

**Miscellaneous Organic NESHAP Compliance for a  
New Countermeasure Flare Production Facility  
At the Milan Army Ammunition Plant**

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## ABSTRACT

FR Countermeasures, Inc. (FRC), a division of Flight Refuelling Ltd. of the United Kingdom, has sited a countermeasure flare production facility at the Milan Army Ammunition Plant (MLAAP) in Milan, TN. Franklin Engineering Group, Inc. (Franklin Engineering) worked in cooperation with FRC to develop an air permitting strategy that would allow expedited regulatory review and approval to meet an aggressive construction schedule. This strategy addressed eventual compliance with the 40 CFR, Subpart FFFF (Miscellaneous Organic NESHAP (MON) standard) by permitting the facility as a conditional major source to allow for construction, start-up, and initial operation with eventual operation as a major source (i.e., Title V) at full processing rates.

The facility was modeled after Flight Refuelling, Ltd.'s North Stockbridge, U.K. manufacturing facility, with several important distinctions. First, the regulatory standards for air emissions from this type of facility in the United States in combination with a higher production capacity necessitated a higher level of control for Hazardous Air Pollutants (HAPs). Additionally, FRC had to address increased volume of effluent water from the solvent recovery process and carbon regeneration process. Finally, this effluent water had to meet the Sewer Use Agreement which required additional acetone removal prior to discharge to the sewer. The selection of an integrated air pollution control system to achieve these environmental objectives required special consideration of safety issues inherent to energetics manufacturing.

After consideration of several air pollution control technologies, FRC and Franklin Engineering selected an activated carbon adsorption system for treatment of combined gases from two main batch sources: mixing and drying processes. This system will achieve greater than 95% recovery of HAPs from these processes, as required for regulatory purposes. Carbon beds are regenerated via steam stripping to yield two streams: recovered hydrocarbons and a re-condensed aqueous stream. Recovered solvents are reused or sold. The aqueous stream is combined with water from the batch wash process and steam stripped for solvent recovery. Crucial to assuring safe operation of the air pollution control system was the utilization of a flame isolation valve with gas cartridge actuators to eliminate potential flame/deflagration passage between each process unit.

## INTRODUCTION

FR Countermeasures, Inc. (FRC), a division of Flight Refuelling Ltd. of the United Kingdom, recently completed construction of a state-of-the-art countermeasure flare production facility at the Milan Army Ammunition Plant (MLAAP) located in Milan, Tennessee. These countermeasure flares will be produced for all branches of military service and some of our allies. This project was partially funded by the Armament Retooling and Manufacturing Support (ARMS) program. American Ordnance (AO) is the government contracted operator at MLAAP. FRC entered into a Facilities Use Agreement with AO prior to beginning renovation of a former ammunition-loading line (Z line) that was originally constructed in 1941.

Franklin Engineering Group, Inc. (Franklin Engineering) was contracted to provide engineering and environmental services for the project at its inception. Engineering services included project management, concept develop-

ment, detailed design engineering, construction oversight, and start-up support. Safe operation was the immediate priority during the design phase of the project. Many of the manual energetics handling steps were automated utilizing state-of-the-art equipment to reduce employee exposure. Environmental services included air permitting and development of an environmental compliance program to address air, water and waste disposal issues. A particular concern was developing a compliance strategy that would provide for meeting the aggressive construction schedule as well as addressing eventual compliance with the Miscellaneous Organic NESHAP (MON) maximum achievable control technology (MACT) standard.

This paper provides a description of the project and the air permitting strategy utilized to meet the construction schedule and provide for eventual compliance with the MON standard. Furthermore, it includes a description of issues that had to be addressed for wastewater and energetic solid waste disposal. A description of the air

pollution control equipment evaluation process is also included with details of the carbon adsorption process that was installed. At the time this paper was prepared, FRC was completing final checkout of the process equipment and control system programming. Government approval of the manufacturing process and production is expected in the Spring of 2004. A Title V Permit Application has been submitted to the State of Tennessee that provides for compliance with the new source requirements in the MON standard upon issuance of the permit.



