

Appendix E:

Microbiological Evaluations of MI LCW Before Biocide Treatment



Fermi National Accelerator Laboratory
P.O. Box 500, MS343
Batavia, IL 60510
Phone: (630) 840-3274
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Main Injector LCW Repairs

**NALCO Microbiological Evaluation of Water Samples Before
Introduction of Biocides**

(4-9-98)



ANALYTICAL LABORATORY REPORT

From:
Fermi National Lab
Batavia, IL

Sample Marked:
MI-60 Tank Outlet

Analysis No. MB 208440
Date Sampled 11/21/97
Date Received 11/21/97
Date Completed 11/24/97
Date Printed 11/24/97

>>> Microbiological Evaluation <<<

PHYSICAL APPEARANCE	Liquid with floc
TOTAL AEROBIC BACTERIA	6,000
Enterobacter	<1,000
Pigmented	<1,000
Mucoids	<1,000
Pseudomonas	<1,000
TOTAL ANAEROBIC BACTERIA	
Sulfate Reducers	<1
TOTAL FUNGI	
Yeasts	<10
Molds	<10
IRON-DEPOSITING	
Gallionella	None
Sphaerotilus	None
ALGAE	
Filamentous	None
Nonfilamentous	None
OTHER ORGANISMS	None

Lab Comments:

All counts express colony forming units per ml.

Microscopic examination: few crystals.

Sample sent via non-sterile pkg. Results may be inaccurate.

Analytical Laboratory Location:

NALCO CHEMICAL COMPANY
NALCO CENTER • NAPERVILLE, ILLINOIS 60563-1188





ANALYTICAL LABORATORY REPORT

From:
Fermi National Lab
Batavia, IL

Sample Marked:
628 Supply

Analysis No. MB 208441
Date Sampled 11/21/97
Date Received 11/21/97
Date Completed 11/24/97
Date Printed 11/24/97

>>> Microbiological Evaluation <<<

PHYSICAL APPEARANCE

Amber liquid with floc

TOTAL AEROBIC BACTERIA

Enterobacter	3,000
Pigmented	<1,000
Mucoids	<1,000
Pseudomonas	<1,000

TOTAL ANAEROBIC BACTERIA

Sulfate Reducers	5
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TOTAL FUNGI

Yeasts	<10
Molds	<10

IRON-DEPOSITING

Gallionella	None
Sphaerotilus	None

ALGAE

Filamentous	None
Nonfilamentous	None

OTHER ORGANISMS

None

Lab Comments:

All counts express colony forming units per ml.

Microscopic examination: many aggregates of particles.

Sample sent via non-sterile pkg. Results may be inaccurate.

Analytical Laboratory Location:

NALCO CHEMICAL COMPANY
300 NALCO CENTER □ NAPERVILLE, ILLINOIS 60563-1198





ANALYTICAL LABORATORY REPORT

From:
Fermi National Lab
Batavia, IL

Sample Marked:
628 Return

Analysis No. MB 208442
Date Sampled 11/21/97
Date Received 11/21/97
Date Completed 11/24/97
Date Printed 11/24/97

>>> Microbiological Evaluation <<<

PHYSICAL APPEARANCE

Amber liquid with floc

TOTAL AEROBIC BACTERIA

Enterobacter	10,000
Pigmented	<1,000
Mucoids	<1,000
Pseudomonas	<1,000

TOTAL ANAEROBIC BACTERIA

Sulfate Reducers	<1
------------------	----

TOTAL FUNGI

Yeasts	<10
Molds	<10

IRON-DEPOSITING

Gallionella	None
Sphaerotilus	None

ALGAE

Filamentous	None
Nonfilamentous	None

OTHER ORGANISMS

None

Lab Comments:

All counts express colony forming units per ml.

Microscopic examination: many aggregates of particles and few crystals.

Sample sent via non-sterile pkg. Results may be inaccurate.

