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The SHRP Materials Reference Library

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Abstract

This report contains information about the materials collected and stored at the Materials Reference Library of SHRP. These materials were selected for use by the Asphalt Research Program Contractors and other SHRP researchers. The report provides a general description of all the MRL materials and includes details regarding the selection, properties, procurement, storage, and processing of these materials.

Executive Summary

The Materials Reference Library (MRL) was initially intended to serve as a holding facility for asphalt cements and aggregates selected for use by the Asphalt Research Program (ARP) of SHRP. A total of 30 asphalt cements and ten aggregates were to be stored at the MRL. That number was increased to 32 asphalts, 11 aggregates and 82 asphalt modifiers, in addition to loose materials and post construction cores from numerous other projects in North America and overseas. Some of these materials were not initially scheduled for use in Strategic Highway Research Program (SHRP) projects but were sampled at the request of the Asphalt Research Program researchers for use in their research activities, and the others were sampled for possible future use by other researchers. A complete listing of all the materials stored at the MRL is included in Appendix B.

Of the thirty-two asphalt cements selected, eight were designated as "core" asphalts and were to be used by all ARP researchers. One thousand gallons of the paving grade of each of the thirty two asphalts were sampled for the MRL. For the core asphalts, an additional three hundred gallons of a softer grade to be used in modifier research were also collected. All the samples were taken in five gallon, epoxy lined metal pails with tightly fitting lids.

For each aggregate, approximately thirty tons of production material were sampled in fifty-five gallon plastic barrels. Similar to the core asphalts, four aggregates were selected as "core" aggregates. Several asphalts and aggregates had to be re-sampled during the project to maintain the required holdings at the MRL.

The modifiers were shipped to the MRL in various quantities and containers by the manufacturers. In all, eighty-two different modifiers in eight categories were received at the MRL.

All the asphalts, aggregates, and modifiers were assigned codes by the A-001 contractor to protect the confidentiality of the sources.

Small quantities of all the MRL asphalts were sent to two independent laboratories for determination of their basic properties. For the aggregates, the two agencies determined the Physical, Chemical and Petrographic properties of the MRL aggregates. One agency tested only the four core aggregates.

MRL materials were shipped to researchers by written request. Research organizations not affiliated with SHRP were required to seek approval from SHRP Headquarters prior to obtaining MRL materials.

The sampling and collection of loose materials from the SPS sites in the Long Term Pavement Performance (LTPP) program will continue until the supply of containers at the MRL is depleted or until the A-001 Contract expires on March 31, 1993, whichever comes first.

As to the future of the MRL beyond SHRP, it appears that the Federal Highway Administration (FHWA) is planning on operating the MRL as of April 1993. The function and the role of the MRL under FHWA control remains unclear at this time, but one positive outcome is that researchers will have access to MRL materials after SHRP ends in March 1993.

Chapter 1 Introduction

In 1987 the University of Texas at Austin was awarded a research contract by the Strategic Highway Research Program (SHRP), which is a unit of the National Research Council, to act as the Technical Assistance Contractor for the SHRP Asphalt Research Program. As part of its contract, the University of Texas was required to establish and operate a Materials Reference Library (MRL) which contained asphalts, aggregates and modifiers to be used by all contractors performing experiments in the SHRP Asphalt Program. Using the same materials from the same sources was essential in order to compare experimental data from numerous researchers, verify results, and reduce the number of variables to be considered when analyzing the experimental data produced using a wide variety of materials.

The MRL facilities are located in Austin, Texas. A total of 32 asphalts, 11 aggregates, and 82 modifiers were sampled and made available for the use of all the asphalt program contractors. In addition, a number of other materials, including pavement cores, special asphalts, and aggregates, have been obtained and stored at the MRL. The role of the MRL, since its beginning has gradually expanded from a support facility for the SHRP Asphalt Research Program materials to provide a repository for samples and specimens for the SHRP Long Term Pavement Performance (LTPP) program.

The additional materials stored at the MRL include small quantities of special request materials by the asphalt research contractors. LTPP materials, include 1) asphalt cores and loose pavement materials from Specific Pavement Study Sections (SPS); 2) 12 inch cores from General Pavement Study (GPS) sections, 3) asphalt cements to be tested for verification of the performance-based asphalt binder specifications developed by the Asphalt Research Program; and 4) Special RAP and aggregates requested by ARP contractors to complete their area of research.

The following chapters describe, in detail, the material selection, procurement, and shipment processes. Data reported on the basic properties of the MRL asphalts and aggregates from several different organizations are included in appendix A.

Chapter 2 Material Selection Process

Asphalts

The basic premise of the selection process was that the performance of asphalt pavements is directly influenced by the physicochemical properties of asphalt cement. Thus, asphalt cements were deliberately chosen to create an MRL containing currently available asphalt cements representing a wide range of field performance histories, crude oil sources, refinery practices, and physical and chemical properties.

Thirty-two asphalt cements were selected, sampled, and stored by the University of Texas at Austin for detailed analysis and evaluation during the SHRP Asphalt Research Program (ARP). The selection of the asphalt cements took place in three phases:

- eight initial or core asphalts - Phase I;
- fourteen additional asphalts - Phase II; and
- ten final asphalts - Phase III.

PHASE I involved the selection of eight initial asphalts that represent a common set of core asphalts to be tested by all contractors. An attempt was made to obtain asphalts produced by a straight run distillation process from a single source crude oil in order to minimize the number of variables. More importantly, however, was the need to have asphalts that exhibited a wide range of field performance and physicochemical characteristics.

Two grades of these eight core asphalts were sampled, a normal paving grade for the locale where the refinery was located, as well as a softer grade which could be used in the asphalt modification portion of the ARP.

PHASE II involved the identification of fourteen additional asphalts with a range of physicochemical properties, crude oil sources, refinery processes, and performance histories. Information developed in the Refinery Survey conducted by the A-001 Contract was used extensively in the selection of these fourteen asphalts.

PHASE II extended the matrix of performance and physicochemical properties found in the core asphalts and included additional asphalts produced by solvent refinery processes in order to evaluate the effect of different refinery techniques.

In the selection of both Phase I and II asphalts, plots of temperature susceptibility versus aging index were used to ensure that a broad range of asphalts were represented. Figure 1 is a plot of temperature susceptibility versus aging index for many of the crude oil sources available to refineries in the United States and Canada.

PHASE III involved the selection of the final ten asphalts. Gaps in asphalt properties or performance histories identified by the initial research data developed by the A-002A and A-003A Contracts of the SHRP Asphalt Program had a strong influence on the selection of the final ten asphalts. In addition, data developed for the previously sampled MRL asphalts and the Refinery Survey were utilized. Thus, the PHASE III asphalt selection criteria were focussed on the completeness of the Phase I and II selection process.

In the process of selecting the thirty two asphalts, an attempt was made to characterize the various asphalts as good or poor performers based on the perceived performance in these studies or in normal field use. The distress related performance factors considered, which are the focus of the entire SHRP Asphalt Research Program, were the following:

- thermal cracking;
- fatigue cracking;
- permanent deformation (rutting);
- adhesion and water sensitivity; and
- aging.

An evaluation of the performance-related physical and chemical properties was undertaken as a secondary means of selecting asphalts with the widest possible range of performance levels.

Because of the difficulty of classifying all asphalts with respect to performance and the lack of information related to distress factors and performance, some asphalts were selected based on crude oil source and the physicochemical properties of these crude oils and asphalt cements produced from them.

The properties of asphalts manufactured from numerous domestic and imported crude oil sources were determined and their performance estimated and then evaluated. Particular attention was given to those crude oils that are major contributors to the North American asphalt supply. It was recognized that since a crude oil may contain petroleum recovered from numerous wells within a field, the asphalt properties from a single-source crude are not necessarily uniform. Still, there are several well known single-source asphalts which have been extensively evaluated in test roads and laboratory studies. Some of them are still available and are expected to be available for future use. These single crude sources include Boscan, California Coastal, California Valley (San Joaquin Valley), and Lloydminster.

Additionally, it is recognized that asphalt chemistry, or composition, determines the physical properties and the ultimate field performance of asphalt, but there are few wellestablished and accepted relationships between asphalt chemistry and pavement performance.

The sulfur, nitrogen, and metal content were used to evaluate crude oil sources and were considered in the asphalt selection process as were performance related physical properties such as temperature susceptibility, and aging.

It has been hypothesized that temperature susceptibility is indicative of thermal cracking and permanent deformation. Temperature susceptibility was evaluated using the penetration-viscosity number (PVN) which is an estimate of the slope of the temperature-viscosity relationship using the penetration at 77° F (25° C) and viscosity at 140° F (60° C). Asphalts typically have PVN values ranging from +0.5 to -3.0. A low PVN, e.g. -2.0, indicates a very temperature susceptible asphalt.

Aging characteristics were evaluated in terms of the aging index, which is the viscosity (140° F) after laboratory aging using the thin film oven test (TFOT) divided by the original viscosity of the asphalt cement. A high aging index number indicates the asphalt is more susceptible to oxidative aging or hardening. Values typically range from 1.0 to 3.5.

Figure 2 illustrates the range of temperature susceptibility and viscosity ratios of asphalts from numerous single-source crudes (Ref 1). It is apparent that these two performance-related physical properties exhibit a wide range of values. The more desirable asphalts would be located in the upper, left corner of Figure 2. These asphalts would have the best combination of properties, i.e., high resistance to age hardening and low temperature susceptibility, and should produce durable, high performance pavements. The most undesirable asphalts would be located in the lower right corner. These asphalts would tend to age rapidly and be very temperature susceptible.

Figures 3 & 4 show the locations of the asphalt cements in the United States and overseas sampled for the MRL. Table 1 shows a list of all the crude oil sources and the codes assigned to the asphalts sampled for the MRL. The purpose of the codes was to protect the confidentiality of the sources. More details about the Asphalt Selection Process are contained in an August 1989 report entitled: "Materials Reference Library Asphalt Selection Process" (Reference 2). The information above was extracted directly from that report and updated where necessary.

Aggregates

Initially, a total of four core aggregates were selected for use by all the asphalt program contractors, and an additional seven were selected later to complete the task of the aggregate selection process. Figure 5 shows the location of the sources for the MRL aggregates. Table 2 is a list of the 11 aggregates by code, type and general documentation of the source, which were selected by the ETG, and sampled for the MRL.

The criteria used in selecting the MRL aggregates involved the following factors:

Physical Properties
Chemical Properties
Petrographic Properties
Known Performance

The physical properties which were considered included:

Porosity
Hardness (L.A. Abrasion)
Absorption
Specific Gravities
Surface Texture
Soundness (Freeze/Thaw Resistance)

Particle Shape
Void System
Surface Area/Gradation

The chemical properties considered in the selection of the aggregates were as follows:

Silica Content
Acid Solubility
Water Solubility
pH
Surface Chemistry
Surface Charge
Clay Content
Calcium Carbonate Content

Silica content, pH, Surface Chemistry, Surface Charge, and Calcium Carbonate Content are believed to be indicators of stripping potential of an aggregate, and the pH content of an aggregate is affected by its Acid and Water Solubility Potential. Excessive clay content may cause potential problems in the asphalt aggregate mixture design. Petrographic properties of the aggregates under consideration were also determined and were used to classify the relative amounts of each constituent in the aggregate. Another factor considered in the selection process was the geographic distribution of the selected aggregates in association with the four LTPP regions.

Modifiers

In order to validate the Test methods and the specifications developed for modified as well as unmodified binders and mixtures, a modifier selection process was initiated by the A-004 contractor with guidance and technical assistance by the A-001 contract.

The A-004 contractor conducted a survey of modified mixtures used in State Highway

Construction Projects and also collected performance data from a large number of modifier manufacturers. The selection of the modifiers was based on documented field performance. The intent of the modifier testing program was not to evaluate the effect of each modifier on the binder and the mixture, but, as stated above, to validate the test methods and the specifications developed for modified mixtures.

A total of 82 modifiers representing eight different categories were obtained from the manufacturers and stored at the MRL. The number of modifiers in each category and the identifier code assigned to each one is listed below:

5 Anti-Oxidants (AO)
1 Recycling Agent (RA)
27 Anti-Stripping Agents (AS)
5 Mineral Fillers (MF)
39 Thermoplastics (TH)
2 Fibers (FB)
2 Extenders (EX)
1 Oxidant (OX)

A complete list of all the MRL modifiers and their corresponding MRL Codes is enclosed in Appendix B.

LTPP Materials

MRL holdings are not limited to materials originally selected for use in the Asphalt Research program. Loose asphalt materials and cores from LTPP Projects are also stored and distributed to ARP researchers from the MRL. Loose materials sampled during construction of several SPS sites and post-construction asphalt cores from those sites were distributed among three different SHRP Asphalt Program contractors to use in the water sensitivity, aging, thermal cracking, and compaction studies.

In addition to the SPS materials, twelve inch cores from GPS sites in each of the four LTPP regions have also been stored at the MRL for possible use by other researchers. These cores were shipped to the MRL in wooden crates and each core is wrapped in plastic and bears a section Identification Number and remains in the original box in which it was shipped. Each LTPP - GPS Section was given a unique identification number. Section ID Numbers corresponding to the contents of the box also appear on the outside of each box.

A complete listing of all the LTPP materials appears in Appendix B (MRL Holdings).

Asphalt-Aggregate Mixture Analysis System (AAMAS) Materials

The AAMAS Project [(NCHRP 9-6(1)] was sponsored by the National Cooperative Highway Research Program (NCHRP) to develop procedures for the design and evaluation of dense-graded hot-mix asphaltic concrete mixtures based on performance-related criteria for high-volume roadways (Reference 3).

These materials include combined coarse and fine aggregate, asphalt cement and asphalt concrete mixtures from the AAMAS sites in New York, Wisconsin, Georgia and California. In the case of the AAMAS site in Wisconsin, Reclaimed Asphalt Pavement (RAP) materials, which were used at the rate of 45% by weight in the mix, were also sampled. Large portions of the materials received at the MRL from California, Wisconsin and Georgia were shipped to the A-003A Subcontractor, Oregon State University (OSU) for their Water Sensitivity, Rutting and Aging Test programs.

Asphalt cores from the above three states which were needed for the testing program were acquired by OSU directly.

Special Request Materials

In 1989, three RAP materials and one aggregate (River gravel) were obtained at the request of the A-003B contractor for their testing program. The three RAP materials were acquired from the states of Iowa, Delaware and New York and the aggregate was sampled by the A-001 staff at a source outside of Odessa, Texas. Small quantities of these materials were shipped to the A-003B contractor. The remainder are currently stored at the MRL in 55 gallon barrels.

In addition to the above, at the request of the A-003B contractor, seven different limestones with widely varying degrees of absorption from various locations across the United States were sampled in 1990 and made available to that contractor for validation of the net absorption test. The sources of these materials were located in Ohio, New York, Florida, Iowa and Kentucky and were selected by the A-001 Contractor to meet the A-003B contractor needs based on physical and chemical properties and past performance history of the aggregate.

Miscellaneous Materials

Since shortly after the beginning of SHRP, asphalt paving materials from a number of projects in and outside of the United States have been received and stored at the MRL. These materials were either sampled by the A-001 staff or shipped to the MRL by the organization handling the project. The following is a list of the miscellaneous materials stored at the MRL:

- California GPS-6B - This project was sampled in 1991. It is similar in construction to SPS-9 projects. A portion of these materials were shipped to the A-003A contractor for their testing program.

• SMA, Michigan - A Stone Mastic Asphalt Project (SMA) in Michigan that was sponsored by The Federal Highway Administration was sampled for future use by researchers. SMA was first developed and constructed in Europe.

• Laboratoire Central des Ponts et Chaussees (LCPC), France - These materials, which include asphalt cement and aggregate, were shipped to the MRL by LCPC in France at the request of the A-003A contractor for their field validation effort. The materials were sampled at a site in southern France.

• USA-CRREL -As part of the low temperature cracking studies at Oregon State University, (A-003A) a test section was built at the U.S. Army Cold Regions Research and Engineering Laboratory (US CRREL) in Hanover, New Hampshire. Materials received from this test site include combined coarse and fine aggregate and 2 grades of asphalt cement.

• Scott, Wilson and Kirkpatrick (SWK) Engineering Materials - These materials, which include aggregates, asphalt cement, asphalt modifier and HMAC, were used by SWK Engineering in Nottingham, England in their Rutting Validation Studies under SHRP contract A-003A. Materials shipped to the MRL include 2 different types of aggregates, 3 different grades of asphalt cement from the same source, 1 modifier and four different asphalt concrete mixtures.

• FHWA Materials - In 1959, The Federal Highway Administration conducted a study in order to develop standards for grading asphalt cements based on viscosity instead of penetration, which at the time, was the standard grading system for asphalt cements. These materials include quart and one gallon metal cans of asphalt cement and HMAC from various locations.

• Special Asphalt Materials - In 1991, a total of twelve asphalt refineries in the US were contacted by the A-001 staff in order to acquire small quantities of asphalt cement for the purpose of validating the Asphalt Binder specifications developed by the SHRP Asphalt Research Program.

In addition to the above, several other materials have been included in this study which are as follows:

- Asphalt Binders from Elk County, Pennsylvania used in a study sponsored by Pennsylvania DOT in 1976 (Reference 4).
- Canadian SHRP (C-SHRP) Asphalt materials from the Lamont and Hearst Test Roads in Alberta and Ontario respectively which were constructed in 1991. These materials include asphalt cements, aggregates and HMAC for both locations.
- Smackover Asphalt which was reported to be an excellent performer in asphalt pavements but is no longer available due to source depletion.
- Rock Asphalt from a Limestone Asphalt Rock deposit in south central Texas.

• Lake and Arabian Heavy asphalts- In 1989, two fifty five gallon barrels each of lake asphalt from Trinidad and Arabian Heavy from Germany were sent to the MRL for possible use by SHRP researchers. Lake asphalt which is collected from the bottom of a lake in Trinidad has been used, in small quantities, by several SHRP researchers. So far the Arabian Heavy asphalt from Germany has not been used.

A complete inventory of all the miscellaneous materials at the MRL is included in Appendix B.

Chapter 3 Material Procurement Process

Once a material was selected for inclusion in the MRL, the producer of the material was contacted and was requested to participate in the SHRP program by making available their material to the MRL using the containers provided by SHRP. Although SHRP offered to reimburse the suppliers for materials, equipment, labor, and shipping charges, most supplied the materials at no charge.

Two types of containers were purchased for the purpose of sampling, shipping and storage of asphalt cements and aggregates at the MRL; fifty-five gallon polyethylene barrels with covers for the aggregates and five-gallon epoxy-lined metal pails with lids for the asphalt cements. The modifiers were shipped in containers of various sizes and shapes provided by the modifier manufacturers.

Plastic barrels for the aggregate were chosen over metal barrels due to the fact that they do not corrode and, although of similar strength, are much lighter in weight than metal drums, and therefore, easier to handle when empty. The five-gallon metal pails used for sampling and storage of asphalt cements are made of heavy gauge steel and lined with an epoxy coating composed of 70% phenol and 30% resin. This epoxy lining was intended to prevent any potential chemical reaction between the asphalt cement and the base metal at the time of sampling and over an extended period of storage. It should be noted that at the time of sampling of each asphalt, the temperature of the asphalt ranged from 270° F to 350° F.

In order to have sufficient quantities of asphalts and aggregates on hand to last through the five-year program, it was decided to obtain the following quantities:

- Eight core asphalts; 1000 gallons of the standard paving grade and 300 gallons of a softer grade produced by the refinery.
- Remaining 22 asphalts; 1000 gallons of the standard paving grade
- Aggregates; a total of 60, 55-gallon barrels sampled from stockpiles used for the production of hot mix asphalt concrete mixtures.

The average weight of a pail of asphalt is approximately 50 lbs. and the average weight of a barrel of aggregate is approximately 650 lb. The five gallon metal pails were shipped to the refinery prior to the visit by one of the SHRP A-001 staff. Codes were assigned to each material for easy identification and to protect the confidentiality of the sources.

In many cases, special arrangements had to be made by the refinery to collect the samples in five-gallon containers. This was accomplished by means of pipes, hoses and valves connected to the outlet valve on the bulk storage tank or to the pipes connected to the tank. In one instance, samples were obtained from a tank truck that was filled with asphalt cement at the refinery and driven off-site. Asphalt from two outlets on the tank were released into the pails which were lined up along both sides of the truck. These special fittings were designed by the refinery for the purpose of filling MRL asphalt pails.

Unless there were last minute schedule changes or unanticipated problems at the refinery, an A-001 staff member was always present during the entire sampling process. In one instance only, due to miscommunications among the refinery personnel, the pails were filled and shipped to the MRL prior to the scheduled visit by one of the A-001 staff members. All containers were inspected prior to being filled with asphalt cement to ensure that they were dry and free of debris and rust. Immediately after each pail was filled, a lid was placed over it to prevent contamination of the sample, and the label containing the code assigned to the particular asphalt was placed on the lid. Within twenty-four hours after the completion of sampling, all lids were tightly crimped and the pails were placed on pallets and shipped to the MRL. In some instances, the pallets were stretch wrapped with a polyfilm; in other instances, they were banded.

For the aggregates, like the asphalts, a member of the A-001 staff was present at the time of sampling to 1) inspect the stockpiles and verify the approximate gradation and 2) provide instructions, where required, to the crew during the sampling operation. Typically, the aggregate was loaded into the barrels with a small front end loader. After the sampling was complete, covers were placed on the barrels and shipped to the MRL. The contents of the barrels were identified on each barrel prior to shipment.

Chapter 4 Storage Requirements

The Materials Reference Library, located in Austin, Texas, is a warehouse facility which contains approximately 10,000 square feet of storage space for all SHRP Asphalt Research Program materials.

The MRL is divided into two separate areas, one for the storage of aggregates and the other for asphalt cement and asphalt concrete mixtures, with the exception of the GPS cores.

The space utilized for the storage of asphaltic materials is a climate-controlled area with approximately 5,000 square feet of space. The temperature in this area ranges between 40° and 70° F throughout the year which is the allowable range set forth by SHRP. This temperature range is intended to protect the materials from freezing or excessive heat which may induce chemical changes in the materials.

Originally, the asphalt area covered 3800 square feet of the total MRL space. The need for additional air-conditioned space became obvious as the A-001 contractor was asked to provide storage space for SPS-1, SPS-5, SPS-6, and SPS-9 materials of the LTPP program. As a result, in the summer of 1990, an additional 1200 square feet of air-conditioned space, which used to be a part of the aggregate area, was partitioned off and added to the asphalt area.

The aggregate area covers the remaining 5000 square feet of the storage space at the MRL. This area is not air-conditioned, since aggregates are not as sensitive to temperature variations, and therefore, do not need to be stored in an air-conditioned area. This area is accessible from the asphalt area by means of an overhead door and regular hinged door. Three bay doors at the front provide access to trucks for shipping and receiving purposes.

In the asphalt area, five-gallon pails of asphalt cement are stacked on pallets and each stack is separated by source. In early 1988, a forklift was purchased for lifting and moving the pallets of asphalt cement and 55 gallon barrels of aggregate. The forklift is also used for loading and unloading of shipments.

In mid-1990, a sprinkler system was installed at the MRL to provide protection for the MRL materials in the event of a fire. The system is monitored by a private firm twenty-four hours a day, each day of the year, through a computer system at their site connected to the signaling devices at the MRL. In the event of an actual fire or tampering with the sprinkler system controls, the computer will send a warning which will initiate a response by the fire and police departments.

All of the thirty-two MRL asphalt cements are stored in the original asphalt area. The recently added air-conditioned area contains materials from AAMAS, SPS and miscellaneous materials and modifiers.

The aggregate area contains all the MRL aggregates, plus FHWA materials and twelve-inch GPS cores which are crated and could not be stored in the asphalt because 1) the fact that they would occupy a large area which could otherwise be used for other asphalt materials, and 2) that these cores were taken from existing roadways which had already been exposed to relatively long term temperature variations prior to coring.

All aggregate barrels are labeled for easy identification. The labels contain the stockpile ID and the code, and all the barrels remain sealed until they are ready to be used.

Figure 6 shows a diagram of the MRL, and the location of all the materials, and figures 6a-6f are photographs of the MRL.

Chapter 5 Asphalt And Aggregate Testing Program

Asphalts

Shortly after each asphalt cement was received at the MRL, a special one-gallon container of the asphalt, sampled at the refinery at the same time as the 5-gallon samples, was sent to the Asphalt Institute for determination of its basic properties such as viscosity, penetration, ductility, Ring and Ball softening point, thin film oven properties as well as compositional and elemental analysis.

The testing of all grades of the thirty-two MRL asphalts has been completed and the results appear in Appendix A. The total number of samples tested is forty-seven, which also includes test results for re-sampled asphalts.

In early 1988, another independent laboratory, Matrecon, Inc., in California was asked to perform the same set of tests on both grades of the eight MRL core asphalts. This was done to obtain more reliability in the test results, and to determine the amount of variability in the results between two independent laboratories. The test results for the harder grade, the -1 designation, viz. AAA-1, of the core asphalts from the Asphalt Institute and Matrecon are included in Table 3, and a complete set of test results from Matrecon appears in Appendix A.

The MRL asphalts are graded based on three different grading systems. The MRL inventory is comprised of six penetration graded, four aged residue, and twenty-two viscosity graded asphalt cements. Differing grades of the MRL asphalt cements include

AC-5, AC-8, AC-10, AC-20, and AC-30 or their equivalents in aged residue or pen graded asphalts.

For the elemental analysis, determinations were made of the amount, in percent , of nitrogen, sulfur, vanadium, nickel, carbon and hydrogen for all the asphalts. Only thirty one of the forty seven asphalts report Carbon and Hydrogen determinations. For the other sixteen samples, the total percentages of the six elements fall outside of the acceptable range of 97% to 102%, and therefore were not considered accurate and are not included in the report. The A-002A contractor (WRI) duplicated the elemental analysis of all the MRL asphalts, including carbon and hydrogen values.

Aggregates

Samples of aggregates from the MRL were sent to two independent laboratories, which tested the aggregates and submitted their findings in two separate reports to the A-001 contractor.

One of these reports prepared by Southwestern Laboratories, was entitled "Test Results for MRL Aggregates" which covered only the four MRL core aggregates RC, RD, RJ, and RL. Shortly thereafter, RL was replaced as a core aggregate mainly due to difficulties with obtaining finer sizes of this aggregate from the source. Physical, chemical and petrographic properties of these four aggregates were measured and discussed in the SWL report.

The other report was prepared for the A-001 Contract by the Center for Applied Energy Research of the University of Kentucky through the Asphalt Institute, and is entitled "The SHRP Aggregates". The report covers all the eleven MRL aggregates. Like the Southwestern Laboratories report, it provides information regarding the petrographic properties of the aggregates which include major mineral and percentage of major oxides in each aggregate, as well as test results on chemical and physical properties of the aggregates.

Copies of both of these reports are contained in Appendix A.

Chapter 6 Material Shipment Process

Shipments To Asphalt Research Program Contractors

Asphalts

As mentioned earlier, the MRL asphalt cements were sampled in five-gallon metal pails and shipped to the contractors in the original containers. For the contractors requiring smaller quantities, the five-gallon pails are heated and smaller quantities of the asphalt are placed into quart cans and sent to them following the handling protocol developed by A-001. A copy of the SHRP Protocol for Handling and Use of Asphalt Cements, is included in Appendix B.

The standard procedure calls for the contractors to request MRL asphalts by completion of an MRL Materials Request Form which is available to anyone requesting materials from the MRL. Figure 7 shows a copy of the form. As shown on the form, the contractor is required to identify their SHRP contract number, name of agency, and both shipping and billing addresses. To request any of the MRL asphalt cements, the contractor provides a list of required asphalts identifying each one by its code, grade, and the quantity needed in quarts or gallons. The form may then be mailed or sent by facsimile to the A-001 contractor. Immediately after the receipt of the form, it is checked for completeness of information and sent to the MRL for processing. In most cases, the asphalt samples, accompanied by Materials Safety Data Sheet (MSDS), are shipped to the contractors by United Parcel Service, and reach their destination within five working days.

Aggregates

Aggregates are shipped to the contractors in five-gallon pails or fifty-five gallon barrels. The contractor is required to complete the aggregate portion of the MRL Materials Request Form by using the aggregate code and entering the required amount. The aggregates are shipped by United Parcel Service or by common carrier depending upon weight and volume of shipment. Overseas shipments are handled through custom brokers.

Modifiers

Shipment of modifiers is handled in the same manner as the asphalt cements. However, due to the potentially hazardous nature of some of the MRL modifiers, Materials Safety Data Sheets always accompany the shipments.

Non-SHRP Shipments

SHRP's policy concerning the shipment of MRL materials to Researchers outside of SHRP has been to require a written request from the researcher outlining the nature of the research and the reasons for the interest in using MRL materials. SHRP will consider each request based on its potential benefits to the SHRP Asphalt Research Program. If the request is granted, the A-001 contractor is directed to send the materials to the researcher. There is a nominal ten dollar per quart charge for asphalt cements which is paid directly to SHRP. Since the beginning of SHRP, several requests for MRL Asphalt cements have been granted and shipments have been made to various organizations in the United States and abroad. The policy of providing aggregates for non-SHRP related research has been more strict due to the limited quantities of aggregate available at the MRL. No such requests have been granted by SHRP to date.

Chapter 7 Future Of The MRL

The need for materials from the MRL by the Asphalt Research Program contractors has greatly diminished since most of the testing has been completed. However, large quantities of asphalt cement, aggregate and modifiers remain on hand at the MRL facility. An inventory of the MRL as of September 30, 1992 is contained in Appendix B.

Additionally, loose materials from SPS sites and asphalt concrete cores from GPS sites are stored at the MRL and the A-001 contractor has been directed to continue the sampling of materials for new SPS-9 sites through March 1993 when the asphalt program ends.

It is the author's understanding that the Federal Highway Administration has decided to take over the operation of the MRL as of April 1, 1993, and continue its operation until October 1997. The task of collecting the MRL materials has been a major undertaking at a cost of well over half of a million dollars. After the Asphalt Research Program ends in March 1993, and the FHWA takes control of it, its role could be expanded to serve as a holding facility for other government sponsored pavement projects, in addition to providing storage for samples from ongoing SPS construction projects. In addition, materials stored at the MRL could prove to be very valuable in the future to those researchers who wish to duplicate or expand on any of the SHRP tests for which MRL materials have been used. It may also be utilized as a permanent holding and distribution center for pavement materials from a variety of pavement research and construction projects in the United States and overseas.

References

1. Goodrich, J.L., and Dimphl, L.H. Performance and Supply Factors to Consider in Paving Asphalt Specifications. Proceedings of the Association of Asphalt Paving Technologists. Clearwater Beach, Florida. February 1986.
2. Report SHRP-A/IR-89-002. Strategic Highway Research Program, Materials Reference Library Asphalt Selection Process. August 1989.
3. National Cooperative Highway Research Program, Report 338 Asphalt-Aggregate Mixture Analysis System (AAMAS). Washington, D.C., March 1991.
4. Kandhal, P.S., Low Temperature Shrinkage Cracking of Pavements in Pennsylvania. Proceedings of the Association of Asphalt Paving Technologists. Lake Buena Vista, Florida. February 1978.

Tables and Figures

*AAA	Lloydminster
*AAB	Wyoming High Sulfur
*AAC	Redwater
*AAD	California Coastal
AAE	Lloydminster (Air Blown)
*AAF	West Texas Sour
*AAG	California Valley
AAH	Rangely
AAJ	Oklahoma Mix (SDA)
*AAK	Boscan
AAL	Cold Lake
*AAM	West Texas Intermediate (SDA)
AAN	Bow River
AAO	Arabian Heavy
AAP	Oklahoma Mix
AAQ	Wyoming Mix (SDA)
AAR	Maya/Wyoming High Sulfur
AAS	Arabian Heavy
AAT	Maya/Lloydminster
AAU	Alaska North Slope/CA Coastal
AAV	Alaska North Slope
AAX	Potaku Sweet/Light Louisiana Sweet
AAY	Maya/Arabian Heavy
AAZ	West Tx Sour/Coastal Crudes
ABA	West Texas Intermediate/West Texas Sour (Air Blown)
ABC	Mississippi Valley
ABD	California Valley
ABF	Tijuana Pesado
ABG	Laguna
ABH	Russian
ABK	Wilmington
ABL	Boscan
ABM	California Valley

* Core Asphalts

Table 1. MRL Asphalt Codes

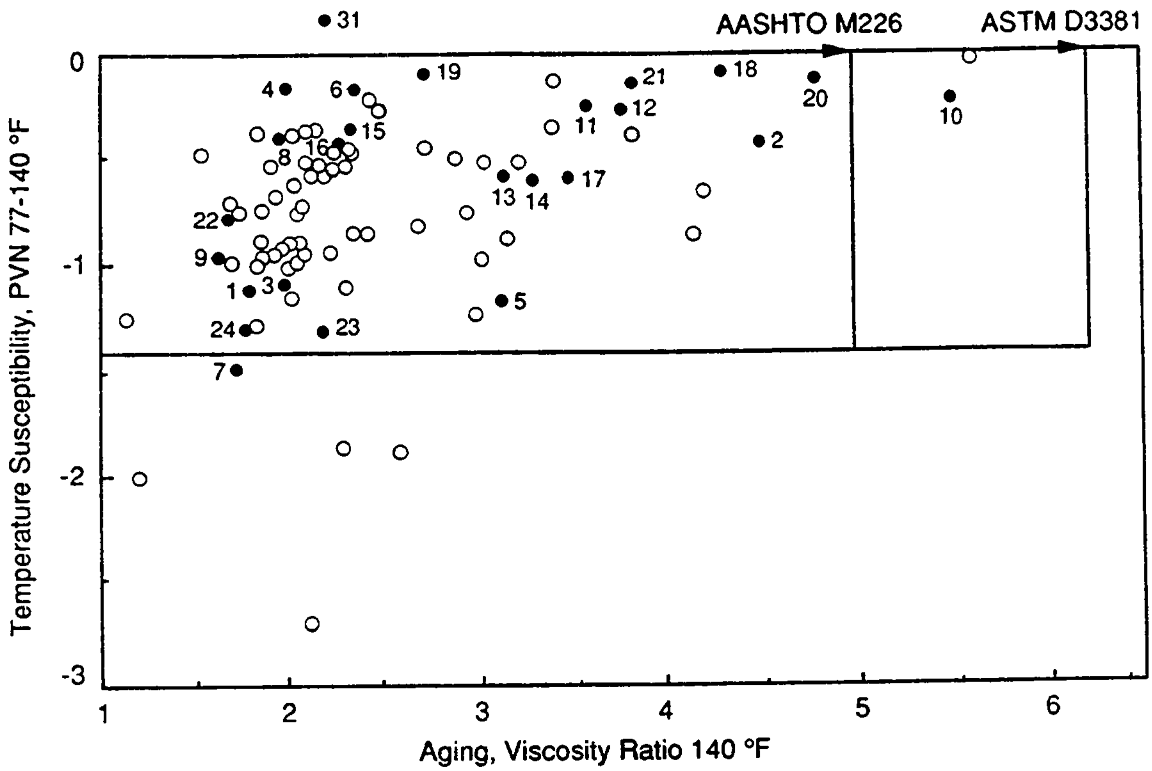
Table 2 - Aggregate ID Codes for Materials Reference Library

Code	Geolegic Type	Source Location
RA	Lithonia Granite (Stripper)	Georgia
RB	Watsonville Granite (Non-Stripper)	California
*RC	Limestone (Higher Absorption)	Kansas
*RD	Limestone (Lower Absorption)	Maryland
*RE	Piedmont Gravel	Maryland
RF	Glacial Gravel	Illinois
RG	Sandstone	Pennsylvania
*RH	Greywacke	California
*RJ	Mountain Gravel Conglomerate	Wyoming
RK	Basalt	Oregon
RL	Gulf Coast Gravel	Texas

* Core Aggregate

Table 3 - PROPERTIES OF THE EIGHT MRL CORE ASPHALTS BY THE ASPHALT INSTITUTE AND MATRECON INC.

	ASPHALT INSTITUTE								MATRECON							
ASPHALT GRADE	150-200	AC-10	AC-8	AR-4000	AC-20	AR-4000	AC-30	AC-20	150/200	AC-10	AC-8	AR-4000	AC-20	AR-4000	AC-30	AC-20
MRL CODE	AAA-1	AAB-1	AAC-1	AAD-1	AAF-1	AAG-1	AAK-1	AAM-1	AAA-1	AAB-1	AAC-1	AAD-1	AAF-1	AAG-1	AAK-1	AAM-1
VISCOSITY:																
140 F, poises	864	1029	419	1055	1872	1862	3256	1992	858	1030	695	1100	1750	1910	3220	1760
275 F, cSt	283	289	179	309	327	243	562	569	360	300	232	311	330	278	580	586
PENETRATION:																
100g,5s,77F,0.1mm	160	98	133	135	55	53	70	64	162	105	106	143	57	54	73	68
PVN:																
77 PEN, 140 VISC.	-0.129	-0.770	-1.277	-0.205	-1.020	-1.077	-0.103	-0.738	-0.114	-0.658	-1.071	-0.054	-1.036	-1.026	-0.044	-0.772
77 PEN, 275 VISC.	-0.195	-0.743	-1.173	-0.266	-1.135	-1.576	-0.127	-0.209	0.229	-0.610	-0.999	-0.183	-1.090	-1.375	-0.034	-0.099
DUCTILITY:																
39.2 F,1cm/min,cm	150+	40.1	137.0	150+	7.6	0.0	27.8	4.6	150+	7	0	86	0	0	6	3
R&B SOFT. PT., F:	112	118	109	118	122	120	121	125	108	117	115	113	121	119	126	122
COMPONENT ANALYSIS:																
ASPHALTENES, %	18.3	18.2	11.0	23.0	14.1	5.8	21.1	3.9	13.9	13.1	8.4	17.7	11.9	3.7	16.8	2.9
POLAR AROMATICS, %	37.3	38.3	37.4	41.3	38.3	51.2	41.8	50.3	43.1	45.9	49.2	47.5	55.8	52.9	47.6	59.4
NAPHTHENE AROM., %	31.8	33.4	37.1	25.1	37.7	32.5	30.0	41.9	25.6	27.3	26.2	19.9	22.6	24.8	22.0	34.2
SATURATES, %	10.6	8.6	12.9	8.6	9.6	8.5	5.1	1.9	12.0	9.7	13.0	8.4	9.4	9.6	5.9	2.5
ELEMENTAL ANALYSIS:																
NITROGEN,%	0.49	0.55	0.42	0.90	0.24	1.12	0.80	0.53	0.45	0.52	0.52	0.85	0.51	1.05	0.77	0.51
SULFUR,%	7.27	5.60	2.74	8.55	4.52	2.03	6.58	2.44	4.94	3.85	1.86	6.21	3.08	1.10	4.37	0.90
VANADIUM,ppm	158.3	185.6	71.2	292.8	68	32.1	1427.1	59.9	137.0	190.0	62	278.0	35	50.6	1401.0	43.7
NICKEL,ppm	77.94	45.00	39.95	144.70	27	71.40	128.35	29.45	46.6	47.4	12	127.0	4.3	91.2	126.0	32.2
TFO RESIDUE PROP.:																
MASS CHANGE, %	-0.31	-0.04	-0.26	-0.81	-0.09	-0.18	-0.55	0.05	-0.37	-0.06	-0.17	-0.95	-0.13	-0.20	-0.65	0.06
VISCOSITY:																
140 F, poises	1901	2380	1014	3420	4579	3253	9708	3947	1960	2520	1700	3910	4880	3460	10600	4320
VISC. RATIO,140 F	2.20	2.31	2.42	3.24	2.45	1.75	2.98	1.98	2.28	2.45	2.45	3.55	2.79	1.81	3.29	2.45



CODE

1. California Coastal
2. California Coastal
3. Boscan
4. Lloydminster
5. Redwater
6. Wyoming High Sulfur
7. West Texas Intermediate
8. Arabian Heavy
9. Alaska North Slope
10. Maya
11. Maya/Wyoming Sour (40-60)
12. Maya/Arabian Heavy (80-20)
13. CA Valley/CA Coastal
14. ANS/CA Coastal
15. Cold Lake
16. Bow River
17. West Texas Sour/Maya (65-35)
18. Boscan/Maya
19. Boscan/Bachaquero
20. Arabian Light/Maya (50-50)
21. Raspo More
22. Baxterville
23. Oklahoma Mix
24. Rangley
*25. Wyoming/Canadian Mix
*26. Wyoming/Canadian Mix
*27. Cracked 1
*28. Cracked 2
*29. Cracked 0
*30. Wilmington
31. Lloydminster-Oxidized
*32. El Paso-Oxidized
*33. Kansas/Oklahoma

* Data not Available

Figure 1. Properties of crudes most often used in U.S. and Canada in asphalt production (after reference 1).

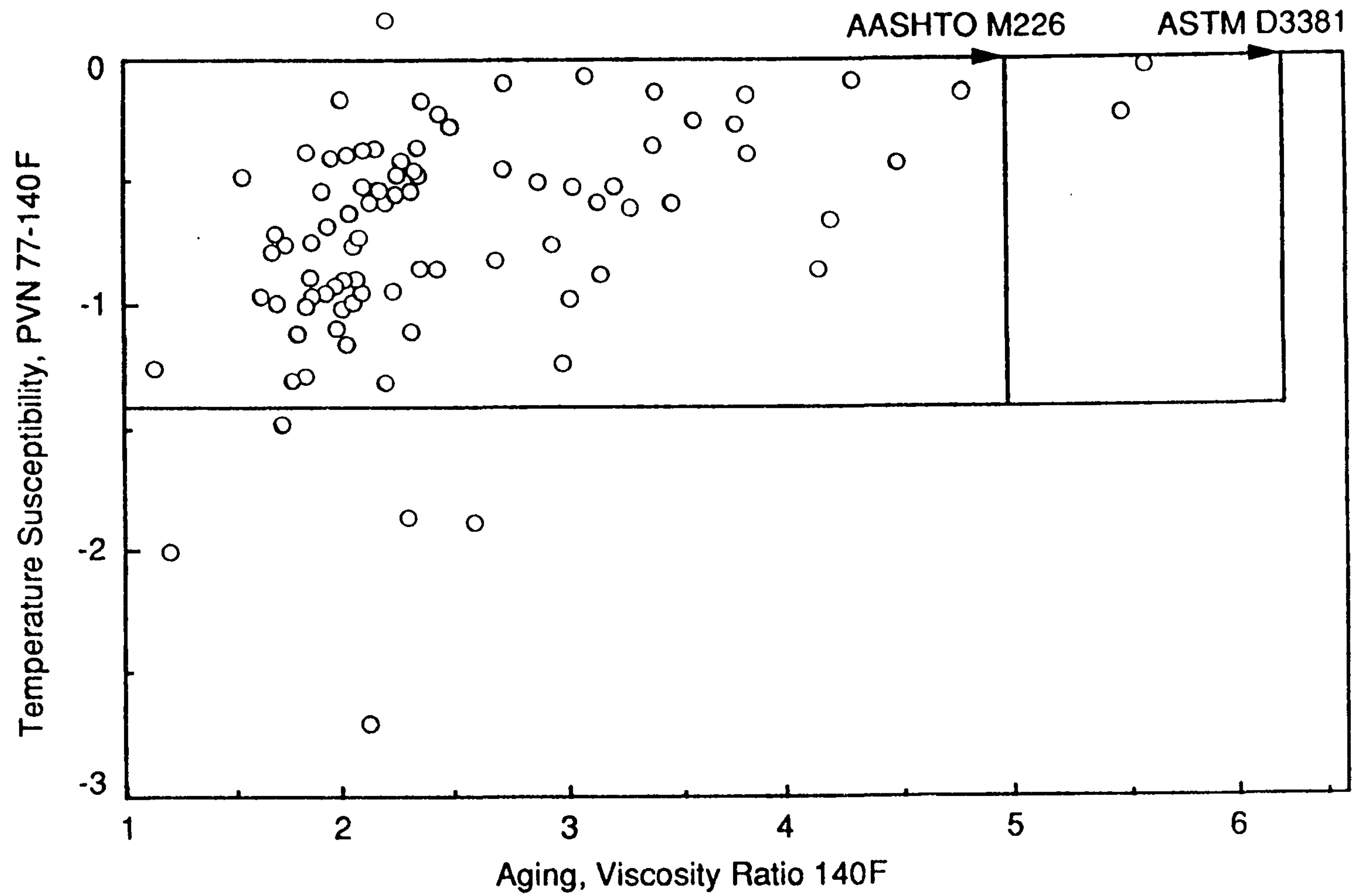


Figure 2. Range of PVN and Aging Index for single source crudes (after reference 1).

