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CONTRACTOR REPORT ARLCD-CR-81019

ULTRA-HIGH SURFACE SPEED FOR METAL REMOVAL, ARTILLERY SHELL

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US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
LARGE CALIBER
WEAPON SYSTEMS LABORATORY
DOVER, NEW JERSEY

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Four types of steel (AISI 1340, 4140, 4340, and HF-1) which are commonly used in large caliber projectile manufacture were machined with five types of tools at different hardness ranges representing the as-forged and the heat-treated condition. Results show that machining speeds can be increased significantly over current practice using the present available tooling.

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SUMMARY

Using a special dynamometer lathe as the basic tool, Jones & Lamson Research engineers have documented data for the use of high surface cutting speeds to good advantage. Improvements, as compared to data presently published in the Machining Data Handbook, 3rd Edition, range as high as 400% dependent upon workpiece material and cutting tool material.

Four different grades of work-piece materials were tested, using five different grades of cutting tools.

Three of the projectile materials were tested at three different hardness ranges, and the fourth was tested at two hardness levels.

A total of over 800 different cutting conditions and parameters were studied. Tool life lines, tool load, speeds, feeds, depth of cut, cutting tool materials and geometry were thoroughly analyzed.

The results point towards further study in terms of optimum machine design characteristics and horsepower requirements.

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TABLES

FIGURES

INTRODUCTION

The purpose of this effort is to demonstrate the feasibility of ultra-high surface speed for metal removal in turning operations. The end goal being criteria necessary to improve the productivity of the turning operations required in the manufacture of artillery shells.

The dynamometer lathe, initially designed by Jones & Lamson to study high velocity turning techniques, serves as the basic tool for this work.

Other equipment used by Jones & Lamson Metal Turning Research Engineers during this project include: Recording equipment, tachometer, toolmaker's microscope, profilometer and a Bausch and Lomb Model ILS Metallograph.

Aside from finding the optimum methods for machining this type of product, it is also desirable to identify the new machine parameters that will be necessary to take full advantage of this work in improving manufacturing methods and technology.

EXPERIMENTAL PROCEDURE

THE PROCESS

The work-pieces are chucked in the dynamometer lathe and the end of the work-piece supported by a live-center. The surface speed, in feet per minute, of the uncut diameter, is adjusted by using a hand-held tachometer. The feed rate is set in inches per revolution.

A cut of the proper depth, .100" for "rough" and .050" for "finish ", is taken until the feed load reaches a pre-determined amount of increase of at least 50% of the sharp tool load at start of cut. The cut is then stopped. The wear land, of the cutting tool insert, is measured by use of a toolmaker's microscope, and the results are recorded.

The wear-land is that area on the clearance face and nose radius where chemical and mechanical removal of some of the cutting tool material has taken place.

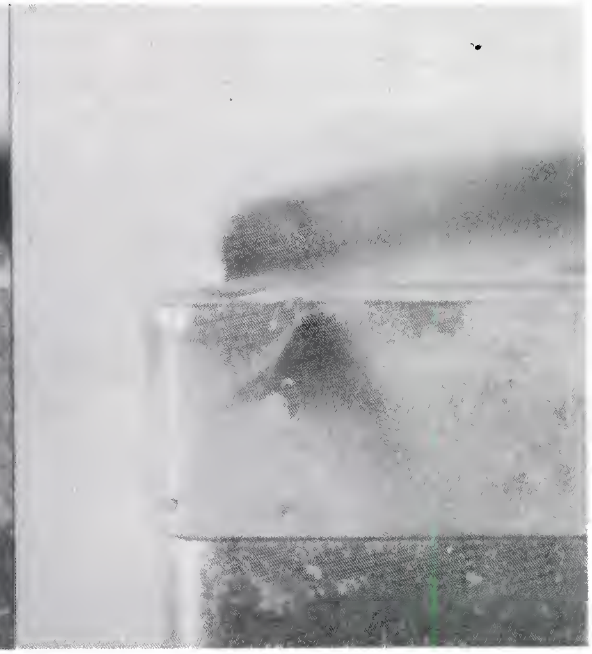
The diameter of the turned portion and the length of cut are measured. The circumference is then calculated, and multiplied by the length of the turn in inches which provided a value of square inches of machined surface. This value becomes a point on log-log paper of square inches of machined surface versus surface speed in feet per minute. A new surface speed is used for finding another value of square inches of machined surface. When the second point is plotted, the slope of the line is estimated and a third point will confirm the slope and location of the line. This line is the tool-life line.

This process is repeated at various feedrates, so the optimum feedrate can be determined. The optimum feedrate is found by using the combination of surface speed and feedrate which gives the highest production index for a predetermined amount of tool wear.

The production index is obtained by finding the largest product of surface speed in feet per minute and feedrate in inches per revolution. The production index is a number that is used for comparing one set of cutting conditions to another, on the same operation and is directly proportional to the metal removal rate. The surface speed used is

SAMPLE WEARLANDS

Carboloy 350



Kennametal KC-810

Carboloy 570

Babcox & Wilcox - G-10

determined from the life-line plots by using 2,500 square inches of machined surface as the reference tool-life. The economic factors for tool life may change for various operations in different plants. However, for purposes of this effort, 2,500 square inches was used as the reference for comparative purposes.

For comparison purposes, feed-rates were held to a maximum of .033 inches per revolution for all materials. Some materials exhibit feed-sensitivity at high feed rates which may result in lower production indexes.

Once the optimum feedrate was determined, the life-line for each type of carbide tooling was found. The same procedure was used to determine the optimum parameters for ceramic tools. The highest feed used in testing the ceramic inserts was .022 inches per revolution. Past experience with ceramic inserts indicated, that excessively high tool loads are encountered at high feed rates. While determining the tool loads, insert breakage was experienced at these high feed rates and was also experienced at increased depths of cut.

When the tool loads were recorded, the work-piece surface speed was extrapolated by using the reference tool-life of 2,500 square inches of machined surface, and the feed used was that which gave the highest production index. Various depths of cut were taken, and the tangential, feed, and radial tool loads were recorded. When conducting tests to find tool loads, only sharp tools were used, and the inserts were inspected for any chips or nicks before being used.

While conducting the tests, some poor chip conditions were encountered when lower feed-rates were tested. These conditions are noted on the data sheets when they occurred. In general, chip conditions were acceptable during roughing cuts and should not present problems. During finish cut tests, some problems with chip control were encountered, expecially with the higher hardness materials.

WORK-PIECE MATERIALS

The project was conducted with work-piece material of four (4) types of steel: HF-1 and AISI 4140, AISI 4340 and AISI 1340. The AISI 4140 and AISI 4340 materials were purchased as 6" diameter bars, which were cut to suitable length for machining. The AISI 1340 and HF-1 materials were not commercially available in small quantities, so projectile forgings of these materials were used. The AISI 1340 material had been hot-forged for heavy-wall M-483 projectile metal parts and the HF-1 was hot-forged for XM-795 projectile metal parts. The certified copies of the chemical analysis of AISI 1340, AISI 4140, AISI 4340 and HF-1 may be found in the documentation for these materials. See Figures 14 to 17 pages 23 to 26.

The bars and the projectile bodies were heat-treated to the following hardnesses to simulate the "rough" and "finish" machining conditions of projectile bodies. See Table 1, page 5. Two hardness conditions were considered for finish machining.

Material	**"Rough" Machining**	**"Finish" Machining**	
AISI -1340	21 Rc	28 Rc	35/37 Rc
AISI - 4140	33/35 Rc	28/30 Rc	47/50 Rc
AISI - 4340	35/38 Rc	33 Rc	49/50 Rc
HF-1	28/29 Rc	42 Rc	---

For "rough" machining tests, the projectile bodies were checked for hardness using a King Brinell Hardness Tester, and machined with no heat-treatment. The hardness was taken for each projectile body and recorded as the projectiles were used. For "finish" machining tests, all materials were heat-treated to the proper hardness.

Material Conditions and Specifications used in Projectile Manufacturing.

MATERIAL	AISI - 1340	AISI -4140	AISI -4340	HFI
Hardness -				
"Rough" Machining	25 Rc	30 Rc	36 Rc	30 Rc
"Finish" Machining				
1st Condition	29 Rc	33 Rc	31 Rc	38 Rc
2nd Condition	38/40 Rc	42/44 Rc	48/50 Rc	—
Surface Finish -				
"Finish" Cuts	125 A.A.	125 A.A.	125 A.A.	125 A.A.
Depth of Cut -				
"Rough"	.100	.100	.100	.100
'Finish"	.050	.050	.050	.050

NOTE:
The "Roughing" Cut is open tolerance-part not finished to size - merely to remove material object is "true" the part and hold concentricity.

The "Finish" Cut is done to establish size and maintain surface finish.

A.A.- Arithmetic Average

TABLE 1 - MATERIAL CONDITIONS

The metallographic preparations of the eleven samples for microscopic examination were done using standard metallographic methods. Sections were cut using a water-cooled abrasive cut-off wheel, then mounted in bakelite (phenolic powder). These samples were ground with 240, 320, 400, and 600 grit silicon carbide papers, then polished with 0.3 micron alpha alumina powder on a microcloth lap. All samples were etched with a 3% Nital solution and photographed at 100X and 1,000X magnification using Polaroid Type 55 Film on a Reichert Metallographic Microscope.

The 6" diameter bars (AISI - 4140 and AISI - 4340) were checked for hardness prior to machining and as the diameter was reduced by approximately one inch, the hardness was checked again. This was repeated until the hardness had dropped to an unacceptable level.

When using ceramic inserts, the end of the work-piece was chamfered with a 45^{o} lead angle tool to reduce the shock of entry for the ceramic tool. This was done in all cases and helped to alleviate the tool breakage, although some breakage still occurred. The hot-press (G-10) ceramic was the grade being used when unexplained breakage would occur. Because of these inconsistencies, the data for cold-press (G-30) ceramic was used for production indexes, as shown in the data sheets.

CUTTING TOOL MATERIALS

The five (5) cutting tool materials tested were tungsten carbide, titanium coated tungsten carbide, ceramic ($AL_2 0_3$) coated tungsten carbide, hot pressed cermet ($AL_2 0_3$ +TIC) and cold pressed pure ceramic (99.75% $AL_2 0_3$) inserts. Figure 1 page 7, is a designation sheet explaining the symbols used for inserts.

The tungsten carbide was Carboloy Grade 350, which has been in use for over twenty years. The titanium coated tungsten carbide was Kennametal KC-810, a multi-coated general purpose steel cutting grade. The ceramic coated tungsten carbide was Carboloy 570.

DESIGNATION SYMBOLS FOR THROW—AWAY INSERT NUMBERS

	1	2	3	4	5	6	7	8	9	10
CARBIDE	T	N	M	G	4	3	3			
CERAMIC	C	N	G		4	5	4	A	.008	20

1 SHAPE

R-Round
S-Square
T-Triangle
P-Pentagon
D-Diamond 55°
O-Octagon
C-Diamond 80°
H-Hexagon
L-Rectangle
B-Parallelogram 82°
M-Diamond 86°
A-Parallelogram 85°
E-Parallelogram 55°
F-Parallelogram 70°
V-Parallelogram 35°

2 CLEARANCE

N-0°
A-3°
B-5°
C-7°
P-10°
D-15°
E-20°
F-25°
G-30°

3 CLASS

Cutting Point	Thickness
A = ±.0002	±.001
B = ±.0002	±.005
C = ±.0005	±.001
D = ±.0005	±.005
E = ±.001	±.001
G = ±.001	±.005
**M = ±.002 ±.004	±.005
**U = ±.005 ±.012	±.005
R = Blank with grind stock on all surfaces	±.005
S = Blank with grind stock on top and bottom surfaces only.	±.005

4 TYPE

A-With hole
B-With hole and one countersink
C-With hole and two countersinks
D-Smaller than 1/4" I.C. with hole
E-Smaller than 1/4" I.C. without hole
F-Clamp-on type with chipbreaker
G-With hole and chipbreaker
H-With hole, one countersink and chipbreaker
J-With hole, two countersinks and chipbreaker
K-Smaller than 1/4" I.C. with hole and chipbreaker
L-Smaller than 1/4" I.C. without hole with chipbreaker

5 SIZE

Number of 1/32nds on inserts less than 1/4" I.C.
Number of 1/8ths on inserts 1/4" I.C. and over.
Rectangle and Parallelogram Inserts require two digits
1st Digit - Number of 1/8ths in width
2nd Digit - Number of 1/4ths in length

6 THICKNESS

Number of 1/32nds on inserts less than 1/4" I.C.
Number of 1/16ths on inserts 1/4" I.C. and over.
Use width dimension in place of I.C. on Rectangle and Parallelogram inserts.

7 CUTTING POINT

Radius or Flats

0-Sharp corner
1-1/64 Radius
2-1/32 Radius
3-3/64 Radius
4-1/16 Radius
6-3/32 Radius
8-1/8 Radius

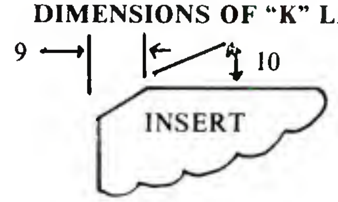
8 OTHER CONDITIONS

A-Ground all over-light honed
B-Ground all over-heavy honed
C-Ground top and bottom only-light honed
D-Ground top and bottom only-heavy honed
E-Unground Insert-honed
F-Unground Insert-not honed

9 WIDTH OF CHAMFER IN INCHES

10 ANGLE OF CHAMFER IN DEGREES

DIMENSIONS OF "K" LAND



*Shall be used only when required.
**Exact tolerance is determined by size of insert.

Figure 1:

The hot press cermet, G10, (black ceramic) and cold press ceramic, G-30, (white ceramic) were from Babcock and Wilcox, Rochester, Michigan. These particular grades were selected because of the extensive experience in their application.

The tool holders used for these tests had zero degree lead angles; that is, the cutting edge is 90^{o} to the centerline of the work-piece. This condition is a standard procedure for tool testing. (See Figure 2 on page 8).

When testing the carbide grades, plain and coated, only one side of the insert was used. The heat from the cutting process travels through the insert, so the opposite side may give erratic results. For machining these materials, the thickness of the insert will be an important consideration.

OBSERVATIONS OF METALLOGRAPHIC SPECIMENS

Of the eleven workpiece samples taken for metallographic examinations, six were processed at Dartmouth College - Thayer School of Engineering and five were processed at Jones and Lamson with the following results.

General Observations

1.) Samples labeled R or Rough (those used for rough turning operations) have a coarse structure indicating little or no heat treatment.

2.) Samples labeled F (those used for finish turning operations) have been heat treated.

3.) The heat treated samples, those used for finish turning, show a finer more homogeneous structure.

Specific Observations

AISI-1340 -Rough turn condition: (21Rc) This material shows grains of ferrite (white) and pearlite (dark) with some ferrite at the previous austenite grain boundaries. (See Figure 3, page 12.)

Finish turn condition: (Rc 28) Photomicrograph shows a fine dispersion of ferrite and either pearlite or bainite. Even at high magnification it is not possible to distinguish between fine pearlite and bainite. See Figure 4, page 13.

Finish turn condition: (Rc 38) This photomicrograph displays a structure typical of a tempered martensite. See Figure 5, page 14.

AISI-4140-Rough turn condition: (33/35 Rc) The structure of this material is coarse grained, with ferrite and bainite present. The material is not martensitic. Hardness should be approximately 30 Rc. See Figure 6, page 15.

Finish turn condition: (Rc 28/30) A fine grained microstructure dominates this photomicrograph. This is evidence of subsequent heat treatment from the rough condition. See Figure 7, page 16.

Finish turn condition: (Rc 42/44) This material exhibits a structure typical of a tempered martensite. See Figure 8, page 17.

AISI-4340-Rough turn condition: (35/38 Rc) The microstructure of this material is very similar to that of AISI 4140. The grain size is large, and ferrite and bainite are present. See Figure 9, page 18.

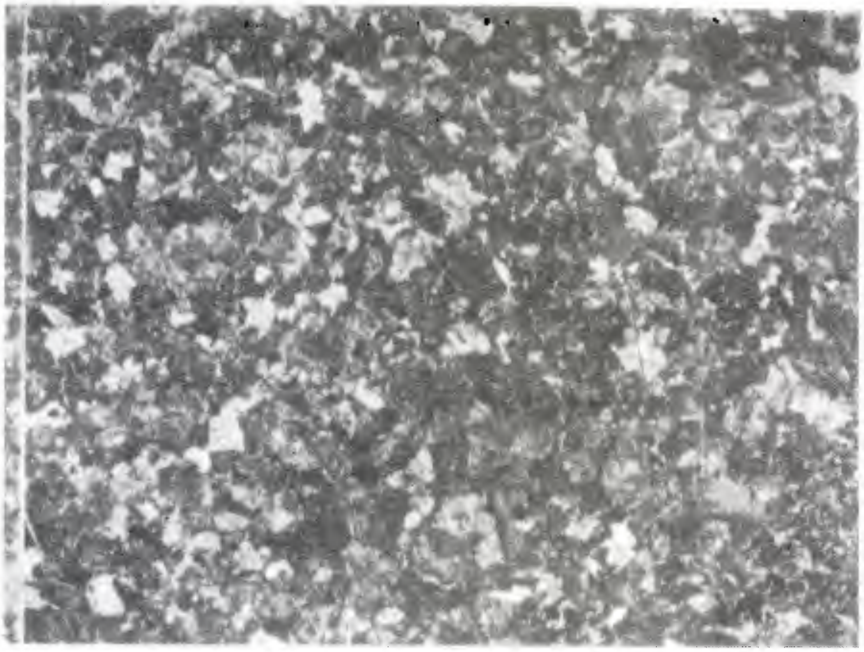
Finish turn condition: (Rc 33) This material is also similar to its AISI 4140 counterpart. The microstructure is fine-grained, and there is evidence of heat-treatment between the rough and finish materials. See Figure 10, page 19.

Finish turn condition: (Rc 48/50) The finish turn condition exhibits a tempered martensitic structure with a moderate degree of banding evident. See Figure 11, page 20.

HF-1-Rough turn condition: (28/29 Rc) A predominatly pearlitic microstructure is evident. See Figure 12, page 21.

Finish turn condition: (Rc 42) There is an abundance of alloy metal carbides precipitated through the material. These are the small white spots in the 1000X photomicrograph. The matrix is composed of fine pearlite or bainite. See Figure 13, page 22.

Metallographic Sample
AISI-1340 - "Rough" - 20/22 Rc



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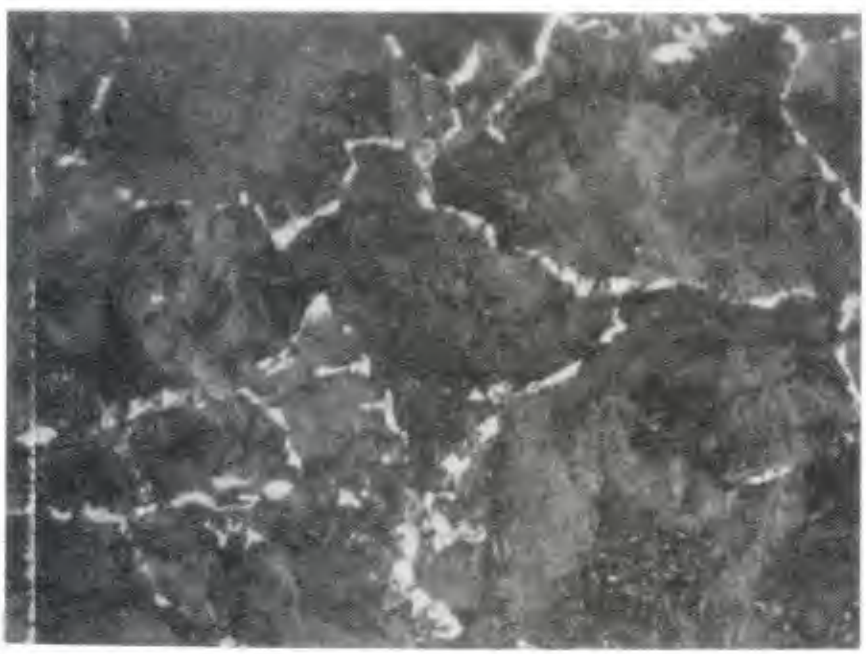

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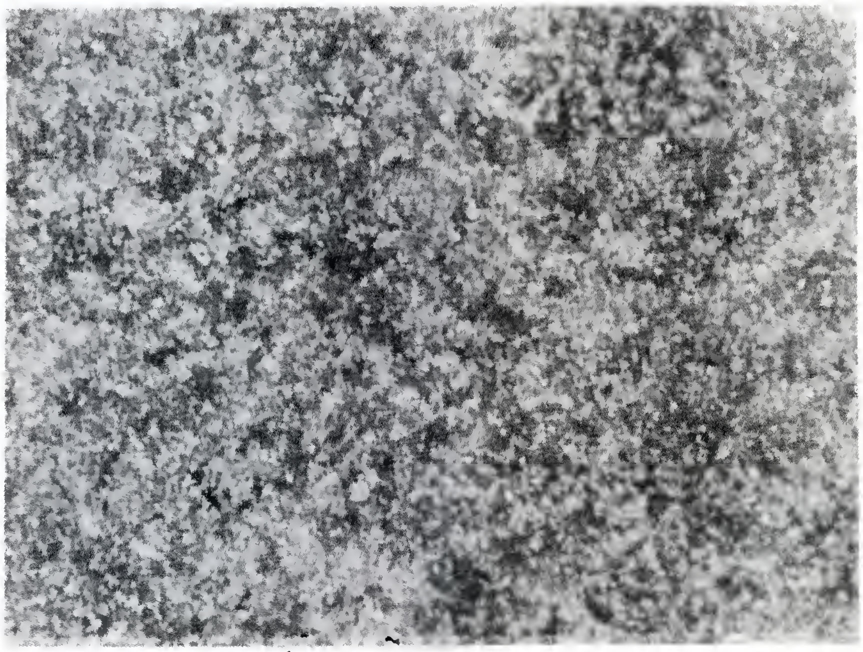
Figure 3

Metallographic Sample
AISI-1340 - "Finish" - 28 Rc



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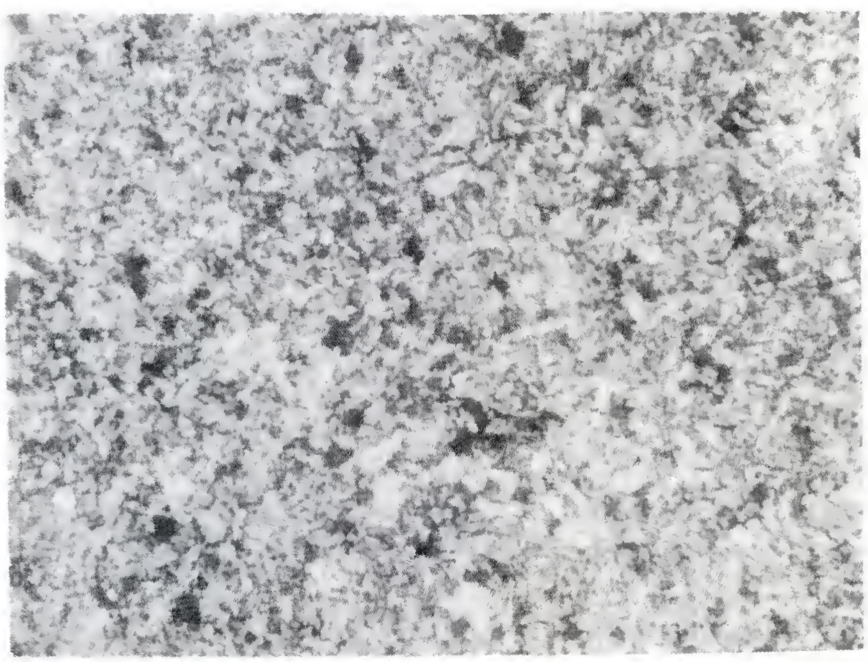

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Figure 4

Metallographic Sample
AISI-1340 - "Finish" - 38/40 Rc

100X

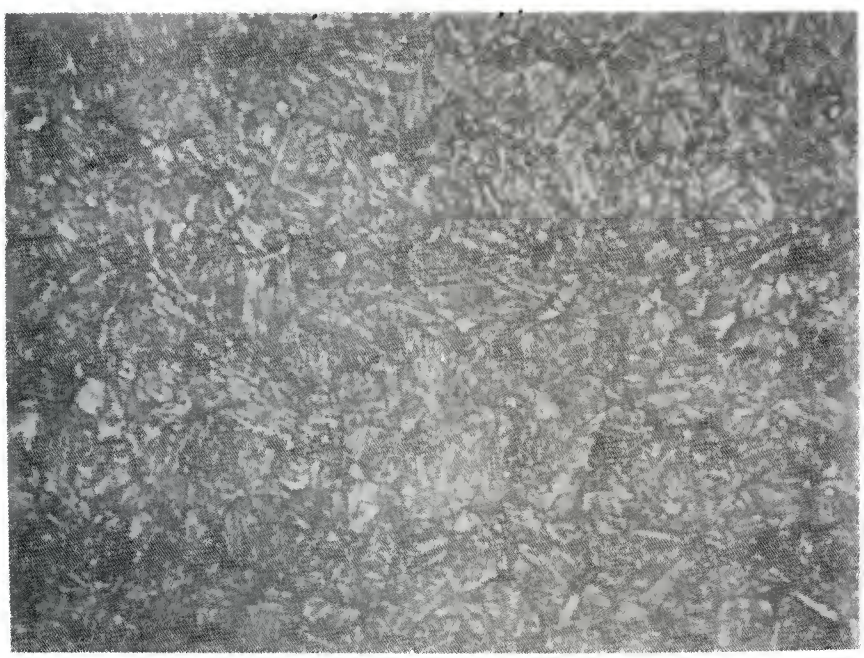

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Figure 5

Metallographic Sample
AISI-4140 - "Rough" - 33/34 Rc

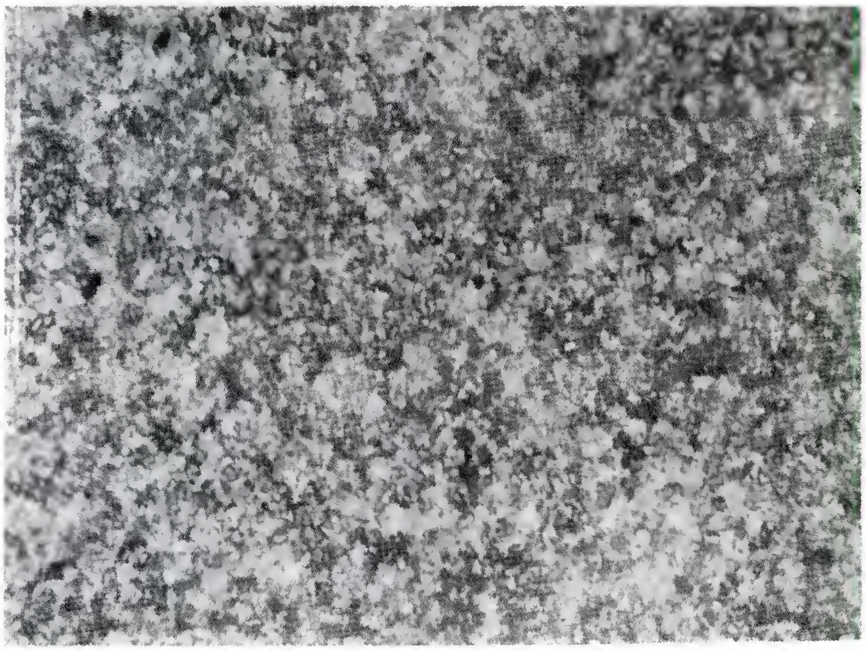

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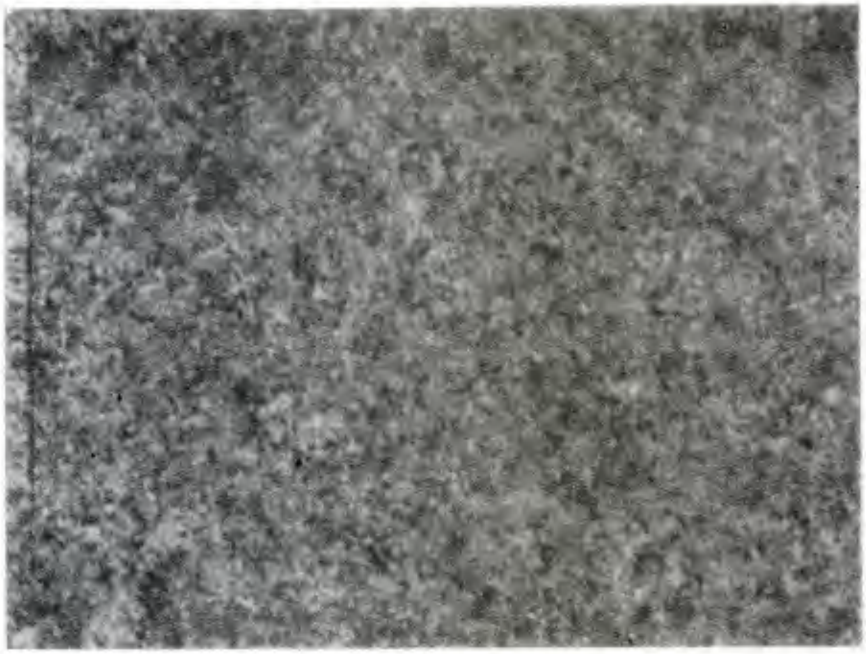
Figure 6

Metallographic Sample
AISI-4140 - "Finish" - 27/30 Rc



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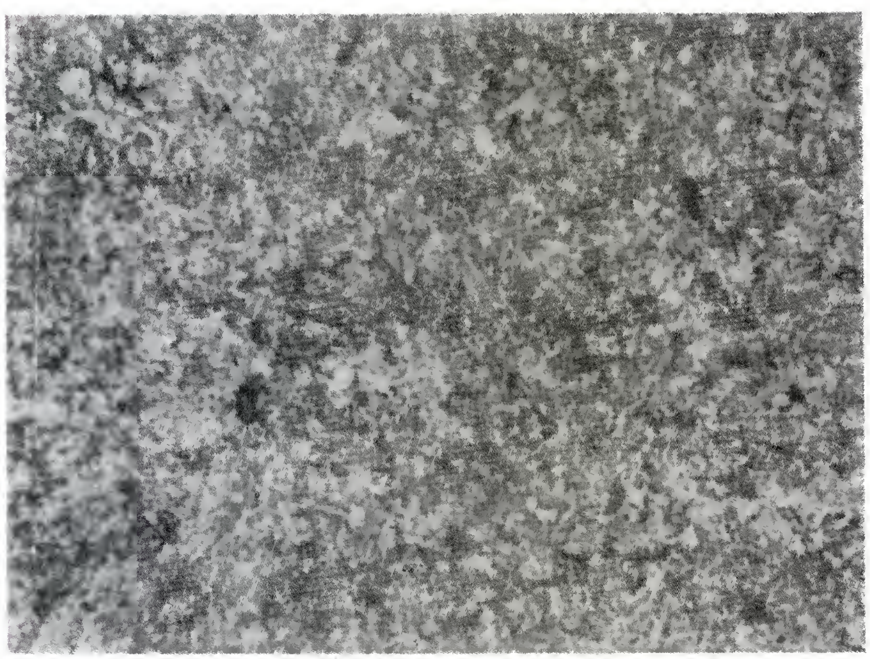

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Figure 7

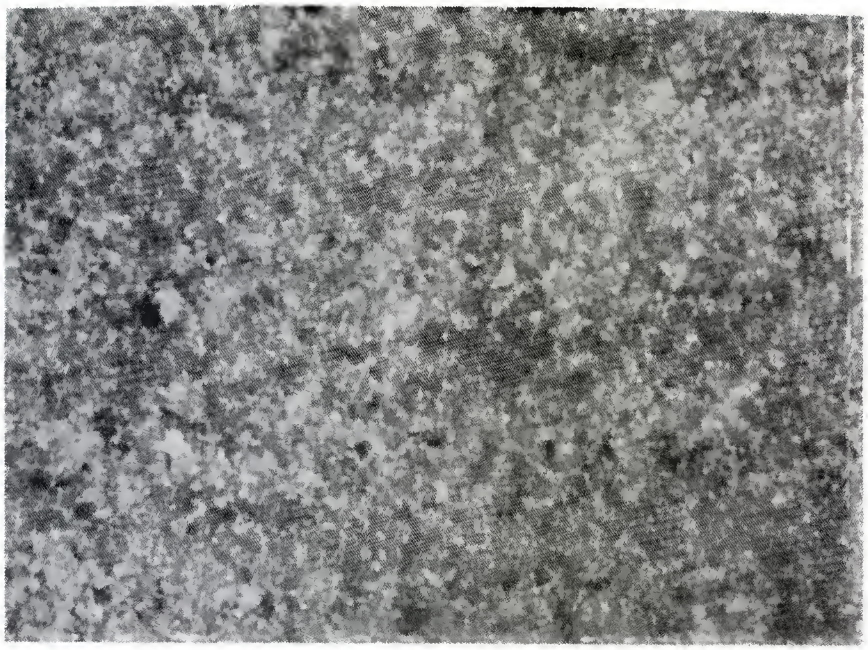
Metallographic Sample
AISI-4140 - "Finish" - 42/44 Rc

100X

1000X

Figure 8

Metallographic Sample
AISI-4340 - "Rough" - 36/39 Rc



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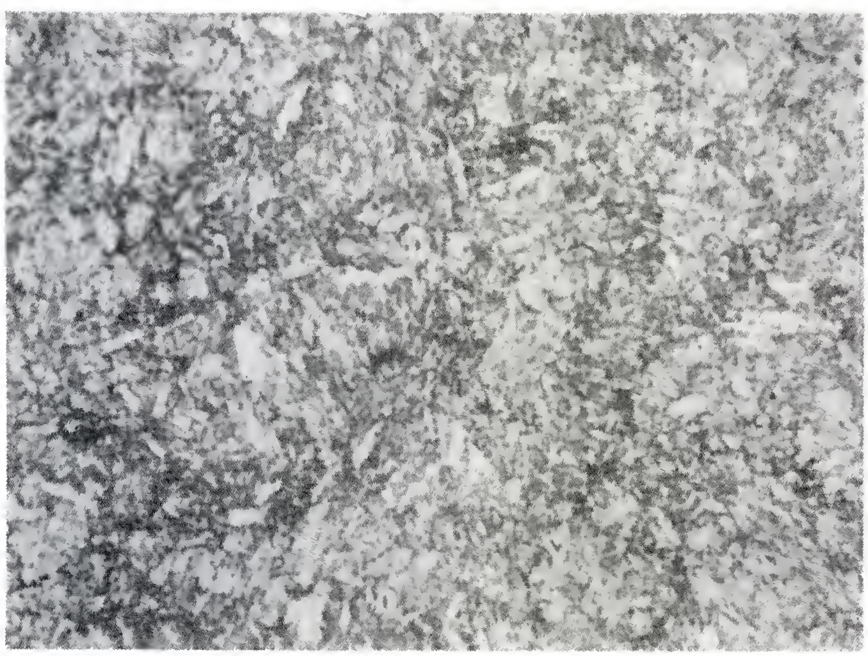

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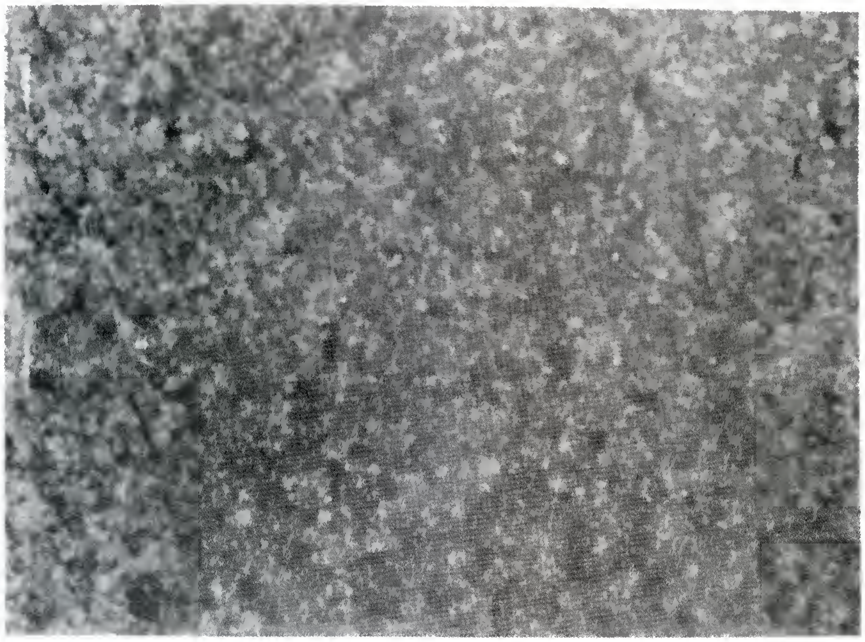
Figure 9

Metallographic Sample
AISI-4340 - "Finish" - 33 Rc



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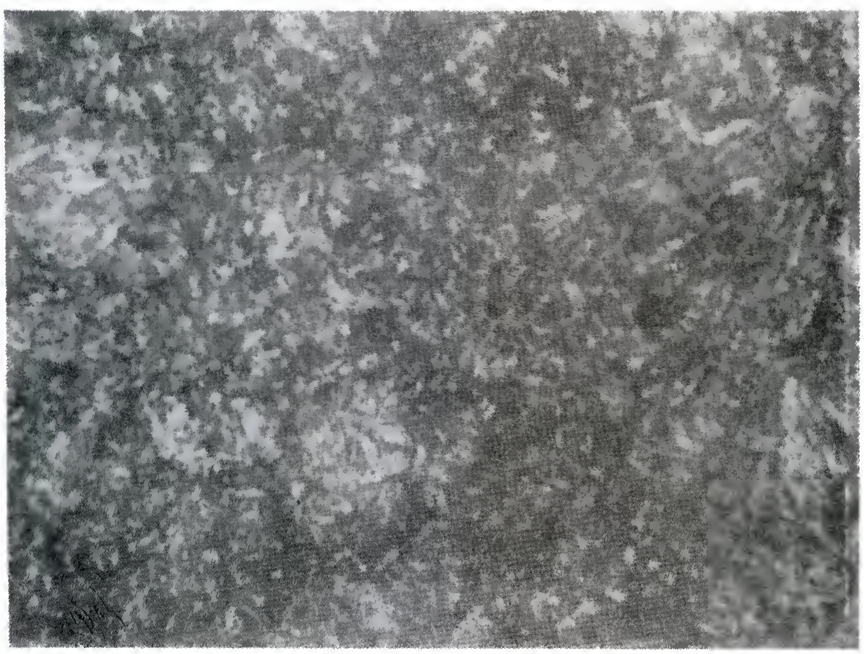

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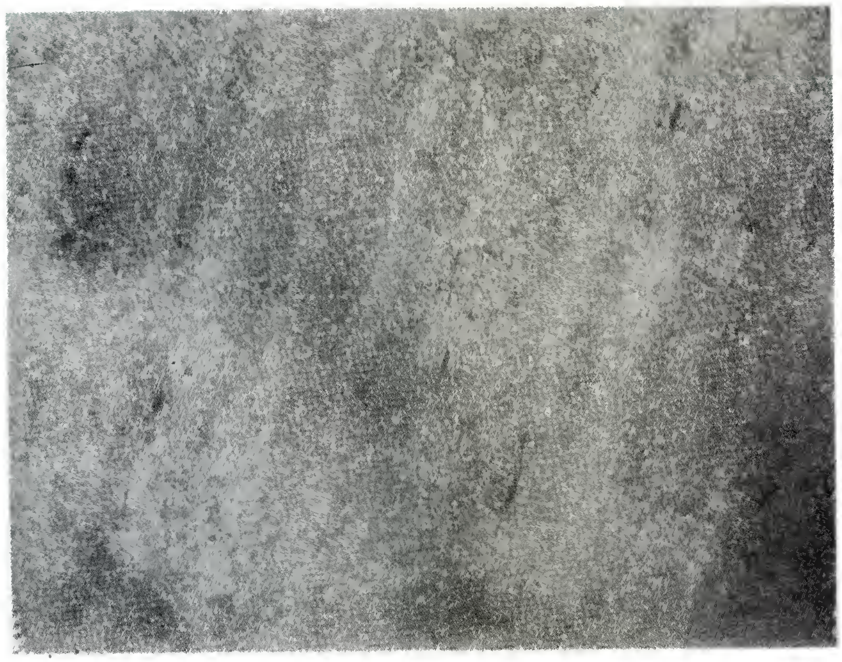
Figure 10

Metallographic Sample
AISI-4340 - "Finish" - 48/50 Rc



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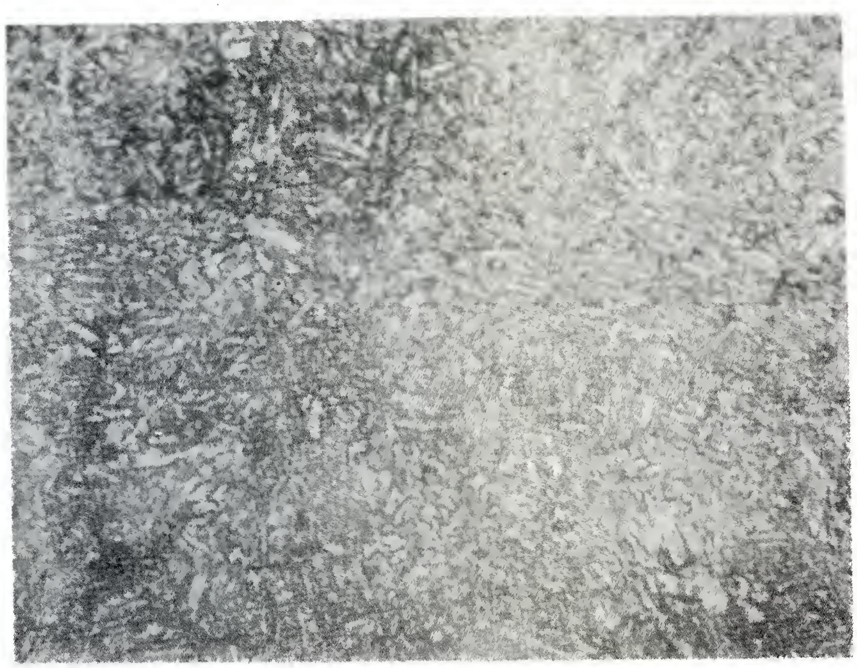

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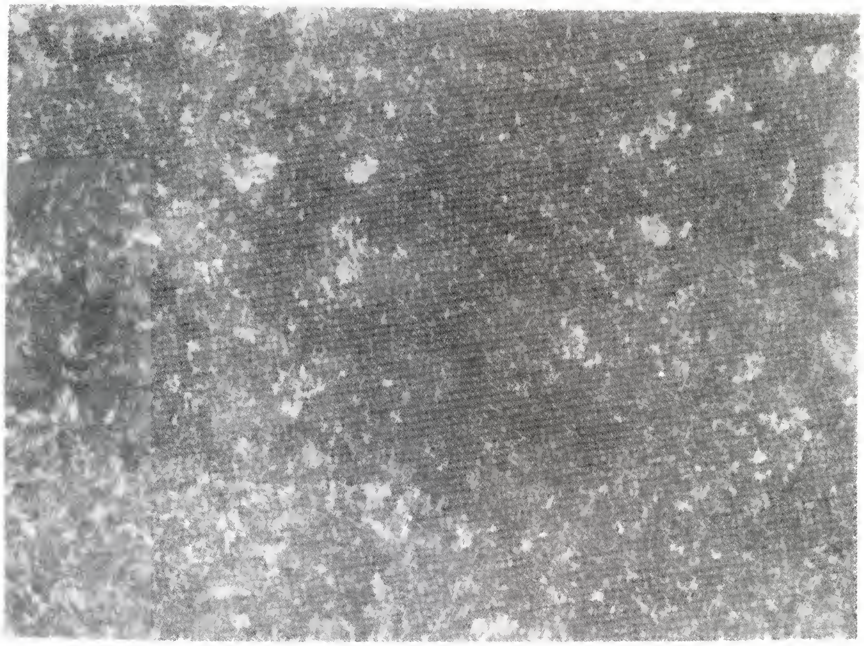
Figure 11

Metallographic Sample
HF-1 - "Rough" - 28/31 Rc



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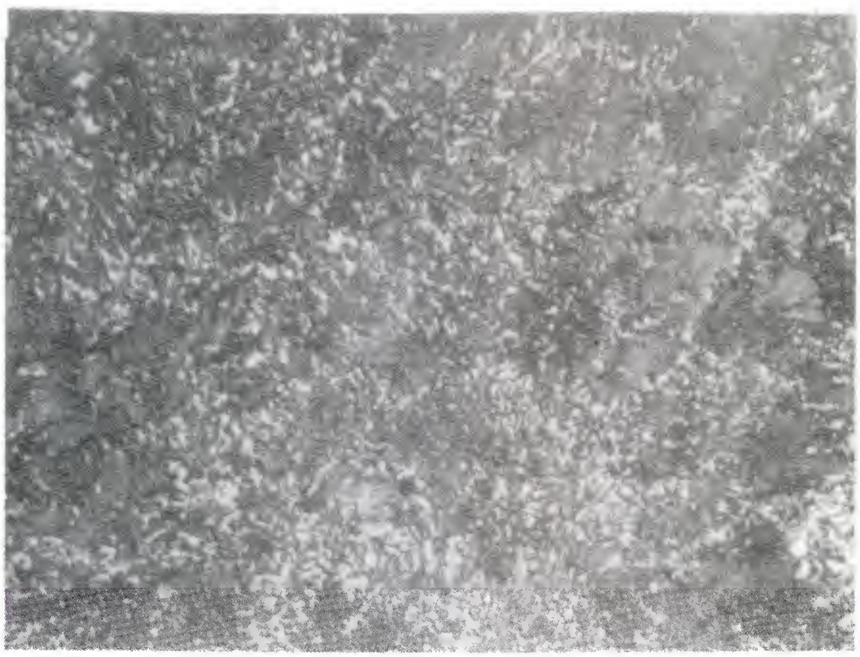
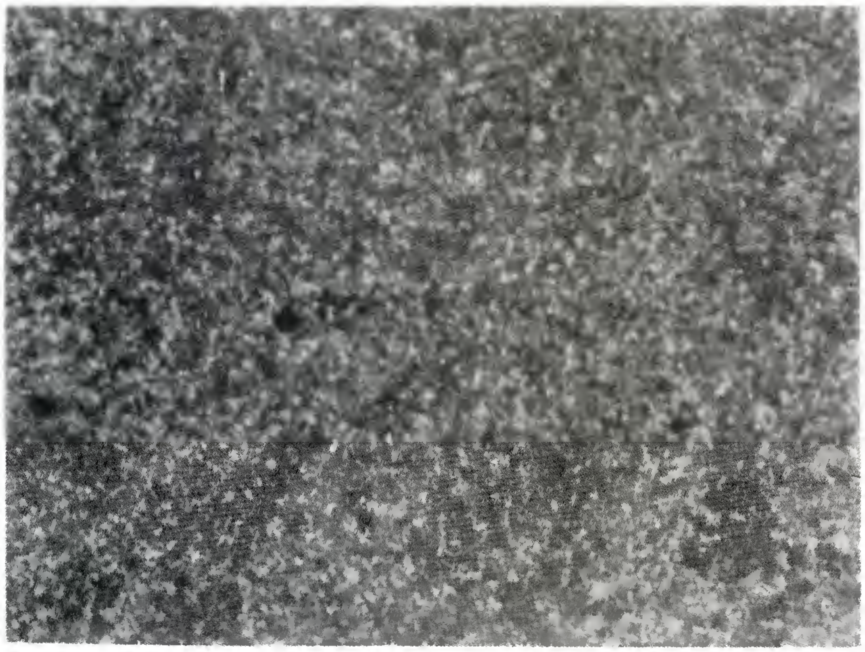


1000X

Figure 12

Metallographic Sample
HF-1 - "Finish" - 41 Rc



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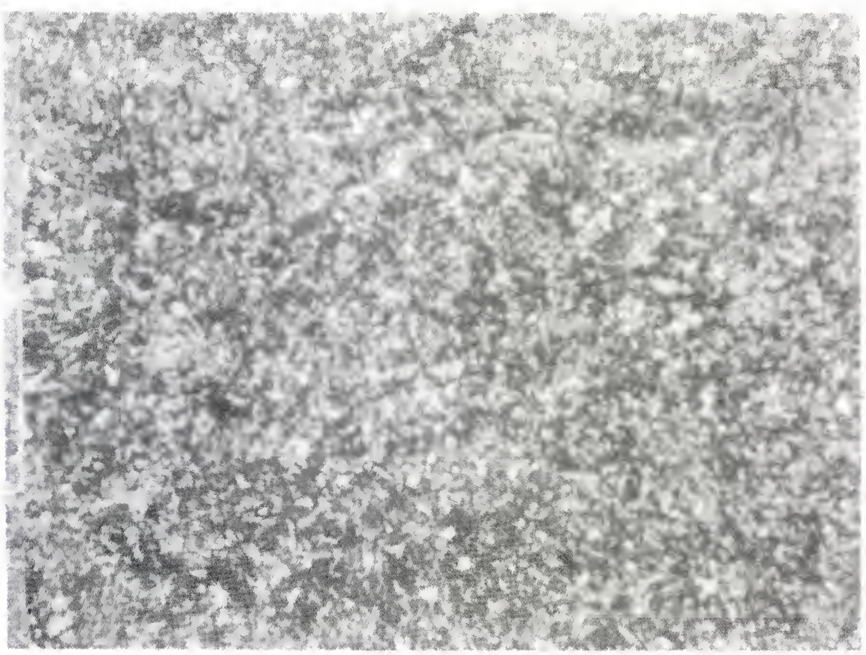

1000X

Figure 13

OB 101 GA 6 pt. 10/72

Republic Steel

Republic Steel Corporation
Cleveland OH 44101

CUSTOMER ORDER NUMBER AND DATE: *29902 ADD 9/24/73

SHIPPED FROM: 62 MASS BF 2

INVOICE DATE

INVOICE NUMBER: 303-12093

DATE SHIPPED: 21373 C&O 31736 PCP PCH

REPUBLIC ORDER NO.: 8- 2200-303 | CUSTOMER ABBREVIATION: CHAMBRLN MFG 1010413

CONTROL CARD: 3900 | 0200033 | 3000804C | ACCOUNT NUMBER: 13857004970

3A 3 30-1/2-10

SALES PRODUCT: 30300018

CHAMBERLAIN MFG CORP
117 KINGS STREET
NEW BEDFORD MA 02741

CHAMBERLAIN MFG CORP
STORES - REC. YD.
ATTN A FERNANDEZ
NEW BEDFORD MA

Certificate of Tests

("SHIP TO" SAME AS "SOLD TO" UNLESS OTHERWISE INDICATED)

"P" PARTIAL SHIPMENT "C" COMPLETE SHIPMENT

REPUBLIC PRODUCT DESCRIPTION	ITEM NO.	UNITS SHIPPED
MIL-STD-430A & ASTM A-274-64 EF AISI-1340 SEMI FIN FORGING STEEL		
6 RC SQ 8 LIFTS 38 PCS 19 FT 3-1/2 IN MULTS TO CUT 836 OF 10-1/2 IN ACTUAL WT 87030* THEO WT 88703* 1 PCE 17 FT 6 IN 3 PCS 18 FT 4-1/2 IN ABOVE 4 PCS IN 1 LIFT MULTS TO CUT 83 OF 10-1/2 IN ACTUAL WT 8720* THEO WT 8788* 1 PCE 11 FT 5 IN 2 PCS 14 FT 0 IN 1 PCE 15 FT 9 IN 1 PCE 19 FT 3-1/2 IN ABOVE 5 PCS IN 1 LIFT MULTS TO CUT 85 OF 10-1/2 IN ACTUAL WT 9040* THEO WT 9004*	1P	120093*

I HEREBY CERTIFY THAT THE MATERIAL LISTED HEREIN HAS BEEN INSPECTED AND TESTED IN ACCORDANCE WITH THE METHODS PRESCRIBED IN THE GOVERNING SPECIFICATIONS AND BASED UPON THE RESULTS OF SUCH INSPECTION AND TESTING HAS BEEN APPROVED FOR CONFORMANCE TO THE SPECIFICATIONS.

R. D. SMITH - GENERAL SUPERINTENDENT METALLURGICAL SERVICES

C. C. Cady
NOTARY PUBLIC
TERM EXPIRES 9/1/76

By: [signature]

FRT. PPD

SEE SHEET 2

	HEAT NO	C H N	CARBON	MANG	PHOS	SUL	SIL	COPPER	NICKEL	CHROME	MOLY	V.A.
1	8062513	7	.400	1.78	.015	.013	.31					

HEAT NO	SIZE	YIELD POINT (LBS PER SQ IN)	TENSILE STRENGTH	% ELONG	% RED AREA	BRINELL ROCKWELL	BEND TEST	REMARKS
AVG: OXIDE 4 SLAG 3 MACRO ETCH S1 R1 C2								

Figure 14:

MASSACHUSETTS MATERIALS RESEARCH, Inc.
241 West Boylston Street
West Boylston, Massachusetts 01583

Date: November 7, 1980

P. O. No. 4053

MMR No. H37-17

Jones & Lamson
Waterbury Farrel Division of Textron
Springfield, CT 05156

Attention: M. Walsh

Report of tests

Sample Identification: #4140 Steel

Element	Composition (%)
Carbon	.38
Manganese	.85
Phosphorus	.018
Sulfur	.015
Silicon	.22
Chromium	.92
Molybdenum	.21

Yield at 0.2% offset, unless otherwise noted
% Elongation in 2" gage length, unless otherwise noted

Sworn to and subscribed
before me this day
of 19

Notary Public

MASSACHUSETTS MATERIALS RESEARCH, Inc

Cynda Beaulieu

We believe the above test to be reliable and correct. Inaccuracies or errors, if they occur will be corrected free of charge. In no event shall Massachusetts Materials Research Inc. be liable for any special, consequential or other damages

Figure 15:

COPPERWELD STEEL COMPANY - WARREN, OHIO 44482 SALES

ENTRY DATE (MO. DAY YR)	DISTRICT	CUSTOMER'S PURCHASE ORDER NUMBER	& DATE (MO. DAY YR)	ITEM	DATE WANTED	SHIPPING PROMISE WEEK OF:	SALES ORDER NO
120178	NY CLE	XS 03796	112778	1 1	2/4/79	2/11/79	51688

F O B MILL WARREN	COMPETITIVE FREIGHT FROM	PRICE: IN EFFECT AT TIME OF SHIPMENT	TERMS OF PAYMENT: % OF 1% OF MILL VALUE
	NBP		10 DAYS, NET 30 DAYS

	PPD	COL	SHIP VIA	CLASS
BARS	X		OPEN TOP TRK - TARPED	

SOLD TO:
PETER A FRASSE & CO INC
THREE DAKOTA DRIVE
PO BOX 115
LAKE SUCCESS, NEW YORK 11040
P

SHIP TO: (SAME AS "SOLD TO" UNLESS OTHERWISE NOTED)
PETER A FRASSE & CO INC
2060 ENTERPRISE PARKWAY
TWINSBURG, OHIO

FEET	PIECES	LBS.	SIZE AND SHAPE	SIZE TOLERANCE STD.	PLUS	MINUS	PURPOSE	CUSTOMER S FIRST OPERATION
		10,000	6"Ø	X			WHSE STOCK	

LENGTH	SHORTS	MULTS	LENGTH TOLERANCE STD.	PLUS	MINUS
22/18'					

PRODUCT DESCRIPTION: HR ANN MS AQ — MPG (205)
PART: 006023

GRAIN: FINE
HARDNESS: 235 MAX BHN
ADDIT. MACRO/MICRO REQ.: AIM 50% LAM 50% Sphere
TAG: "HR AQ"
STRAIGHTNESS:
SPECIFICATION NO.: PAF-142-01 MIL-S-5000D AM 1 EXC MARK COND C1 AMS-6415H EXC MARK & ASTM-A-322 -76 EXC SIL AMS 2301E

BUNDLE: 6000# MAX OVRHD CRANE UNLD
PAINT & MARK: STAMP HEAT NO BDL WITH PINK & WHITE STRIPE
INSPECTION: CLASS X | CUST | GOVT | OTHER

COPPERWELD STEEL COMPANY
BOX 1.1 / WARREN, OHIO 44482

TEST REPORT

ilh

ORDER NUMBER CUSTOMER	COPPERWELD
	51688

DATE 2/6/79

E 4340 DH AQ

ANALYSIS

HEAT NO.	C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Pb	Al		GRAIN SIZE
81611	.40	.81	.010	.019	.28	1.89	.88	.23	.13				6-8

JOMINY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	20	24	28	32	36
57	57	56	56	56	56	55	55	.	55		55		55		55	54	54	54	54	

MECHANICAL PROP.

YIELD PSI	TENSILE PSI	OFFSET %	ELONG. %	R.A. %	HARDNESS*	OTHER DATA
					201	Freq./Sev. .02/.02 Macro etch equal to or better than S2 R1 C2 Decarb .034

*Surface unless otherwise noted

a Copperweld product

FRASSE-TWINSBURG ... CHECK ... DATE: CA 2-14-79

THIS CERTIFICATE NOTARIZED WHEN REQUIRED

, a Notary Public do hereby certify that affidavit was subscribed and sworn to before me by a duly authorized representative of Copperweld Steel Company.

this ... day of ...

MY COMMISSION EXPIRES

NOTARY PUBLIC

CSS 8/1 9

We hereby certify that the above data are correct as contained in the records of Copperweld Steel Company.

Supv. Met. Lab.

Figure 16:

Crucible SP 25.500 REV. 4/71

Colt Industries Crucible Inc

RP CAR/TRUCK # CR544461 ALLOY DIVISION, MIDLAND, PA. 15059 2 04

GRADE	PROD.	MFG.	CUSTOMER CODE	SHIPPED FROM	DATE SHIPPED	INSTRUCTIONS
99701	050	021	137985-02	MIDLAND PA	06/27/9	MAIL CTS TO ATTN C HENDRICKS

SOLD TO:
CHAMBERLAIN MFG CORP
NEW BEDFORD DIV
P O BOX B-940
NEW BEDFORD MASS 02741

SHIP TO:
CHAMBERLAIN MFG CORP
SCRANTON ARMY AMMUNITION PLANT
156 CEDAR AVENUE
SCRANTON PA 18510

PAPERS	B/L	S/N	CT	INV.	H/A	HRD	NTZ
SOLD	1	1	3	2	Y	Y	Y
SHIP					N		

ITEM	CUSTOMER ORDER NO.	OUR ORDER NO.	DESCRIPTION	SIZE
	77341	602104349	TOC OH HF-1 HR NAT ALY BLTS SHELL QUAL FRG Q MIL-S-50783/MU /	5.250 IN RCS X 216 IN

HEAT NO.	C	MN	P	S	SI	NI	CR	MO
92901	1.05	1.85	.030	.011	.74	.14	.20	.05

HEAT #	COIL #	QUANTITY	GRAIN	HARDNESS	YIELD	TENS.	BND	OG&FAC	ELONG %&GL	RA %	CHAR	IZOD
92901		63000										

MACRO ETCH RATED PER ASTM E-381: SRC
A1-2-5-112
X1-2-5-111

SWORN TO AND SUBSCRIBED BEFORE ME

THIS ______ DAY OF ____________ 19____

____
NOTARY PUBLIC

Colt Industries Crucible Inc

CERTIFICATE OF TEST

THE TEST RESULTS SHOWN IN THIS REPORT ARE CORRECT TO THE BEST OF OUR KNOWLEDGE AND BELIEF.

COLT INDUSTRIES CRUCIBLE Inc

CERTIFIED BY: [signature]
REPRESENTATIVE

Figure 17:

Results of Turning Tests:

From the following tables, it can be seen that significant improvements can be achieved using the machining conditions found in the tests over those recommended in the Machining Data Handbook, 3rd Edition. Table 2 documents the "roughing-cuts" data, and Table 3 documents the "finishing-cuts" data.

For the "roughing-cuts", the percentage increases in the productivity index ranged up to 148% for carbide and 209% for ceramic tooling over the data in the Machining Data Handbook . In each case, the reference inserts were coated carbides, and the comparison materials were 570 carbide and G-30 (cold-press) ceramic.

The results of the finishing-cuts gave similar increases, as those for the roughing-cuts. The productivity index increase was up to 200% for carbide inserts and 419% for ceramic inserts.

The tool load charts show the power requirements for the spindle and the tool carrying slide, when using the various types of cutting materials at the proposed cutting speeds. There is a considerable increase in spindle power requirements, when ceramic cutting tools are applied. The power requirements for all of the materials tested are shown on the "Summary of Results" sheets, at the beginning of each material section.

Overall, it can be seen that by using the results of this effort, significant increases in metal removal rates can be achieved.

TABLE 2: **COMPARISON OF TEST DATA WITH DATA FROM <u>MACHINING DATA HANDBOOK</u>**
"ROUGH CUTS"

PROJECTILE MATERIAL and HARDNESS	DATA FROM MACHINING DATA HANDBOOK — 3rd Edition —			- DATA FROM TESTS -											
				TOOL MATERIAL									Percentage Increase Using Test Results		
				KC-810			570			Cold Press Ceramic - G-30					
	SFM	Feed In./Rev.	Prod. Index	SFM	Feed In./Rev.	Prod. Index	SFM	Feed In./Rev.	Prod. Index	SFM	Feed In./Rev.	Prod. Index	SFM	Feed In./Rev.	Prod. Index
AISI-1340 217/241 Bhn	500	.015	7.5	430	.025	10.75	700	·.025	17.5	830	.022	18.26	133% (570)		143%
AISI-4140 302/321 Bhn	435	.015	6.53	255	.033	8.42	360	.033	11.88	760	.022	16.72	82% (570)		156%
AISI-4340 321/364 Bhn	355	.015	5.33	290	.033	9.57	400	.033	13.2	750	.022	16.5	148% (570)		209%
HF-1 * 262/293 Bhn	425	.015	6.38	330	.022	7.26	420	.022	9.24	470	.022	10.34	45% (570)		62%

* NOTE: No data available for HF-1
Data for 50100, 51100, 52100 and M-50 used.

TABLE 3: **COMPARISON OF TEST DATA WITH DATA FROM _MACHINING DATA HANDBOOK_**
"FINISH CUTS"

PROJECTILE MATERIAL and HARDNESS	DATA FROM MACHINING DATA HANDBOOK — 3rd Edition —			- DATA FROM TESTS - TOOL MATERIAL: KC-810			570			Cold Press Ceramic - G-30			Percentage Increase Using Test Results	
	SFM	Feed In./Rev.	Prod. Index	SFM	Feed In./Rev.	Prod. Index	SFM	Feed In./Rev.	Prod. Index	SFM	Feed In./Rev.	Prod. Index	Carbide (Grade)	Ceramic
AISI-1340 269Bhn	580	.007	4.06	370	.011	4.07	330	.011	3.63	630	.011	6.93	.2% (KC-810)	71%
AISI-1340 321/340 Bhn	510	.007	3.57	310	.015	4.65	470	.015	7.05	660	.015	9.90	97% (570)	177%
AISI-4140 262/286 Bhn	620	.007	4.34	500	.015	7.5	560	.015	8.4	1180	.015	17.7	94% (570)	307%
AISI-4140 444/477 Bhn	260	.005	1.3	165	.015	2.48	255	.015	3.83	450	.015	6.75	195% (570)	419%
AISI-4340 311 Bhn	560	.007	3.92	500	.015 (350 Carbide)	7.5	600	.015	9.0	630	.015	9.45	130% (570)	141%
AISI-4340 477/512 Bhn	180	.005	.9	135	.015	2.03	180	.015	2.70	250	.015	3.75	200% (570)	317%
HF-1 * 387 Bhn	385	.007	2.70	310	.011	3.41	340	.011	3.74	590	.011	6.49	39% (570)	140%

* NOTE: No data available for HF-1
Data for 50100, 51100, 52100 and M-50 used.

AISI 1340 Projectile Material - "Roughing" Cuts-21 Rc

Table 4, page 31 is a summary chart showing the results of the life-line and tool load tests on AISI 1340 material. Figures 18 through 21, pages 32 to 35, depict the results of the variety of individual tests that were made in the roughing cuts of the AISI 1340 steel. Table 5 through Table 10, page 36 through page 41, contain the tabulations of data used in plotting the previous charts.

This material is feed-sensitive. As the feed is increased, the production index will reach a peak and then decrease with an additional increase in feed rate. For these tests, the peak came at .025 inches per revolution feed. See Table 4.

The titanium coated carbide did not give as good a tool life as that provided by tungsten carbide at .025 inches per revolution feed. The hot-pressed (G-10) ceramic gave almost equal tool-life for both .015 and .022 inches per revolution feed rate. The cold-pressed ceramic (G-30) gave similar results as the G-10, except that the slope of the life-line was lower than the G-10 life-line.

The tool loads were similar for the three grades of carbide, but when the tool load tests for G-10 were tried, the tool broke at .200 depth of cut. This was due to the "brittleness" of G-10 and the small inscribed circle (.500") of the test insert.

When conducting the life-line test, there was some non-uniform wearing of the insert flank. The nose was wearing more than the insert flank so the nose wear-land value was used in plotting tool life-lines. To the user, this means that a well-directed, copius supply of coolant should be used when machining this material.

SUMMARY OF RESULTS

"ROUGHING CUT"

MATERIAL	AISI-1340
HARDNESS	217/241 Bhn.
TOOL LIFE	2500 In^2 of Machined Surface
DEPTH OF CUT	.100 Inches

Tool Cutting Material	S.F.M.	Feed In./Rev.	Prod. Index	Tangential Tool Load - Lbs. .100 Depth of Cut	H.P. .100 Depth of Cut
350	450	.022	9.9	—	—
350	430	.025	10.7	730	9.51
350	300	.033	9.9	—	—
KC-810	410	.025	10.2	760	9.44
570	700	.025	17.5	800	16.97
G-10	1000	.015	15.0	—	—
G-10	970	.022	21.3	680	19.99
G-30	870	.015	13.1	480	12.65
G-30	830	.022	18.3	—	—

TABLE 4: AISI-1340 Results of Tests

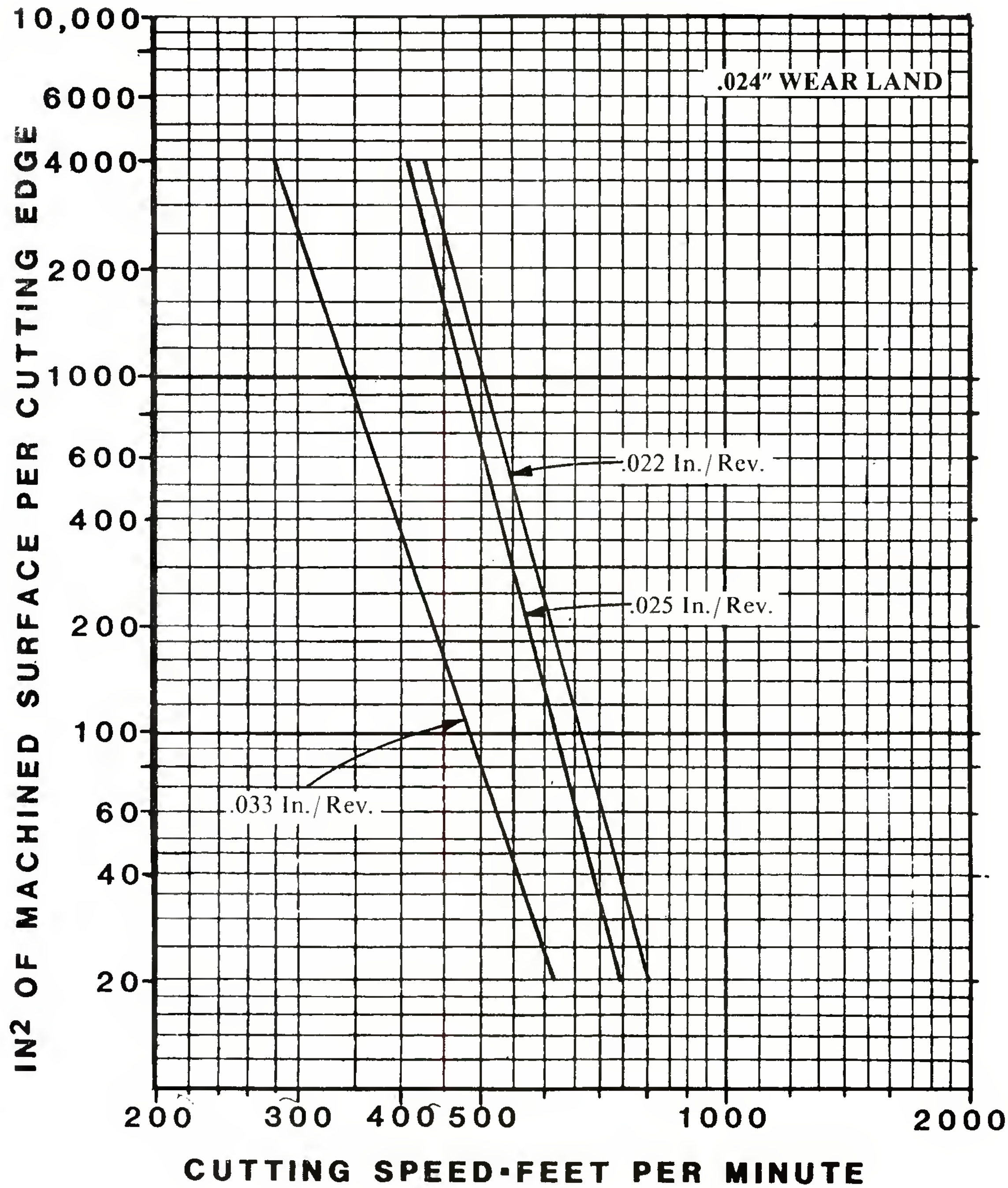

Figure 18: Tool-Life Lines of Carboloy Grade 350 on AISI 1340 Steel at 228/235 Brinell Hardness for Listed Feed-Rates.

Depth of Cut - .100 Inches
Tool Holder - MTANR-164 (0^0 Lead Angle)
Insert - TNMG-433

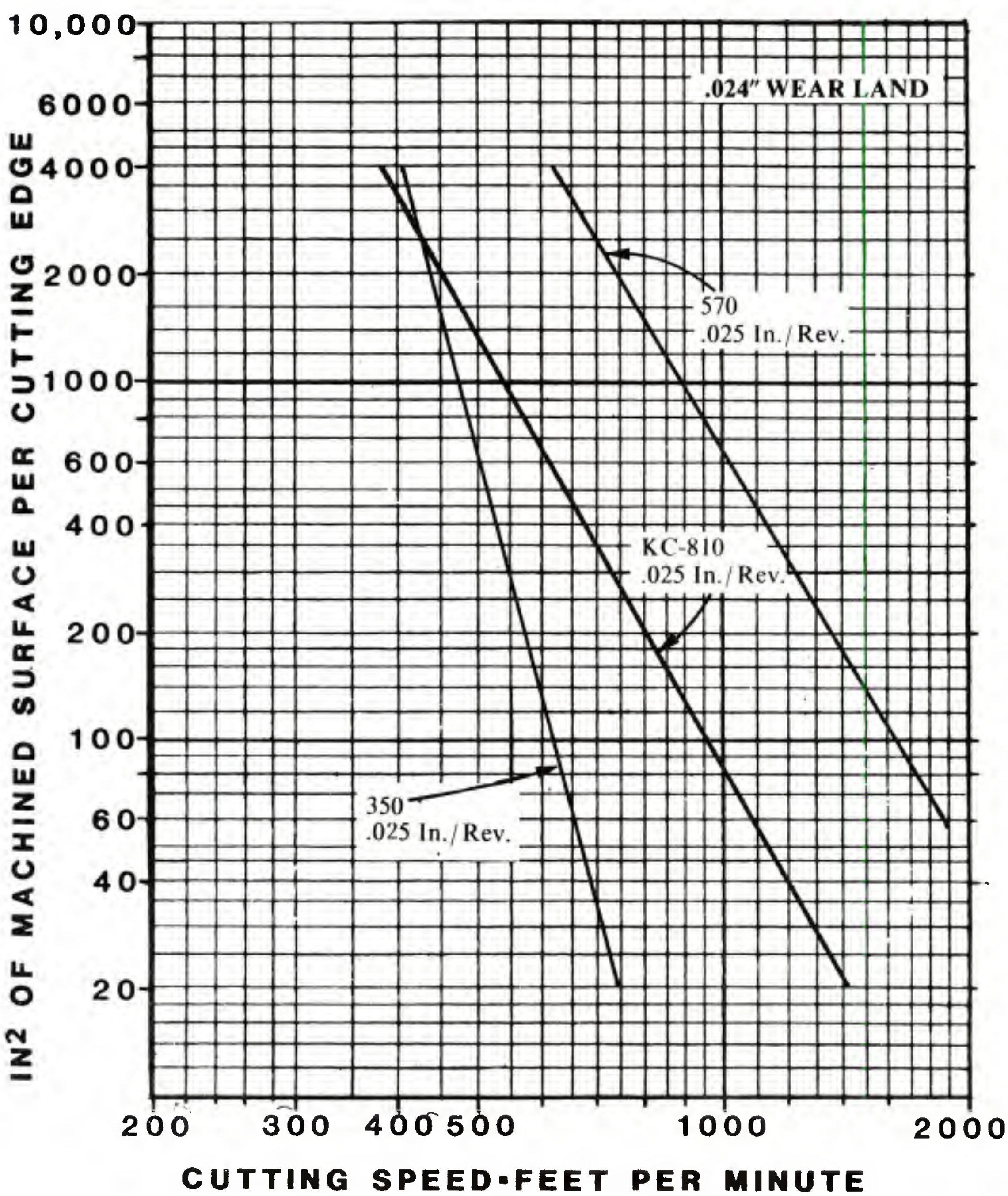

Figure 19: Tool-Life Lines of Listed Cutting Materials on AISI 1340 Steel at 223/235 Brinell Hardness for .025 Inches/Revolution Feed.

Depth of Cut - .100 Inches
Tool Holder - MTANR-164 (0^0 Lead Angle)
Insert - TNMG-433

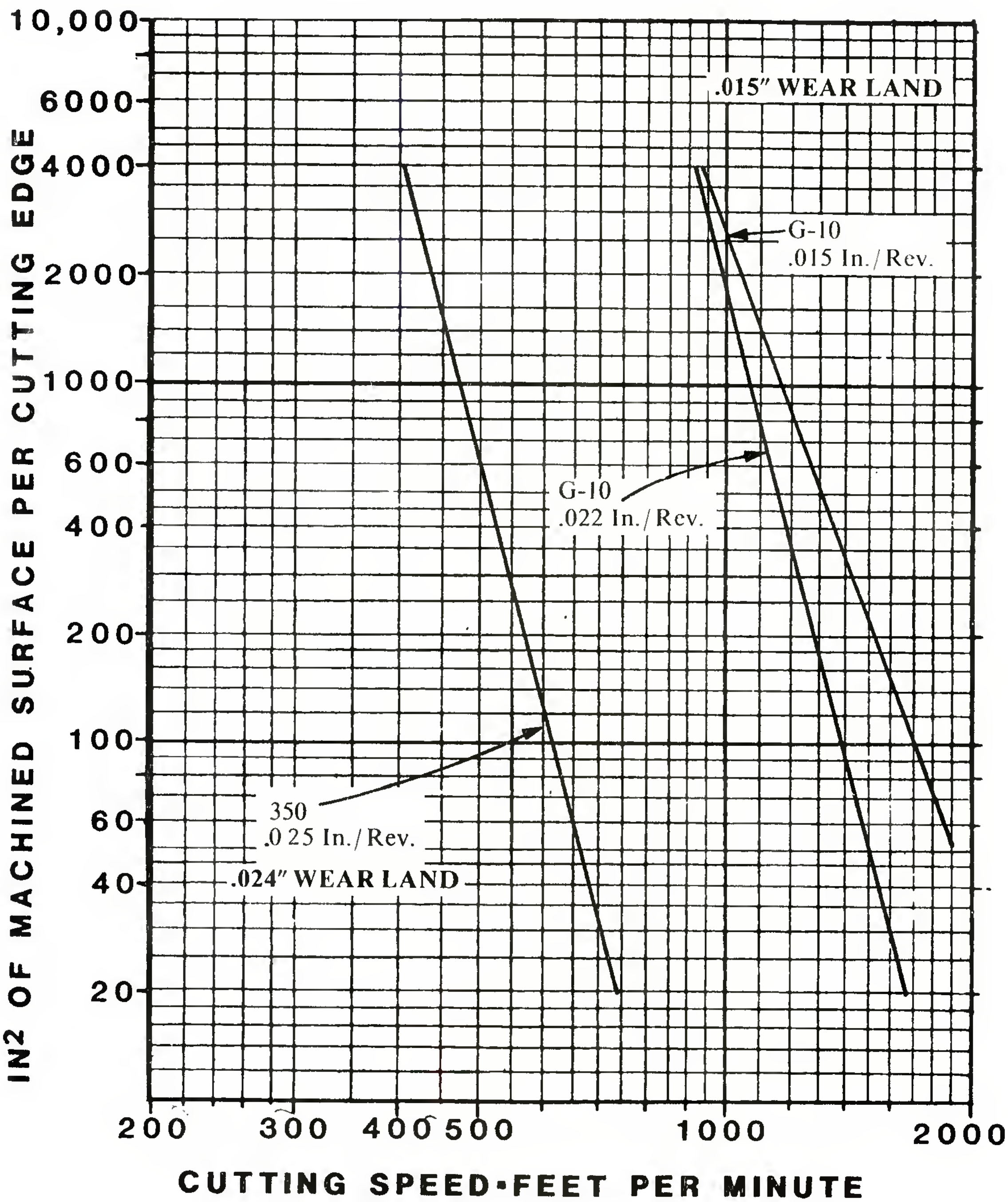

Figure 20: Tool-Life Lines of Listed Cutting Materials on AISI 1340 Steel at 228/241 Brinell Hardness for Listed Feed-Rates.

Depth of Cut - .100 Inches
Tool Holder - CCGNR-164 (0^{0} Lead Angle)
Insert - CNG-454 .008 x 20^{0} Grade G-10

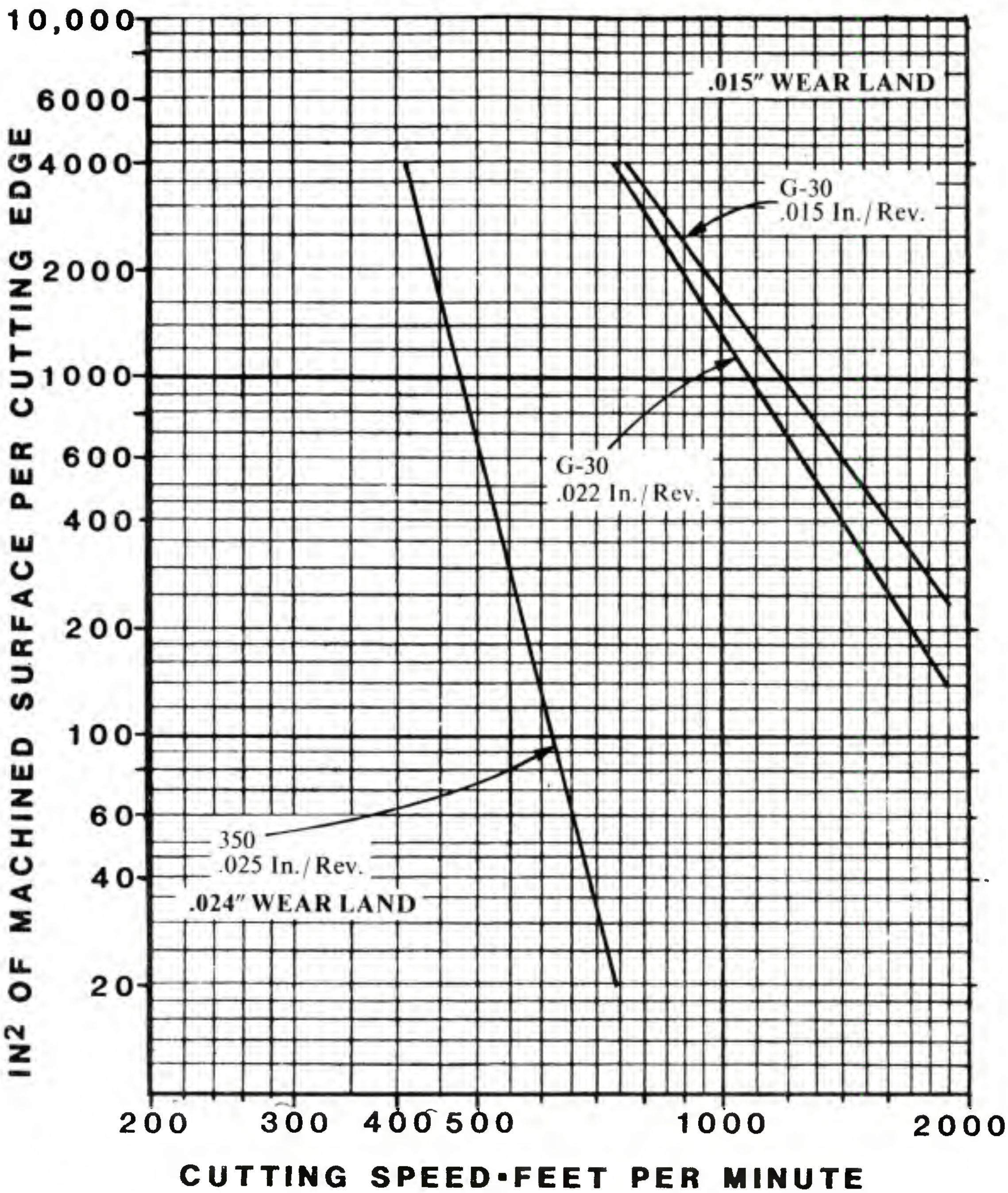

Figure 21: Tool-Life Lines of Listed Cutting Materials on AISI 1340 Steel at 217/238 Brinell Hardness for Listed Feed-Rates.

Depth of Cut - .100 Inches
Tool Holder - CCGNR-164 (0^0 Lead Angle)
Insert - CNG-454 .008 x 20^0 Grade G-30

Date:	7/22/80	**Material:**	AISI 1340
Depth of Cut:	.100 APPROX.	**Coolant:**	TRIM-SOL 20:1
Hardness:	SEE TAB.	**Tool Description:**	
Coolant Application:	TOP	**Holder:**	MTANR-164
		Insert:	TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
			SHELL HARDNESS 228/235 BHN							
1	350	700	.022	6.325	6.175	3.8	73.7	.022	80.4	.024
2	"	500	"	"	"	18.4	357			
2a	"	"	"	6.175	5.955	10.125	189.4	.013	547 1010	TOTAL .024
3	"	600	"	"	"	6	112	.015	180	.024
			SHELL HARDNESS 228/235 BHN							
4	"	600	.025	6.330	6.133	12.56	242	.041*N	NOSE 140	WEAR .024
5	"	650	"	"	"	2.1	40.5	.012*N	NOSE 81	WEAR .024
6	"	700	"	"	"	2.7	52	.055*N	NOSE 23	WEAR .024
7	"	500	"	"	"	2.6	50			
7a	"	"	"	6.133	5.945	14.8	276.4	.0105	746	.024
			SHELL HARDNESS 228/235 BHN							
8	350	650	.033	6.330	6.110	1.45	TOO FAST –	–		

NOTES:

TABLE 5 : DATA FOR LIFE LINES

Date: 7/22/80
Material: AISI 1340
Depth of Cut: .100 APPROX.
Coolant: TRIM-SOL 20:1
Hardness: SEE TAB.
Tool Description:
Coolant Application: TOP
Holder: MTANR-164
Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
			SHELL HARDNESS 228/235 BHN				(cont'd.)			
9	350	600	.033	6.330	6.110	1.3	25.	.023 *N	NOSE 26	WEAR .024
10	"	400	"	"	"	–	–	–		
11	"	400	"	"	"	16-3/4	324	.0215	360	.024
12	"	350	"	6.135	5.955	19.75	369	.009	985	.024

NOTES: RUN NO. 10 TOOL BROKE
BAD "HOLE" IN SHELL

*WEAR LAND ON NOSE USED

TABLE 6 : DATA FOR LIFE LINES

Date: 7/23/80

Material: AISI 1340

Depth of Cut: .100" APPROX.