## PROJECT OVERVIEW AND REGULATORY CONSIDERATIONS

This project was part of the ARMS program to find tenants that can renovate existing manufacturing process lines at US Army ammunition plants that are no longer in use. Some buildings of this particular process line (Z line) had not been utilized since the early 1970s. The Army provides funding for site preparation and facility renovation. Much of the existing facilities, including storage magazines, buildings, and bunkers, are intact and provide for a cost effective approach for constructing a new countermeasure flare manufacturing facility.

Wallop Defence Systems (a division of Flight Refuelling, Ltd.) manufactures countermeasure flares at a facility in Middle Wallop, UK. The process includes mixing, drying, extruding, and packaging steps that provide the final product for use by the military. This project involved a scale-up of the existing process operated in the UK. A primary consideration of the project was to automate manual tasks to the extent possible and minimize handling of the intermediate energetic by employees. Flight Refuelling, Ltd. stresses safety at all its manufacturing facilities and has an exemplary safety record in the industry. Franklin Engineering was contracted to execute detailed design of the manufacturing process, and in conjunction with FRC personnel, pro-

vided construction oversight and start-up support. The project resulted in a state-of-the-art countermeasure flare production facility. A process flow diagram for the facility is shown in Figure 1. Franklin Engineering also provided environmental engineering and permitting services for this project. This required working closely with the State of Tennessee permitting authority and the MLAAP operator, American Ordnance (AO). A significant consideration was to expedite the construction permitting process to meet the project schedule deadlines.

The primary emissions from the process are solvents utilized in the mixing process, acetone and hexane. Hexane is considered a hazardous air pollutant (HAP) and volatile organic compound (VOC) under the Clean Air Act. An additional consideration was eventual compliance with the MON standard that was proposed on April 4, 2002. Since the MON standard was a proposed regulation during the construction permitting phase of this project, regulatory requirements related to air pollution control could not be assured. The eventual strategy was to design the process and air pollution control strategies based on the requirements in the proposed MON standard and utilize operating hour limitations to permit the facility as a conditional major source.

This provided for construction and start-up within the project timeline and allowed time for the MON standard to be promulgated. The facility will eventually be operated as a major source that is compliant with the new source MON requirements.

Additional environmental and permitting considerations included treatment of wastewater from the process and energetic waste disposal issues. FRC worked with AO personnel to develop a sewer use agreement that provided for utilization of existing sewer lines and the MLAAP wastewater treatment facility. Additionally, an agreement was reached that allows wastewater with the potential for energetic contamination to be treated at MLAAP facilities on-site. Finally, an agreement was reached that provided for treatment of solid energetic waste at the open burning facility at the MLAAP.

A major task in the project was to evaluate potential air pollution control technologies that would address eventual compliance with the MON standard in addition to meeting the most strict safety requirements. This included evaluation of condensers, thermal

treatment technologies and adsorption technologies. Condensers could not cost effectively provide adequate recovery due to the nature of the solvents utilized in the process and the fact that the concentrations in the vent streams were expected to be very low.

The overall costs for a regenerative thermal oxidizer and activated carbon adsorption were comparable; however, there were overriding safety concerns with the thermal oxidation device. This led to the final decision to utilize a carbon adsorption system to recover organics from the vent stream. Other factors that led to this decision included recovery and reuse of the solvents, availability of steam for activated carbon regeneration, and the availability of the sewer system for wastewater discharge. A distillation unit is included to provide for final cleanup of the wastewater prior to discharge to the sewer. Hexane recovered from this system can be mixed with fresh solvent and reused in the manufacturing process. The design of the process vent system includes sensors and isolation valves that can react in a fraction of a second to prevent propagation of energy between the process units and to protect personnel and equipment.

