Institute of Paper Science and Technology

AN INDUSTRY WIDE ROUND ROBIN ON THE TENSILE PROPERTIES AND TEAR RESISTANCE OF MULTIWALL BAG PAPER

A Progress Report

to

THE KRAFT AND PACKAGING PAPERS DIVISION

OF THE

THE AMERICAN FOREST AND PAPER ASSOCIATION

Project 3679

Report Two

January 10, 1994

IPST

Atlanta, Georgia

INSTITUTE OF PAPER SCIENCE AND TECHNOLOGY
PURPOSE AND MISSION STATEMENT

The Institute of Paper Science and Technology is a unique organization whose charitable, educational, and scientific purpose evolves from the singular relationship between the Institute and the pulp and paper industry which has existed since 1929. The purpose of the Institute is fulfilled through three missions, which are:

- to provide high quality students with a multidisciplinary graduate educational experience which is of the highest standard of excellence recognized by the national academic community and which enables them to perform to their maximum potential in a society with a technological base; and
- to sustain an international position of leadership in dynamic scientific research which is participated in by both students and faculty and which is focused on areas of significance to the pulp and paper industry; and
- to contribute to the economic and technical well-being of the nation through innovative educational, informational, and technical services.

ACCREDITATION

The Institute of Paper Science and Technology is accredited by the Commission on Colleges of the Southern Association of Colleges and Schools to award the Master of Science and Doctor of Philosophy degrees.

NOTICE AND DISCLAIMER

The Institute of Paper Science and Technology (IPST) has provided a high standard of professional service and has put forth its best efforts within the time and funds available for this project. The information and conclusions are advisory and are intended only for internal use by any company who may receive this report. Each company must decide for itself the best approach to solving any problems it may have and how, or whether, this reported information should be considered in its approach.

IPST does not recommend particular products, procedures, materials, or service. These are included only in the interest of completeness within a laboratory context and budgetary constraint. Actual products, procedures, materials, and services used may differ and are peculiar to the operations of each company.

In no event shall IPST or its employees and agents have any obligation or liability for damages including, but not limited to, consequential damages arising out of or in connection with any company's use of or inability to use the reported information. IPST provides no warranty or guaranty of results.

THE INSTITUTE OF PAPER SCIENCE AND TECHNOLOGY

Atlanta, Georgia

AN INDUSTRY WIDE ROUND ROBIN ON THE TENSILE PROPERTIES AND TEAR RESISTANCE OF MULTIWALL BAG PAPER

Project 3679

Report Two

A Progress Report

TO

THE KRAFT AND PACKAGING PAPERS DIVISION

OF THE

THE AMERICAN FOREST AND PAPER ASSOCIATION

January 10, 1994

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Laboratories who test multiwall bag paper at mill sites and in converting plants were invited to participate in round robin testing of tear and tensile properties. Twenty six laboratories, including 2 converting plants and the laboratory of the Institute of Paper Science and Technology (IPST) responded.

The results suggest that industry wide variability in the measurement of strength properties is significantly greater than can be accounted for by product variability.

It is the intent of this project that individual laboratories will use the results as a guide toward improvements in instrument calibration and testing methodology.

INTRODUCTION

Important performance properties of multiwall bag paper include tensile strength, stretch, tensile energy absorption, and tear resistance. These properties are routinely measured in mill laboratories as an indicator of product quality. Converters may also measure these properties to help ensure that the bags they produce conform to the requirements of Uniform Freight Classification Rule 40.

The test results obtained by any laboratory will depend on the accuracy of calibration of test instruments, the closeness with which the laboratory follows the prescribed TAPPI test methods, the relative humidity of the testing atmosphere, and the property distribution of the population from which the test sample is taken. Hence it is not usually known whether reported differences in properties from two or more mills is a true indicator of differences in product quality.

This study was undertaken to provide information to testing laboratories on how closely their test results agree with comparable results from other laboratories when testing the same product. No attempt will be made to statistically analyze the data. Instead, it is hoped that individual laboratories whose results differ significantly from "population averages" will closely examine their testing procedures and then take steps aimed at minimizing industry variability.

SAMPLES AND PROCEDURES

This round robin study included one flat and one extensible sample each of 40, 50, 60, and 70 lb. multiwall bag paper. The samples were selected from those submitted to IPST for KPPD Project 3679 (Report One, January 5, 1994). In each case the sample selected was the one having the smallest variability and for which enough material was available for the round robin.

For each sample, all specimens were taken from the same 12-inch cross reel position. Individual test specimens for MD and CD tensile and tear were cut in the IPST laboratory. These were randomized and distributed so that each participating laboratory could make 10 tests for each test variable.

Not all test laboratories have preconditioning capability. To ensure that this would not be an added source of variability, the samples were all first preconditioned and conditioned in accord with TAPPI test requirements, in the IPST laboratory. The individual packets were then sealed in vapor proof enclosures. Participating laboratories were then instructed to open the pack only in a 50% RH testing environment.

TEST RESULTS

The results submitted by the participating laboratories are tabulated in Tables I- VIII. Three of the packets were tested by IPST and these are identified in the tables. All other laboratories are identified by a letter code. Two of these were converter labs and the rest were mill labs.

Three of the laboratories reported that tensile properties were measured using a pendulum instrument in accord with TAPPI method T404. All other laboratories used a CRE instrument in accord with TAPPI method T494. All laboratories reported using a "new style" tear tester having a cut out in the pendulum sector.

Distribution of test results from participating laboratories is shown graphically in Figures 1 - 32. Data plotted as an x in these figure indicate IPST results. The results from a few laboratories did not fit the sample distribution established by all participating laboratories. These are marked with an * in the tables and are not included in the figures.

Table I
PROPERTIES OF 40 LB FLAT MULTIWALL BAG PAPER

Lab Code	Tensile, lb/in MD		CD		Stretch, % MD		CD		TEA, ft lb/sq ft MD		CD		Tear, g MD		CD	
A	27.8		14.4		1.53		3.65		2.85		4.68		63.2		75.2	
B	28.6		14.7		1.33		3.89		2.92		5.23		66.4		76.9	
C	30.3		15.0		1.37		3.62		3.14		4.98		64.4		75.6	
D	31.1		15.2		1.39		3.46		3.23		4.83		62.8		72.7	
E	28.2		14.9		1.92		4.47	*	3.97		6.13	*	66.0		76.3	
F	28.0		15.0		1.48		4.13						64.8		74.9	
Gx	30.2		17.3										67.8		73.4	
H	25.9		14.6	*	1.35		3.57		2.55		4.77		65.6		78.4	
I	30.7		15.6		1.24		3.42		2.80		4.86		52.0		69.3	*
J	31.6		17.0										66.8		64.9	
K													68.0		80.0	
L	28.6		15.6		1.53		3.89		3.04		5.51		65.2		73.2	
M	29.6		15.1		1.50		3.71		3.17		5.08		59.3		75.5	*
N	29.7		15.6		1.31		3.78		2.99		5.38		68.2		79.3	
O	30.1		15.9		1.47		3.84		3.14		5.48		64.9		74.2	
P	28.7		13.5		1.29		3.02	*					64.8		73.8	
Q	30.0		15.1		1.32		3.38						64.0		70.4	
R	30.8		15.5		1.44		3.38						64.0		78.4	
S	28.9		14.9		1.37		3.47		2.87		4.65		62.4		74.1	
T	28.5		15.8		1.27		3.58		2.60		5.18		68.1		79.8	
Ux	29.2		16.5										65.6		82.8	
Vx	27.1		14.9										63.9		79.3	
W	28.0		15.0		1.57		4.51		3.11		6.08		65.3		76.3	
X	27.2		15.2		1.80		4.70	*					65.9		80.2	
Y	29.7		14.7		1.43		3.63									
Z	30.1		15.5										65.5		79.0	
IPST-1	28.9		14.8		1.32		3.52		2.83		4.80		65.3		72.3	
IPST-2	29.4		14.5		1.38		3.56		2.71		4.72		65.1		75.8	
IPST-3	29.8		15.3		1.35		3.43		2.77		4.95		65.6		77.8	
Avg.	29.2		15.2		1.43		3.72		2.98		5.14		64.7		75.7	
S.D.	1.3		0.8		0.16		0.40		0.32		0.45		3.1		3.8	

NOTE: A * following a value indicates that either the MD, CD, or both test results are significantly different than the expected distribution as defined by the TAPPI procedure for rejecting an outlying result. These data are not included in Figures 1 to 32.

Table II
PROPERTIES OF 50 LB FLAT MULTIWALL BAG PAPER

Lab Code	Tensile, lb/in MD	CD	Stretch, % MD	CD	TEA, ft lb/sq ft MD	CD	Tear, g MD	CD
A	32.1	22.3	1.91	2.53	4.31	4.56 *	106	117
B	32.4	24.0	1.58	2.95	3.98	6.11	108	118
C	32.9	23.9	1.67	2.74	4.16	5.67	108	120
D	33.0	25.3	1.67	2.61	3.93	5.48	105	112
E	33.6	25.6	2.22	3.56	5.52	7.55 *	108	118
F	30.3	23.5	1.70	2.85			110	125
Gx	32.2	25.7					108	112
H	31.2	24.5	1.57	2.66	3.51	5.54	111	130
I	33.2	25.6	1.43	2.53	3.71	5.59	110	144 *
J	32.5	26.6					103	100 *
K							96	112
L	31.5	23.1	1.66	2.70	3.80	5.01	110	115
M	33.8	25.6	1.81	3.12	4.47	6.63	101	118
N	32.7	26.4	1.57	2.88	4.01	6.48	106	120
O	32.1	24.5	1.74	2.83	4.13	5.84	104	117
P	32.4	24.0	1.62	2.60			102	112
Q	31.3	26.2	1.61	3.02			112	112
R	31.4	25.9	1.60	2.69			106	112
S	31.2	23.4	1.59	2.66	3.65	5.26	107	117
T	33.7	25.5	1.51	2.53	3.79	5.36	106	120
Ux	34.2	25.5					112	117
Vx	31.7	23.3					107	122
W	31.1	24.3	1.84	3.29	4.17	6.62	111	131
X	27.2	23.9 *	1.98	3.01			111	123
Y	31.3	22.1	1.62	2.03				
Z	29.7	24.6		2.83		5.52	102	118
IPST-1	31.3	23.9	1.54	2.66	3.74	5.72	106	115
IPST-2	31.8	25.5	1.77	2.82	4.02	5.38	105	120
IPST-3	33.4	24.3	1.61	2.73	3.88	5.45	109	120
Avg.	32.0	24.6	1.69	2.78	4.05	5.77	106.7	118.4
S.D.	1.4	1.2	0.17	0.30	0.45	0.70	3.7	7.9

NOTE: A * following a value indicates that either the MD, CD, or both test results are significantly different than the expected distribution as defined by the TAPPI procedure for rejecting an outlying result. These data are not included in Figures 1 to 32.

Table III
PROPERTIES OF 60 LB FLAT MULTIWALL BAG PAPER

Lab Code	Tensile, lb/in MD	Tensile, lb/in CD	Stretch, % MD	Stretch, % CD		TEA, ft lb/sq ft MD	TEA, ft lb/sq ft CD		Tear, g MD	Tear, g CD	
A	38.1	32.0	2.10	5.92		5.59	15.25		139	129	
B	41.5	33.3	1.87	5.86		6.10	15.73		142	131	
C	38.1	33.2	1.76	5.90		5.16	16.13		139	124	
D	39.6	33.1	1.73	5.70		5.05	14.96		144	130	
E	38.7	31.1	2.54	7.01	*	7.32	18.08	*	143	128	
F	36.3	31.1	1.86	5.88					143	130	
Gx	36.1	33.3							141	122	
H	38.5	32.4	1.72	5.57		5.10	14.76		125	136	
I	40.3	32.7	1.56	5.32		4.90	14.65		138	190	*
J	37.8	35.6							128	133	
K									131	118	
L	35.3	32.8	1.80	5.86		4.98	15.16		133	130	
M	36.4	33.1	1.82	5.79		4.82	15.43		132	121	
N	36.9	34.1	1.75	5.78		4.91	16.01		139	132	
O	37.8	32.4	1.91	5.71		5.26	14.96		135	122	
P	37.8	30.6	1.68	5.40					138	130	
Q	39.0	32.7	1.66	5.76					133	117	
R	39.7	32.4	1.75	5.60					136	125	
S	36.3	32.1	1.81	5.74		4.91	15.03		135	124	
T	39.4	33.7	1.86	5.27		5.54	14.72		137	127	
Ux	35.4	34.2							146	128	
Vx	33.4	32.7							138	130	
W	37.0	32.8	1.97	6.32		5.30	16.37		147	138	
X	39.0	30.3	1.80	6.10					153	129	
Y	37.0	32.7	1.86	5.73							
Z	40.1	33.2	1.82	5.32		5.33	14.70		131	126	
IPST-1	38.5	32.2	1.81	5.71		5.03	15.37		135	126	
IPST-2	36.5	33.4	1.67	5.66		5.33	15.33		143	132	
IPST-3	38.4	31.8	1.73	5.51		5.11	14.98		138	130	
Avg.	37.8	32.7	1.83	5.77		5.32	15.42		137.9	129.9	
S.D.	1.8	1.1	0.19	0.36		0.59	0.83		5.9	12.7	

NOTE: A * following a value indicates that either the MD, CD, or both test results are significantly different than the expected distribution as defined by the TAPPI procedure for rejecting an outlying result. These data are not included in Figures 1 to 32.

Table IV
PROPERTIES OF 70 LB FLAT MULTIWALL BAG PAPER

Lab Code	Tensile, lb/in MD		Stretch, % MD		TEA, ft lb/sq ft MD		Tear, g MD	
A	50.2	26.7	1.83	4.26	6.15	9.42	185	199
B	50.4	26.8	1.35	3.97	5.06	9.22	184	202
C	50.9	27.5	1.54	4.18	5.77	9.92	187	192
D	50.1	27.5	1.42	3.80	4.89	8.94	182	210
E	51.8	28.2	2.34	5.63 *	8.43	13.60 *	184	198
F	48.4	25.7	1.45	4.02			194	199
Gx	51.6	28.4					193	203
H	51.7	27.1	1.49	3.95	5.58	9.11	179	208
I	52.6	26.4	1.32	3.48	5.19	7.98	152	199 *
J	56.4	29.6 *					182	180
K							180	192
L	46.8	27.2	1.61	4.17	4.97	9.67	191	210
M	52.6	27.6	1.65	4.34	6.08	10.16	175	194
N	51.6	27.7	1.44	4.31	5.66	10.17	187	200
O	52.4	27.3	1.78	4.29	6.49	9.93	183	189
P	50.9	26.6	1.48	4.20			177	198
Q	51.6	28.0	1.49	4.24			192	195
R	52.4	27.1	1.59	3.97			176	196
S	49.7	27.3	1.44	4.24	5.07	9.80	184	198
T	52.3	29.6	1.44	4.21	5.40	10.59	183	202
Ux	55.6	30.8 *					186	203
Vx	51.6	26.5					188	203
W	47.8	26.9	1.67	4.68	5.45	10.48	197	209
X	51.6	26.0	1.88	4.56			190	210
Y	50.2	27.4	1.53	4.22				
Z	53.0	26.7	1.55	3.85	5.81	8.80	174	192
IPST-1	52.0	26.5	1.47	4.06	5.21	9.03	184	202
IPST-2	50.5	27.4	1.42	4.01	5.37	9.76	185	197
IPST-3	51.3	28.0	1.55	3.80	5.66	9.45	189	198
Avg.	51.4	27.4	1.57	4.18	5.68	9.78	183.6	199.2
S.D.	2.0	1.1	0.22	0.40	0.81	1.15	8.4	6.9

NOTE: A * following a value indicates that either the MD, CD, or both test results are significantly different than the expected distribution as defined by the TAPPI procedure for rejecting an outlying result. These data are not included in Figures 1 to 32.

Table V
PROPERTIES OF 40 LB EXTENSIBLE MULTIWALL BAG PAPER

Lab Code	Tensile, lb/in MD	Tensile, lb/in CD	Stretch, % MD	Stretch, % CD	TEA, ft lb/sq ft MD	TEA, ft lb/sq ft CD	Tear, g MD	Tear, g CD	
A	17.3	15.0	6.25	6.71	8.77	8.55	96.1	103.1	
B	17.4	15.0	6.80	7.19	9.70	9.22	95.5	105.0	
C									
D	17.1	16.0	6.12	6.62	8.65	9.04	90.0	96.6	
E									
F	17.7	16.3	6.80	7.62			99.7	102.1	
Gx	18.8	17.1					101.0	102.8	
H	17.2	14.8	5.77	6.75	8.26	8.57	92.0	106.9	
I	18.3	15.8	6.24	6.40	9.53	8.76	69.7	95.0	*
J	18.2	16.1					95.8	98.4	
K									
L	17.8	15.9	6.11	6.81	9.00	9.18	95.6	97.8	
M	18.2	15.6	6.25	6.92	9.36	9.14	92.1	98.2	
N	18.5	16.1	6.13	6.90	9.38	9.46	96.8	106.0	
O	18.8	16.5	6.08	6.84	9.57	9.54	91.9	97.5	
P	17.0	15.6	5.97	6.70			97.4	101.3	
Q	18.1	16.2	6.53	7.42	10.04	10.39	91.5	95.0	
R									
S	17.6	15.4	6.78	6.78	9.61	8.92	91.7	97.6	
T	18.0	17.0	5.96	6.80	9.01	9.83	93.7	99.3	
Ux	19.0	16.6					96.0	102.4	
Vx	18.6	16.4					98.7	100.8	
W	18.1	14.4	7.01	7.38	10.10	8.94	97.3	106.9	
X	17.8	15.8	6.66	7.56			96.7	110.1	
Y									
Z	17.2	15.4	5.72	6.46	8.25	8.55	90.2	99.3	
IPST-1	17.6	15.6	5.92	6.72	8.93	9.22	97.6	100.3	
IPST-2	18.2	16.6	6.31	7.02	9.02	8.87	94.5	104.4	
IPST-3	17.5	16.1	6.08	6.81	9.37	9.03	96.0	101.4	
Avg.	17.9	15.9	6.27	6.92	9.21	9.13	94.1	101.2	
S.D.	0.6	0.7	0.37	0.34	0.54	0.48	6.0	4.0	

NOTE: A * following a value indicates that either the MD, CD, or both test results are significantly different than the expected distribution as defined by the TAPPI procedure for rejecting an outlying result. These data are not included in Figures 1 to 32.

