Mineral Processing Costs ($/tonne)

Company, Mill	Crushing	Grinding	Reagents	Flotation	Leaching	De-watering	Tailings disposal	Assaying	Power	Super-vision & labour	Main-tenance	Other	Total
Agnico-Eagle, Laronde	nil	0.08	7.66	0.055	0.26	0.045	0.28		2.08	2.56	1.94	1.34	16.30
Aur Louvicourt		1.36	1.18	0.25		0.42	0.22	0.18	2.12	1.42	1.18	0.33	8.66
Barrick, Eskay Creek													55.54
Breakwater, Bouchard-Hebert			3.19				1.09		1.61	2,15	2.80		10.84
Cambior, Doyon	0.38	3.90	4.03		4.35		0.17	0.13	1.93	1.93	1.59	0.61	10.18
Cambior, Niobec	0.10	0.43	2.73	0.23	0.05	0.24	0.38	0.35	1.16	1.59	0.57	0.15	7.97
Cambior, Sleeping Giant	0.62	1.21	5.07		0.47	0.05	0.17	0.34	2.79	6.97	Incl	0.30	17.99
Cameco, Key Lake		4.48	13.90			7.47				10.22	1.60		15.85
Huckleberry Mines	0.269	1.940	0.009	0.545		0.122	0.056	0.047	Incl	Incl	Incl	0.359	3.342
Inmet, Troilus	0.21	0.95	0.16	0.15		0.04	0.02	0.02	0.93	0.31	0.80		3.59
N.Amer. Palladium, Lac des Iles	0.57	1.24	1.48	0.15		0.09	0.01	0.20	2.79	1.19	0.67		8.39
Placer Dome, Musselwhite	1.40	1.71	2.38		1.55	incl	0.09	0.06				2.73	9.92

Grinding circuits

Company, Mill	Grinding mills	Milling rate	Power consumption	Liners	Media consumption	Fineness of grind	Pulp density	Classifiers	Circulating load
Agnico-Eagle, Laronde	1 Svedala 24'x13'6" prim SAG	325 mtph		Rubber	0.50 kg/t	85% -65 mesh	80-85%	2 Warman 800CVX 31" cyclones (1 running)	200-275%
	1 Dominion 16'5" x 28' secd			Rubber	1.4 kg/t	80% -200 mesh	85%	1 Warman 400 CVX 10 10 x 15" Cyclopak (6 or 7 running)	250-350%
	1 Marcy 7x10' regrind Cu			Rubber	0.15 kg/t	95% -200 mesh	38%	1 Krebs DSF 10LB-gMAX 3007. 3 x 10" (1 running)	
	1 Allis-Chalmers 10'6" x 14' regrind (Zn)			Rubber	0.15 kg/t	95% -200 mesh	38%	1 Technequip H10BC-AS8 4 x 10" Cyclopak (2 running)	
Aur Louvicourt	1 Allis SAG 22x10.5' primary	180 mtph	10 kWh/t	Cr-Mo with rubber shell plates & grate discharge	0.39 kg/t	100% -2 mm 80% -0.6 mm	82%	Taylor 6x16' overhead vibratory screen	7-12%
	1 AMS 16'5"x24' primary ball	180 mtph	14 kWh/t	Rubber	1.30 kg/t	80% -50 microns	78%	12 Warman 10" cyclones	300%
	1 Dominion 11x14' Cu regrind ball	35 mtph	16 kWh/t	Rubber	0.17 kg/t	80% -20 microns	68%	6 Krebs 10" cyclones	225%
	1 Allis-Chalmers 9x14' Zn regrind ball	15 mtph	23 kWh/t	Rubber	0.1 kg/t	80% -18 microns	65%	6 Krebs 10" cyclones	275%
Barrick, Eskay Creek	1 Marcy 12'x8'6" ball	14 mtph	21.2 kWh/t	Rubber	1.01 kg/t	80% -200 mesh	72%	2 Technequip 15" cyclones	250%
Breakwater, Bouchard-Hebert	Aerofall 4.5x4.2m SAG	125 mtph	30 kWh/t	Rubber	0.46 kg/t	80% -1.2 mm	74%		
	Marcy 10x15' No.1 ball	160 mtph	6.6 kWh/t	Rubber	0.59 kg/t	80% -115 mesh	80%	6 Krebs 15" cyclones	250%
	Dominion 11x15' No.2 ball	160 mtph	6.6 kWh/t	Rubber	k0.59 kg/t	80% -115 mesh	80%	6 Krebs 15" cyclones	250%
	Dominion 10'6"x13' No.3 ball	160 mtph	9.3 kWh/t	Rubber	0.40 kg/t	80% -400 mesh	78%	5 Krebs 10" cyclones	125%
Breakwater, Langlois	Marcy 20 diam x 11' prim SAG	75-85 mtph	9.3 kWh/t	Rubber	0.8 kg/t	80% -48 mesh	80%		
	A-C 13'6"x20' ball closed circuit, 2500 hp	250 mtph	11.8 kWh/t	Rubber	0.85 kg/t	80% -150 mesh	70%	3 Technequip 15" cyclones	200-300%
Cambior, Doyon	Aerofall 5.4 diam x 6.3m SAG, 2700 hp	150 mtph	14.6 kWh/t	Polymet plates & rubber	0.69 kg/t	80% -270 microns	65-82%	36" spiral 15 Krebs 20" cyclones	15-25%
	Koppers Hardinge 3.5x4.9m secd ball, 1000 hp	100 mtph	10 kWh/t	Rubber	0.76 kg/t	80% -74 microns	72-76%	Krebs 20" hydrocyclones	300-400%
	Koppers Hardinge 2.4x3.8m secd ball	100 mtph	10 kWh/t	Rubber	0.76 kg/t	80% -74 microns -400 mesh		Krebs 20" cyclones	300-400%
Cambior, Niobec	Allis-Chalmers 10'6"x14' rod	150 mtph	5 kWh/t	Cr-Mo	0.059 kg/t	100% -4 microns	82%		
	Hardinge 10'6"x14' secd ball	250 mtph	5 kWh/t	Cr-Mo	0.57 kg/t	100% -10 microns	70%	12 Derrick K48-96 screens, 0.23 mm	200%
Cambior, Sleeping Giant	Hardinge 8x12', 350 hp rod 2 Hardinge Tricone 8x12', 350 hp ball	38 mtph			0.561 kg/t 0.573 kg/t each	82-85% -200 mesh	80% 70-73%	4 Linatex 12" cyclones	200% each
Cameco, Key Lake	1 Svedala prim SAG 9.5 diam x 14' long	20 mtph	10 kWh/t	Rubber	0.94 kg/t	68% -200 mesh	75-80%	2 Krebs 15" cyclones	150-200%
Elk Valley, Elkview	Course: Heavy media circuit	240 mtph				+½" to -3"	1.36-1.58 s.g.	1 Krebs 40" cyclone	
	Intermediate: Heavy media circuit	790 mtph				+0.65mm to to -½"	1.36-1.56 s.g.	12 R&S 24" cyclones	
	Water only cyclone circuit	540 mtph				-0.65 mm	12%	60 R&S 14" cyclones	
	Froth flotation	340 mtph				-0.35 mm	8%	5 banks of Wemco cyclones	

