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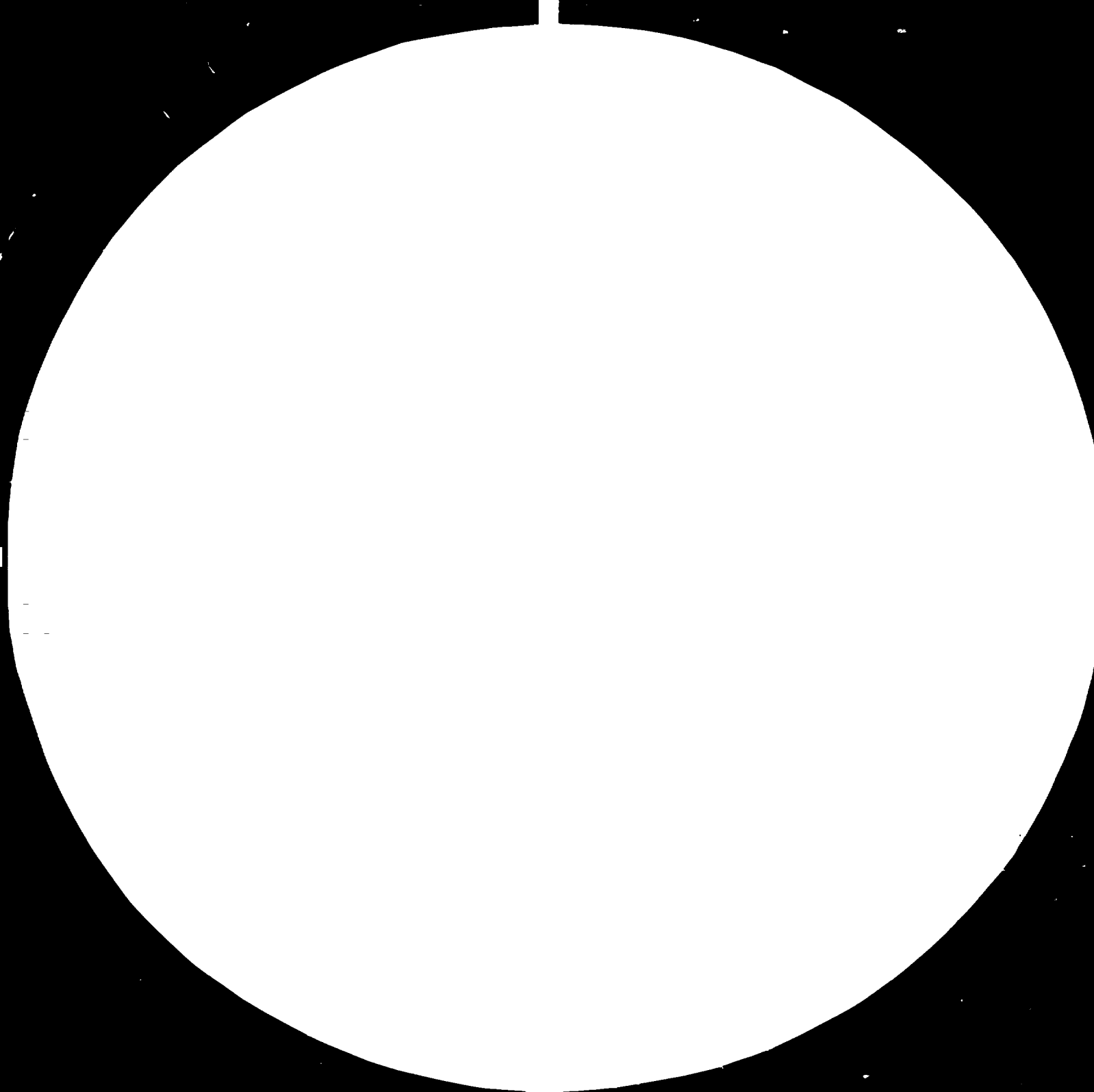

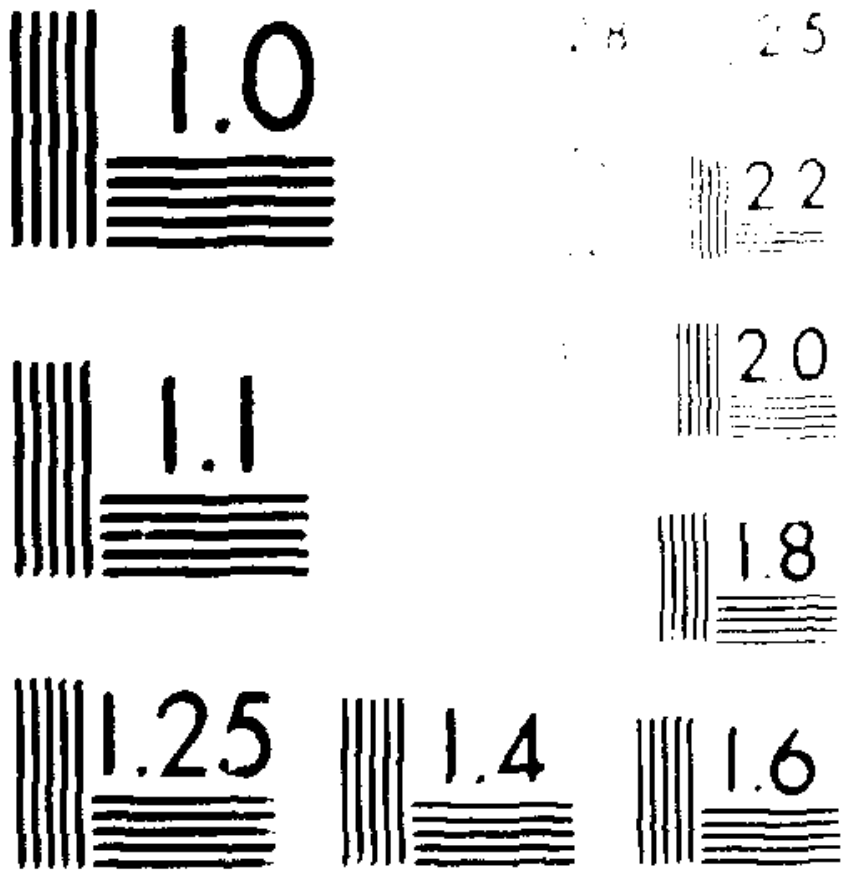
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17 May 1982
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CONSOLIDATION OF THE MEXICAN INSTITUTE FOR ASSISTANCE TO THE INDUSTRY

Rennert

DP/MEX/78/011

MEXICO.

Technical report: Qualitative and quantitative improvement* of the training courses on packaging material production and food packaging technologies.

Prepared for the Government of Mexico
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of: Theron Downes, expert in food packaging, Jack Giacin, expert in packaging analysis, Bruce Harte, expert in food packaging, Hugh Lockhart, expert in package testing, Chester Mackson, expert in packaging administration

United Nations Industrial Development Organization
Vienna

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CONTENTS

SUMMARY

This report describes the work performed by the School of Packaging at Michigan State University under UNIDO Contract #80/157. The report consists of this document and six separate volumes describing the work with special emphasis on the preparation and presentation of two courses on site in Mexico City. The two courses were:

1. Food Packaging
2. Analytical Aspects of Packaging

In addition to the material above this report also describes compliance with the contract request for proposals for continuing cooperation.

It is concluded that the utilization of a team approach with several team members working on site for short periods of time coupled with significant work at the contractors location provides an effective and efficient adjunct to long term consultants. It is recommended that cooperative links should be established between IMAI and Michigan State University as described elsewhere in this report.

