



**Weyerhaeuser**

# **FIRE TECHNOLOGY LABORATORY**

P.O. BOX 188 LAB B  
LONGVIEW, WA 98632

Report on:

## **LC<sub>50</sub> VALUES OF WOOD PRODUCTS USING THE UNIVERSITY OF PITTSBURGH TOXICITY TEST APPARATUS**

Conducted on:

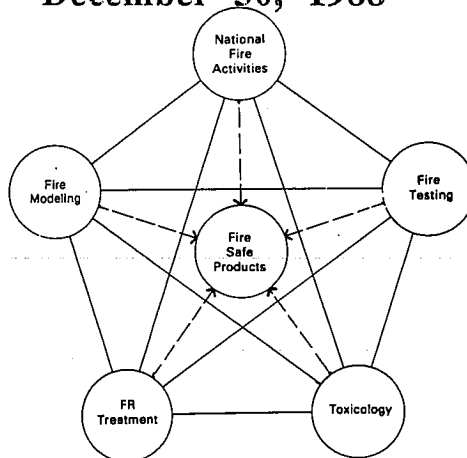
### **EIGHTEEN WOOD PRODUCTS**

Conducted for:

**ROBERT W. GLOWINSKI  
NATIONAL FOREST PRODUCTS  
ASSOCIATION  
1250 CONNECTICUT AVENUE  
WASHINGTON, DC 20036**

Completed on:

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## **NOTICE**

This test method is intended to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or the fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.

## INTRODUCTION

Wood products were received from various members of National Forest Products Association for testing. The toxic potency values or LC<sub>50</sub> values for these wood products were determined using the University of Pittsburgh (UPITT) test procedure as described in Article 15 Part of the *New York State Uniform Fire Prevention and Building Code* [1].

This report includes dimensions of the wood products, test methodology, and the test results.

## METHOD

The protocol used is published under Article 15 of the *New York State Uniform Fire Prevention and Building Code* [1]. The LC<sub>50</sub> values and their confidence intervals were calculated by the Weil method [2].

The UPITT apparatus consisted of a Lindberg furnace (Pittsburgh, PA) connected to an animal exposure chamber. Within the furnace there was a weight load cell upon which the specimen was placed. There was an air flow of eleven (11) liters/minute proceeding from the furnace toward the animal exposure chamber. That air flow was mixed, cooled and diluted with nine (9) liters/minute of cold air (~15°C) before being presented to the animals. The furnace temperature was ramped 20° C/minute. The furnace, however, was not connected to the animals exposure chamber until the specimen had loss 1% of its weight as indicated by the weight load cell. The time at which this occurred was the beginning of the thirty (30)-minute animal exposure. The animal exposure chamber simultaneously housed four (4) male Swiss-Webster mice (Simenon Laboratories, Inc.; Gilroy, CA) in a head-only exposure mode. The decomposition products passed to gas analyzers (carbon monoxide, carbon dioxide and oxygen) after being presented to the animals. The apparatus and protocol were according to the methodology of New York State Protocol [1].

Procedurally, a ten (10)-gram quantity of the material was placed in the furnace after which the ramping of the furnace started. At the 1% weight loss, the animal exposure chamber was connected to the furnace. After the thirty (30)-minute exposure was completed, the animals were observed for an additional ten (10) minutes. Any deaths occurring during these forty (40) minutes were used in the determination of the LC<sub>50</sub> value. If all the animals died with the ten (10) grams, the next experiment would be with a lower weight. If no animals died, then a higher weight would be used in the next experiment.

That next weight would be determined by a geometric factor. The geometric factor was necessary because of the statistical procedure [2] used for determining the LC<sub>50</sub> values. This factor (for example, 1.1) would be multiplied by the weight to determine the next higher weight, or the weight would be divided by the factor to determine the next lower weight. Using this statistical procedure, four consequent weights (spaced by the geometric factor along with the corresponding deaths as required by the tables supplied in the reference) were needed to determine an LC<sub>50</sub> value.

A program was written for a Macintosh® Plus Computer in conjunction with a Fluke 2400A (A/D and D/A measurement and control link) to specifically operate this apparatus. Ramping of the furnace was accomplished by the Macintosh® monitoring the

furnace temperature and varying the power supply to the furnace. The specimen weight, the percent of weight loss, concentrations of carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>) and oxygen (O<sub>2</sub>), time (from the initiation of ramping and from the 1% weight loss), temperatures of the furnace and chamber, and the difference between the actual and theoretical furnace temperatures were displayed on the computer monitor during the experiment as well as recorded on a diskette. The O<sub>2</sub> gas analyzer was a Servomex O<sub>2</sub> Analyzer OA 580 (Sybron/Taylor), and the CO/CO<sub>2</sub> analyzer was a Dual Gas Analyzer (Infrared Industries, Inc.)

In order to confirm that there were no leaks in the system and that the pump, air flow and flowmeters were operating properly, the flow rates of nine (9) and twenty (20) liters/minutes were tested prior to each test with a Mini-Buck Calibrator (A.P. Buck, Inc., Orlando, FL). This flowmeter is traceable to the National Institute of Standards and Technology (formerly National Bureau of Standards). Calibration of the CO and CO<sub>2</sub> analyzers was performed with calibration gases (CO - 0.9% and CO<sub>2</sub> - 5%) certified by Alphagaz Division (Tacoma, WA). The O<sub>2</sub> analyzer was calibrated with room air.

## TEST RESULTS

The LC<sub>50</sub> values and their confidence intervals are presented in Table 1. A number of parameters are reported in summary tables (Table 2-19), such as the minimum oxygen concentration, the maximum carbon monoxide and carbon dioxide concentrations, the maximum animal exposure chamber temperature, the maximum furnace temperature, and the percentage of the specimen weight. Tabulation of the data required by New York State is included (Table 20). These data are from a specimen weight close to the LC<sub>50</sub> value. The concentration-time (Ct) products for carbon monoxide (Figures 1-18) and carbon dioxide (Figures 19-36) plotted vs the specimen weight are presented for each of the eighteen products. [This Ct product is a value calculated by multiplying the gas concentration, such as carbon monoxide, with the time of animal exposure to the gas concentration. In other words, it is the area under the curve of the gas concentrations vs time.]

## REFERENCES

1. Article 15, Part 1120 -- New York State Fire Prevention and Building Code. New York Standards & Fire Information Network, Office of Fire Prevention and Control. Albany, NY.
2. Weil, C.S., Tables For Convenient Calculation Of Median-Effective Dose (LC<sub>50</sub> or ED<sub>50</sub>) And Instructions In Their Use. *Biometrics* 8: 249-263, 1952.

## SAMPLE PREPARATION

These wood products were stored in a conditioning room ( $23.8 \pm 2.8^{\circ}$  C and  $50 \pm 10\%$  Relative Humidity) for at least 48 hours prior to testing. Each specimen placed in the furnace was a piece of a wood product cut to a specific weight.



### WOOD PRODUCT DIMENISONS

Wood Product	Length (inch)	Width (inch)	Thickness (inch)
Douglas Fir	37	7.1	1.50
Redwood	16.3	7.3	0.76
Southern Pine	>72	3.4	1.48
White Spruce	>72	3.5	1.50
Red Oak	~36	7.8	0.79
Yellow Poplar	~36	8.1	0.82
Douglas Fir Plywood	45.8	24	0.60
Southern Pine Plywood	46	24	0.60
Oriented Strandboard	48	24	0.46
Waferboard	48	24	0.43
Standard Hardboard	48	48	0.25
Tempered Hardboard	48	48	0.25
Fiberboard	24	24	0.75
Particleboard	24	24	0.76
Lauan Plywood	96	16	0.15
CCA-treated Southern Pine	24	3.5	1.47
AZCA-treated Douglas Fir	11.8	7.4	1.47
Fire Retardant-treated Southern Pine	23.8	3.5	1.50

Table 1: LC<sub>50</sub> Values and their Confidence Intervals

Wood Product	LC50 Value	95% Confidence Interval	
	(grams)	Lower Value	High Value
<i>Douglas Fir</i>	25.38	22.60	28.50
<i>Redwood</i>	7.68	6.61	8.93
<i>Southern Pine</i>	12.39	10.70	14.35
<i>White Spruce</i>	7.47	6.53	8.54
<i>Red Oak</i>	15.75	11.12	22.31
<i>Yellow Poplar</i>	11.07	9.90	12.38
<i>Douglas Fir Plywood</i>	11.83	10.59	13.20
<i>Southern Pine Plywood</i>	11.64	9.30	14.56
<i>Oriented Strandboard</i>	12.40	9.95	15.45
<i>Waferboard</i>	13.64	9.63	19.31
<i>Standard Hardboard</i>	8.16	6.59	10.11
<i>Tempered Hardboard</i>	8.04	6.99	9.24
<i>Fiberboard</i>	10.11	7.25	14.10
<i>Particleboard</i>	8.94	7.70	10.37
<i>Lauan Plywood</i>	20.95	17.68	24.82
<i>CCA-treated Southern Pine</i>	24.16	20.30	28.76
<i>AZCA-treated Douglas Fir</i>	11.28	10.04	12.66
<i>Fire Retardant-treated Southern Pine</i>	15.74	14.71	16.83

## SUMMARY TABLES

Table 2: Douglas Fir

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5
Specimen Weight (grams)	30.69	27.92	25.38	23.07	20.97
Maximum Chamber Temperature (°C)	51.5	45.4	51.3	48.9	51.3
Maximum Furnace Temperature (°C)	791.9	823.0	834.2	827.2	829.5
Weight Loss (%)	80.45	73.07	87.16	71.65	69.43
Minimum Oxygen Concentration (%)	20.8	20.87	20.88	20.84	19.92
Maximum CO Concentration (ppm)	11518	11135	11567	8466	8495
Maximum CO2 Concentration (ppm)	59862	49012	49500	46960	41486
Number of Animals Exposed	4	4	4	4	4
Number of Dead Animals	4	2	3	1	0
Lethality (%)	100	50	75	25	0
Ct Product for CO (ppm x min)	36351	34783	33325	19953	22526
Ct Product for CO2 (ppm x min)	558741	456663	448379	442884	345227
TI% (°C)	199	233	245	232	236

Table 3: Redwood

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	Test 11
Specimen Weight (grams)	14.32	13.02	13.02	11.84	10.76	9.77	8.88	8.07	7.33	6.66	6.66
Maximum Chamber Temperature (°C)	44	47.7	48.5	48	45	47.1	45.2	46.6	48.7	43.5	45.5
Maximum Furnace Temperature (°C)	826	816.6	830.7	832.4	864.8	831.9	823.6	829.5	837.7	833	836.6
Weight Loss (%)	86.5	79.5	92.2	85.1	82.4	not reliable	94.8	70.5	not reliable	not reliable	not reliable
Minimum Oxygen Concentration (%)	18.24	19.21	18.43	19.43	19.5	19.47	19.91	19.79	19.91	19.94	20.09
Maximum CO Concentration (ppm)	10860	9604	9997	8613	8809	7799	6337	6023	5090	5081	4963
Maximum CO2 Concentration (ppm)	18028	7863	17442	6788	6104	6837	5983	5908	5469	5713	5908
Number of Animals Exposed	4	4	4	4	4	4	4	4	4	4	4
Number of Dead Animals	3	4	4	4	3	4	3	3	1	3	1
Lethality (%)	75	100	100	100	75	100	75	75	25	75	25
CI Product for CO (ppm x min)	63960	69789	55983	65394	65315	55178	48767	44512	42000	38213	38593
CI Product for CO2 (ppm x min)	173619	154945	165693	129898	118521	103332	104647	97096	95120	82177	84225
TI% (°C)	231	225	234	237	274	235	231	237	244	237	244

