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Institute of Paper Science and Technology

SLIDE MATERIAL

To The

SURFACE AND COLLOID SCIENCE

PROJECT ADVISORY COMMITTEE

December 17, 1990
Institute of Paper Science and Technology
Atlanta, GA

IPST

Atlanta, Georgia

SURFACE AND COLLOID SCIENCE
PROJECT ADVISORY COMMITTEE

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AGENDA

SURFACE AND COLLOID SCIENCE
PROJECT ADVISORY COMMITTEE

December 17, 1990
Institute of Paper Science and Technology
Atlanta, Georgia

MONDAY--December 17

10:30	Coffee and doughnuts	
10:45	Welcome, Introductions, Antitrust Statement	Stratton
10:50	Goals and Objectives	Yeske/Ellis
11:15	NHANC Internal Strength Enhancement Project 3526	Stratton
12:00	LUNCH	
1:00	WETAB Fundamentals of Paper Surface Wettability Project 3646	Etzler
1:45	RECYC Utilization of Recycled Fiber Project 3681	Ellis/Stratton
2:30	Committee Discussions	
3:00	Adjournment	

DUES FUNDED RESEARCH PROGRAM

SURFACE AND COLLOID SCIENCE

PROJECT	TITLE	FY 90-91 BUDGET (K$)
NHANC	Internal Strength Enhancement Project 3526	60
WETAB	Fundamentals of Paper Surface Wettability Project 3646	135
RECYC	Utilization of Recycled Fibers Project 3681	185

INTERNAL STRENGTH ENHANCEMENT
PROJECT 3526

December 17, 1990
Institute of Paper Science and Technology
Atlanta, Georgia

DUES-FUNDED PROJECT SUMMARY FORM
FY 90-91

Project Title:	INTERNAL STRENGTH ENHANCEMENT
Division:	Engineering and Paper Materials
Project Code:	NHANC
Project Number:	3526
Project Staff:	R. Stratton
FY 90-91 Budget:	$60,000

PROJECT OBJECTIVE: To improve internal strength and moisture tolerance in paper and paperboard. The short term goals are to establish those fundamental parameters affecting inter-fiber and intra-fiber bounding in conventional and ultra high yield pulps and to control these parameters, if possible, by chemical or mechanical treatments.

PROGRAM AREAS: End Use Performance, Reduced Operating Costs.

RATIONALE: Major limitations of paper and board for many uses are low internal bond strength and poor moisture tolerance. Improved internal strength and enhanced moisture resistance would allow a number of present grades to be produced using less fiber and would also allow new end uses to be developed.

At present, commercial papers do not attain strength levels that realize the full potential of the wood fibers. Most paper mechanical properties are markedly degraded with increasing moisture content. We need to better understand the nature of fiber properties and fiber-to-fiber bonding and changes in them with increasing moisture content, if we are eventually to improve the moisture tolerance of paper.

GOALS FOR 1990-1991:

1. Prepare woodgrain reports on the single fiber and handsheet studies on strength enhancement.

2. Determine the relationship between different measures of fiber/fiber bonding:

   - z-direction tensile strength
   - z-toughness
   - in-plane longitudinal modulus
   - out-of-plane longitudinal modulus
   - zx shear strength

3. Achieve substantial dry and moist strength enhancement through the use of novel chemical additives.

ACCOMPLISHMENTS TO DATE:

1. Developed the delamination tester as a sensitive measure of the toughness of fiber/fiber bonds.

2. Showed that Tensile Energy Adsorption (TEA) is a unique function of tensile strength independent of pulp yield and treatment with strength aids.

3. Showed that STFI compressive strength can be increased by the use of strength aids to a limited extent. Factors other than bond strength curtail further increases.

4. Showed that specific z-toughness, a measure of the inherent bondability of a pulp, is independent of pulp yield but is strongly increased when strength aids are present.

5. STFI compressive strength can be increased by the use of strength aids to a limited extent. Factors other than bond strength curtail further increases. STFI is directly correlated with the tensile strength independent of pulp yield and strength aid addition. Pulp fines increase both tensile strength and Z-toughness. Fines in a system treated with a strength aid are much more effective in enhancing Z-toughness than in the untreated case. Tensile Energy Adsorption (TEA) is a unique function of the tensile strength independent of pulp yield and treatment with strength aids.

6. Analysis of the damage produced during failure of individual fiber-fiber bonds showed that both fibers of the pair sustained similar damage. The damage of a population of fibers is normally distibuted. No correlation between breaking load and damage was found for individual bond pairs. For both chemical and mechanical pulps use of strength aid increases the damage produced by bond failure.

RELATED STUDENT RESEARCH:

M.A. Friese, Ph.D. - 1991; M.T. Goulet, Ph.D. -1989; C.O. Luettgen, Ph.D. - 1990; C.E. Miller, Ph.D. - 1989; D.L. Horstmann, M.S. -1989; M.H. Lang, M.S. - 1990; M.W. Sachs, M.S. - 1989;

Michael Friese, Ph.D. Thesis, "An Experimental Study of Adsorbed Polymer Configurations Using FTIR-CIR Spectroscopy" (in progress).

Todd Braga, M.S. Project, "The Effects of Supercalendering on the Bonding in Paper" (in progress).

Michael Cresswell, M.S. Project, "Interactions of the Wet Strength Resin Melamine-Formaldehyde with Cellulose Surfaces"(in progress).

GOALS FOR DECEMBER 1990 - APRIL 1991:

1. Prepare woodgrain reports on work completed to date.

2. Design and construct an instrument to measure the stress-strain properties of paper in the Z direction.

PROJECT 3526

INTERNAL STRENGTH ENHANCEMENT

PROJECT OBJECTIVES

To improve internal strength and moisture tolerance in paper and paperboard.
The current goals are to establish those fundamental parameters affecting inter-fiber and intra-fiber bonding in conventional and ultra high yield pulps and to control these parameters, if possible, by chemical or mechanical treatments.

GOALS FOR YEAR

1. PREPARE WOOD GRAIN REPORTS ON WORK COMPLETED TO DATE.

2. DETERMINE THE RELATIONSHIPS AMONG THE VARIOUS MEASURES OF FIBER-FIBER BONDING IN SHEETS.

3. DEVELOP AN INSTRUMENT TO MEASURE THE Z DIRECTION STRESS-STRAIN PROPERTIES.

GOALS FOR PAST PERIOD

1. COMPLETE ANALYSIS OF FIBER-FIBER SINGLE BOND STUDIES.

2. MEASURE ZDT STRENGTH FOR HANDSHEET STUDY.

3. COMPLETE IN-PLANE ELASTIC PROPERTY MEASUREMENTS FOR HANDSHEET STUDY.

4. MEASURE FIBER LENGTH, WIDTH, CELL WALL THICKNESS, AND COARSENESS FOR FIBERS USED IN HANDSHEET STUDY.

MAJOR CONCLUSIONS

SINGLE FIBER:

1. SEVERITY OF DAMAGE IS INDEPENDENT OF CONFIGURATION.

2. SEVERITY OF DAMAGE IS NORMALLY DISTRIBUTED.

3. FOR INDIVIDUAL SAMPLES, BOND BREAKING LOAD DOES NOT CORRELATE WITH DAMAGE.

4. USE OF ADDITIVES INCREASES DAMAGE.

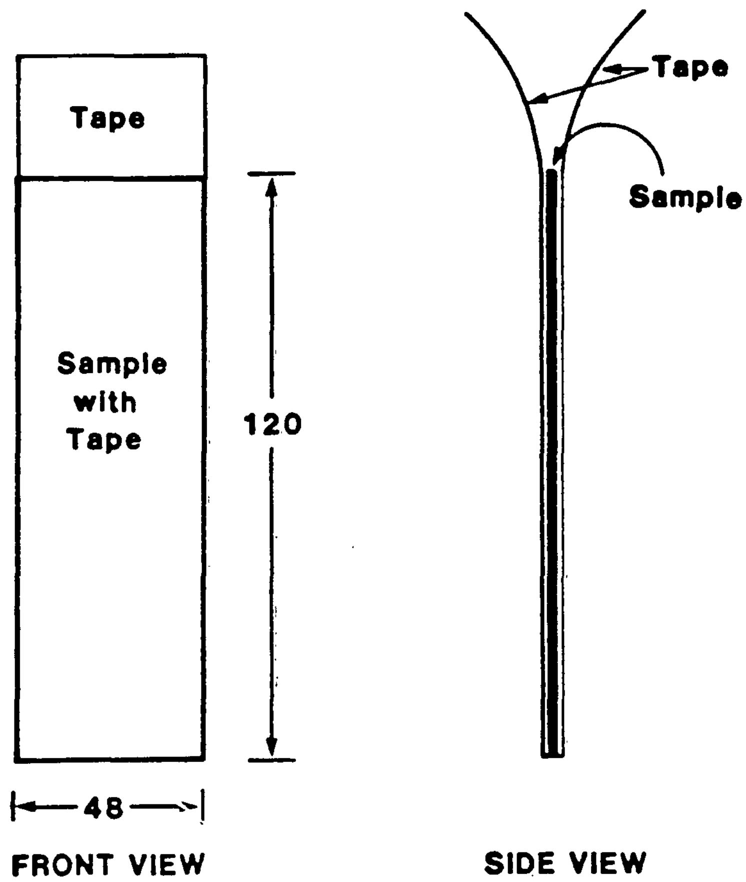
HANDSHEET:

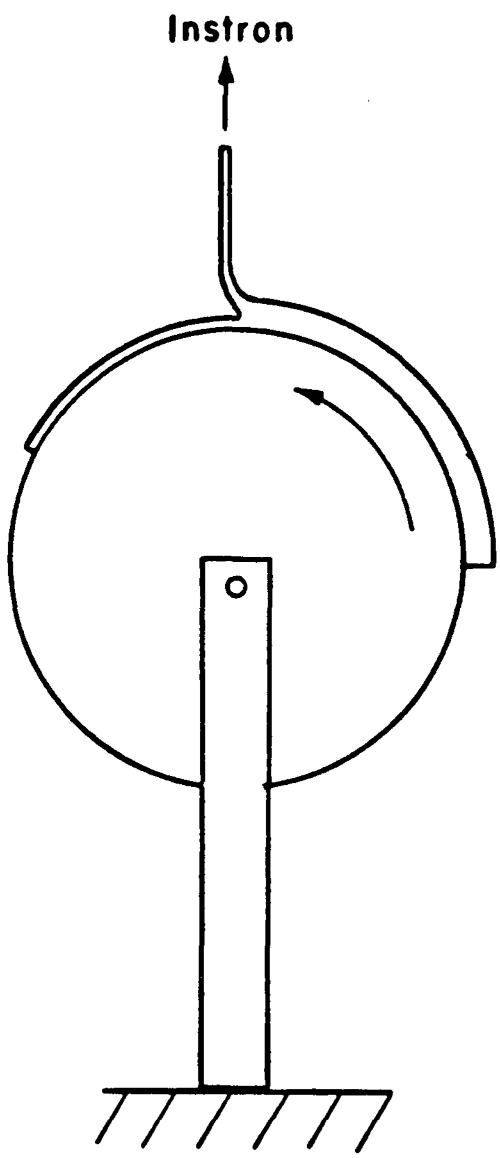
5. ZDT STRENGTH CORRELATES WITH Z TOUGHNESS, BUT NOT WITH OUT-OF-PLANE ELASTIC PROPERTIES.

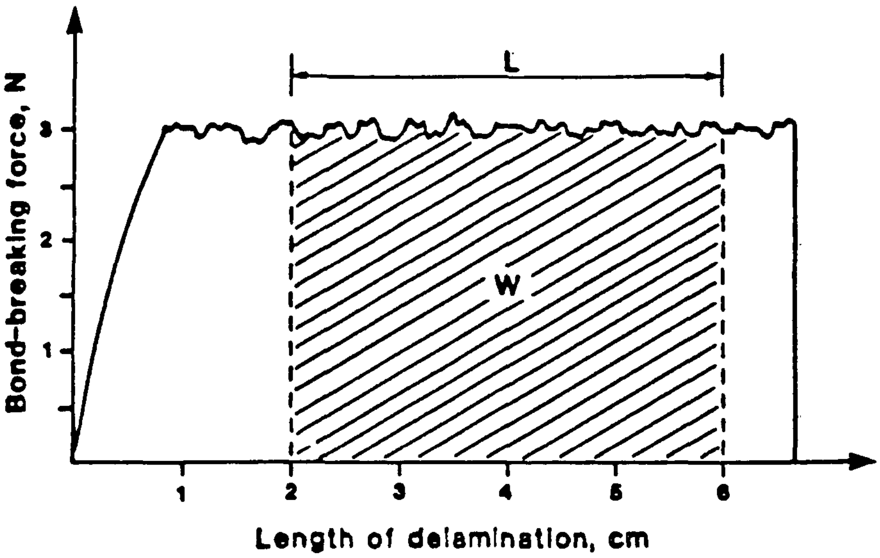
GOALS:
DECEMBER 1990 - APRIL 1991

1. PREPARE WOOD GRAIN REPORTS ON WORK COMPLETED TO DATE.

2. DESIGN AND CONSTRUCT AN INSTRUMENT TO MEASURE THE STRESS-STRAIN PROPERTIES OF SHEETS IN THE Z DIRECTION.


Tape
Sample
with
Tape
120
48
FRONT VIEW
Tape
Sample
SIDE VIEW


Instron

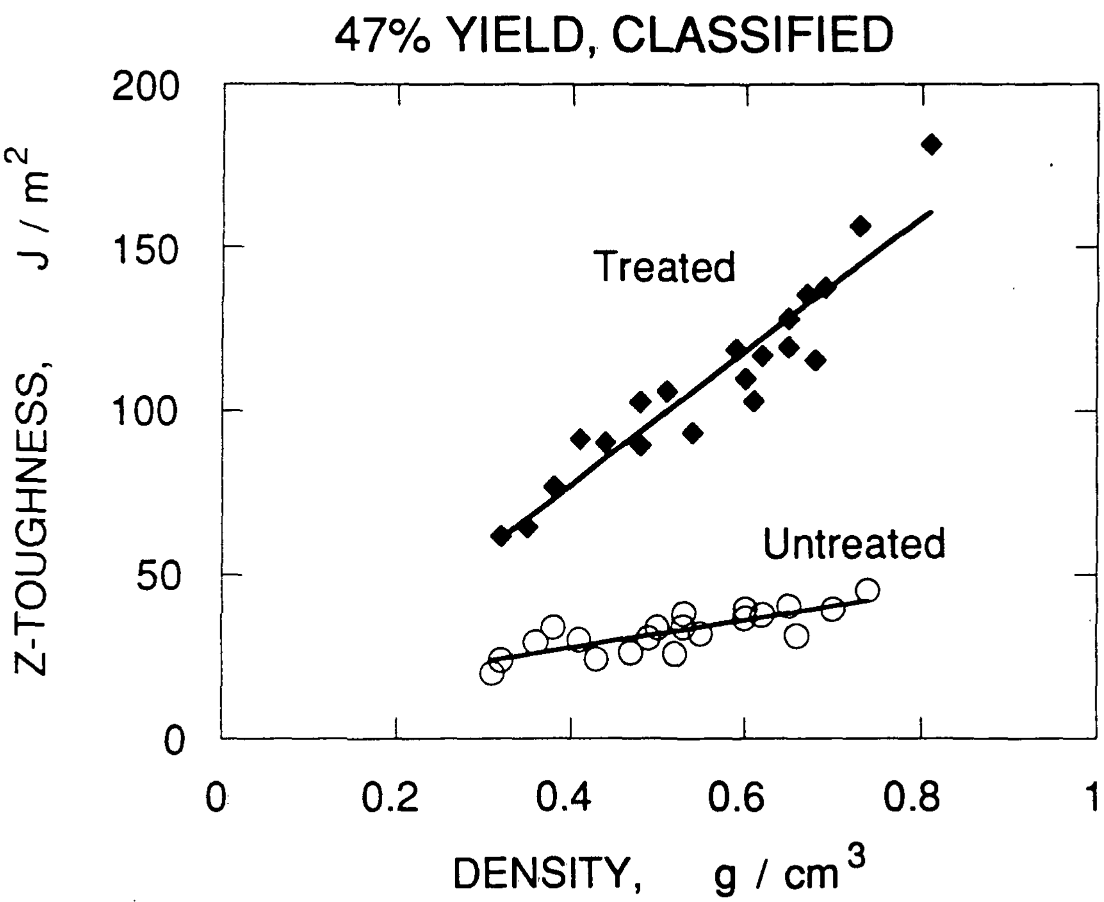

Bond-breaking force, N
3
2
1
L
W
1
2
3
4
5
6
Length of delamination, cm

PULP PROPERTIES

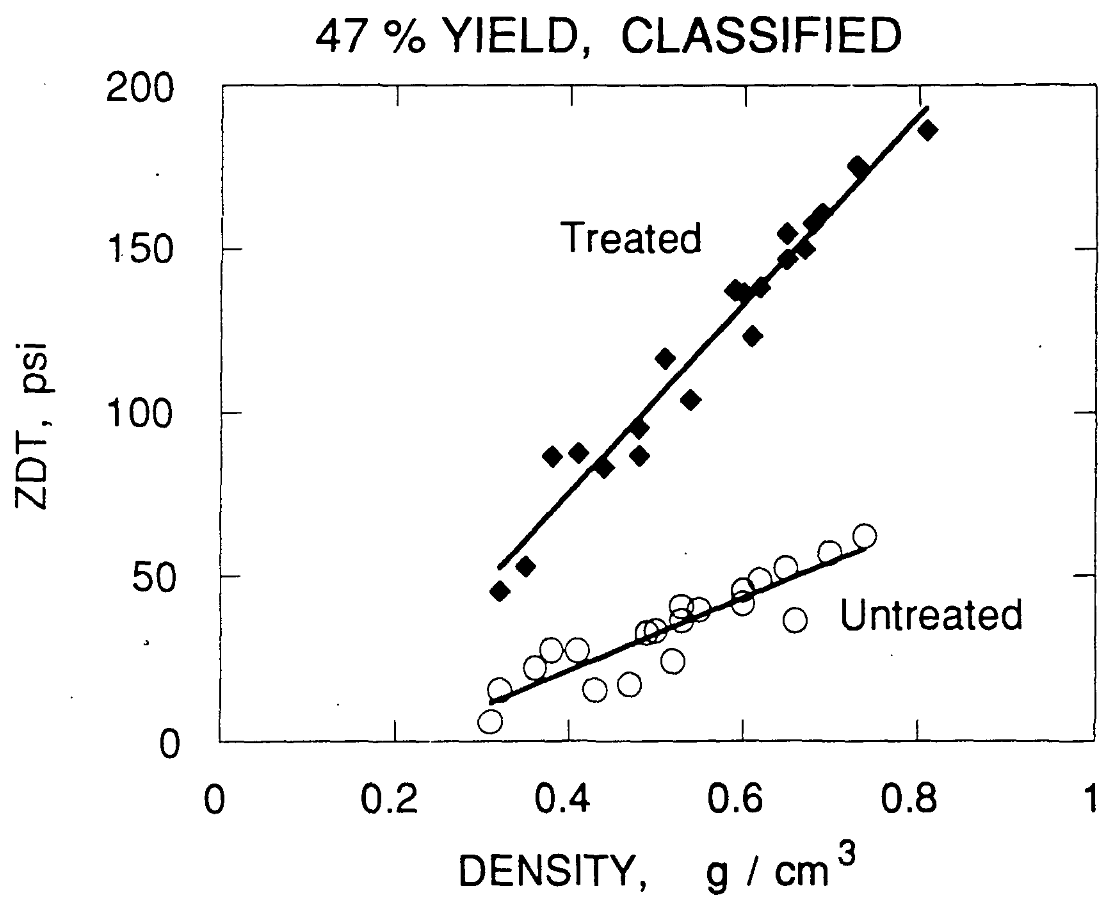
YIELD, %	KAPPA NO.
47.5	34.7
51.2	42.2
60.4	116.0
80.7	167.0