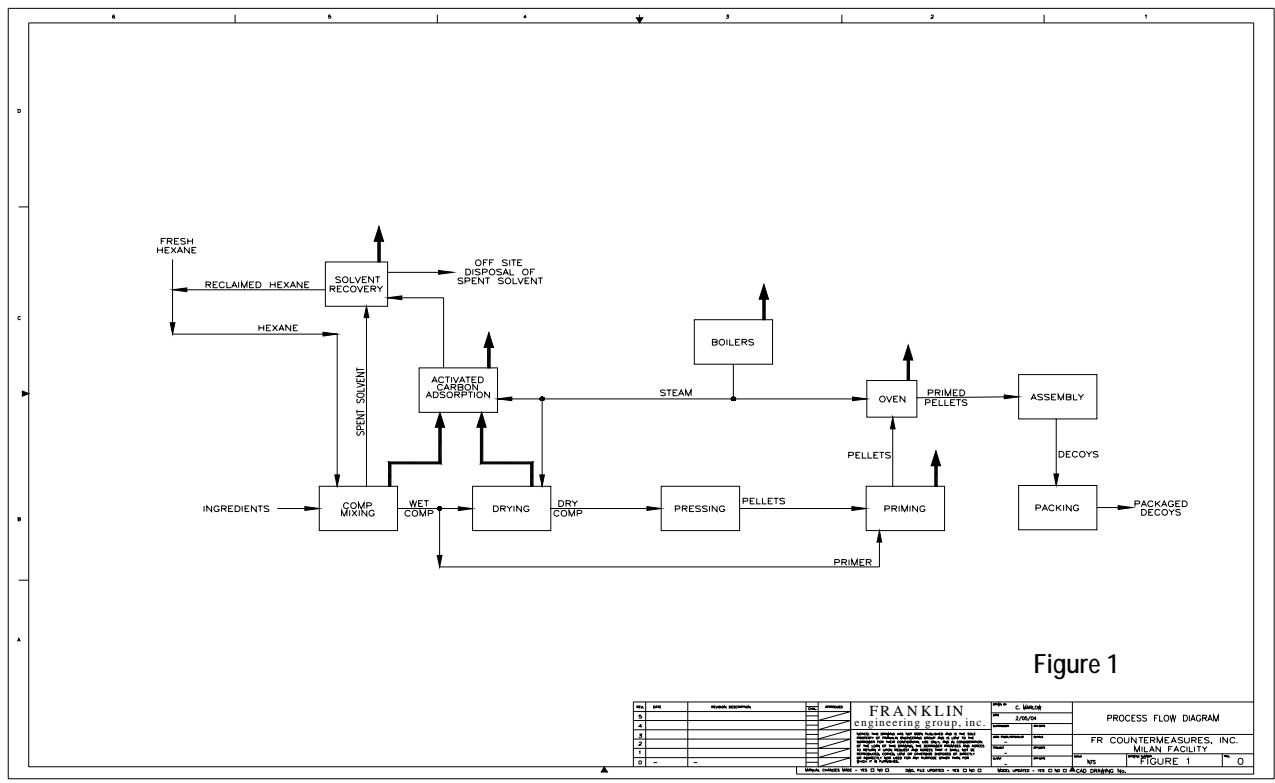


Figure 1

## PERMITTING APPROACH

Consistent with most capital projects the goal was to obtain a construction permit as soon as possible so that construction could begin. This project was a scale-up of a similar manufacturing facility operated by Wallop Defence Systems in the UK. A site visit to gather existing emission characterization data and other data that could be utilized to assist in emission estimates was performed early in the project. Furthermore, emission testing was conducted on the mixing operation and primary dryer stack at the existing facility. These data were utilized to generate emission estimates for permitting purposes.

The solvents utilized in the production of countermeasure flares are hexane and acetone. Hexane emissions

were the primary concern because hexane is both a hazardous air pollutant (HAP) and a volatile organic compound (VOC) under the Clean Air Act. Initial emission estimates indicated that the hexane emissions from the new countermeasure manufacturing facility would exceed the new source review (NSR) trigger level of 40 tons/year (tpy) VOC. Since the timing of the project did not provide for the time required to obtain a NSR permit, an alternative strategy had to be adopted.

