



Eaton Corporation

Vehicle Group-Valvetrain

19218 B Drive South

Marshall, Michigan 49068

269/781-0200

Background:

Materials and Basic Processes Report

Prepared By

E. Vincent

Work Done By

E. Vincent

Date

20 Sept. 2017

Pages

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26 specimens (P/N 329273 see appendix) were received at Eaton-Marshall from AISI for RBF testing at room temperature. The specimens were vacuum carburized and gas quenched by Dana with no finish grinding after heat treatment. The test machine is a Fatigue Dynamics RBF-200 operating at 4,500rpm in air. The beam load (in-lbs) was calculated using the bar diameter in the gage section. Specimens were tested until fracture or suspension at 10,000,000cycles.



Fatigue Dynamics RBF-200

Objective:

1. Perform metallurgical characterization on representative post-test RBF specimens.

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Findings:

1. Sample Blue-30 tested at 120 KSI for 44,360 cycles was selected for metallurgical analysis.
2. The sub-surface hardness at 0.05 mm is 61.6 HRC converted from HV0.5.
3. The case depth is 0.386 mm.
4. Etched micrographs exhibit a typical carburized case and core microstructure.

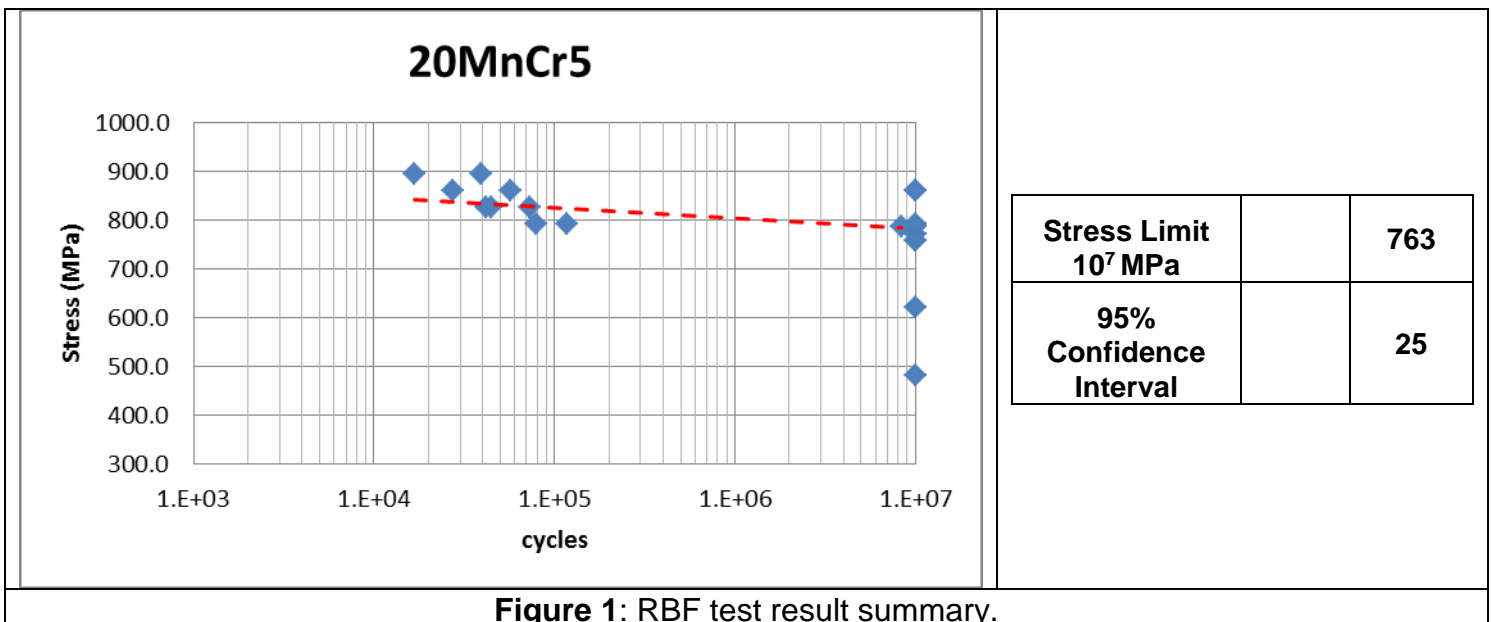


Figure 1: RBF test result summary.

