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Industrial Hygiene Assessment Employee Awareness Training and Limited Bulk Sampling Aboard the SS *Arco Anchorage* for ARCO Marine, Inc. Long Beach, California

Clayton Project No. 36087.05

December 12, 1991

CONTENTS

1.0 INTRODUCTION

ARCO Marine, Inc. retained Clayton Environmental Consultants, Inc. to conduct an industrial hygiene monitoring and employee awareness training program during the northbound sailing of the SS *Arco Anchorage*. 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) 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 Anchorage* a 120,000-dwt ship constructed in 1973, covered approximately 2,100 nautical miles at a total time of just under five days. Air sampling was conducted during normal working operations while at sea. The following locations were monitored:

- Main deck, athwartship
- D-deck, athwartship
- Select staterooms
- Several locations throughout the engine room
- Radio room
- Cargo control room
- Gym

From October 21 through October 27, 1991, Mr. Mark Hammer, Industrial Hygienist with Clayton assessed the condition of the asbestos-containing materials, collected air and bulk samples, and performed the training sessions. Forensic Analytical Specialties, Inc. laboratory analyzed all air samples using phase-contrast microscopy (PCM) in accordance with the National Institute of Occupational Safety and Health (NIOSH) Method 7400A. Clayton Environmental Consultants, Inc.'s laboratory in Novi, Michigan, a National Voluntary Laboratory Accreditation Program (NVLAP)-accredited laboratory analyzed the bulk 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. Hammer's subjective observations.

2.1 SUMMARY OF ASSESSMENT

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

Area samples were collected randomly throughout the house, and engine room. Samples were also collected in specific locations such as the radio room and gymnasium.

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

- Tank insulation
- Pump insulation
- Pipe insulation
- Cloth pipe lagging

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 Anchorage* routinely travels in ballast from ARCO terminals along the U.S. West Coast to the Alyeska Terminal in Valdez, Alaska. The vessel carried approximately 337,000 bbls of ballast water, which is an average winter load. Sea conditions were moderate, with slight to rough seas and cloudy 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 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

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 total of 23 samples were collected and submitted for laboratory analysis during this survey in order to evaluate all potential exposure areas.

5.1 AIR MONITORING RESULTS

The results of PCM analysis for these samples indicated airborne fiber concentrations ranging from less than 0.001 to 0.01 f/cc. Samples showing concentrations of airborne fibers at 0.01 f/cc or above were analyzed by Transmission Electron Microscopy (TEM) for positive

identification of asbestos. The result of the TEM analysis for one sample (AN-1024-01) indicated an airborne asbestos fiber concentration of less than 0.00034 f/cc. Results of TEM analysis are shown in Table 4 of Appendix A.

5.2 BULK SAMPLE RESULTS

Clayton's assessment included the collection of samples of suspect asbestos-containing materials for testing. As detailed in Appendix B, asbestos was not identified in any of the materials we tested.

Although asbestos was not detected in any of the bulk samples collected, asbestos-containing materials are known to be present on this and other ARCO ships.

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: _____
Mark Hammer
Industrial Hygienist

This report reviewed by: _____
Jaswant Singh, Ph.D., CIH
Senior Vice President
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December 12, 1991

APPENDIX A

RESULTS OF SAMPLING FOR AIRBORNE FIBERS

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

CLAYTON PROJECT NO. 36087.05
SAMPLING DATE: OCTOBER 22, 1991

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration
		Start	Stop		Fibers Per cc
AN-1022-01	Third Officer's stateroom	1205	1435	2,300	0.001
AN-1022-02	Crew Mess	1220	1455	2,400	0.002
AN-1022-03	Cargo Control Room	1209	1405	1,800	<0.001
AN-1022-04	Engine Room - at Control Panel	1211	1445	2,400	<0.001
AN-1022-05	Gym - during ceiling panel removal	1405	1605	1,900	0.006
AN-1022-08	Gym - during ceiling panel removal	1605	1730	1,300	<0.002
AN-1022-06	Hospital Stateroom	1435	1645	2,000	0.002
AN-1022-07	Crew Lounge	1455	1655	1,900	0.002
AN-1022-09	Main Deck Athwartship Passageway	1730	1930	1,900	<0.001
Blank 1	Blank	-	-	0	None Detected

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: Rough Seas
Approximate Ship Location: Point Arena
Ballast: Normal Winter Load

