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Report SE-89-03

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APPLICATION OF HIGH-RATE CUTTING TOOLS

Manufacturing Methods & Technology
Project No. 6828248

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March 1989

Rock Island Arsenal
Rock Island, IL 61299-5000



TECHNICAL REPORT

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19. ABSTRACT (Continue on reverse if necessary and identify by block number) Widespread application of the newest high-rate cutting tools to the most appropriate jobs is slowed by the sheer magnitude of developments in tool types, materials, workpiece applications, and by the rapid pace of change. Therefore, a study of finishing and roughing sizes of coated carbide inserts having a variety of geometries for single point turning was completed. The cutting tools were tested for tool life, chip quality, and workpiece surface finish at various cutting conditions with medium alloy steel. An empirical wear-life data base was established, and a computer program was developed to facilitate technology transfer, assist selection of carbide insert grades, and provide machine operating parameters. A follow-on test program was implemented suitable for next generation coated carbides, rotary cutting tools, cutting fluids, and ceramic tool materials. Computer program algorithms were used to quantify comparisons among different manufacturer's tools. Benefits realized are a selective and reduced tool inventory, increased productivity, improved part quality, and more extended, accelerated application of new tooling.					
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CONTENTS

<u>Section</u>	<u>Page</u>
ACKNOWLEDGEMENT	v
TABLE OF CONTENTS	iii
LIST OF FIGURES	iv
LIST OF TABLES	iv
1.0 INTRODUCTION	1
2.0 EXPERIMENTAL DETAILS	2
2.1 Workpiece	2
2.2 Tool	2
2.3 Cutting Fluid	4
2.4 Cutting Conditions	4
2.5 Tool Life Criteria	6
2.6 Tool Wear Measurement	6
2.7 Equipment	6
2.8 Tool Life Test Procedures	6
3.0 RECORDING AND REPORTING RESULTS	11
4.0 EVALUATION AND DISCUSSION	11
5.0 TECHNOLOGY TRANSFER	19
6.0 SUMMARY	23
APPENDIX A - SORTING PROGRAM FLOWCHART	A1
APPENDIX B - COMPUTER PROGRAM LISTING	B1
APPENDIX C - FINISHING SIZE INSERT DATA	C1
APPENDIX D - ROUGHING SIZE INSERT DATA	D1
APPENDIX E - MACHINING DATA SORTING PROGRAM	E1
BIBLIOGRAPHY	25

LIST OF FIGURES

<u>Number</u>		<u>Page</u>
1	4140 Workpiece Material	3
2	Tool Wear Modes	7
3	Dedicated Testing Lathe	8
4	Tool Wear Measurement	9
5	Tool Data Documentation	10
6	Flank Wear To Determine Tool Life	12
7	Photo Data Display	13
8	Machining Performance	15
9	Observations	16
10	Tool Life Equation	17
11	Inputs for Tool Selection Program	20
12	Outputs for Tool Selection Program	21

LIST OF TABLES

<u>Number</u>		<u>Page</u>
1	Cutting Test Machining Parameters	5
2	Linear Least Squares - Regression Analysis	14

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1.0 INTRODUCTION

At present, the rapid evolution of cutting tools and the problems subsequently affecting cutting tool selection are among the most important topics in machining. Improved tool management, including cutting tool selection, offers a practical and achievable solution to the constant demand to reduce costs and improve productivity in today's competitive manufacturing environment. It has been said, 'there is no easier, less expensive, or faster way to achieve productivity and product excellence than by applying the right cutting tools to the job.' This presumes state-of-the-art equipment and trained support personnel.

The machining process and accompanying tool wear are highly complex, with many interrelated variables and dynamic reactions occurring in a very hostile environment. Experimental studies frequently are undertaken to test workpiece materials for machinability and generate operational data, but 'machinability' is difficult to define. It is not a unique material property which can be more or less easily measured like hardness or ultimate strength, as it cannot be divorced from the tool or other cutting conditions.

Early pioneering work by F. Taylor (c. 1907) established a machinability relation, an empirically derived relationship between tool life and cutting speed. Now, as in the earlier work, the nature of tool life before tool failure is recognized as probabilistic rather than deterministic. Thus, results of tool tests are influenced by rules of statistics. The variability and scatter of tool life data is an accepted fact, and scatter, itself, varies depending on machining conditions.

Throughout the recent decade, and particularly during the past 4 or 5 years, there have been major advances in the development of high productivity machining, cutting tool materials, and tool designs. New tools with thin film bonded coatings have been marketed in such numbers, with suggested applications for a wide range of work materials and conditions, that no single data base or timely reference for machining parameters exists. An increasing need for reliable technical data for efficient implementation of this new tooling was apparent.

Rock Island Arsenal's long range goals are to apply the newest cutting tools and cutting tool materials for higher productivity and lower costs and to improve tool management and inventory control. This project set the basis for meeting those goals by testing, analyzing, recommending, and applying the latest high-rate metal removal tools and materials to turning, establishing procedures for continued testing with newer tools, and creating a reliable tool life data base containing verified operating parameters for coated carbide single point turning inserts. An interactive computer program useful in identifying and ranking specific tool grades in this database to meet process requirements was also developed.

During the cutting tests at Rock Island Arsenal, the workpiece materials were not considered as test variables as care was taken to use workpiece material with very similar machinability and hardness. Care was exercised to minimize the number and sources of other possible variables during the entire study. Throughout the project, testing was carried out in random sequence, with precautions taken to ensure observations were independent of factors other than the prime variables being studied.

2.0 EXPERIMENTAL DETAILS

2.1 Workpiece

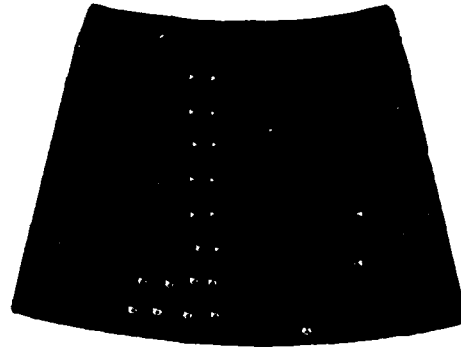
The test workpiece materials used in this study were spectro-analysis verified medium alloy steels. AISI 4140 steel (7 3/16 inch outer diameter X 1 3/16 inch wall X 36 inch long) hot rolled tubing used for finishing insert tests was heat treated, quenched, and tempered to HRC 31-33 (see Figure 1). AISI 4140 steel (same dimensions as above) and AISI 4130 (8 1/2 inch outer diameter X 1 5/8 inch wall X 36 inch long) hot rolled tubing used for roughing inset tests were heat treated, quenched, and tempered to HRC 32-35 and HRC 29-30, respectively. These steels are the most representative materials for the majority of machining at Rock Island Arsenal, and the hardnesses range from the middle to the upper end of allowances for Rock Island Arsenal products. All of the workpiece surfaces were sandblasted prior to testing and were free of mill scale and rust. Cleanup cuts were made on the outer diameters of every tube to assure that each test insert cut uniform hardness material.

2.2 Tool

The sintered carbide, indexable inserts were purchased from manufacturer's distributors. The substrate grades conformed to the U.S. 'C' classifications group C5-C8 for machining steel. Twenty-two different grades of chemical vapor deposition (CVD) coated carbides representing 13 manufacturers were tested. Each grade was either Al_2O_3 -coated or multicoated. The Al_2O_3 -coated grades had an Al_2O_3 exterior layer with a TiC coat just below it at the substrate interface. The multi-coated grades had a TiN exterior layer with Al_2O_3 as an intermediate, and a TiC or TaC coat at the substrate interface.

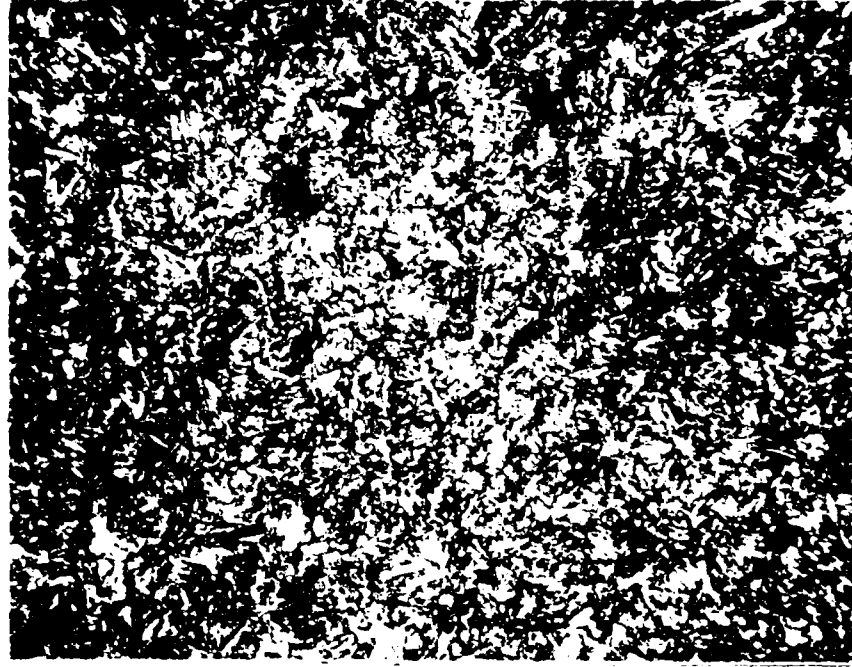
Five basic insert geometries were studied, listed here in order of both strength and lowest costs: round, square, triangle, 80 degree diamond, and 55 degree diamond. Round inserts are cheaper than squares and these are cheaper than triangles, etc. Size, which is determined by measuring the inscribed circle (IC) and thickness, affects an insert's strength, no matter what its shape. The strength of an insert is a measure of the transverse force it can withstand before fracturing. Size (IC) was chosen as a means to differentiate between those inserts applied to finishing cuts and those applied to roughing cuts. Cuts were finishing or roughing, depending upon depth of cut (DOC), i.e., with inserts having an IC of 1/2 inch, finishing tests were performed at a DOC of 0.060 inch, and with inserts having an IC of 5/8 inch and 3/4 inch, roughing tests were performed at DOC of 0.200 inch.

4140 WORKPIECE MATERIAL



1.5X

HARDNESS SURVEY HRC-31 AVE.



400X

TEMPERED MARTENSITE

FIGURE 1

Most manufacturers offer grades listing a variety of configurations or styles of molded chip breakers. For an equitable comparison between vendors, the recommendations in vendor literature were followed for particular chip breaker styles suitable for the DOCs and feed rates of the tests. The effectiveness of the chip breakers was examined.

Although not considered as a prime test variable, the corner radii of inserts was varied to examine the effect on tool life and surface finish.

Toolholders used in the tests had negative 5 degree back and side rake angles, regardless of insert size or geometry. Side cutting edge angles or lead angles were positive 15 degrees, 0 degrees, or negative 3 degrees and were based on the shape of insert, not on the size of insert. Holder designations were as follows:

Triangular - MTRNR - 20-4
MTRNR - 24-5

Square - MSRRR - 16-4
MSRRR - 24-6

80 degree diamond - MCGNR - 16-4
MCGNR - 20-5
MCGNR - 24-6

55 degree diamond - MDJNR - 24-4
MDJNR - 24-5

Round - MRGRR - 16-4
MRGRR - 24-6

2.3 Cutting Fluid

During the insert tests, the cutting fluid was not varied. The fluid used throughout the project was CIMCOOL 400, a synthetic lubricant marketed by Cincinnati Milacron. It was diluted 1:25 with water as recommended for turning applications with carbon steels where cooling properties are important. The fluid was applied to the backside of the workpiece tubes and directed 6 inches ahead of the cutting tool. The flow rate of the fluid was maintained at 6 gallons per minute to assure ambient temperature of the workpieces during cutting. All cutting was considered to be performed 'dry,' despite the adhering film of coolant on the rotating work material, as the tool-workpiece interface was at no time flooded by coolant.

2.4 Cutting Conditions

The set of machining parameters used throughout this study is shown in Table 1. Numerous cutting speed tests were conducted at each feed rate setting.

TABLE 1
CUTTING TEST MACHINING PARAMETERS

TYPE OF CUT	DOC (in.)	FEED RATES (ipr)	SPEED RANGE (SFPM)
FINISHING	0.060	0.012, 0.017, 0.020, 0.023	350 TO 700
ROUGHING	0.200	0.020, 0.023, 0.027, 0.030	250 TO 600

2.5 Tool Life Criteria

Flank wear and DOC notching both contribute toward ending useful cutting life of sintered carbide tools. During this study, width of the flank wear land (Figure 2.1) was the predominate tool life determining factor, although nose wear and rake face cratering (Figures 2.2 and 2.3) occurred as accompanying wear modes. The criteria employed for establishing tool life (T_L) were flank wear limits chosen of 0.010 inch average or 0.020 inch maximum for finishing cuts and of 0.015 inch average or 0.030 inch maximum for roughing cuts.

2.6 Tool Wear Measurement

A Gaertner toolmaker's microscope was used to measure the width of the flank wear land (VB_m), the DOC notch (VB_n), and nose wear/deformation (VB_c). The microscope was calibrated using steel shim stock in 0.001 inch increments over the range of interest from 0.001 inch to 0.030 inch. The microscope was 30X power, and the micrometer drums were divided in 0.0001 inch units, providing an estimated measurement uncertainty of ± 0.0005 inch.

2.7 Equipment

The tests were carried out on the Warner and Swasey 30/60 horsepower turret lathe, saddle type chucker, style 3A, model 3500, (shown in Figure 3) dedicated to the RIA single point tool testing program. The machine tool was modified with the turret serving as the tailstock, and this was fitted with a specially constructed live-center bell end to accommodate the workpieces. The lathe was equipped with a finite step variable speed spindle. The spindle speeds were calibrated with a digital phototach covering the range of interest from 155 to 851 rpm; this was done at both 30 and 60 horsepower settings, and under both 'no load' and cutting conditions. During testing, as the workpiece diameter was reduced with successive cuts, the cutting speeds were predetermined (by calculation) in order to stay within ± 3 percent of the original designated cutting speed. Other equipment included a timing clock, suitable span micrometer calipers, and a workpiece surface roughness comparator. Surface finishes were estimated (visually and tactilely) using a Number 10 Standard Ordnance Finishes Set, manufactured by Universal Machining Company.

2.8 Tool Life Test Procedures

Tool flank wear was measured at the predetermined sequence of intervals of 1, 1, 2, 2, 4, 4, 6, and 6 minutes until the average uniform wear limit or the maximum localized wear limit was reached.

Inserts remained in the toolholder while the measurements were made (Figure 4) and the accumulated wear was recorded along with elapsed time-in-cut. Individual tool wear data sheets (Figure 5) were used to document the test data and record assessments of chip quality, workpiece surface finish,

TOOL WEAR MODES



2.1 Average Flank Wear = 0.0135 in. 20X

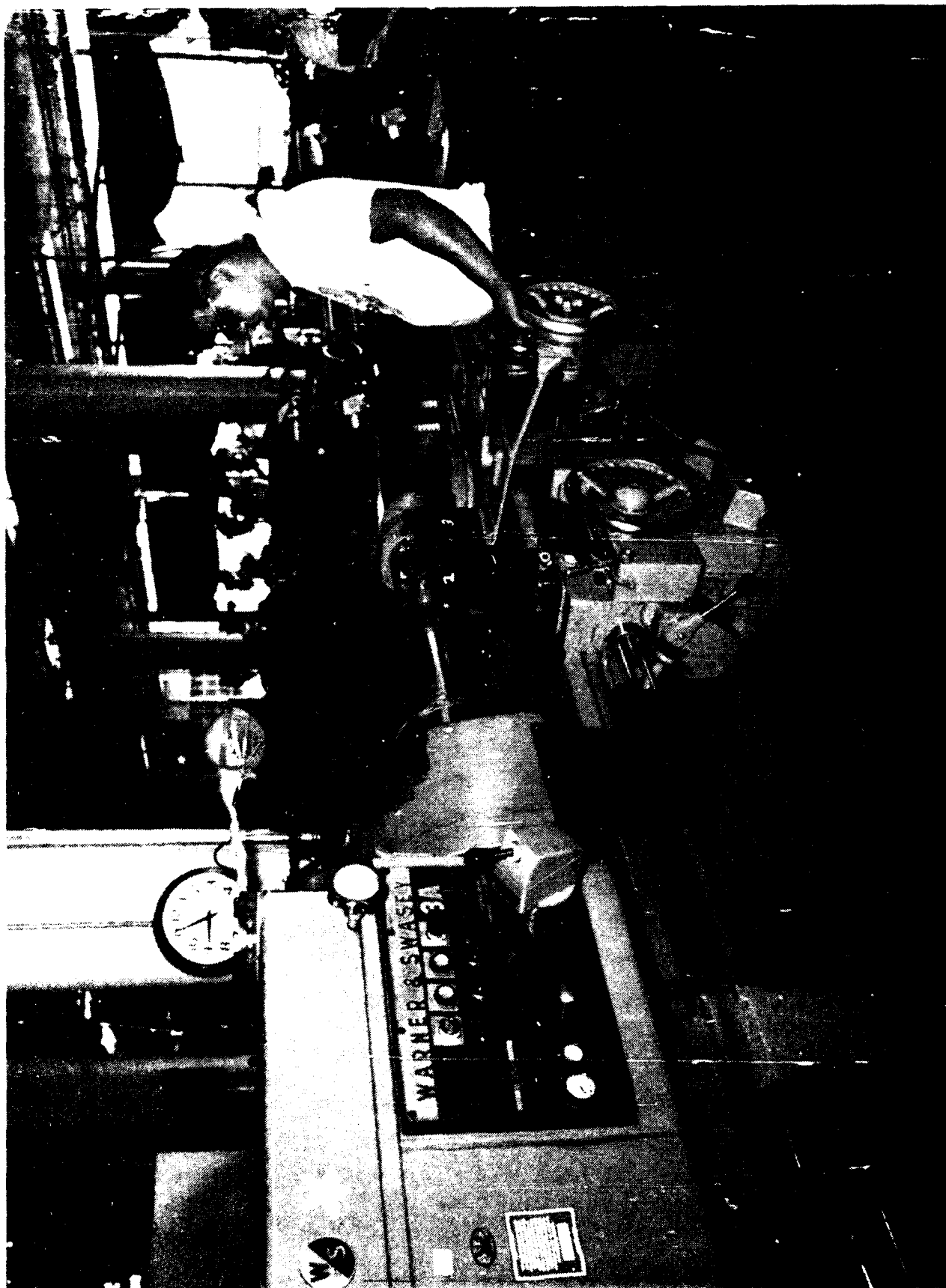


2.2 Nose Wear & Cratering on Rake Face 20X



2.3 Nose Deformation & Cratering 50X

Figure 2



DEDICATED TESTING LATHE

FIGURE 3



TOOL WEAR MEASUREMENT

FIGURE 4

[illegible]

FIGURE 5
TOOL DATA DOCUMENTATION

the machining parameters, and other observations, e.g., sparking or screeching. Wear modes were recorded for each insert edge, as was the calculation of metal removal rate. The occurrence frequency of wear modes was determined for each grade-shape combination. Catastrophic failure such as tool breakage was not found to be a problem for the regime of tested parameters.

3.0 RECORDING AND REPORTING RESULTS

Progressive flank wear measurements versus cumulative cutting times, taken at several cutting speeds (V), provided curves similar to the examples for finishing cuts shown in Figure 6. Plots of this type were the means of determining tool life (T_L) for a particular insert grade, shape, and designation run under a given set of machining conditions. Photo data displays (Figure 7) were made to document the test results for each insert cutting edge tested. Speed (Sp) and Feed (Fd) are given in units of surface feet per minute (SFPM) and inches per revolution (IPR), respectively. Figure 8 shows a typical diagram of tool life versus metal removal rate (MRR) for a family of curves plotted for different feed rates. Noted at each datum is the corresponding speed calculated in surface feet per minute and the assessment of chip quality as good (G), fair (F), or poor (P). For the same tool life, higher speeds are more economical. Consistent with Rock Island Arsenal production practice, a 10 minute tool life to achieve 0.010 inch flank wear was selected for determining the desired cutting speed (V_{10}). Figure 9 exhibits comparative results for constant feed rate tests for four different tool shapes, all of the same insert grade.

A complete tabulation of test results for both finishing size and roughing size inserts is presented in Appendices C and D, respectively.

4.0 EVALUATION AND DISCUSSION

The Taylor tool life expression, $VT^n = C$ is valid under many conditions with many materials. It relates speed (V) and tool life (T) through a constant (C) and an exponent (n), the latter two parameters varying with machining conditions. Values for C and n can be obtained graphically from plots of empirical data such as those shown in Figure 10. Here three different shapes of inserts of the same size and grade were compared. A value of the speed (V_{10}) for 10 minute tool life can be estimated from this type of linear log-log relationship.

The test data obtained during this study showed that both Al_2O_3 -coated and multicoated carbide tools behaved in accordance with the Taylor equation. All experimental data was reduced using linear least squares regression analysis, and in each case the calculated statistical correlation coefficients were greater than 0.92. Table 2 displays the results of analytically fitting some typical data by this method. This table conveys how variations in feed affect speed for 10 minute tool life and chip configuration. Table 2, viewed in conjunction with Figures 8, 9, and 10, permits comparisons of metal removal

FLANK WEAR TO DETERMINE TOOL LIFE

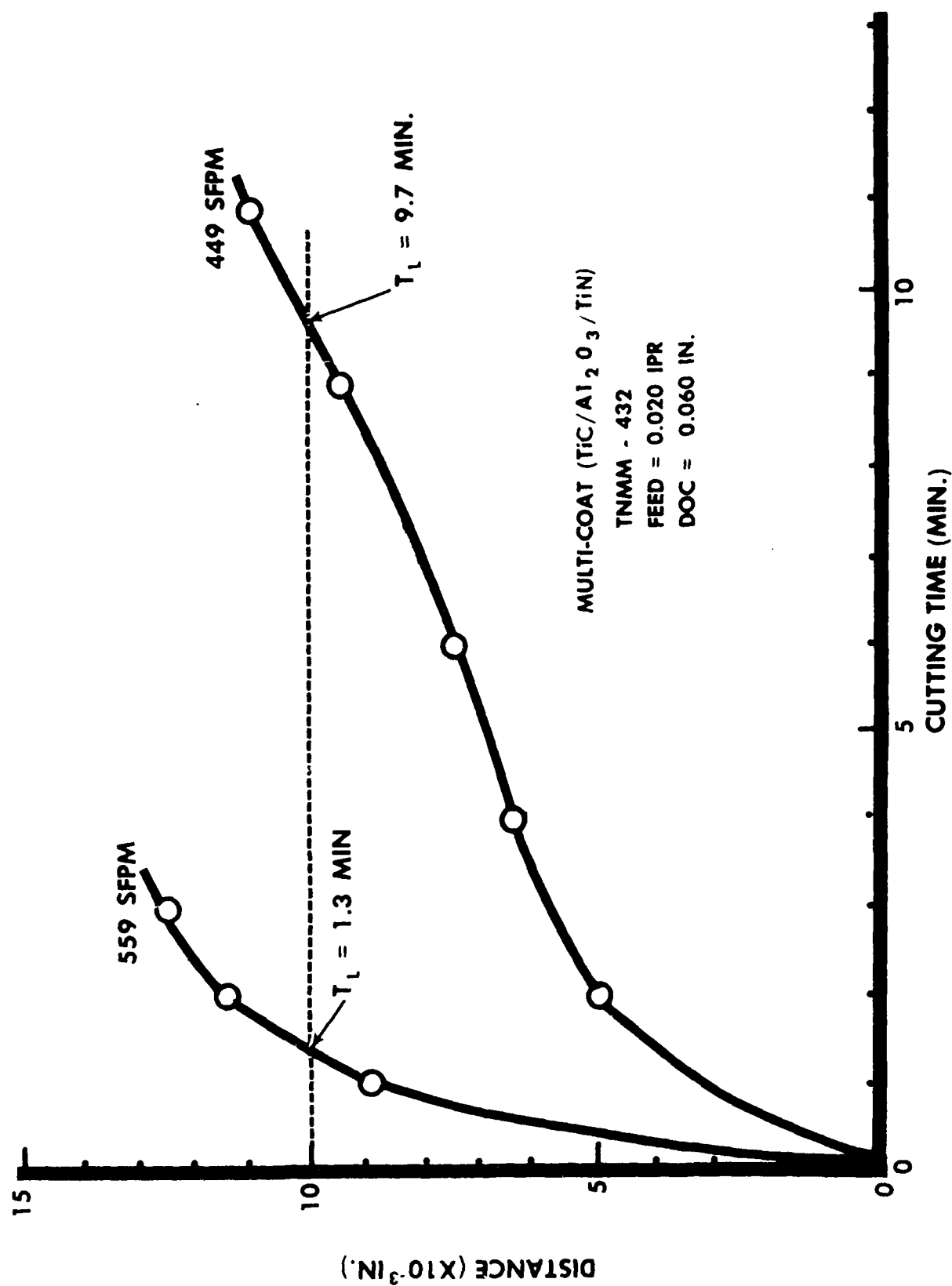


FIGURE 6

PHOTO DATA DISPLAY



TNMM-432 MULTI-COAT

Sp	Fd	DOC
599	0.017	0.060 in.
sfp	ipr	

$T_L = 4.0 \text{ min.}$ $RMS = 250 \mu \text{ in.}$ $MRR = 7.3 \text{ in}^3/\text{min}$

Figure 7

LINEAR LEAST SQUARES - REGRESSION ANALYSIS

MULTI-COAT	Insert Geom.	Size Style	Sp @ $T_L = 10 \text{ min.}$ (Sfpm)	Chips & RMS (μ in.)	MRR @ $T_L = 10 \text{ min.}$ (in^3/min)	log Sp vs log T_L Slope
Finishing Grade Inserts	TNMM	432	542	F - 125	4.7	-0.09
	SNMM	432	550	F - 125	4.8	-0.12
	CNMM	432	501	G - 125	4.3	-0.08
	DNMM	442	413	F - 125 +	3.6	-0.15
Single Point Turning: DOC = 0.060 inches Fd = 0.012 ipr	TNMM	432	475	G - 125 +	5.8	-0.25
	SNMM	432	404	G - 125 +	4.9	-0.30
	CNMM	432	380	G - 125	4.7	-0.24
	DNMM	442	284	G - 125	3.5	-0.21
Fd = 0.017 ipr	TNMM	432	447	G - 125 +	6.4	-0.11
	SNMM	432	376	G - 125 +	5.4	-0.13
	CNMM	432	311	G - 125	4.5	-0.14
Fd = 0.020 ipr	TNMM	432	447	G - 125 +	6.4	-0.11
	SNMM	432	376	G - 125 +	5.4	-0.13
	CNMM	432	311	G - 125	4.5	-0.14

MACHINING PERFORMANCE

TNMM - 432
FINISHING CUT
MULTI-COAT
DOC = 0.060 in.

