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16. ABSTRACT
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Based on the tests performed in this abrasion project, Pacific Linings and Coatings, formerly C.I.M., showed the best wear resistance to aggregates up to 1" rock. The next best was galvanized steel followed by aluminized steel with alcad aluminum being last.

From this project we have found relationships between the three flow rates and the various materials tested. Our plan is to develop a standard test so that we can take a new material and subject it to a standard number of revolutions with one size aggregate to determine the relative wear characteristics and how long it will last under various flows and bed loads.

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ABRASION EVALUATION OF COATED & UNCOATED C.M.P. INVERT PROTECTION USING DIFFERENT FLOW RATES

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From this project we have found relationships between the three flow rates and the various materials tested. Our plan is to develop a standard test so that we can take a new material and subject it to a standard number of revolutions with one size aggregate to determine the relative wear characteristics and how long it will last under various flows and bed loads.

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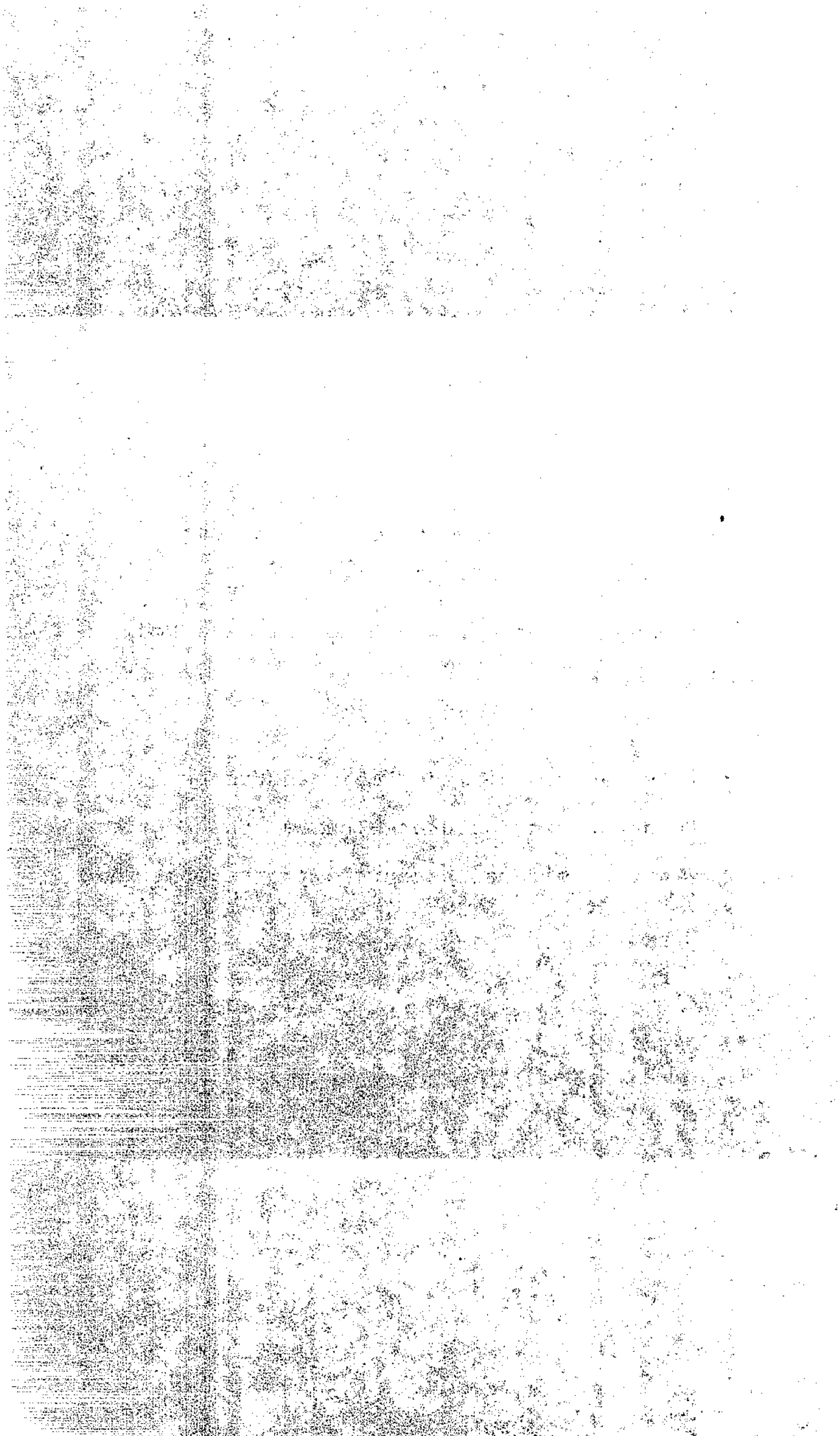

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INTRODUCTION

This research project is a follow-up to two previous projects; one of which was completed on September 10, 1985, titled, "Invert Abrasion Protection for C.M.P."; the second was completed on March 20, 1987, titled, "Evaluation of C.M.P. Invert Protection Under Different Bed Loads". In the second project, it was noted that one of the test coatings, Chevron Industrial Membrane (C.I.M.) now called Pacific Linings & Coatings, (P.L.C.) was more abrasion resistant than the other test coatings under the same test conditions.

This project was planned to test the effects of different flow rates on a variety of aggregate sizes. The first two projects used only one flow rate, 4.60 feet per second. On this project we used the same variety of aggregate gradings but ran them at 3.00 and 6.30 feet per second. The products to be tested would again be uncoated samples of the three most often used corrugated metal pipes; galvanized steel, aluminized steel, and alclad aluminum. The galvanized steel corrugated (2-2/3" x 1/2") pipe would again serve as the standard to which all other materials and coatings would be compared. Since it had performed so well in the other project, we decided to also compare the abrasion rate of the P.L.C. coating under these conditions. We wished to see if it was still a superior product under different flow rates. The 24-inch rotating drum used in previous abrasion tests was also used for this project (see figures 3a and 3b).

Caltrans does not have a method to predict the minimum service life of culverts considering different abrasive bed loads. We hope to combine the information in this report with future research to develop a standard test method. This test method would predict the service life of culverts and/or coatings under abrasive conditions and compare them with the service life of galvanized steel culverts under the same conditions.

The aluminized steel sample was made from 16 gage steel coil that had been hot dipped in commercially pure aluminum to a total thickness (both sides) of 1 oz per square foot (AASHTO M274-81) and formed into 2-2/3" x 1/2" culvert stock. This hot dip process has been used for sewer and drainage pipe for several years. It should be noted that the thickness of a 1 oz coating of aluminum is equal to the thickness of 2.5 oz of zinc.

Alclad aluminum consists of a solid aluminum alloy 3004 core to which a differnt cladding alloy is metallurgically bonded on both sides during hot rolling. The alclad sample was made from 12 gage bonded aluminum coil and formed into 2-2/3" x 1/2" culvert stock. The cladding alloy for alclad 3004, which is used for most drainage products, is 7072 which contains 0.8 to 1.3% zinc and provides galvanic protection to the core alloy (AASHTO* M196-82 and M197-82). The alclad aluminum has been used satisfactorily for culverts and underdrains where soil and water ph are 4 to 9, also where minimum resistivities are greater than 500 ohm-cm. However, the Caltrans Design Manual is more restrictive and requires ph to be between 5.5 and 8.5 and the resistivity to be greater than 1500 ohm-cm.

P.L.C. is a protective coating usually placed on the inside of galvanized corrugated pipe. The polymerizable black liquid, when mixed with an activator, becomes a tough, durable, resilient elastomer. The P.L.C. used on our project was applied by the Pacific Corrugated Pipe Co. to 16 gage galvanized 2-2/3" x 1/2" culvert stock. Approximately 50 mils thickness was applied.

SAMPLE PREPARATION

Samples of each product 7" wide by 17" long were cut from 2-2/3" x 1/2" corrugated metal pipe having a diameter of 48". The thinnest gage produced in that diameter was used for the sample (16 ga. for steel and 12 ga. for aluminum). The plates were shaped to conform to the inside diameter of the 24" drum. Two slotted holes for a 5/16" mounting bolt had to be milled at each end of the plates.

On the backside of all plates, 2 inches in from each side, 52 marks were made to identify the locations where thickness measurements were to be taken (see figure 1). Initially, we had 42 measurement locations, however, we added 5 inches to the length of the samples, giving us 10 additional locations for our "most critical" measurements (see figure 2). The reason for the additional 5 inches was to keep the ends of samples as close together as possible. This kept the aggregate from getting stuck between plates and building up in piles at the ends of the samples. The sample designation, flow rate and water flow direction were also noted on the backside.

ABRASIVE CHARGES

The aggregates used in the various abrasive charges were from the Bear River, north of Colfax near I-80. This material, consisting of large amounts of quartz, is considered one of the hardest river run aggregates in California. Five separate test series were run on the various samples at both the 3.00 and 6.30 feet per second flow rates. The first using a graded sand, followed by aggregate with gradings of 3/8" x No. 4, 3/4" x 1/2",1-1/2" x 1" and finally 2" x 1-1/2". The specific gradation of the sand was as follows:

Sieve Size Pass x Retain	Percent by Weight
4 x 8	10
8 x 16	7
16 x 30	14
30 x 50	49
50 x 100	19
100 x 200	1
200 x ---	0

This is the same gradation as that used in the 1977, 1985 and 1987 studies except the aggregate used in the 1985 study was from a different source.

The two groups of samples were given the following designation:

1) Flow rate of 3.00 feet per second

A - Aluminized steel: A_1 was used for all gradation tests.

B - Galvanized Steel: B_1 as noted above.

C - Alclad aluminum: C_1 as noted above.

D - P.L.C.: D_1 as noted above.

2) Flow Rate of 6.30 feet per second

A - Aluminized Steel: A_1 was used for sand, 1/2" and 1" gradation tests and A_2 for #4 and 1 1/2" gradations.

B - Galvanized steel: B_1 and B_2 as noted above

C - Alclad aluminum: C_1 and C_2 as noted above.

D - P.L.C.: D_1 and D_2 as noted above.

The plates were weighed and thickness measurements were taken before testing and at various intervals. Thicknesses were measured using a 2" x 3" deep, digital outside micrometer.

Pictures of the plates were taken before and after each abrasive charge in both flow rate groups. A continuous foam pad, 8" wide x 2" thick was used under the plates to keep the aggregate from getting under the sample and to contain the wear to the upper surface. The pad also saved the writing on the back from being washed away.

TEST PROCEDURES

After initial measurements and weighing, photographs were taken of the samples. Photographs were also taken of the aggregates before and after they were used. All four sample plates were bolted into the abrasion test drum and the machine was charged with 7 pounds of Bear River material and 35 pounds of water. After sealing the drum watertight, group one was allowed to rotate at approximately 29 revolutions per minute and group two at approximately 61 revolutions per minute. Those rates simulate a flow of close to 3.00 and 6.30 feet per second, respectively. The abrasion machine ran continuously until stopped at predetermined times to check and observe samples. For the graded sand the drum was stopped after each million cycles for evaluation and recharging. For the larger aggregate where the number of revolutions was less than one million, the evaluation was made at the end of that run. In evaluating the samples, the water and aggregate were removed from the drum and the drum was rinsed thoroughly. After washing the samples with clear water, thickness measurements were taken using the digital micrometer. Each one of the 52 measurement locations was read at least three times for an average reading at that one location.

After all measurements and photographs were taken, the samples were replaced and the drum was recharged with 7 pounds of fresh aggregate and 35 pounds of water.

The water remained clear enough to see the sand material. However, with larger rock from #4 to 1-1/2", the water turned dark brown within a few hours due to breakdown of the aggregate.

In the previous tests, we had some problems with pressure developing in the drum. The pressure inside the drum would build up and, if allowed to go unchecked, would blow mud, sand and water out through the plastic window seals. A water sample was taken to our chemical testing unit for analysis. They found that the ph of the water was 9.5 to 10.1 and stated that under these conditions, finely divided aluminum or zinc could form H_2 gas in the water. After receiving this information, we stopped the machine daily and carefully released the internal pressure. After deliberations with our corrosion engineers, it was decided that this condition would not adversely affect the abrasion of the samples. We continued to release the pressure once a day on the project.

After completing more than one half of this research project, we thought it would be a good idea to monitor the ph level. (See data summary sheets). We took ph readings (average of 5.9) on the water before starting any rotations. We also took water samples every time we stopped the machine to release the internal pressure, which was once a day.

TEST RESULTS

There are two data summary sheets located in Appendix B, one for 3.00 f/s and the other for 6.30 f/s, both showing a summary of average "overall" loss of material, average loss at "critical" areas and average loss at "most critical" areas. Note that losses at "most critical" areas are not included in other averages. Photographs of all samples are shown in Appendix C.

GROUP 1
3.00 FPS

Sample B Galvanized Steel

After 3 million revolutions with the sand charge, the sample had very little wear. Total material loss due to the sand was 9 grams per million revolutions or 1.08%.

After 1 million additional revolutions with the 1/2" x #4 aggregate, the sample showed some visible signs of wear. The galvanized coating was 85% removed and the average material loss was twice that due to the sand. Total material loss due to the 1/2" x #4 was 20.5 grams per million revolutions or 2.54%.

After an additional 1/2 million revolutions with the 3/4" x 1/2" aggregate, most of the original coating was gone and the material was spotty from edge to edge. The leading edges of the corrugations were still smooth but the trailing edges were becoming rough and pitted. The ridges appeared to be forming into points rather than being rounded. Total loss due to the 3/4" x 1/2" was 60 grams per million revolutions or 7.62%.

After an additional 1/4 million revolutions with the 1-1/2" x 1" aggregate, the sample was showing signs of heavy wear. Almost all of the original coating was gone. The ridges that were forming into points had become rounded again. All edges were intact, but some thinning at the outside edges could be seen. The surface was pitted and felt like fine sandpaper. Total material loss due to the 1-1/2" x 1" was 100 grams per million revolutions or 13.20%.

After an additional 1/8 million revolutions with 2" x 1-1/2" aggregate, the sample became even more pitted by the larger rock size. The surface felt like rough sandpaper. The material at the outside leading edges had started to disappear and roll under. Thinning could be seen on all of the outside edges.

There appeared to be some skipping of the aggregate as the rock size increased. This is shown as the "critical" points have more loss than the "most critical" points. This sample had a total weight loss due to the 2" x 1-1/2" of 168 grams per million revolutions or 22.96%.

Sample A Aluminized Steel

After 3 million revolutions with the sand charge the sample had very little wear. Total material loss due to the sand was 5 grams per million revolutions or 0.61%. At the "most critical" points the loss was almost identical to that of the galvanized steel sample.

After 1 million additional revolutions with the 1/2" x # 4 aggregate, the sample showed some visible signs of wear. The aluminum coating was 98% removed and the "overall" average material loss was three times that due to the sand. Total material loss due to the 1/2" x #4 was 19.6 grams per million revolutions or 2.44%. This was almost identical to the loss on the galvanized steel sample.

After an additional 1/2 million revolutions with the 3/4" x 1/2" aggregate, the leading edges of the corrugations were still smooth, but the trailing edges were becoming rough and pitted. Total loss due to the 3/4" x 1/2" was 68 grams per million revolutions or 8.70%. This material loss was 12% more than that of the galvanized steel.

After an additional 1/4 million revolutions with the 1-1/2" x 1" aggregate, the sample was showing signs of heavy wear. All of the original coating was gone. The edges were intact but some rounding of the left leading edges had started. The surface was pitted and felt rough like medium sandpaper. Total material loss due to the 1-1/2" x 1" was 136 grams per million revolutions or 18.20%. The loss at the "overall" points was identical to that of the galvanized steel sample.

After an additional 1/8 million revolutions with 2" x 1-1/2" aggregate, the sample became even more pitted by the larger rock size. The surface felt like rough sandpaper. All edges were still intact but some were much more rounded than others. The left edges were showing the heaviest wear by starting to roll under. The front leading edge did roll under. This sample had a total weight loss due to the 2" x 1-1/2" of 184 grams per million revolutions or 25.84%. This was slightly higher than that of the galvanized steel sample.

Sample C Alclad Aluminum

After 3 million revolutions with the sand charge, the overall appearance of the sample looked good despite having twice the loss of galvanized steel. The cladding on the leading slopes of the corrugations was worn off in less than 500,000 revolutions. Total material loss due to the sand was 10 grams per million revolutions or 1.85%.

After 1 million additional revolutions with the 1/2" x #4 aggregate, the sample showed visible signs of wear. The right outside edge had started to lose some material at the "most critical" points. The wear on the impact faces caused the corrugated ridges to become pointed in the middle, but not on the right or left sides of the ridge. Total material loss due to the

1/2" x #4 was 27 grams per million revolutions or 5.30%. This was twice the loss of the galvanized steel sample.

After an additional 1/2 million revolutions with the 3/4" x 1/2" aggregate, the sample showed signs of heavy wear. All ridges were forming into points rather than being rounded. The left leading edges were starting to fold under. The foremost leading edge was starting to lose material. The overall appearance was rough and pitted. Total loss due to the 3/4" x 1/2" was 46 grams per million revolutions or 9.54%. This was nearly twice the loss of the galvanized steel.

After an additional 1/4 million revolutions with the 1-1/2" x 1" aggregate, the sample continued to show signs of heavy wear. The ridges that had formed into points had started to round again. The left leading edge and the sixth edge from the front had folded underneath as had the front bolt hole. All of the outside leading edges showed marked thinning of the aluminum material. The overall appearance looked pitted and felt rough like medium sandpaper. Total material loss due to the 1-1/2" x 1" was 76 grams per million revolutions or 16.56%. This material loss was 25% more than the galvanized steel sample.

After an additional 1/8 million revolutions with 2" x 1-1/2" aggregate, the sample became so pitted by the larger rock size that the material had started to disappear. The third ridge had buckled under and the fourth ridge had started to buckle. All other ridges had flattened somewhat. The overall surface had large shiny spots from the pitting of the big rocks. The surface felt very rough like coarse sandpaper. The skipping of the aggregate was also apparent in this cycle. This sample had a total weight loss due to the 2" x 1-1/2" of 128 grams per million revolutions or 29.14%.

Sample D Pacific Linings & Coatings

After 3 million revolutions with the sand charge, the overall appearance of the sample was very good. "Overall" loss was the same as for the galvanized steel. Total material loss due to the sand was 2 grams per million revolutions or 0.21%. This was just 20% of the loss suffered by the galvanized steel sample.

After 1 million additional revolutions with the 1/2" x #4 aggregate, the sample showed no visible signs of wear and the overall appearance continued to be very good. Average loss at the "most critical" locations was only one-third of other samples. Total material loss due to the 1/2" x #4 was 1.9 grams per million revolutions or 0.20%. This loss was almost the same as that due to sand and was less than 10% of the loss to the galvanized steel sample.

After an additional 1/2 million revolutions with the 3/4" x 1/2" aggregate, the sample still showed no signs of wear. The overall appearance was still very good. Total loss due to the 3/4" x 1/2" was 6 grams per million revolutions or 0.62%. This loss was still less than 10% of the loss to the galvanized steel sample under the same conditions.

After an additional 1/4 million revolutions with the 1-1/2" x 1" aggregate, the sample suddenly started to show signs of heavy wear. The front edge had rolled under and the coating started to peel back. All of the front leading edges were very rough and pitted. Small grains of rock were embedded in the coating material. At this point there were no holes in the coating. The material loss at the "most critical" points was eight times larger than that for the 1/2" rock. Total material loss due to the 1-1/2" x 1" was 36 grams per million revolutions or 2.48%.

This loss was only 36% that of the galvanized steel sample, but the coating was starting to come apart.

After an additional 1/8 million revolutions with 2" x 1-1/2" aggregate, the sample continued to show heavy wear. The coating on the front leading edge was worn off about 1/8 inch. The right and left sides of the rear edge were also missing about 1/8 inch. All of the front leading edges of the ridges were very rough and pitted. The coating material was almost gone along the leading faces. Grains of sand were still embedded in the coating. The skipping of the aggregate was also apparent on this sample as the "critical" points had a higher loss than the "most critical" points. This sample had a total weight loss due to the 2" x 1-1/2" of 56 grams per million revolutions or 5.84%. This loss was 112 grams less than that of the galvanized steel sample, but the mode of failure was completely different.

GROUP 2

6.30 FPS

Sample B Galvanized Steel

After 1 million revolutions with the sand charge, the sample showed some wear, but the overall appearance was good. Total material loss due to the sand was 17 grams per million revolutions or 1.94%.

After 1/2 million revolutions with the 1/2" x #4 aggregate, the sample showed some visible signs of wear. The left outside edge was worn to the point of being rounded. Total material loss due to the 1/2" x #4 was 58 grams per million revolutions or 6.72%.

After an additional 1/5 million revolutions with the 3/4" x 1/2" aggregate, the sample was showing heavy wear. The right outside edge had lost material at the "most critical" points. The right side was worn round and the leading edges on all of the right side had some material missing. Total loss due to the 3/4" x 1/2" was 95 grams per million revolutions or 11.35%.

After an additional 1/4 million revolutions with the 1-1/2" x 1" aggregate, the sample continued to show signs of heavy wear. The front leading edge looked about the same as after the 1/2" aggregate, but was missing more material. It appeared that more material loss had occurred at the "most critical" points, but this was not so. The measured loss at these points was less than that for the 1/2" aggregate. It appears that with this size of aggregate and this speed, the rocks skip over the tops of the corrugations and only hit part of the time. Total material loss due to the 1-1/2" x 1" was 116 grams per million revolutions or 14.20%.

After an additional 1/8 million revolutions with 2" x 1-1/2" aggregate, the sample continued to show heavy wear with deep pitting from the larger rock size. The galvanized coating on the front leading faces was all removed, but on the trailing side was still intact. The surface felt rough like medium sandpaper. The left outside edges had now become worn round. This sample had a total weight loss due to the 2" x 1-1/2" of 152 grams per million revolutions or 18.24%.

Sample A Aluminized Steel

After 1 million revolutions with the sand charge, the sample showed some wear, but the overall appearance was good. Total material loss due to the sand was 11 grams per million revolutions or 1.35%. For reasons unknown, this loss was only half that of the galvanized steel sample.

After 1/2 million revolutions with the <u>1/2" x #4</u> aggregate, the sample showed visible signs of wear. The left outside edge was worn round. Total material loss due to the 1/2" x #4 was 46 grams per million revolutions or 5.74%. Again, this was 12 grams less than that of the galvanized steel sample.

After an additional 1/5 million revolutions with the <u>3/4" x 1/2"</u> aggregate, the sample showed signs of heavy wear. The outside on the right was now losing material at the "most critical" points. The right side was wearing round and beginning to flatten. Total loss due to the 3/4" x 1/2" was 100 grams per million revolutions or 12.80%. This loss was slightly more than that for the galvanized steel sample.

After an additional 1/4 million revolutions with the <u>1-1/2" x 1"</u> aggregate, the sample was still showing signs of heavy wear, especially on the right outside edge and the leading edges. The skipping of the aggregate also happened with this sample. Total material loss due to the 1-1/2" x 1" was 108 grams per million revolutions or 14.24%. This loss was slightly less than that for the galvanized steel sample.

After an additional 1/8 million revolutions with <u>2" x 1-1/2"</u> aggregate, the sample continued to show heavy wear. The aluminized coating on the front leading edges was all removed, but on the trailing edges was still intact. There was deep pitting from the larger rock size. The surface felt rough like medium sandpaper. The left side edges and all of the "most critical" points were showing signs of heavy wear also. This sample had a total weight loss due to the 2" x 1-1/2" of 152 grams per million revolutions or 19.52%. This loss was exactly the same as that of the galvanized steel sample.

Sample C Alclad Aluminum

After 1 million revolutions with the sand charge, this sample showed the most wear. The weight loss was the same as the galvanized steel sample, but represented a larger percentage of the sample weight. Extremely heavy wear could be seen on all leading edges. The right outside edge was worn round. The corrugated ridge was no longer round, it had become somewhat of a sharp ridge. The aluminum cladding on the leading slopes of the corrugations was worn off in less than 150,000 cycles. Total material loss due to the sand was 17 grams per million revolutions or 3.23%.

After 1/2 million revolutions with the 1/2" x #4 aggregate, the sample showed signs of heavy wear. The left outside edge was now also worn round and the right front corner of the sample was worn off. All of the corrugated ridges were pointed instead of round. Total material loss due to the 1/2" x #4 was 54 grams per million revolutions or 8.36%. This loss was again about the same weight loss as for the galvanized steel sample, but was a larger percentage of the sample weight.

After an additional 1/5 million revolutions with the 3/4" x 1/2" aggregate, the sample continued to show signs of heavy wear. The overall appearance had a pitted look. The leading edge on the right top and side was missing. The pointed ridges had again become somewhat rounded on the left side, but not on the right. The first ridge was buckled over and bent downward on the left side. Total loss due to the 3/4" x 1/2" was 80 grams per million revolutions or 16.65%. This was nearly twice the loss of the previous run of 1/2" aggregate, but less than that for the galvanized steel sample.

After an additional 1/4 million revolutions with the 1-1/2" x 1" aggregate, the sample showed signs of extremely heavy wear. The overall appearance was rough with heavy pitting and torn edges.

The first ridge was buckled over at the top from the right side to the center. Ridges 3, 5 and 6 had also started to buckle at the "most critical" location on the right side. At the "most critical" points the aluminum had started to tear back from the left side on all of the ridges, especially the leading edge on the left. The skipping of the aggregate was also apparent with this sample. Total material loss due to the 1-1/2" x 1" was 85 grams per million revolutions or 18.31%. This loss was less than that for the galvanized steel sample, but a larger percentage of the sample.

After an additional 1/8 million revolutions with 2" x 1-1/2" aggregate, the sample continued to show extremely heavy wear. The overall appearance had large shiny spots, mostly on the leading edge from the pitting of the larger rock. The leading surfaces felt very rough like coarse sandpaper, whereas the trailing surfaces felt more like medium to fine sandpaper. The left outside edges had worn round and were thinning. The ridges of the corrugations had started to round off in some places. The right front corner had worn back even more. This sample had a total weight loss due to the 2" x 1-1/2" of 120 grams per million revolutions or 22.80%. Again this loss was less than the galvanized steel, but a larger percentage of the sample weight.

Sample D Pacific Linings & Coatings

After 1 million revolutions with the sand charge, this sample looked very good. Total material loss due to the sand was 2 grams per million revolutions or 0.20 %. This loss was only 10% that of the galvanized steel sample.

After 1/2 million revolutions with the 1/2" x #4 aggregate, the sample showed no visible signs of wear and the overall appearance continued to be very good. Average loss at the "most critical" locations was only one-third that of other samples. Total material loss due to the 1/2" x #4 was 6 grams per million revolutions or 0.60%. Again, this loss was only 10% that of the galvanized steel sample.

After an additional 1/5 million revolutions with the 3/4" x 1/2" aggregate, the sample looked good except for the trailing edge. The coating had started to wear off at that point. There was a small hole about 1/8" in diameter starting to show up 4/5 of the way back from the front on the left side. Some wear in the impact faces could be seen, also scuffing, pitting and roughness, all very small but visible. The coating seemed to be moving around because some to the thickness measurements were greater than before. Total loss due to the 3/4" x 1/2" was 15 grams per million revolutions or 1.50%. The loss was only about 16% of that of the galvanized steel, but it is obvious that the failure mode will be quite different.

After an additional 1/4 million revolutions with the 1-1/2" x 1" aggregate, the sample suddenly started to show signs of extremely heavy wear. The coating was beginning to wear through to the metal at the leading edge, the fourth and fifth corrugations, and at the trailing edge. The leading edge was worn back about 1/8" from the left side over to the center. The fourth corrugation was worn 3/8" from the top of the ridge down through the "most critical" point and over to the center. This was the 1/8" hole that started in the previous run with the 1/2" aggregate. The fifth corrugation was worn in a similar way. All impact faces were very rough with hundreds of small cuts and pits from the large rocks. Total material loss due to the 1-1/2" x 1" was 42 grams per million revolutions or 4.26%. Again the loss of material was small compared to the galvanized steel sample, but the coating was beginning to come apart.

After an additional 1/8 million revolutions with <u>2" x 1-1/2"</u> aggregate, the sample continued to show extremely heavy wear. The overall appearance looked like coarse sandpaper. The left front edge was missing. The right front edge and very last (back) edge had lost all of their coating. The left outside edges at the "most critical" locations all had lost their coating. The leading faces of all the ridges were very rough and pitted. The trailing faces were smooth. The coating material was very thin and many grains of sand had become embedded in the coating. This sample had a total weight loss due to the 2" x 1-1/2" of 88 grams per million revolutions or 8.88%. This loss was small compared to the galvanized steel sample, but it appears that this would be a total failure of the coating.

It was mentioned in the March 20, 1987 report that during each cycle some of the aggregate breaks down and no longer has the same grading as in the beginning. The extent of this factor is quite significant, especially in the larger sizes. After one million cycles, only 3.88 lb were recovered of the original 7 lb of graded sand. Only 4.10 lb of #4 material were recovered after one million cycles. After 500,000 cycles only 3.28 lb of 1/2" aggregate and only 2.65 lb of the 1" rock were recovered after 250,000 cycles. With the 1-1/2" rock there was 3.56 lb left after 125,000 cycles.

The remainder of all of these materials had degraded into rock flour which was taken into suspension or into fine sand which was lost in the foam pads.

Conclusions and Recommendations

Based on the abrasion testing conducted in this research project, Pacific Linings and Coatings, formerly C.I.M., showed the best wear resistance to aggregates up to 1" rock. The next best was galvanized steel followed by aluminized steel with alclad aluminum being last. This was not unexpected since aluminum is the softest metal of the three. Galvanized and aluminized steel were again very close through all of the tests of varying aggregate sizes and flow rates.

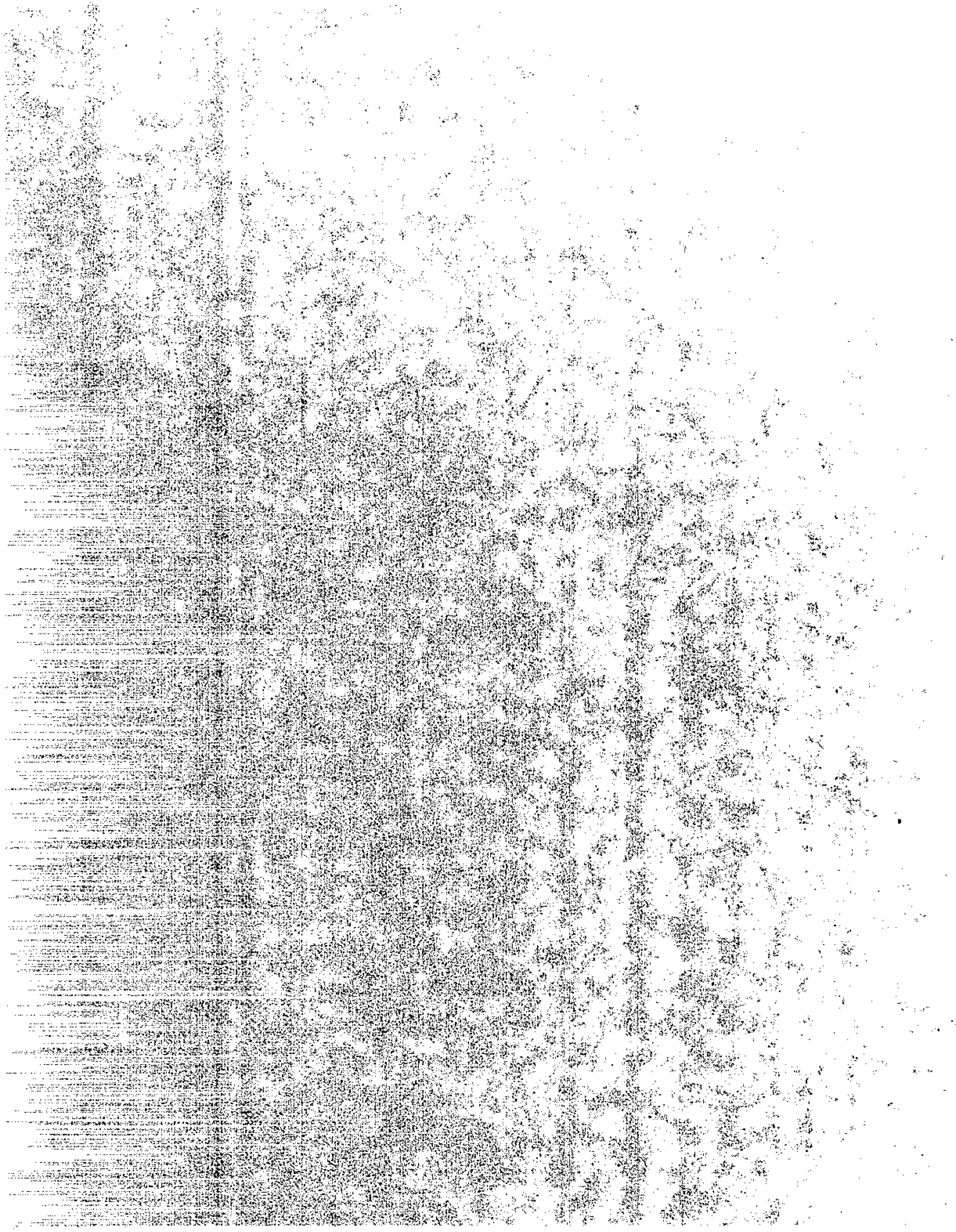
We have confirmed previous findings that significant wear can be obtained by using #4 or 1/2" aggregate only. We have also confirmed that we should not use 1" or 1-1/2" aggregate over 100,000 revolutions at a flow rate of 6.30 feet/second or faster as the rock will beat itself to pieces and cause inconsistent results.

From this project we have found relationships between the three flow rates and the various materials tested.

Our plan is to develop a standard test so that we can take a new material and subject it to a standard number of revolutions with one size aggregate, then interpolate and project the results to predict the wear characteristics and how long it will last under various flows and bed loads.

We recommend further abrasion research be conducted, using #4 or 1/2" aggregate and galvanized steel pipe samples only, to determine a standard flow rate and number of revolutions which will give a significant and consistent wear rate. This could then be used to develop a new standard test procedure using one size of aggregate and one flow rate for accepting new and/or old types of material.

APPENDIX A



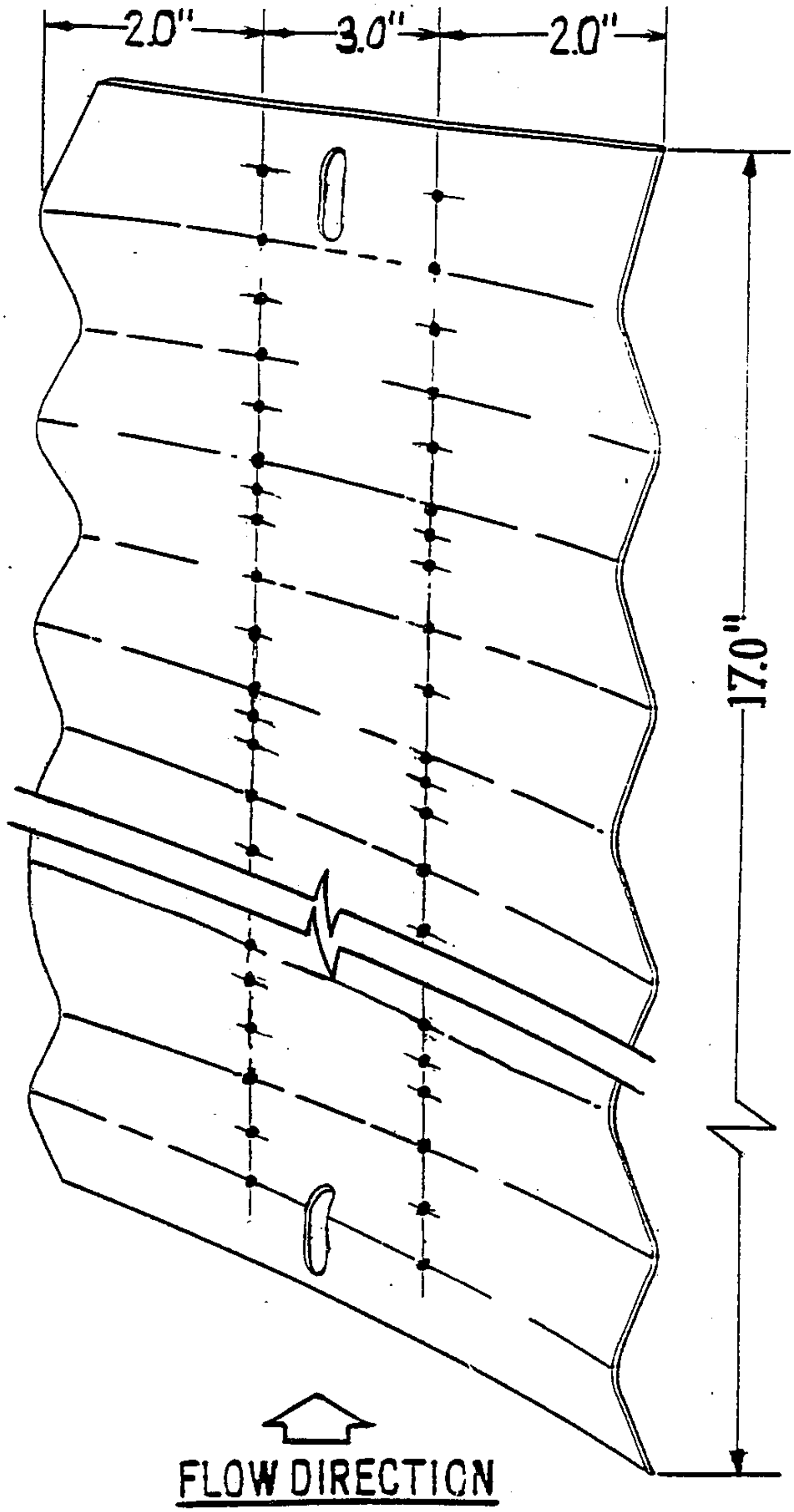


FIGURE 1

Abrasion Test Specimen And Thickness Measurement Locations

MEASUREMENT LOCATIONS

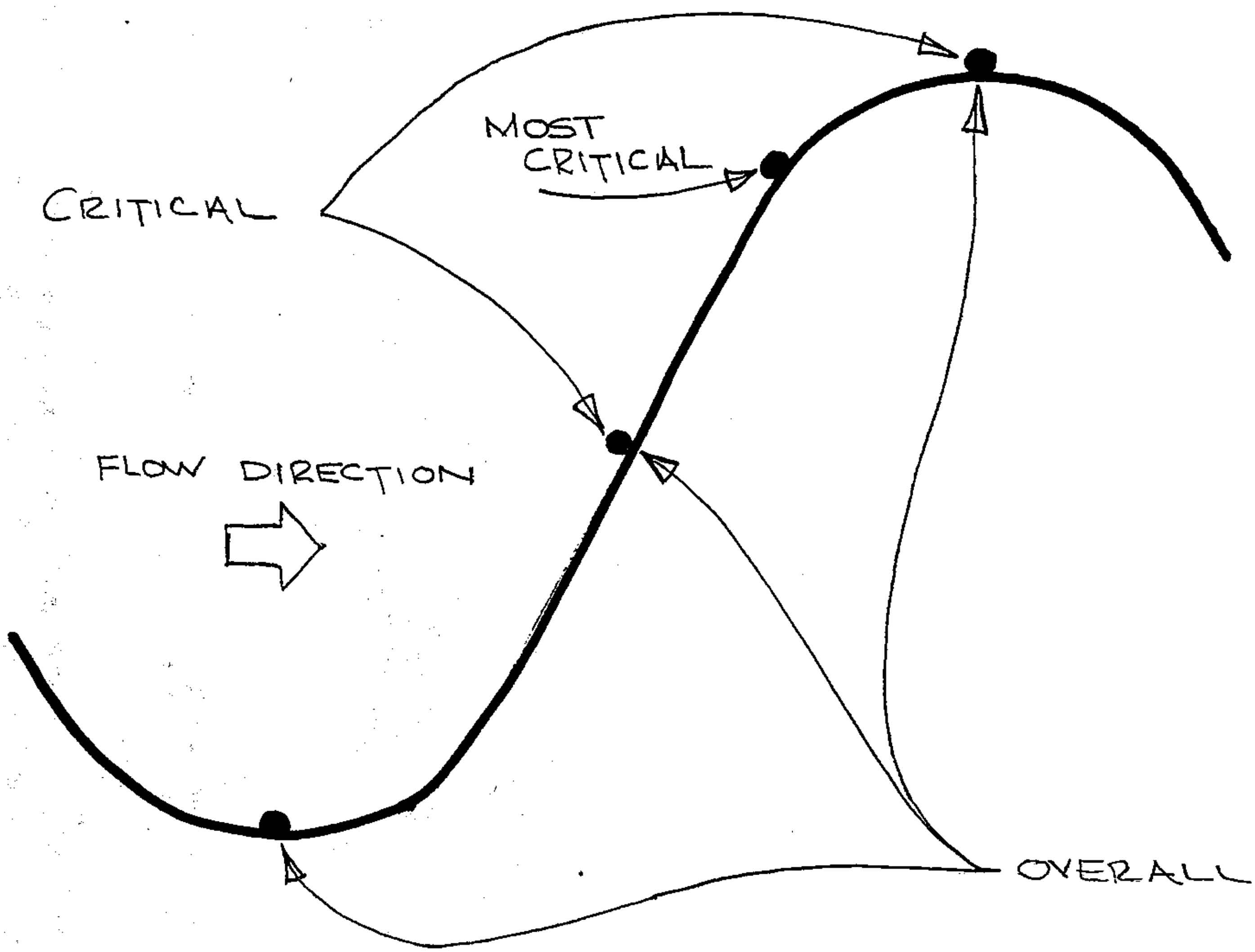
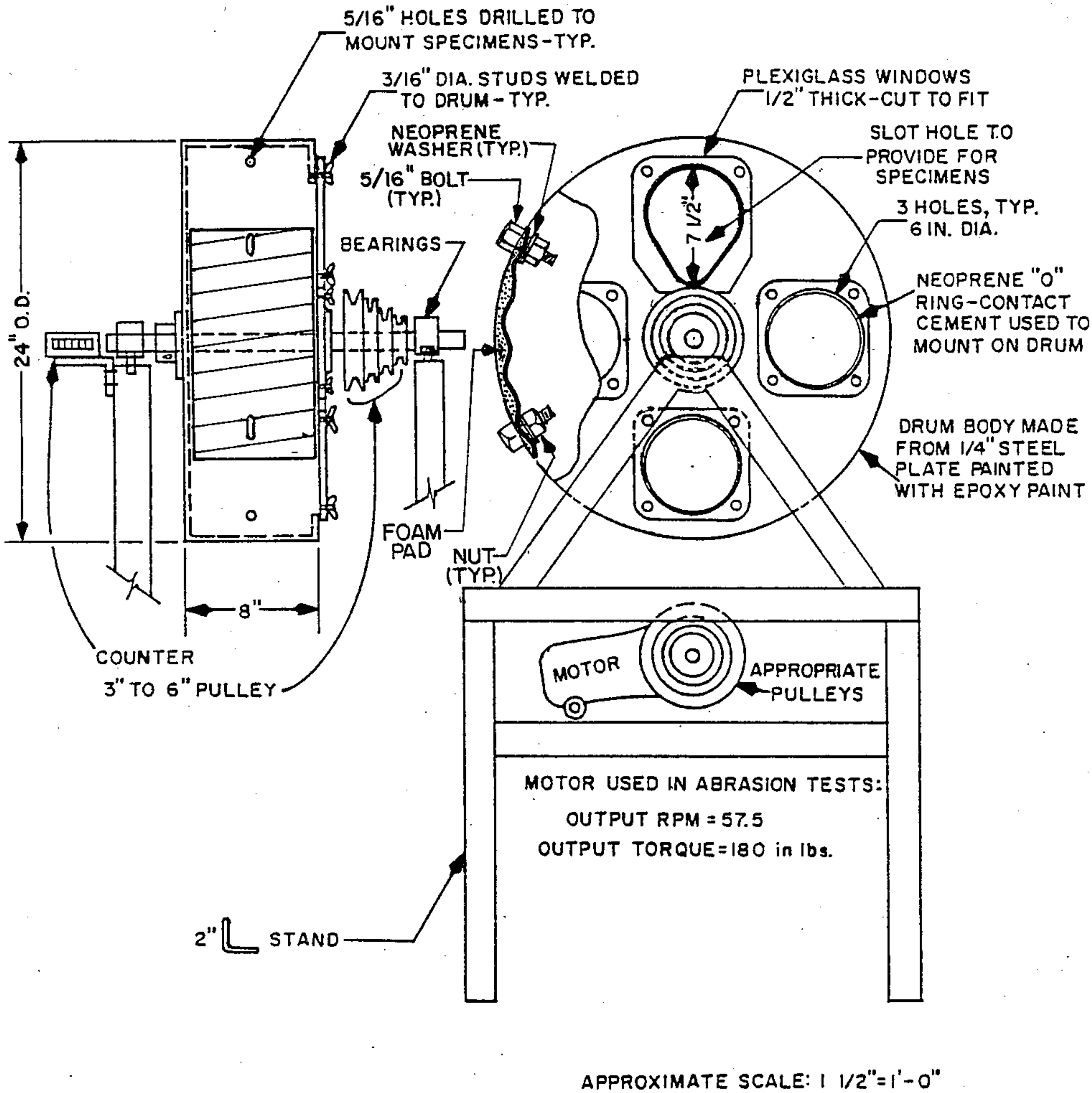
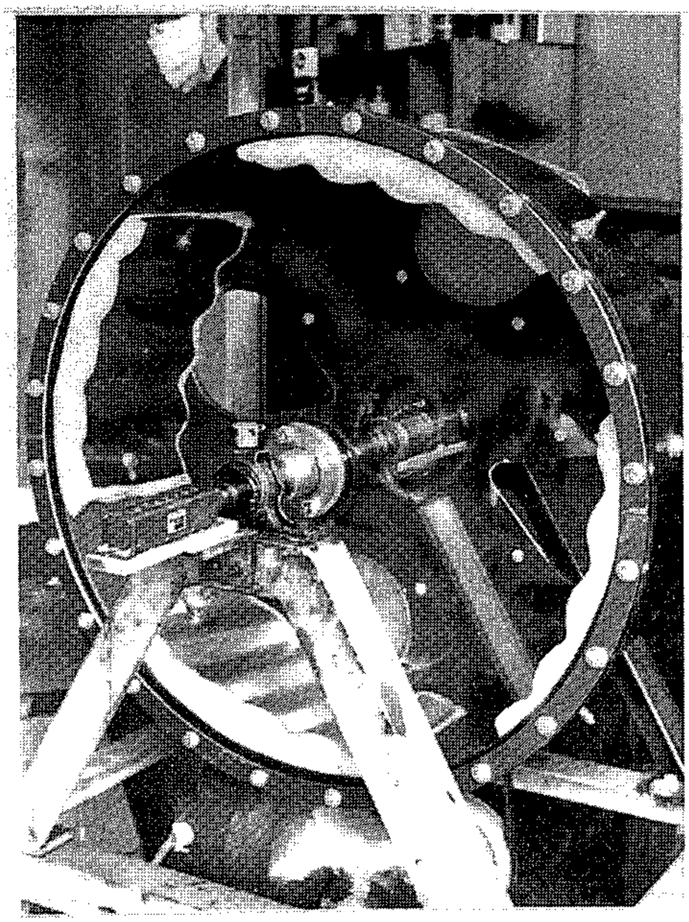


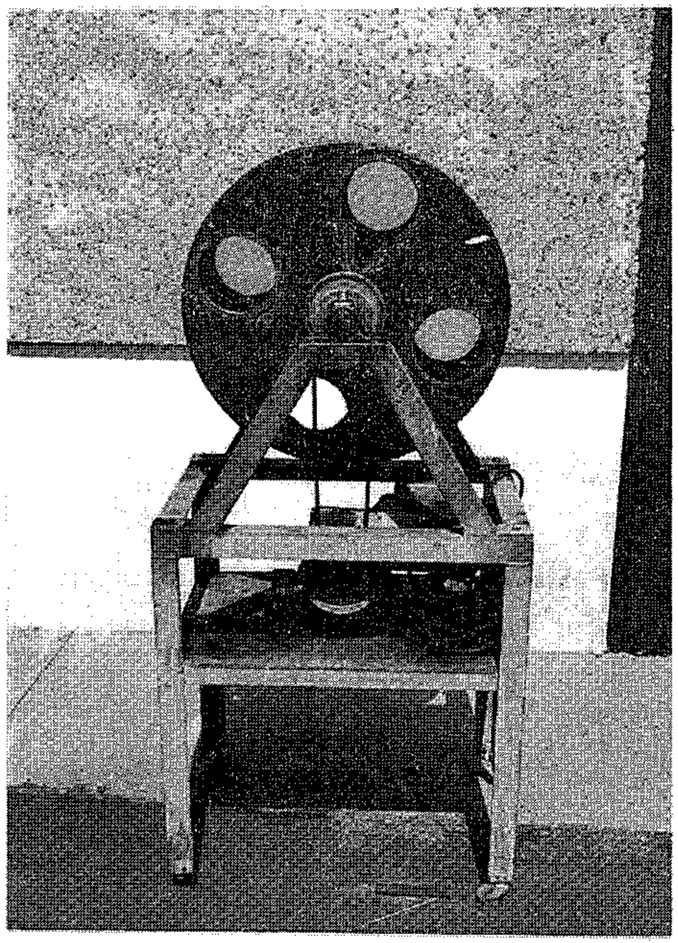
FIGURE 2



ABRASION TESTING MACHINE DETAIL

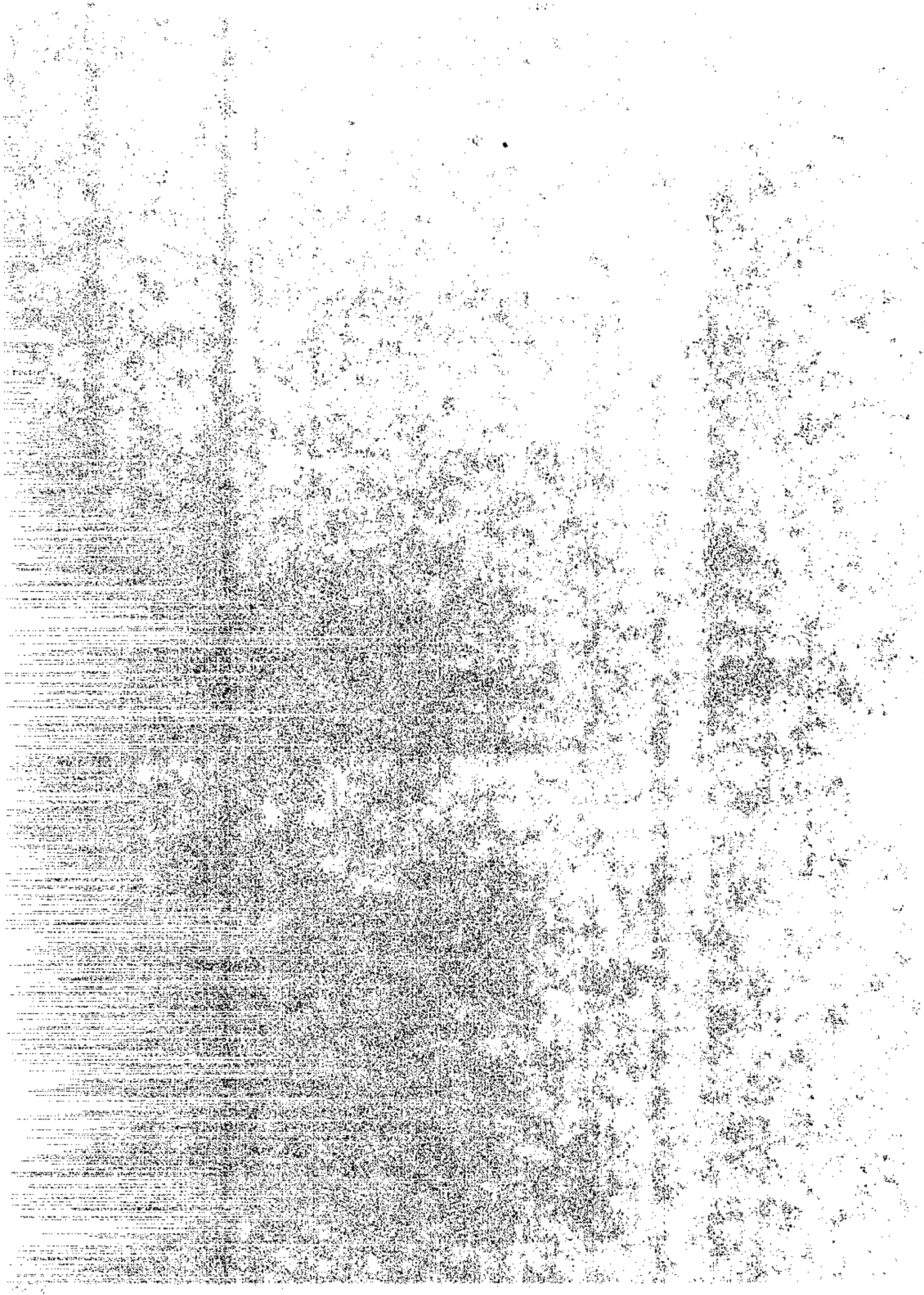
FIGURE 3a





ROTATING DRUM

figure 3b



APPENDIX

B

TEST GROUP 1

3.00 F/S

3.00 Feet Per Second

TYPE OF MATERIAL \ AGGREGATE USED & NUMBER OF ROTATIONS	AVERAGE LOSS PER MILLION ROTATIONS: 3 /Million SAND	1 /Million # 4	1/2 /Million 1/2 "	1/4 /Million 1 "	1/8 /Million 1 1/2 "	
A. ALUMINIZED STEEL						
Overall 42 points	.0007	.0026	.0064	.0104	.0152	
Critical 20 points	.0008	.0031	.0086	.0136	.0224	
* Most Critical 10 points	.0022	.0057	.0130	.0248	.0328	
Weight Loss in grams	5	19.6	68	136	184	
Weight Loss in %	0.61	2.44	8.70	18.20	25.84	
B. GALVANIZED STEEL						
Overall 42 points	.0007	.0016	.0058	.0104	.0184	
Critical 20 points	.0009	.0022	.0086	.0160	.0312	
* Most Critical 10 points	.0020	.0056	.0128	.0200	.0288	
Weight Loss in grams	9	20.5	60	100	168	
Weight Loss in %	1.08	2.54	7.62	13.20	22.96	
C. ALCLAD ALUMINUM						
Overall 41 points	.0015	.0059	.0116	.0188	.0328	
Critical 20 points	.0026	.0097	.0196	.0320	.0568	
* Most Critical 10 points	.0082	.0159	.0222	.0256	.0368	
Weight Loss in grams	10	27.1	46	76	128	
Weight Loss in %	1.85	5.30	9.54	16.56	29.14	
D. P.L.C.						
Overall 42 points	.0007	.0010	.0006	.0040	.0120	
Critical 20 points	.0008	.0010	.0008	.0064	.0416	
* Most Critical 10 points	.0013	.0008	.0014	.0112	.0392	
Weight Loss in grams	2	1.9	6	36	56	
Weight Loss in %	0.21	0.20	0.62	2.48	5.84	
HOURS OF FLOW	565.05	573.65	574.00	574.00	574.00	
FEET PER SECOND	3.03	2.98	2.97	2.97	2.98	
Average pH	-	-	7.53	7.19	6.65	

* - "Most Critical" points are not part of the overall average.

