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IMPROVEMENT OF DESIGN AND MANUFACTURING TECHNOLOGY OF ALL-GROUND PASSENGER VEHICLE BODIES

SI/ROM/74/808

ROMANIA

Terminal report

Prepared for the Government of Romania
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of William Hock, expert in the design and manufacture of bodies for all-ground vehicles

United Nations Industrial Development Organization

Vienna

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Explanatory notes

A comma (,) is used to distinguish thousands and millions.

A full stop (.) is used to indicate decimals.

The monetary unit in Romania is the leu (plural, lei). During the period covered by the report, the value of the leu in relation to the United States dollar was $US 1 = lei 12.000.

The following abbreviations are used in this report:

CKD	Completely knocked down
IABv	Intreprinderea de Autocamioane Braşov
IMM	Intreprinderea Mecanică Muscel
mig	Metal inert gas
QA	Quality audit
QC	Quality control
SUP	Single-unit pack
TUP	Twin-unit pack
VIP	Vapour-inhibiting paper

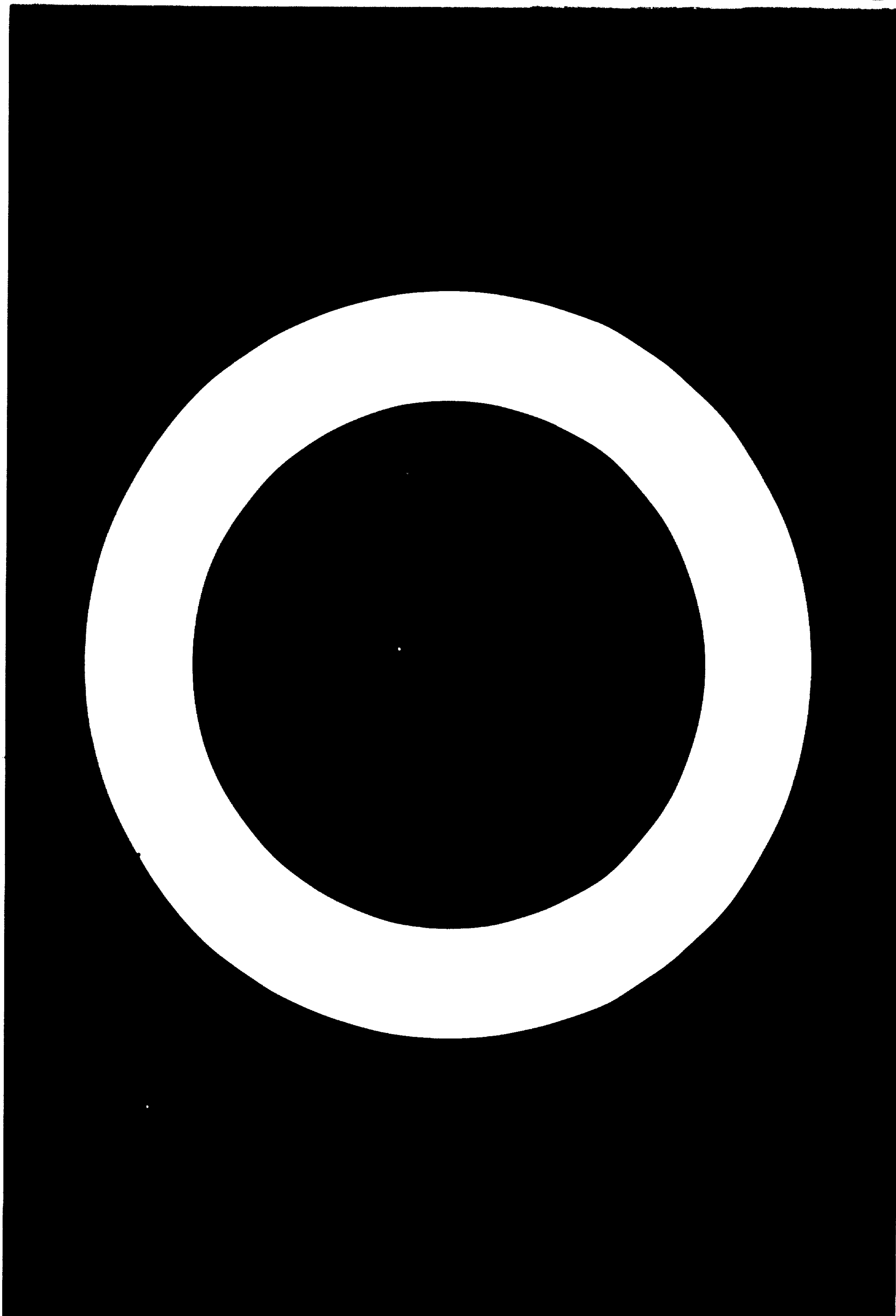
ABSTRACT

The project entitled "Improvement of design and manufacturing technology of all-ground passenger vehicle bodies" (SI/ROM/74/808[1/]) originated in a request made by the Government of Romania in December 1974 for United Nations Development Programme (UNDP) assistance in improving the design and manufacturing technology of all-ground passenger vehicles, with particular reference to methods, quality and cost reduction. The request was approved in July 1975, with the United Nations Industrial Development Organization (UNIDO) designated as the executing agency, and Intreprinderea Mecanică Muscel (IMM) as government co-operating agency. The project was divided into two missions of three months each, the first beginning in February 1977, and the second in September 1977.

The common areas of potential manufacturing improvement and cost reduction in the Romanian vehicle industry are many, and any action taken to achieve these ends should be industry-wide. The technical recommendations contained in the report include low-cost die-making, a change in solder formulation, modernizing welding equipment, more automated material handling in the die shop, better paint shop maintenance, new paint formulation and method of application, and improved body shop processes.

The conclusions and recommendations with regard to managerial functions are more generalized. It was concluded, for example, that a foreman training course would yield more positive control of worker output, improving quality, cost and volume; and that better control of work required would be achieved by detailed planning, including hourly payment, containerized material handling, revised production scheduling, and altered plant layout - all keyed to the line concept. To promote these developments, either specialists in the field should be recruited for service in Romania, or local staff should be trained abroad. Finally, forward planning and factory organization not covered in this report should be reviewed, with the continued support of UNIDO in this as in the other above-mentioned fields of activity.

1/ On 1 January 1977 the project number was changed from IS/ROM/74/008 to SI/ROM/74/808.



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INTRODUCTION

During the 1975-1980 period, the production level of all-ground passenger vehicles in Romania is to be substantially increased to cover the estimated growth in domestic market requirements and export demand, especially in developing countries. To ensure the achievement of the planned production levels while meeting new vehicle safety standards and quality requirements, the Government of Romania considered it essential to improve design and manufacturing technology of all-ground passenger vehicles, with particular reference to methods, quality and cost reduction. It therefore requested, in December 1974, United Nations Development Programme (UNDP) assistance in effecting the necessary improvement. The request was approved in July 1975, and led to the project entitled "Improvement of design and manufacturing technology of all-ground passenger vehicle bodies" (SI/ROM/74/808[1/]), with the United Nations Industrial Development Organization (UNIDO) designated as executing agency, and Intreprinderea Mecanica Muscel (IMM) as Government co-operating agency. The project was allotted a budget of $US 24,300 and divided into two missions of three months each, the first beginning in February 1977, and the second in September 1977.

The expert's assignment consisted in providing technical assistance to IMM in improving the design and manufacture of bodies for all-ground passenger vehicles, with special emphasis on the following elements: body design improvement, reduction of development work, increase in body manufacturing productivity and in quality. Following submission of his mid-term report, the expert's work was expanded to include the whole automotive vehicle industry, that is, passenger cars, busses, trucks and trolleys, in addition to the jeep-type ARO all-ground vehicle. Four of the six months devoted to the project were spent at the jeep plant, which was therefore the subject of more detailed analysis and comment than the other factories, although each plant may benefit by the comments made about the others.

1/ On 1 January 1977 the project number was changed from IS/ROM/74/808 to SI/ROM/74/808.

The products of the car plant are the four-door Dacia passenger car, a pick-up truck using the car chassis and front end up to the "B" or centre pillar, and a panel van set on the car chassis. The volume of production was 72,000 units in 1976. Starting in 1968 as a Renault completely-knocked-down (CKD) operation, local content is now over 95%.

The truck plant started in 1954 with a CKD Russian four-ton truck. In 1962, manufacture of the current standard cab began. The cab-over-engine diesel is a MAN-licensed design that started in 1971. The model range is now broad. With a total staff of 26,000, the volume of production in 1976 was 36,000 trucks, 30% of which was for export. The target for 1980 is 50,000 units.

The bus plant produces an urban bus powered by diesel or electric motor, and an intercity bus 9 m in length with standard appointments or 11 m in length with de luxe appointments. It also builds a series of commercial vehicles on one frame, including a chassis cab, drop side, and several van variants. Bus production is in its twenty-fifth year, and the employment level is nearly 7,000.

The final timetable for the second three-month mission was agreed as follows:

Time (weeks)	Location	Subject
2	United States	Data collection and special conferences
3	Cîmpulung	ARO jeep
1	Pitești	Cars
3	Bucharest	Buses
3	Brașov	Trucks
1	Vienna and travel	Final report
13		

At IMM the discussions centred on the following: the remaining critical departments of quality control, plant layout and final assembly; passing on the United States data, catalogues, and results of meetings with automative specialists; and reviewing progress on the recommendations made five months earlier, and discussing additional IMM problems. Subjects not discussed were organization, forward planning, research, sales, service and CKD export.

The short time spent in the other three plants was insufficient to make the kind of analysis and recommendations provided for IMM, but gave a broader picture of the overall vehicle industry. Accordingly, the report covers IMM in detail, and contains separate sections on the car, bus and truck plants.

I. INTREPRINDEREA MECANICA MUSCEL

A. Problems

Probably the single most important condition for the achievement of lower cost and better quality would be a change in worker attitude. Suitable guidelines are established by the product design and processing studies, but the effectiveness of the system is hampered by the lack of precise instructions to be followed by the workers in the performance of their duties. Batch-flow and piece-part payment are also major drawbacks to optimum worker performance. There is no production-line control, many lines are stopped, and those that run are for transport only, not worker control.

If major improvement in quality and cost reductions are to be obtained, foremen and supervisors must lay greater stress on working to established standards and production schedules. A change to bright, spacious, modern and safe factory installations would also contribute to the achievement of these goals.

A conscientious effort is being made by the factory planning staff. The plans for manufacture and assembly are detailed and well conceived, but in many areas the programme on paper is not applied in practice.

Solutions require a major change in effort and direction. The expert was unable to see the general organization chart or to obtain detailed information concerning the support and direction given by Government to this industry, or even to this plant. Attempts to arrange meetings with government staff were unsuccessful, although such backing would be necessary for a solution.

The above general problems require a shift in manufacturing approach and attitude by government planners and factory management. There were, however, many specific problems of a technical nature that could be acted upon now, as follows:

Specific problems

Many IMM problems, at the expert's request, were written as departmental lists, others were observed by the expert during his time in the factory. Both were handled as follows:

(a) Minutes were taken on all discussions and are summarized in annex II of this report. They are presented logically as: subject, problem, discussion, conclusion, and recommendation. The reader is advised to study each carefully for a full appreciation of the difficulties facing IMM and their recommended solutions;

(b) A list of proposed changes drawn up by the expert, the reasons for them, and the advantages derived therefrom is given in annex I. Not included in the mid-term report, this list represents potential improvements in areas other than the problems referred to in (a) above.

Rather than repeat each solution and/or recommendation in the body of the report, the expert has incorporated them in the annexed minutes and proposals. Most describe a well-defined problem and a concrete solution and recommendation to give effect to the conclusion reached. They represent a report on the bulk of the expert's work. The minutes provide a complete record of the discussion and results of all meetings. The proposals consist in suggestions for plant improvements based upon the expert's worldwide experience in vehicle manufacture.

B. Solutions and progress

Some more interesting problems and solutions as well as progress made during the five-month mission of the UNIDO expert are discussed below.

Concerning product design, the ARO frame is subject to warping and is difficult to manufacture. The closed "C" design proposed was supported by United States experts. ARO hopes to manufacture an experimental prototype. Harder rubber for redesigned body mounts will also be tested.

Of the several ideas reviewed to lower costs, the most important was the proposal to develop a two-wheel-drive, low-cost model, which is row in prototype development. It is difficult to assign dollar value to a design proposal, but a 50% sales increase over a period of three to five years could result from this UNIDO proposal. Finally, a system of value analysis was taught; that is, how to evaluate the ARO versus competition, and how to determine the cost/sales potential of a new design.

In die-manufacturing and press-shop analysis, less down-time and faster cycle time of presses is needed. Cycle time especially can be improved by a press-shop time-and-motion study of materials handling and press loading. Existing dies can be reworked, and scrap cutters, positive knock-outs and air ejection can be added. New die design should incorporate these devices and consider automatic feeds, inclinable presses, and possibly automatic load/

unload and conveyor-belt piece transfer between presses for progressive parts. United States automation data was given to the die staff. The above proposals should almost double press capacity, improve quality, reduce rusting, and improve piece-part storage, all with a relatively modest investment.

Faster lower-cost die manufacture for die tryout, prototype or low to medium-volume production was discussed at some length. Most large modern auto factories use either template dies or steel rule dies for blank and pierce, and Kirksite draw dies for the above. Cost savings of 75% or more are not uncommon and average die saving of 60% is a conservative estimate. Prototype development time and draw-die manufacturing time can be shortened by months.

Considerable additional data was presented during the second trip and lengthy manufacturing discussions with cost saving examples took place. Use of these methods was recommended and know-how imparted, but it is doubtful whether ARO will use these programmes. The representatives showed polite interest and intellectual curiosity but did not take enough notes to use, nor did they make copies of the data.

It is difficult to understand why such a decided improvement will not be put into use.

The body shop manufacturing programme suffers greatly from independent worker action, such as unscheduled building of subassemblies and failure to use fixtures. However, there are many areas where UNIDO recommendations are or will be put into effect. The change to less expensive welding tips will be made, and newer welding guns of modern design will replace the old kick-cable units and save power. Automatic gas welding shut-off valves, not now available in Romania, will be made and used at ARO. Special metal finishing equipment will be provided.

Thus in these and other areas the expert's proposals are or will be put into use for better quality and cost reductions.

The paint, trim and final proposals involve extensive changes in layout and paint methods. There was no time to see what progress has or will be made. Paint-shop savings can be obtained by teaching correct spray methods, good maintenance, new paint selection and processing, as recommended in earlier discussions.

The major problem solutions are neither as simple nor as clearly defined as those just discussed. Worker attitude can be changed to yield greater quality and production, but it will be slow and difficult unless a strong incentive is found. The proposals for a quality audit programme and a more rewarding suggestion programme will help.

Foreman training is needed. Until the foreman can control the worker and insist on work to specifications and of good quality, progress at IMM will be slow. A training programme for foremen and supervisors was recommended in detail in the mid-term report. When it is implemented, production lines can be run with assurance and workers will keep pace with good quality work. Thus the line will control the rate of work as well as transport goods. At this point payment by the hour can replace piece-part payment. There will be no need to have piece-payment incentives as each man, when assigned a fair day's work, must work to keep up with the production line flow.

Work assignments that take into account use of proper tools and methods will improve quality. With reliable quality information going to management, daily corrections can be made immediately if quality is not good.

The recommendations designed to deal with these major problems are not new to the industry, but will represent a major change at ARO. The sooner introduced, the easier it will be to implement them. Most developing plants install this system at about three units per hour, and ARO production is 30% above that. Once established, continued expansion to higher volumes will be simpler and more efficiently accomplished.

C. Cost savings

To develop effective cost-saving programmes requires first of all cost awareness. Such awareness is often lacking at IMM, even at high management levels, and more so at intermediate and lower levels. Design engineers are unfamiliar with material costs, so they have difficulty choosing lower-priced alternatives. Production engineers have little experience of overheads and equipment costs, so they cannot analyse the cost benefit of new layouts or fixtures. With the normal one-supply source no choice based on best cost and quality is possible.

Cost-saving suggestion programmes with cash awards based upon a percentage of the savings could develop cost awareness. Along with it quality should improve. Worker motivation directed into more beneficial channels is needed, and a cash suggestion programme is an effective motivation method.

Cost reductions can of course be achieved at static motivation levels and all recommendations have a cost/quality basis. But competition, the basic factor behind cost reduction action, is largely not present. Whereas the results are accepted within the country, when the ARO is competing on the open market in other countries, there is a decided disadvantage.

Cost reduction estimates are not frequently used because of uncertain cost knowledge, but the cost figures sprinkled throughout the report are summed up in table 1.

Table 1. Cost reduction estimates

Item	Time interval	Cost reduction	
		Lei	Dollars
Spot weld tips	1 year	3 511 200	292 600
Welding gas	1 year	1 075 000	89 600
Paint overspray	1 year	1 520 000	126 700
Paint labor	1 year	8 000 000	670 000
Paint gauges	-	400 000	33 300
Template dies	Length of programme	84% saving	84% saving
Steel rule dies	Length of programme	88.6% saving	88.6% saving
Grinding disc	1 year	125 000	10 400
Die and knock-outs (small)	-	40 500	3 375

Discussion with top IMM people did not take place, so the cause of, and remedy for, the unfamiliarity with cost problems cannot be dealt with here. What part of it is controlled by planners remote from the factory site is also not known.

D. Safety

A discussion was held with the safety director and others as to current safety practice, its adequacy, and the method of enforcement. The agrarian background and young age of the factory personnel makes it especially difficult to enforce safety regulations, and especially important to do so.

The programme of safety training, as outlined, appears quite adequate. Instructions upon being hired, a demonstration using sample equipment, the responsibility and legal liability of the supervisor or instructor are all designed to promote safety. Use of billboard posters and foreman lectures should keep safety constantly in mind. Safety records were said to be very high, but when judged by world standards for modern high-volume factories, there are many areas of safety that can be further improved. The use of two of the most fundamental types of safety equipment, namely eye protection and toe protection (steel-capped shoes), is not made mandatory. No hearing protection is available in any area, not even in areas of high-decible or high-pitched sound. Other shortcomings included narrow aisles, inadequate lighting, neglected housekeeping standards, uneven or pitted floors, and a lack of warning devices. The following practices were also observed: personnel wearing ear-rings, watches, rings and scarves in machine shop areas; loose hair or no glasses when grinding or spot-welding; slippery floors in the paint shop; speeding motor vehicles on company property.

The discrepency between the outlined programme and actual practice demands much thought and analysis. The following is self-evident:

(a) Those responsible for enforcing regulations should report infractions;

(b) Regulations should be few, simple, easily understood and enforceable. A large detailed list or book of regulations is for a lawyer, not a worker;

(c) If some infractions of rules are allowed it encourages disobedience of others;

(d) Leadership, as always, must come from supervision;

(e) An independent, mobile, changing group charged with reporting (not enforcing) any breach of regulations or safety practice will be more effective than a static group of workers assigned to report on themselves or each other.

Plant protection personnel charged with the safety and security of the factory are the ideal group to report on violations of safety regulations. As a rotating body of men they can impersonally and uniformly report violations. Safety rules, like traffic rules, must have an enforcing staff.

In conclusion, safety regulations, plant layout, safety maintenance, and enforcement and violations of current standards can be improved or reported. To achieve this goal, the following safety protection measures should be taken: provision of eye protection for all workers and visitors in the factory (supervision should be provided to start this programme); foot and hearing protection provided on a selective basis; observance of better housekeeping, with aisles being kept clear at all times; summarizing the most important regulations in simple, clear, concise, form and having all become familiar with them; revising plant design standards to provide greater plant safety; charging plant protection personnel with observation of all employee safety regulations and requiring written reports of all violations; publishing safety violations, describing the consequences and citing employee penalty incurred.

