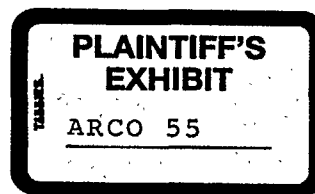


Pacific Operations
Los Angeles

3785 Corporate Avenue
Suite 150
Cypress, CA 90630
(714) 229-4806
Fax: (714) 229-4805

Clayton
ENVIRONMENTAL
CONSULTANTS



**Industrial Hygiene Assessment
Airborne Asbestos Fiber Concentrations
and Limited Bulk Sampling Aboard
the SS *Arco Sag River*
for
ARCO Marine, Inc.
Long Beach, California**

Clayton Project No. 36087.00

September 4, 1991

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1.0 INTRODUCTION

ARCO Marine, Inc. retained Clayton Environmental Consultants, Inc. to conduct an industrial hygiene monitoring and employee awareness training during the northbound sailing of the SS *Arco Sag River*. The scope of services provided by Clayton is described in our Proposal 91-PIH-148, dated June 19, 1991, and includes the Terms and Conditions under which the work was performed.

The purpose of the assessment was to (1) monitor potential airborne fiber concentrations aboard the ship during normal work activities, (2) collect a limited number of bulk samples, (3) conduct asbestos awareness training sessions on board the ship while underway.

The northbound trip aboard the SS *Arco Sag River* a 70,000 dwt ship constructed in 1972, covered approximately 2,100 nautical miles and a total time of just over five days. Air sampling was conducted during normal working operations while at sea. The following locations were monitored:

- Officer's and Crew's mess
- Officer's and Crew's lounge
- Main deck, athwartship
- Computer Room
- Select staterooms
- Several locations throughout the engine room
- Radio room
- Galley
- Wheelhouse (Bridge)
- Cargo control room
- Pump room

From June 15 through June 20, 1991, Mr. Steven R. O'Donnell Industrial Hygienist with Clayton assessed the condition of the asbestos-containing materials, collected air and bulk samples, and performed the training sessions. Clayton analyzed all air samples using phase-contrast microscopy (PCM) in accordance with the National Institute of Occupational Safety and Health (NIOSH) Method 7400A. Forensic Analytical Specialties, Inc. a National Voluntary Laboratory Accreditation Program (NVLAP)-accredited laboratory analyzed the samples for asbestos content using the polarized light microscopy (PLM) technique and following the EPA "Interim Method for the Determination of Asbestos in Bulk Samples", EPA-600/M4-82-020, December 1982.

2.0 SUMMARY OF ASSESSMENT AND TRAINING

The following summary is based on the results of sampling and Mr. O'Donnell's subjective observations.

2.1 SUMMARY OF ASSESSMENT

Sampling was performed to measure airborne concentrations of asbestos fibers. The sampling was accomplished by using electrically-operated high volume sampling pumps at approximately 15 liters per minute (LPM). All samples collected were area samples.

Area samples were collected randomly throughout the house, engine, and pump rooms. Select samples were collected in specific locations such as the radio room, second and third assistant engineer's stateroom, and the Chief Mate's stateroom.

Several bulk samples of materials were collected to determine their asbestos content. The materials tested included the following:

- Cloth pipe lagging (over fibrous glass insulation)
- Cement and asbestos ceiling panels (overheads)
- Dust and debris generated during ceiling panel removal (overheads)

2.2 SUMMARY OF TRAINING SESSIONS

During the northbound voyage an "Asbestos Awareness Training" session was presented to the officers and crew. The following is a summary of the topics covered during the presentation:

- Introduction (What is asbestos?)
- Health effects from asbestos exposure
- US Coast Guard and OSHA Regulations
- Exposure assessment
- Control options
- Work practices
- Personal protection
- Disposal

During and following the presentation, an informal question and answer session was carried out.

3.0 DESCRIPTION OF OPERATIONS

The SS *Arco Sag River* routinely travels in ballast from ARCO terminals along the U.S. West Coast to the Alyeska Terminal in Valdez, Alaska. Although the vessel normally carries approximately 110,000 bbls of ballast water during summer months, the ship carried only 80,000 bbls on this voyage. This was done to create a rougher than normal journey, thus providing "worst condition" scenario with respect to potential dislodging of asbestos fibers.