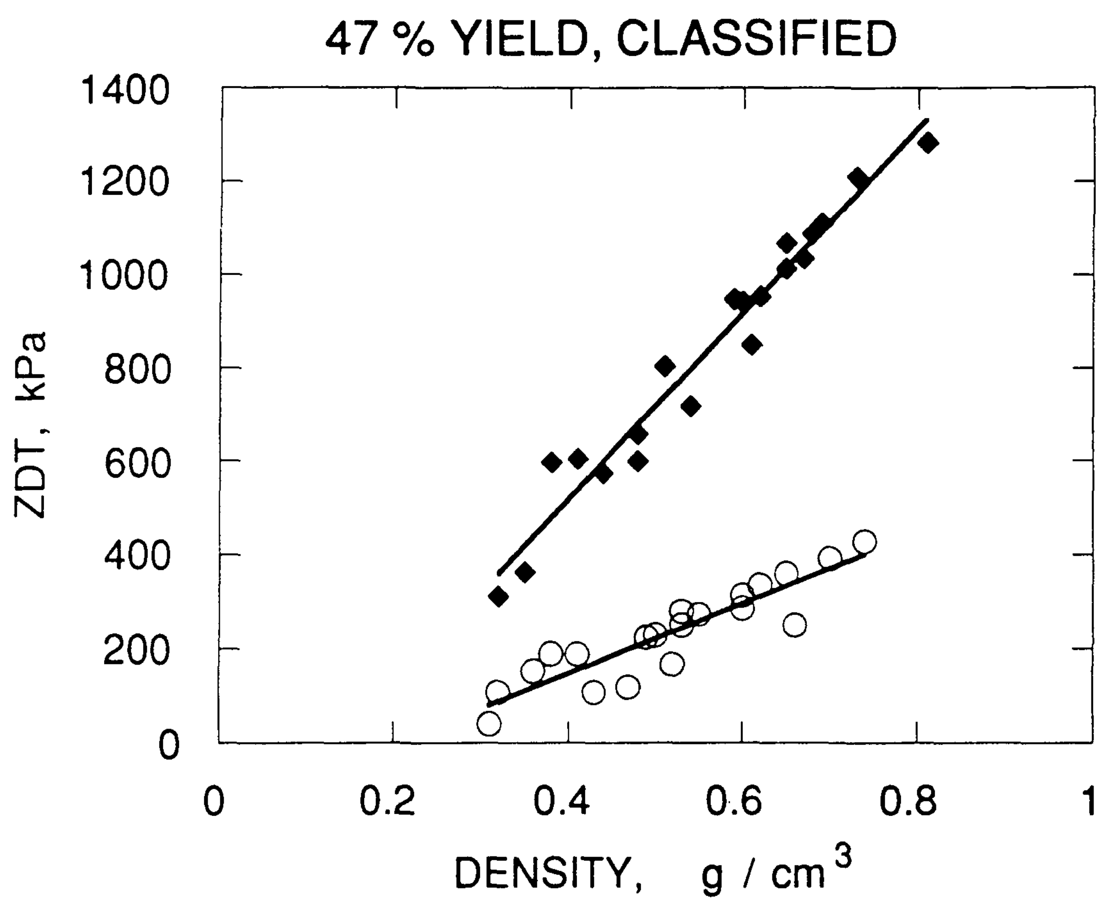
PULPS

YIELD, %	FREENESS, mL CSF			
47	685	600	350	200
52	740	600	340	200
60	750	600	350	200
80	780	600	340	200

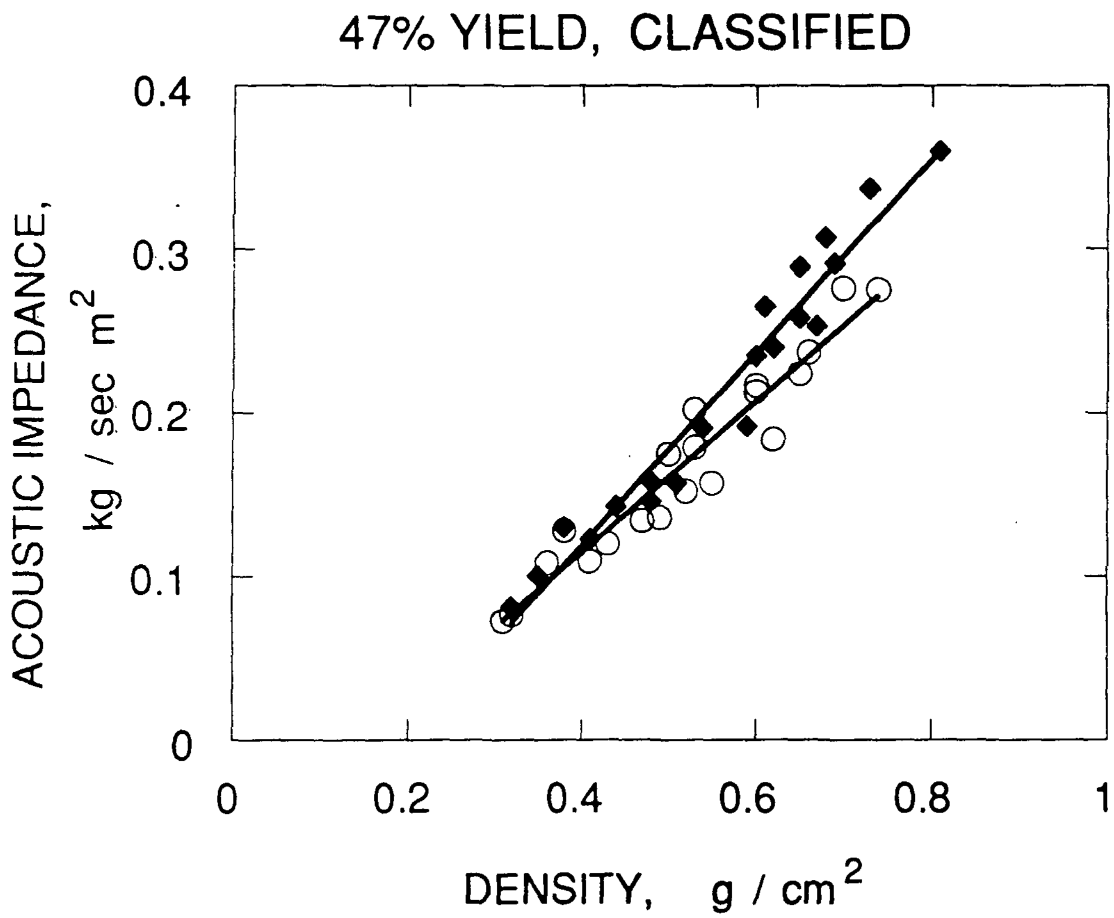


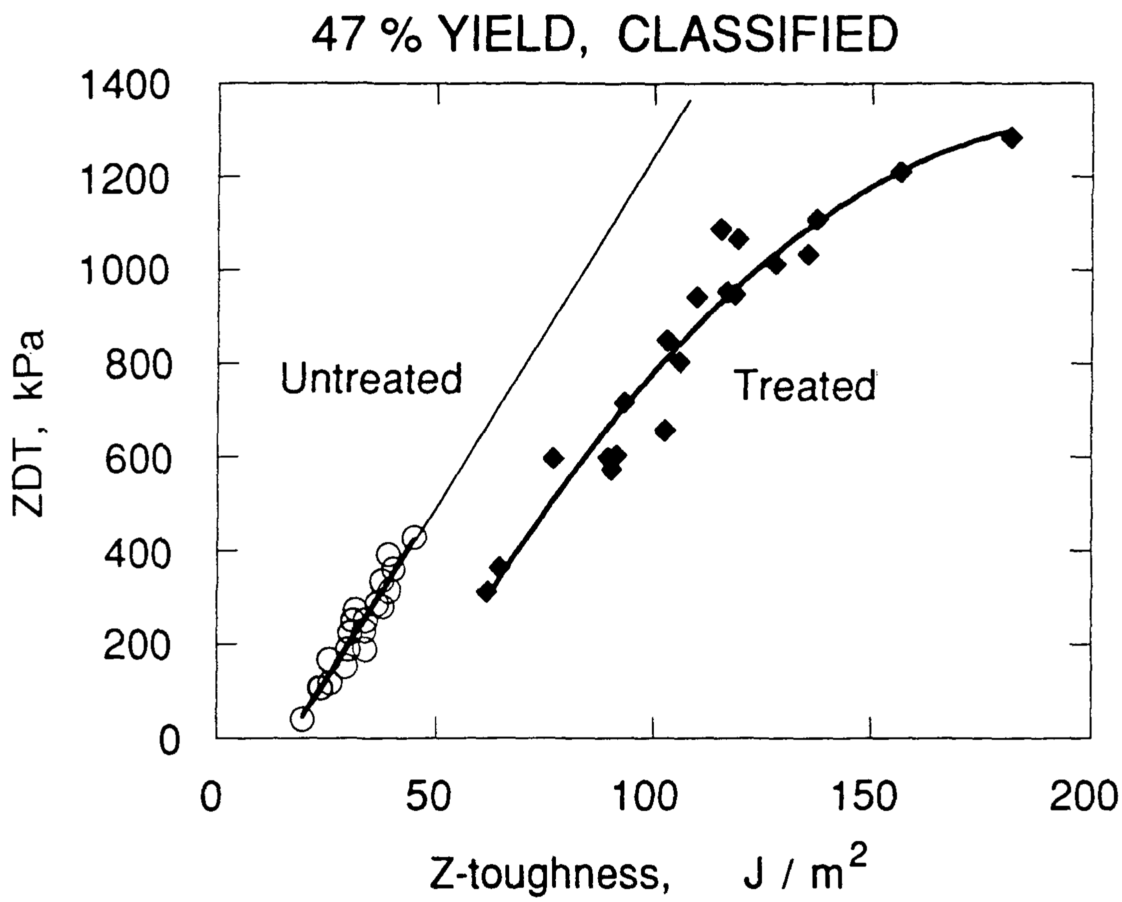
47% YIELD, CLASSIFIED
Z-TOUGHNESS, J / m2
DENSITY, g / cm3
Treated
Untreated
0
50
100
150
200
0
0.2
0.4
0.6
0.8
1


47 % YIELD, CLASSIFIED
ZDT, psi
DENSITY, g / cm 3
Treated
Untreated
200
150
100
50
0
0
0.2
0.4
0.6
0.8
1



47 % YIELD, CLASSIFIED
ZDT, kPa
0
200
400
600
800
1000
1200
1400
0
0.2
0.4
0.6
0.8
1
DENSITY, g / cm 3


47% YIELD, CLASSIFIED
ACOUSTIC IMPEDANCE, kg / sec m2
DENSITY, g / cm2
0
0.1
0.2
0.3
0.4
0.2
0.4
0.6
0.8
1


47 % YIELD, CLASSIFIED
1400
1200
1000
800
600
400
200
0
0
50
100
150
200
ZDT, kPa
Z-toughness, J / m2
Untreated
Treated

EFFECT OF REFINING

FREENESS, mL CSF	LOAD, g	AREA, microns^2	BOND STRENGTH, N/mm^2
570	0.73	2070	3.5
345	0.68	2290	3.7

EFFECT OF STRENGTH AID
(EARLYWOOD FIBERS)

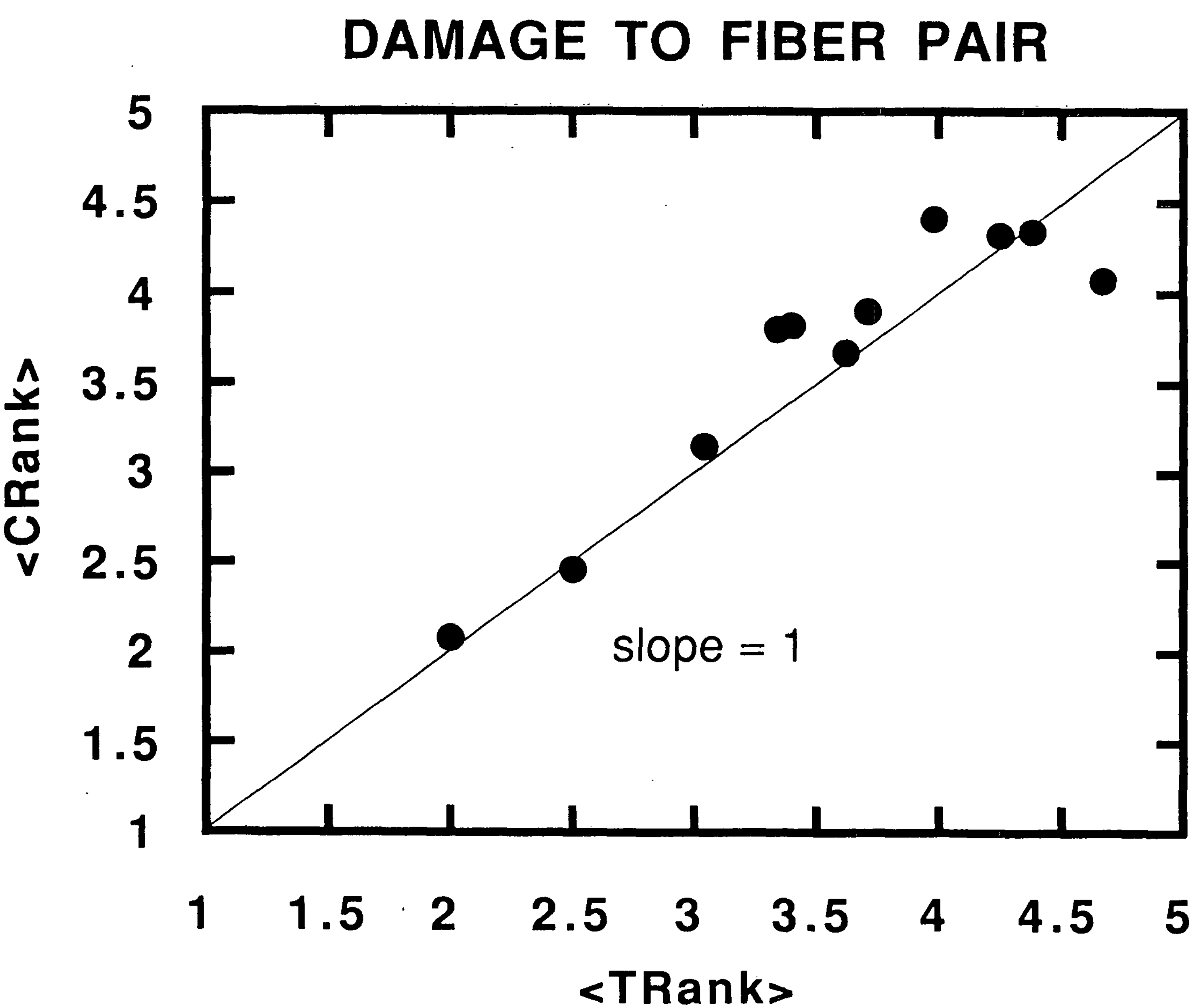
ADDITIVE	LOAD, g	AREA, microns^2	BOND STRENGTH, N/mm^2
NO	0.47	2410	2.1
YES	1.14	3000	3.9

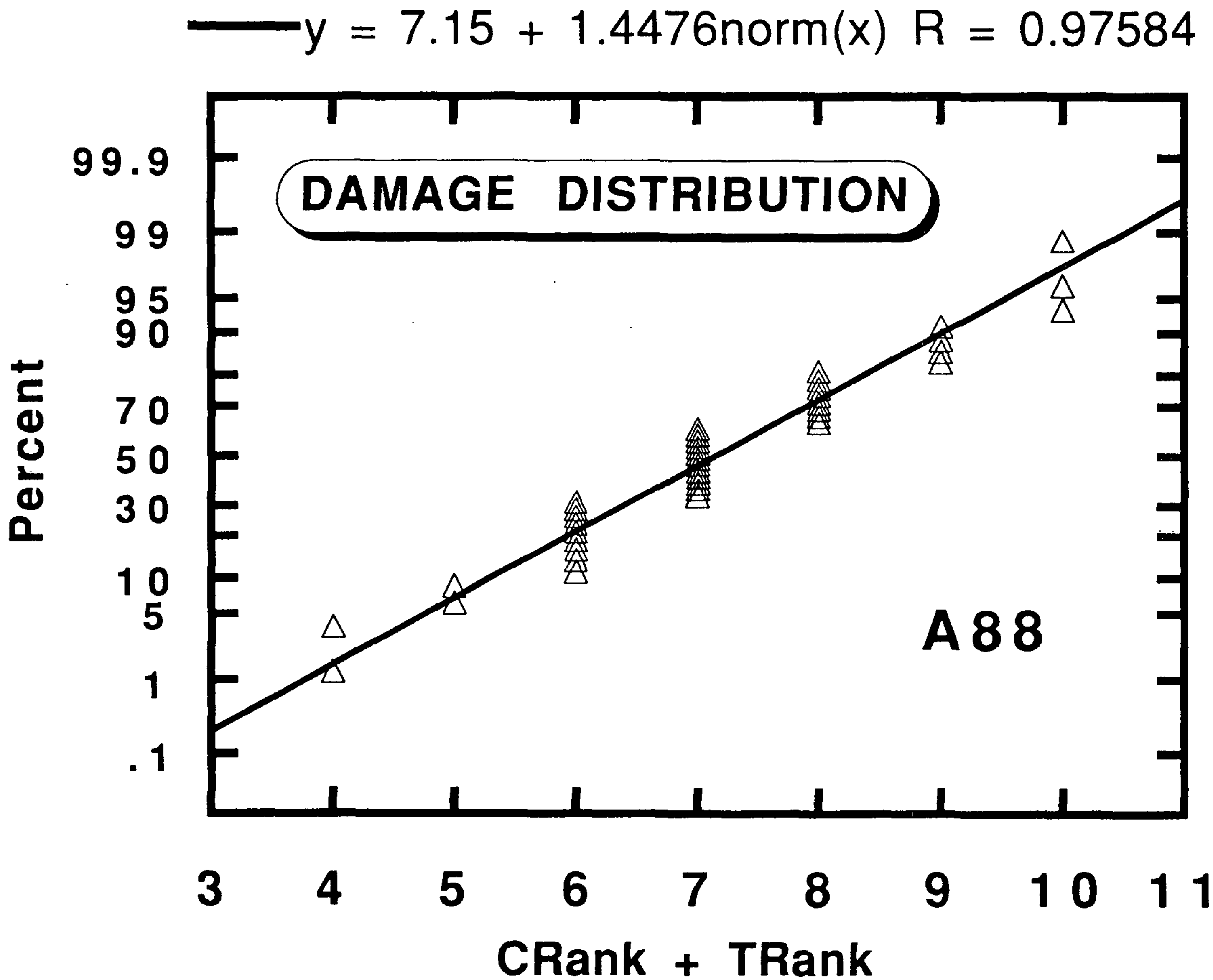
EFFECT OF BOND TYPE
(REFINED PULP)

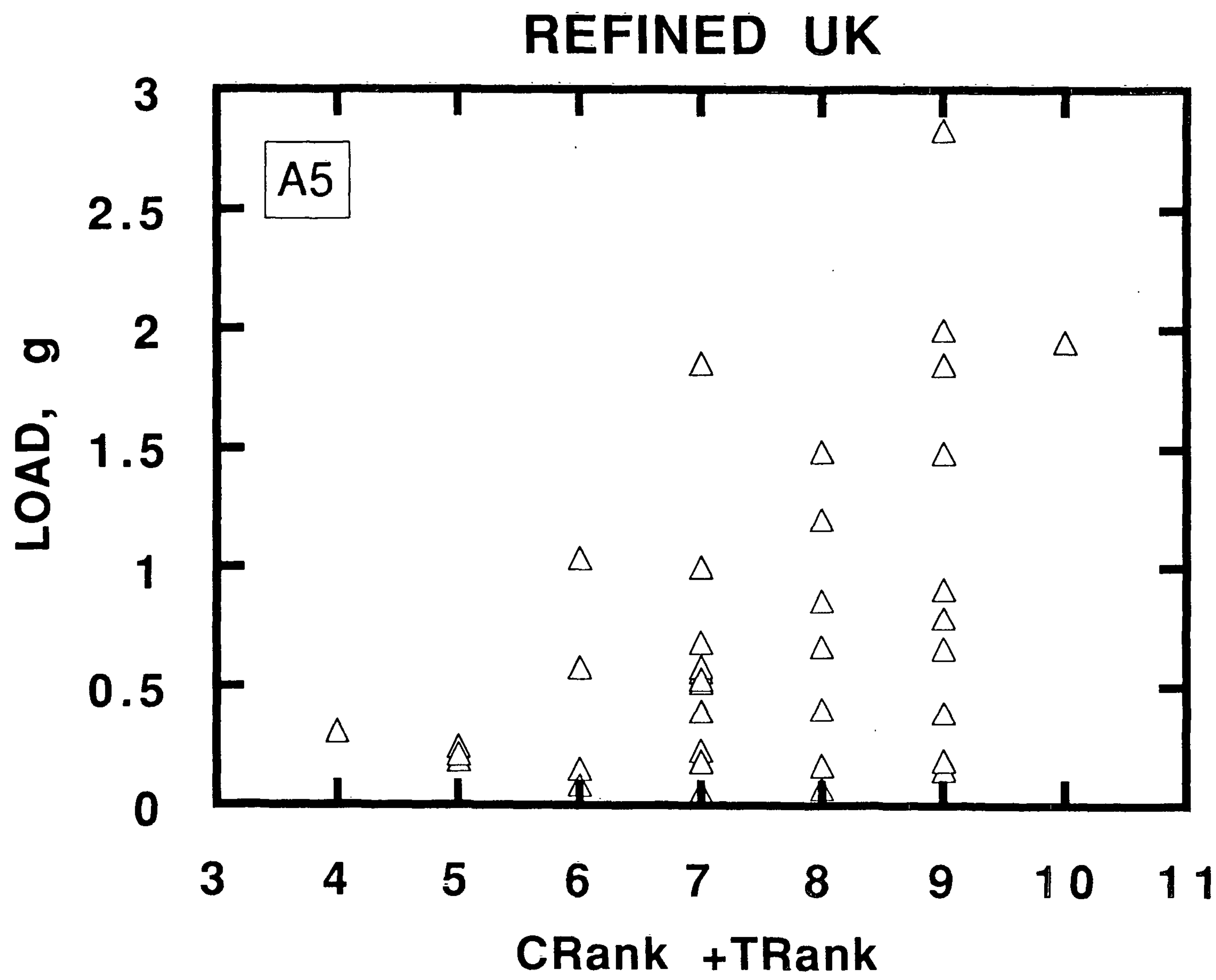
BOND TYPE	LOAD, g	AREA, $microns^2$	BOND STRENGTH, N/mm^2
H	0.73	2070	3.5
COVALENT	1.44	2130	7.5
IONIC	1.51	2040	9.3

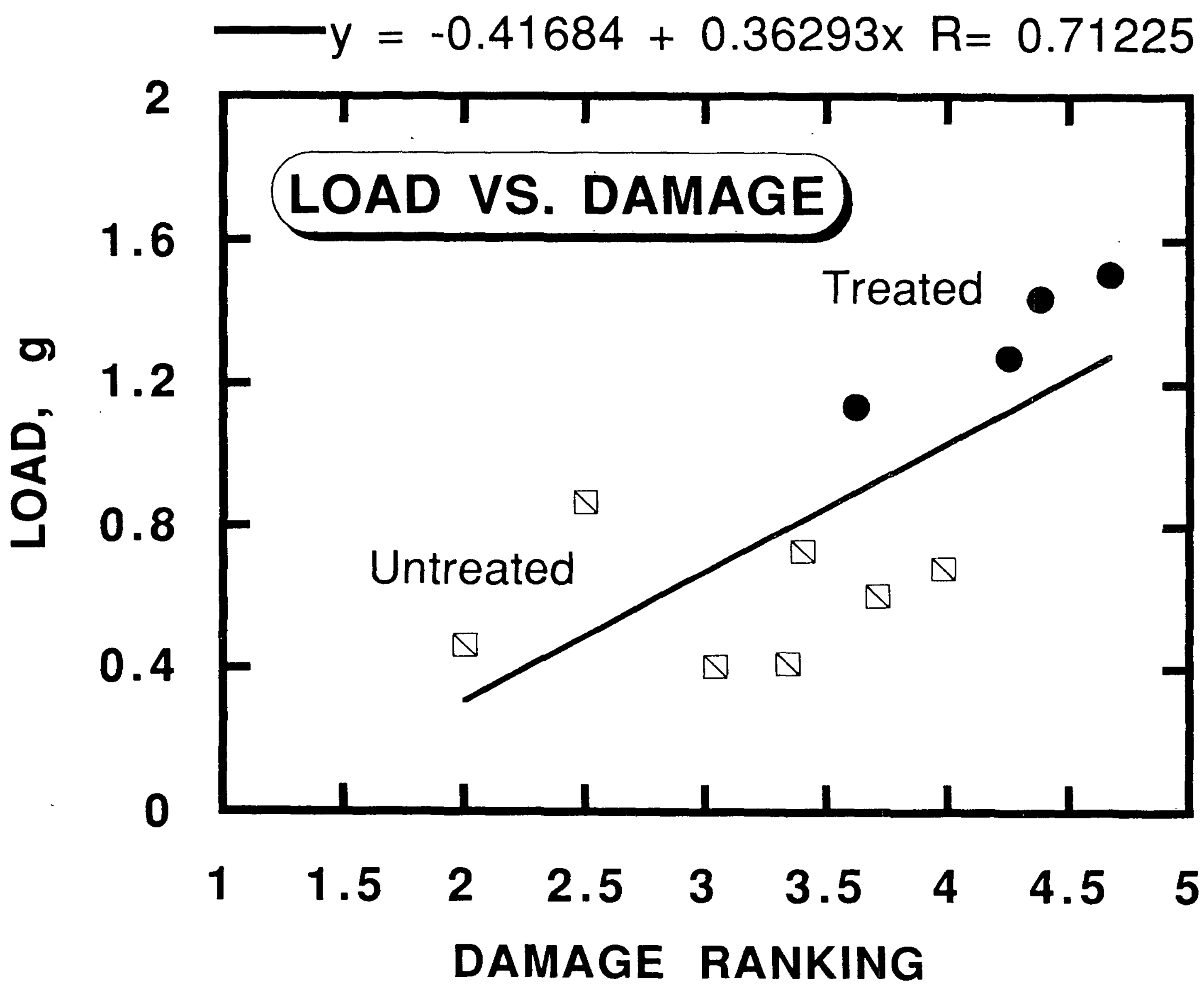
EFFECT OF RELATIVE HUMIDITY
(REFINED PULP)

R.H. %	LOAD, g	AREA, $microns^2$	BOND STRENGTH, N/mm^2
50	0.73	2070	3.5
75	0.60	2260	2.9
88	0.41	2220	2.1


DAMAGE TO FIBER PAIR
<CRank>
5
4.5
4
3.5
3
2.5
2
1.5
1
1 1.5 2 2.5 3 3.5 4 4.5 5
<TRank>
slope = 1


y = 7.15 + 1.4476norm(x) R = 0.97584
DAMAGE DISTRIBUTION
A88
Percent
99.9
99
95
90
70
50
30
10
5
1
.1
3
4
5
6
7
8
9
10
11
CRank + TRank


REFINED UK
A5
LOAD, g
0
0.5
1
1.5
2
2.5
3
3
4
5
6
7
8
9
10
11
CRank +TRank


y = -0.41684 + 0.36293x R= 0.71225
LOAD VS. DAMAGE
Treated
Untreated
LOAD, g
2
1.6
1.2
0.8
0.4
0
1
1.5
2
2.5
3
3.5
4
4.5
5
DAMAGE RANKING

EFFECT OF ADDITIVE ON DAMAGE

PULP	UNTREATED	TREATED
Earlywood	2.0	3.6
TMP	3.0	4.2
Refined UK	3.4	4.7, 4.4

FUNDAMENTALS OF PAPER SURFACE WETTABILITY
PROJECT 3646

December 17, 1990
Institute of Paper Science and Technology
Atlanta, Georgia

DUES-FUNDED PROJECT SUMMARY FORM
FY 90-91

Project Title:	FUNDAMENTALS OF PAPER SURFACE WETTABILITY
Division:	Engineering and Paper Materials Division
Project Code:	WETAB
Project Number:	3646
Project Staff:	F. Etzler/J. Conners
FY 90-91 Budget:	$134,000

PROGRAM OBJECTIVE: Develop an understanding of the structure and properties of interfacial water and their relation to the properties of paper and board.

PROJECT RATIONALE: Many converting and end uses of paper and board are associated with the application of a liquid to a surface. These processes include the printing, coating and production of combined board. Cyclic humidity phenomena or adsorption of combined board. Cyclic humidity phenomena or adsorption of water vapor is also important to end use properties. In order to improve various processes and point the way to new products, it will be necessary to understand the interaction of water and other liquids with cellulosics.

GOALS FOR 1990-1991:

1. To continue exploration the properties of water associated with cellulosics and model substrates.

2. To develop methods for the study of water vapor adsorption as related to related to cyclic humidity phenomena.

3. Understand the role of paper surface chemistry and its role in wetting and water vapor adsorption.

ACCOMPLISHMENTS TO DATE:

The properties of water near a variety of surfaces have been found to differ from those of the bulk. Etzler [JCIS, 92, 43 (1983); Langmuir 4, 878 (1989)] has developed a statistical thermodynamic model for vicinal water which has been successful in correlating some properties of vicinal water. The model suggests that hydrogen bonding between water molecules is enhanced by propinquity to a solid interface. Experimental results suggest that vicinal modification of water structure extends approximately 5nm from the interface. Careful comparison of the properties of water associated with a variety of materials including cellulosics suggests that the structure of vicinal water is relatively insensitive to the physico-chemical details of the surface. The structure of water near model substrates if thus nearly identical with that near cellulosics. The experimental evidence suggests that vicinal water structure undergoes transitions near the Drost-Hansen temperatures (15, 30, 45, and 60°C. The heat capacity of water has been measured as a function of temperature for three different sized silica pores. All the heat capacity data show heat capacity spikes near the Drost-Hansen temperatures. The data collected represent the first transitions. Recent work by others indicates that the surface conformation of insoluble polymeric materials is influenced by the vicinal water structure and transition at Drost-Hansen temperatures. The correlation between surface conformation of polymers and vicinal water structure suggests water plays a complex and not well understood role in wetting and in cyclic humidity phenomena.

Etzler's model of vicinal water has been confirmed at the microscopic level by showing that the distribution of molecular (Voronoi) volumes is bimodal for computer simulated water. The Voronoi volume data obtained in our study are the first rigorous statistical mechanical data to support Rontegen's hypothesis (1892).

A method using DSC/TGA has recently been developed to determine the instantaneous heat of vaporization for water and other liquids evaporating from porous materials. Preliminary data have been obtained from bacterial cellulose, silica, and a limited number of kraft paper samples. The method appears to be novel. The data obtained show that the heat of vaporization depends on the water content of the sample and may be as much as twice the heat of vaporization of normal bulk water. The heat of vaporization appears to depend on the proximity of the water to the substrate and not on the specific nature of the substrate.

