OPERATING ENGINEERS NATIONAL HAZMAT PROGRAM

INTERNATIONAL ENVIRONMENTAL TECHNOLOGY & TRAINING CENTER

SURFACE TECHNOLOGY SYSTEMS (STS)
ADVANCED RECYCLABLE MEDIA SYSTEM
(ARMS™)
(METAL)

HUMAN FACTORS ASSESSMENT

MARCH, 1998

SURFACE TECHNOLOGY SYSTEMS (STS)

ADVANCED RECYCLABLE MEDIA SYSTEM (ARMSÔ)(METAL)

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ACKNOWLEDGEMENTS

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Barbara McCabe	Operating Engineers National Hazmat Program
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EXECUTIVE SUMMARY

The ARMS™ uses a soft media that is highly absorptive and can be used either dry or wetted to capture, adsorb, and remove surface contaminants, such as oils, grease, lead compounds, chemicals, and radionuclides. Steam may also be used to provide for dust control without creating a liquid waste steam.

The system consists of transportable modules. The feed unit is a portable pneumatically powered device for propelling the cleaning media against the surface to be cleaned. A hopper, mounted atop the unit, holds the cleaning media. The media is fed by the auger device into a metering chamber which mixes the cleaning media with compressed air. The mixture is transported, using standard abrasive blasting hose through a standard abrasive nozzle, to the surface to be cleaned. By varying the unit air pressure and grade of cleaning media, the system can remove surface contamination from soot to fully cured high-performance protective coatings from steel and concrete surfaces.

The sifter unit is used to mechanically remove large debris and powdery residues from the cleaning media after each use. The cleaning media is collected in the work area and placed into the electrically-powered screener. The unit vibrates causing the used media to pass vertically downward through a series of separation screens. Any course materials, such as point flakes, rust particles, etc., are collected in the first and coarsest screen. Next, the reusable media is collected on the finer screen. Finally, any dust particles pass through the screener for proper collection and disposal.

The system requires that it be used in a contained work space or a containment area be built. During the testing demonstration, the system was used inside a shed that was built for the purpose of conducting the metal decontamination demonstrations. An air mover, which provided general ventilation at approximately 2000 cfm (according to the technology developer), was installed in one of the window openings of the shed. The air from inside the shed was filtered by a high efficiency particulate air (HEPA) filter before being exhausted outside of the shed.

The media used for blasting during the testing demonstration was ARMS™ Aluminum Oxide Fiber Media which is classified as a dry abrasive sponge. It is composed of alpha alumina and titanium dioxide. The percent of each is not provided on the material data sheet (MSDS) but is listed as a proprietary composition.

During the assessment sampling was conducted for dust and noise and general observational techniques were conducted for ergonomics. The main ergonomic concern is the posture the arms (of the operator) must be in while holding the weight of the blast nozzle. This has the potential to cause sprain/strain/fatique to the arms, shoulders, and upper and lower back. Reducing the weight of the nozzle or mounting the nozzle on an adjustable frame so it can be moved where needed would help to reduce and/or alleviate these ergonomic concerns.

Area dust samplings were conducted for total dust. There were three operators and they changed out of the work area every 20-30 minutes. Therefore, area sampling was conducted to determine the potential exposures over a longer period of time.

All of the area air sampling values were in excess of the OSHA PEL and the ACGIH TLV of 15 mg/m^3 and 10 mg/m^3, respectively for total dust. It must also be noted that at the end of each sampling period, there was ¼ - ½ inch of dust on the sampling filter. These dust levels indicate the possible need for air-line respirators or SCBAs when working inside the work area.

Area noise monitoring was conducted. Monitoring showed noise doses of 3079.62% which gives a time-weighted average (TWA) of 109.4 dBA, 137.05% (TWA – 92.3 dBA), and 226.40% (TWA – 95.9 dBA).

The OSHA allowable PEL for noise is a 100% dose or an 8-hour TWA of 90 dBA. The above noise doses and TWA's show noise to be an exposure hazard for the operator of the ARMS™. Feasible engineering controls, administrative controls, and personal protective equipment (hearing protection devices) need to be used as appropriate. Operators would be required to be included in a hearing conservation program.

Recommendations for improved worker safety and health during use of the ARMS™ include: 1. keeping all hoses and lines as orderly as possible in compliance with good housekeeping requirements; 2. ergonomic training to include techniques in lifting, bending, stooping, twisting, etc.; 3. PPE compatible with the level of exposure; 4. GFCI and appropriate grounding on all electrical connections; 5. warning lights for communication in the containment area; 6. one worker in the containment area at a time; and 7. engineering and administrative controls as well as hearing protection devices to reduce noise exposure.

SURFACE TECHNOLOGY SYSTEMS (STS)
ADVANCED RECYCLABLE MEDIA SYSTEM (ARMS™)
(METAL)
Human Factors Assessment

SECTION 1 - SUMMARY

TECHNOLOGY DESCRIPTION

The Surface Technology Systems (STS) Advanced Recyclable Media System (ARMS™) technology was tested and is being evaluated at Florida International University (FIU). In conjunction with FIU's evaluation of efficiency and cost, this report covers the hazard analysis and safety evaluation that was conducted. It is a commercially available technology that has been used for various projects at locations throughout the country.

The ARMS™ uses a soft media that is highly absorptive and can be used either dry or wetted to capture, adsorb, and remove surface contaminants, such as oils, grease, lead compounds, chemicals, and radionuclides. Steam may also be used to provide for dust control without creating a liquid waste stream. The ARMS™ equipment consists of a feed and sifter unit.

KEY RESULTS

The safety and health evaluation during the testing demonstration focused on two main areas of exposure: dust and noise. Dust and noise exposure was significant. Both were in excess of the Occupational Safety and Health (OSHA) permissible exposure limits (PEL) and American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV). Other safety and health hazards found were ergonomics, heat stress, tripping hazards, electrical hazards, and lockout/tagout.

SECTION 2 - SYSTEM OPERATION

The ARMS™ uses a soft media that is highly absorptive and can be used either dry or wetted to capture, adsorb, and remove surface contaminants, such as oils, grease, lead compounds, chemicals, and radionuclides. Steam may also be used to provide for dust control without creating a liquid waste stream.

The system consists of transportable modules. The feed unit is a portable pneumatically powered device for propelling the cleaning media against the surface to be cleaned. A hopper, mounted atop the unit, holds the cleaning media. The media is feed by the auger device into a metering chamber which mixes the cleaning media with compressed air. The mixture is transported using standard abrasive blasting hose through a standard abrasive nozzle to the surface to be cleaned. By varying the unit air pressure and grade of cleaning media, the system can remove surface contamination from soot to fully cured high-performance protective coatings from steel and concrete surfaces.

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Figure 1. ARMS unit located outside shed where metal decontamination is taking place.

The system requires that it be used in a contained work space or that a containment area be built. During the testing demonstration, the system was used inside a shed that was built for the purpose of conducting the metal decontamination demonstrations. An air mover, which provided general ventilation at approximately 2000 cfm (according to the technology developer), was installed in one of the window openings of the shed. The air from inside the shed was filtered by a high efficiency particulate air (HEPA) filter before being exhausted outside of the shed.

Figure 2. Worker inside shed blasting metal plate.

The media used for blasting during the testing demonstration was ARMS^{TM} Aluminum Oxide Fiber Media which is classified as a dry abrasive sponge. It is composed of alpha alumina and titanium dioxide. The percent of each is not provided on the material safety data sheet (MSDS) but is listed as a proprietary composition.