Table VI
PROPERTIES OF 50 LB EXTENSIBLE MULTIWALL BAG PAPER

Lab Code	Tensile, lb/in MD	Tensile, lb/in CD	Stretch, % MD	Stretch, % CD	TEA, ft lb/sq ft MD	TEA, ft lb/sq ft CD	Tear, g MD	Tear, g CD	
A	27.3	18.6	6.23	3.37	13.15	5.47	90.0	133	
B	27.0	18.0	5.85	3.87	12.64	6.27	90.2	136	
C									
D	28.3	19.9	5.81	3.66	12.98	6.12	86.3	125	
E									
F	27.7	17.9	6.58	3.58			91.9	135	
Gx	30.3	22.1					90.1	141	
H	27.7	18.3	6.03	3.34	13.00	5.42	90.4	132	
I	28.3	18.7	5.66	3.02	12.82	5.10	81.2	106	*
J	29.8	21.4					86.9	112	
K									
L	27.3	18.0	6.29	3.33	12.87	5.19	88.9	122	
M	27.9	17.3	5.81	3.10	12.82	4.97	87.6	127	
N	28.2	18.9	6.19	3.41	13.57	5.80	89.1	134	
O	29.3	19.9	5.89	3.82	13.48	6.64	88.4	129	
P	26.2	19.4	5.68	3.50			89.4	132	
Q	25.9	17.6	6.43	3.46	12.88	5.33	92.8	134	
R									
S	28.3	18.6	6.00	3.41	13.20	5.65	89.3	130	
T	29.3	19.3	5.60	3.28	13.17	5.65	91.3	132	
Ux	28.9	22.1					92.8	128	
Vx	27.8	18.9					94.0	139	
W	28.3	19.8	6.39	4.50	13.62	7.62	102.7	135	*
X	28.3	18.8	6.54	4.27			93.3	142	
Y									
Z	28.4	19.1	5.70	3.30	12.89	5.44	91.8	130	
IPST-1	28.9	19.4	6.08	3.32	13.31	5.53	88.6	128	
IPST-2	27.5	17.9	5.81	3.48	12.95	6.04	89.3	135	
IPST-3	27.8	18.8	5.93	3.62	13.04	5.78	91.7	131	
Avg.	28.1	19.1	6.03	3.53	13.08	5.77	90.3	130.3	
S.D.	1.0	1.3	0.30	0.36	0.28	0.64	3.8	8.1	

NOTE: A * following a value indicates that either the MD, CD, or both test results are significantly different than the expected distribution as defined by the TAPPI procedure for rejecting an outlying result. These data are not included in Figures 1 to 32.

Table VII
PROPERTIES OF 60 LB EXTENSIBLE MULTIWALL BAG PAPER

Lab Code	Tensile, lb/in MD	Tensile, lb/in CD	Stretch, % MD	Stretch, % CD	TEA, ft lb/sq ft MD	TEA, ft lb/sq ft CD		Tear, g MD	Tear, g CD	
A	23.8	25.4	7.42	6.55	14.39	15.08		162	168	
B	22.6	25.0	7.56	7.05	14.06	14.53		160	170	
C										
D	23.3	26.1	7.00	7.05	14.52	14.75		152	161	
E										
F	23.2	25.9	7.97	7.65				159	166	
Gx	24.5	27.4						145	163	
H	22.2	25.9	6.99	6.45	13.02	14.20		164	165	
I	23.4	25.7	7.00	6.68	13.92	14.47		149	205	*
J	24.5	28.9						152	148	
K										
L	22.5	26.7	7.21	7.11	13.33	15.11		159	160	
M	22.3	26.6	7.15	7.26	13.29	15.46		155	157	
N	23.3	27.1	7.46	7.37	14.38	16.08		160	158	
O	26.1	26.4	7.29	6.87	15.40	14.92		156	155	
P	21.9	26.6	6.93	7.04				150	165	
Q	23.8	27.6	8.01	7.84	16.10	17.81	*	150	157	
R										
S	22.1	25.3	7.60	7.25	14.01	14.83		155	160	
T	23.8	27.7	6.95	6.95	13.88	15.82		157	165	
Ux	24.5	26.2						150	165	
Vx	22.8	24.4						161	166	
W	22.8	23.3	7.97	7.81	14.41	14.55		169	168	
X	22.5	26.9	7.65	7.71				165	170	
Y										
Z	24.5	27.2	7.28	7.07	14.77	15.58		148	152	
IPST-1	24.0	26.5	7.43	6.84	13.71	15.11		162	159	
IPST-2	22.7	27.0	7.33	7.22	14.41	15.00		157	165	
IPST-3	23.7	25.8	7.16	7.06	13.95	14.60		155	162	
Avg.	23.4	26.3	7.37	7.14	14.21	15.17		156.3	163.8	
S.D.	1.0	1.2	0.34	0.39	0.76	0.84		6.0	10.4	

NOTE: A * following a value indicates that either the MD, CD, or both test results are significantly different than the expected distribution as defined by the TAPPI procedure for rejecting an outlying result. These data are not included in Figures 1 to 32.

Table VIII
PROPERTIES OF 70 LB EXTENSIBLE MULTIWALL BAG PAPER

Lab Code	Tensile, lb/in MD	Tensile, lb/in CD	Stretch, % MD	Stretch, % CD	TEA, ft lb/sq ft MD	TEA, ft lb/sq ft CD	Tear, g MD	Tear, g CD	
A	26.2	24.9	7.09	4.76	14.36	10.11	192	244	
B	26.1	24.7	6.92	4.70	14.20	10.06	193	243	
C									
D	25.8	25.9	6.45	4.56	13.30	10.08	186	240	
E									
F	24.9	25.3	7.49	5.25			184	233	
Gx	25.9	27.1					200	238	
H	25.5	24.5	6.37	4.34	13.01	9.14	180	249	
I	26.5	26.6	6.40	4.27	13.77	9.82	139	184	*
J	27.2	29.1					177	182	*
K									
L	25.1	25.9	6.69	5.37	13.14	11.01	192	236	
M	26.7	26.8	6.95	4.78	14.31	10.68	181	227	
N	27.4	27.7	6.95	5.10	14.91	11.68	185	235	
O	27.3	25.8	6.98	4.97	14.88	10.67	178	222	
P	24.7	25.4	6.39	4.89			174	224	
Q	24.7	25.4	7.20	5.25	13.95	11.45	176	232	
R									
S	26.9	24.9	7.25	4.70	14.84	9.93	185	230	
T	28.6	27.8	7.01	4.68	15.71	10.90	180	232	
Ux	28.3	26.5					184	237	
Vx	25.6	25.4					189	241	
W	24.8	25.0	7.54	5.40	14.35	11.06	196	245	
X	26.6	25.4	7.26	5.39			191	246	
Y									
Z	27.7	26.6	6.82	4.68	14.77	10.26	176	214	
IPST-1	26.0	26.8	6.95	4.68	13.89	10.02	187	232	
IPST-2	27.1	27.0	6.58	4.93	14.53	10.72	183	240	
IPST-3	26.5	25.4	6.79	4.77	13.64	10.31	189	238	
Avg.	26.3	26.1	6.90	4.87	14.21	10.47	183.2	231.0	
S.D.	1.1	1.1	0.35	0.33	0.71	0.64	11.7	16.9	

NOTE: A * following a value indicates that either the MD, CD, or both test results are significantly different than the expected distribution as defined by the TAPPI procedure for rejecting an outlying result. These data are not included in Figures 1 to 32.

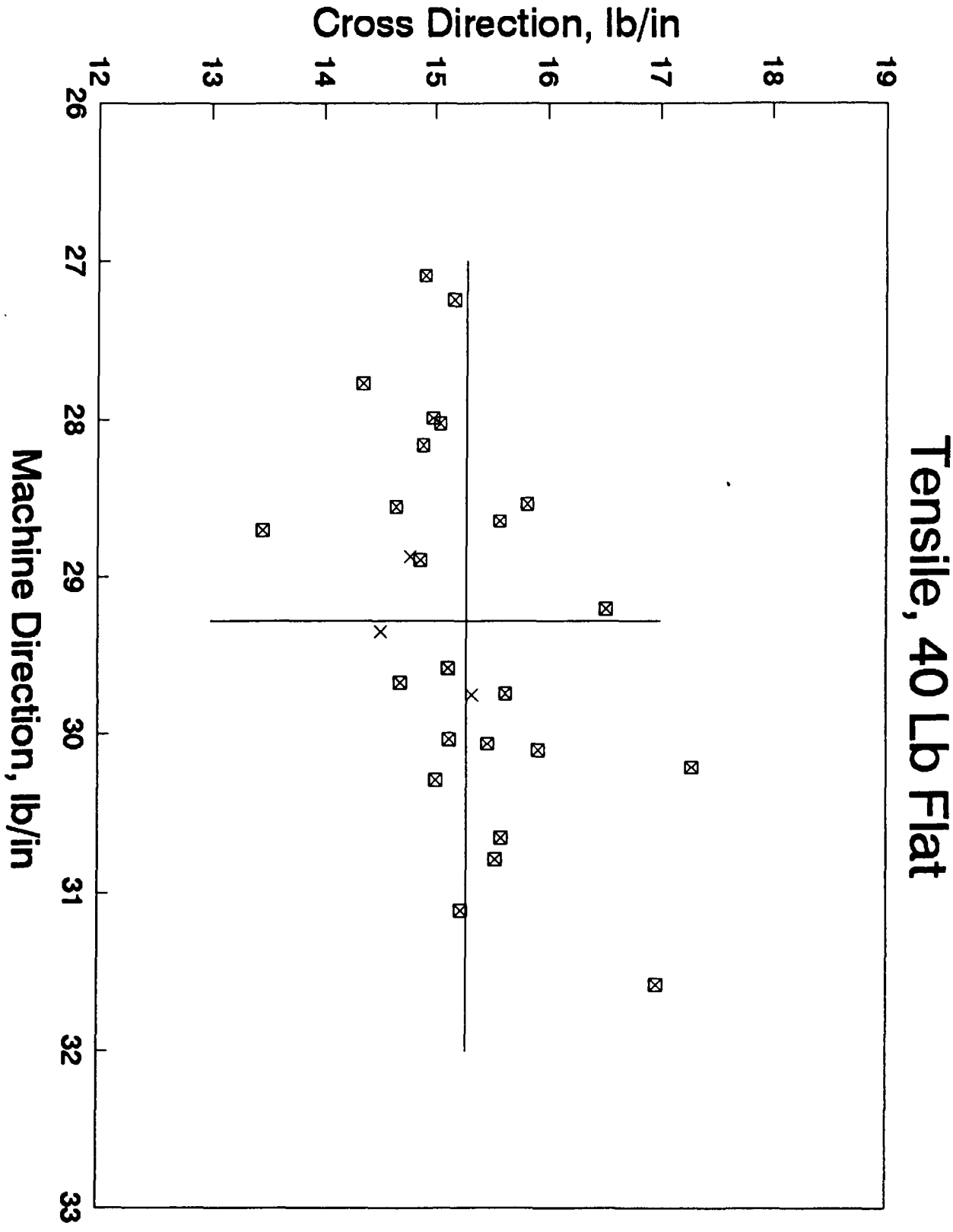

Figure 1. Industry variability in the measurement of Tensile Strength of 40 lb. flat grades. (x = IPST Data).

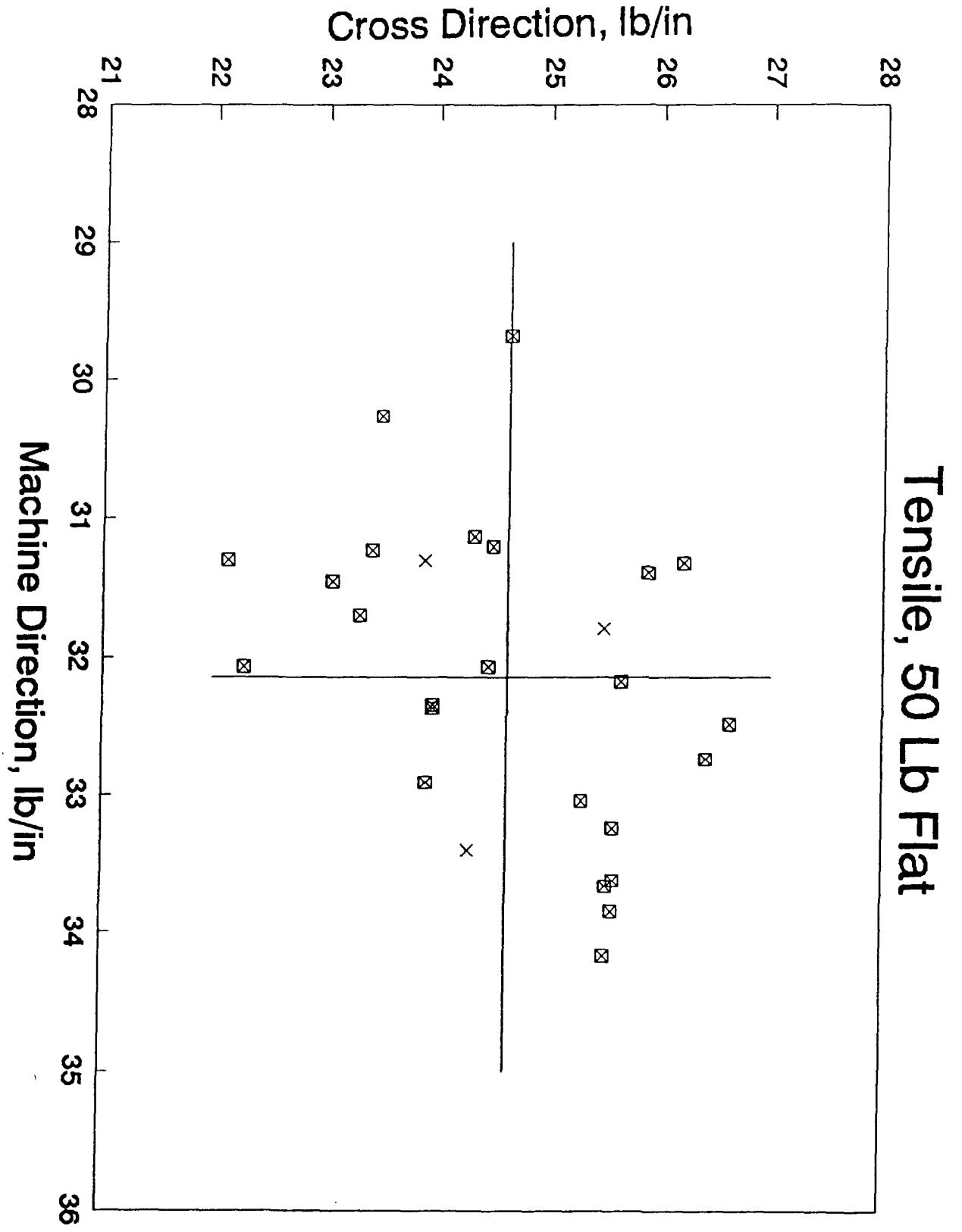

Figure 2. Industry variability in the measurement of Tensile Strength of 50 lb. flat grades. (x = IPST Data).

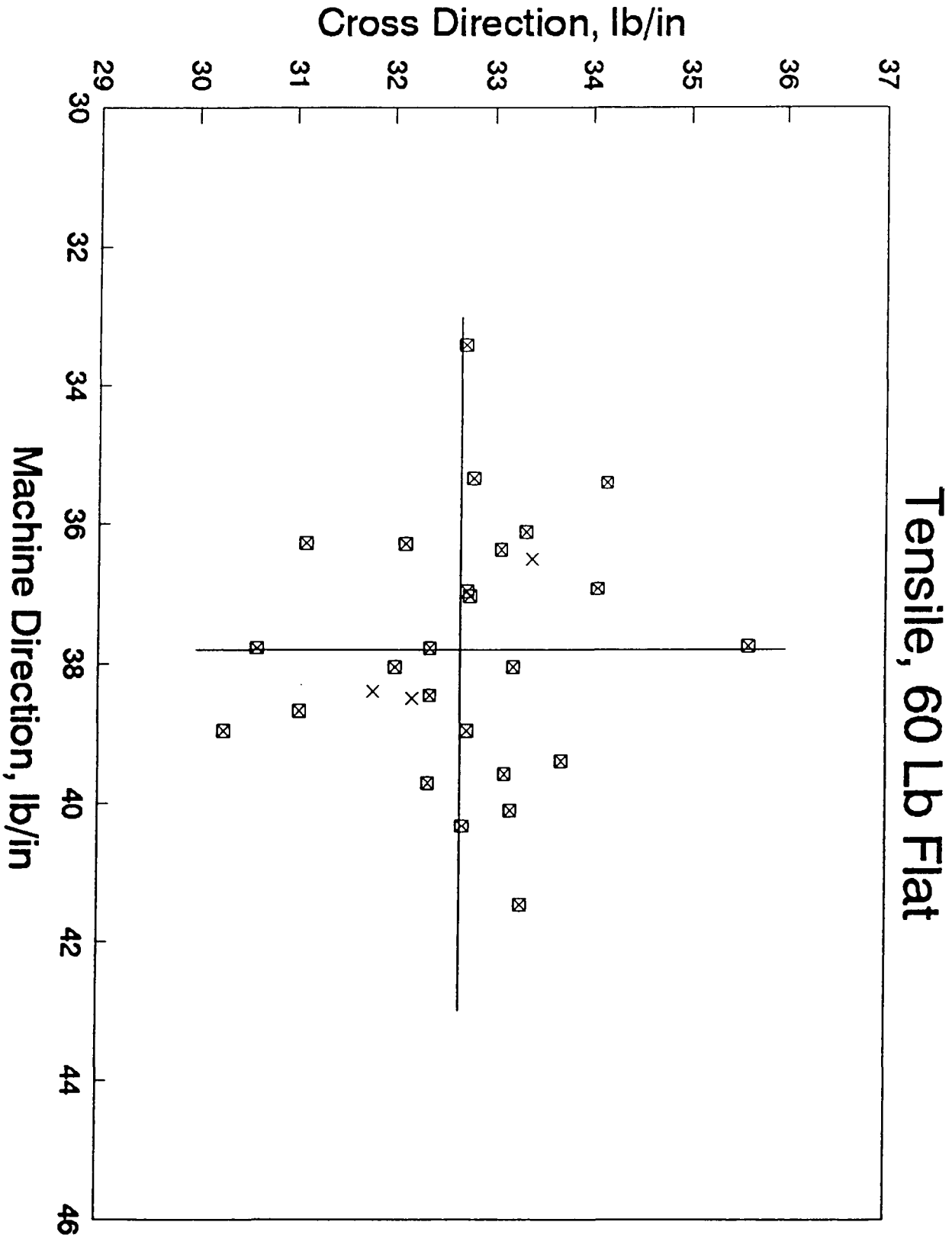

Figure 3 Industry variability in the measurement of Tensile Strength of 60 lb. flat grades. (x = IPST Data).

