

15th EDITION

TITANIUM DIOXIDE COMPETITIVE QUALITY

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TITANIUM DIOXIDE: COMPETITIVE QUALITY

Averaged competitive pigment quality data for domestic and selected foreign titanium dioxides are presented in the following form:

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These tables are guides to normally-expected quality relationships of competitive products to their approximate Ti-Pure® titanium dioxide counterparts. Any particular code has a range of quality that depends on the test system; consequently, results of specific determinations may not always agree with our averaged results.

Miscellaneous information, such as ASTM Specifications and key laboratory contacts, is listed on pages 32 and 33.

CHALK-RESISTANT GRADES

Table I shows that Ti-Pure®, titanium dioxide, R-950 is outstanding in chalk resistance. Tronox® CH-822 and Zepaque® RGL-6 are comparable.

Among the various chalk resistant competitive grades we see evidence of various package codes similar to our own. Values listed in these tables are average data.

Low Shear Dispersion Ratings (Condes Type Equipment)

Excellent - can be dispersed under less than optimum conditions
 Good - can be dispersed under optimum conditions
 Fair - difficult to disperse even at optimum conditions
 Poor - not suitable for this type of equipment

Chalk Resistance Ratings are based on the following

<u>Description</u>	<u>Rating*</u>
Excellent	Better than 28
Very Good	20-28
Good	15-19
Fair	10-15
Poor	Less than 10

*Standard chalk fade data (10/20 scale) in air dry alkyl

TABLE 1: CHALK-RESISTANT PAINT GRADES

Grade	30J Gloss	HP-1	Dispersion ²	Chalk Resistance ²	Carbon ³	Undercoat	% Tint ²
TI-Pure® R-950(01)	18	91	Excellent	Excellent	<0.06	11	89
TI-Pure® R-950(08)	17	91	Good	Excellent	<0.06	11	89
TI-Pure® R-950(09)	17	91	Excellent	Excellent	<0.06	11	89
TI-Pure® R-950(18)	17	91	Excellent	Excellent	<0.06	11	89
TI-Pure® R-950(19)	17	91	Excellent	Excellent	<0.06	11	89
TI-Pure® R-950(48)	17	91	Excellent	Excellent	0.13	11	89
TI-Pure® R-902(01)	17	94	Good	Very Good	<0.06	12	90
TI-Pure® R-902(08)	17	94	Excellent	Very Good	<0.06	12	90
TI-Pure® R-902(18)	16	94	Excellent	Very Good	0.17	12	90
TI-Pure® R-902(28)	17	94	Good-Excellent	Very Good	<0.06	12	90
TI-Pure® R-902(48)	16	—	Good	—	0.14	11	90
Titanox® 2101	20	93	Good-Excellent	Very Good	0.23	12	91
Titanox® 2160	16	96	Excellent	—	0.05	12	89
Unitane® R-650	17	87	Good	Very Good	0.15	11	93
Unitane® CR-500	15	97	Good-Excellent	Good	0.10	12	96
Zepaque® RCL-2	15	92	Good	Very Good	<0.06	11	91
Zepaque® RCL-6	18	90	Excellent	Excellent	<0.06	10	89
House Heat® R-760	20	91	Good	Good	0.34	9	94
Troxol® CR-822	15	90	Good	Excellent	0.16	14	92
Rand® RC-576	23	92	—	Very Good	<0.06	12	90
Tioxide® RCR-6	14	96	Good	—	<0.06	13	92
Tioxide® RCR-3	16	97	Good	Good	0.11	12	94
Tioxide® RCR-7	18	92	Excellent	Good	0.14	12	92
Tioxide® RCR-6	17	—	Fair	—	—	13	—
Tioxide® RCR-2	18	99	Excellent	Good	0.14	11	93

1. Alkali (architectural) enamel hiding power at 15% PVC (R-900-100).

2. See page 2 for description of ratings.

3. Pigments analyzing 0.06% or less are not normally considered organically treated.

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CHALK-RESISTANT GRADES
IN TRADE SALES EMULSION PAINTS

- TM-Purce R-902 and R-960 are comparable in hiding power and tinting strength in emulsion systems.
- For exterior gloss market, R-902 and R-960, package codes 08 and 48, should be promoted versus the high gloss competitors.
- R-942 provides comparable high gloss levels for slurry users.

