Title: Large-Bore Pipe Decontamination and Characterization System

Joseph F. Boudreaux
josephb@eng.fiu.edu
423-220-8844
Fax 423-220-8444
Florida International University
Hemispheric Center for Environmental Technology
132 Mitchell Road
Oak Ridge, TN 37830

Abstract:

In 1995, the Department of Energy's (DOE) Office of Science and Technology (OST), in partnership with Florida International University (FIU), established the Hemispheric Center for Environmental Technology (HCET) at FIU. The driving goals of this venture are to research, develop, demonstrate, test and evaluate environmental technologies, and to form partnerships with governments and industries throughout the Western Hemisphere in order to disseminate, market and transfer these technologies. Since its founding, HCET has worked in tandem with DOE to advance the development, utilization and deployment of cost-effective environmental technologies. The Large-Bore Pipe Decontamination and Characterization System is currently begin developed through these partnerships.

The decontamination and decommissioning (D&D) of 1200 buildings within the U.S. Department of Energy-Office of Environmental Management (DOE-EM) Complex will require the disposition of miles of pipe. The disposition of large-bore pipe, in particular, presents difficulties in the area of decontamination and characterization. The pipe is potentially contaminated internally as well as externally. This situation requires a system capable of decontaminating and characterizing both the inside and outside of the pipe. Current decontamination and characterization systems are not designed for application to this geometry, making the direct disposal of piping systems necessary in many cases. The pipe often creates voids in the disposal cell, which requires the pipe to be cut in half or filled with a grout material. These methods are labor intensive and costly to perform on large volumes of pipe. Direct disposal does not take advantage of recycling, which could provide monetary dividends.

To facilitate the decontamination and characterization of large-bore piping and thereby reduce the volume of piping required for disposal, a detailed analysis was conducted to document the pipe remediation problem set (completed FY97); determine potential technologies to solve this remediation problem set (completed FY97); design and laboratory test potential decontamination and characterization technologies (completed FY97); fabricate a prototype system (FY98 and FY99); provide a cost-benefit analysis of the proposed system (preliminary completed FY98); and deployment of the system (FY99 and beyond).

The large-bore decontamination and characterization process consists of three main systems the decontamination system, characterization system and the material handling system integration system. The decontamination system is further segregated into two modules the decontamination module and the ventilation module. The paper will discuss the progress to date, the system capabilities, and the expected results of the completed large-bore pipe decontamination and characterization system.

Background:

Florida International University

During the past 25 years, Florida International University has capitalized on its unique geographic location and cultural resources to reach out to academic, industrial, and governmental institutions throughout the Americas. With over 30,000 students and 250 degree programs, FIU is the leading public educational institution in Southeast Florida and the third-largest in the State of Florida. FIU graduates more Hispanics than any other university in the continental United States and ranks third in the country for graduating minorities.

FIU's vision and commitment are now sharply focused on evolving the institution into becoming the top, public, urban research university in the United States, and indeed one of the leading institutions of higher learning in the Western Hemisphere. Five academic strategic themes focus the development of FIU's educational and research programs, namely **International, Environmental, Urban, Health, and Information**.

Hemispheric Center for Environmental Technology

Prior to 1995, FIU's Mechanical Engineering Department developed a multifaceted R&D program for DOE-EM that delivered promising new concepts and products on a fast track for development. DOE decided that further expansion of this program would strengthen its drive to faster technology development, evaluation, and deployment within DOE-EM, as well as expansion into U.S. and foreign markets. Based on FIU's performance in its R&D projects and its stance as an independent institution, DOE envisioned that, over time, a dedicated entity within FIU would help DOE to achieve its objectives by overcoming technical and programmatic barriers. Recognizing their common environmental goals, DOE-EM's OST and Florida International University entered into a partnership in 1995 that established HCET at FIU to advance R&D of environmental technologies. DOE's decision to partner with FIU was based on the University's technical expertise in the field and its comprehensive understanding of the magnitude of the environmental challenges faced by DOE in its cleanup programs. Since 1995 through HCET's operations, this convergence has become much stronger and HCET aims to continue this trend by expansion of its operations in the 21st century.

