BUEHLER SERVICE

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Certificate of Calibration

Customer Site

ECHO INC.
400 OAKWOOD RD.

LAKE ZURICH IL 60047

ACCREDITED 2237.01 Calibration

Certificate - 2578-1

Original

This certifies that the Hardness Tester listed has been calibrated in accordance with **ASTM E384-11e1**
verification procedures and incorporating the requirements of ISO 17025-2005. Stage Micrometers used for measuring eyepiece are traceable to N.I.S.T. and all test blocks used were standardized on a verified tester with loads traceable to N.I.S.T. Uncertainty was calculated using a factor of K=2 with a confidence level of 95%.

Model Number	**TUKON 1202**	*Location Calibrated*		**Customer Site**		
Serial Number	**1202-02-0170**	*Condition of Equipment as Found*		**Good**		
Asset #/PO #	**PH86914 N/A**	Indenter(s)	Vickers	**EV002873**	Knoop	

Measuring Microscope

These measurements are not part of the ASTM E384-11e1 indirect method and are for reference only. Therefore, this section of the report is not accredited by A2LA.

Stage Micrometer #	14504	with a	50X	Objective		
Nominal Length (µm)	*0*	*20*	*60*	*100*	*200*	*Result*
Readings as found (µm)	**0.00**	**20.00**	**59.60**	**99.70**	**199.10**	**Pass**
Readings as left (µm)	**0.00**	**20.00**	**59.60**	**99.70**	**199.10**	**Pass**
± Tolerance (µm)	*0.4*	*0.4*	*0.4*	*0.5*	*1*	
Uncertainty	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	

Environmental Data

Start			**Finish**	
Temp (F.) **71**	Humidity **21.7%**		Temp (F.) **71**	Humidity **26.6%**

Summary of Hardness Tester Results

See page 5 for additional notes and information on any deviations.

Test Block	Readings as Found				Readings as Left			
	Tol +/-	Actual	Error %	Pass/Fail	Actual	Error %	Pass/Fail	Uncertainty
718HV0.3	31	742	1.51	Pass	742	1.51	Pass	27
500HV1.0	20	495	0.54	Pass	495	0.54	Pass	14
-	-	-	-			-		-
-	-	-	-			-		-

X

Report Date: *January 29, 2016*
Requested Due Date: *January 28, 2017*

Data Sheet
(As Found)

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Stage Micrometer #	14504	with a	50X	Objective			
Nominal Length (µm)		*0*	*20*	*60*	*100*	*200*	*Result*
Readings as Found (µm)		**0.00**	**20.00**	**59.60**	**99.70**	**199.10**	**Pass**
± Tolerance (µm)		**0.4**	**0.4**	**0.4**	**0.5**	**1.0**	
Result		*Pass*	*Pass*	*Pass*	*Pass*	*Pass*	

Test Block # 1	39LS
Ave Hardness	718.0
Load (gf)	300
Indenter type	Vickers
Diagonals	27.8
Uncertainty (a)	0.22
Resolution (b)	0.10

	D_2	D_1	Average	Hardness
1	27.5	27.5	27.50	735
2	27.5	27.4	27.45	738
3	27.2	27.7	27.45	738
4	26.6	27.4	27.00	763
5	27.6	27.4	27.50	735
		Average	27.38	742

Error (µ)	0.42	Pass
Repeatability	1.83%	Pass
Result	Pass	
Range (c)	0.5	

U_1 $\frac{t_1}{2}$	U_2 $\frac{b}{1.732}(1000)$	U_3	Combined Uncertainty $\sqrt{(U_1)^2+(U_2)^2+(U_3)^2}$	Expanded Uncertainty (mm) *Combined Uncertainty * 2*	Expanded Uncertainty (%)	
0.00011	5.77367E-05	0.000500	0.000515202	0.001030405	3.71%	
					Vickers	27

Test Block # 2	63LR
Ave Hardness	500.0
Load (gf)	1000
Indenter type	Vickers
Diagonals	60.9
Uncertainty (a)	0.44
Resolution (b)	0.10

	D_2	D_1	Average	Hardness
1	61.0	60.8	60.90	500
2	61.8	61.6	61.70	487
3	61.2	61.1	61.15	496
4	61.2	61.1	61.15	496
5	61.2	61.3	61.25	494
		Average	61.23	495

Error (µ)	0.33	Pass
Repeatability	1.31%	Pass
Result	Pass	
Range (c)	0.8	

U_1 $\frac{t_1}{2}$	U_2 $\frac{b}{1.732}(1000)$	U_3	Combined Uncertainty $\sqrt{(U_1)^2+(U_2)^2+(U_3)^2}$	Expanded Uncertainty (mm) *Combined Uncertainty * 2*	Expanded Uncertainty (%)	
0.00022	5.77367E-05	0.000800	0.000831705	0.00166341	2.73%	
					Vickers	14

The reported uncertainty uses a coverage factor of K=2, representing a confidence level of 95%.

Data Sheet
(As Found)

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Test Block # 3	
Ave Hardness	
Load (gf)	
Indenter type	
Diagonals	
Uncertainty (a)	
Resolution (b)	

	D_2	D_1	Average	Hardness
1				
2				
3				
4				
5				
		Average		

Error (μ)		
Repeatability		
Result		
Range (c)		

U_1 $\frac{a}{2}$	U_2 $\frac{b}{1.732}(1000)$	U_3	Combined Uncertainty $\sqrt{(U_1)^2+(U_2)^2+(U_3)^2}$	Expanded Uncertainty (mm) *Combined Uncertainty * 2*	Expanded Uncertainty (%) *Combined Uncertainty * 2*
-	-	-	-	-	-
					0
					#VALUE!