Table 4: Southern Pine

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10
Specimen Weight (grams)	10.00	7.00	8.47	7.70	6.36	12.38	18.16	21.96	26.58	8.06
Maximum Chamber Temperature (°C)	46.0	49.0	44.8	46.0	45.7	44.4	42.9	44.9	37.7	38.0
Maximum Furnace Temperature (°C)	801.3	799.9	798.1	797	798.3	796.1	798.5	797.4	799.1	795.1
Weight Loss (%)	85	87	84	89.5	86	89.4	87.1	84.6	85	85.3
Minimum Oxygen Concentration (%)	17.97	20.09	18.16	19.93	20.11	17.57	17.06	16.09	16.1	18.11
Maximum CO Concentration (ppm)	7385	4759	6682	4624	3638	7185	11021	11276	10397	6176
Maximum CO2 Concentration (ppm)	21065	3993	12787	4733	4174	22014	26137	29662	39548	9567
Number of Animals Exposed	0	4	4	4	4	4	4	4	4	4
Number of Dead Animals	-	1	1	3	0	0	3	1	0	1
Lethality (%)	-	25	25	75	0	0	75	25	0	25
Ct Product for CO (ppm x min)	23343	29256	24398	29885	24447	21638	32059	28811	29201	26782
Ct Product for CO2 (ppm x min)	112837	59834	77072	69141	59388	132588	188749	127918	228286	68553
T1% (°C)	198	196	196	196	196	196	196	196	196	196

Test Sequence	Test 11	Test 12	Test 15	Test 16	Test 17	Test 18	Test 19	Test 20	Test 21	Test 22
Specimen Weight (grams)	7.34	6.67	32.16	38.92	10.24	26.58	29.24	24.17	12.40	9.32
Maximum Chamber Temperature (°C)	44.1	42.8	42.8	44.3	45.1	47.2	42.1	49.2	44.7	47.5
Maximum Furnace Temperature (°C)	798.3	796.3	797.2	796.8	800.7	797.9	795.2	799.4	818.1	800.4
Weight Loss (%)	89.9	88	84.3	82.9	89.2	10.5?	84.1	85.5	88.6	92.1
Minimum Oxygen Concentration (%)	19.91	20.24	14.69	6.48?	16.69	12.38	12.28	13.82	16.92	19.53
Maximum CO Concentration (ppm)	5369	4457	12433	14169	9911	13075	17010	15178	11790	8969
Maximum CO2 Concentration (ppm)	4527	3805	52773	80422	30565	74970	45455	35011	25364	7129
Number of Animals Exposed	4	4	4	4	4	4	4	4	4	4
Number of Dead Animals	2	0	3	1	0	3	3	4	2	2
Lethality (%)	50	0	75	25	0	75	75	100	50	50
Ct Product for CO (ppm x min)	32411	27750	36514	49383	31826	26333	46445	41556	29559	49560
Ct Product for CO2 (ppm x min)	67735	55802	373716	500558	148344	415552	340636	299702	152076	105848
T1% (°C)	196	196	196	196	196	196	196	196	196	196

Test Sequence	Test 23	Test 24	Test 25	Test 26	Test 27
Specimen Weight (grams)	15.01	16.51	13.64	11.27	13.64
Maximum Chamber Temperature (°C)	46.9	47.0	42.2	49.3	48.0
Maximum Furnace Temperature (°C)	797.6	798.7	798.8	804.3	810.5
Weight Loss (%)	87.4	86.2	83.9	87.5	88.8
Minimum Oxygen Concentration (%)	15.46	16.51	16.88	17.81	17.42
Maximum CO Concentration (ppm)	15693	14401	14717	11430	13696
Maximum CO2 Concentration (ppm)	27996	29751	25984	20244	23836
Number of Animals Exposed	4	4	4	4	4
Number of Dead Animals	4	1	0	3	2
Lethality (%)	100	25	0	75	50
Ct Product for CO (ppm x min)	48038	42740	46023	38885	49380
Ct Product for CO2 (ppm x min)	163313	222782	176999	121687	166137
T1% (°C)	196	196	196	196	196

Table 5: White Spruce

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
Specimen Weight (grams)	10.00	7.00	8.47	7.70	10.24	5.79
Maximum Chamber Temperature (°C)	49.2	46.8	48.8	48.9	44.2	42.0
Maximum Furnace Temperature (°C)	773.9	775.4	774.5	773.7	771	773.2
Weight Loss (%)	94.5	94	93.6	89.1	91.3	91
Minimum Oxygen Concentration (%)	19.35	19.92	19.54	19.88	19.32	20.51
Maximum CO Concentration (ppm)	8226	5349	7366	5426	9324	4254
Maximum CO2 Concentration (ppm)	7929	5257	6663	5869	7992	5349
Number of Animals Exposed	0	4	4	4	4	4
Number of Dead Animals	-	1	4	0	3	0
Lethality (%)	-	25	100	0	75	0
Ct Product for CO (ppm x min)	46020	30804	38637	31298	46882	26128
Ct Product for CO2 (ppm x min)	115758	75571	90018	78318	108793	65658
TI% (°C)	172	172	172	172	172	172

Table 6: Red Oak

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7
Specimen Weight (grams)	25.40	23.08	20.98	19.07	17.34	15.76	14.32
Maximum Chamber Temperature (°C)	43.7	48.7	47.8	47.7	44.7	47.7	47.5
Maximum Furnace Temperature (°C)	730.8	829.5	833.0	827.2	803.6	833.0	811.9
Weight Loss (%)	83.03	70.02	86.7	92.61	82.64	4.12*	68.51
Minimum Oxygen Concentration (%)	13.89	19.89	20.98	14.62	14.72	14.79	15.64
Maximum CO Concentration (ppm)	10222	12587	10821	12077	8142	13127	12705
Maximum CO2 Concentration (ppm)	57711	54193	52922	49696	51602	46178	40460
Number of Animals Exposed	4	4	4	4	4	4	4
Number of Dead Animals	4	3	3	4	1	2	3
Lethality (%)	100	75	75	100	25	50	75
Ct Product for CO (ppm x min)	34796	41656	34881	38284	26807	30731	42812
Ct Product for CO2 (ppm x min)	341668	335828	329666	285181	288667	233861	198355
TI% (°C)	129	238	244	235	207	241	221



Table 7: Yellow Poplar

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
Specimen Weight (grams)	19.05	17.32	15.75	14.32	13.02	11.83	10.74	9.76	9.75
Maximum Chamber Temperature (°C)	42.3	43.9	50.6	42.7	45.3	47.8	47.3	45.9	47.8
Maximum Furnace Temperature (°C)	817.8	857.7	814.2	810.7	822.5	823.6	830.7	822.5	826
Weight Loss (%)	80.1	not reliable	93.5	85.2	not reliable	81.2	87.5	81.4	80.0
Minimum Oxygen Concentration (%)	15.39	14.94	16.23	17.82	19.06	17.06	16.88	19.5	18.23
Maximum CO Concentration (ppm)	12548	13245	13725	10585	11567	9290	7710	8505	8741
Maximum CO2 Concentration (ppm)	46960	43050	33862	39727	7668	27705	29953	7228	19152
Number of Animals Exposed	4	4	4	4	4	4	4	4	4
Number of Dead Animals	4	4	4	3	4	2	2	4	1
Lethality (%)	100	100	100	75	100	50	50	100	25
Ct Product for CO (ppm x min)	46242	48073	data can not be	37829	66639	36460	30102	50889	33127
Ct Product for CO2 (ppm x min)	254541	243162	read again	212712	119846	180248	159722	93605	126918
TI% (°C)	221	268		219	228	231	237	228	231

Table 8: Douglas Fir Plywood

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7
Specimen Weight (grams)	10.00	10.25	12.40	13.64	15.01	12.40	11.27
Maximum Chamber Temperature (°C)	41.3	36.91	43.09	44.5	38.2	39.38	42.42
Maximum Furnace Temperature (°C)	831.2	854.7	834.6	846.9	836.3	833.9	835.0
Weight Loss (%)	not reliable	82.1	84.6	79.6	82.4	77.0	84.1
Minimum Oxygen Concentration (%)	19.22	19.08	19.26	16.36	15.90	20.75	19.42
Maximum CO Concentration (ppm)	9518	8636	4946	11361	11052	13204	11669
Maximum CO2 Concentration (ppm)	7501	6600	4002	24586	28841	8288	7963
Number of Animals Exposed	0	4	4	4	4	4	4
Number of Dead Animals	-	0	0	2	0	1	4
Lethality (%)	-	0	0	50	0	25	100
Ct Product for CO (ppm x min)	53564	54248	34885	38655	30682	77719	68838
Ct Product for CO2 (ppm x min)	99675	108050	58663	157739	173121	119296	114947
T1% (°C)	230	230	230	230	230	230	230

Table 9: Southern Pine Plywood

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
Specimen Weight (grams)	10.00	12.40	10.25	8.47	9.32	11.27	13.64	11.27	15.01
Maximum Chamber Temperature (°C)	46.4	41.5	45.1	42.6	43.7	48.3	42.6	42.4	45.5
Maximum Furnace Temperature (°C)	880.6	835.9	836.1	835.4	836.9	833.1	836.1	831.8	832.2
Weight Loss (%)	79.2	74.8	74.5	70.6	72.0	79.9	76.2	73.7	77.3
Minimum Oxygen Concentration (%)	19.08	19.34	19.77	19.83	19.66	19.28	15.81	19.34	15.82
Maximum CO Concentration (ppm)	8467	13739	9092	8232	9146	11669	14612	13055	15315
Maximum CO2 Concentration (ppm)	6912	7993	6207	6527	7766	9906	36170	8074	40010
Number of Animals Exposed	0	4	4	4	4	4	4	4	4
Number of Dead Animals	-	2	2	0	0	1	1	0	3
Lethality (%)	-	50	50	0	0	25	25	0	75
CI Product for CO (ppm x min)	41627	64453	46747	38791	44069	55258	37602	57003	44378
CI Product for CO2 (ppm x min)	107241	105639	98745	90523	113082	129634	176697	109175	200152
TI% (°C)	275	230	230	230	230	230	230	230	230

Table 10: Oriented Strandboard

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
Specimen Weight (grams)	10.00	7.00	8.47	10.25	12.39	15.00
Maximum Chamber Temperature (°C)	45.1	43.6	41.6	46.2	44.5	43.9
Maximum Furnace Temperature (°C)	801.3	801.2	800.7	801.6	799.9	797.6
Weight Loss (%)	86.4	91	84.7	86	84	83.3
Minimum Oxygen Concentration (%)	19.8	20.15	20.09	20.01	19.69	19.48
Maximum CO Concentration (ppm)	6082	3503	4230	5292	7406	9350
Maximum CO <sub>2</sub> Concentration (ppm)	5844	3257	4228	4899	6210	7693
Number of Animals Exposed	0	4	4	4	4	4
Number of Dead Animals	-	2	2	0	2	4
Lethality (%)	-	50	50	0	50	100
Ct Product for CO (ppm x min)	31021	18737	24022	27489	36468	43220
Ct Product for CO <sub>2</sub> (ppm x min)	77970	53270	67179	75088	81156	96628
T1% (°C)	198	198	198	198	198	198