Research and Development (R&D) Strategy

Florida International University's Hemispheric Center for Environmental Technology (FIU-HCET) was established on the founding principle that it would be first and foremost a research and development center. Among its partners, FIU-HCET is the primary institution involved in R&D, and along with the FIU Research Foundation, it serves the role of a bridging institution between FIU, the federal government, U.S. industry, and foreign entities. Leveraging these resources, FIU-HCET pursues its mandate to advance the research, development, and deployment of sustainable environmental technologies. In planning and executing its program mandate, FIU-HCET adopted six key strategic approaches:

- Identify major-impact environmental R&D programs to solve high-priority concerns of DOE.
- Identify opportunities to accelerate existing DOE environmental R&D programs and pursue those that address the highest priority concerns of the department.
- Identify, adopt, and/or develop technologies to address environmental concerns of DOE.
- Advance and use applicable state-of-the-art decision modeling and simulation capabilities to accomplish its goals.
- Develop the technical and research capabilities and information dissemination resources of the Center to better serve the environmental technology community.
- Transition research results and successfully proven technologies from demonstration and validation to implementation and commercialization.

In pursuing these avenues, HCET has leveraged its relationships with vendors, manufacturers, inventors, small businesses, and entrepreneurs, as well as the technical, academic, and infra-structural resources of FIU, to form synergistic partnerships to expedite the development and deployment of technologies. HCET is now in an excellent position to expand its R&D activities and existing relationships to affect areas and programs of OST that have not had a chance to benefit from HCET's involvement.

Pipe Disposition Needs Statement

The D&D of 1200 buildings within the DOE-EM complex will require the disposition of miles of pipe. The disposition of large-bore pipe, in particular, presents difficulties in the area of decontamination and characterization. The pipe is potentially contaminated internally as well as externally. This situation requires a system capable of decontaminating and characterizing both the inside and outside of the pipe. Current decontamination and characterization systems are not designed for application to this geometry, making the direct disposal of piping systems necessary in many cases. The pipe often creates voids in the disposal cell, which requires the pipe to be cut in half or filled with a grout material. These methods are labor-intensive and costly to perform on large volumes of pipe. Direct disposal does not take advantage of recycling, which could provide monetary dividends.

Solution to Pipe Disposition Need

The decontamination and characterization of large-bore pipe is difficult because of the various geometries and diameters of pipe and its different material types. A robust decontamination system must be capable of adapting to different pipe diameters (project scope is 6- to 24-inches), cleaning surfaces with various surface conditions and material types (i.e., painted, rusted, carbon steel, or stainless steel), and be cost-effective to operate and maintain. The characterization system must be capable of handling the different pipe parameters and detecting contamination on the inside and outside surfaces. It must also operate in a cost-effective manner. Current technology options do not provide a robust system to meet these objectives.

To facilitate the decontamination and characterization of large-bore piping and thereby reduce the volume of piping required for disposal, a detailed analysis was conducted to document the pipe remediation problem set (completed FY97); determine potential technologies to solve this remediation problem set (completed FY97); design and laboratory test potential decontamination and characterization technologies (completed FY97); fabricate a prototype system (FY98 and FY99); provide a cost-benefit analysis of the proposed system (preliminary completed FY98); and deployment of the system (FY99 and beyond). The large bore decontamination and characterization process consists of three main systems the decontamination system, characterization system and the material handling system integration system. The decontamination system is further segregated into two modules the decontamination module and the ventilation module.