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

CLAYTON PROJECT NO. 36087.05
SAMPLING DATE: OCTOBER 23, 1991

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration
		Start	Stop		Fibers Per cc
AN-1023-01	Engine Room at Control Panel	1215	1415	1,900	<0.001
AN-1023-02	Main Deck Athwartship Passageway	1215	1425	2,000	<0.001
AN-1023-03	Radio Room - During Ceiling Panel Removal	1355	1630	2,400	0.003
AN-1023-04	D-Deck Athwartship Passageway - During Ceiling Panel Removal	1420	1630	2,000	0.006
AN-1023-05	Crew Lounge	1435	1730	2,700	<0.001
AN-1023-06	Third Officer's Stateroom	1505	1735	2,300	0.001
AN-1023-07	Hospital Stateroom	1736	1948	2,100	<0.001
AN-1023-08	Pumpman #2 Stateroom	1740	1948	2,000	<0.001
Blank 1	Blank	-	-	0	None Detected

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: Slight Seas
Approximate Ship Location: Newport, Oregon
Ballast: Normal Winter Load

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TABLE 3
RESULTS OF SAMPLING FOR AIRBORNE FIBER CONCENTRATIONS ABOARD THE S/S ARCO ANCHORAGE FOR ARCO MARINE INCORPORATED LONG BEACH, CALIFORNIA

CLAYTON PROJECT NO. 36087.05
SAMPLING DATE: OCTOBER 24, 1991

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration
		Start	Stop		Fibers Per cc
AN-1024-01	Pumpman #2 Stateroom	0940	1200	2,200	0.010*
AN-1024-02	Cargo Control Room	0942	1200	2,200	<0.001
AN-1024-03	Radio Room - During Ceiling Panel Removal	1323	1628	2,900	0.003
AN-1024-04	D-Deck Athwartship Passageway - During Ceiling Panel Removal	1323	1628	2,900	0.003
AN-1024-05	Crew Mess	1310	1510	1,900	0.002
AN-1024-06	Gym	1200	1415	2,200	<0.001
Blank 1	Blank	-	-	0	None Detected

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: Moderate Seas
Approximate Ship Location: Vancouver Island
Ballast: Normal Winter Load
*Sample submitted for TEM analysis (See Table 4)

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TABLE 4
RESULTS OF SAMPLING FOR AIRBORNE FIBER CONCENTRATIONS BY TEM
ABOARD THE S/S ARCO ANCHORAGE
FOR
ARCO MARINE INCORPORATED
LONG BEACH, CALIFORNIA

CLAYTON PROJECT NO. 36087.05
SAMPLING DATE: OCTOBER 24, 1991

Sample Number	Sample Location	Sampling Period		Volume of Air (Liters)	Concentration
		Start	Stop		Fibers Per cc
AN-1024-01	Pumpman #2 Stateroom	0940	1200	2,200	<0.00034

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: Moderate Seas
Approximate Ship Location: Vancouver Island
Ballast: Normal Winter Load

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.

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BULK SAMPLE ANALYTICAL RESULTS

Building: S/S Arco Anchorage
Date: October 23, 1991
Investigator: M. Hammer

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

Material Sampled	Location of Material in Building	Estimated Amount Present: Length	Dia	Sq Ft	Cond	Access	Friability	Field I.D.	Sample Location	Percent Asbestos*: Amos	Chrys	Croc	ND	Total Percent Asbestos
Blanket-type insulation	Throughout Engine Room			NQ	G	E	L	AN-BULK-01	Port Feed Pump - Engine Room				X	
Lagging on blanket-type insulation	Throughout Engine Room			NQ	G	E	L	AN-BULK-02	Port Feed Pump - Engine Room				X	
Tank insulation	Throughout Engine Room			NQ	F	E	M	AN-BULK-03	DA Tank - Engine Room (A Deck)				X	
Cloth lagging	Throughout Engine Room			NQ	F	E	L	AN-BULK-04	DA Tank - Engine Room (A Deck)				X	
Elbow joint cloth lagging	Throughout Ship			NQ	F	E	L	AN-BULK-05	Emergency Battery Room				X	
Cloth lagging	Throughout Ship			NQ	F	E	L	AN-BULK-07	No. 2 Cargo Pump Exhaust Line				X	
Pipe insulation	Throughout Ship			NQ	F	E	M	AN-BULK-08	No. 2 Cargo Pump Exhaust Line				X	

*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
Croc = Crocidolite

ND = Not Detected (<1%)
NQ = Not Quantified

APPENDIX C

SAMPLING AND ANALYTICAL METHODS

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 staining[1]. 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) method[2].

[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 METHOD[3]

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 um 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.

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

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).

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.