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Table 1: RBF test data.

Specimen #	Material	Gage	Runout	cycles to failure on SN Curve	Stress	
		Diameter			ksi	MPa
blue-26	20MnCr5	6.383	0.01524	10,000,000	70	482.7
blue-27	20MnCr5	6.312	0.01016	10,000,000	90	620.6
blue-29	20MnCr5	6.358	0.04318	10,000,000	110	758.5
blue-33	20MnCr5	6.368	0.02286	10,000,000	110	758.5
blue-35	20MnCr5	6.365	0.04826	10,000,000	112	772.2
blue-36	20MnCr5	6.36	0.01778	10,000,000	114	786.0
blue-37	20MnCr5	6.385	0.03556	10,000,000	114	786.0
blue-38	20MnCr5	6.373	0.0381	8,335,290	114	786.0
blue-31	20MnCr5	6.36	0.01524	79,020	115	792.9
blue-32	20MnCr5	6.364	0.06096	117,020	115	792.9
blue-39	20MnCr5	6.37	0.03556	10,000,000	115	792.9
blue-30	20MnCr5	6.349	0.02794	44,360	120	827.4
blue-34	20MnCr5	6.364	0.0127	41,720	120	827.4
blue-40	20MnCr5	6.368	0.04318	72,600	120	827.4
blue-42	20MnCr5	6.361	0.03302	10,000,000	125	861.9
blue-45	20MnCr5	6.355	0.0762	27,210	125	861.9
blue-46	20MnCr5	6.347	0.08636	57,050	125	861.9
blue-47	20MnCr5	6.358	0.01778	10,000,000	125	861.9
blue-49	20MnCr5	6.356	0.02032	16,750	130	896.4
blue-50	20MnCr5	6.373	0.02032	38930	130	896.4

Table 2: Representative sample test history.

Sample	Stress (KSI)	Test Temp.	Cycles
Blue-30	120	R.T.	44,360



Figure 2: Blue-30 representative test sample.

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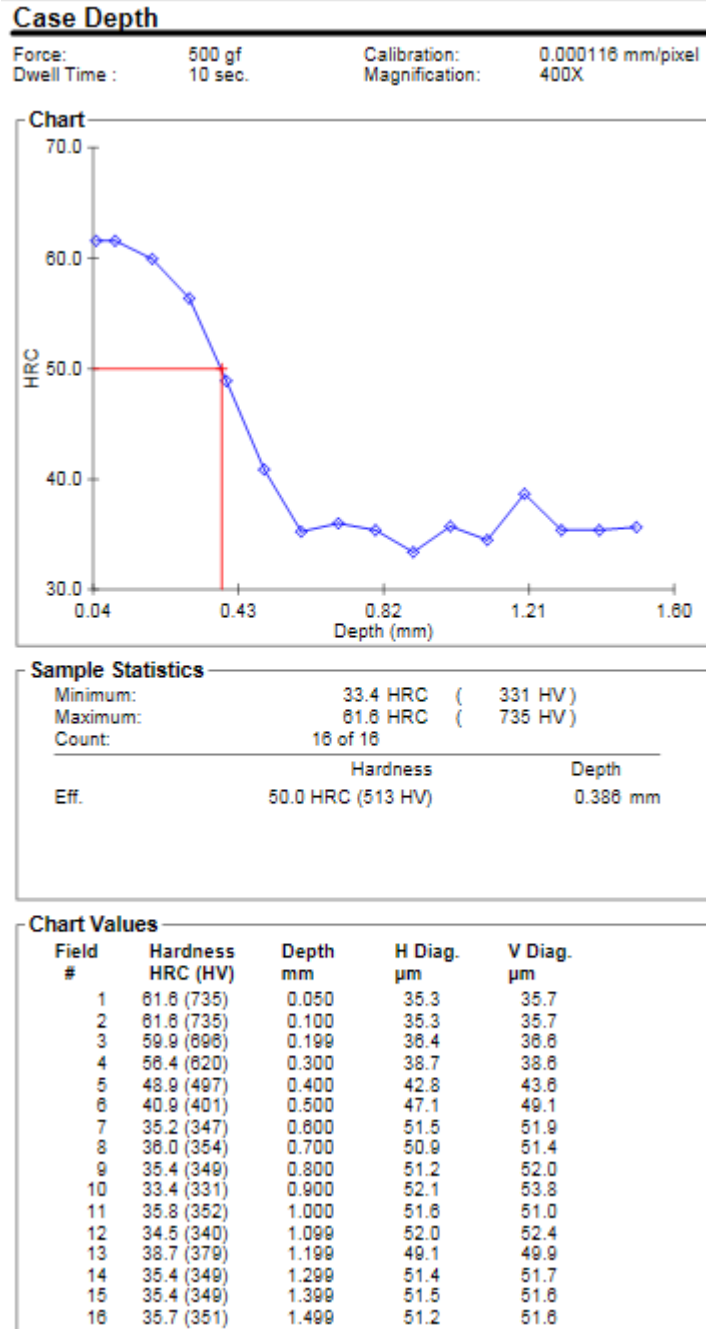