TABLE 1a: CHALK-RESISTANT GRADES IN TRADE SALES EMULSION PAINTS

Grade	Exterior Gloss Trim ¹			Exterior Flat ²		
	H.P.	T.S.	Gloss	H.P.	T.S.	Gloss
TI-Pure® R-902(01)	100	100	49	100	100	
TI-Pure® R-902(03)	97	98	61	100	103	
TI-Pure® R-902(13)	97	98	48	98	99	
TI-Pure® R-902(23)	98	98	48	98	99	
TI-Pure® R-902(33)	100	105	58	100	100	
TI-Pure® R-902(43)	100	100	58	98	102	
TI-Pure® R-902 (slurry)	96	103	41	98	103	
TI-Pure® R-960(01)	98	96	61	98	103	
TI-Pure® R-960(08)	97	96	61	99	98	
TI-Pure® R-960(09)	95	99	46	99	98	
TI-Pure® R-960(23)	99	104	58	99	99	
TI-Pure® R-960(43)	102	100	46	99	99	
Tibonox® 2101	-	-	-	-	-	
Tibonox® 2160	100	100	63	102	102	
Ultimate® CR-500	95	93	58	94	99	
Ultimate® CR-550	-	-	-	-	-	
Ultimate® UIR-506	98	96	48	97	99	
Trenox® CR-822	-	-	-	-	-	
Trenox® CR-822-S	-	-	-	-	-	
Zopaque® RCL-2	-	-	54	102	101	
Zopaque® RCL-6	-	-	51	102	105	
Zopaque® RCL-2	-	-	45	-	-	
Horis Heat® R-760	99	99	39	98	99	
Flonide® RCR-2	-	-	-	98	101	
Flonide® RCR-3	-	-	-	98	99	

1. Exterior Acrylic Emulsion Gloss Trim, 235 FPG, 2.75 lbs., TSP/gal., R-902(01) = 100
 2. Exterior Acrylic Emulsion Flat, 105 FPG, 2.5/2.0 TSP/gal. (lbs./gal.), R-902(01) = 100
 3. Higher Number = Higher T.S.

INDUSTRIAL AND TRADE SALES ENAMEL GRADES

Data in Table II show that:

- Ti-Pure® R-900 is still our best offering for this segment of the market.
- Of the domestic products Tronox® CR-800, Unitane® CR-580, Titanox® 2020 and 2090, and Zepaque® RCL-9 compete successfully with R-900.
- Samples of Tioxide® RHD6U we have evaluated indicate it is an R-900(48) counterpart.
- Among the various competitive grades used in enamel systems we see evidence of package codes similar to our own. Values listed in these tables are average data.

TABLE II: INDUSTRIAL AND TRADE SALES PIGMENT GRUDES

Grades	O.A.	301 Gloss	HP ¹	Dispersion ²	Chalk Resistance	Carbon %	Undertone	% TDS
TI-Pure® R-900(01)	16	71	100	Good	Pair	<0.05	12	94
TI-Pure® R-900(08)	15	76	100	Good	Pair	<0.05	12	94
TI-Pure® R-900(18)	15	77	100	Excellent	Pair	0.11	12	94
TI-Pure® R-900(19)	15	77	100	Good	Pair	<0.05	12	94
TI-Pure® R-900(28)	16	71	100	Excellent	Pair	<0.05	12	94
TI-Pure® R-900(48)	15	78	100	Good	Pair	0.11	12	94
TI-Pure® R-902(01)**	17	67	94	Good	Very Good	<0.05	12	90
Titanone 2020	14	75	102	Excellent	Pair	0.20	14	95
Titanone 2050 (R4-50)	15	73	101	Excellent	Pair	0.24	13	94
Unitane® CR-550	17	79	99	Excellent	Poor	0.13	13	96
Unitane® CR-600	15	73	97	Good-Excellent	Good	0.10	12	96
Troxone® CR-800	15	71	102	Excellent	Pair	0.19	15	96
Zonaque® RCL-9	15	70	98	Good-Excellent	Pair	<0.05	13	95
Horesa Hexa® HX-30	16	75	97	Good-Excellent	Pair	0.22	11	94
Flonidex R-105	13	76	95	—	Good	<0.05	10	95
Flonidex R-403	17	78	100	Excellent	Poor	0.13	12	95
Flonidex R-4060	16	82	100	Excellent	Pair	0.19	14	94
Titantrone® TR-48	20	74	100	Good-Excellent	—	0.17	13	94

1. Architectural R.F., 165 PW, R-900-100

2. See page 2 for description of ratings.

3. Pigments analyzing 0.055 carbon or less are not normally considered organic treated.

** See Table I for properties of other TI-Pure® R-902 pigments codes.

ENAMEL GRADES IN TRADE SALES EMULSION PAINTS

- Unlike the alkyl systems, Ti-Pure® R-900, R-902, and R-960 show minimal differences in hiding power and tinting strength in emulsion systems. The optical data in Table IIIa and in Table Ia are on the same numerical basis.
- Ti-Pure® R-940 and R-942 are comparable in emulsion gloss to their respective 08 and 48 package codes.