Coolant: TRIM-SOL 20:1

Hardness: SEE DATA

Tool Description:

Coolant Application: TOP

Holder: MTANR-164

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
			SHELL HARDNESS 223/235 BHN							
1	KC-810	850	.025	6.338	6.145	5.2	100	.017	142	.024
2	"	650	"	"	"	15.1	291.5	.015	466	.024
3	"	550	"	6.145	5.968	20.1	377	.011	822	.024
			SHELL HARDNESS 228/228 BHN							
4	"	500	.025	6.338	6.172	20.9	405	.0085	1144	.024

NOTES:

TABLE 7 : DATA FOR LIFE LINES

Date: 7/24/80	**Material:** AISI 1340
Depth of Cut: .100 APPROX.	**Coolant:** TRIM-SOL 20:1
Hardness: SEE DATA	**Tool Description:**
Coolant Application: TOP	**Holder:** MTANR-164
	Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
			SHELL HARDNESS 228/228 BHN							
1	570	850	.025	6.330	6.136	8.25				
1a	"	"	"	"	"	20.6	397.6	.008	1193	.024
2	"	1100	"	6.136	5.941	6.25	117	.0065	431	.024
3	"	1200	"	"	6.007	6.625	125	.0175	171	.024

NOTES:

TABLE 8 : DATA FOR LIFE LINES

Date: 7/25/80	Material: AISI 1340
Depth of Cut: .100 APPROX.	Coolant: TRIM-SOL 20:1
Hardness: SEE DATA	Tool Description:
Coolant Application: TOP	Holder: CCGNR-164
	Insert: CNG-454 820

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
			SHELL HARDNESS 228/241 BHN							
1	G-10	1200	.015	6.335	6.160	8.1	157	.0035	670	.015
2	"	1100	"	"	"	11.3	220	.0022	1490	.015
3	"	1000	"	6.160	5.945	17.8	332	.0024	2080	.015
			SHELL HARDNESS 228/241 BHN							
4	G-10	850	.022	6.230	6.030	19.25	365	–	CUT CONTINUED	
4a	"	"	"	6.030	5.925	19	719	.002	5390	.015
			SHELL HARDNESS 235/241 BHN							
5	G-10	1100	.022	6.330	6.162	6.375	123.4	.004	463	.015
6	"	1200	"	"	"	12.75	246.8	.0075	493	.015
7	"	1000	"	6.162	5.970	19	356	.002	2670	.015

NOTES:

TABLE 9 : DATA FOR LIFE LINES

Date:	7/29/80	**Material:**	AISI 1340
Depth of Cut:	.100 APPROX.	**Coolant:**	–
Hardness:	SEE DATA	**Tool Description:**	
Coolant Application:	NONE	**Holder:**	CCGNR-164
		Insert:	CNG-454 - 820

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
			SHELL HARDNESS 217/238 BHN							
1	G-30	1200	.015	6.350	6.225	7	137	.002	1027	.015
2	"	1400	"	"	"	12.1	237	.006	590	.015
3	"	1100	"	6.225	6.050	19.1	363	.0052	1047	.015
4	"	1000	"	6.050	5.850	19.1	351	–	CUT CONTINUED	
4a	"	"	"	5.850	5.670	19.6	700	.0065	1615	.015
			SHELL HARDNESS - 235/241 BHN							
5	G-30	1400	.022	6.320	6.140	9.25	178.4	.006	446	.015
6	"	1200	"	"	"	9.85	190	.005	570	.015
7	"	1000	"	6.140	5.950	19.0	336	–		
7a	"	"	"	5.950	5.780	19.0	681	.0072	1418	.015

NOTES:

TABLE 10 : DATA FOR LIFE LINES

TOOL LOAD VERSUS DEPTH OF CUT

Material:	AISI 1340	**Holder:**	0^{0} LEAD ANGLE
Hardness:	235/255 BHN	**Insert:**	TNMG-433
Feed Rate:	.025 IN./REV.	**Grade:**	350
Surface Speed:	430 FT./MIN.	**Coolant:**	TRIM-SOL 20:1 TOP

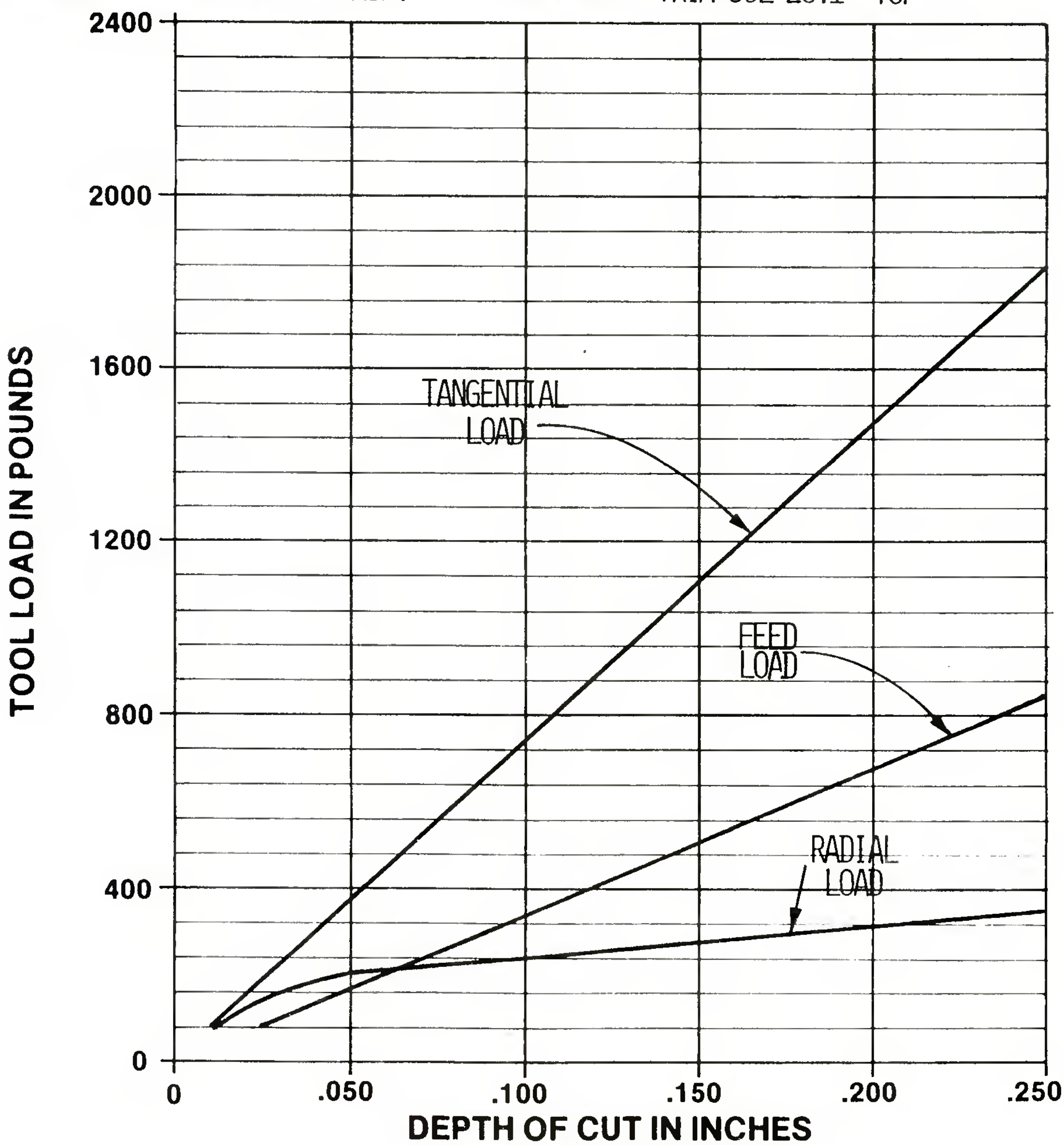

Figure 22: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material:	AISI 1340	**Holder:**	0° LEAD ANGLE
Hardness:	235/255 BHN	**Insert:**	TNMG-433
Feed Rate:	.025 IN./REV.	**Grade:**	KC-810
Surface Speed:	410 FT./MIN.	**Coolant:**	TRIM-SOL 20:1 TOP

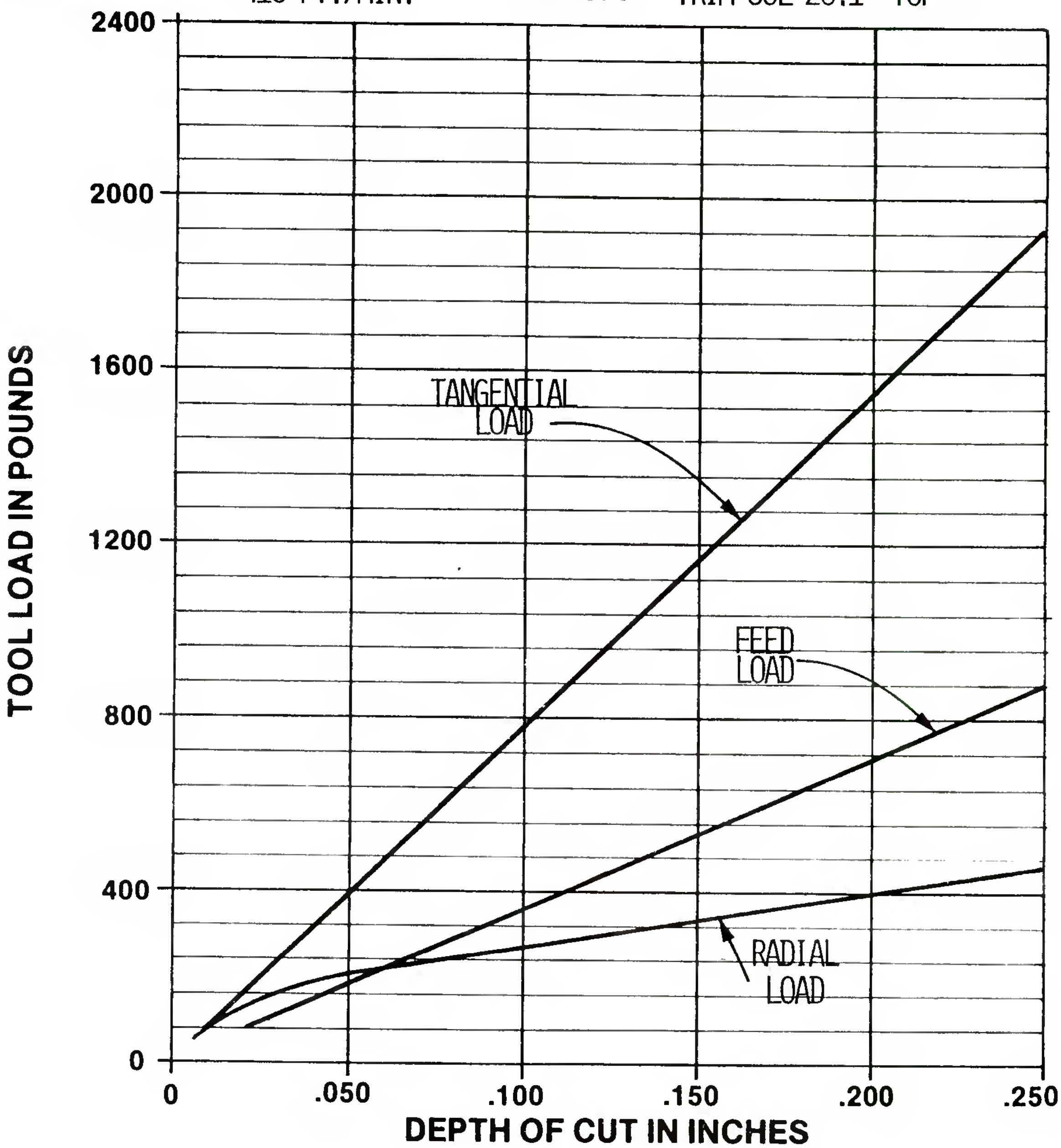

Figure 23: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material: AISI 1340 **Holder:** 0^{o} LEAD ANGLE

Hardness: 235/255 BHN **Insert:** TNMG-433

Feed Rate: .025 IN./REV. **Grade:** 570

Surface Speed: 700 FT./MIN. **Coolant:** TRIM-SOL 20:1 TOP

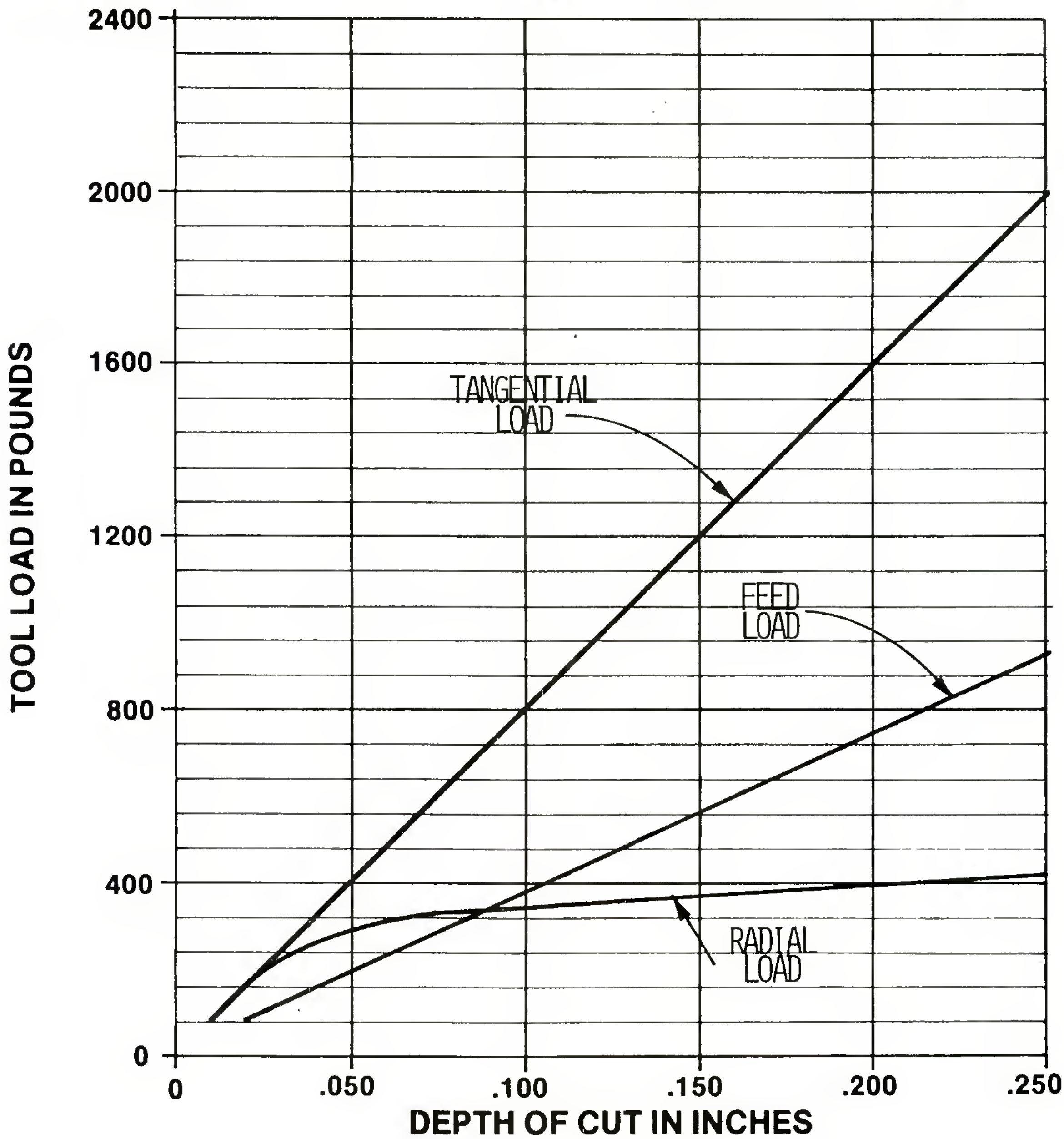

Figure 24: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material:	AISI 1340	**Holder:**	0° LEAD ANGLE
Hardness:	235/255 BHN	**Insert:**	CNG-454
Feed Rate:	.022 IN./REV.	**Grade:**	G-10 820
Surface Speed:	970 FT./MIN.	**Coolant:**	TRIM-SOL 20:1 TOP

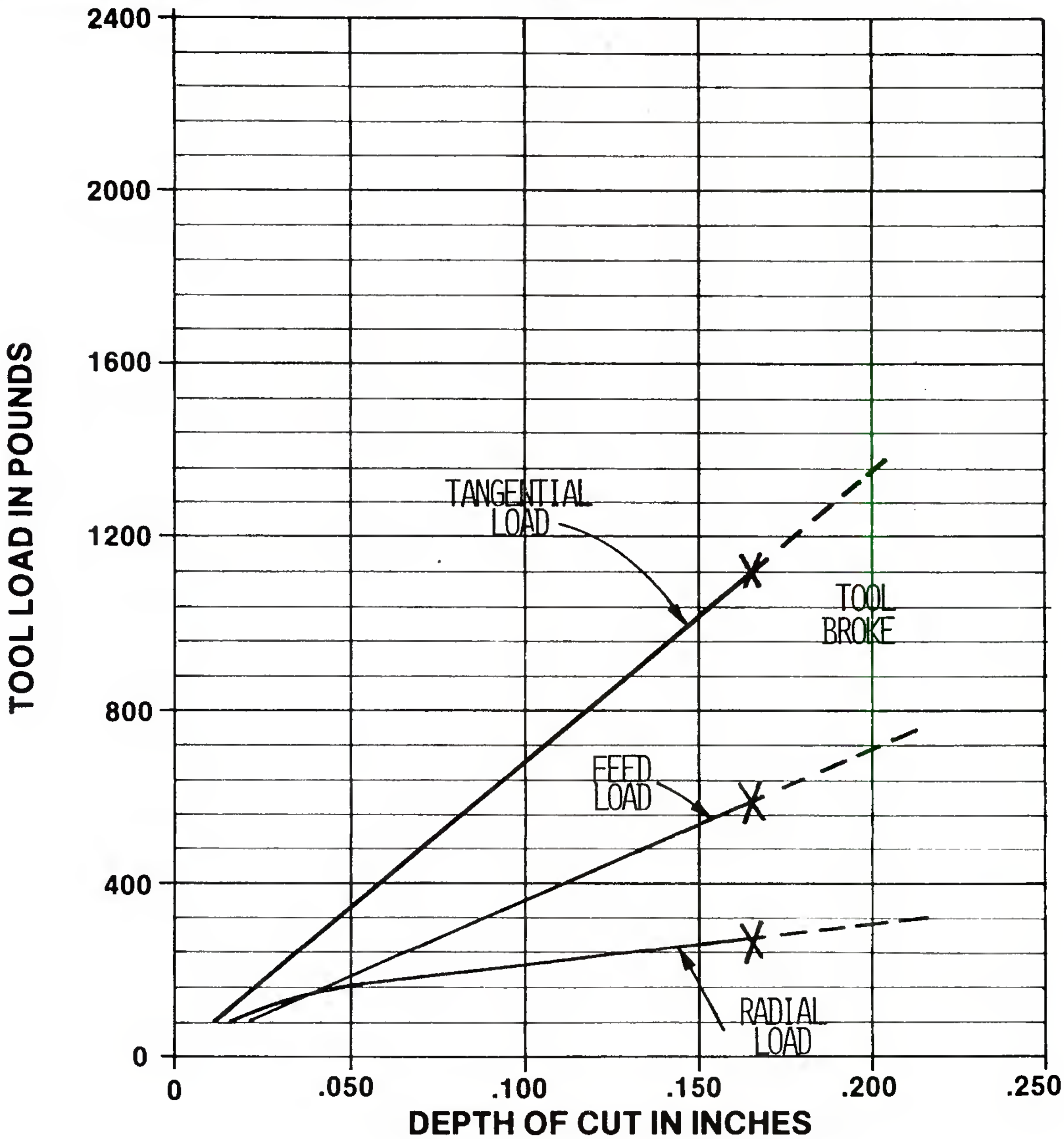

Figure 25: **TOOL LOAD CHART**

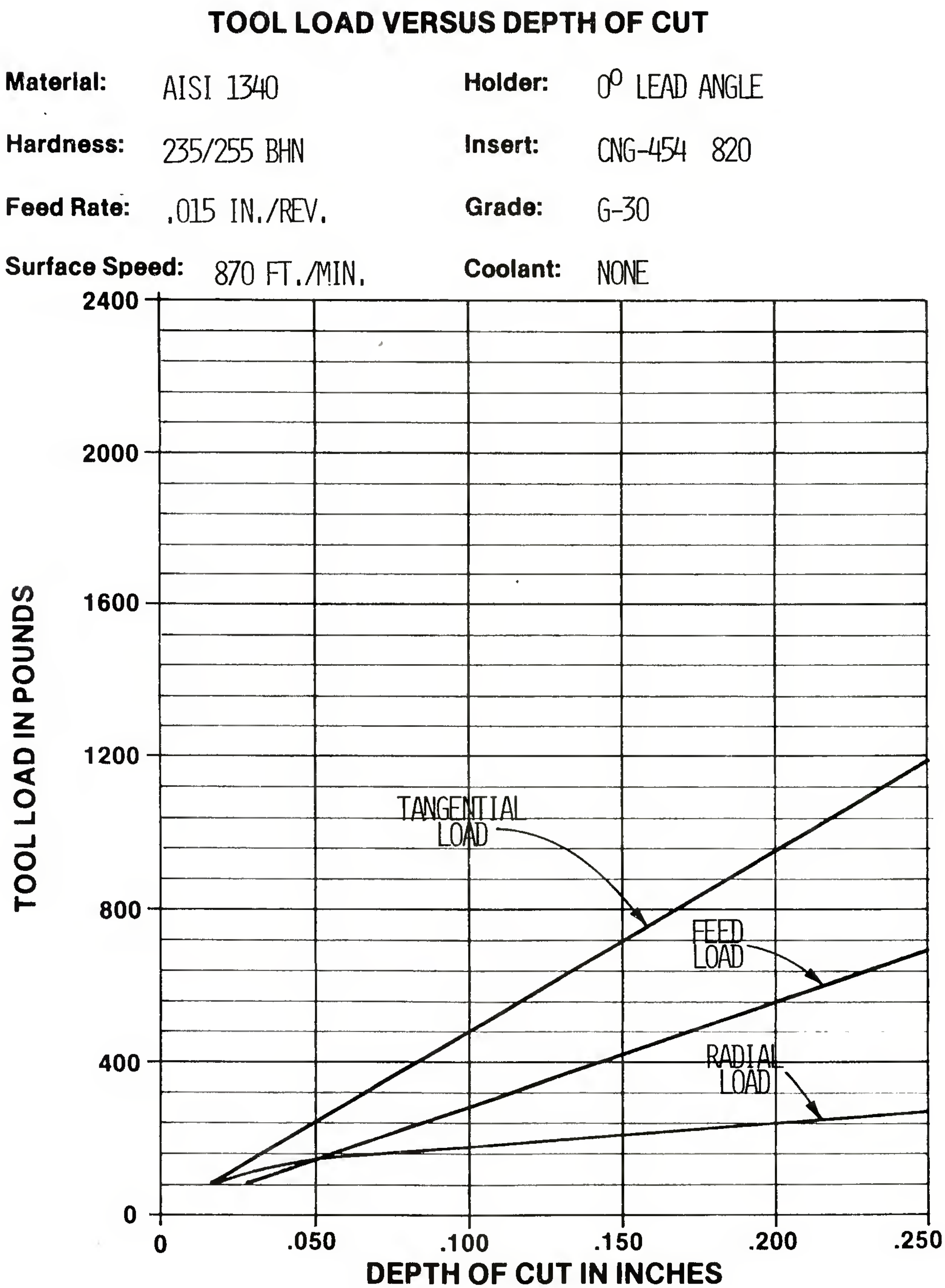

Figure 26: **TOOL LOAD CHART**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 1340 **HARDNESS:** 235/255 BHN

INSERT: TNMG-433 **SURFACE FEED:** 430 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 350 **FEEDRATE:** .025 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	400	175	205
.100	700	300	240
.150	1100	500	295
.200	1450	700	320

INSERT: TNMG-433 **SURFACE FEED:** 410 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: KC-810 **FEEDRATE:** .025 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	390	150	210
.100	760	320	250
.150	1160	520	340
.200	1540	720	410

INSERT: TNMG-433 **SURFACE FEED:** 700 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 570 **FEEDRATE:** .025 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	400	175	275
.100	800	370	325
.150	1200	570	370
.200	1560	740	385

TABLE 11 **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 1340 **HARDNESS:** 235/255 BHN

INSERT: CNG-454 .008 x 20° **SURFACE FEED:** 970 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	340	120	160
.100	680	280	200
.150	1000	440	230
.200	-	-	-

INSERT: CNG-454 .008" x 20° **SURFACE FEED:** 870 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	240	100	125
.100	480	260	165
.150	720	420	190
.200	960	570	220

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050			
.100			
.150			
.200			

TABLE 12 **DATA FOR TOOL LOAD CHARTS**

AISI 4140 Projectile Material - "Roughing" Cuts-33/35 Rc

Table 13, page 51 is the summary of tests done on AISI 4140 steel. It presents the results of the life-line tests for the various cutting materials and feed rates, as well as the horsepower calculations using the tangential tool load values from the charts.

Figures 27 through Figure 30, pages 52 to 55 depict the results of the variety of tests that were made during the roughing cuts in the AISI 4140 material. Tables 14 through 20, pages 56 through 62, contain the corresponding data for these figures.

The life-lines of this material were plotted at .015, .022, .025, .033, and .047 inches per revolution feed-rates. As the feed-rate was increased, the production indexes also increased, but for comparison purposes with other carbides, a maximum feed-rate of .033 inches per revolution was used.

The hot-press and cold-press ceramics did show some difference from past results in that an increase in feed rate did not require a lowering of surface speed. This means that it is better, from a tool life standpoint, to use the higher feed rate of .022" for higher production rates. This increase in feed-rate does cause an increase in the tangential tool load which increases the horsepower required for a cut.

Different "K" lands on the ceramic inserts were tested to determine the effect on the tool loads when the feed rates were changed. When the feed-rate was lowered on inserts with equal "K" lands, the tool loads decreased. This is similar to other commonly used materials because when the horsepower is calculated, the feed is a factor. When the "K" land width was increased, keeping the angle the same, the tangential tool load increased only slightly. However, the feed load almost doubled in value. This means that the power source, driving the tool slide, should have the capacity to handle these larger loads.

This material also shows the effect on wear land as the lead-angle of the tool is changed, Figures 41 through 45, Tables 24 through 28, pages 76 to 85. When these charts were evaluated, it was concluded that they served no useful purpose and that this work would not be done for the other three materials.

SUMMARY OF RESULTS

"ROUGHING CUT"

MATERIAL	AISI-4140
HARDNESS	302/321 Bhn.
TOOL LIFE	2500 In^2 of Machined Surface
DEPTH OF CUT	.100 Inches

Tool Cutting Material	S.F.M.	Feed In./Rev.	Prod. Index	Tangential Tool Load - Lbs. .100 Depth of Cut	H.P. .100 Depth of Cut
350	330	.015	4.95	—	—
350	285	.022	6.27	—	—
350	275	.025	6.88	—	—
350	255	.033	8.42	900	6.95
350	230	.047	10.81	—	—
KC-810	320	.033	10.56	840	8.15
570	360	.033	11.88	800	8.73
G-10	840	.015	12.6	—	—
G-10	810	.022	17.82	800	19.64
G-30	780	.015	11.7	—	—
G-30	760	.022	16.72	800	18.43

TABLE 13 AISI-4140 Results of Tests

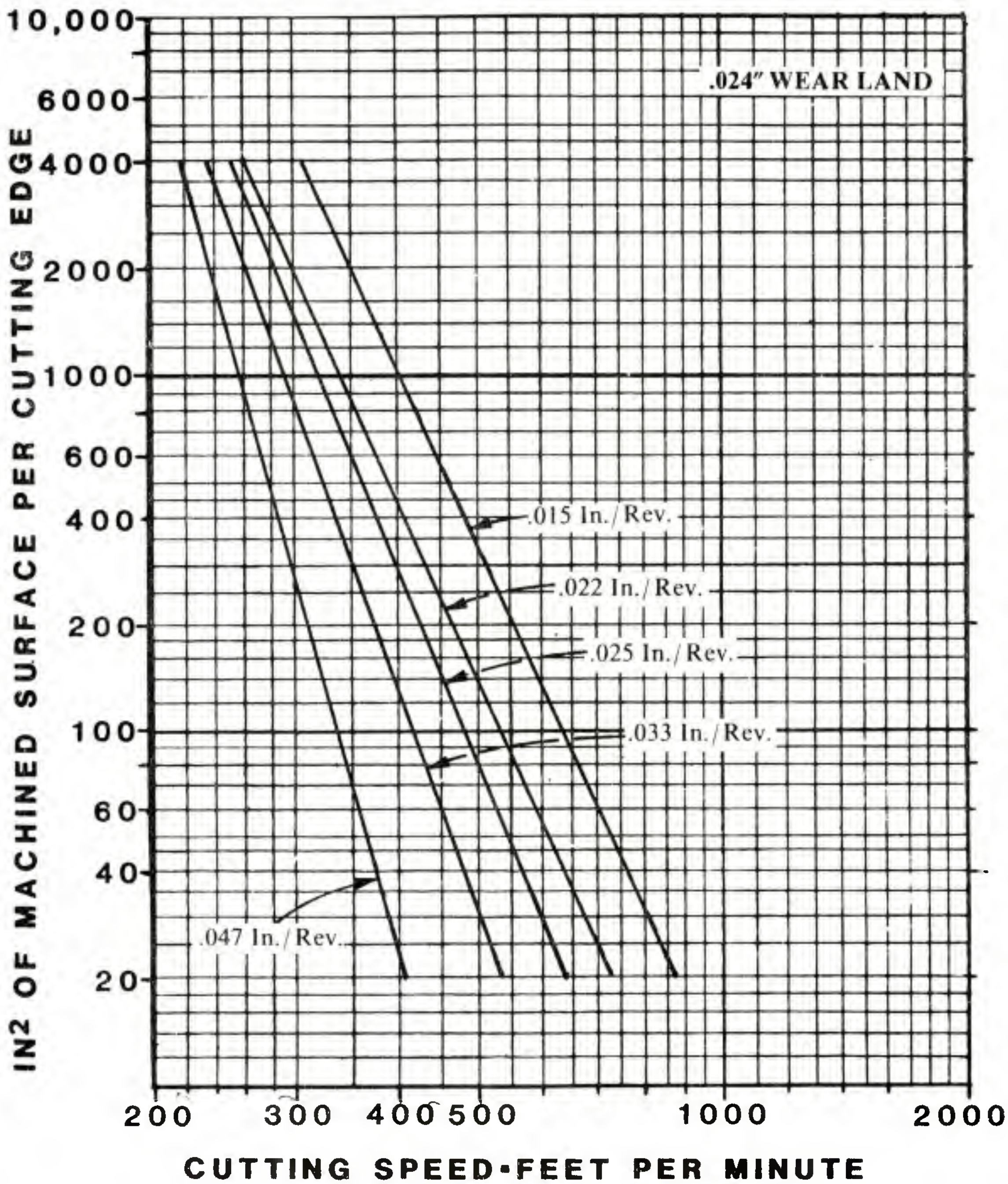

Figure 27: Tool-Life Lines of Carboloy Grade 350 on AISI 4140 Steel at 311/321 Brinell Hardness for Listed Feed-Rates.

Depth of Cut - .100 Inches
Tool Holder - MTANR-164 (0^0 Lead Angle)
Insert - TNMG-433

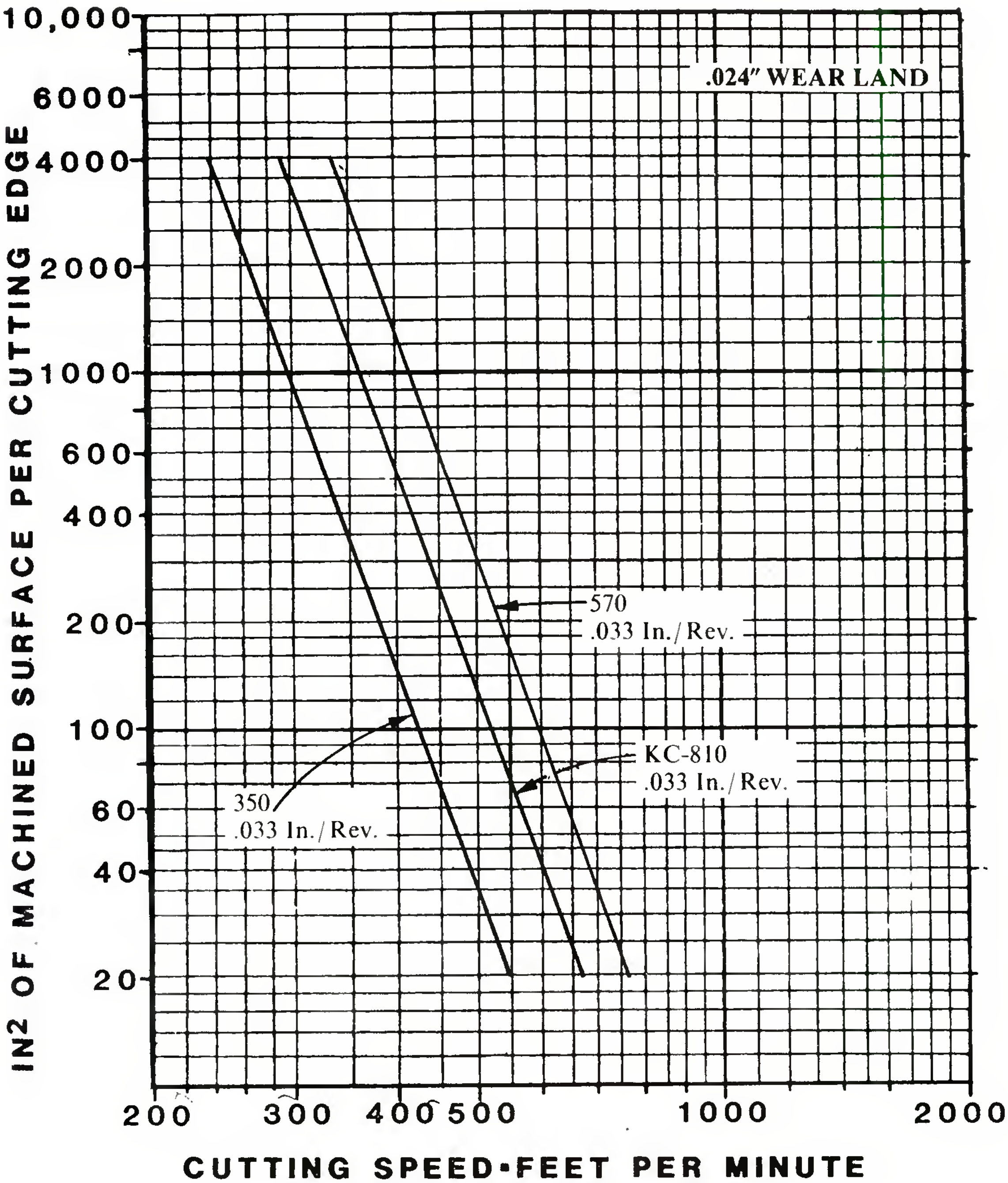

Figure 28: Tool-Life Lines of Listed Cutting Materials on AISI 4140 Steel at 311/321 Brinell Hardness for .033 Inches/Revolution Feed.

Depth of Cut - .100 Inches
Tool Holder - MTANR-164 (0° Lead Angle)
Insert - TNMG-433

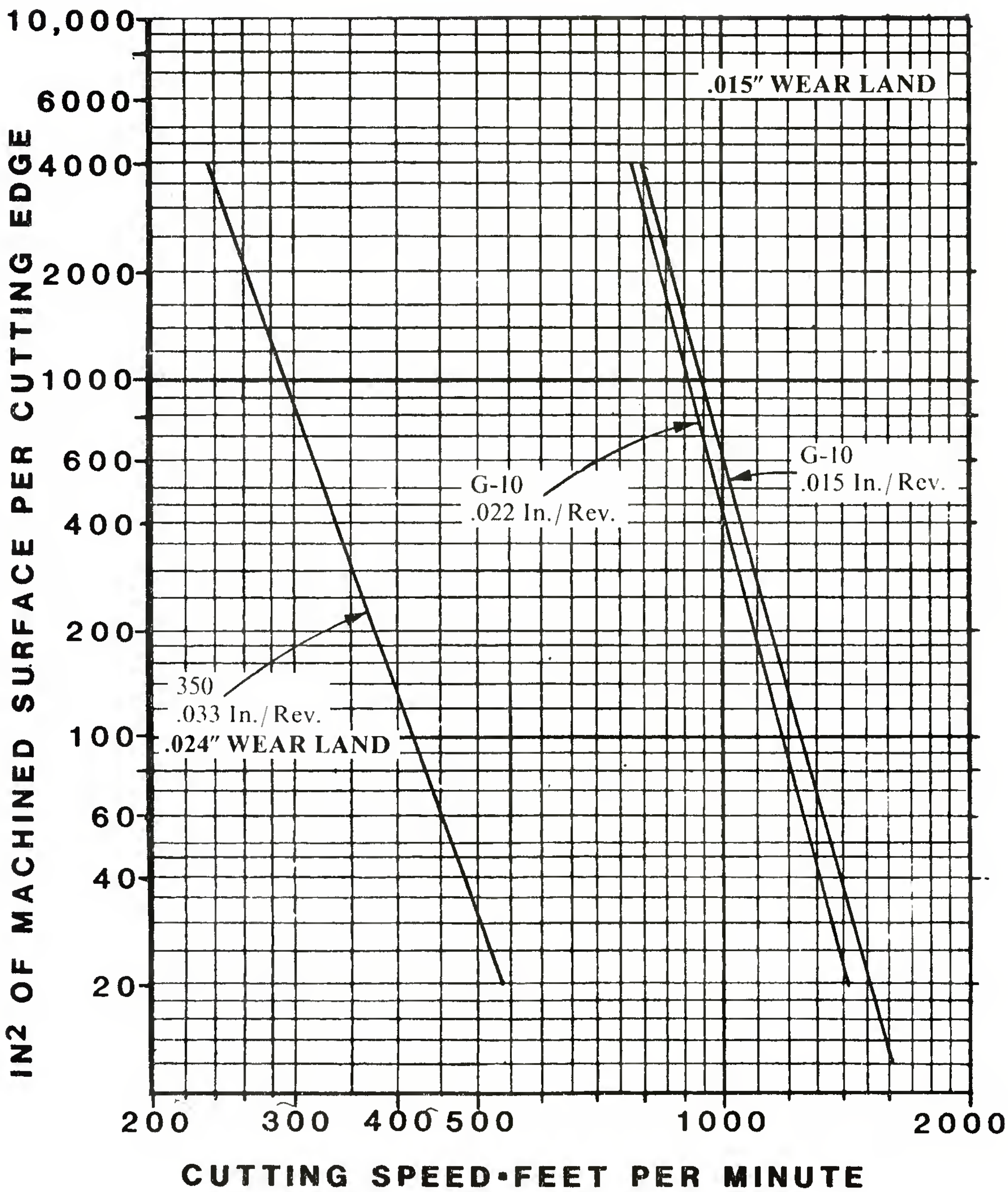

Figure 29: Tool-Life Lines of Listed Cutting Materials on AISI 4140 Steel at 311/321 Brinell Hardness for Listed Feed-Rates.

Depth of Cut - .100 Inches
Tool Holder - CCGNR-164 (0^0 Lead Angle)
Insert - CNG-454 .008 x 20^0 Grade G-10

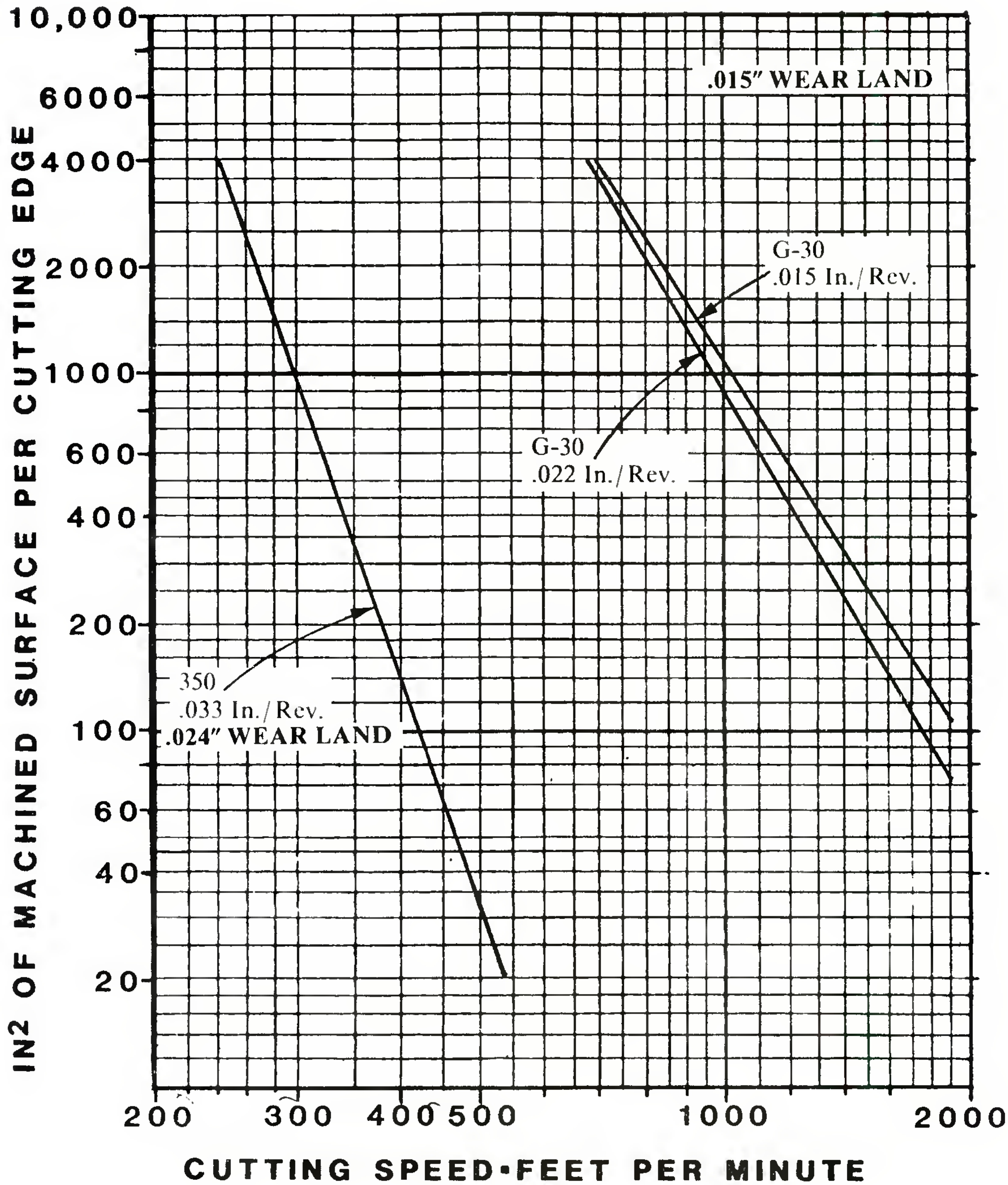

Figure 30: Tool-Life Lines of Listed Cutting Materials on AISI 4140 Steel at 302/321 Brinell Hardness for Listed Feed-Rates.

Depth of Cut - .100 Inches
Tool Holder - CCGNR-164 (0^0 Lead Angle)
Insert - CNG-454 .008 x 20^0 Grade G-30

Date: 3/5/80

Material: AISI 4140

Depth of Cut: .100

Coolant: TRIM-SOL 20:1

Hardness: 311/321 BHN

Tool Description:

Coolant Application: TOP

Holder: MTANR-164

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
1	350	750	.022	6.005	5.805	.700	–	–	TOO FAST	
2	"	650	"	"	"	.4	7.29	.021	8.33	.024
3	"	600	"	"	"	5.4	98	.047	50	.024
4	"	500	"	"	5.805	7.3	133	.018	177	.024
5	"	450	"	"	"	7.2	131			
5a	"	"	"	5.805	5.605	2.95	183	.014	183 313	TOTAL .024
5b	"	"	"	"	"	1.75	–	–		
6	"	400	"	"	"	16.4	288.8	.017	408	.024
				DECREASE FEED TO .015 IN/REV.						
7	350	750	.015	5.605	5.405	.4	–	–	TOO FAST	
8	"	700	"	"	"	.95	–	–	TOO FAST	
9	"	650	"	"	"	3.15	53.5	.035	36	.024

NOTES:

TABLE 14: DATA FOR LIFE LINES

Date: 3/5/80		**Material:** AISI 4140	
Depth of Cut: .100		**Coolant:** TRIM-SOL 20:1	
Hardness: 311/321 BHN		**Tool Description:**	
Coolant Application: TOP		**Holder:** MTANR-164	
		Insert: TNMG-433	

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
				HARDNESS CHECK - 321/311						
10	350	500	.015	5.605	5.405	11.8	200	.014	343	.024
11	"	600	"	5.405	5.205	5.6	91.6	.0145	152	.024
12	"	450	.025	"	"	.55	- WRONG FEED RATE -			
13	"	"	"	"	"	6.7	109.5	.023	114	.024
14	"	350	"	5.605	5.405	4.9	83.9			
14a	"	"	"	5.450	5.225	8.3	136.2			
14b	"	"	"	5.225	5.005	12.6	418	.015	670	.024

NOTES:

RUN 5b-TIP CRACKED
RUN 7 -CHIP DID NOT BREAK
RUN 8-BAD CHIP
RUN 9-BAD
RUN 10-BAD CHIP
RUN 11-BAD CHIP

TABLE 15: DATA FOR LIFE LINES

Date: 3/6/80 **Material:** AISI 4140

Depth of Cut: .100 **Coolant:** TRIM-SOL 20:1

Hardness: SEE CHART **Tool Description:**

Coolant Application: TOP **Holder:** MTANR-164

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
				HARDNESS CHECK 302/311 BHN						
1	350	400	.033	5.205	5.005	8.6	135	.022	147	.024
2	"	350	"	5.005	4.805	21.1	318	.016	477	.024
3	"	400	.047	4.805	4.605	1.0	14.5	.028	12.4	.024
4	"	300	"	"	"	19.9	290	.0175	397	.024
				HARDNESS CHECK - 302 BHN			3/7/80			
1	KC-810	400	.033	4.640	4.425	20.9	290	.0145	480	.024
2	"	450	.015	4.425	4.225	20.85	276	.006	1106	.024
3	"	"	.033	4.225	4.025	20.8	263	.021	300	.024

NOTES: RUN NO. 2 (KC-810) GOOD CHIP CONDITION

TABLE 16 : DATA FOR LIFE LINES

Date: 3/10/80

Material: AISI 4140

Depth of Cut: .100

Coolant: TRIM-SOL 20:1

Hardness: 321 BHN - INITIAL

Tool Description:

Coolant Application: TOP

Holder: MTANR-164

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
1	570	450	.033	5.985	5.700	21.5	385	.016	577	.024
2	"	500	"	5.700	5.601	11.5	202.5	.0165	294	.024

NOTES:

TABLE 17 : DATA FOR LIFE LINES

Date: 3/10/80		**Material:** AISI 4140	
Depth of Cut: .100		**Coolant:** TRIM-SOL 20:1	
Hardness: 321 BHN		**Tool Description:**	
Coolant Application: TOP		**Holder:** CCGNR-164	
		Insert: CNG-454 - .008 x 20^{o} Grade G-10 Hot Press Ceramic	

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
1	G-10	1200	.015	5.700	5.605	10	176	.004		
1a	"	"	"	5.605	5.400	12.6	213.7	-	TOOL FAILED	
2	"	1000	"	"	"	8.9	151			
2a	"	"	"	5.400	5.207	15.4	403	.008	755	.015
3	"	1100	"	"	"	6.1				
3a	"	"	"	5.207	5.005	10.4	163.5	.008	305	.015
4	"	1400	"	5.205	5.010	11.0	173	-	TOOL FAILED	
				HARDNESS CHECK - 302 BHN						
5	G-10	1000	.022	5.010	4.808	9.6	145	.005	435	.015
5a	"	"	"	"	"	7.3	-	-	FLANK OF TOOL CHIPPED OUT	
6	"	850	.022	5.040	"	4.5	-	-		
6a	"	"	"	4.808	4.608	.5	-	-	COMPLETE FAILURE	
7	"	"	"	"	"	18.9	273.6			

NOTES:

TABLE 18 : DATA FOR LIFE LINES

Date: 3/10/80

Depth of Cut: .100

Hardness: 321 BHN

Coolant Application: TOP

Material: AISI 4140

Coolant: TRIM-SOL 20:1

Tool Description:

Holder: CCGNR-164

Insert: CNG-454 - .008 x 20° Grade G-10 Hot Press Ceramic

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
7a	G-10	850	.022	4.608	4.410	15.3	485	.005	1456	.015

NOTES:

TABLE 19 : DATA FOR LIFE LINES

Date:	5/12/80	**Material:**	AISI 4140
Depth of Cut:	.100	**Coolant:**	NONE
Hardness:	302/321 BHN	**Tool Description:**	
Coolant Application:		**Holder:**	CCGNR-164
		Insert:	CNG-454 - .008 x 20°

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
1	G-30	1000	.015	5.930	5.730	5.12	92.2			
1a	"	"	"	5.730	5.530	5.06	87.9	.006		
1b	"	"	"	5.530	5.330	21.75	544.3	.008	1020	.015
2	"	1100	"	5.330	5.130	21.62	348.5	.008	653	.015
3	"	1400	"	5.130	4.930	9.75	151	.0065	348	.015
			FEED CHANGE - NEW BAR 317/321 BHN							
4	G-30	1200	.022	6.005	5.800	8.5	154.8	.006	387.2	.015
5	"	1400	"	"	"	5.625	102.5	.0055	279.5	.015
6	"	900	"	"	"	7-5/8	140			
6a	"	"	"	5.800	5.600	21.62	520.2	.0058	134.4	.015

NOTES:

TABLE 20: DATA FOR LIFE LINES

TOOL LOAD VERSUS DEPTH OF CUT

Material: AISI 4140 **Holder:** 0^{0} LEAD ANGLE

Hardness: 302/321 BHN **Insert:** TNMG-433

Feed Rate: .033 IN./REV. **Grade:** 350

Surface Speed: 280 FT./MIN. **Coolant:** TRIM-SOL 20:1 TOP

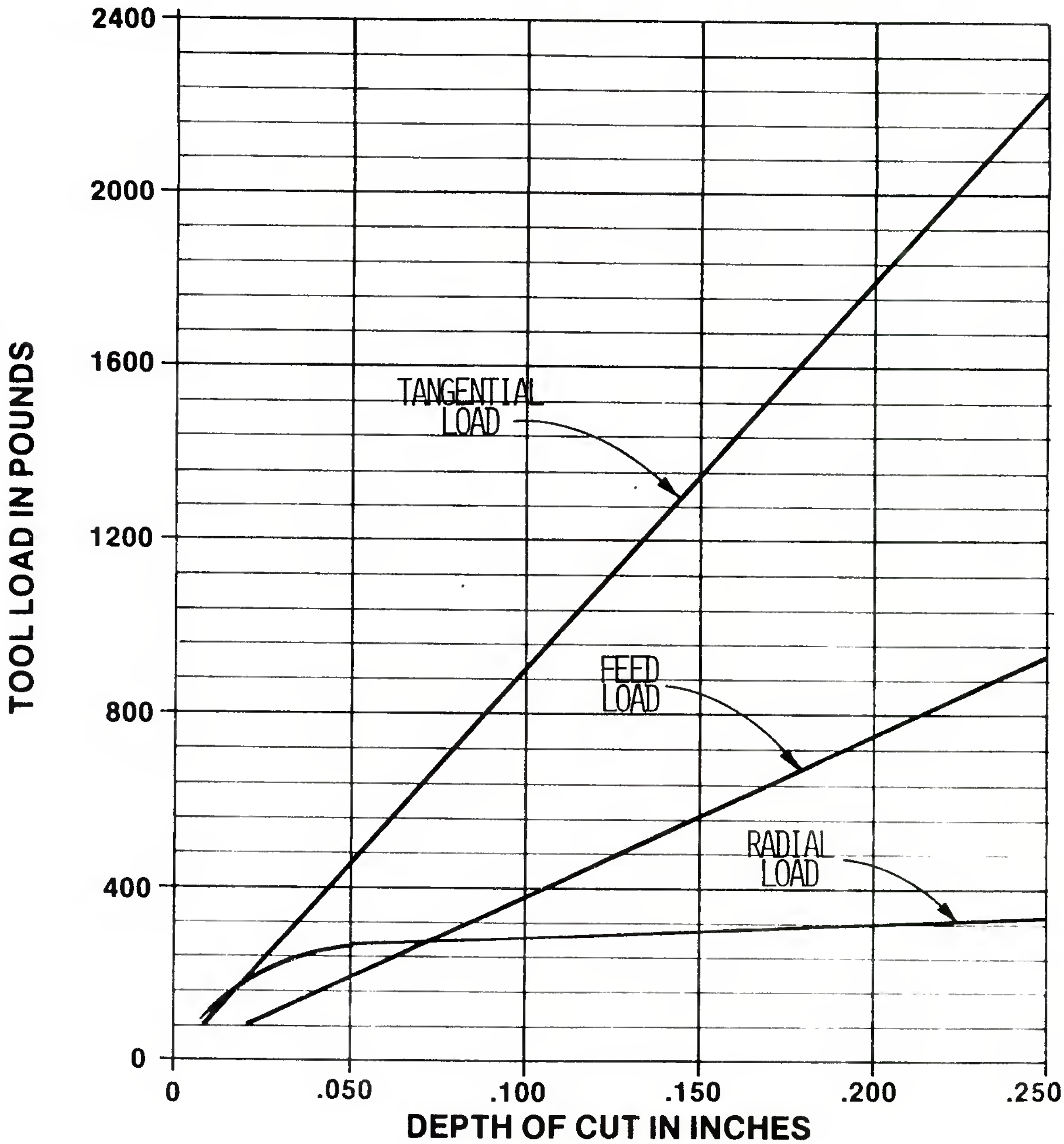

Figure 31: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material: AISI 4140

Hardness: 302/321 BHN

Feed Rate: .033 IN./REV.

Surface Speed: 340 FT./MIN.

Holder: 0° LEAD ANGLE

Insert: TNMG-433

Grade: KC-810

Coolant: TRIM-SOL 20:1 TOP

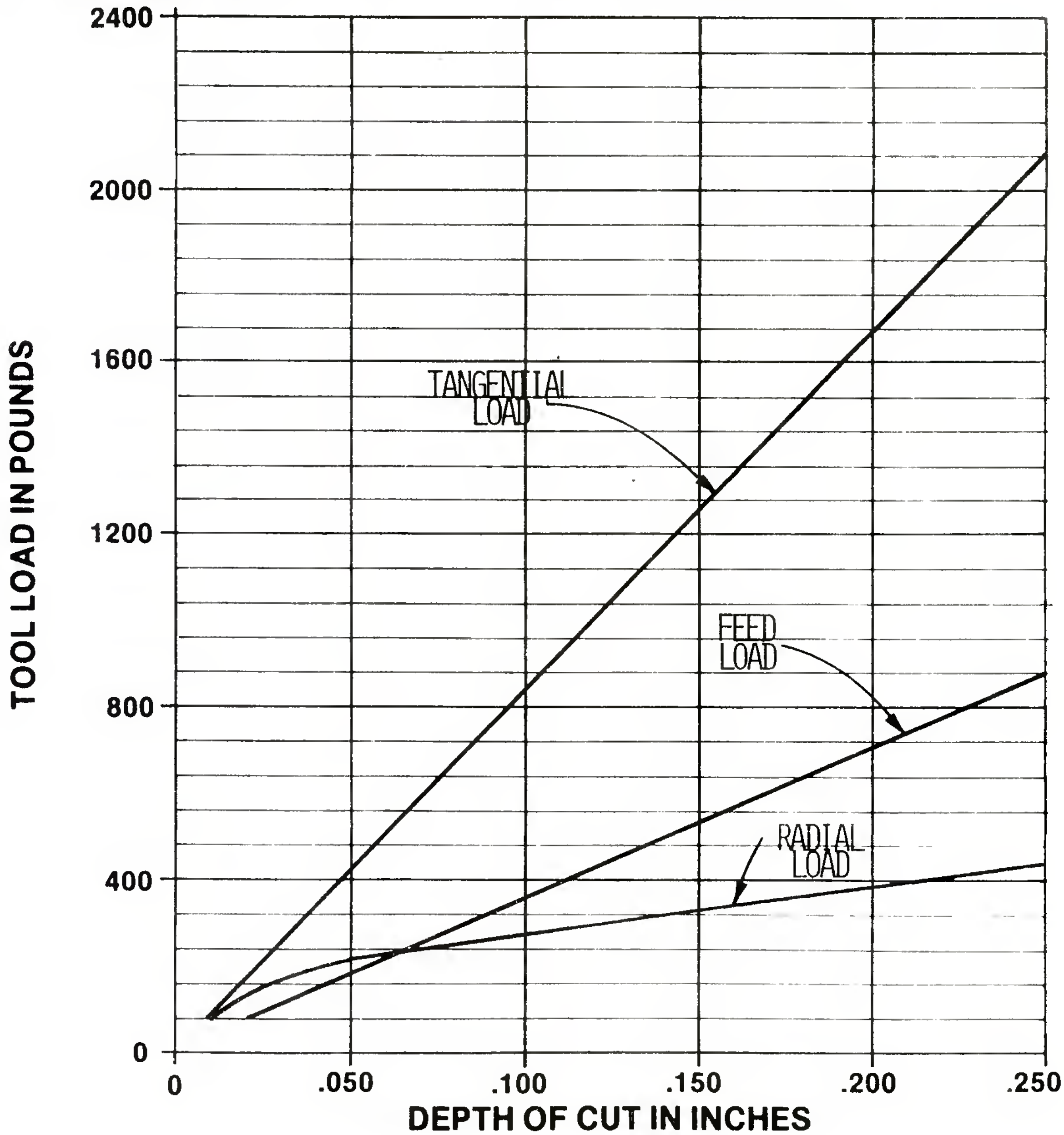

Figure 32: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material:	AISI 4140	**Holder:**	0° LEAD ANGLE
Hardness:	302/321 BHN	**Insert:**	TNMG-433
Feed Rate:	.033 IN./REV.	**Grade:**	570
Surface Speed:	370 FT./MIN.	**Coolant:**	TRIM-SOL 20:1 TOP

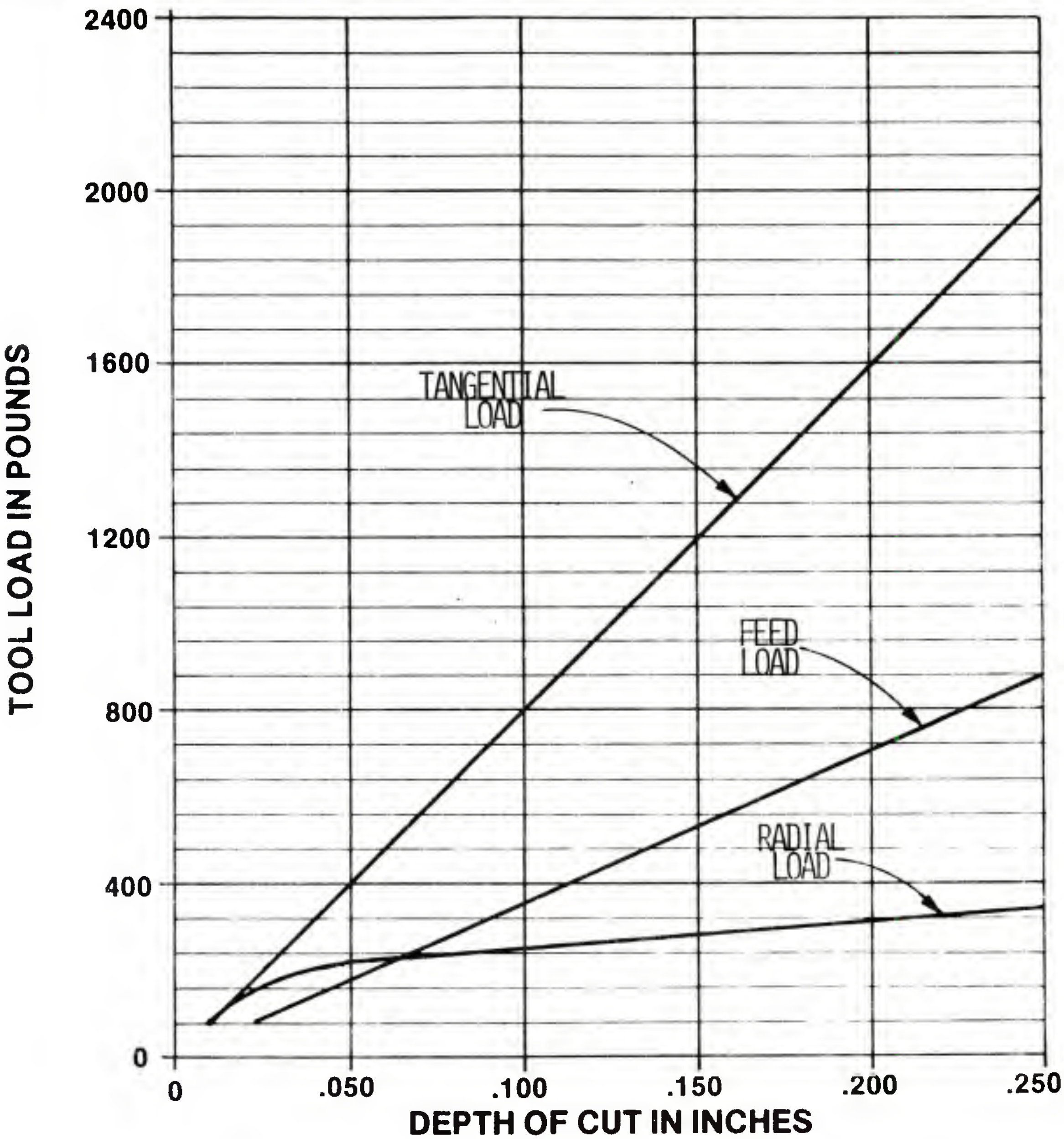

Figure 33: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material: AISI 4140 **Holder:** 0° LEAD ANGLE

Hardness: 302/321 BHN **Insert:** CNG-454 820

Feed Rate: .022 IN./REV. **Grade:** G-10

Surface Speed: 800 FT./MIN. **Coolant:** TRIM-SOL 20:1 TOP

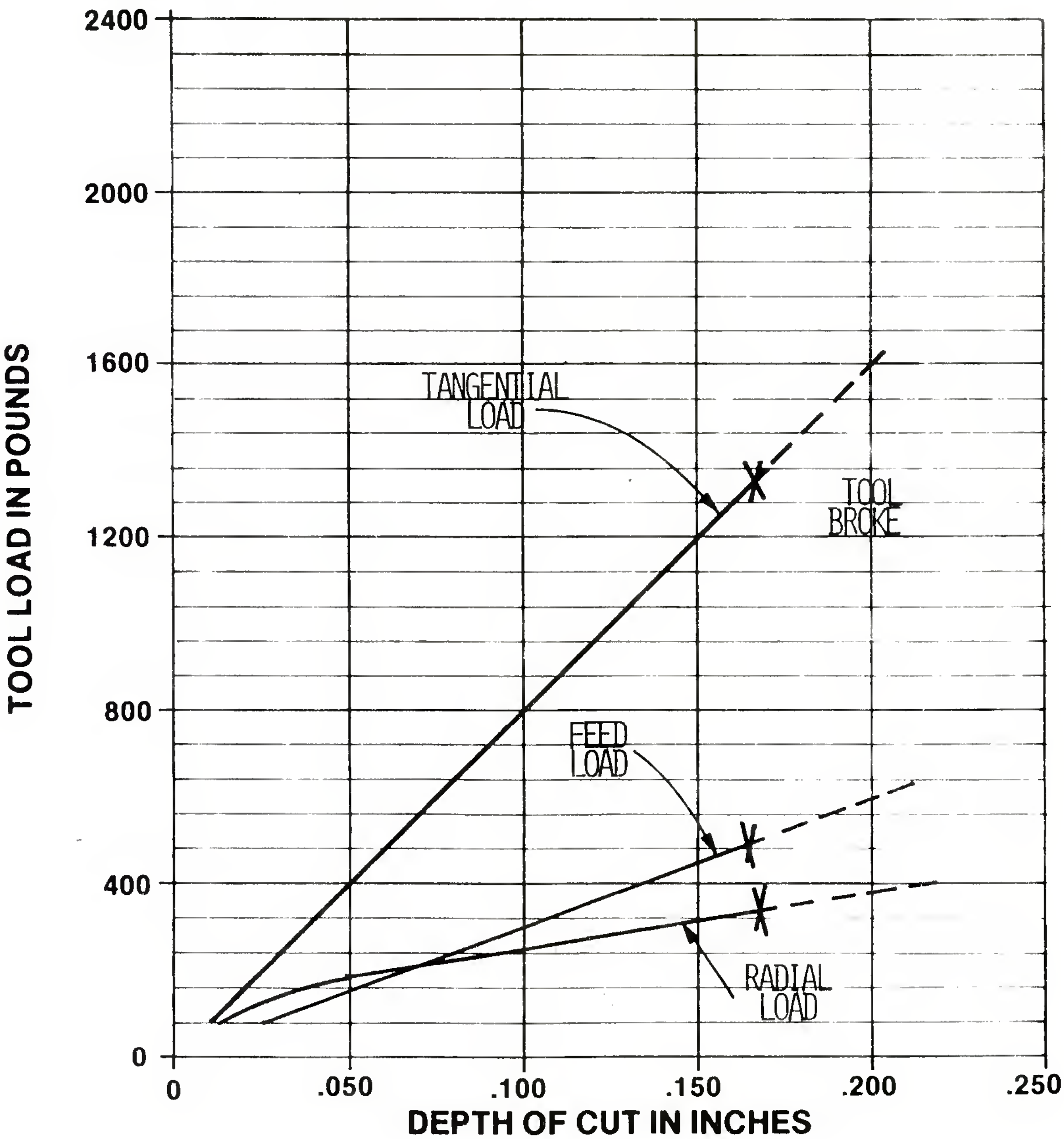

Figure 34: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material: AISI 4140 **Holder:** 0° LEAD ANGLE

Hardness: 302/321 BHN **Insert:** CNG-454 820

Feed Rate: .022 IN./REV. **Grade:** G-30

Surface Speed: 780 FT./MIN. **Coolant:** NONE

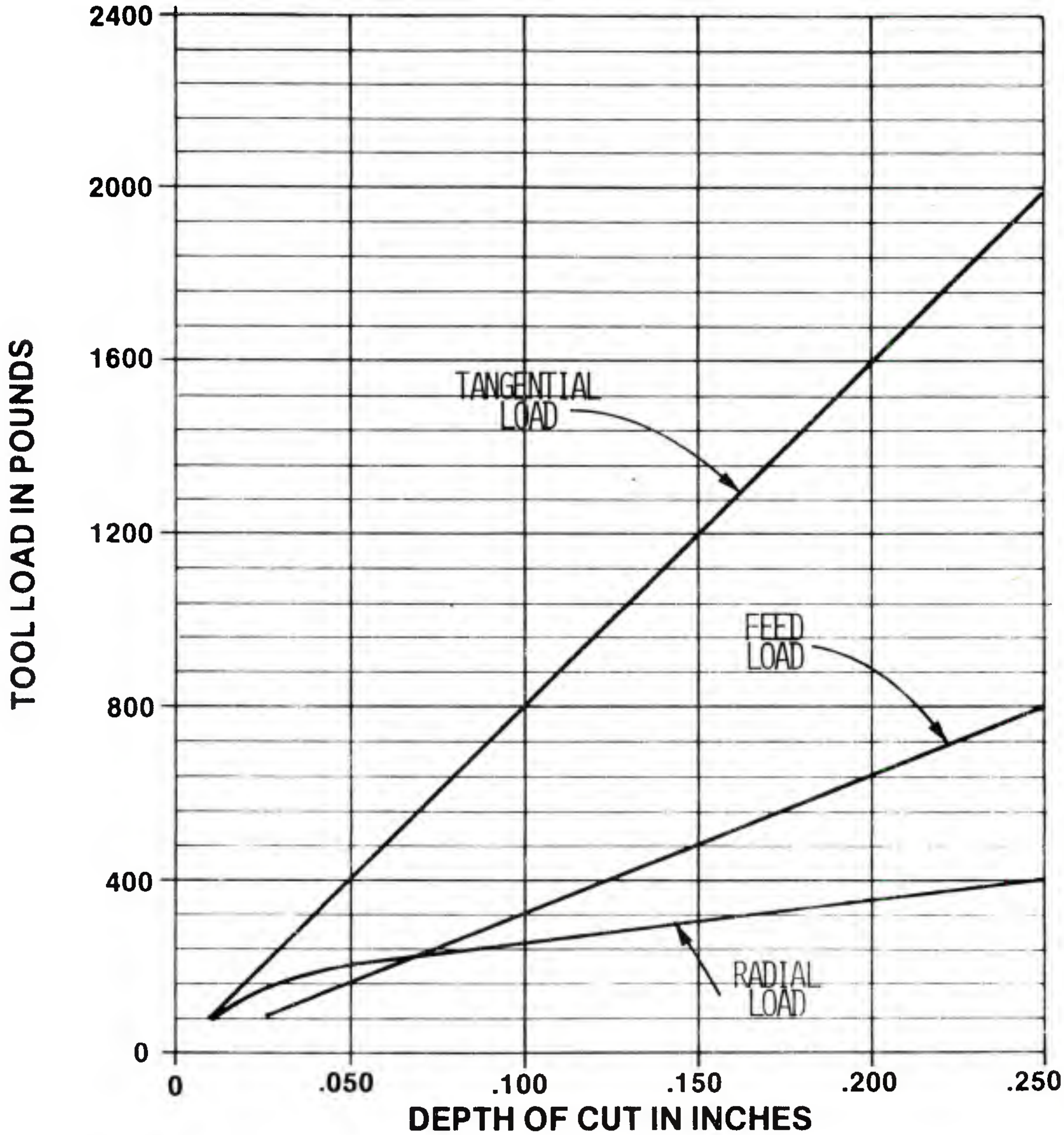

Figure 35: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material: AISI 4140

Hardness: 302/321 BHN

Feed Rate: .015 IN./REV.

Surface Speed: 850 FT./MIN.

Holder: 0° LEAD ANGLE

Insert: CNG-454 820

Grade: G-10

Coolant: NONE

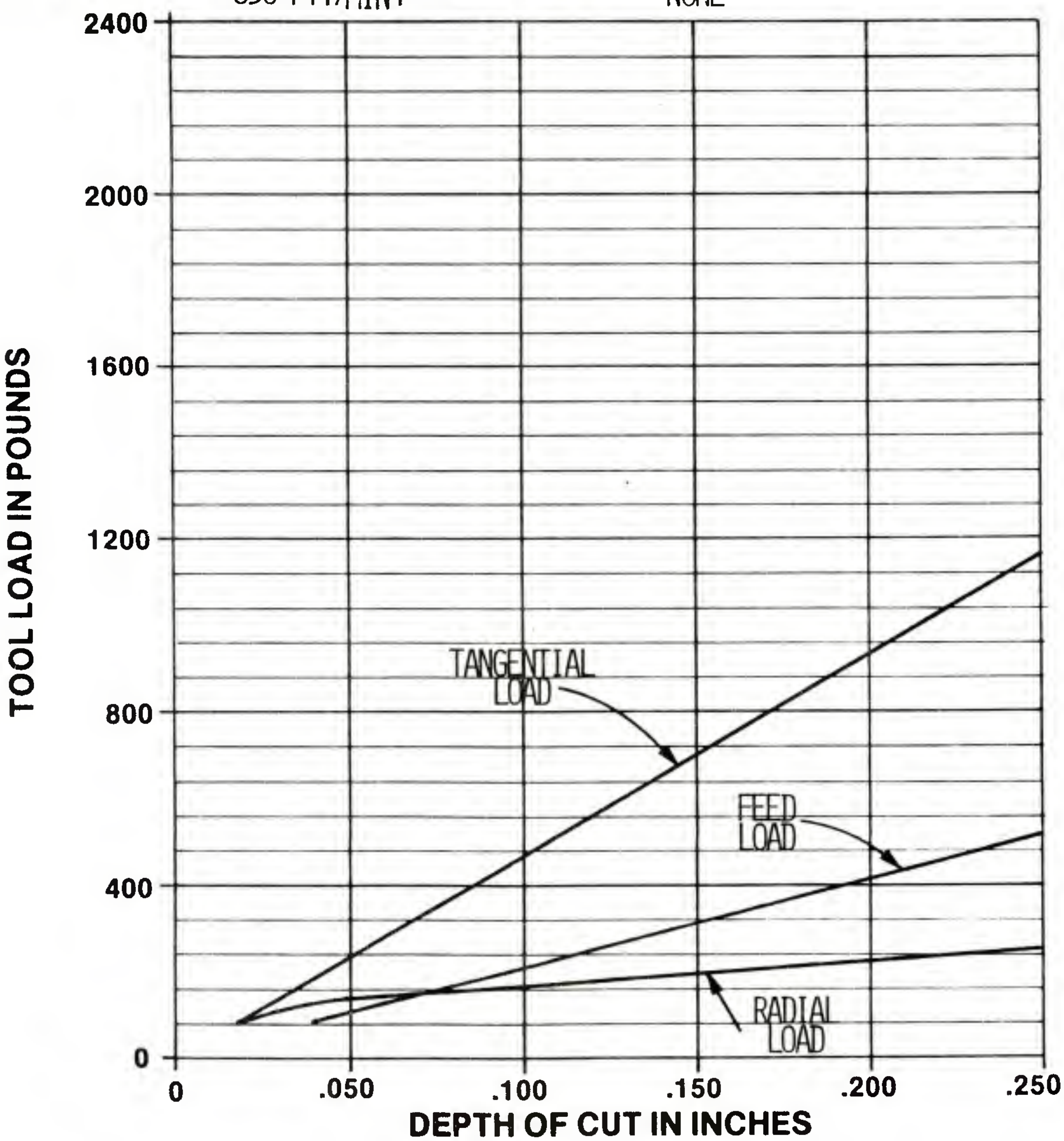

Figure 36: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material:	AISI 4140	**Holder:**	0° LEAD ANGLE
Hardness:	302/321 BHN	**Insert:**	CNG-454 2020
Feed Rate:	.015 IN./REV.	**Grade:**	G-10
Surface Speed:	850 FT./MIN.	**Coolant:**	NONE

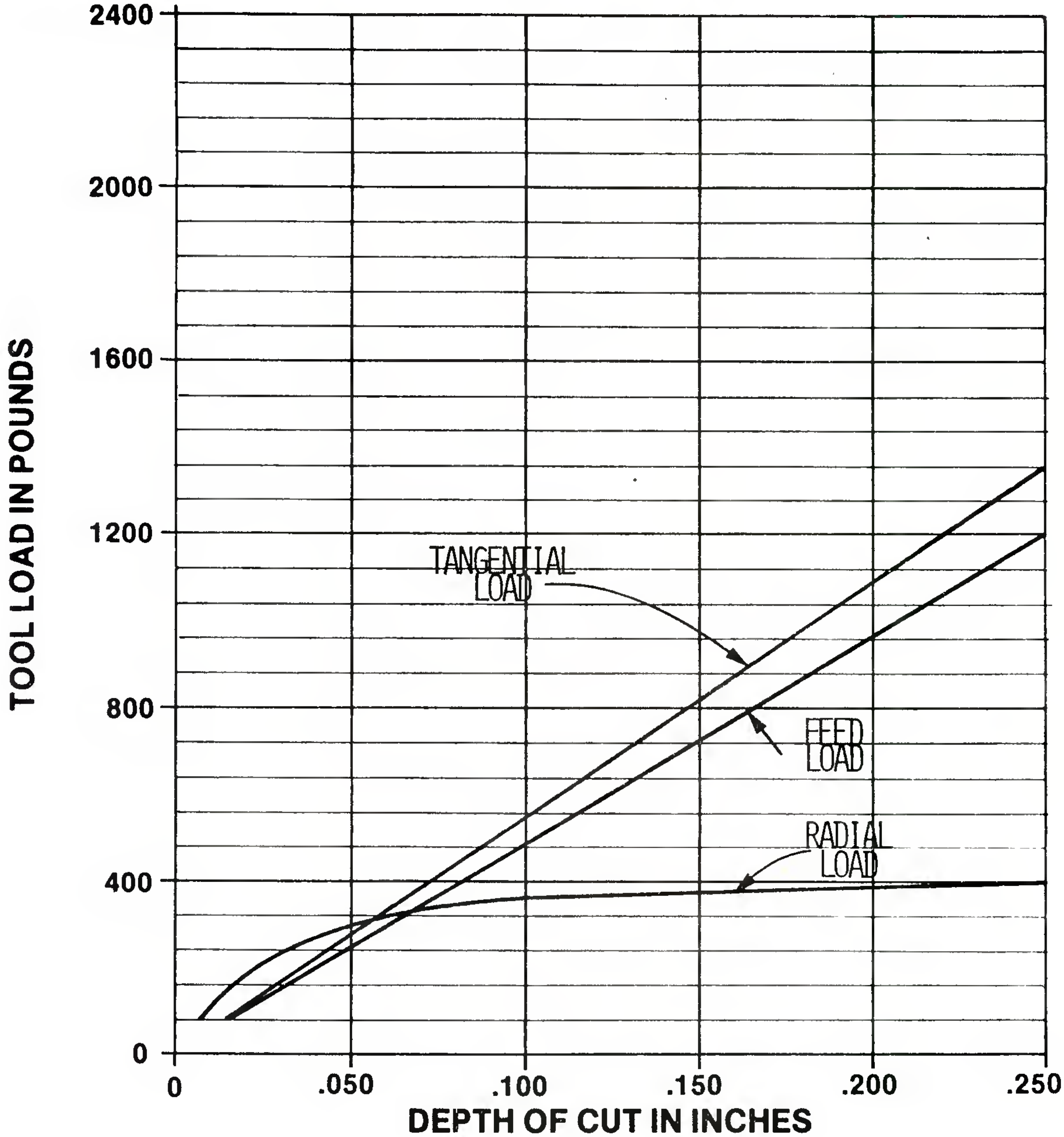

Figure 37: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material: AISI 4140 **Holder:** 0^{0} LEAD ANGLE

Hardness: 302/321 BHN **Insert:** CNG-454 2020

Feed Rate: .015 IN./REV. **Grade:** G-30

Surface Speed: 750 FT./MIN. **Coolant:** NONE

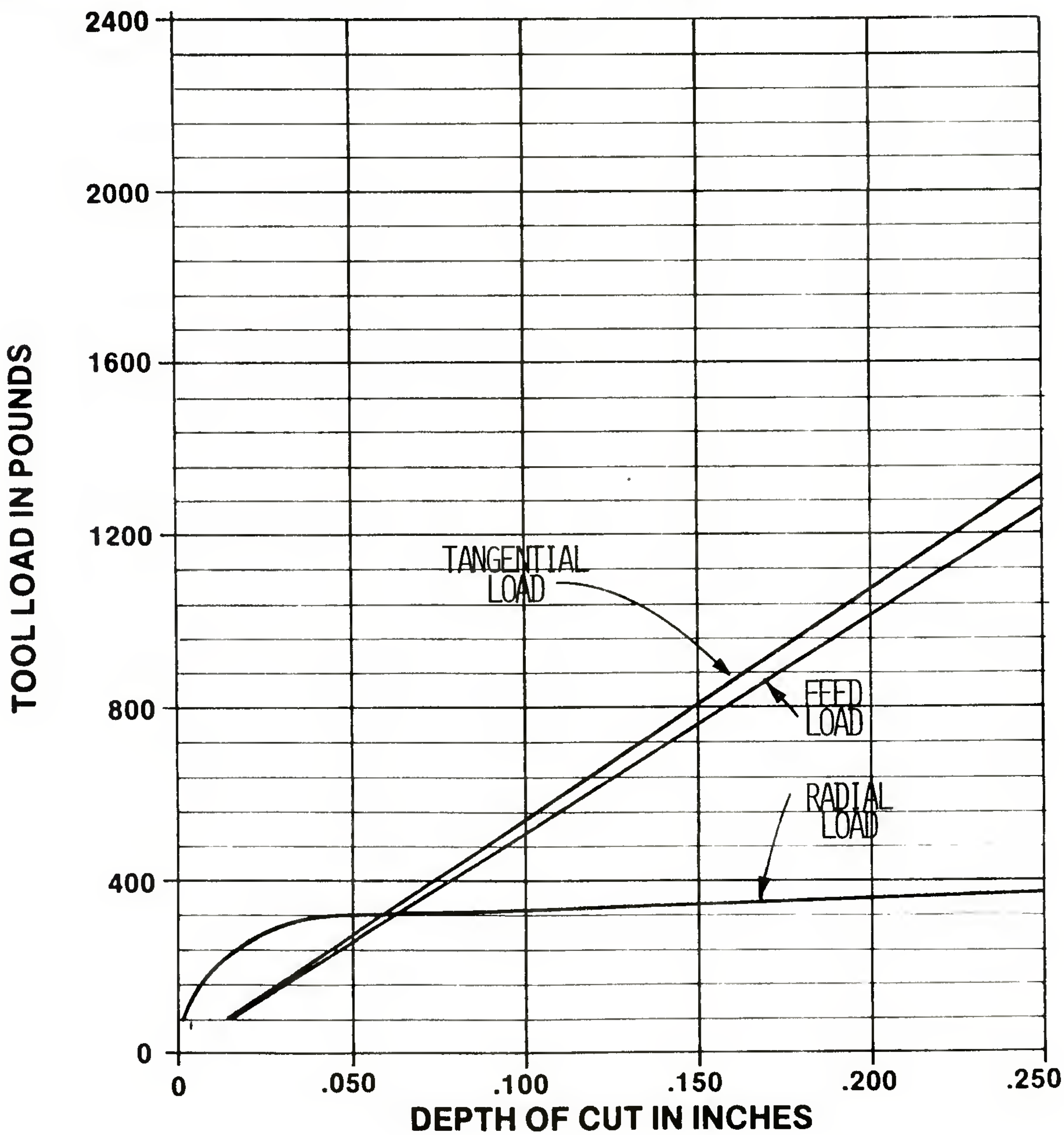

Figure 38: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material: AISI 4140 | **Holder:** 0° LEAD ANGLE

Hardness: 302/322 BHN | **Insert:** SEE BELOW

Feed Rate: .015 IN./REV. | **Grade:** G-10

Surface Speed: 850 FT./MIN. | **Coolant:** NONE

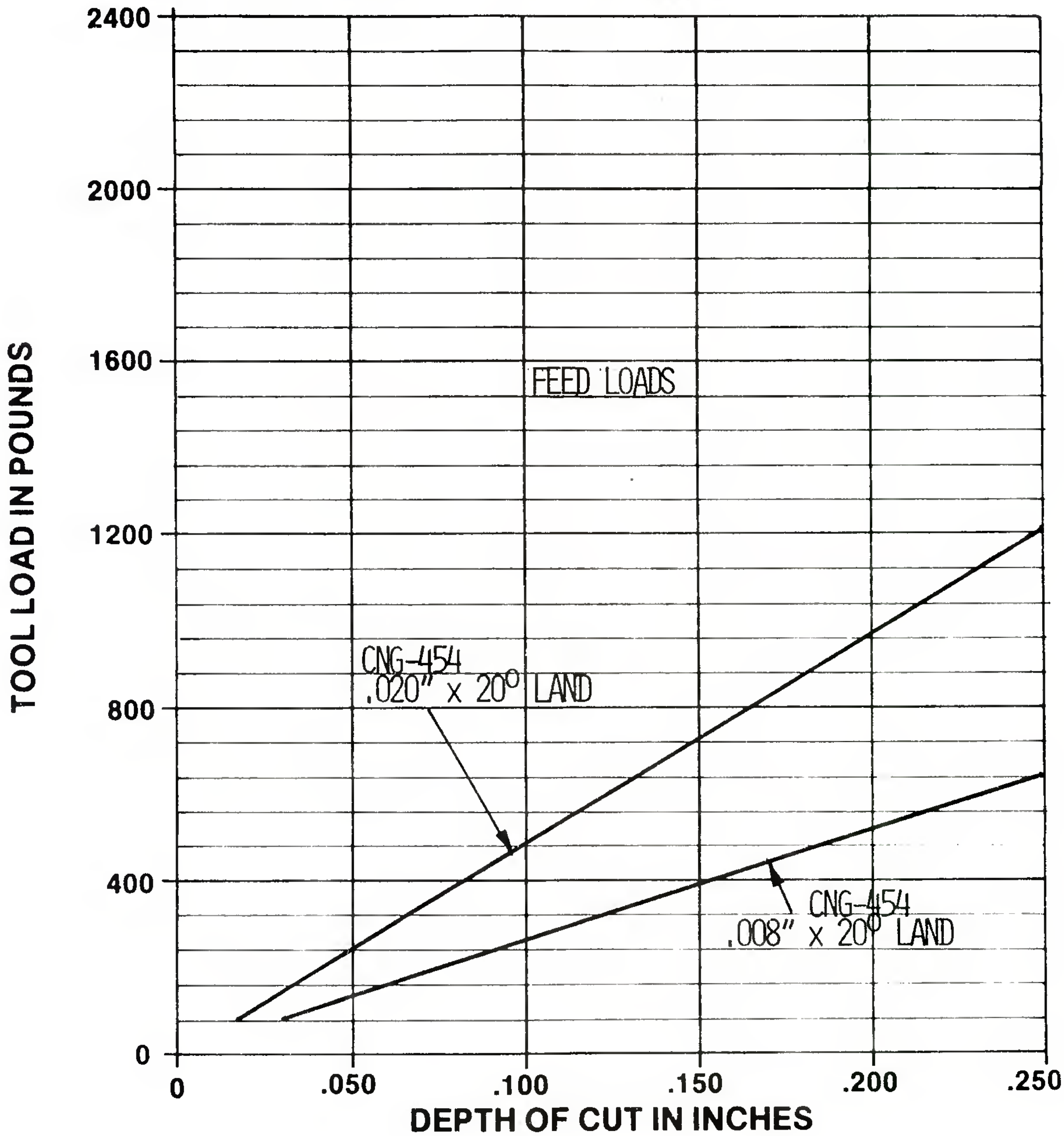

Figure 39: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material: AISI 4140 **Holder:** 0^{o} LEAD ANGLE

Hardness: 302/321 BHN **Insert:** SEE BELOW

Feed Rate: .015 IN./REV. **Grade:** G-10

Surface Speed: 850 FT./MIN. **Coolant:** NONE

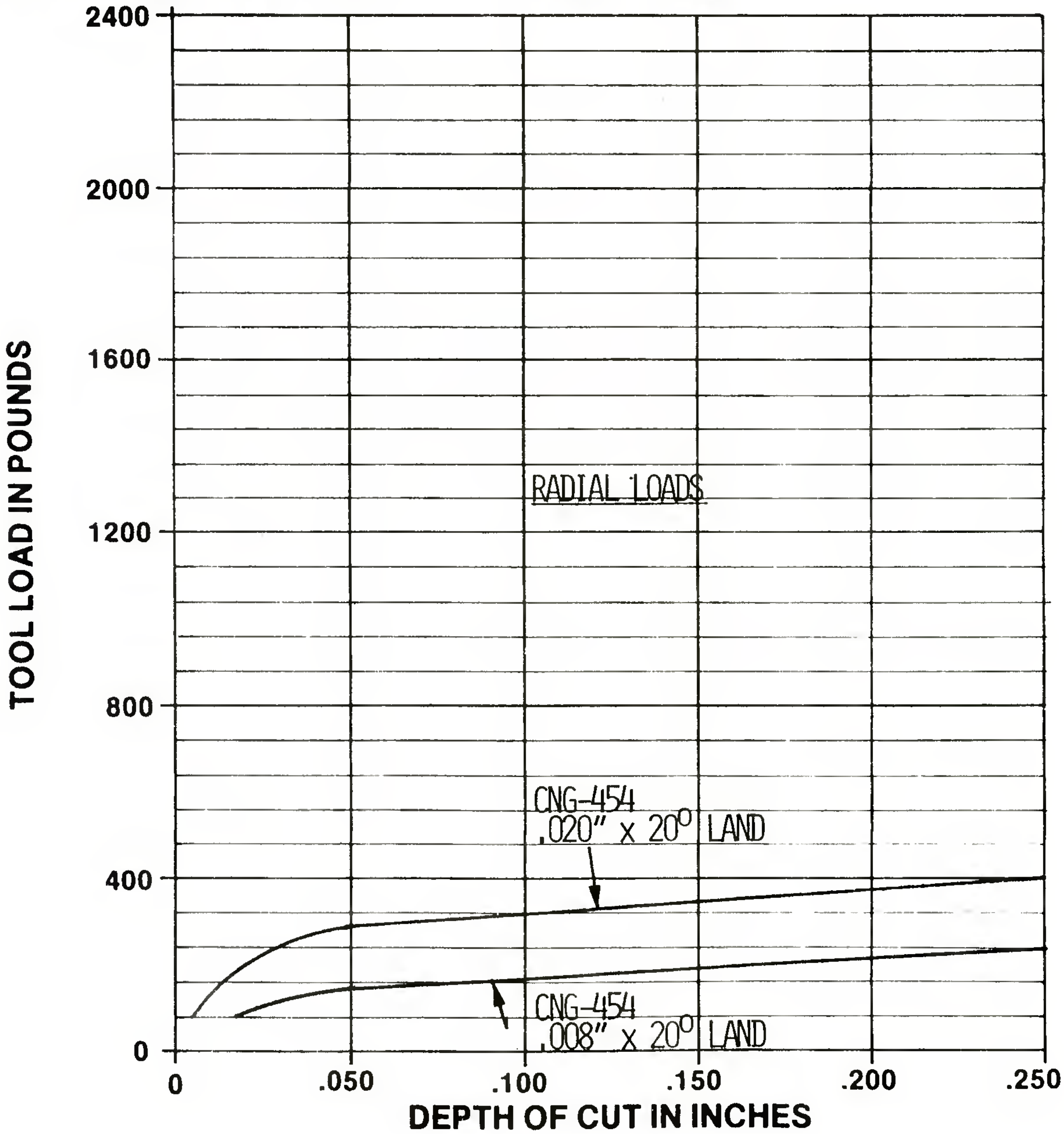

Figure 40: **TOOL LOAD CHART**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4140 **HARDNESS:** 302/321 BHN

INSERT: TNMG-433 **SURFACE FEED:** 280 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: 350 **FEEDRATE:** .033 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	460	160	220
.100	880	320	240
.150	1400	570	300
.200	1750	760	340

INSERT: TNMG-433 **SURFACE FEED:** 340 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: KC-810 **FEEDRATE:** .033 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	400	220	200
.100	800	480	270
.150	1300	640	340
.200	1700	840	360

INSERT: TNMG-433 **SURFACE FEED:** 370 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: 570 **FEEDRATE:** .033 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	400	150	230
.100	800	310	270
.150	1240	550	310
.200	1600	700	330

TABLE 21: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4140 **HARDNESS:** 302/321 BHN

INSERT: CNG-454 .008 x 20° **SURFACE FEED:** 800 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: G-10 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	395	110	200
.100	810	285	250
.150	1200	480	310
.200	X	X	X

INSERT: CNG-454 .008 x 20° **SURFACE FEED:** 780 FT./MIN. **COOLANT:** NONE
GRADE: G-30 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	380	115	200
.100	800	290	260
.150	1220	490	310
.200	1610	675	350

INSERT: CNG-454 .020 x 20° **SURFACE FEED:** 850 FT./MIN. **COOLANT:** NONE
GRADE: G-10 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	280	200	300
.100	575	500	340
.150	835	740	360
.200	1050	960	375

TABLE 22: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4140 **HARDNESS:** 302/321 BHN

INSERT: CNG-454 .008 x 20° **SURFACE FEED:** 850 FT./MIN. **COOLANT:** NONE

GRADE: G-10 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	240	100	135
.100	475	240	170
.150	700	375	195
.200	920	520	220

INSERT: CNG-454 .020 x 20° **SURFACE FEED:** 750 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	290	230	320
.100	560	520	330
.150	820	770	340
.200	1040	1005	355

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050			
.100			
.150			
.200			

TABLE 23: **DATA FOR TOOL LOAD CHARTS**

WEARLAND VERSUS LEAD ANGLE OF TOOLHOLDER

MATERIAL: AISI 4140
FEED RATE: .033 IN./REV.
HARDNESS: 302/311 BHN
HOLDER: SEE CHART
SURFACE SPEED: 280 FT./MIN.
INSERT: -
GRADE: 350

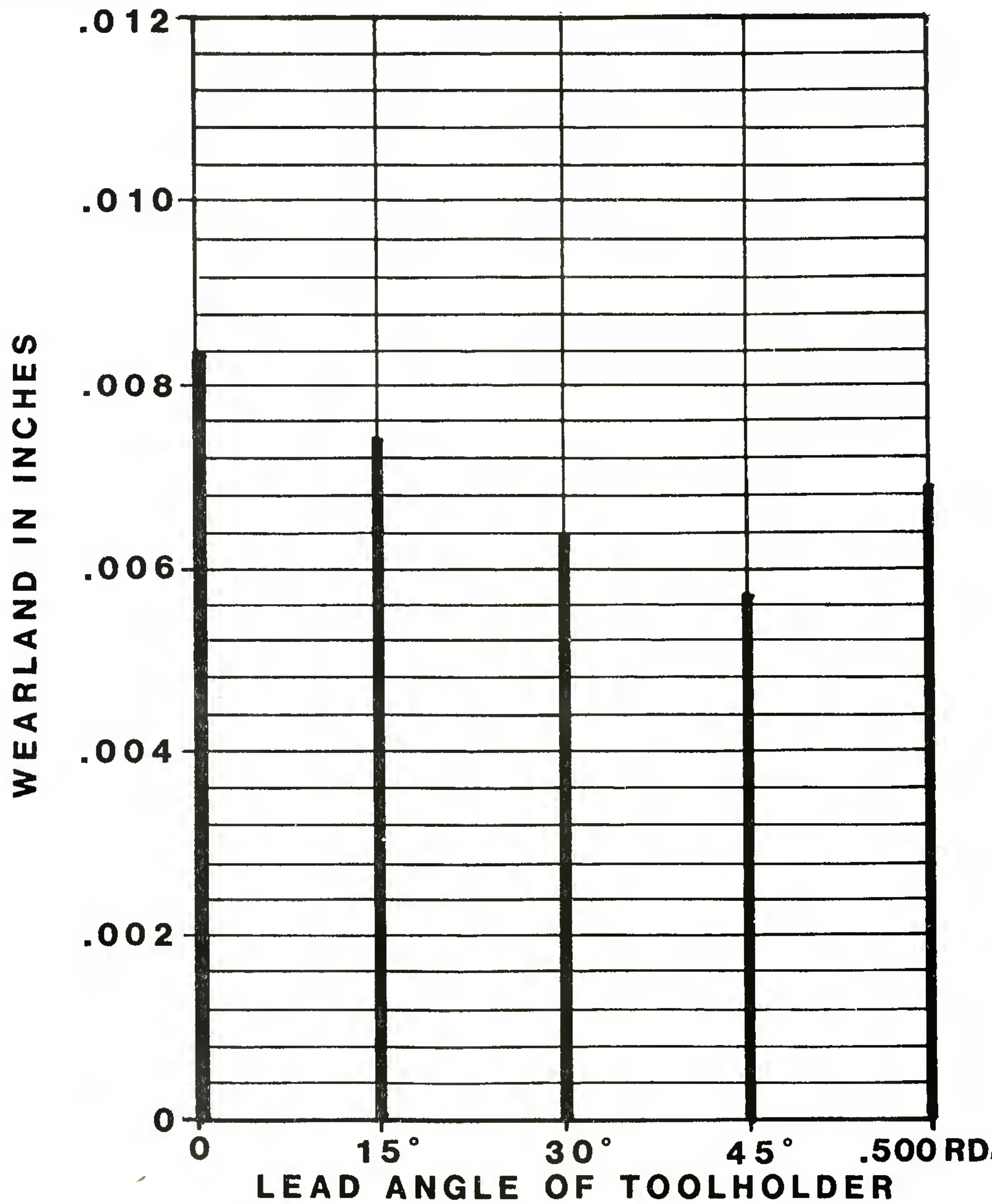

FIGURE 41 **WEARLAND FOR LISTED CUTTING MATERIAL**

WEARLAND VERSUS LEAD ANGLE OF TOOLHOLDER

MATERIAL: AISI 4140
HARDNESS: 293/302 BHN
SURFACE SPEED: 340 FT./MIN.
FEED RATE: .033 IN./REV.
HOLDER: SEE CHART
INSERT: -
GRADE: KC-810

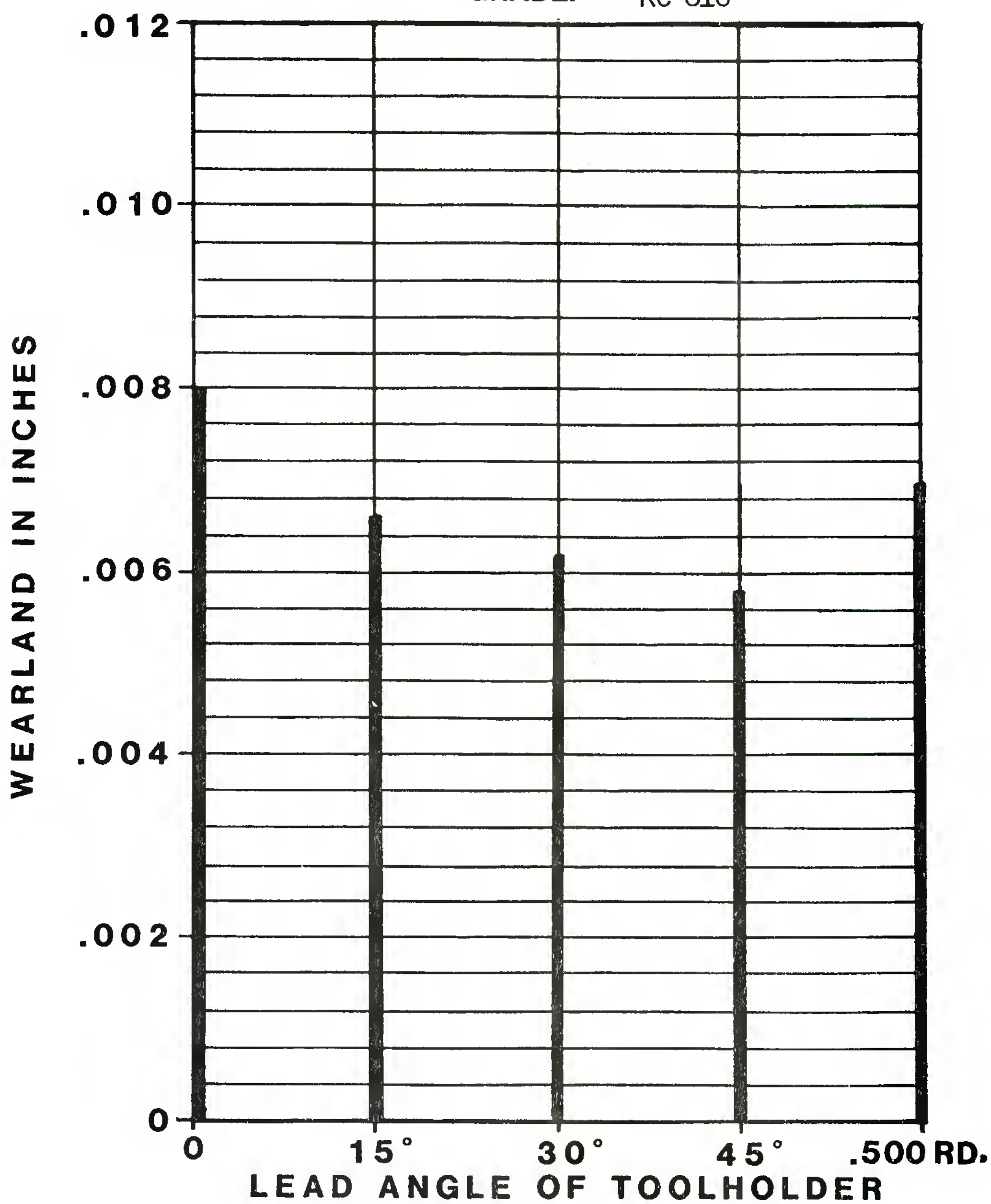

FIGURE 42 **WEARLAND FOR LISTED CUTTING MATERIAL**

WEARLAND VERSUS LEAD ANGLE OF TOOLHOLDER

MATERIAL: AISI 4140 **FEED RATE:** .033 IN./REV.