SECTION 3 - HEALTH AND SAFETY EVALUATION

GENERAL SAFETY AND HEALTH CONCERNS

Personnel where the ARMS^{TM} technology is being used need to be concerned with safety and health issues. Issues that personnel need to be cognizant of may be divided into two categories. Core issues are those that are based on current safety and health regulatory requirements. Best management practices are related to issues that are not based on current safety and health regulations, but are key elements in preventing worker injury and illness on the job.

Safety and health issues of concern with the ARMS^{TM} blaster technology included:

Core Issues:

- Housekeeping - The high pressure lines, water line, electrical lines, and abrasive blasting hose and nozzle are necessary for system operation but are tripping hazards. Stringent housekeeping must be addressed.

- Electrical hazards - The sifter unit and HEPA filter unit require 110 volt 20 amp circuits and the vapor generator requires a 220 volt 30 amp circuit for operation. They may present electrical hazards and the need for ground fault circuit interrupters (GFCI) and grounding must be evaluated. The electrical lines in the area of the vapor generator unit present additional concerns due to the water in the area.

- Lockout/Tagout - Before any maintenance or decontamination activities are conducted hazardous energy sources need to be eliminated. A lockout/tagout program will need to be developed, if the user does not have one.

- Personal Protective Equipment (PPE) - PPE must be chosen based on both the hazard and the severity of the hazard. The total dust levels measured during the testing demonstration indicate that Level B respiratory protection, an air-line respirator/self-contained breathing apparatus, may be the minimum requirement for workers inside the work area.

- Noise - Noise levels were found to be excessive during the operation of the blasting system. This will be discussed in greater detail in the Industrial Hygiene section of this report.

- Dust - Dust levels were found to be excessive during the operation of the blasting system. When blasting was being conducted, the equipment and the operators inside the work area were not visible. This was due to the dust being generated inside the work area.

Best management practices:

- Struck-by hazards - The blasting media bounces off of the surface being cleaned and strikes other surfaces and workers inside the containment. Since anyone inside the containment must wear appropriate PPE, this is not a concern but should be noted. This may, however, cause the spread of contamination to all surfaces inside the containment.

- Compressed Air - There is the potential for injury from the compressed air itself or the air hoses if an accidental disconnect, rupture, or leak occurs.

- Diesel exhaust - Operation of the ARMS™ requires an air compressor. If a diesel generated air compressor is used, the potential exists for exposure to diesel exhaust. Diesel should not be exhausted indoors or where the exhaust can be pulled into an air intake.

- Heat stress - Workers are subjected to an increase in heat stress due to the need to utilize PPE. The user will need to develop a heat stress program for the environment in which the blaster is being used, taking into consideration any PPE that may need to be utilized, ambient temperatures, etc.

- Ergonomics - There are ergonomic stressors associated with the use of the ARMS™. The main concern is the posture, particularly with the arms, that must be assumed while holding the blast nozzle, which has considerable weight.

- Communication - Due to the noise generated by the technology during operation, communication was difficult. Hand signals may be beneficial but due to the high levels of dust and therefore, low visibility inside the containment, they would be of limited value. Other types of signals may be necessary inside the containment such as flashing lights.

INDUSTRIAL HYGIENE MONITORING

During the testing demonstration with the STS ARMS™, sampling was conducted for dust and noise. In addition, the wet-bulb globe temperature was monitored to evaluate heat stress and observational evaluation was conducted for ergonomics.

Through general observational techniques the potential for ergonomic stressors was evaluated during the testing demonstration. The main ergonomic concern is the posture the arms (of the operator) must be in while holding the weight of the blast nozzle. This has the potential to cause sprain/strain/fatigue to the arms, shoulders, and upper and lower back. Reducing the weight of the nozzle or mounting the nozzle on an adjustable frame so it can be moved where needed would help to reduce and/or alleviate these ergonomic stressors.

When blasting low on the metal piece, there is the potential for sprain/strain to the back, knees, legs, and ankles due to the bending, stooping, and kneeling required to blast the lower areas. When blasting the higher areas, there is the potential for sprain/strain to the back, neck, shoulders, and arms.

As previously stated, many of these stressors could be lessened or eliminated by reducing the weight of the blast nozzle and/or by mounting the nozzle to an adjustable/moveable frame.

Heat stress parameters were monitored using a Quest QuestTemp°15 Heat Stress Monitor. The wet-bulb globe temperature was used to determine the work/rest regimen in accordance with ACGIH recommendations. The wet-bulb globe temperature was adjusted in accordance with ACGIH recommendations for the type of clothing, including PPE, that the worker was wearing. While heat stress will be increased when wearing PPE, the overall heat stress response will vary from worker to worker. Each situation in which the current technology is used will need to be evaluated for the heat stress potential, taking into consideration the wet-bulb globe temperature, PPE in use, physical condition of the worker, and amount of worker acclimatization.

Dust monitoring was conducted with a sampling train consisting of an SKC IOM Inhalable dust sampler coupled with an MSA Escort Elf air sampling pump. Pre- and post-sampling calibration was accomplished using a BIOS International DryCal DC1 primary calibration system. Sampling filters were desiccated pre- and post-sampling and weighed on an OHAUS Scout Electronic Balance. Sampling was conducted in accordance with the National Institute of Occupational Safety and Health (NIOSH) method 0500.

Area dust sampling was conducted for total dust. There were three operators and they changed out of the work area every 20-30 minutes. Therefore, area sampling was conducted to determine the potential exposures over a longer period of time. All dust sampling results were in excess of the OSHA PEL and ACGIH TLV of 15 mg/m^3 and 10 mg/m^3 respectively. At the end of each sampling period, it was noted that there was ¼ - ½ inch of visible dust on the sampling filter.

In addition to monitoring for total dust, respirable dust, coating constituents, and/or metal constituents, consideration needs to be given to monitoring for the constituents of the blasting media. The media is broken down as it is continually used to blast the surface being cleaned. The blasting media used during the testing demonstration was aluminum oxide. This may also need to be sampled to assess potential operator exposure.

Area dust sampling results showed potential exposure levels of 43.0 mg/m^3, 72.49 mg/m^3, 72.49 mg/m^3, and 1230.0 mg/m^3. These dust levels indicate the need for air-line respirators or SCBA when working inside the containment area where blasting is occurring. See Appendix B for a table of the air sampling results.
Area noise monitoring was conducted during the operation of the blaster. As with dust sampling, since the operators were changing every 20-30 minutes, area monitoring was conducted to determine the potential for exposure to noise over a longer period of time. Noise monitoring was conducted using Metrosonic db-3100 data logging noise dosimeter. Calibration was conducted pre- and post-monitoring using a Metrosonics CL304 acoustical calibrator.

Area noise measurements were taken for 2.68 hours (161 minutes), 2.65 hours (159 minutes), 2.65 hours (159 minutes), 2.60 hours (156 minutes), and 3.46 hours (208 minutes). This gave noise doses of 3079.62% which gives a time-weighted average (TWA) of 114.7 dBA, 2895.11% (TWA-114.3 dBA), 1472.60% (TWA-109.4 dBA) 137.05% (TWA-92.3 dBA), and 226.40% (TWA-95.9 dBA). If theses noise levels were the same over an 8-hour period, projected noise doses would be 9169.72% (TWA-122.6 dBA), 8733.40% (TWA-122.2 dBA), 4437.59% (TWA-117.3 dBA), 420.58% (TWA-100.3 dBA), and 521.48% (TWA-101.9 dBA). During these time periods the noise levels were averaged for each one-minute period of time. An overall average was calculated yielding an average exposure level of 122.6 dB, 122.2 dB, 117.3 dB,100.3 dB, and 101.9 dB. The maximum sound levels during the sampling periods were 132.5 dB, 132.4 dB, 129.7 dB, 100.3 dB, and 101.9 dB. The highest instantaneous sound pressure level for all samples was greater than 140.0 dB. The amount of time spent at each loudness level that comprises the exposures can be seen in Appendix B.