TABLE 11a: FINISH GRADES IN TRADE SALES EMISSION PAINTS

Grade	Interior Gloss Enamel			Exterior Gloss Trim			Exterior Flat		
	H.P.	T.S.	Gloss	H.P.	T.S.	Gloss	H.P.	T.S.	
TI-Pure® R-900(01)	100	100	70	100	100	60	100	100	
TI-Pure® R-900(08)	97	97	78	100	100	68	99	102	
TI-Pure® R-900(18)	98	100	60	100	101	60	103	100	
TI-Pure® R-900(28)	100	100	61	103	101	58	-	-	
TI-Pure® R-900(48)	100	100	78	100	100	68	-	-	
TI-Pure® R-902(01)	102	101	55	102	103	54	102	101	
TI-Pure® R-940 (slurry)	100	100	77	100	100	67	100	100	
TI-Pure® R-942 (slurry)	102	101	60	102	103	56	102	101	
Titanox® 2020	96	100	78	100	97	62	103	99	
Titanox® 2090	94	96	66	-	-	-	100	99	
Unitane® CR-580	99	100	78	98	99	67	104	98	
Unitane® CR-600	101	101	76	102	100	62	107	101	
Unitane® IIR-606	101	101	68	-	-	-	-	-	
Treose® CR-800	100	99	75	100	99	60	106	98	
Treose® CR-805	98	100	67	-	-	-	-	-	
Zepaque® HCL-5	101	101	58	100	97	52	98	98	
Zepaque® HCL-9	99	101	67	-	-	-	-	-	
Horse Head® HR-30	95	101	68	98	97	56	103	98	
Horse Head® HR-40	97	100	65	103	102	44	-	-	
Toxide® RHD50	100	102	74	100	97	67	104	98	

1. Interior Acrylic Enamel Gloss Enamel, 22.8% PVC, 2.7 lbs. TiO₂/gal., R-900(01) = 1002. Exterior Acrylic Enamel Gloss Trim, 23% PVC, 2.75 lbs. TiO₂/gal., R-900(01) = 1003. Exterior Acrylic Enamel Flat, 40% PVC, 2.5/2.0 TiO₂/Galo (lbs./gal.), R-900(01) = 100

4. Higher Number = Higher T.S.

WATERBORNE INDUSTRIAL FINISH GRADES

Data in Table IIB show:

- In acrylic solution vehicles, hiding power decreases with amount of surface-oxide treatment on the rutile grade; the reverse is true in polyester solution vehicles.
- Enamel grades (R-900, R-902, and R-960 types) all show similar gloss behavior in a given vehicle system.
- Unitane® CR-600, Zopaque® RCL-9, and Tronox® CR-800 are among the best competitive grades in the R-900/R-902 category.
- Standard quality (OI package code) Ti-Pure® grades perform well.
- Use of Ti-Pure® slurry grades generally provides hiding power equivalent to that obtained from corresponding dry Ti-Pure® grades, but gloss may be different, depending on the vehicle system.

Other important points to keep in mind:

- All waterborne vehicle systems within a given polymer type are not equivalent, so Table IIB should be considered only a guide. Changing vehicles may affect hiding power, gloss, and dispersibility more than changing pigments (among the enamel grades).
- Outdoor exposure information indicates that chalk-resistance of rutile grades in waterborne industrial systems parallels that shown in trade sales or conventional solventborne industrial vehicles.

TABLE 1B: WATERFIRE INDUSTRIAL FINISH GRADES

Grade	Aqueous Solution Vehicle ¹			Polyester Solution Vehicle ²			
	R.P.	SP	Description ³	R.P.	SP	Description ³	
Ti-Pure® R-900-01	101	95	87	74	89	75	excellent
Ti-Pure® R-900-02				71	89	75	excellent
Ti-Pure® R-900-08				73	88	76	excellent
Ti-Pure® R-900-13	98	93	82	78	88	74	poor
Ti-Pure® R-900-48	100	96	87	78	88	74	poor
Ti-Pure® R-900-48 (slurry)	99	90	75	74	98	87	-
Titanox® 2020	96	96	90	75	88	76	excellent
Titanox® 2090				75	88	76	excellent
Zonyl® RZ-9	97	94	87	74	91	79	excellent
Titanox® CR-800	99	96	85	73	93	80	excellent
Titanox® CR-800	103	96	91	75	89	78	excellent
Titanox® CR-850				72	87	52	excellent
Ti-Pure® R-902-01	97	96	86	78	91	78	excellent
Ti-Pure® R-902-13				78	92	78	excellent
Ti-Pure® R-902-13 (slurry)	94	95	81	82	81	64	excellent
Ti-Pure® R-902 (slurry)	97	94	82	82	81	64	excellent
Ti-Pure® R-900-48	93	95	83	80	91	78	excellent
Ti-Pure® R-931-01				88	92	77	excellent
Ti-Pure® R-931-26	91	81	53	88	92	77	excellent
Ti-Pure® R-941 (slurry)	91	72	20	-	-	-	-
Titanox® CR-772	88	78	40	85	78	41	-
Titanox® CR-911				-	-	-	-

1. Avolon® 557, Ashland Chemical Company.

2. Cyplet® 1600, American Cyanamid Company.

3. See page 2 for description of ratings (Low Shear Dispersion Ratings (Toolbox-Type Equipment)).

HIGH PVC FLAT PAINT GRADES

Data in Table III show:

- Ti-Pure® R-931 is our best offering for this segment of the market. Package Code 26 (102 min. Tinting Strength) should show equal performance to the best dry competitive samples we have evaluated. Package Code 01 (96 min. Tinting Strength) compares favorably with average competitive performance.
- Unitars® CR-573, Tronox® CR-813, Titanox® 2131, and Zepaque® RCL-3 also show excellent properties and average 2-4 points higher CEU than R-931. For customers preferring bluer undertone, Ti-Pure® R-933 should be promoted.
- These tables are guides to normally expected quality relationships of competitive products to their approximate Ti-Pure® titanium dioxide counterparts. Any particular code has a range of quality that depends on the test system; consequently, results of specific determinations may not always agree with our averaged results.

