WORLD ENVIRONMENT CENTER

ASSESSMENT OF PAINTING AND PRODUCTION OPERATIONS AT AUTOMOBILE DACIA SA PITESTI, ROMANIA

TRIP REPORT
MARCH 10-14, 1997

WORLD ENVIRONMENT CENTER
419 Park Avenue South
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New York, NY 10016

April 1997

TYPE PROJECT	Assessment
PROJECT	Reduce Energy Consumption and Pollution Emissions
COUNTRY	Romania
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DATES	March 10-14, 1997
FUNDING SOURCE	United States Agency for International Development
PARTICIPANTS	Dacia SA and WEC

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INTRODUCTION

INTRODUCTION

Dacia is the larger of the two car manufacturers in Romania producing 90,000 units/year The plant is presently operating at 50% capacity and produces 52% of the car components Sales are split with 65% going into the domestic market and the balance exported The company is presently 55% state-owned and has 27,500 employees

Dacia's representatives attended the joint WEC/PPC waste minimization workshop held in Bucharest on February 28 and 29, 1996 At that time, they expressed a strong interest in developing a Waste Minimization Demonstration Project (WMDP) at their plant In August, WEC's Mr Thomas McGrath and the PPC Director, Mr Vladimir Gheorghievici met with Dacia's management representative, Mr Ion Ciotei, and it was mutually agreed that WEC/PPC would provide

- A foundry expert to make an assessment of their foundry operations with approximately 400 workers

  Note This assessment was completed by WEC's Project Consultant, Mr Gary Wandtke, and the results summarized in WEC's Trip Report, December 10-13, 1996

- An automobile manufacturing expert to identify and develop a WMDP involving the entire manufacturing operations

  Note This activity is the subject of this trip report and details the results of WEC's Project Consultant's visit to Dacia

- Assistance in establishing a plant-wide waste minimization program

  Note This will be the subject of a future visit to Dacia's plant

EXECUTIVE

SUMMARY

EXECUTIVE SUMMARY

Dacia is definitely committed to establishing a Waste Minimization Program and have confirmed this by implementing WEC's proposals/suggestions made by WEC's foundry expert in last December's plant visit

During our discussions with the plant's operating personnel, it became apparent that a Waste Minimization Demonstration Project (WMDP) could be identified and developed in any one of the following departments with pollution problems Paint, Die Making, Press Plant, Assembly Plant and Machine/Tooling

After reviewing the various departments, WEC recommended that the WMDP be limited to the Paint Department because Phase I could be implemented immediately and with a low equipment investment The goal of the WMDP would be to reduce reworking costs in two phases as follows

Phase I Install an automatic temperature control on the air inlet heater in the paint spray booth Estimated Equipment Cost - $25,000

Phase II Utilize existing paint circulating systems to provide temperature control of paint Estimated Equipment Cost - $50,000

The cost savings would be achieved by a reduction of 25% in the required reworking of vehicles with rejected paintwork This would work out to an **estimated annual savings of $44,000**

The main reason for Dacia's costly paint work and pollution problem is due to the inability of the Romanian steel mills to provide automobile quality steel plate Therefore, to achieve the required paint finish necessitates extensive sanding and/or reworking by Dacia, increasing both production costs as well as the excessive pollution problem at the Paint Department Mentioned Dacia's steel plate problem with Sidex management who stated that they were well aware of the problem but that it will be corrected when their roller modernization project is completed early next year A project involving the new steel plate could demonstrate the maximum monetary and environmental benefits possible for a WMDP at Dacia

In discussions with the plant operating personnel we strongly recommended that no women of child bearing age be assigned to the painting booths due to the toxic fumes and the ineffectiveness of ordinary face masks

During our discussions, the possibility of establishing contact between Dacia and the "Big Three" U S car manufacturers to ascertain any possible interest in a working relationship was explored It was agreed that WEC would make contact with the U S automobile manufacturers on behalf of Dacia One of the contacted car manufacturers has expressed such an interest and WEC will follow up if and when mutual interest is generated

MONETARY

DETAILS

FOR

PROPOSED

WMDP

WASTE MINIMIZATION DEMONSTRATION PROJECT

Proposed Project	Reduce reworking of painted automobile bodies reduced by 25% by improving process control in two phases
Phase I	Install an automobile temperature control on the air inlet heaters in the paint spray booths Estimated cost $25,000
Phase II	Install a temperature control on the paint circulating system lines Estimated Cost $50,000

At the present time the plant is reworking approximately 20%, or 18,000 vehicles per year Reducing this total by 25% or 4,500 vehicles per year would contribute to an estimated cost savings of 9,000 lei per vehicle On an annual basis this totals 405,000,000 lei **Assuming Phase I to contribute only 1/3 of the total, or approximately $40,000 per year**

In addition to the monetary savings, the WMDP will also result in a noticeable reduction in toxic paint emissions, a safer work environment and lower clean-up/maintenance costs at the paint spray booths

ACTION REQUIRED

Dacia to

- Confirm cost details
- Determine reduction in pollution emissions
- Note, if applicable, other benefits to plant/personnel resulting from the WMDP

WEC to

- Visit Dacia to develop/confirm all WMDP details
- Assist management in establishing a plant-wide Waste Minimization Program

DACIA

MANAGEMENT'S

SUMMARY

OF

PLANT

VISIT

DACIA'S SUMMARY OF PLANT VISIT , MARCH 10-14, 1997

WEC/PPC TEAM

Mr Francis J Szyborski	Project Manager
Mr Vladimir Gheorghievici	Director PPC
Mr Nicholas Kachman	Project Consultant
Mr Donald G Hamaker	Project Consultant

DACIA TEAM

Mr Marian Diaconu	Deputy Human Resources Manager
Mrs Rica Cataranciuc	Head of Painting Technology Dept
Mr Florin Mazilu	Engineer
Mr Adrian Manda	Deputy Tehnical Manager
Mr Cristian Buzea	Chief SDV-DCV Design Dept
Mr Gheorghe Petrescu	Head of Audit Dept
Mr Ion Călugăru	Dept Chief
Miss Luiza Nițu	Chemical Engineer
Mr Cristian Deaconescu	Engineer
Mr Ion Aldea	Director
Mr Valeriu Dănăilă	Dept Chief
Mr Ion Ciotei	Head of Work Security Dept
Miss Cristina Onofre	Enviromental Office Chief

As a result of on-site visits to various plant manufacturing facilities and follow-up discussions with pertinent operating personnel,the following waste minimization projects were identified for consideration as a Waste Minimization Demonstration Project (WMDP)

Paint Area

1 Improve process controls in spray cabins involving
 -paint temperature control
 -cabin temperature control
  *seasonal
  *daily
  *hourly
2 Improve steel quality to automotive quality
3 Reduce press room/body shop damage to steel panels

4 Improve housekeeping
5 Improve application methods-improve efficiency of system

Production Area

1 Die making
 -eliminate use of epoxy molds
 -convert die cutting machine from mold follower type to computer disc brain
2 Press plant
 -install mechanical arms for the placing and removal of parts
3 Assembly plant
 -install a robot in the most wasteful assembly operation Dacia to identify operation
4 Machine Dept
 -identify new tooling to reduce waste and energy

To complete identification of the WMDP it was mutually agreed that Dacia would quantify the following
 *all costs related to project
 *reduce waste
 *energy conserved
 *raw materials saved
 *safety/health improvement
For required cost items see Attachment A

To expedite the WMDP, Dacia is requested to submit the required details by April 1st,1997

Upon receipt of the requested data and details,WEC will identify and recommend WMDP to Dacia for their approval

For Dacia	For WEC	For PPC
Mr ~~M Diaconu~~ Deputy HR Manager	Mr F J Szymborski Project Manager	Mr V Gheorghievici Director
Mr Adrian Manda Deputy Technical Manager		
Mr Ion Ciotei Work Security Manager		
Mr Gheorghe Petrescu Head of Audit Dept		

Requested Details

a) Paint Area

Required paint details
1996 Paint Purchases for 90,000 vehicles

Supplier/specific material	Quantity (liters)	Volume solid %	Annual lei value*
Phosphate			
Primer			
Base coat			
Clear coat			
PVC sealer			

*average lei/US $ value

b) Manufacturing Area

1 Die making
-select machine to be converted

2 Press plant
-select two adjoining presses to be equipped with mechanical devices

3 Assembly plant
-select assembly station/operation for installation of a robot

4 Tooling dept
-select tooling operation for demonstration of high tech tooling

RAPORT PRIVIND VIZITA LA S C AUTOMOBILE DACIA SA,10-14 MARTIE 1997

Echipa World Environmental Center (WEC)/Centrul de Prevenire a Poluării(CPP)

Dl Francis J Szyborski	Sef de proiect
Dl Vladimir Gheorghievici	Director CPP
Dl Nicholas Kachman	Expert
Dl Donald G Hamaker	Expert

Echipa S C Automobile Dacia SA

Dl Marian Diaconu	Director Adj Organizare
Dna Rica Cataranciuc	Sef Serviciu Tehnologii Vopsitorie
Dl Florin Mazilu	Inginer
Dl Adrian Manda	Director Adj Tehnic
Dl Cristian Buzea	Sef Departament Proiectare SDV-DCV
Dl Gheorghe Petrescu	Sef Departament Audit
Dl Ion Călugăru	Sef Secţie
Dra Luiza Niţu	Inginer Chimist
Dl Cristian Deaconescu	Inginer
Dl Ion Aldea	Director
Dl Valeriu Dănăilă	Sef Serviciu
Dl Ion Ciotei	Sef Departament Protecţia Muncii
Dra Cristina Onofre	Sef Colectiv Protecţia Mediului

Ca rezultat al vizitelor la zonele/punctele de lucru din diferitele secţii de producţie ale uzinei,precum şi a discuţiilor purtate cu personalul de conducere şi de execuţie reprezentativ,au fost identificate următoarele proiecte de minimizare a pierderilor care pot face obiectul unor proiecte demonstrative(Proiect Demonstrativ de Minimizare a Pierderilor,PDMP)

Sectia Vopsitorie

1 Imbunătăţirea controlului procesului în cabinele de vopsire implicînd
- controlul temperaturii vopselei
- controlul temperaturii în cabină
    - *sezonier
    - *zilnic
    - *orar

2 Imbunătăţirea calităţii tablei de oţel la nivelul calităţii pentru automobile
3 Reducerea defectelor la piesele de oţel în presaj şi caroserie

4 Imbunătăţirea şi menţinerea curăţeniei
5 Imbunătăţirea metodelor de lucru-îmbunătăţirea sistemului de lucru

<u>Secţiile de producţie</u>

1 Secţia Matriţe
- -eliminarea utilizării modele din răşini epoxidice
- -transformarea maşinilor de prelucrare din variantă "copiere cu palpator" în varianta cu comandă numerică cu PC

2 Secţia Presaj
- -instalarea unor braţe mecanice pentru introducere şi scoaterea pieselor

3 Secţia Montaj
- -instalarea unui robot în zona de pe linia de montaj care generează cele mai multe pierderi Dacia va identifica operaţia respectivă

4 Secţia Prelucrări Mecanice
- -identificarea unor scule noi pentru reducerea pierderilor şi energiei

Pentru a finaliza identificarea proiectelor demonstrative de minimizare a pierderilor (PDMP),s-a convenit de comun acord ca S C Automobile Dacia SA să cuantifice următoarele

*toate costurile aferente proiectelor
*reducerea deşeurilor
*economisirea energiei
*materii prime economisite
*îmbunătăţirea nivelului de protecţie/igienă a muncii

Pentru elementele de cost necesare a se vedea Anexa A

Pentru a se menţine ritmul de pregătire/aplicare a PDMP,se solicită ca Automobile Dacia SA să transmită detaliile necesare pînă la 1 Aprilie 1997