ABRASION RATIOS for 3.00 Feet Per Second	AVERAGE PER MILLION				
	SAND	# 4	1/2 "	1 "	1 1/2 "
	OVER SAND	OVER SAND	OVER SAND	OVER SAND	OVER SAND
A. ALUMINIZED STEEL					
Overall	1	3.71	9.14	14.86	21.71
Critical	1	3.88	10.75	17.00	28.00
Most Critical	1	2.59	5.91	11.27	14.91
Weight Loss	1	3.92	19.60	27.20	36.80
B. GALVANIZED STEEL					
Overall	1	2.29	8.29	14.86	26.29
Critical	1	2.44	9.56	17.78	34.67
Most Critical	1	2.80	6.40	10.00	14.40
Weight Loss	1	2.28	6.67	11.11	18.67
C. ALCLAD ALUMINUM					
Overall	1	3.93	7.73	12.53	21.87
Critical	1	3.73	7.54	12.31	21.85
Most Critical	1	1.94	2.71	3.12	4.49
Weight Loss	1	2.71	4.60	7.60	12.80
D. P.L.C. COATING					
Overall	1	1.43	0.86	5.71	17.14
Critical	1	1.25	1.00	8.00	52.00
Most Critical	1	0.62	1.08	8.62	30.15
Weight Loss	1	0.95	3.00	18.00	28.00

SAND

(3.00 Feet Per Second)

T H I C K N E S S   M E A S U R E M E N T S

ALUMINIZED STEEL CORRUGATED PIPE
BEAR RIVER SAND

"A_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		1,002,804		1,000,487		1,000,146	
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	817g		812g		806g		802g	
1	.0571	.0582	.0573	.0577	.0573	.0577	.0573	.0577
2	.0604	.0607	.0591	.0605	.0585	.0600	.0581	.0597
A	.0606	.0604	.0577	.0575	.0545	.0546	.0539	.0535
3	.0595	.0600	.0587	.0577	.0580	.0565	.0575	.0570
4	.0587	.0587	.0584	.0591	.0584	.0591	.0575	.0575
5	.0585	.0562	.0578	.0558	.0572	.0556	.0571	.0553
6	.0584	.0564	.0578	.0565	.0569	.0552	.0563	.0549
B	.0574	.0595	.0546	.0553	.0522	.0532	.0514	.0526
7	.0584	.0573	.0568	.0571	.0565	.0554	.0562	.0553
8	.0620	.0639	.0614	.0634	.0613	.0633	.0607	.0605
9	.0603	.0594	.0600	.0586	.0596	.0580	.0586	.0562
10	.0586	.0601	.0580	.0587	.0568	.0565	.0560	.0557
C	.0584	.0580	.0550	.0565	.0518	.0550	.0496	.0539
11	.0584	.0598	.0575	.0593	.0562	.0581	.0558	.0560
12	.0642	.0601	.0635	.0587	.0619	.0586	.0611	.0573
13	.0610	.0590	.0599	.0586	.0600	.0582	.0602	.0581
14	.0617	.0607	.0601	.0590	.0597	.0584	.0587	.0569
D	.0597	.0593	.0561	.0561	.0526	.0541	.0511	.0531
15	.0573	.0573	.0569	.0568	.0561	.0553	.0559	.0545
16	.0608	.0596	.0596	.0590	.0596	.0585	.0594	.0581
17	.0611	.0586	.0603	.0577	.0596	.0575	.0583	.0575
18	.0589	.0580	.0584	.0578	.0578	.0570	.0579	.0568
E	.0576	.0588	.0549	.0564	.0524	.0543	.0506	.0530
19	.0583	.0575	.0580	.0560	.0572	.0548	.0566	.0545
20	.0605	.0611	.0603		.0594		.0593	.0600
21	.0563	.0594	.0565	.0588	.0564	.0574	.0664	.0572

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

GALVANIZED STEEL CORRUGATED PIPE
BEAR RIVER SAND

"B_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		1,002,804		1,000,487		1,000,146	
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	836g		825g		816g		809g	
1	.0612	.0626	.0608	.0592	.0606	.0572	.0606	.0572
2	.0601	.0619	.0602	.0612	.0597	.0599	.0589	.0596
A	.0606	.0612	.0594	.0575	.0583	.0545	.0547	.0541
3	.0599	.0592	.0600	.0580	.0584	.0571	.0576	.0569
4	.0624	.0618	.0618	.0608	.0615	.0596	.0615	.0591
5	.0617	.0609	.0610	.0610	.0607	.0595	.0594	.0595
6	.0630	.0596	.0618	.0599	.0611	.0587	.0600	.0587
B	.0610	.0594	.0585	.0574	.0569	.0560	.0539	.0549
7	.0594	.0597	.0593	.0579	.0579	.0569	.0576	.0563
8	.0627	.0609	.0616	.0613	.0615	.0608	.0609	.0606
9	.0616	.0606	.0607	.0598	.0604	.0597	.0603	.0597
10	.0613	.0619	.0593	.0601	.0593	.0596	.0585	.0584
C	.0598	.0589	.0576	.0568	.0547	.0545	.0535	.0537
11	.0607	.0602	.0601	.0582	.0587	.0580	.0584	.0578
12	.0625	.0622	.0621	.0611	.0619	.0606	.0617	.0593
13	.0607	.0585	.0594	.0583	.0589	.0581	.0583	.0581
14	.0615	.0603	.0602	.0597	.0592	.0592	.0575	.0586
D	.0597	.0588	.0557	.0546	.0531	.0528	.0520	.0516
15	.0607	.0605	.0591	.0582	.0577	.0577	.0566	.0575
16	.0626	.0612	.0625	.0616	.0619	.0609	.0614	.0603
17	.0604	.0605	.0595	.0602	.0580	.0601	.0580	.0590
18	.0625	.0610	.0608	.0604	.0594	.0603	.0595	.0598
E	.0591	.0577	.0557	.0563	.0540	.0546	.0537	.0544
19	.0625	.0610	.0595	.0596	.0583	.0591	.0581	.0586
20	.0615	.0610	.0611	.0611	.0607	.0608	.0602	.0606
21	.0596	.0589	.0596	.0587	.0594	.0584	.0591	.0582

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

ALCLAD ALUMINUM CORRUGATED PIPE
BEAR RIVER SAND

"C_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		1,002,804		1,000,487		1,000,146	
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	541g		528g		518g		511g	
1	.0990	.0985	.0981	.0975	.0978	.0965	.0977	.0965
2	.1051	.1042	.1010	.1041	.0991	.1018	.0985	.1010
A	.1033	.1057	.0919	.0953	.0810	.0913	.0752	.0890
3	.1026	.1004	.0989	.0947	.0936	.0889	.0869	.0857
4	.1057	.1066	.1057	.1062	.1052	.1057	.1049	.1056
5	.1027	.1013	.1019	.0999	.1014	.0996	.1014	.0996
6	.1070	.1053	.1042	.1035	.1019	.1022	.1010	.0996
B	.1048	.1055	.0885	.0940	.0765	.0903	.0706	.0838
7	.1016	.1012	.0986	.0962	.0938	.0930	.0896	.0875
8	.1060	.1048	.1046	.1043	.1039	.1040	.1039	.1036
9	.0969	.0968	.0970	.0965	.0960	.0963	.0960	.0963
10	.1061	.1040	.1039	.1028	.1016	.1006	.0989	.0993
C	.1055	.1043	.0924	.0963	.0880	.0923	.0817	.0890
11	.1011	.1010	.1003	.0996	.0971	.0970	.0959	.0954
12	.1055	.1046	.1049	.1046	.1044	.1038	.1040	.1138
13	.0994	.0984	.0991	.0982	.0985	.0971	.0983	.0969
14	.1057	.1048	.1047	.1038	.1033	.1016	.1007	.0997
D	.1038	.1038	.0901	.0932	.0828	.0837	.0764	.0781
15	.1040	.1031	.1007	.0988	.0972	.0953	.0948	.0939
16	.1062	.1050	.1061	.1052	.1055	.1037	.1048	.1037
17	.0997	.0995	.0986	.0990	.0984	.0989	.0982	.0986
18	.1064	.1044	.1022	.1035	.1002	.0990	.0993	.0990
E	.1038	.1024	.0902	.0918	.0804	.0862	.0718	.0826
19	.1004	.1031	.0989	.0992	.0961	.0975	.0936	.0958
20	.1058	.1071	.1057	.1062	.1051	.1046	.1050	.1046
21	--	.1022	--	.0985	--	.0979	--	.0975

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

P.L.C. COATING OVER GALVANIZED CORRUGATED PIPE
BEAR RIVER SAND

"D_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		1,002,804		1,000,487		1,000,146	
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	974g		972g		970g		968g	
1	.1091	.1030	.1073	.1012	.1069	.1019	.1068	.1017
2	.1069	.1048	.1069	.1044	.1063	.1031	.1057	.1028
A	.1083	.1125	.1049	.1118	.1040	.1047	.1037	.1051
3	.1143	.1081	.1129	.1069	.1108	.1067	.1092	.1064
4	.1119	.1145	.1107	.1137	.1102	.1124	.1108	.1117
5	.1134	.1148	.1135	.1148	.1132	.1123	.1130	.1122
6	.1071	.1141	.1054	.1134	.1055	.1131	.1056	.1093
B	.1039	.1028	.1025	.1024	.1019	.1001	.1007	.1016
7	.1055	.1049	.1045	.1040	.1043	.1040	.1029	.1032
8	.1052	.1088	.1039	.1063	.1044	.1061	.1033	.1060
9	.1072	.1120	.1052	.1111	.1054	.1112	.1052	.1111
10	.0995	.1047	.0996	.1054	.0995	.1038	.0997	.1014
C	.0975	.0959	.0962	.0964	.0958	.0943	.0934	.0961
11	.0963	.1017	.0963	.1017	.0966	.0996	.0951	.0975
12	.1018	.1067	.1015	.1045	.1010	.1036	.1001	.1039
13	.1035	.1049	.1025	.1051	.1027	.1049	.1025	.1049
14	.0987	.1089	.0978	.1058	.0975	.1055	.0966	.1050
D	.0889	.0961	.0869	.0955	.0860	.0865	.0843	.0944
15	.0962	.0964	.0965	.0959	.0957	.0962	.0906	.0961
16	.0975	.1114	.0976	.1114	.0976	.1081	.0971	.1079
17	.0992	.1124	.0987	.1122	.0975	.1108	.0972	.1107
18	.0884	.1045	.0877	.1047	.0870	.1043	.0873	.1038
E	.0893	.1052	.0877	.1039	.0874	.0898	.0861	.1006
19	.0937	.1087	.0948	.1105	.0935	.1093	.0913	.1084
20	.0983	.1154	.0982	.1154	.0982	.1145	.0978	.1144
21	.0931	.1052	.0929	.1051	.0925	.1031	.0916	.1036

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

#4 AGGREGATE

(3.00 Feet Per Second)

THICKNESS MEASUREMENTS

ALUMINIZED STEEL CORRUGATED PIPE
BEAR RIVER #4 AGGREGATE

"A_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		1,072,087					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	802g		781g					
1	.0573	.0577	.0573	.0577				
2	.0581	.0597	.0572	.0556				
A	.0539	.0535	.0476	.0484				
3	.0575	.0570	.0545	.0563				
4	.0575	.0575	.0561	.0568				
5	.0571	.0553	.0542	.0545				
6	.0563	.0549	.0538	.0533				
B	.0514	.0526	.0432	.0458				
7	.0562	.0553	.0525	.0509				
8	.0607	.0605	.0595	.0561				
9	.0586	.0562	.0557	.0554				
10	.0560	.0557	.0524	.0527				
C	.0476	.0539	.0442	.0485				
11	.0588	.0560	.0512	.0524				
12	.0611	.0573	.0593	.0565				
13	.0602	.0581	.0570	.0557				
14	.0587	.0569	.0519	.0541				
D	.0511	.0531	.0452	.0461				
15	.0559	.0545	.0530	.0525				
16	.0594	.0581	.0575	.0563				
17	.0583	.0575	.0549	.0549				
18	.0579	.0568	.0537	.0528				
E	.0506	.0530	.0451	.0476				
19	.0566	.0545	.0522	.0512				
20	.0593	.0600	.0585	.0579				
21	.0664	.0572	.0575	.0534				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

GALVANIZED STEEL CORRUGATED PIPE
BEAR RIVER #4 AGGREGATE

"B_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		1,072,087					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	809g		787g					
1	.0606	.0572	.0591	.0560				
2	.0589	.0596	.0554	.0568				
A	.0547	.0541	.0474	.0487				
3	.0576	.0569	.0543	.0547				
4	.0615	.0591	.0609	.0585				
5	.0594	.0595	.0584	.0585				
6	.0600	.0587	.0580	.0560				
B	.0539	.0549	.0490	.0488				
7	.0576	.0563	.0561	.0548				
8	.0609	.0606	.0588	.0602				
9	.0603	.0597	.0601	.0576				
10	.0585	.0584	.0574	.0577				
C	.0535	.0537	.0476	.0477				
11	.0584	.0578	.0544	.0560				
12	.0617	.0593	.0605	.0578				
13	.0583	.0581	.0565	.0570				
14	.0575	.0586	.0563	.0559				
D	.0520	.0516	.0455	.0444				
15	.0566	.0575	.0506	.0548				
16	.0614	.0603	.0602	.0592				
17	.0580	.0590	.0569	.0575				
18	.0595	.0598	.0574	.0582				
E	.0537	.0544	.0487	.0487				
19	.0581	.0586	.0562	.0555				
20	.0602	.0606	.0602	.0598				
21	.0591	.0582	.0588	.0574				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

THICKNESS MEASUREMENTS

ALCLAD ALUMINUM CORRUGATED PIPE
BEAR RIVER #4 AGGREGATE

"C_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		1,072,087					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	511g		482g					
1	.0977	.0965	.0977	.0943				
2	.0985	.1010	.0944	.0971				
A	.0752	.0890	.0580	.0752				
3	.0869	.0857	.0658	.0677				
4	.1049	.1056	.1029	.1032				
5	.1014	.0996	.1009	.0978				
6	.1010	.0996	.0925	.0919				
B	.0706	.0838	.0490	.0646				
7	.0896	.0875	.0624	.0671				
8	.1039	.1036	.1019	.1036				
9	.0960	.0963	.0950	.0961				
10	.0989	.0993	.0951	.0930				
C	.0817	.0890	.0639	.0683				
11	.0959	.0954	.0838	.0838				
12	.1040	.1138	.1027	.1044				
13	.0983	.0969	.0966	.0950				
14	.1007	.0997	.0970	.0939				
D	.0764	.0781	.0624	.0593				
15	.0948	.0939	.0786	.0804				
16	.1048	.1037	.1036	.1020				
17	.0982	.0986	.0953	.0965				
18	.0993	.0990	.0966	.0931				
E	.0718	.0826	.0594	.0669				
19	.0936	.0958	.0856	.0892				
20	.1050	.1046	.1036	.1022				
21	-	.0975	-	.0972				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

P.L.C. COATING OVER GALVANIZED CORRUGATED PIPE
BEAR RIVER #4 AGGREGATE

"D_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		1,027,087					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	968g		966g					
1	.1068	.1017	.1067	.1014				
2	.1057	.1028	.1057	.1036				
A	.1037	.1051	.1022	.1049				
3	.1092	.1064	.1086	.1067				
4	.1108	.1117	.1099	.1115				
5	.1130	.1122	.1102	.1123				
6	.1056	.1093	.1049	.1094				
B	.1007	.1016	.1006	.1010				
7	.1029	.1032	.1017	.1040				
8	.1033	.1060	.1006	.1067				
9	.1052	.1111	.1055	.1107				
10	.0997	.1014	.0991	.1008				
C	.0934	.0961	.0926	.0949				
11	.0951	.0975	.0937	.0972				
12	.1001	.1039	.0993	.1036				
13	.1025	.1049	.1020	.1042				
14	.0966	.1050	.0961	.1050				
D	.0843	.0944	.0827	.0941				
15	.0906	.0961	.0892	.0945				
16	.0971	.1079	.0971	.1079				
17	.0972	.1107	.0957	.1114				
18	.0873	.1038	.0862	.1000				
E	.0861	.1006	.0849	.0995				
19	.0913	.1084	.0903	.1083				
20	.0978	.1144	.0950	.1141				
21	.0916	.1036	.0890	.1045				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

1/2" AGGREGATE

(3.00 Feet Per Second)

THICKNESS MEASUREMENTS

ALUMINIZED STEEL CORRUGATED PIPE
BEAR RIVER 1/2" AGGREGATE

"A_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		500,000 x 2					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	781g		747g					
1	.0573	.0577	.0575	.0577				
2	.0572	.0556	.0556	.0521				
A	.0476	.0484	.0433	.0407				
3	.0545	.0563	.0517	.0518				
4	.0561	.0568	.0560	.0568				
5	.0542	.0545	.0542	.0513				
6	.0538	.0533	.0491	.0482				
B	.0432	.0458	.0399	.0376				
7	.0525	.0509	.0496	.0459				
8	.0595	.0561	.0568	.0561				
9	.0557	.0554	.0519	.0518				
10	.0524	.0527	.0481	.0471				
C	.0442	.0485	.0385	.0414				
11	.0512	.0524	.0507	.0492				
12	.0593	.0565	.0573	.0564				
13	.0570	.0557	.0556	.0536				
14	.0519	.0541	.0470	.0491				
D	.0452	.0461	.0383	.0377				
15	.0530	.0525	.0491	.0458				
16	.0575	.0563	.0575	.0562				
17	.0549	.0549	.0530	.0532				
18	.0537	.0528	.0478	.0483				
E	.0451	.0476	.0396	.0402				
19	.0522	.0512	.0484	.0467				
20	.0585	.0579	.0567	.0567				
21	.0575	.0534	.0546	.0516				

OVERALL = 1-21 LOCATIONS

CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS

MOST CRITICAL = A-E LOCATIONS

THICKNESS MEASUREMENTS

GALVANIZED STEEL CORRUGATED PIPE
BEAR RIVER 1/2" AGGREGATE

"B_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		500,00 x 2					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	787g		757g					
1	.0591	.0560	.0551	.0516				
2	.0554	.0568	.0502	.0491				
A	.0474	.0487	.0416	.0400				
3	.0543	.0547	.0494	.0475				
4	.0609	.0585	.0593	.0572				
5	.0584	.0585	.0564	.0561				
6	.0580	.0560	.0555	.0502				
B	.0490	.0488	.0436	.0415				
7	.0561	.0548	.0523	.0509				
8	.0588	.0602	.0586	.0597				
9	.0601	.0576	.0569	.0567				
10	.0574	.0577	.0545	.0547				
C	.0476	.0477	.0430	.0396				
11	.0544	.0560	.0534	.0522				
12	.0605	.0578	.0596	.0574				
13	.0565	.0570	.0554	.0531				
14	.0563	.0559	.0534	.0519				
D	.0455	.0444	.0419	.0349				
15	.0506	.0548	.0444	.0454				
16	.0602	.0592	.0602	.0588				
17	.0569	.0575	.0558	.0573				
18	.0574	.0582	.0555	.0532				
E	.0487	.0487	.0455	.0413				
19	.0562	.0555	.0554	.0525				
20	.0602	.0598	.0593	.0595				
21	.0588	.0574	.0579	.0564				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

ALCLAD ALUMINUM CORRUGATED PIPE
BEAR RIVER 1/2" AGGREGATE

"C_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		500,000 x 2					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	482g		459g					
1	.0977	.0943	.0956	.0925				
2	.0944	.0971	.0884	.0844				
A	.0580	.0752	.0508	.0593				
3	.0658	.0677	.0566	.0517				
4	.1029	.1032	.1017	.1002				
5	.1009	.0978	.0966	.0941				
6	.0925	.0919	.0862	.0815				
B	.0490	.0646	.0386	.0486				
7	.0624	.0671	.0516	.0506				
8	.1019	.1036	.1011	.1017				
9	.0950	.0961	.0950	.0943				
10	.0951	.0930	.0882	.0862				
C	.0639	.0683	.0565	.0552				
11	.0838	.0838	.0767	.0701				
12	.1027	.1044	.1023	.1022				
13	.0966	.0950	.0960	.0943				
14	.0970	.0939	.0918	.0875				
D	.0624	.0593	.0563	.0485				
15	.0786	.0804	.0690	.0625				
16	.1036	.1020	.1030	.1005				
17	.0953	.0965	.0952	.0931				
18	.0966	.0931	.0883	.0843				
E	.0594	.0669	.0510	.0508				
19	.0856	.0892	.0790	.0791				
20	.1036	.1022	.1024	.1014				
21	--	.0972	--	.0946				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

P.L.C. COATING OVER GALVANIZED CORRUGATED PIPE
BEAR RIVER 1/2" AGGREGATE

"D_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		500,000 x 2					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	966g		963g					
1	.1067	.1014	.1066	.1011				
2	.1057	.1036	.1054	.1034				
A	.1022	.1049	.1014	.1048				
3	.1086	.1067	.1079	.1058				
4	.1099	.1115	.1097	.1114				
5	.1102	.1123	.1098	.1121				
6	.1049	.1094	.1045	.1092				
B	.1006	.1010	.1001	.1007				
7	.1017	.1040	.1013	.1034				
8	.1006	.1067	.0999	.1066				
9	.1055	.1107	.1051	.1105				
10	.0991	.1008	.0991	.1005				
C	.0926	.0949	.0915	.0946				
11	.0937	.0972	.0938	.0970				
12	.0993	.1036	.0992	.1034				
13	.1020	.1042	.1017	.1043				
14	.0961	.1050	.0961	.1050				
D	.0827	.0941	.0810	.0931				
15	.0892	.0945	.0888	.0944				
16	.0971	.1079	.0971	.1078				
17	.0957	.1114	.0957	.1110				
18	.0862	.1000	.0859	.0998				
E	.0849	.0995	.0845	.0989				
19	.0903	.1083	.0893	.1081				
20	.0950	.1141	.0946	.1139				
21	.0890	.1045	.0889	.1044				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

1" AGGREGATE

(3.00 Feet Per Second)

THICKNESS MEASUREMENTS

ALUMINIZED STEEL CORRUGATED PIPE
BEAR RIVER 1" AGGREGATE

"A_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		250,000 x 4					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	747g		713g					
1	.0573	.0577	.0573	.0577				
2	.0556	.0521	.0501	.0481				
A	.0433	.0407	.0382	.0335				
3	.0517	.0518	.0493	.0463				
4	.0560	.0568	.0549	.0538				
5	.0542	.0513	.0519	.0492				
6	.0491	.0482	.0471	.0457				
B	.0399	.0376	.0313	.0304				
7	.0496	.0459	.0474	.0406				
8	.0568	.0561	.0550	.0558				
9	.0519	.0518	.0506	.0492				
10	.0481	.0471	.0464	.0433				
C	.0385	.0414	.0339	.0349				
11	.0507	.0492	.0474	.0452				
12	.0573	.0564	.0562	.0544				
13	.0556	.0536	.0533	.0507				
14	.0470	.0491	.0455	.0456				
D	.0383	.0377	.0333	.0307				
15	.0491	.0458	.0469	.0397				
16	.0575	.0562	.0552	.0554				
17	.0530	.0532	.0518	.0518				
18	.0478	.0483	.0433	.0459				
E	.0396	.0402	.0357	.0336				
19	.0484	.0467	.0470	.0420				
20	.0567	.0567	.0567	.0547				
21	.0546	.0516	.0538	.0499				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

GALVANIZED STEEL CORRUGATED PIPE
BEAR RIVER 1" AAGGREGATE

"B_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		250,000 x 4					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	757g		732g					
1	.0551	.0516	.0539	.0508				
2	.0502	.0491	.0470	.0462				
A	.0416	.0400	.0369	.0349				
3	.0494	.0475	.0450	.0418				
4	.0593	.0572	.0578	.0563				
5	.0564	.0561	.0547	.0534				
6	.0555	.0502	.0506	.0466				
B	.0436	.0415	.0390	.0357				
7	.0523	.0509	.0494	.0461				
8	.0586	.0597	.0586	.0597				
9	.0569	.0567	.0559	.0553				
10	.0545	.0547	.0522	.0506				
C	.0430	.0396	.0386	.0331				
11	.0534	.0522	.0458	.0458				
12	.0596	.0574	.0583	.0569				
13	.0554	.0531	.0530	.0517				
14	.0534	.0519	.0500	.0475				
D	.0419	.0349	.0362	.0284				
15	.0444	.0454	.0415	.0399				
16	.0602	.0588	.0591	.0579				
17	.0558	.0573	.0556	.0549				
18	.0555	.0532	.0541	.0521				
E	.0455	.0413	.0407	.0364				
19	.0554	.0525	.0502	.0487				
20	.0593	.0595	.0591	.0588				
21	.0579	.0564	.0561	.0558				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

ALCLAD ALUMINUM CORRUGATED PIPE
BEAR RIVER 1" AGGREGATE

"C_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		250,000 x 4					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	459g		440g					
1	.0956	.0925	.0944	.0906				
2	.0884	.0844	.0821	.0789				
A	.0508	.0593	.0468	.0519				
3	.0566	.0517	.0467	.0423				
4	.1017	.1002	.1016	.0992				
5	.0966	.0941	.0960	.0922				
6	.0862	.0815	.0810	.0752				
B	.0386	.0486	.0337	.0395				
7	.0516	.0506	.0409	.0377				
8	.1011	.1017	.1009	.1004				
9	.0950	.0943	.0931	.0920				
10	.0882	.0862	.0849	.0809				
C	.0565	.0552	.0514	.0478				
11	.0767	.0701	.0664	.0586				
12	.1023	.1022	.1016	.1001				
13	.0960	.0943	.0954	.0936				
14	.0918	.0875	.0903	.0850				
D	.0563	.0485	.0513	.0429				
15	.0690	.0625	.0581	.0502				
16	.1030	.1005	.1017	.0994				
17	.0952	.0931	.0952	.0913				
18	.0883	.0843	.0859	.0807				
E	.0510	.0508	.0445	.0418				
19	.0790	.0791	.0650	.0624				
20	.1024	.1014	.1009	.0990				
21	--	.0946	--	.0917				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

THICKNESS MEASUREMENTS

P.L.C. COATING OVER GALVANIZED CORRUGATED PIPE
BEAR RIVER 1" AGGREGATE

"D_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		250,000 x 4					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	963g		957g					
1	.1066	.1011	.1061	.1008				
2	.1054	.1034	.1049	.1033				
A	.1014	.1048	.0996	.1037				
3	.1079	.1058	.1059	.1038				
4	.1097	.1114	.1094	.1095				
5	.1098	.1121	.1095	.1120				
6	.1045	.1092	.1034	.1084				
B	.1001	.1007	.0957	.0987				
7	.1013	.1034	.0994	.0999				
8	.0999	.1066	.0998	.1064				
9	.1051	.1105	.1047	.1103				
10	.0991	.1005	.0991	.0996				
C	.0915	.0946	.0885	.0923				
11	.0938	.0970	.0926	.0946				
12	.0992	.1034	.0990	.1029				
13	.1017	.1043	.1010	.1035				
14	.0961	.1050	.0956	.1048				
D	.0810	.0931	.0781	.0915				
15	.0888	.0944	.0861	.0912				
16	.0971	.1078	.0965	.1073				
17	.0957	.1110	.0938	.1108				
18	.0859	.0998	.0844	.0983				
E	.0845	.0989	.0810	.0939				
19	.0893	.1081	.0867	.1064				
20	.0946	.1139	.0939	.1133				
21	.0889	.1044	.0885	.1037				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

1 1/2" AGGREGATE

(3.00 Feet Per Second)

THICKNESS MEASUREMENTS

ALUMINIZED STEEL CORRUGATED PIPE
BEAR RIVER 1 1/2" AGGREGATE

"A_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		125,014 x 8					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	713g		690g					
1	.0573	.0577	.0573	.0577				
2	.0501	.0481	.0484	.0465				
A	.0382	.0335	.0337	.0291				
3	.0493	.0463	.0464	.0429				
4	.0549	.0538	.0546	.0538				
5	.0519	.0492	.0512	.0485				
6	.0471	.0457	.0448	.0440				
B	.0313	.0304	.0277	.0266				
7	.0474	.0406	.0444	.0355				
8	.0550	.0558	.0537	.0549				
9	.0506	.0492	.0494	.0487				
10	.0464	.0433	.0431	.0413				
C	.0339	.0349	.0299	.0302				
11	.0474	.0452	.0466	.0421				
12	.0562	.0544	.0548	.0536				
13	.0533	.0507	.0524	.0507				
14	.0455	.0456	.0419	.0443				
D	.0333	.0307	.0298	.0271				
15	.0469	.0397	.0447	.0350				
16	.0552	.0554	.0547	.0551				
17	.0518	.0518	.0506	.0512				
18	.0433	.0459	.0462	.0433				
E	.0357	.0336	.0308	.0295				
19	.0470	.0420	.0432	.0386				
20	.0567	.0547	.0551	.0542				
21	.0538	.0499	.0515	.0491				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

GALVANIZED STEEL CORRUGATED PIPE
BEAR RIVER 1 1/2" AGGREGATE

"B_1"

NUMBERS AND LOCATIONS	R E V O L U T I O N S AT 3.00 f/s							
	-0-		125,014 x 8					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	732g		711g					
1	.0539	.0508	.0527	.0503				
2	.0470	.0462	.0440	.0432				
A	.0369	.0349	.0334	.0313				
3	.0459	.0418	.0388	.0364				
4	.0578	.0563	.0569	.0550				
5	.0547	.0534	.0532	.0522				
6	.0506	.0466	.0488	.0438				
B	.0390	.0357	.0358	.0316				
7	.0494	.0461	.0459	.0417				
8	.0586	.0597	.0583	.0582				
9	.0559	.0553	.0553	.0548				
10	.0522	.0506	.0514	.0484				
C	.0386	.0331	.0339	.0296				
11	.0458	.0458	.0409	.0399				
12	.0583	.0569	.0572	.0559				
13	.0530	.0517	.0520	.0510				
14	.0500	.0475	.0491	.0439				
D	.0362	.0284	.0329	.0253				
15	.0415	.0399	.0339	.0321				
16	.0591	.0579	.0583	.0574				
17	.0556	.0549	.0546	.0542				
18	.0541	.0521	.0525	.0486				
E	.0407	.0364	.0369	.0326				
19	.0502	.0487	.0469	.0433				
20	.0591	.0588	.0584	.0582				
21	.0561	.0558	.0551	.0554				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

ALCLAD ALUMINUM CORRUGATED PIPE
BEAR RIVER 1 1/2" AGGREGATE

"C_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		125,014 x 8					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	440g		424g					
1	.0944	.0906	.0929	.0897				
2	.0821	.0789	.0783	.0742				
A	.0468	.0519	.0409	.0467				
3	.0467	.0423	.0401	.0381				
4	.1016	.0992	.1000	.0971				
5	.0960	.0922	.0947	.0908				
6	.0810	.0752	.0763	.0687				
B	.0337	.0395	.0290	.0359				
7	.0409	.0377	.0307	.0271				
8	.1009	.1004	.1002	.0997				
9	.0931	.0920	.0924	.0911				
10	.0849	.0809	.0816	.0781				
C	.0514	.0478	.0461	.0430				
11	.0664	.0586	.0558	.0419				
12	.1016	.1001	.1011	.0994				
13	.0954	.0936	.0940	.0928				
14	.0903	.0850	.0881	.0816				
D	.0513	.0429	.0482	.0398				
15	.0581	.0502	.0507	.0420				
16	.1017	.0994	.1008	.0977				
17	.0952	.0913	.0934	.0906				
18	.0859	.0807	.0795	.0750				
E	.0445	.0418	.0393	.0366				
19	.0650	.0624	.0547	.0481				
20	.1009	.0990	.0998	.0976				
21	-	.0917	-	.0907				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

THICKNESS MEASUREMENTS

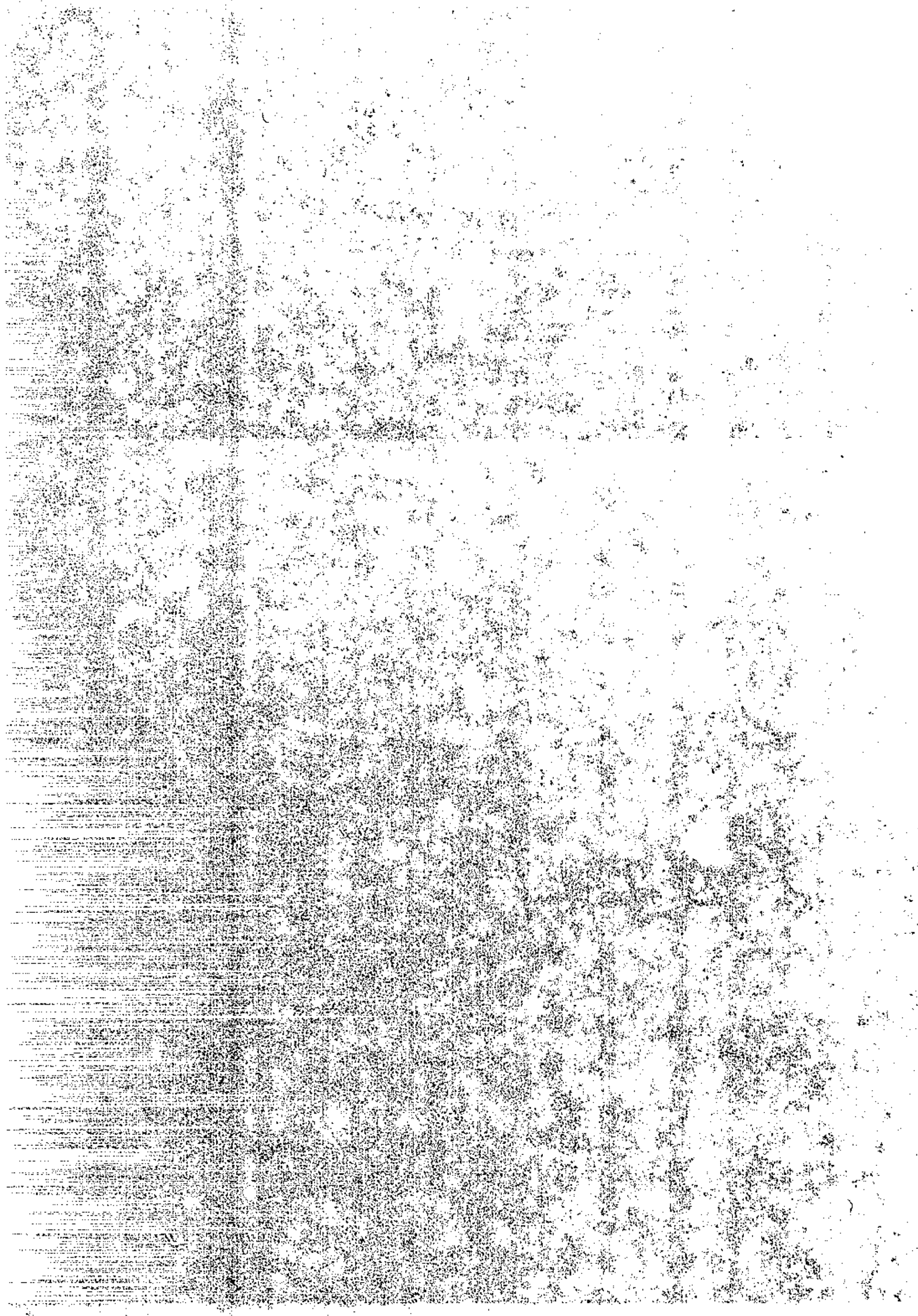
P.L.C. COATING OVER GALVANIZED CORRUGATED PIPE
BEAR RIVER 1 1/2" AGGREGATE

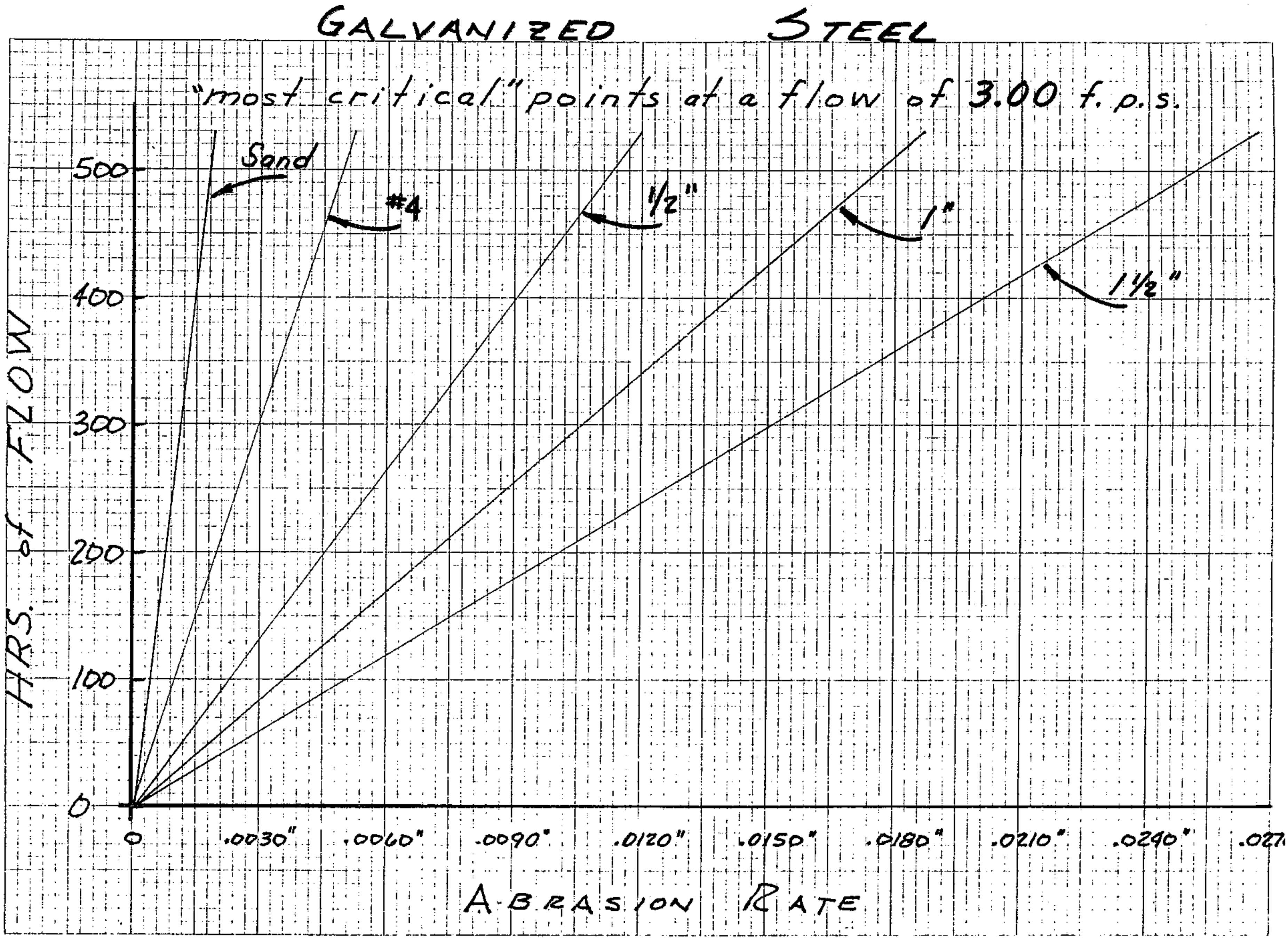
"D_1"

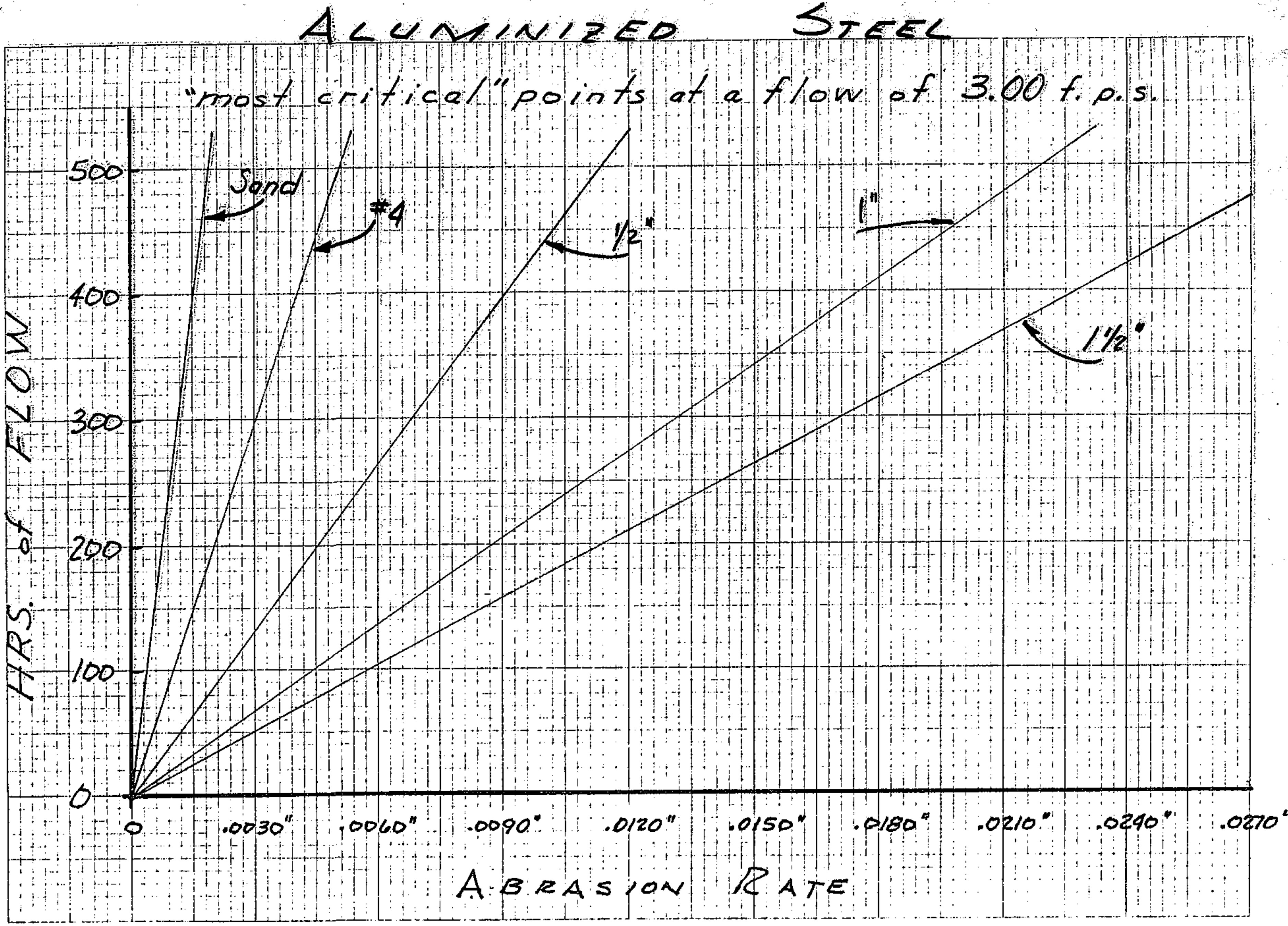
NUMBERS AND LOCATIONS	REVOLUTIONS AT 3.00 f/s							
	-0-		125,014 x 8					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	957g		950g					
1	.1061	.1008	.1059	.0994				
2	.1049	.1033	.1030	.1025				
A	.0996	.1037	.0946	.0991				
3	.1059	.1038	.1020	.1024				
4	.1094	.1095	.1086	.1091				
5	.1095	.1120	.1087	.1116				
6	.1034	.1084	.1028	.1071				
B	.0957	.0987	.0903	.0912				
7	.0994	.0999	.0939	.0957				
8	.0998	.1064	.0994	.1060				
9	.1047	.1103	.1043	.1098				
10	.0991	.0996	.0988	.0979				
C	.0885	.0923	.0847	.0879				
11	.0926	.0946	.0892	.0930				
12	.0990	.1029	.0988	.1019				
13	.1010	.1035	.1008	.1033				
14	.0956	.1048	.0940	.1042				
D	.0781	.0915	.0743	.0875				
15	.0861	.0912	.0817	.0861				
16	.0965	.1073	.0963	.1071				
17	.0938	.1108	.0932	.1102				
18	.0844	.0983	.0839	.0980				
E	.0810	.0939	.0766	.0883				
19	.0867	.1064	.0816	.0986				
20	.0939	.1133	.0935	.1128				
21	.0885	.1037	.0883	.1027				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