INTRODUCTION

This report describes the work performed under UNIDO Contract #80/157 Qualitative and Quantitative Improvement of the Training Courses on Packaging Material Production and Food Packaging Technologies. The nature of the work performed is consistant with historical approaches to these efforts. The manner of implementation represents a departure from conventional methods. A total of 2.75 man months of time was spent working on site in Mexico City. This total, however, is the sum of the work performed by a team of five individual members of the faculty of the School of Packaging at Michigan State University. The work performed is described in the body of this report in roughly chronological order. The work performed is outlined below:

1. Initial visit to Mexico City for appraisal of national conditions for implementation
2. Preparation of tentative course outlines
3. Determination and collection of assigned reading materials
4. Course material preparation
5. Presentation of the course, Food Packaging (Mexico City)
6. Presentation of the course, Analytical Aspects of Packaging (Mexico City)
7. Special projects consisting of individual laboratory assistance and advice on specific research projects
8. Preparation of proposals for continuing cooperation
9. Meetings related to proposals for continuing cooperation (Mexico City)

The team approach to execution of duties of this nature is somewhat novel. Oral and written evaluations of the work indicate that it was well received and effective. The team approach would not be well suited to work which requires individuals to be on site for extended periods. The duties requested for this project included training and course development and appear to have been ideally suited to a team approach. It is suggested that the team approach be strongly considered in the future as an adjunct to long term consultants.

Individual staff members at LANFI have solid technical backgrounds, in general. Their experience in packaging is somewhat limited. Exposure to the breadth of background experience and training represented by a faculty of packaging is extremely beneficial to their professional growth. Continued exposure through additional follow-up courses on site, visits to MSU and, work toward graduate degrees is recommended.

APPRAISAL OF NATIONAL CONDITIONS

The initial visit to the LANFI Laboratories in Mexico City was made by Theron W. Downes and Hugh E. Lockhart during the period May 10, 1981 to May 17, 1981. The primary purpose of this visit was to get acquainted with the resources of IMAI for training purposes with particular regard to the available personnel, equipment and technical support. During this period personal interviews were conducted with most of the individuals from LANFI who were planning to be attending the courses to be offered in the Fall. Tentative course outlines were prepared for approval at that time. The courses as offered in the Fall did not differ significantly from the agreements and understandings which were reached in May. The guidance, assistance, and cooperation of Senors Francisco Munoz and Luis Madi in this phase of the project are gratefully acknowledged.

COURSE 1 - FOOD PACKAGING

The tentative outline for the course on Food Packaging as prepared in May, 1981 in Mexico City is presented below.

FOOD PACKAGING

Instructors: Dr. Theron W. Downes
Dr. Bruce R. Harte

A. INTRODUCTION

1. Product Problems Affected by Package (Lipid oxidation, non-enzymatic browning, freezer burn, etc.)

2. Environmental Influences

B. PACKAGING REQUIREMENTS BY PRODUCT TYPE

1. General Principles

2. Specific Products:

-fish
-meat
-eggs
-milk and milk products
-juice
-baked goods (eg. tortilla)
-oils and lipid containing foods
-fresh and processed fruits and vegetables (tomato, chili, etc.)

C. COMPATABILITY

1. Flavor - permeation, adsorption, absorption, migration

2. Environmental Stress Cracking, Properties Alteration

D. SHELF-LIFE (except cans)

1. Moisture Content

a. isotherms by product type
b. A_w and reaction rates
c. Shelf-life estimation

1. low moisture
2. intermediate moisture

2. Oxidation

3. Respiration (trucks, packages)

E. SHELF STABLE ("commercially" sterile) FOODS

1. In Package Thermal Processing

a. cans
b. glass
c. retort pouch
d. rigid plastic

2. Alternate Techniques

a. Aseptic

1. cans - steam, hot air
2. form-fill-seal
ethylene oxide
H_2O_2
radiation
acid

b. In Package

1. radiation
2. ethylene oxide

F. INTRODUCTION TO HEAT PROCESSING

1. Heat Penetration

a. Principles
b. Measurement
c. Kinetics

1. chemical reaction
2. microbial death

d. Analysis

$T_1 - T = j(T_i - T_0)10^{-t/f}$
CUT
g, z, F_o, F_T^Z

The outlines for week 1 and week 2 of the course on food packaging as presented at LANFI October 19, 1981 through October 30, 1981 are given below.

FOOD PACKAGING

Course Outline Week 1

TOPICS

Shelf life as a function of the environmental severity, product fragility, and packaging performance.

- Environmental components
- Product components
- Package properties

Product problems effected by the environment and packaging

- Lipid oxidation
- Microbial spoilage
- Nonenzymatic browning
- Freezer burn
- Staling
- Other textural changes
- Regeneration of enzymatic activity

Definition of water activity (A_w) equilibrium water content and moisture sorption isotherms. The use of isotherms in product stability. The effect of (A_w) on product deterioration.

Product problems, packaging requirements, and package systems used for specific product groups.

- Red meat
  - Fresh
  - Cured
- Poultry
- Fish
- Eggs

Course Outline Week II

SHELF LIFE

I. MOISTURE SENSITIVE PRODUCTS

1. Adsorption
2. Desorption
3. Effect of temperature on isotherms
4. Effect of moisture on kinetics

    a. Microbiological
    b. Enzymes
    c. Browning
    d. Oxidation

5. Estimation

    a. Low moisture products
    b. Intermediate moisture products
    c. High moisture products
    d. Permeability in laminations

II. OXYGEN SENSITIVE PRODUCTS

1. Estimation

    a. Allowable uptake
    b. Calculation

2. Constraints

    a. Effect of light
    b. Effect of moisture
    c. Effect of prooxidants
    d. Effect of antioxidants
    e. Effect of oxygen concentration on rate constants
    f. Effect of temperature

3. Iteration techniques

III. INTRODUCTION TO HEAT PROCESSING

1. Effect of temperature

    a. Reaction kinetics
    b. Microbial death
    c. Lethality
        D, z, t, F

2. The general method

3. Time temperature history
   T, J, f_h, t

4. Formula Methods

   a. g, z, f_h, f_c, j_n, j_c
   b. The exponential integral
   c. Ball's method (graphical)
   d. Ball's tables
   e. Hayakawa's Method

      1. Downes and Hayakawa (1981)

   f. Container geometry

      1. Estimation for pouches

The difference between the course on Food Packaging as described in May and the course as it was actually presented in October consists solely of the deletion of the topics related to aseptic systems and some small changes in emphasis. Time constraints were the major consideration in making these changes.

Assigned reading materials selected from the literature were collected, bound and sent to Mexico City prior to the presentation of the course so that students would have the opportunity to read related material prior to the course. These materials are supplied with this report as Appendix 3 and 4.

The language of the course presentation was English with simultaneous translation in class. Most of the material discussed in class was prepared on overhead transparencies and also supplied to students so that they could have the written material in front of them as it was being discussed in class. This procedure was quite effective in improving communication. These materials can be found in Appendix 6 of this report. The students who attended this course were employees of LANFI. The students were asked in written evaluation form to evaluate the knowledge obtained in this course as it compared to their expectations on a scale of 1 to 10. This course averaged 8.8 on that scale. A number of the students who rated the course at less than 10 did so with the comment that they wished there had been more time. The individual instructors involved were also evaluated on a scale of 1 to 10 for qualities such as clearness, organization, knowledge, explaination, visual aid use, content, summary, participation, written material, etc. These evaluations averaged 8.9 indicating that the students were quite satisfied with the course and the manner of presentation.

The format for the course presentation consisted of three to three and one-half hours of oral presentation per day with time spent in the afternoon working in the laboratory or on special projects. These special project activities are described in a later section of this report.

The following ten pages of this report consist of materials prepared for utilization in the course on food packaging which were not included in either the assigned readings or the class notes. These inclusions consist of a set of problem assignments for the students to work on, a table of lethal rates for the death of microorganisms prepared in degrees Celsius, a work sheet for the solution of thermal processing problems and a figure and set of tables for computation of lethalities of thermal processes.

Estimate the useful shelf-life for a product characterized by the following parameters:

PRODUCT WEIGHT = 100g
PACKAGE SURFACE AREA = 0.1 m^2
INITIAL MOISTURE CONTENT = R.H. 3%, 12%
CRITICAL MOISTURE CONTENT = R.H. 9%, 28%

The package will be exposed to an environmental condition which can be approximated by an average of 26.7°C and 80% R.H.

Evaluate the following materials:

One mil LDPE WVTR = $\frac{18g \times mil}{m^2 \times day}$ at 37.8°C, 90% R.H.

One mil Saran (PVDC) WVTR = $\frac{1.5g \times mil}{m^2 \times day}$ at 37.8°C, 90% R.H.

Waxed Glassine WVTR = $\frac{4g}{m^2 \times day}$ at 37.8°C, 95% R.H.