Project Status:

Literature Search to Determine Pipe Remediation Problem Set

Rough order-of-magnitude quantities were obtained from Hanford and Fernald, including 150,000 m^3 of pipe at Hanford and 5,880 m^3 of pipe at Fernald. Obtaining quantities from other DOE operations offices would require a significant level of effort; therefore, FIU-HCET and the Deactivation and Decommissioning Focus Area (DDFA) decided that acquiring the additional information would not be cost-effective and concluded that significant volumes of pipe exist to warrant the continuation of the project. If the unit operates 2,000 hours per year, the system will be run for 84 years to complete the quantities reported by these two remediation sites. Additional sites are currently performing D&D and will generate quantities of pipe requiring disposition; therefore, it is projected that the system would be implemented for an extended period of time if it is proven cost-effective and reliable.

Review of Decontamination and Characterization Technologies

Established sources and databases were used for categorizing and performing the initial technology screening. These sources and databases included the following:

- DOE/EM-0142P *Decommissioning Handbook*
- ORNL/M-2751 *Oak Ridge National Laboratory Technology Logic Diagram*
- EGG-WTD-11104 *Idaho National Engineering Laboratory Decontamination and Decommissioning Technology Logic Diagram*
- DOE-EM, 1996, Draft-4, *Preferred Decommissioning Technologies Guide*
- UC-706 Hemispheric Center for Environmental Technology, 1995, *Analysis of Potential Surface Blasting Decontamination Technologies for Structural Steel*
- Hemispheric Center for Environmental Technology (HCET), Draft January 1997, *Analysis of Potential Concrete Floor Surface Removal Technologies*
- Remedial Action Program Information Center (RAPIC) database
- Nuclear News Buyers Guide
- Fernald Environmental Restoration Management Corporation (FERMCO), 1993, *Operable Unit 3 Remedial Investigation and Feasibility Study Work Plan Addendum, Final*

Based on the information reviewed, an initial screening method used for pipe decontamination technologies was developed and implemented. The initial criteria include the technology's ability to meet the required clean, near-white metal surface finish[1] on the interior or exterior of a pipe and the system's potential to be developed into a field mobile system. Seventeen decontamination technologies were evaluated as part of the initial screening process. Of the technologies screened, six technologies were selected for further evaluation; these six were then narrowed to one technology: grit blasting.

Based on the review performed by FIU-HCET and an independent consultant, a total of five companies passed the screening of the 21 technologies identified during the review of possible characterization technologies. The screening criteria included the following:

- System must be capable of characterizing pipe and structural steel meeting DOE Order 5400.5 Reg. Guide 1.86 for alpha, beta, and gamma emitters.
- System must characterize 6-inch in diameter through 24-inch diameter pipe made of different materials excluding aluminum.
- System must characterize 2- to 10-foot length sections of pipe.
- System must characterize structural steel shapes with width dimensions from 2- to 24-inches.
- System must characterize 2- to 10-foot length sections of structural steel.

1 "A cleaned, near-white surface, when viewed without magnifications, shall be free of all visible oil, grease, dirt, dust, mill scale, rust, paint and oxides, corrosion products, and other foreign matter, except for staining. Staining shall be limited to no more than 5 percent of each square inch of the surface area and may consist of light shadows, slight streaks, or minor discolorations caused by rust stains, mill scale stains, or previously applied paint stains." (Structural Steel Painting Council, 1991, *Surface Preparation Specifications*, Structural Steel Painting Council, Pittsburgh, PA, pp. 53-56.)

- The operation of the system must not result in contamination of personnel, equipment, or create airborne radioactive contamination.
- The system must be field mobile.
- The system must be able to be calibrated in the field.

The five technologies, which potentially meet the initial criteria, were provided performance specifications and a request for proposal.

Perform Bench-Scale Testing to Obtain Comprehensive and Comparable Data

Carbon steel samples were sent to two laser ablation vendors to obtain an indication of whether laser ablation can achieve a near-white metal finish on a painted carbon steel surface. Both vendors' results were similar; indicating the surface could not be cleaned to a near-white metal surface with the laser systems they used. Based on this review, laser ablation was eliminated from further consideration.