HARDNESS: 302 BHN **HOLDER:** SEE CHART

SURFACE SPEED: 370 FT./MIN. **INSERT:** -

GRADE: 570

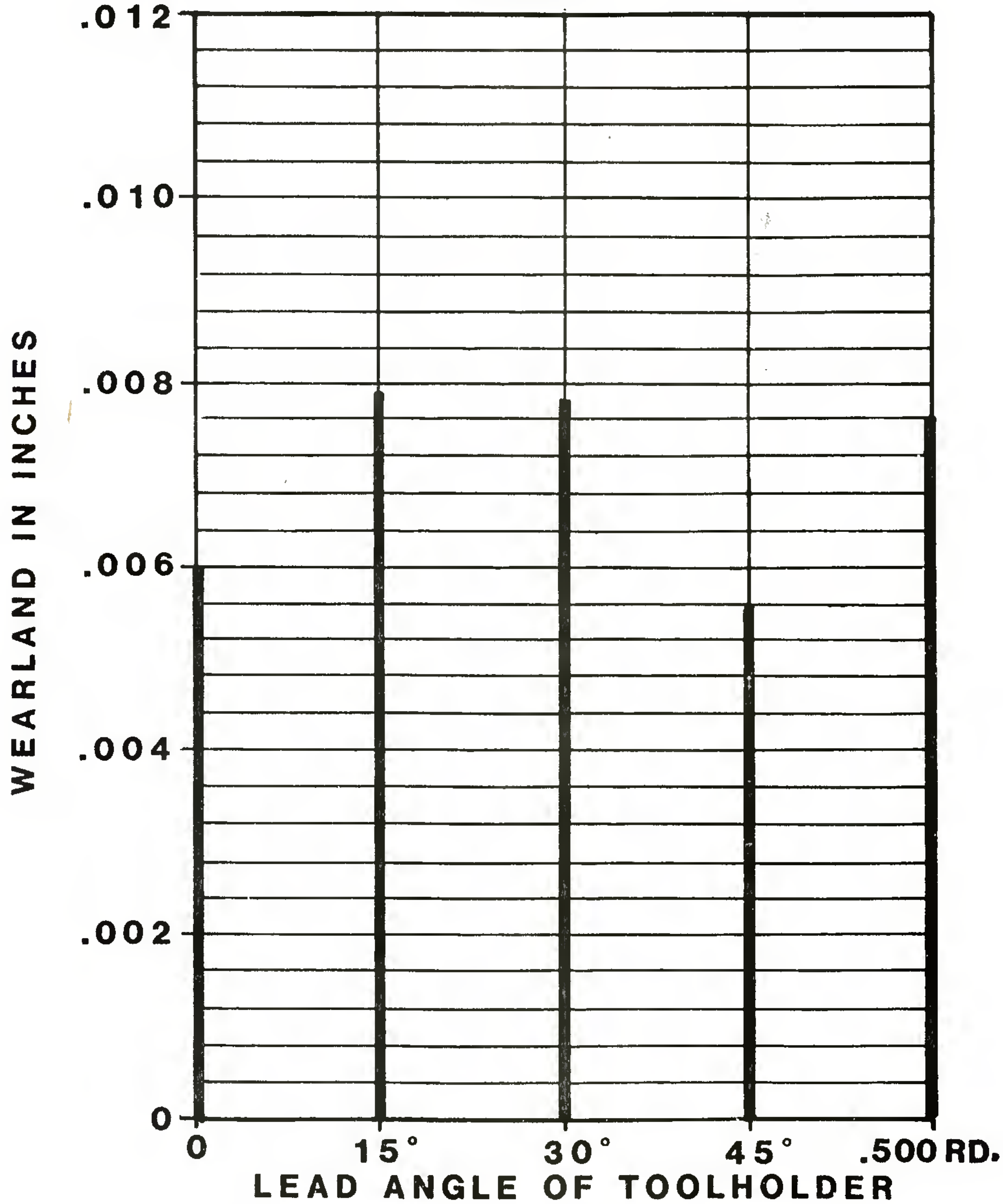

FIGURE 43 **WEARLAND FOR LISTED CUTTING MATERIAL**

WEARLAND VERSUS LEAD ANGLE OF TOOLHOLDER

MATERIAL: AISI 4140 **FEED RATE:** .022 IN./REV.

HARDNESS: 302/311 BHN **HOLDER:** SEE CHART

SURFACE SPEED: 850 FT./MIN. **INSERT:** -

GRADE: G-10

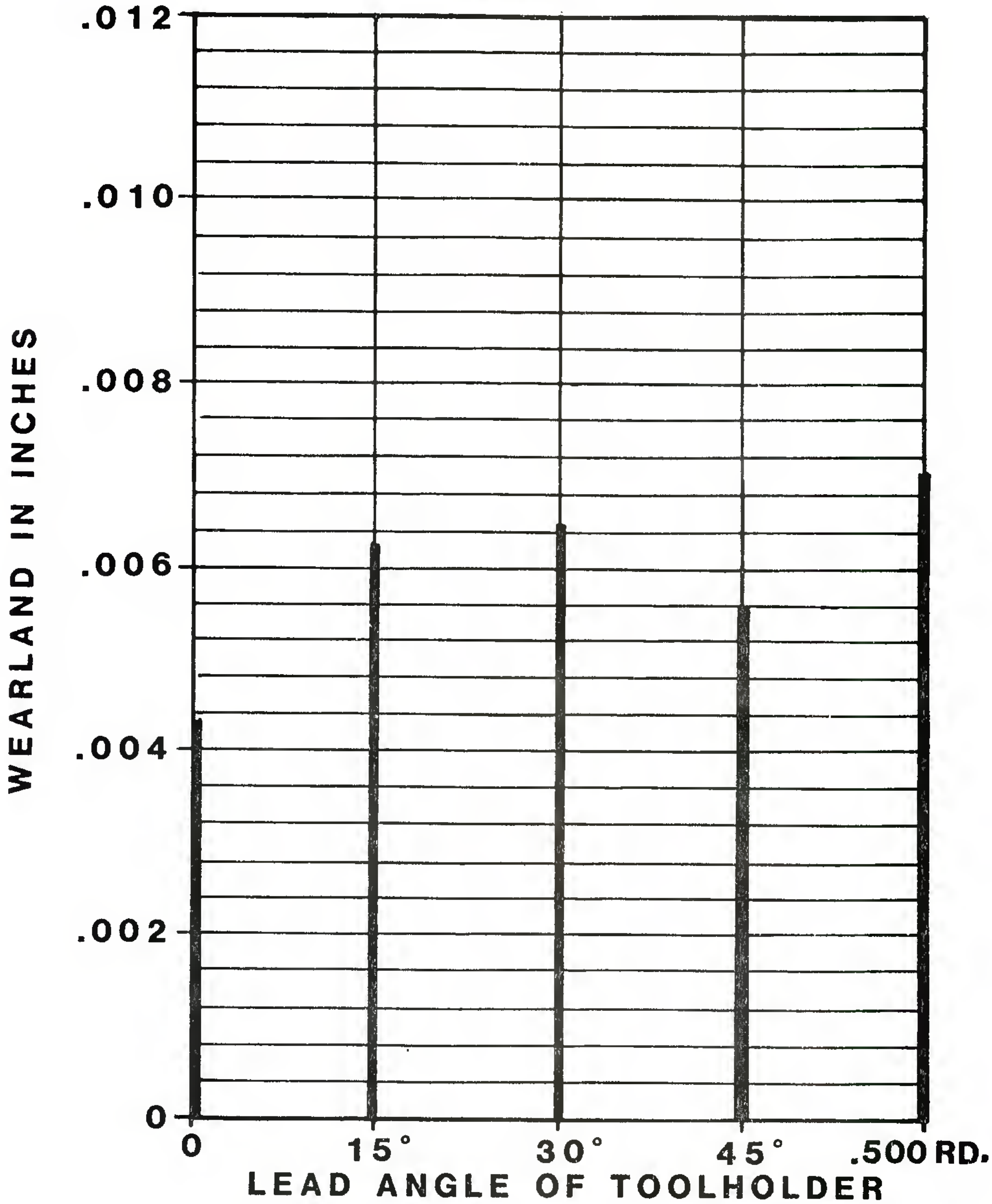

FIGURE 44 **WEARLAND FOR LISTED CUTTING MATERIAL**

WEARLAND VERSUS LEAD ANGLE OF TOOLHOLDER

MATERIAL: AISI 4140
HARDNESS: 302/311 BHN
SURFACE SPEED: 750 FT./MIN.

FEED RATE: .015 IN./REV.
HOLDER: SEE CHART
INSERT: -
GRADE: G-30

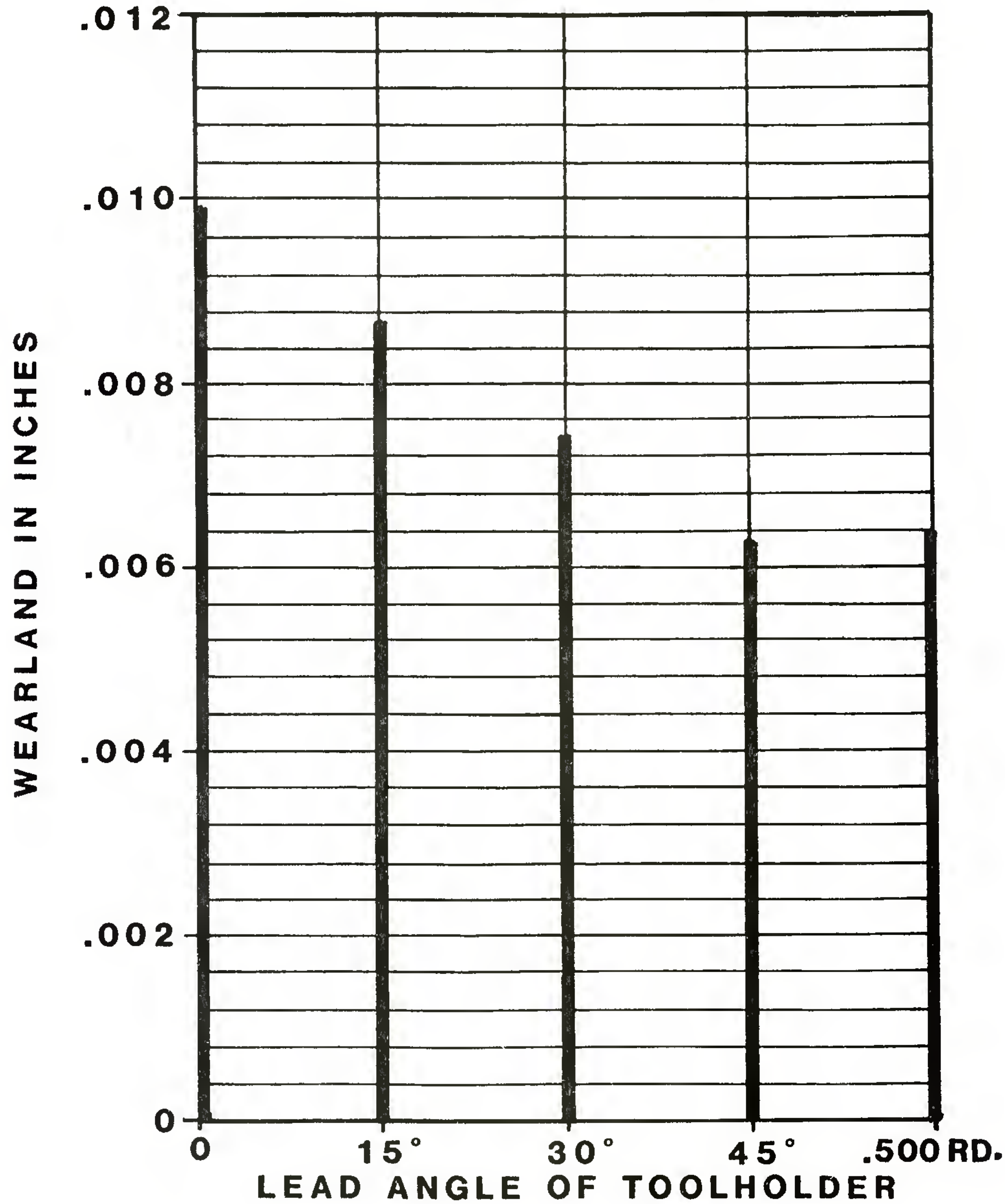

FIGURE 45 **WEARLAND FOR LISTED CUTTING MATERIAL**

Date: 3/18/80

Material: AISI 4140

Depth of Cut: .100

Coolant: TRIM-SOL 20:1

Hardness: 302/311 BHN

Tool Description:

Coolant Application: TOP

Holder:

Insert: SEE TAB

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
				0^{o} LEAD ANGLE - INSERT TNMG-433						
1	350	280	.033	5.810	5.610	21.688	382	.008	400	.0084
				15^{o} LEAD ANGLE - INSERT TNMG-433						
2	350	280	.033	5.610	5.410	21.625	367.7	.0068	400	.0074
				30^{o} LEAD ANGLE - INSERT TNMG-433						
3	350	280	.033	5.412	5.217	21.5	352.4	.0058	400	.0064
				45^{o} LEAD ANGLE - INSERT SNMG-433						
4	350	280	.033	5.217	5.024	21.25	335.4	.0048	400	.0057
				1/2" ROUND INSERT - RNMG-43						
5	350	280	.033	5.024	4.833	21	318.8	.0055	400	.0069

NOTES:

TABLE 24: DATA FOR WEAR-LAND BAR GRAPHS

Date: 4/21/80

Material: AISI 4140

Depth of Cut: .100

Coolant: TRIM-SOL 20:1

Hardness: 293/302 BHN

Tool Description:

Coolant Application: TOP

Holder:

Insert: SEE TAB

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
				0^O LEAD ANGLE - TNMG-433						
1		FROM LIFE-LINE CHART					1200	.024	400	.008
				15^O LEAD ANGLE - TNMG-433						
2	KC-810	340	.033	4.833	4.639	21.0	306	.0051	400	.0066
				30^O LEAD ANGLE - TNMG-433						
3	KC-810	340	.033	4.639	4.450	20.875	291.8	.0045	400	.0062
				45^O LEAD ANGLE - SNMG-433						
4	KC-810	340	.033	4.450	4.267	20.75	278	.004	400	.0058
				1/2" ROUND INSERT - RNMG-433						
5	KC-810	340	.033	4.267	4.070	20.625	263.7	.0045	400	.007

NOTES:

TABLE 25: DATA FOR WEAR-LAND BAR GRAPHS

Date:	5/8/80	**Material:**	AISI 4140
Depth of Cut:	.100	**Coolant:**	TRIM-SOL 20:1
Hardness:	302 BHN	**Tool Description:**	
Coolant Application:	TOP	**Holder:**	
		Insert:	SEE TAB

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
				"0^o" LEAD ANGLE - INSERT TNMG-433						
1	570	FROM LIFE-LINE CHART					1600	.024	400	.006
				15^o LEAD ANGLE - INSERT TNMG-433						
2	570	370	.033	3.940	3.745	20.63	243	.0045	400	.0079
				30^o LEAD ANGLE - INSERT SNMG-433						
3	570	370	.033	3.745	3.543	20.5	228	.0045	400	.0078
				45^o LEAD ANGLE - INSERT SNMG-433						
4	570	370	.033	3.543	3.342	20.38	214	.003	400	.0056
				1/2" ROUND INSERT - RNMG-43						
5	570	370	.033	3.342	3.140	20.13	199	.0038	400	.0076

NOTES:

TABLE 26: DATA FOR WEAR-LAND BAR GRAPHS

Date: 5/12/80 **Material:** AISI 4140

Depth of Cut: .100 **Coolant:** TRIM-SOL 20:1

Hardness: 302/311 BHN **Tool Description:**

Coolant Application: TOP **Holder:**

Insert: SEE TAB

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
				0^o LEAD ANGLE - INSERT CNG-454						
1	G-10	850	.022	FROM LIFE-LINE CHART 1400/.015					400	.0043
				15^o LEAD ANGLE - INSERT SNG-454						
2	G-10	850	.022	4.040	3.830	20.25	244	.033	400	.0057
				30^o LEAD ANGLE - INSERT SNG-454						
3	G-10	850	.022	3.830	3.630	20.	228	.0035	400	.0065
				45^o LEAD ANGLE - INSERT SNG-454						
4	G-10	850	.022	3.630	3.430	19.75	213	.003	400	.0056
				.500" ROUND - INSERT RNG-45						
5	G-10	850	.022	3.430	3.230	19.5	198	.0035	400	.007
				HARDNESS CHECK - 302/293 BHN						

NOTES:

TABLE 27: DATA FOR WEAR-LAND BAR GRAPHS

Date:	5/15/80	**Material:**	AISI 4140
Depth of Cut:	.100	**Coolant:**	NONE
Hardness:	302/321 BHN	**Tool Description:**	
Coolant Application:	NONE	**Holder:**	
		Insert:	SEE TAB

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
			0^{o} LEAD ANGLE - INSERT CNG-454							
1	G-30	750	.015	3.995	3.798	20.38	243.1	.006	400	.0099
			15^{o} LEAD ANGLE - INSERT SNG-454							
2	G-30	750	.015	3.798	3.595	20.31	230	.005	400	.0087
			30^{o} LEAD ANGLE - INSERT SNG-454							
3	G-30	750	.015	3.595	3.405	20.25	217	.004	400	.0074
			45^{o} LEAD ANGLE - INSERT SNG-454							
4	G-30	750	.015	3.405	3.205	20.25	204	.0032	400	.0063
				HARDNESS CHECK - 286 BHN						
	NEW BAR - HARDNESS 302 BHN									
			.500 ROUND - INSERT RNG-45							
5	G-30	750	.015	3.312	3.117	19.25	188.5	.003	400	.0064

NOTES:

TABLE 28: DATA FOR WEAR-LAND BAR GRAPHS

AISI 4340 Projectile Material-"Roughing Cuts"-35/38 Rc

Table 29, page 87 is a summary showing the results of the life-line tests and load charts for AISI 4340 material. The large increase in production indexes, is significant when the feed is increased while using ceramic inserts.

From previous experience, it was found that the selection of the proper "K"-land was important. Further study may prove that even more production gains can be had when this is done.

Figure 46 through Figure 49 pages 88 to 91, depict the results of the individual tests that were made during the roughing cuts in the AISI 4340 material. Tables 30 through 34, pages 92 through 96 are the corresponding data sheets.

When machining AISI 4340 with various carbide tools, plain and coated, a large difference in tool life was discovered when using different grades of cutting tools. Life-lines show that the proper selection of carbide grades is of paramount importance.

When the hot-pressed ceramic (G-10) inserts were tested, an increase in feed rate allowed an increase in surface speed for the same amount of tool wear. This condition is not normal, but has been encountered before. When using cold-pressed ceramic (G-30) inserts, similar results were observed, although not as pronounced.

SUMMARY OF RESULTS

"ROUGHING CUT"

MATERIAL	AISI-4340
HARDNESS	321/364 Bhn.
TOOL LIFE	2500 In^2 of Machined Surface
DEPTH OF CUT	.100 Inches

Tool Cutting Material	S.F.M.	Feed In./Rev.	Prod. Index	Tangential Tool Load - Lbs. .100 Depth of Cut	H.P. .100 Depth of Cut
350	300	.022	6.6	—	—
350	260	.025	6.5	—	—
350	235	.033	7.76	1100	7.83
KC-810	290	.033	9.57	960	8.44
570	400	.033	13.2	1040	12.6
G-10	800	.015	12.0	—	—
G-10	880	.022	19.36	700	16.97
G-30	700	.015	10.5	—	—
G-30	750	.022	16.5	700	15.91

TABLE 29: AISI-4340 Results of Tests

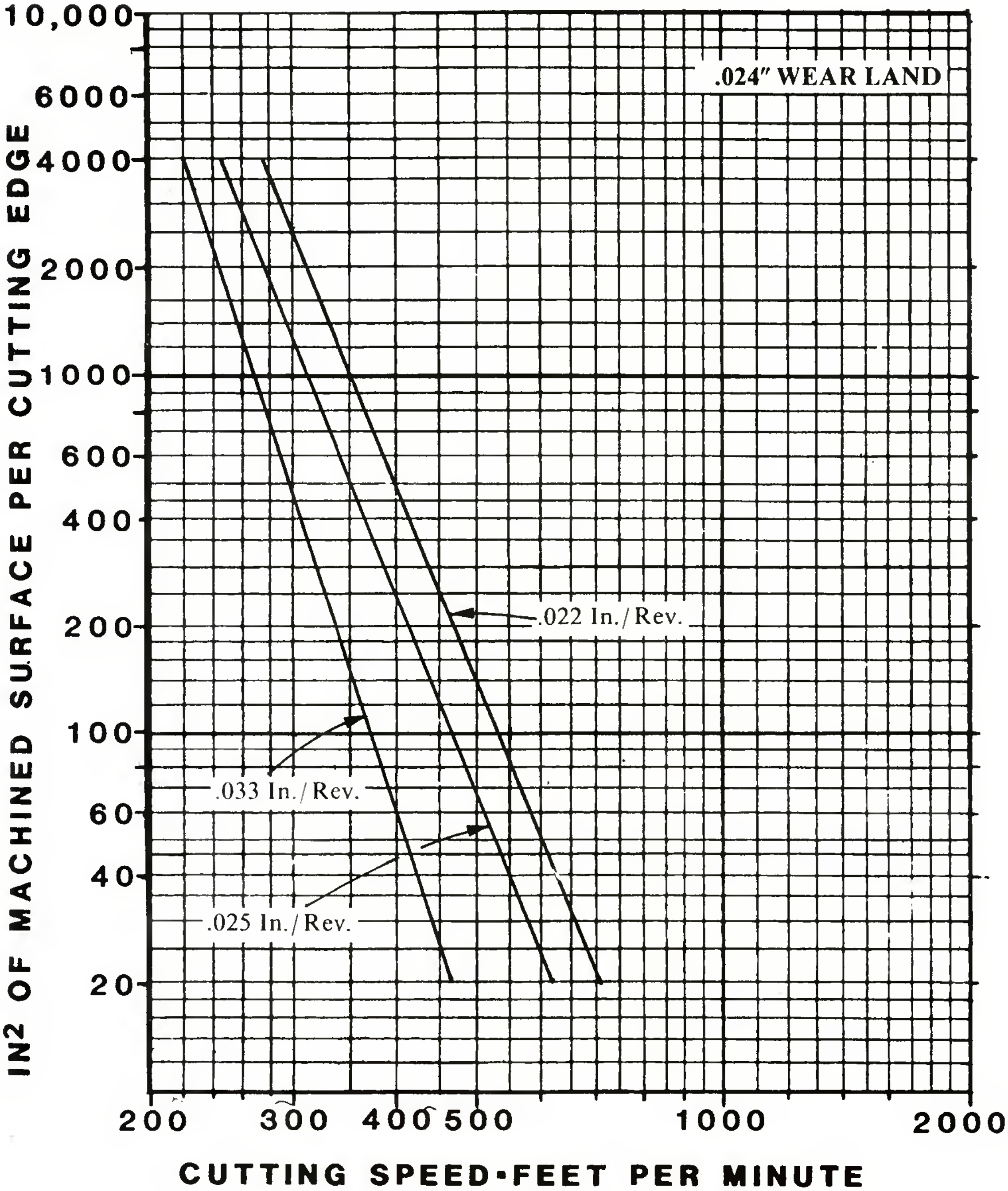

Figure 46: Tool-Life Lines of Carboloy Grade 350 on AISI 4340 Steel at 332/364 Brinell Hardness for Listed Feed-Rates.

Depth of Cut - .100 Inches
Tool Holder - MTANR-164 (0^0 Lead Angle)
Insert - TNMG-433

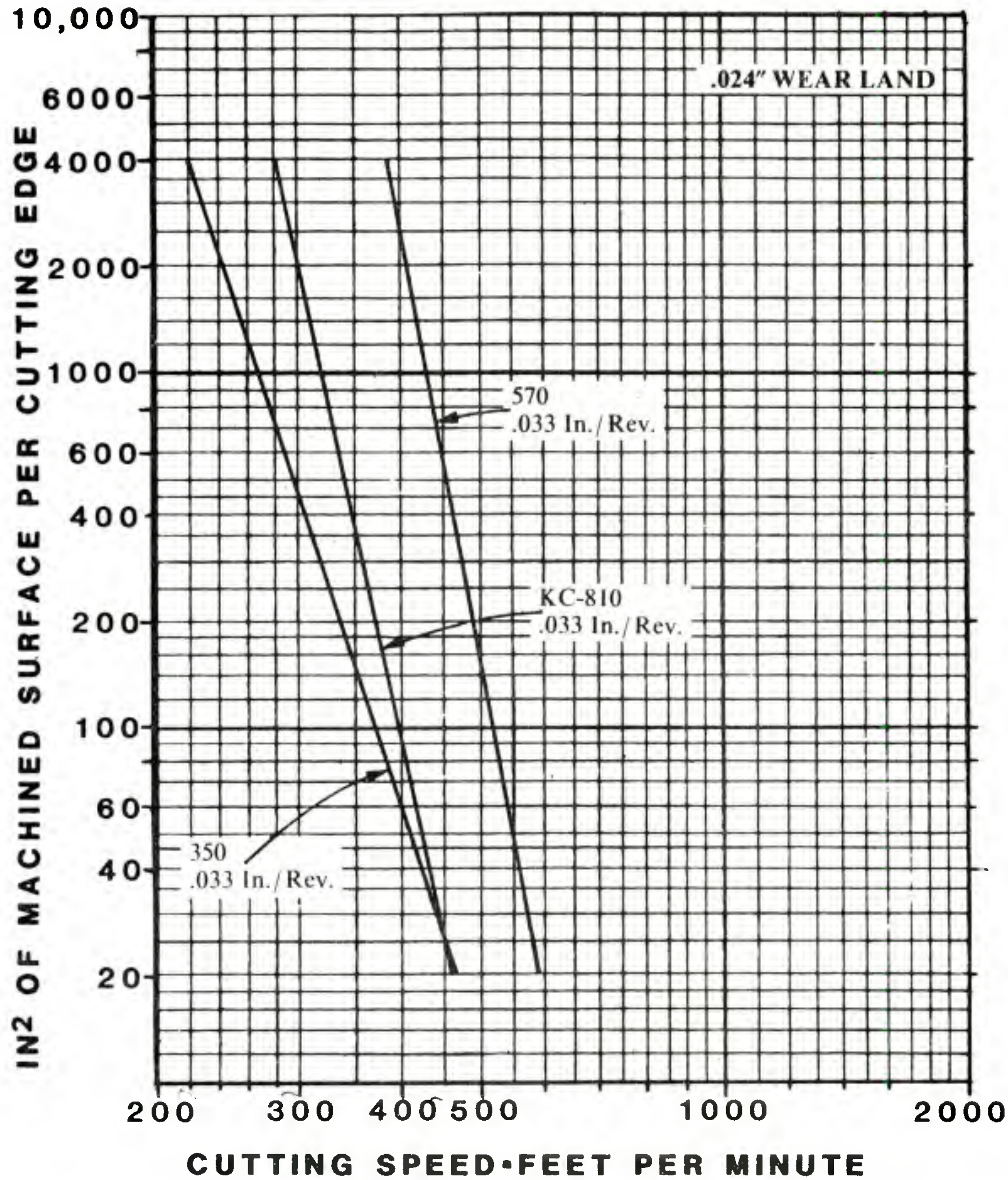

Figure 47: Tool-Life Lines of Listed Cutting Materials on AISI 4340 Steel at 321/332 Brinell Hardness for .033 Inches/Revolution Feed.

Depth of Cut - .100 Inches
Tool Holder - MTANR-164 (0^0 Lead Angle)
Insert - TNMG-433

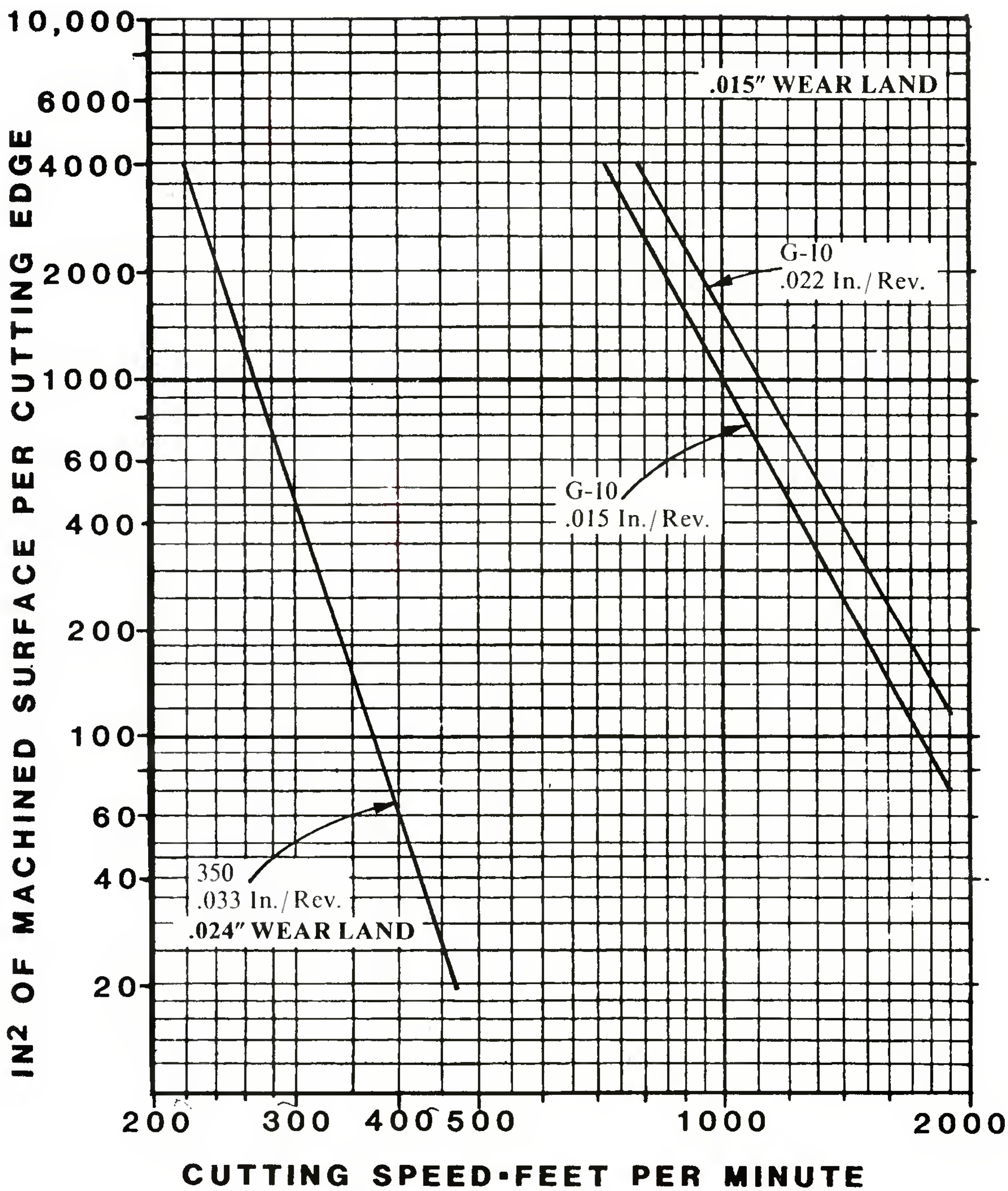

Figure 48: Tool-Life Lines of Listed Cutting Materials on AISI 4340 Steel at 321/332 Brinell Hardness for Listed Feed-Rates.

Depth of Cut - .100 Inches
Tool Holder - CCGNR-164 (0^0 Lead Angle)
Insert - CNG-454 .008 x 20^0 Grade G-10

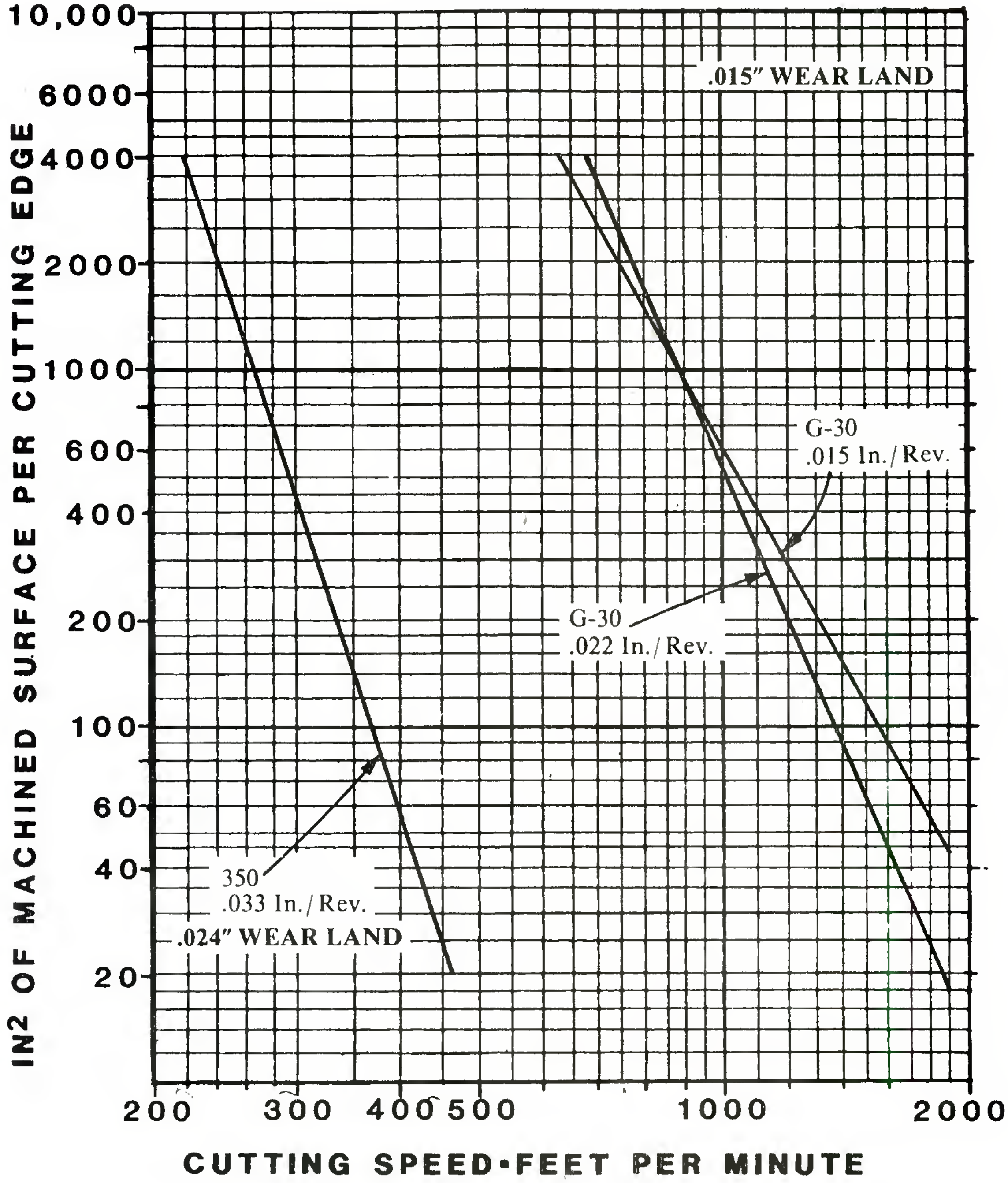

Figure 49: Tool-Life of Listed Cutting Materials on AISI 4340 Steel at 321/340 Brinell Hardness for Listed Feed-Rates.

Depth of Cut - .100 Inches
Tool Holder - CCGNR-164 (0^0 Lead Angle)
Insert - CNG-454 .008 x 20^0 Grade G-30

Date:	6/5/80	**Material:**	AISI 4340
Depth of Cut:	.100	**Coolant:**	TRIM-SOL 20:1
Hardness:	340/364 BHN	**Tool Description:**	
Coolant Application:	TOP	**Holder:**	MTANR-164
		Insert:	TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
1	350	600	.022	6.007	5.807	7/8"	–	–	TOO FAST	
2	"	550	"	"	"	3-3/16	–	–	EXCESSIVE WEAR	
3	"	500	"	"	"	5	91.2	.011	199	.024
4	"	400	"	"	"	11.69	213.3	.0105	487.5	.024
5	"	350	"	5.808	5.608	13-5/16	234.5	.014	402	.024
				HARDNESS CHECK		340/332				
6	350	350	.022	5.808	5.608	7-3/16	126.6			
6a	"	"	"	5.608	5.419	14-1/4	368.7	.009	983	.024
7	"	550	"	"	"	2-1/2	42.6	.018	56.8	.024
			–	FEED CHANGE	–					
8	350	500	.025	5.608	5.419	2-3/8	40.4	.015	64.6	.024
9	"	350	"	5.419	5.220	19-1/16	321.8	.0165	468	.024

NOTES:

TABLE 30 : DATA FOR LIFE LINES

Date: 6/5/80

Material: AISI 4340

Depth of Cut: .100

Coolant: TRIM-SOL 20:1

Hardness: 340/364 BHN

Tool Description:

Coolant Application: TOP

Holder: MTANR-164

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
				– FEED	CHANGE	–				
10	350	450	.033	5.615	5.418	1-7/16	24.5	.023	25.5	.024
11	"	300	"	5.220	5.015	19	299.3	.016	449	.024
12	"	400	"	5.425	5.225	1.5	24.6			
12a	"	"	"	5.225	5.025	1.5	48.3	.023	50.4	.024

NOTES:

TABLE 31 : DATA FOR LIFE LINES

Date: 6/19/80

Depth of Cut: .100

Hardness: 321/332 BHN

Coolant Application: TOP

Material: AISI 4340

Coolant: TRIM-SOL 20:1

Tool Description:

Holder: MTANR-164

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
1	KC-810	500	.033	6.010	5.820	2.687	–	–	EXCESSIVE WEAR	
2	"	450	"	"	"	1.75	32	.030	25.6	.024
3	"	350	"	"	"	10.31	188.5	.015	302	.024
4	"	400	"	5.820	5.620	3	53	.021	60.5	.024
			–	CHANGE	INSERT	GRADE –				
5	570	550	.033	5.820	5.620	1-1/2	26.5	.0165	38.5	.024
6	"	450	"	6.010	5.830	6.75	124			
6a	"	"	"	5.820	5.620	7.625	258.6	.012	517.2	.024
7	"	500	"	"	"	6.375	106.5	.0145	176.3	.024

NOTES:

TABLE 32 : DATA FOR LIFE LINES

Date: 6/23/80

Material: AISI 4340

Depth of Cut: .100

Coolant: TRIM-SOL 20:1

Hardness: 321/332 BHN

Tool Description:

Coolant Application: TOP

Holder: CCGNR-164

Insert: CNG-454 - 8 x 20°

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
1	G-10	1000	.015	5.655	5.425	13-3/32	223.4	.004		
1a	"	"	"	5.855	5.655	3-1/16	54.4			
1b	"	"	"	5.655	5.425	8-3/8	420.5	.006	1051	.015
2	G-10	1100	"	5.425	5.220	13-7/8	227.5	.0055	620.6	.015
3	"	1200	"	"	"	7-5/8	125	.004	470	.015
3a	"	"	"	5.220	5.020	-		BROKE AT START OF CUT		
			HARDNESS CHECK - 311 BHN							
			NEW BAR - HARDNESS 332/321 BHN							
1	G-10	1100	.022	5.990	5.795	9.25	168.4			
1a	"	"	"	"	"	12.44	394.8	.0058	1021	.015
2	"	1200	"	5.795	5.602	9-7/8	-	-	TOOL BROKE	
3	"	"	"	"	"	11-7/16	201.3	.004	754.8	.015
4	"	1400	"	5.602	5.402	5-7/16	92.3	.004	346	.015

NOTES:

TABLE 33 : DATA FOR LIFE LINES

Date: 9/3/80

Material: AISI 4340

Depth of Cut: .100

Coolant: NONE

Hardness: 321/340 BHN

Tool Description:

Coolant Application: –

Holder: CCGNR-164

Insert: CNG-454 – 8 x 20°

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
1	G-30	1200	.015	5.605	5.417	7.6	129	.0075	259	.015
2	"	1100	"	"	"	8.2	139.5	.0055	380.5	.015
3	"	1000	"	5.417	5.220	11.9	195	.0055	NOTE 532	1 .015
			CHANGE FEED-RATE							
4	G-30	1100	.022	5.417	5.270	9.3	154	.007	330	.015
5	"	1000	"	5.270	5.040	15.9	252	.0065	581	.015
6	"	900	"	5.270	5.060	5.2	83	–	CUT CONT	INUED
6a	"	"	"	5.060	4.860	21.0	403	.0075	806	.015

NOTES: NOTE 1 – POOR CHIP CONDITION
LONG STRINGY CURLS

TABLE 34 : DATA FOR LIFE LINES

TOOL LOAD VERSUS DEPTH OF CUT

Material: AISI 4340 **Holder:** 0° LEAD ANGLE

Hardness: 332/340 BHN **Insert:** TNMG-433

Feed Rate: .033 IN./REV. **Grade:** 350

Surface Speed: 235 FT./MIN. **Coolant:** TRIM-SOL 20:1 TOP

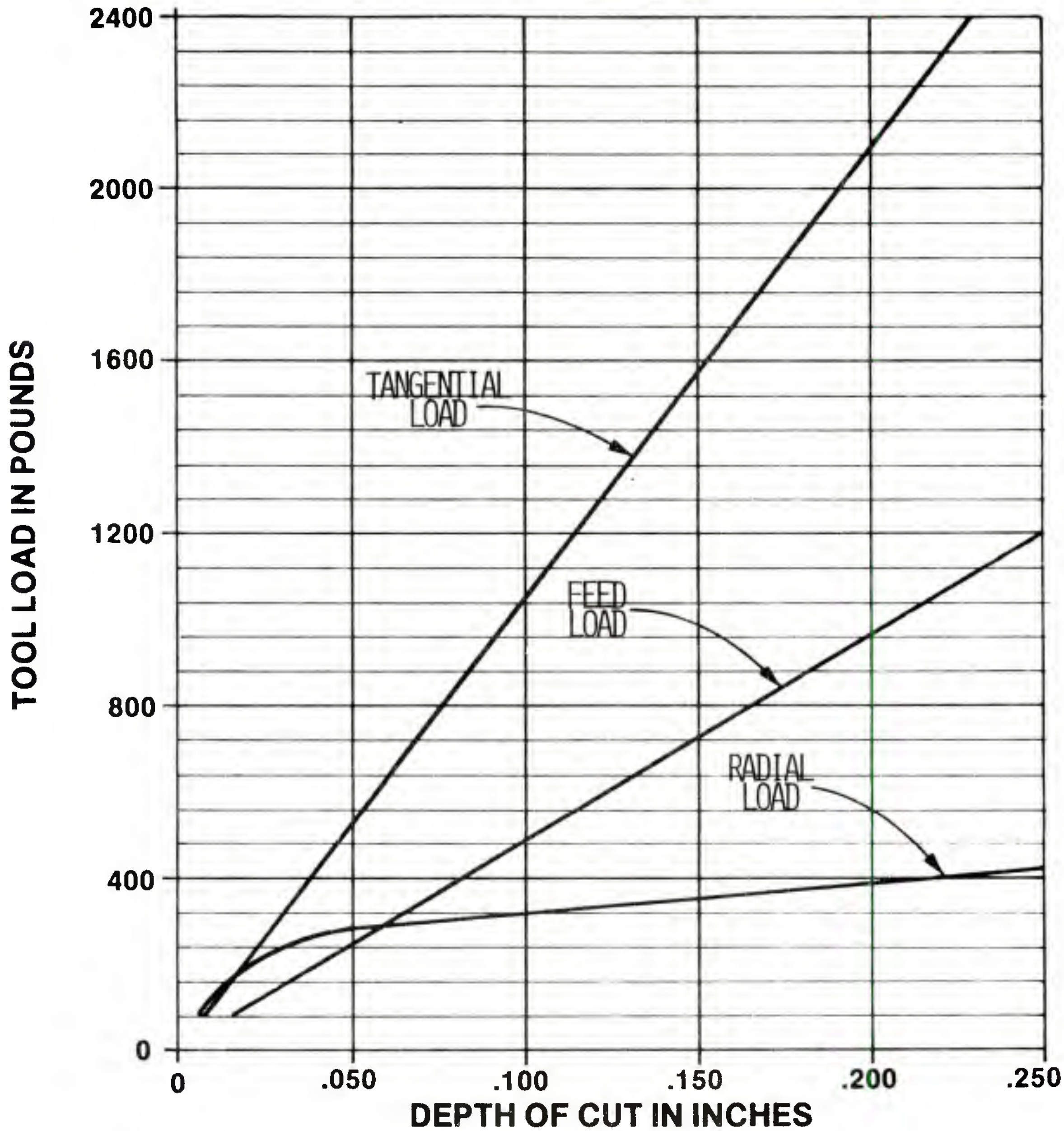

Figure 50: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material:	AISI 4340	**Holder:**	0° LEAD ANGLE
Hardness:	332/340 BHN	**Insert:**	TNMG-433
Feed Rate:	.033 IN./REV.	**Grade:**	KC-810
Surface Speed:	290 FT./MIN.	**Coolant:**	TRIM-SOL 20:1 TOP

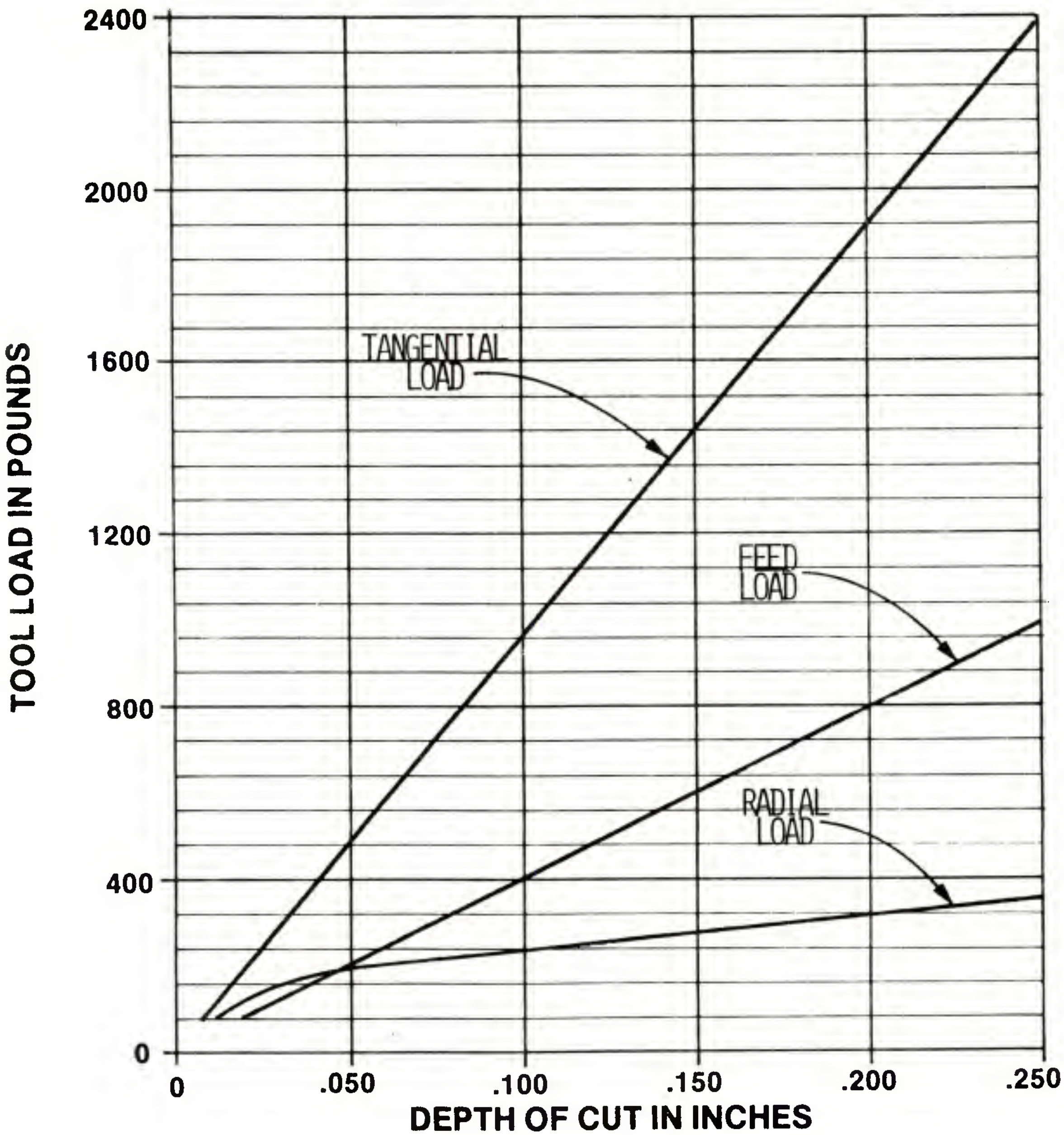

Figure 51: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material:	AISI 4340	**Holder:**	0° LEAD ANGLE
Hardness:	332/340 BHN	**Insert:**	TNMG-433
Feed Rate:	.033 IN./REV.	**Grade:**	570
Surface Speed:	400 FT./MIN.	**Coolant:**	TRIM-SOL 20:1 TOP

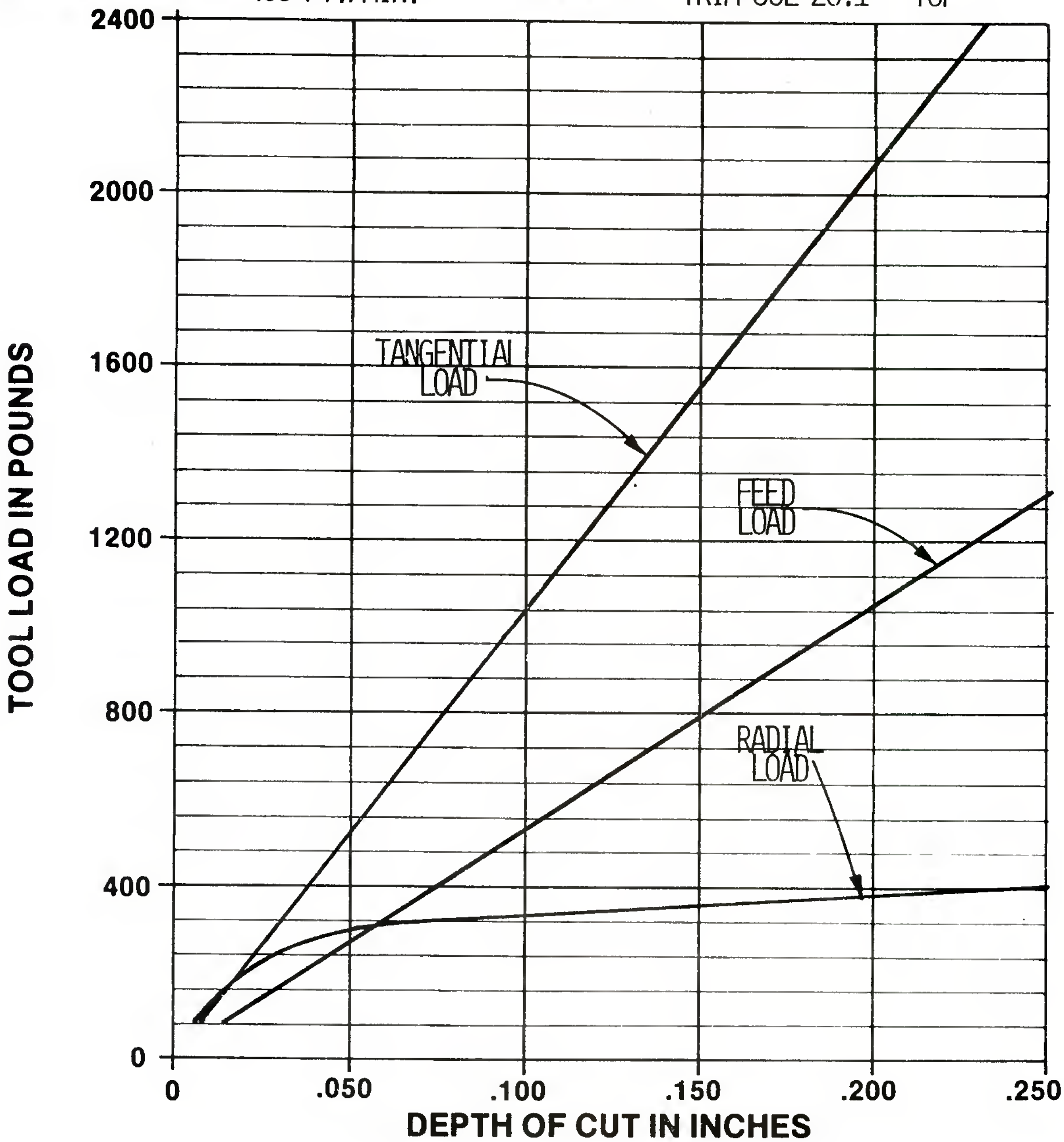

Figure 52: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material: AISI 4340 **Holder:** 0^{0} LEAD ANGLE

Hardness: 321/340 BHN **Insert:** CNG-454 820

Feed Rate: .022 IN./REV. **Grade:** G-10

Surface Speed: 800 FT./MIN. **Coolant:** TRIM-SOL 20:1 TOP

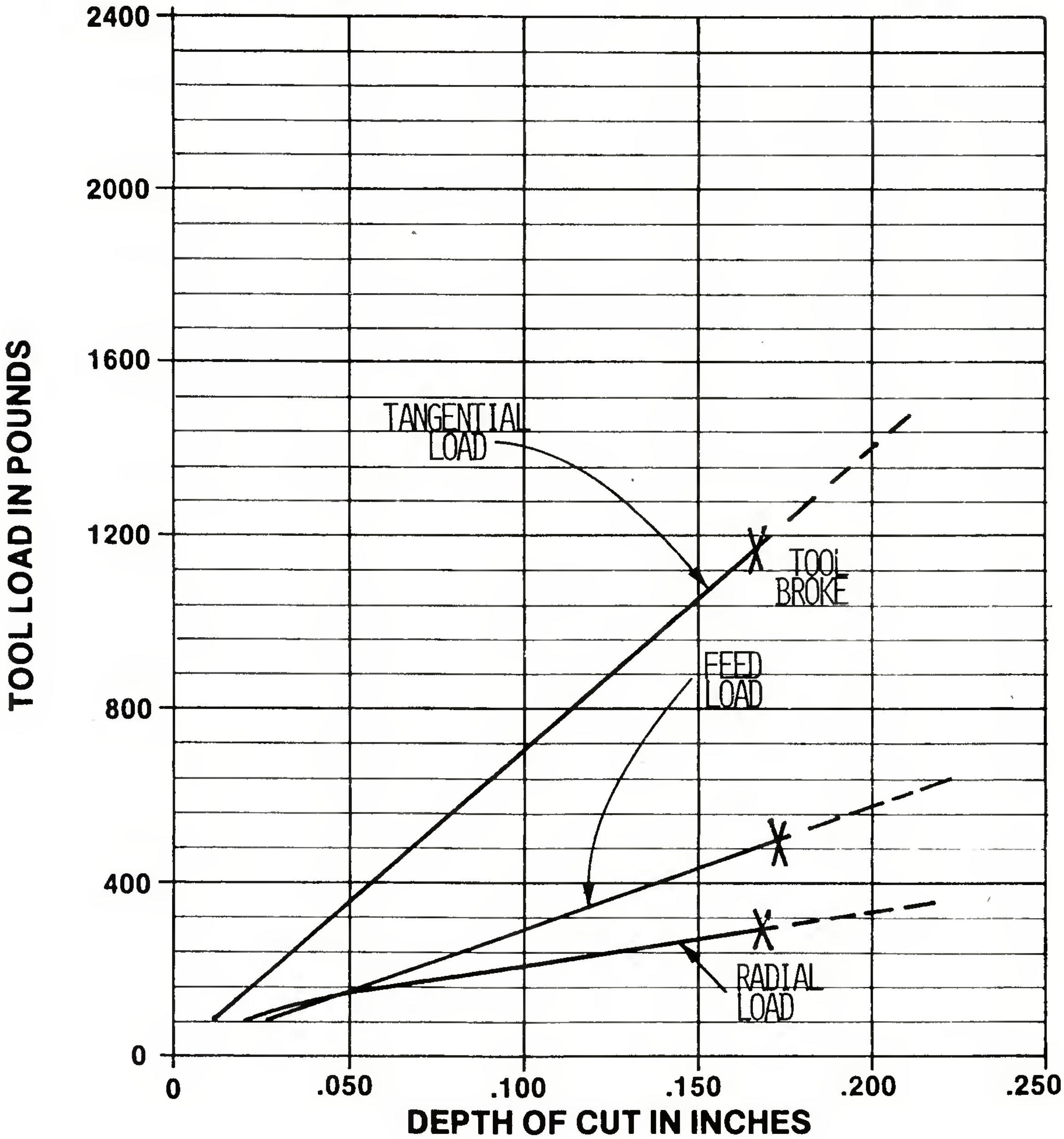

Figure 53: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material:	AISI 4340	**Holder:**	0° LEAD ANGLE
Hardness:	321/340 BHN	**Insert:**	CNG-454 820
Feed Rate:	.022 IN./REV.	**Grade:**	G-30
Surface Speed:	750 FT./MIN.	**Coolant:**	NONE

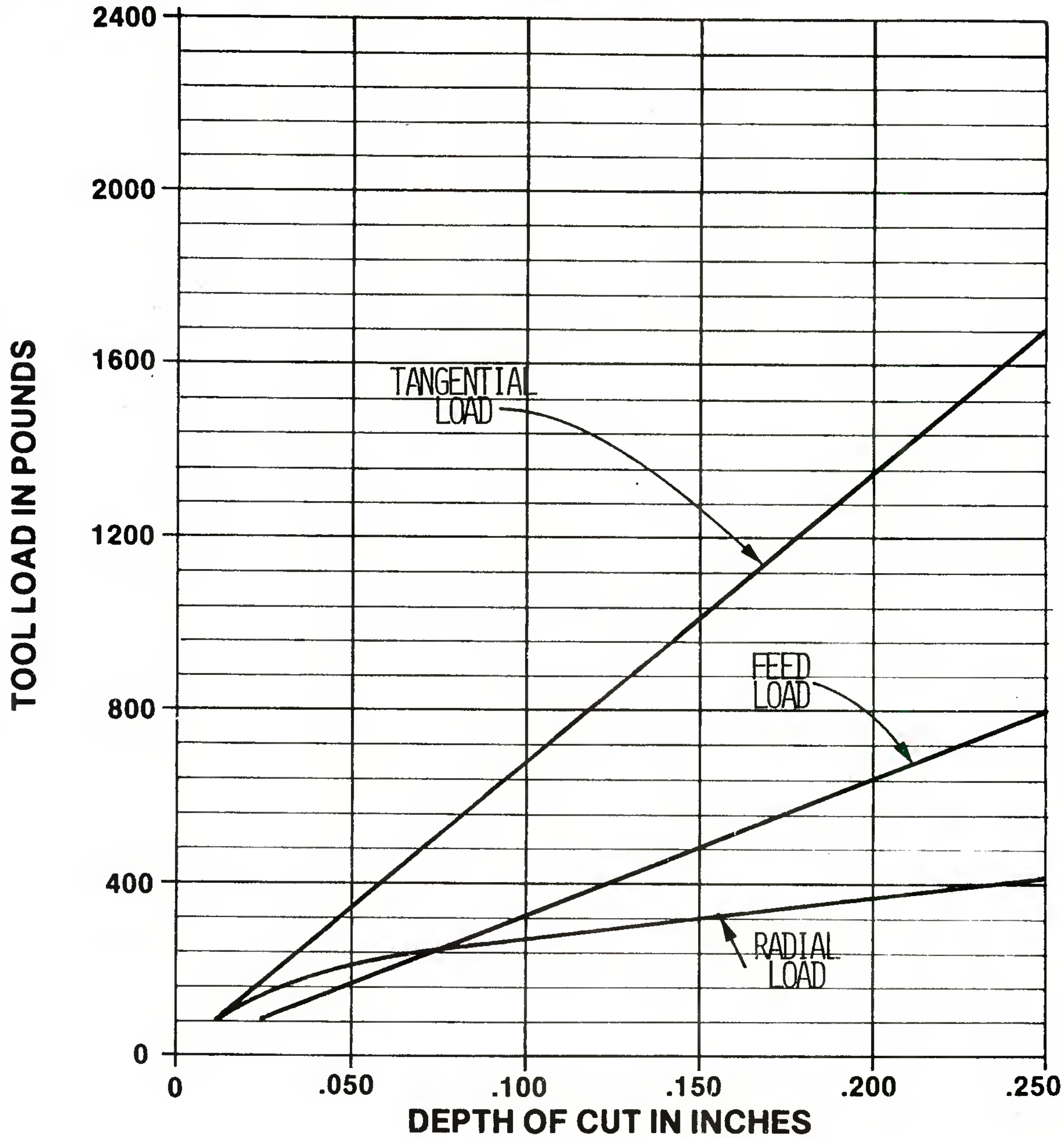

Figure 54: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material:	AISI 4340	**Holder:**	0^{o} LEAD ANGLE
Hardness:	332/340 BHN	**Insert:**	CNG-454 820
Feed Rate:	.015 IN./REV.	**Grade:**	G-10
Surface Speed:	800 FT./MIN.	**Coolant:**	TRIM-SOL 20:1 TOP

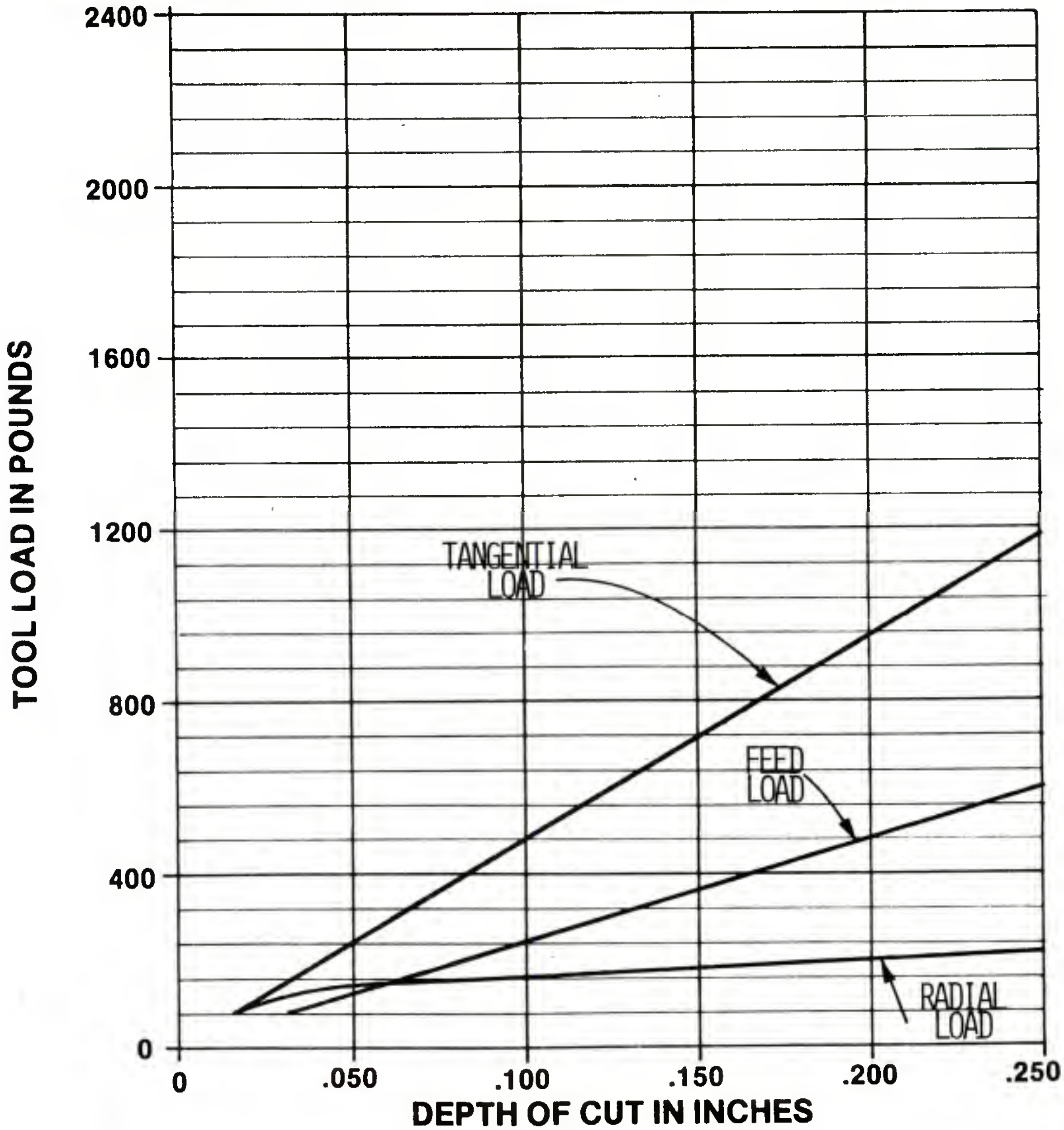

Figure 55: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material:	AISI 4340	**Holder:**	0^{o} LEAD ANGLE
Hardness:	332/340 BHN	**Insert:**	CNG-454 2020
Feed Rate:	.015 IN./REV.	**Grade:**	G-10
Surface Speed:	800 FT./MIN.	**Coolant:**	TRIM-SOL 20:1 TOP

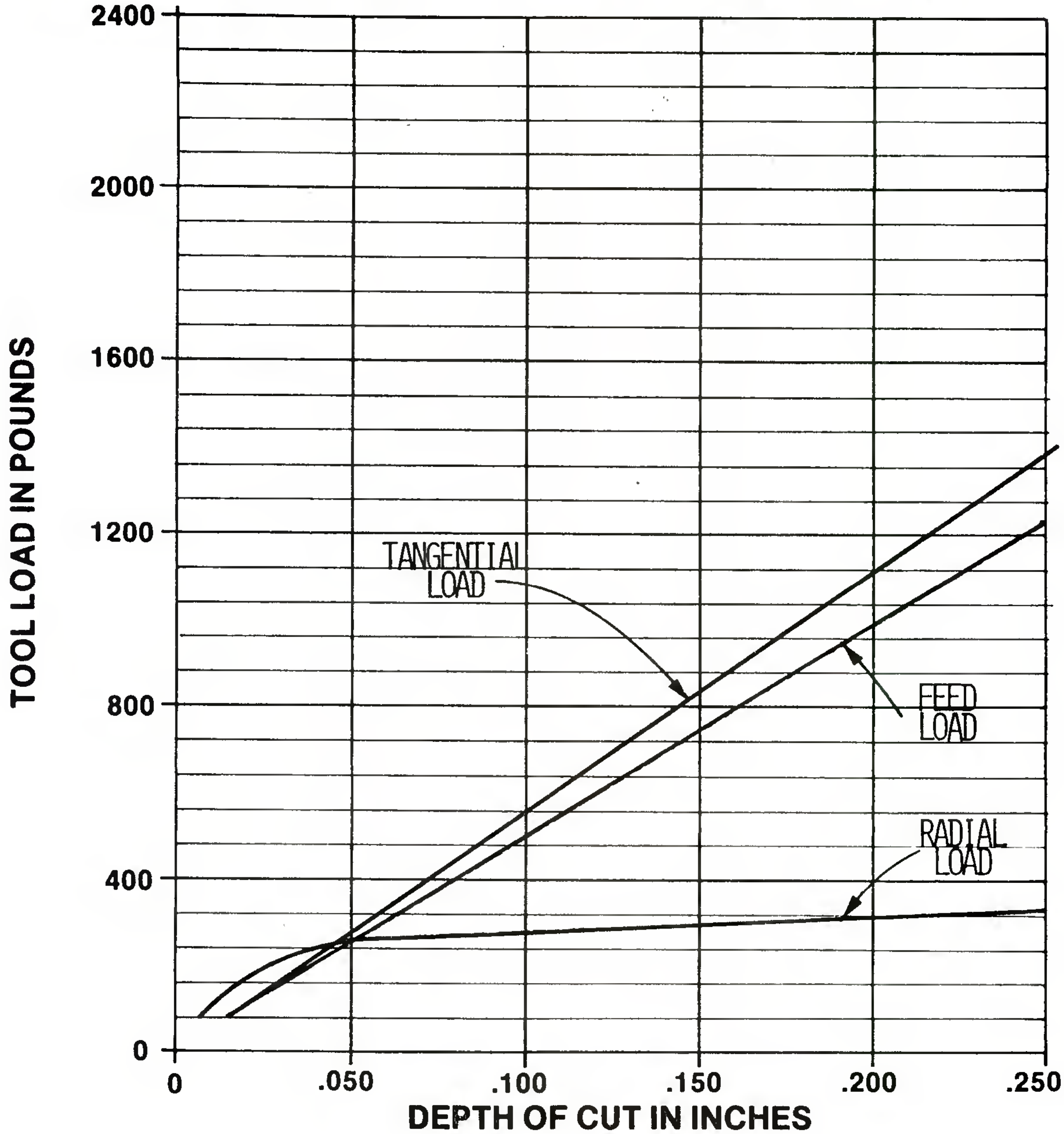

Figure 56: **TOOL LOAD CHART**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4340 **HARDNESS:** 332/340 BHN

INSERT: TNMG-433 **SURFACE FEED:** 235 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 350 **FEEDRATE:** .033 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	570	240	280
.100	1110	500	320
.150	1600	750	360
.200	2100	960	370

INSERT: TNMG-433 **SURFACE FEED:** 290 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: KC-810 **FEEDRATE:** .033 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	500	130	190
.100	960	350	240
.150	1400	640	300
.200	1900	880	320

INSERT: TNMG-433 **SURFACE FEED:** 400 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 570 **FEEDRATE:** .033 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	550	275	285
.100	1080	550	335
.150	1590	840	365
.200	2050	1040	380

TABLE 35: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4340 **HARDNESS:** 321/340 BHN

INSERT: CNG-454 .008 x 20° **SURFACE FEED:** 800 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	360	120	190
.100	680	280	220
.150	1060	450	280
.200	TOOL BROKE	-	-

INSERT: CNG-454 .008 x 20° **SURFACE FEED:** 750 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	360	125	200
.100	680	300	260
.150	1040	495	300
.200	1340	670	360

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050			
.100			
.150			
.200			

TABLE 36: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4340 **HARDNESS:** 332/340 BHN

INSERT: CNG-454 .008 x 20° **SURFACE FEED:** 800 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	250	110	125
.100	480	240	155
.150	720	360	180
.200	950	480	205

INSERT: CNG-454 .020 x 20° **SURFACE FEED:** 800 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	290	200	260
.100	595	490	290
.150	860	760	310
.100	1120	1000	325

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050			
.100			
.150			
.200			

TABLE 37: **DATA FOR TOOL LOAD CHARTS**

HF-1 Projectile Material-"Roughing" Cuts-28/29 Rc

Table 38 page 108 is a summary of tests made in HF-1 material. It presents the results of the life-line charts, and calculations of the horsepower for various materials from the tool load charts.

Figure 57 through Figure 66, page 109 to 124, depict the results of the individual tests that were made during the roughing cuts in the HF-1 material. Tables 39 through 46 pages 114 through 126 contain the data for these curves. Figures 67 and 68 and Tables 47 and 48 contain information relavent to the "rock-in" tests.

This material is extremely "feed sensitive" when being machined by plain carbide. The slope for the .022 in./rev. feed rate is much lower than the slope for .015 in./rev. feed rate. When the titanium coated inserts are used, the results are reversed. The life-lines have steeper slopes. The ceramic coated carbide also gave a difference in life-line slopes, with the .022 in./rev. feed rate life-line having a steeper slope than .015 in./rev. feed rate life line.

When using hot-press ceramic (G-10), the life-lines for both the .015 in./rev. and the .022 in./rev. feed rates were almost identical. This means that the higher feed rate should be used wherever possible.

For equal tool life, the cold-press ceramic (G-30) had about a 20% lower cutting speed at .022 in./rev. feed than at .015 in./rev. feed rate. However, the increase in feed rate is more than enough to give a higher production index at the higher feed rate.

The tool loads are 25% lower than those found while machining AISI 4340 for the same depth of cut, at the proper surface speed. Tool loads in HF-1 material are also 10% lower than the loads when machining AISI 1340 and AISI 4140.

In all cutting tests for this material, chip-breaking was not a problem. The chips were small and should be easily disposed of. When the "rock-in" tests were made, the "rock-in" was at a lower .007 in./rev. feed rate and the chips broke in small curls. "Rock-in" is entering the work at an acute angle to the center-line of the work-piece, so clearance is allowed for the geometry of the cutting tool.

SUMMARY OF RESULTS

"ROUGHING CUT"

MATERIAL	HF-1
HARDNESS	262/293 Bhn.
TOOL LIFE	2500 In^2 of Machined Surface
DEPTH OF CUT	.100 Inches

Tool Cutting Material	S.F.M.	Feed In./Rev.	Prod. Index	Tangential Tool Load - Lbs. .100 Depth of Cut	H.P. .100 Depth of Cut
350	290	.015	4.35	600	5.28
350	160	.022	3.52	—	—
KC-810	350	.015	5.25	760	8.06
KC-810	330	.022	7.26	—	—
570	405	.015	6.08	—	—
570	420	.022	9.24	720	9.17
G-10	630	.015	9.45	—	—
G-10	640	.022	14.08	640	12.41
G-30	610	.015	9.15	520	9.61
G-30	470	.022	10.34	—	—

TABLE **38** HF 1 Results of Tests

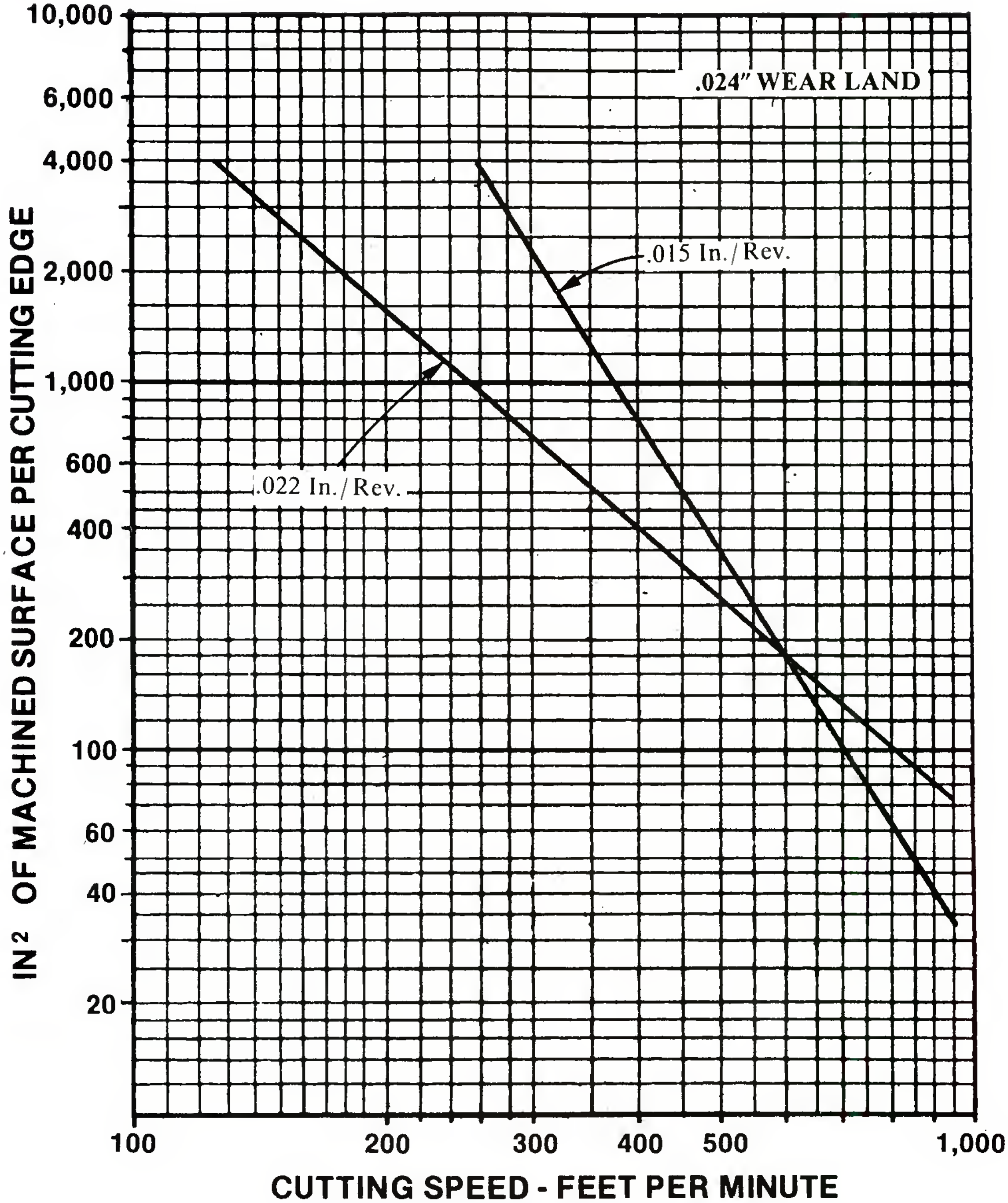

Figure 57: Tool-Life Lines of Carboloy Grade 350 on HF-1 Steel at 269/277 Brinell Hardness for Listed Feed-Rates.

Depth of Cut - .100 Inches
Tool Holder - MTANR-164 (0^0 Lead Angle)
Insert - TNMG-433

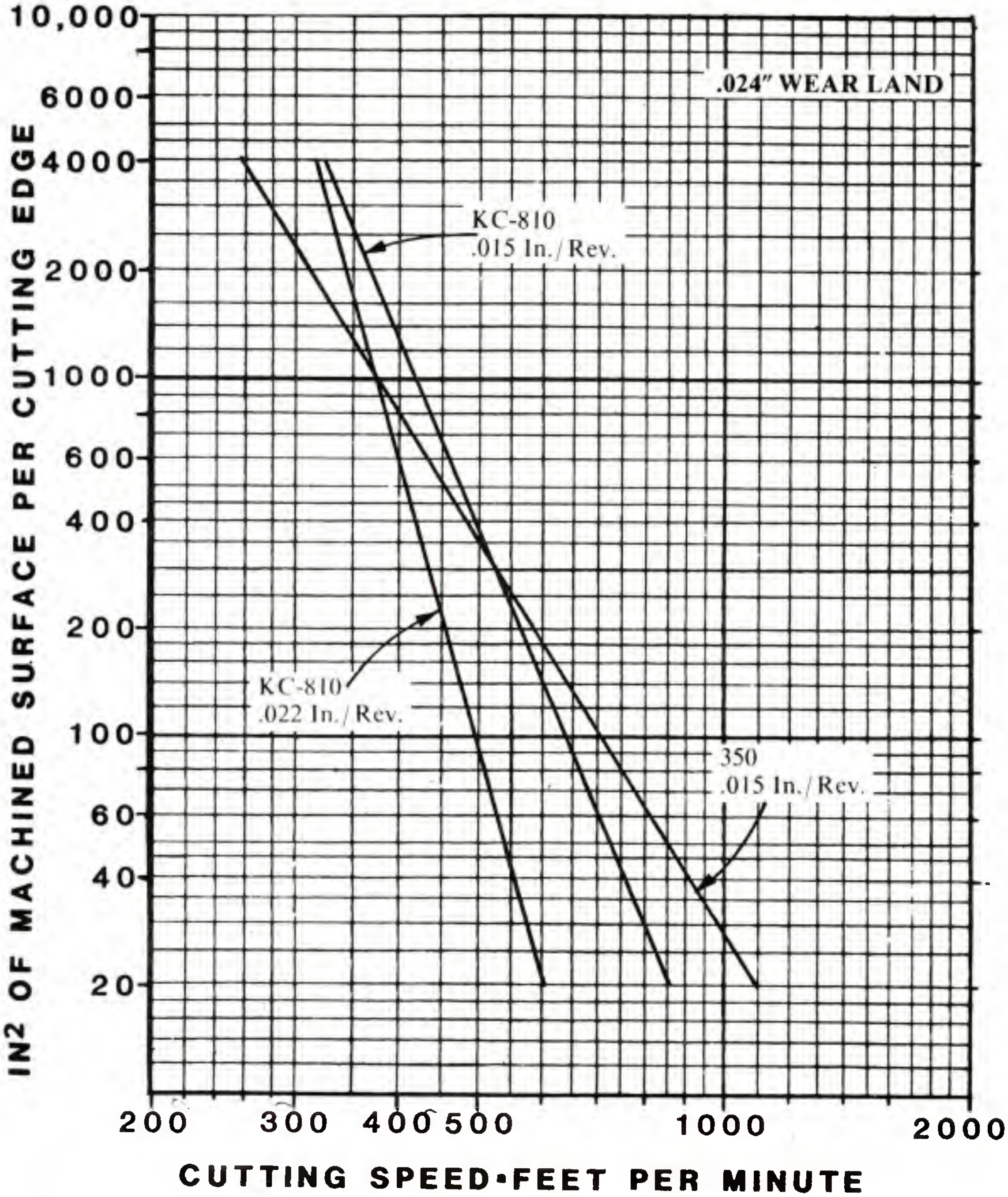

Figure 58: Tool-Life Lines of Kennametal Grade KC-810 HF-1 Steel at 269 Brinell Hardness for Listed Feed-Rates.

Depth of Cut - .100 Inches
Tool Holder - MTANR-164 (0^0 Lead Angle)
Insert - TNMG-433

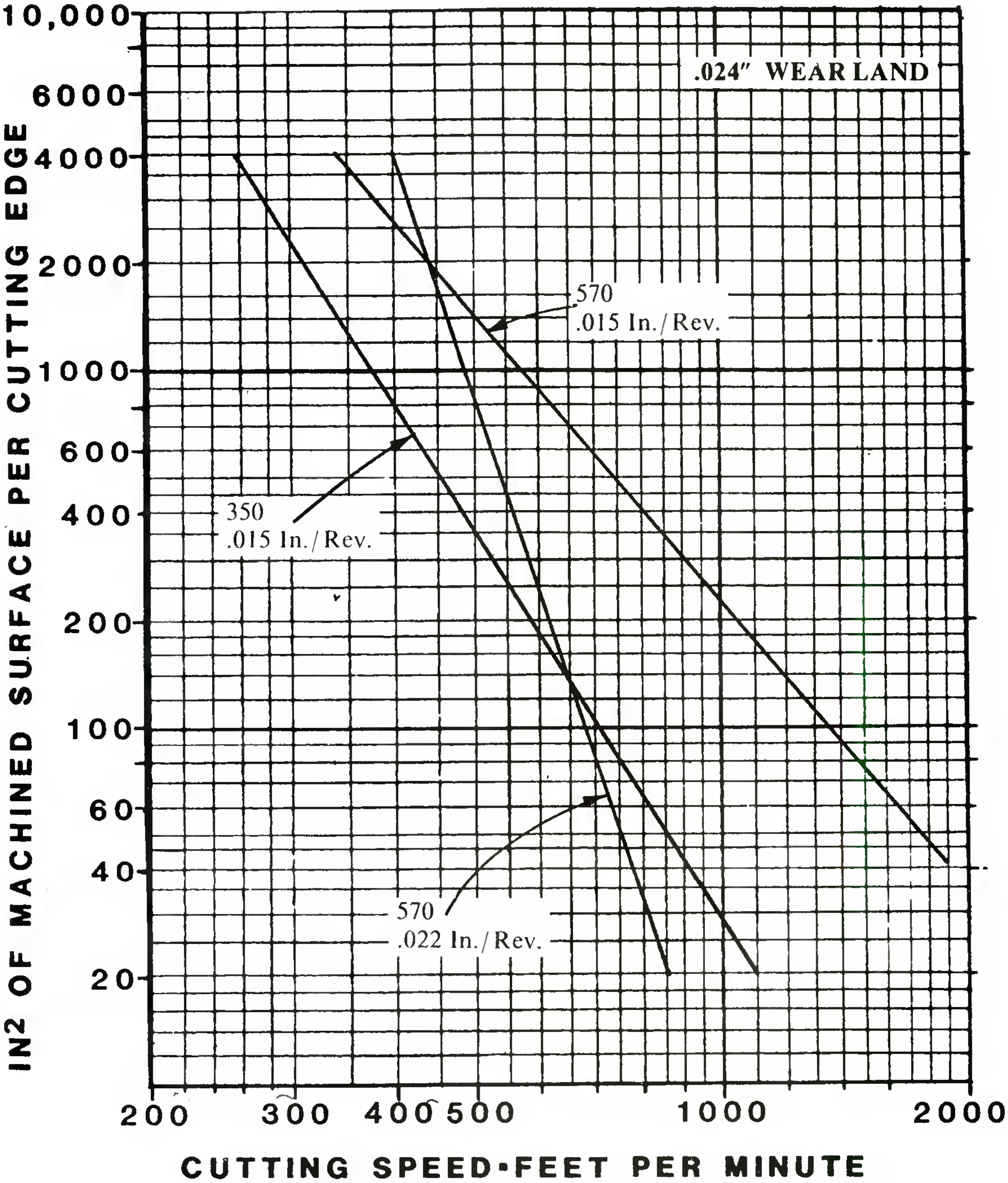

Figure 59: Tool-Life Lines of Carboloy Grade 570 on HF-1 Steel at 269/294 Brinell Hardness for Listed Feed-Rates.

Depth of Cut - .100 Inches
Tool Holder - MTANR-164 (0° Lead Angle)
Insert - TNMG-433

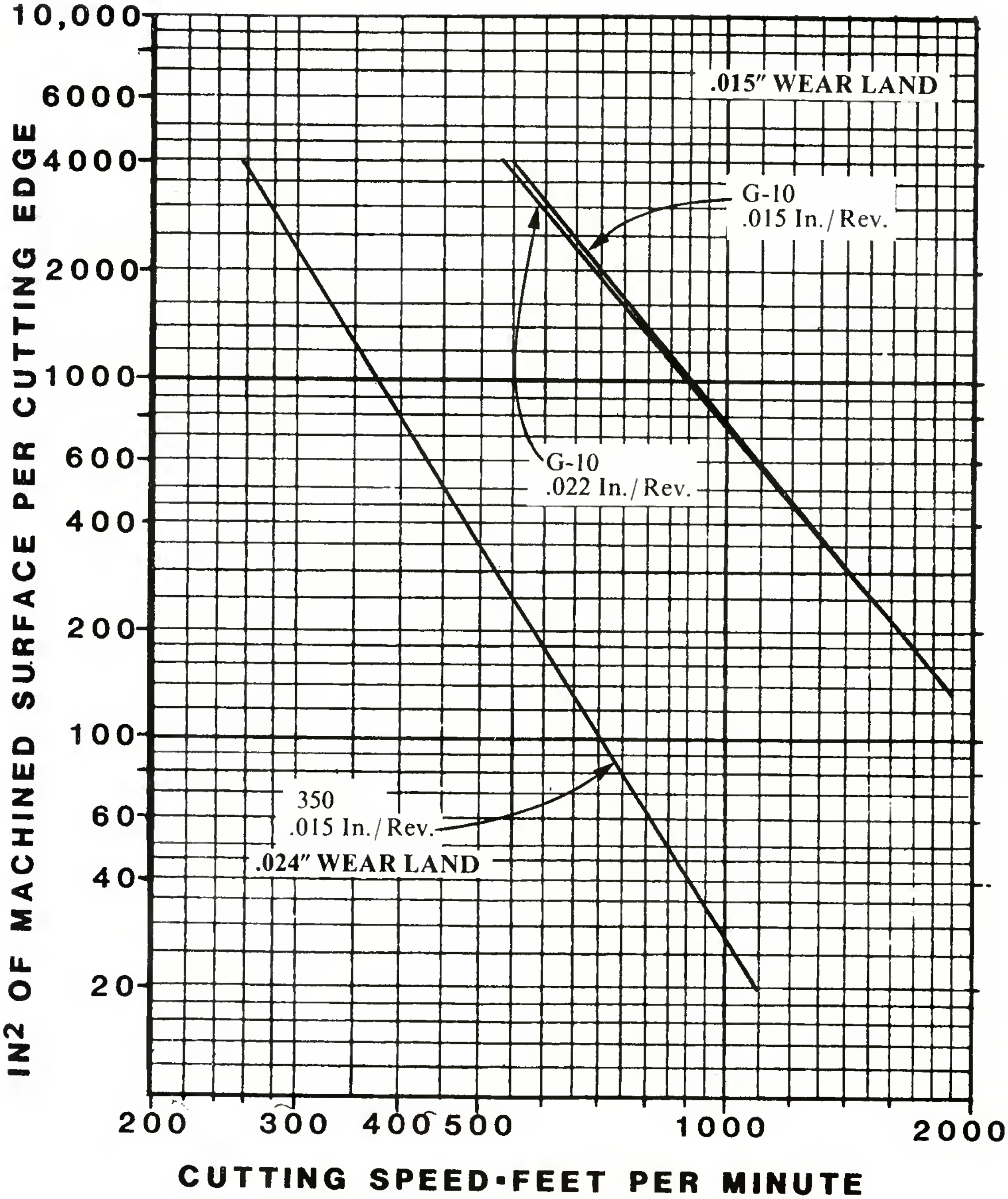

Figure 60: Tool-Life Lines of Listed Cutting Materials on HF-1 Steel at 262/293 Brinell Hardness for Listed Feed-Rates.

Depth of Cut - .100 Inches
Tool Holder - CCGNR-164 (0° Lead Angle)
Insert - CNG-454 .008 x 20° Grade G-10

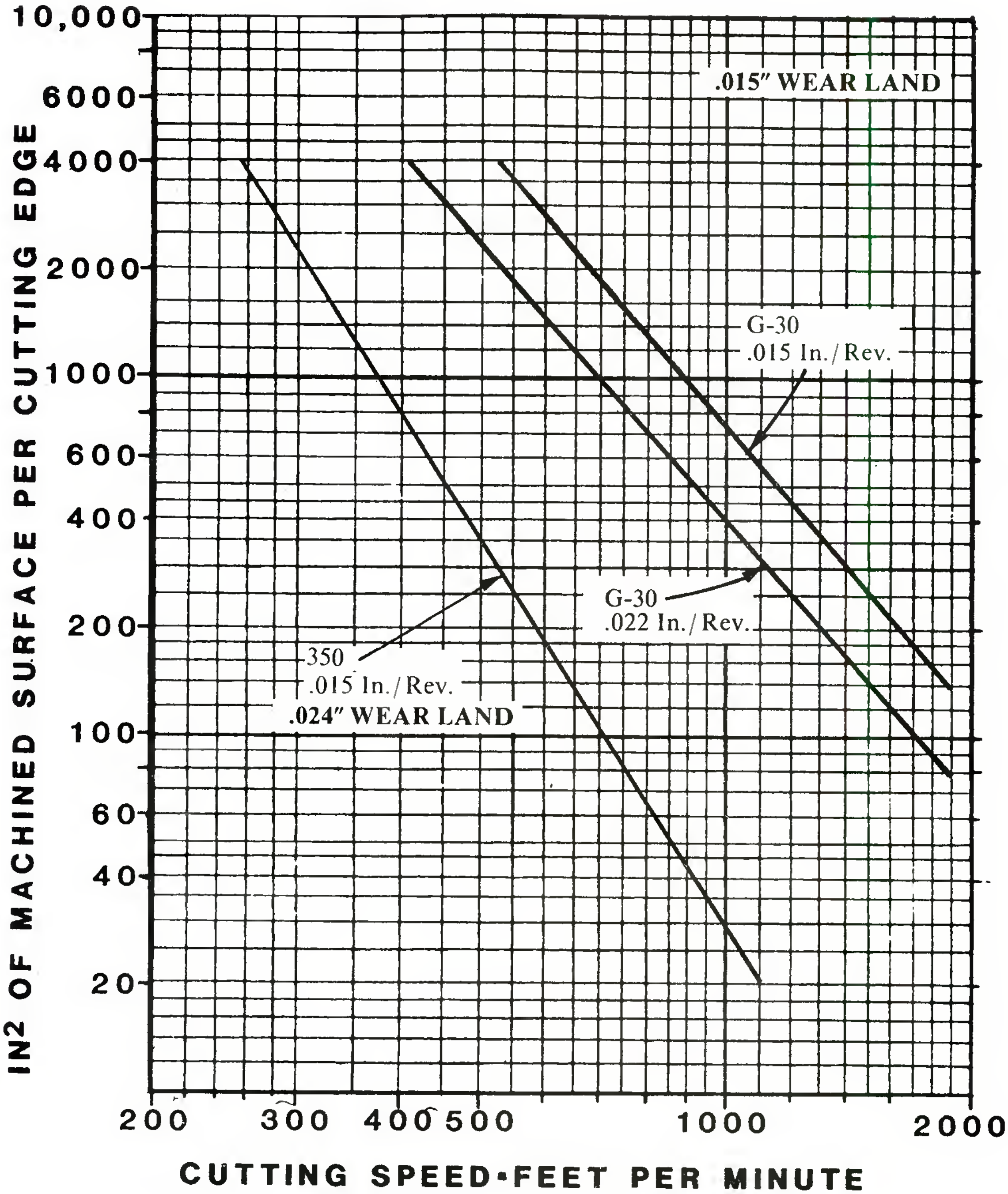

Figure 61: Tool-Life Lines of Listed Cutting Materials on HF-1 Steel at 262/269 Brinell Hardness for Listed Feed-Rates.