NOTE: The tendency of these highly treated pigment grades to lose hiding power when dispersed under severe conditions should be taken into consideration when discussing these data. We feel that the results here represent the maximum obtainable values under ideal dispersed conditions. Pigments with similar treatment levels are subject to similar changes in hiding; however, surfactant and fluid demand of the specific pigment involved are the critical parameters.

TABLE III: HIGH P.V.C. PLAST PAINT GRADINGS

Grade	O.A.	SP ¹	TS ⁴	Film Properties	Chalk Resistance	Carbon ²	Understone	Y T ₁₀₂
Ti-Pure® R-901	28	88	88	Standard	Pair	<0.06	8	85
Ti-Pure® R-931	35	100	100	Minus	Good	<0.06	6	80
Ti-Pure® R-933	36	101	101	Minus	Good	<0.06	9	79
Ti-Pure® R-941 (slurry)	—	100	100	Minus	—	—	6	64(3)
Ti-Pure® R-943 (slurry)	—	101	101	Minus	—	—	9	64(3)
Titanox® 2030 (R-47)	22	88	87	SI -	Pair	0.12	10	83
Titanox® 2131	35	100	99	Minus	Good	0.04	9	81
Unitane® CR-560	28	86	86	"	Good	0.29	12	89
Unitane® CR-572	30	98	99	Minus	Good	0.20	9	84
Unitane® CR-573	29	97	96	Minus	Good	0.23	10	84
Unitane® CR-576	—	—	—	—	—	—	—	65(3)
Tromox® CR-801	28	87	83	SI -	Good	0.01	13	93
Tromox® CR-812	30	90	89	Cons -	Good	0.01	12	89
Tromox® CR-813	33	101	100	Minus	Good	0.03	12	86
Tromox® CR-823	32	97	94	—	Good	0.02	11	88
Tromox® CR-813-S	—	—	—	—	—	—	—	63(3)
Zopaque® RZ-7	27	87	86	"	Good	0.02	10	90
Zopaque® RZ-3	35	101	102	Minus	Good	0.04	8	82
Zopaque® RZ-3	—	104	100	Minus	—	—	10	65(3)
Horse Head® HF-31	30	90	89	"	Good	0.05	9	83
Horse Head® HF-771	35	97	97	Minus	Good	0.26	7	84
Horse Head® HF-41	—	—	—	—	—	—	—	84(3)
Flonides® F-1D-4	28	98	96	Cons -	Pair	<0.06	7	88
Flonides® F-1L	36	108	108	Minus	Pair	0.02	7	83
Titanox® R-75	37	—	103	Minus	—	0.03	8	83

1. SP, TS, and Film properties determined in a 50% PVC, 2.5 lbs. KDG/gal. Interior flat testing formula.

(R-931, L-678 = 100)

2. Pigments analyzing 0.06% carbon or less are not normally considered organic treated.

3. Percent carbon, in slurry.

4. Higher number - higher film.

PLASTIC GRADES

Ti-Pure® TiO₂ performance in Plastics is dependent upon the system in which it is used. We can take maximum advantage of this by remembering the following:

1. In Vinyl Systems

- a) Ti-Pure® R-900 offers the best combination of strength, flocculation resistance, and plasticizer or soft stock dispersibility in flexible vinyls. Ti-Pure® R-900 is neutral in undertone. We currently do not have a blue undertone grade for flexible vinyls except Ti-Pure® R-101. It is less dispersible than R-900 in these minimum shear systems.
- b) Ti-Pure® R-101 and Ti-Pure® R-100 are generally preferred in rigid systems, where a combination of high strength, good dry-blend dispersibility and known weathering resistance are needed.
- c) Ti-Pure® R-902 offers improved durability at little sacrifice in strength, and Ti-Pure® R-960 offers still better durability at lower strength. Both of these have good soft stock and plasticizer dispersibility.

2. In Polystyrene, ABS, Polyolefin and Other Molding Systems

- a) Ti-Pure® R-101 and Ti-Pure® R-100 are ideally suited for general use because of their high strength and excellent dry-blend dispersibility.
- b) Ti-Pure® R-902 and Ti-Pure® R-960 offer excellent durability and yellowing resistance, but with some sacrifice in strength and dry-blend dispersibility. They may also cause lacing in thin film extrusions.
- c) Ti-Pure® R-994 offers outstanding color stability in melamine moldings and laminates.

Promotion to Plastics accounts is admittedly difficult because the definition of the "best" pigment depends largely on the customer's systems, uses, and requirements. Our best strategy is to learn his needs and to promote the product with the best combination of properties to fill them.