Table 11: Waferboard

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10
Specimen Weight (grams)	10.00	11.27	10.25	13.64	16.51	15.01	12.40	18.16	12.40	13.64
Maximum Chamber Temperature (°C)	45.5	45.5	41.7	44.5	41.6	40.9	45.2	37.5	49.6	48.1
Maximum Furnace Temperature (°C)	831.6	917.5	914.8	898.3	898.2	895.6	897.2	900.5	899.1	901.7
Weight Loss (%)	not reliable	84.6	77.5	80.3	83.8	88.2	81.7	81.4	82.9	87.3
Minimum Oxygen Concentration (%)	19.09	19.13	19.06	19.01	15.09	15.67	19.11	13.72	19.19	18.67
Maximum CO Concentration (ppm)	9773	13050	13647	15925	17912	17175	14115	14347	13360	17713
Maximum CO2 Concentration (ppm)	8554	9718	9889	11929	41835	33485	9504	60248	9697	12454
Number of Animals Exposed	0	4	4	4	4	4	4	4	4	4
Number of Dead Animals	-	1	1	2	1	2	1	0	0	3
Lethality (%)	-	25	25	50	25	50	25	0	0	75
Ct Product for CO (ppm x min)	44498	58841	55509	72472	49973	49031	66541	35337	62605	74128
Ct Product for CO2 (ppm x min)	96103	119225	109747	144697	211721	195553	128689	281878	137745	147258
TI% (°C)	230	310	310	290	290	290	290	290	290	290

Table 12: Standard Hardboard

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5
Specimen Weight (grams)	14.99	7.68	9.21	11.05	6.40
Maximum Chamber Temperature (°C)	50.1	52.5	52.2	47.5	46.7
Maximum Furnace Temperature (°C)	823.6	814.2	823.0	824.8	820.1
Weight Loss (%)	82.1	79.3	not reliable	not reliable	not reliable
Minimum Oxygen Concentration (%)	19.32	20.06	19.97	19.6	20.25
Maximum CO Concentration (ppm)	10693	5208	6189	7563	4031
Maximum CO2 Concentration (ppm)	9134	4442	5126	6886	3465
Number of Animals Exposed	0	4	4	4	4
Number of Dead Animals	-	2	2	4	1
Lethality (%)	-	50	50	100	25
Ct Product for CO (ppm x min)	62881	30632	37699	45643	25856
Ct Product for CO2 (ppm x min)	154560	67539	76713	102369	57758
T1% (°C)	228	223	228	228	225

Table 13: Tempered Hardboard

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10
Specimen Weight (grams)	7.68	9.21	11.05	6.40	11.05	11.04	19.79	34.40	28.52	23.75
Maximum Chamber Temperature (°C)	48.2	48.2	41.2	51.4	52.5	53.3	45.5	42.3	43.3	45.7
Maximum Furnace Temperature (°C)	827.2	827.2	823.6	829.5	835.4	822.5	824.8	824.2	824.8	818.9
Weight Loss (%)	not reliable	67.86	73.85	65.47	80.36	83.24	86.71	82.89	not reliable	88.72
Minimum Oxygen Concentration (%)	20.16	19.23	19.92	20.38	19.75	19.66	18.79	12.28	13.33	18.54
Maximum CO Concentration (ppm)	5208	5679	5041	4266	8221	8701	14501	15923	21144	16895
Maximum CO2 Concentration (ppm)	4149	5726	4296	4100	7277	8010	11919	67687	61816	13679
Number of Animals Exposed	4	4	4	4	4	4	4	4	4	4
Number of Dead Animals	3	2	1	0	1	4	4	4	4	4
Lethality (%)	75	50	25	0	25	100	100	100	100	100
CI Product for CO (ppm x min)	28279	33972	31449	24460	45624	47738	82280	96199	85492	95396
CI Product for CO2 (ppm x min)	69868	92434	89262	76409	122013	121417	188537	419264	318155	223692
TI% (°C)	232	235	232	232	234	230	228	228	228	225

Table 14: Fiberboard

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5
Specimen Weight (grams)	7.02	10.11	12.13	8.42	14.56
Maximum Chamber Temperature (°C)	32.6	51.4	51.1	52.9	46.8
Maximum Furnace Temperature (°C)	829.5	823.6	827.2	818.9	829.5
Weight Loss (%)	not reliable	not reliable	94.97	not reliable	89.9
Minimum Oxygen Concentration (%)	18.23	19.99	19.7	20.16	19.27
Maximum CO Concentration (ppm)	1980	4933	6729	4060	9526
Maximum CO <sub>2</sub> Concentration (ppm)	4540	5517	7032	5078	9769
Number of Animals Exposed	4	4	4	4	4
Number of Dead Animals	0	3	2	1	3
Lethality (%)	0	75	50	25	75
CI Product for CO (ppm x min)	13287	33493	40995	27034	53205
CI Product for CO <sub>2</sub> (ppm x min)	94392	114129	141464	107431	171765
TI% (°C)	233	232	230	229	230



Table 15: Particleboard

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5
Specimen Weight (grams)	9.79	11.75	14.10	8.16	6.80
Maximum Chamber Temperature (°C)	48.1	48	46.8	47.8	48
Maximum Furnace Temperature (°C)	829.5	822.5	824.8	823.6	829.5
Weight Loss (%)	85.5	90.2	89.7	88.9	not reliable
Minimum Oxygen Concentration (%)	19.89	19.58	19.43	20	20.09
Maximum CO Concentration (ppm)	6562	6857	8858	4305	4256
Maximum CO2 Concentration (ppm)	6641	6982	8059	5322	5908
Number of Animals Exposed	4	4	4	4	4
Number of Dead Animals	2	4	4	2	0
Lethality (%)	50	100	100	50	0
Cl Product for CO (ppm x min)	36355	38259	51744	27143	23775
Cl Product for CO2 (ppm x min)	122904	120542	153872	101522	97313
T1% (°C)	230	231	229	232	231

Table 16: Lauan Plywood

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
Specimen Weight (grams)	10.00	9.32	10.25	13.64	16.51	19.97	21.97	18.16	24.17
Maximum Chamber Temperature (°C)	34.4	40.31	42.38	40.1	35.61	32.99	33.01	41.88	39.54
Maximum Furnace Temperature (°C)	798.6	803.2	791.7	798.2	798.1	797.3	796.3	799.3	791.5
Weight Loss (%)	79.9	83.6	84.6	77.3	80.9	82.5	83.6	81.8	88.0
Minimum Oxygen Concentration (%)	17.35	19.28	19.76	15.99	15.12	14.62	14.28	11.76	13.56
Maximum CO Concentration (ppm)	3979	4075	4179	4409	5788	7883	7196	6338	11732
Maximum CO2 Concentration (ppm)	6762	5504	6636	7375	9684	11361	11587	14121	17349
Number of Animals Exposed	4	4	4	4	4	4	4	4	4
Number of Dead Animals	1	0	0	0	0	2	2	1	3
Lethality (%)	25	0	0	0	0	50	50	25	75
Ct Product for CO (ppm x min)	34388	31219	37176	37759	43370	49087	48995	49847	72803
Ct Product for CO2 (ppm x min)	110369	98905	117159	136202	163392	179356	191424	185720	279274
T1% (°C)	187	193	190	190	190	190	190	190	190

Table 17: CCA-Treated Southern Pine

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10
Specimen Weight (grams)	10.00	13.64	18.16	16.51	21.97	19.97	24.17	26.58	29.24	32.16
Maximum Chamber Temperature (°C)	44.82	36.38	46.58	41.5	40.15	37.38	38.21	47.47	38.32	36.73
Maximum Furnace Temperature (°C)	881.2	863.3	857.3	852.1	851.9	862.7	859.4	859.3	867.2	854.7
Weight Loss (%)	75.4	77.2	80.3	85.8	79.4	76.3	78.8	80.3	77.9	76.3
Minimum Oxygen Concentration (%)	20.35	17.42	13.02	17.31	14.19	15.93	13.54	11.69	13.90	13.66
Maximum CO Concentration (ppm)	6570	6543	8768	7371	10348	8186	10595	12759	12626	12996
Maximum CO2 Concentration (ppm)	7813	20846	30411	31954	39393	33749	34323	38774	43724	41432
Number of Animals Exposed	4	4	4	4	4	4	4	4	4	4
Number of Dead Animals	0	0	1	0	3	0	1	1	2	1
Lethality (%)	0	0	25	0	75	0	25	25	50	25
Ct Product for CO (ppm x min)	44477	30745	27726	30246	34064	28498	38599	38931	39787	45657
Ct Product for CO2 (ppm x min)	129761	160054	205811	228041	262532	254023	269821	328396	355292	361273
TI% (°C)	273	255	250	250	250	250	250	250	250	250

Test Sequence	Test 11	Test 12
Specimen Weight (grams)	35.38	26.58
Maximum Chamber Temperature (°C)	36.5	38.4
Maximum Furnace Temperature (°C)	859.6	861.8
Weight Loss (%)	76.7	76
Minimum Oxygen Concentration (%)	15.87	15.43
Maximum CO Concentration (ppm)	14413	11291
Maximum CO2 Concentration (ppm)	45867	38036
Number of Animals Exposed	4	4
Number of Dead Animals	1	0
Lethality (%)	25	0
Ct Product for CO (ppm x min)	48535	38939
Ct Product for CO2 (ppm x min)	314017	306230
TI% (°C)	250	250

Table 18: AZCA-Treated Douglas Fir

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10
Specimen Weight (grams)	10.00	10.25	12.40	13.64	15.01	16.51	19.97	24.17	32.16	35.38
Maximum Chamber Temperature (°C)	44.1	41.01	45.16	43.9	39.27	39.43	47.74	44.8	40.41	42.24
Maximum Furnace Temperature (°C)	906.8	829.6	894.2	893.2	897.4	888.8	865.0	897.1	862.1	888.5
Weight Loss (%)	83.5	78.4	77.3	76.9	77.2	78.0	81.5	78.6	79.5	78.1
Minimum Oxygen Concentration (%)	19.56	19.57	19.39	19.00	15.05	15.22	11.80	11.81	15.06	14.70
Maximum CO Concentration (ppm)	9528	8888	9977	14082	12950	13683	14396	12364	12493	11290
Maximum CO2 Concentration (ppm)	7793	8129	9344	11296	43196	35073	43120	48380	52957	57367
Number of Animals Exposed	0	4	4	4	4	4	4	4	4	4
Number of Dead Animals	-	0	1	0	0	0	0	0	0	0
Lethality (%)	-	0	25	0	0	0	0	0	0	0
Ct Product for CO (ppm x min)	43661	42119	50718	65467	29125	35389	36647	31708	31223	26854
Ct Product for CO2 (ppm x min)	111394	103951	130683	133969	201656	193742	245588	309778	384345	507165
TI% (°C)	300	227	286	285	286	285	262	286	260	279

