retained should not be changed.

   Examples: 2.4 becomes 2
   2.43 becomes 2.4
   2.434 becomes 2.43
   2.4341 becomes 2.434

2. When the first digit discarded is 5 or greater, the last digit retained should be increased by one unit.

   Examples: 2.6 becomes 3
   2.56 becomes 2.6
   2.416 becomes 2.42
   2.4157 becomes 2.416

The Certified Aggregate Producer Program requires that test and statistical values be calculated to the nearest decimal place as indicated in Figure 1-1.

Property	Nearest Whole Unit (0)	First Decimal Place (0.0)	Second Decimal Place (0.00)	Third Decimal Place (0.000)
Crushed Particles	X			
Flat & Elongated	X			
Percent Compliance	X			
Control Limits*	X	X		
Absorption		X		
Decantation		X		
Deleterious		X		
Gradation		X		
Surface Moisture		X		
Target Mean		X		
5-Point Moving Ave.		X		
Fineness Modulus			X	
Standard Deviation			X	
Z Value			X	
Bulk Specific Gravity				X
Proportionate Factor				X

* May be rounded to (0.0) or (0)

Figure 1-1. Decimal Places.

THE MEAN

The simple mathematical average of any group of numbers is the mean. In other words, the mean is the sum of all the measurement values divided by the number of measurements. The symbol for the mean is $\bar{x}$. As an example, the mean for five numbers would be calculated as follows:

$$\bar{x} = \frac{x_1 + x_2 + x_3 + x_4 + x_5}{5}$$

STANDARD DEVIATION

Whereas the mean is an average of all the data values, the standard deviation is an average value of the dispersion of data from the mean. Standard deviation is usually signified by a small s or the Greek letter Sigma (σ). For the CAP Program σ_{n-1} is used.

The procedure used to compute the standard deviation is to subtract the mean from each value, square this difference, sum, divide by one less than the number of values, and take the square root. These steps may be expressed in terms of a formula as follows:

$$\sigma_{n-1} = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$$

where $\bar{x}$ is the arithmetic mean, n is the number of sample values and $\sum$ indicates the summation of all values.

Note that squaring the deviations from the mean removes the negative signs. Dividing by n - 1 gives us approximately an average squared deviation. Taking the square root puts the result back into the same units as the original values.

Example:

x_i	$x_i - \bar{x}$	$(x_i - \bar{x})^2$
14.3	1.7	2.89
11.2	-1.4	1.96
14.1	1.5	2.25
12.6	0.0	0.00
12.9	0.3	0.09
12.7	0.1	0.01
13.2	0.6	0.36
11.4	-1.2	1.44
12.3	-0.3	0.09
11.6	-1.0	1.00
126.3		10.09 (Sum of squared differences)

n = 10

$$\bar{x} = \frac{\sum x_i}{n} = 12.6$$

$$\sigma_{n-1} = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{10.09}{9}} = \sqrt{1.121} = 1.06$$

FIVE-POINT MOVING AVERAGE

The moving average is a useful tool for tracking trends of the mean. The CAPP requires that the moving average be the average of the most recent five data points.

For a moving average of five test values, the group of the first five measurements is averaged. When an additional test value is obtained, the first value is dropped, the sixth value is added, and the new group averaged. When a seventh value is obtained, the second value is dropped, and the new group averaged, and so on. An example of this procedure is as follows:

Data: 4.8, 5.3, 5.0, 4.7, 5.1, 5.5, 4.6

$$\text{First Average} = \frac{4.8 + 5.3 + 5.0 + 4.7 + 5.1}{5}$$

$$= \frac{24.9}{5} = 5.0$$

The first number, or 4.8, is dropped and the sixth value, or 5.5, is added and the second average is:

$$\text{Second Average} = \frac{5.3 + 5.0 + 4.7 + 5.1 + 5.5}{5}$$

$$= \frac{25.6}{5} = 5.1$$

Next, the 5.3 is dropped and 4.6 is added:

$$\text{Third Average} = \frac{5.0 + 4.7 + 5.1 + 5.5 + 4.6}{5}$$

$$= \frac{24.9}{5} = 5.0$$

TERMS RELATED TO AGGREGATES

AASHTO - American Association of State Highway and Transportation Officials

Abrasion Resistance - The resistance of coarse aggregates to fracturing under impact and breaking down into smaller pieces from abrasive action

Absorption - The increase in the mass of aggregate due to water in the pores of the material, but not including water adhering to the outside surface of the particles, expressed as a percentage of the dry mass

Adherent Fines - Fine particles smaller than the No. 200 (75 µm) sieve created from handling, or silt or clay that adheres to the coarse aggregate particles

Aggregate Base - A layer of aggregate placed on a subgrade or subbase to support a surface course

Air-Cooled Blast Furnace Slag (ACBF) - Material resulting from solidification of molten blast-furnace slag under atmospheric conditions

Apparent Specific Gravity - The ratio of the weight in air of a unit volume of the impermeable portion of aggregate at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature

ASTM - American Society for Testing and Materials

Bulk Specific Gravity - The ratio of the weight in air of a unit volume of aggregate (including the permeable and impermeable voids in the particles, but not including the voids between particles) at a stated temperature to the weight of an equal volume of gas-free distilled water at a stated temperature

Artificial Aggregates - Aggregates that are manufactured or by-products of an industrial process. Blast furnace slag, steel slag and wet bottom boiler slag are examples of by-product artificial aggregates.

B Borrow - Material used for special filling such as for displaced peat deposits, bridge approach embankments, and fillings over structures. B borrow is required to be acceptable quality, free from large or frozen lumps, wood, or other extraneous matter. Materials used for B Borrow are suitable sands, gravel, crushed stone, ACBF, GBF, or other approved materials.

Bulk Specific Gravity (SSD) - The ratio of the mass in air of a unit volume of aggregate, including the mass of water within the voids filled to the extent achieved by submerging in water for approximately 15 hours (but not including the voids between particles) at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature

Category - Source classification used to determine the production quality sampling frequency

Certified Material - An aggregate product produced in accordance with the Certified Aggregate Producer Program (CAPP) for Department use

Certified Aggregate Producer - A Plant/Redistribution Terminal that meets the requirements of ITM 211, continues to be under the same ownership, and is approved by the Department

Certified Aggregate Technician – A Producer or Consultant employee that has successfully completed the Certified Aggregate Technician Training Program and has been certified by the Department

Chert – An aggregate of varied color, composed of glassy silica, and very fined grained quartz. Unweathered chert appears hard, dense, and brittle with a greasy texture. Weathered chert appears chalky and dull. Chert is likely to have concave surfaces with sharp outer edges when freshly broken.

Class A - Quality rating assigned to aggregates which meet requirements for all Department uses except for specified slab on grade concrete applications

Class AP - Quality rating assigned to coarse aggregates cast into concrete beams and subjected to freeze and thaw cycling procedures in accordance with ITM 210. Class AP aggregates are required for concrete pavement and other concrete applications

Classes B, C, D, E, and F - Quality ratings assigned to aggregates with restricted uses

Class G - Quality rating assigned to materials which do not meet requirements for any Department use

Clay Lumps – Materials that are easily crumbled or mashed with the fingers as determined by AASHTO T 112

Coarse Aggregate - Aggregate that has a minimum of 20 percent retained on the No. 4 (4.75 mm) sieve

Coatings – A layer of substance covering a part or all the surface of an aggregate particle. The coating may be of natural origin, such as mineral deposits formed in sand and gravel by ground water, or may be artificial such as dust formed by crushing and handling. (see Adherent Fines)

Composite Stockpiling – Stockpiling of natural fine aggregate from multiple sources into one stockpile

Core Drilling Log - A written field description of a rock core sample and the operations

Core Sample - A rock sample obtained with a bit affixed to a barrel with drill rods that are advanced by a rotary drilling machine

Decantation - A test utilizing water to determine the amount of material that is passing the No. 200 sieve. The decantation test is conducted on both fine and coarse aggregate and is usually done in conjunction with the sieve analysis test.

Deleterious - Undesirable aggregate material

Density - The weight per unit volume of a substance

Dolomite - Carbonite rock containing at least 10.3% elemental magnesium when tested in accordance with ITM 205

DTE – District Testing Engineer

Fine Aggregate - Aggregate that is 100 percent passing the 3/8 in. (9.5 mm) sieve and a minimum of 80 percent passing the No. 4 (4.75 mm) sieve

Fineness Modulus - A factor commonly associated with aggregates used for portland cement concrete that is used to determine the relative coarseness or fineness of the aggregate grading

Gradation - The range and relative distribution of particle sizes in the aggregate material

Granulated Blast Furnace Slag (GBF) - Glassy, granular material formed when molten blast-furnace slag is rapidly chilled, as by immersion in water

Gravel - Unconsolidated deposits of all rock types transported and deposited by glaciers

HMA – Hot Mix Asphalt

Hardness - A measure of the cementing and interlocking quality of an aggregate that controls the resistance of the aggregate to abrasion and degradation. The Mohs Hardness Scale is frequently used for determination of mineral hardness.

Igneous Rocks - Rocks formed from hot volcanic magma-molten mineral material

Independent Assurance – Independent Assurance testing is conducted by District Testing personnel to verify the reliability of the results obtained in acceptance sampling and testing. Certified Aggregate Technicians are checked annually by Independent Assurance Technicians for the sampling and testing procedures that are conducted at the aggregate source.

Lightweight Aggregate – Aggregates that may range in dry loose weight from 6 to 70 pounds per cubic foot and which are used in making lightweight concrete.

Lightweight Chert - Chert that has a bulk specific gravity of less than 2.45 as determined using the saturated surface dry condition

Recycled Foundry Sand - A mixture of residual materials used for the production of ferrous or non-ferrous metal castings and natural sands. Recycled foundry sand is required to comply with the Indiana Department of Environmental Management (IDEM) Class III or Class IV residual sands classification.

Ledge - Any stratigraphic unit which may be separated from adjacent units by lithologic differences

Ledge Sample - Core or face sample taken to represent ledges

Limestone - Sedimentary rock primarily consisting of carbonates of calcium and dolomite

Maximum Particle Size - The sieve on which 100 percent of the material will pass

Metamorphic Rock - Rocks that were originally igneous or sedimentary rocks, but were changed by pressure and/or heat

Mineral Filler - Dust produced by crushing stone, portland cement, or other inert mineral matter having similar characteristics. Mineral filler shall be in accordance with the gradation requirements for size No.16.

Natural Aggregates - Rock fragments which are used in their natural state such as crushed stone, sand, and gravel

Nominal Maximum Particle Size - The smallest sieve opening through which the entire amount of the aggregate is permitted to pass

Non-durable particles - Soft particles as determined by ITM 206 and other particles which are structurally weak, such as soft sandstone, shale, limonite concretions, coal, weathered schist, cemented gravel, ocher, shells, wood, or other objectionable material

Point-Of-Use Sample - Production quality sample obtained at the last opportunity prior to incorporation into the end use

Polish Resistant Aggregates - Dolomite containing less than 10.3% elemental magnesium, crushed limestone, or gravel meeting the requirements of ITM 214. A ggregates meeting these requirements are maintained on the INDOT Approved List of Polish Resistant Aggregates.

Production Quality Sample - An aggregate sample representing finished materials obtained at the aggregate source or the point-of-use

Quality Assurance Materials - Certified Materials controlled by aggregate gradations by the Producer

Quality Control Plan (QCP) - A document written by the Producer that is site-specific and includes the production, policies, and procedures used by the Producer

Qualified Technician - An individual who has successfully completed the written and proficiency testing requirements of the Department Qualified Laboratory and Technician Program

Rating L - A rating for information only

Riprap - Typically large aggregate materials used as a protective coating. Riprap may consist of steel furnace slag for dumped riprap only, sound stone, stone masonry, or other approved materials, free from structural defects and of approved quality.

Sandstone - Sedimentary rock composed of siliceous sand grains containing quartz, chert, and quartzose rock fragments in a car bonate matrix or cemented with silica, calcite, or dolomite

Sedimentary - Rocks formed from the disintegration of other rocks and organic materials. Limestone, dolomite, sandstone, shale, and siltstone are examples of sedimentary rock types.

Sieving - A test procedure that is used to determine the gradation of a material. A sample of the aggregate material being tested is weighed and then passed through a series of sieves to determine the gradation.

SMA – Stone Matrix Asphalt (AS-904.03(a)) an asphalt mix comprised of a significant percentage of durable, coarse (≥ no. 8) aggregate resulting in stone to stone contact.

Soundness - The durability of fine and coarse aggregate and their resistance to the forces of weathering, in particular to alternate freezing and thawing conditions

Source - Facility that processes or handles aggregates. A Redistribution Terminal is classified as a source.

Source Map - A map of the quarry showing critical features and operating areas

Source Sample **-** Production quality sample representing finished materials that are stored at an aggregate source or redistribution terminal

Subbase - A layer of aggregate placed on a subgrade to support an aggregate base

Subgrade - The layer below the subbase that may be comprised of various aggregate types

Specific Gravity - The ratio of the mass of a unit volume of a material to the mass of the same volume of gas-free distilled water at a s tated temperature

Standard Specification Materials - Certified Materials controlled by aggregate gradations as defined in the Department Standard Specifications and the construction contract documents

Steel Furnace Slag (SF) - A material derived from the further refinement of iron to steel

Subcategory - Source classification based on results of tests conducted on source samples and used to determine the production quality sampling frequency

Structural Backfill - Suitable sand, gravel, crushed stone, air-cooled blast furnace slag, or granulated blast furnace slag used to fill designated areas excavated for structures that are not occupied by permanent work

Wet Bottom Boiler Slag - A material which is a by-product from coal combustion at electrical generating plants

INTERNET CONNECTION

1) www.in.gov/indot/
2) Doing Business with INDOT
3) Contractors/Construction
4) Materials Management Information

2 Aggregates in Indiana

Origin of Aggregates

Gravel and Natural Sands
Crushed Stone
Slag

Distribution of Aggregates

Glacial Deposits
Bedrock Deposits

Aggregate Types

Natural Aggregates
Artificial Aggregates

Classifications of Aggregates

Fine Aggregate
Coarse Aggregate

CHAPTER TWO:
AGGREGATES IN INDIANA

Aggregates play an important role in highway construction. Without aggregate, concrete bridges and structures, Hot Mix Asphalt (HMA) pavements, and concrete pavements could not be constructed and very few roads would sustain the current loads. The use of aggregates in highway construction has literally brought the transportation industry out of the mud.

Aggregates are not used indiscriminately in construction, as not all aggregates are appropriate for every application. Some aggregates do not have the correct chemical or physical properties or the correct size or shape for the job. This chapter includes the requirements that aggregates are required to meet, the tests of INDOT, and the documentation that is required to be completed for the test results.

ORIGIN OF AGGREGATES

The three main sources of mineral aggregates in Indiana, gravel and natural sand, crushed stone, and slag, all have different origins.

GRAVEL AND NATURAL SANDS

Most of the gravels and natural sands used today are a product of the Ice Ages (glaciation). Geologists concur that glaciers may have been up to 1 mile thick. As the glaciers advanced southward, rock was scraped beneath them. When the glaciers melted, the flowing water carried the rock fragments and deposited them downstream. The scraping action of the ice and flowing waters gave the gravels and natural sands the rounded appearance.

In addition, minor amounts of gravel and sand are obtained from postglacial or modern stream deposits. This operation is called fluvial and is largely restricted to the river bars, bottom lands, and flood plains of the Ohio River and the lower reaches of the White and Wabash Rivers.

Gravel and sand are unconsolidated granular materials resulting from the natural disintegration of rocks. They disintegrated primarily from the abrading action of water or ice on rock material. Therefore in Indiana, deposits are likely to be found in stream bottoms, in terraces adjacent to streams, and in outwash plains, all of which are areas beyond the physical limits of the original glaciers.

CRUSHED STONE

Crushed stone produced within Indiana originates from sedimentary bedrock deposits. There are three general classes of rocks: igneous, sedimentary, and metamorphic. Igneous rocks were formed from hot volcanic magma--molten mineral material. Sedimentary rocks were formed from the disintegration of other rocks and organic materials. Metamorphic rocks were originally igneous or sedimentary rocks, but were changed by pressure and/or heat. Across the United States, variations of the above noted rock types are utilized for crushed stone aggregate. Sedimentary rock types, limestone and dolostone, are primarily used as construction aggregates within Indiana. S andstone from southern Illinois, a sedimentary rock type, is permitted for use in hot mix asphalt surface courses.

SLAGS

There are four main types of slag used as construction aggregate in the state of Indiana:

1) Blast Furnace Slag -- a non-metallic material removed in the molten state of iron production. The further refinement of this blast furnace slag results in three aggregate variations: air-cooled slag, expanded slag, and granulated slag.

2) Steel slag -- a material derived from the further refinement of iron to steel.

3) Wet-bottom boiler slag -- a material which is a by-product from coal combustion at electrical generating plants. A secondary product created at these power plants is a residue in the flue gases known as fly ash.

4) Lightweight aggregate -- a material which is created as a by-product of the manufacturing process of construction brick. The primary constituent is shale, sedimentary rock.

DISTRIBUTION OF AGGREGATES

All types of aggregates are not found in every area of Indiana. The composition of each type of aggregate also varies.

GLACIAL DEPOSITS

Gravel and sand deposits are found along almost any river in Indiana, except the south-central part of the state. At one time glaciers covered five-sixths of Indiana. Figure 2-1 shows the southern boundaries of the two glaciers which moved into Indiana.

The size of the gravel and the type of minerals and rocks found in the deposits varies from place to place. As shown in Figure 2-2, the size of the gravel, in general, tends to get smaller downstream within a drainageway. Statewide, the occurrence of gravel decreases from northeastern to southwestern Indiana.

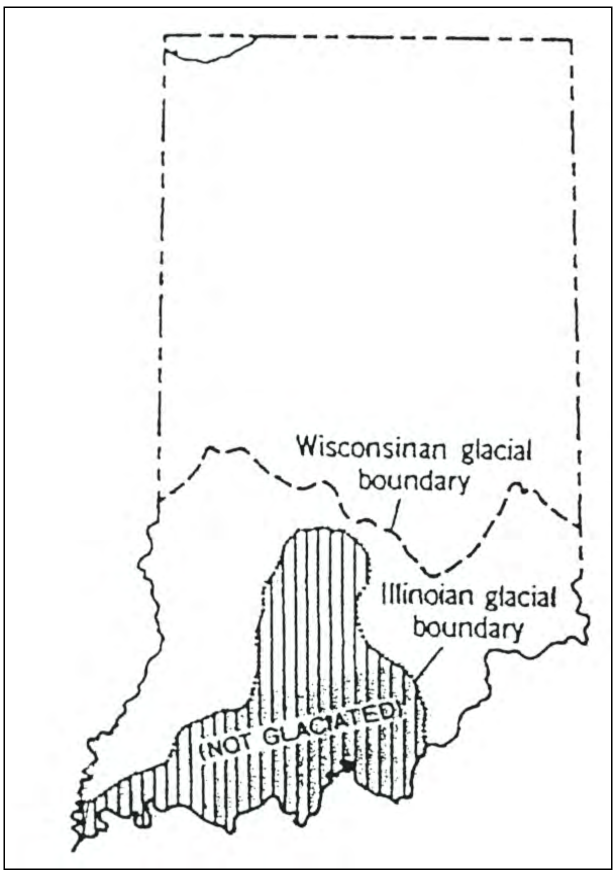


Figure 2-1. Southern Boundaries of Glaciers which moved into Indiana.

The composition of a deposit also varies from place to place. In some deposits, 10 to 20 different types of rocks may be found. G ranite, gneiss, and schist (igneous and metamorphic rocks) or limestone, dolostone, chert, sandstone, siltstone, and shale (sedimentary rocks) are typically found. Porous chert, siltstone, sandstone, ocher, and shale are deleterious, meaning that the material does not perform well in certain applications in highway construction. T he map in Figure 2-3 illustrates the distribution of deleterious materials around Indiana.

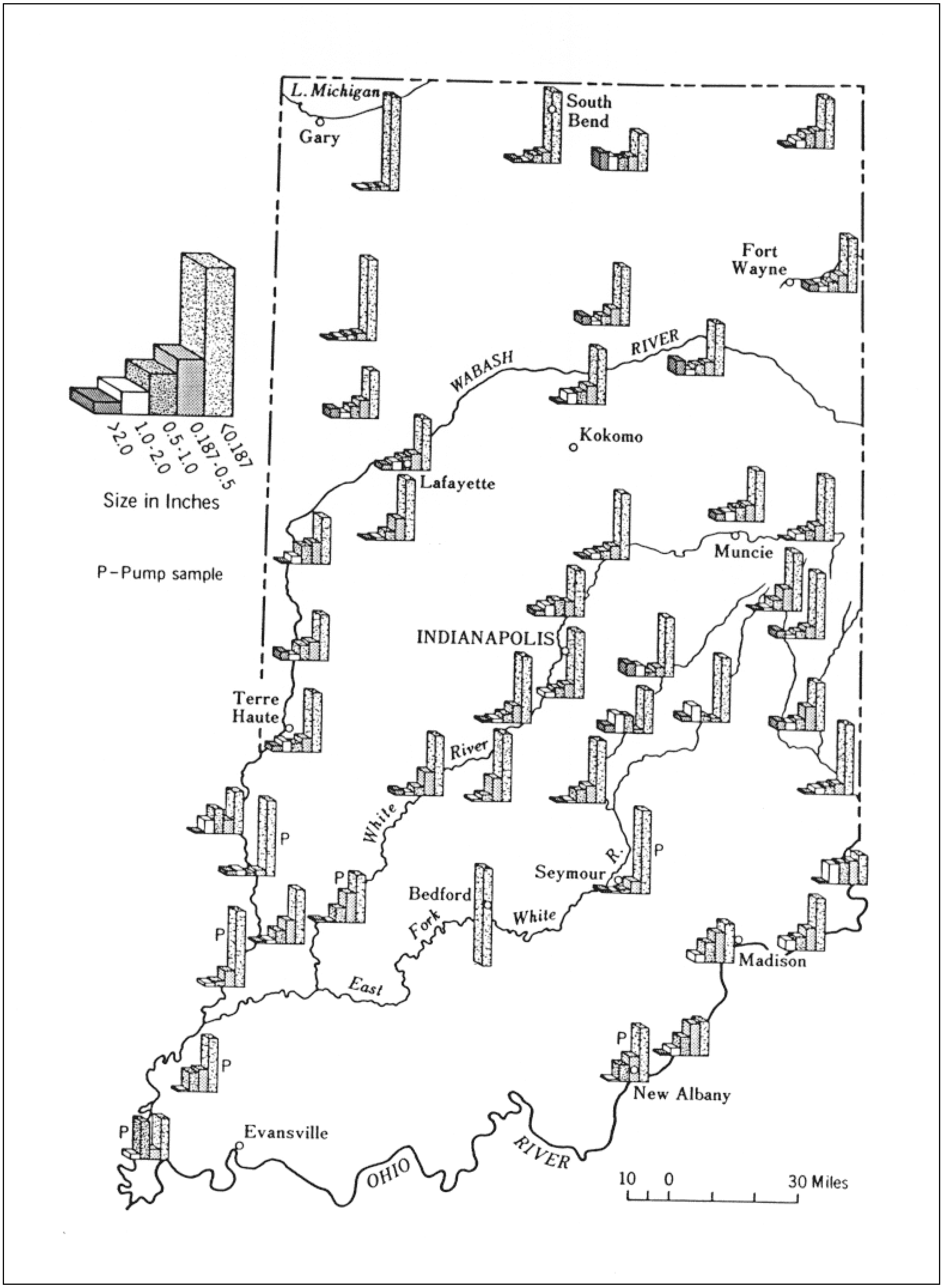


Figure 2-2. Gravel Size Distribution Map of Indiana.

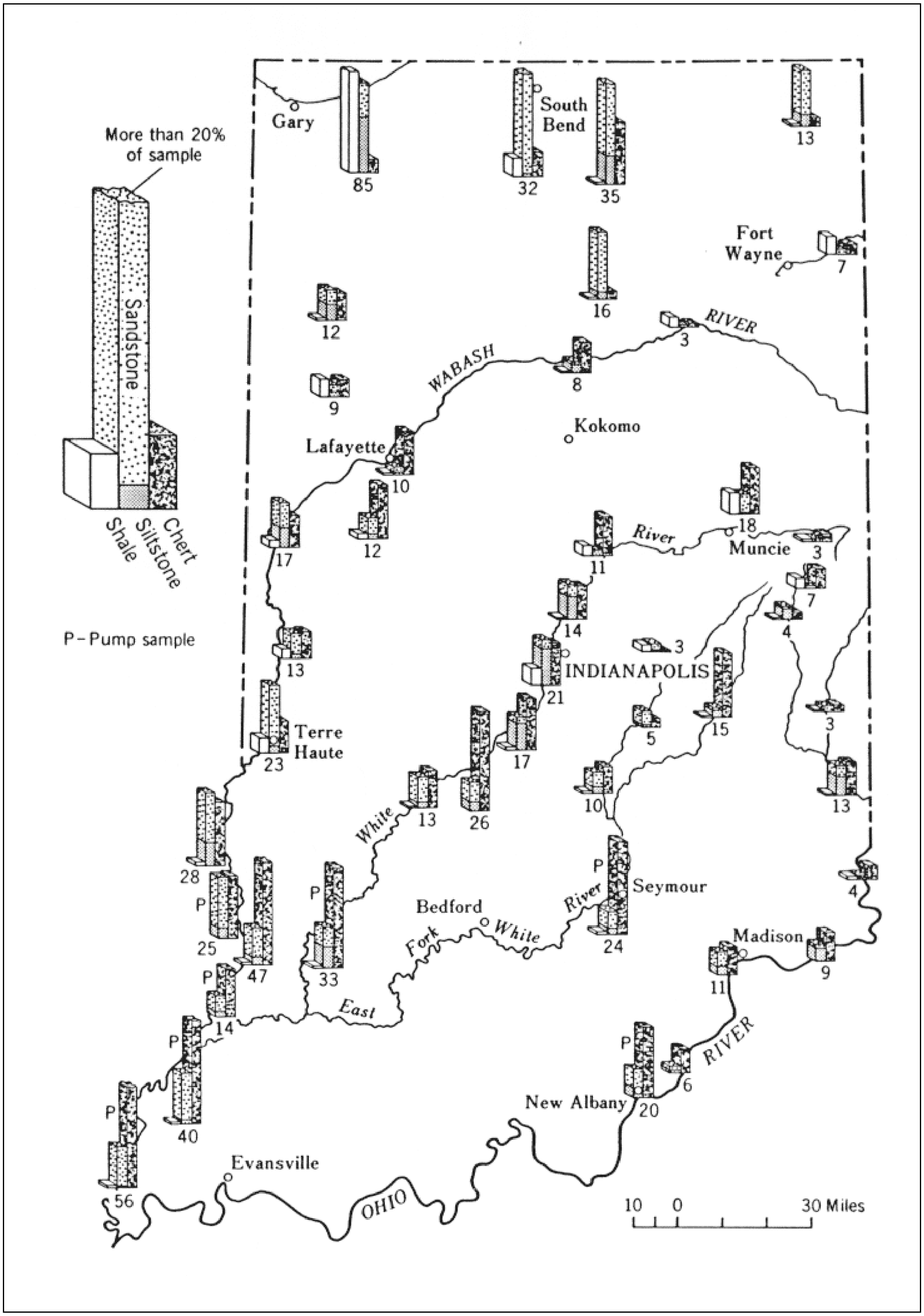


Figure 2-3. Deleterious Materials Distribution Map of Indiana.

BEDROCK DEPOSITS

As shown in the bedrock map of Indiana (Figure 2-4), the bedrock belongs to five geologic periods which are listed from the oldest to youngest: Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian.

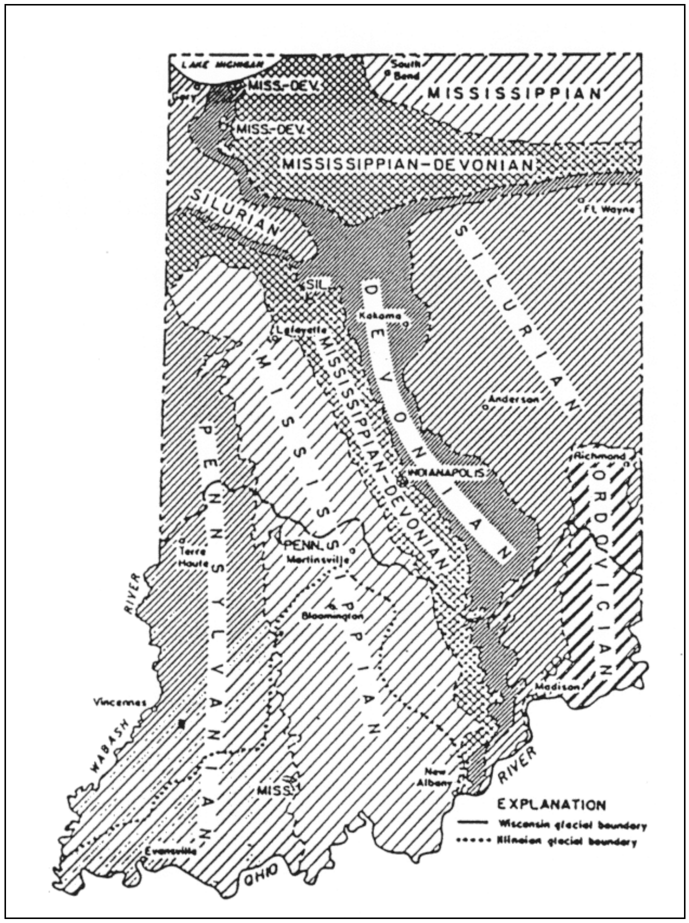


Figure 2-4. Bedrock Map of Indiana.

Comparing the map of the quarry locations (Figure 2-5), to the bedrock map (Figure 2-4), almost all of Indiana's crushed stone quarries are in areas underlain by rock of Mississippian, Devonian, or Silurian Ages (Figure 2-6). During these periods, thick beds of high-grade limestone or dolostone were formed. Rock types formed during other geologic periods are either inaccessible or do not possess the minimum quality requirements needed for highway construction.

Since most of Indiana once was covered by glaciers, the deposits left by these glaciers have also had an effect on the location of quarry sites in the state. Quarry sites are more easily developed in southern Indiana than in northern Indiana where the overburden may reach several hundred feet in depth. In the glaciated parts of Indiana, quarry sites are limited to areas where streams have eroded to bedrock or areas where bedrock was usually high in pre-glacial times, such as ancient coral reefs. Many quarries have been developed in areas where sand and gravel deposits were mined to the bedrock surface.

Figure 2-5. Quarry Locations in Indiana

AGGREGATE TYPES

The aggregates used in highway construction are all mineral aggregates. Aggregates are composed of a naturally occurring solid chemical element or compound formed as a product of an inorganic process. There are two distinct types of aggregate: natural, and artificial.

NATURAL AGGREGATES

Rock or stone (either term may be used) fragments which are used in their natural state are considered natural aggregates. Crushed stone, sand, and gravel are natural aggregates.

Crushed Stone

Crushed stone is produced from quarries where the bedrock is blasted (shot) with explosives and further fragmented by mechanical crushing. All crushed stone fragments are angular in shape and all faces of the fragments are created by the crushing operation.

The most common sedimentary rock types found in Indiana are limestone, dolostone, sandstone, shale, and siltstone. Only limestone and dolostone are routinely used for highway construction, although some sandstone from southern Illinois is allowed for high-friction HMA surface.

Sand and Gravel

Sand and gravel are the result of the weathering and erosion of bedrock by natural forces. The two are generally found together, in pockets deposited by a stream or a glacier. These aggregates may be mined from a water-filled pit (a deposit below the water table) or from a cut-bank deposit (a deposit above the water table). If the aggregates come from a pit, the aggregate is referred to as "pit-run" material. A cut-bank deposit is termed "bank-run" material.

Sand from these deposits are often referred to as natural sand, while sand made by crushing stone, pieces of gravel, or slag are commonly called manufactured sand.

The sand and gravel found in the deposits have a variety of assorted sizes. Further processing is required including screening, washing, and some crushing. The crushing is done to produce aggregates of the proper size.

ARTIFICIAL AGGREGATES

Artificial (synthetic) aggregates are manufactured aggregates or by-products of industrial processes. Of the artificial aggregates, INDOT most commonly uses the by-product aggregates. These aggregates are processed either from blast furnace slag, steel slag, or wet bottom boiler slag.

CLASSIFICATIONS OF AGGREGATES

Aggregates are separated into two classifications: coarse aggregates, and fine aggregates. The No. 4 sieve generally determines the difference between coarse aggregate and fine aggregate for most highway construction work.

FINE AGGREGATE

Fine aggregate is defined as aggregate that is 100 percent passing the 3/8 in. sieve and a minimum of 80 percent passing the No. 4 sieve. Natural sand and manufactured sand produced by crushing stone, steel furnace slag, air cooled blast furnace slag and wet-bottom slag are all fine aggregates.

COARSE AGGREGATE

Coarse aggregate is defined as aggregate that has a minimum of 20 percent retained on the No. 4 sieve. Crushed stone, crushed or uncrushed gravel, and crushed blast-furnace and steel slag all fall within this category.

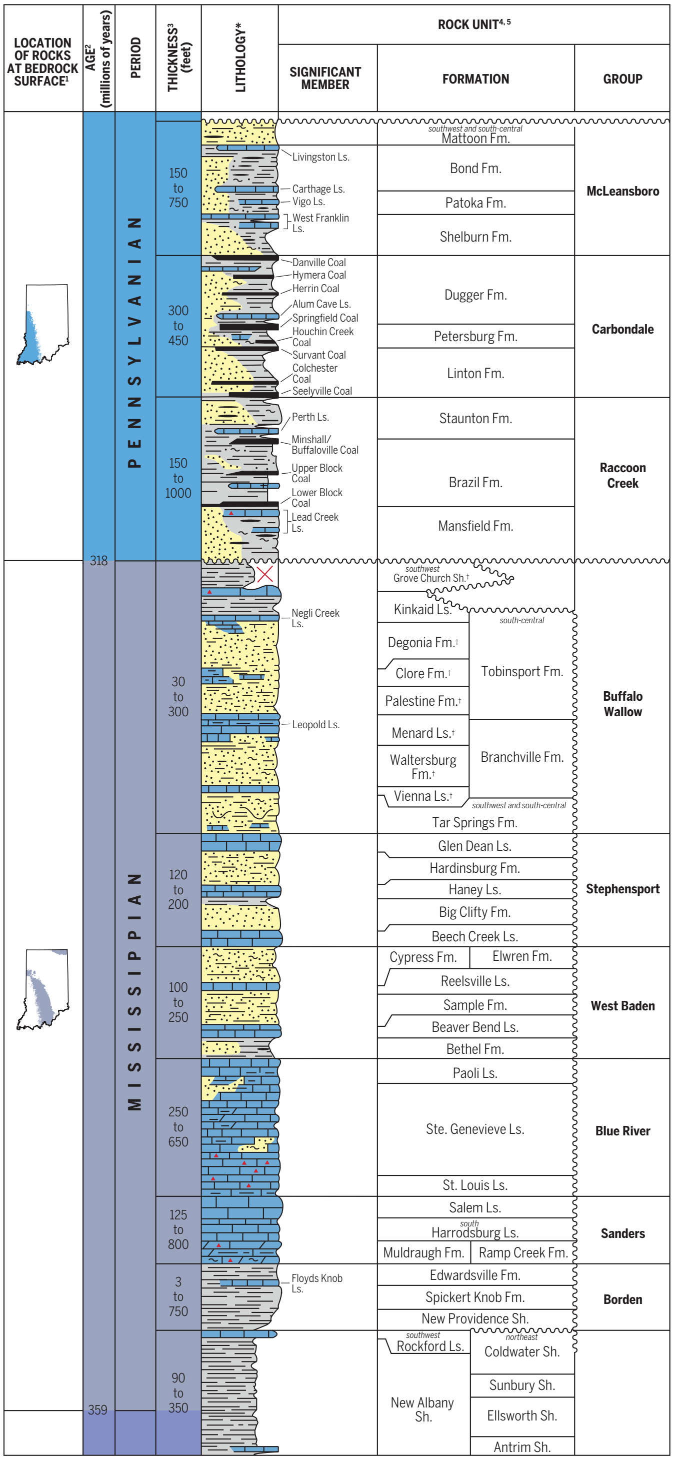
INDIANA GEOLOGICAL SURVEY
INDIANA UNIVERSITY

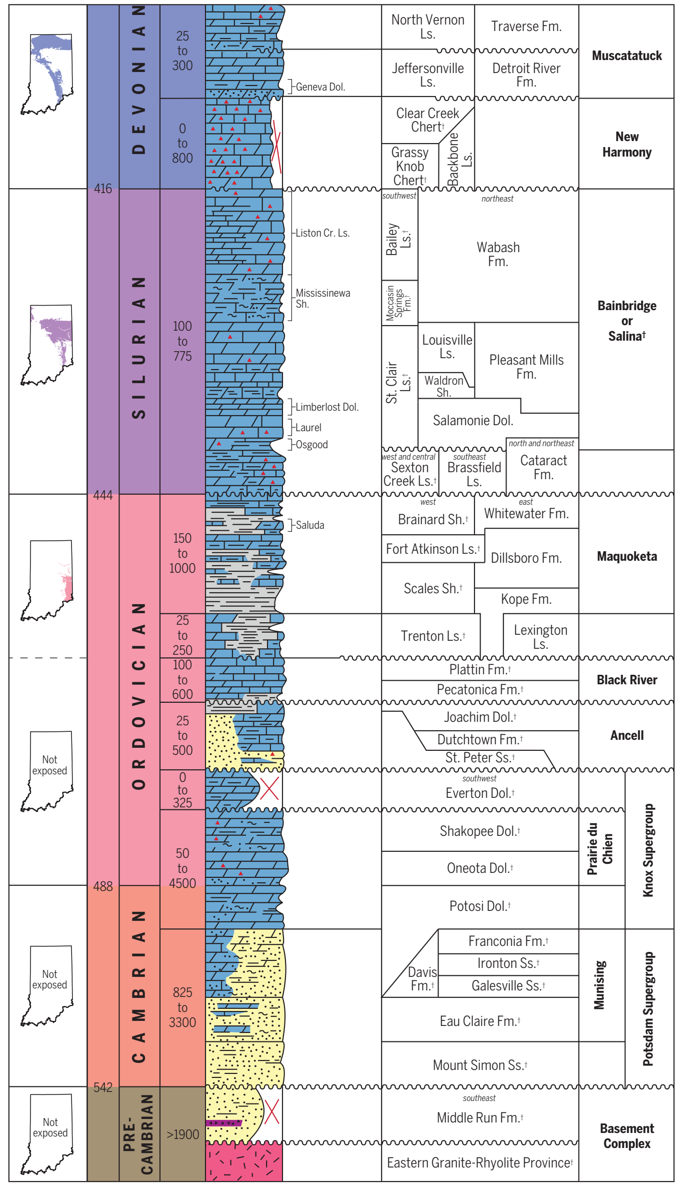
Generalized Stratigraphic Column of Indiana Bedrock

Todd A. Thompson, Indiana State Geologist

By Todd A. Thompson, Kimberly H. Sowder, and Matthew R. Johnson

Bloomington, Indiana: 2010, revised 2016





Additional information about bedrock stratigraphic units of Indiana can be found at the Indiana Geological Survey Indiana Geologic Names Information System website at https://igs.indiana.edu/IGNIS/.

sandstone, conglomerate
shale, mudstone, siltstone
limestone
dolostone
coal
volcanic rocks
igneous rocks
rocks absent
unconformity
bioturbation
chert

Note: Mixtures and interbedding of lithologies can occur.

Italics indicate geographic areas in Indiana where unit names are used.

*Simplified to illustrate common lithologies.

†These units normally occur only in the subsurface. However, some units of Ordovician and Lower Silurian age are exposed at the Kentland impact structure in northwestern Indiana.

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[3] Rupp, J. A., 1991, Structure and isopach maps of Paleozoic rocks of Indiana: Indiana Geological Survey Special Report 48, 106 p.

[4] Shaver, R. H., Ault, C. H., Burger, A. M., Carr, D. D., and others, 1986, Compendium of Paleozoic rock-unit stratigraphy in Indiana—a revision: Indiana Geological Survey Bulletin 59, 203 p.

[5] Hasenmueller, W. A., Hasenmueller, N. R., and Daniels, M. S., 2013, Indiana Geologic Names Information System: Indiana Geological Survey website, <http://igs.indiana.edu/IGNIS/Search.cfm>, date accessed, July 1, 2013.

3 Aggregate Properties

Physical Properties

Absoprtion, Porosity, and Permeability
Surface Texture
Strength and Elasticity
Density and Specific Gravity
Aggregate Voids
Hardness
Particle Shape
Coatings
Undesirable Physical Components

Chemical Properties

Composition
Reactions with Asphalt and Cement

Surface Charge

General Characteristics

Compacted Aggregates
Aggregate for Hot Mix Asphalt
Aggregate for Portland Cement Concrete
Other Aggregates

CHAPTER THREE:
AGGREGATE PROPERTIES

The origin, distribution, and aggregate types found within Indiana were discussed in Chapter Two. The intent of this chapter is to familiarize the personnel responsible for aggregate testing with:

1) Related physical properties

2) Chemical properties

3) General field characteristics of these aggregates

Recognition of these properties and characteristics assists the Technician in evaluating the different aggregates used in highway construction.

Aggregate particles have certain physical and chemical properties which make the aggregate acceptable or unacceptable for specific uses and conditions. The following are of concern to INDOT.

PHYSICAL PROPERTIES

The physical properties of aggregates are those that refer to the physical structure of the particles that make up the aggregate.

ABSORPTION, POROSITY, AND PERMEABILITY

The internal pore characteristics are very important properties of aggregates. The size, the number, and the continuity of the pores through an aggregate particle may affect the strength of the aggregate, abrasion resistance, surface texture, specific gravity, bonding capabilities, and resistance to freezing and thawing action. Absorption relates to the particle's ability to take in a liquid. Porosity is a ratio of the volume of the pores to the total volume of the particle. Permeability refers to the particle's ability to allow liquids to pass through. If the rock pores are not connected, a rock may have high porosity and low permeability.

SURFACE TEXTURE

Surface texture is the pattern and the relative roughness or smoothness of the aggregate particle. Surface texture plays a big role in developing the bond between an aggregate particle and a cementing material. A rough surface texture gives the cementing material something to grip, producing a stronger bond, and thus creating a stronger hot mix asphalt or portland cement concrete. Surface texture also affects the workability of hot mix asphalt, the asphalt requirements of hot mix asphalt, and the water requirements of portland cement concrete.

Some aggregates may initially have good surface texture, but may polish smooth later under traffic. These aggregates are unacceptable for final wearing surfaces. Limestone usually falls into this category. Dolomite does not, in general, when the magnesium content exceeds a minimum quantity of the material.

STRENGTH AND ELASTICITY

Strength is a measure of the ability of an aggregate particle to stand up to pulling or crushing forces. Elasticity measures the "stretch" in a particle.

High strength and elasticity are desirable in aggregate base and surface courses. These qualities minimize the rate of disintegration and maximize the stability of the compacted material. The best results for portland cement concrete may be obtained by compromising between high and low strength, and elasticity. This permits volumetric changes to take place more uniformly throughout the concrete.

DENSITY AND SPECIFIC GRAVITY

Density is the weight per unit of volume of a substance. Specific gravity is the ratio of the density of the substance to the density of water.

The following chart illustrates these relationships for some common substances.

Typical Values		
Substance	**Specific Gravity**	**Density (lb/ft^3)**
Water	1.0 (73.4 °F)	62.4 lb/ft^3 (73.4 °F)
Limestone	2.6	165 to 170 lb/ft^3
Lead	11.0	680 to 690 lb/ft^3

The density and the specific gravity of an aggregate particle is dependent upon the density and specific gravity of the minerals making up the particle and upon the porosity of the particle. These may be defined as follows:

1) All of the pore space (bulk density or specific gravity)

2) Some of the pore space (effective density or specific gravity)

3) None of the pore space (apparent density or specific gravity)

Determining the porosity of aggregate is often necessary; however, measuring the volume of pore space is difficult. Correlations may be made between porosity and the bulk, apparent and effective specific gravities of the aggregate.

As an example, specific gravity information about a particular aggregate helps in determining the amount of asphalt needed in the hot mix asphalt. If an aggregate is highly absorptive, the aggregate continues to absorb asphalt, after initial mixing at the plant, until the mix cools down completely. This process leaves less asphalt for bonding purposes; therefore, a more porous aggregate requires more asphalt than a less porous aggregate. The porosity of the aggregate may be taken into consideration in determining the amount of asphalt required by applying the three types of specific gravity measurements.

In the example in Figure 3-1, the bulk specific gravity includes all the pores, the apparent specific gravity does not include any of the pores that would fill with water during a soaking, and the effective specific gravity excludes only those pores that would absorb asphalt. Correlation charts and tables provide guidance to asphalt quantities or acceptability of the aggregate.

AGGREGATE VOIDS

There are aggregate particle voids, and there are voids between aggregate particles. As solid as aggregate may be to the naked eye, most aggregate particles have voids, which are natural pores that are filled with air or water. These voids or pores influence the specific gravity and absorption of the aggregate materials.

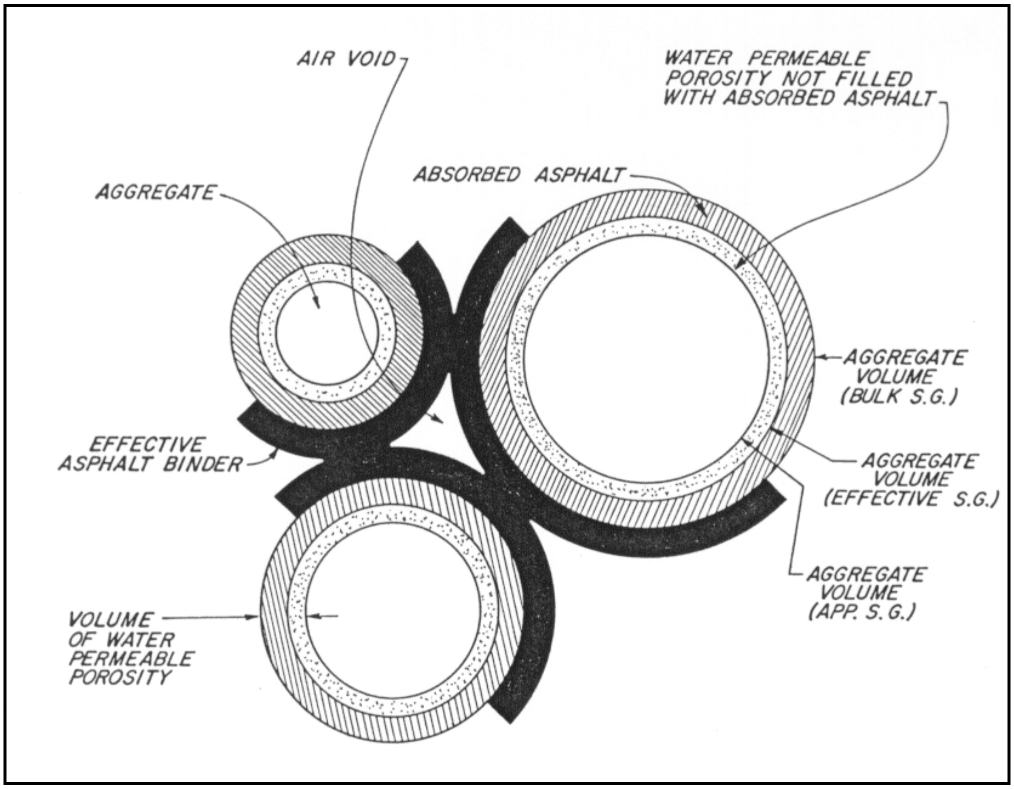


Figure 3-1. Aggregate Specific Gravities.

The voids within an aggregate particle should not be confused with the void system which makes up the space between particles in an aggregate mass. The voids between the particles influence the design of hot mix asphalt or portland cement concrete.

HARDNESS

The hardness of the minerals that make up the aggregate particles and the firmness with which the individual grains are cemented or interlocked control the resistance of the aggregate to abrasion and degradation. Soft aggregate particles are composed of minerals with a low degree of hardness. Weak particles have poor cementation. Neither type is acceptable. The Mohs Hardness Scale is frequently used for determination of mineral hardness (Figure 3-2). Although there is no recognizable INDOT specification or requirement which pertains to Mohs Hardness Scale, the interpretation, concept, and use of this scale is useful for the field identification of potentially inferior aggregates.

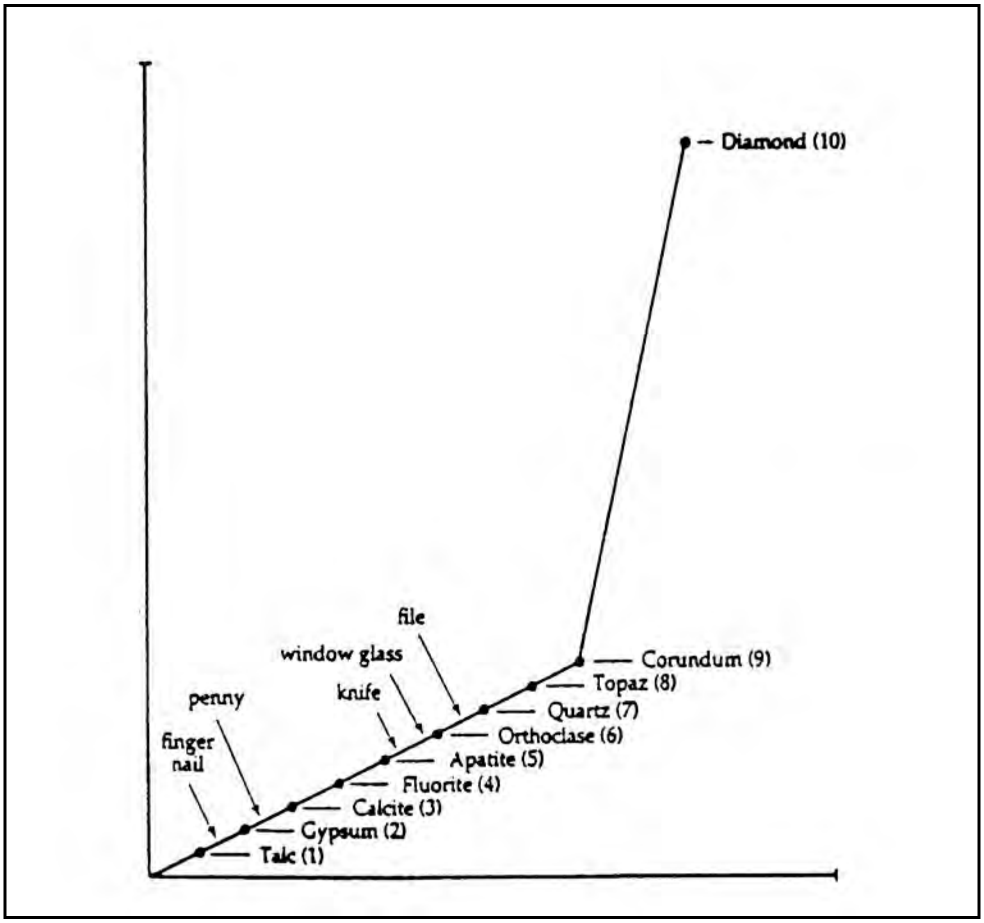


Figure 3-2. Relative Hardness of Minerals in Mohs Scale (numbers in parentheses)

PARTICLE SHAPE

The shape of the aggregate particles affects such things as:

1) The asphalt demands of hot mix asphalt

2) The workability and the strength of both portland cement concrete and asphalt pavements

The best aggregates to use for strength are crushed stone or crushed gravel. Crushed aggregate have irregular, angular particles that tend to interlock when compacted or consolidated.

The crushed stone or crushed gravel aggregate make the asphalt or concrete mix somewhat difficult to place. To improve the workability, many mixes contain both angular and round particles. The coarse aggregate particles are usually crushed stone or crushed gravel, and the fine aggregate particles are usually natural sand. The Standard Specifications detail the requirements for crushed materials for various uses.

COATINGS

Coating is a layer of substance covering a part or all of the surface of an aggregate particle. The coating may be of natural origin, such as mineral deposits formed in sand and gravel by ground water, or may be artificial, such as dust formed by crushing and handling.

Generally when the aggregates are used in hot mix asphalt or portland cement concrete mixes, the aggregates are required to be washed to remove the coating (contaminant) left on the particles. The coating may prevent a good bond from forming between the aggregate surfaces and the cementing agent. The coating could even increase the quantity of bonding agent required in the mixture. If the quantity of the coating varies from batch to batch, undesirable fluctuations in the consistency of the mix may result. Deposits containing aggregates which display a history of coating problems require decantation.

UNDESIRABLE PHYSICAL COMPONENTS

Particles with undesirable physical characteristics include but are not limited to the following:

1) Non-durable soft or structurally weak particles

2) Clay lumps or clay balls

3) Flat or elongated particles

4) Organic matter contaminants

4) Lightweight chert

Some metallic minerals of the sulfite and hydroxide chemical families; particularly, pyrite (FeS_2), marcasite (FeS_2), hematite (Fe_2O_3) and magnetite (Fe_3O_4) may cause concerns. The latter three minerals, when they occur, can be traced to sand and gravel deposits. Pyrite, for the most part, is found in shales and limestones of crushed stone sources.

The primary effect of these minerals is a rust-like staining in exposed concrete and hot-mix asphalt pavements (HMA). Elevated percentages of pyrite may necessitate alternative tests methods when determining HMA mixture properties.

CHEMICAL PROPERTIES

The chemical properties of aggregates have to do with the molecular structure of the minerals in the aggregate particles.

COMPOSITION

The chemical composition of aggregate is significant in determining the difference between limestone and dolomite. Limestone is a rock consisting mainly or wholly of calcium carbonate and has a tendency to polish smooth under traffic. Therefore, limestone is limited to use in low traffic-volume HMA surface courses. Dolostone under traffic maintains a higher-friction, skid-resistant surface and is used on higher traffic volume locations. Dolostone is a carbonate rock which consists largely of calcium magnesium carbonate. The word dolomite is the mineral calcium magnesium carbonate $Ca\,Mg\,(Co_3)_2$. INDOT uses an elemental magnesium (Mg) content test to determine if a rock source is dolomitic. An elemental magnesium content of 10.3 percent or above is required for dolomite aggregates.

Some aggregates have minerals that are subject to oxidation, hydration, and carbonation. These properties are not particularly harmful, except when the aggregates are used in portland cement concrete. As might be expected, iron sulfides, ferric and ferrous oxides, free lime, and free magnesia in industrial products and wastes are some of the common substances. Any of these substances may cause distress in the portland cement concrete and give the concrete an unsightly appearance.

REACTIONS WITH ASPHALT AND CEMENT

There are several types of substances found in mineral aggregates which may have a negative effect on the cementing and overall performance qualities of asphalt and cement. Most are rarely significant but various organic substances may retard hardening, reduce strength development or cause excessive air entrainment in portland cement concrete. These organic substances include, but are not limited to, mica, iron oxide, lightweight chert, shale, coal, and lignite.

SURFACE CHARGE

Aggregate particle surfaces possess either positive or negative electrical charges. Limestone and dolostone generally have a high affection for liquid asphalt.

GENERAL CHARACTERISTICS

Aggregates have three primary uses in highway construction:

1) As compacted aggregates in bases, subbases and shoulders

2) As ingredients in hot mix asphalt

3) As ingredients in portland cement concrete

Aggregates may also be used as special backfill material, riprap, mineral filler, and other less significant uses.

COMPACTED AGGREGATES

Compacted aggregates without the addition of a cementing material may be used as a base or subbase for hot mix asphalt and portland cement concrete pavements. Portland cement concrete pavements are rigid pavements. For these types of pavements, the purpose of the base may be to improve drainage, to prevent pumping, or to cover a material that is highly susceptible to frost. Consequently, gradation and soundness are the primary considerations in selecting or evaluating aggregates for bases under rigid pavements.

The load-carrying capacity is a primary factor in the selection of aggregates for hot mix asphalt pavements. A hot mix asphalt pavement does not carry the load; help from the underlying base courses is required. In addition to gradation requirements, the aggregates are required to also possess the strength to carry and transmit the applied loads.

Aggregates are sometimes used to make up the entire pavement structure. In this type of pavement, aggregates are placed on the natural soil to serve as a base course and surface course. A gain, the primary requirement is the gradation.

In many instances, compacted aggregates are also used to construct roadway shoulders and berms. In these applications, gradation and stability are very important.

AGGREGATE FOR HOT MIX ASPHALT

INDOT uses hot mix asphalt in a number of different ways. In all cases the aggregates used should meet five requirements:

1) Strong, tough and durable

2) The ability to be crushed into bulky particles, without many flaky particles, slivers or pieces that are thin and elongated

3) Low porosity

4) Low permeability

5) Correct particle size and gradation for the type of pavement

AGGREGATES FOR PORTLAND CEMENT CONCRETE

There are many uses of portland cement concrete in highway construction. Some of the major uses of aggregates are in rigid-pavement slabs, bridges, concrete barriers, sidewalks, curbs, slopewalls, and other structures.

Aggregates in portland cement concrete are required to always be physically and chemically stable. Other factors to be considered include:

1) The size, distribution, and interconnection of voids within individual particles

2) The surface character and texture of the particles

3) The gradation of the coarse and fine aggregates

4) The mineral composition of the particles

5) The particle shape

6) Soundness abrasion resistance

7) Water absorption

OTHER AGGREGATES

There are other uses for aggregates in highway construction. The requirements are somewhat different from the ones already discussed; however, in most cases, gradation as a controlling factor is common to all applications.

4 Aggregate Specifications and Requirements

Physical Quality Requirements

Fine Aggregates
Coarse Aggregates

Physical Quality Tests

Absorption
Abrasion Resistance
Soundness
Deleterious Materials
Special Requirements

General Usage Requirements

Fine Aggregates
Coarse Aggregates

Gradation Requirements

Fine Aggregates
Coarse Aggregates
B Borrow and Structure Backfilll
Riprap
Aggregate Base
Subbase
Aggregate Pavements or Shoulders
Summary of Gradation Requirements

CHAPTER FOUR:
AGGREGATE SPECIFICATIONS and REQUIREMENTS

The Specifications for aggregates are detailed in Section **904** and other sections for the various types of construction. These specifications are to be followed when inspecting aggregates. There are two general types of requirements for aggregate: quality and gradation.

PHYSICAL QUALITY REQUIREMENTS

Physical quality requirements are all specification provisions other than gradation or usage requirements. These requirements may be divided into five distinct groups as follow:

1) Absorption
2) Abrasion resistance
3) Soundness
4) Restriction on deleterious constituents
5) Special requirements

FINE AGGREGATES

Section **904.02** defines the acceptable limits for all uses of fine aggregates.

Fine aggregates are not divided into classes. The quality ratings assigned to fine aggregates regarding their approval for use on highway construction contracts are:

A5 = approved for all uses

B5 = approved for all uses where manufactured fine aggregate is allowed

G5 = not approved

The "A" rating is for all natural sands. The "B" rating is for manufactured fine aggregates.

COARSE AGGREGATES

Section **904.03** defines the acceptable limits for all uses of coarse aggregates.

Coarse aggregates are divided into classes based on quality requirements as noted in the Classification of Aggregates table. Class AP is the highest class and is assigned to aggregates which meet the requirements for all INDOT uses. Some INDOT contracts specify type AP aggregates for use in specific applications of portland cement concrete. Parameters concerning type AP aggregate are contained in **ITM 210**. Aggregates having restricted approval are rated Classes A, AS, B, C, D, E, and F.

PHYSICAL QUALITY TESTS

Approval and use of aggregates is based upon meeting test requirements in the following physical tests.

ABSORPTION

The absorption quality requirement applies only to coarse aggregates, but this data is necessary on fine aggregate for other purposes, such as mix design and water/cementitious ratios.

All aggregates are porous, but some are more porous than others. How porous an aggregate is determines how much liquid may be absorbed when soaked in water. **AASHTO T 85** defines absorption as the increase in the weight of aggregate because of water in the pores of the material, but not including water adhering to the outside surface of the particles. Absorption is expressed as a percentage of the dry weight.

Absorption requirements are of concern only regarding aggregates used in hot mix asphalt and portland cement concrete. The intent is to avoid using highly porous, absorptive aggregates because extra water and cement or asphalt is needed to make a good mix. However, some aggregates, such as blast furnace slag, may be used despite their high absorptive capacity because of other characteristics that make them desirable, including skid resistance, economics, etc.

ABRASION RESISTANCE

Abrasion resistance applies only to coarse aggregates. Aggregates vary in their resistance to fracturing under impact (toughness) and breaking down into smaller pieces from abrasive action (hardness). The acceptable limits are set by the Los Angeles Abrasion Test **AASHTO T 96**. The limits vary from 30.0 to 50.0 percent, depending on the classification of the aggregate. The percentage is a measure of the degradation or loss of material as a result of impact and abrasive actions. Section **904.03** details the requirements. Abrasion requirements do not apply to blast furnace slag.

SOUNDNESS

The quality of soundness applies to both fine and coarse aggregates. The durability of aggregates or their resistance to the forces of weathering is one of the most important considerations in the selection of a material for highway construction. Alternate freezing and thawing of the aggregates is the major concern.

INDOT uses three different test methods to evaluate soundness:

1) The water freeze and thaw test in accordance with **AASHTO T 103, Procedure A**

2) The sodium sulfate test in accordance with **AASHTO T 104**

3) The brine freeze and thaw test in accordance with **ITM 209**

The water freeze and thaw test requires the aggregate to be sealed and totally immersed in water and then be subjected to *50 cycles* of freeze and thaw. The sodium sulfate test requires the aggregate to be immersed in a sodium sulfate solution and then be subjected to *5 cycles* of alternate immersion and drying. The brine freeze and thaw test requires the aggregate to be enclosed in a bag containing a 3 percent sodium chloride solution and then be subjected to *25 cycles* of freeze and thaw.

The freezing and thawing in water test is the method that most accurately simulates actual field conditions; however, the test requires a long period of time to conduct. The "quick" checks for soundness of the aggregate are the brine freeze and thaw and sodium sulfate tests. If the aggregate fails either the brine freeze and thaw or the sodium sulfate test, the aggregate is tested using the freeze and thaw in water method. An aggregate that passes the freeze and thaw in water test is an acceptable material for use on INDOT contracts.

DELETERIOUS MATERIALS

Certain substances in aggregates are undesirable for use in portland cement concrete. Therefore, the Specifications limit the amount of deleterious constituents to a level consistent with the quality sought in the final product.

Organic impurities are the only concern in fine aggregates. Section **904.02** places a restriction for fine aggregate for use in portland cement concrete and mortar. No restrictions are placed on organic impurities in fine aggregate for use in other types of construction.

The limitations on the amount of organic impurities allowed in fine aggregates are determined by the test method for organic impurities in **AASHTO T 21** and the test method for Mortar Strength in **AASHTO T 71**. According to the Specifications, materials failing the organic impurities test are to be tested for the effect of organic impurities using the mortar strength test. The results of the test are the basis for acceptance or rejection of the fine aggregate.

Section **904.03** includes a general statement regarding deleterious substances that applies to all classes of coarse aggregates. Section **904.03** also details more specific restrictions for other harmful substances as a maximum allowable percentage of the mass of each of the deleterious materials in a total sample of aggregates being tested. Figure 4-1 illustrates the materials which are classified as deleterious and the specification limits for each.

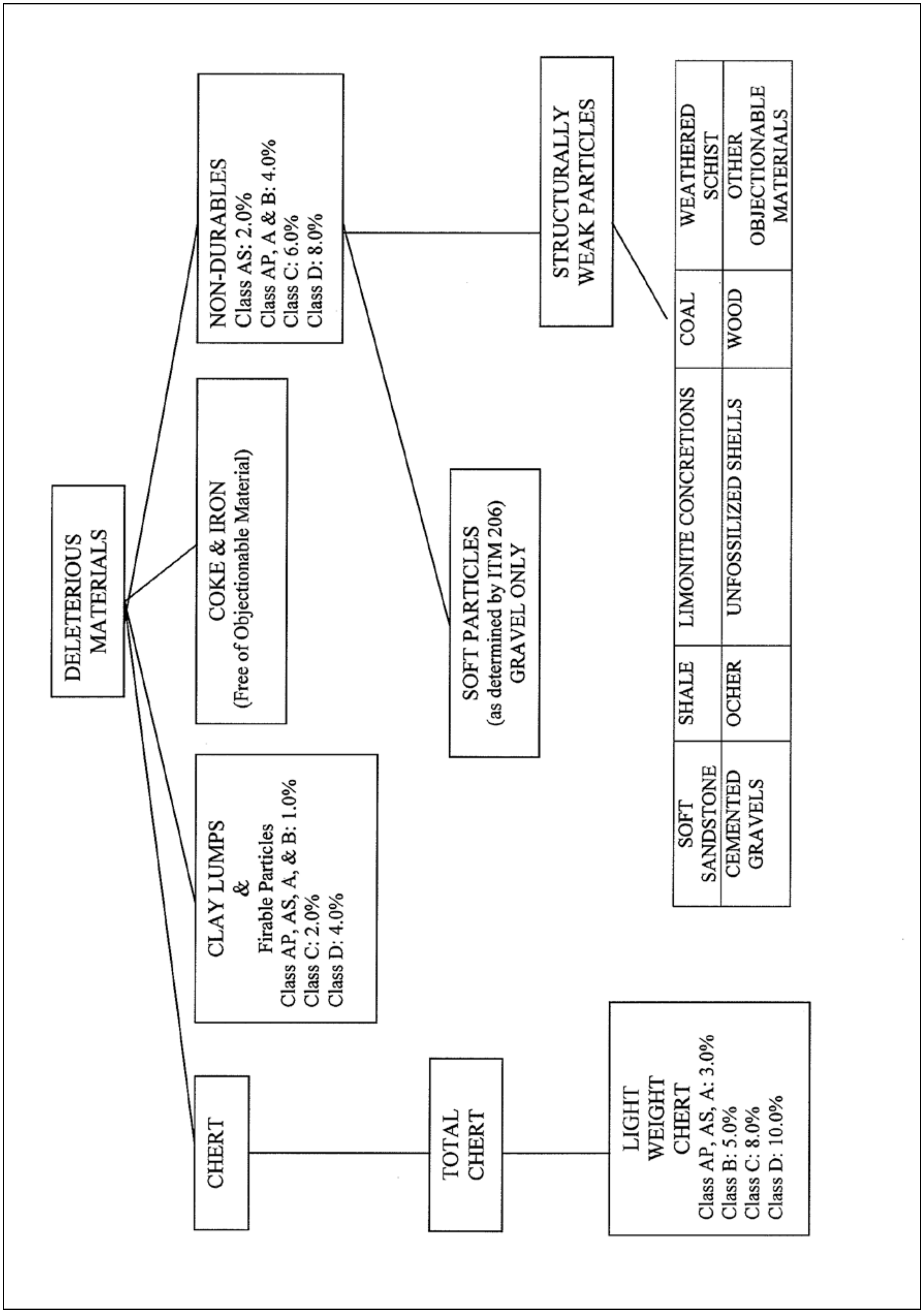


Figure 4-1. Deleterious Materials

Clay Lumps and Friable Particles

Clay lumps and friable particles are materials that are easily crumbled or mashed with the fingers. Testing for these particles is performed by **AASHTO T 112**, Clay Lumps and Friable Particles in Aggregates.

Non-Durable Particles

Non-durable particles are divided into two types: soft materials as determined by **ITM 206**, Scratch Hardness, and structurally weak material as determined by visual inspection. Structurally weak materials include the following:

1) Conglomerates -- cemented gravels

2) Soft sandstone

3) Shale -- laminated rock of clay-size minerals

4) Limonite -- iron oxide ranging in color from brown to black and is frequently a concretion around a soft core

5) Weathered schist -- structurally weak

6) Ocher -- soft rock clay to sand particles cemented with iron oxide which ranges in color from tan, through yellows, reds, and browns (looks and acts like chalk)

7) Shells -- unfossilized shell of fresh water clams

8) Coal, wood, and other foreign materials

9) Materials with loosely cemented grains and/or a weathered coating

Coke and Iron

Coke and iron are of concern only with the slag materials. Coke is an ingredient in the steel making process. Slag from air-cooled blast and steel furnaces normally are free of objectionable amounts of coke and iron.

Chert

Chert is a rock of almost any color and is composed of glassy silica and very fine-grained quartz. Chert breaks into rounded surfaces with sharp edges. Unweathered chert appears hard, dense and brittle with a waxy or greasy texture. Weathered chert appears chalky or earthy and porous with a dull texture.

Lightweight chert is defined as aggregate that has a bulk specific gravity less than 2.45. The bulk specific gravity is determined using the saturated surface dry condition.

SPECIAL REQUIREMENTS

In some cases, aggregates are required to meet special requirements for a particular use in construction as required by various Sections of **904**. Some contracts may specify a unique gradation or aggregate. Details pertaining to this special requirement appear in the Special Provision section of the contract.

Fine Aggregates

The fine aggregate, including blended fine aggregate, used in HMA Surface 4.75 mm mixtures is required to have an acid insoluble content of not less than 40 percent. For air-cooled blast furnace slag or granulated blast furnace slag sand, the acid insoluble content is required to not be less than 25 % for this application. Acid insoluble requirements do not apply to crushed gravel, limestone, or dolomite sands. The acid insoluble content is determined by **ITM 202**.

All fine aggregates used for HMA are required to be in accordance with **904.02** for soundness. If soundness testing cannot be conducted, the aggregate is required to originate from a Category I source in accordance with **ITM 203**.

The total blended aggregate from the fine and coarse aggregates, and recycled materials used in HMA are required to meet the fine aggregate angularity (FAA) requirements of Section **904.02(b)**. The procedure for determining the FAA value is described in Method A of **AASHTO T 304**.

The clay content of the blended aggregate is required to meet the requirements of Section **904.02(b)**. The procedure for determining this value is described in **AASHTO T 176**.

All Coarse Aggregates

A special requirement placed on all coarse aggregates concerns the restriction on the number of *flat and elongated* pieces. Section **904.03** sets the limits for the number of flat and elongated pieces. A flat and elongated piece is defined as one having a ratio of length to thickness greater than five. The test method for determining the actual percentage of elongated pieces is **ASTM D 4791**.

Dolomitic Aggregates

There is a special requirement to be met when dolomitic coarse aggregates are specified in HMA. These aggregates are specified for use under some conditions to obtain high-friction, skid-resistant HMA surface courses. **ITM 205** is used to veify that the aggregate is carbonate rock containing at least 10.3 percent elemental magnesium.

Polish Resistant Aggregates

Aggregates that meet the requirements of **ITM 214** may be used in place of dolomitic aggregates in HMA surface mixtures. The procedure for approval requires initial British Pendulum testing, placement of a test section on an INDOT contract, and subsequent skid testing for two years.

Sandstone Aggregates

Coarse sandstone is required to meet the Class B quality requirements, and may only be used in HMA or SMA surface mixtures. Sandstone is defined as a sedimentary rock composed of siliceous sandgrains containing quartz, chert, and quartzose rock fragments in a carbonite matrix or cemented with silica, calcite, or dolomite.

Slag Aggregates

When slag is furnished as an alternate to natural aggregate and payment is on a weight basis, adjustments are required to be made to compensate for the difference in specific gravity of the slag compared to the specific gravity of the natural aggregate. For any pay item less than 500 tons on a contract, no adjustment is made. The following typical values are used.

TYPICAL VALUES FOR SPECIFIC GRAVITY	
Natural aggregates (both fine and coarse)	**2.6**
Air cooled blast furnace slag coarse aggregate	**2.3**
Air cooled blast furnace slag fine aggregate	**2.6**
Granulated blast furnace slag fine aggregate	**2.1**
Steel furnace slag, both fine and coarse	**3.2**

Type AS Aggregates

Aggregates used for stone matrix asphalt mixtures are required to meet the requirements of AS aggregates in accordance with Section **904.03 (a)**. These requirements include testing with the Micro-Deval abrasion apparatus **(AASHTO T 327)** and determination of the aggregate degradation in accordance with **ITM 220**. Additional requirements for control of the specific gravity of the steel furnace slag are included in Section **904.01**.

Gravel Coarse Aggregates

There is a specific requirement for gravel coarse aggregates regarding crushed particles. T his requirement applies, however, only when gravel coarse aggregates are used in HMA, compacted aggregates, and asphalt seal coats except asphalt seal coats used on shoulders. Crushed particles are defined as those particles having one or more sharp, angular, fractured faces. Fractured faces that have an area less than *25 %* of the maximum cross sectional area of the particle are not considered crushed. **ASTM D 5821** is used to determine the crushed particle content. Crushed gravel is required to comply with the requirements in Section **904.03**.

Type AP Aggregates

INDOT requires specific applications of portland cement concrete to be constructed with AP aggregate. D etails and parameters concerning AP aggregate are described in **ITM 210**.

GENERAL USAGE REQUIREMENTS

The general usage requirements describe the type of material which is considered acceptable for the type of construction, and the requirements which influence the acceptability of the material.

FINE AGGREGATES

Section **904.02** states that fine aggregate is required to consist of natural sand or manufactured sand produced by crushing limestone, dolomite, steel furnace slag, air cooled blast furnace slag, granulated blast furnace slag, or wet bottom boiler slag. At the time of use, these materials are required to be free from lumps or crusts of hardened or frozen materials.

THE SPECIFIC REQUIREMENTS OF FINE AGGREGATES IN ACCORDANCE WITH SECTION 904.02:	
TYPE OF CONSTRUCTION	***ACCEPTABLE FINE AGGREGATE***
Portland cement concrete for pavement or bridge decks	Natural sand
Portland cement concrete for other construction	Natural sand or crushed limestone, dolomite, or air-cooled blast furnace slag
Hot mix asphalt	Natural sand or manufactured sand. Steel furnace slag sand is permitted only with steel furnace slag coarse aggregate. A combination of natural sand and manufactured sand is permitted. However, not more than 20 pe rcent of the total aggregate used in HMA surface mixtures with ESAL equal to or greater than 3,000,000 may be crushed limestone sand if the limestone sand is from a source not on the Approved Polish Resistant Aggregate List.
Pneumatic placement	Natural sand suitable for use with a pneumatic sand cement gun
Mortar	Natural sand
Mineral Filler	Dust produced by crushing stone, portland cement, or other inert mineral matter
Snow and ice abrasives	Steel furnace slag, air-cooled blast furnace slag, granulated blast furnace slag, natural sand, crushed stone sand, or cinders

COARSE AGGREGATES

Section **904.03** includes the general requirements for coarse aggregate. This section lists several of the types of materials that may be used as coarse aggregate, and their applications and limitations.

CLASS OF COARSE AGGREGATES REQUIRED FOR VARIOUS TYPES OF CONSTRUCTION	
TYPE OF CONSTRUCTION	***REQUIRED QUALITY CLASSIFICATION***
Aggregate Base	Class A, B, C, or D
Subbase	Class A or B (No. 8) Class A, B, C, or D (No. 53)
Aggregate Pavements or Shoulders	Class A, B, C, or D
HMA base coarse	Class A, B, C, or D
HMA intermediate course	Class A, B, or C
HMA surface course	Class A or B
SMA surface course	Class AS
Asphalt seal coat	Class A or B
Portland cement concrete pavement	Class AP
Portland cement concrete structural--exposed	Class A or AP
Portland cement concrete structural --non-exposed	Class A or B
Cover (choke) coarse aggregate	Class A or B

Where more than one aggregate classification is allowed, the Contractor has a choice, unless specified by provisions within a given contract. The class of aggregate may never be less than the lowest class for the designated use. For example, the highest class of aggregate for HMA surface course, Class A, may be used (with no additional payment to the Contractor or Producer). Class B aggregate may be used as the minimum requirement.

GRADATION REQUIREMENTS

The gradation or particle-size distribution of an aggregate is usually specified to be within certain limits for various types of construction. There is a great difference between what is considered an acceptable grading for aggregates for the various HMA mixes, for portland cement concrete, or for base layers. The gradation that aggregates are to meet for specific types of construction is contained in the contract plans, Special Provisions, or Standard Specifications and is usually designated by the aggregate size.

Sections **904.02 and 904.03** contain tables describing the acceptable particle-size distribution for various sizes of both fine and coarse aggregates. Section **904.04** specifies the sizes for riprap and Section **904.05** lists the acceptable gradations for structure backfill.

FINE AGGREGATES

The table found in Section **904.02** is used to accept six aggregates used for HMA mixes, portland cement concrete, pneumatic placement mortar, mortar sand, mineral filler, and snow and ice abrasives. T he six sizes of fine aggregates include No. 23, No. 24, No. 15, No. 16, PP, and S&I. No. 16 is the finest aggregate, because 100 percent of the fine aggregate is required to pass the No. 30 sieve. No. 23 is the coarsest of the six sizes. All fine aggregate particles are generally expected to pass the No. 4 sieve.

The aggregates for mortar sand are required to meet the gradation for size number 15 or an approved gradation from a CAPP source. The fine aggregates for pneumatic placement may meet size number 15, P P, or an approved gradation from a CAPP source. Mineral filler for SMA is required to meet size number 16.

Snow and ice abrasives are required to meet the gradation requirements of Section **904.02(f)**.

COARSE AGGREGATES

The table found in Section **904.03** applies to coarse aggregates. The ten sizes of coarse aggregates include No. 2, No. 5, No. 8, No. 9, No. 11, No. 12, No. 43, No. 53, No. 73, and No. 91. No. 2 is the coarsest size and No. 12 is the finest. No. 53 and No. 73 are dense graded aggregates, and No. 91 is used for aggregates in precast concrete. The majority of the coarse aggregate is retained on the No. 4 sieve and larger.

B BORROW AND STRUCTURE BACKFILL

B Borrow and structure backfill requirements are listed in Section **211**.

Materials for B Borrow are required to contain no more than 10 % passing the No. 200 sieve and be otherwise suitably graded as noted in Section **211.02**. The use of an essentially one-size material is not permitted unless approved.

Materials for structure backfill are required to be of acceptable quality, free from large or frozen lumps, wood, or other extraneous matter. Structure backfill gradations are included in Section **904.05**. Aggregate sizes No. 5, No. 8, No. 9, No. 11, No. 12, No. 53, and No. 73 crushed stone or air cooled blast furnace slag are allowed. Additional aggregate sizes permitted for structure backfill are listed in the table in this section. The structural backfill types that allow aggregates and the specific uses of each type are as follows.

Type 1 structural backfill is used in longitudinal or transverse structures placed under, or within 5 ft of, the back of paved shoulders or the back of sidewalks of a new facility. This type is also used for a structure of an existing facility where all existing pavement is to be replaced. Structural backfill in accordance with Section **904.05** may be used for Type 1 applications.

Type 2 structural backfill is used in longitudinal or transverse structures placed under, or within 5 ft of, the back of the paved shoulder or back of the sidewalk where undisturbed existing pavement is to remain. This type is also used for precast concrete three-sided or four-sided structures with a height of cover of 2 ft or more. Crushed stone or ACBF in accordance with Section **904.05** may be used for Type 2 applications, except No. 30, No. 4, and 2 in. nominal size aggregate may not be used.

Type 3 structural backfill is used behind mechanically-stabilized earth retaining walls. Structural backfill in accordance with Section **904.05** may be used for Type 3 applications, except only nominal size aggregates 1 in., 1/2 in., or No. 4. or coarse aggregates No.5, No. 8, No. 11, or No. 12 may be used. No slag other than ACBF is permitted.

RIPRAP

Aggregate used for riprap is included in Section **904.04**. These materials are typically large and are used as a protective coating as specified. Revetment, Class 1, Class 2, Uniform A, and Uniform B Riprap are required to meet the requirements of Section **904.04(f).** The other ripraps listed have general size limitations.

AGGREGATE BASE

Section **301** includes the requirements for dense graded compacted aggregate material. No. 53 aggregate is used for this purpose.

SUBBASE

Section **302** includes the requirements for subbase placed on a prepared subgrade for portland cement concrete pavement. Subbase consists of a No. 8 aggregate as the drainage layer over a No. 53 aggregate as the separation layer. Where a dense graded subbase is required, only No. 53 aggregate is used.

AGGREGATE PAVEMENTS OR SHOULDERS

Section **303** includes the requirements for aggregates when used for pavements or shoulders. No. 53 and No. 73 aggregate are used for this purpose except that No. 73 aggregate is only used for surface courses.

SUMMARY OF GRADATION REQUIREMENTS

The gradation requirements for fine and coarse aggregates as specified in various sections of the Specifications for significantly different types of construction are summarized below. This listing is not all inclusive, but covers the major uses of aggregates.

TYPE OF CONSTRUCTION REQUIREMENTS	GRADATION
Aggregate Base Coarse Aggregate	 No. 53
Subbase Coarse Aggregate	 No. 8, 53
Aggregate Pavements or Shoulders Coarse Aggregate	 No. 53, 73
Asphalt Seal Coat Fine Aggregate Coarse Aggregate	 Nos. 23 or 24 Nos. 8, 9, 11, 12 Nos. SC 11, 12, 16
Portland Cement Concrete Pavement (PCCP)/Structural Concrete Fine Aggregate Coarse Aggregate	 No. 23 No. 8

5 Aggregate Production

Extraction

Stripping
Drilling and Blasting
Shot Rock or Gravel Bank

Crushing

Scalping
Primary Crushing
Secondary and Tertiary Crushing
Impact Crushing

Other Benefaction

Screening

Product Quality
Gradation Control

Sand Production

Natural Sand
Manufactured Sand
Processing

Segregation

Stockpiling and Handling

Cone Stockpiles
Radial Stockpiles
Truck-Built Stockpiles
Layered Stockpiles
Stockpiling - General

Degradation

Contamination

Retrieval

CHAPTER FIVE:
AGGREGATE PRODUCTION

This chapter discusses the total process of aggregate production from extraction through processing. Also discussed is the handling, stockpiling, and shipping of the product up to the point where the material leaves the Producer's control. Processing influences mineral quality and integrity, aggregate physical properties, and, in particular, gradation (size control). Establishing a stable production process may reduce variability of the product.

EXTRACTION

With the exception of slag and other manufactured aggregates most materials for aggregate production come from bedrock or unconsolidated deposits. The vast majority of materials used in the mineral aggregate industry are obtained from surface-mined stone quarries or from sand and gravel pits. How materials are extracted influences their quality.

Extraction Influences on Quality

STRIPPING

- Not clean enough
- Spillage over mining face

DRILLING AND BLASTING

- Hole size, depth, and spacing (pattern)
- Blast delay sequence
- Blast intensity or charge

SHOTROCK OR GRAVEL BANK

- Non-uniform load-out
- Equipment changes
- Geologic variability
- Moisture variability in shotrock
- Above/below-water gravel deposits

STRIPPING

As a first step, a Producer is required to designate a detailed stripping procedure (Figure 5-1) for each and every deposit that is mined. This phase often is overlooked, yet has a great influence on the quality and variability of the product. Inadequate removal of overburden from the mineral deposit often may be the source of excessive variation in minus No. 200 material and may even have a deleterious affect on nearby vegetation and other aspects of the mine.

For example, excessive knobs and depressions on the surface of a stone deposit may necessitate the use of smaller equipment or special techniques to clean the stone. Inexperienced equipment operators may easily corrupt good stripping practices (which are somewhat of an art and site specific). Spillage over the working face and other sloppy practices can also affect the cleaning process.

Figure 5-1. Stripping

Quarry operators commonly design fragmentation shots for safety, economy, ease of use at the primary crusher, and even public relations, but they often forget about quality.

The shot layout is required to be properly engineered, documented, and adhered to for maximum consistency. Varying the shot pattern may mean changes in product size throughout the operation. S maller shot rock, resulting in less crushing in the secondary and tertiary stages, may mean less improvement through crushing. Therefore, the mineral quality and/or changes in physical properties of the product may be affected.

Figure 5-2. Drilling

Figure 5-3. Blast or Shot

Hole detonation-sequencing and blast intensity also are required to be properly engineered. Size changes resulting from inattention to detail can have the same effects as mentioned above. Also, an erratic blast that throws the shot rock over a large area tends to cause variation in size gradation that is delivered to the primary crusher. Any deviation from previously established shot patterns, sequencing, and intensity should be carefully thought out as to the effect on product quality. P roduction changes are required to be documented in the Producer's Quality Control Plan and notification is required to be given to INDOT.

SHOT ROCK OR GRAVEL BANK

A constant problem of gravel pit and quarry operators is the difficulty in maintaining uniform load-out from either the shot rock pile or the gravel bank. Even the best shot has some variation from side to side and from front to back. O nly experienced and well-trained equipment operators may accomplish the mixing from around the shot for the most uniform feed to the processing plant.

Subsurface sampling and testing are required to inform gravel-pit managers where the size of the material changes. In many cases, for example, material from both above and below ground water level is required to be blended in a prescribed manner to maintain uniform feed to the plant.

Changes in equipment, if done without thought as to how to maintain uniform sizing, also may have the same effect. Any change in equipment is required to be evaluated for effect. These changes are incorporated as an addenda to the Producer's Quality Control Plan.

Figure 5-4. Loading Quarry Truck

Figure 5-5. Sand and Gravel Excavation

Geologic variability in the deposit may sometimes affect sizing but more often causes a change in mineral integrity and physical properties. If a large variation exists, some products at later stages in the process may require separation.

Moisture variation in shot rock may also cause significant problems during processing. Shot-rock moisture is required to be monitored because significant changes in moisture almost always require changes in downstream processing.

CRUSHING

The first step of processing begins after the extraction from quarry or pit. Many of these steps also are common to recycled materials, clay, and other manufactured aggregates. The first stage in most operations is the reduction and sizing by crushing. Some operations, however, provide a step prior to crushing called scalping.

SCALPING

Scalping (Figure 5-6) most often is used to divert fines at a jaw primary crusher in order to improve crusher efficiency. In this way the very coarse portion is crushed and then recombined with the portion of crusher-run material before further processing. This first step may, however, be an excellent time to improve a deleterious problem. If a deleterious or fines problem exists in the finer fraction of crusher-run material (namely, clay, shale, finely weathered material, etc.) the fall-through of the scalping operation may be totally or partially diverted and wasted, or may be made into a product of lesser quality. In any case, only acceptable amounts, if any, should be returned back into the higher quality product. Consideration of process variables in this early stage may be very important.

Figure 5-6. Scalping

PRIMARY CRUSHING

In stone quarries or in very "boney" gravel pits, large material usually is reduced in size by either a jaw (Figure 5-7) or a gyratory crusher. Both types are compression crushers. Although economical, they have the tendency to create thin, elongated particles. Particle shapes sometimes may be a problem for Producers of hot mix asphalt. In some operations impact crushers are used for primary crushing, but they may have a slightly higher cost per ton. Impact crushers may upgrade poor-quality aggregate and increase separation, such as removal of rebar from concrete in recycling operations.

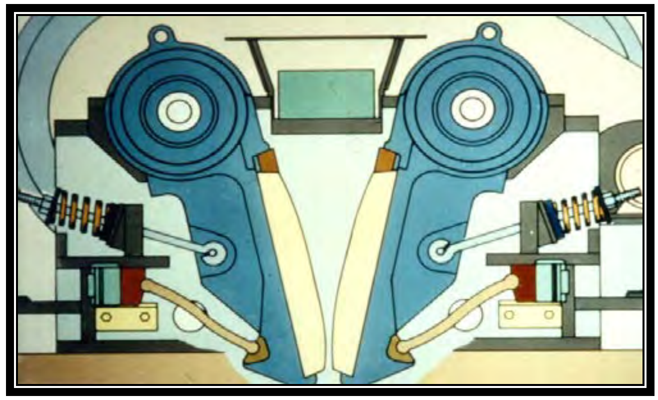


Figure 5-7. Jaw Crusher

After primary crushing/reduction the resulting aggregate generally is placed in a large "surge" pile where the aggregate may be fed into the secondary operation whenever convenient.

Care is always taken when building up and loading out surge piles, as this step may be a major source of segregation of material going to the secondary plant. Variation at this point may affect both mineral quality and gradation. Drawing from an inverted cone over a load-out tunnel works well after material has been deposited and left undisturbed to form the walls of the draw-down cone. If the need ever arises to consume the entire pile, care is taken to thoroughly mix the older material a little at a time with fresh product to make the surge as uniform as possible as the aggregate is being pushed into the tunnel. If the operation relies on end loaders to feed the secondary plant from the surge pile (Figure 5-8), the same care is taken to mix coarse with fine material from the outside to the inside of the pile.

Figure 5-8 Surge Pile

SECONDARY AND TERTIARY CRUSHING

Secondary and tertiary crushing, if necessary, are the final steps in reducing the material to a desired product size. Historically, cone and roll crushers were the most common choice crushers, but in recent years impact crushers are more widely used. These crushers also are sometimes used as primary crushers for fine-grained gravel deposits.

The cone crusher (a compression type) simply crushes the aggregate between the oscillating cone and the crusher wall (Figure 5-9). Clearance settings on this equipment are required to be checked and maintained as part of standard operating procedure.

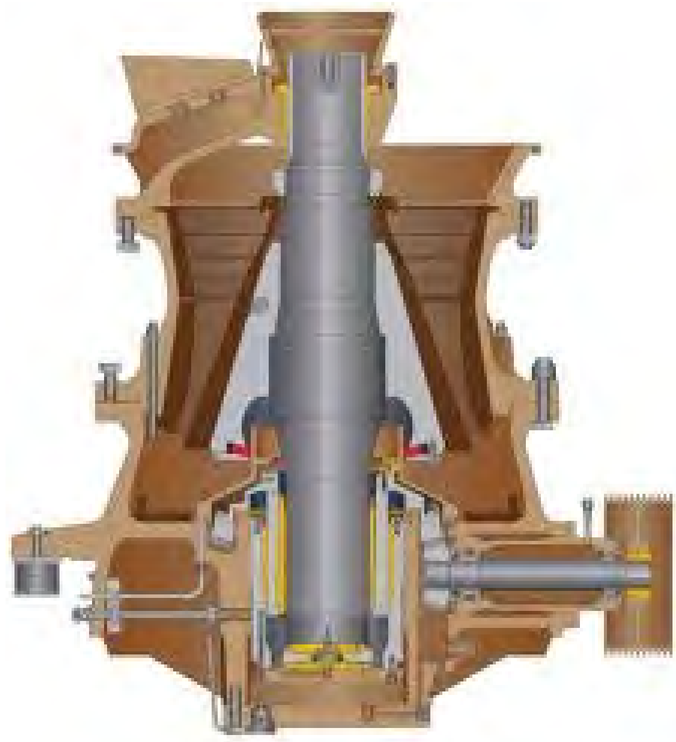


Figure 5-9. Cone Crusher

As with other compression crushers, the cone crusher yields a somewhat elongated and slivery particle shape. This may be minimized, however, by "choke" feeding the crusher. This technique will also make the shape and size more uniform. One way to choke feed is with a surge hopper and a controlled belt-feed to the cone crusher (Figure 5-10). Automatic level controls measure the head of the material over the top of the cone.

Figure 5-10. Crusher Feed System

A roller crusher (Figure 5-11) is another compression type crusher that simply breaks the material by pinching the aggregates. These types of crushers are often found in gravel operations. Roller crushers have constant maintenance problems and are prone to excessive wear. The rollers are required to be checked frequently to insure proper clearance and uniformity across each roller. Rebuilding and re-milling the roller is a standard operating procedure.

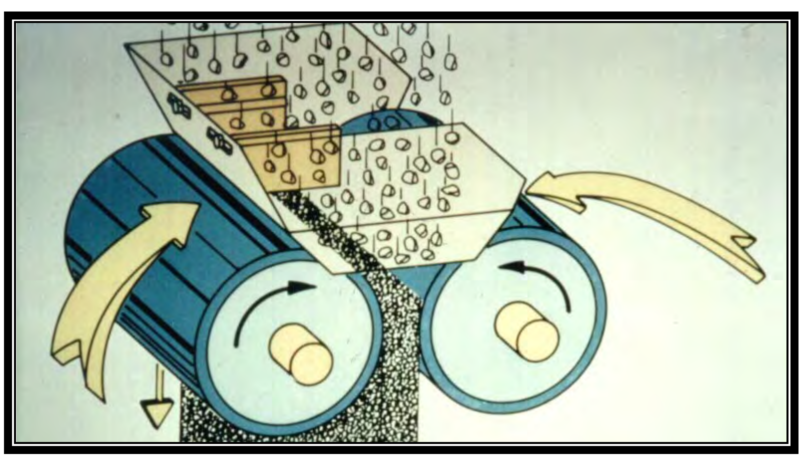


Figure 5-11. Roller Crusher

IMPACT CRUSHING

Impact crushers may be used as primary, secondary, or tertiary crushers. Despite having a somewhat higher operating cost than other crushers, they tend to produce a more uniform particle shape. Impact crushers usually will benefit the aggregate better than compression crushers, and they may generate more fines. Common types are the horizontal shaft (Figure 5-12), vertical shaft, and hammermill impactors.

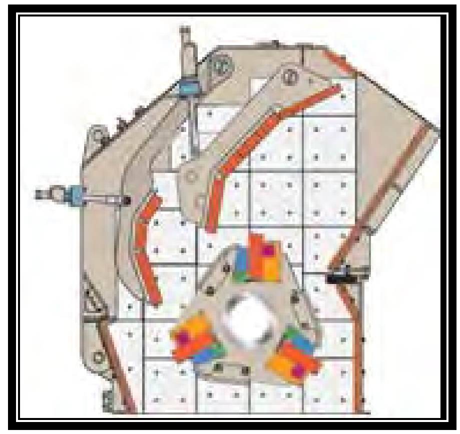



Figure 5-12. Horizontal Shaft Impactor

The horizontal shaft single or double rotor may aggressively handle large and odd-shaped material. Large horizontal impactors sometimes are used as primary crushers. Fracturing occurs at the same time by rock against rotor, rock against breaker bar, and rock on rock**.**

The vertical shaft impactor (Figure 5-13) is operated in rock against anvil, or rock against rock (through the installation of a rock shelf) modes. The Producer is required to decide carefully the mode best suited to the raw material.


Figure 5-13. Vertical Shaft Impactor

The hammermill impactor (Figure 5-14) provides excellent reduction and beneficiation through the impacting and shearing action of the hammers and grates; however, a large amount of fines is produced. This type of crusher is sometimes used in the manufacture of agricultural ground limestone.

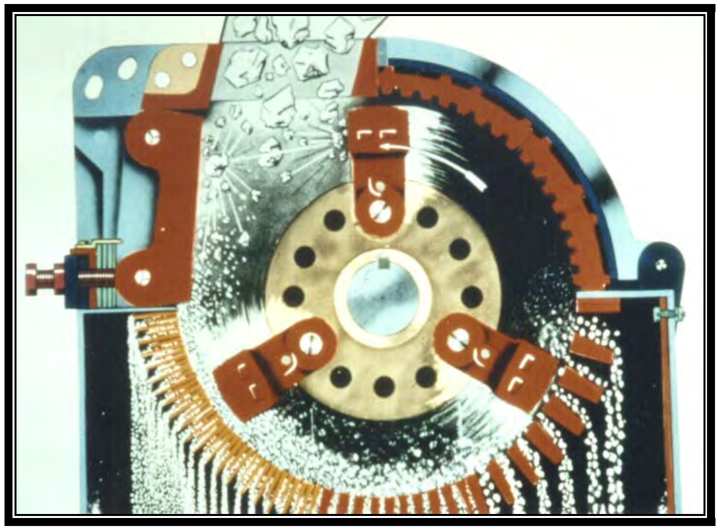


Figure 5-14. Hammermill Impactor

OTHER BENEFACTION

Other forms of benefaction for quality are available to the Producer. These include the log washer, heavy media separator, and attrition mill.

The log washer (Figure 5-15) commonly is used in wet operations to agitate and scrub clay and other objectionable fines from coarse aggregate. A Producer may need to use a log washer when rinsing screens do not remove these objectionable fines.

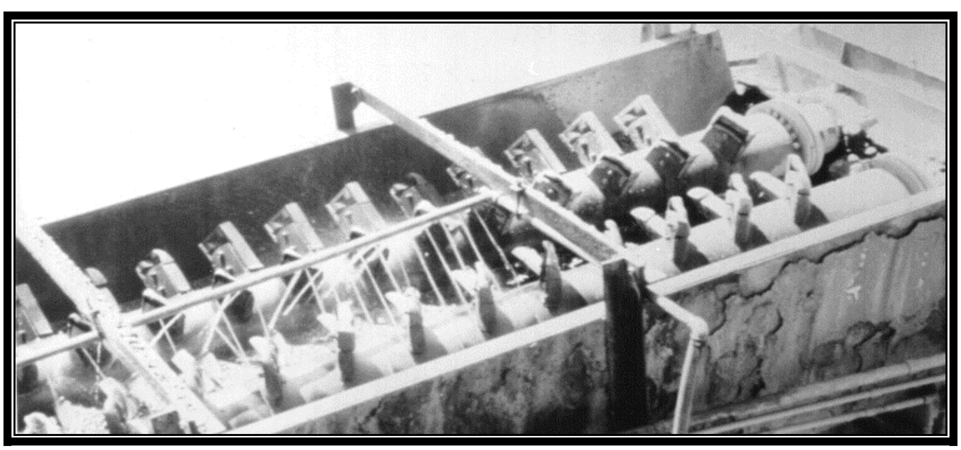


Figure 5-15. Log Washer

Heavy media separation is somewhat costly, but may be the only practical way for a Producer to meet quality requirements. This method works only when the undesirable material has a different specific gravity than the desirable material. The deleterious material is discarded after the media is separated for recycling.