TABLE IV. CARBONATED VINYL

Ti-Pure®	TS(1)	VT(2)	Dispersion	
			Soft Vinyl (0-10 Scale)	Resin Fineness (Plasticizer)(4)
R-100	99	.95	3-7	6.0
R-101	103	1.00	3-7	6.5
R-200	100	.97	4-7.5	6.5
R-300	96	.96	4-7.5	6.5
R-500	91	.96	7-8	6.5
R-594	97	1.01	5-6	-
<u>American Cyanamid (Unitare®)</u>				
CR-242	95	.97	7.0	-
CR-450	102-108	.98-1.02	4-5.5	-
CR-460	106-111	1.01-1.03	4-6	-
CR-580	98	.98	6.5	-
CR-600	99-98	.97	7.5-8.5	-
<u>New Jersey Zinc (Horse Head®) including Cabot</u>				
R-722	94-98	.99-1.02	4-7	-
RP-2	103	1.02	2-8	-
RP-3	105-107	.98-1.02	5-7	-
RP-30	100	.95-.98	4.5	-

TABLE IV. COMPRESSED VINYL (cont'd)

Material (Zonaque)	TS(1)	DT(2)	Dispersion	
			Soft Vinyl (0-10 Scale)	Code's Pileup (Plasticizer)(4)
B-69 RC-4 RC-9	95-101	.97-1.02	3-8	-
	106-109	.98-1.01	5-7	-
	108-105	.98-1.01	5	-
N. Industries (Vinylene [®])	95-107	.99-1.03	4-9	-
	104-108	.98-1.02	2-6	-
Kerr Mc Gee (Therox [®])	101	.96	5	-
	102-108	1.01	1-5	-
Vincelene Co (Vinilitan [®])	91-97	.98-1.01	1-6	4.0
	100	1.01	5-7	-
Bayer (Tritill [®])	96	.99	8	-
	97	1.02	1	3.0
RWC RUP	88-98	.96-1.04	1	-

* The blue underlines type CR-800 is usually designated PG (plastic grade).

TABLE IV: CALENDERED VINYL (cont'd)

British Titan Products Titanides of Canada (Titanides ²)	TS(1)	DT(2)	Dispersion	
			2-Roll Mill(3) Soft Vinyl (Co-10 Base)	Coales Hagen Firmness (Plasticizer)(4)
RVC	88-99	1.01-1.02	2	-
RVC-3	98-100	1.01-1.02	5-7	-
RVC-5	102-111	1.02-1.04	6-8	-
RD-2	96	1.02	1	-
RD-3	98	1.04	1	3.0
RD-7	98	.99	1-6	-
RD-8	98	.99-1.00	9	-
RD-9	97-99	.97-1.00	7-9	-
Tham & Mulhouse (Titanides ²)				
RD-11B	93	1.00	0.5	-
RD-11D	84	.94	3	-
RD-14A	92	1.01	1	-
RD-7	90	.96	7.5	-

(1) Tearing strength measured in medium hard vinyl; all are compared to a testing control @ 100 T.S.
 (2) The higher the number, the higher the tearing strength. A difference of 0.01 can be seen, but is within normal product and testing variations.
 (3) Dispersion measured in soft vinyl; 10 = no visible specking or streaking; 0 = extremely bad specking or streaking.
 (4) Coales Dispersion Test in DDP plasticizer, higher numbers indicate better dispersion.

TABLE V: POLYETHYLENE

High Density (HD)	Dry Blend Dispersion	LPS Leaking (2)	Yellowing Resistance	
			Phenolic Stabilized Polyethylene Brightness (3)	Yellowing Index (4)
Ti-Pure® R-100	1.03	No	92-94	9
R-101	1.06	No	87	8
R-900	-	Yes	91	13
R-902	1.02	Yes	91	4
R-960	1.02	Yes	91	4
Ultarane® CR-150	1.04	Yes	93	6
CR-460	-	No	92	2-3
Zepaque® R-69	-	No	91	4-5
REL-9	-	No	91	11-14
REL-4	-	No	92	3-4
Titanox® 2071 (R4-41)	1.05	Yes	-	3-5
Titanox® CR-800 (4 CR-800 R)	-	Yes	89	9-11
CR-835	-	No	90	10
CR-831	-	Yes	92	3-4
Horse Head® R-722	-	-	94	5
RP-2	-	Yes	93	-
RP-3	-	Yes	-	4-5
Thiodide® RRC-3	1.04	Yes	-	-
RRC-5	-	-	-	-
RRC-2	-	-	-	-
Primittan® RP-2	1.06	Yes	92	3-4
97	-	-	-	4-5

(1) Dry blend and injection mold with no other dispersive action.
 (2) Extruded thin film, 15 phr TiO₂, 600°C.
 (3) Higher numbers are brightest.
 (4) Lower numbers are less yellow; 6 phr TiO₂, 0.1% phenolic antioxidant.

