

FMP 2224

**A POWDER COATING  
LINE AUDIT**

~~P-05513~~

27194

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H.B. Fuller Company

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## INTRODUCTION

Users of powder coatings have access to a variety of resources that can provide valuable technical support. Many pretreatment chemical suppliers will perform chemical titration analysis, accelerated salt spray testing, measure coating weight, water hardness, total dissolved solids, and do other informational testing. They can provide personnel training and troubleshooting assistance for problems related to the cleaning and pretreatment process. Many application equipment manufacturers will analyze equipment performance, evaluate operation and maintenance procedures and do other informational testing. They can provide personnel training and troubleshooting assistance for problems related to the application process. Many powder coatings manufacturers can provide services that include costing analysis, proposed line design and evaluation, new line start-up assistance, color matching, and accelerated coating testing, including adhesion and cured film performance. They can provide personnel training and troubleshooting assistance and perform line audits.

There are two levels of line-audit that can be performed, a so called 'Mini' audit, or a 'Full' line audit. A mini audit would typically take from four to six hours and would not interrupt production, providing time is available before the shift begins to do a walk through of the ovens and washer. Mini audits are normally done because they do not require any production line downtime. A full line audit might take as long as one or two days, and could require from two to six hours of production down-time, depending of the size of the system.

It should be understood that for a line audit to be of real practical value to the powder user, it must assess *all* aspects of the powder coating operation. It is essential that every relevant procedure, process, condition and value that can be tested or measured, *be* tested or measured. It is equally important that the audit be conducted by a qualified technician who is experienced enough to understand what the information obtained from the audit means. That technician must then be able to translate that raw data into recommendations the powder user can use to make only those changes that result in the desired outcome.

# **FULL POWDER COATING LINE AUDIT FOR XYZ CORPORATION**

## **OBSERVATIONS AND RECOMMENDATIONS**

### **CONVEYOR**

The conveyor is an integral part of the total powder coating system. The smoothness of the conveyor travel, grounding, speed control, hook spacing, lubrication and cleanliness are all factors necessary to insure an efficient overall system operation.

### **LOAD/UNLOAD**

The load/unload operation is an important area that is often overlooked. Considerations in this area include grounding, hanger configuration, part orientation in the washer and part presentation to the guns, line density, and speed of load/unload. Access to this area needs to be maximized in order to insure an efficient overall system operation.

### **CLEANING/PRETREATMENT**

There are two main concerns when considering the quality of the powder coating. One is the cure of the powder and the other is surface preparation. This part of the line audit cannot be stressed enough. Great care and attention to detail must be taken with this area. This is often the most neglected element of the powder coating process. With automatic chemical feeders, there is a tendency to assume that "all is well". Nothing could be farther from the truth.

Good adhesion is the result of proper surface preparation, more so than from any other tested area in the line audit. Too little conversion coating is just as bad as too much conversion coating. Both conditions will not allow sufficient adhesion to pass the specified hours of scribed salt spray testing.

### **DRY-OFF OVEN**

In order to obtain good adhesion and oftentimes good appearance, the metal needs to be dry. The dry-off oven needs to be sufficient to insure this surface condition. If the parts do not drain sufficiently, this may not be possible and an air blow-off may be necessary. Part orientation, drain holes and/or part design should be designed to assist in this important draining operation. The oven needs to be operating efficiently in order to assist in this part of the overall system operation.

## **COMPRESSED AIR SUPPLY**

The powder system needs to have clean/dry air in order to propel the powder to the part being coated. If moisture and/or oil finds its way into the system, the powder will not spray effectively and will eventually cause agglomerations, protrusions, orange peel, a variance of film build and eventually powder blockage.

## **POWDER DELIVERY**

### **Powder Hopper**

The effectiveness of the fluidized feed hopper greatly enhances the overall system operation. Powder is better transported when in a "liquid" state. It is also necessary to use as little fluidizing air as possible in order to reach this "liquid" state. Too much air can effect the powder delivery to the powder pump. This is also the first powder area that can cause the powder area to become contaminated.

### **Powder Pumps**

Without the proper powder delivery to the guns, the coating operation will not spray the proper amount of powder. These pumps will also insure that the powder is delivered uniformly in order to coat with as little powder as the powder specifications will allow. This area also sets the balance of the powder delivery air pressures and are key for the best and uniform powder deliveries.

### **Powder Hoses**

The powder hoses can also effect the efficiency of the powder system if they are too long, have too great an angle or bend, are worn and/or are not the right inside diameter for the most efficient powder system delivery. The material that makes up the hose can also influence the charge put on the powder particles.

## **PARTS GROUNDING**

Two areas of concern related to the grounding of the part are transfer efficiency and operational safety. Without proper ground, the gun can arc to the part causing an ignition source and the potential for a fire. Also, in order to create the highest charge differential of potential, the best ground possible is necessary. A proper ground path is necessary from not only the part to the conveyor, but also from the conveyor to a proven 'earth' ground. This is one of the most important factors in insuring an efficient overall powder coating system operation.

## **POWDER BOOTHS**

The average face air velocity at the openings of the booth is determined at the time of the booth design. However, there are outside influences that can alter this velocity. This designed face air velocity needs to be maintained as much as possible. Too little air will allow powder to drift out of the booth, while too much air will cause the powder to be pulled away from the part and adversely affect overall coating efficiency.

The best operation of the guns and H/V multipliers must be maintained in order to insure the best overall operation of the application equipment. The system must be operating as it is designed in order to insure the proper powder delivery. Accurate information can only be obtained from gauges, meters and indicators that function properly.

## **APPLICATION PERFORMANCE**

In order to test the overall application parameters and determine if the powder system is applying powder properly, tests must be made on the parts coated in order to determine the average, cured film thickness. Proper gun placement, part orientation, part density, powder chemistry, system performance, etc. are all parts of the overall system application performance.