Test Sequence	Test 11	Test 12	Test 13	Test 14	Test 15	Test 16	Test 17	Test 18	Test 19
Specimen Weight (grams)	47.09	56.98	68.91	8.47	9.32	11.27	10.25	13.64	12.40
Maximum Chamber Temperature (°C)	47.54	43.2	46.94	50.4	35.29	46.6	41.9	42.3	41.39
Maximum Furnace Temperature (°C)	887.5	887.0	887.9	886.6	890.4	891.0	884.6	893.5	885.1
Weight Loss (%)	76.8	75.02	76.01	95.7	75.7	77.7	80.3	76.2	79.2
Minimum Oxygen Concentration (%)	13.13	12.45	12.42	19.70	19.87	19.01	19.56	19.11	18.73
Maximum CO Concentration (ppm)	12938	12360	10580	9683	8713	13232	8439	12440	15570
Maximum CO2 Concentration (ppm)	68750	76267	82740	6628	7597	9871	7665	10940	11752
Number of Animals Exposed	4	4	4	4	4	4	4	4	4
Number of Dead Animals	1	0	1	0	0	2	1	1	3
Lethality (%)	25	0	25	0	0	50	25	25	75
Ct Product for CO (ppm x min)	30969	34670	30347	41043	39930	56081	44435	57772	72446
Ct Product for CO2 (ppm x min)	569199	718114	886956	74921	117155	112911	107981	133675	159967
TI% (°C)	280	279	280	280	280	280	280	280	280

Table 19: Fire Retardant-Treated Southern Pine

Test Sequence	Test 1	Test 2	Test 3	Test 4	Test 5
Specimen Weight (grams)	10.00	13.64	15.01	16.51	18.16
Maximum Chamber Temperature (°C)	43.09	43.55	42.55	42.0	39.47
Maximum Furnace Temperature (°C)	894.1	861.2	858.1	862.5	862.5
Weight Loss (%)	66.4	68.2	65.6	68.6	65.3
Minimum Oxygen Concentration (%)	19.73	20.10	20.08	19.89	19.74
Maximum CO Concentration (ppm)	2190	6213	7023	8238	8280
Maximum CO2 Concentration (ppm)	4831	5696	6186	6588	6515
Number of Animals Exposed	4	4	4	4	4
Number of Dead Animals	0	0	3	1	4
Lethality (%)	0	0	75	25	100
Ct Product for CO (ppm x min)	20314	40854	48328	53965	50098
Ct Product for CO2 (ppm x min)	89193	96360	115380	118378	117869
TI% (°C)	286	250	250	250	250

Table 20: New York State Data

	Douglas Fir	Redwood	Southern Pine	White Spruce	Red Oak	Yellow Poplar	Douglas Fir Plywood
Number of Samples Tested	5	11	27	6	7	9	7
Furnace Temperature at 1% Sample Mass Loss (°C)	233	235	196	172	223	231	230
Maximal Concentration of Carbon Monoxide in the Exposure Chamber (ppm)	11567	8022	5369	5426	12195	9290	11669
Furnace Temperature at the Point of Maximal Carbon Monoxide (°C)	503	503	487	468	514	482	496
Maximal Concentration of Carbon Dioxide in the Exposure Chamber (%)	4.95	0.61	0.45	0.59	3.32	2.77	0.8
Furnace Temperature at the Point of Maximal Carbon Dioxide (°C)	486	539	532	523	517	458	495
Minimal Concentration of Oxygen in the Exposure Chamber (%)	Not reliable	19.5	19.9	19.9	16.7	17.1	19.4
Furnace Temperature at the Point of Minimal Oxygen (°C)	Not reliable	535	503	473	516	463	496
Number of Times the Exposure Chamber Temperature Exceeded 45°C	4	1	0	1	1	3	0
Average Duration of Exposure Chamber Temperature in Excess of 45°C (sec)	121	103	0	348	998	67	0
Eye Condition of Test Animals: (1) All apparently normal, (2) Some apparent damage, (3) Some severe damage	1	1	1	1	1	1	1

	Southern Pine Plywood	Oriented Strandboard	Waterboard	Standard Hardboard	Tempered Hardboard	Fiberboard	Particleboard
Number of Samples Tested	9	6	10	5	10	5	5
Furnace Temperature at 1% Sample Mass Loss (°C)	230	198	290	223	232	232	232
Maximal Concentration of Carbon Monoxide in the Exposure Chamber (ppm)	13055	7406	17713	5028	5208	4933	4305
Furnace Temperature at the Point of Maximal Carbon Monoxide (°C)	477	467	477	430	404	437	422
Maximal Concentration of Carbon Dioxide in the Exposure Chamber (%)	0.81	0.62	1.25	0.44	0.41	0.49	0.53
Furnace Temperature at the Point of Maximal Carbon Dioxide (°C)	485	472	477	430	485	435	419
Minimal Concentration of Oxygen in the Exposure Chamber (%)	19.3	19.7	18.7	20.1	20.2	20	20
Furnace Temperature at the Point of Minimal Oxygen (°C)	479	472	477	425	498	437	424
Number of Times the Exposure Chamber Temperature Exceeded 45°C	0	0	2	1	2	3	2
Average Duration of Exposure Chamber Temperature in Excess of 45°C (sec)	0	0	121	629	138	174	112
Eye Condition of Test Animals: (1) All apparently normal, (2) Some apparent damage, (3) Some severe damage	1	1	1	1	1	1	1

	Lauan Plywood	CCA-Treated Southern Pine	AZCA-Treated Douglas Fir	Fire Retardant-Treated Southern Pine
Number of Samples Tested	9	12	19	5
Furnace Temperature at 1% Sample Mass Loss (°C)	190	250	280	250
Maximal Concentration of Carbon Monoxide in the Exposure Chamber (ppm)	7883	10595	13232	7023
Furnace Temperature at the Point of Maximal Carbon Monoxide (°C)	409	489	472	492
Maximal Concentration of Carbon Dioxide in the Exposure Chamber (%)	1.14	3.43	0.99	0.62
Furnace Temperature at the Point of Maximal Carbon Dioxide (°C)	409	510	474	722
Minimal Concentration of Oxygen in the Exposure Chamber (%)	14.6	13.5	19	20.1
Furnace Temperature at the Point of Minimal Oxygen (°C)	465	561	474	474
Number of Times the Exposure Chamber Temperature Exceeded 45°C	0	0	1	0
Average Duration of Exposure Chamber Temperature in Excess of 45°C (sec)	0	0	336	0
Eye Condition of Test Animals: (1) All apparently normal, (2) Some apparent damage, (3) Some severe damage	1	1	1	1