Additionally, since hexane is a HAP, compliance with the MON standard had to be considered. The timing of this project related to the NESHAP regulatory process provided additional permitting challenges. The MON standard was proposed on April 4, 2002 and clearly indicated that energetic manufacturing facilities would be regulated. However, the energetic manufacturing industry

had submitted substantial comments on the proposed standard and raised considerable issues related to the safety of implementing the control requirements required by the rule. The proposed MON standard required 98 percent control or 95 percent recovery for Group 1 batch process vents. Furthermore, during the time when this facility was permitted, the US EPA could not provide substantial detail on how the energetic industry comments would be addressed in the final standard. Regardless, the HAP emissions from the facility had to be addressed since it was a new source and HAP (hexane) emissions were greater than 10 tpy. Since there was no final NESHAP in place, at a minimum a case-by-case MACT evaluation (per 112(j)) would need to be prepared and submitted with the construction permit application unless an alternative approach was adopted.

Evaluation and Final Control Technology Selection

A detailed comparison of activated carbon adsorption and regenerative thermal oxidation was completed. A list of the advantages and disadvantages of these technologies for the specific application at FRC was compiled and is presented in Table 2.

**Table 2:**  
**Comparison of Activated Carbon Adsorption and Regenerative Thermal Oxidation for the Site-Specific Application at FRC**

	Activated Carbon Adsorption	Regenerative Thermal Oxidation
Advantages	Recovery of solvent for reuse	Lower capital cost
	Handles spikes in VOC concentration	No wastewater
	Works well with batch or continuous processes	
	Potentially lower operating cost	
Disadvantages	Can easily be expanded to address additional flow	
	Treatment cost of the wastewater stream	Does not handle significant spikes
	Cooling tower required	Continuous flame may be considered unsafe
	Flexibility for future solvents	Not expandable
		Continuously sequencing valves are high maintenance

Selection of the activated carbon adsorption system was based on two primary factors. The activated carbon adsorption system was perceived to be safer because the regenerative thermal oxidizer has a flame. Furthermore, the carbon adsorption system offered more flexibility in accommodating future expansion.

The following discussion provides additional detail on considerations that resulted in the final selection of the activated carbon adsorption system:

- Steam stripping is utilized to regenerate the carbon beds. This results in a wastewater stream that requires treatment to recover the solvents. The readily available sewer connections that could be utilized for disposal of the wastewater streams provided a cost effective manner of treatment. The primary requirement was that the concentration of acetone in the effluent had to be limited to acceptable levels and hexane had to be recovered prior to discharge of the wastewater to the sewer. This precipitated pretreatment of the wastewater stream prior to discharge to the sewer.
- The use of the activated carbon adsorption system resulted in an increased demand on the facility steam supply system (fuel oil fired boilers). The overall increase in demand was not significant when compared to the steam needed for other parts of the manufacturing process and for building heat. However, additional steam generation capacity was required to address the needs of the activated carbon regeneration process.
- The activated carbon adsorption system also generated an organic stream containing acetone and hexane. This stream would be costly to dispose as a waste. The facility design included a batch distillation system to recover the hexane from a liquid stream generated in another part of the plant. This distillation system could also be utilized to recover this organic stream.
- An additional consideration with the activated carbon adsorption system was potential exothermic reactions that can occur with ketones (acetone). The system was designed with thermocouples that could detect thermal excursions in the activated carbon beds. Additionally, a water quench system was included in each bed to address thermal excursions in the event that they occurred.
- As mentioned previously, safety was a primary concern during the evaluation process. One of the main concerns was a catastrophic failure that resulted in flame propagation through the ductwork to multiple unit operations. Several alternatives for isolating the various process units were investigated. It was decided to use a flame isolation valve with a gas cartridge actuator to eliminate flame/deflagration passage. By rapidly closing the valve gate, flame passage is inhibited. This safety feature would have been provided irregardless of the technology selected and was not a factor in technology selection. The total costs of the two systems were comparable when all factors were considered (capital and operating).



The project team determined that by controlling the two major vents from the process (mixing and drying) and adopting operating hour limits, the total HAP emissions could be limited to less than 10 tpy and the facility could be permitted as a conditional major source. A detailed review of potential air pollution control alternatives is presented later in this paper. This evaluation led to the adoption of activated carbon adsorption as the air pollution control system of choice. The carbon adsorption unit was designed to provide a minimum of 95 percent recovery of hexane from the vent streams off the mixing and drying units. Furthermore, this approach provided that construction and operation could begin and eventual compliance with the final MON standard would be achieved.