This table continues...

Grinding Circuits — continued

Company, Mill	Grinding mills	Milling rate	Power consumption	Liners	Media consumption	Fineness of grind	Pulp density	Classifiers	Circulating load
Elk Valley, Greenhills	McLanahan rotary breaker 12x27'	1000 mtph		Algoma 400 screen plates		2½"	100%		
Falconbridge, Strathcona	2 Dominion 10'6"x16' prim rod	200 mtph	2.55 kWh/t	NiHard	0.55 kg/t		82%		
	2 Dominion 13x23' prim ball	200 mtph	6.5 kWh/t	Rubber	0.57 kg/t	56% -200 mesh	75%	Krebs 20" cyclones	300-400%
	2 Dominion 11'6"x20' regrind ball	65 mtph	13.6 kWh/t	Rubber	0.46 kg/t	80% -325 mesh	68%	Krebs 6" cyclones	200%
Highland Valley Copper, Lornex	A/B line: 2 Dominion 32'x15'6" prim SAG	1300 mtph	5.0 kWh/t	Norcast steel	0.33 kg/t	80% -6 mesh	50%	Grate discharge & grizzlies	10%
	C line: 1 Dominion 34x16' prim SAG	1740 mtph	5.1 kWh/t	Norcast steel	0.42 kg/t	80% -6 mesh	50%	Grate discharge & grizzlies	10%
	D/E line: 2 Dominion 34x14' prim autogenous	950 mtph	5.8 kWh/t	Norcast white iron		80% -6 mesh	60%	Grate discharge & vibrating screen deck	10-50%
	A/B line: 4 Dominion 16'6"x23' secd ball	650 mtph	4.4 kWh/t	Skega rubber	0.31 kg/t	55% -100 mesh	77%	Linatex 30" cyclones	200-350%
	C line: 2 Dominion 16'6"x27' secd ball	870 mtph	3.5 kWh/t	Skega rubber	0.27 kg/t	55% -100 mesh	77%	Linatex 30" cyclones	200-350%
	D/E line: 2 Dominion 16'6"x29' secd ball	950 mtph	3.8 kWh/t	Skega rubber	0.28 kg/t	55% -100 mesh	77%	Linatex 30" cyclones	200-350%
Huckleberry Mines	1 Svedala 32x15' prim SAG	940 mtph	9-10 kWh/t	Steel	0.636 kg/t		68%	1-deck vibrating screen	200%
	2 Svedala 16'5"x30' secd ball	470 mtph	10-11 kWh/t each	Rubber	0.365 kg/t	50-55% -200 mesh	73%	12 Technequip 26" cyclones	250%
	1 Dominion 14'6"x18' moly regrind	100 mtph	8-10 kWh/t	Steel	0.049 kg/t	60-65% -325 mesh	50%	4 Technequip 15" cyclones	(nil)
Hudson Bay, Flin Flon	(2) 12'6"x16' rod mills, 1200 hp	275 mtph	10.5 kWh/t	High Cr Hi-Lo wave	0.7 kg/t	80% -500 microns	82%		
	(1) 16'6"x31' ball mill, 5000 hp	280 mtph		Rubber	0.7 kg/t	80% -65 microns	75%	5 Warman 30" cyclones cyclones	
Hudson Bay, Snow Lake	7x10' rod mill	1300 tpd		Rubber	0.42 lb/ton	60% -200 mesh		1 Krebs 18" cyclone	
	10x13 ball mill	1300 tpd		Rubber	1.95 lb/ton	60% -200 mesh		5 Warman 20" cyclones	
Inmet, Troilus	Svedala, 30x13' SAG, 7000 hp	731 mtph	709 kWh/t	Cr-Mo hi-med hi, 40 rows	0.50 kg/t	80% -2200 microns	82%	2-deck vib screen, 8x24'	25%
	Svedala 18x28.5' ball, 6000 hp	731 mtph	5-6 kWh/t	Svedala rubber	0.32 kg/t	65-70% -200 mesh	77%	23 Cavex 15" cyclones	550%
	Allis-Chalmers 10x12' regrind, 800 hp	30 mtph		Rubber		90-95% -400 mesh	65%	6 Cavex 4" cyclones	200%
Iron Ore, Carol	3 Dominion Engineering 9.8m prim wet autogenous	1740 mtph av	3.0 kWh/t			98% -1.44 mm	68%		
	3 Allis-Chalmers 3.7x4.9m ball				4.96 kg/t	85% -44 micron	72%		
	1 Dominion 5x8.5m ball				4.96 kg/t	85% -44 micron	72%		
	8 Allis-Chalmers 27.5x13.5' regrind ball (in pellet plant)	120 mtph	18.2 kWh/t		0.5 kg/t	65% -325 mesh	78%		
	13 Dominion 32x14.5' regrind ball (in pellet plant)	160 mtph	18 kWh/t		0.5 kg/t	65% -325 mesh	78%		
N.Amer. Palladium, Lac des Iles	9.14x4.27m SAG	680 mtph	6341 kWh/t	Alloy steel	1.293 kg/t	80% -1.44 mm	69%	Vibrating screen, 9.5 mm	
	2 Furnell Thompson 6.1x10.36m ball	680 mtph	6341 kWh/t	Rubber	0.586 kg/t	80% -75 microns	75%	10 Krebs 15" cyclones	275%
	3 Svedala VertiMill VTM 1250 regrind tower mill	153 mtph	932 kWh/t	Rubber	0.149 kg/t	80% -35 microns	60%	12 Krebs 6" cyclones	200%
	1 Svedala VertiMill STM 200 regrind tower mill	13.6 mtph	149.2 kWh/t	Rubber	0.149 kg/t	80% -35 microns	60%	3 Krebs 6" cyclones	200%
Northgate, Kemess South	2 Metso 34'x15'3" SAG	900-1400 mtph		Steel	0.38 kg/t		77%	Svedala 1-deck 8'x24" screen with ½" slots	20%
	2 Metso 22'x36'6" ball	900-1400 mtph		Rubber	0.48 kg/t	60% -200 mesh	77%	12 Krebs 26" cyclones (4 on standby)	24%
	1 Metso 16'6"x35'6" regrind ball			Rubber	0.04 kg/t	70% -325 mesh		24 Krebs 6" cyclones	100%
Placer Dome, Musselwhite	1 Nordberg 12x17' rod	150 mtph	6.8 kWh/t	Noranda Wave Ni-Cr	0.35 kg/t		83%		
	1 Nordberg 13'6"x18'	150 mtph	9.0 kWh/t	Rubber	0.6 kg/t	85% -106 microns	78%	82 Technequip 15" cyclones	500%
Quebec Cartier, Mt-Wright	Dominion autogenous	1000 mtph	2 x 3000	Rubber					
Thompson Creek, Endako	5 Allis-Chalmers 12'5" prim rod	250 mtph	9.0 kWh/t	Norcast	0.35 kg/t	80% -1000 microns	79%	30" & 36" Dorrclones	
	5 Allis-Chalmers 12'6"x15' prim ball	250 mtph	9.0 kWh/t	Norcast	0.29 kg/t	24% +48 mesh	75%	30" & 36" Dorrclones	250%
Wabush, Scully	6 Dominion 24x8' prim autogenous	400 mtph	2 kWh/t	Cr-Mo White iron		50% -65 mesh	35-40%	4 Tyler T300R 1-deck screens, 5x12' per mill	20%

