# U.S. Environmental Protection Agency

# Environmental Technology Verification Program

# For Metal Finishing Pollution Prevention Technologies Verification Test Plan

# for the

# Evaluation of The MART Corporation's EQ-1Ô Wastewater Processing System

**Revision 0**

**January 5, 2001**

Concurrent Technologies Corporation is the Verification Partner for the EPA ETV Metal Finishing Pollution Prevention Technologies Center under EPA Cooperative Agreement No. CR826492-01-0.

# U.S. Environmental Protection Agency
# Environmental Technology Verification Program
# For Metal Finishing Pollution Prevention Technologies
# Verification Test Plan

**for the**

**Evaluation of The MART Corporation's EQ-1ô Wastewater Processing System**

**January 5, 2001**

**TITLE:** **EVALUATION OF THE MART CORPORATION'S EQ-1ô WASTEWATER PROCESSING SYSTEM**

**ISSUE DATE**: **January 5, 2001**



## DOCUMENT CONTROL

This document will be maintained by Concurrent Technologies Corporation (*CTC*) in accordance with the EPA Environmental Technology Verification Program Quality and Management Plan for the Period 1995-2000 (EPA/600/R-98/064). Document control elements include unique issue numbers, document identification, numbered pages, document distribution records, tracking of revisions, a document MASTER filing and retrieval system, and a document archiving system.


## ACKNOWLEDGMENT

This is to acknowledge Karrie Jethrow, Percy Peltzer, Jim Totter, Scott Maurer and Valerie Whitman for their help in preparing this document.

Concurrent Technologies Corporation is the Verification Partner for the EPA ETV Metal Finishing Pollution Prevention Technologies Center under EPA Cooperative Agreement No. CR826492-01-0.

Environmental Technology Verification for Metal Finishing Pollution Prevention Technologies Program: Verification Test Plan for the Evaluation of MART Corporation's EQ-1™ Wastewater Processing System.

**Prepared By:**

A.G. Eskamani — 1/8/01

***Gus Eskamani***
***ETV-MF Project Manager*** — **Date**

**Approved By:**

Clinton Twilley — 1/11/01

***Clinton Twilley*** — **Date**
***CTC QA Manager***

Donn Brown — 1/10/01

***Donn Brown*** — **Date**
***CTC ETV-MF Program Manager***

Alva E. Daniels — January 18, 2001

***Alva Daniels*** — **Date**
***EPA ETV Center Manager***

Jim Potthast — 1-18-01

***Jim Potthast, Sales Manager/Special Markets*** — **Date**
***MART Corp.***

Troy A. Cramer — 9 JAN 01

***1st Lt. Troy Cramer, Ohio Air National Guard*** — **Date**
***Base Environmental Manager – 179th Airlift Wing***

Signature denotes acceptance of this test plan as written regarding experimental design, quality assurance, test and analysis methods, operational procedures, equipment configuration, project management and current system operating effectiveness prior to testing.

**TABLE OF CONTENTS**

## LIST OF APPENDICES



## LIST OF FIGURES



## LIST OF TABLES

## ACRONYMS & ABBREVIATIONS

| | |
|---|---|
| **AGE** | Aircraft Ground Equipment |
| **AIHA** | American Industrial Hygiene Association |
| **ANG** | Air National Guard |
| **AW** | Airlift Wing |
| **Ba** | Barium |
| **C-130H** | C-130 Hercules |
| **CAS #** | Chemical Abstract Number |
| **Cd** | Cadmium |
| **Cr** | Chromium |
| ***CTC*** | Concurrent Technologies Corporation |
| **Cu** | Copper |
| **DOD** | Department of Development |
| **EPA** | Environmental Protection Agency |
| **ETV-MF** | Environmental Technology Verification for Metal Finishing Pollution Prevention Technologies |
| **FPS** | Final Polishing System |
| **$ft^3$** | Cubic feet |
| **g/L** | Grams per liter |
| **gph** | Gallon per hour |
| **gpm** | Gallon per minute |
| **Hcl** | Hydrochloric acid |
| **HP** | Horsepower |
| **HQ** | Headquarters |
| **hr** | Hour |
| **Hz** | Hertz |
| **ID** | Identification |
| **IDL** | Instrument detection limit |
| **JTA** | Job Training Analysis |
| **kWh** | Kilowatt hour |
| **lb.** | Pound |
| **L** | Liter |
| **Lpm** | Liter per minute |
| **MART** | The MART Corporation |
| **MDL** | Method detection limit |
| **ml** | Milliliter |
| **mm** | Millimeter |
| **MRL** | Method reporting limit |
| **MSDS** | Material Data Safety Sheet |
| **Ni** | Nickel |
| **NIOSH** | National Institute of Occupational Safety and Health |
| **O&G** | Oil and Grease |
| **O&M** | Operation and Maintenance |
| **OSHA** | Occupational Safety and Health Administration |
| **PARCCS** | Precision, Accuracy, Representativeness, Comparability, Completeness, and |

| | |
|---|---|
| | Sensitivity |
| **Pb** | Lead |
| **POTW** | Publicly Owned Treatment Works |
| **PPE** | Personal Protection Equipment |
| **ppm** | Part per million |
| **PQL** | Practical quantification limit |
| **psi** | Pounds per square inch |
| **PVC** | Polyvinyl chloride |
| **QA** | Quality Assurance |
| **QC** | Quality Control |
| **QMP** | Quality Management Plan |
| **Ref.** | Reference |
| **RPD** | Relative Percent Difference |
| **rpm** | Revolutions per minute |
| **SM** | Standard Methods for Examination of Water and Wastewater, $20^{th}$ ed (1998) |
| **SOP** | Standard Operating Procedures |
| **STEL** | Short Term Exposure Limit |
| **TCLP** | Toxicity Characteristic Leaching Procedure |
| **TPH** | Total Petroleum Hydrocarbons |
| **TS** | Total solids |
| **TSS** | Total suspended solids |
| **TWA** | Time weighted average |
| **U.S.** | United States |
| **VAC** | Vacuum |
| **µ** | Micron |

# 1.0 INTRODUCTION

The purpose of this test plan is to document the objectives, procedures, equipment and other aspects of testing that will be utilized at the Ohio Air National Guard (ANG) 179$^{th}$ Airlift Wing (AW), during verification testing of The MART Corporation's EQ-1™ Wastewater Processing System. This test plan has been prepared to evaluate the performance of the technology by the U.S. Environmental Protection Agency's (EPA's) Environmental Technology Verification for Metal Finishing Pollution Prevention Technologies (ETV-MF) Program. The objective of this program is to identify promising and innovative pollution prevention technologies through EPA-supported performance verifications and to provide objective performance data to purchasers, consulting engineers, and permitters of environmental technologies.

The MART Corporation (MART) has manufactured power washer cleaning equipment, designed for use with aqueous alkaline cleaners, for over 26 years. Power washers generate a large quantity of spent solution that is either evaporated or hauled away for treatment and disposal. In response to this issue, MART developed the MART EQ-1™ System, which is a batch treatment process that separates water from a waste stream in one step. The MART EQ-1™ System consists of the EQ-1™ unit and an optional Final Polishing System (FPS). The MART EQ-1™ unit employs a proprietary chemical called "Magic Dust" to perform the separation of contaminants such as oil/grease (O&G) and metals from the cleaning solution. The MART process utilizes adsorption and electrostatic forces to encapsulate waste products including paint, solid and dissolved metals (e.g., lead, cadmium, chromium), dust, oil, minerals, and even asbestos. The encapsulated material (processed waste) cures and sets up like hardened dough or concrete. The treated water and unused chemical are recycled.

Testing of the MART EQ-1™ system will be conducted at the 179$^{th}$ AW located in Mansfield, Ohio. The 179$^{th}$ AW is charged with a mission of maintaining combat readiness and mobility to deploy globally in the event of a national security action. The 179$^{th}$ AW is an Ohio ANG unit that has Federal, state, and community roles. Its Federal role is to support the Unites States Military Objectives, through participation in America's Armed Forces. Its state role is to support the Governor by providing trained units and equipment capable of protecting life and property, and preserving peace, order, and public safety. Its community role is to be an active participant in domestic concerns through local, state, and national programs. The major activities performed at the Mansfield ANG include aircraft maintenance, aerospace ground equipment maintenance, ground vehicle maintenance and facilities maintenance. The 179$^{th}$ AW has operations, logistics, support, and medical professionals who provide airlift capabilities to serve the state and the nation.

This project will evaluate the ability of the MART EQ-1™ Wastewater Processing System to separate oil/grease, metals, and suspended solids from the spent cleaning solution. Evaluating and verifying the performance of MART's system will be accomplished by collecting operational data and in-process samples for analysis. The resultant test data will be used to prepare a material balance to determine the efficiency of oil/grease, metals, and suspended solids removal for a given set of operating conditions.

The test plan described in this document has been structured based on a format developed for ETV-MF projects. This document describes the intended approach and explains testing plans with respect to areas such as test methodology, procedures, parameters, and instrumentation. Also included in this test plan is Quality Assurance/Quality Control requirements of this task that will ensure the accuracy of data, data interpretation procedures, and worker health and safety considerations.

The test plan will be maintained at the test site, and verification testing will be conducted in strict adherence to the test plan requirements. Any modifications to or deviations from the test plan will be documented according to the procedures outlined in this test plan.

### 1.1 Background

The Federal electroplating and metal finishing pretreatment wastewater standards were developed by EPA by identifying commonly used treatment practices and determining their effectiveness by collecting effluent data from well operated systems. EPA selected conventional wastewater treatment as the standard system. Therefore, for most plating shops, the use of conventional treatment will provide sufficient pollutant removal to meet discharge standards. Some conventional methods used for removal of metals from wastewater include: (1) hydroxide precipitation techniques; and (2) sludge de-watering using gravity thickening followed by a mechanical de-watering device to increase the solids content of the sludge and therefore reduce its volume.