The printability of linerboard has been shown to be related to wettability. It has been shown that the wettability of linerboard is related to the surface chemistry of the paper.

RELATED PROJECTS:

1. Project 2695-26, Printability/Wettability of Linerboard sponsored by CKPG of API.

2. Project 3686-1, Cyclic Humidity Phenomena sponsored by CKPG of API.

RELATED STUDENT PROJECTS:

1. Russell F. Ross, M.S. project entitled "Application of Statistical Geometrical Methods to the Study of Water and other Liquids" Completed March 1990.

GOALS FOR THIS PERIOD:

1. Complete heat capacity measurements for water in silica pores.

2. Develop DSC/TGA methods for measurement of water adsorption by paper and other porous media.

GOALS FOR NEXT PERIOD:

1. Continue development of methods for measurement of water adsorption by cellulosics.

Heat Capacities of Water near a Variety of Surfaces at 25°C

Substance	Heat capacity (cal/g°K)
Bulk water	1.00 ± 0.08
Porous glass	1.27 ± 0.20
Activated carbon	1.28 ± 0.03
Zeolite	1.21 ± 0.03
Diamond	1.20 ± 0.08
Collagen[a]	1.24
Egg albumin[a]	1.25 ± 0.02
DNA[a]	1.26 ± 0.06
Artemia cysts[a]	1.28 ± 0.07

[a] See references listed in (10).

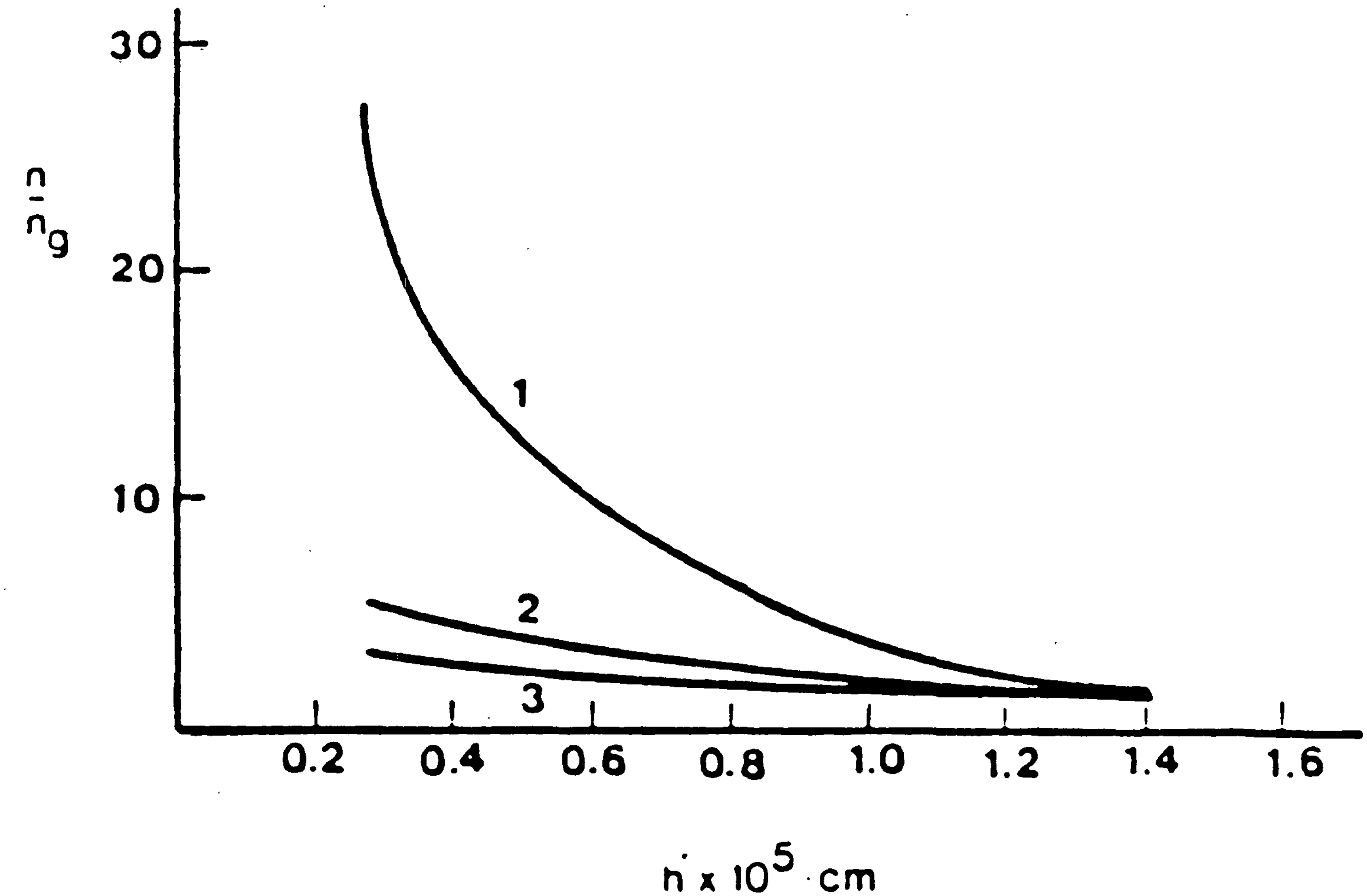
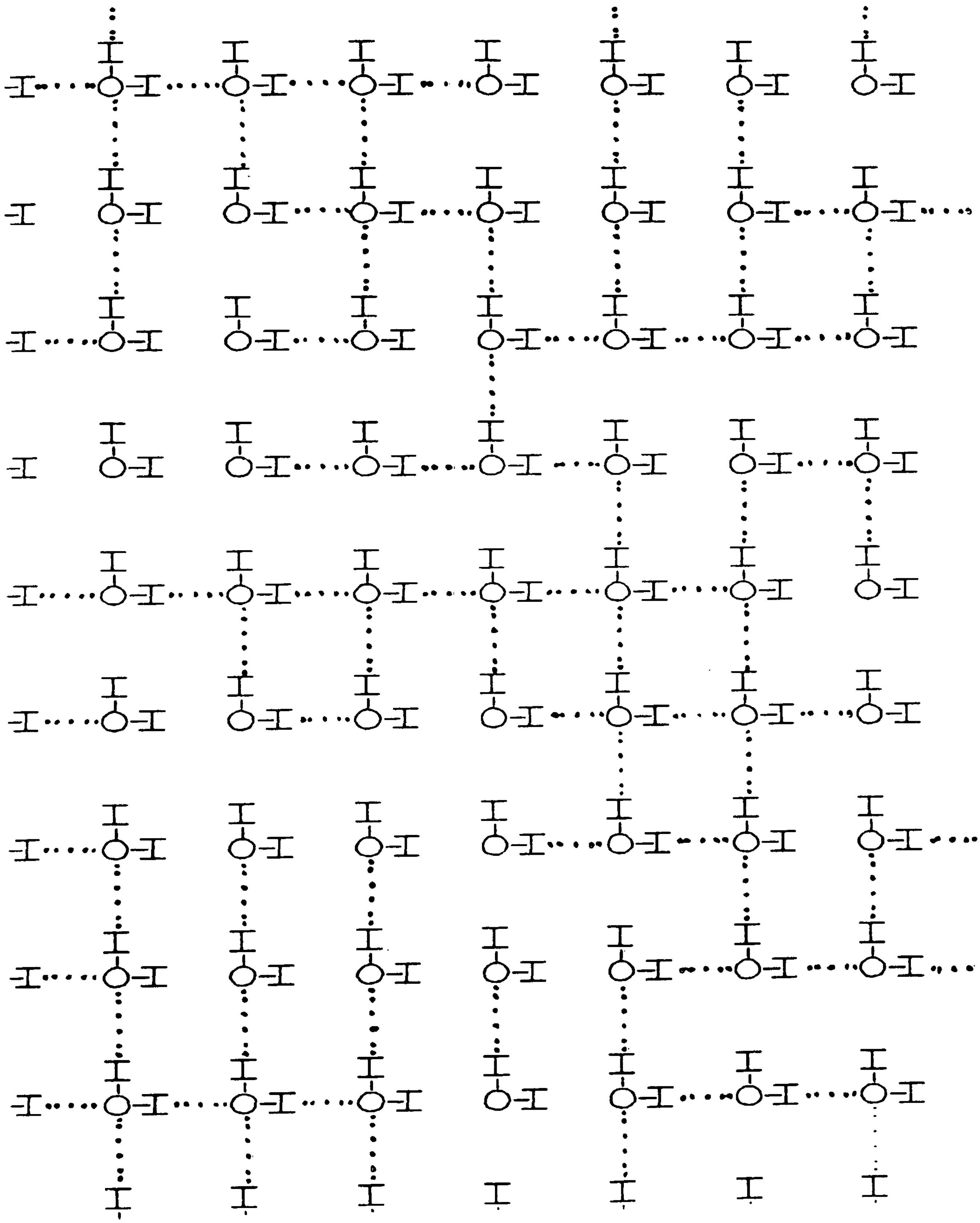
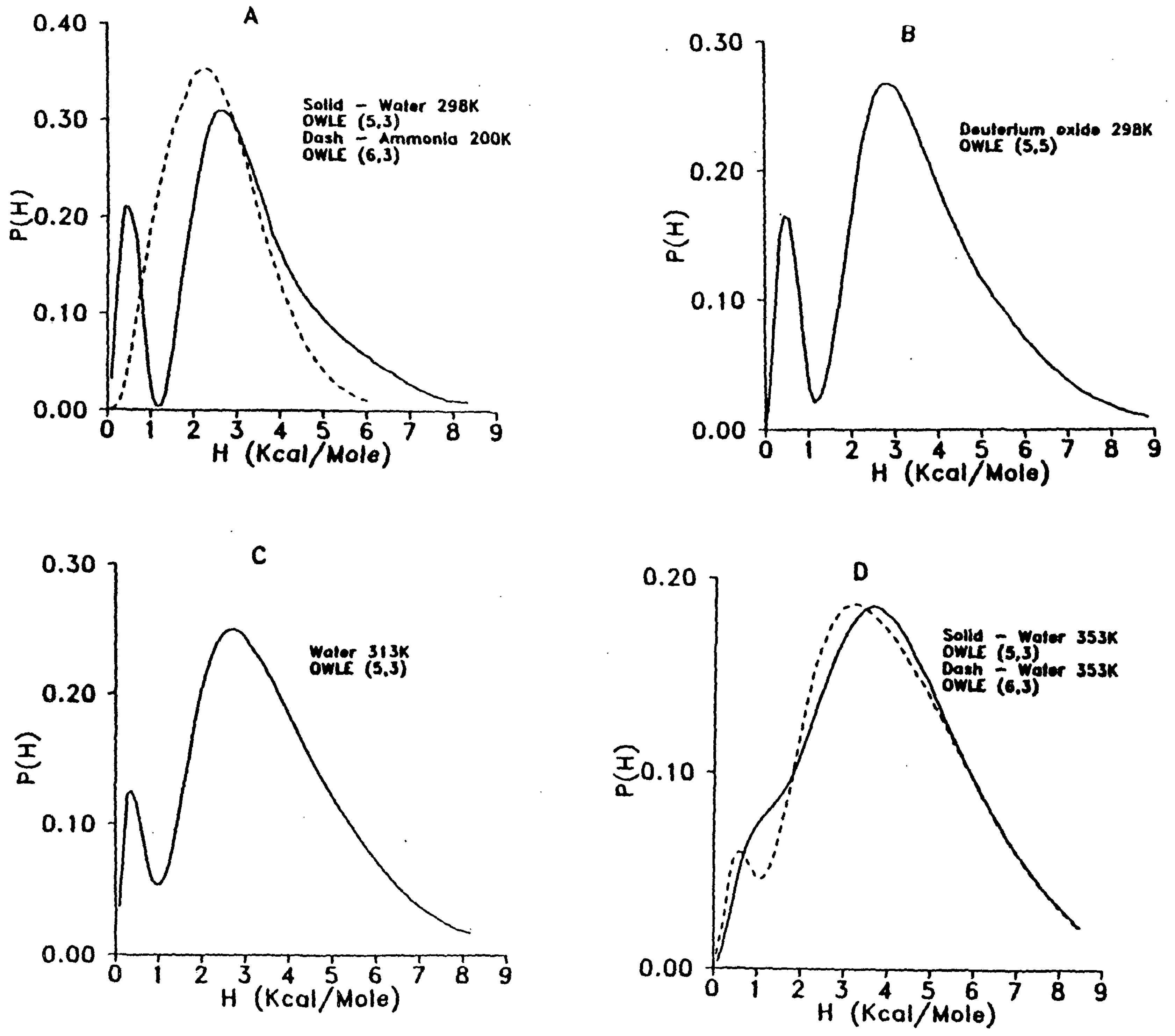


FIG. 3. Distance and shear rate dependence of the relative viscosity of water between quartz plates at various shear rates. Shear rate increase from curve 1 to curve 3. The shear rates correspond to plate forces of 253, 523, and 657 dyn (11, 13).




A
Solid - Water 298K
OWLE (5,3)
Dash - Ammonia 200K
OWLE (6,3)
P(H)
H (Kcal/Mole)
B
Deuterium oxide 298K
OWLE (5,5)
P(H)
H (Kcal/Mole)
C
Water 313K
OWLE (5,3)
P(H)
H (Kcal/Mole)
D
Solid - Water 353K
OWLE (5,3)
Dash - Water 353K
OWLE (6,3)
P(H)
H (Kcal/Mole)

$$\alpha_p = \sigma^2_{ev} / VRT^2$$

$$C_p = \sigma^2_h / RT^2$$

$$\beta_T = \sigma^2_v / VRT$$

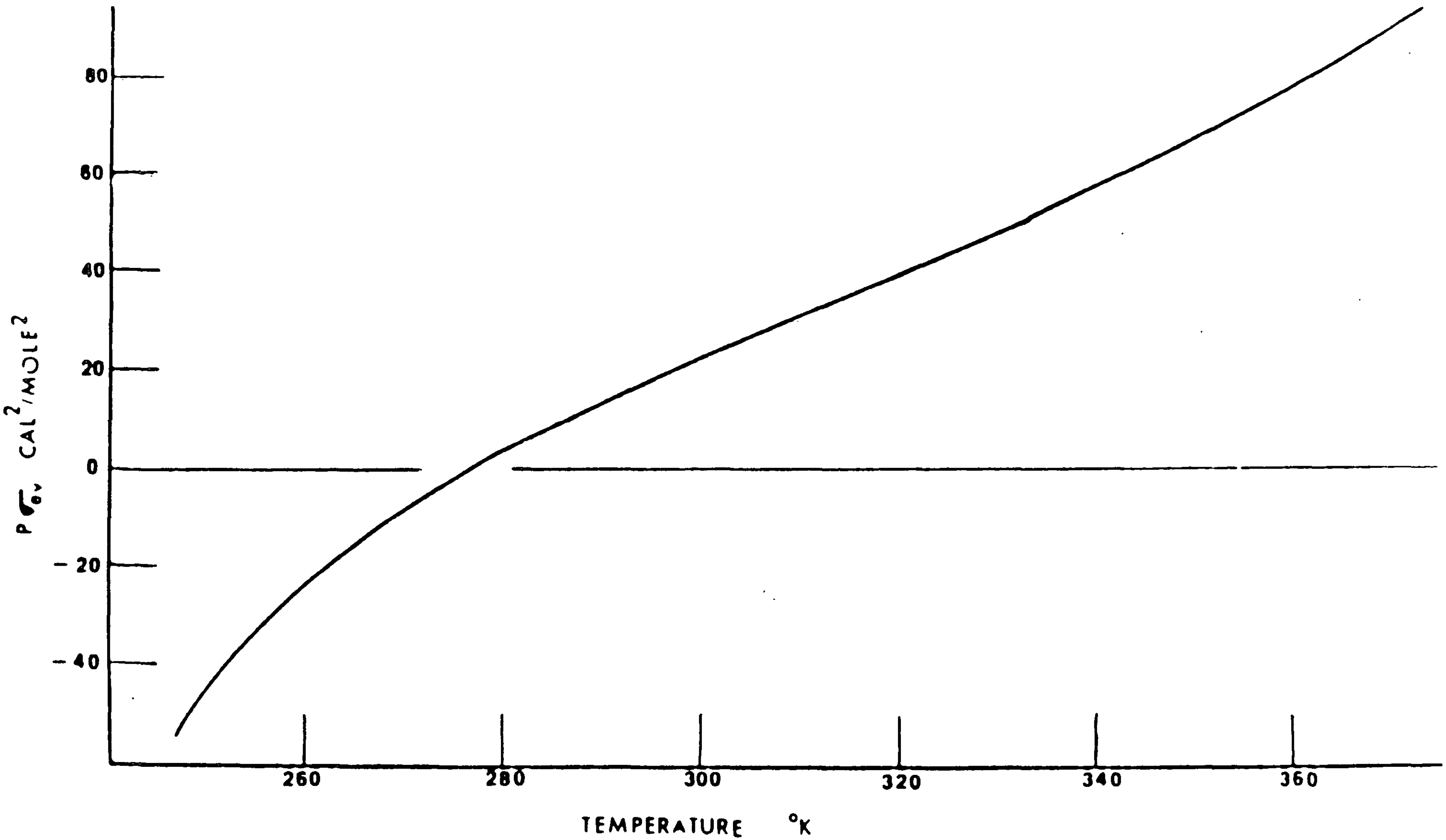
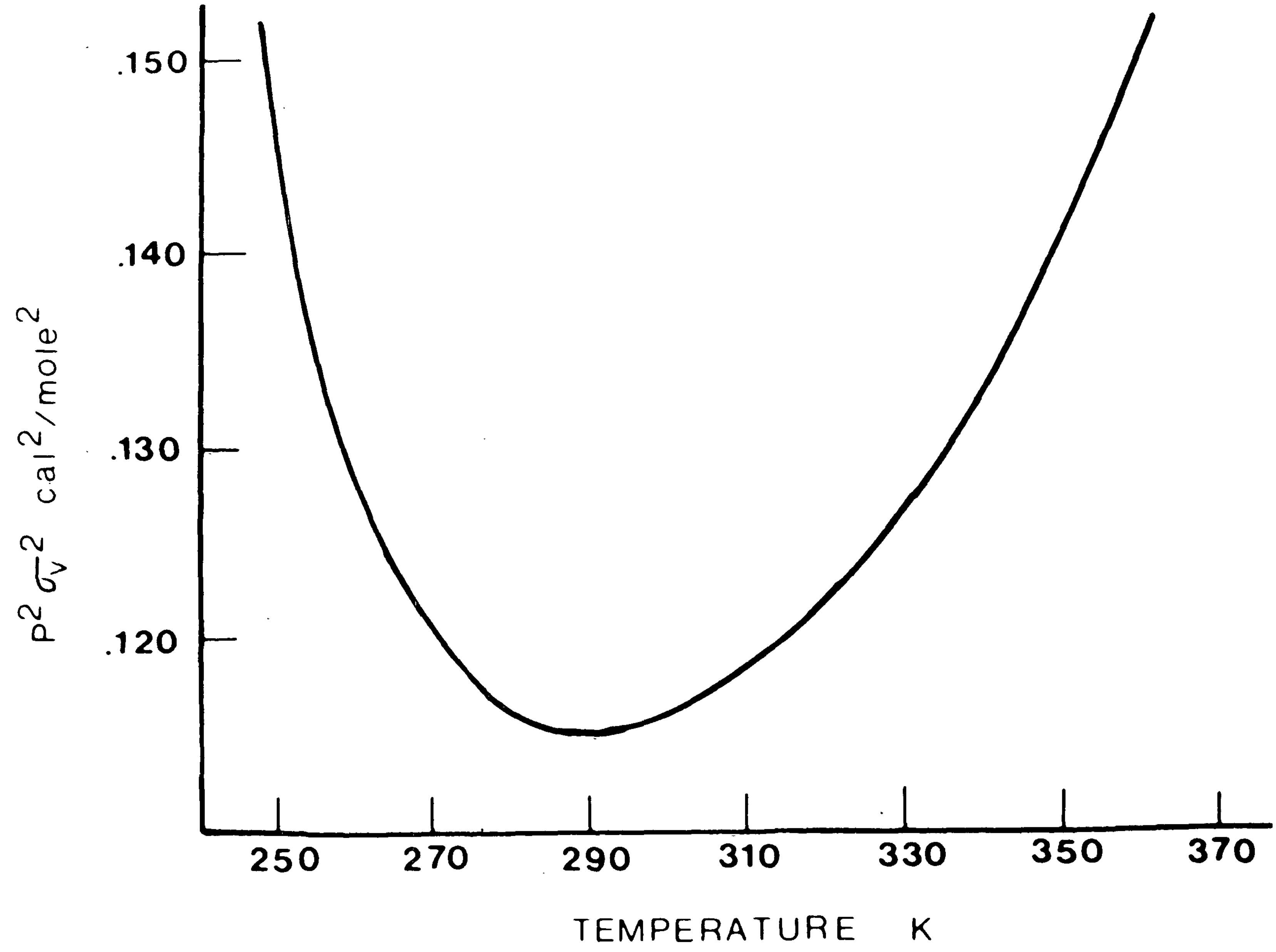


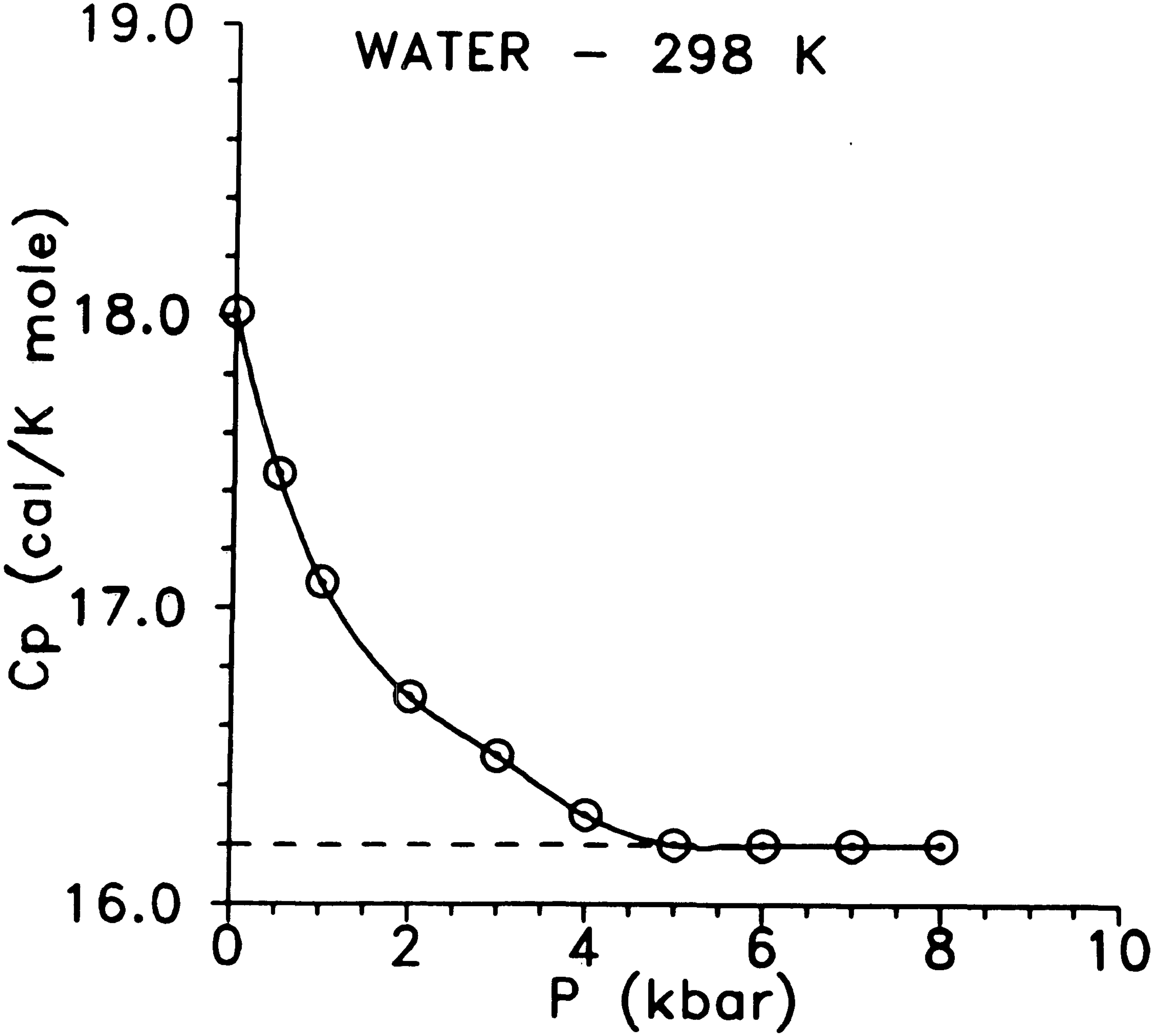
FIG. 8. Covariance between volume and energy for water as a function of temperature, calculated from thermal expansivities by Kell (33). Note negative values below 4°C, suggesting low-energy high-volume states.