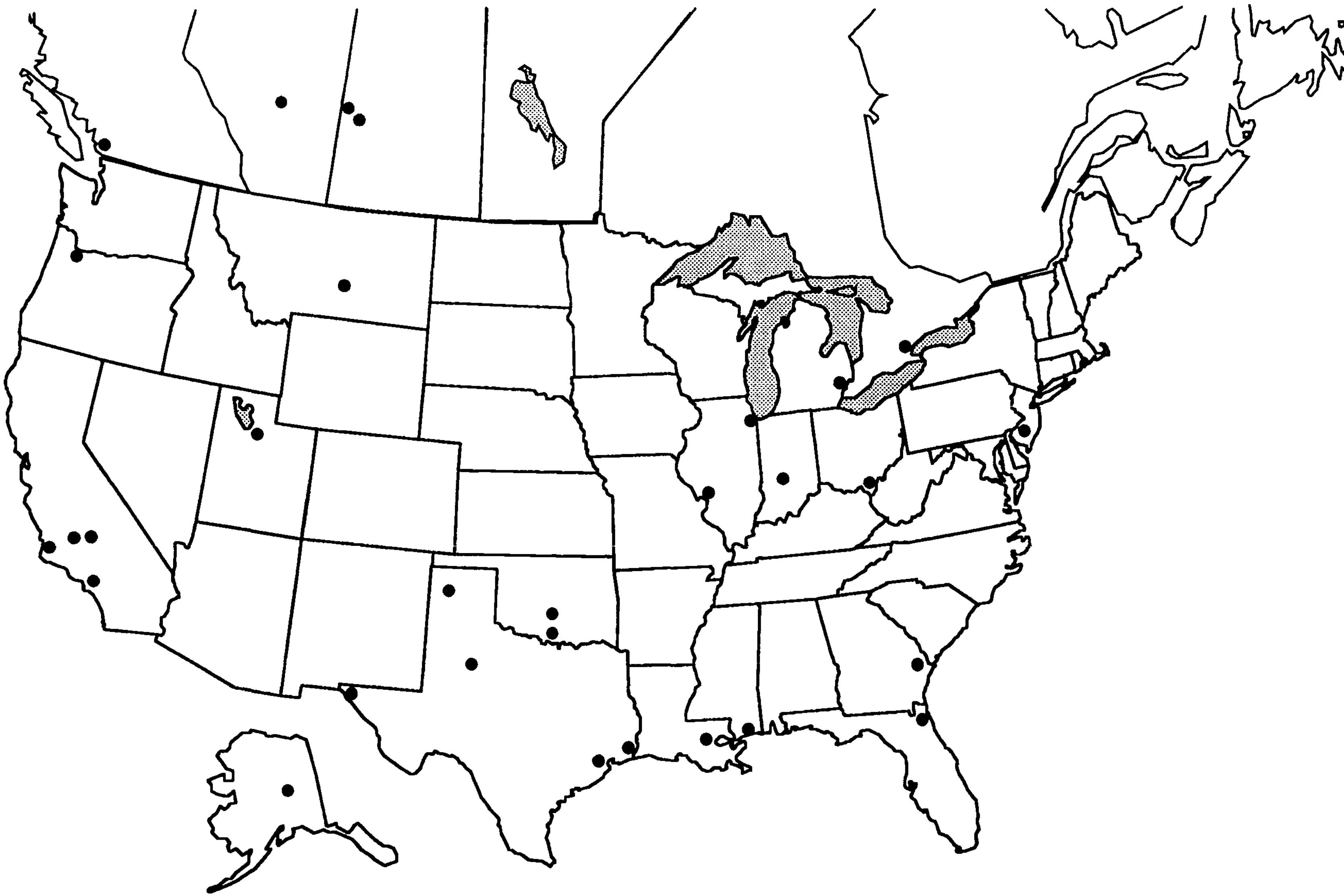


Figure 3. Asphalt Cement Locations (Refinery or Source) in the United States

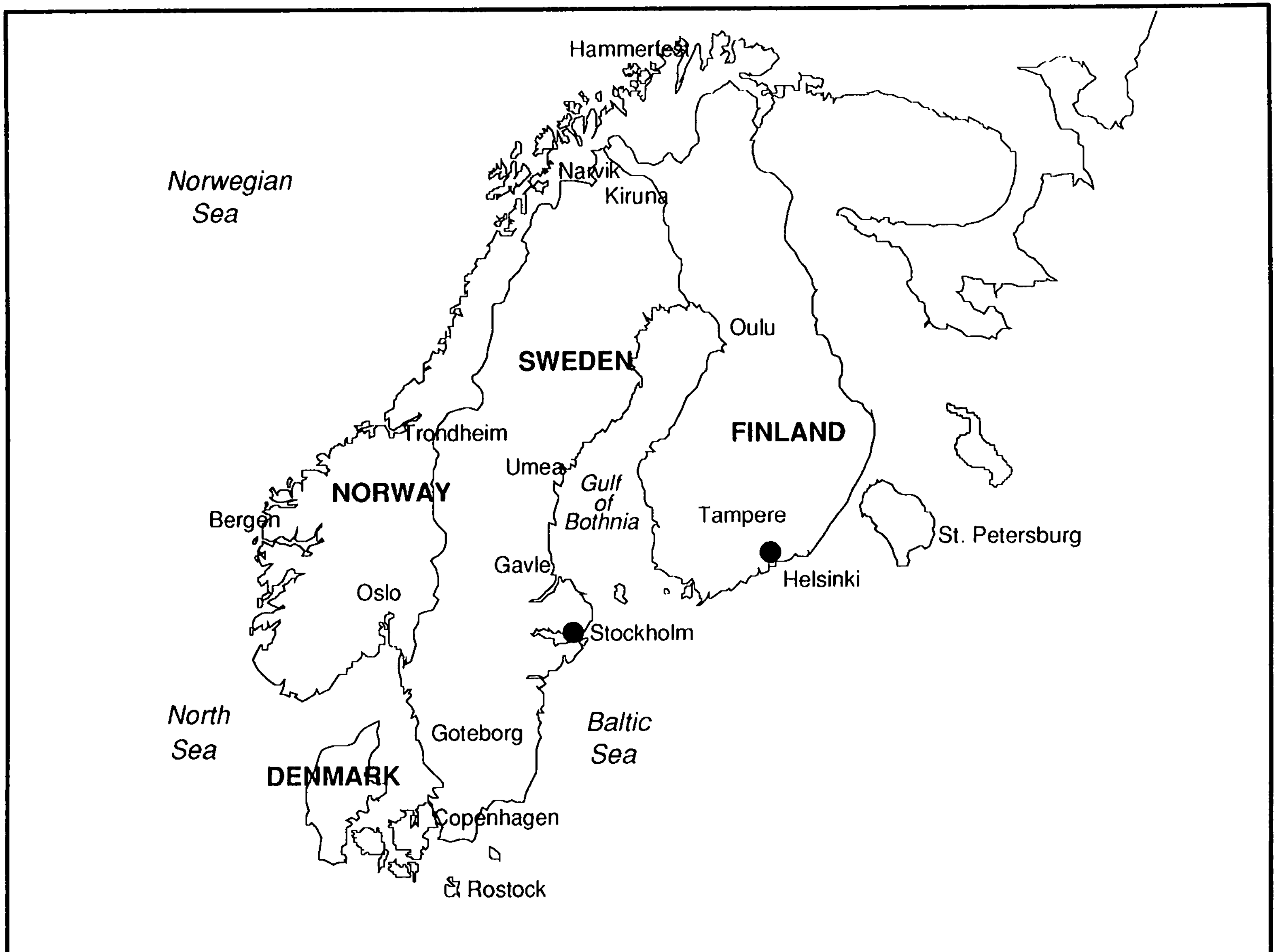


Figure 4. Asphalt Cement Sources Overseas

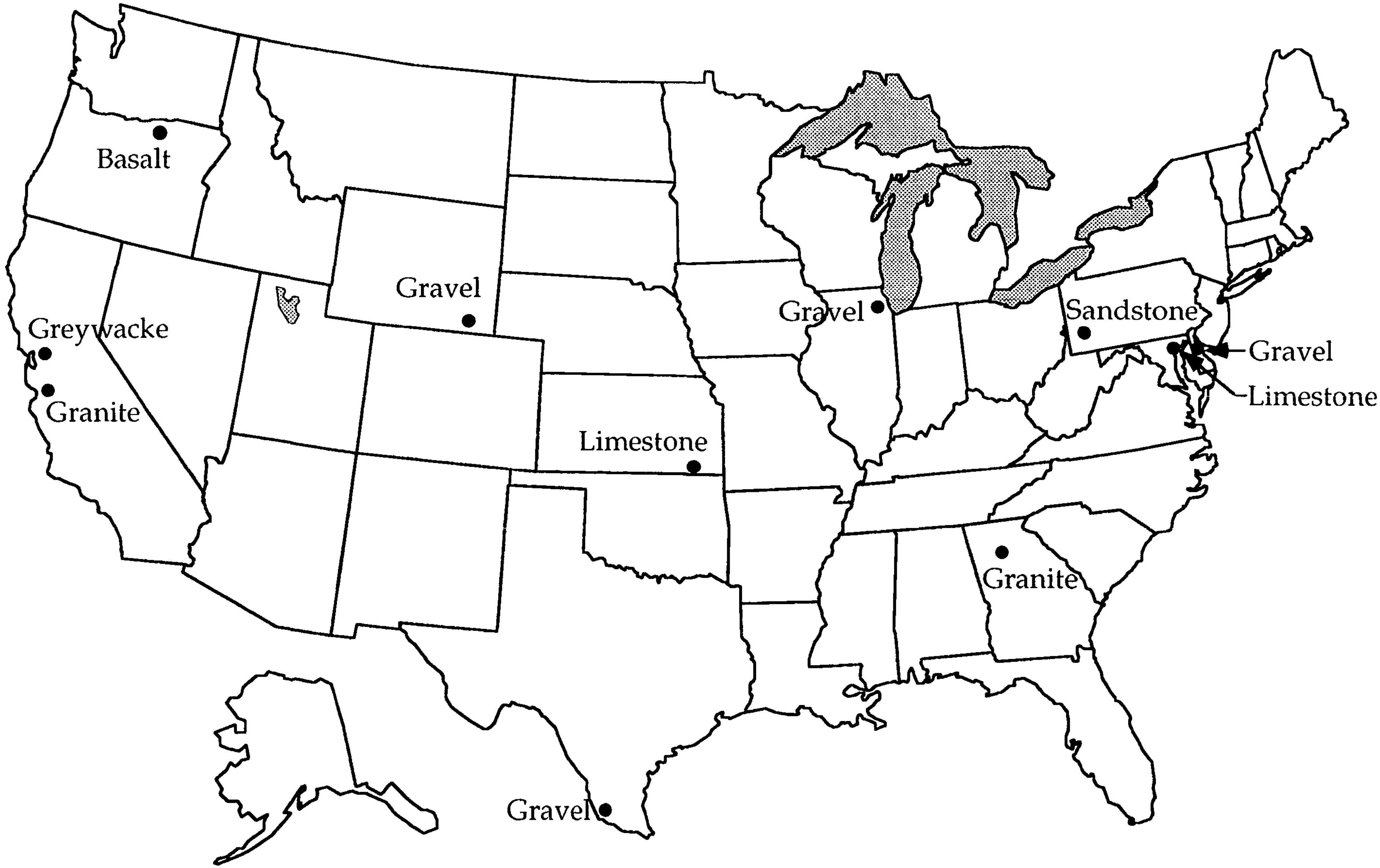
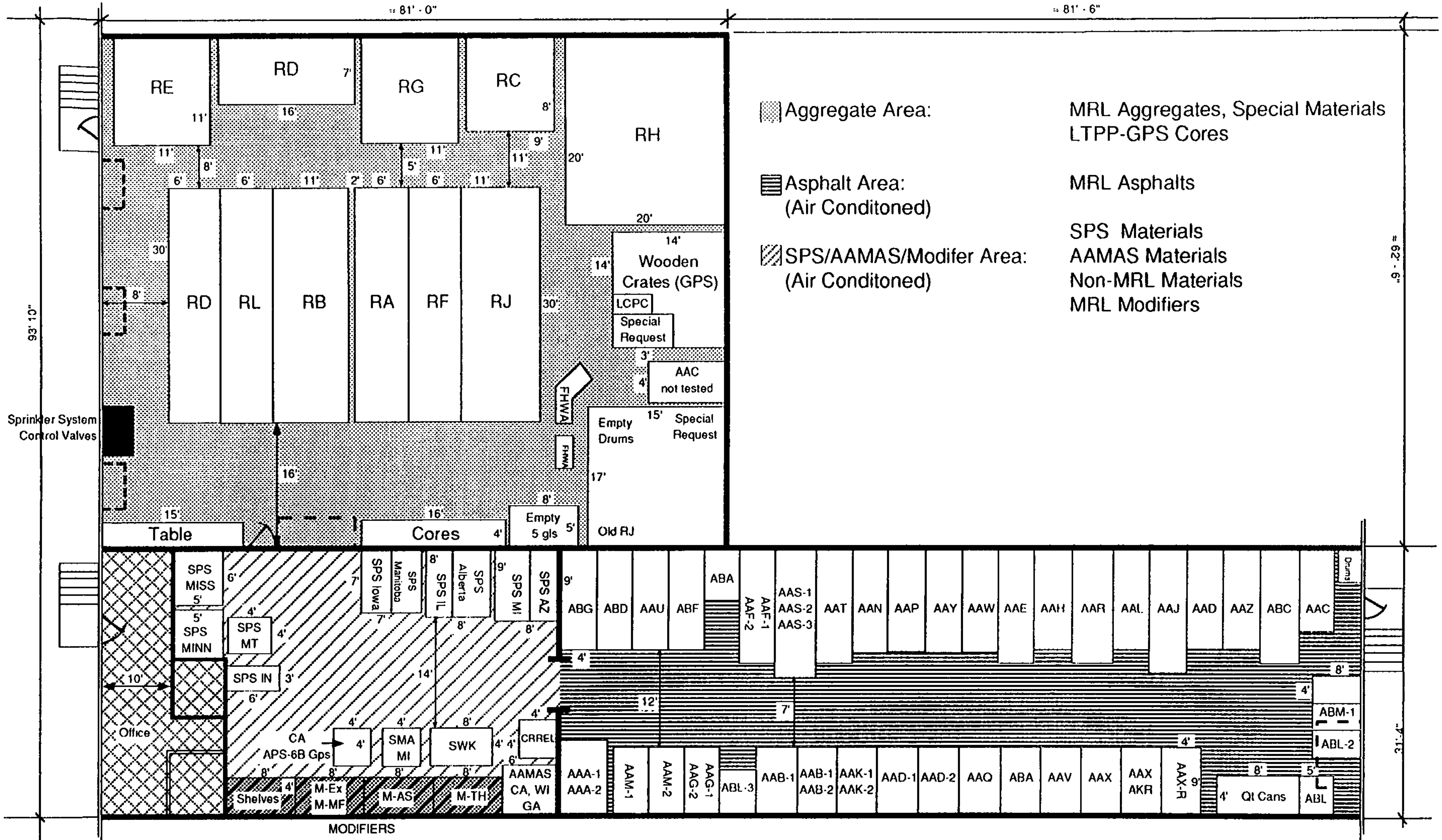


Figure 5. Aggregate Source Locations



Inside dimensions are not to scale.

FIGURE 6. LAYOUT OF SHRP MATERIALS REFERENCE LIBRARY
9416 Neils Thompson Drive, # 113
Austin, Tx

10/9/92

Figure 6a. Materials Reference Library; Main Entrance

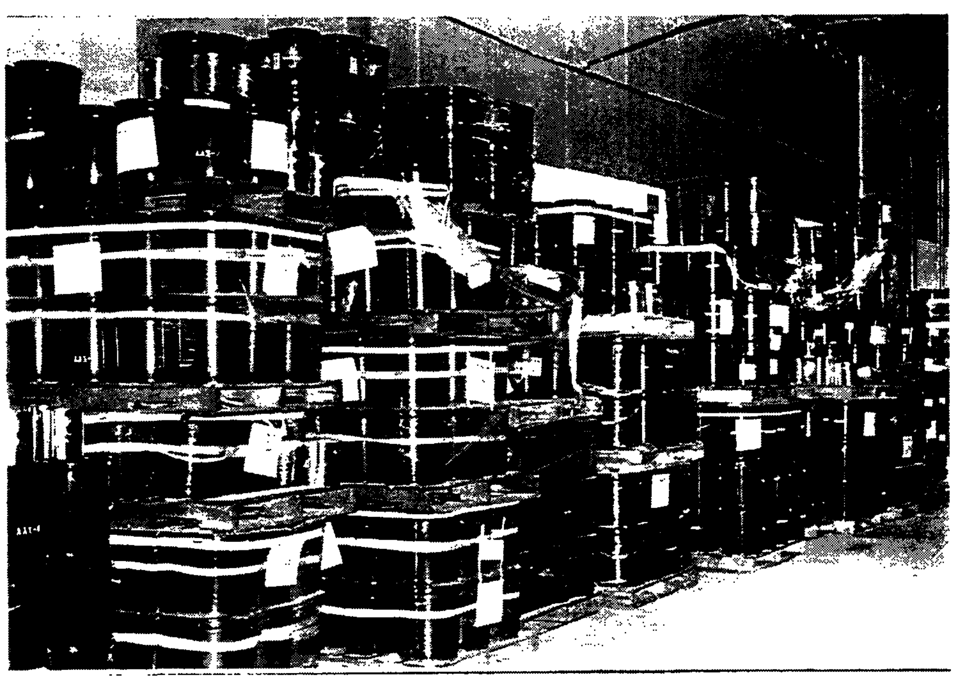


Figure 6b. A few of the MRL Asphalts in the Asphalt Area

Figure 6c. Small Section of the Aggregate Area

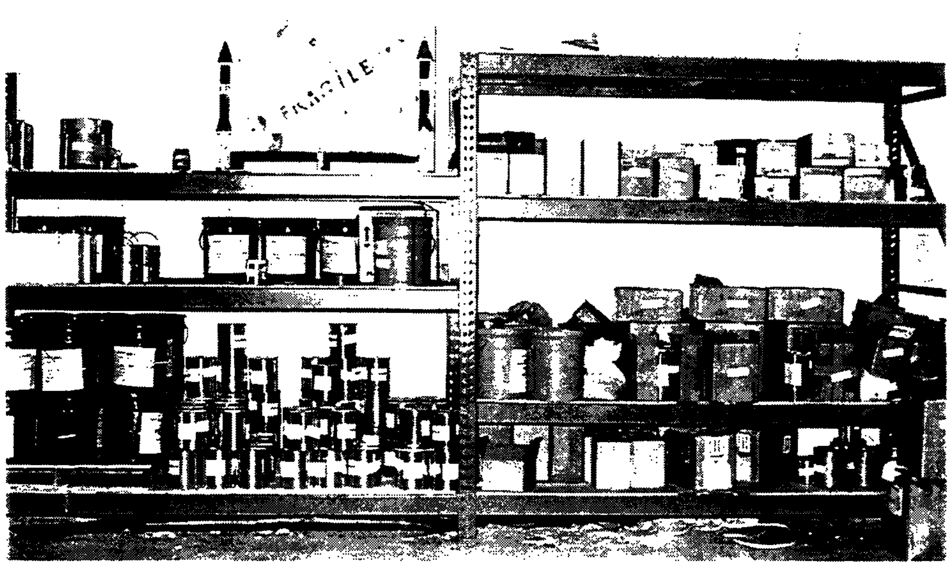


Figure 6d. MRL Modifiers

Figure 6e. Materials from SPS Sites

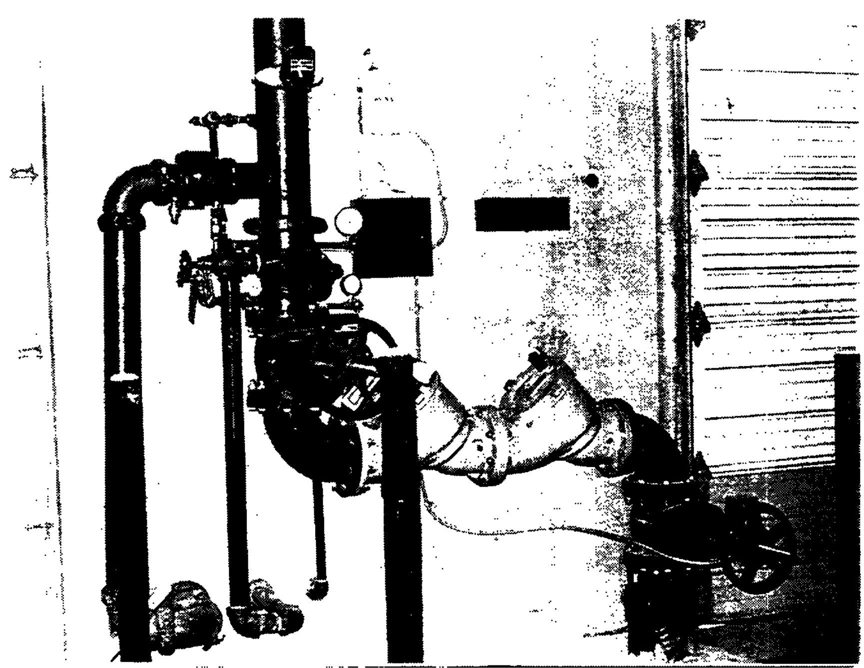


Figure 6f. Sprinkler System Controls in the Aggregate Area

Approved:__________ Order taken by:__________
Date Shipped:__________

MRL MATERIALS REQUEST

To: A001 Contractor

From:

SHRP Contract No.____________________

Name____________________ Date__________

Address____________________

City____________________State__________ Zip__________

Telephone No.____________________ FAX No.__________

****

NAME:____________________

Street *Shipping* Address____________________

City____________________ State__________Zip__________

NAME:____________________

Billing Address____________________

City____________________ State__________Zip__________

Asphalt:

	Quantity	Grade	Source	~~Can No.~~
1.				
2.				
3.				
4.				
5.				
6.				

Aggregates:

	Quantity	Source
1.		
2.		
3.		
4.		

Figure 7

APPENDIX A

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	AAA-1	AAA-2	AAB-1	AAB-2	AAC-1	AAC-2	AAD-1
Crude Oil Source	Lloydminster		WY Sour		Redwater		Ca
Visc./Pen Grade	150/200	200/300	AC-10	AC-5	AC-8	AC-5	AR-4000
SHRP PG Grade	PG58-28	PG46-34	PG58-22	PG52-22	PG58-16	PG52-22	PG58-28
Original Asphalt							
Viscosity							
140°F, poise	864	363	1029	403	419	304	1055
275°F, cSt	283	189	289	193	179	143	309
Penetration, 0.1 mm							
(77°F, 100g, 5s)	160	291	98	166	133	200	135
(39.2°F, 100g, 5s)	15	27	6	13	7	9	9
Ductility, cm							
(39.2 °F,1cm/min)	150+	150+	40.1	81	137	150+	150+
Softening Point (R&B), °F	112	102	118	115	109	107	118
Component Analysis, %							
Asphaltenes (n-heptane)	*16.2*	16.2	*17.3*	16.7	*10.1*	*9.8*	*20.5*
Asphaltenes (iso-Octane)	*3.4*		*2.0*		*3.1*	*3.4*	*3.4*
Polar Aromatics	37.3	36.0	38.3	35.7	37.4	35.4	41.3
Napthene Aromatics	31.8	36.1	33.4	36.5	37.1	37.0	25.1
Saturates	10.6	11.4	8.6	10.8	12.9	16.6	8.6
Elemental Analysis							
C, %	*83.9*	84.12	*82.3*	85.7	86.5	*86.6*	*81.6*
H, %	*10.0*	10.59	*10.6*	10.59	11.3	*10.6*	*10.8*
O, %	*0.6*		*0.8*		0.9	*1.0*	*0.9*
Nitrogen, %	*0.50*	0.50	*0.54*	0.54	*0.66*	*0.90*	*0.77*
Sulfur, %	*5.50*	6.00	*4.70*	5.40	*1.90*	*1.90*	*6.90*
Vanadium, ppm	*174*	138	*220*	163	*146*	*100*	*310*
Nickel, ppm	*86*	77	*56*	36	*63*	*55*	*145*
Fe, ppm	<1		16			*29*	13
Aromatic C, %	28.1		31.9		24.7		23.7
Aromatic H, %	7.68		7.12		6.41		6.81
Molecular wt. (Toluene)	*790*		*840*		*870*	*870*	*700*
% WAX (INTEVEP)	1.62	1.56	3.85	5.05	5.06	4.56	1.94
WAX M. P. (deg. C)	35.8	38.6	62.1	64.3	65.7	66.9	50.6

WRI data in italics PSU data in Monaco **UT data in bold**

TAI data in Helvetica MSU data in outline

MRL Code	**AAA-1**	**AAA-2**	**AAB-1**	**AAB-2**	**AAC-1**	**AAC-2**	**AAD-1**
Crude Oil Source	Lloydminster		WY Sour		Redwater		Ca
Visc./Pen Grade	150/200	200/300	AC-10	AC-5	AC-8	AC-5	AR-4000
SHRP PG Grade	PG58-28	PG46-34	PG58-22	PG52-22	PG58-16	PG52-22	PG58-28
Aged Asphalt (Thin Film Oven Test)							
Mass Change, %	-0.3115	-0.5370	-0.0362	-0.0149	-0.2590	-0.2780	-0.8102
Viscosity							
140°F, poise	1901	869	2380	1073	1014	648	3420
275°F, cSt	393	270	393	263	239	185	511
Viscosity Ratio (140°F)	2.20	2.39	2.31	2.66	2.42	2.13	3.24
IEC Separations (wt %)	AAA-1		AAB-1		AAC-1		AAD-1
Strong Acid*	*6.4*		*15.0*		*7.5*		*11.0*
SA Mol. Wt,VPO, Toluene	*2790*		*2390*				*2500*
Amphoterics*	*11*						*15*
Strong Base	*6.4*		*9.2*		*7.4*		*7.8*
Weak Acid	*8.7*		*8.6*		*8.3*		*7.8*
Weak Base	*5.0*		*6.5*		*7.2*		*5.5*
Neutral	*59.6*		*56.9*		*68.2*		*51.7*
Neutrals plus acids**							*60.0*
Amphoterics**							*25.7*
Bases**							*9.3*
Neutral Fraction Viscosity, poise, 77°F	*355*		*1,553*		*3,100*		*197*
*calculated **WRI Method							
SEC Fraction, MW							
VPO, Toluene I	*11000*		*9200*		*7380*		*7000*
SEC I, TFAAT Aged	*11500*		*9800*		*8400*		*13900*
II							
Fraction II - wt. %	*78.2*		*78.3*		*85.8*	*87.8*	*76.6*
Visc. with SEC fraction 1 removed (77°F, poise)	*5064*		*13675*		*86020*	*53590*	*3366*
Visc. of whole asphalt, 77°F, Poise x10E-3	*275.4*		*1,125*		*945.4*		*405.7*

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	**AAA-1**	**AAA-2**	**AAB-1**	**AAB-2**	**AAC-1**	**AAC-2**	**AAD-1**
Crude Oil Source	Lloydminster		WY Sour		Redwater		Ca
Visc./Pen Grade	150/200	200/300	AC-10	AC-5	AC-8	AC-5	AR-4000
SHRP PG Grade	PG58-28	PG46-34	PG58-22	PG52-22	PG58-16	PG52-22	PG58-28
Viscoelastic Properties	DSR Rheometer, Bending Beam Rheometer, Direct Tension						
Tank Asphalt							
Td,Tank,°C	-19.3		-11.6		-5.5		-17.1
R,Tank	1.50		1.76		1.63		1.66
G*,Pa,60°C,10 rad/s	2860		2486		2152		3148
∂ @ 60° (deg)	84.3		85.2		85.7		81.7
G*/sin∂, kPa,52°C	2.48	46° 1.67		1.90	2.98	1.83	3.16
G*/sin∂, kPa,58°C	0.96	52° .78	1.86	0.84	1.08	0.81	1.47
G*/sin∂, kPa,64°C			0.83		0.51		0.69
G*/sin∂, kPa,70°C							
TFOT Residue							
Td,TFOT,°C	-14.3		-5.3		-3.8		-13.3
R,TFOT	1.75		2.06		1.80		1.80
G*,Pa,60°C,10 rad/s	2723		3229		2664		3784
∂ @ 60° (deg)	83.0		83.3		85.0		78.4
RTFOT Residue							
G*/sin∂, kPa,52°C	4.92	46°4.49		4.82	5.50	3.36	
G*/sin∂, kPa,58°C	2.40	52° 2.01	3.34	1.89	2.34	1.49	4.29
G*/sin∂, kPa,64°C			1.39				1.97
G*/sin∂, kPa,70°C							
PAV Residue							
Td,PAV,°C	-14.5		-6.0		3.5		-8.7
R,PAV	1.90		2.13		2.10		2.07
G*,Pa,60°C,10 rad/s	5899		8888		7175		11319
∂ @ 60° (deg)	79.2		79.0		82.3		72.6
G*sin∂, MPa @ 10° C		4.2					
G*sin∂, MPa @ 15° C		2.1					
G*sin∂, MPa @ 20° C	2.7	1.1	3.8	2.9	6.6	3.4	2.8
G*sin∂, MPa @ 25° C	1.3		2.4	1.6	2.9	1.8	1.7
G*sin∂, MPa @ 30° C							
S(t), MPa, @ 0°C					30		
S(t), MPa, @ -10°C	50		125	65	186	98	83
S(t), MPa, @ -20°C	246	92	471	237		370	346
S(t), MPa, @ -30°C		375					
m @ 0° C					0.40		
m @ -10° C	0.41		0.34	0.36	0.30	0.37	0.38
m @ -20° C	0.33	0.38	0.25	0.28		0.27	0.31
m @ -30° C		0.29					
Failure strain 0°C							
Failure strain -10°C	10.70	>12	7.23	7.63	4.07	4.12	10.51
Failure strain -20°C	0.38	0.47				0.83	

MRL Code	AAA-1	AAA-2	AAB-1	AAB-2	AAC-1	AAC-2	AAD-1
Crude Oil Source	Lloydminster		WY Sour		Redwater		Ca
Visc./Pen Grade	150/200	200/300	AC-10	AC-5	AC-8	AC-5	AR-4000
SHRP PG Grade	PG58-28	PG46-34	PG58-22	PG52-22	PG58-16	PG52-22	PG58-28
Functional Group Analysis		(By Infra-Red Analysis)					
Carboxylic Acids							
(Tank)	*0.015*		*<.005*		*0.010*	*<.005*	*0.015*
Acid Salts							
(Tank)	*<.005*		*<.005*		*<.005*	*<.005*	*<.005*
Acid Anhydrides							
(Tank)	*0.000*		*0.000*		*0.000*		*0.000*
(POV (144 hr.))					*0.012*		
Quinolones							
(Tank)	*0.011*		*0.012*		*0.011*	*0.010*	*0.027*
Ketones							
(Tank)	*<.005*		*<.005*		*<.005*	*<.005*	*<.005*
(TFO)	*0.020*		*0.000*		*0.020*		*0.040*
(POV (144 hr.))	*0.040*		*0.050*		*0.090*	*0.090*	*0.070*
Phenols							
(Tank)	*0.080*		*0.060*		*0.040*	*0.010*	*0.130*
Sulfoxides							
(Tank)	*0.037*		*0.064*		*0.029*	*0.144*	*0.036*
(TFO)	*Tr*		*0.080*		*Tr*		*Tr*
(POV (144 hr.))	*0.220*		*0.250*		*0.190*	*0.220*	*0.250*
Pyrroles							
(Tank)	*0.120*		*0.140*		*0.220*	*0.214*	*0.190*

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	AAD-2	AAE(blown	AAF-1	AAF-2	AAG-1	AAG-2	AAH
Crude Oil Source	Coastal	Lloydminste	W Tx Sour		Ca Valley		Rangely
Visc./Pen Grade	AR-2000	60/70	AC-20	AC-10	AR-4000	AR-2000	AC-10
SHRP PG Grade	PG52-28	PG70-22	PG64-10	PG58-16	PG58-10	PG58-16	PG58-22
Original Asphalt							
Viscosity							
140°F, poise	600	3634	1872	867	1862	1056	1058
275°F, cSt	225	560	327	223	243	170	298
Penetration, 0.1 mm							
(77°F, 100g, 5s)	195	73	55	82	53	76	95
(39.2°F, 100g, 5s)	17	7	0	2	2		7
Ductility, cm							
(39.2 °F,1cm/min)	150+	32.5	7.6	47.1	0.0	150+	18.8
Softening Point (R&B), °F	117	125	122	117	120	111	114
Component Analysis, %							
Asphaltenes (n-heptane)	21.3	*22.9*	*13.3*	13.0	*5.0*	*5.0*	*15.9*
Asphaltenes (iso-Octane)	*3.1*	*1.9*	*3.1*		*3.3*	*2.8*	*3.8*
Polar Aromatics	40.1	30.5	38.3	38.7	51.2	51.0	41.4
Napthene Aromatics	26.7	31.6	37.7	34.6	32.5	35.3	28.6
Saturates	10.0	12.7	9.6	11.9	8.5	6.6	13.5
Elemental Analysis							
C, %	81.9	*83.8*	84.5	84.8	*85.6*	87.0	*86.3*
H, %	10.3	*10.1*	10.4	10.2	*10.5*	10.5	*10.1*
O, %		*1.0*	1.1		*1.1*		*1.0*
Nitrogen, %	0.90	*0.70*	*0.55*	0.28	*1.10*	1.15	*0.80*
Sulfur, %	8.30	*5.20*	*3.40*	4.60	*1.30*	2.90	*2.80*
Vanadium, ppm	266	*179*	*87*	102	*37*	33	*84*
Nickel, ppm	135	*91*	*35*	22	*95*	11	*43*
Fe, ppm		*6*	100		48		*105*
Aromatic C, %			32.8		28.3		
Aromatic H, %			8.66		7.27		
Molecular wt. (Toluene)		*820*	*840*		*710*		*840*
% WAX (INTEVEP)	1.41	1.23	4.19	4.20	1.13	1.11	4.41
WAX M. P. (deg. C)	58.7	42.5	59.6	60.4	33.0	34.6	52.8

WRI data in italics PSU data in Monaco **UT data in bold**

TAI data in Helvetica MSU data in outline

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	**AAD-2**	**AAE(blown**	**AAF-1**	**AAF-2**	**AAG-1**	**AAG-2**	**AAH**
Crude Oil Source	Coastal	Lloydminste	W Tx Sour		Ca Valley		Rangely
Visc./Pen Grade	AR-2000	60/70	AC-20	AC-10	AR-4000	AR-2000	AC-10
SHRP PG Grade	PG52-28	PG70-22	PG64-10	PG58-16	PG58-10	PG58-16	PG58-22
Aged Asphalt							
(Thin Film Oven Test)							
Mass Change, %	-0.7085	-0.2888	-0.0921	-0.0685	-0.1799	-0.0190	-0.4524
Viscosity							
140°F, poise	1715	11589	4579	2011	3253	1781	2809
275°F, cSt	370	914	472	321	304	216	441
Viscosity Ratio (140°F)	2.86	3.19	2.45	2.32	1.75	1.69	2.66
IEC Separations (wt %)							
			AAF-1		AAG-1		
Strong Acid*			*15.4*		*18.1*		
SA Mol. Wt,VPO, Toluene			*1170*		*1080*		
Amphoterics*							
Strong Base			*6.1*		*12.0*		
Weak Acid			*9.8*		*11.4*		
Weak Base			*8.5*		*9.1*		
Neutral			*56.7*		*50.4*		
Neutrals plus acids**					*67.6*		
Amphoterics**					*18.5*		
Bases**					*12.0*		
Neutral Fraction							
Viscosity, poise, 77°F			*4,795*		*2,605*		
*calculated **WRI Method							
SEC Fraction, MW							
VPO, Toluene							
I			*8690*		*7900*		
SEC I, TFAAT Aged			*10100*		*7800*		
II							
Fraction II - wt. %	*76.8*	*73.6*	*85.6*		*87.1*	*89.2*	*75.0*
Visc. with SEC fraction 1 removed (77°F, poise)		*3144*	*533500*		*623800*		*36540*
Vis of whole asphalt, 77 Poise x10E-3			*3,078*		*3,540*		

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	AAD-2	AAE(blown	AAF-1	AAF-2	AAG-1	AAG-2	AAH
Crude Oil Source	Coastal	Lloydminste	W Tx Sour		Ca Valley		Rangely
Visc./Pen Grade	AR-2000	60/70	AC-20	AC-10	AR-4000	AR-2000	AC-10
SHRP PG Grade	PG52-28	PG70-22	PG64-10	PG58-16	PG58-10	PG58-16	PG58-22
Viscoelastic Properties							
Tank Asphalt							
Td, Tank, °C			-7.0		-3.9		
R, Tank			1.60		1.24		
G*, Pa, 60°C, 10 rad/s			3547		8171		
∂ @ 60° (deg)			87.5		88.2		
G*/sin∂, kPa, 52°C	1.41			3.25		4.61	3.80
G*/sin∂, kPa, 58°C	0.67	4.52	2.60	1.39	3.02	1.88	1.66
G*/sin∂, kPa, 64°C		2.15	1.13		1.24	0.77	0.79
G*/sin∂, kPa, 70°C		1.06	0.53		0.57		
TFOT Residue							
Td, TFOT, °C		-18.9	-1.4		0.8		-1.5
R, TFOT		2.05	1.77		1.35		2.08
G*, Pa, 60°C, 10 rad/s		9656	5457		4310		4363
∂ @ 60° (deg)		73.3	86.2		88.8		83.3
RTFOT Residue							
G*/sin∂, kPa, 52°C	4.43			7.95		6.48	
G*/sin∂, kPa, 58°C	2.08		5.83	3.27	4.58	2.38	4.75
G*/sin∂, kPa, 64°C		5.87	2.51	1.46	1.77	0.98	2.14
G*/sin∂, kPa, 70°C		2.82					
PAV Residue							
Td, PAV, °C			5.2		2.7		
R, PAV			2.02		1.44		
G*, Pa, 60°C, 10 rad/s			18845		9581		
∂ @ 60° (deg)			81.5		87.5		
G*sin∂, MPa @ 10° C							
G*sin∂, MPa @ 15° C							
G*sin∂, MPa @ 20° C	2.2						
G*sin∂, MPa @ 25° C	1.0	2.3		4.6		4.8	2.5
G*sin∂, MPa @ 30° C		1.4	3.8	2.2	3.4	1.7	
S(t), MPa, @ 0°C			90		99	50	
S(t), MPa, @ -10°C		100	333	149		417	132
S(t), MPa, @ -20°C	162	334		448		1219	
S(t), MPa, @ -30°C	562						
m @ 0° C			0.30		0.49	0.46	
m @ -10° C		0.31	0.27	0.32		0.34	0.31
m @ -20° C	0.34	0.29		0.23		0.14	
m @ -30° C	0.25						
Failure strain 0°C		13.21	10.04		5.23	>1.0	
Failure strain -10°C	7.33			0.92			0.33
Failure strain -20°C	0.23						

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	AAD-2	AAE(blown	AAF-1	AAF-2	AAG-1	AAG-2	AAH
Crude Oil Source	Coastal	Lloydminste	W Tx Sour		Ca Valley		Rangely
Visc./Pen Grade	AR-2000	60/70	AC-20	AC-10	AR-4000	AR-2000	AC-10
SHRP PG Grade	PG52-28	PG70-22	PG64-10	PG58-16	PG58-10	PG58-16	PG58-22
Functional Group Analysi							
Carboxylic Acids							
(Tank)	0.020	0.015	<.005		<.005		<.005
Acid Salts							
(Tank)	<.005	<.005	<.005		0.055		<.005
Acid Anhydrides							
(Tank)		0.000	0.000		0.000		
(POV (144 hr.))							
Quinolones							
(Tank)	0.018	0.008	0.007		0.010		0.008
Ketones							
(Tank)	<.005	<.005	<.005		<.005		<.005
(TFO)		0.035	0.000		0.030		0.005
(POV (144 hr.))	0.070	0.090	0.070		0.120	0.140	0.130
Phenols							
(Tank)	0.032	0.029	0.010		0.140		0.017
Sulfoxides							
(Tank)	0.016	0.028	0.050		0.046		0.073
(TFO)		tr	0.060		Tr		0.067
(POV (144 hr.))	0.280	0.340	0.250		0.180	0.240	0.280
Pyrroles							
(Tank)	0.213	0.132	0.140		0.380		0.180

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	AAJ	AAK-1	AAK-2	AAL	AAM-1	AAM-2	AAN
Crude Oil Source	OK Mix	Boscan	Boscan	Cold Lake	W Tx Inter		Bow Riv
Visc./Pen Grade	AC-20	AC-30	AC-10	150/200	AC-20	AC-10	85/100
SHRP PG Grade	PG64-22	PG64-22	PG58-28	PG58-28	PG64-16	PG58-22	PG58-16
Original Asphalt							
Viscosity							
140°F, poise	1765	3256	996	800	1992	924	1429
275°F, cSt	415	562	320	259	569	407	328
Penetration, 0.1 mm							
(77°F, 100g, 5s)	67	70	154	156	64	102	90
(39.2°F, 100g, 5s)	0	2	12	16	4	3	2
Ductility, cm							
(39.2 °F,1cm/min)	14.7	27.8	150+	150+	4.6	8.4	51.8
Softening Point (R&B), °F	118	121	108	107	125	116	110
Component Analysis, %							
Asphaltenes (n-heptane)	*10.6*	*20.1*	*19.2*	18.9	*4.0*	*4.8*	*15.7*
Asphaltenes (iso-Octane)	*3.9*	*2.8*	*2.5*		*5.4*	*4.5*	*2.8*
Polar Aromatics	41.5	41.8	39.4	37.3	50.3	50.0	33.9
Napthene Aromatics	35.9	30.0	30.6	30.3	41.9	41.3	40.1
Saturates	10.9	5.1	7.5	12.1	1.9	3.0	10.3
Elemental Analysis							
C, %	*86.5*	*83.7*	83.2	*83.4*	*86.8*	87.3	*84.5*
H, %	*10.7*	*10.2*	10.3	*10.1*	*11.2*	11.0	*10.2*
O, %	*0.7*	*0.8*		*1.0*	*0.5*		*0.8*
Nitrogen, %	*0.60*	*0.70*	0.70	*0.60*	*0.55*	0.55	*0.70*
Sulfur, %	*1.90*	*6.40*	6.90	*5.50*	*1.20*	1.90	*4.30*
Vanadium, ppm	*148*	*1480*	1165	*244*	*58*	54	*157*
Nickel, ppm	*74*	*142*	117	*98*	*36*	32	*65*
Fe, ppm	*63*	24		*8*	255		*21*
Aromatic C, %		31.9			24.7		
Aromatic H, %		5.83			6.51		
Molecular wt. (Toluene)	*1030*	*860*		*760*	*1300*		*890*
% WAX (INTEVEP)	4.91	1.17	1.14	1.23	4.21	6.41	2.74
WAX M. P. (deg. C)	43.2	56.1	54.1	43.9	32.9	32.5	55.3

WRI data in italics PSU data in Monaco UT data in bold

TAI data in Helvetica MSU data in outline

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	**AAJ**	**AAK-1**	**AAK-2**	**AAL**	**AAM-1**	**AAM-2**	**AAN**
Crude Oil Source	OK Mix	Boscan	Boscan	Cold Lake	W Tx Inter		Bow Riv
Visc./Pen Grade	AC-20	AC-30	AC-10	150/200	AC-20	AC-10	85/100
SHRP PG Grade	PG64-22	PG64-22	PG58-28	PG58-28	PG64-16	PG58-22	PG58-16
Aged Asphalt							
(Thin Film Oven Test)							
Mass Change, %	0.0260	-0.5483	-1.2305	-0.4151	+0.0516	+0.0671	-0.0502
Viscosity							
140°F, poise	4021	9708	3098	2180	3947	1816	3027
275°F, cSt	550	930	533	403	744	526	460
Viscosity Ratio (140°F)	2.28	2.98	3.11	2.73	1.98	1.96	2.12
IEC Separations (wt %)							
		AAK-1			AAM-1		
Strong Acid*		3.7			4.7		
SA Mol. Wt,VPO, Toluene		2780			3040		
Amphoterics*		15			9		
Strong Base		8.0			10.4		
Weak Acid		8.6			10.0		
Weak Base		7.5			9.1		
Neutral		52.5			53.4		
Neutrals plus acids**		61.6			65.0		
Amphoterics**		24.3			18.5		
Bases**		9.9			14.3		
Neutral Fraction							
Viscosity, poise, 77°F		463			11,910		
*calculated **WRI Method							
SEC Fraction, MW							
VPO, Toluene							
I		10000			4600		
SEC I, TFAAT Aged		13000			5700		
II							
Fraction II - wt. %	78.9	74.1	76.5	77.3	69.5	72.5	79.2
Visc. with SEC fraction 1 removed (77°F, poise)	47220	11240			263500		23710
Visc. of whole asphalt, 77°F, Poise x10E-3		1,077			1123		

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MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	AAJ	AAK-1	AAK-2	AAL	AAM-1	AAM-2	AAN
Crude Oil Source	OK Mix	Boscan	Boscan	Cold Lake	W Tx Inter		Bow Riv
Visc./Pen Grade	AC-20	AC-30	AC-10	150/200	AC-20	AC-10	85/100
SHRP PG Grade	PG64-22	PG64-22	PG58-28	PG58-28	PG64-16	PG58-22	PG58-16
Viscoelastic Properties							
Tank Asphalt							
Td,Tank,°C		-14.7			1.0		
R,Tank		1.60			1.93		
G*,Pa,60°C,10 rad/s		5445			3784		
δ @ 60° (deg)		80.0			84.0		
G*/sinδ, kPa,52°C			2.76	2.44			
G*/sinδ, kPa,58°C	2.62	3.79	1.32	1.13	2.43	1.72	1.86
G*/sinδ, kPa,64°C	1.19	1.78			1.15	0.84	0.84
G*/sinδ, kPa,70°C		0.86			0.57		
TFOT Residue							
Td,TFOT,°C	-4.3	-9.3		-18.0	4.8		-1.0
R,TFOT	1.92	1.80		1.67	2.21		2.02
G*,Pa,60°C,10 rad/s	5570	8442		2664	4857		3742
δ @ 60° (deg)	83.4	76.2		83.0	82.0		84.6
RTFOT Residue							
G*/sinδ, kPa,52°C			8.05	5.71		7.76	
G*/sinδ, kPa,58°C	6.78	9.55	3.69	2.54	5.51	3.31	3.34
G*/sinδ, kPa,64°C	2.96	4.50	1.77		2.46	1.37	1.50
G*/sinδ, kPa,70°C		2.21			1.17		
PAV Residue							
Td,PAV,°C		-9.2			6.0		
R,PAV		1.94			2.61		
G*,Pa,60°C,10 rad/s		20221			14458		
δ @ 60° (deg)		71.5			74.2		
G*sinδ, MPa @ 10° C							
G*sinδ, MPa @ 15° C							
G*sinδ, MPa @ 20° C			2.7	2.6	3.2	2.7	
G*sinδ, MPa @ 25° C	3.0	3.1	1.2	1.3	1.9	1.5	2.6
G*sinδ, MPa @ 30° C		1.5					
S(t), MPa, @ 0°C							
S(t), MPa, @ -10°C	135	150	46	64	146	95	145
S(t), MPa, @ -20°C			235	276		313	
S(t), MPa, @ -30°C							
m @ 0° C							
m @ -10° C	0.32	0.35	0.42	0.41	0.29	0.33	0.30
m @ -20° C			0.33	0.31		0.26	
m @ -30° C							
Failure strain 0°C		>3.48	>10.6			>5.91	
Failure strain -10°C	4.33	3.48	0.46	3.74	5.23	5.91	1.09
Failure strain -20°C							

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	AAJ	AAK-1	AAK-2	AAL	AAM-1	AAM-2	AAN
Crude Oil Source	OK Mix	Boscan	Boscan	Cold Lake	W Tx Inter		Bow Riv
Visc./Pen Grade	AC-20	AC-30	AC-10	150/200	AC-20	AC-10	85/100
SHRP PG Grade	PG64-22	PG64-22	PG58-28	PG58-28	PG64-16	PG58-22	PG58-16
Functional Group Analysi							
Carboxylic Acids							
(Tank)	*<.005*	*0.012*	*0.023*	*0.013*	*<.005*	*0.008*	*<.005*
Acid Salts							
(Tank)	*<.005*	*<.005*	*<.005*	*<.005*	*<.005*	*<.005*	*<.005*
Acid Anhydrides							
(Tank)		*0.000*			*0.000*		*0.000*
(POV (144 hr.))							
Quinolones							
(Tank)	*0.008*	*0.014*	*0.010*	*0.011*	*0.013*	*0.006*	*0.014*
Ketones							
(Tank)	*<.005*	*<.005*	*<.005*	*<.005*	*<.005*	*<.005*	*<.005*
(TFO)	*0.020*	*0.030*			*0.020*		*0.010*
(POV (144 hr.))	*0.130*	*0.050*	*0.060*		*0.110*	*0.110*	*0.070*
Phenols							
(Tank)	*0.036*	*0.030*	*0.006*	*0.045*	*0.070*	*0.034*	*0.030*
Sulfoxides							
(Tank)	*0.036*	*0.022*	*0.107*	*0.031*	*0.023*	*0.016*	*0.033*
(TFO)	*tr*	*Tr*			*Tr*		*tr*
(POV (144 hr.))	*0.190*	*0.210*	*0.230*		*0.100*	*0.100*	*0.330*
Pyrroles							
(Tank)	*0.218*	*0.120*	*0.182*	*0.166*	*0.170*	*0.187*	*0.168*

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	AAO	AAP	AAQ	AAR	AAS-1	AAS-2	AAS-3
Crude Oil Source	Arab Hvy	OK Mix	WY/Can	Maya/Wy		Arab Hvy	
Visc./Pen Grade	AC-10	AC-20	AC-10	AC-20	AC-20	AC-10	AC-30
SHRP PG Grade	PG58-22	PG64-22	PG58-22	PG64-22	PG64-22	PG58-28	PG64-22
Original Asphalt							
Viscosity							
140°F, poise	1151	2300	994	1896	2187	1220	3129
275°F, cSt	335	505	239	390	472	358	557
Penetration, 0.1 mm							
(77°F, 100g, 5s)	106	71	92	76	64	96	52
(39.2°F, 100g, 5s)	8	1	4	6	8	10	5
Ductility, cm							
(39.2 °F, 1cm/min)	55.3	11.2	25.3	17.3	13.7	66.1	7.7
Softening Point (R&B), °F	115	120	108	120	121	112	124
Component Analysis, %							
Asphaltenes (n-heptane)	16.4	12.6	16.2	18.4	*18.4*	17.1	17.3
Asphaltenes (iso-Octane)					*2.9*		
Polar Aromatics	32.9	36.9	25.9	30.5	34.1	30.0	37.7
Napthene Aromatics	41.8	36.4	44.8	41.1	39.7	46.4	39.9
Saturates	8.6	13.2	12.5	10.0	5.9	6.4	3.8
Elemental Analysis							
C, %	*83.8*	*85.9*	*85.5*	*84.1*	*84.0*	83.1	81.7
H, %	*10.1*	*10.9*	*10.1*	*10.1*	*10.0*	9.8	10.1
O, %	*0.5*	*0.8*	*0.5*	*0.6*	*0.8*		
Nitrogen, %	*0.40*	*0.60*	*0.60*	*0.69*	*0.60*	0.44	0.48
Sulfur, %	*5.00*	*1.70*	*3.60*	*4.60*	*5.40*	6.76	6.21
Vanadium, ppm	*163*	*128*	*126*	*334*	*159*	133	137
Nickel, ppm	*46*	*68*	*51*	*79*	*52*	37	40
Fe, ppm	*18*	*48*	*80*	*13*	*51*		
Aromatic C, %							
Aromatic H, %							
Molecular wt. (Toluene)	*930*	*1090*	*810*	*880*	*960*		
% WAX (INTEVEP)	2.56	4.77	3.55	2.76	2.89	2.85	3.53
WAX M. P. (deg. C)	59.8	51.3	61.6	57.3	55.8	58.9	66.0

WRI data in italics PSU data in Monaco **UT data in bold**

TAI data in Helvetica MSU data in outline

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	AAO	AAP	AAQ	AAR	AAS-1	AAS-2	AAS-3
Crude Oil Source	Arab Hvy	OK Mix	WY/Can	Maya/Wy		Arab Hvy	
Visc./Pen Grade	AC-10	AC-20	AC-10	AC-20	AC-20	AC-10	AC-30
SHRP PG Grade	PG58-22	PG64-22	PG58-22	PG64-22	PG64-22	PG58-28	PG64-22
Aged Asphalt							
(Thin Film Oven Test)							
Mass Change, %	-0.0071	-0.0527	-0.0864	-0.0972	--0.0394	--0.0160	--0.0550
Viscosity							
140°F, poise	2332	5854	1872	4224	4827	2739	7547
275°F, cSt	442	712	299	518	659	495	789
Viscosity Ratio (140°F)	2.03	2.55	1.88	2.23	2.21	3.25	2.41
IEC Separations (wt %)							
Strong Acid*							
SA Mol. Wt,VPO, Toluene							
Amphoterics*							
Strong Base							
Weak Acid							
Weak Base							
Neutral							
Neutrals plus acids**							
Amphoterics**							
Bases**							
Neutral Fraction							
Viscosity, poise, 77°F							
*calculated **WRI Method							
SEC Fraction, MW							
VPO, Toluene							
I							
SEC I, TFAAT Aged							
II							
Fraction II - wt. %	*77.0*	*75.6*	*81.4*	*76.4*	*76.5*		
Visc. with SEC fraction 1 removed (77°F, poise)					*13130*		
Visc. of whole asphalt, 77°F, Poise x10E-3							

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MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	AAO	AAP	AAQ	AAR	AAS-1	AAS-2	AAS-3
Crude Oil Source	Arab Hvy	OK Mix	WY/Can	Maya/Wy		Arab Hvy	
Visc./Pen Grade	AC-10	AC-20	AC-10	AC-20	AC-20	AC-10	AC-30
SHRP PG Grade	PG58-22	PG64-22	PG58-22	PG64-22	PG64-22	PG58-28	PG64-22
Viscoelastic Properties							
Tank Asphalt							
Td,Tank,°C							
R,Tank							
G*,Pa,60°C,10 rad/s							
∂ @ 60° (deg)							
G*/sin∂, kPa,52°C			3.12				
G*/sin∂, kPa,58°C	1.93	3.47	1.40	2.27	2.24	2.07	4.31
G*/sin∂, kPa,64°C	0.92	1.60	0.63	1.06	1.11	0.99	1.94
G*/sin∂, kPa,70°C							0.94
TFOT Residue							
Td,TFOT,°C	-7.8	-7.8	-3.0	-7.4	-8.0		
R,TFOT	1.78	2.08	1.78	1.82	1.84		
G*,Pa,60°C,10 rad/s	3323	6621	2675	4722	5751		
∂ @ 60° (deg)	83.6	82.9	85.9	81.7	81.0		
RTFOT Residue							
G*/sin∂, kPa,52°C			6.25				
G*/sin∂, kPa,58°C	3.05	6.22	2.69	5.04	6.02	3.16	8.52
G*/sin∂, kPa,64°C	1.45	2.87	1.19	2.38	2.67	1.51	3.86
G*/sin∂, kPa,70°C							
PAV Residue							
Td,PAV,°C							
R,PAV							
G*,Pa,60°C,10 rad/s							
∂ @ 60° (deg)							
G*sin∂, MPa @ 10° C							
G*sin∂, MPa @ 15° C							
G*sin∂, MPa @ 20° C	3.2	3.3		4.6		2.5	
G*sin∂, MPa @ 25° C	1.6	2.0	2.9	2.5	2.2	1.5	3.2
G*sin∂, MPa @ 30° C							1.8
S(t), MPa, @ 0°C							
S(t), MPa, @ -10°C	107	93	157	132	109	58	121
S(t), MPa, @ -20°C						243	
S(t), MPa, @ -30°C							
m @ 0° C							
m @ -10° C	0.35	0.32	0.34	0.35	0.35	0.38	0.35
m @ -20° C						0.30	
m @ -30° C							
Failure strain 0°C							>2.55
Failure strain -10°C	4.14	5.32	0.88	2.13	3.24	6.37	2.55
Failure strain -20°C							

MRL Code	**AAO**	**AAP**	**AAQ**	**AAR**	**AAS-1**	**AAS-2**	**AAS-3**
Crude Oil Source	Arab Hvy	OK Mix	WY/Can	Maya/Wy		Arab Hvy	
Visc./Pen Grade	AC-10	AC-20	AC-10	AC-20	AC-20	AC-10	AC-30
SHRP PG Grade	PG58-22	PG64-22	PG58-22	PG64-22	PG64-22	PG58-28	PG64-22
Functional Group Analysi							
Carboxylic Acids							
(Tank)	*0.008*	*<.005*	*<.005*	*0.009*	*<.005*		
Acid Salts							
(Tank)	*<.005*	*<.005*	*<.005*	*<.005*	*<.005*		
Acid Anhydrides							
(Tank)					*0.000*		
(POV (144 hr.))							
Quinolones							
(Tank)	*0.008*	*0.010*	*0.011*	*0.018*	*0.009*		
Ketones							
(Tank)	*<.005*	*0.022*	*<.005*	*<.005*	*<.005*		
(TFO)					*0.000*		
(POV (144 hr.))					*0.070*		
Phenols							
(Tank)	*0.003*	*0.047*	*0.015*	*0.013*	*0.013*		
Sulfoxides							
(Tank)	*0.052*	*0.041*	*0.073*	*0.040*	*0.022*		
(TFO)					*tr*		
(POV (144 hr.))					*0.290*		
Pyrroles							
(Tank)	*0.171*	*0.183*	*0.173*	*0.190*	*0.118*		

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	AAT	AAU	AAV	AAW	AAX	AAY	AAZ
Crude Oil Source	Maya/Blenc	ANS/Ca	ANS	W TX/Maya	Potaku/La	Maya/Arab	WTx/Cost
Visc./Pen Grade	AC-20	AC-20	AC-5	AC-20	AC-20	AC-20	AC-20
SHRP PG Grade	PG64-16	PG64-16	PG52-22	PG64-16	PG64-16	PG64-22	PG58-16
Original Asphalt							
Viscosity							
140°F, poise	2092	2073	561	1971	1908	2155	1952
275°F, cSt	395	381	240	384	380	425	359
Penetration, 0.1 mm							
(77°F, 100g, 5s)	63	68	121	64	51	82	58
(39.2°F, 100g, 5s)	5	2	8	1	4	5	3
Ductility, cm							
(39.2 °F,1cm/min)	9.9	11.1	150+	8.3	7.3	13.9	13.9
Softening Point (R&B), °F	120	121	110	120	121	119	117
Component Analysis, %							
Asphaltenes (n-heptane)	17.3	17.7	*9.7*	*17.9*	*12.0*	22.4	*9.2*
Asphaltenes (iso-Octane)			*3.3*	*2.9*	*3.1*		*4.0*
Polar Aromatics	42.5	40.5	39.5	35.7	41.3	31.4	42.0
Napthene Aromatics	32.3	33.6	38.9	37.1	39.6	35.4	43.1
Saturates	7.7	7.9	10.9	9.3	7.9	9.4	6.8
Elemental Analysis							
C, %	*83.9*	*84.4*	*86.4*	*84.5*	*86.6*	*83.7*	*85.0*
H, %	*10.1*	*10.2*	*10.5*	*10.1*	*10.4*	*10.1*	*10.0*
O, %	*0.7*	*0.7*	*1.1*	*0.9*	*1.1*	*0.5*	*0.9*
Nitrogen, %	*0.60*	*0.80*	*0.80*	*0.70*	*0.80*	*0.60*	*0.60*
Sulfur, %	*5.10*	*4.00*	*2.40*	*4.50*	*2.40*	*5.40*	*4.40*
Vanadium, ppm	*201*	*197*	*92*	*334*	*116*	*439*	*102*
Nickel, ppm	*80*	*98*	*41*	*80*	*56*	*88*	*35*
Fe, ppm	*54*	*22*	*6*	*33*	*94*	*16*	*40*
Aromatic C, %							
Aromatic H, %							
Molecular wt. (Toluene)	*880*	*880*	*890*	*890*	*970*	*860*	*970*
% WAX (INTEVEP)	2.55	2.35	3.13	4.20	3.51	2.60	2.54
WAX M. P. (deg. C)	63.1	58.6	61.3	62.6	55.1	62.3	43.8