## **FIRE DETECTION SYSTEM**

Although rare, powder fires can happen when a system is operated improperly. If this does happen, safeguards are designed into the application equipment that will shut off the powder delivery, close any gates to a reclaim system and shut off the powder exhaust if a fire is detected. It is necessary to insure that this system is not bypassed and is operating properly.

## **CURE OVEN**

The second half of the coating quality equation is the proper cure of the applied powder coating. 'Cure' is defined as when the coating has seen sufficient heat to pass the required cured film specifications. There are different types of curing ovens and they need to be evaluated differently in order to insure proper cure. All ovens need to be balanced and this can be determined by taking metal oven curves when the system is loaded. Adjustments can then be made to insure the proper powder flow, appearance, adhesion and cured film properties.

This is an important part of the powder application system. It cannot be overlooked and its importance cannot be lessened. Cure tests, as well as oven cure curves must be evaluated in order to insure that the system is operating as it was designed. Ambient temperature is needed to test from one dated run to another and for balancing purposes, but metal temperature is necessary to insure sufficient time at metal temperature for proper cure.

## **BURN-OFF OVEN**

This area can effect the efficiency of the system due to its use to burn off powder hooks. This determines a proper ground and is very necessary for the proper overall powder system operation. It can also effect the metal and this must not be over looked.

## **POWDER STORAGE**

It is recommended that powder be stored in an area that is controlled to less than 80 degrees Fahrenheit and less than 50 percent humidity. Some powders must be stored at less that 70 degrees Fahrenheit. This should insure as long a shelf life as the powder is capable.

## **PROCESS MONITORING and DOCUMENTATION**

Paperwork can help determine how effective the system is operating. Records assist in the cost determinations and in powder evaluations.

## **EQUIPMENT MAINTENANCE**

Preventative maintenance procedures insure system operation and longevity. These procedures are as important as breakdown maintenance procedures.

## **HOUSEKEEPING**

A powder system, if properly maintained, can be as clean as those operating it, want it to be.

# **FULL POWDER COATING LINE AUDIT FOR XYZ CORPORATION**

## **PUNCH LIST**

DATE - 11/2-3/94

This report summarizes the recommendations made in the **FULL LINE AUDIT REPORT**. It is being provided to help you assess the current state of your powder coating operation, as well as assist you with your efforts to correct existing deficiencies and improve productivity.

For a full explanation of the reasons these recommendations are being made, and the advantages to be gained by implementing them, see the corresponding section of the report titled: **OBSERVATIONS and RECOMMENDATIONS**.

### **CONVEYOR**

### **LOAD/UNLOAD**

### **CLEANING/PRETREATMENT**

### **DRY-OFF OVEN**

### **POWDER DELIVERY**

### **PARTS GROUNDING**

### **BOOTHS**

### **GUNS**

### **APPLICATION PERFORMANCE**

### **FIRE DETECTION SYSTEM**

### **CURE OVEN**

### **BURN-OFF OVEN**

### **POWDER STORAGE**

### **PROCESS MONITORING and DOCUMENTATION**

### **EQUIPMENT MAINTENANCE**

### **HOUSEKEEPING**



**FULL POWDER COATING LINE AUDIT  
FOR  
XYZ CORPORATION**

**DRY-OFF OVEN TEMPERATURE CURVE**

**FULL LINE POWDER COATING LINE AUDIT  
FOR  
XYZ CORPORATION**

**CURE OVEN TEMPERATURE CURVE**

**POWDER SUPPLIER CORPORATION**

**FULL LINE AUDIT REPORT**

**November 3-4, 1994**

**(CONFIDENTIAL)**

**for**

**THE XYZ CORPORATION  
Anywhere, USA**

**Contact: Powder User**

**Prepared by: P.C. Tech**

**Powder Supplier Corp.**  
Technical Support Group  
123 Supply Drive  
Everywhere, US 45678  
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November 30, 1994

Mr. Powder User  
**THE XYZ CORPORATION**  
876 Enterprise Drive  
Anywhere, US 54321

Dear Mr. User,

This report documents the line audit of your coating operation conducted November 3 and 4, 1994 by the Powder Supplier Corp. technical support group.

The audit consists of a comprehensive suite of equipment tests, extensive process measurement, and a careful assessment of the quality of the powder coating now being applied to your product. Direct observation of the processes and procedures during actual production over a two-day period, provided valuable insight and a more complete and objective understanding of the particular application requirements and production demands your system must satisfy. The findings detailed in this report, and the recommendations offered, are based on those tests, measurements and observations.

Our intent in conducting this audit, is to provide a thorough evaluation of the current performance of your powder coating operation, and a practical reference that you can use as a guide for making changes that will effectively improve the performance of that operation.

Your management has expressed an interest in reducing costs related to the powder coating of your parts. With that in mind, the analysis of this line audit will focus on identifying those operational procedures and conditions where improvements can be made that will result in a reduction of your 'cost per coated part'. The recommendations we have made are primarily directed toward that objective. You have also asked us, specifically, to evaluate the performance of your cured oven and determine how thoroughly your parts are being cured. The concern here relates to the mar resistance and gloss of the cured powder film. The question asked was; How are these physical properties affected by degree of cure? This audit report will address those issues as well.

Please do not hesitate to contact us to discuss this report, or any question regarding your powder coating operation. The Powder Supplier Corp. technical support group appreciates this opportunity to serve you, and we look forward to having the chance to work with you again in the near future. Thanks.

Sincerely,

P.C. Tech  
Technical Support Representative

C: File  
Sales Rep

## OBSERVATIONS and RECOMMENDATIONS

### THE XYZ CORPORATION

November 30, 1994

#### CONVEYOR

##### Observations

- o The conveyor chain travel is not smooth.
- o The conveyor cleaning-brush mechanism is not operational.

##### Recommendations

1. Adjust the conveyor take-up to eliminate excess slack in the chain.
2. Restore the operation of the conveyor cleaning mechanism.

