Original

BROWN AND CALDWELL
CONSULTING ENGINEERS

May 31, 1989

Mr. Rick Andrews
Municipality of Metropolitan Seattle
Exchange Building, Mail Stop 201
821 Second Avenue
Seattle, Washington 98104

4359.16/1

Subject: Seattle Metro Final Design Engineering For The Carkeek Transfer/CSO Facilities Project
North Beach Force Main Inspection Report

Dear Mr. Andrews:

Enclosed for your review and use is a copy of the North Beach Force Main Inspection report documenting the April field activities and subsequent laboratory analysis of pipe wall samples. Please call if you have any questions.

Very truly yours,

BROWN AND CALDWELL

David Clark
Project Manager

DC:dlc
F:RA14
Enclosure

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Attn: Mr. David Clark
Project Manager

Reference: Municipality of Metropolitan Seattle
Final Design Engineering
Carkeek Transfer/CSO Facilites Project
(4359.01/1 and 4359.16/1)

Subject: North Beach Force Main
Excavation and Evaluation - Task 561

Dear Mr. Clark:

Transmitted herewith is our report on the excavation and evaluation work accomplished on the North Beach Force Main in northwest Seattle between the North Beach Pumping Station and Carkeek Park.

We appreciate the opportunity to have been of service to METRO and to Brown and Caldwell Consulting Engineers on this project.

If you have any questions concerning this report, please contact us at your convenience.

Respectfully submitted,

Henry F. Galka

Henry F. Galka
Sr. Corrosion Consultant/Project Manager

HFG/cv

Attachments

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INTRODUCTION

This report covers the excavations and evaluation made during the months of April and May 1989 of the METRO North Beach Force Main located on Puget Sound in northwest Seattle, Washington.

Force Main Description and Location

The North Beach Force Main is comprised of approximately 7,080 LF of 14-inch diameter cast iron pipe and associated fittings, located between the METRO North Beach Pumping Station and the METRO Carkeek Wastewater Treatment Plant. The route of the force main is shown on the location map on page 4.

Approximately 4,700 LF of the force main is located directly on the Puget Sound, paralleling two Burlington Northern Railroad tracks which run in a southwest to northeast direction along the beach. Through this area, the force main is an almost consistent 85 feet northwest of the centerline of the railroad tracks, in the beach which is covered by salt water each day during the high tide periods.

The force main was constructed in 1961 by the Frank Coluccio Construction Company of Seattle, Washington. The force main was buried directly in the native soil along the beach, with approximately five feet of cover.

It was found during this excavation and evaluation work that the cast iron pipe used in the construction of the force main was coated internally with a cement mortar lining. However, there was no coating found on the exterior of the pipe.

Purpose of Work

The purpose of the excavation and evaluation work was to determine the present condition of the force main piping and to estimate the remaining useful service life of the facility.

Scope of Work

The work involved in the excavation and evaluation of the North Beach Force Main included the following items, which are described in detail in this report:

1. Excavation of the force main at three locations along the beach between the North Beach Pumping Station and Carkeek Park.

2. Removal of coupons from the force main pipe at each of the three excavation locations.

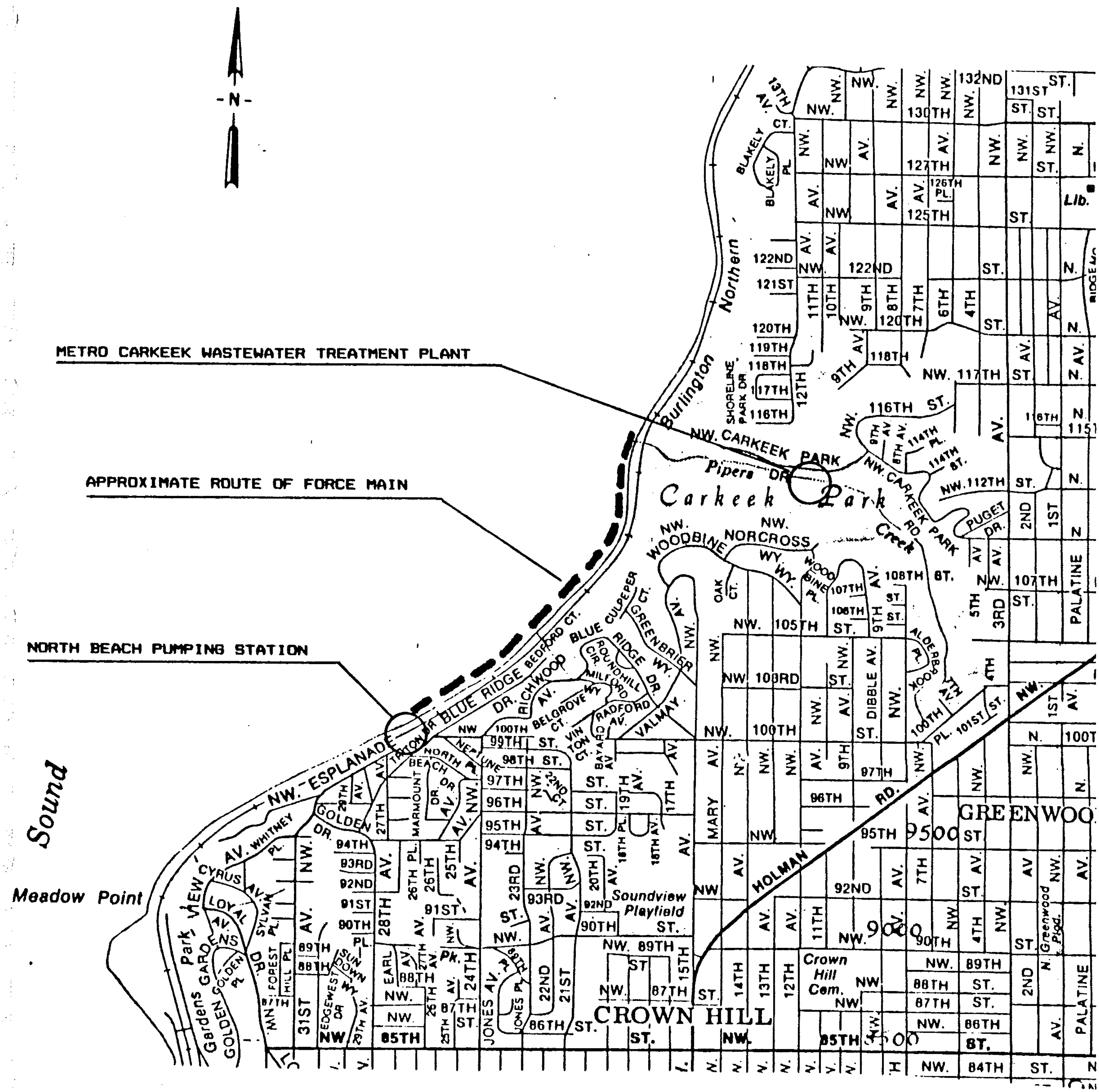
3. Inspection, analysis, and evaluation of the pipe coupons to determine the present condition of the force main and estimate the remaining useful service life of the facility.

4. Testing and analysis of soil and water samples taken from the three excavations to determine the corrosivity of the soil and its long term effects on the cast iron pipe of which the force main is constructed.

Authorization

The excavation and inspection work was carried out in accordance with a professional services agreement between Specialty Consultants Group, Inc. and BROWN AND CALDWELL, INC., as authorized

by the Municipality of Metropolitan Seattle (METRO) in their contract with BROWN AND CALDWELL, INC. titled "Pre-design Engineering Services, CarkeekTransfer/CSO Facilities Project, CW/FI-88."



METRO NORTH BEACH FORCE MAIN

LOCATION MAP

CONCLUSIONS

From the information and data gathered during the excavation and evaluation work carried out in April and May (1989) on the North Beach Force Main, the following conclusions have been reached regarding the present condition of the force main and its remaining useful service life.

PRESENT CONDITION

The present condition of the force main is very good.
This conclusion is based on the observations made of the force main during the excavation work described in this report, and on the evaluation made of the coupons removed from the force main at the three excavation locations.

The good condition of the force main is quite remarkable, considering the rather corrosive environment in which it has operated for the past 28 years.

USEFUL SERVICE LIFE REMAINING

Based on the evaluation made of the three coupons removed from the force main, and using the rather deep pitting found in Coupon No. 2 as a "worst case" situation, it has been estimated that the force main could operate for another 31 years before complete penetration of the pipe wall occurs, resulting in a leak.

This estimate is very conservative, and of necessity, includes some speculation since the three coupons removed from the force main represent only a small percent (approximately 0.00004%) of the total surface area of the entire facility.

In the event that corrosion pitting of a more serious nature than that observed in Coupon No. 2 is present at some other location(s) on the force main, the first failure (or penetration) could actually occur at any time between now and 31 years from now.

It It is our best judgement, however, that serious failures or penetrations in the force main will not occur for at least 10 to 15 years.

FORCE MAIN EXCAVATION

The North Beach Force Main was excavated at three locations along the beach between the North Beach Pumping Station and Carkeek Park. The excavation work was carried out on April 19, 20, and 21, 1989.

The purpose of the excavation work was to inspect the force main piping and remove a coupon at each location for analysis and evaluation.

The force main excavation work was accomplished by the Frank Coluccio Construction Company of Seattle, Washington. Because motorized vehicles and equipment are not permitted on the beach throughout this area, all excavation work was accomplished by hand digging.

Each excavation was shored using wood planks and frames to ensure safety for the workers and to allow maximum dewatering of the holes.

Monitoring of the work at each excavation location was recorded on Daily Field Memos, copies of which are included in Appendix I of this report.

Excavation No. 1

The first excavation of the force main was made on April 19, 1989 on the beach northeast of the North Beach Pumping Station at pipeline STA 6+21. This location was determined by a measurement of 330 feet from the excavation site to the point where the force

main turns southeast from the beach (STA 2+91) into the pumping station.

The excavation work was begun at 7:30 AM in order to provide adequate exposure of the force main piping for removal of a coupon during the low tide period which occurred between 11:00 AM and 12:00 noon of that day. The tide was forecasted to be about +1.3 ft. during the low tide period.

The force main had about five feet of cover at this location, consisting of dark brown coarse sand and rocks, with water encountered at about 30 inches deep.

The coupon removal was begun at 1:15 PM and was completed at about 1:30 PM. Backfilling of the excavation and all cleanup of the site was completed by 3:00 PM.

Pictures Nos. 1 through 10 in Appendix II show the work as it was accomplished at Excavation No. 1.

Excavation No. 2

The second excavation of the force main was made on the beach in the Carkeek Park area on April 20, 1989.

The location of this excavation was established to be at about pipeline STA 48+57, as determined by a measurement of 158 feet made from the excavation north to the point where the force main intersects the 33-inch diameter Outfall Line from the Carkeek Treatment Plant (approx. STA 50+15).

The excavation work at this location was begun at 7:30 AM with water encountered at about six inches deep. The top of the force main, which was about four feet deep, was exposed at about 10:00 AM. The beach material at this location was very rocky, making the excavation work quite difficult. Considerable blue clay was encountered at the pipe depth.

The low tide period for this date occurred between 11:30 AM and 12:30 PM, with a +0.5 ft. tide forecasted.

The coupon removal work was begun at 12:30 PM and was completed at 1:00 PM. Backfilling of the excavation and cleanup of the site was completed at about 2:30 PM.

Pictures Nos. 11 through 16 in Appendix II show the work as it was accomplished at Excavation No 2.

Excavation No. 3

The third excavation of the force main was made on the beach south of Excavation No. 2 on April 21, 1989.

The location of this excavation was estimated to be at about pipeline STA 41+81, as determined by a measurement of 366 feet south from the excavation to the abandoned Blue Ridge Outfall Line at STA 38+15. The abandoned Blue Ridge Outfall Line, which is a 10-inch diameter cast iron main, is shown in Pictures Nos. 17 and 18 in Appendix II.

The work at Excavation No.3 was begun at 7:30 AM; however, due to problems encountered by METRO personnel in accurately locating the

force main in this area, two excavations were started at erroneous locations, with the main finally located in the third excavation at 11:15 AM.

The excavation work to uncover the force main at this location was quite difficult due to extreme rocky conditions and the heavy water intrusion. This location was at a much lower elevation on the beach than the previous two excavation locations.

The top of the force main, which was about four feet deep, was reached at about 1:00 PM. Work was greatly intensified at this time in order to completely expose the entire circumference of the main for the installation of the tapping sleeve, valve assembly, and tapping machine for the removal of the pipe coupon before the incoming tide would wash into the excavation. (The low tide for this date was a minus 0.2 ft. which occurred at about 12:00 noon).

The coupon removal work was started at about 2:20 PM and was completed at 2:50 PM, with the incoming tide starting to wash into the excavation. The excavation had been bermed up on the Sound side by the construction crew in order to delay the filling of the hole for as long as possible, until the coupon removal work could be completed.

All work equipment, tools, pumps, generators, etc. were removed from the site by boat as the tide was fast rushing in at 3:00 PM.

During the low tide period on the next day (Saturday, April 22, 1989), the shoring was removed from the excavation, the excavation was backfilled, and the site was completely cleaned up and restored

to its original condition.

Pictures showing the work at Excavation No. 3 on Friday and Saturday, April 21 and 22, 1989, are included in Appendix II (Pictures Nos. 19 through 23).

GENERAL OBSERVATIONS

The following observations were made at the three excavation locations with respect to the soil conditions found and the general condition of the exterior of the force main.

Soils

The soil or "beach material" in which the force main was found at each of the excavation locations generally consisted of the usual sand and gravels (rocks). However, there were some rather significant differences noted between the three locations. These became even more noticeable by the results of the testing conducted on the samples that were taken during the excavation work -- as reported in the SOIL AND WATER TESTING section of this report.

At Excavation No. 1, the force main was buried in consistent dark brown coarse sand with small to medium sized rocks from the top of the main to the bottom. This soil (material) would be considered to be well aerated, with the force main continuously in seawater at this location.

At Excavation No. 2, the force main was buried in a sandy blue-gray clayey type soil, with small to medium sized rocks. This material was consistent from the top to the bottom of the main. With respect to aeration, this soil would be classified in the fair to

poor range; however, as with Excavation No. 1, the force main at this location is always in contact with seawater.

At Excavation No. 3, the force main was buried in medium to dark brown fine sand, with some blue-gray clay and medium to large sized rocks. This material was consistent from the top to the bottom of the main. With respect to aeration qualities, this material would be classified as well aerated, with the force main continually in contact with seawater at this location.

Pipe Condition

Because of the accelerated pace at which the work had to be accomplished at each of the three force main excavations in order to complete the coupon removal before the low tide period was over, it was not possible to conduct in-depth visual inspections of the complete exterior surface of the main. However, the rather cursory inspections made did reveal differences in the pipe surfaces.

At Excavation No. 1, a heavy (thick) layer of graphitization combined with sand and rocks was found adhering to the surface of the pipe. This layer of material, which was up to two inches thick in places, was removed quite easily from the pipe in large pieces. Of the overall thickness of this material, the graphitization was consistently between 1/4 and 3/8-inch thick. One large piece of this material is shown in Pictures Nos. 3, 4, and 5 in Appendix II of this report.

At Excavation No. 2, a layer of similar material, as found at Excavation No. 1, was also found adhering to the surface of the

pipe. This material was about the same in overall thickness (up to two inches thick in places), with the thickness of the graphitization material being a rather consistent 1/4-inch. This material, however, was slightly different from that at Excavation No. 1, with respect to the following; it was more tightly adhered to the pipe surface, it was not as easily removed, it was more brittle, and it broke up into smaller pieces with removal.

At Excavation No. 3, the pipe was covered with a thin film of graphitization, about 1/16 to 1/8-inch thick. This material was quite soft and not tightly adhered to the pipe surface. It was easily removed by scraping as the pipe was prepared for the installation of the tapping sleeve used in conjunction with the removal of the pipe coupon.

Analysis of Graphitization Products

A sample of the graphitization product removed from the force main at Excavation No. 1 was delivered to AM-TEST Laboratories in Redmond, Washington to be tested for graphite (carbon) content, and for a Plasma Spectrographic Analysis to determine other constituents.

The test reports received from AM-TEST are included in Appendix III as Figures III-1 and III-2.

The results of the AM-TEST analyses showed the major components of the material as follows:

Iron	140,000 ppm
Sulfur	18,000 ppm
Strontium	6,400 ppm
Magnesium	4,300 ppm
Calcium	4,100 ppm
Aluminum	3,600 ppm
Sodium	1,800 ppm

Graphite (carbon) content of the material was tested at 0.76 percent "total organic carbon."

Other pertinent constituents were:

silicon	860 ppm
Phosphorous	590 ppm
Nickel	27 ppm

The major constituents of seawater are shown on the table included in Appendix IV as Figure IV-1. These include sulfates (sulfur), strontium, magnesium, calcium, sodium, potassium, and others as indicated in the AM-TEST analyses (Figure III-2 in Appendix III).

The iron, silicon, phosphorous, nickel, and carbon content of the graphitization material represent constituents that have been removed from the cast iron force main through the normal corrosion process.

Aluminum is, of course, a major constituent of soil, sand, etc.

PIPE SAMPLING, INSPECTION, AND ANALYSIS

In order to assess the present condition of the North Beach Force Main, and estimate the remaining useful service life of the facility, pipe samples (coupons) were removed from the main at each of the three locations where excavations were made on April 19, 20, and 21, 1989.

COUPON REMOVAL

A three-inch (3") diameter coupon was cut out of the top of the force main at each excavation by a Tapping and Services Specialist from the Pacific Waterworks Supply Company of Tacoma, Washington, utilizing a power driven tapping machine.

The tapping machine was used in conjunction with a tapping sleeve and gate valve assembly permanently installed on the force main at each of the three excavation locations -- see Pictures Nos. 6 through 10 and 14 through 16 in Appendix II.

Specification sheets describing the tapping sleeves and gate valve assemblies used for the coupon removal work are included in Appendix V as Figures V-1 through V-6.

The tapping sleeves and gate valve assemblies were coated with two coats of KOPPERS "Bitumastic No. 300-M", a two-component, self-priming, chemically-cured, catalyzed coal tar epoxy protective coating. See coating specifications sheets in Appendix V (Figures V-7 through V-10.)

One coat of the Koppers 300-M was applied to the tapping sleeves, gate valve assemblies, and associated fittings at the Frank Coluccio Construction Company shops prior to transporting them to the project site. A second coat was applied at the project site before installation, with touch-up coating applied after the installation and prior to backfilling; see Pictures Nos. 6, 7, and 8 in Appendix II.

INSPECTION AND ANALYSIS OF COUPONS

The three coupons removed from the North Beach Force Main were visually inspected and photographed, after which they were submitted to SCAN TECH, INC., a material analysis laboratory in Bellevue, Washington for Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) work to determine the metallurgical composition and the wall thickness of each.

Visual Observations

Pictures Nos. 24 through 32 in Appendix II show the condition of the three pipe coupons as they were removed from the force main, before being cleaned and making an in-depth inspection and evaluation.

The exterior surfaces of Coupons Nos. 1 and 3 (removed from the force main at Excavations Nos. 1 and 3 respectively) appeared to be in very good condition, with a thin film of tightly adhering graphitization and no pitting evident. Coupon No. 2 (removed from Excavation No. 2), however, showed some pitting activity.

The interior surfaces of Coupons Nos. 1 and 2 showed evidence of cement mortar lining apparently applied to the interior of the force main pipe before installation, with up to 1/8-inch of the lining still intact on Coupon No. 2. It is suspected that most of the lining was lost from Coupons Nos. 1 and 3 when they were being cut and removed by the tapping machine.

Pictures Nos. 33 through 35 in Appendix II show the exterior and interior surfaces of the coupons after they had been lightly cleaned with a power driven fine bristled wire brush to remove the minor dirt and the thin film of graphitization.

The pitting on the exterior surface of Coupon No. 2 can be seen somewhat better in Picture No. 37 through 39 after lightly cleaning. In addition, the cement mortar lining still intact on the interior surfaces of Coupons Nos. 1 and 2 can be seen quite well in Pictures Nos. 45 through 51.

Metallurgical Analysis

The metallurgical analyses run on the three coupons removed from the force main showed the following constituents, reported as percent by weight:

Element	Coupon No. 1	Coupon No. 2	Coupon No. 3
Carbon (C)	4.47%	6.13%	4.63%
Silicon (Si)	1.31%	1.44%	1.38%
Phosphorous (P)	Ø.69%	Ø.52%	Ø.55%
Chromium (Cr)	Ø.19%	Ø.16%	Ø.13%
Manganese (Mn)	Ø.51%	Ø.49%	Ø.43%
Iron (Fe)	92.84%	91.25%	92.89%

The computer print-outs of these analyses, as run by SCAN TECH, INC. of Bellevue, Washington are included in Appendix III as Figures III-3 through III-8.

The results of the metallurgical analyses run on the three coupons show that the pipe used for the construction of the North Beach Force Main is a gray cast iron-type pipe which generally contains 2 to 4% carbon, 1 to 3% silicon, and up to Ø.7% manganese, with chromium added to increase corrosion resistance. See Appendix VI of this report for a general discussion of cast iron and corrosion.

Thickness Measurements

Wall thickness measurements were made of the three force main coupons by SCAN TECH, INC. by means of Scanning Electron Microscopy (SEM). These measurements were made at several locations across the coupon walls after the coupons had been cut into sections to better reveal the walls.

These measurements are summarized as follows:

	Coupon No. 1	Coupon No. 2	Coupon No. 3
	Ø.6264"	Ø.66ØØ"	Ø.7Ø12"
	Ø.62Ø1"	Ø.64ØØ"	Ø.7Ø22"
	Ø.6242"	Ø.47ØØ"	Ø.7Ø33"
	Ø.621Ø"	Ø.465Ø"	Ø.7ØØ3"
	Ø.627Ø"	Ø.44ØØ"	Ø.7Ø28"
	Ø.6256"	Ø.65ØØ"	Ø.7Ø5Ø"
	Ø.621Ø"	Ø.64ØØ"	Ø.7ØØ8"
	Ø.6247"		Ø.7Ø35"
	Ø.6229"		Ø.6996"
	Ø.6238"		Ø.7ØØ1"
AVG. =	Ø.6237"	Ø.64ØØ"	Ø.7Ø19"

The SCAN TECH report containing these measurements is included in Appendix III as Figure III-9.

The sectioning of Coupon No. 2 by SCAN TECH to measure the wall thicknesses was done across the pitting that was evident on the exterior surface of the coupon. This allowed an accurate measurement to be made not only of the pit depth, but also of the remaining wall thickness beneath the pit.

The pit was measured at 220 mils (0.220"), with a remaining pipe wall thickness of 440 mils (0.440") beneath the pit.

This pitting, which is evident on both sections of Coupon No. 2 was photographed, as shown in Pictures Nos. 56, 57, and 58 in Appendix II.

SOIL AND WATER TESTING

Soil and water samples were taken for testing and analysis at each of the three excavations made on the North Beach Force Main on April 19, 1Ø, and 21, 1989.

One soil sample was taken at the top of the force main and one sample was taken at the bottom at each location. One water sample was taken from each excavation, and one sample of Puget Sound seawater was taken and tested for comparative purposes.

SOIL TESTING PARAMETERS

The Ductile Iron Pipe Research Association (DIPRA), formerly the Cast Iron Pipe Research Association (CIPRA), has established a 1Ø-point soil evaluation procedure based on their extensive experience with soil testing as it relates to corrosion of cast iron and ductile iron pipe.

The DIPRA 1Ø-point evaluation is widely recognized and utilized throughout industry as a guide to determine the necessity for additional corrosion protection when installing new pipe in soils that are considered to be corrosive. This procedure has been included for informational purposes by the American Water Works Association (AWWA) as Appendix A of ANSI/AWWA Specification C1Ø5.

The soil parameters used in the DIPRA 1Ø-point evaluation are listed as follows:

* Resistivity
* pH
* Redox
* Sulfides
* Moisture

A copy of the DIPRA 10-point evaluation scale is included in Appendix IV of this report as Figure IV-2 for reference purposes.

Brief definitions and descriptions of the above soil parameters and their relationship to the corrosivity of soils follow.

Resistivity

Soil resistivity is directly related to soil corrosivity. Low resistivity soils readily conduct DC currents associated with corrosion cells, and therefore, are classified as corrosive. High resistivity soils do not readily conduct electrical current, and therefore, are classified as noncorrosive. This relationship is shown in the following table.

Soil Resistivity	Soil Corrosivity
Below 500 ohm-cm	Very corrosive
500 to 1000 ohm-cm	Corrosive
1000 to 2000 ohm-cm	Moderately corrosive
2000 to 10,000 ohm-cm	Mildly corrosive
Above 10,000 ohm-cm	Progressively less corrosive

Wet, heavy clays are examples of low resistivity soils which are usually very corrosive. Examples of high resistivity soils are dry sands and gravels which are relatively noncorrosive.

pH

pH is the measurement of the hydrogen (H+) ion concentration in a soil or solution. In water, when the pH is 7 (or neutral), the hydroxyl (OH-) ions are in equal concentration to the hydrogen ions at 1x(E-07) moles/liter. The log of the reciprocal of this value is equal to 7, or therefore neutral. At a pH of 6, the H+ ion concentration is 10 times greater than the neutral state, and the

solution is acidic. Conversely, when the pH is 8 the concentration of H+ ions is 10 times less than neutral, and the solution is basic or alkaline.

Soils may be either acid, alkaline, or neutral. Acidic soils tend to be more corrosive than alkaline soils for materials such as steel, cast iron, ductile iron, copper, and concrete; while the more alkaline soils may adversely affect aluminum.

Soil pH, in combination with other factors, will affect the corrosion rate of a buried metallic structure in various ways. For example, at pH 0.0 to 6.5 (acidic range), a soil will serve as a very corrosive electrolyte when moisture is present in sufficient amounts. At pH 6.5 to 7.5 (relatively neutral range), conditions are optimum for bacteriological action, such as sulfate-reducing bacteria, At pH 7.5 to 14.0 (alkaline range), dissolved salts are generally present and low soil resistivity is usually found.

Similar to steel, cast iron and ductile iron are not readily attacked in environments ranging between pH 4.0 and pH 8.5. Below the pH 4.0 range, the iron is increasingly oxidized. Above the pH 8.5 range, the soils provide a good electrolyte for development of anodic and cathodic differential cells that cause extensive pitting. In the neutral pH range (6.5 to 7.5), anaerobic bacteria thrive in soils with low Redox potential, organic food sources, and water present.

Redox

Redox is an abbreviation of the term "Oxidation-Reduction Potential". The measurement of Redox is an indication of the amount of oxidents in a soil. A knowledge of soil Redox is important since metals in a low oxidation environment are anodic to those in a higher state. An increasing Redox potential above 100 millivolts (mv) is an indication of increasing soil aeration. Below that range, the life support for sulfate reducing bacteria is enhanced and increases as the Redox potential decreases. Where negative Redox potentials are found, the growth of anaerobic sulfate reducing bacteria is optimum, providing that other soil conditions are favorable -- such as neutral pH water and the presence of sulfates. Soils containing stagnant water with much organic material, are likely to exhibit low Redox potential and indicate conditions suitable for the growth of sulfate reducing bacteria.