Sea conditions were generally calm, with slight seas and clear weather throughout the voyage.

The ship while underway twists, bends, and vibrates even in calm seas. The engine and propeller vibration is evident throughout the house. Repair work on asbestos-containing materials is limited to emergency repairs at sea and all major work is conducted while in port by a licensed asbestos abatement contractor.

Personal protective equipment includes, but is not limited to Tyvek™ coveralls, half-face negative-pressure respirators, safety goggles, and gloves.

4.0 STANDARDS AND GUIDELINES

The U.S. Coast Guard has two recommended exposure limits for shipboard employees. The exposure limit for working environments is 2.0 fibers (longer than 5 micrometers) per cubic centimeter of air (f/cc) determined as an 8-hour time-weighted average (TWA). For living environments, the permissible U.S. Coast Guard limit is 0.1 f/cc.

OSHA asbestos standards mandate an 8-hour permissible exposure limit (PEL) of 0.2 and an excursion limit of 1.0 f/cc as a 30-minute TWA. The OSHA action level is 0.1 f/cc, the level at which medical monitoring and other activities are required.

ARCO Marine, Inc. has made a commitment to comply with the more stringent OSHA permissible exposure limit of 0.2 f/cc for all of its employees.

The EPA has recommended 0.01 f/cc as an acceptable limit for airborne fiber concentrations following asbestos abatement activities and prior to reoccupancy.

The EPA has limited the asbestos content of some materials; however, asbestos has *not* been eliminated from all manufactured building materials. Therefore, the age of a building or ship cannot be used as the basis for assuming that a material does not contain asbestos.

5.0 RESULTS

Air sampling results are tabulated in Appendix A. Bulk sample analytical results are shown in Appendix B. The sampling and analytical methods are briefly described in Appendix C.

A large number of samples were collected during this survey in order to evaluate all potential exposure areas. A total of 46 samples were collected. A subgroup of 33 of these samples were submitted for laboratory analysis. The remaining samples were archived. Analysis of these samples was to be conducted if the initial data revealed measurable or significant levels of asbestos fibers.

One sample collected in the engine room was overloaded with dust and debris (brown-colored particles) and could not be analyzed.

5.1 AIR MONITORING RESULTS

The results of PCM analysis for these samples indicated airborne fiber concentrations ranging from .0035 to .02 f/cc. Samples showing concentrations of airborne fibers at 0.01 f/cc or above were analyzed by Transmission Electron Microscopy (TEM). The results of TEM analyses for the four samples submitted indicated airborne asbestos fiber concentrations of ranging from <0.00018 to 0.0021 f/cc. Results of analysis are shown in Tables 1 and 2 of Appendix A.

5.2 BULK SAMPLE RESULTS

Our assessment resulted in the collection of samples of suspect asbestos-containing materials for testing. As detailed in Appendix B, asbestos was identified in all of the materials we tested.

Clayton identified and sampled the following materials:

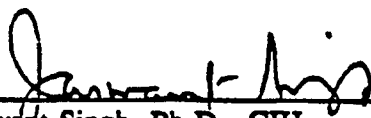
- Cloth pipe lagging collected in the main deck water closet, Stateroom 18, Stateroom 18 head, and crew's laundry contained approximately 65 to 70% chrysotile asbestos. The material located throughout the ship is in good condition with only minor damage observed.
- Cementitious ceiling panels (overheads) collected in the radio room contained approximately 30 to 35% chrysotile asbestos. These panels are considered non-friable and when handled properly should not present a fiber release potential.
- Tiny chips (dust) that had fallen onto a desk during removal of a ceiling panel in the radio room were analyzed and contained approximately 35 to 40% chrysotile asbestos, the same percentage as the ceiling tiles.

Unless damaged or disturbed, cohesive asbestos-containing materials do not tend to become airborne. It is conceivable that water damage, maintenance activities, or vandalism could disturb the asbestos-containing materials, thereby increasing the risk of generating airborne asbestos fibers.