Attrition mills are seldom used but remain an option when the deleterious particles are uniformly softer than the non-deleterious particles. The attrition mill abrades the deleterious particles into fines that may be screened out of the system.

SCREENING

Screening is another technique to control both quality and gradation of the aggregate product.

PRODUCT QUALITY

If deleterious material exists at undesirable levels after crushing and may be identified as being predominantly in one size range that is not needed for product size, the material may be screened out (namely, fines or top size). This step may occur between crushing so that an opportunity exists to recreate the same size downstream, if needed, to create a product. The screened-out lower-quality material may be used for a lower quality product or wasted if no use exists.

The rinse screen (Figure 5-16) is also commonly used. By processing the material over a screen that retains all of the product, the clay and deleterious fines may be rinsed away to make the product acceptable.

Figure 5-16. Rinse Screens

The best technique for gradation control is screening (Figure 5-17). Screening may be done wet or dry, depending on the type of aggregate being processed and the degree of consistency required for each product.

Washing, for example, may be necessary to clean a concrete aggregate, but may not be needed for hot mix asphalt products, which may contain more fines. For gradation control alone, however, consistency sometimes may only be maintained by using wet screening. Gradation consistency is usually an overriding factor for a hot mix asphalt customer. Water volume and flow direction are critical in wet screening. Frequent checking of the gradation is a standard operating procedure.

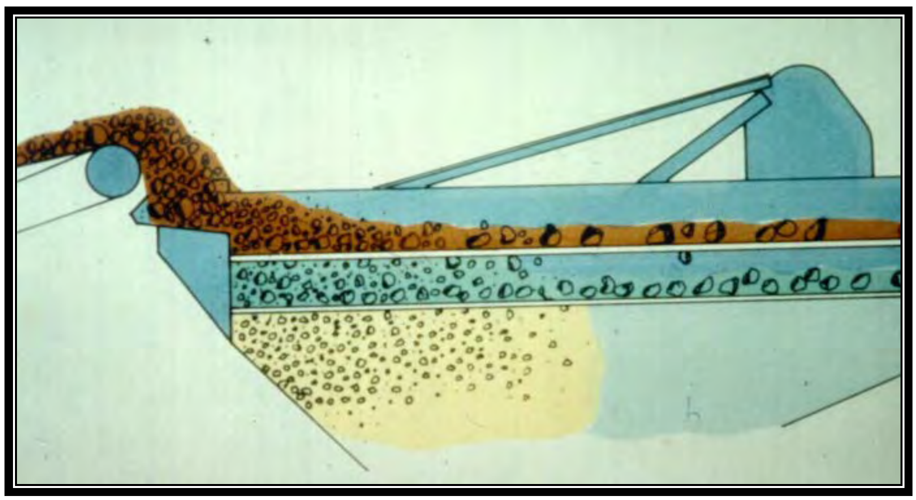


Figure 5-17. Screening

Dry screening is a slight misnomer because the material passing over the screen decks is wet, ranging from slightly damp to very wet, depending on conditions such as rain or subsurface moisture. Non-washed screening is a more accurate description of this screening process. High moisture is a concern because the wet aggregates may cause some material to become sticky and bind together, making the aggregate harder to separate. Furthermore, high-moisture conditions may cause binding of lower screen decks, causing override of the material rather than separation. If these conditions are encountered, the Producer may need to establish a balance between the moisture content of the incoming material and the feed rate through the screens. This balance is required to be made for each hour of operation. If reduced feed rates do not solve the problem or is too costly, washing or an additional screen area may be needed.

Sometimes screening variation is too great even under the most favorable of conditions. When this occurs the Producer is required to check that the equipment and the screen cloth are in good repair. The most common reason for high screening variability is the tendency to push too much material over a screen. The only way to maintain a bed of material thin enough for optimum efficiency is to provide enough screening to allow the desired rate of production. Standard operating procedures should reflect the maximum feed rate for the design of the plant.

For well-graded products having many sieves, (namely, #53s), gradation control may not be done without first separating the material into fractions. Separating the material into numerous small fractions and then back-blending at a set rate for each fraction may be necessary to control the gradation.

Frequent sampling, testing, and control charting are necessary for monitoring because aggregate gradation is subject to so many variables.

SAND PRODUCTION

Sand plays a critical role as a construction aggregate and deserves special attention when considering the means of process control. Unlike coarse aggregate where various types of crushers may be used to upgrade mineral quality, sand basically relies on the same techniques to address both mineral quality and sizing. These techniques are called particle exclusion. Whichever size the Producer decides to eliminate for quality reasons obviously also affects the sizing.

NATURAL SAND

Good quality natural sand is readily available in many areas and may be easy to obtain and process. As with the gravels that they often accompany, the sand deposits may not have been laid uniformly, meaning a potential change in quality and size is possible. In some deposits, sand found below the water table differs in fines content and quality from that found above the water table. Subsurface drilling, sampling, and testing is necessary to know to what degree and where these differences occur. Standard operating procedures in the Quality Control Plan should address the process if differences in size and quality are encountered, as a uniformly graded product of predictable quality is required to be maintained.

MANUFACTURED SAND

Because of the angularity, manufactured sand is very beneficial for use in hot mix asphalt where stability is critical. Many Indiana quarries are high in clay content and often a large amount of dust ends up in the feed stock for manufactured sand. Care is required to be taken to select the appropriate classification equipment that removes the necessary amount of minus No. 200, yet retains other fractions of the sand gradation that are needed. For some uses, particle shape is important. Particle shape is set primarily by the crushing operation for the coarse aggregate. Any changes in crushers or crushing techniques may affect the properties of the manufactured sand product and therefore affect the customer's use of the product.

PROCESSING

Very few sand products are produced by air classification or by direct non-washed screening. Most sands are produced with wash water and water classification. The key to all rinsing and water classifying systems is adequate delivery of water. Inadequate water supply and poor maintenance are the two most common reasons for inconsistent sand gradations.

The most common water classifier is a simple dewatering screw (Figure 5-18) which may make a single "cut" in gradation and float out a certain amount of fines. By altering the through-put and rate of water flow the cut point may be changed.

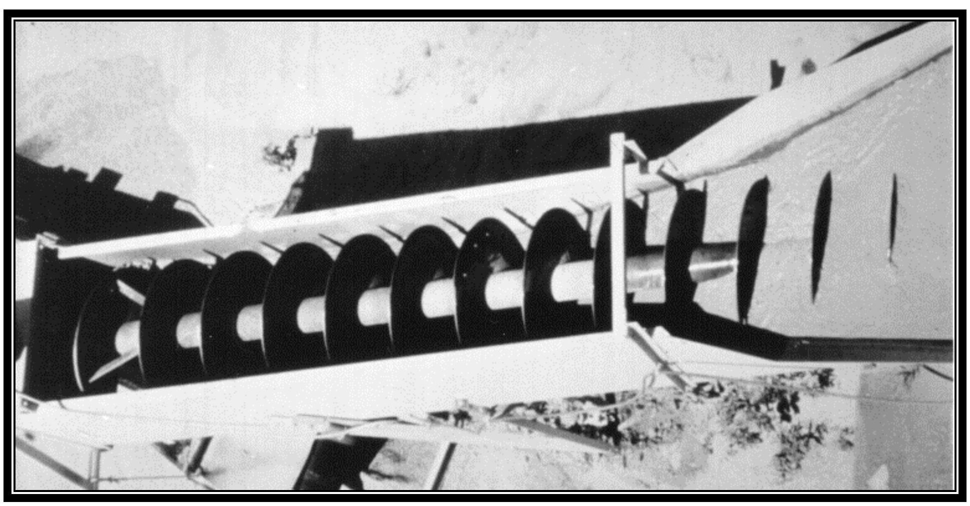


Figure 5-18. Dewatering Screw

A variation of the dewatering screw is the dewatering wheel (Figure 5-19). This device also is capable only of making a cut in the feed stock but may be more finely tuned and may be the better choice when trying to retain as much No. 50 and No. 100 material as possible.

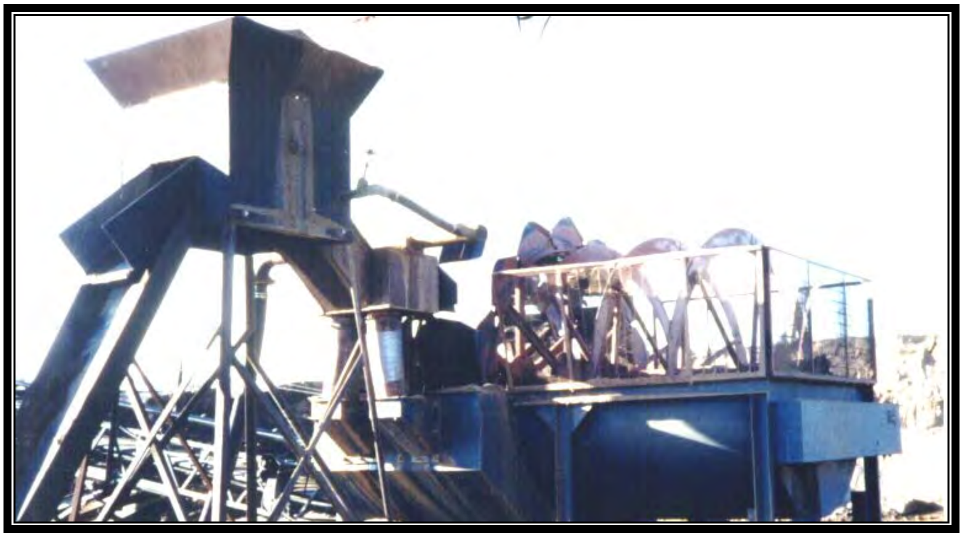


Figure 5-19. Dewatering Wheel

An even more sensitive method of cutting out fines is the wet cyclone (Figure 5-20). The sand slurry in the cyclone is spun at a prescribed velocity. Centrifugal force separates the coarser fraction from the water and fines which exit to the pond.

Figure 5-20. Wet Cyclone

Any of these techniques could conceivably be used with others in tandem or in tandem with rinse screens. The material could then be back-blended to create a desired product. A simpler and probably more cost effective way to control a sand gradation on multiple sieves is the rising current, multiple cell classifier (Figure 5-21). This equipment has numerous cells, each having varying water pressures that for different sizes of material. Any number of cells may then be combined to create the final product. With this type of system a high degree of process control is possible.

Figure 5-21. Multiple Cell Classifier

SEGREGATION

Product conformity and uniformity may be predicted if all of the inputs into the plant are measured, evaluated, and controlled. Whenever one rock is placed upon another rock, segregation may reduce the uniformity that the Producer so carefully has built into the product.

Segregation begins on the belt where fines vibrate to the bottom and coarse aggregate remains on the top as the material bounces across the idlers (Figure 5-22). At the end of the belt, if left un-deflected, the coarse particles are thrown out and away. Fine particles, on the other hand, tend to drop down or if wet even follow back underneath the conveyor. The greater the speed of the belt, the worse the segregation problem is. This is known as front-to-back segregation and may be addressed by the following methods:

1) Belt wipers underneath the head pulley that reduce carry back

2) Movable stackers kept near the top of the pile to reduce the spread

3) Mixing paddles or deflectors at the head pulley to keep the material together (Figure 5-23)

4) Wider belts at lower velocities to prevent segregation

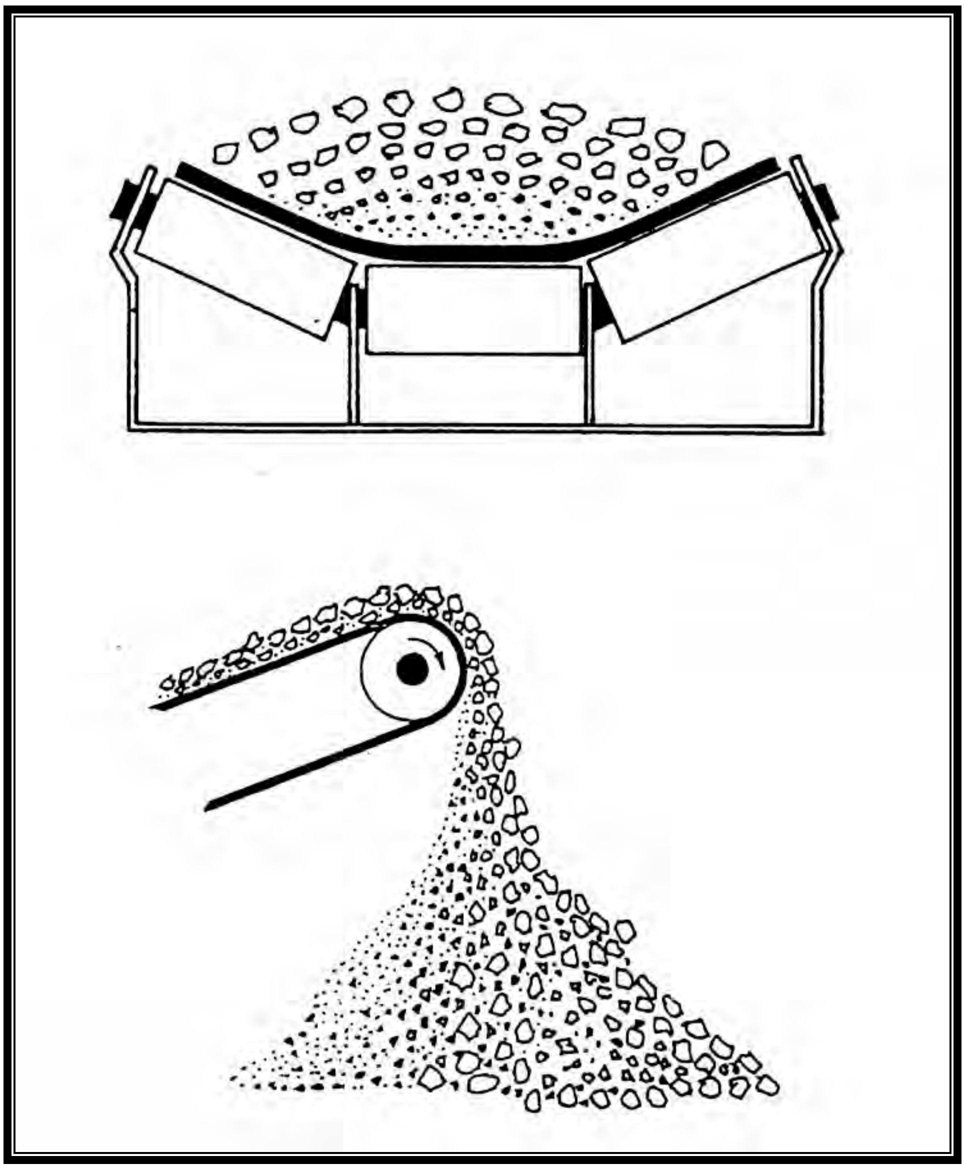


Figure 5-22. Belt Segregation

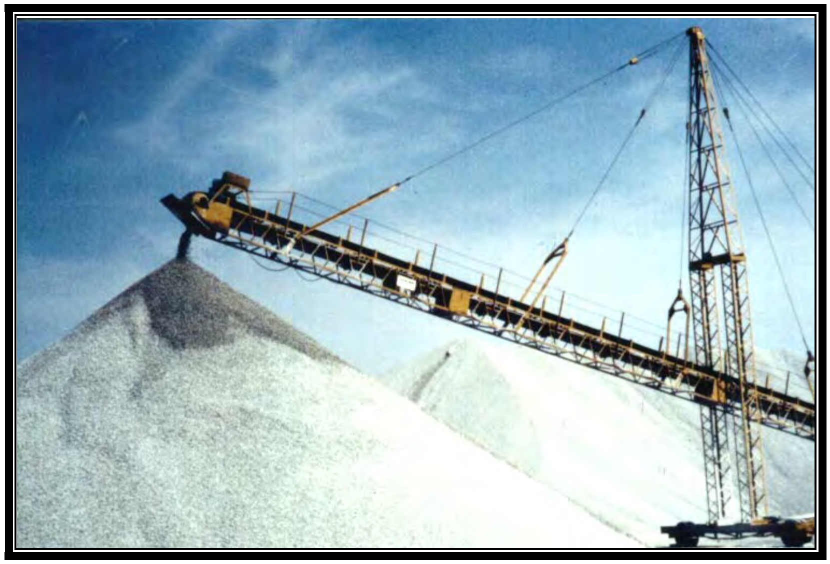


Figure 5-23. Adjustable Conveyor with Mixing Paddle

A second common type of segregation is "roll down," which occurs any time aggregate is piled so that large particles roll down the sloped side of the pile (Figure 5-24). The higher the pile, the worse this problem is. This type of segregation is very obvious in operations with high conical stockpiles, but also occurs in improperly loaded trucks. Keeping storage bins over half-full whenever possible improves the situation.

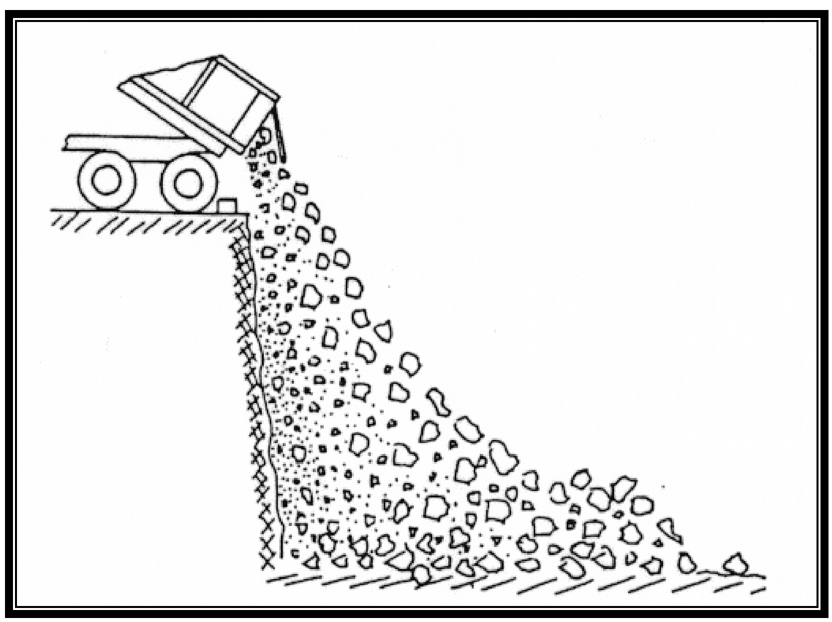


Figure 5-24. End Dump Segregation.

STOCKPILING AND HANDLING

Segregation is probably the greatest problem that occurs because of stockpiling and handling, but certainly other problems such as degradation and contamination may adversely affect product quality. Every possible precaution is required to be taken to protect the product quality from the point of manufacture to the point where the aggregate leaves the Producer's control.

CONE STOCKPILES

Although the cone stockpile is very common in the aggregate industry, two stockpile procedures may easily reduce product integrity. Roll-down segregation obviously occurs in full circle around the pile, and very high piles are difficult to adequately remix before shipping. These piles usually are being replenished with fresh material as old and new material is being removed, which keeps the product size in a state of continual change (Figure 5-25).

Figure 5-25. Material Added to Cone

In some cases the "front-to-back" segregation adds extra coarse material thrown forward and extra fines carried back for even greater variability. In addition, some piles are not fully retrieved for several years and the new product that is added to the old pile may even have different production targets (figure 5-26). Situations like these add up to serious problems for predicting gradation uniformity in the retrieved product.

Figure 5-26. Comingled Cone Piles

The final element of a cone pile that adds to the effects of both the roll-down and front-to-back phenomena is an excessively high drop from the end of a fixed conveyor to the top of the pile (Figure 5-27). This procedure should be avoided. Use of cone stockpiles should be kept to a minimum and used with extreme caution.

Figure 5-27. High Conveyor Drop

RADIAL STOCKPILES

A radial stacker (Figure 5-28) is a compromise solution for conveyor-built stockpiles, especially if kept less than 20 ft. The proper technique is to keep the end of the movable conveyor less than a meter from the top of the pile and raise the conveyor with the pile to the full height. Then the conveyor is moved horizontally with the pile in small increments. In this manner the pile is constructed at one end while the products are retrieved at the other end.

Figure 5-28. Radial Stacker

Although roll-down segregation does occur from the sides of the pile, a continual remixing of coarse and fine material occurs longitudinally as the pile advances. Proper retrieval may take care of the edges.

TRUCK BUILT STOCKPILES

If piles from the end of the product belts are thoroughly remixed then truck-built stockpiles (Figure 5-29) are capable of greatly minimizing segregation, if the trucks are loaded properly. The best truck-built stockpiles are those that are constructed one dump high with each dump placed against previously dumped material. This procedure, because of the low profile, reduces roll-down segregation and allows remixing during load out. However, these stockpiles require more space than the others mentioned. A technique that may help reduce the required area is to restock some dumps on top of other dumps with a large end loader operating from ground level. In this case, care is required to be taken to place the upper lift back from the edge far enough that a long sloped face is not created that would cause the same kind of roll-down problem that this type of pile is meant to eliminate.

Figure 5-29. Low Profile Truck Stockpiles

LAYERED STOCKPILES

A layered stockpile, if built correctly, may also greatly minimize segregation. Unfortunately these types of stockpiles are very difficult to build properly. Each layer is placed uniformly across the top of the pile in thin horizontal lifts. Care is required to be taken to keep the edge of each new lift set back from the edge of each previous lift so as not to create long sloped edges. This is best done with a large clam shell crane, which is slow and tedious, or with specially made equipment that may place the layers without being on the pile. A compromise is to allow hauling equipment on top of the pile; however, this procedure causes degradation of the product, and the pushing equipment may move the material over the edges causing severe segregation (Figure 5-30). Generally, these activities are poorly managed, and the stockpile takes on the shape of a ramp and spills over. These situations are very detrimental to product quality.

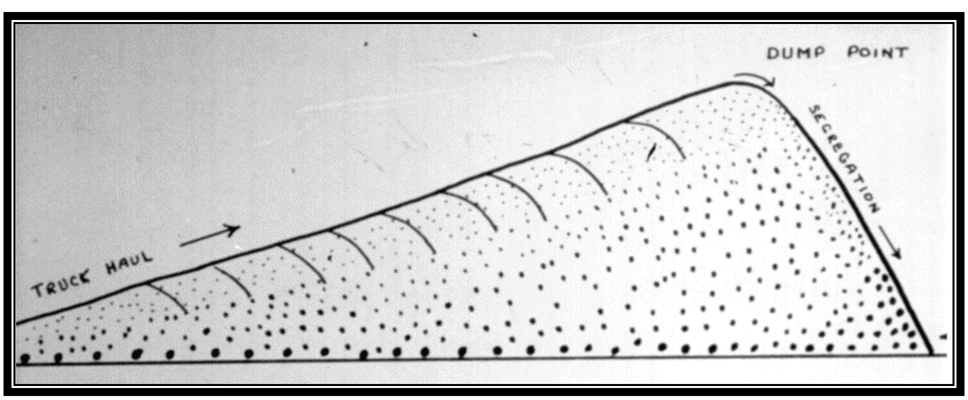


Figure 5-30. Ramp and End Dump

The Producer is required to write standard operating procedures on building stockpiles for each product and to educate all those involved in their responsibilities in the procedure. Most stockpiling problems are created because of inconsistent management. The procedures are required to become part of the Quality Control Plan. Illustrations at the end of this chapter indicate the different techniques that may be used for stockpiling and retrieving. The Segregation Index (S.I.) indicated with each example is a numerical index where the numbers are associated only with the other techniques and indicate greater segregation severity as they become higher.

DEGRADATION

Degradation or breakdown of the product is often caused by equipment running on top of the aggregate when the aggregate is being stockpiled (Figure 5-31). When this occurs, the degraded portion of the pile is required to be discarded before shipping. The difficulty lies in knowing where the "bad" material begins and ends. Extensive sampling and testing in these cases may be needed prior to shipping to determine what product is not good enough to ship. Degradation may also occur during retrieval where some of the lower portion of the pile is carelessly run over with equipment while loading out. A Producer is required to know which products tend to degrade with handling and make appropriate allowances. For example, many stone sands increase in minus No. 200 content each time they are loaded and moved. In some cases old stockpiles may degrade through weathering. Piles two years and older are required to be rechecked for gradation before shipping and possibly even for mineral quality.

Figure 5-31. Equipment on Stockpile

CONTAMINATION

Contamination (Figure 5-32) is usually the result of carelessness and poor housekeeping. In order to save space, stockpiles of different products are placed close together and as they grow in size they grow together. Equipment also may track dirt or other foreign matter into the product pile area. Old piles are subject to wind-blown fines over time and are required to be checked for this before shipping.

Figure 5-32. Comingled Stockpiles

RETRIEVAL

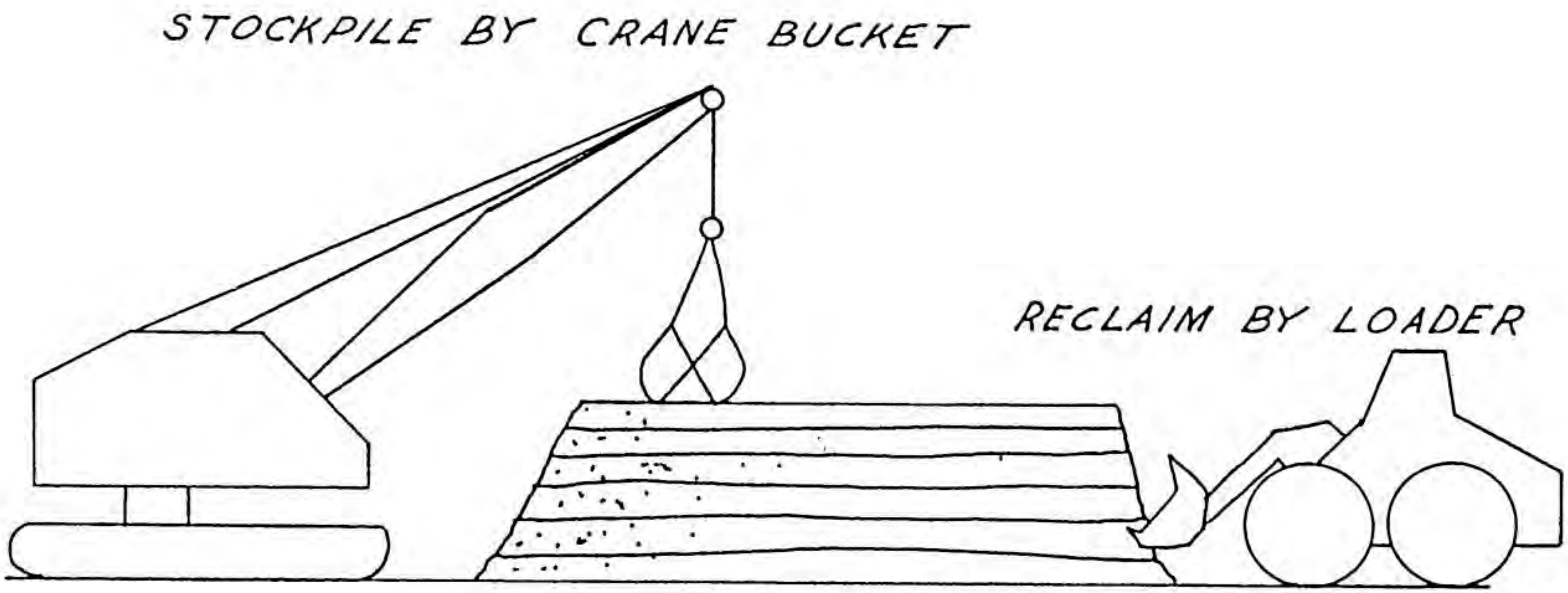
Retrieving material properly from a stockpile is just as important as building the stockpile properly (Figure 5-33). Truckers often force their way into the loading area, causing the loader operator to load from areas other than the working face. This practice is not allowed. Strict procedures for load out are required to be written, adhered to, and become routine as part of standard operating procedures. Loading from the outside of an un-worked pile for the sake of convenience may very quickly result in an unsatisfactory product.

Cone-shaped stockpiles are the most difficult to approach. Once retrieval has begun, no new material is added to the pile. To maintain a representative gradation, exactly one-half of the pile is required to be removed, the edges (coarse) folded into the center (fine), and the entire mass turned over and made into a level pad. The product is then ready for shipping. After shipping the first half of the pile, the procedure is required to be repeated for the second half. New material is required to be placed elsewhere in the meantime.

For radial or tent-shaped stockpiles, retrieval is required to begin at the oldest end while new material continues to be placed at the other end. The first entry into a new pile is handled as described above since the beginning of a radial pile is half-conical shaped. After a face has been established parallel to the stacking conveyor, continued mixing occurs in front of the load out face by pulling material from the center of the pile and mixing the material with the edges. The face is required to be kept as uniform as possible. At no time should new material be placed at the load out face.

For layered stockpiles more than one loader bucket high, remixing is necessary as the height of the pile and type of the product required. For low-profile truck-built stockpiles, only minor remixing is required when encountering the edges.

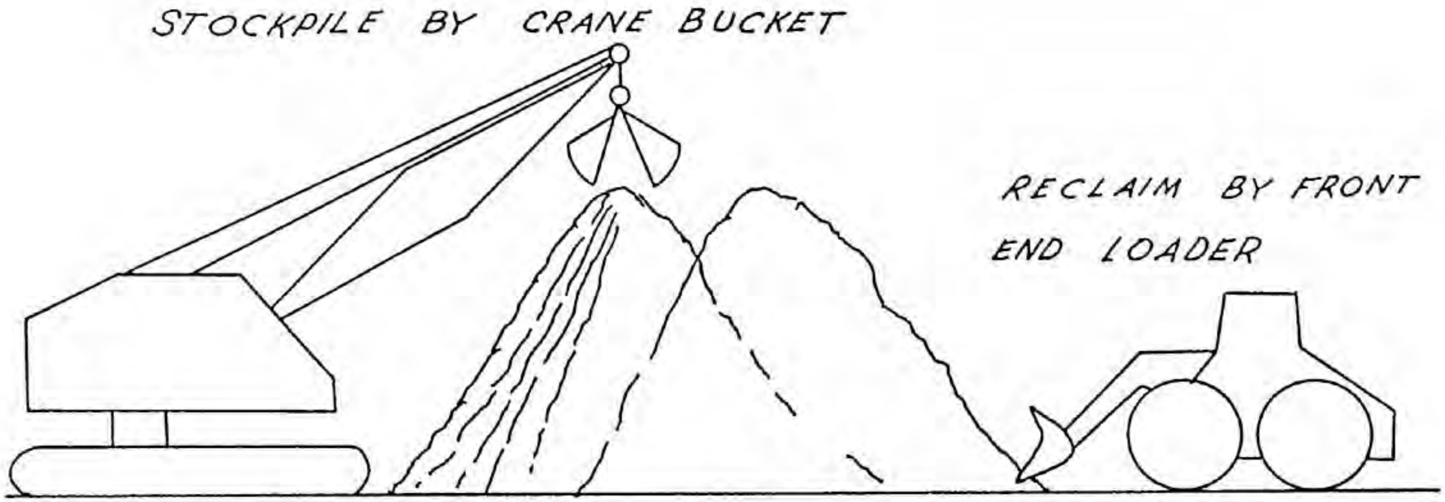
Figure 5-33. Retrieval from Stockpile



STOCKPILE METHOD #1

SPREADING AGGREGATE IN THIN LAYERS WITH CRANE BUCKET

BEST METHOD → SEGREGATION INDEX 1.35



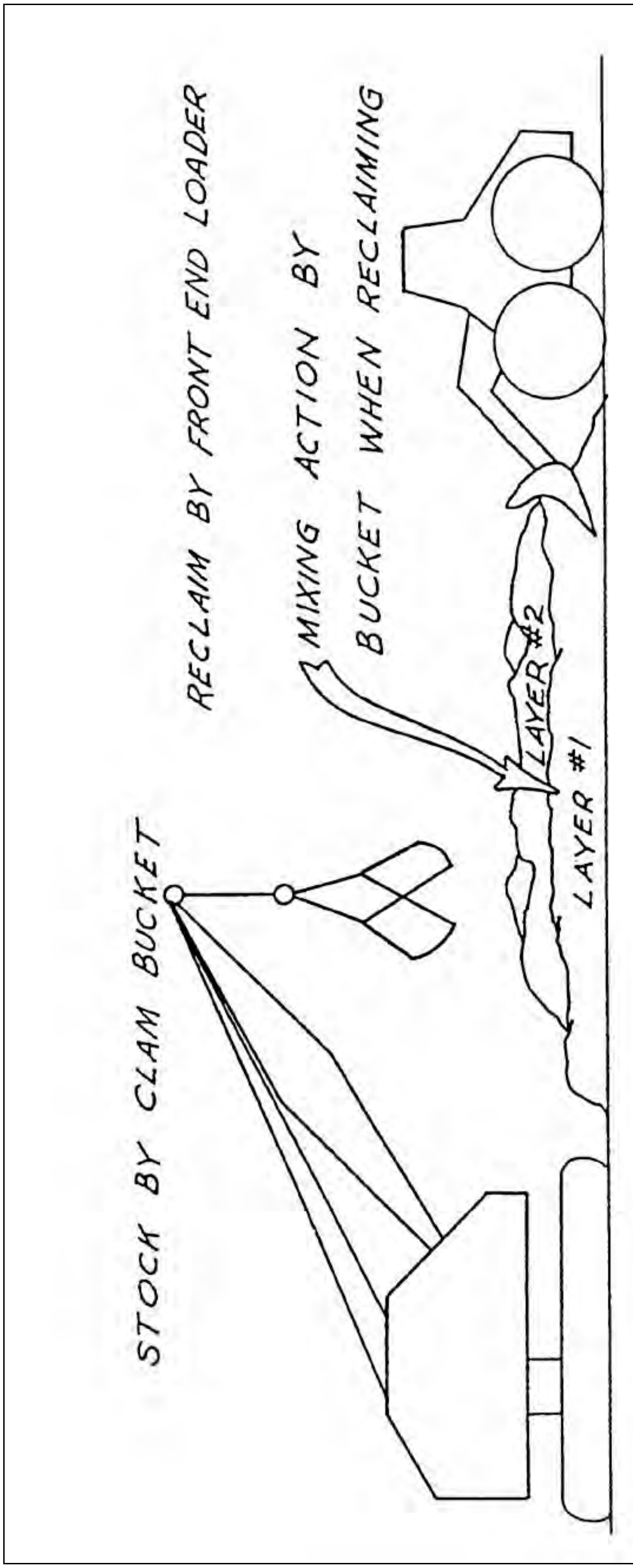
(COARSE GOES TO OUTSIDE OF CONE - FINES TO THE CENTER RECLAIMING BY LOADER REMIXES COARSE AND FINE)

STOCKPILE METHOD #2

TWO CONES (APPROX. 750 TONS) CONSTRUCTED BY CRANE BUCKET

RECLAIM BY FRONT END LOADER

SEGREGATION INDEX - 16.48

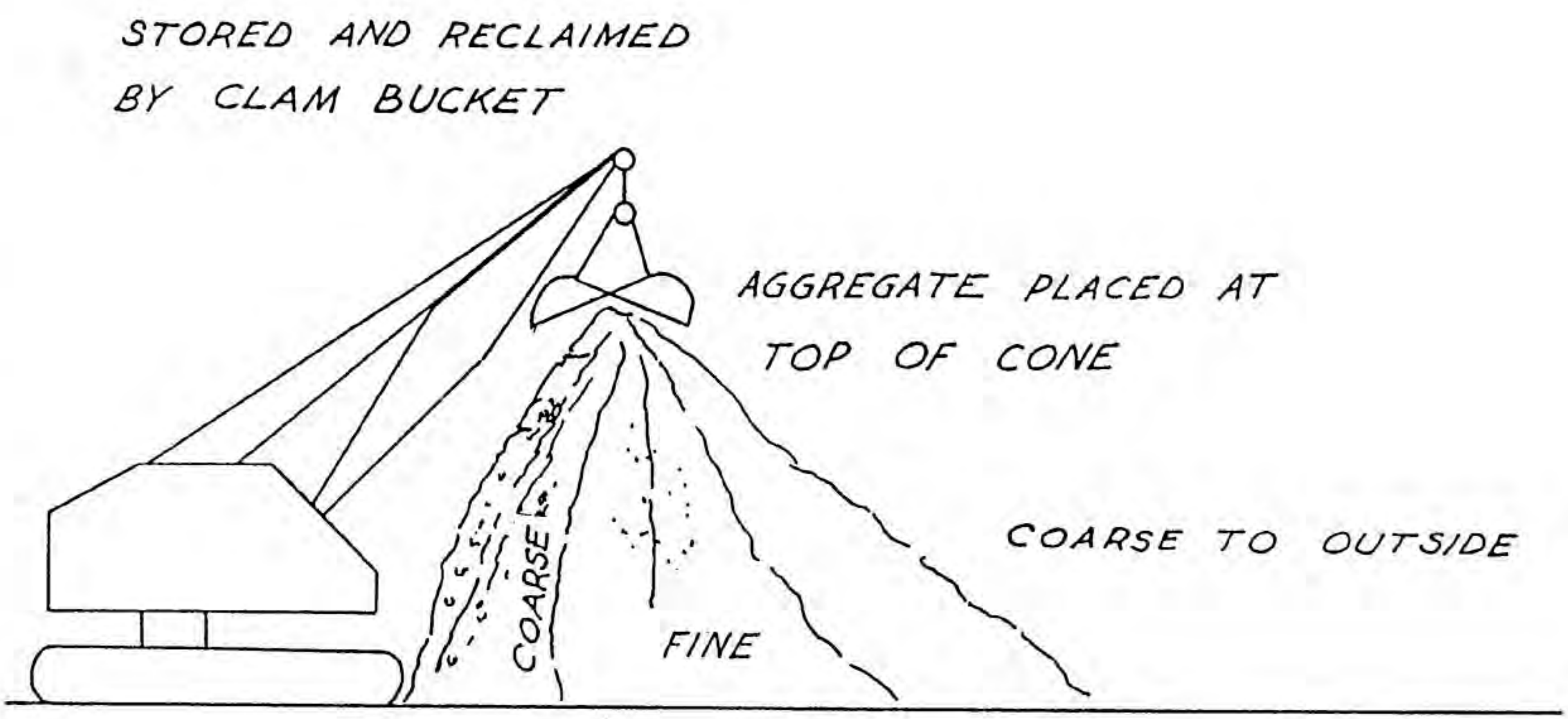


STOCKPILE METHOD #3

FLAT - LAYERED PILE BUILT WITH CLAM BUCKET

RECLAIM WITH FRONT END LOADER

SEGREGATION INDEX - 1.96

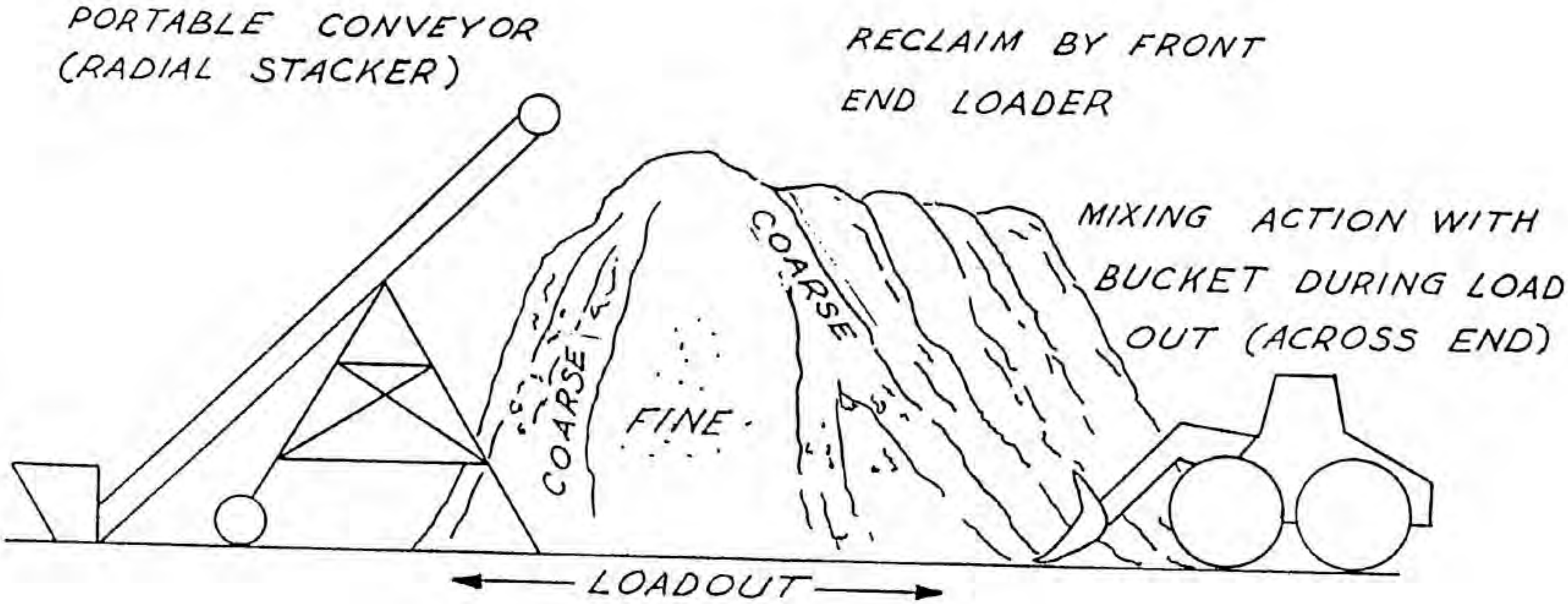


STOCKPILE METHOD #4

SINGLE CONE BUILT WITH CLAM BUCKET (APPROX 1,500 TONS)

RECLAIMED BY CLAM BUCKET IN HORIZONTAL LAYERS

SEGREGATION INDEX - 16.86 (WORST METHOD)



STOCKPILE METHOD #5

TENT SHAPED STOCKPILE - BUILT WITH PORTABLE CONVEYOR

RECLAIMING BY FRONT END LOADER

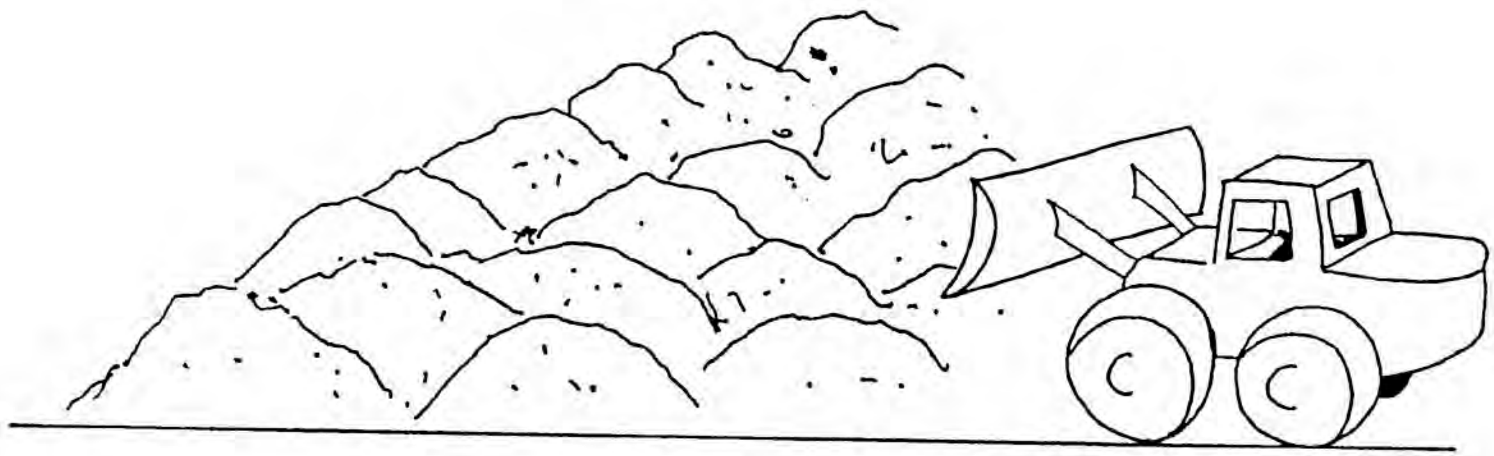
SEGREGATION INDEX - 8.10

LIMITING FACTORS

HEIGHT OF LOADER BUCKET

LARGE AREA REQUIRED

STOCKED AND RECLAIMED BY FRONT END LOADER

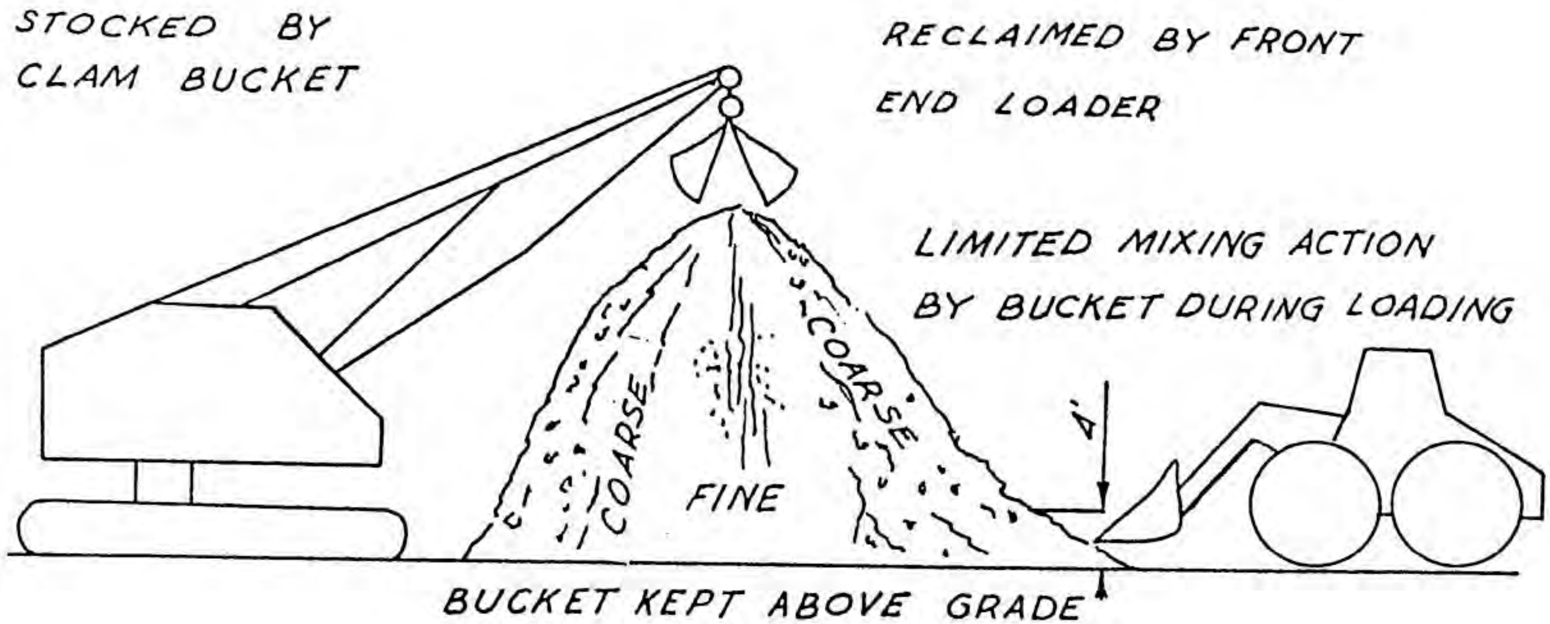


STOCKPILE METHOD # 6

FLAT LAYERED CONSTRUCTED BY FRONT END LOADER

RECLAIMED BY FRONT END LOADER

SEGREGATION INDEX - 4.05

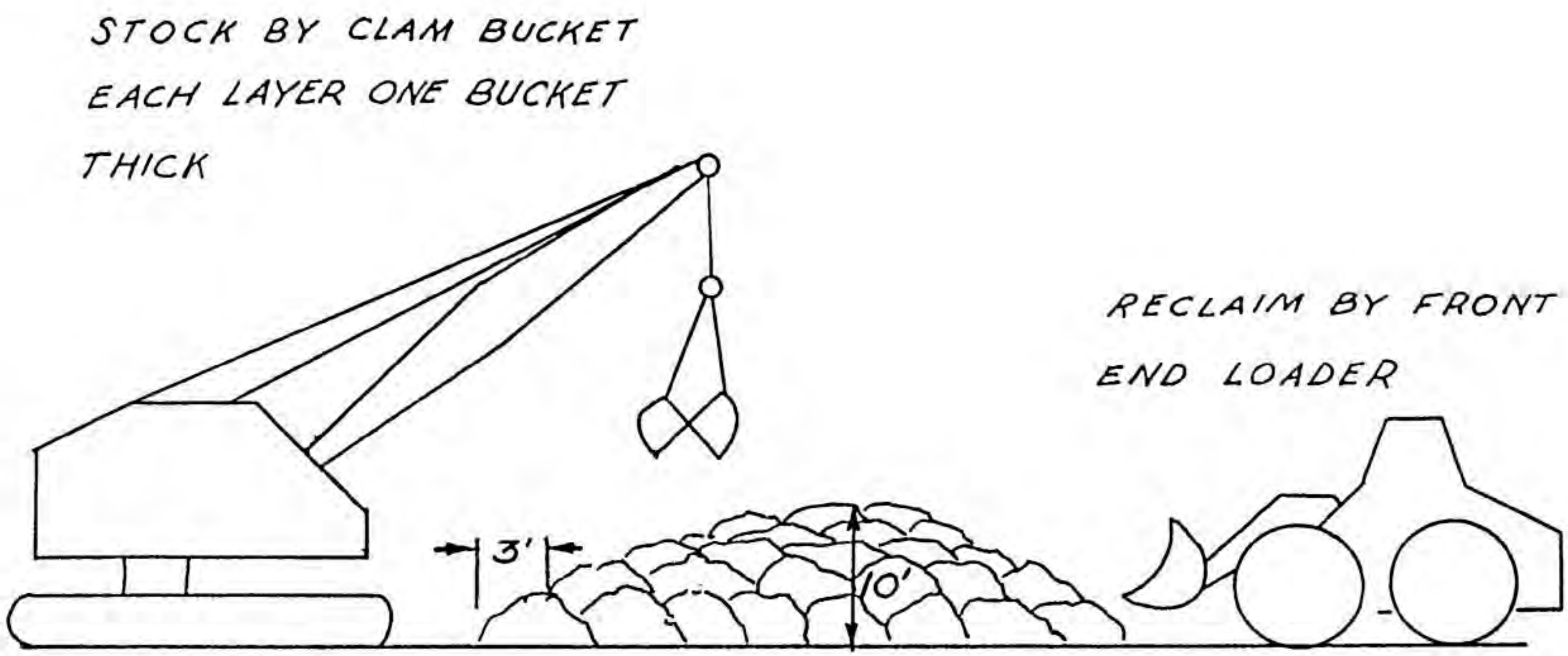


STOCKPILE METHOD #7

SINGLE CONE - CONSTRUCTED BY CLAM BUCKET

RECLAIMED BY FRONT END LOADER

SEGREGATION INDEX - 13.36



METHOD VERY SLOW AND EXPENSIVE
SET BACK OF 3 FT BETWEEN LAYERS

STOCKPILE METHOD #8

TIERED (BERMED) BY CLAM BUCKET

RECLAIMED BY FRONT END LOADER

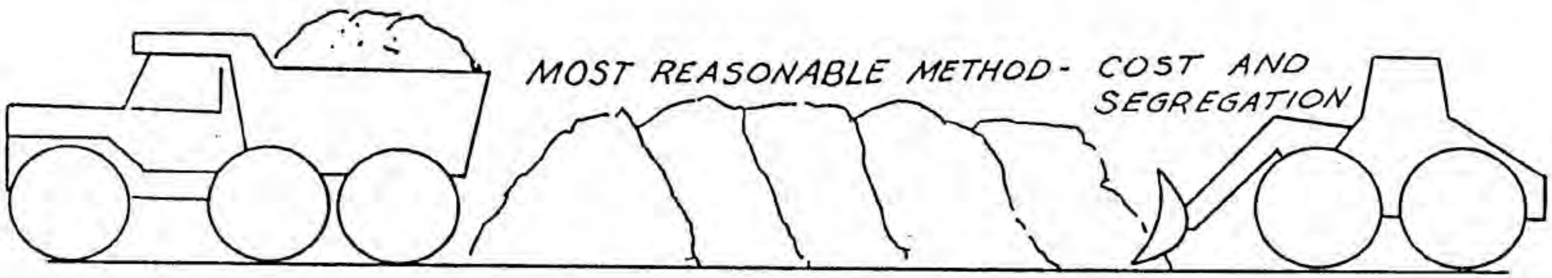
SEGREGATION INDEX - 7.37

STOCKED BY TRUCK BACKED
INTO SIDE OF PRECEDING PILE

RECLAIMED BY FRONT
END LOADER

THIS METHOD CAN BE TIERED

MIXING ACTION BY
BUCKET DURING LOADING

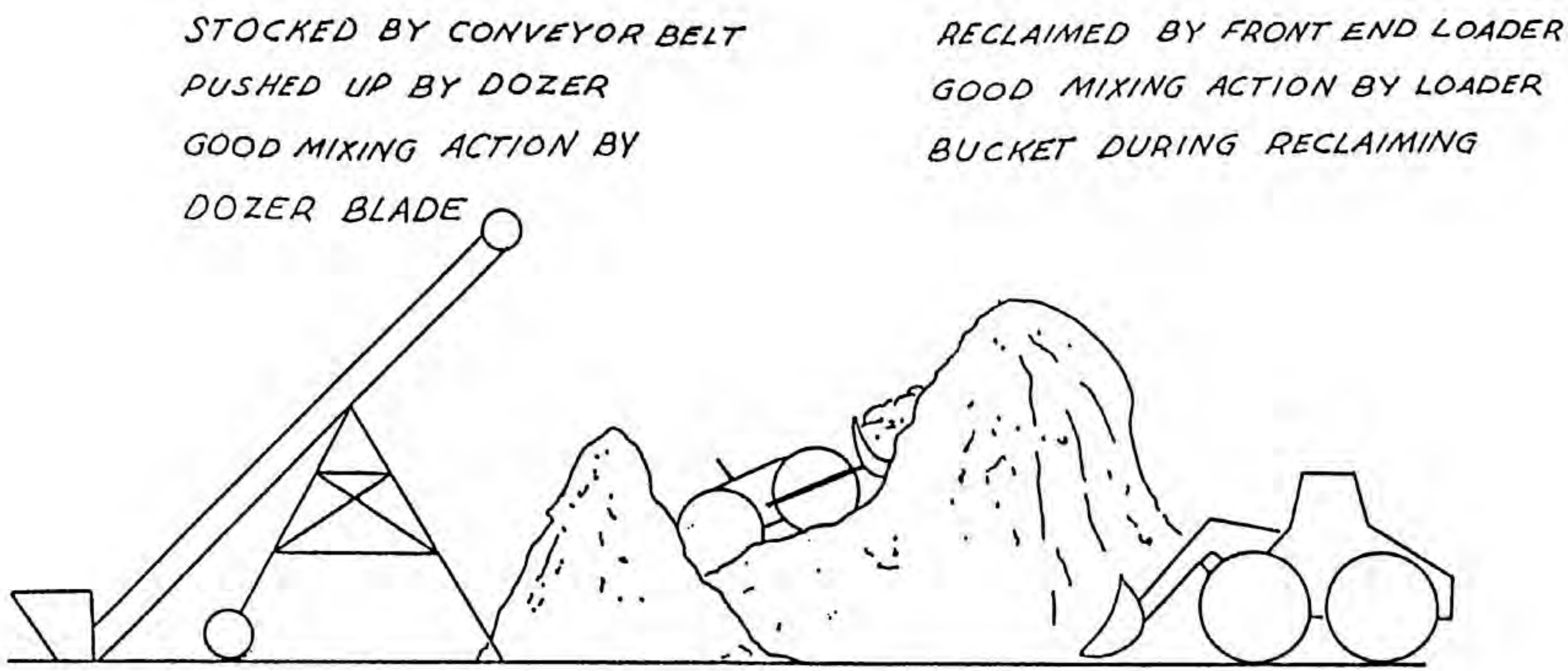


STOCKPILE METHOD #9

TRUCK DUMP SINGLE LOAD - BACKED AND DUMPED

RECLAIMED BY FRONT END LOADER

SEGREGATION INDEX 2.30



STOCKPILE METHOD #10

RAMP BUILT WITH PNEUMATIC - TIRED BULLDOZER

RECLAIMED WITH FRONT END LOADER

SEGREGATION INDEX 1.59

6 Statistical Quality Control for Aggregate Processing

Process Characteristics

Continuous Processing
Product Alteration
Multiple Products

Quality Control

Accuracy
Precision
Capability

Statistical Concepts

Data Sets
The Mean
Standard Deviation
Normal Distribution
Variability
Capability and Compliance

Control Charting

When to Use Charts
Control Chart Legend
Beginning the Control Chart
Plotting the Data
Interpreting Control Charts

Understanding the Process

Current Process
Process Stability
Decision Making
Process Capability
Process Control

CHAPTER SIX:
STATISTICAL QUALITY CONTROL FOR AGGREGATE PROCESSING

The process of producing and shipping mineral aggregate is a relatively simple one. The procedure does not require high technology, and the methods used to control this process are equally as simple. These methods, however, account for all the many difficulties a Producer may encounter in production of aggregate. Each time a decision is made that affects the process, at least three principle characteristics of this industry are required to be kept in mind: continuous processing, product alteration, and multiple products.

PROCESS CHARACTERISTICS

CONTINUOUS PROCESSING

Generally, a continuous run of material is produced which tends to lose identity through stockpiling and shipping. Good controls as far upstream as possible in production are very important.

PRODUCT ALTERATION

All aggregate products degrade and segregate with handling and time. This process occurs from beginning to the end of any production. This process may occur later, such as when the aggregates are used for producing other materials.

MULTIPLE PRODUCTS

Most aggregate operations make more than one product concurrently. A change in one product may affect each and every one of the other products.

QUALITY CONTROL

Generally speaking, the process control techniques that are most desirable are predictive in nature rather than detective techniques that provide information on the product after the material has been stockpiled for shipping. Quality control is the prediction of product performance within pre-established limits for a desired portion of the output. Two principles of quality control that are required to be adhered to are:

1) Make sure the correct target is understood and achievable

2) Control variability within pre-established limits

Once the techniques for prediction of performance are developed, then quality control is required to address three issues: accuracy, precision, and capability.

ACCURACY

If the average of all measurements falls relatively close to an understood point (on target) then the process is said to be accurate.

PRECISION

When all of the measurements over time are very close together, then the process is said to be precise.

CAPABILITY

If the process is both accurate and precise such that the process remains within Specification or other predetermined limits with a high degree of confidence, then the process is said to be capable.

Figure 6-1 gives a graphical representation of accuracy, precision, and capability.

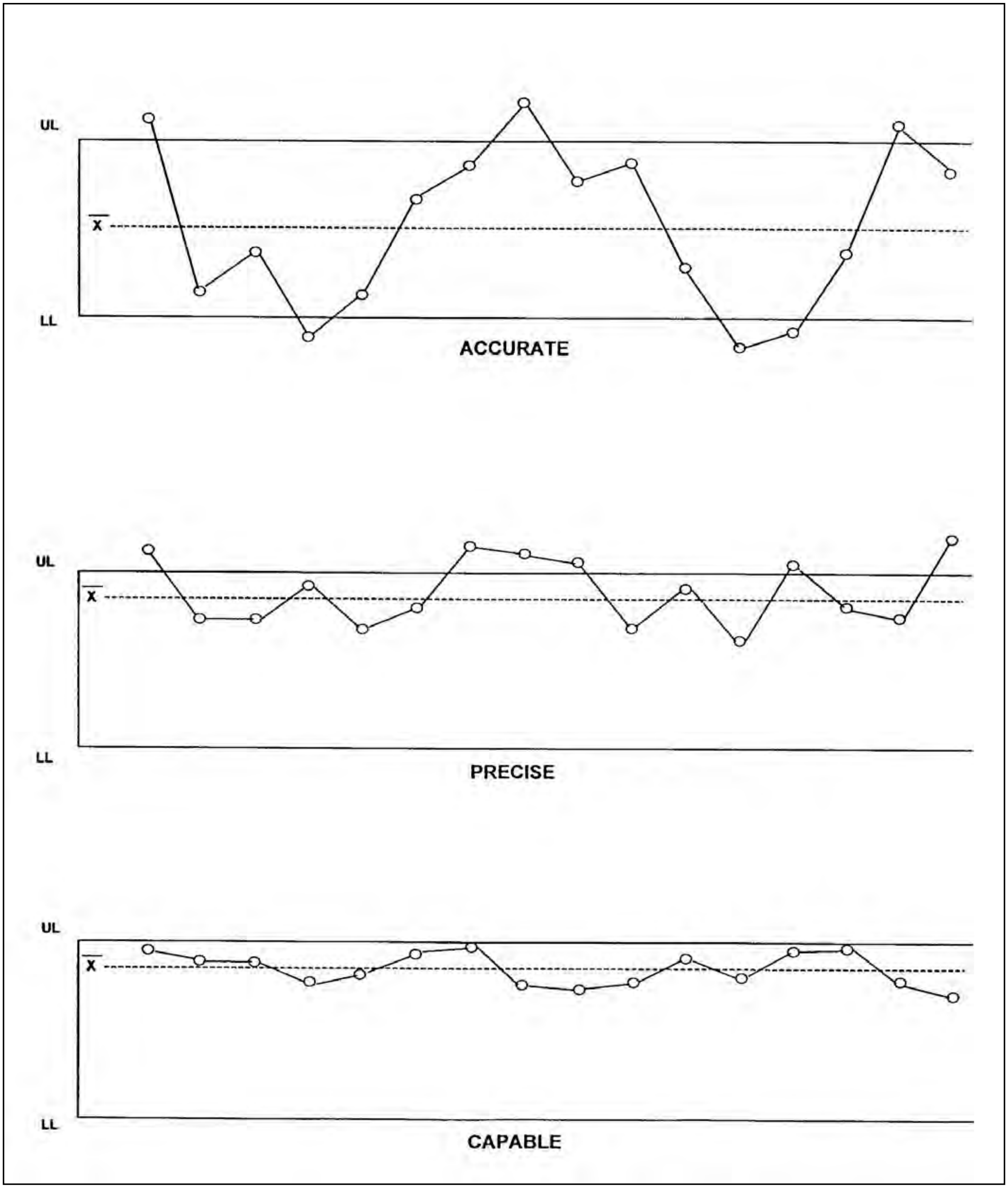


Figure 6-1. Accuracy, Precision, and Capability

STATISTICAL CONCEPTS

Complete control and improvements on any process is made by accurate measurements at critical points within the process. In order to gain confidence, the numbers are required to be generated often at various points so that all the variations of the process are detected. The quantity of measurements accumulates over time and simple tables or listings of these numbers are not enough to evaluate the process. The following statistical tools are used to understand what the numbers mean.

DATA SETS

The numbers from measurements that represent something in common rather than a scattering of unrelated numbers are called a set. When measuring properties of the process that are different, for example, gradation, crush count, or chert count, each property requires a set of numbers. Also, each property has different sets of numbers for different points in the process if the characteristics are known to change. (For example, production gradations versus stockpile gradations). Furthermore, even when properties and points of sampling are the same, a new set of data is required to have to be created if there is a significant sustained change in the process. All of the efforts at understanding, controlling, and predicting the outcome of a process are only as good as the accuracy and make-up of the related data sets. The importance of this step should not be underestimated.

THE MEAN

The average of all the data over time of an unchanged process is sometimes called the "grand mean" or the "population mean". For a shorter snapshot in time, the average may be called the "local mean" or just the "mean". The mean is the center of any distribution of numbers. Figure 1-2 is a graph of a very large group of numbers that are equally distributed on each side of the mean ($\bar{x}$). The graphic representation of these numbers is called a "standard bell curve".

STANDARD DEVIATION

Whereas the mean is an average of all the data values, the standard deviation is an average value of the dispersion of data from the mean. The standard deviation indicates how much the process varies and determines the shape of the bell curve. Small values reflect a tall, narrow curve (good), while large values reflect a flat, broad curve (poor).

NORMAL DISTRIBUTION

To simplify the interpretation of the data sets, the assumption is made that the data mathematically falls into a normal distribution which when plotted resembles the bell shaped curve. Although few actual processes exactly follow this assumption, they are close enough when stable and in control to be useful statistically. By assuming a normal distribution of the data, a few simple formulas may be applied to give the desired picture of the process. Any area under the bell curve falling between certain limits from left to right when expressed as a percentage of the total indicate the portion of that process that conforms to those limits (Figure 6-2). The further data values move right or left from the center of the curve, the less often these values occur.

Some values that serve as handy reference points for the normal distribution are:

1) About two-thirds of the area under the normal curve lies between one standard deviation below the mean and one standard deviation above the mean

2) About 95 percent lies between plus and minus two standard deviations

3) About 99.75 percent lies within three standard deviations of the mean

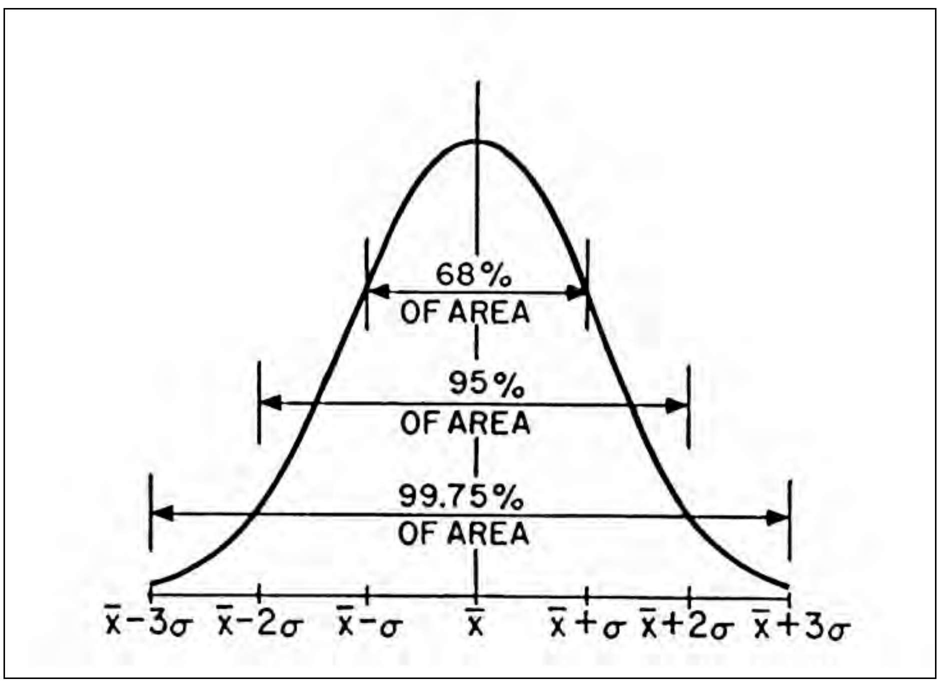


Figure 6-2. Normal Distribution

VARIABILITY

In-control conditions are required to be achieved for each critical characteristic and point in the process. Sources of variability for the same characteristic at different points in the process are cumulative. During the production, handling, and stockpiling of mineral aggregates, the sources of error are potentially many. Therefore, controls are required to be instituted upstream as well as throughout the process. Also, sampling and testing error may affect the variability. Although sampling and testing error will not affect the actual variation of the process, the misleading information may cause incorrect control techniques to be employed and possibly increase variability in the product. The lower the sampling and testing error, the more indicative the data of the process is.

CAPABILITY AND COMPLIANCE

The mean, standard deviation and variance indicate the location of the process and how consistent the process is. This is very important in exercising control. By themselves, however, they do not indicate how well the process meets certain specifications or other limits. The ability of the process to comply with externally imposed limits is called capability. The first useful tool in making this assessment is the Z value. This value indicates the number of standard deviations that the mean is from a particular limit. The greater the Z value, the more compliant or capable the process is (Figure 6-3).

There are two principle applications of the Z value in the Certified Aggregate Producer (CAP) Program:

1) Qualifying a Product -- Before a critical sieve product may qualify for use under the CAP Program, the data generation during new product qualification testing is required to demonstrate a Z value of at least 1.65 or higher within the specification limits of that product.

2) Control and Compliance -- After qualification of a product, the Z value from the data generated during control and shipping is required to result in a compliance level of 95 % or better for all control sieve products within 10 % above and 10 % below the target mean.

The Z Value

$$Z = \frac{X_{Limit} - \overline{X}}{\sigma_{n-1}}$$

$$Z_{Upper} = \frac{UpperLimit - \overline{X}}{\sigma_{n-1}}$$

$$Z_{Lower} = \frac{\overline{X} - LowerLimit}{\sigma_{n-1}}$$

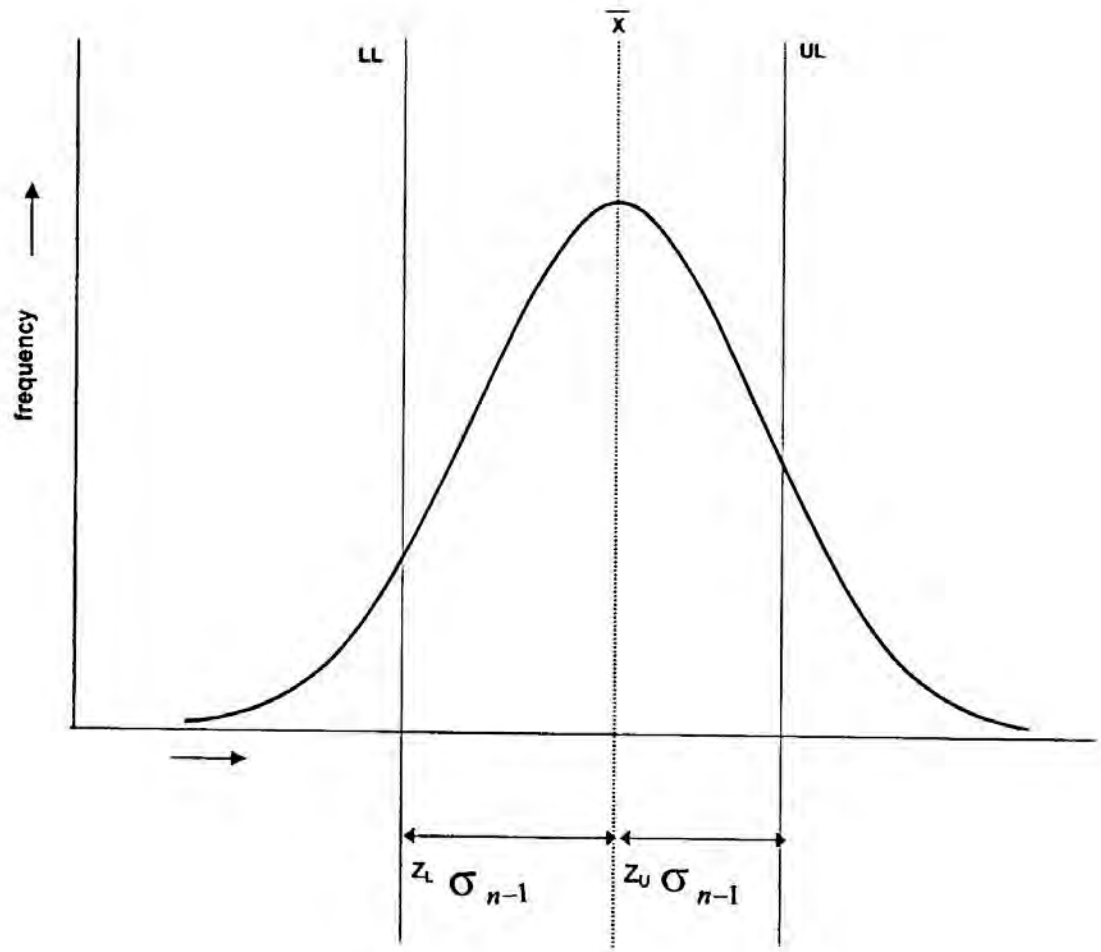


Figure 6-3. The area under the curve between the mean ($\overline{x}$) and another point (x), depends on Z which is the arithmetic difference between x and $\overline{x}$, divided by the standard deviation (σ_{n-1}).

When the Z values to each limit are known, this table indicates the area of probability between limits by summing the area left of the $\bar{x}$ with the area right of the $\bar{x}$ The sum of the two area factors should be multiplied by 100 to give the percent probability of compliance.

	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0159	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2518	0.2549
0.7	0.2580	0.2612	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4083	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4430	0.4441
1.6	0.4452	0.4463	0.4474	0.4485	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4758	0.4762	0.4767
2.0	0.4773	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4865	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4980	0.4980	0.4981
2.9	0.4981	0.4982	0.4983	0.4984	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4986	0.4987	0.4987	0.4988	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990
3.1	0.4990	0.4991	0.4991	0.4991	0.4992	0.4992	0.4992	0.4992	0.4993	0.4993
3.2	0.4993									
3.3	0.4995									
3.4	0.4997									

Table 6-1. Area of Probability Table for Specifications Involving > 0 Percent and < 100 Percent

The CAP Program requires that 95 % of all gradation test results on the critical sieve statistically be between 10 % below and 10 % above the target mean at any one point of sampling. An example of how to calculate percent compliance is as follows:

Product:	#8 Stone
Critical Sieve:	1/2 in.
QCP Target Mean:	52.2%

The most recent 30 production sample test results:

55.5	49.4	49.5	55.6	61.3
51.2	46.0	50.8	53.8	49.7
53.2	42.4	50.5	52.8	54.6
56.4	53.1	55.2	53.6	58.1
54.2	65.7	56.1	52.6	56.4
48.1	50.3	59.1	52.1	50.9

$\bar{x} = 53.3$ $\sigma_{n-1} = 4.53$

$$Z_{upper} = \frac{(\text{QCP Target Mean} + 10) - \bar{x}}{\sigma_{n-1}} = \frac{(52.2 + 10) - 53.3}{4.53} = 1.96$$

from Table 6-1, 1.96 is .4750

.4750 x 100 = 47.50

$$Z_{lower} = \frac{\bar{x} - (\text{QCP Target Mean} - 10)}{\sigma_{n-1}} = \frac{53.3 - (52.2 - 10)}{4.53} = 2.45$$

from Table 6-1, 2.45 is .4929

.4929 x 100 = 49.29

% Compliance = 47.50 + 49.29 = 96.79 ≈ 97 (Whole Number)

CONTROL CHARTING

Controlling a process with one measurement is not possible. Also, only a few measurements do not provide the level of confidence needed for proper decision-making and a clear picture of the process. The only way control and decisions may be made with confidence is through the use of large data sets. The control chart is a process that may be used to guide the Aggregate Producer on a daily basis. Graphic representation of the data indicated in conjunction with prescribed limits may provide the Aggregate Producer with everything that is needed if used with the proper interpretation techniques.

WHEN TO USE CHARTS

INDOT requires that gradation control charts be maintained for most products made by a certified plant for use on INDOT contracts. Also, any characteristic that is critical to a product is a candidate for control charting. For example, crush count, chert count, or any other characteristics that may apply are characteristics that are considered for charting. In these cases, the items considered and the proposed limits are required to be included in the Quality Control Plan submitted to INDOT for approval.

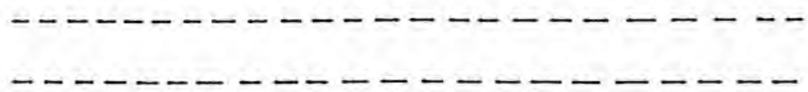
CONTROL CHART LEGEND

CAPP establishes a legend for specific information to be plotted on control charts. This legend convention is required to be followed, except that any proposed deviation from the procedures may be clearly identified in the Quality Control Plan.

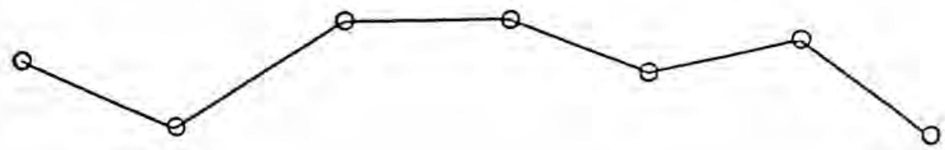
The target mean is represented by a heavy long dash followed by a short dash.

Control limits are represented by heavy solid lines placed at plus and minus two standard deviations, but no greater than plus or minus 10 percent from the target mean.

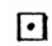
Upper and lower specification limits are indicated by short dashed lines.



Production plot points are surrounded by small circle and each consecutive point is connected by a solid straight line.



The moving average plot point is indicated by a small triangle and connected by straight lines.

The stockpile load-out plot point is indicated by a small square. 

BEGINNING THE CONTROL CHART

The principle purpose of the control chart is to visually depict a repeatable and controlled process. If the new data is expected to be part of the process population, then some definition of the process is required. The entire chart is centered around the target mean value. Ideally, the target mean is the grand mean which would be based on as much data as possible (perhaps a year), providing the process has not changed (Table 6-2 and Figure 6-4). If valid data does not exist on the process, then the control chart is established around a mean calculated from the first ten test results (Figure 6-5). The CAPP requires a QCP Annex to the Quality Control Plan identifying the new target mean to be filed with INDOT. Next, control limits are required to be added at plus and minus two standard deviations from the target mean. In no case may these limits exceed plus and minus 10 %. The Z value is required to be 1.65 or greater. If the Z value is not 1.65 or greater, the process is required to be changed.

A quick check of the location of the target mean in relation to the closest specification limit is to multiply 1.65 times the standard deviation. Then, either add or subtract the value, as appropriate, to the target mean. If the resultant number falls outside the specification band, the current process does not meet the requirements of CAPP (Specification Limit Check in Table 6-2).

PLANT: INDIANA MATERIAL SIZE: INDOT No. 9

SPEC.	100	60 - 85	30 - 60	0 - 15	0 - 10
SIEVE	3/4 in.	1/2 in.	3/8 in.	No. 4	No. 8
Mar 19	100.0	68.9	38.4	4.9	2.3
Mar 19	100.0	71.2	40.8	5.2	2.9
Mar 25	100.0	70.8	36.4	3.3	2.8
Mar 25	100.0	69.8	35.2	4.5	3.6
Mar 27	100.0	69.2	37.7	3.9	2.2
Mar 31	100.0	66.3	36.9	3.3	2.1
Mar 31	100.0	70.1	40.1	3.9	2.5
Apr 6	100.0	68.0	37.2	3.6	2.8
Apr 6	100.0	69.7	34.1	3.5	2.8
Apr 8	100.0	71.6	35.1	3.0	1.9
Apr 8	100.0	70.9	37.5	3.7	2.6
Apr 11	100.0	74.8	46.0	4.0	3.1
Apr 15	100.0	77.4	42.9	3.9	1.8
Apr 17	100.0	80.3	49.2	4.9	3.1
Apr 17	100.0	74.0	34.5	3.9	2.4
Apr 20	100.0	73.4	35.4	2.9	1.9
Apr 20	100.0	79.3	40.1	4.4	3.0
Apr 21	100.0	77.5	39.7	4.0	3.2
Apr 21	100.0	78.4	43.1	3.7	2.1
Apr 22	100.0	75.2	39.7	3.6	2.3
Apr 24	100.0	80.9	45.1	4.5	1.9
Apr 24	100.0	80.4	46.5	4.6	2.3
Apr 25	100.0	75.5	38.5	3.5	1.9
Apr 30	100.0	77.2	38.0	5.8	3.6
Apr 30	100.0	76.8	42.2	3.3	2.2
MEAN	100.0	73.9	39.6	4.0	2.5
STD. DEV.	0.000	4.34	4.05	0.71	0.54

For the 3/8 in. Critical Sieve: $n = 25$, $\bar{x} = 39.6$, $\sigma_{n-1} = 4.05$

Specification Limit Check

1.65 times $\sigma_{n-1} = 1.65(4.05) = 6.7$

Upper Specification Limit (USL) check = 39.6 + 6.7 = **46.3 ≈ 46 ≤ 60**

Lower Specification Limit (LSL) check = 39.6 - 6.7 = **32.9 ≈33 ≥ 30**

Z Value Check

$Z_u = \frac{60-39.6}{4.05} = 5.04 > 1.65$

$Z_L = \frac{39.6 - 30.0}{4.05} = 2.37 > 1.65$

Establish Control Limits

Upper Control Limit (UCL) = $\bar{x} + 2\,\sigma_{n-1} = 39.6 + 2(4.05) =$ **47.7 or 48**

Lower Control Limit (LCL) = $\bar{x} - 2\,\sigma_{n-1} = 39.6 - 2(4.05) =$ **31.5 or 32**

Table 6-2. Historical Data Gradation Analysis

FROM HISTORICAL DATA

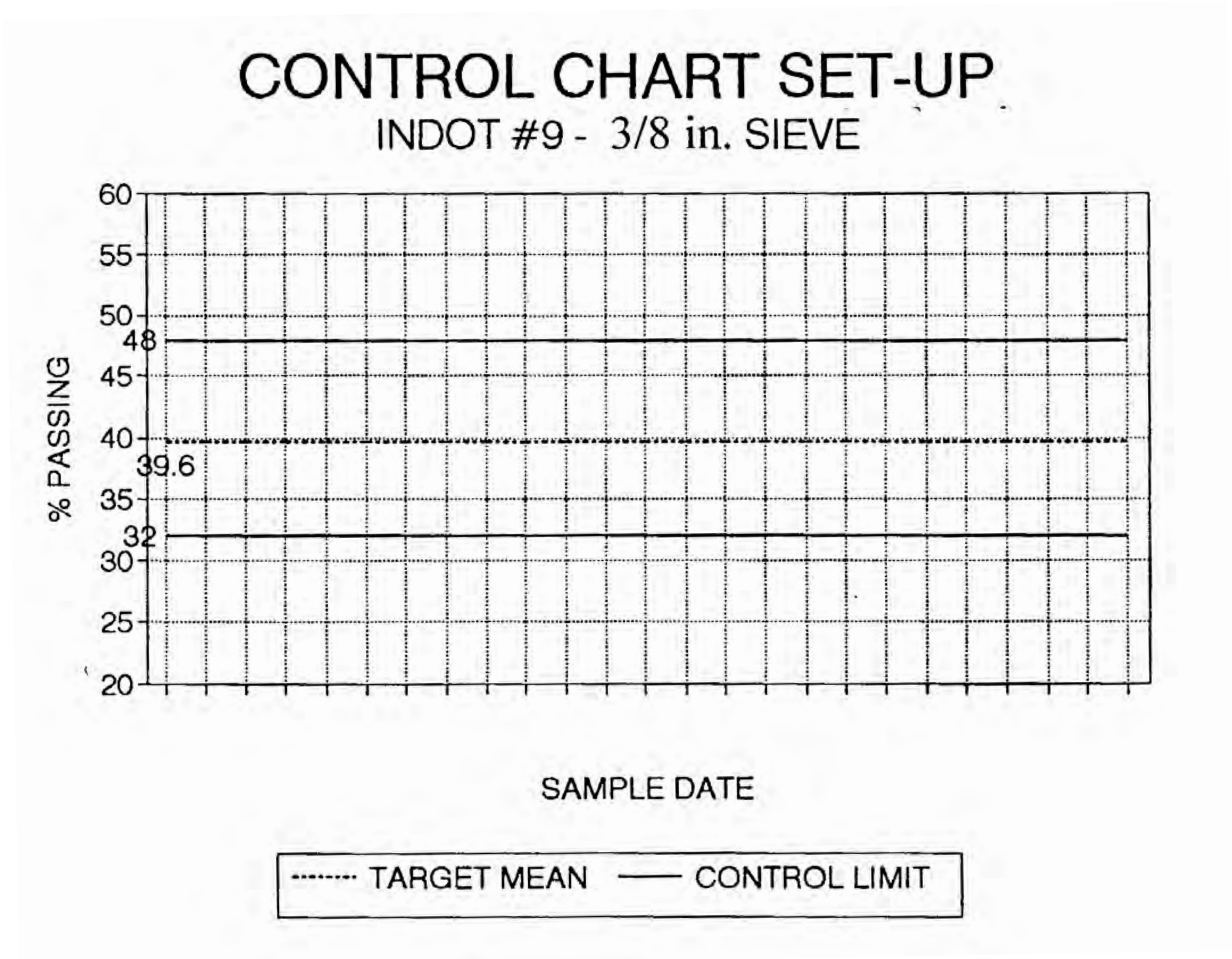


Figure 6-4. Control Chart Set-Up

FROM NEW DATA

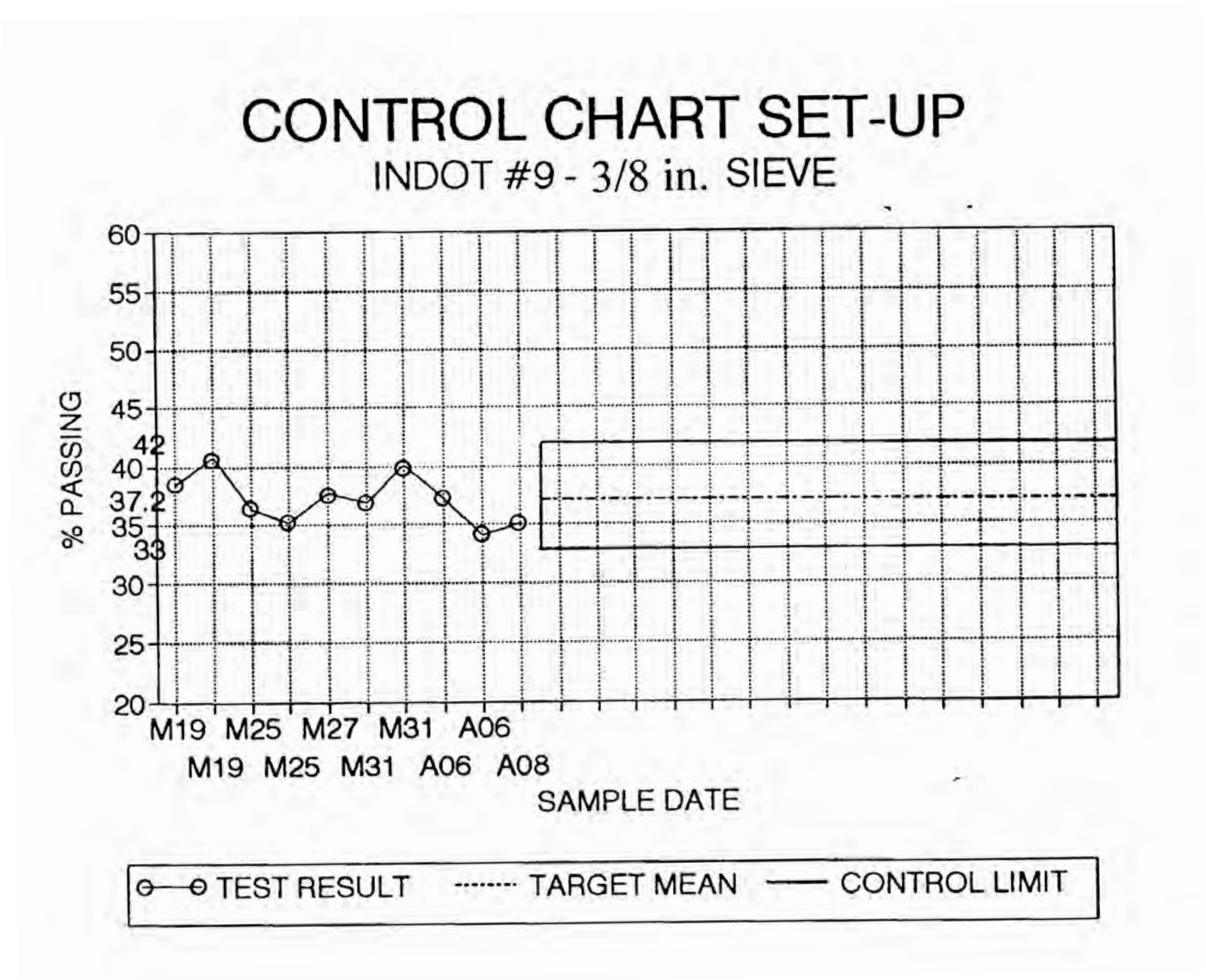


Figure 6-5. Control Chart Set-Up

Control charts indicate constant accuracy and precision if the process is in control and repeatable. The scattering of individual data points give a feel for precision or variability of the process when viewed against the control limits. In addition, a running average of the most current five data points is required to track the accuracy of the process. Averages tend to lessen the effect of erratic data points that could reflect errors not related to the actual material (sampling, testing, etc.) and that distract the viewer away from trends comparing to the target mean. Although this technique is not as accurate as data points that are each comprised of averages of subsets and which require an accompanying chart of ranges, the process works well for the mineral aggregate industry. When aggregates are tested at frequencies of 2000t per sample, the requirement to wait for the accumulation of five tests before generating a single data point is not acceptable. Table 6-3 and Figure 6-6 illustrate how data points and the running average for a product critical sieve are plotted on a control chart with a pre-established target mean and control limits.

ITM 211 requires that non-conforming normal production or load-out tests be followed immediately by a corrective action to include as a minimum an investigation for assignable cause, correction of known assignable cause, and retesting. These retests are not plotted on the control charts.

The check of the specification limits and establishment of the control limits for Table 6-3 are conducted as follows.

For the No. 4 critical sieve for the INDOT Standard Specifications No.11 material:

Data Set Results

$n = 36$ $\bar{x} = 14.8$ $\sigma_{n-1} = 2.60$

Specification Limit Check

1.65 times $\sigma_{n-1} = 1.65(2.60) = 4.3$

USL check = 14.8 + 4.3 = **19.1** $\leq$ **30** OK

LSL check = 14.8 - 4.3 = **10.5** $\geq$ **10** OK

Z Value Check

$Z_u = \frac{30-14.8}{2.60} = 5.85 > 1.65$ OK

$Z_L = \frac{14.8 - 10}{2.60} = 1.85 > 1.65$ OK

Establish Control Limits

$UCL = \bar{x} + 2\ \sigma_{n-1} = 14.8 + 2(2.6) =$ **20.0** or **20**

$LCL = \bar{x} - 2\ \sigma_{n-1} = 14.8 - 2(2.6) =$ **9.6** or **10**

PLANT: INDIANA MATERIAL SIZE: #11

SPEC.	100	75 - 95	10 - 30	5 PT AVG	0 - 10
SIEVE	1/2 in.	3/8 in.	No. 4	No. 4	No. 8
Jun 3	100.0	87.5	13.1		3.3
Jun 4	100.0	86.7	17.9		4.4
Jun 4	100.0	90.8	17.9		6.1
Jun 5	100.0	85.9	15.1		5.7
Jun 8	100.0	87.1	10.8	**15.0**	3.9
Jun 8	100.0	89.6	15.4	**15.4**	5.1
Jun 9	100.0	84.8	10.4	**13.9**	3.9
Jun 9	100.0	84.8	16.2	**13.6**	3.8
Jun 10	100.0	85.2	14.4	**13.4**	4.9
Jun 10	100.0	88.9	17.8	**14.8**	3.1
Jun 11	100.0	86.2	12.2	**14.2**	4.4
Jun 12	100.0	87.2	14.1	**14.9**	5.3
Jun 12	100.0	86.0	13.0	**14.3**	4.9
Jun 12	100.0	87.7	16.2	**14.7**	4.5
Jun 15	100.0	82.0	16.1	**14.3**	4.2
Jun 16	100.0	88.3	14.4	**14.8**	5.4
Jun 16	100.0	89.7	11.8	**14.3**	3.5
Jun 16	100.0	89.4	12.5	**14.2**	4.7
Jun 17	100.0	86.2	11.5	**13.3**	2.9
Jun 18	100.0	86.1	14.7	**13.0**	4.3
Jun 19	100.0	88.5	11.2	**12.3**	5.4
Jun 19	100.0	86.0	18.7	**13.7**	3.3
Jun 19	100.0	87.4	14.8	**14.2**	5.8
Jun 19	100.0	87.5	12.1	**14.3**	3.3
Jun 22	100.0	85.9	16.0	**14.6**	4.9
Jun 22	100.0	96.3	14.0	**15.1**	4.5
Jun 23	100.0	86.9	11.3	**13.6**	3.7
Jun 24	100.0	88.5	16.3	**13.9**	4.2
Jun 25	100.0	88.6	15.0	**14.5**	5.0
Jun 25	100.0	89.5	16.9	**14.7**	5.5
Jun 26	100.0	86.6	13.9	**14.7**	5.0
Jun 29	100.0	87.9	14.7	**15.4**	5.1
Jun 29	100.0	89.6	16.7	**15.4**	6.2
Jun 30	100.0	90.1	18.2	**16.1**	8.8
Jun 30	100.0	92.3	21.8	**17.1**	8.3
Jun 30	100.0	90.7	14.0	**17.1**	4.1
MEAN	100.0	87.8	14.8		4.8
STD. DEV.	0.000	2.50	2.57		1.27

Table 6-3: Gradation Analysis

GOOD PROCESS CONTROL

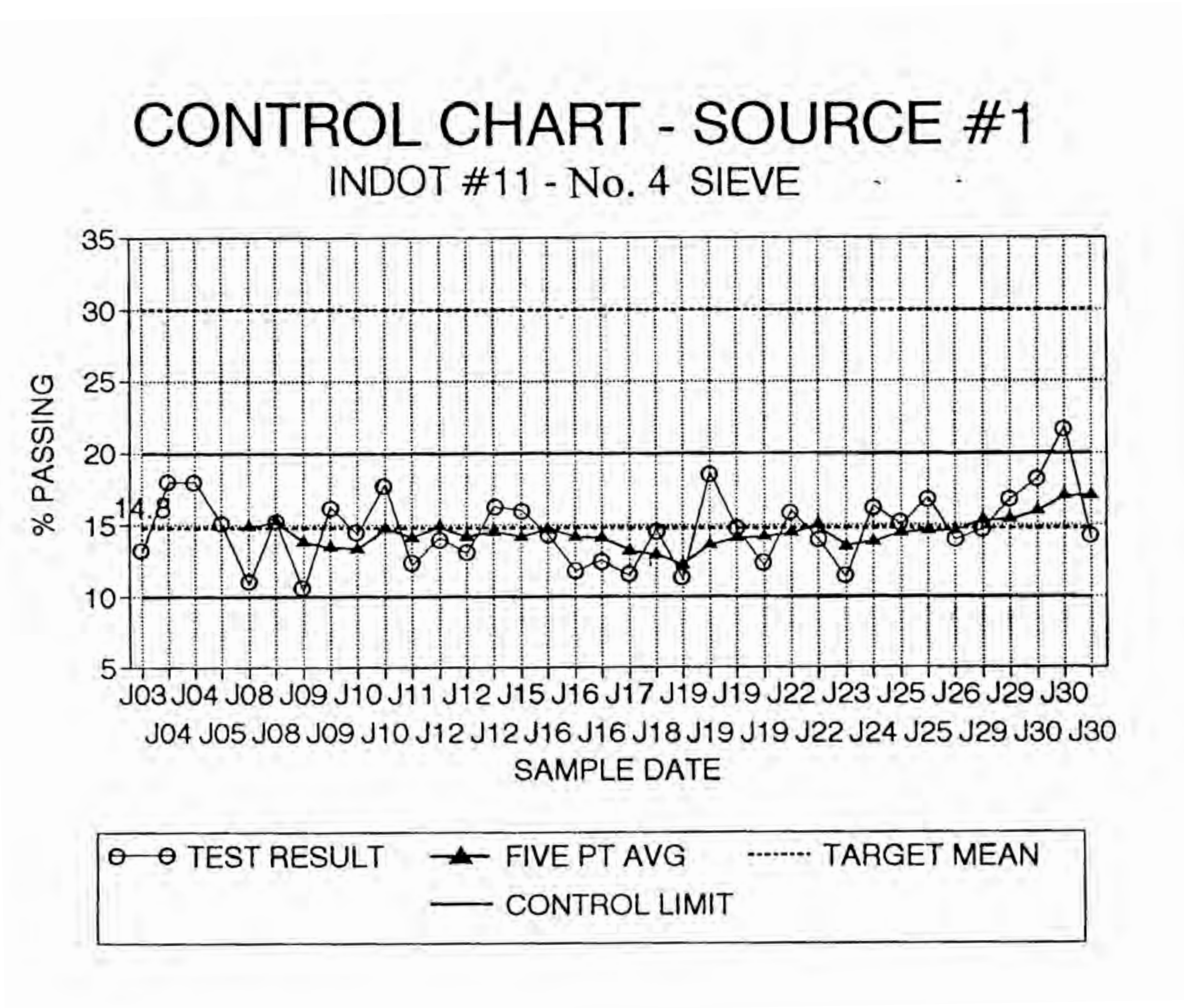


Figure 6-6. Good Process Control

Under the CAP Program, specific treatment of nonconforming tests is required. Action is required to be taken after the first nonconforming test (outside of control limits). These requirements are required to be met in all cases and take precedence over any other control technique. When individual test results, even on an intermittent basis, frequently fall outside the control limits or specification limits, a nonconforming condition exists. A capability calculation in conjunction with whichever limits are being violated may quickly verify the condition. The following trends involving the 5-point moving average points (Figure 6-7) may require investigation by the Producer and as a minimum an entry in the diary to denote the problem.