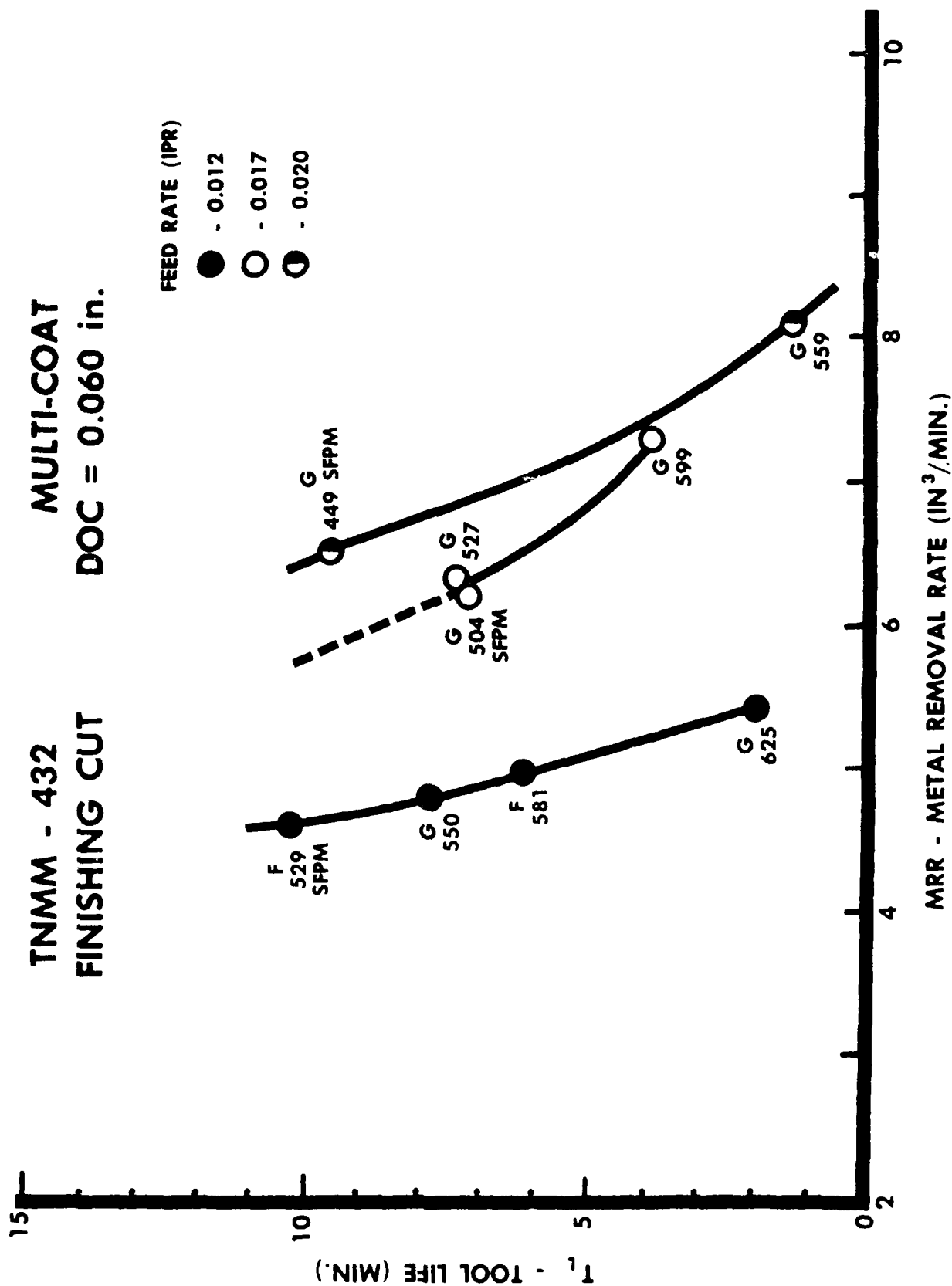


FIGURE 8

OBSERVATIONS

MULTI-COAT

Finishing Grade Inserts

Single Point Turning:

Workpiece: 4140 Steel
H.R. Tubing

Hardness: HRC = 32

CUTTING CONDITION:

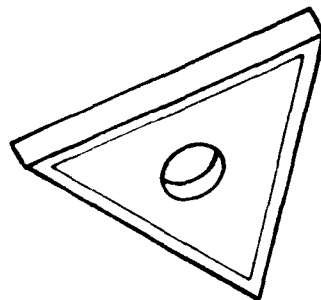
Dry, Cool Workpiece

WEAR LIMIT: 0.010 in.
Flank

Feed = 0.017 ipr
DOC = 0.060 inches

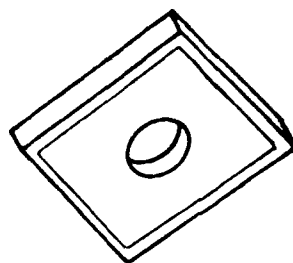
TNMM 432

Sp = 475 sfpm
@ $T_L = 10$ min.



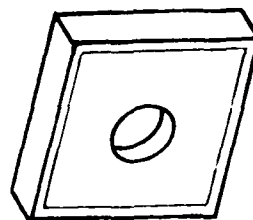
CNMM 432

Sp = 380 sfpm
@ $T_L = 10$ min.



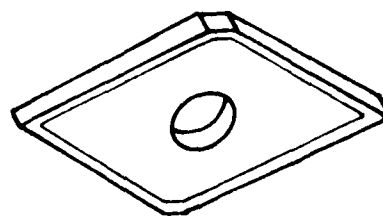
SNMM 432

Sp = 406 sfpm
@ $T_L = 10$ min.



DNMM 442

Sp = 284 sfpm
@ $T_L = 10$ min.



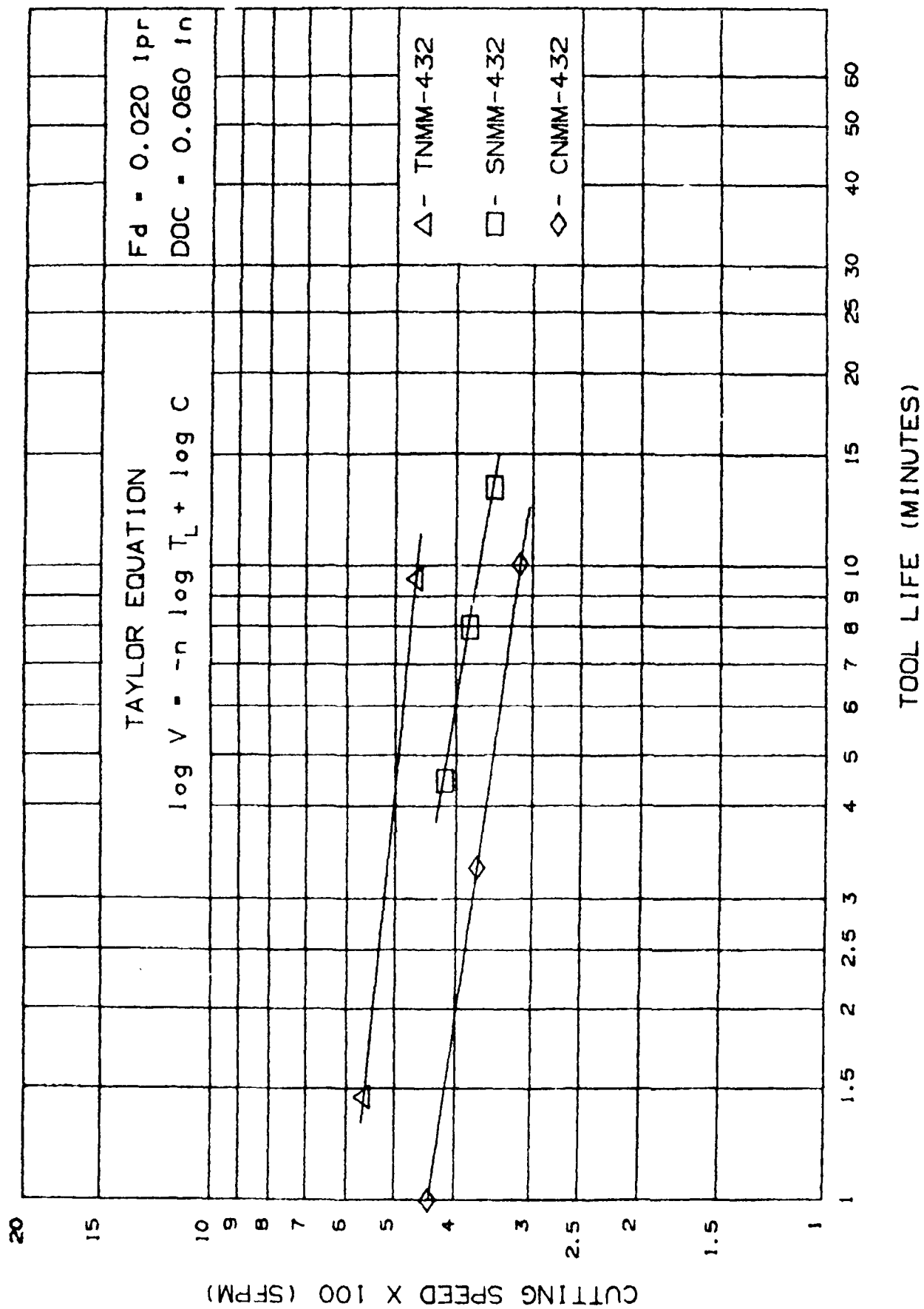


FIGURE 10

rates and surface finish of the workpiece when cutting with various sizes and shapes of inserts. Clearly, the results (Figures 8 and 10) demonstrate that as cutting speeds, and proportionately cutting temperatures, increase at a given feed rate, tool life will decrease regardless of the insert size or shape. This is also true regardless of coating, grade, or substrate. For any insert shape, as feed rate and MRR increases, the speed (V_{10}) allowing a tool life of 10 minutes will correspondingly decrease. The influence of insert shape on V_{10} (see Table 2) was the same as the order of geometric strengths described in section 2.2. Rounds can withstand higher speeds than squares or triangles, which in turn can out-perform either of the two diamond shapes. These observations were valid for the Al_2O_3 - and multi-coated insert grades and for both finishing and roughing sizes (see Appendices C and D, respectively). Depending upon substrate class, coating, shape and style, there was a significant difference of V_{10} among some vendors for the tested tools.

For corresponding insert shapes, the average speeds (V_{10}) at $T_L=10$ minutes differed by very little between the two coating types for finishing inserts. However, based on fewer test results for roughing size inserts, the multi-coated grades appeared to be slightly favored. To compare the performance of non-coated versus coated inserts, several shapes and carbide substrate classes were examined and documented in Appendices C and D. It was noted that in every case for both finishing and roughing sizes where style, shape, substrate, and feed rate were the same, the coated inserts could be run at significantly higher speeds (V_{10}).

Machining data computer program with two example runs are presented in Appendix E. First, 18 finishing size insert grades for the 80 degree diamond geometry were compared. Using the same given set of machining conditions, the computer program selected nine inserts, which satisfied the application specifications. Examination of the results for tools No. 310 (a multicoated grade) and No. 318 (a noncoated grade) of the same size and substrate class shows the distinct advantage of a coated insert. Insert No. 318 has a T_L of 5.0 min., and can be run at only 422 SFPM for a MRR of 5.2 in.³/min. This means a cost of \$0.23/in.³ while yielding a length of cut of 23 inches before a fresh cutting edge is needed. Whereas, insert No. 310 has a T_L of 11.7 min. running at 500 SFPM and removing 6.1 in.³/min. at a cost of \$0.18/in.³. It produces a length of cut of 63 inches before a new cutting edge is required. A cost savings of 28 percent per in.³ of metal removed is shown, along with a substantial time savings by not having to index the insert while producing a greater length of cut. Similar comparisons are validated for roughing size inserts using the second example seen in Appendix E.

It is well known that as feed rate is increased workpiece surface roughness will increase. Also, as cutting tool wear progresses, surface quality and chip control tend to deteriorate. These patterns were both observed during the tests. Also in the tests, an increase in nose radius for most inserts enhanced the T_L at a given speed. The increased nose radius improved surface finishes at various feed rates, independent of shape, IC, size, and coating type. Therefore, it was not unexpected that round inserts

did produce the best surface finishes, frequently even when tested at higher feed rates than the other shapes. Also, round inserts showed the largest 10 minute tool life speeds (V_{10}).

Chip control was independent of coating type, but as expected, it was very dependent on feed rates. Results confirmed that increased feed rate increases the percentage of good or fair chips over poor chips, regardless of cutting speed, shape, or insert grade. In general, manufacturer technical data sheet recommendations for applying varied molded chip groove styles were validated within specified ranges of feeds and DOCs.

5.0 TECHNOLOGY TRANSFER

For effective transfer of the large quantities of technical data from this project to the Rock Island Arsenal Operations Directorate, various means were employed. Individual test results in the form of photo documentation were prepared, e.g., Figure 7. These displays represented in excess of 700 individual tests and provided rapid visual comparative assessment of results. The photos were arranged in order of ascending MRR according to insert grade, size, shape, and coating type. Tabulated data summaries (Appendices C and D) were distributed to Rock Island Arsenal Operations Factory and Process Engineering Divisions. Included were the Methods and Standards Branch, where inserts are selected and machining parameters are set; the N/C Programming Branch, where machine cutter paths are generated; and the N/C Toolsetting Branch, which is responsible for tool inventory control and carbide insert ordering.

To foster implementation of the established empirical data base, a user interactive tool selection computer program was prepared (Appendix E). Figures 11 and 12 outline the inputs and outputs for this sorting program. The program permits the entire data base to be accessed to aid the factory process personnel in selecting a specific insert best suited to a particular application and to establish operating parameters. Computer calculations of minimum costs and maximum production rates also can be requested. Information on insert stock number, availability, and optimum tool life are likewise provided for the user. The cutting tool data base program is written in Fortran 77, with versions for both Prime and DEC VAC systems. This information is available on 1/2 inch magnetic tape to DoD users.

To reach DoD users, some of whom have requested the data and data base program, an End of Project Presentation was held on November 6, 1986, and a paper was presented at MTA3 '85 in Washington, DC.

A shop floor test data validation plan was developed and adapted to production requirements. The usage of 26 top performing finishing size inserts (as selected by Methods and Standards personnel) were tracked in several cost centers using numerical controlled machine tools for 12 months. At the end of that period it was noted that 65 percent of the insert grade-shape combinations had been called for and tried. Interviews with N/C programmers and machine operators verified the correctness of the established data base and its value in properly applying single point turning or boring tools.

INPUTS FOR CUTTING TOOL SELECTION PROGRAM

- SHAPE OF INSERT (TRIANGLE, SQUARE, ETC.)
- FINISH REQUIRED (MICRO-INCHES RMS)
- CHIP QUALITY (GOOD, FAIR, POOR)
- DEPTH OF CUT (THOUSANDTHS OF AN INCH)
- FEED (THOUSANDTHS OF AN INCH/REV)
- USER SPECIFIED
- PROGRAM SEARCHES DATA FOR ALL FEEDS
- TOOL LIFE
 - USER SPECIFIED (MINUTES)
 - LENGTH OF CUT (INCHES)
 - SURFACE SPEED (FEET/MINUTE)
 - MINIMUM COST - - (APPROX. BASED ON USER SUPPLIED DATA)
 - TIME TO CHANGE INSERT (MINUTES)
 - COST/EDGE (DOLLARS)
 - LABOR-OVERHEAD RATE (DOLLARS/HOUR)
 - MAXIMUM PRODUCTION (CUBIC INCHES/MINUTE)

FIGURE 11

OUTPUTS OF CUTTING TOOL SELECTION PROGRAM

- INPUTS RESTATED
- IDENTIFICATION OF SELECTED INSERTS
 - TOOL OR INVENTORY NUMBER
 - VENDOR
 - GRADE
 - GEOMETRY & SIZE CODE(COATING)
- SPEEDS
 - SURFACE
 - ROTATION(FEET/MINUTE)
(REVOLUTIONS/MINUTE)
- METAL REMOVAL RATE
- BASED ON CLOSEST EMPIRICAL DATA
- COMPUTED FROM SPECIFIED DEPTH & FEED
(CUBIC INCHES/MINUTE)
- LENGTH OF CUT OR TOOL LIFE
(IF NOT SPECIFIED BY USER)
- COST -- FOR OPTIMUM TOOL LIFE
(DOLLARS/CUBIC-INCH)

FIGURE 12

As a consequence of this project, several follow-on test programs for machining were initiated at Rock Island Arsenal. Turning tests have continued using next generation coated carbides and allowing for performance comparisons with TiC/TiN coated inserts. Plans have been made to test coolants and the newest ceramic and cermet tool materials.

In-production testing of rotary cutting tools has been underway under another project for more than a year, as test results are being used for cost effectiveness comparisons and analyses and the selection of upgraded tooling. Algorithms were developed which quantify information needed for objective comparison of different vendor's tools and for tool edge preparations. Automatic recording of measured operational data enables calculations of productivity, cost, and horsepower per rate of metal removed as well as trend identification with wear and regrinding. Consequently, certain critical stages during a tool's life cycle can be monitored and necessary corrective actions adopted, e.g., if reconditioning steps are required or if the tool needs to be replaced. Selective reduction in tool inventory should result, along with increased productivity and improved part quality.

The project in this report developed reliable data on tool life and process parameters, largely for production planning and inventory control purposes, although it can be used to guide the lathe or turning center operator as to when the tool should be changed. The second project mentioned in this report, which provides automatic recording of measured operational data, goes a step beyond, since it allows operators of special machining centers to see the effect of tool wear on these operational data. However, with the advent of cells, the situation will occur where there will not be an operator assigned to each machine tool to monitor just the machining on that machine tool. In that case, the data base developed in this project is invaluable for accurate prediction of cycle times and schedules and for proper tool management, which will not only make certain a fresh tool is available, but also will minimize tool failure and cutting with worn tools. Nevertheless, the task of empirical investigation of tool life for all combinations of feeds, speeds, and workpiece materials would be prohibitive. Therefore, a third effort is underway to develop at least one automatic integrated sensing system capable of accepting data on part dimensions and surface finish, direct measurement of tool wear and cutting forces, and, accordingly, exercising limited control over the machining. Not only could this system provide protection in situations where reliable and extensive testing had not been performed, but it could also perform the monitoring functions that would be normally conducted by an operator if an operator were assigned to the machine tool.

Finally, it is envisioned that data from all these systems will be inputs to a custom tool management system that will ensure high percentages of machine cutting time, high metal removal rates, acceptable parts including first parts in a flexible automated environment as well as an attended one, providing cost effective machining and low tooling costs.

6.0 SUMMARY

A reliable, empirically derived tool wear life data base for both finishing and roughing sizes of coated carbide inserts was created. A menu driven user interactive computer program was developed which facilitated technology transfer. This program provided the means to sort, rank, and select insert grades and to obtain recommended machining parameters applicable to medium alloy steels for turning and boring. A shop floor test data verification study was carried out proving to be adaptable to production requirements. Algorithms were developed permitting quantitative comparisons among different manufacturer's tools. Benefits have been derived from more universal application of coated carbides, and selective reduction in tool inventory, setting of optimum machining parameters, and improved part quality as this program has fostered the extended and accelerated application of new and upgraded tooling at Rock Island Arsenal. A follow-on testing program was implemented, which is applicable for next generation coated carbides, coolants, ceramic tool materials, and other projects for rotary tools and for machine tool monitoring are supplementing or building upon the reported effort.

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APPENDIX A
SORTING PROGRAM FLOWCHART

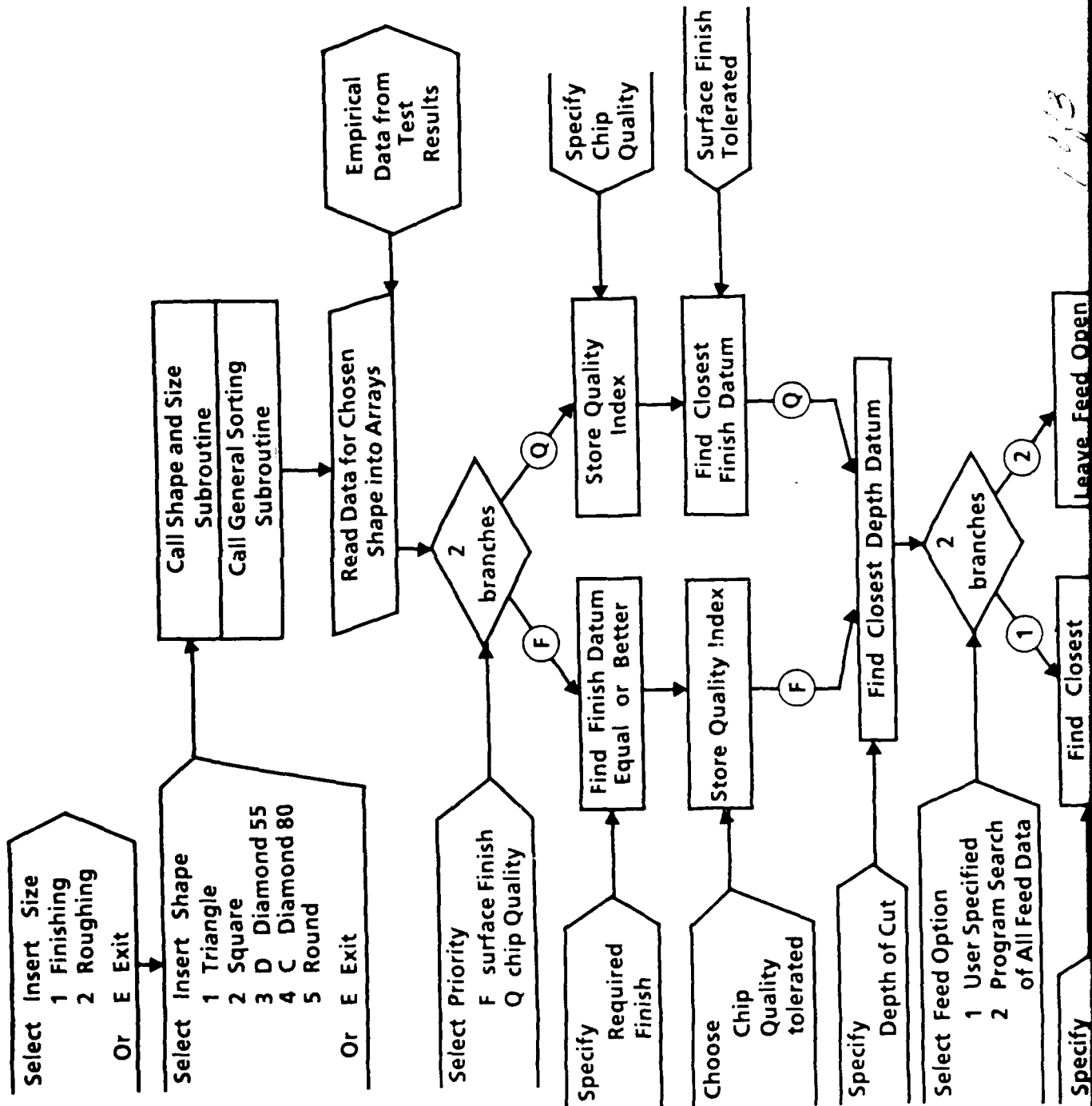
This page intentionally left blank.

DATA INPUT/OUTPUT

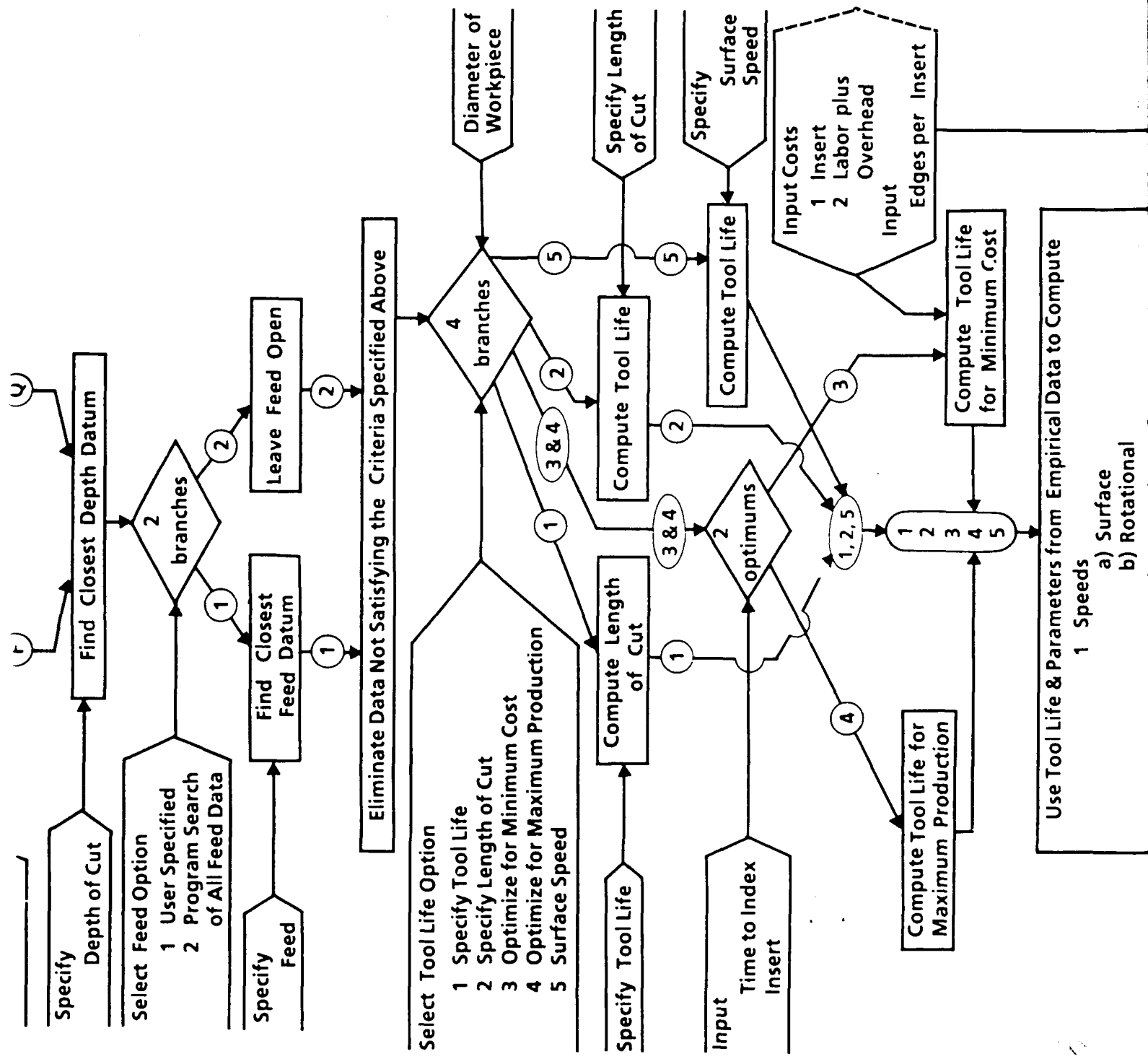
PROCESSES

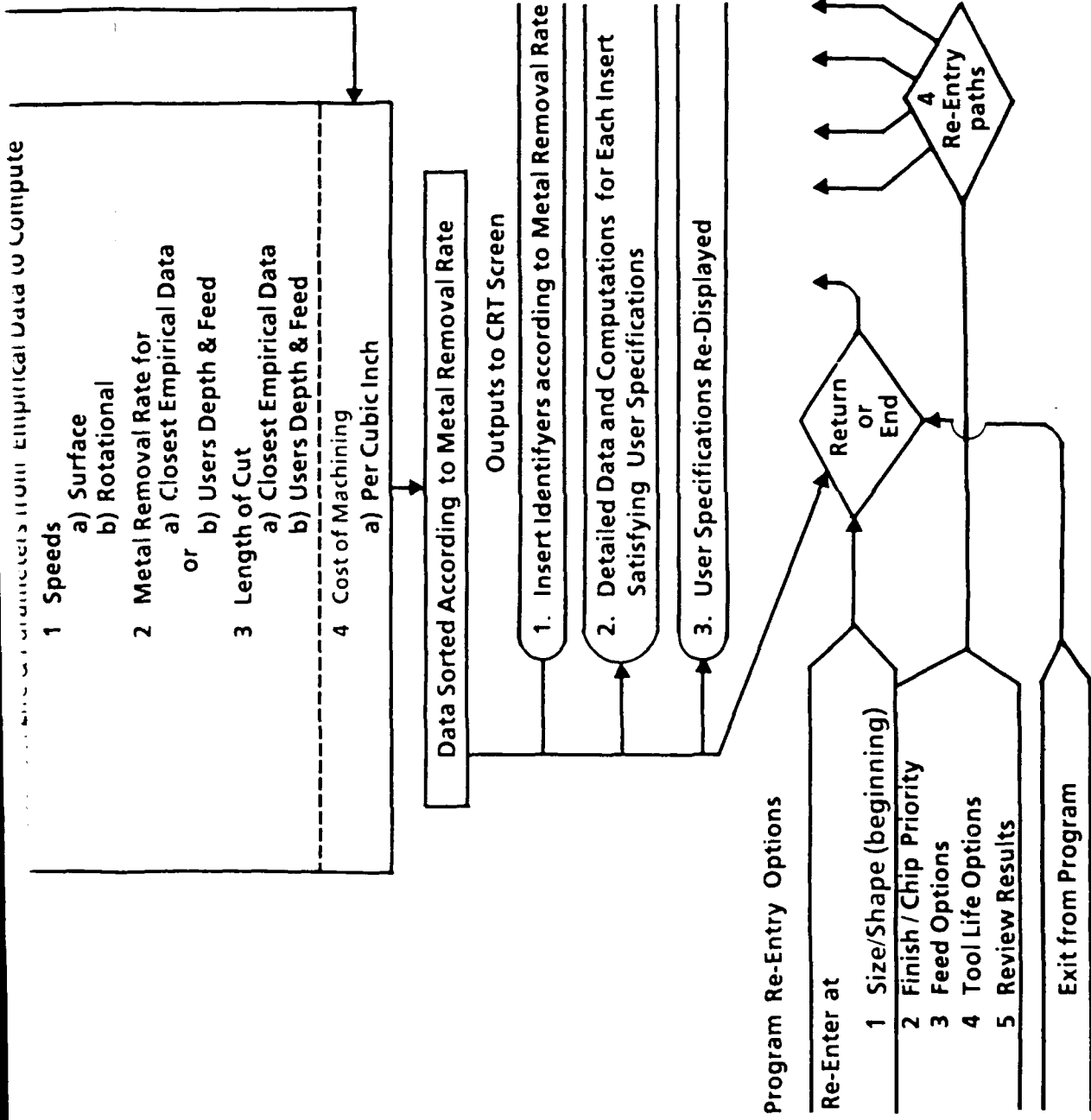
PROGRAM

USER INPUTS



14/3





24/3

APPENDIX B

SORTING PROGRAM LISTING, INCLUDING THE DATA FILES

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PROGRAM TOOL06

***** FILE NAME ***** TOOL *****

=====

COMPUTER SYSTEM : PRIME
COMPUTER LANGUAGE : FORTRAN 77
SYSTEMS DESIGNER : BILL BREWER, MARY CROSHECK
VERSION/DATE : 6 / 01-JUL-1986

