Environmental Technology Verification Coatings and Coating Equipment Program (ETV CCEP)

Allied PhotoChemical KrohnZone™ 7014 – Testing and Quality Assurance Project Plan (TQAPP)

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SI to English Conversions

SI Unit	English Unit	Multiply SI by factor to obtain English
°C	°F	(1.80 E + 00), then add 32
L	gal. (U.S.)	2.642 E - 01
m	ft	3.281 E + 00
kg	lbm	2.205 E + 00
kPa	psi	1.4504 E - 01
cm	in.	3.937 E - 01
mm	mil (1 mil = 1/1000 in.)	3.937 E + 01
m/s	ft/min	1.969 E + 02
kg/L	lbm/gal. (U.S.)	8.345 E + 00

List of Abbreviations and Acronyms

ACGIH	American Conference of Governmental Industrial Hygienists
ACS	American Chemical Society
ANSI	American National Standards Institute
AOAC	Association of Official Analytical Chemists
ARDEC	Armaments Research, Development and Engineering Command
ASQC	American Society for Quality Control
ASTM	American Society for Testing and Materials
CCEP	Coatings and Coating Equipment Program
CTC	Concurrent Technologies Corporation
DFT	dry film thickness
EPA	Environmental Protection Agency
ETF	Environmental Technology Facility
ETV	Environmental Technology Verification
HAP	hazardous air pollutant
HVLP	high-volume, low-pressure
IR	infrared
ISO	International Standardization Organization
NDCEE	National Defense Center for Environmental Excellence
NIST	National Institute for Standards and Technology
QA/QC	quality assurance/quality control
QMP	Quality Management Plan
SOP	Standard Operating Procedures
TQAPP	Testing and Quality Assurance Project Plan
UV	Ultraviolet
VOC	volatile organic compound
WBS	work breakdown structure

1.0 INTRODUCTION

1.1 Purpose of the Allied PhotoChemical KrohnZone™ 7014 - TQAPP

The primary purpose of this document is to establish the Testing and Quality Assurance Project Plan (TQAPP) for the Allied PhotoChemical (APC) KrohnZone™ 7014 Clear Coat coating. The objective of this TQAPP is to verify the performance of the KrohnZone™ 7014 coating, which is a near-zero VOC ultraviolet (UV) curable coating. The format and guidelines for this TQAPP were established by the Environmental Technology Verification Coatings and Coating Equipment Program (ETV CCEP) UV-Curable Coatings – Generic Testing and Quality Assurance Protocol (DRAFT Version), to which reference will be made frequently throughout this document as the Draft UV Coatings Generic Protocol.

This TQAPP establishes specific data quality requirements for all technical parties involved in the verification of the KrohnZone™ 7014 system. This TQAPP follows the format described below to facilitate independent reviews of the project plans and test results, and to provide a standard platform of understanding for stakeholders and participants.

1.2 Quality Assurance for the ETV CCEP

Projects conducted under the auspices of the Environmental Technology Verification Coatings and Coating Equipment Program (ETV CCEP) meet or exceed the requirements of the American National Standards Institute/American Society for Quality Control (ANSI/ASQC), Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs, ANSI/ASQC E-4 (1994) standard. This TQAPP will ensure that project results are compatible with and complementary to similar projects. All ETV CCEP TQAPPs are adapted from this standard and the ETV Program Quality Management Plan (QMP). TQAPPs will contain sufficient detail to ensure that measurements are appropriate for achieving project objectives, that data quality is known, and that the data are legally defensible and reproducible.

1.3 Organization of the KrohnZone™ 7014 TQAPP

This TQAPP contains the sections outlined in the ANSI/ASQC E-4 standard. As such, this TQAPP identifies processes to be used, test and quality objectives, measurements to be made, data quality requirements and indicators, and procedures for the recording, reviewing and reporting of data.

The major technical sections discussed in this TQAPP are as follows:

- Project Description
- Project Organization and Responsibilities
- Quality Assurance (QA) Objectives
- Site Selection and Sampling Procedures
- Analytical Procedures and Calibration
- Data Reduction, Validation and Reporting
- Internal Quality Control (QC) Checks
- Performance and System Audits
- Calculation of Data Quality Indicators
- Corrective Action
- Quality Control Reports to Management
- Appendices

1.4 Formatting

In addition to the technical content, this TQAPP also contains standard formatting elements required by the ANSI/ASQC E-4 standard and Concurrent Technologies Corporation (*CTC*) deliverables (see Section 1.4 of the Draft UV Coatings Generic Protocol).

1.5 Approval Form

Key ETV CCEP personnel indicate their agreement and common understanding of the project objectives and requirements by signing the TQAPP Approval Form for the verification testing of KrohnZone™ 7014. Acknowledgment by each key person indicates commitment toward implementation of the plan (see Figure 1 of the Draft UV Coatings Generic Protocol for the template of the Approval Form).

2.0 PROJECT DESCRIPTION

2.1 General Overview

The overall objective of the ETV CCEP is to verify pollution prevention and performance characteristics of coating technologies and make the results of the testing available to prospective coating technology users. The objective of this particular TQAPP is to establish the performance of the KrohnZone™ 7014 UV-curable coating. This innovative coating was developed and patented by APC. Utilizing free radical chemistry, APC uses vehicles without solvents in their coating formulation, thus eliminating the source of volatile organic compound (VOC) and hazardous air pollutant (HAP) emissions. Since there is currently no approved method to determine VOC or HAP content/emissions from UV-curable coatings, the total volatile content will be determined per ASTM D 5403 Method A, as a surrogate for VOC and HAP analyses. Total volatile content, the quality, and durability of the cured coating will be the primary criteria for verifying the performance of the coating. The test data from this verification test will be compiled and used to develop a Verification Report, and, at the discretion of the vendor, a Verification Statement will be developed from the data contained in the Verification Report. APC may use the Verification Statement as a marketing tool for the KrohnZone™ 7014, in accordance with the ETV Program Policy Compendium.

2.1.1 Off-Site Coating Application Phase

APC's facility in Marysville, MI will be the location for the coating application and curing portion of this verification test. APC staff will prepare the coating, apply the coating to the Standard Test Panels, and operate the cure oven. ETV CCEP staff will conduct a site survey and pre-test audit of APC's facility and equipment to ensure that all the QA/QC requirements are met. The ETV CCEP staff will also oversee all coating application and curing procedures, transport the Standard Test Panels between locations as appropriate, measure all process variables, conduct the on-site laboratory analyses, and package the Standard Test Panels for transport to the National Defense Center for Environmental Excellence (NDCEE) Environmental Coatings Laboratory. The ASTM D 5403 analysis of processing volatile content will be performed by ETV CCEP personnel using APC's equipment, potential volatiles done at *CTC*.