The manufacturer-recommended honing devices for 4-inch, 6-inch, and 10-inch diameter pipes were obtained from Brush Research Manufacturing Company and evaluated on non-contaminated carbon steel at the HCET test facility. The device was operated inside the test pipe as directed by the manufacturer. The technology was able to achieve a near-white metal finish; however, the honing device showed excessive wear and would not be practical for high volume, high production rate applications.

Based on these bench-scale tests, laser ablation and the honing device were eliminated from further consideration.

Decontamination System

Delong Equipment Company completed the initial design for the decontamination system on November 20, 1997. The design consists of an initial layout of the decontamination system confirming the system will conform to the requirement of fitting within transportable strong tight containers. Overall dimensions for the blast cabinet, conveyors, and material conveyance systems were specified. The initial design also indicated material flow paths and the preliminary ventilation requirements. The overall safety requirements and interlocks were also defined. The overall configuration of the decontamination system is shown in Figure 1.

The final design for the decontamination system was completed on June 15, 1998. The detailed design consisted of a narrative and a set of design prints. The final design submittals indicate the requirements set forth in the performance specifications will be met or exceeded.

These performance specifications require the following:

- System must handle 6-inch in diameter through 24-inch diameter pipe.
- System must handle 4- to 10-foot length pipe.
- System must be capable of achieving a near white metal finish on structural steel.
- System must handle a minimum dimension of 2- through 24-inches structural steel shapes.
- System must handle 10-foot length structural steel.
- The output of the system must produce a surface that is free of moisture and dust.
- Process rate must be 3- to 5-feet per minute for 6-inch diameter pipe.
- The ventilation system must follow ANSI 509 and 510 standards for nuclear systems.
- The system must have nuclear grade bag-in bag-out HEPA filtration as the final stage of filtration.
- All spent media and waste from the pipe must be collected in standard waste drums.
- All waste must be dry and be considered non-hazardous.
- System components must fit inside a nuclear grade container or containers.
- The system must be field mobile.

Figure 2 illustrates the ventilation module configuration. The design drawings were reviewed by FIU-HCET and comments were incorporated prior to starting Title III design.

Title II also included the development of the layout of the strong tight containers for the decontamination module and the ventilation module. The layout of each of these containers was completed during FY98. The procurement of the ventilation module strong tight container was completed during FY98 with the detailed design and fabrication to occur during the first quarter of FY99. The detailed design and fabrication for the decontamination system strong tight container will be completed during the first quarter of FY99.

During FY98 the majority of the fabrication work was completed for the decontamination and the ventilation modules. The remainder of the Title III design work will be completed during the first quarter of FY99.

Characterization System

Canberra, Inc. was selected as contractor to design and fabricate the characterization module. A kick-off meeting was held on August 28,1998. Title I design was completed on November 30, 1998. Title I design included an initial layout of the characterization system confirming the system will conform to the requirement of fitting within a transportable strong tight container. Also, overall dimensions for the system were specified, and software design specifications were developed. Title II design is scheduled for completion on February 16, 1999.

Figure 3 is a conceptual view of the overall arrangement of the characterization system.

Overall System Description:

The Large-Bore Pipe Decontamination and Characterization System consists of two main sub systems and a material handling system. Figure 4 illustrates the overall system layout and process flow. The process design provides for a material flow through the decontamination and characterization systems with minimal operator involvement. Material is loaded on an entrance conveyor, which transfers the material to a centrifugal wheel grit blast system for external surface decontamination. The conveyor than transfers the material to the compressed air driven lance blasting system for internal pipe decontamination. The material is then transferred to the characterization system. The characterization system is capable of meeting DOE Order 5400.5 and Regulatory Guide 1.86 for the unrestricted reuse of reactor and uranium contaminated components. The characterization system is also capable of proving material is not contaminated with transuranic contamination allowing material to be disposed of as low-level radioactive waste. All components are housed in strong tight containers to facilitate transportation of the system from site to site. The decontamination system is equipped with a nuclear grade HEPA ventilation system ensuring operations are performed under a negative pressure. After the completion of the process standard roll-off boxes are employed to separate contaminated material from non-contaminated material using the systems automated kicker system.