The OSHA allowable PEL for noise is a 100% dose or an 8-hour TWA of 90 dBA. The above noise doses and TWA's show noise to be an exposure hazard for the operator of the ARMS™. The TWA's are at a level where the operator would be required to be included in a hearing conservation program. Engineering controls need to be initiated for this system. In addition to engineering controls, administrative controls and PPE will need to be utilized.

HUMAN FACTORS INTERFACE

The need to utilize different levels of personal protective equipment, such as Level A, B, C, or D will depend on the contaminants associated with the metal being decontaminated and the amount of dust being generated. Contaminants should be identified by the site characterization prior to the start of the metal decontamination job. The amount of dust being generated will be identified by air sampling conducted during operation of the ARMS™.

The level of protection being utilized has the potential to cause several human factors interface problems. These may include but not be limited to visibility, manual dexterity, tactile sensation, an increase in heat stress, and an overall increase in physical stress.

The ergonomic stressors the operator was exposed to during operation of the ARMS™, creates an additional human factors interface issue. It is recommended that further evaluation of these ergonomic stressors be evaluated.

TECHNOLOGY APPLICABILITY

The technology produced an excessive amount of dust and noise during operation. All dust samples were in excess of the OSHA PEL and the ACGIH TLV. The ventilation system (filter unit) used in the building where decontamination took place needs to be evaluated to determine what needs to be done to improve the system. All noise monitoring indicated that workers would be overexposed in accordance with the OSHA PEL and the ACGIH TLV.

The ARMS™ will need to be disassembled to be decontaminated. This will not necessarily guarantee that the equipment will be “clean”. Parts of the system may need to be considered consumables. There is a special concern with the recycling of the blasting media and spreading contamination to the internal parts of the equipment.

SECTION 4 - JOB SAFETY ANALYSIS

JOB SAFETY ANALYSIS
SURFACE TECHNOLOGY SYSTEMS (STS)
ADVANCED RECYCLABLE MEDIA SYSTEM (ARMS™)
(METAL)

HAZARD	CORRECTIVE ACTION
UNLOADING EQUIPMENT/SETUP	
* Pinch points	* Use of hand protection * Use proper hand tools for the job * Never place hand or finger inside the blast pot to assure media flow
* Slips/Trips/Falls	* Awareness of specific hazards * Organization of materials (housekeeping) * Walking around areas that are congested/slippery when possible * Walking around tripping hazards when possible * Marking, isolating, bunching together tripping hazards, such as air lines
* Struck-by/Caught between	* Awareness of where equipment is being moved at all times * Prohibit worker from being between moving and stationary objects at all times * Keep personnel clear of moving objects
* Muscular/back injury (from setting up equipment and loading media into hopper)	* Ergonomic training to include safe lifting techniques * Use of equipment such as forklift or crane for unloading * Use mechanical lifting device to load media into hopper

* Electrical Hazards	* Inspect all cords before using * Keep all cords out of wet areas, do not place in water, inspect water line before connecting * Assure grounding of all equipment, assure use of GFCI
OPERATION OF THE ARMS™	
* Struck-by hazard from air-line	* Inspect all air lines and secure with safety pin before operation * Use of safety line (in addition to pin) between male and female ends of connectors
* Electrical hazards	* Inspect all cords before using * Keep all cords out of wet areas, do not place in water, inspect water line before connecting (to make sure does not leak) * Assure grounding of all equipment, assure use of GFCI
* Injury from hitting self or co-worker with blast from blast nozzle	* Do not allow workers to place body parts in front of blast nozzle * Do not allow operator of nozzle to turn from surface being blasted while trigger is engaged * Do not set nozzle down until the system is completely turned off
* Exposure to noise	* Assess ARMS™ for feasible engineering controls * Use administrative controls * Use of proper hearing protection devices * Worker included in a hearing conservation program
* Exposure to contaminant	* Evaluation of system for engineering controls * Use of proper PPE, including respiratory protection
* Restricted communication (associated with noise generated)	* Use of hand signals as SOP's * Use other signals such as flashing lights when hand signals of limited use

* Back injury/strain/sprain (from lifting/moving waste drum and from putting reclaimed blasting media back into hopper)	* Ergonomic training to include proper lifting techniques * Use a mechanical method to lift/move the drum of waste and to load blasting media into hopper
MAINTENANCE	
* Exposure to contaminants	* Use appropriate PPE, including respiratory protection
* Injury from accidental activation of moving parts	* Assure appropriate lockout/tagout program is used before any maintenance is conducted
* Pinch Points	* Use of hand protection * Use of hand-held tools appropriate for the job * Use of appropriate lockout/tagout procedures
* Slips/Trips/Falls	* Awareness of the specific hazards * Organization of materials (housekeeping) * Walking around areas that are congested/slippery when possible * Walking around tripping hazards when possible
* Ergonomics stressors	* Limit duration of work * Use proper lifting techniques * Ergonomic training to include proper lifting techniques
DECONTAMINATION OF SYSTEM	
* Exposure to contaminants	* Use of appropriate PPE, including respiratory protection
* Injury from accidental activation of moving parts	* Assure appropriate lockout/tagout program is used before any decontamination activities are conducted
* Pinch Points	* Use of hand protection * Use of hand-held tools appropriate for the job * Use of appropriate lockout/tagout procedures

* Slips/Trips/Falls	* Awareness of the specific hazards * Organization of materials (housekeeping) * Walking around areas that are congested/slippery when possible * Walking around tripping hazards when possible
* Ergonomics stressors	* Limit duration of work * Use proper lifting techniques * Ergonomic training to include proper lifting techniques
LOADING/TEAR DOWN	
* Pinch points	* Use of hand protection * Use proper hand tools for the job
* Slips/Trips/falls	* Awareness of specific hazards * Organization of materials (housekeeping) * Walking around areas that are congested/slippery when possible * Walking around tripping hazards when possible
* Struck-by/Caught between	* Awareness of where equipment is being moved at all times * Prohibit worker from being between moving and stationary objects at all times * Keep personnel clear of moving objects
* Muscular/back injury (from disassembling equipment)	* Ergonomic training to include safe lifting techniques * Use of equipment such as forklift or crane for loading

SECTION 5 - FAILURE MODE AND EFFECTS ANALYSIS

FAILURE MODE AND EFFECTS ANALYSIS
SURFACE TECHNOLOGY SYSTEMS (STS)
ADVANCED RECYCLABLE MEDIA SYSTEM (ARMS™)
(METAL)

FAILURE MODE	EFFECT
* Air line ruptures or disconnects	* Injury to worker from being struck by air line * Injury to worker from being struck by high pressure air
* Safety pin on air line breaks	* Injury to worker from being struck by air line * Injury to worker from being struck by high pressure air
* Steam generator fails and does not generate steam	* Increased exposure to contaminants due to more dust being produced
* Vapor generator overpressurizes and pop-off by-pass fails	* Injury from vapor releasing violently * Injury from explosive release of built up pressure
* Filter on ventilation system clogs	* Increased exposure to contaminant due to less air being pulled out of containment * Release of contaminant from the containment (through seams and openings) because of loss of negative pressure inside containment
* Ventilation system fails	* Increased exposure to contaminant due to less air being pulled out of containment * Release of contaminant from the containment (through seams and openings) because of loss of negative pressure inside containment

* Dead man switch on blast nozzle fails	* Injury to workers from being struck by the blast media and air because fails to shut off if nozzle dropped or otherwise accidentally released by the operator