Sulfides

When sulfate reducing bacteria consume sulfates present in soil, the by-products of that process include sulfide compounds. These compounds act as depolarizing agents that enhance corrosion activity in localized cells on buried metallic structures.

Anaerobic bacteria thrive best at soil temperatures above 50 degrees F and a pH o 7.0. They become less active at lower temperatures and as pH departs from the neutral range.

The presence of sulfides in soil is determined by the Sodium-Azide Iodine qualitative test. In this test, sulfides in the soil sample

act as a catalyst and release free nitrogen from the compound mixture, with resultant bubbling or foaming.

The results of this test are placed within three categories for reporting purposes: Negative, Trace, and Positive. These categories reflect an increasing scale of reaction from nothing to vigorous foaming or evolution of gas. The greater the gas evolution, the higher the amounts of sulfides present in the soil sample.

SOIL TESTING RESULTS

The results of the testing conducted on the soil samples taken from the three excavations made on the North Beach Force Main are summarized as follows:

Excavation No 1.

Top of Pipe - Dark brown coarse sand with small to medium sized rocks, saturated.

Resistivity	390 ohm-cm
pH	6.61
Redox	+82 mv
Sulfides	negative
Moisture	saturated

Bottom of Pipe - Dark brown coarse sand with small to medium sized rocks, saturated.

Resistivity	360 ohm-cm
pH	6.69
Redox	+47 mv
Sulfides	negative
Moisture	saturated

Excavation No. 2

Top of Pipe - Sandy blue-gray clay with small to medium rocks, saturated.

Resistivity	170 ohm-cm
pH	6.12
Redox	+31 mv
Sulfides	negative
Moisture	saturated

Bottom of Pipe - Sandy blue-gray clay with small to medium sized rocks, saturated.

Resistivity	220 ohm-cm
pH	6.98
Redox	-25 mv
Sulfides	negative
Moisture	saturated

Excavation No. 3

Top of Pipe - Medium to dark fine sand with some blue-gray clay and medium sized to large rocks, saturated.

Resistivity	1,200 ohm-cm
pH	7.19
Redox	+58 mv
Sulfides	negative
Moisture	saturated

Bottom of Pipe - Medium to dark fine sand with some blue-gray clay and medium sized to large rocks, saturated.

Resistivity	1,100 ohm-cm
pH	7.25
Redox	+72 mv
Sulfides	negative
Moisture	saturated

WATER TESTING PARAMETERS

The water samples taken from the three excavations made of the North Beach Force Main, and the sample taken from the Puget Sound were tested to determine resistivity and pH.

In addition, the water samples taken from the three excavations were tested for sulfates and chlorides.

Sulfates and chlorides are two common salts which affect the corrosion rate of buried or submerged metallic structures. High concentrations of these particular salts increase the ability of the electrolyte to conduct corrosion currents, since they effectively lower the resistivity of the electrolyte.

Sulfates in soils can result in higher corrosion rates on buried metallic structures, since they are utilized by sulfate-reducing bacteria which thrive in anaerobic and near neutral pH conditions.

Chlorides in soil or water will contribute significantly to the corrosion of buried metallic structures and the deterioration of concrete, when occurring in sufficient quantities to cause low resistivity in the soil or water. This will occur especially in neutral and alkaline pH environments (i.e. seawater), and in conjunction with sulfates.

WATER TESTING RESULTS

The results of the testing conducted on the water samples taken from the three excavations made on the North Beach Force Main, and of the Puget Sound seawater are summarized as follows:

Excavation No. 1

Resistivity	39 ohm-cm
pH	6.75
Sulfates	1,460 ppm
Chlorides	9,230 ppm

Excavation No. 2

Resistivity	43 ohm-cm
pH	7.06
Sulfides	1,530 ppm
Chlorides	8,750 ppm

Excavation No. 3

Resistivity	37 ohm-cm
pH	7.23
Sulfates	1,500 ppm
Chlorides	9,400 ppm

Puget Sound Seawater

Resistivity	26 ohm-cm
pH	7.99

Note: The sulfate and chloride testing was done by AM-TEST LABORATORIES in Redmond, Washington. Their analysis sheet is included in Appendix IV as Figure IV-10.

EVALUATION OF SOIL AND WATER CORROSIVITY

A review of the soil and water testing results indicated that the environment in which the North Beach Force Main is located is quite corrosive, with the conditions at Excavation No. 2 being somewhat more corrosive than the other two locations (lower resistivity, lower pH, and negative Redox.)

The soils at all three locations are continually saturated with seawater, are reasonably well aerated, and are influenced by the tide changes each day.

The corrosion rates for bare steel in an environment such as this could range from 6 to 30 mils per year (mpy) with deep pitting anticipated because of the soil mixture: sand, blue-gray clay,

rocks.

Referring to the DIPRA/CIPRA 10-point evaluation scale (Figure IV-2 in Appendix IV), for cast and ductile iron, the resistivity of the soil and water in contact with the force main, alone, would give 10 points -- which would indicate the need for a protective coating and/or cathodic protection for corrosion control.

The fact that the environment around the main is continually saturated (with low resistivity seawater) would add additional points -- making the conditions even more corrosive.

In addition, the negative Redox and the large amount of blue-gray clay at Excavation No. 2 are an indication of deep pitting potential.

The fact that the cast iron pipe used in the construction of the North Beach Force Main has been alloyed with nickel has helped in keeping corrosion rates lower than would normally be anticipated for this environment.

FORCE MAIN EVALUATION

Utilizing the information and data obtained from the excavation and inspection work accomplished on the North End Force Main, and from the inspection and analysis made of the coupons removed from the force main on April 19, 20, and 21, 1989, an evaluation was made to determine the present condition of the force main and estimate the remaining useful service life of the facility.

In formulating the determination of the present condition and the estimation of remaining useful service life, theoretical values were calculated for pipe wall thicknesses with somewhat hypothetical conclusions reached with respect to metal loss and corrosion rates, because of the following factors:

1. There was no documentation available pertaining to the actual original wall thickness of the cast iron pipe used in the construction of the force main; therefore, an assumption was made concerning this item, based on published data.

2. The combined surface areas of the three coupons removed from the force main represents only a fraction of a percent (about 0.00004%) of the total surface area of the entire force main as it exists from the North Beach Pumping Station to the Carkeek Wastewater Treatment Plant.

Evaluation Approach

The North Beach Force Main was constructed in 1961 of 14-inch diameter cast iron pipe. According to American National Standards Institute (ANSI) specifications, there were eleven classes of

14-inch diameter cast iron pipe manufactured, ranging in wall thickness from Ø.43" (Class 2Ø) to Ø.94" (Class 3Ø). These pipe classes are shown in ANSI Table 1-7 included in Appendix IV of this report as Figure IV-3.

The allowable wall thickness tolerance for the manufacturing (casting) of 14-inch diameter cast iron pipe was a plus or minus Ø.Ø8", as indicated in ANSI Table 1-6 included in Appendix IV as Figure IV-4.

The present pipe wall thickness of the North Beach Force Main, as determined by the measurements made of the three coupons removed from the main on April 19, 2Ø, and 21, 1989, ranges from a low of Ø.44Ø" to a high of Ø.7Ø5" -- see the SCAN TECH, INC. report in Appendix III Figure III-9). The low measurement of Ø.44Ø" is the wall thickness remaining beneath the deep pit in Coupon No. 2 (see Pictures Nos. 56, 57, and 58 in Appendix II).

The average thickness of the three force main coupons, excluding the deep pit in Coupon No. 2, are listed as follows:

Coupon No. 1	Ø.624"
Coupon No. 2	Ø.648"
Coupon No. 3	Ø.7Ø2"

In order to determine which class of cast iron pipe may have been used in the construction of the North Beach Force Main, the wall thicknesses listed for the various classes of 14-inch diameter pipe in the ANSI Table 1-7 were compared with the high and low wall thickness of the force main coupons. This comparison indicated that the pipe used in the construction of the North Beach Force

Main could possibly have been either Class 24, Class 25, Class 26, or Class 27.

The maximum and minimum allowable wall thickness for these four classes of cast iron pipe were estimated in accordance with the ANSI casting tolerance specification, in order to make further comparisons with the present wall thicknesses of the North Beach Force Main as represented by the coupons.

The results of these calculations are tabulated as follows:

<u>Class 24 Pipe</u>

Ø.59" Wall Thickness +Ø.Ø8" tolerance = Ø.67" Max.
-Ø.Ø8" tolerance = Ø.51" Min.

<u>Class 25 Pipe</u>

Ø.64" Wall Thickness +Ø.Ø8" tolerance = Ø.72" Max.
-Ø.Ø8" tolerance = Ø.56" Min.

<u>Class 26 Pipe</u>

Ø.69" Wall Thickness +Ø.Ø8" tolerance = Ø.77" Max.
-Ø.Ø8" tolerance = Ø.61" Min.

<u>Class 27 Pipe</u>

Ø.75" Wall Thickness +Ø.Ø8" tolerance = Ø.83" Max.
-Ø.Ø8" tolerance = Ø.67" Min.

A comparison of the present high and low North Beach Force Main wall thickness measurements, as provided by the three coupons removed from the force main, was made with the above estimated maximum and minimum wall thicknesses for the four classes of cast iron pipe. This comparison indicated that the force main coupon thicknesses could only fit within the maximum and minimum wall thickness parameters of the Class 27 pipe. Therefore, for further

evaluation purposes, it has been assumed that the pipe used in the construction of the North Beach Force Main was the ANSI Class 27 cast iron pipe.

Determination of Metal Loss/Corrosion Rates

The maximum and minimum wall thickness measurements for Class 27 cast iron pipe, as developed from the ANSI specifications and subject to the allowable casting tolerances, were compared with the average thicknesses of the three coupons removed from the North Beach Force Main.

The purpose of making these comparisons was twofold: 1) to determine an estimate of the metal loss that has occurred on the force main during the past 28 years at the three locations where the coupons were removed; and 2) to determine the approximate rates of corrosion in mils per year (mpy) that have been occurring at each of the three locations.

The results of these comparisons are tabulated as follows:

Coupon No. 1 (Metal Loss/Corrosion Rates)

Class 27 Cast Iron Pipe		
Maximum Wall Thickness	Ø.83"	
Minimum Wall Thickness		Ø.67"
Coupon No. 1		
Average Thickness	Ø.62"	Ø.62"
Metal Loss (28 years)	Ø.21"	Ø.Ø5"
Corrosion Rates	7.5Ø mpy	1.79 mpy

Coupon No. 2 (Metal Loss/Corrosion Rates)

Class 27 Cast Iron Pipe

Maximum Wall Thickness	0.83"	
Minimum Wall Thickness		0.67"
Coupon No. 2		
Average Thickness	0.65"	0.65"
Metal Loss (28 years)	0.18"	0.02"
Corrosion Rates	6.43" mpy	0.71" mpy

Coupon No. 3 (Metal Loss/Corrosion Rates)

Class 27 Cast Iron Pipe

Maximum Wall Thickness	0.83"	
Minimum Wall Thickness		0.67"
Coupon No. 3		
Average Thickness	0.70"	0.70"
Metal Loss (28 years)	0.13"	---
Corrosion Rates	4.64 mpy	---

The corrosion rates developed for the force main at the three locations where the coupons were removed are much lower than would be anticipated for unprotected cast or ductile iron pipe installed in an environment such as that in which the North Beach Force Main is buried. It is apparent that the nickel in the cast iron alloy used for the pipe has kept the corrosion rates down.

Present Condition Assessment

From the inspections made of the North Beach Force Main at the three locations excavated on April 19, 20, and 21, 1989; and from the subsequent analyses and evaluations made of the coupons removed

from the force main at the excavation locations, it has been determined that the force main is in very good condition -- considering the number of years it has been in service, and the rather corrosive environment in which it is located.

Remaining Useful Service Life

Since the remaining useful service life of the North Beach Force Main would theoretically be determined by the time it would take for a failure or failures to occur, a hypothetical "worst case" situation was used to estimate the time to the first failure.

This "worst case" situation was based on the conditions involved with the deep pit found in Coupon No. 2. Since the pipe wall thickness remaining beneath this pit represents the (presently known) least thickness of metal at any one point along the force main, it therefore, represents the location at which the first penetration or failure would occur.

In comparing the metal thickness remaining beneath this pit with the previously calculated maximum and minimum pipe wall thicknesses of which the force main was probably constructed, a 28 year metal loss determination and a rate of corrosion were developed, as follows:

Close 27 Cast Iron Pipe		
Maximum Wall Thickness	Ø.83"	
Minimum Wall Thickness		Ø.67"
Coupon No. 2		
Metal Remaining Beneath Pit	Ø.44"	Ø.44"
Metal Loss (28 years)	Ø.39"	Ø.23"
Corrosion Rates	13.93 mpy	8.21 mpy

If the maximum corrosion rate of 13.93 mpy, as hypothetically determined above, was to continue, the remaining pipe wall of the force main would be penetrated at the pit location in 31.6 years.

This calculated time-to-failure prediction of 31.6 years is believed to be quite conservative, since the rate of corrosion would be reduced considerably by the buildup of the tightly adhering corrosion product (graphitization) in the pit, which would tend to exclude oxygen and stifle the corrosion activity considerably.

In addition, the cement mortar lining on the interior of the force main will delay the actual occurrence of a leak for some period of time -- until too great an area of the pipe wall has been corroded away and the cement mortar lining ruptures.

Therefore, it would be safe to predict that the time-to-failure period for any location on the force main (that is similar or comparable to the "worst case" situation presented by the pit in Coupon No. 2) would be considerably greater than 31.6 years.

Again, however, it must be pointed out that this estimate of remaining useful service life for the North Beach Force Main was developed on a purely hypothetical basis, since the combined surface areas of the three coupons removed from the force main represent only a fraction of a percent (Ø.ØØØØ4%) of the entire surface area of the force main.

It is entirely possible that pitting of an even more serious nature than that found in Coupon No. 2 is present on the North Beach Force

Main. The substantiation of this possibility and a determination of the extent to which the force main has suffered from such pitting activity can be made only by further extensive excavation and inspection of the main.

Assuming that pitting of a somewhat more serious nature than that already found does exist, a more realistic estimate of the remaining useful service life for the North Beach Force Main would probably be in the range of 10 to 15 years.

APPENDIX I

Daily Field Memos

SPECIALTY CONSULTANTS GROUP, INC.
Redmond, Washington

DAILY FIELD MEMO

Date: APRIL 19, 1989 Memo No. 1 (OF 5)

Weather: 6:45 AM - LIGHT RAIN, 39° Project No. 563973

Client: BROWN & CALDWELL / METRO

Project: NORTH BEACH FORCE MAIN EXCAVATION / EVALUATION

Location: NORTH BEACH PUMPING STATION
(EXCAVATION NO. 1)

Contractor: FRANK COLUCCIO CONSTRUCTION COMPANY

Present at Site: 6:45 AM - BILL MUSTERED, METRO
DICK CARLSON, METRO

Comments: 7:00 AM - BILL MUSTERED LOCATE FORCE MAIN
7:00 AM - FRANK COLUCCIO CONSTRUCTION CREW ARRIVED
UNLOAD EQUIPMENT - HAUL TO BEACH
(10 MAN CREW)
7:30 AM BEGIN DIGGING
8:00 AM GENE JOHNSON, BROWN & CALDWELL INSP. ARR
8:30 AM DIGGING AT 30" DEEP - WATER, ROCKY, SANDY
9:00 AM INSTALLING SHORING IN EXCAVATION.
NOON - PIPE ABOUT 5' DEEP
HEAVY LAYER GRAPHITIZATION WITH SAND, ROCKS
ABOUT 2" THICK, REMOVED EASILY, IN LARGE PIEC
1:15 PM - TAPPING MACHINE INSTALLED, MAKING TAP
RICK ANDREWS, DON JOHNSON OF METRO,
VINCE COLUCCIO AT SITE
1:30 PM - TAP COMPLETED, DISMANTLE SHORING, HAUL
EQUIP, MATERIALS TO TRUCKS.
3:00 PM - EXCAVATION FILLED, SITE CLEANED UP.
LEAVE SITE.

Henry J. Galka

SPECIALTY CONSULTANTS GROUP, INC.
Redmond, Washington

DAILY FIELD MEMO

Date APRIL 20, 1989 Memo No. 2 (OF 5)

Weather 7:00 AM - CLDY, WNDY 39° Project No. 563973

Client BROWN & CALDWELL / METRO

Project NORTH BEACH FORCE MAIN EXCAVATION / EVALUATION

Location CARKEEK PARK - (EXCAVATION NO. 2)

Contractor FRANK COLUCCIO CONSTRUCTION COMPANY

Present at Site 7:00 AM - BILL MUSTERED, METRO
DICK CARLSON, METRO

Comments 7:00 AM - COLUCCIO CONSTRUCTION CREW (8 MEN) ARR
BILL MUSTERED LOCATE LINE
COLUCCIO CREW HAULING EQUIP. TO BEACH
7:30 AM - BEGIN DIGGING - VERY ROCKY, WATER 6" DEEP
8:00 AM - GENE JOHNSON, BROWN & CALDWELL INSP. ARR
10:00 AM - STARTED SHORING OF EXCAVATION
10:30 AM - 11:00 AM HEAVY RAIN SQUALLS
11:30 AM - PIPE UNCOVERD, ABOUT 4' DEEP TO TOP
LARGE AMOUNTS OF BLUE-GRAY CLAY
THICK LAYER OF GRAPHITIZATION MIXED WITH
SAND AND ROCKS ADHERING TO PIPE. REMOVED IN
SMALL PIECES - MORE BRITTLE THAN EXCAVATION #1.
12:30 PM - TAPPING MACHINE INSTALLED - BEGIN TAPPING.
1:00 PM - COUPON REMOVAL COMPLETE
DISMANTLE SHORING, HAUL EQUIPMENT AND
MATERIALS TO TRUCKS.
2:30 P.M. - SITE CLEANED UP, EXCAVATION BACKFILED.
LEAVE SITE.

[signature]

SPECIALTY CONSULTANTS GROUP, INC.
Redmond, Washington

DAILY FIELD MEMO

Date: APRIL 21, 1989
Memo No. 3 (OF 5)

Weather: 7:00 AM - OVERCAST, 42°
Project No. 563973

Client: BROWN & CALDWELL / METRO

Project: NORTH BEACH FORCE MAIN EXCAVATION / EVALUATION

Location: CARKEEK PARK - (EXCAVATION NO. 3)

Contractor: FRANK COLUCCIO CONSTRUCTION COMPANY

Present at Site: 7:00 AM - BILL MUSTERED, METRO
DICK CARLSON, METRO

Comments: COLUCCIO CREW MOVING EQUIPMENT AND MATERIALS INTO SITE BY BOAT. (8 MAN CREW).

7:30 AM BILL MUSTERED LOCATING LINE

8:00 AM BEGIN DIGGING - TIDE GOING OUT
ELEVATION LOWER - STILL COVERED WITH WATER

8:00 AM GENE JOHNSON, BROWN & CALDWELL INSP. AT SITE.

9:00 AM DIGGING HARD - VERY ROCKY, LOTS OF CLAMS.
UNABLE TO FIND PIPE - RELOCATE.

10:00 AM STILL UNABLE TO FIND PIPE IN 2ND HOLE
RELOCATE - BEGIN 3RD EXCAVATION.

11:15 AM PIPE LOCATED (79' WEST OF FACE OF RAILROAD RIP-RAP WALL)

11:45 AM RAINING HARD - BLUE GRAY CLAY IN HOLE.
BEGIN INSTALLING SHORING IN EXCAVATION

1:00 PM PIPE NOT YET UNCOVERED, TIDE COMING IN.
WORKERS BERMING UP WATER (SOUND) SIDE OF EXCAVATION WITH MATERIAL BEING REMOVED.

— (CONTINUED ON NEXT PAGE — MEMO NO. 4) — [initials]

SPECIALTY CONSULTANTS GROUP, INC.
Redmond, Washington

DAILY FIELD MEMO

Date APRIL 21, 1989 Memo No. 4 (OF 5)

Weather Project No. 563973

Client

Project

Location EXCAVATION NO. 3
(CONTINUED FROM MEMO NO. 3)

Contractor

Present at Site

Comments

2:00 PM PIPE EXPOSED, MATERIAL BEING REMOVED AROUND PIPE FOR INSTALLATION OF TAPPING SLEEVE, ETC.

- SOFT THIN FILM OF GRAPHITIZATION ON PIPE SURFACE - EASILY REMOVED BY SCRAPING. PIPE DOES NOT APPEAR TO BE PITTED.
- SOME BLUE-GRAY CLAY MIXED WITH SAND AND ROCKS AROUND PIPE.

2:20 PM TAPPING MACHINE INSTALLED - START TAPPING WORK. TIDE STARTING TO COME INTO EXCAVATION.

2:50 PM TAPPING FINISHED. TOUCH UP COATING OF VALVE ASSEMBLY AND TAPPING SLEEVE, EXCAVATION FILLING WITH WATER

3:00 PM EQUIPMENT, TOOLS, MATERIALS LOADED INTO BOAT. EXCAVATION FULL OF WATER

LEAVE SITE 3:15 PM

[signature]

SPECIALTY CONSULTANTS GROUP, INC.
Redmond, Washington

DAILY FIELD MEMO

Date: APRIL 22, 1989
Memo No. 5 (OF 5)
Weather: 7:00 AM - OVERCAST, 40°
Project No. 563973
Client: BROWN & CALDWELL / METRO
Project: NORTH BEACH FORCE MAIN EXCAVATION / EVALUATION
Location: CARKEEK PARK (EXCAVATION NO. 3)
- FINAL CLEANUP OF SITE -
Contractor: FRANK COLUCCIO CONSTRUCTION COMPANY
Present at Site: DICK CARLSON, METRO
COLUCCIO CREW (6 MEN)

Comments

ARRIVED AT SITE 10:00 AM FROM MEETING WITH DAVE CLARK & STU OPPENHIEM (BROWN & CALDWELL) AT CARKEEK WWTP - REVIEW ROUTE OF NEW FORCE MAIN OUT OF EAST END OF PLANT.

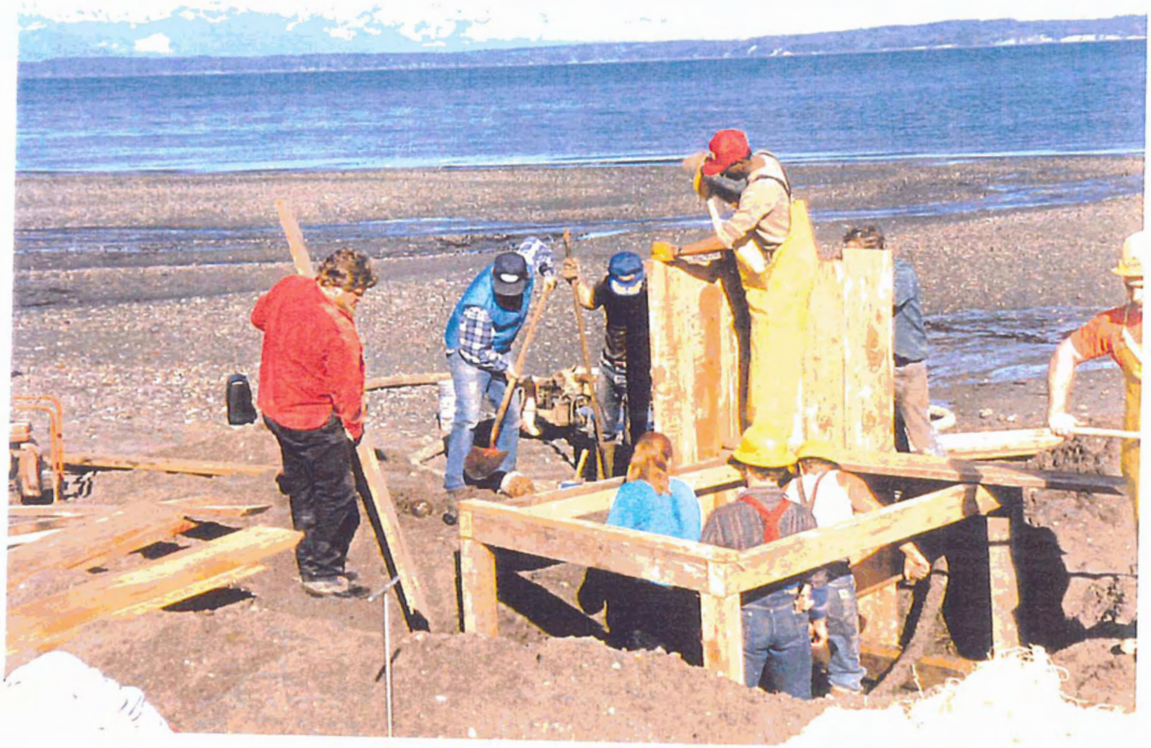
10:00 AM COLUCCIO CREW REMOVING SHORING FROM EXCAVATION

12:00 PM FINISHED CLEANUP OF SITE, EXCAVATION BACKFILLED. LEAVE SITE

[signature]

APPENDIX II

Pictures



PICTURE NO. 1

Excavation of the North Beach Force Main at location #1 in the vicinity of the North Beach Pumping Station on April 19, 1989. Construction crew installing shoring to prevent caving of excavation and allow exposure of the main.

PICTURE NO. 2

North Beach Force Main (14-inch diameter cast iron pipe) exposed at Excavation No. 1 near the North Beach Pumping Station on April 19, 1989. Pipe was encased in a thick layer of graphitization combined with sand and rocks, which was easily removed from the pipe surface (see next three pictures).

PICTURE NO. 3

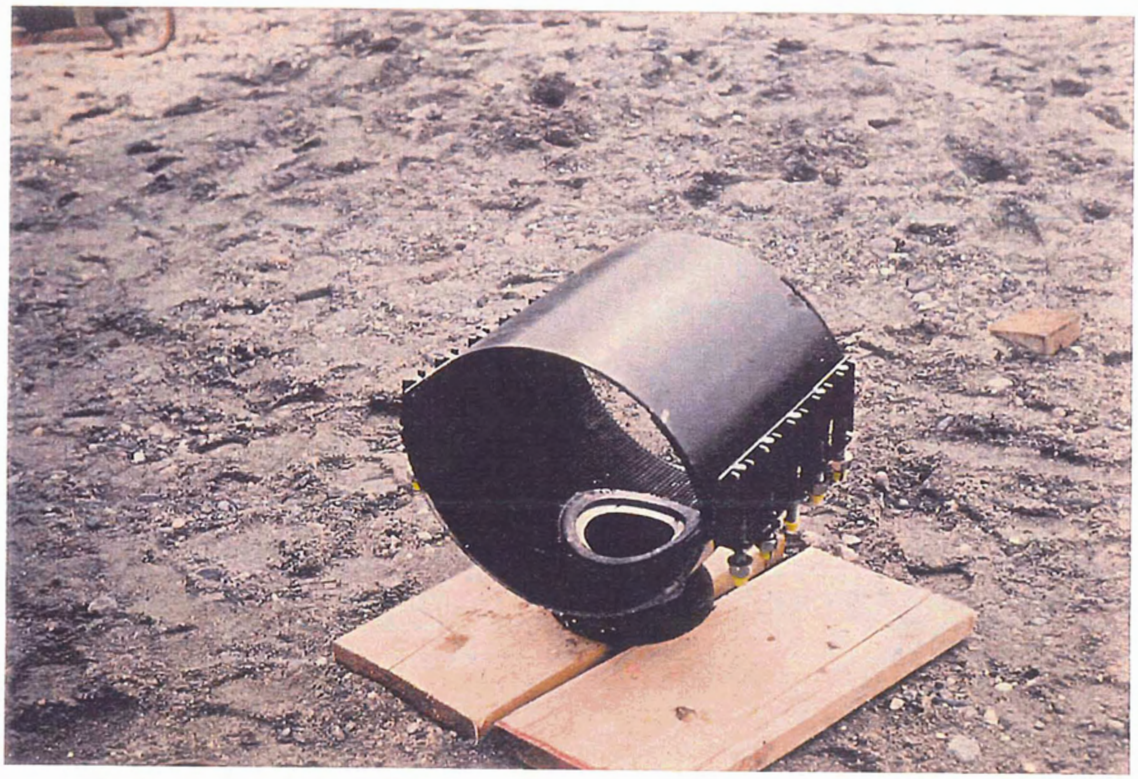
Large piece of thick layer of material removed from the North Beach Force Main at Excavation No. 1 on April 19, 1989. The pipe was encased in this material which consisted of a layer of graphitization, sand, and rocks. This picture shows the soil-side of the material. See next picture for view of the pipe side.