1) Seven or more points in a row are above or below the target mean ($\bar{x}$)

2) Seven or more points in a row are consistently increasing or decreasing

Finally, the Technician is required to always be alert for a sudden jump in the data, whether the data remains in control or not. This condition usually represents the addition of a completely different process and may be detected immediately without waiting for trends in the moving average (Figure 6-8). Corrective action is required to be taken immediately. If the shift to a new process is done intentionally, then a clean break is required to be made in the control chart by means of a vertical line on the chart. After ten valid test results on the new process, a new target mean $\bar{x}$ is required to be calculated and new control limits established (Figure 6-9).

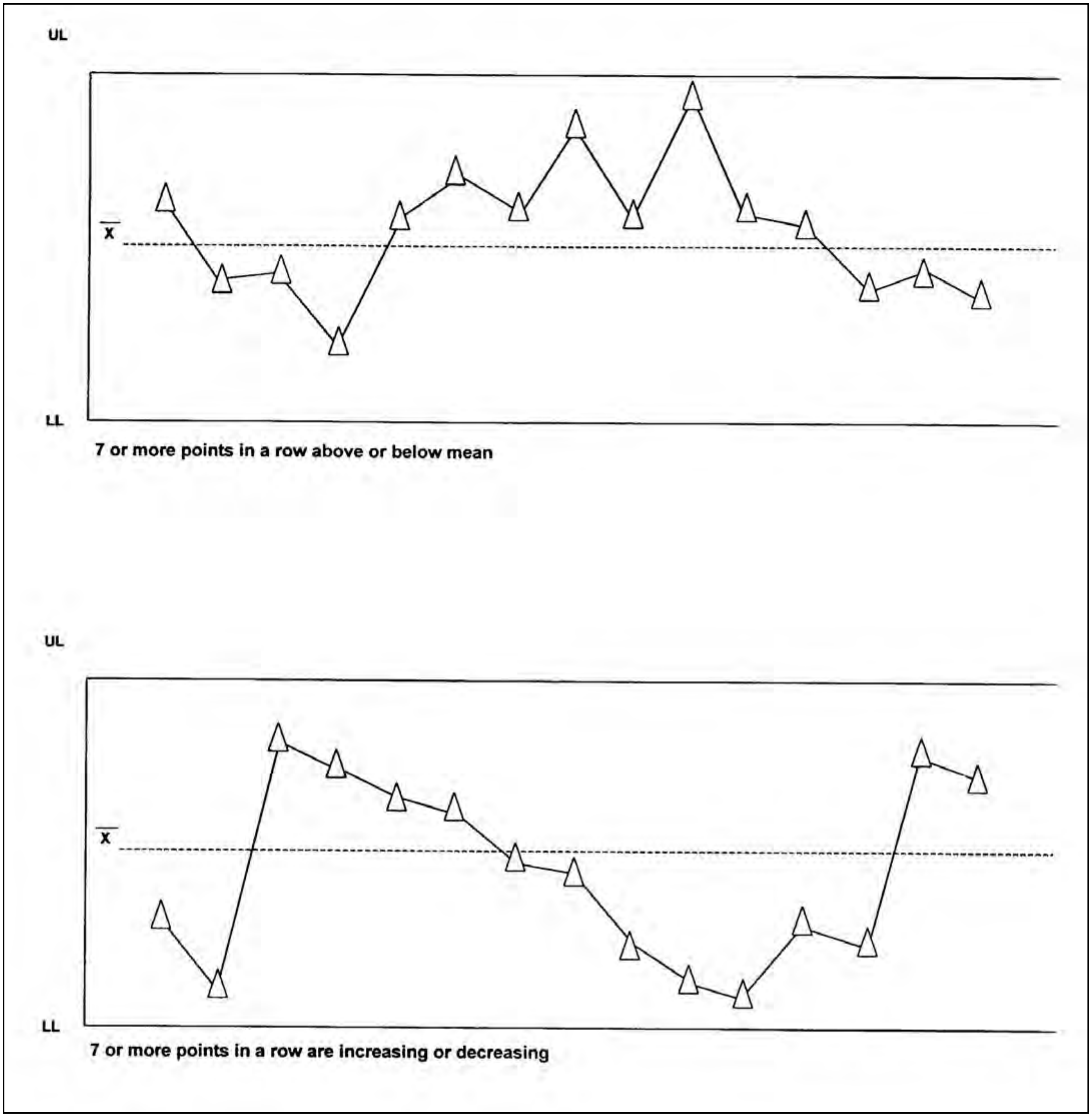


Figure 6-7. Five-Point Moving Average Trends

NONCONFORMING PROCESS

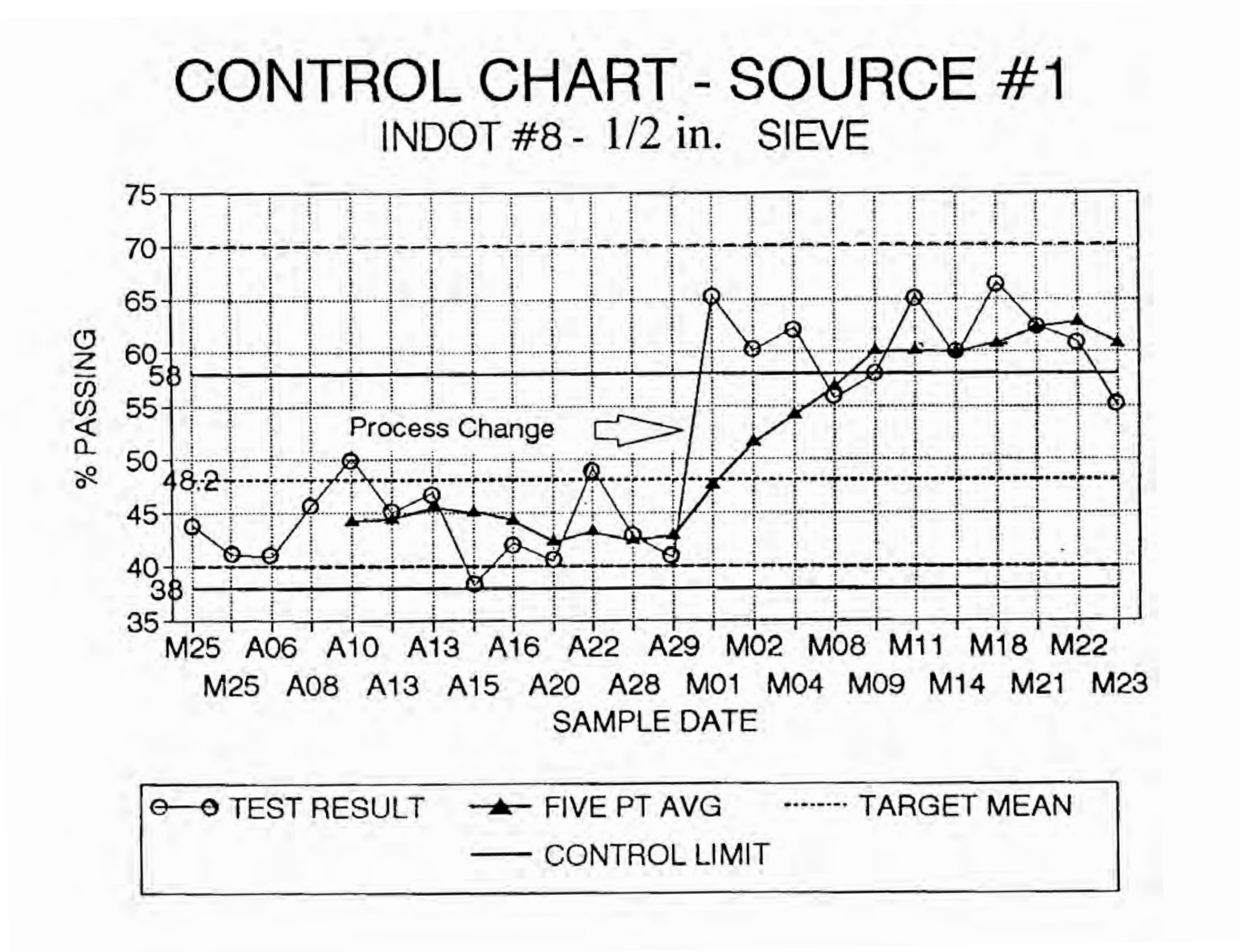


Figure 6-8. Nonconforming Process

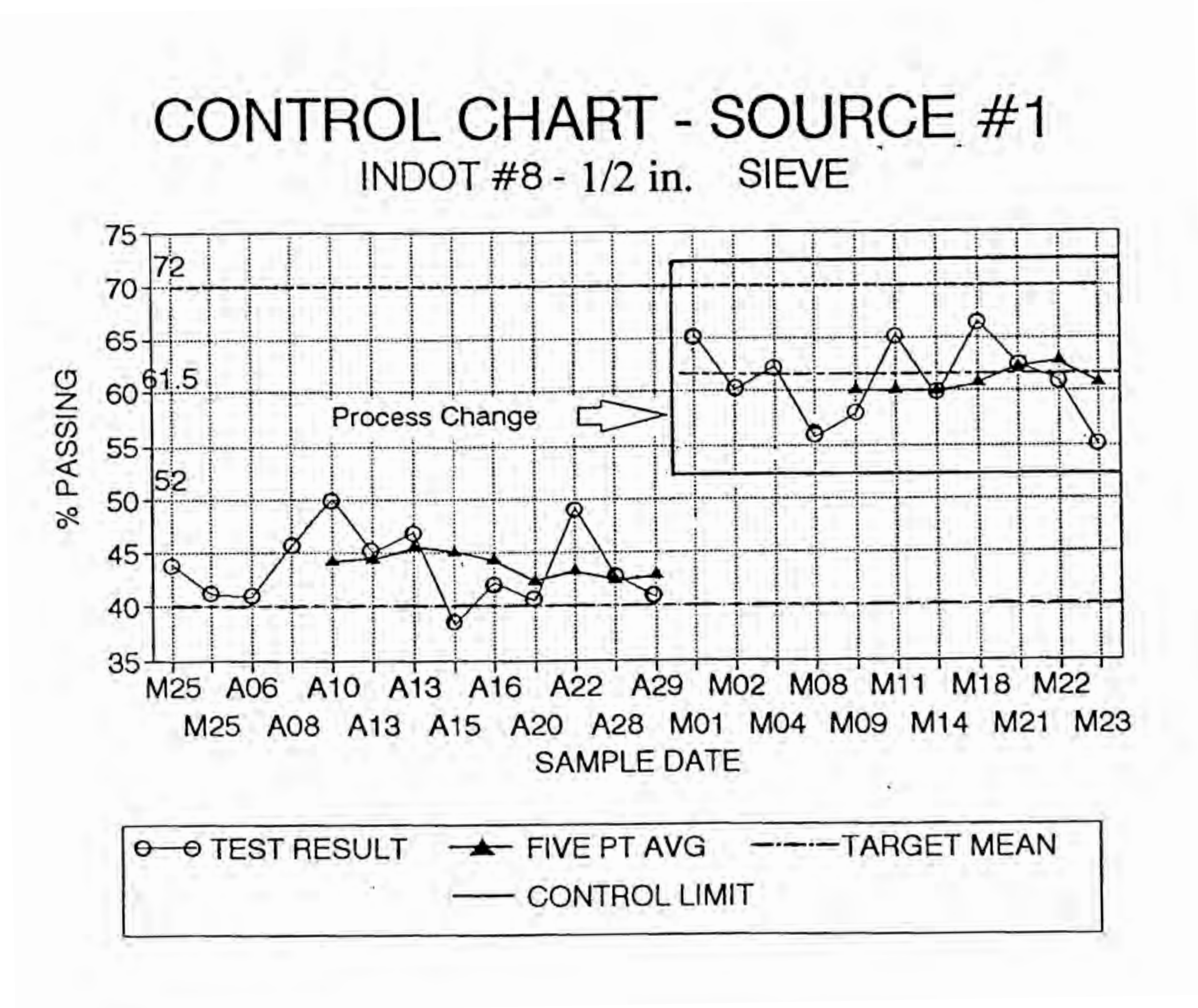


Figure 6-9. Process Adjustment

UNDERSTANDING THE PROCESS

Attempting to control an unstable process is like trying to answer an unsolvable riddle. Nothing is predictable; hence, nothing may be assumed. The Technician is required to follow a logical path to understand how, when, and what controls are necessary. The following path is a series of measurements, observations, communications, and decision-making.

CURRENT PROCESS

The current process is required to be thoroughly understood before making wise decisions on how to make improvements:

1) Gather honest employee input so that management knows what they know

2) Conduct and document visual observations of which elements seem to cause the greatest variability. Excavating or blasting, crushing, screening, total process stockpiling, and hauling, handling, and loading are all items that may affect quality.

3) Learn how and make accurate measurements at uniform intervals over time. A pply statistical principles to determine current stability and capability of the process.

PROCESS STABILITY

The process is required to first be stabilized before any other improvements may be made using the following procedures:

1) Identify the variables that most affect the process, called the Key Process Variables. These variables require the greatest attention from the operations managers (Figure 6-10).

2) Establish standards. The first reduction in variability may be recognized through "Standard Operating Procedures" (S.O.P.'s). T hese procedures include job descriptions, measurements (type and frequency), protocol for extreme conditions, etc.

3) Determine special causes. A n absolute requirement for a stable process is the elimination of special causes of variability, namely, the ones that are external and not a part of the natural process. (e.g. conditions created by personnel)

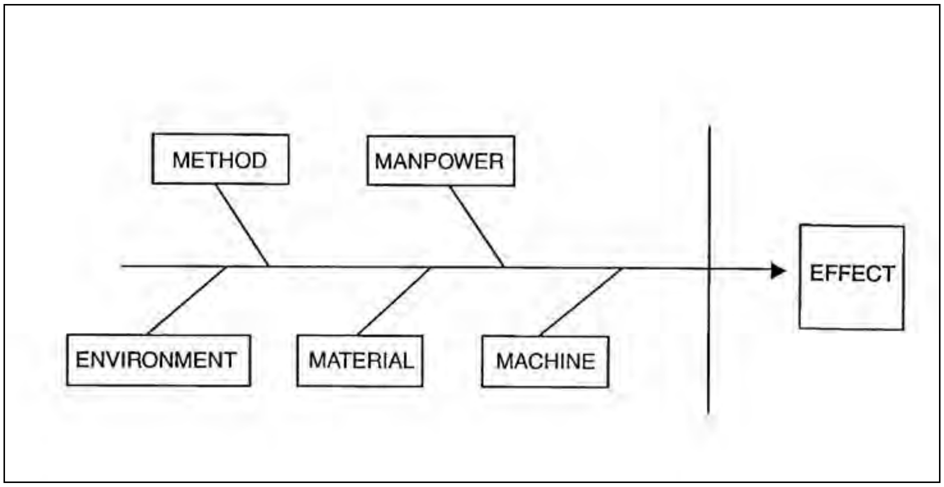


Figure 6-10. Key Process Variables

DECISION MAKING

After operating for some time with a stable process, some important decisions may be made. There are two items that are required to occur first:

1) Communicate with customers so they understand the new stable products. Also, obtain input from the customers on the need for further adjustment.

2) Make concurrent measurements to assess the need for further improvement

PROCESS CAPABILITY

Decisions previously made are required to include any techniques needed to bring the process into desired compliance with a high degree of confidence such as:

1) Establish final desired product targets and limits

2) Reduce common causes of variability as required. This generally means a change in the process.

PROCESS CONTROL

Implement ongoing statistical process control along with continuous improvement.

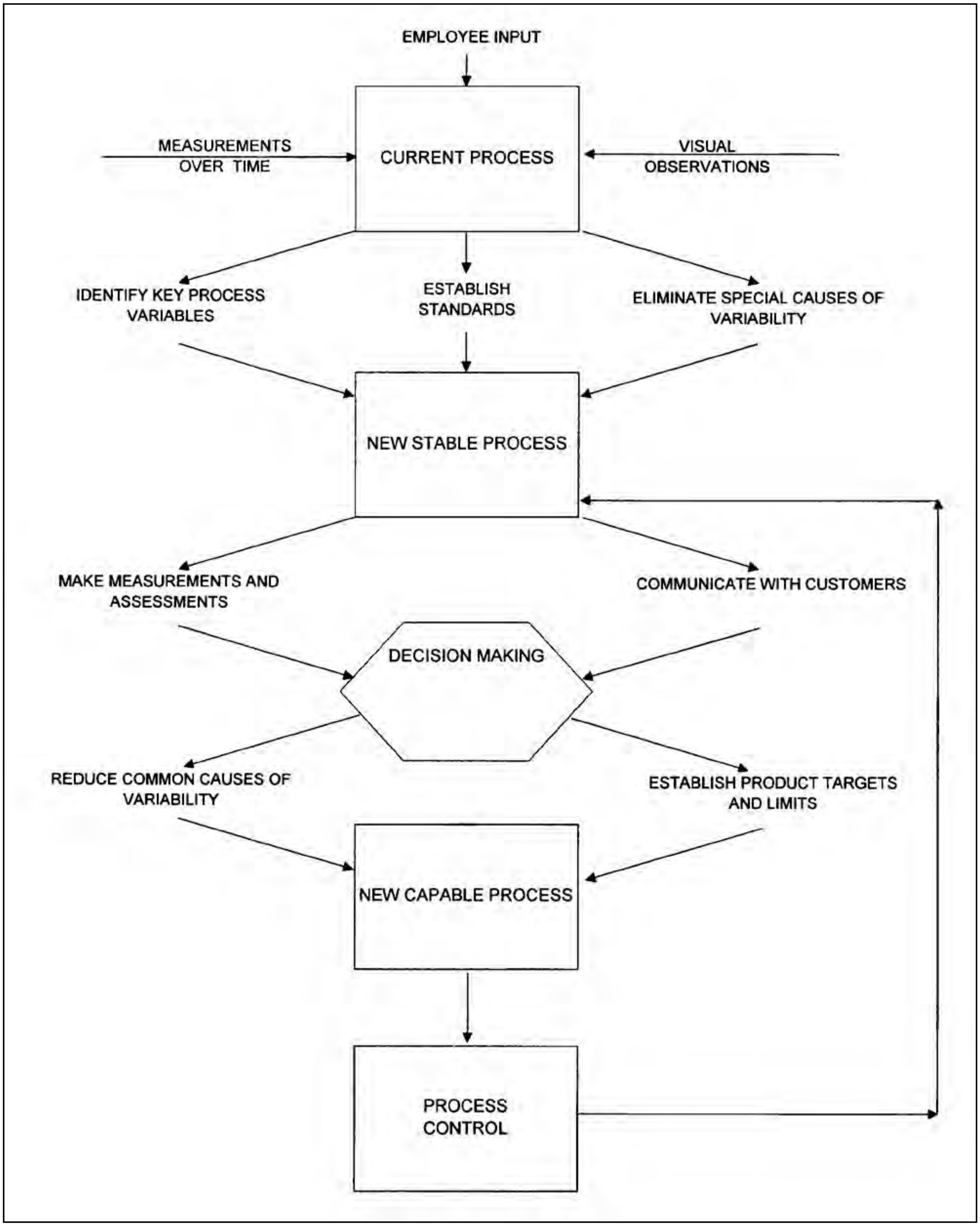


Figure 6-11. Steps for Managing Quality

7 Quality Control Plan

The Quality Control Plan

Development
Details
Addenda
Operational Types

QCP Annex

Quality Control Plan Checklist

CHAPTER SEVEN:
QUALITY CONTROL PLAN

If a single part of the Certified Aggregate Producer Program is considered to be the most important, then that is the Quality Control Plan (QCP). The QCP is required to encompass the total process from preliminary site approval up to the point where the material leaves the Producer's control. The QCP is required to identify and address all products generated and the type, frequency, and limits of sampling and testing to be done. The QCP focuses on a quality product and answers the questions of who, what, when, where, and how.

QUALITY CONTROL PLAN

DEVELOPMENT

The QCP is developed while the Producer is in the Coordinated Testing Phase. When starting to develop the QCP, the Producer is required to refer to this chapter, the model QCP's (Appendix C), INDOT's preliminary site approval letter, the CAP Program (**ITM 211**), and Section **917**.

The QCP is site and plant specific. A QCP for one site would not necessarily be satisfactory for another site.

DETAILS

The following list is provided to assist in the preparation of a QCP; however, the list is not to be considered all-inclusive (ITM 211 Section 14.0). A QCP is required to include:

1. The location and physical description of the site

2. Management Representative and Certified Technician(s) and their CAPP duties and responsibilities

3. A list and description of all portions of the mineral deposit as well as the manner in which each quality class is to be handled

4. A statement regarding AP aggregates. The AP Aggregate Production Control Plan may be included in an Appendix.

5. A statement regarding leachate testing for air cooled blast furnace slag. The requirements are listed in ITM 212.

6. A statement regarding bulk specific gravity testing for steel furnace slag when this material is used in stone mastic asphalt.

7. A statement regarding sampling and testing of natural sand fine aggregate when composite stockpiling multiple sources into one stockpile is done.

8. Identification of and a plan for handling materials having marginal quality characteristics

9. A list of all products produced at the plant. A CAPP category shall be identified for each of the products. This list could also be an appropriate place to identify those products for which no controls or limits are appropriate

10. A generic production flow diagram

11. A sampling plan that includes locations, devices, techniques, frequencies, and test methods

12. A testing plan that includes the types of tests and test methods, and the means to isolate material represented by nonconforming tests

13. A list of the target mean values, standard deviations, and control limits on the critical sieves for each material controlled by critical sieve requirements

14. A description of other process control techniques that are used beyond the minimum required

15. A plan for downstream controls that includes identification of stockpiles by signing, construction of stockpiles, and material retrieval

16. A statement of laboratory capability including the location of the lab, a list of equipment that is verified, and the test methods and frequency of verification

17. A documentation plan with details on control charting, test data, and the diary, etc.

18. The method by which the frequency of production and load-out testing of Certified Materials is verified

19. The location of the reference documents, control charts, diary, test data, material shipment records, and other pertinent information

20. The method of control for each Producer Yard

21. The procedure for handling addenda

22 The Annual Aggregate Source Report in an Appendix

23. An Appendix. As a minimum the Appendix is required to contain an Addenda Summary Sheet

24. Authentication and approval (two signatures required)

A QCP checklist is provided to assure that all the applicable items required in **ITM 211** are addressed in the QCP.

ADDENDA

Addenda are defined as any addition or deletion to the QCP. Each page of the QCP that is revised is required to include the source number, date of revision, and means of identifying the revision. The addenda are required to include a signed and dated authentication page.

Revisions for Certified Material additions, Certified Material deletions, target mean and control limit values, or Certified Aggregate Technicians are submitted in the format of the QCP Annex as they occur. Upon approval by the District Testing Engineer, the QCP Annex is placed in the Appendix of the QCP until such time that the revisions are incorporated into the QCP.

Revisions, other than items on the QCP Annex, are maintained on an Addenda Summary Sheet. The Addenda Summary Sheet is a page of the QCP Appendix that is used to record a brief description of the revision until such time that the revision is incorporated into the QCP.

Addenda may be submitted at the audit close-out meeting or between January 1st and April 1st of each calendar year. The addenda are required to include items on the QCP Annex, items on the Addenda Summary Sheet, and any other necessary revisions at the time of submittal. Upon incorporation into the QCP as addenda, the QCP Annex and items on the Addenda Summary Sheet are required to be removed from the QCP Appendix.

OPERATIONAL TYPES

The CAPP provides for Plants and Redistribution Terminals. The QCP is required to identify the intended type of operation. In some instances a primary source may also sell material produced at another source and therefore would be operating as both a Plant and a Redistribution Terminal.

QCP ANNEX

Company ____

Source No. ______________________ Q No. __________________________

NEW CERTIFIED MATERIAL ADDITION

Size Designation: ___________________ Specification: Standard or QA (see attached gradation)
Originating SC #: ___________________ Category Rating: IA IB IIA IIB III GS-A GS-B

Circle all that apply

Type: [Stone] [Gvl (Crushed/Uncrushed)] [Sand (Man./Nat./Slag)] [Slag (ACBF/SF)]
[Dolomite Approved (ITM 205)] [Recycled Concrete (Contract #: _________________)]
[Alternate Polish Resistant Aggregate (ITM 214)] [Other ___________________________]

Product Quality Rating: AP AS A B C D E F NA

Ledges and/or Area of Production: ____
Does finished product go into Separate or Composite Stockpile? ____________________________
Is material from New Production, Existing Stockpile, or Both? _____________________________
Size of Existing Stockpile: _______________ t Annual Production: <10000 t ≥10000t

EXISTING CERTIFIED MATERIAL REVISION

Current Size Designation: ________________________________ Originating SC #: __________
New Size Designation: __________________________________ Type (see above): _____________
Ledges: _____________________________ Product Quality Rating: AP AS A B C D E F NA

EXISTING CERTIFIED MATERIAL DELETION

Size Designation: ________ Originating SC #: _________ Type (see above): _________________
Product Quality Rating: AP AS A B C D E F NA D# (DTE)______________________

TARGET MEAN and CONTROL LIMITS REVISION

Certified Material: ____
Current $\overline{X}$: ______________________ Existing Control Limits: ______________________
New $\overline{X}$: ________ σ: __________ # Tests: __________ New Control Limits: _____________

CERTIFIED AGGREGATE TECHNICIAN REVISION

Delete CAT from QCP ____
Add CAT to QCP ____

______________________________ ___________ __________________________ ___________
District Testing Engineer Date Management Representative Date

3/27/09

CERTIFIED AGGREGATE
QUALITY CONTROL PLAN CHECKLIST

Date ___________________

Source No. ___________________

Plant/Redistribution Terminal Name ____

Plant/Redistribution Terminal Location ____

[ ] Telephone Number
[ ] Address
[ ] County
[ ] Section
[ ] Township
[ ] Range
[ ] Reference to Identifiable Points

Parent Company Name ____

[ ] Address

Type of Aggregate Source

[ ] Plant, Redistribution Terminal, or Combination

Organizational Structure

[ ] Management Representative
[ ] Certified Technician(s) by Location
[ ] CAPP Duties and Responsibilities of People Listed

Mineral Deposits

[ ] List
[ ] Description
[ ] Quality Class
[ ] Processing, Handling, & Stockpiling Procedures
[ ] Summary of Ledge Quality Test Letter Date (Stone)
[ ]* Marginal Quality Products and Plan for Control

* Only If Occurs

AP Aggregate *

[ ] Ledges for Stone or Production Zone for Gravel
[ ] General Handling and Crushing Procedures
[ ] Stockpile Signage
[ ] AP Production Control Plan in Appendix (optional)

Air Cooled Blast Furnace Slag -- Leachate Testing*

[ ] Sampling Procedure
[ ] Testing Procedure (ITM 212)
[ ] Frequency

Steel Furnace Slag – Deleterious Testing*

[ ] Sampling Procedure
[ ] Testing Procedure (ITM 219)
[ ] Frequency

Steel Furnace Slag -- Bulk Specific Gravity Testing (SMA)*

[ ] Sampling Procedure
[ ] Testing Procedure (AASHTO T 85)
[ ] Frequency

Composite Stockpiling*

[ ] Sources
[ ] Monthly Summary Report
[ ] Means of Tracking Bulk Specific Gravity and Absorption

Material Categories - Each

[ ] Standard Specifications
[ ] Quality Assurance
[ ] Alternate

Production Flow Diagram

[ ] Points of Sampling
[ ] Symbol Legend

* Only If Occurs

Sampling Plan

[ ] Frequency
[ ] Locations
[ ] Sampling Devices and Techniques
[ ] Test Method Numbers
[ ] Means of Tracking Production and Load-out Tests

Testing Plan

[ ] Gradation
[ ] Decantation (Load-out only)
[ ]* Crushed Particles (Min. 1/Week, None If < 100 t)
[ ]* Deleterious Material (Min. 1/Week, None If < 100 t)
[ ] Procedure for Isolating Non-Conforming Material
[ ] Test Method Numbers

Gradation Control

[ ] Critical Sieve for Quality Assurance Materials
[ ] Target Mean Values - Each
[ ] Standard Deviations - Each
[ ] Control Limits - Each
[ ] Gradation Limits for all Applicable Sieves for Quality Assurance Materials
[ ]* Identification of Materials with no Control Limits
[ ]* Load-Out Target Mean and Control Limits Different from Normal Production Values

Process Control Techniques

[ ]* Types or Greater Frequencies of Testing
[ ]* Mid Stream Sampling & Testing
[ ]* Visual Checks & Monitoring

Downstream Control

[ ] Identification of Stockpiles (Size of Material)
[ ] Stockpile Construction Technique
[ ] Product Retrieval Technique - Loading & Shipping Safeguards

* Only If Occurs

Laboratory Capability

[ ] Location
[ ] List and Description of Verified Equipment
[ ] Verification Test Methods and Frequency

Documentation Plan

[ ] Reference Publications
[ ] Diary
[ ] Control Charts
[ ] Test Data
[ ] Material Shipment Record
[ ] Location of Documents
[ ] Copies of Forms (optional)

Producer Yard

[ ]* Method of Control

Addenda

[ ] Means of Handling Addenda
[ ] Statement Concerning Source Number, Date of Revision, and Means of Identifying Revision

Annual Aggregate Source Report (Stone Only)

[ ] Included in Appendix

Authentication

[ ] Last Page
[ ] Right Hand Signature Block Signed and Dated by Producer Management Representative
[ ] Left Hand Blank & Title – Manager, Office of Materials Management

QCP ANNEX

Company ______________________________________

Source No. ______________________ Q No. _________________________

NEW CERTIFIED MATERIAL ADDITION

Size Designation: ___________________ Specification: Standard or QA (see attached gradation)
Originating SC #: ___________________ Category Rating: IA IB IIA IIB III GS-A GS-B

Circle all that apply

Type: [Stone] [Gvl (Crushed/Uncrushed)] [Sand (Man./Nat./Slag)] [Slag (ACBF/SF)]
[Dolomite Approved (ITM 205)] [Recycled Concrete (Contract #: _________________)]
[Alternate Polish Resistant Aggregate (ITM 214)] [Other _________________________]

Product Quality Rating: AP AS A B C D E F NA

Ledges and/or Area of Production: ____
Does finished product go into Separate or Composite Stockpile? ___________________________
Is material from New Production, Existing Stockpile, or Both? ___________________________
Size of Existing Stockpile: _______________ t Annual Production: <10000 t ≥10000t

EXISTING CERTIFIED MATERIAL REVISION

Current Size Designation: _______________________________ Originating SC #: __________
New Size Designation: _________________________________ Type (see above): _____________
Ledges: _____________________________ Product Quality Rating: AP AS A B C D E F NA

EXISTING CERTIFIED MATERIAL DELETION

Size Designation: _______ Originating SC #: ________ Type (see above): _________________
Product Quality Rating: AP AS A B C D E F NA D# (DTE)_____________________

TARGET MEAN and CONTROL LIMITS REVISION

Certified Material: ____
Current $\overline{X}$: _____________________ Existing Control Limits: ______________________
New $\overline{X}$: _______ σ: _________ # Tests: _________ New Control Limits: _____________

CERTIFIED AGGREGATE TECHNICIAN REVISION

Delete CAT from QCP ____
Add CAT to QCP ____

______________________________	___________	__________________________	___________
District Testing Engineer	Date	Management Representative	Date

3/27/09

CERTIFIED AGGREGATE
QUALITY CONTROL PLAN CHECKLIST

Date ___________________

Source No. ___________________

Plant/Redistribution Terminal Name ____

Plant/Redistribution Terminal Location ____

[ ] Telephone Number
[ ] Address
[ ] County
[ ] Section
[ ] Township
[ ] Range
[ ] Reference to Identifiable Points

Parent Company Name ____

[ ] Address

Type of Aggregate Source

[ ] Plant, Redistribution Terminal, or Combination

Organizational Structure

[ ] Management Representative
[ ] Certified Technician(s) by Location
[ ] CAPP Duties and Responsibilities of People Listed

Mineral Deposits

[ ] List
[ ] Description
[ ] Quality Class
[ ] Processing, Handling, & Stockpiling Procedures
[ ] Summary of Ledge Quality Test Letter Date (Stone)
[ ]* Marginal Quality Products and Plan for Control

* Only If Occurs

____

____

AP Aggregate *

[ ] Ledges for Stone or Production Zone for Gravel
[ ] General Handling and Crushing Procedures
[ ] Stockpile Signage
[ ] AP Production Control Plan in Appendix (optional)

Air Cooled Blast Furnace Slag -- Leachate Testing*

[ ] Sampling Procedure
[ ] Testing Procedure (ITM 212)
[ ] Frequency

Steel Furnace Slag – Deleterious Testing*

[ ] Sampling Procedure
[ ] Testing Procedure (ITM 219)
[ ] Frequency

Steel Furnace Slag -- Bulk Specific Gravity Testing (SMA)*

[ ] Sampling Procedure
[ ] Testing Procedure (AASHTO T 85)
[ ] Frequency

Composite Stockpiling*

[ ] Sources
[ ] Monthly Summary Report
[ ] Means of Tracking Bulk Specific Gravity and Absorption

Material Categories - Each

[ ] Standard Specifications
[ ] Quality Assurance
[ ] Alternate

Production Flow Diagram

[ ] Points of Sampling
[ ] Symbol Legend

* Only If Occurs

Sampling Plan

[ ] Frequency
[ ] Locations
[ ] Sampling Devices and Techniques
[ ] Test Method Numbers
[ ] Means of Tracking Production and Load-out Tests

Testing Plan

[ ] Gradation
[ ] Decantation (Load-out only)
[ ]* Crushed Particles (Min. 1/Week, None If < 100 t)
[ ]* Deleterious Material (Min. 1/Week, None If < 100 t)
[ ] Procedure for Isolating Non-Conforming Material
[ ] Test Method Numbers

Gradation Control

[ ] Critical Sieve for Quality Assurance Materials
[ ] Target Mean Values - Each
[ ] Standard Deviations - Each
[ ] Control Limits - Each
[ ] Gradation Limits for all Applicable Sieves for Quality Assurance Materials
[ ]* Identification of Materials with no Control Limits
[ ]* Load-Out Target Mean and Control Limits Different from Normal Production Values

Process Control Techniques

[ ]* Types or Greater Frequencies of Testing
[ ]* Mid Stream Sampling & Testing
[ ]* Visual Checks & Monitoring

Downstream Control

[ ] Identification of Stockpiles (Size of Material)
[ ] Stockpile Construction Technique
[ ] Product Retrieval Technique - Loading & Shipping Safeguards

* Only If Occurs

____

____

____

Laboratory Capability

[ ] Location
[ ] List and Description of Verified Equipment
[ ] Verification Test Methods and Frequency

Documentation Plan

[ ] Reference Publications
[ ] Diary
[ ] Control Charts
[ ] Test Data
[ ] Material Shipment Record
[ ] Location of Documents
[ ] Copies of Forms (optional)

Producer Yard

[ ]* Method of Control

Addenda

[ ] Means of Handling Addenda
[ ] Statement Concerning Source Number, Date of Revision, and Means of Identifying Revision

Annual Aggregate Source Report (Stone Only)

[ ] Included in Appendix

Authentication

[ ] Last Page
[ ] Right Hand Signature Block Signed and Dated by Producer Management Representative
[ ] Left Hand Blank & Title – Manager, Office of Materials Management

8 Testing Equipment

Laboratory

General
Sampling
Sample Reduction
Sieve Analysis
Decantation
Deleterious and Chert

Test Equipment Verification

Laboratory Set-Up

CHAPTER EIGHT:
TESTING EQUIPMENT

Before entering the Coordinated Testing Phase of the Certified Aggregate Producer Program, the Producer is required to have a suitable laboratory and testing equipment that has been verified to accomplish the program requirements. Laboratories are checked by an INDOT representative before start-up of the Coordinated Testing Phase and periodically to maintain the integrity of certified production.

LABORATORY

GENERAL

Equipment required for the various general procedures:

1) Electronic balance, Class G2, general purpose balance in accordance with **AASHTO M 231**. The balance is required to be readable to 0.1 g and accurate to 0.2 g or 0.1 percent of the test load, whichever is greater, throughout the range of use.

2) Laboratory oven, (optional) capable of maintaining a temperature of 230 ± 9° F, and ample interior volume to handle the anticipated sample load

3) Metal pans for drying and storage

4) Utensils for washing and drying samples, such as trowels, spatulas, etc.

5) Appropriate data sheets, log books, etc.

SAMPLING

Equipment required for **AASHTO T 2 (ASTM E-75)** or **ITM 207**:

1) Square-nose shovel

2) Sampling tube or fire shovel for fine aggregate

3) Containers, such as 5 gallon buckets, plastic fiber bag, etc. Galvanized bushel tubs work well and will stand up to oven temperatures.

4) Labels of sufficient size to allow for proper identification of samples

SAMPLE REDUCTION

Equipment required for **AASHTO R 76**:

1) Mechanical splitters with proper fitting pans

2) 5 gallon buckets

SIEVE ANALYSIS

Equipment required for **AASHTO T 27**:

1) For coarse aggregates a 15 in x 23 in. or 14 in. x 14 in. sieves are recommended. The sieve sizes should be of appropriate sizes to accommodate the material being tested. Cutter sieves may be used to ensure overloading does not occur.

2) For fine aggregates; 8 in. or 12 in round sieves are recommended. The sieve sizes should be of appropriate sizes to accommodate the material being tested. Cutter sieves may be used to ensure overloading does not occur.

3) Sieve brushes never use a wire brush on sieves smaller than the No. 50 sieve)

DECANTATION

Equipment required for **AASHTO T 11**:

1) Sieves sizes No. 16 and No. 200. The No. 200 sieve is protected from punctures and tears by covering with the No. 16 sieve.

2) Container, size sufficient to hold the sample covered with water and to permit vigorous agitation

3) Wetting agent (optional), such as liquid detergent, etc. Some fine materials, especially limestone dust, require a wetting agent to break the surface tension of the particles. A drop or two of dishwashing liquid is usually sufficient.

4) Decant machine (optional) (may be used provided the results are consistent with those obtained using manual operations)

DELETERIOUS AND CHERT

Equipment required for deleterious and chert:

1) Scratch hardness tester – ITM-206 (Gravel only)

2) Hydrochloric acid and glass plate

TEST EQUIPMENT VERIFICATION

The test equipment is required to be properly verified and maintained within the limits described in the applicable test method. Verification of the test equipment is to be prior to beginning testing in the Coordinated Testing Phase. The Producer is to verify the equipment at the minimum frequency as follows:

Equipment	Requirement	Min. Freq.	Procedure
Balances	Verification	12 mo.	ITM 910
Mechanical Shakers	Check sieving thoroughness	12 mo.	ITM 906
Sieves	Check physical thoroughness	12 mo.	ITM 902

LABORATORY SET-UP

Proper organization of the laboratory will maximize efficiency and minimize problems and erroneous results. The laboratory should be organized in the direction of a consistent flow. For example, the equipment may be arranged from left to right when conducting sieve analyses as follows:

1) Riffle splitter -- for reduction of incoming samples

2) Oven or other heat source -- for drying samples after reduction

3) Cooling rack and fan -- (note: make sure that the fan does not blow towards the balance in the weighing area or disperse sample fines)

4) Coarse aggregate shaker

5) Fine aggregate shaker

6) Weighing area -- balance should be in an area free from vibration, dust, and air flow

Every laboratory situation is different. Set up the lab to meet the flow requirements of routine tests. Minimize the need for back-tracking, especially if more than one Technician is working at a time. A little extra time and thought to the set up of the lab significantly increases productivity and decreases turn-around time of test results.

9 Sampling

CHAPTER NINE: SAMPLING

Sampling is perhaps the most important step in assuring that good quality aggregates are being used on INDOT contracts. Since a sample is just a small portion of the total material, the importance that the sample be representative of the material being delivered cannot be overemphasized. Any test conducted on the sample, regardless of how carefully and accurately done, is worthless unless the sample is truly representative of the material used on the contract.

SAFETY

The sampling of materials may expose the Technician to machinery, moving belts, large stockpiles, and other potential dangers. Proper safety practices are always the first concern. When an unsafe condition exists, instructions from the Supervisor on the safety procedures for sampling are required to be obtained.

SAMPLE REFERENCES

A representative sample may be obtained by following the standard procedures detailed in **AASHTO T 2,** or **ITM 207**, Method of Sampling Stockpile Aggregate. Any deviations from the aforementioned procedures will require a detailed description within the QCP (ITM 214 Section 14.2.12).

SIZES OF ORIGINAL SAMPLES

The key to any sample program is to obtain a representative sample. A standard sampling method is required to be followed to obtain uniform samples.

The following is a list of recommended minimum sizes of composite samples to be used as a guide when collecting samples.

MATERIAL	SAMPLE SIZE
No. 1 coarse aggregate	385 lb
No. 2 coarse aggregate	220 lb
No. 5 coarse aggregate	110 lb
No. 8 coarse aggregate	55 lb
No. 9 coarse aggregate	35 lb
No. 11, No. 12 & No. 16 coarse aggregate	25 lb
No. 43 coarse aggregate	110 lb
No. 53 coarse aggregate	135 lb
No. 73 coarse aggregate	80 lb
2 in. Structure Backfill	245 lb
1½ in. Structure Backfill	190 lb
1 in. Structure Backfill	135 lb
½ in. Structure Backfill	60 lb
All sands No. 4 & No. 30 B Borrow	25 lb

The weight of the sample depends on the maximum particle size of the material being inspected. As a rule, a larger top size material requires a larger sample. A 25 lb sample of No. 2 coarse aggregate would not be as representative of that material as a 25 lb sample of natural sand.

TWO IMPORTANT DEFINITIONS TO REMEMBER

Top Size or Maximum Particle Size -- The sieve on which 100 percent of the material passes.

Nominal Maximum Particle Size -- Smallest sieve opening through which the entire amount of the aggregate is permitted to pass.

Although these two definitions are almost identical, the difference is important. An INDOT 53 aggregate, for example, is required to have 100 % of the material passing the 1 1/2 in. sieve. The next smallest sieve by Specification is the 1 in. sieve which requires 80-100 % of the material to pass the sieve. The maximum particle size therefore is 1 1/2 in. since 100 % of the aggregate is required to pass the 1 1/2 in. sieve. The nominal maximum particle size is 1 in. since the 1 in. sieve is the smallest sieve which is permitted to have 100 % of the material pass but is not required.

SAMPLE TYPES

The Technician is required to realize there are different types of samples. The most common sample is a stockpile sample, which is normally the method of load-out sampling under CAPP.

Some samples are required to be taken in the processing operation to assure that the final product is within control limits. These samples are referred to as production samples. The gradation of the production sample may not be the same as a load-out sample at some facilities.

Occasionally, an investigative sample is obtained when verifying a specific feature, such as a certain sieve, oversized material, etc. These tests may consist of many shortcuts and are only used as a quick comfort level check.

Every source may have other types of samples which are unique to their operation.

METHODS OF SAMPLING

Because of the various sampling locations and the availability of equipment, there are several methods of taking aggregate samples. Uniformity of obtaining the sample is very important, since the sampling procedure eliminates one variable in the test results. The Technician should remember that safety comes first.

PRODUCTION SAMPLING

Bin Sampling

Sampling the top of the bin is an extremely dangerous as well as a difficult, if not impossible, method to obtain a representative sample. For this reason, this method of sampling is undesirable.

Discharge Sampling of Bins or Belts

Bin samples may be taken at the discharge chute. In these situations, a number of small samples are taken at short intervals and combined to make the total sample. Each of these samples is required to include the entire cross section of the flow of material from the chute or belt.

Continuity of operation normally does not allow the Technician to control the rate of flow from the discharge chute. A mechanical diversion or slide chute system is the quickest, safest, and most accurate system (Figure 9-1). Unfortunately very few mechanical systems exist. All methods, including manual methods, are required to be included in the Quality Control Plan for the source and the proper safety practices should be designated.

Figure 9-1. Discharge Sampling of Belt

Belt Sampling

Belt sampling consists of taking samples of materials directly from the conveyor belts. This may be done by a mechanical sampling device (Figure 9-2) or manually. The proper procedure for manual belt sampling is designated in **AASHTO T 2** and includes the following:

1) Make sure that the belt is carrying a normal load of material that is not segregated

2) Have the plant operator stop the belt and use proper lock out procedures

3) Take a complete cross section of the material, being careful to include all the material on the belt and only the material in the section. A template is recommended, especially on steeply inclined belts. Remove most of the sample with a scoop or shovel and the remainder with a brush.

4) Take as many complete cross sections as necessary to obtain a sample that meets the minimum sample size.

Figure 9-2. Belt Sampling with Mechanical Device

LOAD-OUT SAMPLING

Coarse Aggregate Stockpiles

Coarse aggregates are recommended to be sampled using **ITM 207**.

Fine Aggregate Stockpiles

Fine aggregate samples normally are obtained in the same method as coarse aggregate samples, except a fire shovel or sampling tube is used to collect the material.

SAMPLING DIRECTLY FROM TRUCKS, RAIL CARS, OR BARGES

Direct sampling from trucks, rail cars, or barges is not recommended. There are a number of factors that may influence the gradation of the material, such as segregation or particle breakdown during loading, transporting, and unloading. Therefore, material being shipped by cars or barges is required to be sampled at the point of delivery. Materials being shipped by trucks for local delivery points also are required to be sampled at the point of delivery.

REDUCING A SAMPLE TO TEST SIZE

The total sample (production or load-out) is required to be reduced to a sample size that may be quickly tested. The procedure is conducted in accordance with **AASHTO R 76**. Time does not allow the Technician to test the total sample. The key to sample reduction is to ensure that the sample remains representative of the material in the stockpile. This practice is commonly referred to as splitting a sample. There are four different methods to reduce a sample to the proper test size.

1) The mechanical splitter is the most accepted method of reducing to test size all coarse aggregate material smaller than No. 2 aggregate, except highly moistened compacted aggregate. To determine if a compacted aggregate sample is too wet, a small portion of the sample is tightly squeezed in the palm of the hand. If the small sample crumbles readily, the correct moisture range has been obtained.

2) The sand splitter is the accepted method of reducing fine aggregate or the minus No. 4 material from compacted aggregate samples that is drier than the saturated surface-dry condition. As a quick check to determine this condition, if the material retains the shape when molded in the hand, the material is considered wetter than saturated surface-dry.

3) The miniature stockpile is the method used for fine aggregate that has free moisture on the particle surfaces.

4) Quartering is the method that is used for highly moistened compacted aggregate or when a mechanical splitter is not available.

MECHANICAL SPLITTER

The mechanical splitter (Figure 9-3) separates the sample into halves as the material passes through the spaces between the bars in the splitter. The same number of each particle size goes into each half of the sample, thus keeping the reduced sample representative of the total collected sample.

Figure 9-3. Mechanical Splitter

In using the mechanical splitter, the splitter bars are adjusted so that the bar opening is approximately 50% larger than the maximum particle size of the material to be split. A No. 5 aggregate has a maximum particle size of 1½ in. Therefore, the recommended bar opening is approximately 2.25 in. INDOT allows the bar opening at 3 in. or 6 bars (each bar is approximately 1/2 in) for all coarse aggregate No. 5 or smaller. The splitter is required to be level to ensure that each half of the split is approximately the same size; within approximately 10 percent of each other by weight.

The splitting procedure is as follows:

1) Properly place the pans under the splitter in such a way that all of the particles diverting in both directions will be caught

2) Pour the sample evenly into the hopper

3) Open the hopper fully and allow the material to free fall through the splitter

4) If wet particles stick inside the splitter, gently tap the splitter with a rubber hammer to loosen them

5) To ensure that the sample has not been segregated during sampling, place both halves of the sample back into the hopper and repeat the splitting operation

6) After the second splitting, the two receiving pans contain approximately the same amount of material. Only one pan is placed back into the hopper and the splitting procedure repeated until a sample of the desired size is obtained. Skillful manipulation of the splitter allows a sample of nearly any size to be made that is still representative of the material in the stockpile.

SAND SPLITTER

The sand splitter (Figure 9-4) is a small version of the mechanical splitter except that the openings are fixed and there are no hopper doors.

Figure 9-4. Sand Splitter

The splitting procedure is as follows:

1) Place the pans under the splitter to catch all of the particles

2) Slowly pour the dry sample into the splitter from the side (never from the end or corner)

3) Recombine the samples and split the sample a second time to eliminate any segregation

4) Reduce the sample to proper size by additional splitting of the material in one of the pans

MINIATURE STOCKPILE

The miniature stockpile (Figure 9-5) method is used for reducing all samples of fine aggregates when the material is in a damp or moist condition. If the sample to be split is dry, then the material is required to be moistened before using this method.

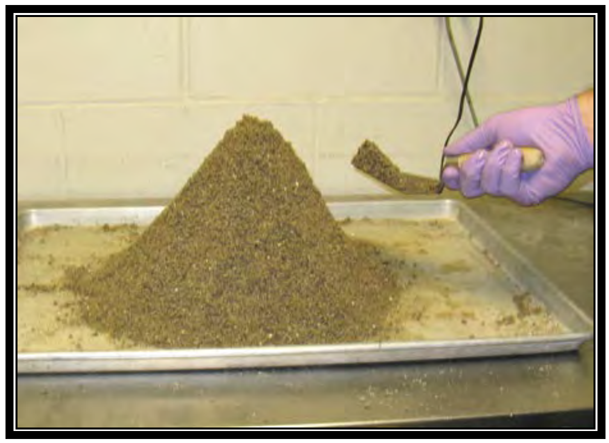


Figure 9-5. Miniature Stockpile

The splitting procedure is as follows:

1) Place the original sample on a clean, dry plate or other hard, smooth, non-absorptive surface

2) Using a trowel or other suitable tool, turn the entire sample over three times

3) Shape the material into a conical pile

4) With a spoon or small trowel, randomly take at least five small portions of material around the pile and one-third way up the cone until the required test sample is obtained

QUARTERING

Quartering (Figure 9-6) is a non-mechanical method of reducing a sample. This is the best method of reducing highly moistened compacted aggregate or when a mechanical splitter is not available.

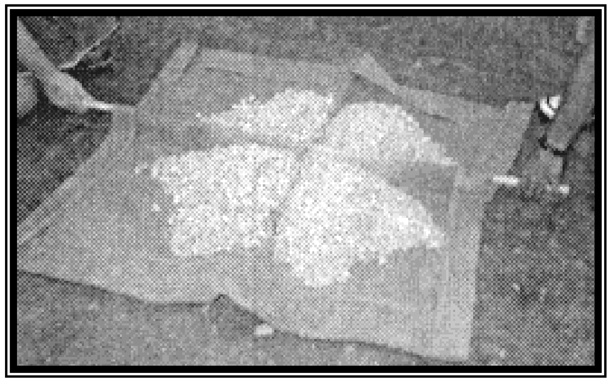


Figure 9-6. Quartering

The quartering procedure is as follows:

1) Place the sample on a hard, clean, level, non-absorptive surface where there will be neither loss of material nor the accidental addition of foreign material.

2) Using a large trowel, shovel, or other suitable tool turn the entire sample over at least three times. Form the sample into a conical pile by depositing individual lifts on top of the preceding lift.

3) Flatten the pile to a uniform thickness by pressing down the apex with a shovel or trowel. E ach quarter sector of the resulting pile is required to contain the material originally in the pile. The diameter of the pile should be equal to 4-8 times the thickness of the pile.

4) With a large trowel or other suitable tool, divide the sample into four equal quarters. Remove two diagonally opposite quarters, including all fine material, and brush the cleared spaces clean.

5) Combine diagonally opposite quarters of the material into two samples. All fine materials shall be included by brushing the surface clean. Store one of these two halves. If the remaining material still weighs too much, repeat the entire quartering process until the proper test sample size is obtained

SIZE OF TEST SAMPLE (AFTER SPLITTING)

The original sample is required to be reduced to a test sample size that is within the minimum and maximum weights of the following table.

WEIGHT OF TEST SAMPLE

AGGREGATE SIZE	MINIMUM	MAXIMUM
No. 2	11,300 g	---
No. 5	6000 g	8000 g
No. 8	6000 g	8000 g
No. 9	4000 g	6000 g
No. 11	2000 g	---
No. 12	1000 g	---
No. 16	1000 g	---
No. 43	6000 g	8000 g
No. 53	6000 g	8000 g
No. 73	6000 g	8000 g
No. 91	6000 g	8000 g
B Borrow	4000 g	6000 g
Structure Backfill, 2 in.	11,300 g	---
Structure Backfill, 1 1/2 in. & 1 in.	6000 g	8000 g
Structure Backfill, 1/2 in.	4000 g	6000 g
Structure Backfill, No. 4 & No. 30	300 g	---
Fine Aggregate	300 g	---

10 Testing

Gradation

Sieving
Decantation
Sieve Analysis Test
Fineness Modulus
Sieve Analysis for Dense Graded (Long Graded) Materials

Deleterious Materials

Deleterious Materials in Coarse Materials
Deleterious Materials in Natural Sands

Crushed Particles

Flat and Elongated Particles

Plastic Limit

Total Moisture Content

CHAPTER TEN:
TESTING

After obtaining and splitting the sample, the next step is to conduct the test. Uniform and consistent testing is required to remove variables in the total operation.

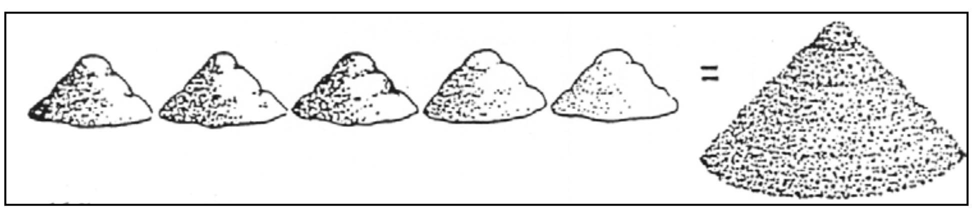
GRADATION

Gradation is the range and relative distribution of particle sizes in the aggregate material.

Range refers to the size limits of an aggregate set and to the number of sizes in that set. For example, the sizes in a set may extend from 1½ in. aggregates to 3/8 in. aggregates and include sizes of 1 in., 3/4 in. and 1/2 in. Another set may extend from 2½ in. aggregates to 1/2 in. aggregates with intermediate sizes of 1½ in., 1 in., and 3/4 in.

The relative distribution refers to the percentage of each particle size in the total material. For example, in a given set of aggregates, 16 percent of the total material could be 1½ in. aggregates, 23 percent could be 1 in. aggregates, 14 percent could be 3/4 in. aggregates and so on.

1½ in. 1 in. 3/4 in. 1/2 in. 3/8 in. Specified Sizes



16 % 23 % 14 % 19 % 28 % 100 %

Sets of graded aggregates are referred to by size number with each having a specified range and relative distribution.

The sizes of fine and coarse aggregates used by INDOT and the gradation requirements for each size are found in Section **904**.

SIEVING

Gradation is determined by sieving. A sample of the aggregate material being tested is weighed and then passed through a series of sieves (Figure 10-1).

Sieve sizes correspond to the size of the openings in the mesh. Range is determined by the number and sizes of sieves used. Relative distribution is calculated by weighing the aggregates retained on each sieve.

The coarser sieves are classified according to the size of the openings, in linear inches. Thus, the 1 in. sieve has openings 1 in. square.

Aggregates coarser than the 1 in. sieve are called plus 1 in. material. Aggregates finer than the 1 in. sieve are called minus 1 in. material. Plus (retained) means coarser than and minus (passing) means finer than. To be retained on any sieve, the aggregates are required to be coarser in every direction than the sieve size.

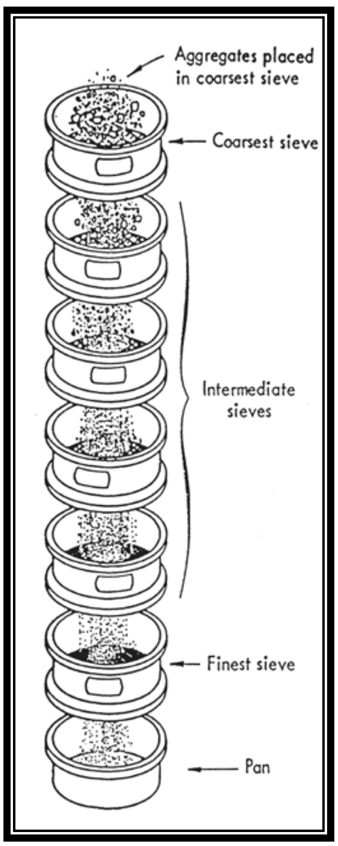


Figure 10-1. Sieves

DECANTATION

The decantation test (Figure 10-2) determines the amount of material finer than the No. 200 sieve. The test is conducted on both fine and coarse aggregate and is usually done in conjunction with the sieve analysis test. The test is conducted according to **AASHTO T 11**, with exceptions noted in Section **904.06**.

Figure 10-2. Mechanical Decant Device

If the total amount passing the No. 200 sieve is required to be determined by the Specifications, the amount is determined by a combination of wet and dry sieving and is represented by the total amount passing the No. 200 sieve following both decantation and dry sieve analysis.

The procedure for decantation is:

1) After the sample has been reduced to the proper size, the sample is thoroughly dried and allowed to cool to room temperature. The weight is recorded on a gradation analysis sheet.

2) The dried material is then placed in a container large enough to hold the sample with adequate wash water and room for agitating the sample.

3) The sample is covered with water.

4) The sample is agitated with a spoon or trowel to separate all particles and to suspend the minus No. 200 material.

5) The wash water is immediately poured or allowed to overflow through a No. 200 sieve. A protector sieve (No. 16) is nested above the No. 200 sieve for protection from the larger particles. Only the wash water (not the sample) is poured on the sieves.

6) The washing and sieving of the wash water is continued until the water runs clear.

7) After the wash water has cleared, the excess water is drained from the sample through the No. 200 sieve. Any residue material is removed from the protector sieve and the No. 200 sieve and placed with the test sample.

8) The washed sample is dried, allowed to cool to room temperature, and weighed. The weight is recorded in the decant section of the gradation analysis sheet.

9) The percentage of material finer than a No. 200 sieve is calculated by using the formula:

$$\% \text{ Decant} = \frac{\text{Original Dry Weight - Dry Weight after Decant}}{\text{Original Dry Weight}} \times 100$$

Example

$$\% \text{ Decant} = \frac{5942.1 - 5885.2}{5942.1} \times 100 = 0.96\% \approx 1.0\,\%$$

Decant	**Original**	**Final**	**Grams Loss**	**% Loss**	**% Req.**
	5942.1	5885.2	56.9	1.0	

Sieve analysis is used primarily to determine the particle-size distribution or gradation of materials. The results are used to determine compliance with the applicable Specification requirements. The test is conducted on both the fine and coarse aggregates and is usually done in conjunction with the decantation test.

The sieve analysis for mineral filler is conducted in accordance with **AASHTO T 37**. Because of the very fine particle-size of mineral filler, this test requires washing the material over the required sieves. The sieve analysis for all other fine aggregates and all coarse aggregates is conducted in accordance with **AASHTO T 27**. Exceptions to **AASHTO T 37** and **AASHTO T 27** are listed in Section **904.06**.

The procedure for the sieve analysis in accordance with **AASHTO T 27** is as follows:

1) The dried (decanted) sample is placed in the top sieve of properly nested sieves. The sieves are nested in sequence with the smallest sieve placed on the pan and stacked by increasing size.

2) The shaking time is required to be sufficient to ensure that the sample is divided into fractional sizes. The actual shaking time is required to be determined in accordance with **ITM 906**. The following times are minimum for shakers used by the industry.

Coarse Aggregate, Size 9 or larger	5 Minutes
Coarse Aggregate, Smaller than Size 9	10 Minutes
Fine Aggregates	15 Minutes

3) At the conclusion of sieving, the material retained on each sieve is carefully transferred to a weigh pan and weighed. The weight retained of the material on each sieve is recorded on the Gradation Analysis sheet. The weight may not exceed the allowable amount on each sieve as indicated in Table 1.

The larger sieves (above the No. 16) are cleaned with a small trowel or piece of flat metal. The sieves between the No. 16 and No. 50 are cleaned with a wire brush. The sieves smaller than the No. 50 are cleaned with a soft bristle brush. Care is required to be taken not to damage the sieves.

TABLE 1
APPROXIMATED SIEVE OVERLOAD

SCREEN SIZE	STANDARD 15 in. x 23in.	STANDARD 14 in. x 14 in.	12 in. DIAMETER	8 in. DIAMETER
3 in.	40.5 kg	23.0 kg	12.6 kg	-------------
2 in.	27.0 kg	15.3 kg	8.4 kg	3.6 kg
1-1/2 in.	20.2 kg	11.5 kg	6.3 kg	2.7 kg
1 in.	13.5 kg	7.7 kg	4.2 kg	1.8 kg
3/4 in.	10.2 kg	5.8 kg	3.2 kg	1.4 kg
1/2 in.	6.7 kg	3.8 kg	2.1 kg	890 g
3/8 in.	5.1 kg	2.9 kg	1.6 kg	670 g
No. 4	2.6 kg	1.5 kg	800 g	330 g

8 in. diameter sieves, No. 8 to No. 200 shall not exceed 200g / sieve

12 in. diameter sieves, No. 8 to No. 200 shall not exceed 469g / sieve

TOTAL WEIGHT: 5942.1g				
SIEVE SIZE	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED
1½ in.	g	g	%	%
1 in.	0 g	5942.1 g	%	%
¾ in.	690.6 g	g	%	%
½ in.	2462.7 g	g	%	%
⅜ in.	1368.1 g	g	%	%
No. 4	997.0 g	g	%	%
No. 8	264.5 g	g	%	%
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	88.1 g	g	%	%
<u>DECANT</u> ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
5942.1 g	5885.2 g	56.9 g	1.0 %	%

4) The weight passing each sieve is calculated next by subtracting the weight retained on the largest sieve from the total sample weight. The weight retained on the next largest sieve is subtracted from the weight of material remaining from the first subtraction. This process is continued for all sieves.

Example:

1 in.	5942.1 – 690.6	= 5251.5
3/4 in	5251.5 –2462.7	= 2788.8
3/8 in	2788.8 – 1368.1	= 1420.7
No. 4	1420.7 - 997.0	= 423.7
No. 8	423.7 - 264.5	= 159.2
Pan material		= 88.1

TOTAL WEIGHT: 5942.1g				
SIEVE SIZE	**WEIGHT RETAINED**	**WEIGHT PASSING**	**PERCENT PASSING**	**PERCENT REQUIRED**
1½ in.	**g**	**g**	**%**	**%**
1 in.	**0 g**	**5942.1 g**	**%**	**%**
¾ in.	**690.6 g**	**5251.5 g**	**%**	**%**
½ in.	**2462.7 g**	**2788.8 g**	**%**	**%**
⅜ in.	**1368.1 g**	**1420.7 g**	**%**	**%**
No. 4	**997.0 g**	**423.7 g**	**%**	**%**
No. 8	**264.5 g**	**159.2 g**	**%**	**%**
No. 16	**g**	**g**	**%**	**%**
No. 30	**g**	**g**	**%**	**%**
No. 50	**g**	**g**	**%**	**%**
No. 100	**g**	**g**	**%**	**%**
No. 200	**g**	**g**	**%**	**%**
PAN	**88.1 g**	**g**	**%**	**%**
DECANT ORIGINAL	**FINAL**	**GRAMS LOSS**	**PERCENT LOSS**	**PERCENT REQUIRED**
5942.1 g	**5885.2 g**	**56.9 g**	**1.0 %**	**%**

5) The percent passing is calculated for each sieve by using the following formula:

$$\% \text{ Passing} = \frac{\text{Weight Passing Each Sieve}}{\text{Original Dry Sample Weight}} \text{ x } 100$$

Example:

$$\text{3/4 in.} \quad \frac{5251.5}{5942.1} \text{ x } 100 = 88.4\%$$

$$\text{1/2 in.} \quad \frac{2788.8}{5942.1} \text{ x } 100 = 46.9\% \quad \text{etc.}$$

TOTAL WEIGHT: 5942.1g				
SIEVE SIZE	**WEIGHT RETAINED**	**WEIGHT PASSING**	**PERCENT PASSING**	**PERCENT REQUIRED**
1½ in.	**g**	**g**	**%**	**%**
1 in.	**0 g**	**5942.1 g**	**100 %**	**%**
¾ in.	**690.6 g**	**5251.5 g**	**88.4 %**	**%**
½ in.	**2462.7 g**	**2788.8 g**	**46.9 %**	**%**
⅜ in.	**1368.1 g**	**1420.7 g**	**23.9 %**	**%**
No. 4	**997.0 g**	**423.7 g**	**7.1 %**	**%**
No. 8	**264.5 g**	**159.2 g**	**2.7 %**	**%**
No. 16	**g**	**g**	**%**	**%**
No. 30	**g**	**g**	**%**	**%**
No. 50	**g**	**g**	**%**	**%**
No. 100	**g**	**g**	**%**	**%**
No. 200	**g**	**g**	**%**	**%**
PAN	**88.1 g**	**g**	**%**	**%**
DECANT ORIGINAL	**FINAL**	**GRAMS LOSS**	**PERCENT LOSS**	**PERCENT REQUIRED**
5942.1 g	**5885.2 g**	**56.9 g**	**1.0 %**	**%**

6) If the test has been done accurately, the sum of all the fractional weights retained (including the material in the pan) and the weight of material removed by decantation are approximately equal to the original dry weight. If the two weights differ by more than 0.3 percent, based on the original dry sample weight, the results are considered invalid.

$$\frac{\text{Original Dry Weight - Summation Weights Measured}}{\text{Original Dry Weight}} \times 100$$

Example:

$$\frac{5942.1 - (690.6 + 2462.7 + 1368.1 + 997.0 + 264.5 + 88.1 + 56.9)}{5942.1} \times 100 =$$

0.2% = valid test

FINENESS MODULUS

The fineness modulus is related to gradation. This term is commonly associated with aggregates for portland cement concrete. The purpose of this value is to determine the relative coarseness or fineness of the aggregate grading.

The fineness modulus is computed in accordance with **AASHTO T 27** by adding the cumulative percentages retained on the 3 1/2 in., 2 1/2 in., 2 in., 1½ in., 3/4 in., 3/8 in., No. 4, No. 8, No. 16, No. 30, No. 50, and No. 100 sieves, and then dividing by 100. A large number indicates a coarse material. A small number indicates a fine material.

Sieve Size	100	-	% Passing	=	% Retained
3/8 in.	100	-	100	=	0.0
No. 4	100	-	100	=	0.0
No. 8	100	-	89.2	=	10.8
No. 16	100	-	68.3	=	31.7
No. 30	100	-	45.1	=	54.9
No. 50	100	-	13.8	=	86.2
No. 100	100	-	2.6	=	97.4
					281.0

281.0 / 100 = 2.81 = Fineness Modulus

SIEVE ANALYSIS FOR DENSE GRADED (LONG GRADED) MATERIALS

Dense graded materials, such as compacted aggregates and some B borrows or subbase, consist of substantial quantities of material retained on and passing the No. 4 sieve.

The procedure for conducting a sieve analysis on a dense graded material is:

1) The entire sample is sieved and weighed in the same manner as well-graded materials, except the smallest sieve is required to be the No. 4 sieve.

2) The portion of the sample passing the No. 4 sieve is weighed.

3) Using a sand sample splitter, the portion of the sample passing the No. 4 sieve is reduced to approximately 500 grams.

4) The reduced sample is weighed and a proportionate factor is determined by dividing the weight of the portion of the sample passing the No. 4 sieve by the weight of the reduced sample. For example, if the total weight of the portion of material passing the No. 4 sieve is 2221.4 grams and the reduced sample weight is 503.4 grams, the proportionate factor would be equal to 2221.4 grams divided by 503.4 grams, which equals 4.413.

5) The reduced sample is sieved for 15 minutes.

6) The material on each sieve is weighed and multiplied by the proportionate factor. The calculated weight is recorded as the total weight of material retained on that sieve.

7) The calculations for percentage passing are completed as for well-graded aggregates.

TOTAL WEIGHT: 6800.8g					
SIEVE SIZE	LONG GRADED WEIGHT RET.	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED
1½ in.		0 g	6800.8 g	100 %	100 %
1 in.		312.9 g	6487.9 g	95.4 %	80-100 %
¾ in.		877.2 g	5610.7 g	82.5 %	70-90 %
½ in.		1228.3 g	4382.4 g	64.4 %	55-80 %
⅜ in.		580.5 g	3801.9 g	55.9 %	%
No. 4		1072.1 g	2729.8 g	40.1 %	35-60 %
No. 8	222.1 g	940.4 g	1789.4 g	26.3 %	25-50 %
No. 16	g	g	g	%	%
No. 30	192.7 g	815.9 g	973.5 g	14.3 %	12-30 %
No. 50	g	g	g	%	%
No. 100	g	g	g	%	%
No. 200	84.8 g	359.0 g	614.5 g	9.0 %	5.0-10.0 %
PAN	4.2 g	17.8 g	g	%	%
DECANT	ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
	6800.8 g	6220.7 g	580.1 g	8.5 %	%

PROPORTIONATE FACTOR	TOTAL WEIGHT PASSING No. 4	SAMPLE SIZE	
	2133.2 g	503.8 g	4.234

DELETERIOUS MATERIALS

Most of the tests for deleterious materials apply to coarse aggregates. The only concern in fine aggregates for deleterious materials is organic impurities.

DELETERIOUS MATERIALS IN COARSE MATERIALS

Deleterious tests for coarse aggregates are based on visual inspection and require training and judgment. Deleterious substances of concern are clay lumps and friable particles, non-durable materials, coke, iron, and chert. Coke and iron are only of concern in slag, and no guidelines are given.

Clay Lumps and Friable Particles

Clay lumps and friable particles are defined as the material remaining after decantation that may be mashed with the fingers. The test is conducted according to **AASHTO T 112**.

A sample consists of material retained on the No. 4 sieve and each sieve above the No. 4 sieve, following decantation of sieve analysis. The sample is soaked 24 hours, plus or minus 4 hours, in distilled water. After soaking, any material or particles that may be broken by the fingers and (Figure 10-4) are removable by wet sieving are classified as clay lumps or friable material. The material retained after wet sieving is dried to constant weight and weighed.

Figure 10-4. Testing for Clay Lumps and Friable Particles

The percent clay or friable material is calculated by:

$$\% \, Clay \; or \; Friable = \frac{\text{Dry Wt. of Sample - Dry Wt. Retained (Wet Sieving)}}{\text{Dry Wt. of Sample}} \text{ x 100}$$

Non-Durable Materials

Non-durable materials are divided into two types:

1) Soft material as determined by **ITM 206**

2) Structurally weak material as determined by visual inspection

Both tests are conducted on the sample material retained on the 3/8 in. sieve and each sieve above the No. 3/8 in. sieve.

The Scratch Hardness test (Figure 10-5) is conducted on gravel coarse aggregate. Each particle to be tested is subjected to a scratching motion of a brass rod, using a 2 lbf load.

Figure 10-5. Scratch Hardness Tester

Particles are considered soft if a groove is made in the particle without deposition of metal from the brass rod or if separate particles are detached from the rock mass. A particle is classified as soft only if one-third or more of the volume is found to be soft. Structurally weak materials are visually identified and include:

1) Ocher
2) Unfossilized shells
3) Conglomerates -- cemented gravels
4) Shale -- laminated rock of clay-size minerals
5) Limonite -- iron oxide, ranging from yellow-brown to black in color and is frequently a concretion around a soft core
6) Weathered rock that is structurally weak
7) Coal, wood, and other foreign materials
8) Materials with loosely cemented grains or a weathered coating

Particles determined to be soft or structurally weak are combined and the percent by weight of non-durable material is calculated by:

$$\% \text{ Non - Durable} = \frac{\text{Weight of Non - Durable Material above 3/8 in. Sieve}}{\text{Weight of Sample above the 3/8 in. Sieve}} \text{ x } 100$$

Chert

Chert is a rock of varied color, composed of glassy silica, and very fine-grained quartz, and is only picked from coarse aggregate. Unweathered chert appears hard, dense, and brittle with a greasy texture. Weathered chert appears chalky and dull. Chert is likely to have concave surfaces with sharp outer edges when freshly broken.

Total chert is picked from the sample following decantation and gradation. Chert is picked from the material retained on the 3/8 in. sieve and each sieve above the 3/8 in. sieve for aggregate sizes 2 through 8, 43, 53, and 73. For aggregate sizes 9, 11, 12, and 91, chert is picked from the material retained on the No. 4 sieve and each sieve above the No. 4 sieve. The procedure for determining the total chert includes:

1) All chert, including questionable chert, is picked from the sample.

2) All pieces of questionable chert are further tested by the following procedures:

   a. Scratching glass. Chert pieces scratch glass.

   b. Breaking Pieces. Chert breaks into rounded surfaces with sharp edges. If pieces do not break into rounded surfaces with sharp edges, they are added to the soft or non-durable material.

   c. Reaction with acid. Chert does not react with 0.1 N hydrochloric acid.

3) All material determined to be chert is weighed and the percent of total chert is calculated using the following formulas:

For aggregate sizes 2 through 8, 43, 53, and 73:

$$\% \text{ Total Chert} = \frac{\text{Weight of Chert above the 3/8 in. Sieve}}{\text{Total Weight of Sample above the 3/8 in. Sieve}} \text{ x } 100$$

For aggregate sizes 9, 11, 12, and 91:

$$\% \text{ Total Chert} = \frac{\text{Weight of Chert above the No. 4 Sieve}}{\text{Total Weight of Sample above the No. 4 Sieve}} \text{ x } 100$$

The percent chert requirement of **904.03(a)** applies to chert less than 2.45 bulk specific gravity. If the percent total chert exceeds this chert requirement, the sample is tested for lightweight pieces in accordance with **AASHTO T 113** to determine the percent chert less than 2.45 bulk specific gravity (Figure 10-6).

Figure 10-5. Test for Lightweight Chert

DELETERIOUS MATERIALS IN NATURAL SANDS

The purpose of the **AASHTO T 21** test is to provide a warning that further tests of the sand are necessary before the sands are approved for use. The procedure is as follows:

1) A glass bottle is filled with approximately 4½ fl oz of the sand to be tested.

2) A 3 percent sodium hydroxide (NaOH) solution in water is added until the volume of the sand and liquid, indicated after shaking, is approximately 7 fl oz.

3) The bottle is stoppered, shaken vigorously, and allowed to stand for 24 hours.

4) The color of the supernatant liquid above the test sample is compared to reference standard colors.

5) If the color of the supernatant liquid is darker than that of the reference color, the sand may contain injurious organic compounds, and further tests are to be made before approving the sand for use in concrete.

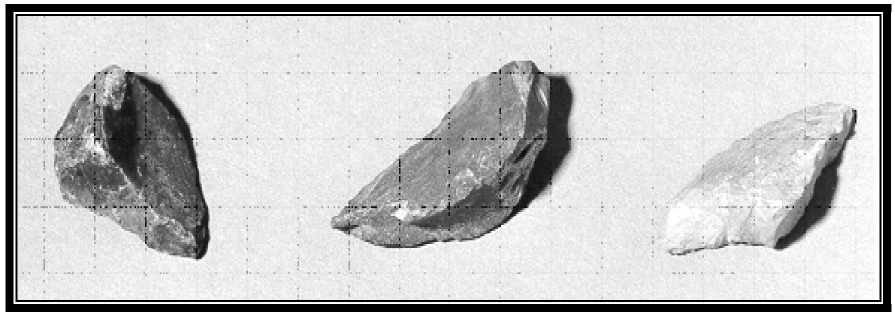
The **AASHTO T 71** test compares the compressive strength of mortar specimens made from the suspect sand to the compressive strength of mortar made from acceptable sand.

The colorimetric test (**AASHTO T 21**) is conducted first (Figure 10-6). If the color in solution is lighter than a standard, the fine aggregate is acceptable. If the color is darker, further testing of the fine aggregate for strength in mortar, **AASHTO T 71**, is required. If the effect of any organic matter reduces the strength no more than 5 percent, the fine aggregate is acceptable. Also, observations are required to be made to determine whether the organic material retards the mortar set or changes the necessary air-entraining admixture dosage.

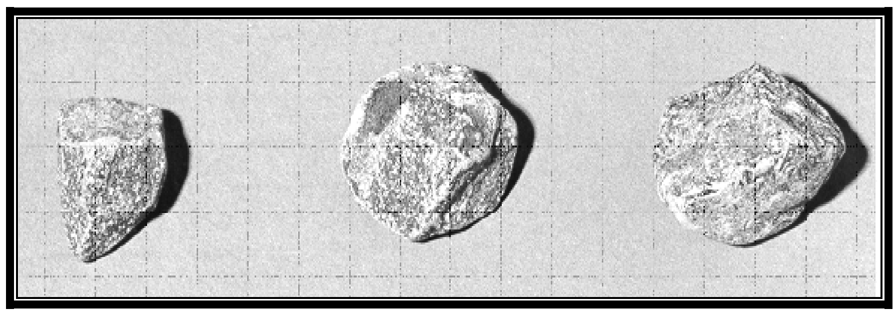
Figure 10-6. Colorimetric Test

CRUSHED PARTICLES

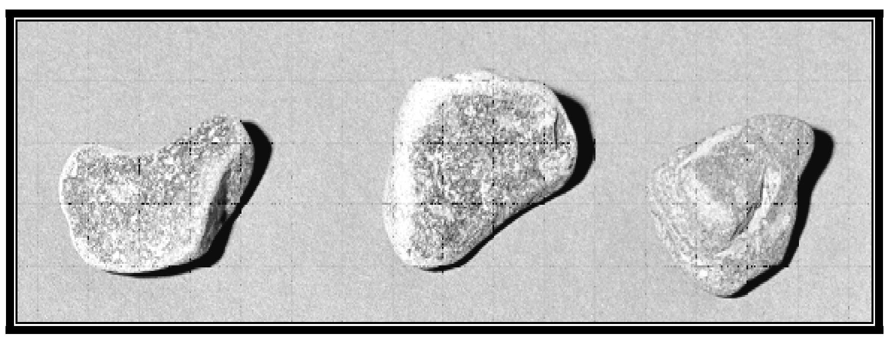
ASTM D 5821 includes the procedure for determining the quantity of crushed particles (Figure 10-7). Crushed particle requirements are used for gravel coarse aggregates in HMA (one and two-faced), compacted aggregates, and asphalt seal coats (except seal coats used on shoulders).



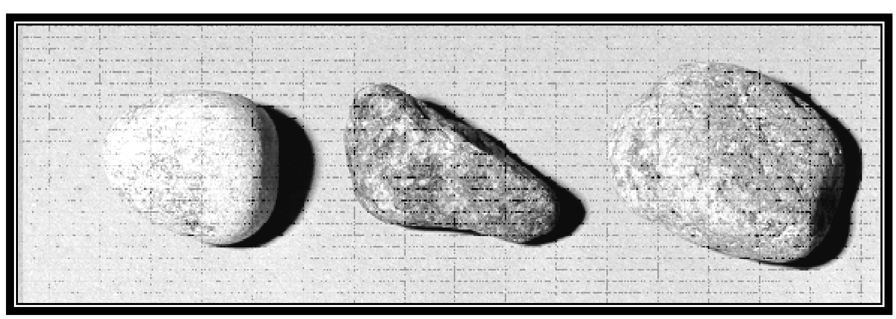
Crushed Particles (Sharp Edges, Smooth Surfaces)



Crushed Particles (Round Edges, Rough Surfaces)



Non-Crushed Particles (Round Edges, Smooth Surfaces)



Non-Crushed Particles (Rounded Particles, Smooth Surfaces)

Figure 10-7. Crushed and Uncrushed Particles

The test applies to all particles retained on the No. 4 sieve and is conducted as follows:

1) The total sample is washed over the No. 4 sieve and dried to a constant weight.

2) Each particle is evaluated to verify that the crushed criteria is met. If the fractured face constitutes at least one-quarter of the maximum cross-sectional area of the rock particle and the face has sharp or slightly blunt edges, the particle is considered a crushed particle.

3) Particles are separated into two categories: (a) crushed particles, and (b) non-crushed particles.

4) When two-faced crushed particles are required for aggregates used in HMA the procedure is repeated on the same sample.

5) The percent of crushed particles is determined by the following formula:

$$P = \frac{F}{F + N} \times 100$$

where:

P = percentage of crushed particles
F = weight of crushed particles
N = weight of uncrushed particles

FLAT AND ELONGATED PARTICLES

ASTM D 4791 (Method B) includes the procedure for determining the quantity of flat and elongated particles (Figure 10-8). The Specifications define a flat and elongated particle as "one having a length to thickness ratio greater than five".

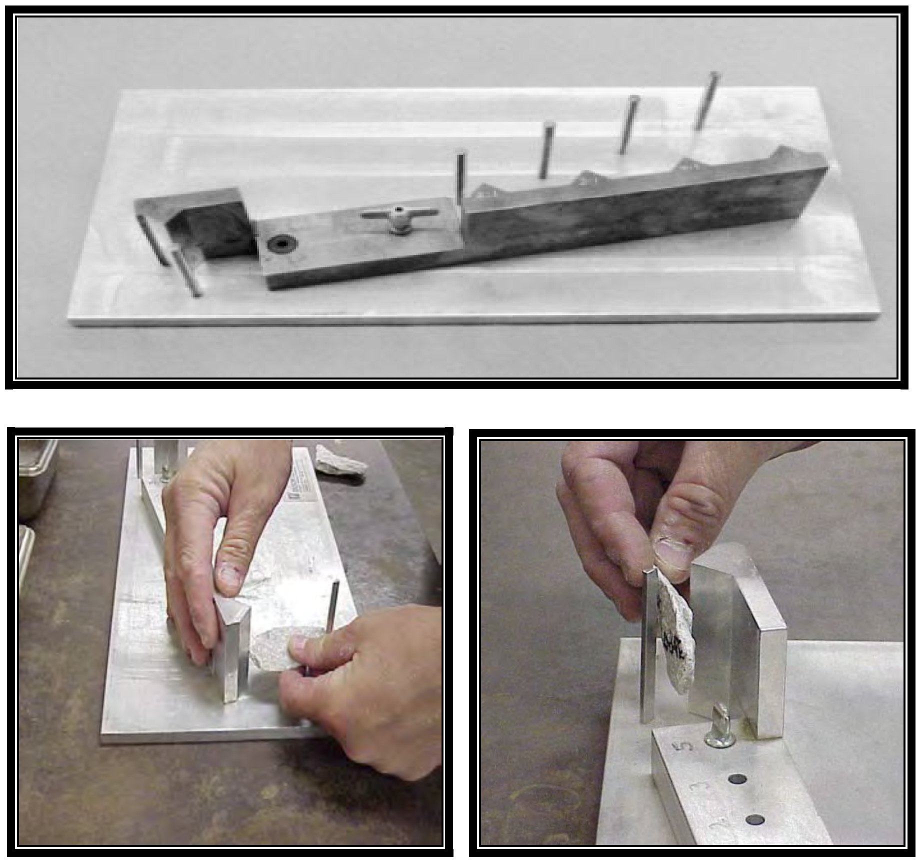


Figure 10-8. Flat and Elongated Test

The test is conducted on particles retained on the 3/8 in. sieve and each sieve above the 3/8 in. sieve as follows:

1) The total sample retained on the 3/8 in. sieve is weighed.

2) Each size fraction above the 3/8 in. sieve present in the amount of 10 % or more of the original sample is reduced until approximately 100 particles are obtained for each size fraction.

3) Each particle is measured with the proportionate caliper device set at the required ratio

4) The flat and elongated particles are weighed for each sieve.

5) The percent of the flat and elongated particles is then determined on each sieve by the following formula:

$$\text{\% Flat and Elongated} = \frac{\text{Weight of F \& E Particles for each Sieve}}{\text{Total Weight of Reduced Sample for each Sieve}} \text{ x } 100$$

PLASTIC LIMIT

Compacted aggregate materials, fine aggregate for SMA, mineral filler for SMA, and coarse aggregate sizes No. 43, 53, and 73, require tests for determining the plastic limit and liquid limit (Figure 10-9) of minus No. 40 sieve material. The plastic limit test may be conducted accurately only in a laboratory; however, the possibility of a plastic condition may be determined by a field check test. The liquid limit is required to be conducted in the laboratory.

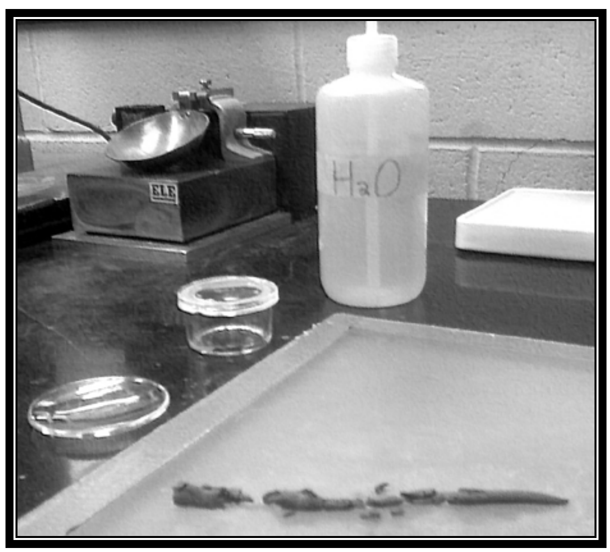


Figure 10-9. Plastic Limit and Liquid Limit

The plastic limit test may not be conducted on the same sample used for any other field tests. Therefore, in addition to the sample selected for the other field tests, the Technician is required to split and dry a sample of approximately 1000 grams. The test is conducted using a small spatula, a ground-glass plate, and an evaporating dish in accordance with **AASHTO T 90** as follows:

1) Using sufficient sieves, remove the material above the No. 40 sieve. All of the minus No. 40 sieve material in the sample is required. Any minus No. 40 sieve material clinging to the larger particles is required to be scraped free and all the dried composite particles retained above the No. 40 sieve is required to be broken up.

2) Thoroughly mix the minus No. 40 sieve material and select a sample of about 20 grams.

3) Place the sample in a suitable container, preferably an evaporating dish, and thoroughly mix with distilled or demineralized water until the material becomes plastic enough to be easily shaped into a ball.

4) Take about half of the sample and squeeze and form the sample into the shape of a small cigar. Place the specimen on a ground glass plate. With fingers, using just sufficient pressure, roll the specimen into a thread of uniform diameter throughout the sample length. The rate of rolling will be between 80 and 90 strokes per minute, counting a stroke as a complete motion of the hand forward and back to the starting position. The rolling continues until the thread is 1/8 in. in diameter.

Most compacted aggregate materials do not contain plastic fines. If the specimen cannot be rolled into a thread of 1/8 in. diameter, the Technician may assume that the material is either nonplastic or has a low plastic content, and no additional testing is required. If the specimen may be rolled into a thread of 1/8 in., the material is considered plastic and a sample is required to be sent to the District laboratory for an accurate determination of plasticity index.

TOTAL MOISTURE CONTENT

When aggregates are used in portland cement concrete mixtures, the moisture of the aggregates is required to be determined to adjust aggregate weights for moisture content and to determine the moisture contribution to the mixing water.

When a moisture content is desired, the sample is required to be reduced to test size and the test is conducted as quickly as possible after the sample has been obtained. Any delay in conducting the test after the sample has been selected may allow the material to lose moisture and result in inaccurate results.

The test is conducted in accordance with **AASHTO T 255** as follows:

1) Weigh the sample before drying and record the weight.

2) Dry the sample and cool to room temperature.

3) Weigh the sample and record the weight.

4) Determine the moisture percent using this formula:

$$\% \text{ Moisture} = \frac{\text{Weight Wet - Weight Dry}}{\text{Weight Dry}} \text{ x } 100$$

Table of Formulas

$$\% \text{ Decant} = \frac{\text{Original Dry Weight - Dry Weight after Decant}}{\text{Original Dry Weight}} \text{ x } 100$$ (0.0) p. 10-4

$$\% \text{ Passing} = \frac{\text{Weight Passing Each Sieve}}{\text{Original Dry Sample Weight}} \text{ x } 100$$ (0.0) p. 10-10

$$\% \text{ Error} = \frac{\text{Original Dry Weight - Summation Weights Measured}}{\text{Original Dry Weight}} \text{ x } 100$$ (0.0) p. 10-12

(>+-0.3% is Invalid Test)

$$\text{Fineness Modulus} = \frac{\text{Cumulative Percentages "Retained"}}{100}$$ (0.00) p. 10-12

DELETERIOUS, CRUSHED, FLAT AND ELONGATED, MOISTURE

$$\% \text{ Clay or Friable} = \frac{\text{Dry Wt. of Sample - Dry Wt. Retained (Wet Sieving)}}{\text{Dry Wt. of Sample}} \text{ x } 100$$ (0.0) p. 10-16

$$\% \text{ Non - Durable} = \frac{\text{Weight of Non - Durable Material above 3/8 in. Sieve}}{\text{Weight of Sample above the 3/8 in. Sieve}} \text{ x } 100$$ (0.0) p. 10-17

$$\% \text{ Total Chert} = \frac{\text{Weight of Chert above the 3/8 in. Sieve}}{\text{Total Weight of Sample above the 3/8 in. Sieve}} \text{ x } 100$$ (0.0) p. 10-18

$$\% \text{ Total Chert} = \frac{\text{Weight of Chert above the No. 4 Sieve}}{\text{Total Weight of Sample above the No. 4 Sieve}} \text{ x } 100$$ (0.0) p. 10-18

$$\% \text{ Crushed (P)} = \frac{\text{Wt. of Crushed Particles (F)}}{\text{(F) + Wt. of Uncrushed Particles (N)}} \text{ x } 100 = P = \frac{F}{F + N} \text{ x } 100$$ (0) p. 10-22

$$\% \text{ Flat and Elongated} = \frac{\text{Weight of F \& E Particles for each Sieve}}{\text{Total Weight of Reduced Sample for each Sieve}} \text{ x } 100$$ (0) p. 10-24

$$\% \text{ Moisture} = \frac{\text{Weight Wet - Weight Dry}}{\text{Weight Dry}} \text{ x } 100$$ (0.0) p. 10-26

11 Job Responsibilities

Time Management

Time Consuming Activities
Example Schedule

Frequency of Sampling and Testing

Gradation
Decantation
Crushed Particles
Deleterious Materials
Additional Tests

Diary Requirements

Examples

CHAPTER ELEVEN: *JOB RESPONSIBILITIES*

All persons in the chain of command at the processing plant are required to be aware of their responsibilities and how they fit into the overall manufacturing process. As problems occur in the process, each individual in the system is required to perform in a professional manner to insure the final result is a quality product.

TIME MANAGEMENT

The Certified Aggregate Technician may be responsible for more than one plant. Therefore, the Technician and Supervisor are required to know how much time is needed for conducting tests and the travel time between plants before writing the Quality Control Plan. Job duties other than quality control also are required to be addressed.

TIME CONSUMING ACTIVITIES

The approximate times for the various required duties include the following:

ACTIVITY	EXPENDED TIME
Meeting with management to receive production information	1 to 3 hours or more
Notifying the persons involved with process of sampling	5 minutes to 1 hour
Sampling the material per size	5 minutes to 1 hour or more
53, 73, and B borrow: splitting, drying, decant, drying, calculation, and charting per size	3 hours or more

ACTIVITY	EXPENDED TIME
5, 8 9, 11, 12 and fine aggregates: splitting, drying, decant, drying, calculation, and charting per size.	1 hour or more
Checking problems in the plant that may have caused a g radation problem	1 hour or more
Checking the quality control in the pit daily	1 hour or more
Notifying supervisor of any problems	5 minutes to 1 hour or more
Travel time	5 minutes to 1 hour; more than 1 hour will affect test time
Diaries	5 minutes to 1 hour
Cleaning lab	30 minutes to 1 hour

EXAMPLE SCHEDULE

Every morning or at the beginning of the shift, the Technician should meet with the Supervisor to schedule the production and stockpile testing. The mining area the material is being produced, and if the material is required to meet any special requirements are necessary to know.

If process control is maintained at one or more locations, a time schedule is required to be established to meet the testing frequency of products at each location.

EXAMPLE OF A TYPICAL DAY
1. Meet with supervisor to receive production information
2. Notify the persons involved with the process of sampling from production or stockpile (plant operator, stockpile driver, loader operator)
3. Sample the material using the approved method and equipment
4. Check stockpiles for any contamination or segregation problems, and check the mining area to make sure what material is being produced and what quality control procedures are being followed
5. Record all the sample information in the log book and start testing procedures
6. Notify the Supervisor of any failures and make copies of gradation analysis for customer, Supervisor, and file
7. Plot all test results on the control charts and conduct statistical analysis before the end of the day
8. Maintain a daily file on all tests conducted and keep a clean and orderly lab

Day-to-day operations may be interrupted by unexpected occurrences, such as customer relations, special requests, writing reports, or working with INDOT personnel.

FREQUENCY OF SAMPLING AND TESTING

The most time consuming activity required by the CAPP is the sampling and testing of the aggregates.

Each Plant/Redistribution Terminal is required to determine the frequency of sampling and testing based on the control required to assure that the customer is obtaining the product specified.

The term certified material is defined as a product produced under the CAP Program intended for INDOT use. A frequency is required to be established for each certified material in the Quality Control Plan.

GRADATION

The minimum frequencies of sampling and testing for gradation include three time periods: Start of Production, Normal Production, and Load-Out.

The minimum requirement for sampling and testing a certified material during Start of Production is:

1) One test per 1000 t for the first 5000 t produced

2) A maximum of two per calendar day

The minimum requirement for sampling and testing a certified material during Normal Production is:

1) One test per 2000 t

2) A maximum of two per calendar day

The minimum requirement for sampling and testing a certified material during Load-Out is:

1) One test per 8000 t shipped

2) A minimum of one test per month for any certified material shipped that exceeds 1000 t

DECANTATION

All load-out samples are required to be decanted. Unless specific problems are encountered, start of production and normal production samples do not require a decant test.

CRUSHED PARTICLES

The minimum requirement for determining the amount of crushed particles is one test per week for each size of material during start of production and normal production. No test is required if the week's production is less than 100 t.

DELETERIOUS MATERIALS

The minimum requirement for determining the percentage of deleterious materials is one test per week for each size of material during the start of production and normal production. No test is required if the week's production is less than 100 t.

ADDITIONAL TESTS

The exact frequency of sampling and testing is source specific and is required to be defined in the Quality Control Plan.

Each Plant/Redistribution Terminal may conduct additional tests to maintain control of their operation. More testing may provide an additional assurance that the product being shipped is within the controls established.

DIARY REQUIREMENTS

Each Plant/Redistribution Terminal is required to maintain a diary. Test reports do not substitute for a diary. The diary is required to be an open-format book with at least one page devoted to each day that there is a material related operation. Entries into the diary are required to include:

1) General weather conditions

2) Area of extraction-location and ledges or pit area

3) Estimated quantity of materials produced

4) Time test samples obtained and tested, and corrective action if there were problems

5) Changes in key personnel, if any

6) Changes in equipment, plant, screens, etc., which may affect the current statistical results of aggregate materials

7) Any significant events or problems

8) Any nonconforming condition, as well as the action taken to correct the condition, if needed.

The diary entry is to be routinely signed each day by the Certified Aggregate Technician or Management Representative. On occasion the diary may be signed by another person; however, the diary is required to then be counter-signed by the Certified Aggregate Technician or Management Representative. Examples of diaries are shown on the following pages.

CAPP' DIARY

LOCATION: DATE: ______ START: ______

INDOT #: CAPP #: ________ STOP: ______

WEATHER: ______________________________ DOWN DATES: ______

IDLE TIME: ___________ (HOLIDAYS), ____________ (WEEKENDS)

GRID: ______________ : ___________

SAMPLES PULLED		
SIZE	TYPE *	TIME

TONS PRODUCED TODAY AND MONTHLY RUNNING TOTALS (MRT)

SIZE											TOTAL
TONS											
MRT											

SUPERINTENDENT'S (OR REPRESENTATIVE) REMARKS

CHANGES – PLANT, GRID, KEY PERSONNEL, ETC: ________________________

____

____

EVENTS – PROBLEMS WITH PLANT, SCREENS, EQUIPMENT, ETC; ______________

____

____

____

____

____

____

____

____ (INITIALS ____)

***SAMPLE TYPES**

S = START UP FREQUENCY

N = NORMAL FREQUENCY

L = LOAD-OUT FREQUENCY

M = MISC.