WRI data in italics PSU data in Monaco **UT data in bold**

TAI data in Helvetica MSU data in outline

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	AAT	AAU	AAV	AAW	AAX	AAY	AAZ
Crude Oil Source	Maya/Blenc	ANS/Ca	ANS	W TX/Maya	Potaku/La	Maya/Arab	WTx/Cost
Visc./Pen Grade	AC-20	AC-20	AC-5	AC-20	AC-20	AC-20	AC-20
SHRP PG Grade	PG64-16	PG64-16	PG52-22	PG64-16	PG64-16	PG64-22	PG58-16
Aged Asphalt							
(Thin Film Oven Test)							
Mass Change, %	-0.1559	-0.6364	-0.1338	-0.0819	-0.0576	-0.1877	0.0716
Viscosity							
140°F, poise	5297	5526	1037	4868	4048	6356	3214
275°F, cSt	562	566	293	526	503	664	446
Viscosity Ratio (140°F)	2.53	2.67	1.85	2.47	2.12	2.95	1.65
IEC Separations (wt %)							
Strong Acid*							
SA Mol. Wt,VPO, Toluene							
Amphoterics*							
Strong Base							
Weak Acid							
Weak Base							
Neutral							
Neutrals plus acids**							
Amphoterics**							
Bases**							
Neutral Fraction							
Viscosity, poise, 77°F							
*calculated **WRI Method							
SEC Fraction, MW							
VPO, Toluene							
I							
SEC I, TFAAT Aged							
II							
Fraction II - wt. %	*76.0*	*78.9*	*84.3*	*80.1*	*81.8*	*74.0*	*84.6*
Visc. with SEC fraction 1 removed (77°F, poise)			*36930*	*42770*	*137700*		*228300*
Visc. of whole asphalt, 77°F, Poise x10E-3							

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	AAT	AAU	AAV	AAW	AAX	AAY	AAZ
Crude Oil Source	Maya/Blenc	ANS/Ca	ANS	W TX/Maya	Potaku/La	Maya/Arab	WTx/Cost
Visc./Pen Grade	AC-20	AC-20	AC-5	AC-20	AC-20	AC-20	AC-20
SHRP PG Grade	PG64-16	PG64-16	PG52-22	PG64-16	PG64-16	PG64-22	PG58-16
Viscoelastic Properties							
Tank Asphalt							
Td,Tank,°C							
R,Tank							
G*,Pa,60°C,10 rad/s							
∂ @ 60° (deg)							
G*/sin∂, kPa,52°C			1.70				
G*/sin∂, kPa,58°C	3.68	2.67	0.77	3.12	2.19	2.97	2.43
G*/sin∂, kPa,64°C	1.60	1.21		1.41	1.04	1.36	1.09
G*/sin∂, kPa,70°C							
TFOT Residue							
Td,TFOT,°C	-4.3	-4.1	-5.5	-1.4		-9.2	
R,TFOT	1.69	1.64	1.50	1.80		2.12	
G*,Pa,60°C,10 rad/s	6741	7374	1332	4978	6003	6221	4290
∂ @ 60° (deg)	82.3	82.0	87.9	81.2	85.1	75.1	87.8
RTFOT Residue							
G*/sin∂, kPa,52°C			3.38				
G*/sin∂, kPa,58°C	6.22	7.74	1.46	7.60	5.21	10.42	4.58
G*/sin∂, kPa,64°C	2.75	3.30		3.31	2.26	4.82	1.96
G*/sin∂, kPa,70°C		1.49				2.32	
PAV Residue							
Td,PAV,°C							
R,PAV							
G*,Pa,60°C,10 rad/s							
∂ @ 60° (deg)							
G*sin∂, MPa @ 10° C							
G*sin∂, MPa @ 15° C							
G*sin∂, MPa @ 20° C			3.8				
G*sin∂, MPa @ 25° C	6.0		1.8	3.7	4.6	2.1	4.2
G*sin∂, MPa @ 30° C	3.2	2.6		2.0	2.3	1.0	1.8
S(t), MPa, @ 0°C	64	69		54			
S(t), MPa, @ -10°C	217	242	124	200	209	104	235
S(t), MPa, @ -20°C						316	
S(t), MPa, @ -30°C							
m @ 0° C	0.40	0.41		0.40			
m @ -10° C	0.29	0.30	0.39	0.30	0.30	0.33	0.34
m @ -20° C						0.27	
m @ -30° C							
Failure strain 0°C	7.17	6.16		7.30	6.58	11.41	8.47
Failure strain -10°C			2.14		0.92		
Failure strain -20°C							

MRL Code	AAT	AAU	AAV	AAW	AAX	AAY	AAZ
Crude Oil Source	Maya/Blenc	ANS/Ca	ANS	W TX/Maya	Potaku/La	Maya/Arab	WTx/Cost
Visc./Pen Grade	AC-20	AC-20	AC-5	AC-20	AC-20	AC-20	AC-20
SHRP PG Grade	PG64-16	PG64-16	PG52-22	PG64-16	PG64-16	PG64-22	PG58-16
Functional Group Analysi							
Carboxylic Acids							
(Tank)	0.006	0.007	<.005	<.005	0.009	<.005	0.008
Acid Salts							
(Tank)	<.005	<.005	<.005	<.005	<.005	<.005	<.005
Acid Anhydrides							
(Tank)				0.000			
(POV (144 hr.))							
Quinolones							
(Tank)	0.012	0.019	0.007	0.017	0.011	0.012	0.008
Ketones							
(Tank)	<.005	<.005	<.005	<.005	<.005	<.005	<.005
(TFO)			0.005	0.000	0.005		
(POV (144 hr.))			0.100	0.070	0.120		
Phenols							
(Tank)	0.017	0.043	0.036	0.052	0.048	0.027	0.022
Sulfoxides							
(Tank)	0.057	0.039	0.033	0.030	0.075	0.048	0.045
(TFO)			tr	tr	0.080		
(POV (144 hr.))			0.270	0.340	0.240		
Pyrroles							
(Tank)	0.214	0.239	0.196	0.155	0.196	0.204	0.166

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	ABA(blown	ABC	ABD	ABF	ABG	ABH	ABK
Crude Oil Source	WTxI/S	Ms Valley	Ca Valley	TiaJuana(H)	Laguna	Russian	CaWilm
Visc./Pen Grade	AC-20	AC-20	AR-4000	AC-20	B-85	AC-20	AR-4000
SHRP PG Grade	PG64-16	PG64-28	PG58-10	PG64-28	PG64-28	PG58-22	PG64-16
Original Asphalt							
Viscosity							
140°F, poise	1822	2091	2112	2527	2226	782	2148
275°F, cSt	356	474	241	416	392	212	275
Penetration, 0.1 mm							
(77°F, 100g, 5s)	70	76	47	66	89	98	56
(39.2°F, 100g, 5s)	8	10	1	5	7	5	3
Ductility, cm							
(39.2 °F,1cm/min)	5.5	31.4	0	103.5	112.4	69.6	0
Softening Point (R&B), °F	120	117	120	119	118	114	119
Component Analysis, %							
Asphaltenes (n-heptane)	15.7	25.6	*7.0*	15.4	15.7	19.5	9.3
Asphaltenes (iso-Octane)			*3.2*				
Polar Aromatics	34.1	23.2	52.7	32.0	18.7	26.4	46.3
Napthene Aromatics	37.5	44.0	28.4	40.0	46.6	44.3	33.1
Saturates	11.2	7.1	10.4	11.2	19.1	9.7	10.4
Elemental Analysis							
C, %	86.4	*83.2*	*86.8*	85.5	83.7	89.8(?)	85
H, %	10.8	*9.9*	*10.7*	10.28	11.2	11.0	10.7
O, %	1.5	*0.4*	*1.2*				
Nitrogen, %	0.42	*0.30*	*1.20*	0.85	0.38	0.72	1.03
Sulfur, %	2.30	*6.40*	*1.60*	3.50	4.05	2.69	2.79
Vanadium, ppm	28	*37*	*62*	612	494	141	64
Nickel, ppm	14	*25*	*123*	82	82	40	113
Fe, ppm	61	*12*	*54*				
Aromatic C, %							
Aromatic H, %							
Molecular wt. (Toluene)		*870*	*728*				
% WAX (INTEVEP)	4.85	2.90	0.81	0.78	0.91	3.52	1.03
WAX M. P. (deg. C)	66.2	56.6	38.2	24.5	24.3	64.3	56.5

WRI data in italics PSU data in Monaco **UT data in bold**

TAI data in Helvetica MSU data in outline

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	ABA(blown	ABC	ABD	ABF	ABG	ABH	ABK
Crude Oil Source	WTxI/S	Ms Valley	Ca Valley	TiaJuana(H'	Laguna	Russian	CaWilm
Visc./Pen Grade	AC-20	AC-20	AR-4000	AC-20	B-85	AC-20	AR-4000
SHRP PG Grade	PG64-16	PG64-28	PG58-10	PG64-28	PG64-28	PG58-22	PG64-16
Aged Asphalt							
(Thin Film Oven Test)							
Mass Change, %	-0.0205	-0.219	-0.1208	-0.1445	-0.288	0.0303	-0.1521
Viscosity							
140°F, poise	4024	5009	3800	5231	5415	1967	4212
275°F, cSt	456	668	321	581	577	317	378
Viscosity Ratio (140°F)	2.21	2.4	1.79	2.07	2.43	2.51	1.96
IEC Separations (wt %)							
Strong Acid*							
SA Mol. Wt,VPO, Toluene							
Amphoterics*							
Strong Base							
Weak Acid							
Weak Base							
Neutral							
Neutrals plus acids**							
Amphoterics**							
Bases**							
Neutral Fraction							
Viscosity, poise, 77°F							
*calculated **WRI Method							
SEC Fraction, MW							
VPO, Toluene							
I							
SEC I, TFAAT Aged							
II							
Fraction II - wt. %	78.3	71.5	88.7		79.4	86.6	
Visc. with SEC fraction 1 removed (77°F, poise)			686800				
Visc. of whole asphalt, 77°F Poise x10E-3							

MRL Code	ABA(blown	ABC	ABD	ABF	ABG	ABH	ABK
Crude Oil Source	WTxI/S	Ms Valley	Ca Valley	TiaJuana(H)	Laguna	Russian	CaWilm
Visc./Pen Grade	AC-20	AC-20	AR-4000	AC-20	B-85	AC-20	AR-4000
SHRP PG Grade	PG64-16	PG64-28	PG58-10	PG64-28	PG64-28	PG58-22	PG64-16
Viscoelastic Properties							
Tank Asphalt							
Td,Tank,°C							
R,Tank							
G*,Pa,60°C,10 rad/s							
∂ @ 60° (deg)							
G*/sin∂, kPa,52°C						2.33	
G*/sin∂, kPa,58°C	2.50	2.39	2.68	2.66	2.38	1.03	2.58
G*/sin∂, kPa,64°C	1.11	1.18	1.10	1.22	1.11		1.17
G*/sin∂, kPa,70°C							
TFOT Residue							
Td,TFOT,°C	-6.3						
R,TFOT	2.40						
G*,Pa,60°C,10 rad/s	4573	5802	6498	5307		2949	
∂ @ 60° (deg)	78.8	78.7	87.9	82.2		84.5	
RTFOT Residue							
G*/sin∂, kPa,52°C						5.22	
G*/sin∂, kPa,58°C	5.15	5.46	4.74	6.03	5.71	2.23	5.28
G*/sin∂, kPa,64°C	2.23	2.57	1.92	2.70	2.55	1.02	2.22
G*/sin∂, kPa,70°C							
PAV Residue							
Td,PAV,°C							
R,PAV							
G*,Pa,60°C,10 rad/s							
∂ @ 60° (deg)							
G*sin∂, MPa @ 10° C							
G*sin∂, MPa @ 15° C							
G*sin∂, MPa @ 20° C	2.5	3.0			3.7		
G*sin∂, MPa @ 25° C	1.5	1.7		2.7	2.0	2.5	
G*sin∂, MPa @ 30° C			4.1				3.0
S(t), MPa, @ 0°C							40
S(t), MPa, @ -10°C	80	93	279	143	76	121	399
S(t), MPa, @ -20°C	242	270			369		979
S(t), MPa, @ -30°C							
m @ 0° C							
m @ -10° C	0.30	0.37	0.28	0.39	0.41	0.33	0.31
m @ -20° C	0.25	0.28			0.30		0.16
m @ -30° C							
Failure strain 0°C							
Failure strain -10°C	8.90	2.43		2.91	1.74	3.22	
Failure strain -20°C		0.30			<1.0		

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	ABA(blown	ABC	ABD	ABF	ABG	ABH	ABK
Crude Oil Source	WTxI/S	Ms Valley	Ca Valley	TiaJuana(H)	Laguna	Russian	CaWilm
Visc./Pen Grade	AC-20	AC-20	AR-4000	AC-20	B-85	AC-20	AR-4000
SHRP PG Grade	PG64-16	PG64-28	PG58-10	PG64-28	PG64-28	PG58-22	PG64-16

Functional Group Analysi							
Carboxylic Acids							
(Tank)			*0.025*				
Acid Salts							
(Tank)			*<.005*				
Acid Anhydrides							
(Tank)							
(POV (144 hr.))							
Quinolones							
(Tank)			*0.015*				
Ketones							
(Tank)			*<.005*				
(TFO)			*0.030*				
(POV (144 hr.))			*0.150*				
Phenols							
(Tank)			*0.077*				
Sulfoxides							
(Tank)			*0.024*				
(TFO)			*tr*				
(POV (144 hr.))			*0.300*				
Pyrroles							
(Tank)			*0.376*				

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	**ABL-1**	**ABL-2**	**ABL-3**	**ABM-1**	**ABM-2**
Crude Oil Source		Boscan		Ca Valley	
Visc./Pen Grade	AC-20	EB-10	AC-10	AR-4000	AR-2000
SHRP PG Grade	PG64-	PG58-	PG58-	PG58-	PG58-
Original Asphalt					
Viscosity					
140°F, poise	2201	1097	1051	2230	1388
275°F, cSt	441	338	321	243	189
Penetration, 0.1 mm					
(77°F, 100g, 5s)	87	169	137	48	64
(39.2°F, 100g, 5s)	9	12	12	0	1
Ductility, cm					
(39.2 °F,1cm/min)	54	150	150	0	0
Softening Point (R&B), °F	117	106	111	120	116
Component Analysis, %					
Asphaltenes (n-heptane)	22.3	17.0	20.8	7.1	6.4
Asphaltenes (iso-Octane)					
Polar Aromatics	46.1	47.6	39.1	52.4	50.0
Napthene Aromatics	22.4	24.9	28.6	29.6	33.1
Saturates	7.3	8.6	9.5	9.0	9.1
Elemental Analysis					
C, %	83	82.3	82.8	86.3	86.6
H, %	9.72	10.14	10.33	10.3	10.2
O, %					
Nitrogen, %	0.59	0.50	1.48	1.09	1.00
Sulfur, %	5.82	6.28	5.86	1.28	1.28
Vanadium, ppm	1469	1484	1309	63	55
Nickel, ppm	129	134	118	111	98
Fe, ppm					
Aromatic C, %					
Aromatic H, %					
Molecular wt. (Toluene)					
% WAX (INTEVEP)	2.58	2.11	2.42	1.10	0.97
WAX M. P. (deg. C)	52.2	45.6	41.1	36.8	36.2

WRI data in italics PSU data in Monaco **UT data in bold**

TAI data in Helvetica MSU data in outline

MRL ASPHALT PROPERTIES (Data Various Sources, key below)

MRL Code	ABL-1	ABL-2	ABL-3	ABM-1	ABM-2
Crude Oil Source		Boscan		Ca Valley	
Visc./Pen Grade	AC-20	EB-10	AC-10	AR-4000	AR-2000
SHRP PG Grade	PG64-	PG58-	PG58-	PG58-	PG58-
Aged Asphalt					
(Thin Film Oven Test)					
Mass Change, %	-0.566	-1.335	-0.399	-0.248	-0.248
Viscosity					
140°F, poise	5788	3700	2604	3603	2223
275°F, cSt	716	596	484	301	232
Viscosity Ratio (140°F)	2.63	3.37	2.48	1.62	1.6
IEC Separations (wt %)					
Strong Acid*					
SA Mol. Wt,VPO, Toluene					
Amphoterics*					
Strong Base					
Weak Acid					
Weak Base					
Neutral					
Neutrals plus acids**					
Amphoterics**					
Bases**					
Neutral Fraction					
Viscosity, poise, 77°F					
*calculated **WRI Method					
SEC Fraction, MW					
VPO, Toluene					
I					
SEC I, TFAAT Aged					
II					
Fraction II - wt. %					
Visc. with SEC fraction 1 removed (77°F, poise)					
Visc. of whole asphalt, 77°F, Poise x10E-3					

MRL Code	ABL-1	ABL-2	ABL-3	ABM-1	ABM-2
Crude Oil Source		Boscan		Ca Valley	
Visc./Pen Grade	AC-20	EB-10	AC-10	AR-4000	AR-2000
SHRP PG Grade	PG64-	PG58-	PG58-	PG58-	PG58-
Viscoelastic Properties					
Tank Asphalt					
Td,Tank,°C					
R,Tank					
G*,Pa,60°C,10 rad/s					
∂ @ 60° (deg)					
G*/sin∂, kPa,52°C	5.46	2.57			
G*/sin∂, kPa,58°C	2.52	1.21	1.20	2.79	2.31
G*/sin∂, kPa,64°C	1.21		0.62	1.19	0.97
G*/sin∂, kPa,70°C					
TFOT Residue					
Td,TFOT,°C					
R,TFOT					
G*,Pa,60°C,10 rad/s					
∂ @ 60° (deg)					
RTFOT Residue					
G*/sin∂, kPa,52°C			6.58		7.82
G*/sin∂, kPa,58°C	6.27	4.21	3.05	4.74	2.89
G*/sin∂, kPa,64°C	3.00	2.01	1.52	1.88	1.24
G*/sin∂, kPa,70°C					
PAV Residue					
Td,PAV,°C					
R,PAV					
G*,Pa,60°C,10 rad/s					
∂ @ 60° (deg)					
G*sin∂, MPa @ 10° C					
G*sin∂, MPa @ 15° C					
G*sin∂, MPa @ 20° C					
G*sin∂, MPa @ 25° C					
G*sin∂, MPa @ 30° C					
S(t), MPa, @ 0°C					
S(t), MPa, @ -10°C					
S(t), MPa, @ -20°C					
S(t), MPa, @ -30°C					
m @ 0° C					
m @ -10° C					
m @ -20° C					
m @ -30° C					
Failure strain 0°C					
Failure strain -10°C					
Failure strain -20°C					

MRL Code	ABL-1	ABL-2	ABL-3	ABM-1	ABM-2
Crude Oil Source		Boscan		Ca Valley	
Visc./Pen Grade	AC-20	EB-10	AC-10	AR-4000	AR-2000
SHRP PG Grade	PG64-	PG58-	PG58-	PG58-	PG58-

Functional Group Analysi

Carboxylic Acids
(Tank)
Acid Salts
(Tank)
Acid Anhydrides
(Tank)
(POV (144 hr.))
Quinolones
(Tank)
Ketones
(Tank)
(TFO)
(POV (144 hr.))
Phenols
(Tank)
Sulfoxides
(Tank)
(TFO)
(POV (144 hr.))
Pyrroles
(Tank)

Test Data from Matrecon on MRL Asphalts

PHYSICAL PROPERTIES OF MRL CORE ASPHALTS TESTED BY MATRECON INC.

SAMPLE CODE / GRADE	AAA-1 150/200	AAA-2 200/300	AAB-1 AC-10	AAB-2 AC-5	AAC-1 AC-8	AAC-2 AC-5	AAD-1 AR-4000	AAD-2 AR-2000	AAF-1 AC-20	AAF-2 AC-10	AAG-1 AR-4000	AAG-2 AR-2000	AAK-1 AC-30	AAK-2 AC-10	AAM-1 AC-20	AAM-2 AC-10
PENETRATION(T49)																
77 F, 100 g, 5 s	162	308	105	180	106	220	143	211	57	84	54	80	73	159	68	106
39.2 F, 100 g, 5 s	14	28	11	13	8	13	14	20	5	7	1	2	6	14	4	8
39.2 F, 200 g, 60 s	56	111	35	47	25	44	49	71	16	22	16	20	25	53	17	25
DUCTILITY(T51)																
39.2 F,5 cm/min, cm	150+	150+	7	8	0	50	86	150+	0	0	0	0	6	150+	3	4
VISCOSITY																
140 F(T202), P	858	373	1030	424	695	288	1100	576	1750	847	1910	1060	3220	1030	1760	900
275 F(T201), cSt	360	199	300	199	232	148	311	233	330	236	278	174	580	278	586	434
R&B SOFTENING PT.(T53)																
DEGREES F	42.1	35.9	47.0	45.6	115	107	45.2	40.3	121	116.5	48.6	44.2	52.0	44.0	50.0	46.7
DEGREES C	108	97	117	114	46.1	41.7	113	105	49.5	47	119	112	126	111	122	116
ELEMENTAL ANALYSIS																
SULFUR, %	4.94	4.79	3.85	3.48	1.86	1.67	6.21	5.93	3.08	3.65	1.10	1.05	4.37	5.24	0.90	0.66
NITROGEN, %	0.45	0.39	0.52	0.37	0.52	0.62	0.85	0.76	0.51	0.06	1.05	1.05	0.77	0.73	0.51	0.46
NICKEL, ppm	46.6	72.5	47.4	37.5	12.0	22.0	127.0	118.0	4.3	6.9	91.2	105.0	126.0	102.0	32.2	22.8
VANADIUM, ppm	137.0	153.0	190.0	148.0	62.0	114.0	278.0	266.0	35.0	70.0	50.6	43.1	1401.0	1136.0	43.7	33.7
FRACTIONAL COMP., %																
SATURATES	12.0	16.7	9.7	10.4	13.1	14.7	8.4	9.6	9.4	11.7	9.6	9.0	5.9	7.2	2.5	4.4
NAPHTENE AROMATICS	25.6	22.9	27.3	29.0	26.2	31.7	19.9	20.6	22.6	38.1	24.8	27.0	22.0	30.2	34.2	34.2
POLAR AROMATICS	43.1	38.3	45.9	45.2	49.2	42.1	47.5	46.7	55.8	37.9	52.9	54.4	47.6	38.0	59.4	49.1
ASPHALTENES	13.9	12.4	13.1	13.0	8.4	9.5	17.7	16.1	11.9	12.7	3.7	3.5	16.8	14.9	2.9	3.1
TOTAL RECOVERY	94.6	90.3	96.0	97.6	96.9	98	93.5	93.0	99.7	100.4	91.0	93.9	92.3	90.3	99.0	90.8
TFOT(T179)																
MASS CHANGE, %	-0.37	-0.60	-0.06	-0.04	-0.17	-0.29	-0.95	-0.93	-0.13	-0.08	-0.20	-0.24	-0.65	-1.40	0.06	0.07
TFOT VISCOSITY (T202)																
140 F, P	1960	926	2520	1170	1700	633	3910	2150	4880	2190	3460	1880	10600	3440	4320	2020
VISCOSITY RATIO(140 F)	2.28	2.48	2.45	2.76	2.45	2.20	3.55	3.73	2.79	2.59	1.81	1.77	3.29	3.34	2.45	2.24

TEST RESULTS FOR MRL AGGREGATES

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SwL File No. 2-7982-03
SwL Report No. 913661

SUMMARY OF TEST RESULTS FOR MRL AGGREGATES

Test	RJ	RD	RC	RL
Porosity, ASTM D-4404				
Avg. Pore Dia. ($m \times 10^{-6}$)	0.0151	0.0111	0.0611	0.0138
Total Pore Area (m^2/g)	1.888	1.465	2.548	3.027
L.A. Abrasion, AASTHO T-96				
% Wear	29.5	23.4	39.1	24.0
Water Absorption, AASHTO T-84, T-85				
% Absorption	0.7	0.3	3.7	0.9
Specific Gravity, AASHTO T-84, T-85				
Bulk	2.625	2.704	2.536	2.568
Saturated Surface Dry	2.646	2.717	2.595	2.593
Apparent	2.680	2.739	2.682	2.635
CKE, AASHTO T-270				
Uncorrected, C.K.E., %	1.8	3.8	8.5	1.2
Uncorrected Oil Retained, %	2.6	2.7	3.9	2.6
Flakiness Index, Asphalt Inst.				
Flakiness Index, %	9.6	34.7	22.6	23.9
Sand Equivalent, AASHTO T-176				
Sand Equivalent, %	60	69	32	86
Magnesium Soundness, AASHTO T-104				
% Loss for Fine Fraction	1.29	1.52	6.32	3.06
% Loss for Coarse Fraction	0.16	0.04	0.51	0.56
Polish Value, ASTM D-3319				
BPN Before Polish	41	38	42	34
BPN After Polish	22	28	31	22
Acid Insolubles, ASTM D-3042				
Insoluble Residue, %	99.2	18.1	4.8	88.2
Water Insolubles				
Water Solubles, %	4.1	1.9	2.4	1.8
pH	9.12	9.12	9.47	9.18
Zeta Potential				
Zeta Potential, mv	-49.0	-20.3	-23.8	-25.6

Test	RJ*	RD	RC	RL
X-Ray Diffraction				
Major Minerals	Phlogopite Anorthite Quartz	Calcite Dolomite Quartz	Calcite Dolomite Quartz	Quartz Calcite Albite
Major Oxides, %				
Silicon Dioxide	63.98	14.84	11.79	51.27
Aluminum Oxide	14.60	1.95	1.46	5.95
Ferric Oxide	4.54	0.96	0.89	3.77
Calcium Oxide	6.09	33.71	35.04	20.25
Magnesium Oxide	1.52	11.43	11.76	2.49
Sulfur Trioxide	0.10	0.34	0.48	0.15
Sodium Oxide	1.67	0.08	0.21	0.48
Potassium Oxide	3.31	2.00	0.51	1.41
Titanium Dioxide	0.41	0.21	0.18	0.88
Phosphorus Pentoxide	0.11	<0.01	<0.01	0.02
Manganic Oxide	0.13	0.02	0.03	0.04
Loss On Ignition	3.54	34.45	37.64	13.29

Petrographical Analysis: Attached

* Revised August 6, 1990

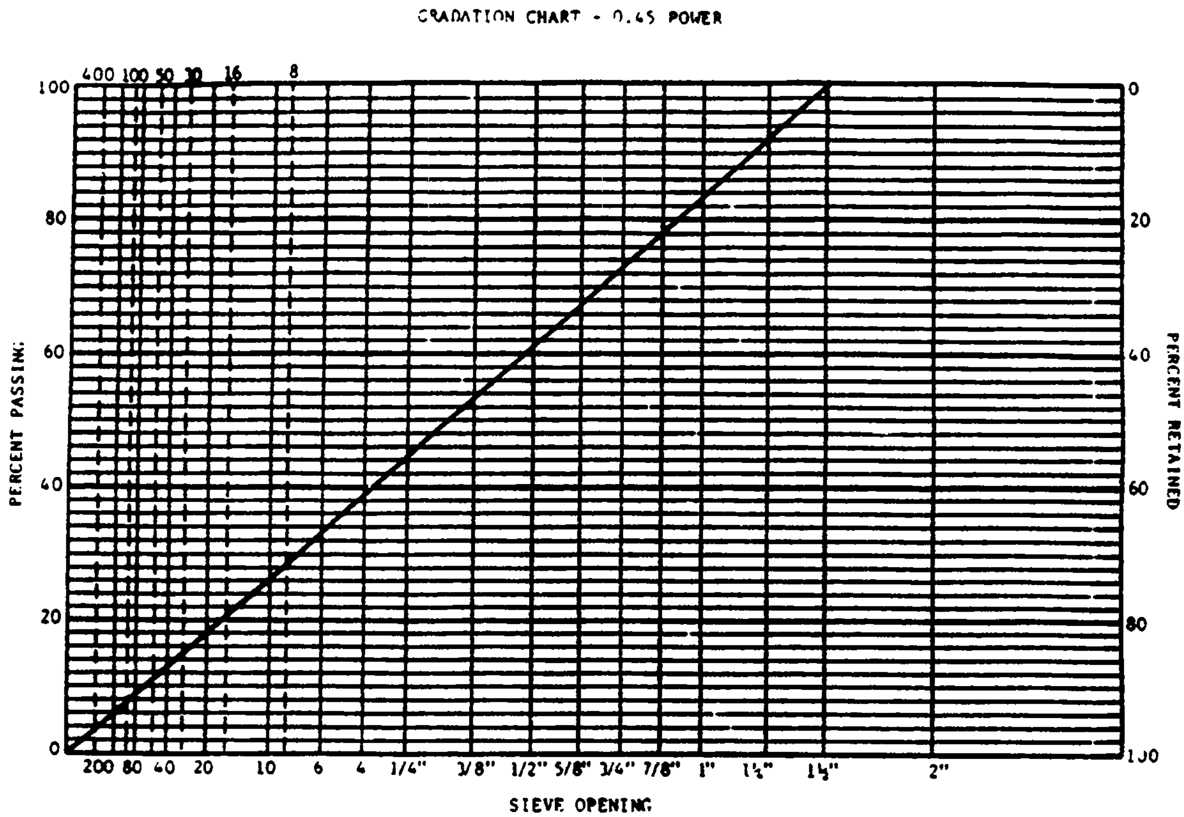

Figure 1. Hypothetical 0.45 Power Gradation Utilized for Combining the Aggregates

Table 1. 0.45 Power Gradation Used in the Project

Sieve Size	Percent Passing	Percent Retained
1 1/2"	100	0
1	83	17
3/4"	73	27
1/2"	61	39
3/8"	54	46
#4	39	61
#8	29	71

Table 2. Porosity Data for MRL Aggregate[1]

Aggregate	Sample Weight, gm	Total Intrusion Volume, ml/g	Total Pore Area, (m^2/g)	Median Pore Diameter (Volume), ($m^3 x 10^{-6}$)	Median Pore Diameter (Area), ($m^2 x 10^{-6}$)	Average Pore Diameter, ($m x 10^{-6}$)	Bulk Density, (g/ml)	Apparent (Skeletal) Density, (g/ml)
RJ	5.4800	0.0071	1.888	0.1322	0.0042	0.0151	2.5886	2.6373
RD	7.3283	0.0041	1.465	0.0194	0.0045	0.0111	2.6981	2.7280
RC	6.9421	0.0389	2.548	0.2598	0.0075	0.0611	2.4478	2.7048
RL	5.2907	0.0104	3.027	0.0589	0.0041	0.0138	2.5544	2.6243

Note 1: Tests were performed in accordance with ASTM D-4404-84.

Note 2: The following condition existed for all aggregates:

Advancing Contact Angel: 130.0 degrees
Receding Contact Angel: 130.0 degrees
Mercury Surface Tension: 485.0 dyn/cm
Mercury Density : 13.5384 g/ml

Note 3: Plot of cumulative pore volume vs diameter are given in Figures 2, 3, 4 and 5.
Plot of incremental pore volume vs diameter are given in Figures 6, 7, 8, and 9.
Tables 2A through 2D contain the values of pore volume and diameter for each aggregate.

Table 2A: Mercury Porosimeter Data for RJ aggregate.

Pressure, Psia	Pore Diameter, m	Cumulative Volume, ml/g	Incremental Volume, ml/g	Mean Diameter, m
1.52	1.1913E-04	0.0000	0.0000	1.1913E-04
3	6.0363E-05	0.0006	0.0006	8.9746E-05
4.98	3.6339E-05	0.0008	0.0002	4.8351E-05
6.96	2.6998E-05	0.0009	0.0001	3.1166E-05
8.95	2.0215E-05	0.0010	0.0001	2.3104E-05
11.94	1.6143E-05	0.0011	0.0001	1.7679E-05
14.92	1.2119E-05	0.0012	0.0001	1.3631E-05
17.92	1.0091E-05	0.0012	0.0000	1.1105E-05
20.91	8.6478E-06	0.0012	0.0000	9.3695E-06
23.91	7.5656E-06	0.0012	0.0000	8.1067E-06
35.12	5.1498E-06	0.0013	0.0001	6.3577E-06
45.26	3.9964E-06	0.0013	0.0000	4.5781E-06
75.21	2.4048E-06	0.0014	0.0001	3.2006E-06
149.74	1.2079E-06	0.0017	0.0003	1.8063E-06
199.08	9.0850E-07	0.0019	0.0002	1.0582E-06
349.31	6.1780E-07	0.0025	0.0006	7.1310E-07
498.14	3.6310E-07	0.0028	0.0003	4.4040E-07
750.33	2.4100E-07	0.0031	0.0003	3.0210E-07
995.18	1.8170E-07	0.0033	0.0003	2.1140E-07
1991.23	9.0800E-08	0.0038	0.0005	1.3630E-07
3982.91	4.5400E-08	0.0043	0.0005	6.8100E-08
6978.52	2.5900E-08	0.0046	0.0003	3.5700E-08
9948.26	1.8200E-08	0.0048	0.0002	2.2100E-08
14928	1.2100E-08	0.0051	0.0003	1.5100E-08
24887.51	7.3000E-09	0.0056	0.0004	9.7000E-09
29874.98	6.1000E-09	0.0058	0.0003	6.7000E-09
34854.73	5.2000E-09	0.0060	0.0002	5.6000E-09
44823.89	4.0000E-09	0.0064	0.0004	4.6000E-09
49821	3.6000E-09	0.0066	0.0002	3.8000E-09
54825.82	3.3000E-09	0.0069	0.0003	3.5000E-09
69768.95	3.0000E-09	0.0071	0.0003	3.2000E-09

Table 2B: Mercury Porosimeter Data for RD aggregate.

Pressure, Psia	Pore Diameter, m	Cumulative Volume, ml/g	Incremental Volume, ml/g	Mean Diameter, m
1.52	1.1913E-04	0.0000	0.0000	1.1913E-04
3	6.0363E-05	0.0004	0.0004	8.9746E-05
4.98	3.6339E-05	0.0006	0.0002	4.8351E-05
6.96	2.5993E-05	0.0007	0.0001	3.1166E-05
8.95	2.0215E-05	0.0007	0.0001	2.3104E-05
11.94	1.5143E-05	0.0008	0.0000	1.7679E-05
14.92	1.2119E-05	0.0009	0.0001	1.3631E-05
17.92	1.0091E-05	0.0009	0.0000	1.1105E-05
20.91	8.6478E-06	0.0009	0.0000	9.3695E-06
23.91	7.5656E-06	0.0009	0.0000	8.1067E-06
35.45	5.1021E-06	0.0009	0.0000	6.3339E-06
45.38	3.9856E-06	0.0009	0.0000	4.5439E-06
75.15	2.4068E-06	0.0009	0.0000	3.1962E-06
149.92	1.2064E-06	0.0009	0.0001	1.8066E-06
199.67	9.0580E-07	0.0009	0.0000	1.0561E-06
349.42	5.1760E-07	0.0010	0.0001	7.1170E-07
499.41	3.6220E-07	0.0010	0.0000	4.3990E-07
750.35	2.4100E-07	0.0011	0.0001	3.0160E-07
997.77	1.8130E-07	0.0011	0.0000	2.1120E-07
1997.22	9.0600E-08	0.0013	0.0002	1.3590E-07
3985.81	4.5400E-08	0.0016	0.0003	6.8000E-08
6971.82	2.5900E-08	0.0018	0.0002	3.5700E-08
9954.27	1.8200E-08	0.0021	0.0003	2.2100E-08
14945.59	1.2100E-08	0.0025	0.0004	1.5100E-08
24893.54	7.3000E-09	0.0029	0.0003	9.7000E-09
29879.07	6.1000E-09	0.0032	0.0003	6.7000E-09
34901.25	5.2000E-09	0.0032	0.0001	5.6000E-09
44822.21	4.0000E-09	0.0036	0.0003	4.6000E-09
49821.25	3.6000E-09	0.0037	0.0001	3.8000E-09
54828	3.3000E-09	0.0038	0.0001	3.5000E-09
59800.04	3.0000E-09	0.0041	0.0003	3.2000E-09

Table 2C: Mercury Porosimeter Data for RC aggregate.

Pressure, Psia	Pore Diameter, m	Cumulative Volume, ml/g	Incremental Volume, ml/g	Mean Diameter, m
1.52	1.1913E-04	0.0000	0.0000	1.1913E-04
3	6.0363E-05	0.0006	0.0006	8.9746E-05
4.98	3.6339E-05	0.0009	0.0004	4.8351E-05
6.96	2.5993E-05	0.0012	0.0002	3.1166E-05
8.95	2.0215E-05	0.0013	0.0001	2.3104E-05
11.94	1.5143E-05	0.0015	0.0002	1.7679E-05
14.92	1.2119E-05	0.0017	0.0002	1.3631E-05
17.92	1.0091E-05	0.0019	0.0002	1.1105E-05
20.91	8.6478E-06	0.0019	0.0001	9.3695E-06
23.91	7.5656E-06	0.0020	0.0001	8.1067E-06
35.27	5.1275E-06	0.0025	0.0005	6.3466E-06
43.17	4.0044E-06	0.0030	0.0005	4.5659E-06
74.85	2.4164E-06	0.0041	0.0011	3.2104E-06
149.44	1.2103E-06	0.0061	0.0021	1.8133E-06
199.12	9.0830E-07	0.0073	0.0012	1.0593E-06
348.51	5.1900E-07	0.0118	0.0045	7.1360E-07
498.36	3.6290E-07	0.0158	0.0039	4.4090E-07
748.79	2.4130E-07	0.0203	0.0045	3.0220E-07
996.11	1.8160E-07	0.0235	0.0032	2.1160E-07
1994.91	9.0700E-08	0.0298	0.0064	1.3610E-07
3983.16	4.5400E-08	0.0342	0.0044	6.8000E-08
6969.06	2.6000E-08	0.0358	0.0016	3.5700E-08
9951.49	1.3200E-08	0.0364	0.0006	2.2100E-08
14940.86	1.2100E-08	0.0370	0.0006	1.5100E-08
24892.65	7.3000E-09	0.0375	0.0005	9.7000E-09
29876.26	6.1000E-09	0.0378	0.0003	6.7000E-09
34896.51	5.2000E-09	0.0380	0.0002	6.5000E-09
44823.26	4.0000E-09	0.0383	0.0003	4.6000E-09
49818.45	3.6000E-09	0.0385	0.0002	3.8000E-09
54823.28	3.3000E-09	0.0387	0.0002	3.5000E-09
59801.12	3.0000E-09	0.0389	0.0002	3.2000E-09

Table 2D: Mercury Porosimeter Data for RL aggregate.

Pressure, Psia	Pore Diameter, m	Cumulative Volume, ml/g	Incremental Volume, ml/g	Mean Diameter, m
1.52	1.1913E-04	0.0000	0.0000	1.1913E-04
3	6.0363E-05	0.0008	0.0008	8.9755E-05
4.98	3.6339E-05	0.0011	0.0002	4.8351E-05
6.96	2.5993E-05	0.0013	0.0002	3.1166E-05
8.95	2.0215E-05	0.0015	0.0002	2.3104E-05
11.94	1.5143E-05	0.0016	0.0001	1.7679E-05
14.92	1.2119E-05	0.0016	0.0000	1.3631E-05
17.92	1.0091E-05	0.0018	0.0002	1.1105E-05
20.91	8.6478E-06	0.0018	0.0000	9.3695E-06
23.91	7.5656E-06	0.0018	0.0000	8.1067E-06
35.16	5.1437E-06	0.0018	0.0001	6.3547E-06
45.3	3.9929E-06	0.0019	0.0001	4.5683E-06
75.26	2.4033E-06	0.0020	0.0001	3.1981E-06
149.79	1.2075E-06	0.0028	0.0007	1.8054E-06
199.14	9.0820E-07	0.0029	0.0001	1.0578E-06
349.39	5.1770E-07	0.0034	0.0005	7.1290E-07
498.24	3.6300E-07	0.0037	0.0004	4.4030E-07
750.46	2.4100E-07	0.0040	0.0002	3.0200E-07
995.3	1.8170E-07	0.0042	0.0002	2.1140E-07
1991.37	9.0800E-08	0.0049	0.0007	1.3630E-07
3983.06	4.5400E-08	0.0055	0.0006	6.8100E-08
6973.67	2.5900E-08	0.0064	0.0009	3.5700E-08
9948.4	1.8200E-08	0.0068	0.0003	2.2100E-08
14926.23	1.2100E-08	0.0072	0.0005	1.5100E-08
24887.66	7.3000E-09	0.0079	0.0007	9.7000E-09
29077.05	6.1000E-09	0.0083	0.0004	6.7000E-09
34852.95	5.2000E-09	0.0087	0.0004	5.6000E-09
44824.03	4.0000E-09	0.0092	0.0005	4.6000E-09
49821.13	3.6000E-09	0.0097	0.0005	3.8000E-09
54825.95	3.3000E-09	0.0099	0.0003	3.5000E-09
59769.07	3.0000E-09	0.0104	0.0005	3.2000E-09

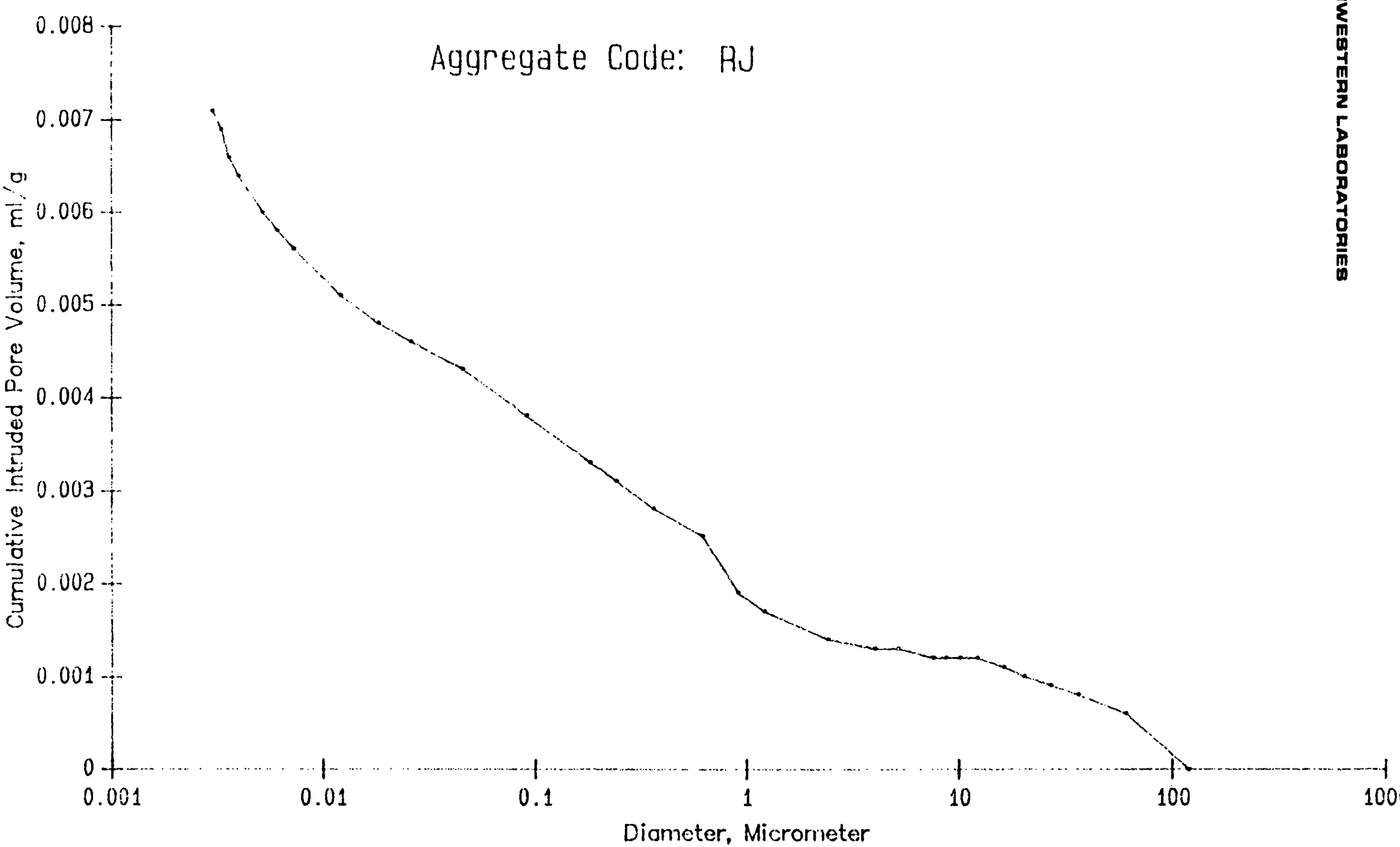

Figure 2. Cumulative Pore Volume versus Pore Diameter for RJ Aggregate.

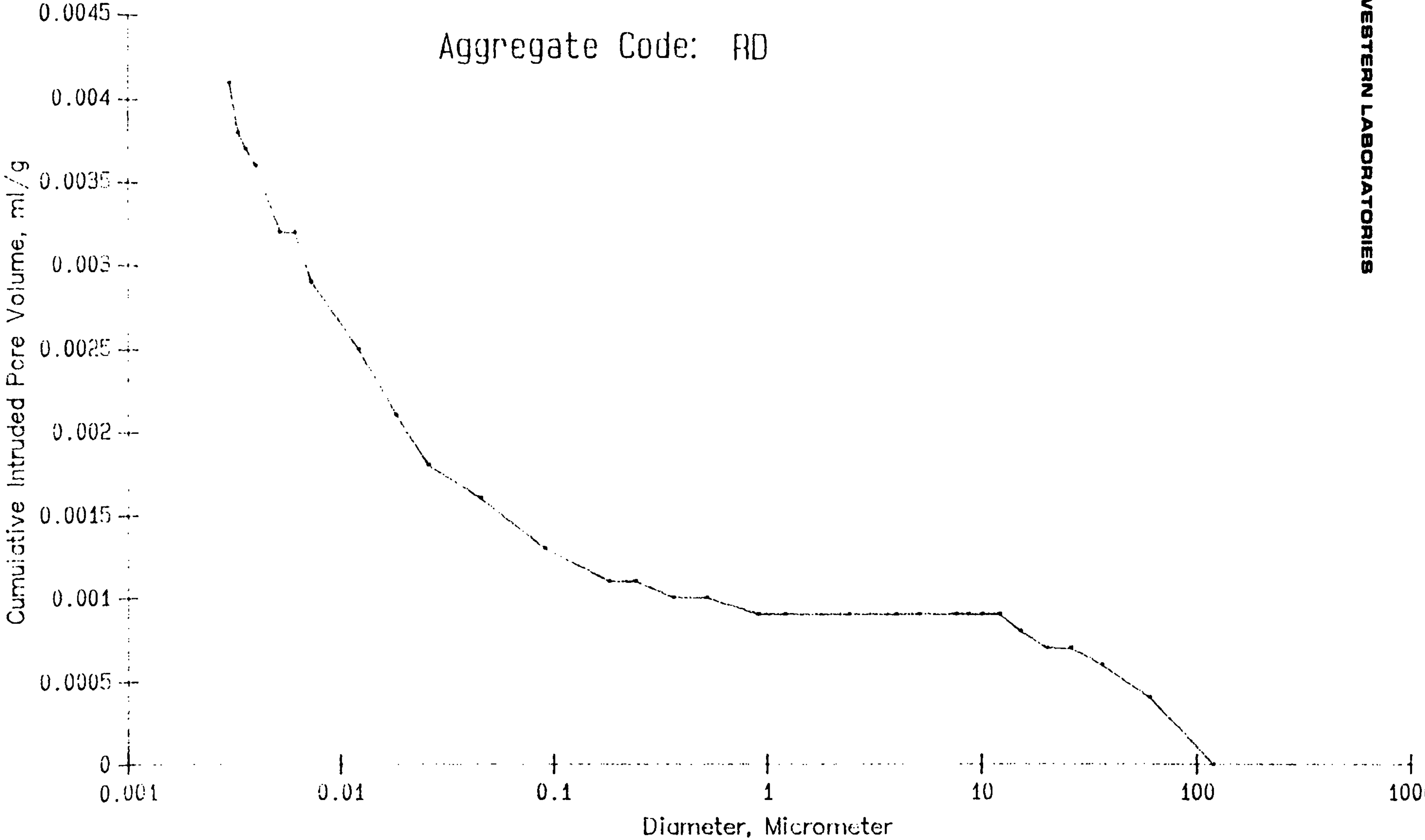

Figure 3. Cumulative Pore Volume versus Pore Diameter for RD Aggregate.

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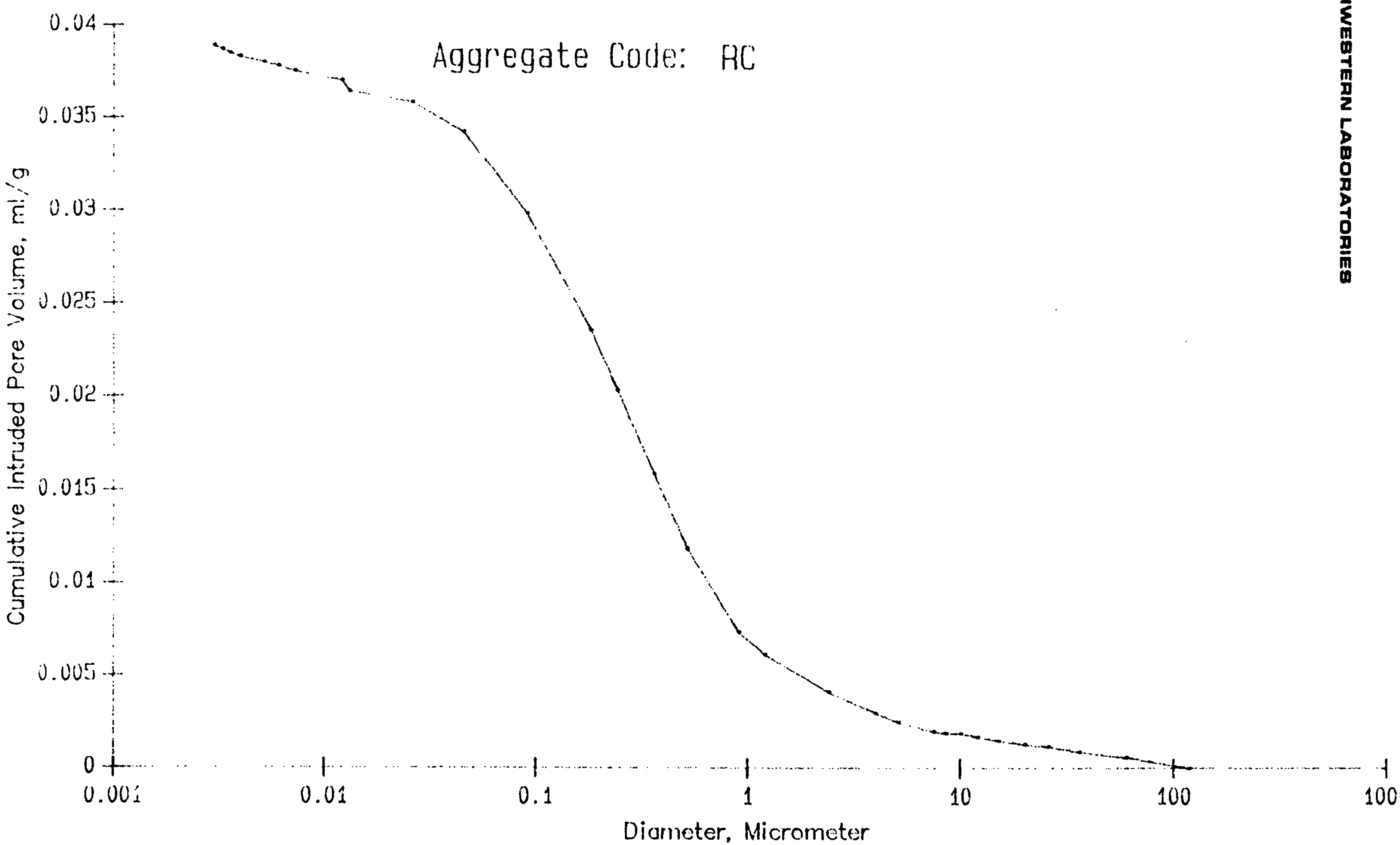

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Figure 4. Cumulative Pore Volume versus Pore Diameter for RC Aggregate.

