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SIGNIFICANT SHEET PROPERTIES FOR DEVELOPING SPECIFICATIONS

FOR VARIOUS PAPERS AND PAPERBOARDS

By

P. K. BAIRD
Senior Chemist

FOR PUBLICATION



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P. K. Baird², Senior Chemist

Forest Products Laboratory³, Forest Service,
U. S. Department of Agriculture

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INTRODUCTION

This report is an analytical summary of the returns from a questionnaire on the use requirements of papers and paperboards issued by the Technical Association of the Pulp and Paper Industry and the Forest Products Laboratory and sent to the manufacturers of these products. It is a reflection of the necessary properties as required by the users of paper and paperboard tempered with the point of view and experience of the manufacturers. In view of the present fragmentary knowledge of the significance of the various sheet properties relative to use, it is perhaps the most accurate source of these fundamental data available. Nothing better can be had except by direct use analysis.

¹ Presented at the fall meeting of the Technical Association of the Pulp and Paper Industry, Appleton, Wis., Sept. 26-28, 1933.

² Chairman, Use Requirements Committee, Technical Association of the Pulp and Paper Industry.

³ Maintained at Madison, Wisconsin, in cooperation with the University of Wisconsin.

The objectives of the Committee on Use Requirements of the Technical Association of the Pulp and Paper Industry are: (1) To delineate the general sheet properties of papers, (2) to determine these properties in order of importance for each kind of paper and paperboard, (3) to select (or to request development of by the proper committee, where not now available) a standard test method for each property, and (4) to set maximum and minimum values for each property for each specified paper, after having established approximate commercial values.

In compliance with the second objective of the research program of this committee, the writer as chairman of the committee, issued and received the returns of a questionnaire on the use analysis for fifty-four sheet properties as applied to about one-hundred grades of papers made in the United States and Canada. This report recommends action as to the proper order in which methods should be developed or perfected for use in writing specifications.

METHOD OF ATTACK

The following steps were taken in this study:

(1) A questionnaire, with instructions covering the fifty-four selected properties was circulated and the respondents were asked to rate these properties in order of importance for each of their products; (2) returns were classified as to classes and grades according to the outline given in "Classification and Definitions of Paper" 1928, p. 7, published by the Lockwood Trade Journal Company Inc., New York; (3) arbitrary values for unrated properties⁴ (respondents were asked to rate only those properties considered important in their product) were assigned, and the statistical means and ratings were selected for each grade; (4) all classes of papers were summarized for a grand rating for each property, pointing out the order of importance for the fifty-four fundamental and empirical sheet properties considered.

⁴ The rating value for all properties not reported by a respondent for any grade but reported by other respondents was arbitrarily set at the next higher numerical value above the highest reported by that respondent. This is not a precise method for getting the average above the lowest high rating for the class and it affects principally the properties of less importance. Exact values could only be obtained where all respondents rated all properties on all grades.

RESULTS

Returns were received from about 25 percent of the mills solicited, which is considered a good return and should be an excellent sample of the universe to be studied in the simple statistical manner set forth here. These results are confined to the relative ratings for each class and grade of paper covered in the survey.

The classes of papers analyzed, the number of properties rated out of the total, and the corresponding table numbers showing detailed rating follow:

<u>Class of paper</u>	<u>Properties rated No.</u>	<u>Table No.</u>
Absorbent	23	1
Boards	42	2
Building	25	3
Cardboard	27	4
Cover	17	5
News	31	6
Printing	36	7
Tissue	26	8
Wrapping	33	9
Bag	23	10
Writing	34	11
Specialties	34	12

Table 1.--Absorbent paper class

Grade ratings			Properties	Class		
Filter	Blotting	Towel		Total	Average	Rating
9	6		Thickness	29	9.7	15
3	5		Apparent density	22	7.3	3
		7	Bulk	30	10.0	17
			Footage			
		11	Sheetage	34	11.3	22
	7	9	Ream weight	27	9.0	9
8		12	Formation	32	10.7	20
		5	Color	28	9.3	12
		10	Finish	33	11.0	21
			Gloss			
			Two-sidedness			
			Opacity			
7	8	13	Cleanliness	28	9.3	13
		2	Tensile strength	25	8.3	6
6			Tearing strength	32	10.7	19
	10	3	Bursting strength	24	8.0	5
5			Folding strength	31	10.3	18
			Bending strength			
			Elongation at rupture			
4		4	Wet strength	20	6.7	2
			() strength			
			Elastic properties			
			Moisture content			
		1	Water absorbency	24	8.0	4
			Oil absorbency			
	4		Writing ink absorbency	29	9.7	14
	11		Printing ink absorbency	36	12.0	23
			Blood or fat absorbency			
			() absorbency			
10	9	8	Water penetration	27	9.0	10
			Turpentine penetration			
	2		Writing ink penetration	27	9.0	8
			Printing ink penetration			
			Water vapor penetration			
			() Vapor penetration			
	1		Ink wetability	26	8.7	7
1	3		Porosity	18	6.0	1
			Air resistance			
			Expansion (temperature)			
			Expansion (moisture)			
			Curl			
			Lignin content			
			Alpha cellulose			
2			Ash content	28	9.3	11
			Sized			
			Filled			
			Coated			
			Permanence			
			Electrical resistance			
			Heat insulation			
			Odor			
			Anti-tarnish			
			Erase resistance			
		6	Hardness	29	9.7	16