Note the absence of a thickness parameter for glassine. The saturated vapor pressure of water of 37.8°C is 49.2 mmHg, at 26.7°C it is 26.2 mmHg.

A moisture sensitive product is characterized by the following parameters:

INITIAL MOISTURE CONTENT = 2.0% E.R.H. = 8%
CRITICAL MOISTURE CONTENT = 6.5% E.R.H. = 32%
INITIAL PRODUCT WEIGHT = 100g
PACKAGE SURFACE AREA = 0.0258 m^2

Estimate the shelf-life of the product when distributed in a package made from 1.5 mil Polypropylene if the distribution environment can be approximated by an average temperature of 23.9°C and average relative humidity of 75%. The vapor pressure of pure water is 49.2 mmHg at 37.8°C and and 22.2 mmHg at 23.9°C .

WVTR for polypropylene = $\frac{0.5g \times mil}{0.0645\ m^2 \times day}$ at 37.8°C, 90% R.H.

A moisture sensitive product is characterized by the following parameters:

INITIAL MOISTURE CONTENT = 4.5% E.R.H. = 16%
CRITICAL MOISTURE CONTENT = 9.0% E.R.H. = 42%
INITIAL PRODUCT WEIGHT = 60g
PACKAGE SURFACE AREA = 0.0161 m^2

Estimate the shelf-life of the product in a package made from 1.0 mil PVC if the distribution environment can be approximated by an average temperature of 21.1°C and Relative Humidity of 65%. (The saturated vapor pressure of pure water is 49.2 mmHg at 37.8°C and 18.8 mmHg at 21.1°C.

The water vapor permeability of the PVC was found to be

$$\frac{1.5g \times mil}{0.0645\ m^2 \times day}$$ at 37.8°C and 90% R.H.

How long will it take for the product described below to reach its critical moisture content (end of shelf-life) in an environment which can be approximated by an average temperature of 21.1°C (P_s = 18.8 mmHg) and an average relative humidity of 60%? The product is packed on a f x f x S machine using 2 mil medium density polyethylene which measures 10.1 cm x 12.7 cm.

$$\text{WVTR for MDPE} = \frac{21\text{g x mil}}{\text{m}^2 \text{ x day}} \text{ at } 37.8^\circ\text{C, } 90\% \text{ R.H.}$$

Product weight = 70g

M_o = 5.2% E.R.H. = 22%

M_c^o = 14.8% E.R.H. = 70%

Estimate the O_2 permeability of a laminate consisting of 0.5 mil PVDC laminated to 1.0 mil Polyester. Use the permeability constants given below:

PVDC: $P(O_2) = \dfrac{10 \text{ cc x mil}}{\text{m}^2 \text{ x day x atm}}$

PET: $P(O_2) = \dfrac{60 \text{ cc x mil}}{\text{m}^2 \text{ x day x atm}}$

LETHAL RATES (L) $Z = 10°C$ $L = 10^{\frac{T - 121.1}{Z}}$

TEMP °C	.0(.1111)	.2	.4	.6	.8
95	0.002	0.003	0.003	0.003	0.003
96	0.003	0.003	0.003	0.004	0.004
97	0.004	0.004	0.004	0.004	0.005
98	0.005	0.005	0.005	0.006	0.006
99	0.006	0.006	0.007	0.007	0.007
100	0.008	0.008	0.008	0.009	0.009
101	0.010	0.010	0.011	0.011	0.012
102	0.012	0.013	0.013	0.014	0.015
103	0.015	0.016	0.017	0.018	0.019
104	0.019	0.020	0.021	0.022	0.023
105	0.024	0.026	0.027	0.028	0.029
106	0.031	0.032	0.034	0.035	0.037
107	0.039	0.041	0.043	0.045	0.047
108	0.049	0.051	0.054	0.056	0.059
109	0.062	0.064	0.067	0.071	0.074
110	0.077	0.081	0.085	0.089	0.093
111	0.097 (0.100)	0.102	0.107	0.112	0.117
112	0.123	0.128	0.135	0.141	0.148
113	0.154	0.162	0.169	0.177	0.186
114	0.194	0.204	0.213	0.223	0.234
115	0.245	0.256	0.268	0.281	0.294
116	0.308	0.323	0.339	0.354	0.371
117	0.388	0.406	0.425	0.446	0.467
118	0.489	0.512	0.536	0.561	0.587
119	0.615	0.644	0.674	0.706	0.739
120	0.774	0.811	0.849	0.889	0.931

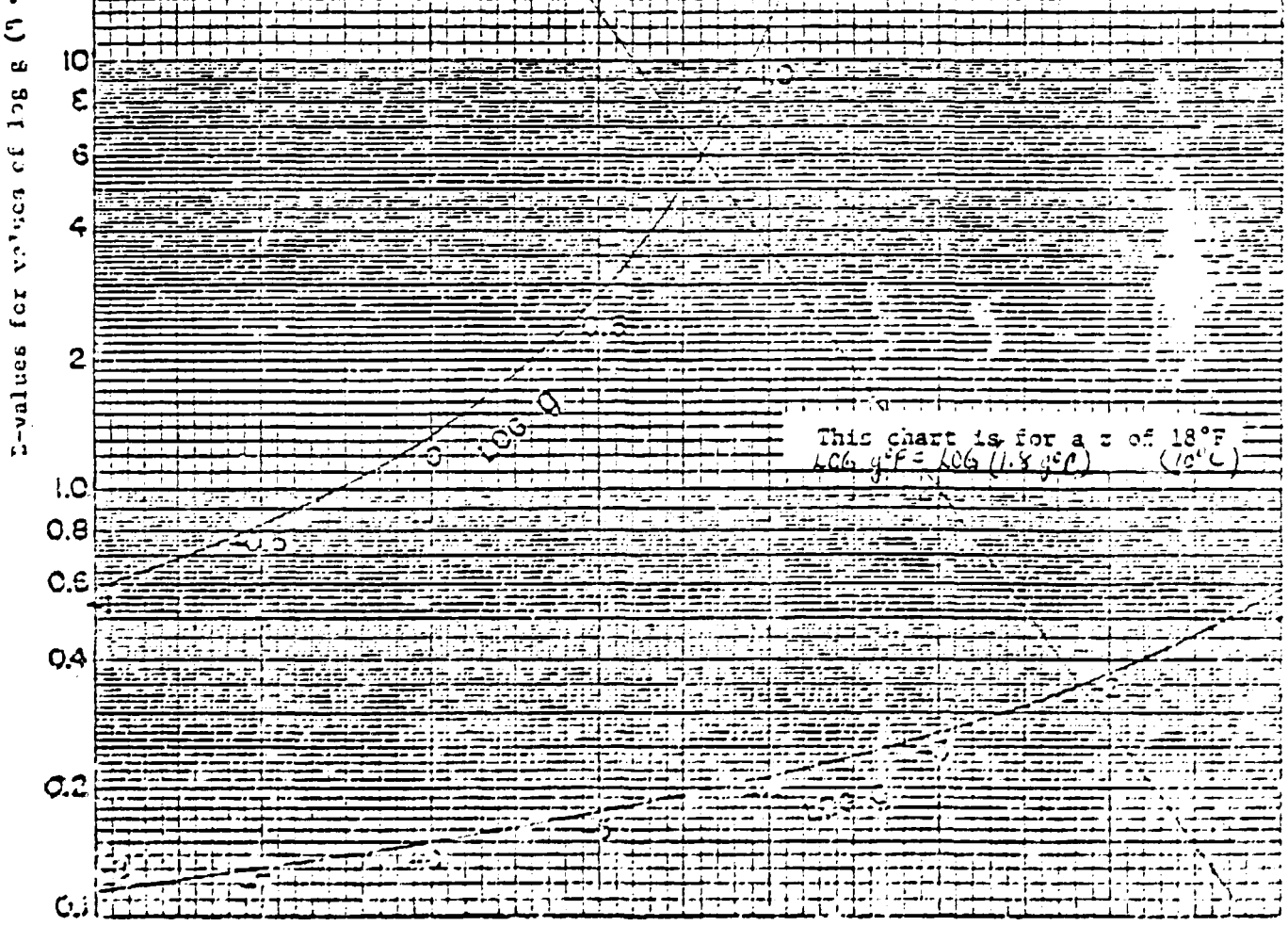
TEMP °C	.0(.1111)	.2	.4	.6	.8
121	0.975 (1.000)	1.021	1.069	1.119	1.172
122	1.227	1.285	1.346	1.409	1.475
123	1.545	1.618	1.694	1.774	1.857
124	1.945	2.037	2.132	2.223	2.338
125	2.448	2.564	2.685	2.811	2.944
126	3.082	3.228	3.380	3.539	3.706
127	3.881	4.063	4.255	4.455	4.665
128	4.885	5.116	5.357	5.609	5.873
129	6.150	6.440	6.744	7.061	7.394
130	7.743	8.108	8.490	8.890	9.309
131	9.747 (10.000)	10.207	10.688	11.192	11.719
132	12.271	12.850	13.455	14.089	14.753
133	15.449	16.177	16.939	17.737	18.573
134	19.449	20.365	21.325	22.330	23.382
135	24.484	25.638	26.847	28.112	29.437
136	30.824	32.277	33.798	35.391	37.059
137	38.805	40.634	42.549	44.554	46.654
138	48.853	51.155	53.566	56.090	58.734
139	61.502	64.400	67.436	70.614	73.942
140	77.426	81.075	84.896	88.897	93.087
141	97.474 (100.0)	102.068	106.878	111.915	117.190
142	122.713	128.496	134.552	140.893	147.533
143	154.486	161.767	169.390	177.374	185.733
144	194.486	203.652	213.250	223.300	233.824
145	244.844	256.383	268.466	281.118	294.367