As an alternative to removal, ARCO has taken steps to help prevent the release of fibers by regularly examining and repairing all damaged asbestos-containing materials. An effective asbestos management program can prevent exposure of employees to airborne asbestos fibers

during routine maintenance and renovation activities. A brief summary of these precautions is provided in Appendix D.

This report prepared by: 
for Steven R. O'Donnell
Industrial Hygienist

This report reviewed by: 
Jaswant Singh, Ph.D., CIH
Senior Vice President
Director, Pacific Operations

September 4, 1991

APPENDIX A
RESULTS OF SAMPLING FOR AIRBORNE FIBERS

TABLE 1
RESULTS OF SAMPLING FOR AIRBORNE FIBER CONCENTRATIONS
ABOARD THE S/S ARCO SAG RIVER
FOR
ARCO MARINE INCORPORATED
LONG BEACH, CALIFORNIA

CLAYTON PROJECT NO. 36087.00
SAMPLING DATE: July 16, 1991

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration Fibers Per cc
		Start	Stop		
SR-716-01	Officer's Mess	0837	1155	3,100	*
SR-716-02	Main Deck Athwartship Passageway	0855	1203	2,800	*
SR-716-03	Computer Room	0908	1245	3,400	0.002
SR-716-04	Boatswain's Stateroom	0902	1207	2,900	0.001
SR-716-05	Crew's Lounge	0913	1247	3,300	*
SR-716-06	Officer's Lounge	0917	1248	3,300	*

Fiber Concentration Standards

OSHA PEL = 0.2 f/cc

Coast Guard (Working Environment) = 2.0 f/cc

Coast Guard (Living Environment) = 0.1 f/cc

EPA Recommended Clearance Level = 0.01 f/cc

Weather: Calm Seas

Approximate Ship Location: Point Sur

* = Archived (See reference on archived samples on p. 3)

Ballast = Minimal

**RESULTS OF SAMPLING FOR AIRBORNE FIBER CONCENTRATIONS
ABOARD THE S/S ARCO SAG RIVER
FOR
ARCO MARINE INCORPORATED
LONG BEACH, CALIFORNIA**

**CLAYTON PROJECT NO. 36087.00
SAMPLING DATE: July 17, 1991**

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration
		Start	Stop		Fibers Per cc
SR-717-01	Engine Room Control Panel Area	0707	1129	4,100	0.01**
SR-717-02	Engine Room Forward of Main Generator	0713	1131	4,100	0.02**
SR-717-03	Engine Room Port Side of Main Circulating Pump	0718	1133	4,000	0.008
SR-717-04	Engine Room Fire Station No. 23	0725	1134	3,600	***
SR-717-05	Engine Room Astern of Boilers	0735	1135	3,800	0.003
SR-717-06	Master's Office	1452	1834	3,400	0.001
SR-717-07	First Mate's Stateroom	1608	1926	3,000	0.003
SR-717-08	Chief Engineer's Office	1447	1832	3,600	*
SR-717-09	Radio Room	1849	2256	3,900	0.001

Fiber Concentration Standards

OSHA PEL = 0.2 f/cc

Coast Guard (Working Environment) = 2.0 f/cc

Coast Guard (Living Environment) = 0.1 f/cc

EPA Recommended Clearance Level = 0.01 f/cc

Weather: Calm Seas

Approximate Ship Location: Oregon Coast

* = Archived (See reference on archived samples on p. 3)

Ballast = Minimal

** = Sample submitted for TEM analysis (see results on Table 2)

*** = Sample overloaded with dust

**RESULTS OF SAMPLING FOR AIRBORNE FIBER CONCENTRATIONS
ABOARD THE S/S ARCO SAG RIVER
FOR
ARCO MARINE INCORPORATED
LONG BEACH, CALIFORNIA**