E. Quality control

For management to improve quality it must first be able to measure it. Possibly no other tool is as valuable to management as reliable data on the quality level of the factory output. This data will be available to IMM by establishing a quality audit (QA) system for completed products, as proposed by the expert, and expanding its concepts to include internal department audits.

A major area of potential cost reduction and quality improvement at IMM is the motivation of the worker and inspector alike to work to established specifications in a conscientious and cost-conscious manner. The Quality Control (QC) Department has the potential to provide accurate, uniform, statistical data that, when presented properly, can serve as a major inspirational force toward producing a better product. By rating charts, progress graphs, improvement contests and publicized management recognition of superior performance, worker motivation is improved. Inspection is also improved. If defects found during QA were not detected earlier, the inspector knows he was not doing a thorough job.

The extremely young age of the average worker, the lack of broad industrial experience in the country, and his village or agrarian background make it difficult for IMM to obtain production results to specifications. These factors also affect the QC Department. Because of this it is especially important to establish a QA system at IMM similar to those in general use throughout the world of developed car manufacturers.

Although there have been occasional audits of finished vehicles, this is not established practice. It should be. It is not established practice to record inspection defects in a form suitable to statistical analysis. It should be.

It was strongly recommended that a QA system, that is an inspection of the inspectors, be put into effect at IMM. It was also recommended that the concept be expanded to include recorded inspection data of all internal departments in a form suitable to statistical analysis for similar use.

<u>Quality audit system</u>

Sufficient data was provided to IMM to enable them to develop a successful audit system. In discussions the system proposed was briefly this.

At least 2% of production, and a minimum of one vehicle per shift or ten per week should be audited. A QA involves picking a completed unit, ready for delivery, at random from the delivery parking lot by the auditor and taking it to a special area reserved for auditing. A complete inspection is made, covering in particular the following: chassis appearance and mechanical function; body appearance and mechanical function; body and chassis electrical system; underhood; underbody; front end geometry; headlight aiming; body and chassis road and water tests; body and chassis paint and metalwork.

The audit is made to specifications where applicable, otherwise to judgement standards defined in the QC Manual, set by agreement of all factory senior staff. The results supplement and support internal quality control statistical reporting. The information provided in the recommended QA system can serve as a guide to establish better internal quality ratings and report procedures. The purpose is to provide a uniform rating method to management so that it may evaluate each group's quality and progress and the effectiveness of corrective programmes. If conscientiously followed, it will effectively and markedly improve quality.

Separate tools and facilities are to be provided, or easy access to them made available at all times, including equipment for the following: water-booth testing; front-end alignment; headlight-aim area; lit exterior appearance area; underbody checking facilities.

Written reporting is mandatory and uniformity of reports necessary to statistical analysis. For that reason inspection forms are provided listing all inspection points, requiring only that the inspector check if acceptable or note the numerical value of the demerit. Each defect has a weighted numerical rating in proportion to its severity.

The complete system, how it operates, ratings, definitions, forms etc. were reviewed in detail with IMM, and sufficient data provided so that it could be put into effective use. A similar system devised especially for the ARO should be developed and used, both internally and for final audit.

The organizational structure was examined and found satisfactory. QC is independent of any production group, as it must be for a correct manufacturing/ inspection relationship. The inspector/worker ratio, approximately one in fifteen, is also acceptable. Exact figures of the productive/non-productive ratio were not available, so the above must be an approximation.

Questions submitted in writing during the previous month of February, when reviewed, were, with one exception, all answered during the QA discussion. The exception, how to reduce run-in time, is not in the expert's field. More accurate machining, tighter tolerances, and matched fits will reduce the need for run-in. Also, the user, if required to follow an 800 km break-in schedule, can do the run-in for IMM.

F. Data supplied

Assembly operations

During the first visit some of the proposed solutions involved equipment unknown to ARO or not available from normal sources. Between visits, while in the United States, the expert talked with specialists and collected data to solve the problems or to provide sources and prices of specific equipment.

For example, according to the ARO welding engineer, the average spot-welding tip cost is lei 70. By substituting cap tips, replacement cost is reduced almost 90%. At current replacement rates, annual savings will be lei 3,511,200, per year. Tip design, price lists and two-purchase sources were provided so that IMM can make this saving.

Below is a list of the data supplied and its purpose, such as cost saving, quality improvement, new or more modern methods, or improvement in worker technique.

Catalogue on spot-welding tips. See above for purpose and cost savings.

Spot-welding tip specifications. Material and classification of tip alloys was provided so that ARO can match correct tips with use. Longer life, lower cost and better product quality will result. Similarly, alloy bar stock can be ordered for in situ manufacture with similar benefits.

Welding catalogue. ARO has spot-welding equipment on hand, but had no spare-part data. They can now order direct new guns, spares and accessories. This will improve flexibility and extend the useful life of their equipment by many years.

Spot-welding maintenance manual. This is an excellent book on welding theory, factory installation and maintenance for body shops. Proper use of good equipment is essential to high quality and low cost. Fewer work stoppages, improved quality and longer life will result if the book is used.

Ammeter/voltmeter. Charts for setting values of amperage, pressure, etc. were provided, but ARO was unfamiliar with the means of measuring some of these values. Incorrect spot-welding settings give poor quality and short tip life. The correct ammeter data and ordering source was provided, and how to use it was explained, as were pressure calculations.

Shut-off valves. ARO calculated that lei 10,700,000 were wasted annually by workers not shutting off gas welding torches when not in use. Data was provided on two types of valves, in-line or on-torch, that shut off automatically when the torch is released. For a very minor investment this huge annual savings will be realized.

Automatic robot. Automatic robots now load, unload, spot-weld etc. Although ARO is not ready now for this equipment, it was reviewed to stimulate interest and guide future thinking.

Toggle clamps. Use of factory-made poor-quality clamps is expensive and makes for inaccurate work. Catalogue data on purchase clamps, from two sources and with prices, was provided.

Body and tool design dimensional tolerances. Detailed review was made of dimensional limits in current use for body draft development, making master models, die models or other take-offs, die stampings, checking fixtures, production pieces, assemblies and the like. This subject is controversial, and was reviewed with product design, die design and all assembly groups. It should do much to end frequent accusations and arguments.

Product design

Frame design. The closed-hat ARO frame design is expensive, difficult for attachments and warps or twists during manufacture. Frame specialists consulted state a closed "C" design of the same bending moment would be slightly stronger and offer other advantages, such as the following: protection of brake and gas lines; easier manufacture; lower cost; no warping; simplified assembly process. This confirms earlier discussions.

Body stress analysis. An expert from the Cranfield Institute of Technology was available for a complete discussion of this subject, for he was at the truck plant in Braşov for six months, but IMM did not request him to visit their plant. A visit could be arranged sometime in future, possibly with UNIDO assistance.

Body stress analysis can be ensured by the following means: plastic model of reduced size stressed and observed by stroboscopic light; crash test programme; strain gage analysis; rental of stress analysis equipment with staff testing; hiring professional help from various engineering firms. Discussion of all of the foregoing, and a listing of a series of stress analysis papers were all provided.

Body and tool design dimensional tolerances. A review of this subject was made, as described above in the section on assembly operations.

Model-making materials. Wood, plaster and clay are still frequently used. In searching the United States for newer or different substances, it was found that the epoxy plastic and fibreglass reinforcement most used, along with the European supply source, is the same as used by IMM. Bead or sheet polystyrene foam is also popular.

Aperture cards. Drawings of product, dies, tools and even plant layouts are being filed on aperture cards with increasing frequency. Greater convenience and space-saving result. The advantages and use of this equipment, and sources of supply in Europe, were reviewed and data provided.

Low-cost die-making. Prototype development and relatively short die runs can use low-cost dies to advantage. Three types, steel rule dies, template dies and Kirksite dies are low in cost, save storage, are simple and faster to make and in wide use by car manufacturers. This was thoroughly discussed, and sufficient data to allow development of the system was provided.

Drawing aids. Use of polyester film or other transparent plastic sheets for industrial transparencies was discussed. Commercial aids such as transfer of letters, or tapes of lines, arrows etc. to set on mylar were also illustrated. Supply sources were provided.

Die design

Press conversion. Flexibility between single and double action presses can be realized by using the convertable unit as shown to IMM by the expert. Use of such a device should ease die-shop scheduling, save material cost, and reduce die cost. This unit makes a double-action die work in a single-action press.

Die design book. As requested, one of the best books published in the United States on die design was selected and reviewed. IMM was then advised on how to procure it.

Automation. Handling of steel by conveyor between presses with iron claws to load and unload is feasible at high volume and with in-line presses and several progressive dies. It is doubtful whether IMM can use the devices but they were shown as requested.

Low-cost die-making. For die try-out, for prototype development, or for limited production, low-cost die-making methods were shown. Savings of 85% in money and time are not unrealistic. The die designers showed some interest, but do not intend to take advantage of this method, which is used in many other auto plants.

Miscellaneous

Material specifications. Several basic material specifications, basic to low price and good quality, were provided, including European supplier sources.

Among them are a weld-through sealer and deadener. Controlled use of materials to these specifications will improve quality and lower cost.

Protective wax. A major IMM problem is vehicle surface protection during export or for long yard storage. Wax sprayed on over bright work and paint will give protection for up to one year. The wax specification, method of application and how to remove it were described.

G. Final assembly line

Chassis

The problem was to review assembly line procedures and propose the most suitable method for use at IMM. The general approach to final assembly line plant layout took into account the need to start with aisleways and line location. A profile of the line was drawn to determine spacing, for example: 3 m for body width with doors open, 1 m on each side of open doors for workers, and 1 m stock rack space. Additionally, on one side 3 m to 4 m are provided for sub-assembly, plus 2 m more for supply stock. Thus the aisles are normally 3.5 m on one side of the line and 9 m on the other. All utilities and special lights are suspended overhead at outer edge of worker space. All air lines are off ground and tool holders are provided.

Main aisle spacing is 4 m and side aisles 3 m. Bulky items, such as engines, tyres, axles etc. can be moved to assembly by conveyor. Subassembly fixtures are made interchangeable for all models. By being placed next to the line, the line speed also controls sub-assembly rate. Very little space is provided for bank stock.

Front fenders and grill should be assembled for best quality. The frame locator heights should be measured before body drop and shim as required. Front and rear axles, with brake line, springs and tyres should be sub-assembled if desired. Normal assembly sequence is in two stages as follows:

With frame upside-down

Front and rear axles
Brake lines and hand brake
Gas lines and tank
Muffler system
Drive shaft and miscellaneous

With frame turned right side up

Wheels

Checking of frame body locators

Engine and transmission

Body spacers and complete chassis assembly

Body drop

Fire wall

Engine tune-up, radiator

Front-end sheet metal

Fluids, complete assembly

Inspection

Repair

Buy-off (re-inspection and approval)

In conclusion, all assembly work, including inspection and normal repair, should be done on line. Provision for special problems and major repair should be made by including a "Hold" operation in the assembly sequence. It is recommended that line, aisles, space and assembly sequence should be re-arranged as outlined.

Body

The problem in this connection was the same as above, namely to review assembly line procedures and propose the best methods for use at IMM.

Body line layout should follow the principles set out in the chassis line discussion. Width of line with room for personnel, subassembly area, overhead utilities and main aisles should be the same. Assembly sequence can vary according to need but is normally as follows: electrical devices; exterior hardware; glass;inside trim (cloth); interior hardware.

Special tools for assembly are not normally expensive, but big reductions can be made in labour hours. Improvements proposed were: suction cups for glass; spray of adhesive for headliner; aprons for workers to carry tools or attachments; portable seats for workers inside the body;and push-pull screw drivers. Tyres should be filled with snap-on air valve and pre-set gauge. Heat introduced by hot water or lamps should be used to soften rubber for simple assembly. Special tables, fixtures and tools for subassembly should be used, together with special wood and rug-lined in-process racks to prevent paint damage. Two-hours bank stock at body drop.

In conclusion, probably in no other place in the factory can so much labour be saved for so little investment as in the trim shop, with the making of special tables and tools. It is recommended that tools and special devices should be made as needed, and the layout should be changed to place subassembly along the line, and to provide more space on line.

Layout

The problem now under consideration consisted in proposing the best layout for IMM in trim and chassis lines. A new layout and rearrangement of this area to place subassembly along the final line would reduce handling damage, have line speed control of subassembly, and allow for better line assembly and operational sequence.

Chassis assembly should be started with frame in upside-down position, and then turned over as proposed above in the section dealing with the chassis. The layout should be revised as recommended above to give more line width space and an assembly sequence that will reduce repair. Consideration should be given to the assembly of pre-painted fenders to grill, and final attachment of this assembly after body drop and firewall hook-up.

In conclusion, improvement in layout, tooling and assembly sequence should reduce labor, improve quality and lessen the repair required. It is recommended that the layout should be revised as outlined.

II. CAR PLANT

The two days' plant tour of the Dacia plant and four days' discussion was too brief to make detailed recommendations but potential areas of process improvement, cost saving and quality improvement were found and the suggestions are outlined below in the recommendations section.

The Intreprinderea de autoturisme in Piteşti produces, under a Renault licence, the Dacia 1300, which resembles the Renault 12 and has a 95% local content. The employment level is about 20,000, and annual volume, on a 3-shift basis is 70,000. A pick-up and panel van, both using the Dacia chassis and underbody, are also made. The pick-up uses the Dacia front end and body to the "B" (center) pillar.

The factory started in 1968 with CKD units of the Dacia 1100 (Renault 10). The royalty agreement expired in September 1976, but technical aid is still received. Vehicle sales have a six-month waiting period for all sales in Romania. About 30% of the production is exported.

The supervisor of all factory technical activities accompanied the expert throughout his visit to the factory. Ranking below the Technical Director, his title would correspond to master mechanic in the United States, except his work also includes product development. In the general meeting with the Technical Director, staff managers and production department heads, the one week spent at the Dacia plant was planned as follows:

Activity	Time (days)
General meeting, programme planning	½
Plant tour	1½
Discussions	
Die shop and design	½
Quality control and inspection	½
Body shop, welding, metal finish and fixture design	1
Product design, prototype development	1
Painting and paint equipment, final meeting with Technical Director	1
	6

Because of the limited time, some meetings were not held, and discussion of the various subjects had to be considerably shortened. The expert was able to spend only one week at Dacia, with the remainder of the six months at the ARO truck and bus plants, and had too little time to give detailed consideration to all the matters that required attention.

As requested, each group prepared a list of questions outlining their problems or areas in which discussion was needed. During the plant tour, a list of observations of potential cost savings and quality improvements was drawn up by the expert. The lists were combined to form the basis of a general discussion of the problems and areas involved.

Although the advanced know-how of Renault was obvious, Dacia has several areas where appreciable savings in cost or quality improvements can be made, some in common with the other vehicle factories. QA, spot-welding equipment, direct and indirect material savings, painting methods and paint - all these can be improved.

A. Findings

Because of the short time spent in this large industrial complex, analysis and discussion were limited to the areas of major potential improvements. Many discussions were only statements of principle or fact.

The product design discussions reviewed in some detail the principle of design to make maximum use of model interchangeability. To keep all daylight openings the same, but to permit variations in sheet metal contours at low die cost will allow for frequent styling changes in grille, lights, trim, and exterior hardware without costly tool changes.

Stress analysis may be by stroboscopic light, strain gage or plastic model. More involved programmes can use outside specialized services to help in equipment selection, equipment rental or other services. Mention was made of a reliable international group devoted to all phases of vehicle design and manufacture that was available to help. Crash tests, both destructive and non-destructive, were discussed, as were standards for dimensional limitations of master models, tooling aids, checking fixtures, production stampings and assembly of the body.

The means of estimating design labour hours for long-term programmes and how to co-ordinate the timing of all phases of a new model programme were reviewed. A brief time was used to outline new methods of drawing, drawing materials, blueprint filing and reproduction by using aperture cards.

Discussions of die design first included the prototype development staff in addition to the die design staff, because low-cost die-making methods were outlined (for further details see ARO die section).

Template die, steel rule die and Kirksite die making were dealt with, and the Dacia staff were impressed by the cost savings of 84% and 89% over standard methods. Time savings are equally large. The data will be reproduced and the methods put into use for Kirksite and steel rule dies.

The discussion of automated press loading and unloading was well received, with several recommendations on how to develop the programme. The need for an under-floor scrap conveyor was noted, for automatic handling of parts must be accompanied by automatic scrap removal. Use of inclined presses and air ejection of work piece and/or scrap was detailed. With automatic coil stock feeders, press availability could be tripled at a fraction of the cost of new presses.

Dacia's roller-leveller machine, not now in use, can be used with sheets of lower specification to reduce material costs. Better material handling between presses can be had with use of the roller or power conveyors, as shown.

Determination of the ideal size of metal run by means of unit piece cost graphs and storage cost graphs was shown. Both lines together add to total piece part cost at various volumes. The ideal theoretical batch size is then the target, but the number of presses, type, number of containers, handling equipment etc. may alter the ideal target size. Equipment should then be adjusted accordingly. Final discussion concerned the principles of material handling and the need for stock movement to be controlled by the Material Handling Department. The preservation of steel, in-plant and for CKD units, was outlined. There was no time to discuss general die design or controlled movement.

Body shop discussions started with a list of 19 involved questions from the Dacia staff and a similar list of proposals from the expert. Detailed coverage would require three to four weeks. Discussion centered on spot-welding, metal finish and soldering, the area of greatest potential cost saving and quality improvement. Newer equipment was recommended for spot-welding, including cellular transformers, coaxial welding apparatus, secondary cables and replaceable tip electrodes. With correct water cooling, savings up to 20% in the welding department power requirements may be possible. Cost figures were not available, but this is a very impressive goal. Welding cables normally last six to twelve months without maintenance, compared to weekly repair of present equipment.

The new design of capped spot-welding tips, according to figures of the Dacia welding experts, should save lei 58,000,000 annually in copper replacement cost, give better quality and simplify maintenance.

It was explained that the way to measure current flow and calculate pressure so that the welder can be set to proper value was not known. Such a determination would improve weld quality. Multiple press electrode, projection and automatic spot-welding was also discussed.

Solder cost reduction by using a better formulation with 5% antimony would save lei 24,255,000 over the 70-30 lead/tin formula now in use. The figures were based on 1972 prices. Today's savings should be at least 50% higher. Better metal finishing methods were quickly reviewed before time ran out.

The discussion of QC lasted four hours. After reviewing the fine points of the most critical inspection procedures, such as torque, body opening and spot welds, it was suggested that body and glass opening checking fixtures should be made. The QC Department organization is satisfactory, and the correct QA staff relationship was sketched on an organization chart.

A final QA system was explained. It offers the management a statistical measurement of quality, a means of determining the effectiveness of corrective action, and a check on inspection (see chapter II, section E, for details). The QC staff will obtain data from IMM. Finally, incentives to improve quality were discussed briefly.

Paint discussions lasted two hours. The expert's comments on the system for material and labour savings included the following: reduced use of mineral spirits; reduced prime thickness; less prime sanding by approximately 70%; paint savings by controlled thickness, less overspray and less sanding. A 20% material saving goal is not unrealistic, and savings could exceed lei 7,500,000 annually.

It should be emphasized that time limitations required discussions to be confined to the subjects of cost and quality. Many questions on planning, future expansion, use of more automated equipment, worker control and incentives, plus department reviews of trim, safety etc. were not considered because of insufficient time.

B. Recommendations

Recommendations made on the basis of a few hours' talk and a brief tour would be presumptuous. However, suggested measures for potential quality improvement or cost savings would involve the following:

(a) Use of independent consultants when purchasing expensive modern equipment;

(b) Use of low-cost die-making methods for prototype, die try-out and limited production;

(c) Automating press feed, stock and scrap removal, especially on small and medium presses;

(d) Modernizing spot-welding equipment for power and indirect material savings (20% on power, lei 58,000,000 annually on copper);

(e) Changing soler formulation (savings of lei 24,255,000 annually);

(f) Installing a QA system (to improve quality it must first be measured);

(g) Reducing paint consumption (goal of 20%, or savings of lei 7,500,000 annually).