There are two major exceptions to this rule. First, many plating shops are regulated by local discharge standards that are more stringent than the Federal standards, and conventional treatment may be insufficient to meet these limitations. Second, the treatment system selected by EPA for establishing Federal standards were those systems that EPA determined to be "properly operating facilities." For example, EPA omitted facilities that: (1) did not have well operated treatment processes; (2) had complexing agents (e.g., non-segregated wastes from electroless plating); and (3) had dilution from non-plating wastewaters. Consequently, some plating facilities may not meet the properly operated facility criteria used by EPA and may have difficulty meeting Federal and/or local discharge standards using conventional treatment. In light of many facilities that may have difficulty cost-effectively meeting applicable discharge standards using conventional methods, there is a need for innovative wastewater treatment technologies. A cost-effective, waste minimization process that can effectively treat wastewater will have the desirable effects of water reuse, reduction in generation of hazardous waste, reduction in hazardous waste disposal costs, reduction in raw material costs, and ultimately, regulatory compliance when discharging.

## 2.0 TECHNOLOGY DESCRIPTION

### 2.1 Theory of Operation

The MART EQ-1™ Wastewater Processing System (**Figure 1**) is an inventive technology that chemically separates and clarifies the wash solution and encapsulates the waste for disposal. The MART process utilizes adsorption and electrostatic forces to encapsulate waste products. The chemical compound used in the MART encapsulating process is a non-hazardous proprietary product called Magic Dust, which is formulated for the specific site and application.

The heart of the MART EQ-1™ process is based on the performance of the Magic Dust. The Magic Dust is a blend of clay, polymeric, acidic, and various other additives that allow the compound to integrate several reactions in one. The function of the Magic Dust is as follows: (1) The acidic components cause oily contaminants to coalesce and separate from the wastewater; (2) the polymeric cationic portion attracts any remaining oils and the larger, more highly charged anions; (3) the third component group precipitates metallic hydroxides and drives the system to a fully flocculated condition where the clay particles attract the cationic polymer molecules (with absorbed oil), metallic ions and positively charged contaminants; and (4) the heavy metal cations still remaining in solution exchange with sodium in the clay and electrostatically bond to the clay platelets. The fully reacted mass is a complex mixture of encapsulated contaminants and waste solids that are held together by van der Waals as well as electrostatic forces. The clay particles agglomerate, completely entrapping and surrounding suspended solids. Pozzolanic reactions also occur, which form cement-like particles that settle to the bottom of the reaction vessel.


**Figure 1: The MART EQ-1™ Unit**

The Magic Dust is added to the wastewater and the agglomerate is mixed to cause the necessary complex reactions and microencapsulation: molecules with adsorbed oil, metallic ions, and charged contaminants are attracted to the Magic Dust to form a mass. The Magic Dust formulation also includes chemistry to demineralize the treated water. After microencapsulation, the flocculated waste is filtered through a disposable media paper to collect the waste for disposal. The encapsulated waste is collected in the filter paper and the clarified solution is collected in a holding tank. The filter paper containing the encapsulated waste is rolled up and allowed to harden into a cement-like material. The filter paper and waste material are put into a drum and disposed of off-site as hazardous waste. The clarified solution can be recycled and reused or treated further with an optional FPS and discharged to the sanitary sewer. The MART FPS is a basic ion exchange system that utilizes a granular activated carbon filter along with a polymer resin chamber, which employs polystyrene beads with sodium ions as the resin media. The pre-filter removes oil/grease, and other contaminants that may hinder the effectiveness of the beads. Next, the solution is sent through the resin chamber where heavy metals are removed.

### 2.2 Commercial Status

The MART EQ-1™ Technology was introduced into the market in January 1998. Since the product launch, the Navy, Air Force, and Marines have utilized the EQ-1™, as have industrial companies wanting to reduce waste and disposal costs. MART currently has 64 units installed.

### 2.3 Pollution Prevention Classification

The MART EQ-1™ is a wastewater recycling technology. MART has manufactured Power Washer cleaning equipment for over 26 years. The Power Washer is designed for use with aqueous alkaline cleaners. Many of MART's customers over the years have relied on the expensive services of waste haulers to remove and transport the spent solution from the Power washer. In response to MART's customers' need for solution maintenance, they launched the MART EQ-1™ in January 1998. The EQ-1™ focuses on the recycling of water used in cleaning processes.

### 2.4 Environmental Significance

The MART EQ-1™ is employed to: (1) reduce the quantity of fresh water needed in the cleaning process, by recycling treated water back into the original process, (2) reduce the volume of sludge and leachability of heavy metals in the hazardous sludge, and (3) remove heavy metals, and oil/grease from the discharged waste stream.

## 3.0 PROCESS DESCRIPTION

### 3.1 Equipment and Flow Diagram

The MART EQ-1™ unit is equipped with two connecting tanks (**Figure 2**): a mixing/reaction tank (upper reservoir tank) and a holding tank (lower reservoir tank). Each tank is made of sheet steel and has a capacity of 125 gallons. The upper tank is of a trapezoidal design; this is where the untreated water is pumped and the treatment chemical (Magic Dust) is added. Once the solution is thoroughly mixed the encapsulated material is allowed to settle to the bottom of the mixing/reaction tank. A sight glass is provided on this tank so that the separation/encapsulation process can be observed.

After encapsulation the treated water is allowed to drain into the holding tank. The treated water flow is controlled by two separate ball valves located at the bottom of the upper tank. Both valves are two inches in diameter and are operated manually. The standpipe valve controls the flow of the clarified solution and light flocculation, and the bottom valve controls the flow of heavy precipitation. The standpipe, located on the inside of the upper tank, can be cut to adjust the height of the pipe to the depth of the flocculated material.

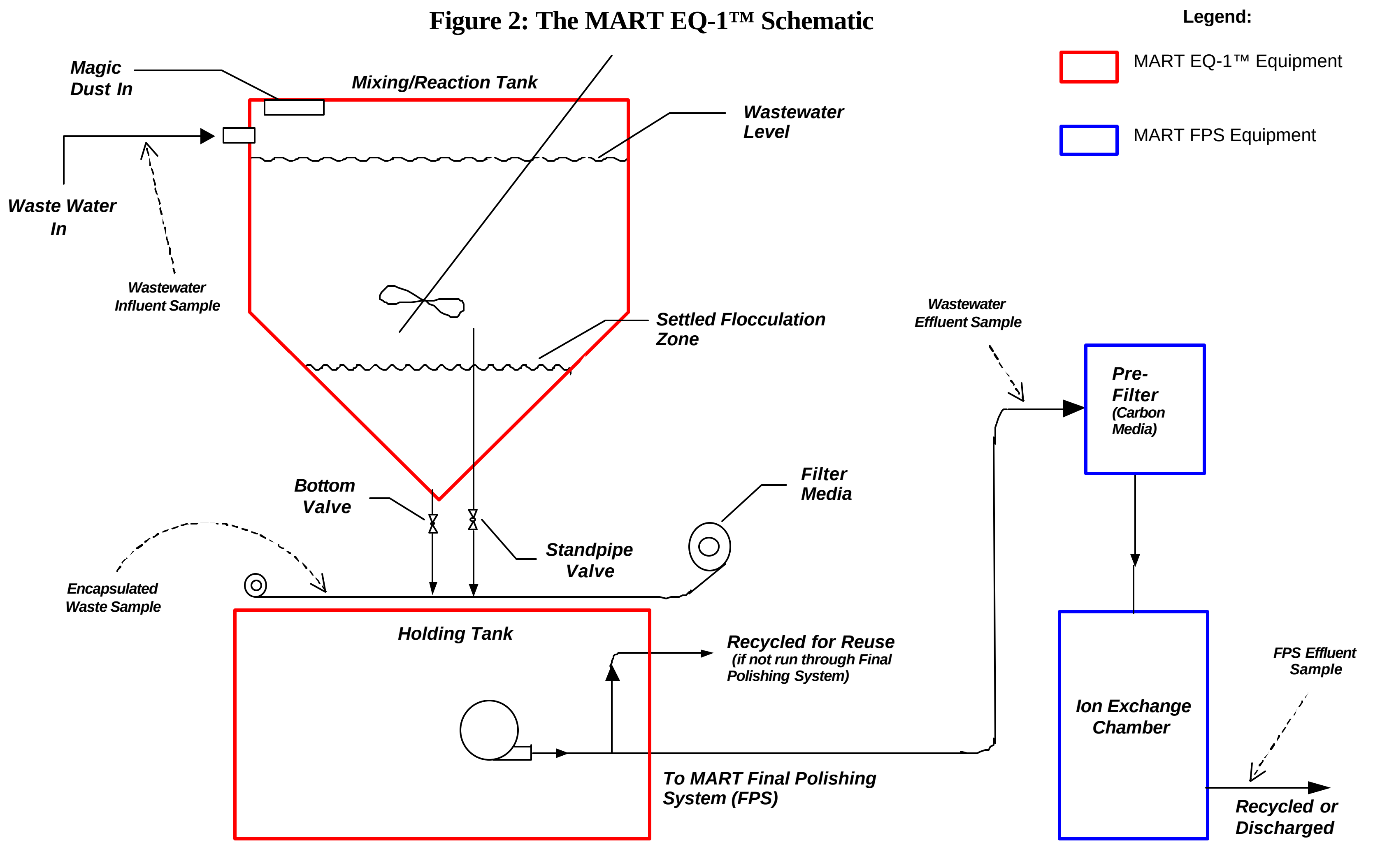
All treated water is allowed to pass through a filtration media (30 micron (µ) paper) before entering the holding tank. The MART system contains a metal filter pan, directly below the upper tank, to hold the filter media. The filter media is constructed of rayon fiber and collects the treatment chemical with the encapsulated waste. As the waste is collected on the filter paper, the paper is slowly pulled forward and wrapped around the encapsulated waste. When the waste has been sufficiently wrapped, the filter paper is cut. The encapsulated waste is removed and placed in the drying tray, which is located on the right side of the unit. This process is repeated until all the wastewater has been processed. As the encapsulated waste is rolled in the filter paper, the paper is squeezed to remove excess solution. The clarified solution in the holding tank is transferred with a submersible pump to the FPS, which is an optional secondary treatment.