**CLAYTON PROJECT NO. 36087.00
SAMPLING DATE: July 17, 1991**

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration
		Start	Stop		Fibers Per cc
SR-717-10	Wheelhouse (Bridge)	1505	1839	3,400	0.004
SR-717-11	Stateroom 18 AB Seaman	1510	1859	3,600	*
SR-717-12	Officer's Mess	1854	2258	3,800	0.002
SR-717-13	Galley	1856	2300	3,900	0.001
SR-717-14	Crew's Mess	1858	2301	3,800	0.001
SR-717-15	Main Deck Athwartship Passageway	1905	2306	3,800	*
SR-717-16	Cargo Control Room	1931	2304	3,200	*

Fiber Concentration Standards

OSHA PEL = 0.2 f/cc

Coast Guard (Working Environment) = 2.0 f/cc

Coast Guard (Living Environment) = 0.1 f/cc

EPA Recommended Clearance Level = 0.01 f/cc

Weather: Calm Seas

Approximate Ship Location: Northern Washington - B.C.

* = Archived (See reference on archived samples on p. 3)

Ballast = Minimal

**RESULTS OF SAMPLING FOR AIRBORNE FIBER CONCENTRATIONS
ABOARD THE S/S ARCO SAG RIVER
FOR
ARCO MARINE INCORPORATED
LONG BEACH, CALIFORNIA**

**CLAYTON PROJECT NO. 36087.00
SAMPLING DATE: July 18, 1991**

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration
		Start	Stop		Fibers Per cc
SR-718-01	Engine Room Control Panel Area	1129	1521	3,500	0.002
SR-718-02	Aft of Boilers, Port Side	1132	1350	2,200	0.006
SR-718-03	Starboard Side of High-Pressure Steam Turbine	1138	1522	3,500	0.003
SR-718-04	Port Side of Low-Pressure Steam Turbine	1142	1523	3,400	0.004
SR-718-05	Starboard Side of Turbine Reduction Gear Case	1146	1525	3,400	0.002
SR-718-06	Fire Station No. 23	1150	1524	3,300	0.002
SR-718-07	Radio Room (During Ceiling Panel Removal)	1441	1617	1,400	0.02**
SR-718-08	Officer's Lounge	1634	1807	1,400	0.012**
SR-718-09	Crew's Lounge	1637	2004	3,100	0.002
SR-718-10	First Mate's Stateroom	1642	2008	3,200	0.0035

Fiber Concentration Standards

OSHA PEL = 0.2 f/cc

Coast Guard (Working Environment) = 2.0 f/cc

Coast Guard (Living Environment) = 0.1 f/cc

EPA Recommended Clearance Level = 0.01 f/cc

Weather: Calm Seas

Approximate Ship Location: Straights of Juan de Fuca

* = Archived (See reference on archived samples on p. 3)

Ballast = Minimal

** = Sample submitted for TEM analysis (see results on Table 2)

**RESULTS OF SAMPLING FOR AIRBORNE FIBER CONCENTRATIONS
ABOARD THE S/S ARCO SAG RIVER
FOR
ARCO MARINE INCORPORATED
LONG BEACH, CALIFORNIA**

**CLAYTON PROJECT NO. 36087.00
SAMPLING DATE: July 18, 1991**

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration Fibers Per cc
		Start	Stop		
SR-718-11	Chief Engineer's Office	1644	2012	3,200	0.001
SR-718-12	Master's Office	1646	2013	3,200	0.002
SR-718-13	Cargo Control Room	1651	2017	3,200	*
SR-718-14	Crew's Mess	1814	2130	2,900	*
SR-718-15	Galley	2005	0002	3,600	0.001
SR-718-16	Wheelhouse (Bridge)	2015	0010	3,600	*
SR-718-17	Stateroom 18 AB Seaman	2019	0012	3,600	*
SR-718-18	Computer Room	2011	0007	3,700	0.002
SR-718-19	Boatswain's Stateroom	2016	0004	3,500	0.001

Fiber Concentration Standards

OSHA PEL = 0.2 f/cc

Coast Guard (Working Environment) = 2.0 f/cc

Coast Guard (Living Environment) = 0.1 f/cc

EPA Recommended Clearance Level = 0.01 f/cc

Weather: Calm Seas

Approximate Ship Location: Straights of Juan de Fuca

* = Archived (See reference on archived samples on p. 3)