III. TRUCK PLANT

Because of the variety of models and sporadic growth of the plant, the need to integrate, standardize and automate is pressing. This is no easy task for any truck factory, and Intreprinderea de Autocamioane Braşov (IABv) will require a forward planning programme both comprehensive and realistic to develop their future in the most effective manner. With a goal of 50,000 trucks to be produced in 1980, such a plan should be well under way. Because of the time limits, the expert could not analyse the above, and has limited his comments to only cost and quality aspects of current production.

The truck-building enterprise in Braşov has been producing trucks since 1954. The first products were CKD units with rapid change to local content, the design modelled after the Russian four-ton No. 101 unit. In 1960 this truck type was given up, the enterprise beginning with a new truck family of 2.5 t to 5 t, with a 140 hp, V8 gasoline engine. In 1971, under license from Maschinenfabrik Augsburg-Nürnberg AG (MAN), the modern-looking, wide, cab-over-engine diesel unit of 135 hp to 265 hp was introduced. The older standard cab gasoline engine still continues to be produced in both gasoline and diesel designs.

Of the 36,000 trucks built in 1976 in this factory of 26,000 employees, there were 23,000 diesels. Exported were 11,175 trucks and 2,300 separate diesel engines (a 1975 figure). Work in general is on a three-shift basis for manufacturing, and two shifts for assembly. In this factory complex there are foundry, forge and press shops. Axles, transmissions, diesel engines and frames are also made, as well as cab and final assembly.

It was agreed that questions from each department would be prepared while the expert toured the factory. Then a discussion schedule would be developed for a review of plant observations and factory problems.

After a slow beginning, interest developed at a high level, and more people of importance attended the discussions than at any other plant, all of them showing strong interest in the subjects dealt with.

A. Findings

The truck factory reflects the problems of a rapidly expanding plant that offers a great variety of models with gasoline or diesel engines and two types of cabs. With the largest employment of all the Romanian vehicle plants, some imbalance is to be expected.

The press plant, however, has much more inbalance than should be. Awaiting construction of an in-process storage warehouse cannot excuse the presence of aisle storage, scrap in aisles and on the floor, lack of containers for materials, insufficient material handling devices and need for better movement schedule of stock. The need to engineer not only the die design but also the material movement was explained and how to do it was discussed.

That the know-how exists is evident in the modern up-to-date movement of stock in the large press section. Here is found conveyorized scrap tunnels, conveyor stock movement between presses, co-ordinated die design and scrap disposal to allow a five-press continuous operation with minimum down time and good cycle time. It reflects competent and knowledgeable planning. But planning here has been at the exclusion of planning elsewhere.

The medium and small press areas are sub-standard and seem to be seriously neglected. The need to improve operations and reduce cost is great. The small press operations can be automated to a much greater degree with automatic feed by coil or strip stock, inclinable presses, air blow-out into containers via channel guides, and positive metal ejection of both punch and die.

The process of determining the degree of automation by cost analysis was shown, but there was some unfamiliarity with costing and economic matters. It is recommended that a small team should be developed and assigned cost analysis work. The designers can then be made aware of cost factors by percentages of die run, total pieces, labour, overhead etc. A time-and-motion group is also needed. Improvements in die loading/unloading should not be limited to new die designs, but each die now in use should be restudied on the basis of these principles.

The side frame die shop is good. Removable punches in the blank die may eliminate some special hole drilling, and quick-change chucks will speed up others. Although the design of a combined right/left form die was shown, no demonstration of the use of this knowledge was given.

The wheel plant was excellent in layout and management on the rim line. Flange manufacture can use automation in moving this heavy piece. A stacker-leveller, conveyors between presses and possible automatic load/unload may be economically justified.

Template dies, steel rule dies and Kirksite die-making are three low-cost die-making methods in common use in the vehicle industry, and were taught to the truck-plant staff. Cost savings of 84% and 89% were shown for blank and pierce dies, and the time saving to match. It was recommended that both methods should be put into use, and this recommendation was well received. This die-making is for low-run production, die try-out, blank development and prototype.

Spot-welding principles and theory and their practical application in the factory were reviewed. More modern equipment of the Hypercell transformers, coaxial cables for secondary current and cap electrodes of a new shape should reduce power consumption up to 20%, and save millions of lei/year in copper costs.

The first two factory spot welders tested were found to be poorly adjusted, and the spot weld was unsatisfactory. The method and frequency of testing was reviewed and correct adjustments explained. A review and better control of spot-welding is recommended. All controls should be inaccessible to the worker.

Use of automatic shut-off valves on gas-welding equipment may save millions of lei. Where to buy and how they work was explained. Metal inert gas (mig) welding is recommended over arc welding. Briefly the design principles of automatic mig-welding, press electrode spot-welding and automatic spot-welding was discussed.

Solder formulations were reviewed and annual savings in millions of lei were mentioned for other plants, but could not be calculated here, as the formulations were not known. The use of five per cent antimony in the solder was recommended and its method of application explained.

Metal finishing tools, methods and tests were reviewed. Grits of 80, 60 and 50 applied only at one metal finish section on the body line was recommended.

Line control of the amount of work each worker does, even at subassembly and material handling stations, was explained in detail. From here the need for a specific plant layout and jig and fixture design was developed, plus the argument in favour of hourly payment. Economic justification is the basis for all decisions, and, as this background is not normally part of the Romanian engineers' training, a cost analysis group should be formed to develop cost estimates for all major projects.

The decision as to the inspection devices needed for stamped parts, sub-assemblies and major assemblies is made by the process engineer (technician). The design of checking fixtures, die model take-offs, spotting blocks etc. is as much a part of the designer's responsibility as is the design of the tool, jig or fixture. Based upon experience, some checking devices are invariably used (windshield opening check), and others only when a problem arises.

Paint application is inconsistant and at times contrary to normal practice. Use of a high-brake enamel is good, but to clean and prime the chassis frame is not necessary, nor is priming the exnaust system. Wheels are insufficiently treated for there is no priming or cleaning. The gas tank should be terne-plate with chassis black only. No flash-off priming is used at touch-up, although it should be. Complete repaint for export should not be necessary, and extra paint should be added in the paint shop. Wax protection of single-unit pack (SUP) should be considered. Color paint is not needed inside doors, but special anti-rust treatment is, there and in other high-rust areas.

Paint savings of 10% are reasonable, and would save lei 1,500,000 annually in material, plus labour. It may be realized by the following means: using uniform thickness of coat; less overspray; automated spray; triggering the gun; less sanding; wages as high as required to get the best spray painters; eliminating unnecessary painting.

To reduce dirt in the paint all spray booths and ovens should be kept under positive air pressure and checked with a manometer gage. Spray booth maintenance should be improved so that "capture velocity" air flow is 50 m per minute. Tack rags should be used and water flow increased in wet sand to wash away loose paint, while sanding less. Air blow-off should be used inside the cab before it enters the spray booth.

Chassis black air dry paint does not normally need oven drying. Dipping of black small parts will save material and labour if it replaces black spray.

Discussions of trim and final assembly were held as one subject. First was reviewed the basic principles of plant layout, material handling, and time and motion study. From this dicussion the following recommendations emerged:

(a) Worker responsibility should be relieved and fixtures assigned whenever possible;

(b) Worker fatigue should be reduced;

(c) Time and motion analysis should be used for each operation;

(d) A distinction should be made between productive work and non-productive work, the latter being eliminated;

(e) Worker damage to vehicle should be eliminated.

Based upon these principles and the discussion in general, an analysis and reworking of both areas was recommended.

Although it was claimed that the above was known, there were in fact many unsatisfactory areas in these departments. They included dirty work areas with no place to dispose of waste; poor design or no storage containers; painted products stacked on floor; insufficient aisle space; crowded and disorganized appearance; lack of special stock racks; incorrect torque wrench use; incorrect assembly procedures; fixtures that scratched the product; and work out of station.

Much more work is done in final car conditioning than normal. To repaint the complete truck is not considered necessary. A road test should be done, but a 1½ hour run-in is not normal. At this point only assembly operations, not product design or component performance, should be checked.

Quality control discussions were in two parts. The first covered those important inspections upon which a quality product is based. How to inspect a rivet, a spot-weld, how to determine proper torque, all these are critical inspections and the correct technique was demonstrated. The second part concerned statistical quality audit and development of a quality index number to evaluate quality level.

Although the system is in use it appears that the data is insufficient to yield significant numbers in which management has confidence. It was recommended that the system should be further developed, on the basis of the expert's data, and expanded to 2% of all production until the data is accurate and generates confidence.

After final assembly it appears that inspection covers both the assembly process, a standard procedure, and product analysis. This later is not normal, and should be only an occasional check, if at all.

The discussions on CKD units took the form of general comment on a practical approach to the CKD process. Because there were no firm statements of CKD volume, number or size of plants etc., it was not possible to give specific recommendations on methods, costs or improvements.

In addition to general observations on CKD methods in many countries, the advantages of the following points were emphasized: base unit size on a 24 truck pack; box with 20 mm plywood and banding irons to minimize pilferage; vent box to minimize condensation damage; use of vapour-inhibiting paper (VIP), oil fog, plastic side and umbrella sheets to protect from rust; request of a nine-month order, first three months firm, updated each month; consideration of twin-unit packs (TUP) in addition to CKD; use of vaporizing pellets to protect metal from rust in transmission, engine, axle etc.; continual study and adjustment of CKD pack to control cost and product damage; for some models use of a four-unit pack.

In conclusion, it is realized that many of the expert's comments were known by the truck staff. However, many of these points were not applied in the production process. It is hoped that the factory management will look at each recommendation from a cost and quality viewpoint, and support their use wherever possible.

B. Recommendations

The main recommendations involve action to achieve the objectives indicated below:

Press plant and die design

Keeping aisles clean, disposing of scrap, and moving stock containers as soon as filled in all parts of the die shop;

Automating medium and small dies;

Automating material handling in all areas;

Altering all dies in use, not just new designs;

Developing a cost analysis staff;

Improving material handling of wheel flanges;

Installing a Kirksite foundry and die-making area;

Making steel rule or template dies;

Body shop

Using Hypercell transformers, coaxial cables and cap-tipped electrodes for spot-welding;

Improving spot-weld testing and equipment adjusting;

Having automatic shut-off valves on all gas-welding torches;

Changing to low-cost solder formula;

Changing metal finish grinding process;

Considering hourly worker payment;

Developing a cost analysis group;

Process engineering of inspection devices as required;

Paint shop

No priming of frame or exhaust system;

Improving wheel painting system;

Ensuring that the gas tank is chassis black over terne-plate;

Stopping export repainting;

Carrying out anti-rust treatment where required;

Reducing material cost at least 10%;

Improving maintenance of spray booths;

Keeping ovens and booths under positive pressure;

Sanding less, using more water;

Dipping black chassis parts;

Saving utiliites by air-drying, not oven-drying, of chassis;

Trim and final assembly

Restudying and rearranging both departments as discussed;

Reducing work of final testing as discussed;

Quality control

Spot-checking spot-welds and rivets until both are consistantly good;

Checking over-torque as well as under-torque;

Using separate inspection tools;

Checking always for wrong parts;

Installing a workable and reliable quality audit for final assembly;

Developing department audits along similar lines;

After final assembly, distinguishing between inspection of the assembly activity and making a product design analysis;

Road testing;

Eliminating complete repainting for touching up inspected defects.

It is not possible to make recommendations concerning CKD units and export boxing, as CKD activities were not observed and no information about CKD plants was obtained. Some suggestions or guidelines on CKD units are included above in section A.

IV. BUS PLANT

Of the four Romanian vehicle plants visited, Autobuzul is in greatest need of updating manufacturing techniques and quality improvement.

Although the plant layout and material flow has much to recommend it, the technical engineering, again, is ahead of material development and worker incentive. This has affected the quality of the commercial vehicles with regard to spot-welds, painting and assembly.

Time limitations confined discussion to fundamentals of proper technique, major improvements required, and review of specific problems. To correct conditions and improve manufacturing know-how will necessitate a prolonged effort and appreciable monetary commitment.

The Autobuzul-Work is a manufacturing complex of approximately 7,000 employees engaged in the manufacture of buses and utility vehicles for 20 years. The following four bus models are built with two types of bus bodies:

Model 112 UD: an urban 12-meter 192-hp diesel-engine, centre-mounted bus with a centre and two end doors. It has a capacity of 110+1 persons with 27 seats;

Model 112 E: an electrical driven trolley-bus with the same specifications as the 112 UD;

Model 109 RD: an inter-city bus, 9 m long, with a 135-hp diesel engine, made in Romania under a Saviem license, having a capacity of 43+1 persons;

Model 111 RDT: a de luxe inter-city bus, 11 m long, with a 192-HP Diesel engine. Its body is similar to the 109 RD but longer and with better appointments

The utility vehicles use the ARO engine, gearbox and rear axle, all mounted on a rectangular tube frame. With a choice of diesel or gasoline engine and two or four-wheel drive, the models listed below in total options come to 37 variants. The models are:

TV 12-A	chassis cab
TV 12-FI	service van
TV 12-F	delivery van
TV 12-C	pick-up (or drop-side)
TV 12-M	mini-bus
TV 12-S	ambulance
TV 12-FS	extra-tall delivery van

Annual volume is approximately 4,000 buses and 11,500 commercial vehicles a year. Production is on a three-shift basis. The bus works started 20 years ago and commercial vehicles were introduced several years later. Both products are currently manufactured.

Arrangements for the expert's visit were similar to those for the other vehicle plants, a list of questions being submitted by each department to outline their interests and a list of observations being made by the expert. These two lists served as a basis for discussions designed to outline fundamentals and review latest applicable technology, develop recommendations and suggestions for improvements where observations showed such to be needed, and answer all written and oral questions by the truck staff, to the full extent of the expert's knowledge.

A. Findings

Because of the short time at this factory, general discussion was directed to commercial vehicle production. Bus manufacturing techniques were reviewed as general manufacturing principles applied (i.e. welding, forming, painting etc.), but time was insufficient to make a critique of bus plant layout and assembly methods.

The quality level of the commercial vehicles is below that of other Romanian vehicle plants. Bus quality is at a similar level. It may be sufficient for the bus trade and for product use in this area, but there is much room for improvement, even in matters such as housekeeping maintenance, tooling quality, and the demeanour and dress of the worker.

Of five production spot-welding guns tested, four had the welds break apart, and the fifth had a weld 16% of its normal size. Paint is applied on rusted metal without first chemically neutralizing the rust. One painter walked backwards on a van roof, spraying the final colour coat directly over his boot prints. No torque wrench could be found at final assembly to check such critical safety items as axle "U" bolts, wheel nuts and steering linkage nuts. Hand-push spot-welding guns, a poor welding substitute, are used extensively for bus body welding, even where standard portable welding guns could be used. Eye protection safety violations were frequent. Men walked on outer skin sheet metal panels and dragged them on the floor, despite the possibility of dents or metal finish damage.

On the plus side, the plant layout is generally good, the material flow well thought out, and the workers more conscientious than in some other places. Fixture design seems well thought out, although accuracy of metal, fixture, and final assembly is questionable because of the inordinate amount of hand fit at assembly.

The plant, like other Romanian vehicle plants, needs a production supervision group that can assure that the worker works to standard. The supervisory training programme recommended elsewhere is certainly needed here. Additionally, an effective quality control group that can define good quality and insist on getting it must be developed. Better tools and more accurate fixtures can be provided by a step-by-step detailed process improvement study. Modernizing the welding equipment will save money and improve quality, if production welding inspection is correctly carried out. A team spirit of co-operation and mutual responsibility, if developed, can and should go far in quality improvement and reduction of labour cost, both of which are necessary steps to increased production.

To aid in the above the expert asked for broad attendance at a series of meetings in which fundamentals were reviewed, production defects violating these concepts were shown by specific examples, the way to correct these defects was outlined, and specific engineering questions were answered.

A summary of these discussions is given below including conclusions and recommendations.

The die shop discussions were limited because not all the die plant was shown. Volume here does not justify automated handling between large presses, although these devices were considered. More automated part and trim ejection for small and medium presses is recommended. Material handling was acceptable. Low-cost die-making is especially valuable for the limited volume runs in this factory. They will probably use the Kirksite and steel rule methods recommended. Template dies were reviewed also.

It was concluded that the die shop is acceptably run for this volume. Low-cost die manufacture is especially valuable here and should be used. Complicated draw dies, till now made outside this country, will require more design knowledge and a copy of the Die Design and Construction Manual should be studied. Not discussed because of time limits, it is questionable whether sufficient panel measuring equipment is on hand.

In the body shop spot-welding equipment should be updated with new guns, coaxial cables, cellular transformers and cap electrodes. This may reduce power costs by 20% and save 90% of electrode costs.

Weld quality needs improvement. Upon testing five guns, four had no weld, but mechanical bonds only, the fifth had a weld only 16% of its normal size. A revised programme of testing and gun settings was recommended, and welding theory explained.

Push-gun spot-welding is a poor substitute. Probably 80% of all bus welds are made with push guns, whereas most could use "C" guns, as recommended, for a considerable improvement in quality. Mig welding can be with heavier wire, to reduce time by 50%. Using CO_2 is normally adequate, and cheaper. Gas welding torches should have automatic shut-off valves on the handle. Soldering irons can have built-in heaters of natural gas.

The new solder formula will reduce cost by a 6:1 to 10:1 ratio, for up to 90% cost savings. Metal-grinding discs should be 50, 60 and 80 grit. Maintenance is important, as outlined, with filters and oil lubes in each line.

Fixture design to the principles outlined will give accurate sheet metal. Good surface plate measuring is required in addition to checking fixtures, spotting models and other tool aids.

Improvements in the body shop can be made if the proposals discussed are put into effect. The need to learn and use time-and-motion-study principles was emphasized.

Paint discussions were influenced by the following two facts: paint equipment and paint quality are unsatisfactory; and present processes are not likely to lead to much improvement.

Efforts were recommended (also for the whole industry) to develop a wet-on-wet two-colour primer/filler with bake followed by a wet-on-wet colour and bake. This is to replace the four-bake system now in use. Using prime under black was questioned. Recording temperatures are necessary to establish correct time/temperature baking periods. Less wet sand and more water should be used. Masking with pre-applied tape on paper will save labour. Better van cleaning requires spray application of white spirits inside and outside. Doors should be held open during cleaning. Men and equipment should be prevented from touching wet bodies after prime dip. Airless guns for deadener and electrostatic for bus frames will save materials. Dirt should be removed before spraying to keep dirt out of paint. A platform for van roof spray will eliminate the need for the painter to walk on the roof. The best painters should receive wage incentives.

The QC discussions revealed that the Department reports to the Technical Director. It is recommended that this group should report direct to the General Director.

Upon review of the major inspection processes the following recommendations were made:

(a) Spot-weld inspection should be frequent enough to ensure 100% quality welds and not have four failures and one only 16% of normal as found by the expert;

(b) A Tinsley paint thickness gauge should be provided to paint inspectors;

(c) The inspectors should learn how to evaluate metal finish properly and reject all poor quality;

(d) Sufficient measuring equipment should be provided to check metal dimensionally and plastic models should be provided for complicated panels.

When it was noted that no torque wrenches were available anywhere on the final lines, QC stated that torques were checked after road test. However, it should be noted that many torques cannot be tested after assembly, and by testing soon after assembly defects can be corrected sooner.

The recommended QA procedure may have to cover more than 2% of production to get statistically significant figures in this relatively low-volume plant.

There is room for impressive improvements in quality on these plant products, and it was recommended that the suggestions made should be given careful consideration. Unfortunately the limited time available resulted in statements of opinion rather than detailed discussion.