2.1.2 NDCEE Environmental Coatings Laboratory Facilities

In support of the ETV CCEP, the NDCEE's extensive state-of-the-art Environmental Coatings Laboratory facilities will be available to evaluate the cured Standard Test Panels. Laboratory facilities available from the NDCEE are described in Section 2.1.2 of the Draft UV Coatings Generic Protocol.

2.1.4 Statement of Project Objectives

The overall objective of the ETV CCEP is to verify pollution prevention characteristics and/or performance of coatings and coating equipment technologies, and to make the results of the verification tests available to prospective technology users. The ETV CCEP aspires to increase the use of more environmentally friendly technologies in products finishing in an effort to reduce emissions.

The primary criteria for verification of KrohnZone™ 7014 coating will be:

- Does the coating provide an environmental benefit in terms of reduced total volatile content compared to existing regulatory limits?
- Does the coating provide a finish of acceptable quality and performance?
- Is there a reduction of solid, liquid, or hazardous waste resulting from reduced paint usage?
- Is there a reduction or increase in energy usage for the curing stage?

Based on the best available data, as presented by an unbiased third party, end-users will be able to determine whether the coating can provide them with a pollution prevention benefit while meeting the finish quality requirements of their application. This program intends to supply end-users with the unbiased technical data to assist them in the decision-making process.

The quantitative pollution prevention benefit in terms of reducing or eliminating total volatile emissions depends on a multitude of factors; therefore, the KrohnZone™ 7014 coating will be applied per APC's instructions, and the resulting verification data will be representative of the exact conditions tested.

The potential reduction in waste and energy usage will be determined qualitatively. The unsprayed coating and uncured coating overspray could potentially be recycled, thus reducing the amount of raw material needed and the amount of liquid and solid waste generated when compared to other coatings. In addition, an estimate of energy usage will be determined and compared to typical curing operations for similar non-UV coatings.

2.2 Technical/Experimental Approach and Guidelines

The following tasks are planned for this project (see estimated schedule in Section 2.3, Table 5):

- Obtain APC's concurrence with this TQAPP.
- Obtain *CTC* and EPA approval of this TQAPP.
- Conduct verification test of the KrohnZone™ 7014.
- Prepare and provide the draft Verification Report to EPA.
- Prepare and provide the final Verification Report to EPA.
- Prepare Verification Statement for approval and distribution.

Table 1 describes the general guidelines and procedures that will be applied to this TQAPP.

Table 1. Overall Guidelines and Procedures to be applied to this TQAPP

• A detailed description of each part of the test will be given. • Critical and non-critical factors will be listed. Non-critical factors will remain constant throughout the testing. Critical factors will be listed as control (process) factors or response (UV curable coating product quality) factors (see Section 2.2.11 below). • This TQAPP will identify the testing sites. • All testing will be under the control and close supervision of ETV CCEP representatives to ensure the integrity of the third party testing. • The QA portion of the Draft UV Coatings Generic Protocol will be strictly adhered to. • A statistically significant number of samples will be analyzed for each critical response factor (see Table 4). Variances (or standard deviations) of each critical response factor will be reported for all results.

2.2.1 Test Approach

The following approach will be used in this TQAPP.

- APC will identify the performance parameters to be verified and recommend the optimum equipment settings for application and curing;
- The Standard Test Panels will be purchased through Q-Panel Lab Products, an independent organization;
- APC will provide the KrohnZone™ 7014 coating;
- The APC will provide the HVLP spray gun to be used in the application;

- Data such as dry film thickness, gloss, adhesion, salt spray, etc. will be collected, following the ASTM methods, or equivalent; and,
- A statistically valid test program that efficiently accomplishes the required objectives will then be used to analyze the data.

2.2.2. Verification Test Objectives

The objectives of the verification test performed per this TQAPP are to determine the total volatile content and to verify the quality and performance of the KrohnZone™ 7014 coating. The coated and cured Standard Test Panels will be tested for dry film thickness (DFT), DFT variation, visual appearance, and the following analyses chosen by APC: gloss (20° and 60°), direct impact, conical mandrel bend, tape adhesion (x-cut and cross-hatch), abrasion resistance, MEK rub, salt-spray resistance (2000 hrs.) and humidity resistance (2000 hrs.).

2.2.3 Standard Test Panels

The Standard Test Panel to be used for this verification test is shown in Appendix A (Standard Test Panel). It is a flat cold rolled steel panel from Q-Panel Lab Products. The cold rolled steel meets SAE 1008 specifications. The Standard Test Panel is 30.5 cm (12 in.) long, 10.2 cm (4 in.) wide and made of 22 gauge steel. The Standard Test Panels will receive a zinc phosphate pretreatment coating by *CTC*. APC has specifically requested that no MEK cleaning solvent be used on the Standard Test Panels prior to application of the KrohnZone™ 7014 coating.

2.2.4 Coating Specification

The KrohnZone™ 7014 is a UV curable coating that was developed for automotive applications in addition to other metal coating applications that require only one-coat applications, (such as lawnmowers, metal coil, etc.). KrohnZone™ 7014 is a one component, ready-to-spray or ready-for-use (RFU) coating with a manufacturer recommended shelf life of one year. The coating can be tailored to a specific viscosity range as designated by the customer. The standard KrohnZone materials are RFU in the 300-1000 cps range, which can be applied by an HVLP spray gun.

KrohnZone™ 7014 is reported to meet the following specifications:

- 100% UV-curable
- contains 100% solids with no VOCs, HAPs
- one component, ready-for-use coating

- shelf life of one year with no prolonged exposure to light
- theoretical coverage of 1020 ft^2/gal (65% TE, 1 mil)
- curable up to 6 mils with a cure energy greater than 0.35 J/cm^2

The test coating data sheet is shown in Appendix B (KrohnZone™ 7014 Clear Coat Product Data Sheets). APC will provide the ETV CCEP with the necessary quantity of the KrohnZone™ 7014 coating to complete the verification test. The coating will be received as ready-for-use (RFU) or ready-to-spray. Other coating preparation procedures recommended by APC will be recorded on the paint batch worksheets.

ETV CCEP staff will measure the coating temperature and viscosity prior to each run. Samples will also be collected and packaged for shipment to the NDCEE Environmental Coatings Laboratory for percent solids and density analyses. The coating measurements will be recorded on the paint batch worksheet. A separate batch of coating will be connected to the HVLP spray gun setup for each run for application to the Standard Test Panels.

2.2.5 UV-Curable Coating Apparatus

The KrohnZone™ 7014 coating will be manually applied to the Standard Test Panels using a HVLP gun. The application parameters for the HVLP gun, such as distance to the panels, number of passes, fluid delivery pressure, etc., will be determined during the start-up phase, prior to the verification test.