Milling costs ($/ton)

Company, Mill	Crushing Grinding	Flotation Drying	Cyanidation Leaching	Supplies Assaying	Supervision Labor	Conveying Power	Tailings disposal Other	Total
Agnico-Eagle Mines, Gold Div								13.92
Agnico-Eagle Mines, Penn	4.11	3.33	1.07	0.27		0.38	0.03	17.37
	5.26	—	—	—		—	2.92[1]	
Algoma Steel Corp								3.20
Barrick Resources, Camflo	0.592		1.790	0.075	0.260	—		5.07
	1.193		—	0.079	—	1.016		
Brinco Mining, Cassiar	0.53[2]	—		1.08	0.64	—	—	12.88
		0.92		—	4.44	4.63	0.62	
Cominco Ltd, Valley Copper	0.308	0.272		—	0.281		0.109	1.967
	0.934	—		0.045	—		0.018	
Corp Falconbridge Copper, Opemiska	0.12	0.22		0.04	0.45			2.77
	0.50	0.11		—	1.37			
Crows Nest Resources, Line Creek								3.00
Detour Lake Mine	0.50		3.04	Note 3	0.63	0.19	0.31[4]	11.60
	2.38[5]		—	0.35	Note 3	1.54	2.68[6]	
Dickenson Mines Ltd*	0.61		3.52	0.25	1.67		0.29	16.44
	1.35		—	0.27	6.74		1.74[7]	
Dome Mines Ltd	1.26		—				0.11	7.60
	0.99[8]		2.02				0.18[9]	
Eldorado Resources, Rabbit Lake	0.77	—	—	—	4.36	—	3.45	20.42
	1.36	0.86	1.52	0.86	—	7.24	—	
Equity Silver Mines Ltd	0.463	0.464		—	0.124	—	0.054	3.580
	1.256	0.165		0.071	—	0.642	0.341	
Giant Yellowknife Mines Ltd, Giant*	0.95	0.75	1.74	—	1.47		0.25	12.44
	1.09	—	—	0.72	—		5.47[10]	
Giant Yellowknife Mines Ltd, Salmita	2.35		2.39	—	6.18	0.33	0.11	54.72
	2.64		—	0.70	20.70	13.38[11]	6.27[12]	
Hudson Bay M&S, Snow Lake								5.84
Kidd Creek Mines Ltd	0.46	1.19		Note 3	Note 3	Note 3	0.34	6.75
	1.52	0.72		0.02	Note 3	1.18	1.32	
Kiena Gold Mines Ltd	2.00	0.50	1.31	0.53	0.50	—	0.02	7.27
	—	—	—	—	—	0.68	1.73[13]	
Lac Minerals Ltd, Doyon	3.53		2.76	0.63	0.59	—	1.19	15.23
	2.72		—	—	—	1.25	2.56	
Maclaren Forest Products, Bell	0.41	0.33		1.18	0.13	0.01	0.15	2.23
	0.97	0.06		0.03	0.37	0.54	0.01	
Newmont Mines, Similkameen	0.096	0.244		—	0.094	0.091	0.137	2.728
	1.844	0.075		0.015	0.437	0.921	—	
Niobec Inc	0.22	2.78	—	0.67	0.48	0.14	0.27	7.33
	0.86	0.10	0.90	0.13	0.05	0.73	—	
Northgate Mines, Copper Rand	0.26	0.76		0.39	0.34	—	—	3.47
	0.60	Note 3		0.21	0.31	0.47	0.13	
Potash Corp of Saskatchewan, Lanigan	0.58	2.37	—	2.69	—	—	0.60	Note 14
	1.12	1.90	2.18	0.19	2.49	5.10	1.12[15]	
Sherritt Gordon Mines, Fox	0.39	1.30		0.26	0.62		0.83	5.46
	1.18	0.22		0.20	—		1.10	
Sherritt Gordon Mines, Ruttan*	0.289	1.20		0.59	0.36		0.04	4.61
	1.29	0.14		0.03	0.59		0.076[16]	
Sigma Mines (Quebec) Ltd	0.81	1.28	Note 3	Note 3	Note 3	Note 3	0.40	6.55
	0.84	0.09	—	—	Note 3	Note 3	3.11	
Société Minière Louvem	3.24		8.51	—	3.12	—	0.097	51.84
	3.50		—	4.88	Note 3	4.93	23.76	
Teck Corp, Lamaque*	1.20		0.75	2.20	0.40	0.50	0.35	9.25
	2.00		0.61	0.60	3.12	0.89	—	
United Keno Hill Mines Ltd								28.00
Westmin Resources Ltd								10.67