=====

PURPOSE : SORTS THE TEST DATA COLLECTED ON CUTTING INSERTS
ACCORDING TO CHIP QUALITY AND SURFACE FINISH
SELECTS FEEDS
COMPUTES SPEEDS, METAL REMOVAL RATE, LENGTH OF CUT,
AND COST

SUBROUTINE CALLED : 1. GEN_SORT
2. F_TRIANGLE 7. R_TRIANGLE
3. F_SQUARE 8. R_SQUARE
4. F_C_DIAMOND_80 9. R_C_DIAMOND_80
5. F_D_DIAMOND_55 10. R_D_DIAMOND_55
6. F_ROUND 11. R_ROUND

=====

=====

INPUTS

1 Size of Insert (finishing or roughing)
2 Shape of Insert (triangle, square, etc.)
3 Finish Required (micro-inches RMS)
4 Chip Quality (good, fair, poor)
5 Depth of Cut (thousandths of an inch)
6 Feed (" " " ")
a) User specified
b) Program searches data for ALL Feeds
7 Tool Life
a) User specified (minutes)
b) Length of Cut (inches)
c) Surface Speed (feet / min.)
d) Minimum Cost -- approx. based on user supplied data
i) time to change insert (minutes)
ii) cost / edge (dollars)
iii) labor + overhead rate (dollars / hour)
e) Maximum Production

=====

=====

OUTPUTS

1 Inputs Restated
2 Identification of Selected Inserts
a) Tool or inventory number

C b) Vendor
 C c) Grade (coating)
 C d) Geometry & Size code
 C 3 Speeds
 C a) Surface (feet / minute)
 C b) Rotation (revolutions / minute)
 C 4 Metal Removal Rate (cubic inches/ minute)
 C a) Based on closest empirical data
 C b) Computed from specified depth & feed
 C 5 Length of Cut or Tool Life (if not specified by user)
 C 6 Cost -- for optimum tool life (dollars / cubic-inch)

FILES USED

FILE NAME	EMPIRICAL DATA FOR	TYPE	I/O
-----	-----	----	----
F_TRIDATA	TRIANGULAR INSERTS IN FINISHING	DISK	I
F_SQDATA	SQUARE INSERTS IN FINISHING	DISK	I
F_DIA80DATA	80 DEG DIAMOND INSERTS IN FINISHING	DISK	I
F_DIA55DATA	55 DEG DIAMOND INSERTS IN FINISHING	DISK	I
F_ROUNDATA	ROUND INSERTS IN FINISHING	DISK	I
R_TRIDATA	TRIANGULAR INSERTS IN ROUGHING	DISK	I
R_SQDATA	SQUARE INSERTS IN ROUGHING	DISK	I
R_DIA80DATA	80 DEG DIAMOND INSERTS IN ROUGHING	DISK	I
R_DIA55DATA	55 DEG DIAMOND INSERTS IN ROUGHING	DISK	I
R_ROUNDATA	ROUND INSERTS IN ROUGHING	DISK	I

PROGRAM LOGIC SYNOPSIS

1. USER SELECTS THE SIZE AND GEOMETRY OF CUTTING TOOL
 OPEN APPROPRIATE DATA FILE
2. USER CHOOSE PRIORITY OF SORTING (CHIP QUALITY/ SURFACE FINISH)
 USER INPUTS PARAMETERS OF CUTTING CONDITIONS
 (DEPTH OF CUT, FEED, TOOL LIFE)

 USER HAS OPTION TO SPECIFY FEED OR TO LEAVE THE FEED OPEN
 (SORT THROUGH ALL FEEDS)

 USER HAS OPTION TO SPECIFY TOOL LIFE IN TERMS OF MINUTES,
 LENGTH OF CUT, SURFACE SPEED, MINIMUM COST,
 OR MAXIMUM PRODUCTION
 (LAST FOUR OPTIONS ARE CONVERTED TO MINUTES)
3. FOR ALL INSERTS WHICH PASS THE CHIP QUALITY AND SURFACE
 FINISH REQUIREMENTS, A SPEED FOR THE PARAMETERS CHOSEN
 IS CALCULATED AND ALL INPUT/OUTPUT DATA IS SHOWN TO USER.
4. USER MAY RE-ENTER PROGRAM AT 4 POINTS:

```

C      * RETURN TO BEGINNING OF PROGRAM
C      * SURFACE FINISH/ CHIP QUALITY OPTIONS
C      * FEED OPTIONS
C      * TOOL LIFE OPTIONS

```

5.

```

C      CLOSE APPROPRIATE DATA FILE
C      EXIT PROGRAM

```

NAME	DEFINITION	TYPE
DEPTH	ARRAY OF ALL POSSIBLE DEPTHS TESTED	REAL
SPEED	ARRAY OF SPEEDS BASED ON TOOL LIFE FOR INSERTS	REAL
FEED	ARRAY OF ALL POSSIBLE FEEDS TESTED	REAL
TOLIFE	ARRAY OF TOOL LIFE (IN MIN.) FOR INSERTS TESTED	REAL
RMR	ARRAY OF METAL REMOVAL RATE FOR INSERTS	REAL
UMR	ARRAY OF M. R. R. BASED ON USER INPUTTED VALUES	REAL
RP1	ARRAY OF SPEEDS (IN RPM) FOR INSERTS	REAL
ULOC	ARRAY OF LENGTH OF CUT FOR USER INPUTTED VALUES	REAL
LOC	ARRAY OF LENGTH OF CUT FOR TEST PARAMETERS	REAL
ASERT	ARRAY OF INSERT DESCRIPTIONS	A79
ANOTE	ARRAY OF CAUTIONS FOR THE INSERTS	A79
ACHIP	ARRAY OF POSSIBLE CHIP QUALITY CHOICES	A50
SFINISH	ARRAY OF OUTPUTTED SURFACE FINISHES	A10
KINSERT	ARRAY OF INSERT INDEXES TO KEEP AFTER SORT	INT
KDEPTH	ARRAY OF DEPTH OF CUT INDEXES AFTER SORT	INT
KFEED	ARRAY OF FEED INDEXES TO KEEP AFTER SORT	INT
MAX	ARRAY OF INSERT INDEXES SORTED BY MAXIMUM M.R.R.	INT
SFINISH	ARRAY OF ALL SURFACE FINISHES TESTED	INT
IFINISH	ARRAY OF SURFACE FINISH INDEX FOR INSERTS	INT
ICHIP	ARRAY OF CHIP QUALITY INDEX FOR INSERTS	INT
TL_MIN	ARRAY OF 1 MIN. LOG INTERCEPT FOR INSERTS	INT
TL_PVR	ARRAY OF SLOPES OF LOG-PLOT FOR INSERTS	INT

INSERIS	MAXIMUM NUMBER OF INSERTS POSSIBLE FOR ANY GEOM.	INT
NSERIS	NUMBER OF INSERTS FOR THE PARTICULAR GEOMETRY	INT
WDEPTHIS	MAXIMUM NUMBER OF DEPTHS POSSIBLE FOR ANY GEOM.	INT
NDEPTHIS	NUMBER OF DEPTHS FOR THE PARTICULAR GEOMETRY	INT
WFEEDS	MAXIMUM NUMBER OF FEEDS POSSIBLE FOR ANY GEOM.	INT
NFEEDS	NUMBER OF FEEDS FOR THE PARTICULAR GEOMETRY	INT
WFINISHS	MAXIMUM NUMBER OF FINISHES POSSIBLE FOR ANY GEOM.	INT
NFINISHS	NUMBER OF FINISHES FOR THE PARTICULAR GEOMETRY	INT
WCHIPS	MAXIMUM NUMBER OF CHIP POSSIBILITIES FOR ANY GEOM.	INT
NCHIPS	NUMBER OF CHIP POSSIBILITIES FOR PARTICULAR GEOM.	INT
WKEEPERS	MAXIMUM NUMBER OF INSERT/FEED COMBINATIONS POSS.	INT
KEEPER	NUMBER OF INSERT/FEED COMBINATIONS KEPT	INT
MUNIT	UNIT FILE NUMBER FOR APPROPRIATE GEOM. DATA FILE	INT
DFILE	UNIT FILE NAME FOR APPROPRIATE GEOMETRIC DATA FILE	A10
GEOM_NAME	GEOMETRIC NAME FOR INSERTS USED IN FORMATS	A15

CHARACTER ASHAPE
 CHARACTER ARUN
 CHARACTER APAGE
 CHARACTER ASIZE

```

    WRITE ( 1, 10 )
10  FORMAT (////////,27X,'MACHINING DATA PROGRAM',///,37X,'FOR',//,
    & 27X,'FINISHING / ROUGHING SIZE',///,25X,'COATED CARBIDE ',
    & 'CUTTING INSERTS',///,35X,'USED IN',///,30X,'TURNING OPERATIONS',
    & '////////,26X,'HIT <RETURN> TO CONTINUE')
    READ ( 1, '(A1)' ) APAGE
    WRITE( 1, 20 )
20  FORMAT( /////,30X,'EXPERIMENTAL',/,30X,'-----',//,
    & 'EQUIPMENT -- Single point turning using a 30/60 ',
    & 'horsepower turret lathe',//,
    & 'CUTTING CONDITION -- Dry cutting only with fluid ',
    & 'cooled workpiece',//,
    & 'WORKPIECE MATERIAL-- AISI 4140 steel, hot rolled tubing ',
    & 'for finishing inserts.',/,22X,'Heat treated, Quenched ',
    & 'and Tempered to HRC 31 - 33',/,16X,'AISI 4140 ',
    & '& 4130 steel, hot rolled tubing for roughing inserts.',
    & '/',16X,'Heat treated, Quenched and Tempered to HRC 31 - 34',
    & '//, 'TOOL MATERIALS -- CVD coated carbide inserts',/,19X,
    & 'ALOX : ALOX exterior coating with TiC coat at ',
    & 'substrate ',/,27X,'interface',/,19X,
    & 'Multi : TiN exterior coating with ALOX coat inter',
    & 'mediate, ',/,26X,
    & 'and TiC or TaC coat at substrate interface',//,
    & 'TOOL HOLDERS -- Negative 5 degree back rake and side ',
    & 'rake angles with SCEA ',/,18X,
    & 'ranging from + 15 degrees to -3 degrees depending on ',/,
    & '18X,'shape of insert ',/,26X,'ENTER <RETURN> TO CONTINUE')
    READ( 1, '(A1)' ) APAGE
    WRITE( 1, 30 )
30  FORMAT( //, 'TOOL INSERT SIZE -- IC = 1/2 in. for finishing ',
    & 'cut, IDC = 0.060 in.',/,
    & '21X,'IC = 5/8 in. or 3/4 in. for roughing cut, ',
    & 'IDC = 0.200 in.',//,
    & 'TOOL WEAR CRITERIA -- Finishing flank wear limits',
    & ' - 0.010" ave, or 0.020" max.',/,
    & '23X,'Roughing flank wear limits - 0.015" ave, ',
    & 'or 0.030" max. ',//,
    & 'MEASURING PROCEDURE -- Tool flank wear was ',
    & 'measured at predetermined time',/,25X,
    & 'intervals (min.) until wear limit was reached',
    & '///, 'PERFORMANCE -- Tool life (min.) was recorded ',
    & 'when the flank wear limit was',/,17X,
    & 'reached, and the quality of chip control/',
    & 'form were judged and',/,17X,
    & 'given a good, fair, or poor rating.',/,16X,
    & 'Workpiece surface finishes were assigned ',
    & 'RtS(micro-inch) values',/,17X,
    & 'by visual/tactual comparisons using a Std. ',
    & 'Ordnance Finishes',/,17X,
  
```

```

&          'Set No. 10.',//,16X,
&          'Wear mode patterns and occurrence frequency ',
&          'were recorded per',/,17X,
&          'insert, as was the calculation of metal ',
&          'removal rate.',//,26X,
&          'ENTER <RETURN> TO CONTINUE' )
      READ( 1, '(A1)' ) APAGE
40  WRITE ( 1, 35 )
35  FORMAT(//////////,10X,'Select Size of Insert to be Used:',
&          //,T30,'1   Finishing   (IC = 1/2 in.)',/,
&          T30,'2   Roughing   (IC = 5/8 in. OR 3/4 in.)',//,
&          T30,'E   Exit from the Program',////)
      READ ( 1, '(A1)' ) ASIZE
      IF ( ASIZE.EQ. 'E' .OR. ASIZE.EQ. 'e' ) GOTO 999
      IF ( ASIZE.NE. '1' .AND.
&        ASIZE.NE. '2' .AND.
&        ASIZE.NE. 'E' .AND.
&        ASIZE.NE. 'e' ) THEN
70  WRITE ( 1, 70 )
      FORMAT(//,10X,'Only Numbers 1 or 2 or the letter E',
&          ' can be read as answers.')
      GOTO 40
      ELSE
      ENDIF
45  WRITE ( 1,50 )
50  FORMAT(//////////,10X,'Select Insert Shape',///,
& T30,'1   triangular',/,
& T30,'2   square',/,
& T30,'3   diamond 80 degree',/,
& T30,'4   diamond 55 degree',/,
& T30,'5   round',//,
& T30,'E   Exit from the program.',////)
C
C For Response 2
C
      READ ( 1, '(A1)' ) ASHAPE
      IF( ASHAPE.EQ. '1' .AND. ASIZE.EQ. '1' ) CALL F_TRIANGLE
      IF( ASHAPE.EQ. '2' .AND. ASIZE.EQ. '1' ) CALL F_SQUARE
      IF( ASHAPE.EQ. '3' .AND. ASIZE.EQ. '1' ) CALL F_C_DIAMOND_80
      IF( ASHAPE.EQ. '4' .AND. ASIZE.EQ. '1' ) CALL F_D_DIAMOND_55
      IF( ASHAPE.EQ. '5' .AND. ASIZE.EQ. '1' ) CALL F_ROUND
C
      IF( ASHAPE.EQ. '1' .AND. ASIZE.EQ. '2' ) CALL R_TRIANGLE
      IF( ASHAPE.EQ. '2' .AND. ASIZE.EQ. '2' ) CALL R_SQUARE
      IF( ASHAPE.EQ. '3' .AND. ASIZE.EQ. '2' ) CALL R_C_DIAMOND_80
      IF( ASHAPE.EQ. '4' .AND. ASIZE.EQ. '2' ) CALL R_D_DIAMOND_55
      IF( ASHAPE.EQ. '5' .AND. ASIZE.EQ. '2' ) CALL R_ROUND
C
      IF( ASHAPE.EQ. 'E' .OR. ASHAPE.EQ. 'e' ) GOTO 999
C
C Escape for Response 2
c
      IF( ASHAPE.NE. '1' .AND.
&        ASHAPE.NE. '2' .AND.
&        ASHAPE.NE. '3' .AND.

```

```

& ASHAPE.NE.'4' .AND.
& ASHAPE.NE.'5' .AND.
& ASHAPE.NE.'E' .AND.
& ASHAPE.NE.'e' ) THEN
  WRITE( 1,60 )
60  FORMAT(//,10X,'Only numbers 1 to 5 or the letter E can be ',
&        'read as answers.',//,
&        10x,'Give it another try.')
  GOTO 45
ELSE
ENDIF
C
999 CALL EXIT

```

END

```

SUBROUTINE GEN_SORT( MONIT, DFILE, GEOM_NAME )
C
C Array Dimension Parameters
C
  PARAMETER(MSERIS=25,MDEPTH=1,MFEEDS=4,MFINISH=6,MCHIP=3
& ,MFINCH=6,MKEEPERS=MSERIS*MDEPTH*MFEEDS,PI=3.14159)
C
C Dimension ARRAYS
  REAL DEPTH( MDEPTH ),FEED( MFEEDS )
  REAL SPEED( MKEEPERS ),TOLIFE( MKEEPERS )
  REAL RARR( MKEEPERS ),UARR( MKEEPERS )
  REAL DARR( MKEEPERS )
  REAL COST( MKEEPERS )
  REAL RPM( MKEEPERS ), ULOC( MKEEPERS ), LOC( MKEEPERS )
  REAL SPIN, LOOPT, DOW, TOOLIFE
  REAL TOL, CPE, RUJ
  CHARACTER*80 ASET( MSERIS )
  CHARACTER*80 ANOTE( MSERIS )
  CHARACTER*50 ACHIP( MCHIP )
  CHARACTER*10 SFINISH( MFINCH )
  INTEGER TOOLNO, TOOLOPT
  INTEGER TOLOPT
  INTEGER KSERI( MKEEPERS )
  INTEGER KDEPTH( MKEEPERS )
  INTEGER KFEED( MKEEPERS )
  INTEGER MAX( MKEEPERS )
  INTEGER SFINISH( MFINISH )
  INTEGER IFINISH( MSERIS, MDEPTH, MFEEDS )
  INTEGER ICHIP( MSERIS, MDEPTH, MFEEDS )
  REAL TL_MIN( MSERIS, MDEPTH, MFEEDS )
  REAL TL_PRR( MSERIS, MDEPTH, MFEEDS )
C
  CHARACTER*1 PRIORITY, DEFOPT, FEFOPT
  CHARACTER*1 APAGE, COSTOPT, ACONT
  CHARACTER*15 GEOM_NAME

```

```

      CHARACTER*11 DFILE
C
C
C ***** Read DATA from file
C
      OPEN( MUNIT, FILE = DFILE )
C
C ***** Skip comment lines in data file with a READ and do nothing LOOP.
C
      DO 10 I = 1,11
10    READ( MUNIT,'(11)' )
C
C          * * * * *
C      Read parametric variations used in tests
C
C      Read Data Parameters to be used for the particular
C      geometric Data file being read from.
C          * * * * *
C
      READ( MUNIT,* ) NSEXTS, NDEPTHs, NFEEDs, NFINISHs, NWHIPS
      NFINCH = NFINISHs
C
      IF ( NSEXTS .EQ. 0 ) THEN
          WRITE ( 1, 15 )
15      REWAT(//////////,10X,'THERE WERE NO INSERTS TESTED IN',
          &          ' THAT GEOMETRY AT THIS TIME..',//,
          &          20X,'PLEASE TRY ANOTHER GEOMETRY.',////////,
          &          20X,'ENTER ANY KEY TO CONTINUE',//)
          READ( 1, '(A1)' ) APAGE
          QUIT 9999
      ELSE
      ENDIF
C
C ***** Skip comment lines in data file with a READ and do nothing LOOP.
C
      DO 20 I = 1,3
20    READ( MUNIT,'(11)' )
C
C          * * * * *
C      Read DEPTHs of cut tested ( thousandths of an inch )
C      NOTE: numbers must be entered in the DATA file from the
C            smallest INCREASING to the largest.
C          * * * * *
C
      READ( MUNIT,* ) ( DEPTH( IDEPTH ), IDEPTH = 1,NDEPTHs )
C
C ***** Skip comment lines in data file with a READ and do nothing LOOP.
C
      DO 30 I = 1,3
30    READ( MUNIT,'(11)' )
C
C          * * * * *
C      Read FEED variations ( thousandths of an inch )
C      NOTE: numbers must be entered in the DATA file from the
C            smallest INCREASING to the largest.

```

```

C          * * * * *
C
C      READ( MUNIT,* ) ( IFEED( IFEED ), IFEED = 1,NFEEDS )
C
C      ***** Skip comment lines in data file with a READ and do nothing LOOP.
C
C      DO 40 I = 1,3
40  READ( MUNIT,'(11)' )
C
C          * * * * *
C      Read surface FINISHS obtained from tests ( micro-inchs )
C      NOTE: numbers must be entered in the DATA file from the
C            smallest INCREASING to the largest.
C          * * * * *
C
C      READ( MUNIT,* ) ( SFINISH( JFINISH ), JFINISH = 1,NFINISHS )
C
C      ***** Skip comment lines in data file with a READ and do nothing LOOP.
C
C      DO 50 I = 1,7
50  READ( MUNIT,'(11)' )
C
C          * * * * *
C      Read surface FINISHS for output later in program
C      NOTE: Finishes must be entered in the DATA file from the
C            smallest INCREASING to the largest.
C          * * * * *
C
C      DO 60 I = 1, NFINISHS
60  READ( MUNIT,'(10X,A10)' ) SFINISH(I)
C
C      ***** Skip comment lines in data file with a READ and do nothing LOOP.
C
C      DO 70 I = 1,3
70  READ( MUNIT,'(11)' )
C
C          * * * * *
C      Read CHIP qualities obtained from tests
C      NOTE: descriptions of CHIPS must be entered in the DATA file from the
C            BEST proceeding to the WORST.
C          * * * * *
C
C      READ( MUNIT,'(A50)' ) ( ACHIP( JCHIP ), JCHIP = 1,NCHIPS )
C
C      ***** Skip comment lines in data file with a READ and do nothing LOOP.
C
C      DO 80 I = 1,3
80  READ( MUNIT,'(11)' )
C
C      ***** Confirm choice of insert SHAPE
C
C      WRITE( 1,'(//)')
C      WRITE( 1,50 ) NSERIS, CHOM NAME
50  FORMAT( //,8X,'Program will search DATA for the ',

```

```

      &          12,' ',A15,' inserts tested.',//)
C
C ***** Read INSERT identification lines
C *****      ( 2 lines of 79 spaces for each insert )
C
      DO 100 INSERT = 1,NSEITS
          READ( MUNIT,'(A79)' ) ASENT( INSERT )
          READ( MUNIT,'(A79)' ) ANOTE( INSERT )
100  CONTINUE
      K = 1
110  DO 130 M = 1,NSEITS
          WRITE ( 1,'(A79)' ) ASENT( M )
          IF( ( M - K*15 ) .GE.0 ) THEN
              WRITE( 1,120 )
120             FORMAT( //,25X,'Enter any key to continue .' )
              K = K + 1
              READ( 1,'(A1)' ) ASPACE
          ENDIF
130  CONTINUE
      WRITE ( 1,120 )
      READ ( 1,'(A1)' ) ASPACE
C
C ***** Skip comment lines in data file with a READ and do nothing LOOP.
C
      DO 140 I = 1,40
140  READ( MUNIT,'(11)' )
C
C ***** Read empirical RESULTS from tests into data ARRAYS
C
      DO 170 INSERT = 1,NSEITS
          READ( MUNIT,'(11)' )
          DO 160 IDEPTH = 1,NDEPTS
              DO 150 IFEED = 1,NFEEDS
150             READ( MUNIT,'(T31,2F10,2F10.4)' )
              &             IFINISH( INSERT, IDEPTH, IFEED ),
              &             ICHIP( INSERT, IDEPTH, IFEED ),
              &             TL_MIN( INSERT, IDEPTH, IFEED ),
              &             TL_PWR( INSERT, IDEPTH, IFEED )
160             CONTINUE
170  CONTINUE
C
C          * * * * *
C
C Menu 2 - Choice of PRIORITY
C
C          * * * * *
C
180  WRITE( 1,190 )
190  FORMAT( //,10X,'Choose FIRST Priority',///,
      &      T30,'F   surface Finish',//,
      &      T30,'Q   chip Quality',//////// )
C
C          * * * * *
C

```

```

C Response 2 - PRIORITY
C
C *****
C
C READ( 1, '(A1)' ) PRIORITY
C IF( PRIORITY.EQ. 'P' .OR. PRIORITY.EQ. 'p' ) THEN
C
C *****
C      Branch for 1st priority = surface Finish
C      Menu 3F Ask for required surface Finish
C      *****
C
C      200 WRITE( 1, 210 )
C      210 FORMAT( //, 10X, 'Priority 1 - surface ',
C      & 'Finish', ///, T20, 'Type in surface Finish you want ',
C      & 'have in', //, F30, 'micro-inches RMS', /// )
C      READ( 1, *, IER = 200 ) FINISH
C
C      *****
C      Find LATEST finish number in data file LESS THAN or equal to that SPECIFIED.
C      NOTE: numbers must be entered in the DATA file from the
C      smallest INCREASING to the largest.
C      *****
C
C      JFINISH = 0
C      DO 220 JFINISH = 1, NFINISH
C      IF( FINISH.GE. SFINISH( JFINISH ) ) KFINISH = JFINISH
C      220 CONTINUE
C      IF( KFINISH.EQ. 0 ) KFINISH = 1
C      WRITE( 1, 230 ) FINISH, SFINISH( KFINISH ),
C      & SFINISH( KFINISH )
C      230 FORMAT( //, 20X, 'You asked for a', F6.0, ' micro-inch ',
C      & 'finish.', //, 20X, 'Surface Finish data from test results',
C      & ' that', //, 20X, ' are closest to your specification',
C      & ' are :', //, T15, A10, ' micro-inches RMS ( ',
C      & 'compared to', I6, ' RMS )', //, 15X, 'All results ',
C      & 'that follow will be based on this value.', // )
C
C      *****
C      Menu 4F Ask for acceptable chip Quality
C
C      *****
C
C      240 WRITE( 1, 250 )
C      250 FORMAT( //, 10X, 'Priority 2',
C      & //, 10X, 'Specify lowest chip Quality ',
C      & 'you can live with.' )
C      DO 260 JCHIP = 1, NCHIPS
C      260 WRITE( 1, '(T20,A50)' ) ACHIP( JCHIP )
C      JCHIP = 0
C      READ( 1, '(I1)', IER = 240 ) KCHIP
C      IF( KCHIP.LE. 1 ) KCHIP = 1
C      IF( KCHIP.GT. NCHIPS ) KCHIP = NCHIPS
C      IF( KCHIP.EQ. 1 .AND. ACHIP.LE. NCHIPS ) THEN