SECTION 6 - TECHNOLOGY SAFETY DATA SHEET

TECHNOLOGY SAFETY DATA SHEET
SURFACE TECHNOLOGY SYSTEMS (STS)
ADVANCED RECYCLABLE MEDIA SYSTEM (ARMS™)
(METAL)

SECTION 1: TECHNOLOGY IDENTITY	
Manufacturer's Name and Address: Surface Technology Systems 75 East Market Street Akron, OH 44308	Emergency Contact: Steven M. Pocock (330) 849-6695 (330)376-2700
	Information Contact: Steven M. Pocock (330) 849-6695 (330)376-2700
	Date Prepared:
Other Names: ARMS™	Signature of Preparer: Operating Engineers National Hazmat Program 1293 Airport Road, Beaver, WV 25813, phone 304-253-8674, fax 304-253-1384 Under cooperative agreement DE-FC21-95 MC 32260

SECTION 2: PROCESS DESCRIPTION

The ARMS™ uses a soft media that is highly absorptive and can be used either dry or wetted to capture, adsorb, and remove surface contaminants, such as oils, grease, lead compounds, chemicals, and radionuclides. Steam may also be used to provide for dust control without creating a liquid waste stream.

The system consists of transportable modules. The feed unit is a portable pneumatically powered device for propelling the cleaning media against the surface to be cleaned. A hopper, mounted atop the unit holds the cleaning media. The media is feed by the auger device into a metering chamber which mixes the cleaning media with compressed air. The mixture is transported using standard abrasive blasting hose through a standard abrasive nozzle to the surface to be cleaned. By varying the unit air pressure and grade of cleaning media, the system can remove surface contamination from soot to fully cured high-performance protective coatings from steel and concrete surfaces.

The sifter unit is used to mechanically remove large debris and powdery residues from the cleaning media after each use. The cleaning media is collected in the work area and placed into the electrically-powered screener. The unit vibrates causing the used media to pass vertically downward through a series of separation screens. Any course materials, such as point flakes, rust particles, etc., are collected in the first and coarsest screen. Next, the reusable media is collected on the finer screen. Finally, any dust particles pass through the screener for proper collection and disposal.

The system requires that it be used in a contained work space or that a containment area be built. During the testing demonstration, the system was used inside a shed that was built for the purpose of conducting the metal decontamination demonstrations. An air mover, which provided general ventilation at approximately 2000 cfm (according to the technology developer), was installed in one of the window openings of the shed. The air from inside the shed was filtered by a high efficiency particulate air (HEPA) filter before being exhausted outside of the shed.

Various blasting media may be used with the ARMS™ and the media needs to be identified prior to the start of the job.

SECTION 3: PROCESS DIAGRAMS

Figure 1. ARMS unit located outside shed where metal decontamination is taking place.

Figure 2. Worker inside shed blasting metal plate.

SECTION 4: CONTAMINANTS AND MEDIA
The blasting operation creates an extreme amount of dust. The dust generated may contain coating, subsurface, and blasting media contaminants. These will need to be identified by the site characterization prior to the beginning of the job. A monitoring plan will need to be developed on a site-by-site job-by-job basis.

SECTION 5: ASSOCIATED SAFETY HAZARDS	
Probability of Occurrence of Hazard: 1 Hazard may be present but not expected over background level 2 Some level of hazard above background level known to be present 3 High hazard potential 4 Potential for imminent danger to life and health	
A. ELECTRICAL (LOCKOUT/TAGOUT)	RISK RATING: 3
The technology has the potential to present electrical hazards. Assure proper grounding and use of ground fault circuit interrupters on all equipment. Compliance with applicable electrical standards and codes and lockout/tagout procedures must be followed to assure the safety of personnel.	
B. FIRE AND EXPLOSION	RISK RATING: 1
Normal fire and explosion hazards in association with electrical powered equipment. The equipment is not intrinsically safe and could not be used in a potentially explosive atmosphere.	
C. CONFINED SPACE ENTRY	RISK RATING: N/A
Not part of this technology.	
D. MECHANICAL HAZARDS	RISK RATING: 3
The ARMS™ has moving parts which may cause severe injury from pinch points. The auger for feeding media is of particular concern. The area needs to be guarded and labeled as a potential hazard.	
E. PRESSURE HAZARDS	RISK RATING: 2
The air lines and the high pressure air present a potential struck-by hazard if they were to rupture or disconnect.	
F. TRIPPING AND FALLING	RISK RATING: 3
The water lines, air lines, and blasting nozzle hose present tripping hazards in the area where they are being used.	
G. LADDERS AND PLATFORMS	RISK RATING: N/A
Not part of this technology.	

H. MOVING VEHICLES	RISK RATING: 3
The presence of multiple pieces of mobile equipment (which may be needed to unload and load technology) in relationship to a small area of operation may pose a significant danger. Sufficient warning devices such as horns, bells, lights, and back up alarms should be utilized. Personnel should be trained to work with and around moving equipment.	
I. BURIED UTILITIES, DRUMS, AND TANKS	RISK RATING: N/A
Not part of this technology.	
J. PROTRUDING OBJECTS	RISK RATING: N/A
Not part of this technology.	
K. GAS CYLINDERS	RISK RATING: N/A
Not part of this technology.	
L. TRENCHING AND EXCAVATIONS	RISK RATING: N/A
Not part of this technology.	
M. OVERHEAD LIFTS	RISK RATING: 4
Unloading and loading of technology may require overhead lifts or the use of a forklift. Proper precautions indicated.	
N. OVERHEAD HAZARDS	RISK RATING: 2
Would only be present if a crane were required to unload or load equipment.	

SECTION 6: ASSOCIATED HEALTH HAZARDS	
A. INHALATION HAZARD	RISK RATING: 4
Dust exposure is excessive during the operation of the ARMS™. Air monitoring samples have shown values in excess of the OSHA PEL and the ACGIH TLV. Air sampling filters have shown 1/4 to 3/4 inch of dust on them at the end of the sampling period. It is recommended that workers inside the containment wear air-line respirators or SCBA. Additional PPE that is compatible with the identified contaminants needs to be utilized, as appropriate.	
B. SKIN ABSORPTION	RISK RATING: 4
The dust from the blasting media may be a skin irritant and unless the PPE worn is impervious to it, skin irritation may occur. PPE appropriate for the contaminants needs to be utilized.	

C. HEAT STRESS	RISK RATING: 4
The need to wear PPE inside the containment area has the potential to increase the heat stress placed on the worker. Ambient conditions, work rate, etc. correlated with PPE levels must be considered.	
D. NOISE	RISK RATING: 4
Noise exposure is excessive during the operation of the ARMS™. Noise monitoring has shown values in excess of the OSHA PEL and ACGIH TLV for an 8-hour work shift. In addition to feasible engineering controls, administrative controls and adequate hearing protection must be incorporated during operation. Workers will need to be included in a hearing conservation program.	
E. NON-IONIZING RADIATION	RISK RATING: N/A
Not part of this technology.	
F. IONIZING RADIATION	RISK RATING: N/A
Not part of this technology.	
G. COLD STRESS	RISK RATING: 1
Technology does not produce a hazard but ambient conditions need to be considered.	
H. ERGONOMIC HAZARDS	RISK RATING: 4
There is potential for ergonomic stressors when operating the ARMS™ blasting nozzle. The main ergonomic concern is the posture the arms (of the operator) must be in while holding the weight of the blast nozzle. This has the potential to cause sprain/strain/fatigue to the arms, shoulders, and upper and lower back. The need to hold the blast nozzle over the shoulder to support it instead of supporting it with the arms increases the stress on the neck and shoulders.	