La primirea datelor şi detaliilor convenite,WEC va identifica şi recomanda proiecte demonstrative de minimizare a pierderilor pentru a fi analizate şi aprobate de conducerea S C Automobile Dacia SA

Pentru Dacia	Pentru WEC	Pentru PPC
Dl M Diaconu Director Adj Organizare	Dl F J Szymborski Director Proiect	Dl V Gheorghievici Director
Dl Adrian Manda Director Tehnic Adj		
Dl Ion Ciotei Sef Dept Protecţia Muncii		
Dl Gheorghe Petrescu Sef Dept Audit		

Detalii cerute

a) Secţia Vopsitorie

Detalii privind vopseaua
Cumpărări vopsea în 1996 pentru 90 000 vehicule

Furnizor/specificaţie material	Cantitate (litri)	Conţinutul de solid %	Valoare anuală (lei)*
Strat fosfat			
Vopsea intermediară (primară)			
Bază metalizată			
Lac			
PVC (etanşare)			

*valoare medie lei/US $

b) Secţiile de producţie

1 Matriţerie
-selectarea maşinilor care vor fi transformate

2 Presaj
-alegerea a 2 prese conjugate pentru a fi echipate cu echipamente mecanice

3 Montaj
-alegerea postului/operaţiei de asamblare pentru instalarea unui robot

4 Secţia prelucrări mecanice
-alegerea operaţiei pentru demonstrarea unei tehnologii de prelucrare avansată

PROJECT

CONSULTANT'S

REPORT

PRODUCTION

OPERATIONS

BY

NICHOLAS C KACHMAN

I Introduction

A visit to the Automobile Dacia S A plant in Colibasi, Romania (near Pitesti, north of Bucharest) was made the week of March 10 thru 14, 1997 The writer accompanied Mr Frank Szymborski of the World Environment Center in New York, as well as Mr Nicholas Kachman (retired Assistant Director, GM Environmental Activities Staff) In addition, Mr Vladimir Gheorghievic, Director, Pollution Prevention Center, Romania, performed very well as technical liaison, transporter and interpreter, throughout the entire week

My visit was initiated from an earlier visit by Mr Szymborski of WEC in December 1996 During this visit the personnel of Dacia requested that someone with paint experience visit them as soon as possible to review the painting operations at Dacia As detailed by Mr Szymborski, the purpose of my visit was to review the painting operations at Dacia, and to initiate dialogue with the technical painting staff to identify problem areas, or areas of opportunity to reduce wastes, minimize costs, improve quality, or to improve the painting operations at Dacia in any manner possible

The majority of my time was spent in the company of Mrs Rica Cataranciuc, Chief Technology, Paint She was very knowledgeable of the painting process and materials used at Dacia With her help, I was able to meet all the on-the-floor supervisory personnel, and gain a good idea of the technology and quality level of the Dacia painting operations I will comment on my initial impressions at a later point in this report We were able to identify their major concerns and problems, and to cooperatively develop a waste minimization project in the paint area This project is shown in appendix A (Summary of plant visit to Dacia, March 10-14, 1997) The personnel involved in the visit and at subsequent meetings are also shown in this same document, and therefore will not be listed here

II Executive Summary

The writer spent the majority of his time in touring and discussing the Dacia painting operations The plant painting personnel were available at all times and spent much time with the WEC team in identifying their major problems and concern areas I found all of the paint technical personnel very knowledgeable, energetic, and extremely helpful

The quality reports reviewed showed that the repair/rerun rate for bodies after paint was approximately 20 percent, or only about 80% first time quality (FTQ) rate The discussion of the causes for reruns led to extensive discussion of the root causes of the defects causing the reruns It was recommended that efforts be focused on increasing the FTQ rate, with a goal of 95% FTQ

Such a gain would impact greatly the overall economic picture for Dacia, with reduced costs, decreased material usage, reduced emissions, reduced waste products, and numerous other factors which all relate to the waste minimization projects being encouraged by WEC

The focus on root causes identified the following specific areas meriting attention

- Improving process controls
- Improving steel quality from the Steel mills
- Reducing Body Shop and Press Room damage to body panels
- Improving Housekeeping (reduce dirt rejects)
- Increasing technology in paint application methods (higher transfer efficiency)

As it is stated in the summary (Appendix A), the above objectives will comprise a paint project for consideration as a Waste Minimization project to be pursued by Dacia and WEC

The report will expand on each of these above subjects with pertinent discussion of each to explain the significance of each and the possible steps which can be taken to pursue those objectives

Also, references to similar operations in the United States, and well as recommended direction for improvements, will be made in later sections of this report

Requests from Dacia personnel for further information on methods of cost tracking of all paint materials used, high pressure water blasting for cleaning, and information on paint equipment were made, and information will be provided at a later date

III Waste Minimization Techniques

In the United States, as well as all other major automobile industries throughout the world, the need to show continuous and significant improvements in the painting operations have been driven by many factors Among these factors are

1 The need to reduce air and water pollution (meet ever more stringent environmental regulations)

2 Competitive Pressure
   - to be cost competitive
   - to improve quality (fits and finish)
   - to reduce and control material costs
   - to reduce waste and disposal costs
   - to reduce operating costs

The continuous improvement programs have been especially urgent and active during the past 20 years or so These activities have resulted in revolutionary changes in the coating materials, paint application technologies, pollution controls, pollution reductions and waste reductions, while at the same time meeting increasing quality and appearance expectations

While the need to focus on all of these factors is a necessity in any environment, it is especially accelerated under strong competitive situations In fact, the need for continuous improvement does become an on-going battle for survival The paint industry has been under special pressures, since it is one of the major air and water pollution sources in industry Within the Assembly plant, it is by far the most significant source of emissions

The implementation programs to reduce emissions, lower environmental pollution, improve quality, advance technology, lower costs, remain competitive, etc , are all intertwined

The successful implementation has resulted in beautiful, competitive, world class vehicles, which have established new standards of quality and appearance for the Automotive industry

While it has been proven to be a very difficult and time-consuming process, the ultimate result of the implementation of these improvements has been a very positive experience for the coating industry

The need to utilize all of the supplier capability (materials and equipment) has been especially important The development of lower VOC (volatile organic compounds) coatings, and completely new material technologies (such as waterborne and powder coatings) has necessitated strong "partnerships" with the coating manufacturers

The need to develop higher transfer efficiencies (TE) in the paint application processes have been especially focused upon by the paint equipment suppliers Their significant technological advances have resulted in great reductions in material usages and waste, and resultant reductions in environmental emissions

It is very important that paint engineers know what had transpired up to now, and thoroughly know what the "state of the art" is in every aspect of the coating process

Many times, less than revolutionary changes can be utilized to improve TE, reduce costs, and improve quality at minimal costs These are the types of changes which must be encouraged and discussed regularly to maintain a continuous improvement in your operations

Many times a new product design, or a new plant installation offer opportunities to incorporate the latest technology into an operation These opportunities are however infrequent, but must be seized whenever they arise This requires competent engineers, with knowledge of "State of the Art" coating materials and equipment and processes

The paint project, as proposed for Dacia, is not revolutionary, but is aimed at making changes which can actually be made More importantly, beginning an organized program will create awareness of the need for increased FTQ, and the need for waste minimization awareness in every part of the operation

IV Findings

With the capable help of the paint technical personnel, the writer toured the paint shop of the Automobile Dacia, near Pitesti Romania This tour and the resulting report was at the request of Automobile Dacia management, to have an experienced paint person review their paint operations The purpose of the visit was to develop a critique and comparison of their operations with similar operations in the United States, or elsewhere in the world, and most importantly to develop a project to aid Dacia in efforts to minimize waste and reduce costs

The following statements represent my initial comments after my tour(s) of the paint shops at Dacia The majority of the comments will relate to the new paint shop, since that was where I spent most of the time available Any following recommendations and conclusions will essentially apply to either or both paint shops (new or old)

Comments

1 The basic process through the paint shop is very similar to all paint shops, consisting of the following major steps

   - pretreatment (9 stage zinc phosphate unit)
   - electrophoretic primer (vertical dip) - bake
   - primer surfacer spray - bake
   - undercoat deadener and sealer - bake
   - topcoat spray application (Basecoat/clearcoat on metallics)
(monocoats on solid colors) - bake

2 The spray operations were essentially all manual spray (one exception was the bell station in the old paint shop where primer surfacer was sprayed)

3 The work force appeared to be hard working and attentive to doing a good job

4 The housekeeping in the paint shop was only marginal The large amounts of sawdust on the floor in the underbody PVC sealer area was alarming Numerous people during the day walk through this area, and undoubtedly carry dirt particles into the painting areas The charts for defects causing repaints showed dirt as one of the major problems This will be addressed later in the recommendations section

5 There seemed to be excessive sanding in certain areas, especially on the baked primer surfacer It was explained to me that their steel supplier cannot supply paintable quality steel, and they have no other source This opened a whole new area for discussion, and will be expanded upon in the recommendations section There seemed to be excessive body shop damage also This also will be addressed later, but it should be a problem Dacia can pursue on their own with minimum expense

6 There seemed to be excessive personnel working in the paint shop, based on the production rate (200/day), and this seems to be supported when I was told they have 380 direct labor personnel and 120 indirect This is understandable, for the labor rate is very low, especially when compared to the coating material costs I would not propose reducing the labor force at this time, but future consideration of higher technology application methods would inevitably lead to lower manpower requirements

7 Concentration on increasing FTQ (first time quality), and the concept of DIRTFT (do it right the first time) would reduce the need for extra personnel in many areas

8 The quality of the finished product appeared marginal to me, possibly due to the basic marginal steel quality, and excessive sanding of the primer The gloss and DOI (distinctness of image) should be brighter and more pleasing to the eye, in order to be considered world class Perhaps improvements in the steel quality, as well as improved process controls, to be discussed later, will allow significant appearance improvements

9 There were many cup guns in use in the color spray booths, especially on the metallic colors Cup guns are clumsy to use and make it difficult or impossible to obtain a world class finish in a production environment Later discussion and recommendations will be made to eliminate all cup guns in the spray booths

10 Process Control of every aspect of the painting process is absolutely necessary to obtain consistently high quality products It became obvious to me that the degree of process control on some of the most critical variables in a paint shop were non-existent Two of the most critical control variables are (1) Booth temperature and humidity, and , (2) Paint temperature and viscosity Neither of these are adequately under control at Dacia These will both be addressed in the following section, with recommendations These are also a key part of the Waste Minimization paint project between WEC and Dacia Improvements in these areas can produce untold benefits to the Dacia organization

11 Vehicle Coating Cost Tracking - in order to measure improvements in any aspect of the vehicle coating process it will be necessary to establish a very accurate cost picture of every material applied to the body I was not able to determine if such data was now available, but it will be part of my recommendations that such a system be established I will be providing examples to Dacia of such a costing system used in the United States Accurate costing on many other items such as waste disposal, energy costs, waste treatment, sludge disposal, etc , is also extremely important in making payback decisions on facility improvements

V Conclusions and Recommendations

The conclusions and recommendations are basically as outlined in the summary memo in Appendix A, and consist of, (1) Improve Process Controls, (2) Improve steel quality, (3)Reduce press room/body shop damage to panels, (4)Improve housekeeping, and (5)Consider high TE application equipment in selected areas Each of these will be discussed in more detail in the following paragraphs Following these detailed explanations will be listed other possible future projects for Dacia to consider

Improve Process Controls

The air being drawn into the spray booth passes through filters, and then through a bank of hot water heaters to raise the temperature of the air when necessary There is no automatic control to maintain the temperatures at a constant plus or minus 5 degrees Fahrenheit I was told the temperatures fluctuate greatly throughout the day Manual adjustment to the heaters is the only control they have at the present time This is not adequate to produce consistently good jobs What is needed here is a thermostatically controlled valve mechanism to maintain the temperature constant all day The flashoff rate of the paint and the ultimate appearance is temperature dependent