```

```

270          WRITE( 1,270 ) ACHIP( KCHIP )
          &          FORMAT( //,10X,'Only data for which ',
          &                  'chip Quality equals or exceeds',
          &                  //,T20,A50,/,10X,'will be considered.' )
          ELSE
280          WRITE( 1,280 ) NCHIPS
          &          FORMAT( //,10X,'Only numbers 1 to ',
          &                  '12, can be read.',
          &                  //,20X,'Please try again.',// )
          GO TO 240
        ENDIF
      ELSE
        IF( PRIORITY.EQ. 'Q'.OR.PRIORITY.EQ. 'q' ) THEN
          C          * * * * *
          C          Branch for 1st priority = chip Quality
          C
          C          Menu 3Q      Ask for required chip Quality
          C          * * * * *
          C
          290          WRITE ( 1, 300 )
          300          FORMAT( //,T10,'Priority 1',///,T30,
          &                  'Specify chip quality you must have:',//)
          DO 310 ICHIPS = 1, NCHIPS
          310          WRITE ( 1, '(T20,A50)' ) ACHIP( ICHIPS )
          KCHIP = 0
          READ ( 1, '(I1)', ERR = 290 ) KCHIP
          IF ( KCHIP.LE. 1 ) KCHIP = 1
          IF ( KCHIP.GT.NCHIPS ) KCHIP = NCHIPS
          IF ( KCHIP.LE. 1 .AND. KCHIP.LE.NCHIPS ) THEN
            WRITE ( 1, 270 ) ACHIP( KCHIP )
          ELSE
            WRITE ( 1, 280 ) KCHIP
            GO TO 290
          ENDIF
        ELSE
          C          * * * * *
          C
          C          Menu 4Q      Ask for acceptable surface finish
          C          * * * * *
          C
          320          WRITE( 1,330 )
          330          FORMAT( //,T10,'Priority 2',///,T20,'Type in ',
          &                  'surface finish that would be acceptable in',
          &                  //,T20,'micro-inches RMS',//)
          READ ( 1, *, ERR = 320 ) FINISH
          C          * * * * *
          C          Find CLOSEST finish number in data file to that specified.
          C          NOTE: SFINISHES must be read into appropriate DATA file from
          C          the smallest to the largest.
          C          * * * * *

```

```

      IF ( FINISH.LE.SFINISH(1) ) THEN
        KFINISH = 1
        GOTO 330
      ELSE
        IF ( FINISH.GE.SFINISH( NFINISH ) ) THEN
          KFINISH = NFINISH
          GOTO 330
        ELSE
          DO 340 IFINISH = 1,NFINISH-1
            IF ( FINISH.GT.SFINISH( IFINISH+1 ) .OR.
              & FINISH.LT.SFINISH( IFINISH ) ) GOTO 340
            IF (( SFINISH(IFINISH+1) - FINISH ).LE.
              & ( FINISH - SFINISH(IFINISH) ) ) THEN
              KFINISH = IFINISH + 1
            ELSE
              KFINISH = IFINISH
            ENDIF
          GOTO 340
        ENDIF
      ENDIF
      WRITE ( 1, 230 ) FINISH, SFINISH( KFINISH ),
        & SFINISH( KFINISH )
    ELSE
      ***** Escape from wrong response to Menu 2
      WRITE( 1,360 )
      DO 370
        & REPEAT( 10X,'Only the letter F or Q can be read ',
        & 'as a response.',//,
        & 10X,'Please try again.',// )
      GOTO 150
    ENDIF
  ENDIF
  *****
  End of "surface Finish - chip (quality)" Priority branching.
  *****
  Menu 5 Ask for Depth Of Cut
  *****
  370 WRITE( 1,380 )
  380 REPEAT( //,20X,'Type the Depth Of Cut you want in ',
    & //,25X,'thousandths of an inch.',//,
    & 13X,'( Finishing - DOC = 0.060" ; Roughing -',
    & '0.260" )',// )
  READ( 1,*, ERR = 370 ) DOC
  *****
  Find the CLOSEST DEPTH in the data file to DOC specified.
  Note - DEPTHs must be read into DATA from the
        smallest PLYNTH-PTH to the largest.
  *****

```

```

IF( DOC.LE.DEPTH(1) ) THEN
    JDEPTH = 1
    GOTO 400
ELSE
    IF( DOC.GE.DEPTH( NDEPTH ) ) THEN
        JDEPTH = NDEPTH
        GOTO 400
    ELSE
        DO 390 IDEPTH = 1,NDEPTH - 1
            IF( DOC.GE.DEPTH( IDEPTH + 1 )
                .OR.DOC.LE.DEPTH( IDEPTH ) ) THEN
                GOTO 390
            ENDIF
            IF( ( DEPTH( IDEPTH + 1 ) - DOC ).LE.
                ( DOC - DEPTH( IDEPTH ) ) ) THEN
                JDEPTH = IDEPTH + 1
            ELSE
                JDEPTH = IDEPTH
            ENDIF
390      CONTINUE
        ENDIF
    ENDIF
400    WRITE( 1,410 ) DOC/1000.,DEPTH( JDEPTH )/1000.
410    FORMAT( //,15X,'You asked for a',F8.3,
    &          ' inch Depth Of Cut.',
    &          //,20X,'The DEPTH for which test results are ',
    &          'available',
    &          //,20X,' that is closest to your request is ',
    &          //,T25,F10.3,' inch',
    &          //,15X,'All results that follow will be based',
    &          ' on this value.',// )
C
C      * * * * *
C
C Menu 7 - Choice of Feed OPTIONS
C
C      * * * * *
C
420  WRITE( 1,430 )
430  FORMAT( //,10X,'Choose Feed OPTION',///,
    &          T20,'1 User SPECIFIED Feed',//,
    &          T20,'2 All available Feed DATA that satisfy',
    &          //,T20,' surface Finish & chip Quality criteria',
    &          //,T20,' will be considered.',// )
C
C      * * * * *
C
C Response 7 - Feed OPTION
C
C      * * * * *
C
      READ( 1,'(A1)' ) FEEDOPT
      IF( FEEDOPT.EQ.'1' ) THEN
C
C      * * * * *

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C      Branch for User SPECIFIED feed
C Menu 8  Ask for FEED
C      * * * * *
C
440      WRITE( 1,450 )
450      FORMAT( //,10X,'Feed Option 1 ~ User Specified ',
&          'Feed',//,T20,'Type the FEED you want in',//,
&          T25,'thousandths of an inch / rev.',// )
      READ( 1,*, ERR = 440 ) FEED
C
C      * * * * *
C Find the CLOSEST FEED in the data file to FEED specified.
C Note - FEEDs must be read into DATA from the
C         smallest INCREASING to the largest.
C      * * * * *
      IF( FEED.LE.FEED(1) ) THEN
          JFEED = 1
          GOTO 470
      ELSE
          IF( FEED.GE.FEED( NFEEDS ) ) THEN
              JFEED = NFEEDS
              GOTO 470
          ELSE
              DO 460 IFEED = 1,NFEEDS - 1
                  IF( FEED.GT.FEED( IFEED + 1 )
&                  .OR.FEED.LE.FEED( IFEED ) ) THEN
&                      GOTO 460
                  ENDIF
                  IF( ( FEED( IFEED + 1 ) - FEED ).LE.
&                  ( FEED - FEED( IFEED ) ) ) THEN
&                      JFEED = IFEED + 1
&                  ELSE
&                      JFEED = IFEED
&                  ENDIF
&              CONTINUE
&          ENDIF
&      ENDIF
470      WRITE( 1,480 ) FEED/1000.,FEED( JFEED )/1000.
480      FORMAT( //,15X,'You asked for a',F8.3,
&          ' inch / rev. Feed.',
&          //,20X,'The FEED for which test results are ',
&          'available',
&          //,20X,' that is closest to your request is ',
&          //,T25,F10.3,' inch / rev.',
&          //,15X,'All results that follow will be based',
&          ' on this value.',// )
C
      ELSE
          IF( FEED.GT.FEED( NFEEDS ) ) THEN
              FEED = 0.00
              JFEED = 0
              WRITE( 1,490 )
490              FORMAT( //,10X,'Feed OPTION 2',
&          //,20X,'All non-usable available Feed data ',

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&          /,20X,'satisfying the specified ',
&          /,20X,'finish and chip criteria. ',// )
      ELSE
C
C ***** Escape from wrong response to Menu 7
C
      WRITE( 1,500 )
500      FORMAT( 20X,'Only the numbers 1 or 2 can be read! ',
&          'as a response.',//,
&          10X,'Please try again.',// )
      COTO 420
      ENDIF
    ENDIF
C
C *****
C End of "Feed OPTION" branching.
C
C
C SORT for "surface Finish" and "chip Quality"
C *****
C
      K = 1
      DO 520 INSERT = 1, NINSERTS
        DO 510 IFEEP = 1, NIFEEPS
          IF( ( JFEED.NE.0 ).AND.( JFEED.NE.IFEEP ) ) COTO 510
          IF( ( IFINISH( INSERT, JDEPTH, IFEEP ).LE.ETFINISH )
&          .AND.( ICHIP( INSERT, JDEPTH, IFEEP ).LE.ETCHIP )
&          .AND.( IFINISH( INSERT, JDEPTH, IFEEP ).NE.0 )
&          .AND.( ICHIP( INSERT, JDEPTH, IFEEP ).NE.0 ) ) THEN
            KINSERT( K ) = INSERT
            KFEED( K ) = IFEEP
            K = K + 1
          ENDIF
610      CONTINUE
520 CONTINUE
      KEEPER = K - 1
      IF ( KEEPER.EQ.0 ) COTO 700
C
C *****
C Menu 9 - Tool Life / Length Of Cut OPTIONS
C
C *****
C
530 WRITE( 1,540 )
540 FORMAT( //,10X,'Choose Tool Life OPTION.',
&          //,20X,'1 user specifies Tool Life',
&          //,20X,'2 user specifies Length Of Cut',
&          //,20X,'3 user specifies Surface Speed',
&          //,20X,'4 optimize tool life for Lowest Cost',
&          //,20X,'5 optimize tool life for Maximum Output',
&          //,17X,'Note: Results are most reliable in the Tool Life',
&          ' range from',
&          //,20X,' 5 to 25 minutes. ',

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&          /,20X,'    Computations are limited to this range.' )
C
C          * * * * *
C
C 'response 9 - Tool Life OPTION
C
C          * * * * *
C
      READ( 1, '(I1)', ERR = 530 ) TOLOPT
      IF ( TOLOPT.LE.1 .OR. TOLOPT.GT.5 ) GOTO 530
      IF ( TOLOPT.EQ.1 .OR. TOLOPT.EQ.2 .OR. TOLOPT.EQ.3 ) THEN
        GOTO 550
      ELSE
        COSTOPT = 'Y'
        GOTO 565
      ENDIF

550 WRITE ( 1,560 )
560 FORMAT ( //,10X,'Would you like the Cost($)',
&          'per cubic inch given in the output?',/,25X,'( Y/N )',// )
      READ ( 1, '(A1)' ) COSTOPT
      IF ( COSTOPT.NE.'Y' .AND. COSTOPT.NE.'y' .AND.
&          COSTOPT.NE.'N' .AND. COSTOPT.NE.'n' ) GOTO 550

565 WRITE ( 1,570 )
570 FORMAT ( //,20X,'Type the Diameter Of ',
&          'Workpiece in',/,30X,'inches.',// )
      READ ( 1,*, ERR = 565 ) DIA

      IF ( TOLOPT.EQ. 1 ) THEN
575 WRITE ( 1,580 )
580 FORMAT ( //,20X,'Type the Tool Life you need in ',/,
&          30X,'minutes',// )
      READ ( 1,*, ERR = 575 ) TOOLIFE
      ENDIF

      IF ( TOLOPT.EQ. 2 ) THEN
585 WRITE ( 1,590 )
590 FORMAT ( //,20X,'Type the Length Of Cut you need in ',
&          //,30X,'inches' )
      READ ( 1,*, ERR = 585 ) LOUT
      ENDIF

      IF ( TOLOPT.EQ. 3 ) THEN
595 WRITE ( 1,600 )
600 FORMAT ( //,20X,'Type the Surface Speed you need in ',
&          //,30X,'surface feet per minute' )
      READ ( 1,*, ERR = 595 ) SFFT
      ENDIF

      IF ( COSTOPT.EQ.'Y' .OR. COSTOPT.EQ.'y' ) THEN
610 WRITE ( 1,620 )
620 FORMAT ( //,20X,'Type the Time allowed to Change Inserts ',
&          'in',/,30X,'minutes' )
      READ ( 1,*, ERR = 610 ) TCT

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630 WRITE ( 1,640 )
640 FORMAT ( //,20X,'Type apporoximate Cost per Edge for ',
&          'inserts in',//,30X,'dollars / edge' )
      READ ( 1,*, IERR = 630 ) CPE
650 WRITE ( 1,660 )
660 FORMAT ( //,20X,'Type the Labor plus Overhead rate in ',
&          //,30X,'dollars / hour' )
      READ ( 1,*, IERR = 650 ) RLO
      ENDIF

C
C      * * * * *
C
C Compute SPEED ( surface feet / minute )
C and Real Metal Removal Rate ( cubic inches / minute )
C Find metal removal rate index for MAXimum MRR.
C
C      * * * * *
C
      AMAXMRR = 0.0
      M = 1
      MAX( M ) = 0

C
      DO 670 K = 1,KEEPER
        IF( TOLOPT.EQ.1 ) THEN
          TOLIFE( K ) = TOOLIFE
        ELSE
          IF( TOLOPT.EQ.2 ) THEN
            TOLIFE( K ) = ( ( LOCUT * PI * DOW ) /
&                          ( .012 * FEED( KFEED(K) ) *
&                          10.** TL_MIN( KSEXT(K),JDEPTH,KFEED(K) ) ) )
&                          ** ( 1./ ( 1. - TL_PRR( KSEXT(K),JDEPTH,KFEED(K) ) ) ) )
          ELSE
            IF ( TOLOPT.EQ. 3 ) THEN
              TOLIFE( K ) =
&              ( 10 ** TL_MIN( KSEXT(K),JDEPTH,KFEED(K)) / SEPM )
&              ** ( 1./ TL_PRR( KSEXT(K),JDEPTH,KFEED(K) ) )
            ELSE
              IF ( TOLOPT.EQ. 4 ) THEN
                TOLIFE( K ) =
&                ( 1./ TL_PRR( KSEXT(K),JDEPTH,KFEED(K) )
&                - 1.) * ( TCI + 60.* CPE / RLO )
              ELSE
                TOLIFE( K ) =
&                ( 1./ TL_PRR( KSEXT(K),JDEPTH,KFEED(K) ) - 1.)
&                * TCI
              ENDIF
            ENDIF
          ENDIF
        ENDIF
        IF( TOLIFE(K).LT. 5 ) TOLIFE( K ) = 5.0
        IF( TOLIFE(K).GT.25 ) TOLIFE( K ) = 25.0

C
C
&      SPEED(K) = 10.** TL_MIN( KSEXT(K), JDEPTH, KFEED(K) ) /
&      ( TOLIFE(K) ** TL_PRR( KSEXT(K), JDEPTH, KFEED(K) ) )

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C      RPM(K) = 12.* SPEED(K)/( PI * DCL )
C
C      LCC(K) = FEED( KFEED(K) ) * RPM(K) * TOLIFE(K)/1000.
C      ULCC(K) = FEED      * RPM(K) * TOLIFE(K)/1000.
C
C      IMRR(K) = .000012*SPEED(K)*DEPTH(JOEPH)*FEED(KFEED(K))
C      UIMRR(K) = .000012 * SPEED(K) * DCL      * FEED
C
C      COST(K) = ( RU/D*( TOLIFE(K) + TCI ) + CPE )/
&      ( 60 * IMRR(K) * TOLIFE(K) )
C
C      IF( IMRR( K ).GT.AMAXIMRR ) THEN
C          AMAXIMRR = IMRR( K )
C          MAX( M ) = K
C      ENDIF
C      670 CONTINUE
C
C      * * * * *
C
C      Sort Keepers such that the MAXimum IMRR is indexed 1st
C      decreasing to the minimum IMRR.
C
C      * * * * *
C
C      BMAXIMRR = 0.0
C
C      DO 690 K=1,KEEPER
C          IMRR(K)=UIMRR(K)
C          MAX(K)=K
C      690 CONTINUE
C      DO 680 K=1,KEEPER
C          J=K
C      685 IF (J.EQ.1) GOTO 680
C          IF (IMRR(J).GT.IMRR(J-1)) THEN
C              OTEMP=IMRR(J-1)
C              ITEMP=MAX(J-1)
C              IMRR(J-1)=IMRR(J)
C              MAX(J-1)=MAX(J)
C              IMRR(J)=OTEMP
C              MAX(J)=ITEMP
C              J=J-1
C          GOTO 685
C      ENDIF
C      680 CONTINUE
C
C      AMAXIMRR = BMAXIMRR
C      BMAXIMRR = 0.0
C
C      * * * * *
C
C      Output SORTed Inserts
C
C      * * * * *

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C
700 IF( KEEPER.EQ.0 ) THEN
      WRITE( 1,710 )
710   FORMAT( //,10X,'NONE of the Inserts tested meet ',
&           'your STRICT requirements.',
&           //,10X,'If you can relax a requirement, ',
&           're-enter the program at ',
&           //,20X,'one of the OPTIONS listed below. ',
&           //,25X,'Enter any key to continue.',// )
      READ ( 1, '(A1)' )
      GOTO 1000

      ENDIF
720 WRITE( 1,730 ) KEEPER
730 FORMAT( //,10X,15,' Insert - Feed combinations satisfy ',
&         'your specifications. ',
&         //,20X,'They will be listed according to their ',
&         //,20X,' Metal Removal Rates.',
&         //,20X,'The first will have the highest MRR .',
&         //,20X,' decreasing to the last.',
&         //,15X,'Enter any key to see the 1st PAGE of INSERTS.',// )

C
C
740 READ( 1,'(A1)' ) APAGE
750 WRITE( 1,'(////////////////////)' )
      K = 1
      DO 760 M = ( 1 + ( K - 1 ) * 20 ), KEEPER
        WRITE( 1,'(A79)' ) ASET( KSET( MAX(M) ) )
        IF( ( M - K * 20 ).GT.0 ) THEN
          WRITE ( 1, 120 )
          K = K + 1
          READ ( 1, '(A1)' ) APAGE
        ENDIF
760 CONTINUE
      M = 1
      IF ( KEEPER.EQ.21 .OR. KEEPER.EQ.42 ) THEN
        APAGE = 'Y'
        GOTO 785
      ENDIF
      WRITE( 1,770 )
770 FORMAT( //,5X,'Enter "R" to Return to Option Menu. Enter any ',
&         'other key to continue.' )
780 READ( 1,'(A1)' ) APAGE
785 IF( APAGE.NE.'R'.AND.APAGE.NE.'r' ) THEN
790   WRITE( 1, 800 )
800   FORMAT( //,5X,'ENTER # OF OPTION WANTED:',//,
&           10X,'1 to look at Output of an Individual Insert',//,
&           10X,'2 to see All inserts in order of highest MRR',//,
&           10X,'3 to see the List of sorted inserts',//,
&           10X,'4 to see list of originally Inputted parameters',
&           //,10X,'5 to see Definitions of terms used in line of ',
&           'NOTES on output',//,
&           10X,'6 to Return to Option Menu',// )
      READ( 1,*,ERR=790 ) TOLOPT
      IF ( TOLOPT.LE.1 .OR. TOLOPT.GE.6 ) GOTO 730

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IF ( TOOLOPT .EQ. 3 ) GOTO 750
IF ( TOOLOPT .EQ. 4 ) THEN
  WRITE( 1, 810 ) FINISH, VCHIP(KCHIP), DOC/1000.
  IF ( FEEDOPT .EQ. '1' ) THEN
    WRITE( 1, 820 ) FED/1000.
  ELSE
    WRITE( 1, '()' )
  ENDIF
  IF ( COSTOPT.IX.'Y' .OR. COSTOPT.EQ.'y' ) THEN
    WRITE( 1, 830 ) TCI, CPE, RLD
  ELSE
    WRITE( 1, 805 )
    FORMAT(//////////,22X,'ENTER <RETURN> TO CONTINUE')
  ENDIF
  READ( 1,'(A1)' ) ACNT
  GOTO 790

810  FORMAT( 22X,'ORIGINAL INPUT PARAMETERS',/,22X,
      &      '-----',///,8X,
      &      'SURFACE FINISH = ',F6.0,' micro-inches',/,8X,
      &      'CHIP QUALITY ',/,16X,A50,///,8X,
      &      'DEPTH OF CUT   = ',F8.3,' inch ' )
820  FORMAT( /,8X,'FEED      = ',F8.3,' inch / rev.' )
830  FORMAT( /,8X,'COST INFORMATION:',/,12X,
      &      'INDEXING TIME      = ',F6.1,' minutes',/,12X,
      &      'COST/INSERT EDGE    = $',F6.2,/,12X,
      &      'LABOR + OVERHEAD RATE = $',F6.2,
      &      //,22X,'ENTER <RETURN> TO CONTINUE' )
ELSE
  IF ( TOOLOPT .EQ. 5 ) THEN
    WRITE( 1, 835 )
    FORMAT(/,24X,'COMMENT DEFINITIONS',/,
835  &      'Notch      -- Observed gradual formation of notch at ',
      &      'D.O.C. line',/,
      &      2X,'Nose      -- Observed gouging of rake face on ',
      &      'nose of insert',/,
      &      'Crater      -- Observed gradual formation of crater on ',
      &      'the insert rake face',/,
      &      2X,'CE       -- Observed crater along cutting edge ',
      &      'of chip breaker',/,
      &      'Sparking    -- Sparks were observed during entire ',
      &      'time of cutting',/,
      &      2X,'And      -- Sparks were observed at cutting time ',
      &      'during last .003" flank wear',/,
      &      2X,'Slight   -- Intermittent sparking observed',/,
      &      'Vibration  -- Vibration and chatter noise of workpiece'
      &      'during time of cutting',/,
      &      'BURR      -- Build up edge on insert cutting edge',/,
      &      'Nose Wear  -- Excessive flank wear observed at ',
      &      'nose of insert',/,
      &      'Nose Def.  -- Deformation or melting of the nose tip',/,
      &      'CEL Wear/Def-- Gradual breakdown of cutting edge during'
      &      'tool life of insert',/,
      &      'Modifiers:',/,
      &      3X,'-ing    -- Behavior was observed during entire tool ',

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&          'life to .010" flank wear',/,
&      3X, 'Slight -- Behavior was observed during approx. ',
&          '0.003" flank wear',/,
&      22X, 'ENTER <RETURN> TO CONTINUE' )
      READ( 1, '(A1)' ) ATXIF
      GOTO 790
    ELSE
      IF ( TOOLOPT .EQ. 6 ) THEN
        GOTO 1000
      ENDIF
    ENDIF
  ENDIF
840  IF ( TOOLOPT .EQ. 1 ) THEN
      WRITE( 1, 845 ) KEEPER
845  FORMAT(////////,10X, 'ENTER any SEQUENTIAL Number ( 1 to ',
&          12, ' ) from the list of inserts.',///)
      READ( 1, *, ERR=840 ) TOOLNO
      IF ( TOOLNO .LT. 0 .AND. TOOLNO .GT. KEEPER ) THEN
        GOTO 840
      ELSE
        IF ( TOOLNO .GT. 0 .AND. TOOLNO .LE. KEEPER ) THEN
          IF ( FEEDOPT .EQ. '2' ) THEN
            WRITE ( 1, '(///)' )
          ENDIF
          WRITE( 1, '(A79)' ) A$ERT( K$ERT( MAX(TOOLNO) ) )
          WRITE( 1, '(A79)' ) A$OTE( K$ERT( MAX(TOOLNO) ) )
          WRITE( 1, 850 )
&          A$HP( I$HP( K$ERT( MAX(TOOLNO) ), J$EPHI,
&                K$EED( MAX(TOOLNO) ) ) )
          IF ( FEEDOPT .EQ. '2' ) THEN
            WRITE ( 1, '(///)' )
          ENDIF
          WRITE( 1, 860 )
&          S$FINISH( I$FINISH( K$ERT( MAX(TOOLNO) ), J$EPHI,
&                K$EED( MAX(TOOLNO) ) ) )
          WRITE( 1, 870 ) DEPTH( J$EPHI )/1000.
          WRITE( 1, 880 ) FEED( K$EED( MAX(TOOLNO) ) )/1000.
850  FORMAT( 5X, 'Chip Quality = ', A50 )
860  FORMAT( /, 20X, 'Surf. Finish = ', A10,
&          ' micro - inches ' )
870  FORMAT( 25X, 'Depth of Cut = ', F8.3, ' inch ' )
880  FORMAT( 25X, 'Feed = ', F8.3, ' inch / rev.' )
          WRITE( 1, 890 ) TOOLTIME( MAX( TOOLNO ) )
890  FORMAT( 20X, 'Tool Life = ', F8.1,
&          ' minutes ' )
          WRITE( 1, 900 ) SPEED( MAX( TOOLNO ) )
900  FORMAT( 20X, 'Surface Speed= ', F8.0,
&          ' surface feet / minute ' )
          WRITE( 1, 910 ) R$PR( MAX( TOOLNO ) )
910  FORMAT( 20X, 'P. Rate = ', F8.1,
&          ' cubic inches / minute ' )
          WRITE( 1, 920 ) DOF
920  FORMAT( 25X, 'D. O. Workpe = ', F8.1, ' inches ' )
          WRITE( 1, 930 ) L$CH( MAX( TOOLNO ) )
930  FORMAT( 25X, 'L. O. Cut = ', F8.0, ' inches ' )

```

```

WRITE( 1,940 ) RPM( MAX( TOOLNO ) )
FORMAT( 20X,'R. P. M. = ',F8.0,
& ' rev. / minute' )
IF( COSTOPT.EQ.'Y' .OR. COSTOPT.EQ.'y' ) THEN
WRITE( 1,950 ) COST( MAX( TOOLNO ) )
950 FORMAT( 20X,'Cost = $',F6.2,
& ' per cubic inch' )
ELSE
WRITE ( 1, '(/)' )
ENDIF
IF ( FELOPT.EQ. '2' ) THEN
WRITE ( 1, '(/)' )
ELSE
WRITE( 1,960 )
960 FORMAT( /,10X,'Computations for user specified',
& ' Depth Of Cut and Feed. ' )
WRITE( 1,965 ) DOC/1000.
965 FORMAT( 25X,'D. O. Cut = ',F8.3,' inch' )
WRITE( 1,970 ) FEED/1000.
970 FORMAT( 25X,'Feed = ',F8.3,' inch / rev.' )
WRITE( 1,975 ) IMRR( MAX( TOOLNO ) )
975 FORMAT( 20X,'M. R. Rate = ',F8.1,
& ' cubic inches / minute' )
WRITE( 1,980 ) ULOC( MAX( TOOLNO ) )
980 FORMAT( 20X,'L. O. Cut = ',F8.0,' inches' )
ENDIF
WRITE( 1,985 )
985 FORMAT( /,5X,'Enter "R" to Return to Option Menu.',
& 3X,'Enter any other key to continue.' )
GOTO 780
ENDIF
ENDIF
ELSE
IF ( TOOLOPT.EQ. 2 ) THEN
990 IF( APATE.NE.'R'.AND.APATE.NE.'r' ) THEN
995 IF( M.LE.10000 ) THEN
IF ( FELOPT.EQ. '2' ) THEN
WRITE ( 1, '(/)' )
ENDIF
WRITE( 1,'(A79)') ASERT( KSER( MAX(1) ) )
WRITE( 1,'(A79)') ANOTE( KSER( MAX(2) ) )
WRITE( 1,850 )
& ACHIP( ICHIP( KSER( MAX(3) ),
& JDEPTH, KFEED( MAX(4) ) ) )
IF ( FELOPT.EQ. '2' ) THEN
WRITE ( 1, '(/)' )
ENDIF
WRITE( 1,860 )
& SFINISH( IFINISH( KSER( MAX(5) ),
& JDEPTH, KFEED( MAX(6) ) ) )
WRITE( 1,870 ) DEPTH( JDEPTH )/1000.
WRITE( 1,880 ) FEED(KFEED(MAX(6)))/1000.
WRITE( 1,890 ) TOLIFE( MAX( 7 ) )
WRITE( 1,900 ) SPEED( MAX( 8 ) )
WRITE( 1,910 ) RPRK( MAX( 9 ) )