The discussions of trim and final line were delayed. After reviewing the principles of plant layout and time and motion study appropriate suggestions were made based upon the expert's observations and class questions.

It was proposed that future design should include the line made flush with the floor and based upon the principles discussed. High-cycle electric tools should be replaced with air tools. All power cords should be shortened and kept off the floor. The foreman should keep workers at their station and analyse jobs to eliminate non-productive work. Special lighting will improve quality. Housekeeping and planning , especially at bus door assembly, needs improvement.

All nuts should be set to specified torque and inspected on the line. Correct torque is very important, and torque wrenches should be obtained to ensure this. All fluids should be added at one station, and all assembly done on the line to reduce repair operations. Trim should be gang cut with paper marking patterns to reduce labour and scrap. There should be no hand-stacking; containers should be used. Axle "U" bolts and wheel nuts should be pulled to torque uniformly. There should be more bench subassembly on wire harness and instrument panel, with quick disconnect joints. Wheel assembly should be improved using process and fixture sketched and conveyor delivery deserves attention. The road test should be shortened and only assembly checks, not product checks, made. Bus flooring should be accurately welded and wood cut to a pattern for simpler assembly.

In the discussions on CKD units cubic savings were noted if the frame is shipped knocked down, skids are removed from the boxes, and box braces are put inside. Terms were defined and reasons to ship SUP, CKD or TUP were discussed. Metal rusting can be prevented by venting, desiccant, VIP paper, plastic umbrella sheets, oil fog, or vapor pellets.

The principles of plant layout and building construction guides were reviewed. Column spacing and cross-section of the line area was defined. New methods of making drawings and new storage and printing were discussed.

The use of a cost analysis team and a time and motion study team was outlined, and it is recommended that both should be formed. The principles of the time and motion analysis were explained, and it was recommended that all technologists should learn this science. The need for team action was shown, and the supervisors were advised to contribute to the joint solution of any problems which might arise.

B. Recommendations

The recommendations call for action along the following lines:

Die shop and design

Using low-cost die-making methods where possible;

Unautomated material handling between large presses;

Studying the recommended die design manual;

Altering old and designing new dies for automatic part and trim ejection;

Obtaining adequate panel measuring equipment;

Body shop

Modernizing spot-welding equipment;

Revising spot-welding testing and adjustment to improve quality;

Forbidding workers to touch welding controls or dress electrodes;

Using automatic shut-off valves on gas welding torches;

Using natural gas and different torches for soldering;

Changing solder formulation;

Improving health protection on line by properly ventilated booths;

Using 50, 60 and 80 grit discs;

Obtaining adequate measuring equipment for panel and body assembly;

Using fixture design principles outlined;

Learning and using the science of time and motion study;

Paint shop

Developing wet-on-wet two-bake system;

Improving quality level;

Installing recording thermometers;

Improving wet sand technique;

Using automatic system to put tape on masking paper;

Using spray gun for white spirits;

Improving prime dip equipment;

Using airless and electrostatic guns;

Building platforms to keep painter from walking on the products;

Paying top wages for best men;

Quality control

Changing QC Department reporting from the technical director to the general director;

Improving inspection of spot-welding, metal finish and paint thickness;

Buying paint gauges;

Buying metal measurement equipment and plaster of Paris contour gauges;

Torque checking on assembly line;

Using separate torque wrenches from production;

Starting the QA procedure;

Improving plant quality standards;

Trim and final lines

Promoting positive job attitudes among employees

Improving line design and changing to flush-to-floor concept;

Changing to air-driven power tools;

Cutting trim with gang knife to pattern lines;

Improving lighting;

Improving housekeeping;

Using torque wrenches on all nuts;

Shortening road test;

Developing team action;

Material handling

Forming a Cost Analysis Department;

Forming a Time-and-Motion Study Department;

Having engineers study time and motion;

Using new plant layout drawing methods;

Considering CKD, TUP and local body manufacture for export;

Saving cubage with box redesign and KD frames;

Venting box to prevent rust.

V. FOLLOW-UP ACTION

Fellowships

The recommendation was made that four fellowships should be offered to IMM, averaging three or four months each. They were to be for one senior staff member in die design, one in product design, and two in process engineering. Further details are given in the mid-term report on this project.

UNIDO has concluded that funds for such a project must await a more propitious time.

Foreman training

The need for foreman training is acute. The recommendation was also detailed in the mid-term report on this project. A specialist fluent in the language should conduct a plant-wide foreman and supervision training programme, with follow-up and on-site observations, until the supervisory staff is able to assume responsibility for leadership on a continuous basis.

Aid to the vehicle industry

Mastery of the technical aspects of vehicle manufacture has outpaced the development of managerial techniques. There is still ample room for technical improvements, and many of the technical recommendations made should be on an industry-wide basis. But additional UNIDO aid, if forthcoming, should be extended to the Romanian industry with the following points in mind.

A foreman training programme would benefit the complete industry. In those plants where the production line controls worker output the worker is better regulated, but supervisor training is needed industry-wide.

Line control of worker output is the key to further industrial advances and high-volume production. To achieve it will require the following: a change from piece-work payment to hourly payment; material handling concepts based upon production line control; production scheduling for a uniform model mix at constant line speed; and a plant layout based entirely on line operation.

It is recommended that any further aid given to the Romanian vehicle industry should be along the above lines as much or more than for individual technical projects. Fellowships in production control via the production line, and material scheduling, both recommended in the mid-term report, should still be considered. Alternately an expert in this field should visit Romania.

A follow-up visit several months from the end of this project should also be considered. The factories have stated their intention to act on the UNIDO recommendations. To see the progress made and to assist in overcoming future stumbling-blocks sure to develop would make such a visit worthwhile.

Annex I

PROPOSED CHANGES FOR IMM FACTORIES

The changes proposed for the IMM factories are presented below, together with a statement of the reasons for the proposals and comments relating thereto.

Proposal	Reason	Comment
Die shop		
Tilt small presses on angle where possible; buy presses made for tilting	Better piece and scrap disposal; faster operation; labour-saving	Channel scrap and parts direct into separate containers; use air or mechanical ejection; use automatic feed
Install automatic feed units	Greater press utilization; labour-saving; safety	Cost savings will justify investment; best safety device is to remove the operator from the press
Add scrap cutters, automatic ejection of piece and more positive locators to present dies	Labour saving; faster operation; better press utilization	It is estimated that a 50% increase in press availability is possible by decreasing total cycle time
Improve preventive maintenance; direct die to repair as required by press shop manager or on a time schedule	Faster operation; less labour and scrap; better safety; less costly die repair	Dies not operating perfectly slow the operator, may break, and invite poor safety practice
Improve material handling in die shop by:		
(a) Special die setters and approval of first piece from press;	(a) Accurate pieces;	(a) If first piece is correct, run will be correct;

Proposal	Reason	Comment
(b) Special time-and-motion study expert to arrange feed, stamping and scrap disposal locations	(b) Reduces total cycle time and labour, increases press availability	(b) Currently biggest loss in die shop is due to excessive labour time; this time loss is not necessary, and its elimination can increase press availability up to 50%
(c) Select container for stamping to prevent fall-out and overload	(c) Less damage to parts	(c) This prevents part damage
(d) Schedule quantity in containers to match production schedules	(d) Less part damage; faster staging of production parts	(d) Loss time and part damage caused by worker unloading limited pieces from a large container
Provide follow-up and die correction to correct all dimensional inaccuracies in piece parts	Faster production; better quality; positive assembly	Assembly inaccuracies result from incorrect piece parts. Hammer corrections cause extra labour and metal finish. All stampings must be dimensionally correct
<u>Trim line and trim subassembly</u>		
Rework line to give space around body for operator and stock; move subassembly operation to line for line flow control	Improved quality; reduced repairs	Trim subassembly department can be eliminated, and these operations performed alongside the line; line time can be balanced with subassembly; move line into trim department

Proposal	Reason	Comment
Spray headliner and metal inside roof with adhesive from spray gun; when tacky (sticky) install headlining	Improved quality; reduced labour; saving of material	Adhesive spray application saves the material normally dried on can and applicator; this can reduce consump- up to two thirds
Provide small bench or seat inside body for worker as required	Improved quality; labour-saving	Comfortable workers who are not tired do faster and better quality work
Cover buttons of workers with coverall coat	Reduced repairs	There will be fewer scratches
Provide pocket aprons for workers to carry small stock parts (bolts, nuts etc.)	Reduced labour	This lessens number of trips to supply station
Provide portable tool kits for hand tools and stock	Reduced labour	As above
Locate supply lines for air and electrical tools above workers head	Improved safety; longer tool life	No hoses or power cords should be on the floor; add filters and oil lube to air lines
<u>Body shop</u>		
Use automatic gas weld shut-off valves on torches	Reduced cost; increased safety	Savings of over lei 100,000 yearly may result
Use eye protection for spot-welding and grinding	Increased safety	This is a very bad safety defect
Close all clamps while welding; use all clamps	Improved quality	Poor fit and extra labour result when fixtures are used improperly
Use fixtures for all assembly	Improved quality	No visual alignment can be allowed for accurate body construction

Proposal	Reason	Comment
Build body to exact dimension, including underbody	Improved quality; reduced labour	If dimensions are held in the body shop and the frame shimmed at final assembly, all dimensions should be accurate after car is completed
Use accurate body trucks in body shop to ensure manufacturing accuracy	Improved quality; reduced labour	Underbody must be accurate during door and glass opening welding and adjustments
Redesign body shop for better flow, more accurate assembly and reduced labor; change type of final line	Improved quality; reduce labour providing for future expansion	Complete new layout using modern body assembly methods will improve quality, reduce labour and provide adjustment for future expansion
Train workers to do quality work; pay by hour	Improved quality	Workers work fast but not well
Start follow-up for bad metal fit; check all dies and fixtures; use hammer only when necessary	Improved quality; reduced labour	Unnecessary hammering and incorrect use of fixtures result in poor quality and extra labour
Do all metal finish on final line except for blind panels	Improved quality; reduced labour	This highest skill of all body shop jobs should be reserved for specially trained men and special equipment
Use three grinders of 50 to 60 and 80 grit to metal finish after hammer and file work	Improved quality	Modern practice follows this pattern for best results
Suspend gas and air lines alongside the line with periodic take-off units	Longer tool life; improved safety	The benefits of good organization will last many years

Proposal	Reason	Comment
Fixture design and use		
Use bushed toggle clamps	More accurate; longer life; better quality	Can be reused for many years
Use bullet-nose pins, and panel lead-in guides	Less panel damage; time-saving	Faster, easier loading and less product damage results
Spot-weld in main assembly fixture	Faster assembly; more rigid body	Use roll-away or swing gate design
Use locating clamps on all assemblies	Improved quality	Accurate location requires fixtures with all clamps closed
Use drill jigs	Improved quality	Drills can run off alignment if only centre punch marks are used
Make special metal finish tables and stock racks for doors, hoods, and rear quarter panels	Improved quality, time-saving; better material flow	Keep all panels off floor; have special tools available
Make a preventive maintenance schedule for fixture test and repair	Longer life; improved quality	Fixture wear must be repaired; removal of clamps or readjustment must not be done by unauthorized persons
Design gas tank assembly fixture and weld tanks in ARO	Save transport cost and storage	Stack by nesting each stamping; weld as required
Design more operations in each fixture	Labour-saving; improved quality	Less handling saves labour and will cause less damage

Proposal	Reason	Comment
Paint shop		
Design automatic paint spray for wheels	Material and labour saving; improved quality	Overspray of (estimated) 70% can be reduced to 30%; paint deposit is more uniform
Adjust air pressure, thinner, and spray technique to remove orange peel	Material saving; improved quality	Air pressure is high, causing orange peel; thinner is not wet enough to permit flow-out; gun spacing may be incorrect
Train worker to thumb gun	Material saving	Estimated 15-20% reduction in overspray is possible
Improve painting technique, stiff wrist, overlap, and trigger gun	Improved quality; prevention of rust; material saving	Uniform deposit permits correct paint thickness to be held
Place air and paint gauges on lines for adjustment by operator	Improved quality	Different panels and paints require different settings
Consider spraying hood while on car	Saving oven space and utilities; less repair	Separate oven space is not required. Many plants do this
Reduce booth working area	Saving maintenance and utilities	Use and filter only the space needed
Improve maintenance and paint shop cleanliness	Improved quality; reduced labour and repair	Dirt in paint comes from dirt in the paint shop
Keep body clean and free from finger marks, for they cause rust	Improved quality; reduced rust	Use gloves to touch bare metal; use pull bar to move body truck
Improve body hoist hook	Improved quality	Incorrect hoist will permanently distort body

Proposal	Reason	Comment
Check time/temperature chart for oven bake; reduce temperature if possible; increase oven load if possible	Improved quality; saving of utilities	Oven should have maximum utilization, whatever the line speed
Wet sand for cleaner paint	Improved quality	Prime coat sanding can cause dirty cover coat if left on job or in air
Change sanding technique by scuffing sand only, moving fingers side ways	Save material; improved quality	Excess sanding wastes material and labour. Do not sand in ridges with fingers
Repair inspection lights	Improved quality	Of 96 lights in fixture, 19 were not working. All were dirty
Rework and touch-up station at end of paint line	Improved quality; reduced labour	It is easier to repair paint defects in the paint shop than at final conditioning
Make hood supply racks	Labour saving; reduced repair	Floor storage causes damage; racks for transport and storage reduce handling labour and damage
Move tyre assembly fixture to centre of area; use pallets for wheel and tyre transport; move with fork lift, or by gravity track to final line	Labour saving	Transport to line can be by elevator hoist and roll rack to final line
Seats should be placed in special racks that can be used for transport, storage and line supply	Reduced repair; labour saving	Single unit handling requires considerable labour and invites damage, and the rack at the final line is still needed; racks can be covered in storage

Proposal	Reason	Comment
Final line		
Check all frames for body shims after wheel mounting	Better quality; reduced product failure	Body is built to dimension; shim is adjusted to frame distortion
Subassemble rear axle off line, tyres included	Better material supply	Material flow is improved
Assemble, with frame turned over, axles brake system, muffler, gasoline lines, hand-brake cables, and drive shaft; then turn right side up	Reduced labour and cost; simplified assembly	Makes for easier access and faster assembly
Move subassembly operations adjacent to final line	Improved material flow; balanced labour; line control	Operators can balance subassembly and final line labour as required
Make stock racks for hoods	Reduced paint repair; improved quality; labour saving	All stock set on floor will require double handling and will have paint scratches
Pre-spray roof inside and headliner; when tacky, apply liner without special clamps	Improved quality; reduced labour and cost	This is the normal procedure in modern factories
Use supply racks for front axle	Improved quality; less labour	Less damage and labour with less handling
Processing and material handling		
Create staging area for body shop supply	Improved quality; reduced labour	Less part damage and labour will result with a section of the storage area devoted to material supply; assembly labour will not affect supply containers
Store piece parts in quantities to agree with production schedules	Improved supply procedures; reduced labour	This will extend line control to supply of body shop; for small pieces transfer to smaller containers so that supply in body build is in containers by specific numbers

Proposal	Reason	Comment
Keep all panels in racks or bins and off floors	Improved quality; reduced labour	Eliminate double handling and damage by moving panels to fixture, and then to racks; move full rack of group of assemblies as required; rack is both transport and storage unit
Make racks for painted pieces as hoods etc. for storage and transport to assembly area	Improved quality; reduced labour	Rug or padded racks prevent paint damage
Product design		
Issue new models, i.e. 2400-A, 2404-A etc., with two-wheel drive, no towing hook, reduced cost transmission and other changes to provide a car/pick-up vehicle for on-road use only	Reduced cost	Current design, suitable for military and off-road use, is over-designed for many customers
Use vapour degreasing for frame and other stampings	Cost reduction	Better results, less utility consumption, and recovery of processing materials
Reprocess frame	Less distortion	Spot-weld open hat section members to reduce heat; close hat as final operation
Redesign frame	Lighter; less distortion	Manufacture to open "C" design; no spring back distortion
Hood design: spot-weld inner hood to outer at side flanges	Reduced metal finishing	Redesigning of innerhood required
Side glass: use special tools and racks at assembly	Reduced labour; paint protection	

Proposal	Reason	Comment
<u>Spot-welding</u>		
Modernize equipment:	Reduced utility and other costs;	Use of an out-of-date welding system is costing money daily in the form of higher electrical cost, slower work, more maintenance, shorter equipment life, and lower quality
(a) Buy cellular transformers, without stacked cores;	Improved quality; longer tool life	
(b) Buy coaxial cable, not double cable;		
(c) Buy capped electrodes (removable tips);		
(d) Make adjustable cooling tubes for tips;		
(e) Flow water in cable bottom and out top;		
(f) Flow four gallons (five litres) of water per welding unit;		
(g) Buy welding guns, do not manufacture;		
(h) Flow water in one of four paths to cool as required;		
(i) Have open return in water cooling system;		
(j) Insulate copper as required to prevent shorts		
<u>Maintenance</u>		
Remove water from air lines	Better paint; longer tool and pipe life	This involves after-coolers, down drop drains, storage tank drains, and take-off from top of line

Proposal	Reason	Comment
Remove air hoses and power tools from floor	Improved safety and house-keeping longer hose life; less power drop	Suspend air pipe 2.3 m off floor and have air take-off from top of pipe
Add filter and lube to all air take-offs	Longer tool life; better pressure	Standard design in good factories
Repair floor	Improved safety; less product damage	Use engrained block
Clean paint shop; reduce operating size of spray booth; improve maintenance schedule	Quality improvement; less maintenance; more effective operation	Dirt in paint comes from dirty shop; air flow in booth is ineffective because of dirty booth; full size not needed, reduced size will require less maintenance
Set timer of welding guns to recommended power and trim tips as required	Improved quality; longer tool life; lower cost	Tip failure has many causes. Only maintenance should trim tips, and only after checking and correcting failure cause (i.e., timer setting, water flow, pipe length, etc.)
<u>Export boxing</u>		
Add ventilation holes in end of boxes, and have open cracks in floor	Reduced rusting	Rusting, other than direct water damage, is caused by condensation; proper ventilation removes much of the moisture in the air
Make boxes of plywood	Reduced rusting	All modern boxing for CKD units now use plywood
Make braces of 1" x 4" not 3" x 3"	Increased cubage	Gives greater inside space

Proposal	Reason	Comment
Use VIP to absorb moisture, or use dessicant	Reduced rust	Between metal panels where ventilation is poor moisture must be absorbed
Box and ship in sets of 24 CKD units	Standardized boxing; reduced cost	Large items can be put in one, two three, four, six or twelve boxes, all the same size
Eliminate oil dip for rust protection	Material saving; cost reduction	Use oil fog spray in box while loading and before closing (use paint gun set-up)
<u>Material savings</u>		
Reduce paint overspray	Material and cost savings; maintenance savings	It is estimated that 15% of annual paint cost can be saved with better paint practices and automated wheel painting
Reduce oxygen/acetylene welding-gas consumption	Material and cost saving	Use of automatic shut-off valves in hose lines or on torch, a lei 6,000 investment, was estimated to save lei 213,000,000 over a 20-year period
Reduce mastic and adhesive use	Material, cost and labour savings	Use of pressurized hose with nozzle or spray gun application prevents evaporation, saves labour and materials and improves housekeeping; it soon pays for investment
Reduce oil use for export boxing anti-rust protection	Labour and material savings	See last entry in export boxing section

Annex II

MINUTES OF DISCUSSIONS

The minutes of all meetings, lectures and discussions involving the expert are presented here in brief, concise form, with a statement of the problem, a summary of the discussion, and a presentation of the oonclusions and recommendations. For brevity, drawings and sketches are not included.

A. Design engineering

Frame and unitized body construction

Problem. Review of the construction principles, advantages and disadvantages of passenger car design of unit body construction (monocoque) without frame, and of design with frame.