The final construction permit application was submitted on August 29, 2002 and a construction permit was received on January 10, 2003. Initial start-up of the facility is

expected in early 2004.

Other permitting considerations included disposal of wastewater and energetic waste from the manufacturing processes. The Milan AAP operates an on-site wastewater treatment system and the FRC facility had existing sewer lines. A sewer use agreement was negotiated between American Ordnance (AO) and FRC. The major concern during negotiations was the assuring that the acetone content of the wastewater from the manufacturing process was within acceptable limits for the wastewater treatment system. A final sewer use agreement is in place.

Energetic waste presents unique disposal considerations. The Milan AAP operates an open burning facility to handle energetic waste generated at other operating units at the plant. As part of the ARMS agreement, Milan AAP agreed to obtain a permit modification that would provide for disposal of the energetic hazardous waste at the MLAAP

open burning facility. An additional consideration was disposal of sump water that was potentially contaminated with energetic. Again, existing facilities at the MLAAP are designed and permitted to handle this type of waste. Wastewater that has potential energetic contamination is trucked to this facility.

Franklin Engineering personnel worked closely with FRC to develop a comprehensive environmental program for the facility. In addition to the environmental and permitting issues addressed above the environmental program addressed EPCRA requirements, spill containment and countermeasure (SPCC) plan, and storm water plans. The facility eventually plans to seek certification under ISO 14001.

## AIR POLLUTION CONTROL EVALUATION

### Safety First

Flight Refuelling, Ltd. has an outstanding safety record in the industry and made it clear from the inception of this project that FRC would first consider safety in the evaluation of air pollution control technologies. Based on this overriding concern for safe operation, the following issues were considered:

- A thermal oxidizer that utilized a flame was considered the last resort because of the explosive and flammable nature of the solvents (acetone and hexane). Incidents at other facilities in the industry have occurred as a result of igniting solvent vapors.
- The process vents from several unit operations were combined into a single duct and directed to the final control device. The design had to provide for immediate isolation of the various unit operations such that flame would not propagate to connected unit operation through the ductwork.
- The final design had to account for and minimize the potential for energetic buildup in the ducts.

### Description of Emission Streams

The process vents that had to be controlled were comprised of vapors from mixing booths and dryer ovens that were operated as batch operations. Even though the overall airflow from each stream was constant, acetone and hexane concentrations varied as a function of the progression through the batch operation. Each individual process vent stream oscillated between low and high concentrations of solvent. The ventilation system was designed to assure that the concentration of acetone and hexane in each individual stream would be less than one fourth of the LEL by controlling the airflow. By combining the mixing and drying process vents the net effect was to dampen the variability of the solvent concentration in the air stream and deliver a more consistent stream to the air pollution control device. However, the system selected had to be capable of handling a process vent stream that was highly variable with potential short durations of relatively high solvent concentrations.

### Other Facility Considerations

An on-site wastewater treatment plant was available at MLAAP and the FRC facility had existing sewer connections. The wastewater treatment plant was capable of treating wastewater generated at the FRC facility; however, limitations were placed on the maximum concentrations of solvent that could be discharged to the sewer. Utilization of the existing sewer connections with ultimate treatment at the MLAAP plant was essential to assure cost effective operation.

Other utility considerations were part of the final system selection and design. Steam from on-site, fuel oil fired boilers was utilized for the drying processes and building heat. Fuel oil was utilized since natural gas was not available at the site. The design and operation of these facilities had to consider the increased load from any air pollution control technology selected.

A waste solvent stream was generated as part of the manufacturing process. This stream was to be processed in an on-site distillation unit to recover the spent hexane. This distillation unit could be used to treat any solvent that was recovered by the air pollution control system.