The FPS is a basic ion exchange system. The system is cationic and polystyrene beads with sodium ions are used for the resin media. The FPS includes a granular activated carbon filter along with a polymer resin chamber. The clarified solution enters the pre-filter carbon media to remove oil, grease, and other contaminants. The filtered solution then enters the ion exchange chamber, where the metal ions are removed by being captured on the beads. The pre-filter chamber is 3” in diameter, 25” tall, and requires one 20” - 15 µ filter cartridge. The refillable resin chamber has a polyvinyl chloride (PVC) shell with a 250 µ polypropylene strainer. The strainer prevents resin migration with the solution. The resin has a 1 pound (lb.) per 0.5 cubic feet ($ft^3$) capacity. The specification for the FPS is 72 gallons per hour (gph) or 1-2 gallons per minute (gpm) for maximum removal efficiency.

### 3.2 Testing Site

The test site selected for verification of the MART EQ-1™ system is the Ohio ANG 179$^{th}$ AW in Mansfield, Ohio. The 179$^{th}$ AW has a 52 year history from the early days organizing the 179$^{th}$ unit and flying fighters, to their present day situation as a first string member of the Total Force and flying the C-130 Hercules (C-130H) aircraft. The 179$^{th}$ is an Air Force ANG comprised of 950 personnel, with about 250 being full-time. Their primary mission is to provide airlift capabilities for the state of Ohio and the U.S.

**Figure 2: The MART EQ-1™ Schematic**



The 179th AW utilizes the C-130H transport in their daily airlift capabilities operations. The 179th AW cleans the engines on their eight C-130H aircraft at least once each year as preventative maintenance to ensure maximum performance, as well as aircraft and aircrew safety. In 1993, cadmium was detected in the engine compressor spent wash wastewater. The cadmium rinsate was believed to be coming from the cadmium-plated internal compressor blades in the C-130H aircraft engine. At that time most of the Department of Defense (DOD) facilities were not collecting their spent wash wastewater. Consequently, in 1994 the ANG Headquarters (HQ) stated that there was a possible problem and in 1995 instructed all C-130H bases to stop aircraft engine washing until a collection system could be developed. In 1997 engine compressor washing resumed. The spent wash wastewater was collected and drummed as hazardous waste, using a wastewater collection container.

The spent wash wastewater collected from the cleaning of the C-130H engines has the potential to generate large quantities of hazardous waste annually at each ANG base. The 179th AW realized this environmental impact and began implementing a program to treat the C-130H engine compressor spent wash wastewater at their site, as well as their spent aqueous- based parts washer water.

## 3.3 The 179th AW C-130H Engine Cleaning Process

It is a requirement at the 179th AW to wash the C-130H aircraft engines at least once each year to ensure maximum performance and aircraft and aircrew safety. The cleaning process used at the 179th AW is as follows:

- Soap application (soak for 5 minutes)
- Soap application again (soak for 20 minutes)
- 2 clean water rinses

The aircraft cleaning solution used is Eldorado ED-563. The Material Data Safety Sheet (MSDS) is provided in ***Appendix A***. The entire cleaning process generates no more than 10 gallons of water/soap rinsate per engine and no more than 40 gallons per plane. This results in the generation of approximately 640 gallons of wastewater per year at the 179th AW base. The rinsate mixture is comprised of approximately 94% water, 5% soap, and 1% cadmium and oil/grease. **Table 1** presents background analysis of a C-130H engine spent wash wastewater sample taken before treatment. It was collected by the 179th AW on October 20, 1997 and tested by Clayton Laboratory Services. The spent wash wastewater is hazardous for cadmium at 11 ppm. The cadmium in the rinsate comes from the cadmium-plated internal compressor blades of the engine. The oil/grease in the rinsate come from the engine. It is a mixture of oils and carbon from the exhaust. It is estimated that the concentration of contaminants in this spent wash wastewater remains relatively constant, because the frequency of C-130H engine cleanings is determined based on the number of hours the engine is in service.

**Table 1. Spent Engine Cleaning Wash Wastewater Background Analysis**

| Constituent | Unit | Parameter |
|---|---|---|
| Cadmium (Cd) | ppm | 11 |
| Oil/Grease | ppm | 2500 |
| pH | pH units | 7.1 |

After the four C-130H aircraft engines on each plane are cleaned, the cleaning solution and rinsate are collected in a large 500 gallon plastic polystyrene collection container (**Figure 3**) and transported to the MART system. The treated engine wash wastewater is discharged to the POTW.


**Figure 3: The 179th AW Wash Wastewater Collection Container**

### 3.4 The 179th AW Parts Washer Cleaning Process

There are three part washers at the 179th AW, each of which utilizes an aqueous based alkaline cleaner. MSDSs for each of the cleaner's are provided in **Appendix A**. A description summary of the washers is presented in **Table 2**. The alkaline cleaners are treated individually, by the MART unit. The spent alkaline cleaners contain soils which are primarily cadmium (Cd), chromium (Cr), paint chips, and oil/grease. Some of the minor contaminants include lead (Pb), barium (Ba), nickel (Ni), and copper (Cu). The spent alkaline cleaner concentration varies depending on the type and quantity of soil on the parts and age of the cleaning solution. After treatment in the

MART system the treated alkaline cleaner is pumped back into a tank and than to be used in the parts washer area.

**Table 2. Parts Washers at the 179th AW**

| Parts Washer | Size (Liters) | Alkaline Cleaner | Use | Contaminants |
|---|---|---|---|---|
| Engine Shop *(MART® Tornado 40)* | 680 | DARACLEAN® 235 | Aircraft engine panels | Cd, Cr, Cu, Pb, Oil/grease |
| Aircraft Ground Equipment (AGE) *(MART® Cyclone 30)* | 490 | DARACLEAN® 282 | Burner cans from engine heater | Cd, Cr, Pb, Ba, Oil/grease |
| R&R (Tire Shop) *(MART® Cyclone 30)* | 490 | DARACLEAN® 282 | Rims, bolts, & various brake components | Cd, Cr, Cu, Ni, Ba, Oil/grease |

# 4.0 EXPERIMENTAL DESIGN

## 4.1 Test Goals and Objectives

The overall goal of this ETV-MF project is to evaluate the ability of the MART EQ-1™ system to separate oil/grease, metals, and suspended solids from the spent cleaning solution. This technology will be evaluated under actual production conditions, and the operation of the unit will be characterized through the measurement of various process control factors.

The following is a summary of specific project objectives. Under normal system operating set-points at the 179th AW and varying contaminant-loading rates:

- Prepare a material balance for wastewater constituents (soils and metals) in order to:

  1) Evaluate the ability of the MART EQ-1™ system to remove oil/grease and metals.
  2) Evaluate the ability of the MART EQ-1™ system to recycle cleaner solution.

- Determine the cost of operating the wastewater processing system for the specific conditions encountered during testing.

  1) Determine labor requirements needed to operate and maintain the MART EQ-1™ system.

2) Determine the quantity of energy consumed by the MART EQ-1™ system during operation.

- Quantify the environmental benefit by determining the potential for reduction in water and chemical disposal frequency.

### 4.2 Critical and Non-Critical Measurements

Measurements that will be taken during testing are classified below as either critical or non-critical. Critical measurements are those that are necessary to achieve project objectives. Non-critical measurements are those related to process control or general background readings.

The following are critical measurements:

- Magic Dust chemical additions (lbs.) and related costs
- Treated waste volumes (L) and related costs
- Total Suspended Solids (TSS) of system influent and effluent streams
- Cleaner concentration (system influent and effluent streams for EQ-1™ and FPS based on alkalinity and refractive index or conductivity)
- Conductivity of the influent and effluent streams
- Oil/grease concentration (system influent and effluent streams for EQ-1™ and FPS, encapsulated waste)
- Metal concentration (system influent and effluent streams for EQ-1™ and FPS, and encapsulated waste)
- Operation and Maintenance (O&M) labor requirements (hours) and costs
- Energy use (kilowatt-hour (kWh)) and costs
- Quantity and chemistry of the encapsulated hazardous solids
- Air monitoring (cadmium and chromium)

The following are non-critical measurements:

- pH of the influent
- Flocculation formation time
- Settling time

### 4.3 Test Matrix

Testing will be conducted in four distinct test periods, with each test period having a batch (60 - 100 gallons) processed through the MART EQ-1™ system. The conditions for each test are outlined in the sections below. Test objectives and measurements are summarized in **Table 3**.