Analytical Laboratory Location:

NALCO CHEMICAL COMPANY
THE NALCO CENTER □ NAPERVILLE, ILLINOIS 60563-1188





ANALYTICAL LABORATORY REPORT

From:
Fermi National Lab
Batavia, IL

Sample Marked:
R-F 603 Return

Analysis No. MB 208443
Date Sampled 11/21/97
Date Received 11/21/97
Date Completed 11/24/97
Date Printed 11/24/97

>>> Microbiological Evaluation <<<

PHYSICAL APPEARANCE

• Liquid with floc

TOTAL AEROBIC BACTERIA

Enterobacter	82,000
Pigmented	<1,000
Mucoids	5,000
Pseudomonas	<1,000
	<1,000

TOTAL ANAEROBIC BACTERIA

Sulfate Reducers	<1
------------------	----

TOTAL FUNGI

Yeasts	<10
Molds	<10

IRON-DEPOSITING

Gallionella	None
Sphaerotilus	None

ALGAE

Filamentous	None
Nonfilamentous	None

OTHER ORGANISMS

None

Lab Comments:

All counts express colony forming units per ml.

Microscopic examination: few crystals.

Sample sent via non-sterile pkg. Results may be inaccurate.

Analytical Laboratory Location:

NALCO CHEMICAL COMPANY
ONE NALCO CENTER □ NAPERVILLE, ILLINOIS 60563-1198





ANALYTICAL LABORATORY REPORT

From:
Fermi National Lab
Batavia, IL

Sample Marked:
R-F 603 Supply

Analysis No. MB 208444
Date Sampled 11/21/97
Date Received 11/21/97
Date Completed 11/24/97
Date Printed 11/24/97

>>> Microbiological Evaluation <<<

PHYSICAL APPEARANCE

Liquid with Floc

TOTAL AEROBIC BACTERIA

10,000

Enterobacter

<1,000

Pigmented

<1,000

Mucoids

<1,000

Pseudomonas

<1,000

TOTAL ANAEROBIC BACTERIA

Sulfate Reducers

<1

TOTAL FUNGI

Yeasts

<10

Molds

10

IRON-DEPOSITING

Gallionella

None

Sphaerotilus

None

ALGAE

Filamentous

None

Nonfilamentous

None

OTHER ORGANISMS

None

Lab Comments:

All counts express colony forming units per ml.

Microscopic examination: moderate crystals and aggregates of crystalline particles.

Sample sent via non-sterile pkg. Results may be inaccurate.

Analytical Laboratory Location:

NALCO CHEMICAL COMPANY
ONE NALCO CENTER @ NAPERVILLE, ILLINOIS 60563-1188





ANALYTICAL LABORATORY REPORT

From:
Fermi National Lab
Batavia, IL

Sample Marked:
423 Supply

Analysis No. MB 208445
Date Sampled 11/21/97
Date Received 11/21/97
Date Completed 11/24/97
Date Printed 11/24/97

>>> Microbiological Evaluation <<<

PHYSICAL APPEARANCE

Liquid with floc

TOTAL AEROBIC BACTERIA

19,000

Enterobacter

<1,000

Pigmented

<1,000

Mucoids

<1,000

Pseudomonas

<1,000

TOTAL ANAEROBIC BACTERIA

Sulfate Reducers

<1

TOTAL FUNGI

Yeasts

<10

Molds

<10

IRON-DEPOSITING

Gallionella

None

Sphaerotilus

None

ALGAE

Filamentous

None

Nonfilamentous

None

OTHER ORGANISMS

None

Lab Comments:

All counts express colony forming units per ml.

Microscopic examination: very few crystals.

Sample sent via non-sterile pkg. Results may be inaccurate.

Analytical Laboratory Location:

NALCO CHEMICAL COMPANY
THE NALCO CENTER • NAPERVILLE, ILLINOIS 60563-1188





ANALYTICAL LABORATORY REPORT

From:
Fermi National Lab
Batavia, IL

Analysis No. MB 208446
Date Sampled 11/21/97
Date Received 11/21/97
Date Completed 11/24/97
Date Printed 11/24/97

Sample Marked:
836.3 Supply

>>> Microbiological Evaluation <<<

PHYSICAL APPEARANCE

Liquid with floc

TOTAL AEROBIC BACTERIA

140,000

Enterobacter

<1,000

Pigmented

<1,000

Mucoids

<1,000

Pseudomonas

<1,000

TOTAL ANAEROBIC BACTERIA

Sulfate Reducers

29

TOTAL FUNGI

Yeasts

<10

Molds

<10

IRON-DEPOSITING

Gallionella

None

Sphaerotilus

None

ALGAE

Filamentous

None

Nonfilamentous

None

OTHER ORGANISMS

None

Lab Comments:

All counts express colony forming units per ml.