Likewise the humidity in the booth is important If the humidity is very low (below 50 percent R H) the paint will flash off faster and produce a dry-spray appearance While there are water spray nozzles in the air stream to add humidity when needed, there is no automatic control on it, and a manual adjustment is the only way to make a change There should be some type of automatic humidity control

Another area out of control is the paint temperature It was found that a very well equipped paint mix room was originally provided in the new plant I has not been put into use This equipment has extensive temperature control for the circulating paint I would recommend putting this facility into use, perhaps only 4 systems at first to see the advantages Other systems could them be brought on line

Improve Steel Quality

This is one of the biggest problems I observed at Dacia It is resulting in excessive sanding and inferior appearance of the finished jobs What is necessary here is to determine what specifications are necessary for steel panels for painted surfaces, and to specify that steel, and obtain that steel This has been found a necessity in every automobile producer in the world We will obtain copies of the steel specifications for the United States producers and pass on to Dacia as soon as possible I understand that Dacia does not have alternate steel sources right now, but this point must be made to the steel mill and to government officials in order to break this barrier to better products This should be one of Dacia's priority projects at the present time

Reduce Press Room/Body Shop Damage to Panels

This problem is an in-house problem for Dacia It may be related to the previous problem of questionable steel quality Is must be pursued by Dacia to determine how the in-house damages can be addressed Improvements in this area will show up in reduction of the amount of labor in the paint shop and will lead toward improved appearance in the completed vehicle

Improved Housekeeping

This aspect of the plant operation is extremely important in the paint shop Most of the newer paint shops are treated as "clean rooms", with special lint free uniforms for the spraymen and all persons within the clean room To enter the clean room, the people enter through a double door air lock where any dirt or lint is blown off their special uniforms

It is realized Dacia has not progressed to that state, but they can be made aware of basic dirt avoidance steps

The use of sawdust on the floor near the paint area is one example of a dirt source Cardboard in the paint area should be avoided, since it is a major source of fibers

Spray booth cleaning is another area of dirt control High pressure water blasting equipment was discussed, and information will be forwarded to Dacia as soon as possible High Temperature "Blue Surf" ovens to burn paint buildup off grates was also discussed Information will also be forwarded on this type of equipment

Consider High TE Application Equipment in selected areas

Moving towards higher transfer efficiency in the application of the coatings has been found absolutely necessary to meet all of the objectives of lower emissions, lower material costs, less pollution, less overspray and cleanup and other environmentally related factors The quality level is also raised as automation replaces manual spray operations

It is recommended that Dacia consider a specific area to begin a program of increasing the application technology Technologies such as electrostatics, bell stations, robots, fixed electrostatics, automatic spray machines, HVLP (high volume, low pressure) are some of the technologies which could be considered in different areas

Miscellaneous Recommendations

Many other miscellaneous recommendations have been brought up in the course of the tours, and they can be followed further in future visits Examples of these are removing the cup guns, developing specific cost tracking, using paint suppliers to a much greater degree, use of high pressure water blasting for booth cleaning, Block painting (same color for an hour or other time frame)

In general I believe Dacia has potential for great improvements in their paint operations Many difficulties exist which hamper their ability to do all they would want to do However they must remain positive in their thinking, determine how to do the job right, then persist until it is accomplished!

General Comment

Due to the potential of certain solvents, the health and safety regulations in the United States ban women of child bearing age from working in a spray booth Dacia Health and Safety personnel can follow up on this and take appropriate action

VI Cost and Payback Information

The cost chart in the Appendix, provided by Dacia, shows a total of 17,611,506,000 lei spent in 1996 for coating materials (excluding PVC sealer and phosphate materials)

These costs indicate that a 10 to 15% reduction in material costs through increased FTQ and more efficient application methods could result in 1 76 to 2 6 billion lei savings

This certainly seems to be a reasonable goal for a Phase I program to improve FTQ and increase transfer efficiency It is estimated that most of the manual spray operations are operating in the 20% spray transfer efficiency range

The potential spray efficiency with state of the art application equipment can perform in the 50 to 65% range

The costs for a Phase I program could be determined only after further discussion of the scope of such a program It would be advisable to get an international paint equipment supplier involved to aid in the planning and cost estimating process

VII Implementation Plan and Schedule

Our next visit will be made after Dacia has had time to review these recommendations A more specific and detailed schedule can be made at that time to begin programs to improve FTQ and begin to introduce "state of the air" application equipment

PAINTING

OPERATIONS

EXHIBITS

Paint Quantities in 1996 for 90,000 Automobiles

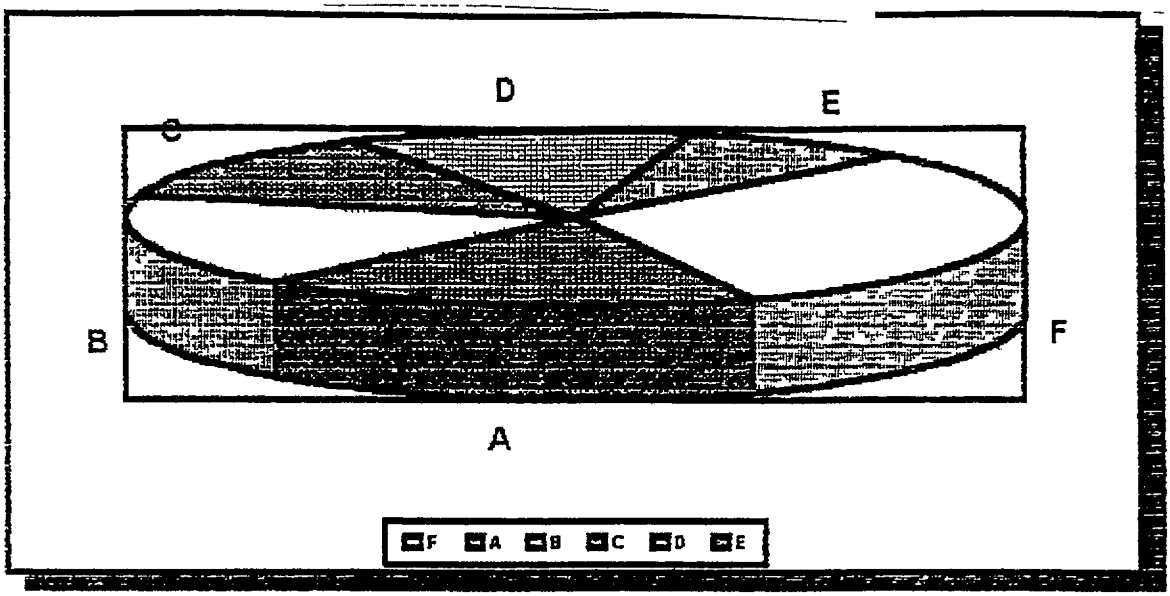
Product	Supplier	Quantity kg	Solid containment %	Yearly value Lei
Phosphating range	Parker	159,570	-	933,498 000
Intermediary (basic) paint	Policolor	324,000	50 - 60	3,185,892.000
Metalized ground	Policolor	360,000	27 - 30	8,072,280,000
Varnish	Policolor	369,000	45 - 50	5,350,500,000
Polyvinylchloride (PVC) - sealing	Flexiplast	1,383,750	> 95	6,848,916,750
Opaque enamel	Policolor	126,000	min. 40	1,002,834,000

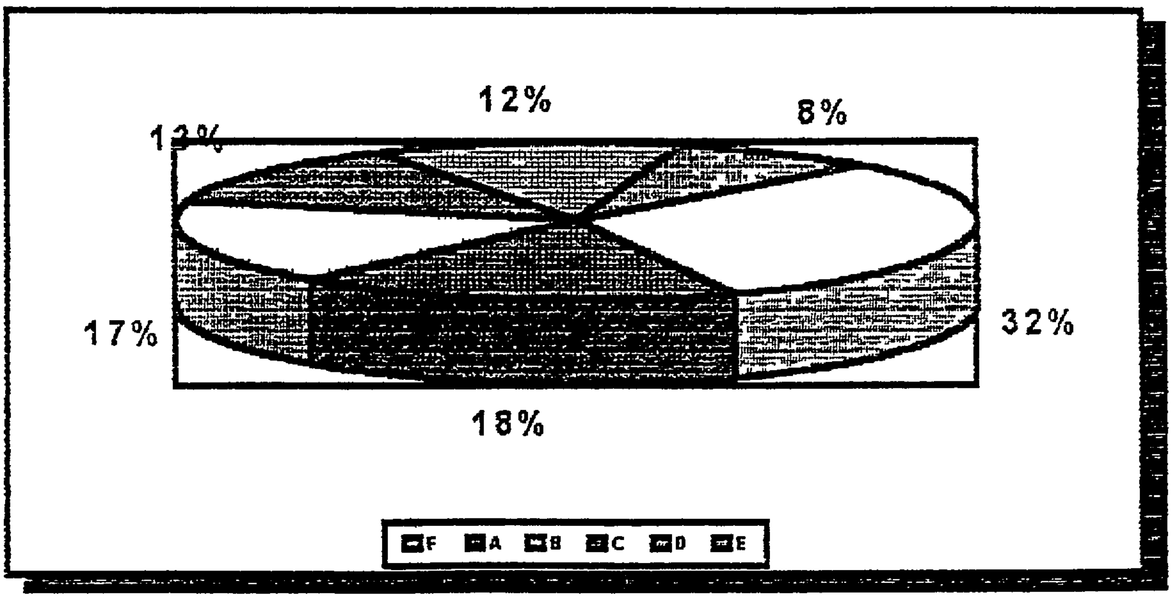
Value of Lei in 1996

	JAN	FEB	MAR	APR	MAI	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
ONTHLY	2594 5	2773 4	2872 0	2911 0	2930 4	2988 0	3064 5	3143 9	3202 0	3295 7	3478 2	3712 6
ARTERLY	2746 6			2943 13			3136 8			3495 51		
HALF EARLY	2844 88						3316 15					
EARLY	3080 51											