Table 2.--Paperboard class

Class ratings														Properties			Class				
White waxing cup	Mill blank	Can body	Oyster shell	Single lined net chip board	B.S.L. manila board	Straw-board	Anti-tarnish box	Packing board	Tubing	Test board	White dot, coated news	Wallboard	Solid news board	Manila-lined chip board	Liners	Folding board	Corrugating board	Plain chip board	Total	Average	Rating
3	1	1	3	1	1	1	2	1	1	8	4	4	4	2	2	2	1	1	48	2.5	1
11	4	1	1	3	1	2	2	2	2	16	16	16	16	12	12	15	15	17	185	9.7	15
5	2	3	12	3	2	2	3	2	2	6	14	22	3	2	6	4	10	12	199	10.6	17
2	5	3	11	5	2	2	4	3	5	6	9	17	6	3	18	11	2	14	183	9.6	11
2	5	3	11	5	2	2	4	3	5	6	9	17	6	3	18	11	2	14	197	10.4	13
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	172	8.1	2
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	108	5.7	2
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	256	13.5	36
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	259	13.5	40
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	221	11.6	3
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	168	8.8	10
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	181	9.5	10
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	172	9.1	5
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	148	7.8	5
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	259	13.5	41
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	248	13.1	21
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	199	10.9	14
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	170	8.9	7
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	246	12.9	29
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	250	13.2	34
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	232	12.2	23
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	202	10.5	16
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	247	13.0	30
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	226	11.9	21
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	240	12.6	26
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	244	12.8	28
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	247	12.8	27
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	257	13.5	39
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	228	12.0	22
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	213	11.2	18
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	223	11.7	20
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	249	13.6	43
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	248	13.5	35
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	249	13.5	35
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	257	13.5	35
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	257	13.5	35
11	3	7	10	2	4	4	2	2	2	7	17	23	1	6	11	5	8	10	253	12.3	34

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Table 3.--Building paper class

Grade ratings					Properties	Class		
Floor lining felt	Linoleum lining felt	Insulating board (heat)	Sheathing	Roofing felt		Total	Average	Rating
6	6	3	7	4	Thickness	26	5.2	3
		2		10	Apparent density	46	9.2	13
				15	Bulk	54	10.8	18
7	7		2	5	Footage	26	5.2	2
					Sheetage			
8	5		5	12	Ream weight	35	7.0	7
4	9			9	Formation	37	7.4	9
	10		6		Color	55	11.0	19
2	8		4	11	Finish	30	6.0	5
					Gloss			
				18	Two-sidedness	57	11.4	22
					Opacity			
					Cleanliness			
9	4			8	Tensile strength	36	7.2	8
				13	Tearing strength	52	10.4	16
3	3		3	1	Bursting strength	15	3.0	1
					Folding strength			
1				2	Bending strength	29	5.8	4
					Elongation at rupture ..			
					Wet strength			
	2				(Vertical) strength	51	10.2	15
					Elastic properties			
10		4	9	7	Moisture content	41	8.2	10
		1			Water absorbency	56	11.2	20
			1	3	Oil absorbency	33	6.6	6
					Writing ink absorbency..			
					Printing ink absorbency..			
					Blood or fat absorbency..			
12				16	(Asphalt) absorbency ...	54	10.8	17
	1				Water penetration	50	10.0	14
					Turpentine penetration..			
					Writing ink penetration..			
					Printing ink penetration..			
					Water vapor penetration..			
					() vapor penetration ..			
					Ink watability			
11				6	Porosity	43	8.6	11
					Air resistance			
					Expansion (temperature)..			
					Expansion (moisture) ...			
5				14	Curl	45	9.0	12
					Lignin content			
					Alpha cellulose			
				19	Ash content	58	11.6	24
			8		Sized	58	11.6	23
					Filled			
					Coated			
				17	Permanence	56	11.2	21
					Electrical resistance ..			
				20	Heat insulation	59	11.8	25
					Odor			
					Anti-tarnish			
					Erasure resistance			
					Hardness			