.150
.140
.130
.120
P2 σv2 cal2/mole2
250
270
290
310
330
350
370
TEMPERATURE K

$$Cp = X_1 Cp_1 + X_2 Cp_2 + X_1 X_2 \left[\frac{\Delta H^2}{R T^2} \right]$$

$$\Delta H = H_2 - H_1$$

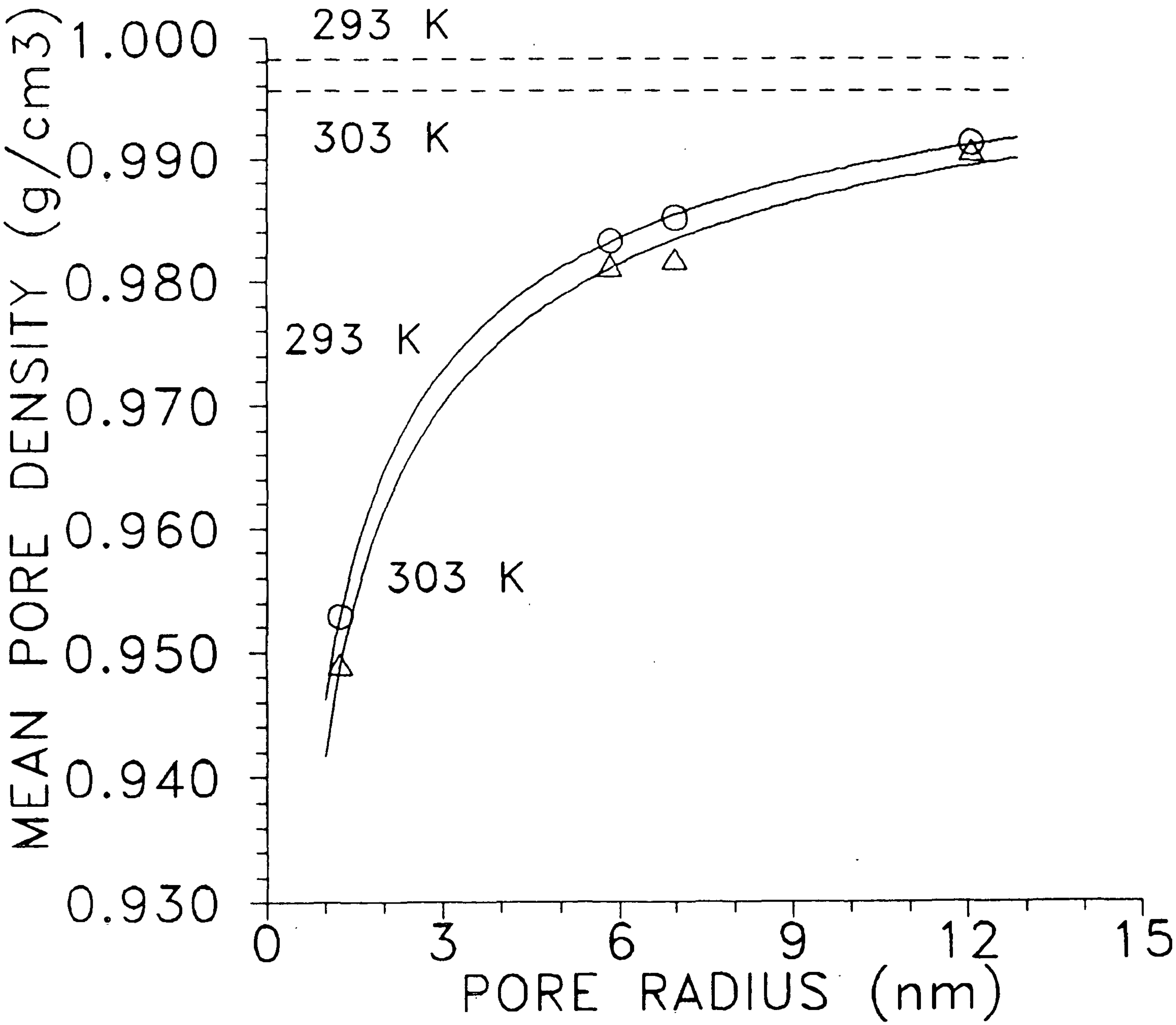


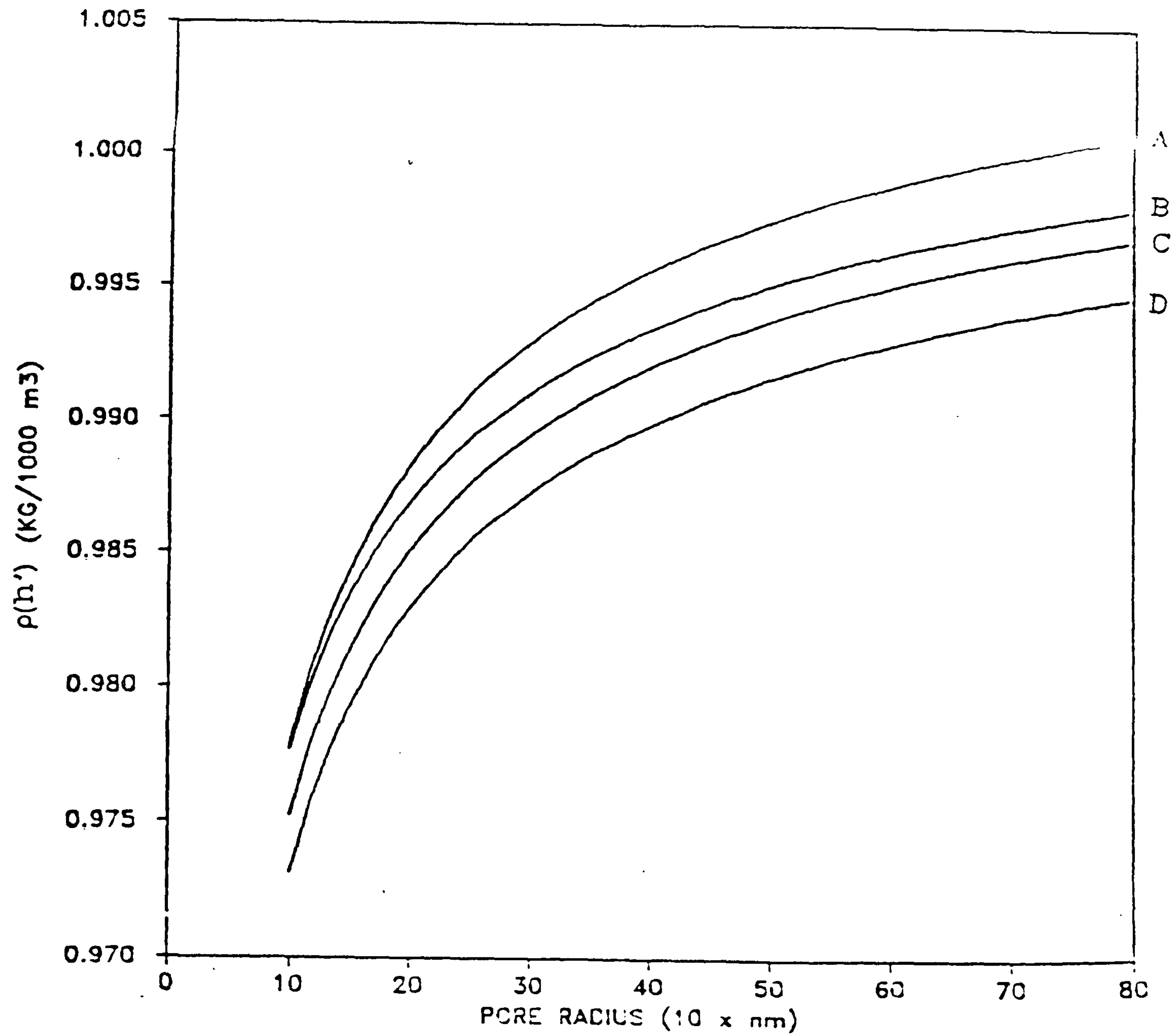
WATER - 298 K
19.0
18.0
17.0
16.0
Cp (cal/K mole)
0
2
4
6
8
10
P (kbar)

FRACTION OF 4-H BONDED MOLECULES AT 25°C

1.	Distribution Function	∿0.1
2.	Stanley and Texeria	0.14
3.	Partial Molar Heat Capacity	0.1

$$V = X_1 V_1 + X_2 V_2$$


293 K
303 K
293 K
303 K
MEAN PORE DENSITY (g/cm3)
1.000
0.990
0.980
0.970
0.960
0.950
0.940
0.930
0
3
6
9
12
15
PORE RADIUS (nm)


1.005
1.000
0.995
0.990
0.985
0.980
0.975
0.970
ρ(h') (KG/1000 m3)
0
10
20
30
40
50
60
70
80
PORE RADIUS (10 x nm)
A
B
C
D

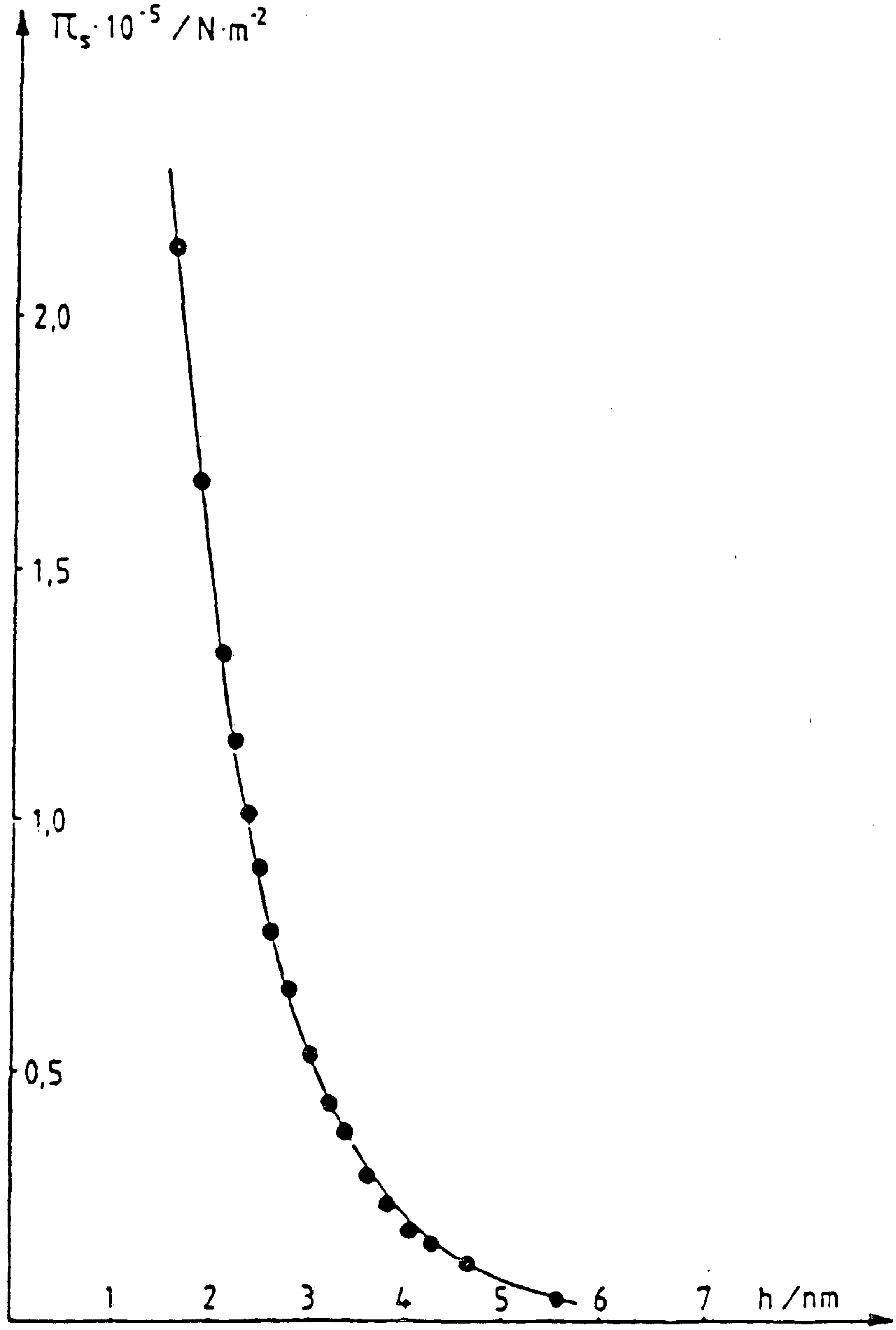
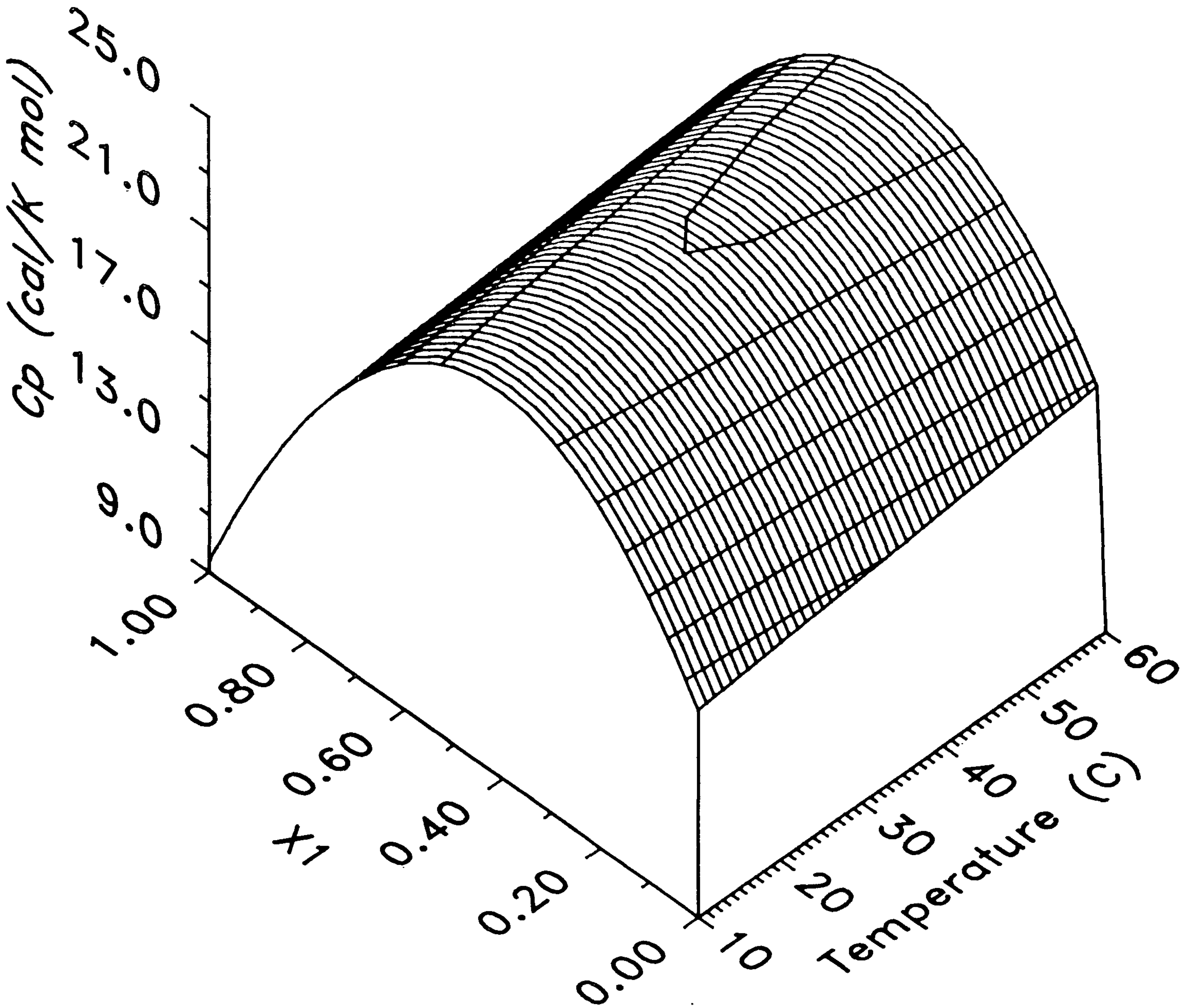
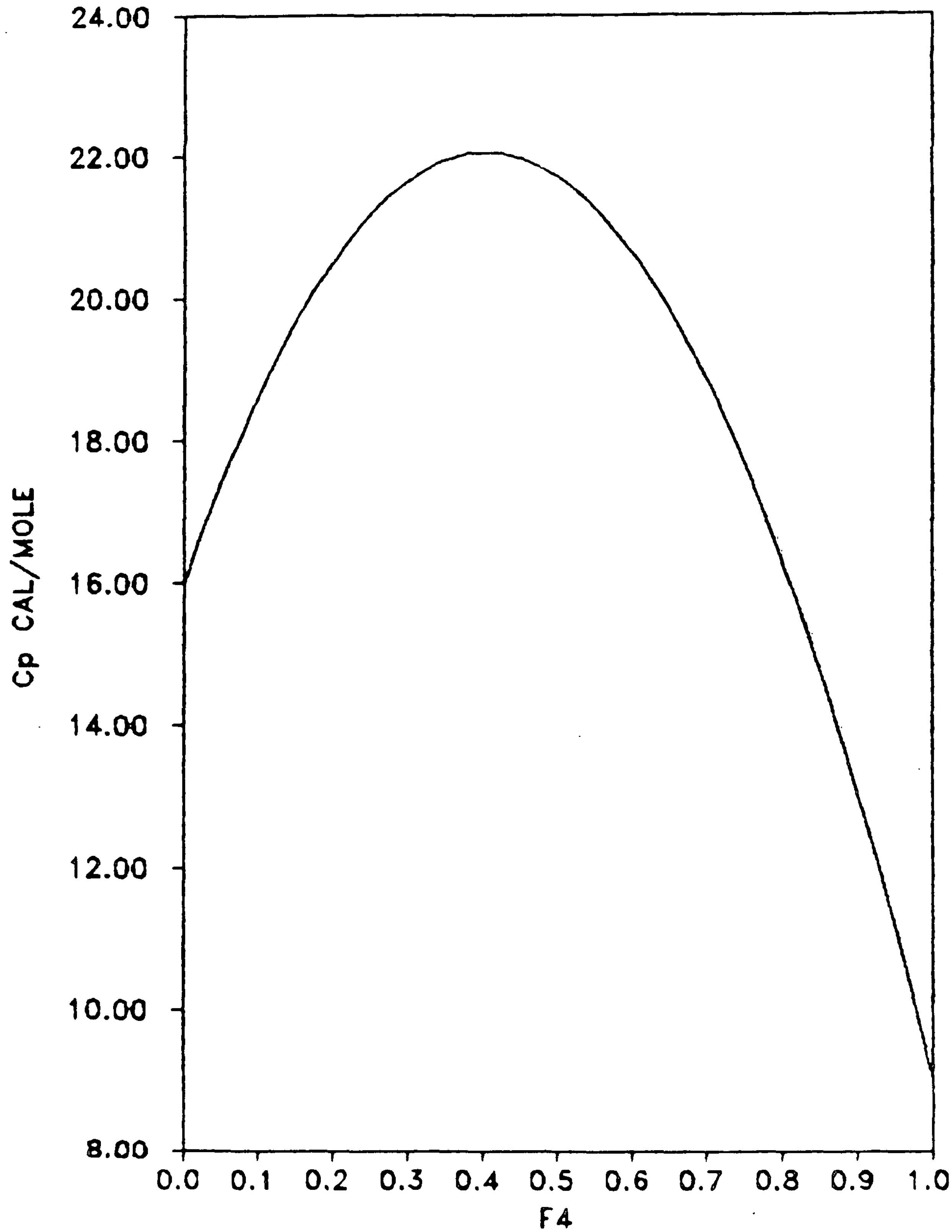


Fig. 3. Additional disjoining pressure component in a thin layer of aqueous 10^{-4} M NaCl solution T = 298 K; pH = 5,4

$$C_p = x_1 C_{p1} + x_2 C_{p2} + x_2 x_1 \Delta H^2 / RT^2$$


Cp (cal/K mol)
25.0
21.0
17.0
13.0
9.0
1.00
0.80
0.60
0.40
0.20
0.00
X1
10
20
30
40
50
60
Temperature (C)



24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
Cp CAL/MOLE
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
F4