Before the test, a set of dummy panels will be coated to ensure that the equipment parameters are set correctly. The fluid delivery pressure will be monitored periodically throughout the test. The paint usage will be determined through gravimetric means.

The Standard Test Panels will be manually placed in the spray booth in groups of five. After the coating is applied, the Standard Test Panels will be manually transported to the cure area. After the Standard Test Panels are cured, they will be prepared for packaging and shipment to the NDCEE facilities in Johnstown, PA.

2.2.6 Process Standards

The Standard Test Panels will be of one type and used for all runs (see Appendix A). The environmental (ambient) conditions of the test site will be monitored, both near the spray zone and in the curing area. The curing process will be the same for all runs. Operating parameters will be held relatively constant throughout the test.

2.2.7 Design of Experiment

This TQAPP will verify the performance of the KrohnZone™ 7014 coating. A mean value and variance (or standard deviation) will be reported for each critical response factor, and default 95% confidence limit will be applied.

The verification test will be comprised of five (5) separate runs with fifteen (15) Standard Test Panels coated per run. This will enable total variation to be determined for each response factor with a reasonable statistical significance. The statistical analyses for all response factors will be carried out using the latest version of Minitab statistical software.

2.2.8 Performance Testing

Recommended equipment settings for the coating, such as input air pressure, coating flow rate, etc. will be obtained from APC during the setup phase. These conditions will be measured prior to starting the verification test. During the tests, no attempt will be made to optimize the equipment.

Standard Test Panels will be used to measure equipment performance. The coating characteristics may be affected by other parameters of the testing process, such as surface preparation, apparatus setup, and cleanup methods. The surface preparation process will be the same for all Standard Test Panels and the variability of the Standard Test Panels should be minimal. Non-critical control factors will be monitored or held relatively constant for the verification test. A comparison will be made from run to run.

2.2.9 Quantitative Measurements

In order to evaluate the finish quality obtained with the tests utilizing the KrohnZone™ 7014 coating, DFT will be measured on the cured Standard Test Panels. The uniformity of the coating applied can be determined by measuring DFT at several specified locations on the Standard Test Panels. Measurement sites will be at nine locations on the coated surface of the Standard Test Panel. Appendix A displays the Standard Test Panels with their respective locations of the mil thickness measurements. These sites will be numbered and measurements will be taken accordingly. The recorded measurements can be correlated to a specific site on each Standard Test Panel for each test. The thickness measurement data will be used to evaluate not only the mean thickness across the product, but also the variation of the thickness and differences in the edge and the central portions of the Standard Test Panels.

In addition to the performance analyses, the ETV CCEP will evaluate the potential environmental benefits associated with using the KrohnZone™ 7014 coating. Therefore, the total volatile content of the coating will be quantitatively measured.

In order to evaluate the finish quality obtained by the coating equipment tested, several measurements will be taken from the coated test specimens such as visual appearance and gloss.

The functional performance of the cured test coating will be evaluated by analyzing the cured Standard Test Panels for flexibility, impact resistance, tape adhesion, abrasion resistance, solvent resistance, humidity resistance, and salt spray resistance.

2.2.10 Participation

APC will assist in the application and curing of the test coating on the Standard Test Panels. The ETV CCEP personnel will be responsible for verifying that all data and QA requirements have been met. The ETV CCEP personnel will also perform all laboratory analyses identified for this verification.

2.2.11 Critical and Non-Critical Factors

In a designed experiment, critical and non-critical control factors must be identified. In this context, the term "critical" does not convey the importance of a particular factor. (Importance can only be determined through experimentation and characterization of the total process.) Rather, this term displays its relationship within the design of experiments. For the purposes of this TQAPP, the following definitions will be used for critical control factors, non-critical control factors, and critical response factors.

- Critical control factor - a factor that is varied in a controlled manner within a design of experiments matrix to determine its effect on a particular outcome of a system.
- Non-critical control factors - factors that remain relatively constant or are randomized throughout the testing.
- Critical response factors - the measured outcomes of each combination of critical and non-critical control factors used in the design of experiments.

In this verification test, there is only one critical control factor, the coating itself. All other processing factors are non-critical control factors; therefore, the multiple runs and sample measurements within each run for each critical response factor will be used to determine the amount of variation expected for each critical response factor.

Tables 2 through 4 identify the factors to be monitored during testing, as well as their acceptance criteria (where appropriate), data quality indicators, measurement locations, and measurement frequencies. The values in the Total Numbers column are based on the default test scenarios.

Table 2. Critical Control Factors

Critical Control Factor	**Resin Type**	**Solvent Type**	**Cure Method**	**Target Industry**
KrohnZone™ 7014 coating	100% UV-curable	None	Standard Fusion UV "H" medium mercury vapor microwave lamp systems	Automotive/ one coat applications

Table 3. Non-Critical Control Factors

Non-Critical Factor	Set Points/ Acceptance Criteria	Measurement Location	Frequency	Total Number for the Test
Dynamic Input Air Pressure	TBD	Factory Floor	Once per test	1
Products involved Testing	Standard Test Panels	N/A	15 Panels per run and 5 for pretreatment analysis	80 Panels
Pretreatment Analysis	Varies <1.0 g/m^2	Random panels removed prior to start-up	5 random panels per test	5
Surface Area of Standard Test Panels	Varies <13 cm^2 (<2 $in.^2$)	Factory floor	Once per test	1
Coating Area Temperature	≤5.0 ºC variation in Temperature	In the Factory	Once per run	5
Coating Area Relative Humidity	≤10% variation in RH	In the Factory	Once per run	5
Cure Area Temperature	≤5.0 ºC variation in Temperature	Near UV lamps	Once per run	5
Cure Area Relative Humidity	≤10% variation in RH	Near UV lamps	Once per run	5
Temperature of Panels, as Coated	≤5.0 ºC variation in Temperature	Factory Floor	Once per run	5
Coating Temperature, as Applied	≤5.0 ºC variation in Temperature	Sample from coating pot	1 sample per run	5
Coating Viscosity, as Applied	≤5 sec. variation in Viscosity on a #4 Ford Cup	Sample from coating pot	1 sample per run	5
Density of Applied Coating	≤20 g/L variation in Density	Sample from coating pot	1 sample per run	5
Weight % Solids of Applied Coating	≤5% variation in Solids Content	Sample from coating pot	1 sample per run	5
Curing Time	1-2 sec.	Factory floor	Once per run	5