#### LOAD/UNLOAD

##### Observations

- o Procedures here were efficient.
- o Parts hanging orientation appears optimal. The presentation of the parts to the washer nozzles, draining in the washer, and presentation to the powder guns are all accounted for.
- o Line density seems maximized for the cabinets.
- o The line density of the multi-racked small parts might be improved.

##### Recommendations

None

#### CLEANING/PRETREATMENT

##### Observations

- o The washer appears to be receiving very good maintenance.
- o It is relatively free of mineral build-up and in good condition structurally.
- o Dissolved solids and pH are monitored and adjusted automatically.
- o Titration is performed every two hours.
- o The coating weight currently being achieved, (per XYZ Corp.) 25-40 milligrams/square foot average, is very good.
- o The spray pressure in Stage #1, alkaline clean, is unusually low at 17 PSI. It was explained to us that they must operate at this very low pressure to prevent the force of the spray patterns from causing the parts to rotate as they pass.

**Comment:** This pressure is probably not generating sufficient impingement on the part surfaces to provide optimal cleaning. Inadequate cleaning and/or rinsing can result in poor adhesion of the cured powder coating to the substrate.

- o The spray patterns of a few nozzles are not properly directed at the parts and need to be adjusted.
- o There are several, (about 9 total) clogged, worn, damaged or leaking nozzles.
- o The mister stages operate only while the primary stages are on.

**Comment:** The misters should become active when parts are in the washer and the primary stages are off, or when the conveyor is stopped. Misters, ideally, should be located after every stage, but at a minimum, after the first three stages.

- o The 'drag-out' collection-tray located on the floor under the conveyor, just after the final stage of the washer, occasionally overflows. (per XYZ Corp.)

### Recommendations

1. Stage #1 Alkaline should have the steel risers and nozzles changed to PVC and plastic respectively. There is also an accumulation of alkaline residue, especially around the conveyor shroud area, that should be removed.
2. Stage #5 Chromic Acid - The tank should (Possibly must, per regulation.) have a containment berm surrounding it to prevent an overflow or spill from flowing into a floor drain. The current situation, besides being a potential safety and environmental hazard, could have legal ramifications.
3. Back-flow Stage #4 rinse to Stage #2 rinse. (Consult your pretreatment chemicals supplier before implementing this change.)
4. Increase the spray pressure in Stage #1 to a minimum of 30 PSI to enhance cleaning effectiveness.

**Comment:** To eliminate the problem of the parts rotating in the spray patterns, (If it is not possible to remove the load bars and swivel hooks, see: CONVEYOR/Recommendations) install guide rails within the washer stages to hold the parts in proper orientation, relative to the spray patterns.

5. Confirm that the nozzles in each stage are of the type, and are producing the spray pattern, recommended by your pretreatment chemicals supplier.
6. Clean or replace defective nozzles as necessary.

7. Correct the operation of the mister stages.
8. Evaluate the frequency and procedures that are currently being followed, for regeneration of the charcoal filter media in the CALGON filter system that conditions the rinse water.
9. Repair or replace the pump in the "drag-out" collection-tray to prevent it from overflowing.

## DRYOFF OVEN

### Observations

- o The parts are dry and at a reasonable temperature when they arrive at the powder booth.
- o The oven temperature set-point is unusually high at 397 F.

### Recommendations

1. Consult your pretreatment chemicals supplier to confirm that 397 F is an appropriate dry-off temperature, and that it will not cause degradation of the iron phosphate conversion coating.

## COMPRESSED AIR SUPPLY

### Observations

- o The air quality appears excellent. No gross water, water vapor or oil vapor is currently detectable. The traps and drains are clean.

### Recommendations

1. Add a drip-leg with automatic drain at the coalescing filters that are suspended from the ceiling in the powder room.
2. Install an interlock circuit that will prevent start-up of the powder booths if the air filters become loaded or the refrigerated airdryer is inoperative. (This provision was suggested by XYZ Corp. management.)

## POWDER DELIVERY

### **Powder Hoppers**

### Observations

- o All hoppers now on line, are fluidizing uniformly and at normal air pressures.
- o All hoppers now on line, are containing the powder well.

## Recommendations

None

## **Powder Pumps**

### Observations

- o Powder delivery from one gun was intermittent, and cycling at near a perfectly constant rate!
- o Powder delivery from two guns was surging erratically

**Note:** It was determined that the "FLOW" to "ATOMIZING" air pressure balance was not adjusted properly. In the first case this imbalance was causing the check valve in the FLOW rate air line at the powder pump, to continuously cycle opened and close. In the second case, the imbalance was allowing powder to settle in the powder traps that are currently present in the powder hoses.

(See:POWDER DELIVERY/Recommendations)

Correcting the pressure balance adjustments eliminated both the intermittent delivery and the surging delivery conditions.

## Recommendations

1. Review proper powder delivery, air-control adjustment procedures.

## **Powder Hoses**

WEST BOOTH (East side)

### Observations

- o All hoses are unnecessarily long.
- o No external wear or internal build-up is visible.

## Recommendations

1. Shorten all hoses as much as is practical.
2. Re-route and anchor all hoses so as not to allow any powder traps or create any pinches or kinks.

WEST BOOTH (West side)

### Observations

- o #1,2,3 and 4 are unnecessarily long.
- o #5,6,7,8,9 and 10 are acceptable.
- o #1,2,3 and 4 have powder traps due to excess length.
- o No external wear or internal build-up is visible.



### Recommendations

1. Shorten #1,2,3 and 4 as much as is practical.
2. Re-route and anchor all hoses so as not to allow any powder traps or create any pinches or kinks.

EAST BOOTH (East side)

### Observations

- o All hoses are excessively long.
- o No external wear or internal build-up is visible.

### Recommendations

1. Shorten all hoses as much as is practical.
2. Re-route and anchor all hoses so as not to allow any powder traps or create any pinches or kinks.

EAST BOOTH (West side)

### Observations

- o All hoses are excessively long.
- o No external wear or internal build-up is visible.
- o The manual-gun powder hoses are laying on the filter belt, and as a result, being subjected to severe abrasion.