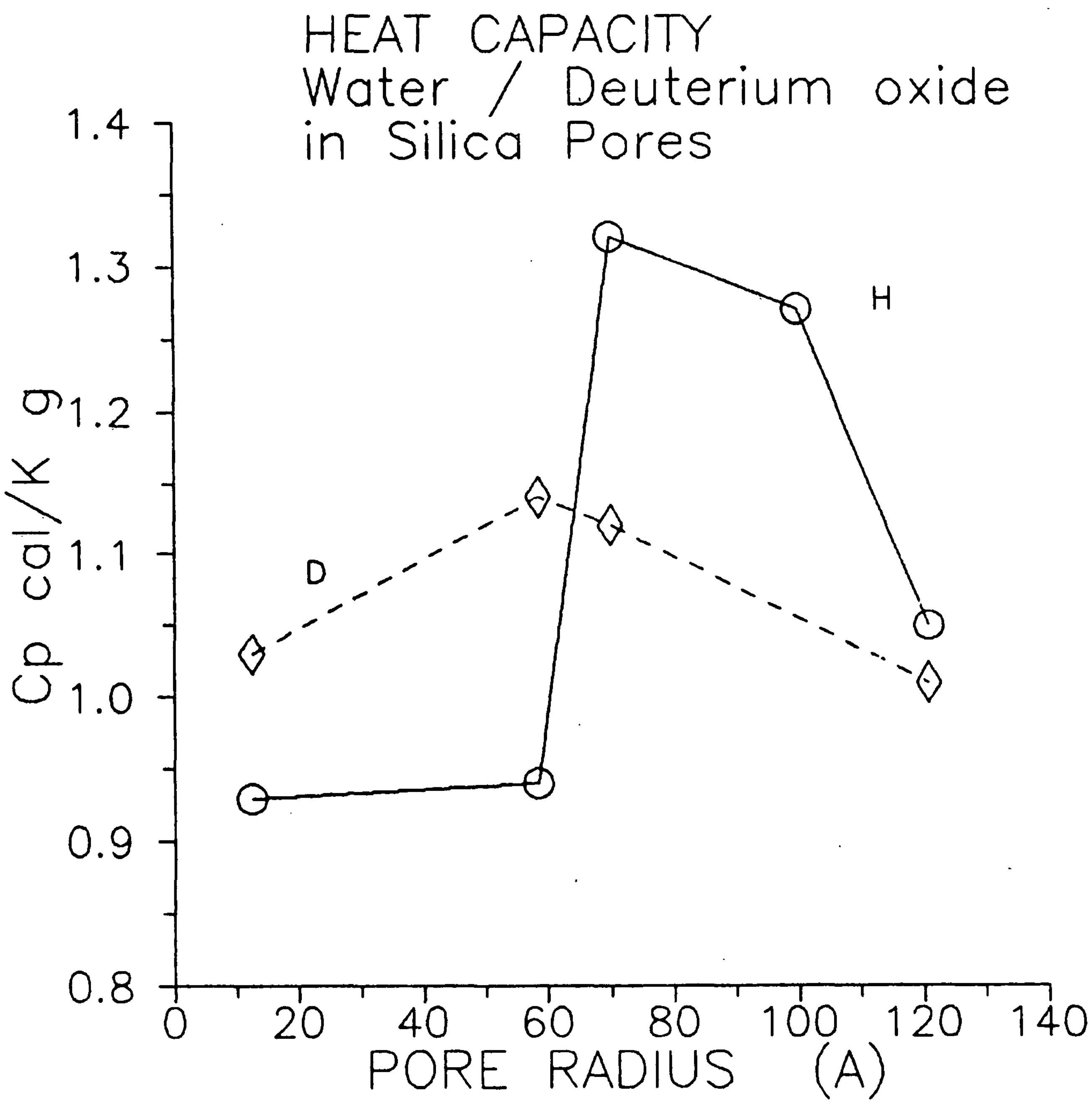
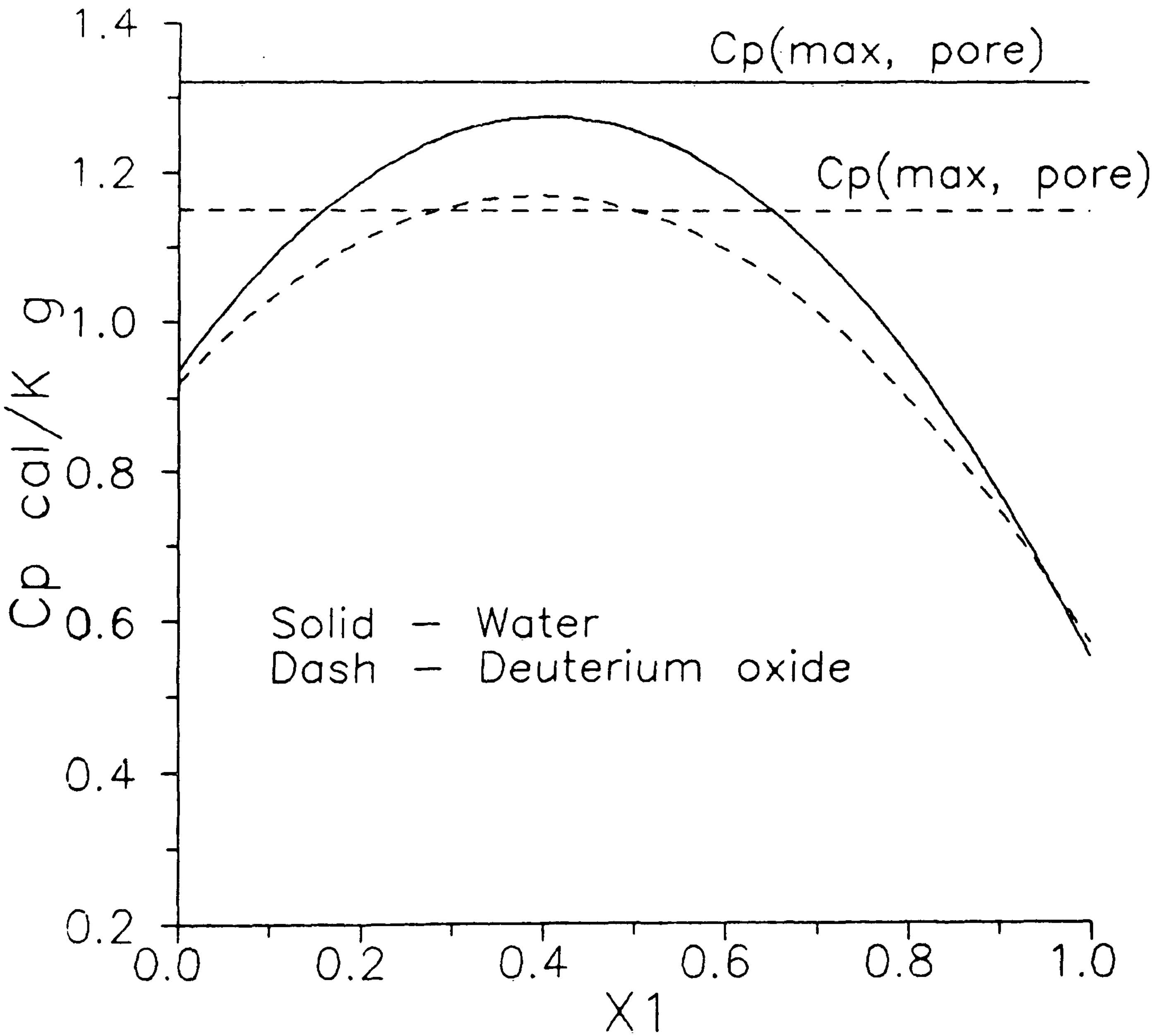
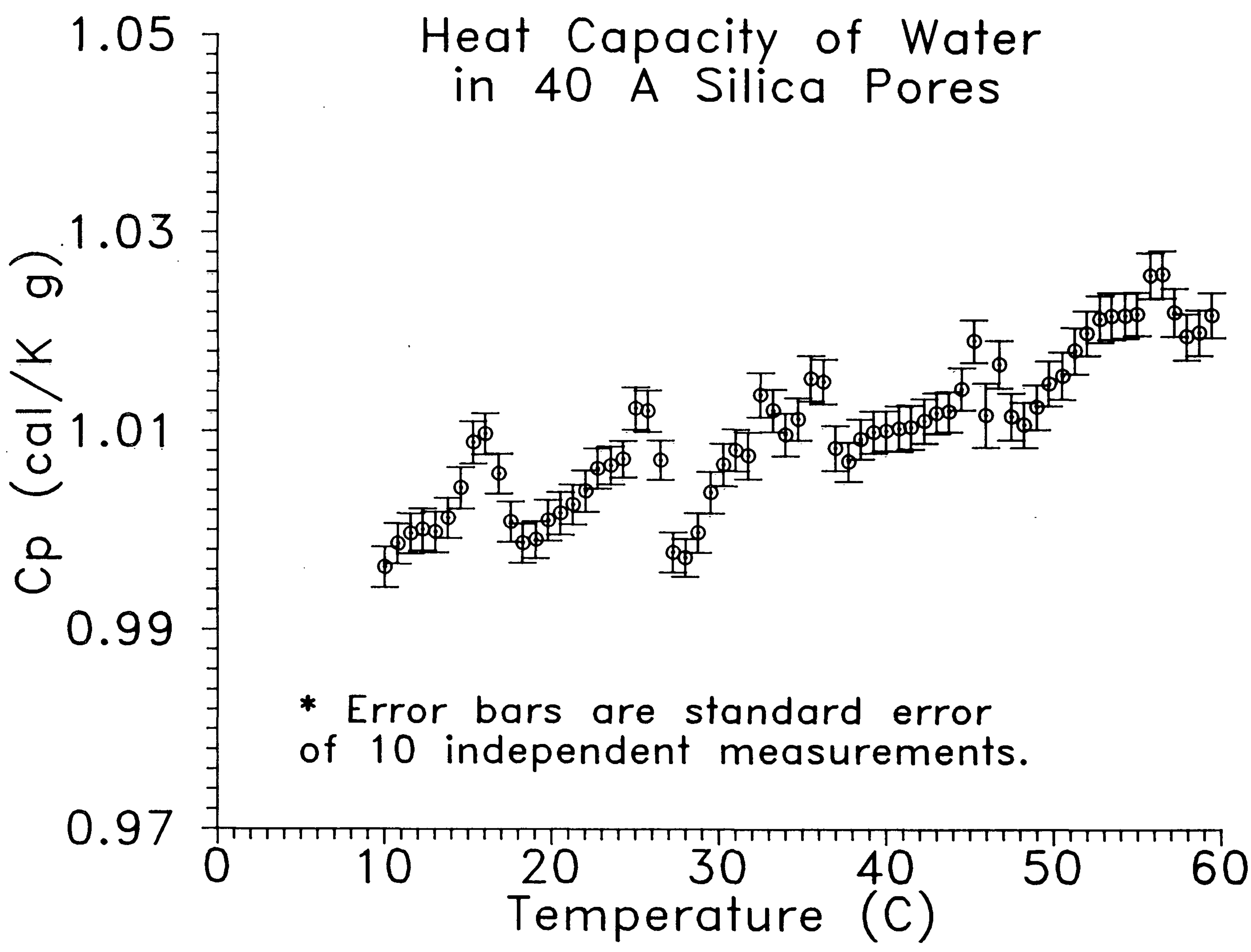

HEAT CAPACITY
Water / Deuterium oxide
in Silica Pores
Cp cal/K g
1.4
1.3
1.2
1.1
1.0
0.9
0.8
H
D
0
20
40
60
80
100
120
140
PORE RADIUS (A)

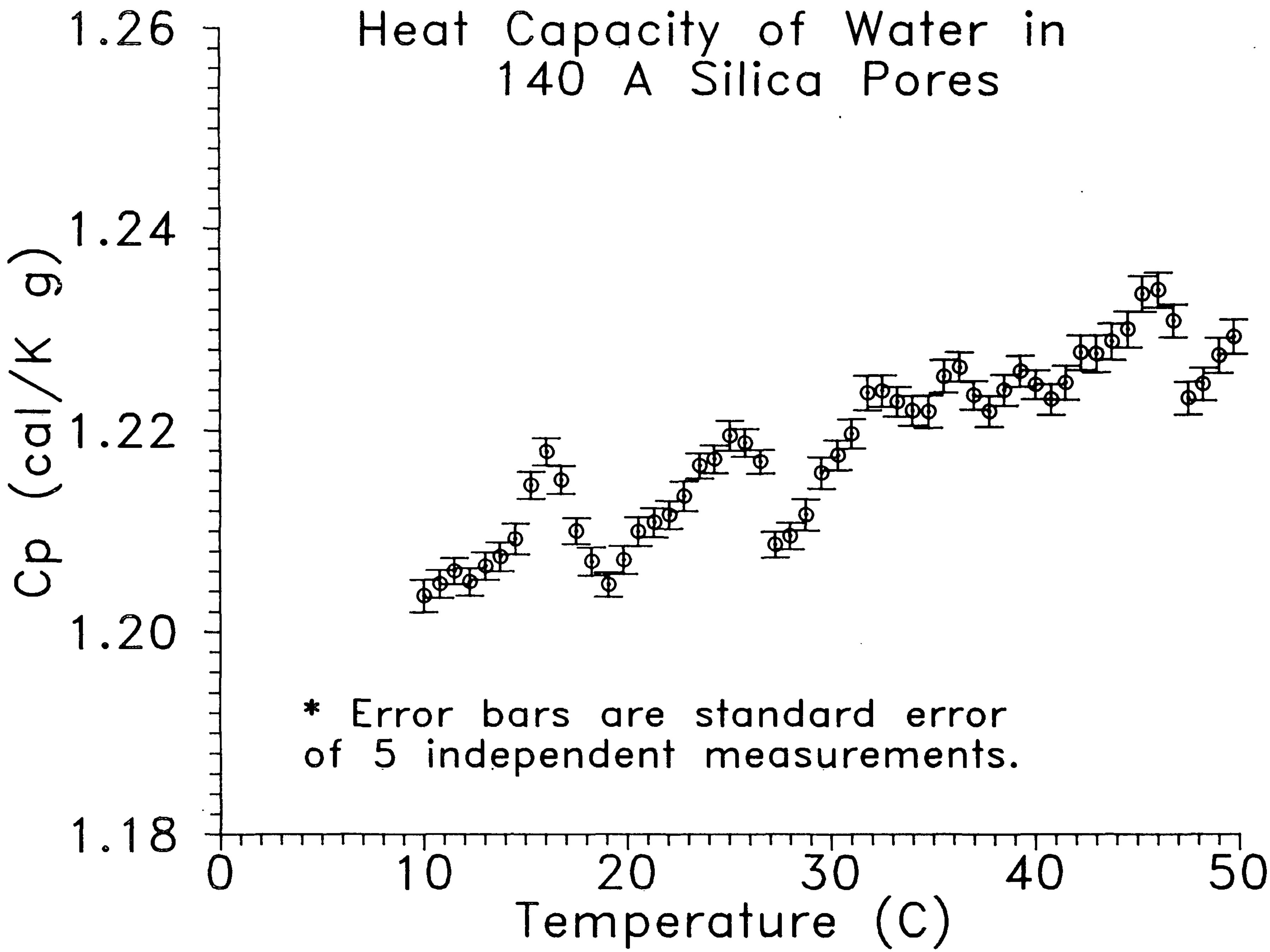
Fig #4

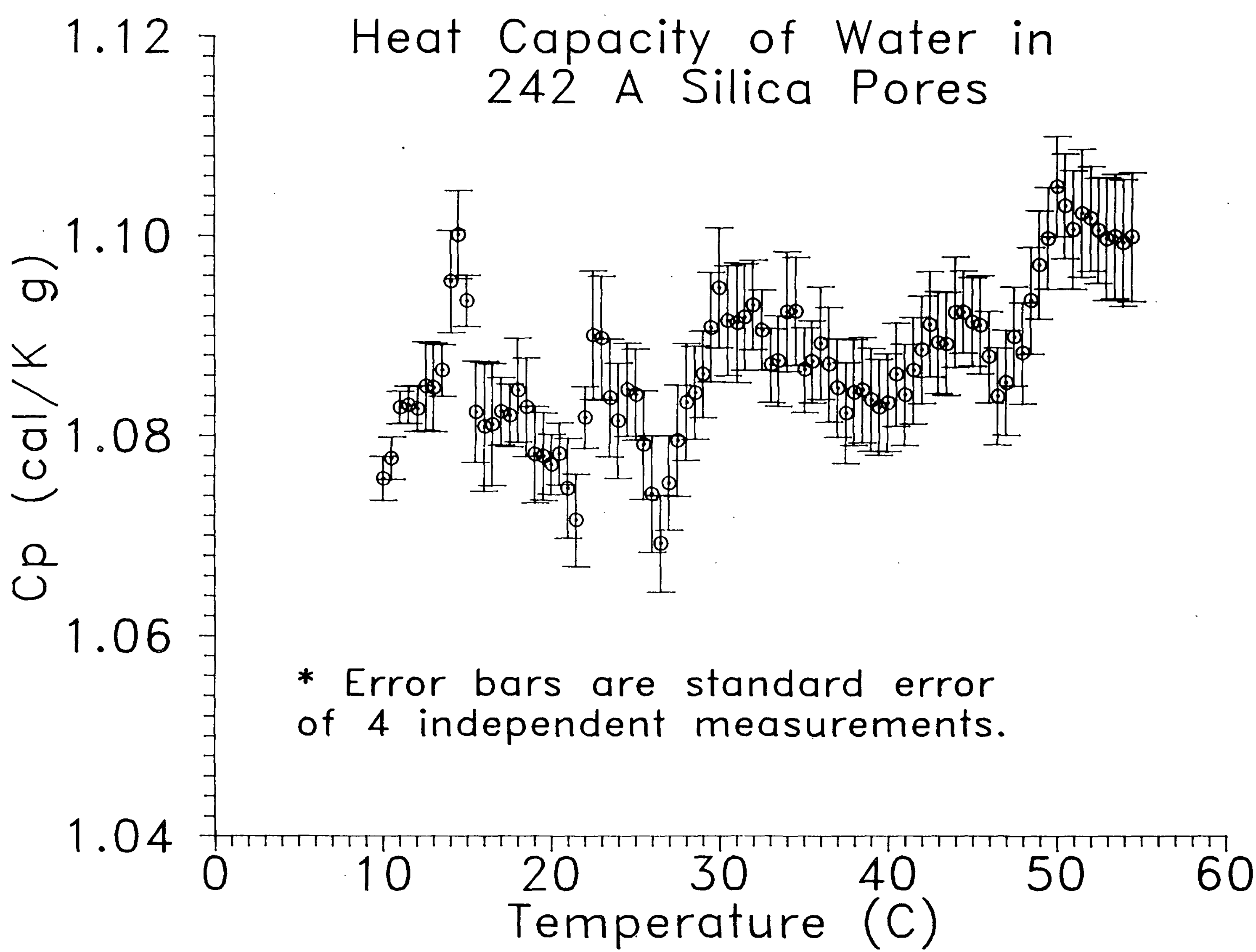


Cp(max, pore)
Cp(max, pore)
Cp cal/K g
Solid – Water
Dash – Deuterium oxide
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.2
0.4
0.6
0.8
1.0
X1

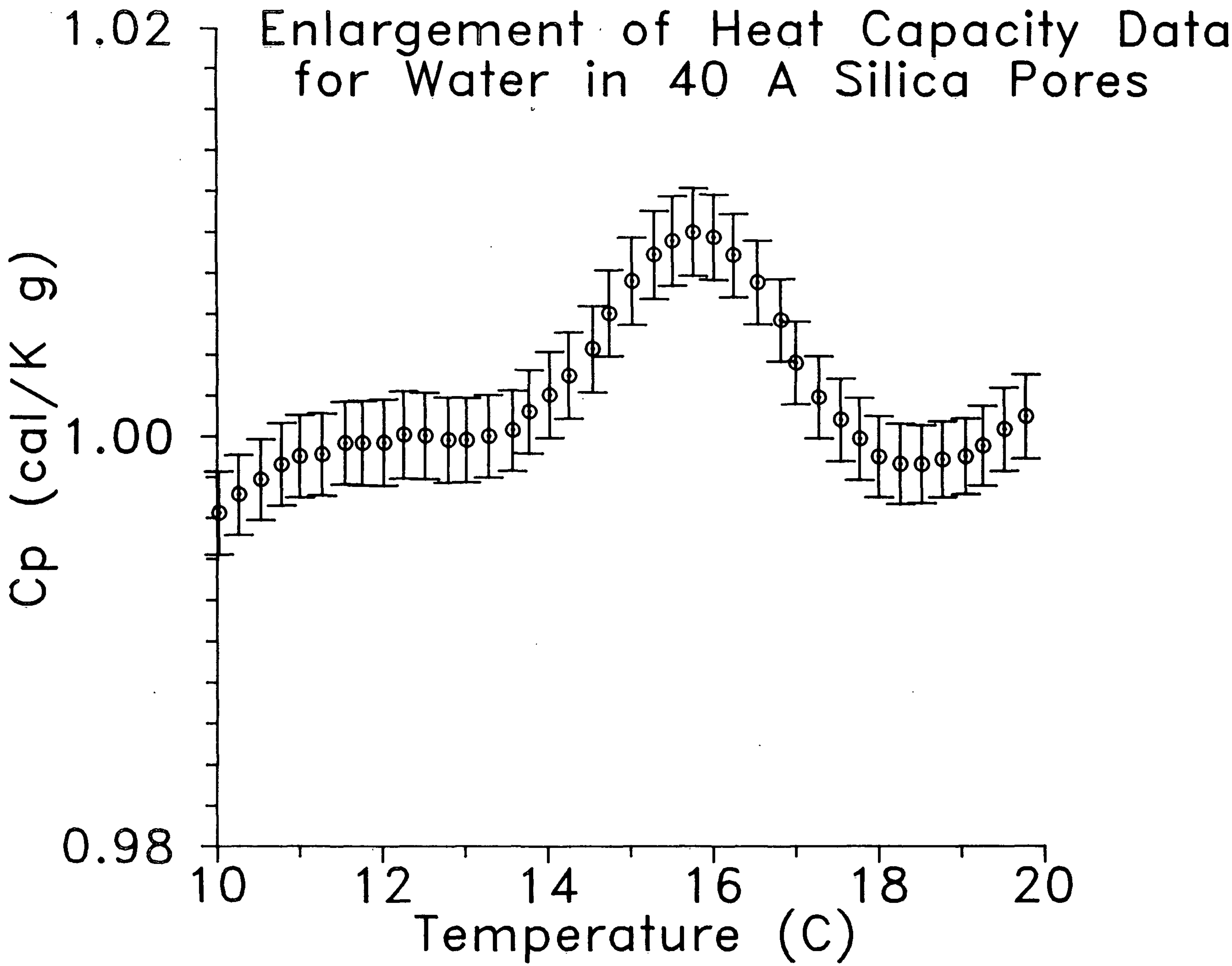


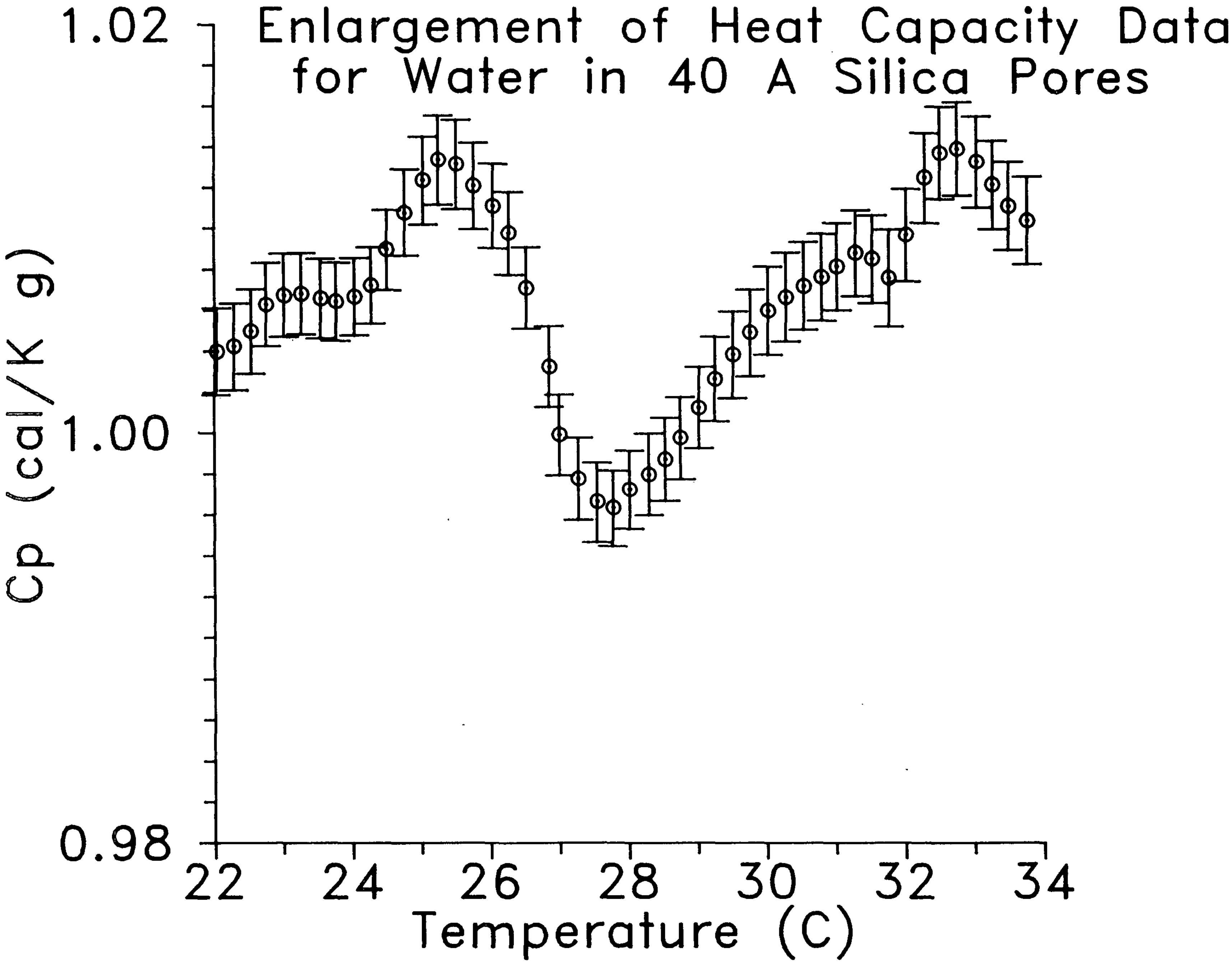
Heat Capacity of Water
in 40 A Silica Pores
Cp (cal/K g)
1.05
1.03
1.01
0.99
0.97
0
10
20
30
40
50
60
Temperature (C)
* Error bars are standard error
of 10 independent measurements.


Heat Capacity of Water in
140 A Silica Pores
Cp (cal/K g)
1.26
1.24
1.22
1.20
1.18
0
10
20
30
40
50
Temperature (C)
* Error bars are standard error
of 5 independent measurements.

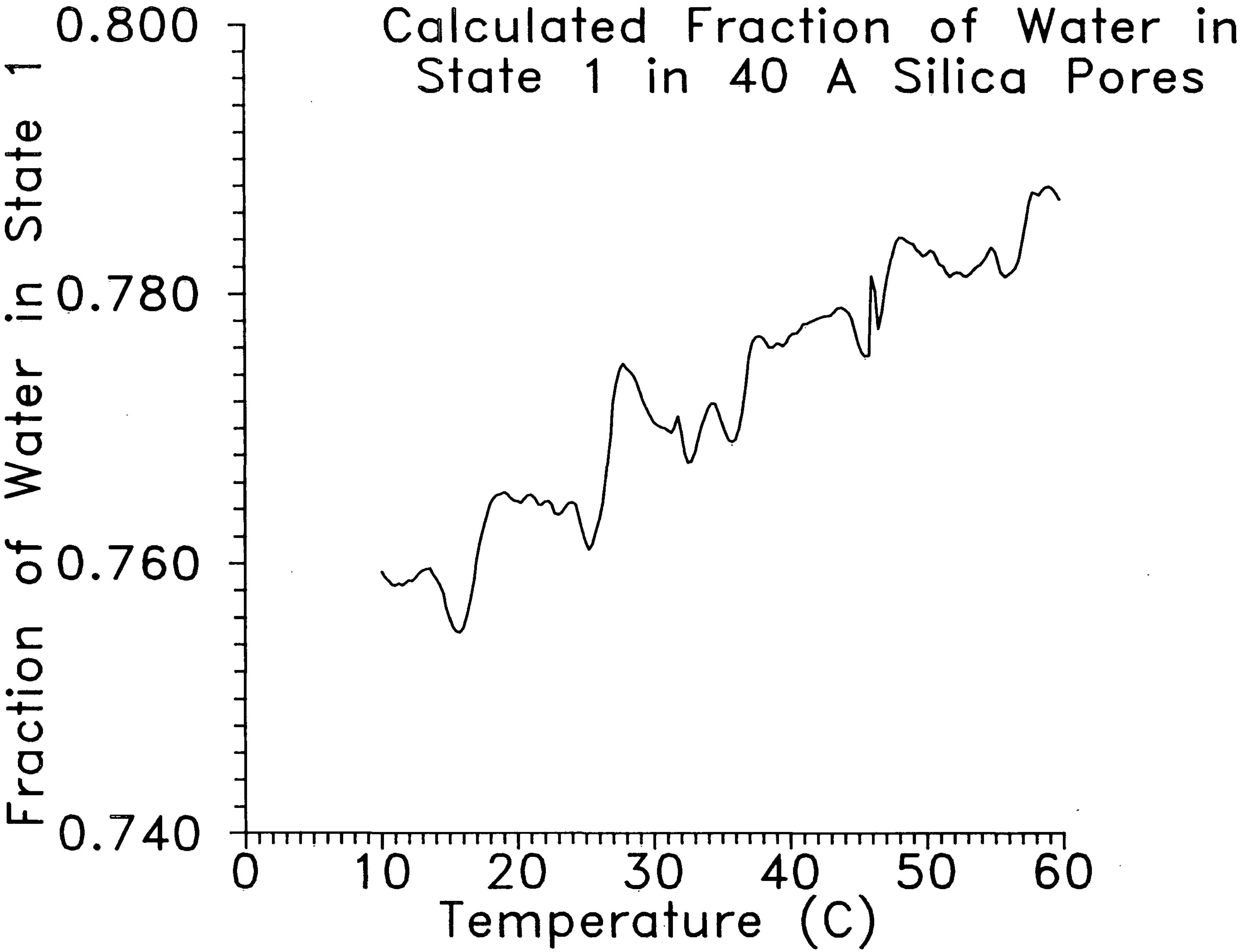


Heat Capacity of Water in
242 A Silica Pores
Cp (cal/K g)
1.12
1.10
1.08
1.06
1.04
0
10
20
30
40
50
60
Temperature (C)
* Error bars are standard error
of 4 independent measurements.