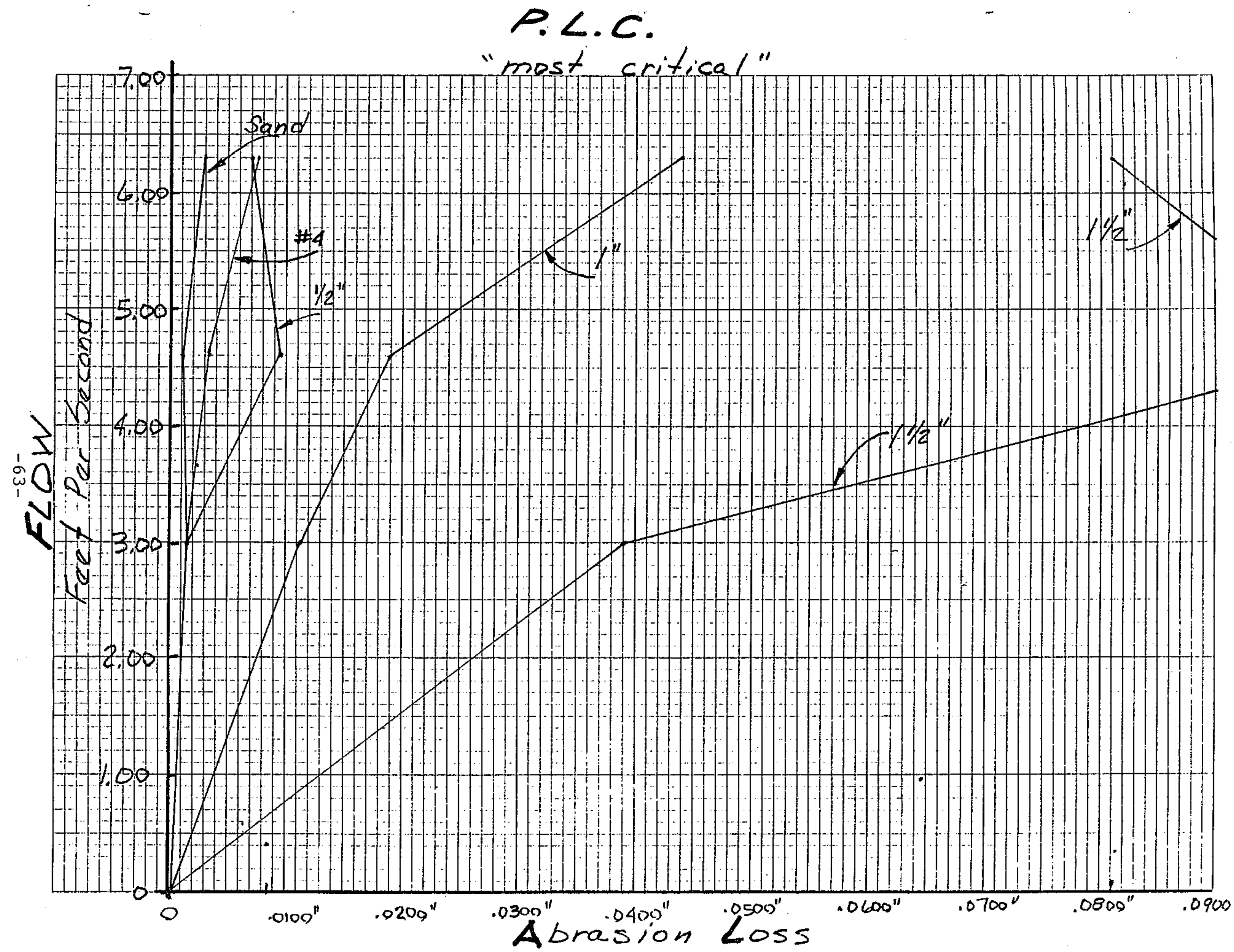
GRAPHS



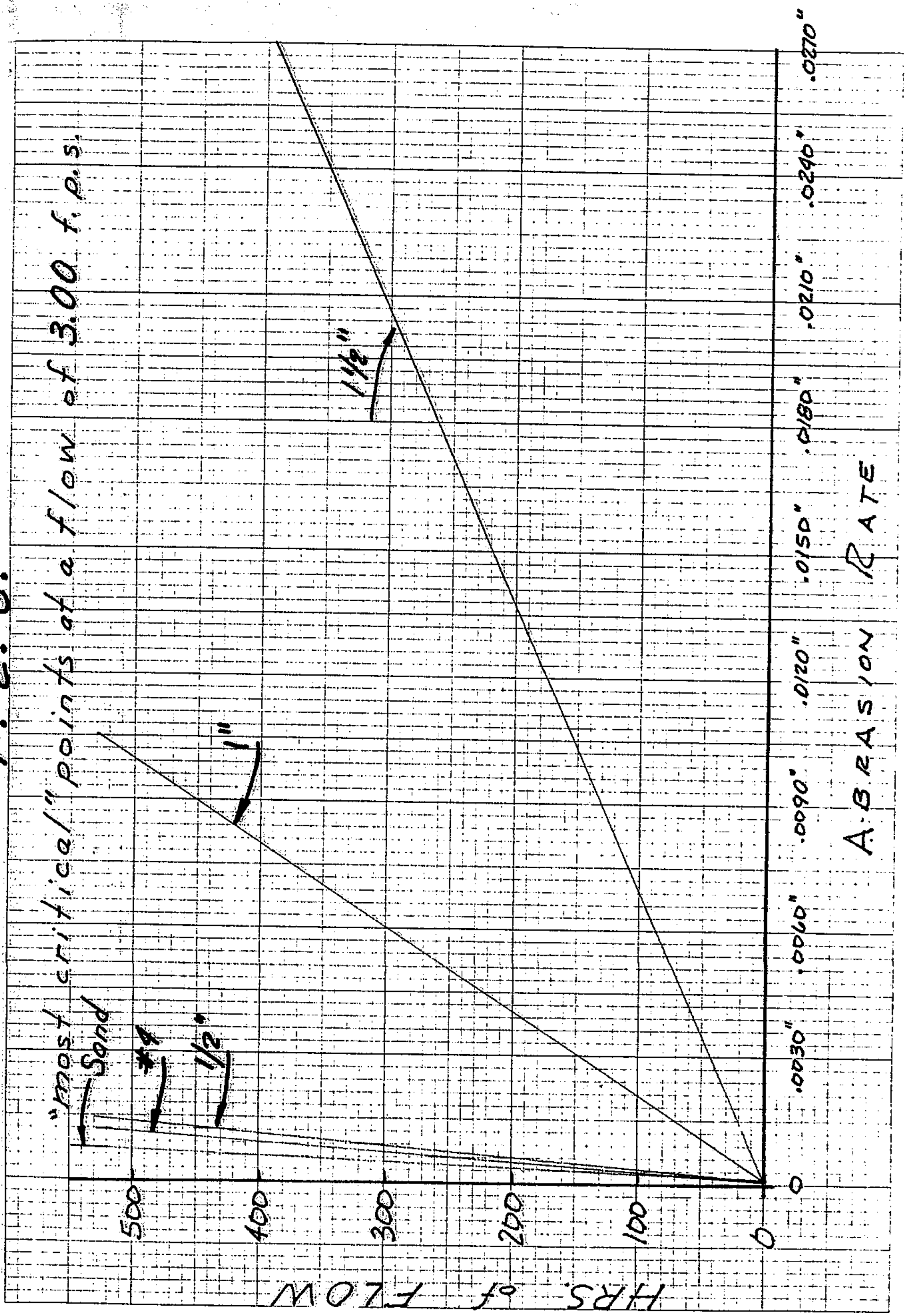

GALVANIZED STEEL
"most critical" points at a flow of 3.00 f.p.s.
Sand
#4
1/2"
1"
1 1/2"
HRS. of FLOW
500
400
300
200
100
0
0
.0030"
.0060"
.0090"
.0120"
.0150"
.0180"
.0210"
.0240"
ABRASION RATE



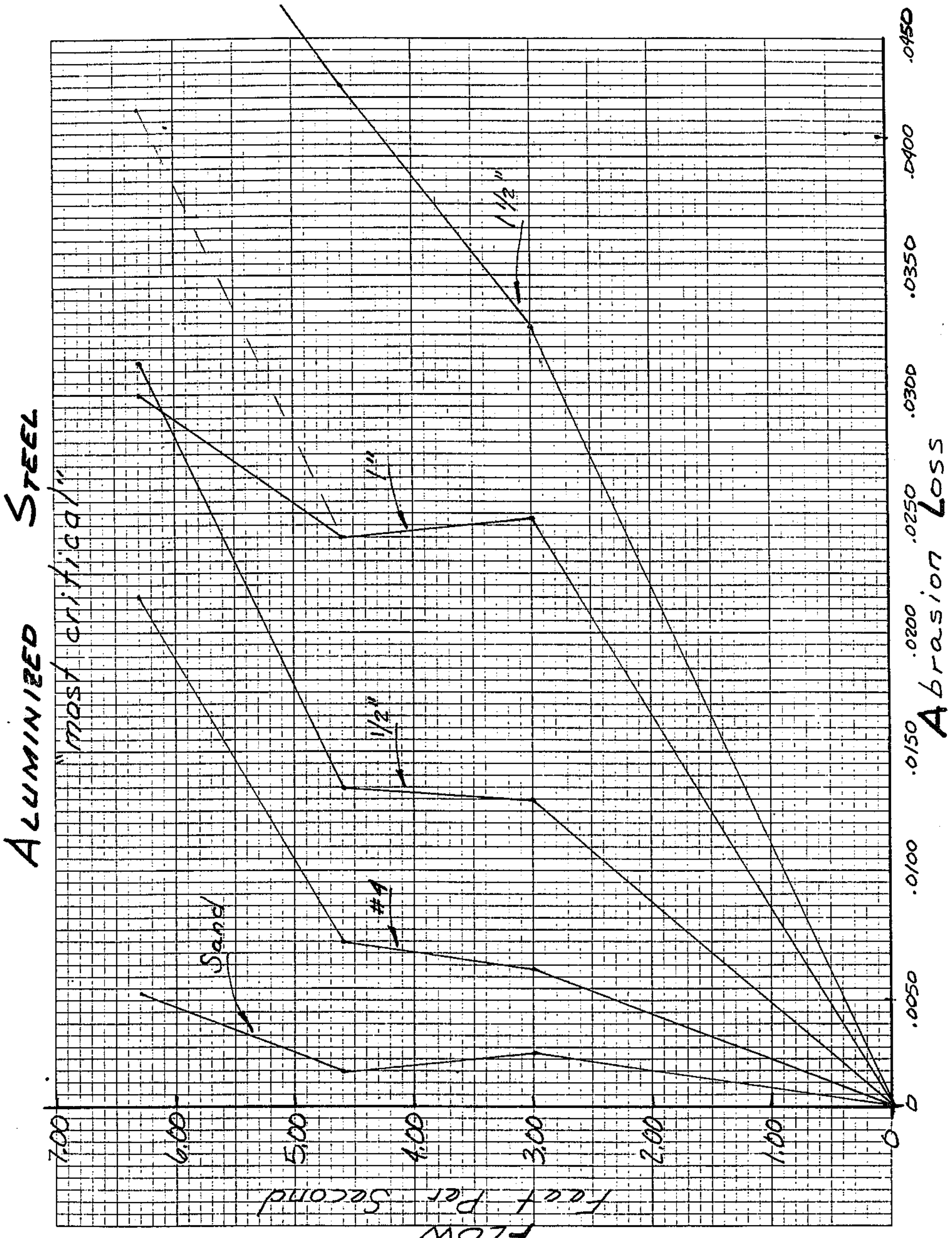
ALUMINIZED STEEL
"most critical" points at a flow of 3.00 f.p.s.
HRS. of FLOW
500
400
300
200
100
0
0
.0030"
.0060"
.0090"
.0120"
.0150"
.0180"
.0210"
.0240"
.0270"
ABRASION RATE
Sand
#4
1/2"
1"
1 1/2"



P.L.C.
"most critical"
Sand
#4
1/2"
1"
1 1/2"
1 1/2"
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0
FLOW
Feet Per Second
0
.0100"
.0200"
.0300"
.0400"
.0500"
.0600"
.0700"
.0800"
.0900
Abrasion Loss

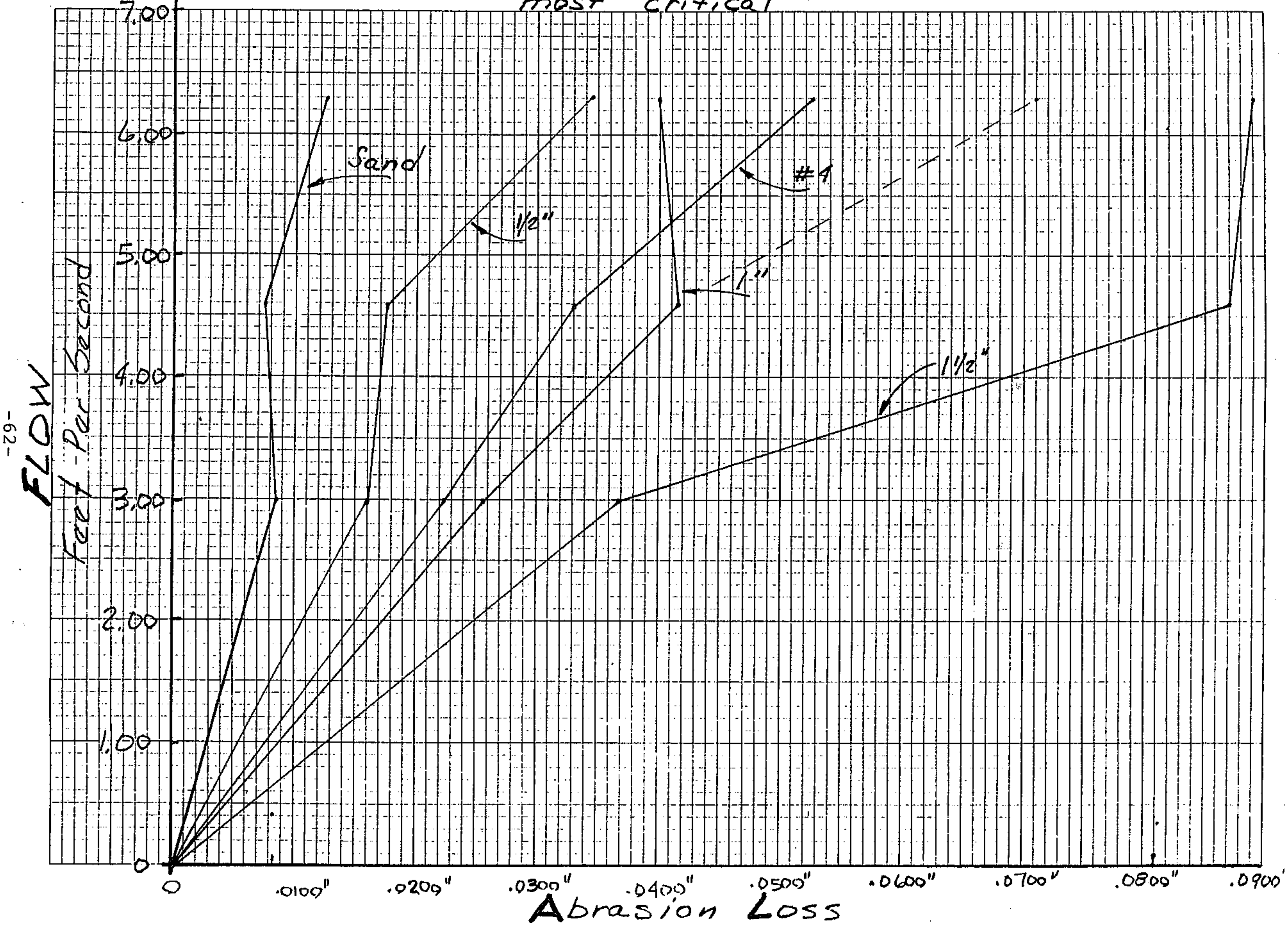

P. V. C.
"most critical" points at a flow of 3.00 f. p. s.
Sand
#4
1/2"
1"
1½"
ABRASION RATE
0
.0030"
.0060"
.0090"
.0120"
.0150"
.0180"
.0210"
.0240"
.0270"
HRS. of FLOW
0
100
200
300
400
500

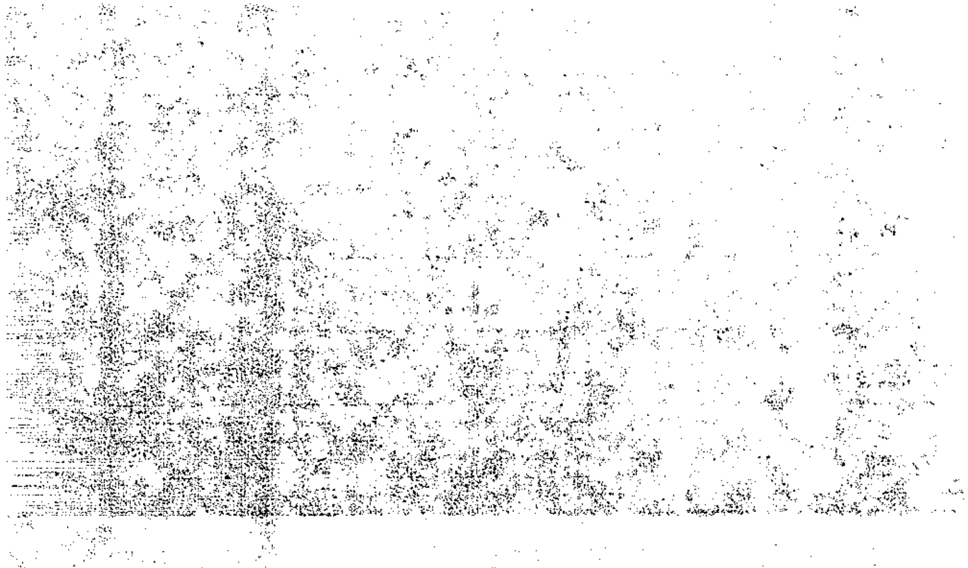
GALVANIZED STEEL
"most critical"
Sand
#4
1/2"
1"
1 1/2"
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0
FLOW
Feet Per Second
0
.0050
.0100
.0150
.0200
.0250
.0300
.0350
.0400
Abrasion

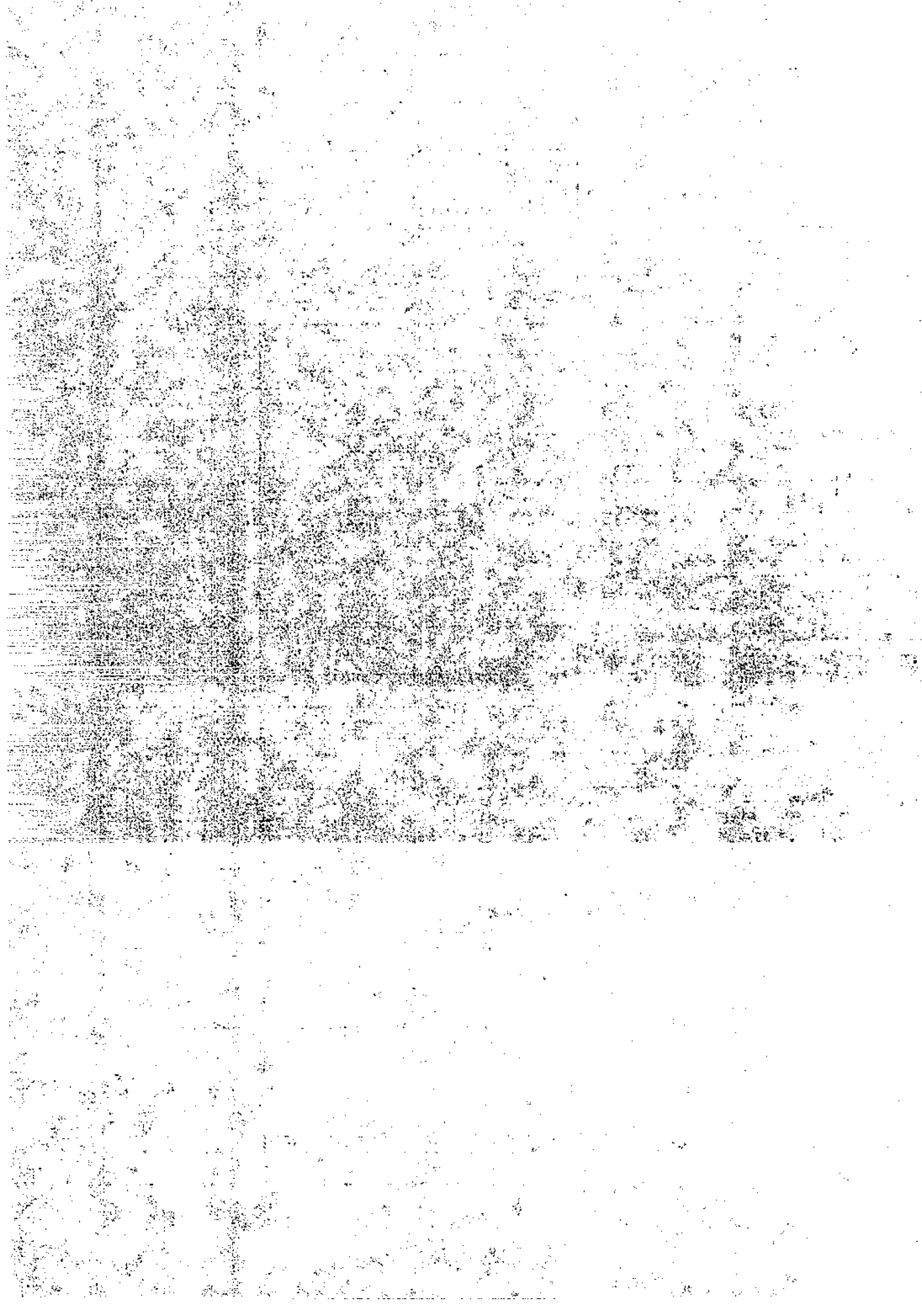

ALUMINIZED STEEL
"most critical"
Sand
#4
1/2"
1"
1 1/2"
Abrasion Loss
0
.0050
.0100
.0150
.0200
.0250
.0300
.0350
.0400
.0450
FLOW Feet Per Second
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00

ALCLAD ALUMINUM

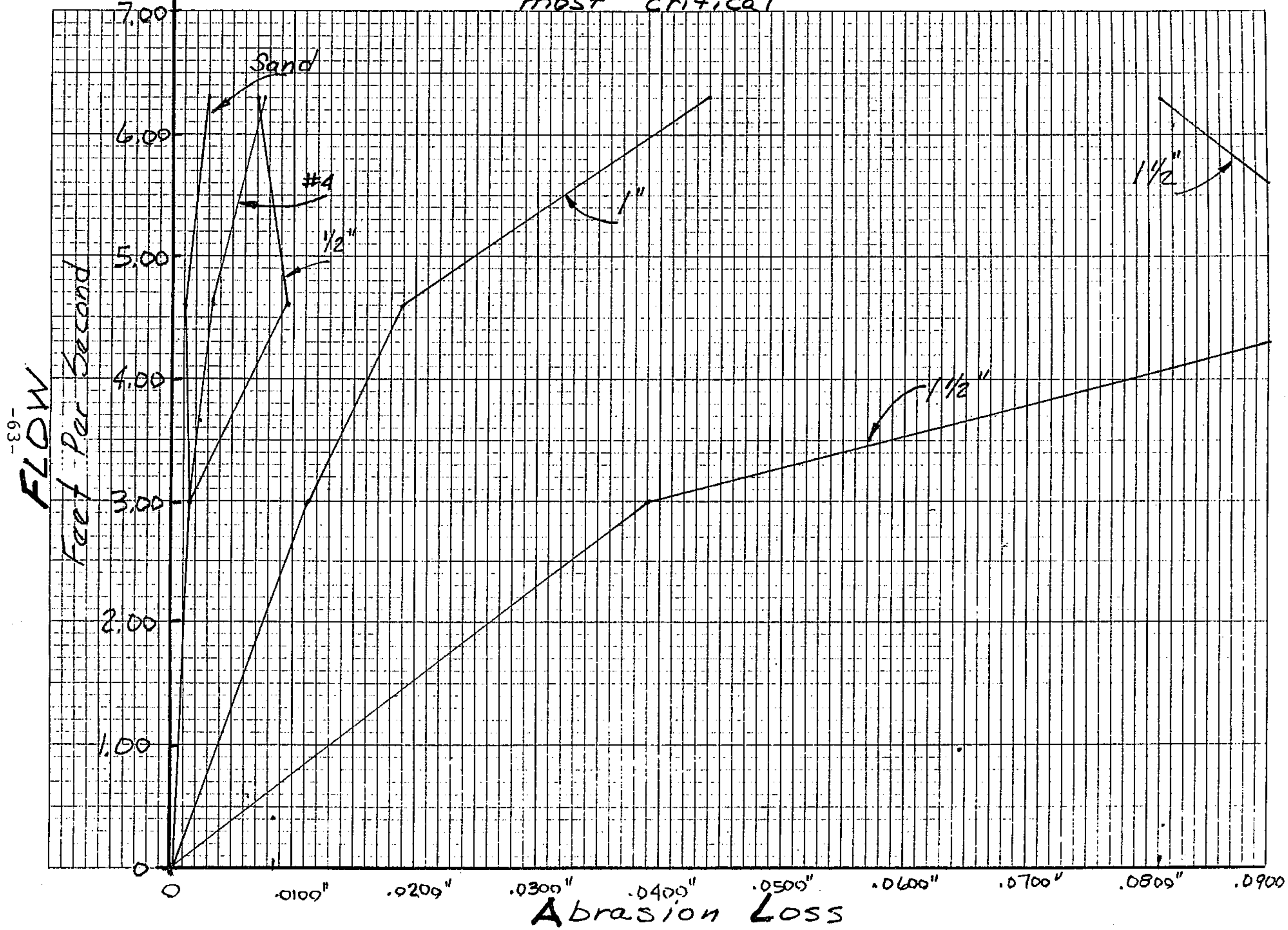
"most critical"

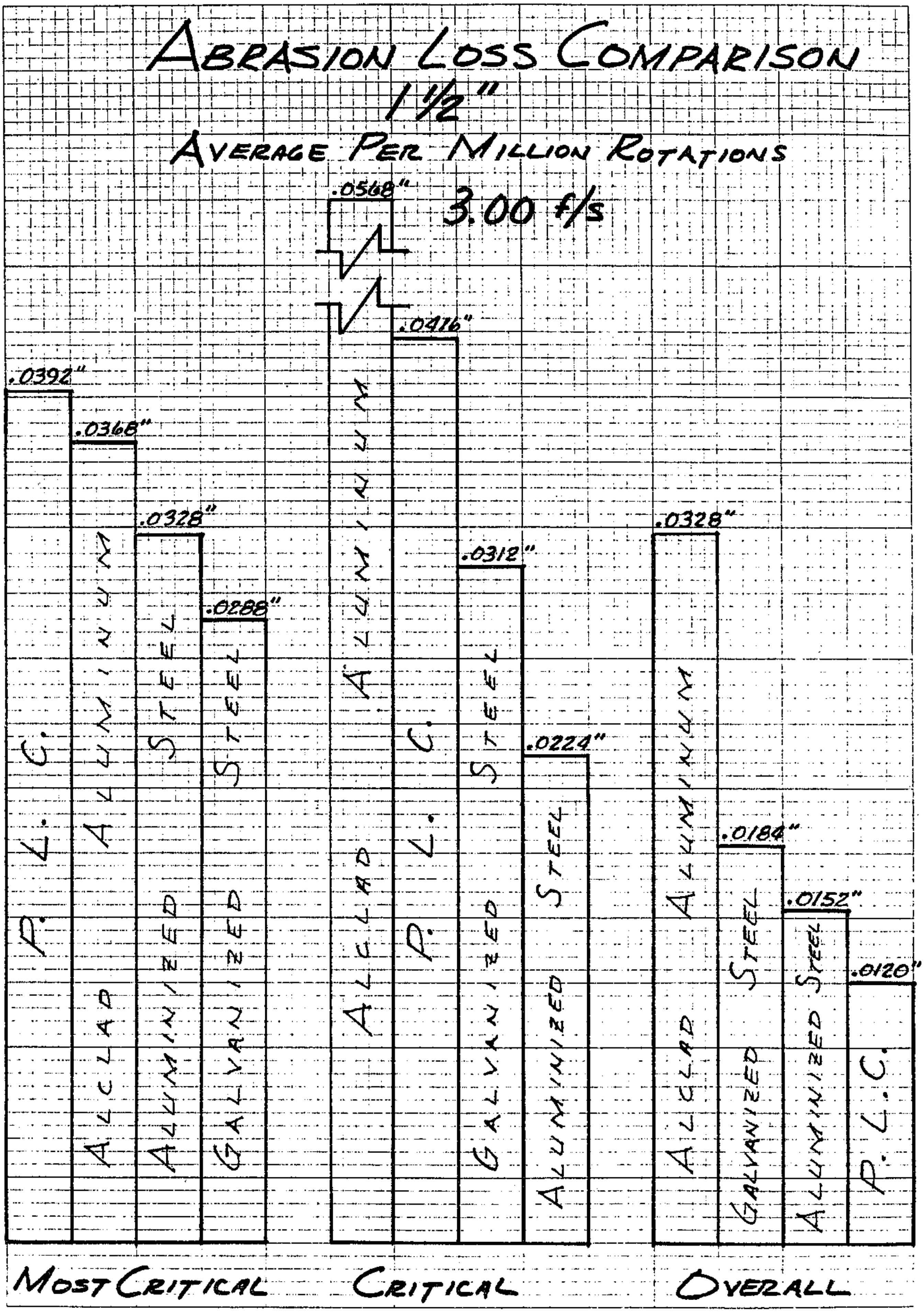


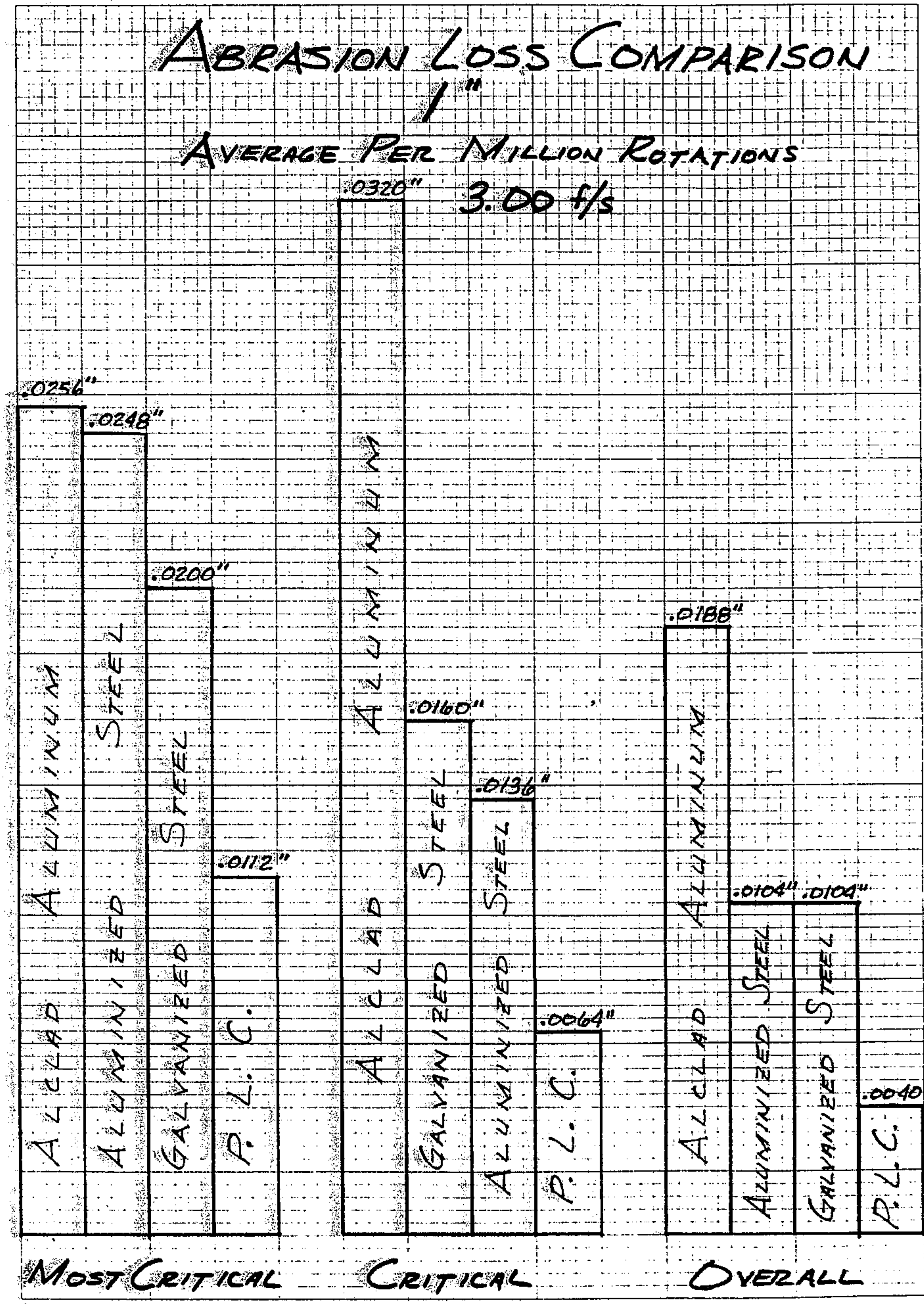


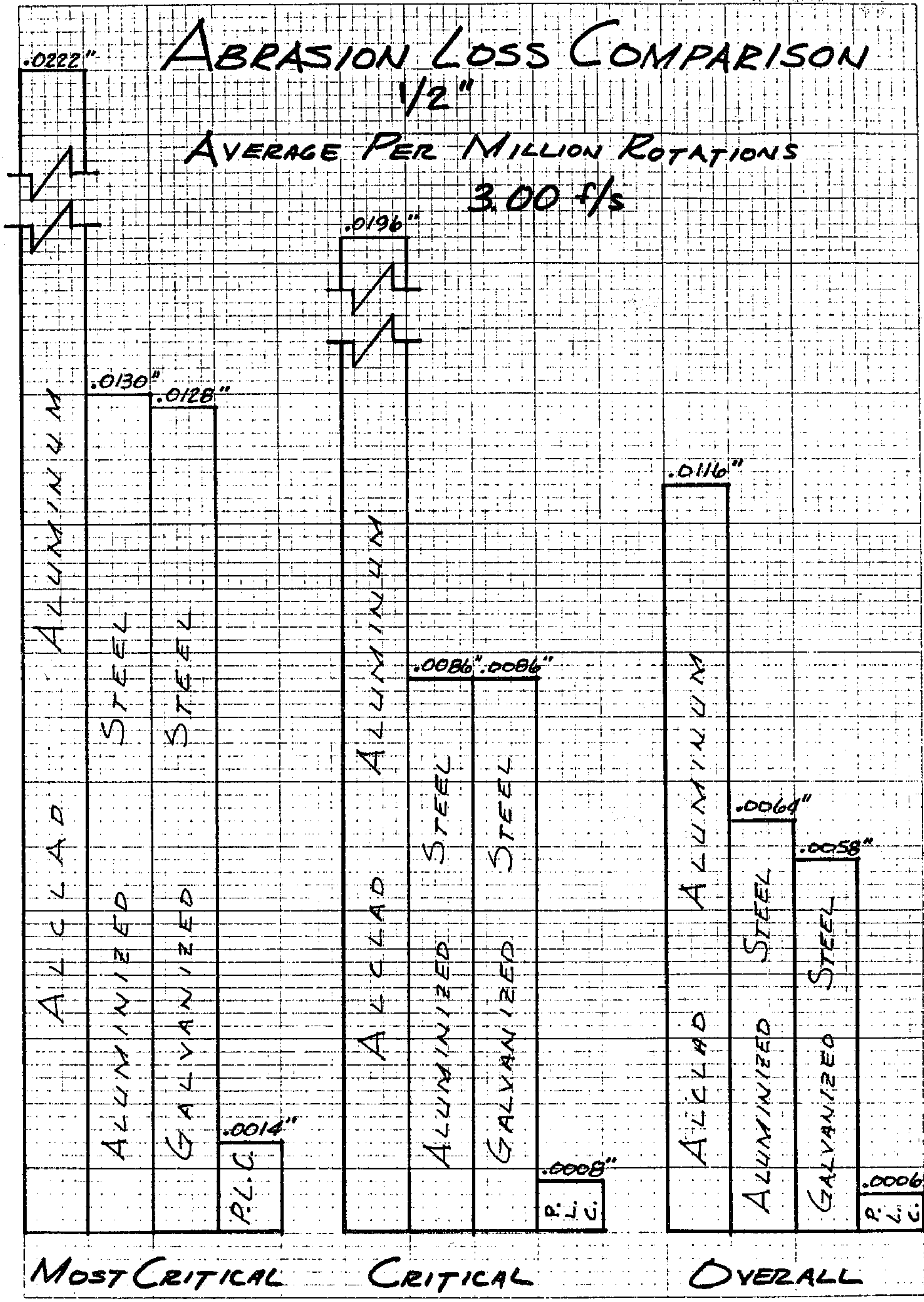


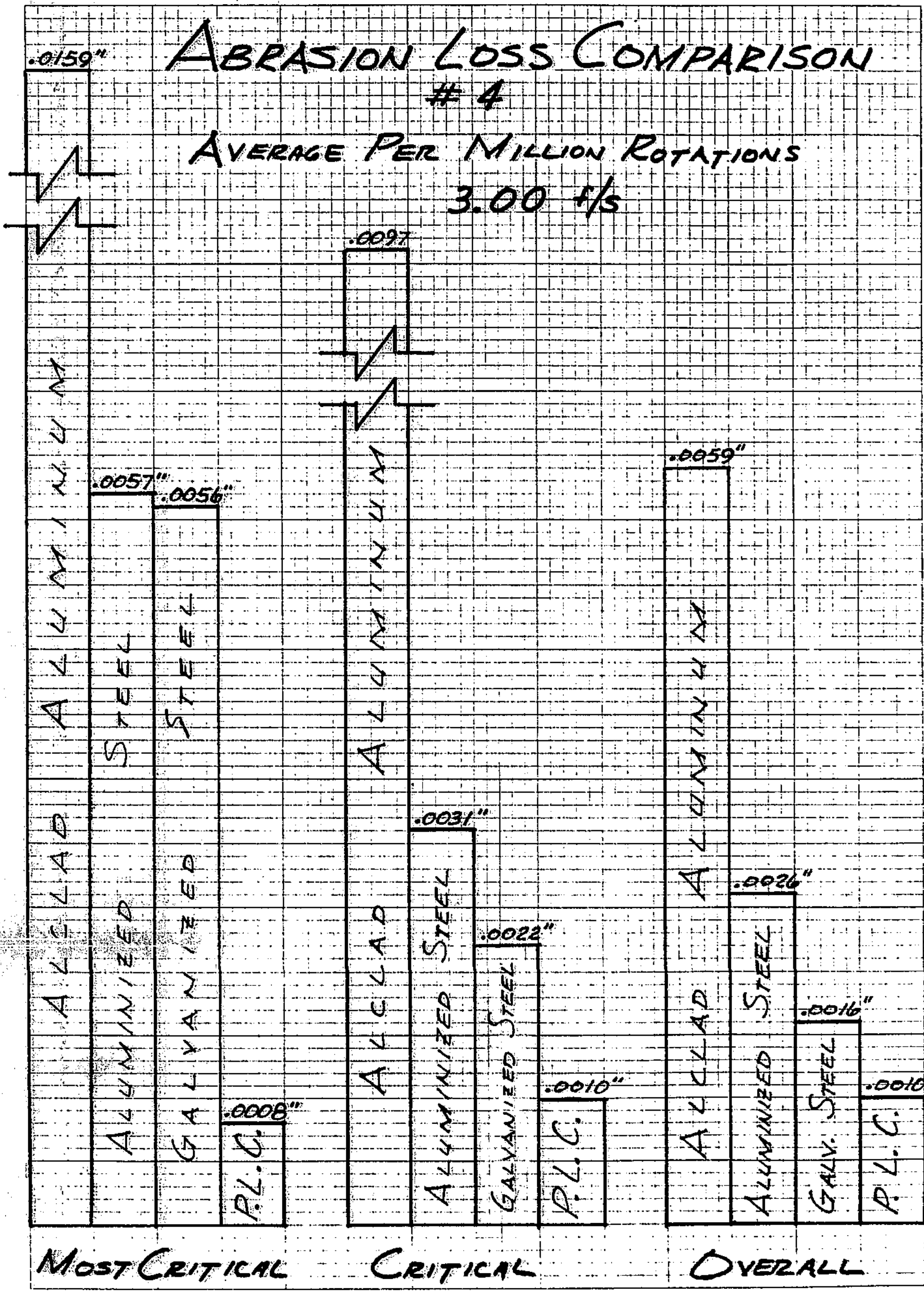
P.L.C.
"most critical"

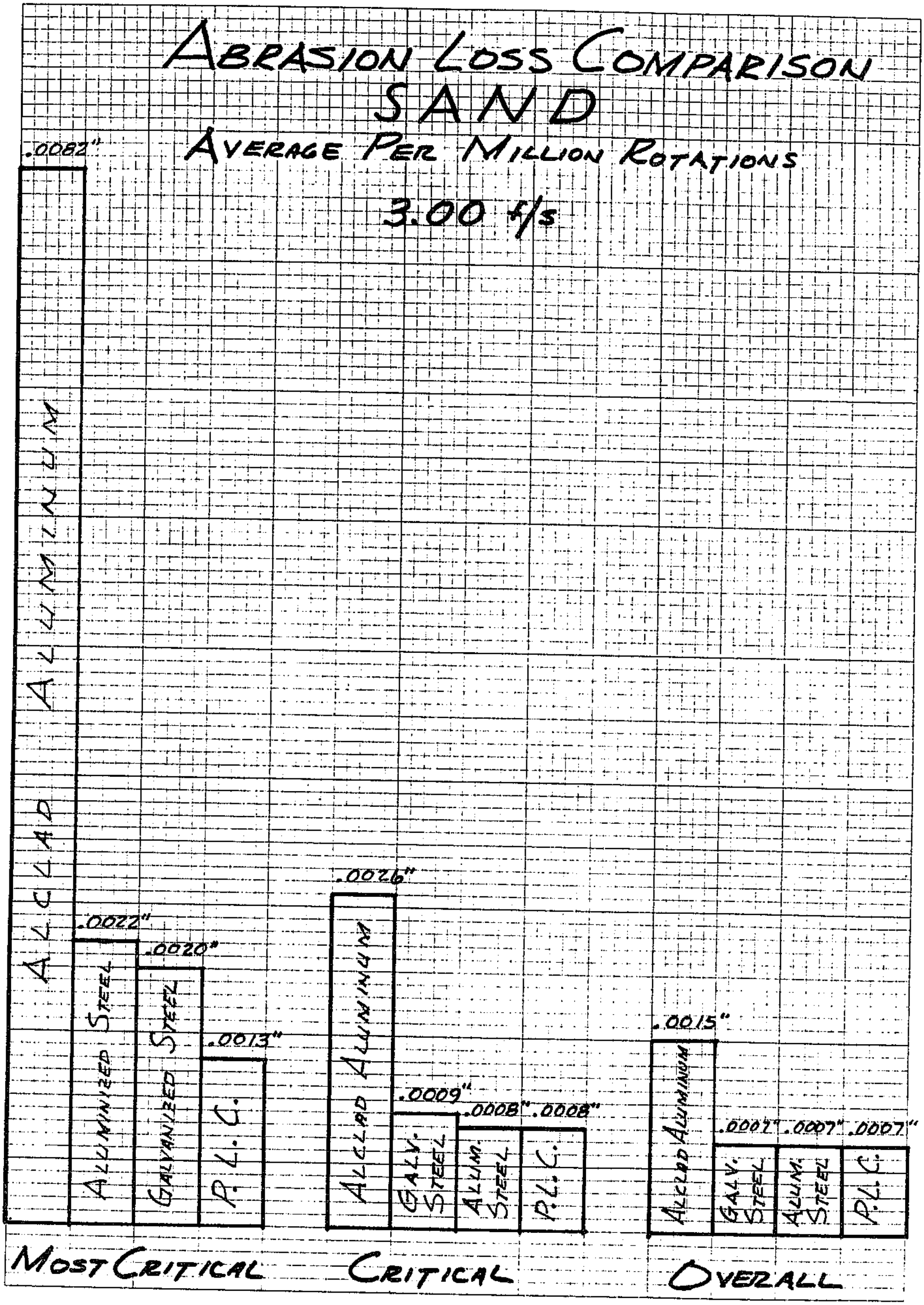



ABRASION LOSS COMPARISON
1½"
AVERAGE PER MILLION ROTATIONS
3.00 f/s
.0392"
P. L. C.
.0368"
ALCLAD ALUMINUM
.0328"
ALUMINIZED STEEL
.0288"
GALVANIZED STEEL
.0568"
ALCLAD ALUMINUM
.0476"
P. L. C.
.0312"
GALVANIZED STEEL
.0224"
ALUMINIZED STEEL
.0328"
ALCLAD ALUMINUM
.0184"
GALVANIZED STEEL
.0152"
ALUMINIZED STEEL
.0120"
P. L. C.
MOST CRITICAL
CRITICAL
OVERALL


Abrasion Loss Comparison
1"
Average Per Million Rotations
3.00 f/s
.0256"
Allclad Aluminum
.0248"
Aluminized Steel
.0200"
Galvanized Steel
.0112"
P. L. C.
.0320"
Allclad Aluminum
.0160"
Galvanized Steel
.0136"
Aluminized Steel
.0064"
P. L. C.
.0188"
Allclad Aluminum
.0104"
Aluminized Steel
.0104"
Galvanized Steel
.0040"
P. L. C.
Most Critical
Critical
Overall

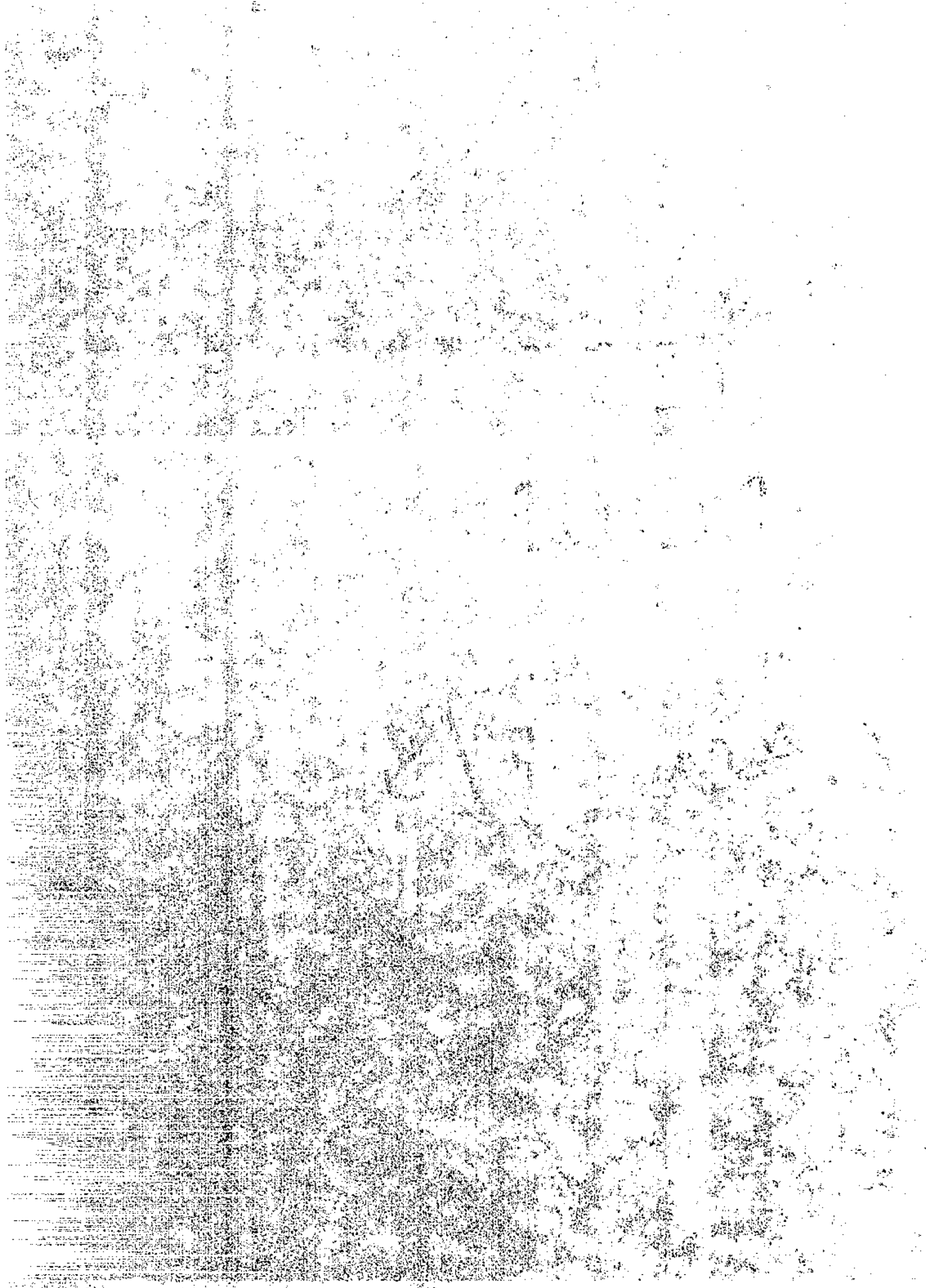

Abrasion Loss Comparison
1/2"
Average Per Million Rotations
3.00 f/s
.0222"
Allclad Aluminum
.0130"
Aluminized Steel
.0128"
Galvanized Steel
.0014"
P.L.C.
.0196"
Allclad Aluminum
.0086"
Aluminized Steel
.0086"
Galvanized Steel
.0008"
P.L.C.
.0116"
Allclad Aluminum
.0064"
Aluminized Steel
.0058"
Galvanized Steel
.0006"
P.L.C.
Most Critical
Critical
Overall


ABRASION LOSS COMPARISON
#4
AVERAGE PER MILLION ROTATIONS
3.00 f/s
.0159"
ALCLAD ALUMINUM
.0057"
ALUMINIZED STEEL
.0056"
GALVANIZED STEEL
.0008"
P.L.C.
.0097
ALCLAD ALUMINUM
.0031"
ALUMINIZED STEEL
.0022"
GALVANIZED STEEL
.0010"
P.L.C.
.0059"
ALCLAD ALUMINUM
.0026"
ALUMINIZED STEEL
.0016"
GALV. STEEL
.0010"
P.L.C.
MOST CRITICAL
CRITICAL
OVERALL


ABRASION LOSS COMPARISON
SAND
AVERAGE PER MILLION ROTATIONS
3.00 f/s
.0082"
ALCLAD ALUMINUM
.0022"
ALUMINIZED STEEL
.0020"
GALVANIZED STEEL
.0013"
P.L.C.
.0026"
ALCLAD ALUMINUM
.0009"
GALV. STEEL
.0008"
ALUM. STEEL
.0008"
P.L.C.
.0015"
ALCLAD ALUMINUM
.0007"
GALV. STEEL
.0007"
ALUM. STEEL
.0007"
P.L.C.
MOST CRITICAL
CRITICAL
OVERALL

TEST GROUP 2

6.30 F/S



6.30 Feet Per Second

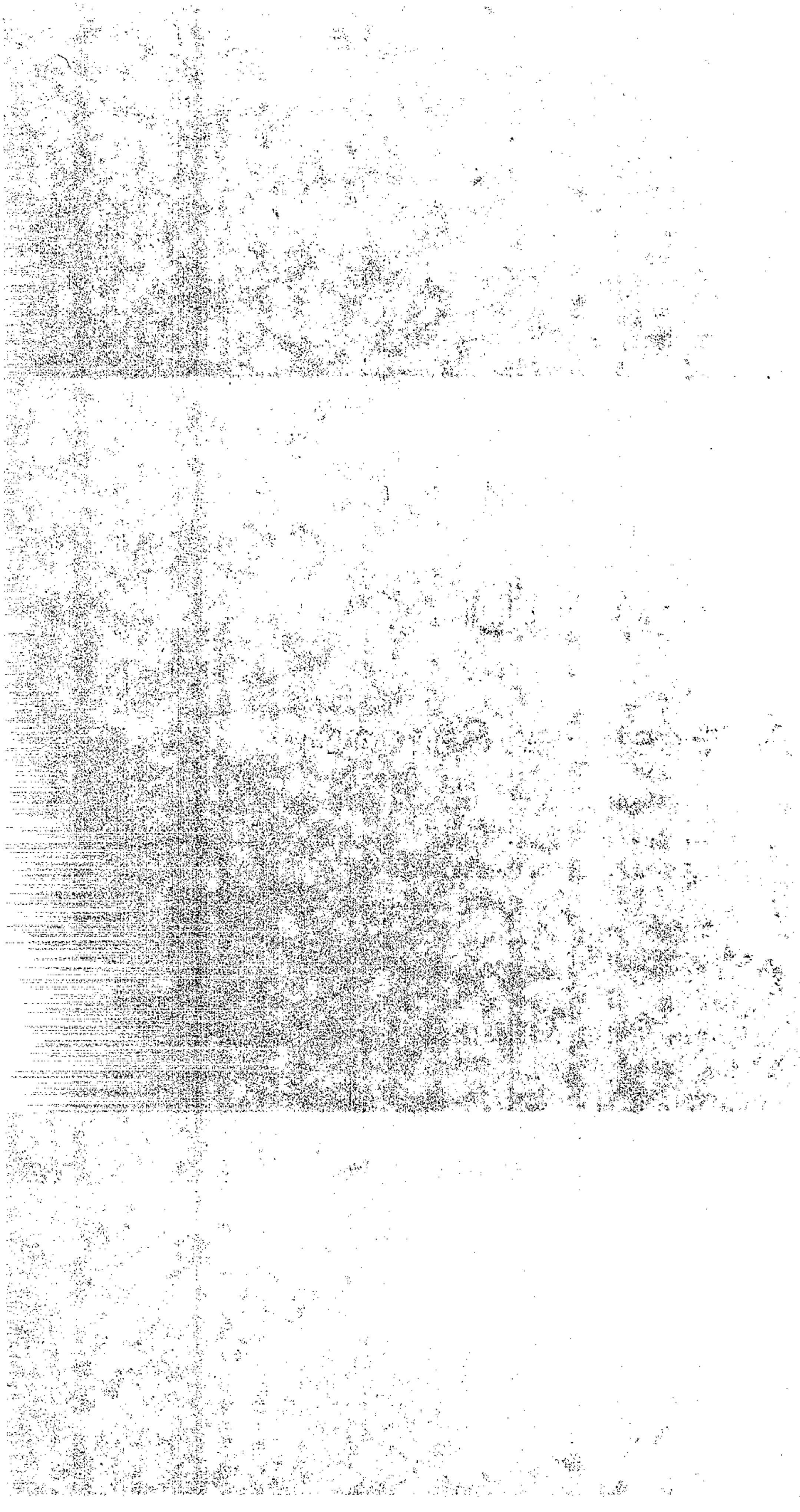
TYPE OF MATERIAL / AGGREGATE USED & NUMBER OF ROTATIONS	AVERAGE LOSS PER MILLION ROTATIONS: 1 /Million SAND	1/2 /Million # 4	1/5 /Million 1/2 "	1/4 /Million 1 "	1/8 /Million 1 1/2 "	
A. ALUMINIZED STEEL						
Overall 42 points	.0016	.0073	.0108	.0089	.0190	
Critical 20 points	.0023	.0114	.0153	.0151	.0291	
* Most Critical 10 points	.0048	.0216	.0313	.0298	.0550	
Weight Loss in grams	11	46	100	108	152	
Weight Loss in %	1.35	5.74	12.80	14.24	19.52	
B. GALVANIZED STEEL						
Overall 42 points	.0012	.0069	.0190	.0124	.0210	
Critical 20 points	.0018	.0104	.0245	.0182	.0348	
* Most Critical 10 points	.0048	.0210	.0365	.0224	.0484	
Weight Loss in grams	17	58	95	116	152	
Weight Loss in %	1.94	6.72	11.35	14.20	18.24	
C. ALCLAD ALUMINUM						
Overall 40 points	.0022	.0094	.0205	.0186	.0310	
Critical 20 points	.0037	.0167	.0370	.0352	.0558	
* Most Critical 10 points	.0123	.0346	.0525	.0399	.0889	
Weight Loss in grams	17	54	80	85	120	
Weight Loss in %	3.23	8.36	16.65	18.31	22.80	
D. P.L.C.						
Overall 42 points	.0014	.0043	.0035	.0163	.0264	
Critical 20 points	.0021	.0055	.0045	.0252	.0461	
* Most Critical 10 points	.0030	.0076	.0070	.0441	.0806	
Weight Loss in grams	2	6	15	42	88	
Weight Loss in %	0.20	0.60	1.50	4.26	8.88	
HOURS OF FLOW	272.23	272.00	271.25	271.56	272.54	
FEET PER SECOND	6.29	6.29	6.29	6.30	6.28	
Average pH	-	-	-	-	7.66	

* - "Most Critical" points are not part of the overall average.