Discussion. Advantages of frame design, such as ease of assembly and repair, lighter body construction etc. were listed, as were those of monocoque design, which are more numerous. Analysis of stress followed. Stress generation, expressed as $S = M \times V$ and related to a constant maximum velocity, increased as the mass increased ($S_M = M\uparrow \times V$). The monocoque design is limited in stress absorbtion by inner and outer body size, practical metal thicknesses and cross-sectional configuration.

Conclusions. Smaller cars are more suited to monocoque design. The bending moments of a heavy frame must be replaced by the larger but thinner metal of the body shell, and special rocker cross-sections.

Recommendations. As ARO vehicles are borderline in size between frame and no frame, a semi-frame or "wishbone" type design should be considered.

Body design and mounting for vibration and stress protection

Problem. How to design and mount the body to the frame with suitable stress and vibration absorbtion, and how to prevent current failures and weld ruptures.

Discussion. Analysis of springs and shock absorbers, springing methods, and related sway bars was made, for this determines the amount of stress introduced into the body. The mounting brackets and absorbent rubber material were considered for size, design and composition. A visit to the production line and review of drawings helped define the problem. Several possible designs were considered.

Conclusions. Redesign of body mount brackets to distribute the stress over a wider area is desirable. The rubber is too soft, and fiber reinforcements are to be considered. No mount is at the maximum frame bending moment, and an extra mount inside the frame there should help. Additional strength can be obtained inexpensively by reinforcements from rear of rocker panel to the rear floor.

Recommendations. Testing should be carried out along the following lines:

(a) Using harder durometer rubber, possibly with cloth reinforcements;

(b) Widening the underbody mounts at mounting area to reduce stress concentration; redesigning one mount;

(c) Adding additional mount inside frame at point of maximum frame bending moment, if shown to be necessary by testing.

Analysis of modern body design techniques and typical sectional joining methods: their effect upon tooling

Problem. Selection of optimum sectional design for best sealing, tooling, assembly and cost.

Discussion. The method of body assembly and tooling techniques normally dictate the design of joining sections of sheet metal. Analysis of typical sections of several vehicles were made. Metal welding and finishing practices also determine sectional design, and discussion on their influence clarified design purposes. Body assembly history, in part, dictates design.

Conclusions. Knowledge of historical assembly practice including the newest automated methods permit design concepts suitable to present volumes and equipment, while providing for future improvements. Joint design and assembly methods are proposed primarily by the die and welding engineers. All efforts are directed to minimum costs.

Recommendations. Joint discussions of design, tooling and die engineering should be the basis of specific joint sectioning. Decisions must be based upon knowledge of future volume, tooling technique changes and detailed cost analysis.

Vibration and sound deadening in modern design

Problem. Analysis and selection of the optimum design for sound and vibration control.

Discussion. Vibration of sheet metal is controlled by ribbing and/or introduction of compound curves into the design. Vibration frequences are effected by mass, and application of mastic to the center of a panel will reduce vibration. Increase of the bending moment reduces vibration. A sound absorbent material inside a metal sandwich effectively does this. Good examples are modern hoods or roofs with both inner and outer panels incasing a jute-based noise and thermal barrier. Vibration materials selected should be high in sound absorbtion characteristics.

Sound absorbtion is primarily by the dissipation of energy within a small cell. The cell wall design transmits sound, so it must be thin and constitute a low percentage by volume. Thermal barriers are improved if the cell structure is closed.

Road noise levels of high decibel ratings cover vehicle sounds. Modern design with climate control within an enclosed body require much greater sound absorbtion. This high level of door and window seal makes desirable power operation of these devices.

Conclusions. Product design and mass can adequately control vibration. Vehicle sounds are partially overcome by road noise in canvas-covered or open designs. Sound, heat and vibration materials applied to sheet-metal are of limited use unless window and door seals are substantial. Engine noise can penetrate the body indirectly through hood or inner fenders into glass or door materials, and especially through inadequate seals. Solid materials transmit sound with little or no reduction.

Recommendations. Design should be in accordance with the basic principles outlined. Acceptable customer levels should be determined and applied.

Modern corrosion protection

Problem. Analysis and selection of optimum corrosion protection, consideration of materials and application techniques.

Discussion. Need for protection is in proportion to the forces generating corrosion. Protection begins by proper metal cleaning, for deposit of protective materials on soil or foreign substances will not protect metal surfaces underneath. Rust or extra heavy soil must be removed by hand if the amount exceeds the system capabilities. Zinc and iron phosphates are used for sheet metal protection, with the higher cost zinc normally used on cars and iron phosphate on trucks. Correct application is mandatory, and a demineralized water rinse normally required. Galvanized plated metal can be used in areas of high corrosion, but requires different welding techniques, and paint adhesion is difficult.

Primer, filler - wet on wet - and colour coat paints of many types and quality are available and their various advantages were reviewed. The tremendous progress in application techniques, some recent ones now in disfavour, were also evaluated.

Sealers of mastic, plastic, epoxy etc. can be applied to the body at the most advantageous moment, and weld-through sealers are extremely useful. Some areas may require several separate protection methods, including special paints. Design techniques to prevent corrosion include stud welding, epoxy joints, chrome strips or other added protection, material changes and plastic or hard metal-plate covering techniques.

Conclusions. Vehicles exported to extreme exposure conditions require a high degree of protection. Defects are so obvious that they affect product reputation. Equipment ensuring positive performance is necessary for a quality product. Product testing, material tests and a goal of continued improvement, coupled with new material and technique analysis is the mark of modern management.

Recommendations. Service statistics and direct field analysis to evaluate problem and prompt improvement where and how required is necessary.

Trends in vehicle design

Problem. Determining design trends, analysing the motivating forces and applying the appropriate guidelines.

Discussion. Sharply increased fuel prices in recent years have established a major trend toward smaller and lighter vehicles. The desire to improve ecology and safety by legislation requires a design to meet these standards. Both trends will continue for some time. Truck size will increase to the permitted road load limits because of high driver cost, and new power will help to control the larger forces involved.

Conclusions. Although styling innovations, performance, comfort and cost will continue to be basic to design, all must conform to the trend of smaller, lighter, safer and ecologically cleaner vehicles.

Recommendations. An engineering group that can determine requirements and develop designs to meet specific export requirements should be established. To this end designs should be worked out involving increased weight/payload ratios. The ARO with many desirable features enabling it to cope with these trends, should vigorously meet these new market challenges.

Body design and safety

Problem. Outlining trends and their causes for vehicle safety development.

Discussion. The air bag is receiving more attention today than any other safety measure. Good on direct impact, its value in minor accidents, secondary accidents and side impact is still in question. Its cost is high, and it is not subject to functional testing.

The record of seat belts and mandatory government regulations requiring their use is impressive. Statistics in Canada and Australia show significant saving of lives under these conditions. Other passive restraints were discussed, but none are too promising.

Vehicle design to control the rate of deceleration by bumper shock absorbers, collapsible front ends and accordion steering column design also provide user safety as a design feature. Innovations in structural design such as door side rails, roll bars, double roofs, break-away mirrors, crash pads on the dash, head supports, lower hoods for better visibility, and pop-out windshields along with laminated glass or tempered glass are additional safety practices now in use in the body.

Mechanical safety improvements were also discussed. The safety of greater acceleration in passing, better heat dissipation in disc brakes, new tyre designs and ventilation to prevent carbon monoxide (CO) poisoning are now possible.

Conclusions. Safety is neither saleable nor popular, so it must be legislated. Design must incorporate passive user acceptance to be effective. User participation, if necessary, requires mandatory regulation and enforcement to be effective.

Recommendations. Seat belts should be used in Romania, with a legislative support programme. There should be selective use of other safety measures on a need/usefulness/cost-weighted basis. An engineering staff should be established to study foreign regulations and qualify ARO for export acceptance. Locally, driver road-lighting practice should be updated and adequate reflecting devices required on each road vehicle.

Attaching body to frame

Problem. Review methods of attaching body to frame, and determining optimum design solution.

Discussion. This subject was discussed in connection with frame and unitized body construction.

Conclusions and recommendations. See those given in connection with frame and unitized body construction.

Principles of body styling

Problem. Outlining the guiding principles of body and vehicle design.

Discussion. The vehicle must incorporate change and follow styling trends, but maintain individuality and character. It should not resemble a particular object, for instance, a bath tub, an open-mouthed fish, a fish tail etc. as do some vehicles.

Change cannot be too radical or it will not have public acceptance. New innovations should be introduced on prestige models. Change should be frequent enough to incorporate technical advances promptly. Popular trends should be satisfied or led, not resisted. Large volume manufacturers can set styling pace by virtue of volume. Lower volume designs, after establishing an acceptable image, need not follow changes in public taste too readily. Public survey can establish dominant preferences in current designs.

Conclusions and recommendations. The main conclusions and recommendations are given above.

Body design and tooling

Problem. Evaluation of manufacturing methods and their influence on design of bodies.

Discussion. Spot-welding has improved to ensure the design of better quality, and automatic welding equipment can reduce cost if the volume of production is sufficient.

Better controls on portable or stationary spot-welders make more positive welds. Replaceable welding tips ensure good welds of proper diameter.

Press electrode welders have improved weld quality and dependability. They increase accurate location, lower cost, reduce time, and give more positive welds. The designer must at times change his design to facilitate their use. Volume production is required, and use at the manufacturing rather than the assembly area is often best.

Projection welding is a second means to better quality and faster production. The desirability of using this technique can be determined by the tool or design engineer.

Welding by an arc is most frequently done today with metal inert gas equipment. Its advantages are many, but the heat will warp outer sheet metal surfaces if not clamped and absorbed. Fixed or wire feed electrodes can be used, and design for both types was reviewed.

Critical locating points when chosen and given priority in design and construction can improve quality at little cost. Normally a function of tooling, they must be selected in co-operation with product design engineering. Their use will improve quality.

Dies and sheet metal quality have improved together. Metal improvement and controls in presses have also contributed to larger, better stampings. Labour costs for assembly and metal finish have hastened the trend to bigger stampings. Die and press history help to understand future trends. Costing of panels influence design, and forward planning knowledge is necessary to the design engineer if he is to have cost awareness.

A review of modern machines for body design development, model-making and tool manufacture indicates a direction for further study, but volume must be increased.

<u>Conclusions.</u> The body designer when aware of modern tooling methods, and in co-operation with die and tool engineers, can design for reduced tooling costs. Use of critical locating points and designs for directional assembly will improve quality. Special welding methods are to be incorporated into design as soon as available, as are more modern tooling techniques. A reciprocal flow of knowledge and information between design, tooling, die and process engineering is required.

<u>Recommendations.</u> A critical locating points committee should be established and its procedure enforced. A co-ordinating committee should be established to promote exchange of new ideas in design, tooling and processing. All departments should be made aware of cost analysis, and a cost analysis group should be established.

<u>Body design technique</u>

<u>Problem.</u> Developing those methods and guides on which a design programme can be based.

<u>Discussion.</u> Normal vehicle design has as its goal public acceptance. The designers' concept may be modified several times, as the need to utilize existing parts, cost, technical modification, life of available materials etc. dictate. Although sometimes altered by competition, regulations, public acceptance or performance, the following is typical of design life:

(a) The body has a three-year design life, with first a minor then a more complete face-lift in the second and third years;

(b) The engine is designed for from seven to eight years for the head and block, with changes in compression ratio, carburator and other "hang-on" improvements;

(c) With regard to the chassis, improvements are introduced as developed, unless they require modification of the components (a) and (b) above. The basis of changes can be improved materials and manufacturing techniques as well as design.

Design concepts must maintain product distinction, not be so radical as to preclude public acceptance, improve in all areas of safety, performance and other standards, and be subject to the latest manufacturing techniques. Styling trends and competitive performance are important guides. Today, in order to introduce a complete new product, about three or three and a half years are required, down from the five years formerly required, and the time is tending to decrease even more.

The steps of styling, from concepts on paper, to quarter-size clay models, to preliminary drawings subject to all departments' analysis, precede acceptance of the final concept. All senior executive personnel participate in these decisions. Drawings of the general concept are then analysed and modified as a result, with the die, tooling, processing, production, scheduling, purchasing, quality and, most important, cost analysis departments contributing. Prototype construction and testing parallel tool design and production planning, and frequent design alterations result.

Conclusions. Shortening the time from design concept to production will increase the cost. Developing countries, with inexperienced or inadequate staffs to perform the above, can buy such services on the open market, possibly at appreciable cost savings. Least expensive would be acceptance of an existing modern design. New product development must be preceeded by adequate forward planning. Team-work and detailed review of the design by all departments is necessary to improve cost and quality.

Recommendations. A new product design should be considered and introduced by acceptance of a suitable existing design with the assistance of the original manufacturer. Purchase of these services, in part or whole, should be the next development step if required. Realistic forward planning and sales forecasts over a ten year period should be made to support and guide the above activities.

Design for 50,000 vehicles/year

Problem. Evaluation of the principle factors for best quality and lowest cost when designing for 50,000 units/year.

Discussion. Product design cost is determined on a unit basis by total design cost over estimated total volume. Tooling cost is normally based upon the above, plus the units per hour to determine the degree of automation. This may be expressed as follows:

$$\text{unit design cost} = \frac{\text{total estimated volume x sales price}}{\text{h/day x days/year x model life (years)}}$$

With tooling and machinery the volume/h must be increased to allow for the efficiency factor. Second and third shifts are less efficient, and are not used unless the tool or machine cost is high.

Product design loads vary considerably with new model introduction dates. These loadings can be helped by outside aid from the following: other vehicle industries in the country; specialist concerns outside the country; purchase of a design; specialized design equipment. Design materials and worker efficiency can help shorten design time.

Conclusions. Modern expensive automated design equipment is justified only when in constant use. Many improvements in design hours may be realized with low-cost improvements in materials, area and methods.

Recommendations. Lighting, room layouts, tools, design paper and pencils should be studied and updated and horizontal drawing boards used.

Body reliability testing

Problem. Review and evaluation of modern body-testing methods.

Discussion. The complications of sheet metal design require that all calculations and laboratory tests should be verified by road tests. Special equipment costs may be avoided by use of outside test laboratories. The development cost of special test machinery may be recovered, in part, by royality charges for independent manufacture. The Government has introduced a special field of testing. When helping to develop these specifications, test results not methods should be emphasized. Many simple low-cost tests can be made to determine progress in quality and control production materials.

Conclusions. Prototype tests establish design parameters, but test of first production and periodically thereafter determine actual performance. Standards depend upon customer acceptance level, design specifications and competition, and should be changed accordingly. It should be noted that the restriction of visitors' access to the test area precludes comments on the IMM factory testing equipment.

Recommendations. Outside test sources should be used for expensive tests, while maintaining a test staff and laboratory for product development. Certificates of performance should be required from suppliers, who should be shown the purchase test procedures, and equal or better supplier testing should be insisted upon. Supplier test facilities should be used for ongoing improvements.

Use of metal substitutes and lubricating methods

Problem. Review of latest practice in selection of metal substitutes.

Discussion. Current trends in the selection of metal substitutes is towards lighter product weight, followed by better rust protection, and cost reduction. Weight reduction is now frequently made at cost penalties in efforts to increase fuel economy. Plastic substitutes are increasing as this new science improves in manufacturing methods and choice of materials. Hand lay-ups of fibreglass-reinforced plastics are now replaced by die manufacture from liquid plastic or sheet plastic. Aluminium is also increasing in use as the problems of assembly, electroplating and manufacture are overcome. High-strength steel is winning back some design on a cost and weight basis as the steel manufacturers offer manufacturing assistance.

Conclusions. Weight reduction is so critical in current design that it sometimes wins over cost and manufacture as the basis of choice. Increased use of plastics is determined primarily by new manufacturing methods. The decrease in steel use will be arrested by the development of new high-strength steels.

Recommendations. A programme of material evaluation in technical magazines and competitive products should be continued.

Tolerances used in body design

Problem. Review and selection of the best system of dimensional tolerances for adequate product control within reasonable manufacturing capabilities.

Discussion. Tolerance limits can be expressed automatically by the number of places used to the right of the decimal point. For example, a dimension written 4.0 m carries a plus/minus limit of 1.5 mm; if written 4.00, the limit is plus/minus 0.15 mm; or if written 4.000 the plus/minus limit must be listed.

Sheet metal clearances for daylight openings and mating parts of 7 mm are normal and acceptable. Product drawing accurancies are normally line thickness. Drawings of the master body draft and the final master model are developed together from the clay. The master model then becomes the standard to which all production metal must conform. No metal tolerance is specified on sheet metal drawings.

In die and tooling manufacture critical locating points need to be specified. Tools and dies are manufactured not to dimensions with tolerances, but to the master model or a model based thereon. Tooling aids include sectional masters and spotting aids made by female/male plasters, or modern material equivalents. This process yields accurate reproduction of product even when multiple assembly fixturing is involved.

Conclusions. The master model must be used without specification of limits in dimensioning. Tool and die drawings dimension their own manufacturing needs, but final shapes of product are based on the master model.

Recommendations. The outlined procedure should be applied along well-established lines by all those involved.

Master model manufacture

Problem. Establishing an inexpensive workable procedure for making master models.

Discussion. Methods of making ultra-modern master models are too expensive and sophisticated for the proposed volumes and the local state of the art. The progress from artisitic sketch to quarter-size clay to full-size clay preceeds the development of master model and drawings. Full-sized egg-shell clay model and templates are used for mahogony master manufacture. More modern, less costly materials may substitute for wood, especially for the multiple tooling aids. Prototype tooling was also discussed, especially zinc alloy draw dies and inexpensive steel rule and/or template blank dies.

Conclusions. Costly modern master-model manufacturing equipment can be bypassed for older methods of woodmasters using templates. Jeep-type vehicles are especially adaptable to this method.

Recommendations. Master models should be established as outlined and used as the basis of manufacturing (see previous section dealing with tolerances used in body design).

Drawing materials and reproduction methods

Problem. Review and selction of the best procedure to make drawings and their reproduction.

Discussion. Latest modern methods are extremely expensive, suitable only to volumes in the millions. Use of photography to put drawings (and books) on 35 mm film is useful and of reasonable cost. These negatives can be stored on IBM punch cards, rolls of film, or plates with several separate negatives on one sheet. Machines for all three forms can project the negatives on to a screen for easy viewing, and can also make prints. Microfilm storage is sometimes useful.

Conclusions. Use of 35 mm reproduction is convenient, reduces storage space, transmits data easily and is suitable for local volumes.

Recommendations. The 35 mm reproduction system should be adopted after study and cost analysis.

Modern drafting methods

Problem. Proposal of drafting equipment and methods for best product design.

Discussion. This subject has already been covered in part and several different sections.

Technical analysis of body design

Problem. Determining when and how technical analysis is applied to body design.

Discussion. The conceptual stages of artistic sketches, quarter-size clay, photos and clay rework should be free of the restraints of technical analysis. Full-size clay development should be subject to technical restraint only in the broadest terms.

From preliminary body draft development through product release technical analysis is required. A standing commitee representing the tool, die, welding and process departments and all concerned meet as required for analysis of design. At this time die, welding and process considerations should dominate assembly procedures and related section design. Committee representatives should get department approval, and upon the concurence of all, released drawings should replace the preliminary issues. Timing charts must be honored.

Conclusions. Concepts free from practical restraints must eventually meet the necessities of manufacture. The team effort to produce the new design at least cost is best achieved if all possible progressive manufacturing concepts are proposed and the product details developed accordingly.

Recommendations. Strong team co-ordination of design and manufacture should be developed through frequent discussions of all those concerned.

Interior master model concepts

Problem. Methods of interior model development.

Discussion. Permanent framework should be separated to provide full-size mock-up of front seats, rear seats, instrument panel, and door inner pads, as necessary. Dimensional considerations in part determine overall vehicle size and must be developed along with the exterior clay. Materials and styling choices depend on new manufacturing processes and local availability, and the design department should frequently consult with the manufacturing staff.