R = RESAMPLE

CERTIFIED AGGREGATE TECHNICIAN'S REMARKS ____________________

____

____

____

____

____

______________________________ / ______________________________

(NAME - PRINTED) (SIGNATURE)

FN: DIARY355

CAPP' DIARY - ADDITIONAL REMARKS

SOURCE #: DATE:

SUPERINTENDENT'S (OR REPRESENTATIVE) REMARKS – CONTINUED

( )
INITIALS

CAT'S REMARKS - CONTINUED

/

(PRINTED NAME) (SIGNATURE)

08/95

AGGREGATE TECHNICIAN PLANT DIARY

COMPANY:

SOURCE & Q #:

DATE: MONDAY TUESDAY WEDNESDAY THURSDAY FRIDAY SATURDAY SUNDAY

WEATHER: CLOUDY. SUNNY. RAIN. THUNDER STORM. SNOW. COOL. COLD. WARM

MATERIAL PRODUCED & TONS:

VISUAL INSPECTION:	1 ST VISIT	2ND VISIT	3RD VISIT	4TH VISIT	START - UP
TIME:/ INITIAL	7AM	9:45AM	12:55PM	3:00PM	TIME
STOCKPILE/LOADOUT:					
DEGREDATION	YES/NO	YES/NO	YES/NO	YES/NO	SHUT-DOWN
SEGREGATION	YES/NO	YES/NO	YES/NO	YES/NO	TIME
CONTAMINATION	YES/NO	YES/NO	YES/NO	YES/NO	

LEDGE/LIFT:	PLANT CHANGES:
SHOT LOCATION:	
PIT AREA:	

SAMPLES PULLED PRODUCTION:				OBTAINED DATE:	OBTAINED TIME:	COMPLETED DATE:	COMPLETED TIME:	PASS/FAIL COMMENTS:
1000 / 2000	LAB #	FREQ	SIZE					
FREQUENCY								
S = START-UP								
N = NORMAL								
I = INFO								
A=AUDIT								
LOADOUT:								
8000								
RESAMPLE:								

PROBLEMS:/ ACTION TAKEN AND CHANGES IN PLANT OR KEY PERSONNEL:	SIGNATURE
	AUDIT SAMPLED BY

TOTAL WEIGHT | GRAMS | LBS. | Report No. | Contract No. | RS 4-95

SIEVE SIZE	LONG GRAD. WEIGHT RET.	WEIGHT RETAINED	WEIGHT. PASSING	PERCENT PASSING	CONTROL LIMITS	CUSTOMER SPECS.
3" (75 mm)						
2 1/2" (63 mm)						
2" (50 mm)						
1 1/2" (37.5 mm)						
1" (25 mm)						
3/4" (19 mm)						
1/2" (12.5 mm)	P/F					
3/8" (9.5 mm)						
No. 4 (4.75 mm)						
No. 6 (3.35 mm)						
No. 8 (2.36 mm)						
No. 12 (1.70 mm)						
No. 16 (1.18 mm)						
No. 20 (850 um)						
No. 30 (600 um)						
No. 50 (300 um)						
No. 60 (250 um)						
No. 80 (180 um)						
No. 100 (150 um)						
No. 140 (106 um)						
No. 200 (75um)						
No. 270 (53 um)						
No. 325 (45 um)						
PAN	ORIGINAL	FINAL	GRAMS LOSS	% LOSS		
DECANT						

NON-DURABLE	TOTAL WT. 3/8" UP	WT. OF NON-DUR.	% NON-DUR.
AGG SIZE 5, 8, 57, 53, 73			
TOTAL CHERT	SAMPLE WT. 3/8" UP	WT. OF TCT CHERT	% TOTAL CHERT
AGG SIZE 5, 8, 57, 53, 73			
MECH. CRUSHED	SAMPLE WT. NO. 4 UP	WT. OF MECH. CRUSHED PT.	% MECH. CRUSHED

SOUTHERN INDIANA STONE CO.

SAMPLE FROM	PLANT
TEST NO.	LOCATION
LEDGES	SHOT LOCATION #
OBTAINED DATE Mo. Day	TIME OBTAINED
COMPLETED DATE Mo. Day	TIME COMPLETED
MATERIAL	Moisture (CAS) (CAB) %
FREQUENCY	☐ START-UP ☐ NORMAL
SPECIFICATION	93 - 1993 95 - 1995 SP - SPEC. PROV.
PURPOSE	73 - JOB CONTROL 75 - INFORMATION
SAMPLED BY	SUPERINTENDENT
TONS REP. BY TEST	PR. ☐ SP. ☐ YES - 3 DELETERIOUS TESTS PERFORMED NO - 4
MATERIAL STATUS K2 ACCEPTED K6 REJECTED K7 VISUAL L1 INFO	WEATHER

QUALITY CHECKS AND CORRECTIVE ACTION	MATERIAL PRODUCED	MATERIAL SAMPLED
TOO FINE		
TOO COARSE		
CRUSHER SETTINGS		
JAW SETTING		
SCREEN CHANGES		
SEGREGATION		
CONTAMINATION		
WASH SAMPLE		
	LEDGE AND STOCKPILE INSPECTION TIMES	
DRY SHAKE		
	AM	PM
RESAMPLE	AM	PM

LONG GRADED MATERIAL	TOTAL WT. PASS No. 4 GM	SAMPLE SIZE GM	PROPORT. FACTORS	AUDIT SAMPLED BY
TOTAL CHERT	SAMPLE WT. No. 4 UP	WT. OF TOTAL CHERT	% TOTAL CHERT	1. Stock/Stockpile 2. Bin or Tank 3. Processing Equipment 4. Truck, Barg, or Car 5. Inplace, Jobsite 6. Ledge or Pit 7. Customer Yard
AGG. SIZE 9, 11				
TOTAL CRUSHED	SAMPLE WT. No. 4 UP	WT. TOTAL CRUSHED	% TOTAL CRUSHED	

REMARKS

Appendix A

Indiana Test Methods

202 Acid Insoluble Content of Fine Aggregates

203 Control Procedures for Classification of Aggregates

205 Acceptance Procedures for Dolomite Aggregates

206 Scratch Hardness of Coarse Aggregate Particles

207 Sampling Stockpiled Aggregates

209 Soundness of Aggregates by Freezing and Thawing in a Brine Solution

210 Class AP Coarse Aggregate for Concrete Pavement and Slab-on-Grade Concrete

211 Certified Aggregate Producer Program

212 Acceptance Procedures of Air Cooled Blast Furnace Slag for Leachate Determination

214 Acceptance Procedures for Polish Resistant Aggregates

219 Acceptance Procedures for Steel Slag for Deleterious Materials (on-line)

220 Class AS Aggregate for Use in SMA Mixture (on-line)

221 HMA Surface Mixture Coarse Aggregate for Seal $\geq$ 10,000,000 (on-line)

223 Hydraulic Fracture Test (on-line)

224 Flakiness Index of Aggregates (on-line)

902 Verifying Sieves

906 Verifying Mechanical Shakers

910 Verifying Balances

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

ACID INSOLUBLE CONTENT OF FINE AGGREGATES
ITM No. 202-15T

1.0 SCOPE.

1.1 This test method covers the procedure for quantitative determination of the acid insoluble content of fine aggregates used in HMA.

1.2 The fine aggregate is crushed or ground to a fineness sufficient to pass through a No. 30 (600 µm) sieve. A dried sample is dissolved and digested in dilute acid, filtered, and the washed and dried residue weighed back as the insoluble fraction.

1.3 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 AASHTO Standards.

M 92 Wire-Cloth Sieves for Testing Purposes
M 231 Weighing Devices Used in the Testing of Materials

2.2 ASTM Standards.

D 1193 Reagent Water
E 960 Laboratory Glass Beakers
E 1406 Laboratory Glass Filtering Flasks
E 145 Gravity-Convection and Forced-Ventilation Ovens

2.3 OTHER Standards.

Reagent Chemicals, American Chemical Society Specifications

3.0 TERMINOLOGY.

Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specification, Section 101.

4.0 SIGNIFICANCE AND USE.

This ITM is used to verify the minimum specification requirements for acid insoluble content of fine aggregates used in HMA.

5.0 APPARATUS.

5.1 Sieve, No. 30, conforming to the requirements of AASHTO M 92

5.2 Mechanical crusher or mortar and pestle

5.3 Drying oven, capable of operation at 210 to 260°F in accordance with ASTM E 145

5.4 Analytical balance, Class A, conforming to the requirements of AASHTO M 231

5.5 Dessicator, glass, with dessicant

5.6 250 mL griffin low form borosilicate glass beakers in accordance with ASTM E 960, Type I

5.7 Erlenmeyer vacuum flask, borosilicate glass, in accordance with ASTM E 1406, Type III, Class 2, with crucible holder

5.8 Vacuum pump or other vacuum source

5.9 Ceramic or glass gooch filtering crucibles, medium porosity fritted disc, 25 mL minimum capacity

5.10 Hot plate, electrical, with heat control

5.11 Chemical fume hood

6.0 REAGENTS.

6.1 **Purity of Reagents.** Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society.

6.1.1 Hydrochloric acid, concentrated

6.1.2 Methanol

6.2 **Purity of Water.** Unless otherwise indicated, references to water shall be Type II reagent water in accordance with ASTM D 1193.

7.0 SAMPLE PREPARATION.

7.1 Separate 100 g of the material to be tested on a No. 30 sieve.

7.2 Crush or grind the portion retained on the sieve, by means that will not contaminate the sample, until substantially all of the material passes the sieve.

7.3 Combine all portions of the original 100 g material.

7.4 Quarter this material until approximately 10 g are obtained as a representative sample.

7.5 Dry the sample at 221 ± 9°F for at least 2 h.

7.6 Remove the sample from the oven and place in desiccator to cool at least 2 h.

8.0 PROCEDURE.

8.1 Weigh two portions of the dried sample of approximately 2.5 g each to 0.0001 g, and transfer separately into 250 mL beakers.

8.2 In a chemical fume hood add to each beaker 75 mL of water and 25 mL of concentrated hydrochloric acid.

8.3 When the initial effervescent reaction has subsided, stir and heat on a hot plate to a boil.

8.4 Remove the beaker from the hot plate and allow to stand at room temperature for 2 h.

8.5 Filter the solution on vacuum through a tared, dried, medium porosity, fritted-disc crucible, retaining the filtrate in a clean flask. If the filtrate is cloudy, refilter.

8.6 Wash the residue four times with water and once with methanol.

8.7 Dry the crucible and residue at 248 ± 9°F for 3 h, or at 221 ± 9°F overnight.

8.8 Cool the sample at least 2 h in a desiccator and weigh to 0.0001 g.

9.0 CALCULATIONS. The percent of acid insoluble content is calculated by the following formula:

$$\text{Acid Insoluble Content, \%} = \frac{(W_3 - W_2)}{W_1} \times 100$$

where:

W_1 = weight (mass) of the dried sample
W_2 = weight (mass) of the crucible
W_3 = weight (mass) of crucible and residue

10.0 REPORT. The average of duplicate determinations shall be reported to the nearest 0.1%.

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

CONTROL PROCEDURES FOR CLASSIFICATION OF AGGREGATES
ITM No. 203-14P

1.0 SCOPE.

1.1 This method covers the control procedures used for the classification of aggregates. This control is accomplished through a rational system of categories and subcategories as set out herein. The tests conducted on ledge and production samples will be in accordance with the applicable requirements of 904.

1.2 These procedures will be administered to protect the interests of the Department. When unforeseen situations or interpretation difficulties arise regarding these procedures, the resolution which provides the highest quality of materials to the Department will be considered as the deciding factor.

1.3 All sampling and testing of production and ledge quality samples will be conducted by the Department or by an AASHTO Accredited Laboratory acceptable to the Department. Test results from the AASHTO Accredited Laboratory will be reviewed to ensure compatibility with previous test results, if applicable.

1.4 The final quality approval of materials for Department use will be contingent on production quality test results. When production quality testing is conducted by an AASHTO Accredited Laboratory, final quality approval will be contingent on point-of-use samples tested by the Department. Test results for other than production quality will be assigned an L rating for information only. Instances where lower classification of ledge test results has been obtained may necessitate a series of production quality samples prior to a source classification and subsequent aggregate usage approval.

1.5 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 ITM Standards.

210 Class AP Coarse Aggregate for Concrete Pavement and Slab-on-Grade Concrete

3.0 TERMINOLOGY.

3.1 AASHTO Accredited Laboratory**.** A laboratory which has demonstrated a proficiency in performing quality tests in accordance with the guidelines of the ASHTO Accreditation Program

3.2 Aggregate Specialist**.** An individual qualified to evaluate various aggregate deposits based on training in Earth Sciences. This person will be approved by the Department as being qualified to conduct various functions described in Department documents.

3.3 Category. Source classification used to determine the production quality sampling frequency

3.4 Certified Aggregate Producer (CAP). A source that has met all of the requirements to supply materials in accordance with 917

3.5 Class A. Quality rating assigned to aggregates which meet requirements for all Department uses except for specified slab on grade concrete applications

3.6 Class AP. Quality rating assigned to coarse aggregates permitted for use in all Department concrete, in particular, concrete pavement and specified slab-on-grade concrete uses in accordance with ITM 210

3.7 Class AS. Quality rating assigned to coarse aggregates permitted for use in SMA mixtures

3.8 Classes B, C, D, E, and F. Quality ratings assigned to aggregates with restricted uses

3.9 Class G. Quality rating assigned to materials which do not meet requirements for any Department use

3.10 Core Drilling Log. A written field description of a rock core sample and the operations

3.11 Core Sample. A rock sample obtained with a bit affixed to a barrel with drill rods that are advanced by a rotary drilling machine

3.12 Finished Material. Material which has been processed and proposed for use

3.13 Geologist. An individual qualified to evaluate various aggregate deposits based on knowledge of the principles of geology, acquired by professional education and practical experience. This person may be employed by either the drilling consultant or aggregate source for the purpose of logging core descriptions and identifying ledges.

3.14 Ledge. Any stratigraphic unit which may be separated from adjacent units by lithologic differences

3.15 Ledge Sample. Core or face sample taken to represent ledges

3.16 New Source. Aggregate source that has never been assigned a Department source number, or does not have past ledge and production quality test results

3.17 Point-Of-Use Sample. Production quality sample obtained at the last opportunity prior to incorporation into the end use

3.18 Production Quality Sample. An aggregate sample representing finished materials obtained at the aggregate source or the point of use

3.19 Source. Facility that processes or handles aggregates. A redistribution terminal will be classified as a source.

3.20 Source Map. A map of the quarry showing critical features and operating areas.

3.21 Source Sample**.** Production quality sample representing finished materials that are stored at an aggregate source or redistribution terminal

3.22 Subcategory. Source classification based on results of tests conducted on source samples and used to determine the production quality sampling frequency

3.23 Rating L. A rating for information only

4.0 SIGNIFICANCE AND US E. This ITM shall be used to assign the category and subcategory classification, if applicable, for each source, and to establish the guidelines for continued approval of sources supplying aggregates for Department use.

5.0 SOURCE CATEGORY AND SUBCATEGORY CLASSIFICATIONS.

5.1 General. Each source will be assigned to one or more of four categories: GS, I, II, or III. Sources assigned to categories GS, I, or II will also be assigned to one of two subcategories: A or B. The Department reserves the right to reclassify a source at such time that reclassification is considered necessary.

5.2 Category GS. Category GS is assigned to all sources supplying gravel, natural sand, manufactured sand from sand and gravel, or slag products.

5.3 Category I. Category I is assigned to crushed stone sources that have finished products with only material from ledges with quality ratings equal to or higher than required for the proposed use, either through selective quarrying or natural occurrence.

5.4 Category II. Category II is assigned to crushed stone sources that include material from ledges with quality ratings lower than required for the proposed use in finished materials. Category II assignment is used to allow the source to include small percentages of materials from lesser quality ledges that cannot be economically removed by selective quarrying, and shall not significantly affect the results of tests conducted on production quality samples. Category II assignment is not intended to allow sources to blend large amounts of lesser quality materials so that the resulting production meets higher quality specifications. Category II is assigned when the source has demonstrated capability of consistently producing material of uniform quality. This capability generally is based on the results of production quality tests conducted over a reasonable period of time, but in some cases may be based on a combination of ledge and production sample quality test results. All new stone sources with no production quality history will be rated Category II, Subcategory B, unless Category III is assigned to the source.

5.5 Category III. Category III is assigned to sources which meet the requirements for Category II, but have not demonstrated a capability to consistently produce uniform products. Sand and gravel, and slag sources may be classified as Category III sources if the requirements of Category GS cannot be met. A Category III assignment is to allow any source to develop a production quality history that may eventually be used to justify a Category II or GS assignment. All Category III materials are processed, stockpiled, sampled, tested, and approved prior to use of the materials. Samples will be taken and tested as the stockpile is being built. Final acceptance will be determined when the stockpile is deemed completed. The source shall not add any material to a stockpile after the final sample has been taken. Material shall not be removed from the stockpile for non-Department use without notification to the Department prior to shipment.

5.6 Subcategory A or B. Subcategory assignment is based on the results of tests conducted on source samples. Sources with production quality test results which consistently fall in the lower 75 percent of the specification range for Class A material in accordance with Table I, are assigned to Subcategory A. Sources with multiple production quality test results which consistently fall above the 75 percent specification range for Class A material in accordance with Table I, or that have quality ratings affected by the deleterious content, are assigned to Subcategory B.

Numeric Values For 75% of the Specification Range (904.03(a))				
Size	**Minimum Size, (in.)**	**Absorption, (%)**	**Los Angeles Abrasion Loss, (%)**	**Freeze and Thaw Loss, (water (%))**
2	2 1/2	---	33.75	12.0
5	1 1/2	4.50	30.0	9.0
8	1	4.50	30.0	9.0
9	3/4	4.50	30.0	9.0
11	1/2	4.50	30.0	9.0
12	3/8	4.50	30.0	9.0
43	1 1/2	---	30.0	9.0
53	1 1/2	---	33.75	12.0
73	1	---	33.75	12.0
23	3/8	---	---	7.5
24	3/8	---	---	7.5

Table I

6.0 FREQUENCY OF SAMPLING FOR TESTING.

6.1 General. The minimum frequency for ledge and production quality sampling and testing shall be as outlined within this section.

New sources proposing to provide aggregates for Department use shall submit a written request to the appropriate District Testing Engineer. The request shall include the method of sampling and other pertinent information.

Sources only supplying aggregates for precast concrete items are not required to have ledge samples. Production quality samples will be required every two years. Point-of-use samples will be obtained when deemed necessary by the Department.

Aggregates for precast prestressed concrete items will require production quality sampling and testing. Point-of-use samples will be obtained when deemed necessary by the Department.

Reclassification of category and subcategory assignments of existing sources will be based on a review of the test results for the ledge and production quality samples, or production quality samples only for GS sources. The source shall request reclassification in writing to the appropriate District Testing Engineer. The Department Geologist will advise the source when a quality problem exists that may necessitate reclassification.

6.2 Ledge Samples. Ledge samples are required for the following conditions:

6.2.1 A new source requests Department approval

6.2.2 An existing crushed stone source encounters previously untested ledges

6.2.3 Significant changes occur in production quality test results indicating a possible variance within existing production ledges

6.2.4 At the request of the Producer to evaluate selective quarrying or reassignment of previous ledge quality test results

6.2.5 At such time that the Department implements a new quality control program, such as adoption of new aggregate quality specifications or tests, investigation of failed materials, or other situations that may occur

6.2.6 At such time that the Department determines a significant lithologic or stratigraphic change has occurred since the last ledge or production samples were obtained and tested

6.2.7 At such time that the Department determines that reactivated areas of approved crushed stone sources are required to be tested.

6.3 **Production Quality Samples.** Production quality samples are required for the following conditions:

6.3.1 Source samples.

a) In conjunction with ledge samples for crushed stone sources requesting initial Department approval
b) Gravel sources requesting initial Department approval
c) After initial Department approval in accordance with Table II

6.3.2 Point-of-Use samples**.** After initial Department approval in accordance with Table II

6.4 **Testing Location.** The location of testing for ledge and production quality samples will be as follows:

6.4.1 Ledge samples will be tested at the Office of Materials Management or an AASHTO Accredited Laboratory

6.4.2 Production quality samples that require L.A. Abrasion, absorption, crushed particles, and deleterious determination will be tested at the District laboratory. Production quality samples that require soundness determination and Micro-Deval determination, if applicable, will be tested at the Office of Materials Management or an AASHTO Accredited Laboratory.

6.4.3 Ledge and production quality samples tested at the AASHTO Accredited Laboratory will be given a SiteManager ID number and the test report from the laboratory will include this sample ID number.

Frequency for Sampling and Testing Source and Point-Of-Use Production Quality Samples			
Category	**Subcategory**	**Source Production Qualities**	**Point-Of-Use Production Qualities**
I	A	Every two years, Department sizes: 2; 5, or 8; 23 or 24 (Notes 1 and 3)	None, if all active ledges are Class A. One per year if selective quarrying and production is used to remove lesser quality materials. (Note 4)
I	B	Every year, Department sizes: 2; 5 or 8; 23 or 24 (Notes 1 and 3)	Two per year of any coarse size used and any fine size used. None in year when no material is used by the Department. (Notes 2 and 4)
II	A	Every year, Department sizes: 2; 5 or 8; 43, 53 or 73; 23 or 24 (Notes 1 and 3)	One per quarter of any coarse size used and any fine size used. None in quarter when no material is used by the Department. (Notes 2 and 4)
II	B	Every year, Department sizes: 2; 5 or 8; 43, 53 or 73; 23 or 24 (Notes 1 and 3)	One per month of any coarse size used and any fine size used. None in month when no material is used by the Department. (Notes 2 and 4)
III	--	Every year, every stockpile	See II B
GS	A	Every two years, Department sizes: 2; 5 or 8; 23 or 24 (Notes 1 and 3)	When deemed necessary by the Department.
GS	B	Every year, Department sizes: 2; 5 or 8; 23 or 24 (Notes 1 and 3)	When deemed necessary by the Department.

Notes:
1. Department approved dolomite and polish resistant aggregate sources will be sampled for size 11 or 1/2 in. material
2. The selection of the size sampled will be at random at each source.
3. Crushed and uncrushed gravel will be tested. Size 2 will be obtained when proposed for use in HMA mixtures.
4. Stone sand size 23 and size 24 will be sampled at the same frequency.

Table II

7.0 LEDGE SAMPLING.

7.1 General. The source shall be responsible for preparing a ledge sampling plan that is acceptable to the Department. Core sampling shall be the primary method of ledge sampling, with face sampling an allowable alternate. If unsafe conditions appear to exist, the source or the Department has the right to refuse to allow face sampling. The sampling and handling costs shall be the responsibility of the source.

7.2 Ledge Sampling Plan. The ledge sampling plan shall include, as a minimum, the following requirements:

7.2.1 The method for obtaining the ledge samples

7.2.2 Sampling locations identified on the latest available copy of the source map from the Annual Aggregate Source Report. Reef structures may necessitate sampling at predetermined mining levels.

7.2.3 Compliance with applicable current Mine Safety and Health Administration regulations

7.2.4 Identification of the Source Safety Officer responsible for enforcing all safety requirements

7.3 Ledge Identification. The rock type, texture, color and bedding shall be as indicated on IT-530Q. The GSA Rock Color Chart may be used as an additional reference.

7.4 Core Sampling. Core sampling shall be conducted in accordance with the following requirements:

7.4.1 The Department Geologist shall be notified prior to starting the coring operation. In the event that thin ledges are encountered with questionable ledge contacts, the District Testing Engineer shall be immediately notified if not present.

7.4.2 The Department Geologist will not direct the coring operation.

7.4.3 Cores shall be drilled a minimum of 30 ft apart and represent a maximum of the equivalent of two years of production, unless otherwise approved.

7.4.4 The source Geologist or Aggregate Specialist shall, in coordination with the Department Geologist, select the core locations, preliminarily identify the ledges, and determine the number of cores sufficient to obtain the required quantity of material.

A minimum of 35 lb of core sample shall be required for laboratory processing for each ledge. The approximate yield of a solid core per 1 ft is as follows:

Nominal Core Diameter	Weight (Mass) of Core
1.875 in	3.2 lb
2.000 in	3.6 lb
2.400 in.	5.2 lb
2.500 in.	5.6 lb
3.000 in.	8.1 lb
3.345 in.	10.1 lb
4.000 in.	14.4 lb
5.875 in.	31.1 lb

7.4.5 A minimum of three cores shall be properly taken, identified and stored.

7.4.6 The minimum ledge thickness for testing purposes shall be 1 ft.

7.4.7 The minimum core diameter shall be a nominal size of 1.875 in.

7.4.8 The source Geologist or Aggregate Specialist shall be responsible for completion of the Core Log TD-539 or other approved form, and the Ledge and Core Sample Description IT-530Q, and for the proper collecting, splitting, packaging, and shipping of the cores to the Office of Materials Management.

7.4.9 Rock core boxes shall be weatherproof and constructed of wood or other durable materials for the protection and storage of cores while en route from the drill site to the Office of Materials Management. All core boxes shall be provided with longitudinal separators.

Recovered cores shall be laid in the box from upper left to lower right. The top and bottom of each coring run shall be identified. Spacers, blocks, or plugs shall be marked and inserted into the core column within the separators to indicate the top and bottom of each coring run and zones of no core recovery.

Each box shall be marked on the outside to indicate the core or boring number, source number, numerical position of the box (e.g., hole X, box 2 of 7), depth of the top and bottom of the particular core run contained in that box, date of coring, possible formation and ledge contacts, and any other pertinent information.

The entire core column shall be put into the boxes and transported to a location for splitting. The split core will be reassembled and replaced in the core box in the pre-split position. The split cores shall be submitted to the Office of Materials Management after consultation with the Department Geologist.

7.4.10 The Department Geologist will examine the split cores and core drilling logs as prepared by the source Geologist or Aggregate Specialist. The following items shall be furnished as a minimum:

a) The core locations and elevations identified by grid coordinate or physical feature reference as marked on the latest available source map from the Annual Aggregate Source Report. The elevation of the bore hole shall be referenced and surveyed from a bench mark that has been previously tied into a U.S.C. & G.S. bench mark or other recognized bench mark.

b) A detailed description of each ledge for location, thickness, rock type, color, lithology, grain size, texture, bedding characteristics, elevation to the nearest 0.1 ft of the top and base of ledges, and any other pertinent observations. This information shall be indicated on IT-530Q.

c) Length of particular core run

d) Percent recovery. This information is used to determine the material that may have been washed away or for locating voids, and is determined as follows:

$$\text{Percent Recovery} = \frac{\text{Length Recovered}}{\text{Length of Core Run}} \text{ x } 100$$

e) Name of the Geologist or Aggregate Specialist, Department representative, and quarry representative present during the coring operation. If a particular boring is not completed during a given day, the date and depth of the drilling shall be noted.

f) Any miscellaneous information such as loss of water from the core hole, decreased or increased effort in coring by the drilling rig, or change in color of the wash cuttings. This information shall be listed in the remarks column with the approximate depth of occurrence.

7.4.11 The wall face to be represented by the cores shall be observed by the Department Geologist prior to final ledge designation and approval.

7.5 Face Sampling. Face sampling shall be conducted in accordance with the following requirements:

7.5.1 The source shall provide a means for the Department Geologist to closely examine the face of the wall to be sampled.

7.5.2 Ledges shall be identified in accordance with 7.3

7.5.3 A source Geologist or Aggregate Specialist shall participate with the Department Geologist in all face sampling at the site.

7.5.4 The source shall provide a minimum of 180 lb of material from each identified ledge.

7.5.5 The sample will consist of approximately 60 lb of representative material from each 1/3 of the identified ledge.

7.5.6 The Department Geologist will determine the acceptable quantity of material with concurrence of the source Geologist or Aggregate Specialist.

8.0 ANNUAL AGGREGATE SOURCE REPORT.

8.1 General. Crushed stone aggregate sources are required to submit an Annual Aggregate Source Report. The report may be submitted electronically or by hard copy. Sources that are not a Certified Aggregate Producer shall submit a report in accordance with 8.2. Certified Aggregate Producers shall submit a report in accordance with 8.2.1, 8.2.4, 8.2.5, 8.2.6 , and 8.3, and include the report in the CAP Quality Control Plan.

8.2 Report.

8.2.1 Format. The report shall be typed, and if maps are hand drawn they shall be in a professional manner. Limited handwritten words will be acceptable on maps and figures. The Department source number and the report date shall be noted in a consistent location on each page of the report. An example of an acceptable Annual Aggregate Source Report is included in Appendix C.

8.2.2 Title Sheet**.** The report shall contain a title sheet that lists the following information:

a) The year for which the report is being submitted

b) Source name

c) Source number

d) Mailing address

e) Phone number

f) Fax number

g) Names of Management and Quality Control Personnel who are responsible for reporting to the Department

h) Source location identified by section, township, range, longitude, latitude, and nearest identifiable points such as highways, towns, etc.

8.2.3 Mineral Deposit Description. On a separate page, an explanation shall be included for the following:

a) Thickness of the current working benches

b) Class AP ledges and quality expiration dates

c) Ledges meeting dolomite and sandstone requirements and the most recent approval dates

d) Ledges requiring special handling procedures

e) The Department classification

f) Any significant differences in the stratigraphic section measurements and the respective ledge thickness as reported on the most recent Summary of Ledge Quality Results letter

8.2.4 Source Map. The report shall include a map of the mineral deposit. If the processing or stockpiling areas are on-site, the areas may be shown on the same map. If the processing or stockpiling areas are at another location, additional maps will be required. The map may be a drawing or an aerial photograph. The source map is required to be submitted once every two years. Each map shall include the following:

a) Title Block. The map shall display a title block containing as a minimum the source name, Department source code number, and submittal or revision date.

b) North Arrow**.** Each map shall display a North arrow.

c) Scale - Each map shall display a scale appropriate to the size of the property or source area; however, no scale shall be less than 1 in. = 100 ft and no greater than 1 in. = 400 ft, unless otherwise approved.

d) Grid. A grid shall be established using a rectangular coordinate system. The grid shall be indicated on the map either directly or using an overlay. The major grid lines shall be no further apart than 300 ft and incremented at least every 75 ft as measured on the map.

e) Benchmarks. At least one permanent benchmark shall be established on the property. All other points shall be referenced to the permanent benchmark through the true elevation. Temporary benchmarks shall also be established, and at least one benchmark shall be available for easy access to each ledge.

f) Control Points. Permanent control points for the grid shall be established within the property perimeter. There shall be enough permanent control points to permit the reestablishment of a portion of the grid within approximately one hour. The control points shall be close enough to the deposit such that all significant features may be conveniently and accurately referred to by standard survey methods.

g) Quarry Walls. All quarry walls, including the quarry outline and all active and inactive benches, shall be shown on the map. Each bench shall be discernable from other benches.

h) Proposed Operating Areas**.** All proposed operating areas for the year represented by the Annual Aggregate Source Report shall be clearly designated in some manner. The source is not committed to production from these areas, but shall designate the areas from which they anticipate production. The map may be revised at any time during the year if production is needed from areas that were not previously marked.

i) Critical Features**.** The map shall show all relative critical features including, as a minimum, the office, scales, testing laboratory, stockpile areas, processing plant areas, ramps, sumps, and pertinent quarry roads.

8.2.5 Legend**.** On the map or on a separate page, the source shall include a legend and map symbols appropriate to the source map.

8.2.6 Stratigraphic Section**.** On a separate page, the source shall include one or more source-specific stratigraphic sections. The stratigraphic sections shall be prepared to an appropriate scale to graphically and descriptively depict the stratigraphic relationships of the various lithologies within the current or anticipated production benches. The addition or deletion of ledges in a bench will require submittal of a new stratigraphic section when the change in the bench ledges occurs. Each stratigraphic section shall include, as a minimum, the following requirements:

a) The grid coordinates near where the section was measured

b) The lithologies above and below the current or anticipated production bench

c) The Department ledge numbers with the thickness, geologic formations and members names, elevation, and date of measurement given for the top of each bench

8.3 **Submittal.** No later than April 1st of each year, each source shall submit an Annual Aggregate Source Report to the appropriate District Testing Engineer. Failure to submit an Annual Aggregate Source Report shall result in rejection of the source to provide materials for Department use until such time that an acceptable report has been received by the District Testing Engineer.

Upon receipt of the report, the District Geologist will verify the contents of the report by field review with the Producer's representative designated in 8.2.2. A summary of this review will be forwarded with a signed cover letter from the District Testing Engineer to the Office of Materials Management. The District will retain one copy and forward another copy of the report to the Office of Materials Management for incorporation into the source QCP Appendix, if applicable. The source shall retain and include the report in their copy of the QCP, if applicable.

IT-530Q
Rev. 10/98

INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS & TESTS
LEDGE AND CORE SAMPLE DESCRIPTION

Date Sampled

YEAR LAB SUBMITTER SEQUENCE Sampled By

SOURCE LOCATION

AREA FROM GRID MAP

X COORDINATE ____________

Y COORDINATE ____________

Section Township N or S

Range E or W

LEDGE INFORMATION

LEDGE NO. 52

LEDGE THICKNESS (0.01 m) 53

ELEV.- Top ledge (0.01 m) 54

ELEV.- Bottom 55

COLOR

SELECT PREDOMINATE GSA COLOR CODE

WET or DRY Surface (Circle one)

STRATIGRAPHY

SYSTEM 72 2

FORMATION 74 2

MEMBER / BED 73 2

COLOR 75 2 5

GRAIN SIZE 76 2

ROCK TYPE 77 2

001	___ Limestone	004	___ Chert
002	___ Dolostone	005	___ Shale
003	___ Sandstone	006	___ Siltstone

CRYSTAL SIZE 79 2

BEDDING (Ingram 1954)

(Check The Three Prominant Characterisitcs)

51	___ Steeply Dipping	66	___ Discontinuous	
52	___ Crossbedded	67	___ Very Thickly Bedded	>1m
56	___ Contorted	68	___ Thickly Bedded	30-100 cm
61	___ Wavy	69	___ Medium Bedded	10-30 cm
62	___ Pinch & Swell	70	___ Thinly Bedded	3-10 cm
63	___ Irregular	71	___ Very Thinly Bedded	1-3 cm
64	___ Lenticular	72	___ Thickly Laminated	0.3-1 cm
65	___ Planar	73	___ Thinly Laminated	< 0.3 cm

GRAIN SIZE (Udden-Wentworth)

(Select One)

014 ___ Cobbles	>64 mm	019 ___ Medium	0.5-0.25 mm
015 ___ Pebbles	64-4 mm	020 ___ Fine	0.25-0.125 mm
016 ___ Granular	4.0-2.0 mm	021 ___ Very Fine	0.125-0.0625 mm
017 ___ Very Coarse	2.0-1.0 mm	022 ___ Silt	0.0625-0.0039 mm
018 ___ Coarse	1.0-0.5 mm	023 ___ Clay	< 0.0039 mm

CRYSTAL SIZE (Folk 1961)

(Select One)

024 ___ Extremely Coarse	>4.0mm
017 ___ Very Coarse	4.0-1.0mm
018 ___ Coarse	1.0-0.25mm
019 ___ Medium	0.25-0.062mm
020 ___ Fine	0.062-0.016mm
021 ___ Very Fine	0.016-0.004mm
025 ___ Aphanocrystalline	<0.004mm

LITHOLOGY (Check The Four Prominant Characterisitcs)

01	___ Cherty	12	___ Arenaceous	23	___ Conglomeritic	34	___ Micritic	44	___ Siliceous
02	___ Clay Pocketed	13	___ Gypsiferous	24	___ Coralline	35	___ Mod. Sorted	45	___ Silty
03	___ Fossiliferous	14	___ Glauconitic	25	___ Crystalline	36	___ Mottled	46	___ Skeletal
04	___ Pelletal	15	___ Vuggy	26	___ Dense	37	___ Pisolitic	47	___ Sparry
05	___ Petroliferous	16	___ Iron Stained	27	___ Ferriferous	38	___ Poorly Indurated	48	___ Stromatolitic
06	___ Pyritic	17	___ Stylolitic	28	___ Fissile	39	___ Poorly Sorted	49	___ Sucrosic
07	___ Oolitic	18	___ Algal	29	___ Flaggy	40	___ Porous	50	___ Variegated
08	___ Argillaceous	19	___ Bioclastic	30	___ Friable	41	___ Reefal	51	___ Vitreous
09	___ Weathered	20	___ Blebby	31	___ Intraclastic	42	___ Rubbly	52	___ Well-Indurated
10	___ Dolomitic	21	___ Brecciated	32	___ Lithographic	43	___ Shaly	53	___ Well-Sorted
11	___ Calcareous	22	___ Carbonaceous	33	___ Micaceous				

LITHOLOGY 85

BEDDING 86

TD-539

INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
AGGREGATE CORE BORING LOG

CORE/LEDGE DESCRIPTION	INDOT Source #:	Hole No:	Sheet of
Producer:	Drilling Contractor:	Hole Dia:	Date Started:
Plant/Source:	Driller:	Total Depth:	Date Finished:
County:	Geologist:	Collar Elev:	Water Level:
D. H. Coordinates	X Y	Datum:	
Twp. ______ Rge. ______ Sec. ______	Quad. ______	Weather:	

Formation	Ledge	Graphic Log	Depth Scale	Lithologic Description (include in order: rock type, color, grain size, texture, bedding angle, weathering)	CORE DATA BOX / RUN	CORE DATA FROM / TO	% Recov.	Remarks

State Form 45230 (2-92)

EXAMPLE

AGGREGATE SOURCE REPORT

TITLE SHEET

Producer Name	Limerock Quarries Inc.
Address	P.O. Box 7-11
City, State	Markle, IN 47025
Phone #'s	219-328-7025
Fax	219-244-7025

1999
Annual Aggregate Source Report

Limerock Quarries Inc.
Markle Plant

INDOT Source #2799

Prepared For INDOT
Materials & Tests Division
120 S. Shortridge Rd.
Indianapolis, IN 46219-0389

Date Submitted
March 1, 1999

Source Location:	Section 11; T 27 N, R 10 E; 2.3 miles South of Markle, IN. One mile West of SR 3. Wells County; Longitude W 85°21'40", Latitude N 40°48'00"
Regional Manager:	Clay Mudstone
Superintendent:	Ferris Ore
Quality Control:	Richard Quality & Crystal Stone

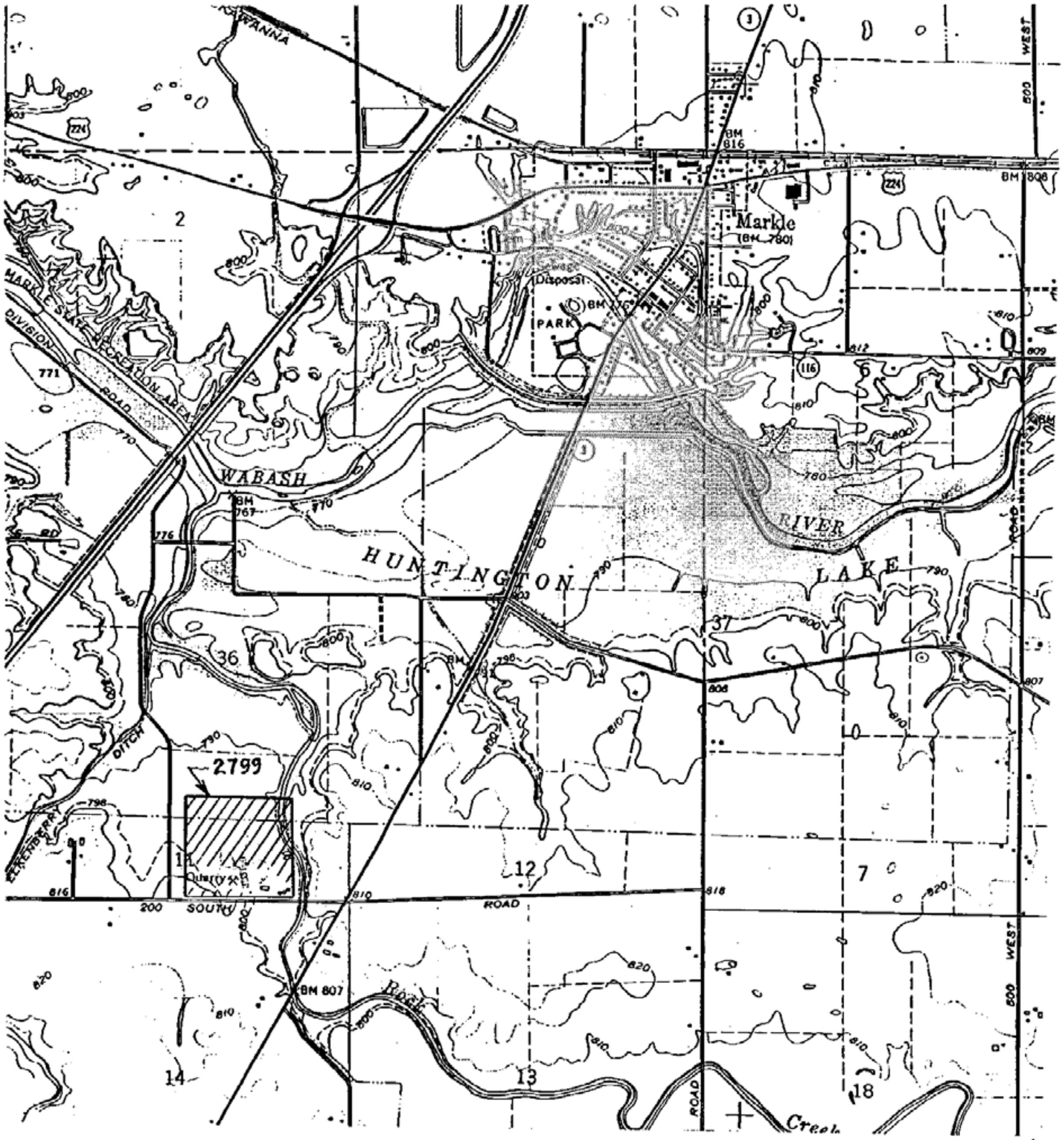
1/7
Source #2799
1-15-99

It is the intention of this report to satisfy the needs of Indiana Test Method (ITM) 203-99P, Section 8.0.

This source currently operates two open-pit benches. The upper bench is mined for commercial purposes only and consists of Ledges 1 and 2. This bench is approximately 60 feet thick. Ledge 3 is Waldron Shale and is wasted. the lower bench (Ledges 4 and 5) is approximately 73 feet thick, is classified as Category IA, and is INDOT Class AP approved up to March 15, 2001. Ledge 5 has a Magnesium content of 10.8 and is Dolomite Approved by INDOT.

Elevations for all benches may be found on the following geologic cross-section. A benchmark with an elevation of 800.82 is located next to the office, which is southeast of the quarry. The proposed 1999 operating areas may be found on the following Source Map. Also included is the location map and quarry map indicating the stockpile areas. The symbol Legend and a Stratagraphic Description for this source are shown on the last two pages.

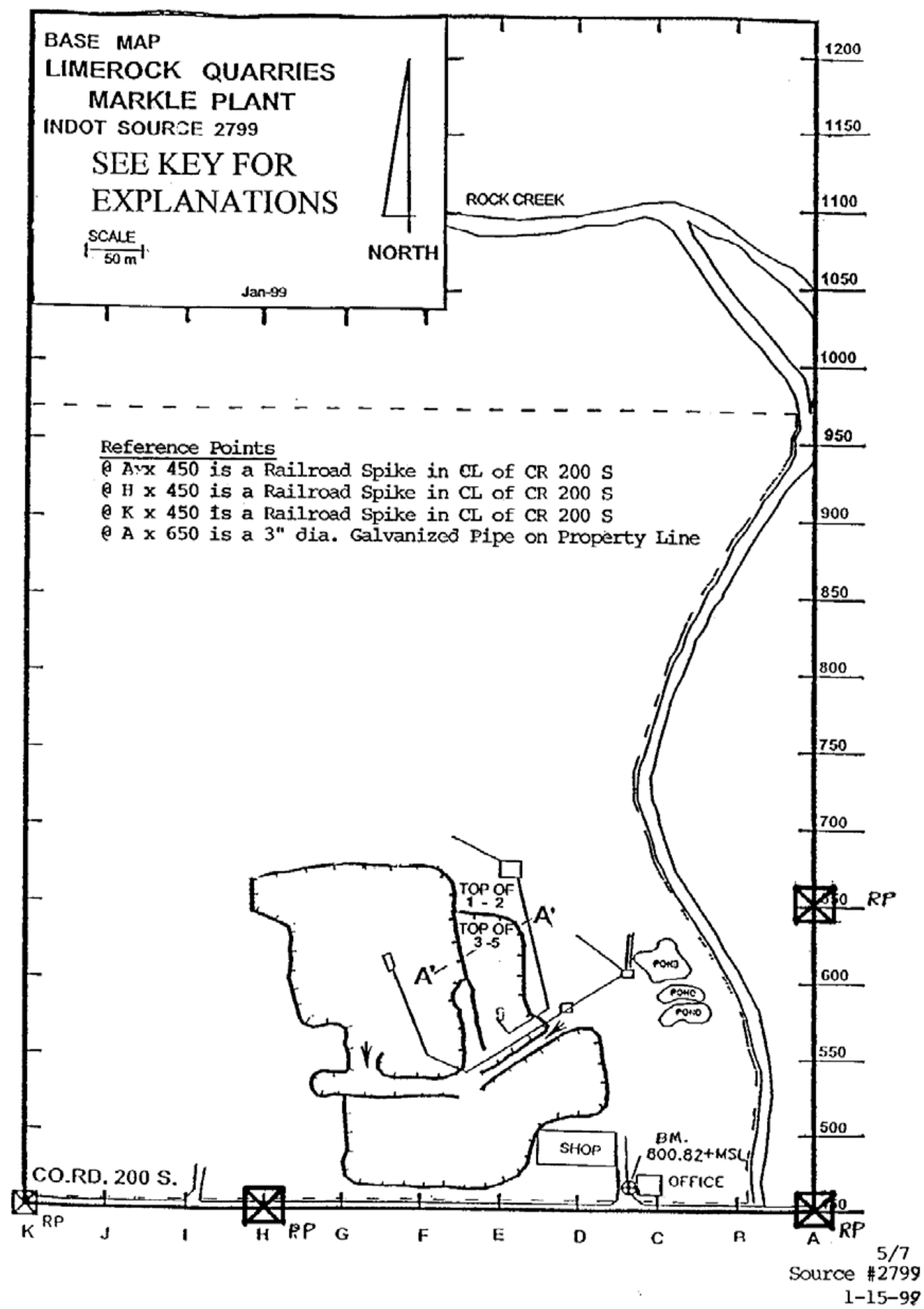
2/7
Source #2799
1-15-99

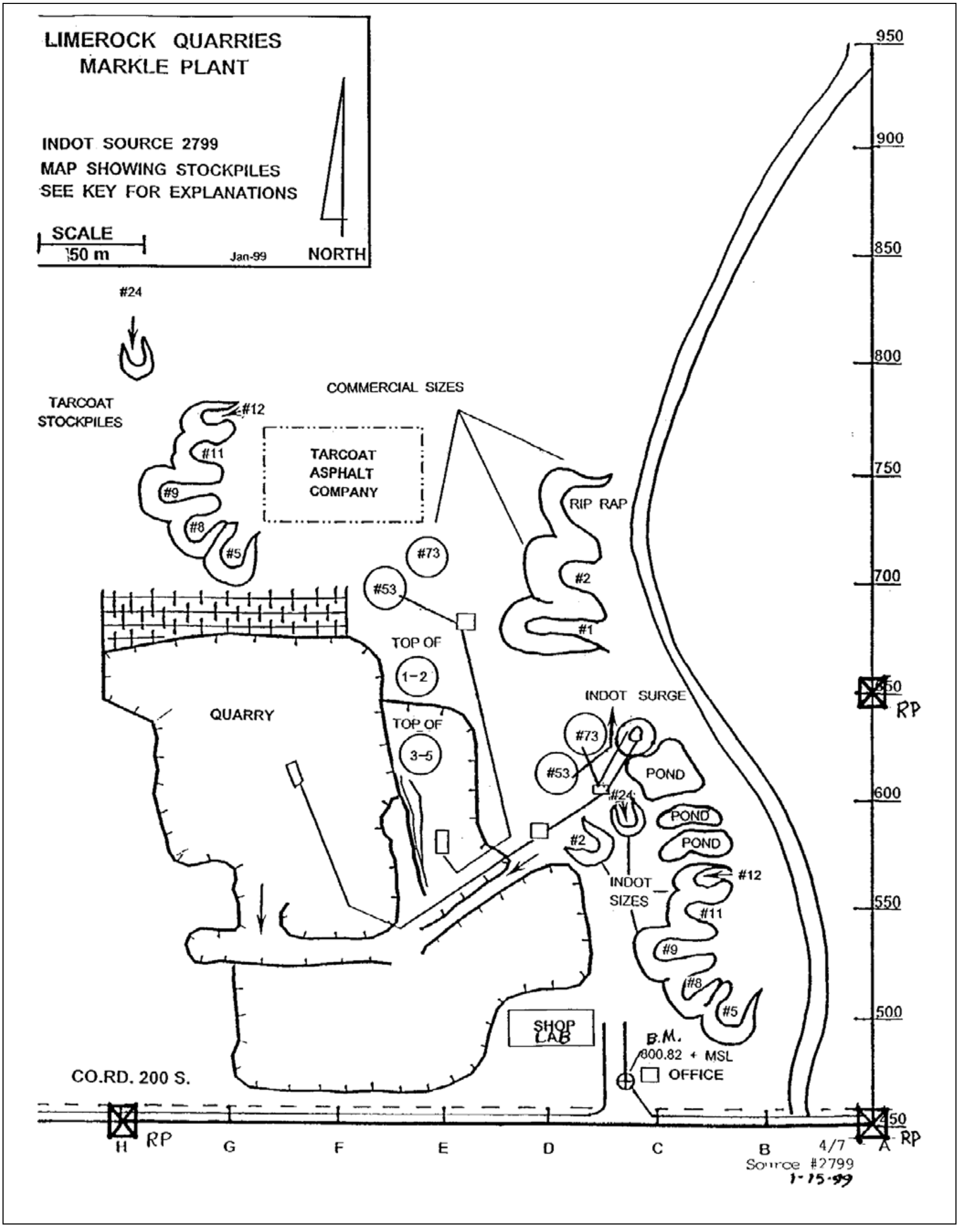


LOCATION MAP FOR LIMEROCK QUARRIES, INC.-MARKLE PLANT

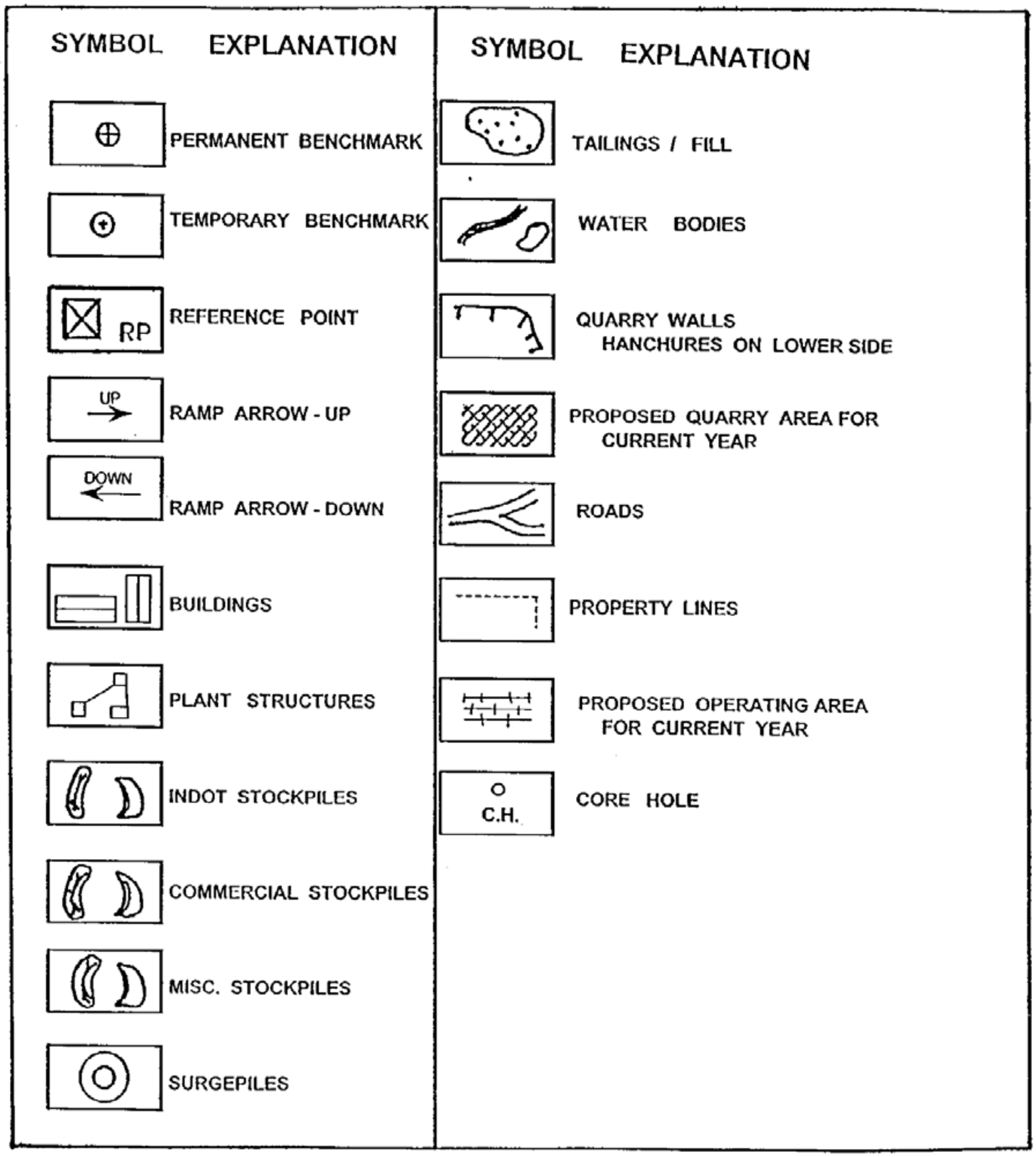
NORTH

3/7
Source #2799
1-15-99


BASE MAP
LIMEROCK QUARRIES
MARKLE PLANT
INDOT SOURCE 2799
SEE KEY FOR
EXPLANATIONS
SCALE
50 m
NORTH
Jan-99
ROCK CREEK
Reference Points
@ A x 450 is a Railroad Spike in CL of CR 200 S
@ H x 450 is a Railroad Spike in CL of CR 200 S
@ K x 450 is a Railroad Spike in CL of CR 200 S
@ A x 650 is a 3" dia. Galvanized Pipe on Property Line
1200
1150
1100
1050
1000
950
900
850
800
750
700
RP
600
550
500
TOP OF
1 - 2
TOP OF
3 -5
A'
A'
POND
POND
POND
SHOP
BM.
800.82+MSL
OFFICE
CO.RD. 200 S.
K
RP
J
I
H
RP
G
F
E
D
C
B
A
RP
5/7
Source #2799
1-15-99


LIMEROCK QUARRIES
MARKLE PLANT
INDOT SOURCE 2799
MAP SHOWING STOCKPILES
SEE KEY FOR EXPLANATIONS
SCALE
150 m
Jan-99
NORTH
#24
TARCOAT
STOCKPILES
#12
#11
#9
#8
#5
COMMERCIAL SIZES
TARCOAT
ASPHALT
COMPANY
RIP RAP
#73
#53
#2
#1
TOP OF
1-2
TOP OF
3-5
QUARRY
INDOT SURGE
#73
#53
#24
POND
POND
POND
#2
INDOT
SIZES
#12
#11
#9
#8
#5
SHOP
LAB
B.M.
800.82 + MSL
OFFICE
CO.RD. 200 S.
950
900
850
800
750
700
650
600
550
500
450
RP
RP
H
G
F
E
D
C
B
A
RP
4/7
Source #2799
1-15-99

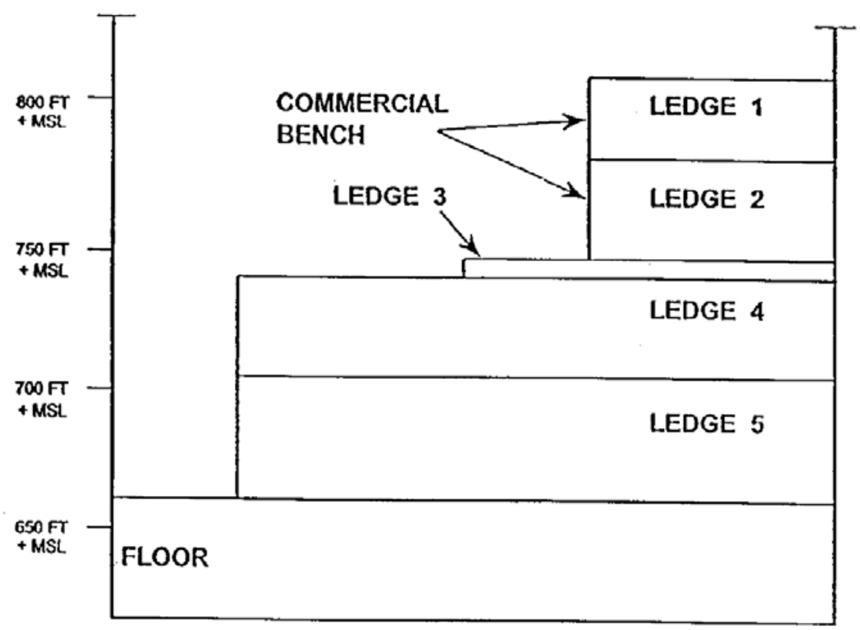
KEY TO QUARRY MAP FOR INDOT
LIMEROCK QUARRIES, INC.
MARKLE PLANT # 2799



6/7
Source 2799
1-15-99

STRATIGRAPHIC DESCRIPTION FOR LIMEROCK QUARRIES, INC. MARKLE PLANT #2799

CORE LOCATIONS
F - 10 x 600 & E x 650



LEDGE	THICKNESS	GEOLOGIC FORMATION
1	20'	LISTON CREEK
2	40'	MISSISSINEWA
3	5'	WALDRON
4	35'	LOUISVILLE
5	38'	LIMBERLOST

MARKLE PLANT - # 2799

* LEDGES 4 & 5 ARE AP APPROVED ; EXPIRES 12/12/99
* THIS SOURCE HAS AN INDOT IA CLASSIFICATION
*LEDGE #5 IS APPROVED DOLOMITE (10.8 Mg.)

7/7
Source #2799
1-15-99

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

ACCEPTANCE PROCEDURES FOR DOLOMITE AGGREGATES
ITM No. 205-17T

1.0 SCOPE.

1.1 This method sets forth the acceptance procedures to be used when Aggregate Producers request that dolomite aggregates be evaluated for use in HMA surface mixtures. Dolomite aggregates are specified for use under certain ESAL loading conditions to obtain skid-resistant HMA surface courses.

These procedures cover the rapid instrumental chemical analysis and the referee chemical analysis of dolomite for elemental magnesium content.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of this test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 AASHTO Standards.

M 92 Wire-Cloth Sieves for Testing Purposes
M 231 Weighing Devices Used in the Testing of Materials
T 248 Reducing Samples of Aggregate to Testing Size

2.2 ASTM Standards.

C 25 Chemical Analysis of Limestone, Quicklime, and Hydrated Lime
C 1271 X-Ray Spectrometric Analysis of Lime and Limestone
C 1301 Major and Trace Elements in Limestone and Lime by Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP) and Atomic Absorption (AA)
D 2698 Determination of Pigment Content of Solvent-Reducible Paints by High Speed Centrifuging

2.3 ITM Standards.

207 Sampling Stockpiled Aggregates
571 Quantitative Extraction of Asphalt/Binder and Gradation of Extracted Aggregate from HMA Mixtures

3.0 TERMINOLOGY. Definitions for terms and abbreviations will be in accordance with the Department's Standard Specifications, Section 101.

4.0 SIGNIFICANCE AND USE. This ITM will be used to evaluate dolomite aggregates for use in HMA surface mixtures.

5.0 APPARATUS.

5.1 Instrumentation in accordance with ASTM C 25, C 1271, or C 1301

5.2 Balance, Class A, in accordance with AASHTO M 231

5.3 High-speed centrifuge in accordance with ASTM D 2698

5.4 Sieves, in accordance with AASHTO M 92

6.0 GENERAL REQUIREMENTS.

6.1 Each Aggregate Producer requesting to have a co arse aggregate tested in accordance with this procedure shall contact the appropriate District Testing Engineer to initiate the approval process.

6.2 Testing will be conducted by the Office of Materials Management.

6.3 Approval of the source as a dolomitic material will be based on results from either the rapid instrumental analysis or the referee analysis tests.

7.0 SAMPLING.

7.1 Sampling of aggregates will be done in accordance with ITM 207.

7.2 Each sample will consist of 10 to 15 lbm of material.

7.3 Source Sampling - Coarse Aggregate.

7.3.1 Coarse Aggregate will be sampled by the District for initial evaluation. Three samples representing materials produced from each proposed dolomitic production ledge or area will be obtained.

7.3.2 Each sample will be taken from a s eparate stockpile of at least 1000 t (1000 Mg) of any gradation material being produced.

7.4 Sampling. All dolomite aggregates will be sampled for acceptance at the HMA plant, either before or preferably during mix production.

7.5 Sample Submittal.

7.5.1 Samples will be submitted to the Office of Materials Management for testing.

7.5.2 The submittal report will indicate the source and the ledges or area represented.

8.0 PREPARATION OF TEST SAMPLE.

8.1 Aggregate Samples.

8.1.1 Split at least 1000 g of material in accordance with AASHTO T 248.

8.1.2 Crush the sample so that all of the material passes the No. 4 sieve.

8.1.3 Split at least 50 g of the minus No. 4 material in accordance with AASHTO T 248.

8.1.4 Pulverize the minus No. 4 material so that the sample will pass the No. 60 sieve.

8.2 HMA Samples.

8.2.1 Extract the binder from the sample in accordance with a procedure in ITM 571.

8.2.2 Prepare the sample in accordance with 8.1.

8.2.3 To extract the binder from the sample passing the No. 60 sieve, weigh 10 g into a 50 mL centrifuge tube and add 25 mL Toluene. Stir the solution with a stirring rod, wash the residue from the stirring rod into the centrifuge tube, and centrifuge the material at 10000 rpm in a highspeed centrifuge for 20 m inutes. Decant the liquid portion and repeat this procedure three more times using acetone for the last extraction. Dry the sample to a constant weight at 220°F.

9.0 PROCEDURE.

9.1 Referee Analysis. Determine the elemental magnesium content by EDTA titration in accordance with ASTM C 25, C 1271, or C 1301.

9.2 Rapid Instrumental Analysis. Determine the elemental magnesium content using instrumentation in accordance with the performance requirements for alternative test methods of ASTM C 25.

10.0 CALCULATIONS. Calculations will be made to convert values reported in accordance with ASTM C 25 to elemental calcium and elemental magnesium contents.

11.0 ACCEPTANCE CRITERIA.

11.1 If the elemental magnesium content of the aggregate is 10.3 percent or greater, the material will be approved as a dolomitic aggregate.

11.2 All samples that do not have a value of at least 10.3 percent elemental magnesium content determined by the rapid instrumental analysis will be verified by determining the elemental magnesium content using the referee analysis method.

11.3 The Department will maintain a list of Approved Dolomite Sources.

12.0 REPORT.

12.1 All elemental calcium and magnesium content values will be reported to the nearest 0.1 percent.

12.2 When the rapid instrumental analysis is used, the elemental magnesium content will be reported.

12.3 When the referee analysis is used, the elemental calcium and elemental magnesium contents will be reported.

13.0 PRECISION.

13.1 The within-laboratory standard deviation for elemental calcium is 0.21 percent, and for elemental magnesium content is 0.13 percent.

13.2 The between-laboratory standard deviation for elemental calcium is 0.22 percent, and for elemental magnesium content is 0.17 percent.

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

SCRATCH HARDNESS OF COARSE AGGREGATE PARTICLES
ITM No. 206-15T

1.0 SCOPE.

1.1 This test method covers determining the quantity of soft particles in gravel coarse aggregates on the basis of scratch hardness.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 AASHTO Standards.

T 27 Sieve Analysis of Fine and Coarse Aggregates
M 92 Wire-Cloth Sieves for Testing Purposes
M 231 Weighing Devices Used in the Testing of Materials

2.2 ITM Standards.

207 Sampling Stockpiled Aggregates

3.0 TERMINOLOGY. Definitions for terms and abbreviations will be in accordance with the Department's Standard Specifications, Section 101.

4.0 SIGNIFICANCE AND USE.

4.1 This ITM is used to identify materials that are soft, including those which are so poorly bonded that the separate particles in the piece are easily detached from the mass. The test method is not intended to identify other types of deleterious materials in aggregates.

4.2 In case of questions, the scratch hardness test should be made on a freshly broken surface of the aggregate particle. If the particle contains more than one type of rock and is partly hard and partly soft, the particle should be classified as soft only if the soft portion is one third or more of the volume of the particle. Scratch hardness tests may be made on the exposed surface of a particle provided consideration is given to softening of the surface due to weathering. A particle with a thin, soft and weathered surface and a hard core should normally be classed as soft.

5.0 APPARATUS.

5.1 Sieves, in accordance with AASHTO M 92

5.2 Balance, Class G2, in accordance with AASHTO M 231

5.3 Pans, as needed

5.4 Brass Rod, 1/16 in. (1.6 mm) in diameter, with a rounded point, mounted in a device so that a load of 2 ± 0.1 lbf (8.9 ± 0.4 N) is applied to the specimen tested. The brass rod shall be of suitable hardness so that when filed to a sharp point, the brass rod will scratch a U.S. Lincoln design copper penny but fail to scratch a U.S. Jefferson design nickel.

6.0 SAMPLES. Sampling shall be done in accordance with ITM 207.

7.0 PREPARATION OF TEST SPECIMEN. Aggregate for the test shall consist of the material retained on the 3/8 in. and larger sieves following completion of AASHTO T 27.

8.0 PROCEDURE. Subject each particle of aggregate under test to a scratching motion of the brass rod, using a pressure of 2 lbf. Particles are considered to be soft if, during the scratching process, a groove is made in them without deposition of metal from the brass rod, or if separate particles are detached from the rock mass. For some sandstones, brass fragments may be deposited on hard individual grains, while at the same time separate particles are detached from the mass due to a weak binding medium. Such particles are to be considered as soft.

9.0 CALCULATIONS. Particles determined to be soft are combined with structurally weak particles to determine the amount of non-durable material. The weight (mass) of non-durable material is calculated by:

$$\text{Non - Durable, \%} = \frac{\text{Weight (Mass) of Non - Durable above 3/8 in. (9.5 mm) Sieve}}{\text{Weight (Mass) of Sample above 3/8 in. (9.5 mm) Sieve}} \text{ x } 100$$

10.0 REPORT. Non-durable particles are reported to the nearest 0.1 percent. A brief lithologic description of the soft particles shall also be included.

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

SAMPLING STOCKPILED AGGREGATES
ITM No. 207-15T

1.0 SCOPE.

1.1 This test method covers sampling fine and coarse aggregate stockpiles.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 SIGNIFICANCE AND USE. This ITM provides guidance on how to obtain aggregate samples from aggregate stockpiles for control of production at the source or control of the materials at the point of use.

3.0 TERMINOLOGY. Definitions for terms and abbreviations will be in accordance with the Department's Standard Specifications, Section 101.

4.0 APPARATUS.

4.1 Square bit shovel

4.2 Fire shovel

4.3 Sampling tube, 3 in. minimum in diameter and 3 ft minimum in length

5.0 SAMPLING.

5.1 Coarse Aggregate Sampling.

5.1.1 Using a front-end loader, dig into the stockpile and set aside a small pile of 10 to 15 t of material. This procedure shall be done in the same manner as if a truck is being loaded for shipment (Figures 1 and 2). When forming the small pile, the loader bucket shall be as low as possible and roll the material from the bucket rather than dumping the material. Reducing the distance the material is allowed to free-fall will reduce the amount of segregation that may occur in the small pile (Figure 3). Each additional bucket load of material shall be obtained and dumped in the same manner as set out above and shall be placed uniformly over the preceding one (Figure 4).

5.1.2 Thoroughly mix the small pile. Using the loader bucket, proceed to the end of the oblong pile and roll the material over. Keeping the loader bucket as low as possible, push the bucket into the material until the front of the bucket is past the midpoint of the original pile. The loader bucket shall then be slowly raised and rolled forward thus producing a smooth mixing of the material (Figures 5, 6, and 7). Proceed to the opposite end of the pile and repeat this mixing procedure. If the pile does not appear to be uniform, additional mixing shall be done.

5.1.3 The pile is now ready for sampling. Do not strike off the top of the stockpile (Figure 8). The sample shall be taken at the center of the volume which is approximately one-third of the height of the pile. The sample shall consist of not less than six full shovels of material taken at equal increments around the pile (Figures 9, 10, and 11). A square bit shovel shall be used. The size of the shovel shall be such that the sample meets the minimum weight (mass) requirements of the test conducted on the sample. The shovel shall be inserted full-depth horizontally into the material and raised vertically. Care shall be taken to retain as much of the material as possible on the blade of the shovel (Figure 12).

5.2 Fine Aggregate Sampling.

5.2.1 Fine aggregate samples are normally obtained as set out above for coarse aggregate, except a fire shovel or sampling tube shall be used.

5.2.2 When fine aggregate stockpiles are constructed so as to not exceed the height of the sampler, and when segregation is not apparent, the samples may be taken directly from the face of the large stockpile. The surface crust of the stockpile is required to be removed from the sampling area.

6.0 SAFETY.

6.1 Samples shall not be obtained by climbing onto stockpiles due to the hazard of burial and suffocation from unstable stockpiles of unconsolidated materials. Also, over-steepened stockpiles that may sluff and engulf personnel in the immediate area should be avoided.

6.2 Personnel requiring additional information concerning specific sampling situations are directed to contact the appropriate District Testing Engineer.

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

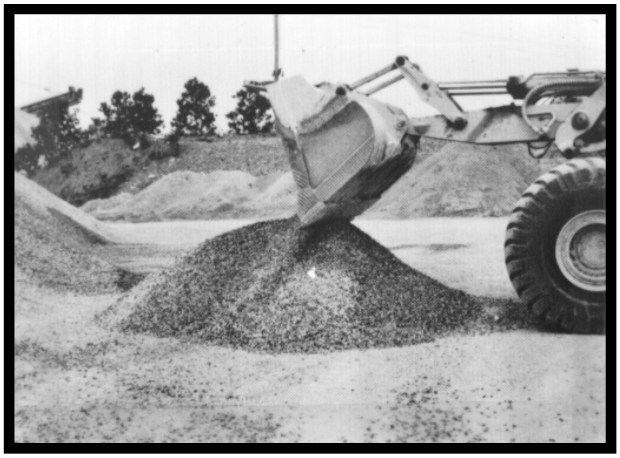


Figure 7

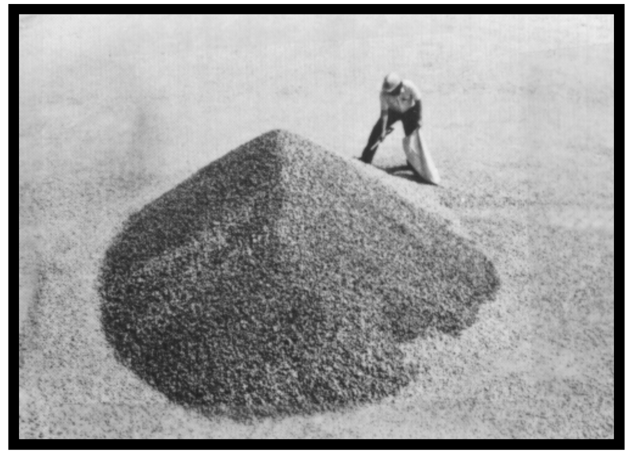


Figure 8

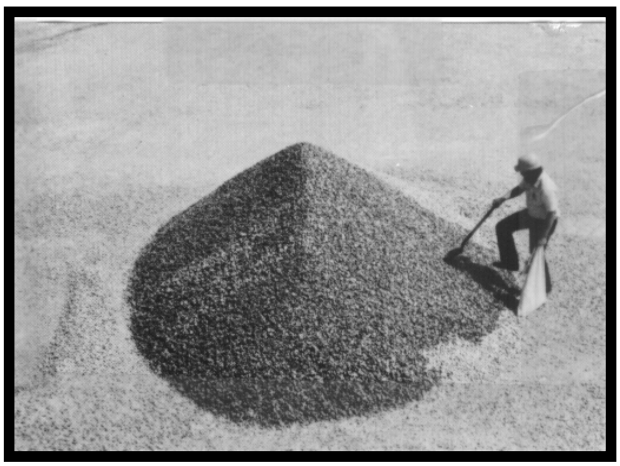


Figure 9

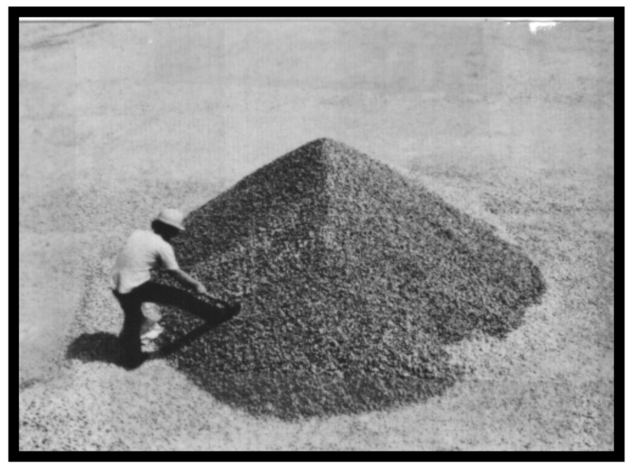


Figure 10

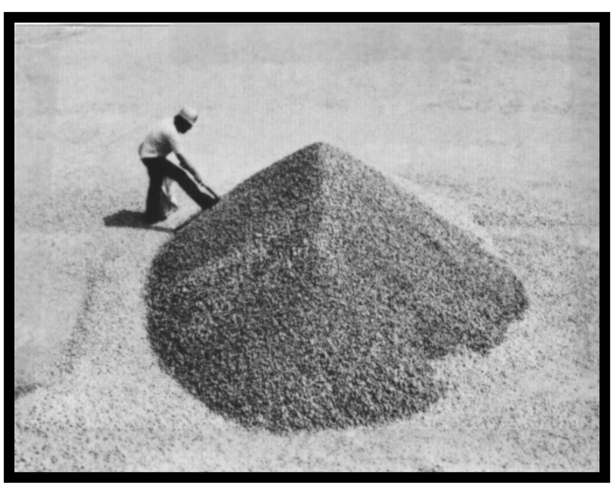


Figure 11

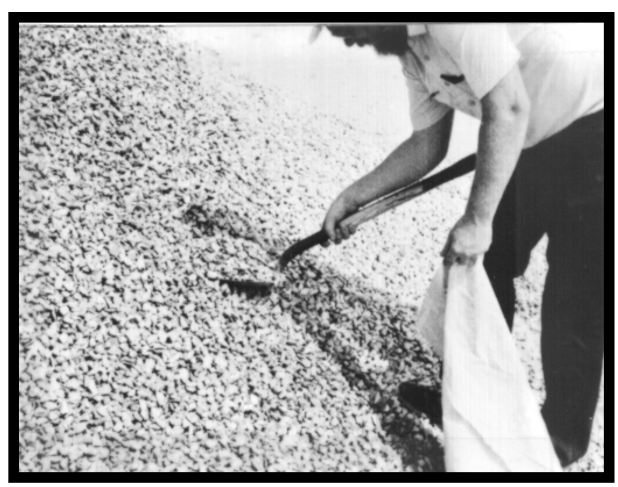


Figure 12

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

SOUNDNESS OF AGGREGATES BY FREEZING AND THAWING IN A BRINE SOLUTION
ITM No. 209-15T

1.0 SCOPE.

1.1 This method of test covers the determination of the resistance of fine or coarse aggregates to disintegration by rapidly repeated cycles of freezing and thawing in the presence of a solution of water and sodium chloride. This test method provides information used in determining the soundness of fine or coarse aggregates subjected to weathering, particularly when adequate information is not available from service records of the behavior of the aggregates.

1.2 Coarse aggregate ledge, production, and point-of-use samples and all fine aggregate production and point-of-use samples are tested using this procedure.

1.3 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 AASHTO Standards.

M 92 Wire-Cloth Sieves for Testing Purposes
M 231 Weighing Devices Used in the Testing of Materials

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

4.0 SIGNIFICANCE AND USE. This ITM is used to verify the minimum specification requirements for brine freeze-and-thaw soundness for aggregates.

5.0 APPARATUS.

5.1 Freezing-and-thawing apparatus, consisting of a suitable environmental chamber, refrigeration and heating equipment, and controls. The apparatus shall produce continuous, automatic, and reproducible cycles at a low temperature freezing range not higher than -15°F at any point in the environmental freezing chamber and a high temperature thawing range between 70°F and 75°F at any point in the environmental thaw water zone of the environmental chamber. In the event that the equipment does not operate automatically, provisions shall be made for either continual manual operation on a 24 h a day basis or for the storage of all specimens in a frozen condition when the equipment is not in operation. In the event that a capacity load of test specimens is not available, provisions shall be made to occupy empty spaces.

5.2 Sample containers, plastic, rubber, or other materials suitable for the procedure to be followed to insure water tightness

5.3 Sieves, in accordance with AASHTO M 92

5.4 Balance, in accordance with AASHTO M 231 for the class of general purpose balance required for the sample weight being tested

5.5 Oven, appropriate size capable of providing a free circulation of air through the oven, and maintaining a temperature of 230 ± 9°F

6.0 REAGENTS. Sodium chloride solution with three percent of sodium chloride by weight

7.0 FREEZING-AND-THAWING CYCLE. The nominal freezing-and-thawing cycle shall consist of alternately lowering the sample temperature from between 70°F and 75°F to below -15 °F and raising the temperature from below -15 °F to between 70°F and 75°F. At the end of the cooling period, the sample temperature shall be below -15°F and shall have been below this temperature for at least 15 minutes. At the end of the heating period the sample temperature shall be between 70°F and 75°F and shall have been maintained in this range at least 15 minutes.

8.0 SAMPLES.

8.1 Fine aggregate shall consist of material passing a 3/8 in. sieve. The sample shall yield not less than 100 g of each of the following sizes, which shall be available in amounts of 5 percent or more, expressed in terms of the following sieves:

Passing Sieve	Retained on Sieve
3/8 in.	No 4
No. 4	No. 8
No. 8	No. 16
No. 16	No. 30
No 30	No 50

Table 1

8.2 Coarse aggregate shall consist of material retained on the No. 4 sieve and all sieves above the No. 4 sieve. The sample shall yield not less than the following amounts of the different sieve sizes, which shall be available in amounts of 5 percent or more.

Size	
No. 4 - 3/8 in.	300 g
3/8 - 3/4 in. consisting of:	1000 g
3/8 - 1/2 in. material	33 percent
1/2 - 3/4 in. material	67 percent
3/4 - 1 1/2 in. consisting of:	1500 g
3/4 - 1 in. material	33 percent
1 - 1/2 in. material	67 percent
1 1/2 - 2 1/2 in. consisting of:	3000 g
1 1/2 - 2 in. material	50 percent
2 - 2 1/2 in. material	50 percent
Larger sizes by 1 in. spread in sieve size each fraction	3000 g

Table 2

8.3 If the sample contains less than 5 percent of the sizes specified in 8.1 or 8.2, that size shall not be tested. For the purpose of calculating the test results, the sample shall be considered to have the same loss in testing as the average of the next smaller and the next larger size. If one of these sizes is absent, the sample shall be considered to have the same loss as the next larger or next smaller size, whichever is present. When the 3/8 to 3/4 in., 3/4 to 1 1/2 in. or 1 1/2 to 2 1/2 in. test samples specified in 8.2 cannot be prepared due to absence of one of the two sizes of aggregate shown for each, the size available shall be used to prepare the sample tested.

8.4 When an aggregate to be tested contains appreciable amounts of both fine and coarse material having a grading with more than 10 percent coarser than the 3/8 in. sieve and more than 10 percent finer than the No. 4 sieve, separate samples of the minus No. 4 fraction and the plus No. 4 fraction shall be tested in accordance with the procedures for fine aggregate and coarse aggregate, respectively. The results shall be reported separately for the fine aggregate fraction and the coarse aggregate fraction, with the percentages of the coarse and fine size fractions in the initial grading stated.

9.0 PREPARATION OF TEST SPECIMEN.

9.1 The sample of fine aggregate shall be washed on a No. 100 sieve, dried to constant weight at a temperature of 230 ± 9°F, and separated into the different sizes by sieving, as follows.

9.2 A rough separation of the graded sample shall be made by means of a nest of the sieves specified in 8.1. From the fractions obtained in this manner, samples of sufficient size shall be selected to yield 100 g after sieving (In general, one 100 g sample will be sufficient). Fine aggregate sticking in the meshes of the sieves shall not be used in preparing the samples. Samples consisting of 100 g shall be weighed from each of the separated fractions after final sieving and placed in separate containers for the test.

9.3 The sample of coarse aggregate shall be thoroughly washed and dried to constant weight at a temperature of 230 ± 9°F and shall be separated into the different sizes shown in 8.2 by sieving. The proper weight of sample for each fraction shall be determined and placed in separate containers for the test. For aggregate coarser than the 3/4 in. sieve, the number of particles shall be counted.

9.4 **Ledge Rock**. For testing ledge rock, the sample shall be prepared by breaking the material into fragments reasonably uniform in size and shape and having a weight of approximately 100 g each. The test sample shall have a weight of 5000 g + 2 percent. The sample shall be thoroughly washed and dried prior to the test as described in 9.3.

10.0 PROCEDURE.

10.1 Each of the fractions specified in 8.1 and 8.2 shall be completely immersed in separate leak proof sample containers containing a 3 percent solution of sodium chloride (NaCl) for a period of 24 h prior to the start of the freezing cycle and shall be frozen and thawed in this completely immersed condition.

10.2 Alternate freezing and thawing shall be repeated until 25 cycles are obtained.

10.3 After the completion of the final cycle, each sample shall be dried to constant weight at 230 ± 9°F, weighed and, except in the case of ledge rock, sieved over the sieve indicated for the appropriate size of aggregate in Table 3. The material retained on the sieve shall be weighed and the weight recorded.

10.3.1 Samples of fine aggregate shall be sieved over the original retaining sieve to determine the loss. The material retained on each sieve shall be weighed and the weight recorded.

10.3.2 For ledge rock, the loss in weight shall be determined by subtracting from the original weight of the sample the final weight of all fragments which have not broken into three or more pieces.

Size of Aggregate	Sieve Used to Determine Loss
2 1/2 to 1 1/2 in.	1 1/4 in.
1 1/2 to 3/4 in.	5/8 in.
3/4 to 3/8 in.	5/16 in.

Table 3

11.0 REPORT.

11.1 The report shall include the following data:

11.1.1 Weight of each fraction of each sample before testing.

11.1.2 Except in the case of ledge rock, the actual loss of each fraction of the sample expressed as a percentage of the original weight of the fraction.

11.1.3 Weighted average calculated from the percentage of loss for each fraction, based on the average grading of the material from that portion of the material of which the sample is representative. In these calculations, sizes finer than the No. 50 sieve shall be assumed to have 0 percent loss.

11.1.4 For an aggregate containing appreciable amounts of both fine and coarse material tested as two separate samples as required in 8.4, the weighted average losses shall be calculated separately for the minus No. 4 and plus No. 4 fractions based on recomputed gradings considering the fine fraction as 100 percent and the coarse fraction as 100 percent. The results shall be reported separately with the percentage of the minus No. 4 and plus No. 4 material in the initial grading stated.

11.1.5 For ledge rock, the loss as determined in 10.2.2 shall be reported as a percentage of the original weight.

11.1.6 If considered beneficial or when requested, the type of failure of the discrete particles in the sample shall be reported.

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

CLASS AP COARSE AGGREGATE
ITM No. 210-14T

1.0 SCOPE

1.1 This method sets forth the control procedures used for classification of an aggregate as Class AP.

1.2 The coarse aggregate is incorporated into the casting of concrete beams, and the beams are cured and tested in a freeze and thaw cycling procedure. The length of the concrete beams is measured before and after the test to determine the average maximum change in length.

1.3 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 GENERAL REQUIREMENTS.

2.1 No testing of the aggregate will be made until the material is rated Class A aggregate; however, the material may be tested for class A and AP concurrently if so directed by the Department. Blending or combining of a ledge that does not meet quality or deleterious requirements will be permitted only by the approval of the Department.

2.2 The coarse aggregate Producer shall provide a written description of the production control in the Source Quality Control Plan in accordance with ITM 211. This plan shall specify the ledges to be incorporated into the production for crushed stone, the relative production zone within the pit for gravel, general handling and crushing procedures used in the production, the final production gradation obtained, and any other pertinent information relative to the coarse aggregate production, such as stockpile signage. Any unauthorized change in the approved Quality Control Plan will be cause for the suspension of shipment of this material.

2.3 Tests will be conducted by the Office of Materials Management or a Department approved AASHTO Accredited Laboratory until Department tests are available. Department tests results will control the re-sampling schedule.

3.0 REFERENCES.

3.1 AASHTO Standards.

M 85	Portland Cement
M 92	Wire Cloth and Sieves for Testing Purposes
M 154	Air-Entraining Admixtures for Concrete
M 210	Apparatus for Use in Measurement of Length Change of Hardened Cement Past, Mortar, and Concrete
M 231	Weighing Devices Used in the Testing of Materials
T 27	Sieve Analysis of Fine and Coarse Aggregate
T 119	Slump of Hydraulic Cement Concrete
T 121	Mass Per Cubic Meter (Cubic Foot), Yield, and Air Content (Gravimetric of Concrete)
T 152	Air Content of Freshly Mixed Concrete by the Pressure Method
T 161	Resistance of Concrete to Rapid Freezing and Thawing
T 196	Air Content of Freshly Mixed Concrete by the Volumetric Method

3.2 ASTM Standards.

C 192	Making and Curing Concrete Test Specimens in the Laboratory
C 666	Resistance of Concrete to Rapid Freezing and Thawing

3.3 ITM Standards.

203	Control Procedures for Classification of Aggregates
207	Sampling Stockpiled Aggregates
211	Certified Aggregate Producer Program

4.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

5.0 SIGNIFICANCE AND USE. This ITM shall be used to classify aggregates as Class AP for use as designated in the Standard Specifications.

6.0 APPARATUS.

6.1 Balance, G2, in accordance with AASHTO M 231

6.2 Beam molds, in accordance with AASHTO T 126, except for the dimensional requirements

6.3 Freezing and Thawing Apparatus, in accordance with AASHTO T 161

6.4 Length Comparator, in accordance with AASHTO M 210

6.5 Mechanical Sieve Shaker, in accordance with AASHTO T 27

6.6 Oven, appropriate size capable of maintaining a uniform temperature of 230 ± 9°F

6.7 Sieves, in accordance with AASHTO M 92

6.8 Miscellaneous equipment, such as tamping rods, scoops, trowels, straightedge, mixing bowl, sieve brush, etc.

7.0 SAMPLING. An approximate 300 lb coarse aggregate sample of the material to be tested will be obtained in accordance with ITM 207.

8.0 PREPARATION OF TEST SPECIMEN.

8.1 Coarse Aggregate. The sample shall be separated into the required sieve sizes in accordance with AASHTO T 27. T he quantity from each sieve size shall be recombined to obtain the following gradation:

Sieve Size	Percent Passing
1 in.	100
3/4 in.	95
1/2 in.	55
3/8 in.	35
No. 4	0

The sample shall be submerged in water for at least 24 h prior to mixing for beam casting and shall be SSD at the time of mixing.

8.2 Fine Aggregate. The fine aggregate sample will be No. 23 natural sand from Source No. 2310. The sample will be separated into the required sieve sizes in accordance with AASHTO T 27. The quantity from each sieve size will be recombined to obtain the following gradation:

Sieve Size	Percent Passing
No. 4	100
No. 8	87
No. 16	67
No. 30	42
No. 50	9
No. 100	0

8.3 Cement. The cement will be Type I cement in accordance with AASHTO M 85 from Source No. 0002.

8.4 Air Entraining Admixtures. The air entraining admixture shall be Catexol VR in accordance with AASHTO M 154 from Source No. 8273.

8.5 Mix Design Parameters. The concrete shall have the following properties:

Portland Cement Content	564 lb/yd^3
Water/Cement Ratio (Weight Basis)	0.43
Air Content	6.5 ± 1.5%
Absolute Volume of Coarse Aggregate (Saturated Surface Dry)	0.40

8.5.1 The air content shall be determined in accordance with AASHTO T 152 or AASHTO T 196.

8.5.2 The unit weight shall be determined in accordance with AASHTO T 121.

8.5.3 The slump shall be determined in accordance with AASHTO T 119.

8.6 Casting of Test Beams. The beams shall be cast in accordance with ASTM C 192 and the beam dimensions shall be 3 in. x 4 in. x 15 in. (depth x width x length). Three or five beams shall be cast depending on the source of aggregates as determined by the Department. Gage studs shall be cast into both ends of the beams. The gage studs shall be stainless steel hex bolts 1/4 in. - 20 UNC 1 in., with the threaded end finished in accordance with AASHTO M 210.

8.7 Curing of Cast Beams. As soon as the concrete surface is capable of supporting a curing material, the beams will be covered with two layers of wet burlap (or similar material) and one layer of at least 4 mil thick plastic sheeting. After 24 h, the beams will be de-molded and placed in submerged curing conditions in accordance with ASTM C 192. At an age of 14 days the freeze-and-thaw exposure will begin.

9.0 PROCEDURE.

9.1 Immediately after the curing period, bring the beams to a temperature of 40 ± 3°F in water.

9.2 Measure the length of the beams from stud tip to stud tip using a length comparator in accordance with AASHTO M 210.

9.3 Apply freeze-and-thaw cycling in accordance with ASTM C 666, Procedure B. The freeze-and-thaw unit will be adjusted to achieve 8 cycles per day (approximately 3 h per cycle).

9.4 Measure the length of the beams at least every 50 cycles throughout the testing at 40 ± 3°F. Check the gage studs to assure that no movement of the studs has occurred.

9.5 Continue the test until at least two beams break or until at least 350 cycles are achieved. When five beams have been cast, continue the test until at least three beams break or until at least 350 cycles are achieved.

10.0 CALCULATIONS.

10.1 Calculate the length change in percent as follows:

$$Lc = \frac{l_2 - l_1}{Lg} \text{ x } 100$$

where:

L_C = length change of the test beam after C cycles of freezing and thawing, %

l_1 = length comparator reading of beam at 0 cycles, in.

l_2 = length compactor reading of beam at C cycles, in.

L_G = effective gage length between the innermost ends of the gage studs

11.0 REPORT.

11.1 Test Report Data will include the following items:

11.1.1 Concrete batch weights

11.1.2 Coarse aggregate source identification

11.1.3 Type of material

11.1.4 Gradation of production material

11.1.5 Ledges of aggregate, if applicable

11.1.6 Date sampled

11.1.7 Individual(s) obtaining sample

11.1.8 Number of beams cast

11.1.9 Plastic concrete parameters (air content, unit weight, and slump)

11.1.10 Duration of freeze-and-thaw cycle used

11.1.11 Date of test completion

11.1.12 Initial length of each beam, length of each beam after C cycles, length change of each beam, and average length change for the beams. Length change values for each beam and the average of all beams will be reported to the nearest 0.001 percent.

11.1.13 Plot of percent length change versus number of cycles for each specimen

11.1.14 Brief description of any specimen which failed during the test including any distress observed from the beams during the testing

11.1.15 Retest date

12.0 AGGREGATE ACCEPTANCE OR REJECTION CRITERIA.

12.1 Aggregate Acceptance Criteria.

12.1.1 Department Acceptance Criteria. The average of all of the beams tested shall be less than .060 percent expansion. When three beams are cast, two of the three beams shall be less than .060 percent expansion. When five beams are cast, three of the five beams shall be less than .060 percent expansion. Broken beams shall be excluded to a maximum of one broken beam per test beam set when three beams are cast and a maximum of two broken beams per test beam set when five beams are cast.

12.1.2 Approved Laboratory Test Results. Acceptance of test results from an approved laboratory will be considered if the test results are less than two years old at the time of submission.

12.2 Retesting of Class AP Aggregate.

12.2.1 AP aggregate sources with an average beam expansion of 0.010 percent or less will be sampled and tested at least every three to five years.

12.2.2 AP aggregate sources with an average beam expansion greater than 0.010 percent but less than 0.045 percent will be sampled and tested at least every two years.

12.2.3 AP Aggregate sources with an average beam expansion of 0.045 percent but less than 0.060 percent will be sampled and tested at least annually.

12.2.4 The Department may approve the retesting of aggregates for AP use by an approved laboratory if prior written request is made and approval is given. In all cases, the Department will obtain the aggregate samples and properly identify them.

12.3 Re-Sampling of Rejected Aggregate. After one year or when enhancing process changes have been made, additional sampling and testing may be considered. Requests for additional sampling and testing shall be submitted in writing to the Manager, Office of Materials Management with a copy to the appropriate District Testing Engineer. If less than one year has elapsed, an explanation of the enhancing process changes shall be included.

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

CERTIFIED AGGREGATE PRODUCER PROGRAM
ITM No. 211- 17P

1.0 SCOPE.

1.1 This procedure covers the requirements for an aggregate supplier to become a Certified Aggregate Producer.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 Documents required by the Program may be maintained electronically or by hard copies.

2.2 AASHTO Standards.

T 11	Materials Finer Than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing
T 27	Sieve Analysis of Fine and Coarse Aggregates
T 112	Clay Lumps and Friable Particles in Aggregates

2.3 ASTM Standards

D 5821	Determining the Percentage of Fractured Particles in Coarse Aggregate
E 29	Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.4 ITM Standards

203	Control Procedures for Classification of Aggregates
207	Sampling Stockpiled Aggregates
206	Scratch Hardness of Coarse Aggregate Particles
210	Class AP Coarse Aggregate
212	Acceptance Procedures of Air Cooled Blast Furnace Slag for Leachate Determination
219	Acceptance Procedures of Steel Furnace Slag for Deleterious Materials
902	Verifying Sieves
906	Verifying Mechanical Shakers
910	Verifying Balances

2.5 Each Plant/Redistribution Terminal shall have the following current documents on file at the location indicated in the Quality Control Plan (QCP):

2.5.1 Indiana Department of Transportation Certified Aggregate Producer Program (ITM 211).

2.5.2 Indiana Department of Transportation Standard Specifications. (Includes applicable Supplemental Specifications)

2.5.3 Indiana Department of Transportation Inspection and Sampling Procedures for Fine and Coarse Aggregates.

2.5.4 Indiana Quality Assurance Certified Aggregate Technician Training Manual for Producer Technicians.

2.5.5 The QCP for the Certified Plant/Redistribution Terminal.

3.0 TERMINOLOGY.

3.1 **Terms and Abbreviations.** Definitions for terms and abbreviations will be in accordance with the Department's Standard Specifications, Section 101 and the following:

3.2 Addenda. Any addition or deletion to the QCP.

3.3 Addenda Summary Sheet. A page of the QCP, located in the Appendix that is used to record a brief description of addenda, other than items on the QCP Annex, until such time that they are incorporated into the QCP.

3.4 Adherent Fines. Fine particles smaller than the No. 200 sieve created from handling or silt or clay that adheres to the coarse aggregate particles.

3.5 Certified Material. An aggregate product produced under the Certified Aggregate Producer Program (CAPP) for Department use.

3.6 Certified Aggregate Producer. A Plant/Redistribution Terminal that meets the requirements of the Program, continues to be under the same ownership, and is approved by the Department.

3.7 Coarse Aggregate**.** Aggregate that has a minimum of 20 percent retained on the No. 4 sieve.

3.8 District. The Department District Office responsible for administering the materials and test functions in a local area of the state.

3.9 Fine Aggregate**.** Aggregate that is 100 percent passing the 3/8 in. sieve and a minimum of 80 percent passing the No. 4 sieve.

3.10 Non-Certified Aggregate Producer**.** Any Plant/Redistribution Terminal not approved under the Program. These shall include Plants/Redistribution Terminals never entering the Program, those dropping out, and those that have been removed from Certified status by the Department for failure to comply with the Program.

3.11 Producer. A company or owner who shall assume responsibility for each of their Certified Plants in compliance with the CAPP.

3.12 Program. The Department CAPP.

3.13 Quality Control Plan (QCP). A document written by the Producer that is site-specific and includes the production, policies, and procedures used by the Producer.

3.14 QCP Annex**.** A page of the QCP, located in the Appendix, that is used to record revisions for Certified Material additions, Certified Material deletions, target mean and control limit values, or Certified Aggregate Technicians until such time that they are incorporated into the QCP.

3.15 Qualified Technician**.** An individual who has successfully completed the written and proficiency testing requirements of the Department Qualified Laboratory and Technician Program.

3.16 SC Aggregate. Aggregate specification required for select seal coat (chip seal) projects.

4.0 SIGNIFICANCE AND USE. The Indiana Certified Aggregate Producer Program is a program whereby a qualified mineral aggregate Producer desiring to supply material to the Indiana Department of Transportation assumes all of the Plant site controls and the Department monitors the Producers production, sampling and testing procedures.