Each sample analyzed by the characterization is assigned a unique identifier, which is permanently marked on the part. This unique identifier references a database, which houses the characterization results. This system provides for a complete data management and tracking system.

- ❖ Performance Data
  - ➢ Production Rate for 6-inch diameter pipe: 180- to 360-linear feet per hour (Dependent on contaminant type)
  - ➢ Waste Production: Average .25 cubic feet per hour
  - ➢ Set-up time Between Batches: One half hour
  - ➢ Secondary Waste Description: fine metallic powder, spent filters

- ❖ System Requirements:
  - ➢ Applicable to Carbon or Stainless Steels
  - ➢ Material must be free of deposits.
  - ➢ Five foot minimum material length.
  - ➢ Ten foot maximum length.
  - ➢ Material processed in batches according to geometry.
  - ➢ Material must be straight and free of obstructions, valves, hangers, etc.
  - ➢ Material must be free of moisture.

- ❖ Pipe 6- through 24-inches in diameter can be processed.

- ❖ Structural steel shapes from 2- to 24-inches maximum dimension can be processed.

Conclusions

Through the selection and initial design of the ex-situ large-bore pipe decontamination and characterization system, the project shows the promise of producing a cost-effective alternative to the direct disposal of piping systems. A cost-benefit analysis has been completed for the decontamination and characterization systems. Broad assumptions were made related to the characterization system because the design and operations costs are not known at this time. The cost-benefit analysis shows a significant savings in the operation of this system over the option of direct disposal. The schedule set forth for the design, procurement, and fabrication of the characterization and decontamination system has been delayed from the baseline schedule established in FY97. These delays were primarily due to an increased amount of design time required to ensure the project meets the overall project objective and the lack of fundamental technologies to select from during the technology selection and procurement process. The development and testing of the system is scheduled for completion during the fall of 1999. A commercial vendor will begin deploying the system during the fall of 1999 at Department of Energy and Nuclear Regulatory Commissioned environmental restoration sites.