**Carbon Monoxide Ct Product**

**VS**

**Specimen Weight**

Figure 1: Douglas Fir

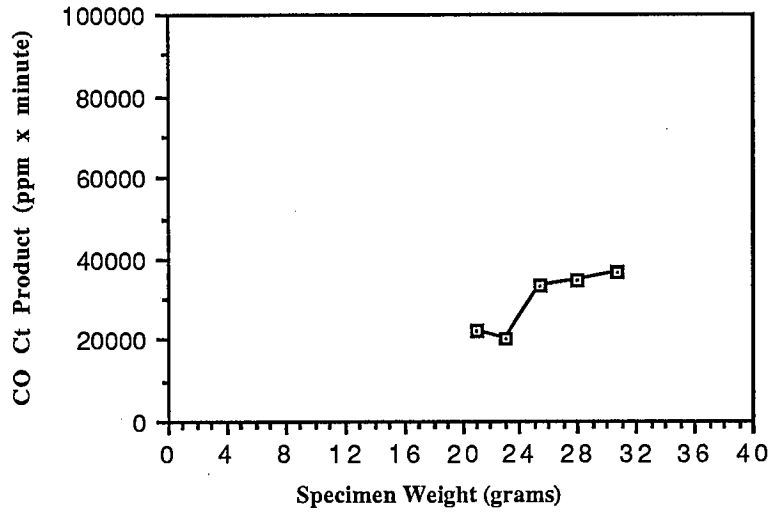


Figure 2: Redwood

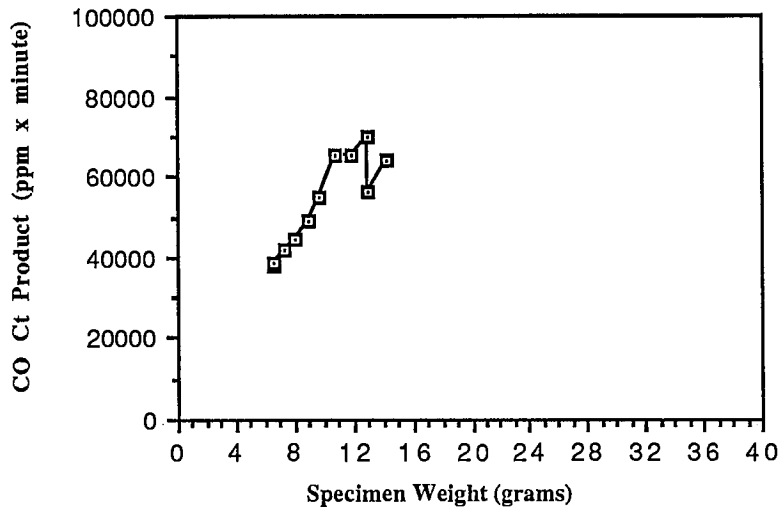




Figure 3: Southern Pine

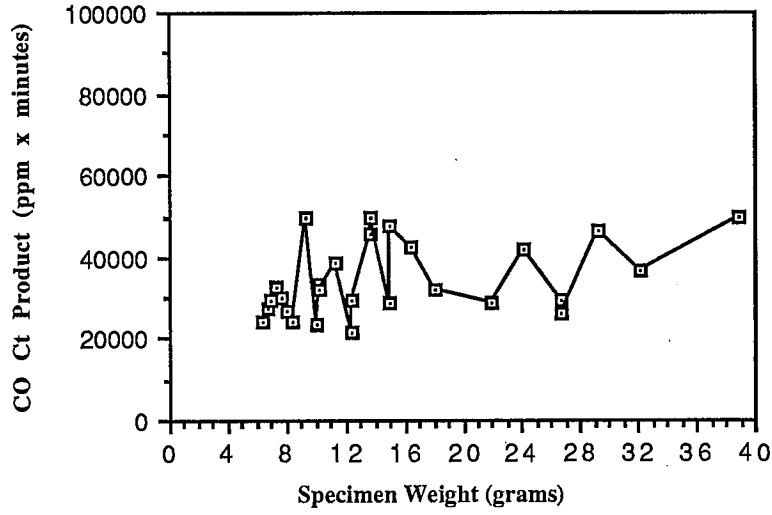


Figure 4: White Spruce

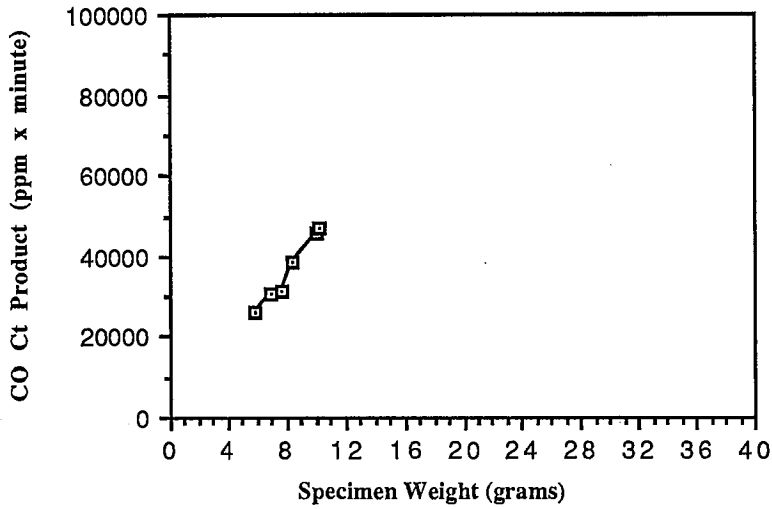


Figure 5: Red Oak

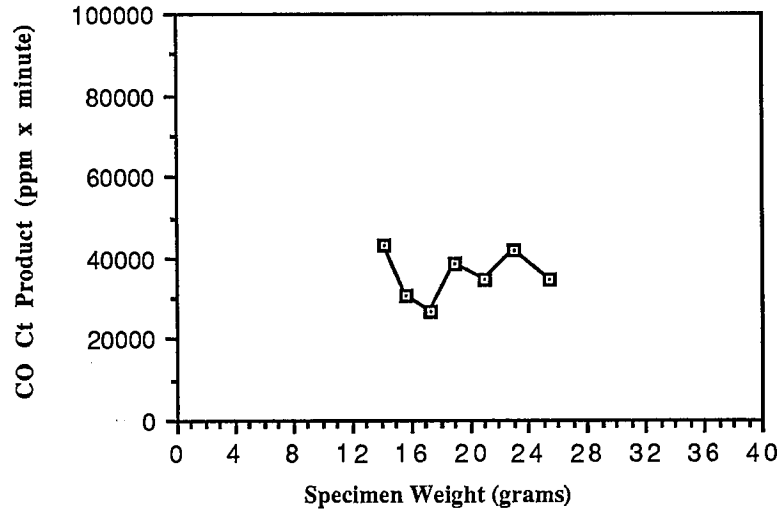


Figure 6: Yellow Poplar

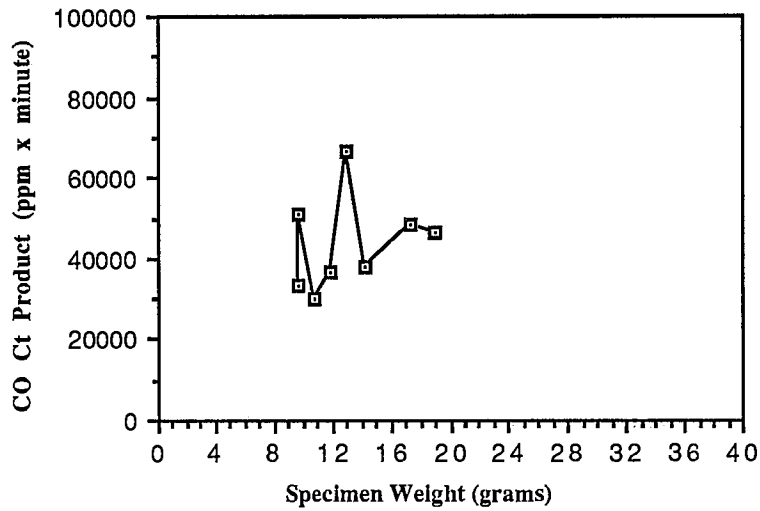


Figure 7: Douglas Fir Plywood

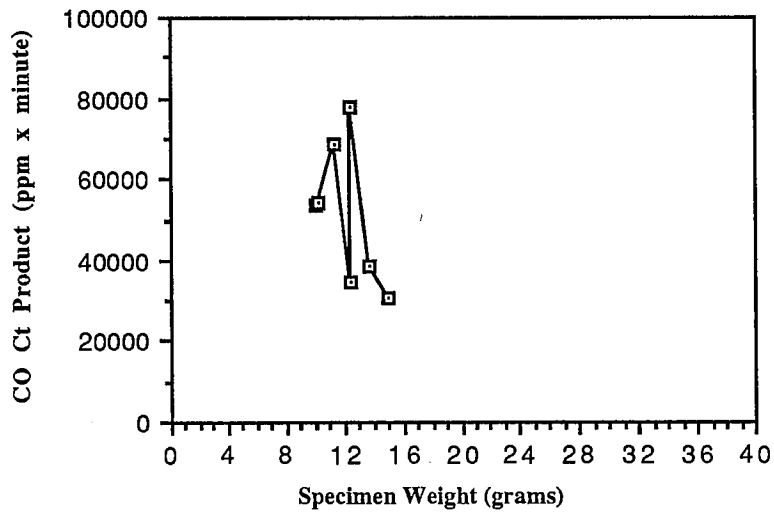


Figure 8: Southern Pine Plywood

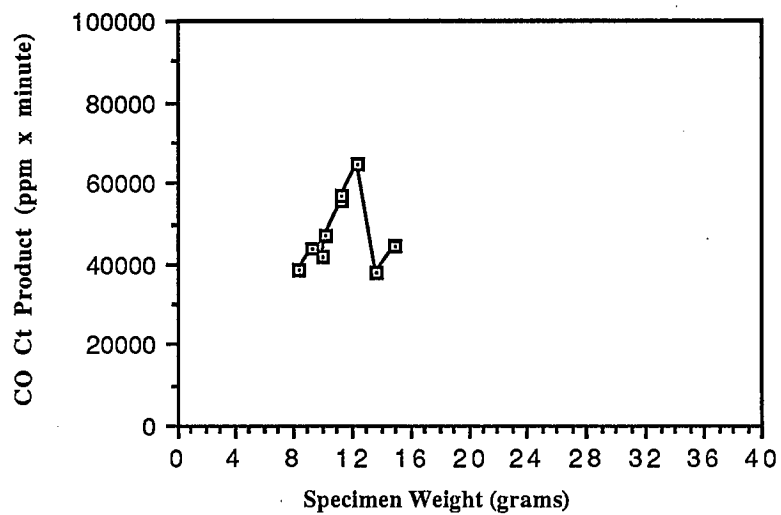


Figure 9: Oriented Strandboard