```

```

        WRITE( 1,920 ) DOX
        WRITE( 1,930 ) LOC( MAX( M ) )
        WRITE( 1,940 ) PTH( MAX( M ) )
        IF( CUSTOPT.EQ.'Y' .OR. CUSTOPT.EQ.'2' ) THEN
            WRITE( 1,950 ) COST( MAX( M ) )
        ELSE
            WRITE( 1,'(//)' )
        ENDIF
        IF ( FIDOPT.EQ. '2' ) THEN
            WRITE ( 1, '(//)' )
        ELSE
            WRITE( 1,960 )
            WRITE( 1,965 ) DOX/1000.
            WRITE( 1,970 ) FED/1000.
            WRITE( 1,975 ) UPR( MAX( M ) )
            WRITE( 1,980 ) ULOC( MAX( M ) )
        ENDIF
        WRITE( 1,985 )
        READ( 1, '(A1)' ) APAGE
        M = M + 1
        GO TO 930
    ENDIF
ENDIF
ENDIF
ENDIF
1000 WRITE( 1,1100 )
1100 FORMAT( '//////////,10X,'Re-enter program at ',
& 'Options for :',/,20X,'1 Shape of Insert ',
& '( the beginning )',/,20X,'2 Finish end ',
& 'Chip priority ',/,20X,'3 Feed ',
& '/',20X,'4 Tool Life / Length of Cut ',
& '/',20X,'5 Repeat of Results ',
& '//,17X,'Exit enter any other key ',/////////)
        READ( 1, '(A1)' ) APAGE
        IF( APAGE.EQ.'2' ) GO TO 180
        IF( APAGE.EQ.'3' ) GO TO 420
        IF( APAGE.EQ.'4' ) GO TO 530
        IF( APAGE.EQ.'5' ) GO TO 700
9999 CLOSE (UNIT)

        RETURN
    END

```

```

SUBROUTINE F_TRIANGLE
C
C   VARIABLE DECLARATIONS
C
C   CHARACTER*11 DEFILETRI
C   CHARACTER*15 GEM_NAME
C
C   VARIABLE INITIALIZATION
C

```


RETURN
END

SUBROUTINE F_D_DIAMOND_55

VARIABLE DECLARATIONS

CHARACTER*11 DFILDI55
CHARACTER*15 GEOM_NAME

VARIABLE INITIALIZATION

NUNIT8 = 8
DFILDI55 = 'F_DIA55DATA'
GEOM_NAME = 'DIAMOND(55.DIG)'

CALL GENERAL SORTING SUBROUTINE

CALL GEN_SORT(NUNIT8, DFILDI55, GEOM_NAME)

RETURN
END

SUBROUTINE F_ROUND

VARIABLE DECLARATIONS

CHARACTER*11 DFILDI00
CHARACTER*15 GEOM_NAME

VARIABLE INITIALIZATION

NUNIT9 = 9
DFILDI00 = 'F_ROUND00'
GEOM_NAME = 'ROUND'

CALL GENERAL SORTING SUBROUTINE

CALL GEN_SORT(NUNIT9, DFILDI00, GEOM_NAME)

RETURN
END

SUBROUTINE R_TRIANGLE

VARIABLE DECLARATIONS

```
C  
C CHARACTER*11 DEFILEM  
C CHARACTER*15 GCDM_NAME
```

```
C  
C VARIABLE INITIALIZATION
```

```
C  
C MINITS = 5  
C DEFILEM = 'R_TRIDATA'  
C GCDM_NAME = 'RIRAS*CLAR'
```

```
C  
C CALL THE GENERAL SORTING SUBROUTINE
```

```
C  
C CALL GEN_SORT( MINITS, DEFILEM, GCDM_NAME )
```

```
C  
C RETURN  
C END
```

```
C  
C SUBROUTINE R_SQUARE
```

```
C  
C VARIABLE DECLARATIONS
```

```
C  
C CHARACTER*11 DEFILESQ  
C CHARACTER*15 GCDM_NAME
```

```
C  
C VARIABLE INITIALIZATION
```

```
C  
C MINITS = 6  
C DEFILESQ = 'R_SQUADA'  
C GCDM_NAME = 'RIRAS SQUARE'
```

```
C  
C CALL GENERAL SORTING SUBROUTINE
```

```
C  
C CALL GEN_SORT( MINITS, DEFILESQ, GCDM_NAME )
```

```
C  
C RETURN  
C END
```

```
C  
C SUBROUTINE R_CDIA80DQ SQ
```

```
C  
C VARIABLE DECLARATIONS
```

```
C  
C CHARACTER*11 DEFILESQ  
C CHARACTER*15 GCDM_NAME
```

```
C  
C VARIABLE INITIALIZATION
```

```
C  
C MINITS = 7  
C DEFILEM = 'R_DIA80DATA'  
C GCDM_NAME = 'RIRAS*CDIA80DQ'
```

```
C  
C CALL GENERAL SORTING SUBROUTINE
```

```

C
CALL GEN_SORT( MINIT7, DEFILED7, GEXT_NAME )

```

```

RETURN
END

```

```

SUBROUTINE R_D_DIAMND_55

```

```

C
C   VARIABLE DECLARATIONS
C

```

```

C   CHARACTER*11 DEFILED11
C   CHARACTER*15 GEXT_NAME

```

```

C   VARIABLE INITIALIZATION
C

```

```

C   MINIT8 = 8
C   DEFILED11 = 'R_DIA55DATA'
C   GEXT_NAME = 'DIAMND(55 DEG)'

```

```

C   CALL GENERAL SORTING SUBROUTINE
C

```

```

C   CALL GEN_SORT( MINIT8, DEFILED11, GEXT_NAME )

```

```

RETURN
END

```

```

SUBROUTINE R_ROUND

```

```

C
C   VARIABLE DECLARATIONS
C

```

```

C   CHARACTER*11 DEFILED11
C   CHARACTER*15 GEXT_NAME

```

```

C   VARIABLE INITIALIZATION
C

```

```

C   MINIT9 = 9
C   DEFILED11 = 'R_ROUNDATA'
C   GEXT_NAME = 'ROUND'

```

```

C   CALL GENERAL SORTING SUBROUTINE
C

```

```

C   CALL GEN_SORT( MINIT9, DEFILED11, GEXT_NAME )

```

```

RETURN
END

```

Data File: F_TRIADATA

```

01  TRIADATA/ data file F for subroutine TRIANGLE called by program SORT
02
03
04  NOTE : Comment lines in the data file are identified at the left.
05          The number of comment lines and their placement are fixed by program
06          SORT. However, the content may be altered or omitted.
07
08          INPUT the number of data entries in the order specified
09          below. These numbers MUST correspond to the number of entries
10          for each category in this data file.
11          INCREASE    INCREASE    INCREASE    INCREASE    INCREASE
12          22          1          2          6          2
13
14  INPUT D.C. Cuts (used in tests to obtain data) after comment line 04
15  Enter INCREASE numbers in thousandths of an inch from the
16  smallest INCREASING to the largest.
17  60
18
19  INPUT FREDS (used in tests to obtain data) after comment line 04
20  Enter FREDS numbers in thousandths of an inch from the
21  smallest INCREASING to the largest.
22  12      17      20
23
24  INPUT FINISHES (obtained from test data) after comment line 04
25  Enter FINISH numbers in micro-inches RMS from the
26  smallest INCREASING to the largest.
27  62      90      125      180      250      320
28
29  Enter FINISH FINISH, corresponding to FINISH numbers, how you
30  would like them to be outputted in the program.
31  Place each FINISH on a separate line, starting the smallest RMS
32  to the largest RMS. Each FINISH is allowed 10 characters,
33  starting in Column 11.
34  1          2          3
35  6789012345678901234567890
36      62
37      62+
38      125
39      125+
40      250
41      250+
42
43  INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
44  Enter NOTES lines describing chip categories used in data collection.
45  Enter the FIRST first, the WORDS last. Begin after comment line 04.
46      1 - good, all small chips, no curls
47      2 - fair, 75% small chips, 25% short curls
48      3 - poor, hind edge, long curls, etc.
49
50  INPUT INPUTS for each input on separate lines up to 80 spaces wide,
51  followed by NOTES or test observations on a line up to 80 spaces wide.
52  Begin input of INPUT INPUTS lines after this comment line 04.
53  101  Tool No. 550 S. TRW - 012 - A1 OX - TUNG - 430
54      01  Note- 3.017" - Notching, 3.220" - Cratering
55  102  Tool No. 550 S. TRW - 012 - A1 OX - TUNG - 430 - 48
56      02  Note- 3.017" - Slt Notching, 3.017" - Slt Sparking & Vibration

```

102 tool No. 50752 Carboloy 570 - A1 Ox TNMG 422 - 26
 02 Note- < 0.017" - Slt Cratering, 0.017" - Nose Notch, 0.020" - Slt Crater
 104 tool No. Carboloy 570 - A1 Ox TNMP 422 - 16
 04 Note- < 0.017" - Cratering, 0.012" - Nose Wear, 0.020" - Slt Crater
 105 tool No. 50752 Carboloy 570 - A1 Ox TNMG 422 - 52
 05 Note- < 0.017" - Slight Notching, 0.020" - Slight Vibration
 106 tool No. Cleveland CP1 - A1 Ox TNMG 422
 06 Note- < 0.017" - Slt Notch, 0.012" - Sparking, 0.020" - Slt Notching
 107 tool No. Cleveland CP1 - A1 Ox TNMP 422 - 41
 07 Note- All Feeds - Nose Wear, 0.012" - Sparking
 108 tool No. Carmet - 7000 - A1 Ox TNMG 422 - 7
 08 Note- 0.012" - Slt Notching & Sparking, 0.017" - Nose Defect Notching, 0.020" - Slt Notch
 109 tool No. 50237 Sandvik - 015 - A1 Ox TNMG 422 - 61
 09 Note- All Feeds - Cratering, 0.017" - Notch
 110 tool No. Fifth Sterling CCH6-A1 Ox TNMG 422
 10 Note- 0.012" - Slt Notching, 0.017" - Notch & Sparking, 0.020" - Notching & Crater
 111 tool No. Valenite- V01 - A1 Ox TNMM 422 - EP
 11 Note- 0.017" - Notching, 0.020" - Slight Vibration & Crater
 112 tool No. Valenite- V01 - A1 Ox TNMM 422 - EEE
 12 Note- < 0.017" - Slt Notch (OE or Nose), 0.020" - Slt Crater & Sparking
 113 tool No. Valenite- V05 - A1 Ox TNMG 422
 13 Note- 0.012" - Slight Notch, 0.017" - Slight Sparking
 114 tool No. Newcomer-NA02 - A1 Ox TNMG 422
 14 Note- 0.012" & 0.020" - Slight Notching, 0.017" - Slight Notch
 115 tool No. Kennametal 050 - Multi TNMG 422 - K
 15 Note- All Feeds - Slight Notching
 116 tool No. 50754 Kennametal 050 - Multi TNMM 422
 16 Note- 0.012" & 0.020" - Slt Notching, 0.017" - Slt Notch, 0.020" - Cratering
 117 tool No. Seco - TP15 - Multi TNMM 422 - 27
 17 Note- < 0.017" - Slt Cratering, 0.012" - Notching, 0.017" - Nose In, 0.020" - Slt Notch
 118 tool No. Seco - TP10 - Multi TNMM 422 - 27
 18 Note- < 0.017" - Cratering, 0.012" - Nose Notch, 0.020" - Slight Cratering
 119 tool No. Cleveland CM2 - Multi TNMP 422 - 41
 19 Note- 0.012" - Slight Notch
 120 tool No. 50261 Sandvik - 415 - Multi TNMM 422 - 71
 20 Note- 0.012" & 0.020" - Slight Crater & Notching, 0.020" - Notching
 121 tool No. 50264 Sandvik - 425 - Multi TNMM 422 - 71
 21 Note- All Feeds - Cratering, 0.012" - Notching
 122 tool No. 50751 VP/Wesson 680 - Multi TNMM 422
 22 Note- > 0.017" - Slight Cratering
 123 tool No. VP/Wesson 680 - Multi TNMG 422 - 2
 23 Note- > 0.017" - Slight Crater

C24

C25

C26

C27

C28

C29

C30

C31

INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
 Finish and chip Qualities are indicated by the integer corresponding to
 categories entered above. These are followed by the COEFFICIENT and POWER
 (used in the tool-life, speed equation) from the data for each test.

ALL of the above values will appear on each line of data entered and be

```

C10 READ from DO LOOPS structured as follows - -
C11
C12 For each INSERT -
C13     DEPTH 1
C14         Feed 1
C15         Feed 2
C16         ...
C17         Feed n ( over the range of feeds input after line C17 above )
C18     DEPTH 2
C19         Feed 1
C20         Feed 2
C21         ...
C22         Feed n
C23     ....
C24     DEPTH m ( over the range of depths input after comment line C11 )
C25         Feed 1
C26         ...
C27 Skip a line ( or put in a comment line ) before each INSERT data set.
C28 Next INSERT
C29     DEPTH 1
C30         Feeds
C31         etc.
C32 Skip etc
C33
C34 Enter a zero if no data was taken for a particular DEPTH and FEED.
C35 Begin entries after comment line C32
C36 Put entries in 7 positions of 10 spaces each as shown from C50 to C72.
C37     1         2         3         4         5         6         7
C38 67800123456780012345678001234567800123456780012345678001234567800
C39 INSERT  DEPTH  FEED  FINISH  CHIP  COEF  POWER
C40 INDEX  INDEX  INDEX  INDEX  INDEX  SIGNIF  EXPONENT
C41

```

This line following comment line C72 is the SKIP line before first INSERT 101.

	101	1	1	2	2	2.9574	.15
	101	1	2	4	1	2.0597	.10
	101	1	2	5	1	2.01125	.22
skip							
	102	1	1	2	2	2.9258	.10
	102	1	2	4	2	2.91120	.15
	102	1	2	5	1	2.7015	.15
skip							
	103	1	1	2	1	2.2480	.50
	103	1	2	4	1	2.0397	.22
	103	1	2	5	1	2.8851	.24
skip							
	104	1	1	2	1	2.1555	.25
	104	1	2	4	1	2.1120	.27
	104	1	2	5	1	2.1040	.45
skip							
	105	1	1	2	2	2.1051	.31

	105	1	2	2	1	2,8211	.17
	105	1	2	6	2	2,0712	.12
skip	106	1	1	2	2	2,0164	.22
	106	1	2	11	2	2,0412	.21
	106	1	2	6	1	2,8866	.20
skip	107	1	1	11	1	2,0808	.22
	107	1	2	5	1	2,0111	.21
	107	1	2	6	1	2,8820	.22
skip	108	1	1	2	2	2,1160	.20
	108	1	2	11	2	2,0715	.20
	108	1	2	11	1	2,7608	.12
skip	109	1	1	2	1	2,0012	.27
	109	1	2	11	1	2,8567	.22
	109	1	2	6	1	2,7155	.11
skip	110	1	1	2	2	2,0676	.20
	110	1	2	11	1	2,0622	.21
	110	1	2	5	1	2,8061	.21
skip	111	1	1	2	2	2,7050	.11
	111	1	2	2	2	2,0211	.22
	111	1	2	5	2	2,0162	.27
skip	112	1	1	2	2	2,0712	.26
	112	1	2	11	1	2,8000	.15
	112	1	2	5	1	2,8255	.27
skip	113	1	1	2	2	2,0891	.20
	113	1	2	2	1	2,8151	.17
	113	1	2	11	1	2,7610	.15
skip	114	1	1	2	2	2,8800	.17
	114	1	2	11	1	2,8081	.20
	114	1	2	11	1	2,0722	.29
skip	115	1	1	2	1	2,0186	.16
	115	1	2	2	1	2,0001	.15
	115	1	2	11	1	2,8502	.17
skip	116	1	1	2	2	2,0127	.10
	116	1	2	11	2	2,0215	.25
	116	1	2	5	2	2,0878	.27
skip	117	1	1	2	2	2,8251	.00
	117	1	2	11	1	2,0286	.25
	117	1	2	11	1	2,7610	.11

skip						
118	1	1	2	1	2,0077	.22
119	1	2	2	1	2,8169	.23
119	1	2	2	1	2,8207	.21
skip						
119	1	1	2	1	2,8071	.21
119	1	2	2	1	2,8100	.20
119	1	2	1	1	2,6825	.21
skip						
120	1	1	2	2	2,0759	.17
120	1	2	2	1	2,0759	.20
120	1	2	2	1	2,8206	.19
skip						
121	1	1	2	2	2,1299	.21
121	1	2	1	2	2,0520	.20
121	1	2	2	2	2,0270	.22
skip						
122	1	1	2	2	2,8982	.00
122	1	2	2	1	2,8051	.00
122	1	2	2	1	2,8001	.16
skip						
122	1	1	2	2	2,8051	.22
122	1	2	2	1	2,8122	.21
122	1	2	1	1	2,7100	.10

Data File: ESQUIDATA

C1 SCUDATA/ data file 6 for subroutine SCUAPL called by program SORT
C2
C3
C4 NOTE : Comment lines in the data file are identified at the left.
C5 The number of comment lines and their placement are fixed by program
C6 SORT. However, the content may be altered or omitted.
C7
C8 INPUT the number of data entries in the order specified
C9 below. These numbers MUST correspond to the number of
C10 entries for each category in this data file.
C11 NSFEEDS NDEPTHs NFEEDS NFINISHS NCHIPS
 12 1 2 6 2
C12 INPUT D.O.Cuts (used in tests to obtain data) after comment line C11
C13 Enter NDEPTHs numbers in thousandths of an inch from the
C14 smallest INCREASING to the largest.
 60
C15 INPUT FEEDS (used in tests to obtain data) after comment line C12
C16 Enter NFEEDS numbers in thousandths of an inch from the
C17 smallest INCREASING to the largest.
 12 17 20
C18 INPUT FINISHes (obtained from test data) after comment line C20
C19 Enter NFINISHS numbers in micro-inches RMS from the
C20 smallest INCREASING to the largest.
 62 90 125 180 250 320
C21 Enter SURFACE FINISH, corresponding to NFINISHS numbers, how you
C22 would like them to be outputted in the program.
C23 Place each SFINISH on a separate line, starting with the smallest
C24 RMS to the largest RMS. Each SFINISH is allowed 10 characters,
C25 starting in Column 11.
C26 1 2 3
C27 6780012345678001234567800
 62
 62+
 125
 125+
 250
 250+
C28 INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
C29 Enter NCHIPS lines describing chip catagories used in data collection.
C30 Enter the BEST first, the WORST last. Begin after comment line C29.
 1 - good, all small chips, no curls
 2 - fair, 70% small chips, 30% short curls
 3 - poor, bird cage, long curls, etc.
C31 INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
C32 followed by NOTES on test observations on a line up to 80 spaces wide.
C33 Begin input of INSERT IDENTIFIER lines after this comment line C33.
201 tool No. 50067 TRW - 018 - A1 Ox SNMG #22
 01 Note- < 0.017" - Notching, 0.020" - Slight Notching
202 tool No. 50746 Carboloy 545 - A1 Ox SNMG #22 - 52
 02 Note- 0.012" - Slight Nose Notch, 0.017" - End Sparking

203 tool No. 50744 Cleveland CP1 - A1 Ox SNMG #22
 03 Note- All Feeds - Crater, 0.012" - Nose Wear, 0.017" - Nose Def.
 204 tool No. Carmet - 7000 - A1 Ox SNMG #22 - E
 04 Note- All Feeds - Cratering, 0.012" - Nose Notching, 0.017" - Notching
 205 tool No. 50748 Fifth Sterling CCH6-A1Ox SNMG #22
 05 Note- All Feeds - Slight Notch
 206 tool No. 50747 Valenite V05 - A1 Ox SNMG #22
 06 Note- 0.012"- Slt Notching, 0.017"- Slt Notch, 0.020"- Slt Crater
 207 tool No. 50740 Kennametal 250 - Multi SNMM #22
 07 Note- 0.012" - Slt Notch, 0.017" - Slt Notching, 0.017" - Crater
 208 tool No. 50745 Seco - TP10 - Multi SNMM #22 - 27
 08 Note- 0.012"-Slt Notch, 0.017"-Slt Notching, 0.020"-Cratering & Nose Notch
 209 tool No. Seco - TP15 - Multi SNMM #22 - 27
 09 Note- 0.012" - Slight RUF & Cratering, 0.017" - Slight Notching
 210 tool No. Cleveland CMP - Multi SNMG #22
 10 Note- All Feeds - Slight Notching
 211 tool No. 50750 Sandvik - 415 - Multi SNMM #22 - 71
 11 Note- 0.012" & 0.020" - Slight Notch, 0.017" - Slight Notching
 212 tool No. VP/Wesson 680 - Multi SNMG #22
 12 Note- < 0.017" - Slight Notch, 0.012" - Sparking

C25

C26

C26 INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.

C27 Finish and chip Qualities are indicated by the integer corresponding to

C28 categories entered above. These are followed by the COEFFICIENT and POWER

C29 (used in the tool-life, speed equation) from the data for each test.

C30

C31 ALL of the above values will appear on each line of data entered and be

C32 READ from DO LOOPS structured as follows - -

C33

C34 For each INSEPT -

C35 DEPTH 1

C36 Feed 1

C37 Feed 2

C38 ...

C39 Feed n (over the range of feeds input after line C17 above)

C40 DEPTH 2

C41 Feed 1

C42 Feed 2

C43 ...

C44 Feed n

C45

C46 DEPTH m (over the range of depths input after comment line C18)

C47 Feed 1

C48 ...

C49 Skip a line (or put in a comment line) before each INSEPT data set.

C50 Next INSEPT

C51 DEPTH 1

C52 Feeds

C53 etc.

064 Skip etc
 065
 066 Enter a zero if no data was taken for a particular DEPTH and FEED.
 067 Begin entrys after comment line 072
 068 Put entrys in 7 positions of 10 spaces each as shown from 069 to 072.
 069 1 2 3 4 5 6 7
 070 67890123456789012345678901234567890123456789012345678901234567890
 071 INSEPT DEPTH FEED FINISH CHIP OFF- POWER
 072 INDEX INDEX INTX INDEX INDEX EFFICIENT EXPONENT
 073
 This line following comment line 072 is the SKIP line before first INSEPT 201.
 201 1 1 2 2 3.0221 .20
 201 1 2 4 2 2.8656 .10
 201 1 3 5 1 2.8508 .21
 comment - All data in this file was taken at ONE depth of cut.
 202 1 1 2 2 2.2631 .11
 202 1 2 3 2 2.0420 .22
 202 1 3 5 2 2.2065 .51
 skip
 203 1 1 2 1 2.1711 .26
 203 1 2 4 1 2.0427 .21
 203 1 3 5 1 2.0155 .22
 skip
 204 1 1 2 2 2.1059 .42
 204 1 2 4 2 2.8291 .15
 204 1 3 4 1 2.0500 .21
 skip
 205 1 1 2 2 2.8141 .00
 205 1 2 3 1 2.2102 .22
 205 1 3 5 1 2.8505 .10
 skip
 206 1 1 2 1 2.0177 .10
 206 1 2 3 1 2.8822 .15
 206 1 3 6 1 2.0011 .26
 skip
 207 1 1 2 2 2.0000 .12
 207 1 2 3 1 2.0072 .27
 207 1 3 5 1 2.7010 .16
 skip
 208 1 1 2 2 2.0552 .10
 208 1 2 3 2 2.8055 .17
 208 1 3 5 2 2.0211 .26
 skip
 209 1 1 2 2 2.8652 .12
 209 1 2 4 1 2.0061 .20
 209 1 3 4 1 2.7006 .12
 skip
 210 1 1 1 1 2.8526 .15
 210 1 2 4 1 2.7808 .16
 210 1 3 4 1 2.7256 .12

skip						
211	1	1	2	2	2,0575	.22
211	1	2	2	1	2,0056	.14
211	1	2	6	1	2,0660	.25
skip						
212	1	1	2	1	2,0460	.19
212	1	2	2	1	2,0010	.32
212	1	2	4	1	2,8200	.26

C1 DIA80DATA(data file 7 for subroutine C_DIAMOND_80 called by program SORT
 C2
 C3
 C4 NOTE : Comment lines in the data file are identified at the left.
 C5 The number of comment lines and their placement are fixed by program
 C6 SORT. However, the content may be altered or omitted.
 C7
 C8 INPUT the number of data entries in the order specified
 C9 below. These numbers MUST correspond to the number of
 C10 entries for each category in this data file.
 C11 NINSERTS NDEPTHIS NFEEDS NFINISHS NCHIPS
 17 1 2 6 2
 C12 INPUT D.O.Cuts (used in tests to obtain data) after comment line C11
 C13 Enter NDEPTHIS numbers in thousandths of an inch from the
 C14 smallest INCREASING to the largest.
 60
 C15 INPUT FEEDS (used in tests to obtain data) after comment line C12
 C16 Enter NFEEDS numbers in thousandths of an inch from the
 C17 smallest INCREASING to the largest.
 12 17 20
 C18 INPUT FINISHES (obtained from test data) after comment line C20
 C19 Enter NFINISHS numbers in micro-inches RMS from the
 C20 smallest INCREASING to the largest.
 62 90 125 180 250 230
 C21 Enter SURFACE FINISH, corresponding to NFINISHS numbers, how you
 C22 would like them to be outputted in the program.
 C23 Place each SFINISH on a separate line, starting with the smallest
 C24 RMS to the largest RMS. Each SFINISH is allowed 10 characters,
 C25 starting in Column 11.
 C26 1 2 3
 C27 6789012345678901234567890
 62
 62+
 125
 125+
 250
 250+
 C28 INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
 C29 Enter NCHIPS lines describing chip categories used in data collection.
 C30 Enter the BEST first, the WORST last. Begin after comment line C30.
 1 - good, all small chips, no curls
 2 - fair, 70% small chips, 30% short curls
 3 - poor, bird cage, long curls, etc.
 C31 INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
 C32 followed by NOTES on test observations on a line up to 80 spaces wide.
 C33 Begin input of INSERT IDENTIFIER lines after this comment line C33.
 301 tool No. 50742 "RW - 918 - A1 Ox CNMG 432
 01 Note- 0.012" - Notch, 0.017" - Slight Notching
 302 tool No. Carbide - 505 - A1 Ox CNMG 432 - 48
 02 Note- < 0.017" - Sparking, 0.017" - Slight Cratering

302 tool No. 50741 Cleveland - CP1 - A1 Ox CNMG #22 - #2
 03 Note- < 0.017" - Slight Notch, 0.020" - Notch
 304 tool No. Cleveland - CP1 - A1 Ox CNMG #22
 04 Note- 0.012"-Notching & Nose Def, 0.017"-Slt CE Wear, 0.020"-Slt Notch
 305 tool No. Carmet - 7000 - A1 Ox CNMG #22 - E
 05 Note- 0.017" - Slight Sparking
 306 tool No. 50129 Sandvik - 015 - A1 Ox CNMG #22 - 61
 06 Note- 0.012" - Crater, 0.017" - Notching, 0.020" - Cratering
 307 tool No. 50742 Fifth Sterling CCH6- A1 Ox CNMG #22
 07 Note- 0.012" - Nose Notch, 0.017" - Slight Notching
 308 tool No. Valenite - V05 - A1 Ox CNMG #22
 08 Note- 0.012" - Slight Notch, 0.017" - Slight Sparking
 309 tool No. Newcomer - NA02 - A1 Ox CNMG #22
 09 Note- < 0.017" - Slight Notch, 0.017" - Nose Wear
 310 tool No. 50000 Kennametal - 050 - Multi CNMG #22
 10 Note- 0.012" - Slight Nose Notch, 0.017" - Slight Sparking
 311 tool No. Secc - TP10 - Multi CNMG #22 - 27
 11 Note- 0.012" - Slight Notch
 312 tool No. Secc - TP15 - Multi CNMG #22 - 27
 12 Note- 0.017" - CE Cratering & Slight Notch
 313 tool No. Cleveland - CM2 - Multi CNMG #22 - #2
 13 Note- All Feeds - Cratering
 314 tool No. Cleveland - CM2 - Multi CNMG #22
 14 Note- < 0.017" - Slight Notch, 0.020" - Crater
 315 tool No. 50127 Sandvik - #15 - Multi CNMG #22 - 15
 15 Note- 0.012" - Slight Notch, 0.020" - Slight Crater
 316 tool No. Sandvik - #25 - Multi CNMG #22 - 61
 16 Note- 0.012" - Slight Cratering, 0.020" - Cratering
 317 tool No. 50740 VR/Wesson - 690 - Multi CNMG #22 - E
 17 Note- 0.017" - Slight Sparking

C24

C25

C26 INPUT below FINISH, CNTP, COEFFICIENT, and POWER data from each test run.
 C27 Finish and chip Qualities are indicated by the integer corresponding to
 C28 categories entered above. These are followed by the COEFFICIENT and POWER
 C29 (used in the tool-life, speed equation) from the data for each test.
 C30

C31

C32 ALL of the above values will appear on each line of data entered and be
 C33 READ from DO LOOPS structured as follows - -

C34

C35 For each INSERT -

C36

C37 FEED 1

C38 Feed 2

C39 ...