A B R A S I O N R A T I O S for 6.30 Feet Per Second	A V E R A G E P E R M I L L I O N				
	S A N D	# 4	1/2 "	1 "	1 1/2 "
	OVER SAND	OVER SAND	OVER SAND	OVER SAND	OVER SAND
A. ALUMINIZED STEEL					
Overall	1	4.56	6.75	5.56	11.88
Critical	1	4.96	6.65	6.57	12.65
Most Critical	1	4.50	6.52	6.21	11.46
Weight Loss	1	4.18	9.09	9.82	13.82
B. GALVANIZED STEEL					
Overall	1	5.75	15.92	10.33	17.50
Critical	1	5.78	13.61	10.11	19.33
Most Critical	1	4.38	7.60	4.67	10.08
Weight Loss	1	3.41	5.59	6.82	8.94
C. ALCLAD ALUMINUM					
Overall	1	4.27	9.32	8.45	14.09
Critical	1	4.51	10.00	9.51	15.08
Most Critical	1	2.81	4.27	3.24	7.23
Weight Loss	1	3.18	4.71	5.00	7.06
D. P.L.C. COATING					
Overall	1	3.07	2.50	11.64	18.86
Critical	1	2.62	2.14	12.00	21.95
Most Critical	1	2.53	2.33	14.70	26.87
Weight Loss	1	3.00	7.50	21.00	44.00

SAND

(6.30 Feet Per Second)



T H I C K N E S S   M E A S U R E M E N T S

ALUMINIZED STEEL CORRUGATED PIPE
BEAR RIVER SAND

"A_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		1,001,657					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	812 g		801 g					
1	.0602	.0575	.0571	.0557				
2	.0590	.0623	.0582	.0580				
A	.0580	.0616	.0564	.0529				
3	.0580	.0604	.0563	.0566				
4	.0600	.0593	.0597	.0591				
5	.0911	.0955	.0910	.0914				
6	.0610	.0617	.0601	.0592				
B	.0618	.0599	.0560	.0515				
7	.0612	.0592	.0589	.0579				
8	.0598	.0621	.0598	.0577				
9	.0571	.0583	.0569	.0561				
10	.0614	.0611	.0584	.0594				
C	.0589	.0600	.0560	.0549				
11	.0574	.0606	.0566	.0569				
12	.0607	.0592	.0595	.0590				
13	.0585	.0607	.0571	.0599				
14	.0572	.0600	.0558	.0558				
D	.0575	.0598	.0549	.0538				
15	.0566	.0591	.0559	.0575				
16	.0608	.0602	.0595	.0599				
17	.0584	.0591	.0568	.0581				
18	.0605	.0610	.0586	.0602				
E	.0596	.0582	.0553	.0550				
19	.0577	.0589	.0565	.0570				
20	.0588	.0605	.0582	.0598				
21	.0576	.0574	.0566	.0565				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7.10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

THICKNESS MEASUREMENTS

GALVANIZED STEEL CORRUGATED PIPE
BEAR RIVER SAND

"B_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		1,001,657					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	878 g		861 g					
1	.0615	.0613	.0612	.0606				
2	.0633	.0666	.0609	.0641				
A	.0643	.0623	.0601	.0599				
3	.0663	.0604	.0633	.0584				
4	.0648	.0621	.0633	.0623				
5	.0643	.0640	.0622	.0639				
6	.0651	.0640	.0616	.0637				
B	.0626	.0659	.0565	.0598				
7	.0619	.0613	.0604	.0610				
8	.0658	.0631	.0635	.0625				
9	.0607	.0635	.0606	.0630				
10	.0622	.0647	.0611	.0612				
C	.0636	.0628	.0575	.0564				
11	.0625	.0633	.0618	.0618				
12	.0649	.0612	.0643	.0611				
13	.0614	.0615	.0613	.0609				
14	.0629	.0635	.0621	.0616				
D	.0641	.0625	.0602	.0579				
15	.0622	.0647	.0615	.0641				
16	.0627	.0654	.0626	.0655				
17	.0622	.0614	.0613	.0614				
18	.0639	.0626	.0620	.0601				
E	.0611	.0621	.0584	.0567				
19	.0613	.0638	.0598	.0615				
20	.0651	.0642	.0651	.0638				
21	.0626	.0651	.0618	.0637				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

ALCLAD ALUMINUM CORRUGATED PIPE
BEAR RIVER SAND

"C_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		1,001,657					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	529 g		512 g					
1	.1036	.1019	.1022	.1011				
2	.1077	.1066	.1041	.1018				
A	.1033	.1049	.0984	.0921				
3	.1031	.1029	.1001	.0923				
4	.1056	.1055	.1050	.1051				
5	.0985	.0990	.0982	.0985				
6	.1060	.1059	.1031	.1006				
B	.1049	.1042	.0963	.0894				
7	.1044	.1040	.1003	.0986				
8	.1056	.1056	.1051	.1048				
9	.0994	.0985	.0988	.0980				
10	.1045	.1049	.1031	.1033				
C	.1040	.1034	.0961	.0912				
11	.1046	.1009	.1006	.0979				
12	.1049	.1063	.1039	.1060				
13	.0987	.0996	.0978	.0994				
14	.1057	.1052	.1036	.0980				
D	.1050	.1026	.0923	.0836				
15	.1055	.1021	.1006	.0977				
16	.1071	.1047	.1064	.1042				
17	.0998	.1013	.0992	.0994				
18	.1057	.1064	.1039	.1018				
E	.1039	.1031	.0910	.0859				
19	.1021	.1011	.0976	.0974				
20	.1076	.1057	.1069	.1052				
21	-	-	-	-				

OVERALL = 1-20 LOCATIONS

CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS

MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S M E A S U R E M E N T S

P.L.C. COATING OVER GALVANIZED CORRUGATED PIPE
BEAR RIVER SAND

"D_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		1,001,657					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	1005 g		1003 g					
1	.1028	.1065	.1017	.1051				
2	.1041	.1045	.1033	.1029				
A	.1017	.1123	.0988	.1064				
3	.1128	.1048	.1091	.1028				
4	.1080	.1059	.1077	.1052				
5	.1232	.1039	.1219	.1034				
6	.1029	.1057	.1021	.1049				
B	.1001	.1069	.0981	.1036				
7	.1136	.1072	.1127	.1055				
8	.1076	.1097	.1075	.1096				
9	.1100	.1062	.1095	.1054				
10	.0978	.1074	.0977	.1071				
C	.0944	.1014	.0914	.0997				
11	.1054	.1013	.1004	.0974				
12	.1059	.1019	.1056	.0998				
13	.1032	.1055	.1028	.1041				
14	.0907	.0895	.0896	.0889				
D	.0933	.0939	.0911	.0909				
15	.1056	.0991	.1015	.0955				
16	.1085	.0962	.1054	.0958				
17	.0866	.0912	.0860	.0908				
18	.0815	.0871	.0814	.0828				
E	.0760	.0815	.0732	.0787				
19	.0852	.0835	.0808	.0822				
20	.0872	.0822	.0864	.0819				
21	.0827	.0799	.0812	.0796				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

#4 AGGREGATE

(6.30 Feet Per Second)

T H I C K N E S S   M E A S U R E M E N T S

ALUMINIZED STEEL CORRUGATED PIPE
BEAR RIVER #4 AGGREGATE

"A_2"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		500,000 x 2					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	802g		779g					
1	.0579	.0586	.0570	.0565				
2	.0612	.0650	.0534	.0589				
A	.0603	.0594	.0459	.0500				
3	.0601	.0591	.0519	.0533				
4	.0591	.0582	.0585	.0579				
5	.0598	.0595	.0569	.0567				
6	.0588	.0617	.0530	.0530				
B	.0582	.0592	.0465	.0464				
7	.0586	.0616	.0512	.0531				
8	.0597	.0594	.0582	.0575				
9	.0599	.0591	.0561	.0575				
10	.0598	.0602	.0552	.0530				
C	.0593	.0612	.0485	.0484				
11	.0594	.0595	.0524	.0556				
12	.0596	.0609	.0577	.0567				
13	.0570	.0593	.0562	.0581				
14	.0579	.0613	.0560	.0552				
D	.0586	.0581	.0497	.0489				
15	.0587	.0605	.0537	.0536				
16	.0600	.0614	.0585	.0607				
17	.0586	.0579	.0563	.0569				
18	.0603	.0605	.0572	.0570				
E	.0583	.0608	.0514	.0495				
19	.0588	.0577	.0563	.0537				
20	.0602	.0593	.0581	.0584				
21	.0584	.0597	.0574	.0578				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

THICKNESS MEASUREMENTS

GALVANIZED STEEL CORRUGATED PIPE
BEAR RIVER #4 AGGREGATE

"B_2"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		500,000 x 2					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	864g		835g					
1	.0632	.0626	.0581	.0592				
2	.0647	.0656	.0580	.0583				
A	.0645	.0639	.0531	.0512				
3	.0656	.0632	.0561	.0564				
4	.0650	.0647	.0612	.0634				
5	.0607	.0627	.0597	.0596				
6	.0641	.0642	.0563	.0578				
B	.0644	.0639	.0508	.0513				
7	.0638	.0631	.0582	.0541				
8	.0654	.0636	.0617	.0623				
9	.0611	.0581	.0604	.0587				
10	.0618	.0649	.0582	.0629				
C	.0650	.0626	.0537	.0509				
11	.0654	.0628	.0586	.0565				
12	.0643	.0642	.0633	.0603				
13	.0624	.0650	.0612	.0633				
14	.0632	.0638	.0604	.0613				
D	.0632	.0652	.0550	.0565				
15	.0638	.0630	.0617	.0592				
16	.0644	.0640	.0633	.0635				
17	.0615	.0664	.0599	.0650				
18	.0631	.0650	.0591	.0606				
E	.0631	.0635	.0554	.0562				
19	.0639	.0658	.0617	.0613				
20	.0626	.0641	.0624	.0638				
21	.0627	.0658	.0608	.0627				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

ALCLAD ALUMINUM CORRUGATED PIPE
BEAR RIVER #4 AGGREGATE

"C_2"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		500,000 x 2					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	550g		527g					
1	.1020	.1075	.0976	.0978				
2	.1081	.1079	.0933	.0885				
A	.1043	.1054	.0755	.0732				
3	.1042	.1056	.0903	.0860				
4	.1061	.1079	.1045	.1073				
5	.0994	.0994	.0982	.0991				
6	.1070	.1064	.0992	.0966				
B	.1059	.1033	.0876	.0834				
7	.1039	.1033	.0972	.0946				
8	.1075	.1053	.1067	.1047				
9	.0988	.1009	.0986	.1005				
10	.1045	.1069	.1019	.1026				
C	.1049	.1034	.0936	.0927				
11	.1017	.1034	.0948	.0961				
12	.1073	.1071	.1068	.1054				
13	.0997	.0995	.0993	.0987				
14	.1071	.1056	.1021	.0986				
D	.1012	.1036	.0888	.0888				
15	.1030	.1060	.0983	.0959				
16	.1070	.1062	.1056	.1056				
17	.0999	.1014	.0995	.1019				
18	.1045	.1056	.1013	.0994				
E	.1017	.1038	.0922	.0888				
19	.1030	.1014	.0986	.0967				
20	.1078	.1044	.1065	.1031				
21	.0992	.1009	.0986	.1006				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

THICKNESS MEASUREMENTS

P.L.C. COATING OVER GALVANIZED CORRUGATED PIPE
BEAR RIVER #4 AGGREGATE

"D_2"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		500,000 x 2					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	991g		988g					
1	.0856	.0846	.0847	.0822				
2	.0930	.0943	.0884	.0907				
A	.0933	.0983	.0909	.0931				
3	.0913	.0990	.0875	.0960				
4	.0961	.1049	.0938	.1022				
5	.0997	.1061	.0991	.1054				
6	.1031	.1069	.0993	.1039				
B	.1099	.1059	.1069	.1028				
7	.1077	.1107	.1024	.1067				
8	.1066	.1072	.1032	.1060				
9	.1111	.1242	.1106	.1239				
10	.1062	.1178	.1047	.1178				
C	.1072	.1238	.1029	.1174				
11	.0980	.1092	.0974	.1084				
12	.1066	.1083	.1038	.1076				
13	.1009	.1177	.1004	.1180				
14	.1030	.1123	.1009	.1090				
D	.1025	.1054	.0988	.1046				
15	.1040	.1171	.1006	.1159				
16	.1055	.1050	.1006	.1060				
17	.1069	.1154	.1064	.1135				
18	.1053	.1071	.1029	.1053				
E	.1096	.1127	.1043	.1135				
19	.1015	.1035	.0997	.1013				
20	.1072	.1037	.1066	.1043				
21	.0966	.1053	.0959	.1051				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

1/2" AGGREGATE

(6.30 Feet Per Second)

THICKNESS MEASUREMENTS

ALUMINIZED STEEL CORRUGATED PIPE
BEAR RIVER 1/2" AGGREGATE

"A_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		199,975 x 5					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	780g		760g					
1	.0559	.0538	.0539	.0521				
2	.0537	.0515	.0479	.0464				
A	.0492	.0414	.0444	.0307				
3	.0535	.0505	.0500	.0455				
4	.0597	.0585	.0587	.0574				
5	.0908	.0914	.0867	.0896				
6	.0576	.0564	.0542	.0537				
B	.0495	.0405	.0429	.0298				
7	.0560	.0563	.0551	.0532				
8	.0596	.0578	.0591	.0571				
9	.0569	.0557	.0566	.0556				
10	.0564	.0591	.0550	.0550				
C	.0503	.0490	.0461	.0442				
11	.0542	.0543	.0520	.0524				
12	.0596	.0588	.0596	.0583				
13	.0570	.0593	.0558	.0576				
14	.0543	.0520	.0510	.0501				
D	.0508	.0490	.0463	.0417				
15	.0549	.0548	.0540	.0527				
16	.0589	.0594	.0588	.0596				
17	.0568	.0576	.0567	.0577				
18	.0578	.0582	.0534	.0538				
E	.0508	.0490	.0468	.0440				
19	.0554	.0544	.0533	.0516				
20	.0581	.0585	.0580	.0544				
21	.0563	.0563	.0562	.0548				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

GALVANIZED STEEL CORRUGATED PIPE
BEAR RIVER 1/2" AGGREGATE

"B 1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		199,975 x 5					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	836g		817g					
1	.0603	.0603	.0545	.0596				
2	.0595	.0591	.0504	.0524				
A	.0546	.0500	.0446	.0407				
3	.0596	.0558	.0506	.0529				
4	.0610	.0621	.0604	.0615				
5	.0617	.0631	.0617	.0601				
6	.0593	.0562	.0554	.0505				
B	.0506	.0445	.0434	.0335				
7	.0563	.0541	.0548	.0479				
8	.0634	.0622	.0596	.0621				
9	.0600	.0625	.0572	.0598				
10	.0578	.0560	.0553	.0510				
C	.0506	.0447	.0469	.0368				
11	.0575	.0551	.0517	.0508				
12	.0642	.0607	.0603	.0601				
13	.0609	.0604	.0565	.0593				
14	.0590	.0599	.0517	.0555				
D	.0534	.0487	.0470	.0413				
15	.0595	.0588	.0544	.0554				
16	.0621	.0635	.0594	.0638				
17	.0611	.0610	.0570	.0602				
18	.0614	.0584	.0537	.0574				
E	.0532	.0501	.0476	.0444				
19	.0583	.0578	.0541	.0548				
20	.0647	.0635	.0581	.0631				
21	.0617	.0638	.0561	.0616				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

THICKNESS MEASUREMENTS

ALCLAD ALUMINUM CORRUGATED PIPE
BEAR RIVER 1/2" AGGREGATE

"C_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		199,975 x 5					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	481g		465g					
1	.1005	.1005	.1001	.0995				
2	.0996	.0986	.0970	.0923				
A	.0834	.0758	.0765	.0642				
3	.0911	.0769	.0828	.0636				
4	.1043	.1047	.1039	.1043				
5	.0969	.0959	.0968	.0948				
6	.0980	.0934	.0958	.0835				
B	.0841	.0660	.0764	.0514				
7	.0958	.0787	.0902	.0639				
8	.1047	.1044	.1045	.1043				
9	.0976	.0975	.0973	.0973				
10	.0982	.0964	.0956	.0941				
C	.0835	.0716	.0754	.0584				
11	.0934	.0807	.0865	.0706				
12	.1028	.1049	.1027	.1049				
13	.0973	.0978	.0966	.0963				
14	.0959	.0871	.0923	.0794				
D	.0774	.0507	.0680	.0370				
15	.0909	.0734	.0856	.0574				
16	.1048	.1042	.1045	.1038				
17	.0979	.0987	.0977	.0978				
18	.0952	.0907	.0907	.0853				
E	.0721	.0568	.0618	.0472				
19	.0890	.0725	.0804	.0614				
20	.1069	.1042	.1055	.1020				
21	-	-	-	-				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

P.L.C. COATING OVER GALVANIZED CORRUGATED PIPE
BEAR RIVER 1/2" AGGREGATE

"D_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		199,975 x 5					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	1001g		998g					
1	.1013	.1048	.1012	.1042				
2	.1029	.1023	.1026	.1010				
A	.0970	.1035	.0971	.1033				
3	.1077	.1011	.1053	.1012				
4	.1062	.1051	.1052	.1053				
5	.1207	.1027	.1197	.1036				
6	.1020	.1031	.1008	.1033				
B	.0972	.1009	.0968	.0989				
7	.1113	.1042	.1102	.1029				
8	.1071	.1088	.1074	.1126				
9	.1089	.1036	.1082	.1034				
10	.0976	.1070	.0977	.1058				
C	.0899	.0971	.0887	.0952				
11	.1002	.0972	.0994	.0968				
12	.1055	.0989	.1040	.0987				
13	.1019	.1041	.1012	.1040				
14	.0881	.0879	.0871	.0871				
D	.0890	.0872	.0882	.0815				
15	.1003	.0935	.0998	.0935				
16	.1054	.0944	.1056	.0945				
17	.0855	.0898	.0849	.0895				
18	.0805	.0820	.0808	.0817				
E	.0722	.0747	.0720	.0736				
19	.0780	.0806	.0782	.0814				
20	.0853	.0819	.0845	.0818				
21	.0810	.0791	.0809	.0791				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

1" AGGREGATE

(6.30 Feet Per Second)

T H I C K N E S S M E A S U R E M E N T S

ALUMINIZED STEEL CORRUGATED PIPE
BEAR RIVER 1" AGGREGATE

"A_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		258,644 x 4					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	760g		732g					
1	.0539	.0521	.0528	.0508				
2	.0479	.0464	.0467	.0406				
A	.0444	.0307	.0375	.0230				
3	.0500	.0455	.0456	.0372				
4	.0587	.0574	.0585	.0566				
5	.0867	.0896	.0857	.0879				
6	.0542	.0537	.0526	.0490				
B	.0429	.0298	.0351	.0199				
7	.0551	.0532	.0494	.0454				
8	.0591	.0571	.0583	.0591				
9	.0566	.0556	.0562	.0549				
10	.0550	.0550	.0535	.0523				
C	.0461	.0442	.0393	.0349				
11	.0520	.0524	.0473	.0473				
12	.0596	.0583	.0587	.0580				
13	.0558	.0576	.0548	.0559				
14	.0510	.0501	.0481	.0460				
D	.0463	.0417	.0398	.0330				
15	.0540	.0527	.0519	.0497				
16	.0588	.0596	.0586	.0586				
17	.0567	.0577	.0559	.0573				
18	.0534	.0538	.0509	.0522				
E	.0468	.0440	.0403	.0370				
19	.0533	.0516	.0484	.0485				
20	.0580	.0544	.0574	.0576				
21	.0562	.0548	.0555	.0545				

OVERALL = 1-21 LOCATIONS

CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS

MOST CRITICAL = A-E LOCATIONS

THICKNESS MEASUREMENTS

GALVANIZED STEEL CORRUGATED PIPE
BEAR RIVER 1" AGGREGATE

"B_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		258,644 x 4					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	817g		787g					
1	.0545	.0596	.0545	.0572				
2	.0504	.0524	.0503	.0466				
A	.0446	.0407	.0447	.0328				
3	.0506	.0529	.0487	.0466				
4	.0604	.0615	.0600	.0614				
5	.0617	.0601	.0595	.0585				
6	.0554	.0505	.0524	.0445				
B	.0434	.0335	.0404	.0271				
7	.0548	.0479	.0429	.0353				
8	.0596	.0621	.0615	.0607				
9	.0572	.0598	.0572	.0584				
10	.0553	.0510	.0520	.0455				
C	.0469	.0368	.0390	.0288				
11	.0517	.0508	.0477	.0395				
12	.0603	.0601	.0630	.0610				
13	.0565	.0593	.0565	.0592				
14	.0517	.0555	.0558	.0537				
D	.0470	.0413	.0439	.0342				
15	.0544	.0554	.0540	.0510				
16	.0594	.0638	.0616	.0644				
17	.0570	.0602	.0615	.0604				
18	.0537	.0574	.0573	.0564				
E	.0476	.0444	.0448	.0383				
19	.0541	.0548	.0538	.0498				
20	.0581	.0631	.0638	.0630				
21	.0561	.0616	.0600	.0605				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S M E A S U R E M E N T S

ALCLAD ALUMINUM CORRUGATED PIPE
BEAR RIVER 1" AGGREGATE

"C_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		258,644 x 4					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	465g		443g					
1	.1001	.0995	.1000	.0995				
2	.0970	.0923	.0937	.0883				
A	.0765	.0642	.0647	.0527				
3	.0828	.0636	.0696	.0487				
4	.1039	.1043	.1038	.1030				
5	.0968	.0948	.0967	.0933				
6	.0958	.0835	.0929	.0766				
B	.0764	.0514	.0663	.0395				
7	.0902	.0639	.0802	.0467				
8	.1045	.1043	.1043	.1040				
9	.0973	.0973	.0972	.0972				
10	.0956	.0941	.0926	.0867				
C	.0754	.0584	.0676	.0470				
11	.0865	.0706	.0766	.0552				
12	.1027	.1049	.1024	.1043				
13	.0966	.0963	.0965	.0956				
14	.0923	.0794	.0898	.0740				
D	.0680	.0370	.0598	.0307				
15	.0856	.0574	.0754	.0384				
16	.1045	.1038	.1041	.1038				
17	.0977	.0978	.0968	.0969				
18	.0907	.0853	.0871	.0790				
E	.0618	.0472	.0514	.0335				
19	.0804	.0614	.0696	.0444				
20	.1055	.1020	.1051	.0998				
21	-	-	-	-				

OVERALL = 1-20 LOCATIONS

CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS

MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

P.L.C. COATING OVER GALVANIZED CORRUGATED PIPE
BEAR RIVER 1" AGGREGATE

"D_1"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		258,644 x 4					
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight	998g		987g					
1	.1012	.1042	.1018	.1023				
2	.1026	.1010	.1008	.0996				
A	.0971	.1033	.0922	.0893				
3	.1053	.1012	.1004	.0893				
4	.1053	.1053	.1043	.1052				
5	.1197	.1036	.1195	.1039				
6	.1008	.1033	.1015	.1010				
B	.0968	.0989	.0928	.0876				
7	.1102	.1029	.1064	.0936				
8	.1074	.1126	.1076	.1121				
9	.1082	.1034	.1086	.1051				
10	.0977	.1058	.0977	.1059				
C	.0887	.0952	.0859	.0863				
11	.0994	.0968	.0955	.0926				
12	.1040	.0987	.1043	.0988				
13	.1012	.1040	.1020	.1032				
14	.0871	.0871	.0854	.0846				
D	.0882	.0815	.0753	.0574				
15	.0998	.0935	.0932	.0714				
16	.1056	.0945	.1049	.0972				
17	.0849	.0895	.0866	.0914				
18	.0808	.0817	.0789	.0782				
E	.0720	.0736	.0605	.0539				
19	.0782	.0814	.0617	.0594				
20	.0845	.0818	.0837	.0827				
21	.0809	.0791	.0796	.0793				

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

1 1/2" AGGREGATE

(6.30 Feet Per Second)

THICKNESS MEASUREMENTS

ALUMINIZED STEEL CORRUGATED PIPE
BEAR RIVER 1 1/2" AGGREGATE

"A_2"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		-0-		125,000 x 8			
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight			779g		760g			
1			.0570	.0565	.0551	.0559		
2			.0534	.0589	.0514	.0519		
A			.0459	.0500	.0390	.0403		
3			.0519	.0533	.0479	.0458		
4			.0585	.0579	.0572	.0562		
5			.0569	.0567	.0553	.0559		
6			.0530	.0530	.0515	.0485		
B			.0465	.0464	.0411	.0387		
7			.0512	.0531	.0477	.0492		
8			.0582	.0575	.0575	.0573		
9			.0561	.0575	.0561	.0563		
10			.0552	.0530	.0531	.0504		
C			.0485	.0484	.0431	.0407		
11			.0524	.0556	.0486	.0513		
12			.0577	.0567	.0577	.0567		
13			.0562	.0581	.0556	.0572		
14			.0560	.0552	.0540	.0529		
D			.0497	.0489	.0447	.0407		
15			.0537	.0536	.0511	.0501		
16			.0585	.0607	.0577	.0571		
17			.0563	.0569	.0561	.0566		
18			.0572	.0570	.0540	.0537		
E			.0514	.0495	.0456	.0422		
19			.0563	.0537	.0517	.0492		
20			.0581	.0584	.0580	.0576		
21			.0574	.0578	.0558	.0568		

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

GALVANIZED STEEL CORRUGATED PIPE
BEAR RIVER 1 1/2" AGGREGATE

"B_2"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		-0-		125,000 x 8			
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight			835g		816g			
1			.0581	.0592	.0573	.0581		
2			.0580	.0583	.0565	.0538		
A			.0531	.0512	.0480	.0458		
3			.0561	.0564	.0487	.0473		
4			.0612	.0634	.0601	.0616		
5			.0597	.0596	.0586	.0578		
6			.0563	.0578	.0519	.0567		
B			.0508	.0513	.0459	.0451		
7			.0582	.0541	.0526	.0428		
8			.0617	.0623	.0610	.0621		
9			.0604	.0587	.0598	.0569		
10			.0582	.0629	.0558	.0565		
C			.0537	.0509	.0474	.0452		
11			.0586	.0565	.0545	.0507		
12			.0633	.0603	.0629	.0603		
13			.0612	.0633	.0607	.0620		
14			.0604	.0613	.0584	.0585		
D			.0550	.0565	.0487	.0491		
15			.0617	.0592	.0585	.0567		
16			.0633	.0635	.0628	.0634		
17			.0599	.0650	.0597	.0650		
18			.0591	.0606	.0557	.0585		
E			.0554	.0562	.0501	.0483		
19			.0617	.0613	.0585	.0570		
20			.0624	.0638	.0612	.0637		
21			.0608	.0627	.0608	.0625		

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

T H I C K N E S S   M E A S U R E M E N T S

ALCLAD ALUMINUM CORRUGATED PIPE
BEAR RIVER 1 1/2" AGGREGATE

"C_2"

NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		-0-		125,000 x8			
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight			527 g		512 g			
1			.0976	.0978	.0969	.0945		
2			.0933	.0885	.0926	.0824		
A			.0755	.0732	.0657	.0595		
3			.0903	.0860	.0786	.0679		
4			.1045	.1073	.1044	.1062		
5			.0982	.0991	.0973	.0972		
6			.0992	.0966	.0958	.0897		
B			.0876	.0834	.0778	.0683		
7			.0972	.0946	.0856	.0789		
8			.1067	.1047	.1061	.1045		
9			.0986	.1005	.0981	.0995		
10			.1019	.1026	.0993	.0984		
C			.0936	.0927	.0853	.0795		
11			.0948	.0961	.0865	.0854		
12			.1068	.1054	.1061	.1050		
13			.0993	.0987	.0991	.0974		
14			.1021	.0986	.0994	.0948		
D			.0888	.0888	.0795	.0758		
15			.0983	.0959	.0921	.0848		
16			.1056	.1056	.1052	.1046		
17			.0995	.1019	.0991	.1005		
18			.1013	.0994	.0992	.0977		
E			.0922	.0888	.0845	.0776		
19			.0986	.0967	.0933	.0902		
20			.1065	.1031	.1057	.1021		
21			.0986	.1006	.0986	.0991		

OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

THICKNESS MEASUREMENTS

P.L.C. COATING OVER GALVANIZED CORRUGATED PIPE
BEAR RIVER 1 1/2" AGGREGATE

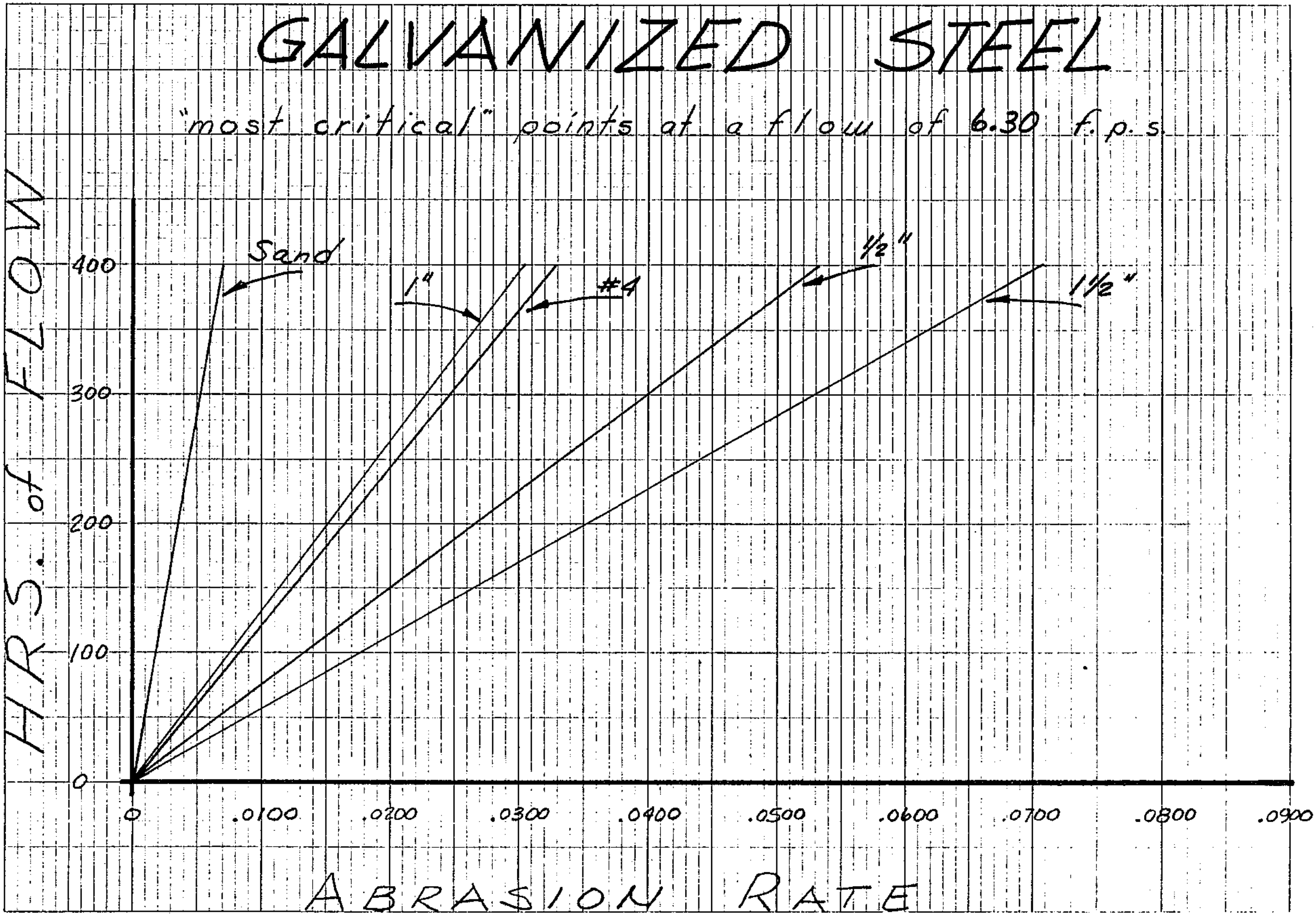
"D_2"

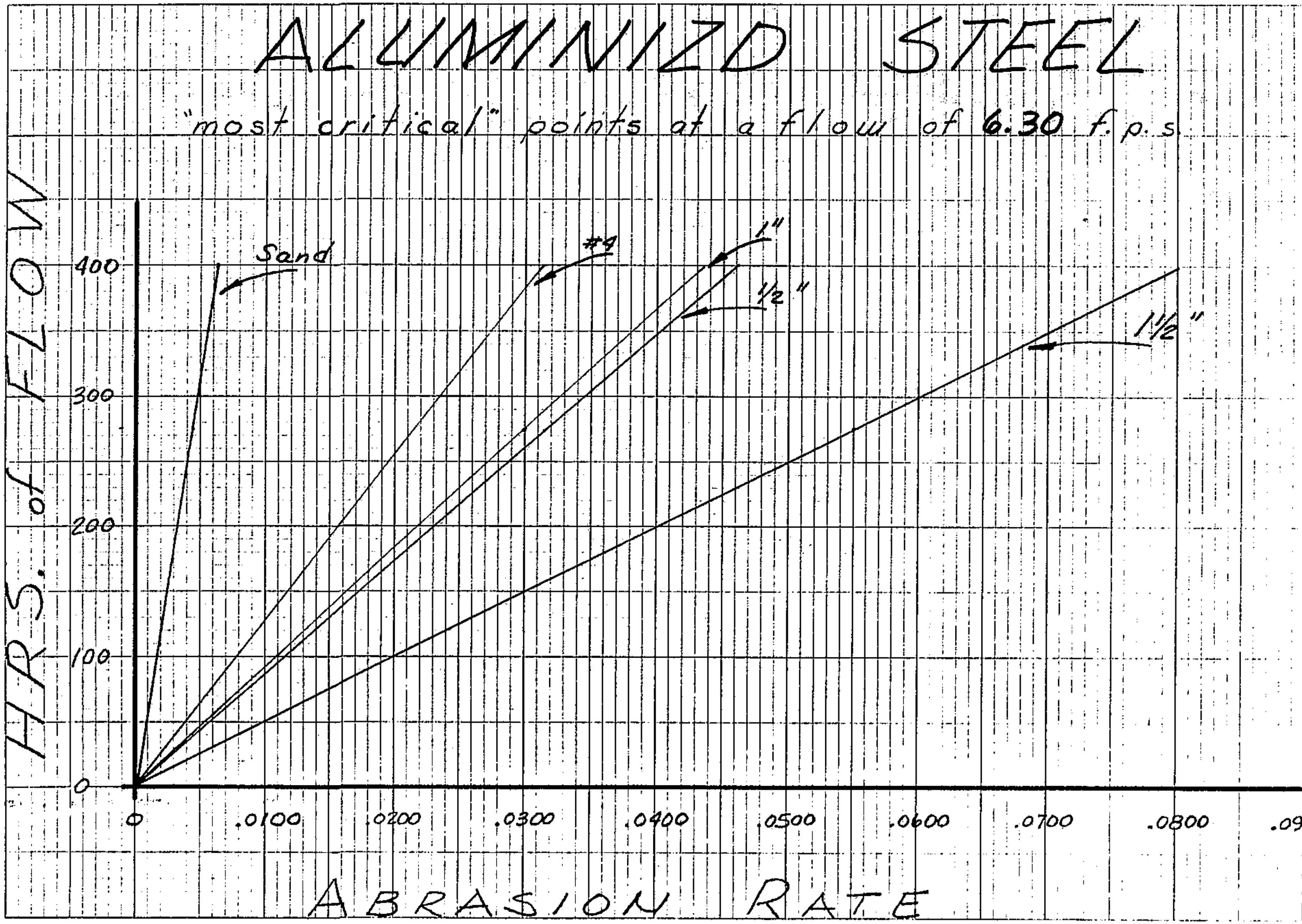
NUMBERS AND LOCATIONS	REVOLUTIONS AT 6.30 f/s							
	-0-		-0-		125,000x8			
	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
Weight			988 g		977 g			
1			.0847	.0822	.0836	.0802		
2			.0884	.0907	.0865	.0867		
A			.0909	.0931	.0869	.0785		
3			.0875	.0960	.0741	.0799		
4			.0938	.1022	.0929	.1019		
5			.0991	.1054	.0982	.1045		
6			.0993	.1039	.0980	.0996		
B			.1069	.1028	.0978	.0893		
7			.1024	.1067	.0969	.0929		
8			.1032	.1060	.1014	.1058		
9			.1106	.1239	.1100	.1223		
10			.1047	.1178	.1034	.1132		
C			.1029	.1174	.0988	.1060		
11			.0974	.1084	.0914	.1032		
12			.1038	.1076	.1017	.1063		
13			.1004	.1180	.0995	.1166		
14			.1009	.1090	.0999	.1082		
D			.0988	.1046	.0905	.0963		
15			.1006	.1159	.0960	.1029		
16			.1006	.1060	.0996	.1055		
17			.1064	.1135	.1062	.1123		
18			.1029	.1053	.1024	.1053		
E			.1043	.1135	.0949	.0955		
19			.0997	.1013	.0898	.0990		
20			.1066	.1043	.1062	.1033		
21			.0959	.1051	.0937	.1051		

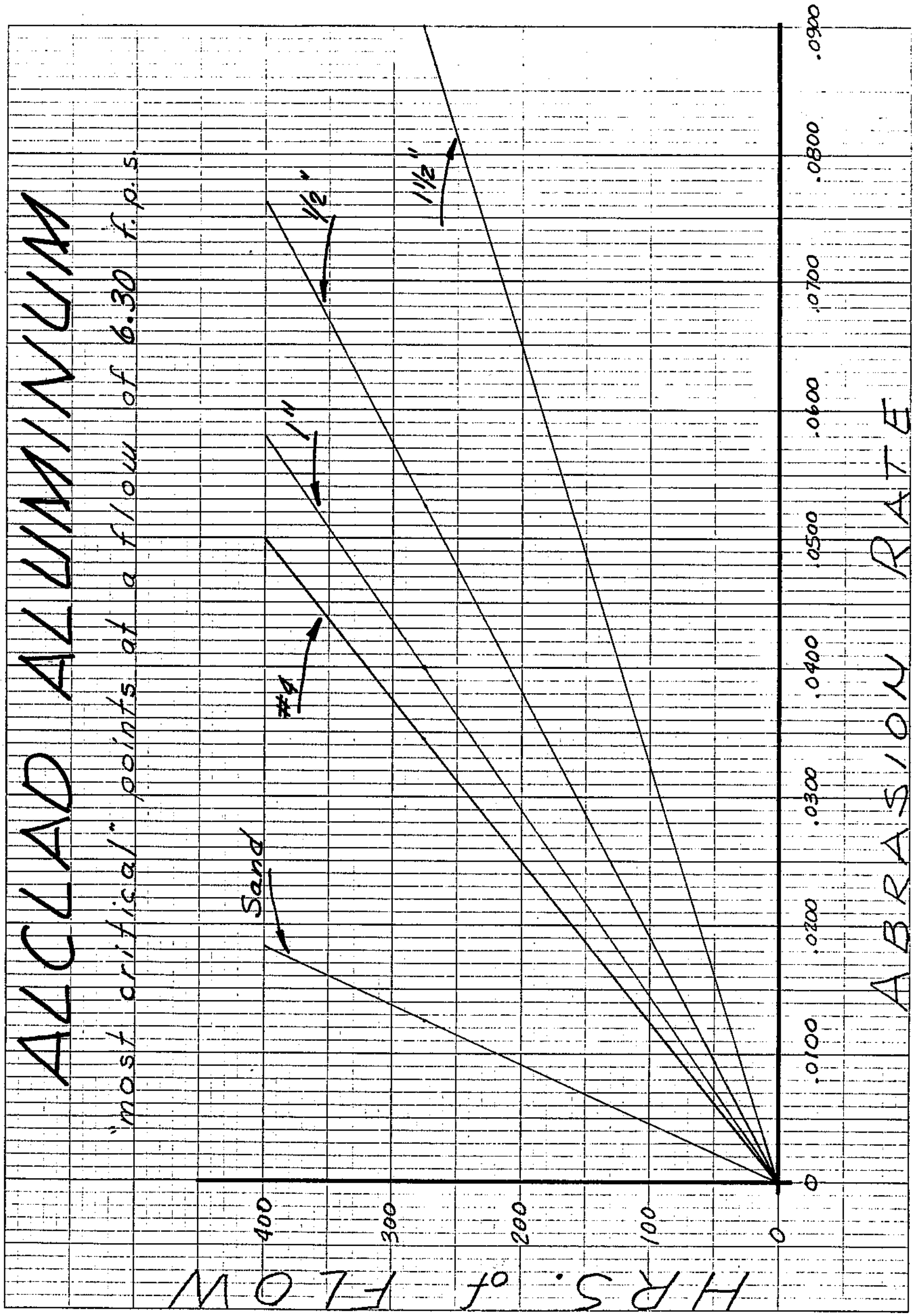
OVERALL = 1-21 LOCATIONS
CRITICAL = 2,3,6,7,10,11,14,15,18, & 19 LOCATIONS
MOST CRITICAL = A-E LOCATIONS

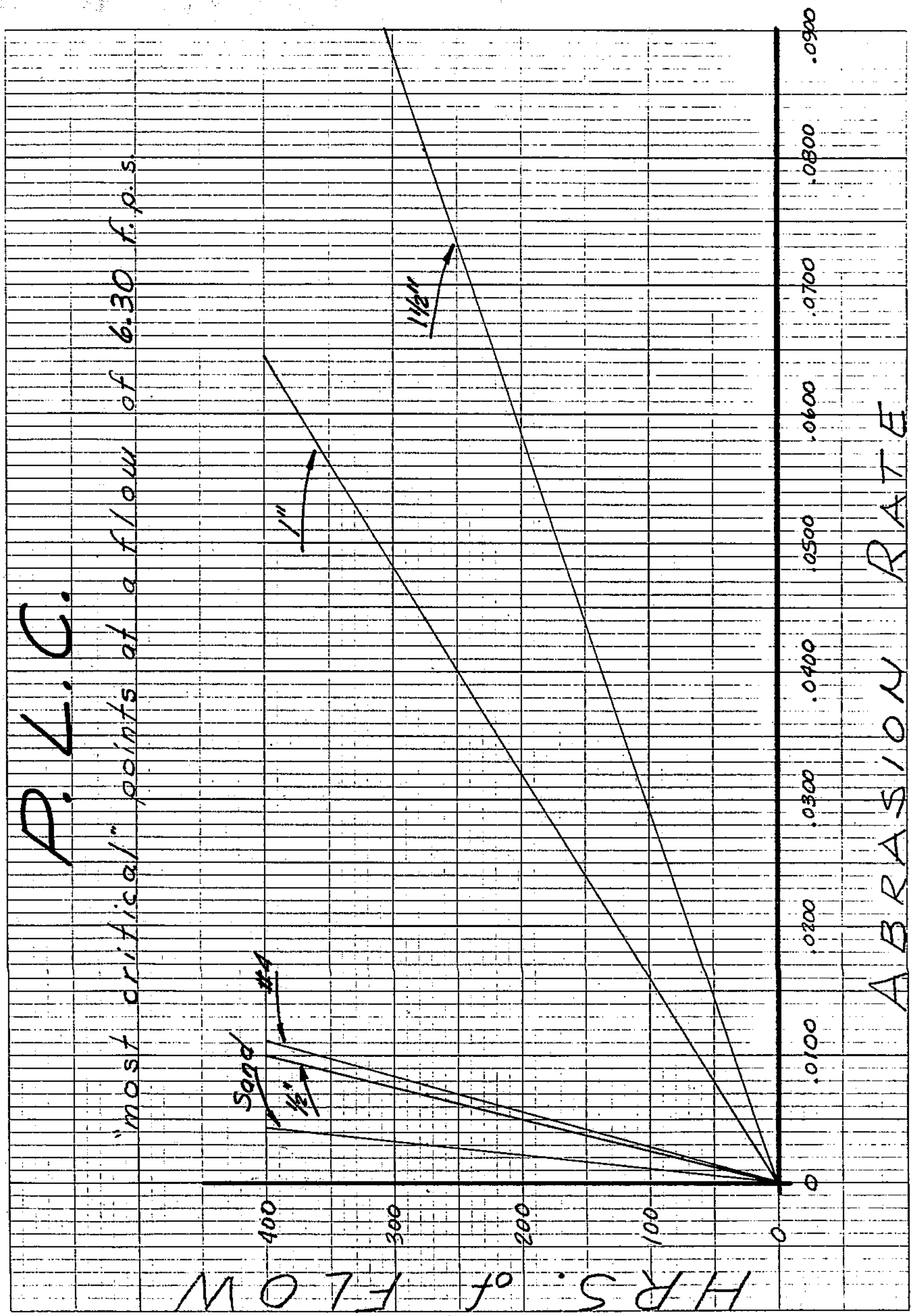
GRAPHS

46 0782

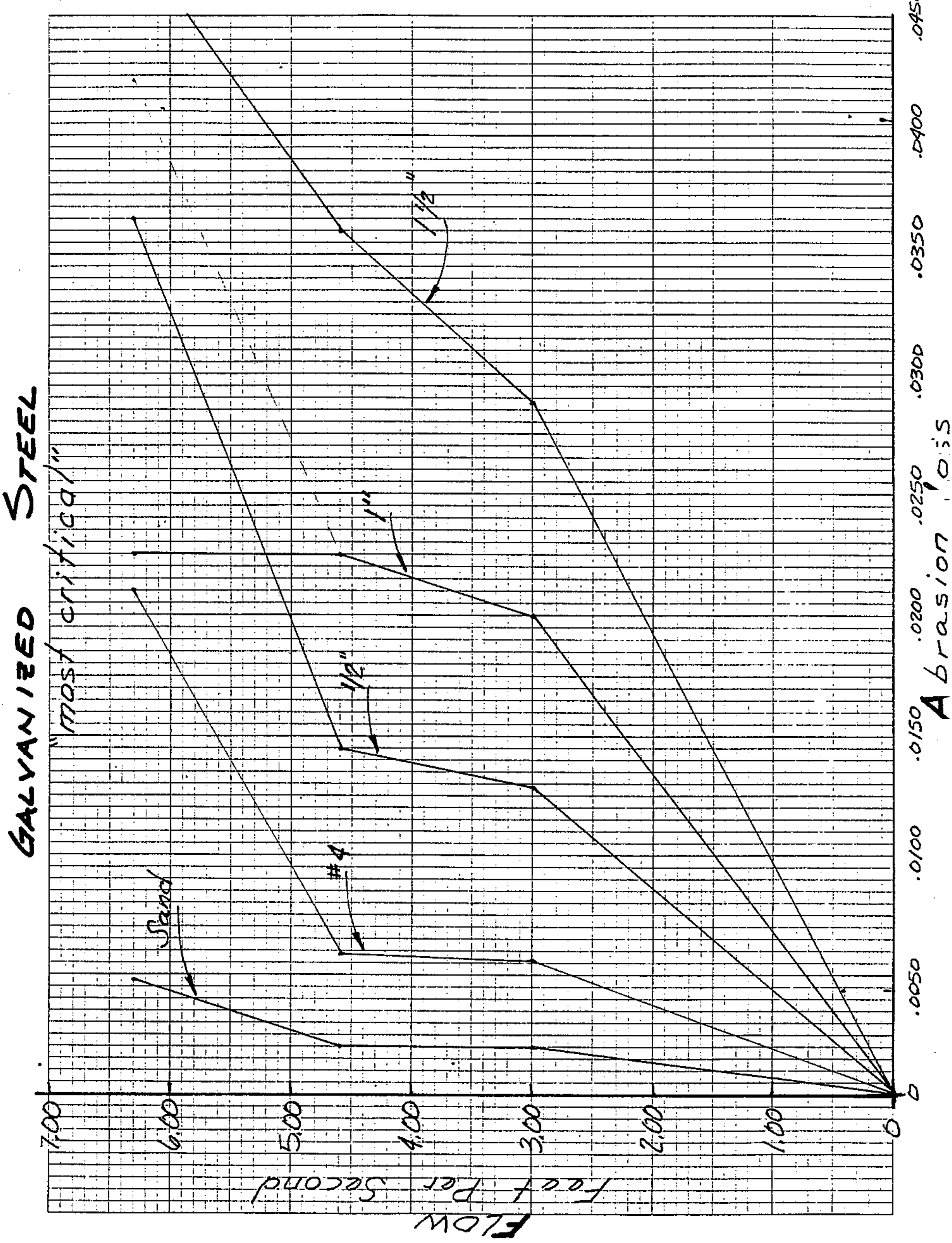

GALVANIZED STEEL
"most critical" points at a flow of 6.30 f.p.s.
HRS. of FLOW
ABRASION RATE
Sand
1"
#4
1/2"
1 1/2"
0
100
200
300
400
0
.0100
.0200
.0300
.0400
.0500
.0600
.0700
.0800
.0900