Figure 3: Case depth measurement, 0.386 mm measured HV0.5 converted to HRC. Sub-surface hardness at 0.05mm is 61.6 HRC.

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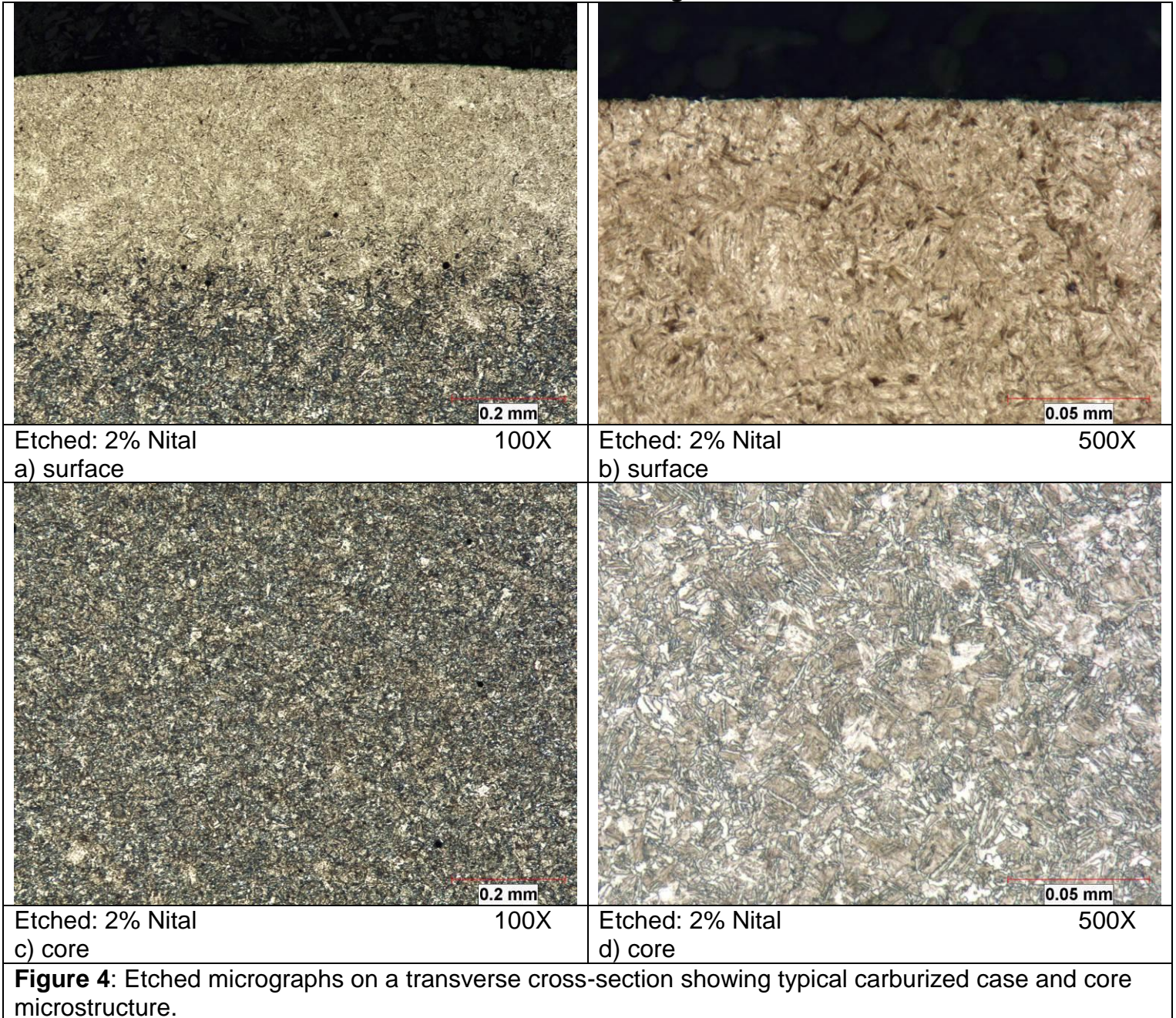
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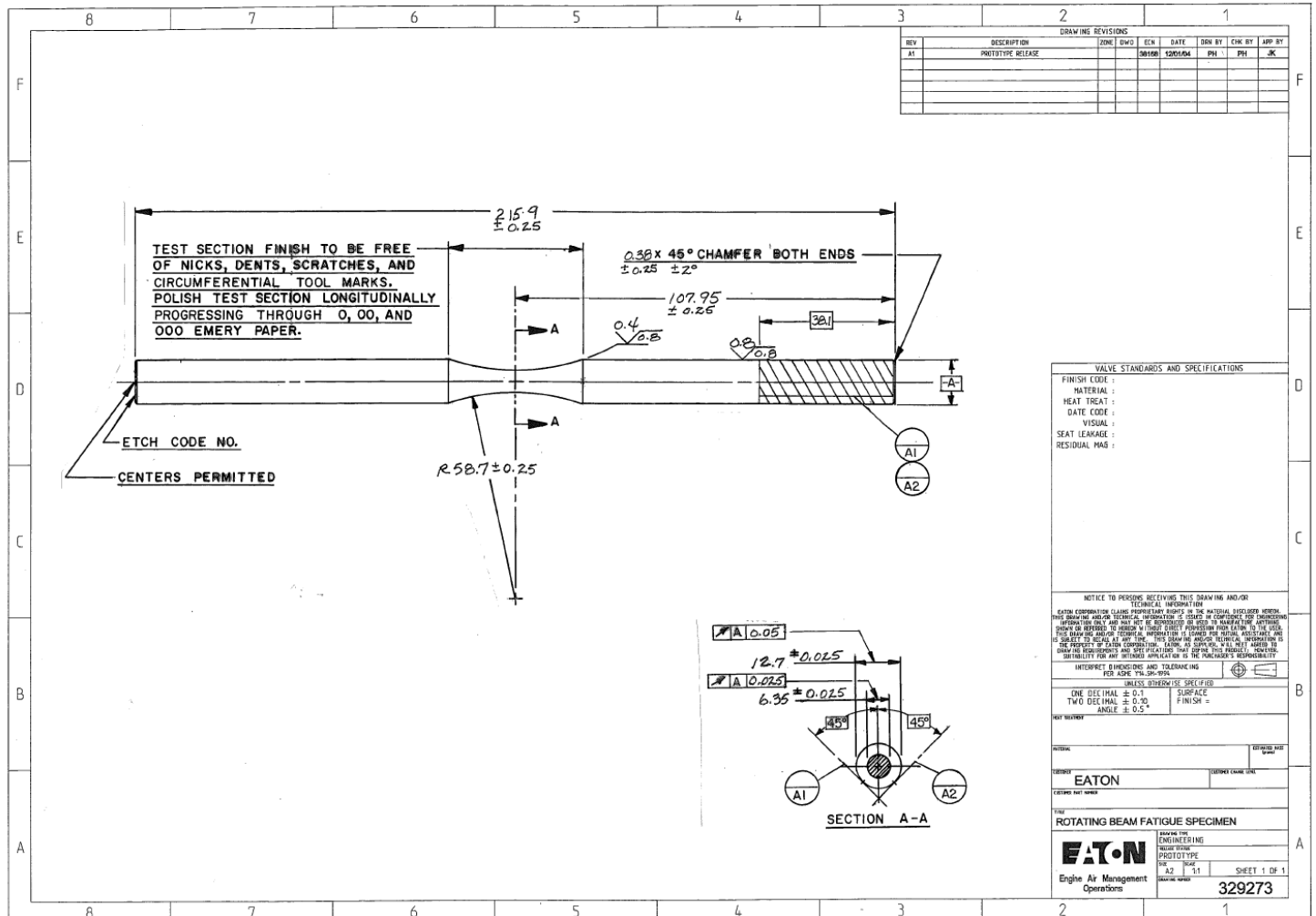