5.0 PARTICIPANTS.

5.1 **Plant.** Any location at which mineral aggregate is processed into a final material shall be considered a Plant. Different processes for separate materials and stockpile yards at one location shall be considered part of the Plant.

A Producer Yard shall be the location of stockpiled aggregate materials under the control of the Producer at a point removed from the Plant. This will be considered part of the Producer's total operation.

5.2 **Redistribution Terminal.** Any supplier of mineral aggregate material(s) other than at a Plant shall be considered a Redistribution Terminal. Prior source documentation will be required by the Department.

6.0 PRODUCER PERSONNEL. The Producer's personnel shall include a Management Representative and a Certified Aggregate Technician.

6.1 Management Representative. The Management Representative shall be responsible for all aspects of production, handling, and control required by the CAPP at each Certified Aggregate Producer's Plant/Redistribution Terminal.

6.2 Certified Aggregate Technician. A Certified Aggregate Technician is a Producer or Consultant employee who has successfully completed the Certified Aggregate Technician Training Program and has been certified by the Department.

The Certified Aggregate Technician may be responsible for more than one Plant/Redistribution Terminal. The technician shall be at the Plant(s)/Redistribution Terminal(s) to perform the pertinent duties during critical activities and to meet the requirements of the QCP. The technician shall supervise the sampling and testing of material, the maintenance of control charts, and the maintenance of the diary. All sampling and testing required by the Program shall be conducted by a Qualified Technician.

7.0 MATERIALS.

7.1 Material shall be produced in one of three categories; Standard Specifications, Quality Assurance, or Alternate. The intended end use of the material, and the control limits shall determine the category in which the material is classified.

7.2 Standard Specifications. Standard Specification materials shall include all Certified Materials controlled by aggregate gradations as defined in the Department Standard Specifications and the construction contract documents.

7.3 Quality Assurance. Quality Assurance materials shall include all Certified Materials controlled by aggregate gradations established by the Producer.

7.4 Alternate. Alternate materials shall include all materials produced which are not intended to comply with either Standard Specification or Quality Assurance material

8.0 LABORATORY

8.1 The Producer shall have a suitable laboratory to accomplish the requirements of the CAPP. Laboratories will be inspected by a Department representative before the Producer enters the Coordinated Testing Phase. Laboratories will also be inspected during audits and as needed to maintain the integrity of the Program.

8.2 The laboratory testing equipment shall meet the requirements of the test methods identified for the required sampling and testing, and as stated herein except that an electronic balance shall be provided. The electronic balance shall be readable to 0.1 g and accurate to 0.2 g or 0.1 percent of the test load, whichever is greater, at any point within the range of use.

8.3 The Producer shall maintain laboratory service for each Certified Plant/Redistribution Terminal. One approved laboratory may be used for more than one Plant/Redistribution Terminal provided the requirements of the Program are being maintained.

9.0 TEST EQUIPMENT CALIBRATION

9.1 The test equipment furnished by the Producer shall be properly calibrated or verified, and maintained within the limits described in the applicable test method. The equipment shall be calibrated or verified prior to beginning testing in the Coordinated Testing Phase.

9.2 The Producer shall verify the equipment at the frequency indicated:

Equipment	Requirement	Minimum Frequency	Procedure
Balances	Verification	12 mo.	ITM 910
Mechanical Shakers	Check Sieving Thoroughness	12 mo.	ITM 906
Sieves	Check Physical Condition	12 mo.	ITM 902

9.3 The equipment verification documentation shall include:

9.3.1 A description of the equipment verified including Model and Serial Number.

9.3.2 Name of the person and company performing the verification

9.3.3 Identification of the verification equipment used, if any (namely, standard weights, thermometers etc.).

9.3.4 Last date verification was performed, and next due date.

9.3.5 A reference to the procedure used.

9.3.6 Detailed records showing the results of the verification performed.

10.0 DIARY.

10.1 Each Certified Aggregate Producer shall maintain a d iary. The diary, either electronic and/or hard copy, shall have at least one page devoted to each day that there is a material related operation.

10.2 The Producer shall retain the diary on file for a minimum period of three years.

10.3 Entries in the diary shall as a minimum include:

10.3.1 General weather conditions;

10.3.2 Area of mining operation (location and ledges, or pit area);

10.3.3 Estimated quantity of materials produced;

10.3.4 Time test samples were obtained and tests completed;

10.3.5 Nonconforming gradation tests, and the resulting appropriate action taken;

10.3.6 Changes in key personnel, if any;

10.3.7 Significant changes in equipment, plant, screens, etc., which may affect the current statistical results of aggregate materials;

10.3.8 Any significant event or problem; and

10.3.9 Any nonconforming trends in the five-point moving average, as well as the action taken to correct the trends, if needed.

10.4 The entry in the diary shall be signed by the Certified Aggregate Technician or Management Representative. On occasion the diary may be signed by another person; however, the diary is required to be counter-signed by the Certified Aggregate Technician or Management Representative.

11.0 MATERIALS SAMPLING AND TESTING.

11.1 Sampling and testing of all materials that require control for aggregate gradation, decantation, deleterious, and crushed particles shall be in conformance with the Department manual, Inspection and Sampling Procedures for Fine and Coarse Aggregates. Sampling shall be performed on uniform tonnage increments in an unbiased manner, and testing of the samples shall be accomplished in such time as to assure that process control is maintained. Testing shall be performed in accordance with the test methods as designated herein, and the applicable exceptions in the Standard Specifications. Test values shall be reported to the nearest 0.1 percent, except for the crushed particle content which shall be reported to the nearest 1 percent. Results are to be rounded using the standard "5" up procedures in accordance with 109.01(a).

11.2 The Producer shall retain the test results on file for a minimum period of three years.

11.3 **Gradation.** The gradation of the material shall be determined in accordance with AASHTO T 27, except as required in 11.4. The frequency of sampling and testing shall be as follows:

11.3.1 **Start of Production Frequency**. Start of production material is the first 5000 t when producing a new material. Sampling and testing shall be performed a minimum of once every 1000 t for the first 5000 t, but not required to exceed two per calendar day per material.

11.3.2 **Normal Production Frequency.** Normal production material is material produced after the start of production. Sampling and testing shall be performed a minimum of once every 2000 t, but not required to exceed two per calendar day per material.

11.3.3 **Load-Out Frequency.** Load-out material is the Certified Material that is shipped from the Plant/Redistribution Terminal. Sampling and testing shall be performed a minimum of once every 8000 t, on any Certified Material that is shipped; however, there shall be at least one sample and test per month for any Certified Material shipped that exceeds 1000 t.

11.4 **Decantation.** The decantation of the material shall be determined in accordance with AASHTO T 11. All load-out samples shall be washed and decanted. Unless specific problems are encountered, start of production and normal production samples need not be washed and decanted.

11.5 **Crushed Particles.** The percentage of crushed coarse aggregate particles for gravel shall be determined in accordance with ASTM D 5821. The frequency of sampling and testing shall not be less than once per week for each size of material during the start of production and normal production or as designated in the QCP. No test is required if the week's production is less than 100 t.

11.6 **Deleterious Materials.** The percentage of deleterious materials shall be determined for coarse aggregates in accordance with AASHTO T 112, ITM 206 and the Standard Specifications. The frequency of sampling and testing shall not be less than once per week for each size of material during the start of production and normal production or as designated in the QCP. No test is required if the week's production is less than 100 t.

11.7 **Flakiness Index.** The flakiness index shall be determined for SC aggregates in accordance with ITM 224 and the Standard Specifications. The frequency of sampling and testing shall be not less than once per week for each size of material during the start of production and normal production or as designated in the QCP. No test is required if the week's production is less than 100 t.

12.0 GRADATION CONTROL

12.1 Gradation control shall be performed for each Plant/Redistribution Terminal in accordance with the QCP and requirements herein.

12.2 **Sieve Control.** Standard Specification materials shall meet the critical sieve requirements for the materials and sieves shown below:

Material	Critical Sieve
No. 5	1/2 in.
No. 8	1/2 in.
No. 9	3/8 in.
No. 11, SC 11	No. 4
No. 12, SC 12	No. 4
SC 16	No. 4

All other Standard Specification materials shall meet the specification or construction contract gradation limit requirements for all sieves, unless controlled by a critical sieve as identified in the QCP.

Quality Assurance coarse aggregate materials, with a d esignated maximum particle size of 1½ in. or smaller, shall have a critical sieve identified in the QCP. All other Quality Assurance materials shall meet the gradation limit requirements for all sieves, unless controlled by a critical sieve as identified in the QCP.

12.3 **Target Mean.** All data that exists on a single process shall be used to establish the target mean. For a totally new process, at least 10 consecutive normal production test results shall be used. If production within a year does not result in sufficient data to establish a target mean, then a target mean shall not be determined.

The target mean on the critical sieve for Standard Specification materials, shall be no closer to either specification limit th an 1.65 multiplied by the standard deviation designated in the QCP. The standard deviation shall be equal to or less than 5.0.

The target mean on the critical sieve for Quality Assurance materials shall be established by the Producer for any sampling point.

12.4 **Control Limits.** Control limits are applicable to all critical sieve test results. They are established as plus or minus two standard deviations, but no greater than plus or minus 10 percent, from the target mean. When a target mean cannot be determined because of insufficient production, the Standard Specification gradation limits or gradation for Quality Assurance material shall be used.

When identified in the Producer's QCP, the Department may agree to designated target mean values and control limits on the critical sieve for the load-out tests that may be different from the production target mean values and control limits.

12.5 Test Compliance. For material produced under either the Standard Specification or Quality Assurance categories, 95 percent of all gradation test results on the critical sieve shall statistically be between 10 percent below and 10 percent above the target mean at any one point of sampling. All other sieves shall be maintained within the Standard Specification, Quality Assurance, or construction contract gradation requirements.

All normal production data on the critical sieves identified for sieve control representing a process shall be included in the calculations for statistical compliance. When the control limits for load-out tests are different than the production control limits, all of the load-out tests may be used. All retest and other extraneous data shall be used for information.

12.6 Alternate Materials. Controls and limits as detailed in the Program herein do not apply for Alternate materials unless so stated in the QCP.

12.7 Nonconforming Tests. A nonconforming test shall be any test which falls outside the control limits identified in the QCP for Standard Specification or Quality Assurance materials controlled by a critical sieve. For sieves other than the critical sieve, a nonconforming test shall be any test which falls outside the control limits identified in the QCP for Quality Assurance materials, or outside the specification limits for materials controlled by Standard Specification requirements. Any nonconforming normal production or load-out test shall be followed immediately by a corrective action. Corrective actions shall include, but are not limited to, investigation for assignable cause, correction of known assignable cause, and retesting. Plants/Redistribution Terminals that continue to have repeated nonconforming normal production or load-out test results, due to lack of appropriate action, shall be subject to suspension from the Certified status by the Department.

A second consecutive nonconforming normal production test result shall require the material to be isolated from the approved stockpile until action has been taken to eliminate the cause of the nonconformity. When a second consecutive nonconforming load-out test occurs, shipping from that stockpile shall cease until corrective action and testing has occurred that verifies the stockpile is acceptable for shipment.

13.0 CONTROL CHARTS.

13.1 Control charts are a visual representation of the process control exercised by a Producer. Unless otherwise provided in the QCP, the control charts shall be posted on a wall at the laboratory. As a minimum, the wall posting shall be maintained until 30 production data points have been plotted. Subsequent to that time at least 30 production data points shall be continuously displayed.

13.2 The Producer shall retain the control charts on file for a minimum period of three years.

13.3 **Application.** As a minimum, control charts shall be required for gradation control using all start of production and normal production test results for all Standard Specification and Quality Assurance materials or for gradation controlled Alternate materials. For materials which have a critical sieve, only the critical sieve is required to be charted. For all other charted materials, all applicable sieves shall be shown on the chart. Load-out test results shall also be plotted and may be displayed on the same chart as start of production and normal production test results when the target mean remains unchanged. When the load-out target mean is designated in the QCP to be different from the production target mean, the load-out samples shall be charted separately. Other properties may also be charted as part of the Producer's overall QCP. A separate chart shall be maintained for each size of material being produced.

13.4 **Chart Construction.**

13.4.1 The target mean shall be represented by a heavy long dash followed by a short dash line.

13.4.2 Control limits shall be represented by heavy solid lines.

13.4.3 Upper and lower specification limits shall be indicated by short dashed lines. Specification limits are not required to be included on charts for critical sieves that have established control limits.

13.4.4 The horizontal lines on the chart indicating the specification limits, control limits, and target mean value, if applicable, shall be numerically identified in the left margin.

13.4.5 The plot point for the production test results shall be surrounded by a small circle, and each consecutive point shall be connected by a solid straight line.

13.4.6 The moving average of the most current five production test values shall be plotted for the critical sieve. The plot points shall be indicated by a small triangle symbol, and connected by solid straight lines.

13.4.7 When load-out test points appear on the same chart as production points, they shall be represented by a small square.

13.4.8 When load-out test points are plotted on a separate chart, they shall be represented by a small square, and connected by a straight line.

13.4.9 Test results shall be plotted left to right in chronological order, and dates corresponding to each test shall be shown along the horizontal axis.

Any proposed deviation from these procedures shall be identified in the QCP.

13.5 Conformance. The Producer shall apply statistical techniques to interpret all control charts and take corrective action when so indicated. Corrective action shall include, but is not limited to, investigation for assignable cause, correction of known assignable cause, and retesting, if necessary.

14.0 QUALITY CONTROL PLAN.

14.1 The QCP is a fundamental element in the Program, and shall be one of the first considerations in approval by the Department. Each Plant/Redistribution Terminal providing aggregate under the Program shall have a written QCP, which shall be site and plant specific, and be the basis of control. The QCP shall describe the methods of controlling all properties and quality aspects, which shall involve greater detail than the basic requirements of the Department specifications and policies. The QCP shall encompass the total process from preliminary material quality approval through the point where the aggregate leaves the Producer's control.

14.2 The QCP shall include the following information for each Plant/Redistribution Terminal, if applicable:

14.2.1 The location of the site, including township, range, section, physical address, and mailing address if different than the physical address. Reference to the nearest identifiable points such as highways and towns shall also be included.

14.2.2 The Parent Company, Management Representative, Certified Aggregate Technician(s) and Qualified Technician(s) at each location and the procedure for contacting these individuals by phone, fax, US Mail, and email address. Also, the CAPP duties and responsibilities of each of the people listed shall be specified.

14.2.3 A list and description of all portions of the mineral deposit(s) indicating the different quality classes as established in the current editions of ITM 203 and ITM 210, and as indicated on the Source Category Classification Approval letter. The manner in which each quality class shall be processed, handled, and stockpiled shall be specified.

14.2.4 A statement regarding AP Aggregate shall be made to include the ledges for stone, production zone for gravel, the general handling and crushing procedures, and stockpile signage. An AP Production Control Plan may be included in the Appendix instead of this statement.

14.2.5 A statement regarding ACBF shall be made to include the procedures for sampling and testing for determination of leachate in accordance with ITM 212.

14.2.6 A statement regarding SF shall be made to include the procedures for sampling and testing for determination of bulk specific gravity when SF is used in SMA mixtures. Also, a statement regarding SF coarse aggregate shall be made to include the procedures for sampling and testing for determination of deleterious materials in accordance with ITM 219.

14.2.7 A statement regarding lightweight aggregate shall be made to include the procedures for sampling and testing for determination of the specific gravity factor and the absorption in accordance with ITM 222.

14.2.8 A statement regarding natural sand fine aggregate shall be made to include the procedures for sampling and testing when composite stockpiling of multiple sources into one stockpile is done.

14.2.9 An explanation for each material having marginal quality characteristics, and the plan or controls to be used for such materials.

14.2.10 An identification of the category in which each material produced is classified.

14.2.11 A generic production flow diagram, which shall be a step-by-step chart using standard symbols, showing all the steps involved with mining and processing from the natural deposit to the finished material and the points of sampling. Detailed items such as equipment manufacturer's names, screen sizes, dimensions, etc., are not required to be listed. A copy of the symbol legend shall be included.

14.2.12 A sampling plan that includes locations, devices, techniques, frequencies, and test methods, if applicable.

14.2.13 A testing plan that includes the types of tests, and test methods. Theprocedure for isolating nonconforming material shall be specified.

14.2.14 A list of the target mean values, standard deviations, and control limits on the critical sieves for each material identified as being controlled by critical sieve requirements. Changes in the target mean are permitted by addenda to the QCP. Materials for which no control limits are appropriate shall be identified. The gradation limits for all Quality Assurance materials shall be included.

14.2.15 A description of any other process control techniques that will be used beyond the minimums established by Department specifications and policies. These controls may include, but are not limited to, the following:

a) Different types or greater frequencies of material testing.
b) Other midstream sampling and testing prior to material completion.
c) Visual checks and monitoring.

14.2.16 A plan for downstream controls after material completion. These controls shall address such items as the identification of material stockpiles by signing or other acceptable methods, techniques for construction of proper stockpiles, material retrieval techniques and safeguards to ensure the loading and shipping of uncontaminated material.

14.2.17 A description and location of the laboratory, a list of equipment that is to be verified, and the test methods and frequency of verification of the equipment

14.2.18 A documentation plan with details on c ontrol charting, test data, and the diary. Copies of the forms may be included.

14.2.19 The method by which the frequency of production and load-out testing of the Certified Materials is verified.

14.2.20 The location of the reference documents, control charts, diary, test data, material shipment records, and any other pertinent information.

14.2.21 The method of control for each Producer Yard.

14.2.22 A statement of the procedure for handling addenda.

14.2.23 Annual Aggregate Source Report (stone sources only). The report shall be in accordance with ITM 203, 8.1, and shall be included in the Appendix of the QCP. Redistribution Terminals are required to include this report for materials received from a source that is not a Certified Aggregate Producer.

14.2.24 An Appendix. As a minimum the appendix shall contain an Addenda Summary Sheet.

14.3 **Authentication.** The last page of the QCP shall contain two signature blocks. The right hand block shall be signed and dated at the time of submittal by the Producer's Management Representative, and shall include the title of the person making the signature. The left hand block shall be signed and dated at the time of approval by the Manager, Office of Materials Management. The Producer shall submit two copies of the QCP to the Department for approval. One copy shall be submitted to the District Testing Engineer and the other copy to the Office of Materials Management. The authentication page will be returned to the Producer after acceptance and approval.

14.4 **Addenda.** The Producer shall transmit all applicable process control revisions to the District Testing Engineer in the format of addenda to the QCP. Each page of the QCP that is revised shall include the source number, date of revision, and means of identifying the revision. The addenda shall include a signed and dated authentication page that is signed by the Management Representative and subsequently signed by the District Testing Engineer upon approval.

Revisions for Certified Material additions, Certified Material deletions, target mean and control limit values, or Certified Aggregate Technicians shall be submitted in the format of a QCP Annex as they occur, and upon approval by the District Testing Engineer shall be included in the Appendix of the QCP. Revisions, other than items on the QCP Annex, shall be maintained on the Addenda Summary Sheet in the QCP Appendix.

Addenda may be submitted at the audit close-out meeting or between January 1st and April 1st of each calendar year. The addenda shall include items on the QCP Annex, items on the Addenda Summary Sheet, and any other necessary revisions at the time of submittal. Upon incorporation into the QCP as addenda, the QCP Annex and items on the Addenda Summary Sheet shall be removed from the QCP Appendix. The Annual Aggregate Source Report shall be submitted by April 1st of each calendar year.

14.5 Certified Material Additions. A Producer without a Certified Material that is controlled by a critical sieve is required to meet the applicable requirements of 12.0 prior to adding the Certified Material. A Producer without a Certified Material that is not controlled by a critical sieve is required to verify that the material meets the requirements of the Standard Specifications or Quality Assurance gradation limits for all sieves prior to adding the Certified Material. A Producer may add a Certified Material using the following procedure:

14.5.1 Prior to shipment of the material, the Producer shall submit a QCP Annex to the District Testing Engineer.

14.5.2 Shipment of the material may begin as soon as approved by the District Testing Engineer.

14.5.3 The control limits will be the Standard Specification gradation limits for the appropriate size of material. If the material is a Quality Assurance material then the Producer shall designate the control limits. If the material is controlled by a critical sieve, then the control limits for that sieve shall be used when the target mean and standard deviation are in accordance with 12.3.

14.5.4 Materials that do not have a critical sieve requirement shall be sampled and tested in accordance with 11.3.

Materials that have a critical sieve requirement shall be sampled and tested a minimum of once every 1000 t, but not required to exceed two per calendar day. Load-out frequency shall be in accordance with 11.3. When the target mean and standard deviation are in accordance with 12.3, the frequency of sampling and testing for normal production shall be in accordance with 11.3.

14.5.5 Split samples shall be obtained by the Producer for each sample, and provided to the Department. The sample splitting procedure and test results agreement shall be the same as the guidelines used during the Coordinated Testing Phase. Split samples shall be obtained until the Department is satisfied with the performance and testing results from the Producer. If the material is similar in size to an existing Certified Material, the District Testing Engineer may waive the requirement for split samples.

15.0 COORDINATED TESTING PHASE.

15.1 The Coordinated Testing Phase is the initial phase for Certification. The purpose of this phase is to build mutual confidence in production capability, capacity, uniformity, and quality. Sampling and testing procedures, and test results will be reviewed in a coordinated and shared manner between the Department and the Producer. While operating in this phase, the Producer shall develop the details of the QCP, and demonstrate the ability to produce to the required test compliance rate. Mean test values and standard deviations are developed during this process for the critical sieves. Each Plant/Redistribution Terminal shall be under the Coordinated Testing Phase for at least three months of production, or a period as determined by the Department.

15.2 Each Plant/Redistribution Terminal requesting to enter the Coordinated Testing Phase shall do so in writing to the Manager, Office of Materials Management. The request shall include all of the materials to be supplied at the source regardless of whether the materials are for Department or other uses.

15.3 **Aggregate Sizes.** While operating in the Coordinated Testing Phase, Producers are encouraged to limit the Coordinated Testing procedures to aggregate sizes 5 or 8; 43, 53, or 73; or 23 or 24. Quality Assurance materials may also be used for the Coordinated Testing procedures.

15.4 **Control Charts.** Test results shall be charted in accordance with requirements for Certified Material, except that the corrective action need not apply. The Producer will be expected to use the charts as basic indicators of variation, and to become aware of limitations needed on any process. During this phase charts shall be maintained for all sieves.

15.5 **Sampling and Testing.** The frequency and types of tests for the Producer's sampling and testing shall be the same as the minimum requirements of the start of production and normal production for Certified Material, except that decantation will be required.

The use of a random sampling method is encouraged; however, if a random sampling method is not used, and if more than one sample per day is required, the samples shall be spread throughout the day's expected production. Department aggregate technicians will conduct coordinated/side-by-side testing on as many of these samples as possible. In any event, Department testing will be conducted on not less than every other test conducted by the Producer, or until the Department is satisfied with the performance and testing results from the Producer.

The coordinated tests shall utilize a split sample for all tests except non-durable, total chert, which shall use the same sample. The procedure for splitting samples shall be in accordance with the Inspection and Sampling Procedures for Fine and Coarse Aggregates. Both split halves on the final split shall weigh within 10 percent of each other after splitting. If not, both halves shall be recombined and split until this requirement is met.

15.6 Producer Records. During the Coordinated Testing Phase the Plant/Redistribution Terminal shall maintain the same references, charts, reports, diary, and Source Category Classification Approval letter as required for the Certified Aggregate Producer.

15.7 Test Results Agreement. The Coordinated Testing Phase guidelines for test agreement are:

Sieve Analysis	
Sieve Size	**Maximum % Difference**
1½ in. thru 3/8 in.	5
No. 4 thru No. 8	3*
Minus No. 200 (decant less than 5.0)	0.5
Minus No. 200 (decant equal to or greater than 5.0)	1.0

* The maximum % difference for sizes 43, 53, and 73 is 5 %.

Crushed Particles. The difference should not exceed 5 percent for both one and two face fractured particles.

Non-Durable, Total Chert. The difference should not exceed 40 percent of the lowest results or 1 percent, whichever is greater.

Test result differences will be resolved on-site between the Producer's technicians and the Department's technician, if feasible. If such differences are not readily resolved, the Area Supervisor and/or the District Testing Engineer will resolve the difference. The resolution will be recorded by both technicians.

15.8 Data Reporting. Within the first week of each month copies of the test results, control charts, and the diary shall be forwarded to the District Testing Engineer.

16.0 TRIAL PHASE. The Trial Phase is the second phase for obtaining Certification. This phase is started when the Producer has successfully completed the Coordinated Testing Phase and the QCP has been approved. During this phase the Producer shall demonstrate the ability to follow the QCP. Monthly submissions of test results, control charts, and the diary shall be continued. Revisions to the QCP by addenda may be made at the Trial Phase Audit close-out meeting.

17.0 CERTIFICATION.

17.1 Each Plant/Redistribution Terminal meeting the requirements of the CAPP shall be eligible for Certification. Each Certified Producer must comply with the Program as detailed herein. After approval, monthly submissions of test results, control charts, and the diary are not required.

17.2 **Material Shipment Record.** Certified Producers shall have records in sufficient detail so as to enable the Department to verify the frequency of load-out testing.

The record shall include:

17.2.1 Date of shipment.

17.2.2 Originating source name of material.

17.2.3 Total amount shipped each day.

17.2.4 The type and size of aggregate.

17.2.5 Ledges for stone materials.

17.3 **Weigh Tickets.** The Certified Producers approval number, originating source name, source number, aggregate size, and ledges for stone materials, shall be entered on each weigh ticket representing material for Department use.

17.4 **Change of Ownership.** Once the Department has Certified a Plant/Redistribution Terminal, there is no automatic expiration date for the Certification; however, in the event of a change in ownership of the Plant/Redistribution Terminal, the certification shall expire on the date of such change. The new ownership may avoid such expiration by immediately submitting a statement to the Manager, Office of Materials Management indicating recognition of the details of the CAPP, the existing QCP, and a clear pronouncement of intent to operate in accordance with the requirements of both documents.

17.5 **Inactive Status.** A Producer may request to be placed on Inactive Status to temporarily suspend meeting the requirements as a Certified Aggregate Producer. The procedures for temporary suspension of the Program shall be as follows:

17.5.1 The Producer shall submit a statement to the Manager, Office of Materials Management requesting Inactive Status

17.5.2 While in the Inactive Status, the Producer may ship all Certified Materials in existing stockpiles at the time of suspension if the requirements of the Program have been met for these stockpiles.

17.5.3 The Producer may obtain the Certified Aggregate Producer status again by submitting a statement to the Manager, Office of Materials Management requesting re-entry into the Program. Any revisions to the Quality Control Plan shall be submitted with the re-entry request. Quality approval in accordance with ITM 203 will be required prior to shipping any Certified Material.

18.0 DEPARTMENT RESPONSIBILITIES

18.1 Certified List. The Department will maintain an updated published listing of all Plants/Redistribution Terminals that are currently certified.

18.2 Auditing. The Department will audit the Program on a random basis at each Plant/Redistribution Terminal to verify that the Producer's production, sampling, and testing procedures are in accordance with the Program.

The audit will include random samples taken by the Producer for informational purposes as directed by the Department. A split of the audit samples shall be provided to the Department. The sample splitting procedure, and test results agreement shall be in accordance with 15.5 and 15.7.

18.3 Mineral Quality. The Department will be responsible for the pre-approval of the mineral quality at each Plant location in accordance with ITM 203 and ITM 210.

18.4 Training. The Department will administer a Certified Aggregate Technician Training Program for those aggregate technicians that perform the required duties of the Program. Certification of the technicians will be provided by the Department upon successful completion of the training. Recertification of the technicians will be required after a period of three years.

The Department will administer the Qualified Laboratory and Technician Program for those aggregate technicians that perform acceptance sampling and testing duties of the Program. Qualification of the technicians will be provided by the Department upon successful completion of a written examination and proficiency test. Certified Aggregate Technicians are required to be Qualified Technicians; however, the written examination will not be required. Proficiency testing is required at least once every three years.

18.5 Certification Removal. Removal from the approved status of a Certified Producer will be the responsibility of the Manager, Office of Materials Management.

The Producer shall have a right to appeal the removal from Certified Producer status to the Director, Construction Management Division.

18.6 District Jurisdiction. The District Testing Engineer will have the authority to suspend shipment of a specific material or stockpile if the Producer has failed to comply with the Program such that material quality and uniformity is not being met. Such action will be promptly reported to the Manager, Office of Materials Management.

The Producer shall have the right to appeal the suspension of shipment by the District to the Manager, Office of Materials Management.

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

ACCEPTANCE PROCEDURES OF AIR COOLED BLAST FURNACE SLAG FOR LEACHATE DETERMINATION
ITM No. 212-15T

1.0 SCOPE.

1.1 This method sets forth the procedure for sampling and testing ACBF slag for determination of leachate from the aggregate.

1.2 Unaged ACBF slag may contain an excessive quantity of calcium sulfide which may leach when inundated with a large volume of water. The leachate may emit hydrogen sulfide gas, and have a greenish-yellow color. When exposed to air, the rate of leaching will diminish with time as the ACBF slag ages. The aging process will allow the calcium sulfide to oxidize to sulfates and carbonates.

1.3 This procedure will apply to all uses of ACBF slag except for use in HMA or PCC.

1.4 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 AASHTO Standards.

M 92 Wire-Cloth Sieves for Testing Purposes
M 231 Weighing Devices Used in the Testing of Materials
T 248 Reducing Samples of Aggregate to Testing Size

2.2 ASTM Standards.

D 1193 Reagent Water
E 70 pH of Aqueous Solutions with the Glass Electrode
E 832 Laboratory Filter Paper
E 960 Laboratory Glass Beakers

2.3 ITM Standards.

207 Sampling Stockpiled Aggregates

3.0 TERMINOLOGY. Definitions for terms and abbreviations will be in accordance with the Department's Standard Specification, Section 101.

4.0 SIGNIFICANCE AND US E. This ITM shall be used to evaluate ACBF slag for determination of leachate from the aggregate. The ACBF slag is required to meet the requirements of this test method before use, except when used in HMA or PCC.

5.0 APPARATUS.

5.1 Balance, Class G20, in accordance with AASHTO M 231

5.2 No. 4 sieve, in accordance with AASHTO M 92

5.3 Filter paper, medium grade, in accordance with ASTM E 832

5.4 The Geological Society of America Rock Color Chart

5.5 Five-gallon bucket, plastic, with lid

5.6 Funnel

5.7 Glass beaker, 150 mL, in accordance with ASTM E 960

5.8 pH meter

5.9 Tamping rod, round, steel, approximately 5/8 in. in diameter, and approximately 24 in. in length

6.0 REAGENTS. Deionized or distilled water, conforming to the requirements of ASTM D 1193

7.0 GENERAL REQUIREMENTS.

7.1 Each Aggregate Producer requesting to have ACBF slag tested in accordance with this procedure shall contact the appropriate District Testing Engineer to initiate the approval process.

7.2 Sampling and testing shall be conducted by the Aggregate Producer.

7.3 ACBF slag shall be sampled as the stockpiles are being constructed. E xisting stockpiles shall be sampled randomly from the exterior and interior of the stockpile.

7.4 Acceptance for use of ACBF slag will be given on each stockpile of approximately 2000 tons. Stockpiles that do not meet the acceptance criteria of this test method may be tested again after 30 days from the test date.

7.5 Stockpile location, stockpile identification, and test results shall be maintained at the ACBF slag source and shall be available for inspection.

8.0 SAMPLING.

8.1 Sampling of aggregates shall be done in accordance with ITM 207.

8.2 Each sample shall consist of 80 to 100 lbm of material.

8.3 The test sample shall be obtained by reducing the original sample in accordance with AASHTO T 248 to a sample size of 20 to 25 lbm

9.0 PROCEDURE.

9.1 Place the test sample in a five-gallon bucket, fill with distilled or deioinized water until the sample is covered with at least 1/2 in. and not more than 1 in. of water, and place the lid on the bucket. No additional water shall be added after the test is started. Allow the sample to soak for one day.

9.2 After the one day soaking period, thoroughly stir the sample with the tamping rod and collect a water sample of approximately 100 mL.

9.3 Using a funnel, filter the water sample through the filter paper into a glass beaker.

9.4 Observe the color of the water.

9.5 Calibrate a pH meter in accordance with the manufacturer's instructions and ASTM E 70, and then determine the pH of the water sample to the nearest 0.1 pH unit.

9.6 If the water color is equal to or darker than the moderate greenish-yellow color (Hue 10 y) from the rock color chart, or the pH is not within 6.0 to 10.5, the material is not acceptable and the test is completed. Upon the completion of the color observation and pH measurement, the 100 mL water sample is discarded.

9.7 If the water color is lighter than the moderate greenish-yellow color (Hue 10 y) from the rock color chart and the pH is within 6.0 to 10.5, then allow the sample to soak for another six days. The bucket shall be covered with the lid and steps 9.3 to 9.6 repeated after three days and seven days from the initial soaking.

10.0 ACCEPTANCE CRITERIA.

10.1 If after one day, three days, or seven days of soaking, the water color is equal to or darker than the moderate greenish-yellow color (Hue 10 y) from the rock color chart, the material will not be acceptable for use.

10.2 If after one day, three days, or seven days of soaking, the pH is not within 6.0 to 10.5, the material will not be acceptable for use.

10.3 If after seven days of soaking, the water color is lighter than the moderate greenish-yellow color (Hue 10 y) from the rock color chart and the pH is within 6.0 to 10.5, the material will be acceptable for use.

11.0 REPORT.

11.1 All pH values shall be reported to the nearest 0.1 unit.

11.2 The color of the water shall be reported as lighter than, equal to, or darker than the moderate greenish-yellow color (Hue 10 y) from the rock color chart.

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

ACCEPTANCE PROCEDURES FOR POLISH RESISTANT AGGREGATES ITM No. 214-16P

1.0 SCOPE.

1.1 This method sets forth the acceptance procedures to be used when Aggregate Producers request that polish resistant coarse aggregates be evaluated for use in HMA surface mixtures.

1.2 Polish resistant coarse aggregates are specified for use under certain traffic ESAL loading conditions to obtain skid-resistant HMA surface courses.

1.3 Coarse aggregates tested in accordance with this procedure shall be dolomite containing less than 10.3 percent elemental magnesium, crushed limestone, or gravel.

1.4 This method is a two part process. Part One requires a comparison of the coarse aggregate to an approved dolomite or polish resistant aggregate material using the British Polishing Wheel in accordance with ASTM D 3319 and the British Pendulum Tester in accordance with ASTM E 303. If the results of the comparison indicate that the coarse aggregate has a Residual Polishing Value (RPV-10) of one less than, equal to, or greater than the RPV-10 value obtained from the approved dolomite or polish resistant aggregate material, then Part Two may be initiated.

Part Two requires that a test section of HMA using the coarse aggregate and a control test section of HMA using an approved dolomite or polish resistant aggregate material be placed on a contract. The coarse aggregate and the approved dolomite or polish resistant aggregate material may be blended with air-cooled blast furnace slag, steel furnace slag, or sandstone coarse aggregate for the two test sections. Acceptance of the coarse aggregate is made on the basis of an evaluation of friction test data obtained after two years of exposure to traffic; however an aggregate may be accepted after one year of exposure to traffic at the discretion of the Department.

1.5 The Aggregate Producer will be required to maintain a warranty bond on the HMA surface course of the test section using the proposed polish resistant aggregate. The bond amount shall be sufficient to replace the test section with material satisfactory to the Department. Upon opening the test section to unrestricted traffic, the warranty bond will be in effect for a total of two years. The warranty bond is required to be properly executed by a surety company satisfactory to the Department and be payable to the State of Indiana. Appendix A shall be used for the warranty bond.

1.6 If within two years of exposure to traffic, the average friction number of the proposed polish resistant aggregate is less than the average friction number of the approved dolomite or polish resistant aggregate material, the Department will evaluate the test section to determine if a problem exists. If remedial work is required, the Aggregate Producer shall conduct the work at no c ost to the Department. If the Aggregate Producer cannot conduct the remedial work within a timely manner, the Department has the option to execute the warranty bond and have the remedial work conducted by other forces.

1.7 This procedure may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 AASHTO Standards.

T 11 Materials Finer than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing

T 27 Sieve Analysis of Fine and Coarse Aggregates

2.2 ASTM Standards.

D 3319 Accelerated Polishing of Aggregates Using the British Wheel

E 274 Skid Resistance of Paved Surfaces Using a Full Scale Tire

E 303 Measuring Surface Frictional Properties Using the British Pendulum Tester

E 524 Smooth Tread Standard Tire for Special-Purpose Pavement Skid Resistance Tests

2.3 ITM Standards.

207 Sampling Stockpiled Aggregates

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

4.0 SIGNIFICANCE AND US E. This ITM shall be used to evaluate polish resistant aggregates for use in HMA surface mixtures.

5.0 APPARATUS.

5.1 British Wheel, in accordance with ASTM D 3319

5.2 British Pendulum Tester, in accordance with ASTM E 303

5.3 Friction vehicle and instrumentation in accordance with ASTM E 274

5.4 Smooth Tread Standard Tire in accordance with ASTM E 524

6.0 GENERAL REQUIREMENTS.

6.1 Each Aggregate Producer requesting to have a co arse aggregate tested in accordance with this procedure shall do so in writing to the Manager, Office of Materials Management with a copy sent to the appropriate District Testing Engineer. Information concerning the type of material, and ledge numbers, if applicable, shall be included.

6.2 The approved dolomite or polish resistant aggregate material used in the control test section shall be obtained from one of the following sources.

2232 – Lehigh Hanson Aggregates Midwest Inc.,
Ft. Wayne, IN (Ledges 1-7)

2267 – U.S.Aggregates, Inc. - Pleasant Mills
Decatur IN (Ledges 1001-4)

2535 – U.S. Aggregates - Columbus
Columbus, IN (Ledges 11-12)

2542 – IMI/Sellersburg Plant
Sellersburg, IN (Ledges 11-13)

2651 – Knox County Sand & Gravel
Vincennes, IN

An alternate dolomite or polish resistant aggregate source for the control section will be approved by the Department if the dolomite or polish resistant aggregate material meets the requirements of Part One in 1.4 w hen compared to the dolomite or polish resistant aggregate from one of the approved sources.

6.3 Testing shall be conducted by the Department or by a Department approved Laboratory. The cost of shipping and testing of the coarse aggregate shall be the responsibility of the Aggregate Producer.

6.4 Friction testing of the test sections will be conducted by the Department at no expense to the Aggregate Producer.

6.5 Approval of the source as a Polish Resistant Material will be based on results from both Part One and Part Two of this procedure.

7.0 SAMPLING.

7.1 Sampling of the coarse aggregate and approved dolomite or polish resistant aggregates shall be in accordance with ITM 207 in the presence of the Department.

7.2 The samples shall be sufficient in quantity to yield a minimum of 50 lb of material that is passing the 3/8 in. sieve and retained on the No. 4 sieve.

7.3 The samples shall be washed and decanted in accordance with AASHTO T 11.

7.4 The samples shall be sieved in accordance with AASHTO T 27 to obtain the appropriate quantity of material passing the 3/8 in. sieve and retained on the No. 4 sieve required for the test of Part One.

8.0 PROCEDURE.

8.1 Calibration and Testing Using the British Polishing Wheel and British Pendulum Tester (PART ONE).

8.1.1 Control Specimens.

a) Control specimens shall be fabricated using a 4 to 1 mixture by weight of 20-30 grade Ottawa sand and polyester resin in accordance with ASTM D 3319. The back portion of the specimen shall be finished with the polyester resin to facilitate preparation of the bearing surface of the specimens.

b) The specimens may be heated in the molds in an oven at a temperature of 212°F for 2 to 4 hours if warping of the specimen occurs due to shrinkage of the polyester resin. Specimens shall be shaped to an 8 in. radius of curvature by mechanical clamps.

c) If the specimens do not properly fit on the road wheel, the bottom of the specimens shall be finished by hand sanding to ensure a proper fit.

8.1.2 Pendulum Calibration. Two sets of four control specimens each shall be prepared and used to calibrate the British Pendulum Tester. The two sets of specimens shall have initial friction values (PV-i) of 29 ± 1 and 38 ± 1 respectively in accordance with ASTM E 303. These values shall be designated as the benchmark values for the control specimens. At the beginning of each polish resistant test, the control specimens shall be tested. The British Pendulum Tester shall be adjusted until the average PV-i values for each of the two calibration groups are within plus or minus one unit from the established averages.

8.1.3 Specimen Preparation and Polish Resistant Calibration.

a) Specimens shall be prepared in accordance with ASTM D 3319. A minimum of five specimens each shall be prepared for the coarse aggregate and the approved dolomite material.

b) Control specimens shall be used to develop consistency in specimen preparation and polishing. Four specimens shall be prepared and included with the test specimens on the British Polishing Wheel. The average of the four control specimens shall have PV-i values of 37 to 39 measured in accordance with ASTM E 303. If these criteria are not met, all specimens prepared for the polish resistant test shall be discarded and new specimens prepared.

c) After polishing for 10 hour s, the RPV-10 values for the four control specimens shall be measured in accordance with ASTM E 303. The average RPV-10 value shall be 28 to 30. If this criteria is not met, the results from the polish resistant test shall not be used.

d) A control chart shall be prepared and maintained for control specimen RPV-10 values and the corresponding date of test. The average of the four values for each test shall be plotted.

8.1.4 Polishing Machine Tire.

a) The Polishing Machine tire shall be a smooth-tread, solid (non-pneumatic), tire approved by the Department.

b) The tire shall be replaced when the RPV-10 values of the control specimens have decreased by more than four points from the RPV-10 values obtained from a new tire.

c) A control chart shall be prepared and maintained for each tire indicating the tire usage hours and the corresponding RPV-10 values of the control specimens.

8.1.5 Pendulum Testing and Reporting.

a) Specimens shall be tested in accordance with ASTM E 303. Broken specimens and specimens with aggregate missing in the slider or contact area shall be discarded. Tests shall be made until four consecutive measurements give the same RPV-10 value.

b) The test value for any aggregate shall be the average from a minimum of four specimens.

c) If the coarse aggregate RPV-10 value is one less, equal to or greater than the approved dolomite or polish resistant aggregate RPV-10 value, the Aggregate Producer may request to proceed to Part Two of this procedure.

d) Copies of the test information shall be sent to the Aggregate Producer and the Department and shall include the following:

1. Coarse aggregate source identification
2. Type of material
3. Ledges of the aggregate, if applicable
4. Date sampled
5. Individual(s) obtaining sample of coarse aggregate
6. PV-i and RPV-10 values for the control specimens
7. Control chart for the RPV-10 values of the control specimens
8. Control chart for the tire usage hours
9. RPV-10 values of the coarse aggregate material
10. RPV-10 values of the approved dolomite or polish resistant aggregate material

8.2 TEST SECTIONS (PART TWO).

8.2.1 Test Section Selection.

a) Upon evaluation and approval of the polish resistant data, a contract will be selected by the Department for placement of the coarse aggregate and approved dolomite or polish resistant aggregate material test sections. The contract will have traffic ESAL's equal to or greater than 3,000,000 and have continuous uninterrupted traffic over the test sections.

b) A 1 mi test section of HMA using the coarse aggregate material shall be placed adjacent to a 1 mi test section of HMA using the approved dolomite or polish resistant aggregate material. Both test sections shall be placed in the same Driving Lane. The two test sections shall be located between any major intersections on the contract.

8.2.2 Friction Testing.

a) Each test section will be tested by the Department in accordance with ASTM E 274. A smooth tire in accordance with ASTM E 524 and a 40 mph test speed will be used.

b) Friction testing will be performed after six months, one year, eighteen months, and two years of exposure to traffic.

9.0 ACCEPTANCE CRITERIA.

9.1 After two years exposure to traffic, if the coarse aggregate HMA friction values are equal to or greater than the approved dolomite or polish resistant aggregate HMA friction values, the material will be approved as a Polish Resistant Aggregate.

-or-

After three years exposure to traffic, if the coarse aggregate HMA friction values are equal to or greater than an average of 35.0, with no individual location value less than 30.0, the material will be approved as a Polish Resistant Aggregate.

9.2 The Department will maintain a list of Approved Polished Resistant Aggregates including those aggregates meeting the requirements outlined herein. The list will include two categories as follows:

9.2.1 Coarse aggregates that are approved for use in HMA surface mixtures for contracts with traffic ESAL's equal to or greater than 3,000,000 and less than 10,000,000.

9.2.2 Coarse aggregates that are approved for use when blended with air-cooled blast furnace slag, steel furnace slag, or sandstone in HMA surface mixtures for contracts with traffic ESAL's equal to or greater than 10,000,000.

The aggregate source and ledge number(s), if applicable, will be placed on the Approved List in the ESAL category that the contract used to approve the aggregate was within.

9.3 The aggregate will remain on the Department Approved List unless the material is not performing satisfactorily, as determined by the Department.

POLISH RESISTANT AGGREGATE PRODUCER
ITM 214
WARRANTY BOND

Know all persons by these presents that we, ________________________________ as principal and ______________________________ as surety, are held and firmly bound unto the State of Indiana (hereinafter referred to as obligee) in the full and just sum of $ ________________________, lawful money of the United States of America, for the payment of which, well and truly to be made, we bind ourselves, our heirs, administrators, executors, successors, and assigns, jointly and severally, firmly by these presents.

The condition of the above obligation is that for two (2) years after the date the test section of HMA pavement located on ___________________________________, reference point ________________________________ (Beginning Point) to reference point ___________________________ (Ending Point) is completed and opened to unrestricted traffic; such warranty is to be in accordance with the Indiana Test Method 214 which is made a part of this bond for warranted test section of HMA pavement. If the principal satisfactorily fulfills the above condition, then this obligation shall be null and void; otherwise such obligation is to remain in full force and effect.

It is agreed that no modifications, omissions, or additions in or to the terms of the ITM 214 or the contract or in or to the plans or specifications shall affect the obligation of the surety on its bond.

In witness whereof, we hereunto set our hands and seal.

Name: ______________________________

Address: ______________________________

By: ______________________________
Signature Surety Title

____
(Print or Typed) Surety

State of Indiana, County of ______________ SS:

Personally appeared before me,

____
as surety and acknowledge the executions of the above bond

this ________ day of ________ , 20 _____

By ______________________________
Signature Notary Public

____
(Print of Typed) Notary

My Commission Expires __________ , 20 _____

____
(County of Residence)

Name: ______________________________

Address: ______________________________

By: ______________________________
Signature Principle Title

____
(Print of Typed) Principal

State of Indiana, County of ______________ SS:

Personally appeared before me,

____
as surety and acknowledge the executions of the above bond

this ________ day of ________ , 20 _____

By ______________________________
Signature Notary Public

____
(Print of Typed) Notary

My Commission Expires __________ , 20 _____

____
(County of Residence)

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

VERIFYING SIEVES
ITM No. 902-15T

1.0 SCOPE

1.1 This test method covers the procedure for verifying the physical condition of laboratory testing sieves ranging in size from 4 in. to No. 200.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and to determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 AASHTO Standards.

M 92 Wire-Cloth Sieves for Testing Purposes

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

4.0 SIGNIFICANCE AND USE. This ITM is used by laboratory personnel to verify the physical condition of testing sieves.

5.0 APPARATUS.

5.1 Calipers, readable to 0.01 mm

6.0 PROCEDURE.

6.1 Sieves #4 and Coarser.

6.1.1 Record the sieve identification, manufacturer, opening size, frame height and diameter.

6.1.2 Hold the sieve against a uniformly illuminated background. Check the general condition of the sieve for cracks in frame, broken solder joints, wire tightness, and irregular openings.

6.1.3 Select two perpendicular fields of five openings each for verification. (Appendix A - Figure 1)

6.1.4 Using the calipers, measure and record the openings at their vertical (Y) and horizontal (X) midpoints (Appendix A - Figure 2). Keep the X and Y components separate and calculate the average of all 10 X measurements and all 10 Y measurements.

6.2 Sieves Finer than #4.

6.2.1 Record the sieve identification, manufacturer, opening size, frame height and diameter.

6.2.2 Hold the sieve against a uniformly illuminated background. Check and record the general condition of the sieve for cracks in frame, broken solder joints, weaving defects, creases, wrinkles, wire tightness, and irregular openings.

7.0 TOLERANCE.

7.1 Sieves #4 and Coarser. The maximum individual opening and average opening for each sieve shall not exceed the sieve tolerances of Table 1. If the tolerances of Table 1 are exceeded or there are general physical condition deficiencies as noted in 6.1.2, the sieve shall be replaced.

7.2 Sieves Finer than #4. If there are general physical condition deficiencies as noted in 6.2.2, the sieve shall be replaced.

SIEVE TOLERANCES

Standard Sieve Designation	Alternative Sieve Designation	Permissible Average Opening	Maximum Individual Opening
100 mm	4 in.	±3.00 mm	104.8 mm
90 mm	3 1/2 in.	±2.70 mm	94.4 mm
75 mm	3 in.	±2.20 mm	78.7 mm
63 mm	2 1/2 in.	±1.90 mm	66.2 mm
50 mm	2 in.	±1.50 mm	52.6 mm
37.5 mm	1 1/2 in.	±1.10 mm	39.5 mm
25 mm	1 in.	±0.800 mm	26.4 mm
19 mm	3/4 in.	±0.600 mm	20.1 mm
12.5 mm	1/2 in.	±0.390 mm	13.31 mm
9.5 mm	3/8 in.	±0.300 mm	10.16 mm
4.75 mm	No. 4	±0.150 mm	5.14 mm

TABLE 1

Tolerances for sieves not in Table 1 may be found in AASHTO M 92

SIEVE VERIFICATION
ITM 902

Sieve Identification: ______________________________

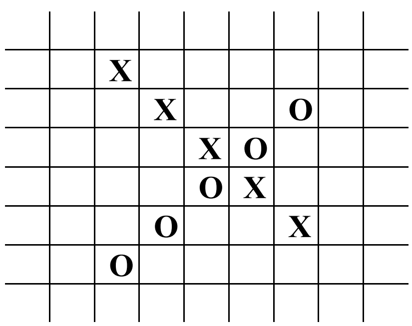
Manufacturer: ______________________________

Sieve Opening Size: ____________ Frame Height/Diameter: ________/__________

General Physical Condition				
For Sieves finer than No. 4			**For sieves No. 4 and coarser**	
	√			√
Is the frame cracked?			Is the frame Cracked?	
Are the welds broken?			Are the welds broken?	
Any weaving defects, creases or wrinkles?			Are the wires tight?	
Is the screen tight?			Are irregular openings apparent?	
Are irregular openings apparent?				

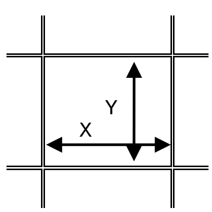
Opening Verification for sieves #4 and coarser

Figure 1:



Field 1: O Field 2: X

Figure 2



	Field 1		**Field 2**	
	X	**Y**	**X**	**Y**
1				
2				
3				
4				
5				

Average of all ten X:	**Average of all ten Y:**

No X or Y component may exceed the maximum individual opening given in Table 1

The X or Y average may not exceed the permissible average opening given in Table 1

Remarks: ______________________________

Calibration Equipment Used: ______________________________

Verified by: ______________________________

Date: ____________________ Next Due Date: ____________________

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

VERIFYING MECHANICAL SHAKERS
ITM No. 906-17T

1.0 SCOPE.

1.1 This test method covers the procedure for verifying the sieving sufficiency of mechanical shakers and the accuracy of timers used in the sieve analysis of aggregates.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and to determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 ITM Standards.

902 Verifying Sieves

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

4.0 SIGNIFICANCE AND USE. This ITM is used by laboratory personnel to verify the sieving sufficiency of mechanical shakers and the accuracy of timers used in the sieve analysis of aggregates.

5.0 APPARATUS.

5.1 Balance, readable to 0.1 g

5.2 Stopwatch, readable to 1 s

5.3 Sieves, verified in accordance with ITM 902

5.4 Sieve pan and lid

6.0 PROCEDURE.

6.1 Timer.

6.1.1 Operate the mechanical shaker with the timer set at 5 min, and measure the time using the stopwatch.

6.1.2 Repeat 5.1.1 with the timer set at 10 min and 15 min.

6.1.3 If the timer is not within the allowable tolerance of 8.1, the manufacturers markings shall not be used, and accurate settings on the shaker shall be established by trial and error determination.

6.2 Shakers using 8 in. and 12 in. diameter sieves.

6.2.1 Determine and record an initial sample weight.

6.2.2 Insert sieves No. 4 through No. 200 for fine aggregates or 1 in. through No. 200 for coarse or dense graded aggregates into the shaker.

6.2.3 Shake sample mechanically for 15 min for sands or 10 min for blended aggregates.

6.2.4 Place the first sieve retaining material on a pan, and cover the sieve with the lid.

6.2.5 Hand shake the first sieve for 1 min by holding the sieve in a slightly inclined position in one hand and striking the side of the sieve sharply and with an upward motion against the heel of the other hand at approximately 150 times per min. The sieve should be turned about 1/6 of a revolution at intervals of about 25 strokes. For sieves larger than the No. 4 sieve, the material on the sieve should be limited to a single layer of particles.

6.2.6 Weigh the material passing the sieve and retained in the pan.

6.2.7 Weigh the material retained on the sieve.

6.2.8 Add the weight retained on the sieve and weight passing the sieve, and verify the sieve was not overloaded in accordance with Table 1. If the sieve was overloaded, verification is void, and a new sample shall be obtained.

Screen Size	Standard 15 in. x 23 in.	Standard 14 in. x 14 in.	12 in. Diameter	8 in. Diameter
3 in.	40.5 kg	23.0 kg	12.6 kg	--------
2 in.	27.0 kg	15.3 kg	8.4 kg	3.6 kg
1 1/2 in.	20.2 kg	11.5 kg	6.3 kg	2.7 kg
1 in.	13.5 kg	7.7 kg	4.2 kg	1.8 kg
3/4 in.	10.2 kg	5.8 kg	3.2 kg	1.4 kg
1/2 in.	6.7 kg	3.8 kg	2.1 kg	890 g
3/8 in.	5.1 kg	2.9 kg	1.6 kg	670 g
No. 4	2.6 kg	1.5 kg	800 g	330 g
8 in. diameter sieves: No. 8 to No. 200 shall not exceed 200 g/sieve				
12 in. diameter sieves: No. 8 to No. 200 shall not exceed 469 g/sieve				

APPROXIMATED SIEVE OVERLOAD
TABLE 1

6.2.9 Repeat 6.2.5 through 6.2.8 on all remaining sieves.

6.2.10 If a sieve does not meet the allowable tolerance of 8.2, the shaking time shall be increased to determining an adequate time.

6.3 Shakers using 15 in. x 23 in., 14 in. x 14 in., or other size sieves.

6.3.1 Determine and record an initial sample weight of an aggregate having a nominal maximum aggregate size of 1 in.

6.3.2 Insert sieves 1 in. through No. 8 into the shaker.

6.3.3 Shake sample mechanically for 5 min.

6.3.4 Remove the first sieve retaining material, determine the weight of material retained, and verify that the sieve was not overloaded in accordance with Table 1. If the sieve was overloaded, verification is void, and a new sample shall be obtained.

6.3.5 Place the material on a 8 in. or 12 in. diameter sieve of equivalent opening size in increments that will not overload the sieve in accordance with Table 1. Place the sieve on a pan and cover the sieve with the lid.

6.3.6 Handshake for one min as described in 6.2.5. Continue until all material has been introduced onto the 8 in. or 12 in. sieve.

6.3.7 Weigh the accumulated material passing the sieve and retained in the pan.

6.3.8 Repeat 6.3.4 through 6.3.7 for all remaining sieves.

6.3.9 If a sieve does not meet the allowable tolerance of 8.2, the shaking time shall be increased to determine an adequate time.

7.0 CALCULATIONS. The percent passing a sieve by hand shaking after mechanical shaking is calculated by the following formula:

$$\% \text{ Passing} = \frac{W_1}{W_2} \times 100$$

where:

W_1 = weight (mass) of sample passing a sieve by hand shaking, g
W_2 = initial sample weight (mass), g

8.0 TOLERANCE.

8.1 The timer of the mechanical shaker shall be within ± 5 s at 5 min, ± 10 s at 10 min, and ± 15 s at 15 min of the stopwatch reading.

8.2 After mechanical shaking, no more than 0.5 percent by weight of the total sample shall pass any sieve after 1 min of hand sieving.

9.0 REPORT. The timing and sieving sufficiency verification shall be reported on the form in Appendix A.

MECHANICAL SHAKER AND TIMER VERIFICATION ITM 906

SHAKER IDENTIFICATION
Manufacturer: ______________________________

Model. No.: ____________________ Serial No.: ____________________

VERIFICATION EQUIPMENT USED
Balance: ____________________ Have sieves been verified using ITM 902? ________

TIMER VERIFICATION

Setting on Shaker Timer	Timing Device Reading	Corrective Adjustment Made
5		
10		
15		

SIEVING SUFFICIENCY VERIFICATION
Frame Dimensions: ____________________ Mechanical Sieving Time: ____________

Total Sample Weight: ____________________

Sieve Size	Weight Retained by Mechanical Sieving	Weight Passing After Hand Sieving	% Passing After Hand Sieving
1 in.			
3/4 in.			
1/2 in.			
3/8 in.			
No. 4			
No. 8			
No. 16			
No. 30			
No. 50			
No. 100			
No. 200			

Remarks: ______________________________

Verified by: ______________________________

Date: ____________________ Next Due Date: ____________________

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

VERIFYING BALANCES
ITM No. 910-15T

1.0 SCOPE.

1.1 This test method covers the procedures for verifying the accuracy and off-center error of balances.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 AASHTO Standards.

M 231 Weighing Devices Used in the Testing of Materials

3.0 TERMINOLOGY. Definitions for terms and abbreviations will be in accordance with the Department's Standard Specifications, Section 101 and the following:

3.1 Accuracy. The degree of agreement of the measurement with the true value of the quantity measured.

3.2 Off-Center Errors. The differences in indicated weight when a sample weight is shifted to various positions on the weighing area of the sample pan.

3.3 National Institute of Standards and Technology (NIST). A federal technology agency that develops and applies technology, measurements, and standards.

4.0 APPARATUS.

4.1 Balance, a Class G2, G5, or G20, in accordance with AASHTO M 231.

4.2 A set of weights up to the capacity of the balance with sufficient subdivisions of weight so that increments of approximately 10 percent of the capacity up to the capacity may be tested. The weights shall be a minimum ASTM Class 3 for use on Class G2 or G5 balances and a minimum of NIST Class F for use on Class G20 balances. The Class 3 or Class F weights shall have a calibration report indicating traceability to NIST. The weights shall be calibrated at a minimum frequency of once each 12 months.

4.3 Thermometer, room temperature, with a resolution of at least 2°F.

5.0 SIGNIFICANCE AND USE. This ITM is used by laboratory personnel to verify the accuracy and off-center error of balances.

6.0 PROCEDURE.

6.1 General. Use the balance in the manner recommended by the manufacturer for each step of the verification procedures.

6.2 Accuracy.

6.2.1 Clean the balance and standard weights with a lint free dry cloth.

6.2.2 Place the standard weights near the instrument.

6.2.3 Allow the balance and the weights to stabilize to the ambient working temperature.

6.2.4 Place the thermometer on the bench near the balance and record the temperature.

6.2.5 Place the standard weight(s) in the center of the balance pan in increasing increments of approximately 10 percent of the capacity and record the indications. If possible, the weights should be stacked upon each other.

6.3 Off-Center Error.

6.3.1 Place the standard weight(s) equal to approximately 50 percent of the capacity of the balance on the center of the sample pan and record the indication.

6.3.2 Place the same standard weight(s) on each corner of the sample pan and record the indication.

7.0 TOLERANCES.

7.1 G2 Balance.

7.1.1 Within any interval equal to approximately 10 percent of the capacity of the balance, the accuracy shall be equal to 0.2 g or 0.1 percent of the test load, whichever is greater.

7.1.2 The maximum off-center error shall be equal to or less than 0.2 g or 0.1 percent of the test load, whichever is greater.

7.2 G5 Balance.

7.2.1 Within any interval equal to approximately 10 percent of the capacity of the balance, the accuracy shall be equal to 2 g or 0.1 percent of the test load, whichever is greater.

7.2.2 The maximum off-center error shall be equal to or less than 2 g or 0.1 percent of the test load, whichever is greater.

7.3 G20 Balance.

7.3.1 Within any interval equal to approximately 10 percent of the capacity of the balance, the accuracy shall be equal to 5 g or 0.1 percent of the test load, whichever is greater.

7.3.2 The maximum off-center error shall be equal to or less than 5 g or 0.1 percent of the test load, whichever is greater.

8.0 REPORT. The accuracy and off-center error are reported on the form in Appendix A.

BALANCE VERIFICATION
ITM 910

Model Number: ______________________________ Serial Number: ______________________

Standard Weights NIST Number: _____________ Class: _________Temperature: ___________

ACCURACY			
Weight Applied	**Indication on Balance**	**Weight Difference**	**Percent of Error**

OFF-CENTER ERROR			
Weight Applied	**Location**	**Indication on Balance**	**Weight Difference**
	Center		
	Corner		
	Corner		
	Corner		
	Corner		

Remarks: ____

Verified by: ____

Date: ____________________ Next Due Date: ______________________

Appendix B

AASHTO Test Methods

AASHTO T 2	Sampling of Aggregates
AASHTO T 11	Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing
AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 84	Specific Gravity and Absorption of Fine Aggregate
AASHTO T 85	Specific Gravity and Absorption of Coarse Aggregate
AASHTO T 112	Clay Lumps and Friable Particles in Aggregate
AASHTO R 76	Reducing Field Samples of Aggregate to Testing Size
AASHTO T 304	Uncompacted Void Content of Fine Aggregate

ASTM Test Methods

ASTM D 4791	Flat Particles, Elongated Particles, and Flat and Elongated Particles in Coarse Aggregate
ASTM D 5821	Determining Percent of Fractured Particles in Coarse Aggregate

SAMPLING OF AGGREGATES

AASHTO T 2

AGGREGATE STREAMFLOW

Before taking a sample, you must first assemble all the equipment you will need to obtain the sample. To obtain a sample using the aggregate streamflow, you will need the following:

1. Sampling device designed for use at each particular plant. This device consists of a pan of sufficient size to intercept the entire cross section of the discharge stream and retain the required quantity of material without overflowing. In some situations, a set of rails may be necessary to support the pan as it is passed through the streamflow.

2. Safety equipment such as hard hat, glasses, etc.

3. Sample containers, tags, etc.

Sampling Procedure

Pass the sampling device through the streamflow, being sure to cut through the entire cross section of the material as the aggregate is being discharged (Figure 1). Care must be taken to pass the device through the stream rapidly enough to prevent any overflow of material during the sampling procedure. Obtain a minimum of three increments for each sample. Be sure to obtain equal increments. Obtain the appropriate weight to accommodate all tests to be performed on the sample. Allow an amount of time to elapse between passes to better get a representative sample of the material. When sampling aggregate from a loaded bin, increments should not be obtained when the belt first starts or when the bin is nearly empty to avoid the natural segregation that may occur as the material exists in the bin.

Figure 1
Streamflow Sampling

CONVEYOR BELT

The equipment to sample from a conveyor belt is somewhat different than that used for sampling from a streamflow. The following is the equipment needed to secure a proper sample from a conveyor belt:

1. A template constructed to conform to the shape of the loaded belt. An adjustable spacer between the two ends of the template is helpful to allow for adjustment of the device to the amount of aggregate on the belt.

2. A scoop or trowel to aid in removing the aggregate from the stopped belt.

3. A brush or broom to aid in removing the fine particles of the increment from the belt surface.

4. Sample containers, tags, etc.

5. Safety equipment such as hard hat, gloves, glasses, etc.

Sampling Procedure

Insert the template into the aggregate on the stopped conveyor belt being sure the template passes through the aggregate and rests on the surface of the belt as close as practicable (Figure 2). Do not sample the portions of material first discharged on the belt or material discharged as the bin empties. These areas are normally segregated and the sample will not be representative. Using the small scoop or hand, remove as much of the aggregate from the belt as possible. Brush the remaining fines into the sample container. A dustpan may be useful in some applications to collect the fines. Obtain at least three increments for each field sample being sure to collect the minimum weight needed to perform all applicable tests. When practicable, allow the belt to run awhile between each increment. This will aid in obtaining a sample more representative of the material being tested.

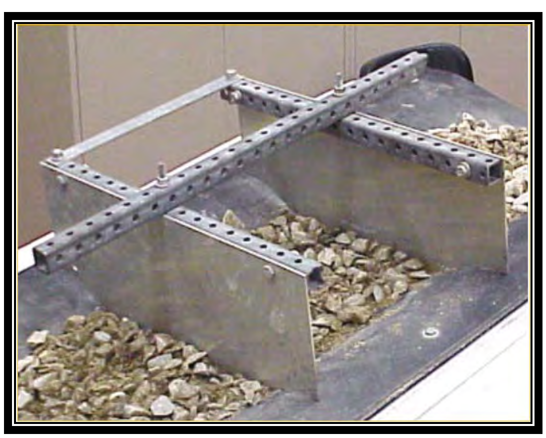


Figure 2
Conveyor Belt Sampling

There are automatic belt sampling devices that have the advantage of sampling the aggregate without stopping the belt (Figure 3). These devices sweep the belt with a small scoop and this increment of the belt is deposited into a sampling container. The number of sweeps of the belt is determined by the required size of the sample.

Figure 3
Automatic Sampling Device

MATERIALS FINER THAN No. 200 (75 µm) SIEVE IN MINERAL AGGREGATES BY WASHING

AASHTO T 11

SCOPE

Aggregates are used in all phases of highway construction from bases, pavement mix, granular shoulders, and granular surfacing, as well as, erosion control. In order to ensure the aggregate performs as intended for the specific use, a variety of tests must be performed on the aggregate. One such test is determining materials finer than No. 200 (75 µm) sieve in mineral aggregates by washing. Fine materials such as clay particles or water soluble particles removed by washing, can cling to larger particles and do not dislodge readily. This test washes the fine particles through the No. 200 (75 µm) sieve to give an accurate determination of fine materials in the sample. The determination of minus No. 200 (75 µm) material is used to compare material performance with gradation specifications, and indirectly to gauge such properties as plasticity, permeability, and soils classifications. Such knowledge helps in determining whether a material is frost susceptible or not, and whether permeability (measurement of material capacity to allow water flow through the aggregate) will be affected.

SUMMARY OF TEST

A known amount of material is placed in a wash container and covered with water, agitated to suspend the fine size particles in the water, and then poured through a No. 200 (75 µm) sieve (Figure 1). After thorough rinsing, the portion remaining on the No. 200 (75 µm) sieve is transferred to a pan, dried and weighed. The percentage passing through the No. 200 (75 µm) sieve is then calculated.

Figure 1
Fines suspended in the water are washed over a No. 8 (2.36 mm) and a No. 200 (75 µm) sieve

Apparatus

Balance, general purpose G_2 (AASHTO M231).

Sieves, a No. 8 (2.36 mm) or No. 16 (1.18 mm) and a No. 200 (75 µm).

Container, of sufficient size to properly agitate the sample without losing material.

Oven, capable of maintaining a temperature of 230 ± 9°F (110 ± 5°C). When tests are performed in the field where ovens are not available, test samples may be dried in suitable containers over an open flame or electric hot plates with sufficient stirring to prevent overheating.

Wetting agent, dispersing material such as dish washing soap.

Sample Preparation

Determine the proper dried sample weight from Table 1 based on the nominal maximum size of the sample to be tested. If the sample is to be tested for gradation in accordance with AASHTO T 27, the minimum weight of that test method shall apply. If the sample is not tested for gradation in accordance with AASHTO T 27 and the nominal maximum size of aggregate to be tested is not listed in Table 1, the next larger size shall be used to determine the sample size.

Table 1-Sample Weight Requirements

Nominal Maximum Size in. (mm)	Minimum Weight of Sample (gm)
No. 4 (4.75 mm)	300
3/8 in.(9.5 mm)	1000
3/4 in.(19.0 mm)	2500
1 1/2 (37.5 mm)	5000

Procedure

1. Dry sample to a constant weight. Record this as the dry weight of the material to the nearest 0.1 g. Allow sample to air cool until cool to the touch.

2. Place sample into a wash container large enough to permit mixing the sample with water (Figure 2). Cover the sample with water (and optionally, at the discretion of the technician, add a small amount of wetting agent) and agitate the sample with sufficient movement so that the particles finer than the No. 200 (75 µm) sieve become suspended in the water. Stirring and agitating the sample may be necessary and may be accomplished with any stirring or agitating instrument. Care should be taken not to lose any portion of the sample or the fines suspended in the water.

Figure 2
Washing Sample

3. Pour the water with the suspended fines through a No. 200 (75 µm) sieve (Figure 3). Occasionally inspect the No. 200 (75 µm) sieve for cracks along the seam or holes in the screen, as any imperfections will effect the final wash sieve results. Take care to pour only the water with suspended fines and not the sample itself, since samples with larger size aggregates might damage or clog the fine screen on the No. 200 (75 µm) sieve (Figure 3). Nesting sieves with larger openings a No. 8 (2.36 mm), or a No. 16 (1.18 mm) above the No. 200 (75 µm) sieve might help to prevent inadvertent clogging.

Figure 3
Pouring Water through Sieves

4. Continue washing the sample with additional water and agitate until a majority of the fines suspended in the water have been washed through. When the washed sample is near completion, the water should be relatively clear compared with the initial water color of the wash sample. If you can see the sample beneath the water, then the sample is probably adequately washed.

5. Give the sample a final rinse, pouring as much of the remaining water as possible out of the sample and into the No. 200 (75 µm) sieve. Put the sample remaining in the washing bowl into a pan for oven drying.

6. Any suspended fines remaining on the No. 200 (75 µm) sieve must be included in the sample for drying. Rinsing any suspended fines to one side of the sieve (Figure 4) and then tapping those fines into the pan is one way of accomplishing this. Be sure to include all fines suspended on the No. 200 (75 µm) sieve in the final sample for drying.

Figure 4
Material Retained on the No. 200 (75µm) sieve

A rinsing bottle (Figure 5) may be used to remove the fines sticking to the No. 200 (75 µm) sieve once the sample has been washed.

Figure 5
Rinsing Fines on No. 200 (75µm) Sieve

7. Place the washed sample into an oven set at 230 ± 9°F (110 ± 5°C), into an electric skillet, or onto an open flame and dry to a constant weight. Record the dry weight.

Calculations

Calculate the total % passing the No. 200 (75 µm) sieve (A) by dividing the difference of the original dry sample weight (B) and the weight of sample after washing and drying (C) to a constant weight by the original dry sample weight (B) and multiplying by 100.

$$A = \frac{(B - C)}{B} \times 100$$

Where: A = Total % passing No. 200 (75 µm) sieve
B = Original dry weight of sample (gms), and
C = Dry weight of sample after washing and drying to constant weight (gms)

Example

B = 532.2 gms
C = 521.6 gms
Formula: $A = \frac{(B - C)}{B} \times 100$

$$A = \frac{(532.3 - 521.6)}{532.3} \times 100$$

A = 2.0%

Report the percentage of material finer than the No. 200 (75 µm) sieve to the nearest 0.1%.

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES

AASHTO T 27

SCOPE

The sieve analysis, commonly known as the gradation test, is a basic essential test for all aggregate technicians. The sieve analysis determines the gradation (the distribution of aggregate particles, by size, within a given sample) in order to determine compliance with design, production control requirements, and verification specifications. The gradation data may be used to calculate relationships between various aggregate or aggregate blends, to check compliance with such blends, and to predict trends during production by plotting gradation curves graphically, to name just a few uses. Used in conjunction with other tests, the sieve analysis is a very good quality control and quality acceptance tool.

NOTE: Accurate determination of material passing the No. 200 (75 µm) sieve cannot be made with this test alone. This test is recommended to be used in conjunction with AASHTO T 11 to determine the amount of material finer than the No. 200 (75 µm) sieve.

SUMMARY OF TEST

A known weight of material, the amount being determined by the largest size of aggregate, is placed upon the top of a group of nested sieves (the top sieve has the largest screen openings and the screen opening sizes decrease with each sieve down to the bottom sieve which has the smallest opening size screen for the type of material specified) and shaken by mechanical means for a period of time. After shaking the material through the nested sieves, the material retained on each of the sieves is weighed.

The cumulative method requires that each sieve beginning at the top be placed in a previously weighed pan (known as the tare weight), weighed, the next sieve's contents added to the pan, and the total weighed. This is repeated until all sieves and the bottom pan have been added and weighed.

Apparatus

Balance, general purpose class G_2 (AASHTO M231).

Sieves, mounted on suitable frames, designed not to leak. Sieves shall conform to AASHTO M92.

Mechanical sieve shaker, if used, must provide a vertical or lateral and vertical motion to the sieve, causing the particles thereon to bounce and turn so as to present different orientations to the sieving surface. Sieve shakers must provide sieving thoroughness within a reasonable time.

Oven, capable of maintaining 230 ± 9°F (110 ± 5°C). When tests are performed in the field where ovens are not available, test samples may be dried in suitable containers over open flame or electric hot plates with sufficient stirring to prevent overheating.

Sample Preparation

Samples should be obtained in the field and reduced to test size in accordance with AASHTO T 248. Samples are dried to a constant weight in an oven set at 230 ± 9°F (110 ± 5°C), in an electric skillet, or over an open flame.

The original sample must be reduced to a test sample size which falls within the minimum and maximum weight in the following table.

WEIGHT OF TEST SAMPLE

AGGREGATE SIZE	MINIMUM	MAXIMUM
No.1	68,000 g	90,700 g
No.2	11,300 g	---
No.5, No. 8, and No. 91	6000 g	8000 g
No. 9	4000 g	6000 g
No. 11	2000 g	---
No. 12	1000 g	--
No.53	6000 g	8000 g
No.73	5000 g	---
B-Borrow: 1/2 in. (12.5 mm), 1 in. (25.0 mm), 1½ in. (37.5 mm), & 2 in. (50 mm)	4000 g	6 000 g
B-Borrow: No. 4 (4.75 mm) & No. 30 (600 µm)	300 g	---
Fine Aggregate	300 g	---

Procedure

1. Weigh the sample to the nearest 0.1 g by total weight of sample. This weight will be used to check for any loss of material after the sample has been graded. Select suitable sieve sizes in accordance with the specifications.

2. Nest the sieves in order of decreasing size from top to bottom and begin agitating and shaking the sample for a sufficient amount of time.

For coarse aggregate, the large tray shaker is most commonly used (Figure 1). This device provides a clamping mechanism which holds the sieve in place during agitation. Shakers of this make need to be run 5 minutes for size 9 or larger and 10 minutes for sizes smaller than size 9.

For fine aggregate, round 8" (203.2 mm) or 12" (304.8 mm) sieves are commonly used (Figure 2). These sieves are self-nesting and supported in a shaking mechanism at the top and bottom by a variety of clamping and/or holding mechanisms. Small shakers of this type require shaking times of 15 minutes to adequately grade the fine aggregate sample.

Figure 1
Large Tray Shaker

Figure 2
Small Sieve Shaker

NOTE: Every effort should be made to avoid overloading the sieves. AASHTO defines overloading large sieves as weight retained in excess of 2.5 times the sieve opening in in. (mm), as expressed in gm/in.^{2} (kg/m^2). For fine aggregate, no weight shall be in excess of 4 gm/in.^{2} (7 kg/m^2).

3. <u>Coarse Aggregates</u>

After the material has been sieved, remove each tray, weigh each size, and record each weight to the nearest 0.1 g. Be sure to remove any aggregate trapped within the sieve openings by gently working from either or both sides with a trowel or piece of flat metal until the aggregate is freed. Banging the sieve on the floor or hitting the sieve with a hammer will damage the sieve. The final total of the weights retained on each sieve should be within 0.3% of the original dry sample weight prior to grading. Particles larger than 3 in. (75 mm) should be hand-sieved. When passing large stones through sieves, do not force the aggregate through the sieve openings.

4. Fine Aggregates

Weigh the material retained on each sieve size to the nearest 0.1 g. Ensure that all material entrapped within the openings of the sieve are cleaned out and included in the weight retained. This may be done using brushes to gently dislodge entrapped materials. The 8 in. (203 mm) or 12 in. (304.8 mm) round sieves need to be handled with special care due to the delicate nature of their screen sizes. As a general rule, use coarse wire brushes to clean the sieves down through the No. 50 (300 µm) sieve (Figure 3). Any sieve with an opening size smaller than the No. 50 (300 µm) should be cleaned with a softer cloth hair brush (Figure 4). The final total of the weights retained on each sieve should be within 0.3% of the original dry sample weight prior to grading.

Figure 3
Use Wire brush on Coarse Sieve

Figure 4
Use Hair Brush on Fine Sieves

SPECIFIC GRAVITY AND ABSORPTION OF FINE AGGREGATES

AASHTO T 84

GLOSSARY

Absorption: The increase in mass due to water in the pores of the material.

Bulk Specific Gravity (also known as Bulk Dry Specific Gravity): The ratio of the weight in air of a unit volume of aggregate at a stated temperature to the weight in air of an equal volume of gas-free distilled water at the stated temperature.

Bulk SSD Specific Gravity: The ratio of the weight in air of a unit volume of aggregate, including the weight of water within the voids filled to the extent achieved by submerging in water for approximately 15 hours, to the weight in air of an equal volume of gas-free distilled water at the stated temperature.

Apparent Specific Gravity: The ratio of the weight in air of a unit volume of the impermeable portion of aggregate (does not include the permeable pores in aggregate) to the weight in air of an equal volume of gas-free distilled water at the stated temperature.

SSD - Saturated, Surface Dry. The condition in which the aggregate has been soaked in water and has absorbed water into its pore spaces. The excess, free surface moisture has been removed so that the particles are still saturated, but the surface of the particle is essentially dry.

SCOPE

Specific Gravity is the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water. Water, at a temperature of 73.4°F (23°C) has a specific gravity of 1. Specific Gravity is important for several reasons. Some deleterious particles are lighter than the "good" aggregates. Tracking specific gravity can sometimes indicate a change of material or possible contamination. Differences in specific gravity may be used to separate the deleterious particles from the good using a heavy media liquid.

Specific gravity is critical information for the Hot Mix Asphalt Design Engineer. This value is used in calculating air voids, voids in mineral aggregate (VMA), and voids filled by asphalt (VFA). All are critical to a well performing and durable asphalt mix. Water absorption may also be an indicator of asphalt absorption. A highly absorptive aggregate may result in a low durability asphalt mix.

In Portland Cement Concrete the specific gravity of the aggregate is used in calculating the percentage of voids and the solid volume of aggregates in computations of yield. The absorption is important in determining the net water-cement ratio in the concrete mix. Knowing the specific gravity of aggregates is also critical to the construction of water filtration systems, slope stabilization projects, railway bedding and many other applications.

This test method determines the specific gravity of fine aggregates that have been soaked for a period of 15-19 hrs. The determinations that may be made from this procedure are identical to those made in AASHTO T 85 (Specific Gravity and Absorption of Coarse Aggregate).

SUMMARY OF TEST

Apparatus

Balance, conforming to the requirements of M 231, Class G2

Pycnometer, a flask or other suitable container into which the fine aggregates may be readily introduced (Figure 1). Volume content for the container needs to be reproduced within ± 100 mm^3. The volume of the container filled to the mark shall be at least 50 percent greater than the space required to accommodate the test sample.

Mold, metal in the form of a frustum of cone with acceptable dimensions of 40 ± 3 mm inside diameter at top, 90 ± 3 mm inside diameter at the bottom, and 75 ± 3 mm in height. The metal thickness is a minimum of 0.8 mm.

Tamper, metal having a mass of 340 ± 15g and having a flat circular tamping face of 25 ± 3 mm in diameter.

Figure 1
Fine Aggregate Specific Gravity Apparatus

Procedure

1. Thoroughly mix the sample and reduce the sample to the required size in accordance with AASHTO T 248 (Reducing Field samples of Aggregates to Test Size). The sample size for this procedure is approximately 1000g of material passing the No. 4 (4.75 mm) sieve.

2. Dry test samples to constant weight in an oven set at 230 ± 9°F (110 ± 5°C). Cool the sample at room temperature for 1 to 3 hours. After the cooling period, immerse the sand in water at room temperature for a period of 15 to 19 hours.

Instead of completely immersing the sand in water, AASHTO considers sand to be "soaked" if the sand is maintained at a moisture content of at least 6% for the prescribed period. This is the recommended procedure to eliminate the need to decant excess water from the sand prior to testing. The decantation process is time consuming and difficult, since great care must be taken to avoid decanting some of the sample along with the water. Additionally, the sand will be much closer to the SSD condition when soaked at 6% moisture, which expedites the dry procedure.

3. Decant water from sample, avoiding loss of fines. Spread the sample on a flat, non-absorbent surface. Stir the sample occasionally to assist in homogeneous drying. A current of warm air may be used to assist drying procedures (Figure 2); however, fine particles may be lost with this procedure if not careful.

Figure 2
A current of air being used
to achieve SSD condition.

4. Determine the SSD condition of the sand using the Cone Test.

<u>Note</u>: Throughout the process of drying in Step 3, test the sand for SSD condition using the cone method. Place the cone with the large diameter down on a glass plate. Fill cone to overflowing with drying sand. Lightly tamp the fine aggregate into the mold with 25 light drops of the tamper (Figure 3). Each drop should start about 1/5 in. above the top surface of the fine aggregate. Remove loose sand from base and carefully lift the mold vertically. If surface moisture is still present, the fine aggregate will retain the molded shape. When the sand achieves an SSD condition, the sand will slump (Figure 4).

Figure 3
Tamping sand using the cone
method to determine SSD

If on the first trial the sand slumps, moisture must be re-added and the drying process repeated. Record the weight of the sand as SSD mass when the sand slumps to the nearest 0.1 g.

Figure 4
Sand at SSD condition will slump
once the cone is removed

5. Calibrate a specific gravity flask pycnometer by filling with water at 73.4 ± 3°F (23 ± 1.7°C) to the calibration line. Record this weight as the weight of the pycnometer filled with water to the nearest 0.1g.

6. Place the SSD sand into the pycnometer (Figure 5) and fill with water (set at 73.4 ± 3°F (23 ± 1.7°C)) to 90% of pycnometer capacity.

Figure 5
Pouring sand into pycnometer
once SSD is achieved

Manually roll, invert, and agitate the pycnometer to eliminate air bubbles (Figure 6). This procedure should be repeated several times to ensure that any entrapped air is eliminated. Agitation of the pycnometer does not have to be constant.

Figure 6
Agitating the pycnometer

7. Bring the pycnometer to the pycnometer calibrated capacity with additional water (Figure 7).

Figure 7
Adding Water to Calibrated Capacity

If bubbles prevent the proper filling of the pycnometer, adding a few drops of isopropyl alcohol is recommended to disperse the foam. Place the pycnometer in a water bath at the regulated temperature and allow the sample to equalize.

8. Determine the total weight of pycnometer, specimen, and water. Record the weight to the nearest 0.1g as Weight of Pycnometer with sample and water.

Calculations

Determine calculations based on appropriate formula for desired result as follows:

A. Bulk Specific Gravity (Gsb): The ratio of the weight in air of a unit volume of aggregate at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

Gsb = A / (B-C)

Where: A = Oven dry wt. B = SSD wt. C = Wt. in water

B. Bulk SSD Specific Gravity (Gsb SSD): The ratio of the weight in air of a unit volume of aggregate, INCLUDING the weight of water within the voids filled to the extent achieved by submerging in water for approximately 15 hours, to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

Gsb SSD = B / (B-C)

C. Apparent Specific Gravity (Gsa): The ratio of the weight in air of a unit volume of the IMPERMEABLE portion of aggregate (does not include the permeable pores in aggregate) to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

Gsa = A / (A-C)

D. Absorption (% Abs): The increase in weight of aggregate due to water in the pores of the material, but not including water adhering to the outside surface of the particles.

% Abs = [(B-A) / A] x 100

Example

Trial	Wet Weight	Dry Weight	Wet - Dry	% Absorbed
1	118.11	117.42	0.69	0.59
2	158.10	157.13	0.97	0.62
3	172.81	171.12	1.09	0.64

Trial	S	A	B	C	B + S - C	B + A - C
1	500.05	497.1	670.7	983.8	186.9	184.0
2	499.77	496.7	679.6	992.4	187.0	183.9
3	499.61	496.5	671.6	984.1	187.1	184.0

Trial	Bulk SSD S/B+S-C	Bulk A/B+S-C	APPARENT A/B+A-C
1	2.675	2.660	2.702
2	2.673	2.656	2.701
3	2.670	2.654	2.698
Average	2.673	2.657	2.700

A = Weight of Oven Dry Specimen in Air
B = Weight of Pycnometer filled with water
C = Weight of Pycnometer with specimen and water to calibration mark
S = SSD Weight

SPECIFIC GRAVITY OF COARSE AGGREGATE

AASHTO T 85

GLOSSARY

Absorption: The increase in weight due to water contained in the pores of the material.

Bulk Specific Gravity (also known as Bulk Dry Specific Gravity): The ratio of the weight in air of a unit volume of aggregate at a stated temperature to the weight in air of an equal volume of gas-free distilled water at the stated temperature.

Bulk SSD Specific Gravity: The ratio of the weight in air of a unit volume of aggregate, including the weight of water within the voids filled to the extent achieved by submerging in water for approximately 15 hours, to the weight in air of an equal volume of gas-free distilled water at the stated temperature.

Apparent Specific Gravity: The ratio of the weight in air of a unit volume of the impermeable portion of aggregate (does not include the permeable pores in aggregate) to the weight in air of an equal volume of gas-free distilled water at the stated temperature.

SSD - Saturated, Surface Dry. The condition in which the aggregate has been soaked in water and has absorbed water into its pore spaces. The excess, free surface moisture has been removed so that the particles are still saturated, but the surface of the particle is essentially dry.

SCOPE

Specific Gravity is the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water. Water, at a temperature of 73.4°F (23°C) has a specific gravity of 1. Specific Gravity is important for several reasons. Some deleterious particles are lighter than the good aggregates. Tracking specific gravity can sometimes indicate a change of material or possible contamination. Differences in specific gravity may be used during production to separate the deleterious particles from the good using a heavy media liquid.

Specific gravity is critical information for the Hot Mix Asphalt Design Engineer. The value is used in calculating air voids, voids in mineral aggregate (VMA), and voids filled by asphalt (VFA). All are critical to a well performing and durable asphalt mix. Water absorption can also be an indicator of asphalt absorption. A highly absorptive aggregate may lead to a low durability asphalt mix.

In Portland Cement Concrete the specific gravity of the aggregate is used in calculating the percentage of voids and the solid volume of aggregates in computations of yield. The absorption is important in determining the net water-cement ratio in the concrete mix. Knowing the specific gravity of aggregates is also critical to the construction of water filtration systems, slope stabilization projects, railway bedding and many other applications.

This test method determines the specific gravity of coarse aggregates that have been soaked for a period of 15 hours (Figure 1). There are four determinations that may be made from this procedure. They are as follows:

Figure 1
Coarse Aggregate Gravity Apparatus

A. <u>Bulk Specific Gravity (Gsb) (also known as Bulk Dry Specific Gravity)</u>

The ratio of the weight in air of a unit volume of aggregate at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature (Figure 2). This unit volume of aggregates is composed of the solid particle, permeable voids, and impermeable voids.

$$Gsb = A / (B-C)$$

Where: A = Oven dry weight.
B = SSD weight.
C = Weight in water.

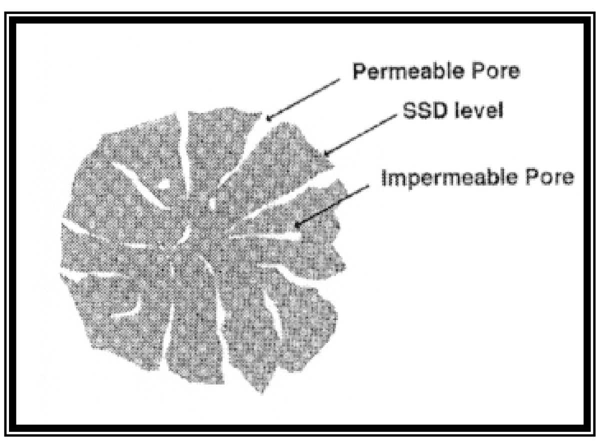


Figure 2
Diagram of Bulk Specific Gravity

B. Bulk SSD Specific Gravity (Gsb SSD)

The ratio of the weight in air of a unit volume of aggregate, INCLUDING the weight of water within the voids filled to the extent achieved by submerging in water for approximately 15 hours, to the weight in air of an equal volume of gas-free distilled water at a stated temperature (Figure 3).

Gsb SSD = B / (B - C)

Where: B = SSD weight.
C = Weight in water.

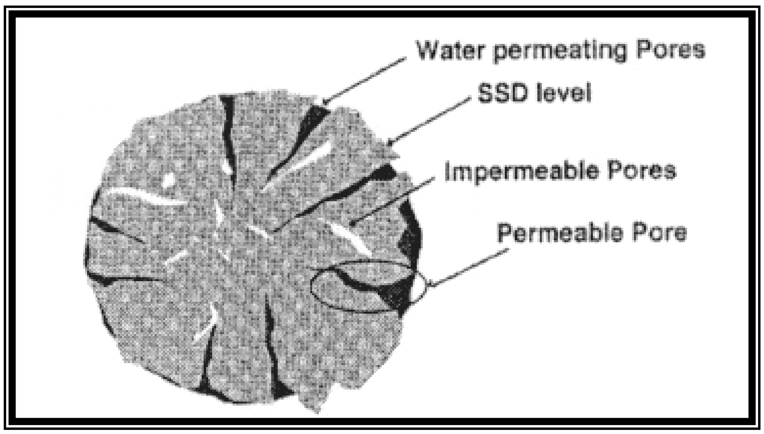


Figure 3
Diagram of Bulk SSD Specific Gravity

C. Apparent Specific Gravity (Gsa)

This ratio of the weight in air of a unit volume of the IMPERMEABLE portion of aggregate (does not include the permeable pores in aggregate) to the weight in air of an equal volume of gas-free distilled water at a stated temperature (Figure 4).

Gsa = A / (A - C)

Where: A = Oven dry weight.
C = Weight in water

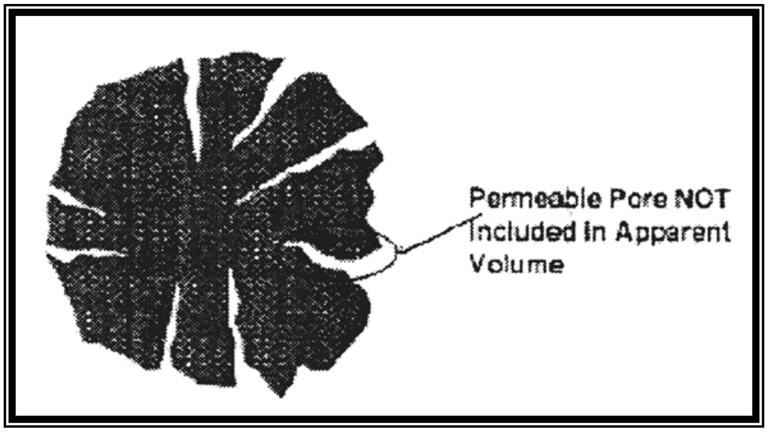


Figure 4
Diagram of Apparent Specific Gravity

D. Absorption (% Abs.)

The increase in weight of aggregate due to water in the pores of the material, but not including water adhering to the outside surface of the particles (Figure 5).

% Abs. = [(B - A) / A] x 10

Where: A = Oven dry weight.
B = SSD weight.

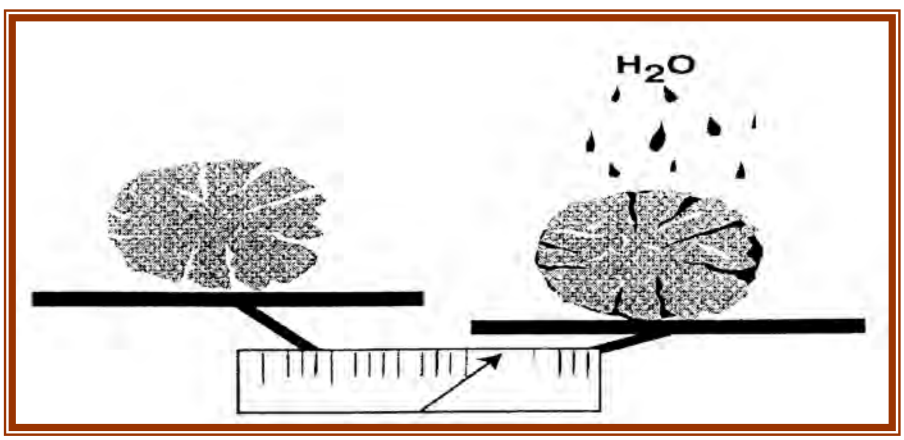


Figure 5
Increase in Mass due to Absorption of Water

SUMMARY OF TEST

Apparatus

Balance, conforming with class G5 (AASHTO M231)

Sample container, wire basket of No. 6 (3.35 mm) or less mesh wire cloth, with a capacity of 1 to 1 3/4 gal. (4 to 7 L) to contain aggregate with a nominal maximum size of 1 1/2 in. (37.5 mm) or smaller; larger basket for larger aggregates.

Water tank, watertight and large enough to completely immerse aggregate and basket, equipped with an overflow valve to keep water at a constant level.

Suspended Apparatus, wire used to suspend apparatus with the smallest practical diameter. A hi-test fishing leader or other thin wire with utility hook can be used with a small hook attached to the handle of the basket or sample container.

Sieves, No. 4 (4.75 mm) or other size as needed, conforming to AASHTO M 92.

Procedure

1. Thoroughly mix the sample and reduce the sample to the required size (Figure 6) in accordance with AASHTO T248 (Reducing Field Samples of Aggregate to Test Size). Use sample sizes as indicated in Table 1.

Figure 6
Reducing Sample to Test Size

TABLE 1

Nominal Maximum Size	Minimum Sample Weight
1/2 in. (12.5 mm)	4.4 lbm (2 kg)
3/4 in. (19 mm)	6.6 lbm (3 kg)
1 in. (25 mm)	8.8 lbm (4 kg)
1 1/2 in. (37.5 mm)	11 lbm (5 kg)
2 in. (50 mm)	18 lbm (8 kg)
2 1/2 in. (63 mm)	26 lbm (12 kg)
3 in. (75 mm)	40 lbm (18 kg)

2. Dry sieve the sample through a No. 4 (4.75 mm) sieve and discard any material that passes the sieve (if a substantial amount of material passes the No. 4 (4.75 mm) sieve, you may need to use a No. 8 (1.18 mm) sieve instead of the No. 4 (4.75 mm), or you may need to perform a specific gravity on the minus No. 4 (4.75 mm) material). Wash the aggregate retained on the No. 4 (4.75 mm) sieve.

3. Dry test sample to constant weight in an oven regulated at 230 ± 9°F (110 ± 5°C). Cool sample at room temperature for 1 to 3 hr. After the cooling period, immerse the aggregate in water at room temperature for a period of 15 hr.

4. Place entire sample in a container and weigh in water maintained at 73.4 ± 3°F (23 ± 1.7°C). Shake container to release any entrapped air and weigh on minimum diameter wire suspended below scale apparatus. The water level in the bath should be maintained at the overflow depth to obtain a constant water level throughout the test (Figure 7). Record to the nearest 1.0 g or 0.1% of total weight, whichever is greater, as the weight in Water (C).

Figure 7
Water Overflow Outlet

5. Remove the sample from the container and drain any excess water from the aggregate. Using an absorbent cloth (an absorbent towel usually works best), roll the aggregate until the surface water has been removed (Figure 8). Rolling up the aggregate into the towel and then shaking and rolling the aggregate from side to side is also an effective procedure in reducing the sample to an SSD (saturated, surface-dry) condition.

Figure 8
Removing Excess Water

An SSD condition is one in which the aggregate has no FREE water on the surface of the aggregate. If the test sample dries past the SSD condition, immerse the sample in water for 30 minutes and resume the process of surface-drying.

6. Weigh SSD sample to nearest 1.0 g or 0.1% of the total weight, whichever is greater and record this as SSD weight.

7. Dry the sample in a pan to a constant weight in an oven set at 230 ± 9°F (110 ± 5°C). Cool in air at room temperature for 1 to 3 hr, or until the aggregate can be comfortably handled. Record weight to nearest 1.0 g or 0.1%, whichever is greater, as oven dry weight.

Calculations

Determine calculations based on appropriate formula.