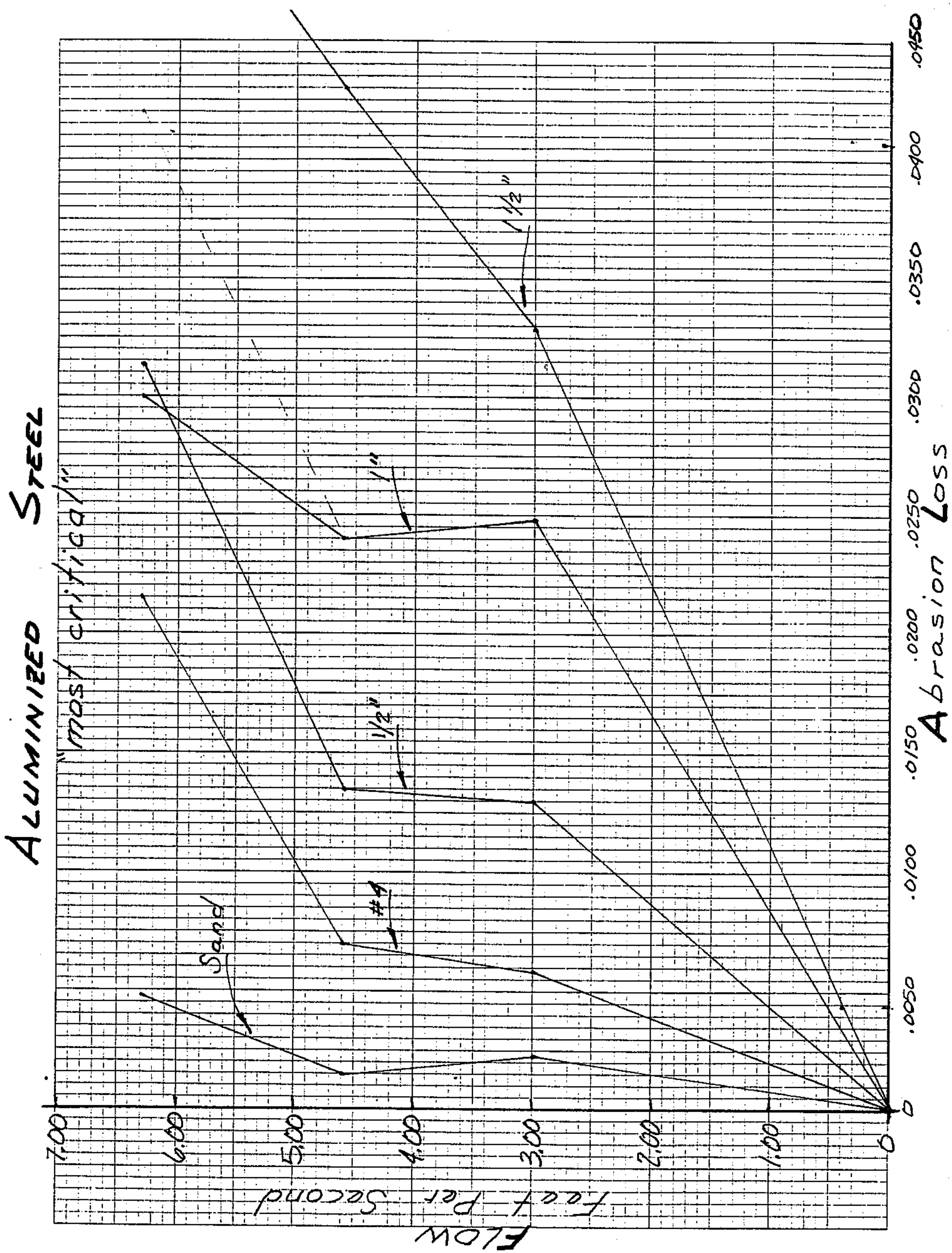

ALUMINIZD STEEL
"most critical" points at a flow of 6.30 f.p.s.
HRS. of FLOW
400
300
200
100
0
Sand
#4
1"
1/2"
1 1/2"
0
.0100
.0200
.0300
.0400
.0500
.0600
.0700
.0800
.0900
ABRASION RATE


ALCLAD ALUMINUM
"most critical" points at a flow of 6.30 f.p.s.
Sand
#4
1"
1/2"
1 1/2"
0
.0100
.0200
.0300
.0400
.0500
.0600
.0700
.0800
.0900
ABRASION RATE
0
100
200
300
400
HRS. of FLOW

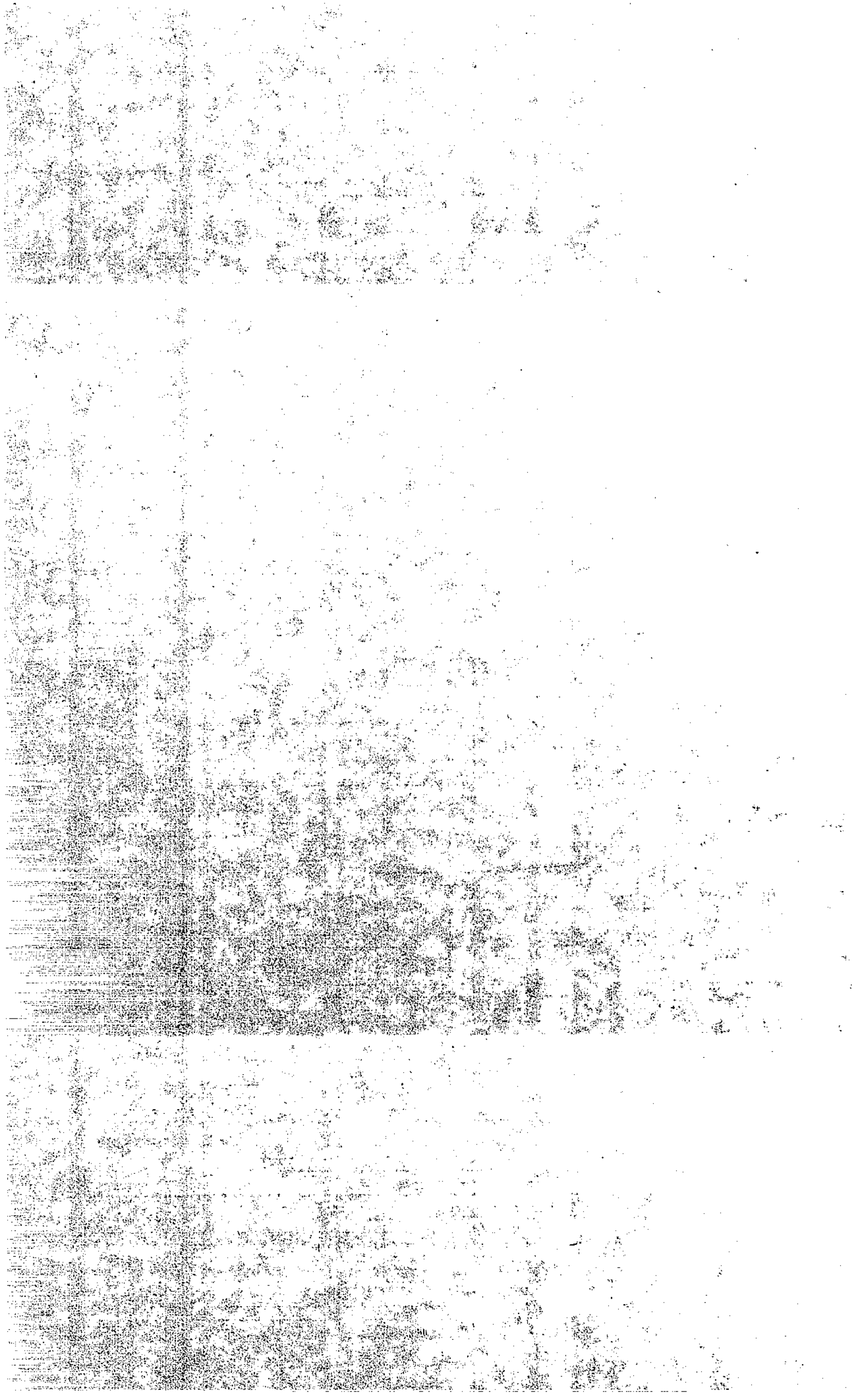


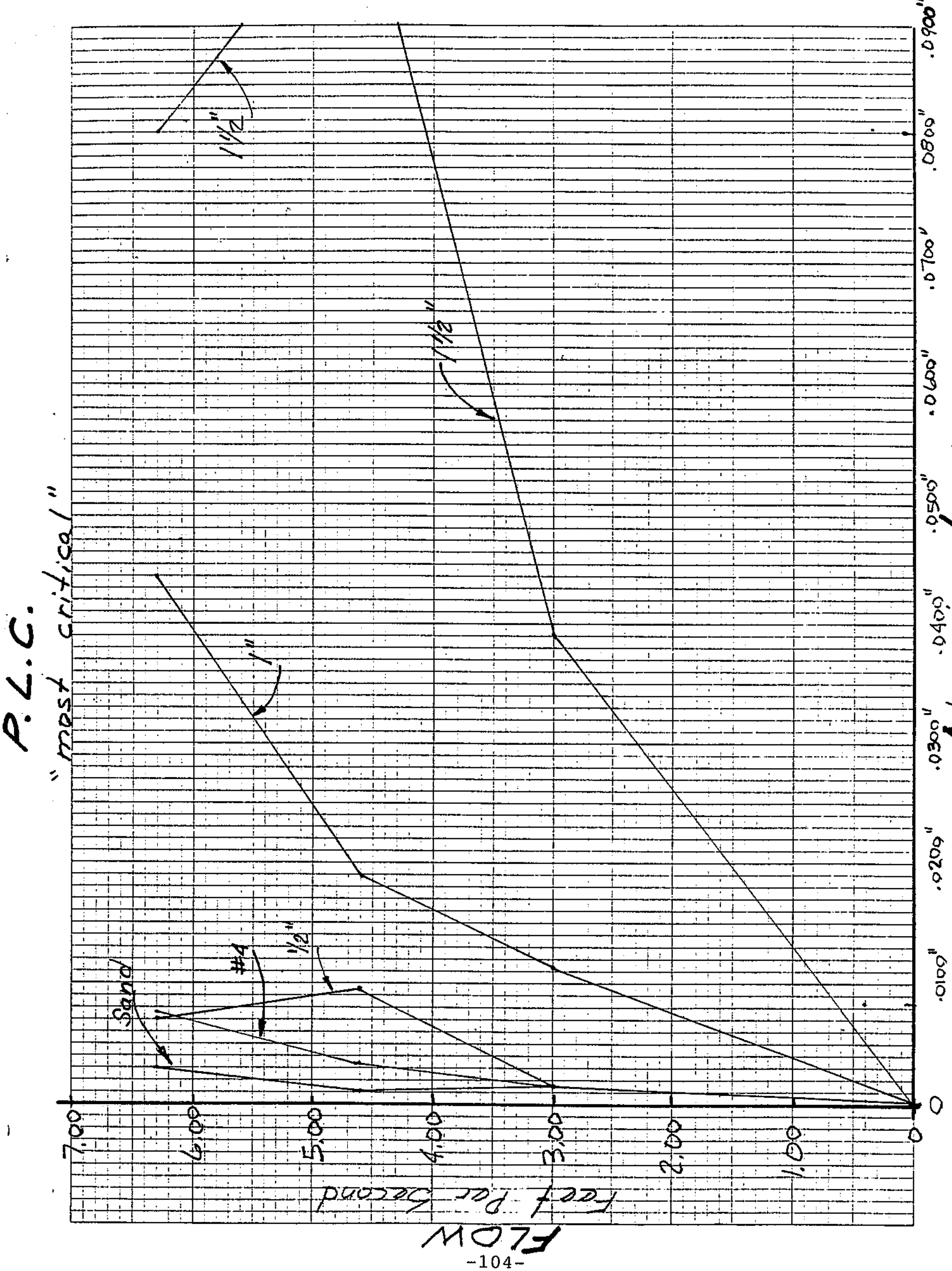
P.L.C.
"most critical" points at a flow of 6.30 f.p.s.
ABRASION RATE
0
.0100
.0200
.0300
.0400
.0500
.0600
.0700
.0800
.0900
HRS. of FLOW
0
100
200
300
400
1½"
1"
#4
Sand
½"

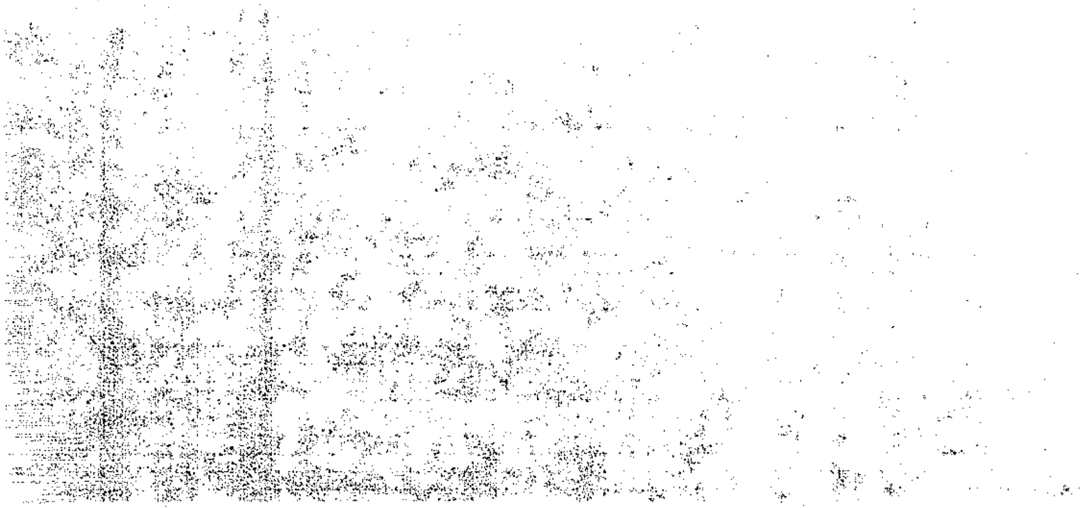

GALVANIZED STEEL
"most critical"
Sand
#4
1/2"
1"
1 1/2"
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0
Feet Per Second
FLOW
0
.0050
.0100
.0150
.0200
.0250
.0300
.0350
.0400
.0450
Abrasion

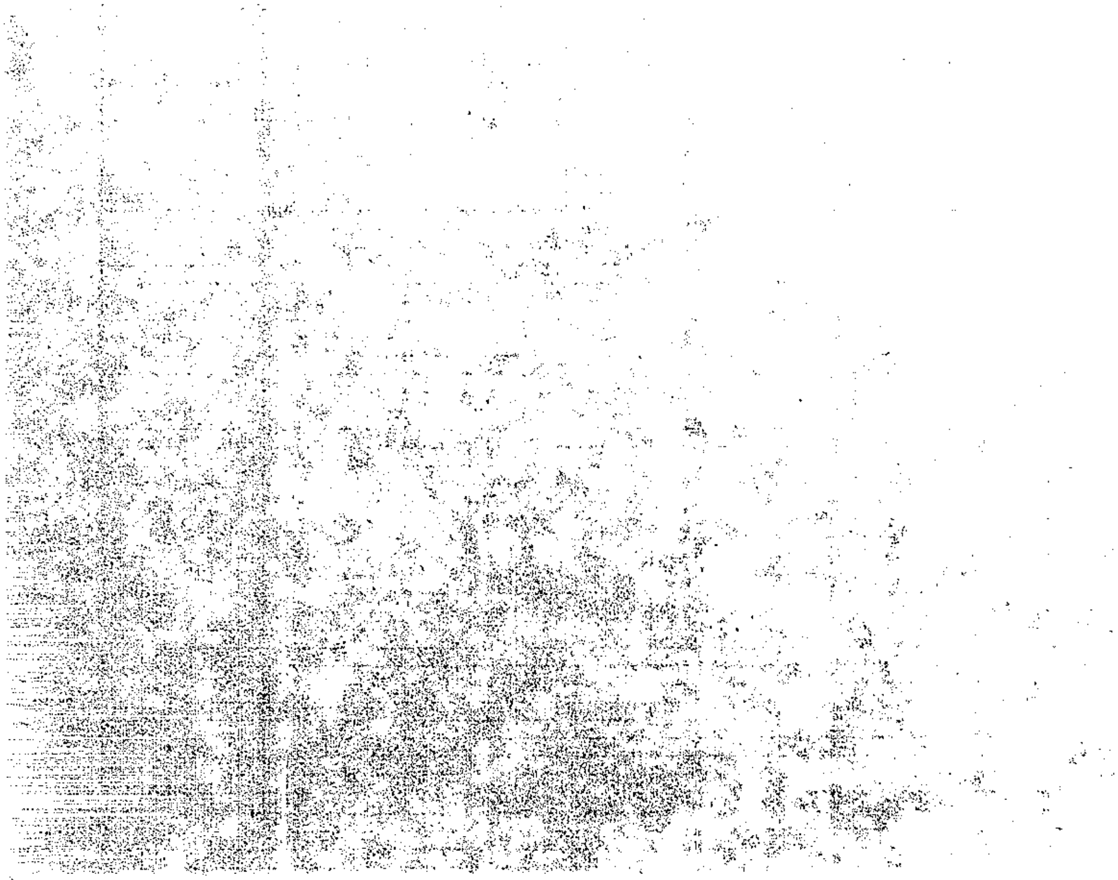


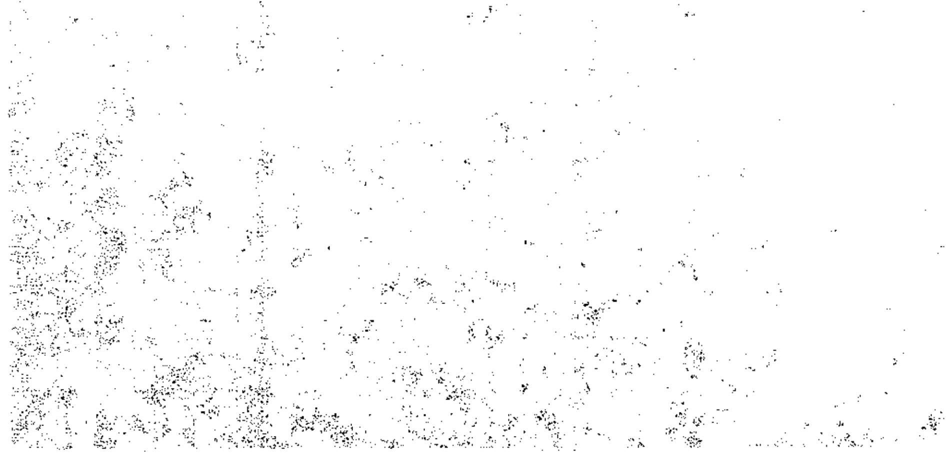
ALUMINIZED STEEL
"most critical"
Abrasion Loss
Flow Feet Per Second
1 1/2"
1"
1/2"
#4
Sand
0
.0050
.0100
.0150
.0200
.0250
.0300
.0350
.0400
.0450
1.00
2.00
3.00
4.00
5.00
6.00
7.00

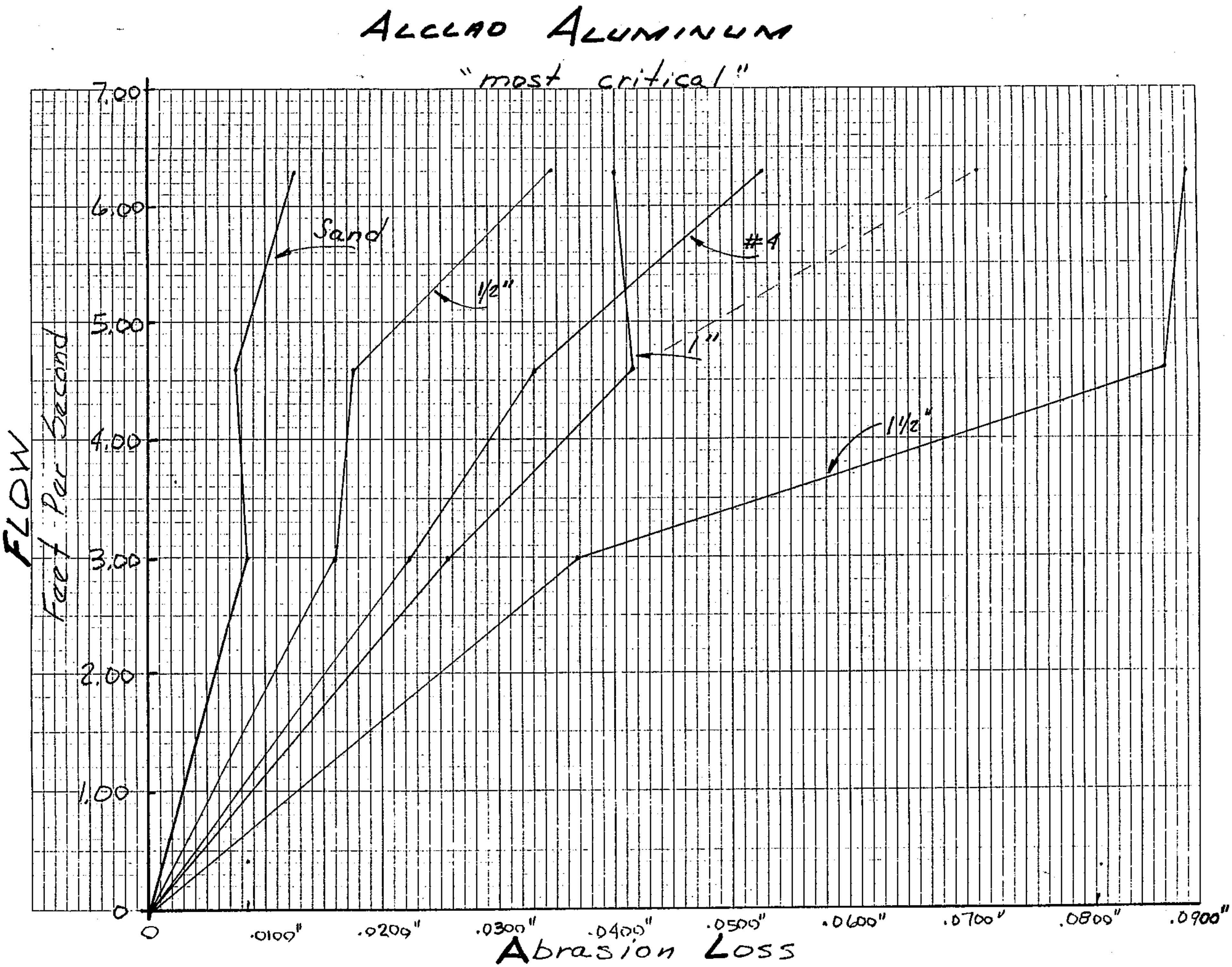



P.L.C.
"most critical"
Abrasion Loss
0
.0100"
.0200"
.0300"
.0400"
.0500"
.0600"
.0700"
.0800"
.0900"
FLOW
Feet Per Second
0
1.00
2.00
3.00
4.00
5.00
6.00
7.00
1 1/2"
1 1/2"
1"
1/2"
#4
Sand



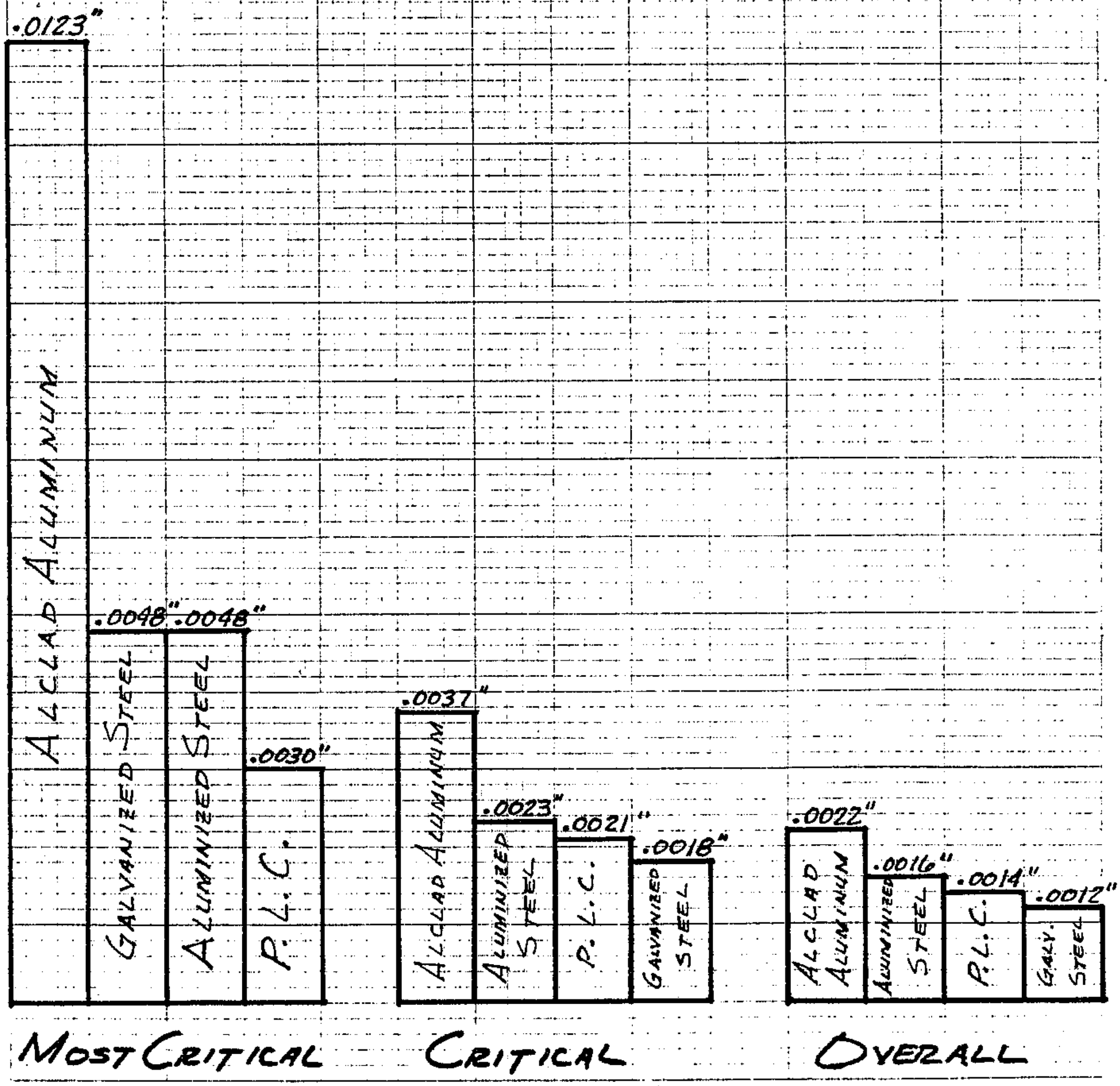


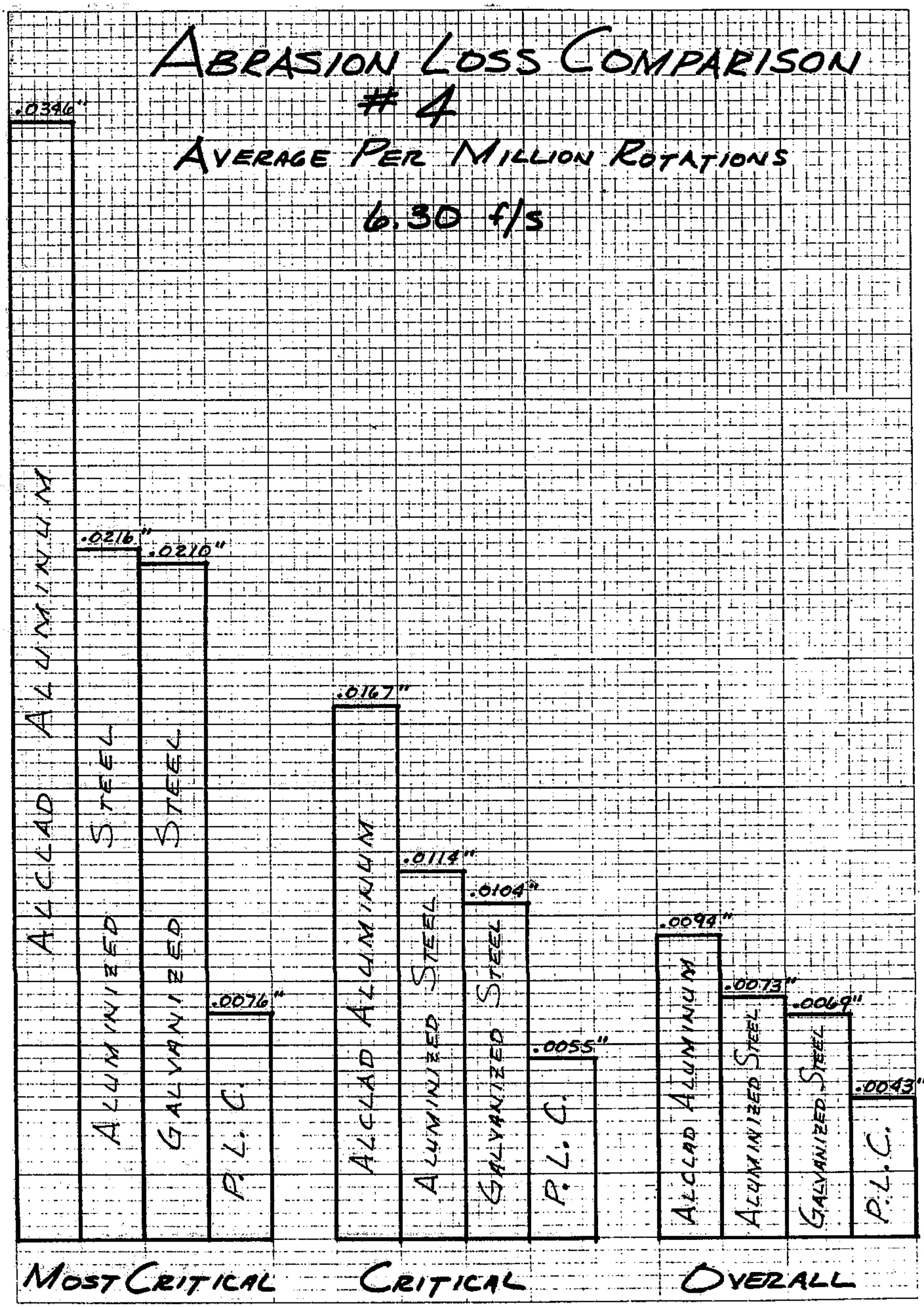


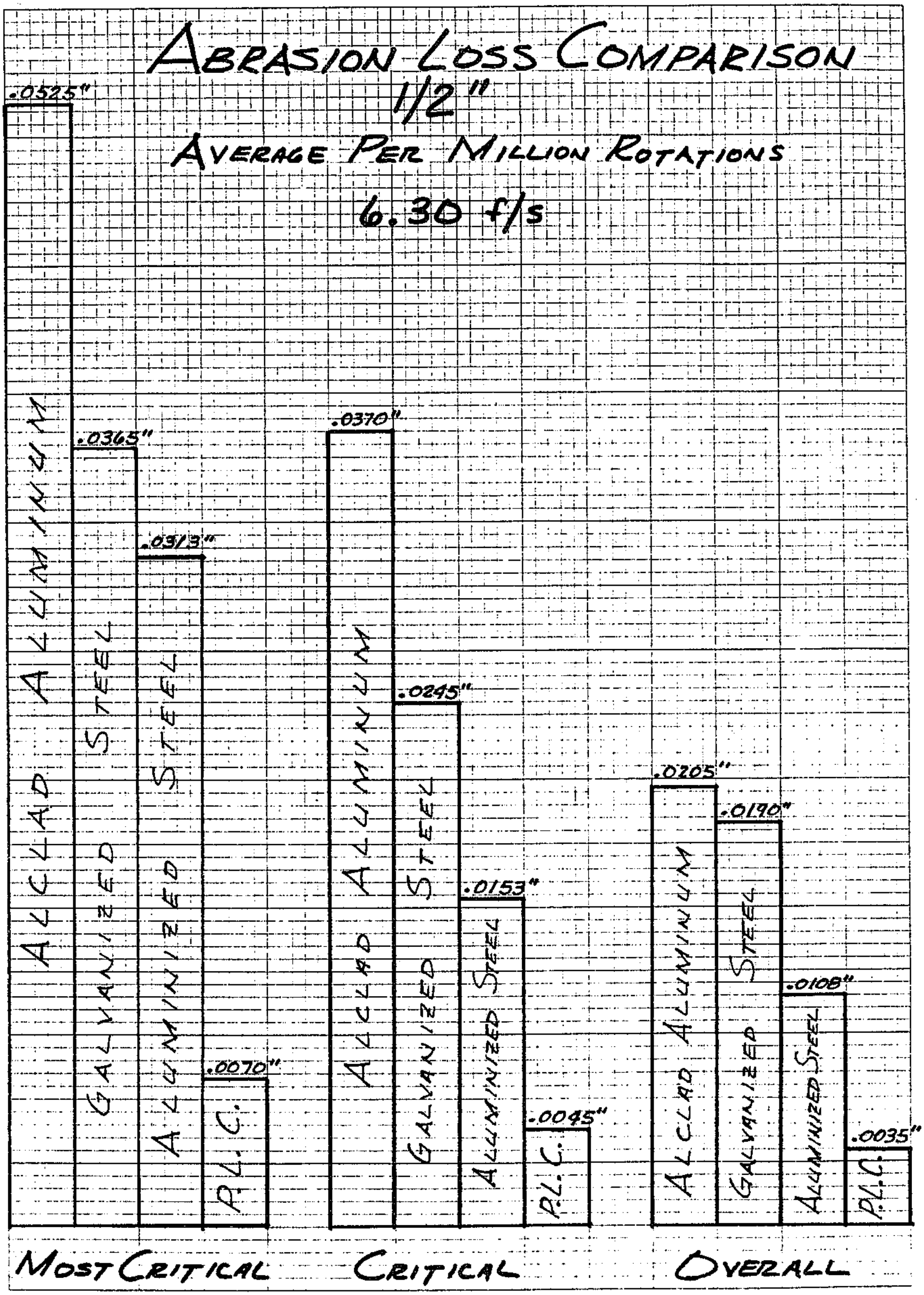


ALCLAD ALUMINUM
"most critical"
Sand
1/2"
#4
1"
1 1/2"
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0
FLOW
Feet Per Second
.0100"
.0200"
.0300"
.0400"
.0500"
.0600"
.0700"
.0800"
.0900"
Abrasion Loss

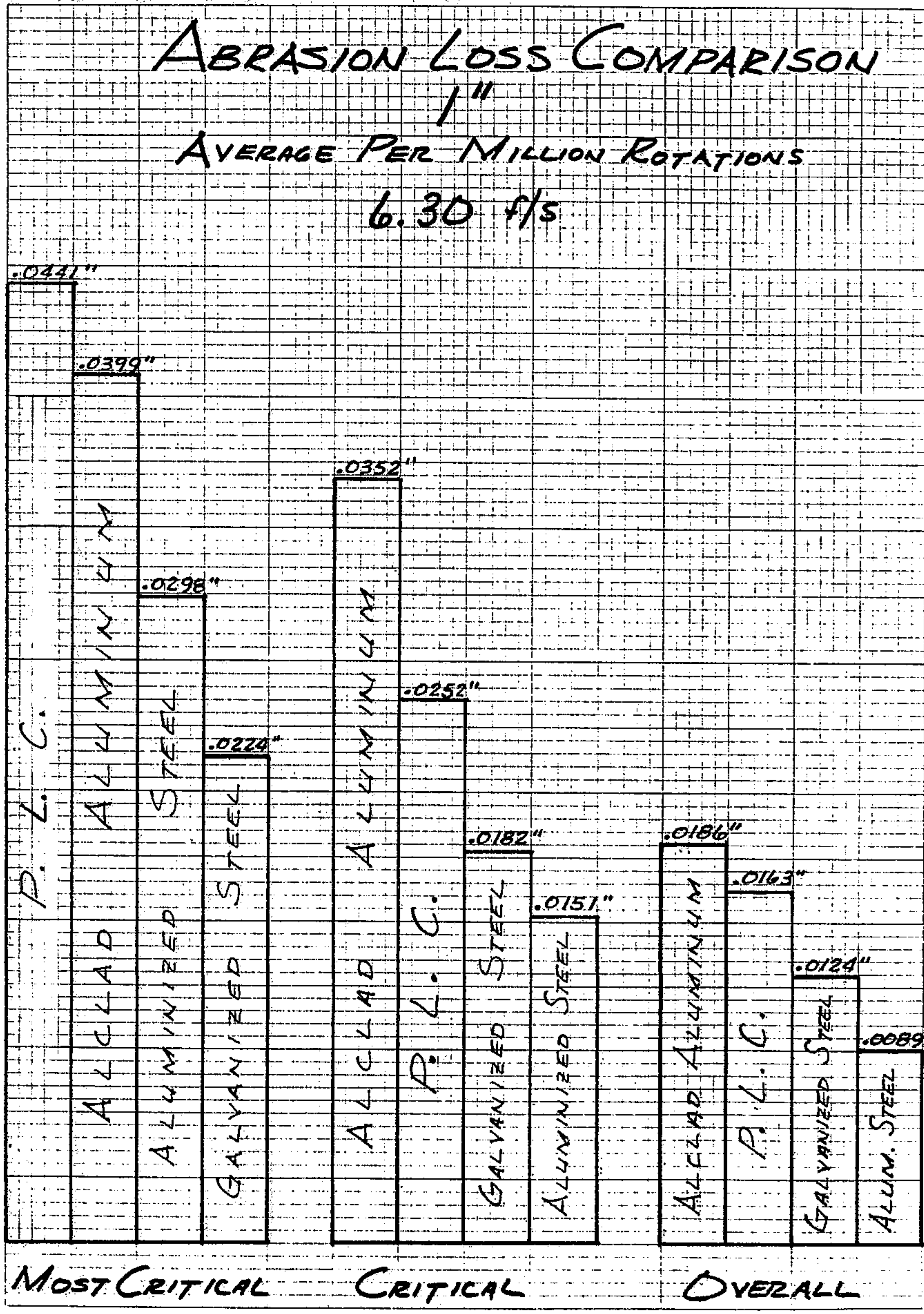
ABRASION LOSS COMPARISON
SAND
AVERAGE PER MILLION ROTATIONS
6.30 f/s

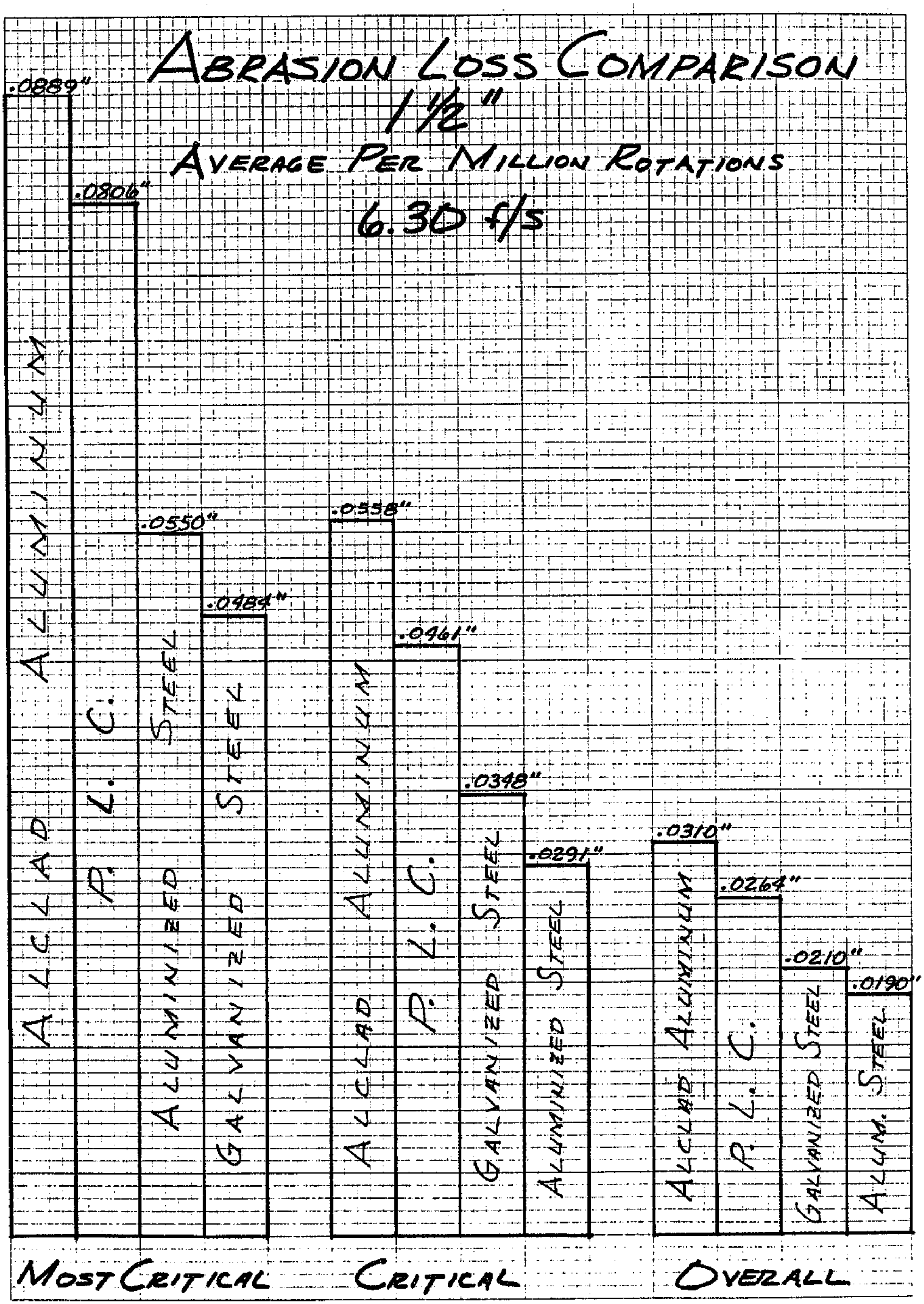


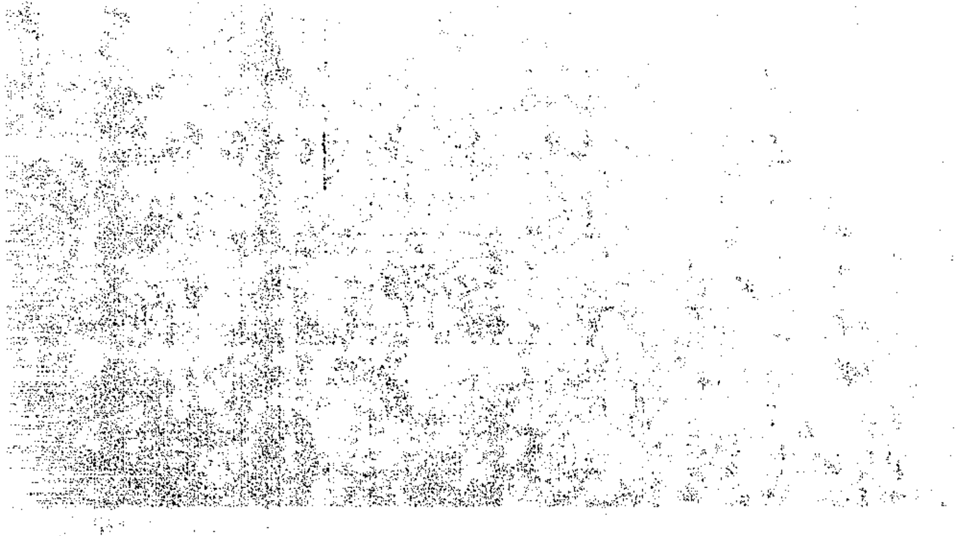

ABRASION LOSS COMPARISON
4
AVERAGE PER MILLION ROTATIONS
6.30 f/s
.0346"
ALCLAD ALUMINUM
.0216"
ALUMINIZED STEEL
.0210"
GALVANIZED STEEL
.0076"
P.L.C.
.0167"
ALCLAD ALUMINUM
.0114"
ALUMINIZED STEEL
.0104"
GALVANIZED STEEL
.0055"
P.L.C.
.0094"
ALCLAD ALUMINUM
.0073"
ALUMINIZED STEEL
.0069"
GALVANIZED STEEL
.0043"
P.L.C.
MOST CRITICAL
CRITICAL
OVERALL

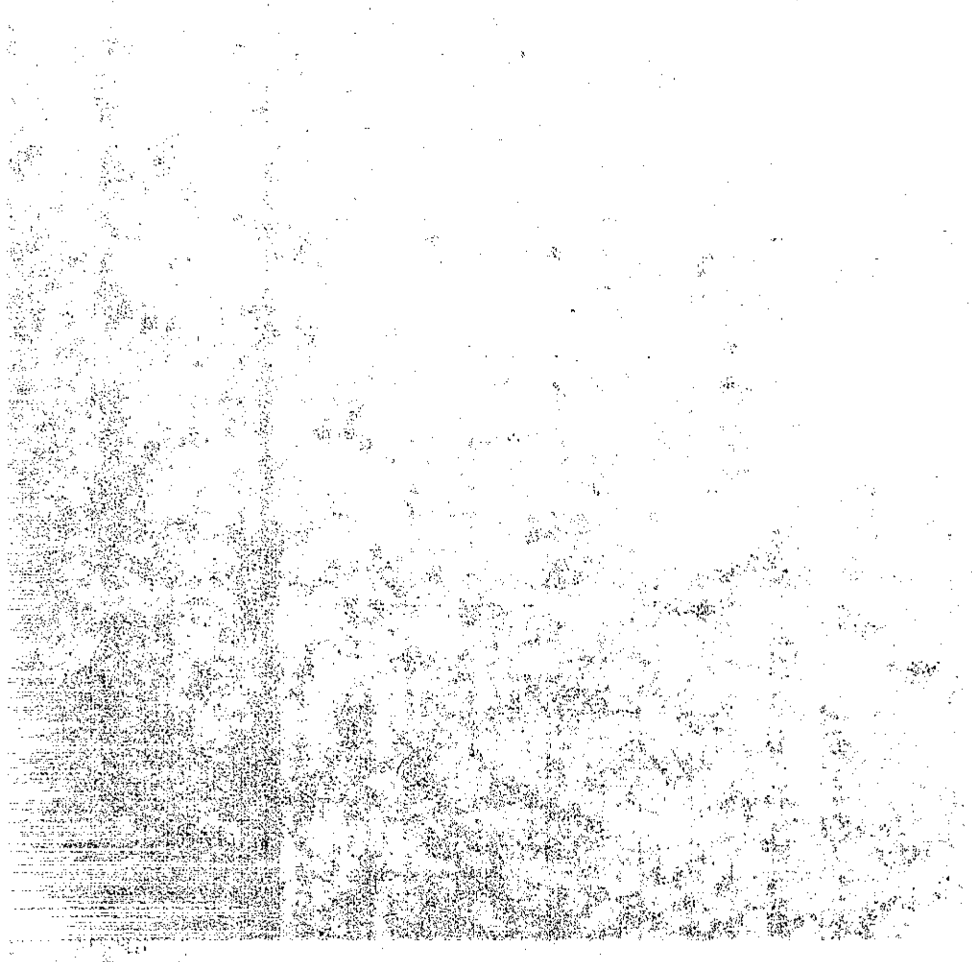


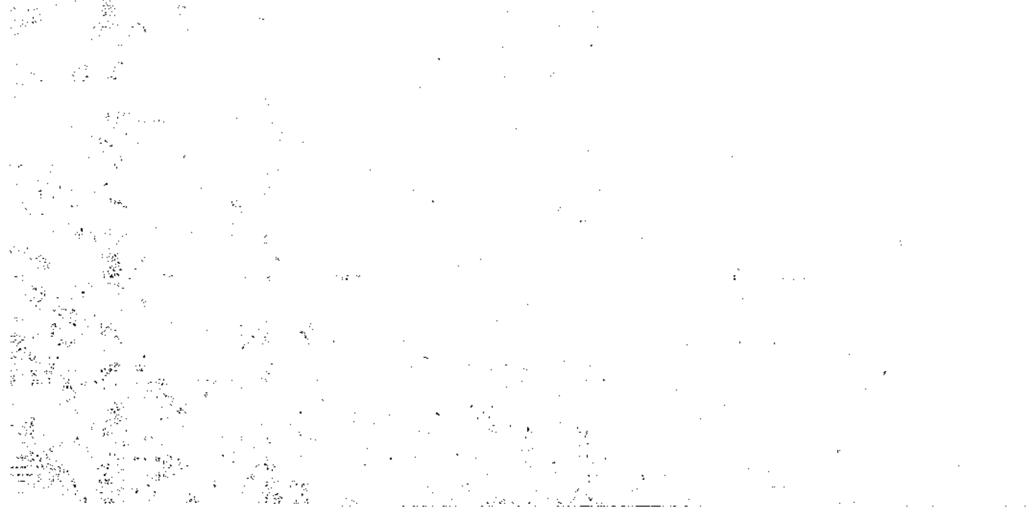
ABRASION LOSS COMPARISON
1/2"
AVERAGE PER MILLION ROTATIONS
6.30 f/s
.0525"
ALCLAD ALUMINUM
.0365"
GALVANIZED STEEL
.0313"
ALUMINIZED STEEL
.0070"
P.L.C.
.0370"
ALCLAD ALUMINUM
.0245"
GALVANIZED STEEL
.0153"
ALUMINIZED STEEL
.0045"
P.L.C.
.0205"
ALCLAD ALUMINUM
.0190"
GALVANIZED STEEL
.0108"
ALUMINIZED STEEL
.0035"
P.L.C.
MOST CRITICAL
CRITICAL
OVERALL