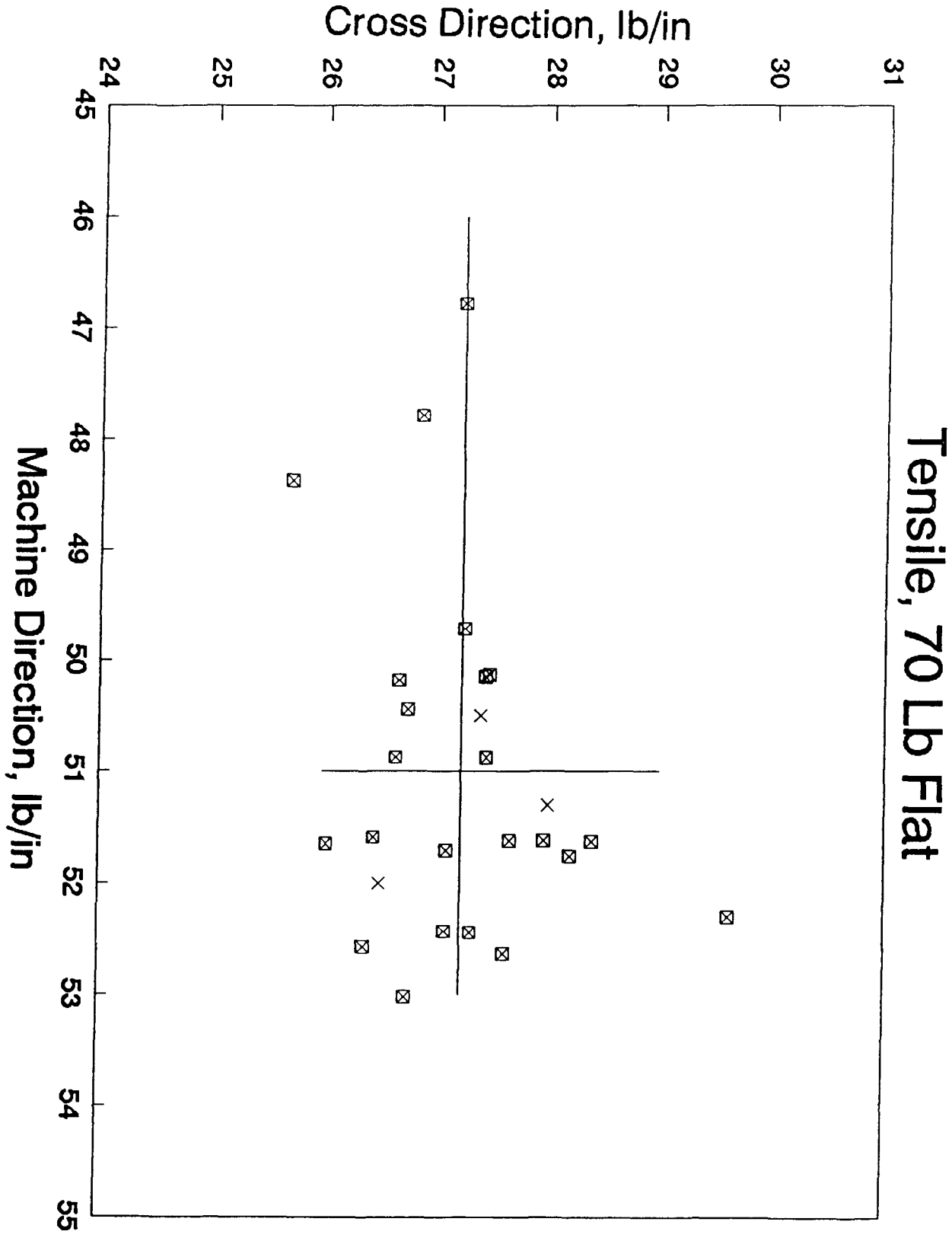

Figure 4. Industry variability in the measurement of Tensile Strength of 70 flat grades. (x = IPST Data).

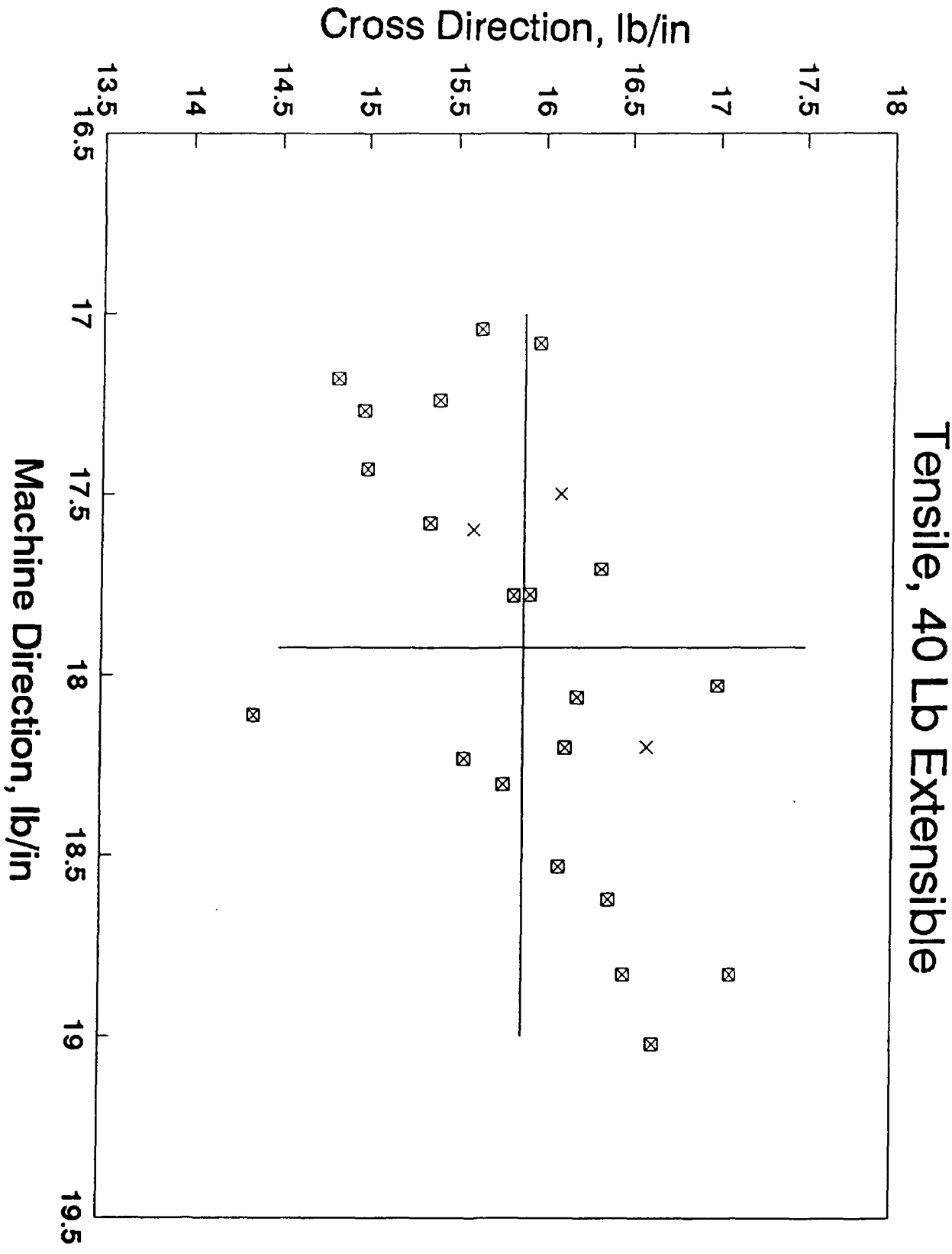

Figure 5. Industry variability in the measurement of Tensile Strength of 40 lb. extensible grades. (x = IPST Data).

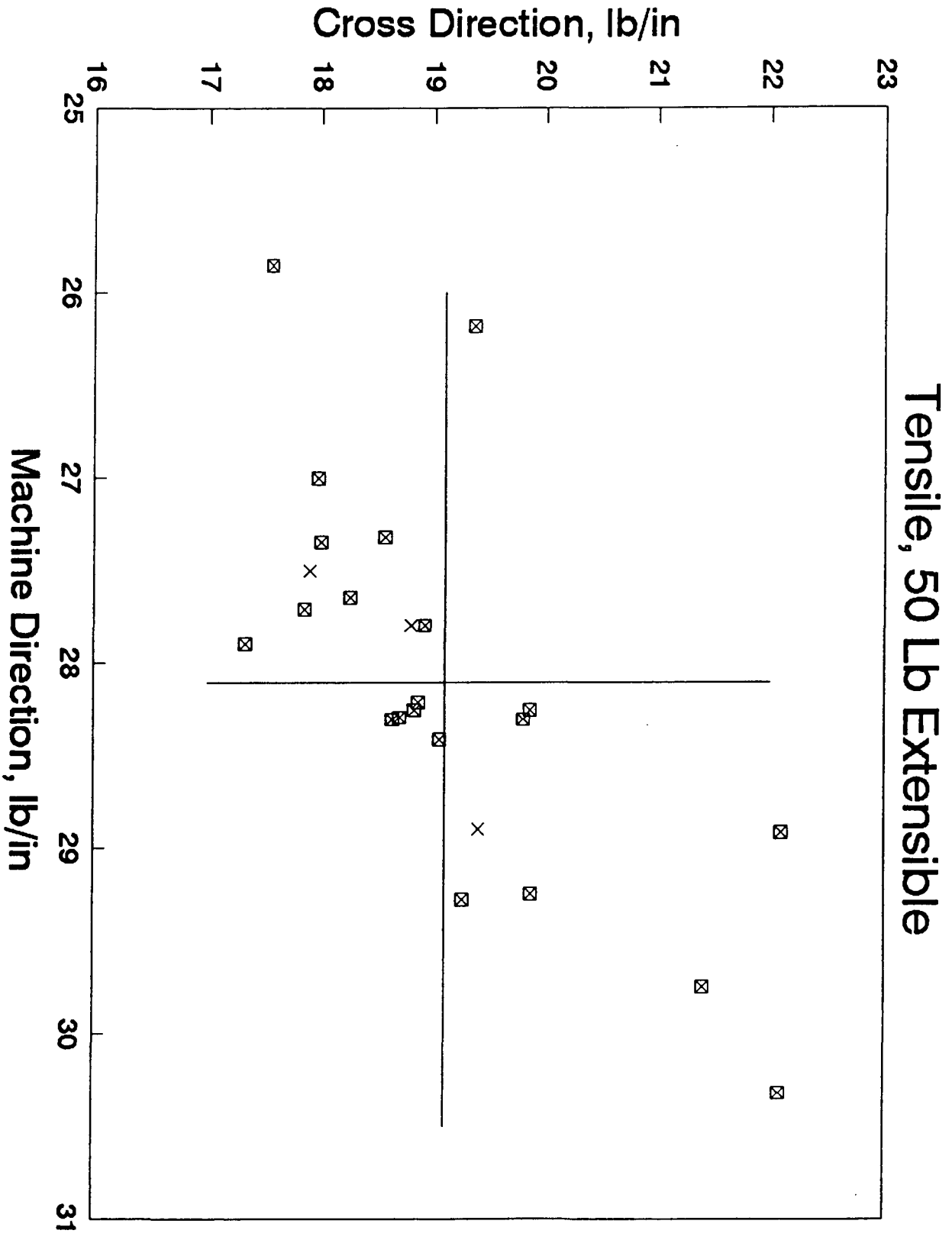

Figure 6. Industry variability in the measurement of Stretch of 50 lb. extensible grades. (x = IPST Data).

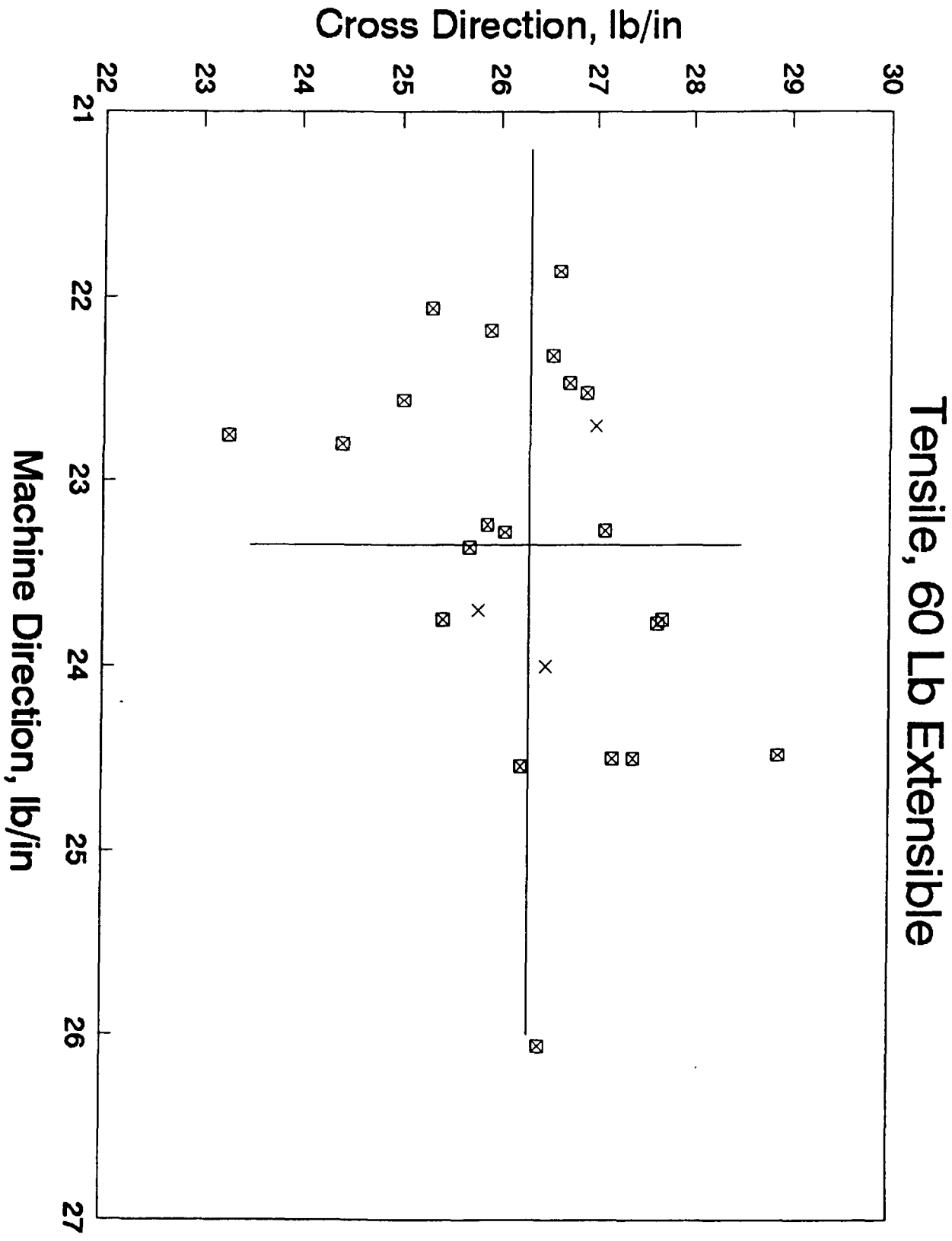

Figure 7. Industry variability in the measurement of Tensile Strength 60 lb. extensible grade. (x = IPST Data).

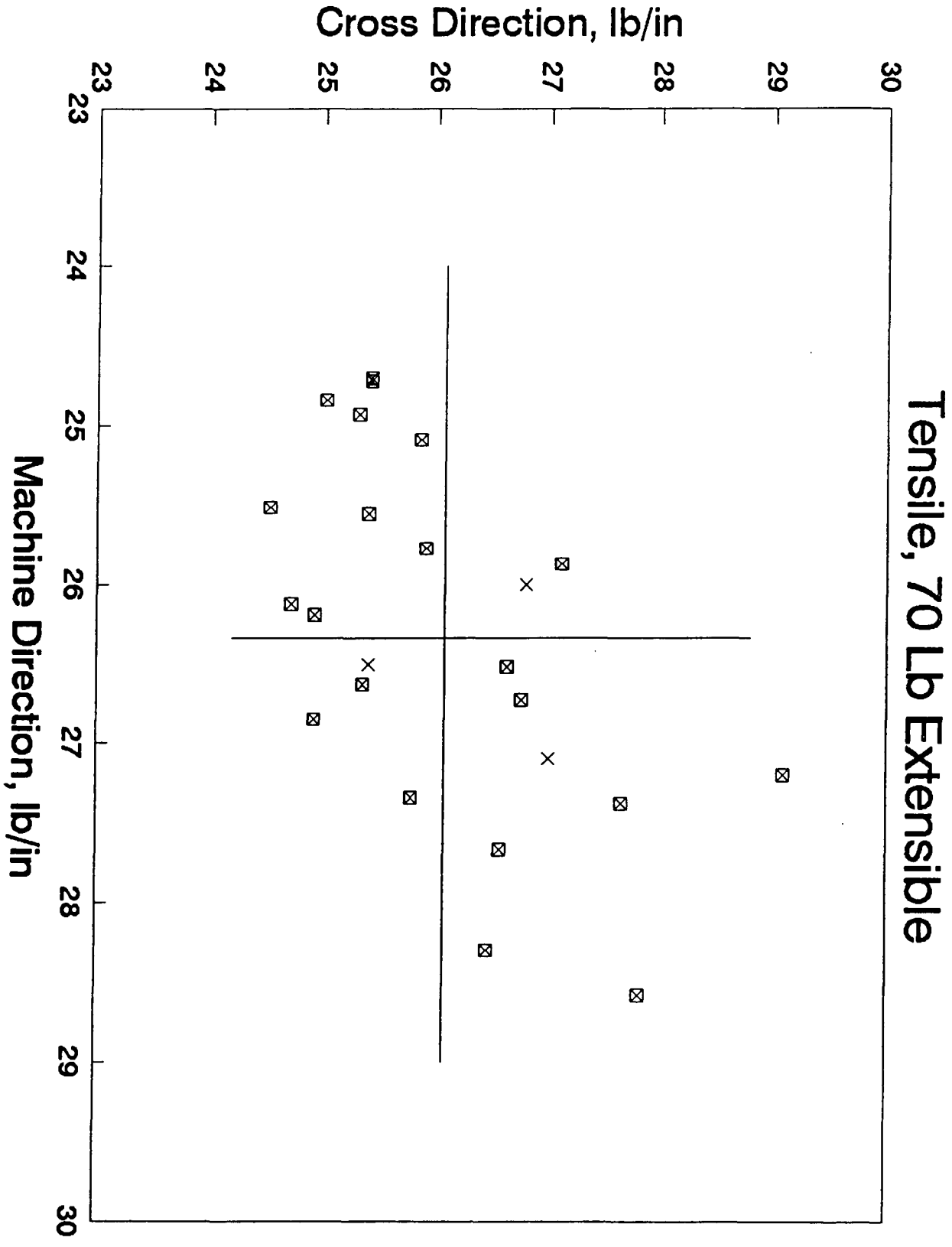

Figure 8. Industry variability in the measurement of Tensile Strength of 70 lb. extensible grade. (x = IPST Data).