I. OTHER	RISK RATING: 3
There are communication problems due to the noise generated by the technology during operation. Hand signals may be beneficial but due to the high levels of dust and therefore, low visibility inside the containment, they would be of limited value. Consideration needs to be given to installing other types of signals such as flashing lights. Since workers inside the containment may not be able to see each other well enough to avoid each other, it may also be necessary to limit the number of workers inside the containment to one.	

SECTION 7: PHASE ANALYSIS
A. CONSTRUCTION/START-UP
The set-up/start-up phase presents several hazards including struck-by/caught between hazards, pinch points, slips/trips/falls, muscular/back injury, and electrical hazards.
B. OPERATION
The operational phase presents several hazards including exposure to contaminant (excessive dust generation), noise hazards (excessive noise generation), hazards associated with the air lines, muscular/back injury, poor communication (between workers) due to operating conditions, and electrical hazards.
C. MAINTENANCE
The maintenance phase presents several hazards including pinch points, slips/trips/falls, struck-by/caught between, muscular/back injury, electrical hazards, exposure to contaminants, and accidental activation of moving parts.
D. DECOMMISSIONING
The decommissioning phase presents several hazards including exposure to the contaminants, pinch points, slips/trips/falls, and muscular/back injury.

SECTION 8: HEALTH AND SAFETY PLAN REQUIRED ELEMENTS
A. AIR MONITORING
Operation of the ARMS™ generates an excessive amount of dust. An air monitoring plan will need to be developed for total and respirable dust, contaminants of the coating being removed, contaminants and constituents of the subsurface, and constituents of the blasting media. Noise generated during operation of the ARMS™ is excessive. A noise monitoring plan is essential.

SECTION 8: HEALTH AND SAFETY PLAN REQUIRED ELEMENTS
B. WORKER TRAINING
Training that would apply in this case may include but not be limited to: HAZWOPER (Hazardous Waste Operations and Emergency Response), HAZCOM (Hazard Communication), Respiratory Protection, Hearing Conservation, Ergonomics (proper lifting, bending, stooping, kneeling), Heat Stress (learning to recognize signs and symptoms), Personal Protective Equipment, Emergency Response/Bloodborne Pathogens, Lockout/Tagout, Hand Signal Communication, Construction Safety (OSHA 500), and/or General Industry Safety (OSHA 501).
C. EMERGENCY RESPONSE
Emergency response planning for a site needs to assure adequate coverage for hazards described in the TSDS. Having at least one worker per shift trained in CPR and first aid is recommended.
D. MEDICAL SURVEILLANCE
Evaluation of personnel's general health with emphasis on the back and cardiovascular/respiratory system. Medical surveillance as required by the OSHA standards needs to be conducted. Initial and annual audiograms.
E. INFORMATIONAL PROGRAM
Workers must be trained in specific operation of equipment before use.

SECTION 9: COMMENTS AND SPECIAL CONSIDERATIONS
Only personnel who have been adequately trained in the operation of the ARMS™ as well as associated hazards should be permitted to operate the system. Consideration needs to be given to the compatibility of the PPE with specific contaminants and the exposure level of the contaminants.

SECTION 7 - EMERGENCY RESPONSE/PREPAREDNESS

The use of the ARMS^{TM} would not be applicable to emergency response situations.

Emergency response/preparedness must be part of every hazardous waste site safety and health plan. In addition to credible site emergencies, site personnel must plan for credible emergencies in connection with the ARMS^{TM}.

All precautions used when responding to an emergency situation at the site will apply. Before entering an area where the centrifugal shot blaster is being used, the equipment needs to be completely shut down (de-energized).

This technology does not appear to present any conditions other than those associated with the use of high pressure air that would lead to out of the ordinary emergencies.

SECTION 8 - REGULATORY/POLICY ISSUES

The site safety and health personnel where the ARMS^{TM} technology is being used need to be concerned with safety and health regulations applicable to the issues discussed above. Regulations that apply may be divided into four categories. Core requirements are those regulations that would apply to any hazardous waste work site, regardless of the type of job. Technology specific requirements are those regulations that apply due to the specific technology being used. Special requirements are standards and policies that are specific to the technology itself and are required by reference in a regulation. Best management practices are not required, but are recommended by organizations such as the American National Standards Institute (ANSI), the National Institute of Occupational Health and Safety (NIOSH), Department of Energy (DOE), National Fire Protection Association (NFPA), etc. These regulations/standards may include but not be limited to the following:

Core requirements:

- ♦ OSHA 29 CFR 1926.25 Housekeeping
- ♦ OSHA 29 CFR 1910.141 Sanitation (1910.141(a)(3) covers housekeeping)
- ♦ OSHA 29 CFR 1926 Subpart Z Toxic and Hazardous Substances
- ♦ OSHA 29 CFR 1910 Subpart Z Toxic and Hazardous Substances
- ♦ OSHA 29 CFR 1926.59 Hazard Communication
- ♦ OSHA 29 CFR 1910.1200 Hazard Communication
- ♦ OSHA 29 CFR 1926.64 Process Safety Management of Highly Hazardous

Chemicals

- OSHA 29 CFR 1910.119 Process Safety Management of Highly Hazardous Chemicals
- OSHA 29 CFR 1926.65 Hazardous Waste Operations and Emergency Response
- OSHA 29 CFR 1910.120 Hazardous Waste Operations and Emergency Response
- Occupational Safety and Health Act 1970(5)(a)(1) General Duty Clause

Technology Specific Requirements:

- OSHA 29 CFR 1926 Subpart K Electrical
- OSHA 29 CFR 1910 Subpart S Electrical
- OSHA 29 CFR 1910 Subpart O Machinery and Machine Guarding
- OSHA 29 CFR 1910.147 The Control of Hazardous Energy (Lockout/Tagout)
- OSHA 29 CFR 1926.52 Occupational Noise Exposure
- OSHA 29 CFR 1910.95 Occupational Noise Exposure
- OSHA 29 CFR 1926.103 Respiratory Protection
- OSHA 29 CFR 1910.134 Respiratory Protection
- OSHA 29 CFR 1926.102 Eye and Face Protection
- OSHA 29 CFR 1910.133 Eye and Face Protection
- OSHA 29 CFR 1926.28 Personal Protective Equipment
- OSHA 29 CFR 1910.132 General Requirements (Personal Protective Equipment)
- OSHA 29 CFR 1926.23 First Aid and Medical Attention
- OSHA 29 CFR 1910.151 Medical Services and First Aid

Best Management Practices:

- ACGIH Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices

In addition to the above regulations and policies, it is imperative that all workers have appropriate and adequate training for the task and associated safety and health conditions. Training that would be required may be divided into four categories. Core training is that which is required for anyone entering a hazardous waste site to perform work, regardless of the type of job. Technology specific training is that training that is specific to the technology and required by safety and health standards. Special training is that which is specific to the technology to assure the worker is adequately trained for the task, but is not necessarily required by safety and health standards. Best management practices are trainings that while not mandated by health and safety standards, provide information and knowledge to the worker that will allow the worker to perform his/her job safely. Training to be applied for the centrifugal shot blast technology may include but not be limited to:

Core Training Requirements:

- HAZWOPER
- HAZCOM

Technology Specific Training:

- Respiratory Protection
- Hearing Conservation
- Personal Protective Equipment
- Electrical Safety
- Lockout/Tagout

Special training:

- Job specific training for equipment operation

Best Management Practice training:

- Ergonomics (proper lifting, bending, stooping, kneeling, and static postures)
- Heat stress (learning to recognize signs and symptoms)