Microscopic examination: very few crystals.

Sample sent via non-sterile pkg. Results may be inaccurate.

Analytical Laboratory Location:

NALCO CHEMICAL COMPANY
E NALCO CENTER • NAPERVILLE, ILLINOIS 60563-1188





ANALYTICAL LABORATORY REPORT

From:
Fermi National Lab
Batavia, IL

Sample Marked:
836.3 Return

Analysis No. MB 208447
Date Sampled 11/21/97
Date Received 11/21/97
Date Completed 11/24/97
Date Printed 11/24/97

>>> Microbiological Evaluation <<<

PHYSICAL APPEARANCE	Liquid with floc
TOTAL AEROBIC BACTERIA	2,000
Enterobacter	<1,000
Pigmented	<1,000
Mucoids	<1,000
Pseudomonas	<1,000
TOTAL ANAEROBIC BACTERIA	
Sulfate Reducers	<1
TOTAL FUNGI	
Yeasts	<10
Molds	<10
IRON-DEPOSITING	
Gallionella	None
Sphaerotilus	None
ALGAE	
Filamentous	None
Nonfilamentous	None
OTHER ORGANISMS	None

Lab Comments:

All counts express colony forming units per ml.

Sample sent via non-sterile pkg. Results may be inaccurate.

Analytical Laboratory Location:

NALCO CHEMICAL COMPANY
1E NALCO CENTER □ NAPERVILLE, ILLINOIS 60563-1198





ANALYTICAL LABORATORY REPORT

From:
Fermi National Lab
Batavia, IL

Analysis No. MB 208448
Date Sampled 11/21/97
Date Received 11/21/97
Date Completed 11/24/97
Date Printed 11/24/97

Sample Marked:
422

>>> Microbiological Evaluation <<<

PHYSICAL APPEARANCE	Amber clouded liquid
TOTAL AEROBIC BACTERIA	12,000
Enterobacter	<1,000
Pigmented	<1,000
Mucoids	<1,000
Pseudomonas	<1,000
TOTAL ANAEROBIC BACTERIA	
Sulfate Reducers	<1
TOTAL FUNGI	
Yeasts	<10
Molds	<10
IRON-DEPOSITING	
Gallionella	None
Sphaerotilus	None
ALGAE	
Filamentous	None
Nonfilamentous	None
OTHER ORGANISMS	None

Lab Comments:

All counts express colony forming units per ml.

Microscopic examination: many aggregates of particles.

Sample sent via non-sterile pkg. Results may be inaccurate.

Analytical Laboratory Location:

NALCO CHEMICAL COMPANY
E NALCO CENTER □ NAPERVILLE, ILLINOIS 60563-1188





ANALYTICAL LABORATORY REPORT

From:
Fermi National Lab
Batavia, IL

Sample Marked:
422 Return

Analysis No. MB 208449
Date Sampled 11/21/97
Date Received 11/21/97
Date Completed 11/24/97
Date Printed 11/24/97

>>> Microbiological Evaluation <<<

PHYSICAL APPEARANCE

• Liquid with rust-colored sediment

TOTAL AEROBIC BACTERIA

Enterobacter	5,000
Pigmented	<1,000
Mucoids	<1,000
Pseudomonas	<1,000

TOTAL ANAEROBIC BACTERIA

Sulfate Reducers	<1
------------------	----

TOTAL FUNGI

Yeasts	<10
Molds	<10

IRON-DEPOSITING

Gallionella	None
Sphaerotilus	None

ALGAE

Filamentous	None
Nonfilamentous	None

OTHER ORGANISMS

None

Lab Comments:

All counts express colony forming units per ml.

Microscopic examination: many aggregates of particles.

Sample sent via non-sterile pkg. Results may be inaccurate.