Table 4. Critical Response Factors

Critical Response Factor	Measurement Location	Frequency	Total Number
Environmental			
Total Volatile Content	ASTM D 5403 Method A	3 Samples from UV curable coating lot to be used during test	3
Energy Usage of the UV Lamps	Calculated from total lamp wattage and total cure time	Once per run	5
Quality/Performance (Mandatory)			
Dry Film Thickness (DFT)	ASTM B 499 (magnetic)	9 points on each standard test panel	540
Visual Appearance	Entire test panel and entire rack	1 standard test panel per run and 1 per test	6
Specular Gloss[a] (20° angle)	ASTM D 523	3 points on each of 5 standard test panels per run	15
Specular Gloss[a] (60° angle)	ASTM D 523	3 points on each of 5 standard test panels per run	15
Quality/Performance (Optional)			
Salt Spray (2000 hours)	ASTM B 117	1 Randomly Selected Panel per Run, 1 test per Panel	5
Humidity Resistance (2000 hrs.)	ASTM D 1735	1 Randomly Selected Panel per Run, 1 test per Panel	5
Tape Adhesion[b] (X-cut)	ASTM D 3359 Method B	1 Randomly Selected Panel per Run	5
Tape Adhesion[b] (Cross hatch)	ASTM D 3359 Method A	1 Randomly Selected Panel per Run	5
Direct Impact	ASTM D 2794	1 Randomly Selected Panel per Run	5
Flexibility (Conical Mandrel Bend)	ASTM D 522	1 Randomly Selected Panel per Run	5
MEK Rub	ASTM D 5402	1 randomly selected panel per run, 1 test per panel	5
Abrasion Resistance	ASTM D 4060	1 randomly selected panel per run, 1 test per panel	5

[a] Both sets of gloss measurements will be taken on the same panels.
[b] Both sets of tape adhesion measurements will be taken on the same panels.

Other factors used to test the KrohnZone™ 7014 coating include:

- Number of coats — One coat
- Target Dry Film Thickness — 1 mil
- Throughput — ~15.3 cm/s
- Cure Time — 1-2 seconds
- Curing Energy — >0.35 J/cm^2

2.2.12 Determination of Total Volatile Content of the KrohnZone™ 7014 UV Curable Coating

This verification test will use ASTM D 5403, Test Method A, which will determine the Total Volatile Content by the following procedure:

- Test substrates will be heavy gage aluminum foil
- Test substrates will be in the shape of square pans with approximately 2 cm tall sides
- Test substrates will measure approximately 10 cm by 30 cm
- Weigh prepared test substrate (without coating) [A]
- Deposit UV-curable coating onto test substrates to a maximum of 1 mil wet film thickness using a syringe (minimum of 0.2g)
- Weigh the coated test substrate [B]
- Cure coated substrate according to manufacturer's specifications
- Weigh the cured test substrate [C]
- Heat cured test substrate at 110±5 °C for 60 minutes
- Weigh test substrate after cooling [D]

% Processing Volatiles = 100 * [(B – C) / (B – A)]

% Potential Volatiles = 100 * [(C – D) / (B – A)]

Total Volatile Content = % Processing Volatiles + % Potential Volatiles

2.3 Schedule

ETV CCEP uses standard tools for project scheduling. Project schedules are prepared in Microsoft Project, which is an accepted industry standard for scheduling. Project schedules show the complete work breakdown structure (WBS) of the project, including technical work, meetings and deliverables. Table 5 shows the estimated schedule for the verification testing of the KrohnZone™ 7014 coating.

Table 5. Estimated Schedule as of 1/24/03

ID	Name	Duration	Start Date	Finish Date
Task 1	Approval of TQAPP	15d	TBD	TBD
Task 2	Verification Testing	15d	TBD	TBD
Task 3	Complete Data Analyses	70d	TBD	TBD
Task 4	Prepare Verification Report	10d	TBD	TBD
Task 5	Approval of Verification Report	30d	TBD	TBD
Task 6	Issue Verification Statement	10d	TBD	TBD

3.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

CTC employs a matrix organization, with program and line management, to perform projects. The laboratory supports the ETV CCEP Project Manager and the ETV CCEP Project Leader by providing test data. Laboratory Analysts report to the ETV CCEP Laboratory Leader. The ETV CCEP Laboratory Leader and Organic Finishing Engineer coordinate with the ETV CCEP Project Leader on testing schedules. The ETV CCEP Project Leader is the conduit between the laboratory and the ETV CCEP Project Manager. The ETV CCEP Project Leader answers directly to the ETV CCEP Project Manager. For the ETV CCEP, the ETV CCEP Project Leader will be responsible for preparing the TQAPPs and Verification Report and Statement for each test.

The ETV CCEP QA Officer, who is independent of both the laboratory and the program, is responsible for administering *CTC* policies developed by the Quality Committee. These policies provide for, and ensure that quality objectives are met for each project. The policies are applicable to laboratory testing, factory demonstration processing, engineering decisions, and deliverables. The ETV CCEP QA Officer reports directly to *CTC* senior management and is organizationally independent of the project or program management activities.

The project organization chart, showing lines of responsibility and the specific *CTC* personnel assigned to this project, is presented in Figure 1. A summary of the responsibilities of each *CTC* participant, his/her applicable experience, and his/her anticipated time dedication to the project during testing and reporting is given in Table 6.