ABRASION LOSS COMPARISON
1"
AVERAGE PER MILLION ROTATIONS
6.30 f/s
.0441"
P. L. C.
.0399"
ALCLAD ALUMINUM
.0298"
ALUMINIZED STEEL
.0224"
GALVANIZED STEEL
.0352"
ALCLAD ALUMINUM
.0252"
P. L. C.
.0182"
GALVANIZED STEEL
.0151"
ALUMINIZED STEEL
.0186"
ALCLAD ALUMINUM
.0163"
P. L. C.
.0124"
GALVANIZED STEEL
.0089"
ALUM. STEEL
MOST CRITICAL
CRITICAL
OVERALL


ABRASION LOSS COMPARISON
1½"
AVERAGE PER MILLION ROTATIONS
6.30 f/s
.0889"
ALCLAD ALUMINUM
.0806"
P. L. C.
.0550"
ALUMINIZED STEEL
.0489"
GALVANIZED STEEL
.0558"
ALCLAD ALUMINUM
.0461"
P. L. C.
.0348"
GALVANIZED STEEL
.0291"
ALUMINIZED STEEL
.0310"
ALCLAD ALUMINUM
.0264"
P. L. C.
.0210"
GALVANIZED STEEL
.0190"
ALUM. STEEL
MOST CRITICAL
CRITICAL
OVERALL





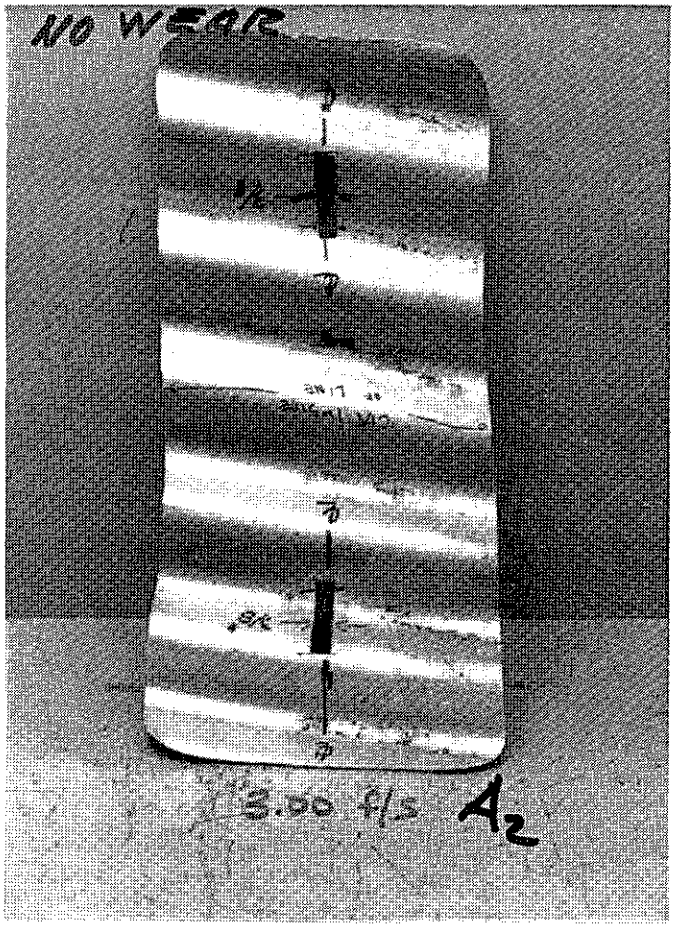
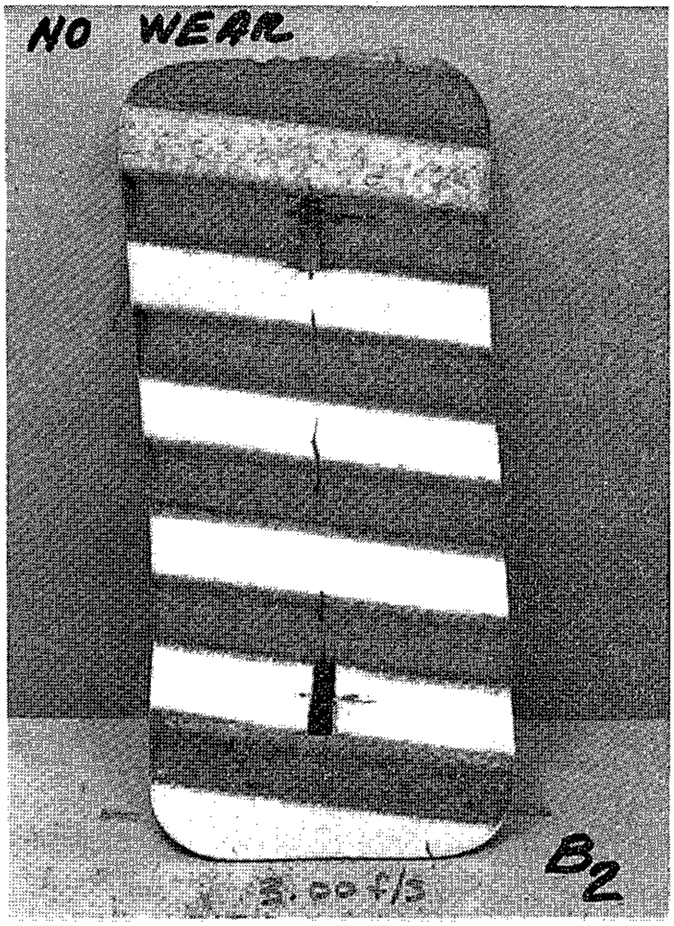
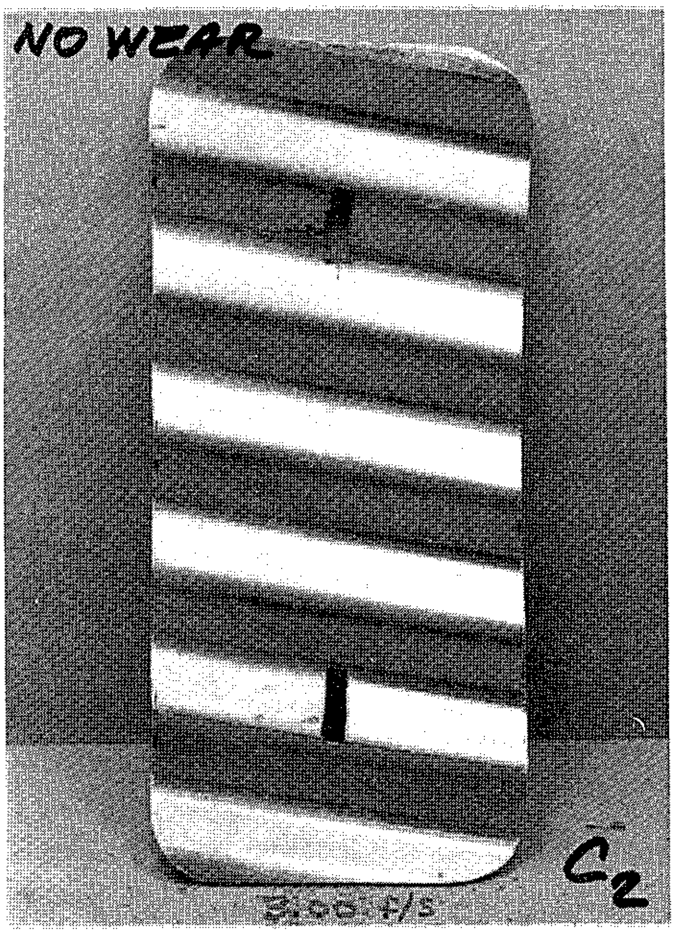
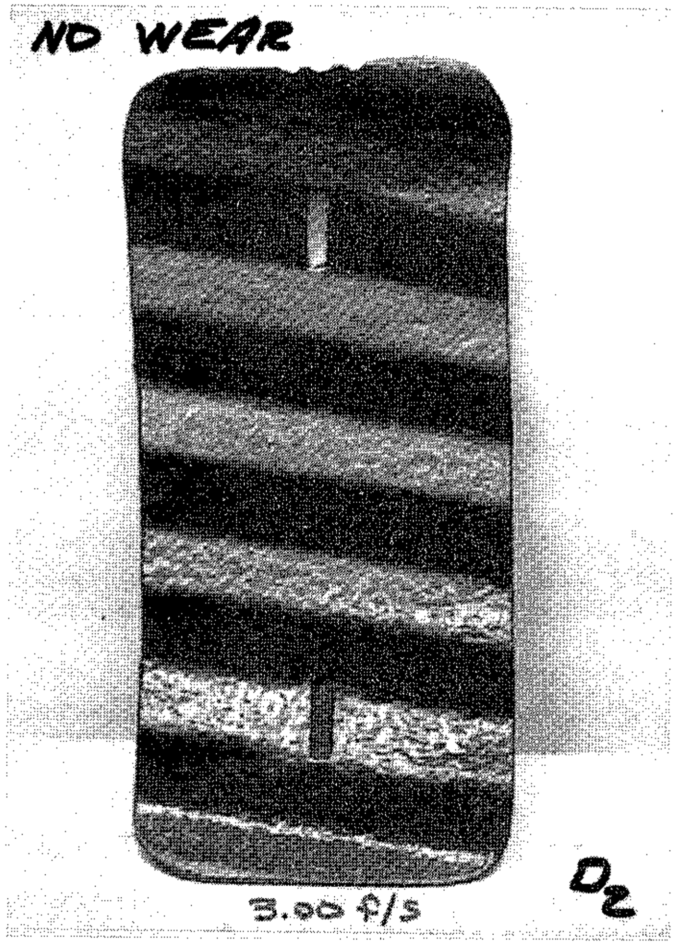


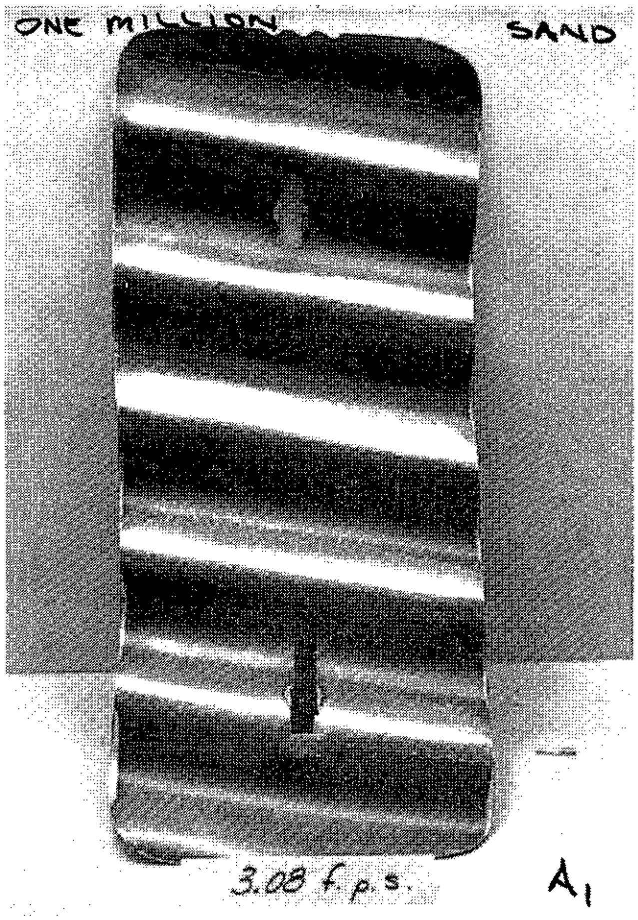
APPENDIX

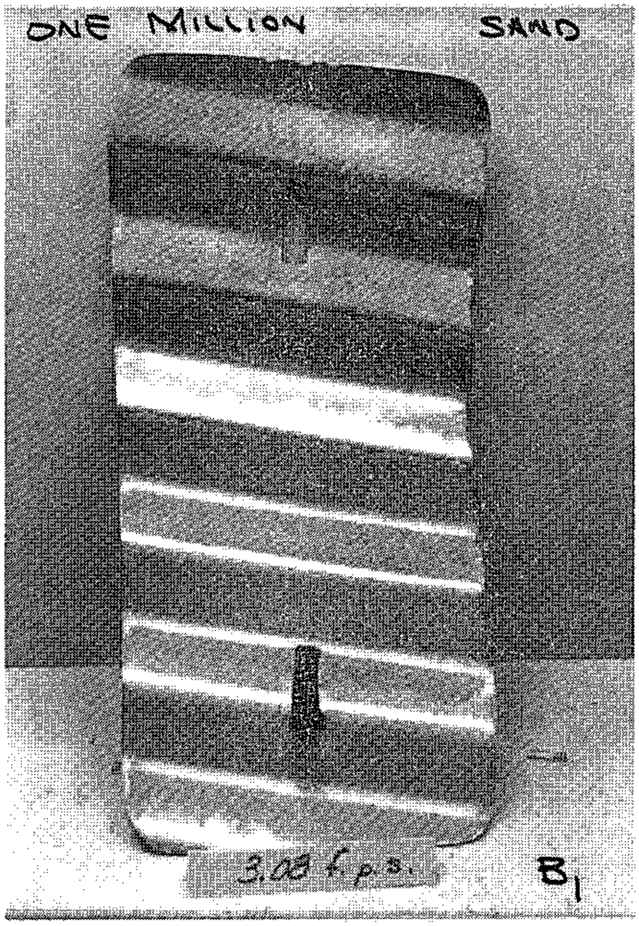
C

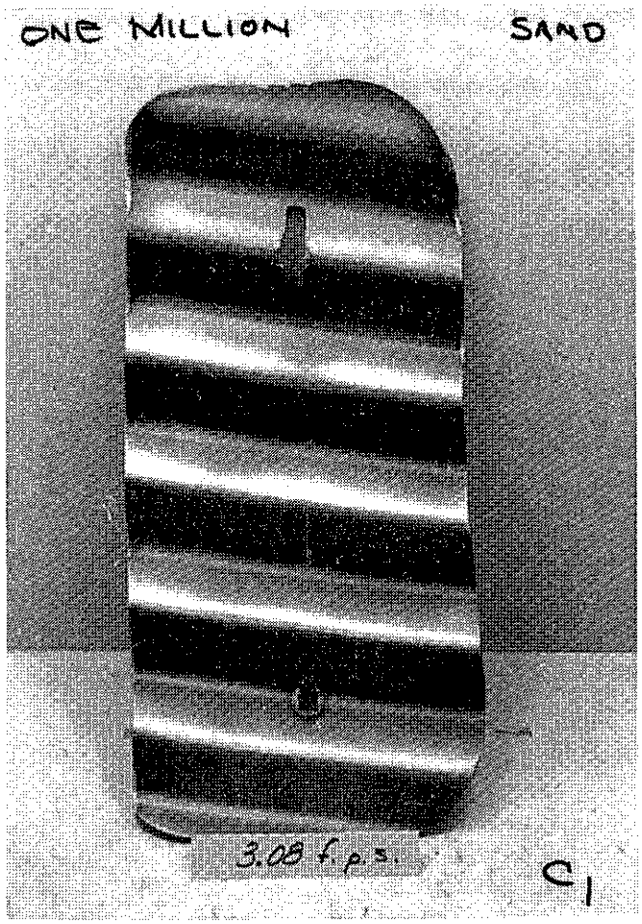
TEST GROUP I

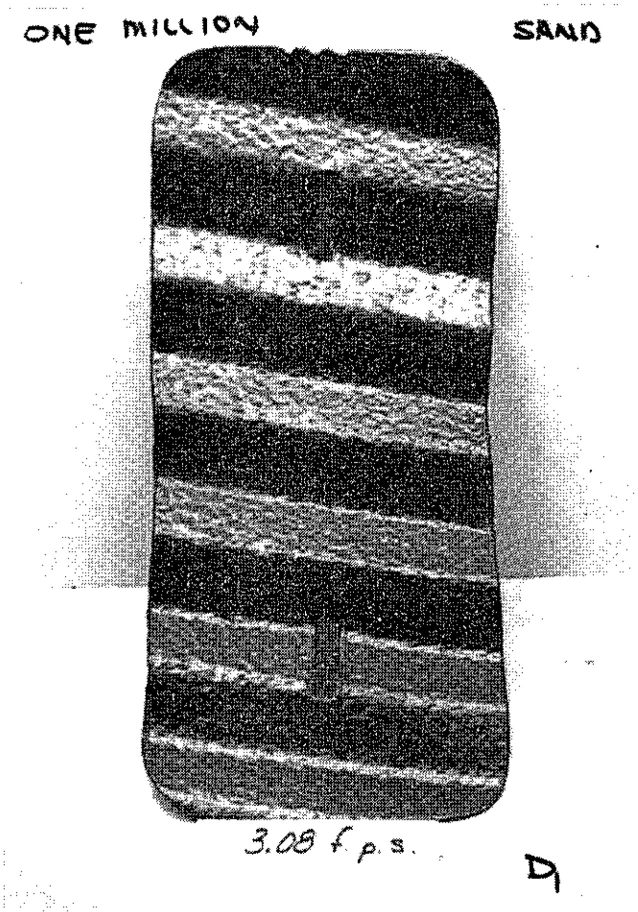
3.00 F/S

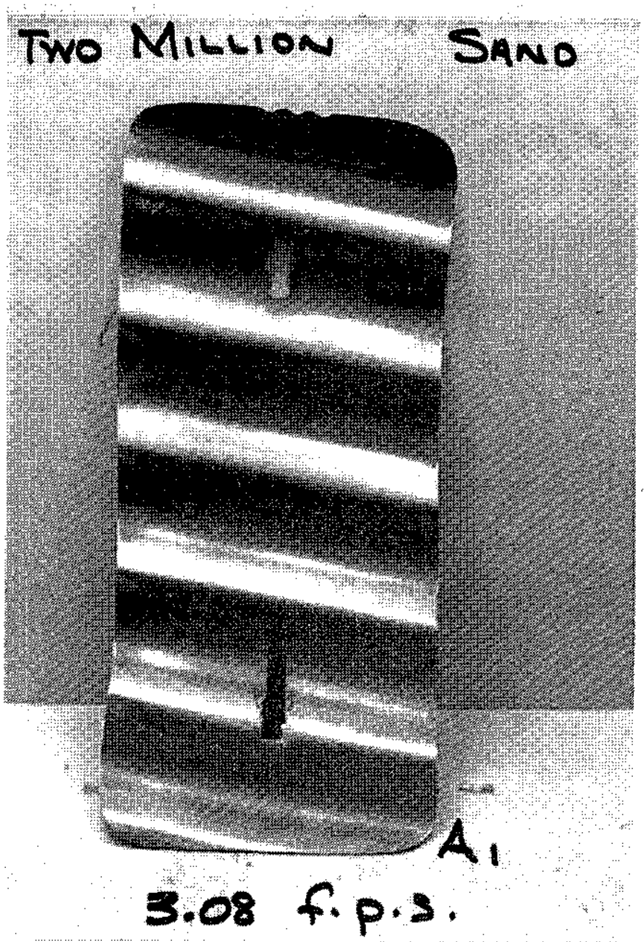

NO WEAR
3.00 f/s
A2

NO WEAR
3.00 f/s
B2

NO WEAR
3.00 f/s
C2

NO WEAR
3.00 f/s
D2

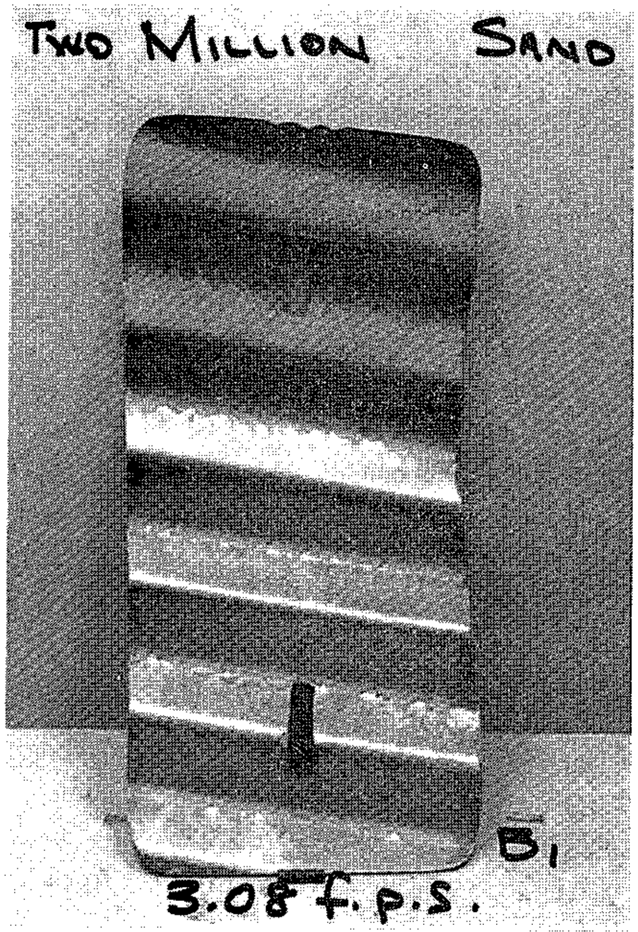

ONE MILLION
SAND
3.08 f.p.s.
A1

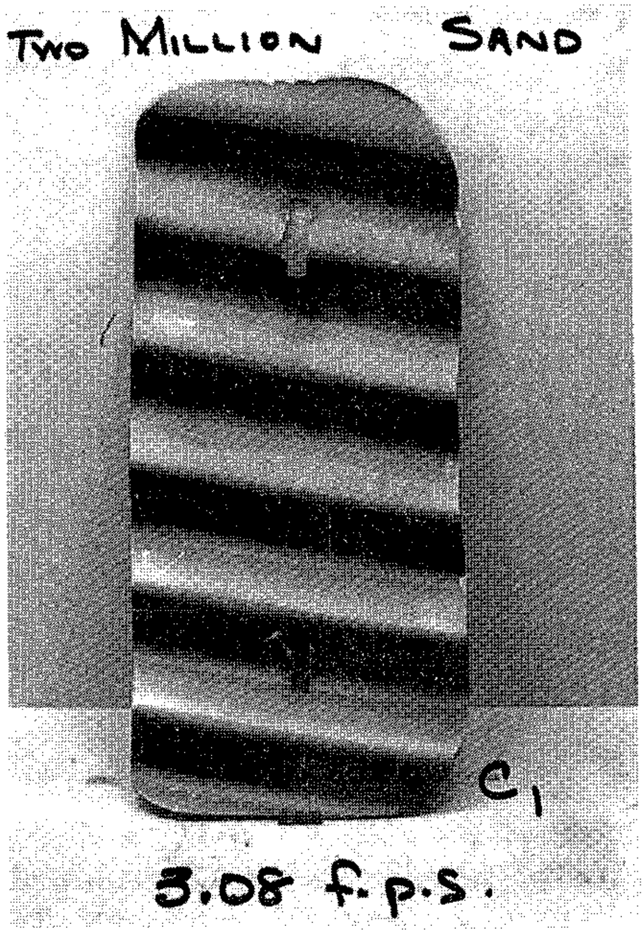

ONE MILLION
SAND
3.08 f.p.s.
B1

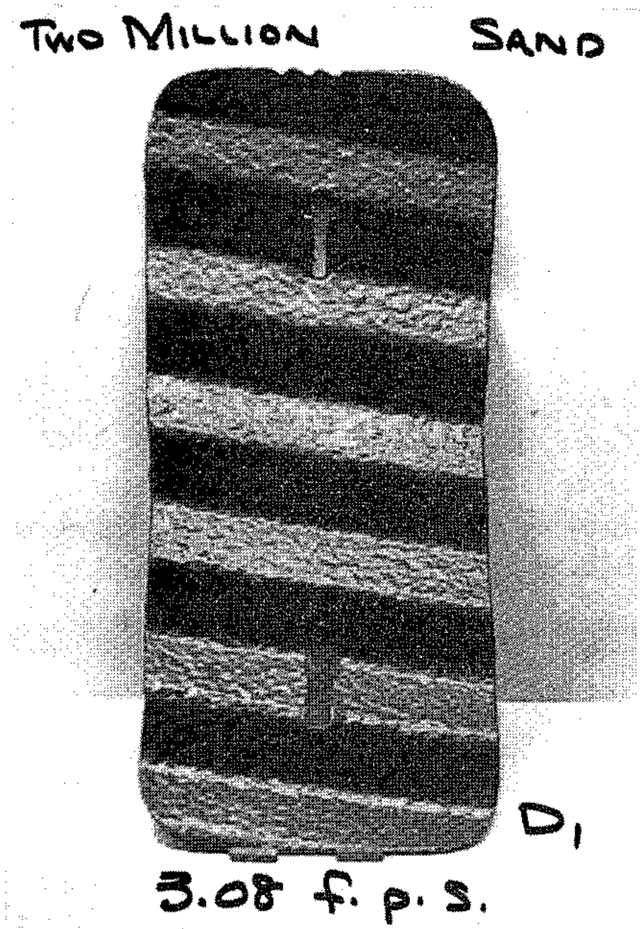

ONE MILLION
SAND
3.08 f.p.s.
C1

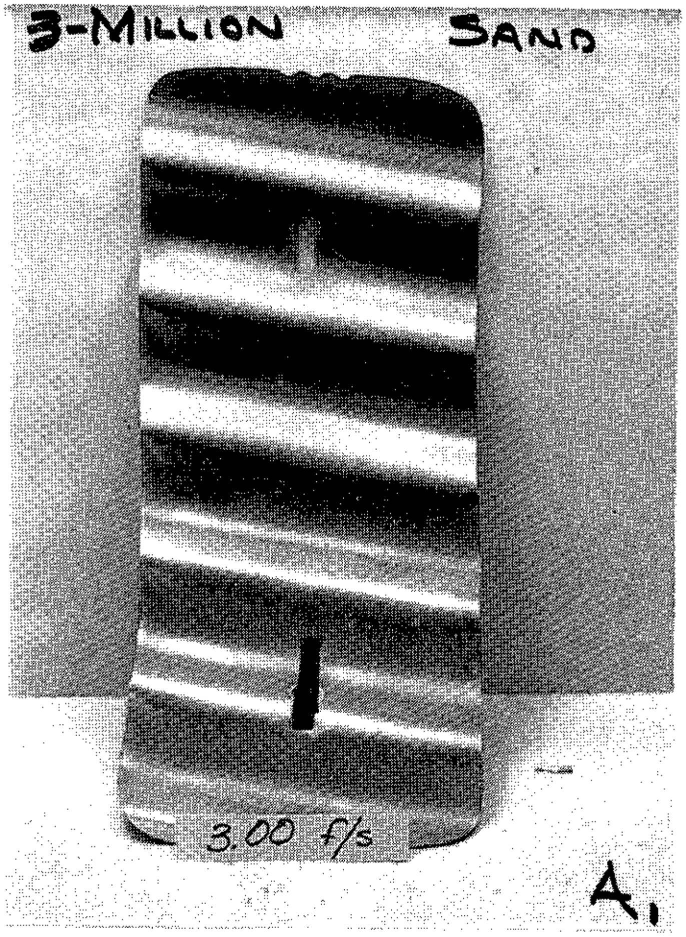

ONE MILLION
SAND
3.08 f.p.s.
D1

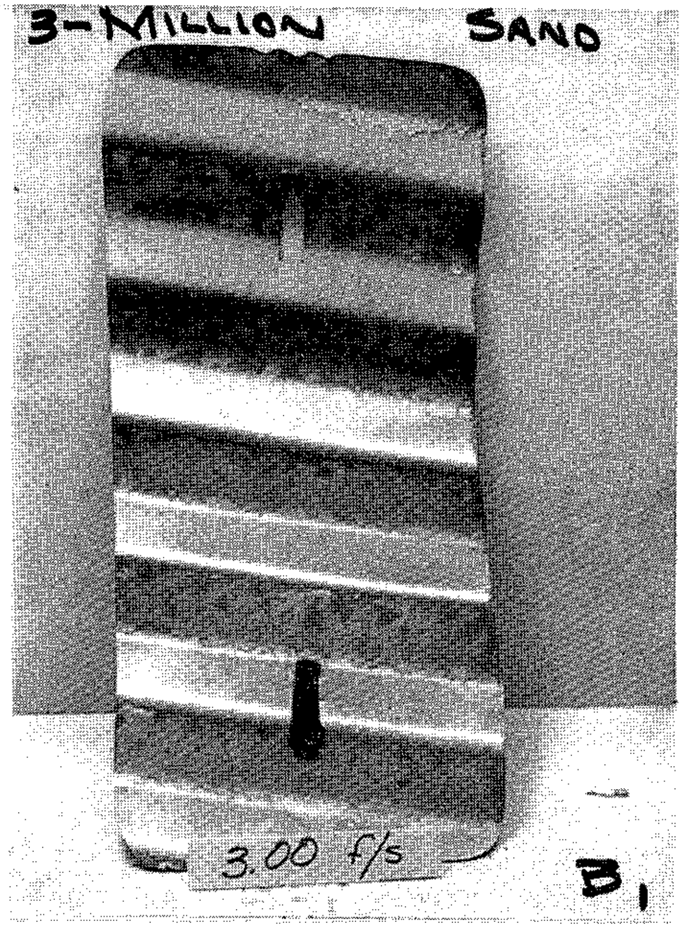

TWO MILLION SAND
A1
3.08 f.p.s.

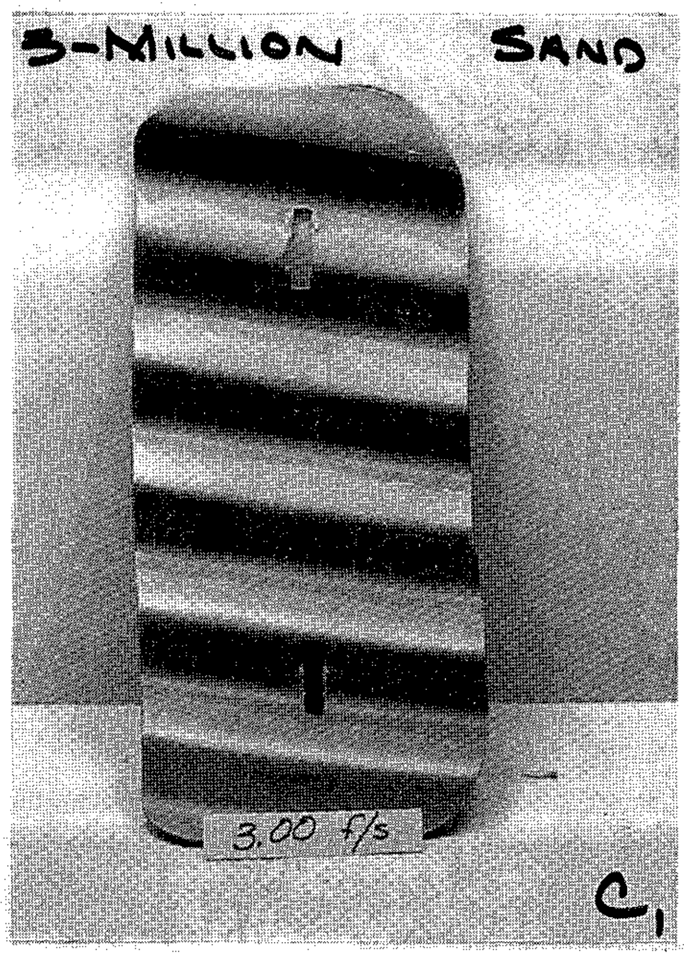

TWO MILLION SAND
B1
3.08 f.p.s.

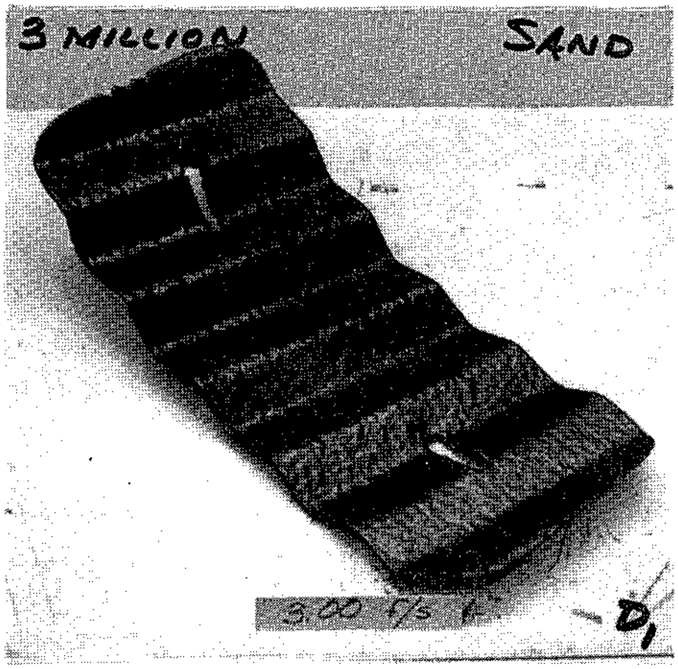

TWO MILLION SAND
C1
3.08 f.p.s.

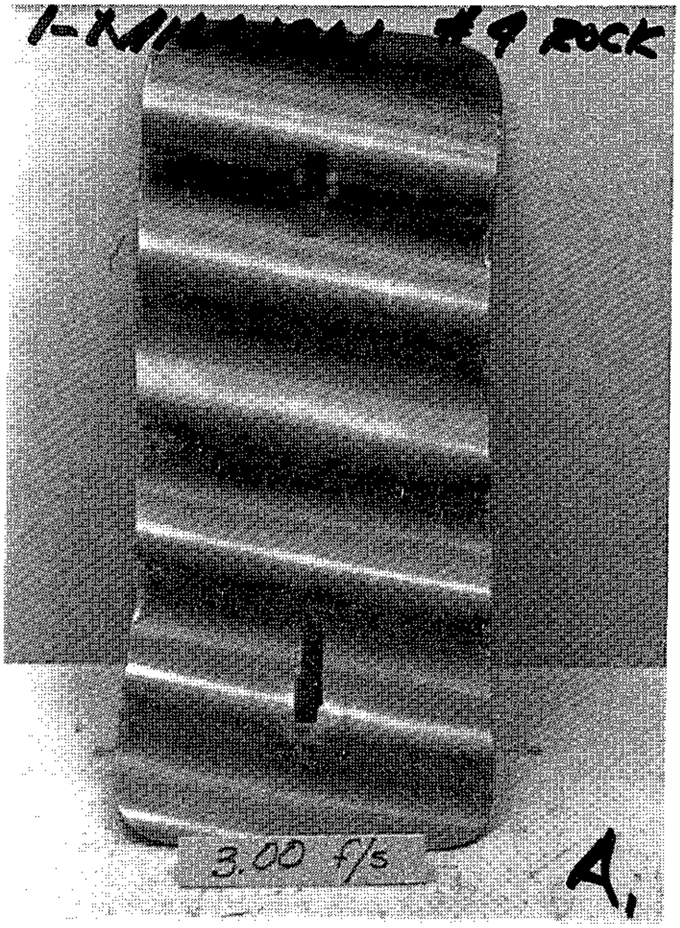

TWO MILLION SAND
D1
3.08 f.p.s.