Table 4.--Cardboard class

Stencil	Playing card	Grade ratings					Properties	Class		
		Folding bristol	Mill bristol	Post card	Index bristol	Tag		Total	Average	Rating
3	3	2	1	3	7	1	Thickness	20	2.9	2
4	3					9	Apparent density	32	11.7	19
	2				8		Bulk	67	9.6	10
							Footage			
							Sheetage			
	17	4	3	4	4	4	Ream weight	42	6.0	4
	16				2	5	Formation	64	9.1	7
	4	5	2	7	6	12	Color	40	5.7	3
2	1	5	4	2	1	3	Finish	18	2.6	1
	5						Gloss	78	11.1	16
	7				3		Two-sidedness	67	9.6	11
	6						Opacity	79	11.3	17
	8		5	5	11	15	Cleanliness	62	8.9	6
					12		Tensile strength	87	12.4	24
	9	9	10	8	10	2	Tearing strength	66	9.4	3
		8	6		5	6	Bursting strength	48	6.9	5
		1			13	7	Folding strength	68	9.7	12
	10				9		Bending strength	76	10.9	15
							Elongation at rupture			
							Wet strength			
							() strength			
		10	11	6		8	Elastic properties	75	10.7	14
		11	9	9		10	Moisture content	79	11.3	13
							Water absorbency			
							Oil absorbency			
		7	8	1		11	Writing ink absorbency	67	9.6	9
	11	6	7			13	Printing ink absorbency	70	10.0	13
							Blood or fat absorbency			
							() absorbency			
1						14	Water penetration	84	12.0	20
							Turpentine penetration			
							Writing ink penetration			
5	12						Printing ink penetration	84	12.0	21
							Water vapor penetration			
							() vapor penetration			
							Ink wetability			
							Porosity			
							Air resistance			
							Expansion (temperature)			
							Expansion (moisture)			
	13						Curl	86	12.3	23
							Lignin content			
							Alpha cellulose			
	14				14		Ash content			
							Sized	85	12.1	22
							Filled			
	15						Coated	88	12.6	25
					15		Permanence	90	12.9	27
							Electrical resistance			
							Heat insulation			
							Odor			
							Anti-tarnish			
				10			Erasure resistance	90	12.9	26
							Hardness			

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Table 5.--Cover paper class

Grade ratings		Properties	Class		
Uncoated	Coated		Total	Average	Rating
6		Thickness	17	8.5	7
		Apparent density			
9		Bulk	20	10.0	11
		Footage			
		Sheetage			
3	3	Ream weight	6	3.0	3
10	8	Formation	18	9.0	8
1	4	Color	5	2.5	1
2	5	Finish	7	3.5	4
		Gloss			
12	7	Two-sidedness	19	9.5	9
		Opacity			
	6	Cleanliness	21	10.5	12
14		Tensile strength	25	12.5	17
8		Tearing strength	19	9.5	10
7	2	Bursting strength	9	4.5	5
4	1	Folding strength	5	2.5	2
13		Bending strength	24	12.0	15
		Elongation at rupture			
		Wet strength			
		() strength			
		Elastic properties			
	10	Moisture content	25	12.5	16
		Water absorbency			
		Oil absorbency			
		Writing ink absorbency			
11		Printing ink absorbency	22	11.0	13
		Blood or fat absorbency			
		() absorbency			
		Water penetration			
		Turpentine penetration			
		Writing ink penetration			
		Printing ink penetration			
		Water vapor penetration			
		() vapor penetration			
		Ink watability			
		Porosity			
		Air resistance			
		Expansion temperature			
		Expansion (moisture)			
		Curl			
		Lignin content			
		Alpha cellulose			
	9	Ash content	24	12.0	14
		Sized			
		Filled			
		Coated			
		Permanence			
		Electrical resistance			
		Heat insulation			
		Odor			
		Anti-tarnish			
		Erasure resistance			
5		Hardness	16	8.0	6