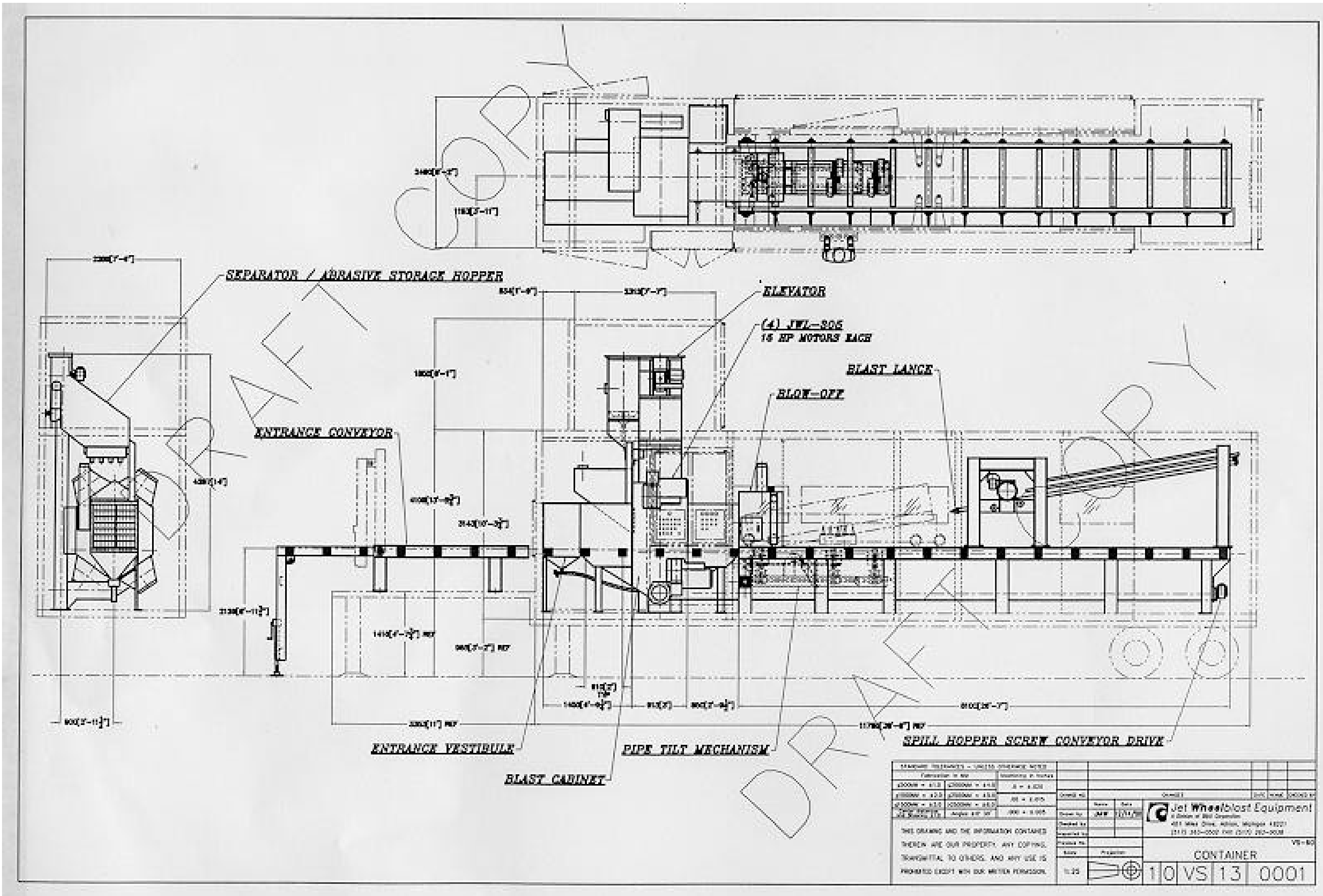

Figure 1. Overall configuration of decon module.

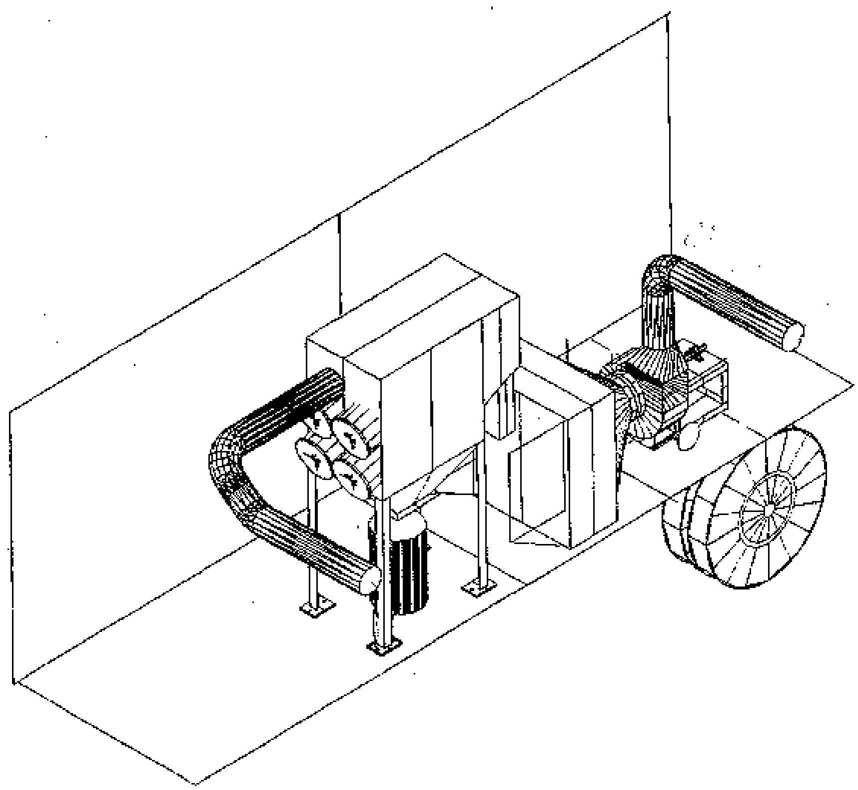

Figure 2. Ventilation module arrangement.

