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ANALYSIS OF SOME CANADIAN HARD AND SOFTWOOD BARKS AND RESIDUES FOR USE IN COMBUSTION INVESTIGATIONS

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by

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INTRODUCTION

The data presented has been extracted from the analytical records of the Solid Fuels Laboratory, and is representative of waste wood products supplied by the Pulp and Paper Research Institute for a utilization study.

Presentation of Data

Each sample was air dried prior to grinding to pass a No.60 sieve and sampling and therefore is not representative of the as sampled moisture condition.

Table I - Analysis of Balsam includes Balsam-fir as identified by the supplier.

Table II - Jackpine

Table III - Spruce is divided into white and black spruce.

Table IV - Poplar, Poplar-aspen, Birch white and yellow, Beech, Hard and Soft Maple, Soft Elm, Tamarach, and Eastern Hemlock.

Tables V to XIII are analyses of composites of samples of each species and include Ultimate Analysis, Ash Fusibility, and Ash analysis as additional information useful in utilization and combustion calculations.

TABLE 1

BARK ANALYSIS

Type of Bark	Mark	As Rec'd Moisture %	Dry			Calorific Value Btu/lb Gross	
			Ash %	Volatile Matter %	Fixed Carbon %	As Rec'd	Dry
Balsam	1	7.14	2.15	77.00	20.85	8560	9220
"	7	6.26	2.55	79.33	18.12	8650	9230
"	13	6.29	1.93	79.37	18.70	9120	9730
"	14	6.67	2.18	79.94	17.88	8550	9160
"	16	8.29	2.94	75.68	21.38	8850	9650
"	18	7.34	3.38	75.58	21.04	8460	9130
"	23	6.27	3.45	78.85	17.70	8670	9250
"	26	6.00	2.94	75.84	21.22	8700	9250
"	27	6.17	2.13	77.95	19.92	8770	9340
"	32	6.35	2.66	77.15	20.19	8580	9160
Balsam Fir	37	5.31	2.78	77.45	19.77	8430	8910
Balsam	39	3.51	2.63	75.54	21.83	8020	8310
"	42	5.44	3.00	76.11	20.89	8730	9230
"	44	7.34	3.58	76.00	20.42	8390	9050
"	49	7.62	3.91	76.32	19.77	8590	9290
"	50	7.45	2.79	78.52	18.69	8520	9200
Balsam Fir	55	6.64	1.63	77.06	21.31	8550	9160
"	57	7.62	1.91	74.64	23.45	8140	8810
Balsam	59	6.95	2.41	78.59	19.00	8090	8690
"	62	7.26	2.72	72.50	21.78	8280	8930
"	63	7.10	2.41	77.71	19.88	8290	8930

TABLE 1 (continued)

Balsam Fir	68	6.29	2.63	78.20	19.17	8380	8940
Balsam	69	6.02	3.47	78.81	17.72	8480	9020
"	73	6.70	2.14	77.52	20.34	8480	9090
Balsam Fir	75	6.40	2.39	79.73	17.88	8650	9240
Balsam	80	6.86	2.13	77.78	20.09	8470	9100
Balsam Fir	82	7.07	1.61	78.05	20.34	8410	9050
"	84	7.62	2.04	76.96	21.00	8120	8790

TABLE II

BARK ANALYSIS

Type of Bark	Mark	As Rec'd Moisture %	Dry			Calorific Value Btu/lb Gross	
			Ash %	Volatile Matter %	Fixed Carbon %	As Rec'd	Dry
Jackpine	2	6.82	2.06	72.50	22.44	8450	9070
"	20	6.99	1.73	73.12	25.15	8370	8990
"	28	6.80	1.45	73.07	25.48	8310	8920
"	31	6.98	1.64	74.88	23.48	9170	9860
"	35	3.74	1.65	71.55	26.80	8840	9180
"	52	8.34	2.57	72.95	24.48	8120	8850
"	53	7.73	1.65	75.21	23.14	8070	8750
"	58	6.89	2.71	73.49	23.80	8510	9140
"	60	7.78	3.33	76.38	20.29	7780	8440
"	65	7.06	3.16	75.33	21.51	7990	8600
"	70	7.26	2.01	73.43	24.56	7900	8520
"	77	7.15	1.49	76.21	22.30	8180	8810