NOTE. This values represent LEI / 1 US$

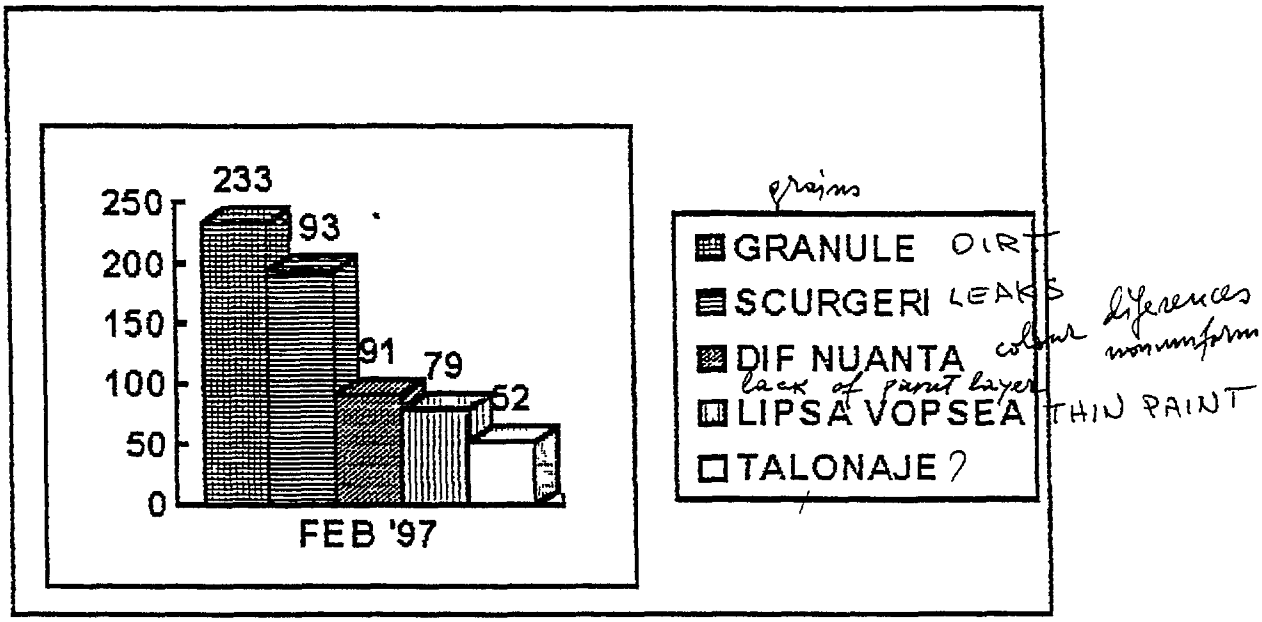
DEFECTS ANALYSIS - 1996

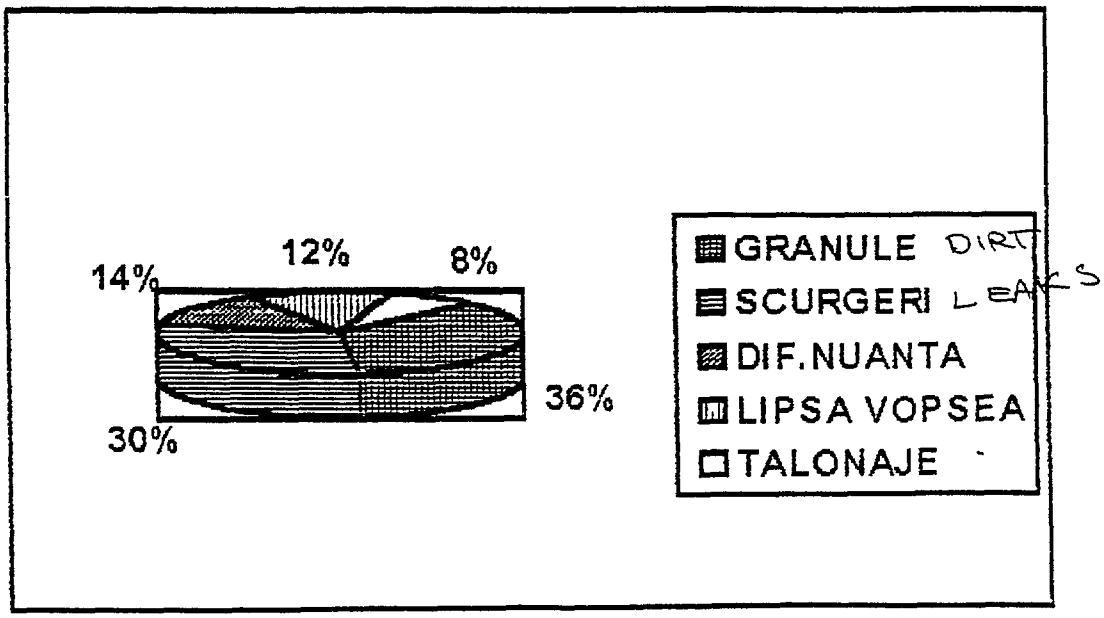




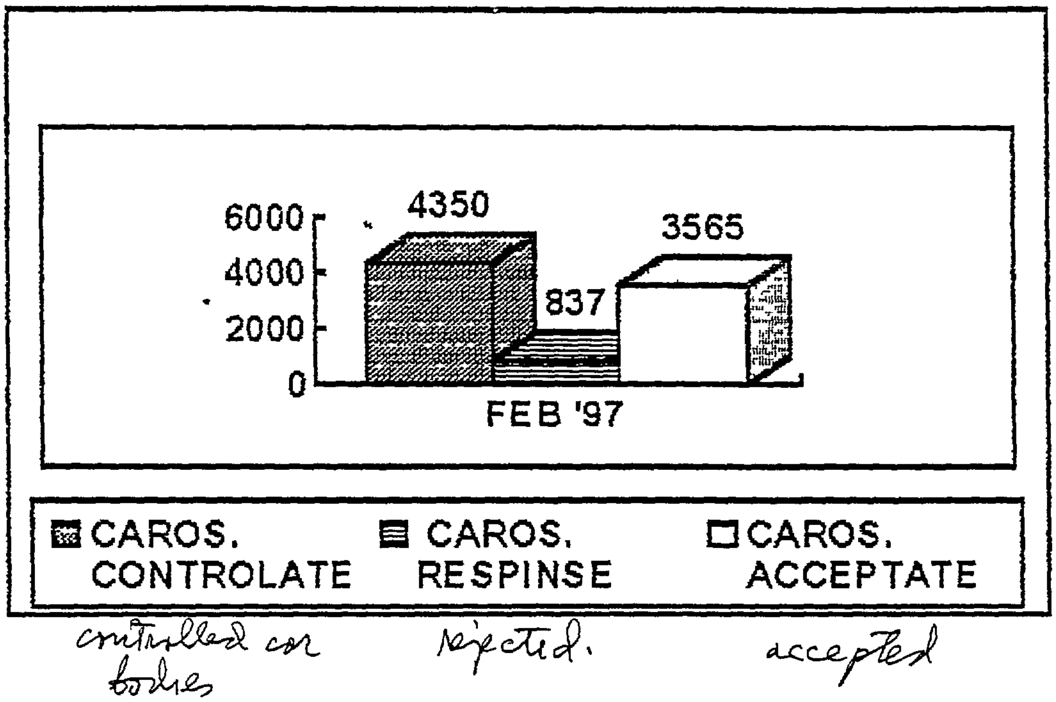
A	SCURGERI DE VOPSEA leaks	1786
B	grains? GRANULE dirt	1700
C	INTEPATURI pinholes	1257
D	PETE SUB VOPSEA shadows under paint	1230
E	without paint LIPSA DE VOPSEA thin paint	812
F	ALTE DEFECTE others	3078

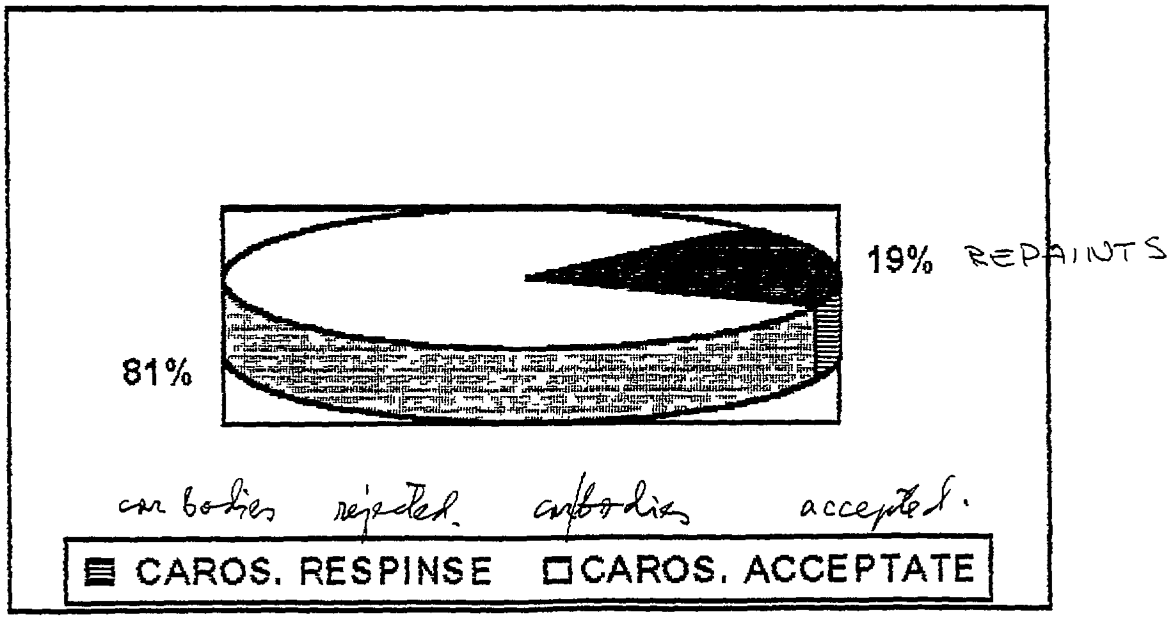
TOP FIVE DEFECTS - FEBRUARY 1997





RATIO OF ACCEPTED/REJECTED CARS - FEBRUARY 1997





PROJECT

CONSULTANT'S

REPORT

PRODUCTION

OPERATIONS

BY

NICHOLAS C KACHMAN

Purpose of Trip

For this consultant to generate and develop the consideration of environmental thinking (saving energy and reducing the use of resources) in the design, fabrication and assembly of Dacia vehicles Through the use of key demonstration projects prove that thinking of energy and waste reductions in and on the factory floor is good business

Since the moneys available for demonstration projects are limited and to get the most "bang for the buck", each project proposed is keyed to technology that would be common to a large number of other production areas In this way the energy and resources saved would be multiplied many times over

The Dacia plant is most unusual from U S plants in that labor savings is not nearly as important as reduction in energy usage and material resources which are so expensive for them Because of their special circumstances in these matters, imposing environmental criteria into their consideration of production methods is a task they easily embrace

The projects proposed for die making, assembly, press, and machinery were selected to address the major concerns of each Dacia department head and for this reason, some moneys should be provided to each to stimulate them into action

General Overview and Observation

We were well received, key management and department heads were interested and available, found to be very open, honest and straight-forward, well informed and realistic about their opportunities, hands on people with good knowledge of critical issues and high priority projects needed Excellent attitudes and well educated

The employees at Dacia are their greatest asset and resource Good appearing and the hardest working that I have ever witnessed The work discipline is to be admired

The manufacturing facilities buildings were large, modern, spacing of equipment good, generally high ceilings with acceptable environmental conditions in the assembly plant No structural or building safety problems noted Buildings compare to those built in the U S thirty years ago and in use today

Areas of Concern

Dacia lacks detail cost data on individual manufacturing processes But a note of caution they still have a great sense of what is needed as a first step to save energy and resources so essential cost data must be available, somewhere

What is missing may be the accumulation of costs when a part is scrapped and/or requires rework For instances, often a part has been poured, deburred, cut to length, transported from one area to another then it is scrapped, for instance, because of a poor turning or boring tool The cost savings, if a better tool was perfected, is the total of all the work and energy and resources that went into it from start to point of scrap This information I'm sure they do not have and the projects proposed forces them to collect these costs and justify the project Hopefully, their discoveries of the great cost savings involved will make this procedure a natural part of their thinking as a good business practice

- Romania lacks a large number of suppliers With many vendors Dacia would be able to force competition to fight for their business which reduces material costs, improves the quality of materials provided and provides a source of technical information not now available to them The most critical example of their need for additional suppliers is the poor quality they now receive in surface sheet-metal for their vehicles from a sole source To improve their marketing of vehicles outside the country, improvement in the fit and finish of the appearance of their product is paramount But that can only start with better quality metal WEC will attempt to make contacts to get at this issue

- Easy access to the latest tooling and assembly technologies was requested by Dacia department heads This is a critical need in their effort to save resources The following ideas are suggested for WEC and Dacia's consideration

Suggestion 1

Key personnel from tooling and assembly should be permitted to travel and attend the next international manufacturing/tooling convention in Europe or the U S At these shows, Dacia representatives would have the opportunity to meet and discuss production problems with the best suppliers of tooling in the world Also, they would build a relationship with key suppliers of a long-term nature They would pick the brains of vendors, obtain the latest technical catalogs and possibly bring samples back of tooling for them to copy

Suggestion 2

While attending the tooling show I am sure arrangements could be made for them to visit and see first hand what the competition is doing If they came to America for the fall tooling show, I could arrange for them to tour several assembly plants, and visit tooling supplier's facilities where the latest technologies are being developed and tested