- CPR/First Aid/Emergency Response/Blood-borne Pathogens
- Hand Signal Communication
- Construction Safety (OSHA 500) and or General Industry Safety (OSHA 501)

SECTION 9 - OPERATIONAL CONSIDERATIONS & RECOMMENDATIONS

Recommendations made in this section for improved worker safety and health take into consideration the operation of the ARMS™ without the use of a steam spray. Specific recommendations include:

- It needs to be assured that workers are aware of the tripping hazards associated with air and nozzle lines that are necessary to operate the equipment. Keeping these as orderly as possible in compliance with good housekeeping regulations will help avoid injury due to tripping.
- If a fitting on an air line fails, the flying hose has the potential to cause severe injury. A safety line connected to the male and female parts of the fitting would keep the hose from becoming a flying object.
- There are electrical hazards associated with the sifter unit and HEPA filter unit which requires 110 volt 20 amp circuits and the vapor generator which requires a 220 volt 30 amp circuit for operation. They need GFCI and appropriate grounding.
- The filter unit in the work area frequently became clogged and the HEPA filter had to be changed often. Additionally, when the filter became clogged and therefore, air movement through the unit was stopped, dust leaked from the work area through the door of the building. The filter system needs to be evaluated for use with the type of dust being generated.
- There are communication problems due to the noise generated by the technology during operation. Hand signals may be beneficial but due to the high levels of dust and therefore, low visibility inside the work area, they would be of limited value. Consideration needs to be given to installing other types of signals such as flashing lights. Since workers inside the work area may not be able to see each other well enough to avoid each other, It may also be necessary to limit the number of workers inside the work area to one.

  An additional concern due to the decreased visibility and the difficulties with verbal communication is the potential for the operator to strike himself/herself or another worker in the area with the blast from the nozzle. This could cause sever injury to the workers. This is another reason to limit the number of workers inside the containment.

- PPE must be chosen that is compatible with the hazards and the job. The dust levels in the work area indicate that air purifying respirators do not provide adequate protection and air-line respirators or self contained breathing apparatus are necessary. The cotton coveralls worn by the operators during the testing demonstration were often soaked with perspiration and therefore provided a route for the dust that was accumulated on them to get to the workers skin. At a minimum tyvek coveralls may be necessary for anyone working inside the containment. The specific level of PPE will need to be determined on a site-by-site job-by-job basis. The specific contaminants for the job also need to be taken into consideration when choosing the appropriate PPE.

- The main ergonomic concern is the posture the arms (of the operator) must be in while holding the weight of the blast nozzle. This has the potential to cause sprain/strain/fatigue to the arms, shoulders, upper back, and lower back.

  When blasting low on the metal piece, there is the potential for sprain/strain to the back, knees, legs, and ankles due to the bending, stooping, and kneeling required to blast the lower areas.   When blasting the higher areas, there is the potential for sprain/strain to the back, neck, shoulders, and arms.

  It is recommended that weight of the blast nozzle be reduced and an engineering design be considered where the nozzle is mounted to an adjustable/moveable frame. Both of these would help to lessen or eliminate most of the ergonomic concerns discussed above.

- Dust exposure was excessive during the operation of the ARMS™. All air monitoring samples showed values well in excess of the OSHA PEL and the ACGIH TLV. All air sampling filters had ¼ to ¾ inch of dust on them at the end of the sampling period. It is recommended that workers inside the confinement wear air-line respirators or SCBAs. It is also recommended that engineering controls be evaluated to control the dust levels produced by the blasting process. This may include capture of the dust as blasting is conducted or a better ventilation system (with air filtration) for the containment.

- Noise exposure was excessive during the operation of the ARMS™. All noise monitoring showed values in excess of the OSHA PEL and ACGIH TLV. It is recommended that engineering controls be evaluated to control the noise levels the operator is exposed to during operation. In addition to feasible engineering controls, administrative controls and adequate hearing protection must be incorporated during operation.

The safety and health issues discussed throughout this report could be reduced and, in some cases, eliminated if this type of metal decontamination technology could operate remotely.

APPENDIX A
REFERENCES

Occupational Safety and Health Standards for General Industry, 29 CFR Part 1910, Occupational Safety and Health Administration United States Department of Labor

Occupational Safety and Health Standards for the Construction Industry, 29 CFR Part 1926, Occupational Safety and Health Administration United States Department of Labor

Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs), American Conference of Governmental Industrial Hygienists, 1995-1996

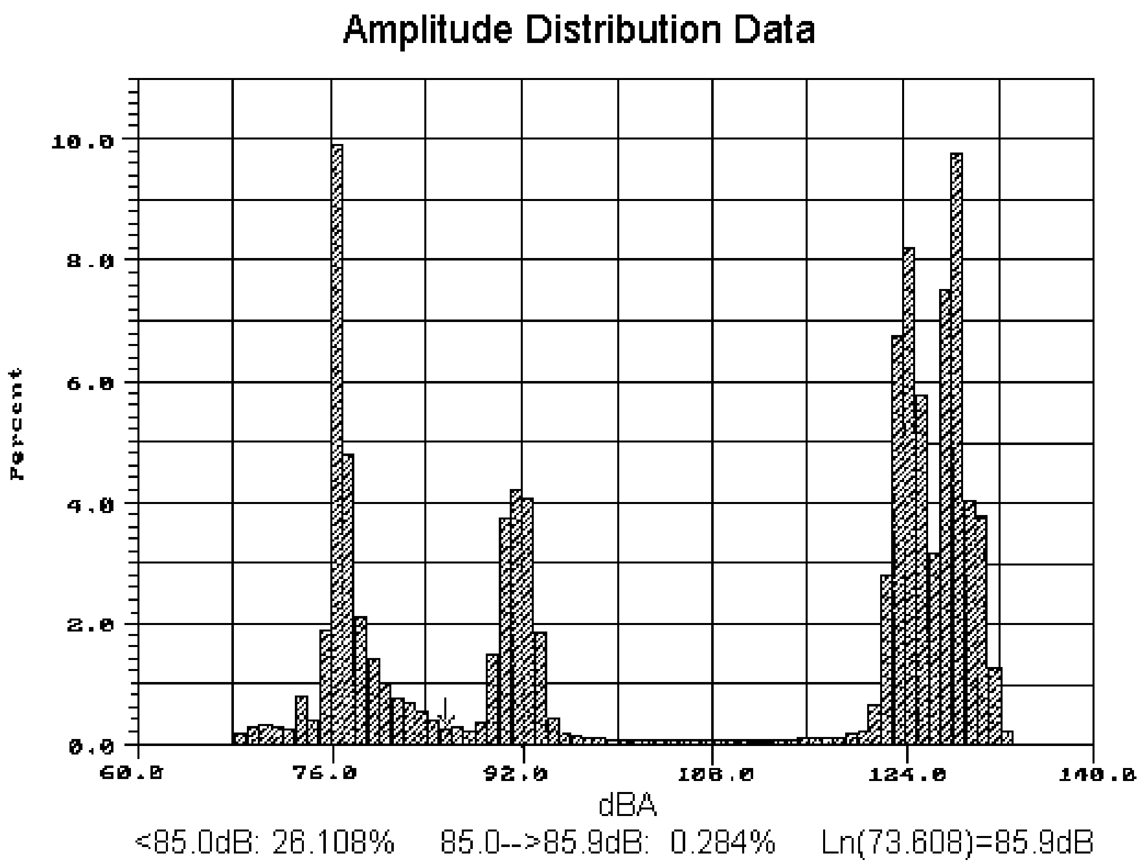
The NIOSH compendium of hearing protection devices, U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control and Prevention, October 1994