Analytical Laboratory Location:

NALCO CHEMICAL COMPANY
ONE NALCO CENTER ■ NAPERVILLE, ILLINOIS 60563-1188





ANALYTICAL LABORATORY REPORT

From:
Fermi National Lab
Batavia, IL

Sample Marked:
510.1 Return

Page 1
Analysis No. MB 208450
Date Sampled 11/21/97
Date Received 11/21/97
Date Completed 11/24/97
Date Printed 11/24/97

>>> Microbiological Evaluation <<<

PHYSICAL APPEARANCE

Liquid with rust-colored
sediment

TOTAL AEROBIC BACTERIA

110,000

Enterobacter

<1,000

Pigmented

15,000

Mucoids

<1,000

Pseudomonas

<1,000

TOTAL ANAEROBIC BACTERIA

Sulfate Reducers

<1

TOTAL FUNGI

Yeasts

<10

Molds

<10

IRON-DEPOSITING

Gallionella

None

Sphaerotilus

None

ALGAE

Filamentous

None

Nonfilamentous

None

OTHER ORGANISMS

None

Lab Comments:

All counts express colony forming units per ml.

Microscopic examination: many aggregates of crystalline particles.

Analytical Laboratory Location:

NALCO CHEMICAL COMPANY
E NALCO CENTER ■ NAPERVILLE, ILLINOIS 60563-1188





ANALYTICAL LABORATORY REPORT

From:
Fermi National Lab
Batavia, IL

Sample Marked:
510.1 Supply

Page 1
Analysis No. MB 208451
Date Sampled 11/21/97
Date Received 11/21/97
Date Completed 11/24/97
Date Printed 11/24/97

>>> Microbiological Evaluation <<<

PHYSICAL APPEARANCE

Liquid with rust-colored
sediment

TOTAL AEROBIC BACTERIA

Enterobacter	46,000
Pigmented	<1,000
Mucoids	9,000
Pseudomonas	<1,000
	<1,000

TOTAL ANAEROBIC BACTERIA

Sulfate Reducers	<1
------------------	----

TOTAL FUNGI

Yeasts	<10
Molds	<10

IRON-DEPOSITING

Gallionella	None
Sphaerotilus	None

ALGAE

Filamentous	None
Nonfilamentous	None

OTHER ORGANISMS

None

Lab Comments:

All counts express colony forming units per ml.

Microscopic examination: many aggregates of particles and very few crystals.

Analytical Laboratory Location:

NALCO CHEMICAL COMPANY
1E NALCO CENTER • NAPERVILLE, ILLINOIS 60563-1198





ANALYTICAL LABORATORY REPORT

From:
Fermi National Lab
Batavia, IL

Analysis No. MB 208454
Date Sampled 11/21/97
Date Received 11/21/97
Date Completed 11/24/97
Date Printed 11/24/97

Sample Marked:
1141 Supply

>>> Microbiological Evaluation <<<

PHYSICAL APPEARANCE

Clouded liquid

TOTAL AEROBIC BACTERIA

Enterobacter	91,000
Pigmented	<1,000
Mucoids	<1,000
Pseudomonas	<1,000

TOTAL ANAEROBIC BACTERIA

Sulfate Reducers	<1
------------------	----

TOTAL FUNGI

Yeasts	<10
Molds	<10

IRON-DEPOSITING

Gallionella	None
Sphaerotilus	None

ALGAE

Filamentous	None
Nonfilamentous	None

OTHER ORGANISMS

None

Lab Comments:

All counts express colony forming units per ml.

Sample sent via non-sterile pkg. Results may be inaccurate.

Analytical Laboratory Location:

NALCO CHEMICAL COMPANY
E NALCO CENTER ■ NAPERVILLE, ILLINOIS 60563-1188





ANALYTICAL LABORATORY REPORT

From:
Fermi National Lab
Batavia, IL

Sample Marked:
1141 Return

Analysis No. MB 208453
Date Sampled 11/21/97
Date Received 11/21/97
Date Completed 11/24/97
Date Printed 11/24/97

>>> Microbiological Evaluation <<<

PHYSICAL APPEARANCE	Liquid with floc
TOTAL AEROBIC BACTERIA	9,000
Enterobacter	<1,000
Pigmented	<1,000
Mucoids	<1,000
Pseudomonas	<1,000
TOTAL ANAEROBIC BACTERIA	
Sulfate Reducers	<1
TOTAL FUNGI	
Yeasts	<10
Molds	<10
IRON-DEPOSITING	
Gallionella	None
Sphaerotilus	None
ALGAE	
Filamentous	None
Nonfilamentous	None
OTHER ORGANISMS	None

Lab Comments:

All counts express colony forming units per ml.