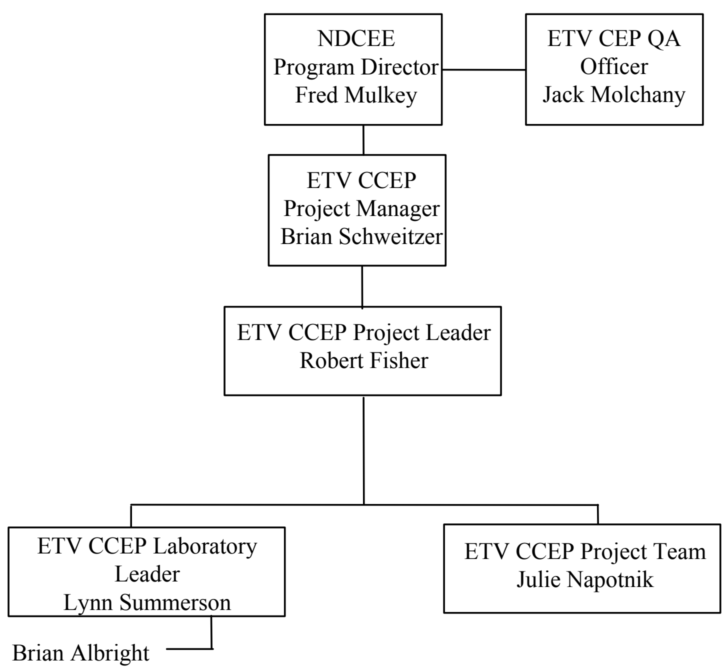


Figure 1. Project Organization Chart

Table 6. Summary of ETV CCEP Experience and Responsibilities

Key *CTC* Personnel and Roles	Responsibilities	Applicable Experience	Education	Time Dedication
Fred Mulkey – NDCEE Program Director	Manages NDCEE Program Accountable to *CTC* Technical Services Manager and *CTC* Corporate Management	Laboratory Chemist and Manager (14 years) Project Quality Assurance (14 years) Project Management (13 years) Registered Environmental Manager	M.S., Chemistry B.S., Chemistry	5%
Jack Molchany – ETV CCEP QA Officer	Responsible for overall project QA Accountable to NDCEE Program Director	Industrial QA/QC and (13 years) Quality Mgmt. /ISO 9000 (7 years) Environmental Compliance and ISO 14000 Management Systems (7 years) Certified Hazardous Materials Mgr.	B.S., Industrial Engineering	10%
Brian Schweitzer – Manager, Process Engineering/ ETV CCEP Project Manager	Responsible for overall ETV CCEP technical aspects, budget, and schedule issues on daily basis Accountable to NDCEE Program Director	Process Engineering Management (3 years) Process Engineer (12 years) Project Manager, Organic Finishing (7 years)	B.S., Mechanical Engineering	30%
Rob Fisher – Staff Process Engineer/ ETV CCEP Project Leader	Technical project support Process design and development Accountable to ETV CCEP Project Manager	Organic Finishing Regulations (5 years) Organic Finishing Operations (5 years) Registered Professional Engineer	M.S., Manufacturing Systems Engineering B.S., Chemical Engineering	70%
Julie Napotnik - Assistant Process Engineer/ ETV CCEP Project Team	Technical project support Process design and development Accountable to ETV CCEP Project Manager	Organic Coating Systems Process Engineer	B.S., Geo-Environmental Engineering	15%
Lynn Summerson – ETV CCEP Laboratory Leader/ Statistical Support Staff	Laboratory analysis Accountable to ETV CCEP Project Leader	Industrial and Environmental Laboratory Testing (18 years)	M.S., Chemistry B.S., Chemistry	10%
Brian Albright – ETV CCEP Assistant Laboratory Analyst	QC Analysis Accountable to ETV CCEP Laboratory Leader	Environmental and QC Testing (5 years)	B.S., Chemistry	10%

The ETV CCEP personnel specified in Table 6 are responsible for maintaining communication with other responsible parties working on the project. The frequency and mechanisms for communication are shown in Table 7.

Table 7. Frequency and Mechanisms of Communications

Initiator	Recipient	Mechanism	Frequency
NDCEE Program Manager, ETV CCEP Project Manager, and/or ETV CCEP Project Leader	EPA ETV CCEP Project Manager	Written Report Verbal Status Report	Monthly Weekly
ETV CCEP Project Manager	NDCEE Program Manager	Written or Verbal Status Report	Weekly
ETV CCEP Laboratory Manager	ETV CCEP Project Leader	Data Reports	As Generated
ETV CCEP Project Leader	ETV CCEP Project Manager	Written or Verbal Status Report	Weekly
ETV CCEP QA Officer	NDCEE Program Manager	Quality Review Report	As Required
EPA ETV CCEP Project Manager	*CTC*	On-Site Visit	At Least Once per Year
Special Occurrence	**Initiator**	**Recipient**	**Mechanism/ Frequency**
Schedule or Financial Variances	NDCEE Program Manager or ETV CCEP Project Manager	EPA ETV CCEP Project Manager	Telephone Call, Written Follow-up Report as Necessary
Major (will prevent accomplishment of verification cycle testing) Quality Objective Deviation	NDCEE Program Manager or ETV CCEP Project Manager	EPA ETV CCEP Project Manager	Telephone Call with Written Follow-up Report

Table 8. Responsibilities During Testing

Position	Responsibility
ETV CCEP Project Manager	Overall coordination of project
ETV CCEP QA Officer	Audits of verification testing operations and laboratory analyses
ETV CCEP Project Leader	Overall coordination of testing, reporting, and data review
Statistical Support	Coordinates interpretation of test results

4.0 QUALITY ASSURANCE OBJECTIVES

4.1 General Objectives

The overall objectives of this ETV CCEP TQAPP are to verify the pollution prevention benefit of the KrohnZone™ 7014 coating and the quality and performance of its applied finish. These objectives will be met by controlling and monitoring the critical and non-critical factors, which are the specific QA objectives for this TQAPP. Tables 2 and 3 list the critical and non-critical factors, respectively.

The analytical methods that will be used for UV curable coating evaluation are adapted from ASTM Standards, or industrial standard equivalent. The QA objectives of the program and the capabilities of these test methods for product and process inspection and evaluation are synonymous because the methods were designed specifically for evaluation of the UV curable coating properties under investigation. The methods will be used as published, or as supplied, without major deviations. The specific methods to be used for this project are attached to this document in Appendix D, *ASTM Methods*.

4.2 Quantitative Quality Assurance Objectives

Quality assurance parameters such as precision, accuracy, and completeness, are presented in Tables 9 and 10. Table 9 presents the manufacturers' stated capabilities of the equipment used to measure non-critical control factors. The precision and accuracy parameters listed are relative to the true value to which the equipment measures. Table 10 presents the precision and accuracy parameters for the measurement equipment for the critical response factors. Precision and accuracy are determined using duplicate analysis and known standards and/or spikes and must fall within the values found in the specific methods expressed.

The Statistical Support Staff, ETV CCEP QA Officer, and laboratory personnel will coordinate efforts to calculate and interpret the test results.

Table 9. QA Objectives for Precision, Accuracy and Completeness for All Non-Critical Control Factor Performance Analyses

Measurement	Method	Units	Precision	Accuracy	Completeness
Dynamic Input Air Pressure	Pressure gauge	psig	±0.2 psig	±5%	90%
Products Involved in Testing	Standard Test Panels	N/A	N/A	N/A	100%
Pretreatment Analysis	ASTM B 767	g/m^2	±0.005	±0.01	90%
Surface Area of Standard Test Panels	Ruler	cm^2 (ft^2)	±0.025 (±0.0036)	±0.025 (±0.0036)	90%
Coating Area Temperature	Thermal Hygrometer	°C	±3% of full scale	±3% of full scale	90%
Coating Area Relative Humidity	Thermal Hygrometer	RH	±3% of full scale	±3% of full scale	90%
Cure Area Temperature	Thermal Hygrometer	°C	±3% of full scale	±3% of full scale	90%
Cure Area Relative Humidity	Thermal Hygrometer	RH	±3% of full scale	±3% of full scale	90%
Temperature of Panels, as Coated	IR Thermometer	°C	±0.5% RPD	±1.0%	90%
Coating Temperature, as Applied	Thermometer	°C	±0.5 °C	±0.2 °C	90%
Coating Viscosity, as Applied	ASTM D 1200 #4 Ford Cup	seconds	±10% RPD	±10%	90%
Density of Applied Coating	ASTM D 1475	g/l (lb/gal)	±0.6% RPD	±1.8%	90%
Weight % Solids of Applied Coating	ASTM D 2369	%	±1.5% RPD	±4.7%	90%
Curing Time	Stopwatch	seconds	±10%	±10%	90%