Table 6.--News class

Standard newsprint	Grade rating						Properties	Class		
	Tablet	Half-tone	Novel	Poster	Wall or hanging	Catalog		Total	Average	Rating
10	6						Thickness	73	10.4	15
26						8	Apparent density	82	11.7	18
17	5		1		5		Bulk	66	9.4	10
16							Footage	85	12.1	23
6	9	4	5	5	2	16	Sheetage			
2	11	1	5		6	6	Ream weight	47	6.7	5
3	2	2	2	1	1	4	Formation	38	5.4	2
1		3		2		5	Color	15	2.1	1
13						10	Finish	42	6.0	3
14			8		9		Gloss	71	10.1	13
8						3	Two-sidedness	81	11.6	17
4	8	5	7	4	4	13	Opacity	59	8.4	9
7						18	Cleanliness	45	6.4	4
20						15	Tensile strength	73	10.4	16
5	10	6	4	3	7	14	Tearing strength	83	11.9	19
21			3				Bursting strength	49	7.0	6
22							Folding strength	84	12.0	20
							Bending strength			
							Elongation at rupture	91	13.0	29
							Wet strength			
							() strength			
12	1				8		Elastic properties			
							Moisture content	68	9.7	11
							Water absorbency			
						11	Oil absorbency			
11		7				1	Writing ink absorbency	86	12.3	24
							Printing ink absorbency	56	8.0	7
							Blood or fat absorbency			
							() absorbency			
	4				3		Water penetration	89	12.7	28
							Turpentine penetration	88	12.6	27
						17	Writing ink penetration	92	13.1	30
9		8				2	Printing ink penetration	56	8.0	8
							Water vapor penetration			
							() vapor penetration			
15						9	Ink watability	72	10.3	14
18		9				7	Porosity	71	10.1	12
25	3						Air resistance	85	12.1	21
							Expansion (temperature)			
							Expansion (moisture)			
24						12	Curly	93	13.3	31
							Lignin content	87	12.4	26
23	7	10				20	Alpha cellulose			
							Ash content	85	12.1	22
							Sized			
							Filled			
							Coated			
							Permanence			
							Electrical resistance			
							Heat insulation			
							Odor			
							Anti-tarnish			
19						19	Erasure resistance			
							Hardness	86	12.3	25

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Table 7.--Print paper class

Grade ratings										Properties			Class	
Lithograph	S.O.	Diagram	English	Order	No. 2	No. 1	Rotogravure	Label	Offset	M.F. book	Total	Average	Rating	
9	17	14	3	14	7		9	16	17	13	183	13.1	20	
25	16							15	25	23	207	14.8	25	
17									21	9	176	12.6	15	
26	19	14					4	10	22	9	177	12.6	16	
12	14						3	17	5	3	98	7.0	3	
11	14						3	12	1	2	86	6.1	2	
14	15	15					3	13	1	2	50	1.6	1	
13	15	15					3	13	1	2	156	11.1	11	
11	15	15					3	13	1	2	165	11.1	12	
9	15	15					3	13	1	2	102	7.3	4	
11	15	15					3	13	1	2	129	9.2	4	
26	15	15					3	13	1	2	183	13.0	4	
27	15	15					3	13	1	2	129	9.2	4	
28	15	15					3	13	1	2	129	9.2	4	
30	15	15					3	13	1	2	129	9.2	4	
31	15	15					3	13	1	2	129	9.2	4	
32	15	15					3	13	1	2	129	9.2	4	
7	10	13					3	13	1	2	152	10.9	10	
12	10	13					3	13	1	2	188	13.4	22	
20	11	19					3	13	1	2	224	16.0	31	
5	11	19					3	13	1	2	107	7.6	5	
15	11	19					3	13	1	2	237	16.9	32	
15	11	19					3	13	1	2	207	14.8	26	
10	11	19					3	13	1	2	198	14.1	24	
16	12	12					3	13	1	2	218	15.6	29	
21	12	12					3	13	1	2	179	12.8	18	
21	12	12					3	13	1	2	159	11.4	12	
21	12	12					3	13	1	2	233	16.6	34	
22	12	12					3	13	1	2	151	10.8	9	
22	12	12					3	13	1	2	179	12.8	17	
22	12	12					3	13	1	2	210	15.0	27	
23	12	12					3	13	1	2	238	17.0	36	
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							3	13	1	2				
							3	13	1	2				
							3	13	1	2				
							3	13	1	2				
							3	13	1					

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Table 8.--Tissue paper class