Depth of Cut - .100 Inches
Tool Holder - CCGNR-164 (0^0 Lead Angle)
Insert - CNG-454 .008 x 20^0 Grade G-30

Date: 8/1/80

Material: HF-1

Depth of Cut: .100 APPROX.

Coolant: TRIM-SOL 20:1

Hardness: 269/277 BHN

Tool Description:

Coolant Application: TOP

Holder: KTAR-164

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN/REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
1	350	500	.022	6.41	6.25	12.8	251	.023	262	.024
2	"	400	"	"	"	13.2	259	.015	414	.024
3	"	300	"	6.25	6.05	20.9	398	.018	530	.024
4	"	600	"	"	"	–	–	–	TOO FAST BROKEN TOOL	
5	"	500	.015	6.41	6.22	11.7	229	.018	304	.024
6	"	400	"	"	"	14	274	.0085	773	.024
7	"	300	"	6.22	6.02	25.5	482	.006	1929	.024

NOTES:

TABLE 39 : DATA FOR LIFE LINES

Date:	8/4/80	**Material:**	HF-1
Depth of Cut:	.100 APPROX.	**Coolant:**	TRIM-SOL 20:1
Hardness:	269 BHN	**Tool Description:**	
Coolant Application:	TOP	**Holder:**	KTAR-164
		Insert:	TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
1	KC-810	600	.015	6.405	6.202	1.7	33	.0085	93.5	.024
2	"	500	"	"	"	9.0	175	.010	421	.024
3	"	450	"	"	"	16.1	314	.0125	602	.024
4	"	400	"	6.202	6.0	25.4	479	.010	1150	.024
5	"	500	.022	6.395	6.220	1.5	29	.011	64	.024
6	"	400	"	"	"	16.9	330	.0105	755	.024
7	"	350	"	"	"	8.4	164	–	CUT CONT	INUED
7a	"	"	"	6.220	6.037	22.9	596T	.012	1192	.024

NOTES:

TABLE 40 : DATA FOR LIFE LINES

Date: 8/4/80

Depth of Cut: .100" APPROX.

Hardness: SEE DATA

Coolant Application: TOP

Material: HF-1

Coolant: TRIM-SOL 20:1

Tool Description:

Holder: KTAR-164

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
	SHELL HARDNESS 269/283 BHN									
1	570	650	.015	6.405	6.230	20.1	393	.012	787	.024
2	"	800	"	"	"	7.4	145	.0085	409	.024
3	"	500	"	6.230	6.050	24.75	470	.009	1254	.024
	SHELL HARDNESS 269/294 BHN									
4	570	700	.022	6.402	6.210	3.9	76	.028	65	.024
5	"	550	"	"	"	12.7	248	.0105	566	.024
6	"	500	"	"	"	10.8	211	.009	562	.024
7	"	450	"	6.210	6.008	26.75	505	.0085	1426	.024

NOTES:

TABLE 41 : DATA FOR LIFE LINES

Date: 8/5/80		**Material:** HF-1	
Depth of Cut: .100		**Coolant:** TRIM-SOL 20:1	
Hardness: SEE TAB		**Tool Description:**	
Coolant Application:		**Holder:** CCGNR-164	
		Insert: CNG-454 - .008 x 20°	

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
				HARDNESS 269/293 BHN						
1	G-10	1000	.015	6.400	6.250	15.1	296.5	.007	635	.015
2	"	1200	"	"	"	-			TOOL BROKE	
3	"	"	"	6.250	6.085	8.1	155	.0045	516	.015
4	"	800	"	"	"	10.7	204.5	.0025	1227.3	.015
				HARDNESS 262/269 BHN						
5	"	1000	.022	6.402	6.260	14.5	285	.0055	778	.015
6	"	1200	"	"	"	6.6	130	.005	389	.015
7	"	800	"	"	"	6.0	118	-		
7a	"	"	"	6.260	6.080	10.5	318T	.0045	1060	.015

NOTES:

TABLE 42 : DATA FOR LIFE LINES

Date: 7/31/80

Depth of Cut: .100

Hardness: 262/269 BHN

Coolant Application:

Material: HF-1

Coolant: NONE

Tool Description:

Holder: CCGNR-164

Insert: CNG-454 - .008 x 20°

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
1	G-30	1000	.015	6.392	6.242	18.7	367	.008	687.6	.015
2	"	1400	"	"	"	9.0	176.5	.0085	311.5	.015
3	"	800	"	6.242	6.042	16.00	304	.004	1139	.015
4	"	1200	"	"	"	10.	190	.0055	517	.015

NOTES: RUN NO. 3 HAD "SING" AND POOR FINISH

TABLE 43 : DATA FOR LIFE LINES

Date:	8/28/80	**Material:**	HF-1 STEEL
Depth of Cut:	.100" APPROX.	**Coolant:**	NONE
Hardness:	269/269 BHN	**Tool Description:**	
Coolant Application:	-	**Holder:**	CCGNR-164
		Insert:	CNG-454 - .008 x 20°

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
1	G-30	1200	.022	6.405	6.232	5.7	111.5	.0055	304	.015
2	"	1000	"	"	6.235	11.1	217.4	.012	272	.015
3	"	1100	"	"	6.238	9.7	190.0	.020	FLANK CHIPPED	
4	"	800	"	6.235	6.081	20.1	391.6	.010	587.5	.015

NOTES:

TABLE 44 : DATA FOR LIFE LINES

TOOL LOAD VERSUS DEPTH OF CUT

Material:	HF-1	**Holder:**	0^{0} LEAD ANGLE
Hardness:	269/277 BHN	**Insert:**	TNMG-433
Feed Rate:	.015 IN./REV.	**Grade:**	350
Surface Speed:	285 FT./MIN.	**Coolant:**	NONE

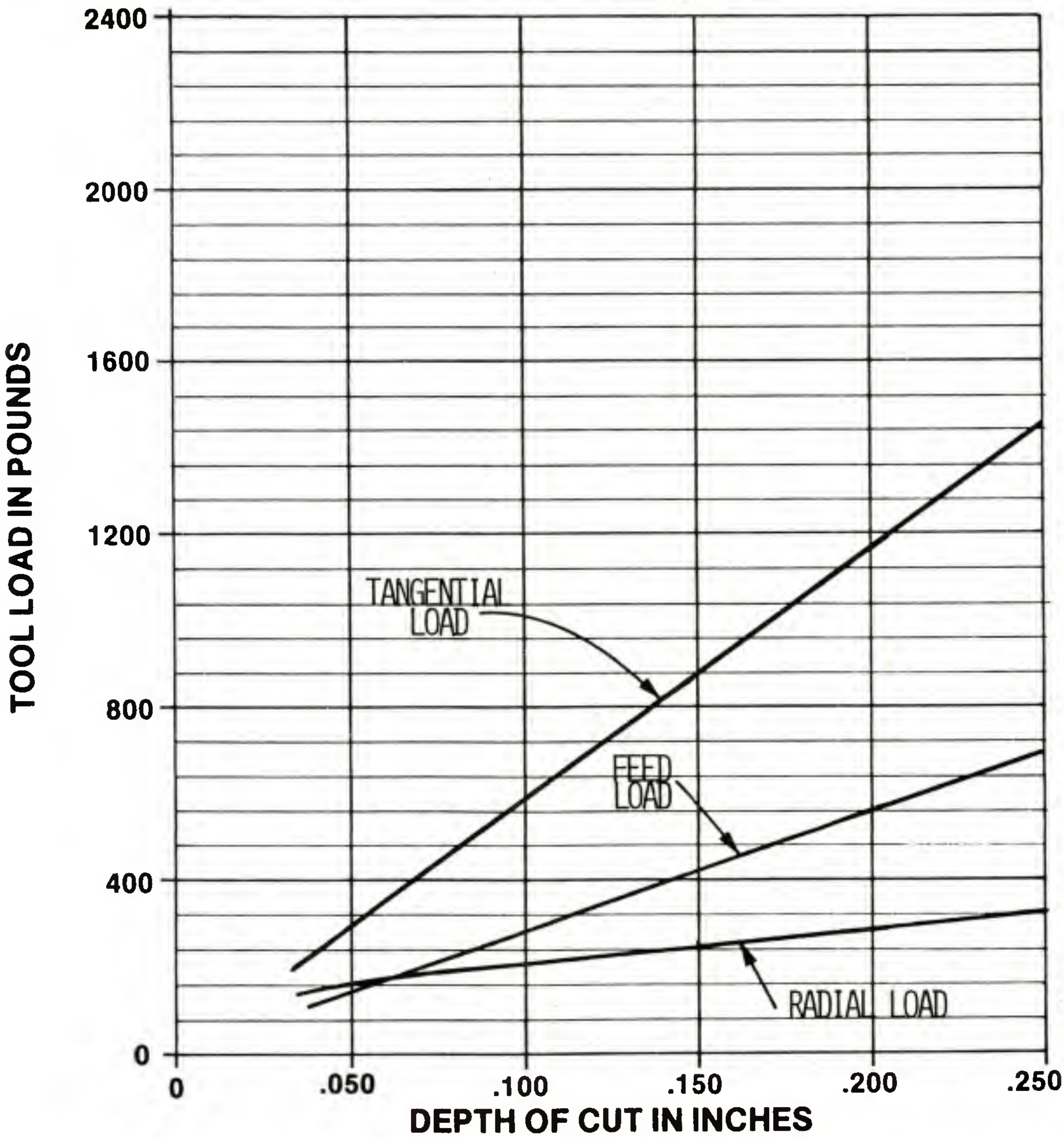

Figure 62: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material: HF-1

Hardness: 269/277 BHN

Feed Rate: .015 IN./REV.

Surface Speed: 330 FT./MIN.

Holder: 0° LEAD ANGLE

Insert: TNMG-433

Grade: KC-810

Coolant: NONE

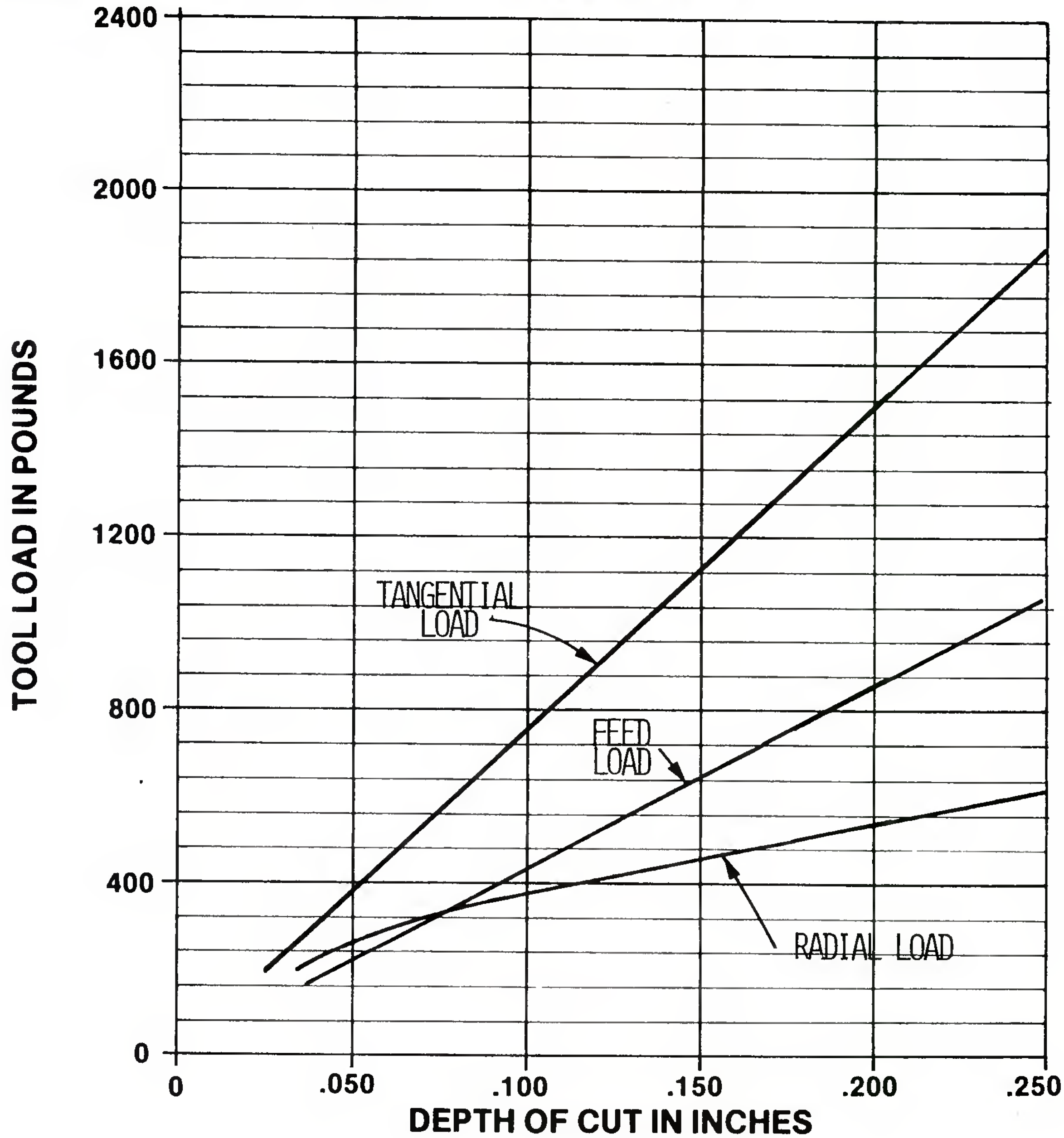

Figure 63: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material:	HF-1	**Holder:**	0^{0} LEAD ANGLE
Hardness:	269/277 BHN	**Insert:**	TNMG-433
Feed Rate:	.022 IN./REV.	**Grade:**	570
Surface Speed:	410 FT./MIN.	**Coolant:**	NONE

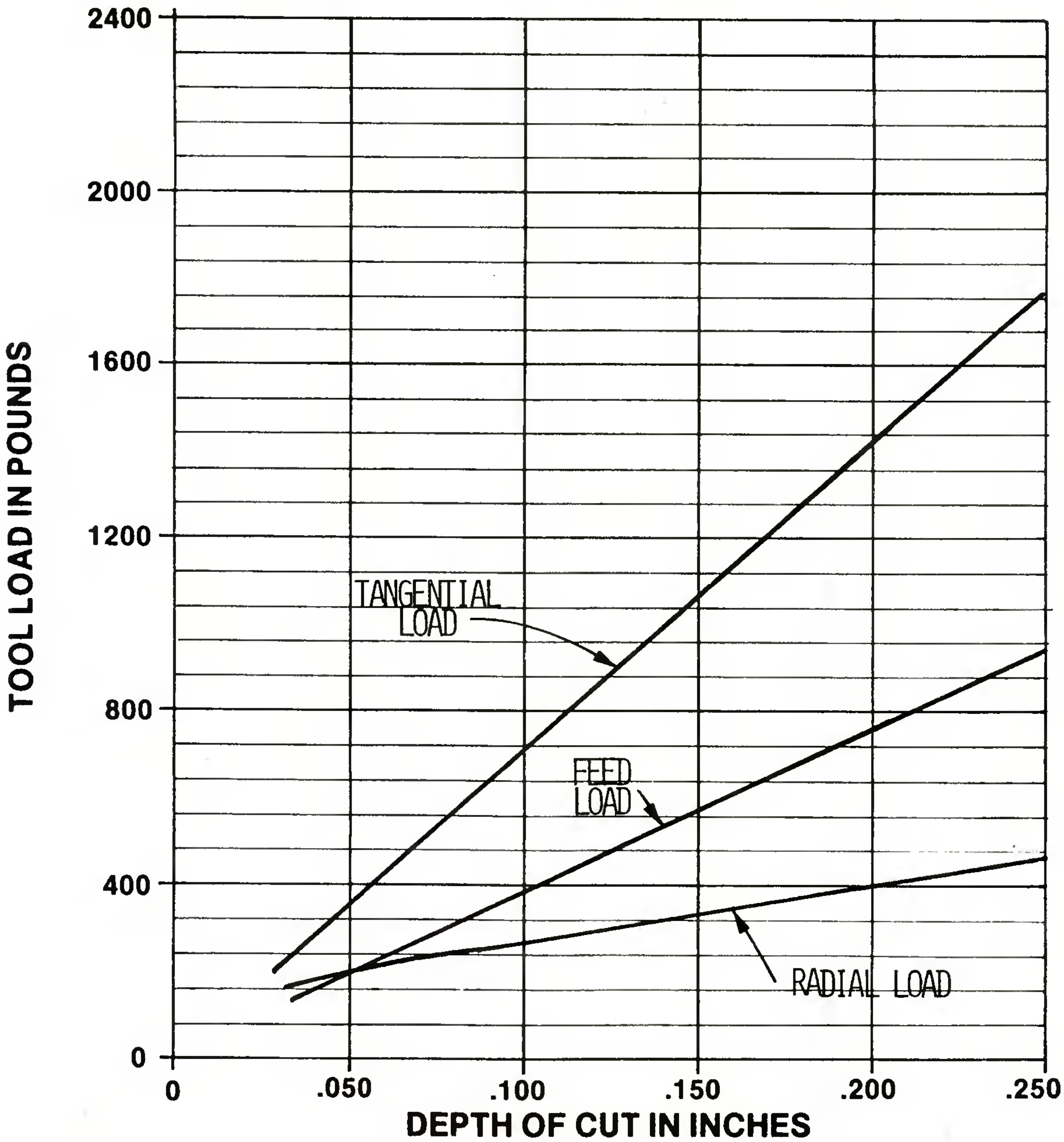

Figure 64: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material:	HF-1	**Holder:**	0^{o} LEAD ANGLE
Hardness:	269/277 BHN	**Insert:**	CNG-454 820
Feed Rate:	.022 IN./REV.	**Grade:**	G-10
Surface Speed:	590 FT./MIN.	**Coolant:**	NONE

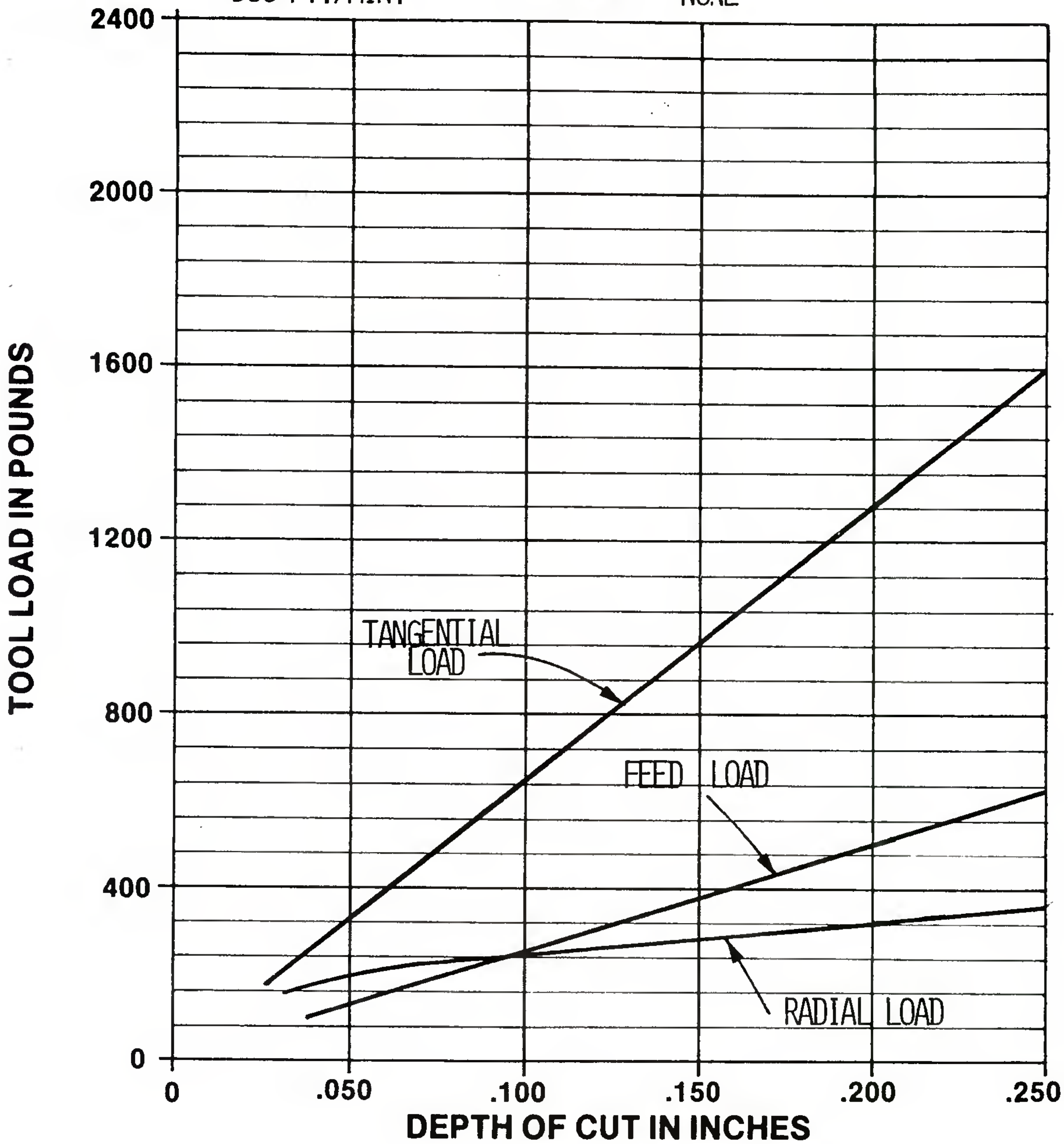

Figure 65: **TOOL LOAD CHART**

TOOL LOAD VERSUS DEPTH OF CUT

Material:	HF-1	**Holder:**	0° LEAD ANGLE
Hardness:	269/277 BHN	**Insert:**	CNG-454 820
Feed Rate:	.015 IN./REV.	**Grade:**	G-30
Surface Speed:	600 FT./MIN.	**Coolant:**	NONE

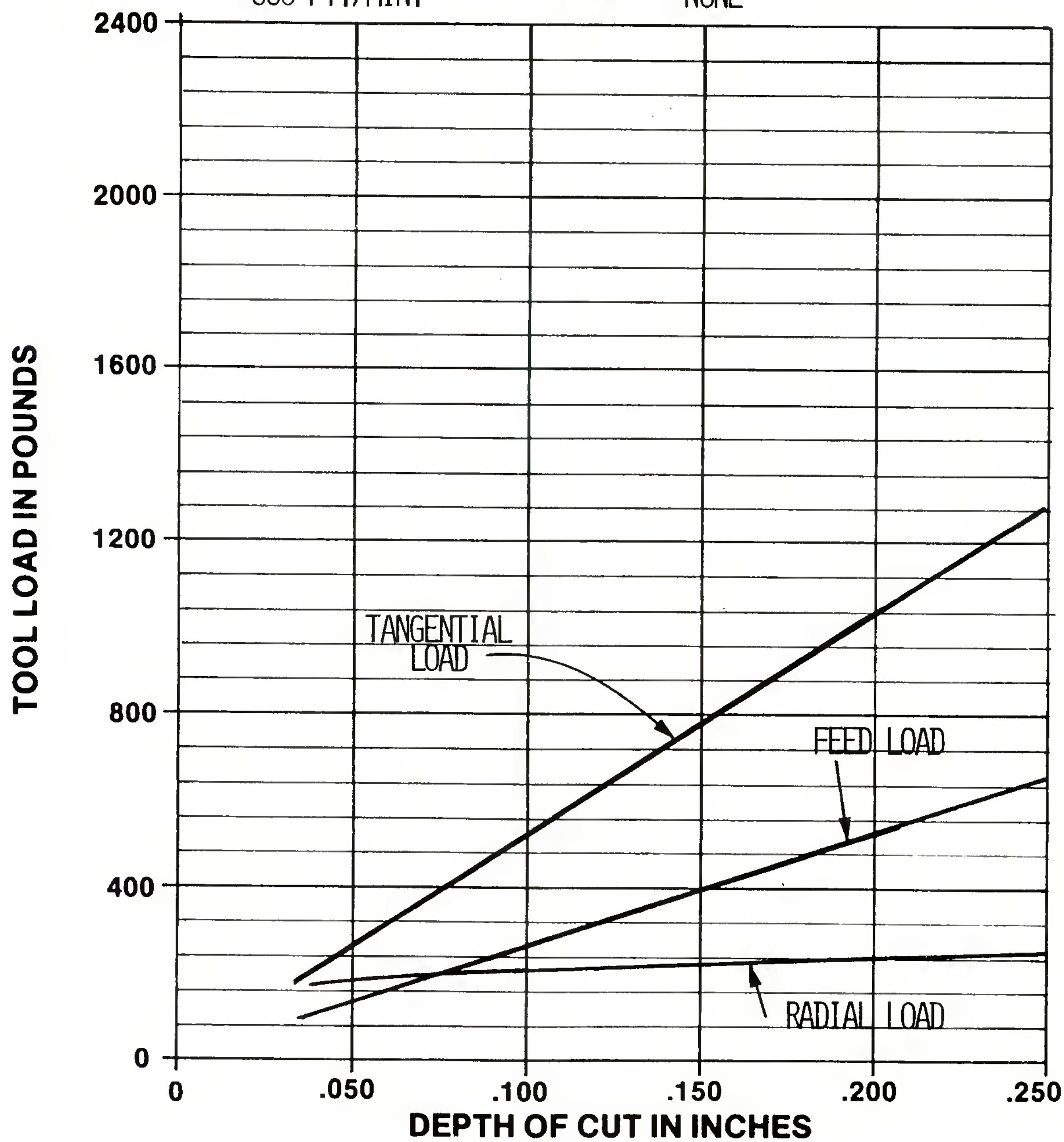

Figure 66: **TOOL LOAD CHART**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: HF-1 **HARDNESS:** 269/277 BHN

INSERT: TNMG-433 **SURFACE FEED:** 285 FT./MIN. **COOLANT:** NONE

GRADE: 350 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	320	170	160
.100	600	290	200
.150	880	420	240
.200	1120	560	280

INSERT: TNMG-433 **SURFACE FEED:** 330 FT./MIN. **COOLANT:** NONE

GRADE: KC-810 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	440	200	250
.100	800	500	380
.150	1160	670	460
.200	1440	820	540

INSERT: TNMG-433 **SURFACE FEED:** 410 FT./MIN. **COOLANT:** NONE

GRADE: 570 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	420	180	180
.100	800	380	270
.150	1120	588	340
.200	1360	730	400

TABLE 45: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: HF-1 **HARDNESS:** 269/277 BHN

INSERT: CNG-454 **SURFACE FEED:** 590 FT./MIN. **COOLANT:** NONE

GRADE: G-10 .008 x 20° **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	380	120	200
.100	720	270	260
.150	1000	400	280
.200	1240	500	340

INSERT: CNG-454 **SURFACE FEED:** 600 FT./MIN. **COOLANT:** NONE

GRADE: G-30 .008 x 20° **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050	310	120	180
.100	560	260	210
.150	800	420	230
.200	920	500	250

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.050			
.100			
.150			
.200			

TABLE 46: **DATA FOR TOOL LOAD CHARTS**

TEST: "Rock-In" tests using Cold-Press Ceramic on XM-795 Projectile bodies of HF-1 Material

These tests were done prior to the life-line tests on HF-1, so there was no previous experience with this material. The purpose of the test was to determine whether ceramic inserts could be used in the concentric rough turning of projectile bodies.

Attached is a data sheet and photographs of the shell after tests showing the condition of the outside diameter of the shell as well as the grooves that were machined. See Tables 45 and 46, and Figures 67 and 68.

The machining was done on a numerically controlled lathe so the tool paths could be controlled. The tool "rocked" into the work at a 60^0 angle for a depth of .200 inches, then turned parallel with the workpiece centerline for .100 inches. The tool then returned 90^0 to the centerline to clear the work. The tool holder used had a 45^0 lead angle and was arranged for a ⅝" I.C. square insert.

Using a surface speed of 1200 feet per minute and a feed-rate of .007 in./rev. for both the "rock-in" and the parallel turn, one corner of the insert machined 17 grooves; with another corner, 12 grooves were machined.

Date: 7/3/80

Material: HF-1

Depth of Cut: .100" to .200"

Coolant: TRIM-SOL 20:1

Hardness: 269 BHN

Tool Description:

Coolant Application: NONE

Holder: CSDNN-205

Insert: SNG-544

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND
1	G-30	900	.007	6.400	-	-	NOTE 1		
2	"	"	"	"	-	-	NOTE 2		
3	"	1200	"	"	6.200	-			
4	"	"	"	"	6.100	-	SAME EDGE OF		INSERT
5-19	"	"	"	"	6.000	-	" "	"	"
							NOTE 3		
20	"	1400	"	6.410	6.210	-	NOTE 4		

NOTES: NOTE 1 - .006" x 30° K-LAND. TOOL FAILURE, CUT TOO DEEP. TURNING FEED .015 IN./REV.

NOTE 2 - .012 x 30° K-LAND. TOOL FAILURE, CUT TOO DEEP. TURNING FEED CHANGED TO .0105 IN./REV.

NOTE 3 - STOPPED AT END OF SHELL. TOOL WORN, STARTING TO CHATTER.

NOTE 4 - NOTE INCREASED SURFACE SPEED. NEW SHELL/ SAME HARDNESS.

TABLE 47

Date:	7/3/80	**Material:**	HF-1
Depth of Cut:	.100" to .200"	**Coolant:**	TRIM-SOL 20:1
Hardness:	269 BHN	**Tool Description:**	
Coolant Application:	NONE	**Holder:**	CSDNN-205
		Insert:	SNG-544

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND
21-23	G-30	1400	.007	6.410	6.010	–	NOTE 5		
24-36	"	1200	"	"	"	–	NOTE 6		

NOTES: NOTE 5 - SAME EDGE OF INSERT. TEST STOPPED DUE TO TOOL CHATTER: EXCESSIVE TOOL WEAR

NOTE 6 - NEW INSERT FOR #24, SAME EDGE TO #36. TEST STOPPED AT END OF SHELL. TOOL WORN.

TABLE 48

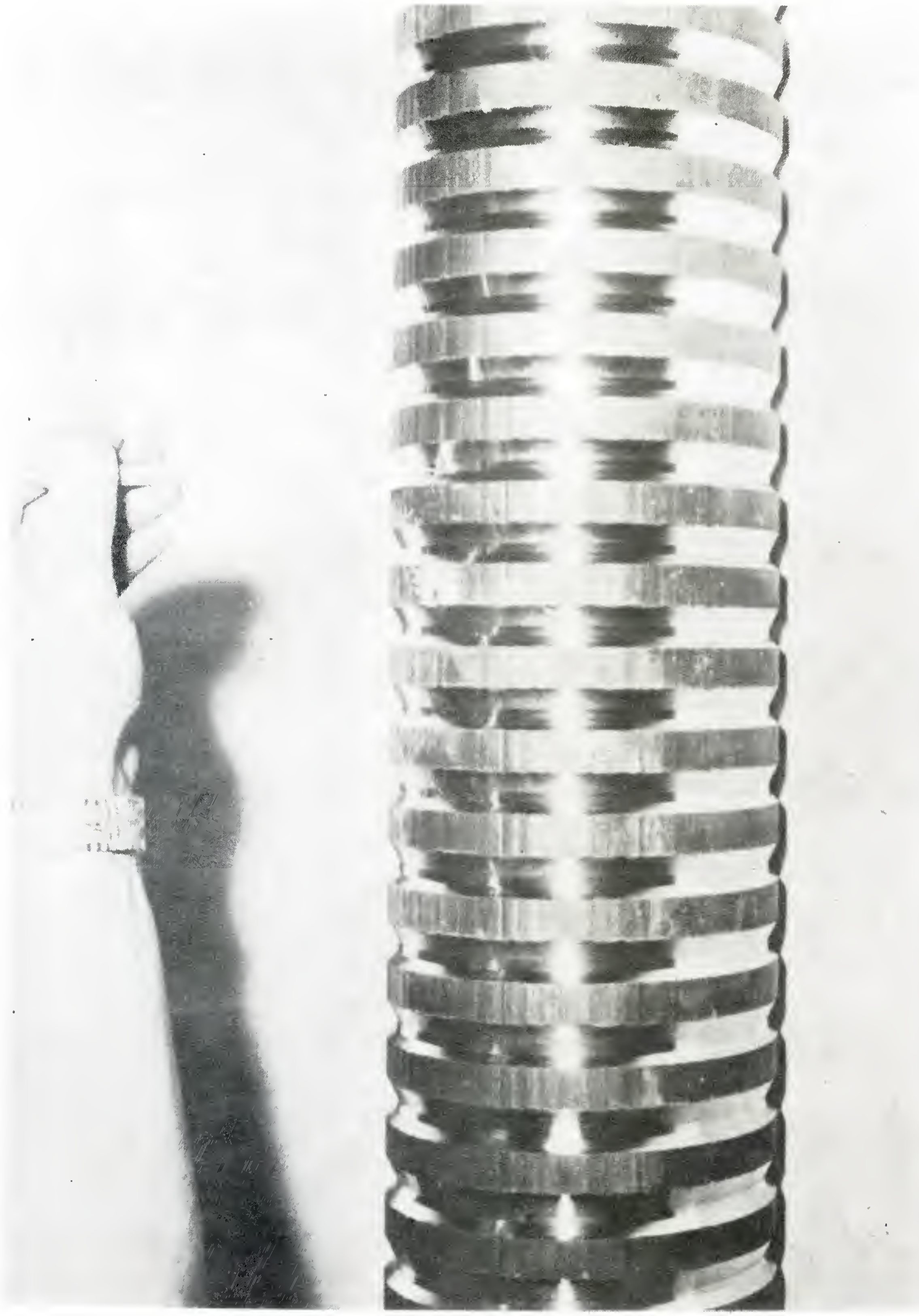

FIGURE 67

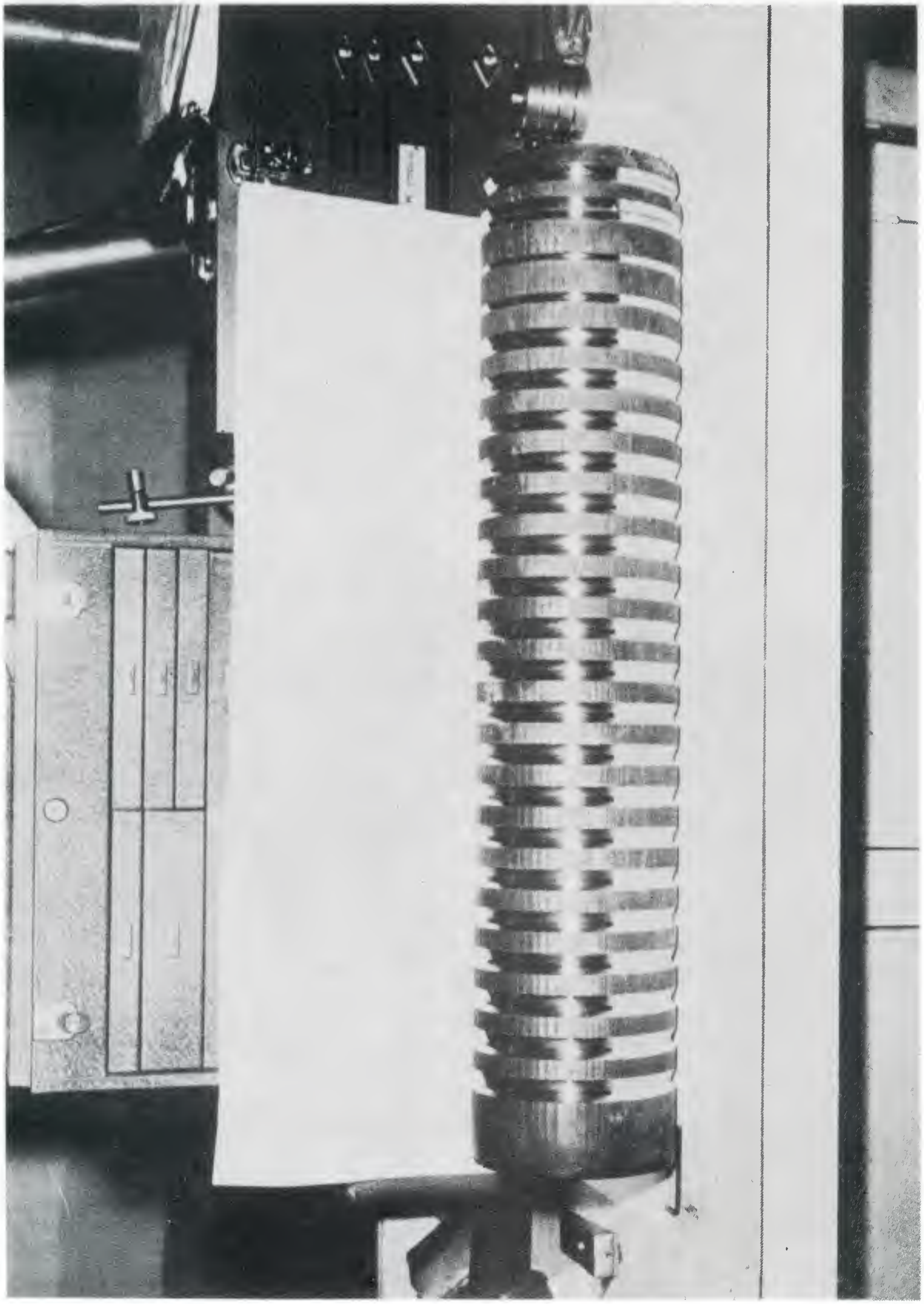

FIGURE 68

AISI 1340 Projectile Material - "Finishing Cuts" - 28 Rc Hardness

The surface finish requirement for this material was 125 A.A. (Arithmetic Average) as shown on Table 1, page 5. This limited the feed for these tests to .011 inches per revolution. The depth of cut was .050 inches as designated in Table 1.

With the combination of low feed and shallow depth of cut, chip-breaking was one of the largest problems during the testing of this material. The swarf came off the tool as long stringers, and in most cases would not break. Some of the new molded-in chip-breakers should be tried on this material to alleviate this problem.

The tool-life curves gave some interesting results in that the carbide tools, either plain titanium coated or ceramic coated, would operate at similar surface speeds for equal tool life. The titanium coated carbide gave the highest cutting speed for equal tool life, as shown on Table 49, page 133.

The ceramic tools gave a lower surface cutting speed than shown on the tests for "roughing" cuts. Where the feed is lowered, this lowers the cutting speed for equal tool life by a substantial amount as can be seen by comparing Figure 69 on page 134 and Figure 20 on page 34.

When comparing the production indexes for the various cutting materials, it is obvious that ceramic cutting tools will give a much higher production rate than carbide.

The horsepower requirements for various tool geometrics are shown on Figures 70 to 79, pages 137 to 146. See also Tables 52 through 55, pages 147 through 150. In most cases, the round inserts will consume horsepower at almost double the rate as triangular inserts. However, they are operating at double the feed rate. Therefore, there is some energy saving when round inserts are used.

Figure 81, page 152 shows the results of varying nose radius and its effect on surface finish. As the nose radius increases, the finish gets better. Figure 80, page 151 shows the effect of changing surface speed on surface finish. In this case, there is very little effect. Tables 56 and 57 contain the corresponding data.

SUMMARY OF RESULTS

"FINISHING CUT"

MATERIAL	AISI-1340
HARDNESS	269 Bhn.
TOOL LIFE	2500 In^2 of Machined Surface
DEPTH OF CUT	.050 Inches

Insert Grade	Insert Style	SFM	Feed In./Rev.	Prod. Index	Tangential Tool Load - Lbs. .050 Depth of Cut	H.P. .050 Depth of Cut
350	TNMG-433	350	.011	3.85	210	2.23
KC-810	TNMG-433	370	.011	4.07	200	2.24
570	TNMG-433	330	.011	3.63	210	2.1
G-10	CNG-454	670	.011	7.37	240	4.87
G-30	CNG-454	630	.011	6.93	210	4.01
350	RNMG-43	350	.022	—	380	4.03
KC-810	RNMG-43	370	.022	—	390	4.37
570	RNMG-43	330	.022	—	440	4.4
G-10	RNG-45	670	.022	—	380	7.72
G-30	RNG-45	630	.022	—	360	6.87

TABLE 49: AISI-1340 RESULTS OF TESTS

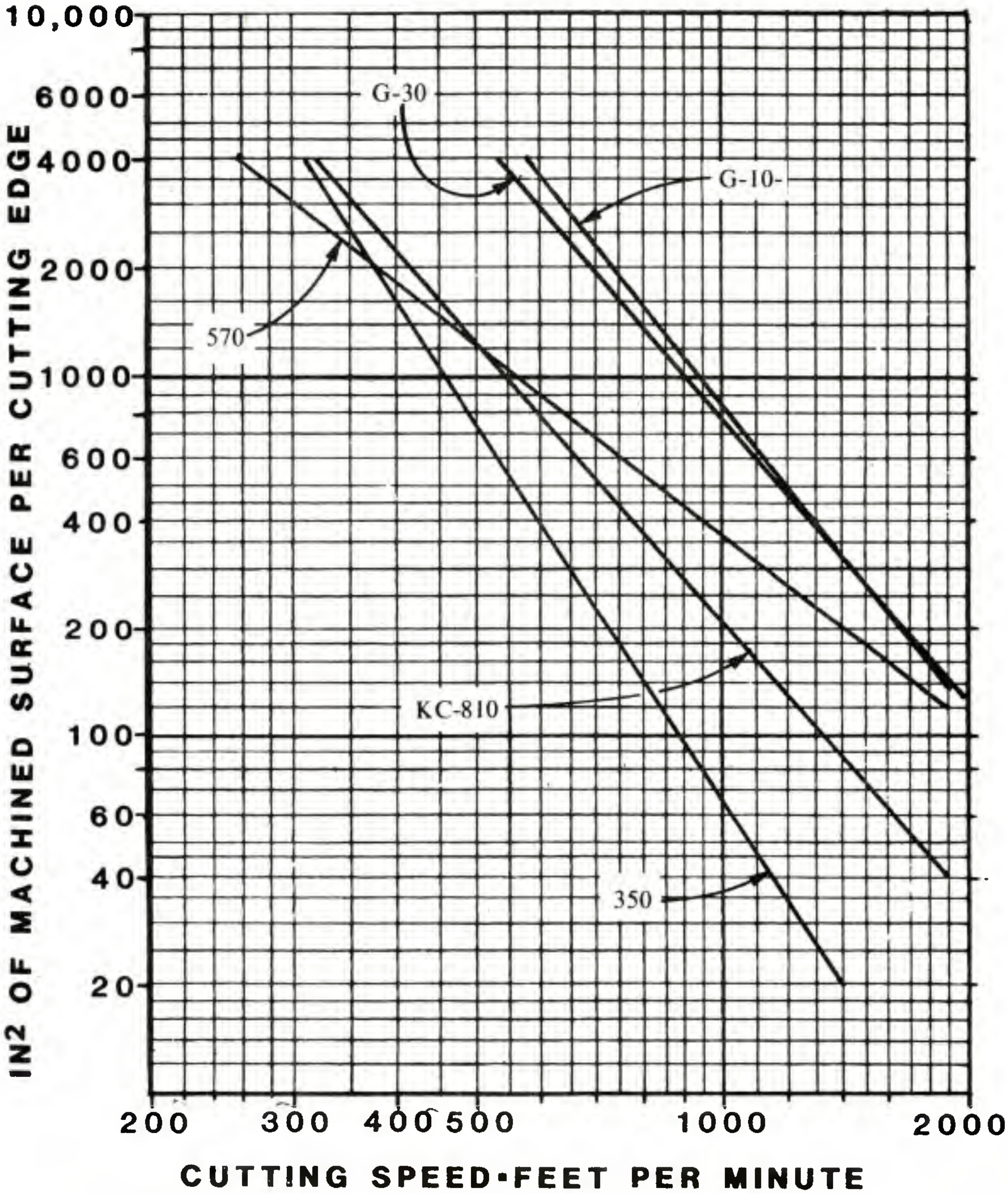

Figure 69: Tool-Life Lines of Listed Cutting Materials on AISI 1340 Steel at 269 Brinell Hardness.

Feed - .011 Inches per Revolution
Depth of Cut - .050 Inches
350, KC-810, 570: Holder - MTANR-164 (0^0 Lead Angle)
Insert - TNMG-433
G-10, G-30: Holder - CCGNR-164 (0^0 Lead Angle)
Insert - CNG-454 .008 x 20^0

Date:	9/8/80	**Material:**	AISI 1340
Depth of Cut:	.050	**Coolant:**	TRIM-SOL 20:1
Hardness:	269 BHN	**Tool Description:**	
Coolant Application:	TOP	**Holder:**	MTANR-164
		Insert:	TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
1	350	500	.011	6.234	6.131	10.85	208.9	.009	557	.024
2	"	600	"	"	"	5.7	109.7	.006	439	.024
3	"	700	"	6.131	6.032	6.3	119.3	.012	238.7	.024
4	KC-810	600	"	"	"	8.1	153.4	.005	736.7	.024
5	"	700	"	6.032	5.936	8.5	158.5	.008	475.5	.024
6	"	800	"	"	"	8.5	158.5	.0095	400.4	.024
				NEW SHELL/SAME HARDNESS						
7	570	700	.011	6.290	6.190	11.7	227.5	.0085	624.4	.024
8	"	800	"	"	"	8.1	157.5	.007	540	.024
9	"	900	"	6.190	6.089	8.0	153	.008	459	.024

NOTES: VERY POOR CHIP CONTROL. ALL TESTS HAD STRINGERS.

TABLE 50 : DATA FOR LIFE LINES

Date: 9/9/80	**Material:** AISI 1340
Depth of Cut: .050	**Coolant:** TRIM-SOL 20:1
Hardness: 269 BHN	**Tool Description:**
Coolant Application: TOP: G-10 NONE: G-30	**Holder:** CCGNR-164
	Insert: CNG-454

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
1	G-10	1100	.011	6.089	5.979	6.2	116.4	.003	582.2	.015
2	"	900	"	5.979	5.889	12.8	236.8	.004	1014.9	.015
3	"	1000	"	"	"	7.3	135.0		CUT CONTINUED	
3a	"	"	"	5.889	5.785	12.3	358.5	.0055	977.7	.015
				NEW SHELL/SAME HARDNESS						
4	G-30	900	.011	6.235	6.138	19.0	366.3	.006	915.9	.015
5	"	1000	"	6.138	6.038	19.5	369.8	.0065	853.6	.015
6	"	1100	"	6.038	5.938	20	373	.0095	589	.015

NOTES: VERY POOR CHIP CONTROL. STRINGERS SMALLER FOR G-30 THAN G-10.

TABLE 51: DATA FOR LIFE LINES

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 1340 **HOLDER:** MTANR-164 0° LEAD ANGLE

HARDNESS: 269/277 BHN **INSERT:** TNMG-433

SURFACE SPEED: 350 FT./MIN. **GRADE:** 350

FEED RATE: .011 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP

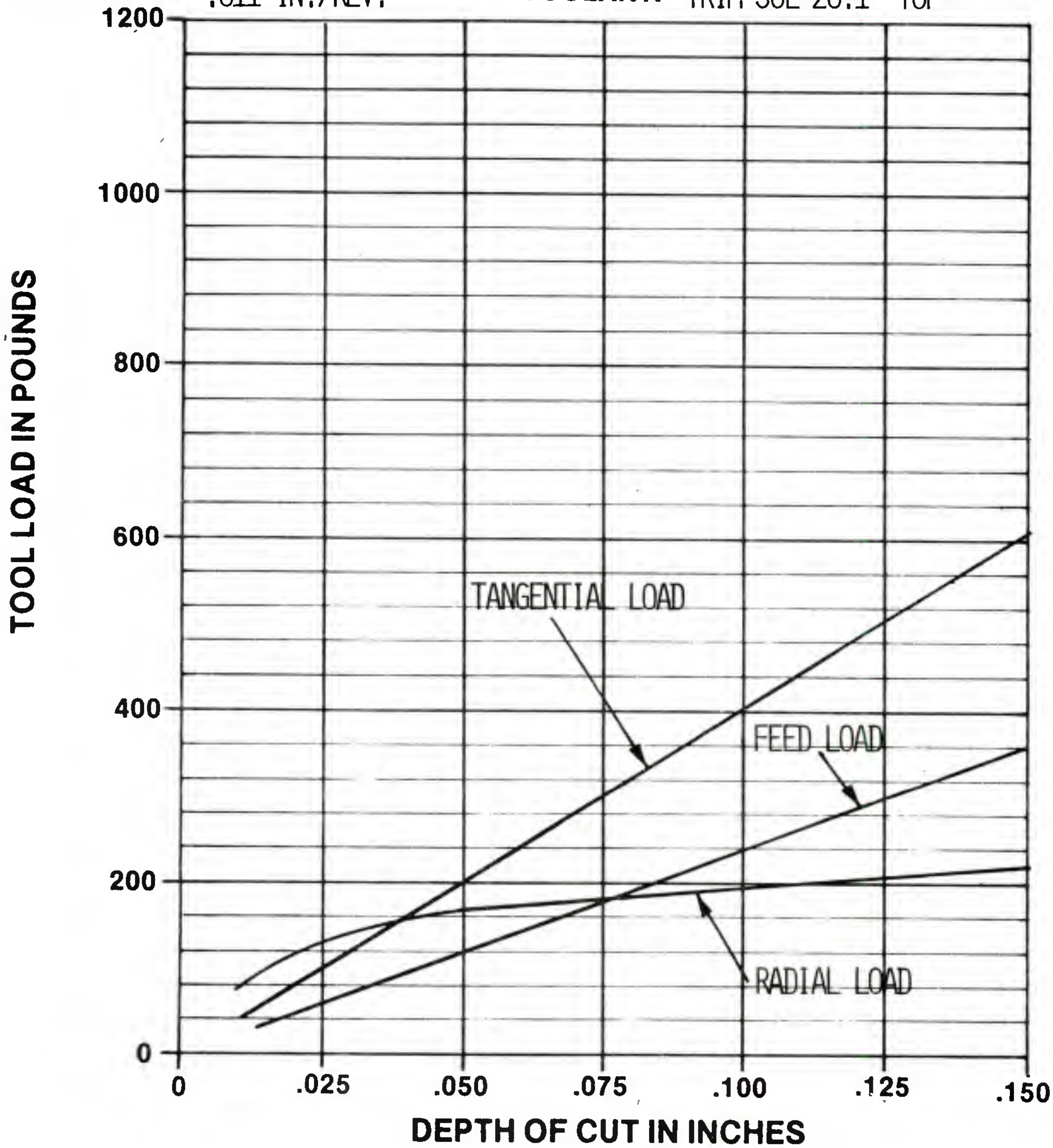

FIGURE 70 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 1340 **HOLDER:** MTANR-164 0° LEAD ANGLE

HARDNESS: 269/277 BHN **INSERT:** TNMG-433

SURFACE SPEED: 370 FT./MIN. **GRADE:** KC-810

FEED RATE: .011 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP

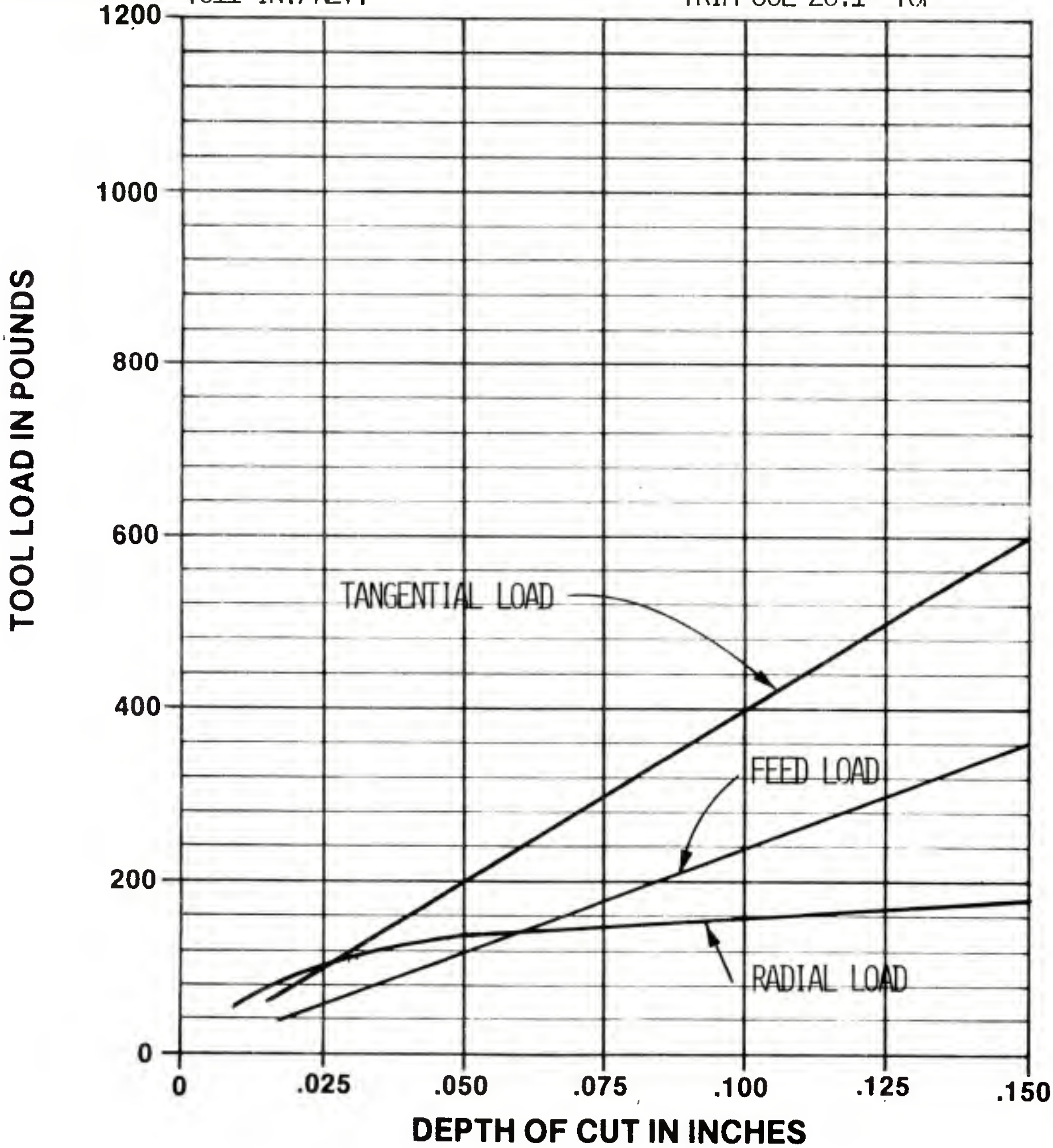

FIGURE 71 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 1340	**HOLDER:**	MTANR-164
HARDNESS:	269/277 BHN	**INSERT:**	TNMG-433 0^{O} LEAD ANGLE
SURFACE SPEED:	.330 FT./MIN.	**GRADE:**	570
FEED RATE:	.011 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP

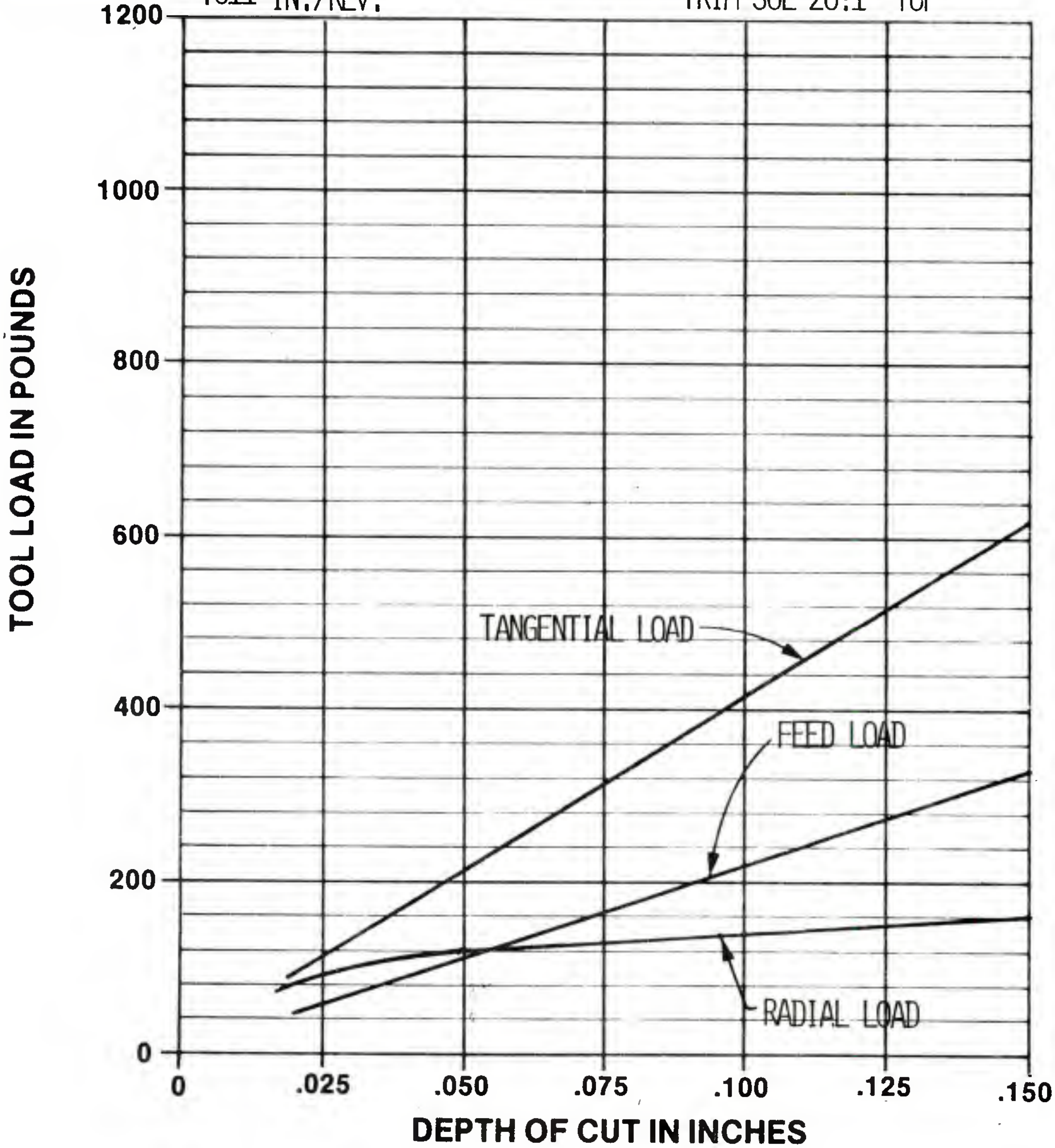

FIGURE 72: TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 1340
HOLDER: CCGNR-164 0^{0} LEAD ANGLE
HARDNESS: 269/277 BHN
INSERT: CNG-454 .008 x 20^{0}
SURFACE SPEED: 670 FT./MIN.
GRADE: G-10
FEED RATE: .011 IN./REV.
COOLANT: TRIM-SOL 20:1 TOP

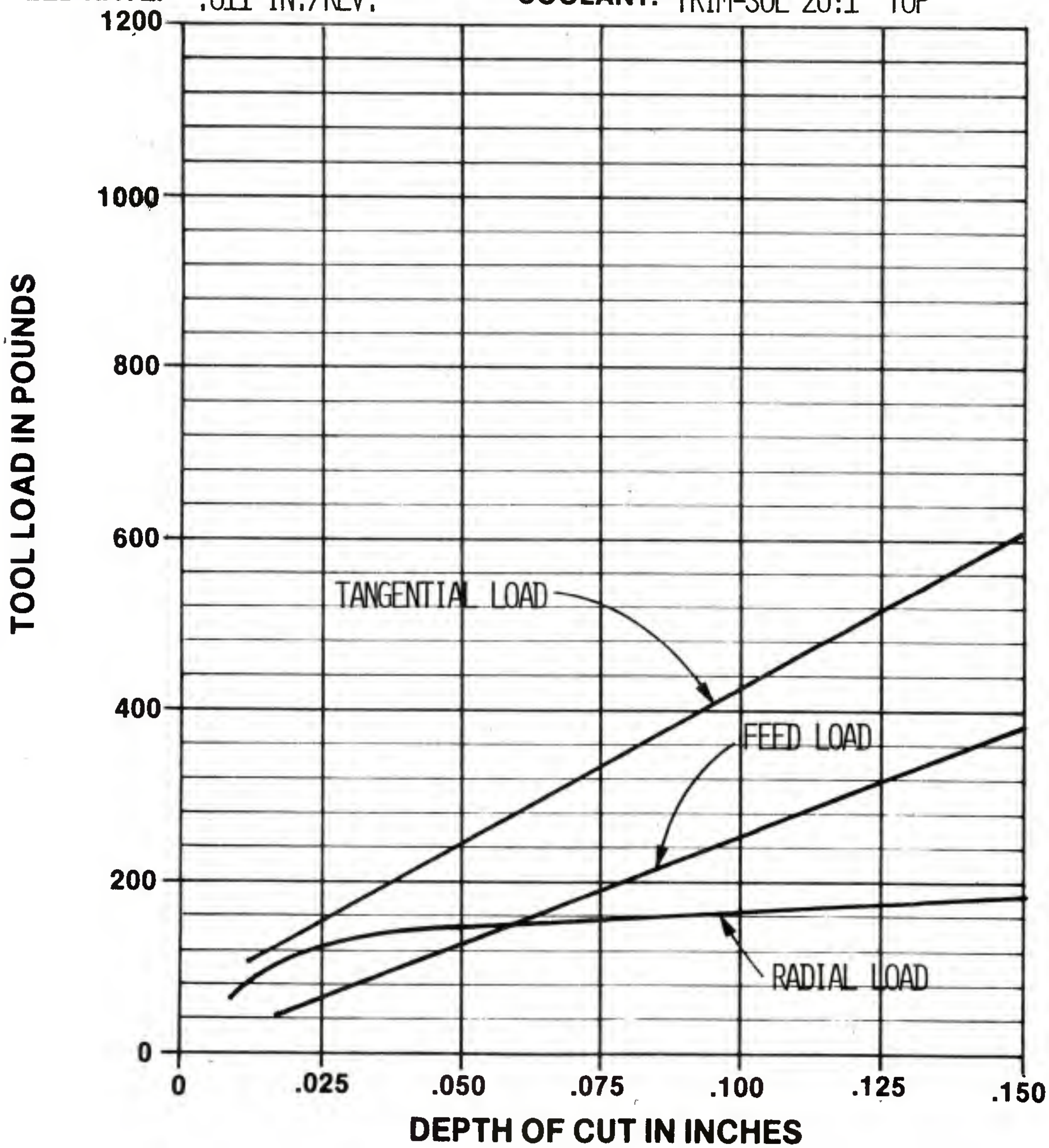

FIGURE 73 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 1340 HOLDER: CCGNR-164 0° LEAD ANGLE

HARDNESS: 269/277 BHN INSERT: CNG-454 .008 x 20°

SURFACE SPEED: 630 FT./MIN. GRADE: G-30

FEED RATE: .011 IN./REV. COOLANT: NONE

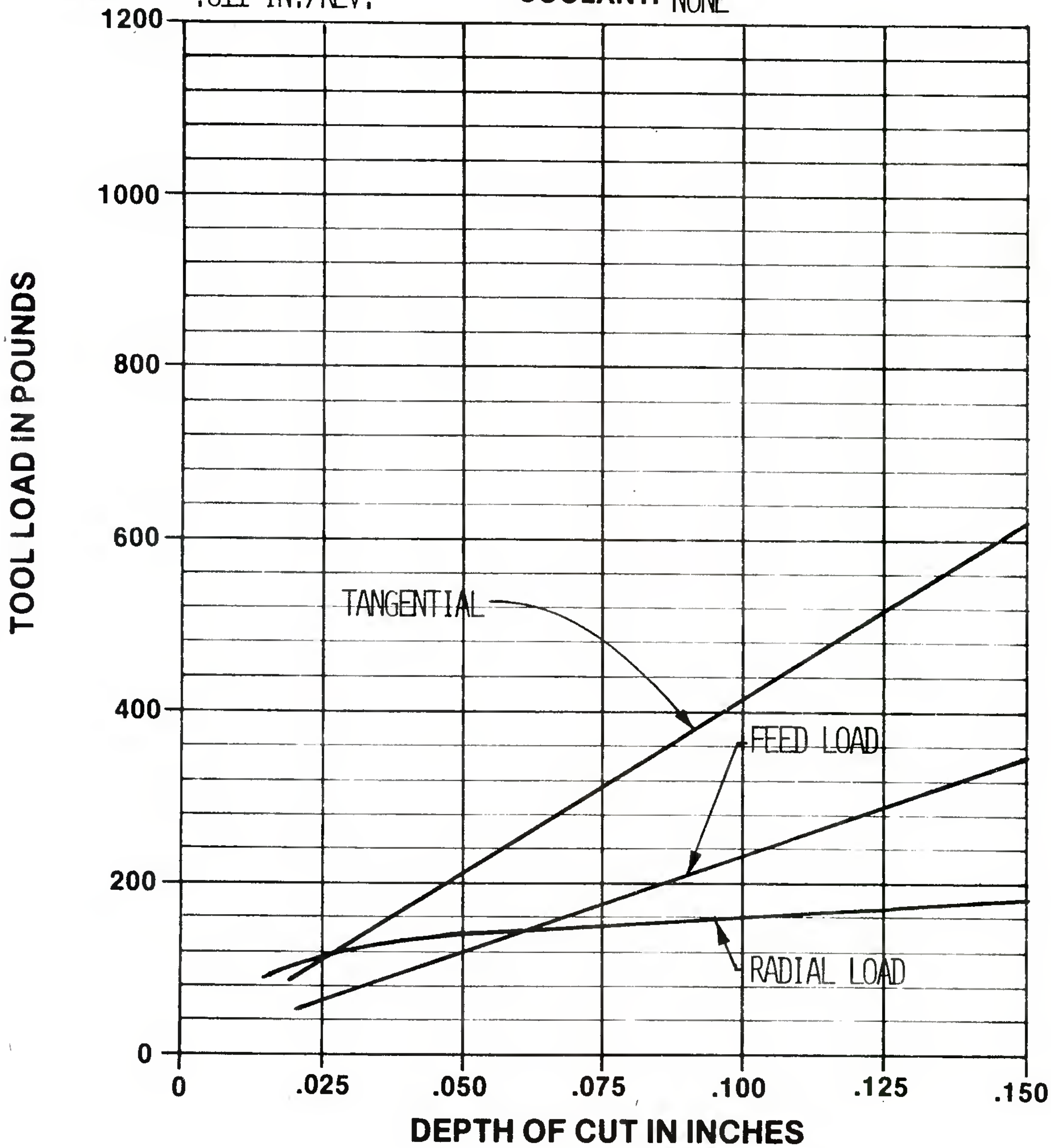

FIGURE 74 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 1340 HOLDER: PRANR-164

HARDNESS: 269/277 BHN INSERT: RNMG-43

SURFACE SPEED: 350 FT./MIN. GRADE: 350

FEED RATE: .022 IN./REV. COOLANT: TRIM-SOL 20:1 TOP

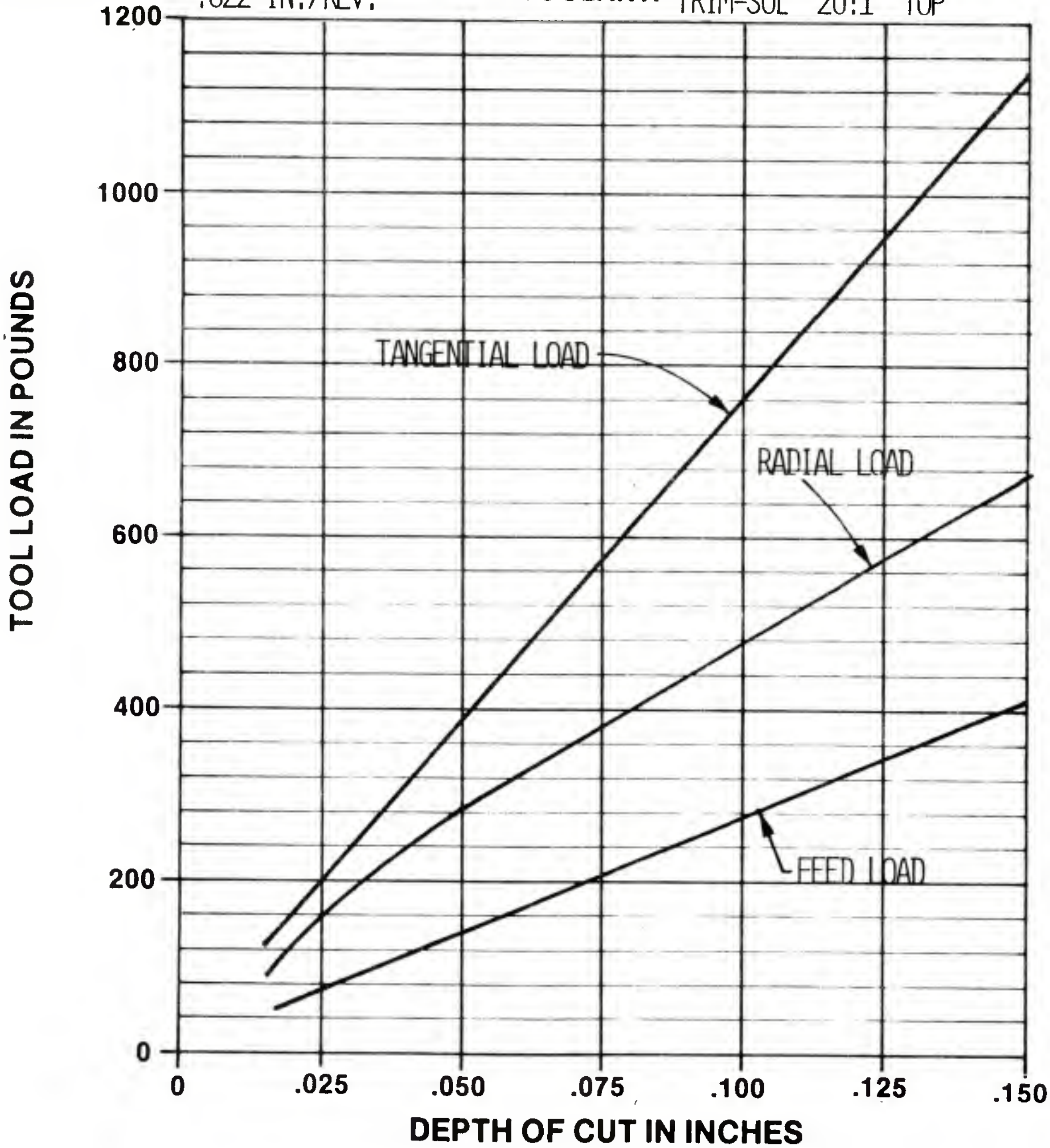

FIGURE 75 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 1340 **HOLDER:** PRANR-164

HARDNESS: 269/277 BHN **INSERT:** RNMG-43

SURFACE SPEED: 370 FT./MIN. **GRADE:** KC-810

FEED RATE: .022 IN./REV. **COOLANT:** TRIM-SOL 20:1

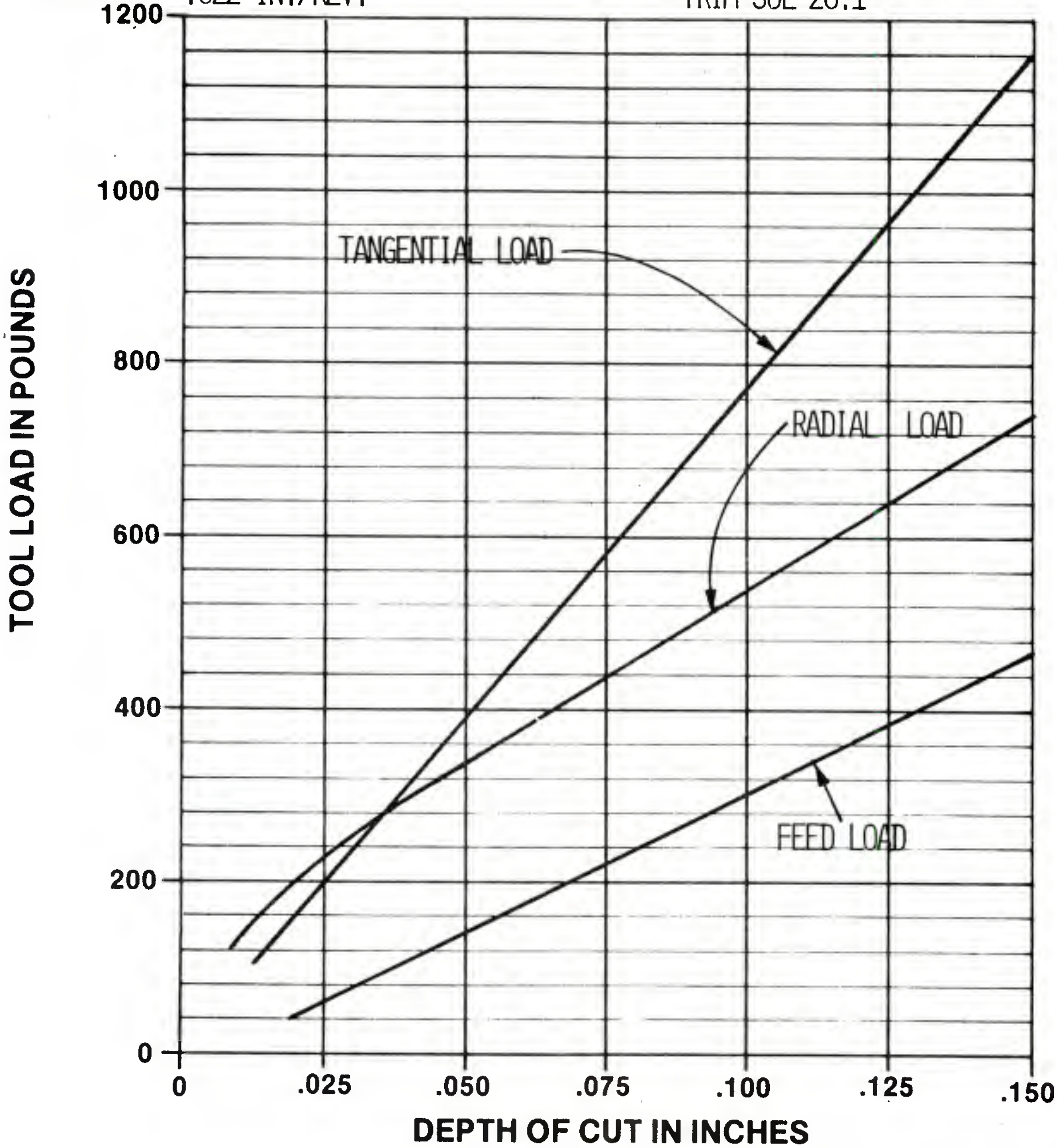

FIGURE 76 : TOOL LOAD CHART

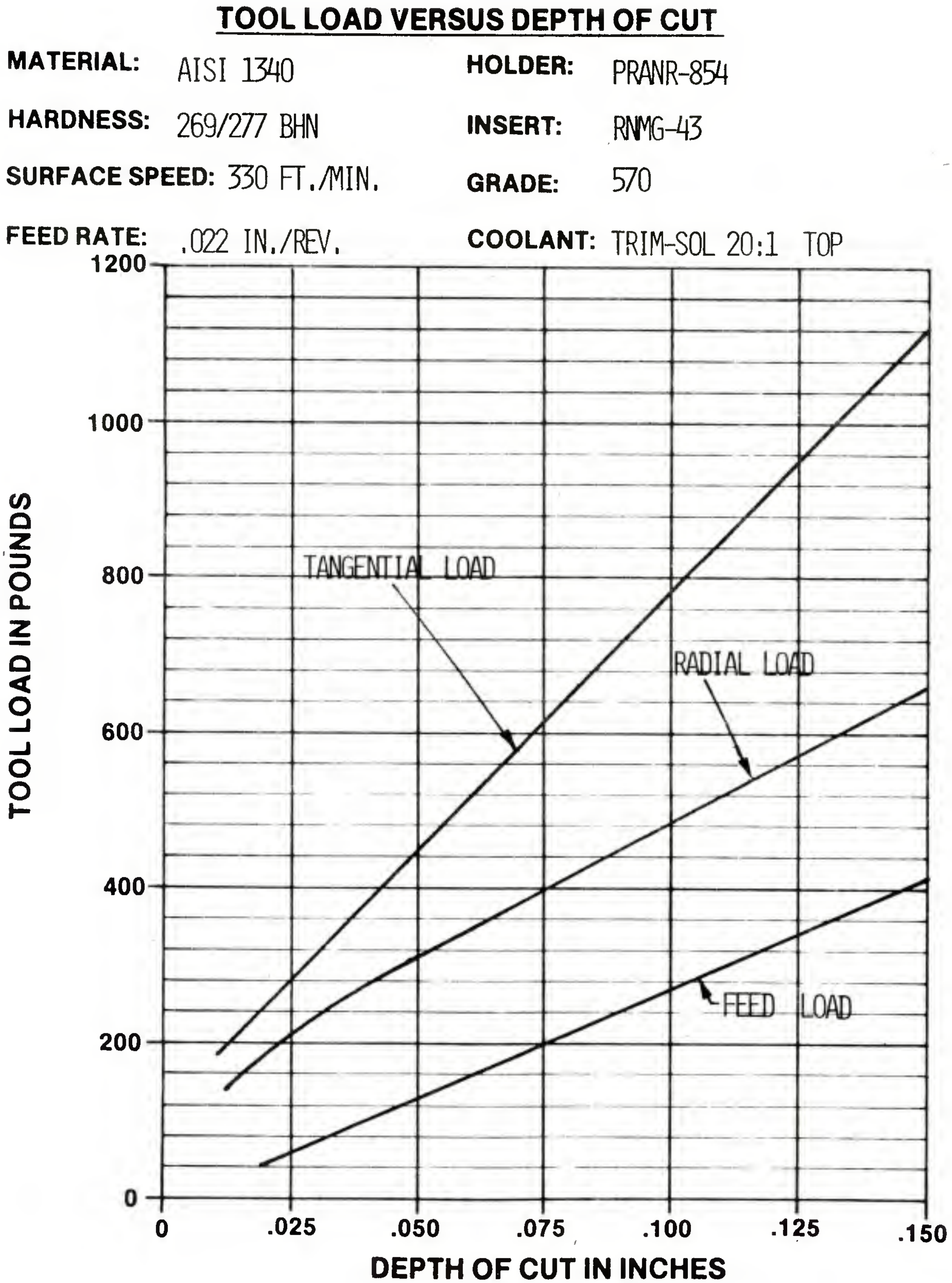

FIGURE 77: TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 1340 **HOLDER:** CRGNR-164

HARDNESS: 269/277 BHN **INSERT:** RNG-45 .008 x 20°

SURFACE SPEED: 650 FT./MIN. **GRADE:** G-10

FEED RATE: .022 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP

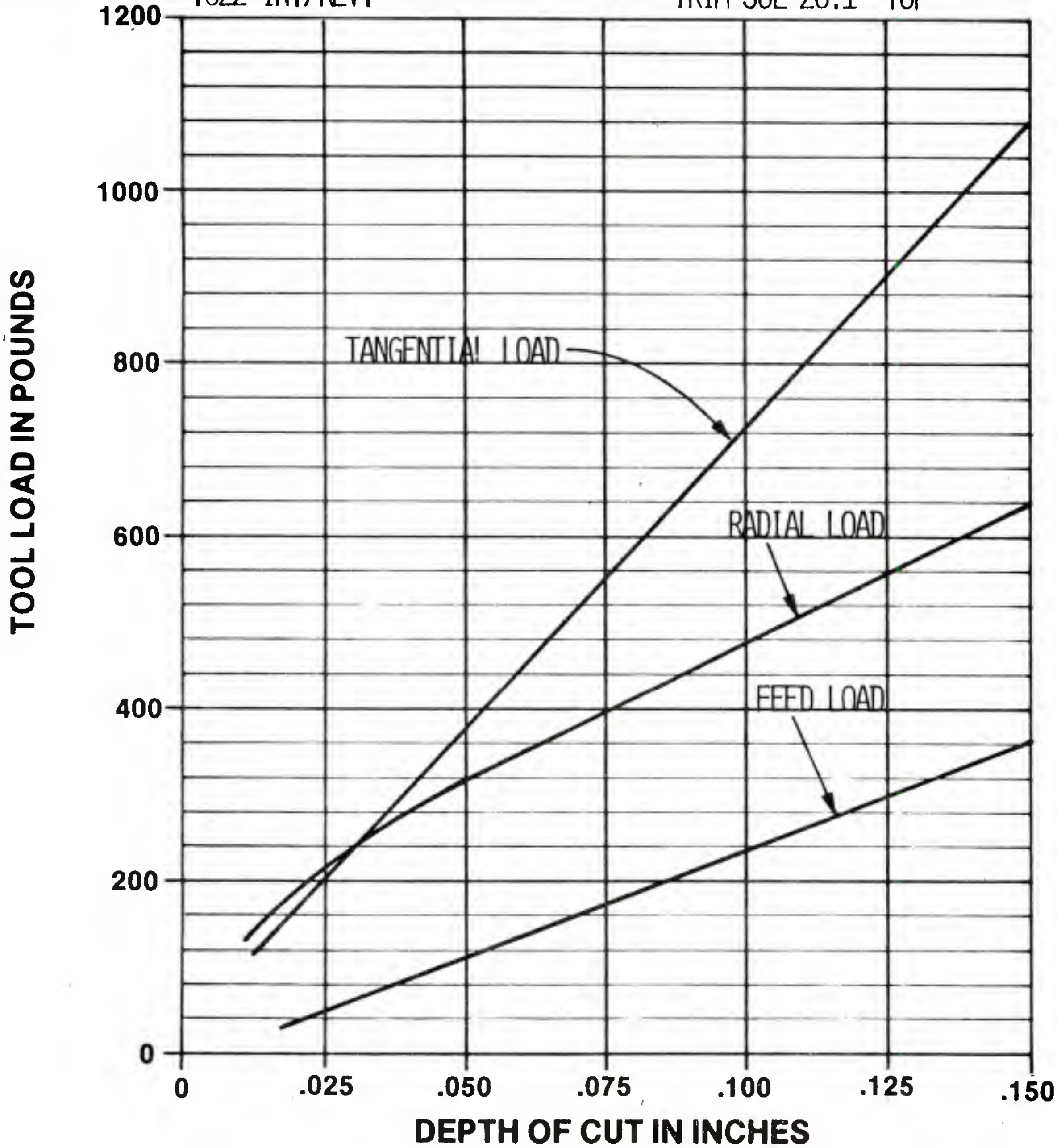

FIGURE 78 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 1340 **HOLDER:** CRGNR-164

HARDNESS: 269/277 BHN **INSERT:** RNG-45 .008" x 20°

SURFACE SPEED: 630 FT./MIN. **GRADE:** G-30

FEED RATE: .022 IN./REV. **COOLANT:** NONE

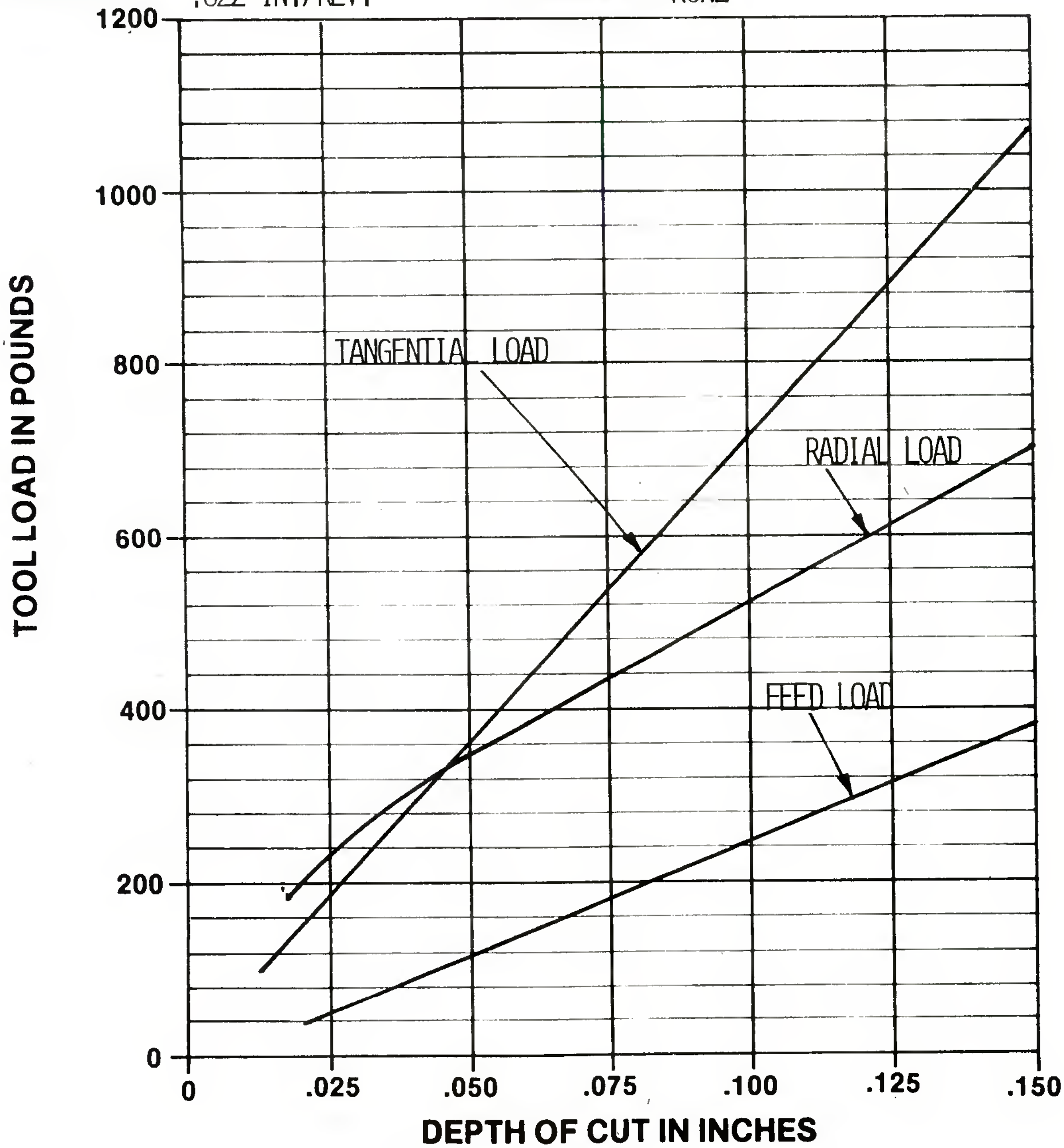

FIGURE 79 : TOOL LOAD CHART

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 1340 **HARDNESS:** 269/277 BHN

INSERT: TNMG-433 **SURFACE FEED:** 350 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 350 **FEEDRATE:** .011 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	120	50	140
.050	220	120	170
.100	420	245	190
.150	600	360	220

INSERT: TNMG-433 **SURFACE FEED:** 370 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: KC-810 **FEEDRATE:** .011 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	120	55	110
.050	220	125	140
.100	400	250	160
.150	580	365	180

INSERT: TNMG-433 **SURFACE FEED:** 330 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 570 **FEEDRATE:** .011 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	140	60	100
.050	240	120	120
.100	420	230	130
.150	600	330	160

TABLE 52: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 1340 **HARDNESS:** 269/277 BHN

INSERT: CNG-454 .008" x 20° **SURFACE FEED:** 670 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .011 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	130	55	110
.050	230	115	140
.100	420	240	170
.150	600	355	180

INSERT: CNG-454 .008" x 20° **SURFACE FEED:** 630 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .011 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	160	70	130
.050	240	115	150
.100	440	250	175
.150	600	370	190

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025			
.050			
.100			
.150			

TABLE 53: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 1340 **HARDNESS:** 269/277 BHN

INSERT: RNMG-43 **SURFACE FEED:** 350 FT./MIN **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 350 **FEEDRATE:** .022 IN./REV. (95AA SURFACE

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	280	55	210
.050	420	105	310
.100	800	220	500
.150	1000	430	660

INSERT: RNMG-43 **SURFACE FEED:** 370 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: KC-810 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	240	50	220
.050	400	110	330
.100	760	280	560
.150	1120	480	740

INSERT: RNMG-43 **SURFACE FEED:** 330 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 570 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	200	40	160
.050	400	100	280
.100	760	260	520
.150	1120	420	660

TABLE 54 **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 1340 **HARDNESS:** 269/277 BHN

INSERT: RNG-45 .008" x 20° **SURFACE FEED:** 650 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	200	40	200
.050	400	100	320
.100	740	235	500
.150	1080	380	645

INSERT: RNG-45 .008" x 20° **SURFACE FEED:** 630 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	200	40	220
.050	400	100	350
.100	720	240	540
.150	1080	390	695

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025			
.050			
.100			
.150			

TABLE 55: **DATA FOR TOOL LOAD CHARTS**

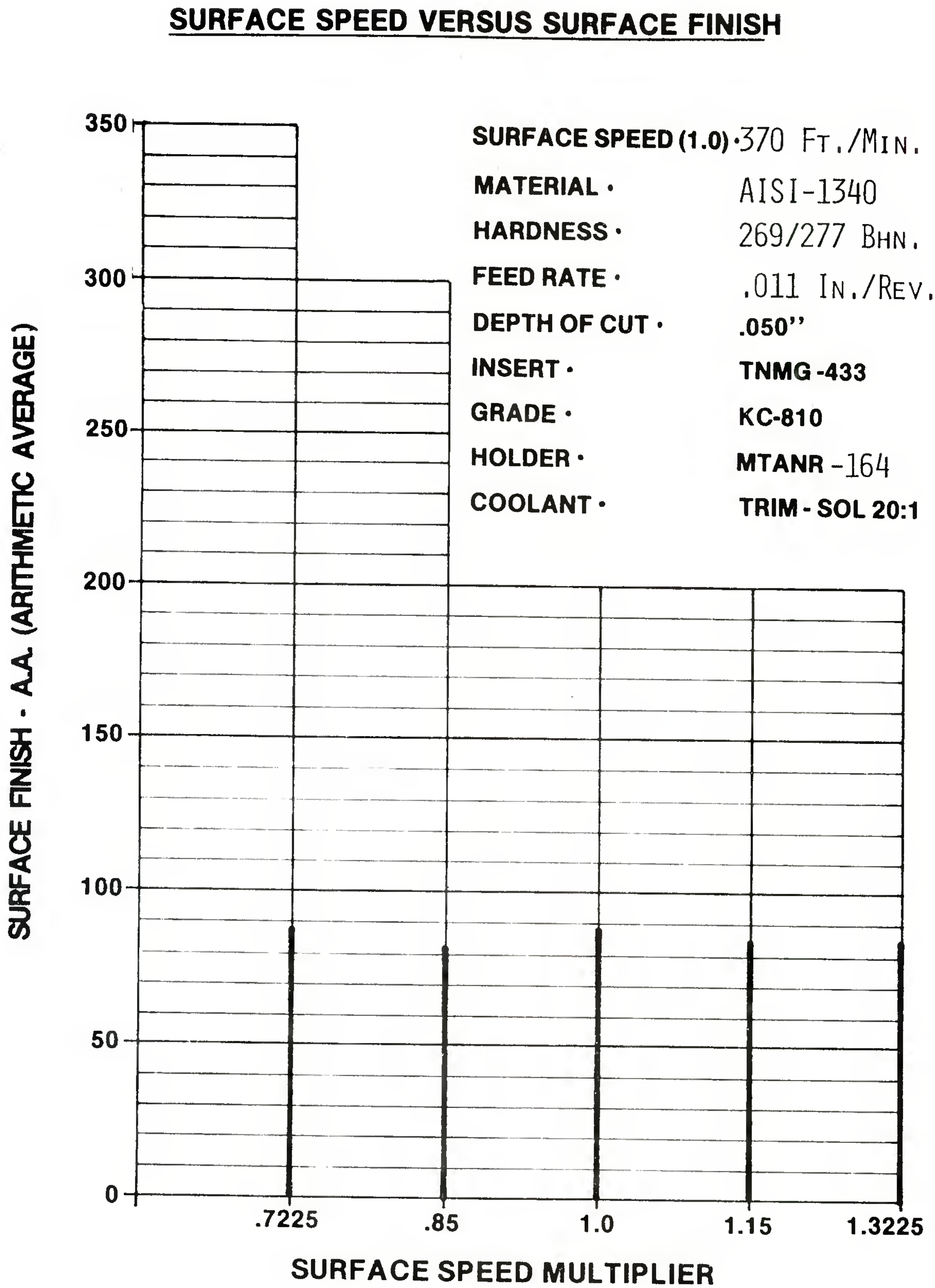
SURFACE SPEED VERSUS SURFACE FINISH
SURFACE SPEED (1.0) · 370 FT./MIN.
MATERIAL · AISI-1340
HARDNESS · 269/277 BHN.
FEED RATE · .011 IN./REV.
DEPTH OF CUT · .050''
INSERT · TNMG -433
GRADE · KC-810
HOLDER · MTANR -164
COOLANT · TRIM - SOL 20:1
350
300
250
200
150
100
50
0
SURFACE FINISH - A.A. (ARITHMETIC AVERAGE)
.7225
.85
1.0
1.15
1.3225
SURFACE SPEED MULTIPLIER

Figure 80:

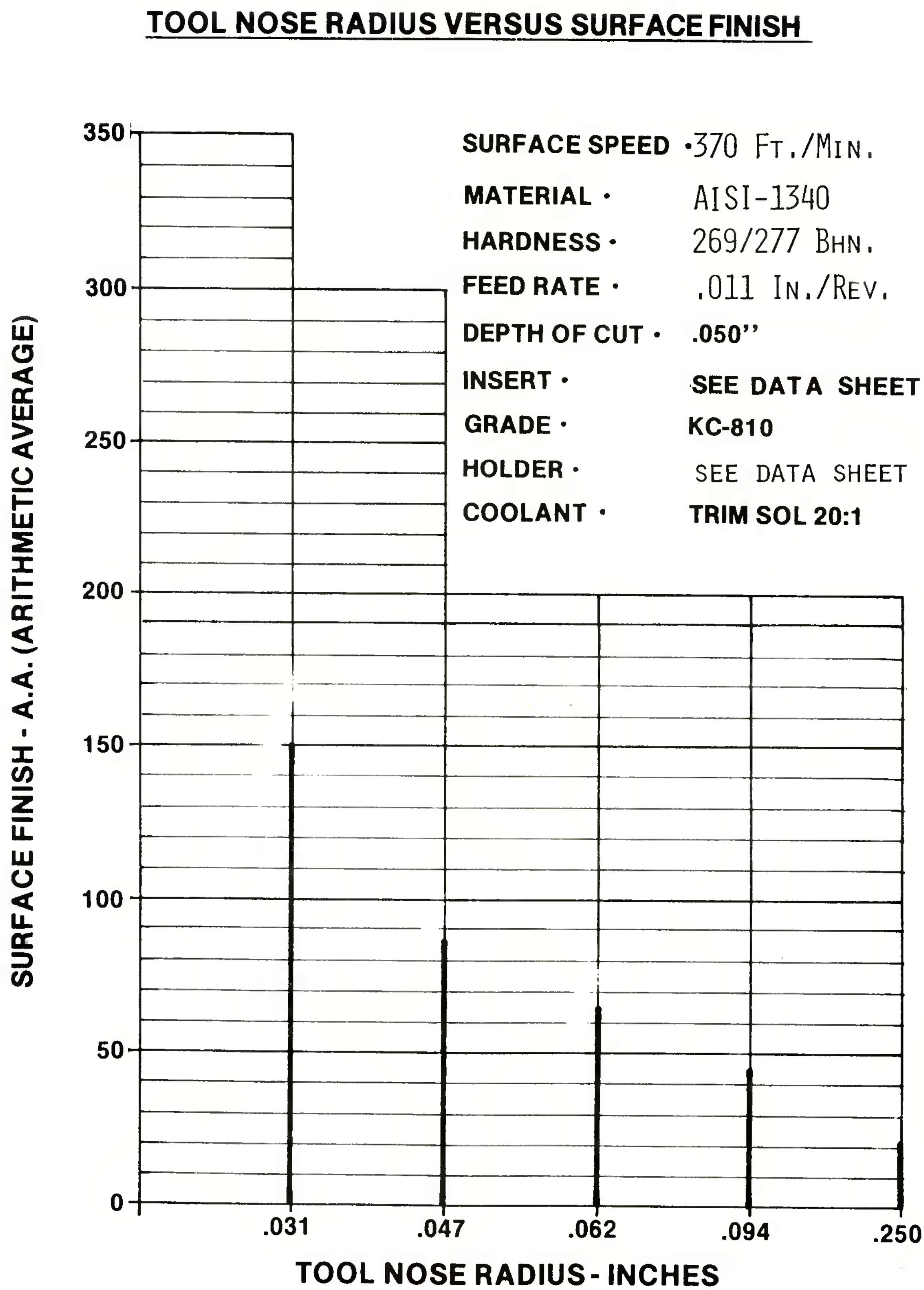
TOOL NOSE RADIUS VERSUS SURFACE FINISH
SURFACE SPEED ·370 FT./MIN.
MATERIAL · AISI-1340
HARDNESS · 269/277 BHN.
FEED RATE · .011 IN./REV.
DEPTH OF CUT · .050"
INSERT · SEE DATA SHEET
GRADE · KC-810
HOLDER · SEE DATA SHEET
COOLANT · TRIM SOL 20:1
SURFACE FINISH - A.A. (ARITHMETIC AVERAGE)
350
300
250
200
150
100
50
0
.031
.047
.062
.094
.250
TOOL NOSE RADIUS - INCHES

Figure 81:

Date: 9/10/80 | Material: AISI 1340

Depth of Cut: .050 Inches | Coolant: Trim - Sol 20:1

Hardness: 269/277 BHN | Tool Description:

Coolant Application: Top | Holder: MTANR-164 (0^{o} LEAD ANGLE)

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	NOSE RADIUS	SURFACE SPEED MULTIPLIER	SURFACE FINISH ARITHMETIC AVERAGE			
1	KC-810	267	.011		.7225	87			
2	"	315	"		.85	82			
3	"	370	"		1.0	87			
4	"	425	"		1.15	85			
5	"	490	"		1.3225	85			

NOTES:

TABLE 56: **DATA FOR SURFACE FINISH TESTS**

Date: 9/10/80

Material: AISI 1340

Depth of Cut: .050 Inches

Coolant: Trim - Sol 20:1

Hardness: 269/277 BHN

Tool Description:

Coolant Application: Top

Holder: SEE NOTES

Insert: SEE NOTES

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	NOSE RADIUS	SURFACE SPEED MULTIPLIER	SURFACE FINISH ARITHMETIC AVERAGE			
1	KC-810	370	.011	.03125		150			
2	"	"	"	.0469		87			
3	"	"	"	.0625		65			
4	"	"	"	.09375		45			
5	"	"	"	.250		22			

NOTES:

TOOL HOLDER	INSERT
KTAR-164	TNMG-432
KTAR-164	TNMG-433
KTAR-164	TNMG-434
WTJNRS-205	TNMG-566
PRANR-854	RNMG-43

(.500" Ø ROUND INSERT)

TABLE 57: **DATA FOR SURFACE FINISH TESTS**

AISI 1340 Projectile Material - "Finishing Cuts" - 38/40 RC

The tool life curves for 321/340 Bhn material, Figure 82, page 157 and Tables 59 and 60, pages 158 and 159, showed a cutting speed of 660 feet per minute for both G-10 and G-30 ceramic material. The tool-life curves for this material, at 269 Bhn, showed cutting speeds of 670 for G-10 and 630 for G-30, but at 0.11 inches per revolution feed rate instead of .015 used in the 321/340 hardness tests. From this, it shows an increase in feed rate and an increase in hardness did not chance the cutting speed, for equal tool-life, by an appreciable amount.