Accuracy is presented as percent recovery of a standard, unless otherwise noted.
RPD - relative percent difference

Table 10. QA Objectives for Precision, Accuracy and Completeness for All Critical Response Factor Performance Analyses

Measurement	Method	Units	Precision	Accuracy[a]	Completeness
Total Volatile Content	ASTM D 5403 Method A	g/kg (lbm/lbm)	2.3% per ASTM D 5403	Not reported in ASTM D 5403	90%
Energy usage	Calculated	KW	±10%	±10%	90%
DFT – Magnetic	ASTM B 499	mils[b]	20% RPD	10% True Thickness	90%
Visual Appearance	N/A	N/A	N/A	N/A	100%
Gloss (20° and 60° angles)	ASTM D 523	Gloss Units	20% RPD	±0.5	90%
Salt Spray	ASTM B117	Pass/Fail	All Pass or All Fail	N/A	90%
Humidity Resistance	ASTM D 1735	Pass/Fail	All Pass or All Fail	N/A	90%
Adhesion (X-Cut and Cross Hatch)	ASTM D 3359 (Tape Test)	Pass/Fail	All Pass or All Fail	N/A	90%
Direct Impact	ASTM D 2794 (Direct & Reverse)	Pass/Fail	All Pass or All Fail	Ranges listed in ASTM D 2794	90%
Flexibility	ASTM D 522 (Mandrel Bend)	Pass/Fail	All Pass or All Fail	±15%	90%
MEK Rub	ASTM D 5402	Rating Units	One Rating Unit	N/A	90%
Abrasion Resistance	ASTM D 4060	Milligrams	46% RPD	Not reported in ASTM D 4060	90%

[a] Accuracy is presented as percent recovery of a standard, unless otherwise noted.
[b] 1 mil = 0.001 inch
N/A = Not Applicable
RPD - relative percent difference

4.2.1 Accuracy

Standard reference materials, traceable to national sources such as the National Institute for Standards and Technology (NIST) for instrument calibration and periodic calibration verification, will be procured and utilized where such materials are available and applicable to this project. For reference calibration materials with certified values, acceptable accuracy for calibration verification will be within the specific guidelines provided in the method if verification limits are given. Otherwise, 80-120 percent of the true reference values will be used (see Tables 9 and 10). Reference materials will be evaluated using the same methods as for the actual test specimens. Calculations for precision, accuracy, etc. are contained in Section 10.0 of the Draft UV Coatings Generic Protocol.

4.2.2 Precision

The experimental approach of this TQAPP specifies the exact number of Standard Test Panels to be coated. The analysis of replicate Standard Test Panels for each coating property at each of the experimental conditions will occur by design. The degree of precision will be assessed based on the agreement of all replicates within a property analysis group.

4.2.3 Completeness

The laboratory strives for at least 90 percent completeness. Completeness is defined as the number of valid determinations expressed as a percentage of the total number of analyses conducted, by analysis type.

4.2.4 Impact and Statistical Significance Quality Objectives

All laboratory analyses will meet the accuracy, precision, and completeness requirements specified in Tables 9 and 10. The precision will also be checked on Standard Test Panel replicates to determine whether a nonconformance exists as a result of limitations in the coating technology. If any non-conformance from TQAPP QA objectives occurs, the cause of the deviation will be determined by checking calculations, verifying the testing and measuring equipment, and performing reanalysis. If an error in analysis is discovered, reanalysis of a new batch for a given trial will be considered, and the impact to overall project objectives will be determined. If the deviation persists despite all corrective action steps, the data will be flagged as not meeting the specific quality criteria, and a written discussion will be generated.

If all analytical conditions are within control limits and instrument and/or measurement system accuracy checks are valid, the nature of any nonconformance may be beyond the control of the laboratory. If, given that laboratory quality control data are within specification and any nonconforming results occur, the results will be interpreted as the inability of the particular UV curable coating undergoing testing to produce parts meeting the performance criteria at the given set of experimental conditions.

4.3 Qualitative QA Objectives: Comparability and Representativeness

4.3.1 Comparability

The KrohnZone™ 7014 coating will be used per APC's recommendations or conditions otherwise established in agreement with APC. The data will be comparable from the standpoint that other testing programs could reproduce similar results using a specific TQAPP. UV curable coating and environmental performance will be evaluated using EPA, ASTM and other nationally or industry wide accepted testing procedures. Process performance parameters and cost data will be generated and evaluated according to standard best engineering practices.

Standard Test Panels used in these tests will be compared to the performance criteria and to other applicable end-user and industry specifications. The specifications will be used to verify the performance of the KrohnZone™ 7014 coating. Additional assurance of comparability comes from the routine use of precision and accuracy indicators as described above, the use of standardized and accepted methods, and the traceability of reference materials.

4.3.2 Representativeness

The limiting factor to representativeness is the availability of a large sample population. Experimental designs will be constructed such that projects will have either sufficiently large sample populations per trial or otherwise statistically significant fractional populations. The tests will be conducted at the paint and equipment supplier-recommended operating conditions. If the test data meets the quantitative QA criteria (precision, accuracy, and completeness), the measurements of the tested samples will be considered representative of the UV curable coating technologies under evaluation and will be used to interpret the outcomes relative to the specific project objectives.

4.4 Other QA Objectives

No other QA objectives have been identified as part of this evaluation.

4.5 Impact of Quality

Due to the highly controllable nature of the Standard Test Panel evaluation methods and predictability of factors affecting the quality of the laboratory testing of panels, the quality control of Standard Test Panel qualifications is expected to fall within acceptable levels. Comparison of response factors will be checked for run-to-run process variations. Deviation from quantitative and qualitative QA objectives is not expected.

5.0 SITE SELECTION AND SAMPLING PROCEDURES

5.1 Site Selection

The vendor's facility was chosen because of its capabilities and to aid in scheduling purposes. Performance analyses will be performed in the NDCEE Environmental Coatings Laboratory. Standard Test Panels will be evaluated after curing and cooling.

5.2 Site Description

APC's facility includes equipment to apply the UV-curable coatings, cure the coatings, and perform a limited number of laboratory analyses. APC's laboratory equipment is calibrated against traceable standards. APC's equipment will be made available to the ETV CCEP staff for the purposes of taking measurements and performing a portion of the volatile content analysis. APC does not have a calibrated laboratory oven. Therefore, the potential volatiles will be determined at the NDCEE facilities in Johnstown, PA.