Grade ratings								Properties	Class		
Fruit wrapper	Napkin tissue	Wrapping tissue	Carbon tissue	Crape tissue	Waxing tissue	Foil mounting	Toilet		Total	Average	Rating
						4		Thickness	79	9.9	14
							6	Apparent density			
								Bulk	81	10.1	18
								Footage			
6							10	Sheetage	77	9.6	12
5	5	5	3	7	2	8	13	Ream weight	48	6.0	5
10	6	2	1	5	3	2	7	Formation	37	4.6	2
3	1	1	0	4	3	7	2	Color	24	3.0	1
8	2	4	5	3	5	9	8	Finish	42	5.2	4
	3							Gloss	65	8.1	7
								Two-sidedness			
11	4		8	6		5	12	Opacity	80	10.0	16
1	8			2	1	12	3	Cleanliness	66	8.2	8
7							9	Tensile strength	39	4.9	3
2		3	7		6	10	4	Tearing strength	82	10.2	19
								Bursting strength	57	7.1	6
								Folding strength			
								Bending strength			
							11	Elongation at rupture			
								Wet strength	86	10.8	23
								() strength			
4								Elastic properties			
							3	Moisture content	79	9.9	15
9								Water absorbency	78	9.8	13
12								Oil absorbency	84	10.5	22
								Writing ink absorbency			
								Printing ink absorbency	87	10.9	26
								Blood or fat absorbency			
							5	() absorbency			
								Water penetration	80	10.0	17
								Turpentine penetration			
								Writing ink penetration			
								Printing ink penetration	84	10.5	21
								Water vapor penetration			
								() vapor penetration			
								Ink wettability			
	9			8		1		Porosity			
								Air resistance	68	8.5	9
								Expansion (temperature)			
							11	Expansion (moisture)			
								Curl	86	10.8	24
	12			11				Lignin content			
								Alpha cellulose	87	10.9	25
	7		2	9		13		Ash content			
								Sized	72	9.0	10
								Filled			
								Coated			
13	10			10				Permanence	83	10.4	20
								Electrical resistance			
								Heat insulation			
								Odor			
								Anti-tarnish			
								Erasure resistance			
11							1	Hardness	74	9.2	11

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Table 9.--Wrapping paper class

Grade ratings						Properties				Class		
Bogus packing	Boas paper wrapper	Carton wrapper	Manilla wrapper	Kraft coating	Waxed wrapper	Sulphite wrapping	Kraft wrapper	Bread wrapper	Butcher's wrapping	Total	Average	Rating
2				14		15				128	12.8	32
					1	8	15			120	12.0	18
										116	11.6	14
					8			13		125	12.5	32
1	2	12	6	11		10	16	7	6	74	7.4	12
3	4	5	4	10		11	8	5	14	83	8.3	8
	5	6	5	9		1	6	9	7	54	5.4	4
							1			111	11.1	13
										120	12.0	19
4		8	5	9		9	10	10		120	12.0	19
		10	11			9	11	11	5	74	7.4	8
						2	1			78	7.8	7
						3	1			27	2.7	1
						5	2			41	4.1	2
	5	4	3	2	5	4	17	12	9	89	8.9	9
										123	12.3	24
										124	12.4	29
										122	12.2	21
										124	12.4	27
		7			2			2		125	12.5	30
										117	11.7	17
										122	12.2	22
										123	12.3	25
			7			12	4		12	102	10.2	11
										123	12.3	26
							11			107	10.7	12
										121	12.1	20
					6	7	12	13	8	128	12.8	32
7							16			91	9.1	10
										116	11.6	15
1*		9	8	12		14	7	15	3	116	11.6	15
										116	11.6	16
							6		17	124	12.4	28

Table 10.--Bag paper class

Grade ratings					Properties	Class		
Flour sacks (kraft)	Kraft flour container	Flour sacks (rope)	Kraft	Cement		Total	Average	Rating
			13		Thickness			
	9		8	5	Apparent density	80	16.0	22
					Bulk	56	11.2	9
					Footage			
					Sheetage			
9	7	9	1	6	Ream weight	32	6.4	4
15	10	15	5	13	Formation	58	11.6	11
6		6	14	7	Color	46	9.2	8
11		11	12	15	Finish	62	12.4	14
12		12			Gloss	74	14.8	18
					Two-sidedness			
					Opacity			
13		13	11	9	Cleanliness	59	11.8	12
2	2	1	4	2	Tensile strength	11	2.2	2
3	3	2	2	1	Tearing strength	11	2.2	1
4	4	3	3	4	Bursting strength	18	3.6	3
5	5	4	10	10	Folding strength	34	6.8	5
					Bending strength			
16	6	16	7	11	Elongation at rupture	56	11.2	10
				19	Wet strength	83	16.6	23
					() strength			
			6	8	Elastic properties			
					Moisture content	61	12.2	13
					Water absorbency			
					Oil absorbency			
					Writing ink absorbency			
					Printing ink absorbency			
					Blood or fat absorbency			
					() absorbency			
			9	12	Water penetration	68	13.6	16
					Turpentine penetration			
					Writing ink penetration			
					Printing ink penetration			
					Water vapor penetration			
					() vapor penetration			
					Ink wetability			
7	8	7	16	3	Porosity	41	8.2	7
					Air resistance			
					Expansion (temperature)			
					Expansion (moisture)			
			15	14	Curl	76	15.2	20
					Lignin content			
					Alpha cellulose			
	11			16	Ash content			
					Sized	78	15.6	21
8		8			Filled			
14	12	14		18	Coated	66	13.2	15
					Permanence	75	15.0	19
					Electrical resistance			
10		10			Heat insulation			
					Odor	70	14.0	17
					Anti-tarnish			
1	1	5		17	Erasure resistance			
					Hardness	41	8.2	6