Microscopic examination: few clusters of particles.

Sample sent via non-sterile pkg. Results may be inaccurate.

Analytical Laboratory Location:

NALCO CHEMICAL COMPANY
ONE NALCO CENTER □ NAPERVILLE, ILLINOIS 60563-1188





ANALYTICAL LABORATORY REPORT

From:
Fermi National Lab
Batavia, IL

Sample Marked:
MI-60 Suction/Pump #2

Analysis No. MB 208452
Date Sampled 11/21/97
Date Received 11/21/97
Date Completed 11/24/97
Date Printed 11/24/97

>>> Microbiological Evaluation <<<

PHYSICAL APPEARANCE	Clouded liquid
TOTAL AEROBIC BACTERIA	4,000
Enterobacter	<1,000
Pigmented	<1,000
Mucoids	<1,000
Pseudomonas	<1,000
TOTAL ANAEROBIC BACTERIA	
Sulfate Reducers	2
TOTAL FUNGI	
Yeasts	<10
Molds	<10
IRON-DEPOSITING	
Gallionella	None
Sphaerotilus	None
ALGAE	
Filamentous	None
Nonfilamentous	None
OTHER ORGANISMS	None

Lab Comments:

All counts express colony forming units per ml.

Microscopic examination: very few clusters of particles.

Sample sent via non-sterile pkg. Results may be inaccurate.

Analytical Laboratory Location:

NALCO CHEMICAL COMPANY
NE NALCO CENTER □ NAPERVILLE, ILLINOIS 60563-1188



**REPORT ON INVESTIGATION OF POSSIBLE CASE OF MICROBIOLOGICALLY
INFLUENCED CORROSION IN STAINLESS STEEL PIPE AT FERMILAB**

SUBMITTED TO

FERMILAB

BY

**BIOINDUSTRIAL TECHNOLOGIES, INC.
GEORGETOWN, TEXAS**

December 30, 1997

1.0 INTRODUCTION

Mr. Steve Holmes of Fermilab contacted Dan Pope of BTI regarding a possible case of microbiologically influenced corrosion (MIC) in 304/304L stainless steel piping at the Fermilab facility. On Nov. 26, 1997 he faxed a copy of the treatment proposed by Nalco representatives. Dr. Pope reviewed this material and left a voice mail for Mr. Holmes on November 29, 1997 giving his comments on the recommendations. On December 1, 1997 Dr. Pope received a request from Mr. Satti via James Frank of ANL to travel to the Fermilab facility for a meeting with Fermilab personnel and an inspection of the facilities. The meeting was held on December 2, 1997, followed by an inspection of the affected facilities. The following background information was relayed to Dan Pope by Fermilab personnel:

- The affected pipe is "304/304L" stainless steel.
- The pipe had been installed over a period of several years.
- The system had been hydrotested in sections, using domestic water without any addition of biocides to control microbes.
- Hydrotest water was used in older sections of the piping first and then reused in newer sections of the system.
- The system was allowed to sit in contact with the hydrotest water weeks to months.
- 215 leaks have been observed thus far, most are associated with field circumferential welds or heat-affected zones, and most occur on the bottom of the pipe.
- Leaks were first observed about the middle of November, 1997.
- Nalco representatives had recommended treatment of the system with glutaraldehyde for 72 hours followed by treatment with a quaternary amine for 72 hours.
- No provision was made in the Nalco procedure for cleaning the system prior to treatment or for testing the effectiveness of each biocide or biocide residuals during treatment. In fact, the directions stated that no microbiological tests were required after the glutaraldehyde treatment. These tests were to be done after the quaternary amine treatment was completed.
- Nalco also recommended refilling the system with domestic water, apparently without further treatment, although there is a handwritten note at the bottom of the page referring to 200 ppm hydrogen peroxide. This may have been added by Fermilab personnel during our meeting.
- Nalco test results showed moderate levels of aerobic bacteria with few specific bacteria being identified. Sulfate-reducing bacteria were seen at low levels in only 2 of the samples. Acid-producing bacteria, iron-related bacteria, and low nutrient bacteria were not tested.
- No chemical tests for fundamental information necessary for proper treatment (e.g. pH, alkalinity) appear to have been reported.
- Dr. Pope was shown pictures of the appearance of the ID of the pipes and cross-sections through some welds.