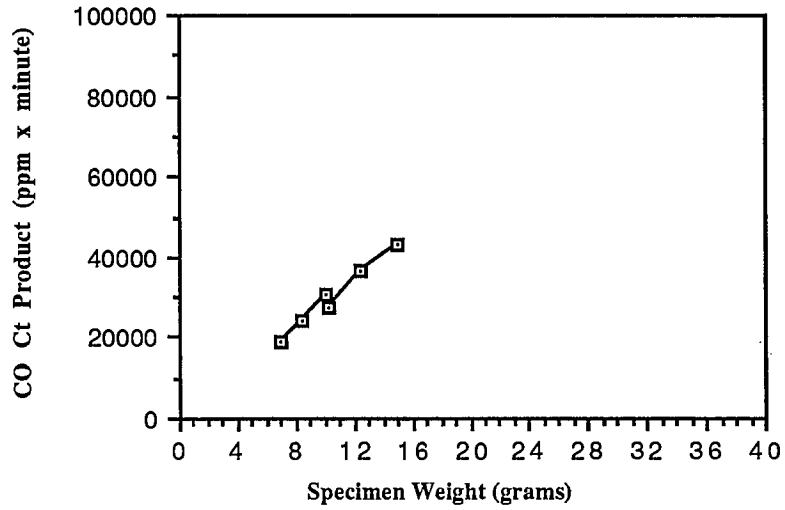


Figure 10: Waferboard

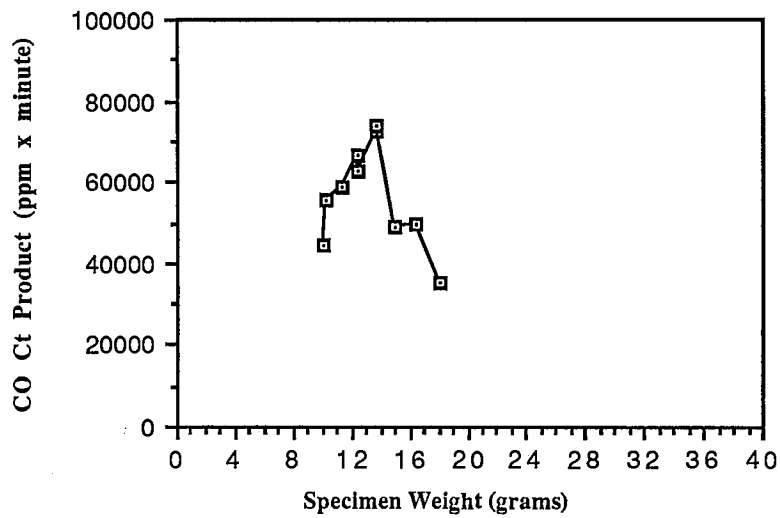


Figure 11: Standard Hardboard

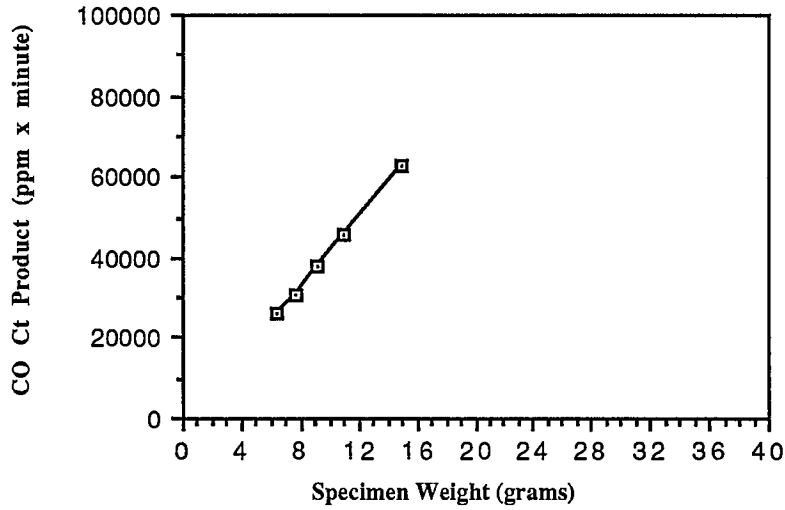


Figure 12: Tempered Hardboard

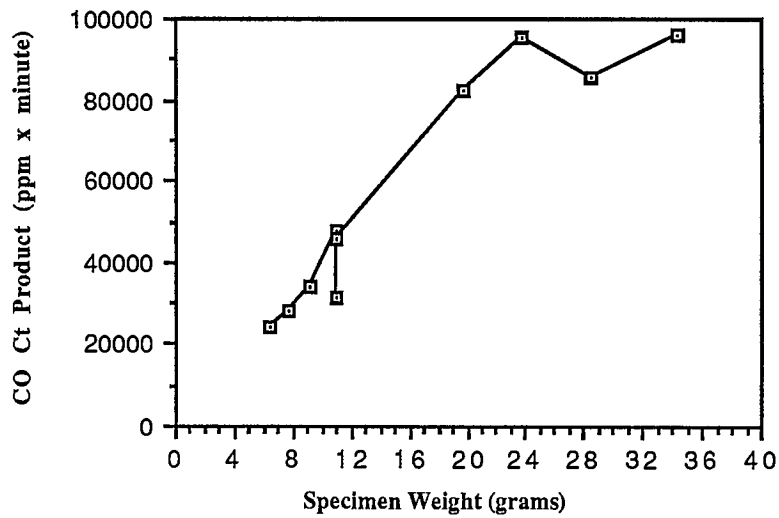


Figure 13: Fiberboard

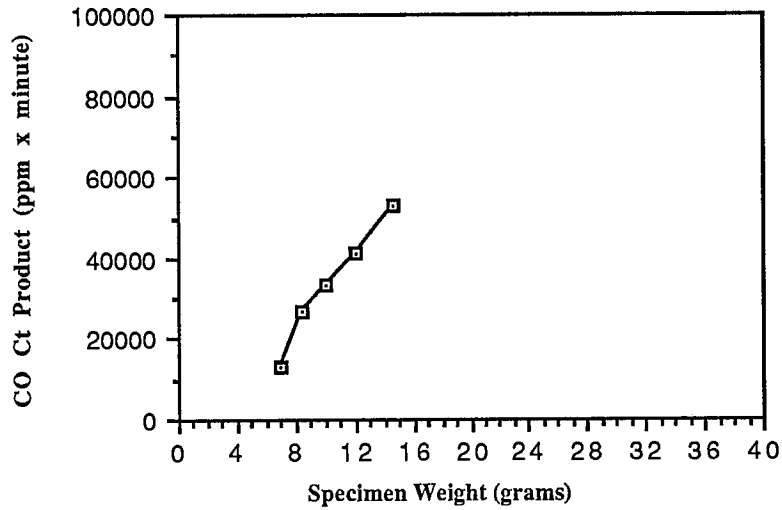


Figure 14: Particleboard

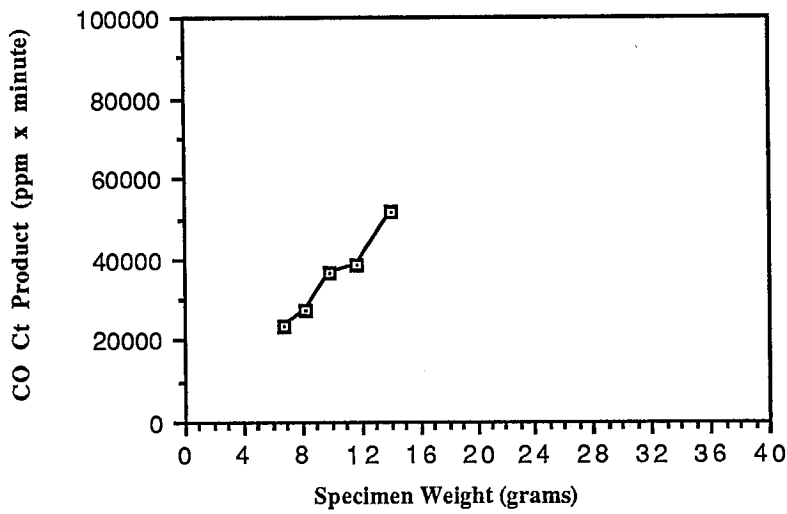


Figure 15: Lauan Plywood

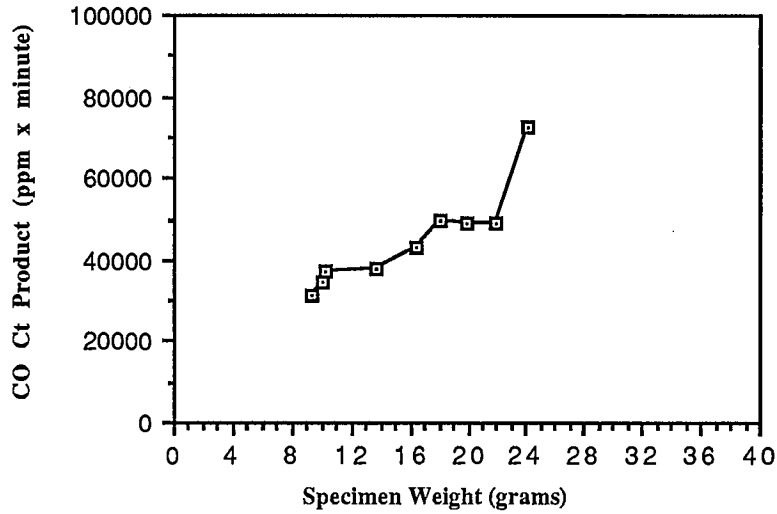


Figure 16: CCA-Treated Southern Pine

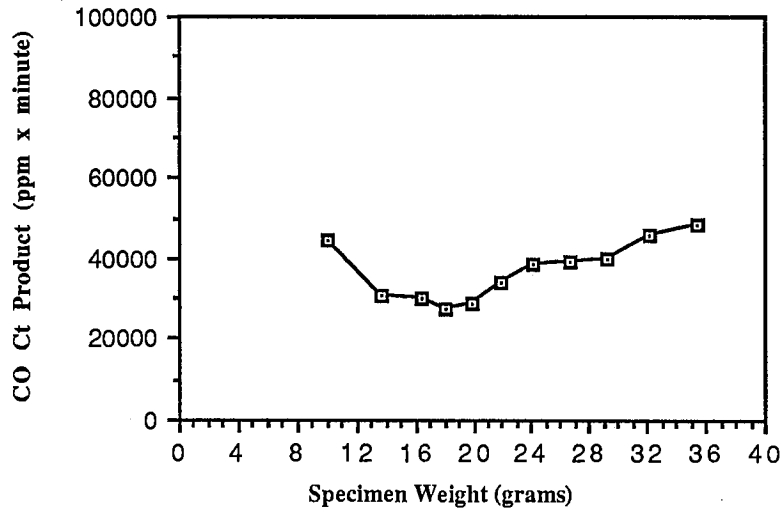


Figure 17: AZCA-Treated Douglas Fir

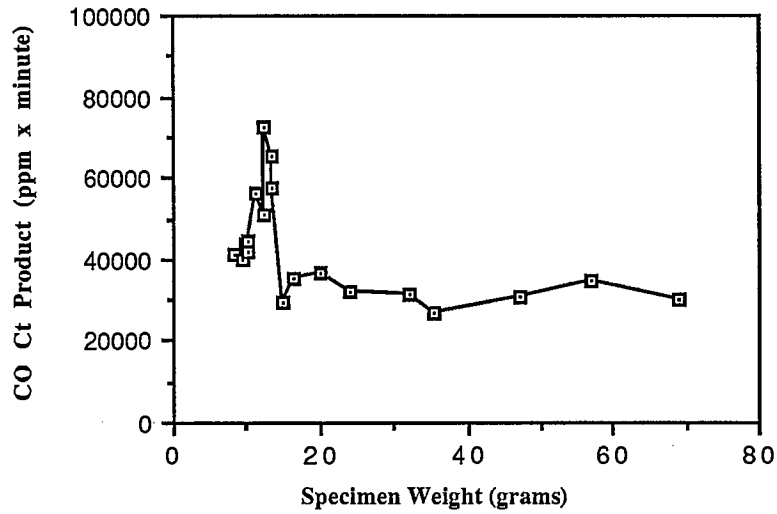
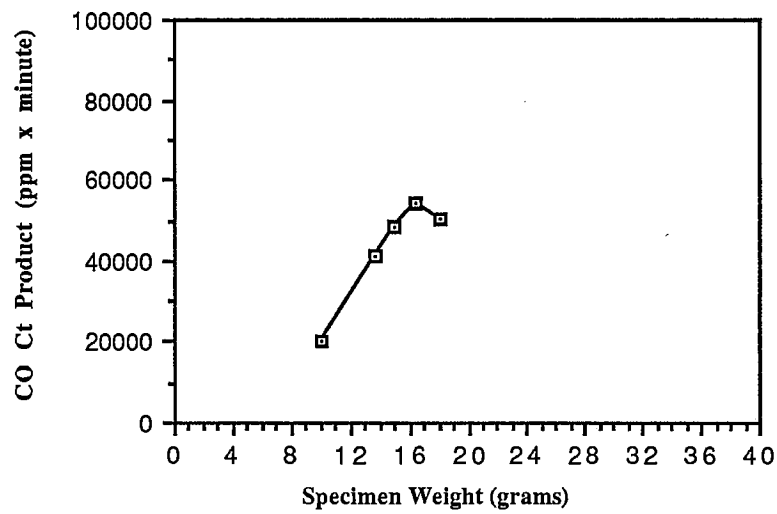