A = Oven dry weight
B = SSD weight.
C = Weight in water

Bulk Specific Gravity (Gsb)	Gsb = A / (B-C)
Bulk SSD Specific Gravity (Gsb SSD)	Gsb SSD = B / (B-C)
Apparent Specific Gravity (Gsa)	Gsa = A / (A-C)
Absorption (% Abs)	% Abs. = [(B-A) / A] x 100

Example

Trial	A	B	C	B-C	A-C	B-A
1	2030.9	2044.9	1304.3	740.6	726.6	14.0
2	1820.0	1832.5	1168.1	664.4	651.9	12.5
3	2035.2	2049.4	1303.9	745.5	731.3	14.2

Trial	Bulk SSD B/B-C	Bulk A/B-C	Apparent A/A-C	Abs. (B-A/A)100
1	2.761	2.742	2.795	0.691
2	2.758	2.739	2.792	0.698
3	2.749	2.730	2.783	0.698
Ave.	2.756	2.737	2.790	0.693

A = Weight of Oven Dry Specimen in Air
B = Weight of SSD Specimen in Air
C = Weight of SSD Specimen in Water

These calculations demonstrate the relationship between Gsb, Gsb SSD, and Gsa. The Gsb (bulk specific gravity) will always be the lowest value since the volume calculated includes voids permeable to water. The Gsb SSD (bulk specific gravity at SSD) will always be the intermediate value, and the Gsa (apparent specific gravity) will always be the highest, since the volume calculated includes only the "solid" aggregate particle (does not include those voids permeable to water). When conducting this test, check to make sure the values calculated make sense in relation to one another.

CLAY LUMPS AND FRIABLE PARTICLES IN AGGREGATE

AASHTO T 112

SCOPE

To ensure the aggregate used performs as intended for highway construction, several tests are performed to determine the physical characteristics of the material. One of these tests is the determination of Clay Lumps and Friable Particles in Aggregate.

Excessive clay lumps in a processed aggregate intended for use in a Portland Cement or Hot Mix Asphalt may interfere with the bonding between the aggregate and cementitious material. This will result in spalling, raveling, or stripping and create weak points and pop-outs if the material is incorporated into the pavement or structure.

Aggregate intended to perform as a drainable base or subbase may also be adversely affected when excess amounts of clay and friable particles are present. This type of material tends to fill the void spaces intended for drainability, eventually contributing to pavement failure.

Attaining a reasonably accurate determination of the amount of clay lumps and friable particles in the processed aggregate is dependent on properly obtained representative samples.

SUMMARY OF TEST

There are two test methods for determining the clay lumps and friable particles in aggregates. There is a method for coarse aggregate and one for fine aggregate. The test methods are similar, but there are differences, so always be sure to follow the correct method for the type of aggregate being tested.

The material is sampled, dried, and soaked according to testing instructions. The clay lumps and friable particles are broken down by manipulation, using the thumb and forefinger. The material is washed, dried, and sieved according to the correct test procedure.

The materials are weighed and the calculations for the percent of clay lumps and friable particles are performed.

FINE AGGREGATE

Apparatus

Balance, sufficient capacity to determine the weight of the test samples, accurate to 0.1 percent of the weight of the sample to be tested, and conforms to the requirements of AASHTO M 231.

Containers, rust-resistant of a size and shape that will permit the spreading of the sample on the bottom in a thin layer.

Sieves, conforming to AASHTO M 92.

Oven, capable of providing free circulation of air and of maintaining a temperature of 230° ± 9°F (110° ± 5°C).

Sample Preparation

First subject the test sample to AASHTO T 11, Amount of Material Finer Than the No. 200 (75 µm) Sieve in Aggregate.

The sample shall be dried to a constant dry weight at a temperature of 230° ± 9°F (110° ± 5°C).

Remove the material smaller than No. 16 (1.18 mm) sieve by thoroughly sieving the original sample over the No. 16 (1.18 mm) sieve. The weight retained on this sieve is the test sample and must be at least 25 grams.

Procedure

1. Weigh the test sample and spread the sample in a thin layer on the bottom of an appropriately sized, rust-resistant container, cover the sample with distilled water and allow the sample to soak for a period of 24 ± 4 hours.

2. Decant the excess water from the sample after soaking. R oll and squeeze individual particles between the thumb and forefinger to attempt to break the particle into smaller pieces. Do not us fingernails, nor press the particles against hard surfaces or each other in the attempt to break the particles.

3. After all discernable clay lumps and friable particles have been broken, sieve the sample on a No. 20 (850 µm) sieve and then place the sample in a suitable drying pan. Dry the sample to a constant dry weight at a temperate of 230° ± 9°F (110° ± 5°C). Allow the sample to cool and weigh the sample to the required accuracy specified for the balance in AASHTO M 231.

Calculations

Calculate the percent of clay lumps and friable particles in fine aggregate using the following formula:

$$P = \frac{M-R}{M} \times 100$$

Where:

P = percent of clay lumps and friable particles
M = weight of test sample retained on the No. 16 (1.18 mm) sieve
R = weight of material retained on the No. 20 (850 µm) sieve

COARSE AGGREGATES

Apparatus

The same apparatus is used for the coarse aggregate test method that is used for the fine aggregate test method.

Sample Preparation

Subject the sample to be tested to AASHTO T 11, Amount of Material Finer Than No. 200 (75 µm) Sieve.

The aggregate sample shall be dried to a constant weight at a temperature of 230° ± 9°F (110° ± 5°C).

Separate the coarse aggregate sample into individual fractions using the following sieves to obtain the minimum weights as shown in Table 1:

Table 1

Sizes of Particles Making Up Test Sample	**Min. Weight of Individual Test Sample, Grams**
No. 4 to 3/8 in. (4.75 mm to 9.5 mm)	1000
3/8 in. to 3/4 in. (9.5 mm to 19.0 mm)	2000
3/4 in. to 1 1/2 in. (19.0 mm to 37.5 mm	3000
Over 1 1/2 in. (37.5 mm)	5000

Note: To provide the minimum required individual weight as indicated in Table 1, combining the material from more than one test by AASHTO T 11 may be necessaty. If the original grading of the sample has less than 5% of material retained on any of the above individual sizes, do not test that size.

Procedure

1. Weigh each fraction size and spread the individual samples in rust-resistant pans to form a thin layer. Cover the samples with distilled water and soak for 24 ± 4 hours (Figure 1).

Figure 1
Sample Soaking

2. After soaking, decant the excess water from the samples. Roll and squeeze suspect particles between the thumb and forefinger to attempt to break the particles into smaller sizes (Figure 2). Do not use fingernails to break the particles, or press the particles against a hard surface or each other.

Figure 2
Attempting to Break Particles

3. After all recognizable clay lumps and friable particles have been broken, remove the undersized material from each tested fraction by wet-sieving. The wet-sieving is to be accomplished by placing the sample on the appropriate size sieve for the size of the individual fraction (Table 2) and passing water over the sample while manually agitating the sieve, until all undersize material has passed the required sieve.

Table 2

Size of Particles Making Up the Sample	Sieve Size for Removing Residue of Clay Lumps and Friable Particles
No. 4 to 3/8 in. (4.75 mm to 9.5 mm)	No. 8 (2.36 mm)
3/8 in. to 3/4 in. (9.5 mm to 19.0 mm)	No. 4 (4.75 mm)
3/4 in to 1 1/2 in. (19.0 mm to 37.5 mm)	No. 4 (4.75 mm)
1 1/2 in. (Over 37.5 mm)	No. 4 (4.75 mm)

The material that can be broken down and removed from the sample by wet-sieving is classified as clay lumps and friable particles.

4. Remove the retained particles carefully from the sieve. D ry the sample to a constant dry weight at 230° ± 9°F (110° ± 5°C), and allow the material to cool.

5. Weigh the record the weight of the material to the accuracy specified for the balance in AASHTO M 231.

Note: Combined aggregates (those containing a substantial amount of coarse and fine material) are separated into two fractions using the No. 4 (4.75 mm) sieve and then prepared as appropriate for the correct size of the material (i.e., coarse or fine aggregate).

In most cases, only the plus No. 4 (4.75 mm) fraction of coarse aggregate is required to be evaluated by this test method regardless of the amount of minus No. 4 (4.75 mm) material present. However, the amount of material between the No. 16 (1.18 mm) and No. 4 (4.75 mm) sieves is included in the weight of the test sample when calculating the percent of clay lumps and friable particles.

Calculations

Calculate the percent of clay lumps and friable particles in the individual sizes as follows:

$$P = \frac{M-R}{M} \times 100$$

where:

P = percent of clay lumps and friable particles
M = weight of test sample (this is the weight of each size increment prepared for test)

Note: include the weight of the plus No. 16 (1.18 mm) to minus No. 4 (4.75 mm) when needed, if the aggregate contains both coarse and fine particles.

R = Weight of particles retained on a designated sieve

The percent of clay lumps and friable particles in coarse aggregate is an average based on the percent of clay lumps and friable particles in each sieve size fraction weighed in accordance with the grading of the original sample, or preferably the average grading of the entire lot. When the sample contains less than 5 % of the total material in a given size, based on the original grading of the aggregate sample, the increment is considered to have the same percent of clay lumps and friable particles as the next larger or smaller fraction, whichever is present (see Table 3).

Table 3

Particle Size	**Original Sample Percent Retained**	**Percent Clay Lumps and Friable Particles**	**Weighted Average Percent**
No. 4 to 3/8 in. (4.75 mm to 9.5 mm)	24	13	3.12
3/8 in. to 3/4 in. (9.5 mm to 19.0 mm)	15	8	1.20
3/4 in. to 1 1/2 in. (19.0 mm to 37.5 mm)	4	8*	0.32
Total Percent in aggregate			4.64
* the percent of material retained on the fraction from 3/4 in. (19.0 mm) to 1 1/2 in. (37.5mm) is less than 5 %, therefore the percent of clay lumps and friable particles found to be in the next smaller size increment (8 %) is used in the weighted average.			

REDUCING SAMPLES OF AGGREGATE TO TESTING SIZE

AASHTO R 76

GLOSSARY

Nominal Maximum size - The smallest sieve opening through which the entire amount of the aggregate is permitted to pass.

Saturated Surface Dry (SSD) - An aggregate is considered to be in a saturated surface dry condition when there is no free moisture present but the aggregate is in a nonabsorbent state.

Air Dry - When the aggregate appears to be dry but still has some absorbed moisture in the pore structure.

SCOPE

The field samples of aggregate must generally be reduced to an appropriate size for testing to determine physical characteristics, such as, sieve analysis, soundness, hardness, etc. T he methods described in this test method are intended to minimize variations in the aggregate characteristics between the smaller test sample and the larger field sample.

Several methods of sample reduction will be described. The technician must be sure to use the appropriate technique dependent on such factors as aggregate size and moisture content.

The reduction methods include:

Method A - Mechanical Splitter

Method B - Quartering

Method C - Miniature Stockpile

In some circumstances, reducing the field sample prior to testing is not recommended. Substantial differences may unavoidably occur during sample reduction, i.e., in the case of an aggregate having relatively few large size particles in the sample. These few particles may be unequally distributed among the reduced size test samples. If the test sample is being examined for certain contaminants occurring as a few discreet particles in a small percentage, the reduced test sample may not be truly representative of the total aggregate as produced. In these cases, the entire original field sample should be tested.

Failure to carefully follow the procedures in these methods of sample reduction may result in providing a nonrepresentative sample for subsequent testing, resulting in inaccurate test results, and ultimately, failure of the aggregate to perform as intended.

SUMMARY OF PROCEDURE

Aggregate and other materials sampled in the field need to be reduced to appropriate sizes for testing. It is, therefore, necessary to reduce field samples while minimizing the chance of variability during handling. In some instances a few particles on a given sieve might effect a gradation significantly enough to alter an interpretation of the field sample and subsequently the entire material's compliance with specifications.

The appropriate field sample reduction method is dependent chiefly on the nominal maximum size of the aggregate, the amount of free moisture in the sample, and the equipment available.

The following chart should be used in selecting the appropriate reduction method for the aggregate to be tested.

Mechanical Splitter	Quartering	Miniature Stockpile
Fine Aggregates - Air Dry	Fine Aggregates –Free Moisture on the Particle Surface	Fine Aggregates – Free Moisture on the Particle Surface
Coarse Aggregates	Coarse Aggregates	Not Permitted for Coarse Aggregates
Combined Aggregates - Dry	Combined Aggregates – Dry or Free Moisture on the Particle Surface	Not Permitted for Combined Aggregates

METHOD A -- MECHANICAL SPLITTER

Apparatus

The mechanical sample splitter shall have an even number of equal width chutes, not less than eight for coarse or combined aggregate, or twelve for fine aggregate. The chutes shall discharge alternately to each side of the splitter. F or coarse and combined aggregate the width of the individual chutes shall be approximately twice the largest size particle in the sample to be reduced. For dry fine aggregate in which the entire sample will pass the 3/8 in. (9.5 mm) sieve, the minimum width of the chutes shall be at least fifty percent larger than the largest particles in the sample with a maximum width of 3/4 in. (20 mm).

The splitter shall be equipped with at least two receptacles (catch pans) to hold the two halves of the sample during splitting. It shall also be equipped with a hopper or straight-edge pan with a width equal to or slightly less than the overall width of the assembly of chutes, by which the sample may be fed at a controlled rate into the chutes.

The splitter and accessories shall be designed to allow the sample to flow smoothly without restriction or loss of material.

Mechanical splitters are commonly available in sizes adequate for aggregate having the largest particle size not over 1 1/2 in. (37.5 mm).

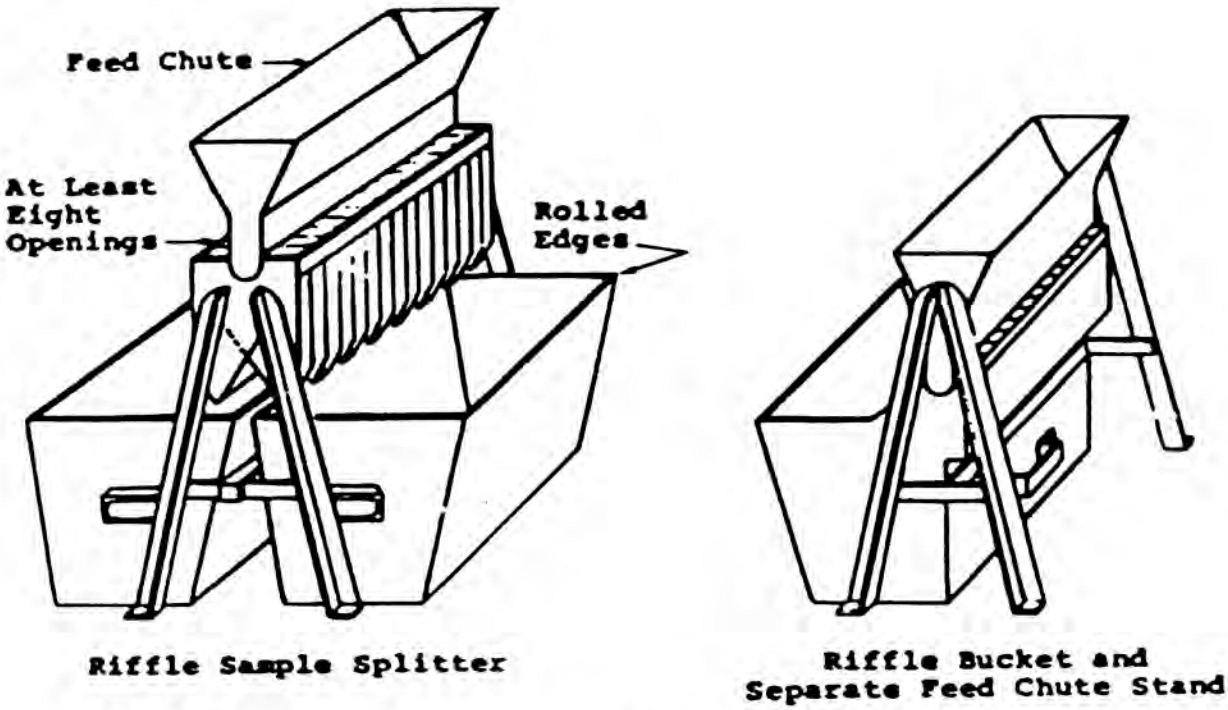
Procedure

1. If the mechanical splitter procedure is desired and the sample is damp or shows free water, the sample may be dried until the sample appears dry or until clumps may be easily broken by hand. The dryness of the sample may be tested by tightly squeezing a small portion of the sample in the palm of the hand. If the cast crumbles readily, the correct moisture range has been obtained.

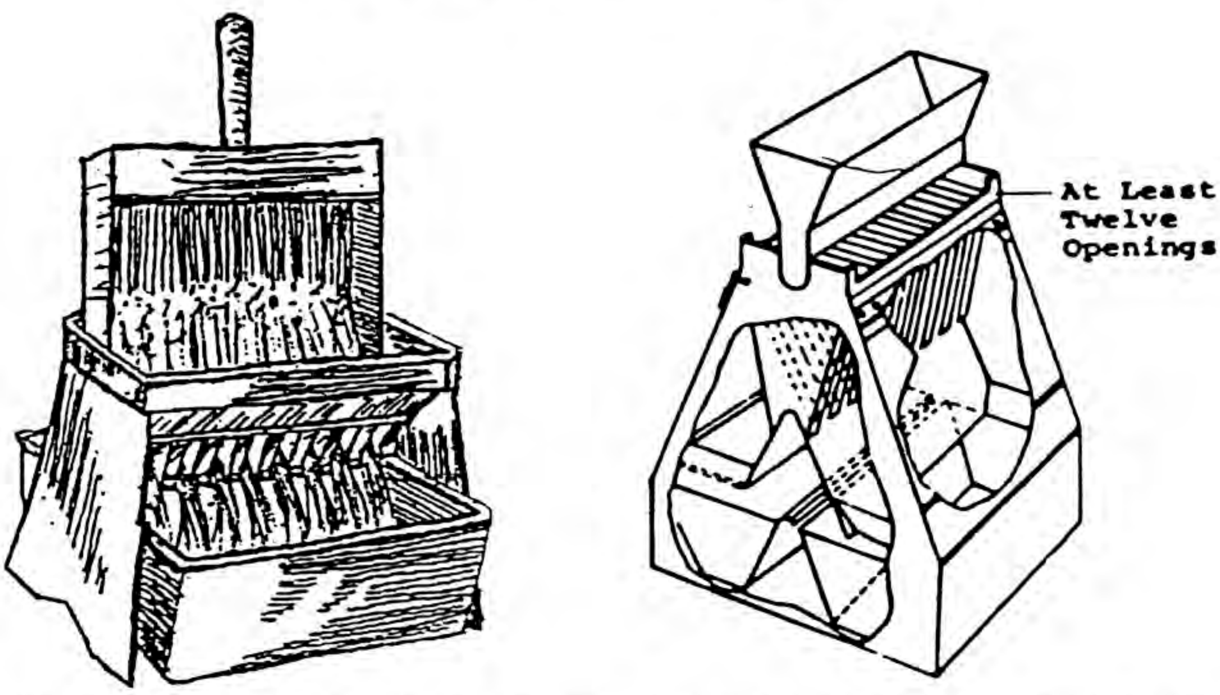
2. Place the original sample, or portion thereof, in the hopper or pan and uniformly distribute it from edge to edge being sure the sample appears homogenous (well-blended). Carefully introduce the sample into the chutes in a manner to allow the aggregate to flow freely through the openings and into the catch pans. Continue this procedure until the entire sample has been halved, being careful that catch pans do not overflow.

3. Remove the catch pans and set aside. Continue splitting one half of the material. Follow this procedure, being sure to split entire increments, until the desired test sample size is obtained. Retain the unused material until all desired tests are performed in case a retest is needed.

   Note: Sometimes a significant amount of fines may be lost in the splitting process if the sample is extremely dry and the action of pouring the sample through the splitter chutes creates a large dust cloud, suspending the fines in the air above the splitter. If this is a serious concern, then add a small amount of water to the original sample and mix thoroughly before splitting the sample. The extra moisture will prevent many of the fines from becoming suspended in the air and drifting off. Remember to not add so much water that the moisture content ends up being at or greater than the SSD condition, in which case the mechanical splitting method would no longer be valid. In any case, be sure to perform the splitting procedure in a well-ventilated area while wearing a suitable dust mask.



(a) Large Riffle Samplers for Coarse Aggregate.



NOTE—May be constructed as either closed or open type. Closed type is preferred. (*b*) Small Riffle Sampler for Fine Aggregate.

Figure 1
Sample Splitters

MECHANICAL SAMPLE SPLITTER

Mechanical Splitter

Sample in Splitter

Sample Being Split

METHOD B -- QUARTERING

Apparatus

Straight-edged scoop.

Flat-edged shovel or trowel.

Broom or brush.

Alternate method only - canvas blanket measuring approximately 6 ft. x 8 ft (2 m by 2.5 m).

Procedure

1. Place the original sample on a hard, clean, level surface. Mix the material thoroughly by turning the entire sample over with the shovel three times. With the last turning, shovel the entire sample into a conical pile by depositing each shovelful on top of the preceding one. Carefully flatten the conical pile to a uniform thickness and diameter by pressing down the apex with the shovel so that each quarter section of the resulting pile will contain the material originally in the pile. The pile diameter should be approximately four to eight times the thickness.

2. Divide the flattened pile into four equal quarters with the shovel or trowel. Remove two diagonally opposite quarters, including all fine material. Brush the cleared spaces clean. Successively mix and quarter the remaining material in the same fashion as the original sample. Continue this process until the desired quantity is obtained.

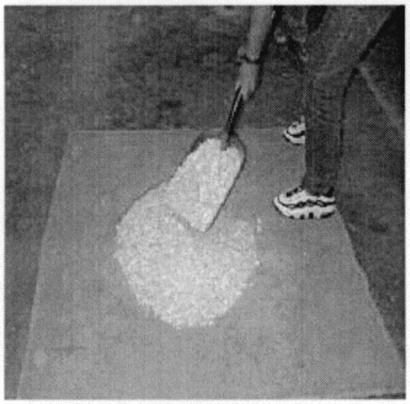
   Save the unused portion of the original field sample until all testing is completed in case a retest is needed.

METHOD B -- ALTERNATIVE

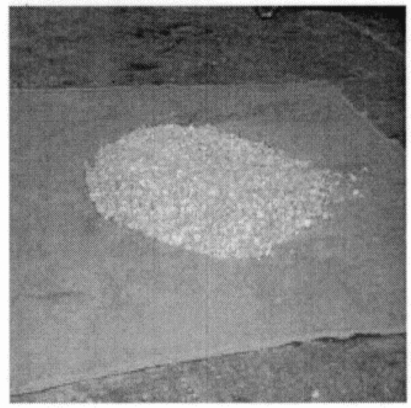
As an alternative to Method B, when the floor surface is uneven, the field sample may be placed on a canvas blanket and mixed with a shovel, or by alternatively lifting each corner of the blanket and pulling the blanket over the sample toward the diagonally opposite corner causing the material to be rolled. Flatten and divide the pile as described in Method B, or if the surface beneath the blanket is too uneven, insert a stick or pipe dividing the pile into two equal parts. Remove the stick leaving a fold in the canvas between the sample halves. Slide the stick under the canvas blanket again at a right angle to the first division and dissecting the two halves of the sample through their centers. Lift the stick evenly from both ends dividing the sample into equal quarters. Remove two diagonal parts including the fine material and clean the area. Successively mix and quarter the remaining material until the desired sample size is obtained.

Note: The quartering method is fairly time intensive and thus is generally used in situations where an adequate mechanical splitter is unavailable. Diligence and care is required to ensure that the samples obtained by quartering remain representative of the entire field sample.

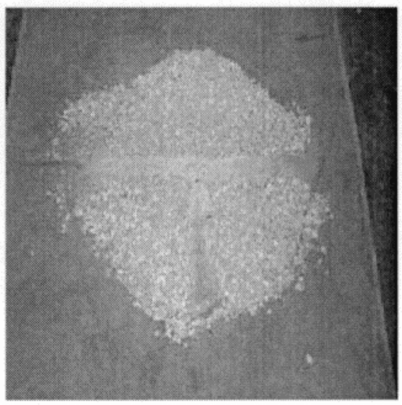
METHOD B



Mix by Forming New Cone

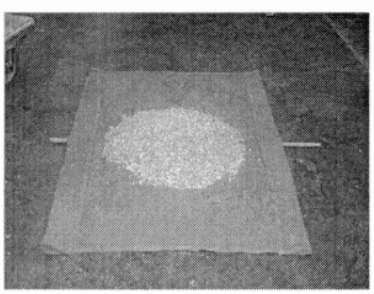


Flatten Cone

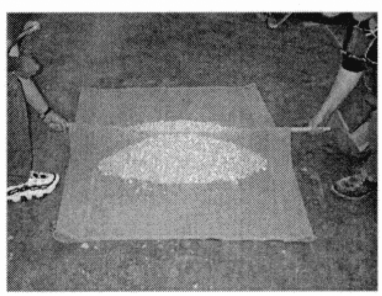


Divide Sample Into Quarters

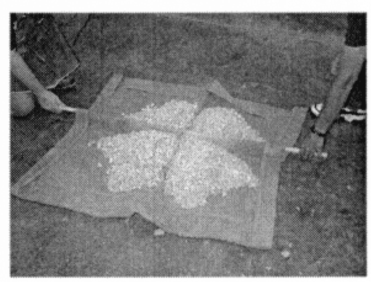
Method B (alternative)



Stick Placed Under Flattened Sample



Sample Divided in Half



Sample Divided Into Quarters

METHOD C -- MINIATURE STOCKPILE

Apparatus

Straight-edge scoop.

Shovel or trowel (for mixing the aggregate).

Small sampling thief, small scoop, or spoon.

Procedure

This method is for damp, fine aggregate only.

1. Place the field sample on a hard, clean, level surface where there will be no loss of material or contamination. Mix the sample by turning the entire sample over three times with a shovel. With the last turning, shovel the entire sample into a conical pile by depositing each shovelful on top of the preceding one.

2. Obtain a sample for each test to be performed by selecting at least five increments of material at random locations from the miniature stockpile using a sample thief, small scoop, or spoon.

Miniature Stockpile

Taking One of at Least Five Samples

UNCOMPACTED VOID CONTENT OF FINE AGGREGATE

AASHTO T 304

GLOSSARY

Voids **-** Difference between the total volume and the volume occupied only by the aggregate particles. The amount of void space (or air space) is a function of the aggregate gradation, particle shape and texture, and the amount of compaction of the material.

Uncompacted Voids **-** The amount of void space present when the material is in an uncompacted, unconsolidated state.

Bulk Dry Specific Gravity **-** The ratio of the weight in air of a unit volume of aggregate at a stated temperature to the weight in air of an equal volume of gas-free distilled water at the stated temperature.

Angularity **-** A description of the degree of roughness, surface irregularities or sharp angles of the aggregate particles (i.e. particle shape).

SCOPE

This method determines the loose uncompacted void content of a sample of fine aggregate. When performed on an aggregate sample of a known, standard grading (Method A), this measurement provides an indication of particle shape. The material angularity, roundness or surface texture relative to other materials of the same standard grading is indicated by the percent of voids determined by this test. The Superpave asphalt mix design method sets minimum requirements for void content that vary depending on traffic loads and depth from the surface of the asphaltic concrete pavement.

In this method, the prepared sample is allowed to free-fall through a standard funnel of a specified diameter from a specified height into a small cylinder of known volume (nominal 100 mL). The material is then leveled with the top of the calibrated cylinder and weighed. Because the volume and weight of the cylinder are known, the weight of the sample contained in the cylinder may be calculated. Using the Bulk Dry Specific Gravity (as determined by AASHTO T 84), the volume of the material in the cylinder is calculated. By subtracting the calculated volume of material from the calibrated volume of the test cylinder, the volume of voids may be calculated.

SUMMARY OF TEST

A sample of sand is prepared in accordance with one of three methods. Method A, a standard gradation, is the most common used. The sample is allowed to free-fall from a funnel into a cylinder of known volume. Using the Bulk Dry Specific Gravity of the sample as determined by AASHTO T 84, the percent of void space in the cylinder is calculated. This value is known as the Fine Aggregate Angularity Value or FAA.

Apparatus

Cylindrical measure, approximately 1.56 in. (39 mm)in diameter, 3.44 in. (86 mm) deep with a capacity of approximately 100 mL.

Funnel, conforming to Figure 2 in AASHTO T 304.

Funnel Stand, conforming to Figure 2 in AASHTO T 304.

Glass Plate, for calibrating cylindrical measure.

Pan, large enough to contain funnel stand and to catch overflow material. The pan shall not be warped so as to prevent rocking of the apparatus during testing.

Metal spatula, with a straight edge approximately 4.0 in. (100 mm) long and 0.8 in. (20 mm) wide.

Balance, accurate and readable to 0.1 grams.

Procedure - Only Method A will be discussed in this procedure. For the other methods consult AASHTO T 304

1. Wash representative sample in accordance with T 11. The size of this sample is dependent on the gradation of the sample. Generally 500 grams to 700 grams is sufficient to yield the necessary size fraction quantities.

2. Dry washed sample material in a 230 ± 9°F (110 ± 5°C) oven to a constant weight.

   Sieve material in accordance with AASHTO T 27. Remove the following size fractions from the sieves and retain in separate, labeled containers:

   Passing No. 8 (2.36 mm) - Retained on No. 16 (1.18 mm)
   Passing No. 16 (1.18 mm) - Retained on No. 30 (600 µm)
   Passing No. 30 (600 µm) - Retained on No. 50 (300 µm)
   Passing No. 50 (300 µm) - Retained on No. 100 (159 µm)

3. Weigh individual size fractions and combine them in accordance with the following:

Size Fraction		Weight, grams
No. 8 (2.36 mm)	x No. 16 (1.18 mm)	44
No. 16 (1.18 mm)	x No. 30 (600 µm)	57
No. 30 (600 µm)	x No. 50 (300 µm)	72
No. 50 (300 µm)	x No. 100 (150 µm)	17
	Total	190

4. Mix combined sample thoroughly with spatula.

5. Place finger under opening in funnel to seal opening. Pour mixed sample into funnel (Figure 1).

Figure 1
Pouring Sample into Funnel

6. Quickly remove finger from funnel and allow sample to free-fall into the calibrated cylinder.

7. Take care not to vibrate or unnecessarily disturb the material in the cylinder to avoid further consolidation. Strike off the excess material above the lip of the cylinder with the spatula edge, held in a vertical position, using one continuous motion.

8. After striking off, remove any excess sand from the outside of the cylinder using a small brush. At this point, additional compaction of the material in the cylinder will not affect the test results and will aid in handling.

9. Weigh the cylinder with the sample and record to the nearest 0.1g (Figure 2). Retain and recombine all materials for the next trial.

Figure 2
Weighing the Cylinder

10. Repeat test using the recombined sample. Calculate and report the average of at least two trials.

Calculations

Calculate the uncompacted voids content as follows:

$$U = \frac{V-(F/G)}{V} \times 100$$

Where:

V = Volume of calibrated cylinder in mL (cubic centimeters)
F = Net Weight of Sample in cylinder (gross weight minus weight of empty cylinder)
G = Bulk Dry Specific Gravity as determined by AASHTO T 84
U = Uncompacted Voids in Percent (reported to nearest 0.1%)

<u>Example:</u>

Volume of Cylinder: 99.92 mL
F = 156.4 g
G = 2.643

$$U = \frac{99.92 - (156.4 / 2.643)}{99.92} \times 100 = 40.8$$

FLAT PARTICLES, ELONGATED PARTICLES, OR FLAT AND ELONGATED PARTICLES IN COARSE AGGREGATE

ASTM D 4791

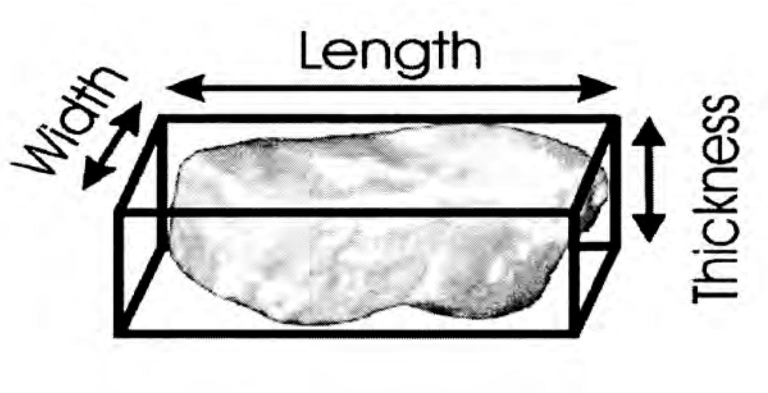
GLOSSARY

Flat and Elongated Particles of Aggregate - Those particles having a ratio of length to thickness greater than a specified value.

Length - the maximum dimension.

Thickness - the maximum dimension perpendicular to the length and width.

Width - the maximum dimension in the plane perpendicular to the length.



SCOPE

This test method covers tests for flat particles, elongated particles, or flat and elongated particles in coarse aggregate. In this text only flat and elongated particles in accordance with the procedure designated in Method B will be covered.

Flat and elongated particles of coarse aggregates have a tendency to fracture more easily than other aggregate particles. When the coarse aggregate does fracture, the gradation will likely change which may be detrimental to the mix. Additionally, flat and elongated particles of aggregate, for some construction uses, may interfere with consolidation and may result in harsh, difficult to place mixtures.

SUMMARY OF TEST

Individual aggregates of specific sieve sizes are tested for ratios of width to thickness, length to width, or length to thickness. The test is performed on a sample of coarse aggregate reduced from a representative field sample. The sample is sieved to separate each size larger than the 3/8 in. (9.5 mm) sieve. Each size is then tested in a proportional caliper device. Particles are weighed to determine a percentage of flat, elongated, or flat and elongated particles in a sample. Superpave specifications require hot mix asphalt to have less than 10% flat and elongated particles using a 5:1 ratio.

Apparatus

Proportional Caliper Device.

Balance, accurate to 0.5% of the weight of the sample.

Oven or hot plate (if determination is made by weight)

Sample Size

Set up the test sample according to the following table:

Nominal Maximum Size	Minimum Weight
3/8 in. (9.5 mm)	2 lbm. (1 kg)
1/2 in. (12.5 mm)	4 lbm. (2 kg)
3/4 in. (19.0 mm)	11 lbm. (5 kg)
1 in. (20.5 mm)	22 lbm. (10 kg)
1 1/2 in. (37.5 mm)	33 lbm. (15 kg)
Note: This is the entire sample. Only test the sieve sizes that are present in the amount of 10% or more of the original sample.	

Procedure

1. If determination by weight is required, oven dry the sample to a constant weight at a temperature of 230° ± 9°F (110° ± 5°C). If determination is by particle count, drying is not necessary.

2. Sieve the sample of coarse aggregate to be tested in accordance with test method AASHTO T 27. Reduce each size fraction larger than the 3/8 in. (9.5 mm) sieve that is present in the amount of 10% or more of the original sample in accordance with method AASHTO T 248 until approximately 100 particles are obtained.

3. Use the proportional caliper device positioned at the 5:1 ratio.

4. Set the larger opening equal to the particles longest dimension. The particle is considered flat and elongated if the particles thinnest dimension passes through the smaller opening. (Figures 1 and 2)

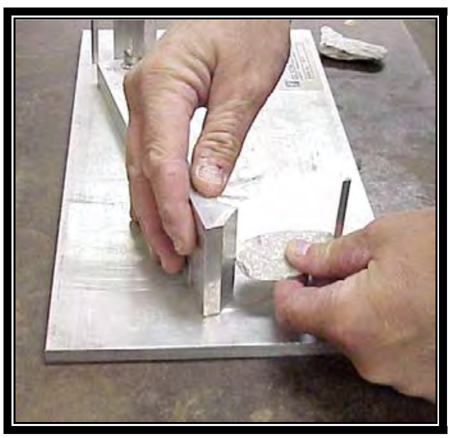


Figure 1
Checking Elongation

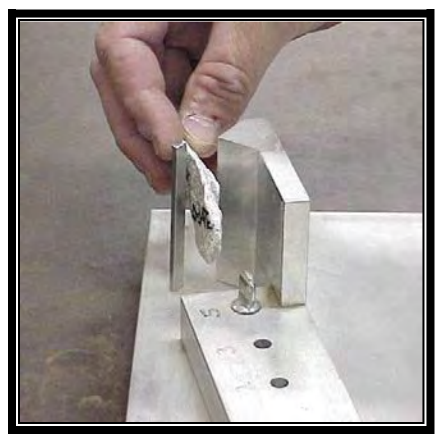


Figure 2
Checking Flatness

5. Test each of the particles in each size fraction and place them into one of two groups: (1) Particles with longest to thinnest ratios over 5:1 and (2) Particles with longest to thinnest ratios less than 5:1

6. After the particles have been classified into the two groups, determine the proportion of the sample in each group by either count or by weight as required.

Calculations

Calculate the percentage of flat and elongated particles to the nearest 1% for each sieve size greater than 3/8 in. (9.5 mm).

<u>Example</u>

3/4 in. (19.0 mm) Stone

Sieve	1 in. (25.0 mm)	3/4 in. (19.0 mm)	1/2 in. (12.5 mm)	3/8 in. (9.5 mm)
% Passing	100	99.4	75.7	46.4
% Retained	0	0.6	23.7	29.3

No test is performed on the 3/4 in. (19.0 mm) size aggregate because this material is less than 10 % of the total sample. Assume that the 3/4 in. (19.0 mm) particles have the same percentage of flat and elongated as the next sieve which is the 1/2 in. (12.5 mm) sieve.

The 1/2 in. (12.5 mm) size material totaled 715.3 grams after reducing to approximately 100 particles. 6 .9 grams were classified as flat and elongated, therefore, the percent flat and elongated on the 1/2 in. (12.5 mm sieve) is:

$$\frac{6.9}{\ } \text{ x } 100 = 1.0\% \approx 1\%$$

Likewise, the 3/8 in (9.5 mm) size totaled 239.7 grams after reduction and 12.2 grams were classified as flat and elongated. The percent flat and elongated on the 3/8 (9.5 mm) sieve is:

$$\frac{12.2}{239.7} \text{ x } 100 = 5.1\% \approx 5\%$$

The percentage of flat and elongated particles on each sieve is reported to the nearest whole percent.

DETERMINING PERCENT OF FRACTURED PARTICLES IN COARSE AGGREGATE

ASTM D 5821

GLOSSARY

Fractured Face - A fractured face is defined as being caused either by mechanical means or by nature and should have sharp or slightly blunted edges. Natural fractures, to be accepted, must be similar to fractures produced by a crusher. A broken surface constituting an area equal to at least 25% of the projected area of the particle, as viewed perpendicular to (looking directly at) the fractured face, is considered an acceptable fractured face.

Fractured Rock Particle - A rock particle having at least one or two fractured faces, as required for that class/type of aggregate in the specifications.

SCOPE

This test procedure determines the amount (percent) of fracture faced rock particles, by visual inspection that meets specific requirements. The fractured face of each rock particle must meet a minimum cross-sectional area. Specifications contain requirements for percentage of crushed aggregate particles, with the purpose of maximizing shear strength in either bound or unbound aggregate mixtures. This method may be used in determining the acceptability of coarse, dense-graded, and open-graded aggregates with respect to such requirements. This procedure is used primarily for hot mix asphalt aggregates.

SUMMARY OF TEST

Apparatus

Sieves, appropriate for the sample type

Balance, appropriate for the size of sample and in accordance with AAASHTO M 231 for a class G_2 balance

Spatula or similar tool to aid in sorting the aggregate particles

Paper containers

Sample Preparation

Air-dry the representative sample prior to the coarse gradation process so that there is a clean separation of the particles. A total + No. 4 (4.75 mm) sample could be used for testing but more commonly the + No. 4 (4.75 mm) material will be split into representative fractions. The minimum size of samples shall be as follows:

Nominal Maximum Sieve Sizes*	Minimum Sample Size lbm (g)
3/8 in. (9.5 mm)	0.5 lbm(200 g)
1/2 in. (12.5 mm)	1 lbm (500 g)
3/4 in.(19.0 mm)	3 lbm (1500 g)
1 in.(25.0 mm)	6 lb,m (3000 g)
1 1/2 in.(37.5 mm)	16.5 lbm (7500 g)

*Note: Nominal maximum sieve size is defined as the smallest sieve opening through which the entire amount of the aggregate is permitted to pass.

For aggregate with a nominal maximum size of 3/4 in. (19.0 mm) or larger, the test sample may be separated on the 3/8 in. (9.5 mm) sieve. The portion passing the 3/8 in. (9.5 mm) sieve may then be further reduced to a minimum of 0.5 lbm (200 g). This will reduce the number of particles to be separated during the procedure. In this case, percent fractured particles is determined on each portion and a weighted average percentage of fractured particles is calculated.

Procedure

1. Wash and dry sample to a constant weight. Weigh the test sample to the nearest 0.1g and record as "Test Sample Weight".

2. Spread the test sample on a clean flat surface large enough to permit the material to be spread thinly for careful inspection and evaluation.

3. Using the spatula or a similar tool separate the particles into one of the following three categories:

   Crushed Particles, using the criteria of "one or more fractured faces" or "two or more fractured faces" as is consistent with the requirements in the specifications.

   Uncrushed Particles

4. Determine the weight of the "Crushed Particles" and record the weights as "Weight of Crushed Particles".

Calculations

1. Calculate the percentage of crushed particles as follows:

$$\text{Percent Crushed Particles } (\mathbf{P}) = \frac{F}{F + N} \times 100$$

Where: F = Weight of crushed particles with at least the specified number of fractured faces, in grams

N = Weight of uncrushed particles, in grams

Example:

F = 730
N = 1016

$$\mathbf{P} = \frac{730}{730 + 1016} \times 100 = 41.8\%$$

2. For aggregate with a nominal maximum size of 3/4 in. (19.0 mm) or larger, the test sample may be separated on the 3/8 in. (9.5 mm) sieve. The percent fractured particles is determined on each portion and a weighted average percentage is calculated.

Example:

3/4 - 3/8 in. (19.0 - 9.5 mm) Material	=	3766g
3/8 - No. 4 (9.5 - 4.75 mm) Material	=	7314g
Total + No. 4 (4.75 mm) Material	=	11080g

$$\text{Percent 3/4 - 3/8 in. (19.0 - 9.5 mm)} = \frac{3766}{11080} \times 100 = 34\%$$

$$\text{Percent 3/8 in. - No. 4 (9.5 - 4.75 mm)} = \frac{7314}{11080} \times 100 = 66\%$$

Total Percent Crushed Particles =

(% Crushed Particles 3/4 to 3/8 in. [19.0 - 9.5 mm]) x
(% of 3/4 to 3/8 in. [19.0 - 9.5 mm] Material)

+

(% Crushed particles 3/8 in. - No.4 [9.5 - 4.75 mm]) x
(% of 3/8 in. - No. 4 [9.5 - 4.75 mm] Material)

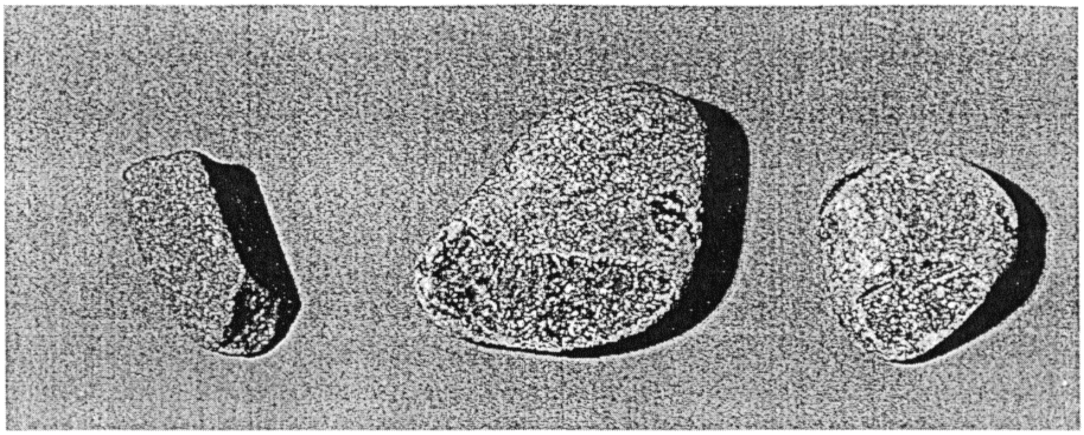
Using the following Data

% Crushed Particles 3/4 - 3/8 in. (19.0 - 9.5 mm) = 35.7%
% Crushed Particles 3/8 in. - No. 4 (9.5 - 4.75 mm) = 75.1%

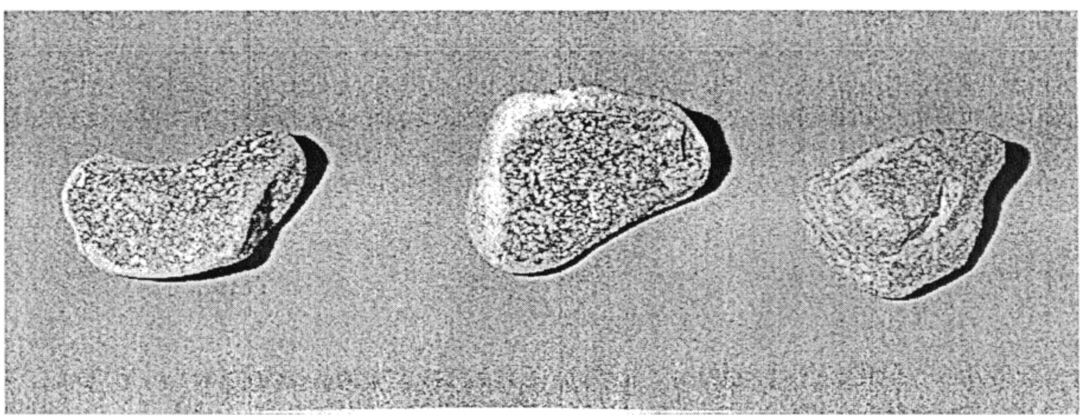
% Crushed Particles = [(0.357 x 0.34) + (0.751 x 0.66)] x 100

= [(0.121) + (0.496)] x 100

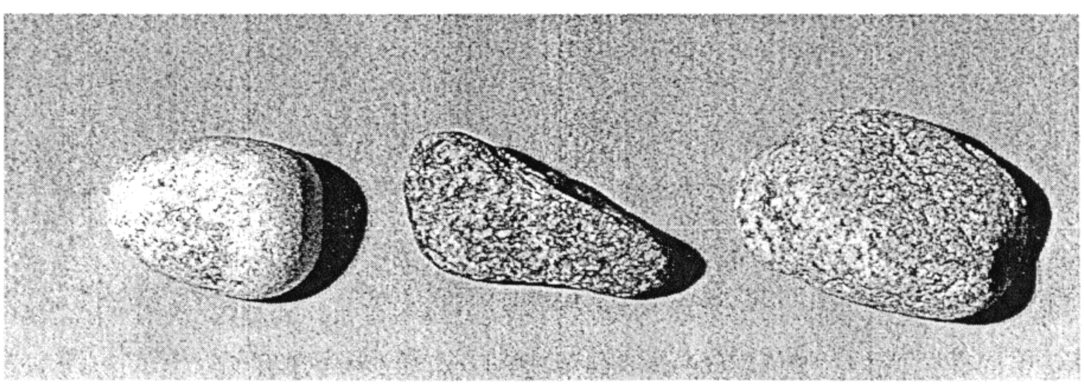
= 61.7%



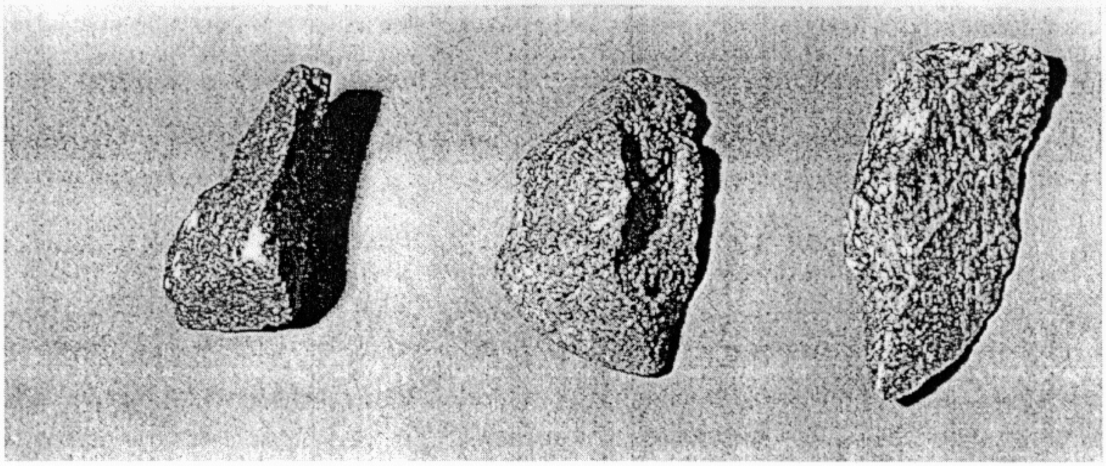
Fractured particle (center) flanked by two non-fractured particles (chipped only).



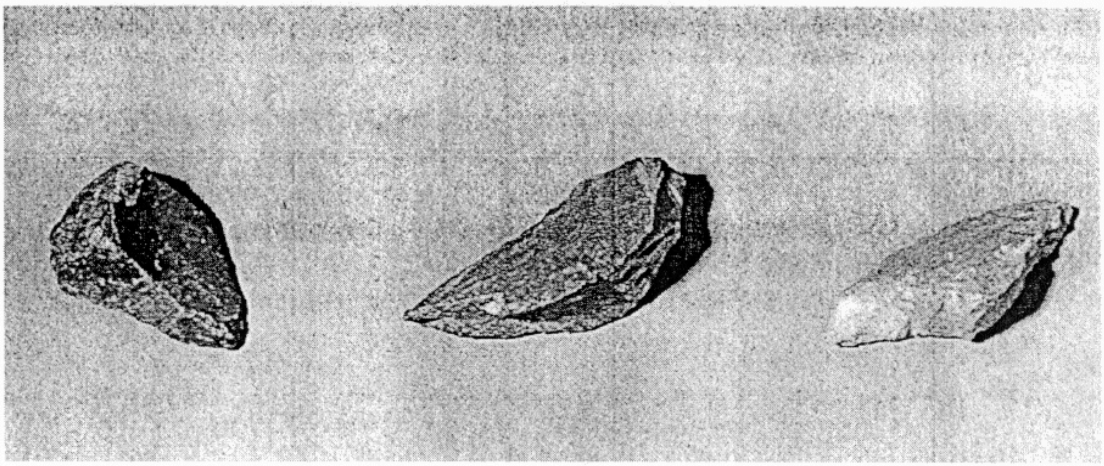
Non Fractured particle (round edges, smooth surfaces



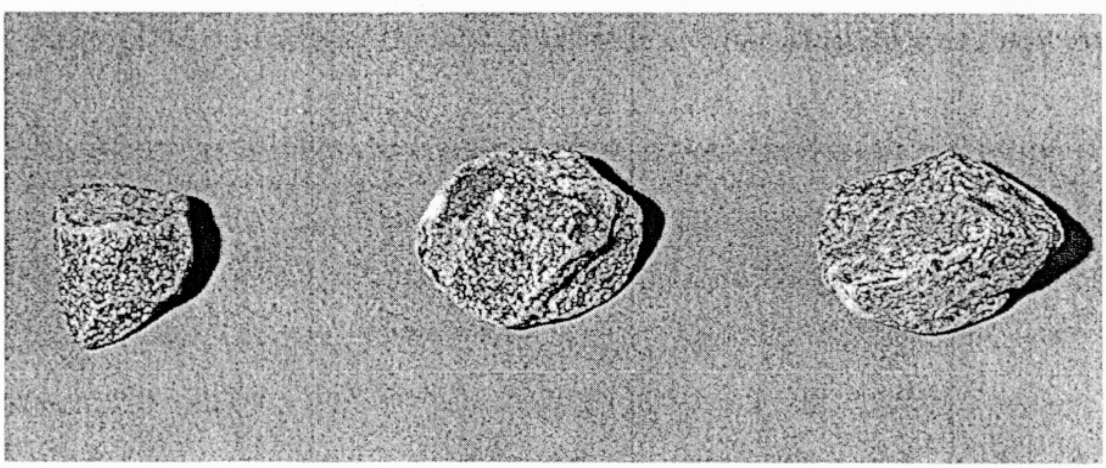
Non Fractured particle (rounded particles, smooth surfaces).



Fractured particle (sharp edges, rough surfaces).



Fractured particle (sharp edges, smooth surfaces



Fractured particle (round edges, rough surfaces).

Appendix C

Quality Control Plans

Limerock Quarries, Inc.

Indiana Quality Sand & Gravel, Inc.

QUALITY CONTROL PLAN

LIMEROCK QUARRIES, INC.

INDOT SOURCE #2799

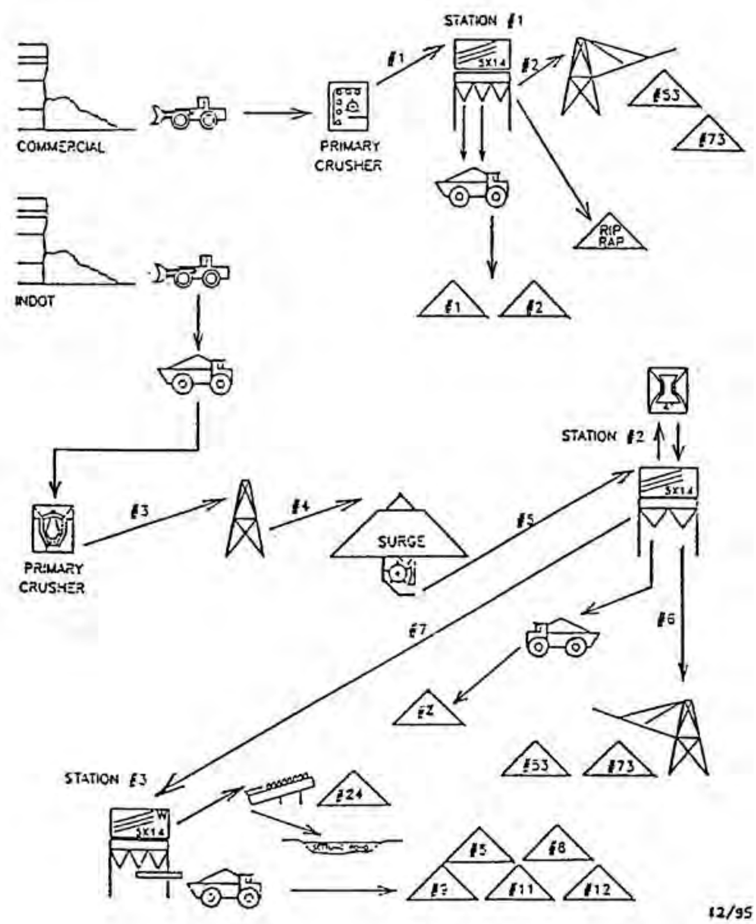


TABLE OF CONTENTS

SECTION 1

PLANT LOCATION

Limerock Quarries, Inc., Markle Plant (2799) is classified as a Plant for CAPP purposes. The location of the plant is indicated on the map in Appendix A. The address and other pertinent information is as follows:

Limerock Quarries Inc.
(INDOT #2799)
6593 County Rd.
Bippus, IN 46713

Latitude - 40E 47' 58"
Longitude - 85E 21' 26"
County - Huntington
Township - T 27 N
Range - R 10 E
Section - 11

Office Phone No. - 219-555-7214
Fax - 219-555-6032
Certified Technician Mobile - 219-555-8381
Lab - 219-555-4621

The Limerock Quarry is approximately 2.3 miles south of the town of Markle and west of SR 3. To locate the plant follow SR 3 south from Markle to CR 200S. At this intersection turn west, cross over Rock Creek and the entrance to the Quarry is the first right.

The Limerock Quarry is owned by Stone City, Inc. which is located at the following address:

Stone City, Inc.
5538 Subbase Ln.
Mineral, IN 46220
317-257-1996
FAX: 317-257-1995

SECTION 2

ORGANIZATIONAL STRUCTURE

MANAGEMENT REPRESENTATIVES

The Quarry Superintendent for Limerock Quarries and Management Representative for this source is Clay Mudstone. He is responsible for all production for this site.

CERTIFIED TECHNICIANS

The CAPP Certified Aggregate Technician responsible for this location is Richard Quality. His duties include testing and reporting results from this site as well as assisting with the CAPP duties at several other sites within the Limerock organization. Mr. Quality communicates all CAPP concerns to Mr. Mudstone who then takes appropriate actions.

Other Quality Control Personnel include Crystal Stone and Chip Samples. Ms. Stone's duties include sampling and reporting test results for three sites within Limerock Quarries, Inc. She may also assist at this site as the need arises. Mr. Samples is a CAPP Certified Aggregate Technician who will substitute for Mr. Quality when necessary.

SECTION 3

MINERAL DEPOSITS

All stone in the production areas are Silurian in age. The stone is derived from bedrock belonging to the Wabash and Pleasant Mills Formations and the Liston Creek, Mississinewa, Louisville and Limberlost Members.

Ledges 1 and 2 are mined as one bench for commercial purposes only. Ledge 3 is not useable for any type of aggregate use and is stripped and wasted.

Useable INDOT aggregates include only ledges 4 and 5, which are mined as one 73 foot thick bench. (A geologic cross-section of these ledges is provided in Appendix A). Test data and Class rating for these ledges appear in the Summary of Ledge Quality Tests letter dated March 31, 1993. This source is currently classified as Category 1A. Ledges 4 and 5 are allowed for use as AP aggregates and dolomite aggregates.

SECTION 4

AP AGGREGATE

Ledges 4 and 5 are approved for Class AP aggregate production as indicated on the approval letter dated November 4, 1994. The AP Production Control Plan is included in Appendix B.

SECTION 5

MATERIAL CATEGORIES

STANDARD SPECIFICATION

Aggregates produced from ledges 4 and 5 are categorized as Standard Specification materials and include the following INDOT sizes:

2, 5, 8, AP 8, 9, 11, 12, 53, 73

ALTERNATE

Aggregates produced from ledges 1 and 2 are categorized as Alternate materials and include the following INDOT sizes:

2, 53, 73, Rip Rap

OTHER

No. 23 natural sand is stockpiled at the on-site Tarcoat asphalt plant. This material is only used for the asphalt plant and is not sampled or tested by Limerock Quarries, Inc.

SECTION 6

PRODUCTION FLOW DIAGRAM

Aggregates produced at this source are produced from 1 production area. Only those aggregates produced from ledges 4 and 5 are used for INDOT purposes. Therefore, the process description will be limited to those matters associated with production from these ledges. The flow diagram for the entire plant and detailed flow diagrams for stations #2 and #3 are shown on the following pages.

Production of materials from ledges 4 and 5 is referred to as Class A production. This part of the plant is referred to as the A Circuit. Materials from the A Circuit that are in the muck pile are all removed with a loader and put into haul trucks. The trucks unload the aggregates into a Traylor 54" gyratory crusher where they are crushed and conveyed to the Primary Surge Pile.

STATION #2

Material from the Primary Surge Pile is fed into Station #2 where the first screening is done with a Drister 5' x 14' 3-deck vibrating screen. The following materials are processed:

1. Oversized materials are closed-circuited to a 4' shorthead Symons cone crusher where they are reduced and returned to Station #2.

2. Materials passing through the first deck and retained on the second deck are #2 size and may either be diverted back to the 4' Symons crusher or routed to a bin where they are loaded into trucks for stockpiling.

3. Materials passing through the second deck and retained on the third deck are always sent to Station #3.

4. Materials passing through all decks at this station are sent to the stacker and stockpiled as #53 or #73.

STATION #3

Material from Station #2 is fed into this station which is the wash station. The screening unit is a 3-deck 5' x 14' Deister vibrating screen with water. The top deck has a combination of 1/2" and 3/8" screen panels, the middle deck has a combination of 1/4" and 5/16" screen panels and the bottom deck has .080" x 5/16" slotted panels or 1/8" square panels. These combinations can be changed to control our products. All materials arriving at this Station are pre-screened. The following materials are washed and stored.

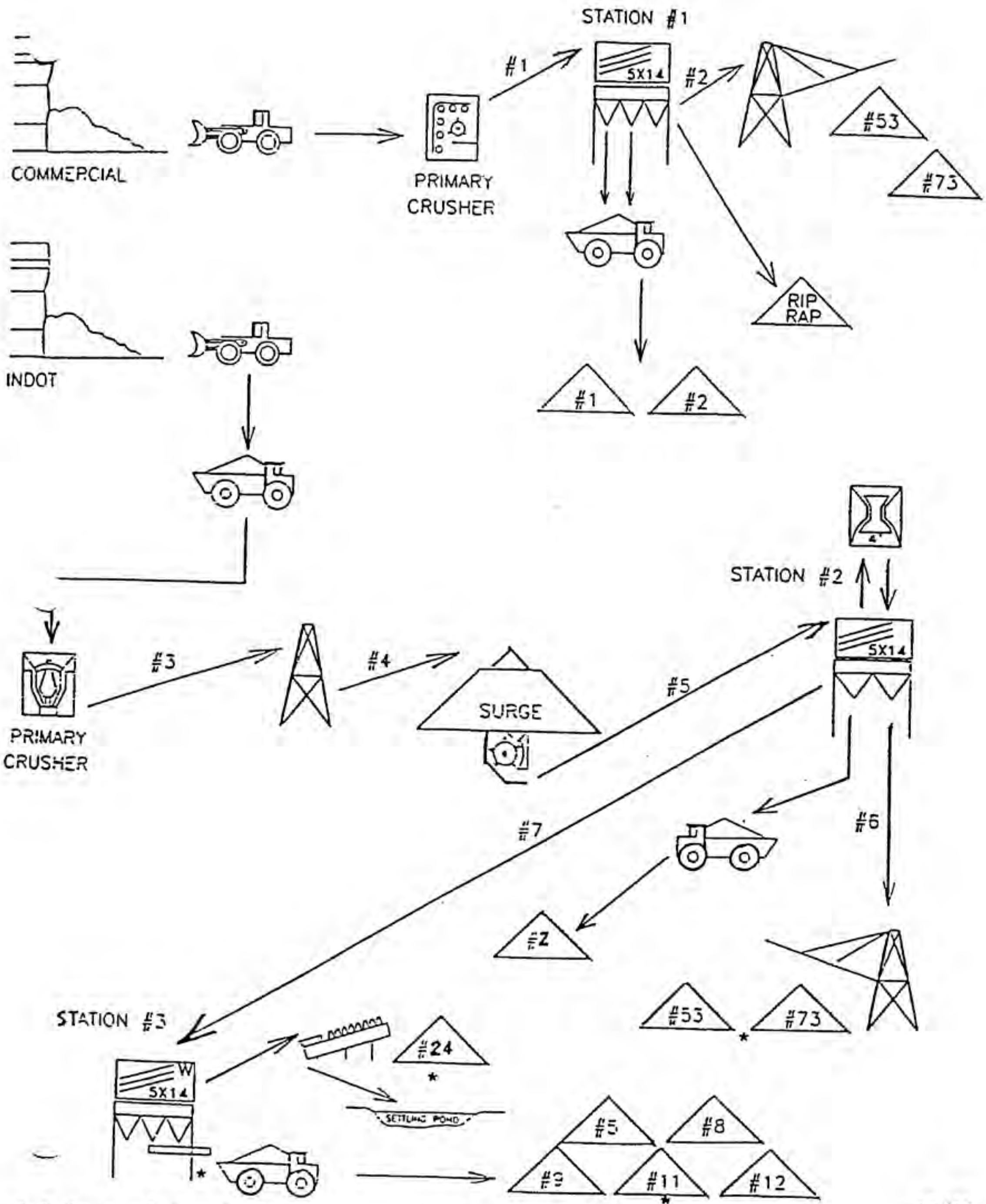
1. Oversized materials are either #5, #8 or #9 and go into the coarse bin to await stockpiling.

2. Materials retained on the second screen go into the #11 bin. The #11 aggregate may either be stockpiled or combined with the coarse bin materials or both.

3. Materials retained on the third screen go into the #12 bin. The #12 aggregate may either be stockpiled or combined with the #11 aggregate or both.

4. Materials passing through all decks at this station are sent to the stone sand screw to produce #24 manufactured fine aggregate. Fines from here go to the settling ponds.

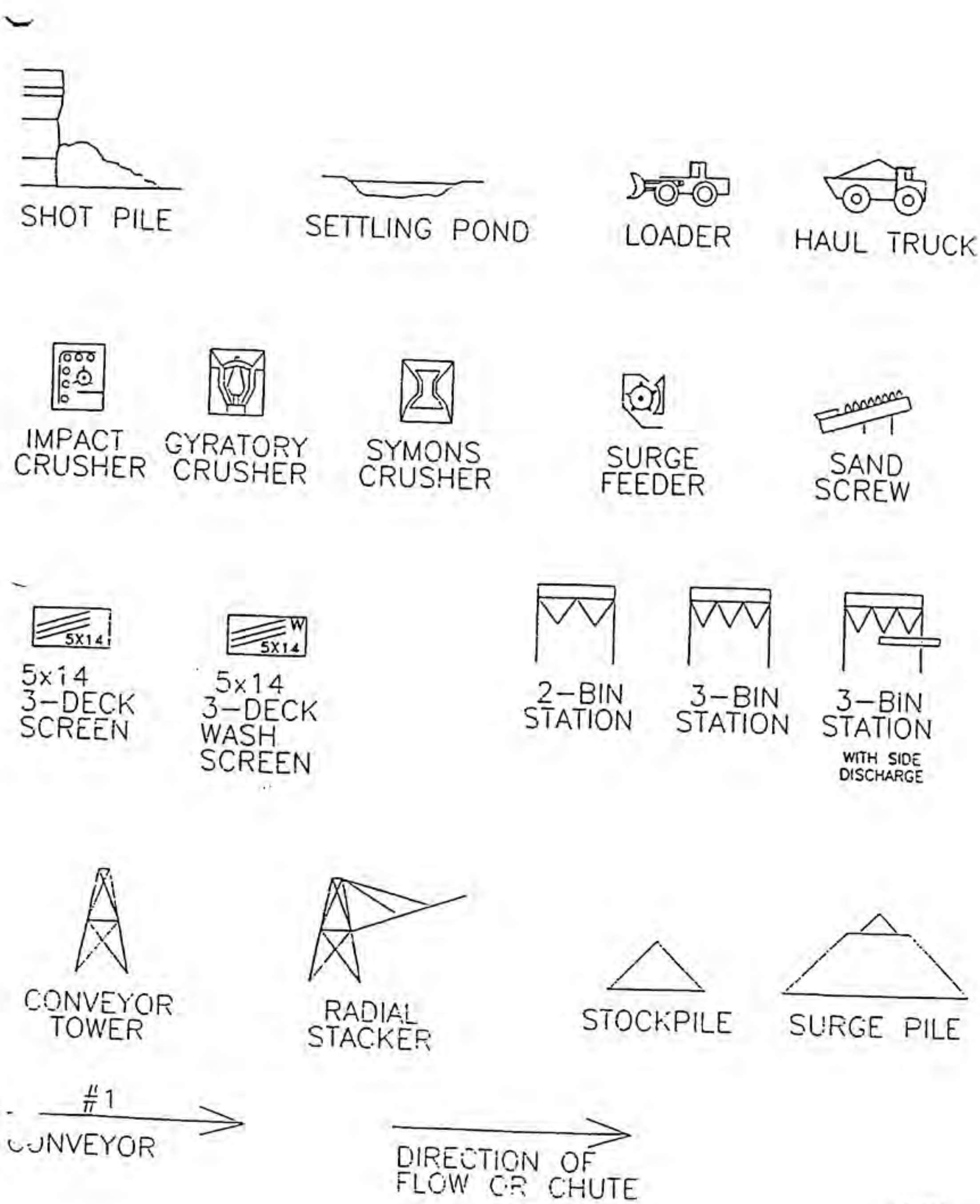
FLOW DIAGRAM FOR LIMEROCK QUARRIES, INC. – #2799



* Points of Sampling

12/95

ALTERNATE TEMPLATE
FOR LIMEROCK OUARRIES, INC. - #2799



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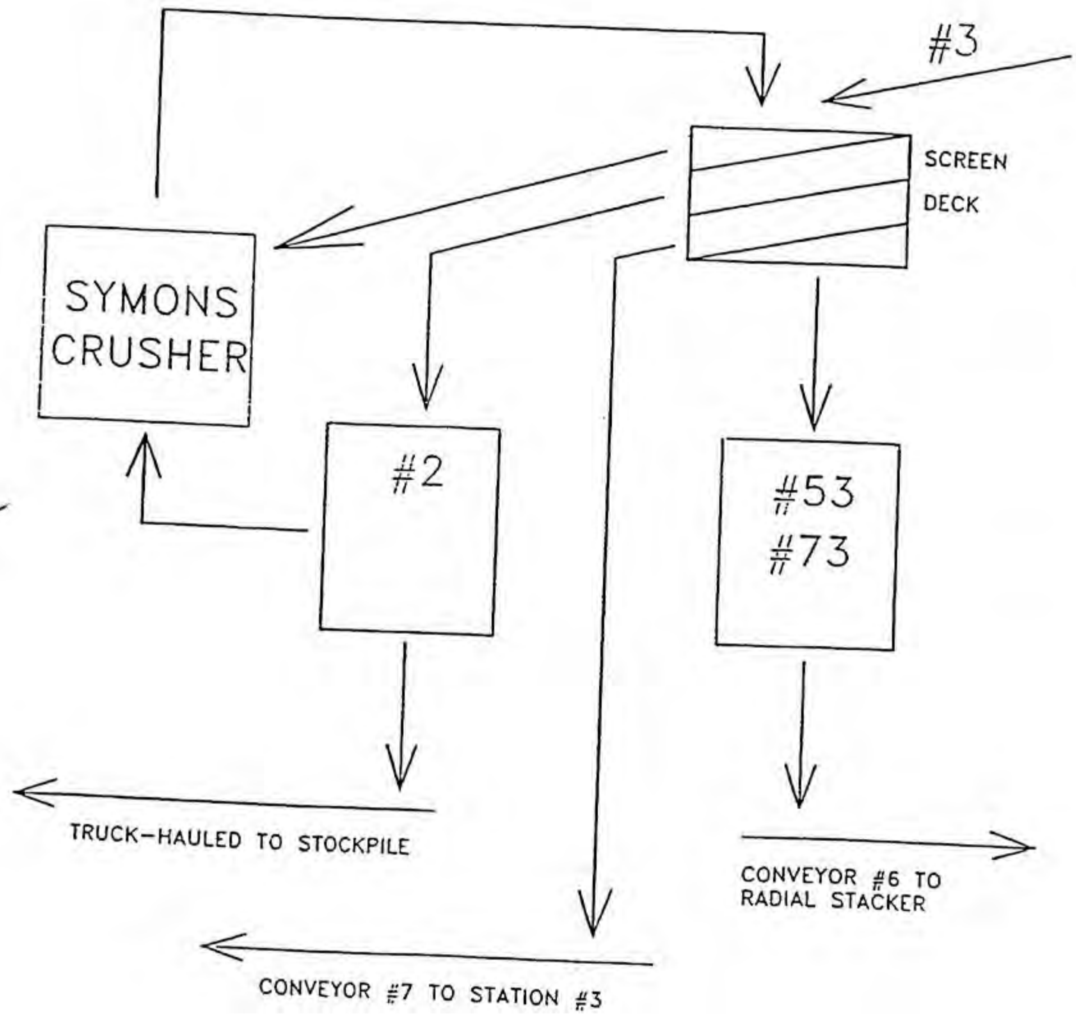
FLOW DIAGRAM FOR #2 STATION



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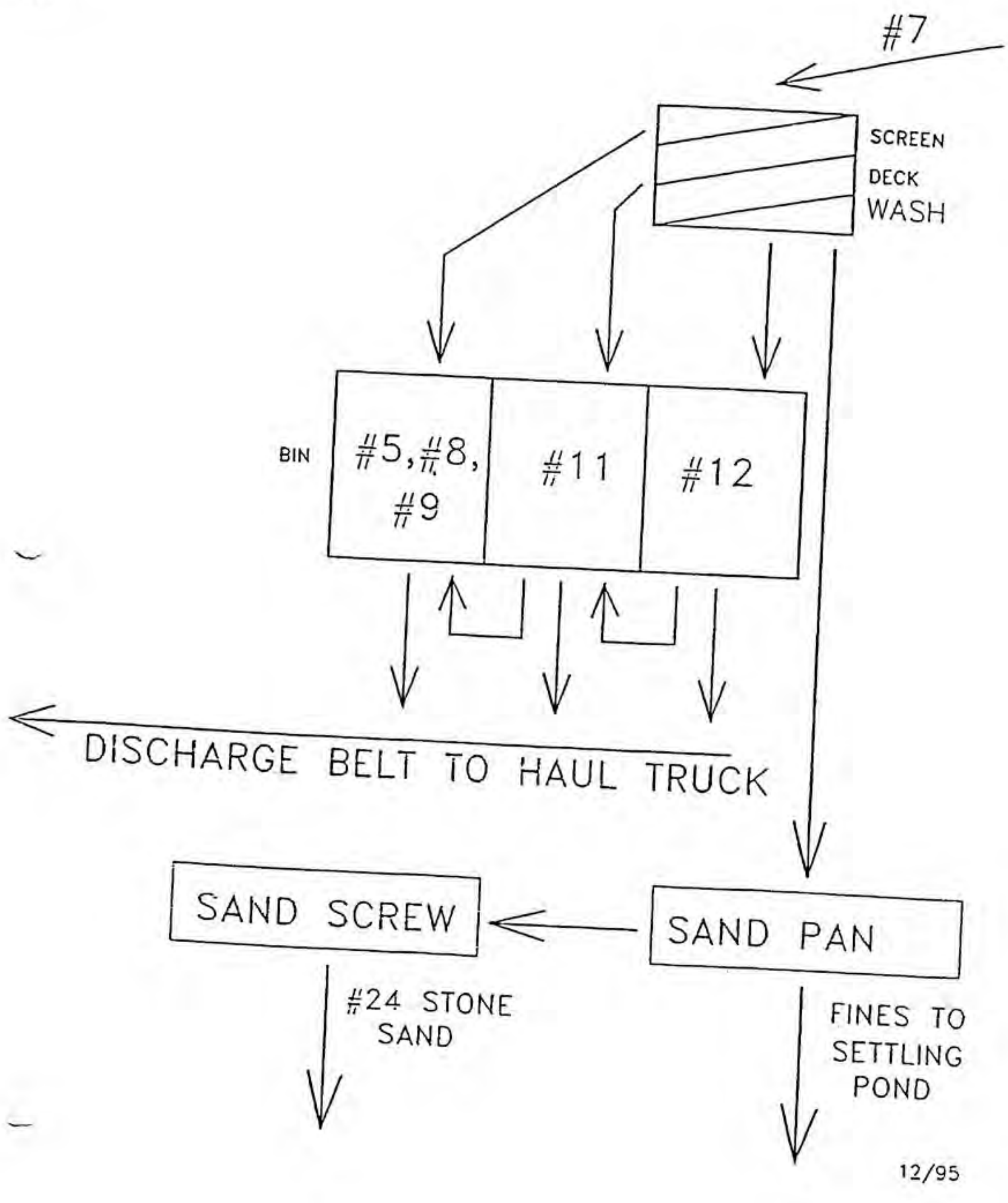
FLOW DIAGRAM FOR #3 STATION



SECTION 7

SAMPLING PLAN

Limerock Quarries, Inc. has developed a coding scheme to distinguish the 5 different types of samples that are obtained. The type of samples, frequency of sampling, location of samples and sampling procedures of any Certified Materials are included as follows.

TYPE OF SAMPLES AND FREQUENCY

(S) Start of Production. After a seasonal shutdown or when producing a new material, start of production samples shall be obtained once every 1000 t for the first 5000 t, but shall not exceed 2 per calendar day.

(N) Normal Production. After the start of production samples have been completed for each material, normal production samples shall be obtained. The frequency of these samples shall be once every 2000 t, but shall not exceed 2 per calendar day.

(L) Load-Out. Load-out samples shall be taken from material that is shipped. The frequency of these samples shall be once every 8000 t; however, there shall be at least one sample taken each month for any Certified Material shipped that exceeds 1000 t.

(M) Miscellaneous. Miscellaneous samples are taken at our own discretion for information purposes outside the start of production or normal production samples.

(R) Resample. When there is a failing normal production or load-out test a resample shall be taken.

MEANS OF TRACKING SAMPLES

Start of production and normal production samples shall be taken on a random basis using the Random Number Form (Appendix C). The Quarry Superintendent shall be responsible for using this form and communicating with production staff as to when to obtain samples. If the random ton to be sampled is determined to be from the first or second load of the day then the third load shall be selected to sample.

Shipping tonnages shall be kept by the office bookkeepers to determine when the load-out samples are to be obtained. The bookkeepers shall inform the Quarry Superintendent of when a sample is required.

SAMPLE LOCATIONS

All start of production and normal production samples, except for #24 stone sand, shall be taken from the bins before incorporation into the stockpiles. No. 24 stone sand shall be sampled from a small pile of material that is stockpiled as it comes off of the sand screw.

Load-out samples shall be taken from the Certified Material stockpiles.

The points of sampling for all samples are indicated on the flow diagram on page 6-3.

SAMPLING PROCEDURES

Start of production and normal production samples, except for #24 stone sand, shall be dumped from a truck into a small stockpile. Sampling from these stockpiles shall be in accordance with ITM 207. No. 24 stone sand shall be sampled using the same procedure for the coarse aggregates after the small sample stockpile is rolled until it appears homogeneous.

Load-out samples shall be sampled in accordance with ITM 207.

SECTION 8

TESTING PLAN

GRADATION

Gradation analysis shall be performed in accordance with AASHTO T 27 on all start of production, normal production and load-out samples. A gradation test shall be performed on resample and miscellaneous samples when necessary.

DECANT

Decant tests shall be performed in accordance with AASHTO T 11 on all load-out samples.

DELETERIOUS

The percent of deleterious materials shall be determined in accordance with AASHTO T 112 at least once per week for each size of material for the start of production and normal production samples. No test shall be performed if the week's production is less than 100 t.

NON-CONFORMING MATERIAL

Any time there is a failing normal production or load-out test the Quarry Superintendent shall be notified immediately and a resample test taken. Typically, retests shall be accompanied by a visual check for any problems at the plant. All actions shall be documented in the Daily Diary.

In the event that a second consecutive normal production sample fails, the materials will be diverted until the problem is corrected. Failing INDOT sizes 2, 5, 8, 9, 11, 12 and 24 shall be taken to the scrap pile and wasted. Failing INDOT sizes 53 and 73 shall be incorporated into the commercial stockpiles.

In the event that a second consecutive load-out sample fails, shipping from that stockpile shall cease. The stockpile problem area shall be checked to determine if the stockpile can be remixed and restored within the quality control limits as verified by the resample tests. If the problem area cannot be remixed, the material shall be removed and taken to the scrap pile.

SECTION 9

GRADATION CONTROL

NO. 5 STONE

1/2 in. Critical Sieve
$\bar{x}$ = 45.1%
σ_{n-1} = 5.0
Upper Control Limit = 55.1%
Lower Control Limit = 35.1%

NO. 8 STONE

1.2 in. Critical Sieve
$\bar{x}$ = 49.0%
σ_{n-1} = 5.0
Upper Control Limit = 59.0%
Lower Control Limit = 39.0%

NO. 9 STONE

3/8 in. Critical Sieve
$\bar{x}$ = 42.5%
σ_{n-1} = 4.0
Upper Control Limit = 50.5%
Lower Control Limit = 34.5%

NO. 11 STONE

No. 4 Critical Sieve
$\bar{x}$ = 22.2%
σ_{n-1} = 4.7
Upper Control Limit = 31.6%
Lower Control Limit = 12.8%

NO. 12 STONE

No. 4 Critical Sieve
$\bar{x}$ = 67.8%
σ_{n-1} = 5.0
Upper Control Limit = 77.8%
Lower Control Limit = 57.8%

SECTION 10

PROCESS CONTROL TECHNIQUES

Los Angeles abrasion and absorption tests may be performed when deemed necessary and shall be posted on the Gradation Analysis Form (Appendix C). A visual check of all stockpiles is an ongoing daily procedure.

SECTION 11

DOWNSTREAM CONTROL

IDENTIFICATION OF STOCKPILES

All stockpiles shall be marked using signs in front of each stockpile that indicate the size of each material and the ledges the material is from. For Standard Specification stockpiles, the signs shall be blue with white lettering and for Alternate stockpiles, the signs shall be red with white lettering.

STOCKPILE CONSTRUCTION

Stockpiling of the aggregates is done by unloading truck loads side by side and then stacking the material only as high as the front-end loader can place the material.

MATERIAL RETRIEVAL

The entire front face of each stockpile shall be worked by a front-end loader from side to side when loading the truck. The sides of the face shall be occasionally mixed with the center to prevent segregation of the stockpile.

SECTION 12

LABORATORY

LOCATION

The laboratory is located near the west boundary of the property at the Bippus facility. The following verified equipment is maintained in the laboratory:

EQUIPMENT

Sieve Analysis
- Gilson TS-1 shaker
- 15 in. x 23 in. screens (2 in. (50 mm), 1½ in. (37.5 mm), 1 in. (25 mm), 3/4 in. (19.0 mm), 1/2 in. (12.5 mm), 3/8 in. (9.5 mm), No. 4 (4.75 mm) and pan)
- Gilson Ro-Tap shaker
- 8 in. round sieves (3/8 in. (9.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (600 µm), No. 50 (300 µm), No. 100 (150 µm), No. 200 (75 µm) and pan)

General
- Humboldt oven
- Ohaus IP12KS Digital Electronic Balance (12000 g capacity)
- Mettler H10 Electronic Balance (160 g capacity)

CALIBRATION

The balances, mechanical shakers, oven, and sieves shall be verified in accordance with the following:

Equipment	Minimum Frequency	Procedure
Balances	12 mo.	ITM 910
Mechanical Shakers	12 mo.	ITM 906
Sieves	12 mo.	ITM 902

SECTION 13

DOCUMENTATION PLAN

Several forms have been developed for the CAP program and all information regarding the CAPP shall be entered on these forms. Examples of these forms may be found in Appendix C.

REFERENCE DOCUMENTS

The following documents are on file at the lab:

1. INDOT Certified Aggregate Producer Program (ITM 211)
2. INDOT Standard Specifications and Current Supplemental Specifications
3. INDOT Inspection and Sampling Procedures for Fine and Coarse Aggregate
4. Indiana Quality Assurance Certified Aggregate Technician Training Manual for Producer Technicians
5. Summary of Ledge Quality Results
6. Summary of Production Quality Results
7. AP Aggregate Letter
8. Quality Control Plan

DIARY

The diary is located in the Superintendent's office. One page is devoted to each day of the year that there is a material related operation and all the pages are maintained in a 3-ring binder.

AGGREGATE INSPECTOR RECORD BOOK

Each aggregate inspector working for this company is issued a number which is unique to that individual. Test data is recorded in the Aggregate Inspector Record Book and is traceable to any inspector through the identification number. This document is located in the laboratory.

GRADATION ANALYSIS FORM

This form is used for a quick visual comparison of up to 16 separate gradations of like materials. There is a different version of this form for each size of CAPP material including a generic version that may be used for any other material. This document is located in the laboratory.

CONTROL CHARTS

Control charts for each size material are posted on the wall in the laboratory. We request that the following deviations be allowed to the control chart legend:

1. The target mean shall be placed at the appropriate location on the critical sieve portion of the chart rather than the middle of the chart. It shall be represented by a heavy long dash followed by a short dash and the value shall be shown in the left-hand column. This change allows us to use one form for all of our sources.

2. The specification limits shall be solid lines instead of short dashed lines. This makes for an overall more attractive control chart.

3. Because of the space limitations on an 11 in. x 17 in. control chart, and that we plot all sieves for all sizes of stone, our charts do not always have a minimum of 2 in. between control limits. The charts, however, are very legible.

RANDOM NUMBER FORM

This form was developed to assist the Quarry Superintendent in determining which loads shall be sampled for production control.

INDOT MATERIAL SHIPPING RECORD FORM

This form was developed to assist our bookkeepers in keeping track of how many tons of each material are shipped from the Certified Material stockpiles. This form is readily available to INDOT personnel at the office.

SHOT CHART

Information concerning the exact mining point of the materials being produced may be found in the shot chart. All production shots at this source are numbered. The assigned number has 2 parts: the first digit(s) represent the sequential order in which that shot was taken during a particular year and the last 2 digits represent the year of that shot (Example: 05-95 would be the fifth shot of 1995). The shot chart is kept with the Daily Diary and the shot number for a given production day is indicated in the diary. The shot chart may be cross-referenced to the original Quarry Map to determine the exact location of the point of mining of that material.

SECTION 14

ADDENDA

Each page in the Quality Control Plan that is revised shall have the source number, date of revision, and a vertical line in the left margin indicating the paragraph that was revised.

Revisions to the QCP shall be maintained on an Addenda Summary Sheet or QCP Annex in the Appendix until such time that the revisions are incorporated into the QCP. Addenda shall be submitted at the close-out meeting for an annual audit. Any outstanding revisions will also be submitted in January of each year along with the Annual Aggregate Source Report.

APPENDIX A

ANNUAL SOURCE REPORT

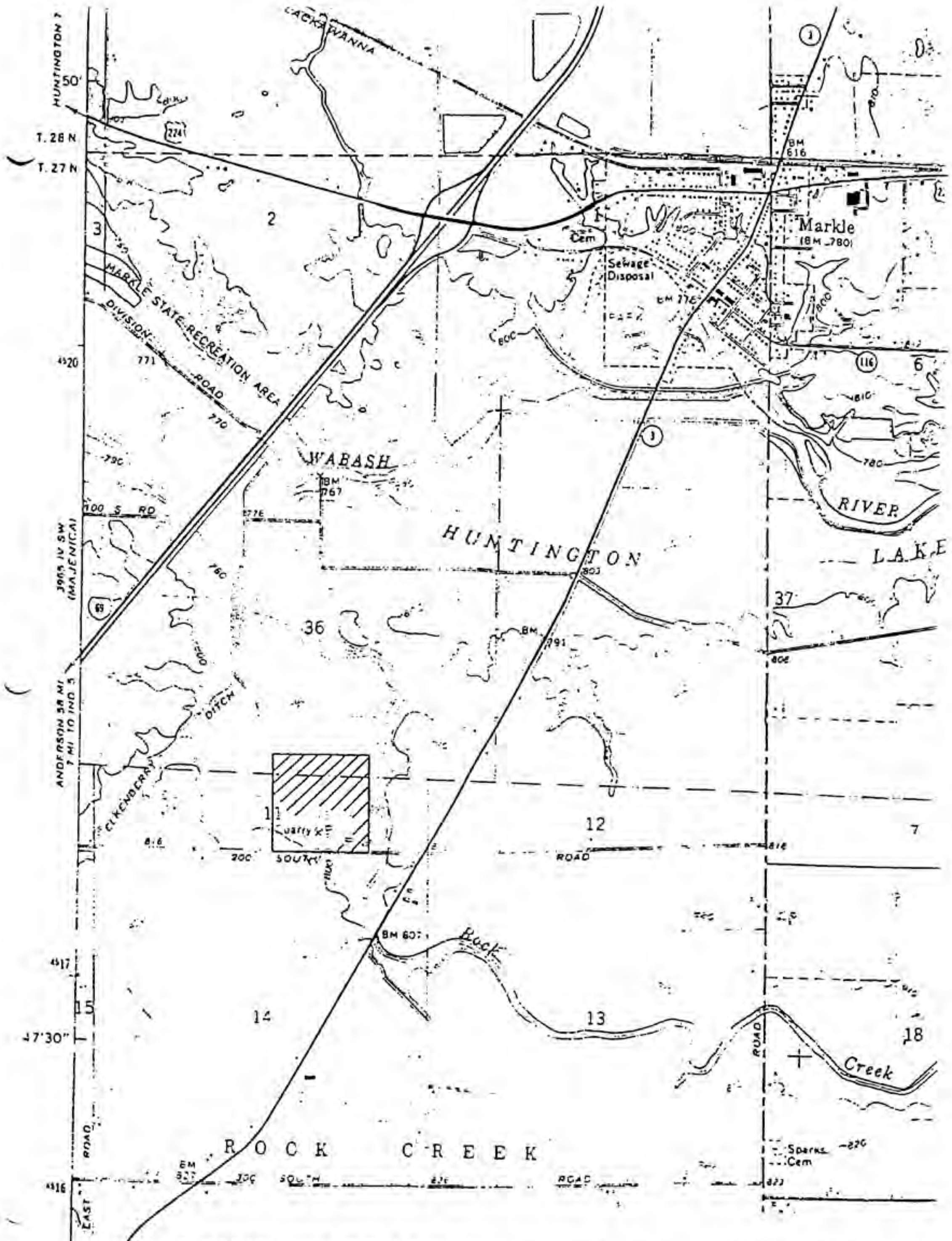
2000 ANNUAL SOURCE REPORT
LIMEROCK QUARRIES, INC.
INDOT SOURCE #2799

Limerock Quarries, Inc. is located in Huntington County, Indiana approximately 2.3 miles south of Markle, Indiana and one mile west of SR 3. The quarry property is within section 11, T 27 N and R 10 E.

The Regional Manager is Ferris Ore, the Quarry Superintendent is Clay Mudstone and quality control is conducted by Richard Quality and Crystal Stone. INDOT may contact any of these persons as the need arises.

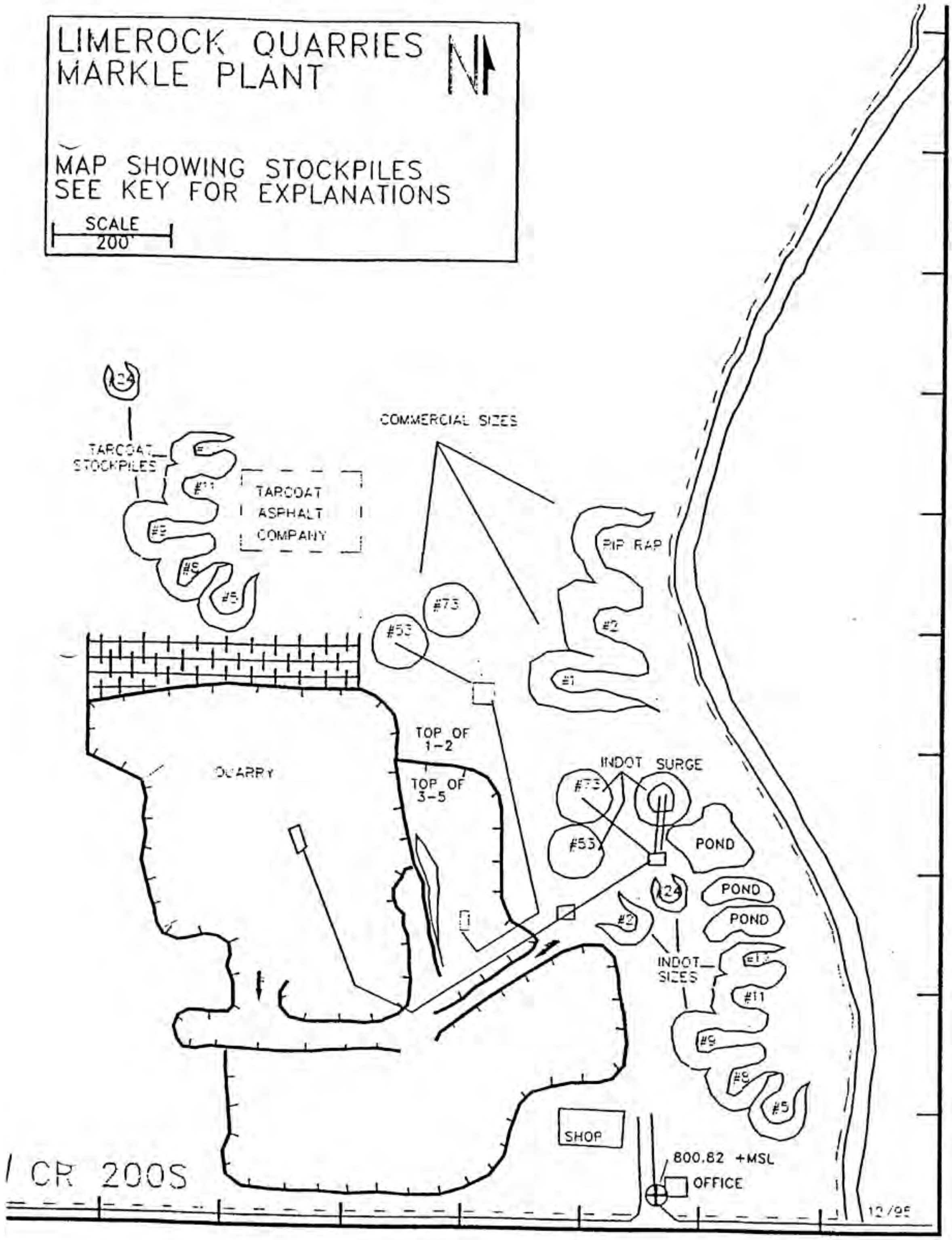
This source currently operates two open-pit benches. The upper bench is mined for commercial purposes only and consists of ledges 1 and 2. Ledge 3 is not useable for any type of aggregate use and is stripped and wasted. The lower bench, containing ledges 4 and 5, is approximately 73' thick and is classified as Category IA, and Class AP materials.

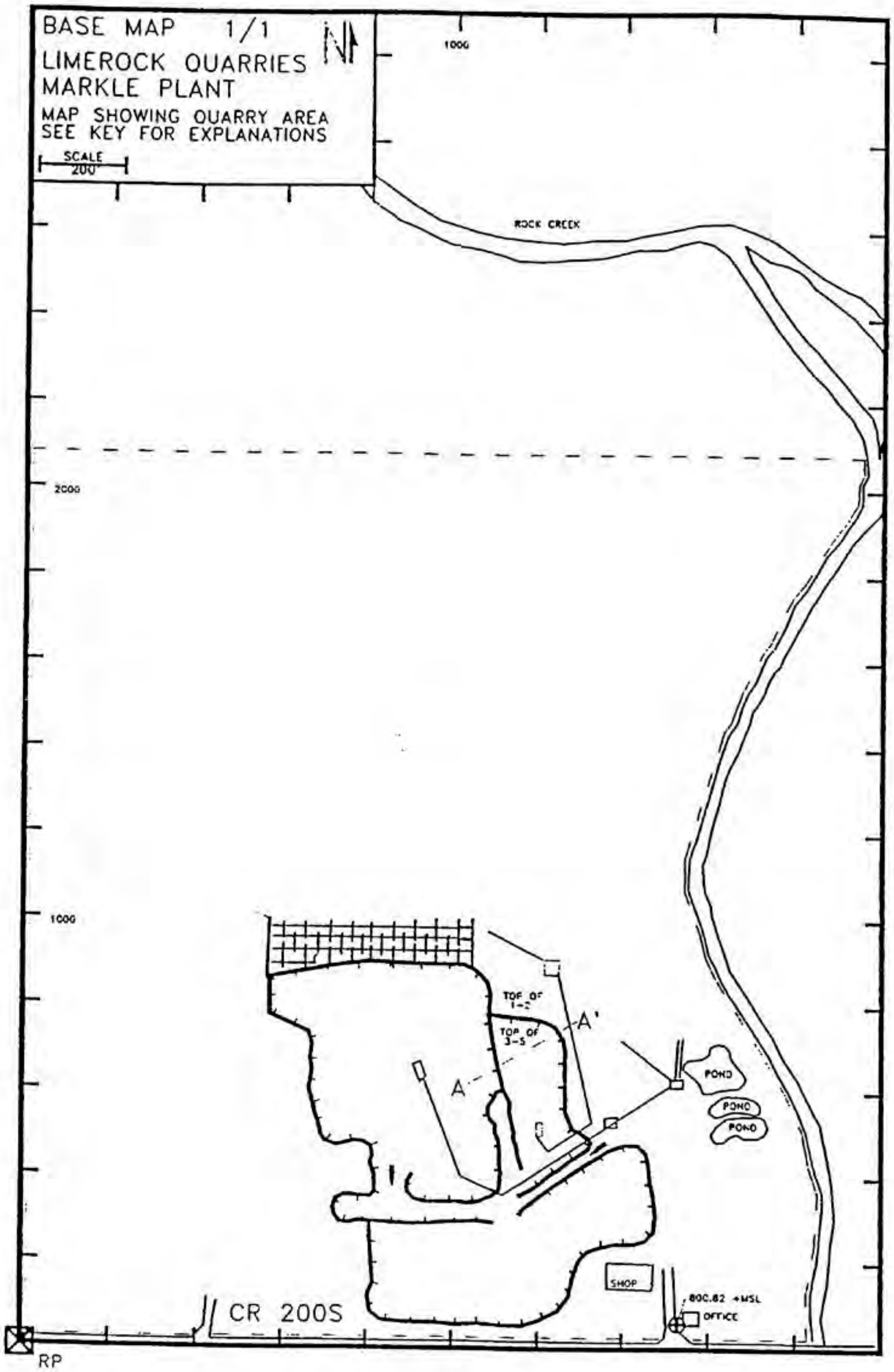
Elevations for all benches may be found on the following geologic cross-sections. A benchmark with an elevation of 800.82 ft. is located next to the office, which is southeast of the quarry. The proposed 1995 operating areas may be found on the following Source Map. Also included is the location map and quarry map indicating the stockpile areas.