Conclusions. New styling based upon new materials and manufacturing techniques must pass the cost/process analysis before being finalized.

Recommendations. Technical analysis for interior design should be subjected to early committee review and team-work.

Value of reduced-scale mock-ups

Problem. Determining scale size and value of small-size mock-ups, review of materials and methods of cost reduction.

Discussion. This subject has been covered earlier.

Conclusions. Quarter-size clay models and their derivatives along with photographic records are useful as a cost-saving device. Interior mock-ups should be full size, and a full-size exterior clay is necessary for proper evaluation and body draft development.

Recommendations. Design and its development aids should include the steps previously recommended, namely sketches, artistic renditions, quarter-size clay, full-size clay, mahogany master and full-size body draft.

Body draft development from master model

The concurrent development for the master model and master draft has been covered.

Template development in master model and draft development

This subject has already been covered.

New body test and manufacturing methods

Problem. Determining reasonable prototype test procedures and methods of ensuring production compliance.

Discussion. The expense of laboratory analysis to be verified by road test is not always possible in limited budgets. However a good proportion of these test results can be obtained by ingenuity and inexpensive equipment. Fluorescent water tests for leaks, vacuum seal tests for seal, and field trips for paint analysis are some examples of these methods.

Prototype vehicles, because they are made by hand, may produce misleading test results. Production test facilities can be used if suitable. Assembly tooling methods, chosen by the tooling staff, can be helped by the product designer by means of tool holes and other locating devices.

Conclusions. New body development offers an opportunity to incorporate new methods and ideas, but many test and material developments, such as paint improvement and rust prevention, are a continuing process. New manufacturing methods are to be selected by the manufacturing staff and require in-depth analysis and costing. New body design is an ideal time for their introduction.

Recommendations. Test procedures should be supported by service statistics, field surveys, supplier tests and a continuing test programme. Improved manufacturing methods should be incorporated into the design at the instigation of the manufacturing staff.

Estimating manpower requirements for biannual new body design

Problem. Outlining the department size for design, test and prototype construction of new vehicles on a two-year model introduction basis.

Discussion. The variables involved, such as type of body, degree of testing, size of prototype test fleet, acceptance of new manufacturing methods etc. were reviewed. These, and the type of testing equipment will influence greatly the size of staff required. High-volume manufactures with wide model choice interchange manpower and make specialists of their most efficient men. The requirements are not equal, nor can they be reduced in proportion.

Conclusion. Past experience coupled with the details of forward plans are the best basis for manpower estimates. Local evaluation will be most accurate.

Recommendation. Department heads should make estimates, compare with past experience and follow up to assess accuracy at a future date.

Use of value analysis in product evaluation

Problem. How to apply value analysis and how to determine true value.

Discussion. Recognizing that the goal of vehicle manufacture is customer satisfaction, or good value for money, the determination of what "value" a customer sets on the design is the first step in value analysis. Other sources are design opinion, public acceptance and approval of competitive design features, professional tests and opinion (i.e. road magazine tests) and the view of professionals in the industry. Determining public opinion can be done by professional survey (i.e. Gallup Polls), card survey in magazines, personal questioning by canvassing or sales staff. An effective, relatively inexpensive method is by card survey at time of sale. Composition of questions and ability to convert answers to statistical analysis is important, as is a balanced selection of those surveyed.

Conclusions. Accurate value analysis, so necessary as a basis of successful design, is difficult to obtain and expensive. This new tool should be studied in depth before use.

Recommendations. Consideration should be given to card surveys of customers at time of sale, salesmen questioning potential customers, and service customer card surveys as sources of value analysis data.

Frame design

Problem. Selection of the best ARO frame design and proposal of frame or assembly changes to prevent twisting and warping of frame.

Discussion. A closed double C design for longitudinal members permits ease of spot-welding and assembly. The flanges must be of sufficient width for adequate bearing, and separated by the vertical member sufficiently for the necessary bending moment. Spot-welding should be reinforced by skip mig-welding where required. Projection welding is the most desirable type of spot-weld.

For reprocessing the current frame design, the following was proposed:

(a) Welding all sub-assemblies and brackets to all cross members and the open-hat-shaped longitudinal members;

(b) Placing in a major assembly fixture, and spot-welding or mig-welding cross members to side members;

(c) Closing up hat-shaped side members with the flat plate.

Correction of current warping may be realized by peening the weld at critical locations, by checking the side members and straightening after welding in an arbor press, and/or by tack spot-welding each 80 cm before welding the side member assembly.

Conclusions. High volume production of ARO type vehicles normally choose a C-type design. Where possible, spot-welding should replace arc or mig-welding to reduce heat input and consequent warping. Projection welding gives better spacing and better size of spot-welds, but skip mig-welding may still be necessary to reinforce joint assembly.

Recommendations. Current production should be corrected by checking side members as soon as cool, and straightening in an arbor press. Welds should be peened as required. Reprocessing should be done as outlined, which is the reverse of the process now in use. Frame should be redesigned for open C side members and hat-shaped cross members, with spot-welding and mig-welding.

Engineering value analysis

Problem. Proposal of a method of vlaue analysis that will improve quality and reduce cost of the ARO all-ground vehicle.

Discussion. A prover method of value analysis is to develop an engineering team representing die design, product design, welding, processing, and cost analysis. The second step is to obtain vehicles of ARO's nearest competitors in size, price and quality, for example among, Bronco, Jeep, Blazer, Toyoto and Land Rover. All vehicles are then disassembled and like parts grouped together. For instance, all door hinges and attaching parts could be mounted on a large piece of wood. Each piece of each model, ARO included, would be costed, and given a quality rating. Quality improvement, cost reduction, or both should result whenever redesign is undertaken.

Conclusions. Value analysis is a means of incorporating the best ideas of competitors into a product, or proving superior quality. It is an excellent method of stimulating new design ideas and better production methods.

Recommendations. A value analysis programme conducted as outlined would be of great material benefit, and result in an improved worldwide position for ARO.

B. Manufacturing methods

Sheet metal die requirements for 20,000 units/year

Problem. Determining the best die designs for a proposed volume with model variations.

Discussion. A review was made of the various methods used to cut and form metal. Cutting by hand, hand-operated power shear, floor-mounted power shear, power nibblers and/or punches - with or without profilers - or by metal band-saw all require no special dies. Inexpensive cutting dies can be made by several designs, including cooky cutters (for paper and cloth), template dies, steel rule dies, as well as standard hardened-steel dies. Forming of sheet metal can be by either hand or power hammer, stretch press, crash die or normal draw die. Die development by use of a zinc alloy (one commercial name is Kirksite) is good for testing regular dies as well as for prototype development. It can be used in production for 1,000 - 5,000 pieces. Details of these die-making methods will come later.

Total die requirements are calculated as follows:

$$\text{Pieces} = (\text{number/car} \times \text{yearly volume} \times \text{years of model}) + 10\%$$

The 10% or other figure allows for service requirements. Piece part cost is determined by dividing pieces required by total cost:

$$\text{Piece cost} = \frac{\text{total cost}}{\text{total pieces required}}$$

Total cost is composed of cost of die design and manufacture, press time, direct and indirect labor and overhead. Other values, in addition, are quality of product, press availability, part storage, material handling and tooling facilities. After calculating all the above the die designer must evaluate all possible manufacturing methods and select the lowest total cost method consistant with the quality required and facilities available.

Process engineering, that is the planning of plant layout and material flow through the plant, affects, and is affected by, die design. All design is greatly affected by cost. Thus a team effort of all departments is necessary for complete planning, and die assessment should be based upon this total value concept.

A sample die now in production was cost-analysed, and the result showed how a lei 3,000 investment in a better die could save lei 40,500 on the lifetime total product cost. The need to expand the die design concept to include material feed and part and scrap disposal was emphasized. Several die designs were then studied as means of design improvement. Knock-out punches, stripping plates, strip feed, low-cost trim methods, draw die used for flange wipe, low-cost roll flange tables and marking templates were studied. Specific design problems were tabled and studied. Each design was intended to reduce cost/piece, and the analysis of economic justification, and the larger concept of material processing in the die area was emphasized. Minimum die cost is set by quality requirements, maximum die cost should be at that design that yields least cost per piece - taking into account material processing. Such designs normally include knock-outs, stock strippers or scrap cutters, locators, and can include air blow-outs angled press, air cushion ejection etc. Cutting chart development is mandatory, as is cutting pattern development.

Progressive dies, and the need for material handling devices between presses do much to reduce piece part cost. Safety improves if die load/unload is performed with pliers, suction cups or mechanical handling. Lost fingers can't occur if tools, not hands, enter the die area. Examples of automatic feed from coil stock or transfer devices between presses were studied and costed.

Conclusions. Die design concepts should include material processing to and from the die, and design of related devices. Lowest possible cost per piece, the goal of each design, must incorporate continuous press cycling.

Recommendations. Consideration should be given to automatic feed and mechanical handling effects on total cycle time when studying piece part costs. Follow-through and engineering control of all action on the press room floor should be improved. Responsability and manufacturing decisions should be removed from the press operator and incorporated into engineering design and planning.

Sheet metal storage and preservation

Problem. Review of the requirements to keep in-process sheet metal from rusting.

Discussion. Prompt use of manufactured metal requires no rust protection. Accurate sheduling and most economical die runs must support prompt use. Mill oil, the oil coating put on the metal at the rolling mill, and stacking protect metal before manufacture. Die lubrication oil, if necessary, is further protection, but is hard to get off and should be avoided. Long storage periods may require a very viscous oil spray for protection, but removal is difficult. Vapour degreasing permits recovery of oil and vapour. Service parts should be protected by prompt painting. A special primer-surfacer, like chassis black, will give sufficient adherance and also sufficient protection.

Conclusions. Engineering control of all floor operations in the die shop should reduce the number of pieces in a die run, and lessen the need for metal protection.

Export boxing

Problem. Proposal of the most practical containers for CKD boxing.

Discussion. Filling a box is more economical than placing sides around a pile of stacked material on a box base. Box materials are normally plywood sides and top with a board base. The base boards are separated by 1/4 to 1/8 inch to allow ventilation to a two-inch-diameter covered hole, two at each end. Use of waxed paper on sides and top, plus VIP paper and oil fog will protect against rust and direct water damage.

Size is normally up to two metres wide, 1.5 m high and three to four metres in length. Weight normally is under 3.5 ton. Interior bracing is used as required, with a maximum thickness of one inch to aid cubage. The wood spacer inside must not touch metal directly, but be separated by wax paper. Extra-heavy loads such as axles can use wood spacers to strengthen the box. Stacking heights of four to six boxes normally equal warehouse heights and/or material handling equipment limits. Returnable cartons and dessicant chemicals should be considered.

Recommendations. Plywood boxes that are well ventilated, well braced, with wax paper over the product and VIP paper or desiccant between, protected by a heavy waterproof paper inside the lid and attached to it should be used for adequate protection.

Minimum sheet metal use and die design

Problem. Principles of die design to achieve the use of least sheet metal.

Discussion. There are ways of using the blank for the cover plate when an access opening and cover design is being considered. Two were presented. Use of metal from door or window openings in the body was covered, as was the same for inner door panels. Nesting of shapes for strip stock, strip stock without side rails on the scrap, deforming or redesigning the piece, and use of scrap in the die to make small pieces were also illustrated and discussed in detail. The cost of making two pieces when one design produced excessive scrap depends upon the factors of part storage, welding, overhead etc., all to offset the scrap cost. This is difficult to justify, and suggests the design of larger pieces whenever possible. This led into a discussion of the principles of draw die design, including the use of Kirksite, a white metal zinc alloy, for try-out and the development of a body draft. Using Kirksite for production of several thousand pieces is possible.

Conclusions. Cost and product quality should determine die design, scrap patterns and the use of progressive dies. Total cost, that is the total cycle time, die change time, part storage and complete overhead costs, must be considered, not just material cost versus direct labour. Die cost is a small fraction of total piece cost, and more expensive automated dies are normally justified when volume increases.

Recommendations. Consideration should be given to Kirksite for die try-out and low volume production. Greater use should be made of progressive dies, automatic feeding, automatic scrap disposal and better material handling in the die shop.

Principles of die design for sheet bodies

Problem. To advise on the method of die design for a completely new passenger car.

Discussion. Development of a design from styling concept sketches through quarter-size clay model, full-size clay model and body draft, master model and tooling was outlined. Committee meetings of engineers from die, welding, product design, processing and cost analysis jointly decide on the technicalities of joint design, weld lines, contours, profiles etc.

Production die design starts upon receipt of body surface lines, or scans. Release of preliminary die designs permit starting on both production dies in cast iron and zinc alloy dies. Alterations of zinc alloy tools is less expensive and can be done quickly, so the cast iron tools can be made with confidence, having been tested in zinc. Use of critical locating points makes the body more accurate in less time.

The detailed method of how all body dimensions are held to a master model was explained. Die stampings, assembly fixtures and checking fixtures are built to one master, even when several sets of tools are made. This system permits quick tool change-over in several different plants of wide geographical location in a short time. Exact duplication of the master model, in part or in whole, permits assembly and/or tryout to "master model duplicates" in several locations at once.

Conclusions. Using a master model eliminates the need to dimension or set limits to the body draft drawings for compound surfaces. Resolution of the technicalities of design by committee yields a product at least cost.

Recommendations. A master model concept in metal design and fabrication should be used, and there should be heavy reliance on a committee for resolution of design and assembly methods.

Body assembly methods

Problem. To propose the method of assembly best suited to the ARO car.

Discussion. A general review was made of the various ways a body can be assembled, the methods most modern plants today use, or have used in the past. The gate fixtures and other forms of a single assembly buck, the balloon fixture and the conveyor line fixture all dictate a different assembly procedure. Time was spent in the factory until the method of assembly used by ARO and the design of body components was familiar to all participants in the discussion.

The present method of assembly of underbody, front end, right and left rear quarter assembly, and roof assembly (when required) is adequate. It was proposed that the underbody assembly fixture should take the panels upside down. The floor panels, right and left rocker assemblies and cross braces should all be assembled in a major fixture. The quarter panels and front end continue to be assembled as they are now. The assembly of roof rails should be considered as separate units, and attached to the body in the main fixture, with the roof going on later. For roofless models a brace between door openings was proposed, to be removed after body drop but left on through paint. The need to build the body to dimension and hold it during travel in the body shop was discussed. The frame should be 100% inspected on the final assembly line and marked plus or minus for each millimetre of deviation. Shims can then be used accordingly to permit bolting body to the frame without distortion. The above requires a frame checking fixture and accurate body trucks in the metal shop. All roof panels, doors and tail gates must be set in racks after assembly for storage. These racks are to be placed along the final assembly line, for assembly direct to the vehicle.

Conclusions. The present system of assembly is acceptable, except for a possible new roof rail design with later roof assembly. Body dimensions must be accurate in the body shop, frame deviations noted and shims applied as required.

Recommendations. There should be a 100% inspection of the frame and shim compensation. Accurate body assembly with rigid body trucks and main assembly fixture should be ensured. Special containers for sheet metal assemblies, with unload direct to the final assembly line, should be used.

Body sheet metal design

Problem. Examination of sheet metal for assembly method and most effective design.

Discussion. This problem led to a discussion of the means of achieving a lighter, stronger body with representatives of product design, welding, die and fixtures. Elimination of the roof rail to roof joint will reduce cost of metal finishing. An outer wheel house should permit lighter gauge metal of the quarter outer. Manufactured hinges are lighter and less expensive than castings and forgings. The hinge die may produce over 3,500,000 pieces. Reinforcing ribs in interior metal will permit gauge reduction and give a stronger design. Use of trim sticks to cover weld marks can eliminate the need of metal finish. Additional contours in body side between belt line and rocker, plus contours in the hood may increase strength and permit lighter gauge metal. There is too much flat area in the ARO design. It is hard to metal finish, is not as strong as curved panels and not as attractive. Curved panels and ribs can be added to present draw dies without too much cost. The above are samples of some points of the detailed discussion on sheet metal design.

Conclusions. There is ample opportunity for product redesign to lighten and strengthen body sheet metal.

Recommendations. Prototype testing of new sheet metal panels should be carried out along the proposed line of discussion. There should be a quality analysis of hinges and other mechanical components (see above the section dealing with the use of value analysis in product evaluation).

Body design and assembly with aid of master models

Problem. Review of modern body manufacturing and design methods.

Discussion. Design and prototype testing to start of production can take from 3.5 to 5 years. A detailed discussion of the complete procedure showed how it is possible at new model introduction to change over thirty plants in a 3,000 mile distance operating at 60-70 bodies per hour in a period of a few weeks. Use of Kirksite, a zinc alloy of white metal, helps speed this process by testing draw die designs and providing prototype panels. For blank and pierce low volume dies, manufacture by steel rule or by template dies can reduce material costs by 50% to 70%, and labour by 40% to 60%. Master model construction, and the accurate master model surface duplications are used for compound surface dimensional accuracy.

Conclusions. Understanding and use of this procedure is essential to modern high volume body manufacture. The ARO because of its design and limited production rate, could possibly eliminate or modify the full procedure.

Recommendations. A master model mock-up should be provided for daylight openings and otherwise as needed.

Spot-welding

Problem. To consider the newest and best spot-welding equipment for use in the factory.

Discussion. The theory of spot-welding, spot-welding testing, current requirements etc. was first discussed. Testing by "pulling a button" on a weld needs to be supplemented by occasional physical destruction testing. To test, a used power hacksaw blade is best, and the method of making a chisel of it was described.

Welding equipment has changed. Cellular or coil wound transformers should replace ARO's stacked core transformers in the future, as they are smaller, lighter, more efficient and less expensive. Coaxial weld cable is also less expensive, more flexible, and cools more easily and efficiently, so that the cost of electric power for welding is appreciably reduced. Welding guns, if purchased from a reliable source, are less expensive and more efficient than factory made guns. Welding gun tips, or electrodes, are a high-expense item. The most recent design, the thimble or removable tip, saves 90% of tip cost and improves quality. High quantity purchase realizes substantial savings, and purchase for all vehicle needs from one source should be investigated. Volume manufacturing methods using cold up-setting produce no scrap and are less costly than local factory manufacture. Usually the copper alloy is also better. Tip life and product quality is greatly improved by proper cooling. Water flow of 5 gal/min (24 l/min) is required for each portable gun. The flow can have separate cooling of the transformer, cable upper arm, and lower arm, or a combination if the heat load is not too great. Hose and pipe sizes were given. Spacing between supply pipe and interior of the weld tip is very critical, and should be one pipe diameter. Setting methods were illustrated. Water flow should be tested by timing water to fill a container. A special air-driven tool is available to shape tips. Cable repair was discussed. Turning cables end on end will double cable life. Air pressure varies with gun design and metal thickness, and must be separately set for each gun. Suspension method and balance were reviewed. Pre-loaded spring balancers are best. Gun bails of 360° rotation with broad "A" cable suspension are most flexable. Rotation design in three planes was illustrated, especially for big guns. Primary cable supports should have a 3:1 ratio, or 4:1 maximum.

Conclusion. Top-quality commercially-supplied welding equipment is least expensive and assures quality welds. Intimate knowledge and correct maintenance of equipment are necessary to quality and long life. Adequate cooling and correct tips should reduce use and cost by over 50%.

Recommendation. Coaxial cables, cellular transformers, commercial welding guns and replacable tip electrodes should be purchased. Old equipment should be replaced to reduce operating costs. Tips should be trimmed only by a qualified repair man who will also check cooling. A weld test schedule and record should be established.

Mig-welding and stud welding

Problem. Review of latest arc-welding equipment and its use.