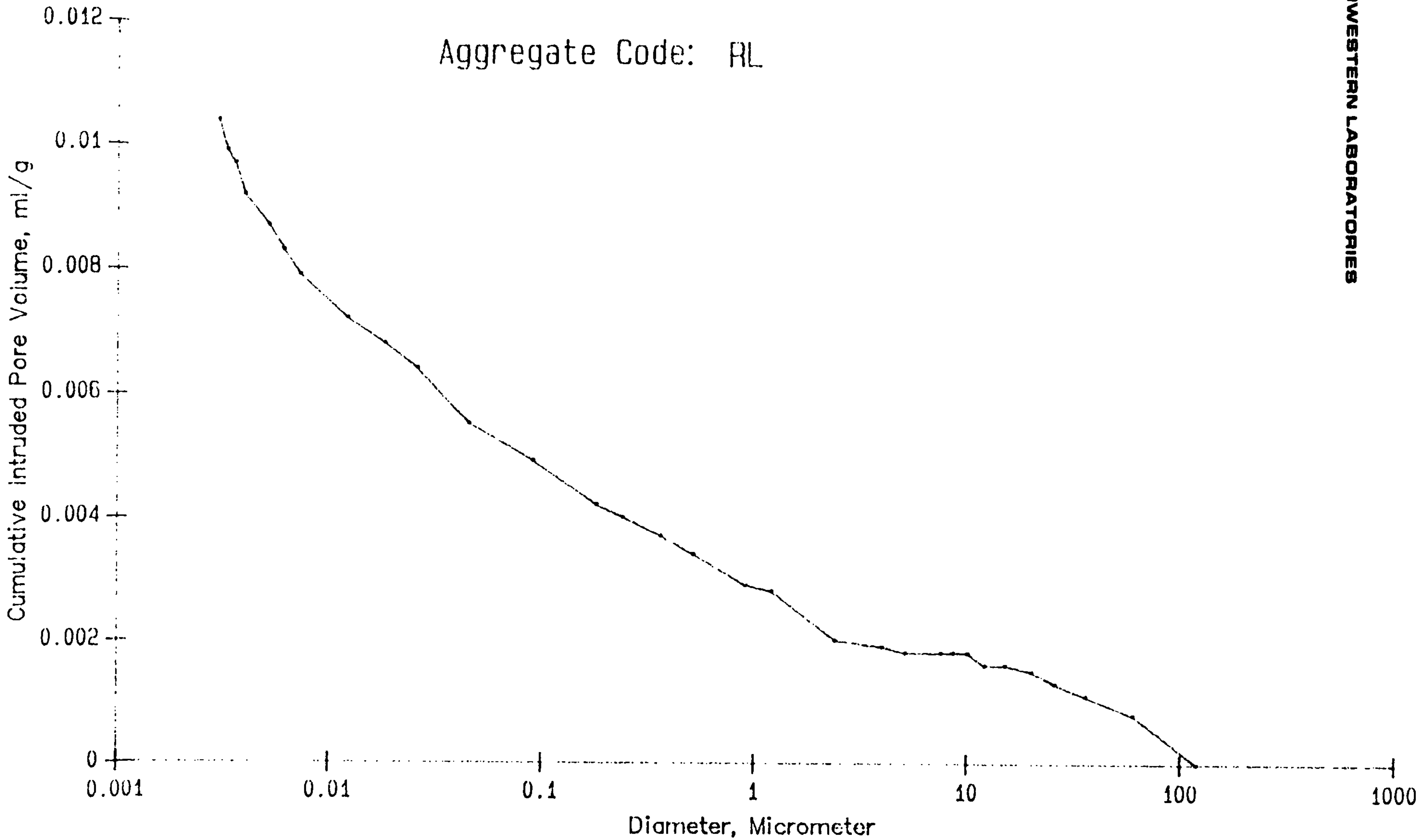

Figure 5. Cumulative Pore Volume versus Pore Diameter for RL Aggregate.

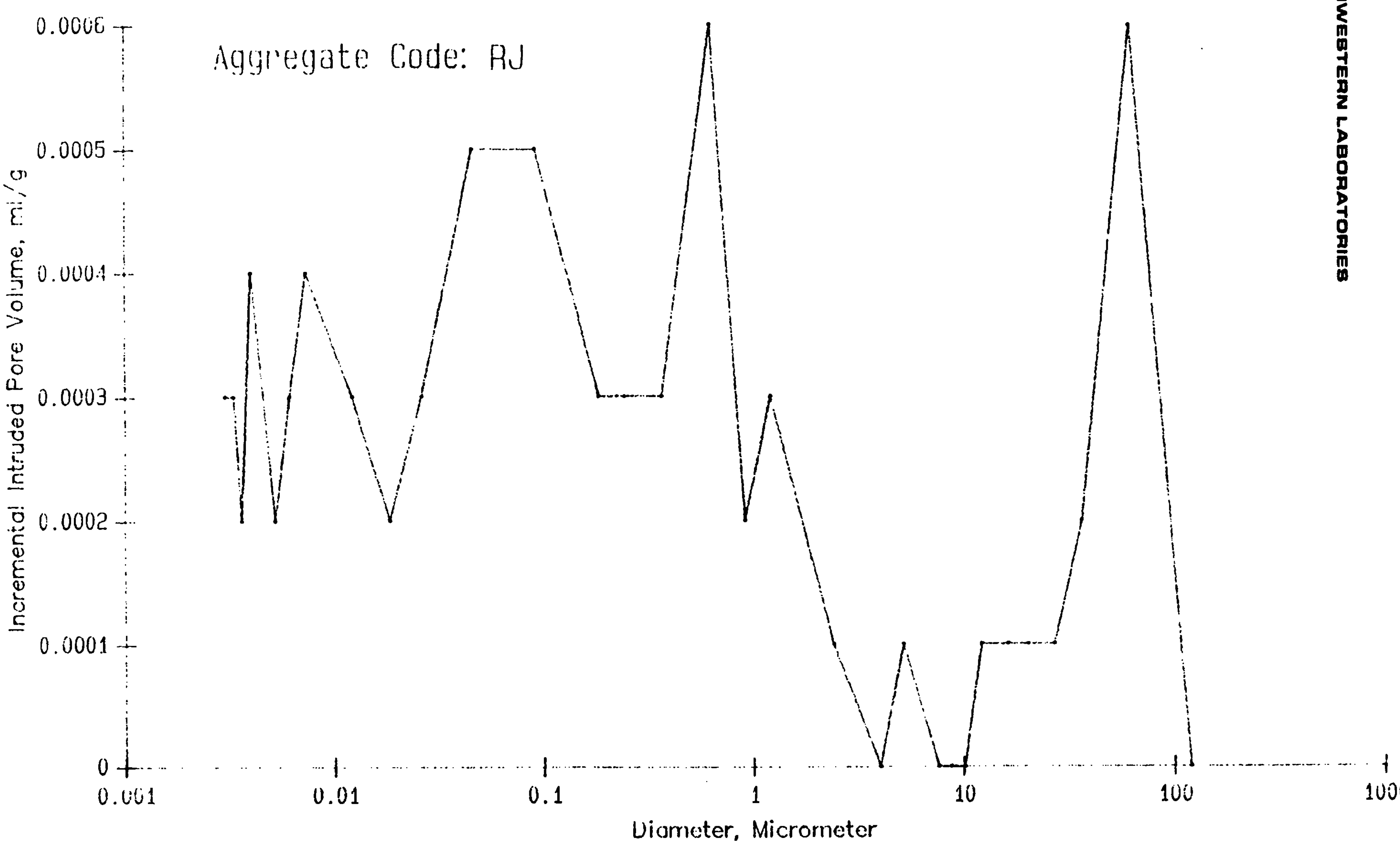

Figure 6. Incremental Pore Volume versus Pore Diameter for RJ Aggregate.

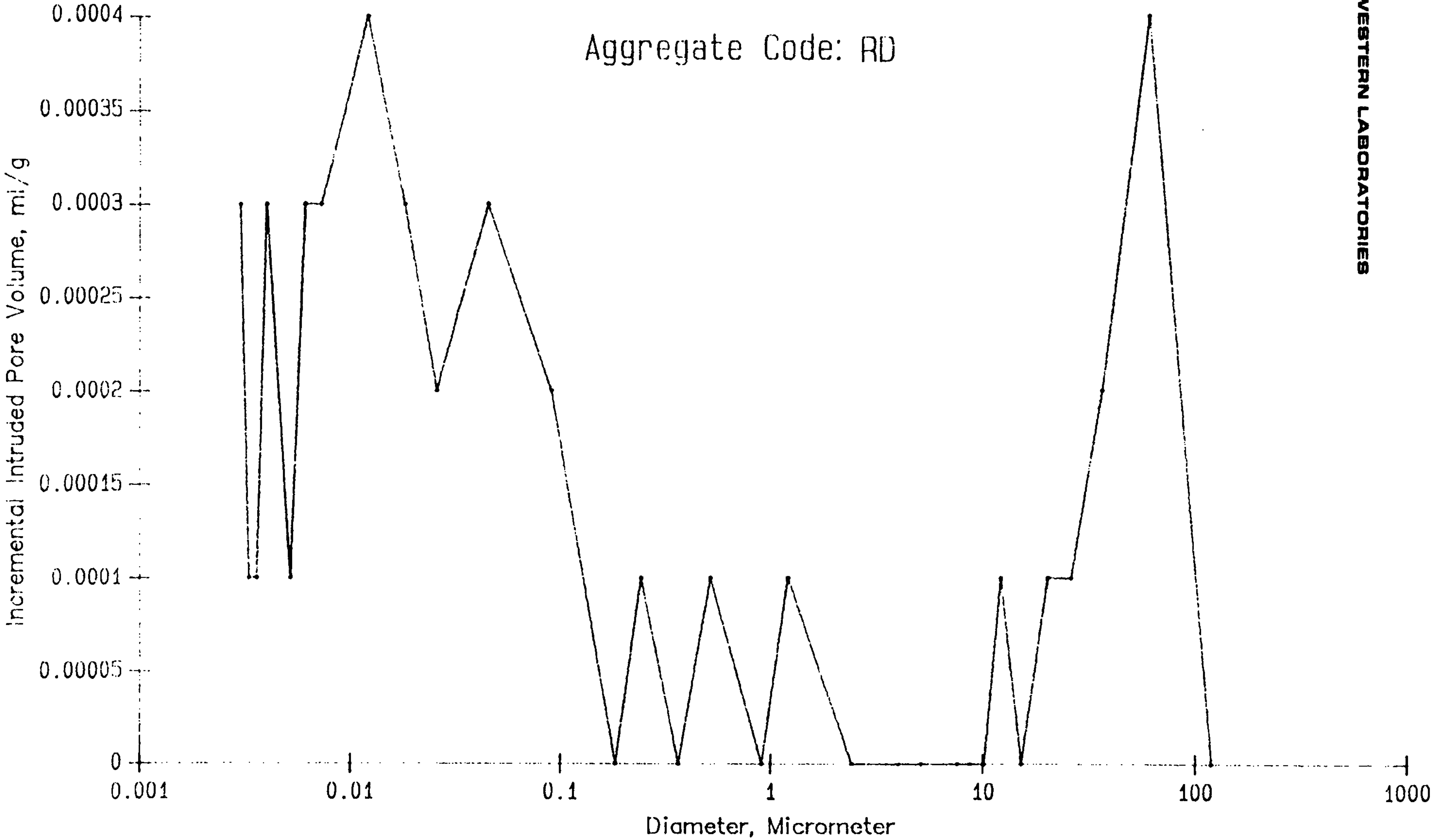

Figure 7. Incremental Pore Volume versus Pore Diameter for RD Aggregate.

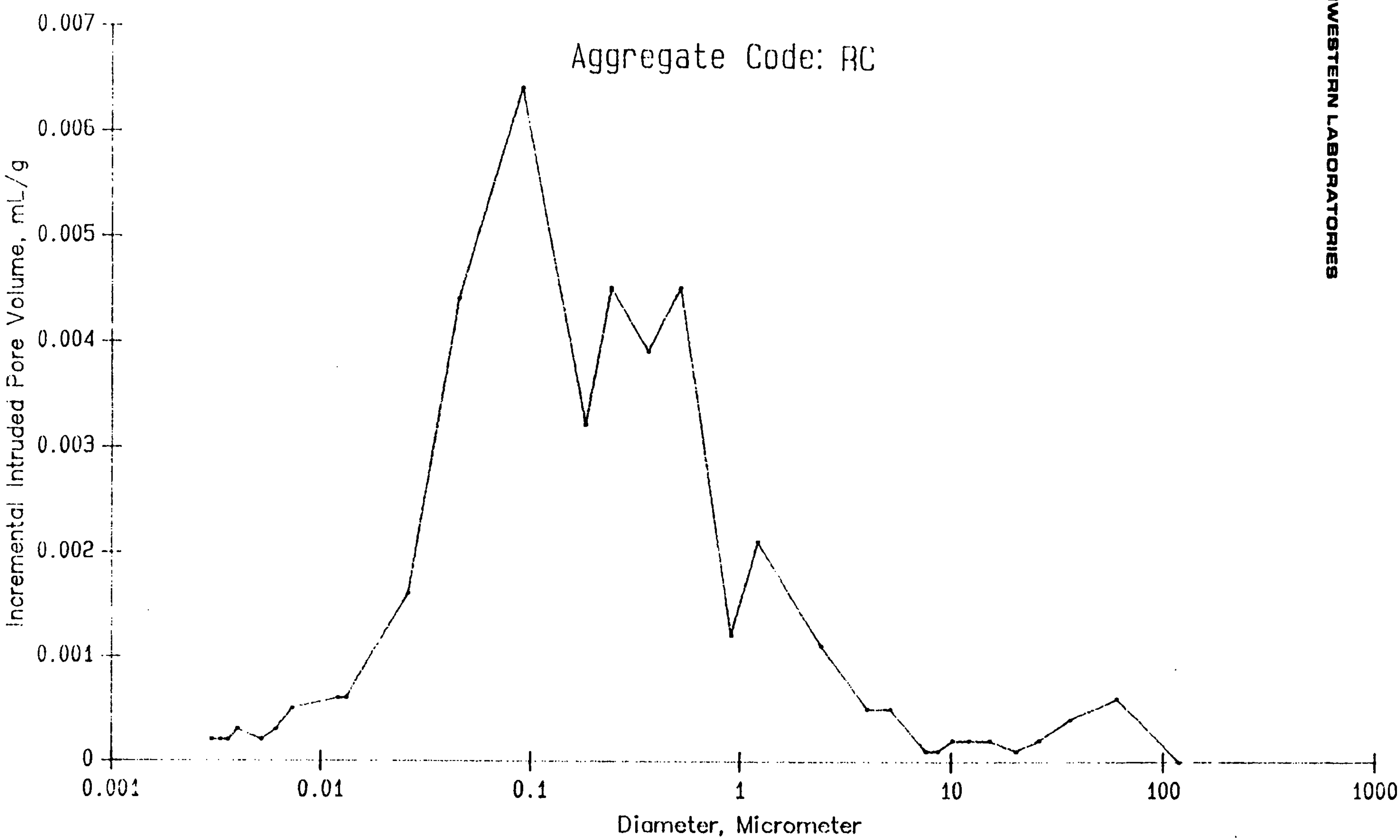

Figure 8. Incremental Pore Volume versus Pore Diameter for RC Aggregate.

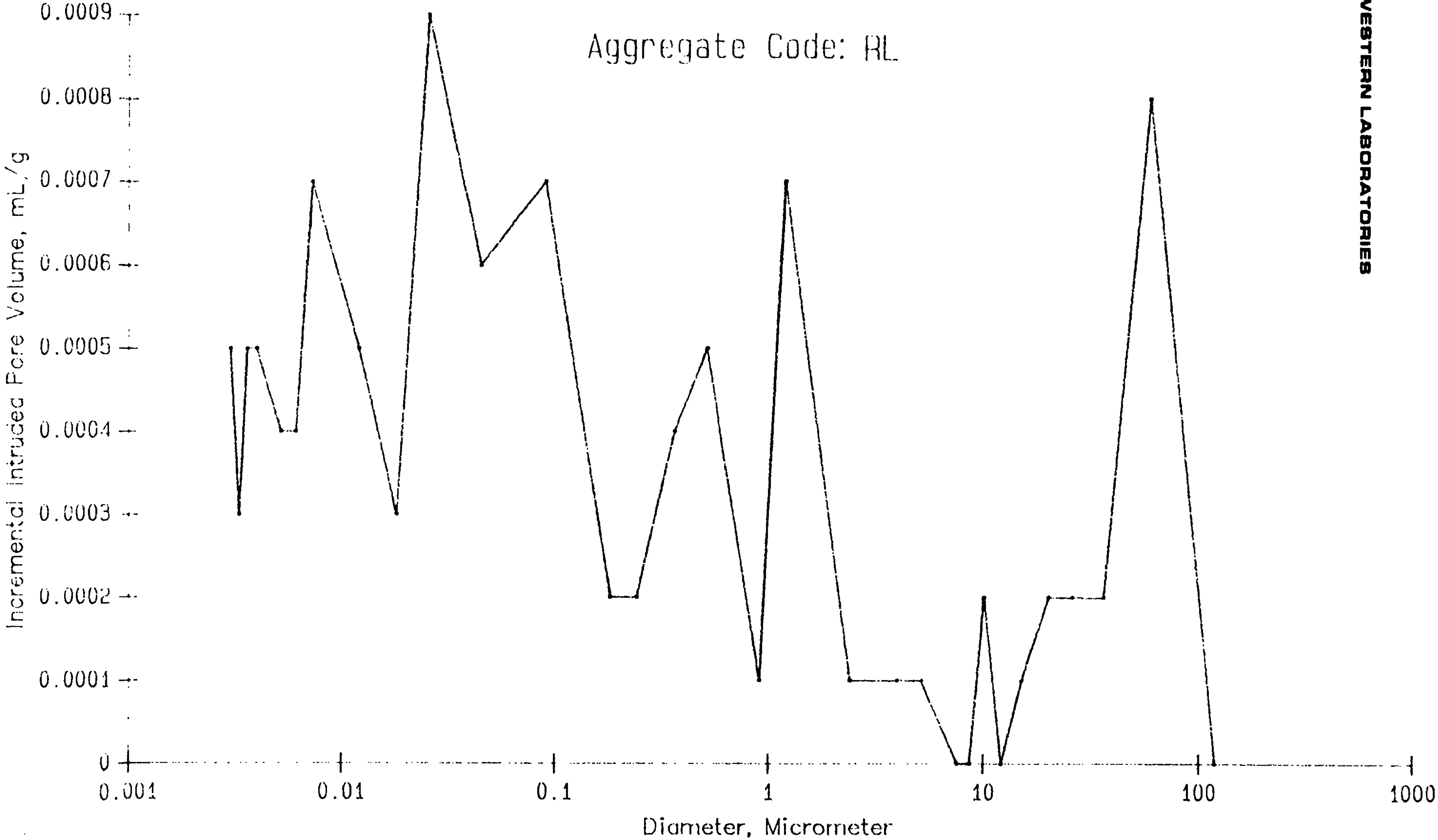

Figure 9. Incremental Pore Volume versus Pore Diameter for RL Aggregate.

Table 3. Los Angeles Abrasion Test Results for MRL Aggregates[1]

Aggregate I.D.	Percentage of Wear
RJ	29.5
RD	23.4
RC	39.1
RL	24.0

Note 1: All tests were performed on AASHTO Grade A samples in accordance with AASHTO T-96.

Table 4. Water Absorption of MRL Aggregates[1]

Sieve Size	Aggregate I.D.			
	RJ	RD	RC	RL
1 1/2" - 1"	0.5	0.2	2.8	0.7
1" - 3/4"	0.7	0.2	3.3	0.8
3/4" - 1/2"	0.7	0.3	2.9	0.8
1/2" - 3/8"	0.7	0.4	3.1	0.6
3/8" - #4	0.9	0.4	3.6	0.1
Passing #8	1.0	0.8	4.5[2]	1.2
Blend[3]	0.7	0.3	3.7	0.9

Note 1: Tests were conducted in accordance with AASHTO T-84 and T-85 procedures.

Note 2: For this aggregate, the water absorption of Total Passing #8 sample could not be measured due to very high clay content. The -#80 portion of the sample had a tendency to conglomerate, therefore giving an incorrect indication of the Saturated Surface Dry Condition. The Passing #8 sample was washed over a #80 and the reported value is for water absorption of materials Passing #8 and retained on #80.

Note 3: Total water absorption of the blend is based on a hypothetical gradation developed from the 0.45 power gradation line.

Table 5A. Bulk Specific Gravity of MRL Aggregates[1]

Sieve Size	Aggregate I.D.			
	RJ	RD	RC	RL
1 1/2" - 1"	2.666	2.725	2.488	2.591
1" - 3/4"	2.631	2.734	2.456	2.581
3/4" - 1/2"	2.642	2.725	2.487	2.570
1/2" - 3/8"	2.642	2.720	2.495	2.601
3/8" - #4	2.611	2.715	2.461	2.582
Passing #8	2.596	2.663	2.672	2.536
Blend[2]	2.625	2.704	2.536	2.568

Note 1: Tests were conducted in accordance with AASHTO T-84 and T-85 procedures.

Note 2: Specific gravity of the blend is based on a hypothetical gradation developed from the 0.45 power gradation line.

Table 5B. Bulk Specific Gravity Based on Saturated Surface Dry Weight of MRL Aggregates[1]

Sieve Size	Aggregate I.D.			
	RJ	RD	RC	RL
1 1/2" - 1"	2.679	2.731	2.558	2.610
1" - 3/4"	2.648	2.741	2.537	2.602
3/4" - 1/2"	2.659	2.733	2.560	2.595
1/2" - 3/8"	2.661	2.730	2.571	2.616
3/8" - #4	2.634	2.726	2.550	2.609
Passing #8	2.623	2.686	2.686	2.567
Blend[2]	2.646	2.717	2.595	2.593

Note 1: Tests were conducted in accordance with AASHTO T-84 and T-85 procedures.
Note 2: Specific gravity of the blend is based on a hypothetical gradation developed from the 0.45 power gradation line.

Table 5C. Apparent Specific Gravity of MRL Aggregates[1]

Sieve Size	Aggregate I.D.			
	RJ	RD	RC	RL
1 1/2" - 1"	2.701	2.742	2.674	2.651
1" - 3/4"	2.677	2.752	2.673	2.636
3/4" - 1/2"	2.689	2.743	2.683	2.636
1/2" - 3/8"	2.692	2.747	2.703	2.641
3/8" - #4	2.672	2.747	2.635	2.649
Passing #8	2.666	2.725	2.710	2.615
Blend[2]	2.680	2.739	2.682	2.635

Note 1: Tests were conducted in accordance with AASHTO T-84 and T-85 procedures.

Note 2: Specific gravity of the blend is based on a hypothetical gradation developed from the 0.45 power gradation line.

Table 6. CKE Test Results for MRL Aggregates[1]

Aggregate I.D.	Uncorrected C. K. E., %	Uncorrected Oil Retained, %
RJ	1.8	2.6
RD	3.8	2.7
RC	8.5	3.9
RL	1.2	2.6

Note 1: Tests were conducted in accordance with AASHTO T-270 procedure.

Table 9A. Magnesium Soundess[1], (5 Cycles) Test Results For RJ Aggregate

Part I: Fine Fraction

Sieve Size	Sample Gradation[2]		Weight of Fraction Before Test, gm	% Passing Designated Sieve After Test	Weighted Percentage Loss
3/8"-No.4	-		-	-	-
No.4-No.8	11.0		101.2	3.0	0.33
No.8-No.16	8.0		101.2	4.2	0.34
No.16-No.30	5.0		101.2	6.1	0.31
No.30-No.50	4.0			6.1[3]	0.31
No.50-No.100	4.0				
Minus No.100	8.0				
Subtotal for Fine Fraction					1.29
1 1/2-1"	16.0	}26.0	1550.0	0.1	0.03
1"-3/4"	10.0				
3/4"-1/2"	12.0	}20.0	1003.2	0.3	0.06
1/2"-3/8"	8.0				
3/8"-No.4	14.0		303.0	0.5	0.07
Subtotal for Coarse Fraction					0.16
Total					1.45

Part II: Quantitative Examination of Coarse Size

Sieve Size	Splitting No.	Splitting %	Crumbling No.	Crumbling %	Cracking No.	Cracking %	Flaking No.	Flaking %	Total No. of Particles Before Test
1 1/2"-1"	0	0	0	0	0	0	0	0	22
1"-3/4"	3	10.7	0	0	1	3.6	0	0	28

Note 1: Test was performed in accordance with AASHTO T-104 procedure.

Note 2: Gradation based on a hypothetical gradation developed from the 0.45 power line.

Note 3: The percentage loss (6.1%) of the next smaller size is used as the percentage loss for this size, since this size contains less than five percent of the original sample.

Table 9B. Magnesium Soundess[1], (5 Cycles) Test Results For RD Aggregate

Part I: Fine Fraction

Sieve Size	Sample Gradation[2]		Weight of Fraction Before Test, gm	% Passing Designated Sieve After Test	Weighted Percentage Loss
3/8"-No.4	-		-	-	-
No.4-No.8	11.0		101.1	6.0	0.66
No.8-No.16	8.0		101.1	4.2	0.34
No.16-No.30	5.0		101.1	5.7	0.29
No.30-No.50	4.0			5.7[3]	0.23
No.50-No.100	4.0				
Minus No.100	8.0				
Subtotal for Fine Fraction					1.52
1 1/2-1"	16.0	}26.0	1514.5	0.01	0.00
1"-3/4"	10.0				
3/4"-1/2"	12.0	}20.0	1001.9	0.04	0.01
1/2"-3/8"	8.0				
3/8"-No.4	14.0		300.4	0.2	0.03
Subtotal for Coarse Fraction					0.04
Total					1.56

Part II: Quantitative Examination of Coarse Size

Sieve Size	Splitting No.	Splitting %	Crumbling No.	Crumbling %	Cracking No.	Cracking %	Flaking No.	Flaking %	Total No. of Particles Before Test
1 1/2"-1"	0	0	0	0	0	0	0	0	21
1"-3/4"	0	0	0	0	0	0	0	0	35

Note 1: Tests were conducted in accordance with AASHTO T-104 procedures.

Note 2: Gradation based on a hypothetical gradation developed from the 0.45 power line.

Note 3: The percentage loss (5.7%) of the next smaller size is used as the percentage loss for this size, since this size contains less than five percent of the original sample.

Table 9C. Magnesium Soundess[1], (5 Cycles) Test Results For RC Aggregate

Part I: Fine Fraction

Sieve Size	Sample Gradation[2]		Weight of Fraction Before Test, gm	% Passing Designated Sieve After Test	Weighted Percentage Loss
3/8"-No.4	-		-	-	-
No.4-No.8	11.0		101.1	12.7	1.4
No.8-No.16	8.0		101.1	25.7	2.06
No.16-No.30	5.0		101.1	31.8	1.59
No.30-No.50	4.0			31.8[3]	1.27
No.50-No.100	4.0				
Minus No.100	8.0				
Subtotal for Fine Fraction					6.32
1 1/2-1"	16.0	}26.0	1527.5	0.1	0.03
1"-3/4"	10.0				
3/4"-1/2"	12.0	}20.0	1002.8	0.38	0.08
1/2"-3/8"	8.0				
3/8"-No.4	14.0		301.3	2.9	0.40
Subtotal for Coarse Fraction					0.51
Total					6.83

Part II: Quantitative Examination of Coarse Size

Sieve Size	Splitting No.	Splitting %	Crumbling No.	Crumbling %	Cracking No.	Cracking %	Flaking No.	Flaking %	Total No. of Particles Before Test
1 1/2"-1"	0	0	0	0	0	0	0	0	21
1"-3/4"	3	9.1	0	0	1	3	2	6	33

Note 1: Tests were conduced in accordance with AASHTO T-104 procedures.

Note 2: Gradation based on a hypothetical gradation developed from the 0.45 power line.

Note 3: The percentage loss (31.8%) of the next smaller size is used as the percentage loss for this size, since this size contains less than five percent of the original sample.

Table 9D. Magnesium Soundess[1], (5 Cycles) Test Results For RL Aggregate

Part I: Fine Fraction

Sieve Size	Sample Gradation[2]	Weight of Fraction Before Test, gm	% Passing Designated Sieve After Test	Weighted Percentage Loss
3/8"-No.4	-	-	-	-
No.4-No.8	11.0	101.4	4.2	0.46
No.8-No.16	8.0	101.4	13.9	1.11
No.16-No.30	5.0	101.4	16.5	0.83
No.30-No.50	4.0		16.5[3]	0.66
No.50-No.100	4.0			
Minus No.100	8.0			
Subtotal for Fine Fraction				3.06
1 1/2-1"				
1"-3/4"	10.0	508.4	0.8	0.08
3/4"-1/2"	12.0 }20.0	1001.2	1.4	0.28
1/2"-3/8"	8.0			
3/8"-No.4	14.0	300.3	1.4	0.20
Subtotal for Coarse Fraction				0.56
Total				3.62

Part II: Quantitative Examination of Coarse Size

Sieve Size	Splitting No.	Splitting %	Crumbling No.	Crumbling %	Cracking No.	Cracking %	Flaking No.	Flaking %	Total No. of Particles Before Test
1 1/2"-1"	0	0	0	0	0	0	0	0	29
1"-3/4"	3	5.3	0	0	0	0	0	0	38

Note 1: Tests were conducted in accordance with AASHTO T-104 procedures.

Note 2: Gradation based on a hypothetical gradation developed from the 0.45 power line.

Note 3: The percentage loss (16.5%) of the next smaller size is used as the percentage loss for this size, since this size contains less than five percent of the original sample.

Table 10. Polish Value Results for MRL Aggregates[1]

Aggregate I. D.	Average BPN[2] Before Polishing	Average BPN[2] After Polishing
RJ	41	22
RD	38	28
RC	42	31
RL	34	22

Note 1: Tests were conducted in accordance with ASTM D-3319-83 procedures.

Note 2: BPN = British Pendulum Number.

Table 11. Petrographic Examination of MRL Aggregate

RJ

The RJ Sample was a mixed gravel consisting of light and dark colored, igneous, metamorphic and a minor amount of sedimentary rocks. Particles included various sizes and were covered with a light dust coating. The sample was partially crushed, therefore shape, roundness and surface texture were variable. Surface texture was lightly textured to rough. Major constituents of the RJ sample were granite family rocks (approximately 70 percent) and quartzite. The granites contained feldspar, quartz and micaceous minerals. Many of the granites were metamorphosed, exhibiting slight mineral alignment to gneissic structure. Minor constituents of the sample were volcanic rocks, chert and limestone. The overall condition of the RJ sample was slightly weathered, with the aggregate considered to be dense.

RD

Petrographic examination of the RD Sample revealed a fine-grained, gray to dark gray, crushed limestone and dolomitic limestone. Particles included various sizes and were covered with a light dust coating. The aggregates were predominantly angular, with a relatively smooth surface texture. Particles ranged from elongated to flattened to equidimensional. The sample was visually separated into two major groups, one group that consisted of black calcareous shale and a second group rich in silt and fine sand sized quartz. Approximately 70 percent of the RD was comprised of the shale-rich rocks and 30 percent was a quartz-rich rock. The calcareous shale group was relatively soft, elongated to flattened, and frequently contained minor amounts of iron pyrite. Quartz was estimated to comprise 25 to 40 percent of the quartz-rich limestone group, which was predominantly equidimensional and had a slightly more rough surface texture. Minor veins of recrystallized, white colored calcite occurred in approximately 35 percent of the entire sample. The overall condition of the RD Sample was considered non-weathered and dense.

RC

The RC sample was a fossiliferous, fine-grained, gray to tan, crushed limestone and dolomitic limestone. Particles included various sizes and were covered with a light dust coating. The sample was predominantly angular and equidimensional, with a moderately rough surface texture. Three major limestone groups were identified in the RC aggregates; approximately 50 percent was gray, massive, hard, dense and fossiliferous; approximately 25 percent was light creamy gray, moderately soft, chalky, porous and granular; and approximately 25 percent contained a significant amount of laminated, dark colored, stylolitic, clay seams that were very soft. Other minor textures observed were vuggy and recrystallized calcite veins. The overall condition of the RC sample was fresh and dense.

RL

Petrographic examination of the aggregate sample revealed a partially crushed, siliceous gravel with a small proportion of limestone. The gravel was comprised of approximately 60 percent chert, 10 percent fine-to coarse-grained clastic sedimentary rock, 10 percent limestone and 20 percent rhyolite. The abundance of these different rock types was basically the same in all sieve sizes. Particles were lightly covered with rock dust and ranged from predominantly equidimensional to elongated. The overall condition of the sample was dense and unweathered.

Gradations between the chert, limestone and sedimentary rocks were apparent, for example calcareous chert and sandy to carbonaceous limestone was observed. Chert (microcrystalline quartz) occurred in shades of tan, brown, white, maroon, gray and black. Bands of calcareous deposits were observed in a small number of the particles. Caliche materials covered part of the surface on a small number of particles. The fine-to coarse-grained siliceous clastic group encompased a wide variety of textures. Colors observed were tan, maroon, black, and light-to dark-gray. Fine-grained sandstones were common, with some cherty, calcareous, carbonaceous and ferruginous varieties. Friable caliche gravel was also observed. Limestone ranged in color from dark to light gray, to red and brown. Some siliceous and shalely grains were observed in the limestone.

The rhyolites were maroon to slightly weathered brown in color. A small amount of fine-grained crystalline inclusions were present in the rhyolite.

Table 12. Results of X-Ray Diffraction for MRL Aggregates

Aggregate I.D.	Chemical Name	JCPD File Number[1]	Chemical Formula	Mineral Name
RJ *	Potassium Magnesium Aluminum Silicate Hydroxide	10-495	$KMg_3(Si_3AlO_{10})(OH)_2$	Phlogopite
	Calcium Aluminum Silicate	12-301	$CaAl_2Si_2O_8$	Anorthite
	Silicon Dioxide	33-1161	SiO_2	Quartz
RD	Calcium Carbonate	5-586	$CaCo_3$	Calcite
	Calcium Magnesium Carbonate	11-78	$CaMg(Co_3)_2$	Dolomite
	Silicon Dioxide	33-1161	$Si0_2$	Quartz
RC	Calcium Carbonate	5-586	$CaCo_3$	Calcite
	Calcium Magnesium Carbonate	11-78	$CaMg(Co_3)_2$	Dolomite
	Silicon Dioxide	33-1161	$Si0_2$	Quartz
RL	Silicon	33-1161	$Si0_2$	Quartz
	Calcium Carbonate	24-27	$CaCo_3$	Calcite
	Sodium Aluminum	9-466	$NaAlSi_30_8$	Albite

Note 1: The attached X-Ray diffraction spectra obtained from the submitted samples were identified by comparison to reference spectra certified by the Joint Committee on Powder Diffraction Standards.

* Revised August 6, 1990

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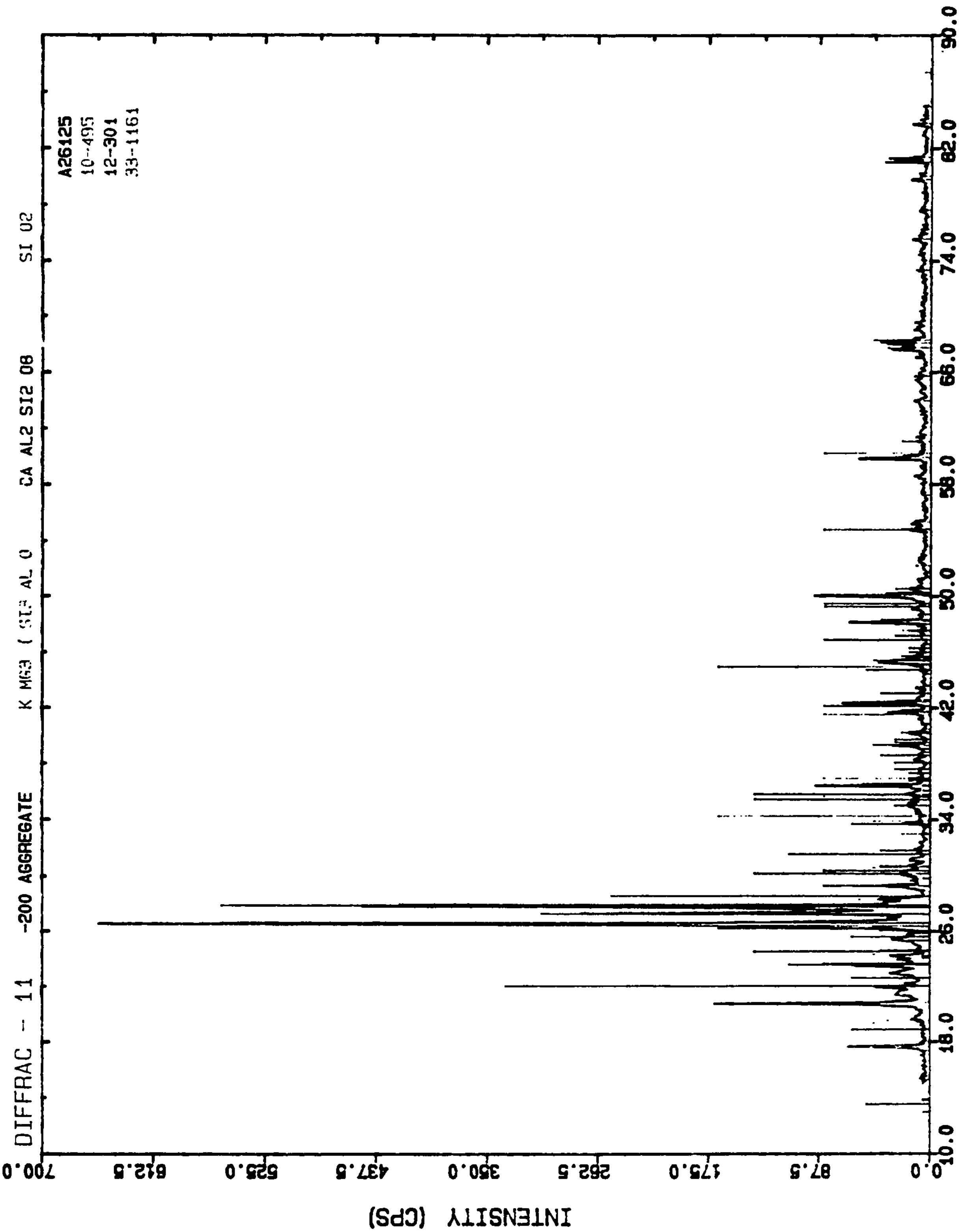

Figure 10. X-Ray Spectra for RJ Aggregate.

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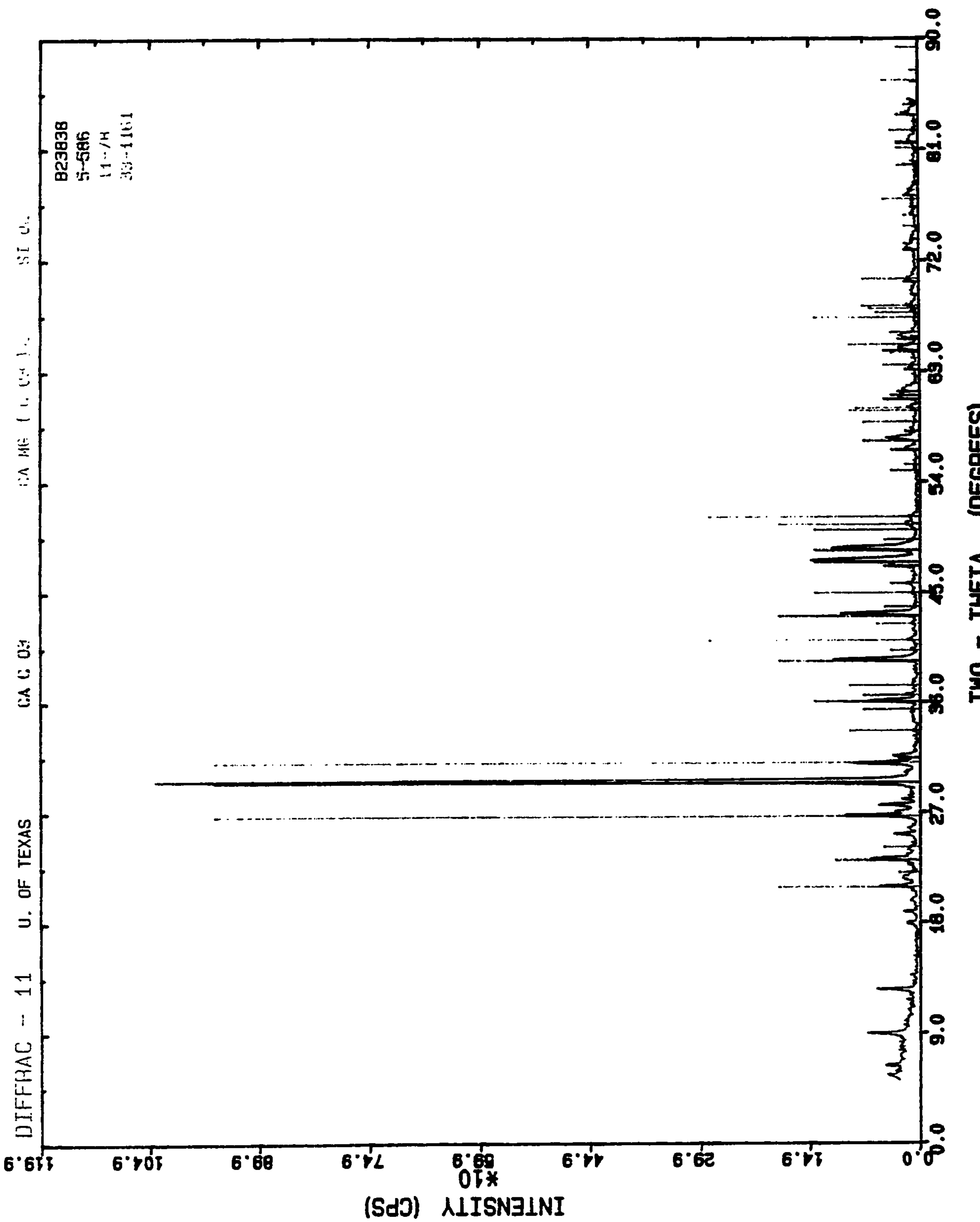

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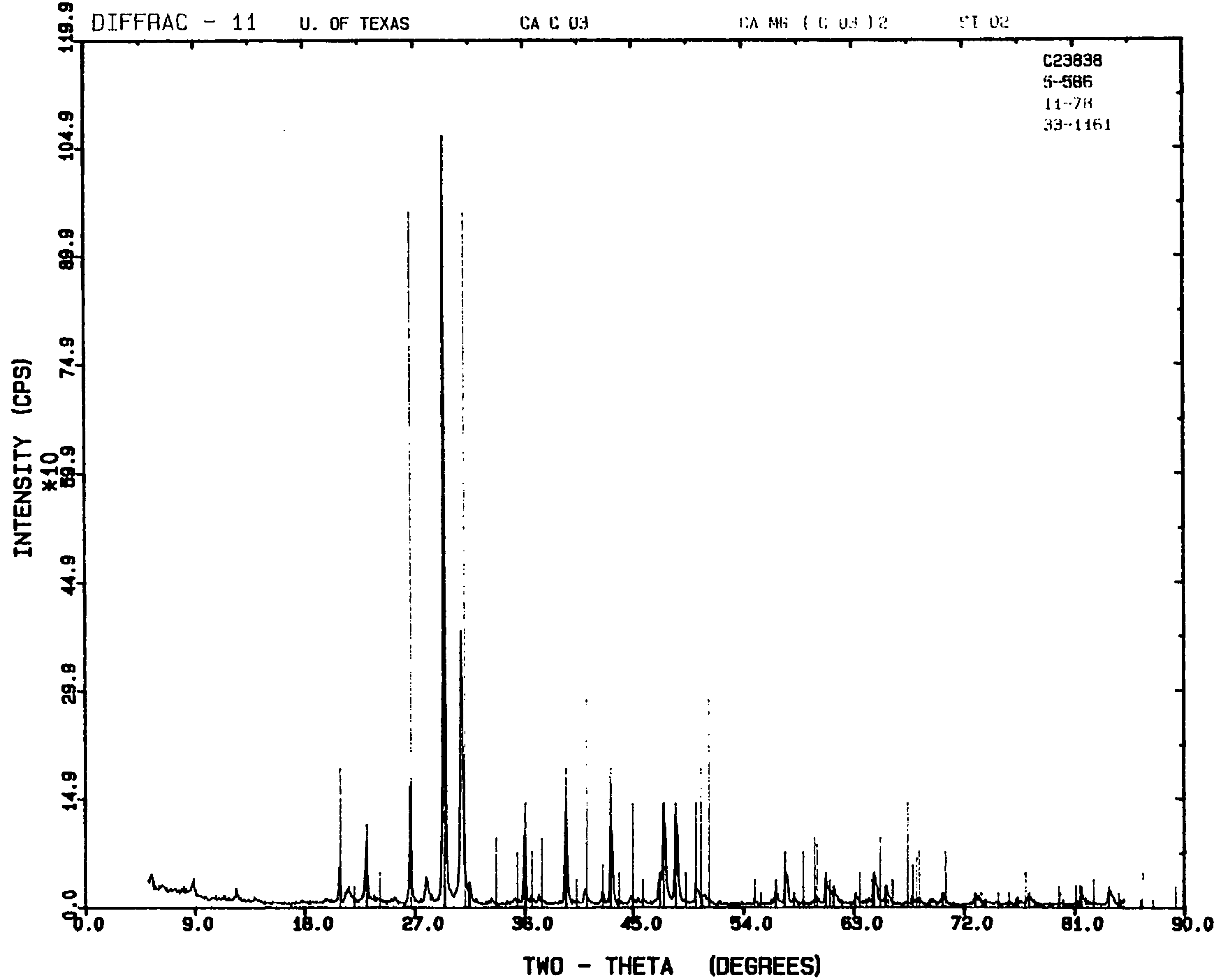

Figure 12. X-Ray Spectra for RC Aggregate.

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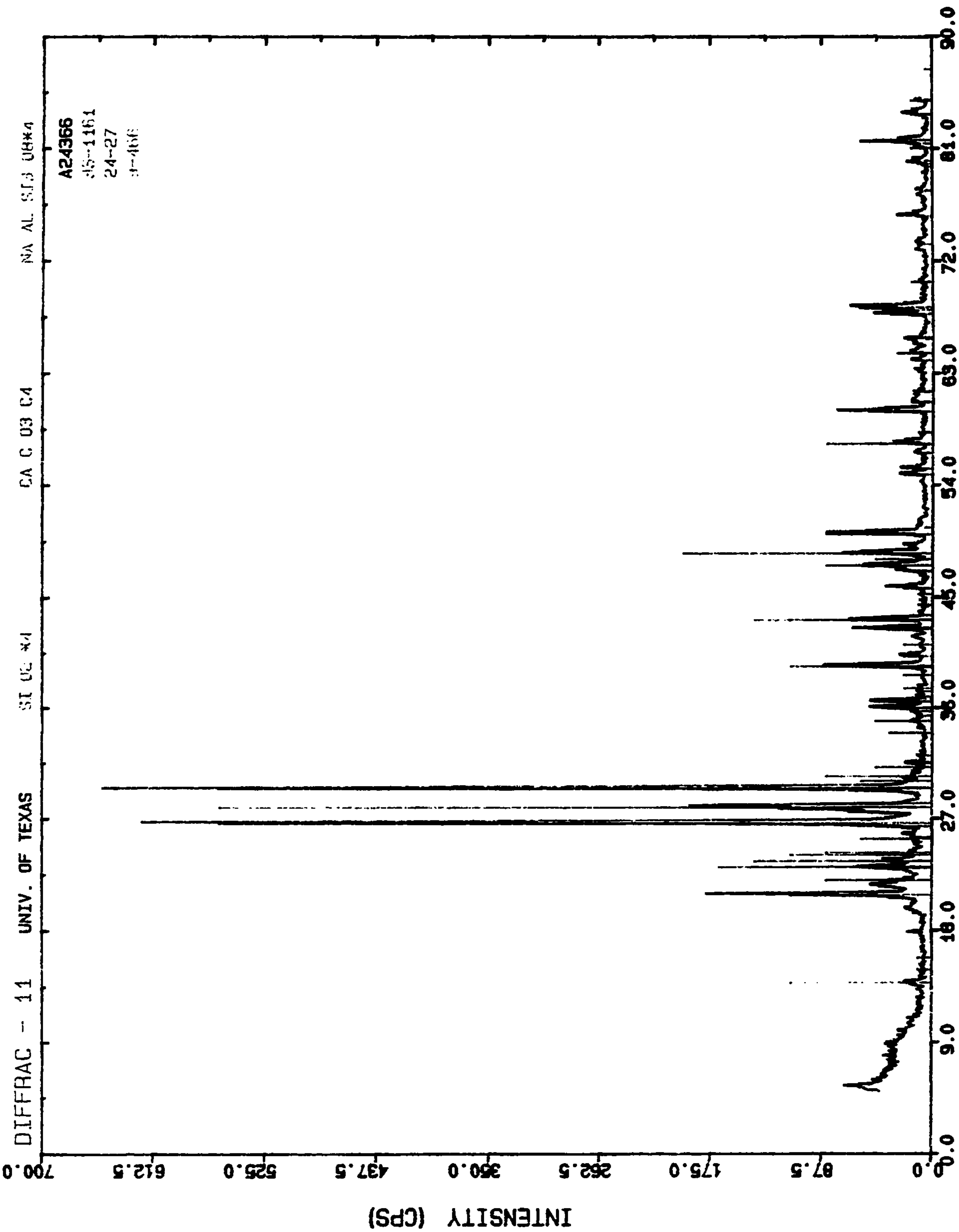

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Table 13. Major Oxides of MRL Aggregates

Oxides	Percentages of Total Weight RJ	RD	RC	RL
Silicon Dioxide (SiO_2)	63.98	14.84	11.79	51.27
Aluminum Oxide (Al_2O_3)	14.60	1.95	1.46	5.95
Ferric Oxide (Fe_2O_3)	4.54	0.96	0.89	3.77
Calicum Oxide (CaO)	6.09	33.71	35.04	20.25
Magnesium Oxide (MgO)	1.52	11.43	11.76	2.49
Sulfur Trioxide (SO_3)	0.10	0.34	0.48	0.15
Sodium Oxide (Na_2O)	1.67	0.08	0.21	0.48
Potassium Oxide (K_2O)	3.31	2.00	0.51	1.41
Titanium Dioxide (TiO_2)	0.41	0.21	0.18	0.88
Phosphorus Pentoxide (P_2O_5)	0.11	<0.01	<0.01	0.02
Manganic Oxide (Mn_2O_3)	0.13	0.02	0.03	0.04
Loss on Ignition	3.54	34.45	37.64	13.29
Moisture	0	0	0	0
Total	100.00	99.99	99.99	100.00

Table 14A. Total Acid Insoluble Residue for MRL Aggregates[1]

Aggregate I.D.	Total Percentage of Insoluble Residue Sample 1	Sample 2	Sample 3	Average
RJ	98.8	99.1	99.3	99.2
RD	18.8	18.1	17.3	18.1
RC	4.3	5.1	4.9	4.8
RL	89.3	86.5	88.9	88.2

Note 1: Tests were conducted in accordance with ASTM D-3042-86.