### Recommendations

1. Shorten all hoses as much as is practical.
2. Re-route and anchor all hoses so as not to allow any powder traps or create any pinches or kinks.
3. Re-route manual gun hoses so they do not lay on the filter belt.
4. Ensure all powder hoses, manual and automatic are 5/8" I.D.

## PARTS GROUNDING

### Observations

Resistance measurements:

- o Between parts on adjacent load bars - generally less than 250K ohms
- o Between parts and ground - generally less than 500K ohms
- o Some doors measured greater than 1 Megohm (part-to-part)
- o One cabinet measured greater than 2 Megohms (part-to-ground)

- o Many contact points are introduced by the inclusion of load bars and the use of swivel type hooks.

**Comment:** Each additional contact point presents another site which has the potential to become coated, and thereby interrupt the parts' conductive path to ground. Poorly grounded parts don't coat efficiently and therefore waste powder, especially with the spray-to-waste colors, and they tend to become rejected parts. Ungrounded parts present a fire and shock hazard. The hangers currently on line are providing only marginally adequate parts grounding.

**Recommendations**

1. Eliminate the load bars and/or swivel hooks if possible.
2. Develop and implement an appropriate hanger burn-off schedule and procedure that will ensure optimum and consistent parts grounding.

**BOOTHS**

**WEST BOOTH**

**Observations**

- o The booth appears to be containing powder effectively.

- o Face velocity at:

- Entrance vestibule 50-60/55
- Exit vestibule 50-60/55
- Conveyor slot 45-65/55
- West side operator opening 25-35/30
- East side operator opening 40-50/45
- West side automatic gun slots 45-55/50
- East side automatic gun slots 45-55/50

- o Air flow in the powder application zone:

- Horizontally 0/0
- Vertically 0-10/5

**Note:** Velocities are expressed in the form - Range/Average in FPM.

- o Static pressure at:

- Pick-up head 18.0
- Filter belt 1.0
- Cy-Cart collector 0.8
- Cy-Cart absolute 0.0
- Main exhaust absolute 0.7

**NOTE:** Static pressures are expressed in inches w.g. (water gauge).

## EAST BOOTH

### Observations

- o The booth appears to be containing the powder effectively.
- o Face velocity at:
  - Entrance vestibule 65-70/67
  - Exit vestibule 45-55/50
  - Conveyor slot 45-75/60
  - West side operator opening 45-50/47
  - East side operator opening 45-50/47
  - West side automatic gun slots 45-55/50
  - East side automatic gun slots 50-60/55
- o Air flow in the powder application zone:
  - Horizontally 0/0
  - Vertically 0-5/2.5

**Note:** Velocities are expressed in the form - Range/Average in FPM.

- o Static pressure at:
  - Pick-up head 17.0
  - Filter belt 0.6
  - Cy-Cart collector 0.8
  - Cy-Cart absolute 0.0
  - Main exhaust absolute 0.6

**NOTE:** Static pressures are expressed in inches w.g. (water gauge).

### Recommendations

1. Re-orient booths so that the manual reinforcement operation occurs prior to the automatic guns position.

**Comment:** This arrangement presents an uncoated part to the hand-gun operator, which provides him a better visual target. He can then more accurately direct powder into those difficult faraday cage areas. A clearer view of the substrate will also allow him to more precisely judge the actual deposition of the powder onto those surfaces. The advantage will be a more uniformly coated part and a reduction of the tendency operators often have to unnecessarily over-coat some surfaces on the parts and thereby waste powder. Careful monitoring and control of the cured film thickness will assure this result.

## GUNS

### Observations

#### EAST BOOTH

- o There is one defective gun selector switch and two faulty H/V adjust potentiometers.
- o All air control functions are normal.
- o High voltage output:

RECLAIM STAGE: <u>Gun#</u>	<u>SCI</u>	VIRGIN STAGE: <u>Gun#</u>	<u>SCI</u>
1	110uA	1	100uA
2	120	2	110
3	90	3	70
4	50	4	95
5	95	5	100
6	90	6	95
7	110	7	75
8	105	8	105
9	85	9	Not accessible
10	105	10	Not accessible

**Note:** SCI - 'Short-Circuit Current'  
SCI values on all guns should be in the 100 to 120uA range.

### Recommendations

1. Repair or replace the VOLT/AMP meter in Reclaim Stage/Gun #1.
2. Make appropriate repairs or adjustments to those guns with low SCI values to bring their output up to spec.
3. Repair or replace the defective switch and potentiometers.

## APPLICATION PERFORMANCE

### Observations

- o Film thickness measurements on: Cabinet

**Note:** Surfaces were measured on each of three different cabinets. Each surface was measured at twelve different points. All measurements were then averaged.

<u>Surface</u>	<u>Thickness</u>
Side panel/Left - Exterior	2.3 mils
Side panel/Right - Exterior	2.4
Back panel - Exterior	3.5
Top panel - Exterior	2.1

Top panel - Exterior	2.1
Refer box wall - Interior	3.5
Refer box floor - Interior	2.0
3/8" wide flange around the door opening	6.0

- o The average film thickness on most surfaces can be reduced by 0.5 to 1.0 mils.

### Recommendations

1. Shut off the automatic guns currently applying powder to the door opening side of the cabinet.

**Note:** The auto guns are initially applying powder to surfaces that are being, and must be, coated manually due to their complex configuration. This additional application of powder unnecessarily increases film build on those surfaces. The hand-gun operators appear to be adequately covering these surfaces while attending to the faraday cage areas. Shutting those auto guns off will reduce overall average film thickness and thereby reduce the cost per coated part.

## FIRE DETECTION SYSTEM

### WEST BOOTH

#### Observations

- o When we arrived, the UV detector controller displayed a '4-0' fault.

**Note:** A '4-0' fault indicates that detector #4 has recognized low level UV radiation. This is most likely the result of an arc from a poorly grounded, and therefore capacitized, part to its hanger.