PICTURE NO. 4

Pipe-side of thick layer of material removed from the North Beach Force Main at Excavation No. 1 on April 19, 1989 showing the layer of graphitization (up to 1/4-inch thick) which was easily removed from the pipe.

PICTURE NO. 5

Side or end view of piece of material removed from the North Beach Force Main at Excavation No. 1 on April 19, 1989; as shown in the two previous pictures. The total thickness of the material (including graphitization, sand, rocks, etc.) was measured at up to 2 inches, with the thickness of the graphitization layer measured at up to 3/8-inch.

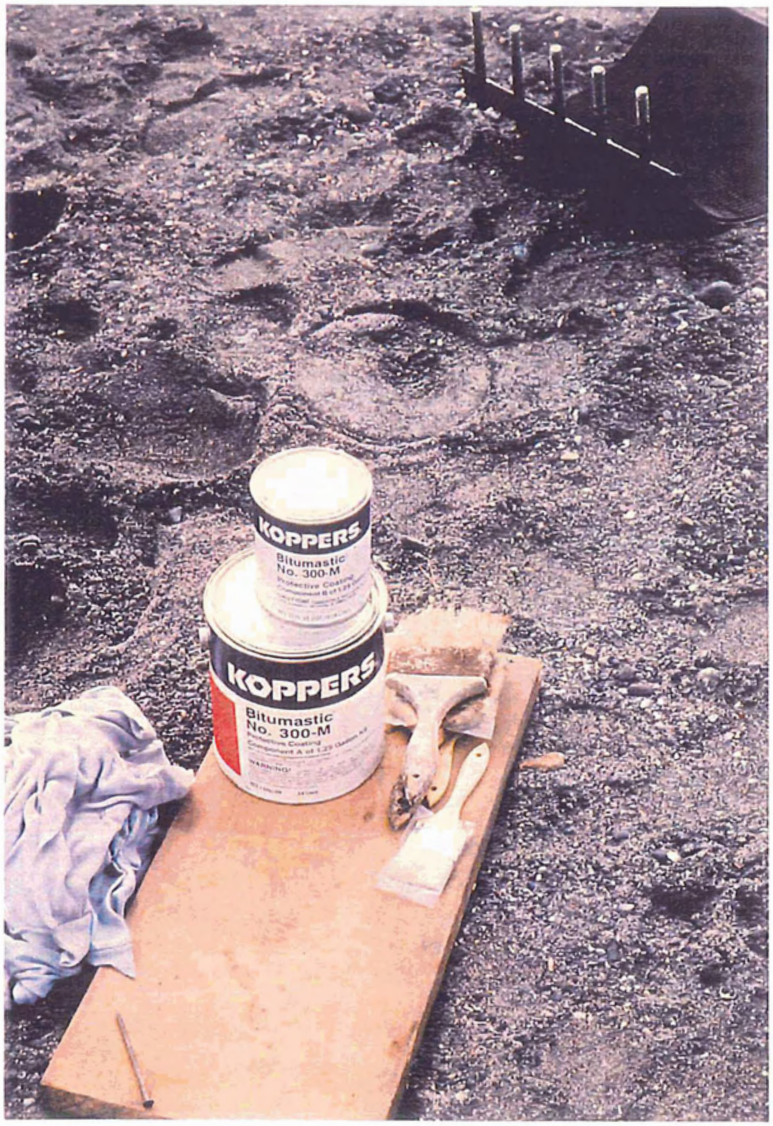


PICTURE NO. 6

Tapping sleeve for installation on North Beach Force Main at Excavation No. 1 on April 19, 1989; to be used in conjunction with gate valve assembly for installation of tapping machine to be used to remove coupon from pipe. Specification sheets for the tapping sleeve and gate valve assembly are included in Appendix III of this report.

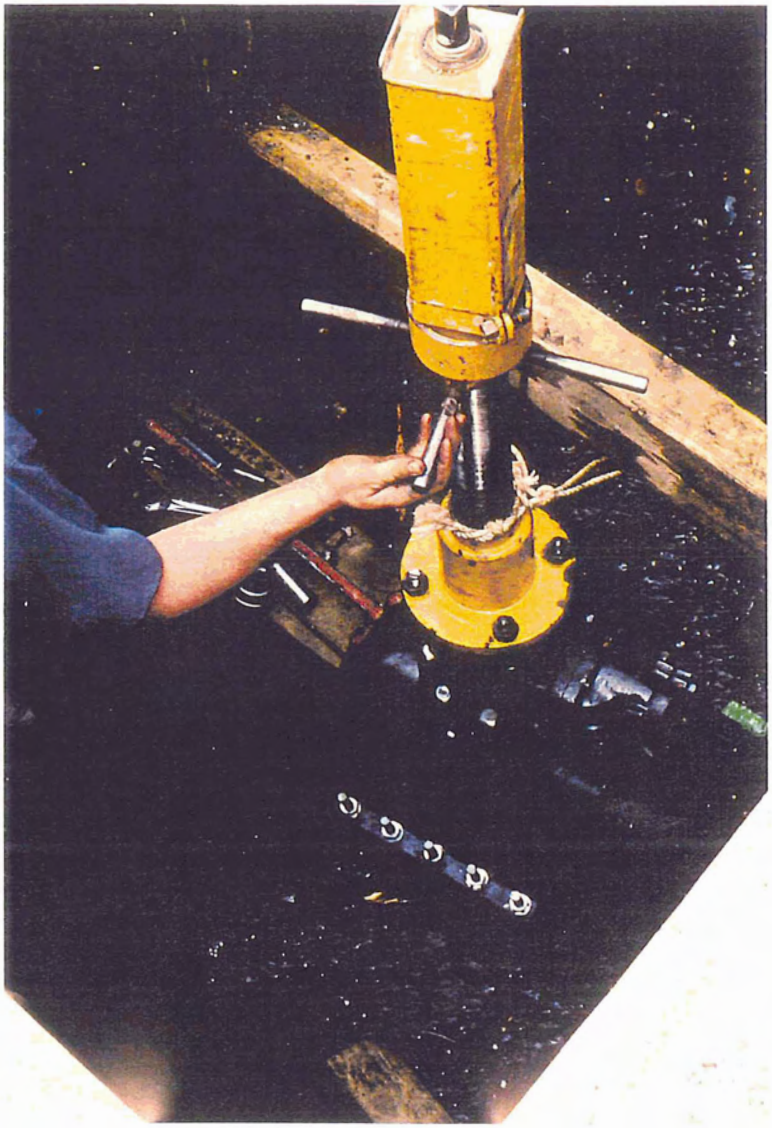
PICTURE NO. 7

Tapping sleeve and gate valve being assembled for installation on the North Beach Force Main at Excavation No. 1 on April 19, 1989. All parts and components had been coated with KOPPERS Bitumastic No. 300-M protective coating.



PICTURE NO. 8

KOPPERS Bitumastic No. 3ØØ-M protective coating at Excavation No. 1 site on April 19, 1989; used for applying a second coat of protective coating to the tapping sleeve and gate valve assembly prior to installation on the force main, and for touch-up repair prior to backfilling the excavation.



PICTURE NO. 9

Installation of tapping machine on tapping sleeve and gate valve assembly on North Beach Force Main at Excavation No. 1 on April 19, 1989; in preparation for cutting 3-inch diameter coupon out of pipe.

PICTURE NO. 1Ø

Tapping machine operation at Excavation No. 1 on the North Beach Force Main on April 19, 1989; removing 3-inch diameter coupon from pipe. Tapping work done by Tapping and Service Specialist from Pacific Waterworks Supply Company of Tacoma, WA.

PICTURE NO. 11

Location of excavation No. 2 made of the North Beach Force Main on April 2Ø, 1989 in the Carkeek Park area. View of the excavation site is to the south from Piper Creek. The excavation location is at pipeline STA 48+57, as determined by a measurement of 158 feet from the 33-inch diameter Outfall Line from the Carkeek WWTP, where it intersects the force main on the beach on the north side of Piper Creek.

PICTURE NO 12

Excavation No. 2 on the North Beach Force Main on April 2Ø, 1989. Excavation is being shored to prevent caving of the hole. A considerable amount of blue-gray clay was found at the force main depth (six feet deep to the bottom of the pipe) at this location.

PICTURE NO. 13

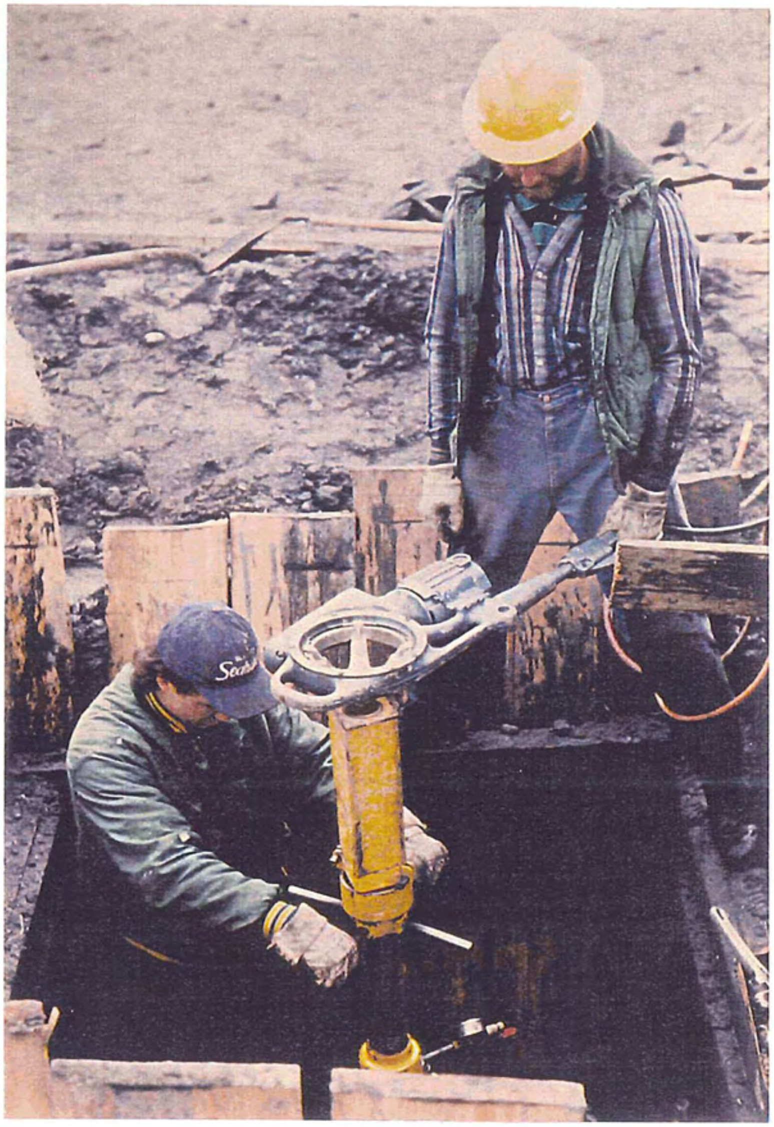
Shoring of Excavation No. 2 on the North Beach Force Main on April 20, 1989.

PICTURE NO. 14

Installation of tapping sleeve and gate valve assembly on the North Beach Force Main at Excavation No. 2 on April 20, 1989.

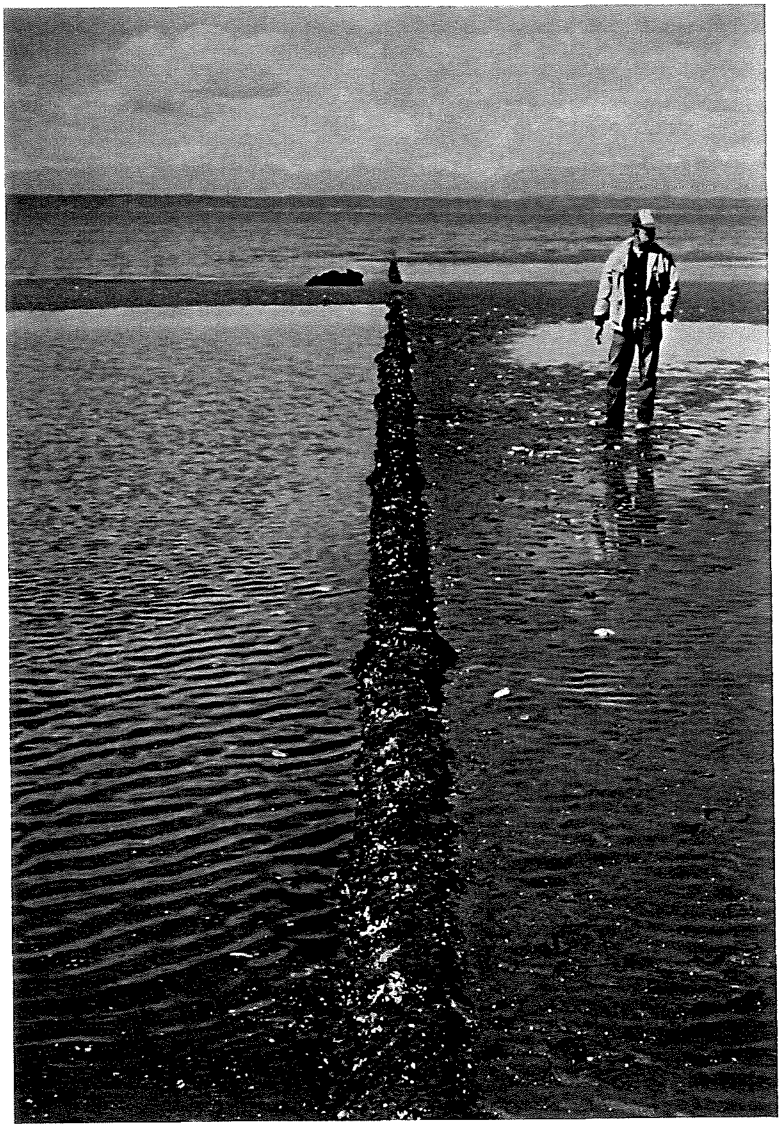
PICTURE NO. 15

Installation of tapping machine on the North Beach Force Main at Excavation No. 2 on April 20, 1989; in preparation for removal of pipe coupon.



PICTURE NO. 16

Tapping machine operation at Excavation No. 2 on the North Beach Force Main on April 20 1989; for the removal of a 3-inch diameter coupon from the pipe.

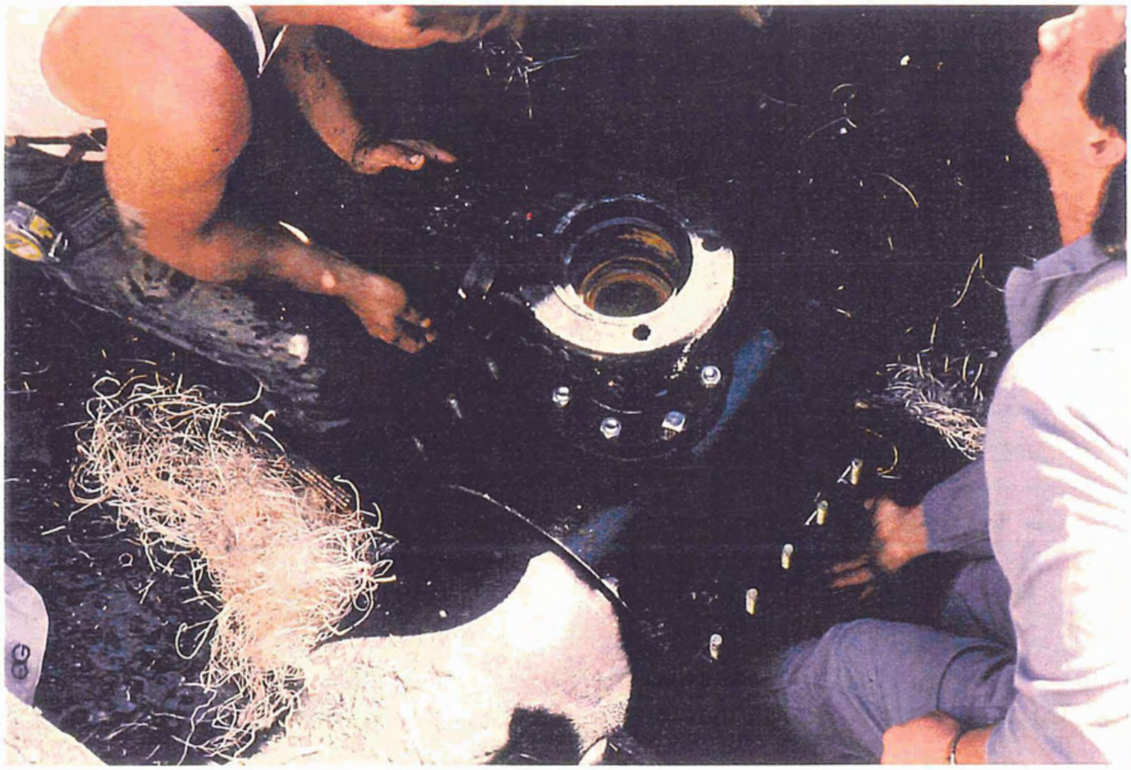


PICTURE NO. 17

Abandoned Blue Ridge Outfall Line located about 366 feet south of Excavation No. 3 on the North Beach Force Main. view is to the west, out into Puget Sound, during the low tide period on April 21, 1989.

PICTURE NO. 18

Abandoned Blue Ridge Outfall Line shown in previous picture, located about 366 feet south of Excavation No. 3 made of the North Beach Force Main on April 21, 1989. View is to the east, from the Sound, towards the Burlington Northern Railroad tracks.



PICTURE NO. 19

Installation of tapping sleeve on North Beach Force Main at Excavation No. 3 on April 21, 1989; in preparation for installation of tapping machine and removal of pipe coupon.

PICTURE NO. 21

Excavation No. 3 on the North Beach Force Main at 3:ØØ PM on April 21, 1989, immediately following the completion of the pipe tapping operation and the hurried removal of the equipment and materials by boat.

PICTURE NO. 20

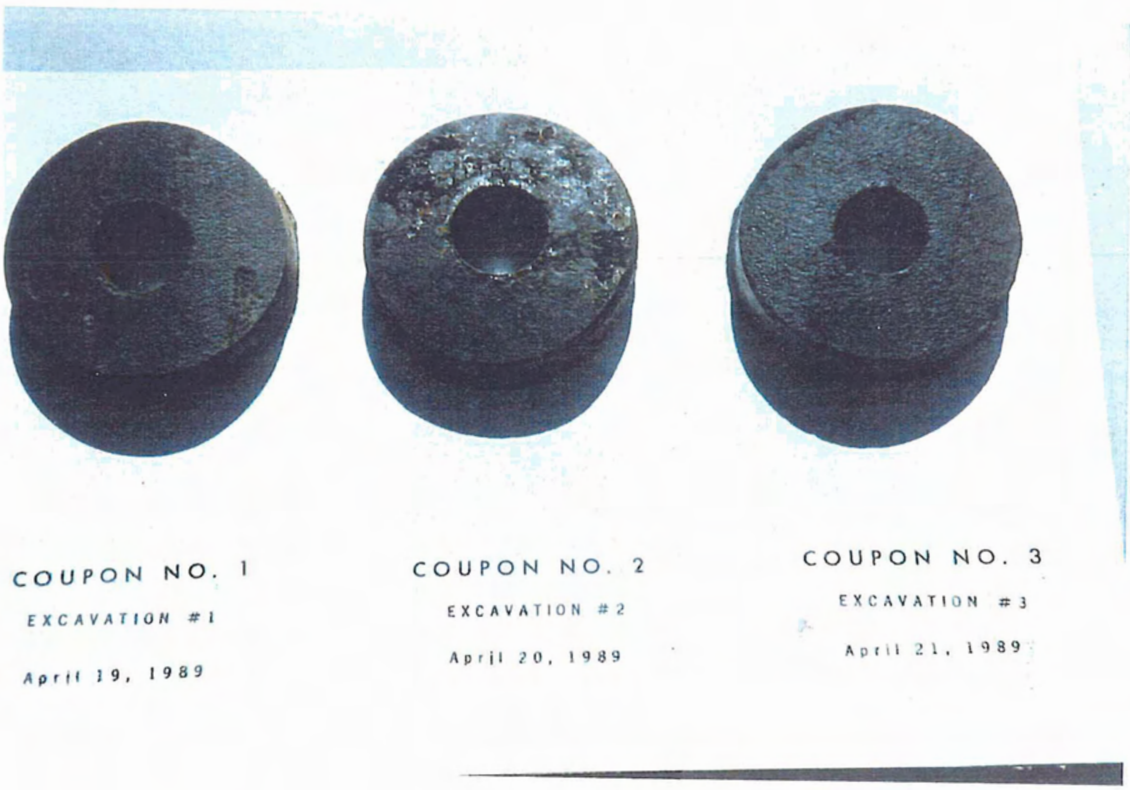
Removing equipment and materials from Excavation No. 3 site following the completion of the pipe tapping operation at 2:50 PM on April 21, 1989, with tide coming in.

PICTURE NO. 22

Removal of shoring materials from Excavation No. 3 on the North Beach Force Main, during low tide period on Saturday, April 22, 1989.

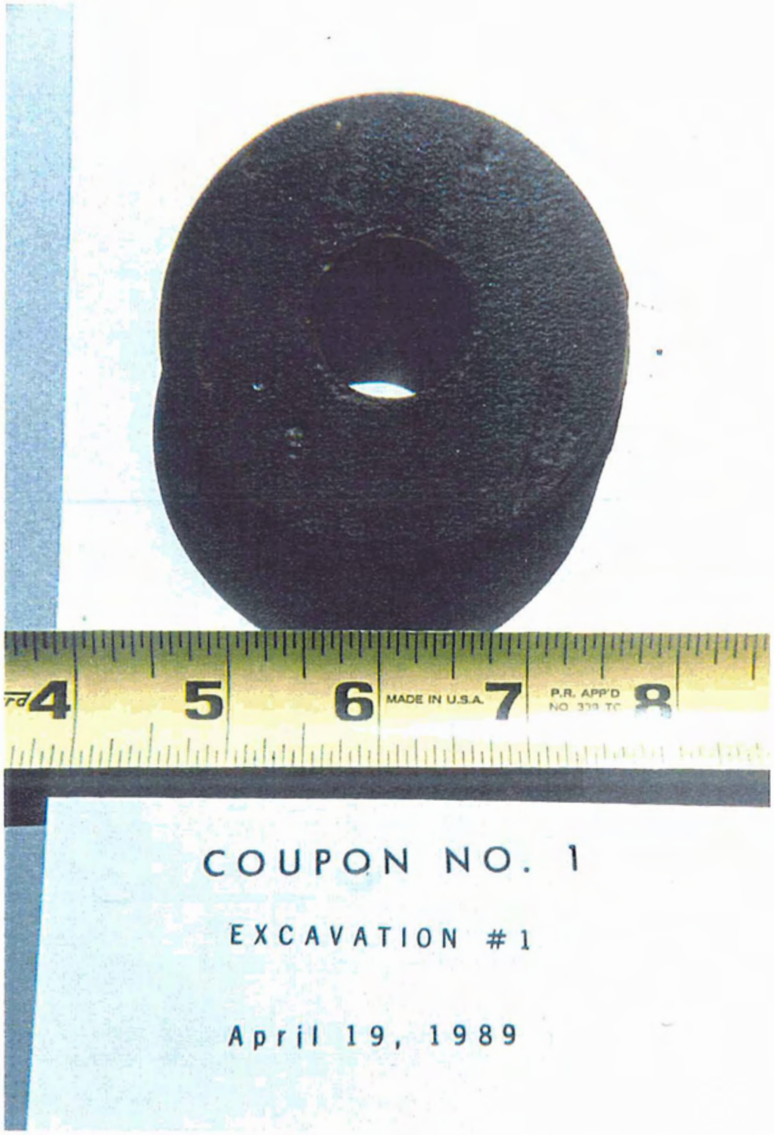
PICTURE NO. 23

Final backfilling of Excavation No. 3 on the North Beach Force Main, and clean-up of the site, on Saturday April 22, 1989.



PICTURE NO. 24

Exterior surfaces of 3-inch diameter coupons as removed from the North Beach Force Main, before cleaning. All three coupons had a thin film of graphitization on their surfaces.



PICTURE NO. 25

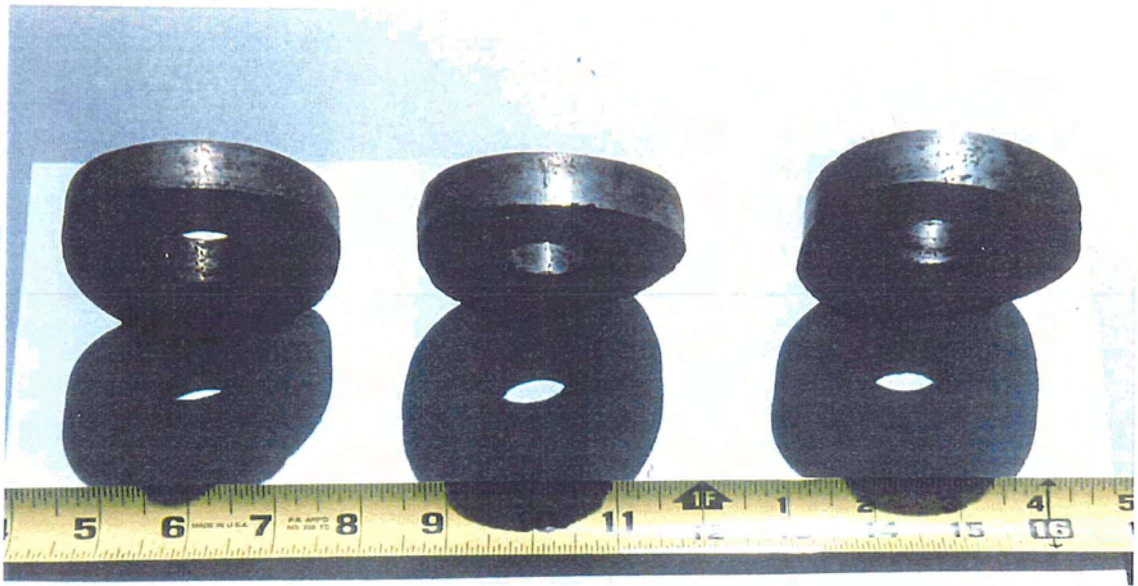
Close-up of exterior surface of Coupon No. 1 as removed from Excavation No. 1 on the North End Force Main, before cleaning.