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Table 12.---Specialties class

Cigarette	Carpet	Tape (Telegraph)	Grade ratings				Properties	Class		Rating
			Envelope	Blueprint	Imitation parchment	Folder		Total	Average	
5			22				Thickness	76	9.5	20
							Apparent density	73	9.1	15
							Bulk	76	9.5	19
4			13	1	7	7	Footage			
			10			4	Sheetage	54	6.8	8
	2		10				Ream weight	48	6.0	7
			10				Formation	45	6.6	9
			10				Color	44	6.5	7
			10				Finish	44	6.5	7
			10				Close	44	6.5	7
			10				Two-sidedness	77	9.1	16
			10				Opacity	73	9.5	19
2			10				Cleanliness	40	5.1	6
			10				Tensile strength	41	5.1	6
			10				Tearing strength	66	8.2	10
			10				Bursting strength	45	6.3	5
10			10				Folding strength	52	6.5	7
			10				Bending strength	44	6.5	7
			10				Elongation at rupture	76	9.5	25
			10				Wet strength	76	9.5	18
11			10				() strength	82	10.2	30
			10				Elastic properties			
			10				Moisture content	76	9.5	22
			10				Water absorbency	78	8.8	26
			10				Oil absorbency	83	10.4	32
			10				Writing ink absorbency	82	10.2	29
			10				Printing ink absorbency			
			10				Blood or fat absorbency			
			10				() absorbency			
			10				Water penetration	76	9.5	21
			10				Turpentine penetration			
			10				Writing ink penetration	67	8.4	11
			10				Printing ink penetration	68	8.5	13
			10				Water vapor penetration			
			10				() vapor penetration			
			10				Ink wettability			
6			10				Porosity	77	9.6	23
			10				Air resistance			
			10				Expansion (temperature)			
			10				Expansion (moisture)	72	9.0	14
			10				Curl	68	8.5	12
			10				Lignin content			
			10				Alpha cellulose			
8			10				Ash content	79	9.9	27
			10				Sized	74	9.2	17
			10				Coated			
			10				Permanence	83	10.4	33
			10				Electrical resistance			
			10				Heat insulation			
12			10				Odor (burning)	83	10.4	34
			10				Anti-tarnish			
			10				Erasure resistance	80	10.0	28
			10				Hardness	82	10.2	31

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Table 13.--Grand ratings of sheet properties for all papers