- o When the technician pressed RESET in an attempt to clear that fault, the controller cycled to an indicated '4-4' fault condition.

**Note:** A '4-4' fault indicates a short-circuit condition exists in the 'C' lead coming to the controller from detector #4.

- o Both detectors at the exit end of the booth, have been intentionally covered with duct tape.

### EAST BOOTH

#### Observations

- o When we arrived, the UV detector controller displayed a '4-8' fault.

**Note:** A '4-8' fault indicates that the UV detector system has been placed in "BYPASS" mode. The UV detection/Fire Protection system is inoperative and therefore not providing protection when it is in BYPASS mode. The powder coating booth must not be operated with the UV detection system in BYPASS.

When the operator moved the key switch from the BYPASS to the NORMAL mode position and pressed RESET, all faults cleared and the controller indicated a normal operating condition.

- o Both detectors at the exit end of the booth, have been intentionally covered with duct tape.

### Recommendations

1. Remove the duct tape covering the detectors.
2. Remove the keys from the "NORMAL/BYPASS" key switches in the controllers. Consign them to the care of an appropriate manager.
3. Have a qualified service technician repair and test the UV Detection/Fire Protection system immediately.
4. Review the purpose, operation, control and maintenance of the UV Detection/Fire Protection system with the operator technicians.

**Note:** The situations with the tape covered detectors and the controller in bypass, were immediately brought to the attention of the operating technicians in the powder coating room and to XYZ Corp. management. We reviewed with them the exact purpose of the UV detection system, and it was explained why defeating or interfering with its function creates a serious safety issue.

5. Establish and implement an effective hanger burn-off schedule and procedure. The intent is to ensure optimal parts grounding and thereby enhance both coating efficiency and operational safety.

### CURE OVEN

### Observations

- o The curve we ran shows a very poorly balanced oven. (See attached curve print-out.)

**Comment:** The deficiencies are severe enough to adversely affect the degree and consistency of parts curing. Furthermore, the uneven heat distribution necessitates the use of a higher than normally required oven set-point and overall average oven temperature. That wastes energy and money.

o Evaluation of Parts Cure: (MEK rub/50 X 2)

**Note:** Tests were done on three cabinets that were widely spaced throughout the production run. Surfaces selected for testing included some located higher in the oven and some that were lower. Surface areas on both thin gauge sheet metal and on heavy brackets were tested.

<u>Surface</u>	<u>Result</u>
Top panel - Exterior	Slight gloss reduction/No transfer
Side panel - Exterior	Slight gloss reduction/No transfer
Back panel - Exterior	Slight gloss reduction/No transfer
Floor of refer box	Slight gloss reduction/No transfer
Face of inside flange	Slight gloss reduction/No transfer
Hinge box - Interior	Slight softening/Slight transfer
Hinge-pin boss	Slight softening/Moderate transfer

**Comment:** Except for on the very heaviest substrates, such as the hinge-pin boss and the hinge box, all surfaces tested showed virtually full cure.

**Recommendations**

1. Install sheet-metal partitions, positioned so that they prevent the intrusion of cold air from the powder coating room, and block the air flow that currently passes between the entrance and exit vestibules.
2. Relocate the burner-control thermocouple from the return-air duct to a position where it directly senses the temperature of the air coming from the inlet duct. This change will smooth out the temperature spikes by forcing the burner to cycle up and down within a tighter range.

**Comment:** Correcting oven balance by improving airflows and burner control response should allow the cure oven set-point to be lowered by 50 or 60 degrees, and at the same time provide more complete and consistent parts curing without changing line speed. Implementing these changes will save energy and thereby reduce operating costs.

Improving the efficiency of the cure oven presents another option. Using the current set-point, production can be run at a greater line speed, provided there are no other system limitations such as load/unload or cleaning/pretreatment capability.

3. Inspect the exhaust fan blades for accumulated powder that may cause an out-of-balance condition and result in bearing or fan failure. Clean or replace as necessary.

4. Clean the accumulated powder residue and burner soot from the interior surfaces of the oven to minimize the potential for contamination of the cured powder film. Include this periodic service in the routine preventive maintenance procedure. About every six months is how often the oven should be cleaned.
5. Correct the problem with the conveyor-turn idler rollers that requires such excessive lubrication.
6. A burner flame viewing window should be installed to allow proper adjustment of the gas.

### BURN-OFF OVEN

#### Observations

- o The temperature limiting sprinkler system is inoperative.
- o The insulation lining the inside chamber walls is damaged.

#### Recommendations

1. Have your oven supplier confirm that it is functioning efficiently and safely.
2. Repair the sprinkler system.
3. Cover the interior walls with heavy expanded metal to protect the insulation.
4. Review proper operating procedures with the operators.

**Note:** A minimum temperature of 800-F is required to effectively burn off powder.

### POWDER STORAGE

#### Observations

- o The powder is stored in a dedicated, climate controlled room.
- o The current ambient conditions in this room are near ideal.
- o Two pallets of powder were left sitting outside the storage room during the two days we were in the plant.

#### Recommendations

1. Place powder in the storage room immediately upon its arrival at the plant.
2. Arrange the storage room so that the powder inventory can be easily accessed and used in a 'first in/first out' rotation.



## PROCESS MONITORING and DOCUMENTATION

### Observations

- o The Cleaning/Pretreatment system is monitored and adjusted automatically. (Every two hours per chemicals supplier)
- o The coating line technicians work from a "DAILY START-UP AND CHECK SHEET" and maintain a "POWDER BOOTH DAILY LOG SHEET."
- o System equipment manuals were readily accessible in the coating line managers office.
- o Cleaning/Pretreatment chemicals documentation was well organized and close at hand, both in the office and on the production floor.
- o MSDS and TDS documents were not obviously apparent.

### Recommendations

1. Ensure that appropriate MSDS and TDS documentation is placed at each stage of the cleaning/pretreatment system so that employees are aware of, and have easy access to them.
2. A set of MSDS and TDS documentation should be placed in the powder storage room.