**Table 3. Test Objectives and Related Test Measurements for Evaluation of the MART EQ-1™ System**

| Test | Test Objective | Test Measurement |
|---|---|---|
| 1. Typical contaminant loading rate found in the C-130H engine wastewater. | Prepare a material balance for wastewater constituents (soils and metals). | • Chemical characteristics of feed solution.<br>• Chemical characteristics of recovered product.<br>• Volume and chemical characteristics of wastes removed from wastewater.<br>• Quantity of fresh cleaning chemicals added during testing. |
| | Evaluate the ability of the MART system to process spent cleaner solution and separate usable cleaner solution chemistry from contaminants. | • Chemical characteristics of feed solution.<br>• Chemical characteristics of recovered product. |
| | Determine the cleaner recovery rate of the system, normalized based on production throughput and soil loading. | • Volume of product produced.<br>• Production throughput for wastewater.<br>• Soil loading. |
| | Determine labor requirements needed to operate and maintain the MART system. | • O&M labor required during test period. |
| | Determine the quantity of energy consumed by the MART system during operation. | • Quantity of energy used by pumps and mixer. |
| | Determine the cost of operating the wastewater recycle system for the specific conditions encountered during testing. | • Costs of O&M labor, materials, and energy required during test period.<br>• Quantity and price of fresh cleaning chemicals added during testing. |
| | Determine if worker exposure is elevated, as a result of operating the MART system. | • Perform air monitoring at a low and high soil load level. |
| | Quantify/identify the environmental benefit. | • Review historical waste disposal records and compare to current practices. |
| 2. High contaminant loading rate using the R&R parts washer wastewater. | Same as above. | Same as above. |
| 3. High contaminant loading rate using the AGE parts washer wastewater. | Same as above, with the exception of worker exposure analysis. | Same as above, with the exception of air monitoring. |
| 4. High contaminant loading rate using the Engine Shop parts washer wastewater. | Same as above, with the exception of worker exposure analysis. | Same as above, with the exception of air monitoring. |

#### 4.3.1 Engine Spent Cleaning Wash Wastewater – Test #1

During the first test period, the MART EQ-1™ system will be operated using normal operating conditions found at the 179th AW (Section 3.3). A "typical" level of contamination found when treating spent engine wash wastewater will be used during this test period. This "typical" level can be defined as the normal contamination load in the wastewater after being used to clean the C-130H engine. This "typical" level will be quantitatively determined during the first test period by collecting and analyzing representative samples of the feed solution.

#### 4.3.2 Parts Washers' Wastewater – Test #2 – 4

During the second through fourth test periods, the MART EQ-1™ system will be operated using normal operating conditions found at the 179th AW (Section 3.4). Test #2 will evaluate the ability of the MART EQ-1™ to remove contaminants in the R&R parts washer wastewater, Test #3 evaluates the AGE parts washer wastewater, and Test #4 the Engine Shop parts washer wastewater. The wastewater from the parts washers has historically contained a higher concentration of heavy metals, specifically cadmium, than the engine wastewater. To evaluate the operation of the MART EQ-1™ system under a higher contamination loading condition, the parts washers' wastewater will be processed through the MART™ unit. The higher contaminant loading level will be quantitatively determined for each of the parts washer streams during the respective test period by collecting and analyzing samples of the feed solution.

### 4.4 Testing and Operating Procedures

#### 4.4.1 Set-Up and System Initialization Procedures

Prior to startup, the MART unit will be flushed with fresh water. The procedure is as follows:

- Position the filter paper to fully cover the metal filter pan.
- Close discharge line valve.
- Fill mixing/reaction tank with fresh water. Rinse walls of tank.
- Open the bottom valve and standpipe valve.
- Allow water to drain through both valves, into the Holding tank, until the mixing/reaction tank is empty.
- Start the holding tank transfer pump.
- Pump rinse water through transfer pump, until adequately cleaned.
- Drain holding tank.
- Close bottom valve, standpipe valve and other discharge valves on MART unit.
- Remove filter paper and appropriately dispose of it.

The mixing/reaction tank will then be filled with 60 to 100 gallons of wastewater solution and the MART EQ-1™ unit will be started according to instructions in the O&M manual (**Appendix B**).

### 4.4.2 System Operation

The unit will be operated on a batch basis, with 60 – 100 gallons processed during each test cycle. Only one batch will be sampled per test cycle. At the completion of the first test cycle, the unit will be drained and cleaned and restarted following the same procedures as those used for set-up and system initialization.

The operation of the MART system will be as follows:

- Mix the wastewater in the collection container for 5 minutes to assure that the wastewater soils and oil/grease have not separated and verify that the pH is above 7.0 using pH paper.
- Transfer 60 – 100 gallons of wastewater from the collection container into the upper reservoir of the MART system, using a pump and commercial duty hose.
- Turn on reservoir mixer to mix wastewater 45 – 60 seconds.
- Add Magic Dust to wastewater.
- Within the upper reservoir the wastewater is mixed with the Magic Dust at the ratio outlined in **Table 4** A portable electronic scale will be used to accurately measure the Magic Dust quantity. A calibration mass will be utilized for calibration of the electronic scale.

**Table 4: Magic Dust Addition to Wastewater**

| Wastewater Stream | Formulation Number | lbs. Magic Dust per 100 gal. Wastewater[1] |
|---|---|---|
| C-130H Engine Wastewater | 29498-73105 | 6.0 - 8.0 |
| Engine Shop Parts Washer | 29498-73105 | 6.0 - 8.0 |
| AGE Parts Washer | 29498-73104 | 6.0 – 8.0 |
| R&R Parts Washer | 29498-73105 | 6.0 - 8.0 |

- Allow to mix for 5 minutes.
- Shut off mixer and observe formation of flocculent in sight glass for 5 minutes. If no flocculent is observed, add 0.5 lbs. Of Magic Dust. Allow to mix for 5 minutes. Shut off mixer and observe flocculent.

1. The additions of Magic Dust are for typical soil loading and may vary with light or heavy soil loading.

Continue in this manner, with 0.5 lbs. Magic Dust increments, until flocculent is observed.

- Prepare filter paper for discharge of clarified solution and encapsulated waste. Roll paper out to cover the filter pan above the holding tank.
- Once separation between the encapsulated waste (flocculent) and clarified solution occurs, open the standpipe valve.
- Discharge clarified solution through the filter paper and into the holding tank.
- Close standpipes valve and open bottom valve.
- Discharge encapsulated waste onto filter paper.
- When a significant quantity accumulates on the filter, close the bottom valve and wrap the filter paper around the encapsulated waste.
- Squeeze out clarified solution when wrapping waste in the filter paper.

### 4.4.3 Sampling and Process Measurements

#### 4.4.3.1 Sampling Responsibilities & Procedures

Sampling and process measurements for the R&R parts cleaner and engine parts cleaner will be taken according to the schedule presented in **Table 5**. Sampling events and process measurements will be recorded on the form shown in **Figure 4**.

Sample ports will be installed to collect feed and product samples from the MART unit (see **Figure 2** for sample locations).

**Table 5. Sampling Frequency and Parameters to Be Measured**

| Sample Name | Sample Location | Frequency/ Type | Parameters |
|---|---|---|---|
| Wastewater Influent | Wastewater In MART EQ-1™ unit | 2 grab samples/batch | O&G, TSS, Alkalinity, Cd, Cr, Pb, Ba, Ni, Cu , Conductivity, Refractive Index |
| Wastewater Effluent/FPS Influent | Wastewater Out MART EQ-1™ unit | 2 grab samples/batch | O&G, TSS, Alkalinity, Cd, Cr, Pb, Ba, Ni, Cu, Conductivity, Refractive Index |
| Encapsulated Waste | Filter Pan | 2 grab samples/batch | O&G, Cd, Cr, Pb, Ba, Ni, Cu, TCLP Metal |

* Refractive Index will be measured when Daraclean 235 is used. Conductivity will be measured when Daraclean 282 is used.

**Figure 4. Data Collection Form**

Test # : ______ Date: _________ Batch # : _________

Revision # : ___0___ Revision Date: ____Original____

Operation: MART EQ-1™ System

Technology Type: Water Recycling

| Date/ Time | Initials | Sample Number | Sample Location | MART EQ-1™ Influent Stream | MART EQ-1™ Effluent /FPS Influent Stream | MART FPS Effluent Stream | Settling Time (minutes) | Flocculation Time (minutes) | Notes and Observations |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Conductivity/ Refractive Index (% Bx) | Conductivity/ Refractive Index (% Bx) | Conductivity/ Refractive Index (% Bx) | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

Total Wastewater Flow into MART EQ-1™ (L) _________

Total Wastewater Flow out of MART™ FPS (L)_________

Page ___ of ___

For the engine wash water and AGE parts washer, three samples for all parameters plus two extra O&G (total of five) will be collected. In addition, three samples for all parameters plus two extra O&G (total of five) will be collected from the FPS during the wash wastewater test. These samples are field duplicates and for laboratory QA/QC analyses identified in Sections 5.2.2.1 and 5.2.2.2.

The appropriate sampling container will be used for each test parameter, as outlined in this Test Plan. Each laboratory sample bottle will be labeled with the date, time, sample identification, and test parameters required.

Samples to be analyzed at off-site laboratories will be accompanied by a chain of custody form. The samples will be stored and transported in appropriate sample transport containers (e.g., coolers with packing and ice packs or bags of ice) by common carrier. Security sealing tape will be applied to the transport containers to ensure sample integrity during delivery process to the analytical laboratories. A Project Team Member will perform sampling and labeling, and ensure that samples are properly stored and secured for transport to the analytical laboratories. Each sample will be taken in duplicate with the duplicates to be shipped in a separate shipping container.

#### 4.4.3.2 Process Measurements

The conductivity of the influent and effluent streams will be measured using digital analyzers. The refractive index will be measured with a refractometer. Calibration of the process measurement equipment will be performed daily, according to suggested manufacturer recommendations.

Electricity use will be calculated by determining the power requirements and cycle times of pumps and other powered devices. The 179$^{th}$ AW will provide the cost of labor, electricity, and other items needed for a cost analysis.

Process fluid flowrates for this demonstration will be measured by Omega Engineering, Inc., Model FD-7000 liquid flowmeter. It is a multi-liquid ultrasonic flowmeter with non-penetrating transducers.