PROCESS CALCULATION

Simple Heating Curve, Determination of F

Product_____ Container size_____ Date_____

Line Number	Variable	Tabulation
1.	j	
2.	f_h	
3.	t_B	
4.	RT (T_1)	
5.	IT (T_o)	
6.	I = RT - IT =	
7.	(jI) = j x I = RT - $(IT)_1$	
8.	log jI	
9.	log "g" = log jI - $\frac{t_B}{f_h}$	
10.		
11.		
12.	F =	


E-values for values of log g (
10
8
6
4
2
1.0
0.8
0.6
0.4
0.2
0.1
This chart is for a z of 18°F
Δlog g°F = Δlog (1.8 g°C)
(10°C)

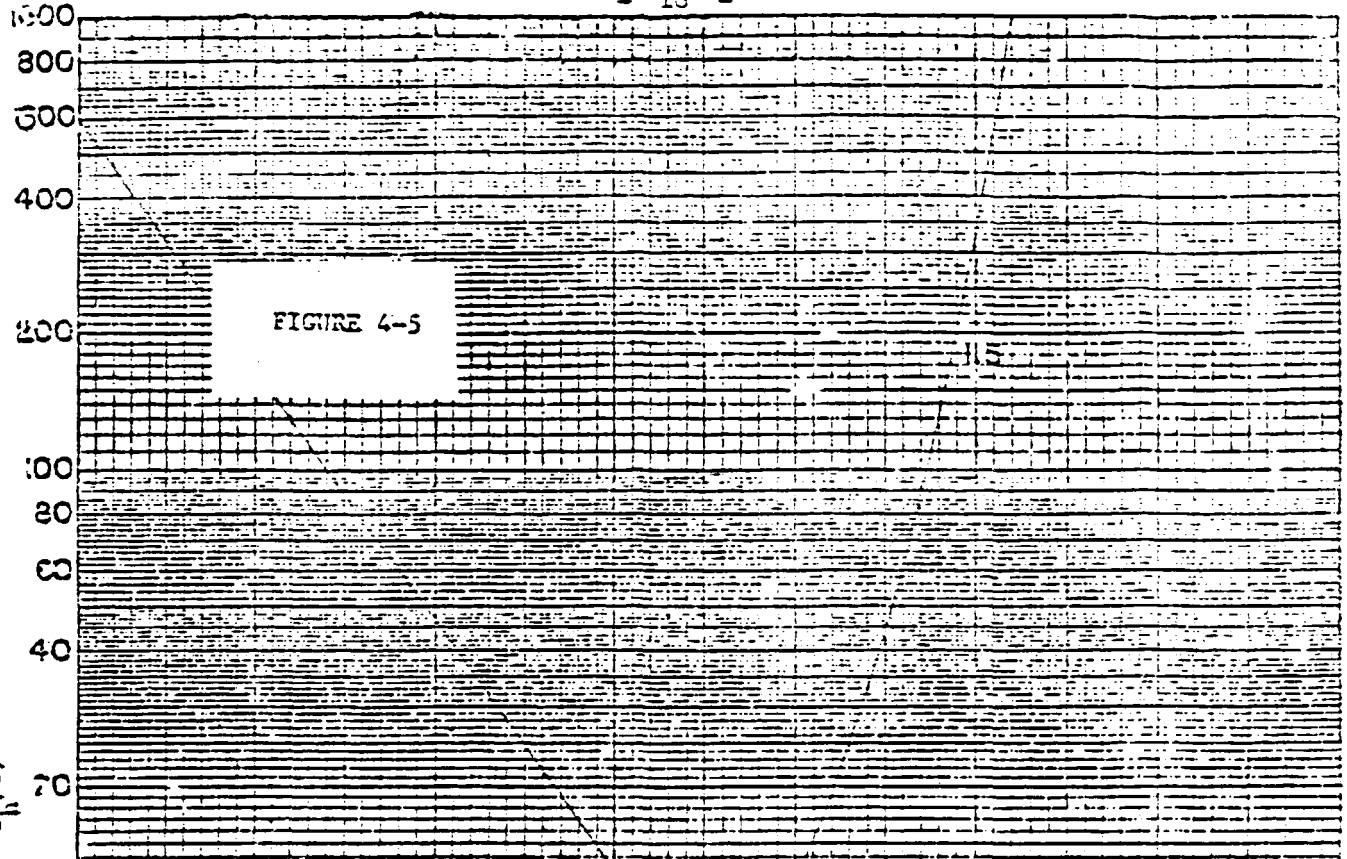

1000
800
600
400
200
100
80
60
40
20
FIGURE 4-5
115

TABLE 12.2. VALUES OF g FOR DIFFERENT VALUES OF $\frac{f}{U}$ AND z (*Continued*)