C40 Feed n (over the range of feeds input after line C17 above)

C41

C42 DEPTH 1

C43 Feed 1

C44 Feed 2

C45

...

```

054          Feed n
055          ....
056          DEPTH m ( over the range of depths input after comment line 011 )
057          Feed 1
058          ...
059      Skip a line ' or put in a comment line ' before each INSERT data set.
060      Next INSERT
061          DEPTH 1
062          Feeds
063          etc.
064      Skip etc
065
066      Enter a zero if no data was taken for a particular DEPTH and FEED.
067      Begin entrys after comment line 072
068      Put entrys in 7 positions of 10 spaces each as shown from 060 to 072.
069      1          2          3          4          5          6          7
070      67890123456789012345678901234567890123456789012345678901234567890
071      INSERT  DEPTH  FEED  FINISH  CHIP  COEF-  POWER
072      INDEX  INDEX  INDEX  INDEX  INDEX  EFFICIENT  EXPONENT
073
This line following comment line 072 is the SKIP line before first INSERT 301.
      301          1          1          2          2          2.8048          .20
      301          1          2          2          2          2.8024          .17
      301          1          2          4          1          2.8222          .26
comment -      All data in this file was taken at ONE depth of cut.
      302          1          1          2          1          2.9000          .26
      302          1          2          2          1          2.7112          .16
      302          1          2          4          1          2.6478          .15
skip
      303          1          1          2          1          2.8917          .20
      303          1          2          4          1          2.8355          .21
      303          1          2          4          1          2.8200          .27
skip
      304          1          1          2          2          2.8366          .18
      304          1          2          4          2          2.8824          .26
      304          1          2          4          2          2.7272          .14
skip
      305          1          1          2          2          2.7814          .11
      305          1          2          2          2          2.7100          .12
      305          1          2          5          1          2.5402          .24
skip
      306          1          1          2          2          2.8522          .21
      306          1          2          4          1          2.8962          .22
      306          1          2          5          1          2.7020          .25
skip
      307          1          1          2          2          2.9050          .15
      307          1          2          2          1          2.9108          .30
      307          1          2          4          1          2.6710          .14
skip
      308          1          1          2          2          2.8022          .16

```

	308	1	2	2	2	2,7208	.17
	308	1	2	2	2	2,7186	.10
skip	300	1	1	2	2	2,0060	.22
	300	1	2	2	1	2,8728	.20
	300	1	2	2	1	2,7082	.22
skip	310	1	1	2	1	2,8457	.10
	310	1	2	2	2	2,0076	.28
	310	1	2	2	1	2,7602	.15
skip	311	1	1	2	1	2,1510	.11
	311	1	2	2	2	2,8122	.18
	311	1	2	5	2	2,8006	.21
skip	312	1	1	2	1	2,7761	.08
	312	1	2	2	1	2,8182	.24
	312	1	2	5	1	2,6282	.14
skip	313	1	1	2	1	2,7711	.22
	313	1	2	2	1	2,7156	.21
	313	1	2	5	1	2,5822	.12
skip	314	1	1	2	2	2,8688	.25
	314	1	2	2	2	2,7161	.12
	314	1	2	2	2	2,6526	.11
skip	315	1	1	2	1	2,8801	.17
	315	1	2	2	1	2,9122	.28
	315	1	2	5	1	2,7215	.12
skip	316	1	1	2	1	2,8162	.22
	316	1	2	2	1	2,6070	.15
	316	1	2	2	1	2,6260	.17
skip	317	1	1	2	1	2,0010	.16
	317	1	2	2	1	2,8517	.12
	317	1	2	2	1	2,7010	.17

C1 DIA55DATA' data file 8 for subroutine D_DIAMOND_55 called by program SORT
 C2
 C3
 C4 NOTE : Comment lines in the data file are identified at the left.
 C5 The number of comment lines and their placement are fixed by program
 C6 SORT. However, the content may be altered or omitted.
 C7
 C8 INPUT the number of data entries in the order specified
 C9 below. These numbers MUST correspond to the number of
 C10 entries for each category in this data file.
 C11 NSEPTS NDEPTHs NFEEDs NFINISHs NCHIPS
 9 1 2 6 2
 C12 INPUT D.O.Cuts (used in tests to obtain data) after comment line C11
 C13 Enter NDEPTHs numbers in thousandths of an inch from the
 C14 smallest INCREASING to the largest.
 60
 C15 INPUT FEEDs (used in tests to obtain data) after comment line C12
 C16 Enter NFEEDs numbers in thousandths of an inch from the
 C17 smallest INCREASING to the largest.
 12 17 20
 C18 INPUT FINISHes (obtained from test data) after comment line C20
 C19 Enter NFINISHs numbers in micro-inches RMS from the
 C20 smallest INCREASING to the largest.
 62 90 125 180 250 320
 C21 Enter SURFACE FINISH, corresponding to NFINISHs numbers, how you
 C22 would like them to be outputted in the program.
 C23 Place each SFINISH on a separate line, starting with the smallest
 C24 RMS to the largest RMS. Each SFINISH is allowed 10 characters,
 C25 starting in Column 11.
 C26 1 2 3
 C27 6789012345678901234567890
 62
 62+
 125
 125+
 250
 250+
 C28 INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
 C29 Enter NCHIPS lines describing chip categories used in data collection.
 C30 Enter the BEST first, the WORST last. Begin after comment line C29.
 1 - good, all small chips, no curls
 2 - fair, 70% small chips, 30% short curls
 3 - poor, bird cage, long curls, etc.
 C31 INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
 C32 followed by NOTES on test observations on a line up to 80 spaces wide.
 C33 Begin input of INSERT IDENTIFIER lines after this comment line C33.
 401 tool No. 50730 Carbide - 570 - A1 Ox DIMG 422 - 48
 01 Note- 0.012"-Slt Notch, 0.017"-Slt Notching, 0.020"-Slt Crater&Notch
 402 tool No. Carmet - 7000 - A1 Ox DIMG 422 - E
 02 Note- 0.012" - Slight Notch, 0.020" - Notching & BUR

402 tool No. Firth Sterling CCH6 - A1 Ox DMMG 432
 03 Note- 0.012" - Nose Notch, 0.017" - Sparking
 404 tool No. Neuromen - NA02 - A1 Ox DMMG 432
 04 Note- 0.012-Slt Notch & RUF, 0.017-Slt Vibration, 0.020-Notch & CF Def.
 405 tool No. 50138 Valenite - V01 - A1 Ox DMMG 433
 05 Note- 0.012"- Vibration & Nose Notch, 0.020"- Slt Notch & Sparking
 406 tool No. Seco - TP10 - Multi DMMG 442 - 27
 06
 407 tool No. Seco - TP15 - Multi DMMG 442 - 27
 07
 408 tool No. Sandvik - 415 - Multi DMMG 432 - 15
 08
 409 tool No. VP/Wesson - 580 - Multi DMMG 432 - F
 09 Note- 0.012" - Nose Tip Notch
 024
 025
 026 INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
 027 Finish and chip Qualities are indicated by the integer corresponding to
 028 categories entered above. These are followed by the COEFFICIENT and POWER
 029 (used in the tool-life, speed equation) from the data for each test.
 030
 031 ALL of the above values will appear on each line of data entered and be
 032 READ from DO LOOPS structured as follows - -
 033
 034 For each INSERT -
 035 DEPTH 1
 036 Feed 1
 037 Feed 2
 038 ...
 039 Feed n (over the range of feeds input after line 017 above)
 040 DEPTH 2
 041 Feed 1
 042 Feed 2
 043 ...
 044 Feed n
 045
 046 DEPTH m (over the range of depths input after comment line 018)
 047 Feed 1
 048 ...
 049 Skip a line (or put in a comment line) before each INSERT data set.
 050 Next INSERT
 051 DEPTH 1
 052 Feeds
 053 etc.
 054 Skip etc
 055
 056 Enter a zero if no data was taken for a particular DEPTH and FEED.
 057 Begin entries after comment line 023
 058 Put entries in 7 positions of 12 spaces each as shown from 060 to 072.
 060 1 2 3 4 5 6 7

C70 6789012345678901234567890123456789012345678901234567890123456789012345678901234567890

C71 INSERT DEPTH FEED FINISH CHIP COEF- POWER
C72 INDEX INDEX INDEX INDEX INDEX EFFICIENT EXPONENT

C73

This line following comment line C72 is the SKIP line before first INSERT #01.

	#01	1	1	2	2	2.0821	.36
	#01	1	2	4	1	2.1062	.32
	#01	1	2	5	1	2.8270	.20
comment -	All data in this file was taken at ONE depth of cut.						
	#02	1	1	2	2	2.9107	.25
	#02	1	2	4	2	2.8070	.20
	#02	1	2	5	2	2.6755	.24
skip	#02	1	1	4	2	2.0060	.17
	#02	1	2	4	1	2.7776	.22
	#02	1	2	4	1	2.7720	.28
skip	#04	1	1	2	2	2.0000	.22
	#04	1	2	4	2	2.8186	.22
	#04	1	2	4	1	2.8526	.20
skip	#05	1	1	4	2	2.8040	.17
	#05	1	2	4	2	2.8252	.22
	#05	1	2	4	2	2.0174	.22
skip	#06	1	1	2	1	2.8252	.22
	#06	1	2	4	2	2.6627	.19
	#06	1	2	0	0	0.0000	.00
skip	#07	1	1	4	2	2.7640	.15
	#07	1	2	4	1	2.6607	.21
	#07	1	2	0	0	0.0000	.00
skip	#08	1	1	4	1	2.7110	.25
	#08	1	2	2	1	2.6627	.22
	#08	1	2	5	1	2.6075	.18
skip	#09	1	1	2	2	2.2220	.60
	#09	1	2	2	1	2.6427	.15
	#09	1	2	4	2	2.6002	.25

Data File: E_POUNDATA

```

C1      POUNDATA( data file 9 for subroutine POUND called by program SORT )
C2
C3
C4 NOTE : Comment lines in the data file are identified at the left.
C5         The number of comment lines and their placement are fixed by program
C6         SORT. However, the content may be altered or omitted.
C7
C8         INPUT the number of data entries in the order specified
C9         below. These numbers MUST correspond to the number of
C10        entries for each category in this data file.
C11        NSEPTS      NDEPTHs      NFEEDs      NFINISHs      NCHIPS
C12              7              1              11              6              2
C13 INPUT D.O.Cuts ( used in tests to obtain data ) after comment line C11
C14 Enter NDEPTHs numbers in thousandths of an inch from the
C15 smallest INCREASING to the largest.
C16        60
C17 INPUT FEEDs ( used in tests to obtain data ) after comment line C13
C18 Enter NFEEDs numbers in thousandths of an inch from the
C19 smallest INCREASING to the largest.
C20        12      17      20      22
C21 INPUT FINISHes ( obtained from test data ) after comment line C20
C22 Enter NFINISHs numbers in micro-inches RMS from the
C23 smallest INCREASING to the largest.
C24        62      90      125      190      250      320
C25 Enter SURFACE FINISH, corresponding to NFINISHs numbers, how you
C26 would like them to be outputted in the program.
C27 Place each SFINISH on a separate line, starting with the smallest
C28 RMS to the largest RMS. Each SFINISH is allowed 10 characters,
C29 starting in Column 11.
C30        1      2      3
C31 6780012345678901234567890
C32        62
C33        62+
C34        125
C35        125+
C36        250
C37        250+
C38 INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
C39 Enter NCHIPS lines describing chip categories used in data collection.
C40 Enter the BEST first, the WORST last. Begin after comment line C39.
C41 1 - good, all small chips, no curls
C42 2 - fair, 70% small chips, 30% short curls
C43 3 - poor, bird cage, long curls, etc.
C44 INPUT IDENTIFIERS for each insert on separate lines up to 90 spaces wide,
C45 followed by NOTES on test observations on a line up to 90 spaces wide.
C46 Begin input of INSERT IDENTIFIER lines after this comment line C46.
C47 501 tool No. Carbide - S45 - A1 Ox RNMG J13 - J10
C48 01 Note- 0.017" x 0.022" - Gratering, 0.022" - Notching
C49 502 tool No. 50755 - Valenite - V01 - A1 Ox RNMG J13
C50 02 Note- 0.017" x 0.020" - Slight CR Notch, 0.022" - Slight Notch

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503 tool No. Valenite - V05 - Al Ox P/MC #2
 02 Note- 0.017" - Slight BUE
 504 tool No. Greenleaf - G14 - Al Ox P/MC #2
 04 Note- 0.012"-Slt CE Def, 0.017"-Slt BUE & Vibration, 0.020"-Vibration
 505 tool No. 50756 Kennametal - 950 - Multi P/MC #2
 05 Note- 0.017" - Slight Cratering, 0.022" - Cratering
 506 tool No. Sandvik - 415 - Multi P/MC #2
 06 Note- 0.012" & 0.022"-Slt Notch, 0.017"-Slt BUE, 0.020"-Some Vibration
 507 tool No. 50757 VP/Wesson - 680 - Multi P/MC #2
 07 Note- 0.017" & 0.020" - Some Vibration

 C34
 C35
 C36 INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
 C37 Finish and chip Qualities are indicated by the integer corresponding to
 C38 categories entered above. These are followed by the COEFFICIENT and POWER
 C39 (used in the tool-life, speed equation) from the data for each test.
 C40
 C41 ALL of the above values will appear on each line of data entered and be
 C42 READ from DO LOOPS structured as follows - -
 C43
 C44 For each INSERT -
 C45 DEPTH 1
 C46 Feed 1
 C47 Feed 2
 C48 ...
 C49 Feed n (over the range of feeds input after line C17 above)
 C50 DEPTH 2
 C51 Feed 1
 C52 Feed 2
 C53 ...
 C54 Feed n
 C55
 C56 DEPTH m (over the range of depths input after comment line C14)
 C57 Feed 1
 C58 ...
 C59 Skip a line (or put in a comment line) before each INSERT data set.
 C60 Next INSERT
 C61 DEPTH 1
 C62 Feeds
 C63 etc.
 C64 Skip etc
 C65
 C66 Enter a zero if no data was taken for a particular DEPTH and FEED.
 C67 Begin entrys after comment line C72
 C68 Put entrys in 7 positions of 10 spaces each as shown 6 to C70.
 C69 1 2 3 4 5 6 7
 C70 67890123456789012345678901234567890123456789012345678901234567890
 C71 INSERT DEPTH FEED FINISH CHIP COEF- POWER
 C72 INDEX INDEX INDEX INDEX INDEX EFFICIENT EXPONENT
 C73

This line following comment line 672 is the SKIP line before first INSERT 501.

501	1	1	0	0	0.0000	.00
501	1	2	1	2	2.0810	.26
501	1	3	1	2	2.1622	.11
501	1	4	2	1	2.0326	.16
comment -	All data in this file was taken at ONE depth of cut.					
502	1	1	0	0	0.0000	.00
502	1	2	1	2	2.1062	.22
502	1	3	1	2	2.0210	.20
502	1	4	4	2	2.2212	.12
skip						
503	1	1	0	0	0.0000	.00
503	1	2	2	2	2.0022	.21
503	1	3	4	2	2.0022	.21
503	1	4	4	2	2.0110	.22
skip						
504	1	1	1	2	2.1277	.21
504	1	2	2	2	2.0220	.25
504	1	3	2	2	2.0215	.26
504	1	4	2	2	2.0025	.28
skip						
505	1	1	0	0	0.0000	.00
505	1	2	1	2	2.0717	.27
505	1	3	1	2	2.1024	.26
505	1	4	2	1	2.1225	.25
skip						
506	1	1	1	2	2.2272	.52
506	1	2	2	2	2.1120	.22
506	1	3	1	2	2.0502	.21
506	1	4	4	2	2.0326	.21
skip						
507	1	1	0	0	0.0000	.00
507	1	2	2	2	2.0821	.15
507	1	3	4	1	2.0102	.21
507	1	4	2	2	2.2742	.26

C1 TRIDATA(data file 5 for subroutine TRIANGLE called by program SORT)
 C2
 C3
 C4 NOTE : Comment lines in the data file are identified at the left.
 C5 The number of comment lines and their placement are fixed by program
 C6 SORT. However, the content may be altered or omitted.
 C7
 C8 INPUT the number of data entries in the order specified
 C9 below. These numbers MUST correspond to the number of entries
 C10 for each category in this data file.
 C11 NSECTS NDEPTHs NFEEDs NFINISHs NCHIPS
 7 1 2 6 2
 C12 INPUT D.O.Cuts (used in tests to obtain data) after comment line C11
 C13 Enter NDEPTHs numbers in thousandths of an inch from the
 C14 smallest INCREASING to the largest.
 200
 C15 INPUT FEEDs (used in tests to obtain data) after comment line C17
 C16 Enter NFEEDs numbers in thousandths of an inch from the
 C17 smallest INCREASING to the largest.
 20 22 27
 C18 INPUT FINISHes (obtained from test data) after comment line C20
 C19 Enter NFINISHs numbers in micro-inches RMS from the
 C20 smallest INCREASING to the largest.
 190 250 330 375 500 600
 C21 Enter SURFACE FINISH, corresponding to NFINISHs numbers, how you
 C22 would like them to be outputted in the program.
 C23 Place each SFINISH on a separate line, starting the smallest RMS
 C24 to the largest RMS. Each SFINISH is allowed 10 characters,
 C25 starting in Column 11.
 C26 1 2 3
 C27 6789012345678901234567890
 125+
 250
 250+
 250-500
 500
 500+
 C28 INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
 C29 Enter NCHIPS lines describing chip categories used in data collection.
 C30 Enter the BEST first, the WORST last. Begin after comment line C30.
 1 - good, all small chips, no curls
 2 - fair, 70% small chips, 30% short curls
 3 - poor, bird cage, long curls, etc.
 C31 INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
 C32 followed by NOTES or test observations on a line up to 80 spaces wide.
 C33 Begin input of INSERT IDENTIFIER lines after this comment line C33.
 101 tool NO. Carbology 570 - A1 Ox TMM 512 - 85 (1140: 24)
 01 Note- All Feeds - Screeching, 0.022" - Nose Wear, 0.027" - Sparking
 102 tool No. TRW 018 - A1 Ox TMM 513 - E (1140: 24)
 02 Note- 0.027" - Slight Sparking

102 tool No. Valenite V05 - A1 Ox TNM 542 (4140: 24)
 02 Note- 0.012" - Nose Wear, All Feeds - Slight Sparking
 104 tool No. Valenite V05 - A1 Ox TNM 542 - EP (4140: 24)
 04 Note- All Feeds - Screeching & Sparking, 0.022" - Nose Def.
 105 tool No. Kennametal 250 - Multi TNM 542 (4140: 24)
 05 Note- All Feeds - Sparking & Screeching
 106 tool No. 50375 Sandvik 425 - Multi TNM 542 - 71 (4140: 24)
 06 Note- All Feeds - Nose Wear
 107 tool No. Widalox TK15 - Multi TNM 542 - 6 (4140: 24)
 07 Note- 0.020" - Nose Wear, > 0.022" - Screeching & Sparking

C34
 C35
 C36 INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
 C37 Finish and chip Qualities are indicated by the integer corresponding to
 C38 categories entered above. These are followed by the COEFFICIENT and POWER
 C39 (used in the tool-life, speed equation) from the data for each test.
 C40
 C41 ALL of the above values will appear on each line of data entered and be
 C42 READ from DO LOOPS structured as follows - -
 C43
 C44 For each INSERT -
 C45 DEPTH 1
 C46 Feed 1
 C47 Feed 2
 C48 ...
 C49 Feed n (over the range of feeds input after line C17 above)
 C50 DEPTH 2
 C51 Feed 1
 C52 Feed 2
 C53 ...
 C54 Feed n
 C55
 C56 DEPTH m (over the range of depths input after comment line C14)
 C57 Feed 1
 C58 ...
 C59 Skip a line (or put in a comment line) before each INSERT data set.
 C60 Next INSERT
 C61 DEPTH 1
 C62 Feeds
 C63 etc.
 C64 Skip etc.
 C65
 C66 Enter a zero if no data was taken for a particular DEPTH and FEED.
 C67 Begin entries after comment line C72
 C68 Put entries in 7 positions of 10 spaces each as shown from C69 to C73.
 C69 1 2 3 4 5 6 7
 C70 67890123456789012345678901234567890123456789012345678901234567890
 C71 INSERT DEPTH FEED FINISH CHIP COEF- POWER
 C72 INDEX INDEX INDEX INDEX INDEX EFFICIENT EXPONENT
 C73

This line following comment line C73 is the SKIP line before first INSERT 101.

101	1	1	2	2	2.81115	.18
101	1	2	4	2	2.8222	.19
101	1	2	4	2	2.8465	.25
skip						
102	1	1	2	2	2.6962	.07
102	1	2	4	1	2.8480	.24
102	1	2	5	1	2.7012	.12
skip						
103	1	1	4	1	2.8015	.07
103	1	2	4	1	2.8043	.10
103	1	2	5	1	2.6407	.05
skip						
104	1	1	2	2	2.7070	.12
104	1	2	4	2	2.6780	.05
104	1	2	5	1	2.6920	.08
skip						
105	1	1	2	2	2.8616	.19
105	1	2	4	1	2.8205	.19
105	1	2	4	2	2.8000	.22
skip						
106	1	1	2	2	2.7120	.15
106	1	2	4	1	2.6802	.11
106	1	2	5	1	2.6458	.10
skip						
107	1	1	2	1	2.7845	.14
107	1	2	2	1	2.7855	.15
107	1	2	4	1	2.8181	.26

Data File: R_SQUADATA

C1 SQUADATA(data file 6 for subroutine SQUARE called by program SORT)
C2
C3
C4 NOTE : Comment lines in the data file are identified at the left.
C5 The number of comment lines and their placement are fixed by program
C6 SORT. However, the content may be altered or omitted.
C7
C8 INPUT the number of data entries in the order specified
C9 below. These numbers MUST correspond to the number of
C10 entries for each category in this data file.
C11 NSFEEDS NDEPTHs NFEEDs NFINISHs NCHIPS
 1 1 2 6 2
C12 INPUT D.O.Cuts (used in tests to obtain data) after comment line C11
C13 Enter NDEPTHs numbers in thousandths of an inch from the
C14 smallest INCREASING to the largest.
 200
C15 INPUT FEEDs (used in tests to obtain data) after comment line C12
C16 Enter NFEEDs numbers in thousandths of an inch from the
C17 smallest INCREASING to the largest.
 20 23 27
C18 INPUT FINISHes (obtained from test data) after comment line C20
C19 Enter NFINISHs numbers in micro-inches RMS from the
C20 smallest INCREASING to the largest.
 180 250 320 375 500 600
C21 Enter SURFACE FINISH, corresponding to NFINISHs numbers, how you
C22 would like them to be outputted in the program.
C23 Place each SFINISH on a separate line, starting with the smallest
C24 RMS to the largest RMS. Each SFINISH is allowed 10 characters,
C25 starting in Column 11.
C26 1 2 3
C27 6789012345678901234567890
 125+
 250
 250+
 250-500
 500
 500+
C28 INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
C29 Enter NCHIPS lines describing chip categories used in data collection.
C30 Enter the BEST first, the WORST last. Begin after comment line C20.
 1 - good, all small chips, no curls
 2 - fair, 70% small chips, 30% short curls
 3 - poor, bird cage, long curls, etc.
C31 INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
C32 followed by NOTES on test observations on a line up to 80 spaces wide.
C33 Begin input of INSERT IDENTIFIER lines after this comment line C33.
201 tool No. 50026 Sandvik 415 - Multi SNMM 642 - 71 (4140: 24)
01 Note- All Feeds - Sparking, > 0.022" - Nose Rof.
202 tool No. Sandvik 425 - Multi SNMM 642 - 71 (4140: 24)
02 Note-

203 tool No. Seco TP15 - Multi SNMM 643 - 37 (4110: 241)
 03 Note- < 0.023" - End Sparking, 0.027" - Screeching
 204 tool No. Widalon TK15 - Multi SNMM 643 - 6 (4110: 241)
 04 Note-

C34
 C35
 C36 INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
 C37 Finish and chip Qualities are indicated by the integer corresponding to
 C38 categories entered above. These are followed by the COEFFICIENT and POWER
 C39 (used in the tool-life, speed equation) from the data for each test.
 C40
 C41 ALL of the above values will appear on each line of data entered and be
 C42 READ from DO LOOPS structured as follows - -
 C43
 C44 For each INSERT -
 C45 DEPTH 1
 C46 Feed 1
 C47 Feed 2
 C48 ...
 C49 Feed n (over the range of feeds input after line C17 above)
 C50 DEPTH 2
 C51 Feed 1
 C52 Feed 2
 C53 ...
 C54 Feed n
 C55
 C56 DEPTH m (over the range of depths input after comment line C44)
 C57 Feed 1
 C58 ...
 C59 Skip a line (or put in a comment line) before each INSERT data set.
 C60 Next INSERT
 C61 DEPTH 1
 C62 Feeds
 C63 etc.
 C64 Skip etc
 C65
 C66 Enter a zero if no data was taken for a particular DEPTH and FEED.
 C67 Begin entrys after comment line C72
 C68 Put entrys in 7 positions of 10 spaces each as shown from C62 to C72.
 C69 1 2 3 4 5 6 7
 C70 67890123456789012345678901234567890123456789012345678901234567890
 C71 INSERT DEPTH FEED FINISH CHIP COEFF- POWER
 C72 INDEX INDEX INDEX INDEX INDEX FICIENT EXPONENT
 C73
 This line following comment line C73 is the SKIP line before first INSERT 201.
 201 1 1 2 1 2.6218 .00
 201 1 2 2 1 2.7140 .20
 201 1 3 2 1 2.5456 .06
 skip
 202 1 1 4 2 2.6404 .10

	202	1	2	2	1	2.5757	.10
	202	1	2	5	1	2.5025	.12
skip							
	203	1	1	2	2	2.7127	.17
	203	1	2	4	1	2.6150	.00
	203	1	2	4	1	2.6204	.12
skip							
	204	1	1	2	2	2.7451	.00
	204	1	2	4	2	2.8662	.22
	204	1	2	5	1	2.7122	.12

Data File: R_DIA80DATA

C1 DIA80DATA(data file 7 for subroutine C_DIAMOND_80 called by program SORT
C2
C3
C4 NOTE : Comment lines in the data file are identified at the left.
C5 The number of comment lines and their placement are fixed by program
C6 SORT. However, the content may be altered or omitted.
C7
C8 INPUT the number of data entries in the order specified
C9 below. These numbers MUST correspond to the number of
C10 entries for each category in this data file.
C11 NSERTS NDEPths NFEEDS NFINISHS NCHIPS
7 1 3 6 3
C12 INPUT D.O.Cuts (used in tests to obtain data) after comment line C11
C13 Enter NDEPths numbers in thousandths of an inch from the
C14 smallest INCREASING to the largest.
200
C15 INPUT FEEDS (used in tests to obtain data) after comment line C17
C16 Enter NFEEDS numbers in thousandths of an inch from the
C17 smallest INCREASING to the largest.
20 23 27
C18 INPUT FINISHES (obtained from test data) after comment line C20
C19 Enter NFINISHS numbers in micro-inches RMS from the
C20 smallest INCREASING to the largest.
180 250 330 375 500 500
C21 Enter SURFACE FINISH, corresponding to NFINISHS numbers, how you
C22 would like them to be outputted in the program.
C23 Place each SFINISH on a separate line, starting with the smallest
C24 RMS to the largest RMS. Each SFINISH is allowed 10 characters,
C25 starting in Column 11.
C26 1 2 3
C27 6180012345678001234567800
125+
250
250+
250-500
500
500+
C28 INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
C29 Enter NCHIPS lines describing chip categories used in data collection.
C30 Enter the BEST first, the WORST last. Begin after comment line C30.
1 - good, all small chips, no curls
2 - fair, 70% small chips, 30% short curls
3 - poor, bird cage, long curls, etc.
C31 INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
C32 followed by NOTES on test observations on a line up to 80 spaces wide.
C33 Begin input of INSERT IDENTIFIER lines after this comment line C33.
301 tool No. TRW 955 - A1 Ox CNMC 643 - E (4140: 34)

01 Note- 0.020" - Slight Sparking
 302 tool No. 50024 TRW 018 - A1 Ox CNMG 643 - CF1 (4140: 24)
 02 Note- 0.027" - Slight Sparking
 303 tool No. Sandvik 415 - Multi CNMG 643 - 71 (4140: 24)
 03 Note- All Feeds - Slight Sparking
 304 tool No. Sandvik 425 - Multi CNMG 643 - 71 (4140: 24)
 04 Note- 0.023" - Slight Sparking
 305 tool No. Seco TP20 - Multi CNMG 643 (4130: 30)
 05 Note- All Feeds - Slight Sparking, 0.027" - Nose Wear
 306 tool No. Carboloy 560 - Multi CNMG 543 - 68 (4130: 30)
 06 Note- 0.027" - Vibration & Sparking
 307 tool No. Carboloy 560 - Multi CNMG 643 - 68 (4130: 30)
 07 Note- 0.020" - Sparking

C34

C35

C36 INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
 C37 Finish and chip Qualities are indicated by the integer corresponding to
 C38 categories entered above. These are followed by the COEFFICIENT and POWER
 C39 (used in the tool-life, speed equation) from the data for each test.

C40

C41 ALL of the above values will appear on each line of data entered and be
 C42 READ from DO LOOPS structured as follows - -

C43

C44 For each INSERT -

C45 DEPTH 1

C46 Feed 1

C47 Feed 2

C48 ...

C49 Feed n (over the range of feeds input after line C17 above)

C50 DEPTH 2

C51 Feed 1

C52 Feed 2

C53 ...

C54 Feed n

C55

C56 DEPTH m (over the range of depths input after comment line C14)

C57 Feed 1

C58 ...

C59 Skip a line (or put in a comment line) before each INSERT data set.

C60 Next INSERT

C61 DEPTH 1

C62 Feeds

C63 etc.

C64 Skip etc

C65

C66 Enter a zero if no data was taken for a particular DEPTH and FEED.

C67 Begin entries after comment line C72

C68 Put entries in 7 positions of 10 spaces each as shown from C69 to C72.

C69 1 2 3 4 5 6 7
 C70 67890123456789012345678901234567890123456789012345678901234567890

C71 INSERT C72 INDEX C73	DEPTH INDEX	FEED INDEX	FINISH INDEX	CHIP INDEX	COEF- FICIENT	POWER EXPONENT
This line following comment line C73 is the SKIP line before first INSERT 301.						
301	1	1	2	1	2.5681	.14
301	1	2	4	1	2.4871	.03
301	1	3	5	1	2.4898	.18
skip						
302	1	1	2	3	2.7997	.20
302	1	2	4	2	2.7606	.16
302	1	3	5	1	2.6582	.14
skip						
303	1	1	2	2	2.7506	.13
303	1	2	4	1	2.8759	.25
303	1	3	5	1	2.7711	.21
skip						
304	1	1	2	2	2.6445	.21
304	1	2	5	1	2.6045	.12
304	1	3	4	1	2.6493	.27
skip						
305	1	1	4	1	2.9076	.29
305	1	2	5	1	2.6774	.11
305	1	3	5	1	2.6913	.15
skip						
306	1	1	2	1	2.7081	.07
306	1	2	3	1	2.7082	.08
306	1	3	5	1	2.6454	.11
skip						
307	1	1	2	1	2.7171	.04
307	1	2	4	1	2.7016	.08
307	1	3	5	1	2.6777	.09