Special notes Dacia engineers have had to be most creative and inventive Once they see and experience a new technology, they modify and adopt it to their situation in a most innovative way Several examples of their creative nature were viewed in assembly and die-making operations Again, for this reason, I suggest that all the projects be given some moneys to force environmental thinking and to encourage the expansion of technologies across all areas of production

In the U S , auto companies use suppliers to solve problems and improve the use of resources, a free engineering service The association between the company and vendor is considered a joint venture for the success of both Not having this opportunity places Dacia at a disadvantage with world-wide competition

At the same time, the company policy must be very clear as to improper relationships leading to kick-backs, free lunches, and gifts from vendors that harm the company These crimes occur at the highest and lowest levels of management

Potential In-Plant Environmental Problems

Women of childbearing age should not be working in areas where exposure to hazardous chemicals occur With my report, I have included the U S Industrial Hygiene Standards for worker exposure to chemicals With this report and the knowledge that women of child-bearing age are not allowed to work in core-making, paint spraying, body soldering and brazing and certain pre-painting and sanding operations in the U S , my hope is that Dacia will start a program to review and correct any hazardous exposure that may exist in their facilities

I have also attached two books or design manuals on the proper installation of ventilation systems in these hazardous areas along with many others for their use

Forwarded to Dacia SA under separate cover

Waste Minimization Demonstration projects

Project I **Scope (Die Making Department)** Eliminate the need for the manufacturing of epoxy models of new car parts used as a pattern or guide in the machining of dies to make the part

Waste and energy savings

Epoxy resins are hazardous to the environment and worker, besides being an expensive resource The energy used to make the resins, to make the wooden models, and the epoxy molds would be saved The engineering talent and the skills of the model makers could be better utilized elsewhere Also, half of the machining table and weight is eliminated The cutting of the die is done with greater accuracy and faster using less energy

How accomplished

The die cutting machine will be modified to accept a computerized generated disc containing the shape of the car part and fabrication lines for the milling of the die without any epoxy molds being required

Savings to be provided by Dacia

- Epoxy material for typical mold/machine
- Epoxy material for typical molds per year
- Energy saved first year, one machine
- Energy saved first year, X machines

Potential savings in dies to be modified because of a change in design or to correct a production problem So much easier via this new technique over present methods

Project Cost

- Cost to buy electronics for one machine (all mechanical and other electrical items to be provided by Dacia)
- Cost for 4 machines

Project II **Scope (Press Department)** Eliminate the need for the manual placement of parts into and out of a stamping press and the scrap caused by the improper location of the metal in the press Also, save the bodily injuries that are occurring on a regular basis This takes precedent over all other energy and material savings

Waste and energy savings

For this demonstration project the press operation requiring the placement and handling of the largest and heaviest sheet-metal will be selected It is in these situations that the most scrap is made and the greatest saving in metal and energy resources will be realized over the year

How accomplished

Mechanical arms or a robot will be installed between the presses to insert, remove and insert the stamping into the next press Catalogs have been forwarded for their information The accuracy and repeatability of these devices will be clearly demonstrated

Savings to be provided by Dacia

After selecting the presses for this demonstration project, Dacia will estimate the energy to roll the steel, transport it through the system, stamp it to the point of scraping along with the number of times this occurs at this press location

Moneys required to purchase a minimal number of parts for the automatic handling system will be provided to WEC

Project III **Scope(Assembly Plant)** Install a demonstration project in the use of a robot assembler at an assembly operation now causing much scrap, poor quality, many repairs, etc Again, this is expected to be a real learning tool for their expansion plant-wide with great energy and resource savings

Waste and energy savings

The cost of materials, energy and other resources that went into the making of the sub-assemblies involved in the operation selected will be accumulated whenever the completed assembly has to be redone, scrapped or repaired So much goes into preparing parts before it reaches the assembly operation that the costs of preparation are easily overlooked and not considered This projects second goal is to teach the discipline of considering these costs as vital resources lost

Savings

Dacia to provide savings and cost to purchase such equipment Catalogs have been forwarded for their information

Project IV **Scope (Manufacturing/Tooling Department)** to reduce scrap and eliminate waste of all the energy and materials it takes to cast and form parts that are later destroyed because of bad cutting tools

Waste and Energy Savings

This project would involve the selection of one machining operation with the worst tooling history and develop a new cutting method or purchase a better tool that has endurance, greatly enhances machine performance resulting in large material, energy and resource savings I witnessed a cutting of a casing for the separation of one casing into two parts that resulted in scrap all too frequently New double-sided, even three-sided, trigon coated steel tool bits, cooled by jet stream would make this operation look like cutting cake at party Scrap would be essentially eliminated and the surface finish would be 'A' class

The latest tooling catalogs of most typical cutting operations have previously been forwarded

Savings & Costs of Project

Dacia to select key operation and provide saving and cost data

Again, a review of these demonstration projects will show that the technologies demonstrated will apply to many other sources beyond those chosen

Other Areas for Waste and Energy Savings

1 Outside door air curtains composed of a large fan and motor supplying air through slots on each side of the door should be removed They can not counter mother nature blowing cold air into the building She has an unlimited supply of cold air and a much greater force

A partial solution would be to supply heated air inside the plant to the sides of the door once the door is closed to reheat the work space

But the only real solution that saves all this energy and effort is to install a vestibule attached to the door on the outside of the building A fork-lift truck coming from the outside would enter this chamber and have the door close behind and after it was closed the door to the plant would open No air, no heat, no problem of maintenance, fool proof

2 Smoke from the exhaust pipes in the final test run of the new cars was a problem given to me The plant area had floor exhaust grills for the removal of fumes at floor level Also, exhaust fans were noted above All this effort and yet the air in the breathing zone of the worker was filled with blue smoke This problem was common in the U S and a source of union complaints

We discovered that the grills in the floor got all the air it needs from open doors and in air flows no higher than 2" or 3" off the floor The upper exhaust fans also could not reach down to the six foot breathing level of the plant The use of smoke sticks is recommended to test for air flows and to watch the failure of mechanical air streams to do their attended job

To solve this final assembly line problem two things should be done (Design books have been provided for their use)

A In the roll-test areas, rubber hoses should be attached to the car's exhaust pipe and the fumes exhausted through a fan and duct system capable of matching the output of the vehicle and exhausted outside the plant These systems are very common and in use around the world

B At the assembly point where the vehicles are first started, exhaust ducts should be mounted on the floor about 2 feet high to catch the smoke from the exhaust pipe and from the burning oil off pipes and engine These ducts on the floor should be reasonably long, say 50 feet to 75 feet to catch the worst burn-off

Any supply air should be discharged across this assembly area from the 10 foot level down to the 6 foot breathing zone

Note You can not suck air from any distance and only push it slightly more But, exhausting from a point and pushing air to that point gets air moving where you want it and it works

The design manuals provided will be a great use to Dacia personnel to solve other ventilation problems, particularly in the foundry which I did not see but I am sure could use improved hooding and exhausting techniques The energy savings at other existing systems could be substantial

3 Lighting in the production and assembly areas is satisfactory but not very efficient Much of the electrical energy going into lighting is lost because of the lack of reflectors behind the fluorescent lamps to direct the light to the working zone

It is estimated that as much as 50% to 70% of the light is lost Reflectors have been developed to reflect as much as 95% of the light back down to the working zone

The contour of the reflectors and its surface finish is most important I am sure if they had a few samples of typical reflectors available today (cost $100 to $200) they would make their own The savings would be turning off half the lights and having the same or better lighting for the worker or keeping all the lights but greatly improving worker vision and product quality in the final process area and inspection of parts

Things I did not do

1. No mass balance was made of their water supply to all production sources This evaluation can discover large waste in the use of water, the potential use of water from one source that leave the water clean enough for another (back or counter-flow systems) and reduce waste water flows and resulting waste treatment plant cost in energy and chemicals

2. A close inspection of plant make-up air units was not conducted One unit visited indicated that the discharge temperature to a critical spray booth was made by a man turning a hot water valve off or on Thermostats controlling modulating hot water valves would save energy and provide better work conditions The plant must have hundreds of ventilation/heating units with potential savings in the millions

PRODUCTION

OPERATIONS

EXHIBITS

GM ASSEMBLY DIVISION
GENERAL MOTORS CORPORATION
ANALYSIS OF PAINT MATERIAL USAGE AND COST PER EQUIVALENT CAR

PLANT COMPARATIVE MONTH BUDGET Y.T.D. THRU 12-31-76

Line No		ARL Plant YTD Per Car	BAL Plant YTD Per Car	DOR Plant YTD Per Car	FAIR Plant YTD Per Car	FRAM Plant YTD Per Car	FRE Plant YTD Per Car	JANS. Plant YTD Per Car
	MATERIAL USAGE PER CAR							
1	Paint, Surface Ac ylic Lacquer (gal)	2 10	2 30	2 03	1 97	2 23	2 03	2 66
2	Ac ylic L cquer Mixing Thinner (gal)	2 67	3 09	2 16	2 47	2 36	2 89	3 32
3	Se ler S rf ce Bond for Acrylic La quer (gal)	92	42	25	57	19	21	31
4	Bonde t Body (lb)	1 28	1 33	1 56	1 54	1 19	1 62	1 74
5	Bonderite-Chassis (lb)	52	1 43	1 03	84	42	75	71
6	Fl h P m (gal)		77	38	72			
7	Pr me & Gl (gal)	1 96	1 99	2 01	1 46	1 84	2 35	1 83
8	Black D p Pr me (gal)	32	24	27	52	36	64	12
9	D p Pr me Reducer (gal)	23	26	23				47
10	Chass Bla k (gal)	03			01			01
11	P ly th P t (g l)	03	09	04			03	
12	P t l t & Whe l (l l T t & V yl P) (g l)	16	21	24	22	24	27	21
13	Th e l te & Wh l P t (g l)	12	16	24	12	12	05	03
14	A t R st Comp d FS 1128 (g l)	23	16	11	19	11	08	13
	COST PER CAR							
15	P t Surfac A yl L q er	15 37	16 95	15 31	14 25	16 02	15 75	19 84
16	A yl L que M g Th	5 58	6 04	3 99	4 44	4 49	6 73	4 69
17	Seale S rface Bo d for Ac yl c L q er	3 42	1 35	1 08	2 12	97	80	1 07
18	Bond te Body	40	35	52	45	37	47	47
19	Bond te-Chass	17	11	33	24	13	24	17
20	Fl h P m		2 70	1 82	2 58			
21	Pr me & Gl	8 79	8 99	9 11	5 90	10 13	11 39	8 70
22	Bl k D p Pr me	1 27	1 01	1 06	1 86	1 63	1 95	50
23	D p Pr me R d c	16	34	16				89
24	Ch ss s Black	03			01			02
25	P ly e h P	54	1 01	61			40	01
26	Pa l t & Wh el (l l T & V yl Pa s)	98	1 11	1 40	1 33	1 43	1 51	89
27	Th l te & Wheel P	19	28	37	28	23	09	12
28	Oth P M l	26		01		16		
29	A R C mp d FS 1128	1 65	44	28	49	31	23	34
30	T t l Cost Pe Car	38 81	40 68	36 05	33 95	35 87	39 56	37 71
	R k g	13	16	5	3	4	5	10
31	U ts P od d	83 933	90,559	89845	83 429	42119	68 474	90 792
	Mem Elp C t	6 45			1 09	5 05	2 15	3 31