The surface finish charts, Figures 93 and 94, pages 174 and 175, show this material does not behave any differently at a higher hardness than at a lower hardness value. Data for these charts are on pages 176 and 177. Tool loads for both round and straight sided inserts are shown in Figures 83 through 92, and in Tables 61 through 64, pages 170 through 173.

Chip-control, at both 269 and 321/340 Brinell hardness, was a problem with this material during "Finish" turning cuts. The chips are strong enough after the cutting process to resist bending, so the molded-in chip breakers on carbide tools used in the tests were of little or no value. The chips came off the cutting tool in long "stringers" with little or no effect from the chip groove. The ceramic tools gave better chip-conditions, and after crater formation on the face of the inserts, the chips were broken in very small pieces. Adjusting the angle and width of the "K" land will alter the chip conditions and a good chip condition should be attainable.

SUMMARY OF RESULTS

"FINISHING CUT"

MATERIAL	AISI-1340
HARDNESS	321/340 Bhn.
TOOL LIFE	2500 In^2 of Machined Surface
DEPTH OF CUT	.050 Inches

Insert Grade	Insert Style	SFM	Feed In./Rev.	Prod. Index	Tangential Tool Load - Lbs. .050 Depth of Cut	H.P. .050 Depth of Cut
350	TNMG-433	160	.015	2.4	280	1.36
KC-810	TNMG-433	310	.015	4.65	260	2.44
570	TNMG-433	470	.015	7.05	260	3.70
G-10	CNG-454	660	.015	9.90	240	4.8
G-30	CNG-454	660	.015	9.90	230	4.6
350	RNMG-43	160	.022	—	420	2.04
KC-810	RNMG-43	310	.022	—	390	3.66
570	RNMG-43	470	.022	—	360	5.13
G-10	RNG-45	660	.022	—	370	7.4
G-30	RNG-45	660	.022	—	370	7.4

TABLE 58: AISI-1340 Results of Tests

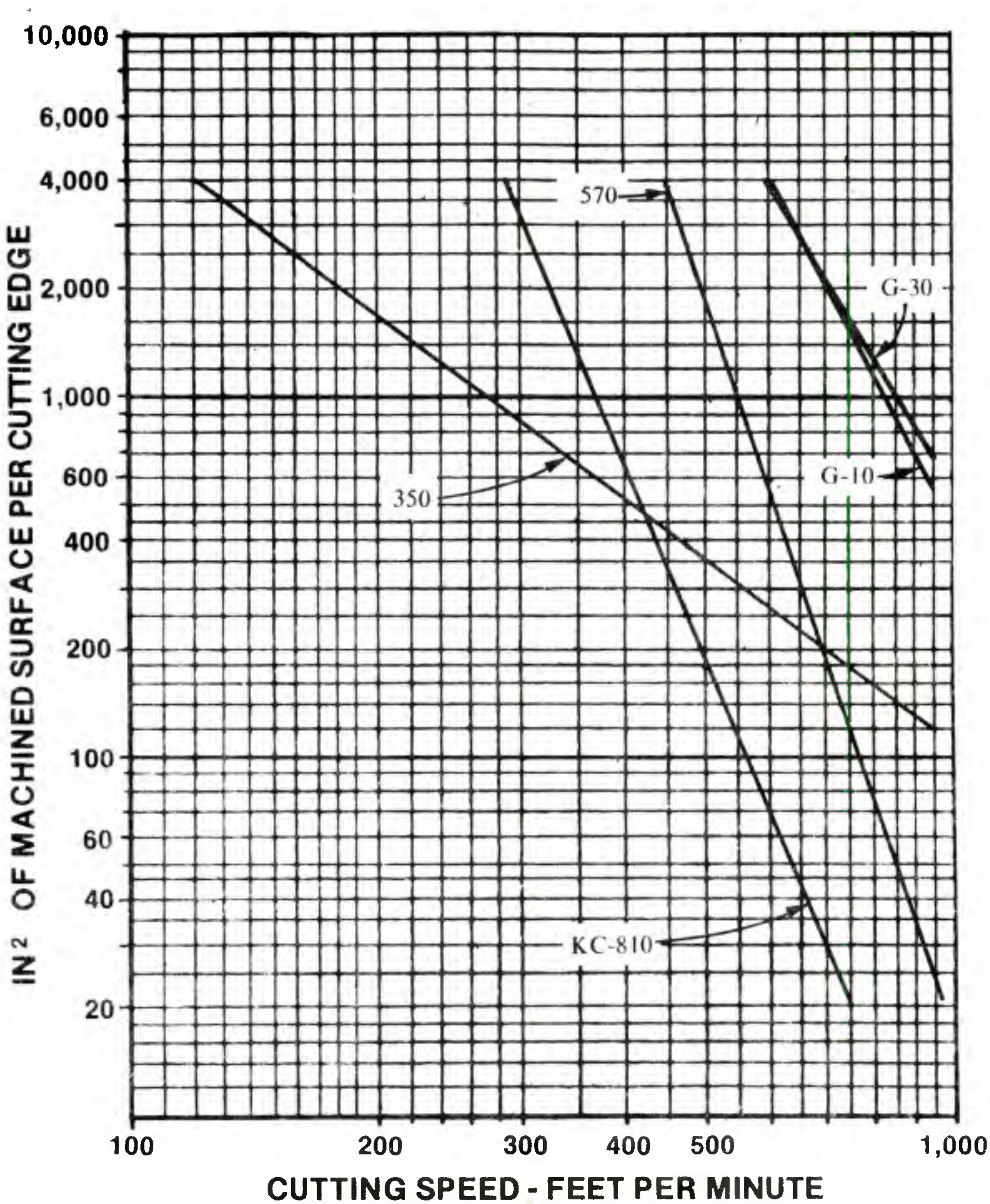

Figure 82: Tool-Life Lines of Listed Cutting Materials on AISI 1340 Steel at 321/340 Brinell Hardness.

Feed - .015 Inches per Revolution
Depth of Cut - .050 Inches
350, KC-810, 570: Holder - MTANR -164 (0^0 Lead Angle)
Insert - TNMG-433
G-10, G-30: Holder - CCGNR-164 (0^0 Lead Angle)
Insert - CNG-454 .008 x 20^0

Date: 1/21/81

Material: AISI 1340

Depth of Cut: .050

Coolant: TRIM-SOL 20:1

Hardness: 340 BHN

Tool Description:

Coolant Application: TOP

Holder: KTAR-164

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
1	350	400	.015	6.265	6.165	9.25	179	.009	477	.024
2	"	500	"	"	"	15.6	123	.0095	328	.024
3	"	600	"	"	"	20.3	91	.008	273	.024
4	"	300	"	6.165	6.070	13.5	257	.0075	824	.024
5	KC-810	500	"	"	"	2.3	43.8	"	140	.024
6	"	400	"	"	"	4.6	87.7	–	–	–
6a	"	"	"	6.070	5.975	6.5	209.7	.008	630	.024
7	"	350	"	"	"	13.5	253	.0055	1106	.024
8	570	500	"	5.975	5.880	17.7	327	.0065	1207	.024
9	"	700	"	"	"	3	55.4	.011	121	.024
10	"	600	"	5.880	5.785	14.8	269	.0085	760	.024

NOTES:

TABLE 59 : DATA FOR LIFE LINES

Date:	1/22/81	**Material:**	AISI 1340
Depth of Cut:	.050"	**Coolant:**	TRIM-SOL 20:1
Hardness:	321/340 BHN	**Tool Description:**	
Coolant Application:	TOP: G-10 NONE: G-30	**Holder:**	CCGNR-164
		Insert:	CNG-454 820

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
1	G-10	800	.015	6.238	6.135	21	404.7	.0055	1103	.015
2	"	900	"	6.135	6.035	11	208.6	.0045	695	.015
3	"	1000	"	"	"	5	94.8	.003	434	.015
4	G-30	900	"	6.035	5.935	11.1	207	.004	776	.015
5	"	1000	"	"	"	9.3	173	.005	520	.015
6	"	800	"	5.935	5.840	15.8	290	.004	1087	.015

NOTES:

TABLE 60: DATA FOR LIFE LINES

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 1340 **HOLDER:** CTNAR-164

HARDNESS: 321/332 BHN **INSERT:** TNMG-433

SURFACE SPEED: 160 FT./MIN. **GRADE:** 350

FEED RATE: .015 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP

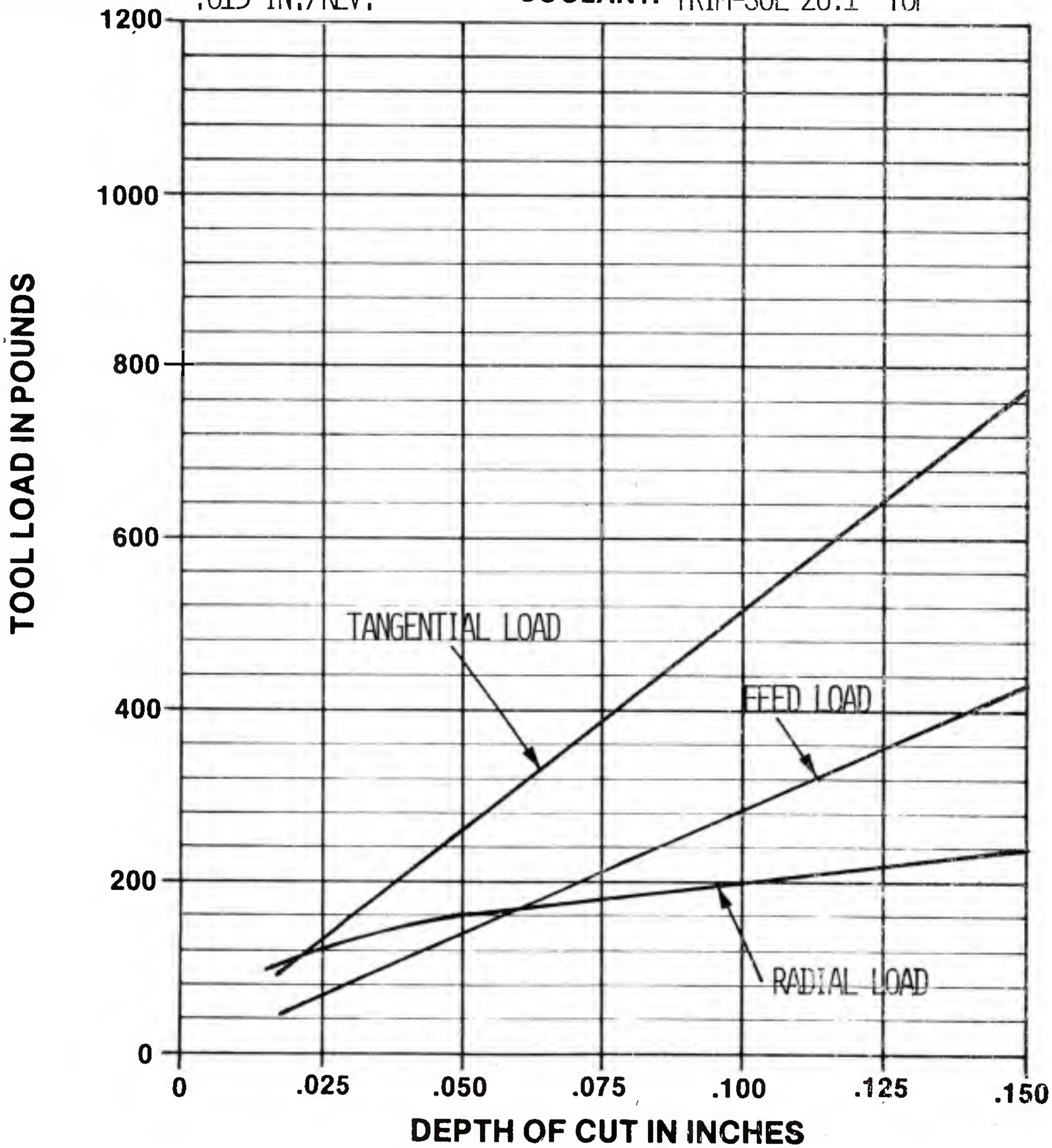

FIGURE 83 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 1340 **HOLDER:** CTNAR-164

HARDNESS: 321/333 BHN **INSERT:** TNMG-433

SURFACE SPEED: 310 FT./MIN. **GRADE:** KC-810

FEED RATE: .015 IN./REV. **COOLANT:** TRIM-SOL 20:1 TCP

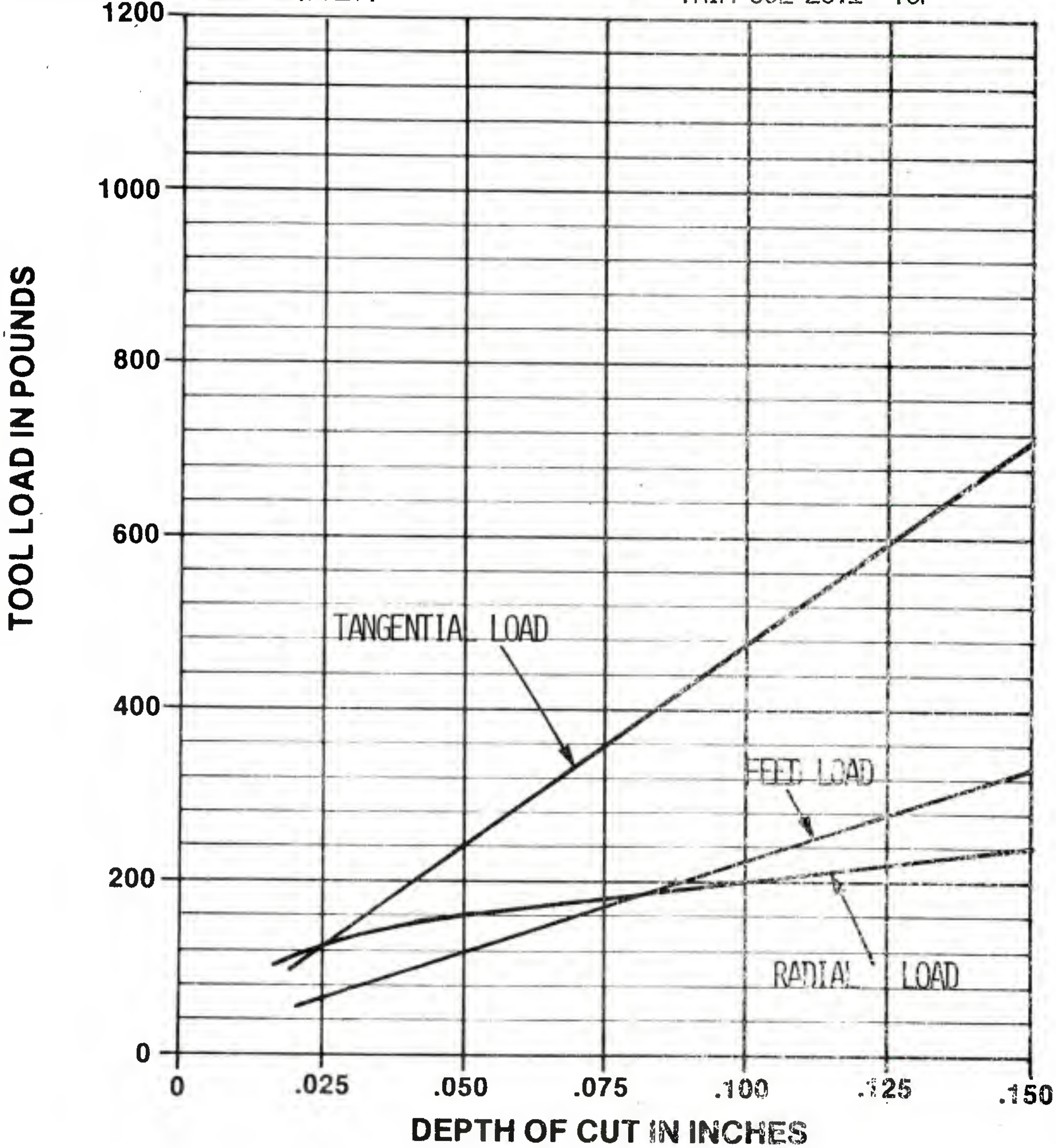

FIGURE 84 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 1340 **HOLDER:** CTNAR-164

HARDNESS: 321/332 BHN **INSERT:** TNMG-433

SURFACE SPEED: 470 FT./MIN. **GRADE:** 570

FEED RATE: .015 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP

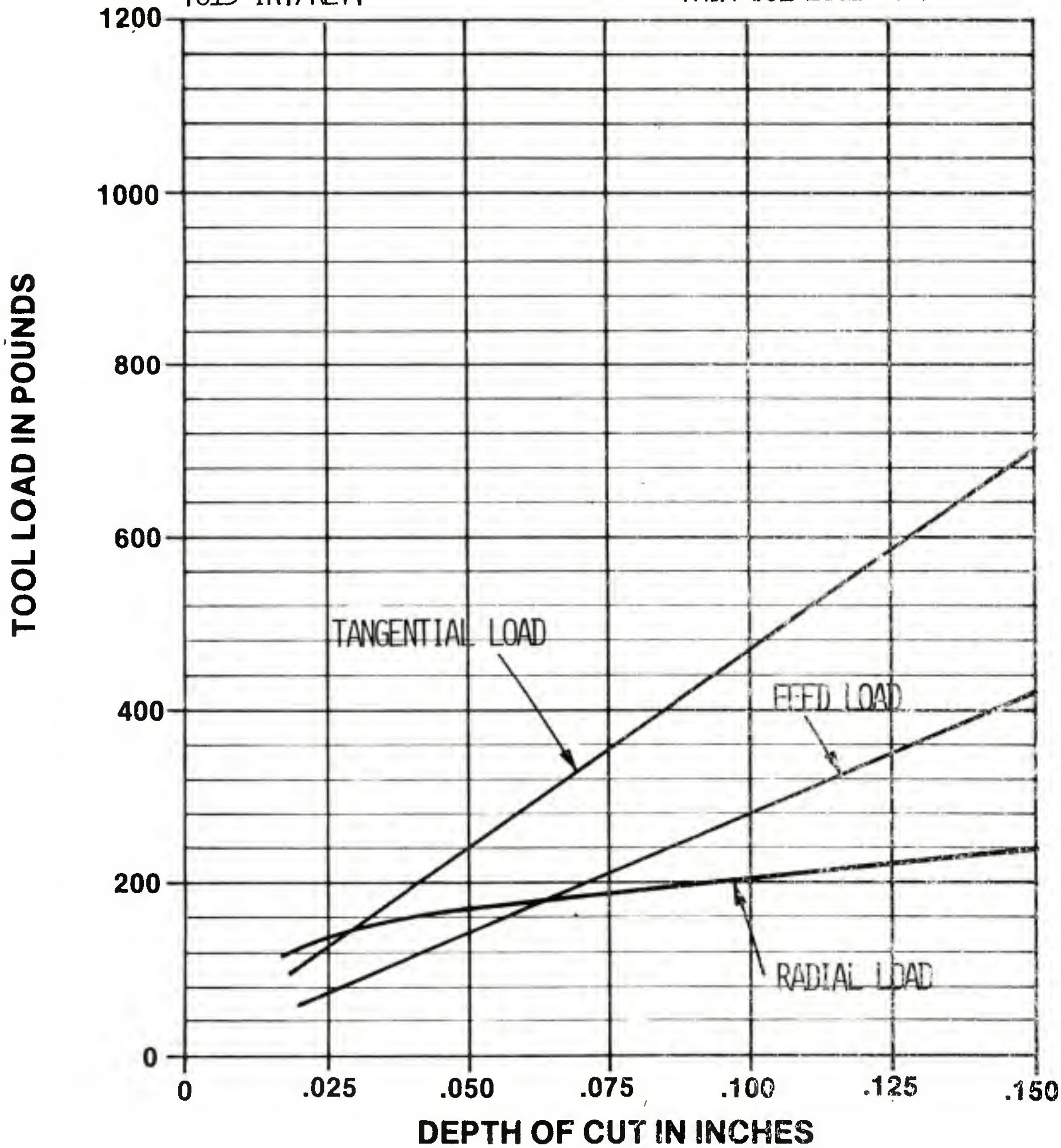

FIGURE 85 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 1340	**HOLDER:**	CCGNR-164
HARDNESS:	321/332 BHN	**INSERT:**	CNG-454-820
SURFACE SPEED:	.015 IN./REV.	**GRADE:**	G-10
FEED RATE:	.015 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP

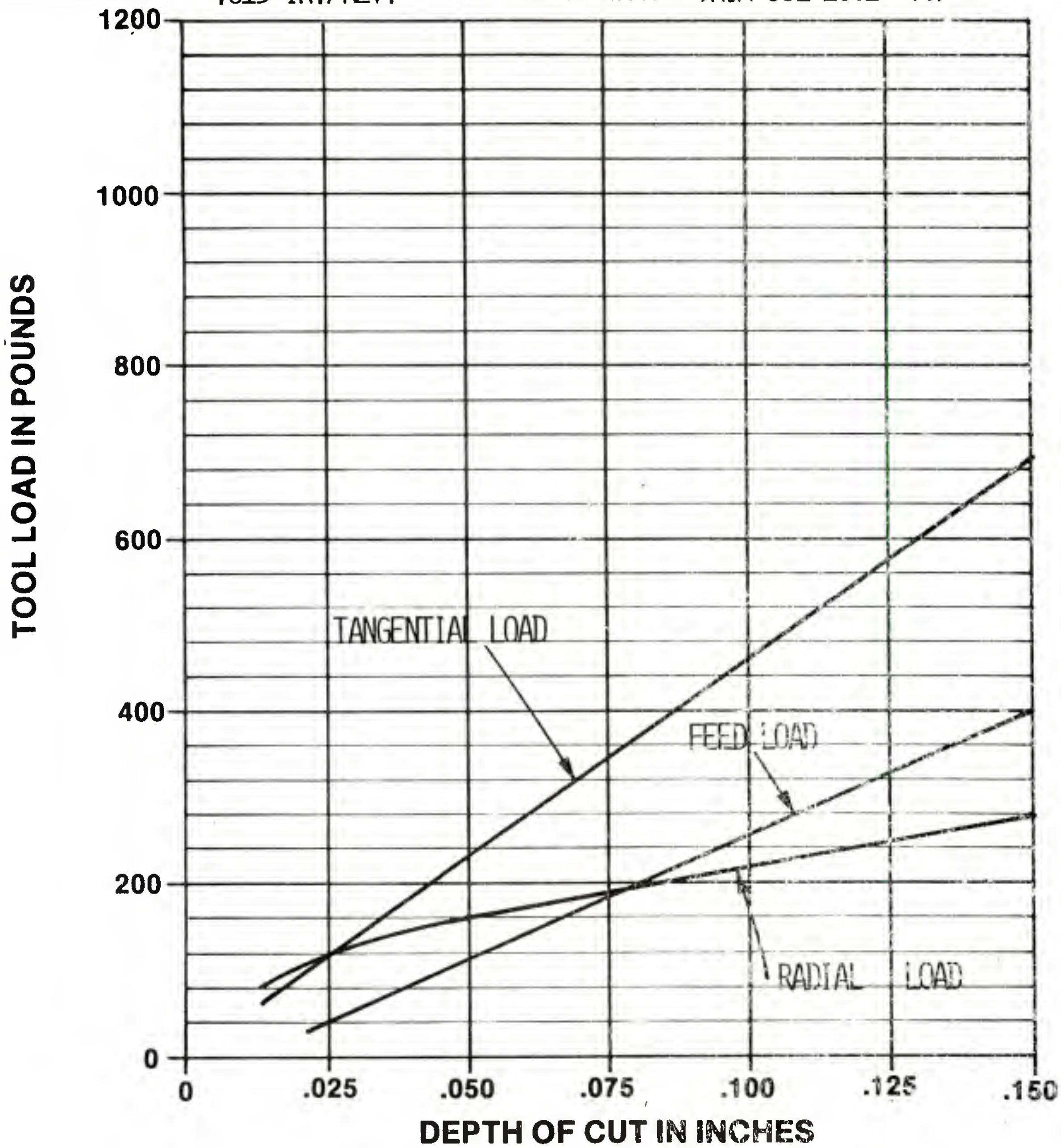

FIGURE 86 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 1340 **HOLDER:** CCGNR-164

HARDNESS: 321/332 BHN **INSERT:** CNG-454-820

SURFACE SPEED: 660 FT./MIN. **GRADE:** G-30

FEED RATE: .015 IN./REV. **COOLANT:** NONE

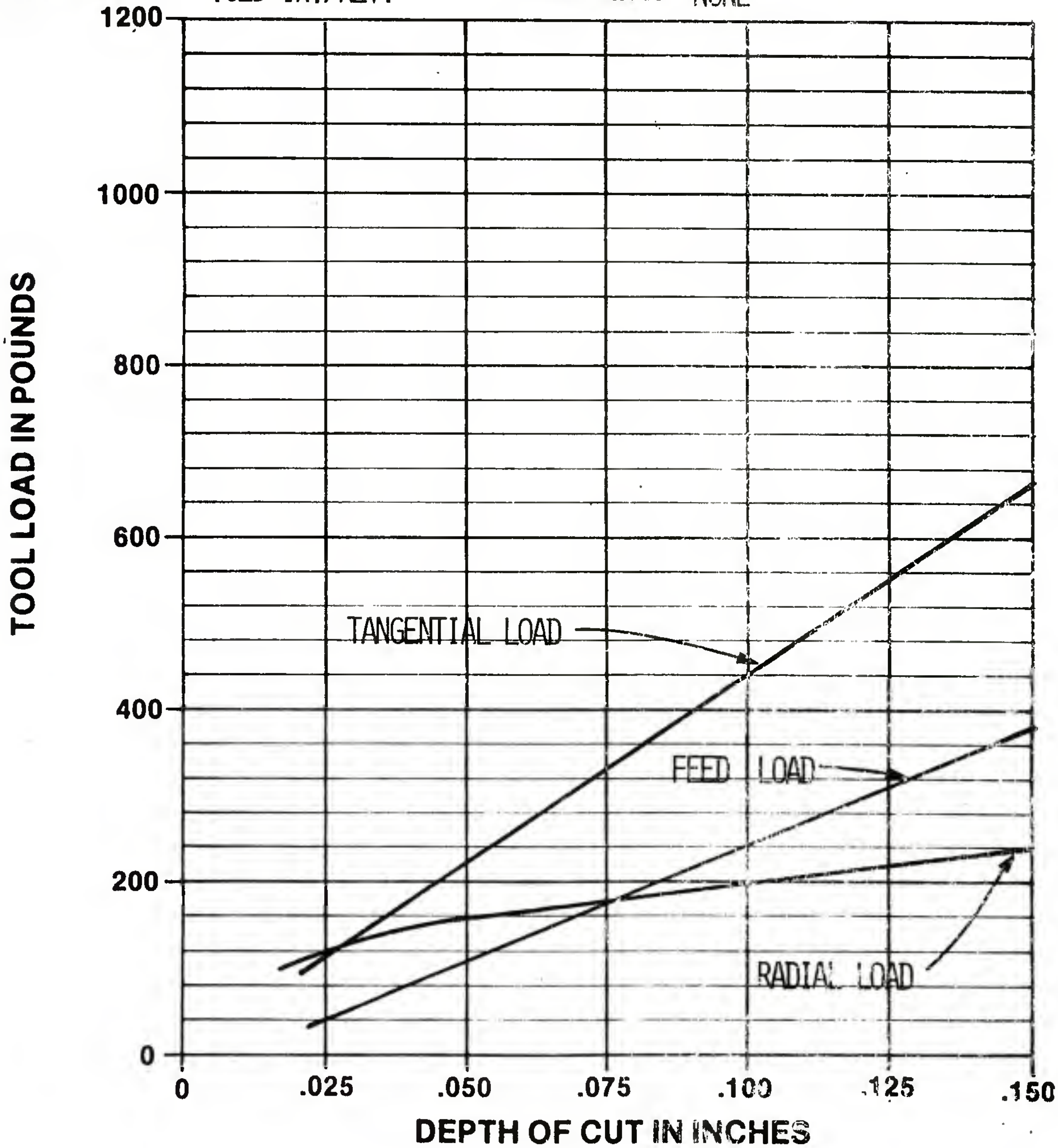

FIGURE 87 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 1340	**HOLDER:**	PRANR-164
HARDNESS:	321/332 BHN	**INSERT:**	RNMG-43
SURFACE SPEED:	160 FT./MIN.	**GRADE:**	350
FEED RATE:	.022 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP

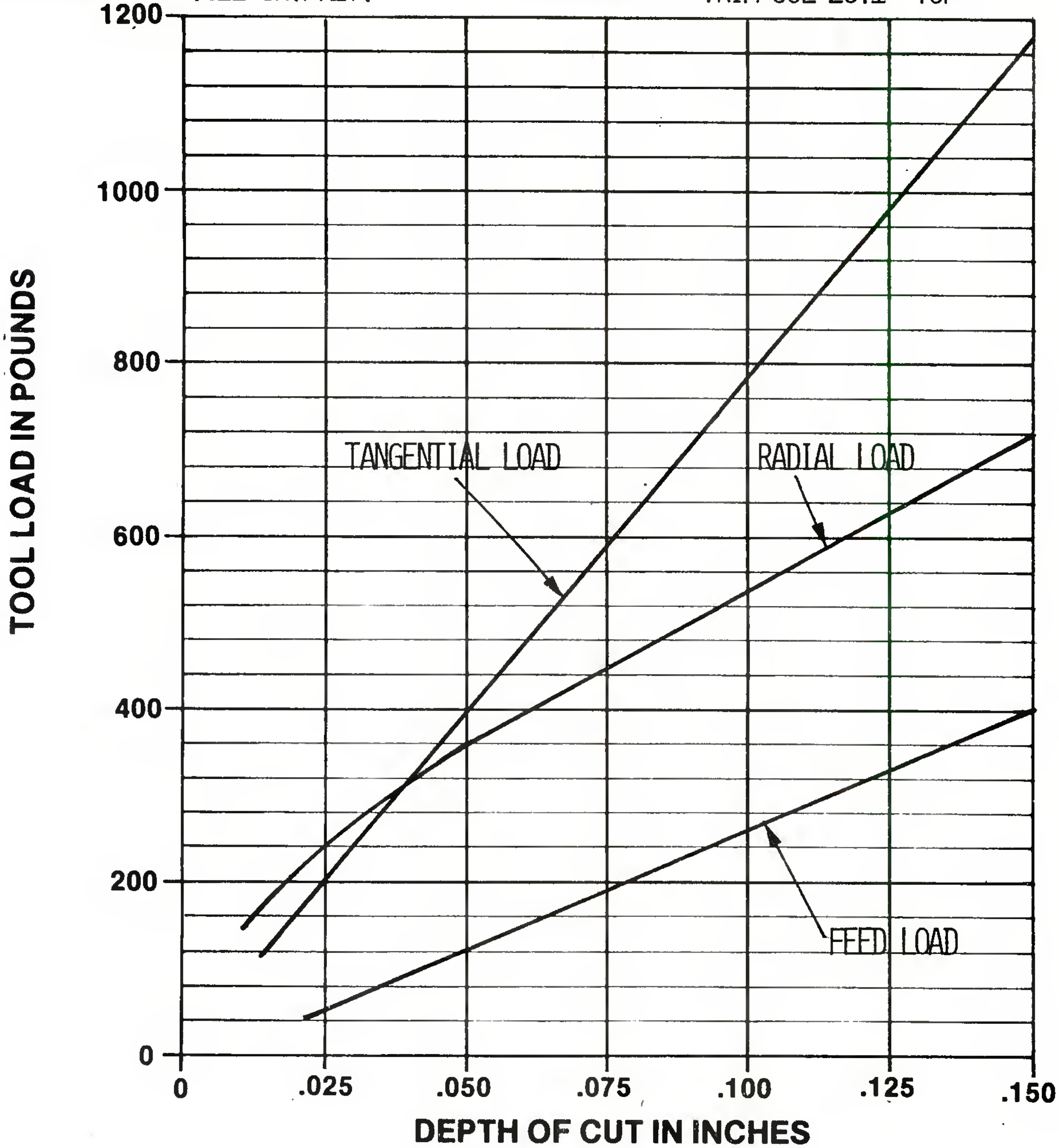

FIGURE 88 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 1340 | **HOLDER:** PRANR-164

HARDNESS: 321/332 BHN | **INSERT:** RNMG-43

SURFACE SPEED: 310 FT./MIN. | **GRADE:** KC-810

FEED RATE: .022 IN./ REV. | **COOLANT:** TRIM-SOL 20:1 TOP

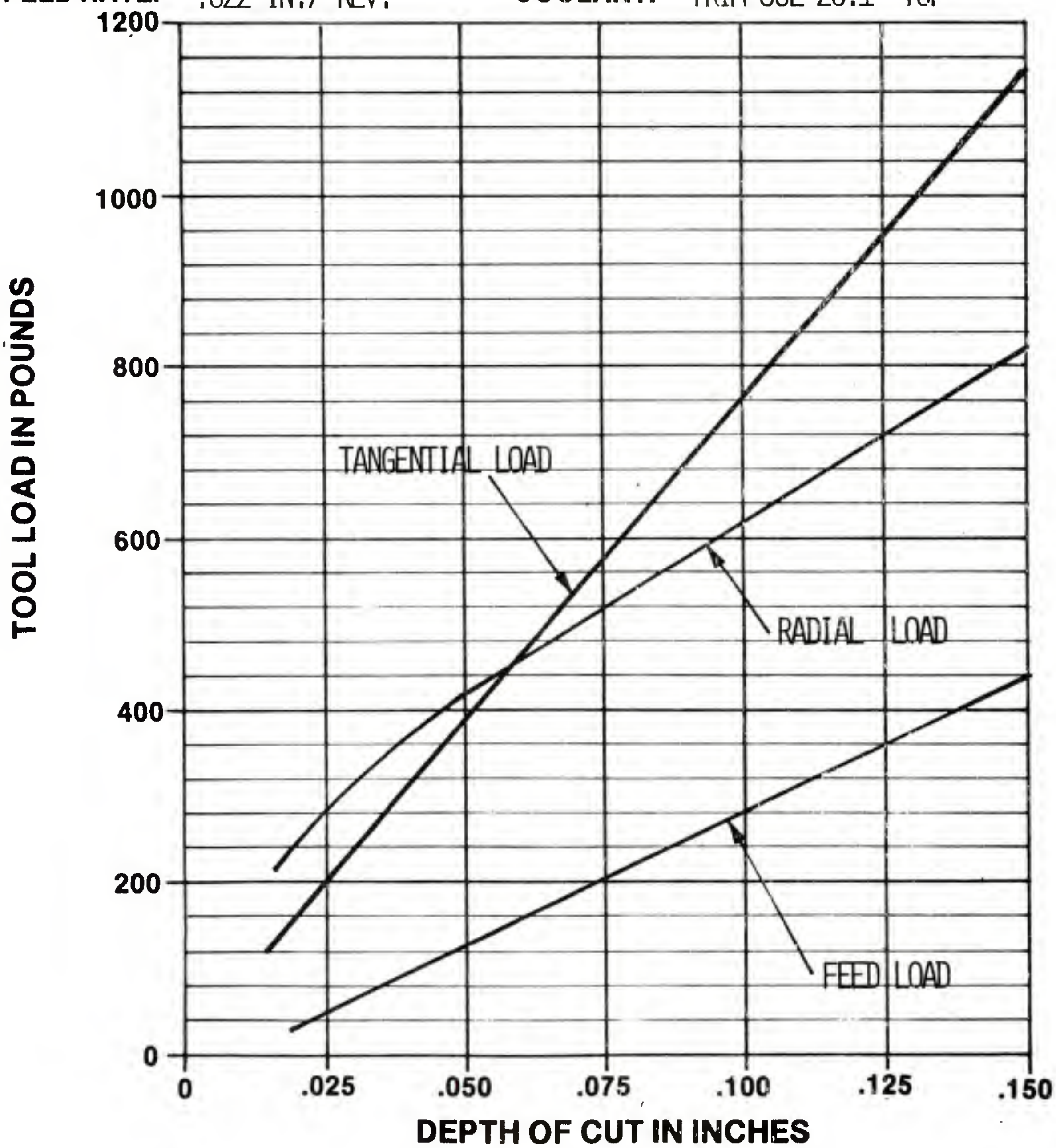

FIGURE 89 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 1340	**HOLDER:**	PRANR-164
HARDNESS:	321/332 BHN	**INSERT:**	RNMG-43
SURFACE SPEED:	470 FT./MIN.	**GRADE:**	570
FEED RATE:	.022 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP

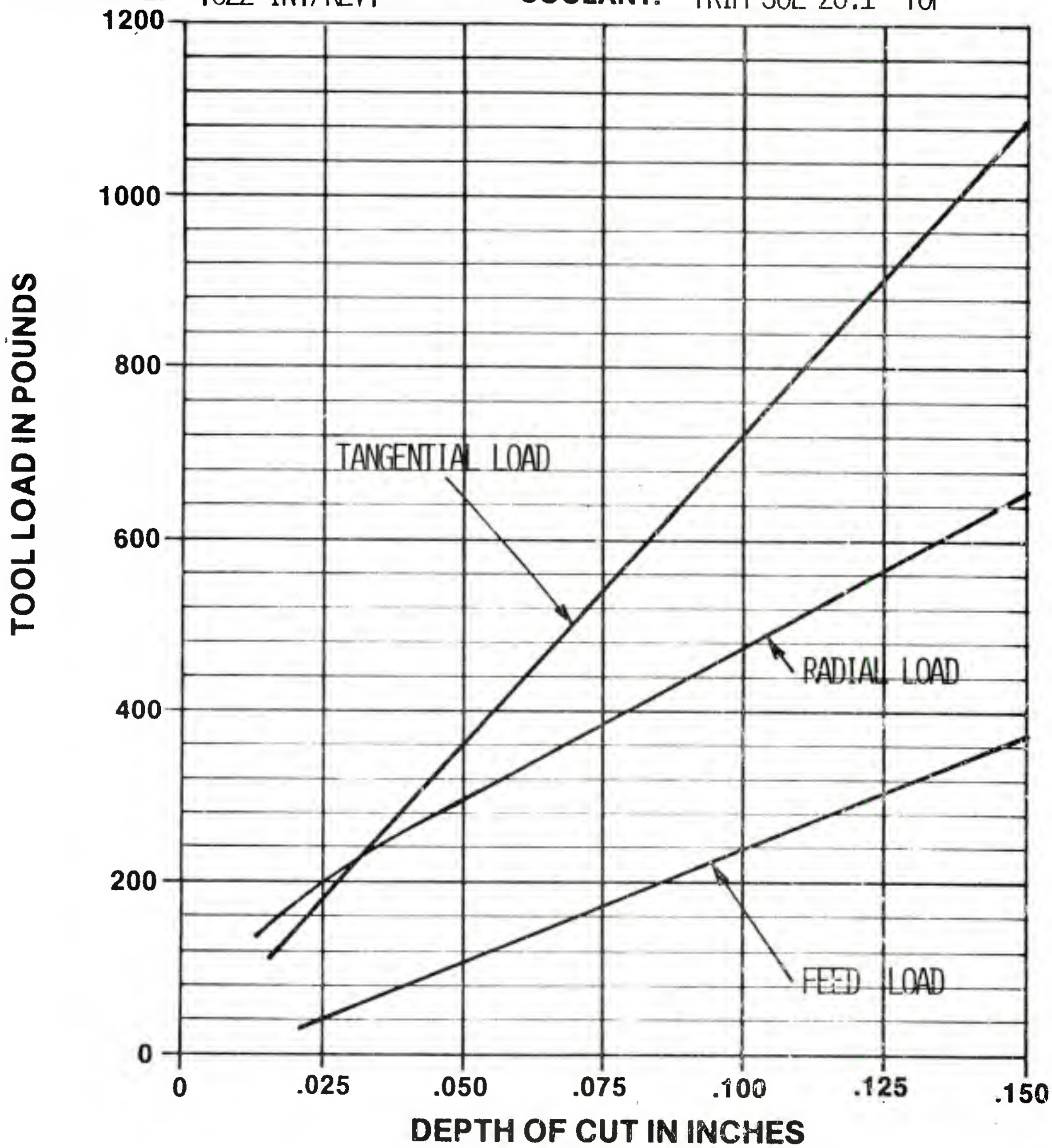

FIGURE 90 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 1340 **HOLDER:** CRGNR-164

HARDNESS: 321/332 BHN **INSERT:** RNG-45 .008 x 20^{0}

SURFACE SPEED: 660 FT./MIN. **GRADE:** G-10

FEED RATE: .022 IN./ REV. **COOLANT:** TRIM-SOL 20:1 TOP

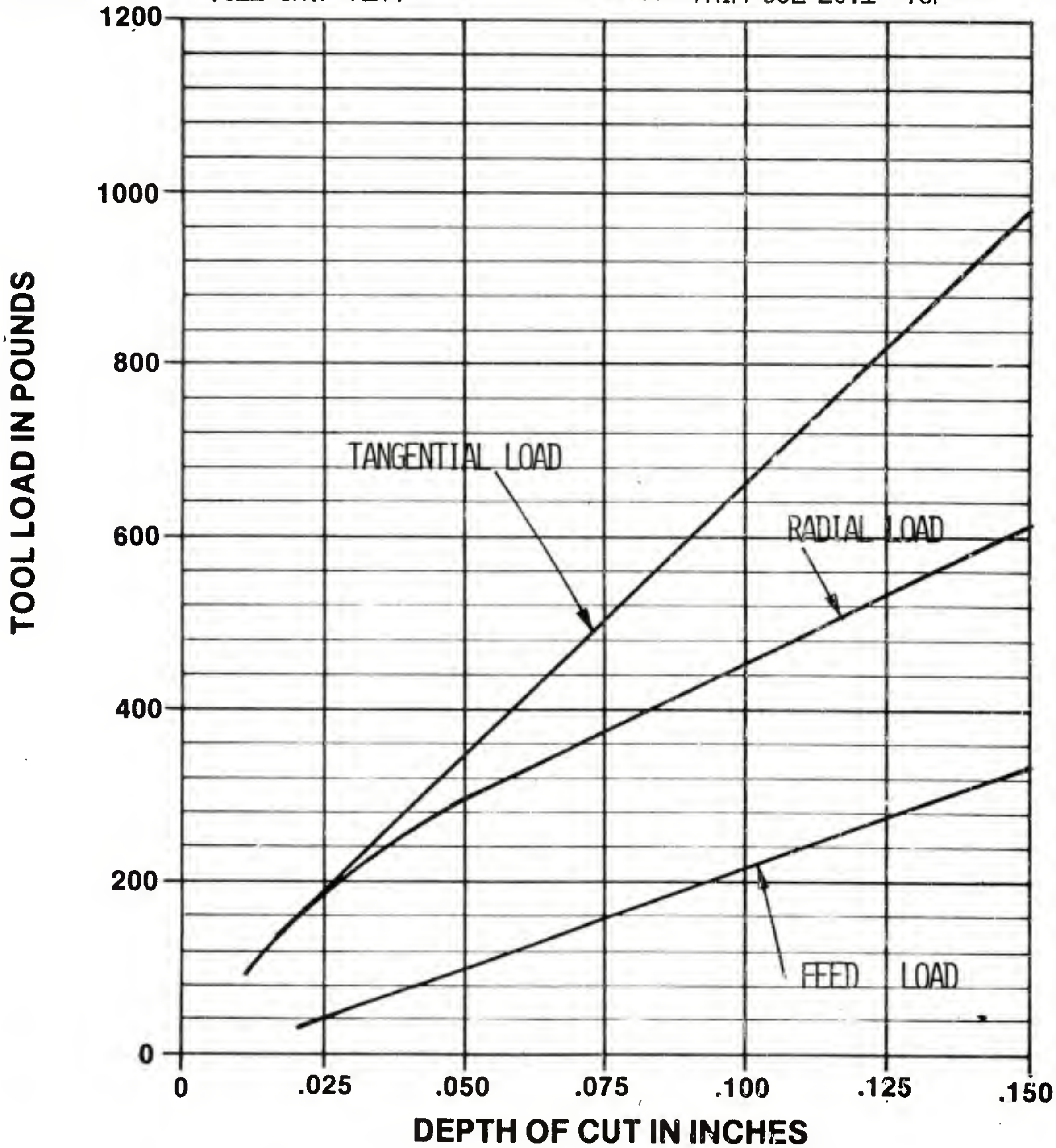

FIGURE 91 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 1340 **HOLDER:** CRGNR-164

HARDNESS: 321/332 BHN **INSERT:** RNG-45 .008 x 20°

SURFACE SPEED: 660 FT./MIN. **GRADE:** G-30

FEED RATE: .022 IN./REV. **COOLANT:** NONE

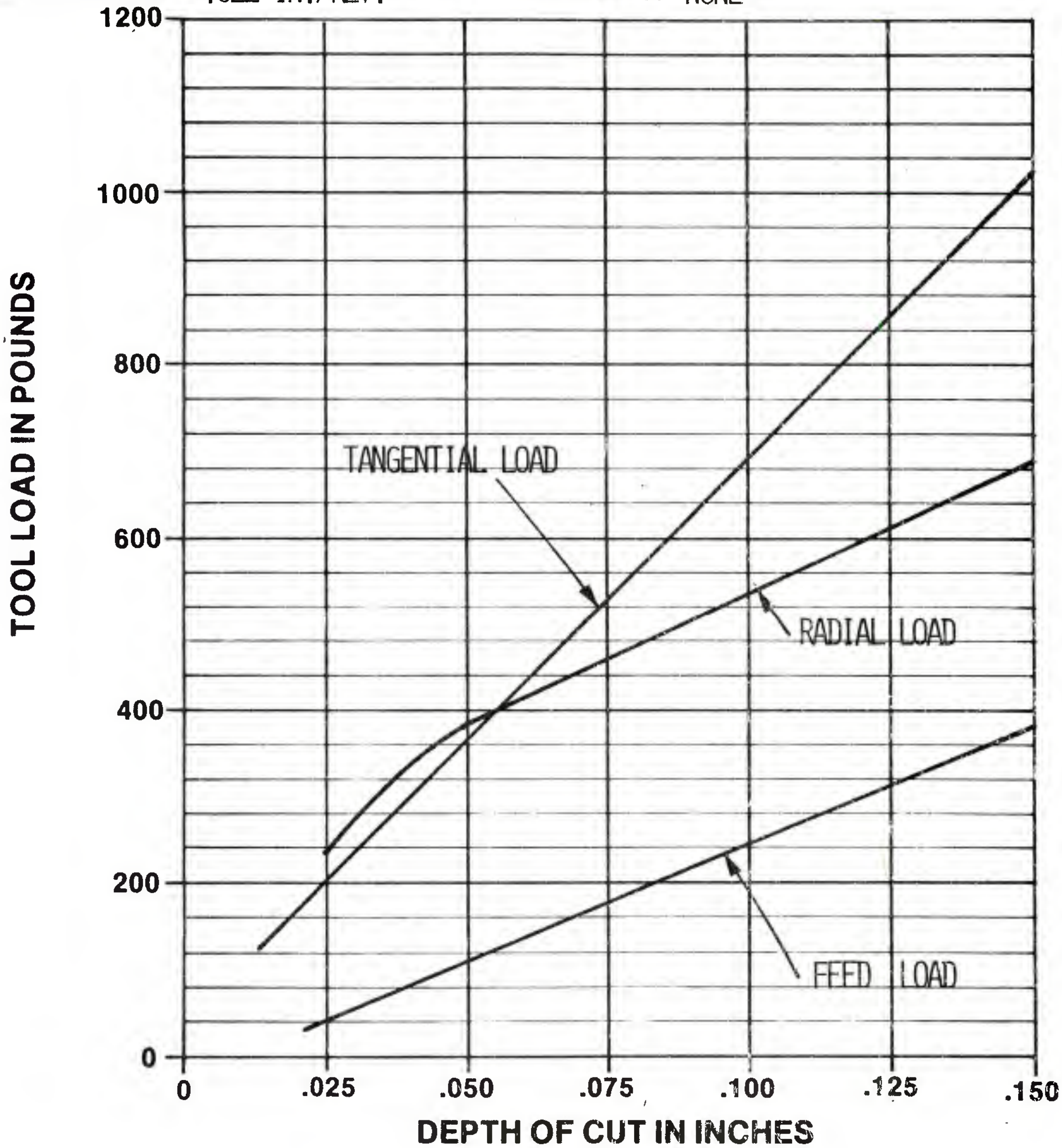

FIGURE 92 : TOOL LOAD CHART

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 1340 **HARDNESS:** 321/332 BHN

INSERT: TNMG-433 **SURFACE FEED:** 160 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: 350 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	150	60	120
.050	280	140	160
.100	520	300	200
.150	760	420	240

INSERT: TNMG-433 **SURFACE FEED:** 310 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: KC-810 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	140	60	120
.050	260	120	160
.100	480	250	200
.150	700	320	240

INSERT: TNMG-433 **SURFACE FEED:** 470 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: 570 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	140	60	130
.050	260	140	165
.100	490	290	205
.150	680	420	240

TABLE 61: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 1340 **HARDNESS:** 321/332 BHN

INSERT: CNG-454 .008 x 20° **SURFACE FEED:** 660 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	115	45	120
.050	240	110	160
.100	460	260	210
.150	700	400	240

INSERT: CNG-454 .008" x 20° **SURFACE FEED:** 660 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	120	40	120
.050	235	100	170
.100	460	240	205
.150	660	380	240

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025			
.050			
.100			
.150			

TABLE 62: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 1340 **HARDNESS:** 321/340 BHN

INSERT: RNMG-43 **SURFACE FEED:** 160 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 350 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	240	50	240
.050	420	110	360
.100	800	260	540
.150	1160	420	730

INSERT: RNMG-43 **SURFACE FEED:** 310 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: KC-810 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	220	50	280
.050	400	120	420
.100	760	270	620
.150	1120	460	830

INSERT: RNMG-43 **SURFACE FEED:** 470 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 570 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	200	40	200
.050	360	100	300
.100	720	220	480
.150	1080	400	660

TABLE 63: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 1340 **HARDNESS:** 321/340 BHN

INSERT: RNG-45 .008" x 20° **SURFACE FEED:** 660 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	200	40	180
.050	380	100	300
.100	680	215	470
.150	960	330	600

INSERT: RNG-45 .008" x 20° **SURFACE FEED:** 660 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	210	40	220
.050	390	100	340
.100	700	230	530
.150	1000	380	700

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025			
.050			
.100			
.150			

TABLE 64: **DATA FOR TOOL LOAD CHARTS**

SURFACE SPEED VERSUS SURFACE FINISH

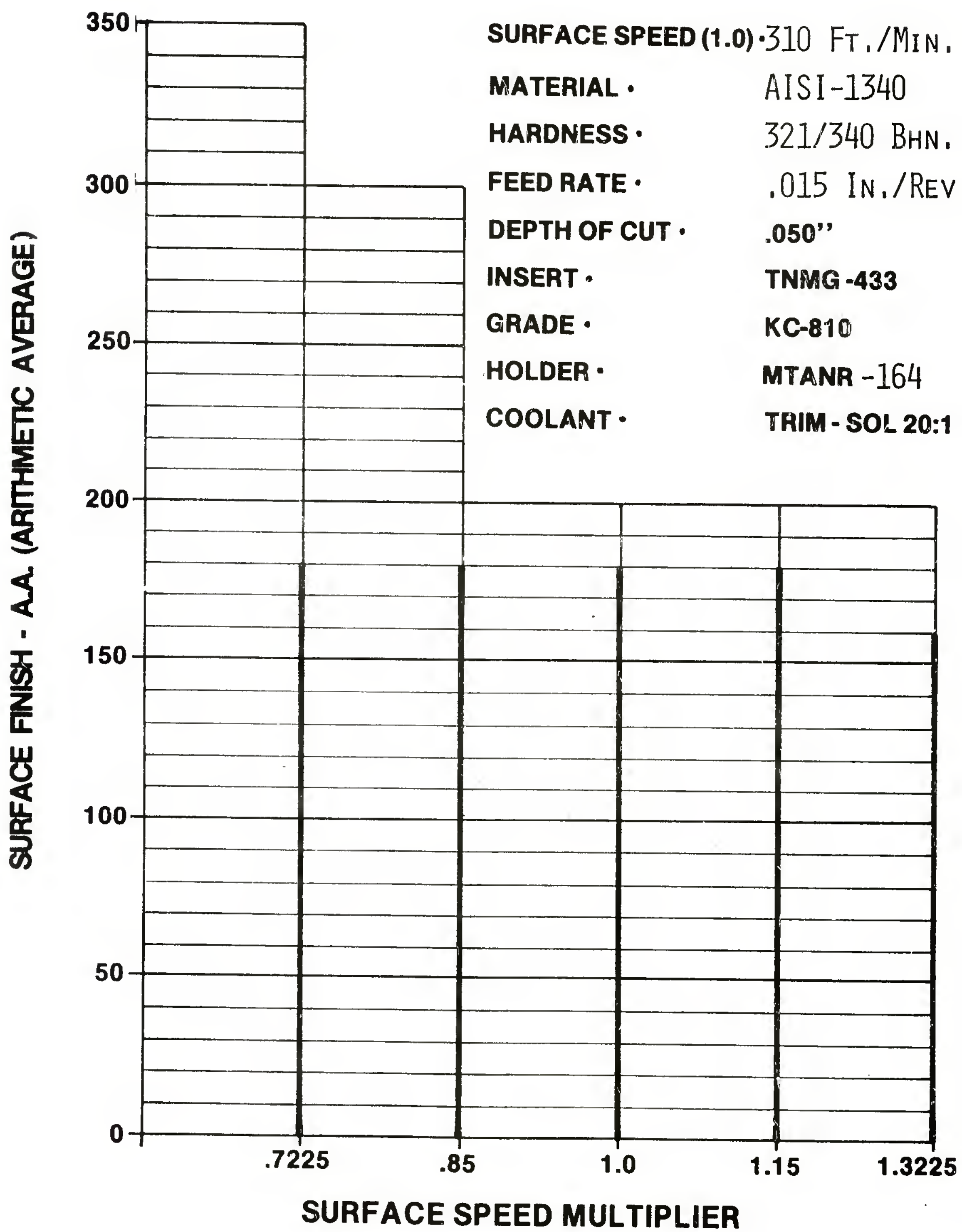

Figure 93

TOOL NOSE RADIUS VERSUS SURFACE FINISH

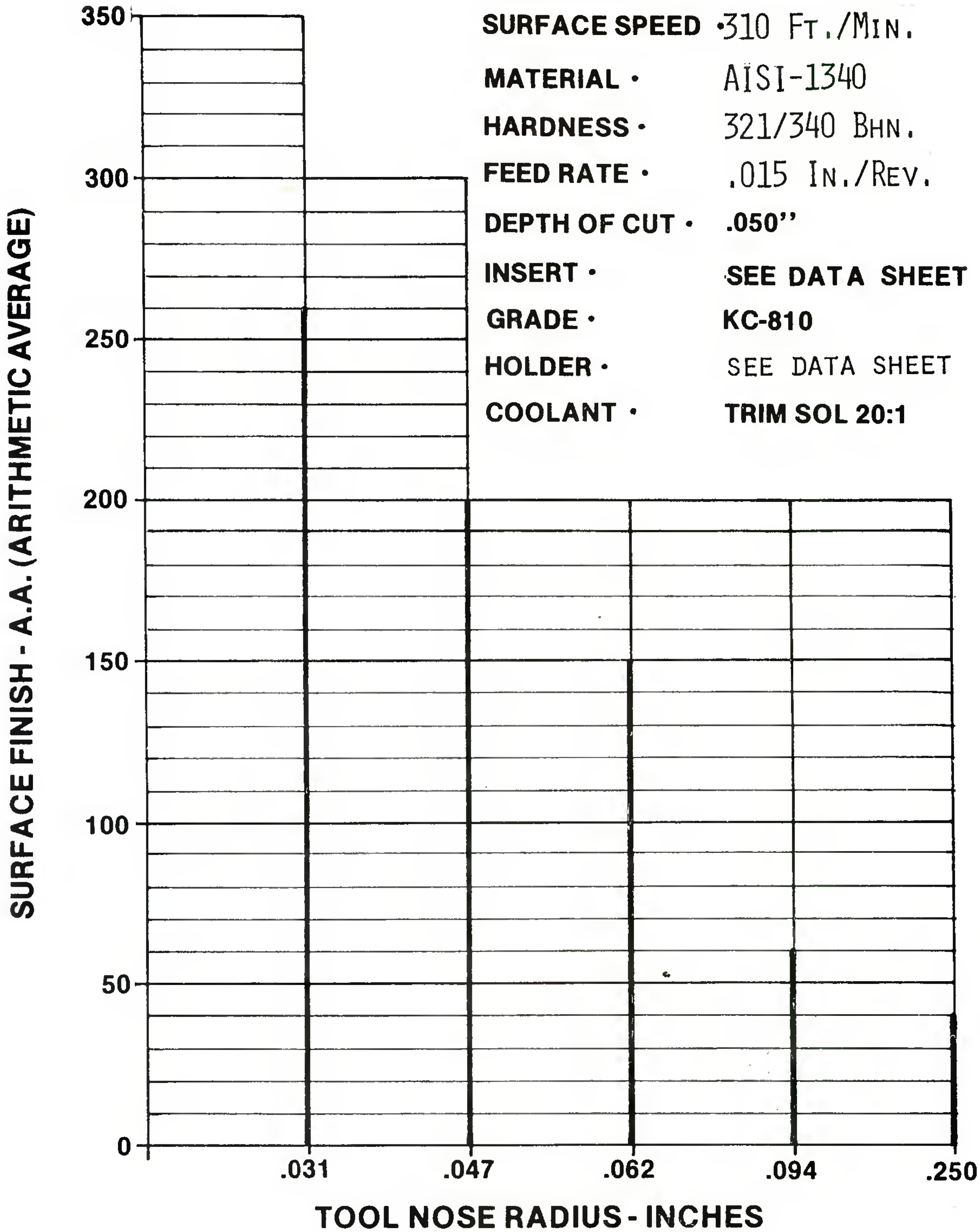

Figure 94

Date: 1/22/81

Material: AISI 1340

Depth of Cut: .050 Inches

Coolant: Trim - Sol 20:1

Hardness: 321/340 BHN

Tool Description:

Coolant Application: Top

Holder: KTAR-164

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	NOSE RADIUS	SURFACE SPEED MULTIPLIER	SURFACE FINISH ARITHMETIC AVERAGE			
1	KC-810	224	.015		.7225	180			
2	"	264	"		.85	"			
3	"	310	"		1.0	"			
4	"	356	"		1.15	"			
5	"	410	"		1.3225	160			

NOTES:

TABLE 65: **DATA FOR SURFACE FINISH TESTS**

Date: 1/22/81		**Material:** AISI 1340	
Depth of Cut: .050 Inches		**Coolant:** Trim - Sol 20:1	
Hardness: 321/340 BHN		**Tool Description:** SEE NOTES	
Coolant Application: Top		**Holder:**	
		Insert:	

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	NOSE RADIUS	SURFACE SPEED MULTIPLIER	SURFACE FINISH ARITHMETIC AVERAGE			
1	KC-810	310	.015	.03125		260			
2	"	"	"	.0469		200			
3	"	"	"	.0625		150			
4	"	"	"	.09375		60			
5	"	"	"	.250		40			

NOTES:

TOOL HOLDER/INSERT	
KTAR-164	TNMG-432
KTAR-164	TNMG-433
KTAR-164	TNMG-434
WTJNRS-205	TNMG-566
PRANR-854	RNMG-43

(.500" Ø ROUND INSERT)

TABLE 66: **DATA FOR SURFACE FINISH TESTS**

AISI 4140 Projectile Material - 'Finishing" Cuts - 28/30 Rc Hardness

Table 67, page 179, shows the large increase in production indexes that occur when ceramic tools are used. An 80% increase over the best carbide tool can be realized when applying the cold-press ceramic, and even higher gains when the hot-press is used. See also pages 180 to 183 for more information on tool life line.

The horsepower requirements for the various tools are listed in Table 67, page 179. These requirements range from 4 horsepower for carbide to 12 horsepower for a ceramic round tool.

Figure 107, page 199, shows the effect of changing nose radius on surface finish, and shows that as the nose radius is increased the surface finish gets better. Figure 106 page 198 shows the effect on surface finish when changing surface speed. The results are inconclusive.

The chip conditions for these tests were better than with AISI 1340, but should be greatly improved for production purposes. The application of some of the new style chip breakers may help in solving the chip problem, which would be a necessity in an automated process.

SUMMARY OF RESULTS

"FINISHING CUT"

MATERIAL	AISI-4140
HARDNESS	262/286 Bhn.
TOOL LIFE	2500 In^2 of Machined Surface
DEPTH OF CUT	.050 Inches

Insert Grade	Insert Style	SFM	Feed In./Rev.	Prod. Index	Tangential Tool Load - Lbs. .050 Depth of Cut	H.P. .050 Depth of Cut
350	TNMG-433	390	.015	5.85	280	3.31
KC-810	TNMG-433	500	.015	7.5	280	4.24
570	TNMG-433	560	.015	8.4	260	4.41
G-10	CNG-454	950	.015	14.25	260	7.48
G-30	CNG-454	1180	.015	17.7	260	9.30
350	RNMG-43	390	.022	—	390	4.61
KC-810	RNMG-43	500	.022	—	400	6.06
570	RNMG-43	560	.022	—	390	6.62
G-10	RNG-45	950	.022	—	360	10.36
G-30	RNG-45	1180	.022	—	360	12.87

TABLE 67: AISI-4140 Results of Tests

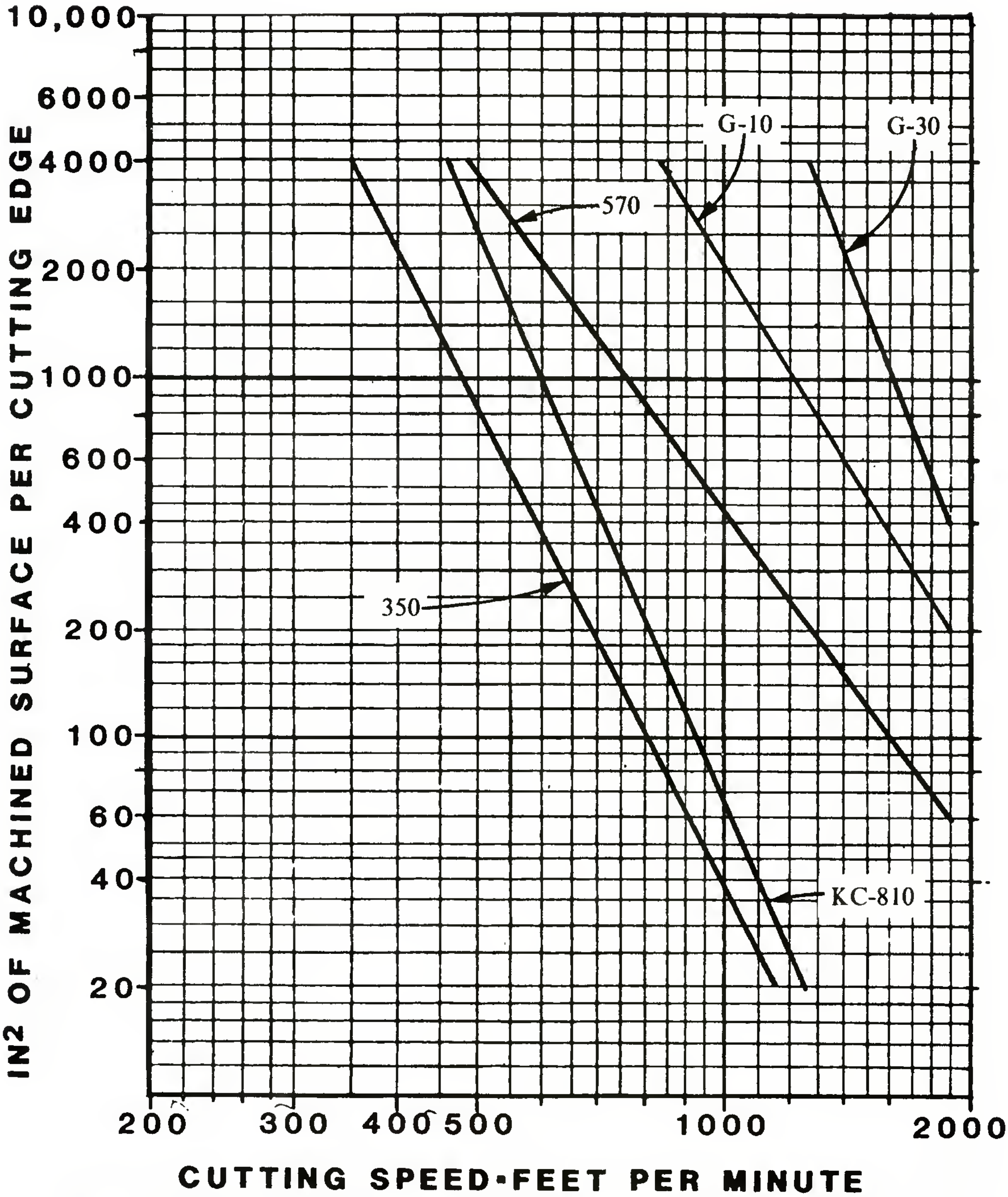

Figure 95: Tool-Life Lines of Listed Cutting Materials on AISI 4140 Steel at 262/286 Brinell Hardness.

Feed -.015 Inches per Revolution
Depth of Cut -.050 Inches
350, KC-810, 570: Holder - MTANR-164 (0° Lead Angle)
Insert - TNMG-433
G-10, G-30: Holder - CCGNR-164 (0° Lead Angle)
Insert - CNG-454 .008 x 20°

Date:	9/15/80	**Material:**	AISI 4140
Depth of Cut:	.050"	**Coolant:**	TRIM-SOL 20:1
Hardness:	286 BHN	**Tool Description:**	
Coolant Application:	TOP	**Holder:**	KTAR-164
		Insert:	TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
1	350	500	.015	5.960	5.866	21.0	387	.011	844	#1 .024
2	"	700	"	5.866	5.766	5.9	107	.0135	190	#1 .024
3	"	600	"	"	"	7.7	139.5	.009	372	#1 .024
4	KC-810	800	"	"	"	4.9	88.8	.011	194	#2 .024
5	"	700	"	5.766	5.667	10.8	229.5	.012	460	#2 .024
6	"	600	"	5.866	5.766	2.5	45	-	CUT CONT	INUED
6a	"	"	"	5.766	5.667	10.1	180	-	CUT CONT	INUED
6b	"	"	"	5.667	5.570	10.2	403.5 T	.011	880	#2 .024
7	570	800	"	5.667	5.570	10.9	190	.006	763	#1 .024
8	"	1100	"	5.570	5.470	5.5	94.5	.007	324	#1 .024
9	"	700	"	"	"	15.5	266	-	CUT CONT	INUED
9a	"	"	"	5.470	5.370	6.5	375.5 T	.007	1287	.0245 #1

NOTES: #1 BAD CHIP CONTROL - STRINGERS

#2 FAIR CHIP CONTROL - CONTINUOUS CURL

TABLE 68: DATA FOR LIFE LINES

Date:	9/17/80	**Material:**	AISI 4140
Depth of Cut:	.050"	**Coolant:**	TRIM-SOL 20:1
Hardness:	262/269 BHN	**Tool Description:**	
Coolant Application:	TOP: G-10	**Holder:**	CCGAR-164
	NONE: G-30	**Insert:**	CNG-454 - 820

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
1	G-10	1200	.015	5.475	5.370	9.2	155	-	CUT CONTINUED	#1
1a	"	"	"	"	"	5	84	-	CUT CONTINUED	#1
1b	"	"	"	5.370	5.272	6.5	107.5	-		#1
							346.5	.005	1040	.015
2	"	1000	"	"	"	15.3	253.5	-	CUT CONTINUED	#1
2a	"	"	"	5.272	5.198	20.8	339.5	-		#1
							593	.004	2224.5	.015
3	G-10	1400	"	5.198	5.108	20.	321	.0075	642	#1,4 .015
1	G-30	"	"	5.108	5.005	10.6	166.5	-	CUT CONTINUED	#2
1a	"	"	"	"	"	9.3	146	-		#2
							312.5	.004	1172	.015

NOTES: ON CHIP CONTROL
#1 - CONTINUOUS CURL - LONG
#2 - CONTINUOUS CURL - MANAGEABLE
#3 - CONTINUOUS CURL - LESS THAN 6" LONG
#4 - NOSE WEAR

TABLE 69 : DATA FOR LIFE LINES

Date: 9/17/80		**Material:** AISI 4140	
Depth of Cut: .050"		**Coolant:** TRIM-SOL 20:1	
Hardness: 262/269 BHN		**Tool Description:**	
Coolant Application: TOP: G-10		**Holder:** CCGAR-164	
NONE: G-30		**Insert:** CNG-454 - 820	

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
2	G-30	1200	.015	5.005	4.907	19.9	307	–	CUT CONTINUED	#2
2a	"	"	"	4.907	4.812	19.9	301	–		#2
							608	.004	2280	.015
3	"	1600	"	4.812	4.716	19.8	293.5	.006	734	#3 .015

NOTES: ON CHIP CONTROL

#1 - CONTINUOUS CURL - LONG
#2 - CONTINUOUS CURL - MANAGEABLE
#3 - CONTINUOUS CURL - LESS THAN 6" LONG
#4 - NOSE WEAR

TABLE 70 : DATA FOR LIFE LINES

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4140

HOLDER: MTANR-164 (0^0 LEAD ANGLE)

HARDNESS: 286 BHN

INSERT: TNMG-433

SURFACE SPEED: 390 FT./MIN.

GRADE: 350

FEED RATE: .015 IN./REV.

COOLANT: TRIM-SOL 20:1 TOP

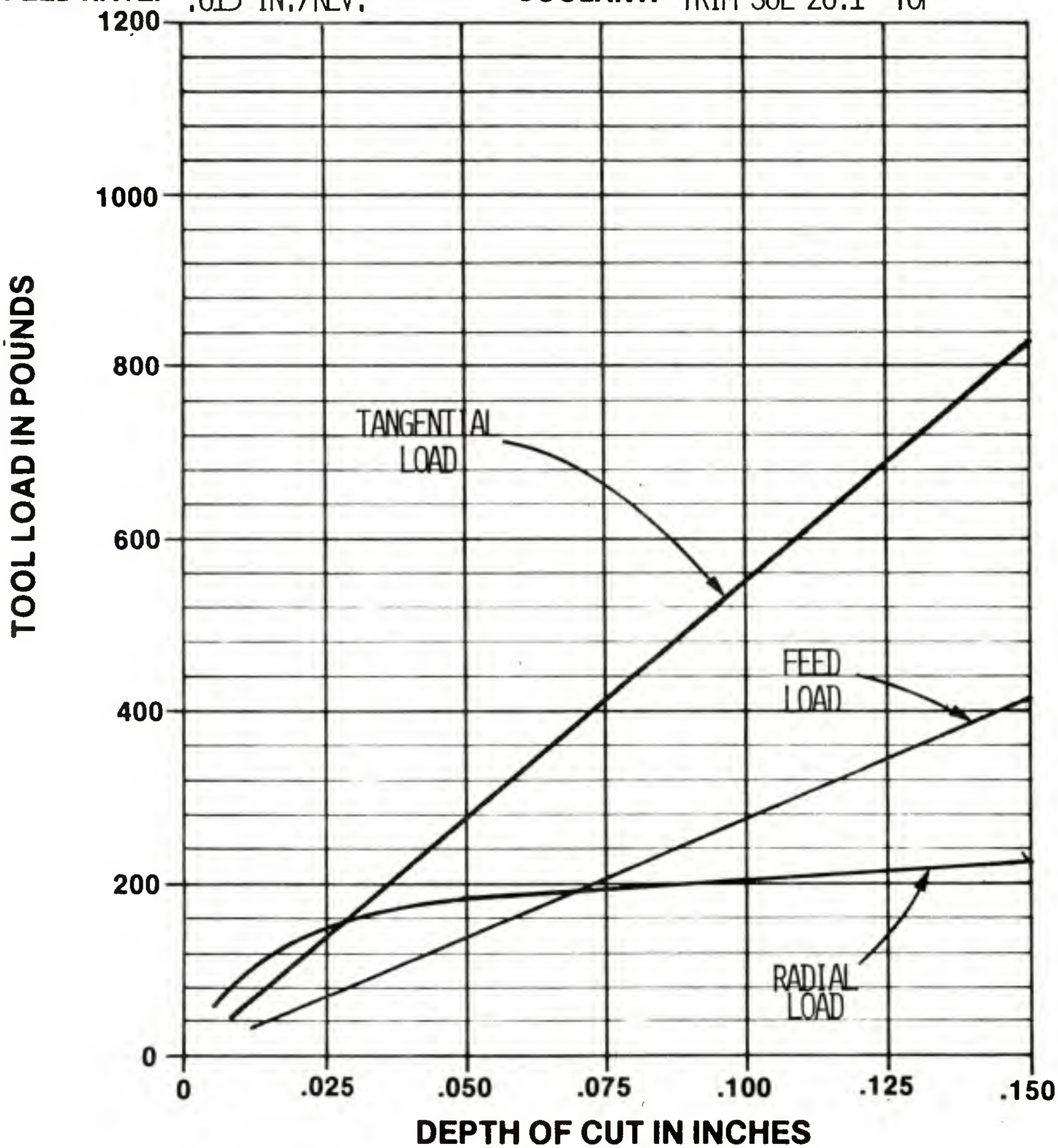

FIGURE 96 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 4140	**HOLDER:**	MTANR-164 (0° LEAD ANGLE)
HARDNESS:	286 BHN	**INSERT:**	TNMG-433
SURFACE SPEED:	500 FT./MIN.	**GRADE:**	KC-810
FEED RATE:	.015 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP

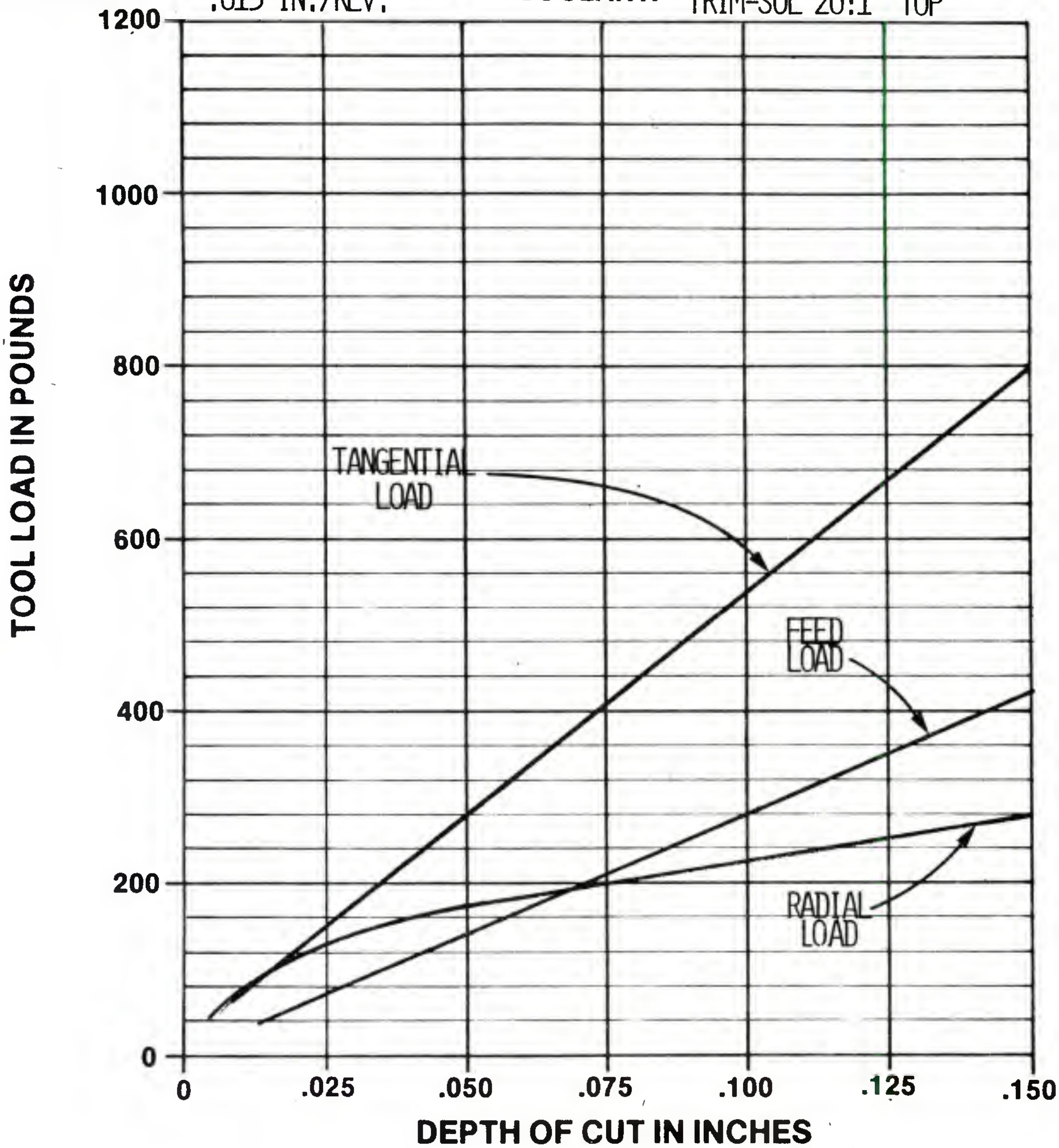

FIGURE 97 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4140 **HOLDER:** MTANR-164 (0^0 LEAD ANGLE)

HARDNESS: 286 BHN **INSERT:** TNMG-433

SURFACE SPEED: 560 FT./MIN. **GRADE:** 570

FEED RATE: .015 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP

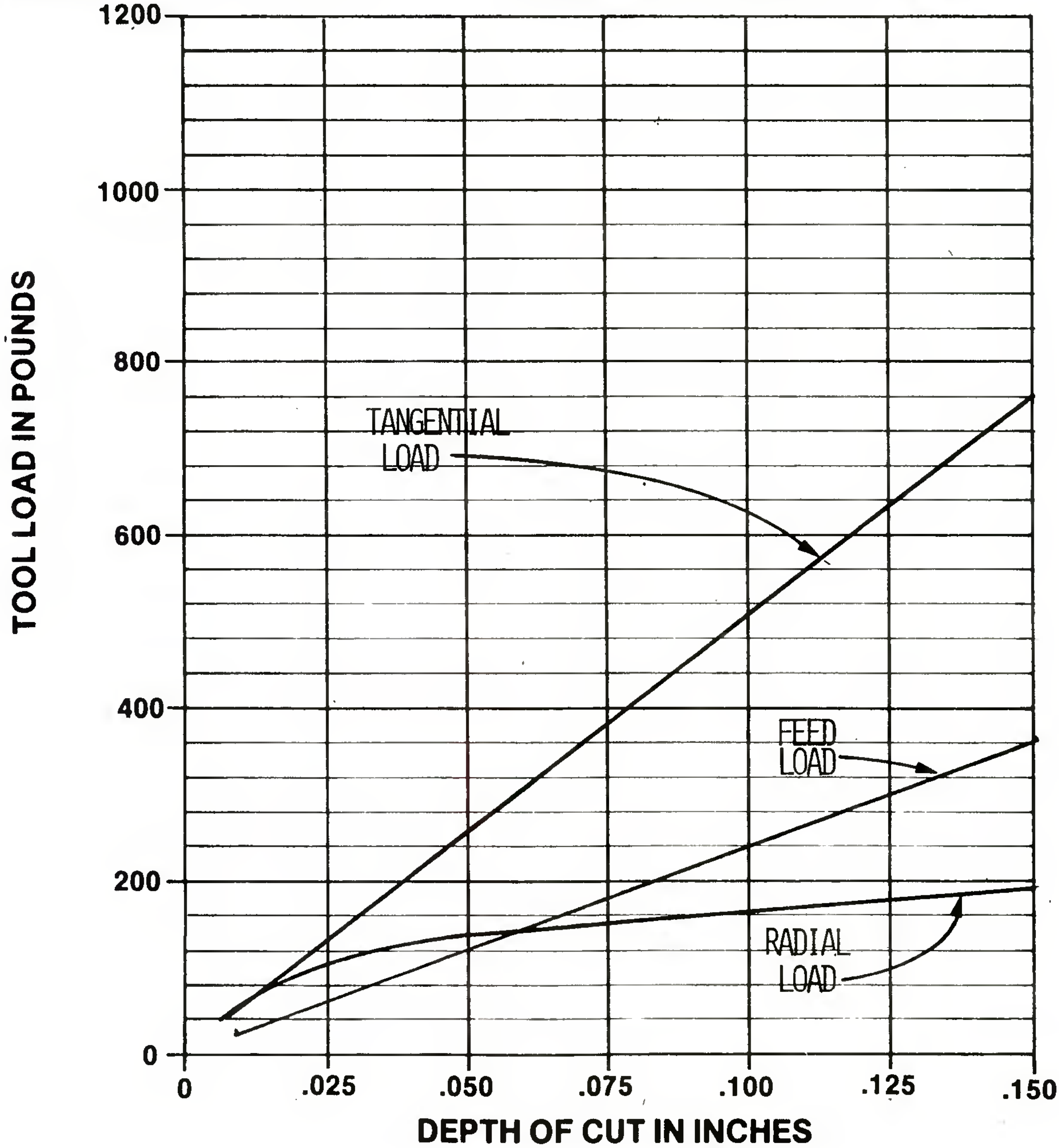

FIGURE 98 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4140 **HOLDER:** CCGNR-164 (0° LEAD ANGLE)

HARDNESS: 286 BHN **INSERT:** CNG-454 820

SURFACE SPEED: 950 FT./MIN. **GRADE:** G-10

FEED RATE: .015 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP

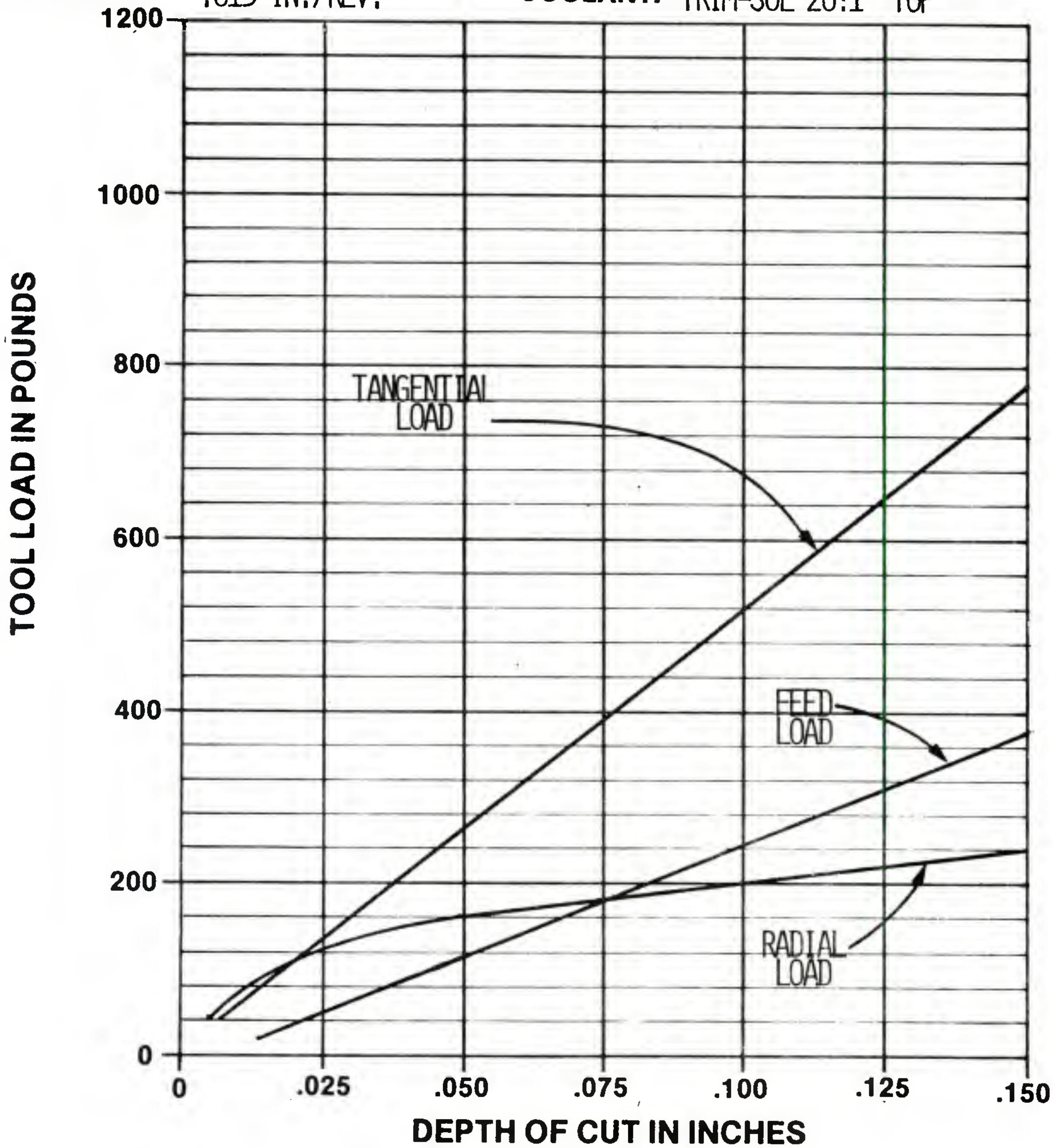

FIGURE 99 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4140 **HOLDER:** CCGNR-164 (0° LEAD ANGLE)