TABLE VI: FILMSTRENGTH (GENERAL PURPOSE)

	TS	DT	Dry Blend Dispersion(1)	Resistance to Yellowing(2)
Ti-Pure® R-100	98-99	.99	Excellent	Fair
R-101	100	1.04-1.05	Excellent	Fair
R-102	98	1.04-1.01	Fair	-
R-200	99	1.01	Poor	Excellent
R-260	77	1.01	Poor	Excellent
Titanox® 2071 (R4-41)	95-98	1.04-1.06	Fair-Good	Good
Unitane® CR-450	100	1.05	Fair-Good	Good
CR-460	103	1.04	Fair	-
Zonyl® R-59	92-98	1.02	Good	-
RCL-4	96-107	1.04	Good	-
Tiron® CR-500 (also CR-500 FG)	96-98	1.01-1.05	Good	-
CR-534	100-101	1.04	Poor-Good	-
Borehead® BR-2	98	1.05	Fair	-
BR-3	97	1.04	Good	-
Tioxide® BRC-3	91	1.07	Fair	Fair
BRC-5	93	1.07	Fair-Poor	-
Fluoritan® FG	96	1.06	Poor	-

(1) Dry blend and injection mold with no other dispersive action; strength development is measure of ease of dispersion.

(2) Yellowness developed under accelerated weathering (correlates with heat stability during processing).

PAPER SYSTEM GRADES

Ti-Pure® RPS - Rutile Paper Slurry

- Specifically designed for use in all paper systems; wet end, paper and board coatings. No domestic or foreign counterparts available.
- Optically superior and greater value in use than anatase grades in most applications.
- Potential value in use advantage versus conventional surface treated, micronized rutile grades.

Anatase Grades - Ti-Pure® LW and LW3

- Equal or superior to domestic and foreign counterpart in opacity, brightness, and retention; excellent coating smoothness.
- Excellent dispersion and rheological properties; low +325 mesh residue.
- Equal or better than competitive anatase coating grades; sometimes better value in use than conventional rutiles at low TiO_2 /clay ratios.

Other Rutile Grades (dry/slurry) Ti-Pure® R-900/R-940, R-902, R-931/R-941, R-933/R-943

- In the wet end rutile is recommended for waxed and glassine systems; R-900/R-940 preferred.
- For coatings, grade selection is influenced by the particular system. R-900/R-940 are preferred where properties like high ink holdout, high gloss are desired.

Paper Laminar Grade (Rutile) - Ti-Pure® R-994

- Superior brightness and equal lightfastness to competitors.

TABLE VII: 70% GRADES FOR WET END AND CONTINUES

Furniture Grades	Options Dispersion (1)	70% Slurries in Distilled Water		Dispersion (2) in Hard Water
		Resology	125 Resolins	
TI-Pure® 1M (all purpose grade)	Zero	Newtonian	Low	Good
Unitars® 1000 (AM)†	Zero	Newtonian	Med	Set up
Unitars® 0-110*	Zero	Newtonian	High	Set up
Unitars® 0-110 Special*	Zero	Newtonian	Med	Good
Zepaque® RP*	Zero	Newtonian	Med	Set up
Zepaque® RW*	Zero	Newtonian	Low-Med	Good
Horve Hard® A-110	Zero	Newtonian	Low	Set up
*These competitive grades not usually recommended for coating systems.				
Rattle Grades				
TI-Pure® R-900	0.3	—	—	—
TI-Pure® R-901	0.4	—	—	—
TI-Pure® R-921	0.5	—	—	—
TI-Pure® R-933	0.6	—	—	—
Unitars® CR-450	0.2	—	—	—
Zepaque® RCL-3	—	—	—	—
Antibase Slurries (3)				
TI-Pure® LRS	Standard	Newtonian	—	Good
Unitars® 1050 (TDA)	Slightly +	Newtonian	—	Good-Poor
Unitars® (IDA)	Equal	Newtonian	—	Good
Zepaque® HSS	Slightly +	Newtonian	—	Good-Poor
Horve Hard® A-500	Equal	Newtonian	—	Good
Rattle Slurries				
TI-Pure® RFS	Slightly -	Newtonian	—	Good
TI-Pure® R-940	Considerably +	Newtonian (4)	—	—
TI-Pure® R-941	Considerably +	Newtonian (4)	—	—
TI-Pure® R-942	Equal	Newtonian (4)	—	—
TI-Pure® R-943	Considerably +	Newtonian (4)	—	—
Horve Hard® RSL	—	Newtonian (4)	—	—
Zepaque® RSL 3	—	Newtonian (4)	—	—
Unitars® IRE576	—	Newtonian (4)	—	—

(1) Percent RSP see PIR-140-18
(2) 70% solids in 500 ppm calcium carbonate hardness water

(3) Generally about 72% solids
(4) Within usual centrifugal pumping range

TABLE VIII: TiO_2 GRADES FOR PAPER LAMINATES

	<u>Lightfastness</u>	<u>Opacity</u>	<u>Brightness</u>
Ti-Pure® R-994	Standard	Standard	Standard
Unitane® CR-690	Equal	Equal	Minus

INK SYSTEM GRADES

Quality data on competitive pigments encountered at ink makers are summarized according to ink types, namely:

- Oleoresinous Inks
(Lithographic and Letterpress)
- Rotogravure (Packaging and Publication)
- Flexographic (Nonaqueous and Aqueous Types
For Packaging)

The data presented, although typical, may not represent pigment performance in some of the specialized ink formulas. With the multiplicity of ink formulas, it would not be feasible to list pigment performance in each vehicle system. Therefore, the data given should be used merely as a guide for the selection of a Ti-Pure[®] titanium dioxide for promotion against a specific competitive.