Line No		LAKE Plant YTD Per Car	LEEDS Plant YTD Per Car	LIND Plant YTD Per Car	LO Plant YTD Per Car	NOR Plant YTD Per Car	S L Plant YTD Per Car	S.G. Plant YTD Per Car	TARR Plant YTD Per Car	V.N. Plant YTD Per Car	W R Plant YTD Per Car	WILM. Plant YTD Per Car
	MATERIAL USAGE PER CAR											
1	Paint, Surface Ac ylic Lacquer (gal)	2 43	2 61	2 32	1 90	2 30	2 76	3 37	2 55	3 21	2 47	3 03
2	Ac ylic L cquer Mixing Thinner (gal)	3 24	1 40	2 59	1 44	2 38	2 81	37	1 96	07	2 90	1 30
3	Se ler S rf ce Bond for Acrylic La quer (gal)	24		21	03	28	08	02	29	04	47	29
4	Bonde t Body (lb)	1 53	1 46	1 07	2 03	1 66	1 55	2 05	1 86	1 44	1 18	2 06
5	Bonderite-Chassis (lb)	80	57	87	41	1 23	80	69	63	49	1 24	70
6	Fl h P m (gal)	34					52				47	83
7	Pr me & Gl (gal)	1 59	2 27	2 10	1 98	2 52	1 70	2 84	1 49	1 29	2 21	1 82
8	Black D p Pr me (gal)	31	09	45	11	10	24	14	51	23		14
9	D p Pr me Reducer (gal)	49			11		49			17		07
10	Chass Bla k (gal)			03			01		01			
11	P ly th P t (g l)		02									
12	P t l t & Whe l (l l T t & V yl P) (g l)	15	20	11	23	15	28	22	27	19	18	27
13	Th e l te & Wh l P t (g l)	11	02	16	15	22	28	01	10	10		10
14	A t R st Comp d FS 1128 (g l)	07	14	09	06	14	09	18	09	07	07	15
	COST PER CAR											
15	P t Surfac A yl L q er	18 10	21 23	16 82	16 58	17 23	19 65	24 68	21 44	22 43	19 72	26 18
16	A yl L que M g Th	6 10	2 27	5 36	2 86	4 40	5 15	81	4 15	15	5 09	2 58
17	Seale S rface Bo d for Ac yl c L q er	1 08	01	66	15	1 19	39	22	94	27	1 41	99
18	Bond te Body	43	41	34	57	46	44	64	51	41	32	57
19	Bond te-Chass	19	20	28	11	34	23	22	17	14	34	1 [illegible]
20	Fl h P m	1 64					1 73				1 51	2 [illegible]
21	Pr me & Gl	6 84	10 51	9 60	8 27	10 04	6 72	13 01	8 20	6 33	9 03	8 3[illegible]
22	Bl k D p Pr me	1 27	41	1 86	44	37	97	81	1 98	93		6[illegible]
23	D p Pr me R d c	34			10		30			17		[illegible]
24	Ch ss s Black			07			05					
25	P ly e h P		35			01						
26	Pa l t & Wh el (l l T & V yl Pa s)	1 01	1 10	83	1 54	93	1 40	99	1 58	1 24	1 07	1 76
27	Th l te & Wheel P	21	05	21	25	39	51	02	19	20	01	15
28	Oth P M l	01	02	02		40	01		01		03	03
29	A R C mp d FS 1128	17	39	23	17	30	24	49	24	20	18	42
30	T t l Cost Pe Car	37 39	36 95	36 28	31 04	36 06	37 79	41 89	39 41	32 47	38 71	44 82
	R k g	9	8	7	1	6	11	17	14	2	12	18
31	U ts P od d	61 502	84 578	77 355	42 945	74 064	38 294	31,418	64 393	91,474	90 713	38 704
	Mem Elp C t		5 23	5 45	3 03	3 75		01		(89)		

GM ASSEMBLY DIVISION
GENERAL MOTORS CORPORATION
ANALYSIS OF PAINT MATERIAL USAGE AND COST PER EQUIVALENT CAR

PLANT COMPARATIVE MONTH DECEMBER 1976

Line No			JANS. T Plant Month Per Car	BAL-T Plant Month Per Car	PRE-T Plant Month Per Car	LAKE. T. Plant Month Per Car	LO. T Plant Month Per Car	S L -T Plant Month Per Car
	MATERIAL USAGE PER CAR							
1	P i t, Surf Ac yll L quer	(gal)	2 05	2 52	3 08	2 33	2 82	2 73
2	Acrylic Locq er M xi g Thinne s	(gal)	58	76	6	1 29	1 36	81
3	Se ler S f e Bond for Ac ylic Locquer	(gal)						
4	Bond r te Body	(lb)						
5	Bond t -Ch s	(lb)	3 18	2 00	2 56	3 18	2 24	2 77
6	Fi h P m	(gal)						
7	Pr me & Gla e	(gal)	1 08	1 32	1 09	99	1 55	1 03
8	Bl k D p Pr me	(gal)	52	34	1 39	44	19	41
9	D p Pr me R d c	(g l)	38	38		57	11	67
10	Ch s Bl k	(gal)	06	97	11	15		01
11	P ly h P	(g l)						
12	P l & Wh l l l T & V yl P)	g l)	13	09		07	09	04
13	Th l l & Wh l P	g l)	03	04			03	
14	A t R t C mp d FS 1128	g l)	13	14	11	01	07	09
	COST PER CAR							
15	P t Surf A yl Lo q e		14 98	20 18	23 17	16 48	20 73	19 62
16	A yl L q M g Th		59	1 02	1 93	86	1 71	88
1	S l S f Bo d f A yl L q er							
18	B d t Bo y							
19	Bo d t Cha		86	53	75	76	59	95
20	F h P m							
1	P m & Gl		[illegible] 81	5 98	5 07	4 92	7 11	4 93
2	Bl k D p Pr m		84	1 47	4 52	1 83	77	1 66
	D p P m R d		28	50		39	10	4"
4	Ch Bl k		14	04	07	05		06
5	P y h P							
26	P l & Wh l l l T & V yl P		74	55	04	52	93	11
27	Th l & Wh l P		02	06			04	
28	O h P M l						21	13
29	A R C mp d FS 1128		37	41	31	02	17	24
30	T t l Cost P C		24 63	30 74	35 86	25 83	32 36	29 00
	R k g		1	4	6	2	5	3
31	U P d d		7 311	6 832	10,4?7	7 424	11,673	9 635
	m Elp C		6 66		3		5 70	

BUDGET YEAR TO DATE THRU 12 31 76

Line No	BAL T Plant Y T D Per Car	PRE-T Plant Y T D Per Car	JANS.-T Plant Y T D Per Car	LAKE. T. Plant Y T D Per Car	LO. T Plant Y T D Per Car	S L -T Plant Y T D Per Car
1	2 52	3 15	1 90	2.41	2 82	2 68
2	76	93	59	1 25	1 18	86
3						
4						
5	2 00	2 90	3 12	3 10	2 3?	2 37
6						
7	1 32	92	1 06	1 07	1 4	1 06
8	34	1 32	51	38	1	42
9	38		38	70	1/	86
10	07	09	07	17		01
11						
12	09		13	07	11	02
13	04		03		04	
14	14	11	12	02	07	09
15	20 18	23 28	14 67	16 80	20 67	18 95
16	1 02	1 86	59	83	1 54	94
17						
18						
19	53	88	81	72	60	80
20						
21	5 98	4 1.	4 77	5 32	6 70	5 08
22	1 47	4 09	1 83	1 53	67	1 66
23	50		29	42	14	54
24	04	05	18	06		05
25						
26	55	03	74	51	1 19	11
27	06		02		05	
28					25	10
29	41	33	31	06	18	23
30	30 74	34 63	24 21	26 25	31 99	8 46
Ranking	4	6	1	2	5	3
31	32 890	47,561	33 209	35 853	51,952	46 145
		3 7	6 67		5 13	

S L -C Plant Month Per Car	S L C Plant Y T D Per Car
1 78	1 7
2 01	1 6'
11	09
10 71	11
1 24	1 4
33	3
55	6
01	01
15	1
41	(
41	
13 03	
3 77	3 u
52	39
2 66	2 7
6 50	7
1 36	1 3
35	
06	0
2 65	8
3 28	3 3
76	
22	2
35 16	35 0?
3 335	15 270

GM ASSEMBLY DIVISION

GENERAL MOTORS CORPORATION

ANALYSIS OF PAINT MATERIAL USAGE AND COST PER EQUIVALENT CAR

PLANT COMPARATIVE MONTH DECEMBER 1976

Line No		Unit	ARL Plant Month Per Car	BAL. Plant Month Per Car	DOR Plant Month Per Car	FAIR Plant Month Per Car	FRAM Plant Month Per Car	FRE Plant Month Per Car	JANS. Plant Month Per Car	LAKE. Plant Month Per Car	LEEDS Plant Month Per Car	LIND Plant Month Per Car
	MATERIAL USAGE PER CAR											
1	Paint, Surface Acrylic Lacquer	(gal)	2 02	2 30	2 07	2 05	2 54	2 07	2 70	2 43	2 59	2 33
2	Ac yli Lacq er Mixing Thinners	(gal)	2 59	3 09	2 11	2 46	2 53	2 67	3 21	2 68	1 52	2 60
3	Sealer, S rface Bond for Acrylic L cq e	(gal)	90	42	24	59	21	17	26	21		19
4	Bonderite Body	(lb)	1 73	1 33	1 58	1 47	1 24	1 36	1 60	1 45	1 38	1 05
5	Bo der te-Chass s	(lb)	50	43	73	80	44	64	65	78	47	81
6	F P m	(gal)		77	37	72				33		
7	Pr me & Gl z	(gal)	1 73	1 99	1 89	1 39	1 74	2 54	76	1 43	2 38	2 13
8	Bl k D p Pr me	(gal)	35	24	24	42	36	69	13	36	05	46
9	D Pr me Reducer	(gal)	20	26	20				45	46		
10	Chass Bla k	(gal)	07			01						03
11	P h P	(g l)	03	09	04			03			02	
12	P i t & Wh el I T & V yl P	(g l)	16	21	25	20	24	31	21	16	20	10
13	Th I & Wh l Pa	(g l)	09	16	20	08	13	06	02	09	02	17
14	A R Comp d FS 1128	(g l)	2	16	10	18	10	08	12	08	15	11
	COST PER CAR											
15	P Surf A yl L q er		1 78	16 95	15 64	14 65	17 99	16 18	20 22	17 84	21 13	16 68
16	A yl La quer M g Th e		5 49	6 04	4 07	4 43	4 82	6 13	4 66	4 94	2 49	5 29
17	Se ler S face Bond for A yl c L cq er		3 41	1 35	1 10	2 20	1 05	65	93	95	06	62
18	Bond t Body		40	35	45	43	40	38	43	41	40	34
19	Bonde te-Chass s		16	11	31	23	14	21	18	19	17	27
20	F P m			2 70	1 76	2 61				1 59		
21	Pr me & Gl		7 83	8 99	8 40	5 79	9 54	12 59	8 56	5 77	11 11	9 79
22	Bl k D p Pr me		1 43	1 01	1 00	1 51	1 79	2 23	55	1 49	22	1 86
23	D p Pr m R d		13	34	14				86	32		
24	Ch ss Bl k		02			01						06
25	P P		57	1 01	65			39	01		40	
26	P & Wh l I T & V yl P		1 02	1 11	1 46	1 23	1 46	1 75	94	95	1 07	77
27	Th I & Wh l P		15	28	33	18	25	11	10	16	05	23
28	C o M e l		28		02		14			01	01	01
29	A R t C mp d FS 1128		1 61	44	25	46	29	22	29	20	38	29
30	T tal Cost Pe Car		37 19	40 68	35 58	33 73	37 87	40 84	37 73	34 82	37 49	36 21
	R g		9	16	5	13	12	17	11	4	10	7
31	U its P d d		19 407	20,142	21189	20 062	12643	15 190	21 448	13 912	17 153	18 705
	Mem Elp C		5 58			74	4 62	3 63	3 33		5 83	5 64