HARDNESS: 286 BHN **INSERT:** CNG-454 820

SURFACE SPEED: 1180 FT./MIN. **GRADE:** G-30

FEED RATE: .015 IN./REV. **COOLANT:** NONE

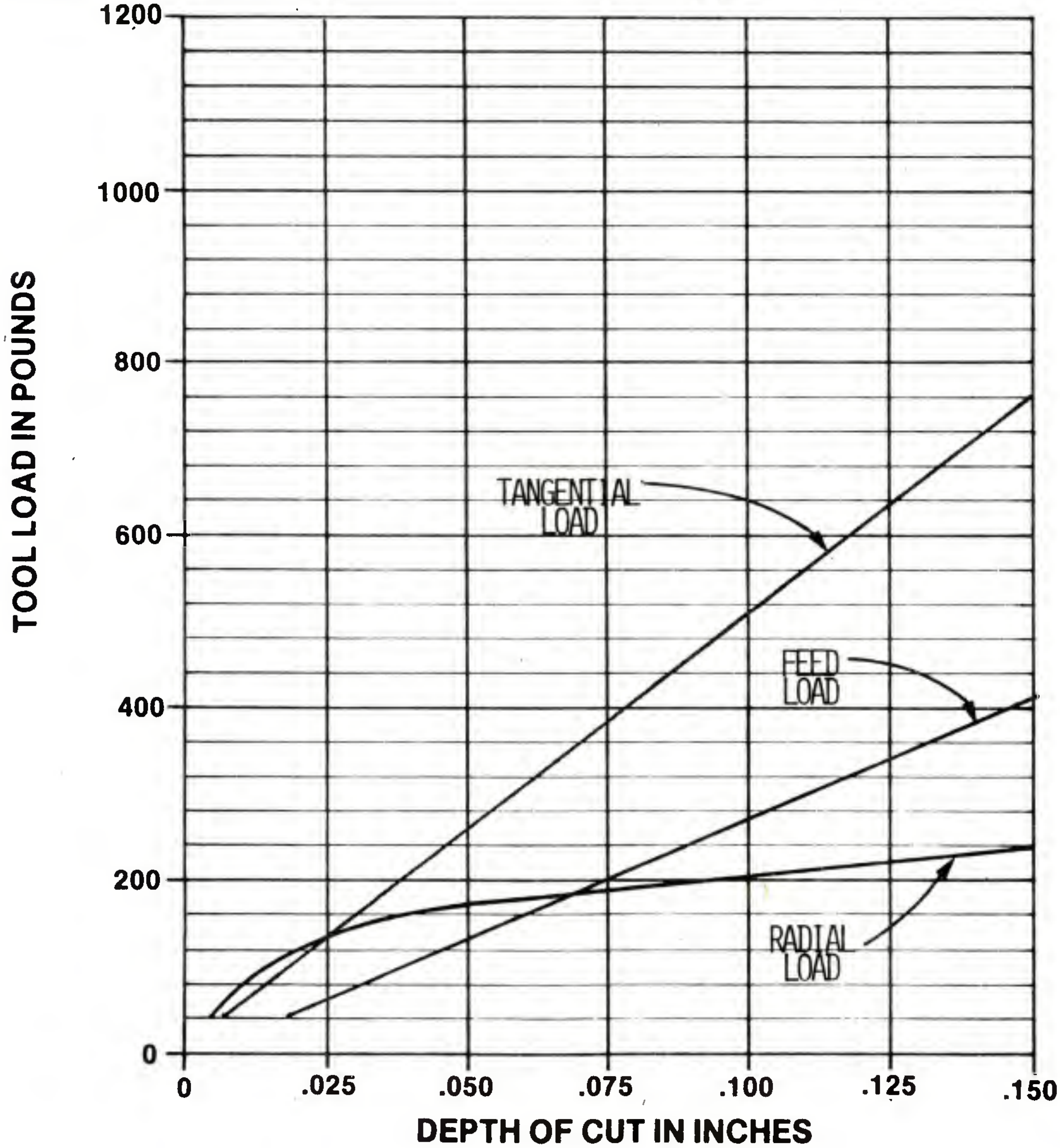

FIGURE 100 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4140 — **HOLDER:** PRANR-164

HARDNESS: 286 BHN — **INSERT:** RNMG-43

SURFACE SPEED: 390 FT./MIN. — **GRADE:** 350

FEED RATE: .022 IN./REV. — **COOLANT:** TRIM-SOL 20:1 TOP

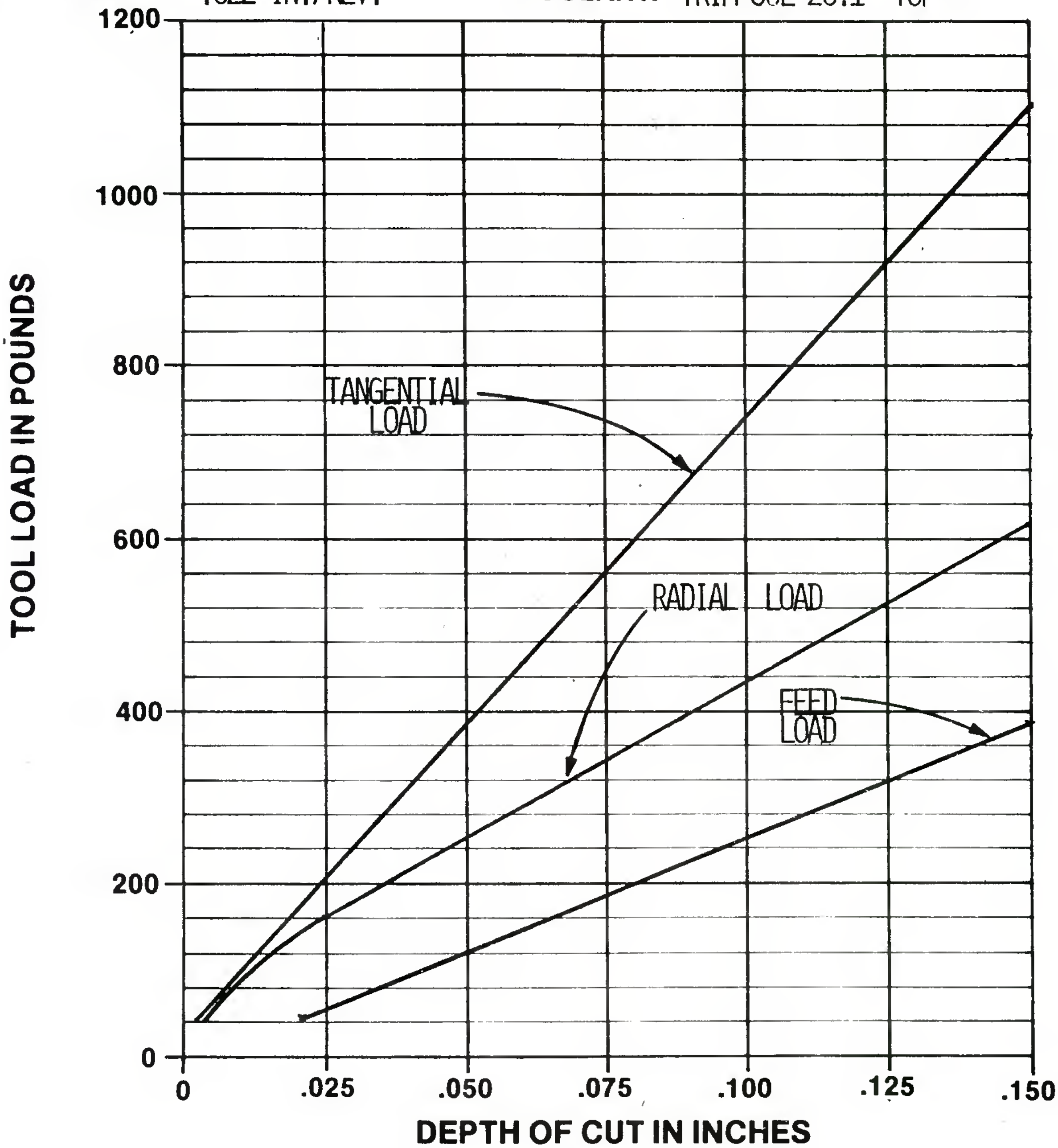

FIGURE 101 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4140 **HOLDER:** PRANR-164

HARDNESS: 286 BHN **INSERT:** RNMG-43

SURFACE SPEED: 500 FT./MIN. **GRADE:** KC-810

FEED RATE: .022 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP APPLICATION

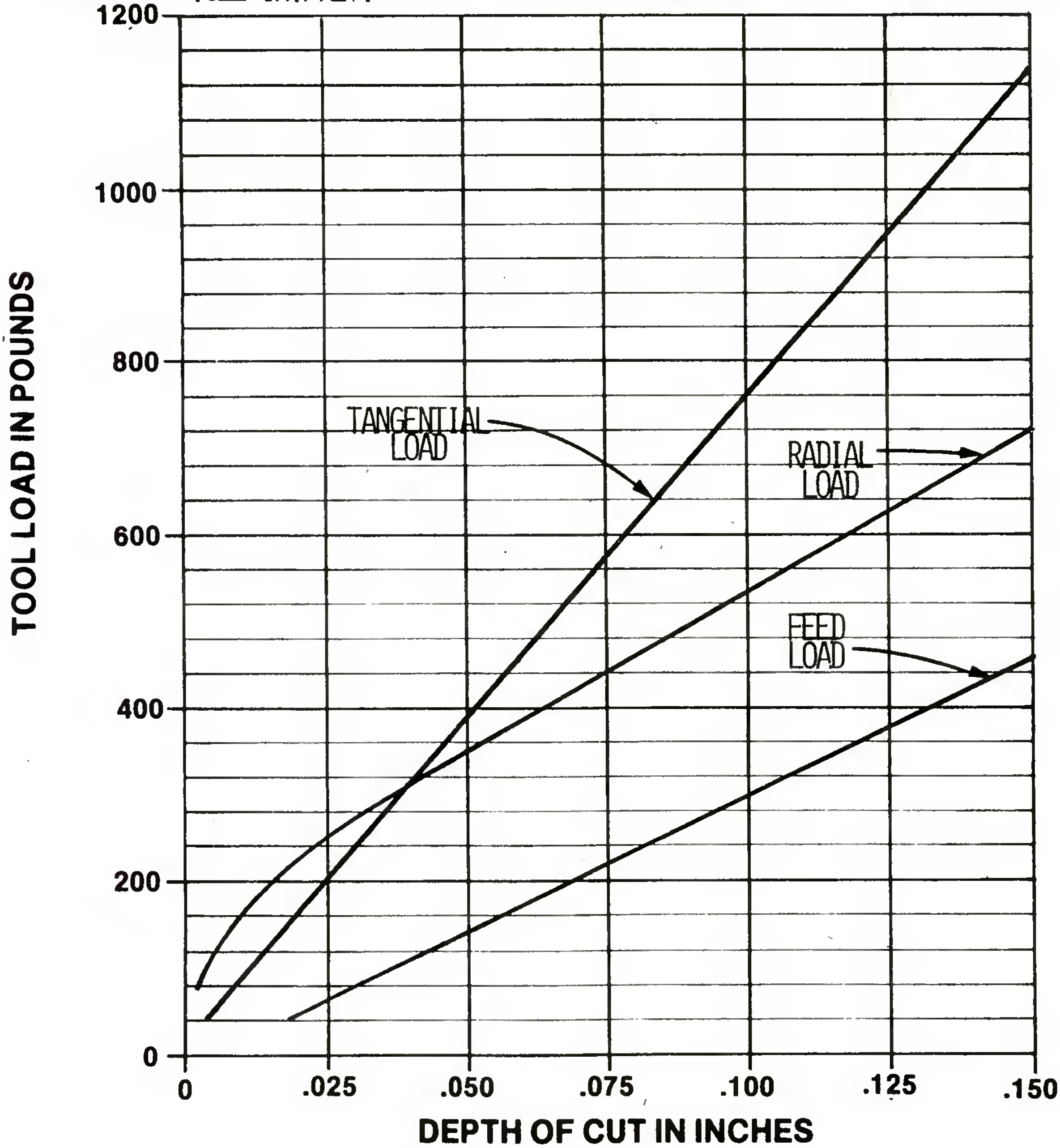

FIGURE 102 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4140 **HOLDER:** PRANR-164

HARDNESS: 286 BHN **INSERT:** RNMG-43

SURFACE SPEED: 560 FT./MIN. **GRADE:** 570

FEED RATE: .022 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP APPLICATION

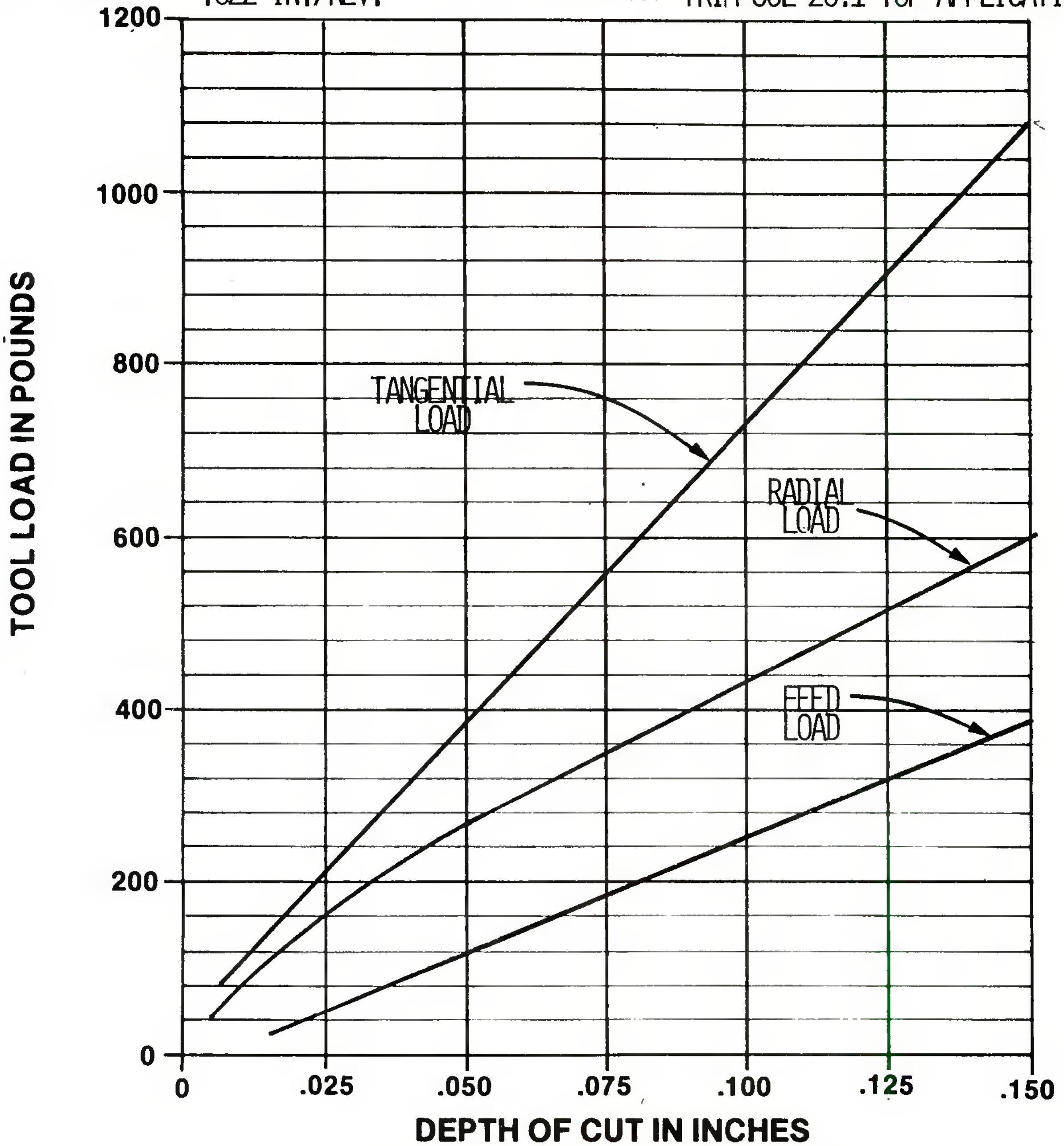

FIGURE 103 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4140 **HOLDER:** CRGNR-164

HARDNESS: 286 BHN **INSERT:** RNG-45 820

SURFACE SPEED: 950 FT./MIN. **GRADE:** G-10

FEED RATE: .022 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP APPLICATION

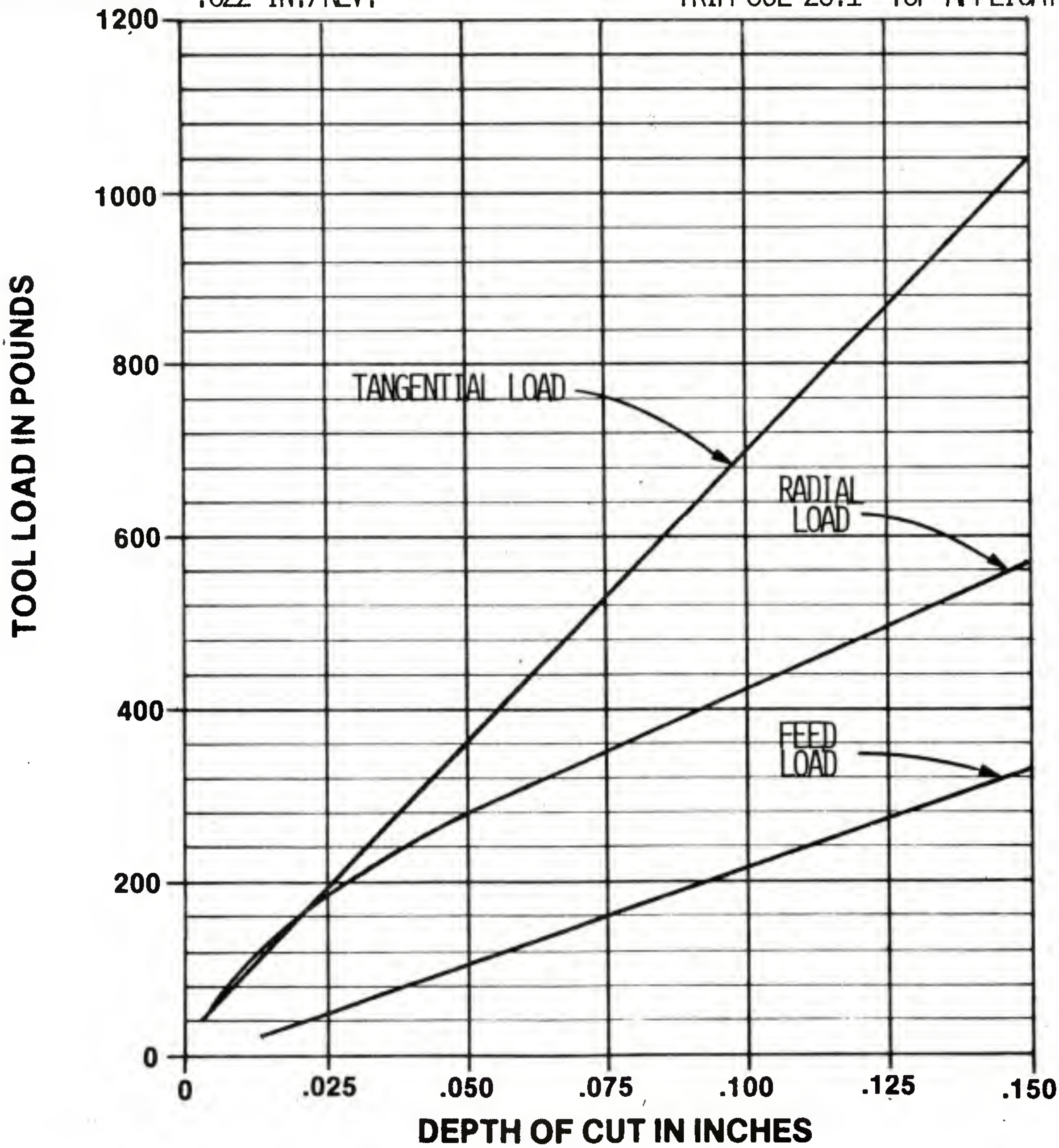

FIGURE 104 : TOOL LOAD CHART

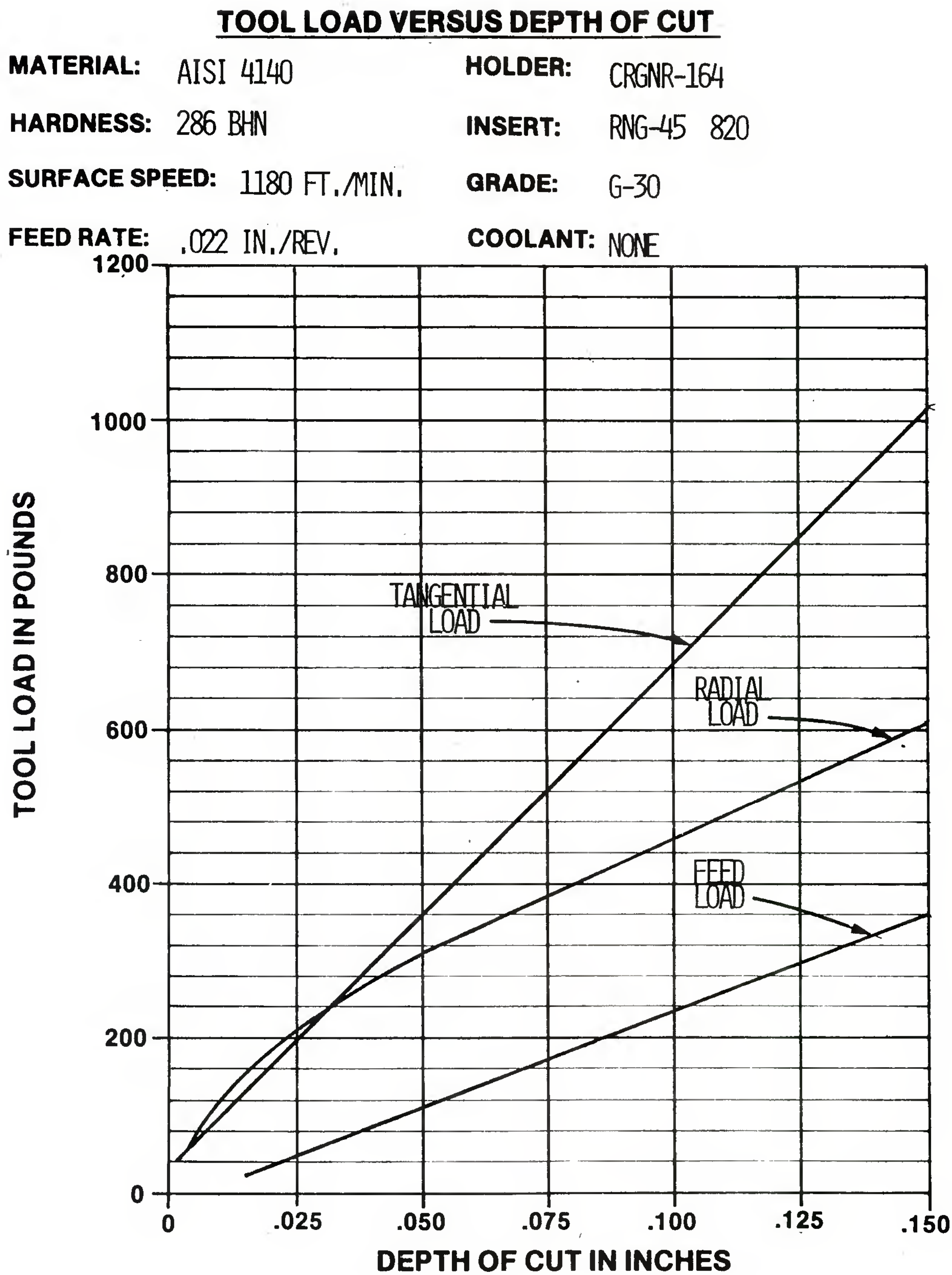

FIGURE 105 : TOOL LOAD CHART

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4140 **HARDNESS:** 286 BHN

INSERT: TNMG-433 **SURFACE FEED:** 390 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: 350 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	160	60	140
.050	300	140	175
.100	540	280	195
.150	810	410	225

INSERT: TNMG-433 **SURFACE FEED:** 500 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: KC-810 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	160	60	130
.050	295	145	170
.100	530	280	200
.150	770	420	240

INSERT: TNMG-433 **SURFACE FEED:** 560 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: 570 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	150	50	100
.050	280	120	135
.100	510	230	160
.150	740	360	190

TABLE 71: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4140 **HARDNESS:** 286 BHN

INSERT: CNG-454 .008 x 20° **SURFACE FEED:** 950 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	140	45	110
.050	265	105	160
.100	520	250	200
.150	765	405	240

INSERT: CNG-454 .008 x 20° **SURFACE FEED:** 1180 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .015 IN.REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	145	50	115
.050	270	110	160
.100	495	270	210
.150	770	430	240

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025			
.050			
.100			
.150			

TABLE 72: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4140 **HARDNESS:** 286 BHN

INSERT: RNMG-43 **SURFACE FEED:** 390 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 350 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	215	40	155
.050	400	95	250
.100	760	230	430
.150	1040	400	620

INSERT: RNMG-43 **SURFACE FEED:** 500 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: KC-810 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	225	60	240
.050	410	120	350
.100	780	280	540
.150	995	480	720

INSERT: RNMG-43 **SURFACE FEED:** 560 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 570 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	215	45	170
.050	400	100	270
.100	760	240	450
.150	1080	390	600

TABLE 73: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4140 **HARDNESS:** 286 BHN

INSERT: RNG-45 .008 x 20° **SURFACE FEED:** 950 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	200	40	175
.050	380	90	285
.100	700	210	440
.150	1010	345	570

INSERT: RNG-45 .008 x 20° **SURFACE FEED:** 1180 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	200	40	185
.050	380	95	300
.100	700	220	480
.150	1000	360	600

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025			
.050			
.100			
.150			

TABLE 74: **DATA FOR TOOL LOAD CHARTS**

SURFACE SPEED VERSUS SURFACE FINISH

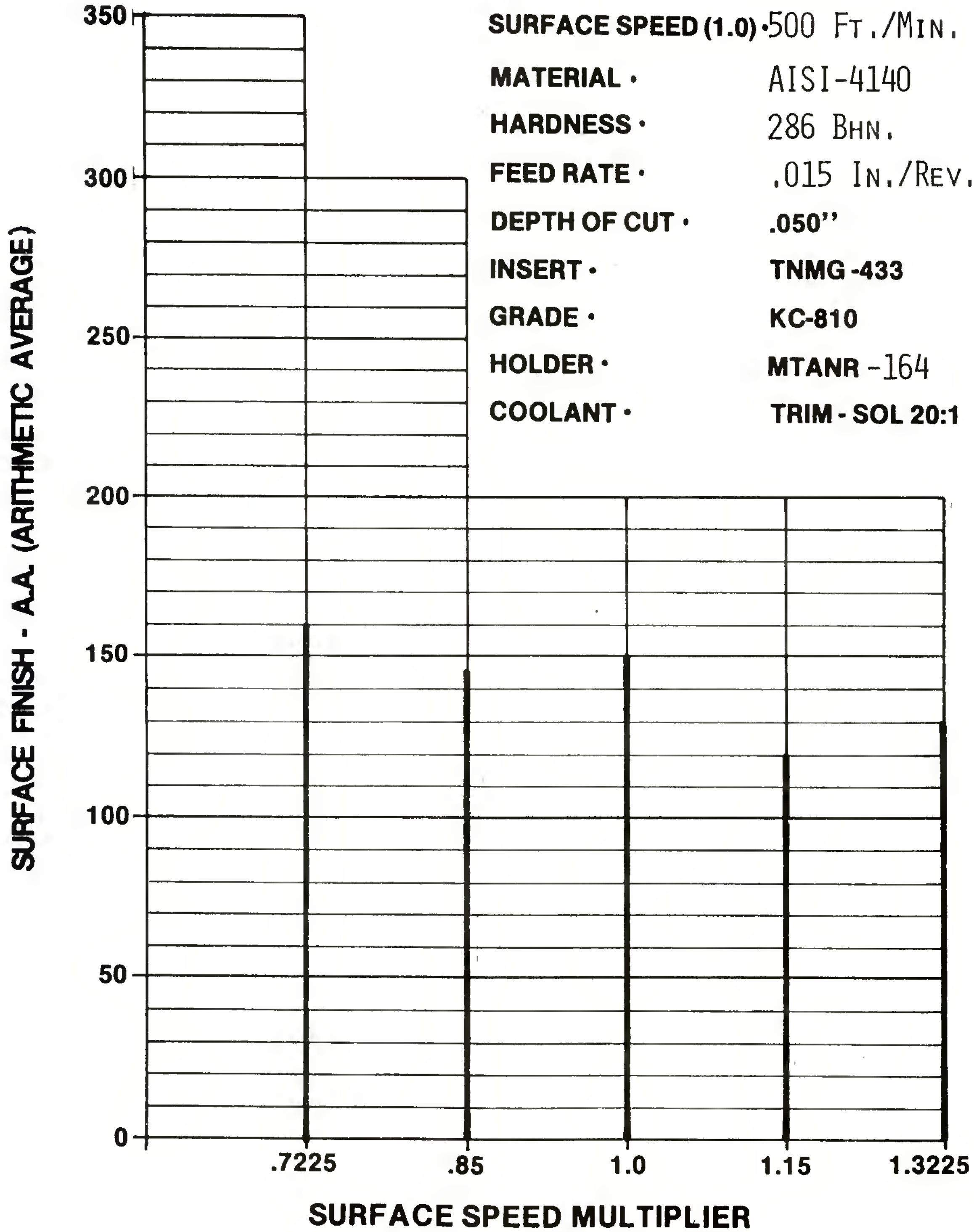

Figure 106

TOOL NOSE RADIUS VERSUS SURFACE FINISH

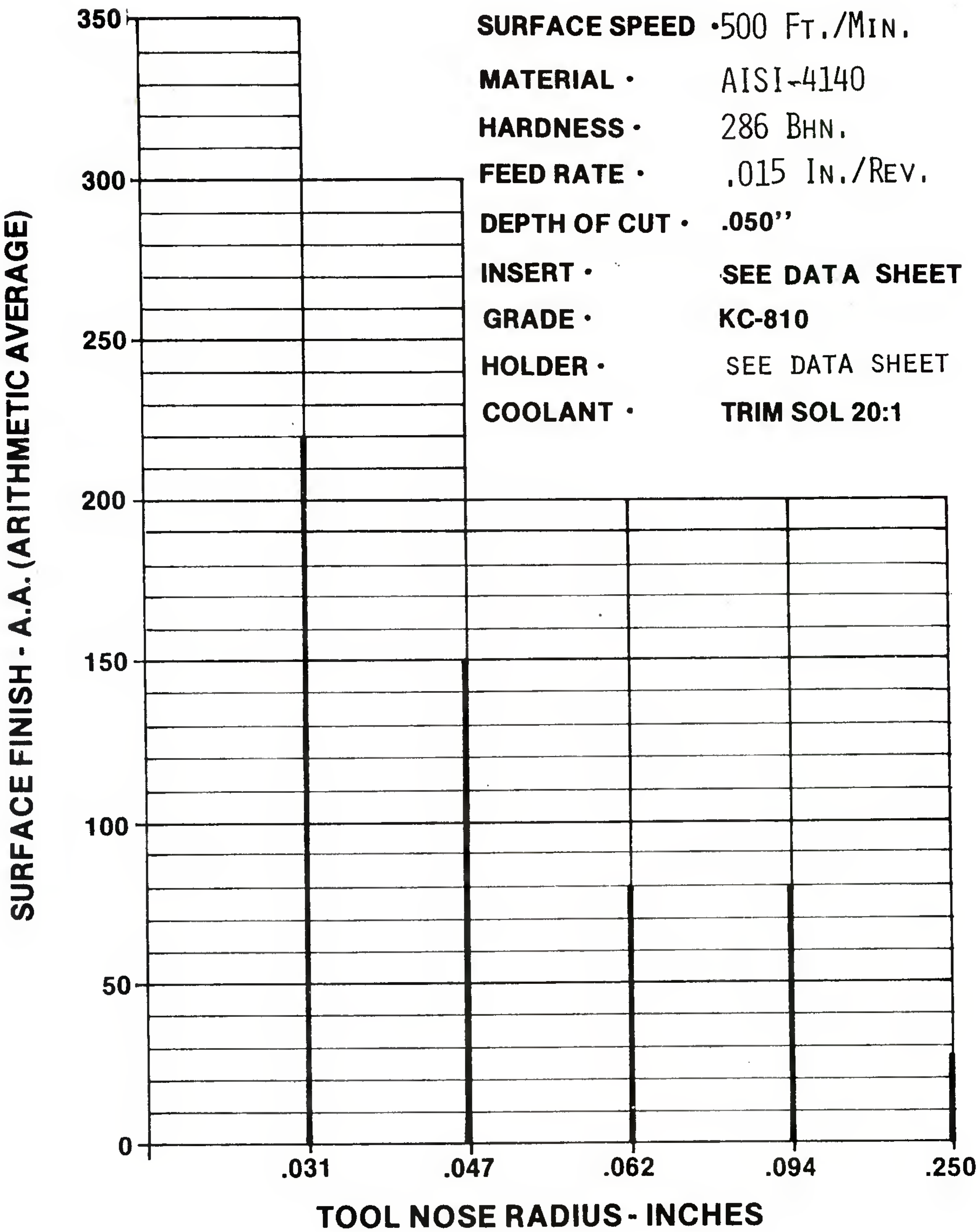

Figure 107

Date: 9/19/80	Material: AISI 4140
Depth of Cut: .050 Inches	Coolant: Trim - Sol 20:1
Hardness: 286 BHN	Tool Description:
Coolant Application: Top	Holder: MTANR-164
	Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	NOSE RADIUS	SURFACE SPEED MULTIPLIER	SURFACE FINISH ARITHMETIC AVERAGE			
1	KC-810	360	.015		.7225	160			
2	"	425	"		.85	145			
3	"	500	"		1.0	150			
4	"	575	"		1.15	120			
5	"	660	"		1.3225	130			

NOTES:

TABLE 75: **DATA FOR SURFACE FINISH TESTS**

Date: 9/19/80	Material: AISI 4140
Depth of Cut: .050 Inches	Coolant: Trim - Sol 20:1
Hardness: 286 BHN	Tool Description: SEE NOTES
Coolant Application: Top	Holder:
	Insert:

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	NOSE RADIUS	SURFACE SPEED MULTIPLIER	SURFACE FINISH ARITHMETIC AVERAGE			
1	KC-810	500	.015	.03125		220			
2	"	"	"	.0469		150			
3	"	"	"	.0625		80			
4	"	"	"	.09375		80			
5	"	"	"	.250		28			

NOTES:

TOOL HOLDER	INSERT
KTAR-164	TNMG-432
KTAR-164	TNMG-433
KTAR-164	TNMG-434
WTJNRS-205	TNMG-566
PRANR-854	RNMG-43
(.500 IN. DIAM. RND.)	

TABLE 76: **DATA FOR SURFACE FINISH TESTS**

AISI 4140 Projectile Material - "Finishing Cuts" - 47/49 Rc

This material, at 444/477 Brinell as well as 262/286 Brinell hardness, presents problems in chip-control. When the hardness on this material was raised to 444/477 Brinell hardness, the cutting speed for equal tool life was lowered from 55% to 68% for all cutting grades tested. When the production indexes are compared for these two hardness conditions, the effect of the lowered cutting speed is obvious. See Table 77, page 203, and Table 67, page 179.

The tangential tool load for .050 inches depth of cut, and at a cutting speed to give 2500 square inches of machined surface, increased from 7 to 16 per cent for various tool materials and geometries as the work-piece hardness was increased from 262/286 to 444/477 Brinell hardness. See Figures 109 through 118 and Tables 80 through 83, pages 207 to 220. This amount of change is very small and in future tests the tool loads should be plotted against a change in surface speed.

The surface finish tests showed that varying the surface speed had little effect on the finish. Varying the nose radius gave the same trends as seen in other tests, in that, as the nose radius is increased, the surface finish improves, although the ½" round insert (.250 nose radius) gave a higher A.A. reading than the 3/32 nose radius. However, the difference is small enough to be insignificant. See Figures 119 and 120 and their accompanying tables on pages 223 and 224.

SUMMARY OF RESULTS

"FINISHING CUT"

MATERIAL AISI-4140
HARDNESS 444/477 Bhn.
TOOL LIFE 2500 In^2 of Machined Surface
DEPTH OF CUT .050 Inches

Insert Grade	Insert Style	SFM	Feed In./Rev.	Prod. Index	Tangential Tool Load - Lbs. .050 Depth of Cut	H.P. .050 Depth of Cut
350	TNMG-433	125	.015	1.875	300	1.14
KC-810	TNMG-433	165	.015	2.475	310	1.55
570	TNMG-433	255	.015	3.825	270	2.09
G-10	CNG-454	430	.015	6.45	250	3.26
G-30	CNG-454	450	.015	6.75	250	3.41
350	RNMG-43	125	.022	—	410	1.55
KC-810	RNMG-43	165	.022	—	410	2.05
570	RNMG-43	255	.022	—	400	3.09
G-10	RNG-45	430	.022	—	420	5.47
G-30	RNG-45	450	.022	—	420	5.73

TABLE 77: AISI-4140 Results of Tests

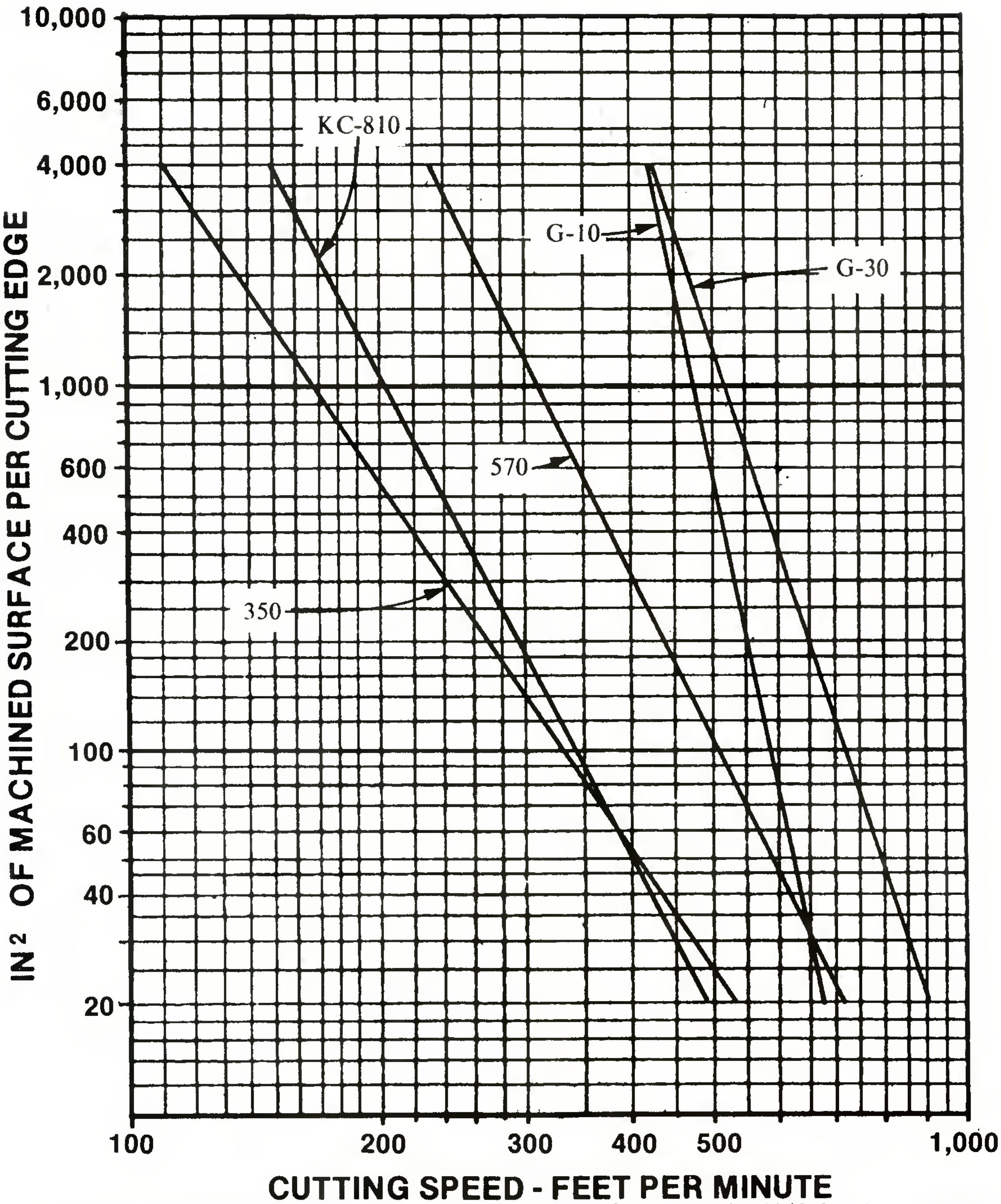

Figure 108: Tool-Life Lines of Listed Cutting Materials on AISI 4140 Steel at 444/477 Brinell Hardness.

Feed - .015 Inches per Revolution
Depth of Cut - .050 Inches
350, KC-810, 570: Holder - MTANR-164 (0^0 Lead Angle)
Insert - TNMG - 433
G-10, G-30: Holder - CCGNR-164 (0^0 Lead Angle)
Insert - CNG-454, .008 x 20^0

Date: 1/20/81 **Material:** AISI 4140

Depth of Cut: .050 **Coolant:** TRIM-SOL 20:1

Hardness: 460/477 BHN **Tool Description:**

Coolant Application: TOP **Holder:** KTAR-164

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
1	350	190	.015	5.618	5.521	10"	173	.0075	554	.024
2	"	260	"	"	"	3.5"	60.7	.0065	224	.024
3	"	350	"	"	5.518	1.1"	19.1	.0115	39.8	.024
4	"	300	"	"	5.524	2.6"	45.12	.0075	144	.024
5	"	400	"	5.522	5.429	1.8"	30.7	.0125	58.9	.024
6	"	350	"	"	"	1.6"	27.3	.010	65.5	.024
7	KC-810	400	"	5.520	-		-	-	TOO	FAST
8	"	350	"	"	5.440	1.9	32.5	.009	86.6	.024
9	"	300	"	"	"	4.2	71.8	.0105	164	.024
10	"	220	"	5.425	5.325	10.8	180.7	.0065	667	.024
11	570	450	"	"	"	6.4	107	.0125	205	.024
12	"	500	"	5.325	5.222	3.5	57.4	.0145	95	.024
13	"	350	"	"	5.225	17.5	287.3	.012	574.5	.024

NOTES:

TABLE 78 : DATA FOR LIFE LINES

Date:	1/20/81	**Material:**	AISI 4140
Depth of Cut:	.050	**Coolant:**	TRIM-SOL 20:1
Hardness:	460/477 BHN	**Tool Description:**	
Coolant Application:	TOP: G-10 NONE: G-30	**Holder:**	CCGNR-164
		Insert:	CNG-454 - 820

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
1	G-10	950	.015	5.650	5.550	3.1				#1
2	"	800	"	"	"	3.5		.0025		#2
3	"	600	"	"	5.528	4.0	69.5	.0085	122.6	.015
4	"	500	"	"	5.540	10.4	181	.0045	603	.015
5	"	450	"	5.540	5.450	15.8	270	.0025	1620	.015
6	G-30	600	"	"	5.445	5.1	87	.0045	290	.015
7	"	500	"	5.445	5.350	14.3	240	.003	1201	.015
8	"	450	"	"	5.345	6.5	109.1		CUT CONT	INUED
8a	"	"	"	5.345	5.240	18.88	419.9	.003	2100	.015

NOTES: #1 - TOOL BROKE
#2 - NOSE CHIPPED-RUN NOT VALID.

TABLE 79 : DATA FOR LIFE LINES

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 4140	**HOLDER:**	CTAR-164
HARDNESS:	444/477 BHN	**INSERT:**	TNMG-433
SURFACE SPEED:	125 FT./MIN.	**GRADE:**	350
FEED RATE:	.015 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP APPLICATION

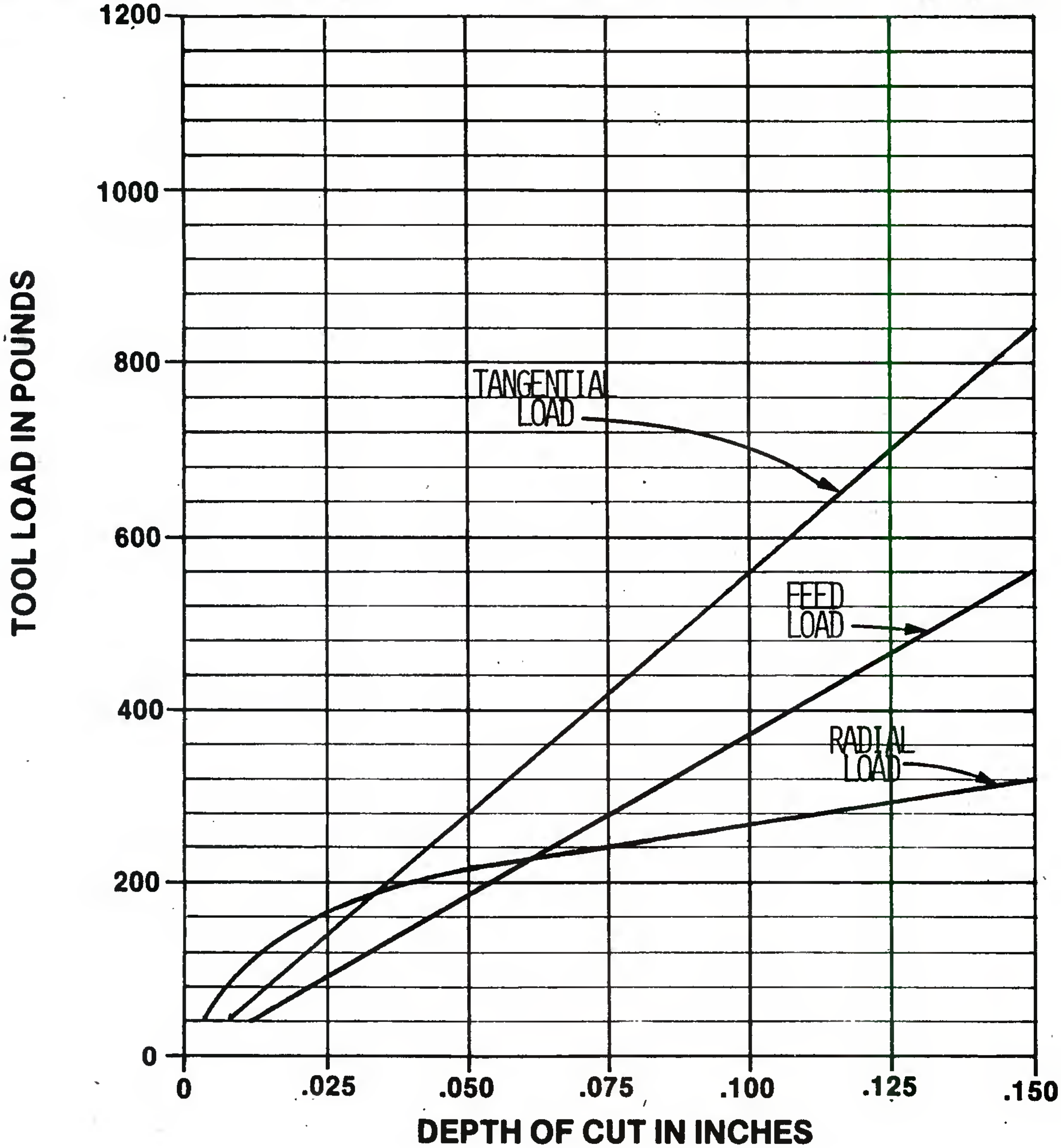

FIGURE 109 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 4140	**HOLDER:**	CTAR-164
HARDNESS:	444/477 BHN	**INSERT:**	TNMG-433
SURFACE SPEED:	165 FT./MIN.	**GRADE:**	KC-810
FEED RATE:	.015 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP APPLICATION

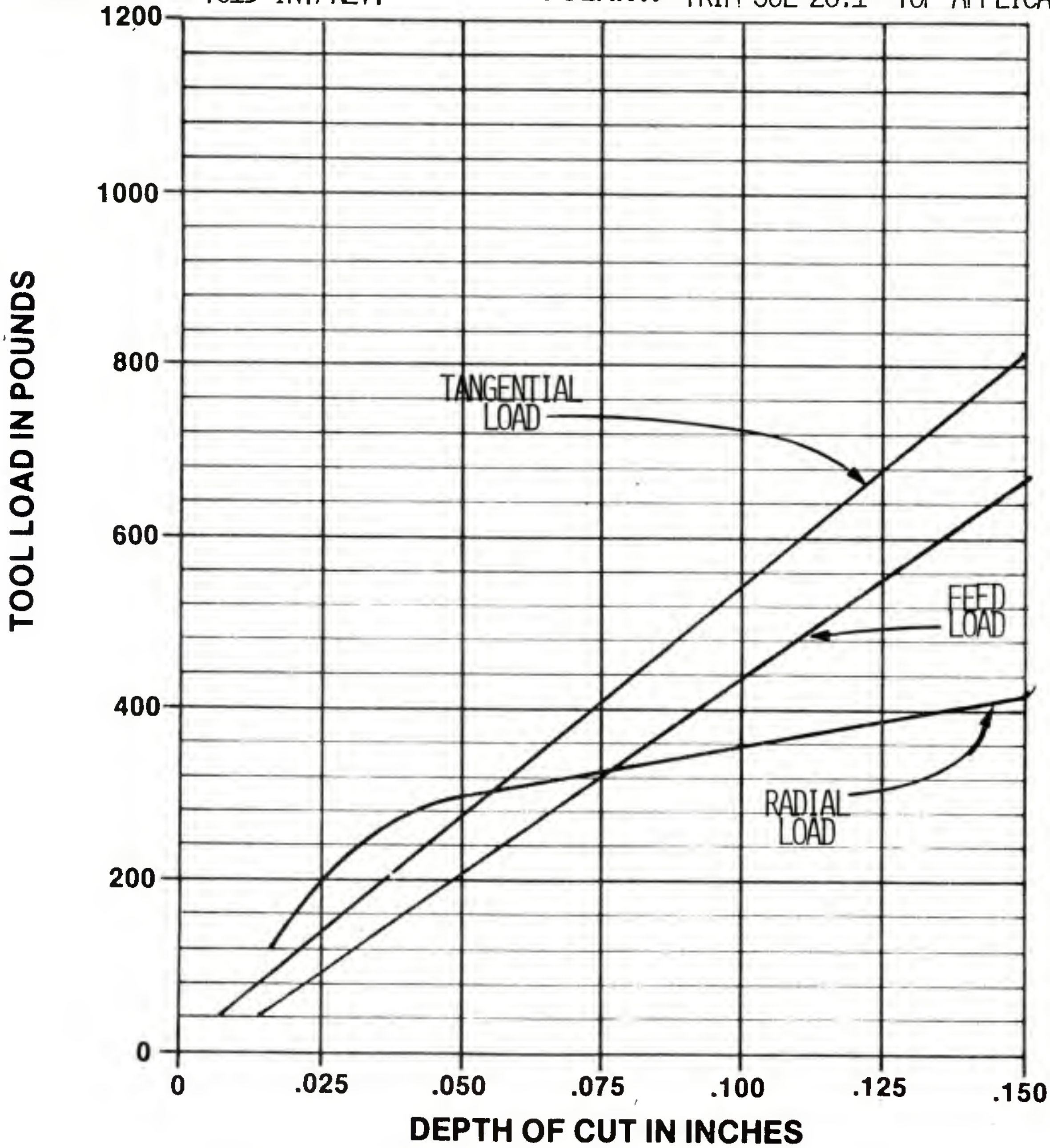

FIGURE 110 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4140 **HOLDER:** CTAR-164

HARDNESS: 444/477 BHN **INSERT:** TNMG-433

SURFACE SPEED: 255 FT./MIN. **GRADE:** 570

FEED RATE: .015 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP APPLICATION

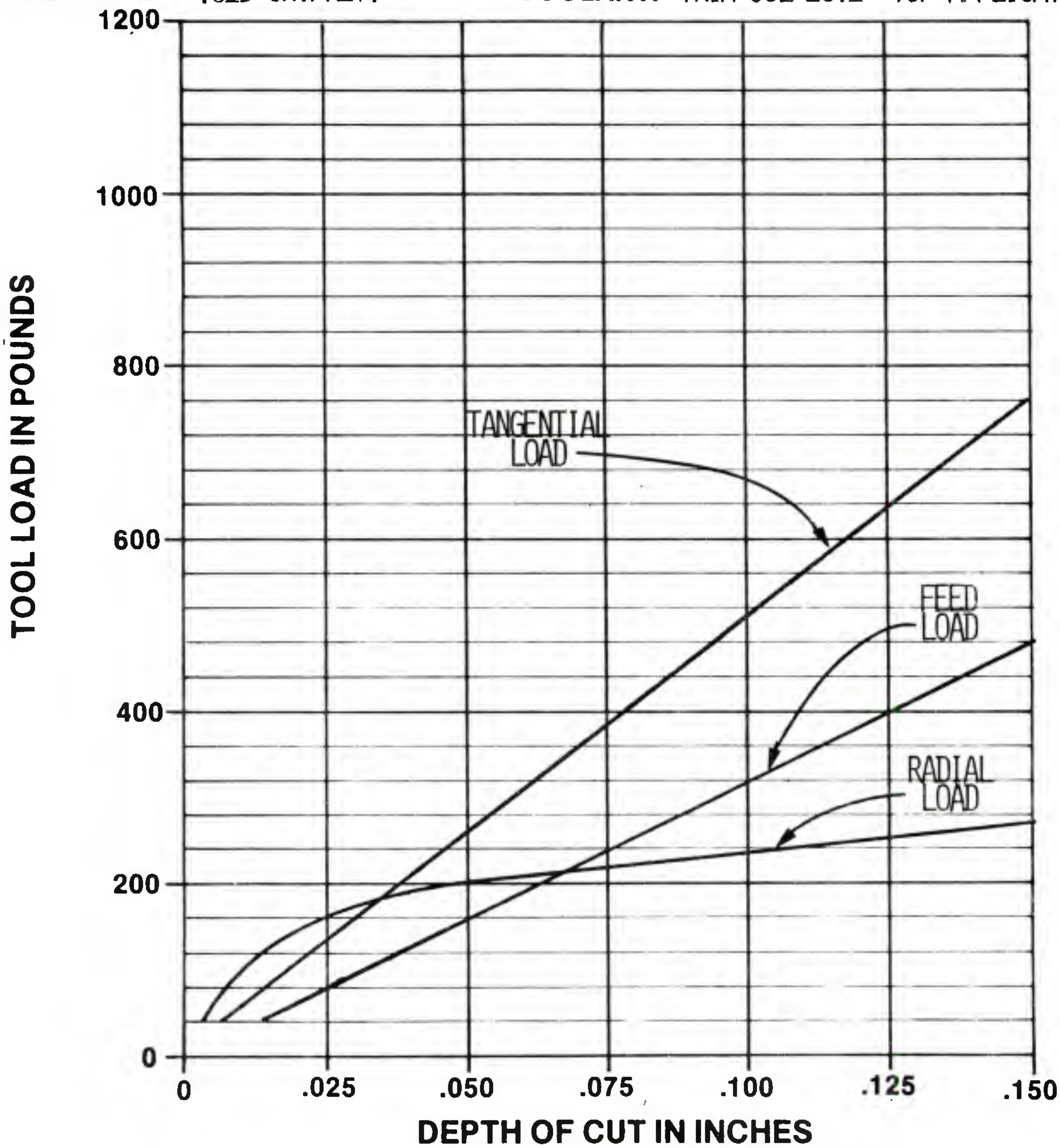

FIGURE 111: TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 4140	**HOLDER:**	CCGNR-164
HARDNESS:	444/477 BHN	**INSERT:**	CNG-454 820
SURFACE SPEED:	430 FT./MIN.	**GRADE:**	G-10
FEED RATE:	.015 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP APPLICATION

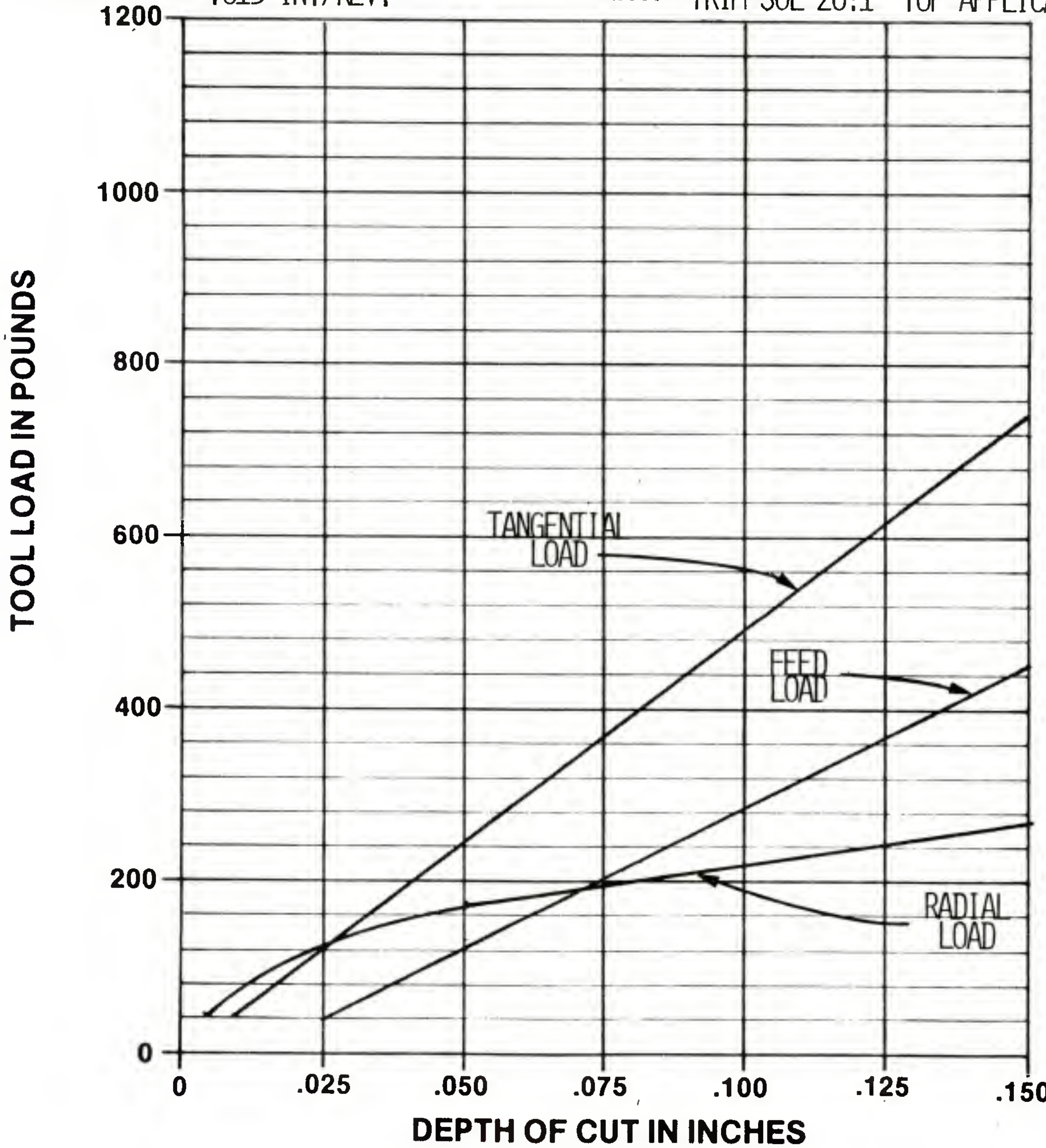

FIGURE 112 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 4140	**HOLDER:**	CCGNR-164
HARDNESS:	444/477 BHN	**INSERT:**	CNG-454 820
SURFACE SPEED:	450 FT./MIN.	**GRADE:**	G-30
FEED RATE:	.015 IN./REV.	**COOLANT:**	NONE

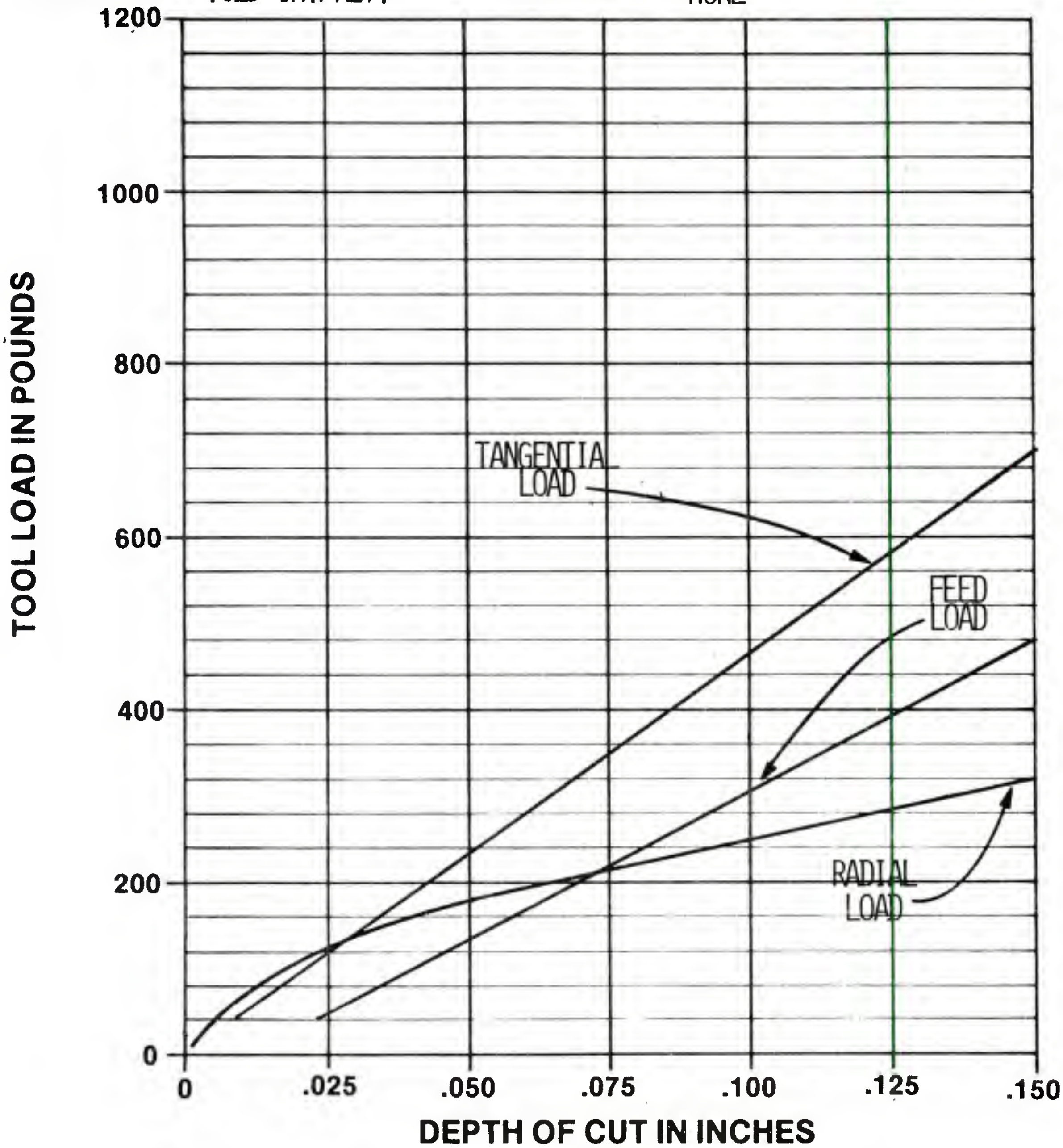

FIGURE 113 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4140 **HOLDER:** PRANR-164

HARDNESS: 460/477 BHN **INSERT:** RNMG-43

SURFACE SPEED: 125 FT./MIN. **GRADE:** 350

FEED RATE: .022 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP APPLICATION

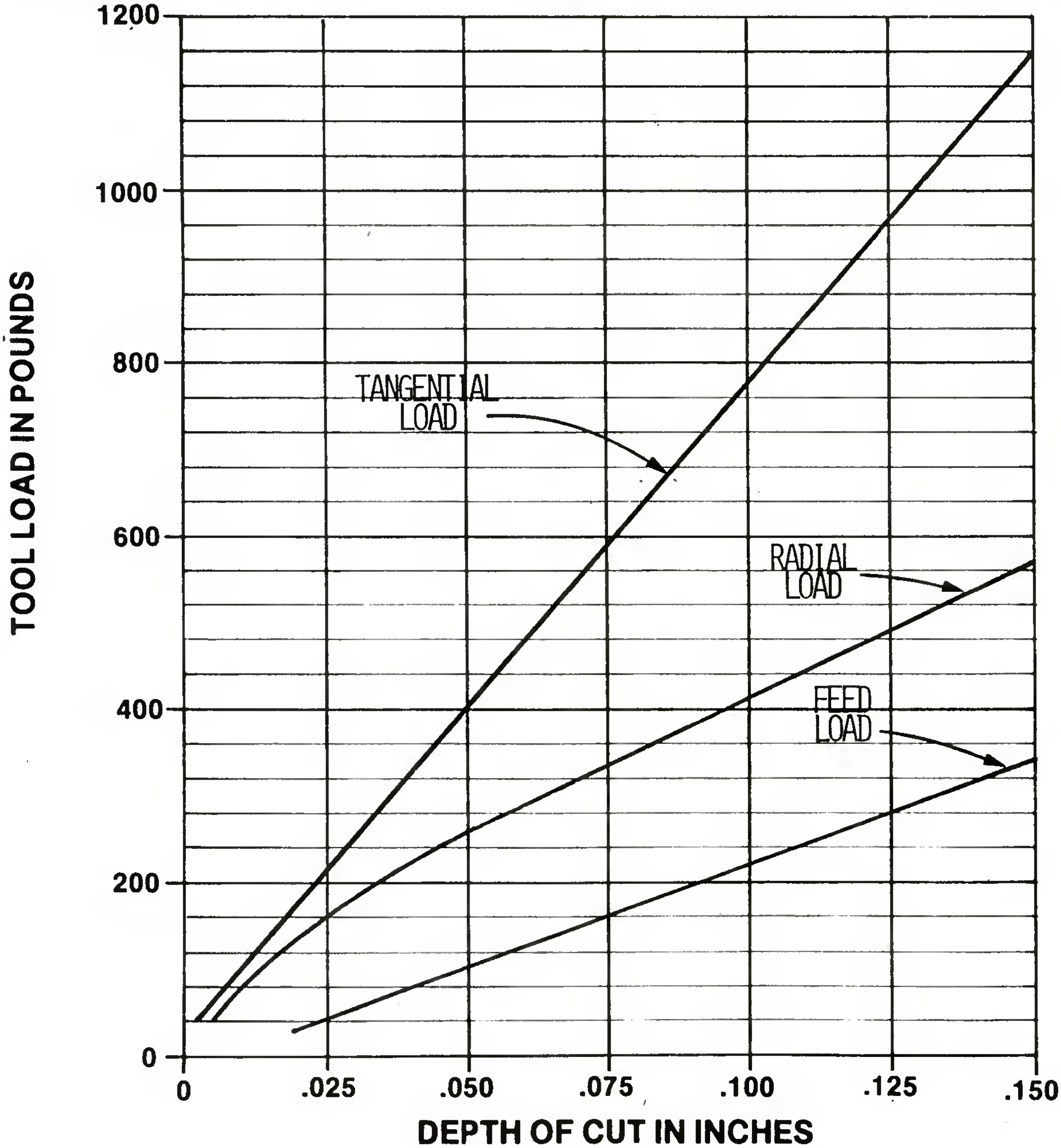

FIGURE 114 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4140 **HOLDER:** PRANR-164

HARDNESS: 460/477 BHN **INSERT:** RNMG-43

SURFACE SPEED: 165 FT./MIN. **GRADE:** KC-810

FEED RATE: .022 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP APPLICATION

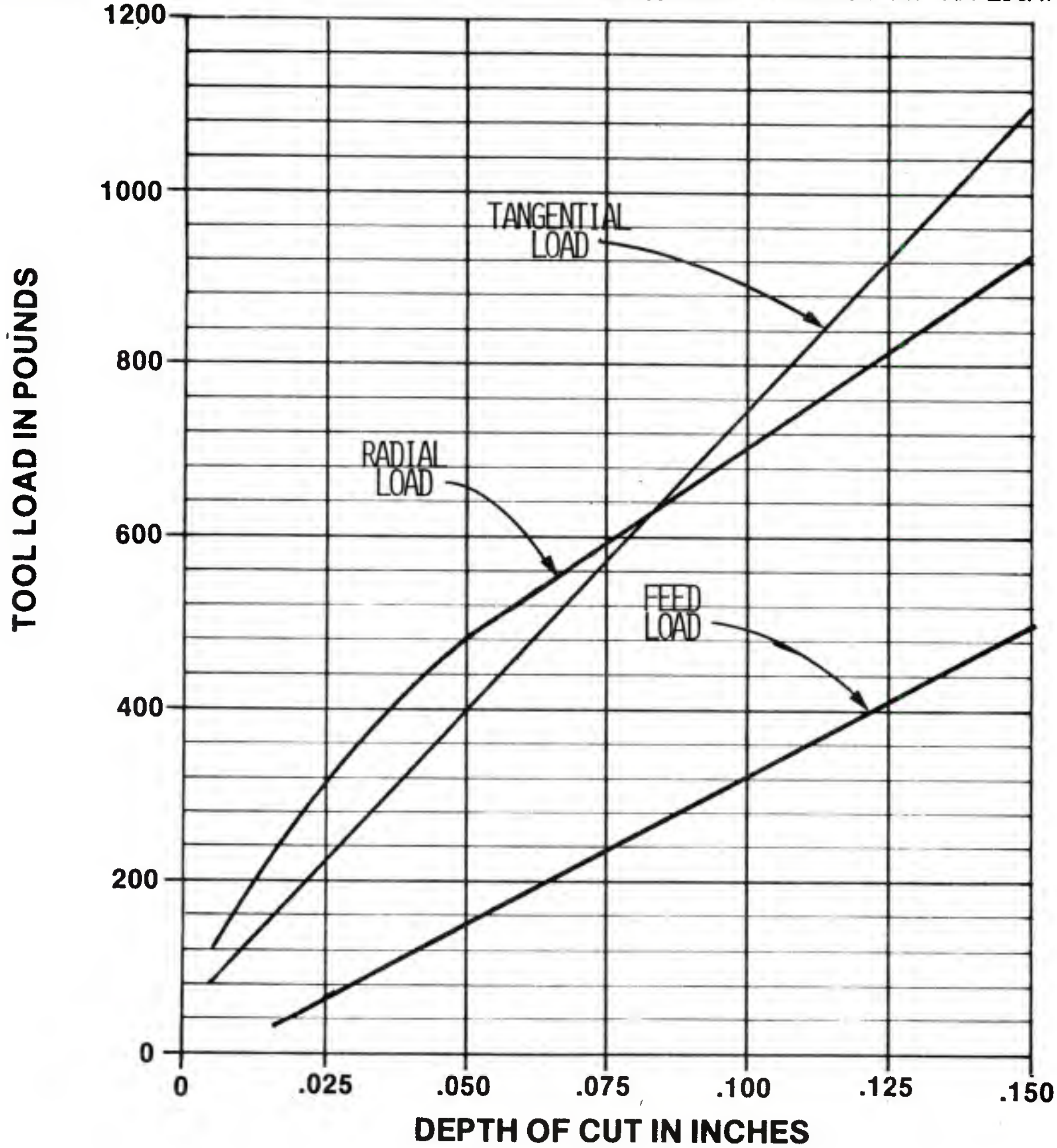

FIGURE 115 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 4140	**HOLDER:**	PRANR-164
HARDNESS:	460/470 BHN	**INSERT:**	RNMG-43
SURFACE SPEED:	255 FT./MIN.	**GRADE:**	570
FEED RATE:	.022 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP APPLICATION

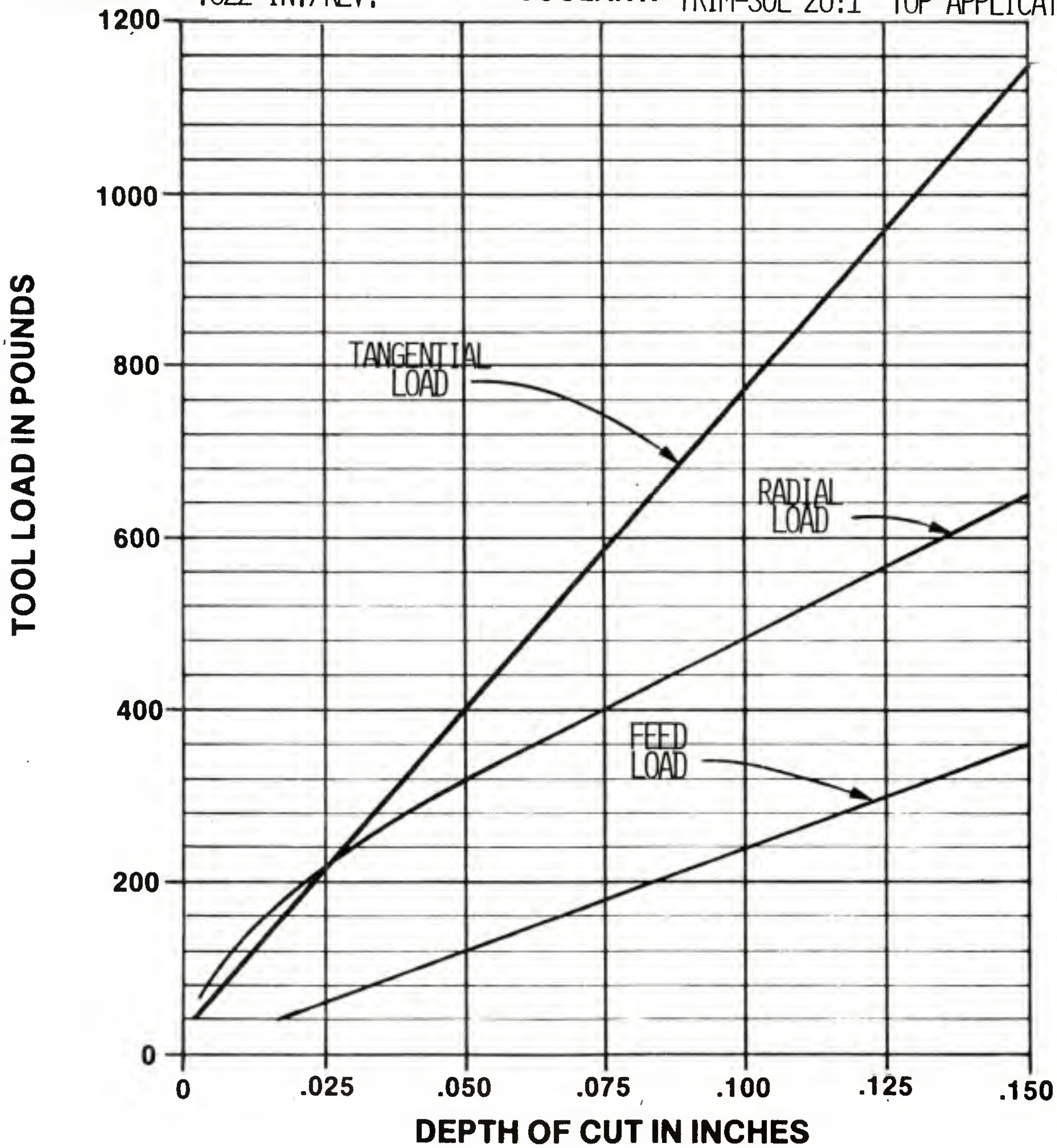

FIGURE 116 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 4140	**HOLDER:**	CRGNR-164
HARDNESS:	460/477 BHN	**INSERT:**	RNG-45 820
SURFACE SPEED:	430 FT./MIN.	**GRADE:**	G-10
FEED RATE:	.022 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP APPLICATION

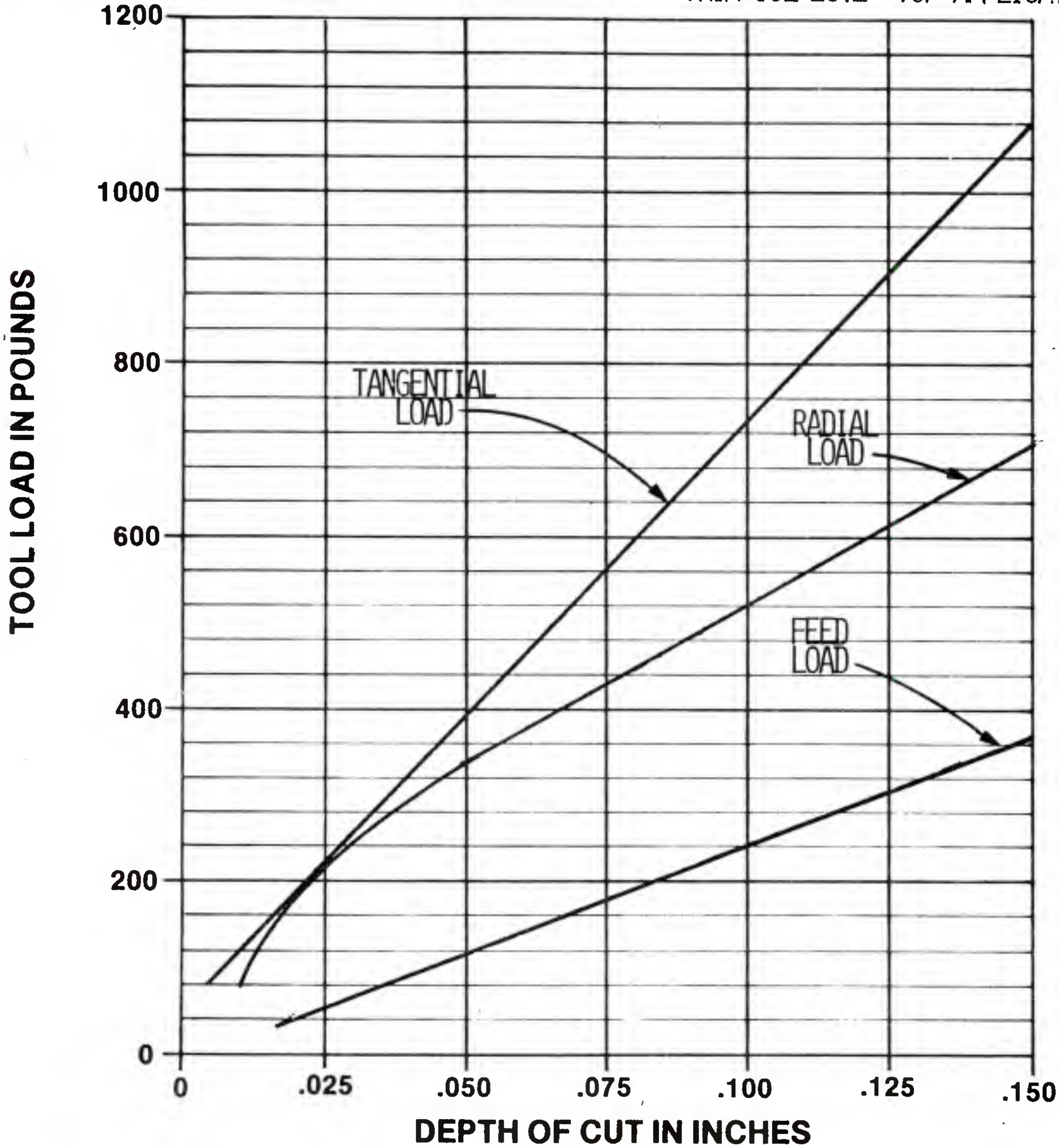

FIGURE 117 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4140 **HOLDER:** CRGNR-164

HARDNESS: 460/477 BHN **INSERT:** RNG-45 820

SURFACE SPEED: 450 FT./MIN. **GRADE:** G-30

FEED RATE: .022 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP APPLICATION

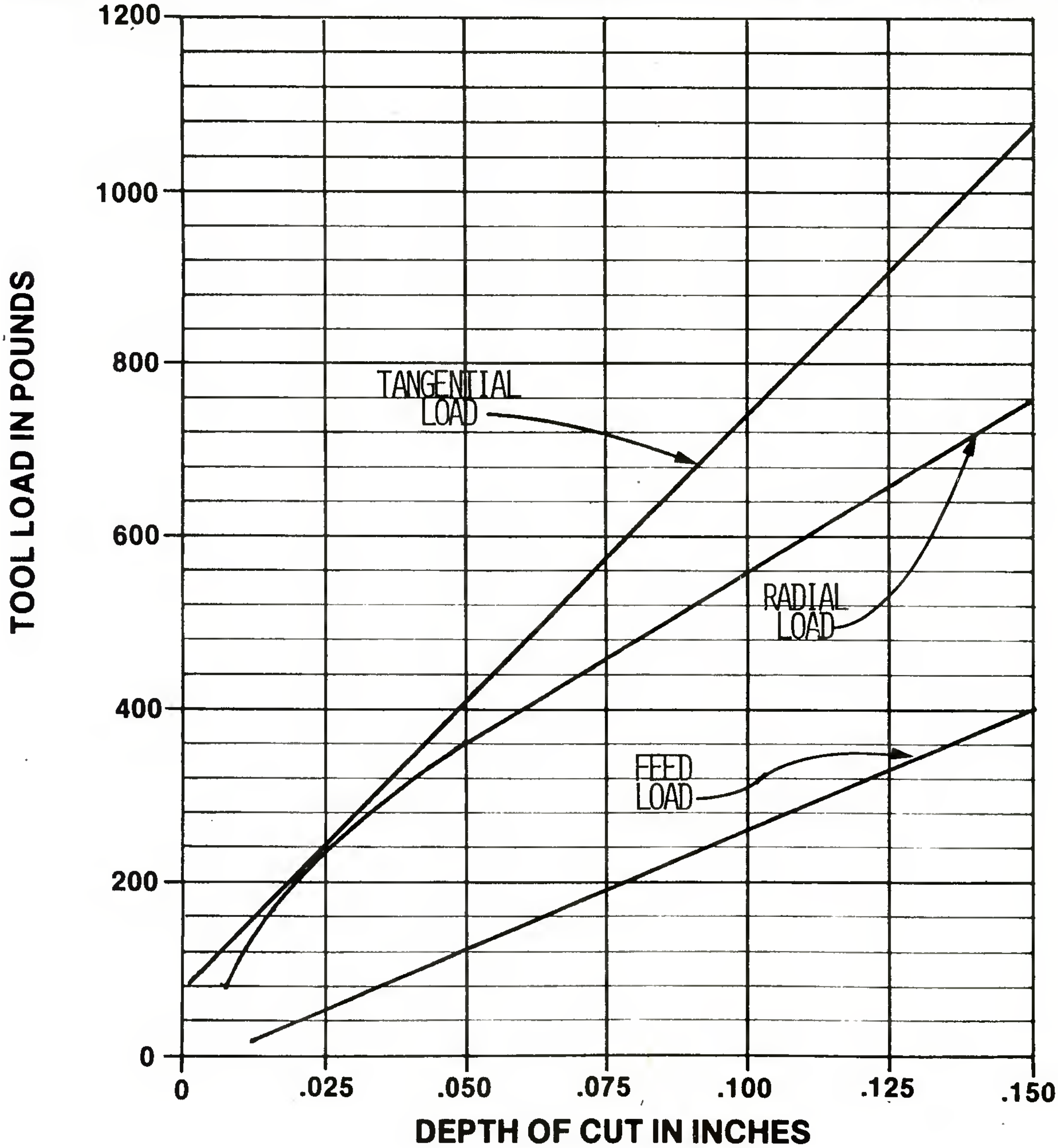

FIGURE 118 : TOOL LOAD CHART

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4140 **HARDNESS:** 444/477 BHN

INSERT: TNMG-433 **SURFACE FEED:** 125 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: 350 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	130	60	150
.050	300	190	220
.100	580	390	270
.150	820	560	320

INSERT: TNMG-433 **SURFACE FEED:** 165 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: KC-810 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	130	80	200
.050	300	220	300
.100	560	460	360
.150	790	660	420

INSERT: TNMG-433 **SURFACE FEED:** 255 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: 570 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	140	60	140
.050	270	160	200
.100	530	320	230
.150	760	480	270

TABLE 80: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4140 **HARDNESS:** 444/477 BHN

INSERT: CNG-454 .008 x 20° **SURFACE FEED:** 430 FT./MIN **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	130	40	120
.050	250	120	170
.100	480	280	220
.150	760	460	270

INSERT: CNG-454 .008 x 20° **SURFACE FEED:** 450 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	130	40	130
.050	250	120	180
.100	460	280	240
.150	720	440	260

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025			
.050			
.100			
.150			

TABLE 81: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4140 **HARDNESS:** 460/477 BHN

INSERT: RNMG-43 **SURFACE FEED:** 125 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 350 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	220	40	170
.050	410	90	260
.100	780	210	420
.150	1140	340	550

INSERT: RNMG-43 **SURFACE FEED:** 165 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: KC-810 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	220	60	320
.050	420	140	490
.100	780	320	720
.150	1120	500	900

INSERT: RNMG-43 **SURFACE FEED:** 255 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 570 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	220	50	220
.050	400	110	320
.100	760	240	490
.150	1140	360	640

TABLE 82: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4140 **HARDNESS:** 460/477 BHN

INSERT: RNG-45 .008 x 20° **SURFACE FEED:** 430 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	240	50	210
.050	420	110	340
.100	760	240	530
.150	1060	380	700

INSERT: RNG-45 .008 x 20° **SURFACE FEED:** 450 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	240	50	220
.050	420	120	350
.100	760	260	560
.150	1080	400	740

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025			
.050			
.100			
.150			

TABLE 83: **DATA FOR TOOL LOAD CHARTS**

SURFACE SPEED VERSUS SURFACE FINISH

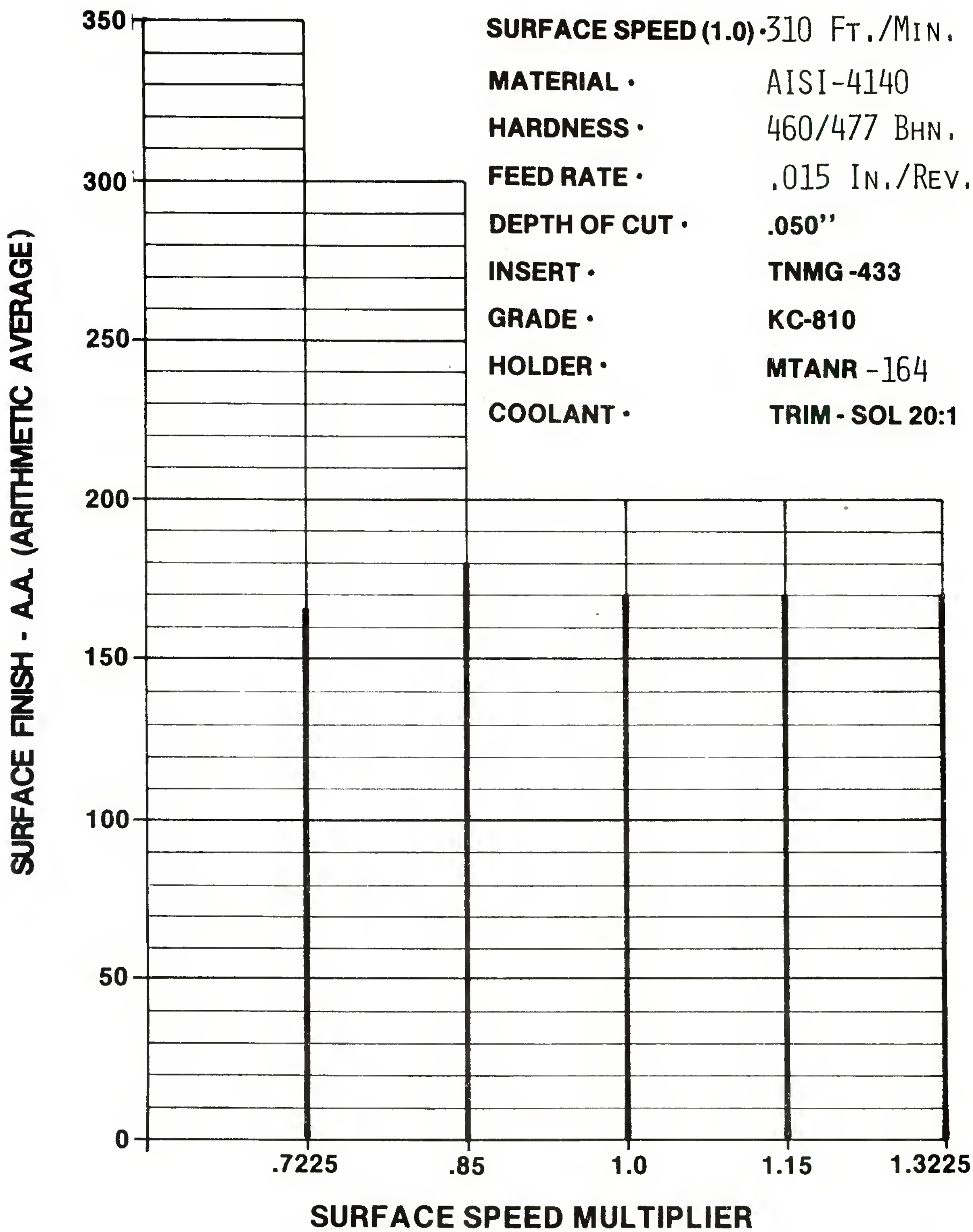

Figure 119

TOOL NOSE RADIUS VERSUS SURFACE FINISH

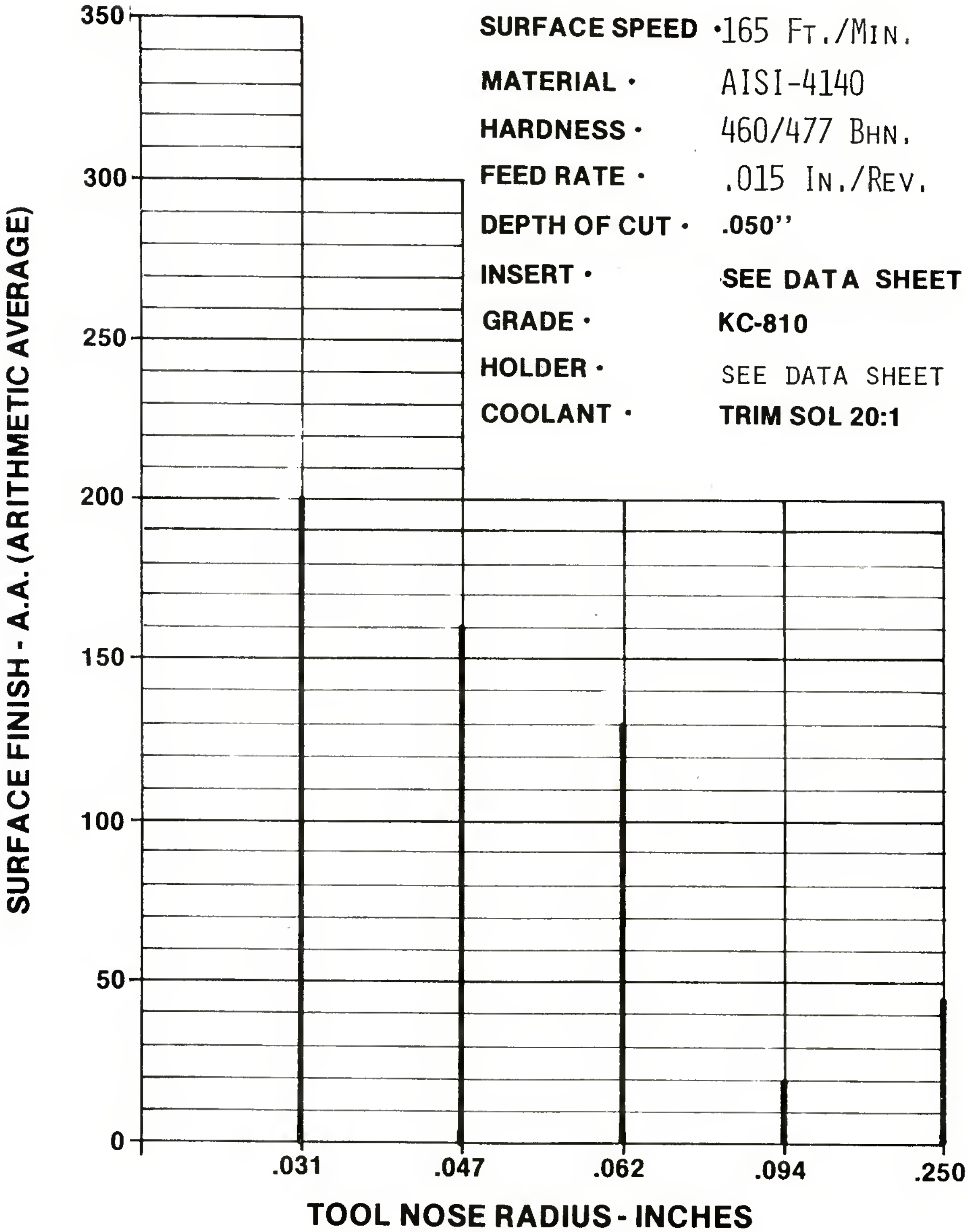

Figure 120

Date: 1/23/81

Material: AISI 4140

Depth of Cut: .050 Inches

Coolant: Trim - Sol 20:1

Hardness: 460/477 BHN

Tool Description:

Coolant Application: Top

Holder: KTAR-164

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	NOSE RADIUS	SURFACE SPEED MULTIPLIER	SURFACE FINISH ARITHMETIC AVERAGE			
1	KC-810	119	.015		.7225	165			
2	"	140	"		.85	180			
3	"	165	"		1.0	170			
4	"	190	"		1.15	170			
5	"	218	"		1.3225	170			

NOTES:

TABLE 84: **DATA FOR SURFACE FINISH TESTS**

Date: 1/21/81

Material: AISI 4140

Depth of Cut: .050 Inches

Coolant: Trim - Sol 20:1

Hardness: 460/477 BHN

Tool Description: SEE NOTES

Coolant Application: Top

Holder:

Insert:

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	NOSE RADIUS	SURFACE SPEED MULTIPLIER	SURFACE FINISH ARITHMETIC AVERAGE			
1	KC-810	165	.015	.03125		200			
2	"	"	"	.0469		160			
3	"	"	"	.0625		130			
4	"	"	"	.0938		20			
5	"	"	"	.250		45			

NOTES:

TOOL HOLDER	INSERT
KTAR-164	TNMG-432
KTAR-164	TNMG-433
KTAR-164	TNMG-434
WTJNRS-205	TNMG-566
PRANR-854	RNMG-43

TABLE 85: **DATA FOR SURFACE FINISH TESTS**

AISI 4340 Projectile Material - 'Finishing" Cuts - 33 Rc Hardness

The life-lines of carbide and ceramic tooling are plotted on Figure 121, page 227. This shows that plain carbide can be run faster than titanium coated carbide for equal tool life. The low feed rate, where abrasive wear becomes an important element, may be part of the reason why the titanium coated carbide does not operate well on this material. Corresponding data is in Tables 87 and 88, pages 228 and 229.