PICTURE NO. 26

Close up of exterior surface of Coupon No. 2 as removed from the North Beach Force Main at Excavation No. 2, before cleaning. Some pitting activity is evident.

PICTURE NO. 27

Close-up of exterior surface of Coupon No. 3 removed from the North Beach Force Main at Excavation No. 3, before cleaning.



COUPON NO. 1
EXCAVATION #1
April 19, 1989

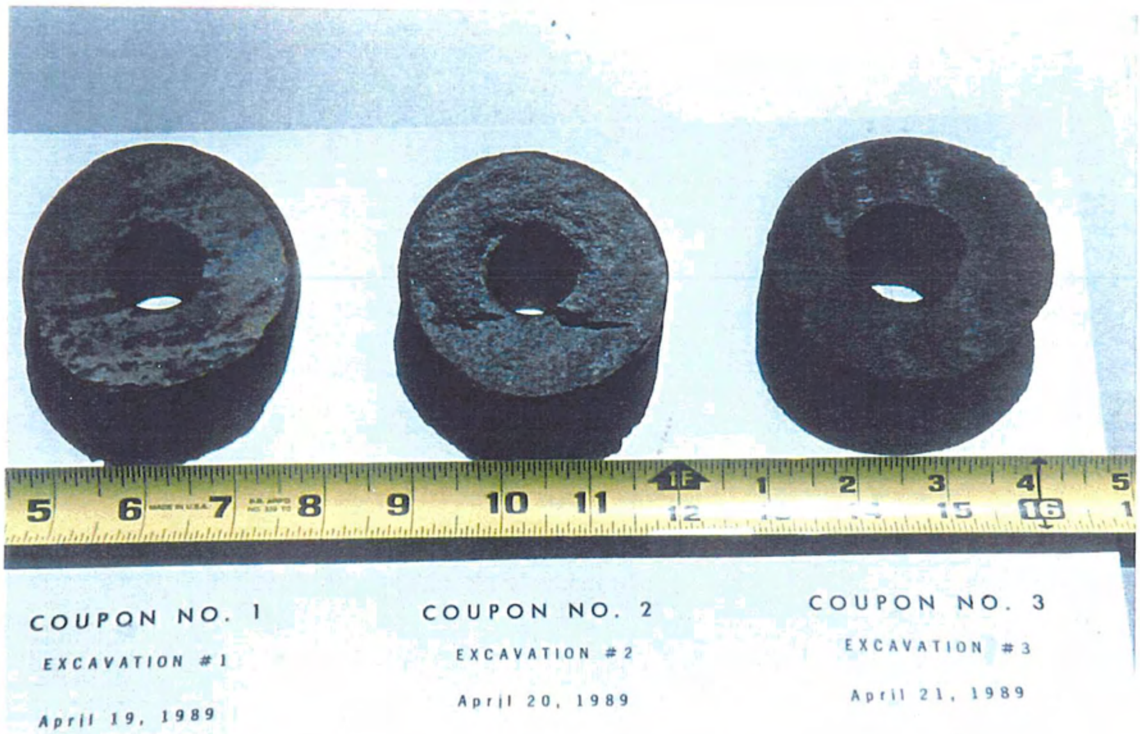
COUPON NO. 2
EXCAVATION #2
April 20, 1989

COUPON NO. 3
EXCAVATION #3
April 21, 1989

PICTURE NO. 28

Coupons removed from the North Beach Force Main showing the pipe wall thickness. The average thicknesses were measured as follows:

Coupon No. 1 = 623 mils (0.623")
Coupon No. 2 = 648 mils (0.648")
Coupon NO. 3 = 701 mils (0.701")



PICTURE NO. 29

Interior surfaces of coupons removed from the North Beach Force Main, before cleaning.

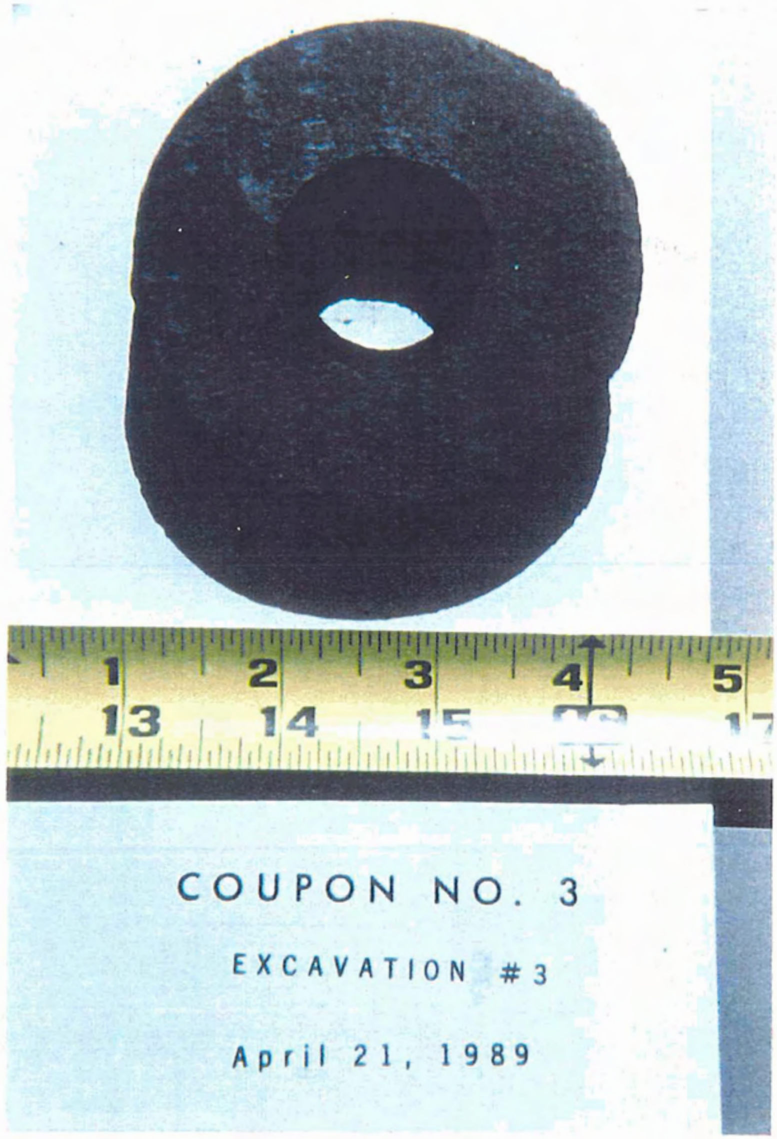
Note mortar coating remaining on coupons from Excavations Nos. 1 and 2.

PICTURE NO. 30

Close-up of interior surface of Coupon No. 1 removed from the North Beach Force Main at Excavation No. 1, before cleaning. Note thin coating of cement mortar lining.

PICTURE NO. 31

Close-up of interior surface of Coupon No. 2 removed from the North Beach Force Main at Excavation No. 2, before cleaning. Note cement mortar lining which measured up to 1/8-inch thick.

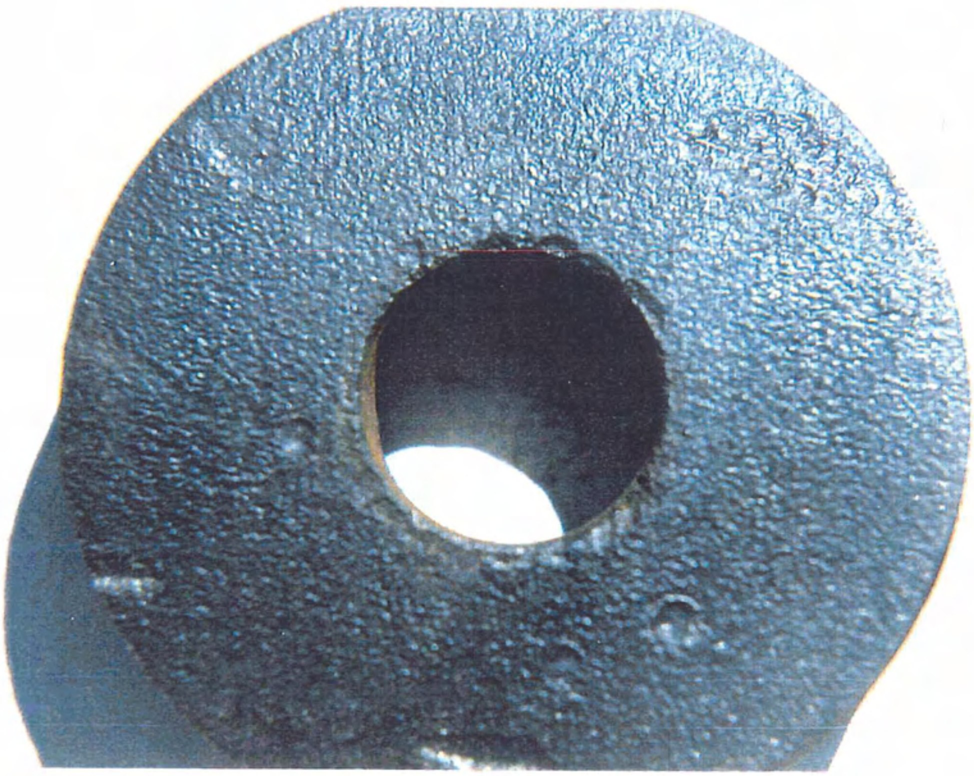


PICTURE NO. 32

Close-up of interior surface of Coupon No. 3 removed from the North Beach Force Main at Excavation No. 3, before cleaning. Only a very thin film of cement mortar lining was noted on small area on this coupon. It is believed that the lining came off during the cutting of the coupon out of the pipe.

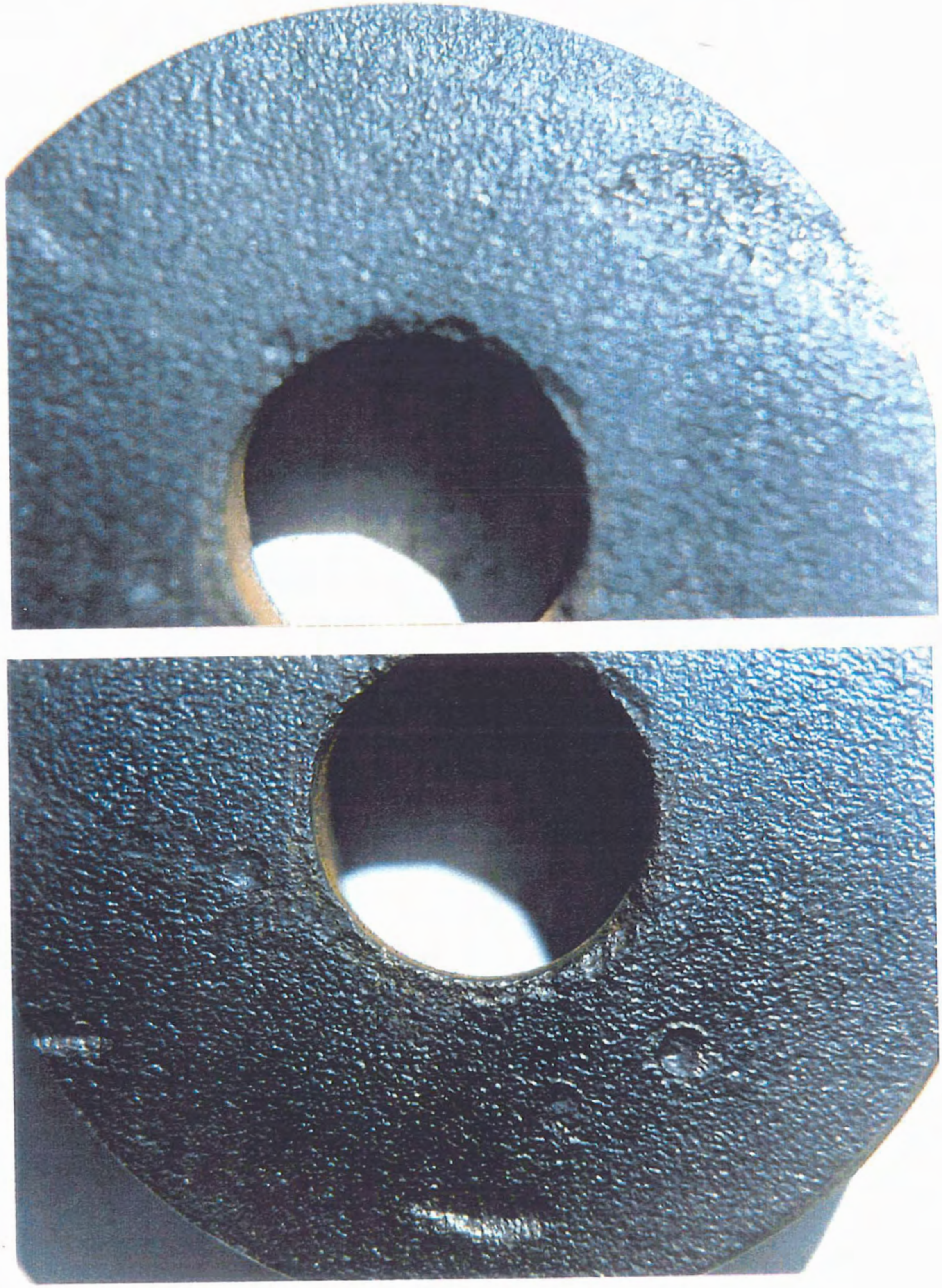
PICTURE NO. 33

Exterior surfaces of coupons removed from the North Beach Force Main, after lightly cleaning with a power driven fine bristled wire brush to remove dirt and thin film of graphitization.



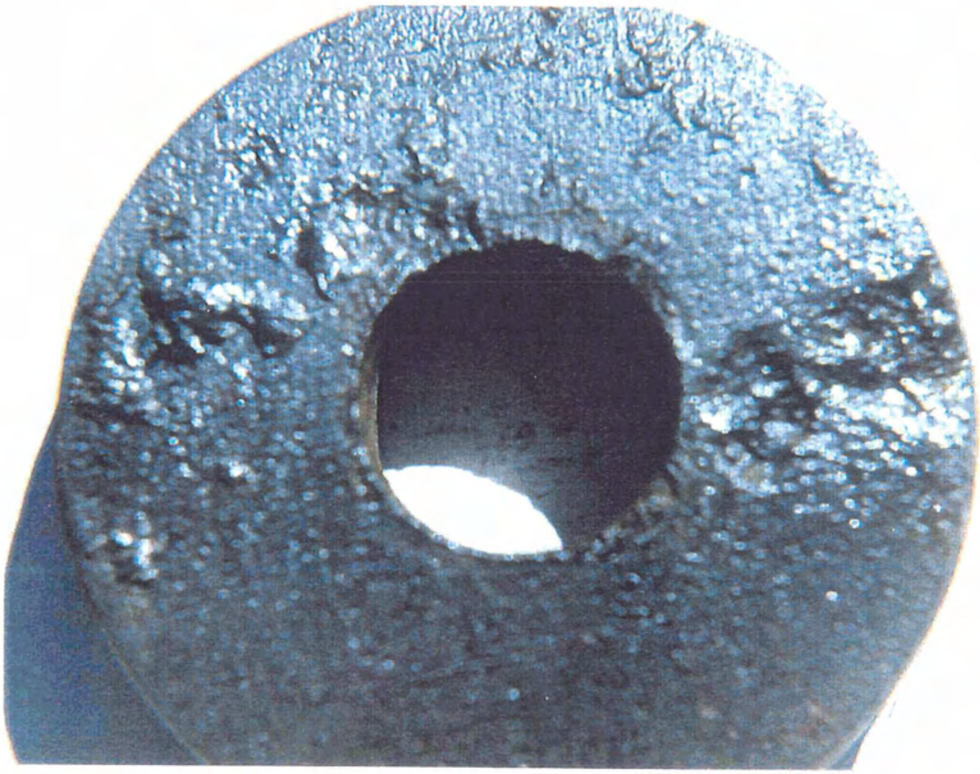
PICTURE NO. 34

Close-up of exterior surface of Coupon No. 1 removed from the North Beach Force Main at Excavation No. 1, after cleaning lightly with a power wire brush. Some very superficial pitting was noticeable on the surface of this coupon.



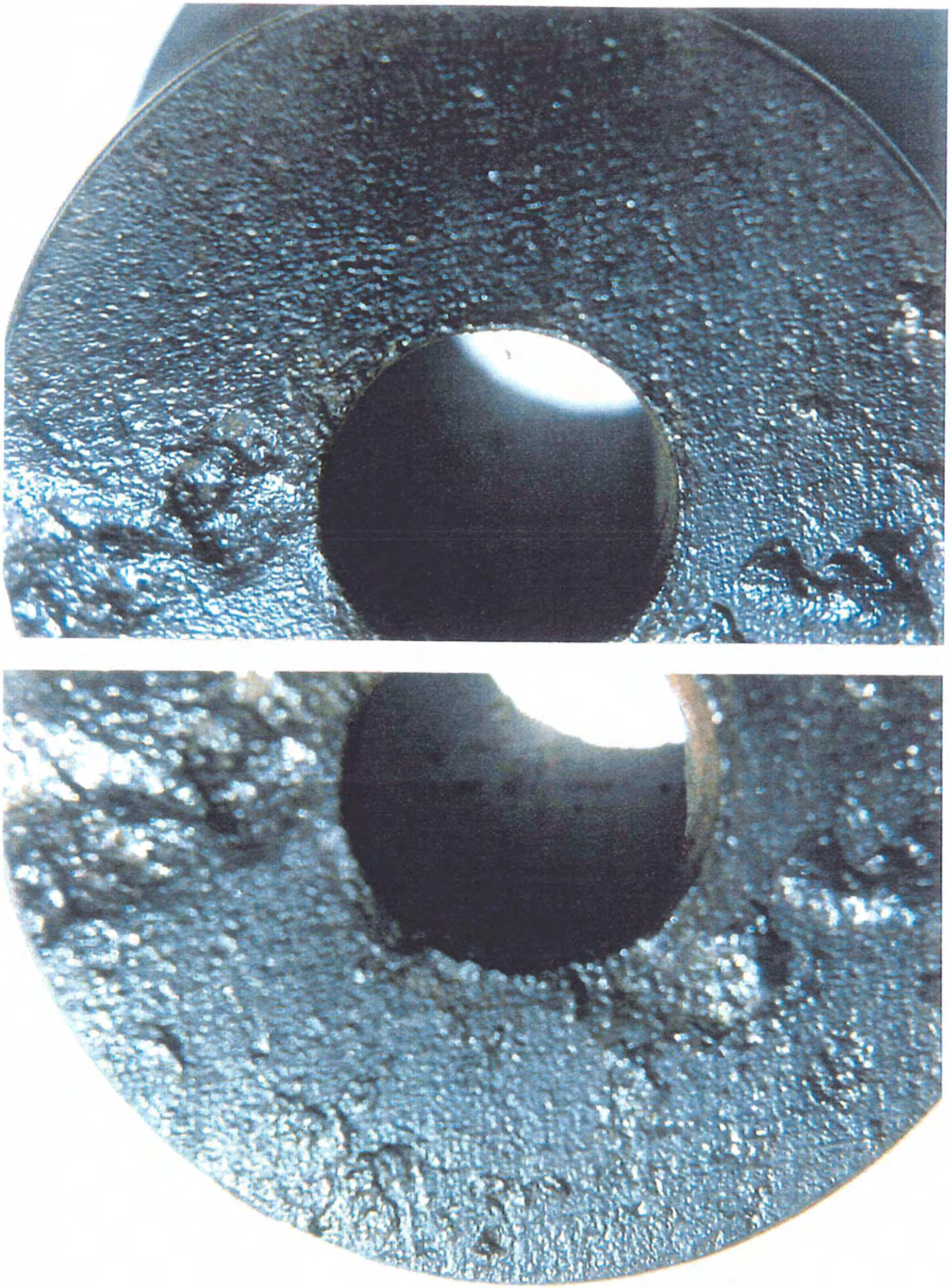
PICTURES NOS. 35 and 36

Enlargements of the exterior surface of Coupon No. 1 removed from the North Beach Force Main at Excavation No. 1, after cleaning. Note the superficial pitting at a few locations on the surface.



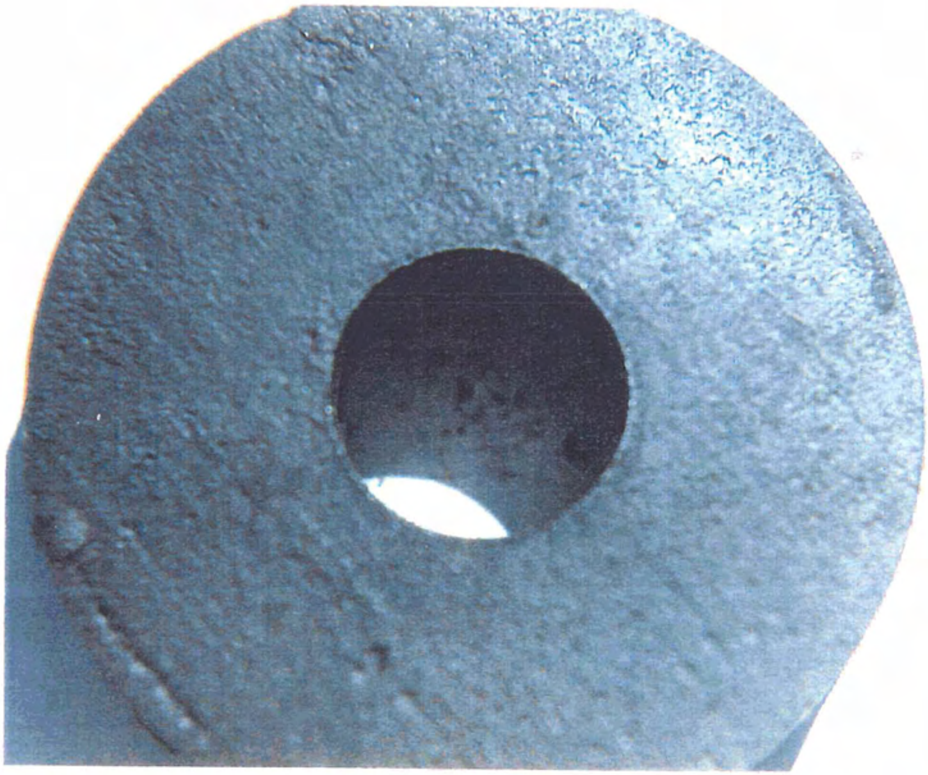
PICTURE NO. 37

Close-up of the exterior surface of Coupon No. 2 removed from the North Beach Force Main at Excavation No. 2, after cleaning lightly with power driven wire brush. Note the extensive pitting, which was investigated further as shown shown in Pictures Nos. 56, 57, and 58.



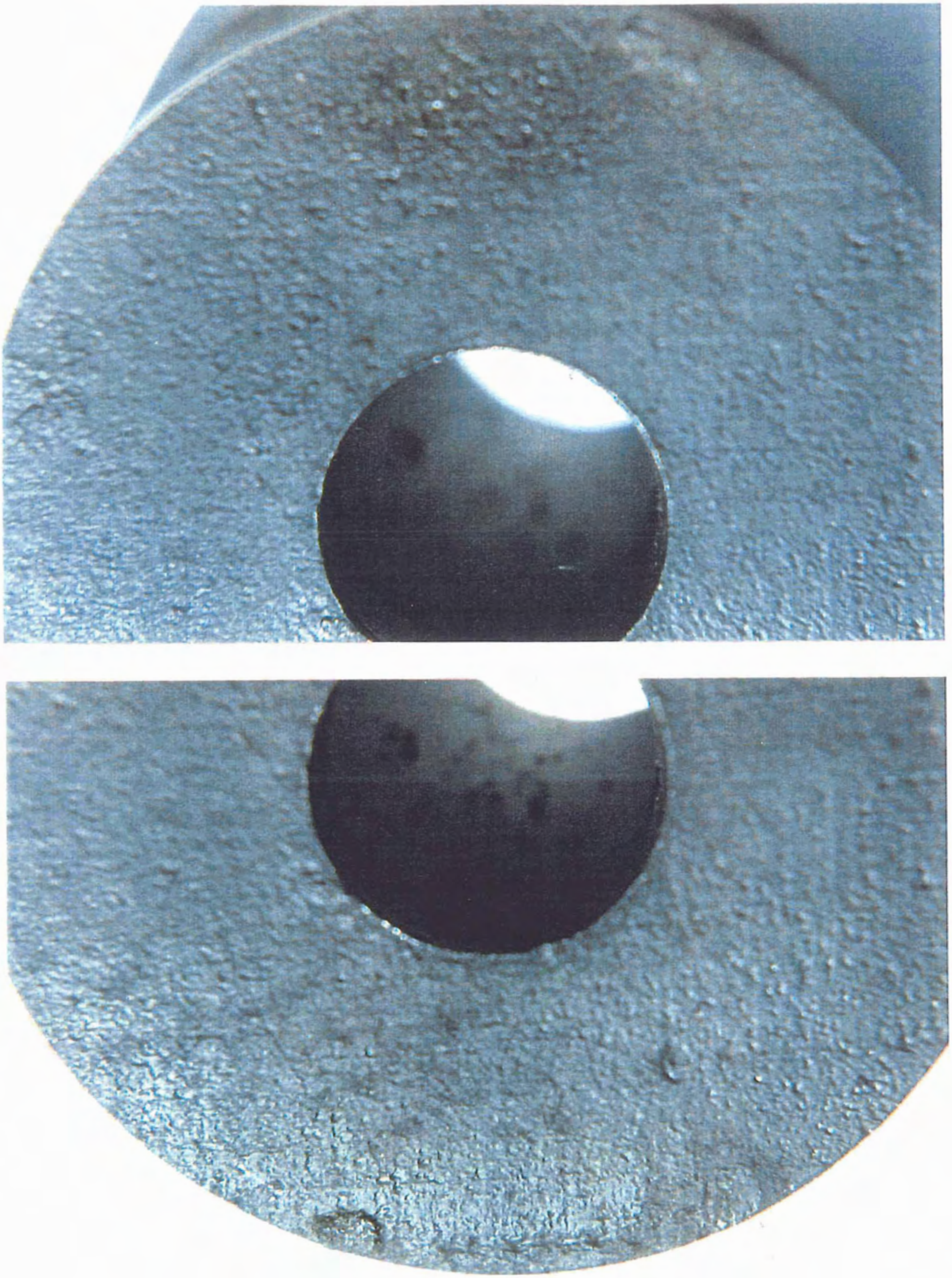
PICTURES NOS. 38 and 39

Enlargements of exterior surface of Coupon No. 2 removed from the North Beach Force Main at Excavation No. 2, after cleaning. Note the extensive pitting on surface, with graphitization build-up directly over pits.