Line No		Unit	LO Plant Month Per Car	NOR Plant Month Per Car	ST. Plant Month Per Car	S.G. Plant Month Per Car	TARR Plant Month Per Car	V.N. Plant Month Per Car	W R Plant Month Per Car	WILM. Plant Month Per Car
	MATERIAL USAGE PER CAR									
1	Paint, Surface Acrylic Lacquer	(gal)	1 93	2 43	2 76	3 39	2 59	3 13	2 17	2 [illegible]
2	Ac yli Lacq er Mixing Thinners	(gal)	1 26	2 45	2 94	25	1 96	06	2 45	1 28
3	Sealer, S rface Bond for Acrylic L cq e	(gal)	03	28	11	02	32	03	48	31
4	Bonderite Body	(lb)	1 99	1 43	1 47	1 69	1 89	1 27	1 10	1 3[illegible]
5	Bo der te-Chass s	(lb)	40	1 03	72	57	64	43	1 16	67
6	F P m	(gal)			46				53	[illegible]
7	Pr me & Gl z	(gal)	1 91	2 43	1 75	2 64	1 42	1 33	2 09	1 [illegible]
8	Bl k D p Pr me	(gal)	13	08		03	54	18		11
9	D Pr me Reducer	(gal)	12		41			12		—
10	Chass Bla k	(gal)			01					
11	P h P	(g l)								
12	P i t & Wh el I T & V yl P	(g l)	26	14	28	18	27	19	19	[illegible]
13	Th I & Wh l Pa	(g l)	11	21	28		11	08		07
14	A R Comp d FS 1128	(g l)	08	12	09	17	09	08	06	1[illegible]
	COST PER CAR									
15	P Surf A yl L q er		17 03	17 74	19 81	25 16	21 85	21 68	17 94	26 0[illegible]
16	A yl La quer M g Th e		2 50	4 50	5 41	58	4 16	12	4 33	2 5[illegible]
17	Se ler S face Bond for A yl c L cq er		15	1 19	47	16	1 06	21	1 52	[illegible]
18	Bond t Body		56	43	43	52	53	36	29	55
19	Bonde te-Chass s		11	33	22	18	18	12	30	1
20	F P m				1 75				1 78	[illegible] 8
21	Pr me & Gl		8 19	9 75	7 04	11 97	7 85	6 54	8 78	7 7
22	Bl k D p Pr me		50	32	98	09	2 09	72		6[illegible]
23	D p Pr m R d		11		26			13		03
24	Ch ss Bl k				06					
25	P P			01						
26	P & Wh l I T & V yl P		1 70	87	1 50	77	1 57	1 18	1 15	1 64
27	Th I & Wh l P		17	36	57		20	18		
28	C o M e l			37	01		01		01	
29	A R t C mp d FS 1128		20	33	24	46	23	21	15	34
30	T tal Cost Pe Car		31 22	36 [illegible]	38 70	39 89	39 73	31 45	36 25	43 5[illegible]
	R g		1	6	13	15	14	2	8	18
31	U its P d d		9 510	17 257	9 505	11,863	16 485	20,577	16 421	7 284
	Mem Elp C		3 10	3 6[illegible]		(71		(69		

Water

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WATER USAGE AND COSTS - JULY 1977

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		WATER PURCHASED / WATER PUMPED EXTERNAL / WELL-W OR SURFACE-S			WATER RECIRCULATED / SEWER MCF & SEWER CHARGE-* / TOTAL WATER DISCHARGED-#			WASTE WATER TREATED		$ PER MCF		
		MCF	COST	$ UNIT COST	MCF	COST	$ UNIT COST	MCF	$ COST	OPER-ATING COST	FIXED CHARGES	TOTAL UNIT COST
					457*			%INTAKE-RECIRC=	2,629	%INTAKE-TREAT=		9
					457#			%INTAKE-DISCHARGED=		100		
	PONTIAC	4,120	$16,553	4.02				1,126	14,702	4.76	8.27	13.06
					3,750*	$8,834*	2.36			%INTAKE-TREAT=		27
					3,786#			%INTAKE-DISCHARGED=		92		
	SYRACUSE	1,434	$4,576	3.19	42,969	$1,884	.04	658	17,843	16.74	10.38	27.12
					238*			%INTAKE-RECIRC=	2,996	%INTAKE-TREAT=		46
					1,155#			%INTAKE-DISCHARGED=		81		
	TECUMSEH				6,605	$4,374	.66					
		310W	$6,198	19.99	79*	$1,372*	17.37	%INTAKE-RECIRC=	2,131			
					79#			%INTAKE-DISCHARGED=		25		
	TRENTON	4,086	$13,751	3.37	33,844	$7,736	.23	3,132	57,012	13.57	4.63	18.20
					3,312*	$9,590*	2.90	%INTAKE-RECIRC=	828	%INTAKE-TREAT=		77
					3,312#			%INTAKE-DISCHARGED=		81		
GM ASSEMBLY	ARLINGTON	6,048	$15,646	2.59	117,514	$14,915	.13	3,722	6,632	1.34	.44	1.78
					4,136*	$12,836*	3.10	%INTAKE-RECIRC=	1,943	%INTAKE-TREAT=		62
					4,136#			%INTAKE-DISCHARGED=		68		
DORAVILLE	ATLANTA	4,091	$12,377	3.03				79	150	1.90		1.90
					1,923*	$24,771*	12.88			%INTAKE-TREAT=		2
					3,518#			%INTAKE-DISCHARGED=		66		
LAKEWOOD	ATLANTA	2,582	$9,642	3.73	106	$932	8.79	1,328	2,979	1.81	.43	2.24
					2,324*	$11,384*	4.90	%INTAKE-RECIRC=	4	%INTAKE-TREAT=		51
					2,324#			%INTAKE-DISCHARGED=		90		
	BALTIMORE	2,988	$4,527	1.52				2,912	9,539	2.38	.90	3.28
					3,211*	$4,527*	1.41			%INTAKE-TREAT=		97
					3,677#			%INTAKE-DISCHARGED=		123		
	FRAMINGHAM	1,367	$5,468	4.00				995	7,513	1.18	6.37	7.55
					1,094*	$2,733*	2.50			%INTAKE-TREAT=		73
					1,094#			%INTAKE-DISCHARGED=		80		
	FREMONT	3,192	$10,895	3.41				2,082	37,533	12.34	5.68	18.03
					2,394*	$5,909*	2.47			%INTAKE-TREAT=		65
					3,192#			%INTAKE-DISCHARGED=		100		
	JANESVILLE	6,552	$3,434	.52				7,843	18,796	.14	2.26	2.40
					5,080*	$4,682*	.92			%INTAKE-TREAT=		120
					12,923#			%INTAKE-DISCHARGED=		197		
FAIRFAX	KANSAS CITY	4,009	$12,110	3.02				143	6,515	31.47	14.09	45.56
		3,147W	$664	.21	2,833*	$9,773*	3.45			%INTAKE-TREAT=		2
					5,895#			%INTAKE-DISCHARGED=		82		
LEEDS	KANSAS CITY	3,554	$8,943	2.52								
					2,773*	$5,559*	2.00					
					2,773#			%INTAKE-DISCHARGED=		78		
	LINDEN	3,542	$12,153	3 43				74	2,520	34.05		34.05
					3,365*					%INTAKE-TREAT=		2
					3,365#			%INTAKE-DISCHARGED=		95		
	LORDSTOWN	6,096	$18,332	3 01				2,503	45,570	2.96	15.25	18.21
					4,123*	$27,757*	6.73			%INTAKE-TREAT=		41
					4,123#			%INTAKE-DISCHARGED=		68		
	NORWOOD	3,319	$10,448	3.15								
					3,224*	$7,047*	2.19					

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STEAM AND COMPRESSED AIR USAGE AND COSTS - JULY 1977

Steam and compressed air cost

	STEAM GENERATED PURCHASED-P SOLD-S NET MLBS EQUIV	TOTAL STEAM COST	DOLLARS PER NET MLBS EQUIV: FUEL COST	OPERATING COST	FIXED CHARGES	TOTAL STEAM UNIT COST	EFF % PLANT BLR-*	COMPRESSED AIR: STEAM ELECTRIC-E MCF	COST	$ PER MCF	TOTAL AREA SQUARE FEET
FRAMINGHAM	10,425	$51,877	2 7527	1.5792	.6443	4.9762	76.2		$275		1,816,260
							84.7*	120,568E	$32,023	.27	
FREMONT											2,660,064
								291,544E	$57,065	.20	
JANESVILLE	29,828	$117,096	1.9954	1.3542	.5761	3 9257	64 7		$169		2,359,526
							85.0*	366,070E	$29,980	.08	
FAIRFAX KANSAS CITY	32,310	$61,829	1 4821	3326	.0989	1 9136	71.1				2,110,648
							77.8*	221,612E	$44,122	.20	
LEEDS KANSAS CITY	23,332	$79,892	1 5556	1 4271	.4415	3.4241	73 0				2,044,780
							81 1*	359,532E	$25,237	.07	
LINDEN	17,104	$88,934	3 3143	1 3963	.4890	5 1996	74.1	58,310	$5,923	.10	1,876,345
							83.1*	361,068E	$47,064	.13	
LORDSTOWN	29,541	$95,964	2.3854	.4261	.4370	3.2485	74 9				2,916,413
	5,904S	$18,703	STEAM SOLD			3.1679	85 8*	556,137E	$60,686	.11	
NORWOOD	17,553	$65,482	2 2669	1.1301	.3316	3 7305	71.3				1,786,412
							79 2*	319,776E	$38,509	.12	
SOUTH GATE	4,397	$8,245	1.8751			1.8751	83 7				1,811,200
							83 7*	228,456E	$38,062	.17	
ST. LOUIS	34,136	$136,172	1.5637	1.3500	1.0755	3.9891	74.9	30,148	$1,620	.05	3,785,166
							86.9*	652,461E	$60,079	.09	
TARRYTOWN	33,273	$185,006	3 7010	1 5493	.3100	5.5602	67.2		$70		2,242,007
							83.1*	390,319E	$88,574	.23	
VAN NUYS											1,864,806
								254,952E	$56,332	22	
WILLOW RUN	16,017	$68,444	2 5681	1 5304	.1748	4.2732	69.1				2,333,516
							78 3*	392,950E	$48,045	.12	
WILMINGTON	14,915	$75,186	2 9240	1.7397	.3773	5 0410	79.7	911	$1,632	1.79	1,997,831
							82.1*	287,581E	$29,029	.10	
UIDE ANDERSON	55,912	$172,953	1 6068	9132	.5733	3 0933	75.0		$205		2,731,142
							83.8*	1,011,032E	$72,860	.07	
MONROE	1,176	$16,629	3.3520	2.3367	8.4515	14.1403	75.6				413,000
							81.7*	77,123E	$14,123	.18	
PARTS GROUP											
M PARTS CENTRAL REGION											1,868,353
NORTHEAST REGION											1,591,945
SOUTHEAST REGION											1,398,930
WEST REGION											1,890,539
TRUCK & COACH REGION											786,678
DETROIT		$1,543									819,177
								4,648E	$2,456	.54	
DRAYTON PLAINS											1,282,085
FLINT	6,679	$57,384	2.3634	5.5749	.6534	8 5917	58.1				2,019,616

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UTILITY USAGE AND COSTS - JULY 1977