Figure 18: Fire Retardant-Treated Southern Pine





**Carbon Dioxide Ct Product**

**vs**

**Specimen Weight**

Figure 19: Douglas Fir

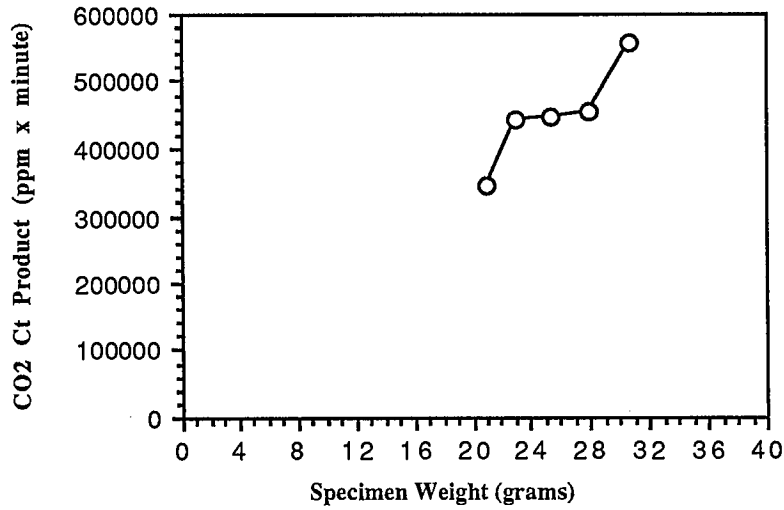


Figure 20: Redwood

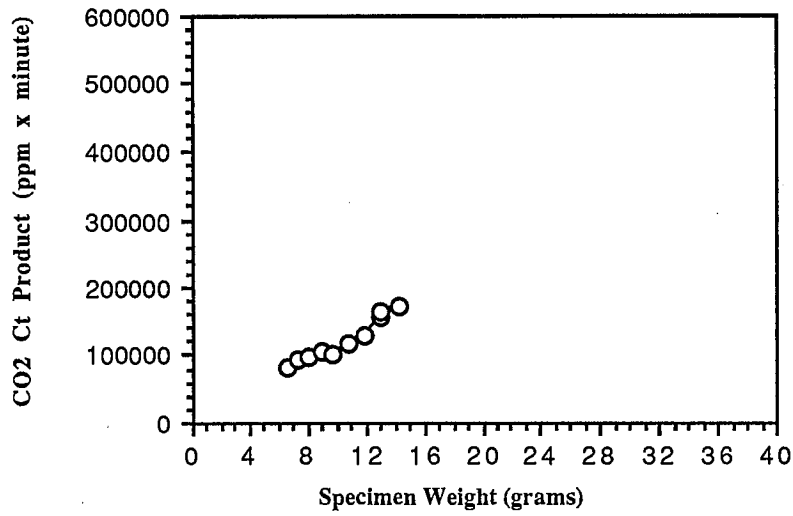


Figure 21: Southern Pine

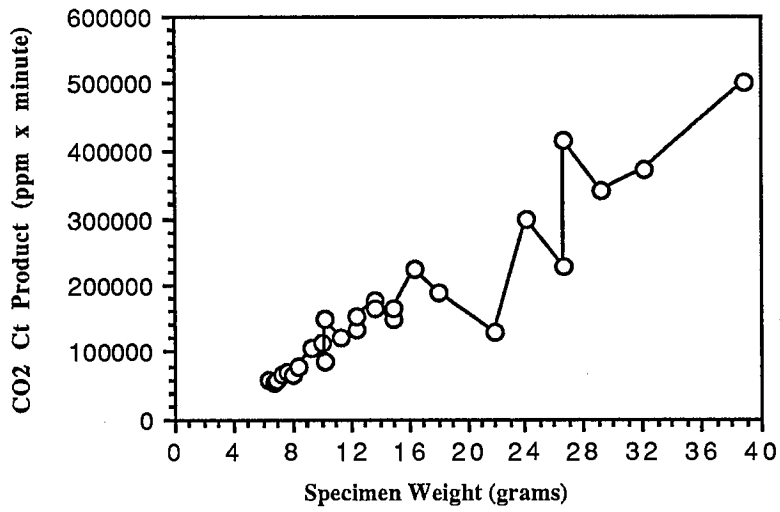


Figure 22: White Spruce

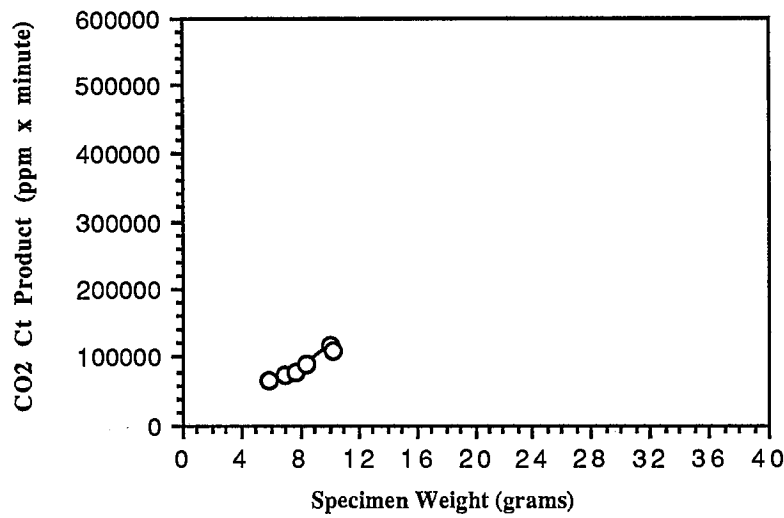


Figure 23: Red Oak

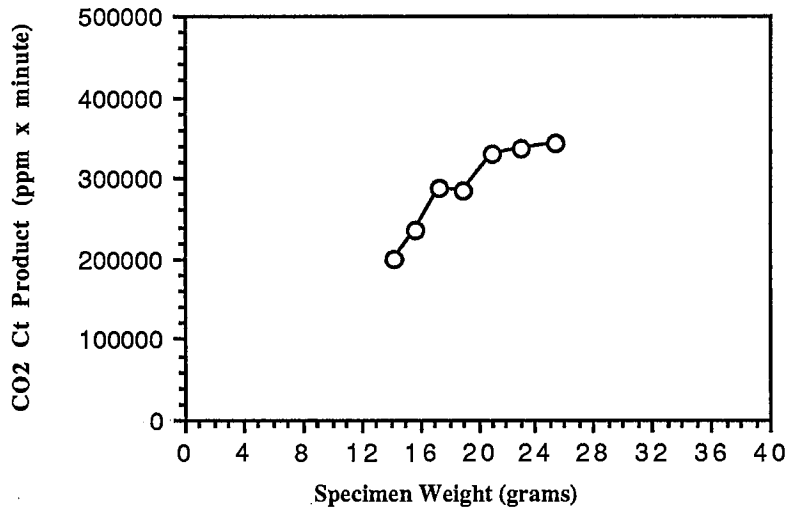


Figure 24: Yellow Poplar

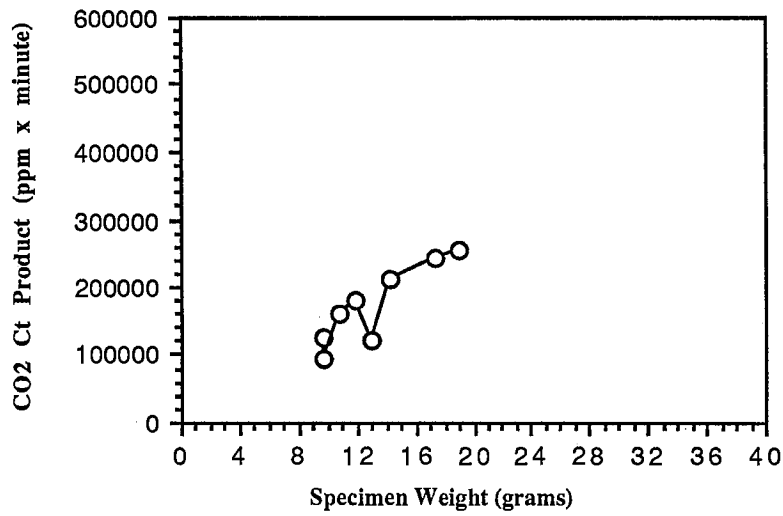


Figure 25: Douglas Fir Plywood

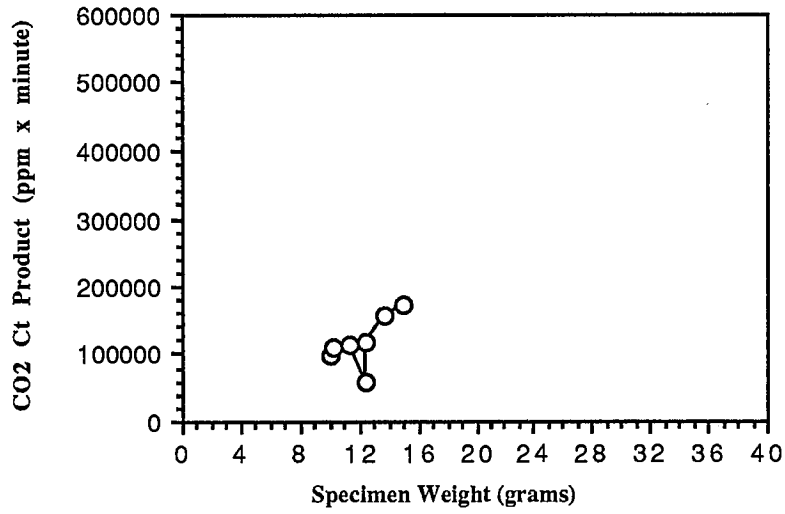


Figure 26: Southern Pine Plywood

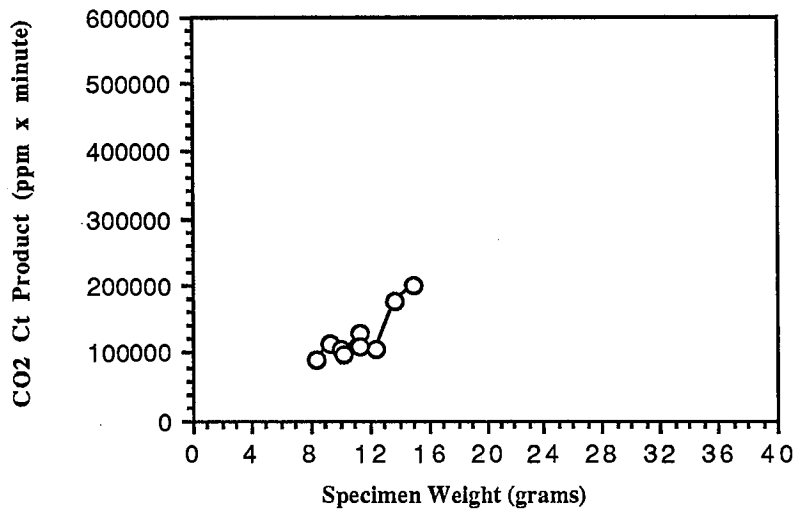


Figure 27: Oriented Strandboard

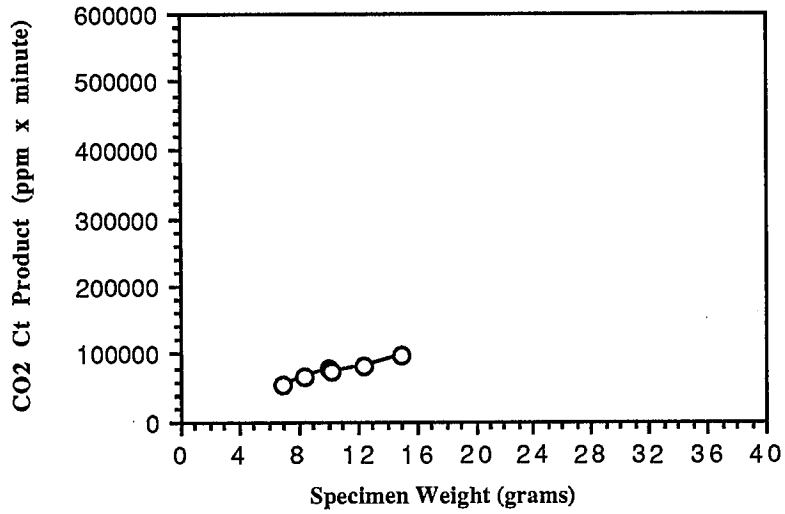


Figure 28: Waferboard

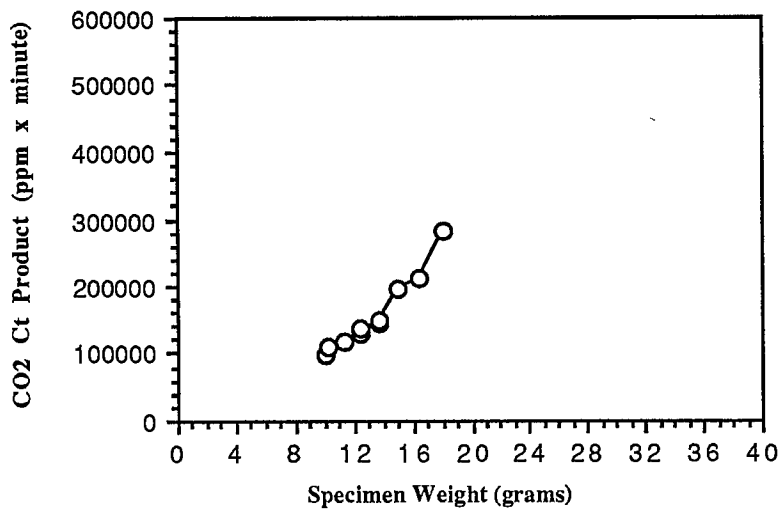


Figure 29: Standard Hardboard

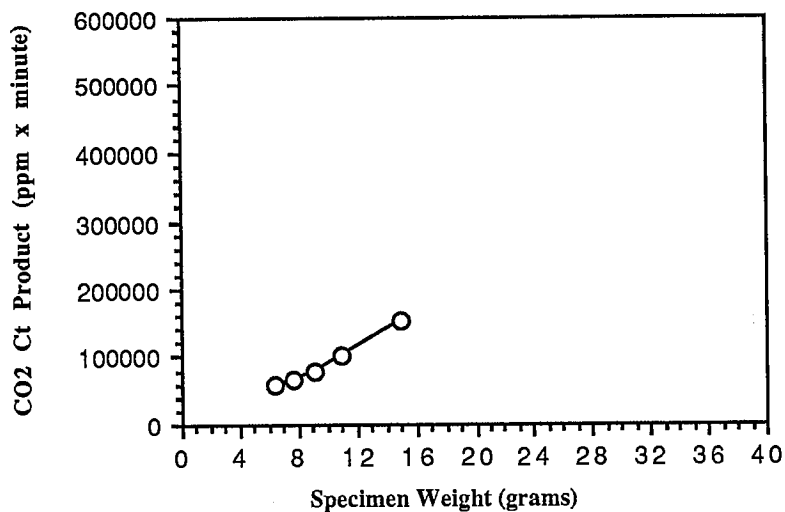


Figure 30: Tempered Hardboard

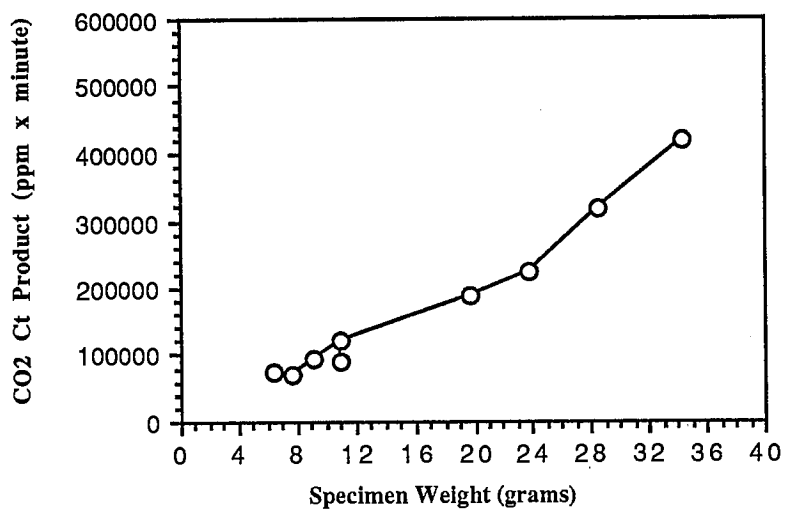