##### 4.4.3.2.1 Calibration Procedures and Frequency

The following procedures will be used to calibrate the instruments/equipment that will be used to collect process measurements:

1. Instruments used to perform analytical methods will be calibrated according to the laboratory quality assurance plan.

2. Instruments used to conduct air sampling and analysis will be calibrated according to equipment manufacturer's specifications and Safety Compliance's and DLZ Laboratories, Inc. specific quality assurance plan's.
3. The ultrasonic liquid flowmeter will be calibrated at the start of each sampling day, in accordance with the equipment manufacturer's instructions.
4. The conductivity meter and refractometer will be calibrated at the start of each sampling day, and in accordance with the equipment manufacturer's instructions. Manufacturer, nominal value, lot number and expiration date of standard solutions used will be recorded on the data collection form and project notebook.

The on-site Project Team will perform field measurements, as well as calibration of field equipment.

## 4.5 Test Parameters

A summary of the sample analysis and handling requirements to be used during the verification test is presented in **Table 6**. Details of the test parameters to be performed are outlined in the ensuing sections.

### 4.5.1 Oil/Grease Concentration

The MART EQ-1™ system will be verified to determine its effectiveness at removing oil/grease from the spent cleaning wastewater. A gravimetric method for measuring organic soils in aqueous and sludge samples was selected for analytical testing. The selected samples will be acidified with 50% hydrochloride acid to lower the pH to less than 2. The method chosen was Standard Methods for the Examination of Water and Wastewater 20$^{th}$ Edition 1998 (SM) 5520B (20$^{th}$ edition), which uses n-hexane as the extraction solvent. The method is a liquid/liquid extraction, gravimetric procedure applicable to aqueous matrices for the determination of n-hexane extractable materials. Obtaining the concentration of oil/grease before and after the MART EQ-1™ and FPS will determine its ability to remove oil/grease from cleaning wastewater. Oil/grease will be extracted from the solids using SM 5520E prior to analysis by SM 5520B.

### 4.5.2 Cleaner Concentration

The MART EQ-1™ system will be verified to determine its effectiveness at recovering cleaner from the wastewater. Obtaining the concentration of cleaner before and after the MART EQ-1™ and FPS will determine its ability to recover cleaner from wastewater.

**Table 6. Summary of Analysis and Handling Requirements**

| Parameter | Test Method | Sample Bottle | Sample Volume Required | Preservation /Handling | Hold Time |
|---|---|---|---|---|---|
| Oil/Grease Wastewater | SM Method 5520B | Glass jar | 1000 ml | Acidify to pH < 2 w/HCL | 28 days |
| Oil/Grease Solids | SM 5520E/ 5520B | Glass jar | 500 g | 4ºC | 28 days |
| Total Alkalinity | EPA Method 310.1 | Glass jar | 500 ml | 4ºC | Analyze as soon as practical |
| TSS | EPA Method 160.2 | Polyethylene | 500 ml | 4ºC | 7 days |
| Metals Wastewater | EPA Method 200.7 | Polyethylene | 500 ml | Acidify to pH < 2 w/$HNO_3$ | 6 months |
| Metals Solids | SW-846 3050B/6010B | Polyethylene | 500 g | 4ºC | .6 months |
| TCLP Metals | SW 846 Method 1311/3010A/ 6010B | Polyethylene | 500 g | 4ºC sample/ $HNO_3$ To extract | 6 months |

A split sample from the solid waste samples will be dried at 100°C to constant weight to determine percent moisture.

### 4.5.3 Metals

The wastewater at the 179th AW contains a large concentration of cadmium and minute concentrations of other metals. The MART EQ-1™ and FPS will be evaluated on its ability to effectively remove cadmium from wastewater. The test will determine the cadmium concentration, as well as chromium, lead, barium, nickel and copper in the wastewater influent and effluent and encapsulated waste streams. The selected samples will be acidified with nitric acid to lower the pH to less than 2. The method selected is the Inductively Coupled Plasma – Atomic Emission Spectrometry, EPA Methods and Guidance for Analysis of Water (EPA) Method 200.7 for aqueous samples. For the analysis of the solid waste samples, the solid waste will be digested using EPA Test Methods for Evaluating Solid Waste (SW-846) method 3050B prior to the analysis using method SW-846 Method 6010B. For Toxicity Characteristic Leaching Procedure (TCLP), SW-846 Method 1311 will be used to leach solid waste samples, followed by digestion using 3010A and analysis by 6010B.

#### 4.5.4 Total Suspended Solids

To determine the effectiveness of the MART EQ-1™ and FPS unit with regard to removal of particulates, tests for total filterable residue (EPA Method 160.2) will be performed. The referenced method produces values commonly referred to as total suspended solids (TSS).

### 4.6 Air Monitoring

Cadmium, lead, and chromates are currently used for corrosion control and protection against wear in coatings, sealants, and surface treatments. Using cadmium, lead, and chromates for these purposes is pervasive throughout the aerospace industry, both within the Department of Defense and the commercial aircraft industry. Cadmium, lead, and chromium particles in air are a serious concern to health and safety personnel. Increasingly, workplace safety procedures include monitoring of toxic substances.

The goal of the ETV-MF Program is to verify the environmental performance characteristics of commercial-ready technology through the evaluation of objective and quality-assured data, an important component of this is to demonstrate that this emerging technology does not increase worker exposure to toxic substances due to its operation. To determine if there is a potential for exposure to cadmium (Chemical Abstract Number (CAS#): 7440-43-9) and chromium (CAS#: 22541-79-3), air monitoring will be conducted during operation of the MART unit and handling of encapsulated waste. Testing will consist of monitoring during two separate tests. The tests include treatment of the C-130H engine compressor wash wastewater and treatment of the R&R parts washer wastewater.

Exposure air monitoring, on an employee who is suspected to be at the highest risk of exposure, will occur during processing of two separate wastewater streams fed into the MART unit. Samples of each of the wastewater streams will be taken prior to testing, in order to determine the contaminant load level. Air monitoring will be conducted in accordance with the National Institute of Occupational Safety and Health (NIOSH) Method 7300. A 0.8 micron (pore size) cellulose ester, 37 millimeter (mm) diameter filter will be used as the collection media. SKC personal air sampling pumps will be utilized and calibrated before and after each sample to a rate of 1 liter per minute (Lpm). The personal pumps will be used to draw the air onto the collection media. Calibration will be performed utilizing a primary standard (MiniBuck) with a representative sample in line. Two sets of sampling will be conducted during the same operation. One sample for low-level exposure, and the other to determine the high-level exposure. A minimum of two field blanks will be included in each sampling set and the total sampling time will be approximately 7 hours. One 15-minute Short-Term Exposure Limit (STEL) sample will be collected during the sampling period. Two Time Weight Average samples for a period of 3.5 to 4.0 hours will also be collected. The samples will be sent to an American Industrial Hygiene Association (AIHA)-accredited laboratory for analysis within 24 hours of collection. There will be a total of five samples per operation (STEL, time weighted average (TWA) morning, TWA afternoon, and two field blanks). Unused collection media will be provided for blank matrix spike/blank matrix spike duplicate determinations. A chain-of-custody form will accompany the samples to the laboratory. Test data will be presented in a formal written report, which will include the laboratory report and sampling sheets. The results will be appropriately compared with the OSHA 8-hour TWA exposure limit.

## 5.0 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

Quality Assurance/Quality Control activities will be performed according to the applicable section of the Environmental Technology Verification Program Metal Finishing Technologies Quality Management Plan (ETV-MF QMP) [Ref. 1].

### 5.1 Quality Assurance Objectives

The first QA objective is to ensure that the process operating conditions and test methods are maintained and documented throughout each test and laboratory analysis of samples. The second QA objective is to use standard test methods for laboratory analyses. The test methods to be used are listed in **Table 6**.

### 5.2 Data Reduction, Validation, and Reporting

#### 5.2.1 Internal Quality Control Checks

Raw Data Handling. Raw data is generated and collected by laboratory analysts at the bench and/or sampling site. These include original observations, printouts and readouts from equipment for sample, standard and reference QC analyses. Data is collected both manually and electronically. At a minimum, the date, time, sample identification (ID), instrument ID, analyst ID, raw signal or processed signal, and/or qualitative observations will be recorded. Comments to document unusual or non-standard observations also will be included on the forms, as necessary. The form presented in **Figure 4** will be used for recording data on-site.

The on-site Project Team member will generate chain of custody forms, and these forms will accompany samples when they are shipped off-site.

Raw data will be processed manually by the analyst, automatically by an electronic program, or electronically after being entered into a computer. The analyst will be responsible for scrutinizing the data according to laboratory precision, accuracy, and completeness policies. Raw data bench sheets and calculation or data summary sheets will be kept together for each sample batch. From the standard operating procedure and the raw data bench files, the steps leading to a final result may be traced. The ETV-MF Program Manager will maintain process-operating data for use in report preparation.

Data Package Validation. The generating analyst will assemble a preliminary data package, which shall be initialed and dated. This package shall contain all QC and raw data results, calculations, electronic printouts, conclusions and laboratory sample tracking information. A second analyst will review the entire package and check sample and storage logs, standard logs, calibration logs, and other files, as necessary, to ensure that all tracking, sample treatments and calculations are correct. After the package is reviewed in this manner, a preliminary data report will be prepared, initialed, and dated. The entire package and final report will be submitted to the Laboratory Manager.

The Laboratory Manager shall be ultimately responsible for all final data released from the laboratory. The Laboratory Manager or designee will review the final results for adequacy to task QA objectives. If the manager or designee suspects an anomaly or non-concurrence with expected or historical performance values, or with task objectives for test specimen performance, the raw data will be reviewed, and the generating and reviewing analysts queried. If suspicion about data validity still exists after internal review of laboratory records, the manager will authorize a re-test. If sufficient sample is not available for re-testing, a re-sampling shall occur. If the sampling window has passed, or re-sampling is not possible, the manager will flag the data as suspect. The Laboratory Manager signs and dates the final data package.