PICTURE NO. 4Ø

Close-up of the exterior surface of Coupon No. 3 removed from the North Beach Force Main at Excavation No. 3, after cleaning lightly with a power driven wire brush. The surface of this coupon was found to be quite smooth, with only a few small minor superficial pits.



PICTURES NOS. 41 and 42

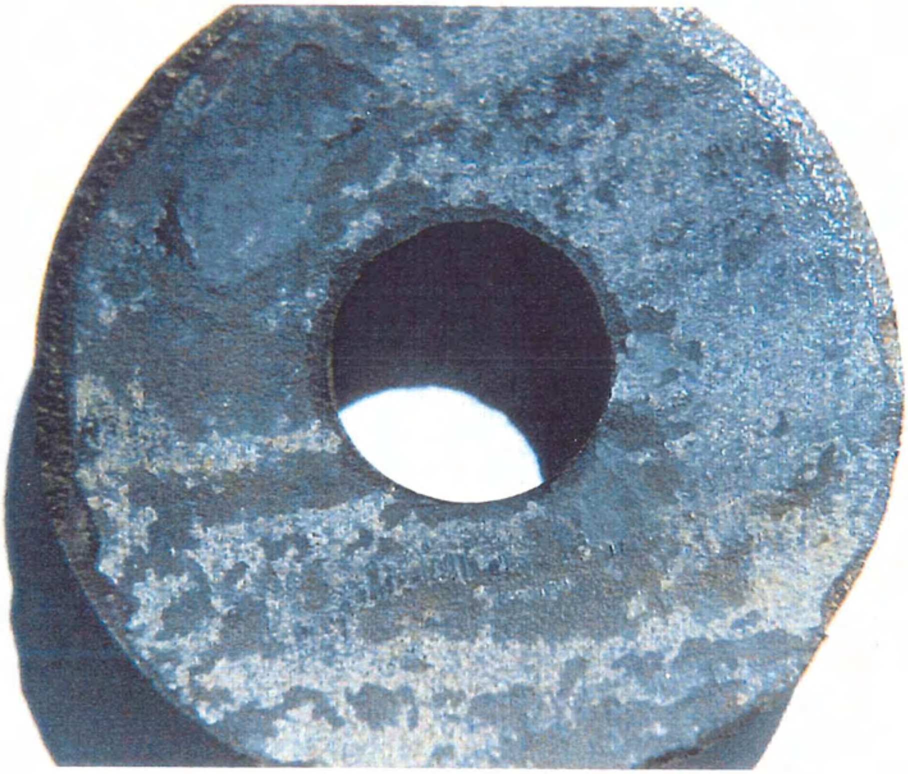
Enlargements of the exterior surface of Coupon No. 3 removed from the North Beach Force Main at Excavation No. 3, after cleaning. Note the relative smoothness of the surface of this coupon, with only a few minor superficial pits.

PICTURE NO. 43

Interior surfaces of the coupons removed from the North Beach Force Main, after lightly cleaning with a power driven wire brush to remove scale and debris.

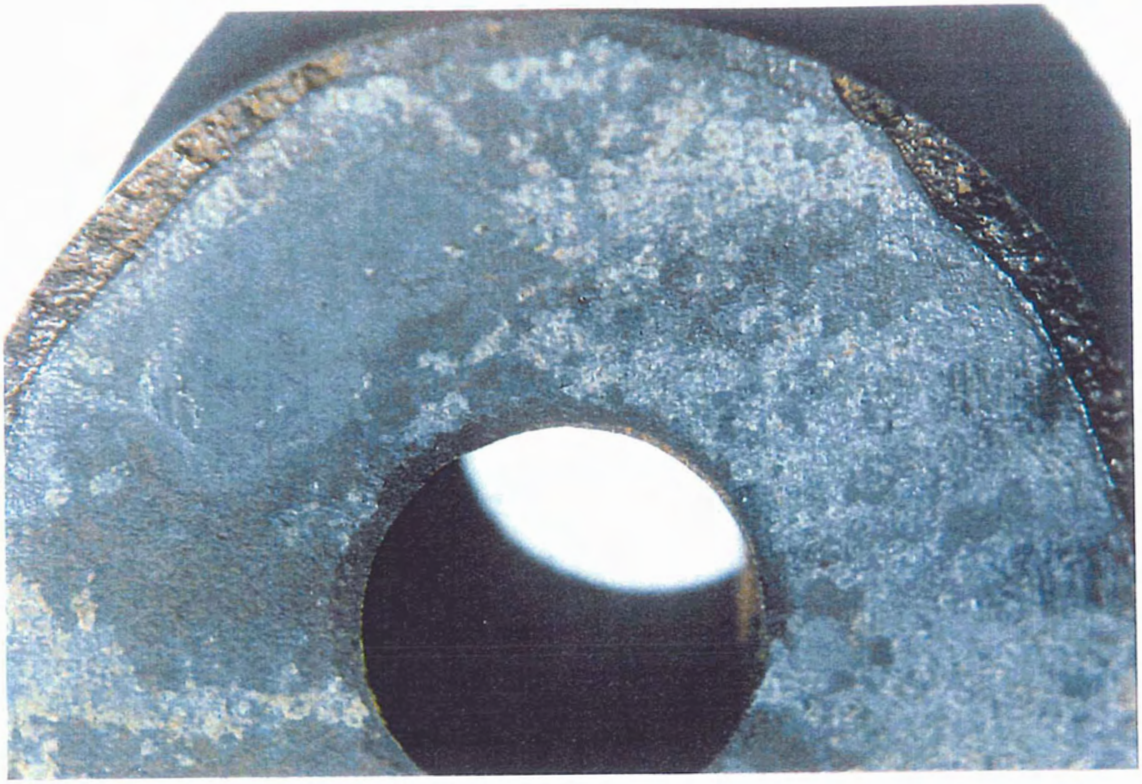
PICTURE NO. 44

Close-up of the interior surface of Coupon No. 1 removed from the North Beach Force Main at Excavation No. 1, after cleaning lightly with a power driven wire brush to remove scale and debris. Note the thin layer of cement mortar lining on the interior surface.



PICTURE NO. 45

Close-up of the interior surface of Coupon No. 1 removed from the North Beach Force Main at Excavation No. 1, after lightly cleaning. Note the thin layer of cement mortar lining still intact on the interior surface.

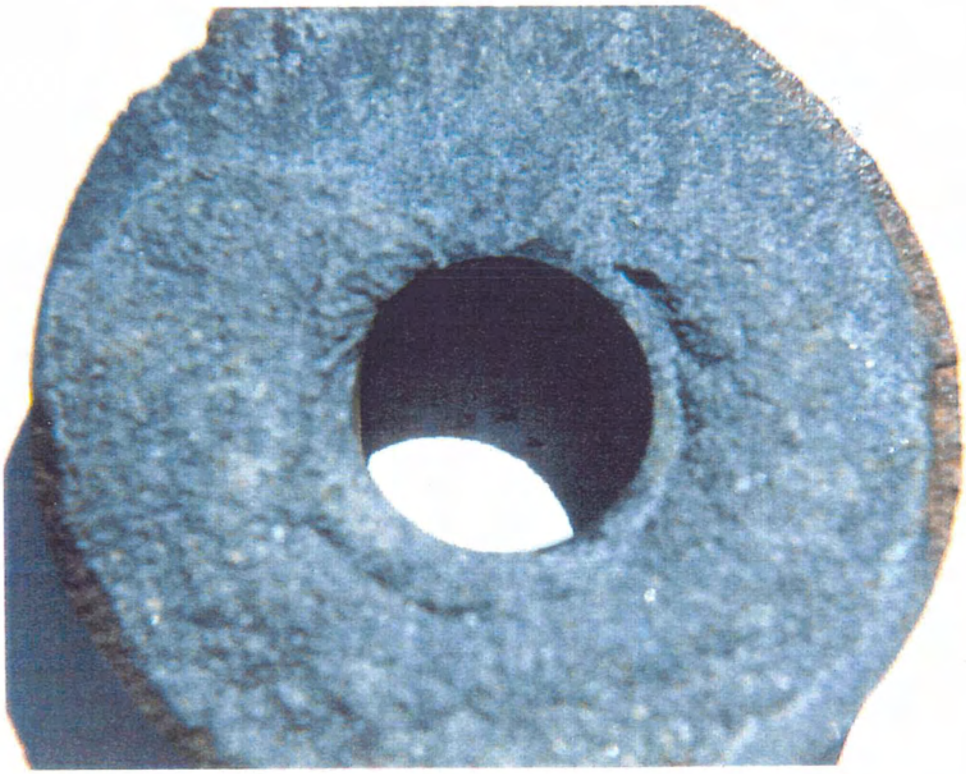


PICTURES NOS. 46 and 47

Enlargements of the interior surface of Coupon No. 1 removed from the North Beach Force Main at Excavation No. 1, after lightly cleaning. The thin layer of cement mortar lining is quite evident.

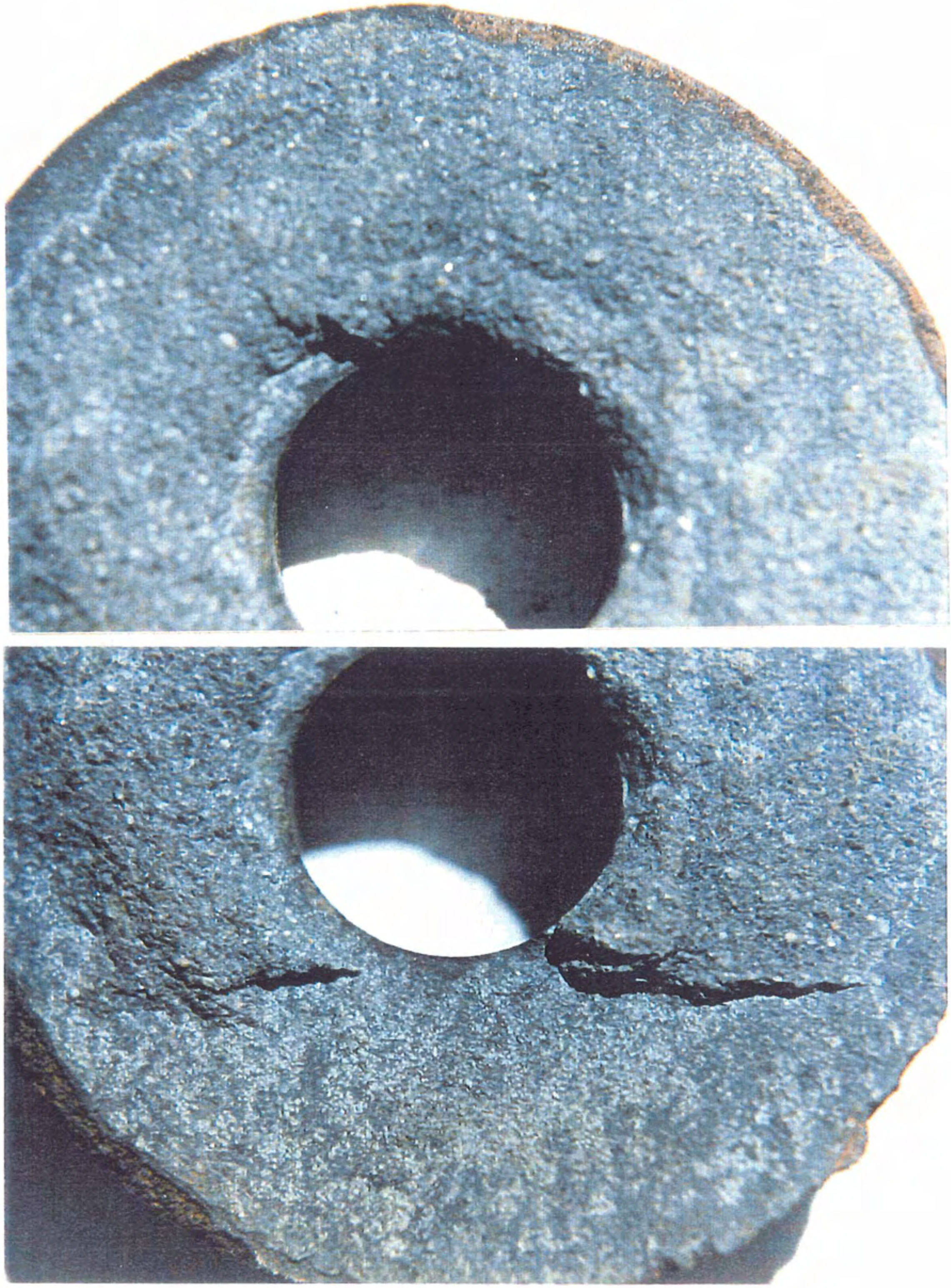
PICTURE NO. 48

Close-up of the interior surface of Coupon No. 2 removed from the North Beach Force Main at Excavation No. 2, after cleaning lightly with a power driven wire brush to remove scale and debris. A heavy layer of cement mortar lining remained intact on the interior of this coupon.



PICTURE NO. 49

Close-up of the interior surface of Coupon No. 2 removed from the North Beach Force Main at Excavation No. 2, after lightly cleaning. Note heavy layer of cement mortar lining still intact on the interior surface of this coupon.

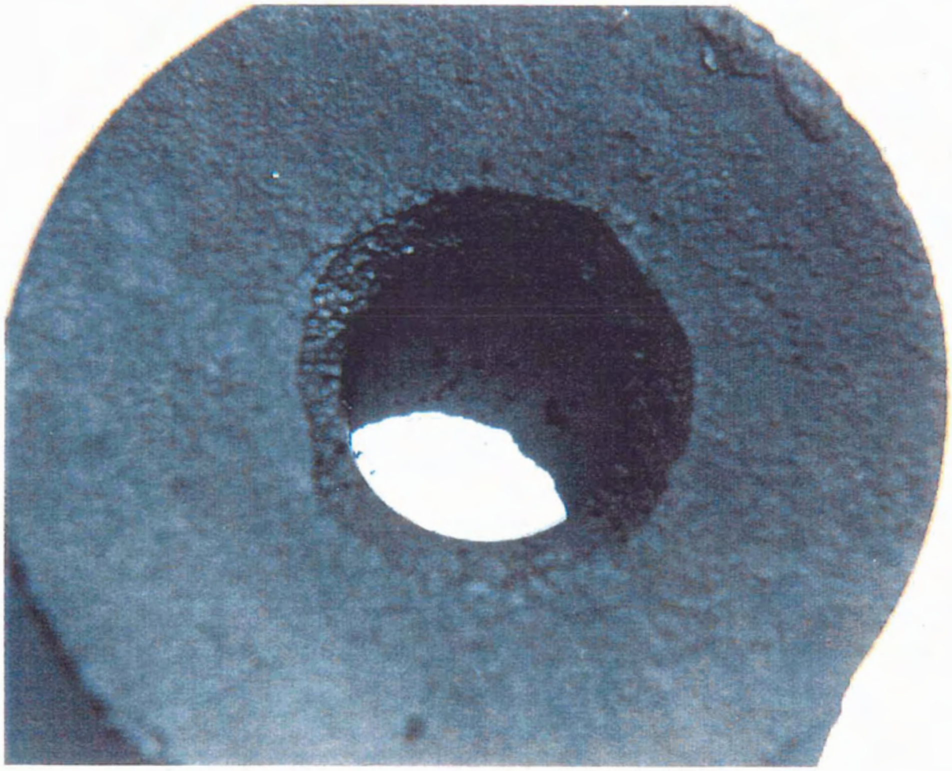


PICTURES NOS. 50 and 51

Enlargements of the interior surface of Coupon No. 2 removed from the North Beach Force Main at Excavation No. 2, after lightly cleaning. The cement mortar lining on the interior surface of this coupon was measured at a thickness of 1/8-inch.

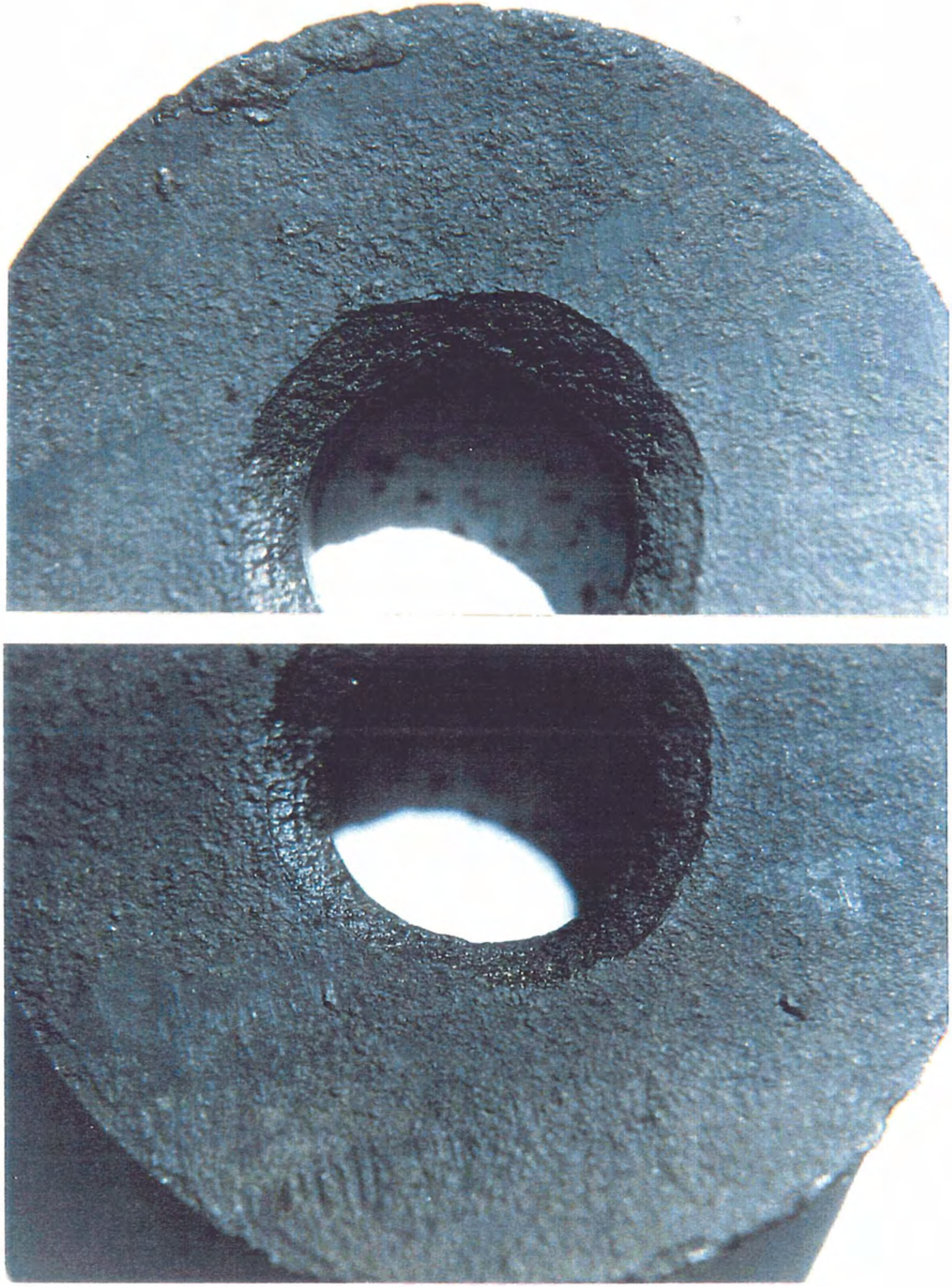
PICTURE NO. 52

Close-up of the interior surface of Coupon No. 3 removed from the North Beach Force Main at Excavation No. 3, after cleaning lightly with a power driven wire brush to remove scale and debris.



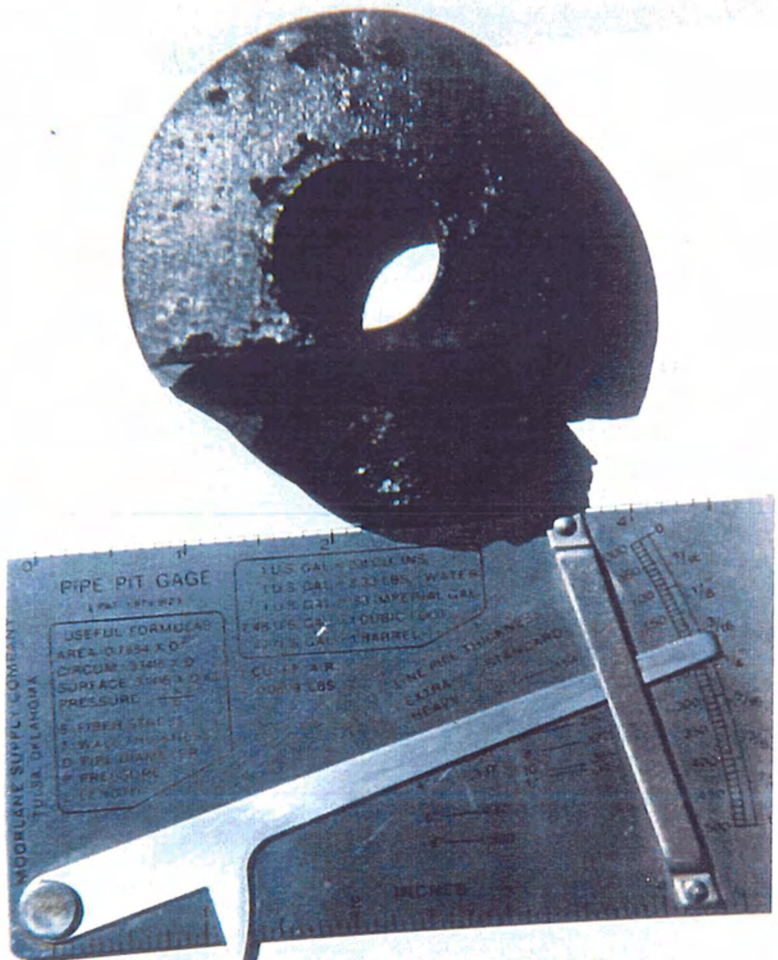
PICTURE NO. 53

Close-up of the interior surface of Coupon No. 3 removed from the North Beach Force Main at Excavation No. 3, after lightly cleaning. The interior surface of this coupon was found to be quite smooth, with only a slight trace of cement mortar lining noted. It is believed that the lining was broken loose from the interior surface of this coupon during the cutting operation.



PICTURES NOS. 54 and 55

Enlargements of the interior surface of Coupon No. 3 removed from the North Beach Force Main at Excavation NO. 3, after lightly cleaning.

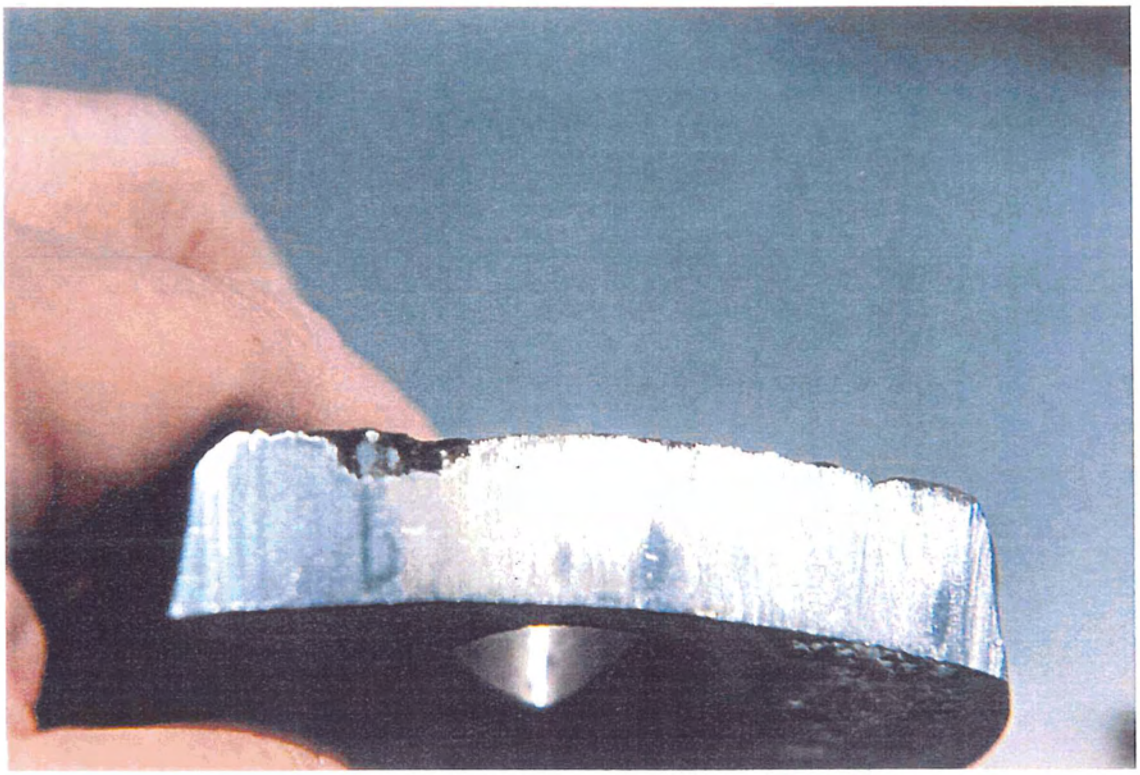


COUPON NO. 2

EXCAVATION #2

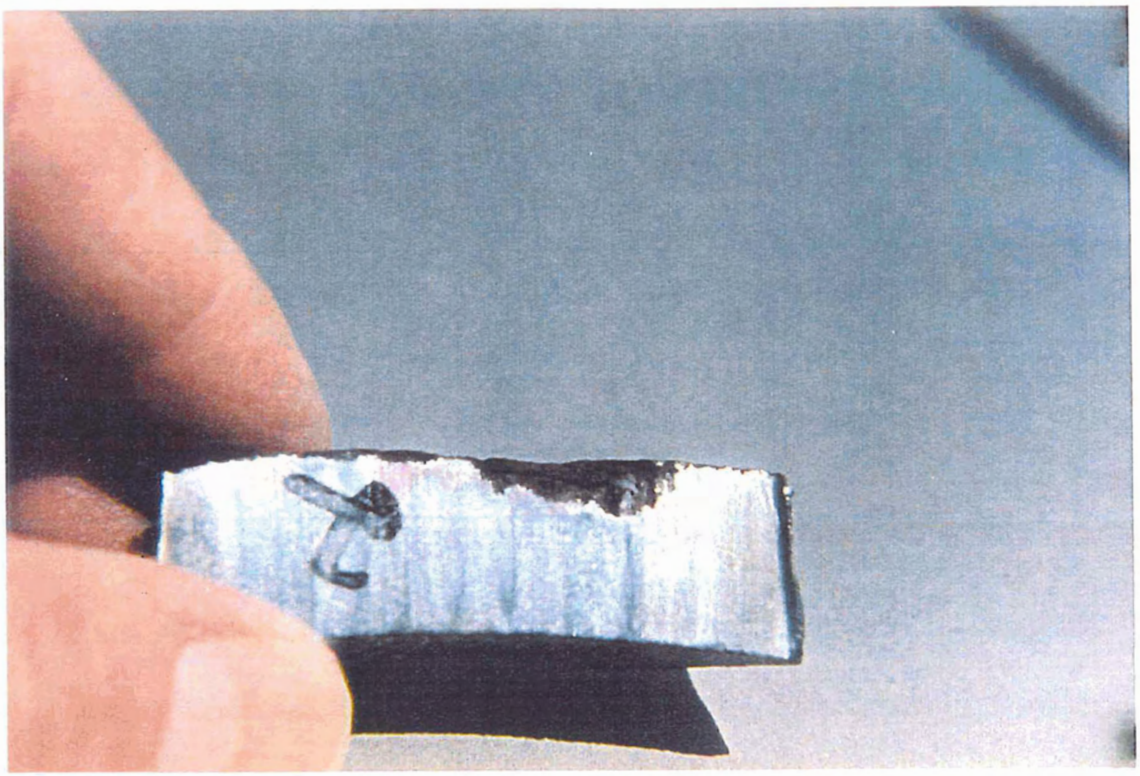
PICTURE NO. 56

Coupon No. 2 as sectioned by SCAN TECH, INC. for wall thickness measurements and metallurigical testing. Sectioning was done across a deep pit in the exterior surface of the coupon -- see the following pictures Nos. 57 and 58.