TABLE II. CLEANSING INK

	Relative Gloss(1)	Relative Opacity(1)	Relative Performance(1)	Tinting Strength(2)
TI-Pure® R-900	9	9	10	115
TI-Pure® R-902	8	10	8	100
Ultimate® CR-302	10	7	5	123
Transit® CR-800	9	9	10	113

(1) Rated on a scale 0-10, 10 is highest; 0 is lowest.

(2) The higher the number, the weaker in tinting strength.

TABLE X: PHOTOGRAPHIC INK

	Relative Gloss(1)	Relative Quantity(1)	% Relative Abrasion(2) Copper Block GMA
Nitrocellulose			
TL-Pure® R-900 (48)	7	10	100
TL-Pure® R-915 (EOL) (*)	10	7	56
Unitars® OR-580	9	8	56
Titanox® 2090	9	8	49
Titanox® CR-800	6	7	44
Zapon® RCL-9	8.5	8	88
Thiodol® R-HX-11	9	8	51
Kronas® RH-63	9.5	7	47
Finitran® RD-1	10	8	44
			75

(1) Rated on scale 0-10, 10 is highest; 0 is lowest.

(2) The higher the number, the greater the abrasiveness. The tests are + 10% in reproducibility.

(*) R-915 (EOL) grade is obsolete. Data is included for reference only.

TABLE XI: PLEKOGRAFIC INK

<u>Polyamide</u>	<u>Relative Gloss(1)</u>	<u>Relative Opacity(1)</u>
Ti-Pure® R-900 (01)	7.5	9.5
Ti-Pure® R-900 (08)	8.5	9
Ti-Pure® R-900 (48)	9	9
Ti-Pure® R-902 (08)	8	10
Ti-Pure® R-915 (E-01)(*)	10	8.5
Unitane® CR-580	9.5	8.5
Titanox® 2090	10	8.5
Tronox® CR-800	8.5	8.5
Zopaque® RGL-9	9.5	8.5
Tioxide® R-HD6-U	10	8
Kronos® RM-63	10	7.5
Printhead® RD-1	10	8
<u>Aqueous</u>		
Ti-Pure® R-901	5	6
Ti-Pure® R-915 (E-01)(*)	10	2
Ti-Pure® R-931	5	9
Unitane® CR-580	9.5	2
Unitane® CR-572	5	7
Unitane® CR-573	5	10
Tronox® CR-801	5	6
Tronox® CR-813	5	8

(1) Rated on scale 0-10, 10 = highest; 0 = lowest.

(*) R-915 (E-01) grade is obsolete. Data included for reference only.

TABLE VII. DOMESTIC GROUPS - FUTURE
 FUTURE GROUPS ANTICIPATED APPROXIMATE COMPETITIVE RELATIONSHIP
 -NOT EQUALITY IN COMPOSITION OR PERFORMANCE

TI-Pure® Du Pont	Titanium ML Industries	Unitcase® Am. Cl.	Zenopus® Glidden	Force Bond® N.J. Zinc	Tenorex® Kent-Moore
R-960	2160		NCL-6		CR-822
R-902	2101	CR-550	NCL-8	R-760	
		CR-560	NCL-2	RF22	
R-900	2020	CR-580	NCL-9	RF30	CR-800
	2030	CR-560			
R-931	2131	CR-572	NCL-3		CR-813
R-933	2030	CR-573	NCL-7	R-770	CR-823
R-901		CR-560	NCL-10	RF-31	CR-812
					CR-801
					CR-892
					CR-893
R-904	2081	CR-590	R-39	RF-2	CR-814
R-101	2071	CR-160	NCL-4	R-722	CR-800-40
		CR-150			
R-100	2010	CR-242		R-710	CR-833
R-900 (Slurry)		URF-666	RF5-9		CR-800-S
R-941 (Slurry)		URF-576	RF5-3	RF-40	CR-813-S
R-942 (Slurry)			RF5-2	RF-41	CR-823-S
R-943 (Slurry)				RF-42	CR-822-S

TABLE VIII: DOMESTIC GRADES - ANGLASE

Ti-Pure® Du Pont LW	Titanium® NL Industries 1000(A-40)	Britane® Am. Cy. 0-110 0-110-S UDA	Zapon® Gillotti R3 RMC R55	Hydro Head® H.J. Zine A-410 A-500 A-420 A-430
14-3 (Slurry)	1050			
(R) **	1070(A-40)	0-230		
(R) **		0-220		
(LO-CP) **	1072	0-310		
**Obsolete				

UDA - Britane® Dispersion Anitase

[illegible][illegible]

TABLE XIV - NORMAN TID- GRADES (Cont'd.)