```

C1   DIA55DATA( data file 8 for subroutine D_DIAMOND_55 called by program SORT )
C2
C3
C4 NOTE : Comment lines in the data file are identified at the left.
C5       The number of comment lines and their placement are fixed by program
C6       SORT. However, the content may be altered or omitted.
C7
C8       INPUT the number of data entries in the order specified
C9       below. These numbers MUST correspond to the number of
C10      entries for each category in this data file.
C11      NSERTS      NDEPTHs      NFEEDS      NFINISHS      NCHIPS
C12      4           1           3           6           3
C12 INPUT D.O.Cuts ( used in tests to obtain data ) after comment line C14
C13 Enter NDEPTHs numbers in thousandths of an inch from the
C14 smallest INCREASING to the largest.
C15      200
C15 INPUT FEEDS ( used in tests to obtain data ) after comment line C17
C16 Enter NFEEDS numbers in thousandths of an inch from the
C17 smallest INCREASING to the largest.
C18      20      23      27
C18 INPUT FINISHes ( obtained from test data ) after comment line C20
C19 Enter NFINISHS numbers in micro-inches RMS from the
C20 smallest INCREASING to the largest.
C21      180      250      330      375      500      600
C21 Enter SURFACE FINISH, corresponding to NFINISHS numbers, how you
C22 would like them to be outputted in the program.
C23 Place each SFINISH on a separate line, starting with the smallest
C24 RMS to the largest RMS. Each SFINISH is allowed 10 characters,
C25 starting in Column 11.
C26      1           2           3
C27 6789012345678901234567890
C28      125+
C29      250
C30      250+
C31      250-500
C32      500
C33      500+
C28 INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
C29 Enter NCHIPS lines describing chip categories used in data collection.
C30 Enter the BEST first, the WORST last. Begin after comment line C30.
C31 1 - good, all small chips, no curls
C32 2 - fair, 70% small chips, 30% short curls
C33 3 - poor, bird cage, long curls, etc.
C31 INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
C32 followed by NOTES on test observations on a line up to 80 spaces wide.
C33 Begin input of INSERT IDENTIFIER lines after this comment line C33.
401 tool No. 50143 Sandvik 415 - Multi DNMG-543 (4130:29/30)
01 Note- All Feeds - Sparking and Some Nose Chipping
402 tool No. Valenite V05 - ALOX DNMG-542 (4130:29/30)
02 Note- All Feeds - Edge and Nose Chipping
403 tool No. Kennametal 950 - Multi DNMG-543 (4130:29/30)
03 Note 0.020"-Spking, 0.023"-Spking/Crater, 0.027"-Spking/Nose Chipping
404 tool No. Carboloy 560 - Multi DNMG-543E-48 (4130:29/30)
04 Note- 0.020"-Nose Wear, 0.023" and 0.027"-Sparking/Nose Chipping

```

C34
 C35
 C36 INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
 C37 Finish and chip Qualities are indicated by the integer corresponding to
 C38 categories entered above. These are followed by the COEFFICIENT and POWER
 C39 (used in the tool-life, speed equation) from the data for each test.
 C40
 C41 ALL of the above values will appear on each line of data entered and be
 C42 READ from DO LOOPS structured as follows - -
 C43
 C44 For each INSERT -
 C45 DEPTH 1
 C46 Feed 1
 C47 Feed 2
 C48 ...
 C49 Feed n (over the range of feeds input after line C17 above)
 C50 DEPTH 2
 C51 Feed 1
 C52 Feed 2
 C53 ...
 C54 Feed n
 C55 ...
 C56 DEPTH m (over the range of depths input after comment line C14)
 C57 Feed 1
 C58 ...
 C59 Skip a line (or put in a comment line) before each INSERT data set.
 C60 Next INSERT
 C61 DEPTH 1
 C62 Feeds
 C63 etc.
 C64 Skip etc
 C65
 C66 Enter a zero if no data was taken for a particular DEPTH and FEED.
 C67 Begin entrys after comment line C73
 C68 Put entrys in 7 positions of 10 spaces each as shown from C69 to C72.
 C69 1 2 3 4 5 6 7
 C70 6789012345678901234567890123456789012345678901234567890123456789
 C71 INSERT: DEPTH : FEED : FINISH : CHIP : COEF- : POWER :
 C72 INDEX : INDEX : INDEX : INDEX : INDEX : FICIENT : EXPONENT:
 C73
 This line following comment line C73 is the SKIP line before first INSERT 401.
 401 1 1 2 2 2.7433 .14
 401 1 2 4 2 2.7579 .15
 401 1 3 3 2 2.6689 .12
 skip
 402 1 1 5 1 2.6047 .08
 402 1 2 5 2 2.6224 .12
 402 1 3 5 2 2.6876 .22
 skip
 403 1 1 4 1 2.9276 .26
 403 1 2 5 1 2.6511 .07
 403 1 3 4 1 2.7067 .13
 skip
 404 1 1 4 1 2.6395 .02
 404 1 2 3 2 2.6430 .07
 404 1 3 5 1 2.6139 .08

Data File: R_ROUDATA