TABLE 111

BARK ANALYSIS

Type of Bark	Mark	As Rec'd Moisture %	Dry			Calorific Value Btu/lb Gross	
			Ash %	Volatile Matter %	Fixed Carbon %	As Rec'd	Dry
Spruce (white)	3	6.97	3.09	73.08	23.83	8080	8685
	6	5.92	3.17	74.05	22.78	7860	8360
	15	7.86	3.03	73.43	23.54	8000	8690
	17	8.44	3.29	72.18	24.53	8140	8890
	19	6.66	3.63	73.07	23.30	7920	8490
	24	6.56	2.64	73.92	23.44	8250	8830
	25	5.43	3.56	71.46	24.98	7930	8390
	29	6.51	3.50	72.71	23.79	7740	8280
	33	7.15	3.63	72.25	24.12	7830	8440
	34	3.32	3.58	71.13	25.29	8160	8440
	41	5.34	3.23	73.20	23.57	7870	8310
	45	6.98	3.87	73.19	22.94	8210	8820
	51	7.68	3.10	76.02	20.88	7810	8460
	54	6.78	2.87	71.50	25.63	8110	8700
	61	7.47	4.30	73.41	22.29	7810	8440
	64	6.54	3.62	70.52	25.86	7780	8320
	67	6.32	3.71	72.13	24.16	8020	8560
	72	7.10	3.40	74.23	22.37	8110	8730
	81	7.13	2.95	73.15	23.90	7940	8550
	88	7.93	2.32	73.09	24.59	8270	8980
Spruce (black)	5	6.69	2.34	76.70	20.96	8150	8740
	10	6.41	3.13	72.19	24.68	8030	8580
	11	6.39	2.88	75.77	21.35	8110	8660
	22	6.17	3.66	75.51	20.83	7790	8310
	38	4.82	2.79	79.19	18.02	8210	8630
	40	5.79	2.60	73.09	24.31	8150	8650
	48	7.96	2.76	74.60	22.64	7920	8600
	56	7.67	3.23	73.07	23.70	7870	8530
	66	6.24	2.41	70.57	27.02	8340	8890
	71	6.65	2.59	75.28	22.13	7890	8450
	74	6.10	2.19	76.00	21.81	8180	8710
	78	6.77	1.91	77.04	21.05	8130	8720

TABLE IV

BARK ANALYSIS

Type of Bark	Mark	As Rec'd Moisture %	Dry			Calorific Value Btu/lb Gross	
			Ash %	Volatile Matter %	Fixed Carbon %	As Rec'd	Dry
Poplar & Aspen	4	5.63	3.88	80.19	15.93	8120	8600
	21	5.10	4.01	79.72	16.27	8420	8870
Poplar	30	5.38	3.94	78.56	17.50	8460	8940
	36	3.94	3.92	77.97	18.11	8220	8560
	43	3.39	4.90	78.78	16.32	8490	8790
	76	5.39	2.94	78.10	18.96	8590	9080
Birch, Yellow	8	5.28	1.94	78.05	20.01	9140	9650
Birch, White	9	5.33	1.79	82.44	15.77	9700	10240
	47	6.14	3.11	74.89	22.00	8220	8760
	79	5.05	1.79	80.72	17.49	10410	10960
	91	5.04	1.56	77.84	20.60	9250	9740
Maple	46	6.45	5.33	73.82	20.85	7630	8160
Beech	83	6.53	7.93	75.18	16.89	7140	7630
Soft Elm	85	6.93	8.09	73.08	18.83	7070	7600
Soft Maple	86	7.37	3.00	78.08	18.92	7500	8100
Tamarack	87	6.44	4.17	69.46	26.37	8430	9010
Hard Maple	89	6.92	4.73	76.41	18.86	7740	8310
Eastern Hemlock	90	6.74	2.51	71.95	25.54	8280	8880

TABLE V

ANALYSIS OF COMPOSITE

JACKPINE

		As Received	Dry
Moisture	%	8.48	0.00
Ash	%	1.85	2.02
Ultimate Analysis			
Carbon	%	48.85	53.38
Hydrogen	%	5.41	5.91
Nitrogen	%	0.10	0.11
Sulphur	%	T	T
Ash	%	1.85	2.02
Oxygen (by difference)	%	35.31	35.58