### Initial Control Technology Screening

Several different control technologies were evaluated. An initial screening process was employed to select the most promising technologies for more detailed study. The technologies considered and initial screening comments are presented in Table 1. Two technologies were identified for detailed evaluation: activated carbon adsorption and regenerative thermal oxidation.

**Table 1**  
**Initial Screening of Available Air Pollution Control Technologies**

Technology	Screening Comments	Further Study
Refrigeration	Solvent concentration in the vent gas was too low. Cost high.	No
Absorption	No viable scrubbing medium found.	No
Activated Carbon Adsorption	Viable candidate.	Yes
Thermal Oxidation	Compared to other oxidation technologies.	No
Catalytic Oxidation	Compared to other oxidation technologies.	No
Regenerative Thermal Oxidation (RTO)	Compared to other oxidation technologies.	Yes <sup>a</sup>
Polymeric Adsorption	High initial cost.	No

<sup>a</sup> The RTO process was the most cost effective option of the thermal oxidation alternatives.

## DESCRIPTION OF ACTIVATED CARBON ADSORPTION SYSTEM AND AUXILIARY UNITS

The solvent laden air flows through a preconditioning unit to cool the inlet air from 160 °F using cooling water as the cooling medium. This improves the adsorptive capacity of the carbon. After preconditioning, the solvent laden air is conveyed by an induced draft fan through two of three specially designed, fixed bed carbon adsorbers where the solvents are removed and clean air is discharged. Periodically, based on a pre-determined adsorption cycle, the flow is automatically diverted by the use of switching valves so that at any time during the process, one adsorber is undergoing regeneration while adsorption is taking place in the other two adsorbers.

Regeneration is accomplished by heating the carbon directly with steam. As the adsorber heats up, the solvents are stripped from the carbon and the steam solvent mixture flows into a shell and tube heat exchanger where the vapors are condensed and cooled by the use of cooling water. The condensed water/solvent mixture flows to a decanter where the aqueous phase and organic phase are separated by gravity. The aqueous phase is automatically pumped to a storage tank. Another pump automatically pumps the organic phase to a separate tank.

After regeneration is completed, a blower transports heated ambient air through the adsorber to cool and dry the activated carbon. This is done to ensure that the activated carbon will operate at optimum efficiency once it is brought back on line.

A unique feature of the activated carbon adsorption system is that it was designed so that more carbon adsorption vessels and associated equipment could be added in the future. This minimized initial costs while allowing for future expansion.

The water and organic phases are processed in the distillation system, which consists of a water wash tank, evaporator tank with condenser, and a stripping column. The water wash tank and evaporator tank are operated in a batch mode. First, organic liquid is pumped into the water wash tank where it is combined with water. The water is circulated by a pump to promote mixing of the water with the organic layer. After circulation for an adequate period of time, the water layer is drawn off and transferred to the water holding tank. This step is repeated three times, and then the organic layer is pumped to the evaporator tank. This step, the water wash, is designed to remove most if not all of the acetone contained in the organic liquid.

Heat is applied to the organic liquid (mostly hexane) by a steam coil in the bottom of the evaporator tank. This causes the organic liquid to evaporate and the vapors to flow overhead. The overhead vapors are condensed and cooled in a water-cooled heat exchanger. A temperature controller is used to operate valves that direct the flow of condensate to different tanks based on boiling point. Steam flow is stopped when a high temperature limit is reached or a low evaporator tank level occurs. This processing step produces a waste solvent stream and a recovered hexane stream. The waste solvent can be sold for solvent recovery or fuel blending. The recovered hexane stream is combined with fresh hexane and reused in the manufacturing process.

The stripping column is used to process water from the water wash tank and the carbon adsorption system. Water is fed into the tower at an intermediate point and flows downward while steam is injected into the bottom of the stripping column and flows upward through the packed column. A rectification section located above the water feed point concentrates the acetone in the vapor flowing upward before it is condensed and cooled in two water cooled heat exchangers. The recovered acetone can be used for cleaning operations within the plant or may be sold for solvent recovery or fuel blending. The stripped water is pumped out of the bottom of the column to a holding tank for testing prior to discharge to the MLAAP wastewater treatment system.



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