Elect, Water & Gas Costs per plant for GM

		ELECTRICITY				WATER			TOTAL GAS		
		MAX DEMAND KW OR KVA*	PURCHASED AND GENERATED-G KWH	COST	$ PER KWH	PURCHASED WELL-W SURFACE-S MCF	COST (INCL. SEWER CHARGE)	$ PER MCF	PIPELINE MCF PRCPANE-P GALS	COST	$ UNIT COST
FLEETWOOD	DETROIT	13,336	6,858,720	$219,580	.0320	4,827	$13,426	2.78	43,181	$79,400	1.84
FORT STREET	DETROIT	11,520	5,933,760	$190,430	.0321	6,596	$15,343	2.33	1,195	$2,471	2.07
	ELYRIA	14,391*	6,534,000	$164,267	.0251	3,795	$9,726	2.56	9,574	$18,273	1 91
	EUCLID	3,690	1,391,600	$44,891	.0323	126	$542	4.30	205	$311	1.52
1	FLINT	20,745	8,468,808	$215,877	.0255	2,901	$18,131	6.25	8,038	$35,078	4.36
COLDWATER 5	FLINT	14,520	7,087,360	$174,165	.0246	3,695	$21,345	5.78	13,336	$37,903	2.84
	GRAND BLANC	16,325	8,332,417	$199,978	.0240	1,332	$7,464	5.60	391	$1,432	3.66
1	GRAND RAPIDS	11,520	5,976,000	$187,651	.0314	613	$3,773	6.15	4,972	$9,376	1.89
2	GRAND RAPIDS	4,261	1,814,400	$49,172	.0271	824	$5,927	7.19	3,408	$5,798	1.70
	HAMILTON	16,241*	7,686,579	$182,847	.0238		$15		145	$319	2.20
						645W	$2,799	4.34			
	KALAMAZOO	21,082	10,915,200	$262,122	.0240	867	$4,813	5.55	6,719	$14,153	2.11
	LANSING	13,200	4,297,000	$114,990	.0268	3,367	$19,397	5.76	5,054	$25,611	5 07
	LIVONIA	3,488	1,374,686	$45,851	.0334	1,695	$11,034	6.51	40	$140	3.50
	LORDSTOWN	61,560*	6,639,800	$159,920	.0241	566	$5,312	9.39	28	—$2,968—	105 99
	MANSFIELD	15,100*	6,660,000	$160,900	.0242	800	$8,353	10.44	49	$114	2.33
	MARION	19,120*	7,992,000	$186,051	.0233	856	$3,765	4.40	2,782	$4,784	1 72
	PITTSBURGH	10,066	5,202,000	$142,046	.0273	457	$2,535	5.55	404	$387	.96
	PONTIAC	17,040	5,911,700	$215,128	.0364	4,120	$25,387	6.16	3,136	$17,056	5.44
	SYRACUSE	15,690	6,768,000	$208,454	.0308	1,434	$4,576	3.19	581	$1,242	2.14
	TECUMSEH	1,651	633,600	$18,666	.0295				1,326	$4,274	3.22
						310W	$7,570	24.42			
	TRENTON	13,321	6,470,400	$202,646	.0313	4,086	$23,341	5.71	7,087	$18,222	2 57
GM ASSEMBLY	ARLINGTON	17,388	9,810,000	$150,998	.0154	6,048	$28,482	4.71	150,311	$271,771	1 81
DORAVILLE	ATLANTA	20,160	9,329,710	$209,118	.0224	4,091	$37,148	9.08	45,174	$121,399	2 69
LAKEWOOD	ATLANTA	15,384	7,428,000	$171,666	.0231	2,582	$21,026	8.14	27,507	$57,706	2.10
	BALTIMORE	17,664	8,730,000	$231,649	.0265	2,988	$9,054	3.03	22,692	$57,186	2.52

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FUEL USAGE AND COSTS - JULY 1977

Boiler / Power house costs per plant

		BOILER FUELS								PROCESS FUELS		
		COAL TONS GAS* MCF	COST	$ UNIT COST	$ PER MMBTU	OIL WASTE OIL* GALS SOLID WASTE# TONS	COST	$ UNIT COST	$ PER MMBTU	COKE TONS PROCESS OIL* GALS	COST	$ UNIT COST
		2,309*	$4,844	2.10	2.05							
	BALTIMORE					181,440	$74,086	.41	2.93			
	FRAMINGHAM					89,666	$28,697	.32	2.16			
	FREMONT											
	JANESVILLE	1,788	$59,520	33.29	1.33							
FAIRFAX	KANSAS CITY											
		44,951*	$47,886	1.07	1.09							
LEEDS	KANSAS CITY											
		30,997*	$36,295	1.17	1.17							
	LINDEN					155,299	$56,688	.37	2.53			
	LORDSTOWN											
		37,065*	$70,468	1.90	1.84							
	NORWOOD	905	$39,826	44.01	1.67							
	SOUTH GATE									15,777*	$5,333	34
		4,740*	$8,245	1.74	1.62							
	ST. LOUIS	1,845	$45,436	24.63	1.15							
		4,105*	$7,942	1.93	1.87	4,554*						
	TARRYTOWN					330,600	$123,143	.37	2.56			
	VAN NUYS											
	WILLOW RUN											
		22,081*	$41,133	1.86	1.83							
	WILMINGTON					122,853	$43,611	.35	2.40			
GUIDE	ANDERSON	3,347	$89,838	26.84	1.24							
	MONROE											
		1,565*	$3,942	2.52	2.61							
	PARTS GROUP											
GM PARTS	CENTRAL REGION											
	NORTHEAST REGION									700*	$276	.39
	SOUTHEAST REGION											
	WEST REGION											
	TRUCK & COACH REGION									300*	$134	.45
	DETROIT											

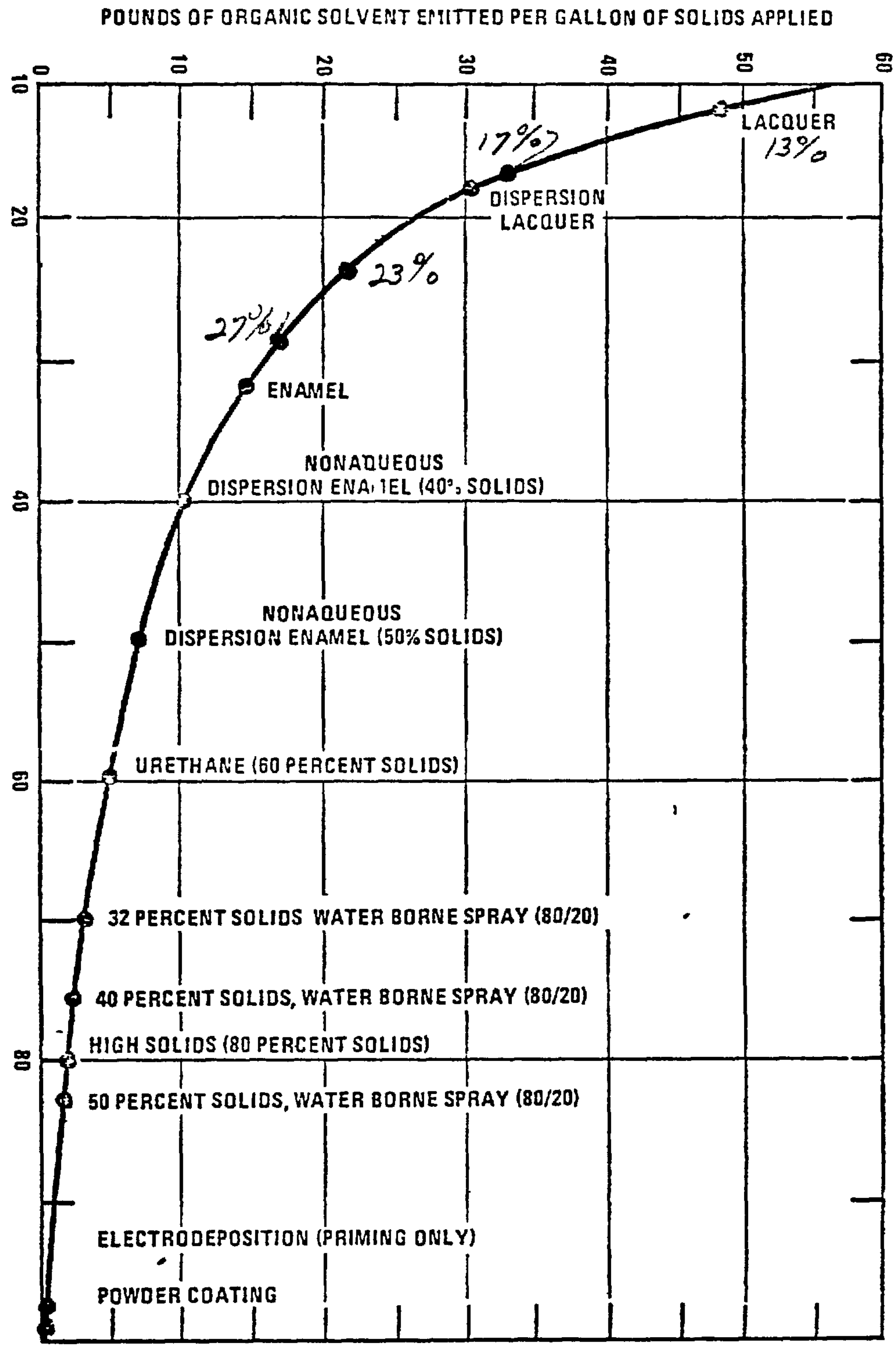

Figure 12 Percent of solids versus pounds of organic solvent emitted per gallon of solvent applied
(Assumption solvent density = 6.6 lb/gal)

RESUMES

OF

PROJECT

CONSULTANTS

CURRICULUM VITAE OF WEC'S PROJECT CONSULTANT

DONALD G HAMAKER

EXPERTISE

A total of 38 years of overall experience, both domestic and international, with General Motors (GM), including 30 years dedicated to developing paint, paint process and facility design

EXPERIENCE SUMMARY

- Developed expertise in the application of all major paint products and chemicals, the utilization of diverse painting facilities, and painting in conformance with military specifications such as nuclear, biological and chemical resistant painting
- Supervised a team of 15 engineers assigned to planning of paint and new process development, paint facility technology, design and specification, and paint strategy for all of the GM truck and bus divisions
- Contributed to the early development and subsequent implementation into production of the following materials alkyd enamels, super enamels-acrylics, high solid enamels, base coat/clear coat enamels, waterborne BC/CC, urethanes, phosphate base, anti-chip, elpo primers, from anodic to high build, low VOC, powder, anti-chip, primer surface and clear coats
- Responsible for the implementation of 8 new paint shops and one conversion project from enamel to base coat/clear coat
- Participated in the design and implementation of the first waterborne BC/CC paint shop in North America
- Technical Service Manager for Akzo-Nobel (America), a large international paint and chemical manufacturer

PROFESSIONAL AFFILIATIONS

Registered Professional Engineer in the State of Michigan - Mechanical Engineering

EDUCATION

University of Michigan - MSE, 1964
General Motors Institute - BIE, 1995

CURRICULUM VITAE OF WEC'S PROJECT CONSULTANT

NICHOLAS C KACHMAN

EXPERTISE

Over 38 years of worlwide experience with General Motors (GM) involving automobile manufacturing operations and control of plant environmental conditions

EXPERIENCE SUMMARY

- Responsible for directing world-wide environmental control corporate policy Projects included coal burning SO2 control systems, noise control program, odor control program, abatement of VOC emissions from paint operations, improvement of paint spraying efficiency, resulting in material savings and waste treatment cost reduction in the order of millions of dollars per plant
- Developed design criteria for new automobile manufacturing foundries, press areas, plating an assembly plants, and warehouses
- Manager of corporate environmental protection programs involving waste minimization and disposal
- Designed heating, ventilation, and air conditioning systems for manufacturing plant work and support areas
- Established preventative maintenance programs and productivity improvement techniques
- Developed new criteria for the sizing of back-up equipment for steam generation, cooling tower, and compressed air installations, which saved tens of millions of dollars in equipment cost
- Conducted a corporate-wide temperature-control system studv for most of the typical manufacturing areas resulting in industry-wide savings in new facilities construction, and operating costs and a higher level of comfort for plant workers

PROFESSIONAL AFFILIATIONS

Registered Professional Engineer in the State of Michigan

EDUCATION

Wayne State University - B S in Mechanical Engineering
Wayne State University - Industrial Engineering

BUSINESS

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DEPARTMENT CHIEF

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