ASH FUSIBILITY - (Reducing Atmosphere)

Initial Deformation Temperature	^{o}F	2450
Softening Temperature (Spherical)	^{o}F	2750
" " (Hemispherical)	^{o}F	—
Fluid Temperature	^{o}F	2760

CHEMICAL ANALYSIS OF ASH - see Appendix "A"

T - Trace

TABLE V1

ANALYSIS OF COMPOSITE

SPRUCE

WHITE & BLACK

		As Received	Dry
Moisture	%	8.24	0.00
Ash	%	2.81	3.06
Ultimate Analysis			
Carbon	%	47.79	52.08
Hydrogen	%	5.22	5.69
Nitrogen	%	0.17	0.19
Sulphur	%	T	T
Ash	%	2.81	3.06
Oxygen (by difference)	%	35.77	38.98

ASH FUSIBILITY - (Reducing Atmosphere)

Initial Deformation Temperature	^{o}F	2470
Softening Temperature (Spherical)	^{o}F	2820
" " (Hemispherical)	^{o}F	—
Fluid Temperature	^{o}F	2830

CHEMICAL ANALYSIS OF ASH - see Appendix "A"

T - Trace

TABLE V11

ANALYSIS OF COMPOSITE

BALSAM & BALSAM-FIR

		As Received	Dry
Moisture	%	7.71	0.00
Ash	%	2.16	2.34
Ultimate Analysis			
Carbon	%	48.76	52.83
Hydrogen	%	5.60	6.07
Nitrogen	%	0.22	0.24
Sulphur	%	T	T
Ash	%	2.16	2.34
Oxygen (by difference)	%	35.55	38.52

ASH FUSIBILITY - (Reducing Atmosphere)

Initial Deformation Temperature	°F	2850
Softening Temperature (Spherical)	°F	2860
" "(Hemispherical)		—
Fluid Temperature	°F	2870

CHEMICAL ANALYSIS OF ASH - see Appendix "A"

T - Trace

TABLE V111

ANALYSIS OF COMPOSITE

HARD MAPLE

		As Received	Dry
Moisture	%	7.62	0.00
Ash	%	4.09	4.43
Ultimate Analysis			
Carbon	%	46.56	50.40
Hydrogen	%	5.46	5.91
Nitrogen	%	0.45	0.49
Sulphur	%	T	T
Ash	%	4.09	4.43
Oxygen (by difference)	%	35.82	38.77

ASH FUSIBILITY - (Reducing Atmosphere)

Initial Deformation Temperature	°F	2650
Softening Temperature (Spherical)	°F	2820
" " (Hemispherical)	°F	—
Fluid Temperature	°F	2830

CHEMICAL ANALYSIS OF ASH - see Appendix "A"

T - Trace

TABLE 1X

ANALYSIS OF COMPOSITE

POPLAR & POPLAR ASPEN

		As Received	Dry
Moisture	%	6.50	0.00
Ash	%	3.19	3.41
Ultimate Analysis	%		
Carbon	%	48.44	51.81
Hydrogen	%	6.05	6.47
Nitrogen	%	0.23	0.25
Sulphur	%	T	T
Ash	%	3.19	3.41
Oxygen (by difference)	%	35.59	38.06

ASH FUSIBILITY - (Reducing Atmosphere)

Initial Deformation Temperature	^{o}F	2680
Softening Temperature (Spherical)	^{o}F	2800
" " (Hemispherical)	^{o}F	—
Fluid Temperature	^{o}F	2810

CHEMICAL ANALYSIS OF ASH - see Appendix "A"

T - Trace

TABLE X

ANALYSIS OF COMPOSITE

BLACK SPRUCE

	As Received	Dry
Moisture %	7.30	0.00
Ash %	2.21	2.38
Ultimate Analysis		
Carbon %	48.17	51.96
Hydrogen %	5.36	5.78
Nitrogen %	0.10	0.11
Sulphur %	T	T
Ash %	2.21	2.38
Oxygen % (by difference)	36.86	39.77