SECTION 2. PART 1

$m + g = 180 \quad z = 26$ to $z = 16$

$\frac{f}{U}$	g (z = 26)	$\frac{\Delta f}{U}$	Δ_g	g (z = 24)	$\frac{\Delta f}{U}$	Δ_g	g (z = 22)	$\frac{\Delta f}{U}$	Δ_g	g (z = 20)	$\frac{\Delta f}{U}$	Δ_g	g (z = 18)	$\frac{\Delta f}{U}$	Δ_g	g (z = 16)	$\frac{\Delta f}{U}$	$\frac{f}{U}$
0.52	0.100	26					...			...			...			...	...	0.52
0.55	0.126	45	115	0.1152	108	110	0.1032	304	103	0.0929	220		...			...	...	0.55
0.60	0.171	55	163	0.1550	[illegible]	154	[illegible]	316	147	0.1219	[illegible]	158	0.1111	344	128	0.0953	293	0.60
0.65	0.226	66	212	0.2018	[illegible]	236	0.1842	[illegible]	198	0.1644	406	199	0.1155	407	177	0.1276	348	0.65
0.70	0.291		275	0.2632		267	0.2308		258	0.2110		212	0.1562		238	0.1624		0.70
		75			655			612			540			472			400	
0.75	0.366	84	34	0.332	75	34	0.298	68	33	0.265	60	31	0.234	[illegible]	31	0.203	45	0.75
0.80	0.450	91	42	0.408	81	42	0.366	[illegible]	41	0.325	[illegible]	35	0.286	56	35	0.248	49	0.80
0.85	0.541	97	52	0.469	87	50	0.425	[illegible]	49	0.370	65	45	0.342	60	45	0.297	[illegible]	0.85
0.90	0.638	101	62	0.576	91	60	0.516	81	58	0.458	72	56	0.402	64	52	0.349	55	0.90
0.95	0.739		72	0.667		70	0.597		67	0.530		64	0.466		62	0.404		0.95
		104			94			85			75			66			55	
1.00	0.843	[illegible]	82	0.761	108	79	0.682	448	77	0.605	300	73	0.532	352	70	0.462	306	1.00
1.25	1.391	[illegible]	132	1.259	515	129	1.130	464	125	1.005	414	121	0.884	366	116	0.768	320	1.25
1.50	1.959	571	185	1.774	517	180	1.594	465	175	1.419	416	169	1.250	369	162	1.088	324	1.50
1.75	2.530	564	229	2.201	514	232	2.059	464	224	1.825	415	216	1.619	365	207	1.412	322	1.75
2.00	3.094		[illegible]	2.805		282	2.523		273	2.250		263	1.987		253	1.734		2.00
		518			499			452			405			359			315	
2.25	3.642	531	338	3.304	455	329	2.975	440	320	2.655	[illegible]	309	2.346	352	297	2.049	308	2.25
2.50	4.172	512	384	3.789	460	374	3.415	425	364	3.051	381	[illegible]	2.695	339	311	2.357	295	2.50
2.75	4.685	490	427	4.258	449	415	3.840	409	408	3.432	370	395	3.037	329	352	2.685	257	2.75
3.00	5.175	468	468	4.707	429	458	4.249	390	447	3.802	351	436	3.366	313	424	2.942	270	3.00
3.25	5.643		507	5.136		497	4.639		486	4.153		474	3.679		461	3.218		3.25
		447			410			377			335			300			265	
3.50	6.09	43	544	5.546	397	535	5.011	364	523	4.488	329	509	3.979	292	496	3.483	256	3.50
3.75	6.52	41	577	5.943	375	568	5.375	340	556	4.817	307	546	4.271	276	532	3.739	246	3.75
4.00	6.93	76	612	6.318	697	603	5.715	636	591	5.124	574	577	4.547	511	562	3.985	448	4.00
4.50	7.69	67	675	7.015	632	664	6.351	573	653	5.698	516	640	5.058	461	625	4.433	407	4.50
5.00	8.38		733	7.647		723	6.924		710	6.214		695	5.519		679	4.840		5.00
		65			593			536			486			431			380	
5.50	9.03	60	79	8.24	56	78	7.45	51	76	6.70	46	75	5.95	41	73	5.22	36	5.50
6.00	9.63	57	83	8.50	52	83	7.97	48	81	7.16	43	80	6.38	38	78	5.55	33	6.00
6.50	10.20	55	88	9.32	50	87	8.45	45	86	7.59	40	85	6.74	36	83	5.91	32	6.50
7.00	10.75	53	93	9.82	48	92	8.90	43	91	7.99	39	89	7.10	35	87	6.23	31	7.00
7.50	11.28		98	10.30		97	9.33		95	8.38		93	7.45		91	6.54		7.50
		50			46			43			39			34			29	
8.00	11.78	66	102	10.76	95	100	9.76	50	99	8.77	[illegible]	98	7.79	65	96	6.83	59	8.00
9.00	12.74	[illegible]	110	11.64	80	108	10.56	[illegible]	107	9.49	[illegible]	105	8.44	60	103	7.41	53	9.00
10.00	13.60	155	116	12.44	160	115	11.29	154	113	10.16	139	112	9.01	122	110	7.94	108	10.00
12.50	15.45	130	132	14.13	137	130	12.53	124	129	11.54	112	127	10.27	100	125	9.02	55	12.50
15.00	16.95		145	15.50		143	14.07		141	12.65		139	11.27		137	9.90		15.00
		132			120			109			98			87			77	
17.50	18.27	[illegible]	157	16.70	110	154	15.16	99	152	13.64	80	150	12.14	80	147	10.67	71	17.50
20.00	19.47	[illegible]	167	17.80	181	165	16.15	168	162	14.53	[illegible]	159	12.94	135	156	11.78	118	20.00
25.00	21.47	[illegible]	183	19.64	155	181	17.63	142	178	16.65	128	176	14.29	114	173	12.56	100	25.00
30.00	23.15	140	198	21.19	126	194	19.25	114	192	17.33	[illegible]	190	15.43	93	187	13.56	52	30.00
35.00	24.55		210	22.45		206	20.39		203	18.36		200	16.26		197	14.39		35.00
		123			115			104			94			84			74	
40.00	25.80	109	220	23.60	102	217	21.43	95	213	19.30	86	210	17.20	77	207	15.13	68	40.00
45.00	26.89	101	227	24.62	92	224	22.38	83	222	20.16	75	219	17.97	67	216	15.81	59	45.00
50.00	27.90	175	236	25.54	165	233	23.21	148	230	20.91	133	227	18.64	119	224	16.40	105	50.00
60.00	29.65	148	251	27.17	137	248	24.69	120	245	22.24	115	241	19.83	103	237	17.46	90	60.00
70.00	31.16		262	28.54		259	25.95		256	23.39		253	20.86		250	18.36		70.00
		121			114			104			94			84			74	
80.00	32.40	110	272	29.68	101	269	26.99	92	266	24.33	83	263	21.70	74	260	19.10	65	80.00
90.00	33.50	102	281	30.69	92	278	27.91	83	275	25.16	74	272	22.44	66	268	19.76	60	90.00
100.00	34.52	411	291	31.61	381	287	28.74	340	284	25.90	317	280	23.10	285	274	20.36	250	100.00
150.00	38.63	290	321	35.42	272	319	32.23	219	316	29.07	[illegible]	312	25.95	202	309	22.56	179	150.00
200.00	41.59		345	38.14		342	34.72		339	31.33		336	27.97		332	24.65		200.00
		230			212			194			170			158			140	
250.00	43.89	191	363	40.26	176	360	36.66	161	357	33.09	146	354	29.55	131	350	26.05	116	250.00
300.00	45.80	165	378	42.02	149	375	38.27	137	372	34.55	124	369	30.86	111	365	27.21	98	300.00
350.00	47.40	140	389	43.51	129	387	39.64	115	385	35.79	108	382	31.97	97	378	28.19	85	350.00
400.00	48.50	240	400	44.80	226	398	40.62	208	395	36.87	189	393	32.94	171	390	29.04	153	400.00
500.00	51.24		416	47.06		415	42.90		411	35.76		411	34.65		405	30.57		500.00

TABLE 12.2. VALUES OF g FOR DIFFERENT VALUES OF $\frac{f}{U}$ AND z (*Continued*)