Dr. Post Tid-Grade	Team Number	Kendra Oy Puntillone	Montedison	Titanium- Defabric T. of these	Dow Urquides T. of these
R-900	R-15 R-17 R-18 R-19 R-20 R-21 R-22 R-23 R-24 R-25 R-26 R-27 R-28 R-29 R-30 R-31 R-32 R-33 R-34 R-35 R-36 R-37 R-38 R-39 R-40 R-41 R-42 R-43 R-44 R-45 R-46 R-47 R-48 R-49 R-50 R-51 R-52 R-53 R-54 R-55 R-56 R-57 R-58 R-59 R-60 R-61 R-62 R-63 R-64 R-65 R-66 R-67 R-68 R-69 R-70 R-71 R-72 R-73 R-74 R-75 R-76 R-77 R-78 R-79 R-80 R-81 R-82 R-83 R-84 R-85 R-86 R-87 R-88 R-89 R-90 R-91 R-92 R-93 R-94 R-95 R-96 R-97 R-98 R-99 R-100 R-101 R-102 R-103 R-104 R-105 R-106 R-107 R-108 R-109 R-110 R-111 R-112 R-113 R-114 R-115 R-116 R-117 R-118 R-119 R-120 R-121 R-122 R-123 R-124 R-125 R-126 R-127 R-128 R-129 R-130 R-131 R-132 R-133 R-134 R-135 R-136 R-137 R-138 R-139 R-140 R-141 R-142 R-143 R-144 R-145 R-146 R-147 R-148 R-149 R-150 R-151 R-152 R-153 R-154 R-155 R-156 R-157 R-158 R-159 R-160 R-161 R-162 R-163 R-164 R-165 R-166 R-167 R-168 R-169 R-170 R-171 R-172 R-173 R-174 R-175 R-176 R-177 R-178 R-179 R-180 R-181 R-182 R-183 R-184 R-185 R-186 R-187 R-188 R-189 R-190 R-191 R-192 R-193 R-194 R-195 R-196 R-197 R-198 R-199 R-200	RP RP			

TABLE XIV - FOREIGN RIFLE TUG GRADES (CONT'D.)

Du Pont Tr-Pure®	Tekthara Tipster®	Tallock Sutro®	Star Tutor®	Tekken	Purdusa	Ball
R-940	CR-30 CR-30 R-830 R-830 R-930	JRC JF700 JF701 JR-602	R650	TR-10 TR-50	R622 R611	TR840
R-902			R-24			
R-900	CR-30 R630 R950 R780 R780-2	JR-500 JR-500 JR-500E JR800 JR801	SR-1	TR-30	JR-30	TR700
R-931			R-45			
R-933						
R-901	R815 R690				JR-31	
R-100	R-580 R-670	JR	R310			

TABLE XV: ASTM SPECIFICATION FOR TITANIUM DIOXIDE PIGMENTS (D-476-70)

Typical Paint applications	- 100 -			
	Type I Anatase Free Chalking	Type II Rutile-Medium Chalk Resistant	Type III Rutile-Medium Chalk Resistant	Type IV Rutile-Highly Chalk Resistant
	White exterior house paint Interior uses	Low-medium PVC enamels and lacquer	Medium-high PVC enamels; alkyl urethane and vinyl resin	Exterior coatings requiring excellent durability and gloss retention
Titanium dioxide (TiO ₂) min. percent	94	92	80	80
Matter soluble in water specific resistance, min., ohm-cm	5000(g)	5000	3000	3000
Moisture and other volatile matter (loss at 105° to 110°C), max. percent(b)	0.7	0.7	1.5	1.5
Specific gravity	3.8 to 4.0	4.0 to 4.3	3.6 to 4.3	3.6 to 4.3
Coarse particles max. percent	0.2	0.2	0.2	0.2

(a) Identification of anatase or rutile thereof is made by x-ray analysis.
 (b) Preconditioned overnight at 50% relative humidity at 25°C (for reference purposes only).
 (c) 1000 permissible for water dispersible type only.

Key Contact: J. A. Stiggle, Extension 2701

TABLE XVI: KEY CONTRACTS AT CHESTNUT RUN

	<u>Name and Extension Number</u>	
	<u>Key Person</u>	<u>Alternate</u>
TiO ₂ - Trade Sales & Industrials	J. G. Dickinson (2379)	J. A. Lemiet (4421)
TiO ₂ - Paper	H. B. Louderback (2166)	J. A. Lemiet (4421)
TiO ₂ - Plastics, Ink, Textile Fibers, Elastomers & Others	N. J. Kane (2014)	H. W. Ling (2005)
TiO ₂ - Automotives	B. H. Garth (2408)	H. W. Ling (2005)