Discussion. Mig-welding can use CO_2, argon, nitrogen or any inert gas that prevents weld oxidation. Skip-welding with metal inert gas gives results like a spot-weld. It can be used like a push-gun spot-welding tool. The book Automatic mig-welding contains a study of the newest processes, controls and equipment. Stud welding is done in modern factories to allow glass or exterior trim attachment. Stud welding can be automatic, or the gun hand applied with a locating fixture and automatically cycled when activated. Studs save labour, cost less, prevent rust and are more effective than attaching trim with screws. The book Automatic stud welding contains a description of this new welding method.

Conclusions. Review and mastery of the more advanced methods of stud welding and mig-welding will increase the engineers' knowledge of his current equipment and its proper use.

Gas welding

Problem. Determining best gas-welding equipment and its use in production.

Discussion. Improper use of gas-welding torches in production cost the ARO factory over lei 1,000,000 each year in excessive oxygen and acetylene usage, according to figures supplied by the ARO welding engineer. It was calculated that a saving of lei 215,000,000 could be realized in a 20-year period by an investment of lei 6,000 in an automatic gas shut-off valve for all production gas-welding torches. These torches are now used to cook food and as personal heaters during the lunch period.

Use of a central system for supply is good, but take-off points must be made so as not to require excessive hose length. Shut-off valves, on the torch handle or in the line, will allow the worker a convenient way to stop gas flow, except when welding. Supply pipes should run 2.4 metres above the floor at areas of use, with convenient take-off points to keep hoses off the floor and short.

Conclusions. There is excessive use of this expensive indirect material that can be controlled.

Recommendations. Shut-off valves should be purchased at once to be set in the lines or torches with valves, in accordance with the discussion drawings. Almost all welding supply sources have this equipment. The workers should be provided with flint sparkers.

Soldering

Problem. Review and recommendation of newest materials and methods of solder application.

Discussion. The eutectic diagram of lead (Pb) with tin (Sn) and antimony (Sb) when studied shows that 5% antimony and 2.5% tin are the best amounts of alloy materials to mix with lead for body solder. To control grain growth 0.5% arsonic (As) is required. This formulation will lower solder cost, be easier for the worker to use, will not melt in the paint oven, and with smaller grain size will make fewer repairs. Different materials are necessary for solder wipe and repair. The best formulas are as follows:

Materials		Solder wipe	Body build	Repair
Lead	Pb	80	91.9	70
Tin	Sn	20	2.5	30
Arsonic	As		0.5	
Antimony	Sb		5.1	
		100%	100.0%	100%

The solder wipe should be powdered material. To mix for solder wipe use the following:

2 parts	HCl	Hydrochloric crystals
2.5 parts	H_2O	Water
4 parts	Solder wipe powder	

Preheat metal with special wide-mouth torch, apply solder wipe with brush full of agitator liquid, wipe (in one stroke if possible), dip spoonful of body solder onto joint and work into shape. Work as little as possible, and quickly. Keep at upper end of soft range of temperatures. Use hardwood paddles, and groove application side.

Conclusion. The above data is in a booklet in Romanian, and can be used for reference to improve this operation.

Recommendation. The new formula and procedure discussed should be immediately adopted.

Metal finish

Problem. Review and recommendation of newest tools and methods for metal finishing.

Discussion. All standard metal finishing tools were discussed. The type of file should be changed to another make available in rough (10 teeth/inch) and fine (14 teeth/inch) in both straight and curved 14-inch lengths. Use of welded studs for inaccessible panel areas was discussed. Shredded asbestos and water mixture used around a gas weld area will limit heat travel and prevent panel warpage. Warped grinding discs will decrease efficiency and reduce their life. A special humidity control cabinet can keep them flat. It was estimated that savings of over lei 125,000 per year can be realized by making this cabinet. With a 20-year life, the cabinet may save lei 2,500,000 for a lei 60,000 investment.

Grinding grits, back-up materials, pads, speeds and diameters need to be properly selected for best results. All materials and usage was reviewed. Disc grinders and suspensions were reviewed, and heavy tools are best suspended with adjustable spring balances of proper capacity. Metal finish of doors and hoods can be done on special tables built and tooled for the purpose. All other finishing can be done at the end of the body line. Use specially trained men, finish only in marked areas, inspect and repair under a bank of lights. Over 60% of defective metal finishing is caused by careless workers. Using kerosene or mineral spirits to wipe the body prior to inspecting will highlight all defects. Use hammer and file to return metal surface to correct plane. Use, in sequence, disc grinders of 50, 60 and 80 grit to remove file marks and scratches.

Conclusions. Every body-man, seems to be a metal finisher, training and equipment is poor, and so are results. Work in one area, by one group of men, under special conditions will improve the operation.

Recommendations. All the proposals discussed and listed above should be put into effect.

Metal finish and paint

Problem. To metal-finish so that metal defects will not show after paint.

Discussion. Metal finish should all be done after body build is complete, at the end of the metal line. The body should be coated with mineral spirits and special lights used to see all defects. Defects should be inspected and marked, then repaired by special metal finishers and reinspected. The use of epoxy for roof joints should be considered. The use of grit size 50 to 60 and 80 on the same area will give maximum depth of 45 millionths of an inch, equal to the original metal condition. Although grinding grits control depth, it is width of a scratch that determines if paint will cover. Lubricant of the pad increases use from 10% to 2,000% by preventing solder or metal clogging, or loading.

Conclusions. Metal finishing to best quality is the highest skill in the body shop, and only specialists under ideal conditions with proper inspection should be allowed to do it.

Recommendations. Pads should be lubricated for longer life (up to 2,000%). Three grits should be used on the same spot, and the metal finish area revised.

General fixture design

Problem. The principles of sheet metal jig and fixture design should be outlined for body assembly.

Discussion. Sheet metal is not rigid, and sufficient location is necessary to hold all parts of a panel in body position. The fixture designer must determine the critical locating dimensions and design the fixture so they will be held accurately. The recommended procedure is outlined below. Locate in all three planes, horizontal, vertical, and in and out. Pin and pad makes a good locator. Diamond-point the pin to make it locate in one plane only. Bullet-nose locating pins and use lead-in guides. Bush-toggle clamps. Use C clamps, push, plier, pinch or lock jaw clamps as needed. Use tool holes in metal as required. Springs for clamping can be used, but are not positive. Use for finger holding of small pieces. Drill jigs can have slip bushings for large holes, using one as a pilot. Mill drills or special tips are good for larger holes.

Make fixture adjustable because of die wear. Have a positive maintenance programme of fixtures and periodic check for accuracy. Do not allow workers to change fixtures. Do not have loose clamps (chain to base). Do not allow visual alignment or hammering of fixture. Design racks and tables, and specify proper hand tools as well as large equipment. Do not allow metal on floor; specify bin and its location, plus method of movement. General steps to fixture design are as follows:

(a) Decide on overall plan (position, number of parts etc.);

(b) Do time analysis (do as much work as possible in each fixture to save cost and reduce load/unload time);

(c) Draw in metal panels and spot-welds;

(d) Make spot-weld gun study (use gun profiles);

(e) Do load/unload study;

(f) Select locators. Be sure all panels are located in three planes. Add clamps;

(g) Locate base and complete pads and risers;

(h) Position above floor for best work height. Provide suspension or wheels for heavy designs that must be portable. Make storage racks or areas for light portable fixtures. Interchange on one base for easier storage.

Conclusions. The correct fixture makes it easy for the worker to use, holds all dimensions to body position, and is strong enough for the job.

Fixture design: major assembly

Problem. Review of alternates and selection of best major fixture design for ARO bodies.

Discussion. The body is spot-welded while held in a rigid fixture that locates each assembly in exact body position. It is normally stationary in low volume, and the fixture is made movable along a line at high volume assembly. To open, the sides may hinge away like a gate, roll away, or pivot above a base pin, opening up like a flower bud. All three methods permit unloading of body vertically. If the base pieces are precision drilled and the bolted locators are removable, interchangeability and simple model change-over are achieved. Top locators may be loose, bolting to side bases. Diagonal braces prevent parallelism of movement.

The general approach to ARO fixture assembly is good. The major sub-assemblies are correctly made. The line fixture is properly positioned. There is no major change for improvement to be suggested. Use, or lack of use, of fixtures by workers is very bad. Excess hammer use, welding without fixtures, home-made fixtures, open clamps, damage to metal, all these and more are worker faults. They do not follow the operation sheets. No one tries to control their work or insist on following engineering design. Lack of good middle management, or foreman and shop supervision know-how is a common problem to industrial developing nations. A suitable training programme is needed. There is also an obvious need for planned plant layout to arrange for fixture location, tool power take-offs and in-process storage.

Conclusion. Fixture design is good, as is engineering planning, but it is almost of no use as workers do not follow the plan or use the fixture properly.

Recommendation. Necessary steps should be taken to use fixture correctly and build the body as processed.

Fixture design: body trucks

Problem. To build and hold accurate body dimensions.

Discussion. Good fixture design and construction will permit a body to be correctly manufactured. It will, however, be twisted out of shape if it does not have proper base support. If twisting occurs on the body assembly line, door fits and glass openings will be incorrect. The underbody must be built properly and held to an accurate base while side and roof are welded. The body must then be placed on a solid body truck with adjustable locators so that it stays in dimension while welding is completed, doors are hung etc. ARO, because of its open top design, is especially liable to go out of alignment. A telescopic spacer in the door opening should be fitted and set to each body and remain with it to chassis mounting. If the body is correct, a warped frame can still twist it out of shape. The frame must be measured after wheel assembly and shims used as needed. Design of the body truck and frame measuring fixture were discussed in detail. A checking fixture for body trucks is also needed. They may be combined.

Conclusion. Poor door fits or broken welds could be caused by incorrect spacing between body and frame. It is now impossible to measure.

Recommendations. Body trucks should be built for use in the body shop. A fixture should be made to check body trucks and frames for accuracy, and shimming done where necessary.

Body sealing from air, water and dust

Problem. Review and recommendation of body sealing methods and testing.

Discussion. Water test for sealing is now improved by use of a phosphorous material and "black" light that shows each water leak by a glow. Speed of water from the nozzle and jet size are critical to good water testing. The test water has to be recirculated. An air or dust test is made on a sealed body by use of a heater fan to pull a vacuum and measure it. Leak sources are found with a smoke candle. Body has to be tested before interior trim so repairs can be made easily. For spot-welded joint seal a "weld-through sealer" must be used before spot-welding. It should be applied with nozzle and power applicator using a guide finger and, if desired, a brush on the applicator. After welding and painting mastic sealer must be used over joints for extra seal protection. Mastic must not melt in hot weather, crack in cold weather or have solvent and odour problems.

Conclusions. Weld sealers and mastic must be carefully applied to be effective. The designer can choose among several mastics, weld sealers, or both to assure a good seal.

Recommendations. The least expensive process necessary to give the degree of protection required should be chosen.

Plant layout

Problem. Describing the best method of body shop plant layout.

Discussion. No plant layout, tool sheet operation description write-up etc. is effective unless the workers follow the outlined procedure. This is not done at DMM. Special training in foreman and supervision management is required to gain worker co-operation.

Plant layout starts with establishing aisleways three and four metres in width. Each tool, spot-welder, stock rack etc. is then made to scale, usually 1 to 100, and located on the drawing. Fixture cycle time is also noted, as is manpower requirements. When the plan is complete it is drawn in; prior to this the tool models are rearranged as desired.

Especially important are material flow, bank stock and in-process material storage. All subassembly must be timed to line speed. Special containers for stock, their movement, special worktables etc. must be designed and built as well as assembly fixtures. Workers must stay in their own work areas and do work in designated spaces. Limited supply lines to portable tools, special lights, anchored tables or fixtures help. Line operation stations must be observed. Storage racks can serve as a small bank stock station for subassembly, and a three to four-hour body bank is necessary between body and paint shop. A body repair area is also necessary at the end of the body line.

All possible operations must be assigned to the production line. Normal line sequence is as follows:

Spot-weld
Mig-weld or arc-weld
Gas weld
Grind weld
Solder
Shape grind solder
Door and miscellaneous assembly
Complete metal finish
Grind disc and sand metal by hand
Inspection
Repair
Final inspection (buy-off)

Provide a "hold" area for repair and rework off line. Direct completed jobs to paint, on paint truck, and return body truck to start of line. Line width should allow 2.5 m for body (with door open), plus one metre on each side for personnel, or 4.5 m between stock racks. In subassembly such as door manufacture, provide special tables and special hand tools as required. Perform multiple operations at one station to limit handling (and damage). Suspend air, gas and electricity overhead in rigid conduit, with special lights as required. Locate connectors to flexible hose drops as desired. Provide filters and oil lubes in air lines to each tool, shut-off valves to gas weld lines. Keep hoses off floor, and make hangers for tools.

Conclusions. A good layout and trained workers should reduce labour by 40% to 60%. In high-volume modern plants, operations and layout are as outlined, and should be the same at IMM.

Recommendations. Body shop layout, tooling, utilities and material handling should be revised as outlined above.

Body dimensions

Problem. Establishing clearances, limits and dimensions of body for most accurate construction.

Discussion. A good fixture designer can build an accurate functionable body regardless of panel shape or body draft dimensions. IMM limits of 7 mm for openings at door, hood etc. and 1.0 mm plus or minus are normal and acceptable. All subassembly fixtures should be built to hold critical dimensions, and also hold accurate matching surfaces for the next assembly. Major assembly fixtures should be built to hold accurate all daylight openings, that is, all door, hood, tail gate and window openings. Checking fixtures and means of adjustment such as door jacks should be provided to shape these openings.

Conclusions. By choice of assembly sequence and position of locators the fixture designer can assemble any body to the exact dimensions required. Checking fixtures or body dimensional check is necessary to prove this accuracy.

Recommendations. Checking fixtures should be made for critical dimensions. Weld design should be followed as outlined. Workers should be required to use all fixtures in designed manner.

Anti-corrosion materials and protection

Problem. Review and recommendation of newest methods for preventing corrosion.

Discussion. Corrosion protection material must be applied directly to the metal, thus the first step requires complete chemical and physical cleaning of the metal. It requires inspection and hand removal of excess rust, soil or grease with deoxidizer containing an iron or zinc phosphate. The metal must then pass into the normal cleaning system of soil removal, zinc phosphate and chromic acid. Hot water rinse follows each, with final rinse of pure demineralized water. The prime paint and filler, applied wet on wet, is baked in an oven prior to coating. Total thickness is 0.004 inches (0.102 mm). For areas where extra protection is needed galvanized (zinc-coated) metal may be used. After normal paint extra coatings of zinc chromate paint or aluminum oxide paint are applied. Finally, a mechanical protection of mastic sealer or other should be considered.

Conclusions. Unless metal is absolutely clean, no protective coatings will be effective. In addition to normal paint protection the designer has the choice of the following: additional paint coats; plated metal; mechanical protection; or a combination of the three methods just mentioned.

Recommendations. The least expensive process necessary to give the degree of protection required should be chosen.

In-process body component movement

Problem. Devising the best method of metal movement in the body shop.

Discussion. No sheet metal should touch the floor. Metal on the floor means extra labour and potential damage. All panels should be supplied in bins or proper containers. They can be stacked in groups to lessen travel time. After subassembly they then go back in bins or special racks for group movement to larger fixtures.

Line flow control extends to subassembly by building at line speeds for direct use. Racks for small groups of bank stock can be used between operations. Major subassembly units are fed from these wooden racks, plus direct from bins of single panel stock. The above reduces material handling, damage and storage space. It extends the line concept over non-line subassembly activity. It requires construction and use of special racks, and their placement in assigned storage places.

Conclusions. Great improvement can be realized by incorporating rack in-process storage into the body shop redesign.

Recommendations. All metal should be kept off floor by use of wood racks and special storage procedures as outlined in discussions.

Body movement without damage

Problem. How to move and transport the body safely.

Discussion. The following procedure seems to be the most suitable. Load body and subassemblies into fixture or body truck with adequate metal guides. Bodies on trucks must be pinned so that a bump or jar will not dislocate them. Drop body on a slight angle with a long pin guide (removable) for alignment. Bolt body, where necessary, to truck with a pin and shoulder bolt with threads. Use spacers in paint shop to hold open doors and lids for free circulation of oven hot air. Wrap body hooks etc. in foam rubber or equivalent to keep accidental bumps from marring surface. Design body hook to pick body up from underside without twist or sag.

Conclusions. Most defective metal finish and repair is caused by poorly designed tools or carelessness. Follow-up analysis of damage will reveal cause, so that it may be corrected.

Recommendations. Body hoists should be redesigned as shown on sketches given for tool design.

New car preparation for delivery and overseas shipment

Problem. Selection of least expensive and best overseas and local new car preparation.

Discussion. A hot water soluble wax can be used to coat the vehicle for surface protection. It can be removed with hot water. Overseas shipment by boxing SUP units has given way to containerization. Storage of new vehicles should be made with a 60 day movement schedule, more or less, as the climate dictates. A ten-minute drive will do the following: charge the battery; lubricate the inside of engine, differential, and transmission to prevent rust formation; and rotate tyres to prevent flat spots from forming.

Conclusions. Containerization gives protection against both pilferage and the elements. Wax may also help. Vehicles should be driven periodically.

Recommendations. Stored vehicles should be driven every two months and containers used for long ocean shipments.

Chassis frame design and assembly

Problem. How to assemble the frame without warping it.

Discussion. Frame redesign, reprocessing and correction of warpage has already been discussed in detail. The essential points may be summed up as follows. With regard to redesign, the C design should be used and spot-welded with mig-weld reinforcement. For reprocessing, open hat design with spot-welding and mig-weld should be used, closing as in final process. To counter warping, the warp should be measured and adjusted with shim after it is on wheels. Correct by peening or arbor press if warpage is too great.

Conclusions. The difficult problem of getting correct spacing between body and frame is best met by building an accurate body and measuring the frame, and using shims to correct the difference.

Recommendations. The programme outlined above and elsewhere should be carried out.

Frame processing

Problem. How to weld frame without distortion.

Discussion. The problem was reviewed with design and die engineers, and the recommendation was made to redesign with the open C design. Pending this change, warpage can be reduced by reducing heat put into the assembly by the following methods: skip welding, spot-welding instead of mig-welding or arc-welding, bolting on units where welding causes warping. If the open side and cross members have attachments spot-welded where possible before being closed, it will lower cost and reduce heat input. Bolting steering bracket to front left side member should be considered. Skip welding is almost as strong as continuous welding, and should be used where possible.

Conclusions. Normal frame design for vehicles of this size is an open C design and it can be used on ARO.

Recommendations. Redesigning should be done to an open C design. The present frame should be reprocessed for less heat until new design is complete. The steering unit should be bolted on. Skip welding should be employed.