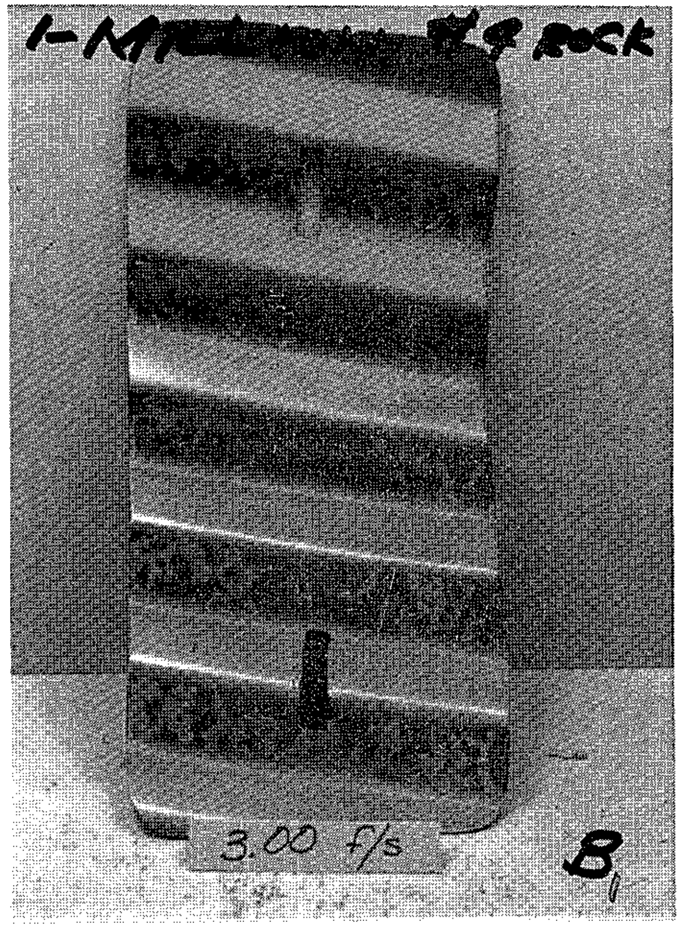

3-MILLION
SAND
3.00 f/s
A1

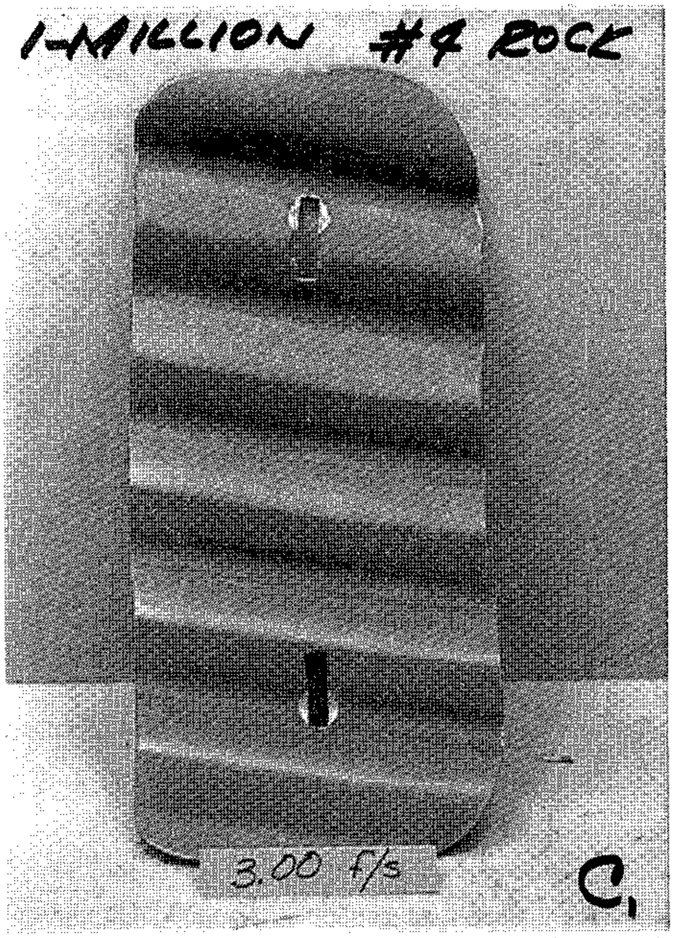

3-MILLION
SAND
3.00 f/s
B1

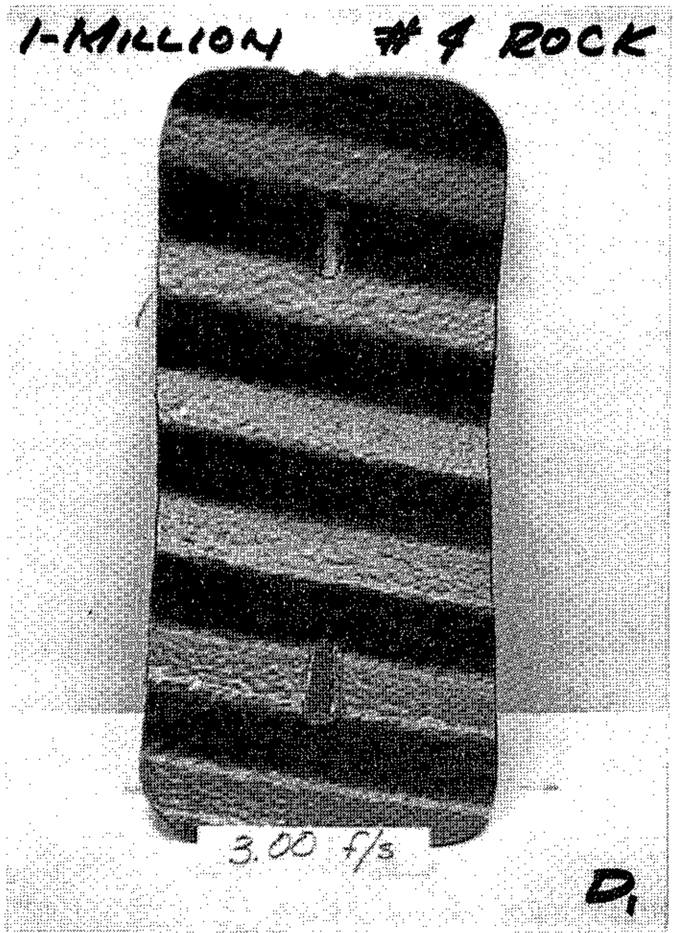

3-MILLION
SAND
3.00 f/s
C1

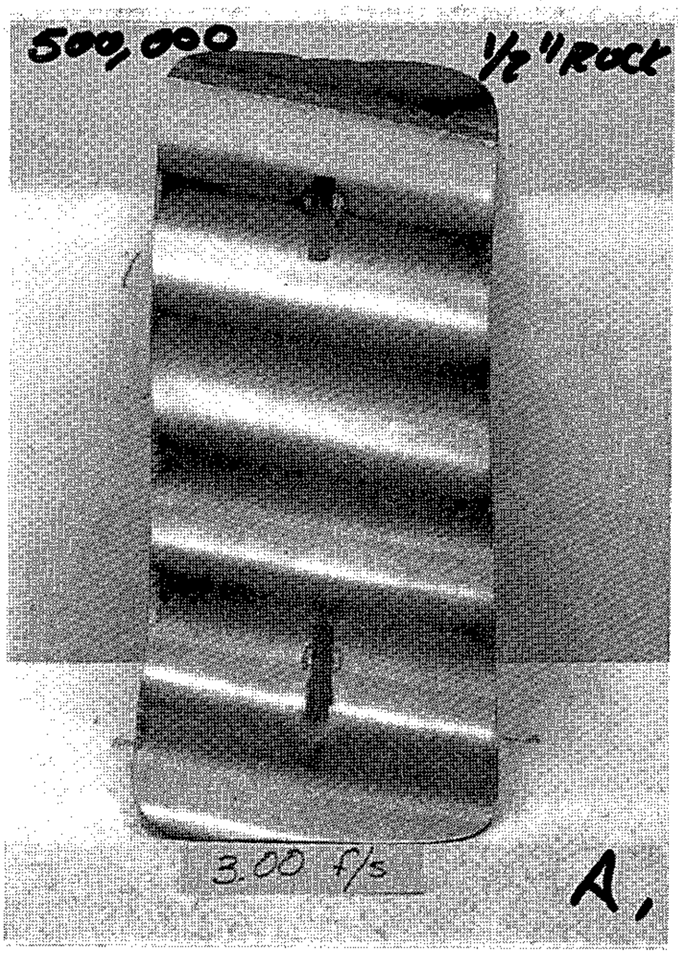

3 MILLION
SAND
3.00 f/s
D1

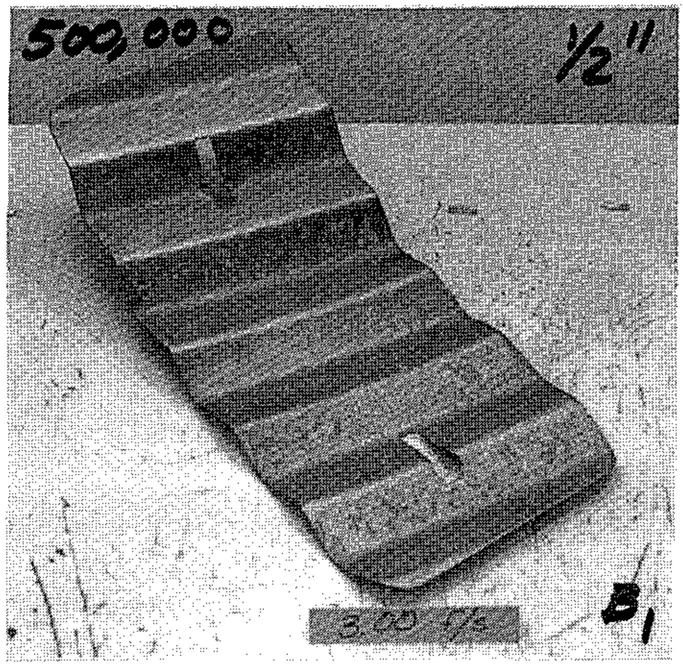

#4 ROCK
3.00 f/s
A1

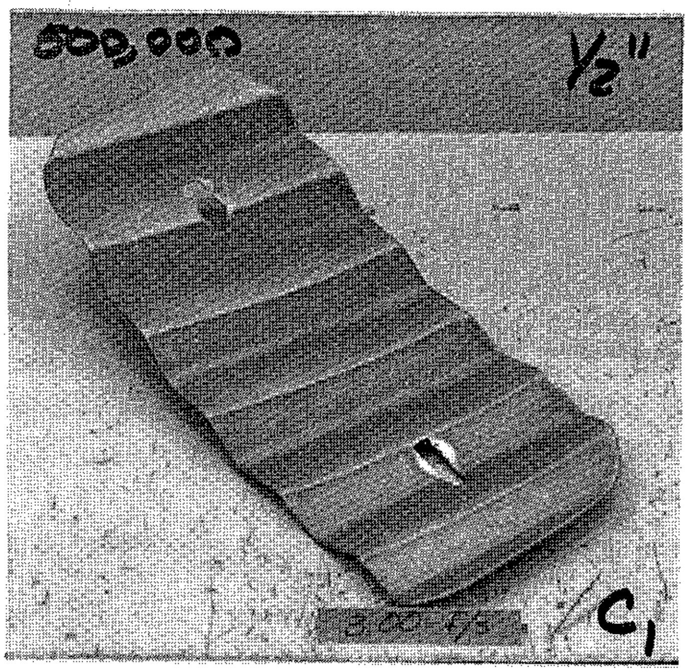

3.00 f/s
B1

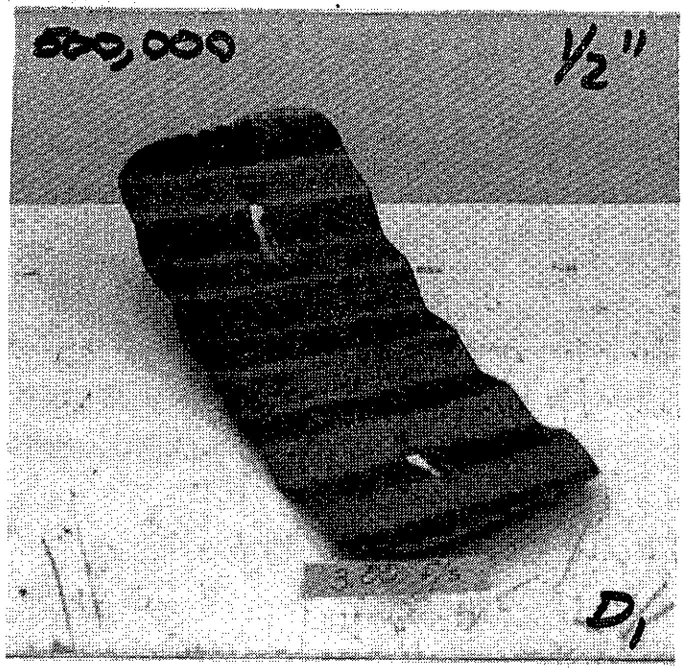

1-MILLION #4 ROCK
3.00 f/s
C1

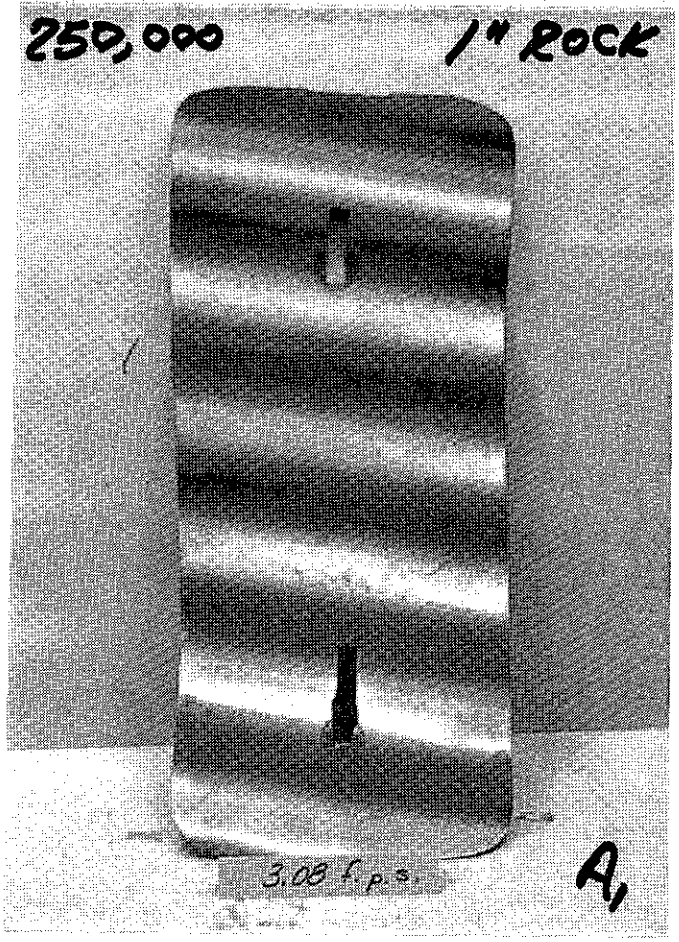

1-MILLION #4 ROCK
3.00 f/s
D1

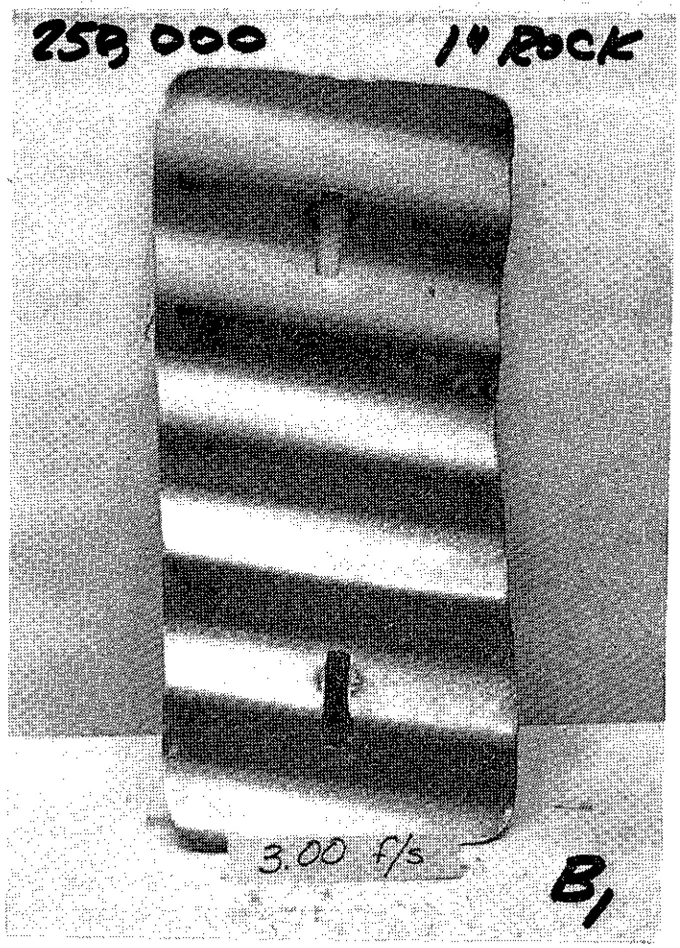

500,000
1/2" Rock
3.00 f/s
A1

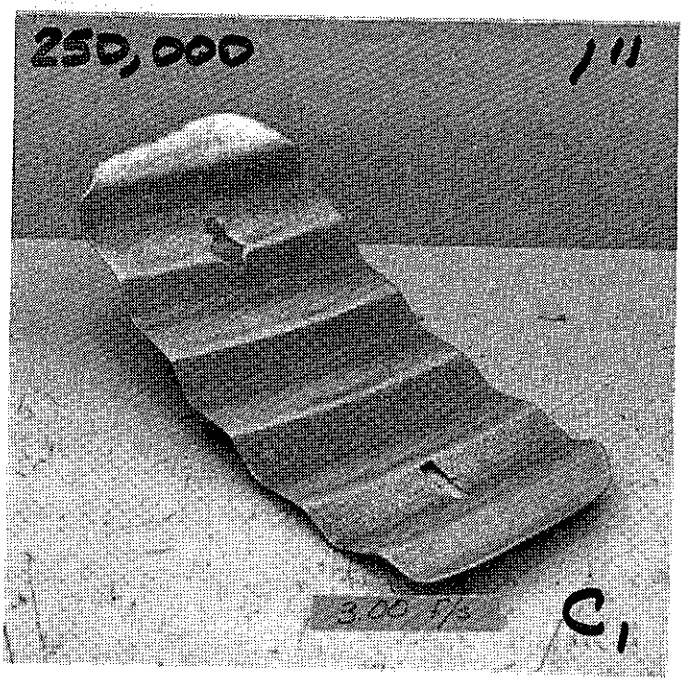

500,000
1/2"
3.00 f/s
B1

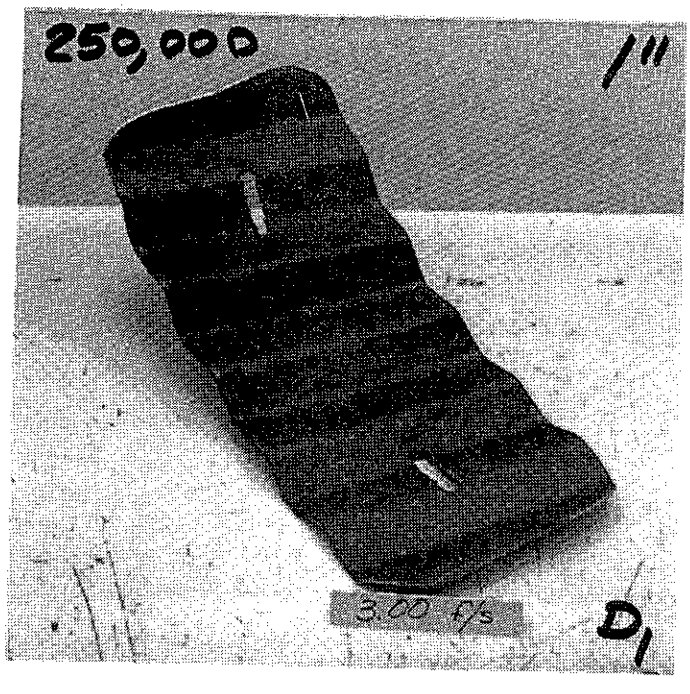

500,000
1/2"
3.00 f/s
C1

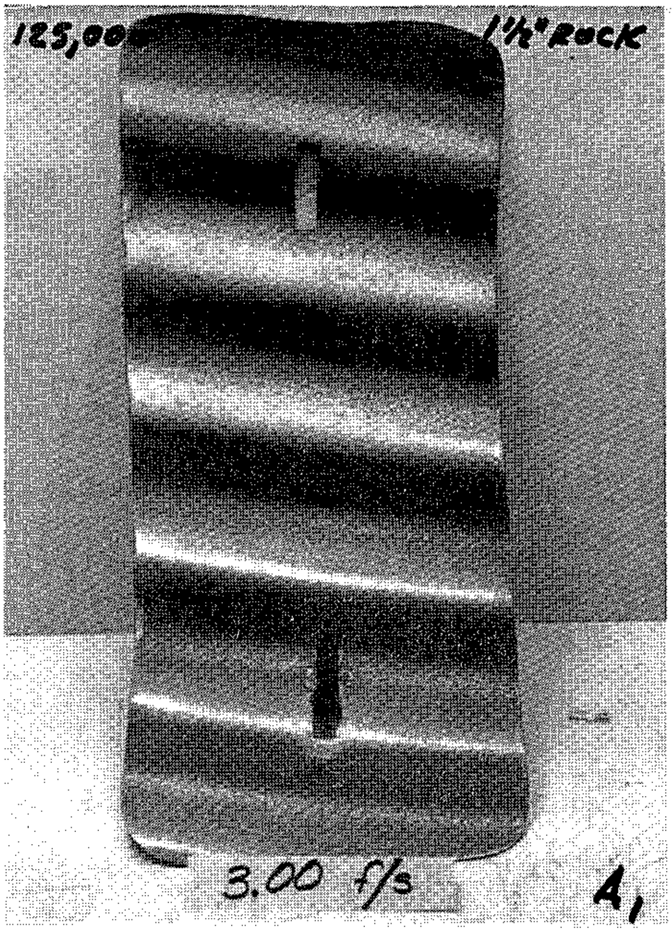

500,000
1/2"
D1

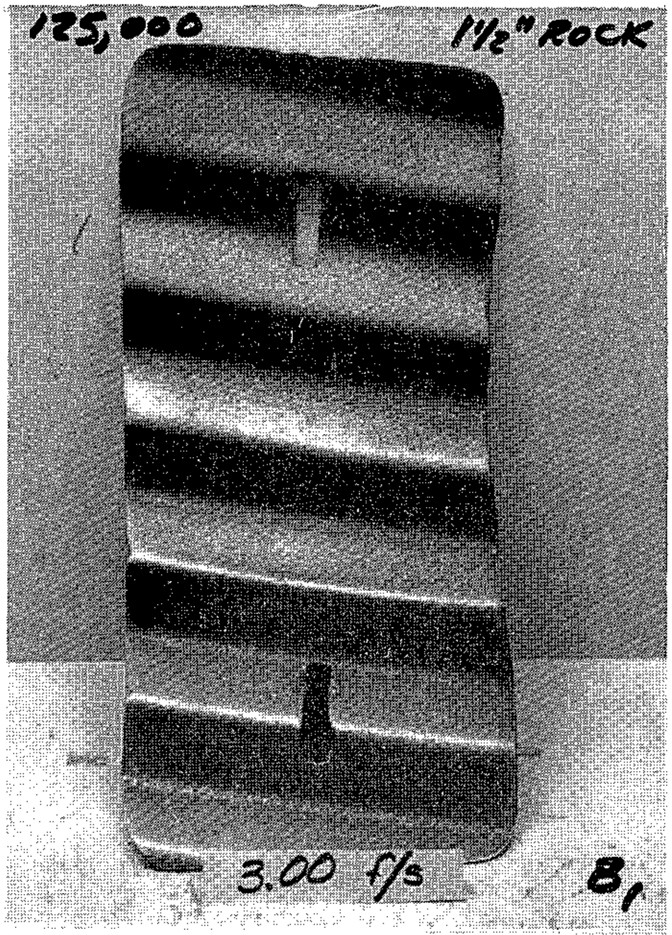

250,000
1" ROCK
3.00 f.p.s.
A1

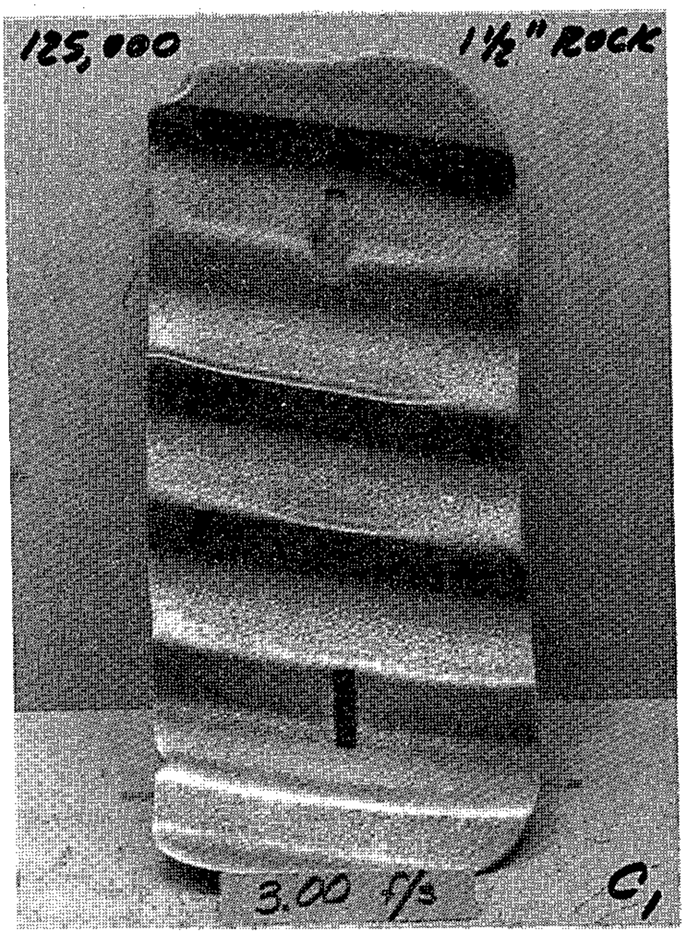

250,000
1" ROCK
3.00 f/s
B1

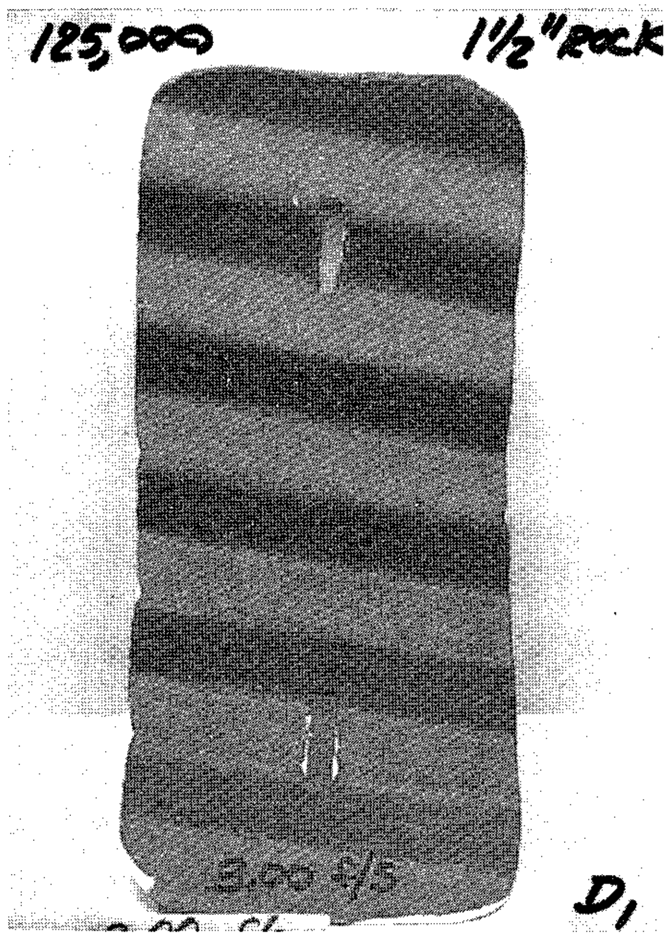

250,000
1"
3.00 f/s
C1

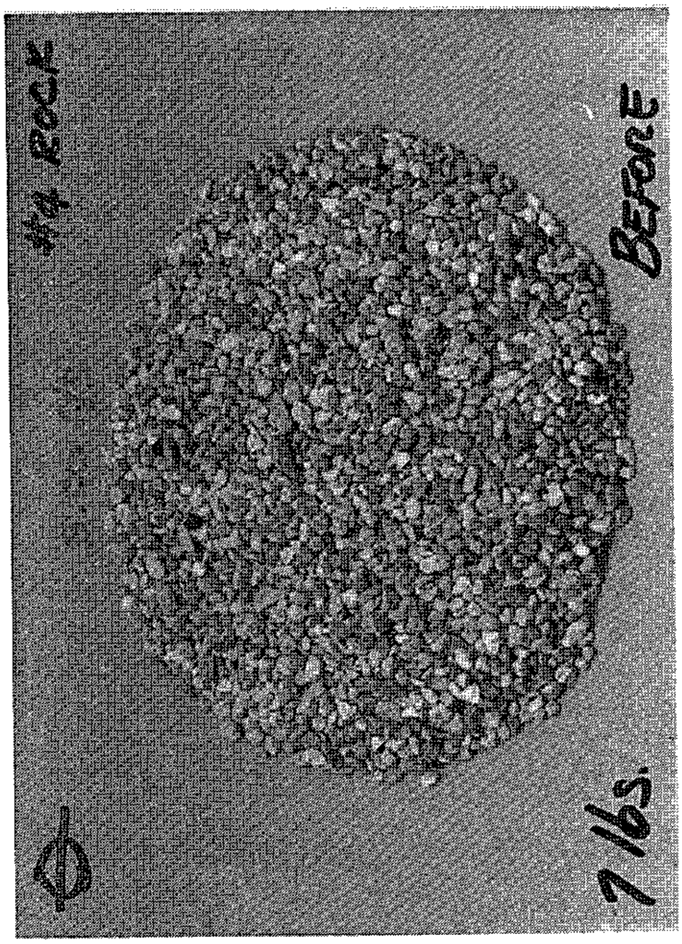

250,000
1"
3.00 f/s
D1

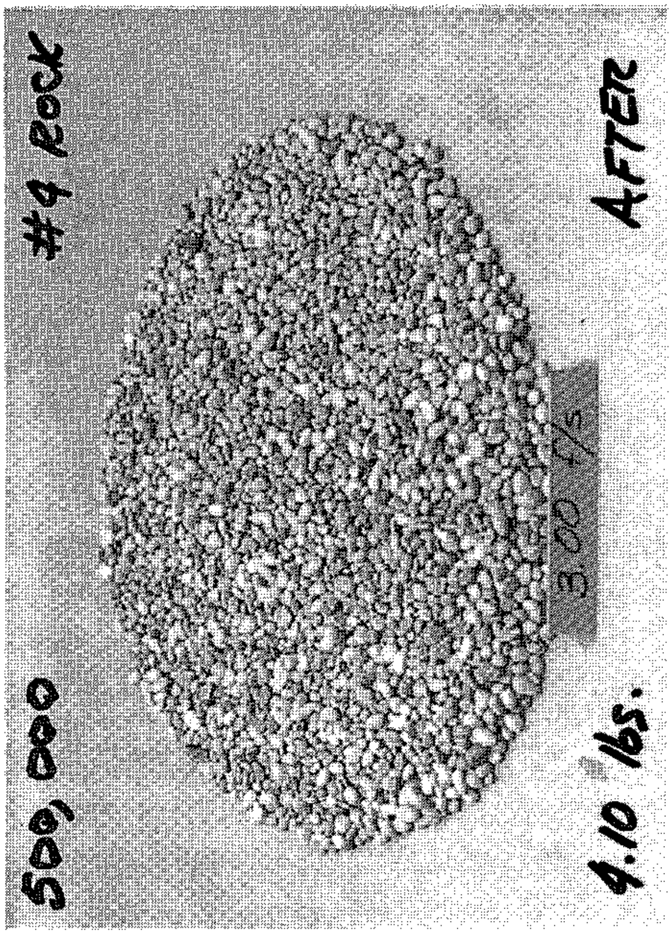

125,000
1½" ROCK
3.00 f/s
A1

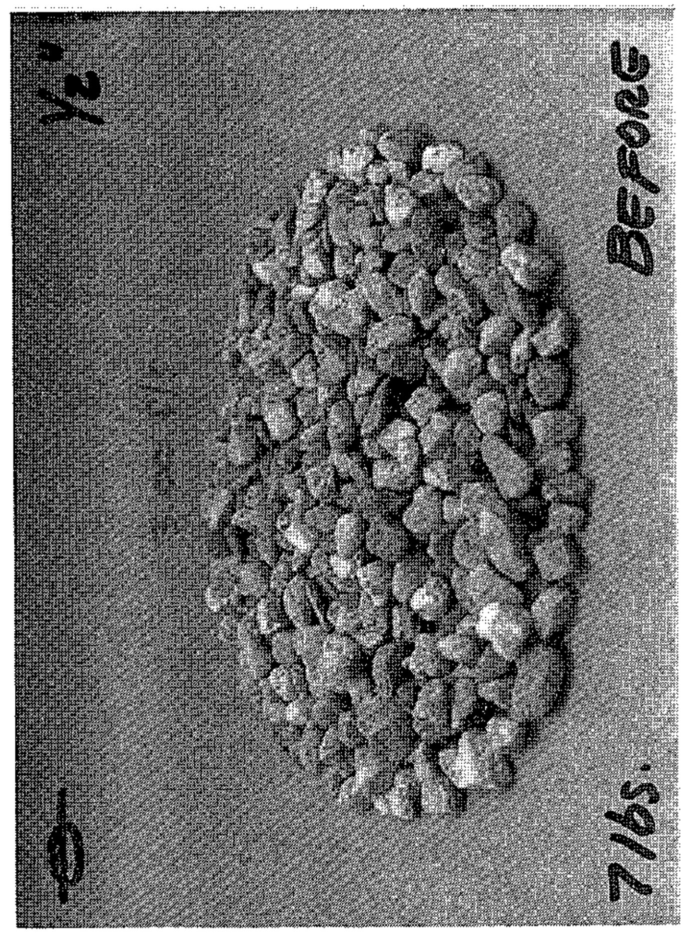

125,000
1½" ROCK
3.00 f/s
B1

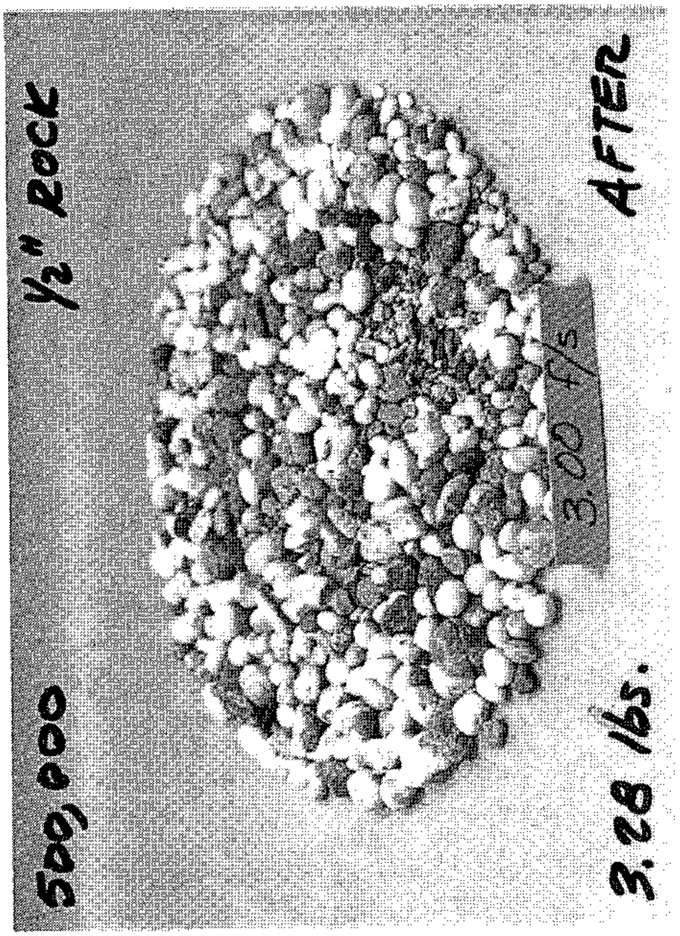

125,000
1½" ROCK
3.00 f/s
C1

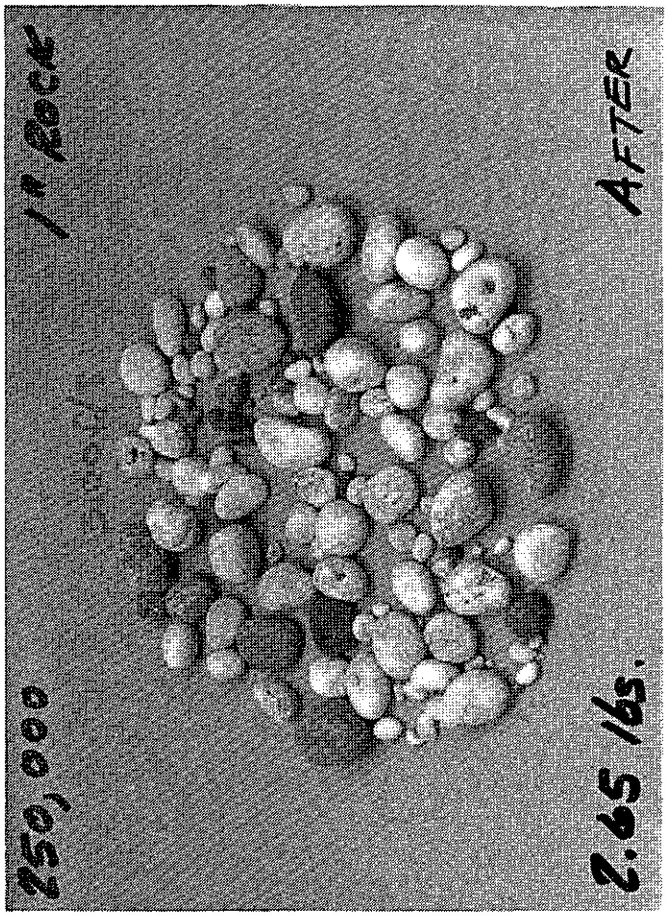

125,000
1½" ROCK
3.00 f/s
D1

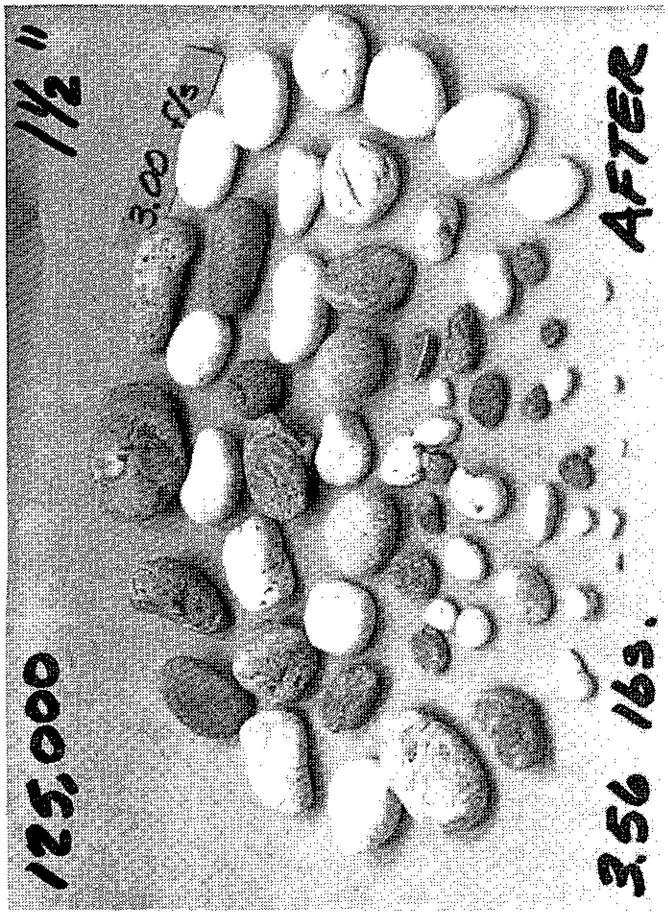

#4 ROCK
BEFORE
7 lbs.

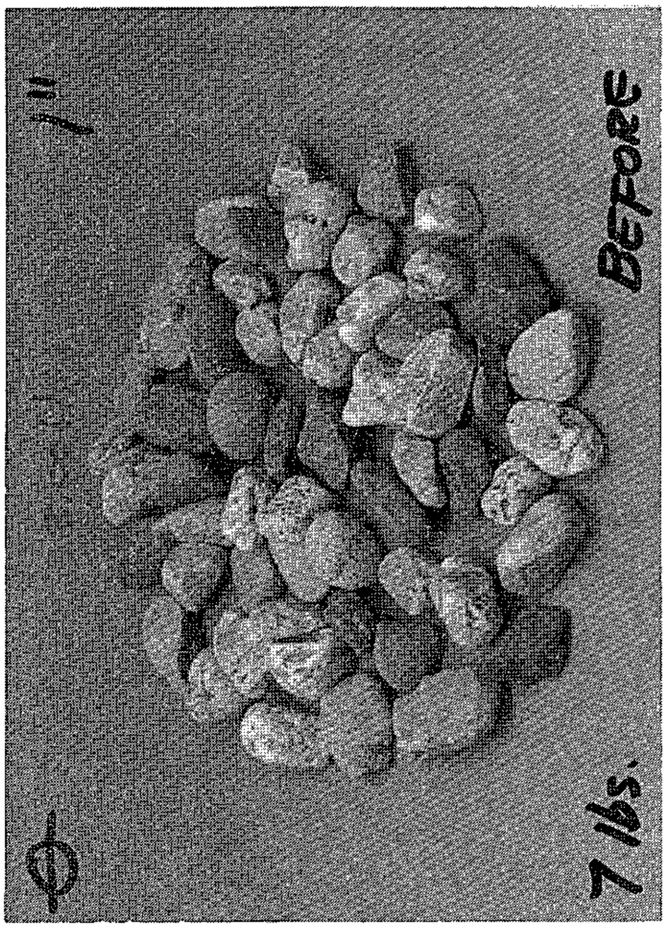

500,000
#4 ROCK
AFTER
4.10 lbs.

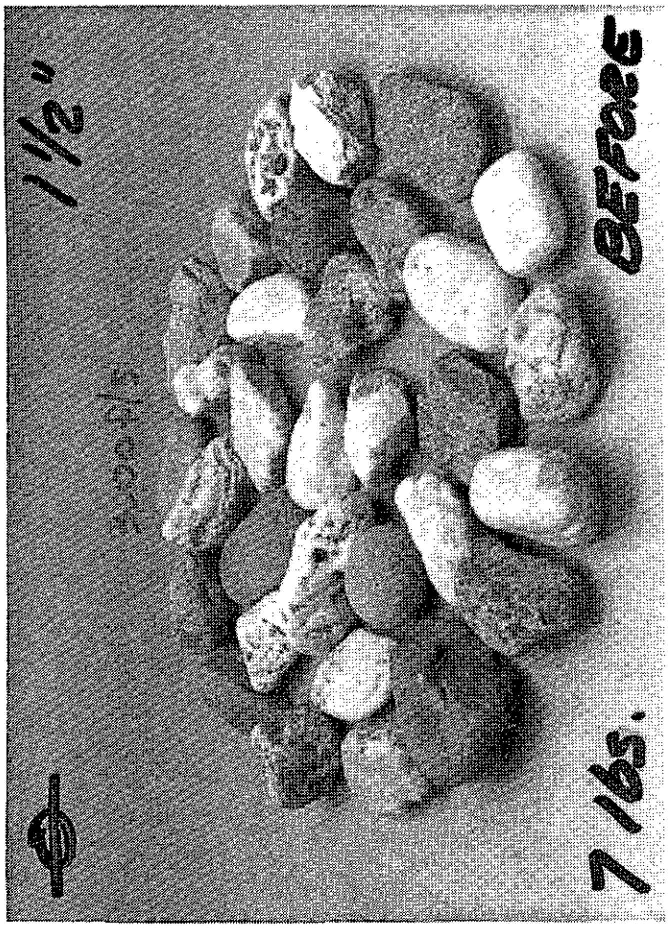

1/2"
BEFORE
7 lbs.


500,000
1/2" ROCK
AFTER
3.28 lbs.