- Dr. Pope toured the facilities with Mr. Satti.
- Dr. Pope talked with Dr. Michael Enzien of Nalco, and both agreed that it appeared to be a classic case of MIC in austenitic SS. Dr. Pope agreed to provide MICKIT FPS test kits to Fermilab/Nalco for use in sampling the system on December 3, 1997.
- 10 MICKIT FPS kits were processed by Fermilab, with samples from various locations in the system, on December 3, 1997 and forwarded to BTI for analysis. BTI performed microscopic examination of the samples and "read" the MICKIT viable culture results on several occasions.

2.0 RESULTS AND DISCUSSION

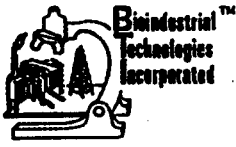
- The history of the construction, operation, and hydrotesting of the SS piping system is consistent with MIC of austenitic SS which has been allowed to come in contact with MIC-causing bacteria (often present in untreated well water and insufficiently treated potable waters supplied by municipal water purveyors) for a period of several days or more.
- The appearance of the nodules on the pipe surfaces, their association with welds, and the morphology of the pits all conform to the picture of classical MIC of austenitic SS.
- The results of viable culture analysis and microscopic analyses are given in the appended table of results. These final results suggest that the source water and water exiting the carbon beds is heavily contaminated with aerobic and low nutrient types of bacteria. The rest of the samples had moderate to high levels of these types of bacteria. Moderate levels of iron-related bacteria were also present in the source water and in water from the carbon beds.
- The aerobic, low nutrient, and iron-related bacteria can form biofilms (slimes) and build nodules on the surface of metals, principally through the precipitation of iron and other materials and accumulation of debris in the biofilm. These biofilms then become sites for the initiation of corrosion, principally due to the formation of corrosion cells. These corrosion cells take the form of crevice corrosion under the biofilms, acid attack under the biofilms, oxygen concentration cell corrosion in which the area under the biofilm is anaerobic, ion (especially chloride) concentration cell corrosion, etc. The exact reason for the affinity of MIC for the weldments is not fully understood, although it is recognized that the segregation of materials, which occurs during the welding process, is important.
- Once a mature corrosion site/nodule/pit is established, the corrosion is chemically/electrochemically driven. This means that simply killing the microbes will not stop the corrosion. The nodules must be removed and the pit repassivated to stop further pitting. This means that such a system must be chemically or mechanically cleaned and then treated with a passivating agent.
- It is very important that all water entering the system after cleaning/repair/passivation treatment be treated to kill microbes and prevent them from entering the system. This can be accomplished very simply by the

addition of a treatment "chamber" through which all make-up water must travel before entering the system, per se.

- The fact that the levels of total bacteria cells (includes live and dead cells) in the samples are close to the viable culture results, suggests that most of the cells in the water samples were alive at the time of sampling. This may be an indication that the biocide treatment was not very effective. Since we do not know what the biocide levels actually were in the system during treatment, it is impossible to accurately interpret this information.

3.0 RECOMMENDATIONS

- Make a list of all components of the system and make sure that they are compatible with any treatments to be done.
- Mechanically or chemically clean the system to remove all biofilms, nodules, corrosion products, and other debris. This might be accomplished by pigging or chemically treating using acid + chelants. Companies specializing in such cleaning techniques should be contacted for advice.
- Rinse the system with high purity water which has been treated to maintain at least 200 ppm free residual hydrogen peroxide for a period of at least 24 hours. This will disinfect the piping ID and help passivate the SS pipe. Be sure that all the components are compatible with the hydrogen peroxide treatment.
- Construct (before cleaning even begins) a device on the make-up to the system which will automatically disinfect all water entering the system and allow the disinfectant to degrade before entering the system. This will prevent reinoculation of the system. Ozone or hydrogen peroxide could easily be used to accomplish this task. BTI can work with Fermilab's engineering staff to effect such a design, if so desired.