APPENDIX B
IH SAMPLING DATA

STS ARMS™ Total Dust Sampling			
Date	**Sample Number**	**Analyte**	*** Results**
7/25/97	072597-FIU-001	Total dust	72.49 mg/m^3
7/25/97	072597-FIU-002	Total dust	43 mg/m^3
7/25/97	072597-FIU-003	Blank	0.00 mg/m^3
7/28/97	072897-FIU-004	Total dust	1230.0 mg/m^3

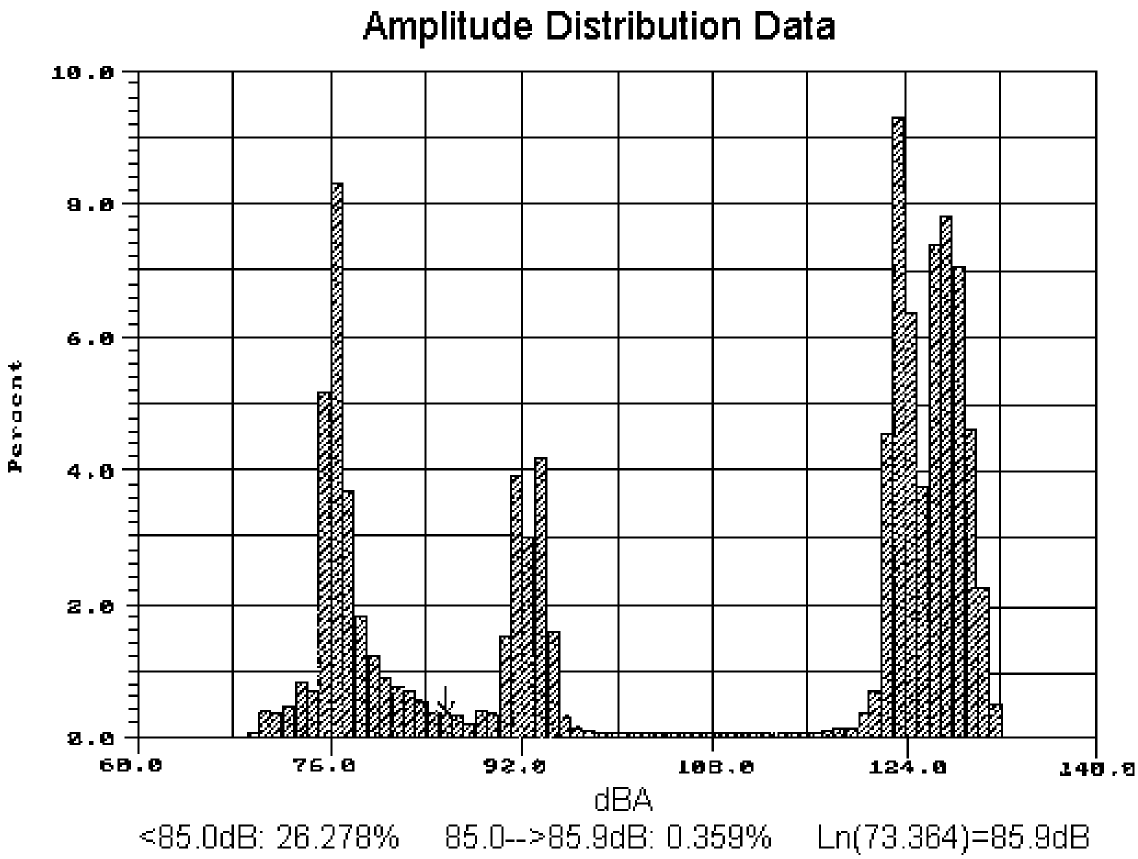
* The OSHA PEL for total dust is 15 mg/m^3 and the ACGIH TLV is 10 mg/m^3. Current sampling was conducted for total dust. The need to sample for respirable dust and silica has to be considered during concrete decontamination and decommissioning activities.

NOISE SAMPLING



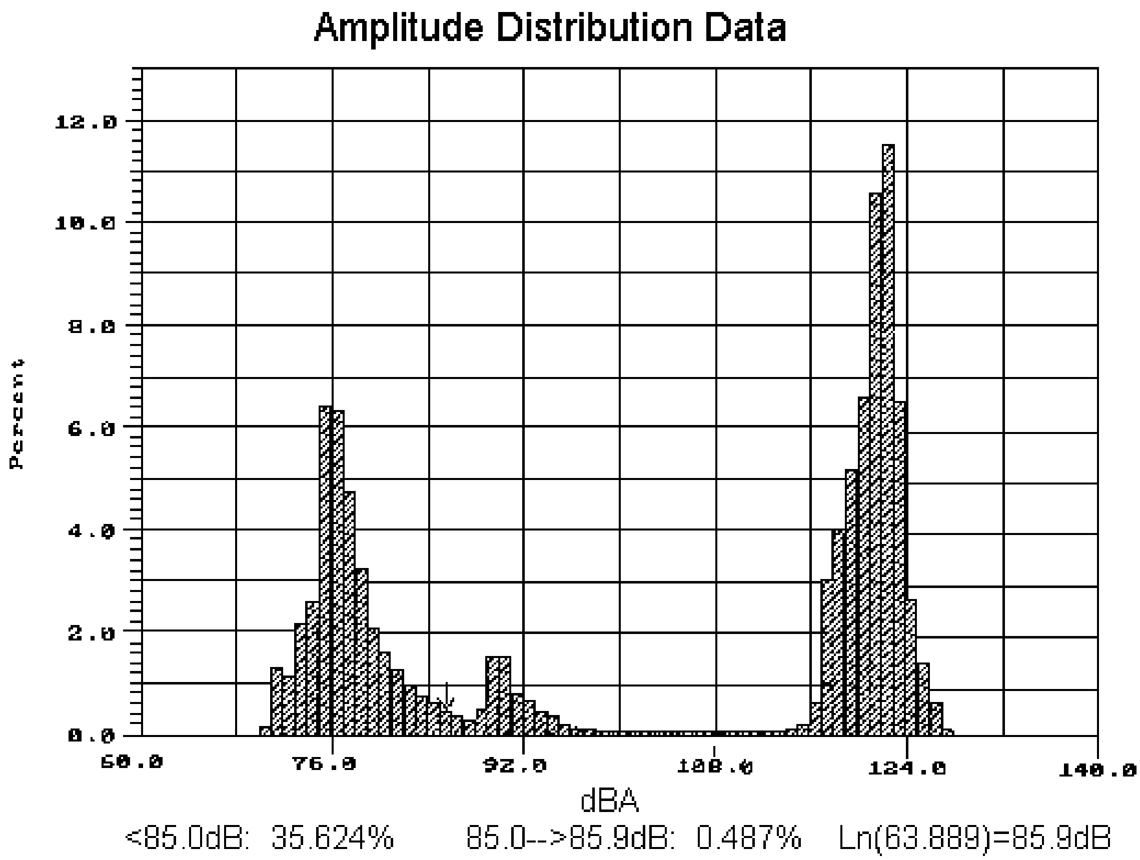
The percentage of time spent at each decibel level can be obtained from the graph. As shown, 26.108% of the time the noise exposure level as less than 85 dBA which means 73.892% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