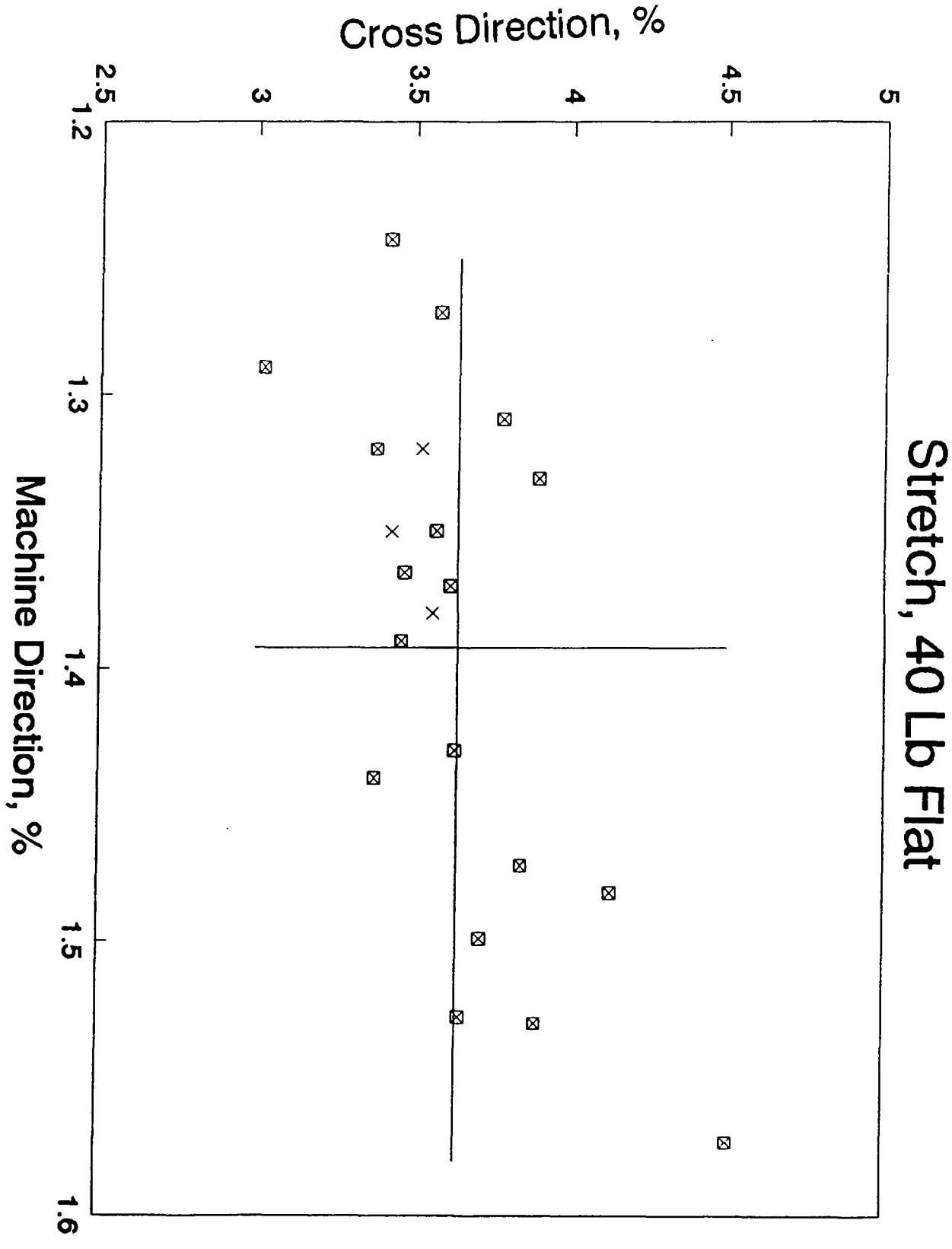

Figure 9. Industry variability in the measurement of Stretch of 40 lb. flat grades. (x= IPST Data).

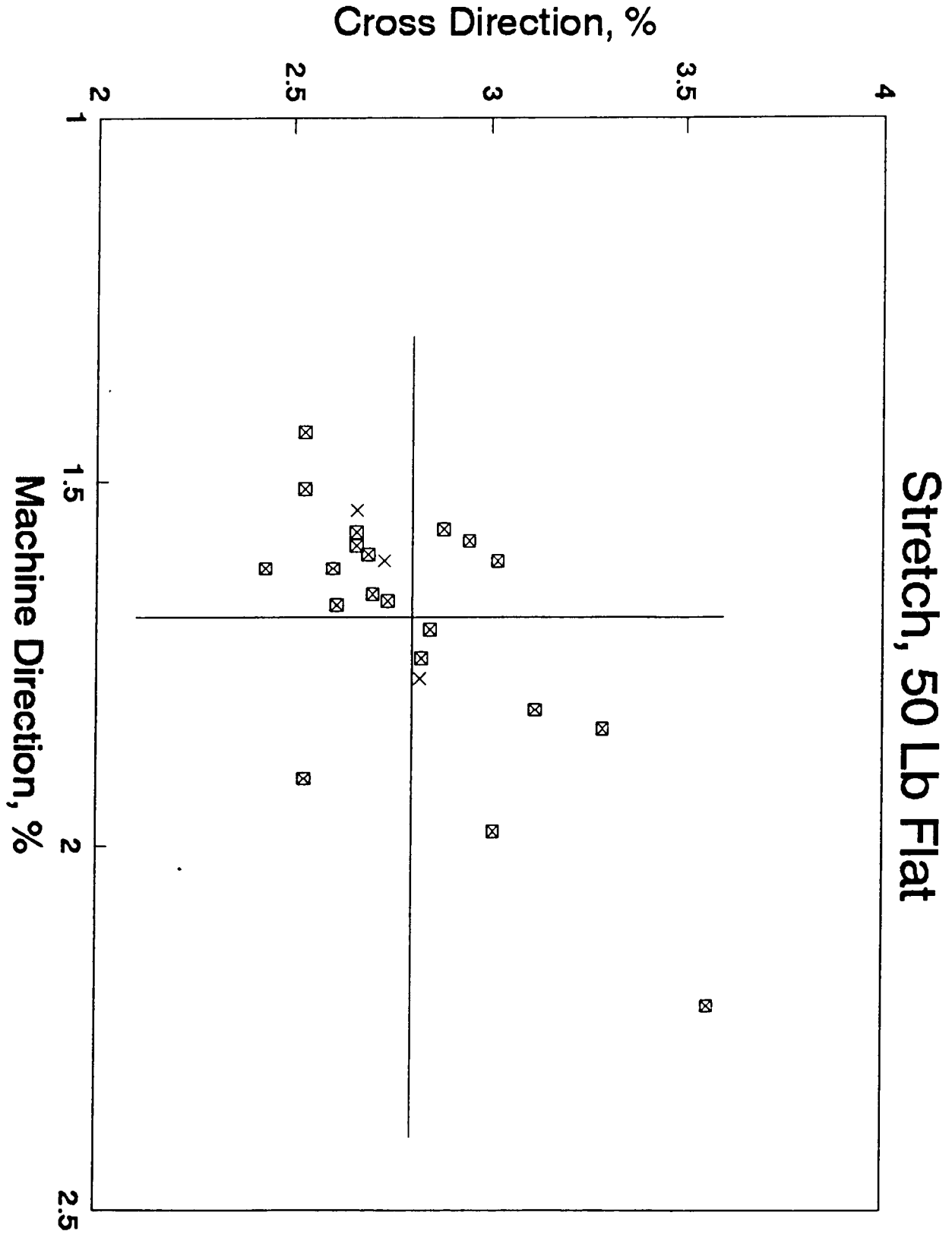

Figure 10. Industry variability in the measurement of Stretch of 50 lb. flat grades. (x = IPST Data).

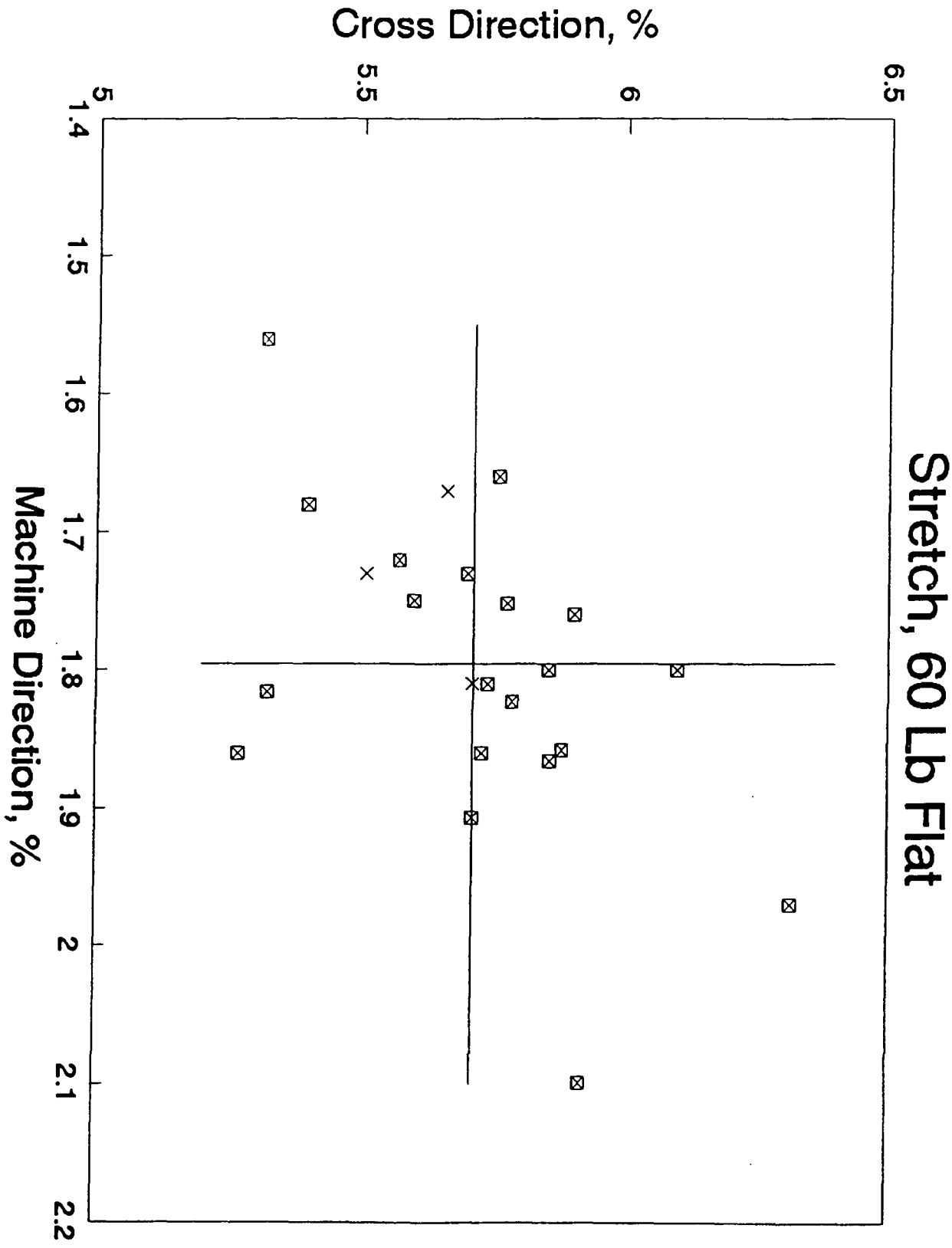

Figure 11. Industry variability in the measurement of Stretch of 60 lb. flat grades. (x = IPST Data).

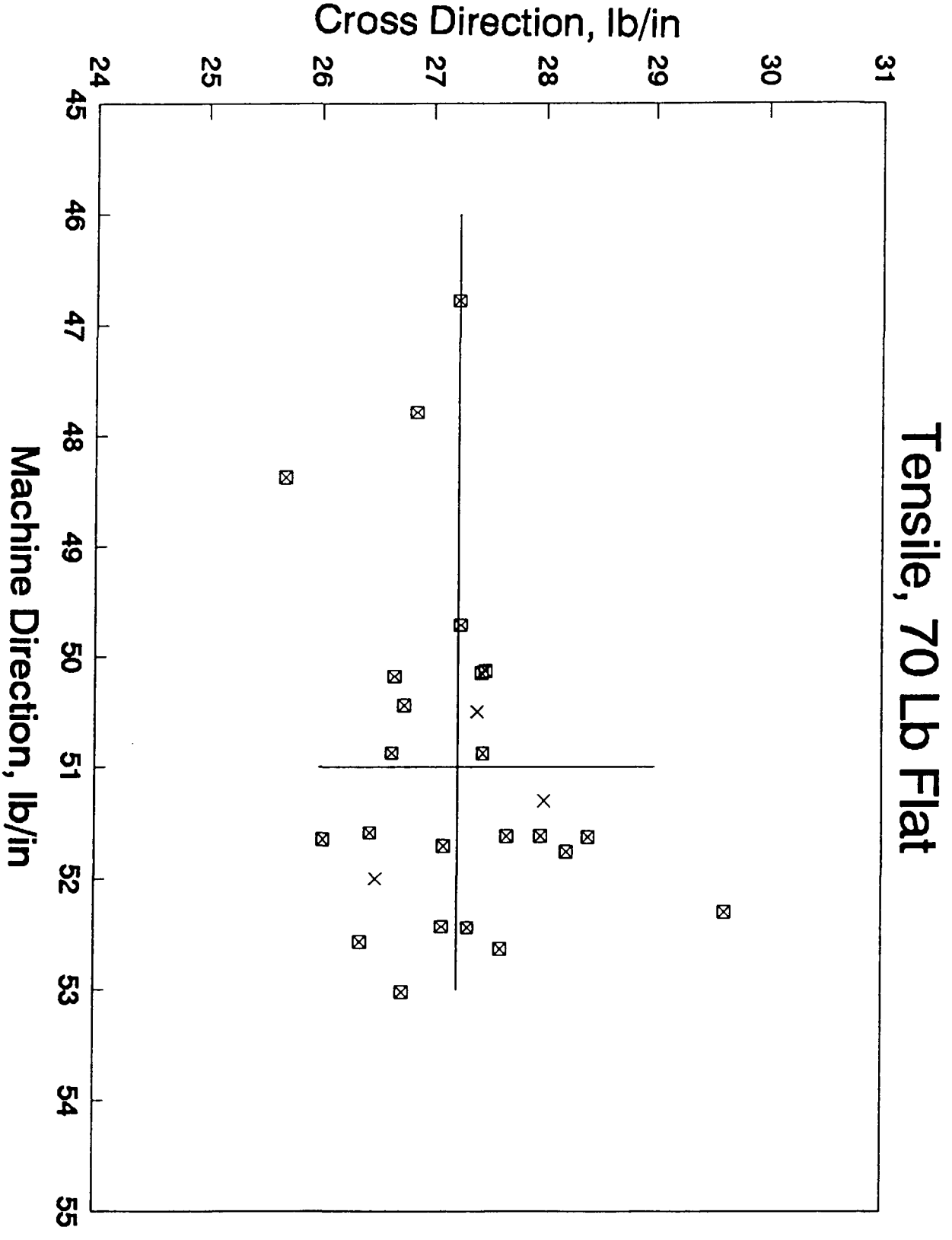

Figure 12. Industry varability in the measurement of Stretch of 70 lb. flat grades. (x= IPST Data).

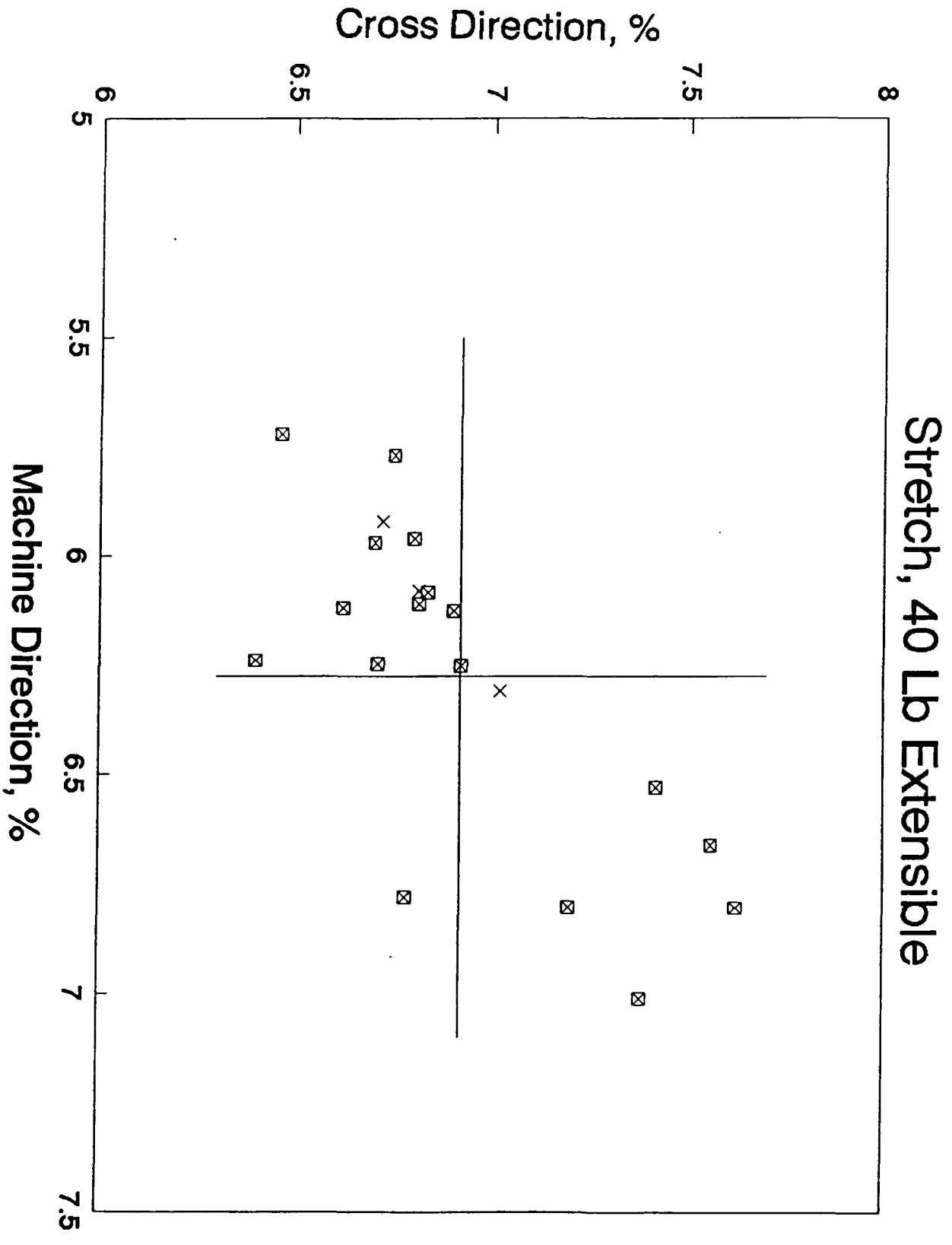

Figure 13. Industry variability in the measurement of Stretch of 40 lb. extensible grades. (x = IPST Data).