*Based on information supplied for 1985 edition. 1. Includes grizzly and bins $1.84; jigs and tables $1.08. 2. Includes grinding. 3. Included elsewhere. 4. Includes water reclaim. 5. Includes storage and feeders. 6. Includes technical $0.52; electrical $0.24; gold recovery $1.27; miscellaneous $0.65. 7. Includes control and research, environmental control, amalgamation, refining, tailings disposal, and backfill plant. 8. Includes conveying. 9. Refining. 10. Includes roasting $1.59; refining $0.24; lubrication $0.17; waste treatment $2.15; environmental control $1.12. 11. Includes power for mill (65%) and mine (35%). 12. Includes dewatering $0.38; precipitation $0.38; safety and training aids $0.33; millsite services $5.18. 13. Includes CIP $1.30; backfill $0.19; other $0.24. 14. Labor and supplies included elsewhere as well as individually. 15. Compacting. 16. Includes research $0.07 and process content.

Grinding data

Company, Mill	Milling rate	Fineness of grind	Pulp density	Grinding mills	Media type & consumption Rods	Balls	Liners
The Adams Mine	180 tph	−6 mesh		3 A-C 11′6″×18′ rod mills,	—		
				1,250 hp, 15 rpm	1.48 lb/t		
		90%		3 13′×18′ ball mills,		—	
		−325 mesh		2,000 hp		0.72 lb/t	
Agnico-Eagle, Gold Division	58 tph	70%	79%	1 A-C 9′×12′	3½″ steel	2½″ steel	Steel
		400 mesh		1 A-C 12′×18′	1.34 lb/t	3.05 lb/t	Rubber
	10 tph	95%	65%	2 A-C 6′8″×16′ regrind		2½″ steel	Rubber
		400 mesh				1.8 lb/t	
Agnico-Eagle, Penn	165 tph	45%	75%	Hardinge 8′×48″		4″ steel	—
		−200 mesh				1.13 lb/t	0.285 lb/t
	95 tph	45%	75%	Allis-Chalmers 7′×5′		4″ steel	—
		−200 mesh				1.13 lb/t	0.282 lb/t

this table continues . . .