5.3 Sampling Procedures and Handling

Standard Test Panels will be used in this project. These will be pre-labeled by stamping their ID (identification) number on one side of the Standard Test Panels. The experimental design will coat 60 Standard Test Panels during the verification test (5 runs and 15 panels per run). ETV CCEP staff will process the Standard Test Panels according to a pre-planned sequence of stages, which includes those identified in Table 11.

Table 11. Process Responsibilities

Procedure	**APC Staff**	**ETV CCEP Staff**
Site Survey and Pre-Audit		X
Visual Inspection of Standard Test Panels		X
Numbering of Standard Test Panels		X
Arrange Standard Test Panels for coating application	X	
Prepare the Coating	X	
Setup the HVLP gun	X	
Take Coating Samples and Measurements		X
Load Coating & Prime Gun	X	
Perform Setup Trials (before first run only)	X	X
Apply Coating to Standard Test Panels	X	
Take Process Measurements		X
Cure Standard Test Panels	X	
Wrap/Stack/Transfer Standard Test Panels to Lab		X

An ETV CCEP staff member will record the date and time of each run and the time each measurement was taken. After curing, the Standard Test Panels will be separated by a layer of packing material and stacked for transport to the laboratory by rental vehicle. The laboratory analyst will process the Standard Test Panels through the NDCEE Environmental Coatings Laboratory login prior to performing the required analyses.

5.4 Sample Custody, Storage and Identification

The Standard Test Panels will be given a unique laboratory ID number and logged into the laboratory record sheets. The analyst delivering the Standard Test Panels will complete a custody log indicating the sampling point IDs, sample material IDs, quantity of samples, time, date, and analyst's initials. The Standard Test Panels will remain in the custody of *CTC*, unless a change of custody form has been completed. The change of custody form should include a signature from *CTC*, the Standard Test Panel ID number, the date of custody transfer, and the signature of the individual to whom custody was transferred.

Laboratory analyses may only begin after each Standard Test Panel is logged into the laboratory record sheets. The laboratory's sample custodian will verify this information. Both personnel will sign the custody log to indicate transfer of the samples from the coating processing area to the laboratory analysis area. The laboratory sample custodian will log the Standard Test Panels into a bound record book; store the Standard Test Panels under appropriate conditions (ambient room temperature and humidity); and create a work order for the various laboratory departments to initiate testing. The product evaluation tests also will be noted on the laboratory record sheet. Testing will begin within several days of coating application.

6.0 ANALYTICAL PROCEDURES AND CALIBRATION

Information regarding facility and laboratory testing and calibration procedures, product quality procedures, standard operating procedures for calibrations, and non-standard methods that will be used for this project can be found in Section 6.0 of the Draft UV Coatings Generic Protocol.

Process Measurements

Before each run, the temperature and viscosity of the coating batch will be measured. Coating samples will be shipped to the NDCEE Environment Coatings Laboratory for density, and percent solids analyses. In addition, a total volatile content analysis will be performed at APC and the NDCEE Environmental Coatings Laboratory by ETV CCEP staff.

The ambient temperature and relative humidity are measured both near the spray area and the cure area. Also, the temperature of the Standard Test Panels is measured prior to starting each test run.

The potential volatiles are determined by weighing cured coating samples, heating them for an hour at 110 °C, then re-weighing them to determine if any additional volatiles were emitted by the cured coating. APC does not have a calibrated laboratory oven. Therefore, the potential volatiles will be determined by two processes. First, cured samples will be weighed at APC, packaged, shipped to *CTC*, reweighed (to ensure the samples were not affected by shipping), heated in a laboratory oven at *CTC*, then weighed again. Second, cured samples will be heated in a non-calibrated oven at APC (where the sample temperature will be periodically checked using an IR thermometer), weighed, packaged, shipped to *CTC*, and reweighed.

All equipment used in the above analyses are calibrated according to Table 10 of the Draft UV Coatings Generic Protocol.

Finish Quality

A listing of the test methods for total volatile content, dry film thickness, visual appearance, specular gloss, salt-spray, tape adhesion, direct impact, mandrel bend, MEK rub, humidity resistance, and abrasion resistance can be found in Appendix D.

The equipment used for these analyses are calibrated according to Table 10 of the Draft UV Coatings Generic Protocol.

7.0 DATA REDUCTION, VALIDATION, AND REPORTING

Information pertaining to raw data handling, preliminary data package validation, final data validation, data reporting and archival, and the Verification Statement can be found in Section 7.0 of the Draft UV Coatings Generic Protocol.

8.0 INTERNAL QUALITY CONTROL CHECKS

Information pertaining to *CTC's* internal quality program, types of QA checks performed, and a summary of basic and specific QA checks to be performed can be found in Section 8.0 of the Draft UV Coatings Generic Protocol.

In addition to the information found in the Draft UV Coatings Generic Protocol, the following specific QC/QA checks will be performed during this test.

A site-survey/pre-audit will be conducted by ETV CCEP staff of APC's facility and equipment. The survey will determine the level of QA/QC that APC adheres to pertaining to the equipment that will be utilized for this verification. The pre-audit will check calibration status and perform the initial QA/QC checks of the appropriate process and laboratory equipment.

Internal QA audits will be performed of the laboratory analyses by the ETV CCEP QA Officer, who is independent of the ETV CCEP Project Manager. These audits will check that processes are completed as per the approved written documentation, both internal and external. The QA audits will also check that the laboratory data is handled properly. The ETV CCEP QA Officer will document the results of the internal audits in a report to the ETV CCEP Project Manager.

The QC checks that are performed by the laboratory personnel may include analyzing un-coated Standard Test Panels for dry film thickness to verify that the instrument has not drifted from zero, performing duplicate analyses on the same samples, and performing calibration checks of the laboratory equipment. The calibration checks generally consist of calibrating the equipment (if applicable), checking the calibration against a secondary standard, analyzing samples, rechecking the calibration, analyzing more samples, etc. The calibration is also checked against the secondary standard at the completion of an analysis series. If at any time the equipment falls out of calibration, all samples analyzed since the last good calibration check will be re-analyzed after the equipment is re-calibrated.

9.0 PERFORMANCE AND SYSTEM AUDITS

A pre-test audit is planned to ensure that the equipment to be used for this test at APC's facility meet the requirements of this TQAPP. Additional information pertaining to the performance and system audits to be performed can be found in Section 9.0 of the Draft UV Coatings Generic Protocol.