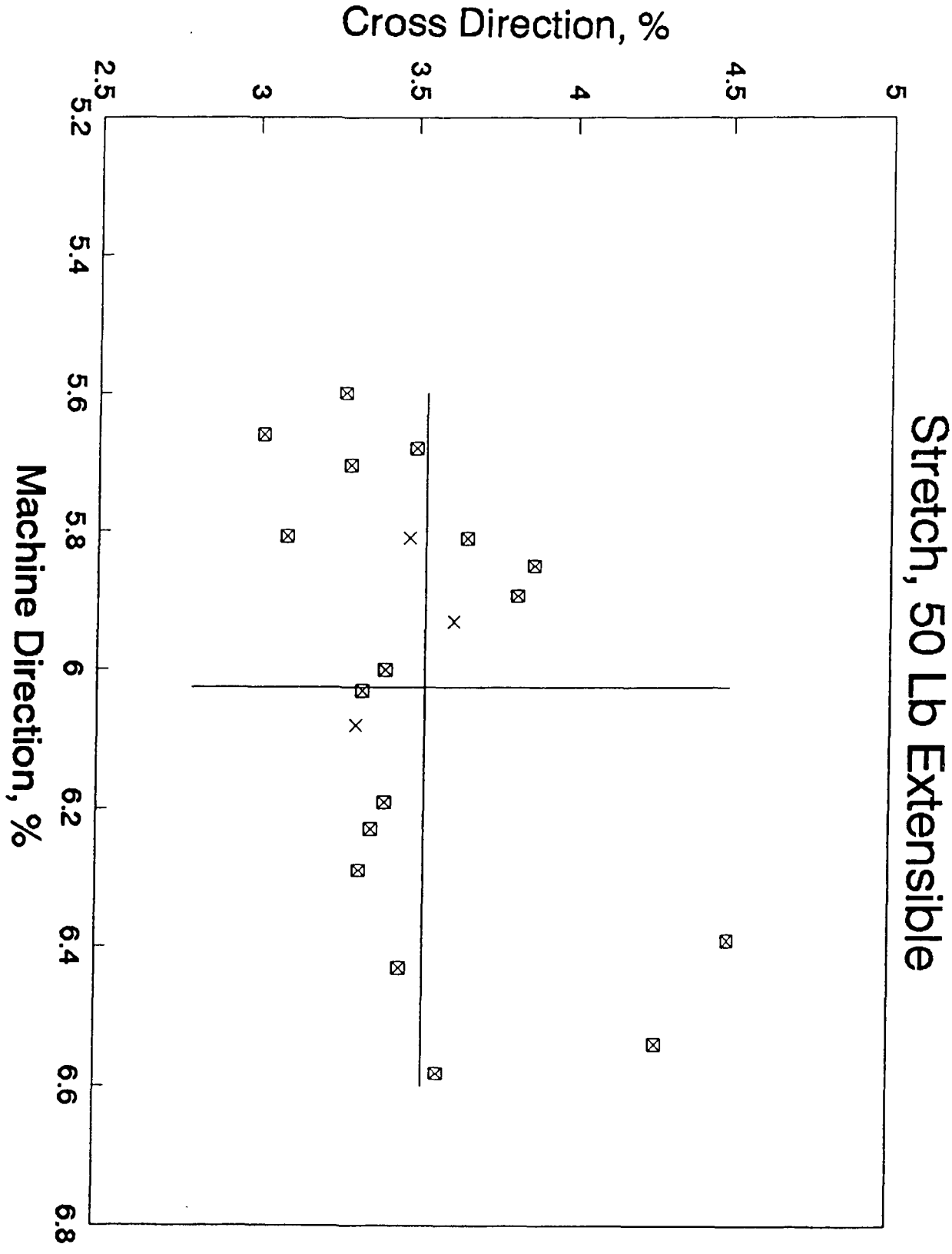

Figure 14. Industry variabiliy in the measurement of Stretch of 50 lb. extensible grades. (x = IPST Data).

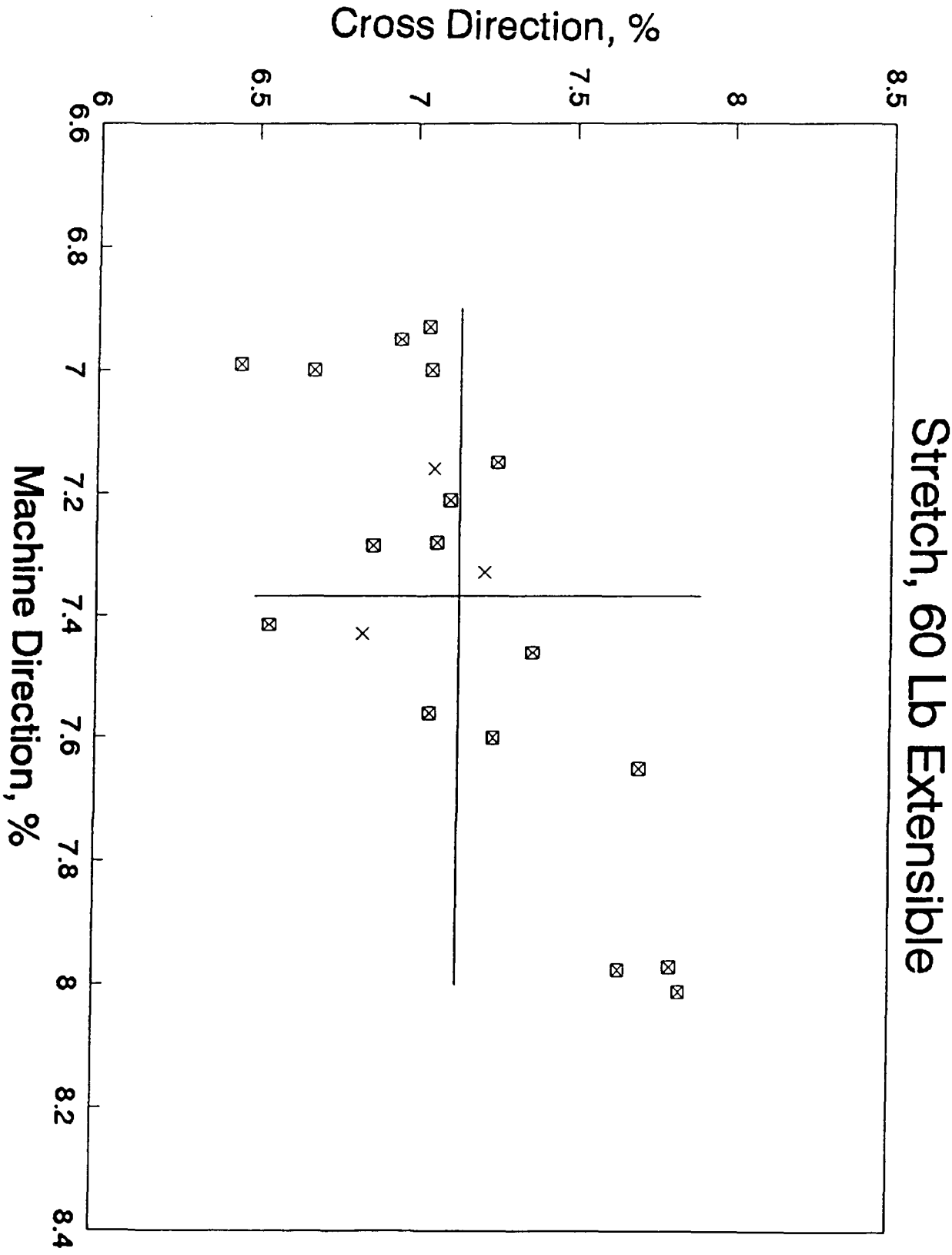

Figure 15. Industry variability in the measurement of Stretch of 60 lb. extensible grades. (x = IPST Data).

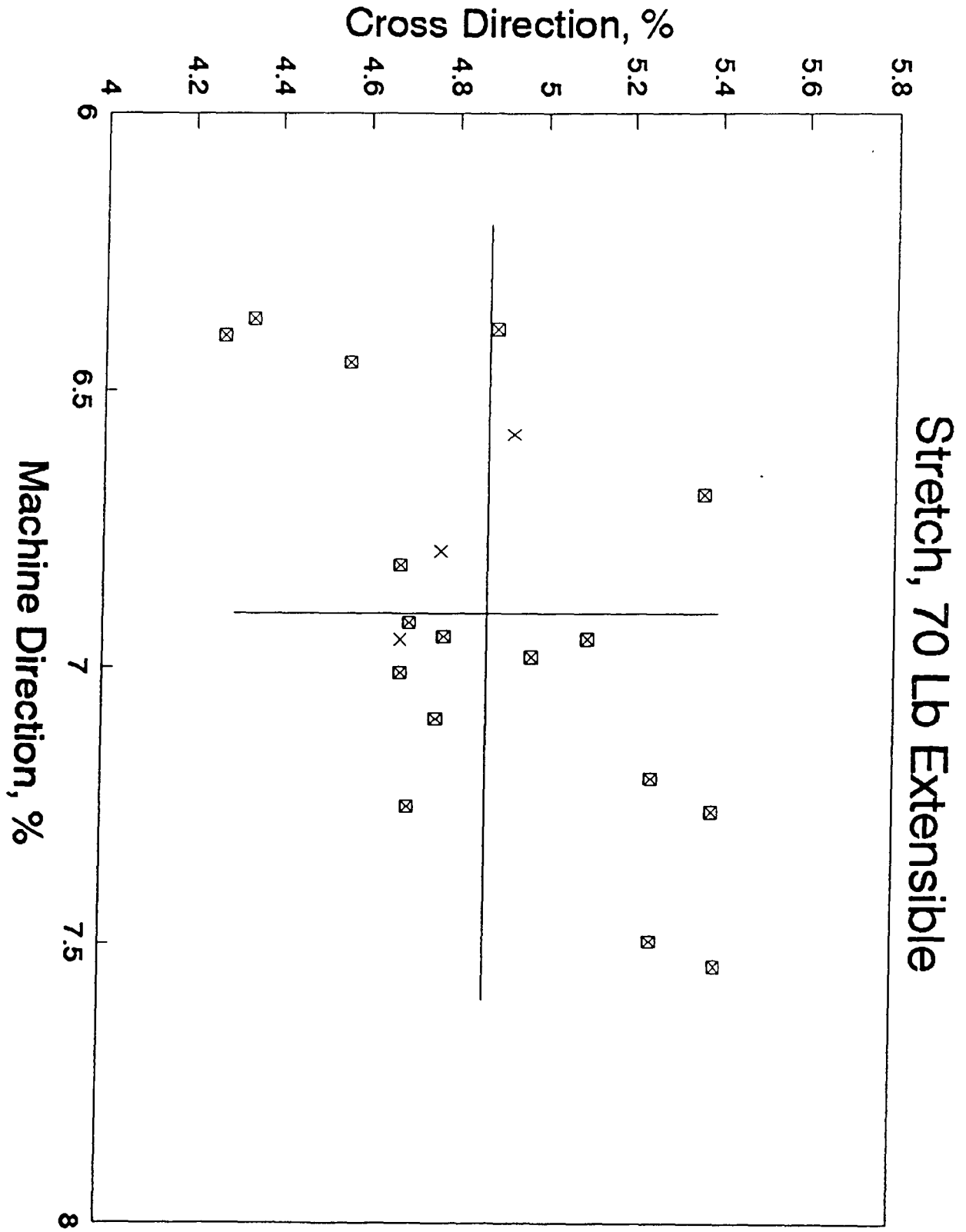

Figure 16. Industry variability in the measurement of Stretch of 70 lb. extensible grades. (x = IPST Data).

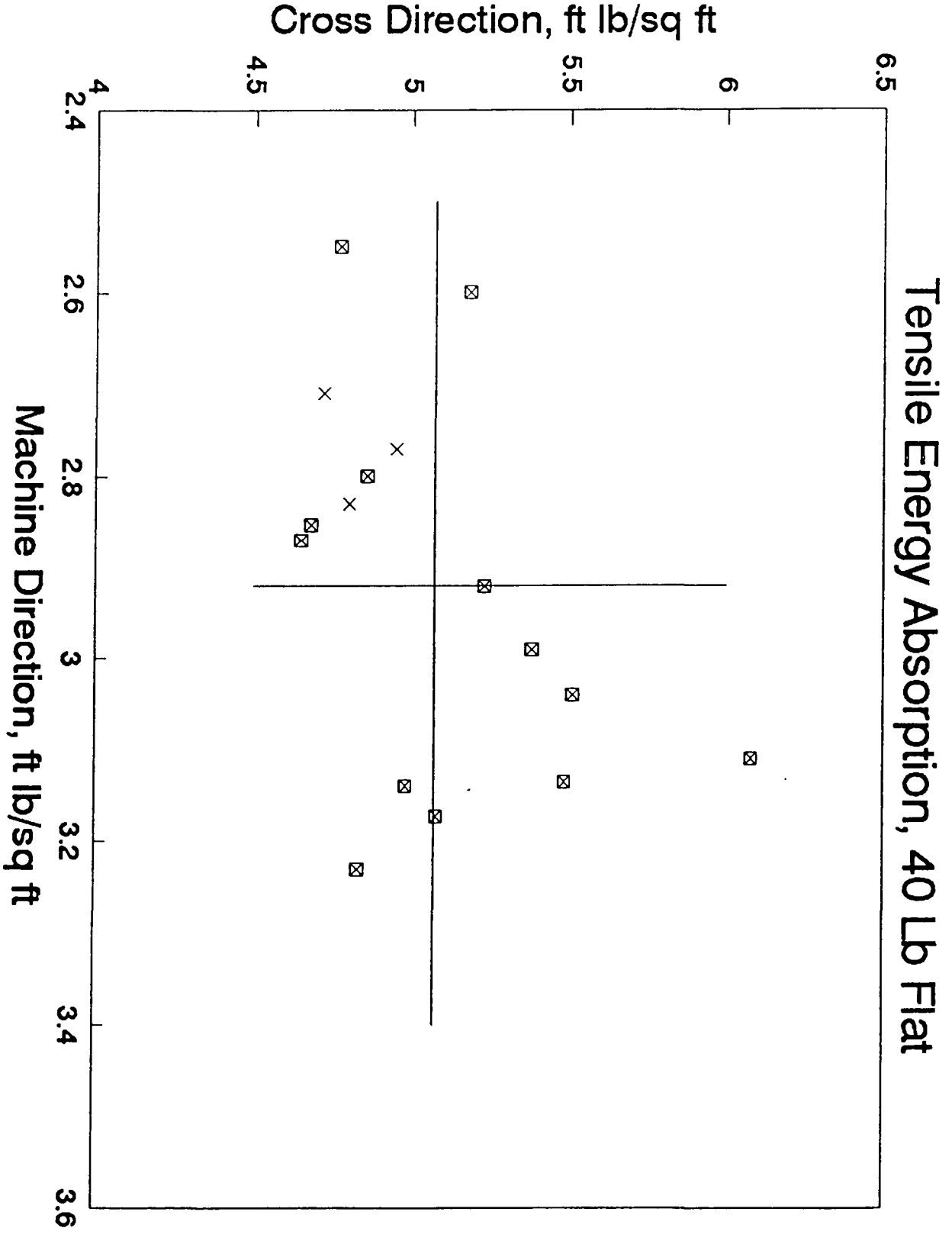

Figure 17. Industry variability in the measurement of TEA of 40 lb. flat grades. (x = IPST Data).

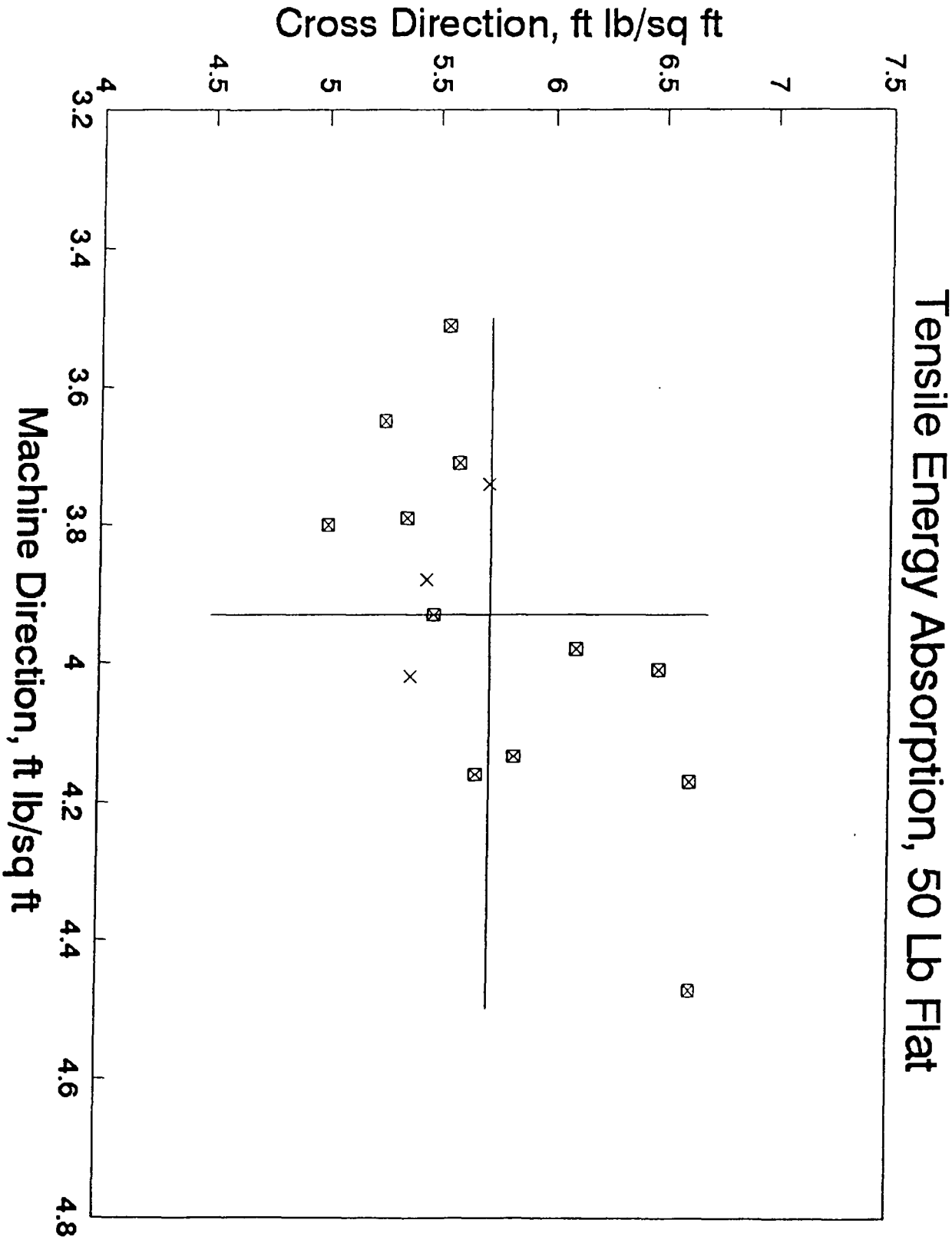

Figure 18. Industry variability in the measurement of TEA of 50 lb. flat grades. (x = IPST Data).