Grinding data — continued

Company, Mill	Milling rate	Fineness of grind	Pulp density	Grinding mills	Media type & consumption: Rods	Balls	Liners
Algoma Steel Corp	150 tph	+¼" −1½"	90%	Wemco 10′×10′ heavy media separator	Note 1		
	150 tph	+¼" −1½"	90%	Hardinge 7′×16′ heavy media separator	Note 1		
	10 tph	−¼" +28 mesh	90%	8 Broms 10" cyclones	Note 2		
Barrick Resources, Camflo	54	80% −200 mesh	72%	CAC 8′×12′ rod CAC 8′×15′ ball Marcy 9′×12 ball	4"×11′6" 1.03 lb/t	1½" 1.54 lb/t	Rubber 0.135 lb/t
Brenda Mines Ltd	1,400 tph	77% −10 mesh	83%	Dominion 13′×18′ rod	4"×17′6" 0.40 lb/t		NiHard 0.004 lb/t
		21% −200 mesh	77%	Dominion 13′6"×22′ ball		2½" 0.30 lb/t	NiHard 0.004 lb/t
	8.2 tph	97% −200 mesh	58%	A-C 9′×14′ copper regrind		1⅛" slugs 2.5 lb/t	Rubber —
	1.0 tph	95% −200 mesh	50%	A-C 6′×14′ moly regrind		1⅛" slugs 1.2 lb/t	Steel
Brunswick M&S Co Ltd	Line 1: 125 tph	65% −400 mesh	50%	Dominion 10′6"×14′ rod	3" dia 0.72 lb/t		Noranda Wave NiHard
				2 Dominion 10′6"×13′ ball		1½" slugs	Rubber
	Line 2: 125 tph	65% −400 mesh	50%	Dominion 10′6"×14′ rod	3" dia 0.72 lb/t		Noranda Wave NiHard
				2 Dominion 10′6"×13′ ball		1½" slugs	Rubber
	Line 3: 220 tph	65% −400 mesh	50%	Dominion 12′6"×16′ rod	3 & 3½" dia 0.88 lb/t		Noranda Wave NiHard
				2 Dominion 12′6"×15′ ball		1½" slugs	
	Note 3			Dominion 8′×12′ regrind 3 Dominion 10′6"×13′ regrind A-C 12′×14′8" regrind A-C 12′6"×16′ regrind		1½" slugs	Rubber
Campbell Red Lake Mines	48 tph	78%	78%	A-C 7′×12′ primary A A-C 7′×11′ primary B		4" steel 0.904 lb/t	NiHard
	48 tph	78% −200 mesh	78%	2 Dominion 7′×6′ secondary A A-C 8′×12′ secondary B		2½" steel 1.5 lb/t	NiHard & rubber
Cominco, Valley Copper	1,150 tph	40% −200 mesh	55%	3 Dominion 12′6"×15′ rod 3 Dominion 11′×14′ ball 1 Dominion 10′6"×14′ ball 2 Dominion 16′6"×32′ pebble	— 0.74 lb/t	— 0.44 lb/t	NiHard 0.18 lb/t
Corp Falconbridge Copper, Opemiska	No. 5: 83 tph	35% −200 mesh	76%	CAC 12′×18′ primary		3" 0.70 lb/t	NiHard
	No. 4: 54 tph	64% −200 mesh	77%	Hardinge 11-3-6-10 secondary		2" 0.40 lb/t	NiHard
	No. 3: 2 tph	64% −200 mesh	76%	Hardinge 11-3-6-10		— 1.10 lb/t	NiHard
	No. 2: 10 tph	64% −200 mesh	76%	Hardinge 8′×72"		— 1.10 lb/t	NiHard
	No. 1: 10 tph	64% −200 mesh	76%	Hardinge 8′×72"		— 1.10 lb/t	NiHard
	2 tph	90% −325 mesh	60%	CAC 9′×16′ regrind		— 0.50 lb/t	Rubber
Cyprus Anvil Mining Corp				3 Hardinge 9′×12′ rod 6 Hardinge 9′×12′ ball 1 A-C 12′6"×16′ rod 3 A-C 13′6"×22′ ball			NiHard Rubber NiHard Rubber
Denison Mines Ltd	300 tph	50% −200 mesh	80%	2 Dominion 10′6"×14′ rod	3½"×13′ 1.2 lb/t		NiHard & manganese
				4 Dominion 10′6"×23′ pebble		2" steel 0.3 lb/t	NiHard & rubber
	350 tph	50% −200 mesh	80%	Koppers 23′×10′ SAG			NiHard & manganese
				2 Koppers 15′6"×22′ pebble		4" steel 1.0 lb/t	NiHard & rubber
Detour Lake Mine	2,425 tpd	76% −700 mesh	75%	A-C 17′×28′ SAG		5" steel 1.66 lb/t	Rubber with Cr-Mo lifters
	27.5 tph	84% −200 mesh	70%	A-C 7′×13′ regrind		1" steel	Rubber
Dickenson Mines Ltd*	30 tph	70% −200 mesh	78%	A-C 9′×12′ rod	— 1.60 lb/t		NiHard
				A-C 7′×8′ ball		2½" steel 1.84 lb/t	NiHard
				A-C 7′×22′ ball regrind			NiHard
Dome Mines Ltd	125 tph		79%	A-C 10′6"×14′ rod	3½"×13′6" 0.707 lb/t		NiHard
	250 tph	82% −200 mesh	72%	A-C 13′×20′ ball		2" slugs 1.590 lb/t	Rubber
Eldorado Resources, Rabbit Lake	85 tph	20% −200 mesh	64%	Hardinge 6′×20′ autogenous			NiHard
	35 tph	48% −200 mesh	70%	Nordberg 9′6"×17′		3" steel 1.1 lb/t	Rubber
Equity Silver Mines Ltd	220 tph	65-75% 80 microns	80%	Hardinge 13′6"×20′ rod	3"×19-18′ 0.824 lb/t		Cr-Mo & NiHard
			78%	Hardinge 13′6"×20′ ball Hardinge 9′6"×16′ regrind Kennedy Van Saun 13′6"×20′ ball		1½" steel 0.880 lb/t	
Giant Yellowknife Mines, Giant*	53 tph	55% −200 mesh	75%	2 Dominion 8′×10′ prim ball		3" steel 1.33 lb/t	NiHard 0.12 lb/t
	35 tph	85% −200 mesh	55%	5′×8′ regrind 6′×12′ regrind		1½" steel 0.34 lb/t	Rubber
Giant Yellowknife Mines, Salmita	8.0 tph	75% −200 mesh	68-70%	A-C 8′×8′ primary ball		3" steel 3.5 lb/t	Rubber 0.15 lb/t
			68-70%	Marcy 5′×8" closed circuit regrind Denver 5′×8′ on standby (primary or regrind)		1½" steel 1.7 lb/t	NiHard NiHard

this table continues . . .