10.0 CALCULATION OF DATA QUALITY INDICATORS

Information pertaining to the calculation of data quality indicators such as precision, accuracy, completeness and other project specific indicators can be found in Section 10.0 of the Draft UV Coatings Generic Protocol.

11.0 CORRECTIVE ACTION

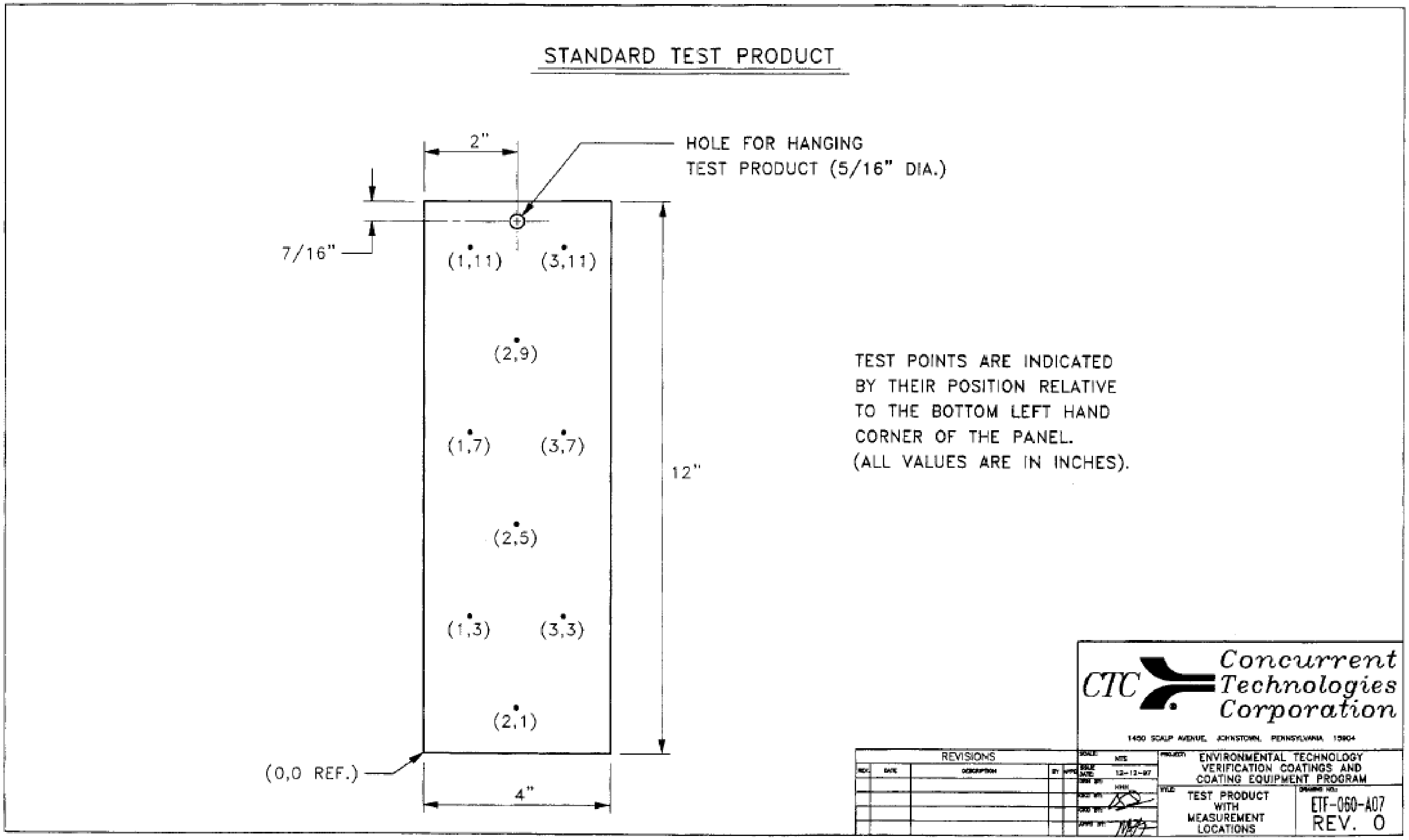
Information pertaining to routine and non-routine corrective actions that may be required during this project can be found in Section 11.0 of the Draft UV Coatings Generic Protocol.

12.0 QUALITY CONTROL REPORTS TO MANAGEMENT

Information pertaining to the quality control reports that the ETV CCEP will deliver to Program Management can be found in Section 12.0 of the Draft UV Coatings Generic Protocol.

APPENDIX A

Standard Test Panels


STANDARD TEST PRODUCT
HOLE FOR HANGING TEST PRODUCT (5/16" DIA.)
2"
7/16"
(1,11)
(3,11)
(2,9)
(1,7)
(3,7)
(2,5)
(1,3)
(3,3)
(2,1)
(0,0 REF.)
4"
12"
TEST POINTS ARE INDICATED BY THEIR POSITION RELATIVE TO THE BOTTOM LEFT HAND CORNER OF THE PANEL. (ALL VALUES ARE IN INCHES).
CTC
Concurrent Technologies Corporation
1450 SCALP AVENUE, JOHNSTOWN, PENNSYLVANIA 15904
REVISIONS
12-12-97
ENVIRONMENTAL TECHNOLOGY VERIFICATION COATINGS AND COATING EQUIPMENT PROGRAM
TEST PRODUCT WITH MEASUREMENT LOCATIONS
ETF-060-A07
REV. 0

APPENDIX B

KrohnZone™ 7014 Clear Coat Product Data Sheets

(Available from Allied PhotoChemical)

APPENDIX C

HVLP Spray Gun Product Data Sheets

(Available from ITW DeVilbiss Automotive Refinishing)

APPENDIX D

ASTM Methods

ASTM Methods

ASTM B 117	--	Standard Test Method of Salt Spray (Fog) Testing
ASTM B 499	--	Standard Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals
ASTM B 767	--	Standard Guide for Determining Mass per Unit Area of Electrodeposited and Related Coatings by Gravimetric and other Chemical Analysis Procedures
ASTM D 522	--	Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings
ASTM D 523	--	Standard Test Method for Specular Gloss
ASTM D 1200	--	Standard Test Method for Viscosity by Ford Viscosity Cup.
ASTM D 1475	--	Standard Test Method for Density of Liquid Coatings, Inks, and Related Standard Test Panels.
ASTM D 1735	--	Standard Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus
ASTM D 2369	--	Standard Test Method for Volatile Content of Coatings
ASTM D 2794	--	Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
ASTM D 3359	--	Standard Test Methods for Measuring Adhesion by Tape Test
ASTM D 4060	--	Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
ASTM D 5402	--	Assessing the Solvent Resistance of Organic Coatings Using Solvent Rubs
ASTM D 5403	--	Standard Test Methods for Volatile Content of Radiation Curable Materials