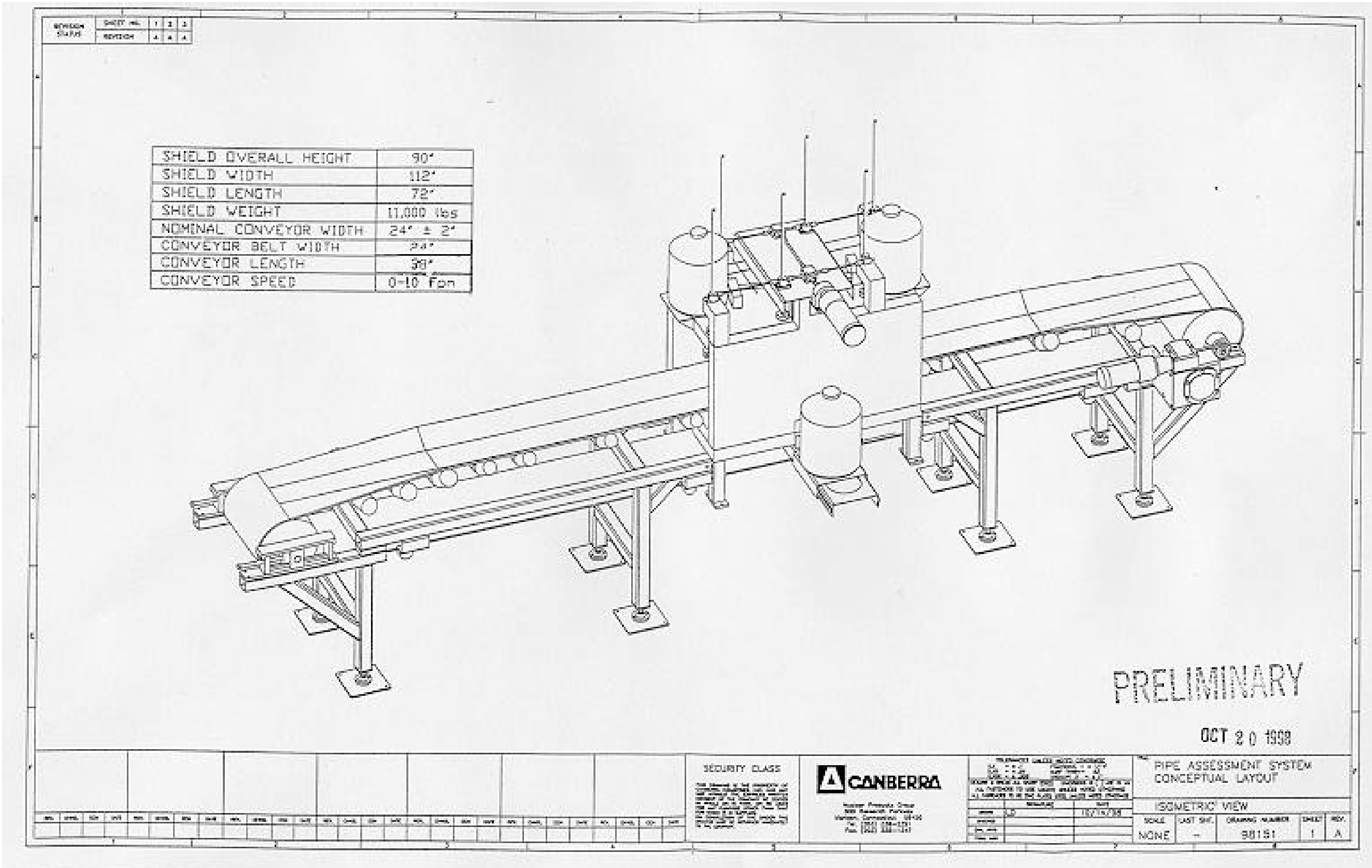

Figure 3. Conceptual view of the characterization system.