PICTURE NO. 57

Large section of Coupon No. 2 showing cut across deep pit. The pit depth was measured at Ø.22", with the thickness of the pipe wall remaining beneath the pit measured at Ø.44". The pit area was filled with tightly adhering graphitization.



PICTURE NO. 58

Small section of Coupon No. 2 showing cut across deep pit. The pit depth was measured at Ø.22", with the thickness of the pipe wall remaining beneath the pit measured at Ø.44". The pit area was filled with tightly adhering graphitization.

APPENDIX III

Testing and Analysis Reports

AMTEST

AmTest Inc.

Professional
Analytical
Services

14603 N.E. 87th St.
Redmond, WA
98052

Fax: 206 883 3495

Tel: 206 885 1664

ANALYSIS REPORT

CLIENT: Specialty Consultants Group Inc.

DATE RECEIVED: 4/28/89

DATE REPORTED: 5/11/89

REPORT TO: Hank Galka
P.O. Box 3428
Redmond, WA 98073

Laboratory Sample Number	905770
Client Identification	Cast Iron Pipe
Total Carbon (%)	0.76
Total Organic Carbon (%)	0.27

Continued . . .

received
5/16/89

FIGURE III-1

AMTEST

CLIENT: Specialty Consultants Group Inc.

REPORT TO: Hank Galka

DATE RECEIVED: 4/28/89

DATE REPORTED: 5/11/89

PLASMA SPECTROGRAPHIC ANALYSIS CERTIFICATE

Laboratory Sample Number		905770	Detection Limit
Client Identification		Cast Iron Pipe	
Silver	Ag	<1.79	0.010
Aluminum	Al	3,600.	0.01
Arsenic	As	<5.4	0.03
Boron	B	160.	0.010
Barium	Ba	14.	0.003
Beryllium	Be	<1.25	0.007
Calcium	Ca	4,100.	0.01
Cadmium	Cd	<0.36	0.002
Cobalt	Co	<0.54	0.003
Chromium	Cr	<1.07	0.006
Copper	Cu	34.	0.002
Iron	Fe	140,000.	0.01
Mercury	Hg	<1.79	0.010
Potassium	K	<180.	1.0
Lithium	Li	3.57	0.02
Magnesium	Mg	4,300.	0.01
Manganese	Mn	160.	0.002
Molybdenum	Mo	<1.79	0.01
Sodium	Na	1,800.	0.02
Nickel	Ni	27.	0.01
Phosphorus	P	590.	0.05
Lead	Pb	<3.58	0.02
Sulfur	S	18,000.	0.1
Antimony	Sb	<1.79	0.02
Selenium	Se	<0.16	0.03
Silicon	Si	860.	0.04
Tin	Sn	<3.57	0.02
Strontium	Sr	6,400.	0.003
Titanium	Ti	260.	0.01
Thallium	Tl	<5.52	0.03
Vanadium	V	0.37	0.002
Yittrium	Y	<0.018	0.001
Zinc	Zn	77.	0.002

All results in parts per million.
L = Less than

REPORTED BY: ______________________
Marc Osso

MO/ja

received
5/16/89

FIGURE III-2

INTE-% :
LABEL = SCG001
10-MAY-89 13:28:38
90.962 LIVE SECONDS

ELEM	CPS	WT % REL.CONC.
C K	3.881	1.000
SI K	24.780	1.679
P K	12.236	1.139
CR K	10.653	0.743
MN K	17.524	1.561
FE K	2062.931	292.550

USED PEIF: USER

INTE-%-ZAF:
LABEL = SCG001
10-MAY-89 13:29:12
90.962 LIVE SECONDS
KV= 20.0 TILT=30. TKOFF=22.
ZAF CORRECTION

ELEM	K	Z	A	F
C K	0.0031	1.174	0.060	1.000
SIK	0.0053	1.103	0.363	1.001
P K	0.0036	1.076	0.483	1.002
CRK	0.0023	0.985	0.988	1.280
MNK	0.0049	0.968	0.997	1.000
FEK	0.9173	0.987	1.001	1.000

ELEM	CPS	WT % ELEM
C K	3.8807	4.47
SI K	24.7796	1.31
P K	12.2359	0.69
CR K	10.6528	0.19
MN K	17.5238	0.51
FE K	2062.9312	92.84

TOTAL		100.00

FIGURE III-3

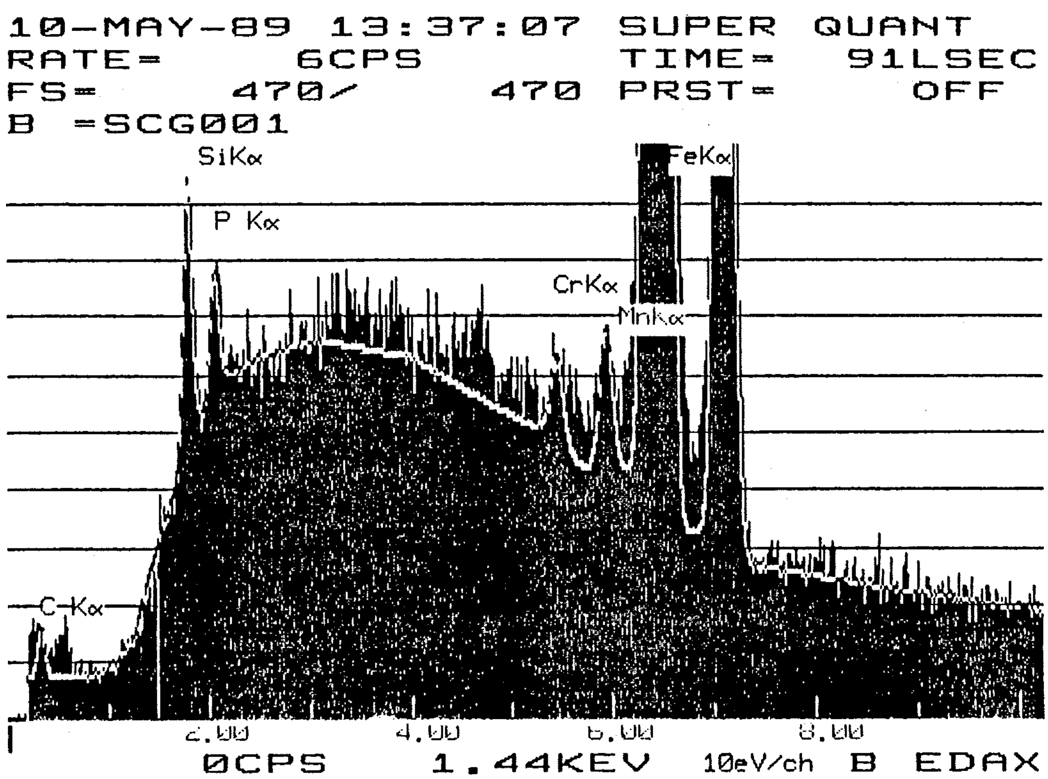

10-MAY-89 13:37:07 SUPER QUANT
RATE= 6CPS TIME= 91LSEC
FS= 470/ 470 PRST= OFF
B =SCG001
SiKα
P Kα
FeKα
CrKα
MnKα
C-Kα
2.00
4.00
6.00
8.00
0CPS 1.44KEV 10eV/ch B EDAX

FIGURE III-4

INTE-% :

LABEL = SCG002
10-MAY-89 14:43:35
96.893 LIVE SECONDS

ELEM	CPS	WT % REL.CONC.
C K	5.181	1.000
SI K	26.442	1.342
P K	9.031	0.630
CR K	8.834	0.461
MN K	16.142	1.077
FE K	1940.500	206.126

USED PEIF: USER

INTE-%-ZAF:
LABEL = SCG002
10-MAY-89 14:44:49
96.893 LIVE SECONDS
KV= 20.0 TILT=30. TKOFF=22.
ZAF CORRECTION

ELEM	K	Z	A	F
C K	0.0044	1.169	0.061	1.000
SIK	0.0059	1.099	0.368	1.001
P K	0.0027	1.072	0.487	1.002
CRK	0.0020	0.982	0.989	1.279
MNK	0.0047	0.965	0.998	1.000
FEK	0.8988	0.984	1.001	1.000

ELEM	CPS	WT % ELEM
C K	5.1810	6.13
SI K	26.4415	1.44
P K	9.0306	0.52
CR K	8.8345	0.16
MN K	16.1415	0.49
FE K	1940.4996	91.25

TOTAL		100.00

FIGURE III-5

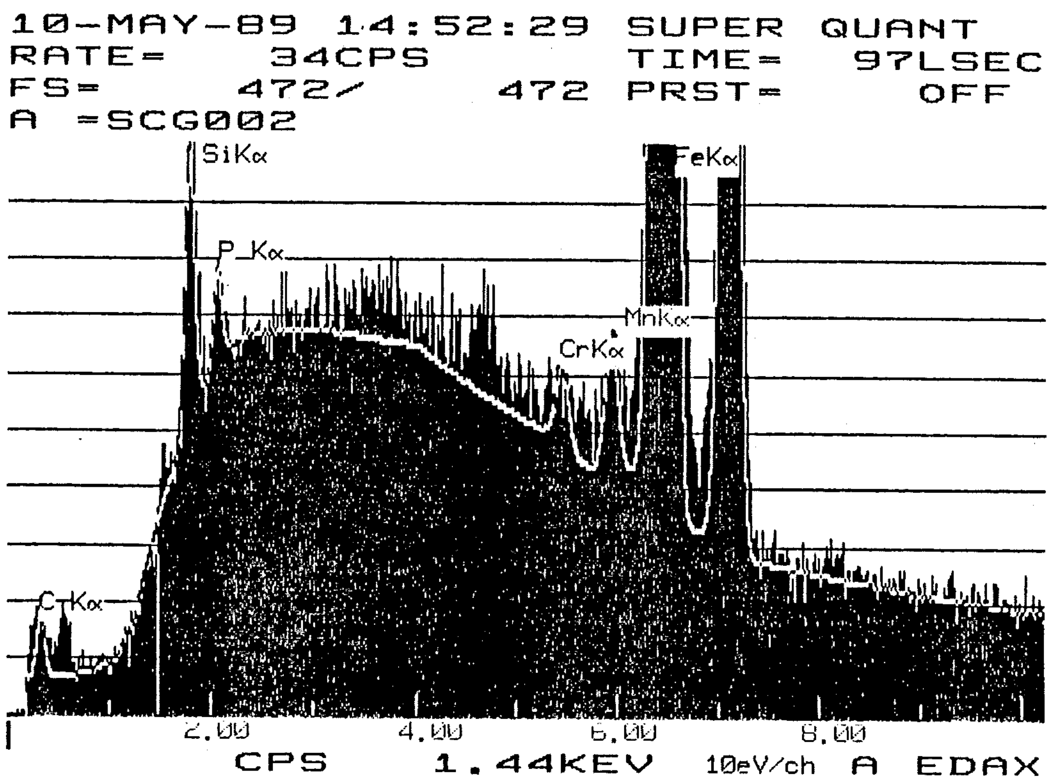

10-MAY-89 14:52:29 SUPER QUANT
RATE= 34CPS TIME= 97LSEC
FS= 472/ 472 PRST= OFF
A =SCG002
SiKα
P Kα
FeKα
MnKα
CrKα
C Kα
2.00
4.00
6.00
8.00
CPS 1.44KEV 10eV/ch A EDAX

FIGURE III-6

INTE-% :

LABEL = SCG003
10-MAY-89 16:14:45
93.935 LIVE SECONDS

ELEM	CPS	WT % REL.CONC.
C K	3.896	1.000
SI K	25.230	1.703
P K	9.507	0.881
CR K	6.930	0.481
MN K	14.425	1.280
FE K	1998.042	282.217

USED PEIF: USER

INTE-%-ZAF:
LABEL = SCG003
10-MAY-89 16:15:30
93.935 LIVE SECONDS
KV= 20.0 TILT=30. TKOFF=22.
ZAF CORRECTION

ELEM	K	Z	A	F
C K	0.0033	1.173	0.060	1.000
SIK	0.0055	1.103	0.364	1.001
P K	0.0029	1.076	0.483	1.002
CRK	0.0016	0.985	0.988	1.281
MNK	0.0042	0.968	0.997	1.000
FEK	0.9177	0.987	1.001	1.000

ELEM	CPS	WT % ELEM
C K	3.8963	4.63
SI K	25.2301	1.38
P K	9.5065	0.55
CR K	6.9303	0.13
MN K	14.4248	0.43
FE K	1998.0420	92.89

TOTAL		100.00

FIGURE III-7

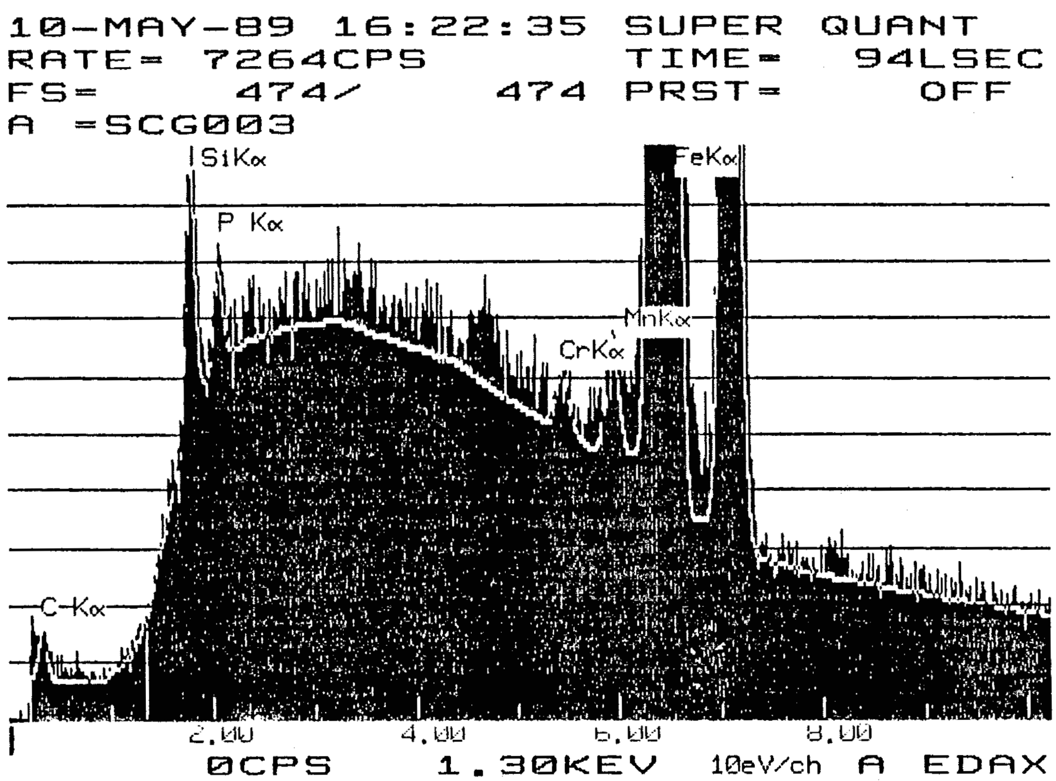

10-MAY-89 16:22:35 SUPER QUANT
RATE= 7264CPS TIME= 94LSEC
FS= 474/ 474 PRST= OFF
A =SCG003
SiKα
P Kα
FeKα
MnKα
CrKα
C-Kα
2.00
4.00
6.00
8.00
0CPS 1.30KEV 10eV/ch A EDAX

FIGURE III-8

Thickness measurements of cast iron water pipe.

Sample #1	Sample #2	Sample #3
.6264	.66	.7012
.6201	.64	.7022
.6242	.47	.7033
.6210	.465	.7003
.6270	.44	.7028
.6256	.65	.7050
.6210	.64	.7008
.6247		.7035
.6229		.6996
.6238		.7001
$\bar{x}$ = .6237	$\bar{x}$ = .566	$\bar{x}$ = .7019
σ .0024	σ = .10	σ = .0018

5/10/89

Ray G Baggerly

SCAN TECH, INC. • 13240 Northrup Way • Suite 26 • Bellevue, WA 98005 • (206) 641-8439

FIGURE III-9

AMTEST

AmTest Inc.

Professional
Analytical
Services

14603 N.E. 87th St.
Redmond, WA
98052

Fax: 206 883 3495

Tel: 206 885 1664

ANALYSIS REPORT

CLIENT: Specialty Consultants Group Inc.

DATE RECEIVED: 4/24/89

DATE REPORTED: 5/8/89

REPORT TO: Hank Galka
P.O. Box 3428
Redmond, WA 98073

Laboratory Sample Number	905505	905506	905507
Client Identification	Excavation #1 4/19/89	#2 4/20/89	#3 4/21/89
Sulfate (mg/l)	1,460.	1,530.	1,500.
Chloride (mg/l)	9,230.	8,750.	9,400.
Fecal Coliform (mg/l)	DNA	DNA	DNA

DNA - Did Not Analyze
Sample expiration time is 30 hours for bacteria analysis.

REPORTED BY: Kathy Fugiel

KF/ja

received 5/12/89

FIGURE III-10

APPENDIX IV

REFERENCE MATERIALS

THE MAJOR CONSTITUENTS OF SEA WATER
Chlorinity = 19‰

Anions	Parts per million	Milliequivalents per litre
Chloride	18980	535.3
Sulphate	2649	55.2
Bicarbonate	142	2.3
Bromide	65	0.8
Fluoride	1.4	0.07
Borate	24.9	0.58
		594.25
Cations		
Sodium	10561	459.4
Potassium	380	9.7
Magnesium	1272	104.4
Calcium	400	20.0
Strontium	13	0.3
		593.8

Notes:
1) The above composition shows slight difference between anions and cations, expressed as milliequivalents per litre because of the presence of traces of other components not listed in the above composition.
2) Chlorinity is the total amount of chlorine, bromine and iodine in grams contained in one kilogram of sea water assuming that the bromine and iodine have been expressed as chlorine.
3) Salinity is the total solid material in grams contained in one kilogram of sea water when all carbonate has been converted to oxide, the bromine and iodine replaced by chlorine, and all organic matter is completely oxidized. In the open sea the salinity varies between 32 and 36.

$$\text{salinity} = 1.807 \times \text{chlorinity}$$

CHEMICAL COMPOSITION OF SUBSTITUTE SEA WATER[a]

Compound	Concentration (g/L)
$NaCl$	24.53
$MgCl_2$	5.20
Na_2SO_4	4.09
$CaCl_2$	1.16
KCl	0.695
$NaHCO_3$	0.201
KBr	0.101
H_3BO_3	0.027
$SrCl_2$	0.025
NaF	0.003
$Ba(NO_3)_2$	0.0000994
$Mn(NO_3)_2$	0.000034
$Cu(NO_3)_2$	0.0000308
$Zn(NO_3)_2$	0.0000151
$Pb(NO_3)_2$	0.0000066
$AgNO_3$	0.00000049

[a] Chlorinity = 19.38. Adjust pH to 8.2 with 0.1 *N* NaOH.

Source: F. L. LaQue, *Marine Corrosion Causes and Prevention*, Wiley, p. 98.

FIGURE IV-1

TABLE 1—SOIL TEST EVALUATION

10 Points = Corrosive to cast pipe
(Protection is indicated)

		Points
Resistivity (ohm-cm³)*	<700	10
	700–1000	8
	1000–1200	5
	1200–1500	2
	1500–2000	1
	>2000	0
pH	0–2	5
	2–4	3
	4–6.5	0
	6.5–7.5	0**
	7.5–8.5	0
	>8.5	3
Redox	>100 mv	0
	50–100 mv	3.5
	0–50 mv	4
	Negative (—)	5
Sulfides	+	3.5
	Trace	2
	Negative	0
Moisture	Poor drainage, continuously wet	2
	Fair drainage, generally moist	1
	Good drainage, generally dry	0

* Based on single probe at pipe depth or water-saturated Miller soil box.
** If sulfides are present and low or negative redox results are obtained, 3 points should be given for this range.

Corrosion of cast iron pipe

BY

W. HARRY SMITH AND CURTIS M. CLARK

Reprinted from the June 1968 Issue of WATER AND WASTES ENGINEERING

FIGURE IV-2

TABLE 1-7—*Standard Thickness Classes of Cast-Iron Pipe*
(See note on facing page)

Pipe Size *in.*	Thickness for Standard Thickness Class Number—*in.*										
	20	21	22	23	24	25	26	27	28	29	30
3			0.32*	0.35	0.38	0.41	0.44	0.48	0.52	0.56	0.60
4			0.35*	0.38	0.41	0.44	0.48	0.52	0.56	0.60	0.65
6		0.35*	0.38	0.41	0.44	0.48	0.52	0.56	0.60	0.65	0.70
8	0.35*	0.38	0.41	0.44	0.48	0.52	0.56	0.60	0.65	0.70	0.76
10	0.38*	0.41	0.44	0.48	0.52	0.56	0.60	0.65	0.70	0.76	0.82
12	0.41*	0.44	0.48	0.52	0.56	0.60	0.65	0.70	0.76	0.82	0.89
14	0.43	0.48*	0.51	0.55	0.59	0.64	0.69	0.75	0.81	0.87	0.94
16	0.46	0.50*	0.54	0.58	0.63	0.68	0.73	0.79	0.85	0.92	0.99
18	0.50	0.54*	0.58	0.63	0.68	0.73	0.79	0.85	0.92	0.99	1.07
20	0.53	0.57*	0.62	0.67	0.72	0.78	0.84	0.91	0.98	1.06	1.14
24	0.58	0.63*	0.68	0.73	0.79	0.85	0.92	0.99	1.07	1.16	1.25
30	0.68*	0.73	0.79	0.85	0.92	0.99	1.07	1.16	1.25	1.35	1.46
36	0.75*	0.81	0.87	0.94	1.02	1.10	1.19	1.29	1.39	1.50	1.62
42	0.83*	0.90	0.97	1.05	1.13	1.22	1.32	1.43	1.54	1.66	1.79
48	0.91*	0.98	1.06	1.14	1.23	1.33	1.44	1.56	1.68	1.81	1.95

7
3

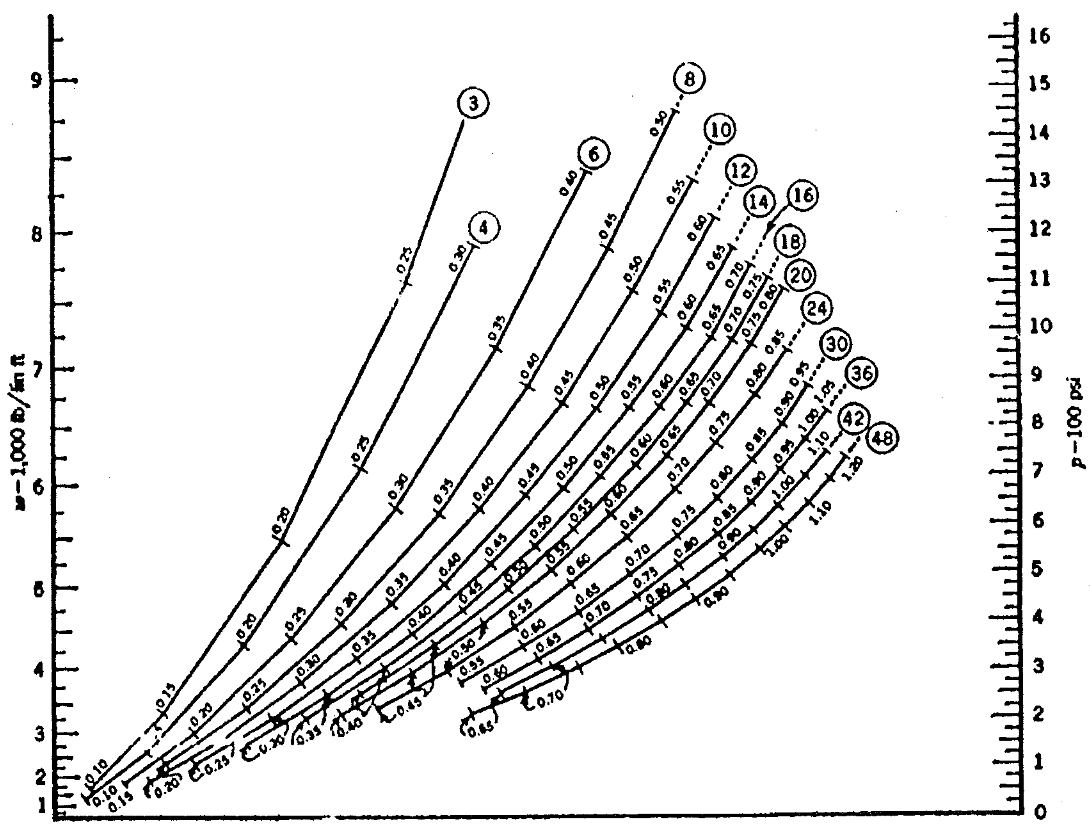


Fig. 1-1. Thickness Nomogram for Pipe of 18/40 Iron Strength, Low-Range Load

Thicknesses are net, and computations are made using nominal pipe diameter for inside diameter. S *equals 18,000,* R *equals 40,000. The encircled values at the end of each curve are for pipe size, in inches.*

FIGURE IV-3

TABLE 1-5

Internal Pressures (p)*

7
2

Pipe Size in.	Rated Working Pressure—psi							
	10	50	100	150	200	250	300	350
Case 1—Internal Pressure With Surge Pressure Allowances†								
3	—	425	550	675	800	925	1,050	1,175
4	—	425	550	675	800	925	1,050	1,175
6	—	425	550	675	800	925	1,050	1,175
8	—	425	550	675	800	925	1,050	1,175
10	—	425	550	675	800	925	1,050	1,175
12	—	400	525	650	775	900	1,025	1,150
14	—	400	525	650	775	900	1,025	1,150
16	—	375	500	625	750	875	1,000	1,125
18	—	375	500	625	750	875	1,000	1,125
20	—	350	475	600	725	850	975	1,100
24	—	338	463	588	713	838	963	1,088
30	—	325	450	575	700	825	950	1,075
36	—	313	438	563	688	813	938	1,063
42	—	300	425	550	675	800	925	1,050
48	—	300	425	550	675	800	925	1,050
54	—	300	425	550	675	800	925	1,050
60	—	300	425	550	675	800	925	1,050
Case 2—Internal Pressure Without Surge Pressure Allowances								
3–60 all	25	125	250	375	500	625	750	875

* Safety factor of 2.5 included.
† For surge pressure allowances, see Table 1-10.