## EQUIPMENT MAINTENANCE

### Observations

- o Some serious deficiencies were identified with respect to the application equipment, the collection system and the fire detection system.

**Note:** See the particular sections of this report that address those particular aspects of the system.

### Recommendations

1. Establish and implement a comprehensive and effective preventive maintenance program.

## HOUSEKEEPING

### Observations

- o Because both booths are containing powder very well, the powder coating room appears to remain, generally, very clean.
- o Each time the booths are rolled on-line/off-line for a color change, the technicians clean the booths, the application and powder delivery equipment and the floor surrounding the system.

Recommendations

1. None

- END REPORT -

## LINE AUDIT PUNCH LIST

### THE XYZ CORPORATION

November 30, 1994

This list is a summary of the recommendations made in the full LINE AUDIT REPORT. It is being provided to help you assess the current state of your powder coating operation, as well as assist you with your efforts to correct existing deficiencies and improve productivity.

For a full explanation of the reasons these recommendations are being made, and the advantages to be gained by implementing them, see the corresponding section of the report titled: OBSERVATIONS and RECOMMENDATIONS.

### CONVEYOR

- % 1. Adjust the conveyor chain to eliminate the excess slack.
- # 2. Restore the operation of the conveyor cleaning mechanism.

### LOAD/UNLOAD

None

### CLEANING/PRETREATMENT

- % 1. Change the Stage #1 steel risers and nozzles to PVC and plastic.
- # 2. Clean the alkaline residue from the conveyor shroud area.
- \* 3. Construct a containment berm around the chromic acid tank.
- % 4. Back-flow the Stage #4 rinse tank into the Stage #2 rinse tank.
- # 5. Increase the spray pressure in Stage #1 to 30 PSI.
- # 6. Clean or replace defective nozzles as necessary.
- # 7. Confirm that recommended nozzle type is installed in each stage.

- # 8. Correct the operation of the mister stages.
- % 9. Review procedures for regeneration of CALGON charcoal filter media.
- \* 10. Repair or replace the pump in the "drag-out" collection-tray.

#### DRYOFF OVEN

- # 1. Confirm that 397-F will not cause degradation of the iron phosphate conversion coating.

#### COMPRESSED AIR SUPPLY

- # 1. Add a drip-leg and automatic drain at the coalescing filters.
- # 2. Install an interlock circuit that will prevent start-up of the powder booths if the air filters become loaded or the refrigerated air-dryer is inoperative.

#### POWDER DELIVERY

##### Hoppers

None

##### Pumps

- \$ 1. Review proper powder delivery, air-control adjustment procedures.

##### Hoses

- % 1. Shorten all automatic gun hoses as much as is practical.
- # 2. Re-route and anchor hoses to avoid powder traps, pinches or kinks.
- % 3. Re-route manual gun hoses so they do not lay on the filter belt.
- % 4. Ensure all powder hoses, manual and automatic, are 5/8" I.D.

### PARTS GROUNDING

- \$ 1. Eliminate the load bars and swivel hooks if possible.
- \* 2. Implement a hanger burn-off routine that will ensure optimum and consistent parts grounding.

### BOOTHS

- \$ 1. Re-orient booths so that the manual reinforcement operation occurs prior to the automatic guns position.

### GUNS

#### WEST BOOTH

None

#### EAST BOOTH

- % 1. Repair or replace the VOLT/AMP meter for Gun #1/Reclaim Stage.
- \$ 2. Adjust or repair all guns having low SCI values.
- % 3. Repair or replace the defective switch and potentiometers.

### APPLICATION PERFORMANCE

- \$ 1. Shut off the automatic guns currently applying powder to the door opening side of the cabinet.

### FIRE DETECTION SYSTEM

- \* 1. Remove the duct tape covering the detectors.
- \* 2. Remove the keys from the "NORMAL/BYPASS" key switches in the controllers. Consign them to the care of the appropriate manager.
- \* 3. Have a qualified service technician repair and test the UV Detection/Fire Protection system as soon as possible.
- \* 4. Review the purpose, operation, control and maintenance of the UV Detection/Fire Protection system.

### CURE OVEN

- % 1. Install sheet-metal partitions, located to prevent the intrusion of cold air from the powder coating room, and block the air flow that currently passes between the entrance and exit vestibules.
- % 2. Relocate the burner-control thermocouple to a position where it senses the temperature of the air coming from the inlet duct.
- % 3. Inspect the exhaust fan blades for accumulated powder. Clean or replace as necessary.
- # 4. Clean the powder residue and soot from all interior surfaces.
- % 5. Correct the problem with the conveyor-turn idler rollers that currently requires such excessive lubrication.

### BURN-OFF OVEN

- \* 1. Ask your oven supplier to confirm that it is functioning efficiently and safely.
- \* 2. Repair the sprinkler system.
- % 3. Cover the interior walls with heavy expanded metal to protect the insulation.
- % 4. Review proper operating procedures.

### POWDER STORAGE

- # 1. Always place powder in the storage room immediately upon its arrival at the plant.
- % 2. Arrange the storage room so that the powder inventory can be easily accessed and used in a "first in/first out" rotation.

### PROCESS MONITORING and DOCUMENTATION

- \* 1. Ensure that MSDS and TDS documentation is placed where all employees are aware of, and have easy access to them.

## EQUIPMENT MAINTENANCE

\$%\*# 1. Implement an effective preventive maintenance procedure.

## HOUSEKEEPING

None

**Note:** To help you prioritize these recommendations for action, the primary benefit of each is identified by using the following notation:

<u>Symbol</u>	<u>Significance</u>
\$	Coating cost
%	Operational efficiency
*	Safety
#	Product quality

# FULL POWDER COATING LINE AUDIT FOR XYZ CORPORATION

## SYSTEM SURVEY

When trouble shooting a powder system, knowing the type of the system and the part details and system design are needed. They are oftentimes not known and this quick reference can greatly assist this operation and reduce down time.