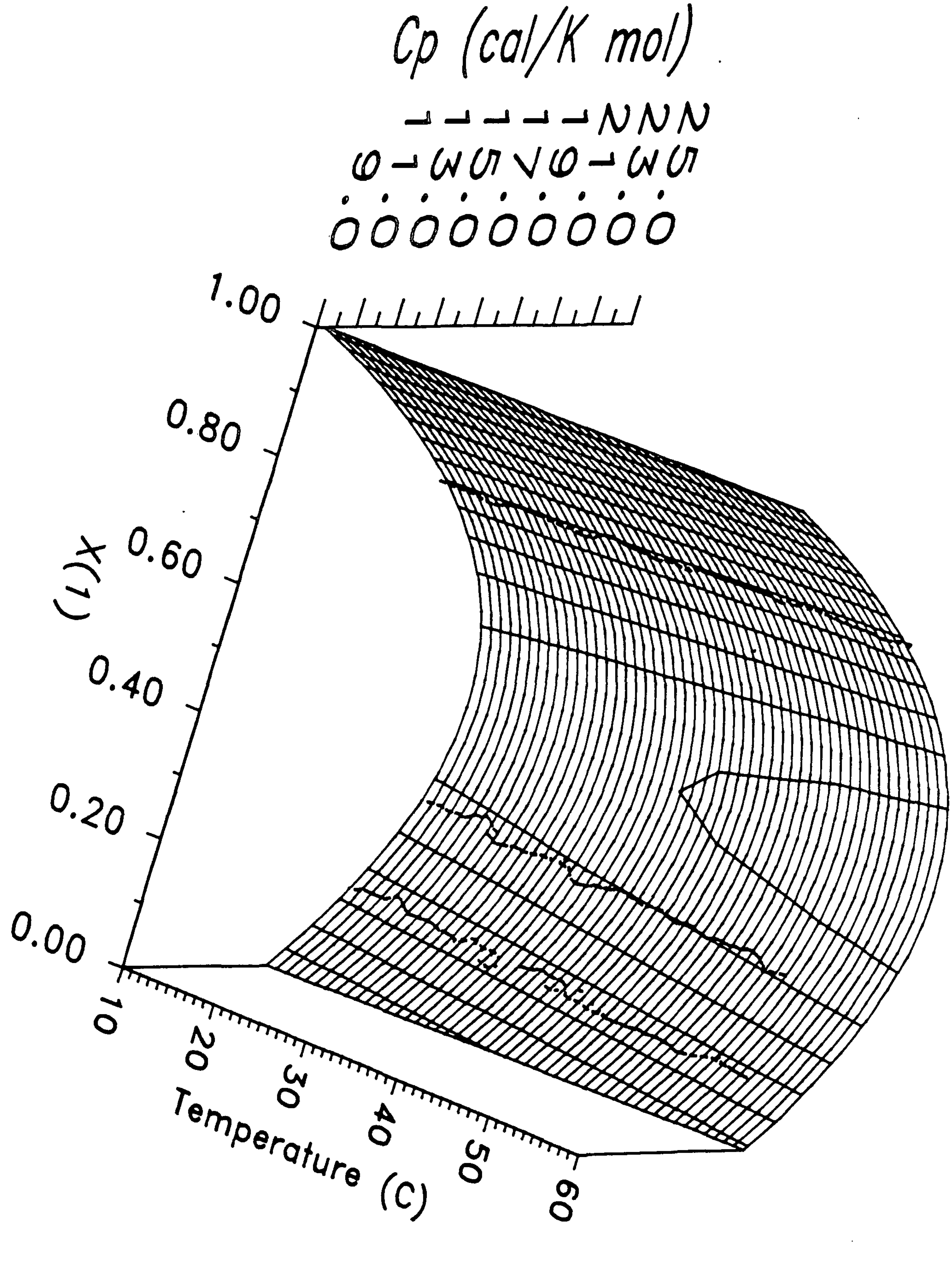

Enlargement of Heat Capacity Data
for Water in 40 A Silica Pores
1.02
1.00
0.98
Cp (cal/K g)
10
12
14
16
18
20
Temperature (C)



Enlargement of Heat Capacity Data
for Water in 40 A Silica Pores
1.02
1.00
0.98
Cp (cal/K g)
22
24
26
28
30
32
34
Temperature (C)



Calculated Fraction of Water in
State 1 in 40 A Silica Pores
Fraction of Water in State 1
0.800
0.780
0.760
0.740
0
10
20
30
40
50
60
Temperature (C)

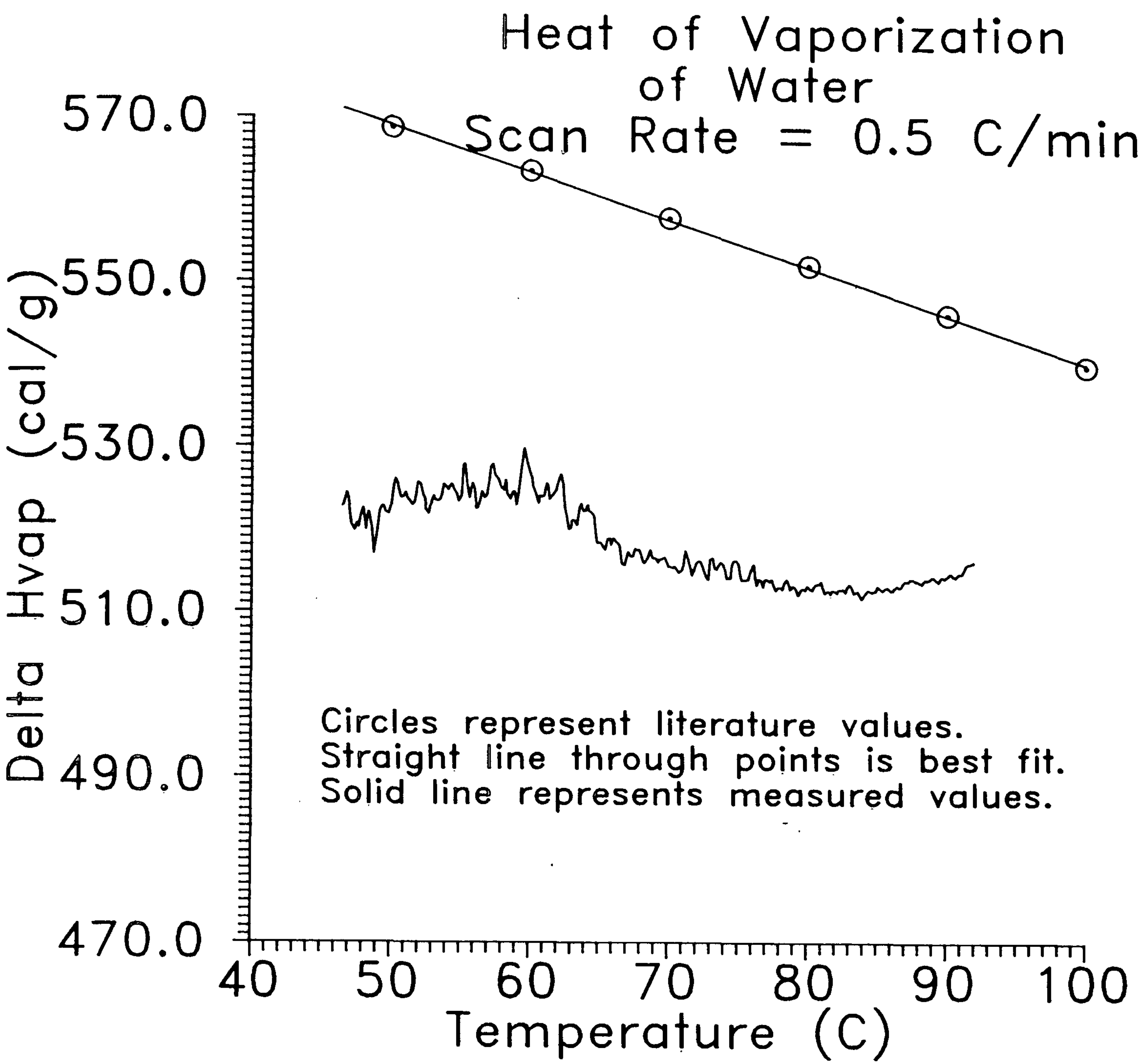

Cp (cal/K mol)
9.00
11.00
13.00
15.00
17.00
19.00
21.00
23.00
25.00
X(1)
1.00
0.80
0.60
0.40
0.20
0.00
Temperature (C)
10
20
30
40
50
60

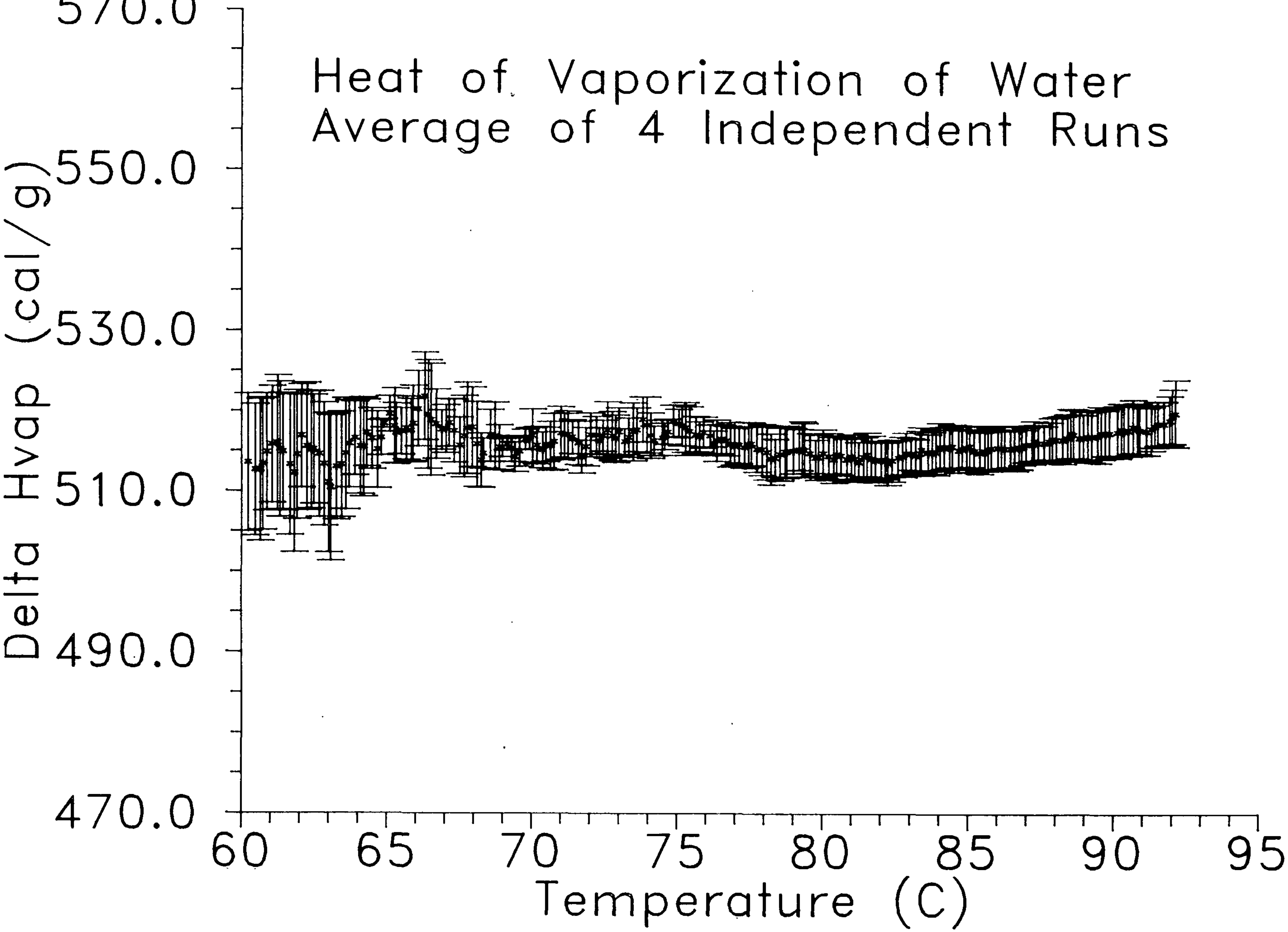
DSC/TGA Technique to Determine the Heat of Vaporization

$$dH/dt = m(t) * Cp(T) * dT/dt + \frac{dm(t)}{dt} * \Delta Hvap(T)$$

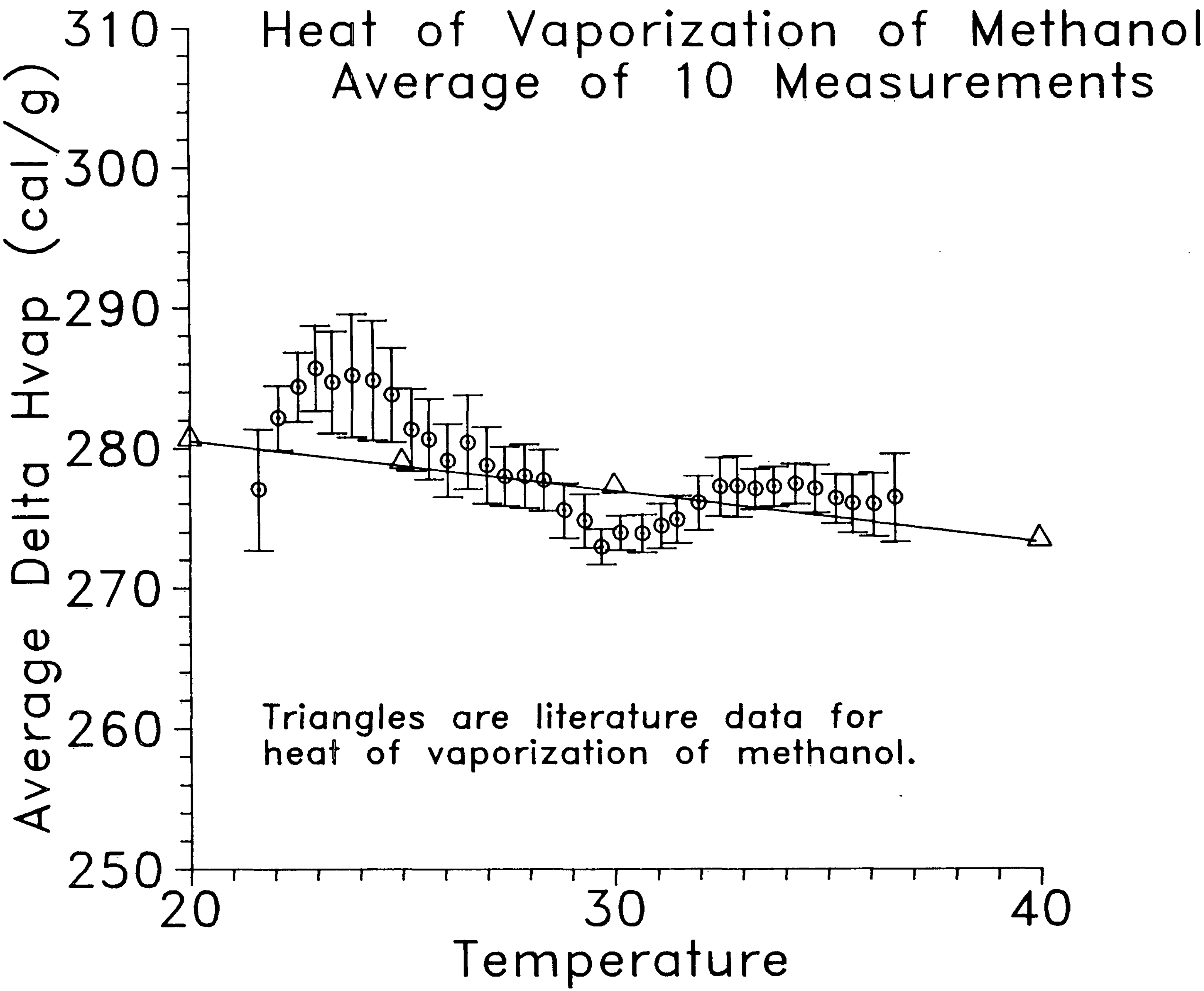
where:

dH/dt	is the measured power
m(t)	is the instantaneous mass of the sample
Cp(T)	is the heat capacity of the liquid as a function of temperature
dT/dt	is the instantaneous scan rate
dm(t)/dt	is the differential mass
ΔHvap(T)	is the heat of vaporization of the liquid as a function of temperature

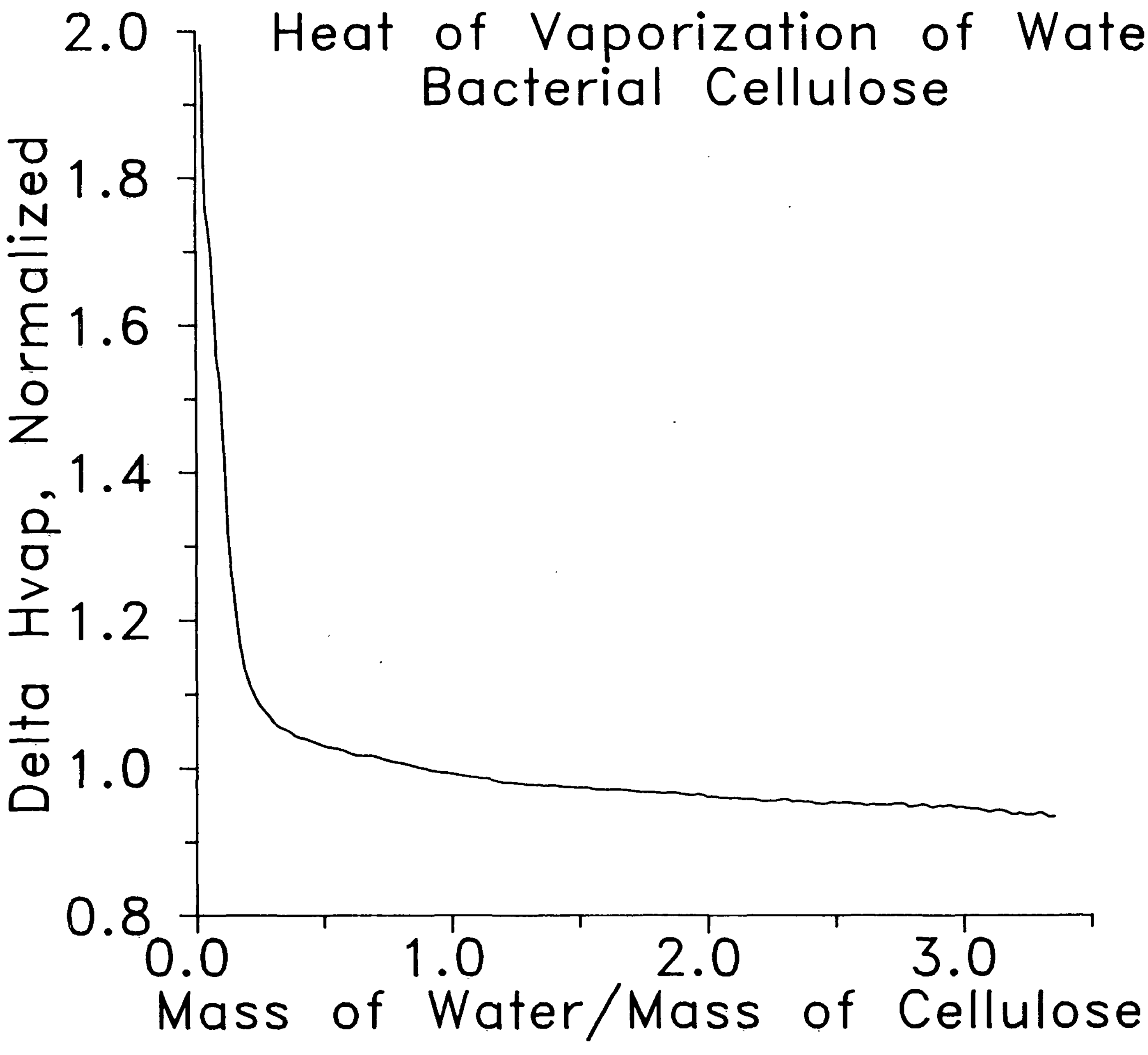

Heat of Vaporization
of Water
Scan Rate = 0.5 C/min
Delta Hvap (cal/g)
570.0
550.0
530.0
510.0
490.0
470.0
40
50
60
70
80
90
100
Temperature (C)
Circles represent literature values.
Straight line through points is best fit.
Solid line represents measured values.

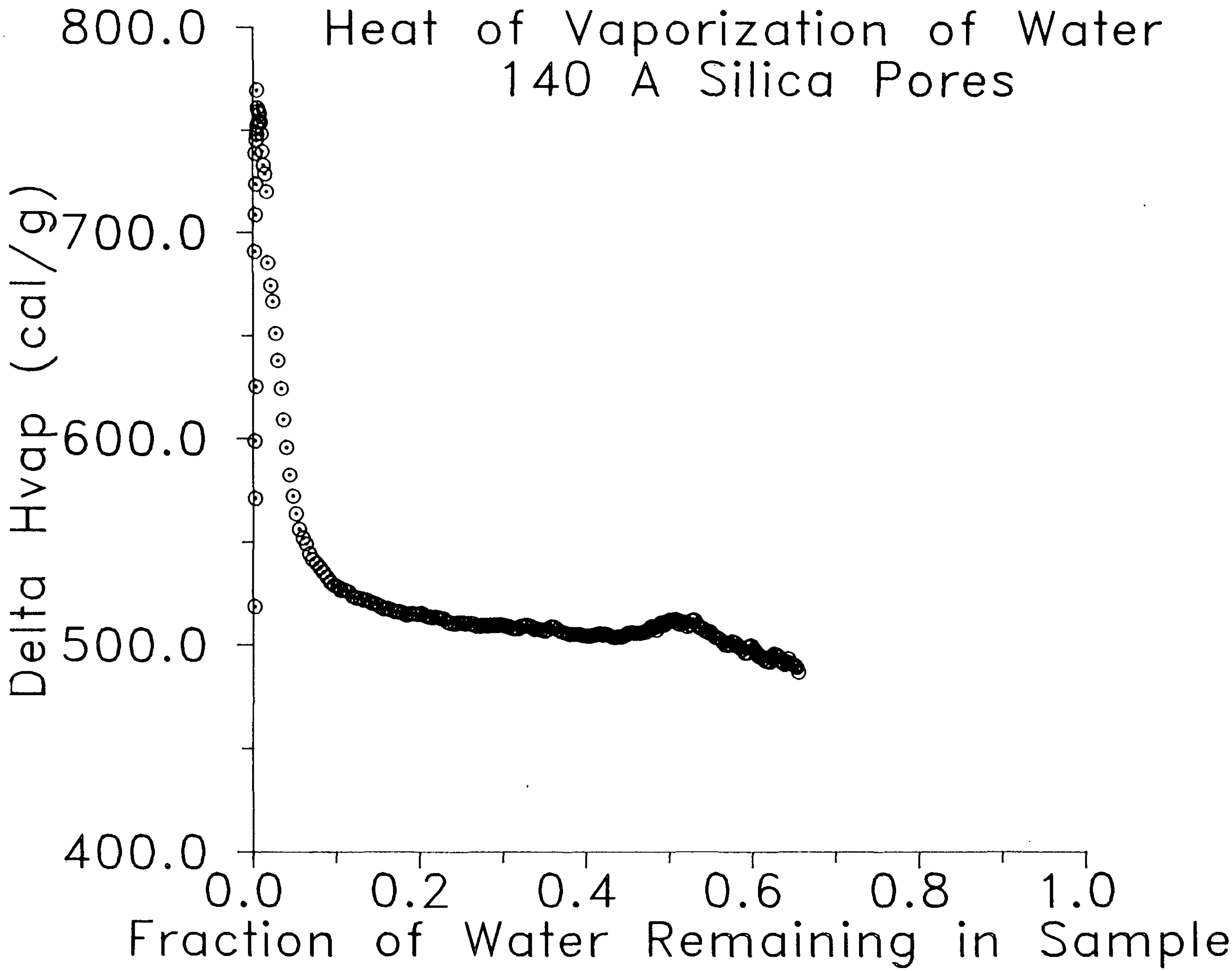


Heat of Vaporization of Water
Average of 4 Independent Runs
Delta Hvap (cal/g)
570.0
550.0
530.0
510.0
490.0
470.0
60
65
70
75
80
85
90
95
Temperature (C)



Heat of Vaporization of Methanol
Average of 10 Measurements
Average Delta Hvap (cal/g)
310
300
290
280
270
260
250
20
30
40
Temperature
Triangles are literature data for
heat of vaporization of methanol.