Data Reporting. The original report signed and dated by the Laboratory Manager will be submitted to the ETV-MF Program Manager. A copy will be submitted to the ETV-MF Project Manager. The ETV-MF Project Manager will decide the appropriateness of the data for the particular application. The final report contains the laboratory sample ID, date reported, date analyzed, the analyst, the SOP used for each parameter, the process or sampling point identification, the final result and the units. The ETV-MF Program Manager shall retain the data packages as required by the ETV-MF QMP [Ref. 1].

### 5.2.2 QA/QC Requirements

For those measurements where duplicates, spikes and spike duplicates are inappropriate (e.g., flow totals, conductivity, and refractive index), duplicate measurements will take place at the time of sampling. A minimum of three repetitions will be conducted for each measurement (conductivity, and refractive index) for each sampling day, in order to ensure compliance with the QA Objectives stated in **Table 7**. The instrument will be calibrated if the objectives for these measurements are not met.

#### 5.2.2.1 Duplicates

Duplicate samples taken in the field will be used to quantify measurement precision associated with the entire sampling and analysis system. Duplicate analyses will be performed on influent, effluent, and solid waste samples from the AGE parts washer and engine wash wastewater.

#### 5.2.2.2 Matrix Spikes

Matrix spike/matrix spike duplicates will be performed on influent, effluent, and solid wastes from the AGE parts washer and the engine wash wastewater. Sample splitting will occur in the analytical laboratory. For air analysis, a blank matrix spike/blank matrix spike duplicate will be performed for cadmium and chromium.

#### 5.2.2.3 Field Blanks

A field blank will be taken at each sampling point at least for air analysis once during the verification test period. Also, field blank sample of each cleaner make up will be sent for analysis. This will ensure the absence of matrix interference's for each sample matrix.

### 5.2.3 Calculation of Data Quality Indicators

Analytical performance requirements are expressed in terms of precision, accuracy, representativeness, comparability, completeness, and sensitivity (PARCCS). Summarized below are definitions and QA objectives for each PARCCS parameter.

**Table 7: QA Objectives for Precision, Accuracy, And Detection Limits**

| Critical Measurements | Matrix | Method | Reporting Units | Method of Determination | MDL | Precision (RPD) | Accuracy (% Recovery) | Completeness (%) |
|---|---|---|---|---|---|---|---|---|
| O&G Concentration | Water | SM 5520B | mg/L | Gravimetric | 5.0 | ± 22 | 75 - 125 | 90 |
| | Solids | SM 5520E/ 5520B | mg/L | Gravimetric | 5.0 | ± 22 | 75 - 125 | 90 |
| Total Metals | Water | EPA 200.7 | mg/L | ICP-AES | .001 | ± 25 | 75 – 125 | 95 |
| | Solids | SW-846 3050B/6010B | mg/L | ICP-AES | .001 | ± 25 | 75 – 125 | 95 |
| TCLP Metals | Solid | SW-846 1311/ 3010A/6010B | mg/L | ICP-AES | 0.25 | ± 35 | 75 – 125 | 90 |
| TSS | Water | EPA 160.2 | mg/L | Gravimetric | 1.0 | ± 19.0 | N/A | 90 |
| Total Alkalinity | Water | EPA 310.1 | mg/L | Titration | 1.0 | ±10 | 85 - 115 | 95 |
| Air Monitoring | Air | NIOSH 7300 | µg/m$^3$ | ICP | < 2.0 | ≤ 20 | N/A | 90 |
| Flowrates: | | | | | | | | |
| Wastewater Feed (Influent) | Water | Flow Totalizer | liters (L) | - | - | ≤ 10 | N/A | 90 |
| Wastewater Product (Effluent) | Water | Flow Totalizer | liters (L) | - | - | ≤ 10 | N/A | 90 |

EPA: EPA Methods and Guidance for Analysis of Water

SM: Standard Methods For the Examination of Water and Wastewater 20th Edition 1998

SW-846: EPA Test methods for Evaluating Solid Waste

NIOSH: NIOSH Manual of Analytical Methods

### 5.2.3.1 Precision

Precision is a measure of the agreement or repeatability of a set of replicate results obtained from duplicate analyses made under identical conditions. Precision is estimated from analytical data and cannot be measured directly. The precision of a duplicate determination can be expressed as the relative percent difference (RPD), and calculated as:

$$RPD = \{(|X_1 - X_2|)/[(X_1 + X_2)/2]\} \text{ x } 100 = \left\{ \frac{|X_1 - X_2|}{\frac{(X_1 + X_2)}{2}} \right\} \text{x} 100$$

RPD = relative percent difference

where: $X_1$ = larger of the two observed values
$X_2$ = smaller of the two observed values

Multiple determinations will be performed for each test on the same test specimen. The replicate analyses must agree within the relative percent deviation limits provided in **Table 7.**

For measurements, such as flowrate, where the absolute variation is more appropriate, precision is usually reported as the absolute range, D, of duplicate measurements:

$$D = |m_1 - m_2|$$

where: D = absolute range
$m_1$ = first measurement
$m_2$ = second measurement

### 5.2.3.2 Accuracy

Accuracy is a measure of the agreement between an experimental determination and the true value of the parameter being measured. Accuracy is estimated through the use of known reference materials or matrix spikes. It is calculated from analytical data and is not measured directly. Spiking of reference materials into a sample matrix is the preferred technique because it provides a measure of the matrix effects on analytical accuracy. Accuracy, defined as percent recovery (P), is calculated as:

$$P = \left[ \frac{(SSR - SR)}{SA} \right] \text{x } 100$$

where: P = percent recovery
SSR = spiked sample result

SR = sample result (native)

SA = the concentration added to the spiked sample

Analyses will be performed with periodic calibration checks with traceable standards to verify instrumental accuracy. These checks will be performed according to established procedures in the contracted laboratory(s) that have been acquired for the MART system verification testing. Analysis with spiked samples will be performed to determine percent recoveries as a means of checking method accuracy. QA objectives will be satisfied if the *average* recovery is within the goals described in **Table 7**.

**5.2.3.3 <u>Comparability</u>**

Comparability is another qualitative measure designed to express the confidence with which one data set may be compared to another. Sample collection and handling techniques, sample matrix type, and analytical method all affect comparability. Comparability is limited by the other PARCCS parameters because data sets can be compared with confidence only when precision and accuracy are known. Comparability will be achieved in the MART technology verification by the use of consistent methods during sampling and analysis and by tractability of standards to a reliable source.

**5.2.3.4 <u>Completeness</u>**

Completeness is defined as the percentage of measurements judged to be valid, compared to the total number of measurements made for a specific sample matrix and analysis. Completeness is calculated using the following formula:

$$\text{Completeness} = \frac{\text{Valid Measurements}}{\text{Total Measurements}} \times 100$$

Experience on similar projects has shown that laboratories typically achieve about 90 percent completeness. QA objectives will be satisfied if the percent completeness is 90 percent or greater as specified in **Table 7**.

**5.2.3.5 <u>Representativeness</u>**

Representativeness refers to the degree to which the data accurately and precisely represent the conditions or characteristics of the parameter represented by the data. For the purposes of this demonstration, representativeness will be achieved by presenting identical analyte samples to the specified lab(s) and executing consistent sample collection and mixing procedures.

#### 5.2.3.6 Sensitivity

Sensitivity is the measure of the concentration at which an analytical method can positively identify and report analytical results. The sensitivity of a given method is commonly referred to as the detection limit. Although there is no single definition of this term, the following terms and definitions of detection will be used for this program.

**Instrument detection limit** (IDL) is the minimum concentration that can be measured from instrument background noise.

**Method detection limit** (MDL) is a statistically determined concentration. It is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero as determined in the same or a similar matrix. [Because of the lack of information on analytical precision at this level, sample results greater than the MDL but less than the practical quantification limit (PQL) will be laboratory qualified as "estimated."]

MDL is defined as follows for all measurements:

$$MDL = t_{(n-1,1-\alpha = 0.99)} \times s$$

| | | | |
|---|---|---|---|
| where: | MDL | = | method detection limit |
| | $t_{(n-1,1-\alpha = 0.99)}$ | = | students t-value for a one-sided 99% confidence level and a standard deviation estimate with n-1 degrees of freedom |
| | s | = | standard deviation of the replicate analyses |

**Method reporting limit** (MRL) is the concentration of the target analyte that the laboratory has demonstrated the ability to measure within specified limits of precision and accuracy during routine laboratory operating conditions. [This value is variable and highly matrix-dependent. It is the minimum concentration that will be reported as "unqualified" by the laboratory.]

### 5.2.4 Mass Balance

The conservation of mass/energy in any isolated system is one of the most fundamental laws in science and engineering. The mass/energy balance is a tool that was developed to account for inputs, outputs, consumption, and accumulation in a system. To determine system efficiency, measuring or quantifying all of the elements for a mass balance in an industrial setting is very difficult. The greatest challenge is generally defining the system boundaries and what degree of accuracy is required. Sampling, measurement, and analytical errors preclude absolute precision; however, the mass/energy balance provides us with a fundamental tool for evaluating the performance of environmental technologies where we are generally evaluating some form of efficiency.

**Figure 5** illustrates the most fundamental form of the material balance equation. Batch systems and continuous systems can both be modeled using this general form.