Table 14B. Cumulative Percentage of Insoluble Residue Retained in Each Sieve as a Percentage of the Insolubles Retained on No. 200 Sieve[1]

Sieve Size	RJ Replicate No. 1	RJ 2	RJ 3	RJ Avg.	RD Replicate No. 1	RD 2	RD 3	RD Avg.	RC Replicate No. 1	RC 2	RC 3	RC Avg.	RL Replicate No. 1	RL 2	RL 3	RL Avg.
#4	98.59	99.81	98.52	96.97	20.80	16.67	25.78	21.08	0.00	0.00	0.00	0.00	98.12	94.45	96.49	96.[illegible]
#8	99.28	99.98	99.23	99.50	41.60	38.41	48.44	42.82	0.00	0.00	0.00	0.00	98.84	98.02	98.28	98.[illegible]
#16	99.57	99.99	99.33	99.63	49.60	44.93	55.47	50.00	0.00	0.00	0.00	0.00	99.08	98.19	98.42	98.[illegible]
#30	99.78	99.99	99.58	99.78	56.80	52.90	63.28	57.66	0.00	11.76	8.70	6.82	99.17	98.28	98.51	98.[illegible]
#50	99.92	99.99	99.89	99.93	73.60	72.49	82.81	76.29	7.69	41.18	21.74	23.54	99.37	98.59	98.72	98.[illegible]
#100	100.00	99.99	99.98	99.99	84.00	89.13	88.28	87.14	30.77	76.47	47.83	51.69	99.78	99.50	99.65	99.[illegible]
#200	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.[illegible]

Note 1: Tests were conducted in accordance with ASTM D-3042 procedure.

Table 14C. Cumulative Percentage of Insoluble Residue Retained in Each Sieve as a Percentage of the Total Insoluble Residue

Sieve Size	RJ Replicate No. 1	RJ 2	RJ 3	RJ Avg.	RD Replicate No. 1	RD 2	RD 3	RD Avg.	RC Replicate No. 1[2]	RC 2	RC 3	RC Avg.	RL Replicate No. 1	RL 2	RL 3	RL Avg.
#4	97.84	99.63	97.81	98.43	16.56	15.13	22.60	18.10	0.00	0.00	0.00	0.00	97.22	94.45	96.49	96.[illegible]
#8	98.52	99.80	98.52	98.95	33.12	34.87	42.47	36.82	0.00	0.00	0.00	0.00	97.93	98.02	98.28	98.[illegible]
#16	98.82	99.81	98.62	99.08	39.49	40.79	48.63	42.97	0.00	0.00	0.00	0.00	98.17	98.19	98.42	98.[illegible]
#30	99.02	99.81	98.87	99.23	45.22	48.03	55.48	49.58	0.00	1.70	1.90	1.80	98.26	98.28	98.51	98.[illegible]
#50	99.16	99.81	99.17	99.38	58.60	65.79	72.60	63.66	0.96	5.96	4.74	5.35	98.46	98.59	98.72	98.[illegible]
#100	99.24	99.81	99.26	99.44	66.88	80.92	77.40	75.07	3.82	11.07	10.43	10.80	98.87	99.50	99.65	99.[illegible]
#200	99.24	99.82	99.28	99.45	79.62	90.79	87.67	86.03	12.42	14.48	21.80	18.14	99.08	100.00	100.00	99.[illegible]

Note 1: Tests were conducted in accordance in ASTM D-3042-86 procedure.

Note 2: The average does not reflect this replicate.

Table 15. Water Insoluble and pH for MRL Aggregates[1]

Aggregate I.D.	Sample Weight,gm	Water Soluble,gm	Water Solubles, %	pH[2]
RJ	5.105	0.209	4.1	9.12
RD	5.113	0.096	1.9	9.12
RC	3.094	0.074	2.4	9.47
RL	4.369	0.078	1.8	9.18

Note 1: Passing #200 size aggregate was stirred in water at room temperature for 30 minutes and the mixture was passed through a No. 44 filter. The weight of aggregate retained on filter was measured as the water insoluble portion.

Note 2: pH was determined using a pH Meter.

Table 16. Zeta Potential for MRL Aggregates[1]

Aggregate I.D.	Zeta Potential, mv
RJ	-49.0
RD	-20.3
RC	-23.8
RL	-25.6

Note 1: Zeta Potential was determined for the materials passing #325 sieve. Zeta Potential of each aggregate was measured at their natural pH with a Zeta Meter.

The SHRP Aggregates

Final Report

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The SHRP Aggregates: Final Report

Section **Page**

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Characterization of the SHRP Aggregates

Introduction

This report summarizes data for the SHRP aggregates, which were collected to serve as reference materials for the Strategic Highway Research Program (SHRP). The eleven aggregates represent a geographically and lithologically diverse collection of materials spanning the more commonly utilized bituminous aggregates. The aggregate collection consists of two limestones (samples RC and RD), two granites (RA, RB), a basalt (RK), a calcareous sandstone (RG) a graywacke (RH) and four gravels (RE, RF, RJ, RL) which range in nature from a glacial till to a cherty conglomerate.

The Center for Applied Energy Research (CAER) conducted a series of physical and chemical tests on the materials as part of a larger characterization effort conducted by the Asphalt Institute. The purpose of this report is to present a summary of the results from this effort.

Sample Processing and Handling.

The aggregates were preblended and homogenized by the Asphalt Institute. The original mixture proportion and particle sizes, as received, are summarized in Appendix A of this report. Approximately 1 to 1.5 kg of each of the aggregates were received in 1 gal paint tins. The aggregates were originally prepared with a nominal -3/4-inch topsize and were reduced to -1/2 inch to facilitate riffle splitting. Two fractions were split out and processed further. One was reduced to approximately 1 mm (-12 mesh) by staged roller crushing and then blended; a second was roller milled and then pulverized for 5 minutes in a ring and puck mill (Figure 1). These fractions were then utilized to perform the various test series which are described below.

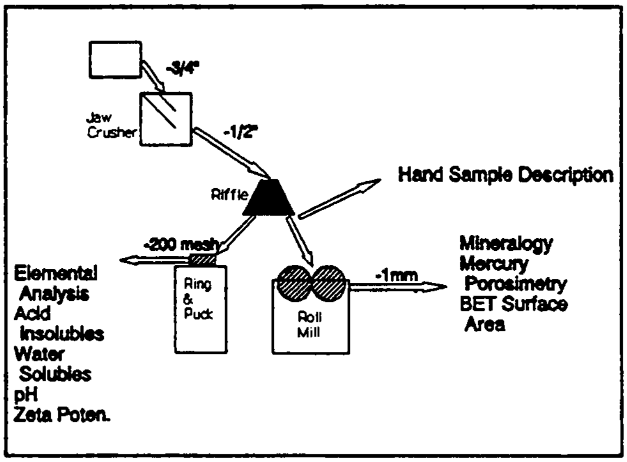

Figure 1. Sample preparation procedures for SHRP Aggregates.

<u>Hand Specimen Description and Mineralogic Determinations.</u> The samples of aggregate were examined in hand specimen with the aid of a hand lens (X14) and in thin section using a research quality petrographic microscope. Petrographic analysis involved study of rock chips mounted with blue epoxy resin on 30 micron thick polished glass slides (4.5 cm

X 2.5 cm). Two thin sections per sample were examined in both plain and polarized light at magnifications ranging from X15 to X400. Minerals were identified by standard petrographic techniques and rock-type abundances and mineral abundances in each rock-type were determined by point counting using a digital point counter (n=500 per sample). In the case of limestones and sandstones, samples were stained with alizarine red in order to distinguish dolomite from calcite. Porosity of individual rock types was determined by counting areas of epoxy resin.

Rock names, size classification and terminology used are similar to that recommended by the American Society of Testing Materials (ASTM) Standard Descriptive Nomenclature for Constituents of Natural Mineral Aggregates (C 294-86) and the ASTM Standard Practice for Petrographic Examination of Aggregates for Concrete (C 295-85). Other terms and abbreviations used are defined in the Notes to Tables 3 and 4 of this report.

The results are presented in two forms: as pie charts indicating the percentage of each rock type (Figures 2 to 7) and individual minerals in each sample, and in tabular form (Tables 2.1 to 2.11). Included in the tables are information on the percentages of abundance and porosity of each rock type in each sample, the percentage of each mineral in each rock type, whether the mineral is primary or secondary, and the texture, shape and size of each mineral.

<u>Mercury Porosimetry and BET Surface Area.</u> Eleven aggregate blends were analyzed using the BET method (surface area calculated from nitrogen adsorption) and mercury intrusion to determine surface area and porosity. The largest possible sample size was analyzed in each case to provide the optimum accuracy.

Prior to nitrogen adsorption/desorption the samples were outgassed at 100 °C and <50 mtorr for at least 12 hours. Twenty point adsorption points were taken at relative pressures less than 0.3 mtorr. The relatively low surface areas of the aggregates place the measurements below the acceptable range of experimental error, therefore these data should not be considered absolute.

Mercury porosimetry was performed following outgassing at ambient temperature to approximately 30 microns of Hg. Intrusion/extrusion measurement were made from ambient to 60,000 psi. A small volume of mercury penetrated the sample in each case, with some being retained in the sample following extrusion, presumably indicating an initial irreversible crushing of the structure. The greatest contribution to total pore volume in all cases came from larger pores ranging from 500 to 30,000 Å in diameter. The contribution from larger pores varies from sample to sample and very little pore volume is provided by pores smaller than 500 Å. However mercury intrusion is considered to be a better measure of meso-and macroporosity than of microporosity. In addition to porosity Rootare-Prenzlow surface area is calculated from the mercury intrusion data.

The porosimetry data is summarized in Table 5 and the complete listing of the mercury data is present in Appendix B of this report.

Acid insoluble, water soluble and pH. Acid insoluble measurements for the sample were carried out on the aggregates using ASTM D 3042-72. The procedure was conducted on the crushed and pulverized material with replicated samples. The ASTM procedure calls for measurement on a series of graded samples, which was not feasible with the sample size available. It is noted here that the procedure is considered archaic and has been dropped from the ASTM methods in compilations later than 1987.

Water soluble measurements were made using a procedure obtained from the Asphalt Institute. The -200 mesh material was stirred at room temperature for 30 minutes and the mixture passed through a no 44 filter which was dried at 100 °C. The amount of sample retained was used to calculate the percent of sample dissolved. The pH of the aggregate was determined using method ASTM C110.

Zeta Potential. Zeta-Potential (ζ, or electrokinetic potential), is the potential difference across the interface between a moving liquid and a fixed liquid layer attached to a particle. The zeta potential for the sample was determined using ASTM procedure D 4187-82 (Blue-White Light--Method B). The instrument used was Zeta Meter Inc. Model 3. The sample was suspended in a 10^{-4} m NaCl solution and 10 counts were made for each sample. The data are presented in Table 7.

Major Element Oxide. The major element composition of the aggregates were determined by X-ray fluorescence using Phillips AX2 system. The samples were fused with lithium tetraborate disks and determined using calibrations made from the appropriate international rock and mineral standards. Loss on ignition (LOI) was performed at 1000 °C.

Presentation of the Data.

A summary table of the information generated for each sample is presented in Tables 1.1 to 1.11. Tables with additional details and appropriate figures follow in subsequent sections. Appendices are presented with a complete compilation of the size distribution for each aggregate blend as determined by the Asphalt Institute in Appendix A. A list of all the Mercury porosimetry data are presented in Appendix B.

Table 1. Informational Summaries for the SHRP Aggregates

Table 1.1 Summary Information for the SHRP Aggregates; RA Lithonia Granite (Stripper); Vulcan Materials

Major Element Oxide

SiO_2	70.50
TiO_2	0.29
Al_2O_3	15.77
Fe_2O_3	2.13
CaO	1.32
MgO	0.42
Na_2O	4.05
K_2O	4.63
LOI	0.43
Total	99.54

Lithologic and Major Mineralogic Composition

Lithology %		Mineralogical Composition %	
Granite	98.6	Quartz	55.9
		K-feldspar	25.2
		Plagioclase	10.4
		Biotite	6.4
		Muscovite	1.7
Basalt	1.4	Fe Oxide	38.0
		Plagioclase	35.0
		Augite	17.0
		Muscovite	10.0

Mercury Porosimetry Data

Pore Size Å	Pore Volume cc/g
>3,000	0.0045
500-3000	0.0100
<500	0.0000

BET Surface Area, 0.19 m^2/g

Acid Insolubles, 94.6%

Water Solubles, 11.7%

Zeta Potential, -28.1 @pH = 7.71

Table 1.2 Summary Information for the SHRP Aggregates; RB Watsonville Granite (Non-Stripper); Granite Rock Company.

Major Element Oxide

SiO_2	56.12
TiO_2	0.52
Al_2O_3	20.14
Fe_2O_3	7.96
CaO	8.63
MgO	2.98
Na_2O	2.31
K_2O	0.46
LOI	2.76
Total	101.88

Lithologic and Major Mineralogic Composition

Lithology	%	Mineralogical Composition	%
Granite	100	Quartz	38.0
		Plagioclase	17.1
		Hornblende	16.8
		K-feldspar	15.3
		Epidote	5.8
		Chlorite	3.6
		Muscovite	1.5

Mercury Porosimetry Data

Pore Size Å	Pore Volume cc/g
>3,000	0.0106
500-3000	0.0344
<500	0.0017

BET Surface Area, 1.62 m^2/g

Acid Insolubles, 87.9%

Water Solubles, 8.1%

Zeta Potential, -17.1 @pH = 9.12

Table 1.3 Summary Information for the SHRP Aggregates; RC Limestone (High Absorption); McAdams Limestone Products

Major Element Oxide

SiO_2	5.58
TiO_2	0.06
Al_2O_3	1.18
Fe_2O_3	0.76
CaO	48.92
MgO	2.35
Na_2O	0.17
K_2O	0.18
LOI	40.62
Total	99.82

Lithologic and Major Mineralogic Composition

Lithology %	Mineralogical Composition %	
Limestone 100%	Calcite	97.1
	Organics	2.9

Mercury Porosimetry Data

Pore Size Å	Pore Volume cc/g
>3,000	0.0099
500-3000	0.1085
<500	0.0045

BET Surface Area, 2.90 m^2/g

Acid Insolubles, 7.9%

Water Solubles, 8.1%

Zeta Potential, -6.1 @pH = 9.82

Table 1.4 Summary Information for the SHRP Aggregates; RD Limestone (Low Absorption); Genstar Stone Products

Major Element Oxide

SiO_2	16.68
TiO_2	0.13
Al_2O_3	3.31
Fe_2O_3	1.20
CaO	38.80
MgO	3.47
Na_2O	0.12
K_2O	1.56
LOI	33.96
Total	99.23

Lithologic and Major Mineralogic Composition

Lithology %		Mineralogical Composition %	
Shaly Limestone	53.3%	Calcite	99.5
		Organics	0.5
Limestone	26.8%	Calcite	77.0
		Organics	19.0
		Quartz	4.0
Arenaceous Limestone	19.7%	Calcite	61.5
		Quartz	37.5
		Organics	0.5

Mercury Porosimetry Data

Pore Size Å	Pore Volume cc/g
>3,000	0.0013
500-3000	0.0301
<500	0.0003

BET Surface Area, 0.72 m^2/g

Acid Insolubles, 23.5%

Water Solubles, 5.1%

Zeta Potential, -13.6 @pH = 9.87

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Table 1.5 Summary Information for the SHRP Aggregates; RE Piedmont Gravel; Genstar Stone Products

Major Element Oxide

SiO_2	94.60
TiO_2	0.15
Al_2O_3	2.15
Fe_2O_3	1.54
CaO	0.25
MgO	0.38
Na_2O	0.26
K_2O	0.42
LOI	0.45
Total	100.20

Lithologic and Major Mineralogic Composition

Lithology %		Mineralogical Composition %	
Misc.	100 %	Quartz	90.0
		K-feldspar	3.0
		Muscovite	2.1
		Hornblende	1.1
		Biotite	1.1
		Chlorite	1.1
		Opaques	0.5

Mercury Porosimetry Data

Pore Size Å	Pore Volume cc/g
>3,000	0.0031
500-3000	0.0098
<500	0.0004

BET Surface Area, 0.95 m^2/g

Acid Insolubles, 96.1%

Water Solubles, 6.6%

Zeta Potential, -24.2 @pH = 8.08

Table 1.6 Summary Information for the SHRP Aggregates; RF Glacial Gravel; Vulcan Materials
Page 1

Major Element Oxide

SiO_2	25.97
TiO_2	0.12
Al_2O_3	2.37
Fe_2O_3	1.38
CaO	22.62
MgO	14.10
Na_2O	0.5
K_2O	0.57
LOI	33.26
Total	100.89

Lithologic and Major Mineralogic Composition

Lithology %		Mineralogical Composition %	
Limestone	72.6%	Calcite	93.5
		Chert	2.7
		Organics	0.3
		Quartz	0.2
		Dolomite	0.6
Misc.	10.8%	Quartz	63.0
		K-feldspar	30.5
		Plagioclase	3.7
		Opaques	2.8
Graywacke	5.9%	Quartz	52.0
		K-feldspar	19.0
		Lithic frag.	7.5
		Chlorite	7.0
		Plagioclase	6.0
		Chert	4.0
		Biotite	3.5
		Opaques	2.0
		Muscovite	1.0
		Dolomite	1.0
Chert	4.4%	Quartz	99.0

Table 1.6 Summary Information for the SHRP Aggregates
Aggregate: RF Glacial Gravel; Vulcan Materials
Page 2

Lithologic and Major Mineralogic Composition, Continued

Lithology %		Mineralogical Composition %	
Granodiorite	3.7%	Quartz	29.0
		Plagioclase	29.0
		Hornblende	17.0
		Biotite	9.5
		Opaques	7.0
		Muscovite	5.0
		K-feldspar	3.5
Basalt	2.6%	Fe Oxide	40.0
		Plagioclase	35.0
		Augite	15.0
		Muscovite	10.0

Mercury Porosimetry Data

Pore Size Å	Pore Volume cc/g
>3,000	0.0019
500-3000	0.0172
<500	0.0018

BET Surface Area, 1.66 m^2/g

Acid Insolubles, 28.2%

Water Solubles, 5.0%

Zeta Potential, -5.8 @pH = 9.51

Table 1.7 Summary Information for the SHRP Aggregates; RG Sandstone; Commercial Stone

Major Element Oxide

SiO_2	51.79
TiO_2	0.15
Al_2O_3	3.37
Fe_2O_3	0.93
CaO	23.12
MgO	0.25
Na_2O	0.16
K_2O	0.84
LOI	19.07
Total	99.68

Lithologic and Major Mineralogic Composition

Lithology %		Mineralogical Composition %	
Calcareous Sandstone	100 %	Calcite	49.1
		Quartz	47.2
		K-feldspar	2.6
		Opaques	0.6
		Plagioclase	0.3

Mercury Porosimetry Data

Pore Size Å	Pore Volume cc/g
>3,000	0.0170
500-3000	0.0482
<500	0.0018

BET Surface Area, 1.99 m^2/g

Acid Insolubles, 55.7%

Water Solubles, 4.9%

Zeta Potential, -9.4 @pH = 9.76

Table 1.8 Summary Information for the SHRP Aggregates; RH Greywacke; Kaiser Sand and Gravel
Page 1

Major Element Oxide

SiO_2	75.91
TiO_2	0.46
Al_2O_3	10.68
Fe_2O_3	4.83
CaO	1.84
MgO	2.28
Na_2O	2.76
K_2O	0.74
LOI	2.41
Total	101.91

Lithologic and Major Mineralogic Composition

Lithology %		Mineralogical Composition %	
Micaceous Sandstone	71.3%	Quartz	56.0
		Chlorite	19.6
		K-feldspar	5.0
		Chert	5.0
		Muscovite	3.0
		Leucoxene	1.0
		Opaques	1.0
		Plagioclase	0.2
		Biotite	0.2
Misc.	11.2%	Quartz	84.8
		K-feldspar	6.2
		Muscovite	4.5
		Chlorite	1.8
		Calcite	0.9
		Plagioclase	0.9
		Opaques	0.9
Granite	10.9%	Chlorite	51.0
		Quartz	26.3
		K-feldspar	22.5
		Hornblende	4.1
		Plagioclase	1.8
		Opaques	1.6
Chert	6.6%	Quartz	100.0

Table 1.8 Summary Information for the SHRP Aggregates
Aggregate: RH Greywacke; Kaiser Sand and Gravel
Page 2

Mercury Porosimetry Data

Pore Size Å	Pore Volume cc/g
>3,000	0.0128
500-3000	0.0905
<500	0.0023

BET Surface Area, 2.74 m^2/g

Acid Insolubles, 92.1%

Water Solubles, 9.7%

Zeta Potential, -20.5 @pH = 8.27

Table 1.9 Summary Information for the SHRP Aggregates; RJ Mountain Gravel Conglomerate; Teton Stone Company Products Page 1

Major Element Oxide

SiO_2	75.40
TiO_2	0.15
Al_2O_3	12.88
Fe_2O_3	2.01
CaO	1.73
MgO	0.39
Na_2O	3.4
K_2O	3.31
LOI	1.13
Total	100.40

Lithologic and Major Mineralogic Composition

Lithology %		Mineralogical Composition %	
Sandstone	47.4%	Quartz	76.3
		K-feldspar	11.2
		Muscovite	3.9
		Chlorite	4.2
		Plagioclase	1.4
		Epidote	1.0
		Opaques	0.6
		Biotite	0.2
Granite	28.4%	K-feldspar	37.7
		Quartz	36.6
		Muscovite	12.9
		Plagioclase	7.3
		Chlorite	6.9
		Epidote	1.8
		Opaques	0.5
		Hornblende	0.5
		Biotite	0.4
		Leucoxene	0.3
Misc.	23.7%	K-feldspar	48.4
		Quartz	36.5
		Plagioclase	10.1
		Chlorite	2.2
		Opaques	1.8
		Muscovite	0.9
		Calcite	1.0
Basalt	0.4 %		

Table 1.9 Summary Information for the SHRP Aggregates
Aggregate: RJ Mountain Gravel Conglomerate; Teton Stone Company Products
Page 2

Mercury Porosimetry Data

Pore Size Å	Pore Volume cc/g
>3,000	0.0026
500-3000	0.0071
<500	0.0002

BET Surface Area, 1.32 m^2/g

Acid Insolubles, 96.2%

Water Solubles, 6.3%

Zeta Potential, -27.5 @pH = 9.45

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Table 1.10 Summary Information for the SHRP Aggregates; RK Basalt; Blue Mountain Asphalt Company

Major Element Oxide

SiO_2	53.54
TiO_2	1.53
Al_2O_3	14.94
Fe_2O_3	11.68
CaO	9.70
MgO	5.62
Na_2O	2.49
K_2O	0.77
LOI	1.13
Total	101.46

Lithologic and Major Mineralogic Composition

Lithology %		Mineralogical Composition %	
Basalt	94.4%	Fe Oxide	38.3
		Plagioclase	35.9
		Augite	13.0
		Muscovite	9.4
		Olivine	1.4
		Iddingsite	1.4
Misc.	4.5%	Quartz	77.8
		K-feldspar	11.1
		Plagioclase	10.0
		Chert	1.0
Sandstone	0.6%	Quartz	100.0

Mercury Porosimetry Data

Pore Size Å	Pore Volume cc/g
>3,000	0.0079
500-3000	0.0289
<500	0.0031

BET Surface Area, 15.73 m^2/g

Acid Insolubles, 90.1%

Water Solubles, 7.4%

Zeta Potential, -23.4 @pH = 7.6

Table 1.11 Summary Information for the SHRP Aggregates; RL Gulf States Chert; Fordyce Incorp.
Page 1

Major Element Oxide

SiO_2	76.08
TiO_2	0.12
Al_2O_3	5.04
Fe_2O_3	1.85
CaO	6.47
MgO	0.00
Na_2O	0.91
K_2O	1.48
LOI	6.12
Total	98.07

Lithologic and Major Mineralogic Composition

Lithology %		Mineralogical Composition %	
Chert	59.1%	Quartz	80.2
		Ilmenite	8.2
		Chalcedony	5.5
		Calcite	4.7
		Dolomite	0.7
		Opaques	0.3
Arenaceous Limestone	18.2%	Calcite	74.2
		Quartz	15.6
		Dolomite	5.0
		Organics	2.6
		K-feldspar	1.3
		Plagioclase	0.5
Granite	11%	Quartz	45.0
		Ilmenite	32.0
		K-feldspar	12.5
		Leucoxene	7.0
		Plagioclase	4.0
		Muscovite	3.5
Misc.	5.8%	Quartz	55.2
		Fe Oxide	38.0
		K-feldspar	3.4
		Plagioclase	3.4

Table 1.11 Summary Information for the SHRP Aggregates
Aggregate: RL Gulf States Chert; Fordyce Incorp.
Page 2

Lithologic and Major Mineralogic Composition, Continued

Lithology %		Mineralogical Composition %	
Sandstone	5.6%	Quartz	55.5
		Calcite	31.0
		K-feldspar	7.0
		Opaques	2.5
		Plagioclase	2.0
Basalt	0.2%		

Mercury Porosimetry Data

Pore Size Å	Pore Volume cc/g
>3,000	0.0010
500-3000	0.0104
<500	0.0012

BET Surface Area, 2.41 m^2/g

Acid Insolubles, 85.3%

Water Solubles, 9.3%

Zeta Potential, -21.2 @pH = 9.66

Table 2. Major Element Oxide Composition of the SHRP Aggregates.

Sam. No.	RA	RB	RC	RD	RE
SiO_2	70.50	56.12	5.58	16.68	94.60
TiO_2	0.29	0.52	0.06	0.13	0.15
Al_2O_3	15.77	20.14	1.18	3.31	2.15
Fe_2O_3	2.13	7.96	0.76	1.20	1.54
CaO	1.32	8.63	48.92	38.80	0.25
MgO	0.42	2.98	2.35	3.47	0.38
Na_2O	4.05	2.31	0.17	0.12	0.26
K_2O	4.63	0.46	0.18	1.56	0.42
LOI	0.43	2.76	40.62	33.96	0.45
Total	99.54	101.88	99.82	99.23	100.20

	RF	RG	RH	RJ	RK	RL
SiO_2	25.97	51.79	75.91	75.40	53.54	76.08
TiO_2	0.12	0.15	0.46	0.15	1.53	0.12
Al_2O_3	2.37	3.37	10.68	12.88	14.94	5.04
Fe_2O_3	1.38	0.93	4.83	2.01	11.68	1.85
CaO	22.62	23.12	1.84	1.73	9.76	6.47
MgO	14.10	0.25	2.28	0.39	5.62	0.00
Na_2O	0.50	0.16	2.76	3.40	2.49	0.91
K_2O	0.57	0.84	0.74	3.31	0.77	1.48
LOI	33.26	19.07	2.41	1.13	1.13	6.12
Total	100.89	99.68	101.91	100.40	101.46	98.07

Table 3. Hand Sample Descriptions of SHRP AGGREGATES:

Table 3.1 RA Lithonia Granite

Quartz
Biotite
Muscovite
Feldspar
Basalt fragments

This is a fine to medium-grained granite composed mostly of quartz, biotite and feldspar. Overall appearance is white-light gray.

Quartz: White and various shades of gray in color. 1-2 mm grain aggregates.

Biotite: Small (<1mm) flakes are oriented in a parallel manner as a foliation.

Muscovite: Small (<1mm) flakes, more scarce than biotite grains.

Feldspar: Off-white to slightly tan in color. 1-2mm in size and fractured along cleavage.

Table 3.2 RB Watsonville Granite

Quartz
Chlorite
Feldspar
Muscovite
Hornblende

This medium-grained granite is white and mottled dark gray.

Quartz: 1-2 mm grains that are white, clear and light gray.

Hornblende: Angular grains and up to 6mm in length that are often broken along cleavage planes.

Biotite: Usually associated with hornblende, these flakes are 1-2 mm and very friable.

Feldspar: White to slightly tan in color. 1-2 mm.

Table 3.3 RC Limestone (higher absorption)
2 distinctive shades of limestone.

Brownish-gray vuggy limestone: vugs (<1mm). Some vugs filled with calcite, others empty. Skeletal fragments present (trilobite, gastropod).

Light gray: Micrite(?) with very light veining (veins <0.5 mm wide). Veins filled with calcite grains, some in crystal form. There are also some dark brown bands of organic material <0.5 mm wide.

Table 3.4 RD Limestone (low absorption)
Composed of 2 different rock types.

Dark gray/black micrite: closely packed, mud supported grains. Possible fossil fragments. Very small calcite veins cut rock.

Quartz (aggregates): medium-sized quartz grains, well rounded and cemented. Dark gray/glassy black.

A minor amount of white vein quartz is present.

Table 3.5 RE Piedmont Gravel

Quartz
Basalt
Granite
Sandstone/Quartzite

Quartz: Pebbles which are rounded dominate the mixture. Dominantly milky qtz, others flesh tones and gray. 1 cm to 1mm diameter. Some red/brown pebbles.

Basalt: Aphanitic, dark gray. White quartz stringers <1mm wide.

Granite: White quartz, biotite, off-white feldspar. Fine-grained granite with biotite defining foliation.

Sandstone: Medium to fine-grained, mostly quartz and muscovite. Very friable.

Table 3.6 RF Glacial Gravel

Limestone
Quartz
Feldspar
Basalt
Granite/Granodiorite
Chert

Limestone: Off-white, tan, gray, closely packed, no vugs. Also a vuggy variety: vugs localized and some filled with calcite crystals. Vugs <1 mm diameter. Off-white to tan color.

Quartz: Mostly in the form of sand with a minor amount of small pebbles (<2mm).

Feldspar: Mostly pink or yellowish sand-sized grains.

Granite: Quartz, orthoclase, biotite make up this fine-grained granite.

Chert: White and light gray, conchoidal fracture.

Basalt: Aphanitic, black.

Table 3.7 RG Sandstone

Sandstone
Granite

Sandstone: Well-cemented, fine to medium-grained, gray. calcite cement.

Granite: Quartz, feldspar and hornblende. Hornblende crystals up to 4 mm, qtz and feldspar smaller.

Table 3.8 RH Graywacke

Chert
Quartz
Granite
Sandstone

Chert: Conchoidal fracture.

Quartz: Dominantly vein quartz.

Granite: Quartz, feldspar, hornblende, fine-grained.

Sandstone: Fine to medium-grained.

Table 3.9 RJ Mountain Gravel Conglomerate
Quartz
Granite
Basalt
Sandstone
Limestone

Quartz: Dominantly vein quartz in a variety of colors; white, rose, yellow.

Granite: Quartz, k-feldspar, minor chlorite and muscovite, augite

Basalt: Aphanitic, black.

Sandstone: Fine-grained.

Limestone: Micritic.

Table 3.10 RK Basalt

Augite
Plagioclase
Quartz

Difficult to discern anything at hand sample level. Aphanitic, black.

glassy white/clear specks-- quartz?
elongate dark mineral-- augite
white, massive mineral-- plagioclase

Table 3.11 RL Gulf Coast Gravel
Chert
granite
rounded pebbles
limestone
basalt
sandstone

Chert: Various colors, conchoidal fracture.

Granite: Fine-grained granite, white with a few biotite grains.

Sandstone: Fine-grained quartz and feldspar fragments in an off-white, muddy matrix.

Rounded pebbles: Quartz pebbles <.5 cm diameter.

Basalt: Aphanitic, black.

Limestone: Micritic.

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Table 4. Mineralogic Determinations for SHRP Aggregates.

Table 4.1 RA Lithonia Granite
LOCALITY: Vulcan Materials Co. Grayson Quarry; Grayson GA.

Rock Type	%	%ϕ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Granite	98.6	0.4	Quartz	55.9			0.7	Anh	minor rextal
			K-feldspar	25.2			0.6	Sub	
			Plagioclase	10.4			0.5	Sub	
			Biotite	6.4			0.4	Tab	
			Muscovite	1.7			0.3	Tab	
Basalt	1.4	0	Fe Oxide	38			<0.02		amorp.masses
			Plagioclase	35			0.1	Laths	
			Augite	17			0.05	Sub	
			Muscovite	10			0.08	Tab	

Table 4.2 RB Watsonville Granite
LOCALITY: Granite Rock Co., Watsonville CA

Rock Type	%	%ϕ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Granite	100	0.5	Quartz	38			0.08	Anh	
			Plagioclase	17.1			0.06	Sub	
			Hornblende	16.8			0.05	Sub	
			K-feldspar	15.3			0.06	Sub	
					Epidote	5.8	0.03	Anh	
					Chlorite	3.6	0.02	Tab	
					Muscovite	1.5	0.02	Tab	
					Leucoxene	.06	<0.02		amorp.masses
			Opaques	0.6				Anh	

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Table 4.3 RC Limestone (higher absorption)
LOCALITY: McAdam Limestone Prod.; Frederick, MD

Rock Type	%	%ϕ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Limestone	100	6.6	Calcite Cement	65.5			.005-.01		Pelleted or xtalline
			Calcite	16.2	Calcite	8.0	0.02-.08	Hex	xtalline
			Organics	2.9			0.02		amorp.masses
			Fossils	0.8			0.4		

Table 4.4 RD Limestone (lower absorption)
LOCALITY: Genstar Stone Prod.; White Marsh, MD

Rock Type	%	%ϕ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Shaly Limestone	53.3	0	Calcite Cement	87			<0.02		Pelleted or xtalline
			Calcite	12.5			0.15	Hex	c. xtalline
			Organics	0.5			0.02		amorp.masses
Limestone	26.8	0	Calcite Cement	76			<0.02		xtalline
			Organics	19			<0.02		amorp.masses
			Quartz	4			0.1	SR-R	
			Calcite	1			0.2	Hex	c. xtalline
Arenaceous Limestone	19.7	0	Calcite Cement	52			<0.02		xtalline
			Quartz	37.5			0.1	SR-R	
			Calcite	9.5			0.06	Hex	c. xtalline
			Organics	1			<0.02		amorp.masses

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Table 4.5 RE Piedmont Gravel
LOCALITY: Genstar Stone Prod.; White Marsh, MD

Rock Type	%	%φ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Misc.	100	0	Quartz	90			0.4	A-SR;Anh	m. rextal
			K-feldspar	3			0.15	Anh	
			Muscovite	2.1			0.2	Tab	
			Hornblende	1.1			0.1	Tab	
			Biotite	1.1			0.4	Tab	
			Chlorite	1.1			0.05	Tab	
			Opaques	0.5			0.1	A-SA	
			Augite	0.3			0.15	Sub	
			Plagioclase	0.2			0.1	Sub	
					Leucoxene	0.2	<0.02		amorp.masses

Table 4.6 RF Glacial Gravel
LOCALITY: Vulcan Minerals Co.; Crystal Lake, IL

Rock Type	%	%ϕ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Limestone	72.6	2.4	Calcite	80.2			0.05	Hex	c. xtalline
			Cement	13.3			<0.02		
					Chert/ Chalcedony	2.7	<0.02		cryptoxtalline fibrous
			Organics	0.3			0.02		amorp.masses
			Fossils	0.3			0.2		
			Quartz	0.2			0.09	SR	
					Dolomite	0.6	0.05	Rhomb	
Misc.	10.8	0	Quartz	63			0.08	SR-R	
			K-feldspar	30.5			0.06	SA-R	
			Plagioclase	3.7			0.05	SA-SR	
			Opaques	2.8			0.03	SA-SR	

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Table 4.6 Sample RF
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Rock Type	%	%ϕ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Graywacke	5.9	0	Quartz	52			0.3	SA-R	
			K-feldspar	19			0.2	SA-SR	
			Lithic frag.	7.5			0.3	SR	
			Chlorite	7			0.6	Tab	
			Plagioclase	6			0.05	SA-SR	
			Chert	4			<0.02		cryptoxtalline
			Biotite	3.5			0.02	Tab	
			Opaques	2			0.04	A-SR	
			Muscovite	1			0.04	Tab	
					Dolomite	1	0.08	Rhomb	
Chert	4.4	0	Quartz	95			<0.02		cryptoxtalline
			Chalcedony	5			0.03	acicular	fibrous

Table 4.6 Sample RF
PAGE 3 of 3

Rock Type	%	%ϕ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Granodiorite	3.7	0	Quartz	29			0.15	Anh	
			Plagioclase	29			0.2	Sub	
			Hornblende	17			0.08	Sub	
			Biotite	9.5			0.03	Tab	
			Opaques	7			0.03	Anh	
					Muscovite	5	0.04	Tab	
			K-feldspar	3.5			0.2	Anh	
Basalt	2.6	0	Fe Oxide	40			<0.02		amorp.masses
			Plagioclase	35			0.1	Euh	
			Augite	15			0.06	Sub	
					Muscovite	10	0.1	Tab	

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Table 4.7 RG Sandstone
LOCALITY: Commercial Stone Co.; Connellsville, PA

Rock Type	%	%ϕ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Calcareous Sandstone	100	0	Calcite	49.1	Calcite	Tr.	<0.02 0.08	Hex	cement
			Quartz	47.2			0.12	A-SR	m.rextal
			K-feldspar	2.6			0.1	SA-SR	
			Opaques	0.6			0.05	SA-SR	
			Plagioclase	0.3			0.06	SA-SR	
					Muscovite	0.2	0.03	Tab	

Table 4.8 RH Graywacke
LOCALITY: Kaiser Sand and Gravel; Pleasanton, CA

Rock Type	%	%ϕ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Micaceous Sandstone	71.3	0	Quartz	56			0.08	SA-SR	
			Chlorite	19.6			0.06	Tab	
			K-feldspar	5			0.06	SA-R	
			Chert frag.	5			0.05		cryptoxtallin e
					Muscovite	3	0.03	Tab	
					Leucoxene	1	<0.02		amorp.masses
			Opaques	1			0.05	SA-SR	
			Plagioclase	0.2			0.06	SA-R	
			Biotite	0.2			0.04	Tab	

Table 4.8 Sample RH
PAGE 2 of 2

Rock Type	%	%ϕ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Misc.	11.2	0	Quartz	84.8			0.1	SA-SR	
			K-feldspar	6.2			0.07	SA-SR	
			Muscovite	4.5			0.05	Tab	
			Chlorite	1.8			0.05	Tab	
			Calcite	0.9			0.04	Hex	
			Plagioclase	0.9			0.05	SA-SR	
			Opaques	0.9			0.06	SA-SR	
Granite	10.9	0			Chlorite	51	0.5	Tab	encrusts
			Quartz	26.3			0.1	Anh	
			K-feldspar	22.5			0.09	Anh	
			Hornblende	4.1			0.14	Sub	
			Plagioclase	1.8			0.06	Sub	
			Opaques	1.6			0.07	Anh	
Chert	6.6	0	Quartz	100			<0.02		cryptoxtallin e

Table 4.9 RJ Mountain Gravel Conglomerate;
LOCATION: Teton Stone Co.; Cheyenne WY
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Rock Type	%	%ϕ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Sandstone	47.4	0	Quartz	76.3			0.1	SA-R	m. rextal
			K-feldspar	11.2			0.08	SA-SR	
			Muscovite	3.9	Muscovite	1	0.06	Tab	
			Chlorite	4.2			0.08	Tab	
			Plagioclase	1.4			0.06	SA-SR	
					Epidote	1	0.03	SR	
			Opaques	0.6			0.05	SA-SR	
			Biotite	0.2			0.02	Tab	

Table 4.9 Sample RJ
PAGE 2 of 3

Rock Type	%	%φ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Granite	28.4	0	K-feldspar	37.7			0.1	Sub	
			Quartz	36.6			0.1	Anh	
					Muscovite	12.9	0.04	Tab	
			Plagioclase	7.3			0.08	Sub	
					Chlorite	6.9	0.08	Tab	
					Epidote	1.8	0.05	Anh	
			Opaques	0.5			0.07	Anh	
			Hornblende	0.5			0.05	Anh	
			Biotite	0.4			0.04	Tab	
					Leucoxene	0.3	<0.02		amorp.masses

Table 4.9 Sample RJ
PAGE 3 of 3

Rock Type	%	%ϕ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Misc.	22.7	0	K-feldspar	48.4					
			Quartz	36.5					
			Plagioclase	10.1					
			Chlorite	2.2					
			Opaques	1.8					
			Muscovite	0.9					
Limestone	1.1	1	Calcite	98			0.08		c.xtalline
			Organics	1			0.06		amorp.masses
Basalt	0.4	0							

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Table 4.10 RK Basalt
LOCALITY: Blue Mountain Asphalt Co.; Hermiston, OR

Rock Type	%	%ϕ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Basalt	94.4	0	Fe Oxide	38.3			<0.02		amorp.masses
			Plagioclase	35.9			0.13	Euh	
			Augite	13			0.06	Sub	
					Muscovite	9.4	0.04	Sub	
			Olivine	1.4			0.06	Anh	
					Iddingsite	1.4	0.06	acicular	fibrous
Misc.	4.5	0	Quartz	77.8			0.06	SR-R	
			K-feldspar	11.1			0.04	SA-SR	
			Plagioclase	10			0.06	SA-SR	
			Chert	2			<0.02		cryptoxtallin e
Sandstone	0.6	0	Silica Cement	60			<0.02		
			Quartz	40			0.08	SR-WR	
Micrite	0.5	0	Calcite				<0.02		mud

Table 4.11 RL Gulf Coast Gravel
LOCALITY: Fordyce, Inc.; Sullivan City, TX

Rock Type	%	%φ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Chert	59.1	0.2	Quartz	80.2			<0.02		cryptoxtallin e
			Ilmenite	8.2			<0.02		amorp.masses
			Chalcedony	5.5			0.05	Acicular	fibrous
					Calcite	4.7	0.08	Hex	
					Dolomite	0.7	0.06	Rhomb	
			Opaques	0.3			0.04	Anh	
Arenaceous Limestone	18.2	1.1	Calcite	74.2			<0.02		cement
			Quartz	15.6			0.02	SA-SR	
					Dolomite	5	0.02	Rhomb	
			Organics	2.6			<0.02		amorp.masses
			K-feldspar	1.3			0.06	SR	
			Plagioclase	0.5			0.04	SR	

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Table 4.11 Sample RL
PAGE 2 of 3

Rock Type	%	%φ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Granite	11	0	Quartz	45			0.08	Anh	
			Ilmenite	32			<0.02		amorp.masses
			K-feldspar	12.5			0.06	Anh	
					Leucoxene	7	<0.02		amorp.masses
			Plagioclase	4			0.04	Anh	
					Muscovite	3.5	0.02	Tab	
Misc.	5.8	0	Quartz	55.2			0.05	SA-SR	
			Fe Oxide	38			<0.02		amorp.masses
			K-feldspar	3.4			0.06	SA-SR	
			Plagioclase	3.4			0.06	SA-SR	

Table 4.11 Sample RL
PAGE 3 of 3

Rock Type	%	%ϕ	Minerals/Rock Constituents				Size (mm)	Shape	Texture
			Primary	%	Secondary	%			
Sandstone	5.6	0	Quartz	55.5			0.05	SA-SR	
			Calcite	31			<0.02		cement
			K-feldspar	7			0.05	SA-SR	
			Opaques	2.5			0.04	SA-SR	
			Plagioclase	2			0.04	SR	
Basalt	0.2	0							

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Figure 2. Aggregate Lithologic Composition for Samples RA and RB.

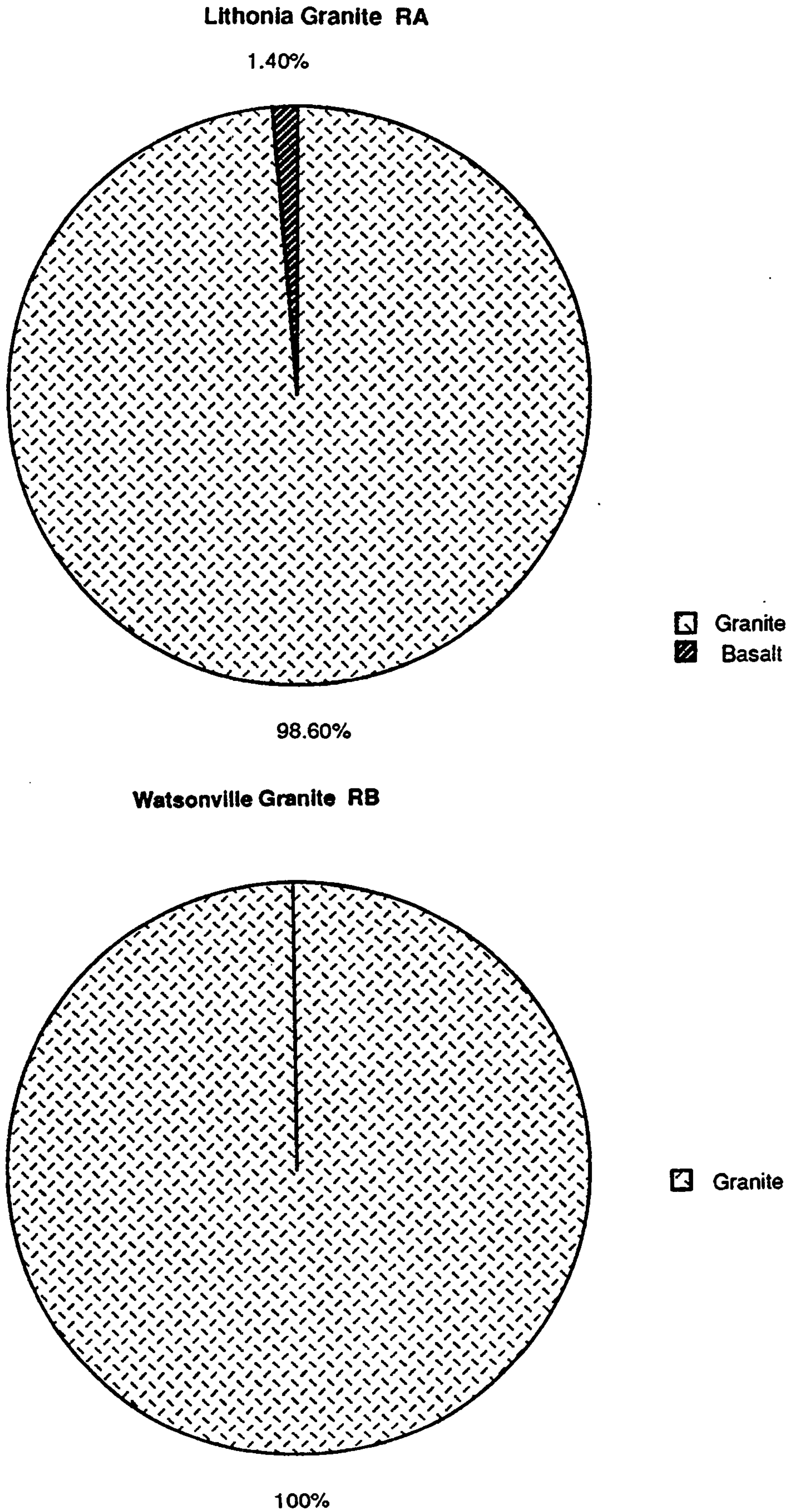

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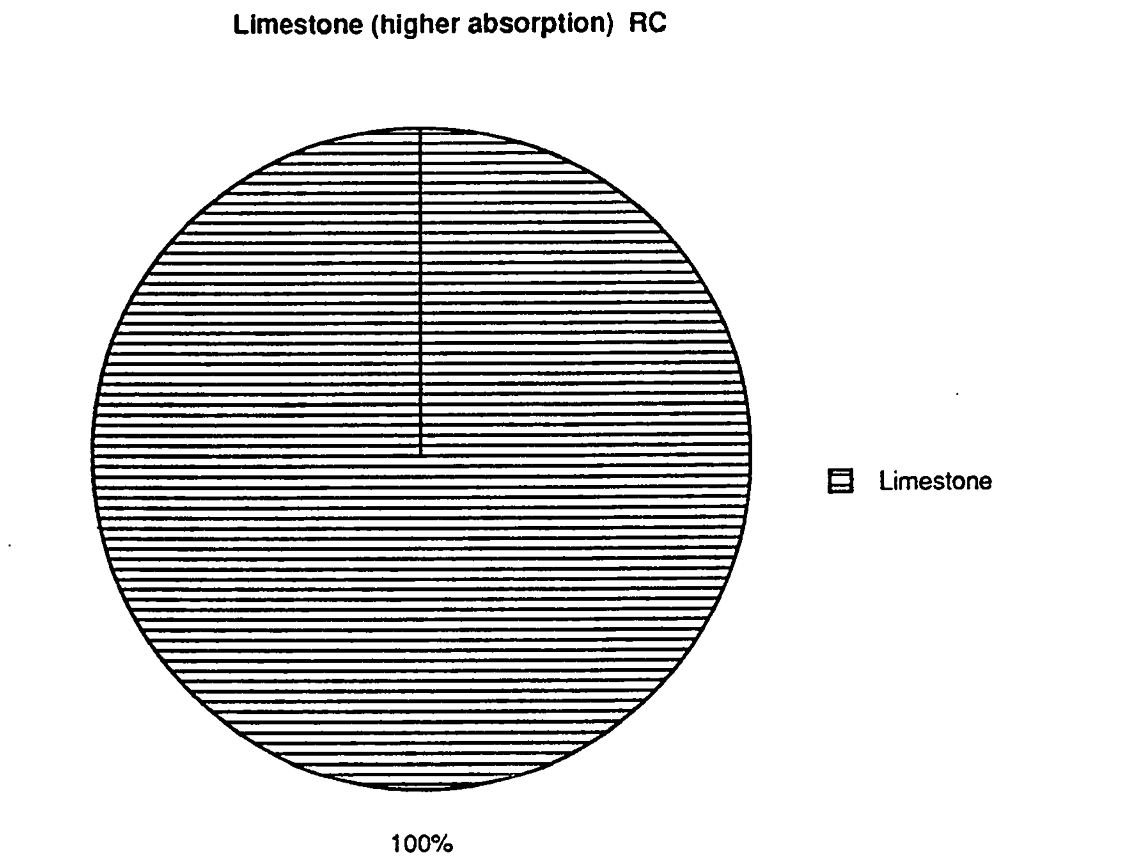
Figure 3. Aggregate Lithologic Composition for Samples RC and RD.