Figure 31: Fiberboard

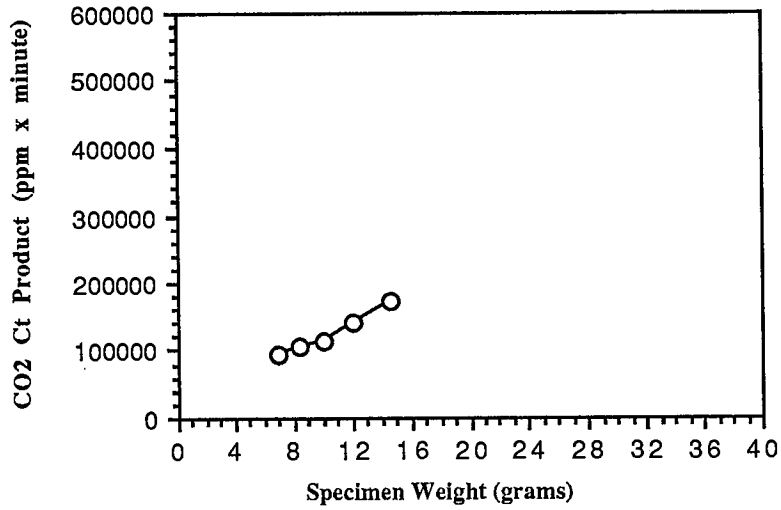


Figure 32: Particleboard

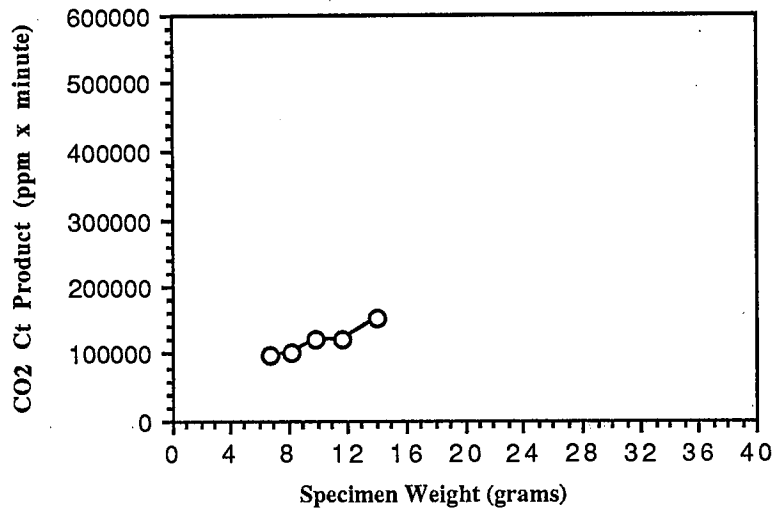




Figure 33: Lauan Plywood

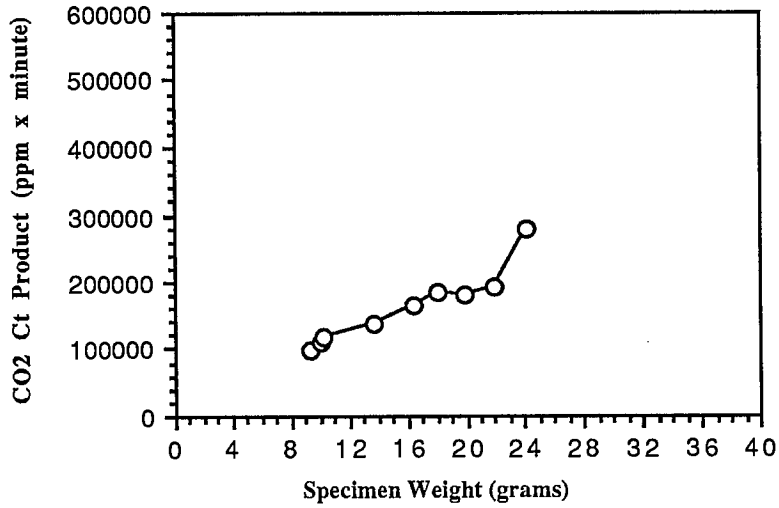


Figure 34: CCA-Treated Southern Pine

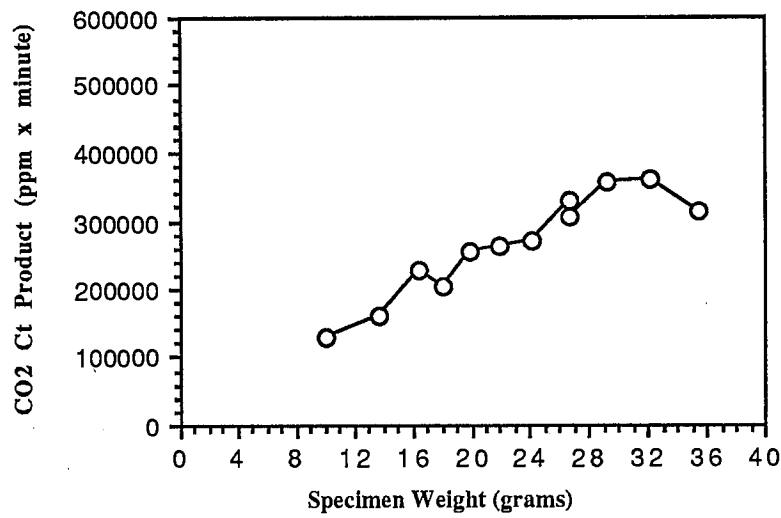


Figure 35: AZCA-Treated Douglas Fir

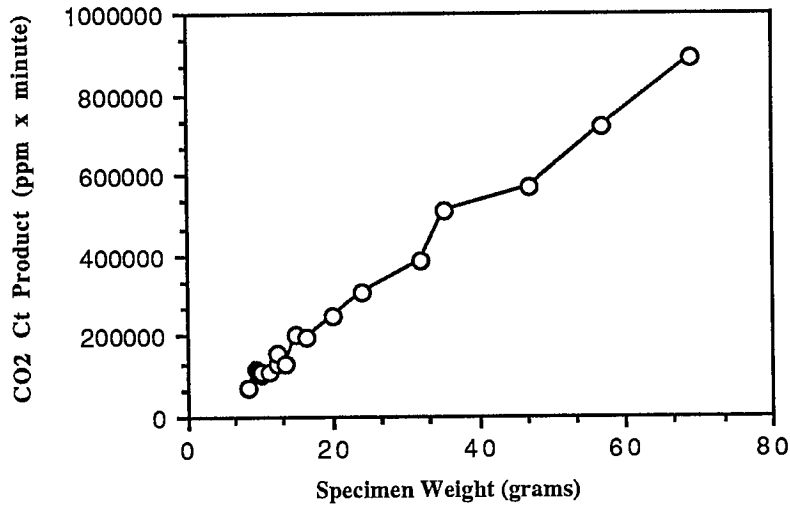
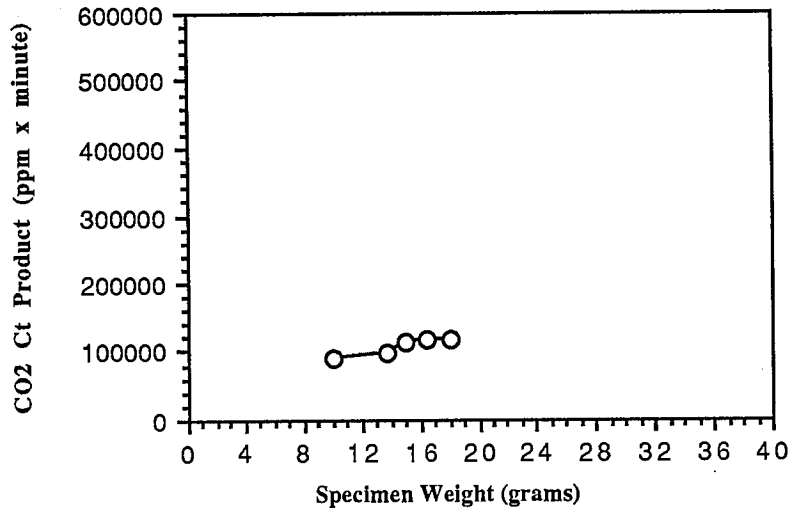
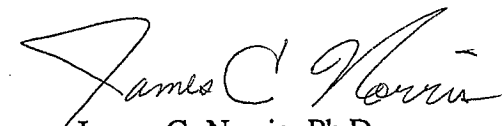


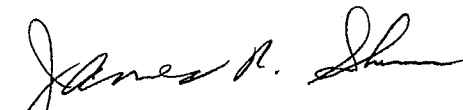
Figure 36: Fire Retardant-Treated Southern Pine



SIGNATURE PAGE

Prepared by,

  
James C. Norris, Ph.D.  
Toxicologist

  
Director

**THE WEYERHAEUSER FIRE TECHNOLOGY LABORATORY  
AUTHORIZES THE CLIENT NAMED HEREIN TO REPRODUCE THIS  
REPORT ONLY IF REPRODUCED IN ITS ENTIRETY.**

APPENDIX C

LC<sub>50</sub> VALUES OF A LAUAN PLYWOOD  
USING THE UNIVERSITY OF PITTSBURGH  
TOXICITY TEST APPARATUS

LAUAN PLYWOOD WITH A PVC LAMINATE