Absorbent (Table 1)	Board (Table 2)	Building (Table 3)	Cardboard (Table 4)	Cover (Table 5)	Class ratings				Properties				All papers	
					News (Table 6)	Printing (Table 7)	Tissue (Table 8)	Wrapping (Table 9)	Base (Table 10)	Writings (Table 11)	Special- ties (Table 12)	Total	Average	Grand Rating
15	12	13	2	7	15	20	14	33	22	23	20	177	14.8	11
17	15	18	10	11	18	15	18	14	9	28	15	218	18.2	13
19	17	20	12	12	20	17	20	15	19	15	19	171	14.2	10
21	19	22	14	13	22	19	22	17	21	17	21	301	25.1	32
23	21	24	16	14	24	21	24	19	23	19	23	300	25.0	31
25	23	26	18	15	26	23	26	21	25	21	25	86	7.2	2
27	25	28	20	16	28	25	28	23	27	23	27	87	7.2	2
29	27	30	22	17	30	27	30	25	29	25	29	62	5.2	5
31	29	32	24	18	32	29	32	27	31	27	31	62	5.2	5
33	31	34	26	19	34	31	34	29	33	29	33	235	19.6	20
35	33	36	28	20	36	33	36	31	35	31	35	243	19.6	20
37	35	38	30	21	38	35	38	33	37	33	37	243	19.6	20
39	37	40	32	22	40	37	40	35	39	35	39	243	19.6	20
41	39	42	34	23	42	39	42	37	41	37	41	243	19.6	20
43	41	44	36	24	44	41	44	39	43	39	43	243	19.6	20
45	43	46	38	25	46	43	46	41	45	41	45	243	19.6	20
47	45	48	40	26	48	45	48	43	47	43	47	243	19.6	20
49	47	50	42	27	50	47	50	45	49	45	49	243	19.6	20
51	49	52	44	28	52	49	52	47	51	47	51	243	19.6	20
53	51	54	46	29	54	51	54	49	53	49	53	243	19.6	20
55	53	56	48	30	56	53	56	51	55	51	55	243	19.6	20
57	55	58	50	31	58	55	58	53	57	53	57	243	19.6	20
59	57	60	52	32	60	57	60	55	59	55	59	243	19.6	20
61	59	62	54	33	62	59	62	57	61	57	61	243	19.6	20
63	61	64	56	34	64	61	64	59	63	59	63	243	19.6	20
65	63	66	58	35	66	63	66	61	65	61	65	243	19.6	20
67	65	68	60	36	68	65	68	63	67	63	67	243	19.6	20
69	67	70	62	37	70	67	70	65	69	65	69	243	19.6	20
71	69	72	64	38	72	69	72	67	71	67	71	243	19.6	20
73	71	74	66	39	74	71	74	69	73	69	73	243	19.6	20
75	73	76	68	40	76	73	76	71	75	71	75	243	19.6	20
77	75	78	70	41	78	75	78	73	77	73	77	243	19.6	20
79	77	80	72	42	80	77	80	75	79	75	79	243	19.6	20
81	79	82	74	43	82	79	82	77	81	77	81	243	19.6	20
83	81	84	76	44	84	81	84	79	83	79	83	243	19.6	20
85	83	86	78	45	86	83	86	81	85	81	85	243	19.6	20
87	85	88	80	46	88	85	88	83	87	83	87	243	19.6	20
89	87	90	82	47	90	87	90	85	89	85	89	243	19.6	20
91	89	92	84	48	92	89	92	87	91	87	91	243	19.6	20
93	91	94	86	49	94	91	94	89	93	89	93	243	19.6	20
95	93	96	88	50	96	93	96	91	95	91	95	243	19.6	20
97	95	98	90	51	98	95	98	93	97	93	97	243	19.6	20
99	97	100	92	52	100	97	100	95	99	95	99	243	19.6	20
101	99	102	94	53	102	99	102	97	101	97	101	243	19.6	20
103	101	104	96	54	104	101	104	99	103	99	103	243	19.6	20
105	103	106	98	55	106	103	106	101	105	101	105	243	19.6	20
107	105	108	100	56	108	105	108	103	107	103	107	243	19.6	20
109	107	110	102	57	110	107	110	105	109	105	109	243	19.6	20
111	109	112	104	58	112	109	112	107	111	107	111	243	19.6	20
113	111	114	106	59	114	111	114	109	113	109	113	243	19.6	20
115	113	116	108	60	116	113	116	111	115	111	115	243	19.6	20
117	115	118	110	61	118	115	118	113	117	113	117	243	19.6	20
119	117	120	112	62	120	117	120	115	119	115	119	243	19.6	20
121	119	122	114	63	122	119	122	117	121	117	121	243	19.6	20
123	121	124	116	64	124	121	124	119	123	119	123	243	19.6	20
125	123	126	118	65	126	123	126	121	125	121	125	243	19.6	20
127	125	128	120	66	128	125	128	123	127	123	127	243	19.6	20
129	127	130	122	67	130	127	130	125	129	125	129	243	19.6	20
131	129	132	124	68	132	129	132	127	131	127	131	243	19.6	20
133	131	134	126	69	134	131	134	129	133	129	133	243	19.6	20
135	133	136	128	70	136	133	136	131	135	131	135	243	19.6	20
137	135	138	130	71	138	135	138	133	137	133	137	243	19.6	20
139	137	140	132	72	140	137	140	135	139	135	139	243	19.6	20
141	139	142	134	73	142	139	142	137	141	137	141	243	19.6	20
143	141	144	136	74	144	141	144	139	143	139	143	243	19.6	20
145	143	146	138	75	146	143	146	141	145	141	145	243	19.6	20
147	145	148	140	76	148	145	148	143	147	143	147	243	19.6	20
149	147	150	142	77	150	147	150	145	149	145	149	243	19.6	20
151	149	152	144	78	152	149	152	147	151	147	151	243	19.6	20
153	151	154	146	79	154	151	154	149	153	149	153	243	19.6	20
155	153	156	148	80	156	153	156	151	155	151	155	243	19.6	20
157	155	158	150	81	158	155	158	153	157	153	157	243	19.6	20
159	157	160	152	82	160	157	160	155	159	155	159	243	19.6	20
161	159	162	154	83	162	159	162	157	161	157	161	243	19.6	20
163	161	164	156	84	164	161	164	159	163	159	163	243	19.6	20
165	163	166	158	85	166	163	166	161	165	161	165	243	19.6	20
167	165	168	160	86	168	165	168	163	167	163	167	243	19.6	20
169	167	170	162	87	170	167	170	165	169	165	169	243	19.6	20
171	169	172	164	88	172	169	172	167	171	167	171	243	19.6	20
173	171	174	166	89	174	171	174	169	173	169	173	243	19.6	20
175	173	176	168	90	176	173	176	171	175	171	175	243	19.6	20
177	175	178	170	91	178	175	178	173	177	173	177	243	19.6	20
179	177	180	172	92	180	177	180	175	179	175	179	243	19.6	20
181	179	182	174	93	182	179	182	177	181	177	181	243	19.6	20
183	181	184	176	94	184	181	184	179	183	179	183	243	19.6	20
185	183	186	178	95	186	183	186	181	185	181	185	243	19.6	20
187	185	188	180	96	188	185	188	183	187	183	187	243	19.6	20
189	187	190	182	97	190	187	190	185	189	185	189	243	19.6	20
191	189	192	184	98	192	189	192	187	191	187	191	243	19.6	20
193	191	194	186	99	194	191	194	189	193	189	193	243	19.6	20
195	193	196	188	100	196	193	196	191	195	191	195	243	19.6	20
197	195	198	190	101	198	195	198	193	197	193	197	243	19.6	20
199	197	200	192	102	200	197	200	195	199	195	199	243	19.6	20
201	199	202	194	103	202	199	202	197	201	197	201	243	19.6	20
203	201	204	196	104	204	201	204	199	203	199	203	243	19.6	20
205	203	206	198	105	206	203	206	201	205	201	205	243	19.6	20
207	205	208	200	106	208	205	208	203	207	203	207	243	19.6	20
209	207	210	202	107	210	207	210	205	209	205	209	243	19.6	20
211	209	212	204	108	212	209	212	207	211	207	211	243	19.6	20
213	211	214	206											

