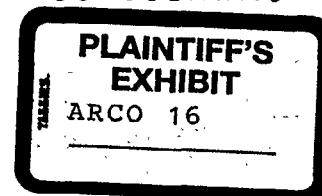


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CONSULTANTS



**Industrial Hygiene Monitoring and
Employee Awareness Training
aboard the SS *Arco Spirit*
for
ARCO Marine, Inc.
Long Beach, California**

Clayton Project No. 36087.04

November 22, 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 Spirit*. The scope of services provided by Clayton is described in our Proposal 91-PIH-148, dated June 19, 1991, and included 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) conduct asbestos awareness training sessions on board the ship while underway.

The northbound trip aboard the SS *Arco Spirit* a 262,000-dwt ship constructed in 1977, covered approximately 2,100 nautical miles at 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
- Select staterooms
- Several locations throughout the engine room
- Galley
- Fan room A-Deck

From October 2 through October 7, 1991, Mr. Steven R. O'Donnell, Industrial Hygienist with Clayton, assessed the condition of the asbestos-containing materials, collected air samples, and performed the asbestos awareness 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. One sample showing airborne fiber concentration of over 0.01 fibers/cubic centimeter (f/cc) was subjected to analysis by transmission electron microscopy (TEM) for positive fiber identification.

No bulk samples of insulation or construction materials were collected for asbestos analysis during this survey.

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

Air sampling was performed using electrically-operated high volume sampling pumps at a flow rate of approximately 15 liters per minute (LPM). All samples collected were area samples.

Area samples were collected randomly throughout the house, engine, and fan rooms. Select samples were collected in specific locations such as the AB stateroom on A-Deck and the Chief Mate's stateroom.

2.2 SUMMARY OF TRAINING SESSIONS

During the northbound voyage an "Asbestos Awareness Training" session was presented to the officers and crew of the SS *Arco Spirit*. 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 asbestos awareness presentation, an informal question and answer session was carried out.

3.0 DESCRIPTION OF OPERATIONS

The SS *Arco Spirit* routinely travels in ballast from ARCO terminals along the U.S. West Coast and Panama to the Alyeska Terminal in Valdez, Alaska. The vessel normally carries approximately 300,000 bbls of ballast water. Sea conditions were generally calm, with slight seas and clear weather throughout the voyage.

During the voyage, the ship 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 on the ship is conducted while in port by a licensed asbestos abatement contractor.

Personal protective equipment on the ship included, but was 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 standard mandates 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

A total of 24 samples were collected on board the ship. Analyses of these samples was performed using Phase Contrast Microscopy (PCM).

Air sampling results are tabulated in Appendix A. The sampling and analytical methods are summarized in Appendix B.

5.1 AIR MONITORING RESULTS

The results of PCM analysis for these samples indicated airborne fiber concentrations ranging from 0.001 to 0.02 f/cc. Samples showing concentrations of airborne fibers at 0.01 f/cc or above were analyzed by TEM. The results of TEM analysis for the one sample submitted indicated airborne asbestos fiber concentrations of <0.00026 fibers per cubic centimeter (f/cc). Results of analysis are shown in Tables 1 and 2 of Appendix A.

5.2 ASBESTOS MATERIALS CONDITION ASSESSMENT

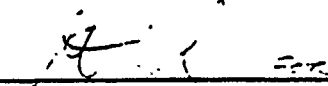
Overall, the asbestos-containing materials found on board the ship were in good condition. The pipe lagging on the domestic water piping was not wide-spread, but was limited to the laundry rooms, linen rooms, and deck water closets. The insulation materials found throughout the engine and pump room was in good condition with a few damaged areas.

The insulation materials in the overhead of the AB stateroom on A-Deck were in fair condition. This was the only overhead that was removed during the course of the voyage to Valdez.

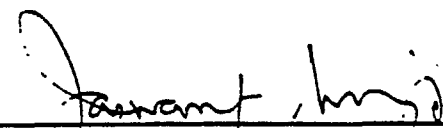
Unless damaged or disturbed, cohesive asbestos-containing materials do not tend to become airborne. It is conceivable that water damage, maintenance activities, or vandalism could disturb the asbestos-containing materials, thereby increasing the risk of generating airborne asbestos fibers.

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 C.