LOCATION MAP FOR LIMEROCK QUARRIES, INC. - MARKLE PLANT

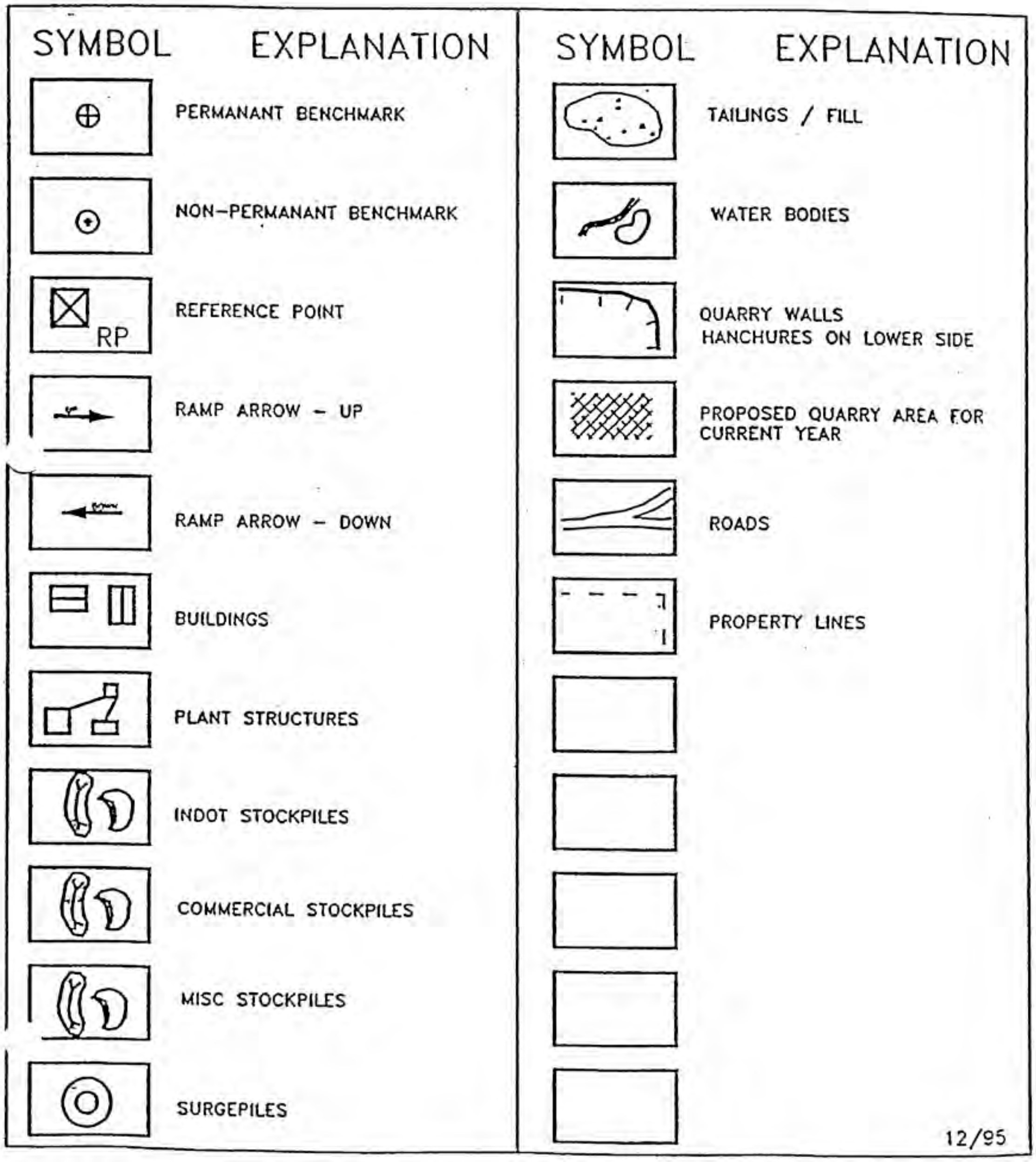
12/95


LIMEROCK QUARRIES
MARKLE PLANT
MAP SHOWING STOCKPILES
SEE KEY FOR EXPLANATIONS
SCALE
200'
COMMERCIAL SIZES
TARCOAT
STOCKPILES
TARCOAT
ASPHALT
COMPANY
#11
#5
#73
#53
#2
#1
TOP OF
1-2
TOP OF
3-5
QUARRY
INDOT SURGE
#73
#53
POND
POND
POND
#24
#2
INDOT
SIZES
#11
#9
#5
SHOP
800.82 +MSL
OFFICE
CR 200S
12/95

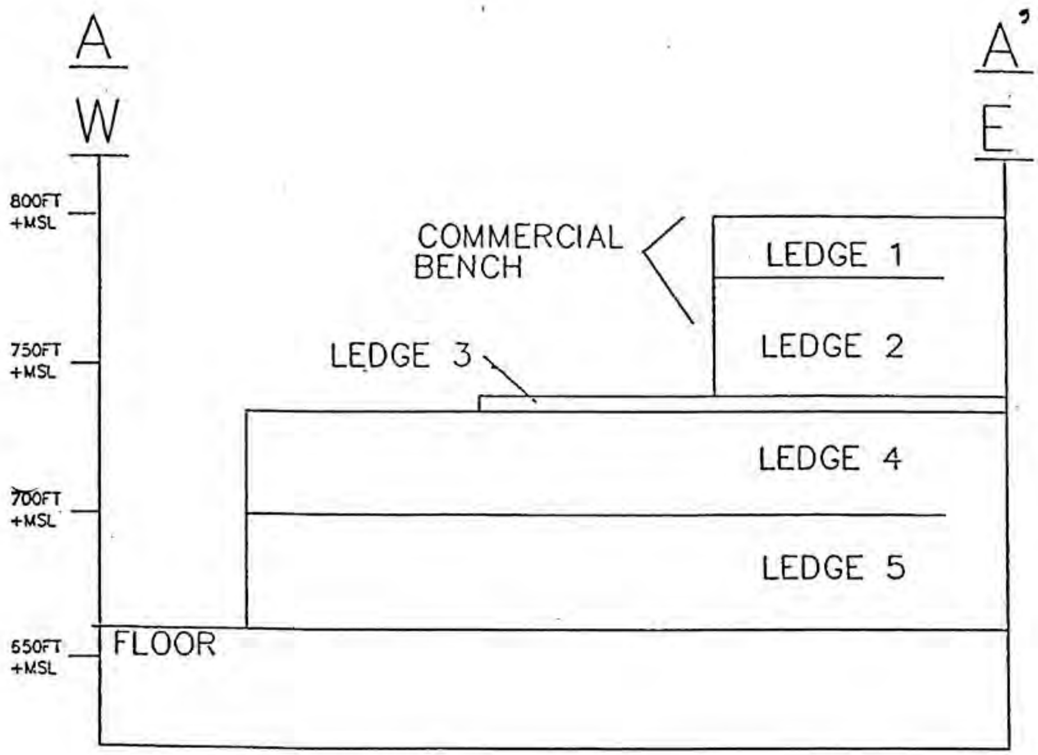

BASE MAP 1/1
LIMEROCK QUARRIES
MARKLE PLANT
MAP SHOWING QUARRY AREA
SEE KEY FOR EXPLANATIONS
SCALE
200'
N
1000
ROCK CREEK
2000
1000
TOP OF
1-2
TOP OF
3-5
A
A'
POND
POND
POND
SHOP
800.82 +MSL
OFFICE
CR 200S
RP

12/95

KEY TO QUARRY MAP FOR INDOT
LIMEROCK QUARRIES, INC.
MARKLE PLANT



GEOLOGIC CROSS - SECTION FOR LIMEROCK QUARRIES, INC.



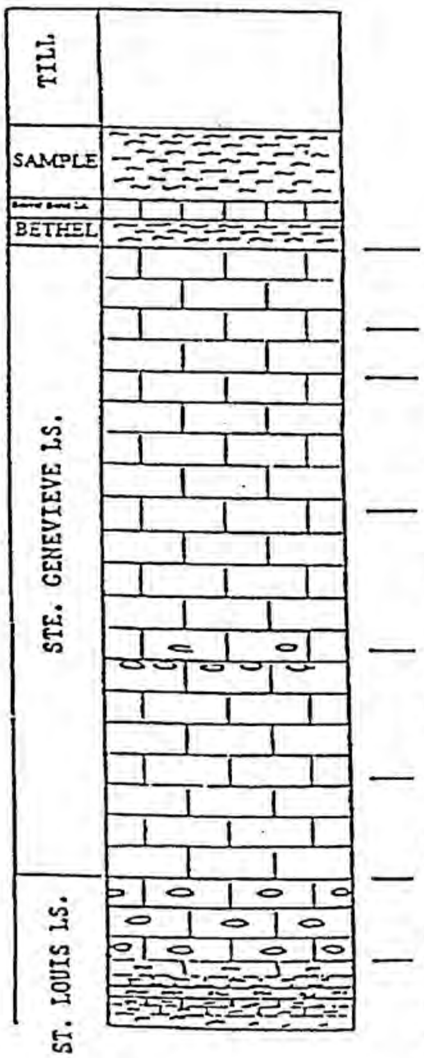
LEDGE	THICKNESS	GEOLOGIC FORMATION
1	20'	LISTON CREEK
2	40'	MISSISSINEWA
3	5'	WALDRON
4	35'	LOUISVILLE
5	38'	LIMBERLOST

MARKLE PLANT - #2799

12/95

LIMEROCK QUARRIES, INC.
MARKLE PLANT

GENERALIZED STRATIGRAPHIC SECTION
MARCH, 1996



716' ELEV. Top of Mineral Resource*

LEDGE 1- (24')Limestone, lt. olive gray, micritic with coarse grained zones, highly oxidized at bedrock/overburden contact.

LEDGE 2- (6')Limestone, very pale orange, oolitic, minor styolites.

LEDGE 3- (17')Limestone, lt. olive gray, micritic to coarsely grained, shaley stringers and stylolites common.

LEDGE 4- (17') Limestone, lt. olive gray, medium grained, sugary texture, shaley remnants, sugary appearance, chert nodules at the base of ledge.

LEDGE 5- (17')Limestone, lt. olive gray, fine grained to micritic, chert nodules near top of ledge, minor shale stringers.

LEDGE 6- (13')Limestone, lt. olive gray, micritic, olive gray dolomite beds near middle of ledge.

LEDGE 7- (11')Limestone, lt. olive gray, fine grained, abundant chert nodules.

622' ELEV. Bottom of Mineral Resource

**Notes that elevation was based on average of three core holes.*

APPENDIX B

AP PRODUCTION CONTROL PLAN

AP PRODUCTION CONTROL PLAN
LIMEROCK QUARRIES, INC.
INDOT SOURCE #2799

Limerock Quarries, Inc. is approved for Class AP aggregate, and produces and controls stone meeting this classification in accordance with the following:

1. The production area for the AP stone is Ledges 4 and 5.

2. AP stone will be processed in accordance with the procedures listed in Section 6.

3. The final production gradation for the AP stone will be INDOT size #8 gradation.

4. The AP stockpile will be identified by a sign indicating AP No. 8, Ledges 4 and 5, and the location and color of the size will be in accordance with Section 11. The No. 8 and AP 8 stockpiles will be separated by another stockpile of a different size.

5. AP stone delivered to concrete plants will be so identified on the aggregate weigh tickets.

APPENDIX C

FORMS

CAPP' DIARY

LOCATION: DATE: ______ START: _____

INDOT #: CAPP #: ________ STOP: _____

WEATHER: ___________________________ DOWN DATES: ______

IDLE TIME: ___________ (HOLIDAYS), ____________ (WEEKENDS)

GRID: _______________ : ____________

SAMPLES PULLED

SIZE	TYPE *	TIME

TONS PRODUCED TODAY AND MONTHLY RUNNING TOTALS (MRT)

SIZE											TOTAL
TONS											
MRT											

SUPERINTENDENT'S (OR REPRESENTATIVE) REMARKS

CHANGES – PLANT, GRID, KEY PERSONNEL, ETC: ______________________

EVENTS – PROBLEMS WITH PLANT, SCREENS, EQUIPMENT, ETC; ____________

(INITIALS _____)

*SAMPLE TYPES

S = START UP FREQUENCY

N = NORMAL FREQUENCY

L = LOAD-OUT FREQUENCY

M = MISC.

R = RESAMPLE

CERTIFIED AGGREGATE TECHNICIAN'S REMARKS ______________________

/

(NAME - PRINTED) (SIGNATURE)

FN: DIARY355

CAPP' DIARY - ADDITIONAL REMARKS

SOURCE #: DATE:

SUPERINTENDENT'S (OR REPRESENTATIVE) REMARKS – CONTINUED

( ) INITIALS

CAT'S REMARKS - CONTINUED

/

(PRINTED NAME) (SIGNATURE)

08/95

RANDOM NUMBERS

PAGE 1

PLANT ______________ MONTH __________ YEAR _____ SIZE _____

INSTRUCTIONS:

1) RANDOMLY SELECT A STARTING ROW AND COLUMN. CIRCLE THIS VALUE.
2) USE THE NUMBER AT THAT POSITION TO CALCULATE THE TONNAGE AT WHICH A SAMPLE WILL BE PULLED.
3) AFTER SELECTING A STARTING VALUE, SUBSEQUENT VALUES WILL BE DERIVED BY SELECTING THE NEXT NUMBER IMMEDIATELY BELOW AND IN THE SAME COLUMN.
4) WHEN THE BOTTOM OF ANY COLUMN IS REACHED, ADDITIONAL NUMBERS WILL BE DERIVED BY MOVING TO THE TOP OF THE NEXT COLUMN IMMEDIATELY TO THE RIGHT OF THE CURRENT COLUMN.
5) WHEN THE LAST NUMBER IN THE LOWER RIGHT-HAND CORNER HAS BEEN USED, ADDITIONAL NUMBERS WILL BE DERIVED BY MOVING TO THE UPPER LEFT-HAND CORNER OF THE TABLE.
6) WHEN THE PRODUCTION RUN IS COMPLETED, REPEAT STEPS 1-6 FOR NEXT RUN.

RANDOM NUMBER TABLE

.84	.28	.26	.14	.77	.03	.76	.89	.55	.86	.92
.78	.37	.17	.13	.79	.73	.85	.75	.25	.67	.96
.95	.19	.94	.11	.98	.71	.64	.81	.38	.62	.23
.49	.08	.58	.65	.69	.57	.83	.44	.51	.04	.16
.31	.40	.15	.35	.43	.91	.48	.50	.74	.80	.24
.63	.02	.42	.05	.97	.87	.30	.39	.12	.66	.10
.54	.90	.56	.68	.29	.22	.21	.72	.33	.47	.60
.61	.45	.18	.41	.70	.01	.20	.93	.32	.52	.06
.82	.53	.99	.88	.36	.46	.09	.59	.27	.35	.07

TONNAGE CALCULATIONS

(F) = FREQUENCY = ____________(TONS)

(NOTE: (F) < 99 X (TC))

(TC) = HAUL-TRUCK CAPACITY ______(TONS)

TABLE VALUE (V)	SAMPLE TONNAGE CALCULATIONS (V) X (F) = ST	FREQUENCY RUNNING TOTAL (FRT)	ACCUMULATED SAMPLE TONS (ST)+(FRT)= (AST)	SAMPLE LOAD NUMBER = (AST) / (TC)
		0000000000000		

FN:RANDNUM

05/95

GRADATION ANALYSIS FOR SIZE 8

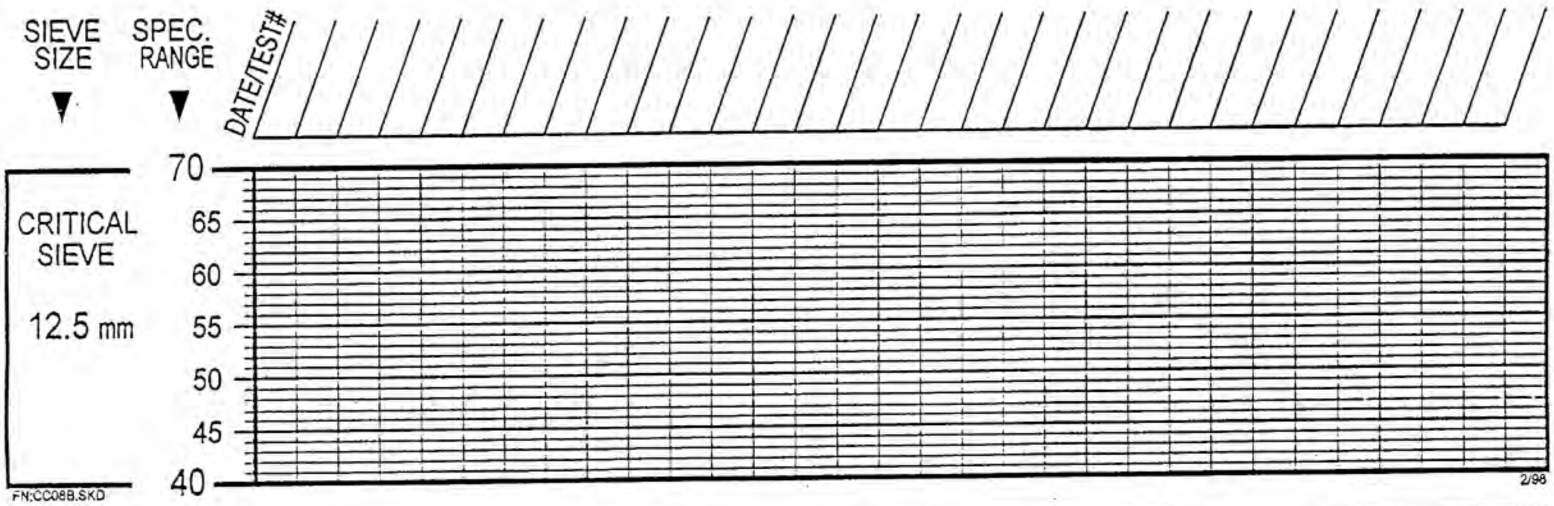
SOURCE ______________ ORIGIN ______________ MONTH / YEAR ______________

DATE																	WHEN CONTROL CHARTING IS REQUIRED, PLACE A CIRCLE AROUND THE ENTRY IN THE ◁ "TEST TYPE" BOX.	
TEST#																		
*TYPE																		
SIEVE																	AVE	SPEC RANGE
25.0 mm																		100
19.0 mm																		75-95
12.5 mm																		40-70
9.5 mm																		20-50
4.75 mm																		0-15
2.36 mm																		0-10
75 µm																		
DECANT																		0-1.5
																	*SAMPLE TYPES	
CHERT																	S = START OF PRODUCTION FREQUENCY N = NORMAL PRODUCTION FREQUENCY L = LOADOUT FREQUENCY M = MISCELLANEOUS R = RESAMPLE	
SOFT																		
LA																		
% ABS																		
BSGR																	STATISTICS	
CRUSH																	UCL = ______	
																	LCL = ______	
5-POINT AVERAGE																	$\bar{X}_T$ = ______	

FHT504 (6/0)　　　　05/97

PROCESS CONTROL CHART - 8

PLANT ____________ NUMBER ____ MONTH / YEAR ____________



EXPLANATION

— — — TARGET MEAN ($\bar{X}_T$) (RED INK)	NORMAL PRODUCTION DATA (RED INK)
——— CONTROL LIMITS. (+) and (-) TWO STANDARD DEVIATIONS (σ_{n-1}) FROM THE TARGET MEAN (RED INK)	*LOAD-OUT DATA (BLACK INK)
	5-POINT MOVING AVERAGE (BLUE INK)

* - Load-out data are connected when they are displayed on a graph separate from the production data.

TARGET MEAN ($\bar{X}_T$) = ________

UPPER CONTROL LIMIT (UCL) = ________

LOWER CONTROL LIMIT (LCL) = ________

CAPP SHIPPING RECORD -

INDOT #: CAPP #: Q97----

SIZE: ____ YEAR: ____ PAGE: ___/___

DATE MATERIAL SHIPPED	SHIPPED TO: CONTRACT OR FACILITY ID	DAILY TONNAGE SHIPPED	1000 TN RUNNING TOTAL	8000 TN RUNNING TOTAL	REPRESENTATIVE TEST ID NUMBER

FN:SHPRD338 ______________________ (CAPP CAT SIGNATURE) 08/97

AUTHENTICATION

APPROVAL	SUBMISSION
_________________________________	_____________________________
Chief, Materials & Tests Division	Management Representative
________________	__________________
Date of Approval	Date of Submission

QUALITY CONTROL PLAN

INDIANA QUALITY SAND & GRAVEL, INC.

INDOT SOURCE # 2000

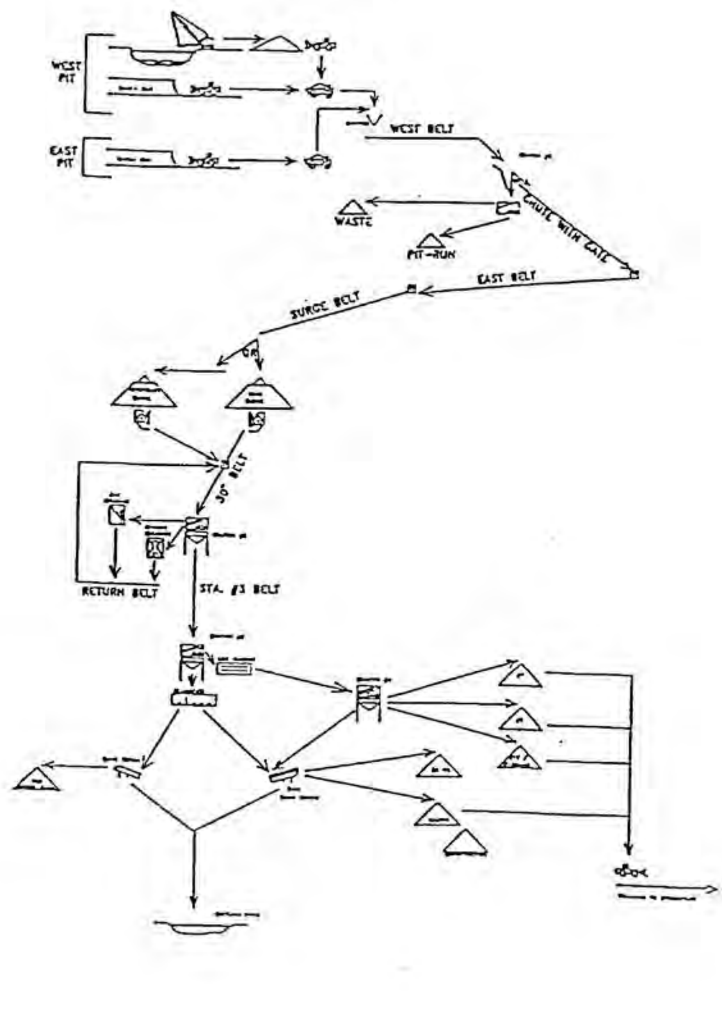


TABLE OF CONTENTS

SECTION 1

PLANT LOCATION

Indiana Quality Sand and Gravel, Quality Plant (2000) is classified as a Plant/Redistribution Terminal for CAPP purposes. The location of the plant is indicated on the map in Appendix B. The address and other pertinent information is as follows:

Indiana Quality Sand and Gravel
(INDOT #2000)
6593 Gravel Rd.
Marion, IN 46713

Latitude - 40E 30, 33"
Longitude - 85E 37, 05"
County - Grant
Township - T 24 N
Range - R 8 E
Sections - 21, 27 and 28

Office Phone No. - 317-675-3421
Fax - 317-675-8221
Lab - 317-992-7681

The Indiana Quality Sand and Gravel pit is situated on both sides of Gravel Road, north of Gas City. To locate the pit follow First Street north approximately 2 miles from the junction of SR 22/35. The pit entrance is on the west side of the road.

Indiana Quality Sand and Gravel is owned by Gravel City, Inc. which is located at the following address:

Gravel City, Inc.
618 S. 7th St.
Vincennes, IN 47591
812-886-4871
FAX: 812-886-4881

SECTION 2

ORGANIZATIONAL STRUCTURE

MANAGEMENT REPRESENTATIVES

The Superintendent for Indiana Quality Sand and Gravel and Management Representative for this pit is Ron Limestone. He is responsible for all production for this site.

CERTIFIED TECHNICIANS

The CAPP Certified Aggregate Technician responsible for the location is Tony Shale. His duties include testing and reporting results from this site as well as assisting with the CAPP duties at several other sites within the Indiana Quality Sand and Gravel organization. Mr. Shale communicates all CAPP concerns to Mr. Limestone who then takes appropriate actions.

Other Quality Control Personnel include Mary Slag and Gary Siltstone. Ms. Slag's duties include sampling and reporting test results for three sites within Indiana Quality Sand and Gravel. She may also assist at this site as the need arises. Mr. Siltstone is a CAPP Certified Aggregate Technician who will substitute for Mr. Shale when necessary.

SECTION 3

MINERAL DEPOSITS

The gravels and sands that are mined at this location are all derived from quaternary sediments that were reworked from earlier glacial deposits. These types of sediments are consistent with deposits that would be found on the inside curve of a large meander loop (in this case from the Mississinewa River). Since the entirety of this deposit is situated on the floor of the Mississinewa valley, this is probably correct. In addition, the proximity of Walnut Creek would lead one to suspect that it is (in part) responsible for some of the reworking and sorting of this deposit. The dry-run areas are mined to a depth of approximately 25' and the wet-run areas can be mined an additional 40'.

The gravels and sands produced at this source may come from areas on the west side of Gravel Road or a newly-opened area on the east side of Gravel Road (see diagrams of pits - Appendix B).

Materials originating from the west side of Gravel Road may come from any combination of different points of extraction. Materials can be selectively taken from these areas as a first measure in controlling the gradation. Depending on what products we are making, we will remove materials from any of these areas.

Materials originating from the east side of Gravel Road are from one area only. This is a newly opened area and has not been developed very much at this point. This side, so far, is bank-run.

SECTION 4

AP AGGREGATE

The gravel at this source is approved for Class AP aggregate production as indicated on the approval letter dated October 21, 1994. The AP Production Control Plan is included in Appendix A.

SECTION 5

MATERIAL CATEGORIES

STANDARD SPECIFICATION

Aggregates that are categorized as Standard Specification materials include the following INDOT sizes:

#AP8 Gravel
#23 Natural Sand
#8 Stone

This site is a Redistribution Terminal for #8 stone, which is used and stockpiled at the concrete plant on site owned by Indiana Quality Sand and Gravel. The stone comes from Stone City, Bedrock, Indiana (#2805) which is not a Certified Aggregate producer.

ALTERNATE

Aggregates that are categorized as Alternate materials include the following materials:

#4 Gravel
#12 Gravel
P-Gravel
Processed Pit-Run
Mason Sand
Construction Sand
Top-Dressed Sand

SECTION 6

PRODUCTION FLOW DIAGRAM

Aggregates produced at this source are from two main areas - East Pit and West Pit. The East Pit is newly opened and presently consists of one main mining area which is dry-run. The West Pit may be mined at several points - one of which is dry-run and the others are wet-run.

The East-Pit is presently restricted to dry-run materials. All materials removed from this area are placed onto haul trucks and transported to the processing plant on the west side of Gravel Road.

The West-Pit is divided into dry and wet-run areas. Materials removed from the dry-run areas are loaded directly into haul trucks. Materials removed from the wet-run areas are allowed to drain before being placed onto haul trucks. Once both materials are placed onto haul trucks, they are transported to the processing plant.

Materials arriving at the processing plant, from any of the mining areas, are all processed the same. The plant consists of four stations (see overall Flow Diagram on the following pages). Each station is set up to perform specific tasks within the overall process.

STATION #1

This station is used only when we are making processed pit-run materials. Materials are initially placed over a Deister 5' x 10', 1-deck vibratory screening unit. Oversized materials are dropped off to the side where a loader removes them to the waste area. Materials passing through the screen are directed to the pit-run stockpile by the processed pit-run conveyor as a finished material.

When not making any processed pit-run materials the aggregate is by-passed onto the east conveyor, which transports the material to either the main surge pile or the secondary surge pile by way of the surge belt.

STATION #2

Station #2 is used to pre-screen and crush the materials before they are sent on to Station #3. Materials arriving at this station come from either or both surge piles by way of the 30" belt. The materials coming from the main surge pile are placed directly on the 30" conveyor while the material from the secondary surge pile is placed onto the 30" belt at a transfer point.

Materials at this station are put over a Deister 5' x 10', 2-deck vibratory screening unit. This screening unit sits above a single bin that merely funnels materials onto the Station #3 conveyor.

Oversized materials are directed to a Lippmann 15" x 36" jaw crusher. Here they are crushed and closed-circuited back to Station #2. They first drop onto the return belt which then drops materials onto the 30" belt at a transfer point.

Materials passing the top deck and retained on the bottom deck are directed to a Symons 3' standard cone crusher. Here they are crushed and closed-circuited back to Station #2. They first drop onto the return belt which then drops materials onto the 30" belt at a transfer point.

Materials that pass through both screens drop into the bin and are then directed to Station #3.

STATION #3

Station #3 is used to separate most of the sand from the coarser materials that are going on to Station #4. Materials arriving at this station are placed over a Deister 5' x 12', 2-deck vibratory screening unit. This station is also a wash station and includes a log washer and a classifier.

Depending on what size will be produced on the bottom deck at Station #4, the sand panels on the bottom deck of this station will be set up in one of the following two ways.

1. When making #12 gravel, the panels on the bottom deck will be configured to produce mason/construction sand.

2. When making P-gravel, the panels on the bottom deck will be configured to produce #23 sand.

All materials that do not pass through the bottom deck are directed to the Eagle Iron Works log washer. At the log washer, materials are pre-washed in preparation for their arrival at Station #4. Waste-water exits the log washer and is directed to the twin screw at Station #4.

All materials that pass through the bottom deck are directed to the Eagle Iron Works classifier. At the classifier, fine materials are sent to the McClanahan 36" single sand screw and come off as top-dress sand. At the classifier, coarse materials are sent to the Eagle Iron Works 36" twin sand screw and come off as either #23 or mason/construction sand. This is the same screw to which materials from Station #4 will be directed. From either screw, the waste water is directed to the settling ponds.

STATION #4

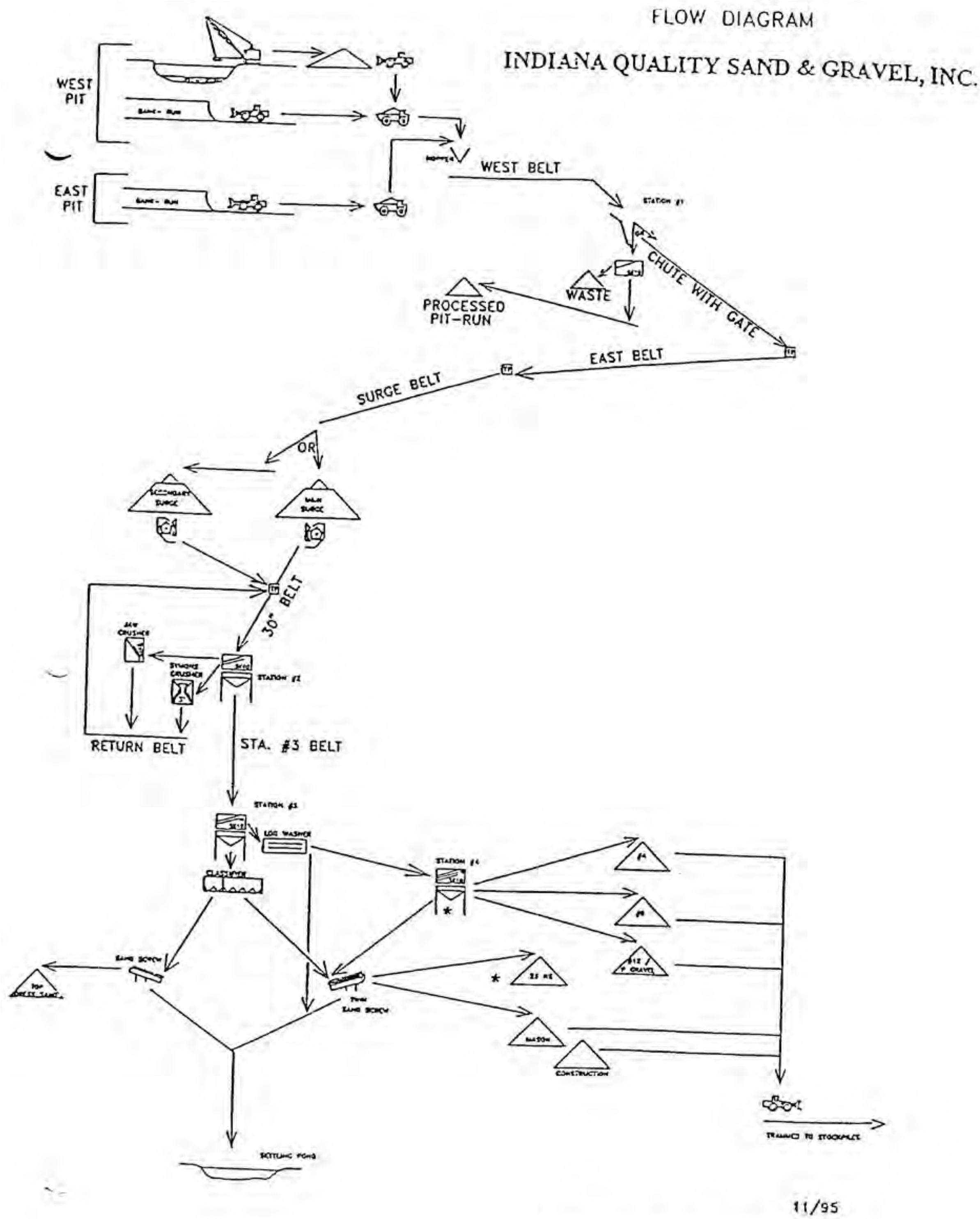
Washed products are made at Station #4. Materials arriving at this station are put over a Deister 5" x 10', 3-deck vibrating screening unit. Since this material has been pre-screened, each bin partition will contain the following finished products:

1. Top-sized materials are size #4 and drop into the first bin partition. They are scooped up with the front-end loader and trammed to the stockpile.

2. Materials passing the top deck and retained on the middle deck are size #8 and drop into the middle bin partition.

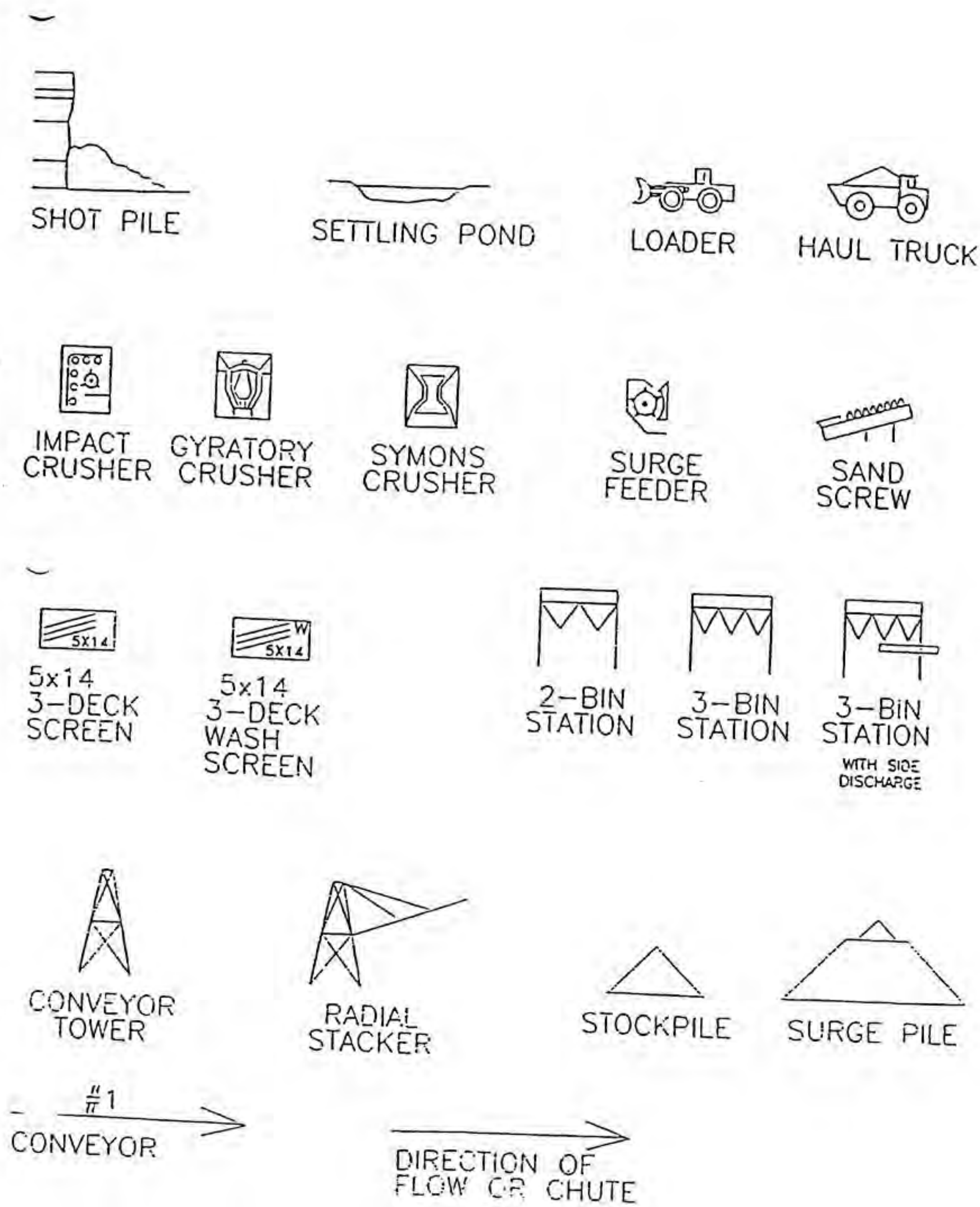
3. Materials passing the middle deck and retained on the bottom deck are #12 size or P-gravel and drop into the third bin partition. When set up to make mason/construction sand at Station #3, this station will make #12 gravel. When set up to make #23 sand at Station #3, this station will make P-gravel.

4. Material passing through all of the screens is sent to the sand screw. At the sand screw, one of three types of sand may be produced. When making #23 sand, the sand coming off the screw drops onto a conveyor belt and is taken directly to the #23 sand stockpile. When making mason sand or construction sand, the sand coming off the screw is diverted from the #23 conveyor and is dropped off onto the mason sand belt and sent to the tram pile to await stockpiling. Waste water from the sand screws is sent to the settling ponds.

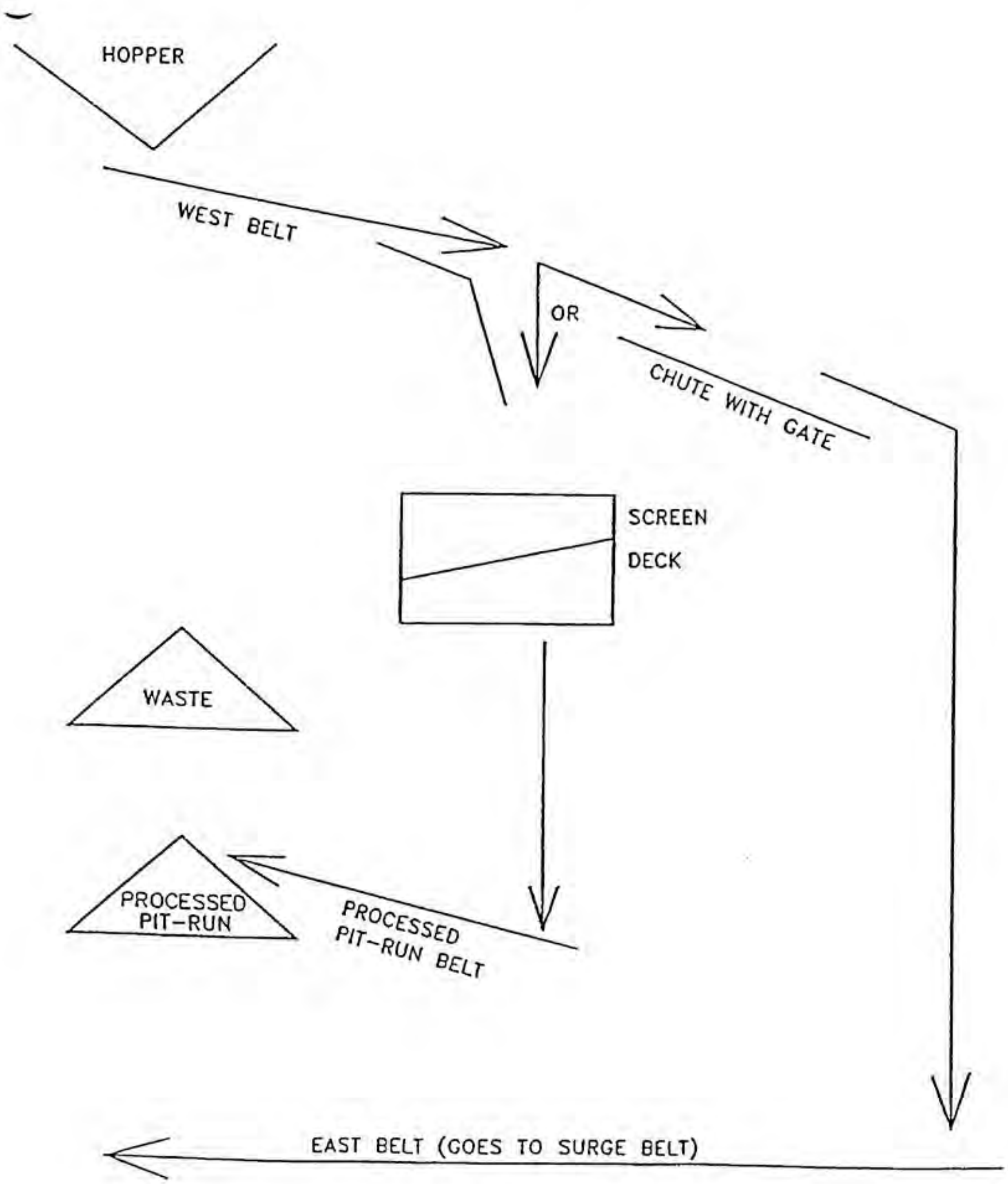


* Point of Sampling

ALTERNATE TEMPLATE



FLOW DIAGRAM FOR #1 STATION



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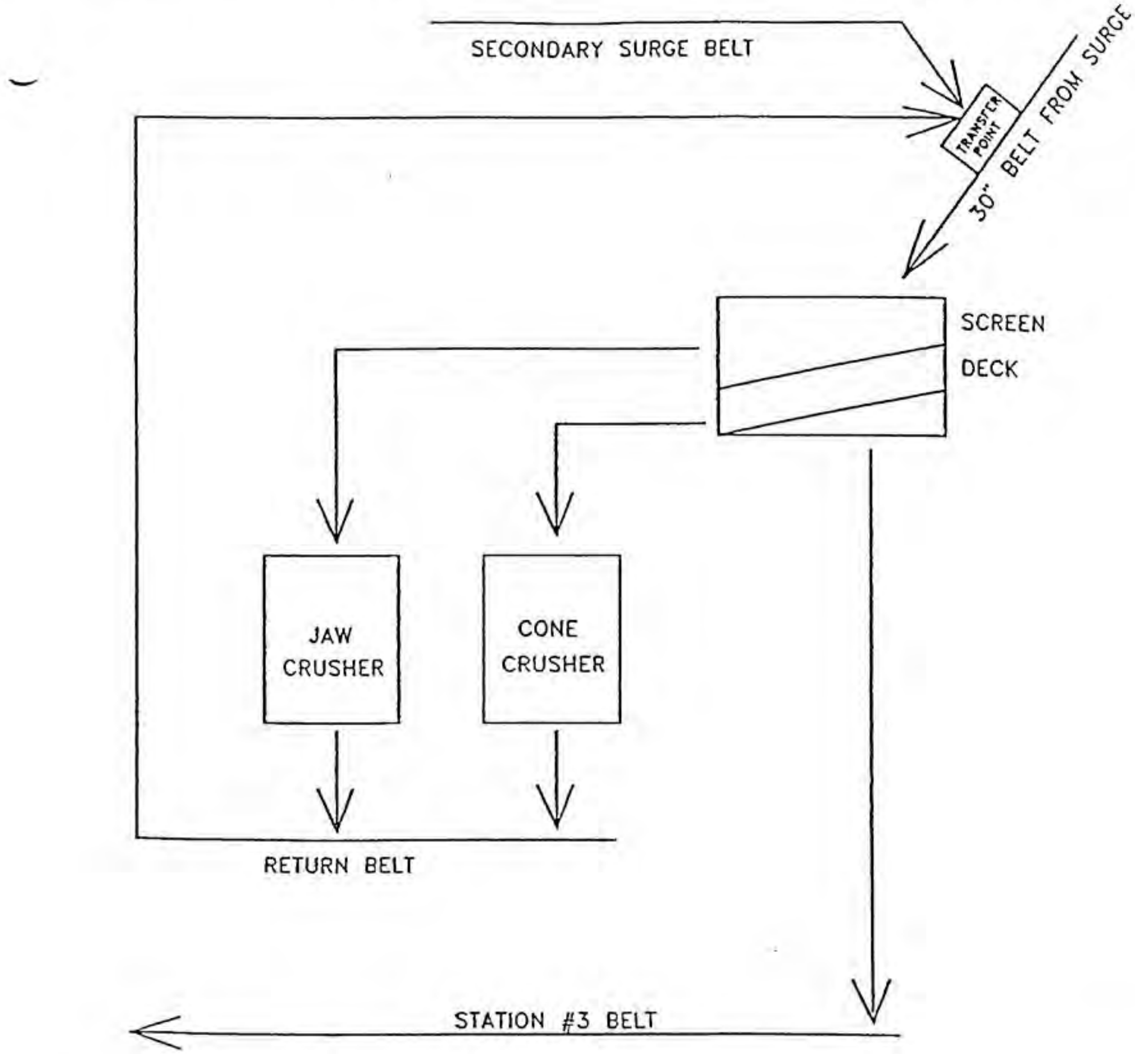
FLOW DIAGRAM FOR #2 STATION



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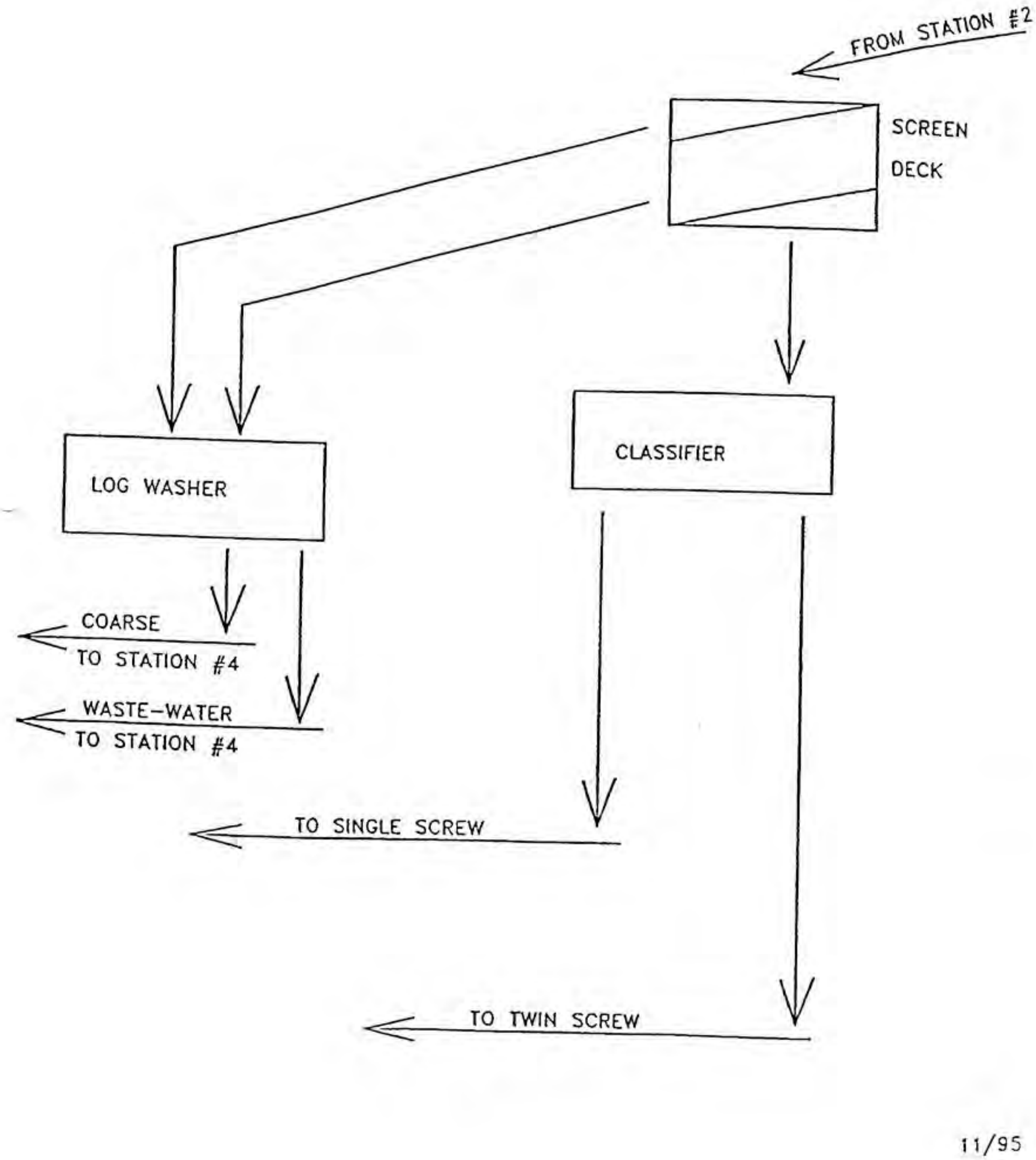
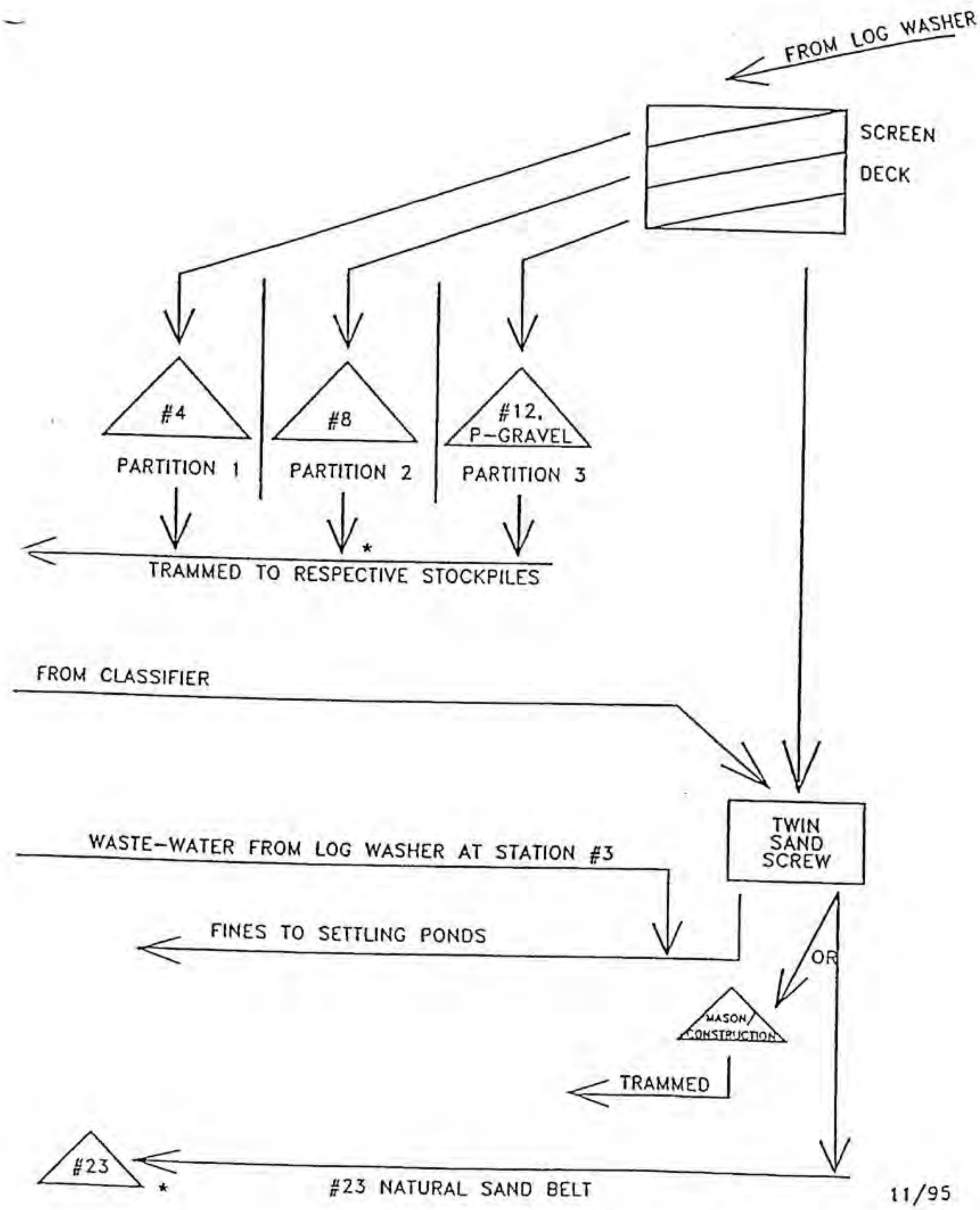
FLOW DIAGRAM FOR #3 STATION



FLOW DIAGRAM FOR #4 STATION



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* Point of Sampling

SECTION 7

SAMPLING PLAN

Indiana Quality Sand and Gravel has developed a coding scheme to distinguish the 5 different types of samples that are obtained. The type of samples, frequency of sampling, location of samples and sampling procedures of any Certified Materials are included as follows.

TYPE OF SAMPLES AND FREQUENCY

(S) Start of Production. After a seasonal shutdown or when producing a new material, start of production samples shall be obtained once every 1000 t for the first 5000 t, but shall not exceed 2 per calendar day.

(N) Normal Production. After the start of production samples have been completed for each material, normal production samples shall be obtained. The frequency of these samples shall be once every 2000 t, but shall not exceed 2 per calendar day.

(L) Load-Out. Load-out samples shall be taken from material that is shipped. The frequency of these samples shall be once every 8000 t; however, there shall be at least one sample taken each month for any Certified Material shipped that exceeds 1000 t.

(M) Miscellaneous. Miscellaneous samples are taken at our own discretion for information purposes outside the start of production or normal production samples.

(R) Resample. When there is a failing normal production or load-out test a resample shall be taken.

MEANS OF TRACKING SAMPLES

Start of production and normal production samples shall be taken from uniform tonnage increments in an unbiased manner. The belt feed rates shall be used to estimate the quantity produced. The Superintendent shall be responsible for communicating with production staff as to when to obtain samples.

Shipping tonnages shall be kept by the office bookkeepers to determine when the load-out samples are to be obtained. The bookkeepers shall inform the Superintendent when a sample is required.

SAMPLE LOCATIONS

All start of production and normal production samples shall be taken from the following locations.

1. #8 GRAVEL - stockpiles made by a front-end loader with material from the bin partitions.

2. #8 STONE - the active area of the finished stockpile.

3. #23 SAND - the active area of the finished stockpile.

Load-out samples shall be taken from the Certified Material stockpiles.

The points of sampling for all samples are indicated on the flow diagram on page 6-4.

SAMPLING PROCEDURES

The #8 stone and #23 sand samples shall be obtained using the procedure for stockpile sampling as set out in the ITM 207. Samples of the #8 gravel from the bin partition shall be obtained by first emptying the bin and then passing a container through the discharge stream.

SECTION 8

TESTING PLAN

GRADATION

Gradation analysis shall be performed in accordance with AASHTO T 27 on all start of production, normal production and load-out samples. A gradation test shall be performed on resample and miscellaneous samples when necessary.

DECANT

Decant tests shall be performed in accordance with AASHTO T 11 on all load-out samples.

CRUSHED PARTICLES

Crushed particle content for the #8 gravel shall be determined in accordance with ASTM D 5821 at least once per week for the start of production and normal production samples. No test shall be performed if the week's production is less than 100 t.

DELETERIOUS

The percent of deleterious materials shall be determined in accordance with AASHTO T 112, ITM 206, and the Standard Specifications at least once per week for each size of material for the start of production and normal production samples. No test shall be performed if the week's production is less than 100 Mg.

Previous testing has indicated that there are high levels of light-weight chert at this source. For this reason, when the total chert exceeds the specification limit for light-weight chert the District Materials and Tests Engineer shall be notified and samples shall be obtained for INDOT to test for light-weight chert.

NON-CONFORMING MATERIAL

Any time there is a failing normal production or load-out test the Superintendent shall be notified immediately and a resample test taken. Typically, retests shall be accompanied by a visual check for any problems at the plant. All actions shall be documented in the Daily Diary.

In the event that a second consecutive normal production sample fails, the materials will be diverted until the problem is corrected as follows:

1. No. 8 gravel and No. 8 stone shall be taken to the scrap pile and wasted.

2. No. 23 sand shall be diverted to the mason/construction sand conveyor.

In the event that a second consecutive load-out sample fails, shipping from that stockpile shall cease. The stockpile problem area shall be checked to determine if the stockpile can be remixed and restored within the quality control limits as verified by the resample tests. If the problem area cannot be remixed, the material shall be removed and taken to the scrap pile.

SECTION 9

GRADATION CONTROL

NO. 8 GRAVEL

1/2 in Critical Sieve
$\overline{x}$ = 49.0%
σ_{n-1} = 5.0
Upper Control Limit = 59.0%
Lower Control Limit = 39.0%

NO. 8 STONE

1/2.in. Critical Sieve
$\overline{x}$ = 47.5%
σ_{n-1} = 4.0
Upper Control Limit = 55.5%
Lower Control Limit = 39.5%

SECTION 10

PROCESS CONTROL TECHNIQUES

Los Angeles abrasion and absorption tests may be performed when deemed necessary and shall be posted on the Gradation Analysis Form (Appendix C). A visual check of all stockpiles is an ongoing daily procedure.

SECTION 11

DOWNSTREAM CONTROL

IDENTIFICATION OF STOCKPILES

All stockpiles shall be marked using signs in front of each stockpile that indicate the size of each material. For Standard Specification stockpiles, the signs shall be blue with white lettering and for Alternate stockpiles, the signs shall be red with white lettering.

STOCKPILE CONSTRUCTION

The #8 gravel stockpile is constructed by tramming materials with a front-end loader from the bin partitions.

The #8 stone stockpile is constructed by unloading truck loads side by side and then stacking the material only as high as the front-end loader can place the material.

The #23 sand is deposited directly onto the stockpile from the #23 sand belt.

MATERIAL RETRIEVAL

The entire front face of each stockpile shall be worked by a front-end loader from side to side when loading the truck. The sides of the face shall be occasionally mixed with the center to prevent segregation of the stockpile.

SECTION 12

LABORATORY

LOCATION

The laboratory is located in the southwest corner of the shop building, which is situated east of the plant. The following verified equipment is maintained in the laboratory:

EQUIPMENT

Sieve Analysis
- Gilson TS-1 shaker
- 15 in. x 23 in. screens (2 in. (50 mm), 1½ in. (37.5 mm), 1 in. (25 mm), 3/4 in. (19.0 mm), 1/2 in. (12.5 mm), 3/8 in (9.5 mm), No. 4 (4.75 mm) and pan)
- Gilson Ro-Tap shaker
- 8 in. round sieves (3/8 in. (9.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (600 µm), No. 50 (300 µm), No. 100 (150 µm), No. 200 (75 µm) and pan)

General
- Humboldt oven
- Ohaus IP12KS Digital Electronic Balance (12000 g capacity)
- Mettler H10 Electronic Balance (160 g capacity)

CALIBRATION

The balances, mechanical shakers, oven, and sieves shall be verified in accordance with the following:

Equipment	Minimum Frequency	Procedure
Balances	12 mo.	ITM 910
Mechanical Shakers	12 mo.	ITM 906
Sieves	12 mo.	ITM 902

SECTION 13

DOCUMENTATION PLAN

Several forms have been developed for the CAP program and all information regarding the CAPP shall be entered on these forms. Examples of these forms may be found in Appendix C.

REFERENCE DOCUMENTS

The following documents are on file at the lab:

1. INDOT Certified Aggregate Producer Program (ITM 211)
2. INDOT Standard Specifications and Current Supplemental Specifications
3. INDOT Inspection and Sampling Procedures for Fine and Coarse Aggregate
4. Indiana Quality Assurance Certified Aggregate Technician Training Manual for Producer Technicians
5. Summary of Production Quality Results
6. AP Aggregate Letter
7. Quality Control Plan

DIARY

The diary is located in the Superintendent's office. One page is devoted to each day of the year that there is a material related operation, and all pages are maintained in a 3-ring binder.

AGGREGATE INSPECTOR RECORD BOOK

Each aggregate inspector working for this company is issued a number which is unique to that individual. Test data is recorded in the Aggregate Inspector Record Book and is traceable to any inspector through the identification number. This document is located in the laboratory.

GRADATION ANALYSIS FORM

This form is used for a quick visual comparison of up to 16 separate gradations of like materials. There is a different version of this form for each size of CAPP material including a generic version that may be used for any other material. This document is located in the laboratory.

CONTROL CHARTS

Control charts for each size material are posted on the wall in the laboratory.

INDOT MATERIAL SHIPPING RECORD FORM

This form was developed to assist our bookkeepers in keeping track of how many tons of each material are shipped from the Certified Material stockpiles. This form is readily available to INDOT personnel at the office.

SECTION 14

ADDENDA

Each page in the Quality Control Plan that is revised shall have the source number, date of revision, and a vertical line in the left margin indicating the paragraph that was revised.

Revisions to the QCP shall be maintained on an Addenda Summary Sheet or QCP Annex in the Appendix until such time that the revisions are incorporated into the QCP. Addenda shall be submitted at the close-out meeting for an annual audit. Any outstanding revisions will also be submitted in January of each year.

APPENDIX A

AP PRODUCTION CONTROL PLAN

AP PRODUCTION CONTROL PLAN
INDIANA QUALITY SAND & GRAVEL, INC.
INDOT SOURCE #2000

Indiana Quality Sand and Gravel, Inc. is approved for Class AP aggregate, and produces and controls gravel meeting this classification in accordance with the following:

1. The production area for the AP gravel is the west side of Gravel Road. A diagram of the pit is included in Appendix B.

2. AP gravel will be processed in accordance with the procedures listed in Section 6.

3. The final production gradation for the AP gravel will be INDOT size #8 gradation.

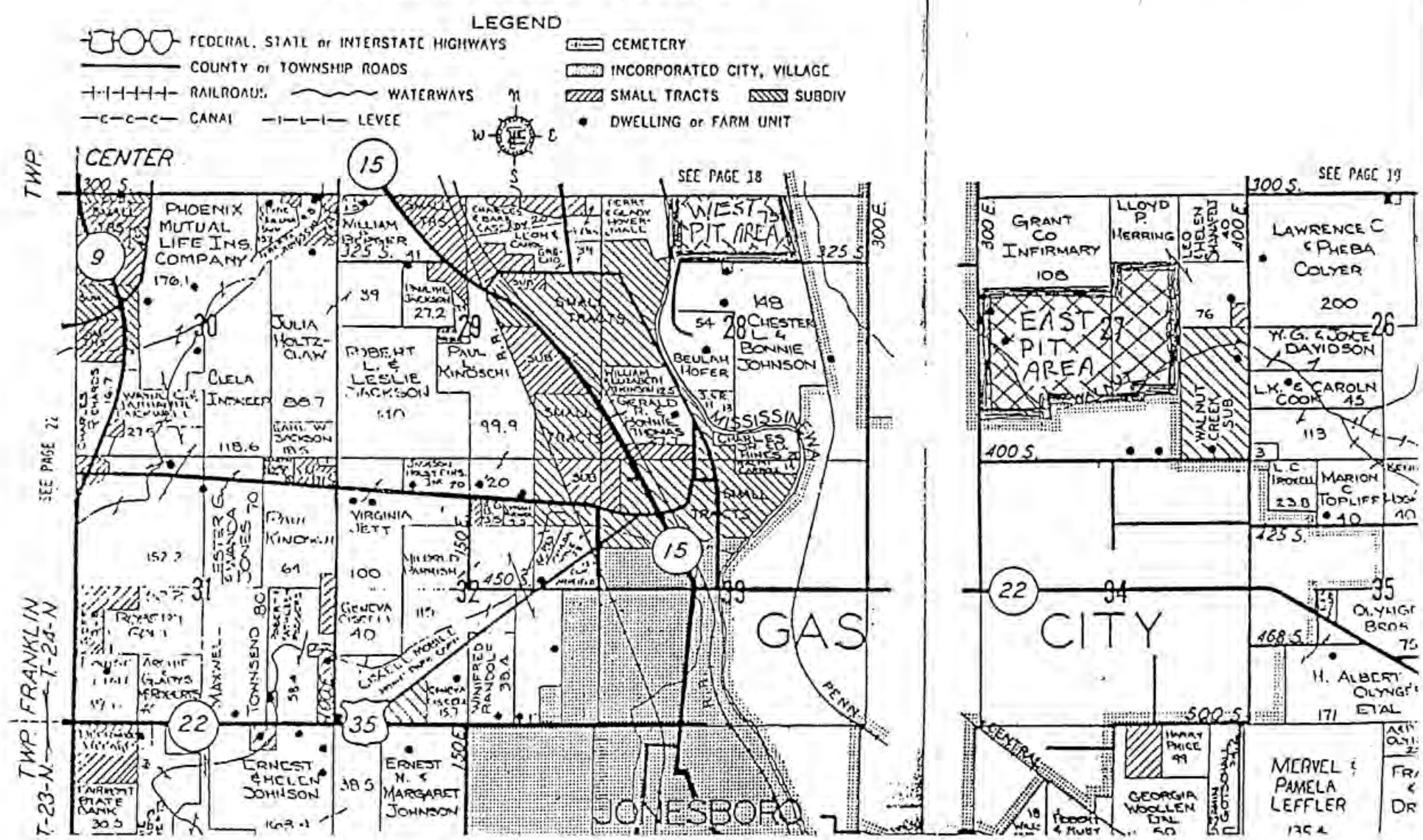
4. The AP stockpile will be identified by a sign indicating AP No. 8, and the location and color of the sign will be in accordance with Section 11.

5. AP gravel delivered to concrete plants will be so identified on the aggregate weigh tickets.

APPENDIX B

GENERAL INFORMATION

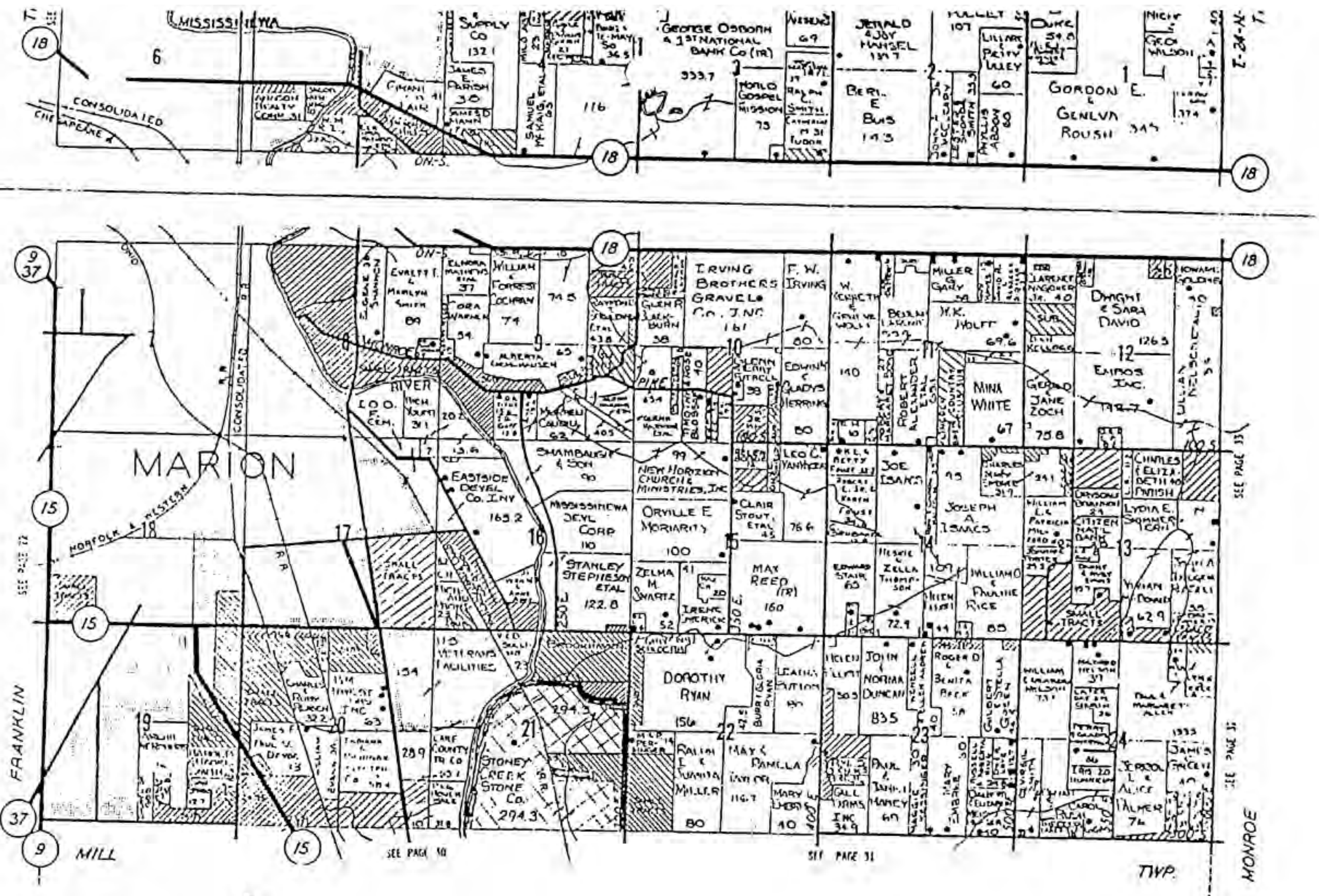
TOWNSHIP 23-24-N. RANGE 8-E.



LOCATION MAP

GRANT COUNTY, INDIANA PAGE 2

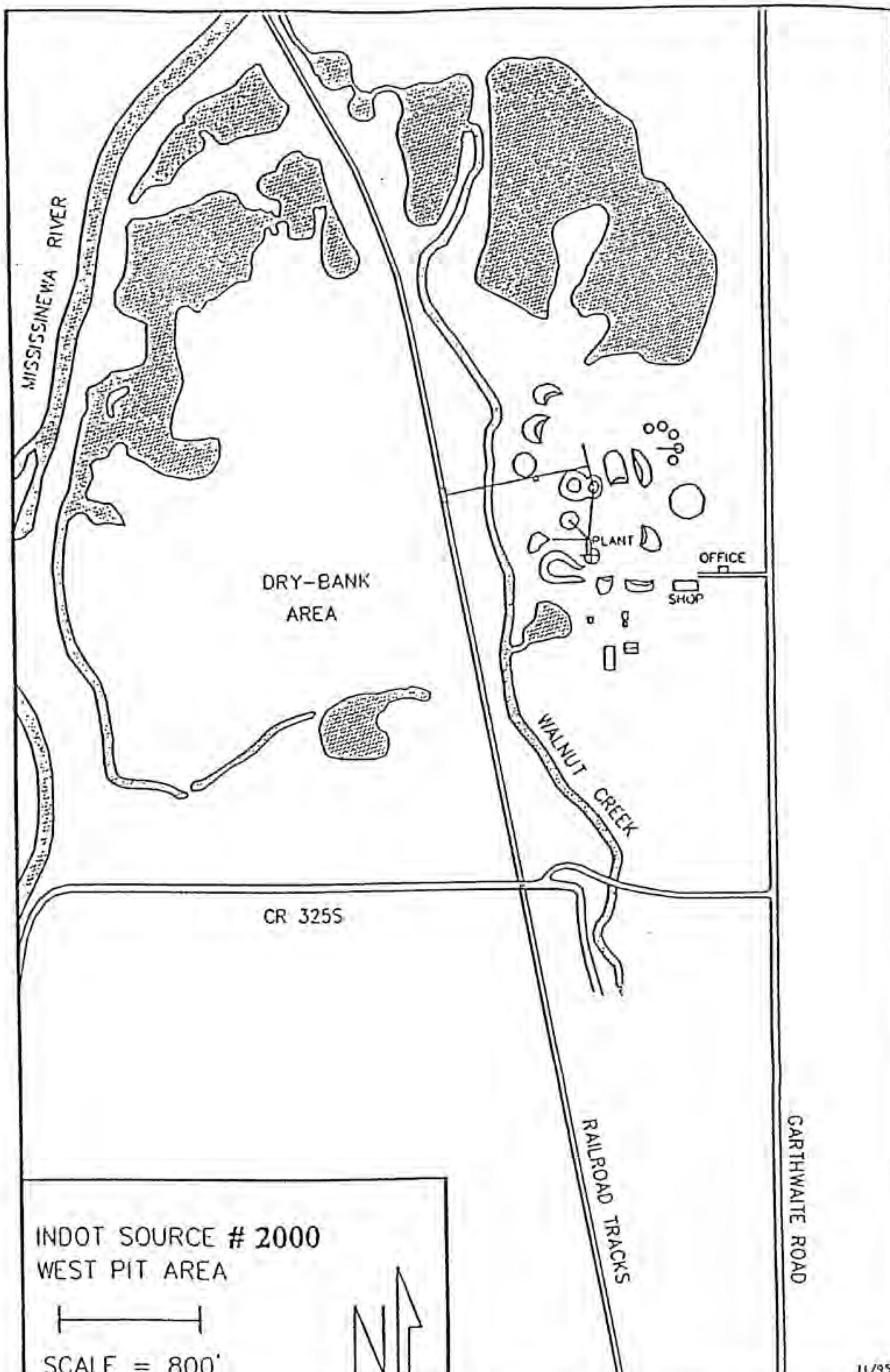
11/95

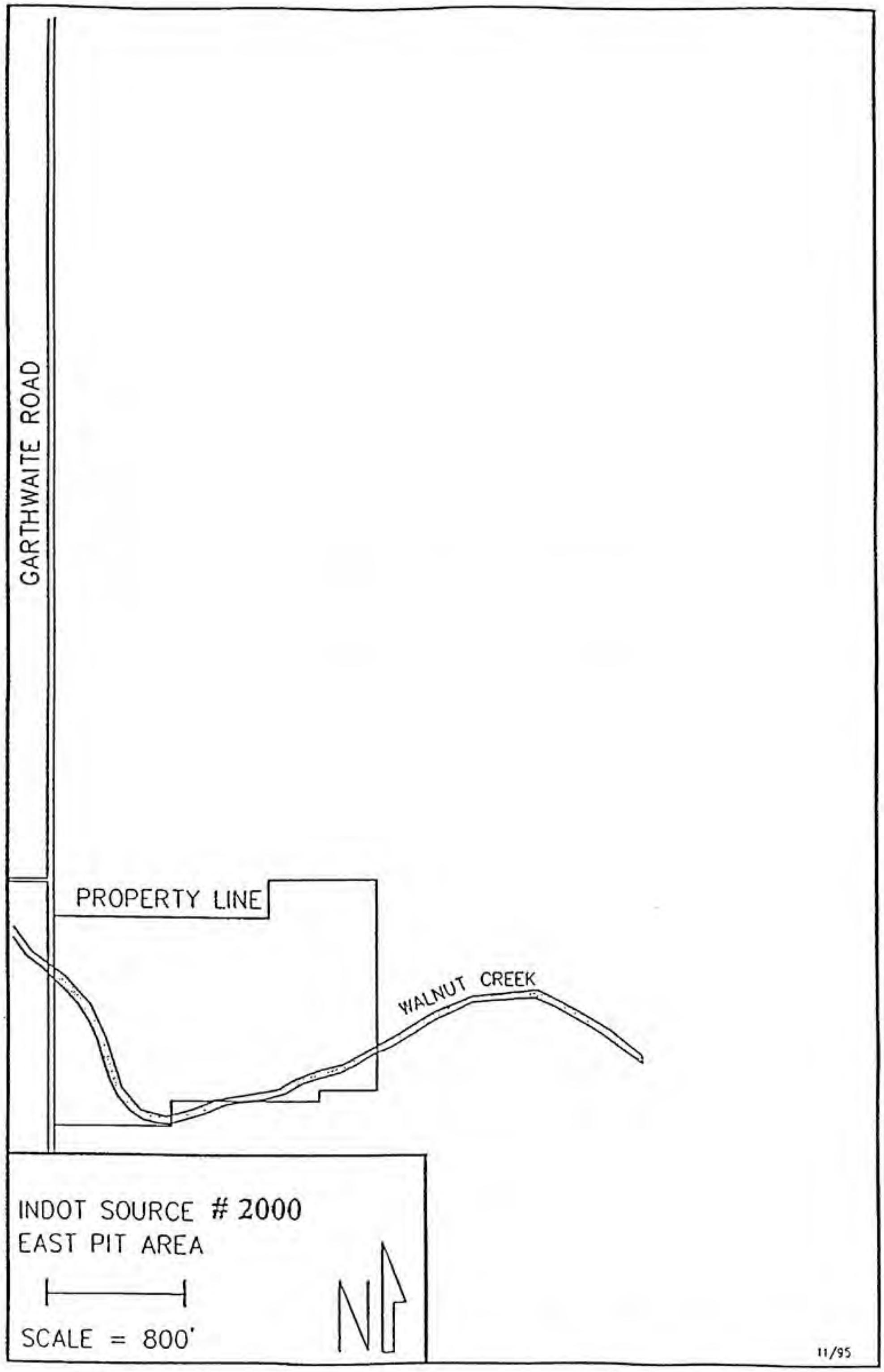


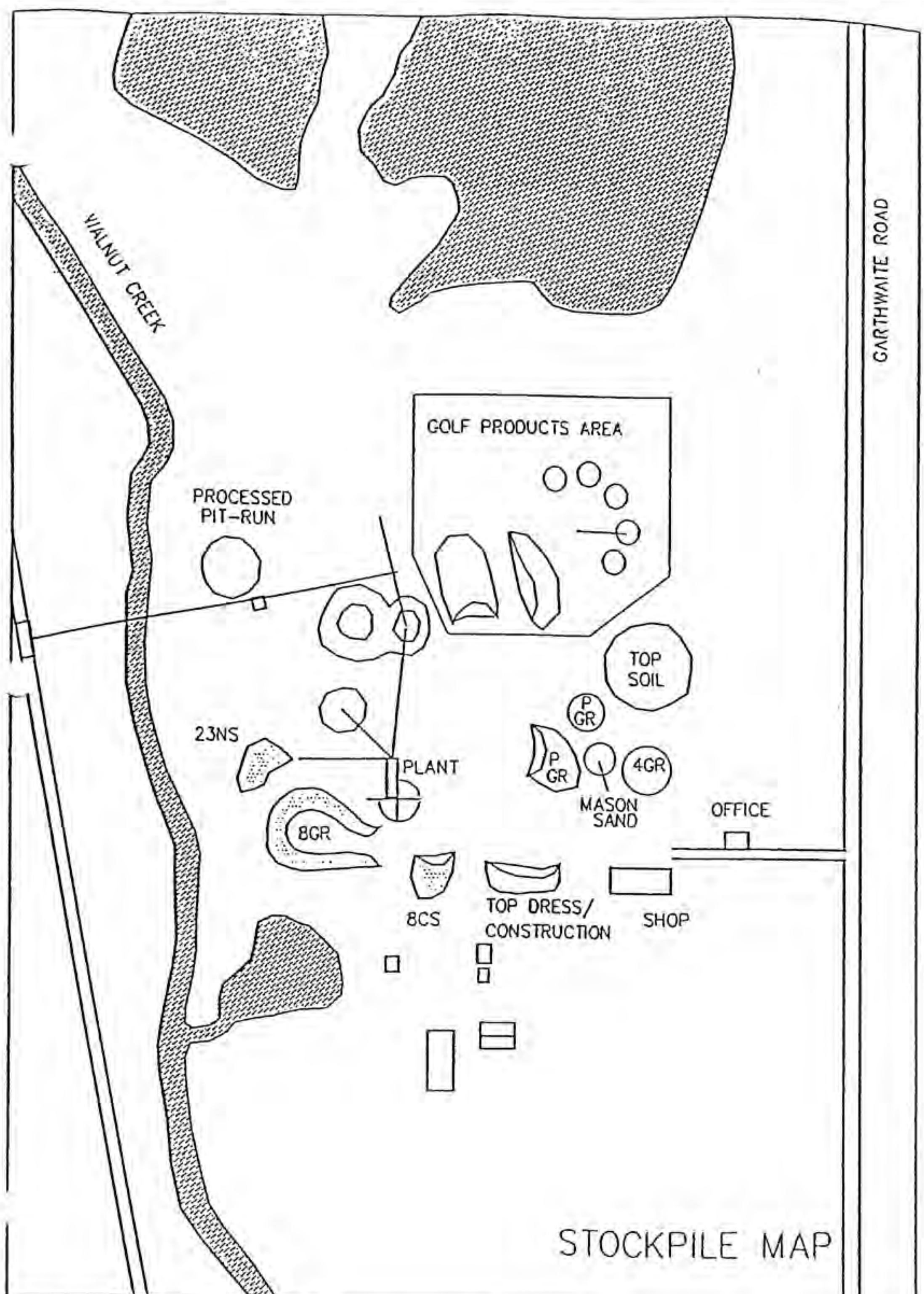
LOCATION MAP

GRANT COUNTY, INDIANA PAGE 1

11/95


MISSISSINEWA RIVER
DRY-BANK
AREA
PLANT
OFFICE
SHOP
WALNUT CREEK
CR 325S
RAILROAD TRACKS
GARTHWAITE ROAD
INDOT SOURCE # 2000
WEST PIT AREA
SCALE = 800'
N
11/95


GARTHWAITE ROAD
PROPERTY LINE
WALNUT CREEK
INDOT SOURCE # 2000
EAST PIT AREA
SCALE = 800'
N
11/95


WALNUT CREEK
GARTHWAITE ROAD
GOLF PRODUCTS AREA
PROCESSED
PIT-RUN
TOP
SOIL
P
GR
23NS
PLANT
P
GR
4GR
MASON
SAND
OFFICE
8GR
8CS
TOP DRESS/
CONSTRUCTION
SHOP
STOCKPILE MAP

APPENDIX C

FORMS

CAPP DIARY

LOCATION:

DATE: ______ START: ______

INDOT #: CAPP #: ________ STOP: ______

WEATHER: ______________________________ DOWN DATES: ______

IDLE TIME: ____________ (HOLIDAYS), ____________ (WEEKENDS)

GRID: ______________ : ____________

SAMPLES PULLED

SIZE	TYPE *	TIME

TONS PRODUCED TODAY AND MONTHLY RUNNING TOTALS (MRT)

SIZE											TOTAL
TONS											
MRT											

SUPERINTENDENT'S (OR REPRESENTATIVE) REMARKS

CHANGES – PLANT, GRID, KEY PERSONNEL, ETC: ____________________

EVENTS – PROBLEMS WITH PLANT, SCREENS, EQUIPMENT, ETC; ____________

(INITIALS ____)

*SAMPLE TYPES

S = START UP FREQUENCY

N = NORMAL FREQUENCY

L = LOAD-OUT FREQUENCY

M = MISC.

R = RESAMPLE

CERTIFIED AGGREGATE TECHNICIAN'S REMARKS ____________________

(NAME - PRINTED) / (SIGNATURE)

FN: DIARY355

CAPP' DIARY - ADDITIONAL REMARKS

SOURCE #: DATE:

SUPERINTENDENT'S (OR REPRESENTATIVE) REMARKS – CONTINUED

( )
INITIALS

CAT'S REMARKS - CONTINUED

/
(PRINTED NAME) (SIGNATURE)

08/95

GRADATION ANALYSIS FOR SIZE 8

SOURCE ______________ ORIGIN ______________ MONTH / YEAR ______________

DATE																	WHEN CONTROL CHARTING IS REQUIRED, PLACE A CIRCLE AROUND THE ENTRY IN THE ◁ * TEST TYPE * BOX.	
TEST#																		
* TYPE																		
SIEVE																	AVE	SPEC RANGE
25.0 mm																		100
19.0 mm																		75-95
12.5 mm																		40-70
9.5 mm																		20-50
4.75 mm																		0-15
2.36 mm																		0-10
75 µm																		
DECANT																		0-1.5
																	*SAMPLE TYPES	
CHERT																	S = START OF PRODUCTION FREQUENCY N = NORMAL PRODUCTION FREQUENCY L = LOADOUT FREQUENCY M = MISCELLANEOUS R = RESAMPLE	
SOFT																		
LA																		
% ABS																		
BSGR																	STATISTICS	
CRUSH																	UCL = ______	
																	LCL = ______	
5-POINT AVERAGE																	$\bar{X}_T$ = ______	

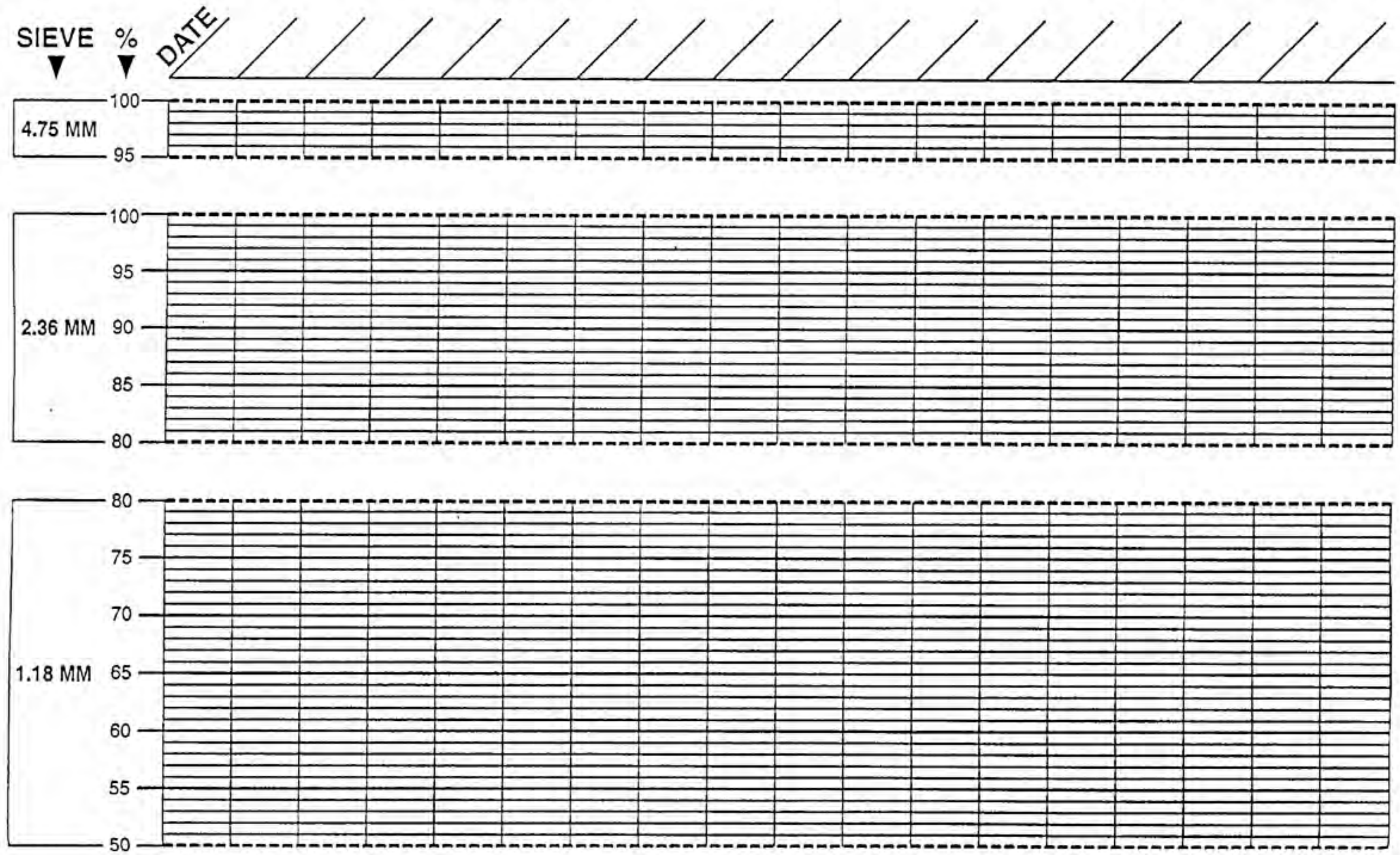
FH T504.RXD 05/97

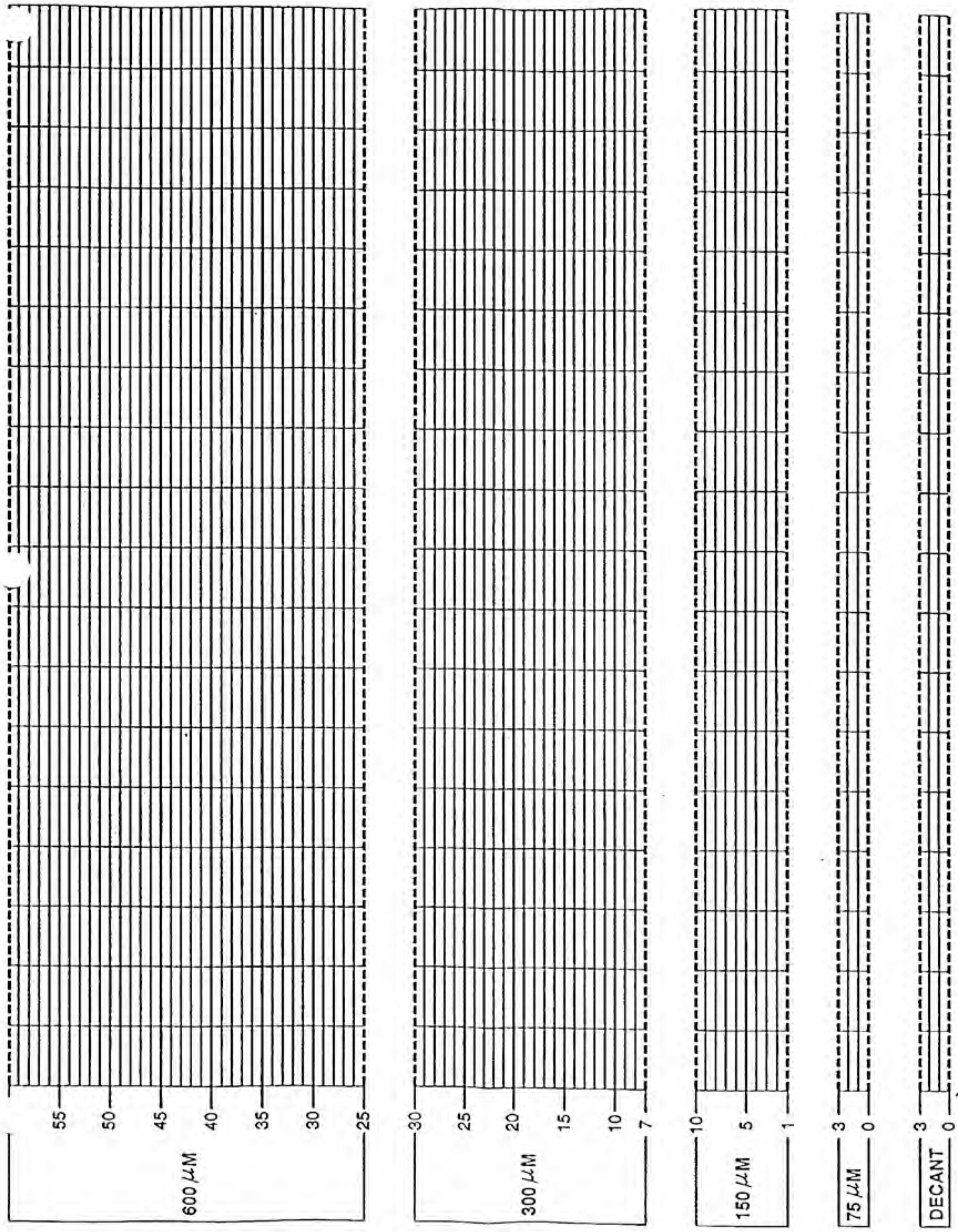
SOURCE #

AGGREGATE PROCESS CONTROL CHART

#23 #24 4B-BORROW

MONTH / YEAR




600 μM
55
50
45
40
35
30
25
300 μM
30
25
20
15
10
7
150 μM
10
5
1
75 μM
3
0
DECANT
3
0

CAPP SHIPPING RECORD -

INDOT #: CAPP #: Q97----

SIZE: ____ YEAR: ____ PAGE: ___/___

DATE MATERIAL SHIPPED	SHIPPED TO: CONTRACT OR FACILITY ID	DAILY TONNAGE SHIPPED	1000 TN RUNNING TOTAL	8000 TN RUNNING TOTAL	REPRESENTATIVE TEST ID NUMBER

FN:SHPRD338 (CAPP CAT SIGNATURE) 08/97

AUTHENTICATION

APPROVAL	SUBMISSION
________________________________ Chief, Materials & Tests Division	________________________________ Management Representative
________________ Date of Approval	________________ Date of Submission

Appendix D

Audits

Certified Aggregate Producer Program Audit Checklist

Certified Aggregate Producer Program Partial Audit Checklist

Sampling, Sample Reduction, and Testing Procedures

CERTIFIED AGGREGATE
PRODUCER PROGRAM
AUDIT CHECKLIST

Date ____________________ Page ___ of ___

Source No. _______________ **Q No.** __________________

Plant/Redistribution Terminal Name ____

Plant/Redistribution Terminal Location ____

District Testing Engineer or ____

INDOT Audit Team Members

	Name	Position
1.	____________________	Geologist
2.	____________________	Area Supervisor
3.	____________________	Aggregate Technician
4.	____________________	____________________
5.	____________________	____________________
6.	____________________	____________________
7.	____________________	____________________

Plant/Redistribution Terminal Members

	Name	Position
1.	____________________	Certified Aggregate Technician
2.	____________________	____________________
3.	____________________	____________________
4.	____________________	____________________
5.	____________________	____________________

1. GENERAL INSTRUCTIONS

DTE

Certified Aggregate Producer Program (CAPP)
Quality Control Plan (QCP)
Certified Aggregate Technician (CAT)

Any square bracket marked by an X on the Audit Checklist requires a Corrective Action Sheet to be prepared. The Corrective Action Sheet will be prepared when a deficiency is found, and a copy given to the Producer by the end of the audit. All other square brackets shall have a check, if the item is satisfactory, or NA if not applicable.

Begin the audit by having all INDOT audit members review the QCP before arriving at the Producer's site. Likewise, checklists prepared during previous audits, especially the last one, will be reviewed. All members of the audit team should compare revision dates of each page to verify that their QCP includes all current addenda.

A listing of applicable INDOT documents and Indiana Test Methods are maintained in the CAPP Document List. The current revision date for each publication is provided in the list.

1.1 [ ] Area Supervisor or ______________________________ has listing of documents

The Addenda Summary Sheet and QCP Annex are required to be maintained in the QCP Appendix. Items on these two sheets should be reviewed and the Producer instructed that the necessary addenda for these items be submitted at the close-out meeting.

1.2 [ ]* Addenda Summary Sheet and QCP Annex reviewed

* Only if applicable

Source # ___ ___ ___ ___ Page ___ of ___

2. PRODUCTION FLOW DIAGRAM

ITM 211 Reference
14.2.10

Geologist or ______________________________

2.1 [ ] The Annual Aggregate Source Report for Stone Producers represents conditions found at source and as required by ITM 203

Review the diary and note locations where material has been extracted.

2.2 [ ] Locations noted in diary match areas that have been mined as shown on grid in the Annual Aggregate Source Report

Begin at the origin of the material, which is the quarry or the pit. Inspect the site and view the entire process tracing all information shown on the QCP flow diagram. Also, note any discrepancies of the production process with that shown or described in the QCP. End at the point of shipment.

The Producer will be reviewed for any deviations in the ledge processing or changes in the plant, including crushers, washers, bins, belt routes, screen combinations, delivery and off loading processes, etc. Specific details, such as manufacturers names, screen sizes, dimensions, etc., are not required on the flow diagram..

2.3 [ ] Plant in accordance with QCP
2.4 [ ] Changes noted in diary

Identify all material stockpiles and bins within Producer's yard.

2.5 [ ]* All stockpiles and bins have signs indicated in QCP
2.6 [ ]* Stockpile map is current and located as indicated in QCP
2.7 [ ] All material stockpiles and bins are listed as materials or otherwise accounted for in QCP
2.8 [ ]* Air-cooled blast furnace slag stockpiles designated for leachate testing are approximately 2000 tons
2.9 [ ]* Steel furnace slag stockpiles designated for deleterious testing are approximately 2000 tons

The QCP will cover any other process control techniques that will be used beyond the minimums established by INDOT specifications and policies.