Company, Mill	Milling rate	Fineness of grind	Pulp density	Grinding mills	Media type & consumption: Rods	Balls	Liners
Gibraltar Mines Ltd	1,750 tph	35% +65 mesh	80%	A-C 13'6"×20' rod	0.6 lb/t		NiHard & Cr-Mo
			75%	A-C 13'6"×20' ball		0.42 lb/t	NiHard & Cr-Mo
Hudson Bay M&S, Flin Flon	287 tph	81% −200 mesh	75%	2 Koppers 12'6"×16' rod	3" dia steel 1.07 lb/t		Steel
				8 Koppers 10'×66" ball		1½" steel 1.53 lb/t	Rubber
Hudson Bay M&S, Snow Lake, SAR circuit	110 tph	33% −200 mesh	78%	A-C 10'6"×16' rod	3" dia 1.15 lb/t		NiHard
		44% −200 mesh	71%	A-C 8'×12' ball		1½" steel 0.57 lb/t	Rubber
		58% −200 mesh	70%	A-C 12'6"×18'		1½" & 2" steel 1.76 lb/t	Rubber
Hudson Bay M&S, Snow Lake, CGL circuit	48 tph	27% −200 mesh	78%	A-C 7'×10' rod	3" dia 0.60 lb/t		NiHard
		63% −200 mesh	68%	A-C 10'6"×13' ball		1½" steel 2.54 lb/t	Rubber
Iron Ore Co of Canada	400 tph	20% −200 mesh		Aerofall 21'×5'6" dry autogenous			
	1,750 tph	20% −200 mesh		Aerofall 34'6"×7'6" dry autogenous			
Kidd Creek Mines Ltd, A ore circuit	140 tph		82%	A-C 10'6'×16' rod	4" dia 0.96 lb/t		NiHard 0.08 lb/t
				A-C 12'×18' secondary ball		1 13/16" 1.26 lb/t	Rubber
				A-C 12'×18' secondary ball		1½" 1.22 lb/t	Rubber
				A-C 8'×12' copper regrind		1" 0.26 lb/t	Rubber
				A-C 8'×12' zinc regrind		1" 0.22 lb/t	Rubber
Kidd Creek Mines Ltd, C ore circuit	140 tph		82%	A-C 10'6'×16' rod	4" dia 0.96 lb/t		NiHard 0.08 lb/t
				A-C 12'×18' primary ball		1 13/16" 0.96 lb/t	Rubber
				A-C 12'×18' secondary ball		1½" 1.06 lb/t	Rubber
				A-C 12'×18' secondary ball		1" 0.22 lb/t	Rubber
				A-C 8'×12' secondary regrind			
Kiena Gold Mines Ltd	60 tph	83% −200 mesh	75%	Dominion 11'6"×18' SAG		5" steel 1.08 lb/t	Rubber 0.30 lb/t
				Dominion 10'6"×13' ball		2" steel 0.90 lb/t	Rubber 0.02 lb/t
Lac Minerals Ltd, Doyon	70 tph	32% −200 mesh	75-78%	Koppers Hardinge 8'×12'6" rod	3½" dia 0.58 lb/t		NiHard
	270 tph	85% −200 mesh	72-74%	Koppers Hardinge 11'6"×16' ball		2" slugs 2.53 lb/t	Rubber
Lornex Mining Corp	1,100 tph	50% −48 mesh	55%	2 Dominion 32'×15'6" ball		4 & 5" steel 0.4 lb/t	Perlitic Cr-Mo 0.09 lb/t
	1,450 tph		55%	Dominion 34'×16' ball		4 & 5" steel 0.4 lb/t	Perlitic Cr-Mo 0.09 lb/t
	550 tph	30% +100 mesh	75%	4 Dominion 16'6"×23' ball		3 & 2½" steel 0.8 lb/t	NiHard 0.035 lb/t
	725 tph	34% +100 mesh	74%	2 Dominion 16'6"×27' ball		3 & 2½" steel 0.8 lb/t	NiHard 0.035 lb/t
		90% −325 mesh	60%	Denver 5'×6' moly regrind		1" steel 0.02 lb/t	NiHard 0.28 lb/t
		90% −325 mesh	60%	Denver 5'×10'		1" steel 0.02 lb/t	NiHard 0.28 lb/t
	1,500 tph	80% −325 mesh	60%	Denver 11'×14'		1 & 1½" White Iron 0.02 lb/t	NiHard 0.13 lb/t
Maclaren Forest Products, Bell	750 tph	27% −200 mesh	80%	2 Dominion 13'×18' rod	4" dia 0.538 lb/t		NiHard 0.046 lb/t
	750 tph	57% −200 mesh	42%	2 Dominion 13'6"×28' ball		2.5" 0.93 lb/t	Rubber 0.005 lb/t
		76% −400 mesh		A-C 9'×11' regrind A-C 9'×13' regrind		1½" 0.20 lb/t	Rubber 0.001 lb/t
Maclaren Forest Products, Gaspé	145 tph	55% −200 mesh	78%		1.34 lb/t	1.08 lb/t	
Mattabi Mines Ltd*	125 tph	75% −200 mesh	85%	Dominion 12'×16' rod Dominion 12'×16' ball	0.99 lb/t	1.22 lb/t	NiHard Rubber
	10 tph	99% −200 mesh	75%	Marcy 5'×8' Cu-Pb regrind		0.10 lb/t	Rubber
	30 tph	95% −200 mesh	80%	A-C 7'×11' Zn regrind		0.20 lb/t	Rubber
Mosquito Creek Gold Mining	4.17 tph	85% −200 mesh	75-80%	Marcy 5'×7' grate discharge		3" steel 2 lb/t	NiHard 1 set/year
Newmont Mines Ltd, Similkameen	300 tph	35% −200 mesh	70%	2 Koppers 32'×14', 8,000 hp		5" 1.140 lb/t	Cr-Mo 0.260 lb/t
	450 tph	65% −200 mesh	72%	2 Dominion 16'6"×28', 5,000 hp		3" 0.312 lb/t	NiHard 0.023 lb/t
Niobec Inc	100 tph	50% −200 mesh	80%	Hardinge 8'×12'6" rod	3½"×11'6" 0.15 lb/t		NiHard
			65%	Hardinge 10'6"×13' ball		Hichrome 0.18 lb/t	NiHard
Noranda Inc, Geco	175 tph	25% −200 mesh	78%	Dominion 12'×14' No. 1 rod	3½"×13'6" 0.848 lb/t		Mn ends, NiHard shells
		36% −200 mesh	76%	Dominion 12'×14' No. 2 ball		3 & 2½" slugs Note 4	NiHard shells & ends
		60% −200 mesh	72%	4 Dominion 12'×14' No. 3 & 4 ball mills		2" slugs 2.1216 lb/t	Rubber
		95% −200 mesh	30%	A-C 7'×9' regrind		1⅛" slugs 0.132 lb/t	

this table continues . . .