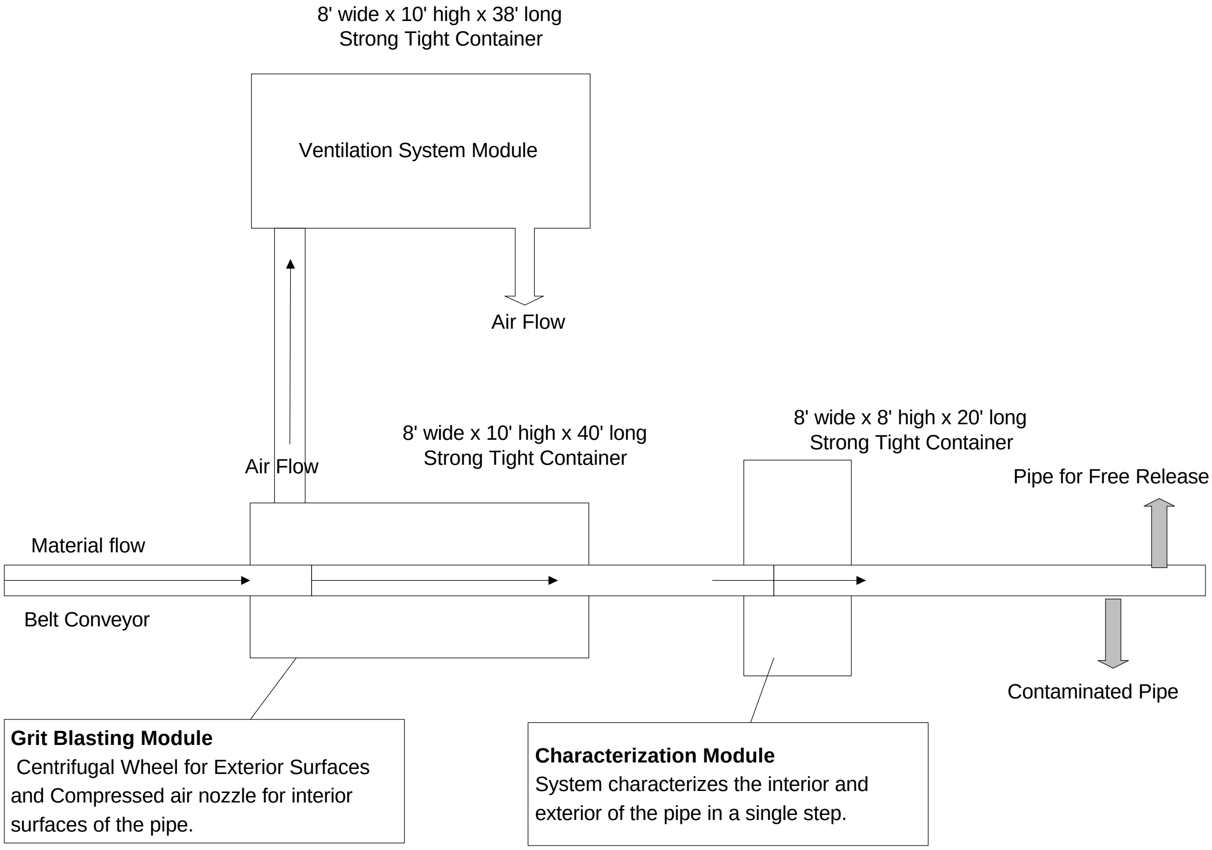

Figure 4. Product Flow Diagram.

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