SECTION 2. PART 2

$m + g = 180$ $z = 16$ to $z = 6$

$\frac{f}{U}$	g ($z = 16$)	$\Delta\frac{f}{U}$	Δ_z	g ($z = 14$)	$\Delta\frac{f}{U}$	Δ_z	g ($z = 12$)	$\Delta\frac{f}{U}$	Δ_z	g ($z = 10$)	$\Delta\frac{f}{U}$	Δ_z	g ($z = 8$)	$\Delta\frac{f}{U}$	Δ_z	g ($z = 6$)	$\Delta\frac{f}{U}$	$\frac{f}{U}$
0.52	......	...	...	......	...	...	......	...	...	......	...	...	......	...	...	......	...	0.52
0.55	......	...	...	......	...	...	......	...	...	......	...	...	......	...	...	......	...	0.55
0.60	0.0983	293	...	......	...	...	......	...	...	......	...	...	......	...	...	......	...	0.60
0.65	0.1275	[illegible]	168	0.1128	250	155	0.0953	...	...	......	...	...	......	...	...	......	...	0.65
0.70	0.1624	342	227	0.1397		215	0.1152	220	201	0.0951	...	...	......	...	...	......	...	0.70
		405			347			292			229							
0.75	0.203	45	256	0.1744	383	270	0.1471	319	251	0.1220	260	238	0.0952	208	218	0.0764	159	0.75
0.80	0.248	49	333	0.2127	407	344	0.1794	[illegible]	313	0.1460	258	290	0.1190	215	267	0.0943	176	0.80
0.85	0.297	52	436	0.2541	451	409	0.2125	[illegible]	377	0.1748	316	330	0.1405	232	306	0.1079	151	0.85
0.90	0.349	55	505	0.2985	473	477	0.2505	384	411	0.2064	335	407	0.1637	265	367	0.1250	206	0.90
0.95	0.404		582	0.3459		547	0.2911	103	512	0.2399		474	0.1925		429	0.1495		0.95
		58			502			429			301			205			224	
1.00	0.462	206	66	0.396	262	62	0.334	220	58	0.276	180	54	0.222	144	50	0.172	111	1.00
1.25	0.768	320	110	0.653	277	104	0.554	232	98	0.456	192	90	0.366	155	87	0.283	115	1.25
1.50	1.088	324	155	0.933	281	147	0.786	240	[illegible]	0.615	200	129	0.519	160	118	0.401	122	1.50
1.75	1.412	322	198	1.214	278	188	1.026	235	[illegible]	0.848	190	169	0.679	159	156	0.523	119	1.75
2.00	1.734		240	1.492		231	1.261		217	1.011		209	0.835		193	0.642		2.00
		315			272			230			191			152			116	
2.25	2.049	308	255	1.764	265	273	1.491	224	256	1.235	185	248	0.987	147	229	0.758	111	2.25
2.50	2.357	298	325	2.029	256	314	1.715	216	295	1.420	177	286	1.134	141	265	0.869	106	2.50
2.75	2.655	287	370	2.285	247	354	1.931	208	334	1.597	169	322	1.275	136	300	0.975	101	2.75
3.00	2.942	276	410	2.532	240	393	2.139	202	373	1.766	164	356	1.410	130	334	1.076	95	3.00
3.25	3.218		446	2.772		431	2.341		411	1.930		390	1.540		365	1.172		3.25
		265			230			195			160			126			92	
3.50	3.483	256	481	3.002	221	456	2.526	189	446	2.080	156	424	1.666	122	402	1.264	88	3.50
3.75	3.739	246	516	3.223	216	495	2.725	185	479	2.246	153	458	1.788	119	436	1.352	85	3.75
4.00	3.985	448	546	3.439	385	529	2.910	357	511	2.399	268	492	1.907	211	470	1.437	156	4.00
4.50	4.433	407	609	3.824	355	587	3.237	300	570	2.667	247	549	2.118	194	525	1.593	143	4.50
5.00	4.840		661	4.179		642	3.537		623	2.914		602	2.312		576	1.736		5.00
		350			328			250			230			180			133	
5.50	5.22	36	713	4.507	305	691	3.816	263	672	3.144	215	652	2.492	160	623	1.869	124	5.50
6.00	5.58	33	768	4.812	288	747	4.065	247	706	3.409	203	695	2.661	163	668	1.993	117	6.00
6.50	5.91	32	810	5.100	276	783	4.317	[illegible]	755	3.562	190	741	2.821	153	711	2.110	111	6.50
7.00	6.23	31	854	5.376	266	816	4.560	221	805	3.755	186	751	2.974	146	753	2.221	106	7.00
7.50	6.54		898	5.642		859	4.753		842	3.941		821	3.120		792	2.327		7.50
		29			258			217			179			140			103	
8.00	6.83	58	93	5.90	50	90	5.00	42	88	4.12	33	86	3.26	29	83	2.43	22	8.00
9.00	7.41	53	101	6.40	45	98	5.42	36	95	4.47	32	92	3.55	25	90	2.65	20	9.00
10.00	7.94	108	108	6.95	94	105	5.81	50	102	4.79	66	99	3.80	52	95	2.85	37	10.00
12.50	9.02	88	122	7.80	70	119	6.61	64	116	5.45	52	113	4.32	40	110	3.22	30	12.50
15.00	9.90		134	8.56		131	7.25		128	5.97		125	4.72		120	3.52		15.00
		77			67			57			47			38			28	
17.50	10.67	71	144	9.23	62	141	7.82	53	138	6.44	44	134	5.10	34	130	3.80	25	17.50
20.00	11.38	118	153	9.85	101	150	8.35	55	147	6.99	70	144	5.44	56	139	4.05	43	20.00
25.00	12.56	100	170	10.86	87	166	9.20	74	162	7.58	61	158	6.00	49	152	4.48	36	25.00
30.00	13.56	83	183	11.73	73	179	9.94	63	173	8.19	53	170	6.49	42	165	4.84	30	30.00
35.00	14.39		193	12.46		189	10.57		185	8.72		181	6.91		177	5.14		35.00
		74			64			54			44			33			26	
40.00	15.13	65	203	13.10	58	199	11.11	48	195	9.16	40	190	7.26	31	186	5.40	23	40.00
45.00	15.81	59	213	13.65	52	209	11.59	45	203	9.58	37	199	7.57	30	194	5.63	22	45.00
50.00	16.40	106	220	14.20	93	216	12.04	80	211	9.93	66	206	7.87	52	202	5.85	39	50.00
60.00	17.46	90	233	15.13	77	229	12.84	64	225	10.53	52	220	8.39	41	215	6.24	30	60.00
70.00	18.36		246	15.90		242	13.48		237	11.11		231	8.80		226	6.54		70.00
		74			64			54			45			35			25	
80.00	19.10	66	256	16.54	58	252	14.02	50	246	11.56	40	241	9.15	31	236	6.79	22	80.00
90.00	19.76	60	264	17.12	51	260	14.52	40	256	11.96	35	250	9.48	29	245	7.01	20	90.00
100.00	20.36	250	270	17.66	215	265	14.95	182	261	12.34	150	259	9.75	117	254	7.21	84	100.00
150.00	22.86	179	305	19.81	160	301	16.80	123	296	13.84	110	292	10.92	85	287	8.05	66	150.00
200.00	24.65		328	21.37		321	18.13		319	14.94		314	11.50		309	8.71		200.00
		140			122			104			86			65			49	
250.00	26.05	116	346	22.59	101	342	19.17	86	337	15.60	71	332	12.48	56	329	9.20	41	250.00
300.00	27.21	98	361	23.60	85	357	20.03	72	352	16.51	59	347	13.04	46	343	9.61	34	300.00
350.00	28.19	85	374	24.45	73	370	20.75	62	365	17.10	51	360	13.50	40	355	9.95	28	350.00
400.00	29.04	153	386	25.18	135	381	21.37	116	376	17.81	96	371	13.90	75	367	10.23	53	400.00
500.00	30.57		404	26.53		400	22.53		396	18.57		392	14.65		387	10.78		500.00

COURSE II - ANALYTICAL ASPECTS OF PACKAGING

The course outline for the course on Analytical Aspects of Packaging as prepared in June 1981 is presented below. The course was presented in Mexico City November 2, 1981 through November 31, 1981 and was essentially unchanged.

ANALYTICAL ASPECTS OF PACKAGING

Instructors: Dr. Jack Giacin
Dr. Hugh Lockhart

The areas to be discussed are presented in the following topical outline:

A. Spectrophotometric Methods of Analysis

1. Quantitative analysis by spectrophotometric methods

2. Application of ultraviolet, visible and infrared spectroscopy to packaging problems

3. Atomic absorption spectroscopy

B. Chromatographic Methods of Analysis

1. Theoretical considerations and basic principles of chromatography

   a. High pressure liquid chromatography (HPLC)
   b. Gel permeation chromatography (GPC)
   c. Gas chromatography (GC)
   d. Gas chromatography/mass spectroscopy (GC/MS)

2. Application of chromatographic techniques to packaging problems

   a. Qualitative analysis
   b. Quantative analysis

C. Mass Transport Considerations (Migration and Permeation)

1. Transport considerations of potential migrants into and from barrier packaging materials

   a. Methods of monitoring migration
   b. Selected examples of potential migrants in packaging materials, their analysis and transfer to a product contact phase

2. Mass transport considerations of barrier packaging materials

a. Methods of measuring permeability and derivation of permeability constant and diffusion coefficient
b. Selected examples of determining permeability and diffusion coefficients of packaging materials and the relationship to product shelf life

D. Thermal Methods of Analysis for Characterization of Packaging Materials

1. Differential scanning calorimetry

2. Thermal gravimetric analysis

TENTATIVE LECTURE OUTLINE

A. Fundamentals of Spectrophotometric Methods of Analysis

1. Quantitative analysis by spectrophotometric methods
2. Application of ultraviolet (UV) and visible spectroscopy to packaging problems
3. Atomic absorption spectroscopy applications in packaging