Company, Mill	Milling rate	Fineness of grind	Pulp density	Grinding mills	Media type & consumption		
					Rods	Balls	Liners
Noranda Inc, Matagami	150 tph	82% −200 mesh	75%	(1) 11′×13′ (2) 11′×15′ (2) 9′×11′6″	3½″×12′8″ 0.699 lb/t 3½″×11′11″ 0.159 lb/t	1½″ Marmet 1.882 lb/t	Paraboloy, Mn & rubber
Northgate Mines, Copper Rand	130 tph	70% −200 mesh	80%	1 Dominion 9′6″×12′ rod	3″×10′ 0.62 lb/t		NiHard
				2 A-C 9′×10′ primary ball		2½″ steel 0.57 lb/t	Rubber
				1 A-C 8′×12′ regrind ball		1¾″ steel 0.27 lb/t	Rubber
				1 Hardinge 7′×10′ regrind or 1 Dominion 9′6″×12′ regrind		1¾″ steel 0.18 lb/t	Rubber
				1 A-C 7′×6′ regrind ball		1¾″ steel 0.10 lb/t	Rubber
Pamour Porcupine Mines, No. 1*	125 tph	55% −200 mesh	75%	2 Dominion 9′×10′ primary ball		4″ slugs 0.56 lb/t	NiHard
				2 Marcy 9′×12′ secondary ball		2″ slugs 0.94 lb/t	Rubber
				1 Dominion 7′×12′ conc regrind		1½″ balls 0.15 lb/t	
Potash Corp of Sask, Lanigan	450 tph	50% +20 mesh	100%	4 Hazemag impact crushers, (2 prim & 2 secd)			
	125 tph	15% +14 mesh	50%	A-C 8′×12′ regrind rod	2″ dia 0.56 lb/t		
Quebec Cartier Mining, Mount Wright	950 tph	8.8% −200 mesh	60%	Dominion 32′×12′ autogenous			
Rio Algom, East Kemptville	208.5 tph each	80% 1,440 μm		2 MPSI 12′6″×18′ rod	3″ dia		Cr-Mo
		80% 710 μm		1 MPSI 12′6″×11′ ball		1½″	Rubber
Rio Algom, Panel	140	45%	47%	Dominion 8′×12′ rod	1.17 lb/t		NiHard 0.06 lb/t
				Koppers 14′×16′8″ pebble			NiHard 0.15 lb/t
Rio Algom, Stanleigh	230 tph	Final: 55% −200 mesh	80%	A-C 26′×9′ semi-autogenous		4″ steel 1.5 lb/t	Cr-Mo 0.175 lb/t
			65%	A-C 15′×24′ pebble		1½-3½″ pebbles 10 tph	Rubber
Sherritt Gordon, Fox	116 tph	65-75% −200 mesh	83%	A-C 9′6″×12′ rod mills	3″×11′6″ 0.538 lb/t		Cr-Mo
				A-C 15′×12′6″ ball mills		1½″ steel 2.02 lb/t	Continental rubber
				Hardinge 8′×6′ Cu regrind		1½″ steel	Skega rubber
				A-C 5′×5′ Zn regrind		1½″ steel	Wajax rubber
				A-C 3′×3′ lime regrind		1½″ steel	NiHard
Sherritt Gordon, Ruttan*	308 tph	65% −200 mesh	45%	Dominion 11′×14′ rod mills	3″×13′ 0.481 lb/t		NiHard liners, Mn lifters
				Dominion 16′6″×18′ ball mills		1½″ steel 2.59 lb/t	Rubber & Cr-Mo ends
Sigma Mines (Quebec) Ltd	58.2 tph	62% −200 mesh	75%	CAC 7′×12′		3 & 4″ steel 0.43 lb/t	NiHard
				Dominion 7′×8′		2″ steel 0.58 lb/t	NiHard
				CAC 6′×7′ Dominion 5′×16′		1½″ steel 0.24 lb/t	Rubber
Société Minière Louvem*	26.09 tph	70% −200 mesh	50%	2 Hardinge 48″×9′ 2 CAC 7′×8′ 1 CAC 6′×8′		1½-4″ 2.61 lb/t	
Tantalum Mining Corp	6.5 tph	50% −200 mesh	70%	Marcy 8′×12′ grate discharge		3″ steel 3 lb/t[5]	Rubber
Teck Corp, Afton	400 tph	−⅜″	79%	Koppers 28′×12′ primary SAG		5″ Armco 0.36 lb/t	Cr-Mo
		70% −200 mesh	72%	Koppers 16′6″×29′ secondary		2½″ Magotteaux 0.24 lb/t	Rubber liners & lifters
			62%	Koppers 9′6″×12′		2½″ Magotteaux 0.08 lb/t	Rubber liners & lifters
Teck Corp, Lamaque*	80 tph		78-80%	6 Marcy 4′×10′ rod mills	3″×9′ 0.60 lb/t		NiHard & Mn 0.03 lb/t
		78% −200 mesh	70%	6 A-C 5′×16′ regrind		1½″ 0.80 lb/t	Rubber & NiHard 0.04 lb/t
Wabush Mines, Scully	376 tph			Dominion 24′×8′ autogenous			NiHard
Westar Mining, Elkview	1,400 tph	25% 4″×¼″		Barvoy vessels			
		35% ¼″×28		Heavy media cyclones			
		20% 28×60		Hydro-cyclones			
		20% 60×0		Froth cells			
Westmin Resources Ltd	38 tph	60% −200 mesh	75%	Allis-Chalmers 8′×12′	3″ dia steel 0.60 lb/t		
				Allis-Chalmers 9′×9′		2″ 0.90 lb/t	
				Allis-Chalmers 7′×7′ regrind		1½″ 0.50 lb/t	

*Based on information supplied for 1985 edition. 1. Ferrosilicon added to feed at the rate of 56 lb/t. 2. Magnetite added to feed at the rate of 3.06 lb/t. 3. Milling rate and grind varies depending on application. 4. Media consumption is 0.3553 lb/t and 0.2286 lb/t. 5. The mill is being used for a pilot operation and is considerably oversized, hence the ball consumption is abnormally high.

Table 6. Determination of Initial Ball Charge to A New Mill*

(a) Assume that 100% 3-in. balls will be charged to a mill on a periodic basis and mill holds 60-ton balls. Method to calculate initial ball charge for new mill follows (ball diameters commercially available from steel manufacturer used):

Diameter, in.	Theo. wt	%	Wt, tons
3	4.00	46.8	28.1
2½	2.32	27.1	16.3
2	1.19	13.9	8.3
1½	0.50	5.8	3.5
1¼	0.29	3.4	2.0
1	0.15	1.8	1.1
⅞	0.10	1.2	0.7
	8.55	100.00	60.0

(b) Assume multiple-size makeup addition for initial charge determination. Assume that 70%–30%, 2 and 3 in., respectively, will be recharged on periodic basis.