## PARTS

**Description:** Vending machine cabinets and related components  
**Material:** Cold-Rolled and 'Readycoat' galvanneal pretreated sheet steel  
**Construction:** Conventional sheared, brake-formed and spot-welded  
**Size:** Cabinet dimensions - 6' high by 3.5' wide by 1.5 deep  
**Weight:** Cabinet - 125 pounds (approx)  
**Notes:** Some moderate to severe faraday cage areas are present.  
Film thickness specification - 1.5 to 2.5 mils generally, but UL compliance requires 100% coverage on all exterior surfaces and 100% on interior surfaces of the refer box section, at a minimum film thickness of 1.5 mils.

## EQUIPMENT

### Conveyor

**Type:** Monorail - Open I-beam/Skate wheel  
**Configured:** Load bars from conveyor pendants / swivel hooks from load bars / wire hangers from swivel hooks to parts  
**Cleaning:** Unpowered, twin wire-wheel brushes  
**Line Speed:** 10.5 FPM



## Booths

**Type:** 2 RANSBURG-GEMA 'Twin Air-Belt'  
**Model:** TAB 528-70-156  
**Size:** Each - 44' long X 13' high X 5'10" wide  
**Collection:** 2 Cy-Cart mini-cyclone cartridge collector system  
**Arranged:** On-line/Off-line for color change expediency  
**Location:** In an enclosed, climate controlled room  
**Designated:** "WEST" - Used for black only (reclaimed)  
"EAST" - Used for red and all other colors ( only red reclaimed)

## Guns

**WEST BOOTH:** 10 Automatic GEMA PG-1 / 8 on recips - 2 fixed  
2 Manual GEMA Mod-726 / After the auto guns  
**EAST BOOTH:** 10 Automatic GEMA Type 700 / 8 on recips - 2 fixed  
2 Manual GEMA Type ? / After the auto guns

## Air/H.V. Controllers

**WEST BOOTH:** 10 GEMA Type-276  
**EAST BOOTH:** 10 GEMA Type-276

## Powder Delivery

**Hoppers:** 18 Automatic/250#  
4 Manual/50#  
**Pumps:** 56 GEMA 'Old' type  
21 GEMA 'New' type

## Washer

**Mfg/Installer:** COMMAND INTERNATIONAL  
**Type:** 5-Stage power spray w/intermediate 'mister' risers  
**Material:** Canopy and all tanks are mild steel  
**Risers:** Both black pipe and PVC  
**Nozzles:** Both steel and plastic  
**Chem. Supplier:** PARKER+AMCHEM

## **Entrance Vestibule**

**Length:** 114"

## **STAGE #1 - CLEAN**

**Chemistry:** Alkaline  
**Product:** PARCO CLEANER - 1000  
**Pressure:** 17psi  
**Temperature:** 112F  
**pH:** 10.5  
**PPMDS:** Not measured  
**Length:** 120"  
**Dwell:** 60 seconds (All dwell times +/-5 seconds)  
**Water Source:** On site well

## **DRAIN SECTION**

**Length:** 60"  
**Dwell:** 30 seconds

## **STAGE #2 - RINSE**

**Chemistry:** Water/CALGON charcoal filtered  
**Product:** N.A.  
**Pressure:** 11.5 psi  
**Temperature:** 95F  
**pH:** 7.0  
**PPMDS:** Not measured  
**Length:** 78"  
**Dwell:** 40 seconds  
**Water Source:** On site well

## **DRAIN SECTION**

**Length:** 60"  
**Dwell:** 30 seconds

### **STAGE #3 - CONVERSION COAT**

**Chemistry:** Phosphoric acid  
**Product:** PREP&COAT - 505  
**Pressure:** 15 psi  
**Temperature:** 120F  
**pH:** 4.5  
**PPMDS:** Not measured  
**Length:** 135"  
**Dwell:** 68 seconds  
**Water Source:** On site well

### **DRAIN SECTION**

**Length:** 60"  
**Dwell:** 30 seconds

### **STAGE #4 - RINSE**

**Chemistry:** CALGON charcoal filtered  
**Product:** N.A.  
**Pressure:** 17 psi  
**Temperature:** 96F  
**pH:** 7.0  
**PPMDS:** Not measured  
**Length:** 85"  
**Dwell:** 43 seconds  
**Water Source:** On site well

### **DRAIN SECTION**

**Length:** 60"  
**Dwell:** 30 seconds

## STAGE #5 - FINAL RINSE

**Chemistry:** Chromic acid  
**Product:** PARCOLENE - 6 & 6A  
**Pressure:** 16 psi  
**Temperature:** 97F  
**pH:** 5.0  
**PPMDS:** Not measured  
**Length:** 120"  
**Dwell:** 60 seconds  
**Water Source:** On site well