40105 Industrial Park Circle
 Georgetown, Texas 78626
 (512) 869-0580

CLIENT INFORMATION:

John Satti
 Fermi National Accelerator Laboratory
 PO Box 500
 Batavia, IL 60510

Customer P.O.#: none
 Job #: FERM-A00

Report Date: December 30, 1997

SAMPLE INFORMATION:

Date Sample(s) Collected: December 3, 1997
 Date Sample(s) Received: December 5, 1997
 Collected by: Client

RESULTS:

Sample Description	RF 603 Supply	510.1 Supply	Mi-8 Supply	Mi-60 Post DI Bottle	Mi-60 Raw Domestic Supply
BTI Control #	970229	970230	970231	970232	970233
Final Viable Culture (ml sample)					
Aerobic Bacteria	100-1,000	1,000-≥10,000	100-1,000	100-1,000	1,000-≥10,000
Acid-Producing Bacteria	0	0	0	0	1-10
Sulfate-Reducing Bacteria	0	0	0	0	0
Iron-Related Bacteria	0	0	0	0	10-100
Low Nutrient Bacteria	100-1,000	1,000-≥10,000	100-1,000	100-1,000	1,000-≥10,000
Microscopic Analyses					
Total Bacteria/ml of Sample, FITC Method	<10,000	<10,000	<10,000	30,000	<10,000

RESULTS CONT'D:

Sample Description	510.1 Return	MI-8 Return	MI-60 Post Charcoal Filter	MI-60 Tank Outlet	RF 603 Return
Control #	970234	970235	970236	970237	970238
Final Viable Culture (per ml sample)					
Aerobic Bacteria	1,000-≥10,000	100-1,000	1,000-≥10,000	100-1,000	10-100
Acid-Producing Bacteria	0	0	100-1,000	0	0
Sulfate-Reducing Bacteria	0	0	0	0	0
Iron-Related Bacteria	0	0	10-100	0	0
Low Nutrient Bacteria	100-1,000	100-1,000	1,000-≥10,000	100-1,000	10-100
Microscopic Analyses					
Total Bacteria/ml of Sample, FITC Method	10,000	<10,000	30,000	<10,000	<10,000

REMARKS:

***** INVOICE *****

PAGE: 1

BIOINDUSTRIAL TECHNOLOGIES, INC.
ACCOUNTING DEPARTMENT
660 COUNTY ROAD 403
TAYLOR, TEXAS 76574

INVOICE NUMBER: 0003160-IN
INVOICE DATE: 12/29/97
FEDERAL ID #: 14-1660155

(512) 352-5767

ATTN: John Satti
Fermilab Co.
Accounts Payable
PO BOX 500, M.S. 340
Batavia

IL 60510

CUSTOMER NO: 03-FERM
CUSTOMER P.O.: per John Satti

TERMS: NET 30
SHIP VIA:

shipping charge-12/02 purchase

SALES CD DESCRIPTION	QUANTITY	PRICE	AMOUNT
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PLEASE NOTE A LATE CHARGE OF 2.5% WILL BE
APPLIED ON ALL INVOICES 30 DAYS PAST DUE

NET INVOICE:	.00
FREIGHT:	20.50
SALES TAX:	.00
INVOICE TOTAL:	20.50

Shipping Charge Corrections Detail

Shipped	Package Identification/ Receiver	Recorded Weight/Service Corrected Weight/Service	Adjustment Amount
12-02	09365978937 JOHN SATTI BATANIA IL 60510	27 Next Day Air 29 Next Day Air Dim 20x17x16	3.00
12-02	09365978946 JOHN SATTI BATANIA IL 60510	19 Next Day Air 29 Next Day Air Dim 20x16x17	15.50
Total			18.50

E

Adjustments
(Continued)

Miscellaneous Detail

Explanation	Charge
BILLING ADJUSTMENT FOR W/E 12/13/97 WEIGHT ERROR 1 ADDL HANDLING PKGS. AT \$2.00 EA	2.00
Total	2.00