```

C1   ROUDATA( data file 9 for subroutine ROUND called by program SORT )
C2
C3
C4 NOTE : Comment lines in the data file are identified at the left.
C5       The number of comment lines and their placement are fixed by program
C6       SORT. However, the content may be altered or omitted.
C7
C8       INPUT the number of data entries in the order specified
C9       below. These numbers MUST correspond to the number of
C10      entries for each category in this data file.
C11      NSERTS      NDEPTHs      NFEEDs      NFINISHs      NCHIPS
C12      4            1            4            6            3
C13 INPUT D.O.Cuts ( used in tests to obtain data ) after comment line C14
C14 Enter NDEPTHs numbers in thousandths of an inch from the
C15 smallest INCREASING to the largest.
C16      200
C17 INPUT FEEDs ( used in tests to obtain data ) after comment line C17
C18 Enter NFEEDs numbers in thousandths of an inch from the
C19 smallest INCREASING to the largest.
C20      20      23      27      20
C21 INPUT FINISHes ( obtained from test data ) after comment line C20
C22 Enter NFINISHs numbers in micro-inches RMS from the
C23 smallest INCREASING to the largest.
C24      180      250      330      375      500      600
C25 Enter SURFACE FINISH, corresponding to NFINISHs numbers, how you
C26 would like them to be outputted in the program.
C27 Place each SFINISH on a separate line, starting with the smallest
C28 RMS to the largest RMS. Each SFINISH is allowed 10 characters,
C29 starting in Column 11.
C30      1            2            3
C31 6789012345678901234567890
C32      125+
C33      250
C34      250+
C35      250-500
C36      500
C37      500+
C38 INPUT chip Quality DESCRIPTIONS on separate lines up to 50 spaces wide.
C39 Enter NCHIPS lines describing chip categories used in data collection.
C40 Enter the BEST first, the WORST last. Begin after comment line C30.
C41 1 - good, all small chips, no curls
C42 2 - fair, 70% small chips, 30% short curls
C43 3 - poor, bird cage, long curls, etc.
C44 INPUT IDENTIFIERS for each insert on separate lines up to 80 spaces wide,
C45 followed by NOTES on test observations on a line up to 80 spaces wide.
C46 Begin input of INSERT IDENTIFIER lines after this comment line C33.
C47 501 Tool No. 51048 Kennametal 950 - Multi RNMG 64 (4130: 29/30)
C48 01 Note - 0.023' Edge Wear, 0.027' + 0.030' Edge Wear + Sparking
C49 502 Tool No. VR/Wesson 680 - Multi RNMG 64 (4130: 29/30)
C50 02 Note - 0.023' Sparking, 0.027' + 0.030' Edge Wear + Sparking
C51 503 Tool No. 51049 Carboloy 570 - ALOX RNMG 64 - 48 (4130: 29/30)
C52 03 Note-0.023' EdgeWear+Sparking, 0.027' Sparking, .030' EdgeWear+Sparking
C53 504 Tool No. 51050 Valenite V05 - ALOX RNMG 64 (4130: 29/30)
C54 04 Note-0.023' Edge Wear + Sparking, 0.027' + 0.030' Edge Wear + Chipping

```

C34
 C35
 C36 INPUT below FINISH, CHIP, COEFFICIENT, and POWER data from each test run.
 C37 Finish and chip Qualities are indicated by the integer corresponding to
 C38 categories entered above. These are followed by the COEFFICIENT and POWER
 C39 (used in the tool-life, speed equation) from the data for each test.
 C40
 C41 ALL of the above values will appear on each line of data entered and be
 C42 READ from DO LOOPS structured as follows - -
 C43
 C44 For each INSERT -
 C45 DEPTH 1
 C46 Feed 1
 C47 Feed 2
 C48 ...
 C49 Feed n (over the range of feeds input after line C17 above)
 C50 DEPTH 2
 C51 Feed 1
 C52 Feed 2
 C53 ...
 C54 Feed n
 C55 ...
 C56 DEPTH m (over the range of depths input after comment line C14)
 C57 Feed 1
 C58 ...
 C59 Skip a line (or put in a comment line) before each INSERT data set.
 C60 Next INSERT
 C61 DEPTH 1
 C62 Feeds
 C63 etc.
 C64 Skip etc
 C65
 C66 Enter a zero if no data was taken for a particular DEPTH and FEED.
 C67 Begin entrys after comment line C73
 C68 Put entrys in 7 positions of 10 spaces each as shown from C69 to C72.
 C69 1 2 3 4 5 6 7
 C70 6789012345678901234567890123456789012345678901234567890123456789
 C71 INSERT: DEPTH : FEED : FINISH : CHIP : COEF- : POWER :
 C72 INDEX : INDEX : INDEX : INDEX : INDEX : FICIENT : EXPONENT:
 C73
 This line following comment line C73 is the SKIP line before first INSERT 501.
 501 1 1 0 0 0 0
 501 1 2 1 1 3.0161 .26
 501 1 3 4 1 3.0735 .31
 501 1 4 4 1 2.8183 .14
 skip
 502 1 1 0 0 0 0
 502 1 2 1 2 2.0370 .21
 502 1 3 4 1 2.6681 .05
 502 1 4 5 1 2.6751 .05
 skip
 503 1 1 0 0 0 0
 503 1 2 3 2 2.9025 .17
 503 1 3 4 1 2.7513 .07
 503 1 4 5 1 2.7371 .07
 skip
 504 1 1 0 0 0 0
 504 1 2 4 1 2.9249 .17
 504 1 3 5 1 2.7896 .10
 504 1 4 5 1 2.7017 .06

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APPENDIX C
FINISHING SIZE INSERTS

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MANUFACTURER AND GRADE, & T.C. SYSTEM CLASS Al ₂ O ₃ COATED	GEOMETRY	SIZE AND STYLE	FEED = 0.012 INCHES/REV				FEED = 0.017 INCHES/REV				FEED = 0.020 INCHES/REV				FEED = 0.023 INCHES/REV			
			V ₁₀ (SP AT T ₁ = 10°)	CHIPS RMS	IN3/MIN MRR AT T ₁ = 10°	LOG OF INT SLOPE	V ₁₀ (SP AT T ₁ = 10°)	CHIPS RMS	IN3/MIN MRR AT T ₁ = 10°	LOG OF INT SLOPE	V ₁₀ (SP AT T ₁ = 10°)	CHIPS RMS	IN3/MIN MRR AT T ₁ = 10°	LOG OF INT SLOPE	V ₁₀ (SP AT T ₁ = 10°)	CHIPS RMS	IN3/MIN MRR AT T ₁ = 10°	LOG OF INT SLOPE
RW 918, C6, C7	TNMG	432	508	F 125	4.4	2.8574 15	460	G 125	5.6	3.0581 40	411	G 125	6.0	3.1415 34				
	SNMG	432	531	F 125	4.6	3.0221 30	475	F 125	5.8	2.8656 19	438	G 125	6.3	2.8508 21				
	CNMG	432	497	P 125	4.3	2.8948 20	427	F 125	5.2	2.8025 17	369	G 125	5.3	2.8713 26				
CARBOLOY 545, C8	TNMG	432 48	526	P 125	4.5	2.8738 10	492	F 125	6.0	2.8433 10	442	G 125	6.4	2.7711 13				
	SNMM	432 52	690	P 125	6.0	3.2531 41	514	P 125	6.3	2.9439 24	468	P 125	6.7	3.2065 54				
	CNMG	432 48	434	C 63	3.7	2.7609 26	379	P 125	4.6	2.7412 16	314	C 63	4.5	2.6478 15				
	RNMG	43 48					672	F 63	8.2	3.0846 20	564	F 63	8.1	3.0638 41	591	G 125	9.8	2.9328 16
CARBOLOY 570, C6, C7	TNMG	432 26	588	G 125	5.1	3.3484 50	527	G 125	6.5	2.9191 22	476	G 125	6.4	2.8811 24				
	TNMP	432 16	645	G 125	5.6	3.5551 30	551	G 125	6.7	3.1179 31	449	G 125	6.9	3.1041 41				
	TNMP	432 52	682	P 63	5.9	3.4511 17	523	G 125	6.4	2.8911 17	452	F 125	6.5	2.9742 42				
	DNMG	433 48	525	P 125	4.5	3.0811 16	517	G 125	6.3	3.1061 19	420	G 125	6.0	2.8719 21				
CLEVELAND CP1, C7, C8	TNMG	432	612	F 63	5.3	3.1384 15	545	F 125	6.1	2.9441 21	484	G 125	7.0	2.8866 20				
	TNMP	432 41	561	G 125	4.9	2.9818 12	534	G 125	6.5	2.9411 21	458	G 125	6.6	2.8819 22				
	SNMG	432	640	G 63	5.1	3.1111 16	542	G 125	6.6	2.9421 21	493	G 125	7.1	3.1324 32				
	CNMP	432 43	495	C 63	4.2	2.8912 21	415	G 125	5.1	2.9355 31	360	G 125	5.2	2.8116 27				
	CNMG	432	572	F 63	4.9	2.9166 8	475	F 125	5.1	2.8874 28	398	P 125	5.7	2.7732 14				
CARVET CA 7000, C7	TNMG	432E	531	F 125	4.6	3.1101 19	473	F 125	5.8	2.9155 30	440	G 125	6.3	2.7868 12				
	SNMG	432E	598	F 63	5.2	3.1958 42	488	F 125	6.0	2.8194 19	417	G 125	6.0	2.7456 34				
	CNMG	432E	465	P 63	4.0	2.7814 11	377	F 125	4.6	2.7130 14	199	G 125	2.9	2.5401 24				
	DNMG	432E	363	P 63	3.1	2.9101 15	332	F 125	4.1	2.9078 29	270	F 125	3.9	2.6755 24				
SANDVIK GC05, C1	TNMG	432 61	527	G 125	4.6	2.9941 27	437	G 125	5.3	2.8567 22	434	G 125	6.2	2.7851 11				
	CNMG	432 61	443	F 63	3.8	2.8511 21	317	G 125	4.6	2.8691 32	348	G 125	5.0	2.7911 25				
FIRTH-STERLING CC46, C7, C8	TNMG	432	591	P 63	5.1	2.9676 20	527	G 125	6.5	3.0632 34	458	G 125	6.6	2.8981 24				
	SNMG	432	527	F 125	4.6	2.8141 09	515	G 125	6.3	2.9402 23	464	G 125	6.7	2.8191 20				
	CNMG	432	571	P 63	4.9	2.9051 15	419	G 125	5.1	2.9198 30	338	G 125	4.9	2.6719 14				
		43	613	P 125	4.7	2.9048 17	361	G 125	4.4	2.7776 41	311	G 125	4.5	2.7330 28				
VALENTE V01, C7, C8	TNMM	432 EF	448	P 63	3.9	2.7951 14	502	P 125	6.1	2.9111 23	416	P 125	6.3	2.9161 28				
	TNMM	432 EF	520	F 125	4.5	2.9742 20	451	G 125	5.5	2.9001 15	361	G 125	5.2	2.8251 27				
	DNMG	431	524	P 125	4.5	2.8441 17	405	P 125	5.0	2.8251 22	184	F 125	5.5	2.9174 31				
	RNMG	12					650	P 63	8.0	3.1361 29	536	F 63	7.7	3.0239 30	613	F 125	10.5	2.2212 42
VALENTE V05, C5, C7	TNMG	433	608	F 125	5.3	2.9884 20	475	G 125	5.8	2.8454 17	415	G 125	6.0	2.7969 15				
	SNMG	432	541	G 125	4.1	2.9111 8	541	G 125	6.6	2.8821 15	438	G 125	6.3	2.9044 26				
	CNMG	432	498	F 63	3.8	2.8621 16	374	F 125	4.6	2.7398 17	357	F 125	4.0	2.5186 19				
	RNMG	43					620	P 125	7.6	2.9982 20	590	F 125	8.5	2.9249 14	501	F 125	8.3	2.9140 42
VALENTE V05, C7, C8	TNMG	431	611	P 63	5.6	3.1211 17	586	P 125	7.2	3.1111 20	585	P 125	8.4	3.1241 26	515	P 125	8.5	2.9915 28
	CNMG	431	606	F 63	4.0	3.1101 12	379	G 125	4.6	2.8178 14	311	G 125	4.5	2.7181 22				
	TNMG	431	314	P 63	4.2	2.7134 22	384	P 125	4.8	2.7134 29	110	G 125	5.2	2.7121 11				

APPENDIX D
ROUGHING SIZE INSERTS

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MANUFACTURER AND GRADE & "C" SYSTEM CLASS	GEOMETRY	SIZE AND STYLE	FEED = 0.020 INCHES REV				FEED = 0.024 INCHES REV				FEED = 0.027 INCHES REV				FEED = 0.030 INCHES REV			
			V. L. SP. AT F. = 10'	CHIPS RMS	INT. MIN. MRR AT F. = 10'	LOG OF INT. SLOPE	V. L. SP. AT F. = 10'	CHIPS RMS	INT. MIN. MRR AT F. = 10'	LOG OF INT. SLOPE	V. L. SP. AT F. = 10'	CHIPS RMS	INT. MIN. MRR AT F. = 10'	LOG OF INT. SLOPE	V. L. SP. AT F. = 10'	CHIPS RMS	INT. MIN. MRR AT F. = 10'	LOG OF INT. SLOPE
KENNAMETAL 950 C6-C7	TNMM	543	470		22.6	2.8416 0.19	442		24.4	2.8899 0.19	398		25.8	2.8725 0.22				
	DNMG	543	467		22.4	2.8276 0.26	383		21.1	2.8511 0.27	375		24.3	2.8506 0.13				
	RNMG	64					574		31.7	2.9181 0.29	580		37.6	2.9774 0.12	482		34.7	2.8811 0.14
SANDVIK 415 C6-C8	SNMM	643-71	342		16.4	2.8118 0.09	326		18.0	2.7749 0.12	308		20.0	2.7536 0.16				
	CNMM	643-71	420		20.2	2.7506 0.13	427		23.6	2.8559 0.23	362		23.5	2.7711 0.27				
	DNMG	543-15	400		19.2	2.7413 0.14	403		22.2	2.7575 0.15	355		27.0	2.8689 0.12				
SANDVIK 415 C9	TNMM	543-71	366		17.6	2.7720 0.15	372		20.5	2.8611 0.11	284		18.4	2.6458 0.19				
	SNMM	643-71	351		16.8	2.8444 0.10	301		16.6	2.5757 0.10	299		19.4	2.7085 0.12				
	CNMM	643-71	272		13.1	2.8445 0.21	299		16.5	2.8645 0.13	238		15.4	2.6491 0.27				
SECO TP15 C6-C7	SNMM	643-37	352		16.9	2.7521 0.17	336		18.5	2.8159 0.19	315		20.4	2.8304 0.11				
	CNMG	643	416		20.0	2.9076 0.23	373		20.6	2.8774 0.11	352		22.8	2.8911 0.15				
VERMET ON 680 C6-C8	RNMG	64					529		29.2	2.9170 0.21	611		26.6	2.9681 0.15	426		30.7	2.9751 0.05
WIDALON T15 C6-C8	TNMM	543-6	442		21.2	2.7845 0.14	437		24.1	2.7855 0.15	360		23.3	2.7181 0.26				
	SNMM	643-6	452		21.2	2.7851 0.09	433		23.9	2.8661 0.21	383		24.8	2.7720 0.11				
CARBOLY 560 C6-C7	CNMG	543E-68	438		21.0	2.7081 0.17	426		23.5	2.7082 0.28	346		22.4	2.6454 0.11				
	CNMG	643-68	477		22.9	2.7155 0.04	420		23.2	2.7376 0.08	383		24.8	2.8171 0.09				
	DNMG	543E-68	413		19.8	2.6185 0.02	377		20.8	2.6430 0.07	340		22.0	2.6155 0.08				
AL ₂ O ₃ COATED																		
CARBOLY 570 C6-C7	TNMM	543-85	433		20.8	2.8145 0.18	426		23.5	2.8272 0.19	397		25.7	2.8465 0.25				
	RNMG	64-48					538		29.6	2.9625 0.17	477		30.9	2.7571 0.07	458		33.0	2.7771 0.02
TRW 955 C9	CNMG	643E	266		12.7	2.6687 0.14	251		13.9	2.6471 0.14	205		13.3	2.6458 0.18				
	TNMG	543E	424		20.4	2.6961 0.17	405		22.4	2.6469 0.24	370		24.0	2.7011 0.13				
TRW 978 C6-C7	CNMG	643 C31	396		19.2	2.6977 0.14	396		21.9	2.7606 0.14	329		21.3	2.6582 0.14				
	TNMG	543	544		26.1	2.8171 0.14	511		28.2	2.8941 0.14	392		25.4	2.8407 0.05				
VALENTE VUS C5-C7	TNMM	543-71	461		22.1	2.7171 0.14	425		23.5	2.7186 0.25	402		26.1	2.8479 0.08				
	DNMG	542	342		16.4	2.6044 0.14	323		17.7	2.7104 0.12	293		19.0	2.6804 0.22				
	RNMG	64					558		31.8	2.9244 0.14	492		31.9	2.7896 0.10	436		31.4	2.7011 0.04
SANDVIK 50	SNMG	644	237		11.3	2.4883 0.12	229		12.6	2.5422 0.18	209		14.8	2.5787 0.22				
	CONTACT PAGES																	

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APPENDIX E

MACHINING DATA PROGRAM FOR FINISHING/ROUGHING SIZE
COATED CARBIDE CUTTING INSERTS USED IN TURNING OPERATIONS

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TURNING DATA PROGRAM
FOR
FINISHING / ROUTING SIZE
COATED CARBIDE CUTTING INSERTS
USED IN
TURNING OPERATIONS

Revision
Jul, 1986

prepared
by

Materials Science Division
Engineering Directorate
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Rock Island, Illinois 61299-5000

Dr. J. Moriarty
Dr. W. Brewer
M. Crosheck

MACHINING DATA PROGRAM

FOR

FINISHING / ROUGHING SIZE

COATED CARBIDE CUTTING INSERTS

USED IN

TURNING OPERATIONS

HIT RETURN TO CONTINUE

EXPERIMENTAL

EQUIPMENT -- Single point turning using a 30/60 horsepower turret lathe

CUTTING CONDITION -- Dry cutting only with fluid cooled workpiece

WORKPIECE MATERIAL-- AISI 4140 steel, hot rolled tubing for finishing inserts.
Heat treated, Quenched and Tempered to HRC 31 - 33
AISI 4140 & 4130 steel, hot rolled tubing for roughing inserts.
Heat treated, Quenched and Tempered to HRC 32 - 35 and 29/30 res

TOOL MATERIALS -- CVD coated carbide inserts
ALOX : ALOX exterior coating with TiC coat at substrate interface
Multi : TiN exterior coating with ALOX coat intermediate, and TiC or TaC coat at substrate interface

TOOL HOLDERS -- Negative 5 degree back rake and side rake angles with SCEA ranging from + 15 degrees to -3 degrees depending on shape of insert

ENTER RETURN TO CONTINUE

TOOL INSERT SIZE -- IC = 1/2 in. for finishing cut, DOC = 0.060 in.
IC = 5/8 in. or 3/4 in. for roughing cut, DOC = 0.200 in.

TOOL WEAR CRITERIA -- Finishing flank wear limits - 0.010" ave, or 0.020" max.
Roughing flank wear limits - 0.015" ave, or 0.030" max.

MEASURING PROCEDURE -- Tool flank wear was measured at predetermined time intervals (min.) until wear limit was reached

PERFORMANCE -- Tool life (min.) was recorded when the flank wear limit was reached, and the quality of chip control/form were judged and given a good, fair, or poor rating.

Workpiece surface finishes were assigned RMS(micro-inch) values by visual/tactual comparisons using a Std. Ordnance Finishes Set No. 10.

Wear mode patterns and occurrence frequency were recorded per insert, as was the calculation of metal removal rate.

ENTER RETURN TO CONTINUE

Select Size of Insert to be Used:

- 1 Finishing (IC = 1/2 in.)
- 2 Roughing (IC = 5/8 in. OR 3/4 in.)
- E Exit from the Program

①

Select Insert Shape

- 1 triangular
- 2 square
- 3 diamond 80 degree
- 4 diamond 55 degree
- 5 round
- E Exit from the program.

③

Program will search DATA for the 18 DIAMOND(80 DEG) inserts tested.

301	tool No. 50743	TRW -	918 - Al Ox	CNMG	432
302	tool No.	Carboloy -	545 - Al Ox	CNMG	432 - 48
303	tool No. 50741	Cleveland -	CP1 - Al Ox	CNMP	432 - 43
304	tool No.	Cleveland -	CP1 - Al Ox	CNMG	432
305	tool No.	Carbet -	7000 - Al Ox	CNMG	432 - E
306	tool No. 50129	Sandvik -	015 - Al Ox	CNMG	432 - 61
307	tool No. 50742	Firth Sterling	CC46 - Al Ox	CNMG	432
308	tool No.	Valenite -	V05 - Al Ox	CNMG	432
309	tool No.	Newcomer -	NA02 - Al Ox	CNMG	432
310	tool No. 50009	Kennametal -	950 - Multi	CNMS	432
311	tool No.	Seco -	TP10 - Multi	CNMM	432 - 37
312	tool No.	Seco -	TP15 - Multi	CNMM	432 - 37
313	tool No.	Cleveland -	CM3 - Multi	CNMP	432 - 43
314	tool No.	Cleveland -	CM3 - Multi	CNMG	432
315	tool No. 50127	Sandvik -	415 - Multi	CNMG	432 - 15

Enter any key to continue .

316	tool No.	Sandvik -	435 - Multi	CNMG	432 - 61
317	tool No. 50740	VR/Wesson -	680 - Multi	CNMM	432 - E
318	tool No.	Valenite -	VC7 - Uncoated	CNMG	432

Enter any key to continue .

Choose FIRST Priority

F surface Finish

Q chip Quality

F

Priority 1 - surface Finish

Type in surface Finish you must have in
micro-inchs RMS

125

You asked for a 125. micro-inch finish.

Surface Finish data from test results that
are closest to your specification are :

125 micro-inches RMS (compared to 125 RMS)

All results that follow will be based on this value.

Priority 2

Specify lowest chip Quality you can live with.

- 1 - good, all small chips, no curls
- 2 - fair, 70% small chips, 30% short curls
- 3 - poor, bird cage, long curls, etc.

(2)

Only data for which chip Quality equals or exceeds

- 2 - fair, 70% small chips, 30% short curls

will be considered.

Type the Depth Of Cut you want in

thousandths of an inch.

(Finishing - DOC = 0.060" : Roughing - 0.200")

(60)

You asked for a 0.060 inch Depth Of Cut.

The DEPTH for which test results are available
that is closest to your request is

0.060 inch

All results that follow will be based on this value.

Choose Feed OPTION

- 1 User SPECIFIED Feed
- 2 All available Feed DATA that satisfy
surface Finish & chip Quality criteria
will be considered.

①

Feed Option 1 - User Specified Feed

Type the FEED you want in
thousandths of an inch / rev.

①7

You asked for a 0.017 inch / rev. Feed.

The FEED for which test results are available
that is closest to your request is

0.017 inch / rev.

All results that follow will be based on this value.

Choose Tool Life OPTION.

- 1 user specifies Tool Life
- 2 user specifies Length Of Cut
- 3 user specifies Surface Speed
- 4 optimize tool life for Lowest Cost
- 5 optimize tool life for Maximum Output

Note: Results are most reliable in the Tool Life range from
5 to 25 minutes.
Computations are limited to this range.

3

Would you like the Cost(\$) per cubic inch given in the output?
(Y/N)

Y

Type the Diameter Of Workpiece in
inches.

6

Type the Surface Speed you need in
surface feet per minute

500

Type the Time allowed to Change Inserts in
minutes

1

Type apporoximate Cost per Edge for inserts in
dollars / edge

2

Type the Labor plus Overhead rate in
dollars / hour

60

9 Insert - Feed combinations satisfy your specifications.

They will be listed according to their ,
Metal Removal Rates.

The first will have the highest MRR .
decreasing to the last.

Enter any key to see the 1st PAGE of INSERTS.

307	tool No. 50742	Firth Sterling CC46- Al Ox	CNMG	432
310	tool No. 50009	Kennametal - 950 - Multi	CNMG	432
301	tool No. 50743	TRW - 315 - Al Ox	CNMG	432
309	tool No.	Newcomer - NA02 - Al Ox	CNMG	432
312	tool No.	Seco - TP15 - Multi	CNMG	432 - 37
302	tool No.	Carboloy - 545 - Al Ox	CNMG	432 - 48
313	tool No.	Valenite - VC7 - Uncoated	CNMG	432
308	tool No.	Valenite - V05 - Al Ox	CNMG	432
305	tool No.	Carbet - 7000 - Al Ox	CNMG	432 - E

Enter "R" to Return to Option Menu. Enter any other key to continue.
ENTER # OF OPTION WANTED:

- 1 to look at Output of an Individual Insert
- 2 to see All inserts in order of highest MRR
- 3 to see the List of sorted inserts
- 4 to see list of originally inputted parameters
- 5 to see Definitions of terms used in line of NOTES on output
- 6 to Return to Option Menu

2

307 tool No. 50742 Firth Sterling CC46- Al Ox CNMG 432
07 Note- 0.012" - Nose Notch, 0.017" - Slight Notching
Chip Quality = 1 - good, all small chips, no curls

Surf. Finish = 125 micro - inches
Depth of Cut = 0.060 inch
Feed = 0.017 inch / rev.
Tool Life = 5.4 minutes
Surface Speed= 500. surface feet / minute
M. R. Rate = 6.1 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 29. inches
R. P. M. = 318. rev. / minute
Cost = \$ 0.19 per cubic inch

Computations for user specified Depth Of Cut and Feed .

D. O. Cut = 0.060 inch
Feed = 0.017 inch / rev.
M. R. Rate = 6.1 cubic inches / minute
L. O. Cut = 29. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

310 tool No. 50009 Kennametal - 950 - Multi CNMS 432
10 Note- 0.012" - Slight Nose Notch, 0.017" - Slight Sparking
Chip Quality = 2 - fair, 70% small chips, 30% short curls

Surf. Finish = 125 micro - inches
Depth of Cut = 0.060 inch
Feed = 0.017 inch / rev.
Tool Life = 11.7 minutes
Surface Speed= 500. surface feet / minute
M. R. Rate = 6.1 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 63. inches
R. P. M. = 318. rev. / minute
Cost = \$ 0.18 per cubic inch

Computations for user specified Depth Of Cut and Feed .

D. O. Cut = 0.060 inch
Feed = 0.017 inch / rev.
M. R. Rate = 6.1 cubic inches / minute
L. O. Cut = 63. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

301 tool No. 50743 TRW - 918 - Al Ox CNMG 432
01 Note- 0.012" - Notch, 0.017" - Slight Notching
Chip Quality = 2 - fair, 70% small chips, 30% short curls

Surf. Finish = 125 micro - inches
Depth of Cut = 0.060 inch
Feed = 0.017 inch / rev.
Tool Life = 5.0 minutes
Surface Speed= 483. surface feet / minute
M. R. Rate = 5.9 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 26. inches
R. P. M. = 307. rev. / minute
Cost = \$ 0.20 per cubic inch

Computations for user specified Depth Of Cut and Feed .

D. O. Cut = 0.060 inch
Feed = 0.017 inch / rev.
M. R. Rate = 5.9 cubic inches / minute
L. O. Cut = 26. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

309 tool No. Newcomer - NA02 - Al Ox CNMG 432
09 Note- 0.017" - Slight Notch, 0.017" - Nose Wear
Chip Quality = 1 - good, all small chips, no curls

Surf. Finish = 125 micro - inches
Depth of Cut = 0.060 inch
Feed = 0.017 inch / rev.
Tool Life = 5.0 minutes
Surface Speed= 463. surface feet / minute
M. R. Rate = 5.7 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 25. inches
R. P. M. = 298. rev. / minute
Cost = \$ 0.21 per cubic inch

Computations for user specified Depth Of Cut and Feed .

D. O. Cut = 0.060 inch
Feed = 0.017 inch / rev.
M. R. Rate = 5.7 cubic inches / minute
L. O. Cut = 25. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

312 tool No. Seco - TP15 - Multi CNMM 432 - 37
12 Note- 0.017" - CE Cratering & Slight Notch
Chip Quality = 1 - good, all small chips, no curls

Surf. Finish = 125 micro - inches
Depth of Cut = 0.060 inch
Feed = 0.017 inch / rev.
Tool Life = 5.0 minutes
Surface Speed= 447. surface feet / minute
M. R. Rate = 5.5 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 24. inches
R. P. M. = 285. rev. / minute
Cost = \$ 0.22 per cubic inch

Computations for user specified Depth Of Cut and Feed .

D. O. Cut = 0.060 inch
Feed = 0.017 inch / rev.
M. R. Rate = 5.5 cubic inches / minute
L. O. Cut = 24. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

302 tool No. Carboloy - 545 - A1 Ox CNMG 432 - 48
02 Note- 0.017" - Sparking, 0.017" - Slight Cratering
Chip Quality = 1 - good, all small chips, no curls

Surf. Finish = 125 micro - inches
Depth of Cut = 0.060 inch
Feed = 0.017 inch / rev.
Tool Life = 5.0 minutes
Surface Speed= 426. surface feet / minute
M. R. Rate = 5.2 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 23. inches
R. P. M. = 271. rev. / minute
Cost = \$ 0.23 per cubic inch

Computations for user specified Depth Of Cut and Feed .

D. O. Cut = 0.060 inch
Feed = 0.017 inch / rev.
M. R. Rate = 5.2 cubic inches / minute
L. O. Cut = 23. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

318 tool No. Valenite - VC7 - Uncoated CNGG - 432
18 Note - 0.012" - Slight Sparking
Chip Quality = 2 - fair, 70% small chips, 30% short curls

Surf. Finish = 125 micro - inches
Depth of Cut = 0.060 inch
Feed = 0.017 inch / rev.
Tool Life = 5.0 minutes
Surface Speed = 422. surface feet / minute
M. R. Rate = 5.2 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 23. inches
R. P. M. = 269. rev. / minute
Cost = \$ 0.23 per cubic inch

Computations for user specified Depth Of Cut and Feed .

D. O. Cut = 0.060 inch
Feed = 0.017 inch / rev.
M. R. Rate = 5.2 cubic inches / minute
L. O. Cut = 23. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

308 tool No. Valenite - V05 - Al Ox CNMG 432
08 Note- 0.012" - Slight Notch, 0.017" - Slight Sparking
Chip Quality = 2 - fair, 70% small chips, 30% short curls

Surf. Finish = 125 micro - inches
Depth of Cut = 0.060 inch
Feed = 0.017 inch / rev.
Tool Life = 5.0 minutes
Surface Speed = 418. surface feet / minute
M. R. Rate = 5.1 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 23. inches
R. P. M. = 266. rev. / minute
Cost = \$ 0.24 per cubic inch

Computations for user specified Depth Of Cut and Feed .

D. O. Cut = 0.060 inch
Feed = 0.017 inch / rev.
M. R. Rate = 5.1 cubic inches / minute
L. O. Cut = 23. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

305 tool No. Carmet - 7000 - A1 Ox CNMG 432 - E
05 Note- 0.017" - Slight Sparking
Chip Quality = 2 - fair, 70% small chips, 30% short curls

Surf. Finish = 125 micro - inches
Depth of Cut = 0.060 inch
Feed = 0.017 inch / rev.
Tool Life = 5.0 minutes
Surface Speed = 416. surface feet / minute
M. R. Rate = 5.1 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 23. inches
R. P. M. = 265. rev. / minute
Cost = \$ 0.24 per cubic inch

Computations for user specified Depth Of Cut and Feed .

D. O. Cut = 0.060 inch
Feed = 0.017 inch / rev.
M. R. Rate = 5.1 cubic inches / minute
L. O. Cut = 23. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

Re-enter program at Options for :

- 1 Shape of Insert (the beginning)
- 2 Finish and Chip priority
- 3 Feed
- 4 Tool Life / Length of Cut
- 5 Repeat of Results

Exit enter any other key

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MACHINING DATA PROGRAM

FOR

FINISHING / ROUGHING SIZE

COATED CARBIDE CUTTING INSERTS

USED IN

TURNING OPERATIONS

HIT RETURN TO CONTINUE

EXPERIMENTAL

EQUIPMENT -- Single point turning using a 30/60 horsepower turret lathe

CUTTING CONDITION -- Dry cutting only with fluid cooled workpiece

WORKPIECE MATERIAL-- AISI 4140 steel, hot rolled tubing for finishing inserts.
Heat treated, Quenched and Tempered to HRC 31 - 33
AISI 4140 & 4130 steel, hot rolled tubing for roughing inserts.
Heat treated, Quenched and Tempered to HRC 32 - 35 and 29/30 res

TOOL MATERIALS -- CVD coated carbide inserts
ALOX : ALOX exterior coating with TiC coat at substrate
interface
Multi : TiN exterior coating with ALOX coat intermediate,
and TiC or TaC coat at substrate interface

TOOL HOLDERS -- Negative 5 degree back rake and side rake angles with SCEA
ranging from + 15 degrees to -3 degrees depending on
shape of insert

ENTER RETURN TO CONTINUE

TOOL INSERT SIZE -- IC = 1/2 in. for finishing cut, DOC = 0.060 in.
IC = 5/8 in. or 3/4 in. for roughing cut, DOC = 0.200 in.

TOOL WEAR CRITERIA -- Finishing flank wear limits - 0.010" ave, or 0.020" max.
Roughing flank wear limits - 0.015" ave, or 0.030" max.

MEASURING PROCEDURE -- Tool flank wear was measured at predetermined time intervals (min.) until wear limit was reached

PERFORMANCE -- Tool life (min.) was recorded when the flank wear limit was reached, and the quality of chip control/form were judged and given a good, fair, or poor rating.

Workpiece surface finishes were assigned RMS(micro-inch) values by visual/tactual comparisons using a Std. Ordnance Finishes Set No. 10.

Wear mode patterns and occurrence frequency were recorded per insert, as was the calculation of metal removal rate.

ENTER $\frac{1}{4}$ RETURN $\frac{1}{2}$ TO CONTINUE

Select Size of Insert to be Used:

- 1 Finishing (IC = 1/2 in.)
- 2 Roughing (IC = 5/8 in. OR 3/4 in.)
- E Exit from the Program

2

Select Insert Shape

- 1 triangular
- 2 square
- 3 diamond 80 degree
- 4 diamond 55 degree
- 5 round
- E Exit from the program.

2

Program will search DATA for the 5 SQUARE inserts tested.

201	tool No. 50086	Sandvik 415 - Multi	SNMM	643 - 71	(4140: 34)
202	tool No.	Sandvik 435 - Multi	SNMM	643 - 71	(4140: 34)
203	tool No. 51046	Seco TP15 - Multi	SNMM	643 - 37	(4140: 34)
204	tool No.	Widalon TK15 - Multi	SNMM	643 - 6	(4140: 34)
205	tool No. 50082	Sandvik S6 - Uncoat	SNMG	644	(4140: 34)

Enter any key to continue .

Choose FIRST Priority

F surface Finish

Q chip Quality

F

Priority 1 - surface Finish

Type in surface Finish you must have in
micro-inchs RMS

500

You asked for a 500. micro-inch finish.

Surface Finish data from test results that
are closest to your specification are :

500 micro-inches RMS (compared to 500 RMS)

All results that follow will be based on this value.

Priority 2

Specify lowest chip Quality you can live with.

- 1 - good, all small chips, no curls
- 2 - fair, 70% small chips, 30% short curls
- 3 - poor, bird cage, long curls, etc.

2

Only data for which chip Quality equals or exceeds

2 - fair, 70% small chips, 30% short curls

will be considered.

Type the Depth Of Cut you want in

thousandths of an inch.

(Finishing - DOC = 0.060" : Roughing - 0.200")

200

You asked for a 0.200 inch Depth Of Cut.

The DEPTH for which test results are available
that is closest to your request is

0.200 inch

All results that follow will be based on this value.

Choose Feed OPTION

- 1 User SPECIFIED Feed
- 2 All available Feed DATA that satisfy
surface Finish & chip Quality criteria
will be considered.

1

Feed Option 1 - User Specified Feed

Type the FEED you want in
thousandths of an inch / rev.

23

You asked for a 0.023 inch / rev. Feed.

The FEED for which test results are available
that is closest to your request is

0.023 inch / rev.

All results that follow will be based on this value.

Choose Tool Life OPTION.

- 1 user specifies Tool Life
- 2 user specifies Length Of Cut
- 3 user specifies Surface Speed
- 4 optimize tool life for Lowest Cost
- 5 optimize tool life for Maximum Output

Note: Results are most reliable in the Tool Life range from
5 to 25 minutes.

Computations are limited to this range.

3

Would you like the Cost(\$) per cubic inch given in the output?
(Y/N)

Y

Type the Diameter Of Workpiece in
inches.

6

Type the Surface Speed you need in
surface feet per minute

400

Type the Time allowed to Change Inserts in
minutes

1

Type apporoximate Cost per Edge for inserts in
dollars / edge

2

Type the Labor plus Overhead rate in
dollars / hour

60

5 Insert - Feed combinations satisfy your specifications.

They will be listed according to their ,
Metal Removal Rates.

The first will have the highest MRR .
decreasing to the last.

Enter any key to see the 1st PAGE of INSERTS.

204	tool No.	Widalon TK15 - Multi	SNMM	643 - 6	(4140: 34)
201	tool No. 50086	Sandvik 415 - Multi	SNMM	643 - 71	(4140: 34)
203	tool No. 51046	Seco TP15 - Multi	SNMM	643 - 37	(4140: 34)
202	tool No.	Sandvik 435 - Multi	SNMM	643 - 71	(4140: 34)
205	tool No. 50082	Sandvik 36 - Uncoat	SNMG	644	(4140: 34)

Enter "R" to Return to Option Menu. Enter any other key to continue.

ENTER # OF OPTION WANTED:

- 1 to look at Output of an Individual Insert
- 2 to see All inserts in order of highest MRR
- 3 to see the List of sorted inserts
- 4 to see list of originally Inputted parameters
- 5 to see Definitions of terms used in line of NOTES on output
- 6 to Return to Option Menu

2

204 tool No. Widalon TK15 - Multi SNMM 643 - 6 (4140: 34)

04 Note-

Chip Quality = 2 - fair, 70% small chips, 30% short curls

Surf. Finish = 250-500 micro - inches
Depth of Cut = 0.200 inch
Feed = 0.023 inch / rev.
Tool Life = 14.1 minutes
Surface Speed = 400. surface feet / minute
M. R. Rate = 22.1 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 83. inches
R. P. M. = 255. rev. / minute
Cost = \$ 0.05 per cubic inch

Computations for user specified Depth Of Cut and Feed .

D. O. Cut = 0.200 inch
Feed = 0.023 inch / rev.
M. R. Rate = 22.1 cubic inches / minute
L. O. Cut = 83. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

201 tool No. 50086 Sandvik 415 - Multi SNMM 643 - 71 (4140: 34)

01 Note- All Feeds - Sparking, > 0.023" - Nose Def.

Chip Quality = 1 - good, all small chips, no curls

Surf. Finish = 250 micro - inches
Depth of Cut = 0.200 inch
Feed = 0.023 inch / rev.
Tool Life = 5.0 minutes
Surface Speed = 376. surface feet / minute
M. R. Rate = 20.8 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 28. inches
R. P. M. = 239. rev. / minute
Cost = \$ 0.06 per cubic inch

Computations for user specified Depth Of Cut and Feed .

D. O. Cut = 0.200 inch
Feed = 0.023 inch / rev.
M. R. Rate = 20.8 cubic inches / minute
L. O. Cut = 28. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

203 tool No. 51046 Seco TP15 - Multi SNMM 643 - 37 (4140: 34)
03 Note- < 0.023" - End Sparking, 0.027" - Screeching
Chip Quality = 1 - good, all small chips, no curls

Surf. Finish = 250-500 micro - inches
Depth of Cut = 0.200 inch
Feed = 0.023 inch / rev.
Tool Life = 5.0 minutes
Surface Speed= 357. surface feet / minute
M. R. Rate = 19.7 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 26. inches
R. P. M. = 227. rev. / minute
Cost = \$ 0.06 per cubic inch

Computations for user specified Depth Of Cut and Feed .

D. O. Cut = 0.200 inch
Feed = 0.023 inch / rev.
M. R. Rate = 19.7 cubic inches / minute
L. O. Cut = 26. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

202 tool No. Sandvik 435 - Multi SNMM 643 - 71 (4140: 34)
02 Note-
Chip Quality = 1 - good, all small chips, no curls

Surf. Finish = 250+ micro - inches
Depth of Cut = 0.200 inch
Feed = 0.023 inch / rev.
Tool Life = 5.0 minutes
Surface Speed= 320. surface feet / minute
M. R. Rate = 17.7 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 23. inches
R. P. M. = 204. rev. / minute
Cost = \$ 0.07 per cubic inch

Computations for user specified Depth Of Cut and Feed .

D. O. Cut = 0.200 inch
Feed = 0.023 inch / rev.
M. R. Rate = 17.7 cubic inches / minute
L. O. Cut = 23. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

205 tool No. 50082 Sandvik S6 - Uncoat SNMG 644 (4140: 34)
05 Note- 0.020" + 0.023" -Sparking/Screeching, 0.027" -Cratering
Chip Quality = 1 - good, all small chips, no curls

Surf. Finish = 250+ micro - inches
Depth of Cut = 0.200 inch
Feed = 0.023 inch / rev.
Tool Life = 5.0 minutes
Surface Speed = 261. surface feet / minute
M. R. Rate = 14.4 cubic inches / minute
D. O. Workpc = 6.0 inches
L. O. Cut = 19. inches
R. P. M. = 166. rev. / minute
Cost = \$ 0.08 per cubic inch

Computations for user specified Depth Of Cut and Feed .

D. O. Cut = 0.200 inch
Feed = 0.023 inch / rev.
M. R. Rate = 14.4 cubic inches / minute
L. O. Cut = 19. inches

Enter "R" to Return to Option Menu. Enter any other key to continue.

Re-enter program at Options for :

- 1 Shape of Insert (the beginning)
- 2 Finish and Chip priority
- 3 Feed
- 4 Tool Life / Length of Cut
- 5 Repeat of Results

Exit enter any other key

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AD	Accession No.	UNCLASSIFIED	AD	Accession No.	UNCLASSIFIED
Commander, Rock Island Arsenal ATTN: SMCRI-SE Rock Island, IL 61299-5000 APPLICATION OF HIGH RATE CUTTING TOOLS John L. Moriarty, Jr. Report SE 89-03, 141 p. incl. illus. tables, (AMS Code 3297 06 8243) Unclassified Report.		1. Cutting Tools 2. Carbide Tools 3. Machinability 4. Turning 5. Machine Shop Practice 6. High Rate Metal Removal 7. Coated Carbide Inserts 8. Tool Life DISTRIBUTION Copies Available from DTIC	Commander, Rock Island Arsenal ATTN: SMCRI-SE Rock Island, IL 61299-5000 APPLICATION OF HIGH RATE CUTTING TOOLS John L. Moriarty, Jr. Report SE 89-03, 141 p. incl. illus. tables, (AMS Code 3297 06 8248) Unclassified Report.		1. Cutting Tools 2. Carbide Tools 3. Machinability 4. Turning 5. Machine Shop Practice 6. High Rate Metal Removal 7. Coated Carbide Inserts 8. Tool Life DISTRIBUTION Copies Available from DTIC
Widespread application of the newest high-rate cutting tools to the most appropriate jobs is slowed by the sheer magnitude of developments in tool types, materials, workpiece applications, and by the rapid pace of change. Therefore, a study of finishing and roughing sizes of coated carbide inserts having a variety of geometries for single point turning was completed. The cutting tools were tested for tool life, chip quality, and workpiece surface finish at various cutting conditions with medium alloy steel. An empirical wear-life data base was established, and a computer program was developed to facilitate technology transfer, assist selection of carbide insert grades, and provide machine operating parameters. A follow-on test program was implemented, suitable for next generation coated carbides, rotary cutting tools, cutting fluids, and ceramic tool materials. Computer program algorithms were used to quantify comparisons among different manufacturer's tools. Benefits realized are a selective and reduced tool inventory, increased productivity, improved part quality, and more extended, accelerated application of new tooling.			Widespread application of the newest high-rate cutting tools to the most appropriate jobs is slowed by the sheer magnitude of developments in tool types, materials, workpiece applications, and by the rapid pace of change. Therefore, a study of finishing and roughing sizes of coated carbide inserts having a variety of geometries for single point turning was completed. The cutting tools were tested for tool life, chip quality, and workpiece surface finish at various cutting conditions with medium alloy steel. An empirical wear-life data base was established, and a computer program was developed to facilitate technology transfer, assist selection of carbide insert grades, and provide machine operating parameters. A follow-on test program was implemented, suitable for next generation coated carbides, rotary cutting tools, cutting fluids, and ceramic tool materials. Computer program algorithms were used to quantify comparisons among different manufacturer's tools. Benefits realized are a selective and reduced tool inventory, increased productivity, improved part quality, and more extended, accelerated application of new tooling.		