For the present purposes, no weighting of averages for grades or classes has been attempted. At some future time it might be advisable to weight the various averages for a grade or class by any or all of several methods, such as tonnage, number of mills, number of significant properties controlled or number of respondents depending upon the particular purpose of the analysis. It is questionable, however, whether the conclusions for weighted averages would be greatly altered from those obtained from the present statistical analysis of the sample at hand. An entirely comprehensive analysis, of course, would be possible only with complete returns on all properties for all grades and classes by all manufacturers. Even with such treatment of the problem the same general order of significant properties would no doubt be obtained, and, consequently, would not greatly change the sequence of developing the desired test methods -- the basic purpose of the survey.

The rating for properties of specialties (table 12) was arbitrarily assigned in order to complete the grand ratings of properties. The rating therefore has no particular significance because the various grades included are unrelated in their use requirements.

An average of 29 properties out of a total of 54 were rated when all papers are considered.

The average class figures are put adjacent to the class ratings because occasionally two or more steps in ratings may differ but slightly in average values and again they may differ very significantly.

Detailed inferences and differences of the various grades and classes will not be attempted in this paper but will be left for the reader's individual study. By way of illustration, the relative rating for the various sheet properties of standard newsprint are as follows:

1. Finish
2. Formation
3. Color
4. Cleanliness
5. Bursting strength
6. Ream weight
7. Tensile strength
8. Opacity
9. Printing ink penetration
10. Thickness

In table 13 the grand ratings are given for all properties as applied to all classes and grades. The first twenty significant properties follow in order of their importance:

- | | |
|----------------------|------------------------------|
| 1. Finish | 11. Thickness |
| 2. Color | 12. Moisture content |
| 3. Bursting strength | 13. Apparent density |
| 4. Ream weight | 14. Opacity |
| 5. Formation | 15. Porosity |
| 6. Cleanliness | 16. Sizing |
| 7. Tearing strength | 17. Water penetration |
| 8. Folding strength | 18. Printing ink penetration |
| 9. Tensile strength | 19. Hardness |
| 10. Bulk | 20. Gloss |

CONCLUSIONS

An analysis of a survey on the use requirements of papers as expressed in sheet properties indicated:

1. The specific properties considered of importance in setting proximate specifications for each class and grade of paper.

2. The order of importance or rating for each of the selected properties for each grade and class.

3. The grand order of importance or rating for each property as related to papers and paperboards (all classes as a group).

RECOMMENDATIONS

These data indicate which standard test methods should be perfected first in order to expedite the establishment of proximate specifications of papers and paperboards according to the third general objective of the program of the Technical Association of the Pulp and Paper Industry.

Specifically, it is here recommended that standard test methods be perfected for the sheet properties in the order shown in the grand ratings for all classes. Test methods for ten of the first twenty properties listed are or could easily be put into tentative standard form. It is after the first twenty properties, in general, that unusual properties to meet special requirements of use enter into a sheet of paper. Therefore, in all probability it will never be necessary to specify more than twenty properties for proximate specifications unless a completely specified sheet is desired for a very special purpose.