NOISE SAMPLING



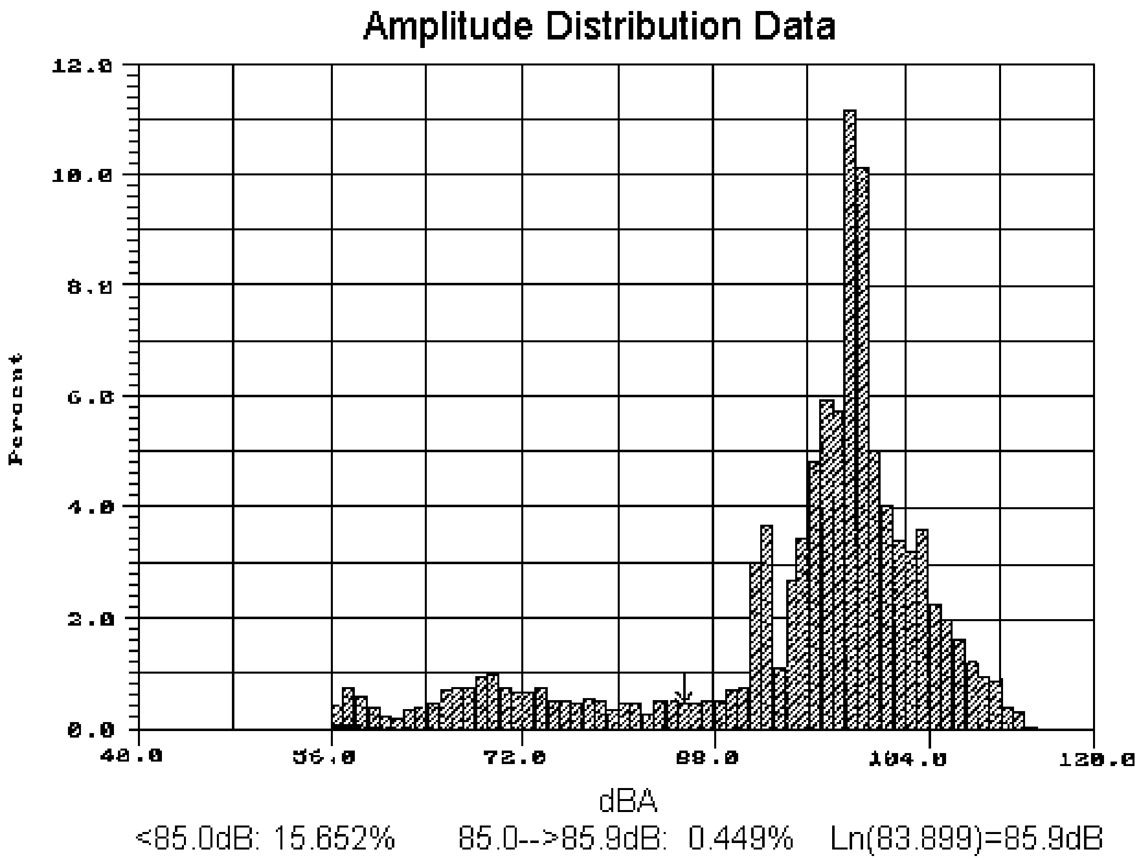
The percentage of time spent at each decibel level can be obtained from the graph. As shown, 26.278% of the time the noise exposure level as less than 85 dBA which means 73.722% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

NOISE SAMPLING



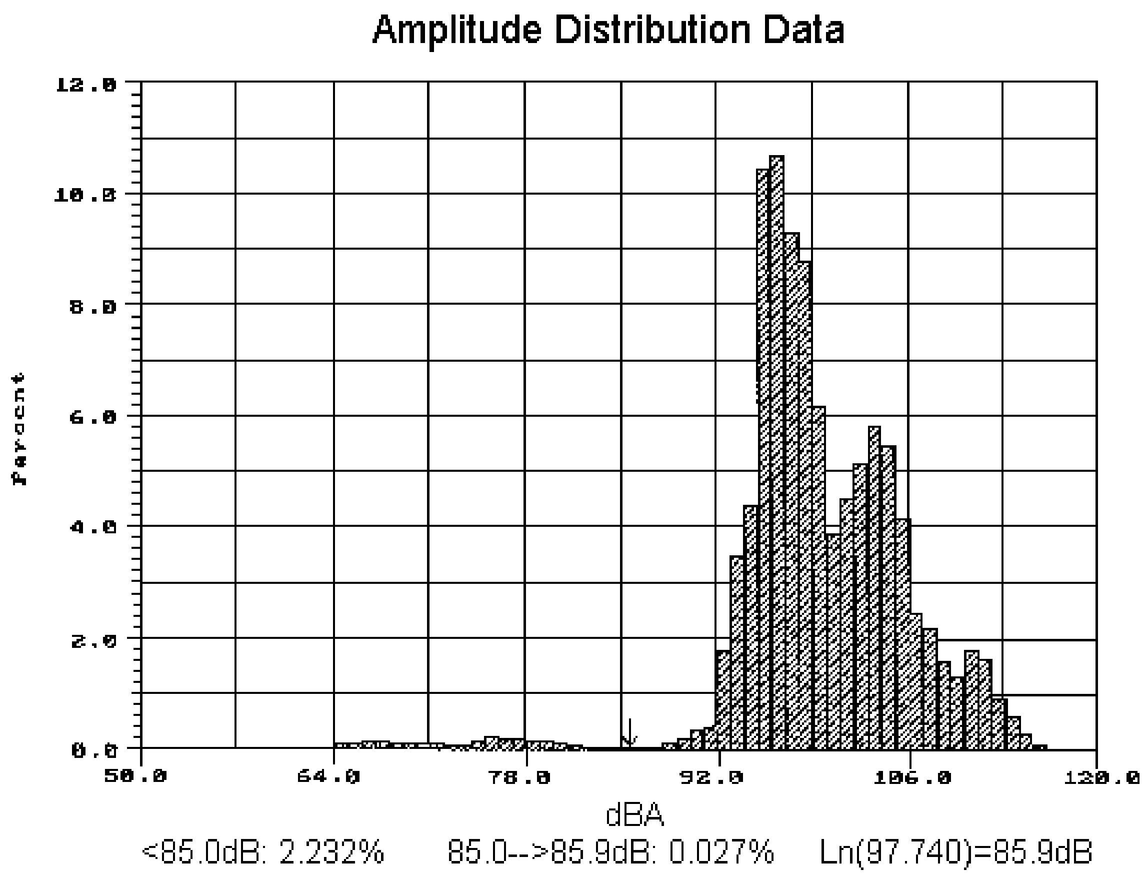
The percentage of time spent at each decibel level can be obtained from the graph. As shown, 35.624% of the time the noise exposure level as less than 85 dBA which means 64.376% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

NOISE SAMPLING



The percentage of time spent at each decibel level can be obtained from the graph. As shown, 15.652% of the time the noise exposure level as less than 85 dBA which means 84.348% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

NOISE SAMPLING



The percentage of time spent at each decibel level can be obtained from the graph. As shown, 2.232% of the time the noise exposure level as less than 85 dBA which means 97.768% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

APPENDIX C
ACRONYMS

ACGIH	-	American Conference of Governmental Industrial Hygienists
ANSI	-	American National Standards Institute
ARMS	-	Advanced Recyclable Media System
cfm	-	cubic feet per minute
CFR	-	Code of Federal Regulations
DOE	-	Department of Energy
FIU	-	Florida International University
GFCI	-	ground fault circuit interrupters
HAZWOPER	-	Hazardous Waste Operations and Emergency Response
HAZCOM	-	Hazard Communication
HEPA	-	high efficiency particular air (filter)
MSDS	-	Material Safety Data Sheet
NFPA	-	National Fire Protection Association
NIOSH	-	National Institute of Occupational Safety and Health
OSHA	-	Occupational Safety and Health Administration
PEL	-	permissible exposure limit
PPE	-	personal protective equipment
SCBA	-	self contained breathing apparatus
STS	-	Surface Technology Systems
TLV	-	threshold limit value
TWA	-	time weighted average