Ballast = Minimal

**RESULTS OF SAMPLING FOR AIRBORNE FIBER CONCENTRATIONS
ABOARD THE S/S ARCO SAG RIVER
FOR
ARCO MARINE INCORPORATED
LONG BEACH, CALIFORNIA**

**CLAYTON PROJECT NO. 36087.00
SAMPLING DATE: July 18, 1991**

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration Fibers Per cc
		Start	Stop		
SR-718-01	Engine Room Control Panel Area	1129	1521	3,500	0.002
SR-718-02	Aft of Boilers, Port Side	1132	1350	2,200	0.006
SR-718-03	Starboard Side of High-Pressure Steam Turbine	1138	1522	3,500	0.003
SR-718-04	Port Side of Low-Pressure Steam Turbine	1142	1523	3,400	0.004
SR-718-05	Starboard Side of Turbine Reduction Gear Case	1146	1525	3,400	0.002
SR-718-06	Fire Station No. 23	1150	1524	3,300	0.002
SR-718-07	Radio Room (During Ceiling Panel Removal)	1441	1617	1,400	0.02**
SR-718-08	Officer's Lounge	1634	1807	1,400	0.012**
SR-718-09	Crew's Lounge	1637	2004	3,100	0.002
SR-718-10	First Mate's Stateroom	1642	2008	3,200	0.0035

Fiber Concentration Standards

OSHA PEL = 0.2 f/cc

Coast Guard (Working Environment) = 2.0 f/cc

Coast Guard (Living Environment) = 0.1 f/cc

EPA Recommended Clearance Level = 0.01 f/cc

Weather: Calm Seas

Approximate Ship Location: Straights of Juan de Fuca

* = Archived (See reference on archived samples on p. 3)

Ballast = Minimal

** = Sample submitted for TEM analysis (see results on Table 2)

**RESULTS OF SAMPLING FOR AIRBORNE FIBER CONCENTRATIONS
ABOARD THE S/S ARCO SAG RIVER
FOR
ARCO MARINE INCORPORATED
LONG BEACH, CALIFORNIA**

**CLAYTON PROJECT NO. 36087.00
SAMPLING DATE: July 18, 1991**

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration
		Start	Stop		Fibers Per cc
SR-718-11	Chief Engineer's Office	1644	2012	3,200	0.001
SR-718-12	Master's Office	1646	2013	3,200	0.002
SR-718-13	Cargo Control Room	1651	2017	3,200	*
SR-718-14	Crew's Mess	1814	2130	2,900	*
SR-718-15	Galley	2005	0002	3,600	0.001
SR-718-16	Wheelhouse (Bridge)	2015	0010	3,600	*
SR-718-17	Stateroom 18 AB Seaman	2019	0012	3,600	*
SR-718-18	Computer Room	2011	0007	3,700	0.002
SR-718-19	Boatswain's Stateroom	2016	0004	3,500	0.001

Fiber Concentration Standards

OSHA PEL = 0.2 f/cc

Coast Guard (Working Environment) = 2.0 f/cc

Coast Guard (Living Environment) = 0.1 f/cc

EPA Recommended Clearance Level = 0.01 f/cc

Weather: Calm Seas

Approximate Ship Location: Straights of Juan de Fuca

* = Archived (See reference on archived samples on p. 3)

Ballast = Minimal

**RESULTS OF SAMPLING FOR AIRBORNE FIBER CONCENTRATIONS
ABOARD THE S/S ARCO SAG RIVER
FOR
ARCO MARINE INCORPORATED
LONG BEACH, CALIFORNIA**

**CLAYTON PROJECT NO. 36087.00
SAMPLING DATE: July 19, 1991**

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration Fibers Per cc
		Start	Stop		
SR-719-01	Second Assistant Engineer's Stateroom (During IGS Fan Operation)	1256	1605	2,900	0.006
SR-719-02	Third Assistant Engineer's Stateroom (During IGS Fan Operation)	1255	1606	3,000	0.006
SR-719-03	Pump Room	1318	1632	2,800	0.001
SR-719-04	Weight Room (Gym)	1306	1634	3,200	0.002
SR-719-05	Pump Room	1632	2000	3,100	0.001