The results of the tests are shown on Table 86, page 226. The production index shows that the hot-press ceramic will give a much higher production rate than other cutting tool materials. The power required for various tool material and styles ranged from 3 to 10 horsepower per tool. This is somewhat lower than for AISI 4140, even though the AISI 4340 was harder than the AISI 4140 material. For tool loads, see Figures 122 to 131 pages 230 to 239, and Tables 89 to 92, pages 249 to 243.

Figure 133, page 245, shows the effect on surface finish when varying the nose radius. Figure 132, page 244, shows the effect on finish when the surface speed is changed. It shows that the finish will deteriorate when the speed is excessively lowered. It also deteriorates when the speed is excessively increased. However, when operating within 15% (up or down) of the proper speed the surface finish remains constant.

SUMMARY OF RESULTS

"FINISHING CUT"

MATERIAL	AISI-4340
HARDNESS	311 Bhn
TOOL LIFE	2500 In^2 of Machined Surface
DEPTH OF CUT	.050 Inches

Insert Grade	Insert Style	SFM	Feed In./Rev.	Prod. Index	Tangential Tool Load - Lbs. .050 Depth of Cut	H.P. .050 Depth of Cut
350	TNMG-433	500	.015	7.5	280	4.24
KC-810	TNMG-433	380	.015	5.7	260	2.99
570	TNMG-433	600	.015	9.0	240	4.36
G-10	CNG-454	920	.015	13.8	260	7.25
G-30	CNG-454	630	.015	9.45	270	5.15
350	RNMG-43	500	.022	—	360	5.45
KC-810	RNMG-43	380	.022	—	380	4.38
570	RNMG-43	600	.022	—	350	6.36
G-10	RNG-45	920	.022	—	360	10.04
G-30	RNG-45	630	.022	—	360	6.87

TABLE 86: AISI-4340 Results of Tests

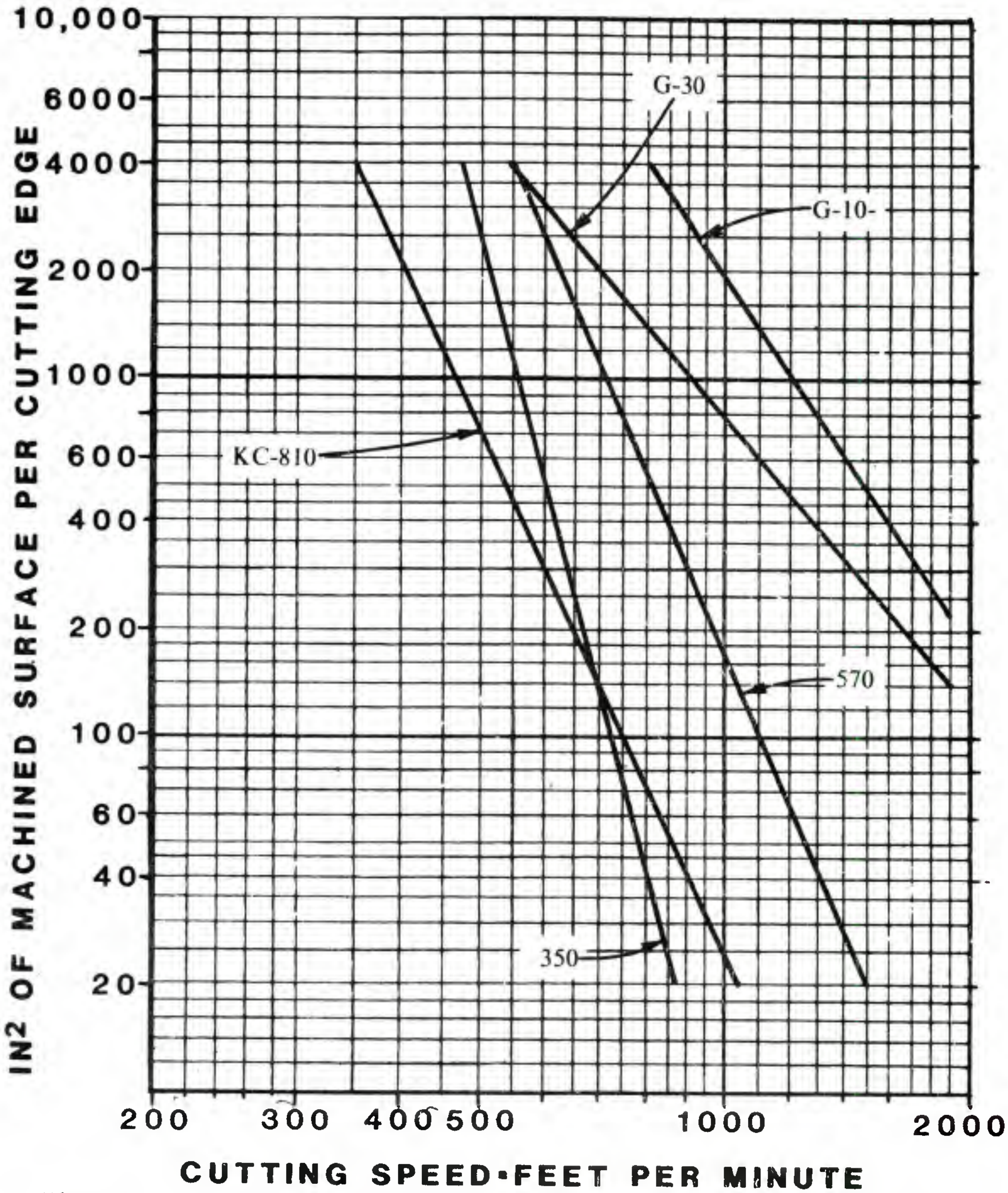

Figure 121: Tool-Life Lines of Listed Cutting Materials on AISI 4340 Steel at 311 Brinell Hardness.

Feed - .015 Inches per Revolution

Depth of Cut - .050 Inches

350, KC-810, 570: Holder - MTANR-164 (0^0 Lead Angle)

Insert - TNMG-433

G-10, G-30: Holder - CCGNR-164 (0^0 Lead Angle)

Insert - CNG-454 .008 x 20^0

Date: 10/1/80		**Material:** AISI 4340	
Depth of Cut: .050		**Coolant:** TRIM-SOL 20:1	
Hardness: 311 BHN		**Tool Description:**	
Coolant Application: TOP		**Holder:** MTANR-164	
		Insert: TNMG-433	

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
1	350	800	.015	5.957	5.862	2.5	46	.020	55	#1 .024
2	"	650	"	"	"	10.5	193	.013	356	.024
3	"	550	"	"	"	8.1	149			
3a	"	"	"	5.862	5.754	12.4	373 T	.011	814	#2 .024
4	"	750	"	"	"	2.2	39.5	.0165	58	#1 .024
5	KC-810	850	"	"	"	1.7	30.5	.0115	64	#1 .024
6	"	700	"	"	"	4.8	86.5	.0105	198	#1 .024
7	"	600	"	5.754	5.655	11.2	199	.015	318	#1 .024
8	"	500	"	"	"	8.8	156	.007	577	#1 .024
9	570	700	"	5.555	5.455	13	222.7	.005	1068.9	.024 #1
10	"	800	"	"	"	7.5	128.5	.0085	362.9	#1 .024
11	"	900	"	5.456	5.355	8.875	149.3	.010	358.3	#1 .024
12	"	950	"	"	"	3.75	63	.006	252	#1 .024

NOTES: #1 – STRINGY CHIPS
#2 – BAD CHIPS

TABLE 87 : DATA FOR LIFE LINES

Date: 10/6/80		**Material:** AISI 4340	
Depth of Cut: .050		**Coolant:** TRIM-SOL 20:1	
Hardness: 311 BHN		**Tool Description:**	
Coolant Application: TOP: G-10		**Holder:** CCGNR-164	
NONE: G-30		**Insert:** CNG-454 - 820	

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
1	G-10	1200	.015	5.456	5.355	7.875	132.5			
1a	"	"	"	5.355	5.255	"	260	.0035	1114	.015
2	"	1400	"	"	"	12.5	206.4	.005	619	.015
3	"	1000	"	5.255	5.155	20.5	332	.003	1660	.015
4	G-30	1200	"	5.970	5.870	21.5	396.5	.0125	475.8	.015
5	"	1000	"	5.870	5.770	21.0	380.6	.0075	761	.015
6	"	1400	"	5.770	5.670	10.38	185	.0085	326	.015

NOTES: GOOD CHIPS ON ALL CUTS

TABLE 88 : DATA FOR LIFE LINES

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4340 **HOLDER:** MTANR-164 - 0^{0} LEAD ANGLE

HARDNESS: 311 BHN **INSERT:** TNMG-433

SURFACE SPEED: 500 FT./MIN. **GRADE:** 350

FEED RATE: .015 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP

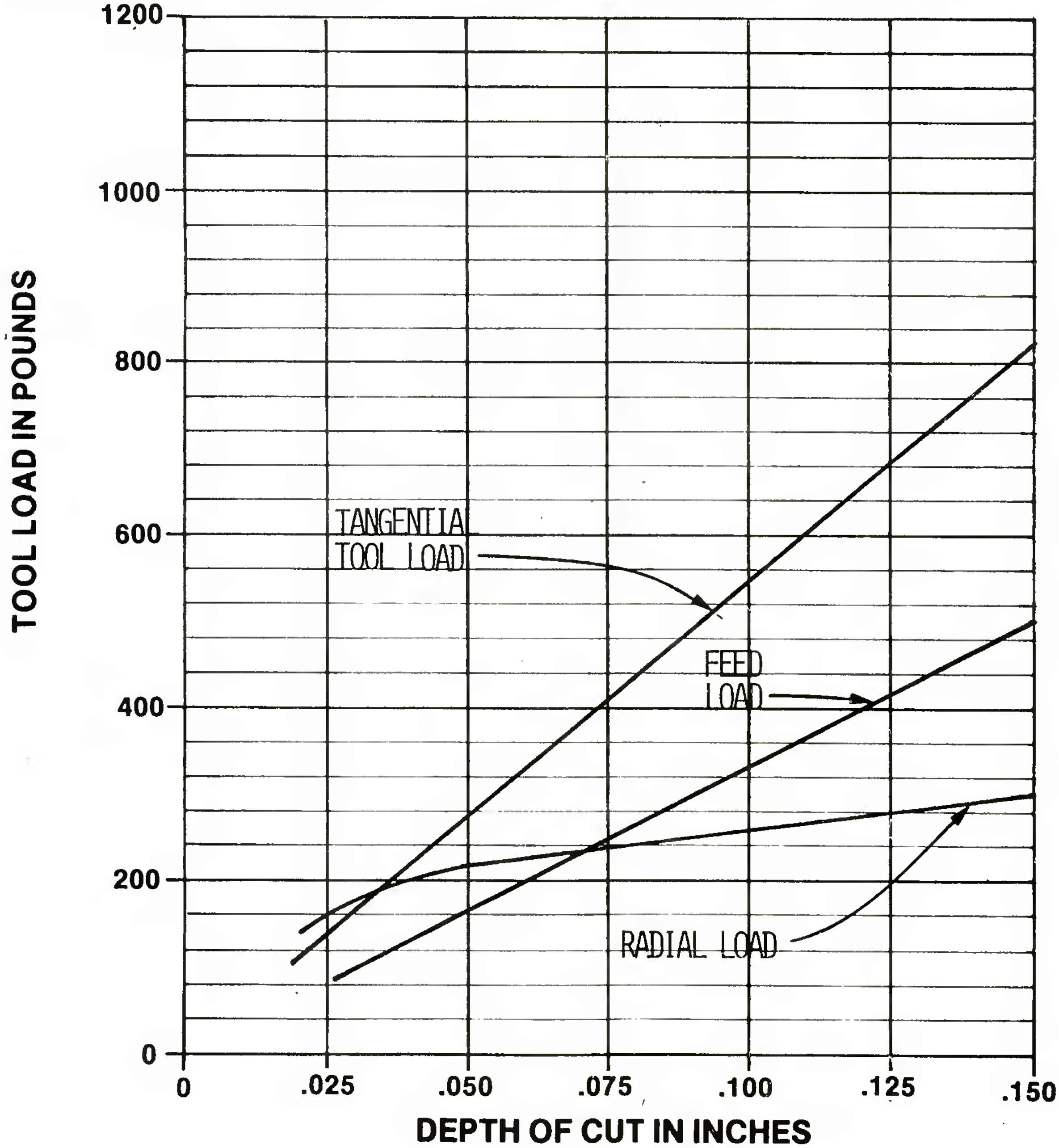

FIGURE 122 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 4340	**HOLDER:**	MTANR-164 0° LEAD ANGLE
HARDNESS:	311 BHN	**INSERT:**	TNMG-433
SURFACE SPEED:	380 FT./MIN.	**GRADE:**	KC-810
FEED RATE:	.015 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP

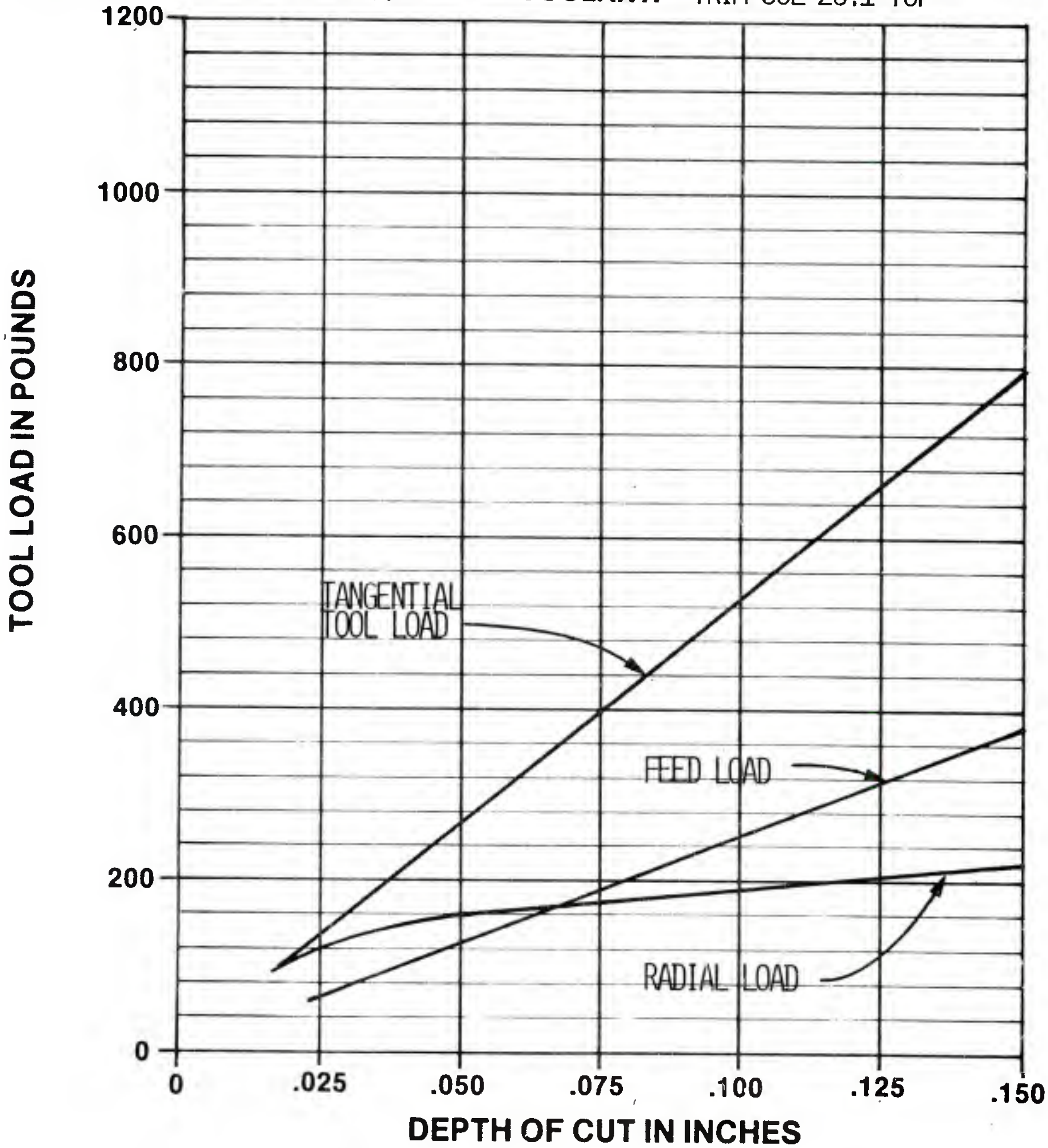

FIGURE 123: TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 4340	**HOLDER:**	MTANR-164 0^{0} LEAD ANGLE
HARDNESS:	311 BHN	**INSERT:**	TNMG-433
SURFACE SPEED:	600 FT./MIN.	**GRADE:**	570
FEED RATE:	.015 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP

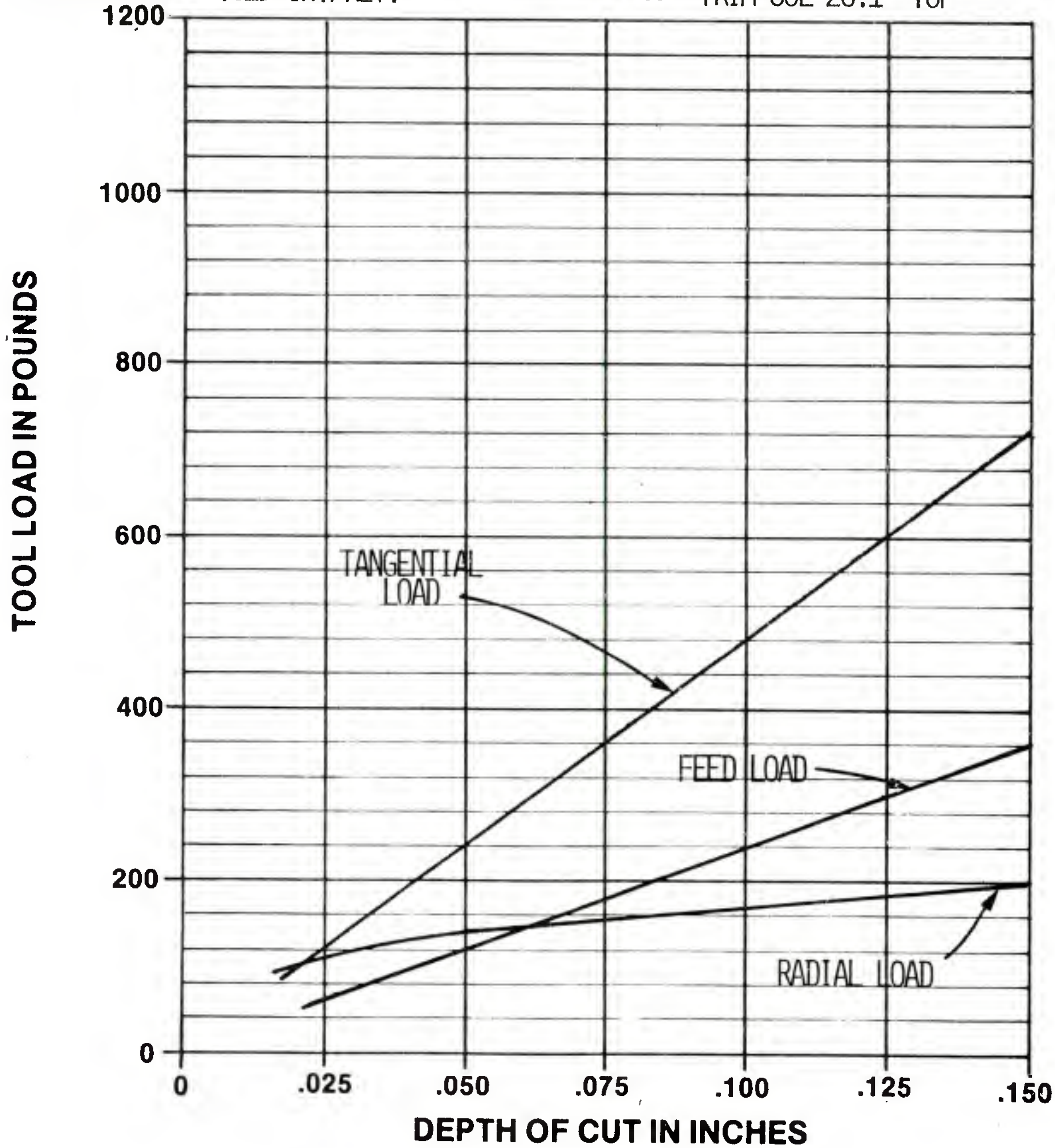

FIGURE 124 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 4340	**HOLDER:**	CCGNR-164 0°LEAD ANGLE
HARDNESS:	311 BHN	**INSERT:**	CNG-454
SURFACE SPEED:	920 FT./MIN.	**GRADE:**	G-10
FEED RATE:	.015 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP

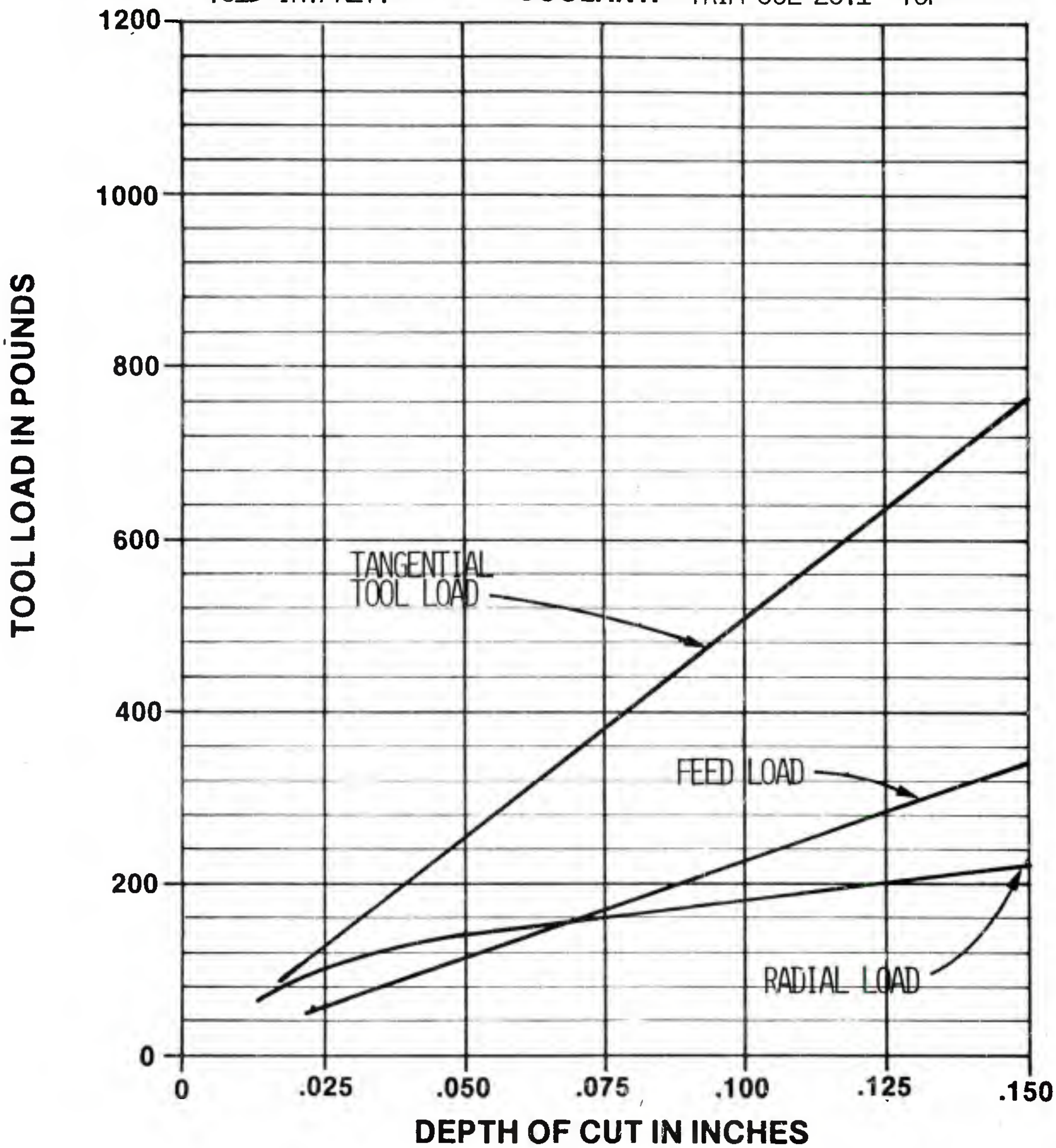

FIGURE 125 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4340 **HOLDER:** CCGNR-164 0° LEAD ANGLE

HARDNESS: 311 BHN **INSERT:** CNG-454

SURFACE SPEED: 630 FT./MIN. **GRADE:** G-30

FEED RATE: .015 IN./REV. **COOLANT:** NONE

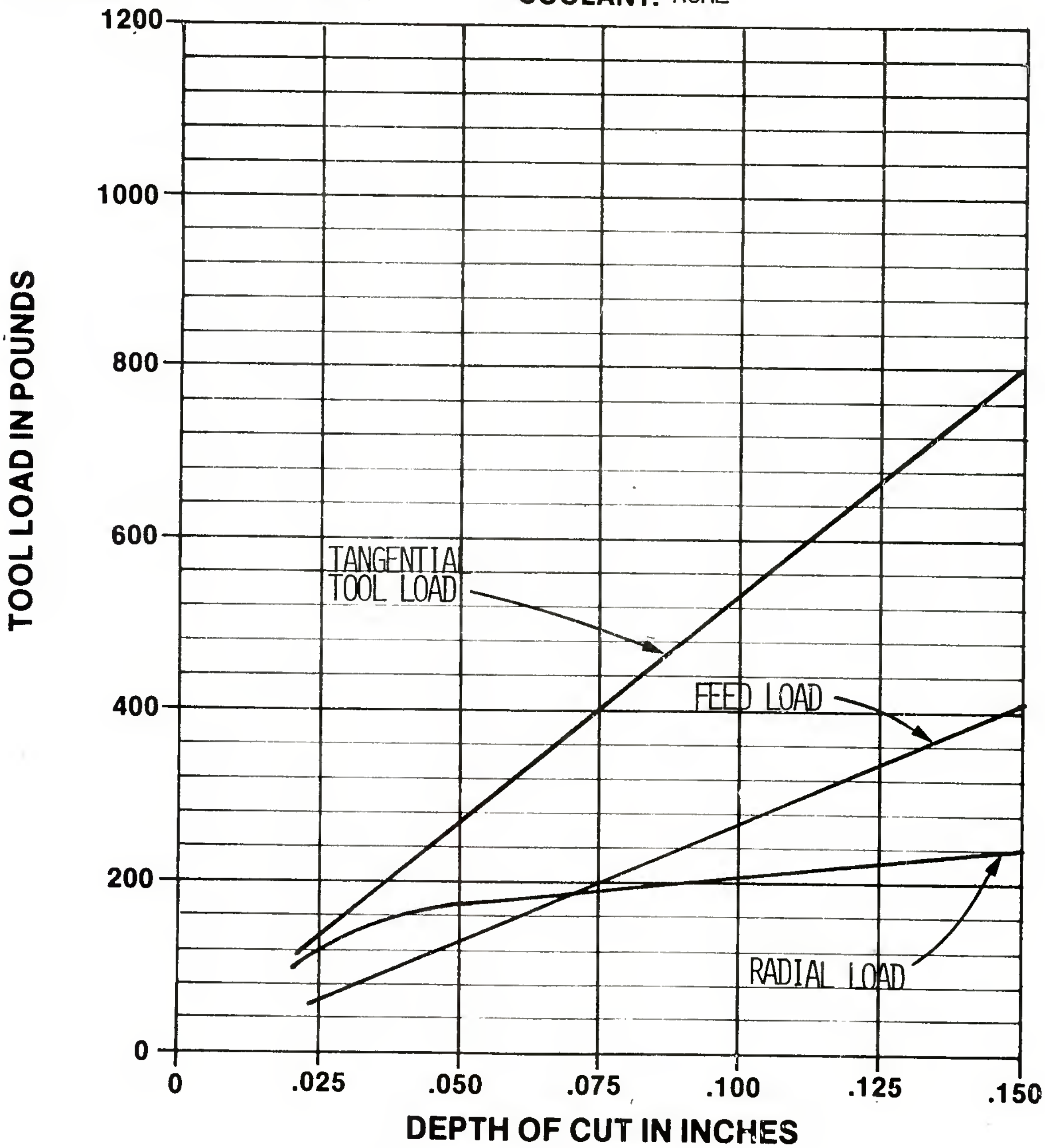

FIGURE 126 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4340 **HOLDER:** PRANR-164

HARDNESS: 311 BHN **INSERT:** RNMG-43

SURFACE SPEED: 500 FT./MIN. **GRADE:** 350

FEED RATE: .022 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP

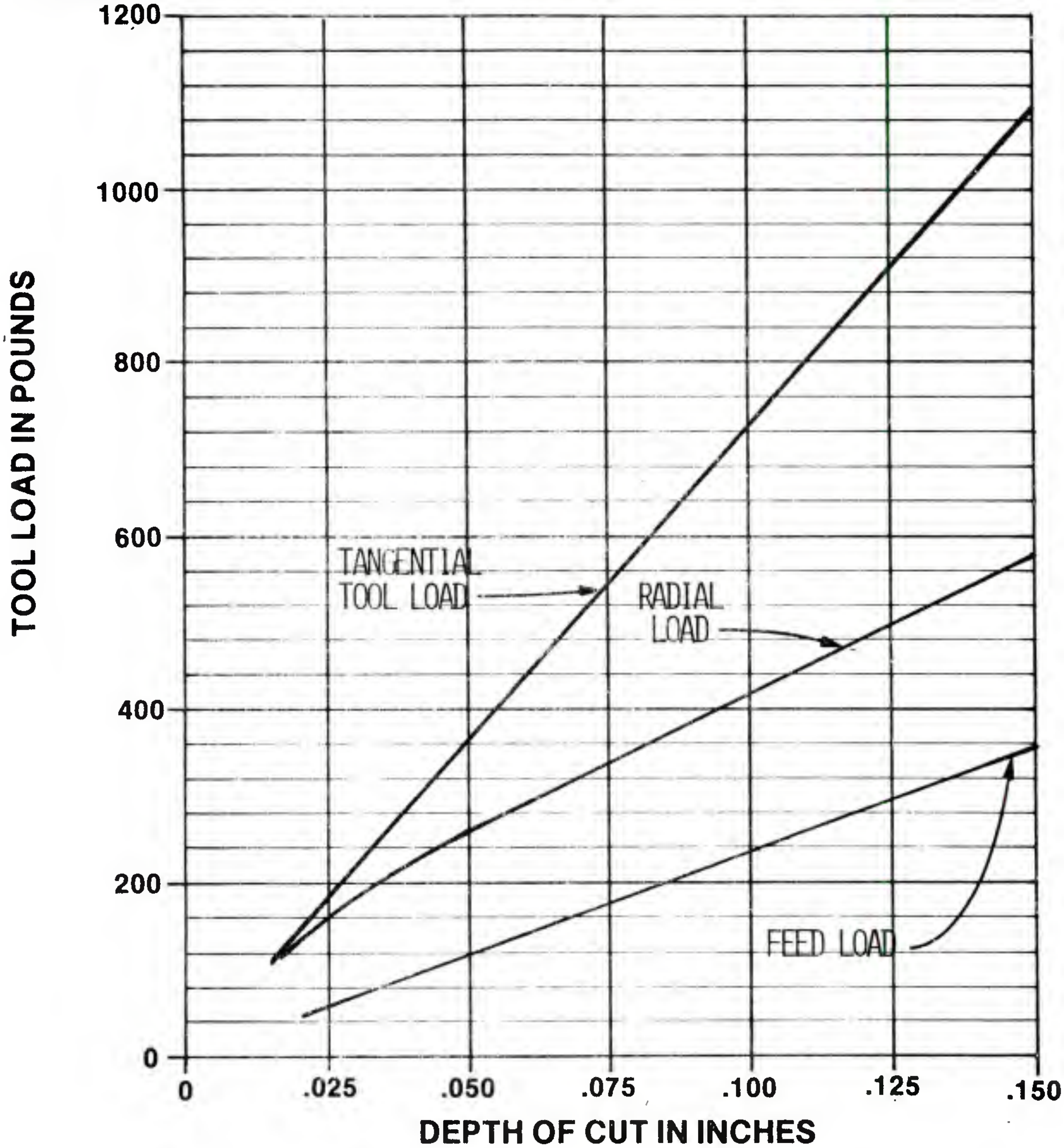

FIGURE 127: TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4340 **HOLDER:** PRANR-164

HARDNESS: 311 BHN **INSERT:** RNMG-43

SURFACE SPEED: 380 FT./MIN. **GRADE:** KC-810

FEED RATE: .022 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP

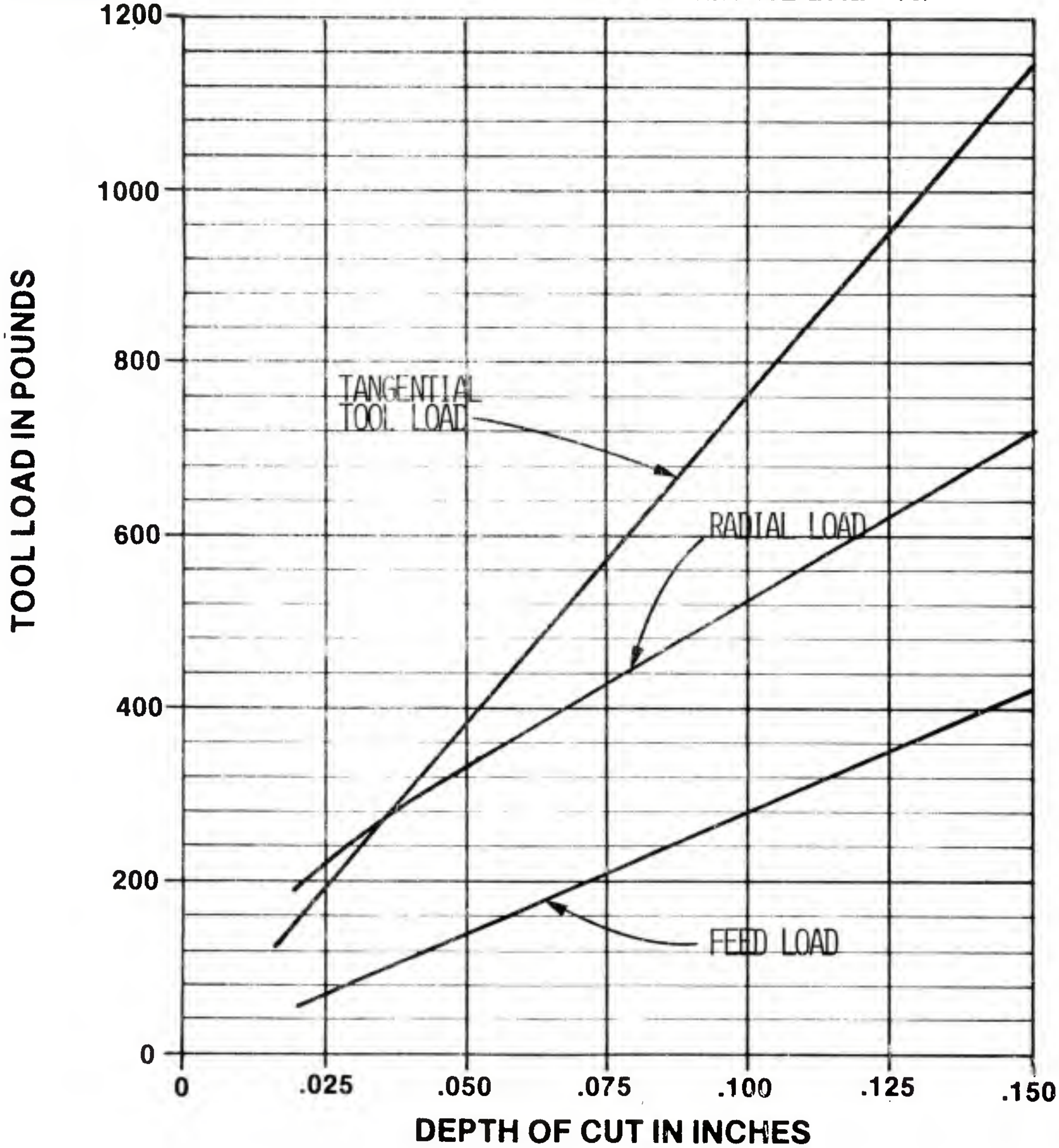

FIGURE 128 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 4340	**HOLDER:**	PRANR-164
HARDNESS:	311 BHN	**INSERT:**	RNMG-43
SURFACE SPEED:	600 FT./MIN.	**GRADE:**	570
FEED RATE:	.022 IN./MIN.	**COOLANT:**	TRIM-SOL 20:1 TOP

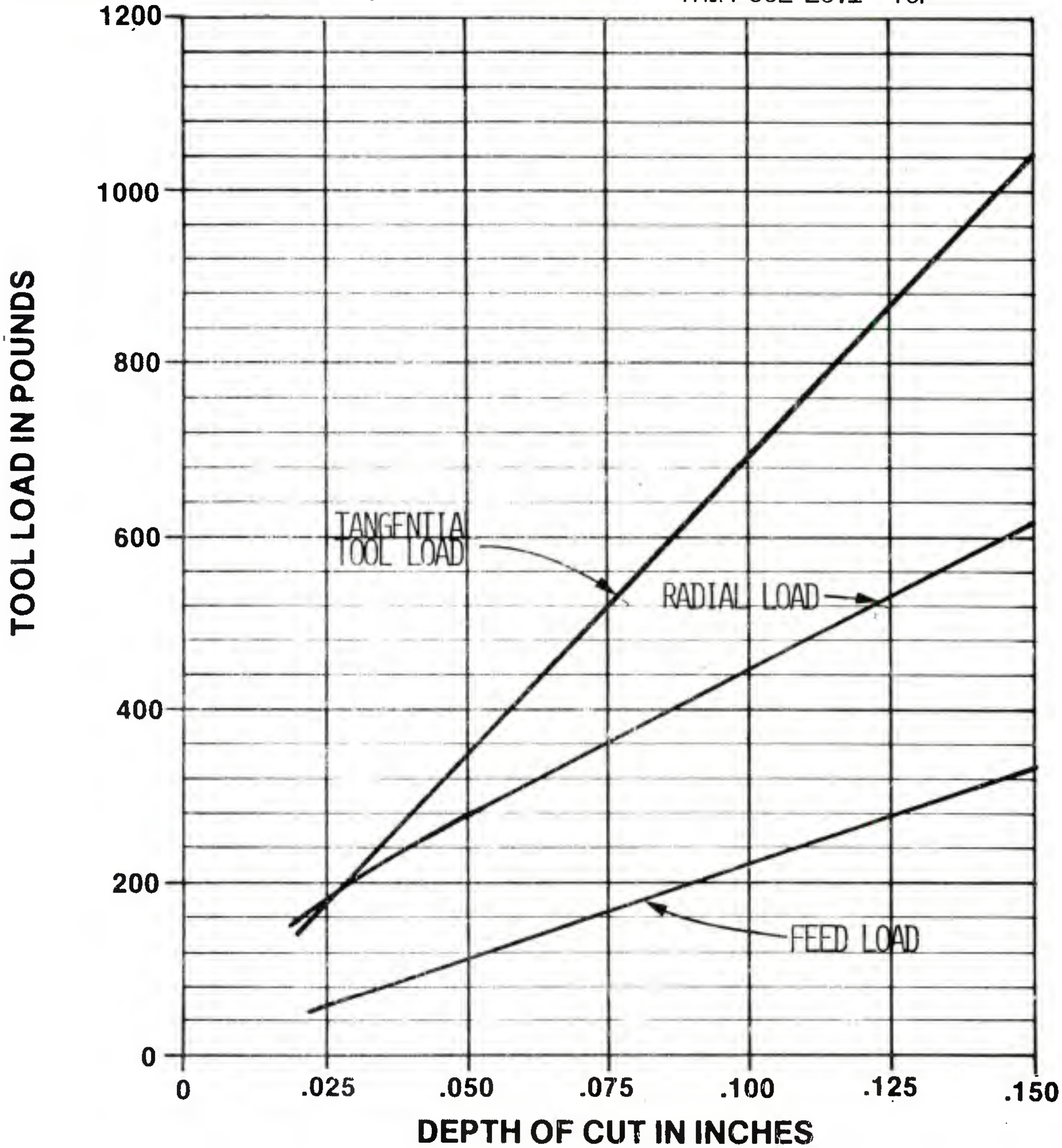

FIGURE 129 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 4340	**HOLDER:**	CRGNR-164
HARDNESS:	311 BHN	**INSERT:**	RNG-45
SURFACE SPEED:	920 FT./MIN.	**GRADE:**	G-10
FEED RATE:	.022 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP

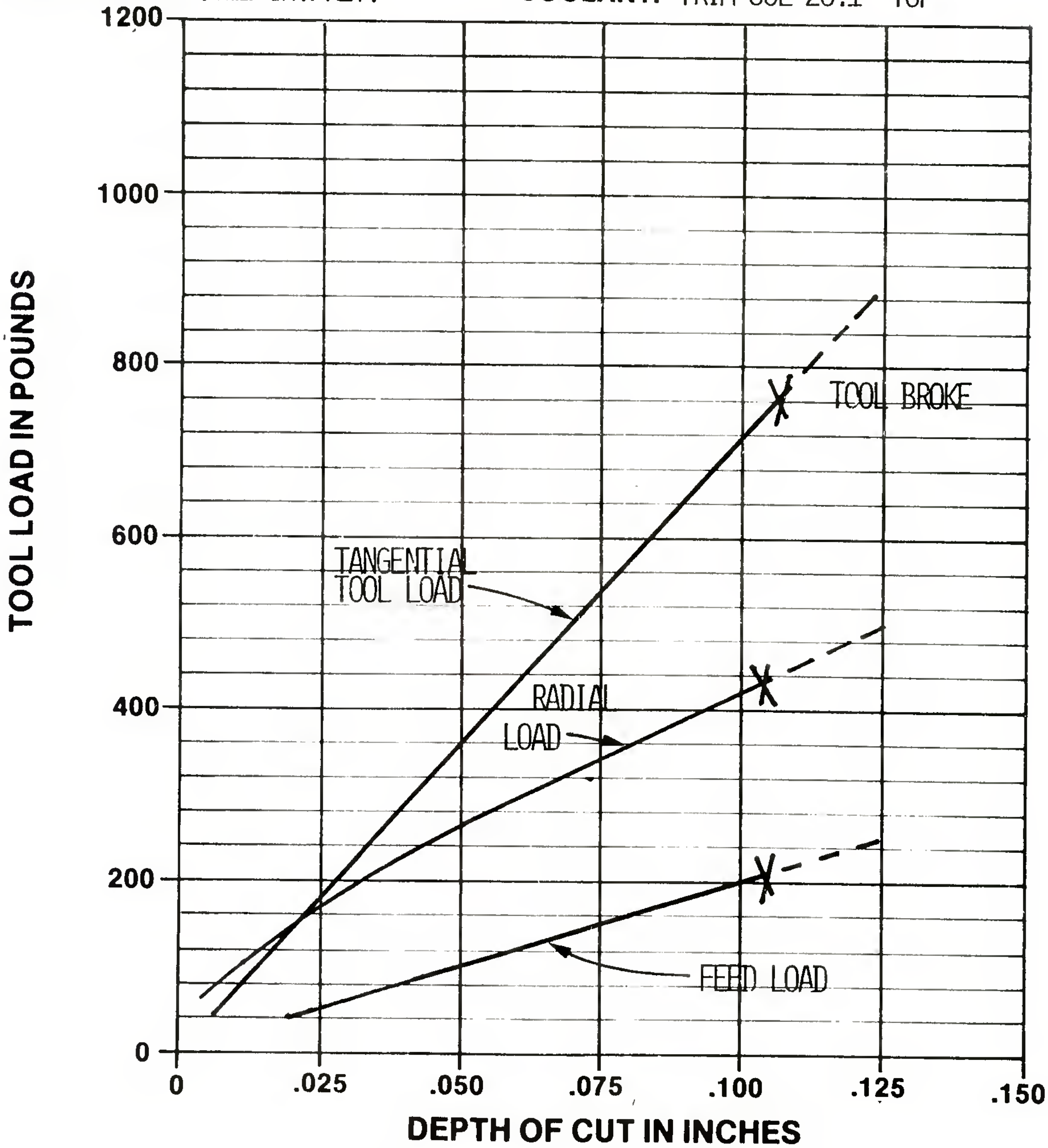

FIGURE 130 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4340 | HOLDER: CRGNR-164

HARDNESS: 311 BHN | INSERT: RNG-45

SURFACE SPEED: 630 FT./MIN. | GRADE: G-30

FEED RATE: .022 IN./REV. | COOLANT: NONE

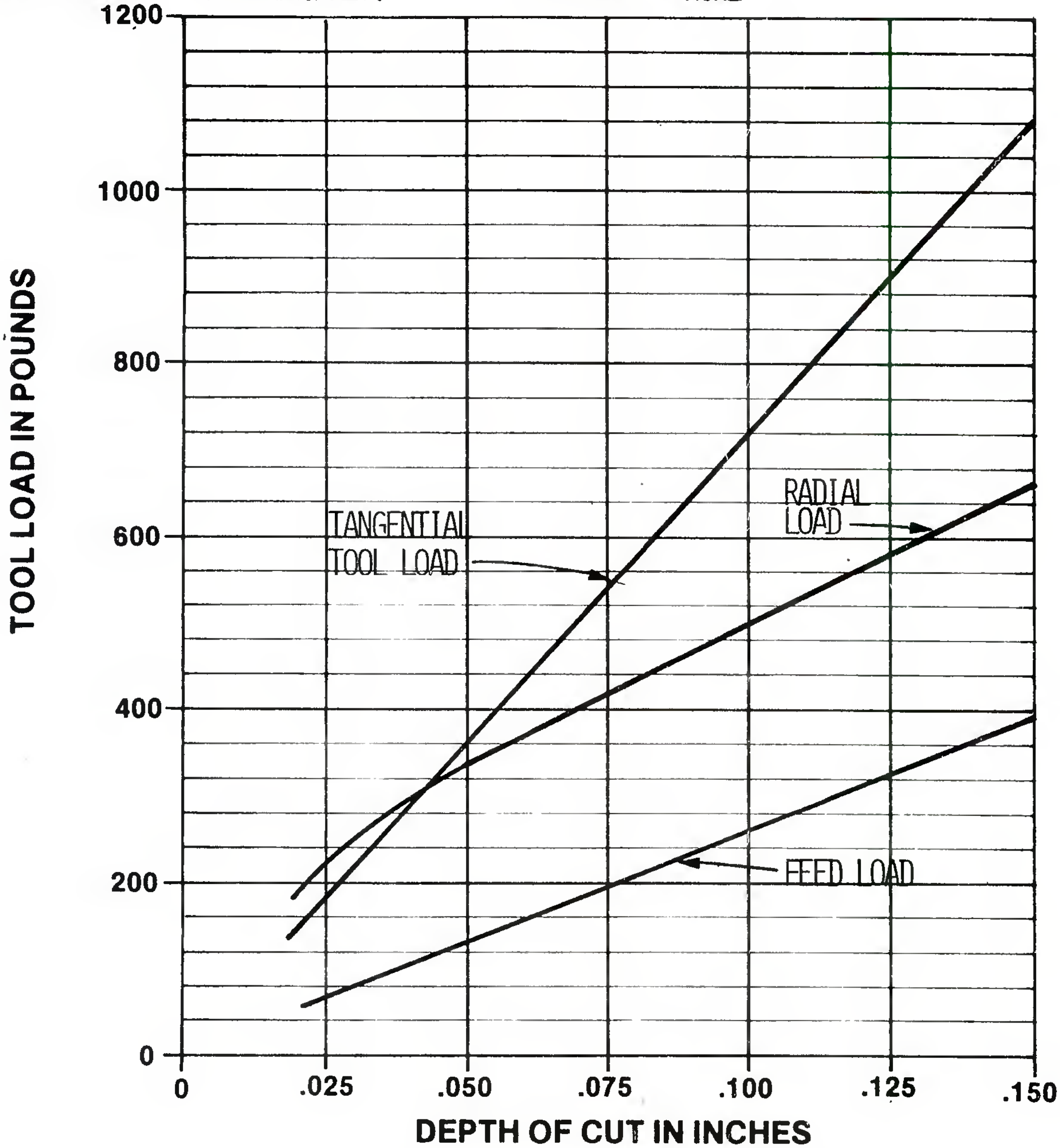

FIGURE 131 : TOOL LOAD CHART

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4340 **HARDNESS:** 311 BHN

INSERT: TNMG-433 **SURFACE FEED:** 500 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 350 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	170	80	160
.050	320	180	220
.100	480	340	260
.150	820	500	300

INSERT: TNMG-433 **SURFACE FEED:** 380 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: KC-810 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	150	50	120
.050	280	120	160
.100	540	260	190
.150	780	390	220

INSERT: TNMG-433 **SURFACE FEED:** 600 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 570 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	150	50	110
.050	280	120	140
.100	530	240	170
.150	660	360	200

TABLE 89: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4340 **HARDNESS:** 311 BHN

INSERT: CNG-454 .008 x 20° **SURFACE FEED:** 920 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	160	40	100
.050	280	100	140
.100	520	220	180
.150	740	350	220

INSERT: CNG-454 .008 x 20° **SURFACE FEED:** 630 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	150	50	120
.050	280	120	170
.100	560	270	210
.150	800	420	240

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025			
.050			
.100			
.150			

TABLE 90: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4340 **HARDNESS:** 311 BHN

INSERT: RNMG-43 **SURFACE FEED:** 500 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: 350 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	200	40	160
.050	380	90	260
.100	750	220	420
.150	1080	380	580

INSERT: RNMG-43 **SURFACE FEED:** 380 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: KC-810 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	240	50	220
.050	420	110	330
.100	780	260	530
.150	1120	450	720

INSERT: RNMG-43 **SURFACE FEED:** 600 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: 570 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	180	30	170
.050	360	80	280
.100	710	220	460
.150	1040	360	620

TABLE 91: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4340 **HARDNESS:** 311 BHN

INSERT: RNG-45 .008 x 20^{0} **SURFACE FEED:** 920 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	190	30	160
.050	370	80	270
.100	700	200	420
.150	X	X	X
	- TOOL BROKE AT	.150 DEPTH -	

INSERT: RNG-45 .008 x 20^{0} **SURFACE FEED:** 630 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	200	40	200
.050	400	110	330
.100	740	250	510
.150	1060	400	670

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025			
.050			
.100			
.150			

TABLE 92: **DATA FOR TOOL LOAD CHARTS**

SURFACE SPEED VERSUS SURFACE FINISH

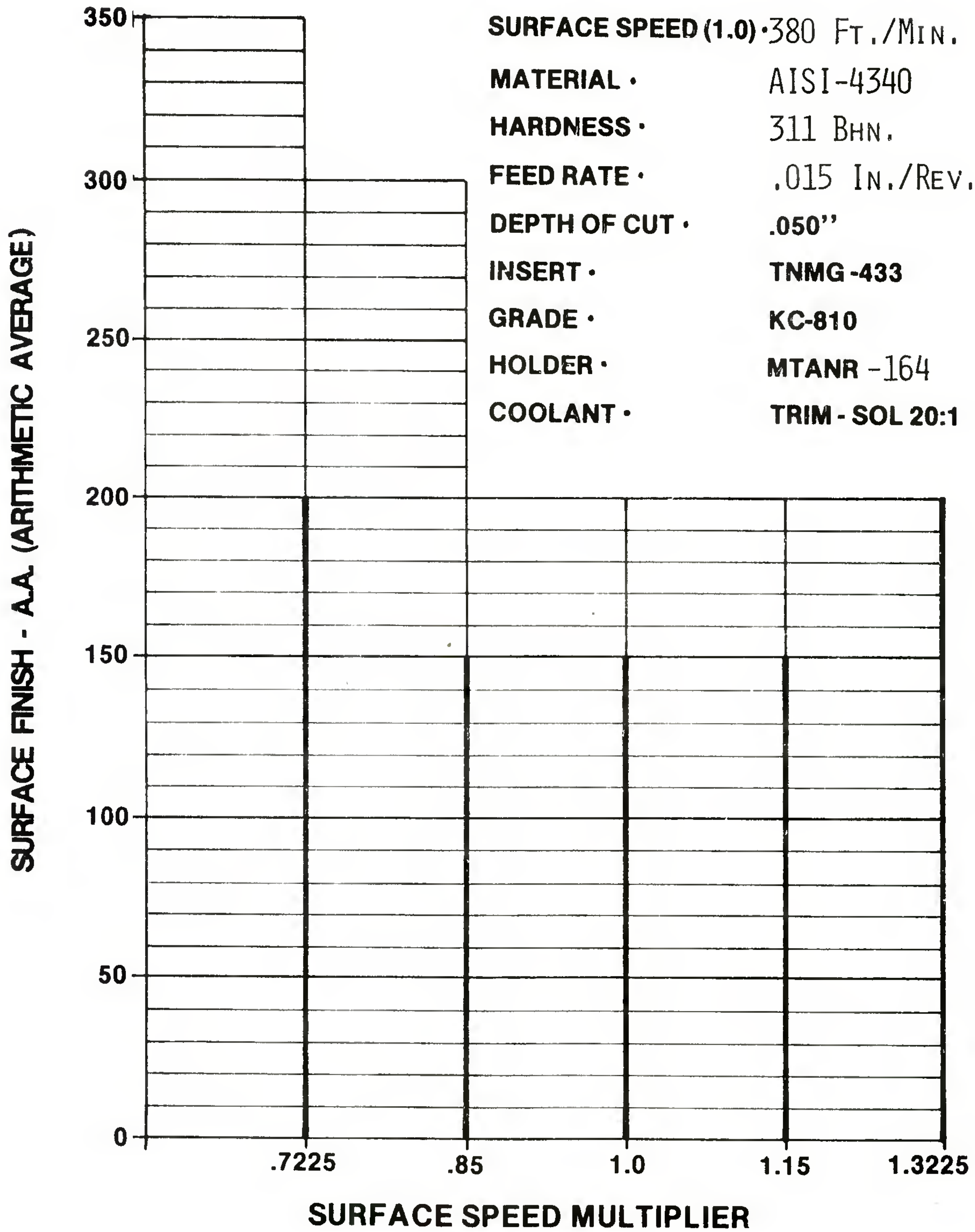

Figure 132

TOOL NOSE RADIUS VERSUS SURFACE FINISH

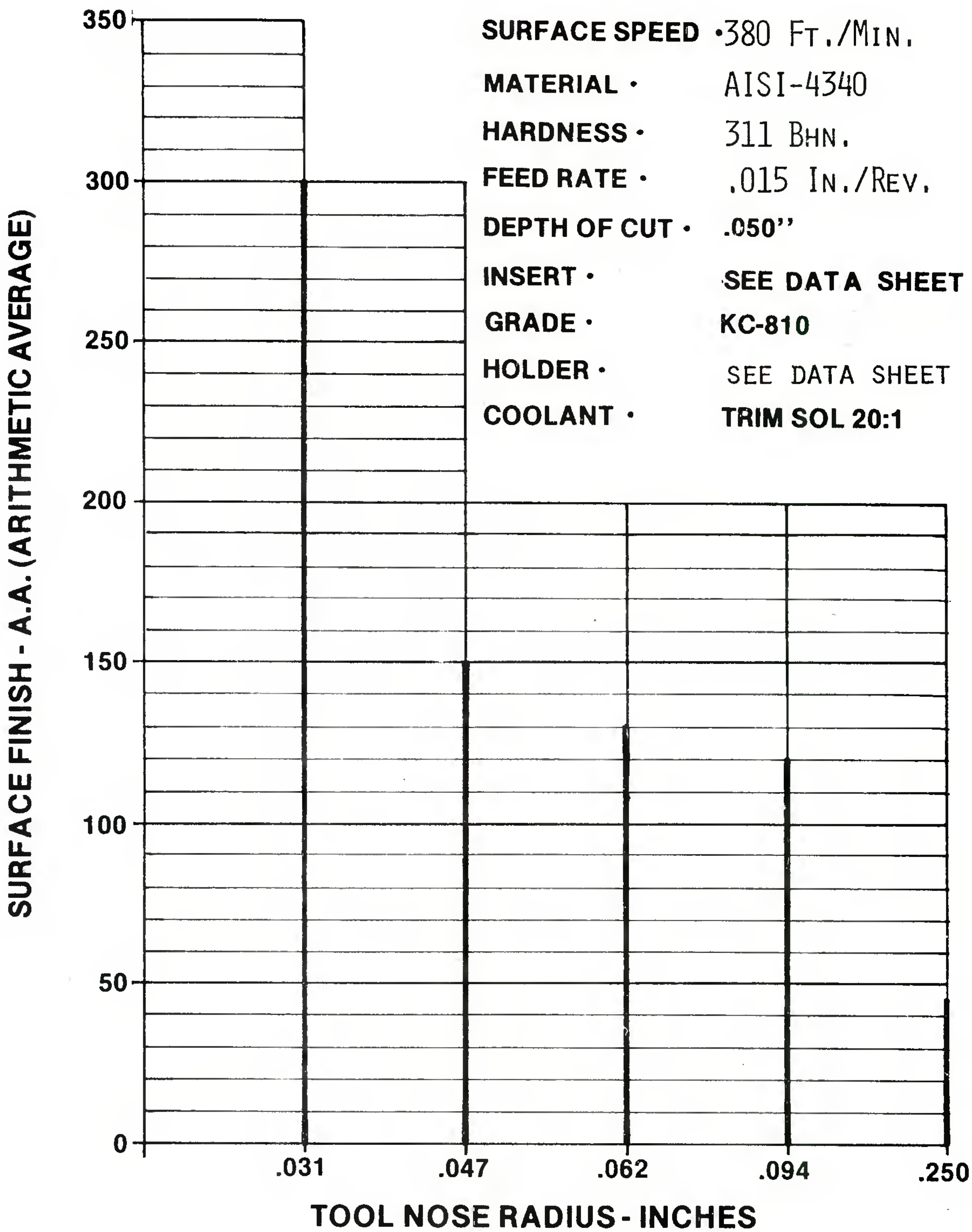

Figure 133

Date: 10/7/80	**Material:** AISI 4340
Depth of Cut: .050 Inches	**Coolant:** Trim - Sol 20:1
Hardness: 311 BHN	**Tool Description:**
Coolant Application: Top	**Holder:** MTANR-164 (0^{o} LEAD ANGLE)
	Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	NOSE RADIUS	SURFACE SPEED MULTIPLIER	SURFACE FINISH ARITHMETIC AVERAGE			
1	KC-810	275	.015		.7225	200			
2	"	323	"		.85	150			
3	"	380	"		1.0	150			
4	"	437	"		1.15	150			
5	"	503	"		1.3225	200			

NOTES:

TABLE 93: **DATA FOR SURFACE FINISH TESTS**

Date: 10/7/80

Material: AISI 4340

Depth of Cut: .050 Inches

Coolant: Trim - Sol 20:1

Hardness: 311 BHN

Tool Description: SEE NOTES

Coolant Application: Top

Holder:

Insert:

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	NOSE RADIUS	SURFACE SPEED MULTIPLIER	SURFACE FINISH ARITHMETIC AVERAGE			
1	KC-810	380	.015	.03125		300			
2	"	"	"	.0469		150			
3	"	"	"	.0625		140			
4	"	"	"	.09375		120			
5	"	"	"	.250		45			

NOTES:

TOOL HOLDER/INSERT

KTAR-164	TNMG-432
KTAR-164	TNMG-433
KTAR-164	TNMG-434
WTJNRS-205	TNMG-566
PRANR-854	RNMG-43

(.500" Ø ROUND INSERT)

TABLE 94: **DATA FOR SURFACE FINISH TESTS**

AISI 4340 Projectile Material - "Finishing Cuts" - 50/52 Rc

The life-lines of this material show the cutting speed for equal tool life for 350, an uncoated carbide, to be the same as KC-810, a coated carbide, and 570, an oxide coated carbide, is higher than G-30, a cold-pressed ceramic. These trends follow the new data shown in the Third Edition of the Machining Data Handbook where titanium coated grades are not recommended for any materials above 425 Brinell hardness and cold-pressed ceramics are not recommended on materials above 250 Brinell hardness.See Figure 134 and Tables 96 and 97, pages 250 to 252. See also Table 95, page 249, for a summary of results.

The surface finish charts showed little or no effect on surface finish as the cutting speed was raised or lowered from the speed selected for a given tool life. When the nose radius was changed using this predetermined cutting speed, the surface finish improved as the radius was increased. See Figures 145 and 146, pages 267 and 268.

This material also presented problems in chip-control as seen with AISI 1340 and AISI 4140; a solution for one material may prove to work with the other materials. For information on tool loads, see Figures 135 to 144 and Tables 98 to 101, pages 253 to 266.

SUMMARY OF RESULTS

"FINISHING CUT"

MATERIAL	AISI-4340
HARDNESS	477/512 Bhn.
TOOL LIFE	2500 In^2 of Machined Surface
DEPTH OF CUT	.050 Inches

Insert Grade	Insert Style	SFM	Feed In./Rev.	Prod. Index	Tangential Tool Load - Lbs. .050 Depth of Cut	H.P. .050 Depth of Cut
350	TNMG-433	135	.015	2.025	320	1.31
KC-810	TNMG-433	135	.015	2.025	330	1.35
570	TNMG-433	180	.015	2.7	340	1.85
G-10	CNG-454	250	.015	3.75	300	2.27
G-30	CNG-454	150	.015	2.25	350	1.59
350	RNMG-43	135	.022	—	440	1.8
KC-810	RNMG-43	135	.022	—	480	1.96
570	RNMG-43	180	.022	—	460	2.51
G-10	RNG-45	250	.022	—	430	3.26
G-30	RNG-45	150	.022	—	490	2.23

TABLE 95: AISI-4340 Results of Tests

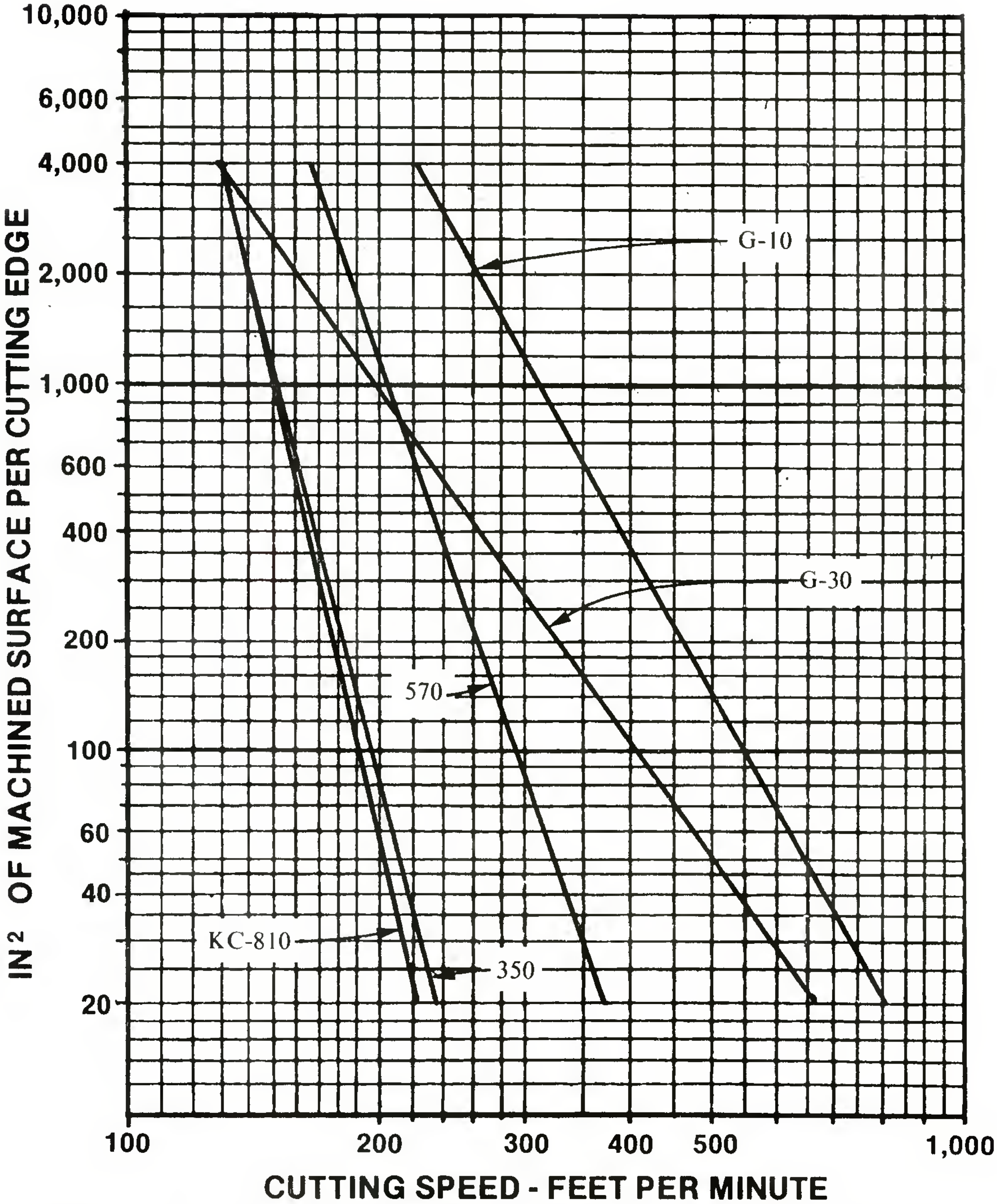

Figure 134: Tool-Life Lines of Listed Cutting Materials on AISI 4340 Steel at 460/477 Brinell Hardness.

Feed - .015 Inches per Revolution
Depth of Cut - .050 Inches

350, KC-810, 570: Holder - MTANR-164 (0^0 Lead Angle)
Insert - TNMG-433

G-10, G-30: Holder - CCGNR-164 (0^0 Lead Angle)
Insert - CNG-454 .008 x 20^0

Date: 2/3/81	**Material:** AISI 4340
Depth of Cut: .050	**Coolant:** TRIM-SOL 20:1
Hardness: 460/477 BHN	**Tool Description:**
Coolant Application: TOP	**Holder:** MTANR-164
	Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
1	350	240	.015	3.945	3.850	.9	10.88	.016	16.3	.024
2	"	160	"	"	"	12.7	153.7	.0065	567	.024
3	"	190	"	"	"	3.5	42.3	.009	113	.024
4	KC-810	240	"	3.850	3.750	.55	6.47	.0135	11.5	.024
5	"	160	"	"	"	15.5	182.6	.010	438.2	.024
6	"	190	"	3.945	3.850	4.0	48.3	.0105	110	.024
7	570	280	"	3.750	3.655	5.35	61.4	.0125	118	.024
8	"	240	"	"	"	10.6	122.	.007	417	.024
9	"	300	"	3.655	3.558	2.5	28	.008	84	.024

NOTES:

TABLE 96 : DATA FOR LIFE LINES

Date: 2/3/81

Material: AISI 4340

Depth of Cut: .050

Coolant: TRIM-SOL 20:1

Hardness: 460/477 BHN

Tool Description:

Coolant Application: TOP: G-10
NONE: G-30

Holder: CCGNR-164

Insert: CNG-454 820

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
1	G-10	500	.015	3.655	3.550	3.4	37.9	.0035	163	.015
2	"	400	"	3.847	3.750	4.8	56.5	–		
2a	"	"	"	3.750	3.664	4.8	55	–		
2b	"	"	"	3.664	3.564	11.0	234.5 T	.010	352	.015
3	"	600	"	3.564	3.455	2.8	30.4	.0065	70	.015
4	G-30	500	"	"	"	1.9	20.6	.0055	56	.015
5	"	400	"	"	"	3.7	40.2	.010	60	.015
6	"	350	"	"	"	8.3	90	.006	225	.015
7	"	300	"	3.455	3.360	16.4	173	.010	260	.015
8	"	260	"	3.360	3.268	16.3	167	.007	358	.015

NOTES:

TABLE 97 : DATA FOR LIFE LINES

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4340 HOLDER: CTANR-164

HARDNESS: 477/512 BHN INSERT: TNMG-433

SURFACE SPEED: 135 FT./MIN. GRADE: 350

FEED RATE: .015 IN./REV. COOLANT: TRIM-SOL 20:1 TOP APPLICATION

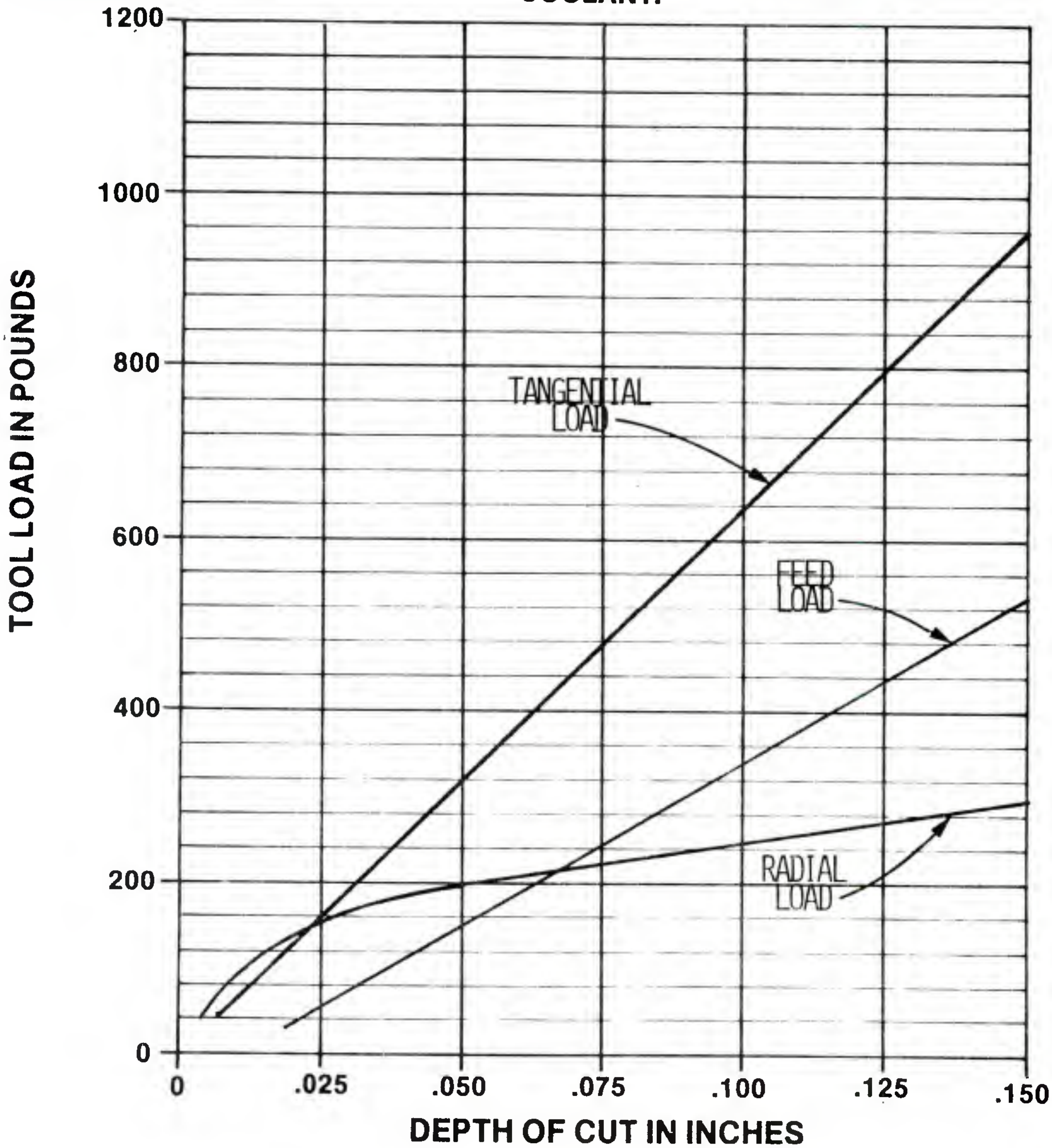

FIGURE 135 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4340 **HOLDER:** CTANR-164

HARDNESS: 477/512 BHN **INSERT:** TNMG-433

SURFACE SPEED: 135 FT./MIN. **GRADE:** KC-810

FEED RATE: .015 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP APPLICATION

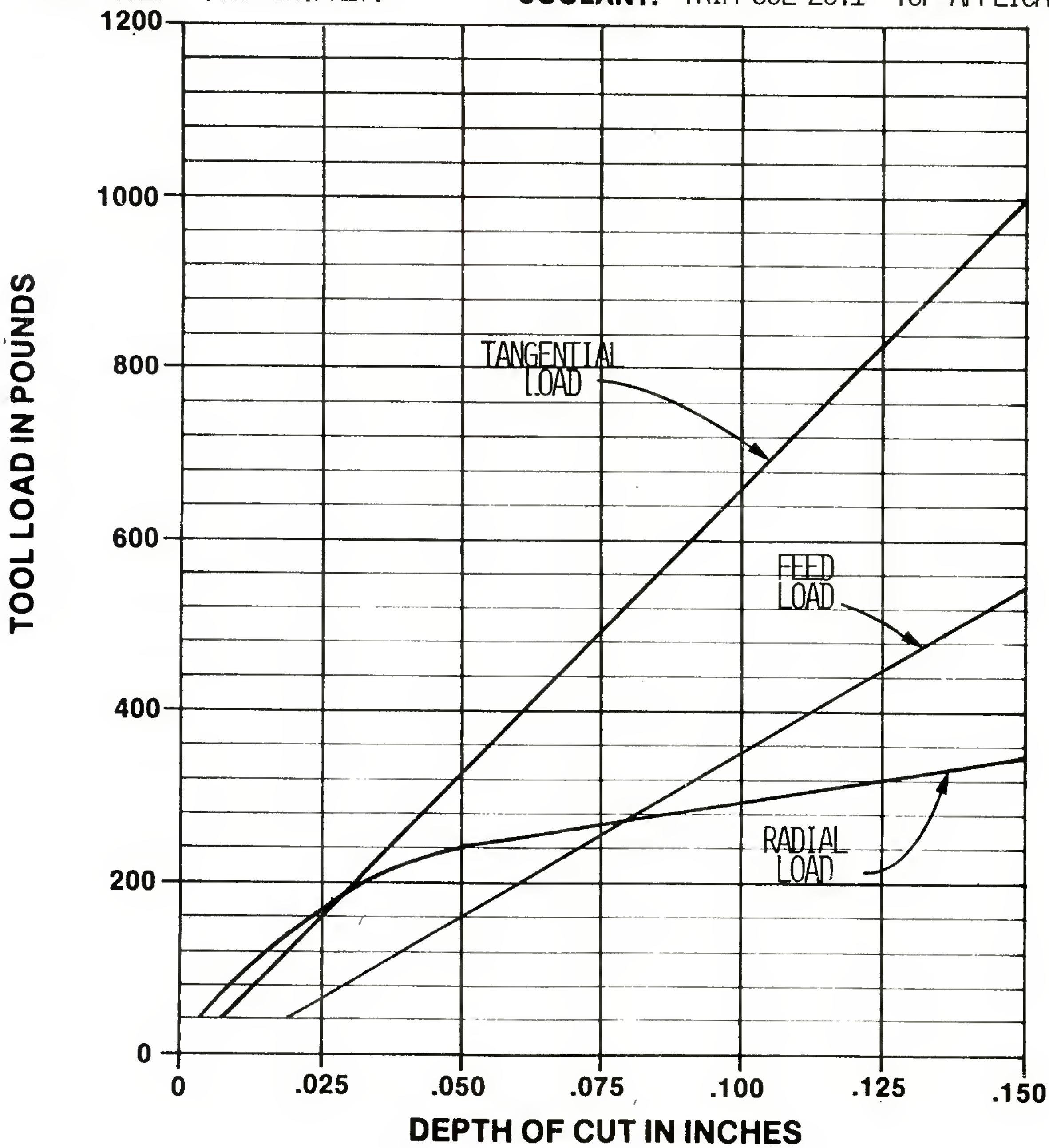

FIGURE 136 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4340 **HOLDER:** CTANR-164

HARDNESS: 477/512 BHN **INSERT:** TNMG-433

SURFACE SPEED: 180 FT./MIN. **GRADE:** 570

FEED RATE: .015 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP APPLICATION

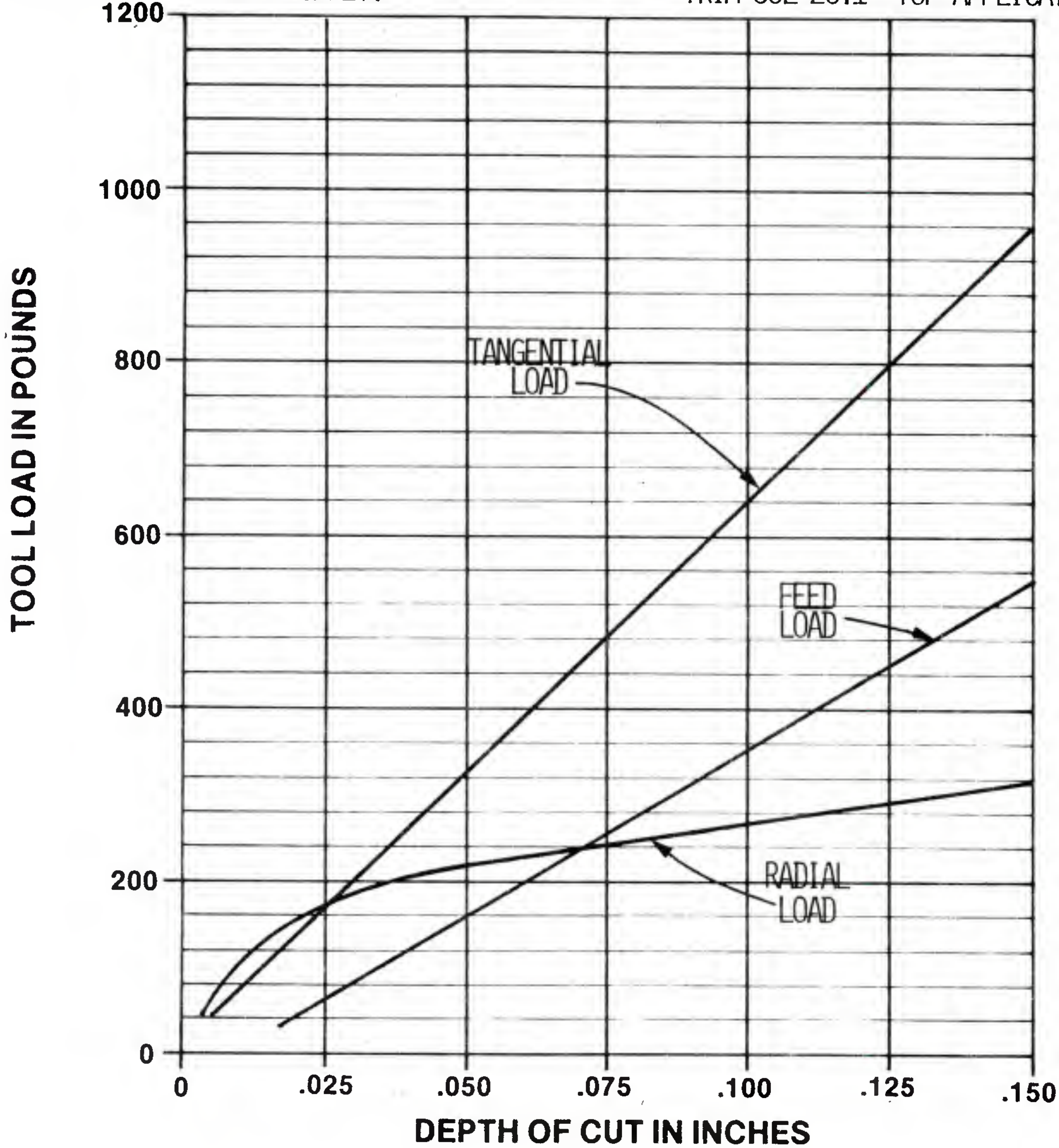

FIGURE 137 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4340 **HOLDER:** CCGNR-164

HARDNESS: 477/512 BHN **INSERT:** CNG-454 820

SURFACE SPEED: 250 FT./MIN. **GRADE:** G-10

FEED RATE: .015 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP APPLICATION

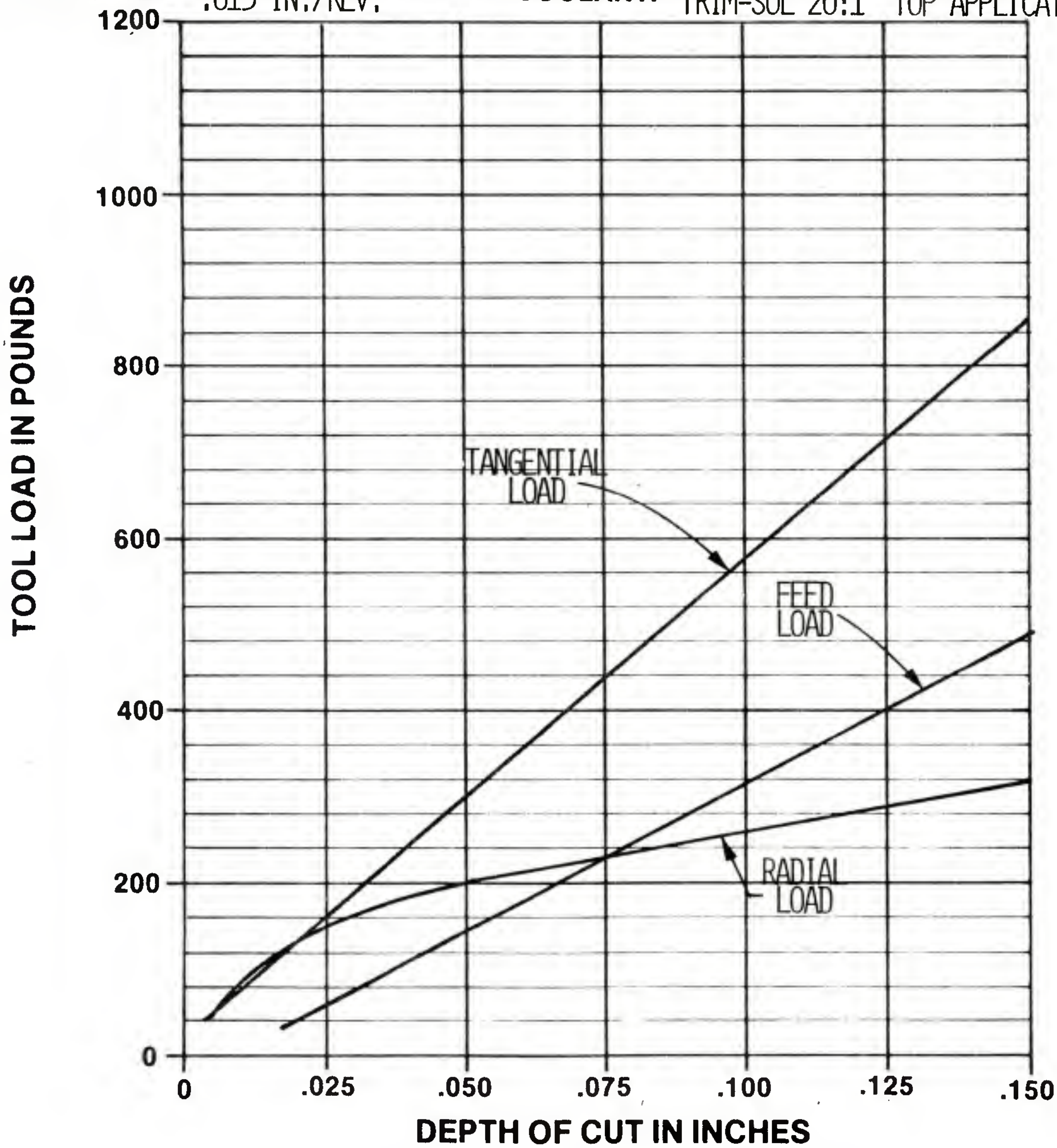

FIGURE 138 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4340 **HOLDER:** CCGNR-164

HARDNESS: 477/512 BHN **INSERT:** CNG-454 820

SURFACE SPEED: 150 FT./MIN. **GRADE:** G-30

FEED RATE: .015 IN./REV. **COOLANT:** NONE

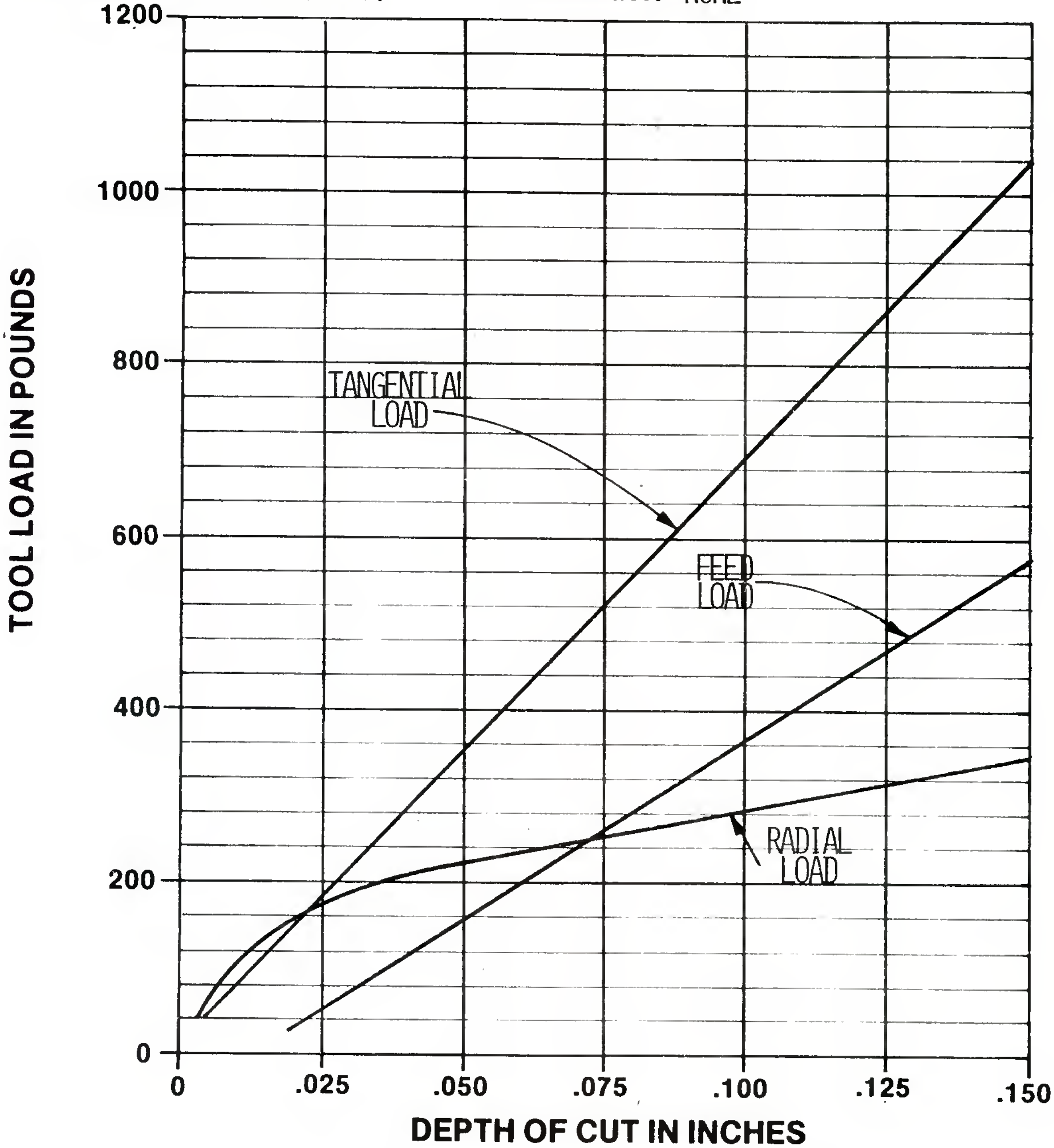

FIGURE 139: TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4340 **HOLDER:** PRANR-164