ASH FUSIBILITY - (Reducing Atmosphere)

Initial Deformation Temperature	°F	2710
Softening Temperature (Spherical)	°F	2720
" " (Hemispherical)	°F	—
Fluid Temperature	°F	2720+

CHEMICAL ANALYSIS OF ASH - see Appendix "A"

T - Trace

TABLE X1

ANALYSIS OF COMPOSITE

YELLOW BIRCH

	As Received	Dry
Moisture %	6.18	0.00
Ash %	2.19	2.33
Ultimate Analysis		
Carbon %	51.17	54.54
Hydrogen %	6.01	6.41
Nitrogen %	0.52	0.55
Sulphur %	T	T
Ash %	2.19	2.33
Oxygen % (by difference)	33.93	36.17

ASH FUSIBILITY - (Reducing Atmosphere)

Initial Deformation Temperature	°F	2730
Softening Temperature (Spherical)	°F	2740
" " (Hemispherical)	°F	—
Fluid Temperature	°F	2740

CHEMICAL ANALYSIS OF ASH - see Appendix "A"

T - Trace

TABLE X11

ANALYSIS OF COMPOSITE

WHITE BIRCH

		As Received	Dry
Moisture	%	5.53	0.00
Ash	%	1.65	1.75
Ultimate Analysis			
Carbon	%	54.21	57.38
Hydrogen	%	6.34	6.71
Nitrogen	%	0.25	0.26
Sulphur	%	T	T
Ash	%	1.65	1.75
Oxygen (by difference)	%	32.02	33.90

ASH FUSIBILITY - (Reducing Atmosphere)

Initial Deformation Temperature	^{o}F	2710
Softening Temperature (Spherical)	^{o}F	2720
" " (Hemispherical)	^{o}F	—
Fluid Temperature	^{o}F	2730

CHEMICAL ANALYSIS OF ASH - see Appendix "A"

T - Trace

TABLE X111

ANALYSIS OF COMPOSITE WHITE SPRUCE		As Received	Dry
Moisture	%	7.38	0.00
Ash	%	2.81	3.03
Ultimate Analysis			
Carbon	%	48.56	52.43
Hydrogen	%	5.96	6.43
Nitrogen	%	0.06	0.06
Sulphur	%	T	T
Ash	%	2.81	3.03
Oxygen (by difference)	%	35.23	38.05

ASH FUSIBILITY - (Reducing Atmosphere)

Initial Deformation Temperature	^{o}F	2700+
Softening Temperature (Spherical)	^{o}F	+
" " (Hemispherical)	^{o}F	-
Fluid Temperature	^{o}F	+

CHEMICAL ANALYSIS OF ASH - see Appendix "A"

T - Trace

APPENDIX "A"

ASH ANALYSIS

TABLE	V	VI	VII	VIII	IX
SiO2	15.95	7.64	24.61	9.46	1.50
Al2O3	6.34	0.00	1.77	3.83	0.46
Fe2O3	4.98	3.14	2.47	1.69	0.61
Mn3O4	1.64	2.04	2.60	0.98	0.30
TiO2	0.22	0.13	0.20	0.01	0.01
P2O5	2.76	2.23	4.56	1.08	1.98
CaO	51.56	58.44	43.22	55.52	62.28
MgO	5.51	4.65	2.22	19.40	1.89
SO3	2.60	1.34	2.74	1.41	0.59
Na2O	3.10	1.97	2.49	2.16	3.92
K2O	4.10	5.25	10.14	0.01	7.20

APPENDIX "A" (cont'd)

ASH ANALYSIS

TABLE	X	XI	XII	XIII	
SiO2	6.35	4.06	3.02	2.02	
Al2O3	1.12	0.27	0.00	0.00	
Fe2O3	1.12	0.79	2.86	0.74	
Mn3O4	2.23	1.33	4.63	1.16	
TiO2	0.01	0.02	0.01	0.02	
P2O5	2.21	3.30	2.90	2.57	
CaO	67.62	54.21	58.18	62.88	
MgO	1.73	5.44	4.15	6.43	
SO3	1.41	1.31	3.16	2.16	
Na2O	2.53	1.71	1.33	0.82	
K2O	6.24	7.99	6.58	7.25	