Fiber Concentration Standards

OSHA PEL = 0.2 f/cc

Coast Guard (Working Environment) = 2.0 f/cc

Coast Guard (Living Environment) = 0.1 f/cc

EPA Recommended Clearance Level = 0.01 f/cc

Weather: Calm Seas

Approximate Ship Location: Alaska Panhandle

* = Archived (See reference on archived samples on p. 3)

Ballast = Minimal

TABLE 2

RESULTS OF SAMPLING FOR AIRBORNE ASBESTOS FIBER CONCENTRATIONS BY TEM
ABOARD THE S/S ARCO SAG RIVER
FOR
ARCO MARINE INCORPORATED
LONG BEACH, CALIFORNIA

CLAYTON PROJECT NO. 36087.00
SAMPLING DATE: JULY 17-18, 1991

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Asbestos Concentration f/cc
		Start	Stop		
SR-717-01	Engine Room Control Panel	0707	1129	4,100	<0.00018
SR-717-02	Engine Room, Forward of Main Generator	0713	1131	4,100	<0.00018
SR-718-07	Radio Room (During Ceiling Panel Removal)	1441	1617	1,400	0.0021
SR-718-08	Officer's Lounge	1634	1807	1,400	<0.00053

< = Less than (below the limit of detection for the analytical method)
cc = Cubic centimeter of air
f = Fibers >5 μ m length, >0.25 μ m diameter, $\geq$ 3:1 length:width

Analytical Method: NIOSH 7402. May 15, 1989

APPENDIX B
BULK SAMPLE ANALYTICAL RESULTS

The tables in Appendix B include the following information:

A. Material Sampled

A physical description of the material sampled in the assessed building or structure.

B. Location of Material in Building

The location of the material (e.g., pipe wrap or joint insulation) in the assessed building or structure).

C. Amount Asbestos Present

The approximate amount of asbestos-containing materials present in the building based on observations, drawings, or other sources of information.

D. Condition

The condition of the material present, which was subjectively evaluated by the investigator (e.g., good, fair, or poor).

E. Accessibility

The accessibility to the material is evaluated as follows:

- S (Staff-only) -- materials behind locked doors (e.g., boiler rooms) and materials above dropped ceilings (e.g., pipe joint wrap)
- M (Moderate) -- materials that can be seen but not reached without some effort (e.g., high ceilings)
- E (Easy) -- materials within the employees' reach (e.g., low or stairwell ceilings, wrap on pipes)

F. Friability

The ability of a material, when dry, to be crumbled, pulverized, or reduced to powder by hand pressure. Friability was subjectively evaluated by the investigator as low, moderate, or high.

G. Field Identification

The first letters in the column are an abbreviation for the client. The number is the material identification number assigned by the Clayton investigator. At least three representative samples were collected for each type of friable or suspect material sampled as material content is not always uniform.

H. Sample Location

The physical location where the sample was collected in the assessed building or structure.

I. Estimated Percent and Type

The numbers indicate the percent of each type of asbestos present in the sample. Percentages are not reported for materials not containing asbestos.

BULK SAMPLE ANALYTICAL RESULTS

Ship: S/S ARCO SAG RIVER
Date: June 18, 1991
Investigator: Steven R. O'Donnell

Client: ARCO Marine, Inc.
Project No.: 36087.00

Material Sampled	Location of Material on Ship	Estimated Amount Present			Access	Fri	Field I.D.	Sample Location	Percent Asbestos*				Total Percent Asbestos
		Length	Dia	Sq Ft	Cond				Amos	Chrys	Croo	ND	
Cement and asbestos ceiling panel	Throughout house			N/Q	G	E	L	SR-RS-CP	Radio room	30-35			30-35
Ceiling panel chips	Radio room			N/Q				SR-RS-CPC	Radio room	30-35			30-35
Ceiling panel dust	Radio room			N/Q				SR-RS-PD	Radio room	35-40			35-40
Cloth pipe lagging	Throughout ship	N/Q			G	E	M	SR-PL-01	Stateroom 18	65-70			65-70
Cloth pipe lagging	Throughout ship	N/Q			G	E	M	SR-PL-02	Stateroom 18 head	65-70			65-70
Cloth pipe lagging	Throughout Ship	N/Q			G	E	M	SR-PL-03	Main deck water closet	65-70			65-70
Cloth pipe lagging	Throughout Ship	N/Q			G	E	M	SR-PL-04	Crew Laundry	65-70			65-70

*Analysis performed in accordance with EPA Protocol for asbestos using polarized light microscopy (PLM).