TABLE 1-6

Allowances For Casting Tolerance

Pipe Size in.	Casting Tolerance in.	Pipe Size in.	Casting Tolerance in.
3–8	0.05	14–24	0.08
10–12	0.06	30–48	0.10

FIGURE IV-4

APPENDIX V

SPECIFICATION SHEETS

"SST"™ SPECIFICATIONS

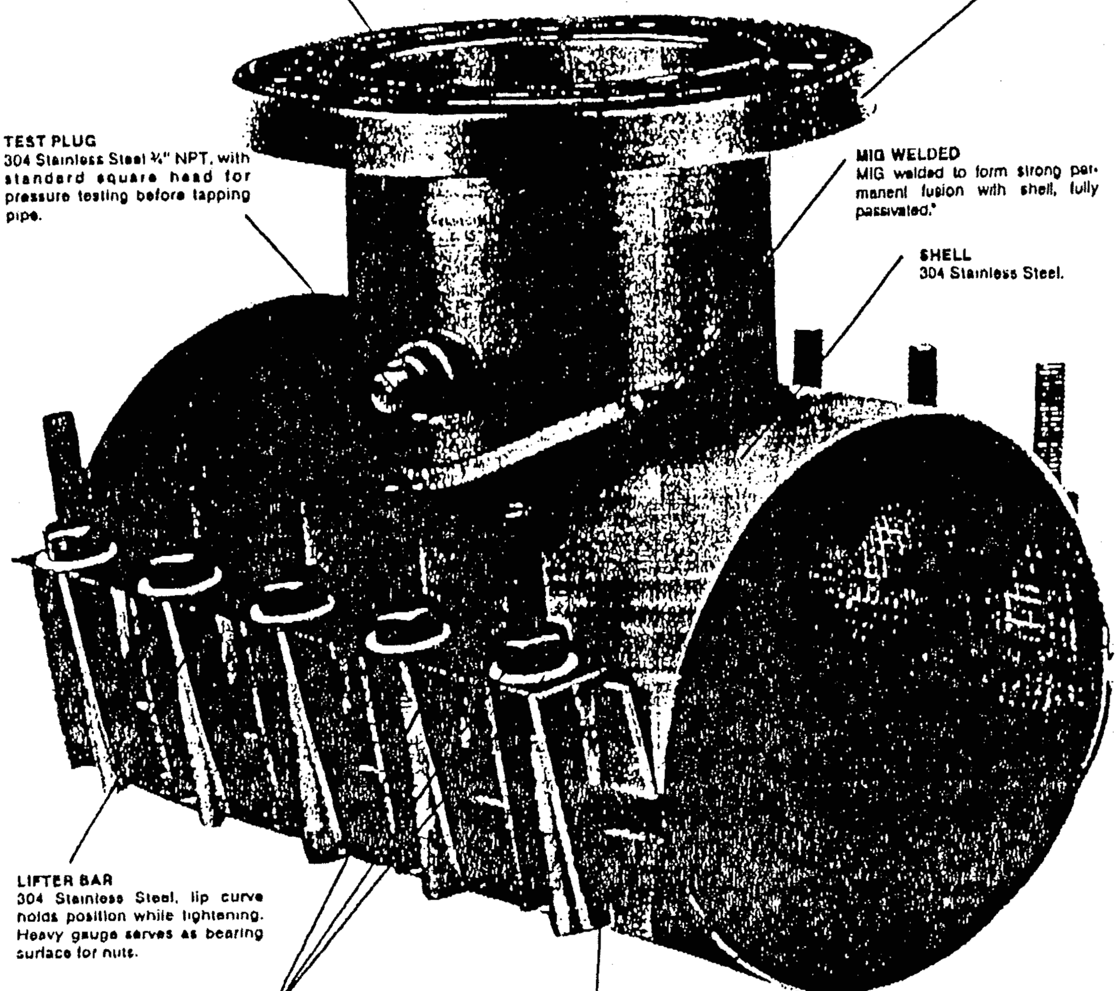
FLANGE GASKET
The SST™ Sleeve comes standard with a special flange gasket made of SBR,glued onto the face of the flange.

304 STAINLESS STEEL OR DUCTILE IRON FLANGE**
ANSI 150 lb. flange drilling accommodates tapping valve MSS-SP60 Flange, welded to 304 stainless steel neck, is coated to provide maximum corrosion resistance.

TEST PLUG
304 Stainless Steel ¾" NPT, with standard square head for pressure testing before tapping pipe.

MIG WELDED
MIG welded to form strong permanent fusion with shell, fully passivated.*

SHELL
304 Stainless Steel.



LIFTER BAR
304 Stainless Steel, lip curve holds position while tightening. Heavy gauge serves as bearing surface for nuts.

NUTS, BOLTS, AND WASHERS
304 Stainless Steel ⅝" NC thread and heavy hex Nuts. Bolt threads are Teflon coated to prevent galling. Plastic lubricating washer.

ARMORS
Heavy gauge 304 Stainless Steel.

GASKET
Specially designed grid pattern, tapered ends. Virgin SBR compounded for water services with antioxidant/antiozonant agents to increase shelf life.

**Additional charge.

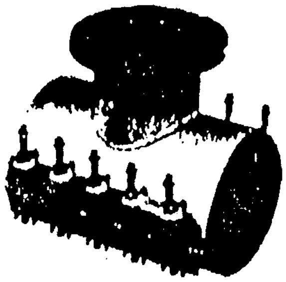
*PASSIVATED - Chemically treated after welding to produce a highly corrosion resistance coating

FIGURE V-1

ROMAC INDUSTRIES, INC.
1064 4th Ave. S., Seattle, WA 98134
P.O. Box 3212, Seattle, WA 98114
(206) 624-6491 Telex 32-8765 1-800-426-9341

EFFECTIVE DATE 7/5/88

STYLE "SST"™ STAINLESS STEEL TAPPING SLEEVE



MATERIAL SPECIFICATIONS:

SHELLS: 304 Stainless Steel.

LUGS: 304 Stainless Steel.

BOLTS, WASHERS and NUTS: NC Rolled Thread, 304 Stainless Steel.

GASKETS: Virgin SBR compounded for water service

FLANGE: 304 Stainless steel** or ductile (nodular) iron. ASTM 536-80, grade 65-45-12.

Nominal Pipe Size	Sleeve O.D. Range (Inches)	Catalog Number: Sleeve Number	By	Branch Size	Ductile Flange	S.S. Flange	Approx. Weight
4"	4.40 - 4.60 4.70 - 4.90 5.10 - 5.30	SST - 4.60 SST - 4.90 SST - 5.30	X	3" FLG. 4" FLG.	N/A 310.97	$422.11 422.11	28 30
6"	6.59 - 6.99 6.89 - 7.30 7.10 - 7.50	SST - 6.99 SST - 7.30 SST - 7.50	X	3" FLG. 4" FLG.	N/A 323.06	439.91 439.91	36 38
6" x 6"***	6.60 - 6.70 6.79 - 6.99 6.90 - 7.10 7.10 - 7.30 7.30 - 7.50	SST - 6.70 SST - 6.99 SST - 7.10 SST - 7.30 SST - 7.50	X	6" FLG.	367.88	501.23	45
8"	7.90 - 8.30 8.62 - 9.06 9.04 - 9.45 9.20 - 9.60	SST - 8.30 SST - 9.06 SST - 9.45 SST - 9.60	X	3" FLG. 4" FLG. 6" FLG.	N/A 327.87 348.68	455.48 455.48 606.57	42 44 48
8" x 8"***	8.62 - 9.06 9.04 - 9.45 9.20 - 9.60	SST - 9.06 SST - 9.45 SST - 9.60	X	8" FLG.	467.02	629.38	66
10"	9.90 - 10.30 10.73 - 11.13 11.05 - 11.45 11.79 - 12.19	SST - 10.30† SST - 11.13 SST - 11.45 SST - 12.19	X	3" FLG. 4" FLG. 6" FLG. 8" FLG. 10" FLG	N/A 361.45 388.66 471.81 806.21	494.64 494.64 537.24 681.21 1128.84	45 48 55 70 80
12"	12.50 - 12.90 13.16 - 13.56 13.98 - 14.38	SST - 12.90† SST - 13.56 SST - 14.38	X	3" FLG. 4" FLG. 6" FLG. 8" FLG 10" FLG. 12" FLG	N/A 403.06 433.43 507.00 641.32 915.69	585.23 585.23 643.89 778.63 1228.16 1460.78	50 52 60 81 96 143
14"	15.20 - 15.60 15.80 - 16.20 16.38 - 16.78	SST - 15.60 SST - 16.20 SST - 16.78	X	3" FLG. 4" FLG. 6" FLG. 8" FLG. 10" FLG. 12" FLG.	N/A 605.99 628.35 819.95 1102.85 1212.50	773.18 773.18 847.73 1114.15 1508.08 1780.24	62 64 74 81 95 154
16"	17.40 - 17.80 17.75 - 18.15 18.58 - 18.98 19.30 - 19.70	SST - 17.80 SST - 18.15 SST - 18.98 SST - 19.70	X	3" FLG. 4" FLG. 6" FLG. 8" FLG. 10" FLG. 12" FLG.	N/A 715.35 737.71 854.57 1187.17 1256.85	892.93 892.93 967.50 1162.37 1600.18 1834.74	78 80 85 100 115 172
18"	19.80 - 20.20 20.20 - 20.60 21.00 - 21.40	SST - 20.20 SST - 20.60 SST - 21.40	X	3" FLG. 4" FLG. 6" FLG. * 8" FLG. * 10" FLG. * 12" FLG. *	N/A 732.46 754.86 885.32 1222.38 1291.96	911.54 911.54 986.25 1185.85 1638.86 1873.29	87 94 98 115 139 191
20"	21.40 - 21.80 21.90 - 22.30 22.30 - 22.70	SST - 21.80 SST - 22.30 SST - 22.70	X	3" FLG. 4" FLG. 6" FLG. * 8" FLG. * 10" FLG. * 12" FLG. *	N/A 854.55 877.21 1052.88 1418.39 1488.06	1045.71 1045.71 1120.27 1369.08 1853.40 2087.96	81 85 89 99 120 205
24"	23.30 - 23.70 25.60 - 26.00	SST - 23.70 SST - 26.00	X	3" FLG 4" FLG. * 6" FLG. * 8" FLG. * 10" FLG. * 12" FLG. *	N/A 900.71 923.03 1103.53 1474.00 1543.63	1035.98 1095.98 1170.50 1424.75 1914.38 2150.85	85 87 90 100 145 230

*Maximum test pressure 200 PSI
**Additional charge.

Other sizes are available on request — P.O.A.
TO ORDER: Specify sleeve number x branch size.

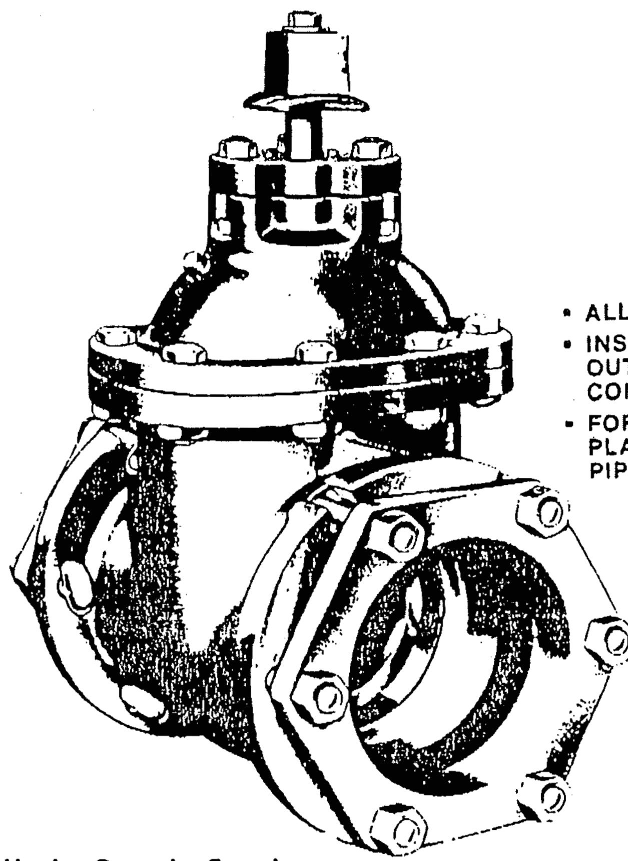
FIGURE V-2

CLOW AWWA GATE VALVES

FOR UNDERGROUND AND PLANT PIPING SYSTEMS 2" THRU 48"

F-5062 thru F-5085

CLOW

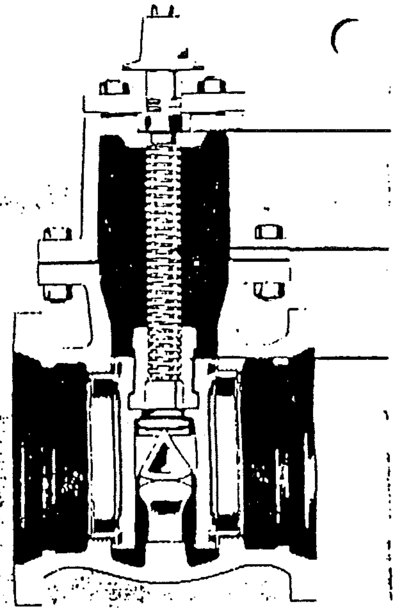


- ALL JOINT ENDS
- INSIDE AND OUTSIDE SCREW CONSTRUCTION
- FOR CAST IRON, PLASTIC AND A/C PIPING

FIGURE V-3

CLOW AWWA GATE VALVES... RUGGE

FOR UNDERGROUND INSTALLATION AND PLANT PIPING SYSTEMS



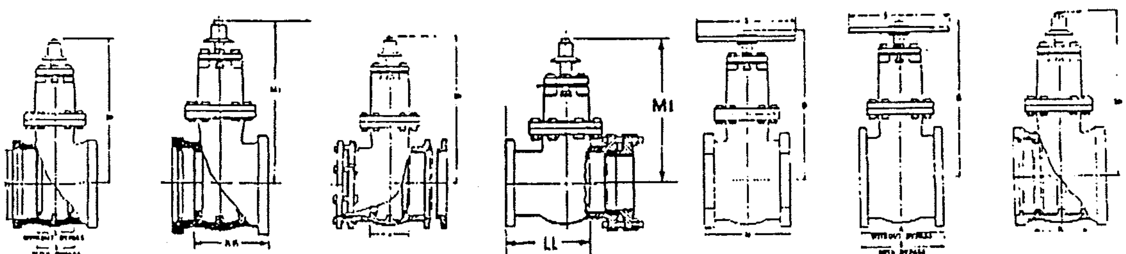
CLOW AWWA gate valves offer rugged construction, easy operation, long service life and economical maintenance. They are double disc, parallel seat valves meeting or exceeding all requirements AWWA Specifications C500, and conform to Federal Specifications WW-V-58b, Type II, Class I.

Component parts are constructed of heavy, rugged proportions for extra strength to withstand pipe strain and possible shifting in underground service. Clean, simple internal construction, illustrated at right, assures long service and easy maintenance.

All joint ends, in sizes shown below, and all commonly used accessories and operating devices can be furnished.

PRESSURE RATINGS

Valve Size Inches	Working Pressure psi Non-Shock Cold Water	Hydrostatic Test Pressure psi
2 thru 12	200	400
14 thru 48	150	300



F-5062 Hub Ends — F-5064 Flanged and A-C Ends — F-5065 Mechanical Joint — F-5066 Flanged and Mechanical Joint Ends — F-5068 Threaded Ends — F-5070 Flanged Ends — F-5080 Push-On Ends For Cast Iron Pipe

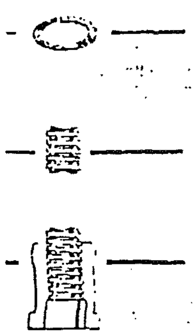
DIMENSIONS — Inches

Flanges are faced and drilled to ANSI 125 pound template, unless otherwise instructed

Valve Size Inches	Turns to Open	Dia. of Stem	A	B	C	D	G	H	J	K	M1	N	P
2	5	7/8	7	...	3½	...	10¼	3⅛	3½	...	10¼	5¼	3
2¼	5	7/8	...	...	3¼	...	10¼	..	3¼	...	10¼	...	
2½	6	7/8	7½	...	...	...	11¾	...	...	..	11¾	5¾	3⅞
3	7	7/8	8	...	3⅞	...	12¼	4⅝	3½	...	12¼	6	3⅛
4	15	1⅛	9	...	4¾	..	14	5¾	4¾	5¼	14	9	4½
5	18	1⅛	10	...	..	...	15½	...		...	15½	...	
6	21	1¼	10½	...	5½	...	16	7⅞	5¼	6½	16	...	5¾
8	27	1⅜	11½	...	6½	...	22	10	6½	7	22	.	6¼
10	33	1½	13	...	6¾	...	25⅝	12⅝	6¾	7¼	25⅝	...	6½
12	39	1½	14	...	6¾	...	29⅛	14¼	7	7¾	29⅛	...	...
14	45	1⅝	15¾	23	7½	13¾	36½	16⅜	7¼	...	39¾	..	
16	52	1⅞	17	23	9⅛	13¾	40¾	18¾	9¼	.	43½	...	
16	56	2⅛	19	24	9½	14	43¼	20¾	9¼	...	46	..	..
20	64	2⅛	20	24	10¼	14½	47¼	23	10	.	50	...	...
24	76	2½	23	28½	10	15	55	27⅞	16	..	56¾	...	...
30	63	2¾	25	32½	12½	20¼	64¾	33¾	12½	..	66½	...	...
36	75	3	27	36	23¾	23¾	75⅞	40⅛	23¾	...	77⅞		.
42	68	3½	34	34	20¾	20¾	...	46½	..	.	.	...	.

FIGURE V-4

... LOW TORQUE... LONG LIFE CLOW



LOW TORQUE THRUST BEARING
4" thru 12" sizes . . . provides high load capacity and low friction which reduces operating torque up to 50%. Seals perfectly for repacking under pressure.

SMOOTH OPERATION
Precise, high strength manganese bronze stem, with extra heavy thrust collar, provides smooth opening and closing of the gates. Stem torque meets Underwriters specifications.

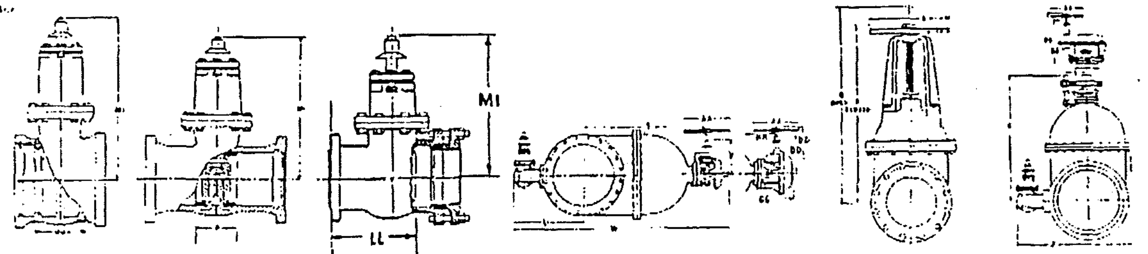
SIMPLE, RUGGED CONSTRUCTION
Stem nut is solid bronze, and independent of hooks, wedges and gates. It is free-floating and self-aligning. For longer wear, the threaded section of stem nut is at least 1½ times the diameter of the stem.

Valve Operation is Easy and Dependable . . . with Two Point, Free-Floating Wedging

The valve operates with only two points of bearing . . . only two points of friction . . . with a simple, self-centering, floating, V-type, bronze gate spreading mechanism . . . for positive action in opening and closing. Separate hooks and bronze wedges permit mechanical adjustment to varying positions.

In opening, turning the stem releases the wedging pressure on the gates, allowing them to move away from their seats before starting upward travel. Further turning of the stem raises the gates into the cover, permitting full opening flow through the valve.

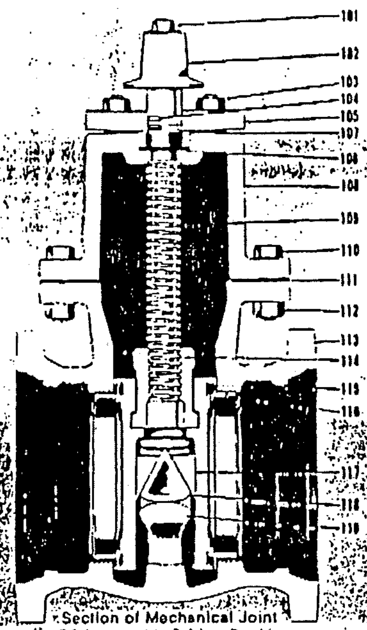
In closing, the gates move freely downward to a position opposite their seats. At this point the hooks come in contact with stops which prevent further downward movement of the hooks. The bronze wedge riding on the hooks then spreads the gates apart and forces them to their seats to make a watertight seal, and shut off the flow through the valve.



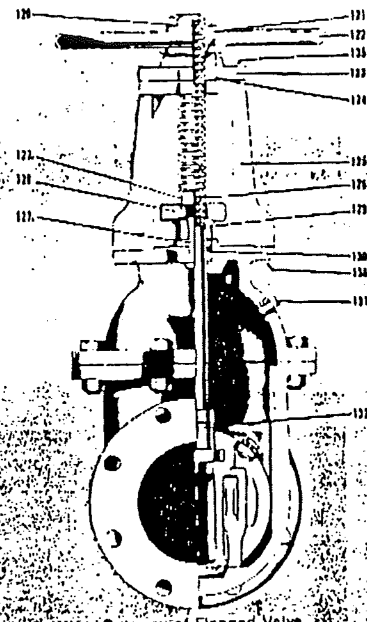
F-5062 Push-On Ends Asbestos-Cement Pipe · F-5085 Push-On Ends For PVC Pipe · F-5093 Mechanical Joint Tapping Valve · F-5070 Flanged Ends, NRS Bevel gearing, by-pass · F-5072 Flanged Ends Outside Screw & Yoke · F-5082 Hub Ends, NRS Spur gearing, by-pass

Q	R	S	T	U	V	W	X	Y	Z	AA	BB	DD	GG	HH	JJ	KK	LL
14	11½	7¼	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5⅛
...	...	7¼	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
15½	12½	7¼	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
20¼	16¾	7¼	...	...	...	...	...	...	...	...	...	...	...	...	3½	...	5¾
24	19¾	10	...	...	...	...	...	...	...	...	...	...	...	...	4½	6⅞	6⅞
27½	21¾	10	...	...	...	...	...	...	...	...		...	...	...	...	...	...
31½	24¾	12	...	...	...	...	...	...	...	...				...	5¼	8½	8
40½	31½	14	...	...	...	...	...	...	...	...	...	...	...	...	6¼	9½	9
47½	35¼	16	...	...	...	...		...	...	...	...	...	...	...	7¼	10⅜	9⅞
56⅜	45⅝	16	27⅞		13	...	36⅝	8	...	16	40¾	12	36½	31⅞	7¾	10⅝	10½
68	53	22	33	19¼	13	57½	41	8	31⅛	18	45	12	42¾	35⅝	7¾	11¾	11½
75¾	58½	22	36⅞	20½	13	62⅞	45	8	33¾	16	49	12	46⅞	39¾	9½	13	15¾
82½	63½	26	39⅞	22½	13	67¾	48	6	36¾	18	52½	12	50	42⅞	9¾	14½	16½
90¼	69¼	26	43¾	24	13	73	51¾	6	40½	18	55¾	12	53⅞	46½	10	15	18¾
107	82	30	50½	28	13	83½	58⅝	8	46	18	62⅞	12	60	52⅞	10		22
125¼	97	30	62¼	31½	17½	100½	71¼	10	54½	18	76¾	15½	72⅛	66	...	...	...
147½	110	36	70½	40	23½	120	67	13¾	66⅛	22	85¾	21½	81⅛	72⅞	...		

CLOW AWWA GATE VALVE PARTS



Section of Mechanical Joint NRS Valve with O-Ring Packing



Cutaway of Flanged Valve with Outside Screw and Yoke

Part		No.	Material
101	Cap Screw	1	Steel
102	Operating Nut	1	Cast Iron
103	O-Ring Plate Bolts & Nuts		Steel
104	O-Rings	2	Rubber
105	O-Ring Plate	1	Cast Iron
106	Low Torque Bearing	1	
107	Stuffing Box Gasket	1	
108	Cover	1	Cast Iron
109	Non-rising Stem	1	Bronze
110	Neck Flange Bolts		Steel—Rust-proofed
111	Neck Flange Gasket	1	Composition
112	Neck Flange Bolt Nuts		Steel

Part		No.	Material
113	Body	1	Cast Iron
114	Gate Nut	1	Bronze
115	Gate Ring	2	Bronze
116	Case Ring	2	Bronze
117	Gate	2	Cast Iron
118	Wedge	2	Bronze
119	Hook	2	Cast Iron
120	Hold Down Nut	1	Bronze
121	Handwheel Key	1	Steel
122	Handwheel	1	Cast Iron
123	O.S. & Y. Retainer Plate	1	Cast Iron
124	O.S.&Y. Stem Nut	1	Bronze
125	O.S.&Y. Yoke	1	Cast Iron
126	Rising Stem	1	Stainless Steel

Part		No.	Material
127a	Follower Nuts	2	Bronze
127b	Follower Studs	2	Steel—Rust-proofed
128	Follower Plate	1	Cast Iron
129	Follower Gland	1	Bronze
130	Packing		Braided Asbestos
131	Test Plug	1	Teflon-coated steel
132	Stem Nut Pin	1	Bronze
135	O.S.&Y. R.P. Cap Screws		Steel—Rust-proofed
136	O.S.&Y. Yoke Bolts & Nuts		Steel—Rust-proofed

CLOW
Clow Valve Co.
Div. of McWane Inc.
902 So. 2nd St.
Oskaloosa, Iowa 52577

Phone: 515-673-8611
FAX: 515-673-8269
Wats: 800-247-CLOW

FIGURE V-6

KOPPERS

Protective Coatings

TECHNICAL DATA SHEET

TYPE OF COATING

COAL TAR EPOXY

Product: BITUMASTIC NO. 300-M

DESCRIPTION: Bitumastic No. 300-M is a two-component, self-priming, chemically-cured, catalyzed coal tar epoxy protective coating.

USE: FOR INDUSTRIAL USE ONLY. NOT INTENDED FOR USE IN THE HOME.

Bitumastic No. 300-M is designed for interior or exterior exposure and combines the outstanding corrosion resistance characteristics of selected coal tar pitch with those of epoxy resin.

NOT FOR USE WITH POTABLE WATER.