250,000
1" ROCK
2.65 lbs.
AFTER

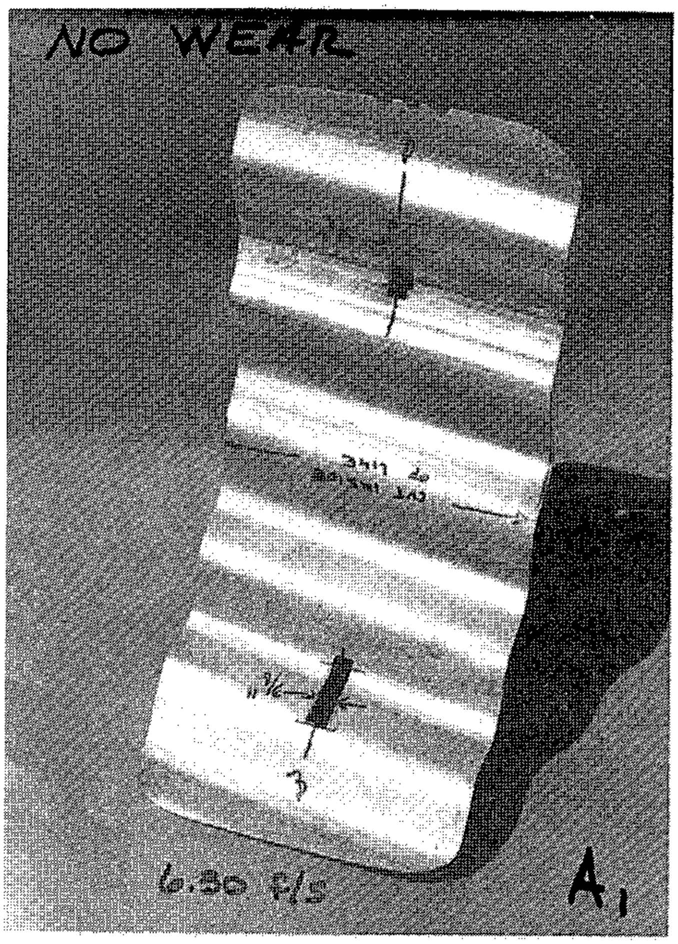

125,000
1½"
3.56 lbs.
AFTER

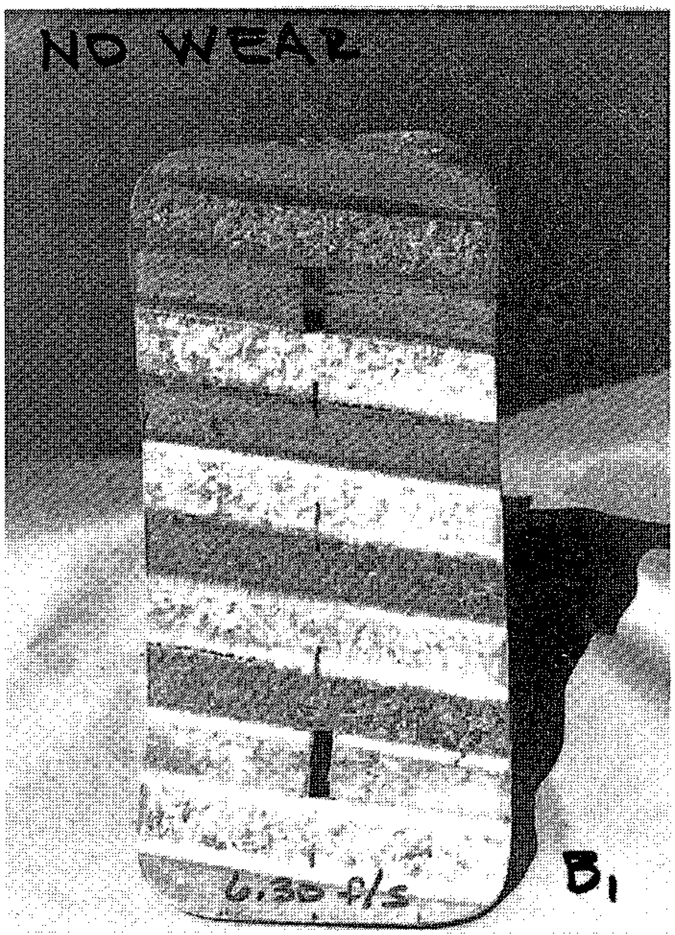

1"
7 lbs.
BEFORE

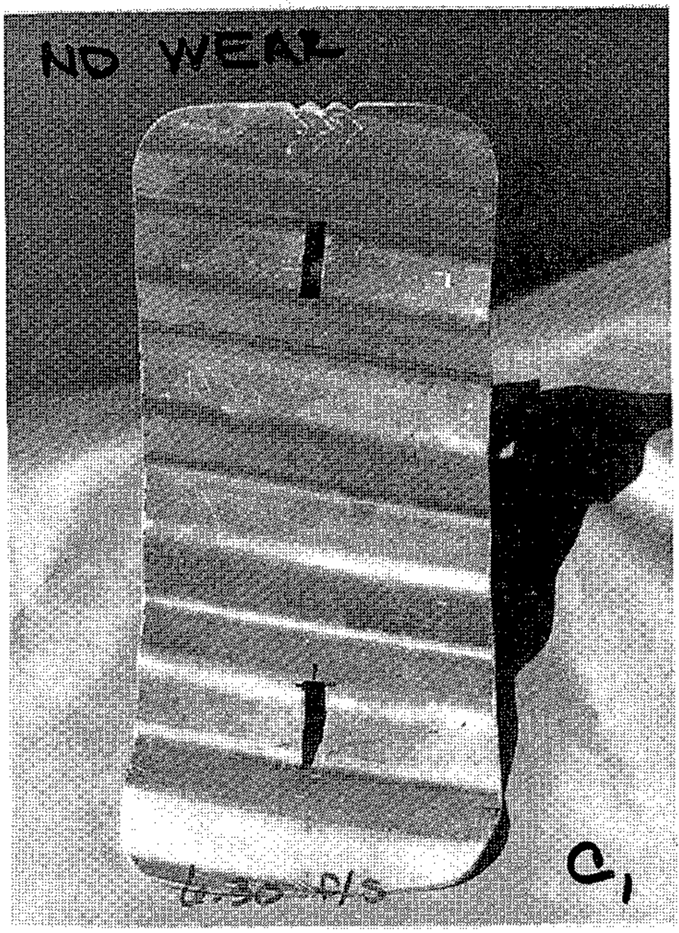

1½"
7 lbs.
BEFORE

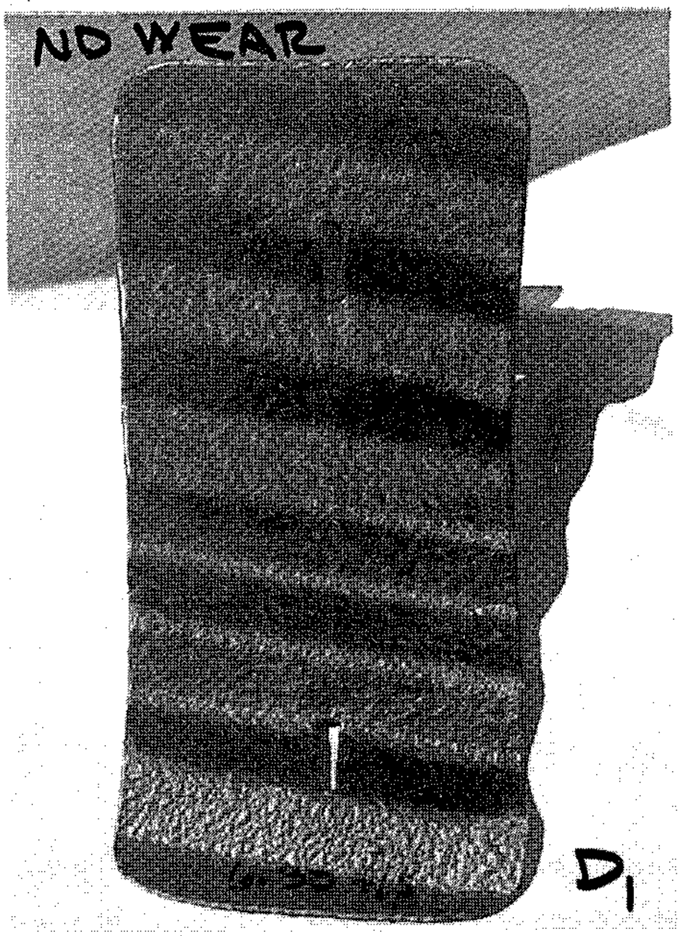
TEST GROUP 2

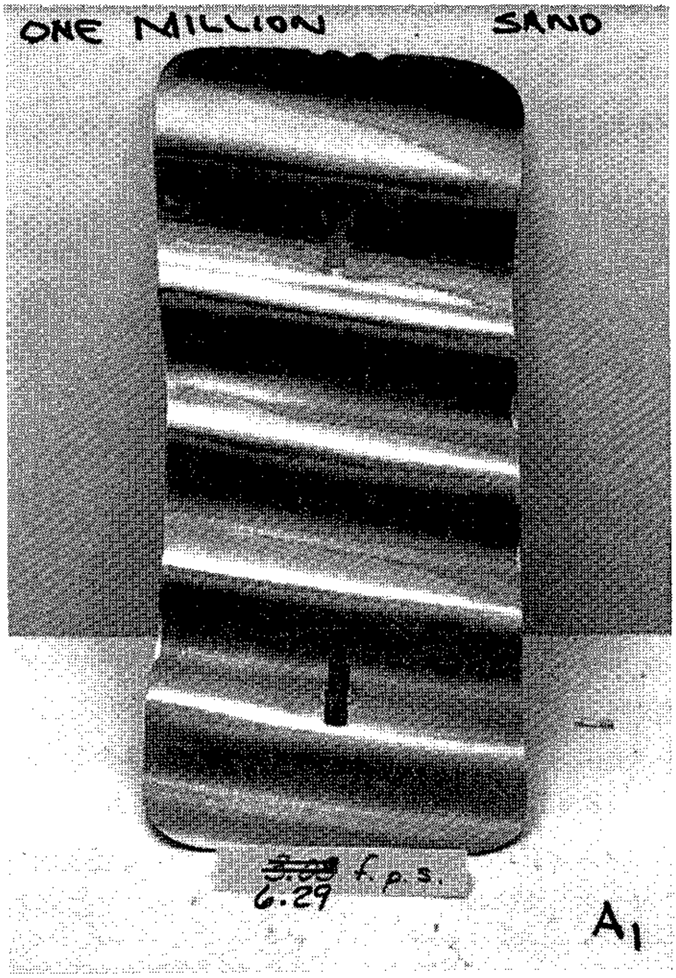
6.30 F/S

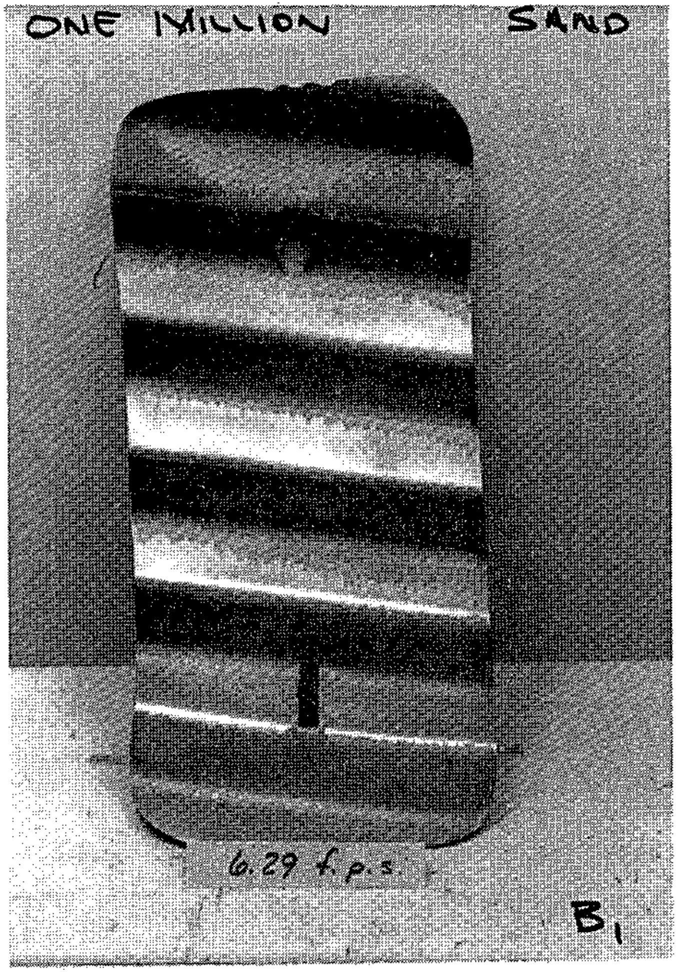

NO WEAR
6.30 f/s
A1

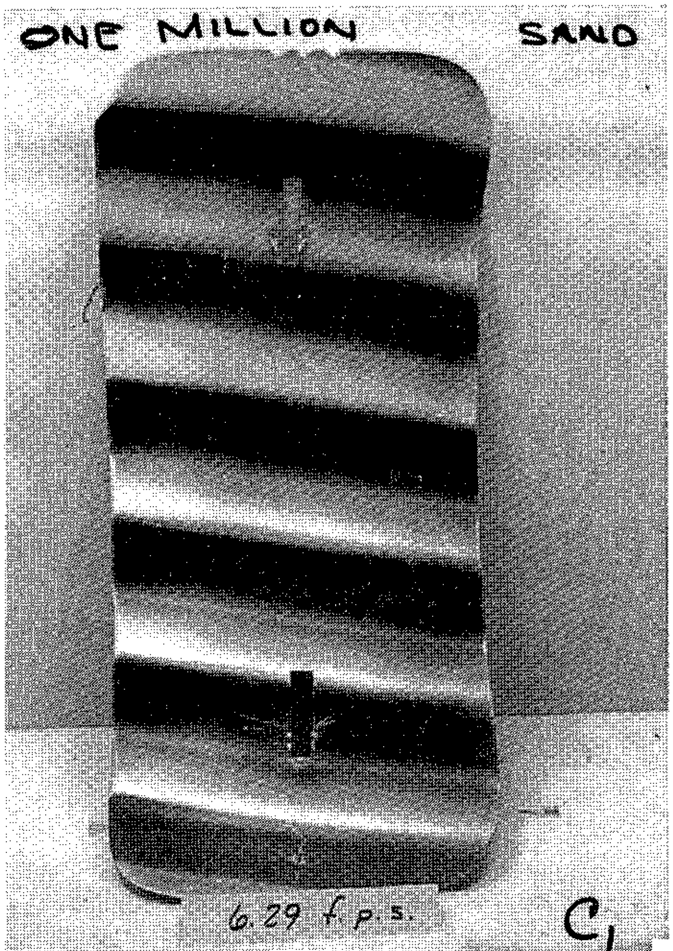

NO WEAR
6.30 f/s
B1

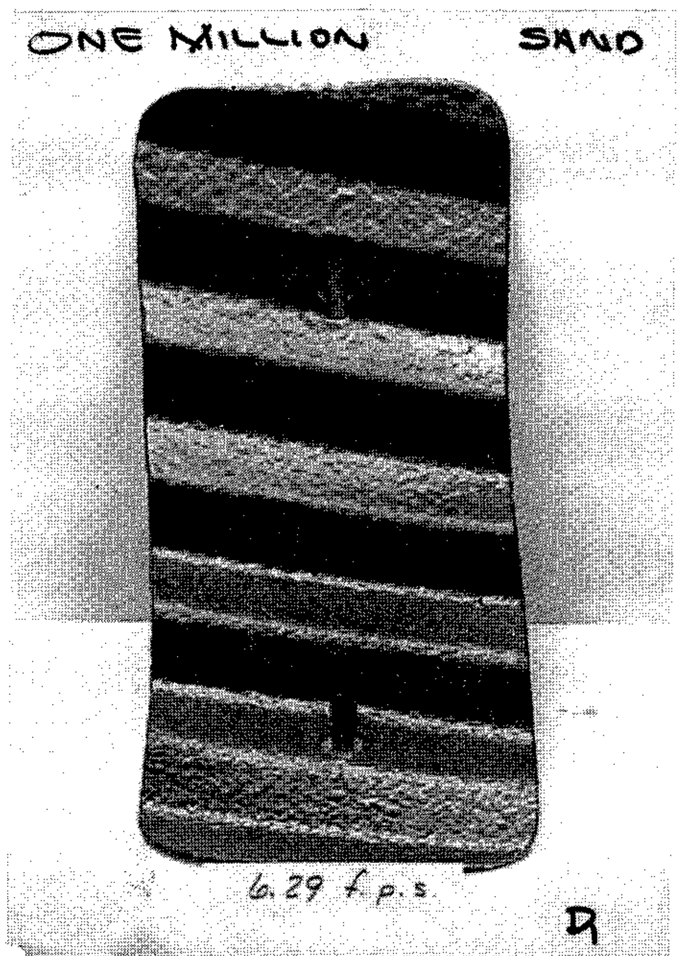

NO WEAR
6.30 f/s
C1

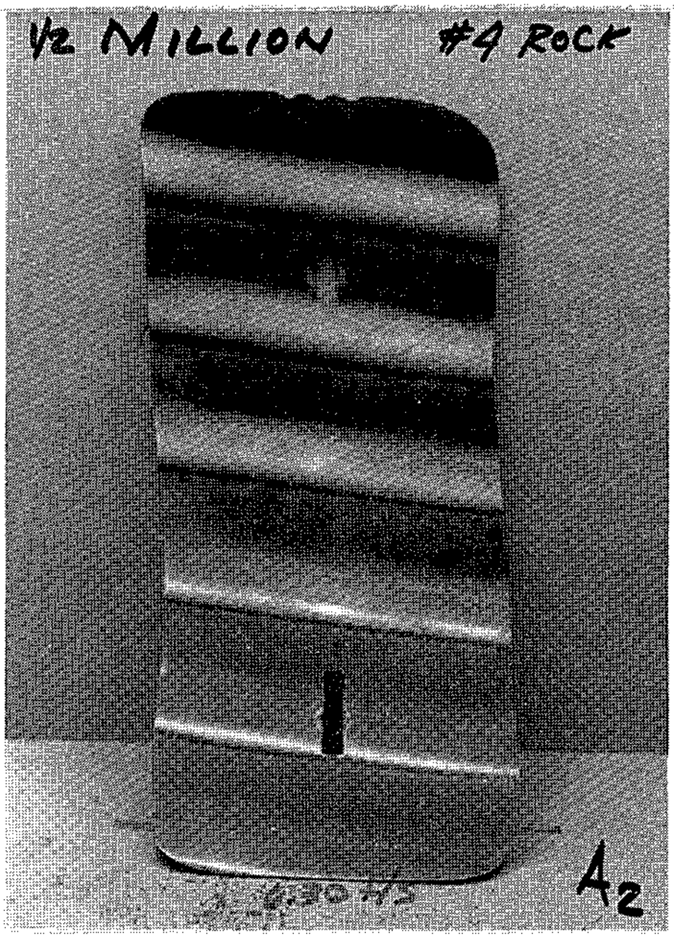

NO WEAR
D1

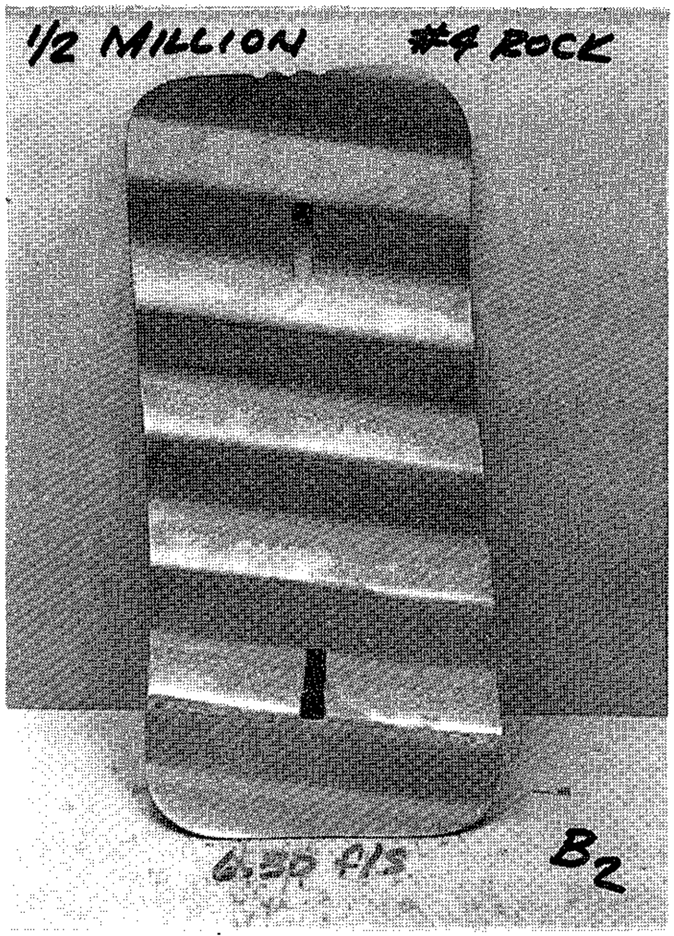

ONE MILLION
SAND
f.p.s.
6.29
A1

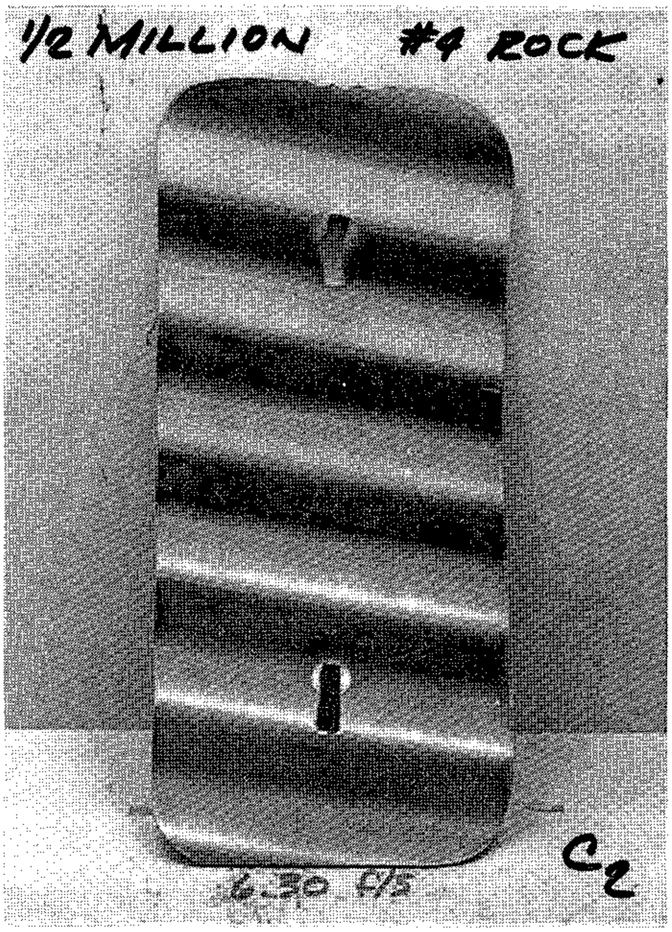

ONE MILLION
SAND
6.29 f.p.s.
B1

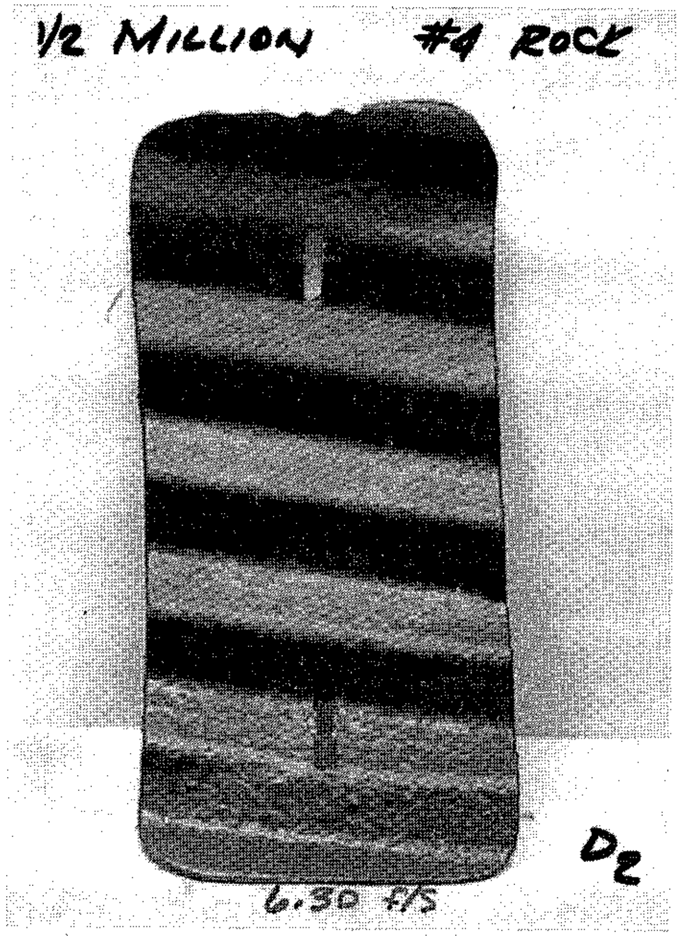

ONE MILLION
SAND
6.29 f.p.s.
C1

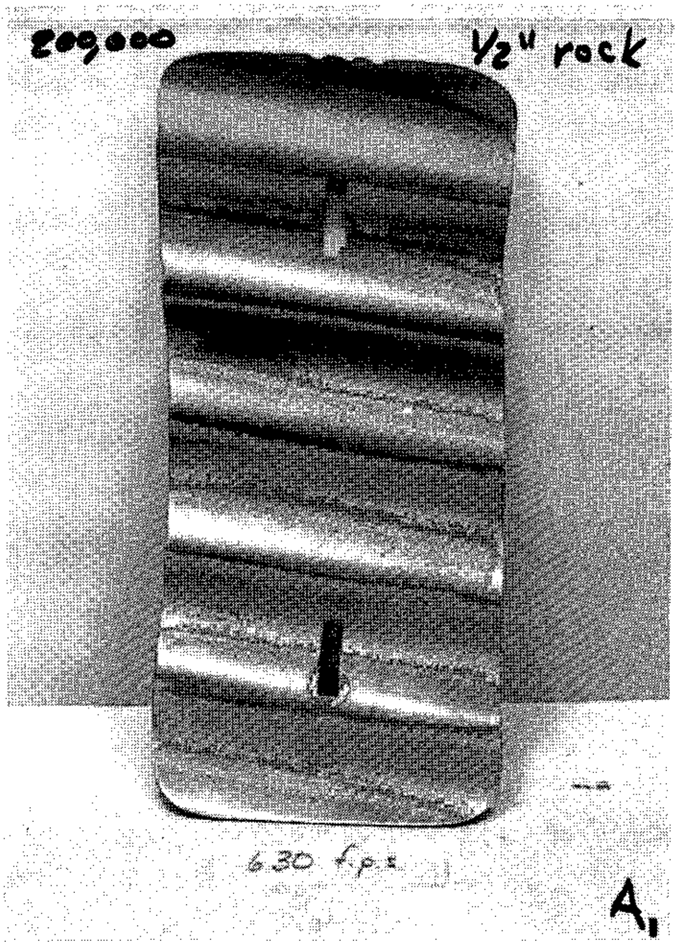

ONE MILLION
SAND
6.29 f.p.s.
D

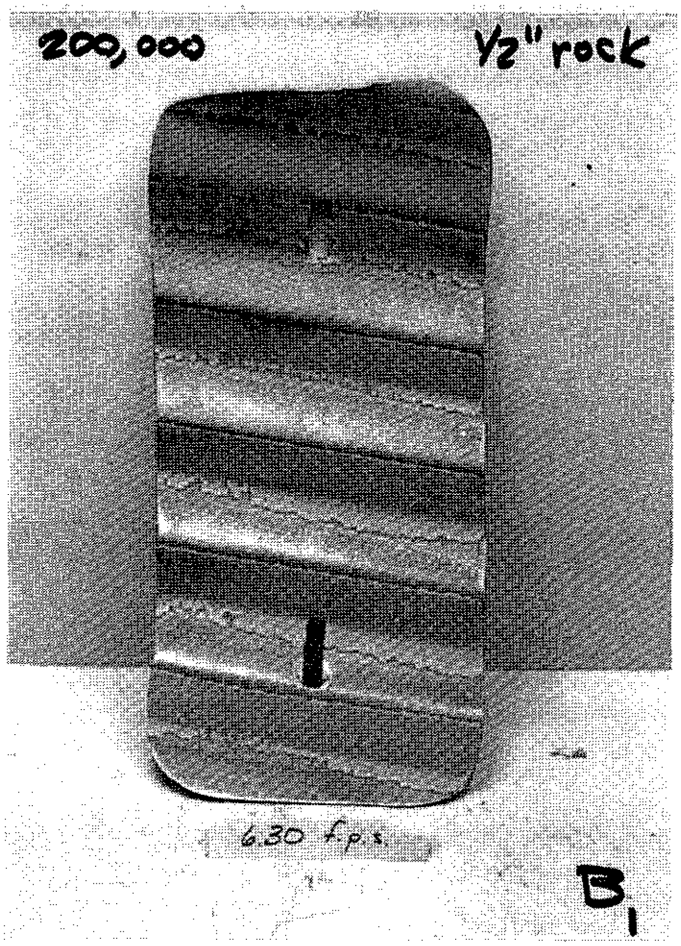

1/2 MILLION
#4 ROCK
6.30 f/s
A2

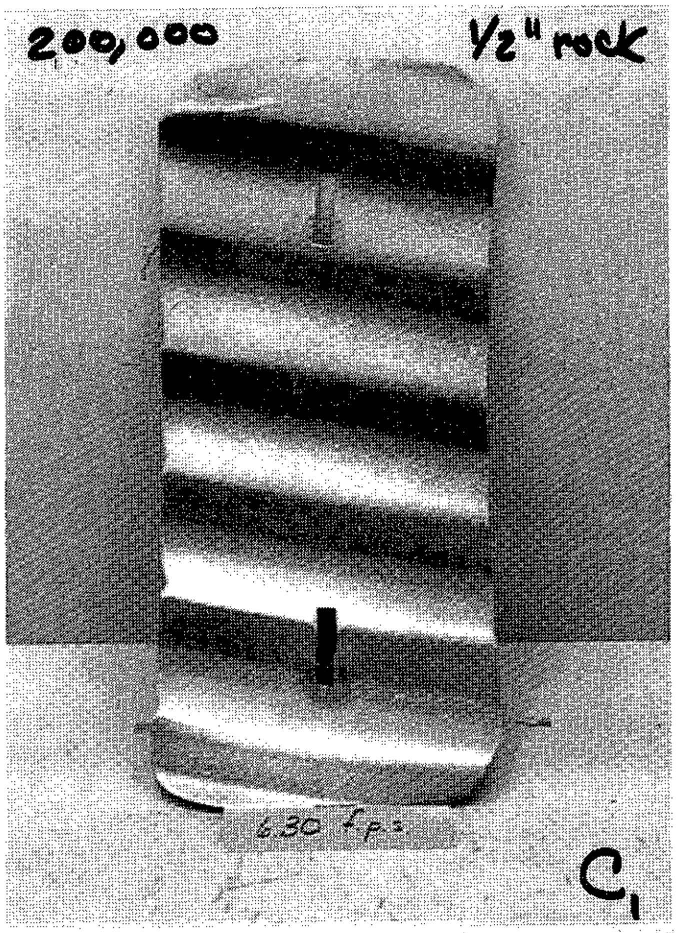

1/2 MILLION
#4 ROCK
6.30 f/s
B2

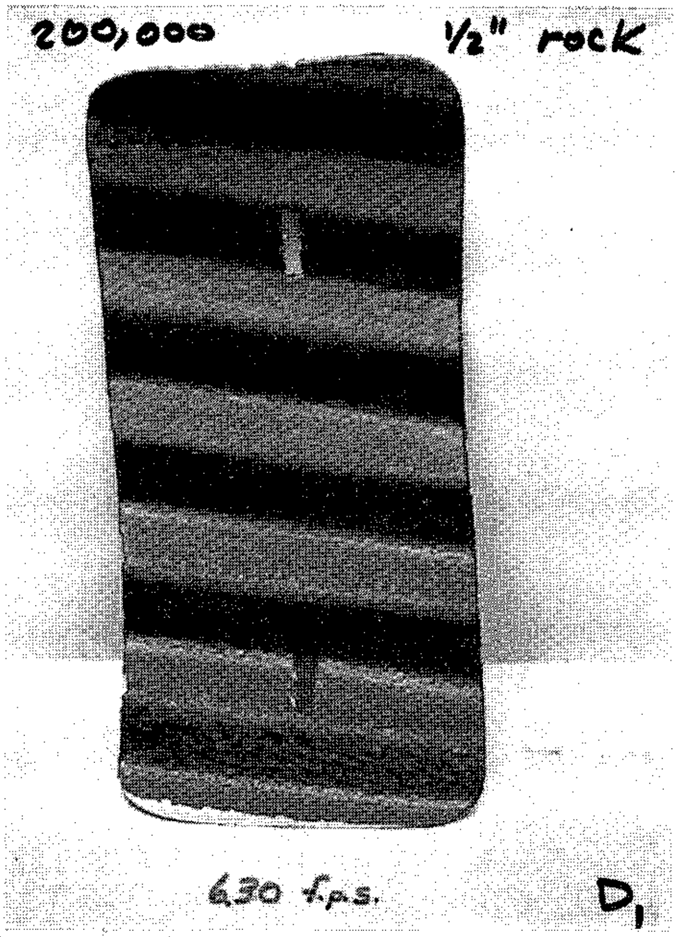

1/2 MILLION
#4 ROCK
6.30 f/s
C2

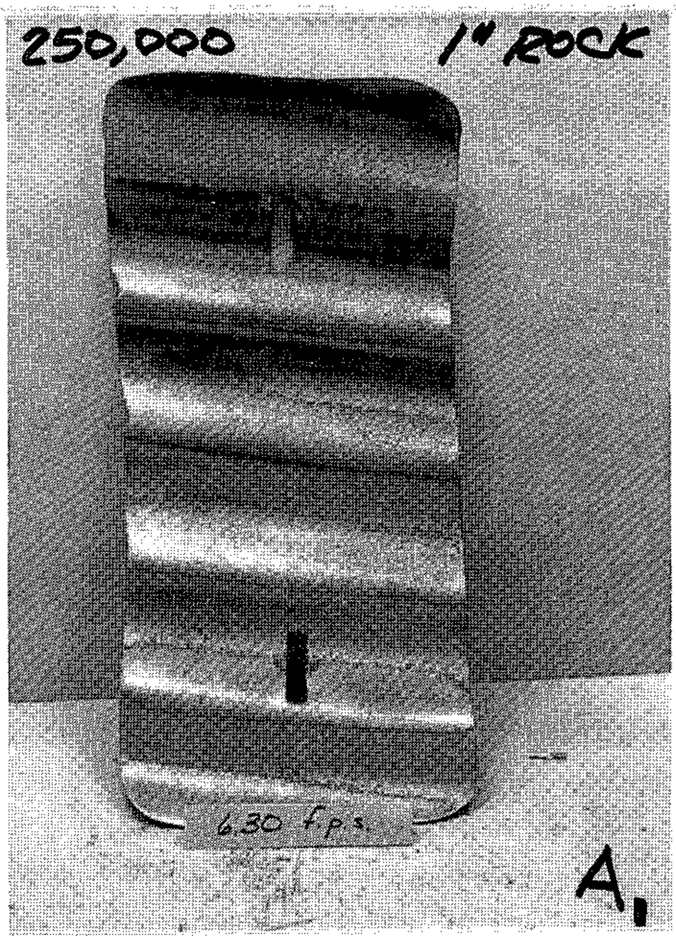

1/2 MILLION
#4 ROCK
6.30 f/s
D2

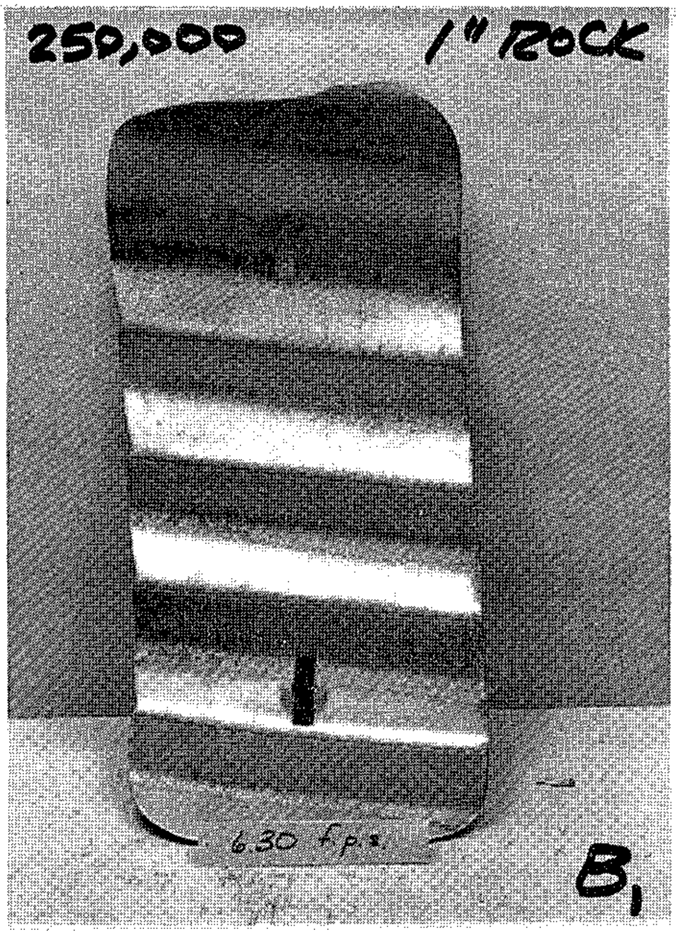

200,000
1/2" rock
6.30 f.p.s.
A_1

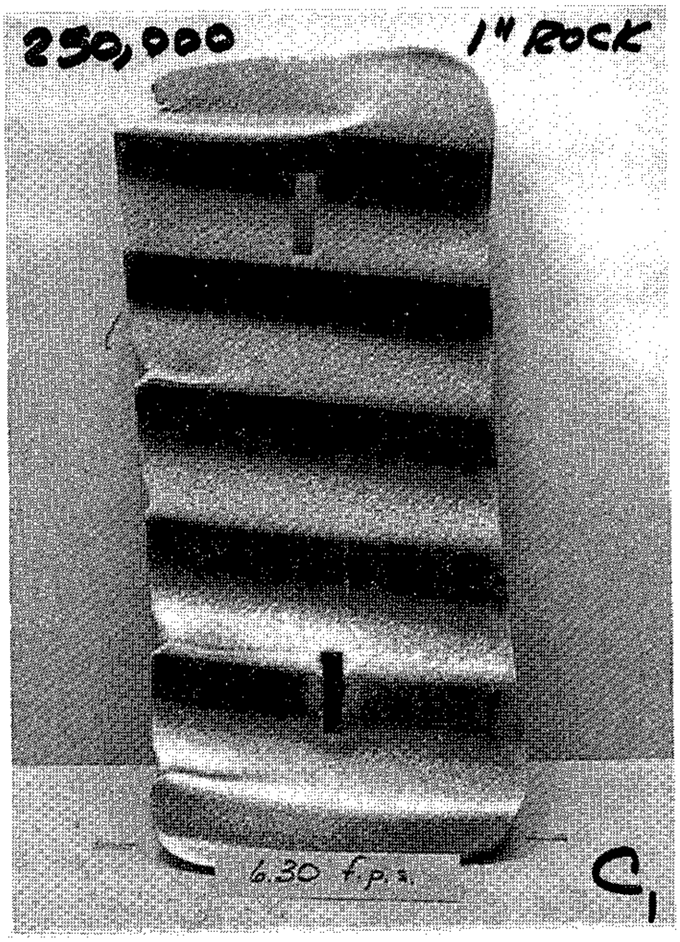

200,000
1/2" rock
6.30 f.p.s.
B_1

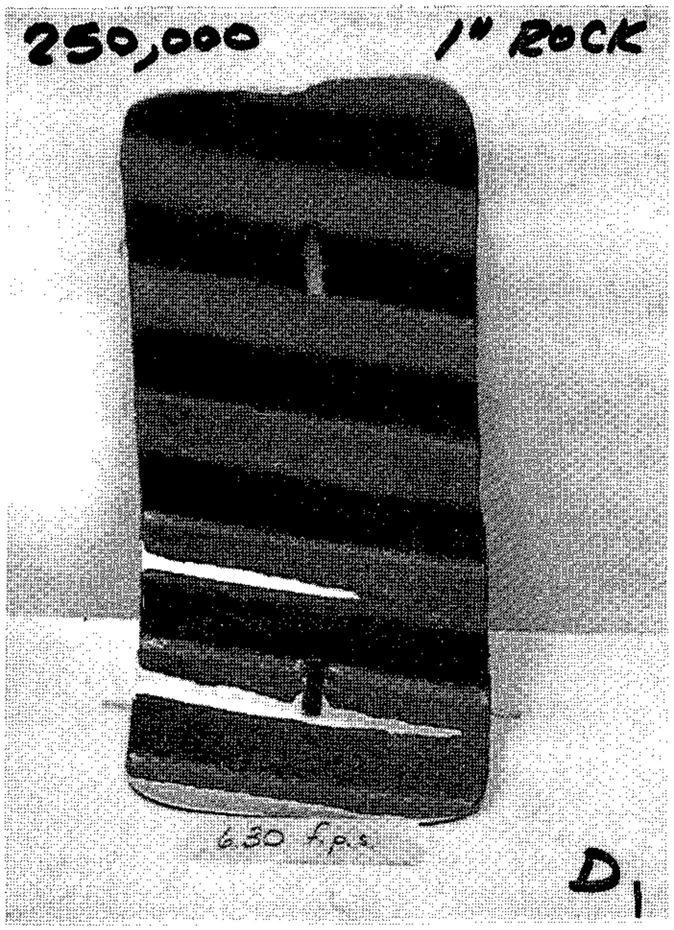

200,000
1/2" rock
6.30 f.p.s.
C_1

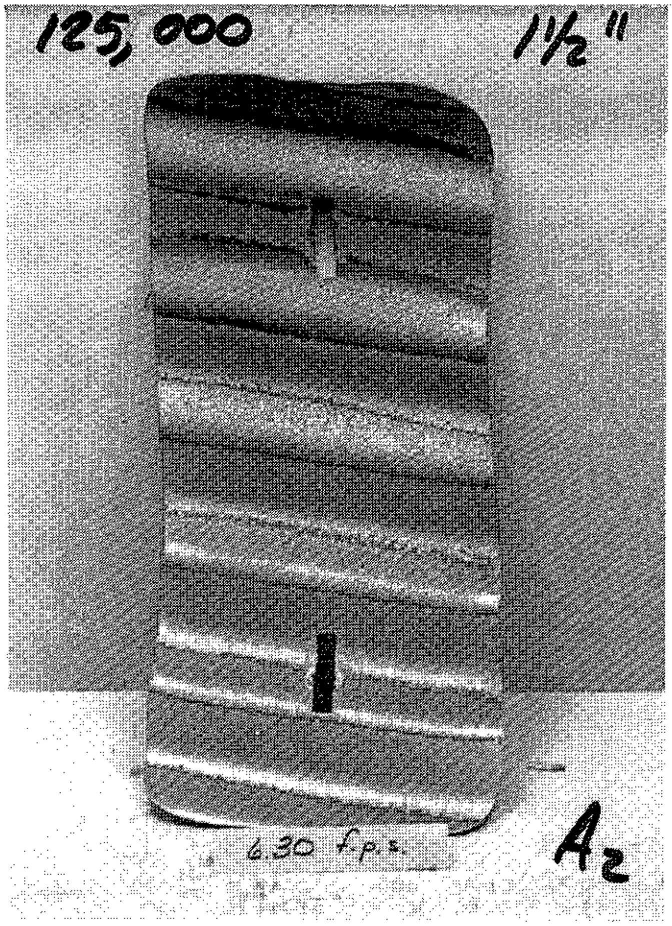

200,000
1/2" rock
6.30 f.p.s.
D_1

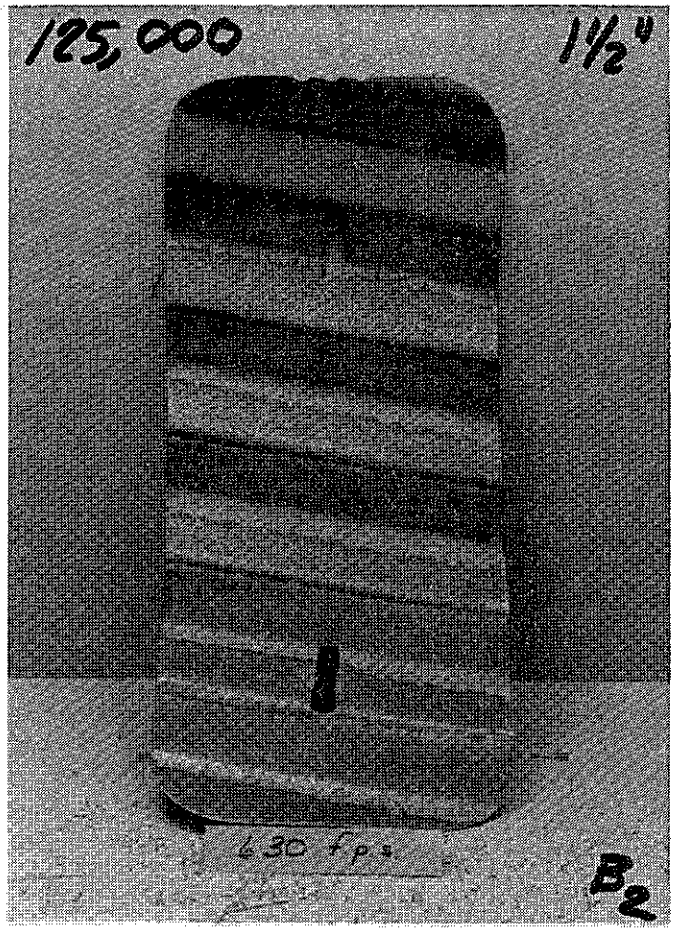

250,000
1" ROCK
6.30 f.p.s.
A1

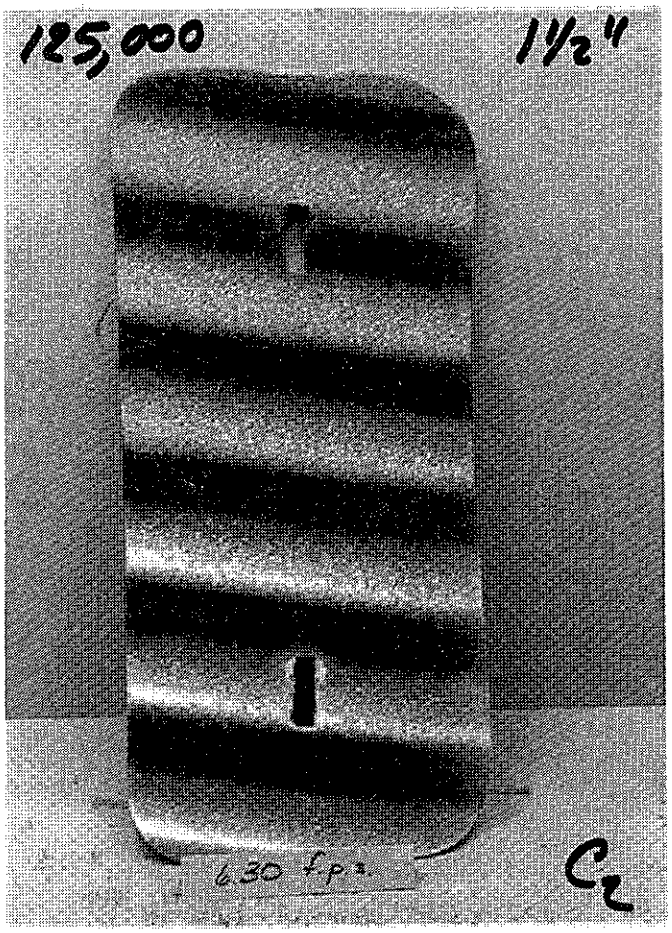

250,000
1" ROCK
6.30 f.p.s.
B1

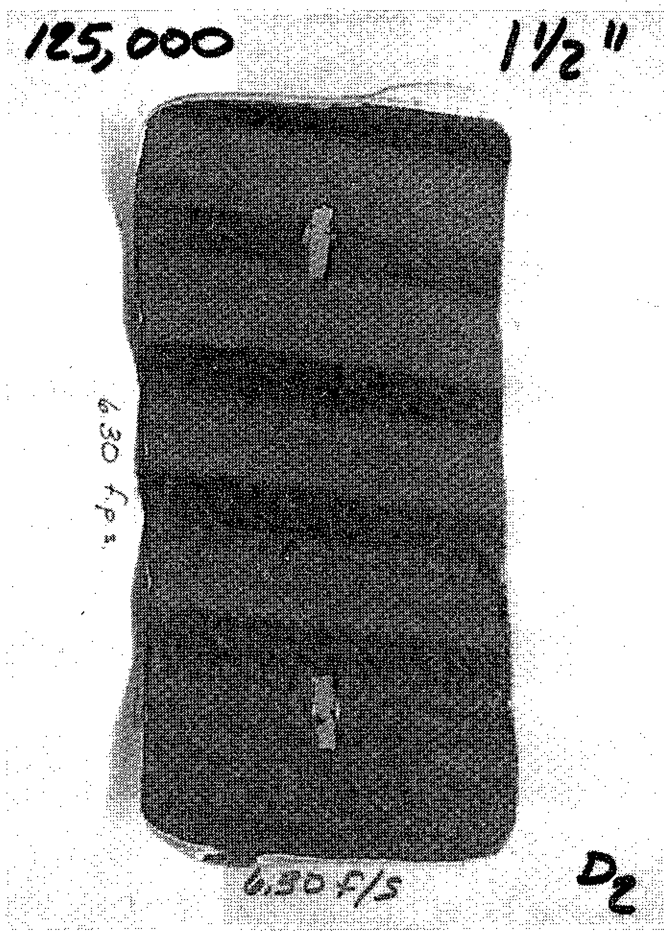

250,000
1" ROCK
6.30 f.p.s.
C1

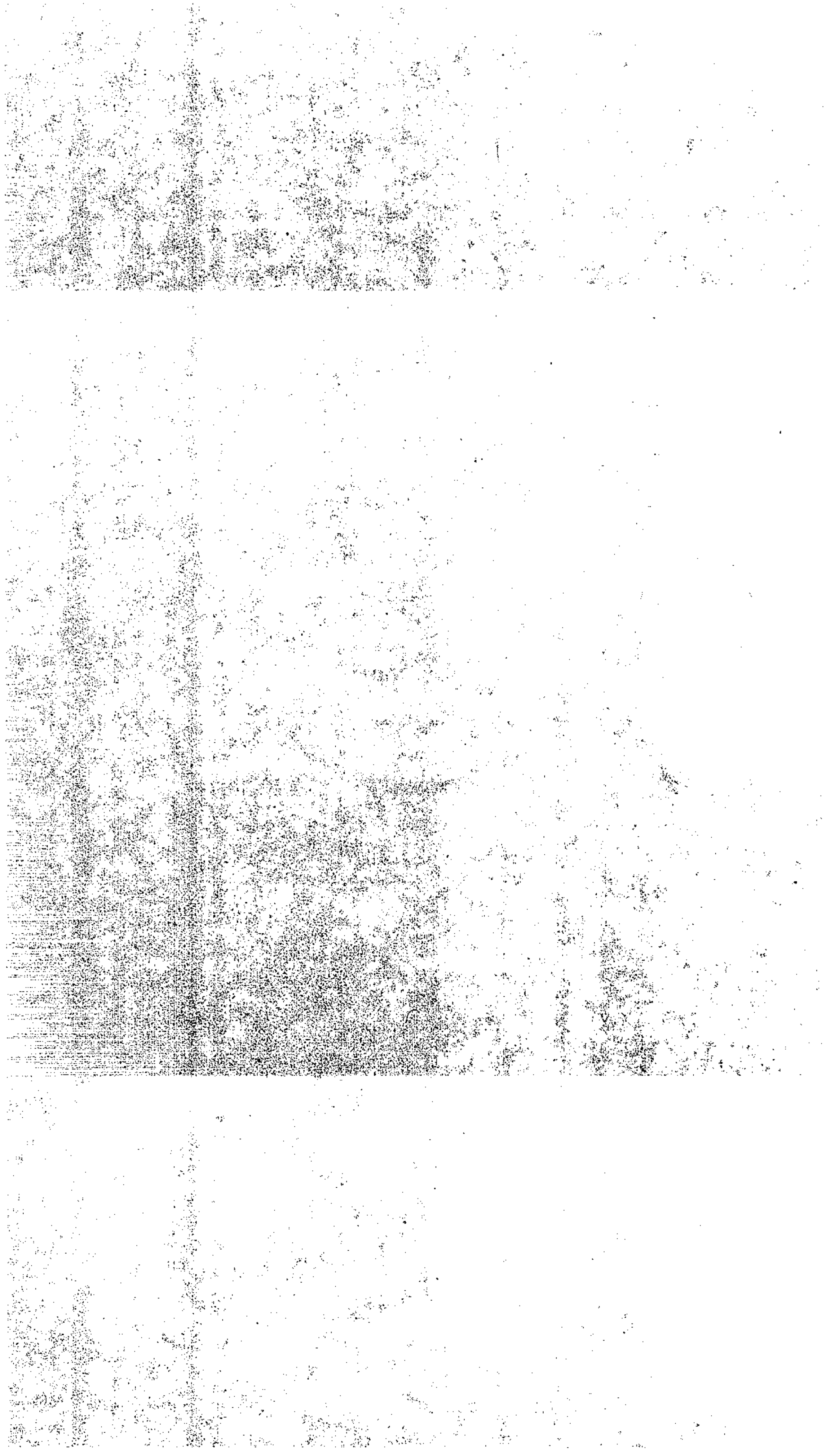

250,000
1" ROCK
6.30 f.p.s.
D1

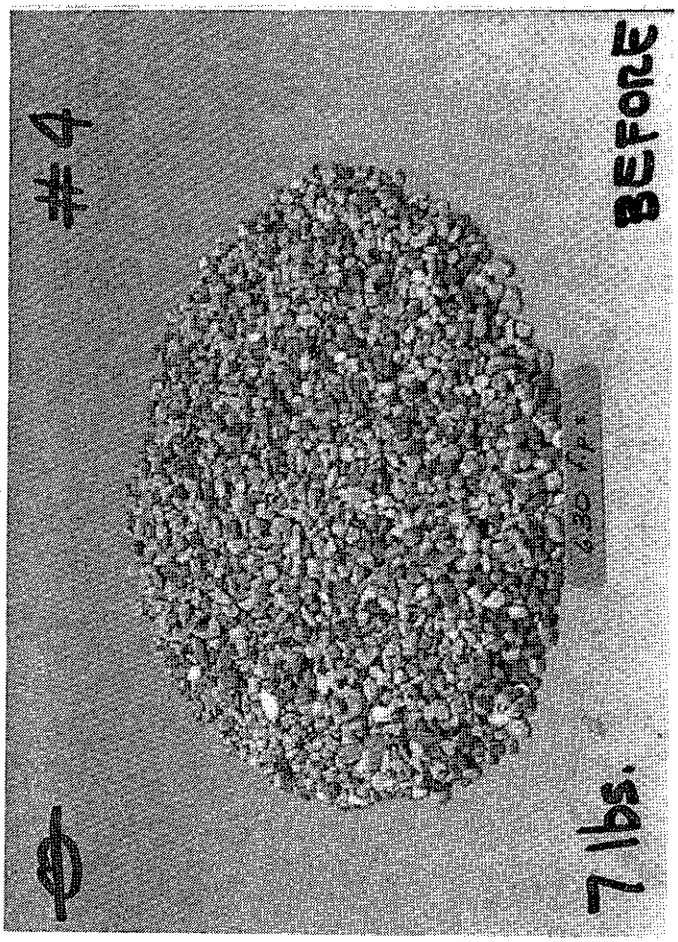

125,000
1½"
6.30 f.p.s.
A2


125,000
1½"
6.30 f.p.s.
B2

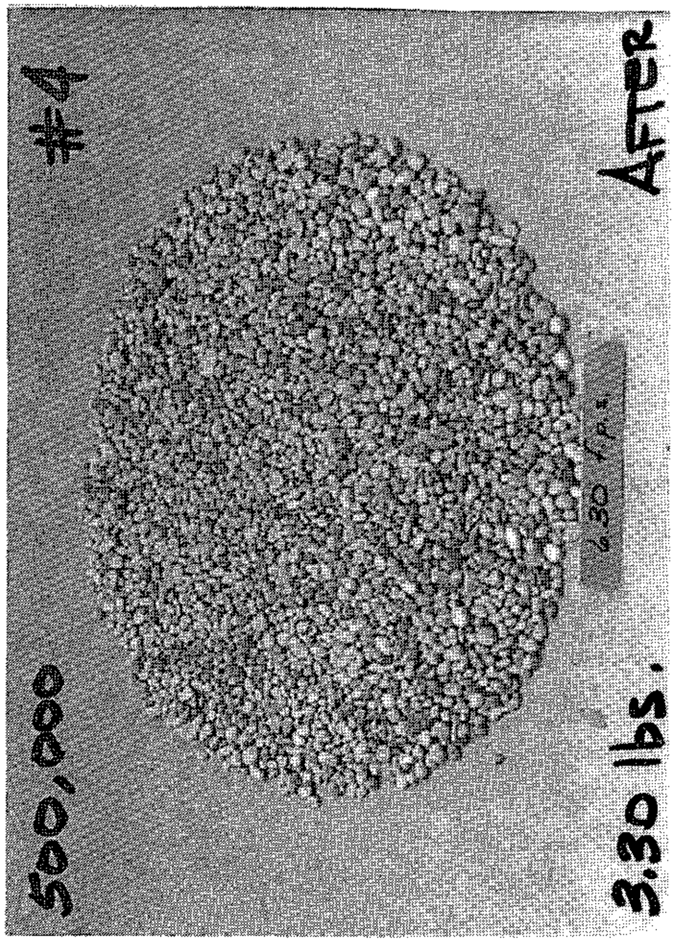

125,000
1½"
6.30 f.p.s.
C2


125,000
1½"
6.30 f.p.s.
6.30 f/s
D2

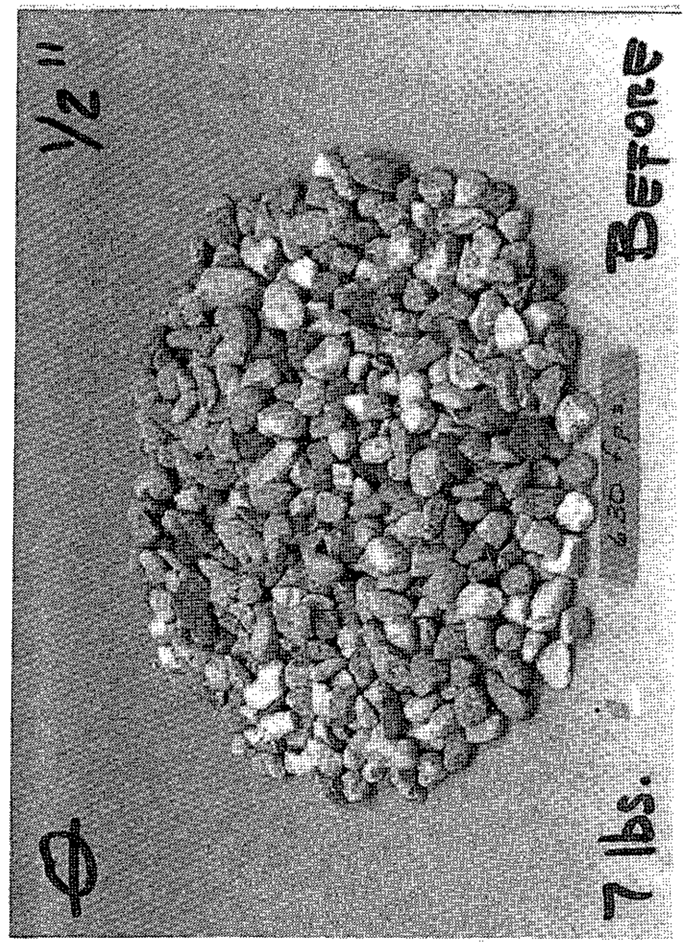




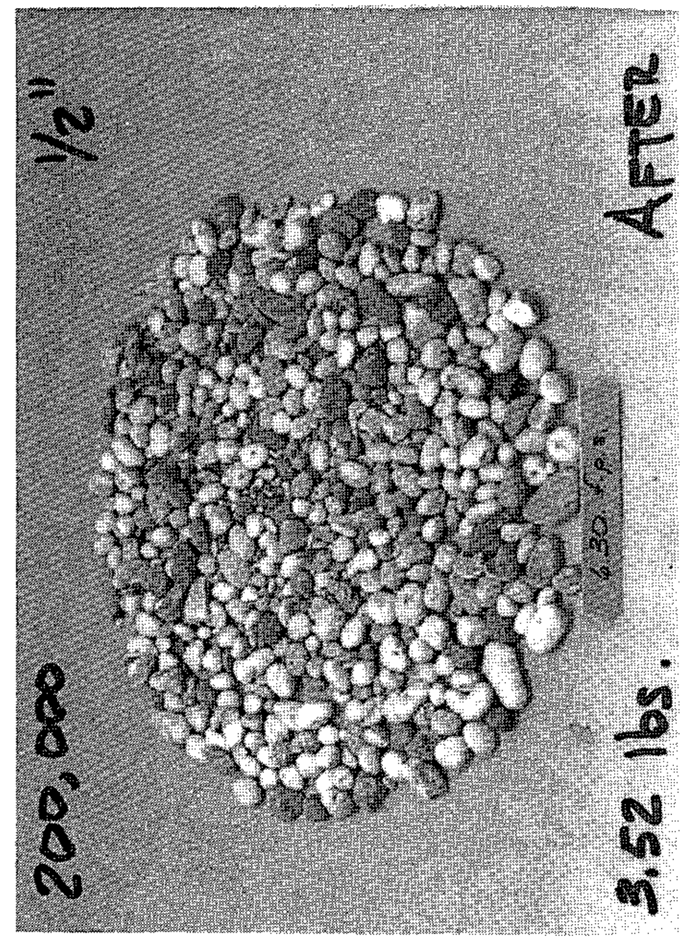
Ø
#4
7 lbs.
BEFORE



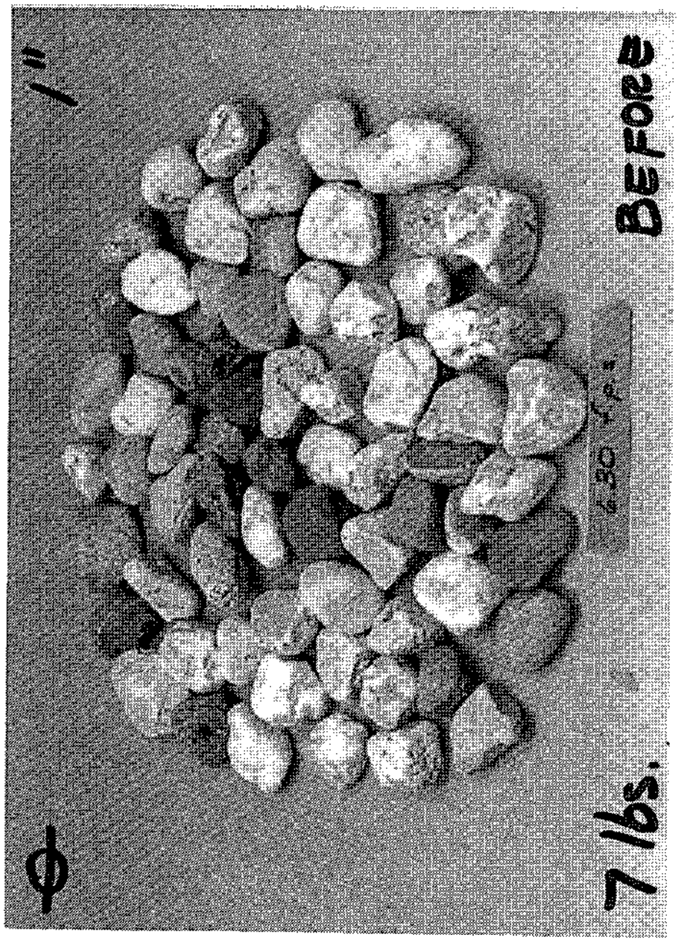
500,000
#4
3,30 lbs.
AFTER

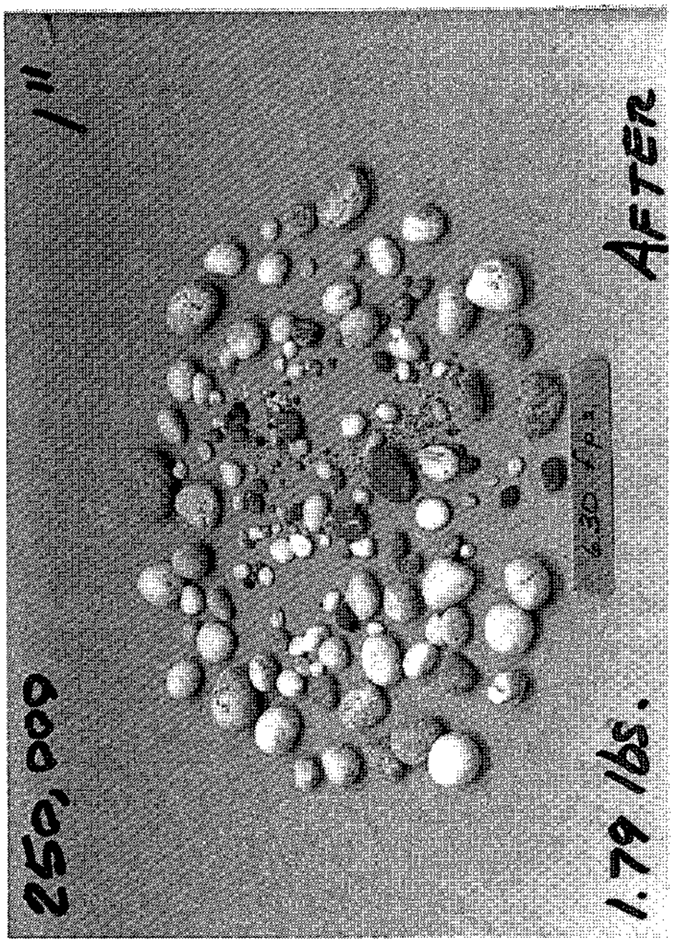


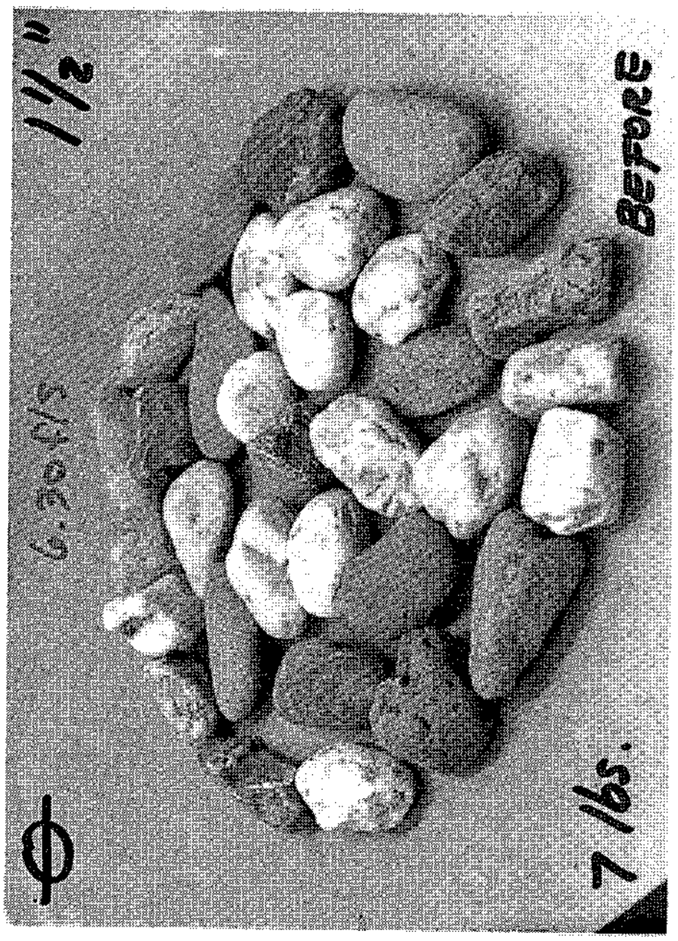
Ø
1/2"
7 lbs.
BEFORE

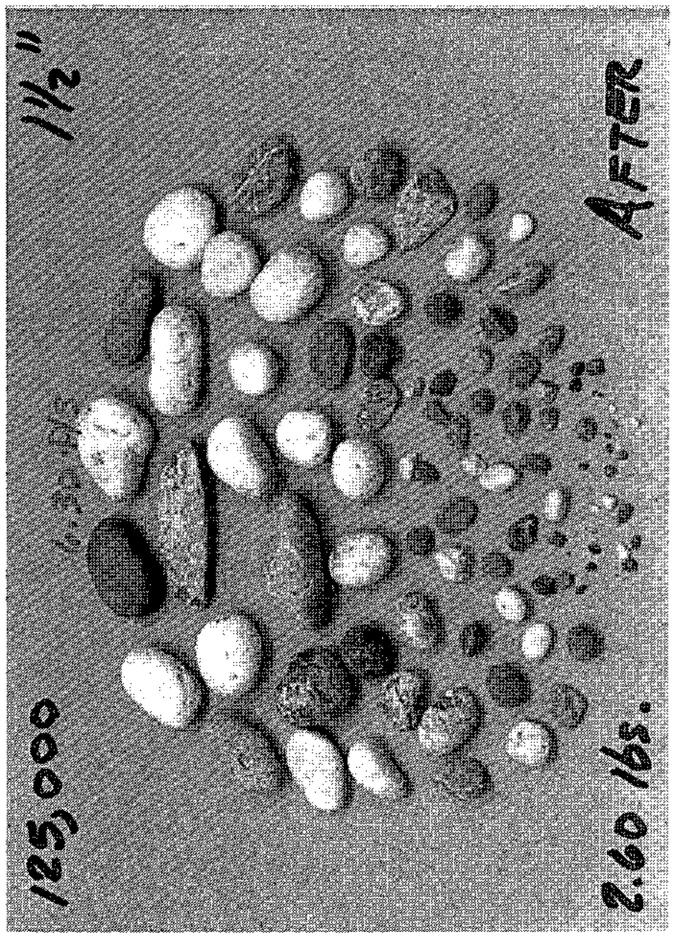


200,000
1/2"
3,52 lbs.
AFTER


Φ
1"
7 lbs.
BEFORE
6.30 fps


250,000
1"
1.79 lbs.
AFTER
6.30 fps


Φ
1½"
7 lbs.
BEFORE
6.30 f/s


125,000
1½"
2.60 lbs.
AFTER
6.30 f/s