Dia = Diameter
Sq Ft = Square Feet

Cond = Condition
G = Good
F = Fair
P = Poor

Access = Accessibility
S = Staff Only
M = Moderate
E = Easy

Fri = Friability
H = High
L = Low

Amos = Amosite
Chrys = Chrysotile
Croo = Crocidolite

ND = Not Detected (<1%)
N/Q = Not Quantified

APPENDIX C
SAMPLING AND ANALYTICAL METHODS

SAMPLING AND ANALYTICAL METHOD PHASE-CONTRAST MICROSCOPY (PCM) DIETHYL OXYLATE

Samples for the evaluation of airborne fibers are collected using portable pumps to draw air at measured flow rates through filters. The filters are contained in open-faced cassettes. The filter is a 25-millimeter diameter mixed cellulose ester membrane type.

Samples are collected with the filter facing downward. Area samples are positioned so that the filter is between 3 and 5 feet above the floor to approximate workers' breathing zone heights. Unless mentioned otherwise in the sample description, all area samples are collected at fixed locations throughout the sampling period. Personal samples are collected using portable pumps worn by the worker, with the cassette in the breathing zone.

Each sample is analyzed for fibers using the microscopic technique currently specified by the National Institute for Occupational Safety and Health (NIOSH) Manual of Analytical Methods No. 7400. Briefly, the technique consists of the following steps:

1. A wedge-shaped sector of each filter is cut carefully from the sample and mounted on a standard microscopy slide. A high-viscosity solution of membrane filter material in 1:1 mixture of diethyl oxalate and dimethyl phthalate is used to render the filter transparent.
2. Fibers (defined as particles having an apparent length to width of three or greater) that are visible on the surface of the film are counted. This is accomplished using a binocular microscope equipped with 10x eyepieces and a 40x objective with phase-contrast illumination.
3. Walton-Beckett recticle fields, selected at random on the sample, are examined. Fibers greater than 5 micrometers in length are counted until either of two conditions is satisfied: (a) A minimum of 100 fibers is counted in 20 or more fields; (b) A minimum of 100 fields is examined.

Results of the microscopic analyses are used with field sampling data (measured flow rates and duration of sampling) to calculate the concentrations of airborne fibers corresponding to each sample. The results are expressed in units of fibers greater than 5 micrometers in length per cubic centimeter of air (f/cc).

METHOD OF ANALYSIS FOR BULK ASBESTOS USING POLARIZED LIGHT MICROSCOPY (PLM)

When a bulk asbestos sample is received, several representative portions of the sample are removed and put into a labeled petri dish. The sample parts are examined through a stereobinocular microscope and fibers are extracted using forceps. These extracted fibers are then placed on a microscope slide and mounted using a refractive index solution [high dispersion (HD) Cargille liquid].

After being mounted, the fibers are identified using PLM, supplemented by dispersion staining¹. After fiber identification by PLM, an estimation is made as to the percentage (area) composition of asbestos. The estimated percentages are based on size, number, shape, and density of each of the components, and comparison to a standard set of samples previously quantitated by the interim Research Triangle Institute (RTI) method².

¹ McCrone, Walter C., The Asbestos Particles Atlas, Ann Arbor Science Publishers, Inc., 1980.

² Research Triangle Institute, "Interim Method for the Determination of Asbestiform Minerals in Bulk Insulation Samples," Page 8 to 12, 1982.

**SAMPLING AND ANALYTICAL METHOD
TRANSMISSION ELECTRON MICROSCOPY (TEM)
MODIFIED NIOSH 7402 METHOD³**

Upon receipt in the laboratory, filters are transferred to a glass slide on a drop of dimethyl formamide/acetic acid clearing solution. After clearing, samples are partially ashed in a plasma asher. The filters are then carbon coated in a vacuum evaporator. Portions of the cleared/ashed/coated filters are excised and placed on 200-mesh copper TEM grids in a wick-type solution washer with 100 percent dimethyl formamide.