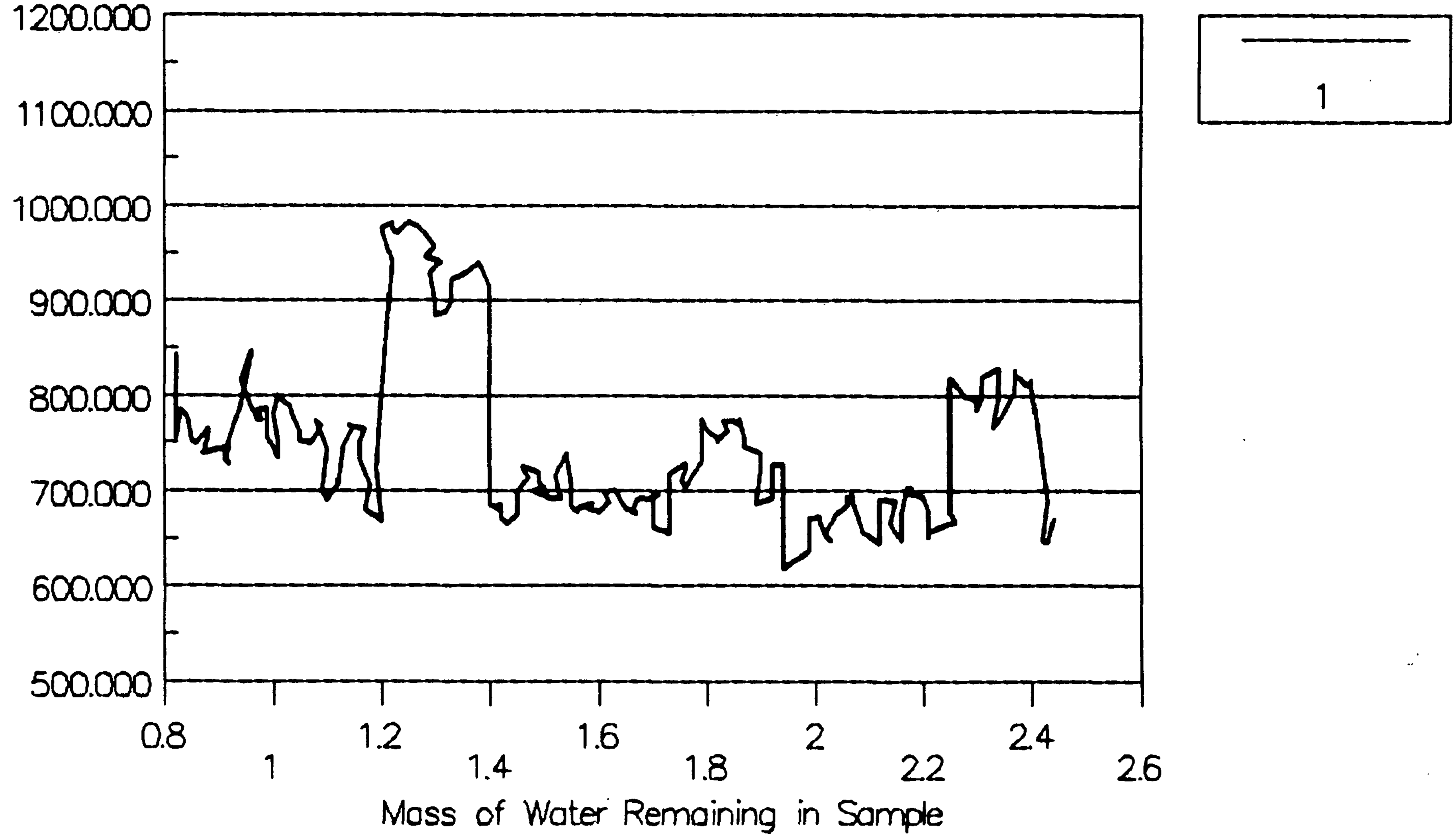

Heat of Vaporization of Water
Bacterial Cellulose
Delta Hvap, Normalized
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.0
1.0
2.0
3.0
Mass of Water/Mass of Cellulose



Heat of Vaporization of Water
140 A Silica Pores
Delta Hvap (cal/g)
800.0
700.0
600.0
500.0
400.0
0.0
0.2
0.4
0.6
0.8
1.0
Fraction of Water Remaining in Sample

Heat of Vaporization of Water

Liner #6781



UTILIZATION OF RECYCLED FIBERS
PROJECT 3681

December 17, 1990
Institute of Paper Science and Technology
Atlanta, Georgia

DUES-FUNDED PROJECT SUMMARY FORM
FY 90-91

Project Title:	UTILIZATION OF RECYCLED FIBERS
Project Code:	RECYC
Project Number:	3681
Division:	Engineering and Paper Materials Division
Project Staff:	R. Stratton, R. Ellis
FY 90-91 Budget:	$185,000

PROGRAM GOAL: To develop the technological understanding necessary for a significant expansion in the use of recycled fiber from secondary sources. Examine the practical limitations on the expanded use of secondary fibers in various paper grades.

PROGRAM AREAS: Environmental Impact, End Use Performance

RATIONALE: The paper industry may be required through legislative or regulatory action to expand its utilization of recycled fiber in papermaking grades where such utilization is not now economically practiced. Some of the secondary fiber material may include recycled grades that are now considered to be of inferior quality, such as mixed grades and newsprint. The inferior quality of these raw materials is likely to be offset by their low cost and availability.

The impact of increased use of lower quality secondary fiber on the important properties of certain product grades such as writing papers, coating stock, linerboard, and the practical limitations on the use of secondary fibers of various types in such grades, have not been systematically explored. The purposes of this study are to characterize the degradation of important properties attendant on the use of non-traditional secondary fibers in non-tradition paper grades, determine the practical limits on the use of secondary fibers in various paper grades, and to identify processing alternatives that will permit the expanded use of such fibers in various paper grades, and to identify processing alternatives that will permit the expanded use of such fibers without degradation of critical product properties.

Recent reports suggest that highly oxidative treatments of secondary fibers can improve strength and related properties, apparently as a result of oxidation of contaminants.

GOALS FOR 1990-1991:

What is the impact of recycled fiber on product performance and papermaking?

a) Select a series of dominate fiber species in the U.S. waste streams and determine the following:

   1) Strength and optical characteristics
   2) Drainage characteristics
   3) Pressing characteristics

b) Modify the MAPPS System to include the effect of recycling.

Can the effect of contaminants be eliminated by using strong Oxidative treatments?

a) Determine the effect of High temperature O_2 and O_3 treatment on the typical contaminants in a waste stream.

ACCOMPLISHMENTS TO DATE:

In FY 89-90, this project was initiated with a review of waste paper utilization in the United States. This review is still underway, but is scheduled for completion by June 1990.

Work carried out under Project 3428, "Removal of 'Sticky' contaminants from Recycled Fiber," has been reexamined. Removal by flotation can be understood in terms of the surface energies of the contaminants and of the flotation medium. The study of the impact of drying on fiber strength and bond has been initiated. Work on Southern bleached and unbleached Hardwood and Pine is underway.

RELATED STUDENT PROJECTS:

1. Jeffrey Faust, M.S. project, "Impact on Strength for Pressing vs. Size Starch on Linerboard and Medium Grade Papers Made from Recycled Material" (in progress).

2. Kelly Sedlachek, M.S. project, "Impact of Recycling on Printing/Writing Papers" (in progress).

3. Ronald Vollbrecht, M.S. project, "The Quantitative Effect of Dry Strength Additives on Fiber-Fiber Bond Strength" (in progress).

4. Cheryl Keller, Special Project, "Effects of Surfactants on the Deinking of Recycled Paper Containing Laser-Printed Ink" (in progress).

GOALS FOR
DECEMBER 1990 - APRIL 1991:

1. Prepare written reexamination of the Project 3428 work.

2. Arrange for the transport and installation of pilot scale deinking equipment (on loan to IPST).

Fiber Properties

3. Analyze the handsheet data for Southern Pine and Hardwood (March 30).

4. Obtain samples of Western long and short fiber material and begin handsheet work (March 1).

5. Set-up drainage measurement instrumentation (April).

6. Begin pressing experiments for Southern Pine and Hardwood (February).

Contaminants

1. Design, construct, and test an O_3 cell to measure the impact of O_3 treatment on the surface energy of contaminants (April).

UTILIZATION OF RECYCLED FIBER

PROJECT 3681

IPST PROJECTS ON RECYCLED FIBER

- THE USE OF RECYCLED FIBER IN LINERBOARD, 1977-1980

- REMOVAL OF "STICKY" CONTAMINANTS FROM RECYCLED FIBER, 1980-1982

MAJOR RESEARCH AREAS

PAPER PROPERTIES

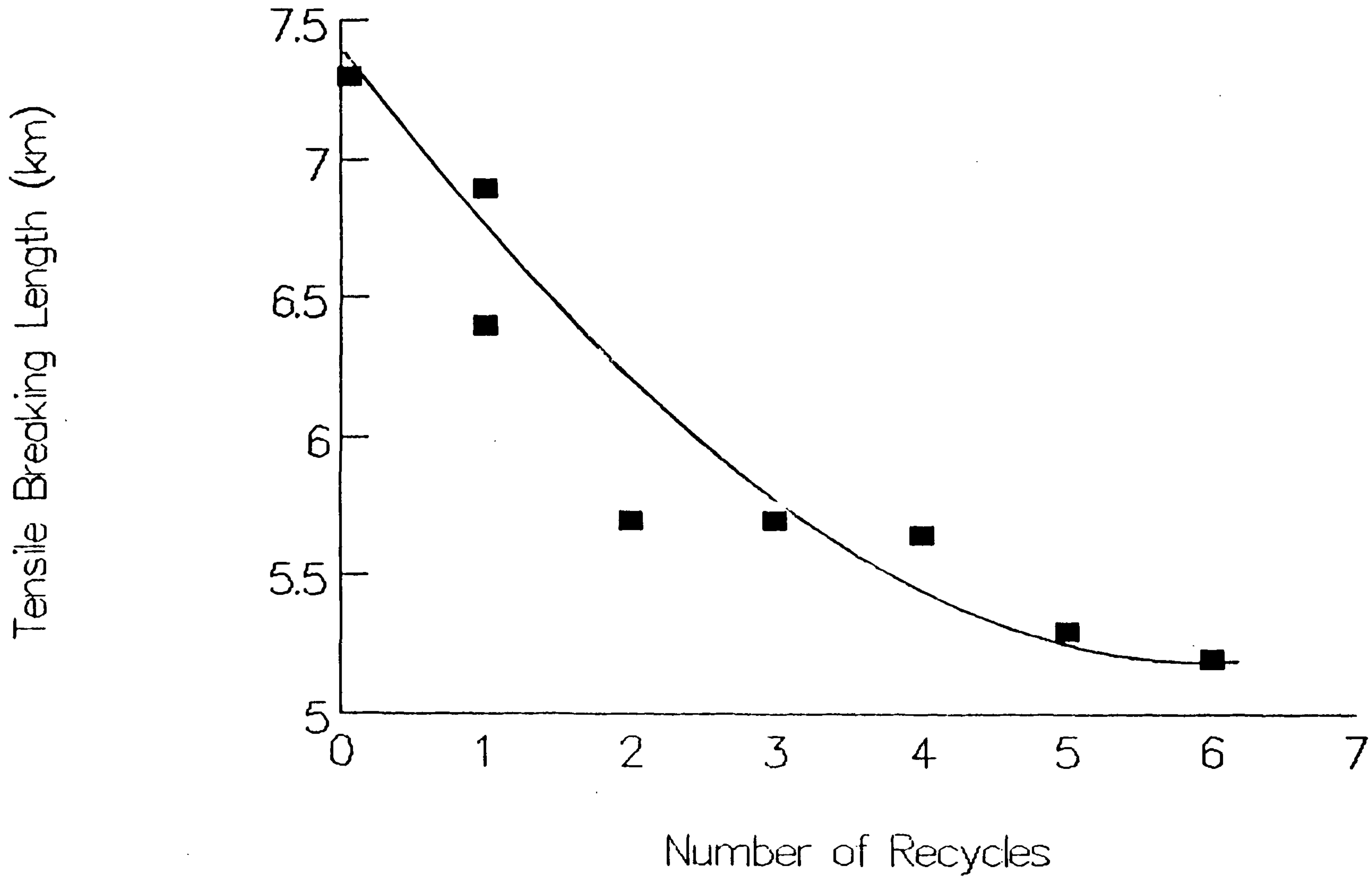
- STRENGTH AND OPTICAL PROPERTIES
- APPEARANCE

PAPERMAKING PROCESS

- DRAINAGE
- PRESSING RESPONSE
- DRYING RESPONSE

EFFECT OF RECYCLING ON SHEET PROPERTIES

TENSILE



MAPPS Equation For Tensile Properties. (Page et al)

$$\frac{1}{T} = \frac{9}{8Z} + \frac{gC}{P\,L\,b\,RBA}$$

T = Tensile Breaking Length

Z = Zero span Breaking Length Fiber

C = Fiber Coarseness

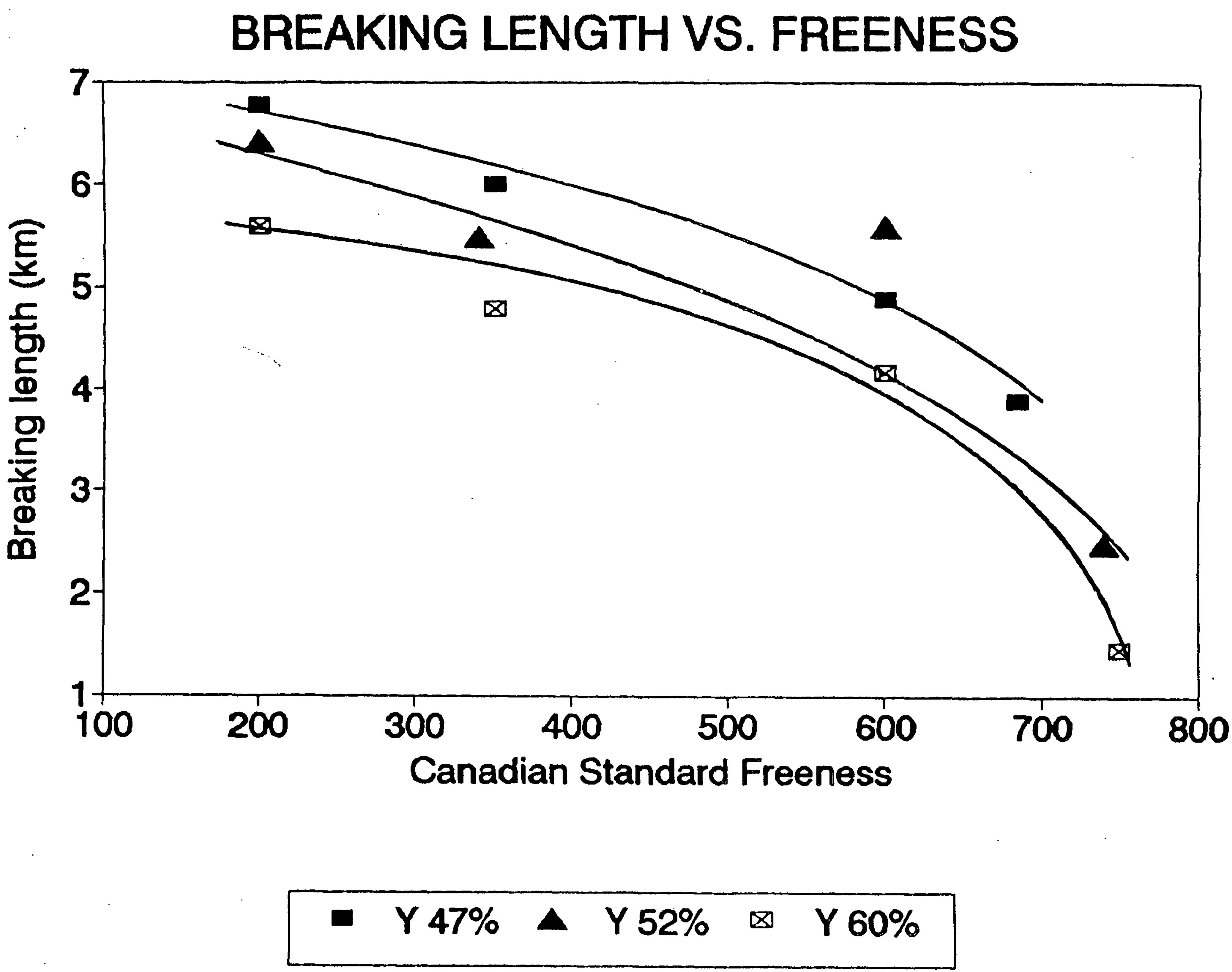
P = Fiber Perimeter

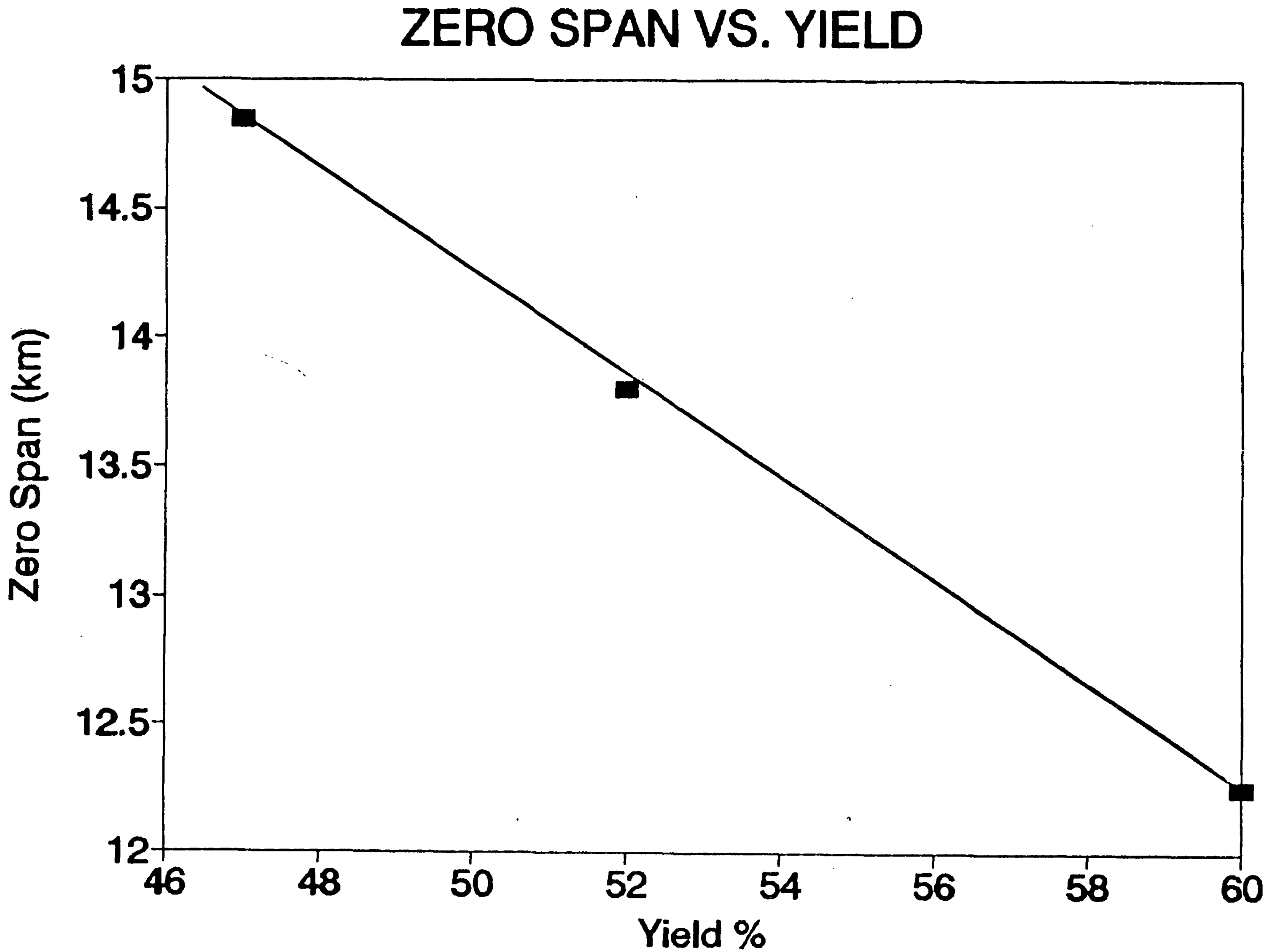
L = Fiber Length

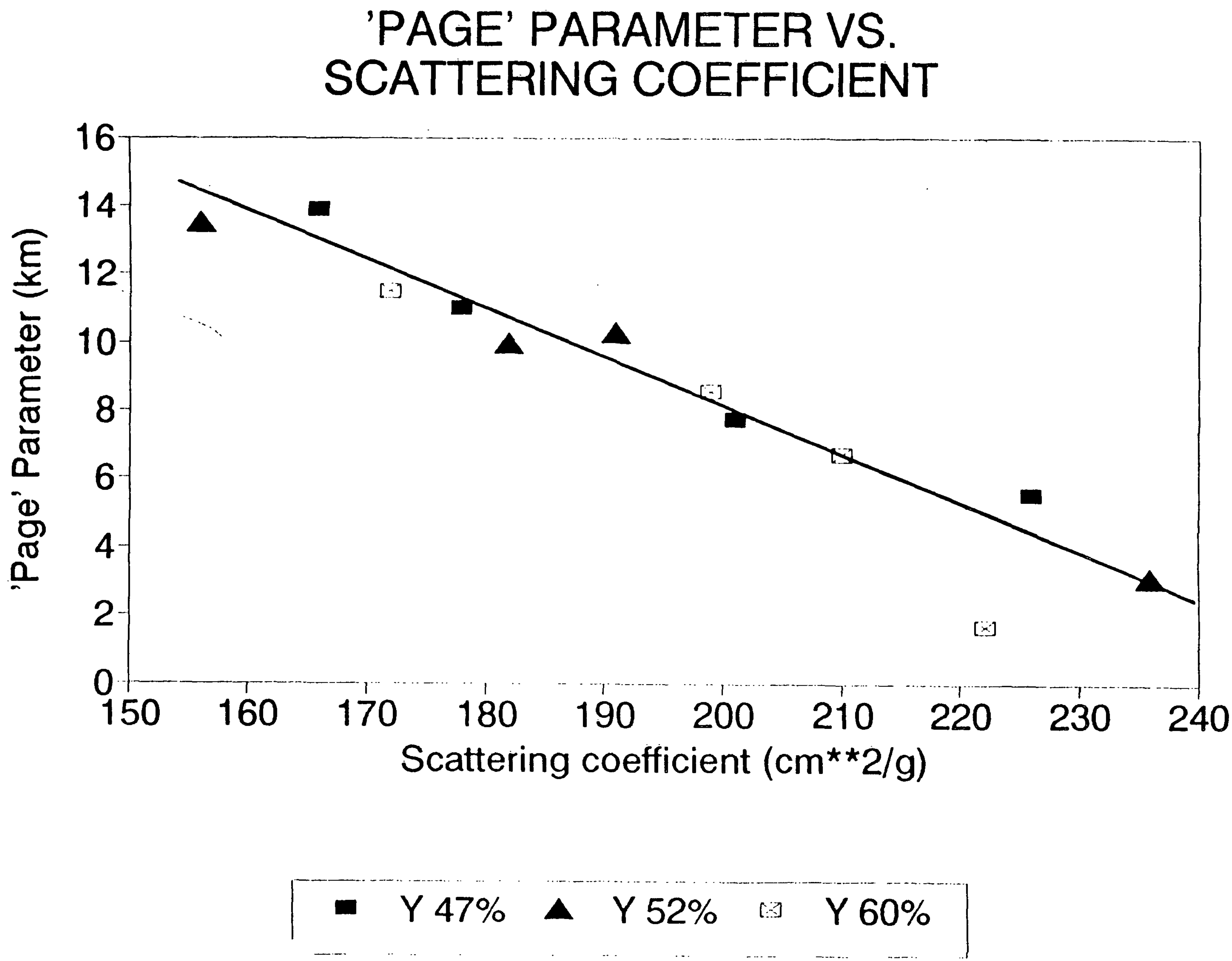
b = Fiber - Fiber Bond Strength

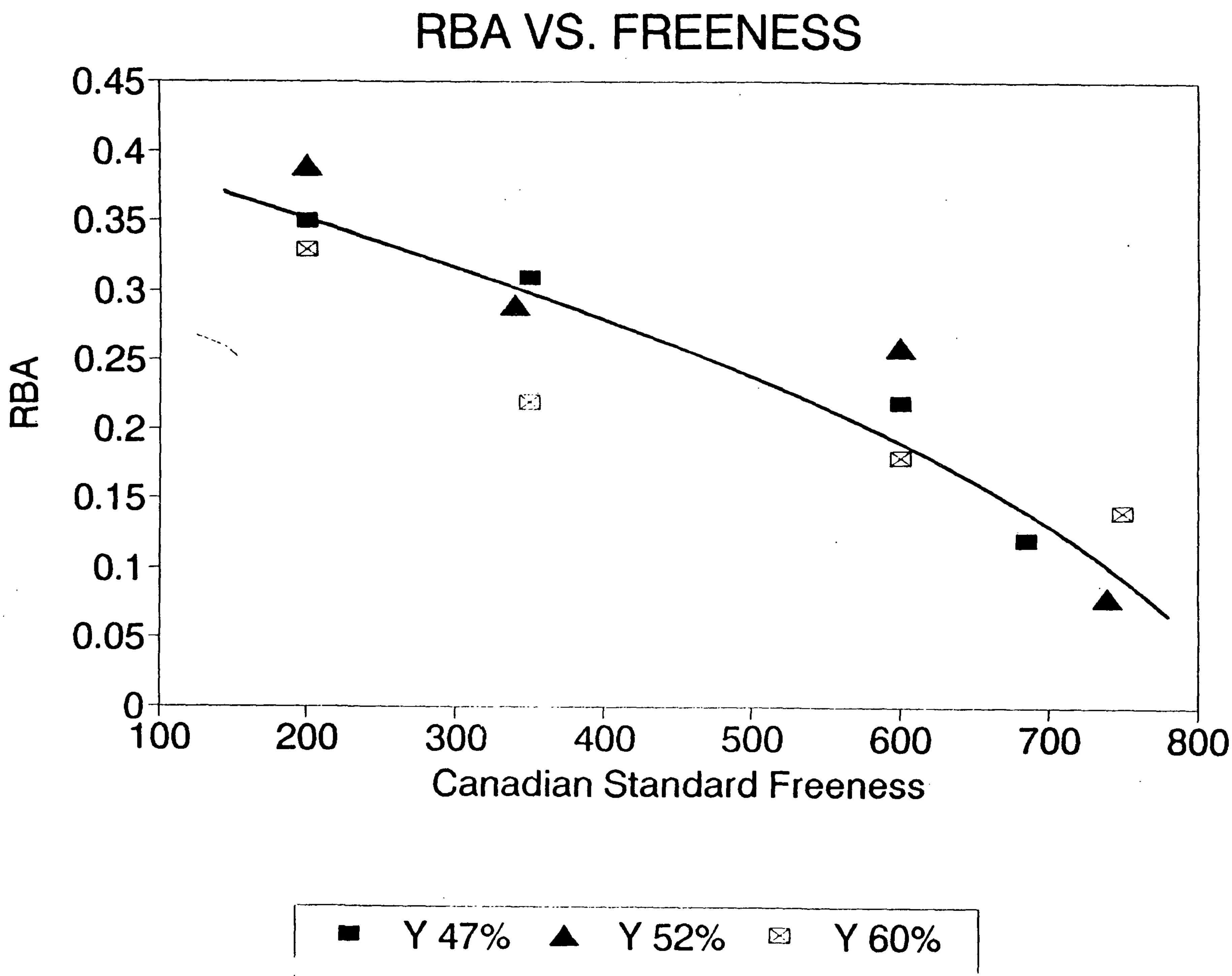
RBA = Relative Bonded Area

$$RBA = \frac{S_0 - S}{S_0}$$


BREAKING LENGTH VS. FREENESS
Breaking length (km)
1
2
3
4
5
6
7
100
200
300
400
500
600
700
800
Canadian Standard Freeness
Y 47%
Y 52%
Y 60%