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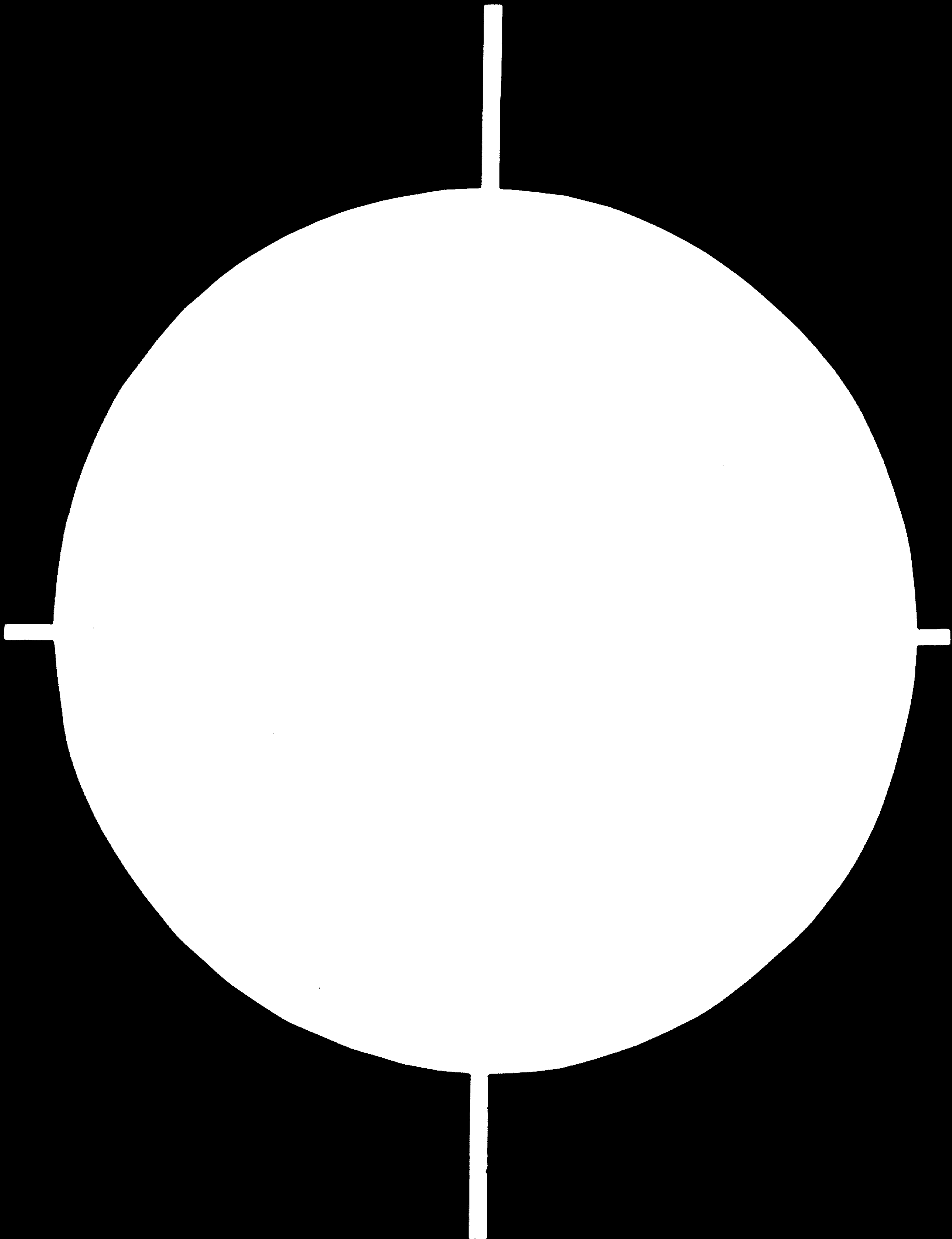

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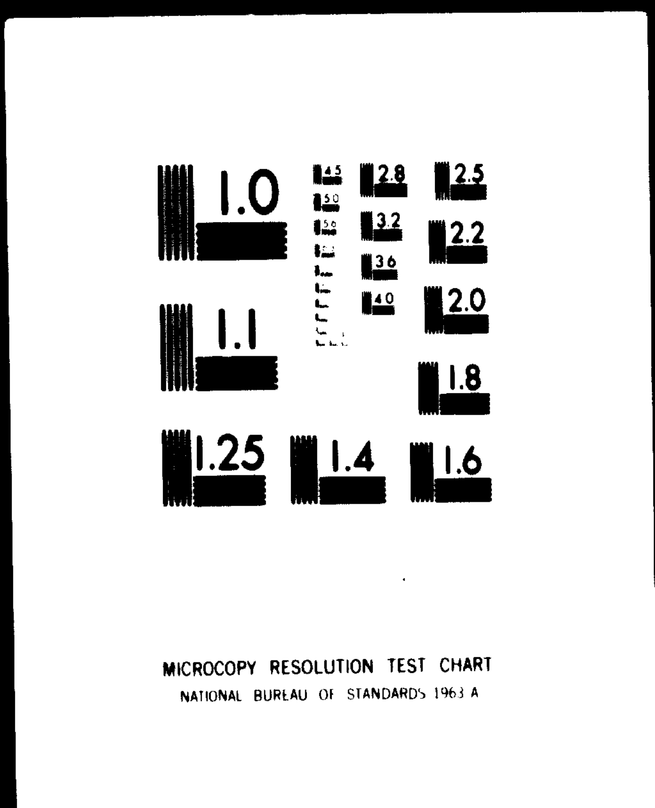

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How to weld body metal properly

Problem. To eliminate or compensate for incorrect weldments.

Discussion. This problem has already been covered. The essential points were briefly as follows:

(a) Use critical locating points in selecting fixture locating pads. Locate to critical assembly conditions, close all clamps when welding. Remember sheet metal is not rigid;

(b) Analyse subsequent assemblies and hold mating part locations;

(c) At final body framing hold all body openings and let body panel extremities go where they may;

(d) Prevent metal distortion by worker with hammer by giving him accurate metal and good fixture design. Follow up on misfit panels and correct cause of defect.

Conclusions. Fixtures must be properly designed, but fixture use must also be correct. Worker adjustment of tools or reprocessing should not be tolerated.

Recommendations. Workers should be paid by the hour, not by the piece, and trained in quality production. Pride in craftsmanship should be developed.

Body checking

Problem. Describing the best method of checking an assembled body for accuracy.

Discussion. For reference a body must be set on a large flat surface plate, approximately 30% longer and wider than it is. Dimensions can then be checked by an optical digital recorder, as IMM is installing in its new die shop, or by hand. The hand procedure was described. It requires scales (rulers) set in all three planes. Then with a large right-angle block that has side as well as face surfaces, set to move parallel to the edge of the base plate, dimensions can be transferred from the scale to the body. To do this a knife blade or height scriber should be used.

Conclusions. The accuracy of panel stampings or assembled bodies can only be determined by measurement, and the methods outlined above are means for doing it accurately.

Recommendations. If die shop measuring equipment is not available, a checking department should be installed as outlined.

C. Painting

Methods of paint application

Problem. Reviewing the different types of paint and advantages of each.

Discussion. The latest type of paint application is powder paint. This dry finely-ground powder of paint applied without solvent with flow-out in the oven permits collection of overspray. It is ecologically attractive because no solvent need be removed from exhaust air. Difficulties are encountered in colour contamination in the overspray collection system. It is still in the experimental stage. It can be applied electrostatically.

Electrophoretic (ELPO) is a water-based paint applied by submersion of product and electrodeposit. The advantages of uniform deposit, all surface coverage and no overspray are offset by a costlier installation, inferior prime paint, equipment maintenance and bacterial growth in the paint. Total protection is considered equal, but not superior to prime spray, and this system has lost favour recently.

Electrostatic spray, with air or airless, gives some advantage of uniform electrodeposition and reduced overspray, especially on round or grid products investment is not great.

Dip is frequently used in car paint for first coat application. Its disadvantages of extra fire hasard and heavy weight installation is partially overcome by flow-coat systems for simple-shaped products. But surface irregularities and non-uniform thickness are problems.

Spray painting still predominates in modern shops. Automatic spray where possible is favoured at higher volumes to minimise human error and reduce cost.

Conclusions. Paint may be applied in a variety of manners, with spraying still the most popular. At the moment no one method is so superior as to require changing equipment.

Recommendations. Use of present equipment should be improved, and paint selected for best quality and least cost.

Spray painting

Problem. Factors affecting spray paint application and the influence on painting quality.

Discussion. There are seven major influences on the quality of spray painting for a given paint. When all are correct the paint application should be of highest quality. They are as follows:

(a) Viscosity. Add paint solvent to control viscosity to a constant and recommended value. Measure with a ford cup or other equivalent. Select solvent as required according to temperature and humidity;

(b) Agitation. Paint is a colloidal solution and must have good mixing originally and until used. Circulation should be continuous from paint container through pipe and hose to the spray gun and back. The IMM factory does not have hose circulation, and it should be changed;

(c) Air pressure. This will vary with consumption, resistance and type of job. Regulators are normally on air hose within three to four metres of the gun. This is not so at IMM, and air pressure ap[illegible]rs high, causing orange peel. Air must be free of moisture;

(d) Paint pressure. Requirements are the same as for air;

(e) Mechanical constants. Items such as paint holes in nozzle, air holes etc. are all part of the system and should not change. Keep clean and free from foreign matter. Do not make oversized by use of reaming wire or damage;

(f) Spray technique. Maintain constant distance of gun from work, normally 8 inches (200 mm). Keep at right angles;

(g) Filters. Paint and air must be free of foreign matter. Water and oil are to be removed from air. Dirt, lumps etc. are to be removed from paint.

Conclusions. Correct paint application can be made only when control of all variables is exercised. Painting instructions start with complete understanding of the above.

Recommendations. Paint and air regulators should be added to the system near guns, if worker control will permit. Paint should be recirculated in hose from pipe to gun.

Spray painting technique

Problem. Describing best spray method to control cost and improve quality.

Discussion. The technique applied in painting a panel was described along the following lines. Keep spray gun a constant distance from the work. Keep wrist stiff and move arm and shoulder. Set spray pattern to symmetrical oval. Overlap one half stroke, starting with half pattern overspray. Commence paint flow as spray pattern touches work. Move at constant speed and distance across work. Trigger gun when pattern leaves work. Decelerate, stop, drop arm ½ of pattern height, accelerate and start flow as pattern is on work. Return back across work. Repeat, with ½ pattern overlap until all of panel has been covered with two strokes.

The above, with illustration and drawings, is a description of how to teach the theory of spray painting, with minimum permitted overspray and uniform paint thickness. A 10% reduction in overspray was, using the paint engineer's figures, estimated to save lei 1,520,000 annually. ARO workers do not trigger the gun and overspray may be 15% to 20% more than normal. Overspray on wheel painting is especially high - possibly 70%. A design for automatic wheel spray was shown.

Conclusions. IMM can save over lei 1.5 million annually in material costs by teaching and demanding better worker spray technique.

Recommendations. All painters should be instructed in the above techniques, and the use of proper paint spray, with least overspray, should be ensured. Wheel spray should be automated.

Paints

Problem. Review of available car paints and their respective advantages.

Discussion. A general discussion on paints, high temperature enamels etc. ended with the comment that acrylic laquer and acrylic enamel were the two paints most used for vehicle painting.

Lacquer is favoured for ease of application, easy low-cost repair, less costly paint shop, no oxidation on the car, and most of all for reflow application. It is more expensive, but fewer rework jobs offset this.

Enamel is less costly. It requires a better paint shop, higher oven temperature, more rework. It has good gloss, but must be cleaned before polishing after ageing. The time/temperature curve of each paint may differ. Required time/temperature figures mean metal temperature, and the time is "time at required temperature". This time, plus heat-up and cool-off equals oven cycle time. A comparative list of operations for application of acrylic lacquer, acrylic enamel and the IMM alkyd paint was made. If IMM should consider use of acrylics, it may offer excellent labour savings by taking steps along the following lines:

(a) Prime and filler can be sprayed wet on wet. This eliminates a bake oven and wet sand operation;

(b) Mastics applied after prime bake will take colour coat and can be baked out with the colour. This eliminates a mastic bake oven operation;

(c) If the reflow lacquer is used a major reduction in rework cost will result.

Labour savings were estimated at up to lei 400 per unit, or lei 6,400,000 to 8,000,000 per year.

Conclusions. Modern paint materials that permit combining of spray operations have reduced the number of ovens and amount of sanding required.

Recommendations. Use of acrylic paint for cost reduction should be considered.

Paint tests

Problem. Review of paint tests for method and value.

Discussion. Paint tests used by IMM are good. There were three areas of possible improvement. They are as follows:

(a) Humidity test. Place test panel with "X" scratched on it into test chamber where heated water in bottom keeps inside at 100% relative humidity and 100°C. After time interval examine for rust (details of test procedure will be obtained);

(b) Thickness gauge. The gauge used by IMM is good, but it can be easily damaged and gives false reading on curved surfaces. Another gauge operating by means of a magnetic pull against a spring is available. It is less expensive, lasts longer and is not so easily broken;

(c) Field tests in which paint experts periodically visit various areas of different climatic conditions to examine cars for paint defects are good. The condition of cars of various ages verify the laboratory tests. The IMM paint cost is about lei 20,000,000 per year. If six inexpensive thickness gages, an investment of about lei 3,600, reduced paint consumption by just 2% (more should be expected), the savings for that investment would be lei 400,000 per year.

Conclusions. Laboratory testing is nothing unless verified by actual results. Controlling paint thickness to specification improves quality, and by eliminating excess deposit reduces material consumption.

Recommendations. Field tests should be started to verify laboratory paint test results. Inspection and paint shop supervisory staff should have a paint thickness gauge.

Paint spray booth

Problem. Review of factors of spray booth design, use and maintenance, and determination of best usage at IBM.

Discussion. Vertical capture velocity of overspray is 150 ft/min (46 m/min). In down-draft booth design, air flow is less. If the floor is covered except in slots at the side of the car it will increase exit air speed and capture velocity. Positive air pressure must be maintained inside booth to keep outside dirt from entering. With only designed openings permitting air escape, the supply system is about 10% larger than the exhaust system. Extra leakage, as open personnel doors, leaks around lights etc. will unbalance system and cause outside dirt to enter. Dirty filters also reduce supply air and permit dirt to enter booth.

Coating walls with soap makes their cleaning easy. Scrape away paint, rewash with soap, and let soap film dry on inside booth wall. Keep floor clean. Wipe spray guns and equipment with mineral spirits (solvent) to remove paint when dirty. Keep lights clean. Treat water with one chemical to suspend paint, and a second to kill stickiness. Compressed air must not contain water, which may be removed by the following methods: installing a chiller on the compressor, using an air trap, draining storage bottles, having bottom take-off down-drops in the distribution system, using top take-off for air taps, using diatomacious earth and/or laminated filters, or standard paint regulator and filter. Air to portable tools should have filter and lubricator at each take-off. Air to spray the booth normally goes through a primary roll filter, a secondary bag filter and a final screen filter. It is to be humidity and temperature-controlled. In the exhaust system paint and water should be removed from air. Ducts should be cleansed of carry-over paint to reduce fire hasard. Some paints attack metal, and galvanized or coated ducts last longer.

Conclusions. A complete understanding of design is necessary to control and best use of the booth. Correct functioning by best maintenance is essential for good use and acceptable painting.

Recommendations. Equipment should be kept clean and used according to design to ensure good painting.

Ovens

Problem. Review oven design features and find best system for IMM.

Discussion. Drying paint requires it to be kept at high temperature for a specified time. Paints have a time/temperature curve showing the following relationship: the longer the time the lower the temperature. To save utility cost, the lowest bake temperature that time will allow should be used. Space units in oven to allow air circulation. Hold open doors, hoods etc. with a wire spacer for good circulation to lock and hinge pillars, inner door, and inside body. Add hood to body if fenders are on, for no more oven space is required. Drop body to chassis after engine is on, a 5° angle with aid of pin guides. Water drying ovens should have direct strong air movement. Filter air for flash off chamber and oven. Do not introduce dirt here. Keep positive air pressure in these places to prevent entrance of non-filtered air. Oven wall should have 10 cm fibreglass insulation. Insulate floors. Coat inner wall with non-melt grease to pick up dust. At vestibule air door place extra body profile outline metal panel over door to reduce heat loss. Seal all wall cracks. Use fail-safe heaters with adjustable on-off temperature gauges. Use also a recording gauge, and clean oven floor frequently to remove dust.

Conclusions. To keep cost of heat low, keep oven full and temperature as low as time will allow. Keep oven clean and filter air to prevent dirt contamination.

Recommendations. A study should be made to determine the source of dirt in paint and to remove it. One-shift use of paint shop should be considered with body bank for second shift. Heat cost should be reduced by filling oven and using low temperature/long time cycle.

Paint defects

Problem. Discussing the various defects that can occur, finding which are present at IMM, and reviewing the causes and possible solutions.

Discussion. To facilitate discussion, a booklet was used with pictures of various paint defects, and a description of their causes and possible solutions. Defects caused by incorrect use of the spray gun were reviewed as a group, but all listed defects were identified and their causes were fully discussed, so that corrective action could be taken. Common defects are dirt, orange peel, fish eyes, pinholes or solvent popping, and poor metal finish. Orange peel, the most common defect, appears to be caused by incorrect spray booth temperature, excessive air pressure, and holding gun too far from work. All three cause "dry deposit", or deposit without sufficient solvent to have the atomized paint flow out smoothly. Silicone is a common cause for fish eye formations. The muffler pipe aluminum paint was found to have silicone in it. Black muffler spray will correct the silicone problem.

The paint shop was visited and detailed discussions held. The major paint shop problems are as follows:

(a) Incorrect or no worker training. To questions concerning so many things done wrong or not done, the answer was "they don't follow the engineering instructions". Some of the matters raised concerned sanding too much, incorrect spray technique, touching a clean body, not closing spray booth doors, dirty equipment and surroundings etc.;

(b) Lack of cleanliness. There was dirt in ovens, on body trucks, in spray booths, on tools, on machinery, booths and equipment;

(c) Poor painting. This was evidenced by the following: filler on bare metal without use of flash primer; asphalt overspray on prime partly removed, leaving a thin coat of sealer between prime and filler; excess sanding for uneven paint thickness; poor spray technique; no removal of rust before cleaning;

(d) Out-of-schedule painting. The paint shop is a warehouse with piles of miscellaneous panels stacked everywhere in all stages of prime etc.

Conclusions. Poor maintenance, dirty workers, and unskilled painters cannot do a first class paint job.

Recommendations. The shop should be cleaned, the workers trained, and the paint regulations enforced.

Painting procedure

Problem. Review of, and comment on, IMM painting procedures.

Discussion. New paints make possible wet-on-wet primer-filler spray, and should be considered to replace the dip, spray prime, bake, wet sand, dry, spray filler process now in use. If a solvent clean and deoxidizing wipe for rust is performed before the metal clean tunnel, the metal will have a better phosphate coating. Sanding between prime and filler is usually done dry. It has two prupoeses, first, to sand off dirt and other protruding defects, and second, to scratch the prime slightly so as to make a better physical bond with the filler coat. Both can be done by a light (scuff) dry sanding. The heavy wet sanding now practised is not necessary. Sanding should be done with a sponge pad, or at right angles to finger direction, not parallel to fingers for uniform coverage. Prime and filler spray technique is not good. Overspray of deadener (asphalt) can be kept off the outer body surface with fibreglass forms in hood and window openings. Too much paint is removed in filler dry-sanding. Sand should only be scuffed. No worker should touch body with hands (gloves should be used) at any time in the paint shop. Make iron hook to move body truck. Keep spray booth door closed, and clean booth and filter system and ovens to keep dirt from paint (in this connection, see schedule in maintenance book provided by expert). Use spacers to hold doors open to get better drying on lock and hinge pillars.

Conclusions. Better understanding and better worker training is necessary at every step of the paint shop procedure. When work is not done properly, the foreman and supervisors are responsible.

Recommendations. The suggested improvements outlined above should be introduced. The workers should be trained in correct painting, engineering procedures should be followed, and there should be better supervision and maintenance.

Maintenance

Problem. Selection of maintenance programme best suited to the IMM paint shop.

Discussion. The IMM paint shop floors and structures are dirty. Dry sand before final colour will give dirt carry-over. Wet sand between prime and filler is not needed. Paint deposit in the spray booth is unbelievably heavy. Dirt in final paint is much worse than need be and is a major paint defect. To correct this situation, filters, spray and oven booth should be kept clean, and the paint shop should be cleaned by vacuuming structures and wet-washing floor daily. Make floor smooth and paint with epoxy. The schedule in the maintenance book provided by the expert, adapted to the IMM installation, should be followed. Keep positive pressure inside booth and oven. Coat with coal tar epoxy paint inside exhaust of spray system if rust is problem.

Conclusions. A dirty paint shop and dirty painters will make a dirty paint job. Poor maintenance shows up in dirty paint on cars. Less overspray will reduce maintenance work.

Recommendations. The maintenance schedule should follow the guidelines laid down in the maintenance book provided by the expert. A major cleaning effort should first be made to bring the paint shop up to standard.

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