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APPENDIX



RBF Specimen

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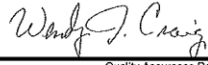
GERDAU SPECIAL STEEL NORTH AMERICA
 5591 MORRILL ROAD
 JACKSON, MICHIGAN 49201

CERTIFIED MATERIAL TEST REPORT

CUSTOMER ORDER NUMBER	CUSTOMER PART NUMBER	HEAT NUMBER	WORK ORDER NUMBER	DATE
6000005089	17512	M53903	286844 101	4/21/14

Danieli Cast

ORDERED

GRADE	SIZE	LENGTH									
20MNCRS5	1.826" RND	25' 8 5/8"									
CUSTOMER SPECIFICATIONS											
MAT17512 DTD 06/05/13; GCG 805000 02 REV 01:2007-04											
CHEMICAL ANALYSIS											
C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Sn	Al	
0.18	1.20	0.010	0.030	0.21	0.16	1.11	0.04	0.21	0.008	0.034	
V	B	Ca	Ti	Nb	N	H	O	Pb	Zr	Sb	
0.002	0.0007	0.0011	0.004	0.002	0.0097	2.3000	0.0008	0.0006	0.0020	0.003	
As	Zn										
0.003	0.004										
GRAIN SIZE			SPECIFICATION EN ISO 643			AUSTENITIC					
GRAIN - Front/Middle/Back = 8.0											
HARDNESS			SPECIFICATION ASTM E10			AFT STRAIGHTEN					
			CENTER	MID RADIUS	SURFACE						
			194.0	176.0	176.0						
PAGE 1			We certify that these data are correct and in compliance with specified requirements.								
Gerdau Monroe 3000 East Front Street Monroe, MI 48161			 Wendy J. Craig <small>Quality Assurance Representative</small>								

CONTINUED ON PAGE 2

Material Certification

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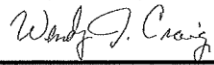
GERDAU SPECIAL STEEL NORTH AMERICA
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CERTIFIED MATERIAL TEST REPORT

CUSTOMER ORDER NUMBER 6000005089	CUSTOMER PART NUMBER 17512	HEAT NUMBER M53903	WORK ORDER NUMBER 286844 1.01	DATE 4/21/14
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Danielli Cast

ORDERED

GRADE 20MNCRS5	SIZE 1.826" RND	LENGTH 25' 8 5/8"
CUSTOMER SPECIFICATIONS MAT17512 DTD 06/05/13; GCG 805000 02 REV 01:2007-04		
HARDENABILITY	SPECIFICATION SEP 1664	CALCULATED
THEORETICAL		
1		
.		
1 5 2 3 4 5 6 7 8 9 10 11 13 15 20 25 30 35 40 45 50		
AVE	44 43 41 38 35 33 31 30	
OXYGEN	SPECIFICATION GCG_805000 PART_02	
AVE:	8.0 ppm	
AL/N RATIO	SPECIFICATION GCG_805000 PART_02	
RATIO= 3.51		
DECARB	SPECIFICATION ASTM E1077	
F	TOTAL= 0.005	
K RATING	SPECIFICATION GCG_805000 PART_02	
K RATING TO 3 = 22.1		
REDUCTION RATIO	SPECIFICATION GCG_805000 PART_02	
RATIO= 13.7 TO 1.0		
PAGE 2		
We certify that these data are correct and in compliance with specified requirements.		
Gerdau Monroe 3000 East Front Street Monroe, MI 48161	 Wendy J. Craig Quality Assurance Representative	

Material Certification Cont.

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