2.10 [ ]* Other process control techniques are as defined in QCP

* Only if occurs

3. QUALITY CLASSIFICATIONS

ITM 211 References
14.2.3
14.2.4
14.2.8

Geologist or ______________________________

A list and description of all portions of the mineral deposits indicating the different quality classes as described in ITM 203, ITM 205, and ITM 210 will be provided in the QCP. The manner in which each quality class is processed, handled and stockpiled will be covered.

3.1 [ ] Each quality class is processed, handled and stockpiled in accordance with the QCP

An explanation for each product having marginal quality characteristics and the plans or controls to be used for such products shall be provided in the QCP.

3.2 [ ]* Each marginal quality class material is processed, handled and stockpiled in accordance with QCP

* Only If Producer has materials with marginal quality characteristics

4. MATERIALS

ITM 211 References
3.10
5.2

Geologist or ______________________________

If the Producer is a Redistribution Terminal, prior source documentation of a material obtained from another aggregate source shall be provided by the Producer.

4.1 [ ] Quality satisfactory as verified by being from a Certified Producer and a Certified Material, or traced to original INDOT approved source

The list of Certified Materials for the Producer shall be compared with the materials indicated in the QCP and the materials on site for Department use.

4.2 [ ] The list of Certified Materials is in accordance with the QCP.

If the source has yet to be CAPP approved, a list of products, ledges, if applicable, and source code numbers will be tabulated and included with the Audit Checklist

5. PRODUCER GENERAL INFORMATION

ITM 211 References
5.1
5.2
14.2.1

Area Supervisor or ______________________________

5.1 [ ] Plant location and address in QCP is correct
5.2 [ ] Plant telephone and FAX numbers in QCP are correct
5.3 [ ] Producers name and address in QCP are correct and ownership has not changed
5.4 [ ] Producers telephone and FAX numbers in QCP are correct
5.5 [ ] Key personnel contact information in QCP is correct. (Management Rep and CAT mobile numbers and email address.)
5.6 [ ] Type of Producer (plant, redistribution terminal, or plant & redistribution terminal) identified in QCP is correct

6. PRODUCER PERSONNEL

ITM 211 References
6.1
6.2
14.2.2

Area Supervisor or ______________________________

The Producer employees occupy the following positions.

6.1 [ ] Management Representative
6.2 [ ] CAT(s)
6.3 [ ] Appointed CAT(s) Certification has not expired
6.4 [ ] All personnel conducting sampling and testing for the CAPP are Qualified Technicians

7. DOCUMENTS

ITM 211 References
2.5, 17.3

Area Supervisor or ________________________

Determine whether the following documents are current and on file at the Producer's site or location indicated in QCP. Check the CAPP Document List for the most current dates of these items.

7.1 [ ]* INDOT Certified Aggregate Producer Program (ITM 211)
7.2 [ ]* INDOT Standard Specification (Includes Supplemental Specifications sections 211, 301, 302, 303, 904 and 917)
7.3 [ ]* Indiana Quality Assurance Certified Aggregate Technician Training Manual for Producer Technicians
7.4 [ ] Summary of Production Quality Test Results Letter, Summary of Ledge Quality Letter, and the AP Aggregate Approval Letter for all applicable materials produced at the Plant
7.5 [ ]* All applicable INDOT, AASHTO, and ASTM Test Methods **referenced in QCP**. The documents are in accordance with the CAPP Document List.

ITM 206 _____	AASHTO T 2 _____
ITM 207 _____	AASHTO T 11 _____
ITM 212 _____	AASHTO T 27 _____
ITM 219 _____	AASHTO T 84 _____
ITM 902 _____	AASHTO T 85 _____
ITM 906 _____	AASHTO T 112 _____
ITM 910 _____	AASHTO R 76 _____
______________	ASTM D 4791 _____
______________	ASTM D 5821 _____
______________	____________________

* May be maintained electronically or by hard copies.

Obtain weigh tickets for an active period of one week that represent material shipped for Department use. Check for accuracy and minimum requirements as follows:

7.6 [ ] Q number listed and is correct
7.7 [ ] Originating source name listed and is correct
7.8 [ ] Source number listed and is correct
7.9 [ ] Aggregate size listed
7.10 [ ] Ledges listed for stone product and they are correct

8. CONTROL CHARTS ITM 211 Reference

Area Supervisor or ________________________ 13.0

ALL CONTROL CHARTS

8.1 [ ] All materials identified as products in the QCP have a control chart which is posted (critical sieve or all sieves charted as required by CAPP)
8.2 [ ] Aggregate sizes are clearly shown on the charts
8.3 [ ] Control charts are maintained as indicated in the QCP
8.4 [ ] Control charts are generated electronically
8.5 [ ] Control charts are hand plotted

*Check the **critical sieve** material control charts for compliance with the QCP and ITM 211. Production and load-out charts (if load-out tests are plotted on a separate chart) are required to be checked.*

Target Mean

8.6 [ ] Values are the same as indicated in QCP
8.7 [ ] Numerically identified in left margin of charts or in accordance with QCP and indicated to the first decimal place (0.0)
8.8 [ ] Heavy long, then short dashed line or in accordance with QCP

Control Limits

8.9 [ ] Upper and lower control limits are the same as indicated in QCP
8.10 [ ] Numerically identified in left margin of charts or in accordance with QCP and indicated to the first decimal place (0.0) or whole number (0)

***Critical sieve** materials that have not obtained a minimum of 10 normal production tests are required to have the specification limits plotted for all sieves. For these materials, check the following:*

Specification Limits

8.11 [ ] Upper and lower limits indicated on all sieves
8.12 [ ] Values are the same as Section 904 for Standard Specification materials or as indicated in the QCP for QA materials
8.13 [ ] Short dashed lines or as indicated in QCP
8.14 [ ] Numerically identified in left margin or in accordance with QCP

*Check the **non-critical sieve** material control charts for compliance with the QCP and ITM 211. Production and load-out charts (if load-out tests are plotted on a separate chart) are required to be checked.*

8.15 [ ] Upper and lower limits indicated on all sieves
8.16 [ ] Values are the same as Section 904 for Standard Specification materials or as indicated in the QCP for QA materials
8.17 [ ] Short dashed lines or as indicated in QCP
8.18 [ ] Numerically identified in left margin or in accordance with QCP

CONTROL CHARTS (continued)

PRODUCTION CONTROL CHARTS WITH CRITICAL SIEVES

*Select one **Production** control chart for a material with a **critical sieve** and check for conformance with the following criteria. Mark the square bracket with a Q for any deviation from the CAPP that is in accordance with the QCP.*

Material selected was: ________________________

8.19 [ ] Maintained until 30 production points are plotted and the previous 30 points, if applicable, are displayed (Certified Producers only)
8.20 [ ] If in the Trial Phase, charts are maintained since entering into the Trial Phase
8.21 [ ] All charts retained at least 3 years for Certified Producers in CAPP > 3 Years

<u>Production Test Results</u>
8.22 [ ] Point surrounded by small circle and plotted to first decimal place (0.0)
8.23 [ ] Consecutive points connected by solid straight line

<u>Moving Average of 5 Test Values</u>
8.24 [ ] Point surrounded by small triangle
8.25 [ ] Consecutive points connected by solid straight line

<u>Stockpile Load-Out Test Results</u>
8.26 [ ] Production chart
8.27 [ ]* Separate chart
8.28 [ ] Point surrounded by small square

* If separate chart, complete stockpile load-out control chart checklist sheet for material with critical sieve

<u>All Test Results</u>
8.29 [ ] Points plotted left to right in chronological order
8.30 [ ] Test dates shown along horizontal axis

Obtain production test reports and load-out test reports (if plotted on same chart) to check for accuracy in reporting and plotting. For hand-plotted charts, check all tests during an active period of one week. For computer generated charts, check two randomly selected tests.

8.31 [ ] All test dates for points plotted on charts are the same as dates reported on test reports and in the daily diary
8.32 [ ] All points are plotted correctly
8.33 [ ] Five point moving average calculated and plotted correctly for two randomly selected points

Source # ___ ___ ___ ___ Page ___ of ___

INCLUDE THIS SHEET ONLY IF STOCKPILE LOAD-OUT IS PLOTTED ON SEPARATE CHART

CONTROL CHARTS (continued)

LOAD-OUT CONTROL CHARTS WITH CRITICAL SIEVES

*Select one stockpile **Load-Out** control chart for a material with a **critical sieve** and check for conformance with the following criteria.*

Material selected was: ________________________

8.34 [ ] Maintained until 30 points are plotted and the previous 30 points, if applicable, are displayed (Certified Producers only)
8.35 [ ] If in the Trial Phase, charts are maintained since entering into the Trial Phase
8.36 [ ] All charts retained at least 3 years for Certified Producers in CAPP > 3 Years

Stockpile Load-Out Test Results

8.37 [ ] Points surrounded by small squares and plotted to first decimal place (0.0)
8.38 [ ] Consecutive points connected by solid straight line

All Test Results

8.39 [ ] Points plotted left to right in chronological order
8.40 [ ] Test dates shown along horizontal axis

Obtain load-out test reports to check for accuracy in reporting and plotting. For hand-plotted charts, check all tests during an active period of one week. For computer generated charts, check two randomly selected tests.

8.41 [ ] All test dates for points plotted on charts are the same as dates reported on test reports and in the daily diary
8.42 [ ] All points are plotted correctly

CONTROL CHARTS (continued)

PRODUCTION CONTROL CHARTS WITH NO CRITICAL SIEVES

*Select one **Production** control chart for a material with **no critical sieve** and check for conformance with the following criteria. Mark the square bracket with a Q for any deviation from the CAPP that is in accordance with the QCP.*

Material with selected was: ________________________

8.43 [ ] Maintained until 30 production points are plotted and the previous 30 points, if applicable, are displayed (Certified Producers only)
8.44 [ ] If in the Trial Phase, charts are maintained since entering into the Trial Phase
8.45 [ ] All charts retained at least 3 years for Certified Producers in CAPP > 3 Years

Production Test Results

8.46 [ ] Point surrounded by small circle and plotted to first decimal place (0.0)
8.47 [ ] Consecutive points connected by solid straight line

Stockpile Load-Out Test Results

8.48 [ ] Production chart
8.49 [ ]* Separate chart
8.50 [ ] Point surrounded by small square

* If separate chart, complete stockpile load-out control chart checklist sheet for material with all sieves

All Test Results

8.51 [ ] Points plotted left to right in chronological order
8.52 [ ] Test dates shown along horizontal axis

Obtain production test reports and load-out test reports (if plotted on same chart) to check for accuracy in reporting and plotting. For hand-plotted charts, check all tests during an active period of one week. For computer generated charts, check two randomly selected tests.

8.53 [ ] All test dates for points plotted on charts are the same as dates reported on test reports and in the daily diary
8.54 [ ] All points are plotted correctly

INCLUDE THIS SHEET ONLY IF STOCKPILE LOAD-OUT IS PLOTTED ON SEPARATE CHART

CONTROL CHARTS (continued)

LOAD-OUT CHARTS WITH NO CRITICAL SIEVES

Select one ***Load-Out*** *control chart for a material with* ***no critical sieve*** *and requiring all sieves to be plotted.*

Material selected was: ________________________

8.55 [ ] Maintained until 30 points are plotted and the previous 30 points, if applicable, are displayed (Certified Producers only)
8.56 [ ] If in the Trial Phase, charts are maintained since entering into the Trial Phase
8.57 [ ] All charts retained at least 3 years for Certified Producers in CAPP > 3 years

Stockpile Load-Out Test Results

8.58 [ ] Point surrounded by small square and plotted to first decimal place (0.0)
8.59 [ ] Consecutive points connected by solid straight line

All Test Results

8.60 [ ] Point plotted left to right in chronological order
8.61 [ ] Test dates shown along horizontal axis

Obtain load-out test reports to check for accuracy in reporting and plotting. For hand-plotted charts, check all tests during an active period of one week. For computer generated charts, check two randomly selected tests.

8.62 [ ] All test dates for points plotted on charts are the same as dates reported on test reports and in the daily diary
8.63 [ ] All points are plotted correctly

COMPLIANCE RATE

Review the 30 most recent normal production tests in the current and previous year that are charted for each Standard Specification or Quality Assurance product controlled by a critical sieve. If 30 tests are not available, the number of tests taken shall be used with at least 10 tests required. For hand-plotted charts, calculate the test compliance rate using the Compliance Rate Worksheet for all materials. For computer generated charts, check the compliance rate for all materials and calculate the compliance rate for one material using the Compliance Rate Worksheet.

8.64 [ ] Compliance rate ≥ 95% for each material

8.65 [ ] *Compliance rate is < 95% and σ ≤ 5.0 for a material (The target mean is required to be adjusted by a QCP Annex)

8.66 [ ] *Compliance is < 95% and σ >5.0 for a material. (The stockpile is required to be designated as a non-Certified material)

**If the number of tests is less than 30, additional testing is required before the target mean is adjusted or the material is designated as a non-Certified material. An additional compliance rate check on the material is required after five additional tests have been taken.*

9. DIARY ITM 211 References 10.0, 12.5, 12.7

Area Supervisor or ________________________

Select at random one active production month for review of the diary. The diary shall be in accordance with the following requirements, except where "only if occurs" is noted

Month Selected: _____________________________

9.1 [ ] Electronic and/or hard copy

9.2 [ ] One page for each day that there is a material related operation

9.3 [ ] General weather conditions

9.4 [ ] Areas of mining operation - ledges or pit area

9.5 [ ] Materials produced and estimated quantities

9.6 [ ] Materials sampled and tested

9.7 [ ] Time samples were obtained and tests completed (may state that all samples obtained were tested the same day)

9.8 [ ]** Changes in key personnel

9.9 [ ]** Significant changes in equipment, plant, screens, etc

9.10 [ ]** Significant events or problems

9.11 [ ]** Nonconforming trend in 5-point moving average of control chart (7 or more points in a row are above or below target mean, or 7 or more points in a row are increasing or decreasing)

9.12 [ ] Signature by CAT or other persons signature counter-signed by CAT

Any nonconforming normal production or load-out test shall be followed immediately by appropriate action. Search control charts for nonconforming tests. If nonconforming tests are found, review the diary on the date of each test for notations regarding action taken.

9.13 [ ] Nonconforming tests are noted in diary

9.14 [ ] Corrective action was taken

9.15 [ ]** After the second consecutive nonconforming normal production test, notations indicate that the material was isolated

9.16 [ ]** After the second consecutive nonconforming load-out test, notations indicate that shipping from the stockpile was stopped

** Only if occurs

10. SAMPLING AND TESTING

ITM 211 References
11.0, 14.2.6, 14.2.7, 14.2.8

Area Supervisor or ________________________

The method of recording the quantities of materials ***produced*** *at the Plant per day or time period will be identified in the QCP. Select an active one month period at random from this record. Obtain all production test reports for materials produced during the one month period. Perform calculations as needed and compare the quantities produced against the production test reports, thereby determining the demonstrated frequency of testing. The previous or subsequent monthly record may need to be obtained to verify the frequency of tests.*

10.1 [ ] Start of production frequency is in accordance with QCP, but is not less than once every 1000 t for the first 5000 t (except not required to exceed 2 per day)
10.2 [ ] Normal frequency is in accordance with QCP, but is not less than once every 2000 t (except not required to exceed 2 per day)

The method of recording the quantities of materials produced at the Plant that are ***shipped*** *per day or time period will be identified in the QCP. Select an active one month period at random from this record. Obtain all load-out test reports for materials shipped during the one month period. Perform calculations as needed and compare the quantities of materials shipped against the load-out test reports, thereby determining the demonstrated frequency of testing. The previous or subsequent monthly record may need to be obtained to verify the frequency of tests.*

10.3 [ ] Load-out frequency is in accordance with QCP, but is not less than once every 8000 t or at least one sample and test performed per month for shipments that exceed 1000 t for each Certified Material
10.4 [ ] All load-out samples for Standard Specifications and Quality Assurance aggregates were decanted and tests are within requirements

If material is obtained from another Certified Producer and is a Certified Material, then load-out tests are required. If the material is obtained from a non-Certified Producer or is not a Certified Material, then the start of production, normal production and load-out tests are required. Search the records for these materials, if applicable, and verify that the required tests have been conducted.

10.5 [ ] Load-out test conducted for Certified Material from another Producer
10.6 [ ] Start of production, normal production and load-out tests conducted for material that is not Certified and is received from another Producer

The Producer shall check coarse aggregates for deleterious materials. Select an active week randomly from the record for quantities of materials made and note all coarse aggregates produced. Find production test reports for that week and search for deleterious test results.

10.7 [ ] Start of production and normal production frequency is in accordance with QCP, but is not less than once per week for each size of Certified Material. (no test is required if the week's production is less than 100 t)
10.8 [ ] Tests are within requirements

SAMPLING AND TESTING (continued)

Select randomly three production test reports and two load-out test reports for any one product and check all calculations performed on the sheets. If test reports are electronic, check calculations on one production test report and one load-out test report.

Indicate type of Report; Electronic Reports: _______ Hand Calculated Reports:_______

10.9 [ ] Calculations on all sheets are correct and rounded to the nearest first decimal place (0.0) (crushed particle content values shall be rounded to the nearest whole number (0))

DECANTATION (AASHTO T 11)

$$\% \text{ Decant} = \frac{\text{Original Dry Weight - Dry Weight after Decant}}{\text{Original Dry Weight}} \times 100$$

GRADATION (AASHTO T 27)

$$\% \text{ Passing} = \frac{\text{Weight Passing Each Sieve}}{\text{Original Dry Sample Weight}} \times 100$$

CLAY LUMPS and FRIABLE PARTICLES (AASHTO T 112)

$$\% \text{ Clay or Friable} = \frac{\text{Dry Wt. of Sample - Dry Wt. Retained (Wet Sieving)}}{\text{Dry Wt. of Sample}} \times 100$$

NON-DURABLE MATERIALS (ITM 206)

$$\% \text{ Non-Durable} = \frac{\text{Weight of Non-Durable Matl. above 3/8 in. Sieve}}{\text{Weight of Sample above 3/8 in. Sieve}} \times 100$$

CHERT

For aggregate sizes 2 through 8, 43, 53, and 73:

$$\% \text{ Total Chert} = \frac{\text{Weight of Chert above the 3/8 in. Sieve}}{\text{Total Weight of Sample above the 3/8 in. Sieve}} \times 100$$

For aggregate sizes 9, 11, 12, and 91:

$$\% \text{ Total Chert} = \frac{\text{Weight of Chert above the No. 4 Sieve}}{\text{Total Weight of Sample above the No. 4 Sieve}} \times 100$$

CRUSHED PARTICLES (ASTM D 5821)

$$\% \text{ Crushed} = \frac{\text{Weight of Crushed Particles}}{\text{Weight of Crushed Particles + Weight of Uncrushed Particles}} \times 100$$

SAMPLING AND TESTING (continued)

Gravel shall be sampled and tested for the percentage of crushed coarse aggregate particles unless the QCP states otherwise. Select a week randomly from the record for quantities of products made, and note all coarse aggregates produced. Find the production test reports for that week and search for crushed particle test results.

10.10 [ ] Start of production and normal production frequency is in accordance with QCP, but is not less than once per week for each size of Certified Material. (no test is required if the week's production is less than 100 t)
10.11 [ ] Tests are within requirements for one and two face fractured particles

Air-Cooled Blast Furnace Slag, except for use in HMA or PCC, shall be sampled and tested for leachate in accordance with ITM 212. Select an active month randomly from the record for quantities made, and verify the frequency of testing.

10.12 [ ] The frequency of testing is in accordance with QCP, but is not less than once for each stockpile of approximately 2000 t
10.13 [ ] Tests are within requirements

Steel Furnace Slag shall be sampled and tested for determination of bulk specific gravity when this material is used in SMA mixtures. Select an active month of production of the steel slag and verify the frequency of testing and compliance with the specification requirements.

10.14 [ ] The frequency of testing is in accordance with QCP, but is not less than once every 2000 t.
10.15 [ ] Individual test results are within 0.050 of the target bulk specific gravity
10.16 [ ] The moving average of four consecutive test results is within 0.040 of the target bulk specific gravity

Steel Furnace Slag shall be sampled and tested for determination of deleterious when this material is used in HMA Base and Intermediate mixtures. Select an active month of production of the steel slag and verify the frequency of testing and compliance with the specification requirements.

10.17 [ ] The frequency of testing is in accordance with QCP, but is not less than once every 2000 t.
10.18 [ ] Individual test results are less than 4.0 % (Stockpiles not meeting this acceptance criteria may be tested again after 30 days from the test date)

SAMPLING AND TESTING (continued)

Source # ___ ___ ___ ___ Page ___ of ___

Composite stockpiling of natural sand fine aggregate from multiple sources into one stockpile may be done provided the fine aggregate is within a range of 0.10 for the bulk specific gravity (dry) and 1.0 % for the absorption for all of the contributing sources. Select an active month of composite stockpiling from the monthly summary reports, and verify the test results are within the bulk specific gravity (dry) and absorption requirements.

10.19 [ ] Bulk specific gravity (dry) test results of all contributing sources are within a range of 0.10.
10.20 [ ] Absorption test results of all contributing sources are within a range of 1.0%

Additional required testing as specified in source's QCP. Select an active month of production and verify the frequency is in accordance with the QCP. Type of test ________________________

10.21 [ ] Testing frequency meets the requirements of the QCP
10.22 [ ] Test results are in specification
10.23 [ ] Test results outside the specification are handled in accordance with the QCP.

11. PRODUCER YARDS ITM 211 Reference 5.1

Area Supervisor or ________________________

If a source has Producer Yards, separate load-out charts are required to be maintained for the materials at these locations. Obtain the load-out charts and check the following:

11.1 [ ] All certified materials have a load-out chart
11.2 [ ] Aggregate sizes are clearly shown on the charts
11.3 [ ] Target means, control limits, and specification limits for all charts are in accordance with QCP

Obtain load-out test reports for one material during an active period of one week. Find the corresponding control chart and check the following:

11.4 [ ] All test dates have points plotted
11.5 [ ] Points surrounded by small square or in accordance with the QCP and plotted to the first decimal place (0.0)
11.6 [ ] All points plotted correctly
11.7 [ ] Consecutive points connected by solid straight line

Obtain all load-out test reports for materials shipped from the Producer Yard during a one month period. Perform calculations as needed and compare the quantities of materials shipped against the load-out test reports, thereby determining the demonstrated frequency of testing. The previous or subsequent monthly record may need to be obtained to verify the frequency of tests.

11.8 [ ] Load-out frequency is in accordance with QCP, but is not less than once every 8000 t or at least one sample and test performed per month for shipments that exceed 1000 t for each Certified Material
11.9 [ ] All load-out samples for Standard Specification and Quality Assurance aggregates were decanted and tests are within requirements

12. MATERIAL SAMPLES

ITM 211 References
11.0
14.2.10
14.2.11
15.7

Aggregate Technician or ________________________

Standard Specification and Quality Assurance materials under production at the site on the day of the audit will be reviewed by the audit team. At least one production sample of Standard Specification or Quality Assurance material shall be obtained.

The audit team will review the shipment records of the Standard Specification and Quality Assurance materials for the previous 6 months of production. A minimum of 3 load-out samples shall be obtained of the materials with the highest tonnages of shipment. Some producers may have less than 3 load-out samples to obtain.

The samples shall be obtained and split by the CAT. The INDOT audit team member shall be given the Department's portion of the samples and these samples will be tested.

Sampling shall be in accordance with the QCP and the following requirements verified.

12.1 [ ] Sample locations are as described or shown in QCP
12.2 [ ] Devices are as described in QCP
12.3 [ ] Techniques are as described in QCP
12.4 [ ] CAT obtained sample and performed split in accordance with CAPP

The following test results will be determined. A copy of all test reports from both the INDOT audit team member and the CAT will be attached to the audit checklist. The variation of test results will be shown in the remarks section of the INDOT audit team member's report for each material sampled and tested.

Standard Specification or Quality Assurance Materials

12.5 [ ] Producer's gradation is within control limits for critical sieve materials and within Specification Limits for all other sieves
12.6 [ ] Producer's gradation is within Specification Limits or QCP identified limits on all sieves for materials without a critical sieve
12.7 [ ] Producer's decant is within Specification Limits
12.8 [ ] Producer's deleterious content is within Specification Limits
12.9 [ ]* Producer's crushed particles are within Specification requirements
12.10 [ ] Test results variations are within CAPP guidelines

* Gravel Producers and Redistribution Terminal Producers handling gravel materials

13. LABORATORY

ITM 211 References
8.0
9.0

Aggregate Technician or ___________________

The laboratory will be inspected for compliance with the QCP.

13.1 [ ] Location as described and/or shown in QCP
13.2 [ ] Facility acceptable for testing of materials
13.3 [ ] All equipment listed in QCP at laboratory
13.4 [ ] All equipment apparently in good working order

Check the testing equipment verification records to verify that the documentation includes the following:

1. Description of equipment including Model or Serial Number, if applicable.
2. Name of person performing verification
3. Identification of verification equipment, if applicable
4. Date of verification and next due date
5. Reference of procedure used
6. Verification results

	DATE CALIBRATED/VERIFIED
13.5 [ ] Balance(s) -- 12 mo.	______________________________
13.6 [ ] Weights used, Min. Class 3 -- 12 mo.	______________________________
13.7 [ ] Mechanical Shaker(s) -- 12 mo.	______________________________
13.8 [ ] Sieves -- 12 mo.	______________________________

14. AUDIT CLOSE-OUT

DTE or Area Supervisor

When all the results from the audit have been accumulated, including Audit Checklist pages, INDOT test reports, Producer test reports, all Compliance rate worksheets, Corrective Action Sheet(s), and other documentation as may be appropriate, the District Testing Engineer and/or Area Supervisor shall review the documents to verify that they are prepared properly and are complete.

The Audit Close-Out meeting with the Producer will be conducted within 10 working days from the date of the audit. The District Testing Engineer and/or Area Supervisor will arrange and conduct the meeting with the Producer. The results of the audit will be discussed and all outstanding matters will be completely resolved, or solutions with deadlines will be established. Any addenda required by items listed on the Addenda Summary Sheet, QCP Annex, or Corrective Action Sheets shall be submitted at this time.

Upon completion of the Audit Close-Out meeting, all documents will be sent to the Geologist Supervisor, Office of Materials Management.

____ __________

DTE/Area Supervisor Signature Date

CAPP GRADATION WORKSHEET

SAMPLE ID____________________________________ DATE SAMPLED ____________

SAMPLE TYPE- PRODUCTION______ LOADOUT______ RERESAMPLE ______

MATERIAL SIZE _______________________________

SOURCE______________________________________ Q__________ LEDGES _______________

AASHTO T-27 SIEVE SIZE		LONG GR.WT. RETAINED	WEIGHT RETAINED	WEIGHT PASSING	INDOT % PASSING	PROD % PASSING	% DIFF	Tolerance (ITM 211)	PERCENT REQUIRED
2.5	63							5%	
2	50							5%	
1.5	37.5							5%	
1	25							5%	
3/4	19							5%	
1/2	12.5							5%	
3/8	9.5	PF-						5%	
4	4.75							3% *	
8	2.36							3% *	
16	1.18								
30	600								
50	300								
100	150								
200	75							0.5 or 1.0%	
PAN			*** The Maximum % difference for #43, #53 and #73 is 5%**						
		ORIGINAL	FINAL	GM LOSS	% LOSS				
DECANT								0.5 or 1.0%	
GRAMS LOST								<0.3	
LONG GRADED MATERIAL									
MINUS #4		SAMP SIZE	PROP. F						
TOTAL CHERT									
3/8" & UP		WEIGHT	INDOT %	PROD %				40% of the lowest value or 1%	
NON DURABLE									
3/8" & UP		WEIGHT	INDOT %	PROD %					
CRUSHED PARTICLES									
FACE	#4 & UP	CRUSHED	INDOT %	PROD %					
1								5%	
2								5%	

REMARKS:

TESTER SIGNATURE____ TEST DATE _____________

COMPLIANCE RATE WORKSHEET
(Critical Sieve Only)

SC # ________

Product ________________________ Critical Sieve ________ QCP Target Mean ___________

Record the most recent 30 normal production sample test results.

________	________	________	________	________	________
________	________	________	________	________	________
________	________	________	________	________	________
________	________	________	________	________	________
________	________	________	________	________	________

Calculate the following Statistics:

$\bar{x}$ = ______________ σ_{n-1} = _______________

$$Z_{max} = \frac{(\text{QCP Target Mean} + 10) - \bar{x}}{\sigma}$$

= _________________________ = __________

Z_{max} Area of Probability = ______________* x 100 = ________

$$Z_{min} = \frac{\bar{x} - (\text{QCP Target Mean} - 10)}{\sigma}$$

= _________________________ = __________

Z_{min} Area of Probability = ________________* x 100 = _________

% Compliance Σ = ________
(Whole No.)

* From Area of Probability Table

AREA OF PROBABILITY TABLE
FOR BOTH SPECIFICATIONS >0% AND <100%

When the z values to each limit are known, this table will indicate the area of probability between limits where summing the area left of the $\bar{x}$ with the area right of the $\bar{x}$. The sum of the 2 area factors should be multiplied by 100 to give the percent probability of compliance.

	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0159	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2518	0.2549
0.7	0.2580	0.2612	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4083	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4430	0.4441
1.6	0.4452	0.4463	0.4474	0.4485	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4758	0.4762	0.4767
2.0	0.4773	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4865	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4980	0.4980	0.4981
2.9	0.4981	0.4982	0.4983	0.4984	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4986	0.4987	0.4987	0.4988	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990
3.1	0.4990	0.4991	0.4991	0.4991	0.4992	0.4992	0.4992	0.4992	0.4993	0.4993
3.2	0.4993									
3.3	0.4995									
3.4	0.4997									

EXAMPLE
COMPLIANCE RATE WORKSHEET
(Critical Sieve Only)

SC # **2799**

Product **#8 Stone** Critical Sieve **12.5 mm** QCP Target Mean **52.2**

Record the most recent 30 normal production sample test results.

55.5	49.4	50.3	56.1	53.6	54.6
51.2	46.0	49.5	59.1	52.6	58.1
53.2	42.4	50.8	55.6	52.1	56.4
56.4	53.1	50.5	53.8	61.3	50.9
54.2	65.7	55.2	52.8	49.7	48.1

Calculate the following Statistics:

$\bar{x}$ = **53.3** σ_{n-1} = **4.53**

$$Z_{max} = \frac{(\text{QCP Target Mean} + 10) - \bar{x}}{\sigma}$$

$$= \frac{(52.2 + 10) - 53.3}{4.53} = 1.96$$

Z_{max} Area of Probability = **.4750** * x 100 = **47.50**

$$Z_{min} = \frac{\bar{x} - (\text{QCP Target Mean} - 10)}{\sigma}$$

$$= \frac{53.3 - (52.2 - 10)}{4.53} = 2.45$$

Z_{min} Area of Probability = **.4929** * x 100 = **49.29**

% Compliance Σ = **97**
(Whole No.)

* From Area of Probability Table

CORRECTIVE ACTION SHEET

SOURCE # ___ ___ ___ ___

DATE ______________

ITEM ______________

Problem Explanation:____

____

____

____

____

____

____

Corrective Action To Be Taken Is:____

____

____

____

____

____

____

Deadline Date Is: __________________________

Follow-up **Date** ________________________

Finding:____

____

____

____

If NOT corrected, prepare another Corrective Action Sheet.

CERTIFIED AGGREGATE PRODUCER PROGRAM AUDIT CHECKLIST

Date ____________________ Page ___ of ___

Source No. _______________ **Q No**. __________________

Plant/Redistribution Terminal Name ____

Plant/Redistribution Terminal Location ____

District Testing Engineer or ____

INDOT Audit Team Members

	Name	Position
1.	___________________________________	Geologist
2.	___________________________________	Area Supervisor
3.	___________________________________	Aggregate Technician
4.	___________________________________	_______________________________
5.	___________________________________	_______________________________
6.	___________________________________	_______________________________
7.	___________________________________	_______________________________

Plant/Redistribution Terminal Members

	Name	Position
1.	___________________________________	Certified Aggregate Technician
2.	___________________________________	_______________________________
3.	___________________________________	_______________________________
4.	___________________________________	_______________________________
5.	___________________________________	_______________________________

1. GENERAL INSTRUCTIONS

DTE

Certified Aggregate Producer Program (CAPP)
Quality Control Plan (QCP)
Certified Aggregate Technician (CAT)

Any square bracket marked by an X on the Audit Checklist requires a Corrective Action Sheet to be prepared. The Corrective Action Sheet will be prepared when a deficiency is found, and a copy given to the Producer by the end of the audit. All other square brackets shall have a check, if the item is satisfactory, or NA if not applicable.

Begin the audit by having all INDOT audit members review the QCP before arriving at the Producer's site. Likewise, checklists prepared during previous audits, especially the last one, will be reviewed. All members of the audit team should compare revision dates of each page to verify that their QCP includes all current addenda.

A listing of applicable INDOT documents and Indiana Test Methods are maintained in the CAPP Document List. The current revision date for each publication is provided in the list.

1.1 [ ] Area Supervisor or ______________________________ has listing of documents

The Addenda Summary Sheet and QCP Annex are required to be maintained in the QCP Appendix. Items on these two sheets should be reviewed and the Producer instructed that the necessary addenda for these items be submitted at the close-out meeting.

1.2 [ ]* Addenda Summary Sheet and QCP Annex reviewed

* Only if applicable

2. PRODUCTION FLOW DIAGRAM

ITM 211 Reference
14.2.10

Geologist or ______________________________

2.1 [ ] The Annual Aggregate Source Report for Stone Producers represents conditions found at source and as required by ITM 203

Review the diary and note locations where material has been extracted.

2.2 [ ] Locations noted in diary match areas that have been mined as shown on grid in the Annual Aggregate Source Report

Begin at the origin of the material, which is the quarry or the pit. Inspect the site and view the entire process tracing all information shown on the QCP flow diagram. Also, note any discrepancies of the production process with that shown or described in the QCP. End at the point of shipment.

The Producer will be reviewed for any deviations in the ledge processing or changes in the plant, including crushers, washers, bins, belt routes, screen combinations, delivery and off loading processes, etc. Specific details, such as manufacturers names, screen sizes, dimensions, etc., are not required on the flow diagram..

2.3 [ ] Plant in accordance with QCP
2.4 [ ] Changes noted in diary

Identify all material stockpiles and bins within Producer's yard.

2.5 [ ]* All stockpiles and bins have signs indicated in QCP
2.6 [ ]* Stockpile map is current and located as indicated in QCP
2.7 [ ] All material stockpiles and bins are listed as materials or otherwise accounted for in QCP
2.8 [ ]* Air-cooled blast furnace slag stockpiles designated for leachate testing are approximately 2000 tons
2.9 [ ]* Steel furnace slag stockpiles designated for deleterious testing are approximately 2000 tons

The QCP will cover any other process control techniques that will be used beyond the minimums established by INDOT specifications and policies.

2.10 [ ]* Other process control techniques are as defined in QCP

* Only if occurs

3. QUALITY CLASSIFICATIONS

ITM 211 References
14.2.3
14.2.4
14.2.8

Geologist or ______________________________

A list and description of all portions of the mineral deposits indicating the different quality classes as described in ITM 203, ITM 205, and ITM 210 will be provided in the QCP. The manner in which each quality class is processed, handled and stockpiled will be covered.

3.1 [ ] Each quality class is processed, handled and stockpiled in accordance with the QCP

An explanation for each product having marginal quality characteristics and the plans or controls to be used for such products shall be provided in the QCP.

3.2 [ ]* Each marginal quality class material is processed, handled and stockpiled in accordance with QCP

* Only If Producer has materials with marginal quality characteristics

4. MATERIALS

ITM 211 References
3.10
5.2

Geologist or ______________________________

If the Producer is a Redistribution Terminal, prior source documentation of a material obtained from another aggregate source shall be provided by the Producer.

4.1 [ ] Quality satisfactory as verified by being from a Certified Producer and a Certified Material, or traced to original INDOT approved source

The list of Certified Materials for the Producer shall be compared with the materials indicated in the QCP and the materials on site for Department use.

4.2 [ ] The list of Certified Materials is in accordance with the QCP.

If the source has yet to be CAPP approved, a list of products, ledges, if applicable, and source code numbers will be tabulated and included with the Audit Checklist

5. PRODUCER GENERAL INFORMATION

ITM 211 References
5.1
5.2
14.2.1

Area Supervisor or ______________________________

5.1 [ ] Plant location and address in QCP is correct
5.2 [ ] Plant telephone and FAX numbers in QCP are correct
5.3 [ ] Producers name and address in QCP are correct and ownership has not changed
5.4 [ ] Producers telephone and FAX numbers in QCP are correct
5.5 [ ] Key personnel contact information in QCP is correct. (Management Rep and CAT mobile numbers and email address.)
5.6 [ ] Type of Producer (plant, redistribution terminal, or plant & redistribution terminal) identified in QCP is correct

6. PRODUCER PERSONNEL

ITM 211 References
6.1
6.2
14.2.2

Area Supervisor or ______________________________

The Producer employees occupy the following positions.

6.1 [ ] Management Representative
6.2 [ ] CAT(s)
6.3 [ ] Appointed CAT(s) Certification has not expired
6.4 [ ] All personnel conducting sampling and testing for the CAPP are Qualified Technicians

7. DOCUMENTS <u>ITM 211 References</u> 2.5, 17.3

Area Supervisor or ________________________

Determine whether the following documents are current and on file at the Producer's site or location indicated in QCP. Check the CAPP Document List for the most current dates of these items.

7.1 [ ]* INDOT Certified Aggregate Producer Program (ITM 211)
7.2 [ ]* INDOT Standard Specification (Includes Supplemental Specifications sections 211, 301, 302, 303, 904 and 917)
7.3 [ ]* INDOT Inspection and Sampling Procedure for Fine And Coarse Aggregates
7.4 [ ]* Indiana Quality Assurance Certified Aggregate Technician Training Manual for Producer Technicians
7.5 [ ] Summary of Production Quality Test Results Letter, Summary of Ledge Quality Letter, and the AP Aggregate Approval Letter for all applicable materials produced at the Plant
7.6 [ ]* All applicable INDOT, AASHTO, and ASTM Test Methods **referenced in QCP**. The documents are in accordance with the CAPP Document List.

ITM 206 _____	AASHTO T 2 _____
ITM 207 _____	AASHTO T 11 _____
ITM 212 _____	AASHTO T 27 _____
ITM 219 _____	AASHTO T 84 _____
ITM 902 _____	AASHTO T 85 _____
ITM 906 _____	AASHTO T 112 _____
ITM 910 _____	AASHTO T 248 _____
______________	ASTM D 4791 _____
______________	ASTM D 5821 _____
______________	____________________

* May be maintained electronically or by hard copies.

Obtain weigh tickets for an active period of one week that represent material shipped for Department use. Check for accuracy and minimum requirements as follows:

7.7 [ ] Q number listed and is correct
7.8 [ ] Originating source name listed and is correct
7.9 [ ] Source number listed and is correct
7.10 [ ] Aggregate size listed
7.11 [ ] Ledges listed for stone product and they are correct

8. CONTROL CHARTS ITM 211 Reference

Area Supervisor or ________________________ 13.0

ALL CONTROL CHARTS

8.1 [ ] All materials identified as products in the QCP have a control chart which is posted (critical sieve or all sieves charted as required by CAPP)
8.2 [ ] Aggregate sizes are clearly shown on the charts
8.3 [ ] Control charts are maintained as indicated in the QCP
8.4 [ ] Control charts are generated electronically
8.5 [ ] Control charts are hand plotted

*Check the **critical sieve** material control charts for compliance with the QCP and ITM 211. Production and load-out charts (if load-out tests are plotted on a separate chart) are required to be checked.*

Target Mean

8.6 [ ] Values are the same as indicated in QCP
8.7 [ ] Numerically identified in left margin of charts or in accordance with QCP and indicated to the first decimal place (0.0)
8.8 [ ] Heavy long, then short dashed line or in accordance with QCP

Control Limits

8.9 [ ] Upper and lower control limits are the same as indicated in QCP
8.10 [ ] Numerically identified in left margin of charts or in accordance with QCP and indicated to the first decimal place (0.0) or whole number (0)

***Critical sieve** materials that have not obtained a minimum of 10 normal production tests are required to have the specification limits plotted for all sieves. For these materials, check the following:*

Specification Limits

8.11 [ ] Upper and lower limits indicated on all sieves
8.12 [ ] Values are the same as Section 904 for Standard Specification materials or as indicated in the QCP for QA materials
8.13 [ ] Short dashed lines or as indicated in QCP
8.14 [ ] Numerically identified in left margin or in accordance with QCP

*Check the **non-critical sieve** material control charts for compliance with the QCP and ITM 211. Production and load-out charts (if load-out tests are plotted on a separate chart) are required to be checked.*

8.15 [ ] Upper and lower limits indicated on all sieves
8.16 [ ] Values are the same as Section 904 for Standard Specification materials or as indicated in the QCP for QA materials
8.17 [ ] Short dashed lines or as indicated in QCP
8.18 [ ] Numerically identified in left margin or in accordance with QCP

CONTROL CHARTS (continued)

PRODUCTION CONTROL CHARTS WITH CRITICAL SIEVES

Select one ***Production*** *control chart for a material with a* ***critical sieve*** *and check for conformance with the following criteria. Mark the square bracket with a Q for any deviation from the CAPP that is in accordance with the QCP.*

Material selected was: ________________________

8.19 [ ] Maintained until 30 production points are plotted and the previous 30 points, if applicable, are displayed (Certified Producers only)
8.20 [ ] If in the Trial Phase, charts are maintained since entering into the Trial Phase
8.21 [ ] All charts retained at least 3 years for Certified Producers in CAPP > 3 Years

Production Test Results
8.22 [ ] Point surrounded by small circle and plotted to first decimal place (0.0)
8.23 [ ] Consecutive points connected by solid straight line

Moving Average of 5 Test Values
8.24 [ ] Point surrounded by small triangle
8.25 [ ] Consecutive points connected by solid straight line

Stockpile Load-Out Test Results
8.26 [ ] Production chart
8.27 [ ]* Separate chart
8.28 [ ] Point surrounded by small square

* If separate chart, complete stockpile load-out control chart checklist sheet for material with critical sieve

All Test Results
8.29 [ ] Points plotted left to right in chronological order
8.30 [ ] Test dates shown along horizontal axis

Obtain production test reports and load-out test reports (if plotted on same chart) to check for accuracy in reporting and plotting. For hand-plotted charts, check all tests during an active period of one week. For computer generated charts, check two randomly selected tests.

8.31 [ ] All test dates for points plotted on charts are the same as dates reported on test reports and in the daily diary
8.32 [ ] All points are plotted correctly
8.33 [ ] Five point moving average calculated and plotted correctly for two randomly selected points

Source # ___ ___ ___ ___ Page ___ of ___

INCLUDE THIS SHEET ONLY IF STOCKPILE LOAD-OUT IS PLOTTED ON SEPARATE CHART

CONTROL CHARTS (continued)

LOAD-OUT CONTROL CHARTS WITH CRITICAL SIEVES

*Select one stockpile **Load-Out** control chart for a material with a **critical sieve** and check for conformance with the following criteria.*

Material selected was: ________________________

8.34 [ ] Maintained until 30 points are plotted and the previous 30 points, if applicable, are displayed (Certified Producers only)
8.35 [ ] If in the Trial Phase, charts are maintained since entering into the Trial Phase
8.36 [ ] All charts retained at least 3 years for Certified Producers in CAPP > 3 Years

Stockpile Load-Out Test Results

8.37 [ ] Points surrounded by small squares and plotted to first decimal place (0.0)
8.38 [ ] Consecutive points connected by solid straight line

All Test Results

8.39 [ ] Points plotted left to right in chronological order
8.40 [ ] Test dates shown along horizontal axis

Obtain load-out test reports to check for accuracy in reporting and plotting. For hand-plotted charts, check all tests during an active period of one week. For computer generated charts, check two randomly selected tests.

8.41 [ ] All test dates for points plotted on charts are the same as dates reported on test reports and in the daily diary
8.42 [ ] All points are plotted correctly

CONTROL CHARTS (continued)

PRODUCTION CONTROL CHARTS WITH NO CRITICAL SIEVES

*Select one **Production** control chart for a material with **no critical sieve** and check for conformance with the following criteria. Mark the square bracket with a Q for any deviation from the CAPP that is in accordance with the QCP.*

Material with selected was: ________________________

8.43 [ ] Maintained until 30 production points are plotted and the previous 30 points, if applicable, are displayed (Certified Producers only)
8.44 [ ] If in the Trial Phase, charts are maintained since entering into the Trial Phase
8.45 [ ] All charts retained at least 3 years for Certified Producers in CAPP > 3 Years

Production Test Results

8.46 [ ] Point surrounded by small circle and plotted to first decimal place (0.0)
8.47 [ ] Consecutive points connected by solid straight line

Stockpile Load-Out Test Results

8.48 [ ] Production chart
8.49 [ ]* Separate chart
8.50 [ ] Point surrounded by small square

* If separate chart, complete stockpile load-out control chart checklist sheet for material with all sieves

All Test Results

8.51 [ ] Points plotted left to right in chronological order
8.52 [ ] Test dates shown along horizontal axis

Obtain production test reports and load-out test reports (if plotted on same chart) to check for accuracy in reporting and plotting. For hand-plotted charts, check all tests during an active period of one week. For computer generated charts, check two randomly selected tests.

8.53 [ ] All test dates for points plotted on charts are the same as dates reported on test reports and in the daily diary
8.54 [ ] All points are plotted correctly

INCLUDE THIS SHEET ONLY IF STOCKPILE LOAD-OUT IS PLOTTED ON SEPARATE CHART

CONTROL CHARTS (continued)

LOAD-OUT CHARTS WITH NO CRITICAL SIEVES

*Select one **Load-Out** control chart for a material with **no critical sieve** and requiring all sieves to be plotted.*

Material selected was: ________________________

8.55 [ ] Maintained until 30 points are plotted and the previous 30 points, if applicable, are displayed (Certified Producers only)
8.56 [ ] If in the Trial Phase, charts are maintained since entering into the Trial Phase
8.57 [ ] All charts retained at least 3 years for Certified Producers in CAPP > 3 years

<u>Stockpile Load-Out Test Results</u>

8.58 [ ] Point surrounded by small square and plotted to first decimal place (0.0)
8.59 [ ] Consecutive points connected by solid straight line

<u>All Test Results</u>

8.60 [ ] Point plotted left to right in chronological order
8.61 [ ] Test dates shown along horizontal axis

Obtain load-out test reports to check for accuracy in reporting and plotting. For hand-plotted charts, check all tests during an active period of one week. For computer generated charts, check two randomly selected tests.

8.62 [ ] All test dates for points plotted on charts are the same as dates reported on test reports and in the daily diary
8.63 [ ] All points are plotted correctly

COMPLIANCE RATE

Review the 30 most recent normal production tests in the current and previous year that are charted for each Standard Specification or Quality Assurance product controlled by a critical sieve. If 30 tests are not available, the number of tests taken shall be used with at least 10 tests required. For hand-plotted charts, calculate the test compliance rate using the Compliance Rate Worksheet for all materials. For computer generated charts, check the compliance rate for all materials and calculate the compliance rate for one material using the Compliance Rate Worksheet.

8.64 [ ] Compliance rate ≥ 95% for each material

8.65 [ ] *Compliance rate is < 95% and σ ≤ 5.0 for a material (The target mean is required to be adjusted by a QCP Annex)

8.66 [ ] *Compliance is < 95% and σ >5.0 for a material. (The stockpile is required to be designated as a non-Certified material)

**If the number of tests is less than 30, additional testing is required before the target mean is adjusted or the material is designated as a non-Certified material. An additional compliance rate check on the material is required after five additional tests have been taken.*

9. DIARY

ITM 211 References
10.0, 12.5, 12.7

Area Supervisor or ________________________

Select at random one active production month for review of the diary. The diary shall be in accordance with the following requirements, except where "only if occurs" is noted

Month Selected: _____________________________

9.1 [ ] Electronic and/or hard copy

9.2 [ ] One page for each day that there is a material related operation

9.3 [ ] General weather conditions

9.4 [ ] Areas of mining operation - ledges or pit area

9.5 [ ] Materials produced and estimated quantities

9.6 [ ] Materials sampled and tested

9.7 [ ] Time samples were obtained and tests completed (may state that all samples obtained were tested the same day)

9.8 [ ]** Changes in key personnel

9.9 [ ]** Significant changes in equipment, plant, screens, etc

9.10 [ ]** Significant events or problems

9.11 [ ]** Nonconforming trend in 5-point moving average of control chart (7 or more points in a row are above or below target mean, or 7 or more points in a row are increasing or decreasing)

9.12 [ ] Signature by CAT or other persons signature counter-signed by CAT

Any nonconforming normal production or load-out test shall be followed immediately by appropriate action. Search control charts for nonconforming tests. If nonconforming tests are found, review the diary on the date of each test for notations regarding action taken.

9.13 [ ] Nonconforming tests are noted in diary

9.14 [ ] Corrective action was taken

9.15 [ ]** After the second consecutive nonconforming normal production test, notations indicate that the material was isolated

9.16 [ ]** After the second consecutive nonconforming load-out test, notations indicate that shipping from the stockpile was stopped

** Only if occurs

10. SAMPLING AND TESTING

<u>ITM 211 References</u>
11.0, 14.2.6, 14.2.7, 14.2.8

Area Supervisor or ________________________

The method of recording the quantities of materials ***produced*** *at the Plant per day or time period will be identified in the QCP. Select an active one month period at random from this record. Obtain all production test reports for materials produced during the one month period. Perform calculations as needed and compare the quantities produced against the production test reports, thereby determining the demonstrated frequency of testing. The previous or subsequent monthly record may need to be obtained to verify the frequency of tests.*

10.1 [ ] Start of production frequency is in accordance with QCP, but is not less than once every 1000 t for the first 5000 t (except not required to exceed 2 per day)
10.2 [ ] Normal frequency is in accordance with QCP, but is not less than once every 2000 t (except not required to exceed 2 per day)

The method of recording the quantities of materials produced at the Plant that are ***shipped*** *per day or time period will be identified in the QCP. Select an active one month period at random from this record. Obtain all load-out test reports for materials shipped during the one month period. Perform calculations as needed and compare the quantities of materials shipped against the load-out test reports, thereby determining the demonstrated frequency of testing. The previous or subsequent monthly record may need to be obtained to verify the frequency of tests.*

10.3 [ ] Load-out frequency is in accordance with QCP, but is not less than once every 8000 t or at least one sample and test performed per month for shipments that exceed 1000 t for each Certified Material
10.4 [ ] All load-out samples for Standard Specifications and Quality Assurance aggregates were decanted and tests are within requirements

If material is obtained from another Certified Producer and is a Certified Material, then load-out tests are required. If the material is obtained from a non-Certified Producer or is not a Certified Material, then the start of production, normal production and load-out tests are required. Search the records for these materials, if applicable, and verify that the required tests have been conducted.

10.5 [ ] Load-out test conducted for Certified Material from another Producer
10.6 [ ] Start of production, normal production and load-out tests conducted for material that is not Certified and is received from another Producer

The Producer shall check coarse aggregates for deleterious materials. Select an active week randomly from the record for quantities of materials made and note all coarse aggregates produced. Find production test reports for that week and search for deleterious test results.

10.7 [ ] Start of production and normal production frequency is in accordance with QCP, but is not less than once per week for each size of Certified Material. (no test is required if the week's production is less than 100 t)
10.8 [ ] Tests are within requirements

SAMPLING AND TESTING (continued)

Select randomly three production test reports and two load-out test reports for any one product and check all calculations performed on the sheets. If test reports are electronic, check calculations on one production test report and one load-out test report.

Indicate type of Report; Electronic Reports: _______ Hand Calculated Reports:_______

10.9 [ ] Calculations on all sheets are correct and rounded to the nearest first decimal place (0.0) (crushed particle content values shall be rounded to the nearest whole number (0))

DECANTATION (AASHTO T 11)

$$\% \text{ Decant} = \frac{\text{Original Dry Weight} - \text{Dry Weight after Decant}}{\text{Original Dry Weight}} \times 100$$

GRADATION (AASHTO T 27)

$$\% \text{ Passing} = \frac{\text{Weight Passing Each Sieve}}{\text{Original Dry Sample Weight}} \times 100$$

CLAY LUMPS and FRIABLE PARTICLES (AASHTO T 112)

$$\% \text{ Clay or Friable} = \frac{\text{Dry Wt. of Sample} - \text{Dry Wt. Retained (Wet Sieving)}}{\text{Dry Wt. of Sample}} \times 100$$

NON-DURABLE MATERIALS (ITM 206)

$$\% \text{ Non-Durable} = \frac{\text{Weight of Non-Durable Matl. above 3/8 in. Sieve}}{\text{Weight of Sample above 3/8 in. Sieve}} \times 100$$

CHERT

For aggregate sizes 2 through 8, 43, 53, and 73:

$$\% \text{ Total Chert} = \frac{\text{Weight of Chert above the 3/8 in. Sieve}}{\text{Total Weight of Sample above the 3/8 in. Sieve}} \times 100$$

For aggregate sizes 9, 11, 12, and 91:

$$\% \text{ Total Chert} = \frac{\text{Weight of Chert above the No. 4 Sieve}}{\text{Total Weight of Sample above the No. 4 Sieve}} \times 100$$

CRUSHED PARTICLES (ASTM D 5821)

$$\% \text{ Crushed} = \frac{\text{Weight of Crushed Particles}}{\text{Weight of Crushed Particles} + \text{Weight of Uncrushed Particles}} \times 100$$

SAMPLING AND TESTING (continued)

Gravel shall be sampled and tested for the percentage of crushed coarse aggregate particles unless the QCP states otherwise. Select a week randomly from the record for quantities of products made, and note all coarse aggregates produced. Find the production test reports for that week and search for crushed particle test results.

10.10 [ ] Start of production and normal production frequency is in accordance with QCP, but is not less than once per week for each size of Certified Material. (no test is required if the week's production is less than 100 t)

10.11 [ ] Tests are within requirements for one and two face fractured particles

Air-Cooled Blast Furnace Slag, except for use in HMA or PCC, shall be sampled and tested for leachate in accordance with ITM 212. Select an active month randomly from the record for quantities made, and verify the frequency of testing.

10.12 [ ] The frequency of testing is in accordance with QCP, but is not less than once for each stockpile of approximately 2000 t

10.13 [ ] Tests are within requirements

Steel Furnace Slag shall be sampled and tested for determination of bulk specific gravity when this material is used in SMA mixtures. Select an active month of production of the steel slag and verify the frequency of testing and compliance with the specification requirements.

10.14 [ ] The frequency of testing is in accordance with QCP, but is not less than once every 2000 t.

10.15 [ ] Individual test results are within 0.050 of the target bulk specific gravity

10.16 [ ] The moving average of four consecutive test results is within 0.040 of the target bulk specific gravity

Steel Furnace Slag shall be sampled and tested for determination of deleterious when this material is used in HMA Base and Intermediate mixtures. Select an active month of production of the steel slag and verify the frequency of testing and compliance with the specification requirements.

10.17 [ ] The frequency of testing is in accordance with QCP, but is not less than once every 2000 t.

10.18 [ ] Individual test results are less than 4.0 % (Stockpiles not meeting this acceptance criteria may be tested again after 30 days from the test date)

SAMPLING AND TESTING (continued)

Source # ___ ___ ___ ___ Page ___ of ___

Composite stockpiling of natural sand fine aggregate from multiple sources into one stockpile may be done provided the fine aggregate is within a range of 0.10 for the bulk specific gravity (dry) and 1.0 % for the absorption for all of the contributing sources. Select an active month of composite stockpiling from the monthly summary reports, and verify the test results are within the bulk specific gravity (dry) and absorption requirements.

10.19 [ ] Bulk specific gravity (dry) test results of all contributing sources are within a range of 0.10.

10.20 [ ] Absorption test results of all contributing sources are within a range of 1.0%

Additional required testing as specified in source's QCP. Select an active month of production and verify the frequency is in accordance with the QCP. Type of test _________________________

10.21 [ ] Testing frequency meets the requirements of the QCP

10.22 [ ] Test results are in specification

10.23 [ ] Test results outside the specification are handled in accordance with the QCP.

11. PRODUCER YARDS

ITM 211 Reference 5.1

Area Supervisor or ________________________

If a source has Producer Yards, separate load-out charts are required to be maintained for the materials at these locations. Obtain the load-out charts and check the following:

11.1 [ ] All certified materials have a load-out chart

11.2 [ ] Aggregate sizes are clearly shown on the charts

11.3 [ ] Target means, control limits, and specification limits for all charts are in accordance with QCP

Obtain load-out test reports for one material during an active period of one week. Find the corresponding control chart and check the following:

11.4 [ ] All test dates have points plotted

11.5 [ ] Points surrounded by small square or in accordance with the QCP and plotted to the first decimal place (0.0)

11.6 [ ] All points plotted correctly

11.7 [ ] Consecutive points connected by solid straight line

Obtain all load-out test reports for materials shipped from the Producer Yard during a one month period. Perform calculations as needed and compare the quantities of materials shipped against the load-out test reports, thereby determining the demonstrated frequency of testing. The previous or subsequent monthly record may need to be obtained to verify the frequency of tests.

11.8 [ ] Load-out frequency is in accordance with QCP, but is not less than once every 8000 t or at least one sample and test performed per month for shipments that exceed 1000 t for each Certified Material

11.9 [ ] All load-out samples for Standard Specification and Quality Assurance aggregates were decanted and tests are within requirements

12. MATERIAL SAMPLES

ITM 211 References
11.0
14.2.10
14.2.11
15.7

Aggregate Technician or _________________________

Standard Specification and Quality Assurance materials under production at the site on the day of the audit will be reviewed by the audit team. At least one production sample of Standard Specification or Quality Assurance material shall be obtained.

The audit team will review the shipment records of the Standard Specification and Quality Assurance materials for the previous 6 months of production. A minimum of 3 load-out samples shall be obtained of the materials with the highest tonnages of shipment. Some producers may have less than 3 load-out samples to obtain.

The samples shall be obtained and split by the CAT. The INDOT audit team member shall be given the Department's portion of the samples and these samples will be tested.

Sampling shall be in accordance with the QCP and the following requirements verified.

12.1 [ ] Sample locations are as described or shown in QCP
12.2 [ ] Devices are as described in QCP
12.3 [ ] Techniques are as described in QCP
12.4 [ ] CAT obtained sample and performed split in accordance with CAPP

The following test results will be determined. A copy of all test reports from both the INDOT audit team member and the CAT will be attached to the audit checklist. The variation of test results will be shown in the remarks section of the INDOT audit team member's report for each material sampled and tested.

Standard Specification or Quality Assurance Materials

12.5 [ ] Producer's gradation is within control limits for critical sieve materials and within Specification Limits for all other sieves
12.6 [ ] Producer's gradation is within Specification Limits or QCP identified limits on all sieves for materials without a critical sieve
12.7 [ ] Producer's decant is within Specification Limits
12.8 [ ] Producer's deleterious content is within Specification Limits
12.9 [ ]* Producer's crushed particles are within Specification requirements
12.10 [ ] Test results variations are within CAPP guidelines

* Gravel Producers and Redistribution Terminal Producers handling gravel materials

13. LABORATORY

ITM 211 References
8.0
9.0

Aggregate Technician or ___________________

The laboratory will be inspected for compliance with the QCP.

13.1 [ ] Location as described and/or shown in QCP
13.2 [ ] Facility acceptable for testing of materials
13.3 [ ] All equipment listed in QCP at laboratory
13.4 [ ] All equipment apparently in good working order

Check the testing equipment verification records to verify that the documentation includes the following:

1. Description of equipment including Model or Serial Number, if applicable.
2. Name of person performing verification
3. Identification of verification equipment, if applicable
4. Date of verification and next due date
5. Reference of procedure used
6. Verification results

	DATE CALIBRATED/VERIFIED
13.5 [ ] Balance(s) -- 12 mo.	______________________________
13.6 [ ] Weights used, Min. Class 3 -- 12 mo.	______________________________
13.7 [ ] Mechanical Shaker(s) -- 12 mo.	______________________________
13.8 [ ] Sieves -- 12 mo.	______________________________

14. AUDIT CLOSE-OUT

DTE or Area Supervisor

When all the results from the audit have been accumulated, including Audit Checklist pages, INDOT test reports, Producer test reports, all Compliance rate worksheets, Corrective Action Sheet(s), and other documentation as may be appropriate, the District Testing Engineer and/or Area Supervisor shall review the documents to verify that they are prepared properly and are complete.

The Audit Close-Out meeting with the Producer will be conducted within 10 working days from the date of the audit. The District Testing Engineer and/or Area Supervisor will arrange and conduct the meeting with the Producer. The results of the audit will be discussed and all outstanding matters will be completely resolved, or solutions with deadlines will be established. Any addenda required by items listed on the Addenda Summary Sheet, QCP Annex, or Corrective Action Sheets shall be submitted at this time.

Upon completion of the Audit Close-Out meeting, all documents will be sent to the Geologist Supervisor, Office of Materials Management.

____ __________

DTE/Area Supervisor Signature Date

CAPP GRADATION WORKSHEET

SAMPLE ID______________________________________ DATE SAMPLED _____________

SAMPLE TYPE- PRODUCTION______ LOADOUT______ RERESAMPLE ______

MATERIAL SIZE _________________________________

SOURCE____ Q__________ LEDGES _______________

AASHTO T-27 SIEVE SIZE		LONG GR.WT. RETAINED	WEIGHT RETAINED	WEIGHT PASSING	INDOT % PASSING	PROD % PASSING	% DIFF	Tolerance (ITM 211)	PERCENT REQUIRED
2.5	63							5%	
2	50							5%	
1.5	37.5							5%	
1	25							5%	
3/4	19							5%	
1/2	12.5							5%	
3/8	9.5	PF-						5%	
4	4.75							3% *	
8	2.36							3% *	
16	1.18								
30	600								
50	300								
100	150								
200	75							0.5 or 1.0%	
PAN			*** The Maximum % difference for #43, #53 and #73 is 5%**						
		ORIGINAL	FINAL	GM LOSS	% LOSS				
DECANT								0.5 or 1.0%	
GRAMS LOST								<0.3	
LONG GRADED MATERIAL									
MINUS #4		SAMP SIZE	PROP. F						
TOTAL CHERT									
3/8" & UP		WEIGHT	INDOT %	PROD %				40% of the lowest value or 1%	
NON DURABLE									
3/8" & UP		WEIGHT	INDOT %	PROD %					
CRUSHED PARTICLES									
FACE	#4 & UP	CRUSHED	INDOT %	PROD %					
1								5%	
2								5%	

REMARKS:

TESTER SIGNATURE____ TEST DATE _____________

COMPLIANCE RATE WORKSHEET
(Critical Sieve Only)

SC # ________

Product ________________________ Critical Sieve ________ QCP Target Mean ___________

Record the most recent 30 normal production sample test results.

________	________	________	________	________	________
________	________	________	________	________	________
________	________	________	________	________	________
________	________	________	________	________	________
________	________	________	________	________	________

Calculate the following Statistics:

$\overline{x}$ = ______________ σ_{n-1} = _______________

$$Z_{max} = \frac{(\text{QCP Target Mean} + 10) - \overline{x}}{\sigma}$$

= __________________________ = __________

Z_{max} Area of Probability = ______________* x 100 = ________

$$Z_{min} = \frac{\overline{x} - (\text{QCP Target Mean} - 10)}{\sigma}$$

= __________________________ = __________

Z_{min} Area of Probability = ________________* x 100 = _________

% Compliance Σ = ________
(Whole No.)

* From Area of Probability Table

AREA OF PROBABILITY TABLE
FOR BOTH SPECIFICATIONS >0% AND <100%

When the z values to each limit are known, this table will indicate the area of probability between limits where summing the area left of the $\bar{x}$ with the area right of the $\bar{x}$. The sum of the 2 area factors should be multiplied by 100 to give the percent probability of compliance.

		.00	**.01**	**.02**	**.03**	**.04**	**.05**	**.06**	**.07**	**.08**	**.09**
0.0		0.0000	0.0040	0.0080	0.0120	0.0159	0.0199	0.0239	0.0279	0.0319	0.0359
0.1		0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2		0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3		0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4		0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5		0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6		0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2518	0.2549
0.7		0.2580	0.2612	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8		0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9		0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0		0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1		0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2		0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3		0.4032	0.4049	0.4066	0.4083	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4		0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5		0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4430	0.4441
1.6		0.4452	0.4463	0.4474	0.4485	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7		0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8		0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9		0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4758	0.4762	0.4767
2.0		0.4773	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1		0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2		0.4861	0.4865	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3		0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4		0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5		0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6		0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7		0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8		0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4980	0.4980	0.4981
2.9		0.4981	0.4982	0.4983	0.4984	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0		0.4986	0.4987	0.4987	0.4988	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990
3.1		0.4990	0.4991	0.4991	0.4991	0.4992	0.4992	0.4992	0.4992	0.4993	0.4993
3.2		0.4993									
3.3		0.4995									
3.4		0.4997									

EXAMPLE
COMPLIANCE RATE WORKSHEET
(Critical Sieve Only)

SC # **2799**

Product **#8 Stone** Critical Sieve **12.5 mm** QCP Target Mean **52.2**

Record the most recent 30 normal production sample test results.

55.5	**49.4**	**50.3**	**56.1**	**53.6**	**54.6**
51.2	**46.0**	**49.5**	**59.1**	**52.6**	**58.1**
53.2	**42.4**	**50.8**	**55.6**	**52.1**	**56.4**
56.4	**53.1**	**50.5**	**53.8**	**61.3**	**50.9**
54.2	**65.7**	**55.2**	**52.8**	**49.7**	**48.1**

Calculate the following Statistics:

$\bar{x}$ = **53.3** σ_{n-1} = **4.53**

$$Z_{max} = \frac{(\text{QCP Target Mean} + 10) - \bar{x}}{\sigma}$$

$$= \frac{(52.2 + 10) - 53.3}{4.53} = 1.96$$

Z_{max} Area of Probability = **.4750** * x 100 = **47.50**

$$Z_{min} = \frac{\bar{x} - (\text{QCP Target Mean} - 10)}{\sigma}$$

$$= \frac{53.3 - (52.2 - 10)}{4.53} = 2.45$$

Z_{min} Area of Probability = **.4929** * x 100 = **49.29**

% Compliance Σ = **97**
(Whole No.)

* From Area of Probability Table

CORRECTIVE ACTION SHEET

SOURCE # ___ ___ ___ ___

DATE ______________

ITEM ______________

Problem Explanation: ____

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Corrective Action To Be Taken Is: ____

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Deadline Date Is: __________________________

Follow-up **Date** ________________________

Finding: ____

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If NOT corrected, prepare another Corrective Action Sheet.

3/27/09

CERTIFIED AGGREGATE
PRODUCER PROGRAM
PARTIAL AUDIT CHECKLIST

Date ____________________ Page ___ of ___

Source No. _______________ **Q No.** _____________

Plant/Redistribution Terminal Name ____

Plant/Redistribution Terminal Location ____

INDOT Audit Team Members

	Name	Position
1.	________________________________	Geologist
2.	________________________________	Area Supervisor
3.	________________________________	Aggregate Technician
4.	________________________________	____________________________
5.	________________________________	____________________________

Plant/Redistribution Terminal Members

	Name	Position
1.	________________________________	Certified Aggregate Technician
2.	________________________________	___________________________
3.	________________________________	___________________________
4.	________________________________	___________________________
5.	________________________________	___________________________

1. **GENERAL INSTRUCTIONS**

Certified Aggregate Producer Program (CAPP)
Quality Control Plan (QCP)
Certified Aggregate Technician (CAT)

Any square bracket marked by an X on the Audit Checklist requires a Corrective Action Sheet to be prepared. The Corrective Action Sheet will be prepared when a deficiency is found, and a copy given to the Producer by the end of the audit. All other square brackets shall have a check, if the item is satisfactory, or NA if not applicable.

Begin the audit by reviewing the QCP before arriving at the Producer's site. Likewise, checklists prepared during previous audits, especially the last one, will be reviewed. An advance notification of one day will be given to the Producer of a scheduled partial audit. The audit will take place during a normal working day.

The Addenda Summary Sheet and QCP Annex, if applicable, are required to be maintained in the QCP Appendix.

1.1 [ ] Addenda Summary Sheet and QCP Annex reviewed

2. DIARY

ITM 211 References
10.0
12.5
12.7

Select at random one active production week for review of the diary. The diary shall be in accordance with the following requirements and information.

2.1 [ ] General weather conditions
2.2 [ ] Areas of mining operation - ledges or pit area
2.3 [ ] Materials produced and estimated quantities
2.4 [ ] Materials sampled and tested
2.5 [ ] Time samples were obtained and tests completed (may state that all samples obtained were tested the same day)
2.6 [ ]* Changes in key personnel
2.7 [ ]* Significant changes in equipment, plant, screens, etc
2.8 [ ]* Significant events or problems
2.9 [ ]* Nonconforming trend in 5-point moving average of control chart (7 or more points in a row are above or below target mean, or 7 or more points in a row are increasing or decreasing)
2.10 [ ] Signature by Certified Aggregate Technician
2.11 [ ]* Other persons signature -- counter-signed by Certified Aggregate Technician

Any nonconforming normal production or load-out test shall be followed immediately by corrective action. Search control charts for nonconforming tests for the week being reviewed. If nonconforming tests are found, review the diary on the date of each test for notations regarding action taken.

2.12 [ ] Nonconforming tests are noted in diary
2.13 [ ] Corrective action was taken
2.14 [ ]* After the second consecutive nonconforming normal production test, notations indicate that the material was isolated
2.15 [ ]* After the second consecutive nonconforming load-out test, notations indicate that shipping from the stockpile was stopped

* Only if occurs

3. SAMPLING AND TESTING

ITM 211 References
11.0, 14.2.6, 14.2.7, 14.2.8

The method of recording the quantities of materials ***produced*** *at the Plant per day or time period will be identified in the QCP. Select an active one week period at random from this record. Obtain all production test reports for materials produced during the one week period. Perform calculations as needed and compare the quantities produced against the production test reports, thereby determining the demonstrated frequency of testing. The previous or subsequent weekly record may need to be obtained to verify the frequency of tests.*

3.1 [ ] Start of production frequency is in accordance with QCP, but is not less than once every 1000 t for the first 5000 t (except not required to exceed 2 per day)
3.2 [ ] Normal frequency is in accordance with QCP, but is not less than once every 2000 t (except not required to exceed 2 per day)

The method of recording the quantities of materials produced at the Plant that are ***shipped*** *per day or time period will be identified in the QCP. Select an active one week period at random from this record. Obtain all load-out test reports for materials shipped during the one week period. Perform calculations as needed and compare the quantities of materials shipped against the load-out test reports, thereby determining the demonstrated frequency of testing. The previous or subsequent weekly record may need to be obtained to verify the frequency of tests.*

3.3 [ ] Load-out frequency is in accordance with QCP, but is not less than once every 8000 t or at least one sample and test performed per month for shipments that exceed 1000 t for each Certified Material

If material is obtained from another Certified Producer and is a Certified Material, then load-out tests are required. If the material is obtained from a Non-Certified Producer or is not a Certified Material, then the start of production, normal production and load-out tests are required. Search the one week period for these materials, if applicable, and verify that the required tests have been conducted.

3.4 [ ] Load-out test conducted for Certified Material from another Producer
3.5 [ ] Start of production, normal production and load-out tests conducted for material that is not Certified and is received from another Producer

Select randomly one production test report and one load-out test report for any one product and check all calculations performed on the sheets.

3.6 [ ] Calculations on all sheets are correct and rounded to the first decimal place (0.0) (crushed particle content values shall be rounded to the whole number (0))

SAMPLING AND TESTING (continued)

The Producer shall check coarse aggregates for deleterious materials. Search the production test reports for deleterious test results during the one week period.

3.7 [ ] Start of production and normal production frequency is in accordance with QCP, but is not less than once per week for each size of Certified Material. (no test is required if the weeks production is less than 100 t)

Gravel shall be sampled and tested for the percentage of crushed coarse aggregate particles unless the QCP states otherwise. Search the production test reports for crushed particle test results during the one week period.

3.8 [ ] Start of production and normal production frequency is in accordance with QCP, but is not less than once per week for each size of Certified Material. (no test is required if the weeks production is less than 100 t)

Air-Cooled Blast Furnace Slag, except for use in HMA or PCC, is required to be sampled and tested in accordance with ITM 212. Search the one week period for this material, if applicable, and verify that the required tests have been conducted.

3.9 [ ] Frequency is in accordance with QCP, but is not less than once for each 2000 t stockpile

Steel Furnace Slag shall be sampled and tested for determination of bulk specific gravity when this material is used in SMA mixtures. Select an active month of production of the steel slag and verify the frequency of testing and compliance with the specification requirements.

3.10 [ ] The frequency of testing is in accordance with QCP, but is not less than once every 2000 t.
3.11 [ ] Individual test results are within 0.050 of the target bulk specific gravity
3.12 [ ] The moving average of four consecutive test results is within 0.040 of the target bulk specific gravity

Steel Furnace Slag shall be sampled and tested for determination of deleterious when this material is used in HMA Base and Intermediate mixtures. Select an active month of production of the steel slag and verify the frequency of testing and compliance with the specification requirements.

3.13 [ ] The frequency of testing is in accordance with QCP, but is not less than once every 2000 t.
3.14 [ ] Individual test results are less than 4.0 % (Stockpiles not meeting this acceptance criteria may be tested again after 30 days from the test date)

4. MATERIAL

Obtain production and load-out test reports for one critical sieve material for the one week period. Find the corresponding control chart and check for the following.

Product with critical sieve selected was: ____________________________

4.1 [ ] All test dates have points plotted
4.2 [ ] All points are plotted correctly
4.3 [ ] Average of 5 test value points plotted correctly for one randomly selected point within the one-week period
4.4 [ ] Calculations for one selected test are correct

Obtain production and load-out test reports for one material not controlled by a critical sieve for the one week period. Find the corresponding control chart and check for the following:

4.5 [ ] All test dates have points plotted
4.6 [ ] All points are plotted correctly
4.7 [ ] Calculations for one selected test are correct

5. MATERIAL SAMPLES

ITM 211 References
11.0, 14.2.10, 14.2.11, 15.7

The Producer's Certified Technician shall obtain a minimum of one sample of a Standard Specification or Quality Assurance material under production at the site on the day of the audit. If there is no production then the sample(s) shall be obtained from an existing stockpile. The stockpile shall be selected by an INDOT audit team member.

The sample(s) obtained shall be split by the CAT. The INDOT audit team member shall be given the Department's portion of the sample(s) for testing.

Sampling and sample reduction procedures for the sample(s) obtained shall be observed to verify that they comply with the corresponding checklists or as stated in the QCP.

5.1 [ ] Stockpiling procedure is in accordance with QCP
5.2 [ ] Stockpiles are adequately spaced and not contaminated
5.3 [ ]* All stockpiles have signs as indicated in QCP
5.4 [ ] Air-cooled blast furnace slag stockpiles for leachate testing are approximately 2000 t in size
5.5 [ ]* Stockpile map is current and located as indicated in QCP
5.6 [ ] Sampling procedures are correct
5.7 [ ] Sampling reduction procedures are correct

* Only if occurs

MATERIAL SAMPLES (continued)

The following test results will be determined. A copy of all test reports from both the INDOT Technician and the CAT will be attached to the audit checklist. The variation of test results will be shown in the remarks section of the INDOT Technician's report. The allowable variation will be as follows:

Sieve Size	Maximum % Difference
1½ in. thru 3/8 in.	5
No. 4 thru No. 8	3
Minus No. 200 (Decant < 5.0)	0.5
Minus No. 200 (Decant ≥ 5.0)	1.0

Non-Durable, Total Chert	40% of lowest result or 1%, whichever is greater
Crushed Particles	5 (Both one and two face)

5.8 [ ] Gradation is within limits for critical sieve material
5.9 [ ] Gradation is within Specification Limits or QCP identified limits on all sieves for material without a critical sieve
5.10 [ ] Decant is within limits
5.11 [ ] Deleterious is within limits
5.12 [ ]* Crushed particles are within limits

* Gravel Producers and Redistribution Terminal Producers handling gravel materials

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6. DOCUMENTS

ITM 211 References
2.5

Determine whether the following documents are current and on file at the Producer's site or location indicated in QCP.

6.1 [ ] Summary of Production Quality Test Results Letter
6.2 [ ] AP Aggregate Approval Letter (if applicable)
6.3 [ ] Supplemental Specifications (sections 211, 301, 302, 303, 904 and 917)

Obtain weigh tickets for an active period of one week that represent material shipped for Department use. Check for accuracy and minimum requirements as follows:

6.4 [ ] Q number listed and is correct
6.5 [ ] Originating source name listed and is correct
6.6 [ ] Source number listed and is correct
6.7 [ ] Aggregate size listed
6.8 [ ] Ledges listed for stone product and they are correct

7. AUDIT CLOSE-OUT

The Audit Close-Out meeting with the Producer will be conducted at the completion of the audit. The results of the audit will be discussed, and all outstanding matters will be completely resolved or deficiencies requiring deadlines will be established. When the INDOT test results of the split samples are complete and results analyzed, an additional meeting with the Producer will be scheduled to review the results.

When all the results from the audit have been accumulated, including Audit Checklist pages, Sampling and Sample Reduction Checklists, INDOT test report, Corrective Action Sheet(s), and other documentation as may be appropriate, the Area Supervisor shall review the documents to verify that they are properly prepared and complete.

Upon completion of the Audit, all documents will be sent to the District Testing Engineer.

________________________________ __________
Aggregate Technician Date

SAMPLING STOCKPILED AGGREGATES
ITM 207

APPARATUS

[ ] Square-tipped shovel for coarse aggregate sampling. Shovel is required to be the size needed to obtain the minimum weight of material for the test conducted.

[ ] Fire shovel or sampling tube for fine aggregate sampling. Sampling tube is 3 in. minimum in diameter and 3 ft minimum in length.

[ ] Front-end loader

PROCEDURE

Stockpile Construction

[ ] Front-end loader obtains material from stockpile in same manner as loading truck

[ ] When forming a small pile the loader bucket is as low as possible and material is rolled from bucket

[ ] Each bucket of material is taken and dumped in the same manner and placed uniformly over the preceding one

[ ] Sample stockpile is 10 to 15 t

Mixing

[ ] Loader bucket begins mixing at end of oblong pile

[ ] Loader bucket is as low as possible and pushed into the material until front of bucket is past the midpoint

[ ] Loader bucket is then slowly raised and rolled forward

[ ] Mixing procedure is repeated at the opposite end of pile

Sampling

[ ] Sample locations are approximately one-third of the height of the pile

[ ] At least 6 full shovels or sampling tubes of material taken at equal increments around the pile

[ ] When shovel is used, the shovel is inserted full-depth horizontally into the material and then raised vertically

NA - Not Applicable
X - Requires Corrective Action
√ - Satisfactory

____
Acceptance Technician

____ __________
INDOT Date

Comments: ____

SAMPLE REDUCTION
OF
AGGREGATE SAMPLES
AASHTO T 248

APPARATUS

- [ ] Sample splitter, open or closed type, with an even number of equal width chutes, but not less than eight. The minimum width of individual chutes shall be approximately two times larger than largest particles in sample. Bar openings of 3 in. or 6 bars wide may be used for all coarse aggregates No. 5 or smaller. (Coarse Aggregate and Mixed Aggregate)
- [ ] Sample splitter with an even number of equal width chutes, but not less than twelve. Individual chutes shall be 1/2 in. to 3/4 in. wide. (Dry Fine Aggregate)
- [ ] Straight-edge scoop, shovel, or trowel; a broom or brush; and a canvas blanket approximately 6 x 8 ft for quartering
- [ ] Straight-edge scoop, shovel, or trowel for mixing the aggregate, and either small sampling thief, small scoop, or spoon for miniature stockpile sampling

PROCEDURE

Method A - Mechanical Splitter (Coarse Aggregate No. 5 or Smaller and Fine Aggregate Drier than SSD Condition)

- [ ] Material uniformly distributed from edge to edge
- [ ] Material allowed to free fall through the splitter. For a splitter with mechanical hopper, the hopper is opened fully.
- [ ] Wet particles stuck to inside of splitter are removed by gently tapping the splitter with a rubber hammer (only if occurs)
- [ ] Procedure repeated

Method B – Quartering (Highly Moistened Compacted Aggregate)

- [ ] Sample placed on hard, clean, level surface
- [ ] Sample mixed by turning the entire sample over three times
- [ ] Sample shoveled into conical pile depositing each shovelful on top of preceding one
- [ ] Sample flattened to uniform thickness by pressing down apex with shovel
- [ ] Sample diameter approximately four to eight times the thickness
- [ ] Sample divided into four equal parts with shovel or trowel
- [ ] Two diagonally opposite quarters removed, including all fine material by brush
- [ ] Sample remixed and quartered, using above-noted procedure, until desired size obtained

Method C - Miniature Stockpile Sample (Fine Aggregate with Free Moisture on Particle Surfaces)

[ ] Sample placed on hard, clean, level surface
[ ] Sample mixed by turning entire sample over three times
[ ] Sample shoveled into conical pile by depositing each shovelful on top of preceding one
[ ] Sample flattened to uniform thickness by pressing down apex with shovel (only if done)
[ ] Sample obtained by selecting at least five increments of material at random locations from the miniature stockpile with sampling thief, scoop, or spoon

NA - Not Applicable
X - Requires Corrective Action
√ - Satisfactory

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Acceptance Technician

____ ___________
INDOT Date

Comments: ____

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CORRECTIVE ACTION SHEET

SOURCE # ____ ____ ____ ____

DATE ________________

ITEM ________________

Problem Explanation:____

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Corrective Action To Be Taken Is:____

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Deadline Date Is: _________________________

Follow-up **Date ___________________________**

Finding:____

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If NOT corrected, prepare another Corrective Action Sheet.

SAMPLING STOCKPILED AGGREGATES
ITM 207

APPARATUS

[ ] Square-tipped shovel for coarse aggregate sampling. Shovel is required to be the size needed to obtain the minimum weight of material for the test conducted.
[ ] Fire shovel or sampling tube for fine aggregate sampling. Sampling tube is 3 in. minimum in diameter and 3 ft minimum in length.
[ ] Front-end loader

PROCEDURE

Stockpile Construction

[ ] Front-end loader obtains material from stockpile in same manner as loading truck
[ ] When forming a small pile the loader bucket is as low as possible and material is rolled from bucket
[ ] Each bucket of material is taken and dumped in the same manner and placed uniformly over the preceding one
[ ] Sample stockpile is 10 to 15 t

Mixing

[ ] Loader bucket begins mixing at end of oblong pile
[ ] Loader bucket is as low as possible and pushed into the material until front of bucket is past the midpoint
[ ] Loader bucket is then slowly raised and rolled forward
[ ] Mixing procedure is repeated at the opposite end of pile

Sampling

[ ] Sample locations are approximately one-third of the height of the pile
[ ] At least 6 full shovels or sampling tubes of material taken at equal increments around the pile
[ ] When shovel is used, the shovel is inserted full-depth horizontally into the material and then raised vertically

NA - Not Applicable
X - Requires Corrective Action
√ - Satisfactory

____
Acceptance Technician

____ ____________
INDOT Date

Comments: ____

10/1/00

SAMPLING BLENDED AGGREGATE

APPARATUS

[ ] Templates conforming to shape of belt
[ ] Sampling device for belt discharge
[ ] Sampling device for bins

PROCEDURE

Conveyor Belt (AASHTO T 2)

[ ] Material between templates is scooped into suitable container
[ ] Fines on belt are removed with brush and dust pan and added to container
[ ] Procedure in accordance with QCP

Belt Discharge

[ ] Material taken from entire cross section as being discharged
[ ] Procedure in accordance with QCP

Bins

[ ] Material taken from entire cross section as being discharged
[ ] Each bin containing material is sampled
[ ] Procedure in accordance with QCP

NA - Not Applicable
X - Requires Corrective Action
√ - Satisfactory

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Acceptance Technician

____ ____________
INDOT Date

Comments ____

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SAMPLE REDUCTION OF AGGREGATE SAMPLES AASHTO R 76

APPARATUS

[ ] Sample splitter, open or closed type, with an even number of equal width chutes, but not less than eight. The minimum width of individual chutes shall be approximately two times larger than largest particles in sample. Bar openings of 3 in. or 6 bars wide may be used for all coarse aggregates No. 5 or smaller. (Coarse Aggregate and Mixed Aggregate)

[ ] Sample splitter with an even number of equal width chutes, but not less than twelve. Individual chutes shall be 1/2 in. to 3/4 in. wide. (Dry Fine Aggregate)

[ ] Straight-edge scoop, shovel, or trowel; a broom or brush; and a canvas blanket approximately 6 x 8 ft for quartering

[ ] Straight-edge scoop, shovel, or trowel for mixing the aggregate, and either small sampling thief, small scoop, or spoon for miniature stockpile sampling

PROCEDURE

Method A - Mechanical Splitter (Coarse Aggregate No. 5 or Smaller, Fine Aggregate Drier than SSD Condition, and Dry Compacted Aggregate)

[ ] Compacted aggregate sample readily crumbles when squeezed in palm of hand

[ ] Material uniformly distributed from edge to edge

[ ] Material allowed to free fall through the splitter. For a splitter with mechanical hopper, the hopper is opened fully.

[ ] Wet particles stuck to inside of splitter are removed by gently tapping the splitter with a rubber hammer (only if occurs)

[ ] Procedure repeated

Method B – Quartering (Highly Moistened Compacted Aggregate)

[ ] Sample placed on hard, clean, level surface

[ ] Sample mixed by turning the entire sample over at least three times

[ ] Sample shoveled into conical pile depositing each shovelful on top of preceding one

[ ] Sample flattened to uniform thickness by pressing down apex with shovel

[ ] Sample diameter approximately four to eight times the thickness

[ ] Sample divided into four equal parts with shovel or trowel

[ ] Two diagonally opposite quarters removed, including all fine material by brush

[ ] Sample remixed and quartered, using above-noted procedure, until desired size obtained

Method C - Miniature Stockpile Sample (Fine Aggregate with Free Moisture on Particle Surfaces)

[ ] Sample placed on hard, clean, level surface
[ ] Sample mixed by turning entire sample over three times
[ ] Sample shoveled into conical pile by depositing each shovelful on top of preceding one
[ ] Sample flattened to uniform thickness by pressing down apex with shovel (only if done)
[ ] Sample obtained by selecting at least five increments of material at random locations from the miniature stockpile with sampling thief, scoop, or spoon

NA - Not Applicable
X - Requires Corrective Action
√ - Satisfactory

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Acceptance Technician

____ __________
INDOT Date

Comments: ____

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MATERIALS FINER THAN No. 200 SIEVE IN MINERAL AGGREGATE BY WASHING AASHTO T 11

APPARATUS

[ ] Balance, sufficient capacity for sample, readable to 0.1 g or better, in accordance with AASHTO M 231
[ ] Sieves
  [ ] Lower Sieve -- No. 200
  [ ] Upper Sieve -- Range of No. 8 to No. 16
[ ] Container of sufficient size to contain sample and permit vigorous agitation without loss of sample or water
[ ] Oven maintained at 230 ± 9°F
[} Electric hot plate or gas stove
[ ] Spoon or trowel
[ ] Mechanical apparatus (optional)

PROCEDURE

[ ] Sample to be tested for gradation in accordance with AASHTO T 27
[ ] Weight of sample if not tested for gradation is as follows:

Nominal Maximum Aggregate Size *	Minimum Weight of Sample, g
No. 4 or smaller	300
3/8 in.	1000
3/4 in.	2500
1 1/2 in.	5000

* If the nominal maximum size of aggregate is not listed, the next larger size shall be used to determine the size of sample.

[ ] Sample dried to constant weight at 230 ± 9°F

Note 1: Constant weight is defined as the weight at which further drying at the required drying temperature does not alter the weight by more than 0.1 percent

[ ] Weight of sample determined to the nearest 0.1 % of the weight of the test sample
[ ] Sample placed in container and covered with water (A wetting agent may be added at this time)
[ ] Sample agitated sufficiently to separate particles finer than No. 200 sieve from coarser particles

[ ] Wash water poured over nested sieves
[ ] Procedure repeated until wash water is clear
[ ] Material retained on nested sieves flushed to washed sample
[ ] Washed aggregate dried to constant weight at 230 ± 9°F
[ ] Weight of sample determined to the nearest 0.1% of the weight of the test sample

CALCULATIONS

[ ] Amount of material passing a No. 200 sieve by washing is calculated correctly to 0.1% as follows:

$$A = \frac{B - C}{B} \times 100$$

where:

A = percentage of material finer than No. 200 sieve by washing
B = original dry weight of sample, g
C = dry weight of sample after washing, g

NA - Not Applicable
X - Requires Corrective Action
√ - Satisfactory

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INDOT Date

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SIEVE ANALYSIS
OF
FINE AND COARSE AGGREGATE
AASHTO T 27

APPARATUS

[ ] Balance, sufficient capacity for sample, readable to 0.1 g or better, in accordance with AASHTO M 231
[ ] Sieves
[ ] Mechanical Sieve Shaker (optional)
[ ] Oven maintained at 230 ± 9°F
[ ] Electric hot plate or gas stove

PROCEDURE

[ ] Weight of sample is as follows. (samples larger than capacity of balance may be divided into suitable increments, tested, and the results combined)

Aggregate	Minimum Weight, g	Maximum Weight, g
Fine Aggregates	300	---
Coarse Aggregates *		
No. 2	11300	---
No.5	6000	8000
No.8	6000	8000
No. 9	4000	6000
No. 11	2000	---
No. 12	1000	---
No. 43	6000	8000
No. 53	6000	8000
No. 73	6000	8000
No. 91	6000	8000
Structural Backfill		
No. 30	300	---
No. 4	300	---
1/2 in.	4000	6000
1 in.	4000	6000
1 1/2 in.	4000	6000
2 in.	4000	6000
B Borrow	4000	6000

* Coarse aggregates other than sizes listed shall have a minimum weight in accordance with the Certified Aggregate Producer Quality Control Plan

[ ] Sample dried to constant weight (Note 1) at 230 ± 9°F in oven or by hot plate
[ ] Weight of sample determined to nearest 0.1% of the total original dry sample weight

Note 1 -- Constant weight is defined as the weight at which further drying at the required drying temperature does not alter the weight by more than 0.1 percent

[ ] Sample sieved for the time determined in accordance with ITM 906
Minimum times are as follows:

Aggregate	Sieving Time, min.
Fine Aggregates	15
Coarse Aggregate size No. 9 or larger	5
Coarse Aggregate smaller than size No. 9	10
Structure Backfill sizes No. 30 and No. 4	15
Structure Backfill sizes 1/2 in., 1 in., 1 1/2 in., and 2 in.	5

[ ] If hand sieving, particles not forced to pass through opening
[ ] Aggregate on each sieve weighed to 0.1% of total original dry sample weight
[ ] Weight of aggregate on each sieve not greater than weight indicated in Table 1
[ ] The difference between the original dry weight and the sum of all the fractional weights retained (including the material in the pan) and the weight of material removed by decantation, if applicable, is equal to or less than 0.3 percent

$$\frac{\text{Original Dry Weight - Summation of Weights Measured}}{\text{Original Dry Weight}} \times 100 \leq 0.3\,\%$$

[ ] Percent passing each sieve is calculated to nearest 0.1% based on or iginal dry sample weight

NA - Not Applicable
X - Requires Corrective Action
√ - Satisfactory

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TABLE 1 APPROXIMATED SIEVE OVERLOAD				
Screen Size	**Standard 15 in. x 23 in.**	**Standard 14 in. x 14 in.**	**12 in. Diameter**	**8 in. Diameter**
3 in.	40.5 kg	23.0 kg	12.6 kg	-------------
2 in.	27.0 kg	15.3 kg	8.4 kg	3.6 kg
1-1/2 in.	20.2 kg	11.5 kg	6.3 kg	2.7 kg
1 in.	13.5 kg	7.7 kg	4.2 kg	1.8 kg
3/4 in.	10.2 kg	5.8 kg	3.2 kg	1.4 kg
1/2 in.	6.7 kg	3.8 kg	2.1 kg	890 g
3/8 in.	5.1 kg	2.9 kg	1.6 kg	670 g
No. 4	2.6 kg	1.5 kg	800 g	330 g
8 in. diameter sieves, No. 8 to No. 200, shall not exceed 200g / sieve				
12 in. diameter sieves, No. 8 to No. 200, shall not exceed 469g / sieve				

CLAY LUMPS and FRIABLE PARTICLES IN AGGREGATE AASHTO T 112

APPARATUS

[ ] Balance, sufficient capacity for sample, readable to 0.1 g or better, in accordance with AASHTO M 231
[ ] Container that is rust-resistant and of a size and shape that will permit the spreading of the sample on the bottom in a thin layer
[ ] Sieves
[ ] Oven maintained at 230 ± 9°F

PROCEDURE

[ ] Weight of sample as follows:

Size of Particles Making up Test Sample	Weight of Test Sample, g
No. 4 to 3/8 in.	1000
3/8 in. to 3/4 in.	2000
3/4 in. 1 1/2 in.	3000
Over 1 1/2 in.	5000

[ ] Sample decanted in accordance with AASHTO T 11
[ ] Weight of sample determined
[ ] Sample spread on bottom of container and covered with distilled water
[ ] Sample soaked for 24 ± 4 h
[ ] Particles rolled and squeezed individually between thumb and forefinger
[ ] Broken particles separated from remainder of sample by wet sieving over sieve in following table while manually agitating the sieve, until all undersize material has been removed

Size of Particles Making up Test Sample	Sieve Size
No. 4 to 3/8 in.	No. 8
3/8 in. to 3/4 in.	No. 4
3/4 in. 1 1/2 in.	No. 4
Over 1 1/2 in.	No. 4

[ ] Retained particles dried to constant weight at 230 ± 9°F
[ ] Weight of sample determined

CALCULATIONS

[ ] Percent of clay lumps and friable particles in individual sizes of coarse aggregate calculated correctly to 0.1% as follows:

$$P = \frac{W - R}{W} \times 100$$

where:

P = percent of clay lumps and friable particles
W = weight of test sample
R = weight of particles retained on designated sieve

[ ] Total percent of clay lumps and friable particles weighted average of individual sizes of coarse aggregate

NA - Not Applicable
X - Requires Corrective Action
√ - Satisfactory

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FRACTURED PARTICLES IN COARSE AGGREGATES ASTM D 5821

APPARATUS

[ ] Balance, sufficient capacity for sample, readable to 0.1 g or better, in accordance with AASHTO M 231
[ ] Sieves

PROCEDURE

[ ] Sample dried to obtain a clean separation of fine and coarse material
[ ] Dried sample sieved over No. 4 sieve
[ ] Sample reduced using a splitter to required size (only if required)
[ ] Weight of sample at least large enough so that largest particle is not more than 1 % of sample weight or at least as large as indicated below, whichever is smaller

Nominal Maximum Aggregate Size	Minimum Weight of Sample, g
3/8 in.	200
1/2 in.	500
3/4 in.	1500
1 in.	3000
1 1/2 in.	7500

[ ] Aggregate with nominal maximum size of 3/4 in. or larger separated on 3/8 in. sieve and weighted average calculated (optional)
[ ] Sample washed over No. 4 sieve, dried to constant weight (Note 1), and weight recorded
[ ] Particles with at least one fractured face separated, and weight recorded
[ ]* Particles with at least two fractured faces separated, and weight recorded
[ ] Particles not meeting fractured particle criteria separated, and weight recorded

Note 1 -- Constant weight is defined as the weight at which further drying at the required drying temperature does not alter the weight by more than 0.05 percent

* Only if specification requirement for two faces

CALCULATIONS

[ ] Fractured particles calculated correctly to 0.1% as follows:

$$\text{Fractured Particles, \%} = \frac{F}{F + N} \times 100$$

where:

F = weight of fractured particles with at least specified number of fractured faces, g

N = weight of particles in uncrushed category not meeting fractured particle criteria, g

NA - Not Applicable
X - Requires Corrective Action
√ - Satisfactory

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SCRATCH HARDNESS
OF
COARSE AGGREGATE PARTICLES
ITM 206

APPARATUS

[ ] Brass rod, 1/16 in. in diameter, with a rounded point capable of scratching a penny but failing to scratch a nickel
[ ] Mounting device for brass rod

PROCEDURE

[ ] Gravel only
[ ] Sample retained on 3/8 in. sieve
[ ] Each particle subjected to scratching motion of brass rod using a pressure of 2 lbf
[ ] Particle classified as soft if one third or more of the volume of the particle has a groove in it without deposition of metal from brass rod or if separate particles are easily detached from mass

CALCULATIONS

[ ] Percent of soft particles calculated correctly to 0.1% as follows:

$$P = \frac{W - S}{W} \text{ x } 100$$

where:

P = percent of soft particles
W = weight of test sample
S = weight of sample that is <u>not</u> classified as soft

NA - Not Applicable
X - Requires Corrective Action
√ - Satisfactory

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