B. Use of Infrared Spectroscopy for Characterization of Packaging Materials

Part 1
1. Theoretical considerations
2. Functional group absorption
3. Spectra interpretation

Part 2
1. Sample handling and preparation
2. Principles and application of attenuated total reflectance (ATR)
3. Application of infrared spectroscopy to packaging problems
4. Laboratory demonstration and assigned laboratory exercise, related to infrared spectrophotometric methods

C. Chromatographic Methods of Analysis for Packaging (Part I)

1. Theoretical considerations and basic principles of chromatography
2. High pressure liquid chromatography (HPLC)
3. High pressure liquid chromatography/mass spectroscopy
4. Application of HPLC to packaging problems

D. Chromatographic Methods of Analysis (Part II)

1. Gel permeation chromatography (GPC)
2. Application of GPC to packaging problems
3. Laboratory demonstration and assigned laboratory exercise related to characterization of packaging materials by HPLC and GPC

E. Chromatographic Methods for Analysis (Part III)

1. Gas chromatography (GC)

2. Gas chromatography/mass spectroscopy (GC/MS)

3. Application of GC and GC/MS to packaging problems

4. Laboratory demonstration of gas chromatography and assigned laboratory exercise in determination of residual solvents and residual monomer by the thermal distillation technique

F. Transport Properties of Packaging Materials (Part I)

1. Methods of measuring permeability of barrier materials and intact package systems

2. Selected examples of determining permeability and diffusion coefficients of packaging materials and their relationship to product shelf life

3. Laboratory demonstration of permeability cell with GC detection for monitoring the permeability of packaging materials to gases and organic vapors

4. Assigned laboratory exercise in determining barrier properties of commercial packaging materials

G. Thermal Methods of Analysis for the Characterization of Packaging Materials

1. Differential scanning calorimetry (DSC)

2. Thermal gravimetric analysis (TGA)

3. Application of DSC and TGA to packaging problems

H. Specifications

1. Definitions

2. Types

   a. material specifications
   b. performance specifications
   c. packing specifications

3. Communication

4. Contents

5. Testing and quality control

6. Package design and development

The format for the course on Analytical Aspects of Packaging was essentially the same as for the course on food packaging consisting of three to three and one-half hours of lecture in the morning with either laboratory exercises or individual assistance on laboratory equipment or special projects in the afternoon. The attendees consisted mostly of the same group of individuals who are employed at LANFI. Attendees were asked to evaluate the course and instructors as before. The course was given an average of 8.2 out of 10 and individual instructors also received high marks for content, expression, knowledge, organization, explaination, time usage, etc. The course materials prepared are presented in this report as Appendix 5. This document includes descriptions of the laboratory exercises prepared as well as the course notes. The special projects with the exception of the laboratory exercises are discussed in the next section.

SPECIAL PROJECTS

Project team members worked closely with LANFI scientists on special projects or laboratory exercises when not involved in class presentations. These discussions were often conducted in a one-on-one or small group format and included evaluations and recommendations with regard to experimental design and data analysis.

Some of the specific projects which were treated during the food packaging phase are listed below. The specific considerations included kinetics, effect of residual headspace oxygen, processing, moisture and oxygen permeability, and force transmission in composite materials among others.

1. Shelf life of tortillas in various containers
2. Tensile testing of laminates
3. Shelf-life of papaya
4. Oxidative degradation of peanuts in barrier materials
5. Keeping quality of various processed, packaged tomato products

The special projects and specific accomplishments during the laboratory assistance phase of the course on analytical aspects of packaging are summarized below. The summary is followed by a detailed description of these activities

SUMMARY: Laboratory Assistance Phase of the course on Analytical Aspects of Packaging

1. Applications of infrared spectrophotometry

   A. Instruction in methods of identifying functional groups by interpretation of spectra

      1. Sample materials were run and students analyzed four known materials and two unknowns

   B. The Attenuated Total Reflectance accessory was installed and made operational

   C. Personnel were instructed in proper use of the ATR unit for materials that cannot transmit infrared because of thickness

   D. LANFI personnel used the technique to obtain identification spectra on two materials that had been a problem because they did not permit transmission

2. Solution of problems with spectrophotometric analysis of browning reaction

   A. A calibration technique was developed

   B. The most reproducible instrument was identified

   C. Improved methods of analysis were developed

3. Revision of water vapor permeability test methods

   A. The WVTR tests for materials were modified

   B. A WVTR test method for cap liner was written

   C. A WVTR test method for polypropylene bottle was written

   D. A method for using WVTR data to predict shelf life was written

4. Psychrometry/Hygrometry

   A. Theory discussed briefly

   B. Written methods prepared for use of psychrometer to obtain reliable values of relative humidity in conditioned spaces

   C. Written instructions were prepared for determination of partial pressure for water. The use of this value in calculating water vapor permeability was explained.

   D. Suitable equipment for relative humidity measurements was recommended

5. Oxygen/Carbon Dioxide Permeability

   A. Recommendations were made for use of their MOCON equipment

   B. Recommendations were made for testing with humidified gases

6. Chromatographic Analysis

   A. Methods for headspace analysis were practiced by laboratory personnel

   B. The methods of using headspace analysis for determining monomer content of a polymer were demonstrated.

Permeability Measurements (Water Vapor)

A. Water vapor permeability measurement techniques were reviewed with Aida.
Materials - we confirmed that WVTR testing of high barrier materials can be conducted by dish method, and low barrier materials by Permatran W. This will improve accuracy and release the Permatran C for running more samples. We recommended that the number of weighings for gravimetric tests be reduced from fifteen over a two week period to only 3 or 4 over the two week period. This will free a significant amount of time for other work.

B. Cap liner for glass jar to contain Tang type drinks.

Test method was written for gravimetric WVTR test to compare WVTR of two liner orientations. This allowed the test to be conducted without dedicating the Permatran W to a long duration test. It also provided for replications in sufficient number.

C. Polypropylene bottle for 5% Dextrose IV solution.

Two bottles had been submitted by the health ministry for evaluation of WVTR. We reviewed the bottles and the request from the health ministry.

A test method for gravimetric determination of WVTR was written for Aida. We also explained how the data could be used to obtain an estimate of the shelf life, taking into account the WVTR, the concentration as packaged and the maximum concentration allowed.

Techniques for preparing samples - removal of contents, removing solution and drying of container.

D. Psychrometry/Hygrometry

We discussed the partial pressure for water vapor in air at various relative humidities, and showed how the value can be obtained from tables and how the value can be used to obtain permeabilities from WVTR data.
A written procedure was prepared for using a psychrometer to verify (calibrate) the hygrometer in the lab and for using the psychrometer to measure the actual conditions being maintained in each of the walk-in chambers. We recommended a specific psychrometer to make the measurements.

E. Oxygen/Carbon Dioxide Permeability

We reviewed the oxygen and carbon dioxide permeability testing and made the following recommendations:

1. Oxygen permeability testing can be continued with the MOCON Oxtran as it is now being done. However, to obtain humidified oxygen, care must be taken to humidify with salt solutions well separated from the Oxtran.

2. Carbon dixoide can only be tested dry in the Permatran C. If humidified gases must be used, the isostatic cell must be used with chromatographic analysis.

3. We explained, but did not have time to demonstrate, how to use the isostatic cell for these measurements for both oxygen and carbon dioxide permeability using humidified gases.

Infrared Spectrophotometry

The ATR unit was assembled and made operational.
Three signed spectra were provided to Maria Rosa consisting of:

1. Blank of KRS-5 cyrstal

2. ATR spectrum of a LANFI stock roll of polyethylene

3. Transmission spectrum of same LANFI stock roll of polyethylene for comparison with the ATR spectrum

Six spectra analyzed by students were reviewed in class showing applications of IR to identification. Care must be exercised because the IR spectrum may be misleading to the unwary. The six spectra with functional group assignments by Jack Giacin were left for reference purposes.

LANFI personnel ran transmission spectrum for polyethylene, blank for KRS-5 crystal and ATR spectrum. An ATR spectrum on thick wall specimen of polypropylene taken from a bottle they were working with was prepared. This material had been analyzed with the complicated technique of solution to get a thin section for transmission spectrum. The time saving value of ATR was effectively demonstrated.