## EXIT VESTIBULE

**Length:** About 15' (Includes a 180 degree turn)

## DRY-OFF OVEN

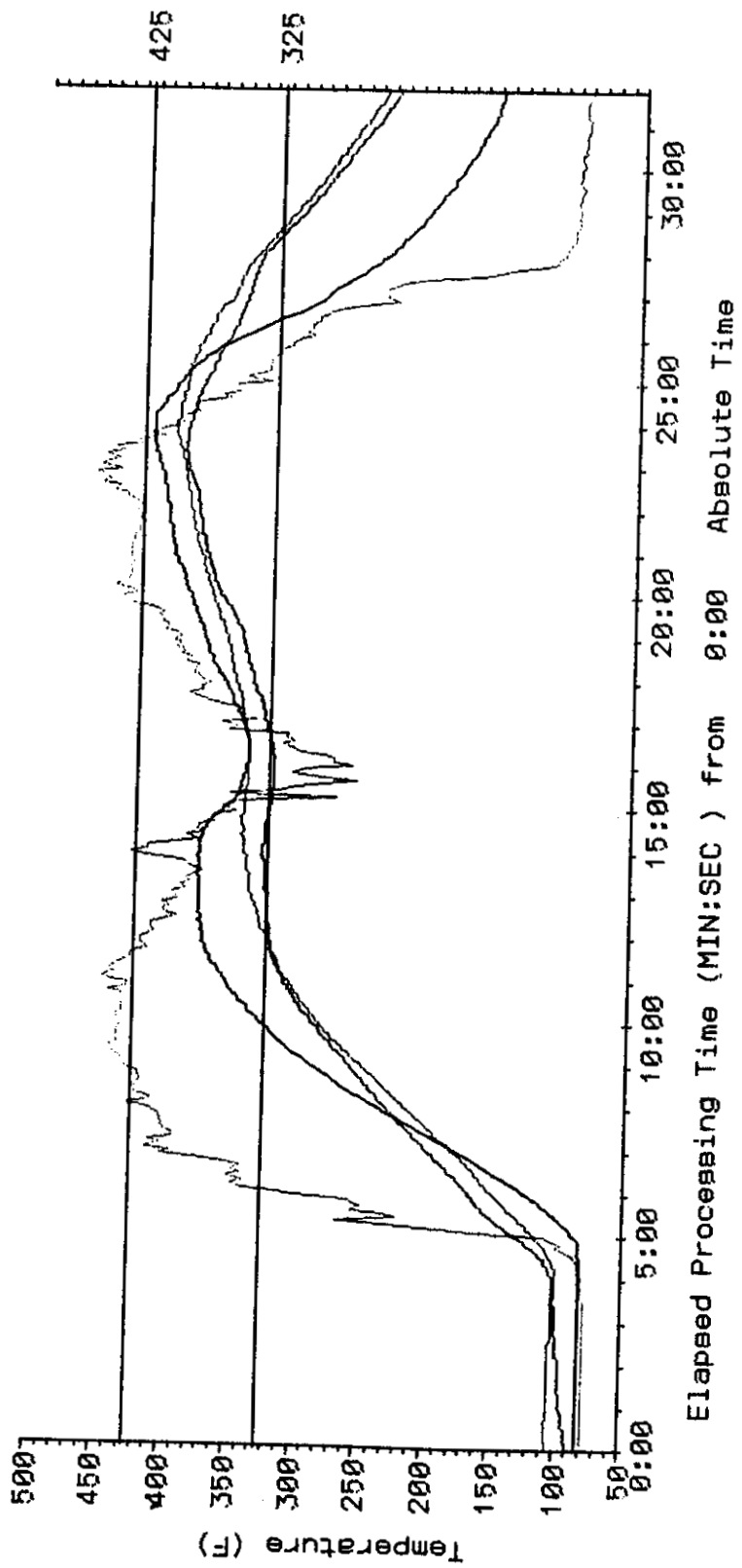
**Mfg/Installer:** COMMAND INTERNATIONAL  
**Type:** Floor level, conveyORIZED, gas-fired convection  
**Configuration:** 2-Stage - Each having separate burner and controls  
Stage 1: Bottom feed/Top return  
Stage 2: Cross flow/ Return to Stage 1  
**Dwell:** About 20 minutes @ 10.5 FPM  
**Set Point:** 400F  
**Indicated:** 428F  
**Parts @ Booth:** 90-94F

## CURE OVEN

**Mfg/Installer:** COMMAND INTERNATIONAL  
**Type:** Over-head, conveyORIZED, gas-fired convection  
**Configuration:** Bottom entrance/exit, bottom feed/top return  
**Dwell:** About 23 minutes @ 10.5 FPM  
**Set Point:** 400F  
**Indicated:** 393F  
**Peak Measured:** 460F

## **BURN-OFF OVEN**

**Manufacturer:** BAYCO  
**Type:** Batch, gas-fired  
**Configuration:** Tracked/Rolling-truck  
**Dwell:**  
**Set Point:**  
**Indicated:**  
**Peak Measured:**



CURING DATA    DEG F            MIN  
 LOW TEMP: 325    TIME: 20  
 MID TEMP: 350    TIME: 15  
 HI TEMP: 375     TIME: 10  
 MIN TEMP: 325  
 MAX TEMP: 425

PROBE 1 DATAPAQ #: 334    PEAK TEMP 460  
 WARNING: ABOVE MAX TEMP FOR 6:40

PROBE 2 DATAPAQ #: 127    PEAK TEMP 395

PROBE 3 DATAPAQ #: 153    PEAK TEMP 401

PROBE 4 DATAPAQ #: 189    PEAK TEMP 419

THRESHOLD TEMPERATURE: 350 (F)

PROBE	TOTAL TIME MIN:SEC	# OF OCCAS
1	16:40	5
2	8:15	1
3	10:15	1
4	13:50	2

THRESHOLD TEMPERATURE: 375 (F)

PROBE	TOTAL TIME MIN:SEC	# OF OCCAS
1	14:45	3
2	4:50	1
3	6:25	1
4	9:50	2

PEAK TEMPERATURE

PROBE	MAX. TEMP F	TIME REACHED MIN:SEC
1	460	22:50
2	395	23:20
3	401	23:40
4	419	23:30

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Experience includes seventeen years in the powder coating industry covering manufacturing, quality control, customer service, technical service and independent consulting services. Co-author of the "Users Guide To Powder Coating" and author of several articles published in Powder Coating Magazine and many papers and presentations presented through the Society of Manufacturing Engineers and the Powder Coating Institute. Also co-author of a new publication on powder coatings published by the Powder Coating Institute to be released shortly. Received a bachelors degree in mathematics from Washburn University. Presently the western area sales manager for the Industrial Coatings Division of The H.B. Fuller Company.

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Experience includes 10 years in the powder coating industry including system installations, system start-ups, equipment technical service, developmental testing of new products and independent technical support. Also managed equipment technical laboratories and conducted training seminars for operator and maintenance personnel. Performed independent long term equipment service contracts, technical support and trouble shooting. Developed operator and maintenance manuals and supporting documentation for ISO9000 certification. Presently the western field technical service representative for the H.B. Fuller Company.