HARDNESS: 477/512 BHN **INSERT:** RNMG-43

SURFACE SPEED: 135 FT./MIN. **GRADE:** 350

FEED RATE: .022 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP

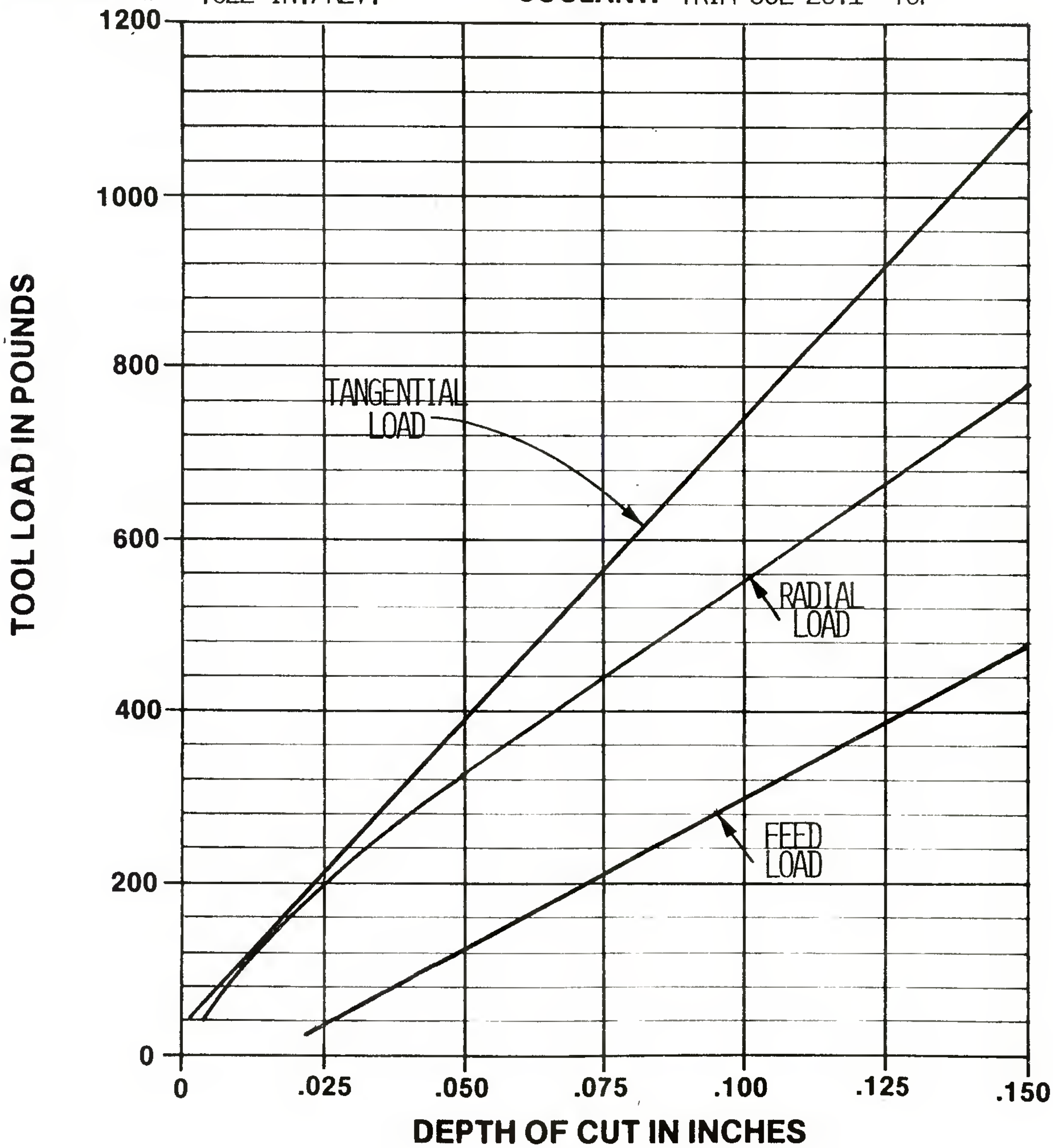

FIGURE 140: TOOL LOAD CHART

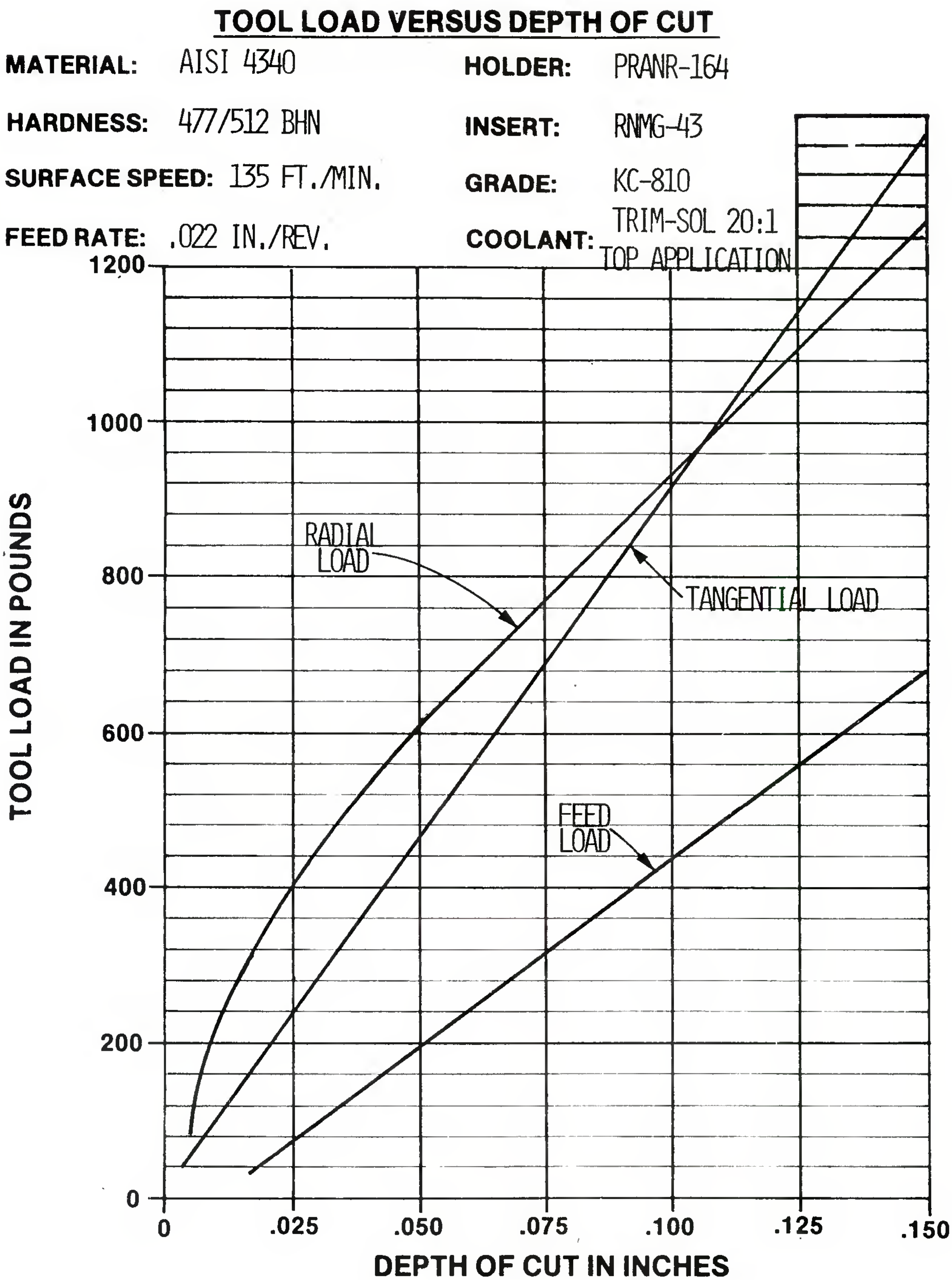

FIGURE 141 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

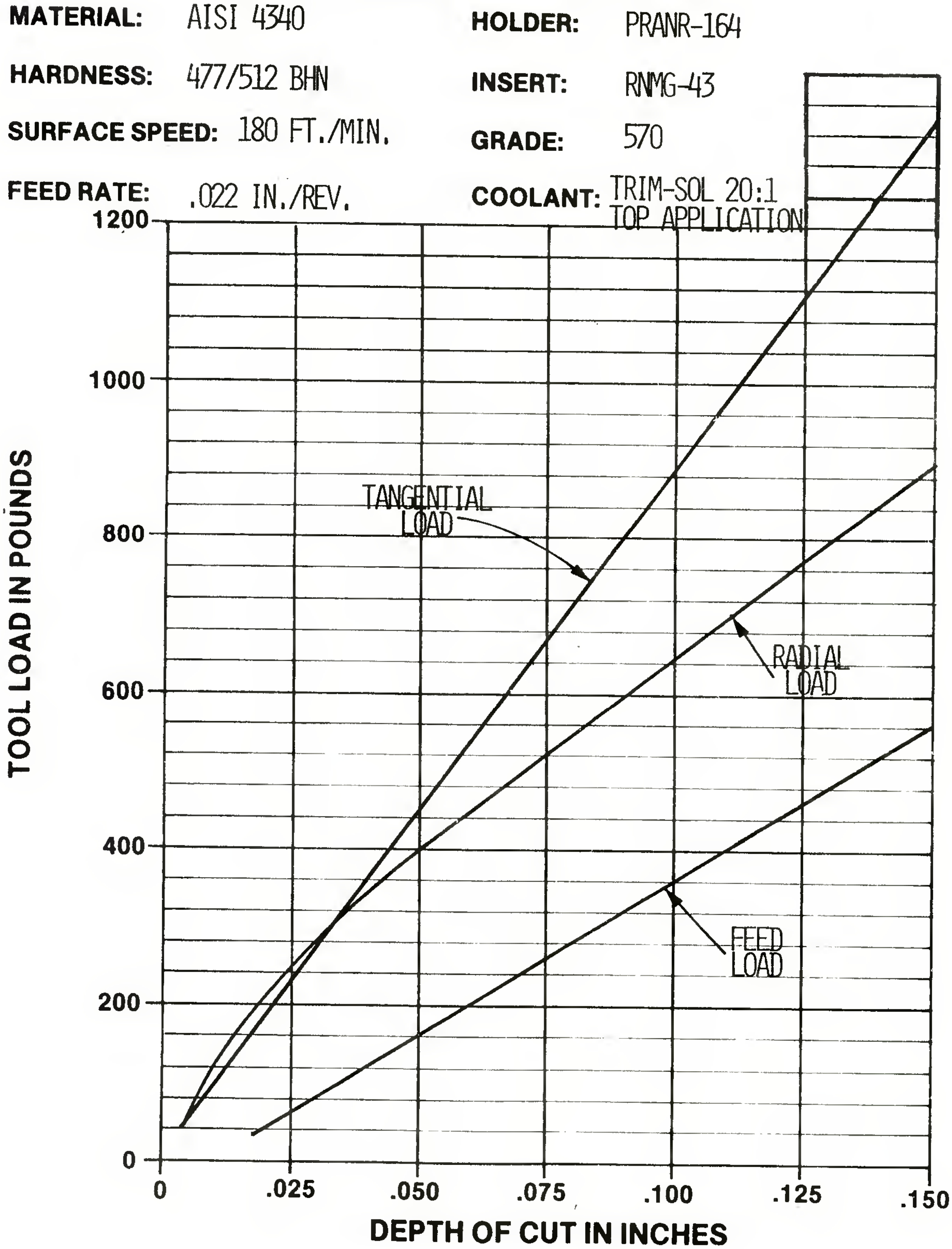

FIGURE 142 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	AISI 4340	**HOLDER:**	CRGNR-164
HARDNESS:	477/512 BHN	**INSERT:**	RNG-45 820
SURFACE SPEED:	250 FT./MIN.	**GRADE:**	G-10
FEED RATE:	.022 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP

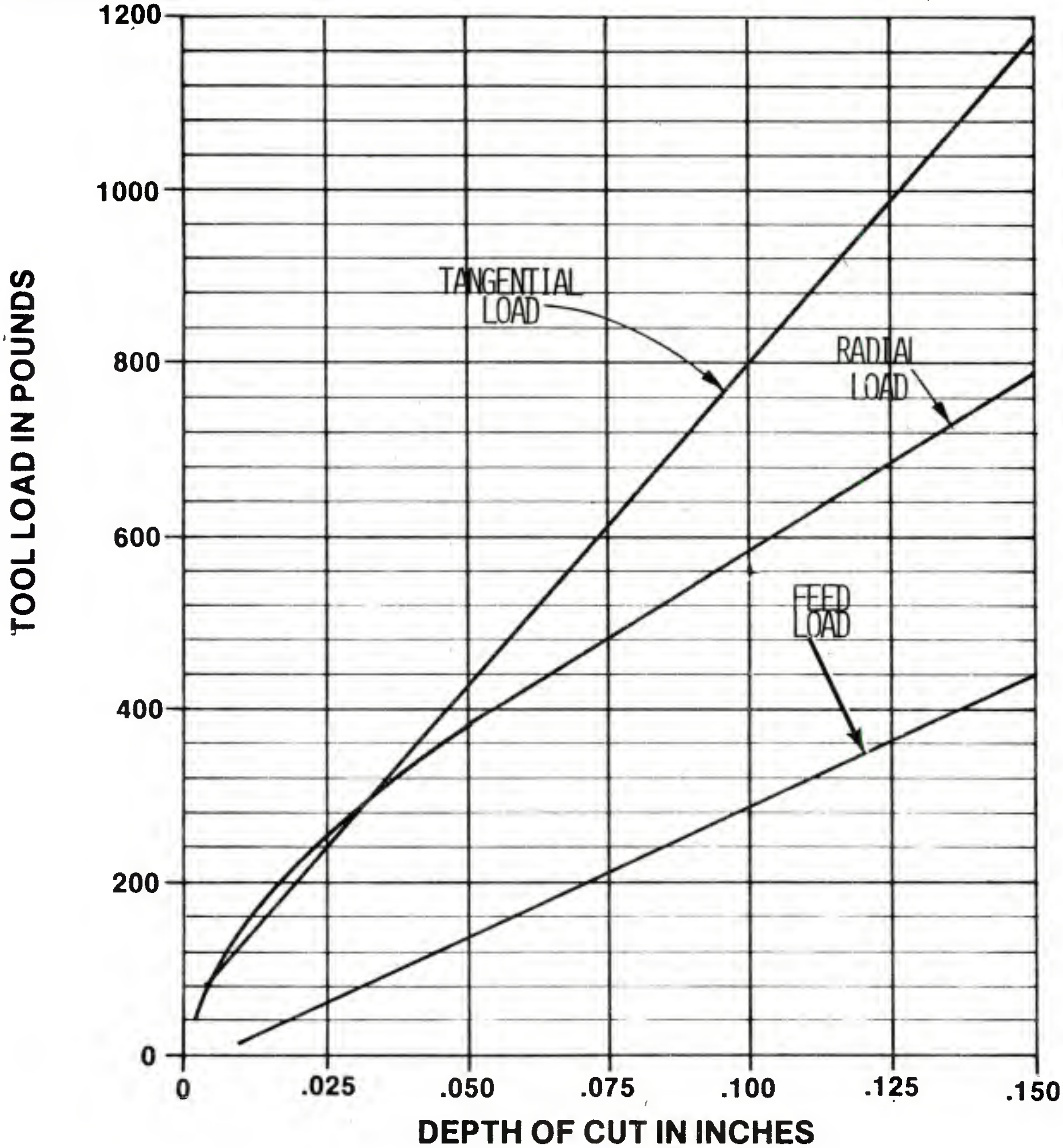

FIGURE 143 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: AISI 4340 **HOLDER:** CRGNR-164

HARDNESS: 477/512 BHN **INSERT:** RNG-45 820

SURFACE SPEED: 150 FT./MIN. **GRADE:** G-30

FEED RATE: .022 IN./REV. **COOLANT:** NONE

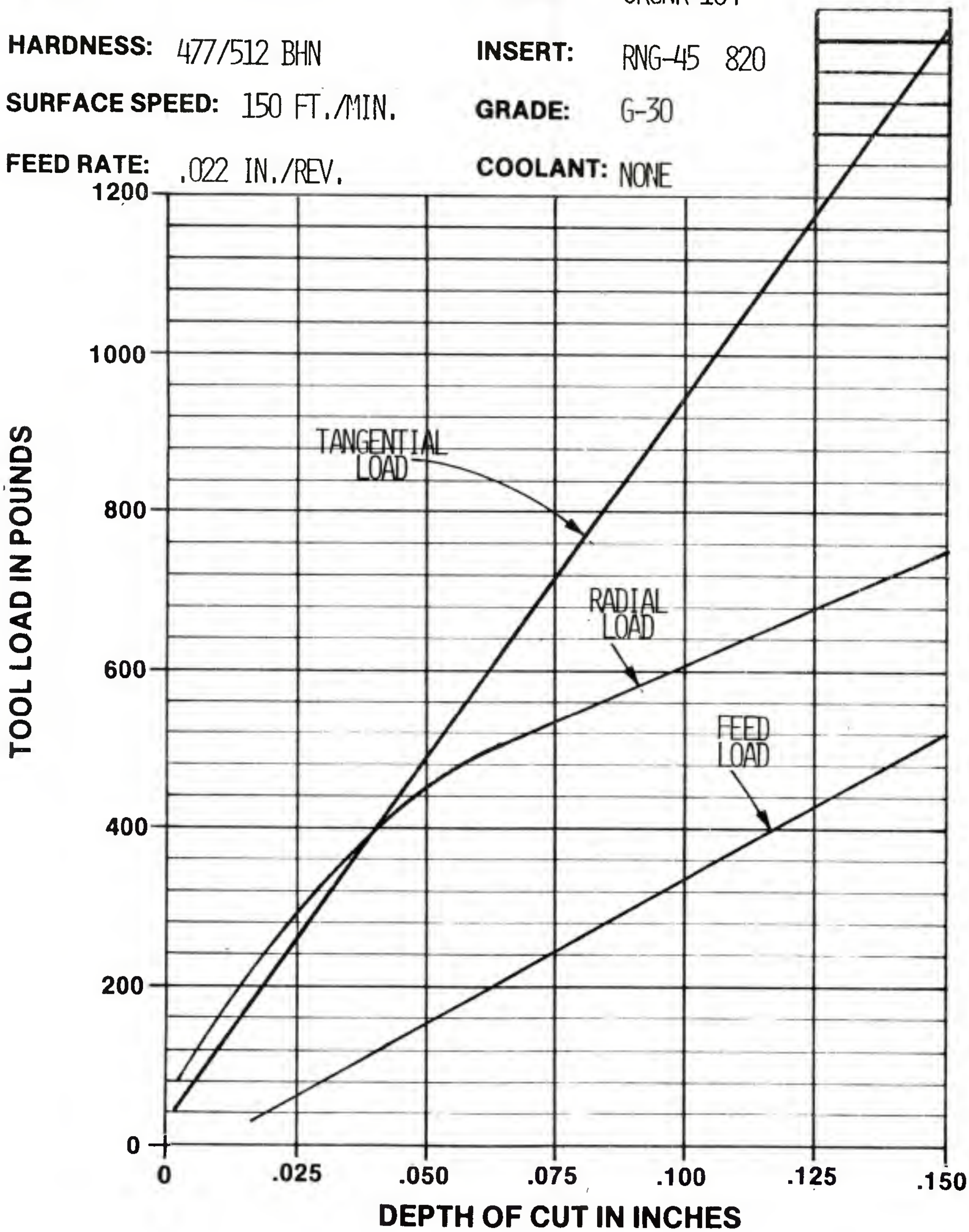

FIGURE 144 : TOOL LOAD CHART

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4340 **HARDNESS:** 477/512 BHN

INSERT: TNMG-433 **SURFACE FEED:** 135 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 350 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	170	40	150
.050	320	150	200
.100	660	340	250
.150	960	520	300

INSERT: TNMG-433 **SURFACE FEED:** 135 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: KC-810 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	160	60	165
.050	340	160	240
.100	660	360	300
.150	960	550	350

INSERT: TNMG-433 **SURFACE FEED:** 180 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 570 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	170	60	155
.050	340	160	210
.100	660	360	260
.0150	960	540	360

TABLE 98: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4340 **HARDNESS:** 477/512 BHN

INSERT: CNG-454 .008" x 20° **SURFACE FEED:** 250 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	180	50	140
.050	300	120	200
.100	580	320	260
.150	840	480	320

INSERT: CNG-454 .008" x 20° **SURFACE FEED:** 150 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .015 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	180	50	155
.050	350	150	225
.100	700	360	280
.150	1040	580	350

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025			
.050			
.100			
.150			

TABLE 99: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4340 **HARDNESS:** 477/512 BHN

INSERT: RNMG-43 **SURFACE FEED:** 135 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: 350 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	230	40	210
.050	440	100	340
.100	860	260	530
.150	1300	510	780

INSERT: RNMG-43 **SURFACE FEED:** 135 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: KC-810 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	260	70	390
.050	480	170	610
.100	920	410	960
.150	1360	700	1240

INSERT: RNMG-43 **SURFACE FEED:** 180 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.
GRADE: 570 **FEEDRATE:** .022 IN/REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	240	50	260
.050	460	130	400
.100	860	300	660
.150	1320	500	900

TABLE 100: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: AISI 4340 **HARDNESS:** 477/512 BHN

INSERT: RNG-45 .008" x 20° **SURFACE FEED:** 250 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	260	60	240
.050	460	120	390
.100	810	280	560
.150	1160	440	780

INSERT: RNG-45 .008" x 20° **SURFACE FEED:** 150 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	270	60	260
.050	520	140	450
.100	970	320	720
.150	1400	520	940

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025			
.050			
.100			
.150			

TABLE 101: **DATA FOR TOOL LOAD CHARTS**

SURFACE SPEED VERSUS SURFACE FINISH

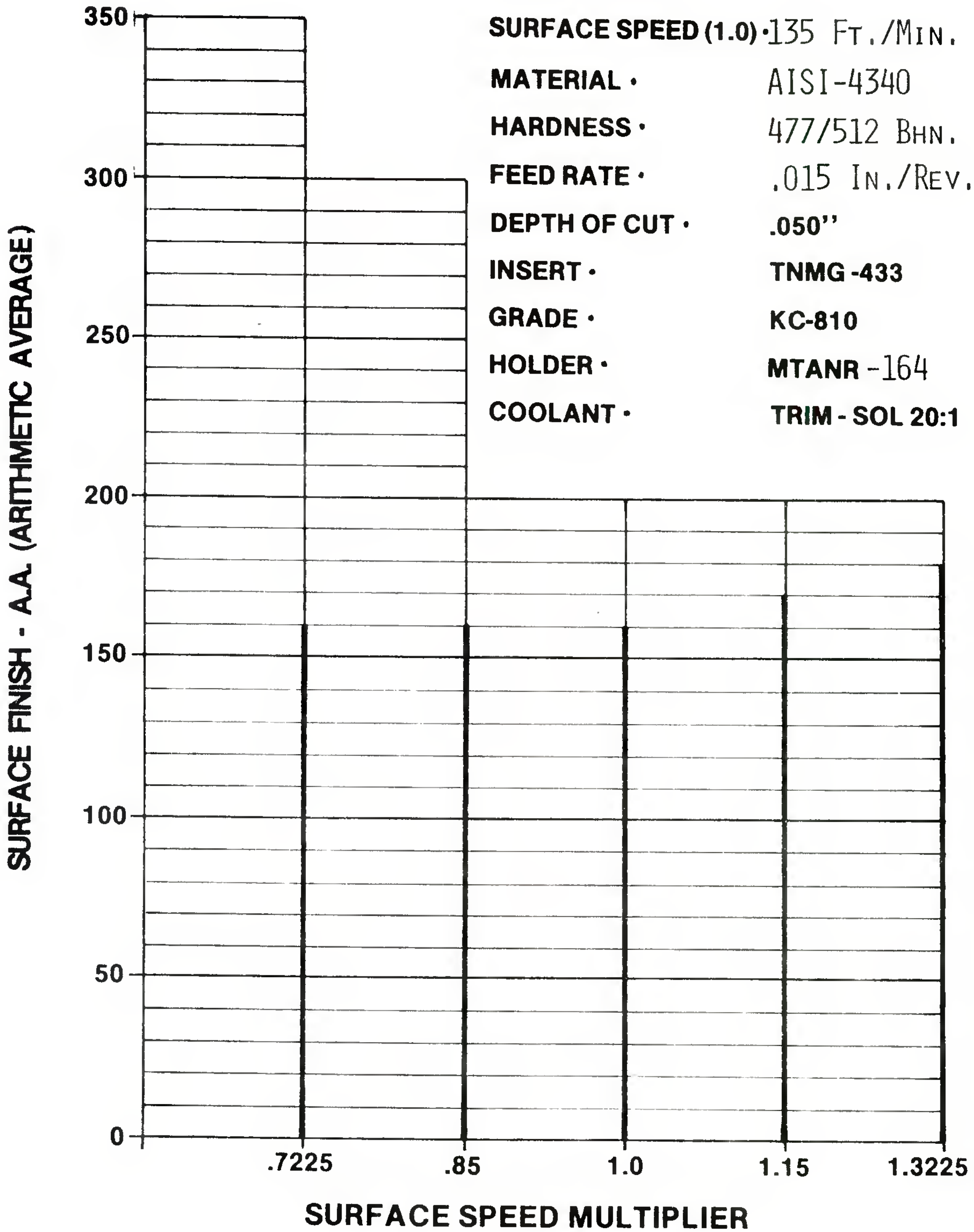

Figure 145

TOOL NOSE RADIUS VERSUS SURFACE FINISH

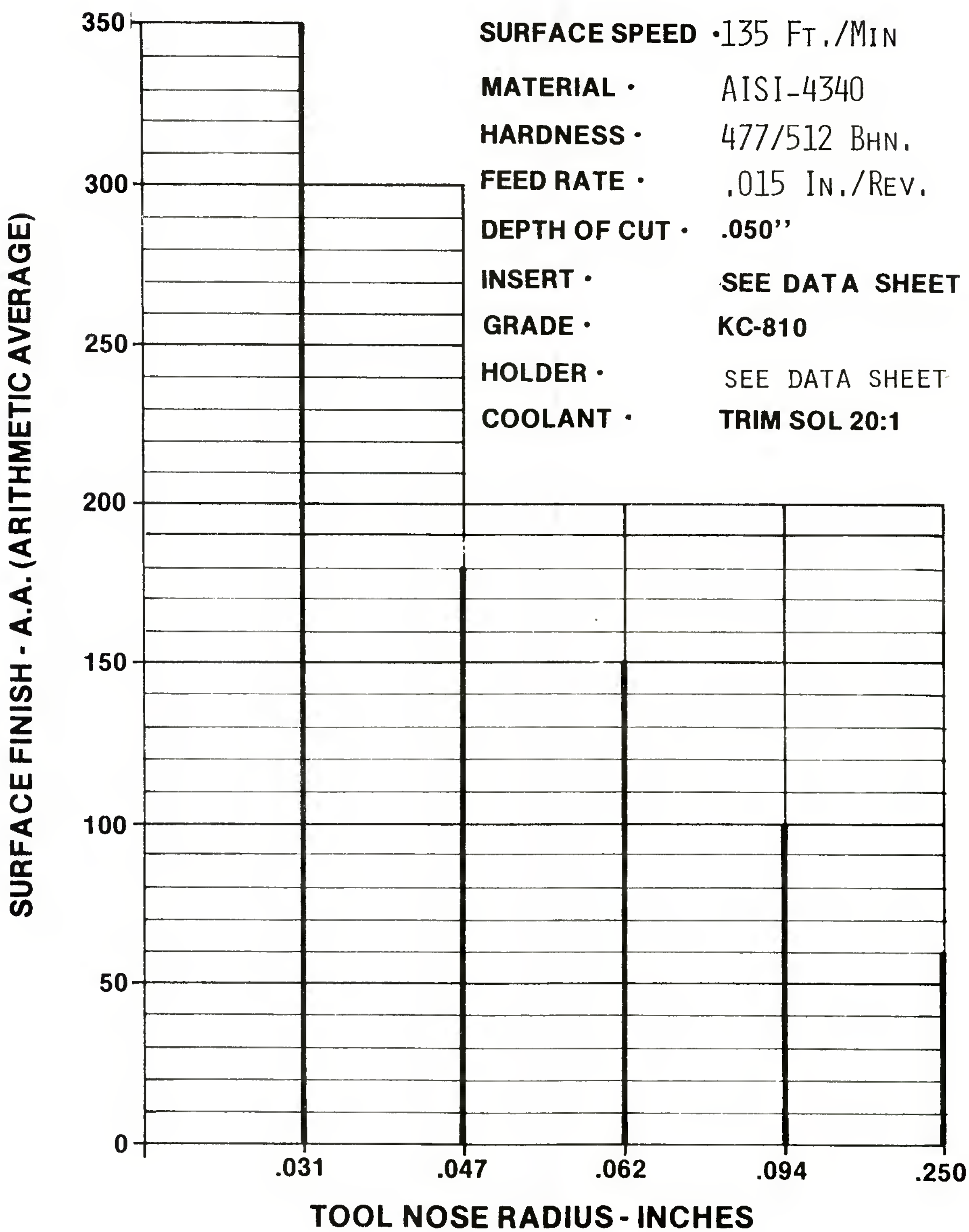

Figure 146

Date: 2/5/81

Material: AISI 4340

Depth of Cut: .050 Inches

Coolant: Trim - Sol 20:1

Hardness: 477/512 BHN

Tool Description:

Coolant Application: Top

Holder: KTAR-164

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	NOSE RADIUS	SURFACE SPEED MULTIPLIER	SURFACE FINISH ARITHMETIC AVERAGE			
1	KC-810	97	.015		.7225	160			
2	"	115	"		.85	160			
3	"	135	"		1.0	160			
4	"	155	"		1.15	170			
5	"	179	"		1.3225	180			

NOTES:

TABLE 102: **DATA FOR SURFACE FINISH TESTS**

Date: 2/4/81

Material: AISI 4340

Depth of Cut: .050 Inches

Coolant: Trim - Sol 20:1

Hardness: 477/512 BHN

Tool Description: SEE NOTES

Coolant Application: Top

Holder:

Insert:

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	NOSE RADIUS	SURFACE SPEED MULTIPLIER	SURFACE FINISH ARITHMETIC AVERAGE			
1	KC-810	135	.015	.03125		350			
2	"	"	"	.0469		180			
3	"	"	"	.0625		150			
4	"	"	"	.09375		100			
5	"	"	"	.250		60			

NOTES:

TOOL HOLDER/INSERT

KTAR-164	TNMG-432
KTAR-164	TNMG-433
KTAR-164	TNMG-434
WTJNRS-205	TNMG-566
PRANR-854	RNMG-43

(.500" Ø ROUND INSERT)

TABLE 103: DATA FOR SURFACE FINISH TESTS

HF-1 Projectile Material - "Finishing" Cuts - 42 Rc Hardness

The hardness of this material was higher (387 Bhn) than that which is specified in Table 1, page 5 (363 Bhn.). Further heat-treatment would cause the shells to go below the desired hardness, so the shells were used in the harder conditions.

This material was the only one in "Finishing" tests where chips were not a problem. When conducting the tests using ceramic tools, the chips were very fine and similar to chips from cast iron. The cutting speed for a tool life of 2500 square inches of machined surface was similar for both hot-press and cold-press ceramic.

Table 104, page 272, summarizes the production indexes for both the carbide and ceramic cutting tools, as well as the horsepower requirements for various tool styles and cutting tool material. This information can be found in more detail in Figures 147 through 157 and Tables 105 to 111. In spite of the higher hardness, the horsepower for this material was lower than for some of the others. The difference, however, is rather small.

The finish tests for this material, as shown on Figure 159, page 292, show the effect of changing nose radius. Figure 158, page 291, shows the effect of changing cutting speed, which in this case is nothing.

SUMMARY OF RESULTS

"FINISHING CUT"

MATERIAL	HF-1
HARDNESS	387 Bhn.
TOOL LIFE	2500 In^2 of Machined Surface
DEPTH OF CUT	.050 inches

Insert Grade	Insert Style	SFM	Feed In./Rev.	Prod. Index	Tangential Tool Load - Lbs. .050 Depth of Cut	H.P. .050 Depth of Cut
350	TNMG-433	210	.011	2.31	240	1.53
KC-810	TNMG-433	310	.011	3.41	230	2.16
570	TNMG-433	340	.011	3.74	240	2.47
G-10	CNG-454	610	.011	6.71	220	4.07
G-30	CNG-454	590	.011	6.49	220	3.93
350	RNMG-43	210	.022	—	420	2.67
KC-810	RNMG-43	310	.022	—	440	4.13
570	RNMG-43	340	.022	—	420	4.33
G-10	RNG-45	610	.022	—	380	7.02
G-30	RNG-45	590	.022	—	400	7.15

TABLE 104: HF-1 Results of Tests

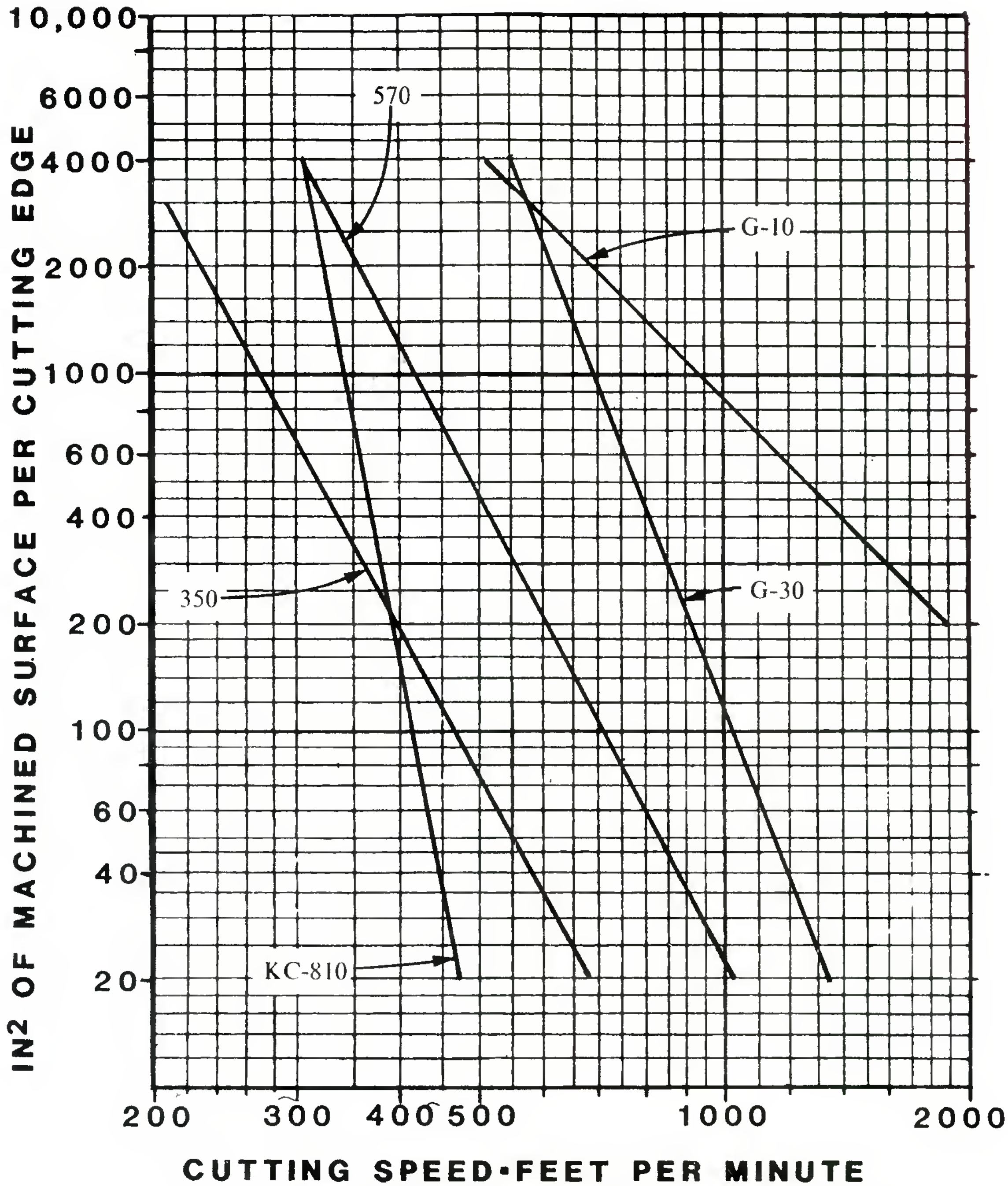

Figure 147: Tool-Life Lines of Listed Cutting Materials on HF-1 Steel at 387 Brinell Hardness.

Feed -.011 Inches per Revolution

Depth of Cut - .050 Inches

350, KC-810, 570: Holder - MTANR-164 (0^0 Lead Angle)

Insert - TNMG-433

G-10, G-30: Holder - CCGNR-164 (0^0 Lead Angle)

Insert - CNG-454 .008 x 20^0

Date: 10/7/80

Material: HF-1

Depth of Cut: .050"

Coolant: TRIM SOL 20:1

Hardness: 387 BHN

Tool Description:

Coolant Application: TOP

Holder: MTANR-164

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT INCHES OF WEAR-LAND	
1	350	450	.011	6.284	6.190	3.6	70	.0125	134	.024
2	"	400	"	"	"	4.5	87.5	.010	210	.024
3	"	350	"	"	"	5.8	113	.013	208	.024
4	"	300	"	"	"	6.7	130.5		CUT CONTINUED	
4a	"	"	"	6.190	6.100	8.1	155			
							286 T.	.0095	722.5	.024
5	KC-810	400	"	"	"	2.5	48	.010	115	.024
6	"	350	"	"	"	9.9	189.5	.0055	828	.024
7	"	450	"	6.100	6.000	.8	15	.0075	48	.024

NOTES:

TABLE 105: DATA FOR LIFE LINES

Date: 10/7/80

Depth of Cut: .050"

Hardness: 387 BHN

Coolant Application: TOP

Material: HF-1

Coolant: TRIM-SOL 20:1

Tool Description:

Holder: MTANR-164

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
8	570	450	.011	6.100	6.000	12.2	230	.0085	649	.024
9	"	600	"	"	"	5.4	102	.011	222.5	.024
10	"	750	"	6.000	5,900	2.0	37	.013	68.5	.024

NOTES:

TABLE 106: DATA FOR LIFE LINES

Date: 10/13/80		**Material:** HF-1	
Depth of Cut: .050"		**Coolant:** TRIM-SOL 20:1	
Hardness: 364BHN		**Tool Description:**	
Coolant Application: TOP: G-10		**Holder:** CCGNR-164	
NONE: G-30		**Insert:** CNG-454	

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	ROUGH DIAMETER	TURNED DIAMETER	TURNED LENGTH	MACHINED AREA — IN^2	WEAR-LAND INCH	IN^2 OF MACHINED SURFACE AT	INCHES OF WEAR-LAND
1	G-10	1000	.011	6.280	6-180	9.4	182.5	.0035	782	.015
2	"	1200	"	"	"	8.8	170.8	.0045	569.5	.015
3	"	1400	"	6.180	6.080	5.95	113.5	.00475	359	.015
4	G-30	1000	"	6.280	6.180	2.6	50.5	.008	95	.015
5	"	900	"	6.180	6.080	10.5	200.5	.012	251	.015
6	"	800	"	"	"	4.4	84.0		CUT CONTINUED	
6a	"	"	"	6.080	5.982	13.2	248			
							332 T.	.014	356	.015

NOTES:

TABLE 107: DATA FOR LIFE LINES

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: HF-1 | **HOLDER:** MTANR-164

HARDNESS: 387 BHN | **INSERT:** TNMG-433

SURFACE SPEED: 210 FT./MIN. | **GRADE:** 350

FEED RATE: .011 IN./REV. | **COOLANT:** TRIM-SOL 20:1 TOP

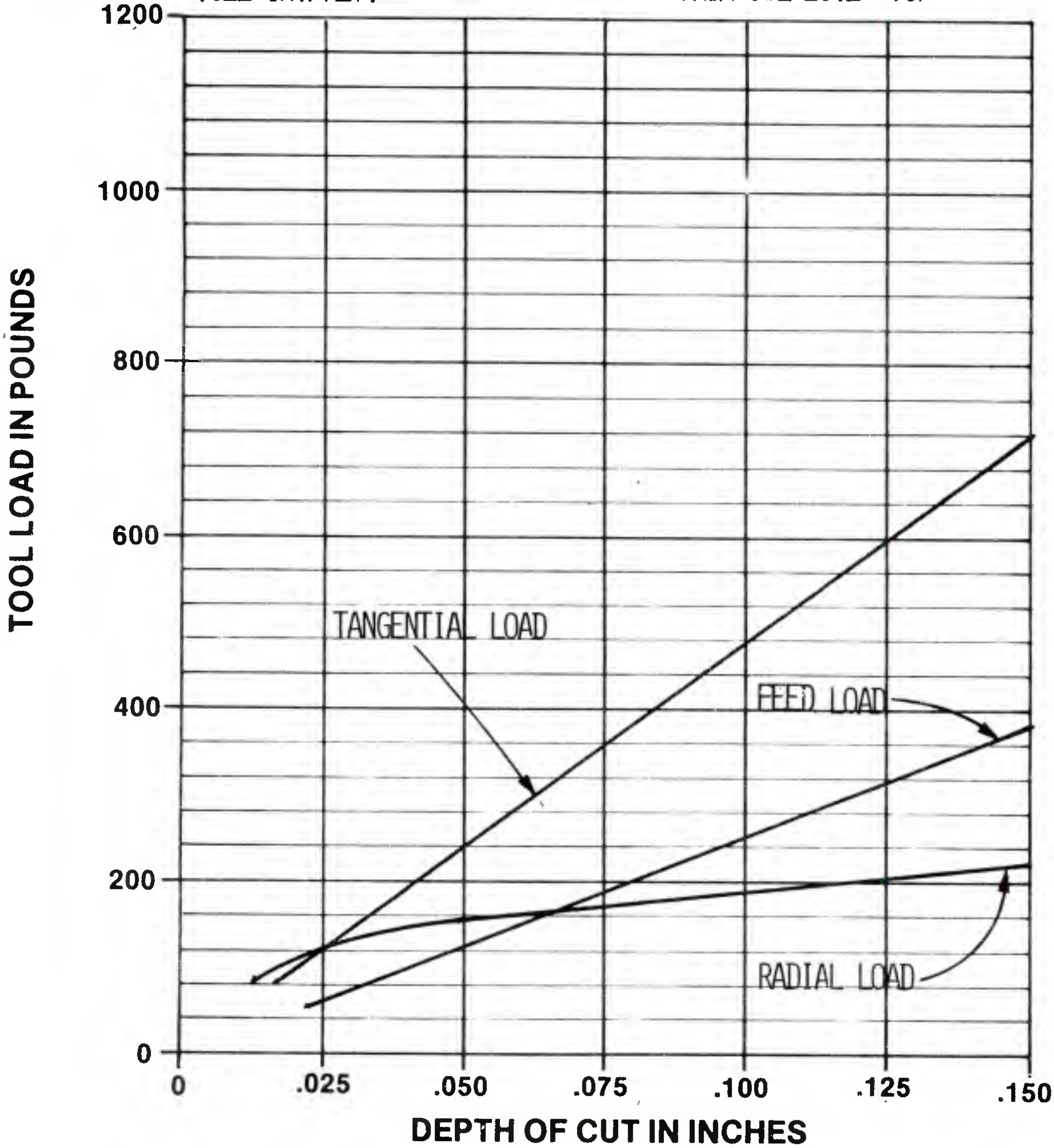

FIGURE 148 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	HF-1	**HOLDER:**	MTANR-164
HARDNESS:	387 BHN	**INSERT:**	TNMG-433
SURFACE SPEED:	310 FT./MIN.	**GRADE:**	KC-810
FEED RATE:	.011 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP

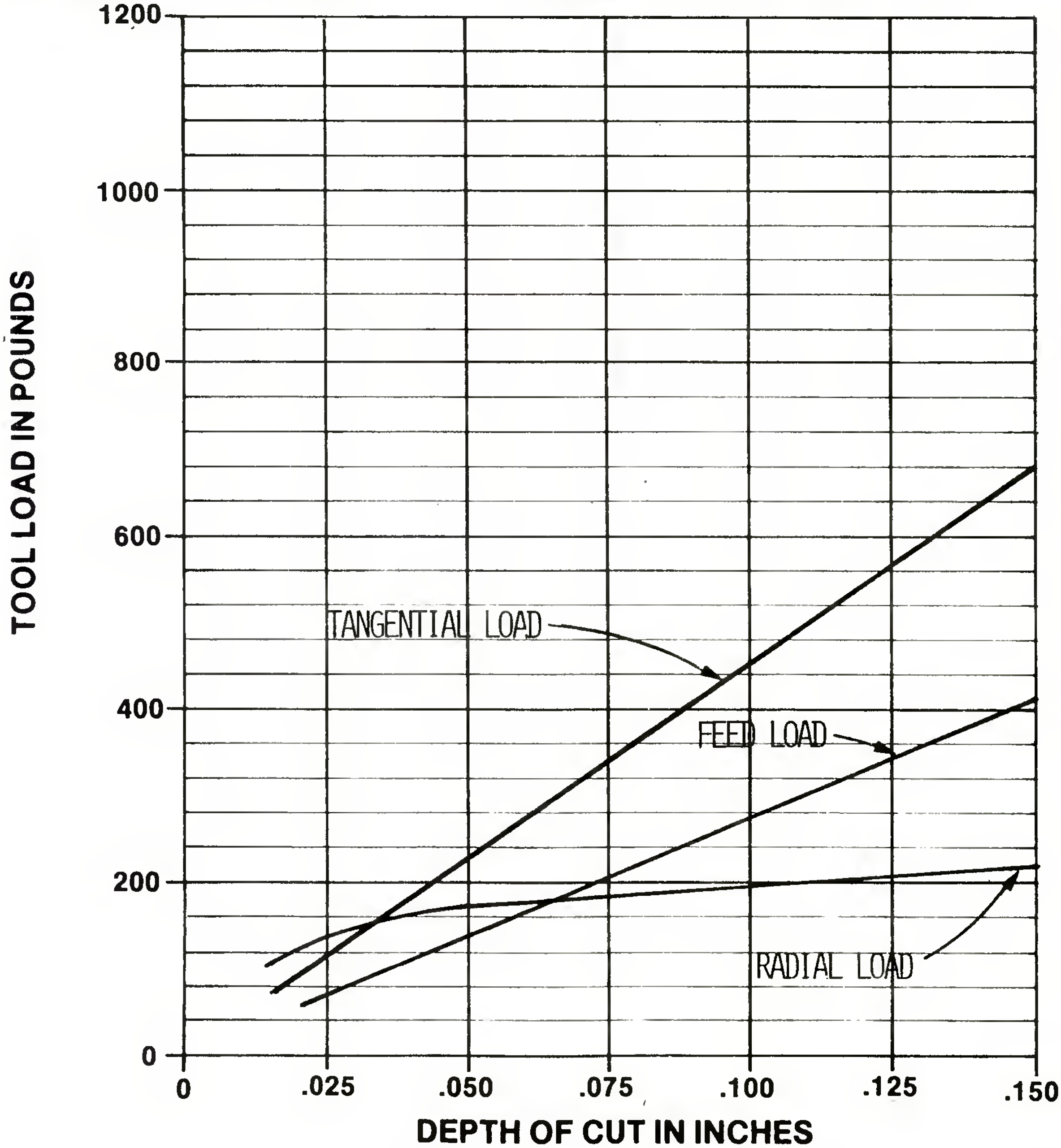

FIGURE 149 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	HF-1	**HOLDER:**	MTANR-164
HARDNESS:	387 BHN	**INSERT:**	TNMG-433
SURFACE SPEED:	340 FT./MIN.	**GRADE:**	570
FEED RATE:	.011 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP APPLICATION

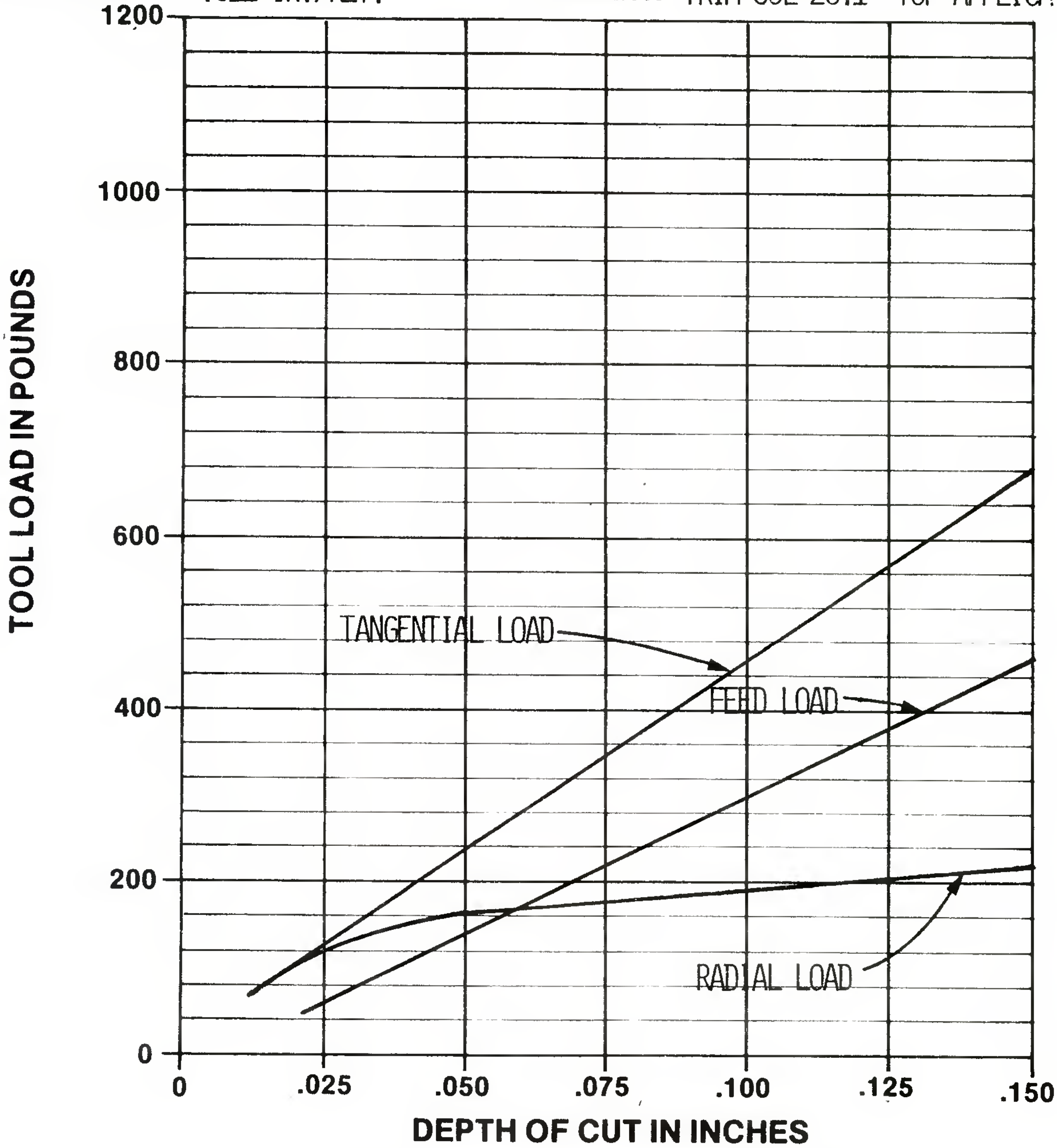

FIGURE 150: TOOL LOAD CHART

<u>**TOOL LOAD VERSUS DEPTH OF CUT**</u>

MATERIAL: HF-1 **HOLDER:** CCGNR-164

HARDNESS: 387 BHN **INSERT:** CNG-454

SURFACE SPEED: 610 FT./MIN. **GRADE:** G-10 .008 x 20°

FEED RATE: .011 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP APPLICATION

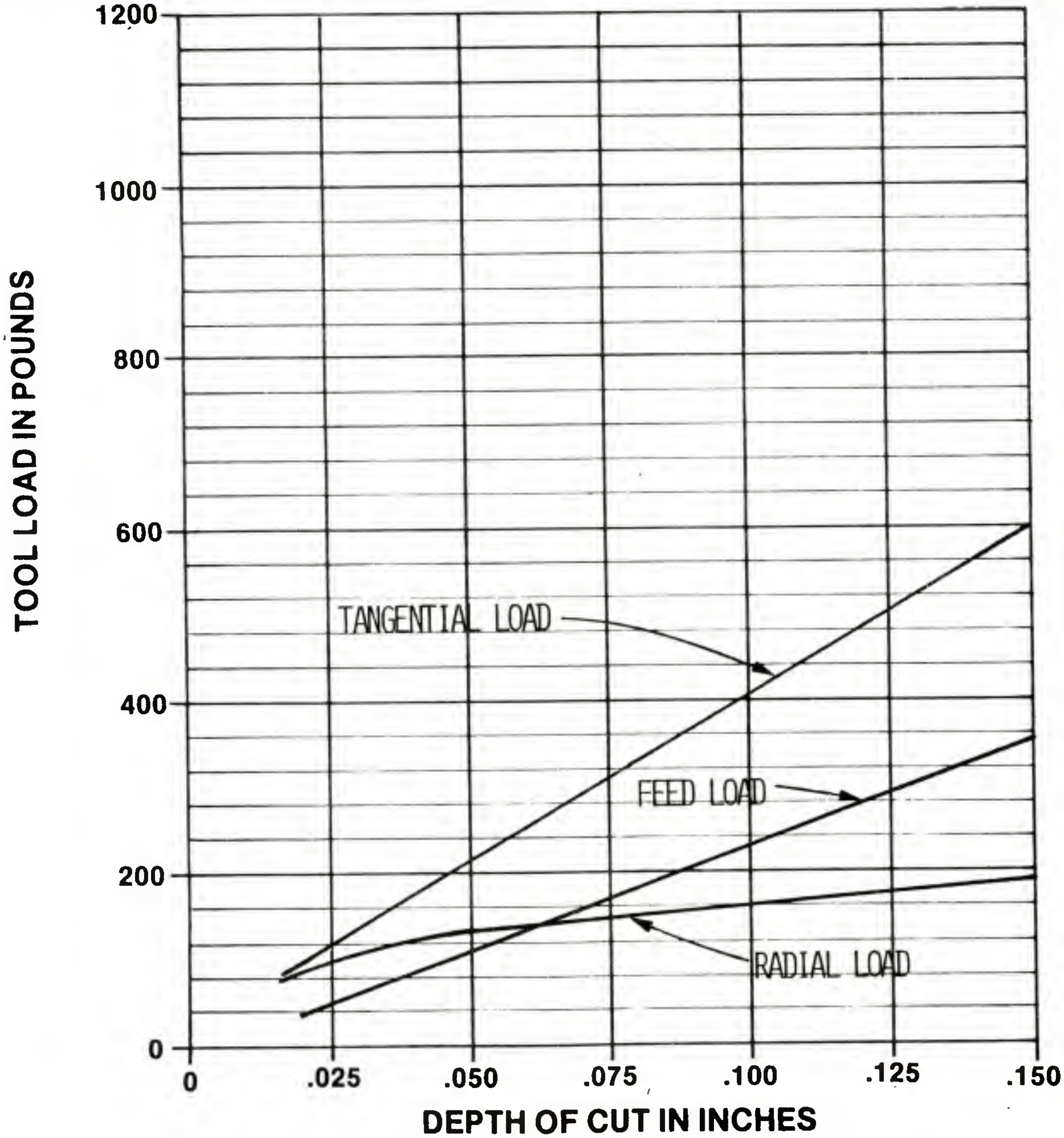

FIGURE 151 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	HF-1	**HOLDER:**	CCGNR-164
HARDNESS:	387 BHN	**INSERT:**	CNG-454
SURFACE SPEED:	590 FT./MIN.	**GRADE:**	G-30 .008 x 20°
FEED RATE:	.011 IN./REV.	**COOLANT:**	NONE

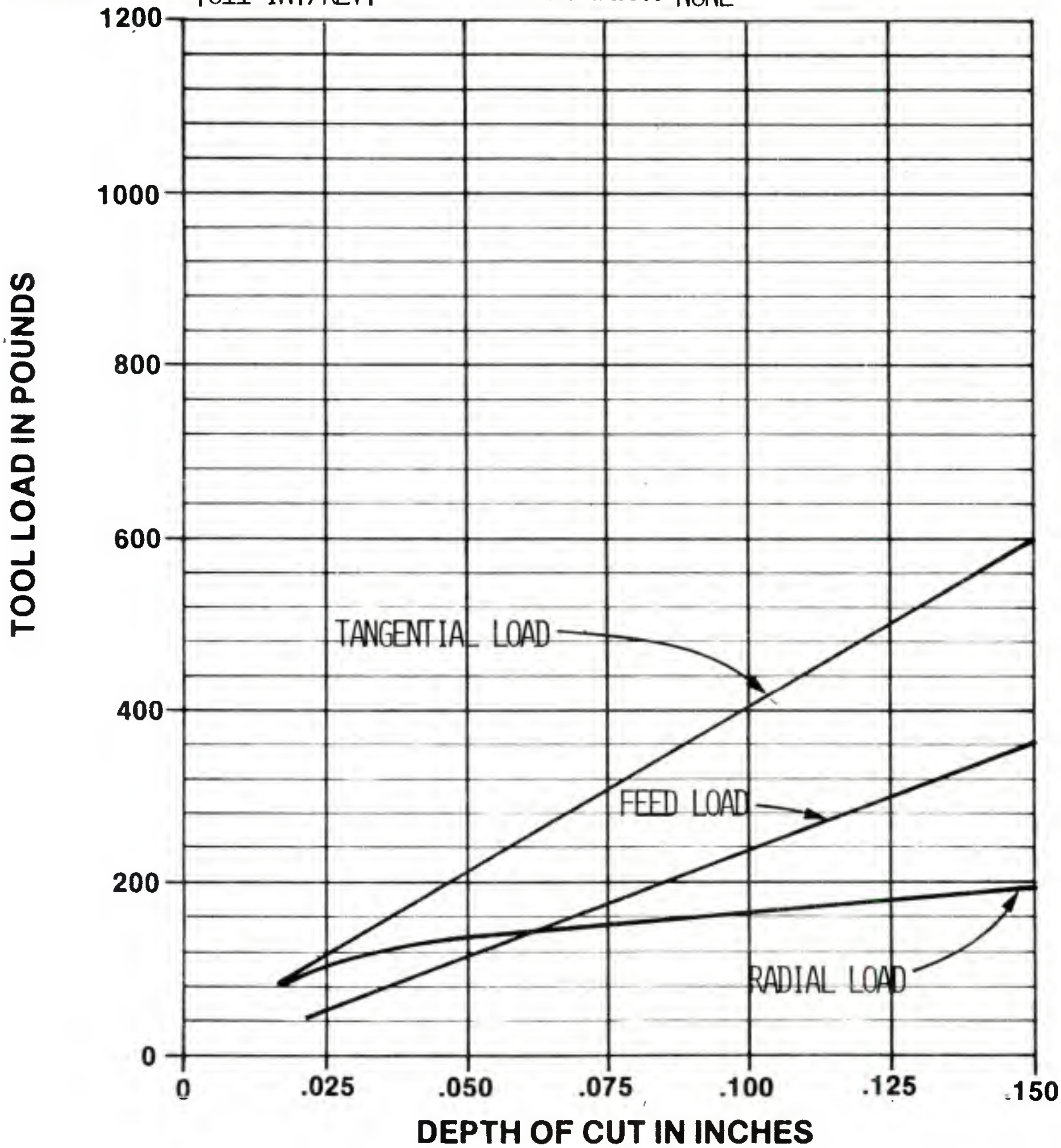

FIGURE 152 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: HF-1 **HOLDER:** PRANR-164

HARDNESS: 387 BHN **INSERT:** RNMG-43

SURFACE SPEED: 210 FT./MIN. **GRADE:** 350

FEED RATE: .022 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP APPLICATION

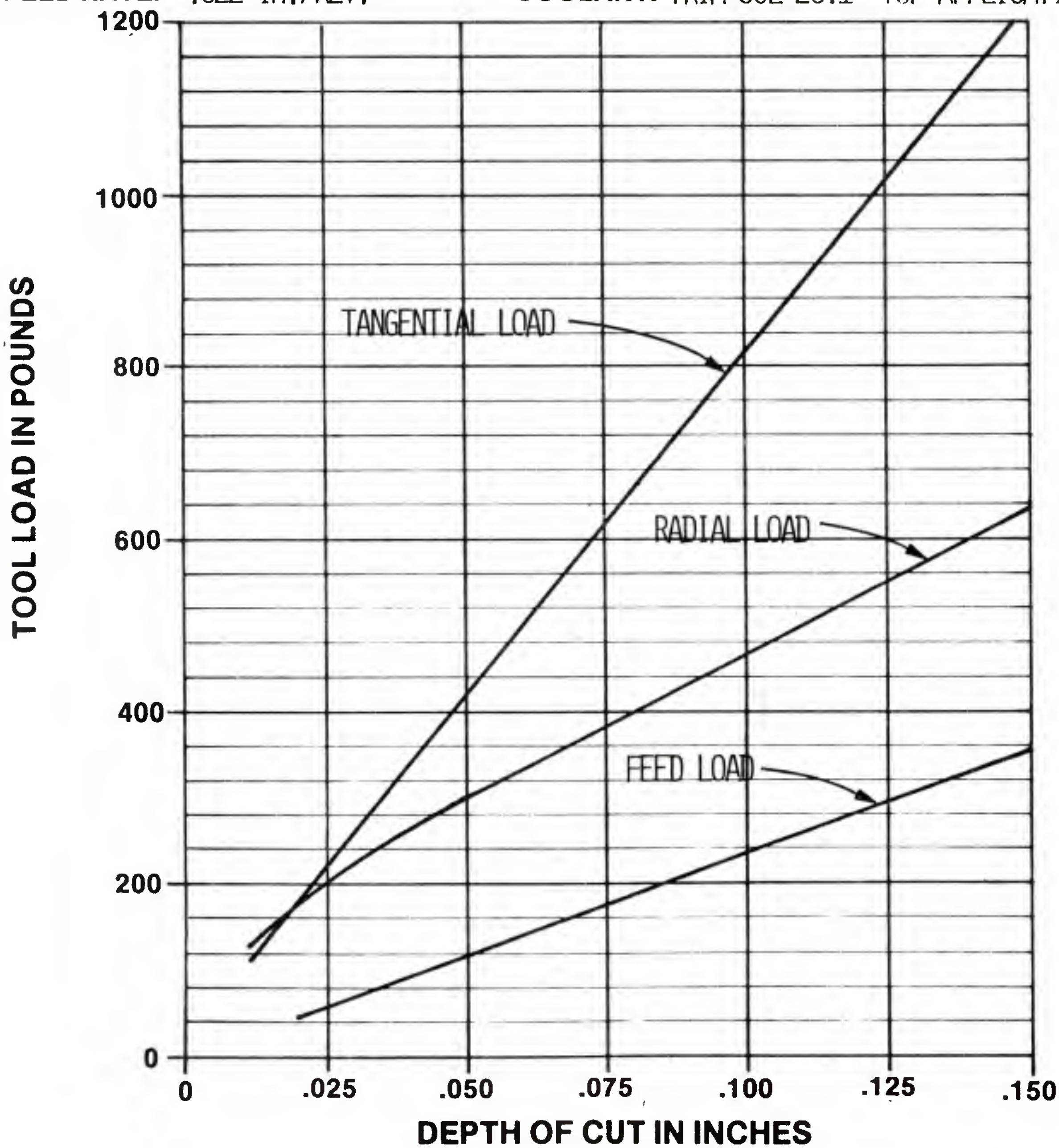

FIGURE 153 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: HF-1 **HOLDER:** PRANR-164

HARDNESS: 387 BHN **INSERT:** RNMG-43

SURFACE SPEED: 310 FT./MIN. **GRADE:** KC-810

FEED RATE: .022 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP APPLICATION

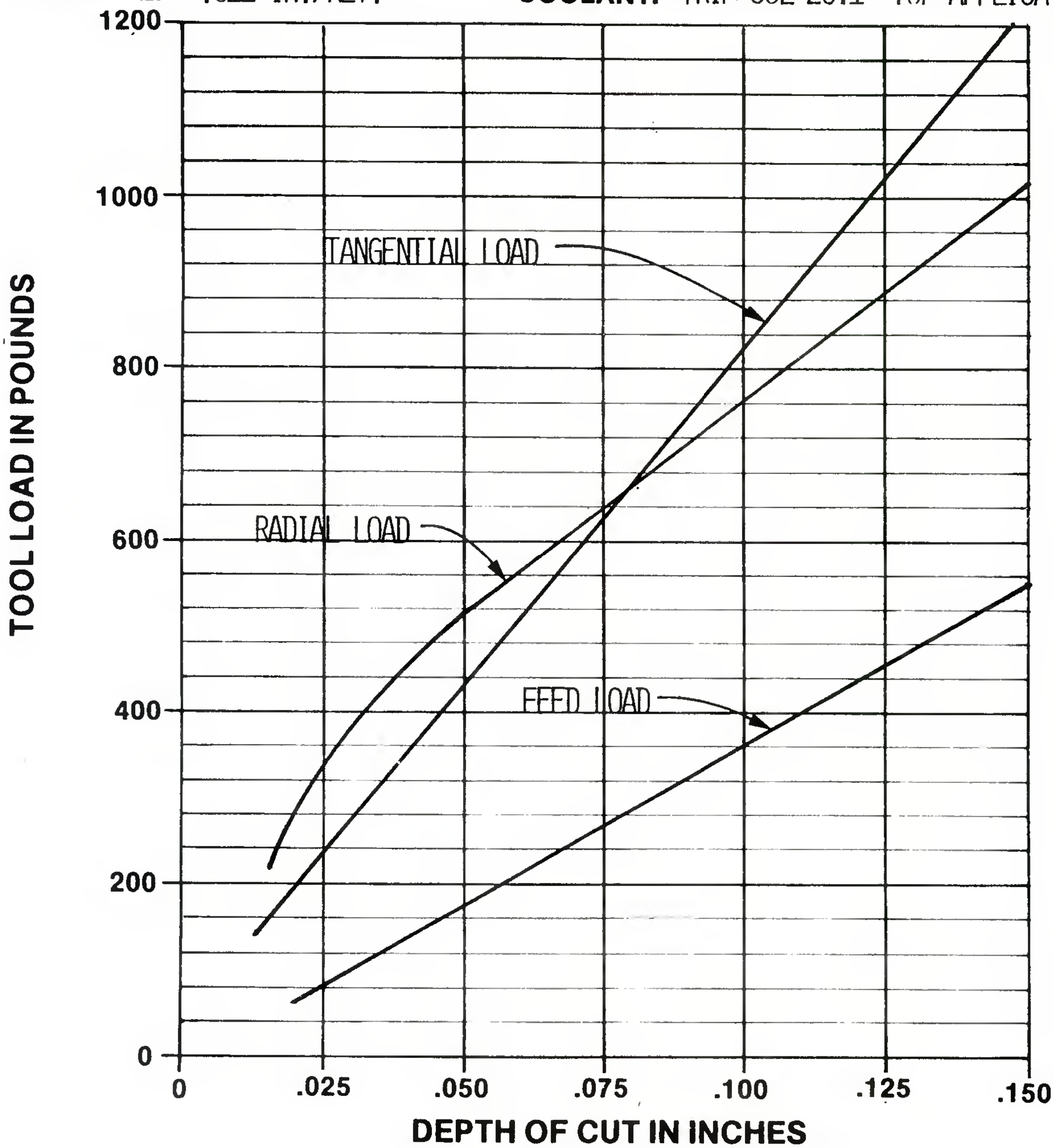

FIGURE 154 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: HF-1 **HOLDER:** PRANR-164

HARDNESS: 387 BHN **INSERT:** RNMG-43

SURFACE SPEED: 340 FT./MIN. **GRADE:** 570

FEED RATE: .022 IN./REV. **COOLANT:** TRIM-SOL 20:1 TOP APPLICATION

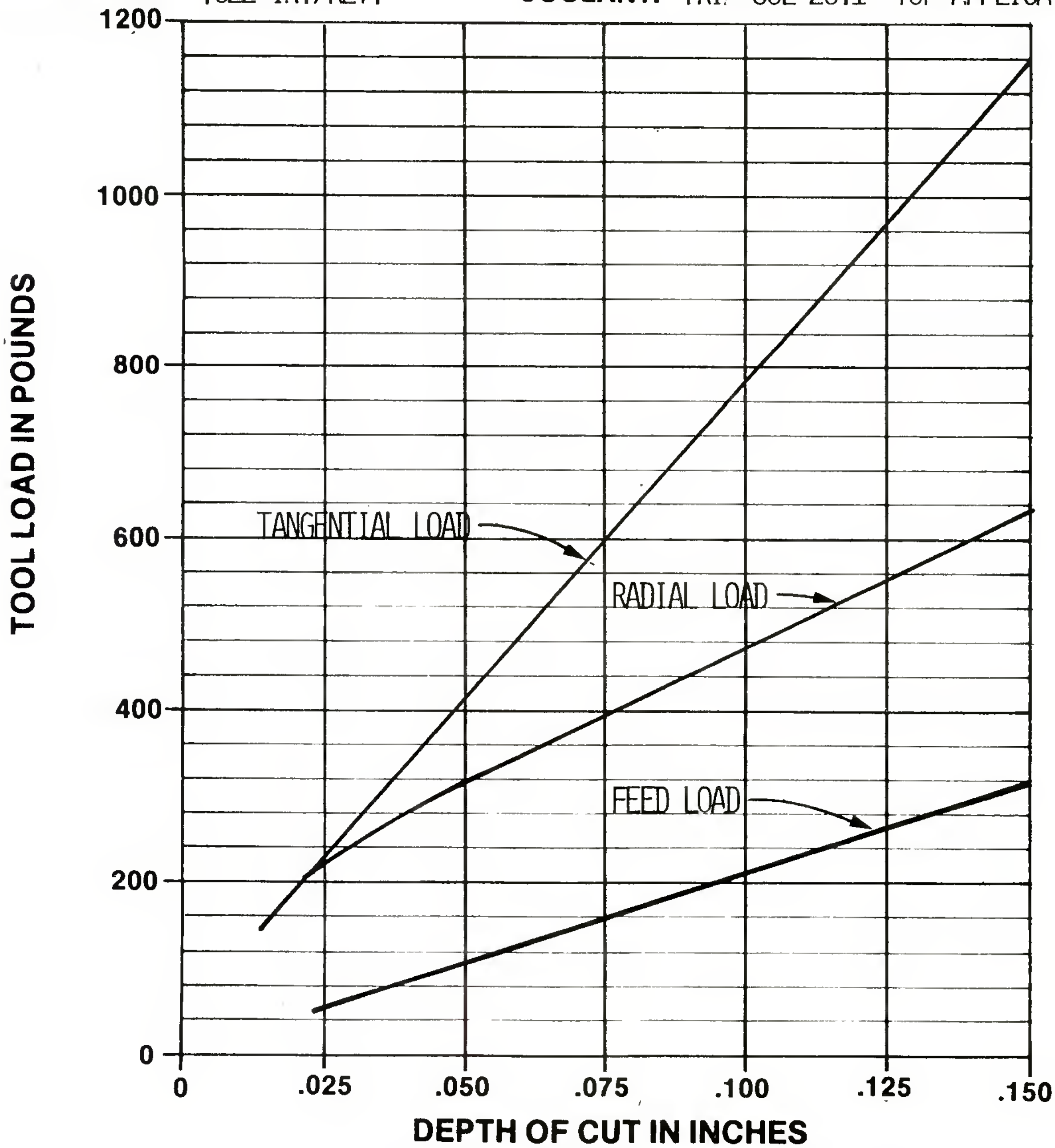

FIGURE 155: TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL:	HF-1	**HOLDER:**	CRGNR-164
HARDNESS:	387 BHN	**INSERT:**	RNG-54 .008 x 20°
SURFACE SPEED:	610 FT./MIN.	**GRADE:**	G-10
FEED RATE:	.022 IN./REV.	**COOLANT:**	TRIM-SOL 20:1 TOP APPLICATION

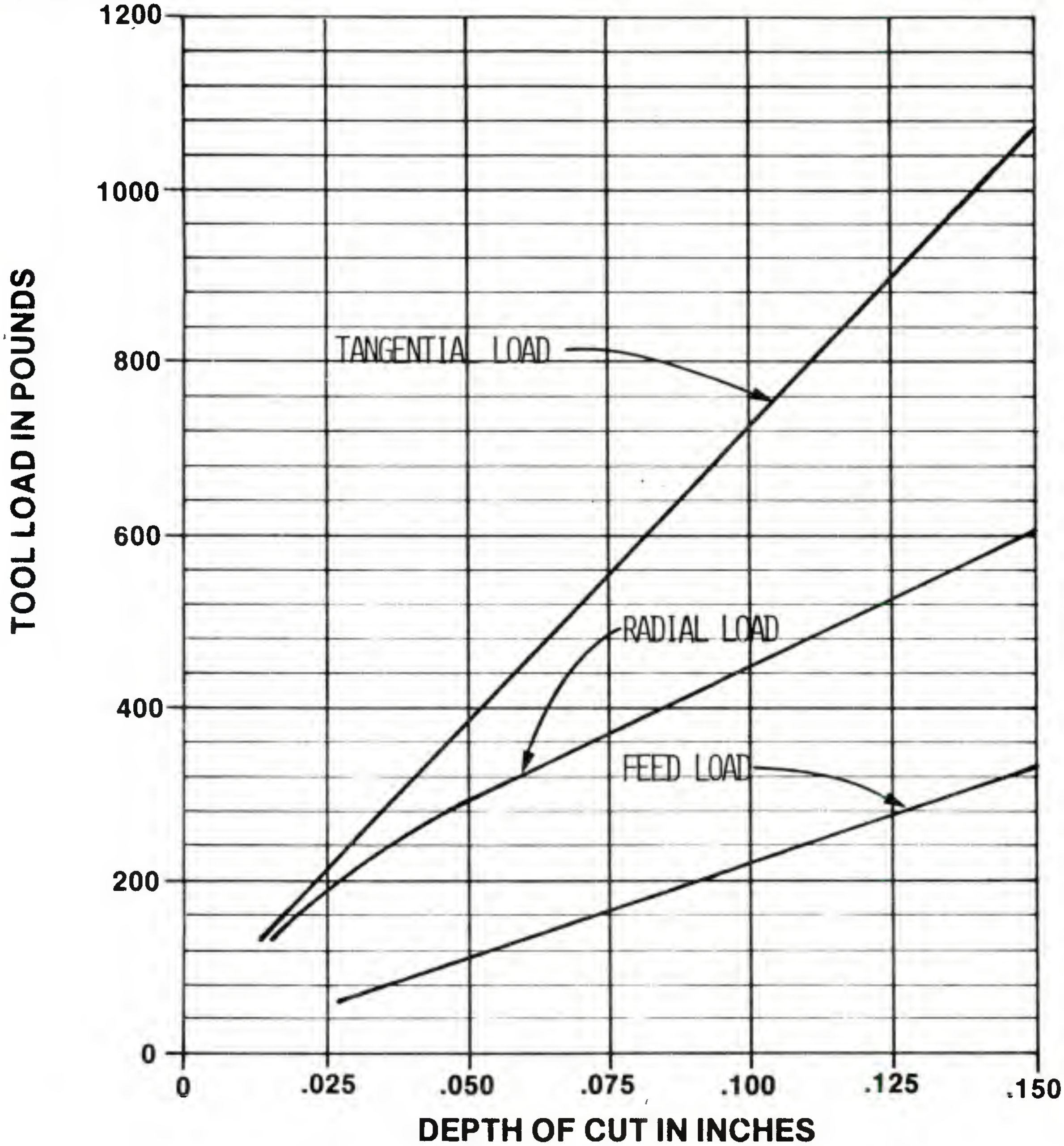

FIGURE 156 : TOOL LOAD CHART

TOOL LOAD VERSUS DEPTH OF CUT

MATERIAL: HF-1 **HOLDER:** CCGNR-164

HARDNESS: 387 BHN **INSERT:** RNG-54 .008" x 20°

SURFACE SPEED: 590 FT./MIN. **GRADE:** G-30

FEED RATE: .022 IN./REV. **COOLANT:** NONE

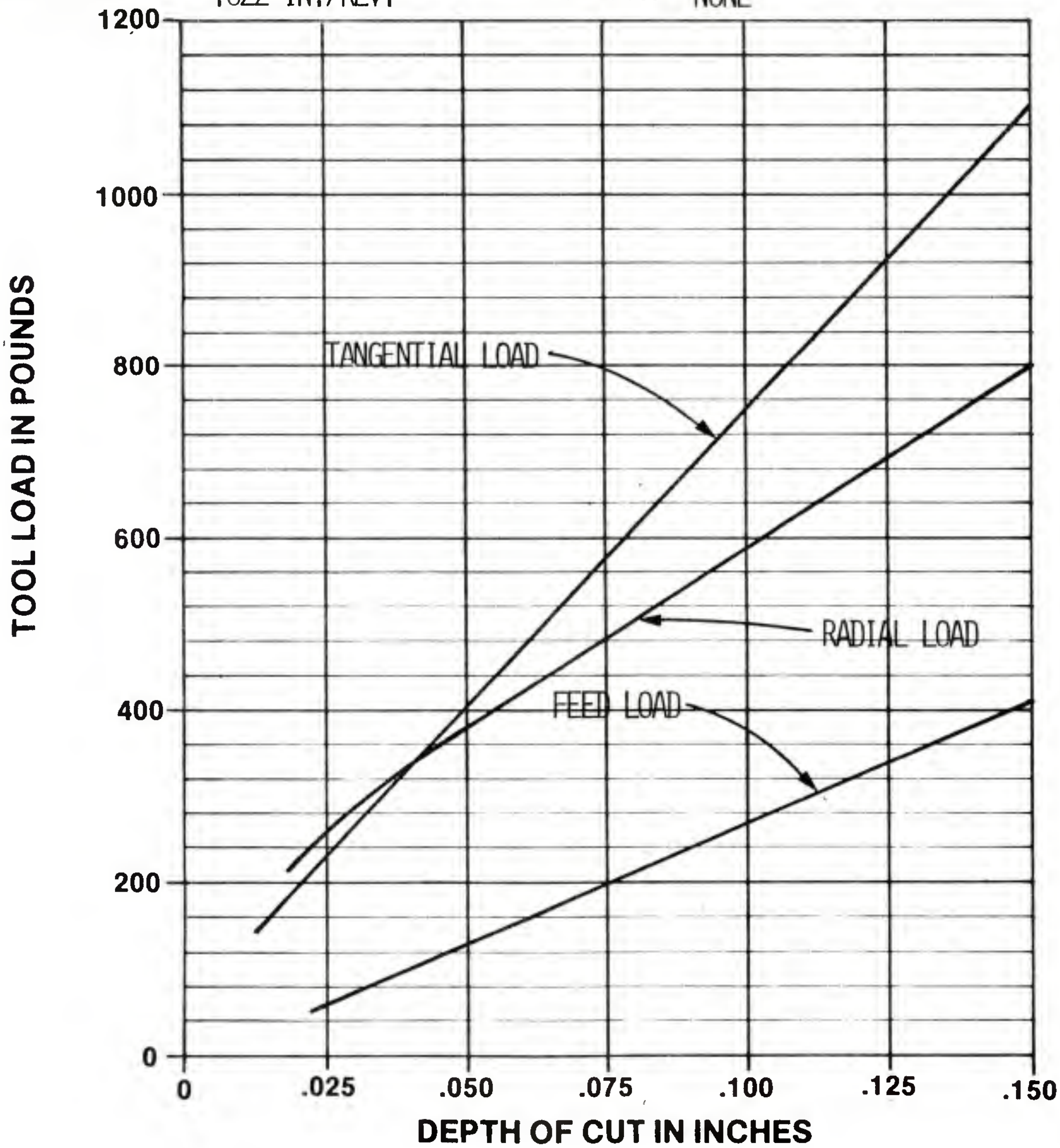

FIGURE 157 : TOOL LOAD CHART

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: HF-1 **HARDNESS:** 387 BHN

INSERT: TNMG-433 **SURFACE FEED:** 210 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 350 **FEEDRATE:** .011 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	125	50	110
.050	250	130	150
.100	480	270	180
.150	700	390	220

INSERT: TNMG-433 **SURFACE FEED:** 310 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: KC-810 **FEEDRATE:** .011 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	125	60	130
.050	240	140	170
.100	460	275	190
.150	660	410	220

INSERT: TNMG-433 **SURFACE FEED:** 340 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 570 **FEEDRATE:** .011 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	130	60	125
.050	240	135	160
.100	460	300	200
.150	680	460	225

TABLE 108: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: HF-1 **HARDNESS:** 387 BHN

INSERT: CNG-454 .008 x 20° **SURFACE FEED:** 610 FT./MIN **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .011 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	120	45	95
.050	220	100	135
.100	420	230	165
.150	600	345	190

INSERT: CNG-454 .008" x 20° **SURFACE FEED:** 590 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .011 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	120	45	100
.050	220	105	140
.100	420	240	180
.150	600	360	195

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025			
.050			
.100			
.150			

TABLE 109: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: HF-1 **HARDNESS:** 387 BHN

INSERT: RNMG-43 **SURFACE FEED:** 210 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 350 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	240	40	200
.050	420	100	300
.100	820	220	480
.150	1200	360	640

INSERT: RNMG-43 **SURFACE FEED:** 310 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: KC-810 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	260	60	340
.050	460	140	520
.100	840	320	800
.150	1200	560	1000

INSERT: RNMG-43 **SURFACE FEED:** 340 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: 570 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	240	40	220
.050	420	100	320
.100	800	220	500
.150	1140	320	640

TABLE 110: **DATA FOR TOOL LOAD CHARTS**

TABLE OF TOOL LOADS IN POUNDS VERSUS DEPTHS OF CUT IN INCHES FOR THE FOLLOWING TOOL MATERIALS OPERATING UNDER LISTED CONDITIONS.

MATERIAL: HF-1 **HARDNESS:** 387 BHN

INSERT: RNG-54 .008" x 20° **SURFACE FEED:** 610 FT./MIN. **COOLANT:** TRIM-SOL 20:1 TOP APPLIC.

GRADE: G-10 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	220	40	180
.050	400	100	290
.100	720	220	460
.150	1040	340	600

INSERT: RNG-54 .008" x 20° **SURFACE FEED:** 590 FT./MIN. **COOLANT:** NONE

GRADE: G-30 **FEEDRATE:** .022 IN./REV.

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025	240	50	250
.050	440	110	380
.100	760	260	580
.150	1080	420	800

INSERT: **SURFACE FEED:** **COOLANT:**

GRADE: **FEEDRATE:**

DEPTH OF CUT	TANGENTIAL TOOL LOAD	FEED TOOL LOAD	RADIAL TOOL LOAD
.025			
.050			
.100			
.150			

TABLE III: **DATA FOR TOOL LOAD CHARTS**

SURFACE SPEED VERSUS SURFACE FINISH

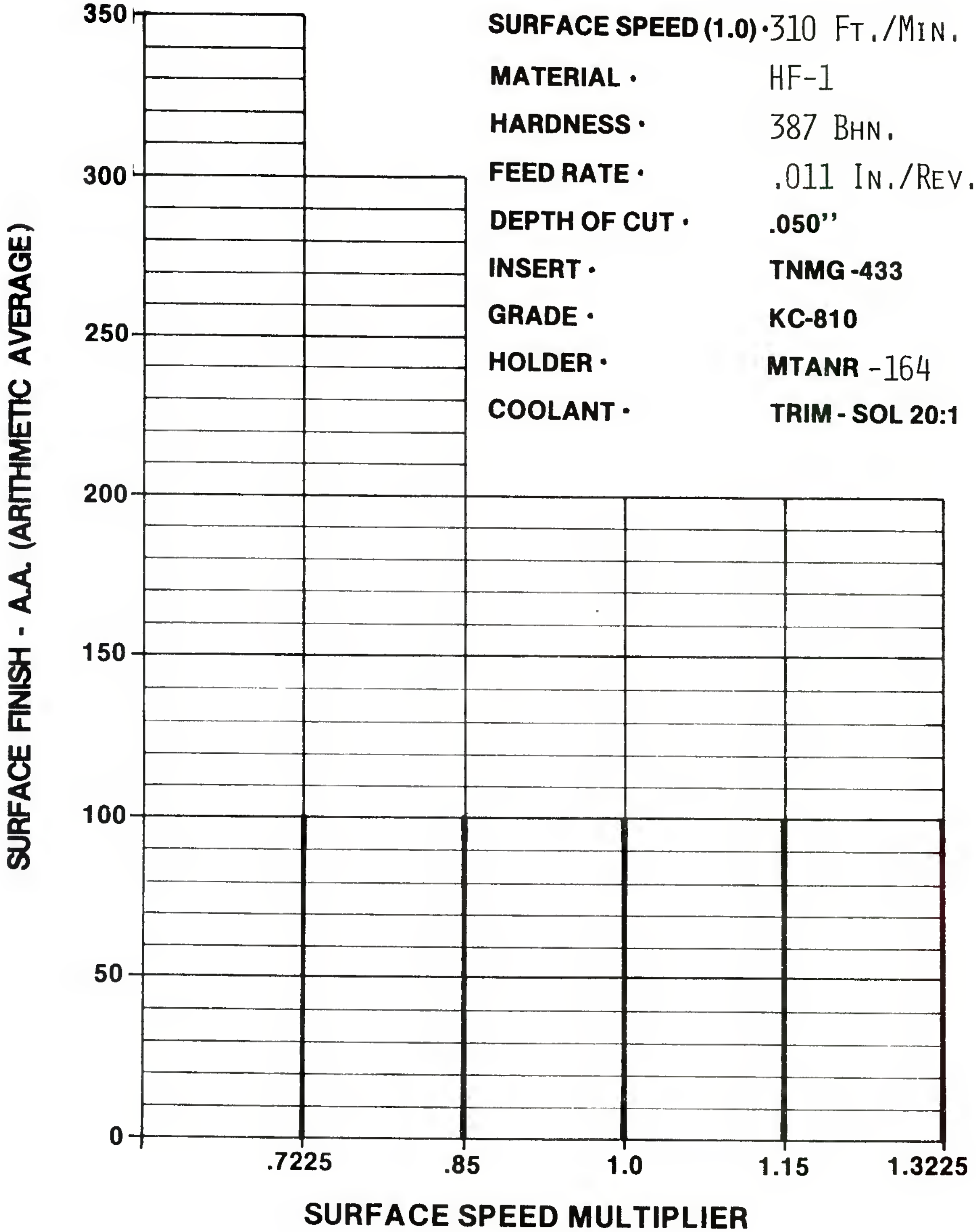

Figure 158

TOOL NOSE RADIUS VERSUS SURFACE FINISH

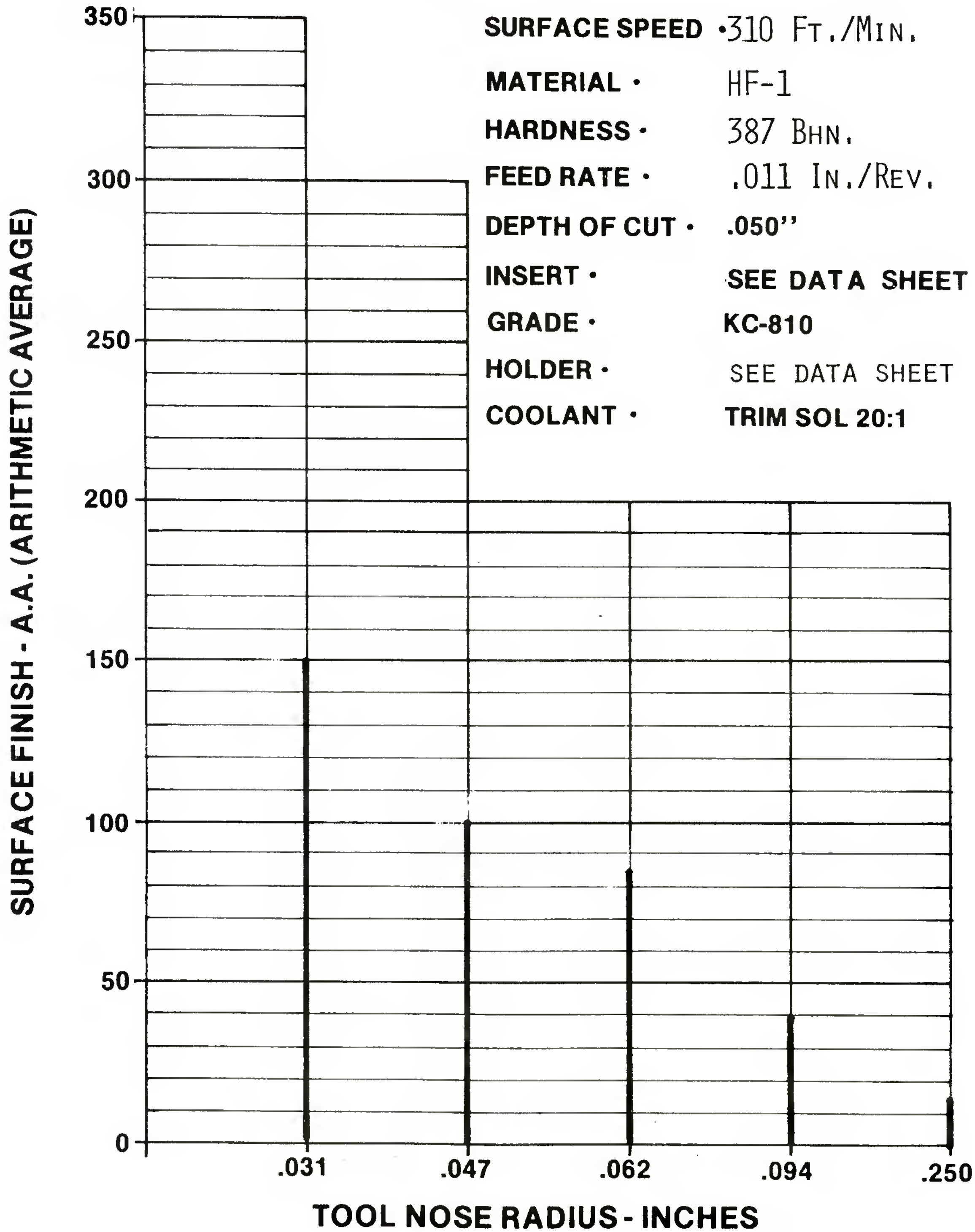

Figure 159

Date: 10/14/80

Material: HF-1

Depth of Cut: .050 Inches

Coolant: Trim - Sol 20:1

Hardness: 387 BHN

Tool Description:

Coolant Application: Top

Holder: MTANR-164

Insert: TNMG-433

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	NOSE RADIUS	SURFACE SPEED MULTIPLIER	SURFACE FINISH ARITHMETIC AVERAGE			
1	KC-810	225	.011		.7225	100			
2	"	265	"		.85	100			
3	"	310	"		1.0	100			
4	"	355	"		1.15	100			
5	"	410	"		1.3225	100			

NOTES:

TABLE 112: DATA FOR SURFACE FINISH TESTS

Date: 10/14/80

Material: HF-1

Depth of Cut: .050 Inches

Coolant: Trim - Sol 20:1

Hardness: 387 BHN

Tool Description: SEE NOTES

Coolant Application: Top

Holder:

Insert:

RUN NO.	CARBIDE GRADE	CUTTING SPEED-FT/MIN.	FEED IN./REV.	NOSE RADIUS	SURFACE SPEED MULTIPLIER	SURFACE FINISH ARITHMETIC AVERAGE			
1	KC-810	310	.011	.03125		150			
2	"	"	"	.0469		100			
3	"	"	"	.0625		85			
4	"	"	"	.09375		40			
5	"	"	"	.250		15			

NOTES:

TOOL HOLDER/INSERT
MTANR-164 TNMG-432
MTANR-164 TNMG-433
MTANR-164 TNMG-434
WRJNRS-205 TNMG-566
PRANR-854 RNMG-43
(.500" Ø ROUND INSERT)

TABLE 113: **DATA FOR SURFACE FINISH TESTS**

Conclusions:

1) The machining rates are significantly higher than those tabulated in the Machining Data Handbook, 3rd Edition.

2) A productivity increase of over 200% can be obtained in "rough" machining operations.

3) A productivity increase of over 400% can be obtained in "finish" machining operations.

4) Increased machining rates require machines with high horsepower and spindle speed control.

5) Chip-control is a problem in finish machining operations.

Recommendations:

1) The machining data figures are derived from extrapolated values, and should be verified by machining metal forgings in the "as forged" (roughing cuts) and in the "nosed and heat-treated" (finishing cuts) conditions, for the 4 materials studied in this effort.

2) Machines used in the fabrication of projectile metal parts should have infinite speed control through applicable speed ranges, feed-control of the tool through its required path, and control over the tool path.

3) Chip-breaking should be investigated to assure good chip-control.

4) Use of ceramic cutting tools should be seriously considered for all machining operations.

5) When ceramic cutting tools are applied, tool holders should be arranged to accept thicker inserts, have a stable insert seat, and a low profile, rugged clamping device.

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