This report prepared by:


Steven R. O'Donnell
Industrial Hygienist

This report reviewed by:


Jaswant Singh, Ph.D., CIH
Senior Vice President
Director, Pacific Operations

November 22, 1991

APPENDIX A
RESULTS OF SAMPLING FOR AIRBORNE FIBERS

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

CLAYTON PROJECT NO. 36087.04
SAMPLING DATE: OCTOBER 3, 1991

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration
		Start	Stop		Fibers Per cc
SP-103-01	Officer's Lounge	1052	1352	2,800	0.0015
SP-103-02	Crew's Lounge	1059	1359	2,600	0.0025
SP-103-03	AB Stateroom, A-Deck	1102	1402	2,800	0.02*
SP-103-04	Chief Engineer's Office	1114	1407	2,500	0.003
SP-103-05	Main Deck Passageway Athwartship	1121	1417	2,600	0.003
SP-103-06	Captain's Office	1357	1641	2,500	0.002
Fiber Concentration Standards		Weather: Calm Seas			
OSHA PEL = 0.2 f/cc		Approximate Ship Location: Monterey, California			
Coast Guard (Working Environment) = 2.0 f/cc		Ballast: Normal			
Coast Guard (Living Environment) = 0.1 f/cc		*Sample submitted for TEM Analysis (See Table 2)			
EPA Recommended Clearance Level = 0.01 f/cc					

TABLE 1 (continued)
RESULTS OF SAMPLING FOR AIRBORNE FIBER CONCENTRATIONS
ABOARD THE S/S ARCO SPIRIT
FOR
ARCO MARINE INCORPORATED
LONG BEACH, CALIFORNIA

CLAYTON PROJECT NO. 36087.04
SAMPLING DATE: OCTOBER 4, 1991

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration
		Start	Stop		Fibers Per cc
SP-104-01	Engine Room, Port side of Control Panel	1038	1346	2,900	0.006
SP-104-02	Engine Room, Stern side of Boilers	1042	1351	3,000	0.001
SP-104-03	Officer's Mess	1236	1552	3,100	0.002
SP-104-04	Galley	1235	1549	2,900	0.001
SP-104-05	Crew's Mess	1232	1539	2,800	0.002
SP-104-06	Fan Room	1547	1939	2,600	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: California/Oregon Border

Ballast: Normal

TABLE 1 (continued)
RESULTS OF SAMPLING FOR AIRBORNE FIBER CONCENTRATIONS
ABOARD THE S/S ARCO SPIRIT
FOR
ARCO MARINE INCORPORATED
LONG BEACH, CALIFORNIA

CLAYTON PROJECT NO. 36087.04
SAMPLING DATE: OCTOBER 5, 1991

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration Fibers Per cc
		Start	Stop		
SP-105-01	Officer's Lounge	0926	1234	2,800	0.004
SP-105-02	Crew's Lounge	1003	1406	3,700	0.002
SP-105-03	Chief Mate's Office	1007	1411	3,700	0.002
SP-105-04	Engine Room, Port side of Contaminated Drain Tank	1020	1415	3,700	0.002
SP-105-05	Engine Room, Forward of Main Circulating Pump #1	1030	1418	3,500	0.001
SP-105-06	Main Deck Passageway Athwartship	1408	1709	2,700	<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/Washington Border

Ballast: Normal

TABLE 1 (continued)
RESULTS OF SAMPLING FOR AIRBORNE FIBER CONCENTRATIONS
ABOARD THE S/S ARCO SPIRIT
FOR
ARCO MARINE INCORPORATED
LONG BEACH, CALIFORNIA

CLAYTON PROJECT NO. 36087.04
SAMPLING DATE: OCTOBER 6, 1991

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration Fibers Per cc
		Start	Stop		
SP-106-01	Officer's Mess	1244	1553	2,800	0.001
SP-106-02	Crew's Mess	1245	1554	2,800	0.003
SP-106-03	Captain's Office	1114	1420	2,800	0.004
SP-106-04	Chief Engineer's Office	1107	1416	2,900	0.006
SP-106-05	Engine Room, Aft side of Boiler Steam Drums	1124	1426	3,000	0.001
SP-106-06	Fan Room, A-Deck	1431	1739	2,800	0.003

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: Graham Island
Ballast: Normal

TABLE 2
RESULTS OF SAMPLING FOR AIRBORNE ASBESTOS FIBER CONCENTRATIONS
ABOARD THE S/S ARCO SPIRIT
FOR
ARCO MARINE INCORPORATED
LONG BEACH, CALIFORNIA

CLAYTON PROJECT NO. 36087.04
SAMPLING DATE: OCTOBER 3, 1991

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration Structures Per cc
		Start	Stop		
SP-103-03	AB Stateroom	1102	1402	2,800	<0.00026

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: Monterey, California

Ballast: Normal

APPENDIX B
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).

**SAMPLING AND ANALYTICAL METHOD
TRANSMISSION ELECTRON MICROSCOPY (TEM)
MODIFIED NIOSH 7402 METHOD¹**

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.

¹NIOSH Method 7402 For Asbestos Fibers (modified), August 15, 1987.

APPENDIX C

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.