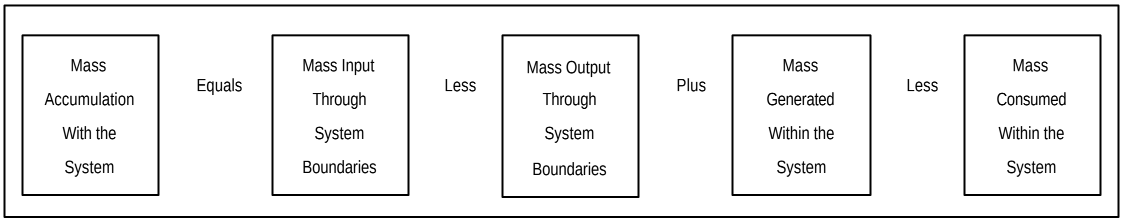



**Figure 5: Fundamental Material Balance Equation**

**Figure 6** illustrates the material flow into and out of MART system.

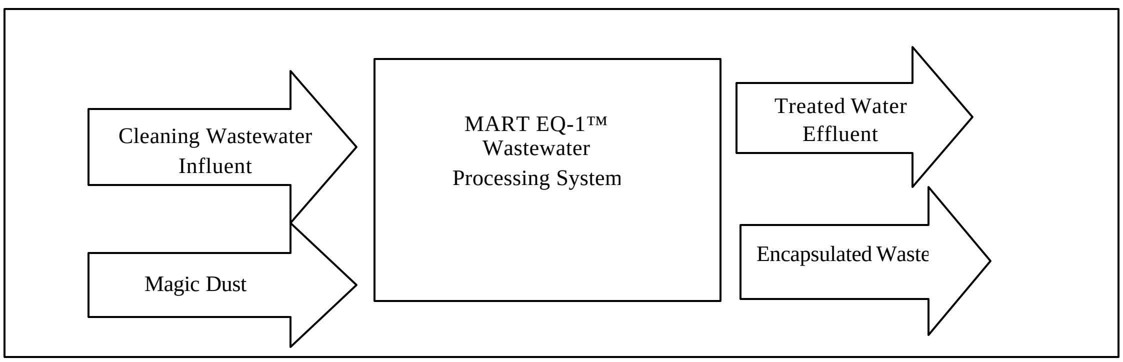



**Figure 6: Material Balance Equation For MART's System**

The goal of the MART verification project is to determine performance, which can generally be measured in terms of efficiency. For solution maintenance technologies, percent contaminant removal and percent solution recovery are measures of system efficiency.

To determine efficiency, the fundamental material balance equation can be simplified as:

$$Xi = Xs + Xe$$

where: Xi = Mass in influent
Xs = Mass in waste
Xe = Mass in effluent

#### 5.2.4.1 Cleaner Recovery Efficiency

Cleaner recovery efficiency can be determined by the following equation:

$$C_{rec}\ (\%) = [(C_{prod} \text{ x } Prod_{vol})/(C_{feed} \text{ x } Feed_{vol})] \text{ x } 100\%$$

where:
- $C_{rec}$ = cleaner recovery efficiency
- $C_{prod}$ = product stream cleaner concentration (g/L)
- $Prod_{vol}$ = product volume collected during cycle (L)
- $C_{feed}$ = feed solution cleaner concentration (g/L)
- $Feed_{vol}$ = feed solution volume processed during cycle (L)

#### 5.2.4.2 Oil Removal Efficiency

Oil removal efficiency is determined by the following equation:

$$O_{eff}\ (\%) = \{[(O_w \text{ x } W_{vol}) + (O_{out} \text{ x } Prod_{vol})]/(O_{in} \text{ x } Feed_{vol})\} \text{ x } 100\%$$

where:
- $O_{eff}$ = oil removal efficiency
- $O_w$ = oil concentration in waste stream (g/L)
- $W_{vol}$ = waste stream volume processed during cycle (L)
- $O_{out}$ = product stream oil concentration (g/L)
- $Prod_{vol}$ = product volume collected during cycle (L)
- $O_{in}$ = feed solution oil concentration (g/L)
- $Feed_{vol}$ = feed solution volume processed during cycle (L)

#### 5.2.4.3 Cadmium Removal Efficiency

Cadmium (Cd) removal efficiency is determined by the following equation:

$$Cd_{eff}\ (\%) = \{[(Cd_w \text{ x } W_{vol}) + (Cd_{out} \text{ x } Prod_{vol})]/Cd_{in} \text{ x } Feed_{vo})\} \text{ x } 100\%$$

where:
- $Cd_{eff}$ = Cd removal efficiency
- $Cd_w$ = Cd concentration in waste stream (g/L)
- $W_{vol}$ = waste stream volume processed during cycle (L)
- $Cd_{out}$ = product stream Cd concentration (g/L)
- $Prod_{vol}$ = product volume collected during cycle (L)
- $Cd_{in}$ = feed solution Cd concentration (g/L)
- $Feed_{vol}$ = feed solution volume processed during cycle (L)

### 5.2.5 Energy Use

Energy requirements for the MART unit will be calculated by summing the total quantity of horsepower hours and dividing by 1.341 HP-hr/kWh to arrive at electrical consumption.

### 5.2.6 Cost Analysis

This analysis will quantify the accumulative cost benefit of the technology. The costs for operating the MART unit at the $179^{th}$ AW will be calculated to compare operating costs for a time period prior to utilization of the unit. For the baseline conditions, the most recent applicable data available, collected by the $179^{th}$ AW, will be used. The cost analysis will compare operating costs, including costs for: chemical costs and savings, waste treatment/disposal cost and savings, labor, utilities, maintenance and other materials.

### 5.2.7 Waste Generation Analysis

This analysis will quantify the environmental benefit of the technology. The waste generation rates for operating the MART unit at the $179^{th}$ AW will be calculated and compared to waste generation rates for a time period prior to the installation of the unit. For the baseline conditions, the most recent applicable data collected by the $179^{th}$ AW will be used. The waste generation analysis will consider type/characteristics of waste generated, volume, and frequency of waste generated.

## 5.3 Quality Audits

<u>Technical System Audits.</u> An audit will be performed during verification testing by the *CTC* QA Manager according to Section 2.9.3 Technical Assessments of the ETV-MF QMP [Ref. 1] to ensure testing and data collection are performed according to the test plan requirements. The decision to perform a quality audit, during this verification test, is at the discretion of the ETV-MF Program Manager.

<u>Internal Audits.</u> In addition to the internal laboratory quality control checks, internal quality audits will be conducted to ensure compliance with written procedures and standard protocols.

<u>Corrective Action.</u> Corrective Action for any deviations to established quality assurance and quality control procedures during verification testing will be performed according to section 2.10 Quality Improvement of the ETV-MF QMP [Ref. 1].

<u>Laboratory Corrective Action.</u> Examples of non-conformances include invalid calibration data, inadvertent failure to perform method-specific QA, process control data outside specified control limits, failed precision and/or accuracy indicators, etc. Such non-conformances will be documented on a standard laboratory form. Corrective action will involve taking all necessary steps to restore a measuring system to proper working order and summarizing the corrective action and results of subsequent system verifications on a standard laboratory form. Some non-conformances are detected while analysis or sample processing is in progress and can be rectified in real time at the bench level. Others may be detected only after a processing trial and/or sample analyses are completed. Typically, these types of non-conformances are detected by the Laboratory

Manager. In all cases of non-conformance, sample re-analysis will be considered as one source of corrective action by the Laboratory Manager. If insufficient sample is available or the holding time has been exceeded, complete re-processing may be ordered to generate new samples if a determination is made by the Task Leader that the non-conformance jeopardizes the integrity of the conclusions to be drawn from the data. In all cases, a non-conformance will be rectified before sample processing and analysis continues.

# 6.0 PROJECT MANAGEMENT

## 6.1 Organization/Personnel Responsibilities

The ETV-MF Project Team that is headed by *CTC* will conduct the evaluation of the MART EQ-1™ system. The ETV-MF Program Manager, Donn Brown, will have ultimate responsibility for all aspects of the technology evaluation. The ETV-MF Project Manager assigned to this evaluation is Dr. A. Gus Eskamani. Dr. Eskamani and/or his Project Team will be on-site throughout the test period and will conduct or oversee all sampling and related measurements.

MART will be on-call during the test period for response in the event of equipment problems. The 179$^{th}$ AW personnel will be responsible for operation of the MART EQ-1™ equipment, related cleaning lines, and ancillary equipment such as pumps and system instrumentation. The 179$^{th}$ AW personnel will also provide safety training as described in Section 10 of this test plan. The ETV-MF Project Manager, and/or his Project Team, and the 179$^{th}$ AW have the authority to stop work when unsafe or unacceptable quality conditions arise.

AMTEST Laboratories, Inc., is responsible for analyzing verification test samples. Director of Inorganic Laboratory Ms. Kathy Fugiel will be the point of contact. AMTEST Laboratories is accredited for the analyses identified in this test plan.

Safety Compliance, Inc. is responsible for performing worker exposure air monitoring. The Principal Scientist, Mr. Kelly Ruff, will be the point of contact. Safety Compliance, Inc. will utilize an AIHA accredited laboratory, DLZ Laboratories, Inc., for the analyses identified in this test plan.

## 6.2 Test Plan Modifications

In the course of verification testing, it may become necessary to modify the test plan due to unforeseen events. These modifications will be documented using a Test Plan Modification Request (**Appendix C**), which will need to be submitted to the *CTC* Program Manager for approval. Upon approval, the modification request will be assigned a number, logged, and transmitted to the requestor for implementation.

## 7.0 UTILITY REQUIREMENTS

The MART EQ-1™ and FPS are intricately wired together. The utility requirements include:

- Electrical Service: 115 VAC, 60 Hz, single-phase
- Submersible Transfer Pump: 30 gpm
- Mixing Turbine: ¼ hp, 1800 rpm

## 8.0 HEALTH AND SAFETY PLAN

This Health and Safety Plan provides guidelines for recognizing, evaluating, and controlling health and physical hazards throughout the workplace. More specifically, the Plan specifies for assigned personnel, the training, materials, and equipment necessary to protect themselves from chemical hazards, and any waste generated by the process.