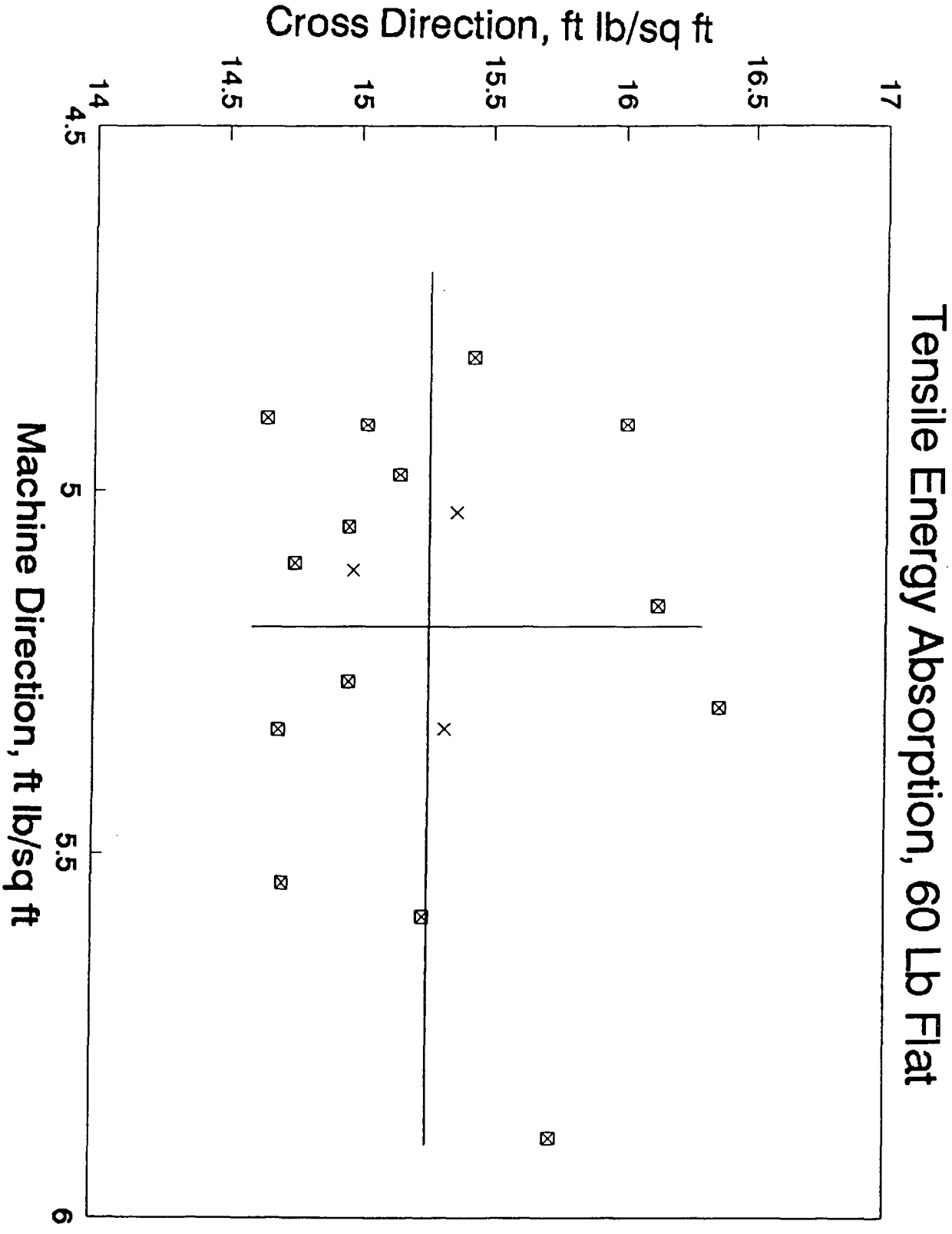

Figure 19. Industry variability in the measurement of TEA of 60 lb. flat grades. (x = IPST Data).

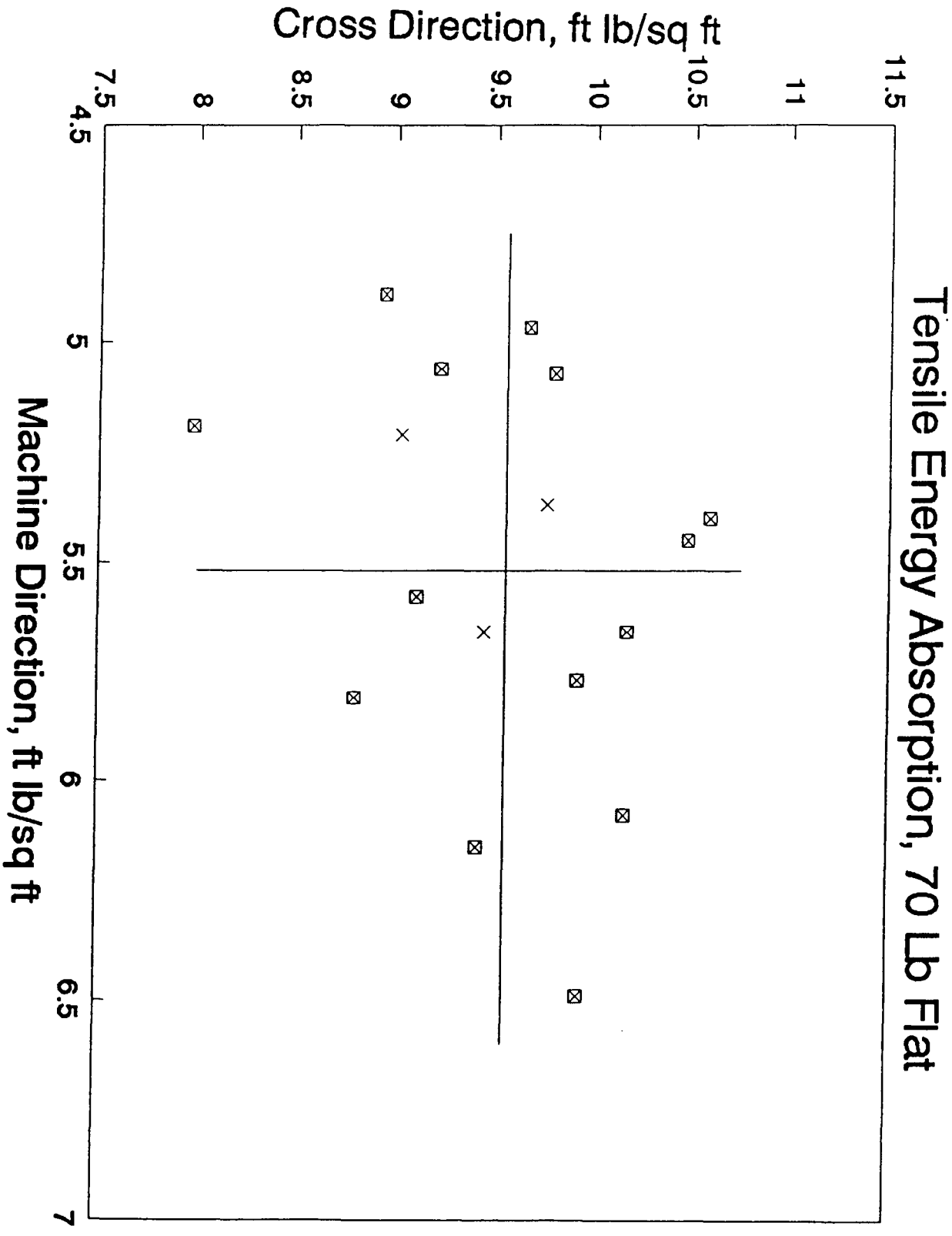

Figure 20. Industry variability in the measurement of TEA of 70 lb. flat grades. (x = IPST Data).

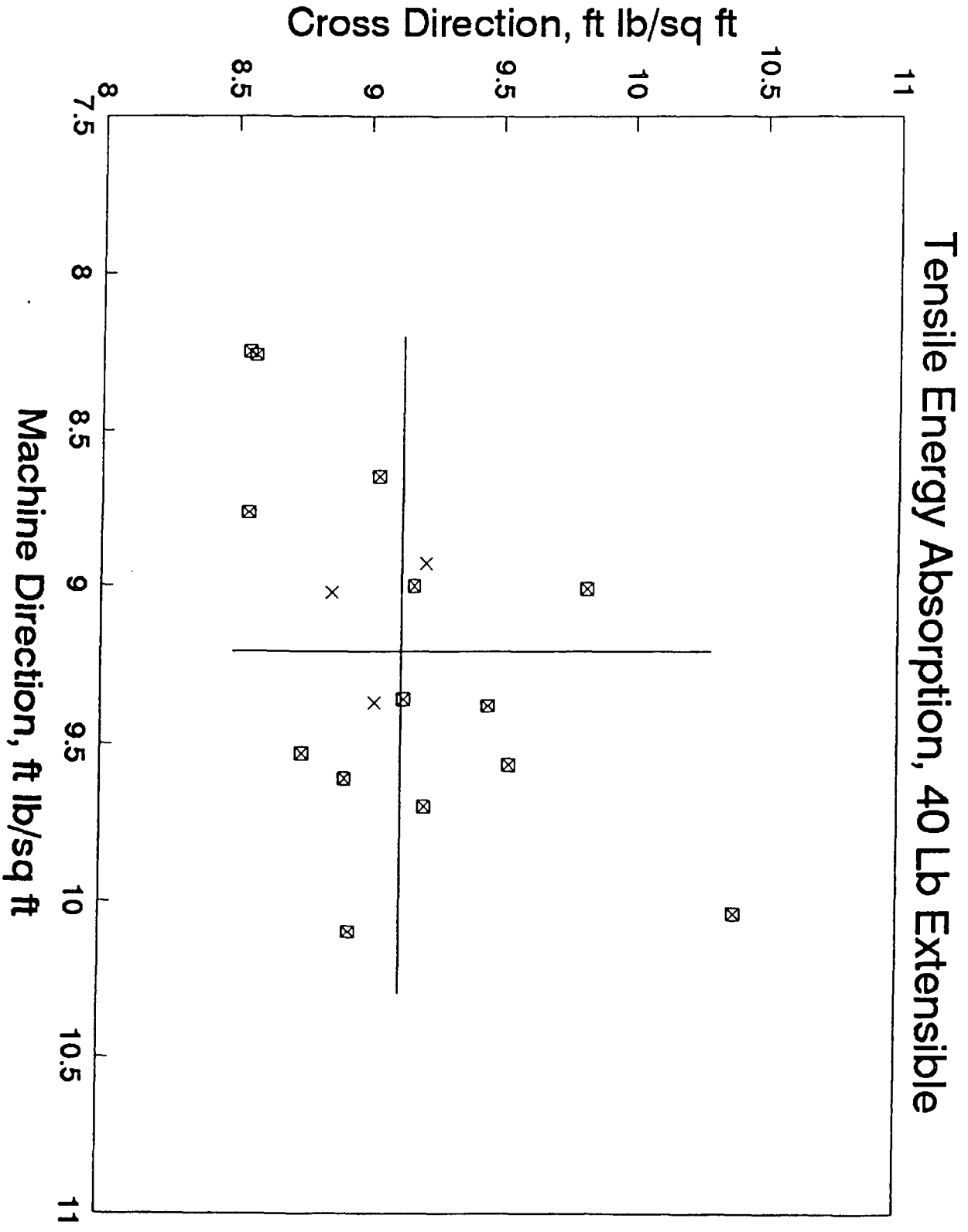

Figure 21. Industry variability in the measurement of TEA of 40 lb. extensible grades. (x = IPST Data).

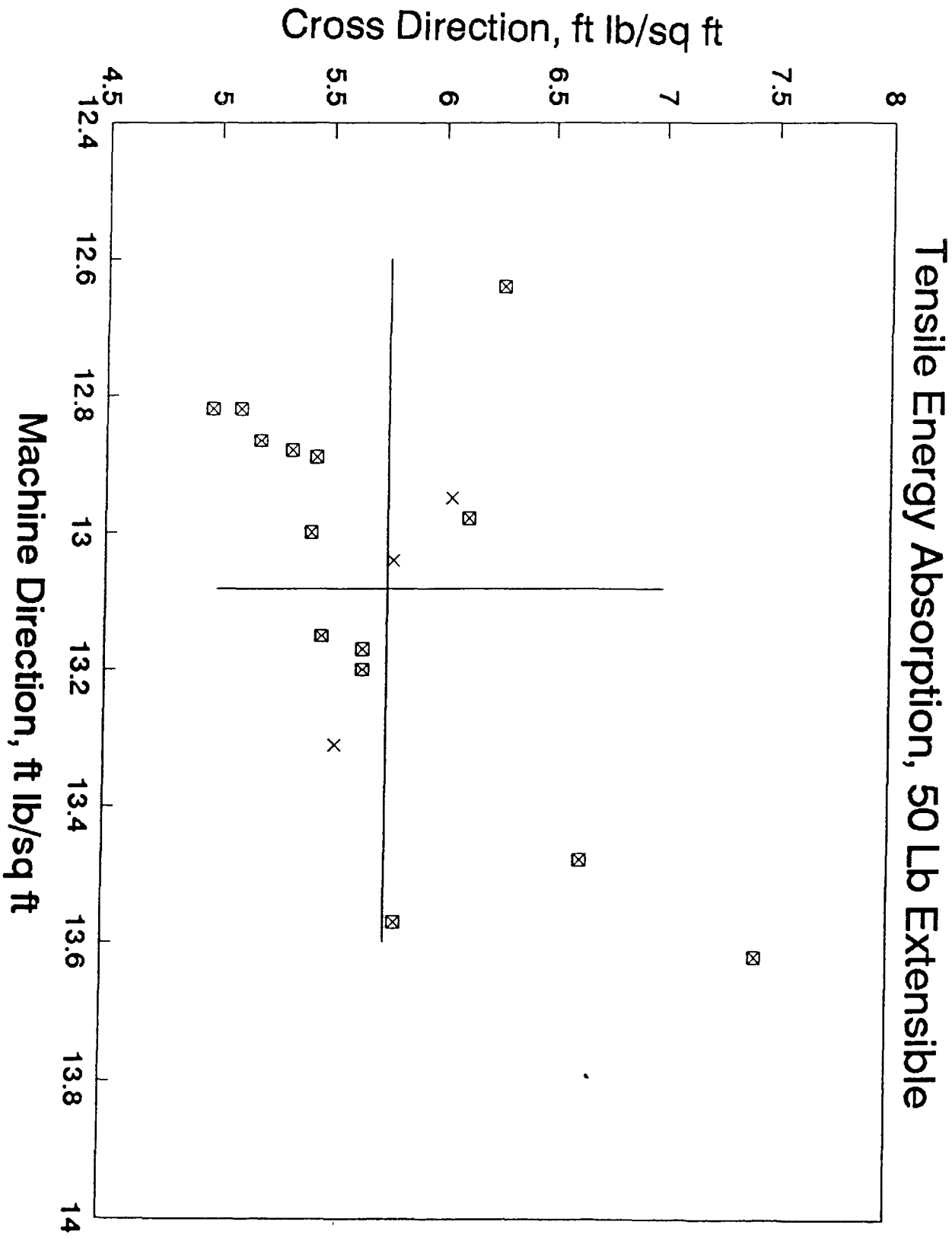

Figure 22. Industry variability in the measurement of TEA of 50 lb. extensible grades. (x = IPST Data).