Techniques for cleaning KRS-5 crystals were demonstrated. Purchase of an ultrasonic cleaner was recommended.

Samples of the walls of coated cans were analyzed on the ATR apparatus. The results were very good. Maria Rosa practiced the technique and became proficient at it. The laboratory now has the capability of doing identification of can coatings without having to remove the coating from the metal. The ATR unit has been made operational, and the IR capability was extended considerably.

Browning Reaction Analysis by Spectrophotometer

The description of the problem indicated that it could be either faulty technique or faulty equipment. Three concentrations of picric acid in alcohol were prepared to give a range of optical density values at a wavelength near that used for browning reactions. The solutions were run in the Spectronic 21 located in the Shelf Life Laboratory and on the Beckman Instrument in the Food Products Laboratory. Optical density versus concentration plots obtained with the Spectronic 21 were not nearly reproducible enough to assure reliable analytic results. Recommendation was made to do all analyses with the Beckman Instrument. Techniques used by the personnel were found to be good.

THREE ENVIRONMENTS

PHYSICAL

SHOCK

VIBRATION

STACKING

CLIMATIC

TEMPERATURE

HUMIDITY

CHEMICAL

HUMAN

HANDLING

READING

EMOTION

EVALUATION

REGULATION

THREE FUNCTIONS OF THE PACKAGE

PROTECTION

PRODUCT FROM ENVIRONMENT

ENVIRONMENT FROM PRODUCT

UTILITY

AIDING IN EASE OF USE

1. CONSUMER
2. USER
3. SUPPLIER

COMMUNICATION

MOTIVATION

TO BUY

TO USE SAFELY

ECONOMICALLY

TESTING

FOR ADHERENCE TO SPECIFICATIONS

- SIMPLE
- RAPID
- INTENDED FOR REPEATED USE
- ECONOMY IS OF PARAMOUNT IMPORTANCE

TO OBTAIN INFORMATION FOR DEVELOPMENT

- MAY BE MORE COMPLEX
- MAY TAKE LONGER TIME
- MAY BE USED ONLY ONCE OR A FEW TIMES
- MAY BE MORE EXPENSIVE

SPECIFICATIONS

PERFORMANCE -- STIPULATES HOW THE PACKAGE SHALL FUNCTION

MATERIAL -- STIPULATES DIMENSIONS, COMPOSITION AND OTHER SPECIFIC REQUIREMENTS FOR THE PACKAGE

CONTINUING COOPERATION

The terms of reference for this project included a request for suggestions and recommendations for cooperative links and continuing cooperation between IMAI and institutions interested in packaging education. The following list presents suggestions for continuing cooperation between the School of Packaging at Michigan State University and LANFI/IMAI.

SUGGESTED PROGRAMS AND MEANS BY WHICH THE SCHOOL OF PACKAGING CAN BE OF ASSISTANCE TO THE MEXICAN PACKAGING RESEARCH INSTITUTE.

1. Some of the Mexican staff members could work on a masters program at MSU doing their course work in East Lansing and their research in Mexico City or East Lansing under the direction of an MSU professor.

2. MSU faculty to advise on research programs in Mexico City. This research could be by students or staff members in Mexico.

3. Staff from the Mexican Institute could spend three or more months at Michigan State University assisting in teaching and research as well as conducting seminars and getting hands-on experience in our laboratory. These people, of course, would be classified as visiting professors or scholars if they have credentials.

4. The Mexican Research Institute could participate in our Intern program. MSU senior students in Mexico could work on existing projects (e.g. shelf life, standardization, etc.).

5. The MSU faculty could help to design and conduct special seminars for special interest groups such as food, pharmaceutical, or other industrial interests. These seminars could be held in Mexico or in the U.S.

6. Our faculty could help in the development of instructional materials of all kinds for the Mexican government.

7. The faculty at MSU could cooperatively design computer programs for the Mexican Institute which are of particular interest to them.

8. Selected graduate students from the MSU program could spend three months or more working cooperatively with the Mexican Research Institute on research or other projects.

9. One or two individuals from the Mexican Research Institute could be made adjunct professors of the School of Packaging so that they could advise and participate in graduate research programs.

10. We could assist the Mexican Institute in developing feasibility studies to determine the need for special seminars for their industry groups or for other special groups.

11. Faculty of the School of Packaging could help identify experts in various areas of the research institute in Mexico.

12. MSU could act as a training center for their packaging people, getting experience in packaging while they learn to speak English.

    a. Summer short courses
    b. Term in residence

13. A follow up program should be designed on the food and analytical methods courses which were taught in Mexico this fall.

14. It is possible that some of our academic year staff would like to spend two or three months in Mexico on various programs in the summer.

15. We could assist the Mexican Research Institute to become a center for packaging expertise in South America.

16. Jointly sponsor undergraduate and graduate students from that part of the world. These students could spend part of their time in Mexico City and part of the time at the School of Packaging at MSU. We could be the degree granting institute and the research and some special instruction could be done in Mexico City.

Dr. Chester J. Mackson, Director of the School of Packaging at MSU, traveled to Mexico City for the week of December 5, 1981 through December 12, 1981. The purpose of this trip was to discuss the relative merits of the various suggestions for continuing cooperation. A number of meetings and discussions were held involving Dr. Mackson and Srs. Luis Madi, Francisco Munoz, and Juan A. Careaga, Director General of LANFI. It was clear from these discussions that continued cooperation between MSU and LANFI would be beneficial to both parties.

Specific recommendations for further cooperation which were considered to be among the most highly desirable are discussed below.

1. Courses to be offered in Mexico City

   The desirability of additional courses prepared by members of the faculty of the School of Packaging of MSU and presented in Mexico City was agreed to by all parties. The general nature of these possible courses was discussed. Two of these courses would be follow up courses based on the courses (Food Packaging and Analytical Aspects of Packaging) presented this fall. A course presenting

packaging principles as they relate to food distribution systems was also suggested. A tentative timetable for these courses was also discussed.

2. Graduate credit

It was agreed that it would be very beneficial for some of the LANFI employees to pursue a Masters degree in Packaging. Several specific possibilities for implementation of this approach were discussed.

a. The courses above could be designed to include earning credits toward the M.S. degree. One format would be to offer the above courses for two credits and to offer one hour of lecture and one laboratory per day for a two week period.

b. Special problems courses for credit could be designed so that students could conduct research and prepare reports based on project work in Mexico City.

c. Students could enroll for credit in courses offered by the School of Packaging in East Lansing. A number of courses offered in the Life Long Education program for periods of three days to two weeks would be very appropriate. This option has the additional advantage that it would provide the opportunity for interaction with the representatives of various U.S. based corporations that normally attend these courses.

RECOMMENDATIONS AND CONCLUSIONS

Written and oral evaluations of the work performed by members of the faculty of the School of Packaging of Michigan State University under UNIDO Contract #80/157 (Qualitative and Quantitative Improvement of the Training Courses on Packaging Material Production and Food Packaging Technologies) indicate that all expectations were met or exceeded. All duties to be performed were described by the request for proposal (P.81/1, Project DP/MEX/78/011), the Michigan State University response, and clarifications by LANFI personnel. These duties have been performed effectively and were well received.

The major tasks performed in compliance with these agreements were:

1. A visit to Mexico City for the purpose of appraisal of national conditions for implementation of the proposal.

2. Design of two courses for presentation in Mexico City. The two courses were titled, "Food Packaging", and "Analytical Aspects of Packaging".

3. Preparation of modular material for use in presentation of the courses in Mexico City.

4. Presentation of the courses in Mexico City.

5. Laboratory assistance in equipment utilization and special projects.

6. A visit to Mexico City for the purpose of discussion of possible modes of continuing cooperation.

The staff at LANFI consists of a number of technically qualified and enthusiastic individuals who are becoming knowledgeable in packaging. It is essential that these individuals actively and energetically pursue continued professional growth in technical aspects of packaging if LANFI is to realize its potential in providing assistance to industry in Mexico.

It is recommended that continued assistance be provided through the use of long term consultants, short term involvement of consulting teams, and continued interaction with packaging institutions interested in education. Some specific possibilities for continuing cooperation with the School of Packaging at Michigan State University are presented in the preceding section of this report.