Bitumastic No. 300-M is designed to be applied in moderately heavy films for the economical protection of metal, masonry or wood structures exposed to chemical plant environments, water flood gates and dam faces, sewage plants, storage tank linings, bridges, pipeline interiors and exteriors, immersion and atmospheric exposures where a tough, abrasion and chemical resistant film is necessary to insure long-term substrate integrity and strength. No. 300-M can be utilized in every industry including chemical processing, pulp and paper, marine, food processing, water and sewage, offshore drilling, nuclear energy, textile, petroleum, plating, steel, public utilities, fertilizer, and space facilities.

Although 300-M exhibits self-priming characteristics, it functions well over compatible primers such as epoxy based inhibitive products and zinc rich primers.

When applied at a minimum of 16 dry mils, it exhibits excellent resistance when immersed in, or subjected to the following environments at ambient temperatures:

1. Chemical Solutions – fresh water, sea water, calcium chloride, magnesium sulfate, potassium alum, sodium carbonate, 20% sodium hydroxide, sodium nitrate, sodium sulfite, etc.
2. Aliphatic hydrocarbons – Although some discoloration of the liquid may take place, the coating film will resist immersion in petroleum products, such as gasoline, naphtha, sour crude, jet fuel and lubricating oils.
3. Acid solutions – Immersion resistance is excellent in 10% phosphoric acid, oxalic acid and citric acid. Exhibits excellent resistance of intermittent or splash exposures to alkalies and mineral acids.
4. Alcohols – Immersion resistance is also excellent in methyl alcohol, ethyl alcohol and isopropyl alcohol.

Although the above are a few of the chemicals and solutions that Bitumastic No. 300-M can withstand in immersion service, continuous immersion service requirements in other chemicals and solutions should be panel-tested because of the unpredictable nature of the multitude and combination of environments possible.

The cured coating will withstand considerable physical damage, such as direct impact, abrasion, flexing and will not sag or flow at dry heat temperatures up to 250°F.

It meets or exceeds all the requirements of Corps of Engineers Specification C-200, Steel Structures Painting Council Paint Specification SSPC-16-68T, and Steel Tank Institute Corrosion Control System STI-P_3. It can be supplied on order in a version approved for use under Military Specification DOD-P-23236A(SH).

Koppers Company, Inc., Pittsburgh, Pennsylvania 15219

FIGURE V-7

TECHNICAL DATA:

Number of coats:	Usually 2 or more. A single application, consisting of multiple passes, is acceptable, only when spraying, provided the minimum dry film thickness of 16 mils (20 mils wet) is achieved without runs, sags, misses, pinholes, etc.
Volume solids:	74%
Theoretical coverage:	1184 mil sq. ft./gal.
Coverage to achieve minimum dry film thickness:	90 to 115 sq. ft./gal. per coat (allows for approx. 20% application loss) on smooth surfaces. Actual coverage will depend on surface porosity and profile.
Film build ratio:	8 to 10 dry mils (10 to 14 wet mils) per coat. Required minimum dry film thickness shall not be less than 16 mils. Dry films in excess of 40 dry mils are not recommended.
Drying time at 70°F and 50% relative humidity:	
To touch:	3-4 hours
Between coats:	Overnight to 24 hours. Faster between-coat applications are possible. Surfaces exposed to and heated to temperatures over 70°F by the sun can be given another coat as soon as the previous coat is solvent-free (but not less than a minimum 2 hours). If an inline heater is used when spraying (See Spray Data Section), dry time between coats can be reduced to approximately 3 hours. If drying time prior to recoating exceeds 24 hours at temperatures above 70°F, the dry coating must be brush-sandblasted, or Bitumastic 2 CB must be used to pretreat the coating surface (See Bitumastic 2 CB Technical Data Sheet). Do not add Bitumastic 2 CB to Bitumastic No. 300-M.
Before submerging:	All chemically-cured coatings require a long curing time to reach maximum chemical resistance. For best results, a minimum curing time of five days at temperatures between 70°F and 100°F is essential before placing in service.
Colors:	Black or red
Thinners:	Koppers Thinner 2000. Use Koppers Thinner 2000C with air regulatory type or when a flash point higher than 99°F is required.
Cleaner:	Use Koppers Cleaner 2300 to clean equipment. Clean equipment if it is expected to remain idle for longer than 30 minutes at 70°F. or approximately 10 minutes at 100°F. (Black hoses laying in the sunlight can reach temperatures of 130 to 140°F. very quickly.) After equipment is washed thoroughly with the Cleaner, follow with a final flushing with Koppers Thinner 2000.
Surface preparation:	All bare or primed or previously painted surfaces must be dry and free of oil, dirt, loose particles and all other foreign matter. On surfaces coated with an unknown primer or coating, or coated with a coating or primer from another manufacturer, spot tests are necessary to assure compatibility of the unknown coating with Bitumastic No. 300-M and to check ultimate integrity and adhesion of the completed system to the substrate. Experience of results over a period of several years confirms that the fundamental factor for a quality job is proper surface preparation. Unless the surface is properly prepared, there is no point in using the better coatings. Steel surfaces must be blasted to a minimum of SSPC-SP-6. For immersion or very severe chemical exposures blast to SSPC-SP-10. For application to concrete, all curing oils, form oils, laitance, soluble salts and loose concrete must be removed. Concrete must be clean and thoroughly dry before coating. Unpainted concrete floors or concrete that will be submerged must be etched with a 15 to 20% muriatic acid solution or brush blasted to achieve a profile similar to medium grade sandpaper. Cast concrete surfaces should be brush-sandblasted to open bugholes and to roughen the surface.
Primer:	
Metal:	Shop and Field Primers: Although normally self-priming at the field location, Bitumastic No. 300-M works well over the following primers: Koppers

FIGURE V-8

TECHNICAL DATA

Metal: (Continued): 654 Primer, Koppers PUG Primer, Koppers Organic Zinc, Koppers Inorganic Zinc No. 701, or Koppers P-1500 Inorganic Zinc No. 3. No. 300-M forms an excellent bond directly to cleaned steel.

Aluminum: Degrease and pretreat with Koppers 40 Passivator or use a very light brush-off sandblasting or sanding of the surface.

Galvanized metal: Degrease and apply Koppers 40 Passivator; or sandblast to provide a profile or tooth; or treat with Koppers 30 Metal Conditioner.

Concrete and masonry: None required; however, the first coat must be thinned (Add one part Thinner 2000 to two parts Bitumastic No. 300-M and apply at the rate of 200-300 sq. ft. per gallon). Allow not more than 24 hours before applying additional coats of Bitumastic No. 300-M at the normal unthinned rate.

Note: In areas where high water tables exist, internally coated concrete pipe that is to be buried may also require external coating if the pipe cannot withstand hydrostatic pressure testing.

Wood: Rough sand, remove dust and apply as for concrete and masonry above.

Asbestos pipe: Roughen the surface, remove all dust and dirt and apply first coat thinned 10%; then topcoat with 1 to 2 coats at the normal unthinned rate. See note under concrete.

Mixing instructions: Mechanically agitate Component A thoroughly. Continue mixing Component A and slowly add Component B to Component A. Mechanically agitate vigorously for two minutes. Pour some of the mixed material back into the Component B can and stir to insure that all of Component B is in solution, then return material to Component A can. Mechanically agitate vigorously for at least two minutes. If proportioning equipment is used, agitate Component A as above. (Note: Both Components A & B will thicken in viscosity when cold. The material should be warmed to room temperature before mixing for best results.)

Mixing ratio by volume: Component A – 3.5 parts, Component B – 1 part.

Pot life after mixing: at 50°F – 10 hours; at 60°F – 6 hours; at 89°F – 2 hours; at 100°F – 1 hour.

Do not mix more of Component A and B than can be applied in the number of hours listed above, using the highest temperature anticipated.

Methods of application: Brush, roller, conventional air spray, or airless spray. Avoid the use of nylon or plastic equipment. Do not apply to surfaces that will be exposed to rain before the coating is dry or on surfaces with temperatures below 50°F.
(Note: Do not continually use the same can for spray equipment pump sump as the material will cure on the side of the can.)

All quality coatings require top grade workmanship and a good knowledge of the materials and systems of application. Special equipment, other than application equipment, should be utilized for top quality results such as a wet film thickness gauge or dry film gauge, low voltage holiday detector, and moisture meter (for concrete, masonry, and wood substrates).

Spray data:

Conventional Spray

Pump – Graco Mogul (8:1) or equal
Pressures-Material – 30 to 55 psi
Atomization – 50 to 90 psi
Fluid Tip – 1/8 in. to 1/4 in.
Atomizing tip – 3/16 in. (external wing)
Hose – 1/2 in. i.d. to 50 ft.
3/4 in i.d. for over 50 ft.
Maximum working pressure 750 psi
Minimum burst pressure 3000 psi

Airless Spray

Pump – Graco Bulldog (30:1) or equal
Line Pressure – 70 to 90 psi
Tip – 23 to 31 mil, reversible.
Tip filter – none
Manfold filter – none or 30 mesh
Hose – 3/8" i.d., high pressure, for 50' or less length; 1/2" i.d., high pressure, for over 50' with 3/8" H.P. whip end hose.

Spray application may be improved by using a heater with a material hose 1/2 in. in diameter, about 50 ft. long between the pump and the heater to minimize pulsation. The temperature of the product leaving the gun should

FIGURE V-9

TECHNICAL DATA

Spray data: (Continued): range between 90°F and 120°F. Heater thermostat should be set to a maximum of 120°F. A heater is recommended if application is made at temperatures between 50 and 70°F. When using a heater, the use of a circulating line is recommended so that the material will not set up in the heater.

Holiday detection: Holiday detection of the cured coating on metal surfaces is recommended, but should be performed with due consideration for its normal recommended thickness (20-24 mils). The typical high voltage jeep detector used for hot applied coal-tar enamels 100-mils thick, which normally operates at 10-12,000 volts should not be used. A wet sponge detector such as a Tinker and Rasor or K-D Bird Dog which operate at 75 volts maximum is suitable and adequate.

Cathodic protection: Bitumastic No. 300-M is compatible with controlled cathodic protection.

Top coating: Bitumastic No. 300-M can be topcoated with colored coatings such as Bitugloss Aluminum Paint and acrylic emulsions.

Temperature limitations: dry: 250°F. wet: 120°F. maximum continuous

Storage life: One year minimum — some moderate bodying of Component A will occur after 6 months of storage at 70°F. High shear or high speed agitation will normally return Component A to its original viscosity. Up to 1 pint Koppers Thinner 2000 per five gallons of coating may be added if necessary.

PRECAUTIONS: Take these precautions during application and before the coating dries. (Applies to the Mixture of Components A and B).

DANGER!

Harmful or fatal if swallowed. Vapor harmful. Skin and eye irritant. May sensitize skin to sunlight.

Regular Type	Air Regulatory Type	DOD-P-23236A(SH) Type
Flammable	Flammable	Combustible
Contains xylene and tri (dimethyl-aminomethyl)-phenol	Contains 2-nitropropane, cyclohexanone, and tri (dimethyl-aminomethyl) phenol	Contains aromatic hydrocarbon solvents and tri (dimethylaminomethyl) phenol

Keep away from heat, sparks and flame. Avoid breathing of vapor or spray mist. Avoid contact with eyes and skin. Use an ultraviolet barrier cream on exposed skin. Wash thoroughly after handling. Keep closures tight and upright to prevent leakage. Keep container closed when not in use. In case of spillage, absorb and dispose of in accordance with local applicable regulations. Do not take internally.

KEEP OUT OF REACH OF CHILDREN.

Use with adequate ventilation during application and drying. In tanks and other confined areas, use only with adequate forced air ventilation to prevent dangerous concentrations of vapors which could cause death from explosion or from breathing. Use fresh air masks, clean protective clothing and explosion-proof equipment. Prevent flames, sparks, welding and smoking. Follow OSHA regulations regarding ventilation and respiratory equipment.

FIRST AID: In case of skin contact, wash thoroughly with soap and water; for eyes, flush immediately with plenty of water for 15 minutes and call a physician. If sunburn occurs, treat symptomatically. If affected by breathing of vapor, move to fresh air. If swallowed, CALL A PHYSICIAN IMMEDIATELY. DO NOT induce vomiting.

IN CASE OF FIRE: Use dry chemical, foam, water fog or CO_2. Cool closed containers with water.

IMPORTANT! Any mixture of Components A and B will have hazards of BOTH Components. **OBSERVE ALL APPLICABLE PRECAUTIONS.**

WARRANTY

All technical advice, recommendations and services are rendered by the Seller gratis. They are based on technical data which the Seller believes to be reliable and are intended for use by persons having skill and knowhow, at their discretion and risk. Seller assumes no responsibility for results obtained or damages incurred from their use by Buyer whether as recommended herein or otherwise. Such recommendations, technical advice or services are not to be taken as a license to operate under or intended to suggest infringement of any existing patent.

Revised March, 1981 Supersedes all previous data sheets printed on this product.
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APPENDIX VI

DISCUSSION OF CAST IRON AND CORROSION OF CAST IRON

DISCUSSION OF CAST IRON AND CORROSION OF CAST IRON

Cast Iron

Cast Iron is a generic term that applies to high carbon-iron alloys containing silicon. The most common are designated as gray cast iron, white cast iron, malleable cast iron, and ductile or nodular cast iron.

Ordinary gray cast irons contain about 2 to 4% carbon and 1 to 3% silicon. The dull or grayish fracture is due to the free graphite flakes in the microstructure. Gray cast irons can be readily cast into intricate shapes because of their excellent fluidity and relatively low melting points. They can also be alloyed for improvement of corrosion resistance and strength.

Figures VI-1 and VI-2 are tables from The Iron Castings Society handbook and the National Association of Corrosion Engineers (NACE) BASIC CORROSION Handbook showing the various alloying of cast iron.

Corrosion Resistance

The corrosion resistance of cast irons depends primarily on their chemical composition and on the distribution of the elements within their microstructure. By definition all cast irons are heterogeneous and thus have at least two different constituents in their microstructure. The various types of cast iron are distinguished by the form and the distribution

of the carbon in the microstructure and by the type of matrix structure in which the carbon occurs.

The corrosion of cast iron is different from steel because of the appreciable amounts of carbon and silicon. In all except the white irons much of the carbon content occurs as graphite which is essentially insoluble and inert in most environments.

Under oxidizing conditions the silicon in iron oxidizes along with the iron and an iron silicate is formed. There are two mechanisms, one involving graphite and one involving silicon, which can occur in the corrosion of iron and do not occur with carbon steel.

Graphitization

Graphitization is a form of dealloying (or corrosion) caused by the selective dissolution of iron from some cast irons, usually gray cast iron.

It usually proceeds uniformly inward from the surface, leaving a porous matrix of the remaining alloying element, carbon. Graphitization occurs in salt waters, acidic mine waters, dilute acids, and soils, especially those containing sulfates and sulfate-reducing bacteria.

There is generally no outward appearance of damage, but the affected metal loses weight, and becomes porous and brittle. Depending on alloy composition, the porous residue may retain appreciable tensile strength and have moderate resistance to

erosion. For example, a completely graphitized buried cast iron pipe may continue to hold water under pressure until jarred by a backhoe or a workman's shovel.

The presence of sulfates and sulfate-reducing bacteria in soil stimulates graphitization attack. The addition of several percent of nickel to cast iron greatly reduces susceptibility to graphitization.

Since the graphite in cast iron is inert in most corrosive environments the attack is essentially on the matrix metal. If the graphite remaining on the surface is not dislodged, it will form a surface layer that will contain other corrosion-resisting microconstituents and any remaining products of corrosion. Because of the graphite in this layer, it appears black or dark gray, and thus is referred to as graphitization.

This graphite residue can either accelerate or retard the corrosion attack on the underlying metal. With a low pH, graphite is strongly cathodic to iron and may electrolytically accelerate the attack on the metal; but, if the corrosion products are retained, they can effect a mechanical blockage which increases the electrical resistance and stifles further attack.

<u>Silicon Subscale Formation</u>

When a raw iron surface is exposed to moisture, the typical orange-brown hydrated oxide (limoniter) rapidly forms. With

continued exposure a black oxide forms on the surface. The presence of silicon in the iron causes the formation of a dense, adhering, iron oxide-iron silicate scale and subscale, which aids in mitigating further corrosion activity.

<u>Corrosion Resistance To Soils</u>

Corrosion in soils is a complex phenomenon. While many studies have been undertaken to measure the life of buried cast iron pipes in different soils, it is difficult to use this data for quantitative predictions. The soil porosity, drainage, and constituents dissolved in the ground water in contact with the pipe have a marked effect on the life of cast iron in soils.

Additions of up to three percent nickel may reduce the initial corrosion rate in poorly drained soils of low electrical resistivity. Pitting attack may be stimulated very markedly by irregular contact of the pipe with the surrounding soil; this emphasizes the desirability of consolidating the backfill around the pipe. Pitting varies from about 2 mils/yr to about 40 mils/yr under extreme conditions.

Figures VI-3 and VI-4 are tables taken from American Cast Iron Society and Cast Iron Pipe Research Association (CIPRA) publications showing the results of corrosion tests run on cast iron and ductile iron in various types of soils and environments.

* * * * * * * * *

CAST IRON ALLOYS

Alloy	ASTM	UNS	Composition, %[a)]	Cond.	Mechanical Properties[b)] Yield Strength ksi(MPa)	Tensile Strength ksi(MPa)	Elongation %	Hardness HB
Gray Cast Iron	A159(G3000)	F10006	3.1-3.4C, 0.6-0.9Mn, 1.9-2.3SI	As cast	—	30(207)	—	187-241
Malleable Cast Iron	A602(M3210)	F20000	2.2-2.9C, 0.15-1.25Mn, 0.9-1.90Si	Ann.	32(229)	50(345)	12.	130
Ductile Cast Iron	A395(60-40-18)	F32800	(none specified)	Ann.	40(276)	60(414)	18.	170
Cast Iron	A436(1)	F41000	3.0C, 1.5-2.5Cr, 5.5-7.5Cu, 0.5-1.5Mn, 13.5-17.5Ni, 1.0-2.8Si	As cast	—	25(172)	—	150
Cast Iron	A436(2)	F41002	3.0C, 1.5-2.5Cr, 0.50Cu, 0.5-1.5Mn, 18.-22.Ni, 1.0-2.8Si	As cast	—	25(172)	—	145
Cast Iron	A436(5)	F41006	2.4C, 0.1Cr, 0.5Cu, 0.5-1.5Mn, 34.-36.Ni, 1.0-2.0Si	As cast	—	20(138)	—	110
Ductile Austenitic Cast Iron	A439(D-2)	F43000	3.0C, 1.75-2.75Cr, 0.7-1.25Mn, 18-22Ni, 1.5-3.0Si	As cast	30(207)	58(400)	—	170
Ductile Austenitic Cast Iron	A439 (D-5)	F43006	2.4C, 0.1Cr, 1.0Mn, 34-36Ni, 1.0-2.8Si	As cast	30(207)	55(379)	—	155
Silicon Cast Iron	A518	F47003	0.7-1.1C, 0.5Cr, 0.5Cu, 1.50Mn, 0.5Mo, 14.2-14.75Si	As cast	—	16(110)	—	520

a)Single values are maximum values.
b)Typical room temperature properties.

FIGURE VI-1

TABLE 1A-1e – "Named" Proprietary Steels, Nickel Alloys and Other Cast and Miscellaneous Alloys

For other alloys, see handbooks, suppliers or *Engineering Alloys* by Norman Woldman, 4th Ed. 1962. Reinhold Publishing Company.

Name	TM(1)	C	Cr	Ni	Other(2)
Armco Iron	AS	0.012	0	0	
Carpenter-20	CS	0.07	20	29	2.5 Mo, 3.5 Cu, 1 Si
Chlorimet-2	DC	0.03	0	Bal	32 Mo, 3 Fe, 1 Si
Chlorimet-3	DC	0.03	18	Bal	18 Mo, 3 Fe, 0.5 Si
Croloy-2	BW	0.15	2	0	0.5 Mo
Croloy-5	BW	0.15	5	0	0.5 Mo
Duranickel (301)	IN	0.15	0	Bal	4.5 Al, 0.5 Ti, 0.5 Si, 0.15 Fe, 0.25 Mn
Durimet-20	DC	(Similar to Carpenter-20)			
Durichlor	DC	0.9	0	0	14.5 Si, 3 Mo
Duriron	DC	0.9	0	0	14.5 Si
Hastelloy B	HS	0.12 max	0	Bal	28 Mo, 5 Fe, 0.3 V
Hastelloy C	HS	0.15 max	16	Bal	16 Mo, 5 Fe, 4 W
Hastelloy X	HS	0.20 max	22	Bal	9 Mo, 18 Fe, 1 W, 1.5 Co
Incoloy (802)	IN	0.35	20.5	32	
Inconel (600)	IN	0.04	15.8	Bal	7.2 Fe, 0.2 Mn, 0.2 Si, 0.1 Cu
Nichrome V	DH		20	80	
NiHard (No. 1)	IN	3.3	2.1	4.5	0.5 Si, 0.6 Mn
Ni Resist (No. 1)	IN	3.0 max	2	15.5	6.5 Cu, 2.0 Si, 1.25 Mn
Zircaloy-2	W	0	0.10	0.05	1.5 Sn, 0.12 Fe, bal Zr
A-242 Steel	–	0.15 max	0.5	0.3	0.2 Cu min, 1 Mn max, 0.1 P
Cast Iron					
Gray	–	3.3	0	0	1.7 Si, 0.7 Mn
Malleable	–	2.3	0	0	1.0 Si, 0.4 Mn
Nodular	–	3.5	0	0	2.5 Si, 0.3 Mn

(1)Trademark:
AS–Armco Steel Corp.
BW–Babcock & Wilcox
CS–Carpenter Steel Co.
DC–Duriron Co.
DH–Driver Harris Co.
HS–Haynes Stellite Co.
IN–International Nickel Co.
W–Westinghouse Electric Co.

(2)Balance iron unless otherwise noted.

TABLE 1A-2 – Some Commonly Used Woods and Their General Corrosion Resistance to Moist Conditions

Corrosion or Decay Resistance						
Good		Fair		Poor		
Black Locust	Redwood	Douglas Fir	Pine, South Yellow	Ash	Cottonwood	Red Oak
Cedar	Walnut	Honey Locust	Sassafras	Aspen	Fir	Spruce
Chestnut	Yew	Larch	White Oak	Beech	Hemlock	Willow
		Pine, East White		Birch	Maple	

FIGURE VI-2

TABLE VI Corrosion of Cast Iron in Field Tests in Soils[17]

Type of Soil	Location of Site	pH	Resistivity at 60 F (15 C) ohm/cm	Aeration *	Mean Wt. Loss oz/ft.^{2}	Mean Wt. Loss *g/dm^2*
1. Chester loam	Jenkintown, Pa.	5.6	6,670	G	15.1	*46.1*
2. Dublin clay adobe	Oakland, CA	7.0	1,346	P	10.5	*32.0*
3. Fargo clay loam	Fargo, N.Dak.	7.6	350	P	21.2	*64.7*
4. Miami clay loam	Milwaukee, Wis.	7.2	1,780	F	3.5	*10.7*
5. Miami silt loam	Springfield, OH	7.3	2,980	G	4.1	*12.5*
6. Ontario loam	Rochester, N.Y.	7.3	5,700	G	4.8	*14.6*
7. Tidal marsh	Elizabeth, N.J.	3.1	60	VP	17.7	*54.0*
8. Lake Charles clay	El Vista, Tex.	7.1	406	VP	40.5	*123.6*
9. Susquehanna clay	Meridan, Miss.	4.1	6,922	F	5.9	*18.0*
10. Docas clay	Cholame, CA	8.3	62	F	58.0	*177.0*

Locations 1 to 7: Duration of exposure 12 years: 4 specimens.

Locations 8 to 10: Duration of exposure 14 years: 8 specimens.

* Aeration of Soils: G, good, F, fair; P, poor; VP, very poor.

TABLE VIII Relative Wear Rates of Mill Liner Materials as 5 Inch Balls at Climax[44]

Abrasion Factor *base	Material	Heat Treatment	Hardness RcA	Hardness RcB	Typical Analysis Percent C	Mn	Si	Cr	Mo	Ni
89	Martensitic Cr-Mo white iron	AQ & T	54	66	2.8	1.0	0.6	15.0	3.0	—
98	Martensitic high-Cr white iron	AQ & T	53	64	2.7	1.0	0.9	26.0	0.5	—
100*	Martensitic Cr-Mo steel	AQ & T	49	55	1.0	0.8	0.6	6.0	1.0	—
107	Chill-cast Ni-Cr-Mo white iron	—	—	59	3.2	0.7	0.5	2.0	1.0	3.0
109	Sand-cast Ni-Cr white iron	—	53	60	3.2	0.6	0.5	2.0	—	4.0
111	Martensitic Cr-Mo steel	salt Q&T	55	58	0.7	1.0	0.6	1.5	0.5	—
115	Austenitic 6-1 alloy steel	WQ	10	49	1.2	6.0	0.5	—	1.0	—
116	Chill-cast Ni-Cr white iron	—	—	55	3.0	0.5	0.4	2.1	—	4.5
120	Martensitic Cr-Mo steel	WQ & T	48	55	0.4	1.5	0.4	0.8	0.5	—
126	Type 420 cast stainless	AQ & T	50	52	0.4	0.5	0.5	13.3	0.7	—
127	Pearlitic Cr-Mo steel	AQ & T	38	39	0.8	0.8	0.6	2.3	0.4	—
140	Austenitic Mn steel	WQ	10	49	1.2	12.0	0.5	—	—	—

Footnotes for Table VIII are shown on previous page.
AQ & T = air quenched and tempered
Q & T = quenched and tempered
WQ = water quenched
WQ & T = water quenched and tempered

RcA is the average Rockwell C hardness 1/8 in. below the original surface of the balls prior to use.
RcB is the average hardness on the worn surface of the balls after the wear test. It reflects the effect of cold-work hardening at this surface.

FIGURE VI-3

Cipra Test of Six-Inch Ductile Iron and Gray Iron Pipe[19]

Soil	Years Exposure	Mean Weight Loss, mdd⁽¹⁾		Mean Maximum Pitting, mpy⁽²⁾		Mean Loss in Burst Strength, %	
		Duct	Gray	Duct	Gray	Duct	Gray
Cinders	3.7	12.2	10.6	35	35	<10	20
	5.9	15.9	16.0	32	32	<10	30
	7.9	12.5	13.8	27	28	<10	31
	9.4	10.6	11.7	18	22	<10	27
	13.5	9.3	11.3	11	20	<15	40
Alkali	3.7	7.2	5.4	22	16	<10	10
	6.0	4.3	3.2	13	10	<10	10
	8.0	3.2	2.3	10	14	<10	24
	9.9	2.3	1.6	10	9	<15	42
	12.0	2.6	2.2	8	10	<15	41
	14.0	2.4	1.9	9	13	<9	39

Analysis of Iron Pipe

Element	C	Si	S	Mn	P	Mg
Ductile	3.40	2.40	0.01	0.30	0.05	0.04
Gray	3.40	1.50	0.08	0.50	0.60	—

(1) mdd = milligrams per square decimetre per day. (2) mpy = mils penetration per year.

FIGURE VI-4