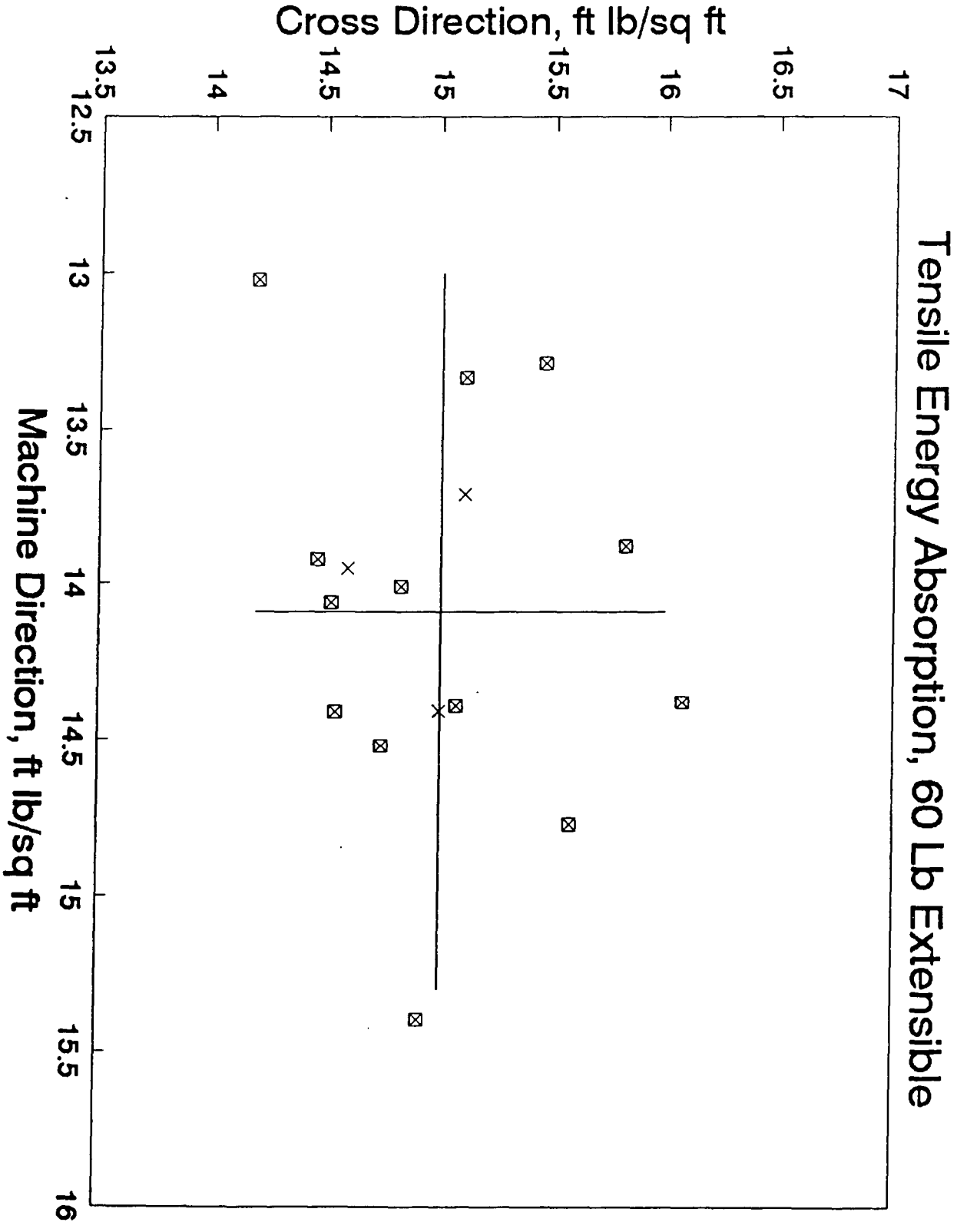

Figure 23. Industry variability in the measurement TEA of 60 lb. extensible grades. (x = IPST Data).

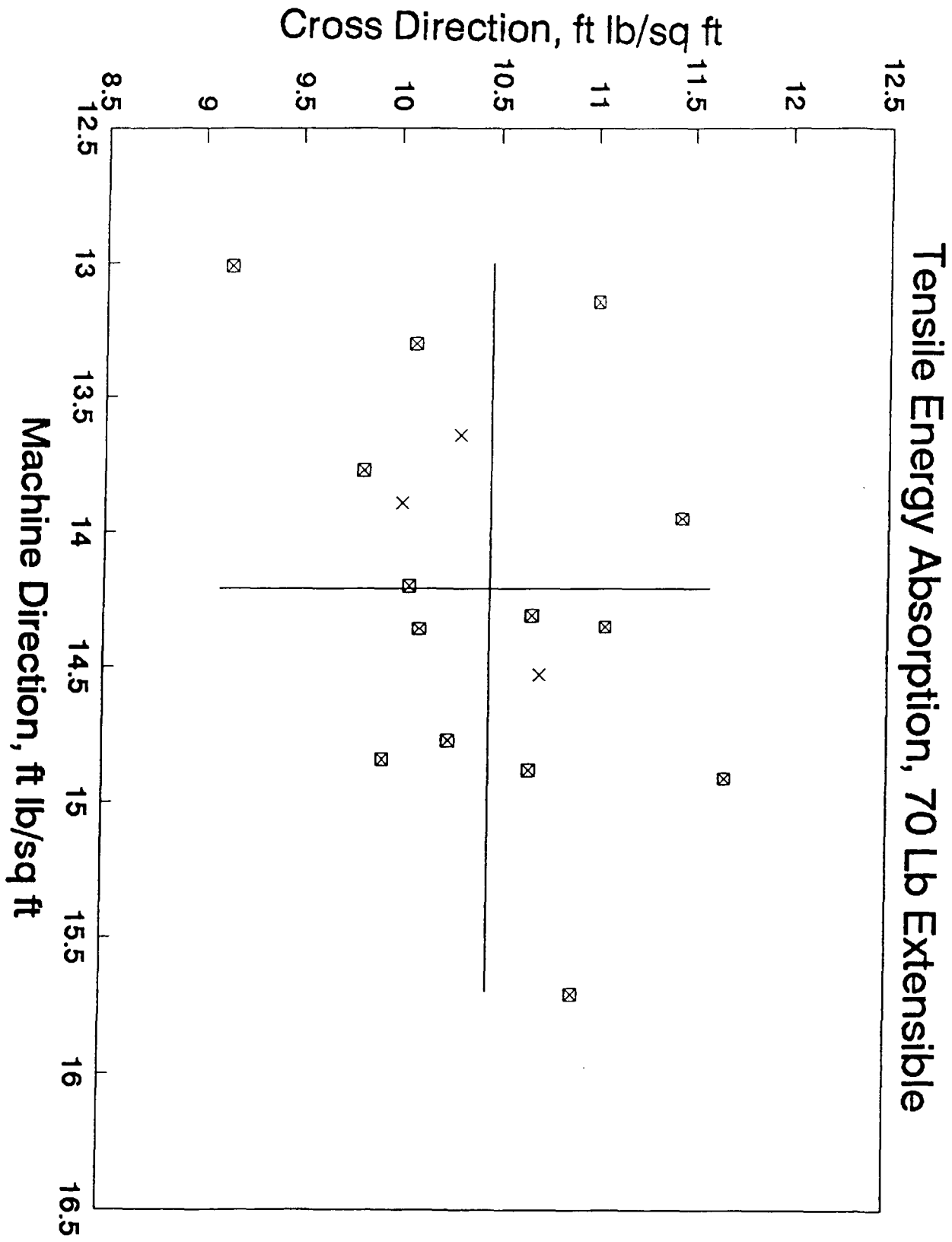

Figure 24. Industry variability in the measurement of TEA of 70 lb. extensible grades. (x = IPST Data).

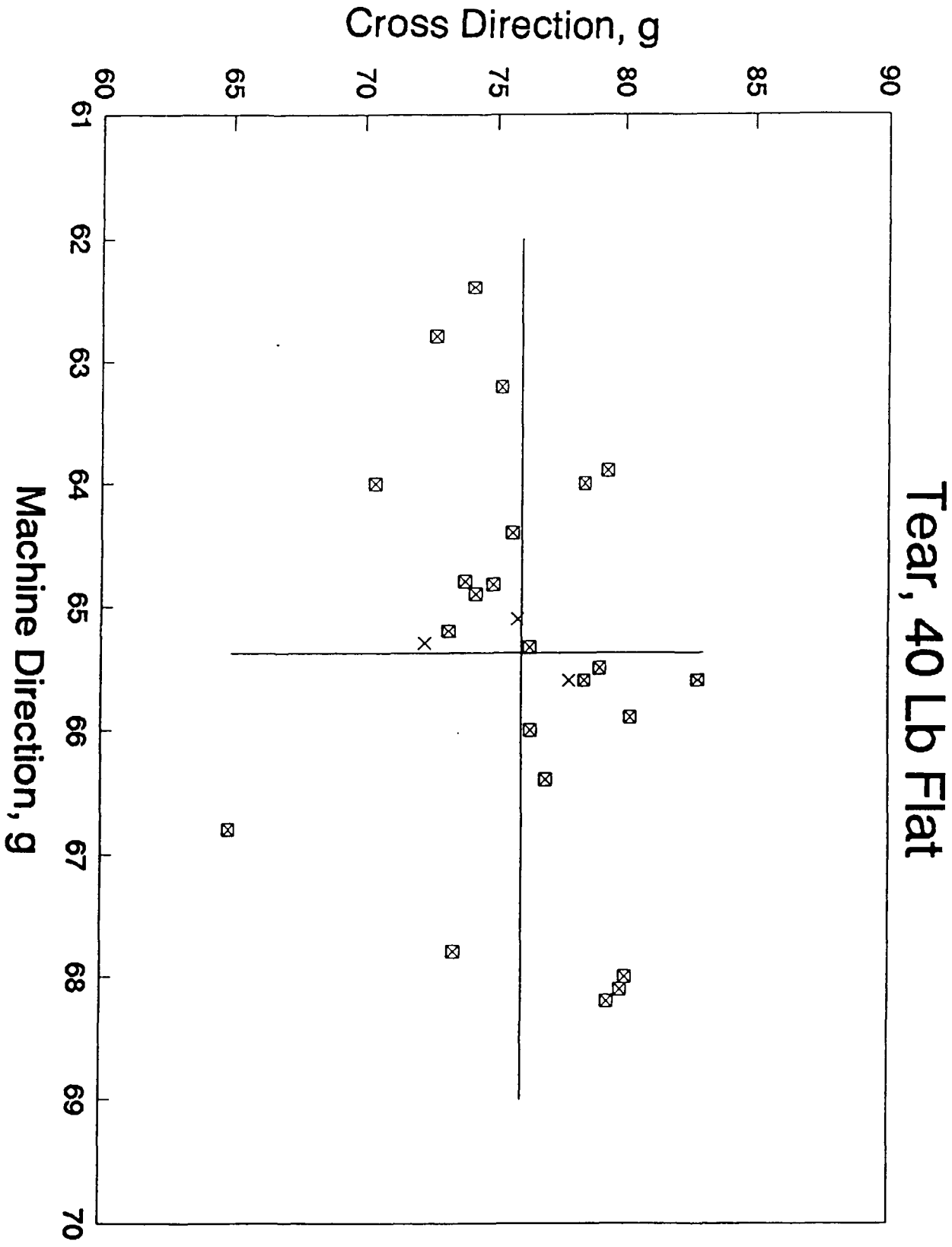

Figure 25. Industry variability in the measurement of Tear of 40 lb. flat grades. (x = IPST Data).

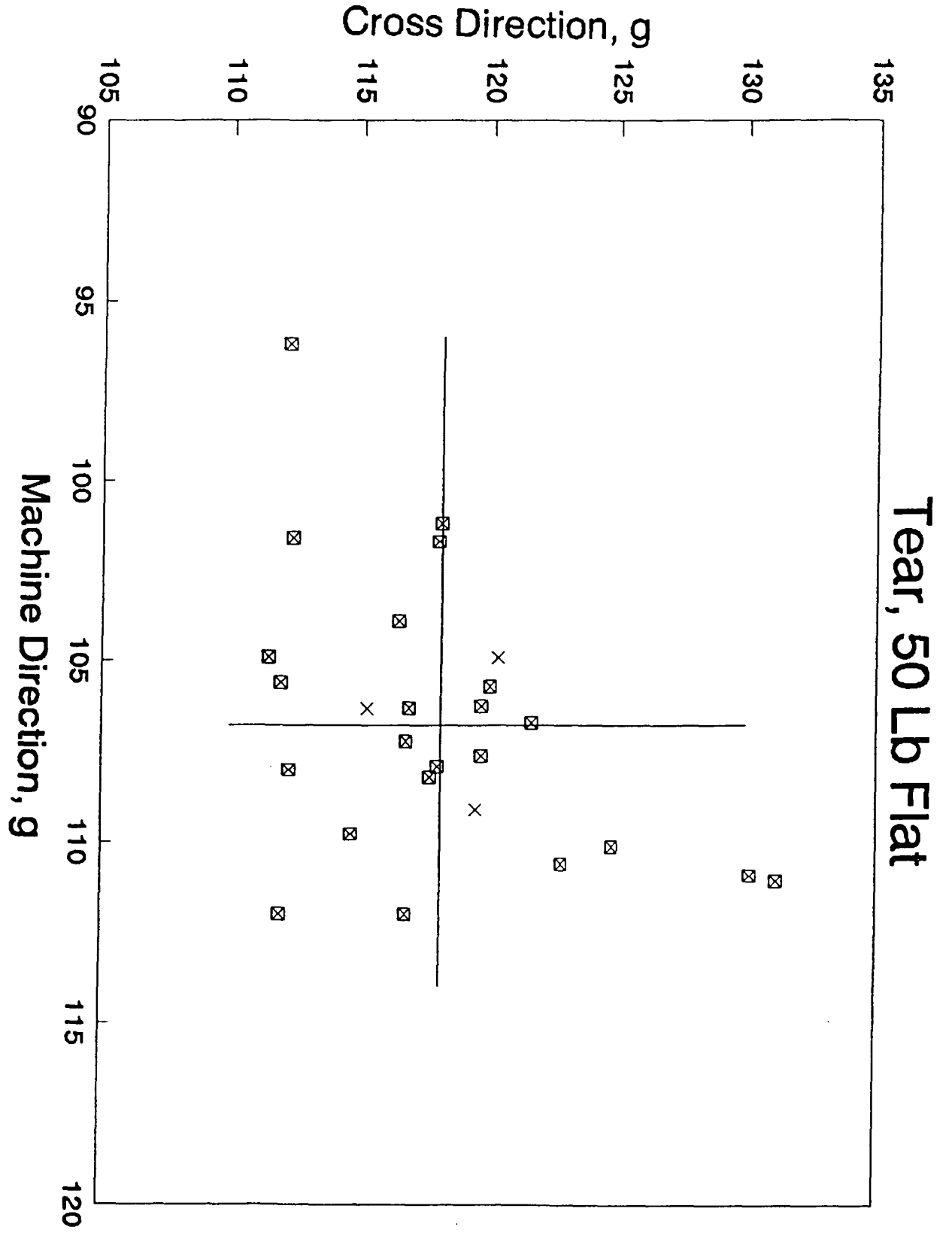

Figure 26. Industry variability in the measurement of Tear of 50 lbs. flat grades. (x = IPST Data).

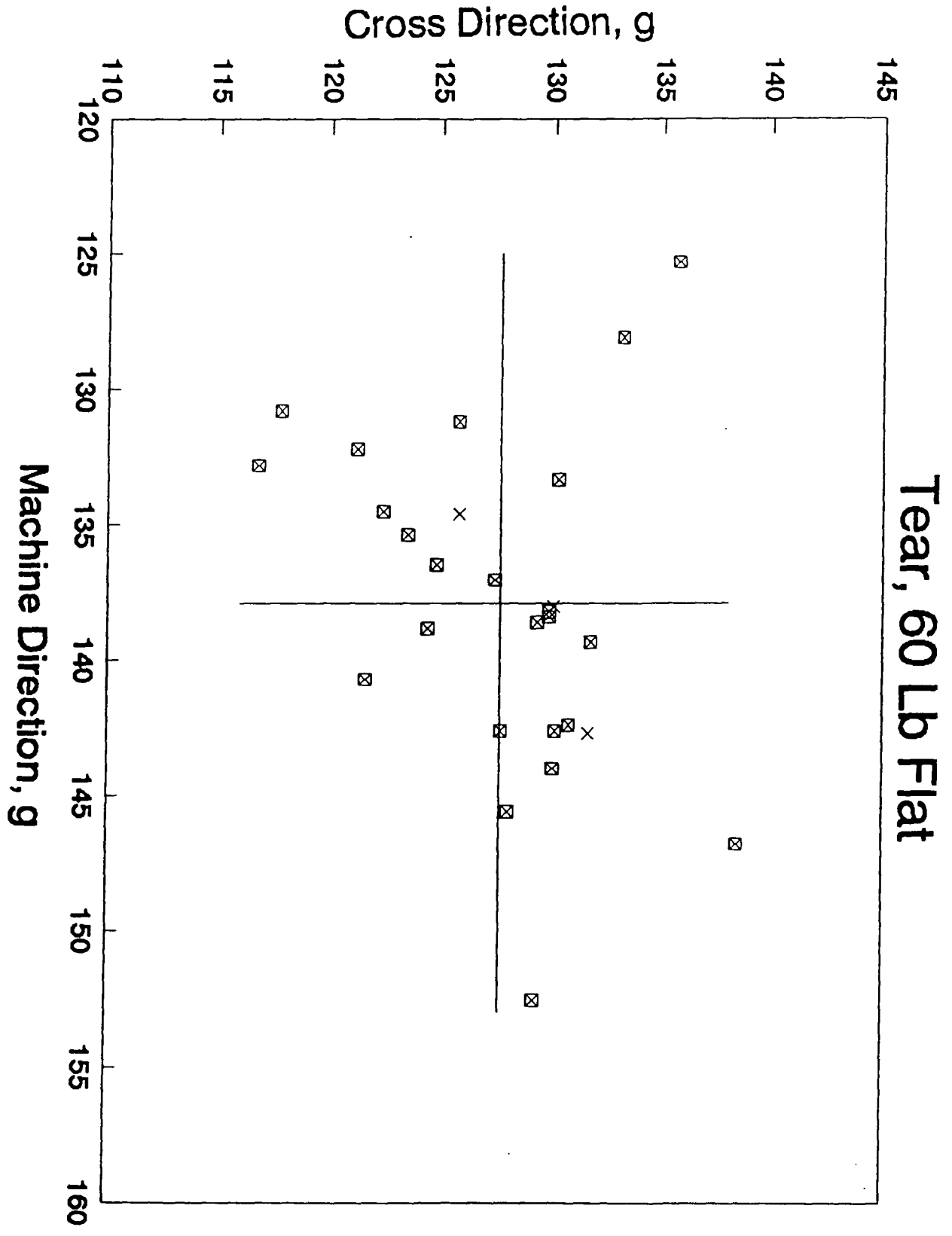

Figure 27. Industry variability in the measurement of Tear of 60 lb. flat grades. (x = IPST Data).