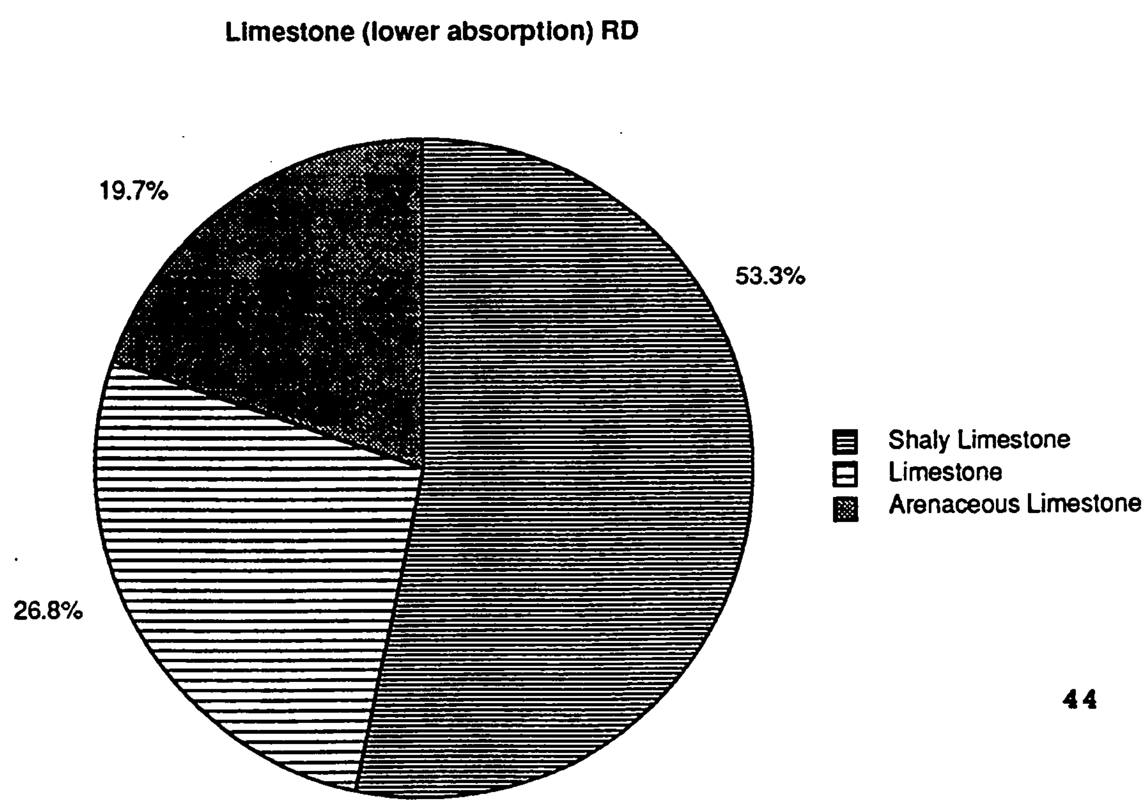


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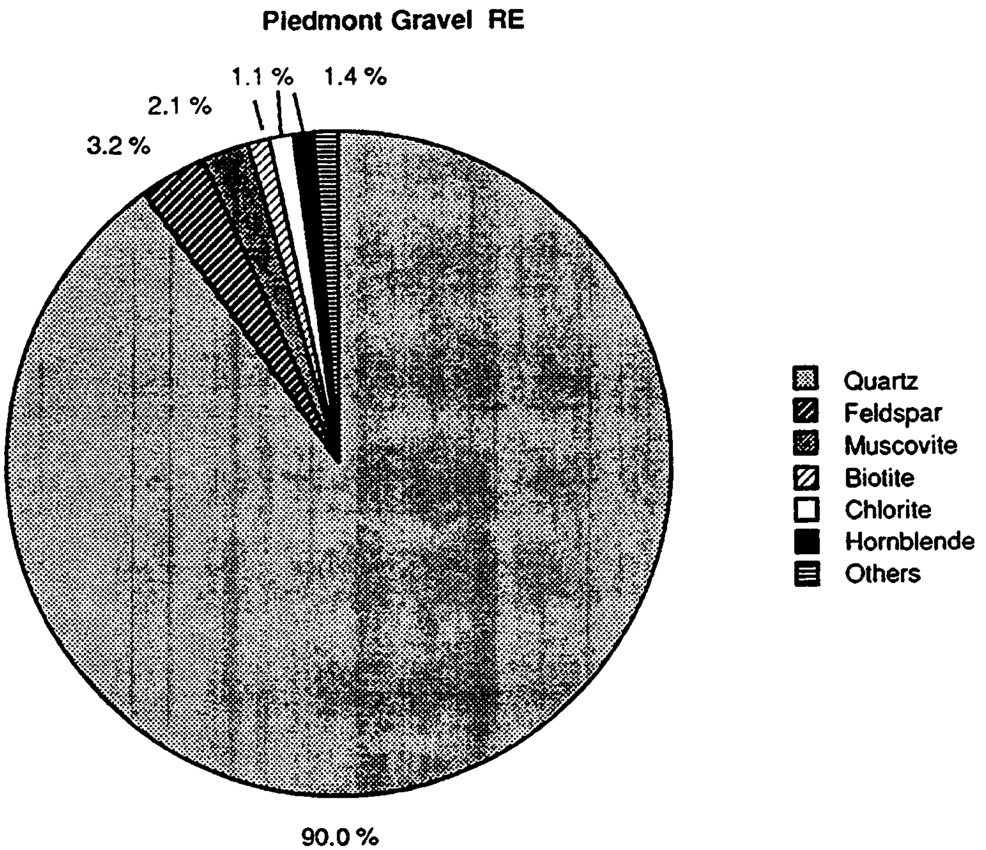
Figure 4. Aggregate Lithologic Composition for Samples RE and RF.



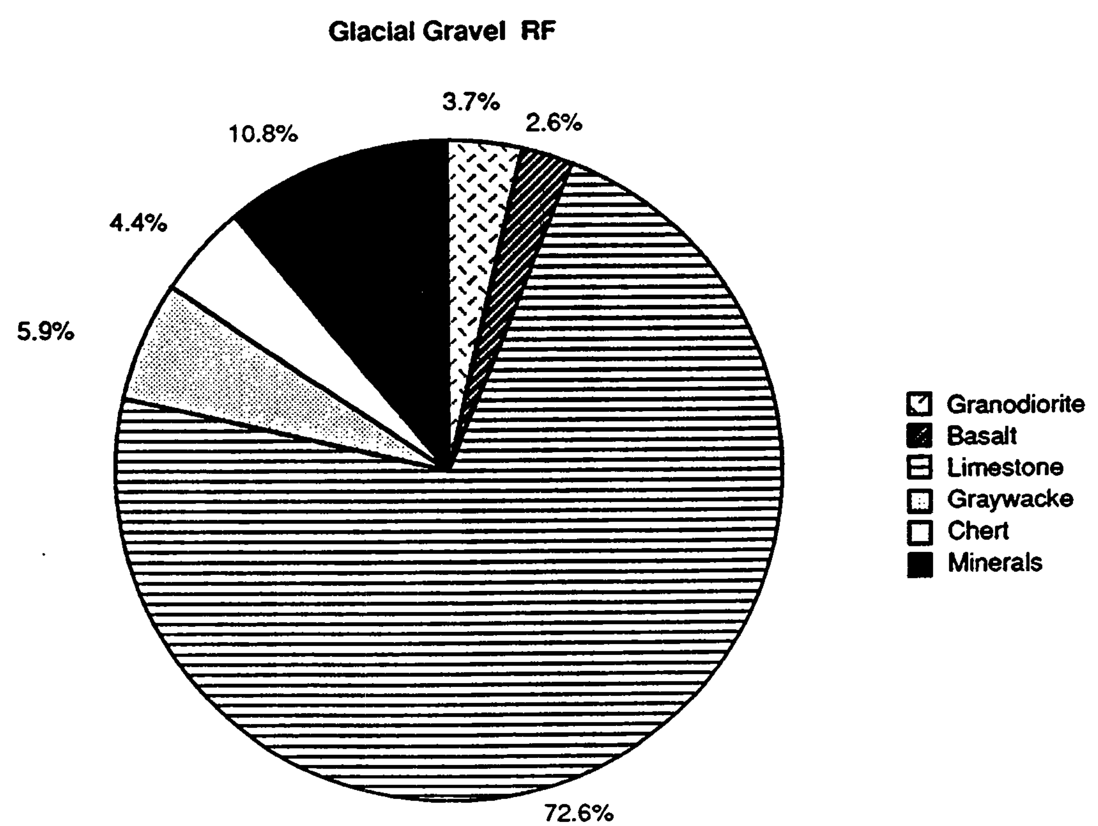


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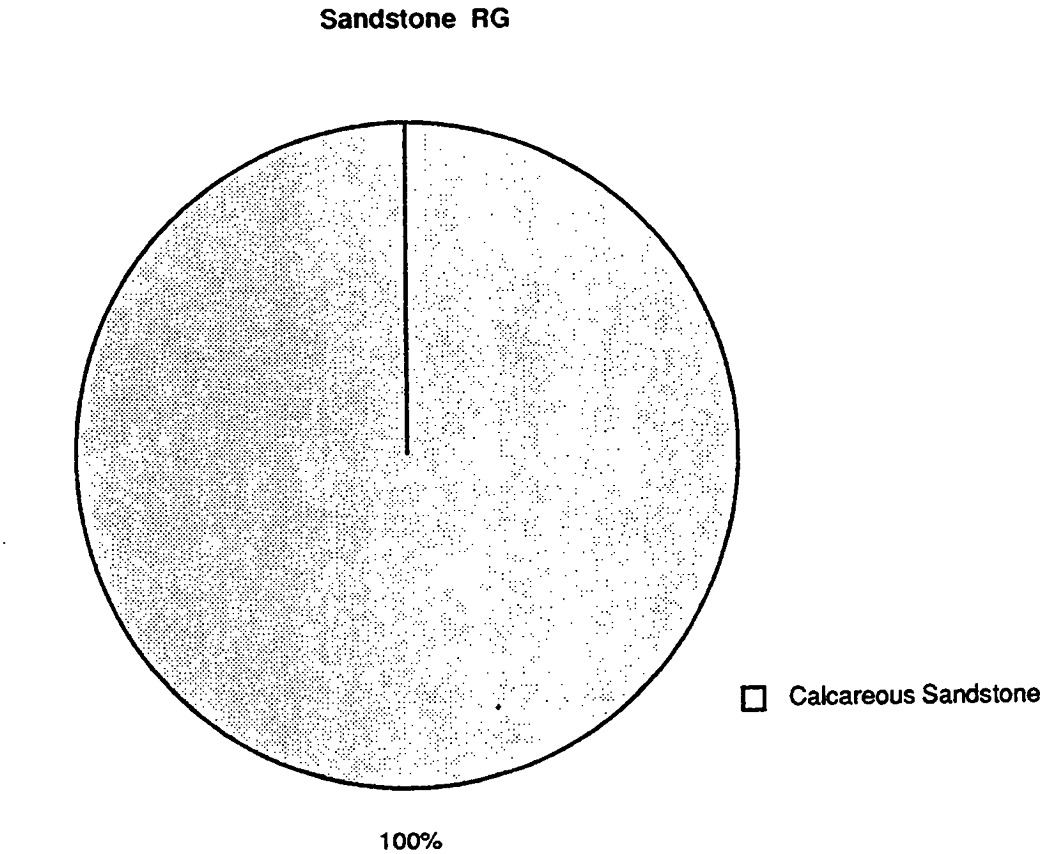
Figure 5. Aggregate Lithologic Composition for Samples RG and RH.



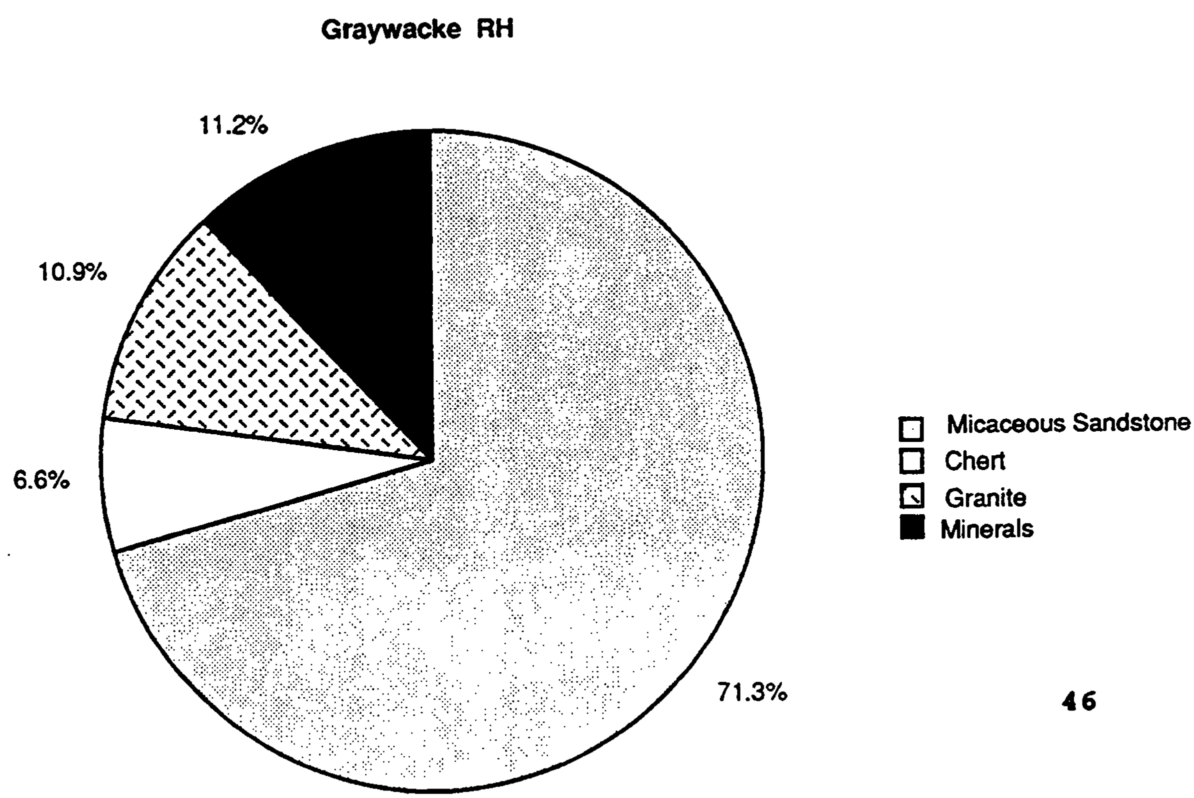
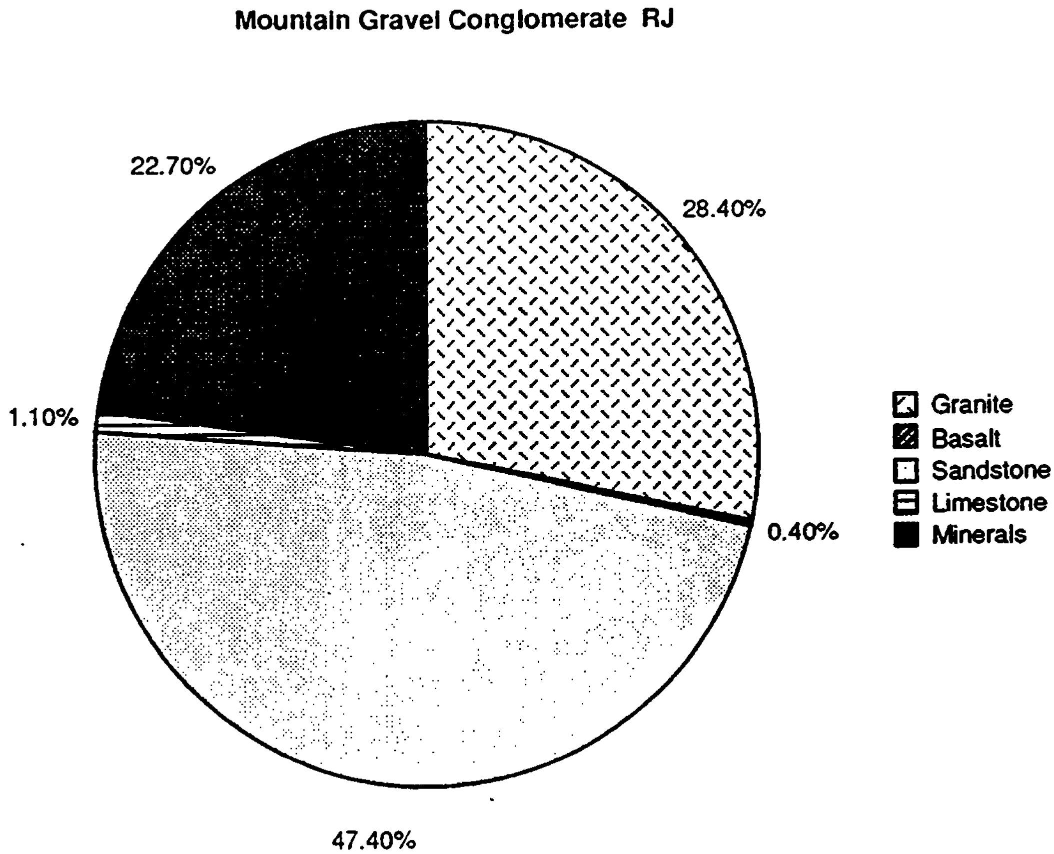


Figure 6. Aggregate Lithologic Composition for Samples RJ and RK.



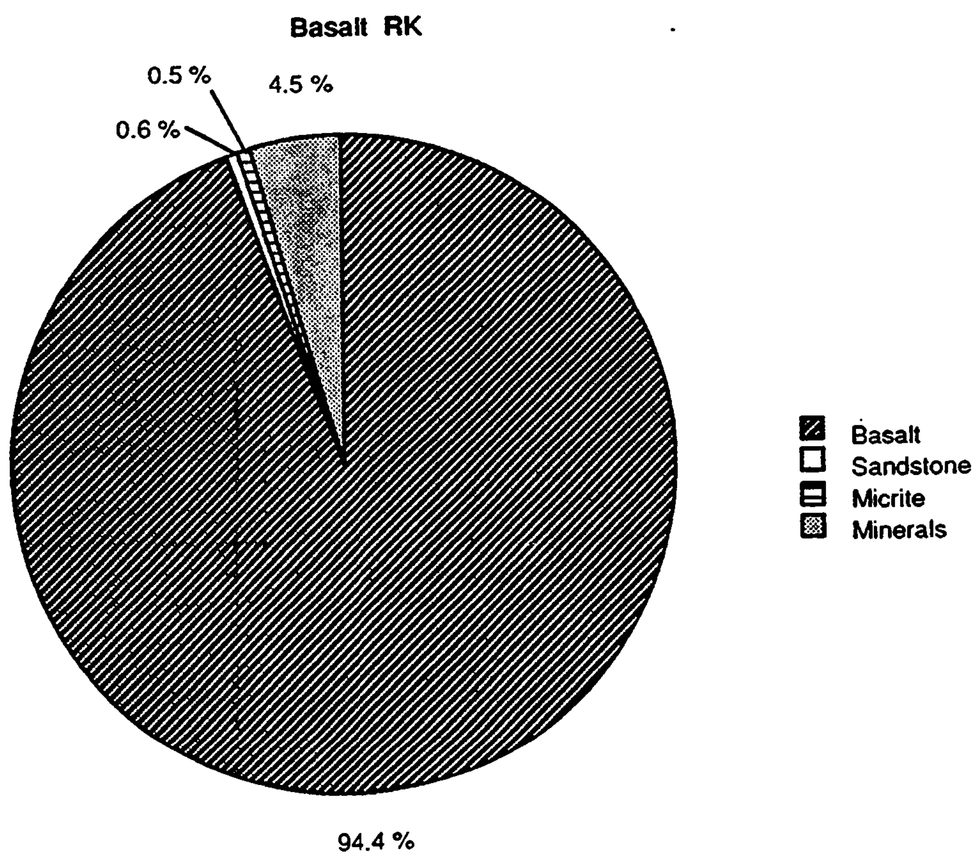


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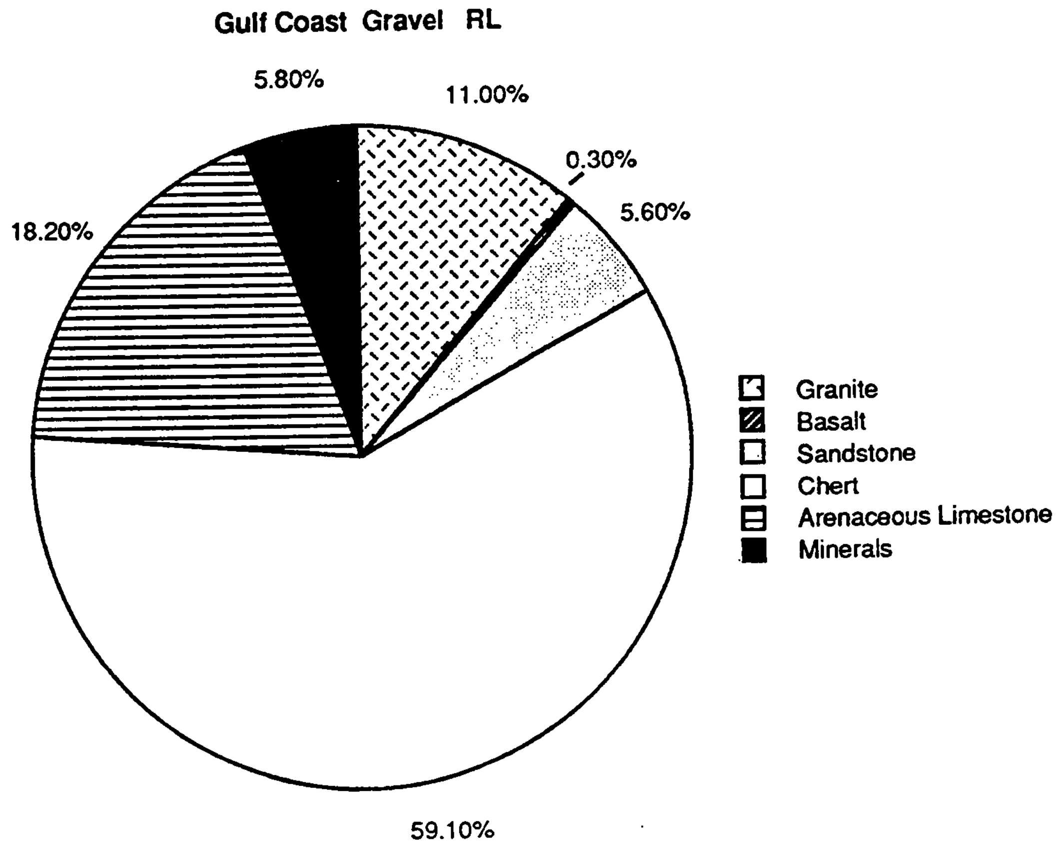
Figure 7. Aggregate Lithologic Composition for Samples RL.

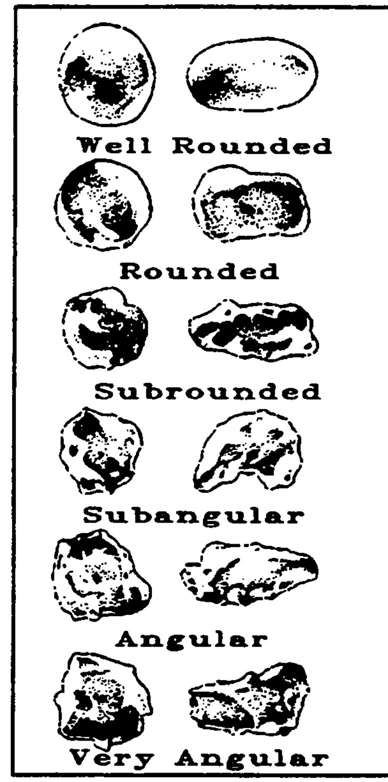


Notes for Tables 3 and 4 and Figures 2 to 7 and List of Abbreviations Used.

ABBREVIATIONS USED

Shape

VA= very angular
A= angular
SA= subangular
SR= subrounded
R= rounded
WR= well rounded
Euh= euhedral
Anh= anhedral
Sub= subhedral
Tab= tabular
Hex= hexagonal
Rhomb= rhombohedral



Adapted from Ehlers and Blatt, 1982.

Textures

xtalline= crystalline
c. xtalline= coarsely crystalline
cryptoxtalline= cryptocrystalline
rextal= recrystallization
m.rextal= minor recrystallization
amorp.masses= amorphous masses

Size Equivalents

very fine grained (clay sized) = <0.002 mm
fine grained (silt sized) = 0.0625 mm - 0.002 mm
medium grained (sand sized) = 0.06 mm - 2 mm

GENERAL GLOSSARY OF TERMS

Acicular	needle shaped or fibrous.
Anhedral	no crystal faces are developed.
Aphanitic	so fine grained that individual crystals are not distinguishable by the unaided eye.
Augite	a calcium magnesium iron rich pyroxene.
Biotite	a iron-magnesium rich mica, black in color.
BET method	surface area calculated from nitrogen adsorption named for originators, S. Brunauer, P. Emmett and E. Teller.
Calcite	calcium carbonate
Conchoidal	a fracture that gives a smoothly curved surface.
Chlorite	a magnesium mica
Dolomite	calcium magnesium carbonate.
Euhedral	well developed crystal faces.
Foliation	a planar arrangement of minerals in a rock.
Hornblend	a calcium iron magnesium rich amphibole
K-feldspar	microcline or orthoclase feldspar
Micrite	very fine grained limestone.
Muscovite	a potassium mica, transparent.
Plagioclase	a calcium-sodium feldspar
Rootare-Prenzlow area	surface area calculated from mercury intrusion as a function of pressure.
Subhedral	only partial development of crystal faces.
Tabular	platy or prismatic.
Zeta Potential	ζ, or electrokinetic potential, is the potential difference across the interface between a moving liquid and a fixed liquid layer attached to a particle.

Table 5. BET Surface Area and Mercury Porosimetry Data Summary.

Aggregate	BET Surface Area m^2/g	Rootare-Prenzlow Surface Area m^2/g	Total Pore Volume cm^2/g
RA	0.19	0.04	0.01
RB	1.62	0.31	0.05
RC	2.90	0.84	0.12
RD	0.72	0.14	0.03
RE	0.95	0.08	0.01
RF	1.66	0.25	0.02
RG	1.99	0.33	0.07
RH	2.74	0.53	0.11
RJ	1.32	0.05	0.01
RK	15.73	2.37	0.04
RL	2.41	0.15	0.01

Aggregate	% Pore Vol. >3000 Å	% Pore Vol. 500-3000 Å	% Pore Vol. <500 Å
RA	31	69	0
RB	23	74	4
RC	8	88	4
RD	4	95	1
RE	23	73	3
RF	9	83	9
RG	25	72	3
RH	12	86	2
RJ	26	72	2
RK	20	72	8
RL	8	83	9

Table 6. Acid Insolubles, Water Soluble and pH for SHRP Aggregates

Aggregate	Acid Insoluble Wt %	Water Soluble WT %	pH
RA	94.6	11.7	9.5
RB	87.9	8.1	9.6
RC	7.9	4.0	9.7
RD	23.5	5.1	9.8
RE	96.1	6.6	9.3
RF	28.2	5.0	10.0
RG	55.7	5.0	9.9
RH	92.1	9.7	8.6
RJ	96.2	6.3	9.6
RK	90.1	9.1	7.4
RL	85.3	9.3	9.8

Table 7. Zeta Potential Measurements of the SHRP Aggregates.

Aggregate	pH	Zeta Potential	s.d.[1]
RA	7.71	-28.1	1.8
RB	9.12	-17.1	2.0
RC	9.82	- 6.12	1.3
RD	9.87	-13.6	2.2
RE	8.08	-24.2	1.7
RF	9.51	- 5.79	1.0
RG	9.76	- 9.40	1.4
RH	7.62	-20.5	0.7
RJ	9.45	-27.5	2.5
RK	7.62	-23.4	2.2
RL	9.66	-22.3	1.3

[1]Standard Deviation of 10 counts.

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Blend Fractions and Grain Size Distribution of SHRP Aggregates

RA LITHONIA GRANITE (STRIPPER):
VULCAN MATERIALS

		PERCENT BLEND					TOTAL	
		38	28	26	8		100	
SIEVE INCH	SIEVE MM	A 7B	B 89D	C 810C	D PD. SCR.	E	PERCENT BLEND	TARGET BLEND
3/4	19.05	100.00	100.00	100.00	100.00		100.00	100
1/2	12.70	76.00	100.00	100.00	100.00		90.88	83.3
3/8	9.65	31.20	98.30	100.00	100.00		73.38	73.6
# 4	4.75	1.40	18.50	89.40	100.00		36.96	53.5
# 8	2.38	0.60	0.80	74.40	99.80		27.78	39.2
# 16	1.19	0.60	0.50	62.60	99.10		24.57	28.7
# 30	0.60	0.60	0.40	47.50	97.90		20.52	21.0
# 50	0.30	0.50	0.30	30.60	94.20		15.77	15.4
# 100	0.15	0.40	0.20	16.30	63.10		9.49	11.3
# 200	0.08	0.30	0.10	8.60	20.80		4.04	8.3

SIEVE INCH	SIEVE MM	A	B	C	D	E	PERCENT	TARGET
3/4	19.05	38.00	28.00	26.00	8.00		100.00	100
1/2	12.70	28.88	28.00	26.00	8.00		90.88	83.3
3/8	9.65	11.86	27.52	26.00	8.00		73.38	73.6
# 4	4.75	0.53	5.18	23.24	8.00		36.96	53.5
# 8	2.38	0.23	0.22	19.34	7.98		27.78	39.2
# 16	1.19	0.23	0.14	16.28	7.93		24.57	28.7
# 30	0.60	0.23	0.11	12.35	7.83		20.52	21.0
# 50	0.30	0.19	0.08	7.96	7.54		15.77	15.4
# 100	0.15	0.15	0.06	4.24	5.05		9.49	11.3
# 200	0.08	0.11	0.03	2.24	1.66		4.04	8.3

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RB WATSONVILLE GRANITE (NON-STRIPPER); GRANITE ROCK CO.

SIEVE INCH	SIEVE MM	A 1/2-#4	B #8-1/4	C CR. FINE	D	E	PERCENT BLEND	TARGET BLEND
PERCENT BLEND		37	23	40			TOTAL 100	
3/4	19.05	100.00	100.00	100.00			100.00	100
1/2	12.70	95.40	100.00	100.00			98.30	83.3
3/8	9.65	56.90	100.00	100.00			84.05	73.6
# 4	4.75	2.00	54.90	100.00			53.37	53.5
# 8	2.38	1.60	3.70	89.90			37.40	39.2
# 16	1.19	1.50	1.70	68.30			28.27	28.7
# 30	0.60	1.40	1.50	51.30			21.38	21.0
# 50	0.30	1.30	1.40	38.00			16.00	15.4
# 100	0.15	1.10	1.30	26.00			11.11	11.3
# 200	0.08	0.90	1.10	17.00			7.39	8.3

SIEVE INCH	SIEVE MM	A	B	C	D	E	PERCENT	TARGET
3/4	19.05	37.00	23.00	40.00			100.00	100
1/2	12.70	35.30	23.00	40.00			98.30	83.3
3/8	9.65	21.05	23.00	40.00			84.05	73.6
# 4	4.75	0.74	12.63	40.00			53.37	53.5
# 8	2.38	0.59	0.85	35.96			37.40	39.2
# 16	1.19	0.56	0.39	27.32			28.27	28.7
# 30	0.60	0.52	0.35	20.52			21.38	21.0
# 50	0.30	0.48	0.32	15.20			16.00	15.4
# 100	0.15	0.41	0.30	10.40			11.11	11.3
# 200	0.08	0.33	0.25	6.80			7.39	8.3

RC LIMESTONE (HIGH ABSORPTION);
McADAMS LIMESTONE PRODUCTS

		PERCENT BLEND					TOTAL	
		33	49	18			100	
SIEVE INCH	SIEVE MM	A 3/4-#8	B 1/2-#8	C -#8	D	E	PERCENT BLEND	TARGET BLEND
3/4	19.05	100.00	100.00	100.00			100.00	100
1/2	12.70	61.90	100.00	100.00			87.43	83.3
3/8	9.65	22.60	94.80	100.00			71.91	73.6
# 4	4.75	6.10	43.00	100.00			41.08	53.5
# 8	2.38	4.20	15.30	94.80			25.95	39.2
# 16	1.19	3.80	10.50	75.50			19.99	28.7
# 30	0.60	3.60	9.10	58.60			16.20	21.0
# 50	0.30	3.40	8.40	46.10			13.54	15.4
# 100	0.15	3.20	7.90	37.20			11.62	11.3
# 200	0.08	3.00	7.40	31.90			10.36	8.3

SIEVE INCH	SIEVE MM	A	B	C	D	E	PERCENT	TARGET
3/4	19.05	33.00	49.00	18.00			100.00	100
1/2	12.70	20.43	49.00	18.00			87.43	83.3
3/8	9.65	7.46	46.45	18.00			71.91	73.6
# 4	4.75	2.01	21.07	18.00			41.08	53.5
# 8	2.38	1.39	7.50	17.06			25.95	39.2
# 16	1.19	1.25	5.15	13.59			19.99	28.7
# 30	0.60	1.19	4.46	10.55			16.20	21.0
# 50	0.30	1.12	4.12	8.30			13.54	15.4
# 100	0.15	1.06	3.87	6.70			11.62	11.3
# 200	0.08	0.99	3.63	5.74			10.36	8.3

RD LIMESTONE (LOW ABSORPTION);
GENSTAR STONE PRODUCTS.

SIEVE INCH	SIEVE MM	A	B	C	D	E	PERCENT BLEND	TARGET BLEND
PERCENT BLEND		20	10	20	25	25	TOTAL 100	
		#1	1/2-#8	BIRDSEYE	#10 SCRA	#12 DUST		
3/4	19.05	100.00	100.00	100.00	100.00	100.00	100.00	100
1/2	12.70	88.80	100.00	100.00	100.00	100.00	97.76	83.3
3/8	9.65	48.90	92.90	99.90	100.00	100.00	89.05	73.6
# 4	4.75	6.30	17.10	64.00	94.40	100.00	64.37	53.5
# 8	2.38	1.90	4.30	19.90	64.10	98.00	45.32	39.2
# 16	1.19	1.30	2.00	5.70	40.90	71.30	29.65	28.7
# 30	0.60	1.20	1.40	3.30	26.50	48.50	19.79	21.0
# 50	0.30	1.10	1.20	2.60	18.20	35.20	14.21	15.4
# 100	0.15	1.00	1.10	2.30	13.40	27.00	10.87	11.3
# 200	0.08	0.90	1.00	2.10	10.90	22.30	9.00	8.3

SIEVE INCH	SIEVE MM	A	B	C	D	E	PERCENT	TARGET
3/4	19.05	20.00	10.00	20.00	25.00	25.00	100.00	100
1/2	12.70	17.76	10.00	20.00	25.00	25.00	97.76	83.3
3/8	9.65	9.78	9.29	19.98	25.00	25.00	89.05	73.6
# 4	4.75	1.26	1.71	12.80	23.60	25.00	64.37	53.5
# 8	2.38	0.38	0.43	3.98	16.03	24.50	45.32	39.2
# 16	1.19	0.26	0.20	1.14	10.23	17.83	29.65	28.7
# 30	0.60	0.24	0.14	0.66	6.63	12.13	19.79	21.0
# 50	0.30	0.22	0.12	0.52	4.55	8.80	14.21	15.4
# 100	0.15	0.20	0.11	0.46	3.35	6.75	10.87	11.3
# 200	0.08	0.18	0.10	0.42	2.73	5.58	9.00	8.3

RE PIEDMONT GRAVEL;
GENSTAR STONE PRODUCTS

SIEVE INCH	SIEVE MM	A 5/8 GR.	B #7 CR.	C 1/4 GR.	D FLUME SD	E	PERCENT BLEND	TARGET BLEND
PERCENT BLEND		5	27	45	23		TOTAL 100	
3/4	19.05	100.00	100.00	100.00	100.00		100.00	100
1/2	12.70	88.40	99.50	100.00	100.00		99.29	83.3
3/8	9.65	51.70	87.70	99.40	99.90		93.97	73.6
# 4	4.75	6.40	23.00	49.50	99.60		51.71	53.5
# 8	2.38	1.10	13.40	6.80	97.50		29.16	39.2
# 16	1.19	0.60	9.90	2.20	90.80		24.58	28.7
# 30	0.60	0.40	7.80	1.50	80.80		21.39	21.0
# 50	0.30	0.30	6.20	1.10	63.60		16.81	15.4
# 100	0.15	0.20	4.60	0.80	40.00		10.81	11.3
# 200	0.08	0.20	3.10	0.60	14.70		4.50	8.3

SIEVE INCH	SIEVE MM	A	B	C	D	E	PERCENT	TARGET
3/4	19.05	5.00	27.00	45.00	23.00		100.00	100
1/2	12.70	4.42	26.87	45.00	23.00		99.29	83.3
3/8	9.65	2.59	23.68	44.73	22.98		93.97	73.6
# 4	4.75	0.32	6.21	22.28	22.91		51.71	53.5
# 8	2.38	0.06	3.62	3.06	22.43		29.16	39.2
# 16	1.19	0.03	2.67	0.99	20.88		24.58	28.7
# 30	0.60	0.02	2.11	0.68	18.58		21.39	21.0
# 50	0.30	0.02	1.67	0.50	14.63		16.81	15.4
# 100	0.15	0.01	1.24	0.36	9.20		10.81	11.3
# 200	0.08	0.01	0.84	0.27	3.38		4.50	8.3

RF GLACIAL GRAVEL;
VULCAN MATERIALS

		PERCENT BLEND					TOTAL	
		56	44				100	
SIEVE INCH	SIEVE MM	A CA 16	B FA 2	C	D	E	PERCENT BLEND	TARGET BLEND
3/4	19.05	100.00	100.00				100.00	100
1/2	12.70	100.00	100.00				100.00	83.3
3/8	9.65	96.40	100.00				97.98	73.6
# 4	4.75	14.90	99.70				52.21	53.5
# 8	2.38	3.90	83.70				39.01	39.2
# 16	1.19	3.20	61.30				28.76	28.7
# 30	0.60	2.90	36.90				17.86	21.0
# 50	0.30	2.70	10.40				6.09	15.4
# 100	0.15	2.50	1.70				2.15	11.3
# 200	0.08	2.10	1.00				1.62	8.3

SIEVE INCH	SIEVE MM	A	B	C	D	E	PERCENT	TARGET
3/4	19.05	56.00	44.00				100.00	100
1/2	12.70	56.00	44.00				100.00	83.3
3/8	9.65	53.98	44.00				97.98	73.6
# 4	4.75	8.34	43.87				52.21	53.5
# 8	2.38	2.18	36.83				39.01	39.2
# 16	1.19	1.79	26.97				28.76	28.7
# 30	0.60	1.62	16.24				17.86	21.0
# 50	0.30	1.51	4.58				6.09	15.4
# 100	0.15	1.40	0.75				2.15	11.3
# 200	0.08	1.18	0.44				1.62	8.3

RG SANDSTONE;
COMMERCIAL STONE

		PERCENT BLEND					TOTAL	
		6	44	50			100	
SIEVE INCH	SIEVE MM	A #8	B SAND	C -200	D	E	PERCENT BLEND	TARGET BLEND
3/4	19.05	100.00	100.00	100.00			100.00	100
1/2	12.70	76.00	100.00	100.00			98.56	83.3
3/8	9.65	31.20	98.30	100.00			95.12	73.6
# 4	4.75	1.40	18.50	89.40			52.92	53.5
# 8	2.38	0.60	0.80	74.40			37.59	39.2
# 16	1.19	0.60	0.50	62.60			31.56	28.7
# 30	0.60	0.60	0.40	47.50			23.96	21.0
# 50	0.30	0.50	0.30	30.60			15.46	15.4
# 100	0.15	0.40	0.20	16.30			8.26	11.3
# 200	0.08	0.30	0.10	8.60			4.36	8.3

SIEVE INCH	SIEVE MM	A	B	C	D	E	PERCENT	TARGET
3/4	19.05	6.00	44.00	50.00			100.00	100
1/2	12.70	4.56	44.00	50.00			98.56	83.3
3/8	9.65	1.87	43.25	50.00			95.12	73.6
# 4	4.75	0.08	8.14	44.70			52.92	53.5
# 8	2.38	0.04	0.35	37.20			37.59	39.2
# 16	1.19	0.04	0.22	31.30			31.56	28.7
# 30	0.60	0.04	0.18	23.75			23.96	21.0
# 50	0.30	0.03	0.13	15.30			15.46	15.4
# 100	0.15	0.02	0.09	8.15			8.26	11.3
# 200	0.08	0.02	0.04	4.30			4.36	8.3

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RH GREYWACKE;
KAISER SAND AND GRAVEL

		PERCENT BLEND					TOTAL	
		59	33	8			100	
SIEVE INCH	SIEVE MM	A 3/8	B SAND	C BG. FIN.	D	E	PERCENT BLEND	TARGET BLEND
3/4	19.05	100.00	100.00	100.00			100.00	100
1/2	12.70	100.00	100.00	100.00			100.00	83.3
3/8	9.65	96.40	100.00	100.00			97.88	73.6
# 4	4.75	5.50	100.00	100.00			44.25	53.5
# 8	2.38	0.70	94.50	100.00			39.60	39.2
# 16	1.19	0.50	69.40	100.00			31.20	28.7
# 30	0.60	0.50	40.10	100.00			21.53	21.0
# 50	0.30	0.50	21.40	99.90			15.35	15.4
# 100	0.15	0.50	7.60	98.70			10.70	11.3
# 200	0.08	0.50	1.70	94.30			8.40	8.3

SIEVE INCH	SIEVE MM	A	B	C	D	E	PERCENT	TARGET
3/4	19.05	59.00	33.00	8.00			100.00	100
1/2	12.70	59.00	33.00	8.00			100.00	83.3
3/8	9.65	56.88	33.00	8.00			97.88	73.6
# 4	4.75	3.25	33.00	8.00			44.25	53.5
# 8	2.38	0.41	31.19	8.00			39.60	39.2
# 16	1.19	0.30	22.90	8.00			31.20	28.7
# 30	0.60	0.30	13.23	8.00			21.53	21.0
# 50	0.30	0.30	7.06	7.99			15.35	15.4
# 100	0.15	0.30	2.51	7.90			10.70	11.3
# 200	0.08	0.30	0.56	7.54			8.40	8.3

RJ MOUNTAIN GRAVEL CONGLOMERATE;
TETON STONE COMPANY

		PERCENT BLEND					TOTAL	
		40	8	52			100	
SIEVE INCH	SIEVE MM	A 1/2 PM	B TYPE G	C - 4	D	E	PERCENT BLEND	TARGET BLEND
3/4	19.05	100.00	100.00	100.00			100.00	100
1/2	12.70	76.00	100.00	100.00			90.40	83.3
3/8	9.65	31.20	98.30	100.00			72.34	73.6
# 4	4.75	1.40	18.50	89.40			48.53	53.5
# 8	2.38	0.60	0.80	74.40			38.99	39.2
# 16	1.19	0.60	0.50	62.60			32.83	28.7
# 30	0.60	0.60	0.40	47.50			24.97	21.0
# 50	0.30	0.50	0.30	30.60			16.14	15.4
# 100	0.15	0.40	0.20	16.30			8.65	11.3
# 200	0.08	0.30	0.10	8.60			4.60	8.3

SIEVE INCH	SIEVE MM	A	B	C	D	E	PERCENT	TARGET
3/4	19.05	40.00	8.00	52.00			100.00	100
1/2	12.70	30.40	8.00	52.00			90.40	83.3
3/8	9.65	12.48	7.86	52.00			72.34	73.6
# 4	4.75	0.56	1.48	46.49			48.53	53.5
# 8	2.38	0.24	0.06	38.69			38.99	39.2
# 16	1.19	0.24	0.04	32.55			32.83	28.7
# 30	0.60	0.24	0.03	24.70			24.97	21.0
# 50	0.30	0.20	0.02	15.91			16.14	15.4
# 100	0.15	0.16	0.02	8.48			8.65	11.3
# 200	0.08	0.12	0.01	4.47			4.60	8.3

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RK BASALT;
BLUE MOUNTAIN ASPHALT COMPANY

		PERCENT BLEND					TOTAL	
		29	20	51			100	
SIEVE INCH	SIEVE MM	A 3/4-1/4	B 1/2-1/4	C 1/4	D	E	PERCENT BLEND	TARGET BLEND
3/4	19.05	100.00	100.00	100.00			100.00	100
1/2	12.70	46.40	100.00	100.00			84.46	83.3
3/8	9.65	9.70	98.30	100.00			73.47	73.6
# 4	4.75	0.90	18.50	89.40			49.56	53.5
# 8	2.38	0.60	0.80	74.40			38.28	39.2
# 16	1.19	0.60	0.50	62.60			32.20	28.7
# 30	0.60	0.60	0.40	47.50			24.48	21.0
# 50	0.30	0.50	0.30	30.60			15.81	15.4
# 100	0.15	0.40	0.20	16.30			8.47	11.3
# 200	0.08	0.30	0.10	8.60			4.49	8.3

SIEVE INCH	SIEVE MM	A	B	C	D	E	PERCENT	TARGET
3/4	19.05	29.00	20.00	51.00			100.00	100
1/2	12.70	13.46	20.00	51.00			84.46	83.3
3/8	9.65	2.81	19.66	51.00			73.47	73.6
# 4	4.75	0.26	3.70	45.59			49.56	53.5
# 8	2.38	0.17	0.16	37.94			38.28	39.2
# 16	1.19	0.17	0.10	31.93			32.20	28.7
# 30	0.60	0.17	0.08	24.23			24.48	21.0
# 50	0.30	0.15	0.06	15.61			15.81	15.4
# 100	0.15	0.12	0.04	8.31			8.47	11.3
# 200	0.08	0.09	0.02	4.39			4.49	8.3

RL GULF STATES CHERT;
FORDYCE INCORP.

		PERCENT BLEND					TOTAL	
		24	41	35			100	
SIEVE INCH	SIEVE MM	A #4	B #6	C #8-200	D	E	PERCENT BLEND	TARGET BLEND
3/4	19.05	100.00	100.00	100.00			100.00	100
1/2	12.70	100.00	100.00	100.00			100.00	83.3
3/8	9.65	87.00	100.00	100.00			96.88	73.6
# 4	4.75	63.20	76.10	100.00			81.37	53.5
# 8	2.38	27.60	8.20	93.00			42.54	39.2
# 16	1.19	18.00	0.30	68.60			28.45	28.7
# 30	0.60	14.20	0.00	52.80			21.89	21.0
# 50	0.30	11.60	0.00	28.10			12.62	15.4
# 100	0.15	7.10	0.00	3.80			3.03	11.3
# 200	0.08	4.60	0.00	0.00			1.10	8.3

SIEVE INCH	SIEVE MM	A	B	C	D	E	PERCENT	TARGET
3/4	19.05	24.00	41.00	35.00			100.00	100
1/2	12.70	24.00	41.00	35.00			100.00	83.3
3/8	9.65	20.88	41.00	35.00			96.88	73.6
# 4	4.75	15.17	31.20	35.00			81.37	53.5
# 8	2.38	6.62	3.36	32.55			42.54	39.2
# 16	1.19	4.32	0.12	24.01			28.45	28.7
# 30	0.60	3.41	0.00	18.48			21.89	21.0
# 50	0.30	2.78	0.00	9.84			12.62	15.4
# 100	0.15	1.70	0.00	1.33			3.03	11.3
# 200	0.08	1.10	0.00	0.00			1.10	8.3

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Appendix B

List of Mercury Porosity Data for Aggregates

Units and Terms used in Appendix B

Ds(r)	first derivative of surface area as a function of radius.
Dv(r)	first derivative of volume as a function of radius.
dV/dP	change in volume with pressure
Radius (r)	units of angstroms
Surface Area	units of m^3/g
Volume	units of cm^3/g
Pressure	units of PSIA

Aggregate A

PORE INTRUSION DATA									
PRESSURE	PORE Radius	INTRUSION VOLUME	DELTA Hg VOLUME	% VOLUME	dV/dP	Dv(r)	Ds(r)	CUMULATIVE SURF. AREA	PORE NUM. FRACTION
25	42664.4	0.001	0.0000	6.88	2.29E-04	1.34E-07	6.29E-08	0.000	0.00E+00
64	16665.8	0.0083	0.0073	57.34	7.62E-05	2.79E-07	3.27E-07	0.005	9.67E-04
114	9356.2	0.0104	0.0021	72.02	2.94E-05	3.45E-07	7.25E-07	0.009	1.60E-03
169	6311.3	0.0115	0.0011	79.36	1.59E-05	4.06E-07	1.26E-06	0.011	3.75E-03
244	4371.4	0.0124	0.0009	85.78	9.61E-06	5.17E-07	2.32E-06	0.015	5.37E-03
339	3146.3	0.0130	0.0006	89.91	5.99E-06	6.24E-07	3.90E-06	0.018	7.93E-03
443	2407.7	0.0135	0.0005	93.35	3.07E-06	5.52E-07	4.54E-06	0.022	6.38E-03
555	1921.8	0.0138	0.0003	95.41	1.71E-06	4.83E-07	4.98E-06	0.025	6.14E-03
672	1587.2	0.0140	0.0002	96.79	1.61E-06	6.72E-07	8.40E-06	0.027	8.54E-03
796	1340.0	0.0140	0.0001	97.25	6.62E-07	3.87E-07	5.73E-06	0.028	5.81E-03
919	1160.6	0.0142	0.0001	98.17	5.09E-07	3.98E-07	6.80E-06	0.030	5.97E-03
1046	1019.7	0.0142	0.0001	98.62	1.06E-06	1.08E-06	2.10E-05	0.031	1.62E-02
1174	908.5	0.0143	0.0000	98.85	5.52E-07	7.05E-07	1.54E-05	0.032	1.06E-02
1303	818.6	0.0143	0.0001	99.31	4.73E-07	7.45E-07	1.81E-05	0.033	1.12E-02
1433	744.3	0.0144	0.0000	99.54	0.00E+00	0.00E+00	0.00E+00	0.034	0.00E+00
1563	682.4	0.0144	0.0000	99.77	4.41E-07	1.00E-06	2.93E-05	0.035	1.39E-02
1699	627.8	0.0144	0.0000	99.77	0.00E+00	0.00E+00	0.00E+00	0.035	0.00E+00
1834	581.6	0.0144	0.0000	99.77	4.42E-07	1.38E-06	4.73E-05	0.035	2.24E-02
1973	540.6	0.0144	0.0000	100.00	0.00E+00	0.00E+00	0.00E+00	0.036	0.00E+00
>2136	NO ADDITIONAL INTRUSION								

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Aggregate A, Continued

INTERPOLATED INTRUSION DATA

Mean Pressure	Pore Radius	Percent Volume	Cumul. Volume Hg	Volume in Interval	dV/dP	dV/log r	Cumul. Surf Area
42.7	20000.0 - 30000.0	19.87	0.0074	2.87E-03	1.61E-04	6.52E-04	0.004
71.1	10000.0 - 20000.0	19.84	0.0102	2.86E-03	5.37E-05	6.86E-04	0.008
112.3	9000.0 - 10000.0	1.88	0.0105	2.72E-04	2.29E-05	6.84E-05	0.009
125.5	8000.0 - 9000.0	2.49	0.0108	3.59E-04	2.42E-05	9.14E-05	0.010
142.2	7000.0 - 8000.0	2.49	0.0112	3.60E-04	1.89E-05	9.29E-05	0.011
164.1	6000.0 - 7000.0	2.70	0.0116	3.89E-04	1.53E-05	1.02E-04	0.012
193.9	5000.0 - 6000.0	3.24	0.0121	4.68E-04	1.32E-05	1.25E-04	0.014
237.0	4000.0 - 5000.0	3.27	0.0125	4.72E-04	8.85E-06	1.29E-04	0.016
304.7	3000.0 - 4000.0	3.87	0.0131	5.59E-04	6.29E-06	1.58E-04	0.019
426.6	2000.0 - 3000.0	4.51	0.0137	6.51E-04	3.66E-06	1.92E-04	0.024
711.1	1000.0 - 2000.0	3.64	0.0143	5.26E-04	9.87E-07	1.66E-04	0.032
1122.7	900.0 - 1000.0	0.00	0.0143	0.00E+00	0.00E+00	0.00E+00	0.032
1254.8	800.0 - 900.0	0.46	0.0143	6.62E-05	4.47E-07	2.26E-05	0.033
1422.1	700.0 - 800.0	0.24	0.0144	3.47E-05	1.82E-07	1.21E-05	0.034
1640.9	600.0 - 700.0	0.22	0.0144	3.15E-05	1.24E-07	1.12E-05	0.035
1939.3	500.0 - 600.0	0.23	0.014	3.31E-05	9.31E-08	1.21E-05	0.036

DATA SUMMARY

PSIA	Å	Cumulative cc/g	Surface m²/g
10666	100.0	0.0144	0.036
1067	1000.0	0.0143	0.032
107	10000.0	0.0102	0.008

Pore volume in pores greater than 30000.0 Angstroms = 0.0045 cc/g
Pore volume between 500.0 and 30000.0 Angstroms = 0.0100 cc/g
Pore volume in pores less than 500.0 Angstroms = 0.0000 cc/g
Total pore volume intruded = 0.0144 cc/g

Aggregate B

PORE INTRUSION DATA

PRESSURE	PORE Radius	INTRUSION VOLUME	DELTA Hg VOLUME	% VOLUME	dV/dP	Dv(r)	Ds(r)	CUMULATIVE SURF. AREA	PORE NUM. FRACTION
26	41023.5	0.0015	0.0000	3.27	6.90E-04	4.37E-07	2.13E-07	0.000	0.00E+00
68	15685.5	0.0225	0.0210	48.32	2.49E-04	1.00E-06	1.23E-06	0.016	1.53E-04
114	9356.2	0.0286	0.0061	61.40	9.50E-05	1.12E-06	2.35E-06	0.026	1.37E-04
166	6425.4	0.0321	0.0035	68.88	5.37E-05	1.34E-06	4.09E-06	0.035	2.46E-04
238	4481.6	0.0349	0.0027	74.77	3.14E-05	1.61E-06	7.08E-06	0.046	3.95E-04
327	3261.8	0.0369	0.0021	79.25	2.09E-05	2.03E-06	1.23E-05	0.057	6.22E-04
429	2486.3	0.0386	0.0016	82.71	1.39E-05	2.34E-06	1.86E-05	0.068	7.89E-04
538	1982.5	0.0397	0.0012	85.23	8.48E-06	2.26E-06	2.26E-05	0.079	6.91E-04
650	1640.9	0.0406	0.0008	87.01	8.27E-06	3.22E-06	3.89E-05	0.088	1.08E-03
769	1387.0	0.0414	0.0008	88.69	5.04E-06	2.75E-06	3.93E-05	0.098	1.09E-03
888	1201.1	0.0419	0.0006	89.91	4.37E-06	3.19E-06	5.27E-05	0.107	1.17E-03
1010	1056.1	0.0425	0.0006	91.12	4.13E-06	3.91E-06	7.35E-05	0.117	1.44E-03
1136	938.9	0.0429	0.0004	92.06	2.79E-06	3.34E-06	7.08E-05	0.126	1.33E-03
1263	844.5	0.0433	0.0004	92.90	2.79E-06	4.14E-06	9.75E-05	0.135	1.52E-03
1392	766.2	0.0436	0.0003	93.55	2.68E-06	4.83E-06	1.25E-04	0.142	1.92E-03
1522	700.8	0.0439	0.0003	94.21	1.96E-06	4.22E-06	1.20E-04	0.150	1.81E-03
1652	645.6	0.0442	0.0003	94.86	1.92E-06	4.86E-06	1.50E-04	0.159	1.93E-03
1783	598.2	0.0444	0.0002	95.23	1.35E-06	3.99E-06	1.33E-04	0.165	1.59E-03
1917	556.4	0.0446	0.0002	95.70	1.29E-06	4.42E-06	1.58E-04	0.173	1.89E-03
2081	512.5	0.0448	0.0002	96.17	1.01E-06	4.06E-06	1.58E-04	0.181	1.74E-03
2299	463.9	0.0451	0.0002	96.64	1.29E-06	6.32E-06	2.71E-04	0.190	5.42E-03
2559	416.8	0.0453	0.0003	97.20	6.22E-07	3.78E-06	1.80E-04	0.201	3.24E-03
2838	375.8	0.0454	0.0001	97.48	9.35E-07	6.99E-06	3.70E-04	0.208	5.99E-03
3122	341.6	0.0456	0.0002	97.85	3.11E-07	2.82E-06	1.64E-04	0.218	2.59E-03
3404	313.3	0.0458	0.0002	98.22	6.02E-07	6.48E-06	4.12E-04	0.228	5.56E-03
3691	289.0	0.0460	0.0002	98.60	6.22E-07	7.89E-06	5.44E-04	0.240	6.76E-03
3982	267.9	0.0460	0.0000	98.69	0.00E+00	0.00E+00	0.00E+00	0.243	0.00E+00
4274	249.6	0.0461	0.0001	98.88	2.90E-07	4.94E-06	3.95E-04	0.250	4.24E-03
4564	233.7	0.0462	0.0001	99.07	0.00E+00	0.00E+00	0.00E+00	0.257	0.00E+00
4852	219.8	0.0463	0.0001	99.25	0.00E+00	0.00E+00	0.00E+00	0.264	0.00E+00
5155	206.9	0.0463	0.0000	99.35	2.07E-07	5.14E-06	4.95E-04	0.268	4.56E-03
5583	191.0	0.0464	0.0001	99.53	1.94E-07	5.61E-06	5.85E-04	0.277	7.73E-03
6023	177.1	0.0464	0.0000	99.63	0.00E+00	0.00E+00	0.00E+00	0.282	0.00E+00
6488	164.4	0.0465	0.0000	99.72	1.78E-07	6.97E-06	8.45E-04	0.287	1.00E-02
6959	153.3	0.0465	0.0000	99.81	1.82E-07	8.19E-06	1.06E-03	0.292	1.20E-02
7440	143.4	0.0466	0.0001	100.00	1.82E-07	9.36E-06	1.30E-03	0.304	1.32E-02
>7925 NO ADDITIONAL INTRUSION									

Aggregate B, Continued

INTERPOLATED INTRUSION DATA							
Mean Pressure	Pore Radius	Percent Volume	Cumul. Volume Hg	Volume in Interval	dV/dP	dV/log r	Cumul. Surf Area
42.7	20000.0 - 30000.0	16.70	0.0184	7.79E-03	4.38E-04	1.77E-03	0.011
71.1	10000.0 - 20000.0	20.59	0.0280	9.60E-03	1.80E-04	2.30E-03	0.025
112.3	9000.0 - 10000.0	2.36	0.0291	1.10E-03	9.28E-05	2.76E-04	0.027
125.5	8000.0 - 9000.0	2.43	0.0302	1.14E-03	7.66E-05	2.89E-04	0.030
142.2	7000.0 - 8000.0	2.44	0.0313	1.14E-03	5.96E-05	2.93E-04	0.033
164.1	6000.0 - 7000.0	2.87	0.0327	1.34E-03	5.27E-05	3.51E-04	0.037
193.9	5000.0 - 6000.0	2.91	0.0340	1.36E-03	3.82E-05	3.63E-04	0.042
237.0	4000.0 - 5000.0	3.42	0.0356	1.59E-03	2.99E-05	4.36E-04	0.049
304.7	3000.0 - 4000.0	3.98	0.0375	1.85E-03	2.09E-05	5.23E-04	0.060
426.6	2000.0 - 3000.0	4.79	0.0397	2.23E-03	1.26E-05	6.57E-04	0.078
711.1	1000.0 - 2000.0	6.39	0.0427	2.98E-03	5.59E-06	9.38E-04	0.121
1122.7	900.0 - 1000.0	0.88	0.0431	4.09E-04	3.45E-06	1.37E-04	0.129
1254.8	800.0 - 900.0	0.90	0.0435	4.20E-04	2.83E-06	1.43E-04	0.139
1422.1	700.0 - 800.0	0.90	0.0439	4.21E-04	2.21E-06	1.46E-04	0.151
1640.9	600.0 - 700.0	1.02	0.0444	4.74E-04	1.86E-06	1.68E-04	0.165
1939.3	500.0 - 600.0	1.11	0.0449	5.17E-04	1.46E-06	1.89E-04	0.184

INTRUSION DATA			
PSIA	Å	Cumulative cc/g	Surface m²/g
10666	100.0	0.0466	0.304
1067	1000.0	0.0427	0.121
107	10000.0	0.0280	0.025

Pore volume in pores greater than 30000.0 Angstroms = 0.0106 cc/g
Pore volume between 500.0 and 30000.0 Angstroms = 0.0344 cc/g
Pore volume in pores less than 500.0 Angstroms = 0.0017 cc/g
Total pore volume intruded = 0.0466 cc/g

Aggregate C

PORE INTRUSION DATA									
PRESSURE	PORE Radius	INTRUSION VOLUME	DELTA Hg VOLUME	% VOLUME	dV/dP	Dv(r)	Ds(r)	CUMULATIVE SURF. AREA	PORE NUM. FRACTION
26	41023.5	0.0014	0.0000	1.12	5.32E-04	3.37E-07	1.64E-07	0.000	0.00E+00
66	16160.8	0.0388	0.0374	31.57	7.92E-04	2.99E-06	3.56E-06	0.032	1.81E-04
110	9696.5	0.0631	0.0243	51.37	4.64E-04	5.03E-06	1.01E-05	0.071	3.05E-04
161	6624.9	0.0781	0.0149	63.53	2.04E-04	4.75E-06	1.40E-05	0.108	4.03E-04
208	5127.9	0.0855	0.0075	69.59	1.26E-04	4.99E-06	1.92E-05	0.134	3.03E-04
270	3950.4	0.0917	0.0062	74.60	8.16E-05	5.45E-06	2.73E-05	0.161	3.97E-04
350	3047.5	0.0967	0.0050	78.64	5.57E-05	6.21E-06	4.02E-05	0.190	7.54E-04
436	2446.4	0.1005	0.0038	81.75	3.77E-05	6.60E-06	5.35E-05	0.218	6.41E-04
533	2001.1	0.1036	0.0031	84.27	2.69E-05	7.04E-06	6.97E-05	0.246	8.54E-04
637	1674.4	0.1060	0.0024	86.26	2.36E-05	8.79E-06	1.04E-04	0.272	1.28E-03
744	1433.6	0.1081	0.0020	87.91	1.75E-05	8.93E-06	1.24E-04	0.299	1.19E-03
855	1247.5	0.1098	0.0017	89.32	1.48E-05	1.00E-05	1.59E-04	0.325	1.33E-03
972	1097.3	0.1113	0.0015	90.51	1.20E-05	1.05E-05	1.91E-04	0.350	1.53E-03
1093	975.9	0.1126	0.0013	91.59	9.76E-06	1.08E-05	2.20E-04	0.375	1.57E-03
1212	880.0	0.1136	0.0010	92.42	7.35E-06	1.00E-05	2.27E-04	0.397	1.46E-03
1335	799.0	0.1145	0.0009	93.18	5.88E-06	9.72E-06	2.42E-04	0.420	1.53E-03
1460	730.6	0.1154	0.0008	93.87	6.42E-06	1.27E-05	3.47E-04	0.442	2.01E-03
1586	672.5	0.1161	0.0007	94.44	5.63E-06	1.32E-05	3.90E-04	0.462	2.08E-03
1714	622.3	0.1168	0.0007	94.99	5.57E-06	1.52E-05	4.88E-04	0.483	2.40E-03
1845	578.1	0.1173	0.0006	95.45	4.75E-06	1.50E-05	5.19E-04	0.502	2.56E-03
1977	539.5	0.1179	0.0006	95.92	3.59E-06	1.31E-05	4.83E-04	0.522	2.22E-03
2177	489.9	0.1186	0.0007	96.46	3.30E-06	1.45E-05	5.87E-04	0.548	4.74E-03
2445	436.2	0.1193	0.0008	97.08	2.64E-06	1.46E-05	6.68E-04	0.581	4.62E-03
2722	391.8	0.1200	0.0006	97.58	1.60E-06	1.10E-05	5.57E-04	0.611	4.00E-03
3000	355.5	0.1204	0.0005	97.98	1.58E-06	1.33E-05	7.42E-04	0.637	4.34E-03
3283	324.9	0.1208	0.0004	98.30	1.57E-06	1.58E-05	9.66E-04	0.661	5.35E-03
3568	298.9	0.1212	0.0004	98.59	1.23E-06	1.46E-05	9.74E-04	0.684	4.97E-03
3858	276.5	0.1215	0.0003	98.85	1.22E-06	1.70E-05	1.22E-03	0.705	5.97E-03
4147	257.2	0.1218	0.0003	99.06	6.01E-07	9.63E-06	7.46E-04	0.725	3.39E-03
4437	240.4	0.1219	0.0001	99.17	6.12E-07	1.12E-05	9.30E-04	0.735	3.95E-03
4731	225.5	0.1222	0.0003	99.39	9.08E-07	1.89E-05	1.68E-03	0.758	6.44E-03
5028	212.1	0.1223	0.0001	99.49	6.01E-07	1.42E-05	1.33E-03	0.770	5.16E-03
5336	199.9	0.1224	0.0001	99.60	3.06E-07	8.10E-06	8.07E-04	0.783	4.42E-03
5762	185.1	0.1226	0.0001	99.71	1.97E-07	6.09E-06	6.55E-04	0.797	3.32E-03
6222	171.4	0.1227	0.0001	99.78	1.93E-07	6.95E-06	8.07E-04	0.807	3.88E-03
6691	159.4	0.1227	0.0001	99.86	0.00E+00	0.00E+00	0.00E+00	0.818	0.00E+00
7169	148.8	0.1228	0.0001	99.93	1.89E-07	9.03E-06	1.21E-03	0.829	5.15E-03
7651	139.4	0.1229	0.0000	99.96	1.81E-07	9.87E-06	1.41E-03	0.836	5.87E-03
8148	130.9	0.1229	0.0000	99.96	0.00E+00	0.00E+00	0.00E+00	0.836	0.00E+00
8646	123.4	0.1229	0.0000	100.00	0.00E+00	0.00E+00	0.00E+00	0.843	0.00E+00
>9158 NO ADDITIONAL INTRUSION									

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Aggregate C, Continued

INTERPOLATED INTRUSION DATA

Mean Pressure	Pore Radius	Percent Volume	Cumul. Volume Hg	Volume in Interval	dV/dP	dV/log r	Cumul. Surf Area
42.7	20000.0 - 30000.0	14.99	0.0283	1.84E-02	1.04E-03	4.19E-03	0.020
71.1	10000.0 - 20000.0	27.37	0.0619	3.36E-02	6.31E-04	8.06E-03	0.069
112.3	9000.0 - 10000.0	3.80	0.0666	4.67E-03	3.94E-04	1.17E-03	0.079
125.5	8000.0 - 9000.0	3.72	0.0712	4.57E-03	3.09E-04	1.16E-03	0.089
142.2	7000.0 - 8000.0	4.04	0.0761	4.97E-03	2.61E-04	1.28E-03	0.103
164.1	6000.0 - 7000.0	4.11	0.0812	5.05E-03	1.99E-04	1.32E-03	0.118
193.9	5000.0 - 6000.0	4.10	0.0862	5.04E-03	1.42E-04	1.35E-03	0.137
237.0	4000.0 - 5000.0	4.19	0.0914	5.15E-03	9.65E-05	1.41E-03	0.160
304.7	3000.0 - 4000.0	4.59	0.0970	5.64E-03	6.34E-05	1.59E-03	0.192
426.6	2000.0 - 3000.0	5.35	0.1036	6.58E-03	3.70E-05	1.94E-03	0.246
711.1	1000.0 - 2000.0	7.12	0.1124	8.75E-03	1.64E-05	2.75E-03	0.370
1122.7	900.0 - 1000.0	0.89	0.1134	1.09E-03	9.18E-06	3.65E-04	0.393
1254.8	800.0 - 900.0	0.89	0.1145	1.10E-03	7.39E-06	3.74E-04	0.419
1422.1	700.0 - 800.0	0.99	0.1158	1.22E-03	6.41E-06	4.25E-04	0.452
1640.9	600.0 - 700.0	1.04	0.1170	1.27E-03	5.01E-06	4.53E-04	0.491
1939.3	500.0 - 600.0	1.11	0.1184	1.36E-03	3.83E-06	4.97E-04	0.541

DATA SUMMARY

PSIA	Å	Cumulative cc/g	Surface m²/g
10666	100.0	0.1229	0.843
1067	1000.0	0.1124	0.370
107	10000.0	0.0619	0.069

Pore volume in pores greater than 30000.0 Angstroms	=	0.0099 cc/g
Pore volume between 500.0 and 30000.0 Angstroms	=	0.1085 cc/g
Pore volume in pores less than 500.0 Angstroms	=	0.0045 cc/g
Total pore volume intruded	=	0.1229 cc/g

Aggregate D

PORE INTRUSION DATA

PRESSURE	PORE Radius	INTRUSION VOLUME Hg	DELTA VOLUME	% VOLUME	dV/dP	Dv(r)	Ds(r)	CUMULATIVE SURF. AREA	PORE NUM. FRACTION
26	41023.5	0.0000	0.0000	0.12	8.21E-05	5.20E-08	2.54E-08	0.000	0.00E+00
68	15685.5	0.0080	0.0079	25.22	2.16E-04	8.71E-07	1.07E-06	0.007	7.67E-04
117	9116.3	0.0153	0.0073	48.45	1.16E-04	1.44E-06	3.10E-06	0.020	1.01E-03
164	6503.7	0.0195	0.0042	61.68	7.56E-05	1.84E-06	5.54E-06	0.031	1.94E-03
228	4678.1	0.0231	0.0036	73.05	4.21E-05	1.99E-06	8.37E-06	0.044	2.45E-03
311	3429.6	0.0257	0.0026	81.33	2.40E-05	2.12E-06	1.22E-05	0.057	2.99E-03
410	2601.5	0.0275	0.0018	86.90	1.34E-05	2.06E-06	1.56E-05	0.068	3.99E-03
522	2043.3	0.0286	0.0011	90.36	9.54E-06	2.38E-06	2.30E-05	0.078	5.04E-03
636	1677.1	0.0293	0.0007	92.58	4.58E-06	1.71E-06	2.02E-05	0.086	3.31E-03
755	1412.7	0.0297	0.0004	93.94	3.88E-06	2.04E-06	2.86E-05	0.091	4.67E-03
877	1216.2	0.0301	0.0004	95.18	3.26E-06	2.31E-06	3.78E-05	0.097	5.30E-03
1000	1066.6	0.0304	0.0003	96.17	3.16E-06	2.92E-06	5.44E-05	0.103	6.70E-03
1127	946.4	0.0306	0.0002	96.91	1.92E-06	2.26E-06	4.74E-05	0.107	5.57E-03
1256	849.2	0.0308	0.0001	97.28	1.25E-06	1.83E-06	4.30E-05	0.110	4.20E-03
1387	769.0	0.0309	0.0002	97.78	5.58E-07	9.97E-07	2.58E-05	0.114	2.29E-03
1518	702.6	0.0310	0.0001	98.02	6.01E-07	1.29E-06	3.65E-05	0.116	2.95E-03
1650	646.4	0.0311	0.0001	98.39	6.01E-07	1.52E-06	4.69E-05	0.119	3.49E-03
1785	597.5	0.0312	0.0001	98.64	6.01E-07	1.78E-06	5.94E-05	0.122	4.40E-03
1920	555.5	0.0313	0.0001	98.89	5.58E-07	1.92E-06	6.87E-05	0.125	4.73E-03
2083	512.1	0.0313	0.0000	99.01	5.58E-07	2.26E-06	8.78E-05	0.126	5.57E-03
2264	471.1	0.0314	0.0001	99.26	2.70E-07	1.28E-06	5.39E-05	0.129	6.54E-03
2527	422.1	0.0314	0.0000	99.38	0.00E+00	0.00E+00	0.00E+00	0.131	0.00E+00
2808	379.8	0.0315	0.0001	99.75	2.70E-07	1.97E-06	1.03E-04	0.137	1.01E-02
3094	344.7	0.0315	0.0000	99.75	2.61E-07	2.32E-06	1.34E-04	0.137	1.18E-02
3384	315.2	0.0316	0.0000	99.88	2.79E-07	2.97E-06	1.88E-04	0.139	1.57E-02
3675	290.2	0.0316	0.0000	100.00	0.00E+00	0.00E+00	0.00E+00	0.142	0.00E+00
>3967	NO ADDITIONAL INTRUSION								

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Aggregate D, Continued

INTERPOLATED INTRUSION DATA							
Mean Pressure	Pore Radius	Percent Volume	Cumul. Volume Hg	Volume in Interval	dV/dP	dV/log r	Cumul. Surf Area
42.7	20000.0 - 30000.0	10.7	0.0047	3.41E-03	1.92E-04	7.75E-04	0.004
71.1	10000.0 - 20000.0	29.81	0.0141	9.42E-03	1.77E-04	2.26E-03	0.017
112.3	9000.0 - 10000.0	4.34	0.0155	1.37E-03	1.16E-04	3.45E-04	0.020
125.5	8000.0 - 9000.0	4.62	0.0169	1.46E-03	9.85E-05	3.72E-04	0.023
142.2	7000.0 - 8000.0	5.33	0.0186	1.68E-03	8.84E-05	4.35E-04	0.028
164.1	6000.0 - 7000.0	5.73	0.0204	1.81E-03	7.13E-05	4.75E-04	0.034
193.9	5000.0 - 6000.0	6.33	0.0224	2.00E-03	5.62E-05	5.35E-04	0.041
237.0	4000.0 - 5000.0	6.31	0.0244	1.99E-03	3.74E-05	5.46E-04	0.050
304.7	3000.0 - 4000.0	6.83	0.0266	2.16E-03	2.43E-05	6.10E-04	0.062
426.6	2000.0 - 3000.0	6.66	0.0287	2.10E-03	1.18E-05	6.19E-04	0.079
711.1	1000.0 - 2000.0	5.77	0.0305	1.82E-03	3.42E-06	5.75E-04	0.105
1122.7	900.0 - 1000.0	0.49	0.0307	1.56E-04	1.32E-06	5.25E-05	0.108
1254.8	800.0 - 900.0	0.61	0.0309	1.93E-04	1.30E-06	6.59E-05	0.113
1422.1	700.0 - 800.0	0.38	0.0310	1.19E-04	6.27E-07	4.15E-05	0.116
1640.9	600.0 - 700.0	0.62	0.0312	1.95E-04	7.69E-07	6.95E-05	0.122
1939.3	500.0 - 600.0	0.45	0.0313	1.41E-04	3.97E-07	5.15E-05	0.127

DATA SUMMARY			
PSIA	Å	Cumulative cc/g	Surface m²/g
10666	100.0	0.0316	0.142
1067	1000.0	0.0305	0.105
107	10000.0	0.0141	0.017

Pore volume in pores greater than 30000.0 Angstroms =	0.0013 cc/g
Pore volume between 500.0 and 30000.0 Angstroms =	0.0301 cc/g
Pore volume in pores less than 500.0 Angstroms =	0.0003 cc/g
Total pore volume intruded =	0.0316 cc/g

Aggregate E

PORE INTRUSION DATA									
PRESSURE	PORE Radius	INTRUSION VOLUME	DELTA Hg VOLUME	% VOLUME	dV/dP	Dv(r)	Ds(r)	CUMULATIVE SURF AREA	PORE NUM. FRACTION
26	41023.5	0.0005	0.0000	3.94	1.84E-04	1.17E-07	5.70E-08	0.000	0.00E+00
67	15919.6	0.0068	0.0063	51.18	6.75E-05	2.63E-07	3.19E-07	0.005	2.15E-04
114	9356.2	0.0084	0.0015	62.73	2.18E-05	2.56E-07	5.38E-07	0.007	1.67E-04
167	6386.9	0.0092	0.0008	68.77	1.22E-05	3.05E-07	9.35E-07	0.009	3.49E-04
239	4462.8	0.0099	0.0007	74.02	8.80E-06	4.58E-07	2.02E-06	0.012	5.24E-04
327	3261.8	0.0105	0.0006	78.22	5.82E-06	5.68E-07	3.43E-06	0.015	8.36E-04
428	2492.1	0.0109	0.0005	81.63	4.04E-06	6.75E-07	5.35E-06	0.018	1.22E-03
535	1993.7	0.0113	0.0004	84.51	2.96E-06	7.80E-07	7.75E-06	0.022	1.28E-03
648	1646.0	0.0116	0.0002	86.35	5.85E-07	2.27E-07	2.73E-06	0.024	3.71E-04
768	1388.8	0.0117	0.0002	87.66	1.22E-06	6.66E-07	9.52E-06	0.027	1.31E-03
887	1202.5	0.0120	0.0002	89.50	1.83E-06	1.33E-06	2.20E-05	0.031	2.61E-03
1010	1056.1	0.0122	0.0002	91.08	1.67E-06	1.57E-06	2.96E-05	0.034	3.34E-03
1135	939.7	0.0123	0.0001	91.86	6.38E-07	7.62E-07	1.61E-05	0.036	1.74E-03
1261	845.8	0.0125	0.0002	93.18	1.08E-06	1.59E-06	3.75E-05	0.040	3.39E-03
1391	766.8	0.0126	0.0001	93.96	5.40E-07	9.70E-07	2.52E-05	0.043	2.22E-03
1522	700.8	0.0126	0.0001	94.49	0.00E+00	0.00E+00	0.00E+00	0.045	0.00E+00
1653	645.3	0.0127	0.0001	95.01	5.40E-07	1.37E-06	4.24E-05	0.047	2.70E-03
1786	597.2	0.0128	0.0001	95.54	5.02E-07	1.49E-06	4.97E-05	0.049	3.17E-03
1921	555.2	0.0129	0.0001	96.59	5.02E-07	1.72E-06	6.18E-05	0.054	3.95E-03
2058	518.3	0.0130	0.0000	96.85	0.00E+00	0.00E+00	0.00E+00	0.055	0.00E+00
2235	477.2	0.0130	0.0001	97.38	2.60E-07	1.20E-06	5.01E-05	0.058	5.32E-03
2499	426.8	0.0131	0.0001	97.90	2.51E-07	1.45E-06	6.77E-05	0.061	6.65E-03
2779	383.8	0.0131	0.0000	98.16	2.51E-07	1.80E-06	9.32E-05	0.063	8.23E-03
3062	348.3	0.0132	0.0001	98.69	0.00E+00	0.00E+00	0.00E+00	0.067	0.00E+00
3350	318.4	0.0133	0.0001	99.21	2.42E-07	2.53E-06	1.58E-04	0.071	1.20E-02
3640	293.0	0.0133	0.0000	99.48	2.51E-07	3.09E-06	2.10E-04	0.073	1.47E-02
3933	271.2	0.0133	0.0000	99.48	2.51E-07	3.61E-06	2.65E-04	0.073	1.83E-02
4227	252.3	0.0134	0.0001	100.00	2.34E-07	3.89E-06	3.08E-04	0.079	1.91E-02
>4522 NO ADDITIONAL INTRUSION									

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Aggregate E, Continued

INTERPOLATED INTRUSION DATA							
Mean Pressure	Pore Radius	Percent Volume	Cumul. Volume Hg	Volume in Interval	dV/dP	dV/log r	Cumul. Surf Area
42.7	20000.0 - 30000.0	19.69	0.0058	2.63E-03	1.48E-04	5.99E-04	0.004
71.1	10000.0 - 20000.0	18.29	0.0082	2.45E-03	4.59E-05	5.86E-04	0.007
112.3	9000.0 - 10000.0	1.83	0.0085	2.45E-04	2.07E-05	6.16E-05	0.008
125.5	8000.0 - 9000.0	2.04	0.0087	2.72E-04	1.84E-05	6.93E-05	0.008
142.2	7000.0 - 8000.0	2.02	0.0090	2.70E-04	1.42E-05	6.96E-05	0.009
164.1	6000.0 - 7000.0	2.23	0.0093	2.99E-04	1.18E-05	7.83E-05	0.010
193.9	5000.0 - 6000.0	2.64	0.0097	3.54E-04	9.95E-06	9.46E-05	0.011
237.0	4000.0 - 5000.0	3.38	0.0101	4.52E-04	8.48E-06	1.24E-04	0.013
304.7	3000.0 - 4000.0	3.85	0.0106	5.15E-04	5.80E-06	1.45E-04	0.016
426.6	2000.0 - 3000.0	4.97	0.0113	6.65E-04	3.74E-06	1.96E-04	0.022
711.1	1000.0 - 2000.0	7.13	0.0123	9.54E-04	1.79E-06	3.00E-04	0.036
1122.7	900.0 - 1000.0	0.77	0.0124	1.03E-04	8.69E-07	3.46E-05	0.038
1254.8	800.0 - 900.0	1.07	0.0125	1.43E-04	9.64E-07	4.88E-05	0.041
1422.1	700.0 - 800.0	1.05	0.0126	1.40E-04	7.37E-07	4.89E-05	0.045
1640.9	600.0 - 700.0	1.05	0.0128	1.40E-04	5.53E-07	4.99E-05	0.049
1939.3	500.0 - 600.0	1.57	0.0130	2.11E-04	5.93E-07	7.69E-05	0.057

DATA SUMMARY			
PSIA	Å	Cumulative cc/g	Surface m^2/g
10666	100.0	0.0134	0.079
1067	1000.0	0.0123	0.036
107	10000.0	0.0082	0.007

Pore volume in pores greater than 30000.0 Angstroms = 0.0031 cc/g
Pore volume between 500.0 and 30000.0 Angstroms = 0.0098 cc/g
Pore volume in pores less than 500.0 Angstroms = 0.0004 cc/g
Total pore volume intruded = 0.0134 cc/g

Aggregate F

PORE INTRUSION DATA

PRESSURE	PORE Radius	INTRUSION VOLUME	DELTA Hg VOLUME	% VOLUME	dV/dP	Dv(r)	Ds(r)	CUMULATIVE SURF. AREA	PORE NUM. FRACTION
25	42664.4	0.0001	0.0000	0.57	1.05E-04	6.15E-08	2.88E-08	0.000	0.00E+00
70	15237.3	0.0059	0.0058	28.54	7.60E-05	3.25E-07	4.11E-07	0.005	4.30E-05
120	8888.4	0.0086	0.0027	41.38	4.19E-05	5.42E-07	1.20E-06	0.010	7.19E-05
187	5703.8	0.0109	0.0023	52.30	2.89E-05	9.16E-07	3.16E-06	0.016	1.46E-04
272	3921.4	0.0126	0.0017	60.54	1.84E-05	1.24E-06	6.23E-06	0.023	2.63E-04
369	2890.5	0.0139	0.0014	67.05	1.20E-05	1.49E-06	1.02E-05	0.031	3.95E-04
478	2231.4	0.0149	0.0010	71.84	7.21E-06	1.51E-06	1.33E-05	0.039	4.79E-04
591	1804.8	0.0157	0.0008	75.48	5.82E-06	1.87E-06	2.05E-05	0.047	5.46E-04
707	1508.6	0.0163	0.0006	78.35	4.11E-06	1.89E-06	2.49E-05	0.054	6.02E-04
827	1289.7	0.0167	0.0004	80.27	3.24E-06	2.04E-06	3.14E-05	0.060	7.57E-04
949	1123.9	0.0171	0.0004	82.18	3.23E-06	2.69E-06	4.75E-05	0.066	9.27E-04
1071	995.9	0.0175	0.0004	83.91	1.95E-06	2.08E-06	4.15E-05	0.073	6.06E-04
1196	891.8	0.0178	0.0003	85.44	1.89E-06	2.51E-06	5.60E-05	0.080	7.99E-04
1325	805.0	0.0181	0.0003	86.78	1.23E-06	2.00E-06	4.94E-05	0.087	6.89E-04
1452	734.6	0.0183	0.0002	87.74	1.23E-06	2.40E-06	6.51E-05	0.092	8.28E-04
1582	674.2	0.0184	0.0002	88.51	1.23E-06	2.85E-06	8.43E-05	0.096	9.84E-04
1711	623.4	0.0186	0.0002	89.46	1.23E-06	3.34E-06	1.07E-04	0.102	1.15E-03
1843	578.7	0.0187	0.0001	90.04	1.18E-06	3.74E-06	1.29E-04	0.106	1.29E-03
1976	539.8	0.0189	0.0002	90.80	9.60E-07	3.49E-06	1.29E-04	0.112	1.20E-03
2150	496.1	0.0191	0.0002	91.57	5.90E-07	2.54E-06	1.02E-04	0.118	9.44E-04
2407	443.1	0.0193	0.0002	92.72	8.87E-07	4.76E-06	2.14E-04	0.129	3.28E-03
2684	397.4	0.0195	0.0002	93.68	8.77E-07	5.86E-06	2.93E-04	0.138	4.50E-03
2960	360.3	0.0196	0.0002	94.44	2.85E-07	2.32E-06	1.28E-04	0.147	1.72E-03
3241	329.1	0.0198	0.0002	95.21	5.60E-07	5.46E-06	3.31E-04	0.156	4.06E-03
3524	302.7	0.0199	0.0001	95.59	2.66E-07	3.07E-06	2.02E-04	0.161	2.28E-03
3811	279.9	0.0200	0.0001	96.17	2.85E-07	3.85E-06	2.74E-04	0.169	2.96E-03
4098	260.3	0.0201	0.0001	96.74	2.75E-07	4.30E-06	3.29E-04	0.178	3.30E-03
4387	243.1	0.0202	0.0000	96.93	2.75E-07	4.92E-06	4.04E-04	0.181	4.05E-03
4675	228.2	0.0203	0.0001	97.51	2.75E-07	5.60E-06	4.89E-04	0.191	4.30E-03
4960	215.0	0.0204	0.0001	97.89	2.75E-07	6.30E-06	5.85E-04	0.199	4.68E-03
5352	199.3	0.0204	0.0001	98.28	3.80E-07	1.01E-05	1.01E-03	0.206	1.10E-02
5790	184.2	0.0205	0.0001	98.66	0.00E+00	0.00E+00	0.00E+00	0.215	0.00E+00
6246	170.8	0.0206	0.0000	98.85	1.66E-07	6.03E-06	7.04E-04	0.219	7.35E-03
6709	159.0	0.0206	0.0001	99.23	0.00E+00	0.00E+00	0.00E+00	0.229	0.00E+00
7177	148.6	0.0207	0.0000	99.43	0.00E+00	0.00E+00	0.00E+00	0.234	0.00E+00
7656	139.3	0.0207	0.0000	99.62	1.66E-07	9.07E-06	1.30E-03	0.240	1.15E-02
8140	131.0	0.0208	0.0000	99.81	0.00E+00	0.00E+00	0.00E+00	0.245	0.00E+00
8637	123.5	0.0208	0.0000	99.81	0.00E+00	0.00E+00	0.00E+00	0.245	0.00E+00
9137	116.7	0.0208	0.0000	99.81	0.00E+00	0.00E+00	0.00E+00	0.245	0.00E+00
9665	110.4	0.0208	0.0000	99.81	0.00E+00	0.00E+00	0.00E+00	0.245	0.00E+00
10339	103.2	0.0208	0.0000	100.00	1.17E-07	1.17E-05	2.25E-03	0.253	2.17E-02
>11047 NO ADDITIONAL INTRUSION									

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Aggregate F, Continued

INTERPOLATED INTRUSION DATA

Mean Pressure	Pore Radius	Percent Volume	Cumul. Volume Hg	Volume in Interval	dV/dP	dV/log r	Cumul. Surf Are
42.7	20000.0 - 30000.0	12.11	0.0044	2.52E-03	1.42E-04	5.73E-04	0.003
71.1	10000.0 - 20000.0	17.33	0.0080	3.61E-03	6.76E-05	8.63E-04	0.008
112.3	9000.0 - 10000.0	2.53	0.0085	5.27E-04	4.45E-05	1.32E-04	0.009
125.5	8000.0 - 9000.0	2.72	0.0091	5.65E-04	3.81E-05	1.44E-04	0.011
142.2	7000.0 - 8000.0	3.52	0.0098	7.33E-04	3.85E-05	1.89E-04	0.013
164.1	6000.0 - 7000.0	3.60	0.0106	7.49E-04	2.95E-05	1.96E-04	0.015
193.9	5000.0 - 6000.0	4.39	0.0115	9.13E-04	2.57E-05	2.44E-04	0.018
237.0	4000.0 - 5000.0	4.76	0.0125	9.90E-04	1.86E-05	2.71E-04	0.023
304.7	3000.0 - 4000.0	6.23	0.0138	1.30E-03	1.46E-05	3.66E-04	0.030
426.6	2000.0 - 3000.0	7.51	0.0153	1.56E-03	8.79E-06	4.60E-04	0.043
711.1	1000.0 - 2000.0	10.07	0.0174	2.09E-03	3.93E-06	6.59E-04	0.073
1122.7	900.0 - 1000.0	1.44	0.0177	2.99E-04	2.52E-06	1.00E-04	0.079
1254.8	800.0 - 900.0	1.51	0.0181	3.15E-04	2.13E-06	1.08E-04	0.087
1422.1	700.0 - 800.0	1.43	0.0184	2.98E-04	1.56E-06	1.04E-04	0.095
1640.9	600.0 - 700.0	1.45	0.0187	3.02E-04	1.19E-06	1.07E-04	0.104
1939.3	500.0 - 600.0	1.89	0.0190	3.92E-04	1.10E-06	1.43E-04	0.118

DATA SUMMARY

PSIA	Å	Cumulative cc/g	Surface m²/g
10666	100.0	0.0208	0.253
1067	1000.0	0.0174	0.073
107	10000.0	0.0080	0.008

Pore volume in pores greater than 30000.0 Angstroms = 0.0019 cc/g
Pore volume between 500.0 and 30000.0 Angstroms = 0.0172 cc/g
Pore volume in pores less than 500.0 Angstroms = 0.0018 cc/g
Total pore volume intruded = 0.0208 cc/g

Aggregate G

PORE INTRUSION DATA									
PRESSURE	PORE Radius	INTRUSION VOLUME	DELTA Hg VOLUME	% VOLUME	dV/dP	Dv(r)	Ds(r)	CUMULATIVE SURF. AREA	PORE NUM. FRACTION
26	41023.5	0.0047	0.0000	6.94	8.88E-04	5.63E-07	2.75E-07	0.000	0.00E+00
66	16160.8	0.0347	0.0301	51.82	3.90E-04	1.47E-06	1.75E-06	0.023	2.63E-04
111	9609.1	0.0449	0.0102	67.03	1.51E-04	1.66E-06	3.38E-06	0.040	2.97E-04
163	6543.6	0.0504	0.0055	75.30	7.62E-05	1.85E-06	5.59E-06	0.054	2.65E-04
218	4892.7	0.0536	0.0032	80.07	4.59E-05	1.98E-06	7.97E-06	0.065	4.95E-04
288	3703.5	0.0561	0.0025	83.75	2.90E-05	2.20E-06	1.17E-05	0.076	5.50E-04
373	2859.5	0.0579	0.0018	86.40	1.71E-05	2.19E-06	1.51E-05	0.087	6.24E-04
470	2269.4	0.0592	0.0013	88.33	1.06E-05	2.14E-06	1.86E-05	0.097	8.41E-04
576	1851.8	0.0601	0.0009	89.75	8.23E-06	2.51E-06	2.68E-05	0.107	9.86E-04
687	1552.6	0.0608	0.0007	90.74	5.10E-06	2.22E-06	2.84E-05	0.115	7.94E-04
803	1328.3	0.0614	0.0007	91.73	4.94E-06	2.94E-06	4.39E-05	0.124	1.26E-03
922	1156.8	0.0620	0.0005	92.54	4.76E-06	3.74E-06	6.43E-05	0.132	1.60E-03
1042	1023.6	0.0625	0.0005	93.34	4.23E-06	4.26E-06	8.27E-05	0.142	1.83E-03
1163	917.1	0.0629	0.0004	93.95	3.62E-06	4.54E-06	9.86E-05	0.151	2.11E-03
1287	828.8	0.0633	0.0004	94.52	2.56E-06	3.93E-06	9.44E-05	0.160	1.68E-03
1412	755.4	0.0637	0.0003	95.04	2.47E-06	4.58E-06	1.21E-04	0.168	2.13E-03
1541	692.2	0.0640	0.0003	95.56	2.56E-06	5.64E-06	1.62E-04	0.178	2.82E-03
1671	638.3	0.0643	0.0003	96.03	2.44E-06	6.33E-06	1.98E-04	0.187	3.17E-03
1802	591.9	0.0646	0.0003	96.41	1.95E-06	5.88E-06	1.98E-04	0.196	2.73E-03
1933	551.8	0.0648	0.0003	96.79	1.89E-06	6.59E-06	2.38E-04	0.204	3.29E-03
2133	500.1	0.0652	0.0003	97.31	9.74E-07	4.10E-06	1.63E-04	0.218	3.96E-03
2389	446.5	0.0655	0.0004	97.87	1.17E-06	6.20E-06	2.76E-04	0.234	6.20E-03
2666	400.1	0.0659	0.0003	98.35	9.04E-07	5.96E-06	2.97E-04	0.249	5.96E-03
2943	362.4	0.0661	0.0002	98.68	6.78E-07	5.45E-06	2.99E-04	0.261	5.45E-03
3224	330.8	0.0662	0.0002	98.91	9.13E-07	8.82E-06	5.31E-04	0.270	9.13E-03
3511	303.8	0.0664	0.0002	99.20	6.78E-07	7.77E-06	5.09E-04	0.282	8.05E-03
3802	280.5	0.0665	0.0001	99.34	4.44E-07	5.97E-06	4.24E-04	0.288	6.40E-03
4093	260.6	0.0667	0.0001	99.53	2.11E-07	3.29E-06	2.51E-04	0.297	3.52E-03
4388	243.1	0.0667	0.0001	99.62	2.11E-07	3.78E-06	3.10E-04	0.303	4.32E-03
4686	227.6	0.0668	0.0001	99.76	2.18E-07	4.46E-06	3.91E-04	0.311	4.78E-03
4983	214.0	0.0668	0.0000	99.81	2.11E-07	4.88E-06	4.55E-04	0.314	5.23E-03
5281	202.0	0.0669	0.0000	99.86	0.00E+00	0.00E+00	0.00E+00	0.317	0.00E+00
5646	188.9	0.0669	0.0000	99.91	0.00E+00	0.00E+00	0.00E+00	0.320	0.00E+00
6097	174.9	0.0669	0.0000	99.95	0.00E+00	0.00E+00	0.00E+00	0.323	0.00E+00
6545	163.0	0.0670	0.0000	100.00	1.41E-07	5.61E-06	6.86E-04	0.327	9.01E-03
>7012 NO ADDITIONAL INTRUSION									

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Aggregate G, Continued

INTERPOLATED INTRUSION DATA

Mean Pressure	Pore Radius	Percent Volume	Cumul. Volume Hg	Volume in Interval	dV/dP	dV/log r	Cumul. Surf Area
42.7	20000.0 - 30000.0	17.84	0.0289	1.20E-02	6.72E-04	2.72E-03	0.017
71.1	10000.0 - 20000.0	22.87	0.0443	1.53E-02	2.87E-04	3.67E-03	0.038
112.3	9000.0 - 10000.0	2.41	0.0459	1.61E-03	1.36E-04	4.06E-04	0.042
125.5	8000.0 - 9000.0	2.64	0.0476	1.77E-03	1.20E-04	4.51E-04	0.046
142.2	7000.0 - 8000.0	2.87	0.0496	1.92E-03	1.01E-04	4.95E-04	0.051
164.1	6000.0 - 7000.0	2.87	0.0515	1.92E-03	7.56E-05	5.04E-04	0.057
193.9	5000.0 - 6000.0	2.91	0.0534	1.95E-03	5.48E-05	5.21E-04	0.064
237.0	4000.0 - 5000.0	2.96	0.0554	1.98E-03	3.72E-05	5.43E-04	0.073
304.7	3000.0 - 4000.0	3.24	0.0576	2.17E-03	2.44E-05	6.12E-04	0.085
426.6	2000.0 - 3000.0	3.24	0.0598	2.17E-03	1.22E-05	6.38E-04	0.103
711.1	1000.0 - 2000.0	4.26	0.0626	2.86E-03	5.36E-06	8.99E-04	0.144
1122.7	900.0 - 1000.0	0.60	0.0630	4.04E-04	3.41E-06	1.36E-04	0.153
1254.8	800.0 - 900.0	0.64	0.0634	4.30E-04	2.90E-06	1.47E-04	0.163
1422.1	700.0 - 800.0	0.80	0.0640	5.39E-04	2.83E-06	1.87E-04	0.177
1640.9	600.0 - 700.0	0.83	0.0645	5.59E-04	2.20E-06	1.99E-04	0.195
1939.3	500.0 - 600.0	0.94	0.0652	6.29E-04	1.77E-06	2.29E-04	0.218

DATA SUMMARY

PSIA	Å	Cumulative cc/g	Surface m²/g
10666	100.0	0.0670	0.327
1067	1000.0	0.0626	0.144
107	10000.0	0.0443	0.038

Pore volume in pores greater than 30000.0 Angstroms = 0.0170 cc/g
Pore volume between 500.0 and 30000.0 Angstroms = 0.0482 cc/g
Pore volume in pores less than 500.0 Angstroms = 0.0018 cc/g
Total pore volume intruded = 0.0670 cc/g

Aggregate H

PORE INTRUSION DATA										
PRESSURE	PORE Radius	INTRUSION VOLUME Hg	DELTA VOLUME	% VOLUME	dV/dP	Dv(r)	Ds(r)	CUMULATIVE SURF. AREA	PORE NUM. FRACTION
26	41023.5	0.0039	0.0000	3.72	5.87E-04	3.72E-07	1.81E-07	0.000	0.00E+00
66	16160.8	0.0367	0.0328	34.80	6.53E-04	2.51E-06	3.01E-06	0.027	2.17E-04
109	9785.4	0.0576	0.0208	54.55	4.11E-04	4.37E-06	8.72E-06	0.061	4.73E-04
161	6624.9	0.0724	0.0148	68.60	2.02E-04	4.70E-06	1.39E-05	0.098	7.13E-04
216	4938.0	0.0810	0.0086	76.78	1.21E-04	5.16E-06	2.07E-05	0.128	5.59E-04
280	3809.3	0.0866	0.0056	82.09	6.85E-05	4.91E-06	2.55E-05	0.153	7.45E-04
357	2987.7	0.0907	0.0041	85.99	4.20E-05	4.93E-06	3.26E-05	0.178	7.47E-04
450	2370.2	0.0937	0.0030	88.79	2.57E-05	4.78E-06	3.99E-05	0.200	9.32E-04
556	1918.4	0.0957	0.0020	90.67	1.62E-05	4.59E-06	4.74E-05	0.219	1.10E-03
662	1611.2	0.0971	0.0014	92.04	9.77E-06	3.95E-06	4.87E-05	0.235	8.57E-04
775	1376.3	0.0984	0.0012	93.22	9.61E-06	5.33E-06	7.69E-05	0.252	1.27E-03
892	1195.8	0.0992	0.0009	94.03	7.04E-06	5.18E-06	8.61E-05	0.265	1.35E-03
1014	1051.9	0.1000	0.0007	94.73	6.38E-06	6.08E-06	1.15E-04	0.278	1.58E-03
1137	938.1	0.1006	0.0006	95.32	4.41E-06	5.28E-06	1.12E-04	0.291	1.60E-03
1259	847.2	0.1011	0.0005	95.76	5.10E-06	7.51E-06	1.76E-04	0.301	2.12E-03
1386	769.6	0.1015	0.0005	96.20	3.79E-06	6.76E-06	1.75E-04	0.313	1.91E-03
1513	705.0	0.1019	0.0004	96.54	3.09E-06	6.58E-06	1.86E-04	0.322	1.85E-03
1642	649.6	0.1022	0.0004	96.87	2.36E-06	5.91E-06	1.81E-04	0.332	1.67E-03
1771	602.3	0.1025	0.0003	97.16	2.36E-06	6.90E-06	2.28E-04	0.342	1.80E-03
1904	560.2	0.1028	0.0003	97.46	1.71E-06	5.77E-06	2.05E-04	0.353	1.63E-03
2065	516.5	0.1031	0.0003	97.71	2.05E-06	8.14E-06	3.14E-04	0.363	2.30E-03
2295	464.8	0.1035	0.0004	98.05	1.15E-06	5.63E-06	2.41E-04	0.378	3.29E-03
2565	415.8	0.1038	0.0003	98.34	8.64E-07	5.28E-06	2.52E-04	0.392	3.09E-03
2843	375.2	0.1040	0.0003	98.60	8.44E-07	6.33E-06	3.36E-04	0.405	3.84E-03
3124	341.4	0.1043	0.0002	98.82	5.56E-07	5.04E-06	2.94E-04	0.419	3.06E-03
3408	313.0	0.1045	0.0002	99.00	5.46E-07	5.89E-06	3.75E-04	0.431	3.71E-03
3695	288.7	0.1046	0.0002	99.15	5.46E-07	6.94E-06	4.79E-04	0.441	4.36E-03
3986	267.6	0.1048	0.0002	99.30	2.78E-07	4.11E-06	3.06E-04	0.452	2.58E-03
4278	249.3	0.1049	0.0002	99.45	2.68E-07	4.57E-06	3.66E-04	0.464	2.87E-03
4572	233.3	0.1050	0.0000	99.48	2.59E-07	5.05E-06	4.32E-04	0.467	3.18E-03
4867	219.2	0.1051	0.0001	99.59	2.59E-07	5.72E-06	5.21E-04	0.478	3.72E-03
5164	206.5	0.1052	0.0001	99.67	0.00E+00	0.00E+00	0.00E+00	0.485	0.00E+00
5534	192.7	0.1053	0.0001	99.78	1.77E-07	5.04E-06	5.21E-04	0.497	4.80E-03
5970	178.7	0.1053	0.0000	99.82	0.00E+00	0.00E+00	0.00E+00	0.501	0.00E+00
6409	166.4	0.1054	0.0000	99.85	0.00E+00	0.00E+00	0.00E+00	0.505	0.00E+00
6876	155.1	0.1054	0.0000	99.89	0.00E+00	0.00E+00	0.00E+00	0.510	0.00E+00
7352	145.1	0.1054	0.0000	99.93	0.00E+00	0.00E+00	0.00E+00	0.516	0.00E+00
7834	136.2	0.1054	0.0000	99.93	1.53E-07	8.72E-06	1.28E-03	0.516	9.08E-03
8331	128.0	0.1055	0.0000	99.96	0.00E+00	0.00E+00	0.00E+00	0.521	0.00E+00
8831	120.8	0.1055	0.0000	99.96	0.00E+00	0.00E+00	0.00E+00	0.521	0.00E+00
9345	114.1	0.1055	0.0000	100.00	1.50E-07	1.22E-05	2.13E-03	0.528	1.37E-02
>9896	NO ADDITIONAL INTRUSION								

Aggregate H, Continued

INTERPOLATED INTRUSION DATA

Mean Pressure	Pore Radius	Percent Volume	Cumul. Volume Hg	Volume in Interval	dV/dP	dV/log r	Cumul. Surf.Area
42.7	20000.0 - 30000.0	14.69	0.0283	1.55E-02	8.72E-04	3.52E-03	0.018
71.1	10000.0 - 20000.0	27.01	0.0568	2.85E-02	5.34E-04	6.82E-03	0.059
112.3	9000.0 - 10000.0	4.11	0.0611	4.34E-03	3.66E-04	1.09E-03	0.068
125.5	8000.0 - 9000.0	4.13	0.0655	4.36E-03	2.94E-04	1.11E-03	0.079
142.2	7000.0 - 8000.0	4.71	0.0705	4.97E-03	2.61E-04	1.28E-03	0.092
164.1	6000.0 - 7000.0	4.85	0.0756	5.12E-03	2.02E-04	1.34E-03	0.108
193.9	5000.0 - 6000.0	4.80	0.0806	5.06E-03	1.42E-04	1.35E-03	0.126
237.0	4000.0 - 5000.0	4.75	0.0857	5.01E-03	9.40E-05	1.37E-03	0.149
304.7	3000.0 - 4000.0	4.76	0.0907	5.02E-03	5.65E-05	1.42E-03	0.177
426.6	2000.0 - 3000.0	4.45	0.0954	4.70E-03	2.64E-05	1.38E-03	0.216
711.1	1000.0 - 2000.0	4.63	0.1003	4.88E-03	9.16E-06	1.54E-03	0.284
1122.7	900.0 - 1000.0	0.45	0.1007	4.78E-04	4.04E-06	1.61E-04	0.294
1254.8	800.0 - 900.0	0.54	0.1013	5.75E-04	3.88E-06	1.96E-04	0.308
1422.1	700.0 - 800.0	0.59	0.1019	6.22E-04	3.27E-06	2.16E-04	0.324
1640.9	600.0 - 700.0	0.58	0.1025	6.09E-04	2.40E-06	2.16E-04	0.343
1939.3	500.0 - 600.0	0.65	0.1032	6.86E-04	1.93E-06	2.50E-04	0.368