ZERO SPAN VS. YIELD
Zero Span (km)
15
14.5
14
13.5
13
12.5
12
46
48
50
52
54
56
58
60
Yield %


'PAGE' PARAMETER VS.
SCATTERING COEFFICIENT
'Page' Parameter (km)
0
2
4
6
8
10
12
14
16
150
160
170
180
190
200
210
220
230
240
Scattering coefficient (cm**2/g)
Y 47%
Y 52%
Y 60%

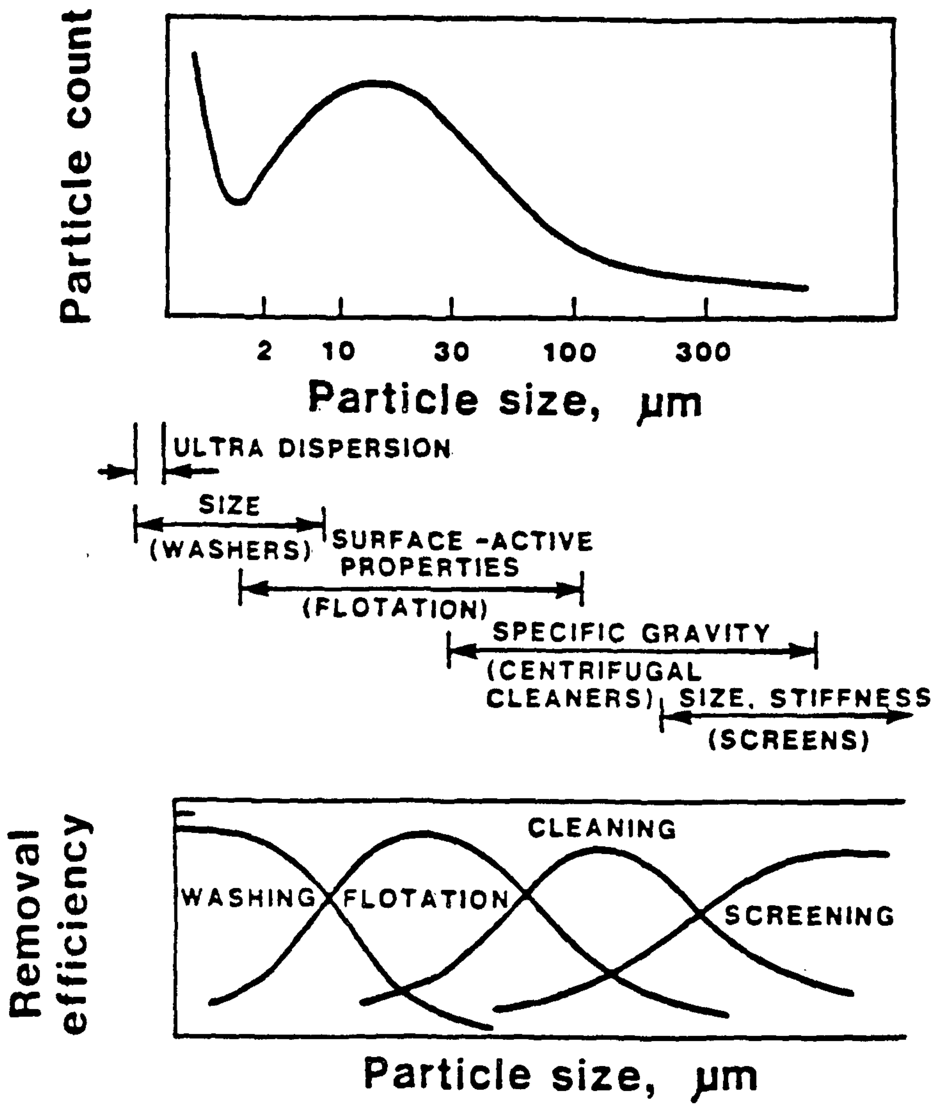

RBA VS. FREENESS
RBA
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
100
200
300
400
500
600
700
800
Canadian Standard Freeness
Y 47%
Y 52%
Y 60%

FIBER-FIBER BOND STRENGTH

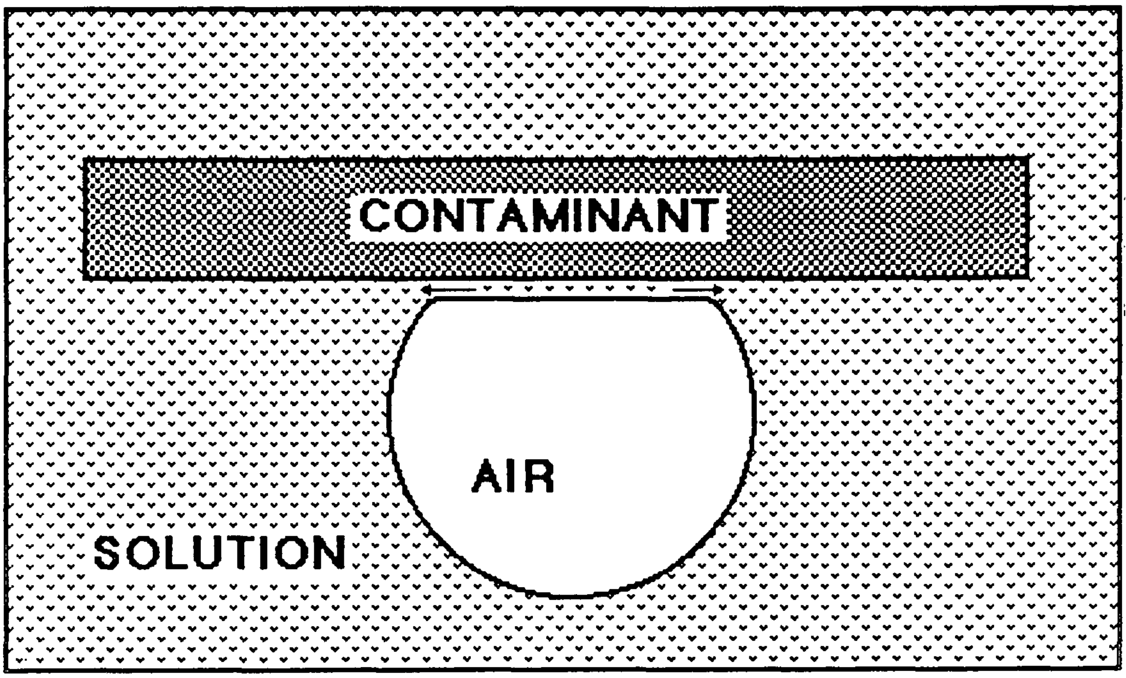
YIELD	BOND STRENGTH
47	3.8
52	4.1
60	4.8

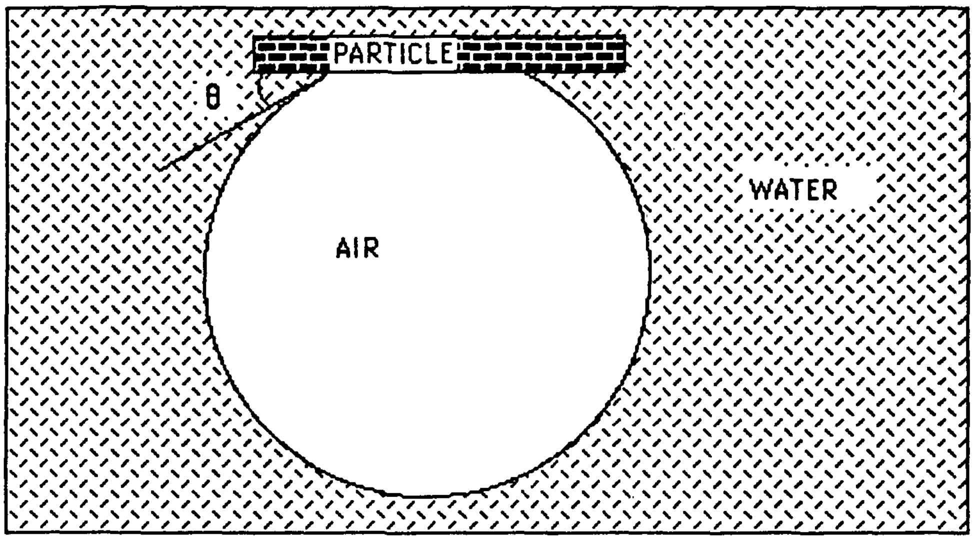
% REDUCTION IN SUMMARY OF FIBER PARAMETERS

	ZERO SPAN	BONDED AREA	BONDING
IPST			
Southern Pine UB	19	7	53
HORN, FPL			
Southern Pine UB	33		
BOBLEC et al, W. Mich			
Southern Pine	(Increase 7)	0	61
Northern Pine		13	25
Eucalyptus		4	78
Aspen	(Increase 25)	2	22

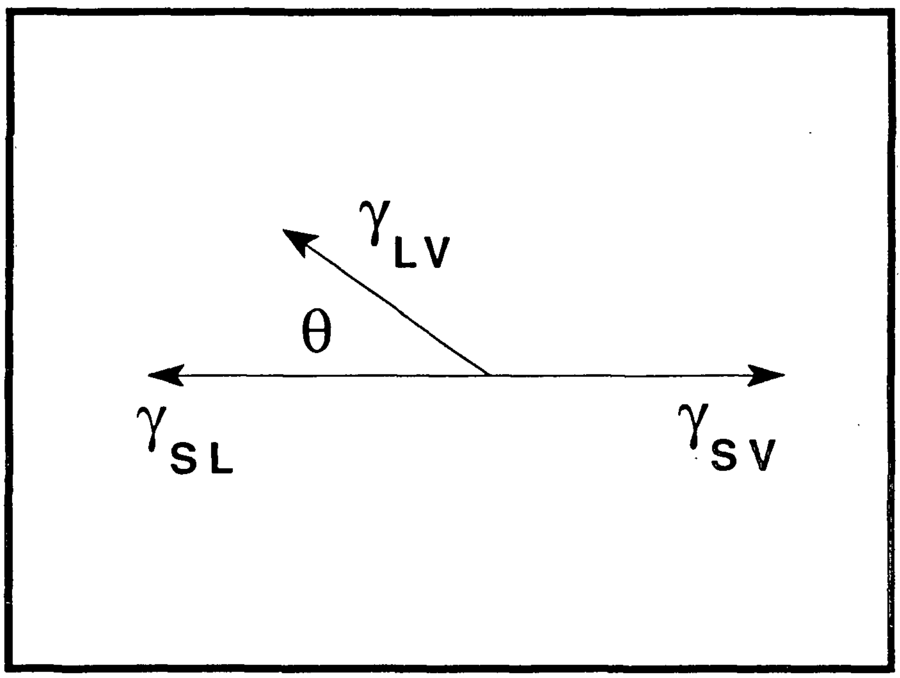


Particle size distribution in a repulper (top) and unit operation removal efficiency as a function of particle size (bottom) [25].

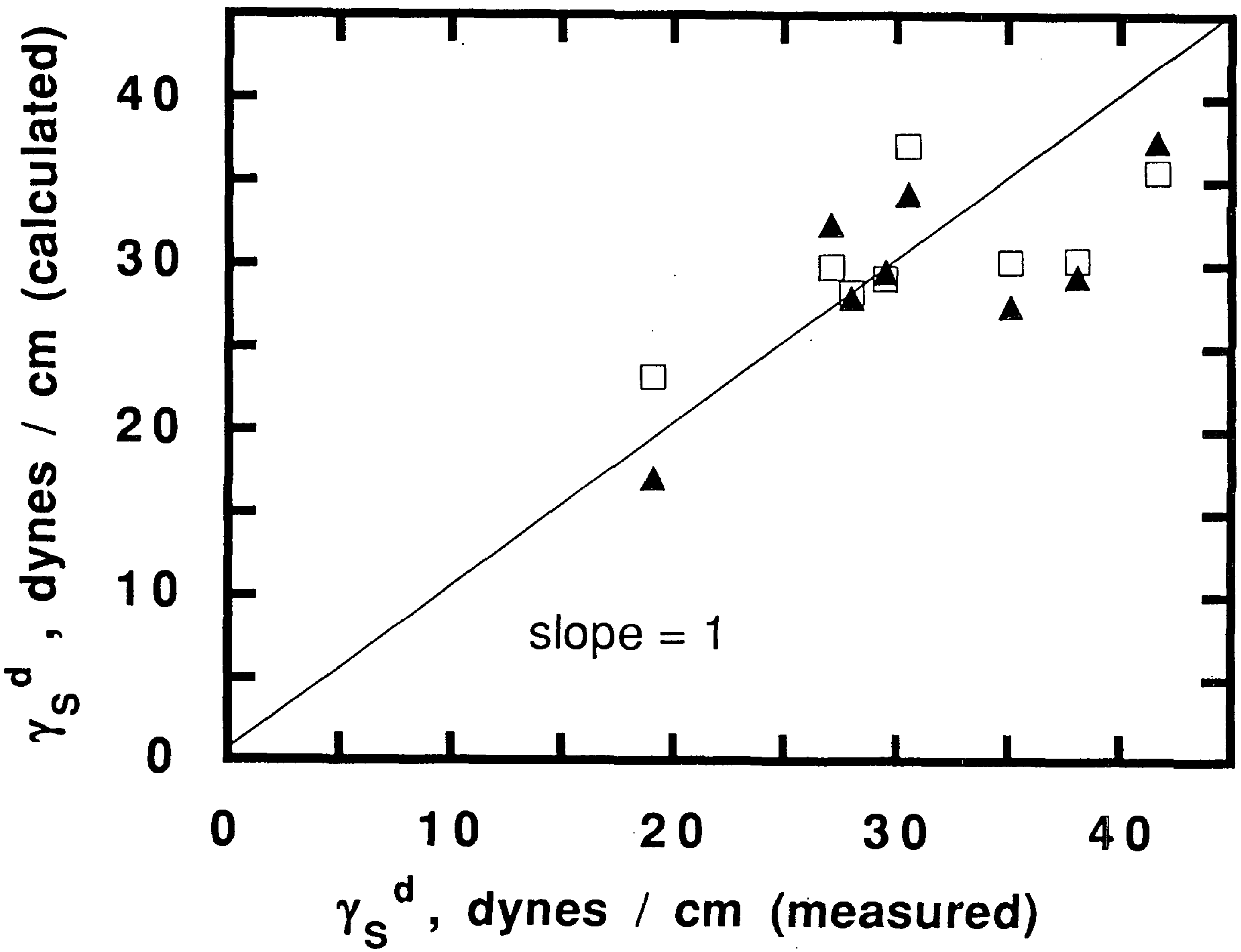

CONTAMINANT
AIR
SOLUTION


PARTICLE
θ
WATER
AIR

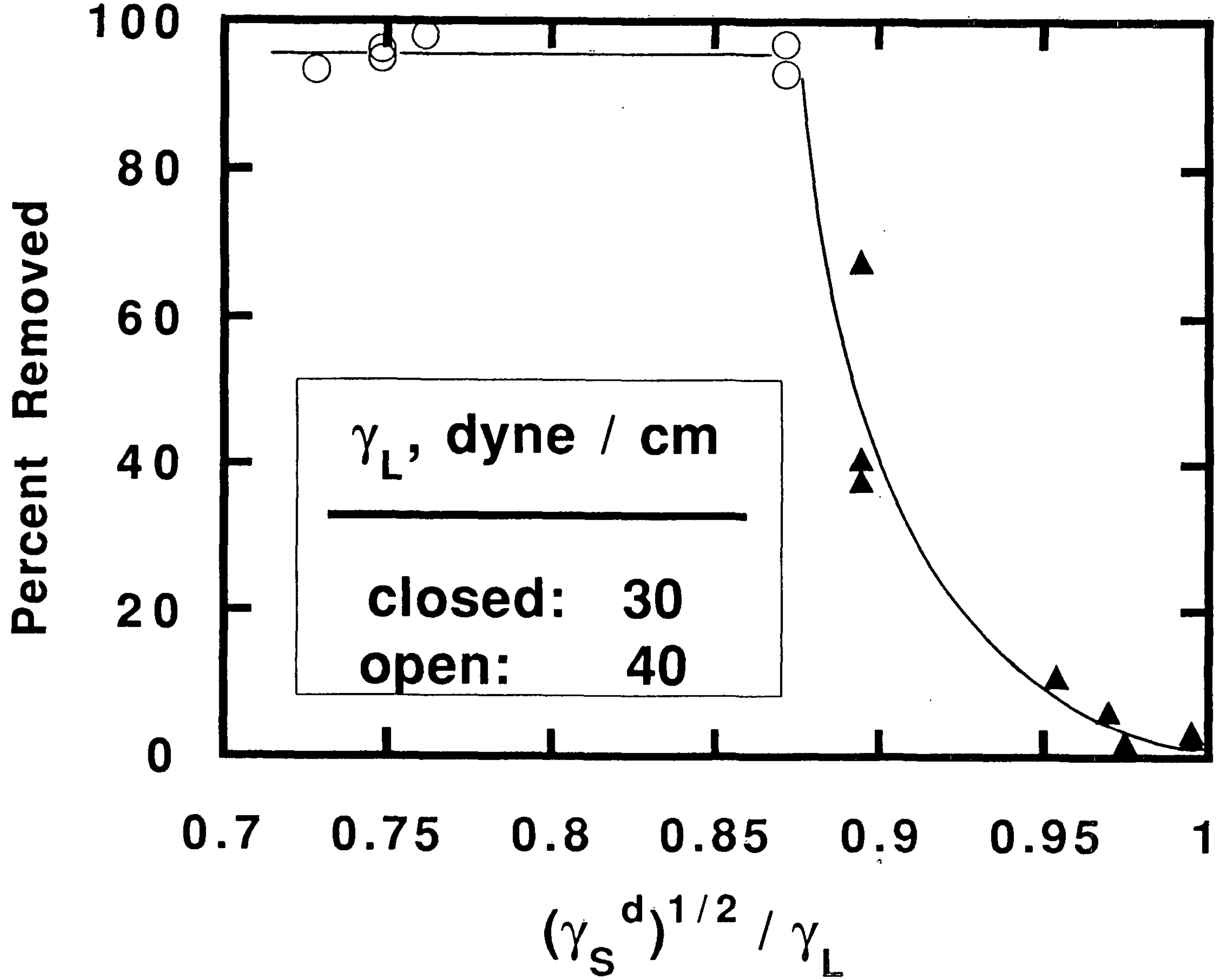
INTERFACIAL TENSIONS

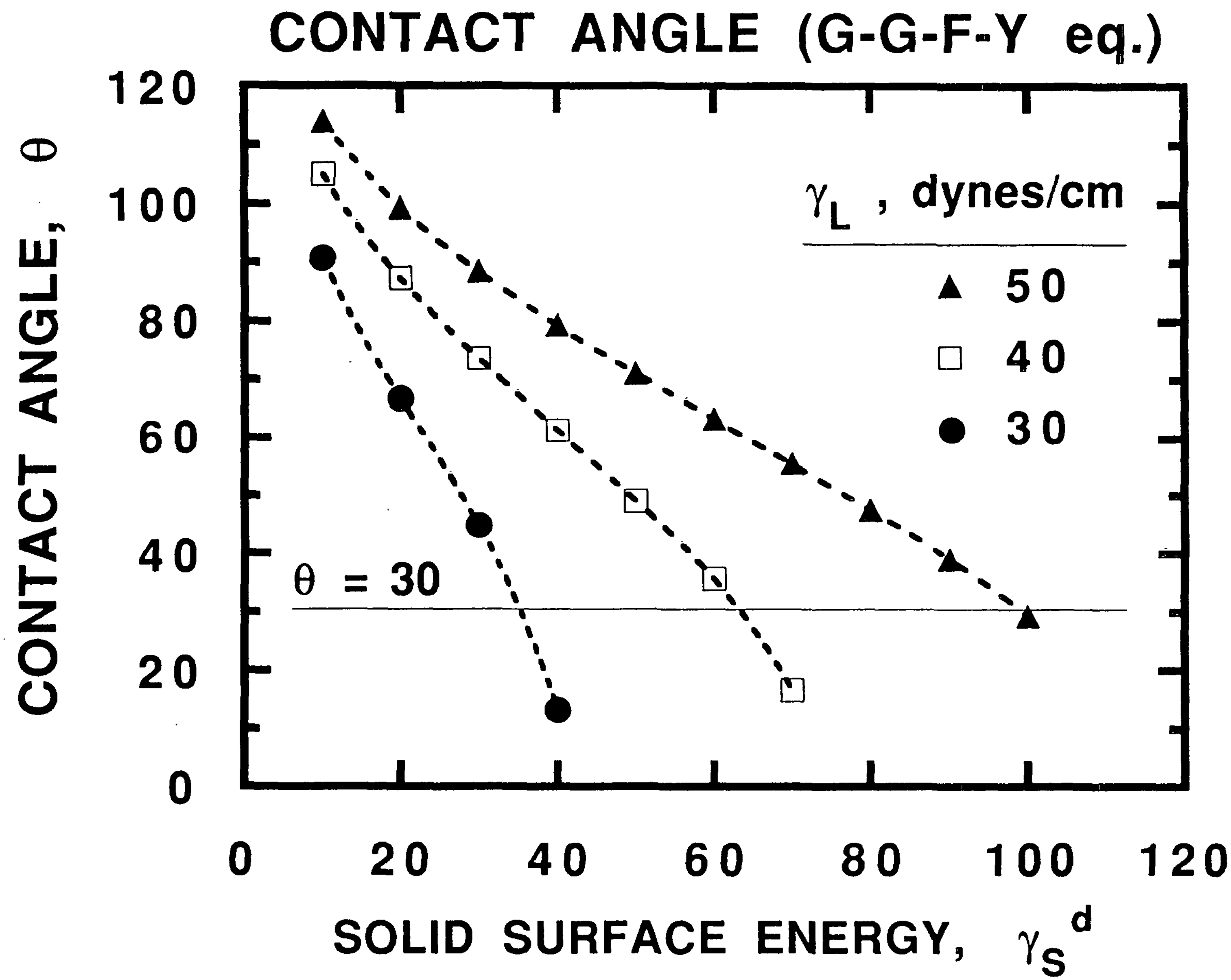


SURFACE ENERGY OF STICKY CONTAMINANTS



FLOTATION EFFICIENCY-- SURFACE ENERGIES




CONTACT ANGLE (G-G-F-Y eq.)
CONTACT ANGLE, θ
120
100
80
60
40
20
0
γL , dynes/cm
50
40
30
θ = 30
0
20
40
60
80
100
120
SOLID SURFACE ENERGY, γS d

GOALS FOR THE PERIOD
DECEMBER 1990 - APRIL 1991

FIBER PROPERTIES

1. ANALYZE THE HANDSHEET DATA FOR SOUTHERN PINE AND HARDWOOD (MARCH 30)

2. OBTAIN SAMPLES OF WESTERN LONG AND SHORT FIBER MATERIAL AND BEGIN HANDSHEET WORK (MARCH 1)

3. SET-UP DRAINAGE MEASUREMENT INSTRUMENTATION (APRIL)

4. BEGIN PRESSING EXPERIMENTS FOR SOUTHERN PINE AND HARDWOOD (FEBRUARY)

GOALS FOR THE PERIOD
DECEMBER 1990 - APRIL 1991

CONTAMINANTS

1. DESIGN, CONSTRUCT, AND TEST AN O_3 CELL TO MEASURE THE IMPACT OF O_3 TREATMENT ON THE SURFACE ENERGY OF CONTAMINANTS (APRIL)