### 8.1 Hazard Communication

All personnel assigned to the project will be provided with the potential hazards, signs and symptoms of exposure, methods or materials to prevent exposures, and procedures to follow, if there is contact with a particular substance. The $179^{th}$ AW Hazard Communication Program will be reviewed during training and will be reinforced throughout the test period. All appropriate MSDS forms will be available for chemical solutions used during testing.

### 8.2 Emergency Response Plan

The $179^{th}$ AW has a contingency plan to protect employees, assigned project personnel, and visitors in the event of an emergency at the facility. This plan will be used throughout the project. All assigned personnel will be provided with information about the plan during training.

### 8.3 Hazard Controls Including Personal Protective Equipment

All assigned project personnel will be provided with appropriate personal protective equipment (PPE) and any training needed for its proper use, considering their assigned tasks. The use of PPE will be covered during training as indicated in Section 10.

The following PPE will be required and must be worn at all times when operating the MART unit and when handling waste: neoprene gloves and safety glasses with side-shields.

### 8.4 Lockout/Tagout Program

The facility lockout/tagout program will be used if necessary.

### 8.5 Material Storage

Any materials used during the project will be kept in proper containers and labeled according to the 179th AW requirements. Proper storage of the materials will be maintained based on associated hazards. Spill trays or similar devices will be used as needed to prevent material loss to the surrounding area.

### 8.6 Safe Handling Procedures

All chemicals and wastes or samples will be transported on-site in non-breakable containers used to prevent spills. Spill kits will be strategically located in the project area. These kits contain various sizes and types of sorbents for emergency spill clean up. Emergency spill clean up will be performed according to the 179th AW Emergency Response Plan.

## 9.0 WASTE MANAGEMENT

The MART unit will be tested on processes already in place and operating at the 179th AW. This equipment currently generates solid waste, as a result of being processed through the MART unit. This waste material is presently collected and treated off-site, while the clarified solution is discharged to the local Publicly Owned Treatment Works (POTW).

During testing, no additional wastes will be generated other than the normal treated quantities. The 179th AW, using their normal practices, will handle this waste appropriately. Therefore, no special or additional provisions for waste management will be necessary.

## 10.0 TRAINING

It is important that the verification activities performed by the ETV-MF Center be conducted with high quality and with regard to the health and safety of the workers and the environment. By identifying the quality requirements, worker safety and health, and environmental issues associated with each verification test, the qualifications or training required for personnel involved can be identified. Training requirements will be identified using the Job Training Analysis (JTA) Plan [Ref. 2].

The purpose of this JTA Plan is to outline the overall procedures for identifying the hazards and quality issues and training needs for each verification test project. This JTA Plan establishes guidelines for creating a work atmosphere that meets the quality, environmental, and safety objectives of the ETV-MF Center. The JTA Plan describes the method for studying ETV-MF project activity and identifying training needs. The ETV-MF Operation Planning Checklist (**Appendix D**) will be used as a guideline for identifying potential hazards, and the Job Training Analysis Form (**Appendix E**) will be used to identify training requirements. After completion of the form, applicable training will be performed. Training will be documented on the ETV-MF Project Training Attendance Form (**Appendix F**). Health and safety training will be coordinated with 1st Lt. Troy Cramer of the 179th AW.

## 11.0 REFERENCES


1. Concurrent Technologies Corporation, "*Environmental Technology Verification Program Metal Finishing Technologies (ETV-MF) Quality Management Plan*," December 9, 1998.
2. Concurrent Technologies Corporation, "*Environmental Technology Verification Program Metal Finishing Technologies (ETV-MF) Pollution Prevention Technologies Pilot Job Training Analysis Plan*," May 10, 1999.


## 12.0 DISTRIBUTION

Alva Daniels, EPA (3)

Jim Potthast, MART

1st Lt. Troy Cramer, 179$^{th}$ AW, Ohio ANG

Gus Eskamani, CAMP, Inc. (2)

Donn Brown, *CTC* (3)

Clinton Twilley, *CTC*

Safety Compliance, Inc.

AMTest Laboratories

# APPENDIX A

## 179th AW Cleaner MSDSs

# APPENDIX B

## The MART EQ-1™ System O&M Manual

# APPENDIX C

## Test Plan Modification Request

# TEST PLAN MODIFICATION REQUEST

**Date:__________** **Number:__________** **Project:________________________**

Original Test Plan Requirement:__________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

Proposed Modification:__________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

Reason: _______________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

Impact:________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

Approvals:

Requestor:___________________________

Project Manager:______________________

Program Manager:_____________________

# Test Plan Modification Requests

In the course of verification testing, it may become necessary to modify the test plan due to unforeseen events. The purpose of this procedure is to provide a vehicle whereby the necessary modifications are documented and approved.

The Test Plan Modification Request form is the document to be used for recording these changes. The following paragraphs provide guidance for filling out the form to insure a complete record of the changes made to the original test plan.

The person requesting the change should record the date and project name in the form's heading. Program management will provide the request number.

Under Original Test Plan Requirement, reference the appropriate sections of the original test plan, and insert the proposed modifications in the section titled Proposed Modification. In the Reason section, document why the modification is necessary; this is where the change is justified. Under Impact, give the impact of not making the change, as well as the consequences of making the proposed modification. Among other things, the impact should address any changes to cost estimates and project schedules.

The requestor should then sign the form and obtain the signature of the project manager. The form should then be transmitted to the *CTC* program manager who will either approve the modification or request clarification. Upon approval, the modification request will be assigned a number, logged, and transmitted to the requestor for implementation.

# APPENDIX D

## ETV-MF Operation Planning Checklist

# ETV-MF Operation Planning Checklist

*The ETV-MF Project Manager prior to initiation of verification testing must complete this form. If a "yes" is checked for any items below, an action must be specified to resolve the concern on the Job Training Analysis Form.*

Project Name: ______________________________________ Expected Start Date: ______________

ETV-MF Project Manager: ______________________________

| Will the operation or activity involve the following: | Yes | No | Initials & Date Completed |
|---|---|---|---|
| 1. Equipment requiring specific, multiple steps for controlled shutdown? (e.g. in case of emergency, does equipment require more than simply pressing a "Stop" button to shut off power?) *Special Procedures for emergency shut-down must be documented in Test Plan.* | | | |
| 2. Equipment requiring special fire prevention precautions? (e.g. Class D fire extinguishers) | | | |
| 3. Modifications to or impairment of building fire alarms, smoke detectors, sprinklers or other fire protection or suppression systems? | | | |
| 4. Equipment lockout/tagout or potential for dangerous energy release? *Lockout/tagout requirements must be documented in Test Plan.* | | | |
| 5. Working in or near confined spaces (e.g., tanks, floor pits) or in cramped quarters? | | | |
| 6. Personal protection from heat, cold, chemical splashes, abrasions, etc.? *Use Personal Protective Equipment Program specified in Test Plan.* | | | |
| 7. Airborne dusts, mists, vapors and/or fumes? *Air monitoring, respiratory protection, and /or medical surveillance may be needed.* | | | |
| 8. Noise levels greater than 80 decibels? *Noise surveys are required. Hearing protection and associated medical surveillance may be necessary.* | | | |
| 9. X-rays or radiation sources? *Notification to the state and exposure monitoring may be necessary.* | | | |
| 10. Welding, arc/torch cutting, or other operations that generate flames and/or sparks outside of designated weld areas? *Follow Hot Work Permit Procedures identified in Test Plan.* | | | |
| 11. The use of hazardous chemicals? *Follow Hazard Communication Program, MSDS Review for Products Containing Hazardous Chemicals. Special training on handling hazardous chemicals and spill clean-up may be needed. Spill containment or local ventilation may be necessary.* | | | |
| 12. Working at a height of six feet or greater? | | | |

# ETV-MF Operation Planning Checklist

*The ETV-MF Project Manager prior to initiation of verification testing must complete this form. If a "yes" is checked for any items below, an action must be specified to resolve the concern on the Job Training Analysis Form.*

Project Name: ____________________

ETV-MF Project Manager: ____________________

| Will the operation or activity involve the following: | Yes | No | Initials & Date Completed |
|---|---|---|---|
| 13. Processing or recycling of hazardous wastes? *Special permitting may be required.* | | | |
| 14. Generation or handling of waste? | | | |
| 15. Work to be conducted before 7:00 a.m., after 6:00 p.m. and/or on weekends? *Two people must always be in the work area together.* | | | |
| 16. Contractors working in *CTC* facilities? *Follow Hazard Communication Program.* | | | |
| 17. Potential discharge of wastewater pollutants? | | | |
| 18. EHS aspects/impacts and legal and other requirements identified? | | | |
| 19. Contaminants exhausted either to the environment or into buildings? *Special permitting or air pollution control devices may be necessary.* | | | |
| 20. Any other hazards not identified above? (e.g. lasers, robots, syringes) *Please indicate with an attached list.* | | | |

The undersigned responsible party certifies that all applicable concerns have been indicated in the "yes" column, necessary procedures will be developed, and applicable personnel will receive required training. As each concern is addressed, the ETV-MF Project Manager will initial and date the "initials & date completed" column above.

ETV-MF Project Manager: ____________________ (Name) ____________________ (Signature) ____________________ (Date)

# APPENDIX E

## Job Training Analysis Form

# JOB TRAINING ANALYSIS FORM

**ETV-MF Project Name:** ______________________________________________

| Basic Job Step | Potential EHS Issues | Potential Quality Issues | Training |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

ETV-MF Project Manager:___________________________ ___________________________

**Name** **Signature**

___________________________

**Date**

# APPENDIX F

## ETV-MF Project Training Attendance Form

# ETV-MF Project Training Attendance Form

ETV-MF Project: ______________________________

| Date Training Completed | Employee Name Last First | Training Topic | Test Score (If applic.) |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

ETV-MF Project Manager: ____________________________________