DATA SUMMARY

PSIA	Å	Cumulative cc/g	Surface m^2/g
10666	100.0	0.1055	0.528
1067	1000.0	0.1003	0.284
107	10000.0	0.0568	0.059

Pore volume in pores greater than 30000.0 Angstroms = 0.0128 cc/g
Pore volume between 500.0 and 30000.0 Angstroms = 0.0905 cc/g
Pore volume in pores less than 500.0 Angstroms = 0.0023 cc/g
Total pore volume intruded = 0.1055 cc/g

Aggregate J

PORE INTRUSION DATA

PRESSURE	PORE Radius	INTRUSION VOLUME	DELTA Hg VOLUME	% VOLUME	dV/dP	Dv(r)	Ds(r)	CUMULATIVE SURF. AREA	PORE NUM. FRACTION
26	41023.5	0.0000	0.0000	0.00	1.15E-04	7.26E-08	3.54E-08	0.000	0.00E+00
66	16160.8	0.0049	0.0049	39.31	7.04E-05	2.66E-07	3.17E-07	0.004	7.78E-04
118	9039.1	0.0073	0.0024	58.62	3.09E-05	3.87E-07	8.38E-07	0.008	1.13E-03
177	6026.1	0.0086	0.0013	68.97	1.76E-05	4.96E-07	1.62E-06	0.011	2.03E-03
262	4071.0	0.0097	0.0011	77.93	1.12E-05	6.91E-07	3.32E-06	0.016	4.45E-03
366	2914.2	0.0106	0.0009	84.83	4.58E-06	5.57E-07	3.76E-06	0.021	3.91E-03
485	2199.2	0.0110	0.0004	88.28	2.75E-06	5.92E-07	5.32E-06	0.024	4.16E-03
612	1742.8	0.0114	0.0004	91.72	2.55E-06	8.78E-07	9.97E-06	0.028	6.16E-03
746	1429.8	0.0118	0.0003	94.48	1.32E-06	6.76E-07	9.36E-06	0.033	5.93E-03
885	1205.2	0.0119	0.0002	95.86	0.00E+00	0.00E+00	0.00E+00	0.035	0.00E+00
1024	1041.6	0.0119	0.0000	95.86	0.00E+00	0.00E+00	0.00E+00	0.035	0.00E+00
1167	914.0	0.0120	0.0001	96.55	0.00E+00	0.00E+00	0.00E+00	0.037	0.00E+00
1310	814.2	0.0121	0.0001	97.24	0.00E+00	0.00E+00	0.00E+00	0.039	0.00E+00
1456	732.6	0.0122	0.0001	97.93	0.00E+00	0.00E+00	0.00E+00	0.041	0.00E+00
1603	665.4	0.0123	0.0001	98.62	0.00E+00	0.00E+00	0.00E+00	0.044	0.00E+00
1756	607.4	0.0124	0.0001	99.31	1.23E-06	3.52E-06	1.15E-04	0.046	3.29E-02
1906	559.6	0.0125	0.0001	100.00	1.07E-06	3.63E-06	1.29E-04	0.049	3.40E-02
>2059 NO ADDITIONAL INTRUSION									

Aggregate J, Continued

INTERPOLATED INTRUSION DATA							
Mean Pressure	Pore Radius	Percent Volume	Cumul. Volume Hg	Volume in Interval	dV/dP	dV/log r	Cumul. Surf.Area
42.7	20000.0 - 30000.0	18.55	0.0041	2.31E-03	1.30E-04	5.25E-04	0.003
71.1	10000.0 - 20000.0	24.25	0.0071	3.02E-03	5.67E-05	7.23E-04	0.007
112.3	9000.0 - 10000.0	2.02	0.0073	2.51E-04	2.12E-05	6.32E-05	0.008
125.5	8000.0 - 9000.0	3.38	0.0077	4.22E-04	2.85E-05	1.07E-04	0.009
142.2	7000.0 - 8000.0	3.61	0.0082	4.50E-04	2.36E-05	1.16E-04	0.010
164.1	6000.0 - 7000.0	3.33	0.0086	4.14E-04	1.63E-05	1.09E-04	0.011
193.9	5000.0 - 6000.0	4.96	0.0092	6.17E-04	1.74E-05	1.65E-04	0.013
237.0	4000.0 - 5000.0	4.66	0.0098	5.81E-04	1.09E-05	1.59E-04	0.016
304.7	3000.0 - 4000.0	5.49	0.0105	6.84E-04	7.70E-06	1.93E-04	0.020
426.6	2000.0 - 3000.0	5.29	0.0112	6.58E-04	3.70E-06	1.94E-04	0.025
711.1	1000.0 - 2000.0	7.04	0.0120	8.77E-04	1.64E-06	2.76E-04	0.037
1122.7	900.0 - 1000.0	0.00	0.0120	0.00E+00	0.00E+00	0.00E+00	0.037
1254.8	800.0 - 900.0	0.69	0.0121	8.59E-05	5.80E-07	2.93E-05	0.039
1422.1	700.0 - 800.0	0.69	0.0122	8.59E-05	4.51E-07	2.99E-05	0.041
1640.9	600.0 - 700.0	1.38	0.0124	1.72E-04	6.77E-07	6.11E-05	0.046
1939.3	500.0 - 600.0	0.69	0.0125	8.59E-05	2.42E-07	3.14E-05	0.049

DATA SUMMARY			
PSIA	Å	Cumulative cc/g	Surface m²/g
10666	100.0	0.0125	0.049
1067	1000.0	0.0120	0.037
107	10000.0	0.0071	0.007

Pore volume in pores greater than 30000.0 Angstroms = 0.0017 cc/g
Pore volume between 500.0 and 30000.0 Angstroms = 0.0107 cc/g
Pore volume in pores less than 500.0 Angstroms = 0.0000 cc/g
Total pore volume intruded = 0.0125 cc/g

Aggregate K

PORE INTRUSION DATA									
PRESSURE	PORE Radius	INTRUSION VOLUME	DELTA Hg VOLUME	% VOLUME	dV/dP	Dv(r)	Ds(r)	CUMULATIVE SURF. AREA	PORE NUM. FRACTION
27	39504.1	0.0025	0.0000	6.29	4.16E-04	2.84E-07	1.44E-07	0.000	0.00E+00
66	16160.8	0.0195	0.0170	48.80	2.51E-04	9.65E-07	1.16E-06	0.014	6.46E-07
115	9274.9	0.0257	0.0062	64.30	8.82E-05	1.03E-06	2.15E-06	0.024	1.20E-06
163	6543.6	0.0284	0.0028	71.26	4.74E-05	1.14E-06	3.41E-06	0.031	1.14E-06
224	4761.7	0.0306	0.0021	76.57	2.82E-05	1.28E-06	5.31E-06	0.039	1.50E-06
308	3463.0	0.0321	0.0015	80.39	1.49E-05	1.29E-06	7.34E-06	0.046	1.94E-06
408	2614.2	0.0332	0.0012	83.31	9.58E-06	1.45E-06	1.09E-05	0.054	2.92E-06
522	2043.3	0.0341	0.0008	85.33	6.33E-06	1.58E-06	1.53E-05	0.061	2.92E-06
644	1656.2	0.0347	0.0007	87.05	4.25E-06	1.62E-06	1.94E-05	0.068	3.26E-06
771	1383.4	0.0351	0.0004	87.95	3.23E-06	1.77E-06	2.54E-05	0.073	3.85E-06
902	1182.5	0.0355	0.0004	88.92	2.66E-06	2.01E-06	3.37E-05	0.079	4.03E-06
1039	1026.6	0.0358	0.0003	89.67	1.72E-06	1.71E-06	3.32E-05	0.084	3.73E-06
1179	904.7	0.0360	0.0002	90.19	2.56E-06	3.30E-06	7.25E-05	0.089	8.29E-06
1319	808.7	0.0362	0.0002	90.64	8.25E-07	1.33E-06	3.28E-05	0.093	3.12E-06
1461	730.1	0.0364	0.0002	91.09	1.18E-06	2.33E-06	6.36E-05	0.098	5.47E-06
1606	664.1	0.0364	0.0001	91.32	8.25E-07	1.98E-06	5.93E-05	0.100	4.64E-06
1752	608.8	0.0366	0.0001	91.62	4.27E-07	1.22E-06	3.98E-05	0.104	3.06E-06
1901	561.1	0.0367	0.0001	91.92	3.98E-07	1.34E-06	4.76E-05	0.108	3.14E-06
2052	519.8	0.0367	0.0001	92.07	8.25E-07	3.23E-06	1.24E-04	0.110	8.66E-06
2202	484.4	0.0368	0.0001	92.22	3.98E-07	1.80E-06	7.40E-05	0.113	4.52E-06
2354	453.1	0.0369	0.0001	92.51	3.73E-07	1.93E-06	8.49E-05	0.118	4.52E-06
2556	417.3	0.0370	0.0001	92.66	3.73E-07	2.27E-06	1.09E-04	0.120	6.09E-06
2865	372.3	0.0370	0.0001	92.81	1.87E-07	1.42E-06	7.59E-05	0.123	7.38E-06
3181	335.3	0.0371	0.0001	92.96	1.87E-07	1.75E-06	1.04E-04	0.127	9.69E-06
3501	304.7	0.0372	0.0001	93.11	0.00E+00	0.00E+00	0.00E+00	0.130	0.00E+00
3822	279.1	0.0372	0.0000	93.19	1.87E-07	2.54E-06	1.81E-04	0.132	1.32E-05
4147	257.2	0.0372	0.0000	93.26	1.87E-07	2.99E-06	2.31E-04	0.135	1.60E-05
4477	238.2	0.0372	0.0000	93.26	0.00E+00	0.00E+00	0.00E+00	0.135	0.00E+00
4805	222.0	0.0372	0.0000	93.26	0.00E+00	0.00E+00	0.00E+00	0.135	0.00E+00
5137	207.6	0.0372	0.0000	93.26	0.00E+00	0.00E+00	0.00E+00	0.135	0.00E+00
5469	195.0	0.0372	0.0000	93.34	0.00E+00	0.00E+00	0.00E+00	0.138	0.00E+00
5800	183.9	0.0372	0.0000	93.34	0.00E+00	0.00E+00	0.00E+00	0.138	0.00E+00
6214--35799 PSI		NO INTRUSION							
35799	29.8	0.0372	0.0000	93.34	0.00E+00	0.00E+00	0.00E+00	0.138	0.00E+00
37728	28.3	0.0372	0.0000	93.34	3.05E-08	4.05E-05	2.85E-02	0.138	1.33E-03
39754	26.8	0.0374	0.0002	93.79	1.10E-07	1.61E-04	1.20E-01	0.268	5.49E-03
42115	25.3	0.0377	0.0003	94.46	1.47E-07	2.43E-04	1.92E-01	0.475	9.82E-03
44587	23.9	0.0380	0.0003	95.28	1.43E-07	2.65E-04	2.21E-01	0.741	1.10E-02
47133	22.6	0.0384	0.0004	96.18	1.40E-07	2.89E-04	2.55E-01	1.049	1.24E-02
49748	21.4	0.0387	0.0003	97.01	1.58E-07	3.65E-04	3.40E-01	1.349	1.61E-02
52449	20.3	0.0391	0.0004	97.98	1.52E-07	3.91E-04	3.84E-01	1.721	1.79E-02
55245	19.3	0.0395	0.0004	98.95	1.69E-07	4.80E-04	4.96E-01	2.114	2.30E-02
58214	18.3	0.0397	0.0002	99.55	9.42E-08	2.98E-04	3.24E-01	2.367	1.48E-02

Aggregate K, Continued

INTERPOLATED INTRUSION DATA

Mean Pressure	Pore Radius	Percent Volume	Cumul. Volume Hg	Volume in Interval	dV/dP	dV/log r	Cumul. Surf Area
42.7	20000.0 - 30000.0	19.94	0.0158	7.96E-03	4.48E-04	1.81E-03	0.010
71.1	10000.0 - 20000.0	22.98	0.0250	9.17E-03	1.72E-04	2.20E-03	0.022
112.3	9000.0 - 10000.0	2.35	0.0259	9.36E-04	7.90E-05	2.35E-04	0.024
125.5	8000.0 - 9000.0	2.41	0.0269	9.62E-04	6.49E-05	2.45E-04	0.027
142.2	7000.0 - 8000.0	2.62	0.0279	1.05E-03	5.49E-05	2.70E-04	0.029
164.1	6000.0 - 7000.0	2.90	0.0291	1.16E-03	4.55E-05	3.03E-04	0.033
193.9	5000.0 - 6000.0	2.89	0.0302	1.15E-03	3.25E-05	3.09E-04	0.037
237.0	4000.0 - 5000.0	3.03	0.0314	1.21E-03	2.27E-05	3.31E-04	0.043
304.7	3000.0 - 4000.0	3.17	0.0327	1.27E-03	1.42E-05	3.57E-04	0.050
426.6	2000.0 - 3000.0	3.56	0.0341	1.42E-03	8.00E-06	4.19E-04	0.061
711.1	1000.0 - 2000.0	4.20	0.0358	1.68E-03	3.15E-06	5.28E-04	0.085
1122.7	900.0 - 1000.0	0.48	0.0360	1.92E-04	1.62E-06	6.46E-05	0.089
1254.8	800.0 - 900.0	0.42	0.0362	1.67E-04	1.13E-06	5.69E-05	0.093
1422.1	700.0 - 800.0	0.60	0.0364	2.38E-04	1.25E-06	8.29E-05	0.099
1640.9	600.0 - 700.0	0.37	0.0366	1.49E-04	5.88E-07	5.31E-05	0.104
1939.3	500.0 - 600.0	0.60	0.0368	2.39E-04	6.72E-07	8.72E-05	0.113

DATA SUMMARY

PSIA	Å	Cumulative cc/g	Surface m^2/g
10666	100.0	0.0372	0.138
1067	1000.0	0.0358	0.085
107	10000.0	0.0250	0.022

Pore volume in pores greater than 30000.0 Angstroms = 0.0079 cc/g
Pore volume between 500.0 and 30000.0 Angstroms = 0.0289 cc/g
Pore volume in pores less than 500.0 Angstroms = 0.0031 cc/g
Total pore volume intruded = 0.0399 cc/g

Aggregate L

PORE INTRUSION DATA

PRESSURE	PORE Radius	INTRUSION VOLUME	DELTA Hg VOLUME	% VOLUME	dV/dP	Dv(r)	Ds(r)	CUMULATIVE SURF. AREA	PORE NUM. FRACTION
26	41023.5	0.0000	0.0000	0.00	7.24E-05	4.59E-08	2.24E-08	0.000	0.00E+00
66	16160.8	0.0034	0.0034	27.21	5.84E-05	2.24E-07	2.69E-07	0.003	4.59E-05
120	8888.4	0.0054	0.0019	42.62	2.47E-05	3.20E-07	7.04E-07	0.006	8.19E-05
188	5673.5	0.0067	0.0013	52.79	1.49E-05	4.76E-07	1.65E-06	0.010	1.71E-04
284	3755.7	0.0078	0.0012	61.97	8.86E-06	6.45E-07	3.37E-06	0.015	3.63E-04
395	2700.3	0.0086	0.0008	68.20	5.60E-06	7.97E-07	5.82E-06	0.020	4.49E-04
518	2059.1	0.0092	0.0006	72.79	4.47E-06	1.09E-06	1.05E-05	0.025	7.84E-04
649	1643.5	0.0096	0.0004	76.07	3.10E-06	1.20E-06	1.45E-05	0.029	7.39E-04
781	1365.7	0.0099	0.0003	78.69	6.37E-07	3.59E-07	5.21E-06	0.033	2.21E-04
915	1165.7	0.0101	0.0002	80.33	2.55E-06	1.97E-06	3.36E-05	0.037	1.31E-03
1055	1011.0	0.0104	0.0003	82.62	1.78E-06	1.83E-06	3.60E-05	0.042	1.41E-03
1193	894.1	0.0106	0.0002	84.26	1.19E-06	1.57E-06	3.49E-05	0.047	1.05E-03
1335	799.0	0.0108	0.0001	85.25	1.14E-06	1.89E-06	4.70E-05	0.050	1.45E-03
1482	719.7	0.0109	0.0002	86.56	5.17E-07	1.05E-06	2.91E-05	0.054	8.64E-04
1627	655.6	0.0111	0.0001	87.54	1.18E-06	2.91E-06	8.84E-05	0.058	2.09E-03
1773	601.6	0.0111	0.0001	88.20	1.07E-06	3.13E-06	1.04E-04	0.060	2.08E-03
1922	554.9	0.0113	0.0002	89.51	5.52E-07	1.90E-06	6.81E-05	0.066	1.46E-03
2071	515.0	0.0114	0.0001	90.16	5.52E-07	2.20E-06	8.53E-05	0.069	1.58E-03
2221	480.2	0.0115	0.0001	91.15	5.52E-07	2.54E-06	1.05E-04	0.074	1.95E-03
2374	449.3	0.0116	0.0001	92.13	5.17E-07	2.72E-06	1.20E-04	0.079	2.23E-03
2591	411.7	0.0118	0.0002	93.44	5.35E-07	3.33E-06	1.61E-04	0.087	5.11E-03
2899	367.9	0.0120	0.0002	94.75	5.35E-07	4.17E-06	2.25E-04	0.096	6.83E-03
3212	332.1	0.0120	0.0001	95.41	0.00E+00	0.00E+00	0.00E+00	0.100	0.00E+00
3533	301.9	0.0121	0.0001	96.07	5.10E-07	5.91E-06	3.90E-04	0.106	9.39E-03
3852	276.9	0.0122	0.0001	96.72	2.59E-07	3.57E-06	2.57E-04	0.111	5.85E-03
4176	255.4	0.0123	0.0001	97.38	2.59E-07	4.20E-06	3.27E-04	0.118	6.88E-03
4505	236.8	0.0124	0.0001	98.03	2.51E-07	4.74E-06	3.99E-04	0.124	7.77E-03
4830	220.8	0.0124	0.0000	98.36	0.00E+00	0.00E+00	0.00E+00	0.128	0.00E+00
5156	206.9	0.0125	0.0000	98.69	0.00E+00	0.00E+00	0.00E+00	0.132	0.00E+00
5487	194.4	0.0125	0.0000	99.02	0.00E+00	0.00E+00	0.00E+00	0.136	0.00E+00
5812	183.5	0.0125	0.0000	99.34	0.00E+00	0.00E+00	0.00E+00	0.140	0.00E+00
6194	172.2	0.0125	0.0000	99.34	0.00E+00	0.00E+00	0.00E+00	0.140	0.00E+00
6662	160.1	0.0126	0.0000	99.67	1.62E-07	6.70E-06	8.34E-04	0.145	1.82E-02
7187	148.4	0.0126	0.0000	99.67	1.53E-07	7.37E-06	9.90E-04	0.145	1.93E-02
7727	138.0	0.0126	0.0000	100.00	0.00E+00	0.00E+00	0.00E+00	0.151	0.00E+00
>8272	NO ADDITIONAL INTRUSION								

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Aggregate L, Continued

INTERPOLATED INTRUSION DATA							
Mean Pressure	Pore Radius	Percent Volume	Cumul. Volume Hg	Volume in Interval	dV/dP	dV/log r	Cumul. Surf. Area
42.7	20000.0 - 30000.0	12.90	0.0026	1.63E-03	9.16E-05	3.70E-04	0.002
71.1	10000.0 - 20000.0	19.15	0.0051	2.42E-03	4.53E-05	5.79E-04	0.005
112.3	9000.0 - 10000.0	2.15	0.0053	2.72E-04	2.29E-05	6.83E-05	0.006
125.5	8000.0 - 9000.0	2.68	0.0057	3.39E-04	2.29E-05	8.62E-05	0.007
142.2	7000.0 - 8000.0	3.07	0.0061	3.87E-04	2.03E-05	1.00E-04	0.008
164.1	6000.0 - 7000.0	3.42	0.0065	4.32E-04	1.70E-05	1.13E-04	0.009
193.9	5000.0 - 6000.0	4.15	0.0070	5.24E-04	1.47E-05	1.40E-04	0.011
237.0	4000.0 - 5000.0	5.29	0.0077	6.68E-04	1.25E-05	1.83E-04	0.014
304.7	3000.0 - 4000.0	5.42	0.0084	6.84E-04	7.69E-06	1.93E-04	0.018
426.6	2000.0 - 3000.0	7.02	0.0093	8.86E-04	4.98E-06	2.61E-04	0.025
711.1	1000.0 - 2000.0	9.34	0.0104	1.18E-03	2.21E-06	3.71E-04	0.042
1122.7	900.0 - 1000.0	1.44	0.0106	1.82E-04	1.53E-06	6.11E-05	0.046
1254.8	800.0 - 900.0	1.18	0.0108	1.49E-04	1.01E-06	5.09E-05	0.050
1422.1	700.0 - 800.0	1.31	0.0109	1.66E-04	8.69E-07	5.76E-05	0.054
1640.9	600.0 - 700.0	1.74	0.0111	2.20E-04	8.66E-07	7.82E-05	0.061
1939.3	500.0 - 600.0	2.24	0.0114	2.83E-04	7.97E-07	1.03E-04	0.071

DATA SUMMARY			
PSIA	Å	Cumulative cc/g	Surface m²/g
10666	100.0	0.0126	0.151
1067	1000.0	0.0104	0.042
107	10000.0	0.0051	0.005

Pore volume in pores greater than 30000.0 Angstroms = 0.0010 cc/g
Pore volume between 500.0 and 30000.0 Angstroms = 0.0104 cc/g
Pore volume in pores less than 500.0 Angstroms = 0.0012 cc/g
Total pore volume intruded = 0.0126 cc/g

APPENDIX B

INVENTORY OF MRL ASPHALTS

Asphalt Code	AC Grade	Crude Source	No. of 5 gallon cans (1992-93)									
			Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
AAA-1	150/200 PEN	Lloydminster	185	183	184							
AAA-2	200/300 PEN	"	50	49	49							
AAB-1	AC-10	Wyoming Sour (Dist)	198	196	197							
AAB-2	AC-5	"	47	46	46							
AAC-1	AC-8	Redwater/Gulf/ Boundary Lake										
AA-C2	AC-5	"										
AAD-1	AR-4000	California Coastal (Dist)	172	170	171							
AAD-2	AR-2000	"	43	42	42							
AAE	60/70 PEN	Lloydminster (Air Blown)	189	188	188							
AAF-1	AC-20	W. Tx Sour	192	190	194							
AAF-2	AC-10	"	53	52	53							
AAG-1	AR-4000	California Valley (Dist) Lime Treated Crude	27	25	35							
AAG-2	AR-2000	"	16	15	15							
AAH	AC-10	Rangely (Dist)	186	185	185							
AAJ	AC-10	Oklahoma Mix (SDA)	187	186	186							

INVENTORY OF MRL ASPHALTS

Asphalt Code	AC Grade	Crude Source	No. of 5 gallon cans (1992-93)									
			Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
AAK-1	AC-30	Boscan (Dist)	49	47	55							
AAK-2	AC-10	"	2	0	0							
AAL	150/200	Cold Lake (Dist)	185	184	184							
AAM-1	AC-20	W. Tx Intermediate (SDA)	164	162	163							
AAM-2	AC-10	"	43	42	42							
AAN	85/100 PEN	Bow River (Dist)	157	156	156							
AAO	AC-10	Arabian Heavy	188	187	187							
AAP	AC-20	Oklahoma Mix (Dist)	177	176	176							
AAQ	AC-10 PEN	Wyoming Canadian Mix (SDA)	187	186	186							
AAR	AC-20	Maya/Wyoming Sour	189	188	188							
AAS-1	AC-20	Arabian Heavy	190	189	189							
AAS-2	AC-10	"	54	53	53							
AAS-3	AC-30	"	39	38	38							
AAT	AC-2	Maya/Lloydminster	188	187	187							
AAU	AC-20	ANS/Cal. Coastal	198	197	197							

INVENTORY OF MRL ASPHALTS

Asphalt Code	AC Grade	Crude Source	No. of 5 gallon cans (1992-93)									
			Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
AAV	AC-5	ANS	179	178	178							
AAW	AC-20	W. Tx Sour/Maya	185	184	184							
AAX-R	RESINS	Potaku Sweet/ Lt. LA Sweet	35	34	35							
AAX-A	ASPHALTENES	"	35	34	35							
AAX-A+R	RESINS+ ASPHALTENES	"	35	34	35							
AAX-DAO	DE-ASPHALTED OIL	Potaku Sweet/ Lt.LA Sweet	36	35	36							
AAX-F	FLUX	W.Tx Sour/ Kansas	36	35	35							
AAX-AC20	AC-20	Potaku Sweet/ Lt. LA Sweet	171	170	170							
AAY	AC-20	Maya/Arabian Heavy	189	188	188							
AAZ	AC-20	W. Tx Sour/ Coastal Crudes	183	182	182							
ABA	AC-20	W. Tx. Intmediate W. Tx. Sour (Air Blowm)	193	192	192							
ABC	AC-20	Mississippi Valley	183	182	182							
ABD	AR-4000	California Valley	170	169	169							
ABE	?	?	3qts	3qts	3qts							
ABF	AC-20	Tia Juana Pesado	116	115	115							

INVENTORY OF MRL ASPHALTS

Asphalt Code	AC Grade	Crude Source	No. of 5 gallon cans (1992-93)									
			Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
ABG	B-85	Laguna	187	186	186							
ABH	BIT-120	Russian	49	48	48							
ABJ	?	Lake	1 Barrel	1 Barrel	1 Barrel	Barrel	Barrel	Barrel	Barrel	Barrel	Barrel	Barrel
ABK	AR-4000	Wilmington	185	184	184							
ABL-1	AC-30	Boscan (5% Gas Oil)	46	45	45							
ABL-2	EB-10	Boscan (Emulsion Based)	71	70	70							
ABL-3	AC-10	Boscan (14% Gas Oil)	62	61	61							
ABM-1	AR-4000	Ca. Valley lime-treated crude	70	69	69							
ABM-2	AR-2000	Ca. Valley lime-treated crude	119	118	118							

INVENTORY OF MRL AGGREGATES

Aggregate Code	Stockpile ID	No. of 55 gallon drums (1992)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
RA	810-C	161/2	161/2	161/2	161/2	161/2	161/2	161/2	161/2	161/2	153/4	153/4	
	89-D	91/2	91/2	91/2	91/2	91/2	91/2	91/2	91/2	91/2	8/34	8/34	
	#57	51/2	51/2	51/2	51/2	51/2	51/2	51/2	51/2	51/2	51/2	51/2	
	#4	11/2	11/2	11/2	11/2	11/2	11/2	11/2	11/2	11/2	11/2	11/2	
	#7	81/2	81/2	81/2	81/2	81/2	81/2	81/2	81/2	81/2	81/2	81/2	
	Pond Screenings	91/4	91/4	91/4	91/4	91/4	91/4	91/4	91/4	91/4	91/4	91/4	
RB	-8 Sand	221/2	221/4	22	22	22	213/4	213/4	213/4	213/4	213/4	213/4	
	Crusher fines	83/4	8	83/4	73/4	73/4	41/2	41/2	41/2	41/2	41/4	41/4	
	1/2 x 4	8	7	7	7	7	63/4	63/4	63/4	63/4	61/2	61/2	
	3/4 x 1/2	71/4	7	5	5	5	43/4	43/4	43/4	43/4	41/2	41/2	
	11/2 x 3/4	73/4	73/4	73/4	73/4	73/4	73/4	73/4	73/4	73/4	71/2	71/2	
	#8 x 3/8	73/4	61/4	6	6	6	51/4	51/4	51/4	51/4	4/34	4/34	
	#8 x 1/4	0	0	0	0	0	0	0	0	0	0	0	
RC	1/2 x #8	5	5	5	7	7	7	7	7	7	7	7	
	-#8	7	7	7	9	9	9	9	9	9	9	9	
	11/2 x 3/4"	0	0	0	3	3	3	3	3	3	3	3	
	3/4" x 8	51/4	51/4	51/4	51/4	51/4	51/4	51/4	51/4	51/4	51/4	51/4	
RD	#10 Screenings	111/2	111/2	111/2	111/2	111/2	81/2	81/2	81/2	81/2	81/2	81/2	
	#7	93/4	93/4	93/4	93/4	93/4	73/4	73/4	73/4	73/4	73/4	63/4	
	#12 dust	11	11	11	11	11	11	11	11	11	11	11	
	1/2 x 4	11/2	11/2	11/2	11/2	11/2	11/2	11/2	11/2	11/2	11/2	11/2	
	#6 AC Rock	7	7	7	7	7	6	6	6	6	6	5	
	Birdeye	51/2	51/2	51/2	51/2	51/2	51/2	51/2	51/2	51/2	51/2	51/2	
	2 x 11/2	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	
	PLS	41/4	41/4	41/4	41/4	41/4	41/4	41/4	41/4	41/4	41/4	41/4	

Aggregate Code	Stockpile ID	No. of 55 gallon drums (1992)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
RE	#7	9	9	9	9	9	9	9	9	9	9	9	
	5/8" gravel	91/2	91/2	91/2	91/2	91/2	91/2	91/2	91/2	91/2	91/2	91/2	
	Sand	231/2	231/2	231/2	231/2	231/2	231/2	231/2	231/2	231/2	231/2	231/2	
	1/4 gravel	9	9	9	9	9	9	9	9	9	9	9	
	1" Roofstone	41/2	41/2	41/2	41/2	41/2	41/2	41/2	41/2	41/2	41/2	41/2	
RF	CA 16	221/2	221/2	221/2	221/2	221/2	221/2	221/2	221/2	221/2	221/2	221/2	
	FA 2	181/2	181/2	181/2	181/2	181/2	181/2	181/2	181/2	181/2	181/2	181/2	
	CA 11	15	15	15	15	15	15	15	15	15	15	15	
RG	Sand	191/2	191/2	191/2	191/2	191/2	191/2	191/2	191/2	191/2	191/2	191/2	
	#8	231/2	231/2	231/2	231/2	231/2	231/2	231/2	231/2	231/2	231/2	231/2	
	467	10	10	10	10	10	10	10	10	10	10	10	
	-200	41/4	41/4	41/4	41/4	41/4	41/4	41/4	41/4	41/4	41/4	41/4	
RH	3/8 x 6	263/4	263/4	263/4	263/4	263/4	263/4	263/4	263/4	263/4	263/4	263/4	
	1/2 x 3/4	181/4	181/4	181/4	181/4	181/4	181/4	181/4	181/4	181/4	18	18	
	1/4 x 1/2	191/4	191/4	191/4	191/4	191/4	191/4	191/4	191/4	191/4	191/4	191/4	
	sand	421/4	421/4	421/4	421/4	421/4	421/4	421/4	421/4	421/4	42	42	
	Baghouse Dust	11/4	11/4	11/4	11/4	11/4	11/4	11/4	11/4	11/4	11/4	11/4	
	3/8 X dust	53/4	53/4	53/4	53/4	53/4	53/4	53/4	53/4	53/4	51/2	51/2	
RJ	1/2" PM	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	
	-#4	243/4	243/4	243/4	243/4	243/4	243/4	243/4	243/4	243/4	243/4	243/4	
	1" concrete	63/4	63/4	63/4	63/4	63/4	63/4	63/4	63/4	63/4	63/4	63/4	
	Type G	41/4	41/4	41/4	41/4	41/4	41/4	41/4	41/4	41/4	41/4	41/4	
	Drain fill	23/4	23/4	23/4	23/4	23/4	23/4	23/4	23/4	23/4	23/4	23/4	
"New" RJ	1/2" PMP "C"	10	10	10	10	10	10	10	10	10	10	10	
	- #4	211/2	211/2	211/2	211/2	211/2	211/2	211/2	211/2	211/2	211/2	211/2	
	1" concrete	12	12	12	12	12	12	12	12	12	12	12	

Aggregate Code	Stockpile ID	No. of 55 gallon drums (1992)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
RK	1 1/2"	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	
	3/4 x 1/4	31/2	31/2	31/2	31/2	31/2	31/2	31/2	31/2	31/2	31/2	31/2	
	-3/4"	21/2	21/2	21/2	21/2	21/2	21/2	21/2	21/2	21/2	21/2	21/2	
	-1"	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	
	-1/4"	36	36	36	26	26	26	26	26	26	26	26	
	1/2 x 1/4	81/2	81/2	81/2	81/2	81/2	81/2	81/2	81/2	81/2	81/2	81/2	
RL	RR Ballast	61/4	61/4	61/4	61/4	61/4	61/4	61/4	61/4	61/4	61/4	61/4	
	Grade 2	61/2	61/2	61/2	61/2	61/2	61/2	61/2	61/2	61/2	61/2	61/2	
	Grade 4	10	9	9	9	9	9	9	9	9	9	9	
	Grade 6	53/4	53/4	53/4	53/4	53/4	53/4	53/4	53/4	53/4	53/4	53/4	
	#8 - 200	61/4	51/4	51/4	51/4	51/4	43/4	43/4	43/4	31/2	31/2	31/2	
	-200	61/4	61/4	61/4	61/4	61/4	53/4	53/4	53/4	53/4	53/4	53/4	

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INVENTORY OF SPS MATERIALS AT THE MRL

Proj. Type	State	No. of 55 gallon drums of:				No. of 5-gallon pails of :				Misc.
		Comb. Coarse & Fine Aggregate		RAP		Asphalt Cement		Hot Mix		
		used in Virgin Mix	used in Recycled Mix	Pure RAP	RAP & Aggregate	used in Virgin Mix	used in Recycled Mix	Virgin Mix	Recycled Mix	
SPS	AZ SPS-6	1/4 + 5~5 gals pails 75 lb shipped to OSU 6/26/91				8 2 Shipped to TTI 1gal to OSU		4		Received 32-4" Cores in April 1991 shipped to TTI in May 91
	MI SPS-6	1/4 BBL + 16~5 gals cans 75 lb shipped to OSU 6/26/91				9 2 Shipped to TTI 1gal to OSU		1		Received 32-4" Cores on Feb. 27 1991 shipped to TTI in May 91
	AZ SPS-5	1/2 11/2 Shipped to TTI on 3//7/91	1.3 425 lb to OSU 6/26/91	2		2(AC-40)Shipped to TTI on 3/7/91 8 (AC-40) 11 (AC-20) 1 AC-40 to OSU		1	1	30-4" Cores picked up by TTI in Feb. 1991
	Manitoba SPS-5	30 lb 500 Shipped to TTI 100 lb to PTI		1	2	8 2 Shipped to TTI 1 shipped to PTI		3	2	50 Cores Rec'd 6/7/91 5 gls Additive 20 to Penn State 6/26/91 30 to TTI 7/1/91
	IA SPS-6	1/2 + 14 ~ 5 gals pails 21 ~ 5 gals Binder Course				11 2 Shipped to TTI		1		50 Cores Rec'd 7/12/91 30 to TTI 20 to PTI on 8/5/91
	AL SPS-5				SEE ATTACHED SHEET					

INVENTORY OF SPS MATERIALS AT THE MRL

Proj. Type	State	No. of 55 gallon drums of:				No. of 5-gallon pails of :				Misc.
		Comb. Coarse & Fine Aggregate		RAP		Asphalt Cement		Hot Mix		
		used in Virgin Mix	used in Recycled Mix	Pure RAP	RAP & Aggregate	used in Virgin Mix	used in Recycled Mix	Virgin Mix	Recycled Mix	
SPS	CA (Barstow) SPS-5	2	2	2		11		4	4	
	CA (Barstow) SPS-9	2 for SMA Vestoplast	2 for rubbrized mix			11		4 for Vestoplast	4 for rubberized mix	5 gal modifier
	MD SPS-5 & SMA				SEE ATTACHED SHEET					
	CA SPS-6	2				11		5		
	WI SPS-9 I-94	2				9		8 Surface 7 Binder		
	OK SPS-6	2 Surface 2 Binder				11		4 Surface 4 Binder		
	WI SPS-9 IH-43	2				11 Amoco 11 Elf		Elf AC: 4 Surface 3 Binder Amoco AC: 4 Surface 6 Binder		
	MO SPS-6	2				11		4 Surface 4 Leveling		1 Package Hydrated Lime

INVENTORY OF SPS MATERIALS AT THE MRL

Proj. Type	State	No. of 55 gallon drums of:				No. of 5-gallon pails of :				Misc.
		Comb. Coarse & Fine Aggregate		RAP		Asphalt Cement		Hot Mix		
		used in Virgin Mix	used in Recycled Mix	Pure RAP	RAP & Aggregate	used in Virgin Mix	used in Recycled Mix	Virgin Mix	Recycled Mix	
SPS	MN SPS-5	1/3 + 7 ~ 5 gals cans 35 gals shipped to OSU	2	2		11 10 1 Shipped to OSU		2		42 Cores Rec'd Jan 92 12 shipped to OSU
	ILL SPS-6	1/2 + 16 ~ 5 gals pails				9 2 Shipped to TTI		1		Received 32-4" Cores in April 1991 shipped to TTI in May 91
	Alberta SPS-5	0 1/2 to OSU 11/2 to TTI 38 lb to PTI		2		7 2 Shipped to TTI 1 to OSU 1 to PTI	11	7 1 to PTI	8	3 bags of aggregates 30 cores rec'd 5/29/91 shipped to TTI 5/30/91
	MS SPS-5	1.5 350 lb to OSU	2	2		9 1 to OSU		4	4	
	IN SPS-6	2				11		4		
	MT SPS-5	2		2		11		4	4	
	CO SPS-5	2	2	2		11		4	4	
	TX SPS-5	59 Bags		18 Bags		11 AC-10	11 AC-5	4 Surface 4Binder	4 Surface 4Binder	

INVENTORY OF SPS MATERIALS AT THE MRL

Proj. Type	State	No. of 55 gallon drums of:				No. of 5-gallon pails of :				Misc.
		Comb. Coarse & Fine Aggregate		RAP		Asphalt Cement		Hot Mix		
		used in Virgin Mix	used in Recycled Mix	Pure RAP	RAP & Aggregate	used in Virgin Mix	used in Recycled Mix	Virgin Mix	Recycled Mix	
SPS	NJ SPS - 5				SEE ATTACHED SHEET					
	SD SPS-6	2				11		4 Corse Mix 4 Fine Mix		
	PA SPS - 6	2 Surface 2 Binder				11 (AC-20)		3 Surface 3 Binder 3 Base		

INVENTORY OF AAMAS MATERIALS AT THE MRL

Proj. Type	State	No. of 55 gallon drums of:				No. of 5-gallon pails of :				Misc.
		Comb. Coarse & Fine Aggregate		RAP		Asphalt Cement		Hot Mix		
		used in Virgin Mix	used in Recycled Mix	Pure RAP	RAP & Aggregate	used in Virgin Mix	used in Recycled Mix	Virgin Mix	Recycled Mix	
AAMAS	GA	1.3 425 lb to OSU 6/26/91				12 1 to OSU		1		
	WI	1.3 425 lb to OSU 6/26/91		2		10 1 to OSU		1		
	CA	1.3 425 lb to OSU 6/26/91				7 1 to OSU		1		
	NY	2				11		1		

INVENTORY OF MISCELLANEOUS MATERIALS AT THE MRL

State/ Project Type	No. of 55 gallon drums of:				No. of 5-gallon pails of :				Misc.	Cores
	Comb. Coarse & Fine Aggregate		RAP		Asphalt Cement		Hot Mix			Section ID No's for Cores Received
	used in Virgin Mix	used in Recycled Mix	Pure RAP	RAP & Aggregate	used in Virgin Mix	used in Recycled Mix	Virgin Mix	Recycled Mix		
CA GPS - 6B	11/2 1/2 shipped to OSU 9/91				10 1 shipped to OSU 9/91		4			
SMA MI	2				11		2(drum) 2(batch)			
LCPC FRANCE	30 gls fine 45 gls course (225 lb shipped to OSU)				1 Total 1 Shell 1 Elf (1gl of each shipped to OSU)					Sec. 4 & 13 (Shell, total, Elf) Shipped to OSU 9/9/91 Sec. 4 & 13 (Shell, Total, Elf) 3 each Rec'd 6/5/92
USA CRREL	1 1 shipped to OSU				4 (AC-10) 16 (AC-20)					
SWK Engineering Nottingham UK	10 (Small drams)				8 (100 pen) 4 (50 pen) 4 (200 pen)		4 (small drums)		2 Buckets Asphapol 2000 modifier	
ALF Novaphalt									AC-20: 1-5 gl can modified AC: 5-qt cans 2-1 gl cans	
ALF ELF Asphalt									1 gallon: AC - 5 AC - 20 AC - 40 Sty 14 - 50	

Material Received from Alabama

55 Gallon Drums (4)

1) Top Half 1½" Limestone (Rap Binder, Virgin Binder)
   Bottom Half ½" Crushed Gravel, (Virgin Wearing, Rap Wearing)

2) Rap (SH52) Used in Rap Binder Section

3) Rap (US84) Used for Rap Wearing

4) Top - 1" Granite (Rap Wearing, Virgin Wearing)
   Mid - ½" Pea Gravel (Rap Binder, Virgin Binder)
   Bottom - Sand (Rap, Virgin), Binder and Wearing - All Mixes

5 Gallons Cans (37)

Limestone Screening	---- 5	(Virgin wearing)
AC-30 (used in virgin section)	----10	(AC-30 Used in Both Virgin Binder and Wearing)
Rap Binder (US84)	---- 4	(Bulk Samples of Rap Binder Mix)
Wearing Layers (Virgin)	---- 4	(Bulk Samples of Wearing Mix)
AC 10 (used in US 84)	----11	(Used in all Rap Mixes)
Rap Wearing w/AC 10 (US 84)	---- 3	(Self Explanatory)

Bags (8)

Rap SPS-5	----5	(SH52 Rap Used in Binder and Inlay)	
Sand	----1	As Stated Above	These are extra sample bags obtained because of the lack of containers at the time, and are explained
½" Pea Gravel	----1	As Stated Above	
1" Granite	----1	As Stated Above	

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MD SPS-5 and SMA

Aggregate:

Surface Course, Virgin SPS-5	2 BBL
RAP, SPS-5	2 BBL
SMA Aggregate	2 BBL
Binder Course, Virgin	3 5-gallon pails
Binder Course, RAP	3 5-gallon pails

AC:

SMA, Styrelf Modified AC	11 5-gallon pails
Asphalt Cement, Recycled Section (AC-5)	11 5-gallon pails
Asphalt Cement, Virgin Section (AC-20)	11 5-gallon pails

HMAC:

Surface Mix, SMA Type "B"	3 5-gallon pails
Surface Mix, SMA Type "A"	3 5-gallon pails
Virgin Mix, Surface Course, SPS-5 (Agency)	4 5-gallon pails
Recycled Mix, Surface Course, SPS-5 (Agency)	3 5-gallon pails
Surface Course, Virgin Mix	3 5-gallon pails
Binder Course, RAP	3 5-gallon pails
Binder Course, Virgin	3 5-gallon pails
SMA Mix w/styrelf modified AC	4 5-gallon pails

Additives:

Arbesul Cellulose Fibers	1 5-gallon pails
Mineral Filler, SMA Type: All	1 5-gallon pails
Vestoplast, Polyoleofin	1 5-gallon pails
Total	6 - 55 gallon drums
	+ 75- 5 gallon pails

INVENTORY OF MATERIALS AT THE MRL FROM NEW JERSEY SPS-5

AGGREGATES:

Quantity	Description
2 - 55 gal. drums	Combined coarse & fine aggregate, surface course, virgin section
2 - 55 gal. drums	RAP, surface and base courses, recycled section
2 - 55 gal. drums	Combined coarse & fine aggregate open graded, state mix
3 - 5 gal. pails	Coarse aggregate (3/4" - 3/8"), base course, virgin section
3 - 5 gal. pails	Combined coarse & fine aggregate, base course, virgin section
2 - 5 gal. pails	Aggregate without RAP, base course, recycled section

HMAC:

Quantity	Description
3 - 5 gal. pails	Surface course, virgin section
2 - 5 gal. pails	Base course, virgin section
3 - 5 gal. pails	Surface course, recycled section, (30% RAP)
3 - 5 gal. pails	Base course, recycled section, (30% RAP)
5 - 5 gal. pails	Surface course, state mix, (10% RAP)
3 - 5 gal. pails	Base course, state mix, (20% RAP)
3 - 5 gal. pails	Open graded mix with rubber additive

AC:

Quantity	Description
11 - 5 gal. pails	AC-10, Citgo, used for SHRP and state base courses, recycled sections
11 - 5 gal. pails	AC-10, Elf, used for surface course recycled mixes
11 - 5 gal. pails	AC-20, Citgo, used for state mixes
11 - 5 gal. pails	AC-20 with rubber additive, used for open graded mix

ADDITIVE:

Quantity	Description
1 - 5 gal. pail	Ground rubber

TOTAL NO. OF CONTAINERS: 6 - 55 gal. drums / 75 - 5 gal. pails

LIST OF MRL MODIFIERS BY CODE

Anti-Oxidants:

M-AO-001-001

M-AO-002-001

M-AO-003-001

M-AO-004-001

M-AO-005-001

Anti-Stripping Agents:

M-AS-001-001

M-AS-002-001

M-AS-003-001

M-AS-004-001

M-AS-005-001

M-AS-006-001

M-AS-007-001

M-AS-008-001

M-AS-009-001

M-AS-010-001

M-AS-011-001

M-AS-012-001

M-AS-013-001

M-AS-014-001

M-AS-015-001

M-AS-016-001

M-AS-017-001

M-AS-018-001

Anti-Stripping Agents:

M-AS-019-001

M-AS-020-001

M-AS-002-002

M-AS-021-001

M-AS-005-002

M-AS-022-001

M-AS-023-001

M-AS-024-001

M-AS-025-001

Extenders:

M-EX-001-001

M-EX-002-001

Fibers:

M-FB-001-001

M-FB-002-001

Mineral Fillers:

M-MF-002-001

M-MF-001-001

M-MF-001-002

M-MF-001-003

M-MF-001-004

Oxidants:

M-OX-001-001

Recycling Agents:

M-RA-001-001

Thermoplastics:

M-TH-001-001

M-TH-002-001

M-TH-003-001

M-TH-004-001

M-TH-005-001

M-TH-006-001

M-TH-007-001

M-TH-008-001

M-TH-009-001

M-TH-010-001

M-TH-011-001

M-TH-012-001

M-TH-013-001

M-TH-014-001

M-TH-015-001

M-TH-016-001

M-TH-017-001

M-TH-018-001

M-TH-019-001

M-TH-020-001

M-TH-021-001

Thermoplastics:

M-TH-022-001

M-TH-023-001

M-TH-024-001

M-TH-025-001

M-TH-026-001

M-TH-027-001

M-TH-028-001

M-TH-029-001

M-TH-030-001

M-TH-005-002

M-TH-005-003

M-TH-005-004

M-TH-005-005

M-TH-005-006

M-TH-005-007

M-TH-005-008

M-TH-005-009

M-TH-031-001

MATERIALS REFERENCE LIBRARY
SECTION 5
PROTOCOL FOR HANDLING AND USE OF ASPHALT CEMENTS

Procedures for Subdividing Large Samples of Asphalt Cement

All asphalts will be supplied in five gallon epoxy coated containers. The following procedures should be followed to insure that the various SHRP asphalt research activities are utilizing the same asphalt cements with as close to the same physical and chemical characteristics as possible.

The procedures as described below were developed to minimize the physical and chemical changes that might occur in the asphalt cement during the process of subdividing samples into smaller containers. All asphalt cements are to be heated twice before use. The first heating is to subdivide the 5 gallon sample into smaller containers for subsequent use. The second heating occurs at the time of use. Asphalt cement not used after the second heating should be discarded except as noted in Item 12.

> These procedures involve the handling of hot asphalt. Therefore, all necessary safety precautions should be observed. Appropriate clothing such as a long-sleeved shirt, heat resistant gloves, and eye protection must be used by the technician. A log book should be kept for each sample in which each heating of the sample is recorded.

1. Determine the quantities of asphalt cement required for each test or research activity and assemble enough containers of the appropriate size (e.g. 3oz., 6oz., 1 quart, 1 gallon) for 5 gallons of asphalt cement. The smaller samples will be required for the initial tests on a given asphalt cement and for tests requiring a small quantity of asphalt cement.

   NOTE: Care must be taken to properly mark the sample containers. Self-adhesive paper labels are satisfactory to use. It is recommended that in addition to the paper label, a diamond-tipped pencil be used to scratch the sample identification on the bottom of all cans in order to ensure identity in the event the paper label is accidentally damaged.

2. Place the five-gallon sample container in a convection or forced-draft oven set at 275±5°F. The sample container should be loosely covered with a metal lid.

3. After approximately one and one-half hours, the sample should be removed from the oven and an attempt made to stir the sample with a large spatula or metal rod to prevent or minimize local overheating. The sample should be stirred approximately every hour after the initial one and one-half hour period during the heating cycle. For a typical five-gallon AC-20 sample, the heating and retention time in the oven should be approximately five hours. If after five hours the asphalt cannot be poured, the time can be extended but the actual heating time should be noted. See item 10.

NOTE: Watch for the indication or signs of blue smoke from the asphalt, which would indicate overheating. If a noticeable amount of smoke is observed, the oven temperature should be reduced by 10 to 15 F.

4. Place kraft paper or newsprint on the floor in a well ventilated space. Place on the paper properly marked one-gallon and one-quart containers in a sequence convenient for pouring the hot asphalt.

5. On a laboratory bench, or a similar space convenient for handling, line up a sufficient number of three and six ounce appropriately marked containers for smaller test samples. Other size containers can be utilized if appropriate.

6. Remove the five-gallon container from the oven and stir the asphalt for approximately one minute to obtain uniform samples. Completely fill the smaller containers which have been lined up on the floor. It is recommended that either a 2-quart all aluminum or glass sauce pan or a 2-quart glass pitcher be used in filling the smaller containers from the five-gallon container.

NOTE: Care should be taken to avoid any obliteration of the sample identification.

7. At the end of the first heat, determine the viscosity at 140°F and 275°F of the sample by AASHTO T-201 and T-202 procedures. See Item 10.

8. After filling, close all containers tightly, and allow to cool to room temperature, and store in a cool place. Closing containers prior to cooling will produce a vacuum seal.

9. When the stored sample is reheated for the second time, make an appropriate notation on the container and in the sample log book. The heating of a one-gallon sample should require about 3-4 hours. A one-quart sample may require approximately 3 hours. Again, samples should be stirred periodically to prevent local overheating and to check uniformity.

> NOTE: Heating of all samples should be in the same type of equipment and the same temperatures described in Item 2. Hot plates and gas burners are not acceptable devices for heating the samples.

10. Record in the log book the date, duration, and temperature of all heating action and the viscosity at 140°F and 275°F of the asphalt cement sample after the first heating. All exceptions to this protocol should be recorded in the log with justifications for the variance.

11. A nitrogen blanket or purge is not required during the subdividing of asphalt samples. It is recognized that subsequent activity could possibly require that the material be covered with a nitrogen blanket to minimize undesirable or unwanted oxidation. This will be considered to be part of the <u>testing</u> or <u>experimental</u> protocol and should be noted by the researcher.

12. Additional heating of the asphalt cement which is part of a testing or experimental protocol is allowable.