Two grids are placed consecutively in the TEM for examination. Five grid openings are examined on each at 15,000 time magnification. Asbestos structures containing fibers which meet a more than 3:1 length:width aspect ratio and a minimum length of 1 μ m are identified by morphology by selected area electron diffraction and energy-dispersive x-ray spectroscopy. Fibers are classified by structure type, sized (length and width), and identified as chrysotile, amphibole, ambiguous, or nonasbestos.

Results are reported as total asbestos structures per square millimeter of filter and asbestos structures per cubic centimeter of air.

³NIOSH Method 7402 For Asbestos Fibers (modified), August 15, 1987.

APPENDIX D

**PRECAUTIONARY MEASURES FOR ROUTINE
MAINTENANCE AND REMODELING OPERATIONS**

PRECAUTIONARY MEASURES FOR ROUTINE MAINTENANCE AND REMODELING OPERATIONS

A. Maintenance Activities

The following precautions should be taken whenever maintenance activities may potentially disturb or release asbestos fibers. Many of these precautions are required by the Occupational Safety and Health Administration's (OSHA) new asbestos standard contained in the Code of Federal Regulations (29 CFR 1926.58).

Maintenance activities should be performed when the affected area is unoccupied. If any asbestos-containing materials have been dislodged during maintenance work, the affected area should be cleaned with a vacuum system equipped with high efficiency particulate air (HEPA) filters. Accumulations of asbestos dust should be cleaned up with a HEPA vacuum or by wet mopping. Dry sweeping causes fibers to become airborne.

Persons performing routine maintenance work should be monitored to determine their exposures to asbestos fibers. Maintenance personnel should be provided with and required to wear respirators approved by the National Institute for Occupational Safety and Health (NIOSH). Each maintenance employee should be trained in the correct use and maintenance of these respirators, evaluated by a physician to determine his or her ability to use a respirator and be fit-tested to determine that the respirator selected will provide adequate protection for that individual.

Maintenance workers should receive instruction in the potential health effects of asbestos and in safe work practices, including what precautions to take to minimize disturbance of the asbestos-containing materials.

B. Renovation Activities

Any plans for renovation should be carefully evaluated to determine if such activities will involve disturbance of asbestos-containing material; if so, the following precautions should be taken.

The renovation area should be isolated from the remainder of the facility. Typically, this involves the construction of a temporary plastic barrier with an "air lock" for worker entry. Ventilation in the zone should be temporarily isolated (the air movement system between the renovation area and neighboring areas should be shut off) and an exhaust fan should be used to place the renovation area under a slight negative air pressure in relation to the rest of the facility. The fan should exhaust out-of-doors and be equipped with a HEPA filter.

All persons entering the renovation area should be provided with and required to use NIOSH-approved respirators and disposable coveralls and caps. Requirements for fit-testing and medical evaluation as described above for maintenance workers also apply to renovation workers. Air monitoring should be performed routinely around the perimeter of the renovation area to ensure that asbestos fibers are not released into other areas of the building. Personal sampling should also be conducted to evaluate potential exposures of renovation workers to asbestos and to determine the type of respiratory protection required.

Construction debris that may contain asbestos must be sealed in impermeable containers, labeled, and disposed in accordance with U.S. EPA and OSHA requirements.

Warning signs must be posted around the renovation area. These signs must meet current OSHA requirements.

Whenever possible, the asbestos-containing materials should be wetted prior to any disturbance to reduce asbestos fiber emission. Prior to dismantling the barriers at the completion of work, the area should be cleaned thoroughly using wet mops or vacuums with HEPA filters. Clearance air sampling should be conducted at this time to ensure that asbestos concentrations are at or below 0.01 fibers (longer than 5 micrometers) per cubic centimeter of air (f/cc). The 0.01 f/cc limit is the EPA recommended clearance criterion for reoccupancy after construction activities involving asbestos-containing materials.