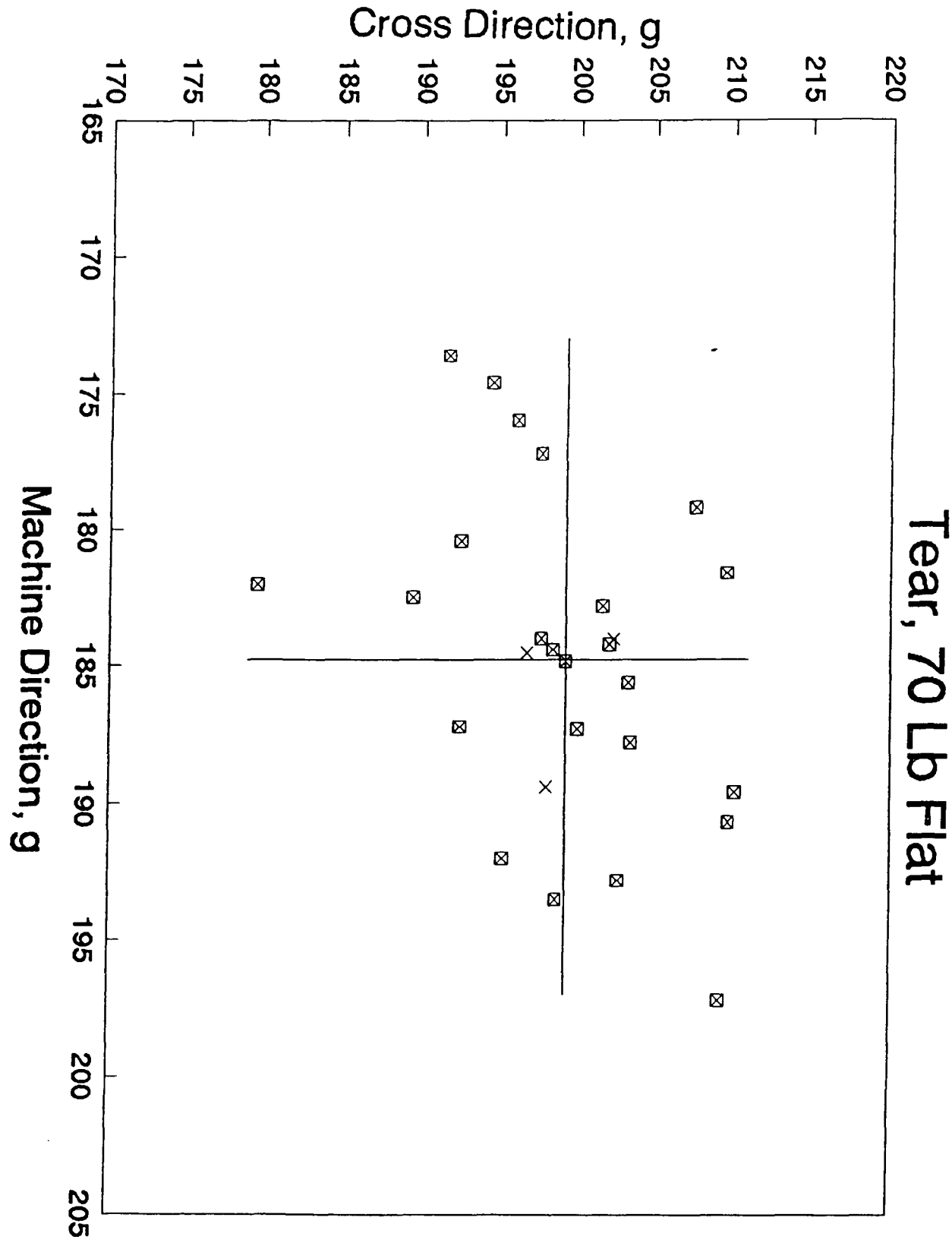

Figure 28. Industry variability in the measurement of Tear of 70 lb. flat grades. (x = IPST Data).

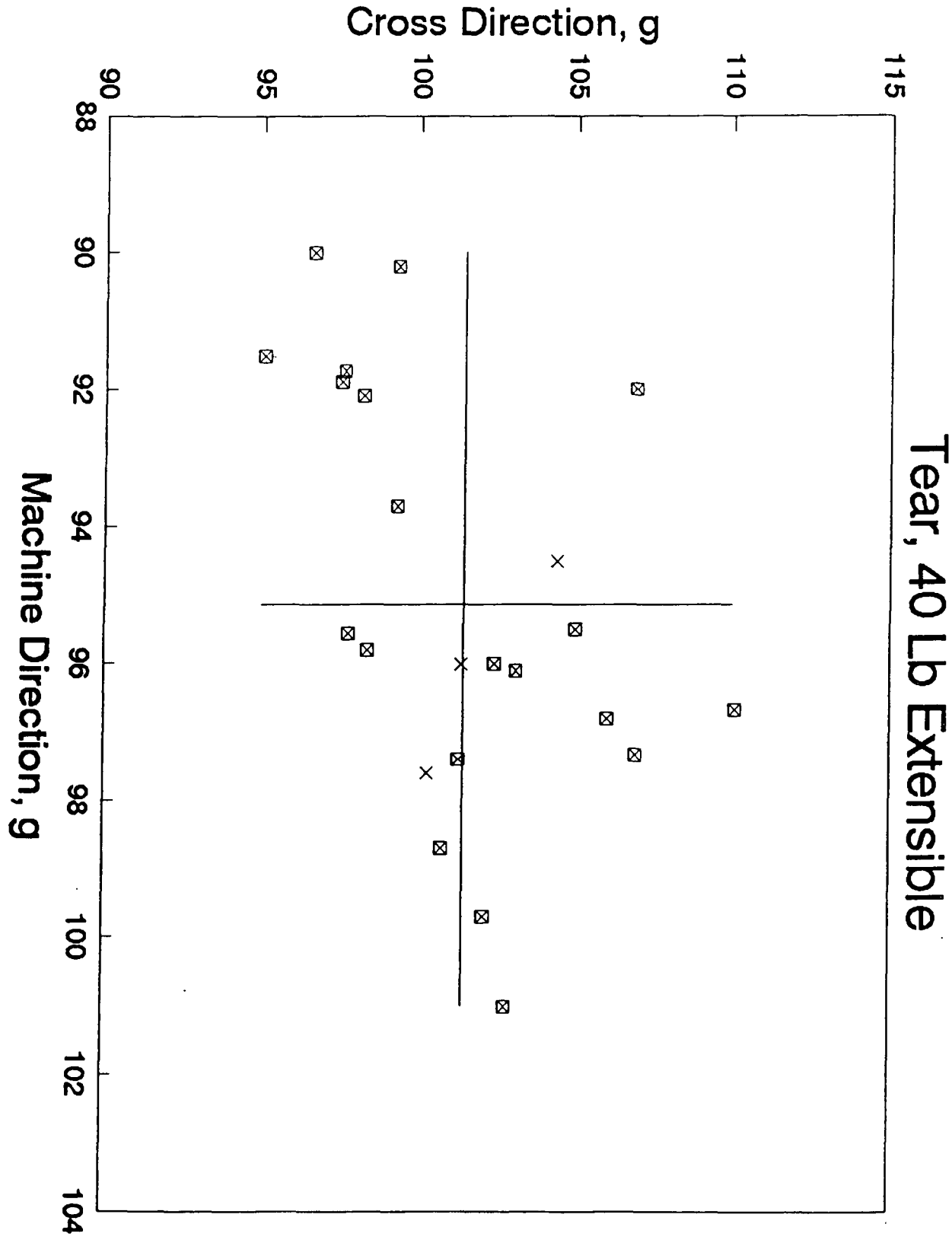

Figure 29. Industry variability in the measurement of Tear of 40 lb. extensible grades. (x = IPST Data).

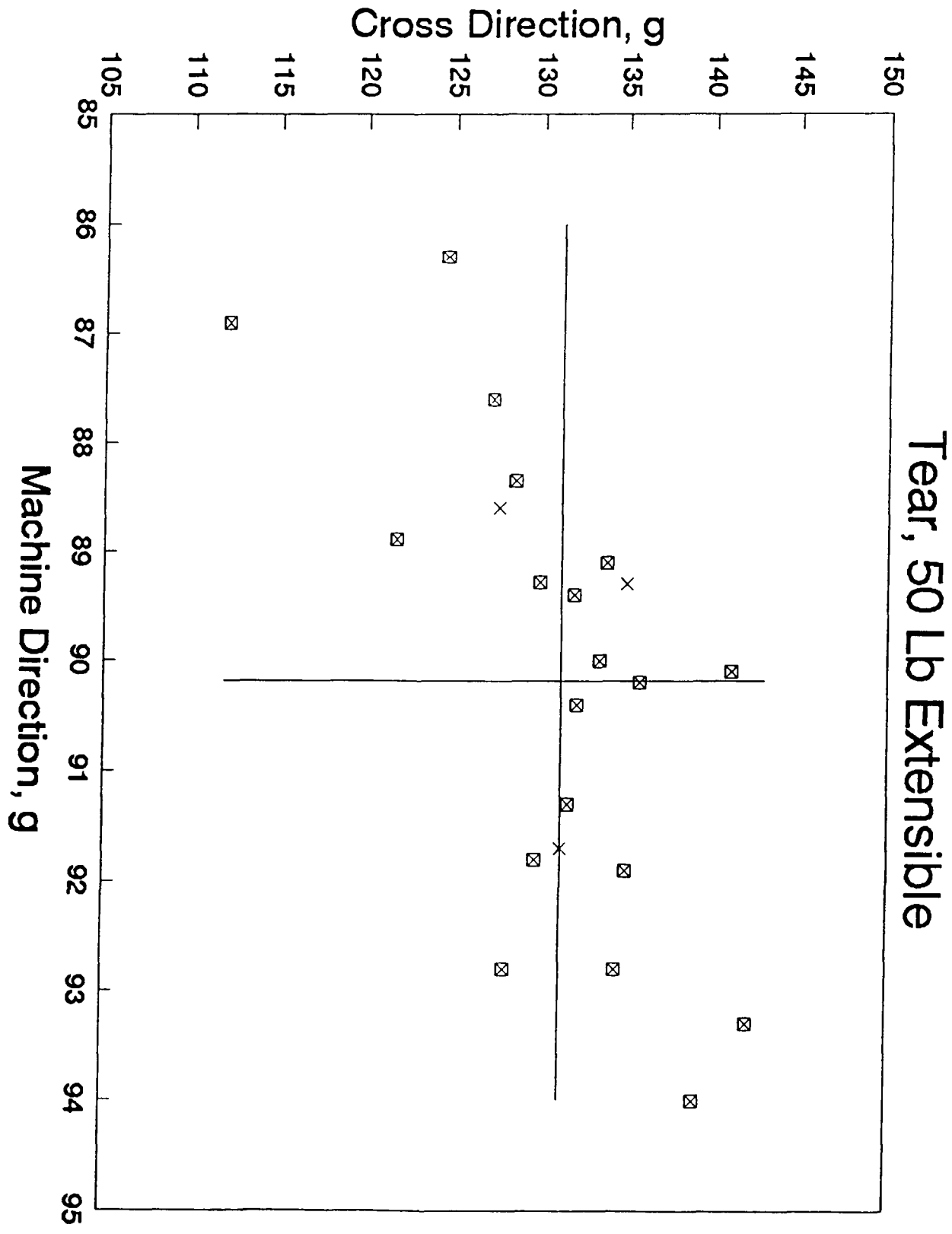

Figure 31. Industry variability in the measurement of Tear of 50 lb. extensible grades. (x = IPST Data).

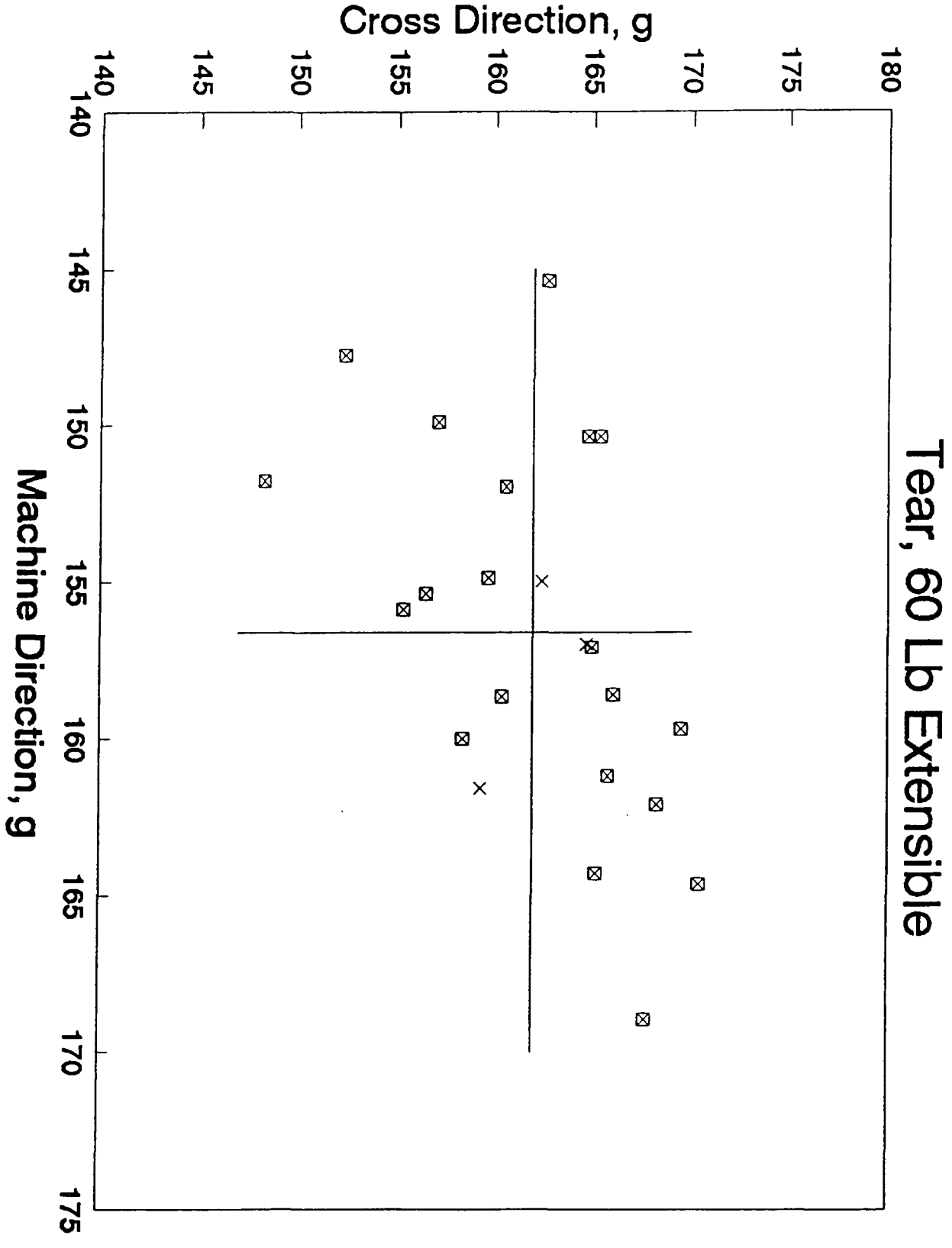

Figure 32. Industry variability in the measurement of Tear of 60 lb. extensible grades. (x = IPST Data).

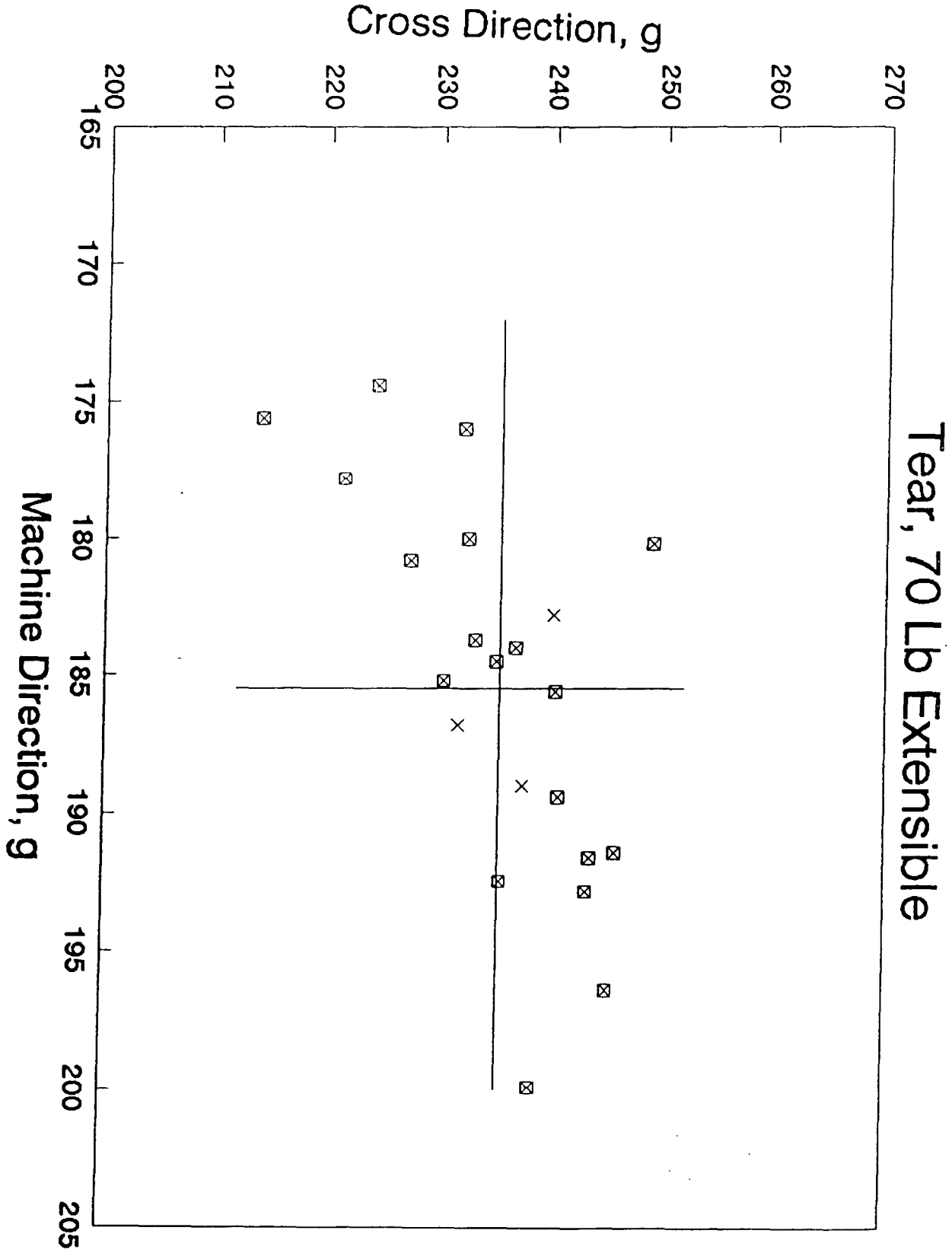

Figure 33. Industry variability in the measurement of Tear of 70 lb. extensible grade. (x = IPST Data).

CONCLUSION

As stated earlier, difference between laboratories can be attributed in part to population distribution of strength properties, and in part to all other causes not associated with product variability. Based on IPST data, but without proof, it is concluded that significant reduction in industry wide testing variability can be achieve through improvements in instrument calibration and standardization of test procedures.

THE INSTITUTE OF PAPER
SCIENCE AND TECHNOLOGY

Submitted by:

Roger H. Van Eperen
Principal Associate Technologist