Calculation follows: $\frac{70}{30}$ Ratio of 2 to 3-in. $\times \frac{4.00}{1.19}$ wt of 3-in Ball wt of 2-in Ball $= 7.84$

There are 7.84 2-in balls to one 3-in ball

Diameter, in.	Theo. Ball wts 3-in.	Theo. Ball wts 2-in.	Balanced wt	%	Wt, tons
3	4.00	----------	4.00	15.4	9.2
2½	2.32	----------	2.32	8.9	5.3
2	1.19	7.84 x 1.19	10.52	40.4	24.3
1½	0.50	7.84 x 0.50	4.42	17.0	10.2
1¼	0.29	7.84 x 0.29	2.56	9.8	5.9
1	0.15	7.84 x 0.15	1.33	5.1	3.1
⅞	0.10	7.84 x 0.10	0.88	3.4	2.0
			26.03	100.0	60.0

This material is based on theory that ball wear is proportional to diameter squared, which is to say that regardless of the number of sizes of balls in the charge, each piece will lose an equal thickness of material from its surface in a given period of time.

* Dependent on ball makeup size to the mill.
After A. Souder, Armco Steel Corp.

balls in each size interval will weigh about 300 pcf. By increasing the proportions of smaller-size balls in the charge, densities up to about 325 pcf are attainable. In a charge where all of the balls are the same diameter, the density is 282 pcf for steel.

Some mills will grind more efficiently to the desired product size when a higher proportion of small balls exist in a seasoned charge than would naturally be obtained when the periodic makeup balls are all of one diameter. This was conclusively demonstrated by Barker and Lewis,[10] in the ball mills at Ajo, Ariz. They found that a certain percentage of the larger diameter balls was needed for initial breakdown of the larger or tougher pieces of mill feed, while a higher percentage of smaller-diameter balls in the charge produced the most desirable screen analysis of the ground product. This condition exists at many single-stage grinding operations. To obtain the desired screen analysis of the mill discharge where these conditions exist, size rationing of the periodic ball makeup may be used. For example, one large single-stage milling operation on a $-\frac{3}{4}$-in. copper ore uses a daily ball makeup ration consisting of about 10% 3½-in., 40% 3-in., and 50% 2-in. balls (weight percentages). This ration was found to be the most desirable after several years of testing with various proportions of the three sizes. A discussion of the many considerations involved in ball size rationing is given by Crow.[11]

When a new mill is charged with balls, it is desirable to proportion the weights of each size charged to the proportions which will exist in the mill after it has operated for a sufficient length of time to produce an equilibrium or seasoned charge. Table 6 illustrates how such initial charges can be calculated when the daily ration to the mill after it is put into operation will be all 3-in. balls, and, when the daily ration will be 70% 2-in. and 30% 3-in. balls.[3]

The rate at which balls lose diameter by wear in a mill determines their service life. This varies over a wide range, depending on the abrasion resistance of the balls, the abrasiveness of the material being ground, the size distribution, and total surface area of the ball charge, and the diameter of the mill. The effect of mill diameter is not generally appreciated. This effect is due to the fact that the weight and surface area of a ball charge in a mill increases as the square of the mill diameter. The energy input to tumble this charge increases as the 2.6 power of the mill diameter, so energy input per unit of total ball area of the charge increases as the 0.6 power of the mill diameter. Since there is direct relationship between energy input and ball wear, it follows that ball wear increases as the 0.6 power of the mill diameter. This statement assumes that the ball charge in each mill occupies a given percentage, such as 50%, of the mill volume. It should also be recognized that even though individual balls lose diameter faster as mill diameter increases, the wear, when expressed in pounds per ton of ore ground or pounds per kilowatt-hour, does not necessarily increase.

$\propto D^{2.6}$

By use of direct-measurement techniques on suitably identified balls, Norman[1, 6] had determined the wear rate and life of balls in a number of mills operated under widely diverse conditions. His results are listed in Table 7. The wear rates are for 0.80% carbon, low-alloy martensitic steel balls, fully hardened through at least 95% of their original volume. The data in Table 7 indicate that the life of the balls, 2- to 3-in. original diameter, in the commercial-size ore-grinding mills, ranges from a minimum of 73 days to a maximum of 312 days. In a 3-ft diam test mill grinding feldspar and calcite, the lives on 3-in. balls were 608 and 7,260 days, respectively. In dry-grinding cement clinker, a calculated life of 13,500 days was obtained on 4-in. balls in the primary compartment and, at a different plant, the calculated life on 1½-in. balls in the second compartment was 2,000 days. These life figures on balls are of particular interest in estimating the time required to completely displace an old charge of balls when a test is started on balls made from a new composition or new source.

Another way of determining the time required to displace a charge of balls in a mill has been proposed by A. L. Bard.[12] This is illustrated in Table 8. In the calculation accompanying Table 8, it is indicated that where x tons of balls are maintained in a mill charge by periodic (daily) additions, then a total of 2.9 times x tons will have to be added to the mill by the periodic makeup before the original charge in the mill has been completely displaced. Bard's calculations are based on the assumption that the balls in the mill lose diameter at a constant rate. His calculations agree well with the data from actual field tests and with the ball-life estimates in Table 7. Bard has made a similar calculation for a charge of grinding rods, as illustrated in Table 9. Here the makeup factor is 2.07 times x.

Corrosion Influence on Grinding Media Consumption. There is considerable disagreement and probably some misunderstanding over the role that corrosion plays in the wear of grinding media. It is well known that when the raw feed to cement plants is ground wet, the wear of grinding media and liners is usually from five to ten times the wear rate when the feed is ground dry. Also in cement finishing mills, which always grind dry, the wear rate, when expressed in weight loss per day or weight loss per kilowatt-hour, is very low when compared to wet grinding operations. These observations are well confirmed by the studies of Wesner et al.,[13] Bond,[14] and other investigators. It is logical to assume that in wet grinding, a freshly abraded metal surface reacts with the water to form an oxide or hydroxide surface coating and hydrogen gas. This freshly formed coating is not usually very adherent or abrasion-resistant, so it is easily abraded off the surface of the ball, rod, or liner, thus permitting further chemical reaction between the water and the metal surface. There are indications that chromium oxide or hydroxide films are more abrasion-resistant than iron oxide or hydroxide films, since high-chromium martensitic steels and irons tend to resist abrasive wear in both wet and dry grinding substantially better than low-chromium martensitic steels. However even high chromium contents fail to protect the softer grades of stainless steels from abrasion in grinding mills.