Test Block # 4	
Ave Hardness	
Load (gf)	
Indenter type	
Diagonals	
Uncertainty (a)	
Resolution (b)	

	D_2	D_1	Average	Hardness
1				
2				
3				
4				
5				
		Average		

Error (μ)		
Repeatability		
Result		
Range (c)		

U_1 $\frac{a}{2}$	U_2 $\frac{b}{1.732}(1000)$	U_3	Combined Uncertainty $\sqrt{(U_1)^2+(U_2)^2+(U_3)^2}$	Expanded Uncertainty (mm) *Combined Uncertainty * 2*	Expanded Uncertainty (%) *Combined Uncertainty * 2*
-	-	-	-	-	-
					0
					#VALUE!

The reported uncertainty uses a coverage factor of K=2, representing a confidence level of 95%.

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Stage Micrometer #	14504	with a	50X	Objective			
Nominal Length (µm)		*0*	*20*	*60*	*100*	*200*	*Result*
Readings as Left (µm)		**0.00**	**20.00**	**59.60**	**99.70**	**199.10**	**Pass**
± Tolerance (µm)		**0.4**	**0.4**	**0.4**	**0.5**	**1.0**	
Result		*Pass*	*Pass*	*Pass*	*Pass*	*Pass*	

Test Block # 1	39LS
Ave Hardness	718.0
Load (gf)	300
Indenter type	Vickers
Diagonals	27.8
Uncertainty (a)	0.22
Resolution (b)	0.10

	D_2	D_1	Average	Hardness	
1	27.5	27.5	27.50	735	
2	27.5	27.4	27.45	738	
3	27.2	27.7	27.45	738	
4	26.6	27.4	27.00	763	
5	27.6	27.4	27.50	735	
		Average	27.38	742	
			Error (µ)	0.42	Pass
			Repeatability	1.83%	Pass
			Result	Pass	
			Range (c)	0.5	

U_1 $\frac{a}{2}\frac{1}{1000}$	U_2 $\frac{b}{1.732}(1000)$	U_3	Combined Uncertainty $\sqrt{(U_1)^2+(U_2)^2+(U_3)^2}$	Expanded Uncertainty (mm) *Combined Uncertainty * 2*	Expanded Uncertainty (%)	
0.00011	5.77367E-05	0.0005	0.000515202	0.001030405	3.71%	
					Vickers	27

Test Block # 2	63LR
Ave Hardness	500
Load (gf)	1000
Indenter type	Vickers
Diagonals	60.9
Uncertainty (a)	0.44
Resolution (b)	0.10

	D_2	D_1	Average	Hardness	
1	61.00	60.80	60.90	500	
2	61.80	61.60	61.70	487	
3	61.20	61.10	61.15	496	
4	61.20	61.10	61.15	496	
5	61.20	61.30	61.25	494	
		Average	61.23	495	
			Error (µ)	0.33	Pass
			Repeatability	1.31%	Pass
			Result	Pass	
			Range (c)	0.80	

U_1 $\frac{a}{2}\frac{1}{1000}$	U_2 $\frac{b}{1.732}(1000)$	U_3	Combined Uncertainty $\sqrt{(U_1)^2+(U_2)^2+(U_3)^2}$	Expanded Uncertainty (mm) *Combined Uncertainty * 2*	Expanded Uncertainty (%)	
0.00022	5.77367E-05	0.0008	0.000831705	0.00166341	2.73%	
					Vickers	14

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Test Block # 3	
Ave Hardness	
Load (gf)	
Indenter type	
Diagonals	
Uncertainty (a)	
Resolution (b)	

	D_2	D_1	Average	Hardness
1				
2				
3				
4				
5				
		Average		
			Error (μ)	
			Repeatability	
			Result	
			Range (c)	

U_1	U_2	U_3	Combined Uncertainty $\sqrt{\left(U_1\right)^2+\left(U_2\right)^2+\left(U_3\right)^2}$	Expanded Uncertainty (mm) *Combined Uncertainty * 2*	Expanded Uncertainty (%)	
$\frac{1}{2}$	$\frac{b}{1.732}(1000)$					
-	0.000058	-	-	-	-	
					0	#VALUE!

Test Block # 4	
Ave Hardness	
Load (gf)	
Indenter type	
Diagonals	
Uncertainty (a)	
Resolution (b)	

	D_2	D_1	Average	Hardness
1				
2				
3				
4				
5				
		Average		
			Error (μ)	
			Repeatability	
			Result	
			Range (c)	

U_1	U_2	U_3	Combined Uncertainty $\sqrt{\left(U_1\right)^2+\left(U_2\right)^2+\left(U_3\right)^2}$	Expanded Uncertainty (mm) *Combined Uncertainty * 2*	Expanded Uncertainty (%)	
$\frac{1}{2}$	$\frac{b}{1.732}(1000)$					
-	-	-	-	-	-	
					0	#VALUE!

The reported uncertainty uses a coverage factor of K=2, representing a confidence level of 95%.

Additional Comments: