Appendix

Appendix Ⅰ－１ ジンバブエ国におけるＮ施肥量の今後の増大

第１部、第１編 4.3.5 において、Ｎ施肥量の伸び率等を下記のとおり仮定した。

商業農場 ： ２％／Ｙ

共同体農場 ： ha当り施肥量は商業農場の 1/5(1995/96年)

このような仮定が妥当であることについて、特定の作物を対象として選定し、これらの場合に例をとって記述する。

社会経済的な構造から見て、経営面積の増大は期待しない方がよいと判断される商業農場については、今後増産が求められている小麦のみを対象とする。

一方、共同体農場ではトウモロコシと綿を対象として選び、前述の仮定が、第１次５ヵ年計画の政策が要望している条件を満たすものであることを以下に説明する。

なお、上記の３種の作物を対象として選定した理由は、これら３種の作物は、第１次５ヵ年計画において重要作物として挙げられており、またこれら３種の作物による肥料消費は、Ａ－Table Ⅰ－４－１に見られるとおり全肥料消費の75％を占めているからである。

用いる手法は、Sensitivity analysisをとりたいが、必要なデーターが不十分なため、これに代わる方法として、現在平均施肥量が商業農場の1/10となっている共同体農場の施肥量に対応する収穫をベースラインとみなし、商業農場の施肥量増分に対応する作物の増収をマクロにとらえて肥料の効果と評価する。この方法では窒素以外の成分の効果が混同するが、その点は窒素の効果が相対的に大きいことから許容されるものとする。

このAuxiliary method で解析するデーターは、Ａ－Table Ⅰ－４－１で1985年単年度のデーターのみに基づくと偏りを生じ易いと判断し、かんばつの激しかった1983年のデーターをのぞき 1980-1985年の平均値を使用した。

商業農場の施肥量をTable Ⅰ－４－16から採用し、共同体農場のそれはその1/10であるとした。この方法による窒素成分の増施効果の具体的計算はＡ－Table Ⅰ－４－15に記述した。

1. トウモロコシの場合

窒素増施の結果として収穫量はA－Table 4－1およびA－Table 4－15を参照して、共同体農場では

1985年の収量	1.394 T/ha
N増施による増収	0.371
1995/96 年の予想収量	1.765 T/ha

1988/89 年度の共同体農場の作付け面積（A－Table 4－3）から1995/96年度を外挿すれば次のような作付け面積が得られる。

$$(945 + 130)\ \text{Kha} \times (1.05)^7 = 1{,}513\ \text{Kha}$$

これに上の予想収量を乗じて95/96 年度の共同体農場の総収量を推定すると

$$1.765\ \text{T/ha} \times 1{,}513\ \text{Kha} = 2{,}670\ \text{KT}$$

これはA－Table 4－1記載の共同体農場における1985年の生産量を年率5％で増加させていくとする第1次5ヵ年計画の線に沿った1995/96 年度の目標生産量

$$1{,}558\ \text{KT} \times (1.05)^{10} = 2{,}538\ \text{KT}$$

を充足するに足るものである。

2. 綿の場合

トウモロコシの場合と全く同様な手法で、共同体農場では

1985年の収量	0.846 T/ha
N増施による増収	0.137
1995/96 年の予想収量	0.983 T/ha

1995/96 年度の作付け面積は

$$(138 + 20)\text{Kha} \times (1.05)^{7} = 222.3\ \text{Kha}$$ となり

同年度の共同体農場の総収量推定は

$$0.983\ \text{T/ha} \times 222\ \text{Kha} = 218\ \text{KT}$$ となる

これはトウモロコシと同様な考え方で計算した1995/96 年度の目標生産量

$$110\ \text{KT} \times (1.05)^{10} = 179\ \text{KT}$$

と比較してやや多い。従って共同体農場に関して先に設定した窒素成分の増加は適切である。

3. 小麦の場合

小麦の生産は現時点でもほとんど商業農場に集中しており、共同体農場の生産の割合は非常に小さい。これは小麦の適作地が商業農場の分布と一致していること、かんがい設備と多肥等の栽培必要条件が投下資本をより多く必要としているなど諸要因がからんでいるからであろう。

ここでは1995／96年に向かって、小麦の生産は商業農場の小麦作付け面積増で増やすものと仮定した。商業農場の経営面積の拡大は考えないとする基本前提からみれば、このことは現在の商業農場の作付けからなにかが減らされて行くことを意味するであろう。

Table Ｉ－４－16に見られるように小麦については

基　肥	複合肥料	650kg/ha
	平均Ｎ含有量	8 %
追　肥	硝安	450kg/ha
	Ｎ含有量	34.5 %

$$650 \text{ kg/ha} \times 0.08 = 52.0 \text{ kgN/ha}$$
$$450 \times 0.345 = 155.3$$
$$207.3 \text{ kgN/ha}$$

が平均Ｎ施肥量である。

第１次５ヵ年計画では1990年に目標として55Kha の作付け面積と５T/haの収穫が想定されている。1990年の小麦の生産量を年率５％増で外挿して、1995/96 年度の目標生産量を計算すれば

$$5 \text{ T/ha} \times 55 \text{ Kha} \times (1.05)^5 = 351\text{KT}$$

となり、これに対応する作付け面積は５T/haの収量を維持するものとして70.2Kha となる。

小麦の作付け面積の最近時点の利用可能なデーターはＡ－Table 4 －１で1984年 16.9Khaである。これから上記の目標生産量を達成するため必要な窒素肥料の増分は

$$0.207 \text{ TN/ha} \times (70.2 - 16.9) \text{ Kha} = 11.0\text{KTN}$$

この窒素必要量は、assumed nitrogenous fertilizer consumption increase in commercial farm　23.5KT/Y （Ａ－Table 4 －16参照）の約 1/2に相当する。

残り 1/2は、商業農場のその他の主要作物、タバコ、コーヒー、および茶（Table Ｉ－４－16によればこの３作物で全肥料の12％を消費している）、その他の作物への増施用のため必要にして充分といえる。

A-Table 4-1(1) Crop Area and Production by Sector

Maize

	Commercial			Communal 1)			Total		
	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)
1980	910,739 2)	227,733 2)	3,999 2)	600,000	900,000	667	1,510,739	1,127,733	1,340
1981	1,833,395	363,448	5,044	1,000,000	1,000,000	1,000	2,833,395	1,363,448	2,078
1982	1,213,376	316,440	3,835	595,000	1,100,000	595	1,808,376	1,416,440	1,277
1983	624,786	283,880	2,201	285,000	1,050,000	271	909,786	1,333,880	682
1984 3)	678,403	224,586	3,021	454,400	1,136,000	400	1,132,803	1,360,586	833
1985 3)	1,153,000	238,000	4,844	1,558,000	1,018,000	1,394	2,711,000	1,256,000	2,158

1) Estimates.
2) Refers to large scale commercial farms only.
3) Provisional data.

Sorghum

	Commercial			Communal 1)			Total		
	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)
1980	16,299 2)	6,766 2)	2,409 2)	66,000	120,000	550	82,299	126,766	649
1981	25,131	9,290	2,705	100,000	200,000	500	125,131	209,290	598
1982	17,355	8,232	2,108	50,000	200,000	250	67,355	208,232	323
1983	7,536	7,672	982	44,000	280,000	157	51,536	287,672	179
1984 3)	18,071	9,903	1,825	37,440	156,000	240	55,511	165,903	335
1985 3)	54,048	15,049	3,591	76,000	211,000	360	130,048	226,049	575

1) Estimates.
2) Refers to large scale commercial farms only.
3) Provisional data.

A-Table 4-1(1) Crop Area and Production by Sector (Cont'd)

Wheat (Commercial farms only)

	Production (tons)	Area (hectares)	Yield (kg/ha)
1980 1)	154,993 1)	36,556 1)	4,749 1)
1981	183,516	36,845	4,981
1982	191,880	37,378	5,134
1983	110,990	21,547	5,151
1984 2)	83,807 1)	16,891 1)	4,962 1)

1) Only large scale commercial farms.
2) Provisional data.

Groundnuts

	Commercial			Communal 1)			Total		
	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)
1980	10,675 2)	3,841 2)	2,779	67,000	175,000	383	77,675	178,841	434
1981	18,797	12,909	1,456	100,000	300,000	333	118,797	312,909	380
1982	16,377	11,923	1,374	95,000	240,000	396	111,377	251,923	442
1983	9,152	10,709	855	22,500	180,000	125	31,652	190,709	166
1984 3)	6,194	7,014	883	18,720	144,000	130	24,914	151,014	165
1985 3)	6,938	6,938	1,000	61,000	118,000	512	67,938	124,938	544

1) Estimates.
2) Refers to large scale commercial farms only.
3) Provisional data.

A-Table 4-1(2) Crop Area and Production by Sector

Soybeans

	Commercial			Communal 1)			Total		
	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)
1980	89,403 2)	40,783 2)	2,192 2)	8,000	12,000	667	97,403	52,783	1,845
1981	66,131	30,971	2,135	6,750	9,000	750	72,881	39,971	1,823
1982	88,596	48,417	1,830	3,000	7,000	429	91,596	55,417	1,653
1983	78,626	54,909	1,432	2,000	4,000	500	80,626	58,909	1,369
1984 3)	88,763	54,169	1,639	970	2,260	429	89,733	56,429	1,590
1985 3)	85,542	40,986	2,087	1,675	2,000	837	87,217	42,986	2,029

1) Estimates.
2) Refers to large scale commercial farms only.
3) Provisional data.

Cotton

	Commercial			Communal 1)			Total		
	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)
1980	145,533	74,921	1,943	12,000	15,000	800	157,533	89,921	1,752
1981	125,594	66,054	1,901	45,000	59,000	763	170,594	125,054	1,364
1982	107,886	58,014	1,860	27,000	51,000	529	134,886	109,014	1,237
1983	114,021	67,976	1,677	32,500	65,000	500	146,521	132,976	1,102
1984 3)	151,746	80,155	1,893	70,000	100,000	700	221,746	180,155	1,231
1985 3)	164,186	79,658	2,061	110,000	130,000	846	274,186	209,658	1,308

1) Estimates.
2) Only large scale commercial farms.
3) Provisional data.

A-Table 4-1(2) Crop Area and Production by Sector (Cont'd)

Coffee 1)

	Productive area 2)			Non productive area 1)
	Production (tons)	Area (hectares)	Yield (kg/ha)	
1980	5,261	4,098	1,284	2,194
1981	5,476	4,608	1,188	3,705
1982	6,073	5,042	1,204	3,990
1983	8,234	7,008	1,177	2,251
1984 3)	9,977	7,296	1,367	1,392

1) Figures relate only to large scale commercial farms.
2) In the table the area planted has been classified into productive and non-productive depending on whether or not it can be harvested. Areas where the coffee has not matured for harvesting is classified as non-productive.
3) Provisional data.

Tobacco

	Commercial 1)			Communal 2)			Total		
	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)
1980	119,818 3)	63,703 3)	1,801 3)	231	365	633	120,049	64,068	1,874
1981	69,226	39,393	1,757	195	367	531	69,421	39,760	1,746
1982	88,423	45,552	1,941	774	1,080	717	89,197	46,632	1,913
1983	93,331	46,327	2,015	645	1,400	460	93,976	47,727	1,969
1984 4)	116,157	49,962	2,325	774	1,210	640	116,931	51,172	2,285
1985 4)	106,557	51,999	2,049	1,190	1,700	700	107,747	53,699	2,006

1) Includes flue-cured and burley tobacco.
2) Estimates.
3) Only large scale commercial farms.
4) Provisional data.

A-Table 4-1(3) Crop Area and Production by Sector

Sugarcane

	Productive area			Non productive area
	Production (tons)	Area (hectares)	Yield (kg/ha)	
1980	2,528,000	24,515	103.1	6,038
1981	3,551,000	34,146	103.9	466
1982	3,587,000	31,547	113.7	533
1983	3,438,000	33,033	104.1	1,400
1984 1)	3,459,000	33,048	104.7	109

1) Provisional data.

Tea (Large scale commercial farms)

	Tea (made or black)		
	Production (tons)	Area (hectares)	Yield (kg/ha)
1980	9,661	4,143	2,332
1981	9,916	4,247	2,335
1982	10,602	4,423	2,397
1983	10,551	4,476	2,357
1984 1)	11,807	4,447	2,655

1) Provisional data.

Source: Statistical Yearbook 1987

A-Table 4-2 Large Scale Commercial Farming (1973-85)

Year	Area of farms covered	Permanent farm and forest employees	Area under crops	Area under fruit	Area under irrigation	Production of						Holdings of		
						Flue-cured Tobacco	Other Tobaccos	Grain Maize	Sorghum	Ground nuts (un-shelled)	Cotton	Cattle	Sheep	Pigs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	'000 ha	no.	hectares	hectares	hectares	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	'000	'000	'000
1973	14,958	236,472	597,647	6,189	113,833	64,216	5,416	784,365	25,632	6,317	105,708	2,573	246	99
1974	15,112	240,985	606,363	5,983	113,332	70,288	3,389	1,567,175	10,560	9,614	120,859	2,575	230	96
1975	15,193	236,542	585,236	5,359	127,194	82,085	2,421	1,260,393	4,411	8,333	121,345	2,781	218	105
1976	15,148	242,224	561,207	5,228	130,558	106,723	1,734	1,205,340	15,319	9,645	107,742	2,902	208	109
1977	15,303	245,444	570,028	4,752	146,787	82,466	1,488	1,140,067	14,532	6,255	115,238	2,959	195	121
1978	15,317	239,469	559,225	4,275	149,377	81,148	2,168	1,102,289	15,585	5,879	129,037	2,812	172	108
1979	15,064	235,455	538,105	4,064	151,698	105,022	2,262	705,466	18,883	7,537	130,218	2,478	152	86
1980	14,798	203,194	571,169	3,663	154,806	117,370	2,452	887,519	16,299	10,675	145,553	2,208	141	89
1981	14,482	196,337	595,870	4,005	158,328	67,267	1,885	1,712,708	24,315	15,360	117,960	2,189	141	95
1982	13,516	169,250	581,331	3,679	165,405	85,452	2,876	1,120,653	16,910	14,271	104,754	2,197	134	103
1983	12,825	159,829	544,882	3,543	143,845	89,084	4,109	575,950	7,209	8,547	111,093	2,161	145	104
1984	12,473	163,036	527,860	4,062	135,597	111,755	4,052	666,403	17,566	5,394	145,346	2,033	144	78
1985	11,299	147,842	537,635	3,415	149,835	101,059	3,668	1,083,100	53,127	4,439	154,960			

Column: Notes and Explanations

1 Includes farms on which no farming activities were being carried out except for 1985.

1 and 2 ....Refers to 30 September of each year.

3-11 ....Refers to year ending 30 September of each year.

12-14 ....Refers to 30 June for 1972-1976 inclusive, from 1977 refers to 31 March.

2 ....Includes owners, partners, occupiers and lessees actively engaged in farming either as private limited liability companies or on a non-corporate basis. Farmers' wives are also included where they take an active part in the running of the farm. Domestics, Other Employees (Storemen, factory employees etc.) and, Casual and Contract employees are excluded.

3 ....The 1975 figure is not precisely comparable with those for other years as it excludes the area planted to other vegetables (other than onions, peas and tomatoes) garden plants etc. grown commercially. The extent of the change was small, however, as is indicated by the fact that the area planted to other vegetables, garden plants, etc. in 1974 was only 2,449 hectares.

5 ....The 1975 figure is not precisely comparable with those for other as it excludes area irrigated to other vegetables (other than onions, peas and tomatoes), garden plants etc. grown commercially. The extent of the change was small, however, as is indicated by the fact that the area irrigated to other vegetables, garden plants etc. in 1974 was only 2,067 hectares.

12-14 ....Excludes unclassified livestock refers to 31 March of each year.

A-Table 4-3 Crop Area Estimates by Sector

Unit: Ha

Crop	1985/86				1986/87					1987/88					1988/89				
	LSC	SSC	Communal & Resettlement	Total	LSC	SSC	Communal	Resettlement	Total	LSC	SSC	Communal	Resettlement	Total	LSC	SSC	Communal	Resettlement	Total
Flue cured tobacco	61,000			61,000	66,000	51	224		66,275	63,000	60	250		63,310	65,000	60	250		65,310
Burley tobacco	12,000	500	1,200	13,700	900	106	1,605		2,611	1,000	120	1,600		2,720	1,000	120	1,600		2,720
Oriental tobacco				0		19	64		83		20	70		90		20	70		90
Cotton*	74,000	10,000	150,000	234,000	80,000	13,000	138,000	15,000	246,000	80,000	13,000	138,000	17,000	248,000	80,000	13,000	138,000	20,000	251,000
Maize grain	195,000	5,000	1,200,000	1400,000	110,000	37,070	942,600	121,400	1,211,070	120,000	37,000	945,000	125,000	1,227,000	150,000	37,000	945,000	130,000	1,262,000
Maize seed	8,000			8,000	9,000				9,000	9,000				9,000	9,000				9,000
Wheat	42,000			42,000	42,000				42,000	36,000				36000	45,000				45,000
Barley	6,000			6,000	5,700				5,700	5,000				5,000	6,000				6,000
Soybeans	50,000	1,000	3,000	54,000	55,000	257	2,488	980	58,725	60,000	300	2,500	1,000	63,900	65,000	300	2,500	1,000	68,800
Groundnuts	2,500	5,000	140,000	147,500	5,000	10,354	176,645	10,200	202,199	6,000	12,000	180,000	11,000	209,000	7,000	12,000	180,000	12,000	211,000
Sunflower	1,600	2,000	32,000	35,600	6,200	6,310	72,670	1,950	87,130	6,200	6,000	70,000	2,250	84,450	6,200	6,000	70,000	2,500	84,700
Sorghua	20,000	2,000	225,000	247000	5000	2,480	164,322	8,400	180,202	4,000	2,500	165,000	8,500	180,000	4,000	2,500	165,000	8,500	180,000
Coffee	9,500			9,500	9500				9,500	10,000				10,000	10,500				10,500
Rapoko			200,000	200,000	50	3,000	109,211	7,040	119,301		3,000	110,000	7,000	120,000	-	3,000	110,000	7,000	120,000
Mhungs			300,000	300,000	112	1,031	187,277	2,600	191,020		1,000	180,000	2,500	183,500		1,000	180,000	2,500	183,500
Edible beans	1,000		20,000	21,000	1,500	574	16,890		18,964	1,500	700	17,000	700	19,900	1,500	700	17,000	700	19,900
Sugar cane	33,000			33,000	33,000				33,000	33,000				33,000	33,000				33,000
Tea	5,500			5,500	5,500				5,500	5,500				5,500	5,500				5,500
Fruit (incl. Citrus)	4,500			4,500	4,500				4,500	4,500				4,500	5,000				5,000
Vegetables/Flowers	2,500			2,500	3,500				3,500	4,000				4,000	4,500				4,500
Potatoes	18,000			18,000	2,000				2,000	2,000				2,000	2,000				2,000
Fodder	7,000			7,000	7,500				7,500	8,000				8,000	8,500				8,500
Silage	10,000			10,000	11,000				11,000	11,500				11,500	12,000				12,000
Pasture	15,000			15,000	15,500				15,500	16,000				16,000	16,500				16,500
Total	578,100	25,500	2,271,200	2,874,800	478,462	74,252	1,811,996	167,570	2,532,280	486,200	75,700	1,809,420	174,950	2,546,270	537,200	75,700	1,809,420	184,200	26,06,520
Sector total	603.6		2,271.2		552.8		1,979.6			561.9		1,984.4			612.9		1993.6		

Source: CSO

A-Table 4-4 (1) Large Scale Commercial Farm

Area and Production of Crops and Fruit, by Province (1985)

Crop	Unit	Manicaland	Mashonaland west	Mashonaland east	Mashonaland central	Matabeleland north	Matabeleland south	Midlands	Masvingo	Total
Tobacco:										
Flue-cured:										
Farm count	no.	78	465	249	224	–	–	*	–	1,017
Area planted	hectares	3,324	22,015	11,310	12,382	–	–	23	–	49,054
Crop sold	tonnes	7,361	43,248	26,035	24,374	–	–	41	–	101,059
Yield per hectare	kg	2,215	1,964	2,302	1,969	–	–	1,783	–	2,060
Burley:										
Farm count	no.	28	18	28	41	–	–	–	–	115
Area planted	hectares	578	212	315	847	–	–	–	–	1,952
Crop sold	tonnes	1,055	349	632	1,528	–	–	–	–	3,564
Yield per hectare	kg	1,825	1,646	2,006	1,804	–	–	–	–	1,826
Maize for grain:										
Total maize for grain:										
Farm count	no.	...	...	...	...	...	...	...	...	...
Area planted	hectares	5,794	92,915	39,435	44,366	1,633	1,355	9,153	2,479	197,130
Crop reaped	tonnes	25,236	516,211	208,152	274,270	7,103	5,435	37,190	9,503	1,083,100
Yield per hectare	kg	4,356	5,556	5,278	6,182	4,350	4,011	4,063	3,833	5,494
Farm retentions (included above)	tonnes	5,147	39,475	52,069	20,083	3,178	2,021	8,947	2,923	133,843
For seed:										
Farm count	no.	*	35	39	62	*	*	5	4	149
Area planted	hectares	64	2,454	2,067	2,924	51	22	185	79	7,846
Crop reaped	tonnes	225	7,817	9,239	11,353	202	29	426	70	29,359
Yield per hectare	kg	3,516	3,185	4,470	3,883	3,961	1,318	2,303	886	3,742
Total area planted to maize:	hectares	5,858	95,369	41,502	47,290	1,684	1,377	37,375	2,558	204,976
Industrial crops:										
Sorghum:										
Total:										
Farm count	no.	...	...	...	...	...	...	...	...	...
Area planted	hectares	455	9,166	553	1,711	332	140	1,104	484	13,945
Crop reaped	tonnes	1,659	34,529	2,862	8,166	1,047	315	3,116	1,433	53,127
Yield per hectare	kg	3,646	3,767	5,175	4,773	3,154	2,250	2,822	2,961	3,810
Farm retentions (included above)	tonnes	47	460	71	33	197	221	723	359	2,111

A-Table 4-4 (2) Large Scale Commercial Farm

Area and Production of Crops and Fruit, by Province (1985)

Crop	Unit	Manicaland	Mashonaland west	Mashonaland east	Mashonaland central	Matabeleland north	Matabeleland south	Midlands	Masvingo	Total
Wheat:										
Farm count	no.	38	143	69	107	*	*	18	10	397
Area planted	hectares	6,960	12,211	5,220	8,506	394	562	640	562	35,055
Crop reaped	tonnes	28,072	61,080	29,789	46,129	1,873	1,927	3,290	2,134	174,294
Yield per hectare	kg	4,033	5,002	5,707	5,423	4,754	3,429	5,141	3,797	4,972
Barley:										
Farm count	no.	*	12	24	6	–	*	22	*	69
Area planted	hectares	28	503	1,725	176	–	40	2,143	22	4,641
Crop reaped	tonnes	163	2,088	9,663	990	–	190	12,058	48	25,200
Yield per hectare	kg	5,821	4,151	5,589	5,625	–	4,750	5,627	2,182	5,430
Coffee (productive):										
Farm count	no.	82	41	*	13	*	–	4	4	148
Area planted	hectares	5,113	1,200	60	293	3	–	188	116	6,973
Crop reaped	tonnes	6,661	1,602	83	357	1	–	301	222	9,227
Yield per hectare	kg	1,303	1,335	1,383	1,218	333	–	1,601	1,914	1,323
Coffee (unproductive):										
Farm count	no.	45	7	*	–	–	–	*	*	56
Area established	hectares	1,243	425	11	–	–	–	13	30	1,722
Cotton (unginned):										
Total										
Farm count	no.	...	...	...	...	–	...	...	...	...
Area planted	hectares	7,258	28,157	408	27,464	–	1,315	887	4,800	70,289
Crop reaped	tonnes	21,610	50,563	702	63,352	–	4,033	1,433	13,267	154,960
Yield per hectare	kg	2,977	1,796	1,721	2,307	–	3,067	1,616	2,764	2,205
Groundnuts (unshelled):										
Farm count	no.	10	29	44	17	*	*	23	7	134
Area planted	hectares	47	682	961	126	1	10	68	31	1,926
Crop reaped	tonnes	76	1,286	2,540	353	–	21	136	27	4,439
Yield per hectare	kg	1,617	1,886	2,643	2,802	–	2,100	2,000	871	2,305
Farm retentions (included above)	tonnes	–	14	45	1	–	1	14	8	83

A-Table 4-4 (3) Large Scale Commercial Farms

Area and Production of Crops and Fruit, by Province (1985)

Crop	Unit	Manicaland	Mashonaland west	Mashonaland east	Mashonaland central	Matabeleland north	Matabeleland south	Midlands	Masvingo	Total
Soya beans (threshed):										
Farm count	no.	18	205	103	113	*	*	19	9	474
Area planted	hectares	850	20,818	8,208	8,960	73	4	1,052	442	40,407
Crop reaped	tonnes	1,681	41,543	17,544	21,048	139	16	1,670	775	84,416
Yield per hectare	kg	1,978	1,996	2,137	2,349	1,904	4,000	1,587	1,753	2,089
Farm retentions (included above)	tonnes	29	934	282	286	16	16	114	156	1,833
Sunflowers (threshed):										
Farm count	no.	14	33	16	9	4	*	20	*	102
Area planted	hectares	51	1,809	226	126	9	22	219	8	2,470
Crop reaped	tonnes	20	592	184	70	5	28	140	3	1,041
Field per hectare	kg	392	327	814	556	556	1,273	639	375	421
Total area under crops:	hectares	41,069	210,619	95,969	117,767	5,101	4,218	19,138	43,744	537,635
Fruit grown Commercially:										
Citrus:										
Orange:										
Farm count	no.	14	10	10	16	*	11	16	*	84
Total number of trees	'000	10	18	6	169	1	38	13	5	260
Area established	hectares	42	84	28	697	13	189	40	40	1,133
Value of sales	$'000	22	127	15	2,469	9	2,060	95	86	4,882
Total citrus:										
Farm count	no.	...	...	...	...	...	...	...	...	...
Total number of trees	'000	13	18	9	203	1	45	13	18	321
Area established	hectares	55	85	50	959	19	223	42	91	1,524
Value of sales	$'000	38	127	23	2,628	13	2,348	97	181	5,454
Tropical:										
Farm count	no.	...	...	...	...	–	...	...	...	...
Area established	hectares	251	137	37	52	–	–	–	18	495
Value of sales	$'000	561	715	13	83	–	2	1	6	1,381
Total area under crops and fruit:	hectares	42,246	210,856	96,353	118,895	5,120	4,512	19,195	43,863	541,050

A-Table 4-5 Nitrogen Fertilizer Statistics

Unit: 1,000 TN

	Total Nitrogen	Ammonium Sulphate	Ammonium Nitrates	Urea	Total Other N	Total Compounds
			Production			
Western Europe						
1984/1985	12,088.5	713.5	4,994.7	2,295.6	789.0	3,295.7
1985/1986	11,539.0	774.8	5,160.1	1,816.1	880.7	2,907.2
1986/1987	11,219.2	702.0	5,058.2	1,788.9	926.5	2,743.7
Eastern Europe						
1984/1985	20,417.7	1,050.5	7,828.6	6,544.9	1,776.4	3,217.3
1985/1986	21,240.5	1,086.8	7,403.1	6,929.5	2,083.6	3,737.6
1986/1987	22,289.3	1,134.9	7,820.9	7,389.1	2,277.0	3,667.5
Africa						
1984/1985	1,829.6	71.2	512.9	864.9	42.9	337.7
1985/1986	1,704.1	60.9	588.4	713.8	41.6	299.4
1986/1987	1,726.9	78.6	636.9	601.2	46.4	363.9
North America						
1984/1985	1,4150.3	466.0	914.6	2,844.0	7,584.9	2,340.8
1985/1986	1,2102.4	443.6	924.4	2,475.3	6,431.8	1,827.3
1986/1987	1,2017.4	450.5	874.5	2,736.1	5,741.0	2,215.4
Central America						
1984/1985	1,408.9	318.5	166.2	589.5	248.2	86.5
1985/1986	1,741.7	391.3	164.2	822.5	263.8	99.9
1986/1987	1,633.9	307.0	165.7	816.0	254.4	90.9
South America						
1984/1985	1,148.6	56.8	120.3	678.3	92.1	201.1
1985/1986	1,174.0	78.6	125.2	644.9	90.3	235.0
1986/1987	1,274.5	55.0	111.0	713.4	100.5	294.8
Middle East						
1984/1985	1,504.0	13.9	30.4	1,271.5	32.0	156.2
1985/1986	1,572.9	12.8	28.7	1,344.2	27.5	159.7
1986/1987	1,731.0	13.9	42.4	1,454.6	30.0	190.1
Asian CPE's						
1984/1985	12,927.0	194.0	712.0	4,311.0	7,695.0	15.0
1985/1986	12,195.1	183.0	679.0	4,655.0	6,663.1	15.0
1986/1987	12,248.0	165.0	700.0	4,820.0	6,548.0	15.0
South and East Asia						
1984/1985	9,030.3	662.9	241.8	6,668.2	119.3	1,338.1
1985/1986	9,747.2	752.1	233.5	7,164.4	140.6	1,456.7
1986/1987	11,207.7	736.7	237.7	8,484.6	129.1	1,619.7
Oceania						
1984/1985	246.5	50.0	20.0	135.0	6.0	35.5
1985/1986	279.0	45.0	18.0	164.0	8.0	44.0
1986/1987	255.1	40.7	25.0	143.0	9.7	36.7
World Total						
1984/1985	74,751.4	3,597.3	15,541.5 20.8%	26,202.9 35.1%	18,385.8	11,023.9
1985/1986	73,295.9	3,828.8	15,324.7 20.9%	26,729.7 36.5%	16,631.0	10,781.7
1986/1987	75,603.1	3,684.2	15,672.2 20.7%	28,946.8 38.3%	16,062.6	11,237.5

Source: Statistical Supplement, 1987 British Sulphur

A-Table 4-5 Nitrogen Fertilizer Statistics (Cont'd)

Unit: 1,000 TN

	Total Nitrogen	Ammonium Sulphate	Ammonium Nitrates	Urea	Total Other N	Total Compounds
	Consumption					
Western Europe						
1984/1985	11,016.2	385.5	5,174.9	1,074.9	953.4	3,427.4
1985/1986	11,125.4	378.1	5,094.0	1,335.9	985.1	3,332.3
1986/1987	11,479.7	379.3	5,176.6	1,547.1	1,093.2	3,283.4
Eastern Europe						
1984/1985	15,409.1	738.5	7,062.5	3,139.5	1,538.6	2,930.1
1985/1986	16,202.3	760.9	6,280.3	3,543.6	1,934.1	3,683.3
1986/1987	16,531.0	851.6	6,716.9	3,776.9	1,694.7	3,491.0
Africa						
1984/1985	1,931.1	108.9	611.6 31.7%	736.6 38.1%	42.1	431.9
1985/1986	2,098.1	150.6	688.7 32.8%	762.0 36.3%	42.0	454.8
1986/1987	1,893.3	90.8	678.2 35.8%	617.4 32.6%	42.1	465.3
North America						
1984/1985	11,717.9	168.0	833.0	1,591.1	6,781.0	2,344.8
1985/1986	10,751.4	148.4	655.7	1,912.6	5,859.9	2,174.8
1986/1987	10,538.7	141.1	642.3	1,851.2	5,774.6	2,129.4
Central America						
1984/1985	1,764.0	479.5	153.9	670.3	248.4	211.9
1985/1986	1,912.5	511.7	150.0	788.6	264.1	198.1
1986/1987	1,929.3	497.1	162.1	834.4	254.6	181.1
South America						
1984/1985	1,430.0	183.0	123.0	780.3	44.0	299.7
1985/1986	1,509.7	178.8	125.8	815.1	38.1	351.9
1986/1987	1,798.7	235.1	131.7	971.8	6.8	453.1
Middle East						
1984/1985	929.2	24.1	38.3	561.3	33.5	272.0
1985/1986	964.0	24.9	48.9	592.8	30.3	267.1
1986/1987	1,075.6	24.2	59.6	707.3	24.0	260.7
Asian CPE's						
1984/1985	15,761.7	245.8	706.0	6,556.3	7,697.0	556.6
1985/1986	14,565.0	219.0	673.0	6,652.7	6,631.3	389.0
1986/1987	14,223.4	165.0	665.0	6,746.8	6,335.0	309.6
South & East Asia						
1984/1985	10,276.2	503.3	240.0	7,465.4	55.5	2,012.0
1985/1986	10,846.0	533.1	277.2	7,945.6	61.8	2,028.4
1986/1987	12,162.8	560.8	225.6	9,145.2	58.7	2,172.5
Oceania						
1984/1985	351.6	58.9	22.6	105.8	6.1	158.2
1985/1986	363.8	52.2	20.4	124.0	8.0	159.2
1986/1987	400.0	64.4	26.2	156.1	9.7	143.7
World total						
1984/1985	70,586.9	2,895.4	14,965.9	22,681.5	17,399.6	12,644.5
1985/1986	70,338.1	2,957.7	14,014.0	24,472.9	15,854.7	13,038.8
1986/1987	72,032.3	3,009.6	14,484.2	26,354.2	15,293.9	12,890.1

Source: Statistical Supplement, 1987 British Sulphur

A-Table 4-6 Nitrogen Fertilizer Statistics

Unit: 1,000 TN

	Production			Consumption		
	1984/85	1985/86	1986/87[1]	1984/85	1985/86	1986/87[1]
World Total	74,751.4	73,295.9	75603.1	70586.9	70338.2	72032.3
Western Europe	12,088.5	11,539.0	11,219.2	11,016.2	11,125.4	11,479.7
Austria	300.5	315.0	278.0	161.1	165.1	136.7
Belgium/Lux	715.0	795.0	752.1	195.0	196.0	193.0
Denmark	186.8	164.0	120.8	398.0	382.1	381.3
Finland	307.1	287.0	298.0	196.1	202.1	211.1
France	1,692.5	1,600.0	1,529.4	2,336.7	2,408.1	2,568.3
Germany F.R.	1,271.9	1,219.2	1,119.9	1,451.8	1,516.8	1,587.9
Greece*	429.7	436.4	406.8	428.3	449.7	432.2
Ireland (Rep)	260.0	243.0	226.9	329.7	322.7	371.9
Italy	1,322.8	1,240.0	1,144.9	1,003.2	1,030.0	1,006.9
Netherlands	1,739.2	1,585.0	1,742.4	484.9	497.8	504.0
Norway	510.0	408.3	384.1	111.5	106.0	109.7
Portugal	130.0	165.0	165.3	123.2	137.4	149.9
Spain	994.0	1,014.5	948.6	913.4	900.9	887.9
Sweden	200.6	190.0	164.8	253.4	246.0	223.6
Switzerland	33.5	39.6	32.5	70.7	71.9	71.2
Turkey	628.4	618.0	574.2	954.8	916.0	950.6
United Kingdom	360.0	1,213.0	1,318.0	1,580.0	1,556.0	1,671.0
Eastern Europe	20,417.7	21,240.5	22,289.3	15,409.1	16,202.3	16,531.0
Bulgaria*	836.1	837.8	817.9	479.0	499.9	440.0
Czech	687.5*	647.6*	613.4*	691.7	670.8	640.0
Germany D.R*	960.1	1,078.2	1,252.0	697.0	770.0	709.0
Hungary*	667.7	682.5	672.2	625.9	558.5	593.4
Poland	1,369.3*	1,253.5*	1,444.9*	1,238.5	1,336.6	1,376.6
Romania*	2,212.0	2,197.0	1,900.0	857.0	817.0	716.0
USSR*	13,143.0	14,000.0	14,996.0	10,279.0	10,950.0	11,475.0
Yugoslavia*	470.0	471.9	517.9	469.0	527.5	506.0
Africa*	1,829.6	1,704.1	1,726.9	1,931.1	2,098.1	1,893.3
Algeria	65.0	101.5	113.8	83.0	96.7	114.4
Egypt	689.5	615.0	601.9	744.0	700.0	655.5
Libya	331.4	278.3	239.9	56.4	20.9	22.5
Morocco	34.6	59.5	72.6	104.3	128.3	140.1
Senegal	10.0	12.5	11.9	15.0	7.5	7.5
South Africa	481.9	420.0	428.5	406.6	379.7	364.5
Tunisia	118.0	120.1	153.5	41.5	43.8	47.1
Zimbabwe	68.6	68.9	76.4	71.6	93.0	81.7
North America	14,150.3	12,102.4	12,017.4	11,717.9	10,751.4	10,538.7
Canada	2,456.3	2,418.9	2,466.5	1,296.8	1,278.6	1,150.0
U.S.A.	11,694.0	9,683.5	9,550.9	10,421.1	9,472.8	9,388.7
Central America*	1408.9	1,741.7	1,633.9	1,764.0	1,912.5	1,929.3
Costa Rica	28.1	27.0	21.8	40.3	44.0	51.0
Cuba	161.1	166.6	164.6	294.4	293.6	321.0
Guatemala	9.0	9.0	9.0	55.5	57.1	73.1
Mexico	1,135.7	1,382.3	1,249.5	1,194.2	1,320.2	1,298.7
Trinidad	75.0	156.8	189.0	4.9	4.3	3.5

A-Table 4-6 Nitrogen Fertilizer Statistics (Cont'd)

Unit: 1,000 TN

	Production			Consumption		
	1984/85	1985/86	1986/87†	1984/85	1985/86	1986/87†
South America	1,148.6	1,174.0	1,274.5	1,430.0	1,509.7	1,798.7
Argentina	34.0	29.3	32.5	97.7	101.7	96.0
Brazil	669.0	723.6	712.4	802.0	852.0	988.1
Chile	113.3	113.0	108.4	86.3	106.1	92.0
Colombia	58.9	65.1	75.0	180.9	184.9	197.2
Peru	18.7	47.2	33.0	53.4	49.7	78.9
Venezuela	254.7	195.8	311.7	123.1	146.5	244.7
Middle East	1,504.0	1,572.9	1,731.0	929.2	964.0	1,075.6
Iran	13.8	7.0	72.5	486.6	465.3	529.1
Iraq*	25.7	38.8	64.0	73.0	120.0	131.0
Israel	81.1	77.5	80.0	81.0	53.8	48.6
Jordan*	102.4	91.9	99.2	7.0	9.8	10.8
Kuwait*	280.8	316.0	316.0	0.5	0.7	0.2
Qatar*	341.0	342.2	343.6	0.6	0.5	0.7
Saudi Arabia	397.0*	421.3*	440.0*	138.6	155.0	181.7
Syria*	104.3	115.5	104.1	107.7	131.5	143.6
U.A.Emirates*	157.9	162.7	211.6	3.0	3.1	1.0
Asian CPE's	12,927.0	12,195.1	12,248.0	15,761.7	14,565.0	14,223.4
China P.R.*	12,212.0	11,440.1	11,588.0	14,800.0	13,581.3	13,283.0
Korea North*	700.0	735.0	640.0	639.0	694.0	605.5
Vietnam*	15.0	20.0	20.0	310.2	272.0	320.1
South and East Asia	9,030.3	9,747.2	11,207.7	10,276.2	10,846.0	12,162.8
Bangladesh	343.1	375.7	391.2	386.3	367.7	423.7
Burma	86.5	115.0	168.0	127.4	134.0	142.0
India	3,917.3	4,322.9	5,411.7	5,333.3	5,701.8	6,531.8
Indonesia*	1,402.4	1,749.1	1,849.0	1,296.2	1,305.2	1,375.0
Japan	1,210.2	1,064.5	989.6	698.0	694.0	687.0
Korea South*	659.9	675.0	630.7	401.8	426.1	418.0
Malaysia	47.0	49.0	180.0	249.0	238.0	237.2
Pakistan	1,027.2	1,036.5	1,117.6	936.2	1,128.1	1,335.4
Philippines*	15.7	88.2	124.2	178.0	204.8	293.2
Taiwan*	208.2	210.6	289.1	265.0	240.0	256.1
Oceania	246.5	279.0	255.1	351.6	363.8	400.0
Australia*	191.5	209.0	202.1	301.0	320.0	360.0
New Zealand	55.0	70.0	53.0	29.2	30.3	27.0

†Preliminary

*Denotes calendar year data (1986/87 includes 1986 data, etc.) Regional totals include countries not specified separately.

Source: Statistical Supplement, 1987, British Sulphur

A-Table 4-7 World Nitrogenous Fertilizer Supply/Demand Forcast

Unit: 1,000 T N, %

	1985/86			1990/91			1991/92			% Change	
	Supply *	Demand	Balance	Supply *	Demand	Balance	Supply *	Demand	Balance	Supply	Demand
Developed Area	22,919	22,900	19	22,851	23,020	–169	22,931	23,240	–309	0.01	0.25
N. America	11,119	10,690	429	11,076	10,500	576	11,048	10,650	398	–0.11	–0.06
W. Europe	10,439	10,720	–281	10,662	10,950	–288	10,670	11,000	–330	0.37	0.43
Oceania	335	360	–25	387	400	–13	506	410	96	7.12	2.19
Others	1,026	1,130	–104	726	1,170	–444	707	1,180	–473	–6.02	0.72
Developing Area	15,140	16,790	–1,650	19,566	21,910	–2,344	20,488	22,960	–2,472	5.17	5.35
Africa	208	860	–652	582	1,030	–448	581	1,070	–489	18.67	3.71
Latin America	4,046	3,410	636	4,525	4,590	–65	4,885	4,890	–5	3.19	6.19
Near East	2,926	2,720	206	4,001	3,290	711	4,137	3,400	737	5.94	3.79
Far East	7,960	9,800	–1,840	10,458	13,000	–2,542	10,884	13,600	–2,716	5.35	5.61
Central Planned Area	35,227	30,290	4,937	37,758	35,180	2,578	37,901	36,100	1,801	1.23	2.97
E. Europe	22,432	15,710	6,722	23,580	18,020	5,560	23,701	18,500	5,201	0.92	2.76
Asia	12,795	14,580	–1,785	14,178	17,160	–2,982	14,201	17,600	–3,399	1.75	3.18
World Total	73,286	69,980	3,306	80,175	80,110	65	81,320	82,300	–980	1.75	2.74

*: Available Supply

Source: FAO/UNIDO/World Bank Fertilizer Working Group, June 1987.

A-Table 4-8 Nitrogen Trade Statistics

Unit: 1,000 TN

	Imports			Exports		
	1984/85	1985/86	1986/87[†]	1984/85	1985/86	1986/87[†]
World Total	15,688.1	14,622.3	16,967.8	15,901.4	14,732.3	16,990.2
Western Europe	4,055.3	4,242.7	5,021.2	4,879.4	4,324.6	4,577.8
Austria	61.8	75.0	82.6	201.6	205.0	145.6
Belgium/Lux	189.1	245.1	379.6	811.8	785.7	1,006.0
Denmark	245.3	267.0	123.8	52.1	53.1	11.0
Finland	13.5	28.7	15.2	105.0	57.5	53.4
France	960.5	1,027.3	1,261.5	339.9	242.8	238.9
Germany F.R.	882.6	839.4	889.2	647.7	574.8	610.2
Greece	58.3	94.1	97.8	14.3	18.7	33.5
Ireland (Rep)	200.5	195.5	234.9	103.2	82.1	64.0
Italy	202.6	223.0	257.6	413.7	383.3	464.4
Netherlands	210.1	238.7	266.3	1,470.3	1,255.2	1,478.6
Norway	6.2	9.9	14.8	370.4	292.8	200.7
Portugal	17.0	16.9	28.1	25.7	43.3	40.7
Spain	35.5	87.7	240.6	96.4	105.2	71.9
Sweden	195.7	167.9	174.2	89.9	105.7	29.2
Switzerland	52.5	51.5	49.9	–	–	–
Turkey	331.0	305.6	376.2	9.5	16.9	32.3
U.K.	374.9	349.0	517.9	127.9	102.5	97.4
Eastern Europe*	592.5	696.8	532.6	4,342.1	4,596.4	5,351.9
Bulgaria	5.8	7.4	5.5	300.0	302.8	966.3
Czechoslovakia	190.4	185.4	90.8	139.5	145.5	134.2
Germany D.R.	32.0	11.8	5.9	284.3	385.1	379.9
Hungary	203.7	284.9	287.1	285.7	320.3	287.3
Poland	10.6	19.5	2.9	103.7	72.5	77.7
Romania	0.4	0.4	3.8	1,231.3	1,187.9	1,016.8
USSR	24.9	36.6	33.6	1,883.9	2,043.2	2,278.4
Yugoslavia	124.7	150.8	103.0	113.7	139.1	179.7
Africa*	636.4	919.0	598.2	531.9	467.7	412.3
Egypt	32.5	147.1	61.0	53.6	–	9.2
Kenya	34.2	51.0	58.2	–	–	–
Libya	31.9	16.6	26.2	309.6	276.0	242.5
Morocco	91.5	83.1	102.1	7.1	18.7	15.3
South Africa	9.3	41.6	19.8	75.4	67.7	36.1
Tunisia	6.4	3.0	8.1	77.1	78.4	99.5
Zambia	56.6	36.5	30.4	–	–	–
Zimbabwe	10.0	33.5	22.9	–	–	–
North America	2,148.0	2,426.4	3,064.9	3,628.2	2,676.3	3,379.6
Canada	175.7	159.2	211.2	1,499.5	1,367.9	1,651.6
U.S.A.	1,972.3	2,267.2	2,853.7	2,128.7	1,308.4	1,728.0

† Preliminary
* Denotes calendar year data (1986/87 includes 1986 data, etc.) Regional totals include countries not specified separately.

Source: Statistical Supplement, 1987, British Sulphur

A-Table 4-8 Nitrogen Trade Statistics (Cont'd)

Unit: 1,000 TN

	Imports			Exports		
	1984/85	1985/86	1986/87[†]	1984/85	1985/86	1986/87[†]
Central America*	522.4	581.8	521.1	134.6	197.2	291.2
Costa Rica	16.7	30.5	17.9	–	–	–
Cuba	191.4	203.8	178.5	–	–	–
Guatemala	36.2	82.7	56.7	8.8	9.2	10.3
Mexico	70.8	71.7	92.6	57.7	18.1	37.5
Nicaragua	28.2	42.9	49.9	–	–	–
Trinidad	1.8	2.4	1.1	56.0	160.9	227.0
South America*	557.7	588.7	829.5	201.7	145.5	148.9
Argentina	54.2	71.7	46.3	–	–	–
Brazil	152.4	160.0	307.1	12.0	6.7	0.3
Chile	52.7	56.4	97.0	51.1	66.4	33.2
Colombia	145.1	129.8	162.2	–	–	–
Ecuador	49.5	56.2	63.9	–	–	–
Peru	26.6	21.0	65.8	–	–	–
Venezuela	29.0	55.7	57.3	137.8	65.3	115.4
Middle East	577.2	608.3	756.2	1,193.5	1,181.5	1,470.2
Iran	432.5	358.6	556.9	–	–	–
Iraq*	66.9	89.3	48.3	3.5	9.3	23.0
Jordan*	8.0	10.1	11.1	94.9	90.6	100.0
Kuwait*	0.1	0.1	0.2	270.7	265.3	377.2
Qatar*	0.1	–	0.1	326.0	323.4	367.6
Saudi Arabia*	29.2	65.6	67.5	325.6	314.5	373.8
U.A.Emirates*	3.1	1.8	1.5	144.0	157.8	224.6
Asian CPE'S	3,058.9	1,845.0	2,220.3	61.8	16.1	7.2
China P.R.	2,755.9	1,565.8	1,780.6	–	–	5.1
Korea North*	10.0	7.9	11.5	61.8	16.1	2.1
Vietnam	280.7	253.6	414.9	–	–	–
South and East Asia	3,348.9	2,579.9	3,163.7	893.0	1,067.2	1,299.5
Burma*	60.2	5.9	2.6	–	11.5	29.5
India	2,102.6	1,433.8	1,893.7	–	–	–
Indonesia*	112.1	5.9	7.1	93.5	347.7	695.8
Japan	71.5	84.3	133.0	325.5	222.2	84.0
Korea South*	8.3	4.0	1.6	240.7	227.7	188.3
Malaysia	241.7	181.7	117.4	–	16.6	88.1
Pakistan	88.2	85.6	144.0	210.2	171.7	80.5
Philippines*	146.6	201.9	306.3	–	40.4	108.0
Taiwan*	86.3	84.8	70.9	–	6.4	1.6
Thailand	269.4	237.3	344.1	–	–	–
Oceania	181.3	133.7	155.0	35.2	59.8	51.6
Australia*	146.5	103.7	130.0	1.4	1.1	1.1
New Zealand	16.4	17.0	14.4	33.8	58.7	50.5

[†] Preliminary

* Denotes calendar year data (1986/87 includes 1986 data, etc.) Regional totals include countries not specified separately.

Source: Statistical Supplement, 1987, British Sulphur

A-Table 4-9 Fertilizer Specifications

1) Compouds

Compound	Nitrogen	Citric soluble phosphate	Potash	Minimum sulphur	Micro nutrient content	Use
A	2	17	15 (sul)	10.0%	0.1% boron	tobacco
B	4	17	13 (sul)	9.0%	0.1% boron	tobacco
C	6	17	15 (11 sul, 4 chlor)	7.5% 6.5%	0.1% boron	tobacco
D	8	14	7 (chlor)	6.5%	–	maize/general
J	15	5	20 (chlor)	3.4%	0.1% boron	fruit trees
L	5	18	10 (chlor)	8.0%	0.25% boron	cotton
M	10	10	10 (chlor)	6.5%	–	maize/general
P	10	18	0	6.5%	–	sunflowers
S	7	21	7 (sul)	9.0%	0.04% boron	maize/general
T*	25	5	5 (sul)	5.0%	–	tea
V	4	17	15 (11 sul, 4 chlor)	8.0%	0.1% boron	tobacco
X	20	10	5 (chlor)	3.0%	–	gardening
Z	8	14	7 (chlor)	6.5%	0.8% zinc.	maize/general

* Manufactured only against firm order
Sul = manufactured with potassium sulphate.
Chlor = manufactured with potassium chloride.

2) Straights

Nitrogen

- Ammonium Nitrate 34.5% N
- Urea 46% N
- Sodium Nitrate 16% N

Phosphate

- Double Superphosphate (Granular) — 37% $P_2 0_5$ (Citric Sol), 5% Sulphur Min.
- Single Superphosphate (Powder) — 18.5% $P_2 0_5$ (Citric Sol), 12% Sulphur Min.

Potosh

- Potassium Chloride (Muriate of Potash) — 60% $K_2 0$
- Potassium Sulphate (Sulphate of Potash) — 50% $K_2 0$, 16% Sulphur Min.

Gypsum

- Calcium Sulphate (Gypsum) 17.5% S

A-Table 4-10 Zimbabwe – Fertilizer Sales by Product

Unit: T

Year (1/3-28/2)	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88
Product								
A	4,655	5,211	3,899	3,170	3,003	2,784	3,804	3,631
B	4,142	3,858	3,593	5,267	4,035	4,654	9,183	10,872
C	18,066	25,070	26,529	36,729	28,558	39,143	40431	30,730
V	8,769	8,595	7,936	8,088	6,430	7,801	7,717	5,742
D	85,559	109,425	100,082	102,835	95,049	113,849	95,980	81,833
J	6,395	5,731	5,068	7,535	5,593	8,625	10,350	9,632
L	39,731	28,421	28,081	38,209	33,898	42,512	37,394	39,870
M	17,831	31,789	28,540	20,792	16,305	18,010	13,337	13,376
P	31,835	10,972	7,334	3,718	5,363	3,295	2,851	2,876
S	25,000	22,876	14,916	18,003	11,076	11,830	13,662	13,037
T	1,174	800	1,676	4,138	1,628	3,784	5,804	5,524
X	6,865	4,378	3,227	1,931	2,405	3,738	2,826	2,972
Z	20,542	23,467	16,992	15,810	13,646	22,362	15,458	12,350
Subtotal	270,564	280,593	247,900	266,225	226,989	282,387	258,797	232,445
AS	229	432	306	371	315	580	749	876
AN	129,044	119,667	168,476	145,415	147,951	171,002	141,919	157,141
Sod. N.	1,031	1,279	1,052	1,489	1,642	1,720	2,199	2,289
Urea	43,408	78,588	22,690	22,850	7,118	25,493	27,155	1,629
SSP	20,395	13,517	10,313	12,594	7,404	12,825	10,913	12,492
D. Super	5,999	5,995	5,852	6,191	5,532	4,693	6,165	5,751
KCl	5,228	5,463	5,858	6,746	4,460	6,790	6,632	6,033
K_2SO_4	514	482	526	720	918	907	1,522	948
Total	476,412	506,016	462,973	462,601	402,329	506,397	456,051	419,604

Source: 1980/81~84/85 FROM: WORLD BANK REPORT NO.6349-ZIM;
1985/86~87/88 FROM: ZFC & WINDMILL AN INDUSTRIAL SECTUR MEMORANDUM (1987)

A-Table 4-11 Ammonia Production and Deliveries in Major Producing Countries

January - December 1987

Unit: 1,000 T N

	Production				Home Deliveries				Exports			
	1985	1986	1987	% change 87/86	1985	1986	1987	% change 87/86	1985	1986	1987	% change 87/86
West Europe												
– France	2,011.5	2,022.0	2,029.0	0.3	1,898.5	1,863.3	1,827.6	–1.9	113.0	158.6	201.4	27.0
– Germany Fed. Rep.	1,907.5	1,570.3	1,931.0	23.0	1,648.0	1,412.6	1,579.6	11.8	259.5	157.7	351.4	122.8
– Italy	1,460.2 E	1,509.7	1,432.1	–5.1	1,316.6	1,320.5	1,368.2	3.6	126.5	158.2	64.4	–59.3
– Netherlands	2,776.3	2,695.4	2,827.9	4.9	2,018.9	1,962.7	2,114.8	7.7	842.4	689.6	782.6	13.5
– Norway	457.7	299.8	347.4	15.9	425.2	298.3	347.4	16.5	32.5	1.6	–	–
– Spain	602.3	464.4	449.3	–3.3	1,124.4	1,076.7	957.0	–11.1	–	–	–	–
– United Kingdom	1,767.0	1,388.0	1,415.0	1.9	1,476.0	1,338.5	1,389.0	3.8	302.0	59.5	26.0	–56.3
North America												
– Canada	2,962.5	2,891.0	2,741.1	–5.2	2,035.3	1,808.4	1,675.5	–7.4	791.6	833.5	1,106.6	32.8
– USA	12,010.0	10,431.3	11,720.5	12.4	11,924.0	10,074.0	11,166.7	10.8	917.0	484.8	769.1	58.6
Latin America												
– Brazil	944.8	882.0	951.5	7.9	926.6	953.2	971.6	1.9	27.6	–	–	–
– Trinidad & Tobago	1,085.2	1,141.0	1,127.1	–1.2	171.0	243.4	237.4	–2.5	915.2	925.3	873.2	–5.6
– Venezuela	410.2	481.1	523.1	8.7	282.8	333.9	413.4	23.8	144.6	135.6	91.4	–32.6
Middle East												
– Abu Dhabi U.E.A	282.3	290.8	302.4	4.0	175.2	215.6	226.0	4.8	95.8	75.1	59.1	–21.4
– Bahrain	110.1	288.6	275.7	–4.5	–	–	–	–	77.9	294.1	282.1	–4.1
– Kuwait	322.7	450.6	577.5	28.2	286.9	359.5	432.9	20.4	54.2	78.6	156.9	99.6
– Lybia	411.0	352.2	NA	NA	298.4	259.9	NA	NA	112.6	91.0	36.2	–60.2
– Qatar	526.1 E	544.1	560.8	3.1	363.2	360.5 E	323.8	–10.2	162.9	185.7	237.1	27.7
– Saudi Arabia	436.2	466.7	636.9	36.5	439.4	464.1	508.9	9.7	–	–	132.9	–
Asia												
– India	4,270.2	4,933.2	5,299.4 P	7.4	4,300.2	5,132.1	5,467.9 P	6.5	–	–	–	–
– Indonesia	2,057.3	2,298.5	2,363.9	2.8	1,674.3	1,819.0	2,137.3	17.5	188.1	212.9	202.2	–5.0
– Japan	1,645.5	1,507.9	1,555.6	3.2	1,644.7	1,539.7 E	1,576.6	2.4	–	–	–	–
– Korea, Rep. of	435.0	419.7	477.1	13.7	480.1	403.3	476.3	18.1	–	–	–	–
– Malaysia	NA	NA	321.3	–	NA	NA	299.3	–	–	–	18.7	–
Oceania												
– Australia	404.5	340.0	413.4	21.6	336.0	287.0	366.8	27.8	68.5	52.9	46.5	–12.1

E : Estimate
P : Preliminary

Source: IFA

A-Table 4-12 (1) Ammonia Exports

January - December 1987

Unit: 1,000 T N

	France	West Germany	Italy	Nether.	United Kingdom	Canada	USA	Trinidad	Venezuela	Libya	Abu Dhabi	Bahrain	Kuwait	Qatar	Saudi Arabia	Indon.	Various	1987 Partial Total	1986 Partial Total
West Europe																			
– Austria	–	0.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.6	0.4
– Belgium	9.4	11.7	–	433.8	–	–	104.1	83.7	–	–	–	1.7	8.3	–	19.4	–	–	672.1	419.1
– Denmark	–	168.4	–	12.9	–	–	6.9	96.9	–	–	–	–	–	–	–	–	–	285.1	203.7
– Finland	–	25.3	–	22.2	–	–	70.9	4.5	8.6	–	–	–	–	–	–	–	–	131.5	64.0
– France	–	25.6	–	18.1	–	–	–	55.9	–	–	–	24.3	–	16.3	–	–	–	140.2	107.0
– W. Germany	79.1	–	–	88.0	–	–	–	–	–	–	–	–	–	–	–	–	–	167.1	234.6
– Greece	–	–	29.9	–	9.0	–	–	25.0	–	–	–	8.6	–	17.3	–	–	–	89.9	72.6
– Iceland	3.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3.3	1.6
– Ireland	–	–	–	1.8	–	–	–	–	–	–	–	–	–	–	–	–	–	1.8	0.0
– Italy	–	–	–	–	–	–	–	25.1	–	–	–	1.2	–	22.7	–	–	–	49.0	12.1
– Netherlands	0.8	0.8	–	–	–	–	–	21.1	–	–	–	–	–	–	–	–	–	22.7	48.0
– Norway	–	6.6	–	8.2	–	–	62.1	–	–	–	–	–	–	–	–	–	–	76.9	75.3
– Portugal	1.7	13.2	–	20.6	3.0	–	–	7.4	–	–	–	3.4	–	–	–	–	–	49.3	37.3
– Spain	47.5	11.3	–	31.1	9.0	–	71.4	53.3	12.2	14.4	–	6.4	–	4.3	–	12.3	–	273.2	281.7
– Sweden	8.5	14.2	–	2.5	–	–	–	–	–	–	–	–	–	–	–	–	–	25.2	22.2
– Switzerland	4.7	5.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10.1	28.3
– United Kingdom	40.9	54.4	–	107.8	–	–	–	26.9	–	–	–	–	–	6.6	–	–	–	236.5	220.7
– Sub Total	195.9	337.5	29.9	746.9	21.0	0.0	315.4	399.8	20.8	14.4	0.0	45.6	8.3	67.3	19.4	12.3	0.0	2,234.5	1,828.6
East Europe																			
– East Germany	–	10.1	–	4.9	–	–	–	–	–	–	–	–	–	–	–	–	–	15.0	0.0
– Sub Total	0.0	10.1	0.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	0.0
North America																			
– Canada	–	–	–	–	–	–	7.2	–	–	–	–	–	–	–	–	–	–	7.2	15.3
– Trinidad	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0	14.4
– USA	–	–	–	–	–	1,077.5	–	419.1	13.0	–	–	–	–	–	–	–	–	1,509.6	1,297.5
– Sub Total	0.0	0.0	0.0	0.0	0.0	1,077.5	7.2	419.1	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,516.8	1,327.2
Latin America																			
– Brazil	–	–	–	–	–	–	–	29.1	–	–	–	–	–	–	–	–	–	29.1	16.7
– Chile	–	–	–	–	–	–	–	–	19.5	–	–	–	–	–	–	–	–	19.5	11.8
– Colombia	–	–	–	–	–	–	–	–	15.2	–	–	–	–	–	–	–	–	15.2	10.4
– Costa Rica	–	–	–	–	–	8.2	–	–	–	–	–	–	–	–	–	–	–	8.2	27.1
– Cuba	–	–	–	–	–	–	–	–	22.9	–	–	–	–	–	–	–	–	22.9	19.3
– El Salvador	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.5
– Mexico	–	–	–	–	–	–	108.4	–	–	–	–	–	–	–	–	–	–	108.4	10.6
– Sub Total	0.0	0.0	0.0	0.0	0.0	8.2	108.4	29.1	57.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	203.3	85.8

Source: IFA

A-Table 4-12 (2) Ammonia Exports

January - December 1987

Unit: 1,000 T N

	France	West Germany	Italy	Nether.	United Kingdom	Canada	USA	Trinidad	Venezuela	Libya	Abu Dhabi	Bahrain	Kuwait	Qatar	Saudi Arabia	Indon.	Various	1987 Partial Total	1986 Partial Total
Africa																			
– Algeria	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.0
– Ivory Coast	0.9	–	–	0.8	–	–	–	–	–	–	–	–	–	–	–	–	–	1.7	0.0
– Liberia	–	–	–	–	–	–	1.4	–	–	–	–	–	–	–	–	–	–	1.4	1.2
– Mauritius	–	–	–	–	–	–	–	–	–	–	2.6	–	–	–	–	–	–	2.6	0.0
– Morocco	3.1	3.8	–	–	5.0	–	15.1	8.0	–	6.6	–	–	–	–	–	–	–	41.5	9.9
– Mozambique	–	–	–	–	–	–	–	–	–	–	7.8	–	–	10.7	–	–	–	18.5	4.1
– Nigeria	1.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.5	0.0
– Senegal	–	–	–	–	–	–	11.5	6.9	–	–	–	–	–	–	–	–	–	18.4	0.0
– South Africa	–	–	–	–	–	10.2	85.9	–	–	–	–	–	–	–	–	–	–	96.1	20.7
– Tanzania	–	–	–	–	–	–	3.3	–	–	–	–	–	–	–	–	–	–	3.3	3.3
– Tunisia	–	–	–	–	–	–	28.0	10.4	–	–	–	49.0	45.1	–	–	–	–	132.5	128.9
– Others	–	–	–	–	–	–	4.9	–	–	–	–	–	–	7.8	–	–	–	12.7	19.8
– Sub Total	5.5	3.8	0.0	0.8	5.0	10.2	150.1	25.3	0.0	6.6	10.4	49.0	45.1	18.5	0.0	0.0	0.0	330.2	187.9
Middle East																			
– Israel	–	–	–	2.5	–	–	–	–	–	–	–	–	–	–	–	–	–	2.5	0.0
– Jordan	–	–	–	–	–	–	–	–	–	15.3	–	51.8	24.4	5.2	12.3	–	–	109.0	54.3
– Turkey	–	–	3.3	–	–	–	–	–	–	–	–	11.2	–	26.0	57.0	–	–	97.4	70.3
– Sub Total	0.0	0.0	3.3	2.5	0.0	0.0	0.0	0.0	0.0	15.3	0.0	62.9	24.4	31.2	69.3	0.0	0.0	208.9	124.6
Asia																			
– India	–	–	–	–	–	–	–	–	–	–	44.2	102.0	58.2	73.1	9.4	19.3	31.7 (2)	337.9	336.4
– Korea, Rep. of	–	–	–	–	–	–	157.6	–	–	–	4.5	22.4	–	24.6	14.3	34.5	–	257.9	320.6
– Malaysia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.1
– Philippines	–	–	–	–	–	9.9	2.9	–	–	–	–	–	12.3	14.9	–	87.4	23.8 (3)	151.2	87.2
– Singapore	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.3	0.3 (1)	2.6	1.6
– Taiwan, China	–	–	–	–	–	–	27.1	–	–	–	–	–	7.4	7.6	12.3	44.8	3.9 (1)	103.1	114.2
– Thailand	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.3	5.4 (1)	6.7	0.6
– Sub Total	0.0	0.0	0.0	0.0	0.0	9.9	187.5	0.0	0.0	0.0	48.7	124.5	77.9	120.2	36.0	189.6	65.2	859.5	860.7
Oceania																			
– Australia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0	8.2
– New Zealand	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.0
– Sub Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2
Others	–	–	31.2	27.5	–	0.8	0.6	–	–	–	–	–	1.0	–	8.2	0.3	13.0 (5)	82.6	75.3
World total	201.4	351.4	64.4	782.6	26.0	1106.6	769.1	873.2	91.3	36.2	59.1	282.0	156.8	237.1	132.9	202.2	78.2	5,450.7	4,498.3
Total 1986	158.6	157.7	158.2	689.6	59.5	833.5	484.7	925.3	136.0	91.0	75.1	294.1	78.6	185.7	–	213.0	54.5 (4)		
% Change 87/86	27.0	122.8	–59.3	13.5	–56.3	32.8	58.7	–5.6	–32.8	–60.2	–21.4	–4.1	99.4	27.7	–	–5.1	43.6		
Total 1985	113.0	259.5	108.0	842.4	302.0	791.6	917.0	915.2	144.6	112.6	95.9	77.9	54.2	162.9	–	188.1	128.7 (6)		

(1) Malaysia
(2) Australia
(3) Australia 14.8, Malaysia 9.0
(4) Australia 53.9, Norway 1.6
(5) Mexico (January - June figures)
(6) Norway 32.5, Brazil 27.6, Australia 68.6

A-Table 4-13 Main Soviet Ammonia Imports

January - December

Unit: 1,000 TN

	1985	1986	1987
Denmark	42.9	22.2	12.4
Finland	169.2	157.5	176.4
India	–	–	55.0
Italy	72.0	72.3	41.1
Korea Rep. of	–	–	29.7
Morocco	48.1	54.3	32.5
Norsk Hydro Group	92.5	125.4	55.9
Portugal	–	32.2	–
Spain	39.6	216.6	148.9
Tunisia	13.1	25.5	13.8
Turkey	344.3	304.6	474.7
United Kingdom	41.0	10.0	10.0
United States	751.1	557.7	675.5
Total	1,613.7	1,578.2	1,726.0

Source: IFA

A-Table 4-14 (1) Fertilizer Sales (Mar. 1984 - Feb. 1985)

Unit: T

Product	ZFC	WINDMILL	Total Tonnes
Compound			
A	1,658	1,345	3,003
B	2,400	1,635	4,035
C	16,821	11,737	28,558
V	3,696	2,734	6,430
D	54,425	40,624	95,049
J	4,666	927	5,593
L	18,838	15,060	33,898
M	11,222	5,083	16,305
P	4,952	411	5,363
S	6,824	4,252	11,076
T	1,628	0	1,628
X	1,606	799	2,405
Z	6,918	6,728	13,646
Total Compounds	135,654	91,335	226,989
Ammonuim Nitrate	90,403	57,548	147,951
Sulphate of Ammonia	264	51	315
Sodium Nitrate	935	707	1,642
Urea	5,542	1576	7,118
Total Nitrogen	97,144	59,882	157,026
Single Supers	5,021	2,383	7,404
Double Supers	2,900	2,632	5,532
Total Phosphates	7,921	5,015	12,936
Potassium Chloride	3,078	1,382	4,460
Potassium Sulphate	326	592	918
Total Potash	3,404	1,974	5,378
Grand Total	244,123	158,206	402,329

A-Table 4-14 (2) Fertilizer Sales (Mar. 1985 - Feb. 1986)

Unit: T

Product	ZFC	WINDMILL	Total Tonnes
Compound			
A	1,442	1,342	2,784
B	2,776	1,878	4,654
C	22,608	16,535	39,143
V	4,205	3,596	7,801
D	64,926	48,923	113,849
J	7,263	1,362	8,625
L	22,871	19,641	42,512
M	12,665	5,345	18,010
P	2,680	615	3,295
S	5,994	5,836	11,830
T	3,764	0	3,784
X	2,766	972	3,738
Z	12,014	10,348	22,362
Total Compounds	165,994	116,393	282,387
Ammonuim Nitrate	102,137	68,865	171,002
Sulphate of Ammonia	515	65	580
Sodium Nitrate	1,023	697	1,720
Urea	12,069	13,424	25,493
Total Nitrogen	115,744	83,051	198,795
Single Supers	8,172	4,653	12,825
Double Supers	3,273	1,420	4,693
Total Phosphates	11,445	6,073	17,518
Potassium Chloride	4,579	2,211	6,790
Potassium Sulphate	492	415	907
Total Potash	5,071	2,626	7,697
Grand Total	298,254	208,143	506,397

A-Table 4-14 (3) Fertilizer Sales (Mar. 1986 - Feb. 1987)

Unit: T

Product	ZFC	WINDMILL	Total Tonnes
Compound			
A	2,409	1,395	3,804
B	5,587	3,596	9,183
C	24,202	16,229	40,431
V	4,468	3,249	7,717
D	55,997	39,983	95,980
J	8,282	2,068	10,350
L	21,561	15,833	37,394
M	8,487	4,850	13,337
P	2,662	189	2,851
S	7,745	5,917	13,662
T	5,804	0	5,804
X	1,724	1,102	2,826
Z	8,260	7,198	15,458
Total Compounds	157,188	101,609	258,797
Ammonuim Nitrate	81,312	60,607	141,919
Sulphate of Ammonia	284	465	749
Sodium Nitrate	1,287	912	2,199
Urea	16,179	10,976	27,155
Total Nitrogen	99,062	72,960	172,022
Single Supers	5,793	5,120	10,913
Double Supers	3,630	2,535	6,165
Total Phosphates	9,423	7,655	17,078
Potassium Chloride	3,743	2,889	6,632
Potassium Sulphate	733	789	1,522
Total Potash	4,476	3,678	8,154
Grand Total	270,149	185,902	45,6051

A-Table 4-14 (4) Fertilizer Sales (Mar. 1987 - Feb. 1988)

Unit: T

Product	ZFC	WINDMILL	Total Tonnes
Compound			
A	1,807	1,824	3,631
B	6,098	4,774	10,872
C	19,589	11,141	30,730
V	3,533	2,209	5,742
D	46,848	34,985	81,833
J	7,705	1,927	9,632
L	21,681	18,189	39,870
M	7,358	6,018	13,376
P	2,237	639	2,876
S	7,566	5,471	13,037
T	5,445	79	5,524
X	1,968	1,004	2,972
Z	5,883	6,467	12,350
Total Compounds	137,718	94,727	232,445
Ammonuim Nitrate	89,224	67,917	157,141
Sulphate of Ammonia	682	194	876
Sodium Nitrate	1,354	935	2,289
Urea	1,314	315	1,629
Total Nitrogen	92,574	69,361	161,935
Single Supers	7,218	5,274	12,492
Double Supers	3,283	2,468	5,751
Total Phosphates	10,501	7,742	18,243
Potassium Chloride	3,429	2,604	6,033
Potassium Sulphate	572	376	948
Total Potash	4,001	2,980	6,981
Grand Total	244,794	174,810	419,604

A-Table 4-15 Effect of Increased Nitrogen Nutrient Dosage

1. Maize

Basal Application	Compound Fertilizer	360 kg/ha
	Average N Content	8.0%
Top Dressing	Ammonium Nitrate	380 kg/ha
	N Content	34.5%

360 kg/ha x 0.08 = 28.8 kgN/ha

380 kg/ha x 0.345 = 131.1 kgN/ha

Total N Applied 159.9 ≒ 160 kgN/ha

Next, the sensitivity is calculated for the following

	dosage	yield
Commercial	160 kgN/ha	4,148 kg/ha
Communal	16 kgN/ha	811 kg/ha

Over the range of 16 kgN/ha:

$$\frac{(4.15 - 0.81) \times 10^3 \text{ kg/ha}}{(160 - 16) \text{ kgN/ha}} = 23.2 \text{ kg/kgN.}$$

Therefore, by increasing the N dosage from 1/10 to 1/5 of commercial farming, that is, adding 16 kgN/ha to the dosage in this case the estimated yield increase is 23.2 kg/kgN x 16 kgN/ha = 371 kg/ha.

A-Table 4-15 Effect of Increased Nitrogen Nutrient Dosage (Cont'd)

2. Cotton

Basal Application	Compound Fertilizer	325 kg/ha
	Average N Content	8.0%
Top Dressing	Ammonium Nitrate	150 kg/ha
	N Content	34.5%

325 kg/ha x 0.08 =	26.0 kgN/ha
150 kg/ha x 0.345 =	51.8 kgN/ha
Total N Applied	77.8 ≑ 78 kgN/ha

Sensitivity is calculated for the following

	dosage	yield
Commercial	78 kgN/ha	1,932 kg/ha
Communal	8 kgN/ha	728 kg/ha

Over the range of 8 kgN/ha:

$$\frac{(1.93 - 0.73) \times 10^3 \text{kg/ha}}{(78 - 8) \text{kgN/ha}} = 17.1 \text{ kg/kgN.}$$

Therefore, by increasing the N dosage from 1/10 to 1/5 of commercial farming, that is, adding 8 kgN/ha to the dosage in this case the estimated yield increase is
17.1 kg/kgN x 8 kgN/ha = 137 kg/ha.

A-Table 4-16 Nitrogenous Fertilizer Increase by Commercial Farming

From Table 4-19: 1985/86 Nitrogen Sales

92,044 T

From Table 4-20: Current Distribution Ratio of Fertilizer

310/430=0.72

The 1985/86 nitrogen consumption of commercial farming is:

92.0 KT x 0.72 = 66.2 KT

The 1995/96 assumed nitrogen consumption of commercial farming according to paragraph 4-3-5(2)-3)- ③ is:

89.7 KT

Therefore the nitrogenouse fertilizer consumption increase by commercial farming is:

89.7 – 66.2 = 23.5 KT

A-Table 4-17 Effect of Electricity Tariff Rivision on NH_3 Production

Increase in electricity cost for SABLE's ammonia production by water electrolysis as a result of electricity tariff on October 1988.

1. Common Premises

ammonia production volume	76,000	T/Y
unit consumption of electricity for ammonia	10,300	kWh/T
capacity	100	MW

2. SABLE's electricity purchasing contract condition (before revision)

Fixed cost		
peak		11,750Z$/MW.month
off peak		3,500Z$/MW.month
Variable cost		
peak	6:00 ~ 20:00	1.15Z¢/kWh
off peak	20:00 ~ 6:00	1.05Z¢/kWh

3. SABLE's electricity purchasing contract condition (after revision)

Fixed cost		20.26Z$/kW.month
Variable cost		
peak	6:00 ~ 21:00	1.91Z¢/kWh
off peak	21:00 ~ 6:00	1.69Z¢/kWh

4. Calculation based on conditions before revision

Fixed Cost

$$\frac{(11{,}750 + 3{,}500)\text{Z\$/MW.month} \times 100\text{MW} \times 12\text{month/Y}}{10{,}300\text{kWh/T} \times 76{,}000\text{T/Y}} = 0.023376\text{Z\$/kWh}$$

Variable Cost

$$\frac{(1.15\text{Z¢/kWh} \times 14\text{h} + 1.05\text{Z¢/kWh} \times 10\text{h})}{24\text{h}} = 1.1083\text{Z¢/kWh}$$

Total : 2.3376 + 1.1083 = 3.446 Z¢/kWh

Power Cost:

3.446Z¢/kWh x 10,300kWh/T x 1/100 = 354.9Z$/T

A-Table 4-17 Effect of Electricity Tariff Rivision on NH_3 Production (Cont'd)

5. Calculation based on conditions after revision

Fixed Cost

$$\frac{20.26Z\$/kW.month \times 100{,}000kW \times 12month/Y}{10{,}300kWh/T \times 76{,}000T/Y} = 0.031058Z\$/kWh$$

Variable Cost

$$\frac{(1.91Z¢/kWh \times 15h + 1.69Z¢/kWh \times 9h)}{24h} = 1.8275Z¢/kWh$$

Total : 3.1058 + 1.8275 = 4.933 Z¢/kWh

Power Cost:

4.933Z¢/kWh x 10,300kWh/T x 1/100 = 508.1Z$/T

6. Electricity Cost Difference

508.1 – 354.9 = 153.2 Z$/T

A-Table 4-18 Area Planted - Commercial/Communal/Total in Hectares and Specific Total Nutrients ($N + P_2O_5 + K_2O$) Consumption in Kg/Ha

Crop Plant \ Planted Area (Ha)	1976			1980			1981			1982			1983		
	Comme	Commu	Total	Comme	Commu	Total	Comme	Commu	Total	Comme	Commu	Total	Comme	Commu	Total
Maize	257,301	760,000	1,017,301	227,733	900,000	1,127,733	363,448	1,000,000	1,363,448	316,440	1,100,000	1,416,440	283,880	1,050,000	1,333,880
Tobacco	66,219	530	66,749	63,703	365	64,068	39,393	367	39,760	45,552	1,080	46,632	46,327	1,439	47,766
Cotton	64,003	35,000	99,003	74,924	15,000	89,924	66,054	59,000	125,054	58,015	51,000	109,014	69,976	65,000	132,976
Wheat	33,325	–	33,325	32,556	–	32,556	36,845	–	36,845	37,378	–	37,378	21,547	–	21,547
Soybeans	24,776	1,577	26,353	40,783	12,000	52,783	30,971	9,000	39,971	48,417	7,000	55,414	54,909	4,000	58,909
Groundnuts	17,755	325,000	342,755	3,841	175,000	178,841	12,909	300,000	312,909	11,923	240,000	251,923	10,703	180,000	190,703
Sorghum	7,131	235,000	242,131	6,766	120,000	126,766	9,290	200,000	209,290	8,232	200,000	208,232	7,672	280,000	287,672
Tea	4,021	–	4,021	4,143	–	4,143	4,247	–	4,247	4,423	–	4,423	4,476	–	4,476
Coffee	3,506	–	3,506	4,098	–	4,098	4,608	–	4,608	5,042	–	5,042	6,986	–	6,986
Sugar	25,328	–	25,328	24,515	–	24,515	34,146	–	34,146	31,547	–	31,547	33,833	–	33,833
Total Planted Area (Ha)	503,365	1,357,107	1,860,472	483,062	1,222,365	1,705,427	601,911	1,568,367	2,170,278	566,969	1,599,080	2,166,049	540,312	1,580,439	2,120,751
Total Fertilizer Consumption (TPY)	345,928	20,000	365,928	386,412	90,000	476,412	–	–	506,016	362,973	** 100,000	462,973	–	–	462,601
Total Nutrient Consumption (TPY) ($N+P_2O_5+K_2O$)	115,540	6,680	* 122,220	129,328	30,122	159,450	–	–	174,389	121,233	33,400	* 154,633	–	–	154,909
Specific Total Nutrient Cons. Kg ($N+P_2O_5+K_2O$) / Ha	229.54	4.92	65.69	267.73	24.64	93.50	–	–	80.35	213.83	20.89	71.39	–	–	72.86

NOTES: Comme – Commercial farming sector
Commu – Communal farming sector
* Assumed average content of total nutrients ($N+P_2O_5+K_2O$) in total fertilizers: 33.4% by mass
** Assumed consumption in communal farming sector

SOURCE:SOCIO – ECONOMIC REVIEW 1980 – 1985, ZIMBABWE (1986)

A-Table 4-19 World Urea Statistics

Unit: 1,000 TN

	Production	Consumption
Western Europe		
1984/1985	2,295.6	1,074.9
1985/1986	1,816.1	1,335.9
1986/1987	1,788.9	1,547.1
Eastern Europe		
1984/1985	6,544.9	3,139.5
1985/1986	6,929.5	3,543.6
1986/1987	7,389.1	3,776.9
Africa		
1984/1985	864.9	736.6
1985/1986	713.8	762.0
1986/1987	601.2	617.4
North America		
1984/1985	2,844.0	1,591.1
1985/1986	2,475.3	1,912.6
1986/1987	2,736.1	1,851.2
Central America		
1984/1985	589.5	670.3
1985/1986	822.5	788.6
1986/1987	816.0	834.4
South America		
1984/1985	678.3	780.3
1985/1986	644.9	815.1
1986/1987	713.4	971.8
Middle East		
1984/1985	1,271.5	561.3
1985/1986	1,344.2	592.8
1986/1987	1,454.6	707.3
Asian CPE's		
1984/1985	4,311.0	6,556.3
1985/1986	4,655.0	6,652.7
1986/1987	4,820.0	6,746.8
South &East Asia		
1984/1985	6,668.2	7,465.4
1985/1986	7,164.4	7,945.6
1986/1987	8,484.6	9,145.2
Oceania		
1984/1985	135.0	105.8
1985/1986	164.0	124.0
1986/1987	143.0	156.1
World Total		
1984/1985	26,202.9	22,681.5
1985/1986	26,729.7	24,472.9
1986/1987	28,946.8	26,354.2

Source: Statistical Supplement, 1987, British Sulphur

A-Table 4-20 World Urea Trade (1984)

Unit: 1,000 T

Import \ Export	W. Germany	Italy	Holland	Burgaria	E.Germany	Hungary	Rumania	USSR	Libya	Indonesia	Kuwait	Quatar	Saudi Arabia	Canada	USA	Venezuela	Others	Total
W. Europe	170	34	233	31	95	45	94	52	100	0	0	0	0	0	6	0	472	1,332
France	84	9	120	5	0	0	0	0	0	0	0	0	0	0	0	0	92	310
Turkey	0	6	0	5	0	0	69	17	100	0	0	0	0	0	0	0	9	206
UK	9	0	31	0	32	5	0	15	0	0	0	0	0	0	0	0	99	191
E. Europe	0	0	0	3	0	41	26	650	0	0	0	0	0	0	0	0	79	799
Hungary	0	0	0	0	0	0	0	397	0	0	0	0	0	0	0	0	0	397
Africa	28	0	47	7	22	0	176	31	0	0	4	0	43	6	19	0	129	512
Nigeria	0	0	0	0	0	0	101	0	0	0	0	0	0	3	0	0	4	108
Asia	158	236	569	438	235	247	815	1,916	559	199	585	673	666	257	807	0	2,199	10,559
China	89	58	41	101	200	247	455	913	332	0	204	196	164	128	296	0	965	4,389
India	52	177	481	183	35	0	188	331	212	0	238	296	178	129	188	0	692	3,380
Iran	0	0	0	103	0	0	90	142	0	0	53	57	43	0	0	0	151	639
Malaysia	0	0	0	0	0	0	10	51	0	113	0	71	0	0	0	0	23	268
Philippine	0	0	15	0	0	0	39	15	0	50	0	0	0	0	126	0	74	319
Vietnam	0	0	0	18	0	0	33	414	0	0	0	47	30	0	0	0	0	542
Oceania	1	0	0	0	0	0	0	32	0	0	0	42	0	0	9	0	14	98
N. America	24	55	175	0	103	0	356	383	14	0	0	0	0	698	121	67	142	2,138
Canada	0	0	64	0	0	0	0	0	0	0	0	0	0	0	121	0	36	221
USA	24	55	111	0	103	0	356	383	14	0	0	0	0	698	0	67	107	1,918
S. America	7	10	93	55	38	22	107	222	0	0	0	0	0	63	190	233	146	1,186
Colombia	0	0	0	0	10	6	27	10	0	0	0	0	0	47	7	142	31	280
Cuba	0	0	0	32	0	0	0	180	0	0	0	0	0	0	0	3	58	273
World Total	389	335	1,118	534	493	355	1,574	3,286	673	199	588	715	709	1,024	1,151	300	3,181	16,624

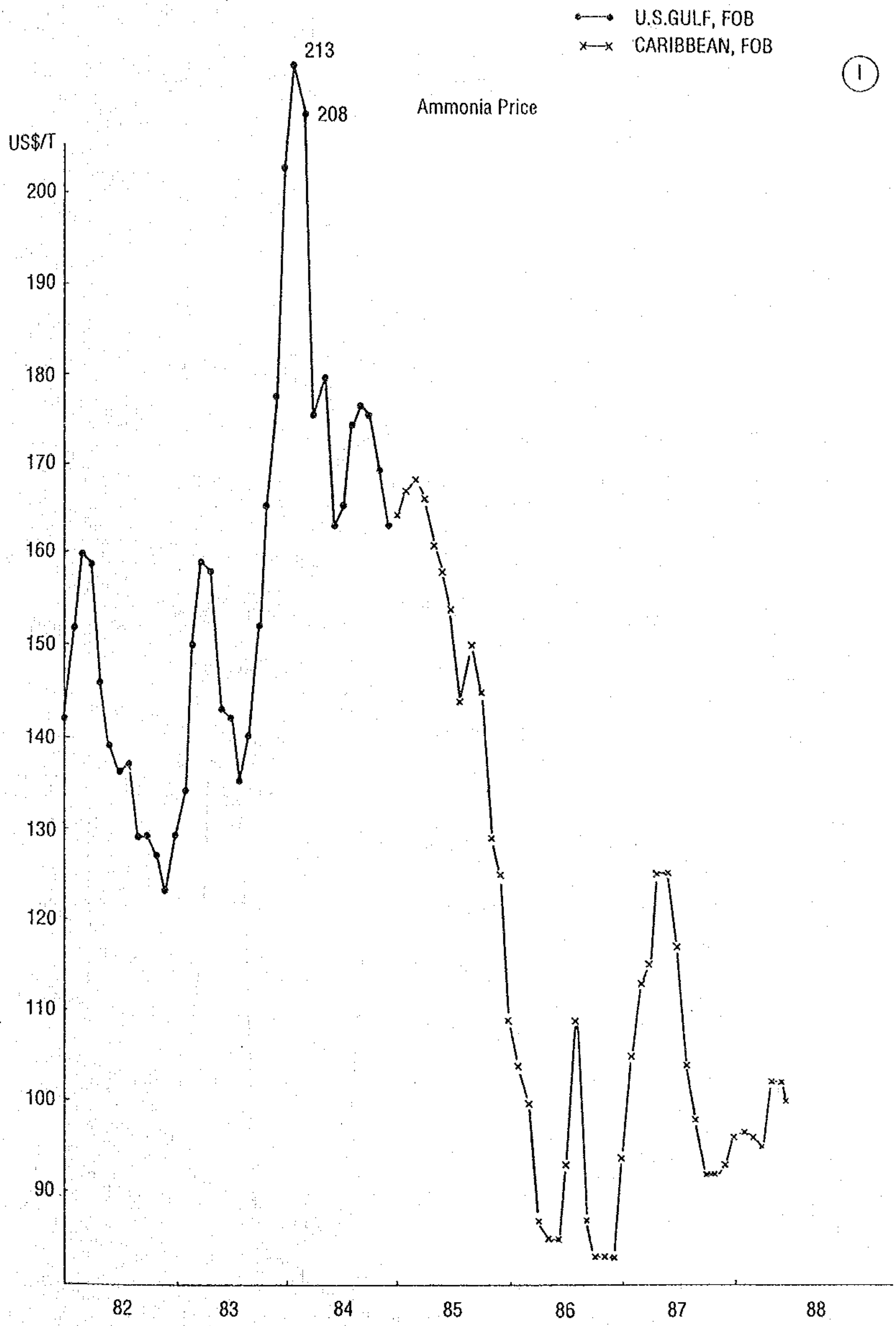
Source: Kagaku Keizai, January, 1988

A-Table 4-21 AN-Urea Price

	1983	1984	1985	1986	1987
AN. (34.5% N)					
Imported quantity (ton)	1,760	2,387	1,875	2,250	2,553
Z$ x 1,000	1,532	1,663	550	753	979
Unit price (Z$/T)	130.3	696.7	293.3	334.7	383.5
(Z$/TN)	377.7	2,019.4	850.1	970.1	1,111.6
(US$/TN)	373.6	1,623.3	527.4	582.6	669.2
Urea (46% N)					
Imported quantity (ton)	24,000	30,265	32,182	24,106	1,031
Z$ x 1,000	3,997	2,814	6,658	3,875	294
Unit price (Z$/T)	166.5	93.0	206.9	160.7	285.2
(Z$/TN)	361.9	202.2	449.8	349.3	620.0
(US$/TN)	358.0	162.5	279.0	209.8	373.3
AN price/Urea price as N	1.04	9.99	1.89	2.78	1.79

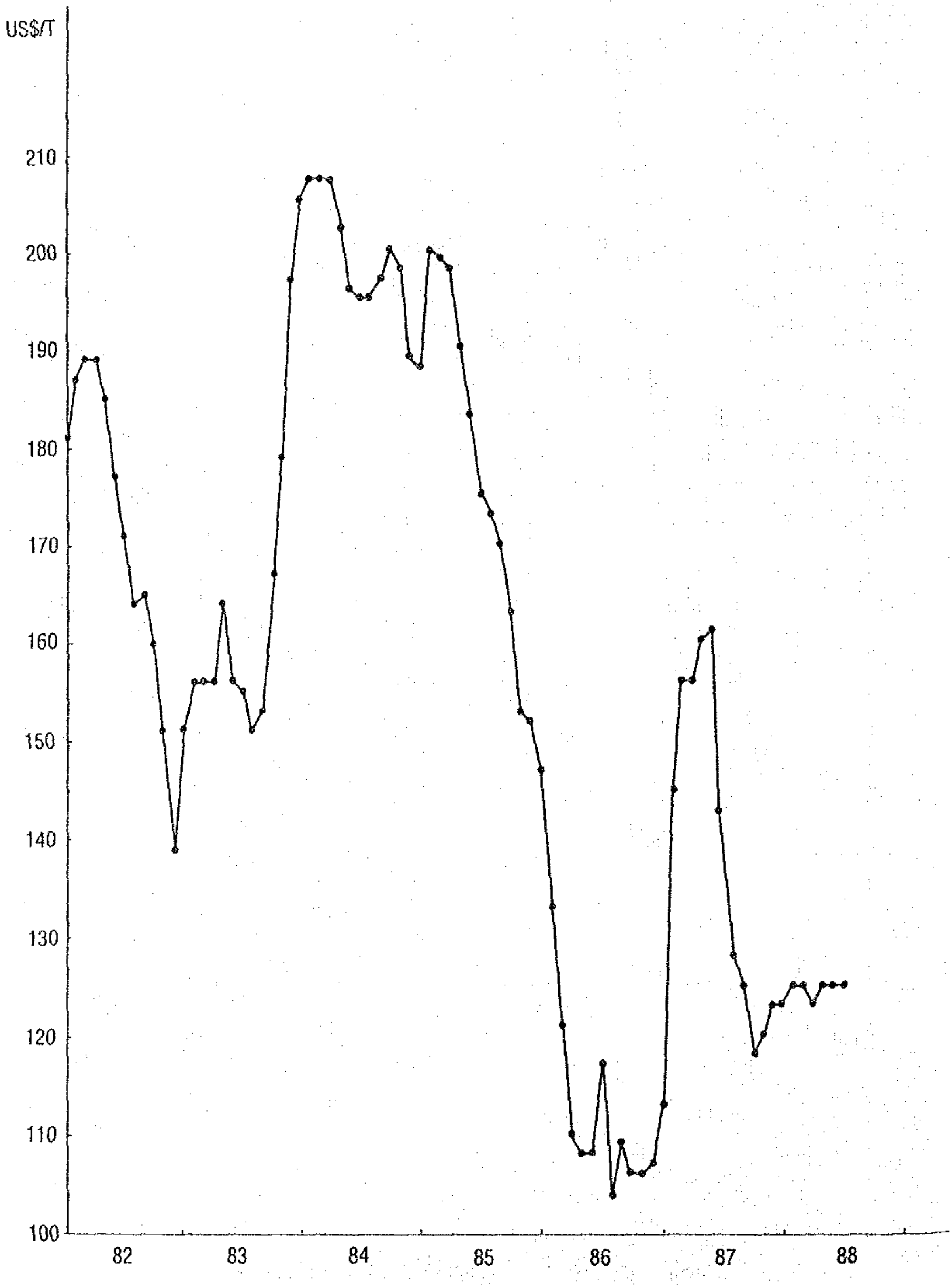
Conversion rates of Zimbabwe dollar into U.S. dollar are in accordance with those given in Table I-4-26.

Source: CSO.

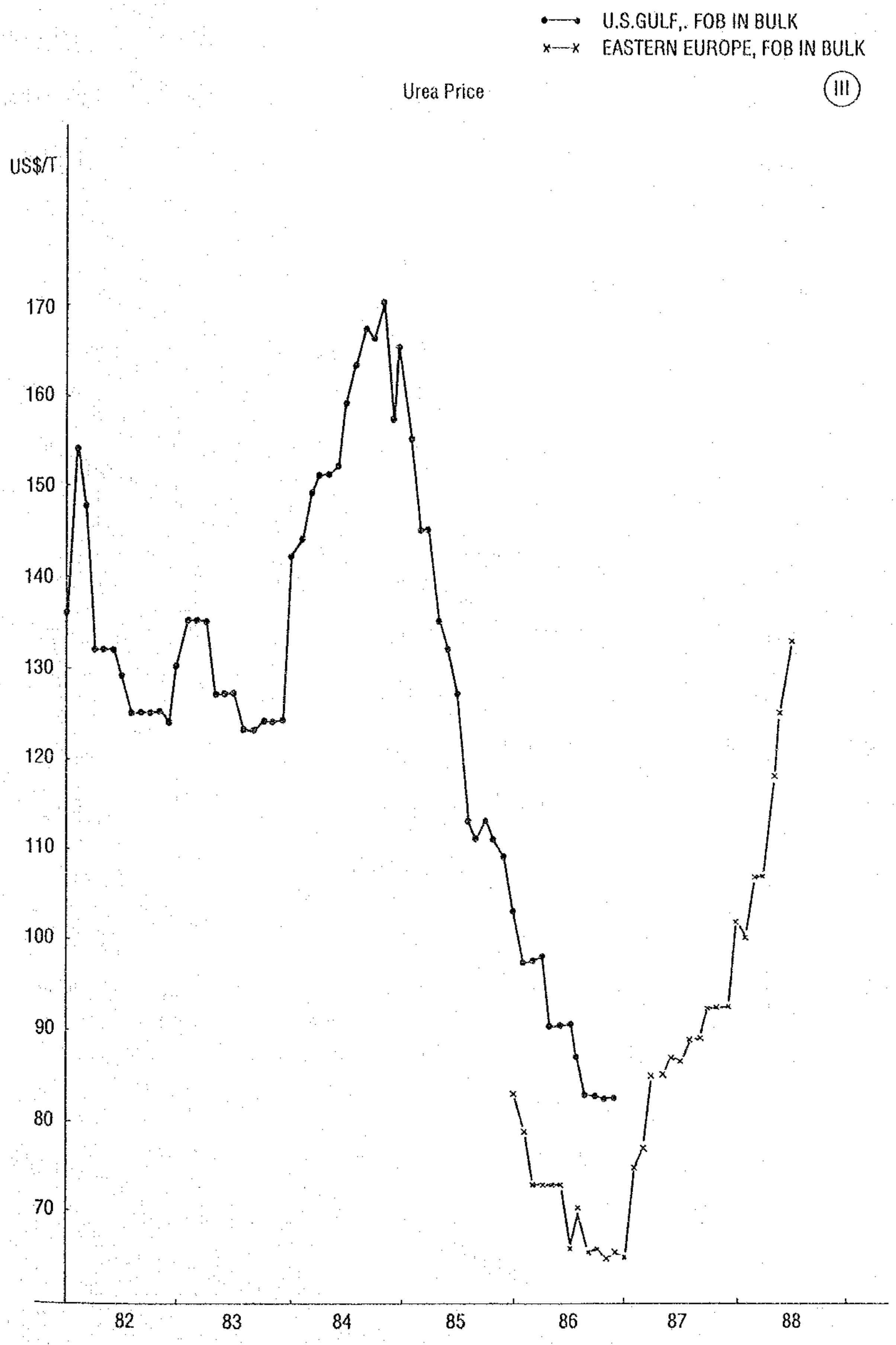


A-Fig. 4-1 Price Fluctuation of Ammonia Price

Ammonia Price



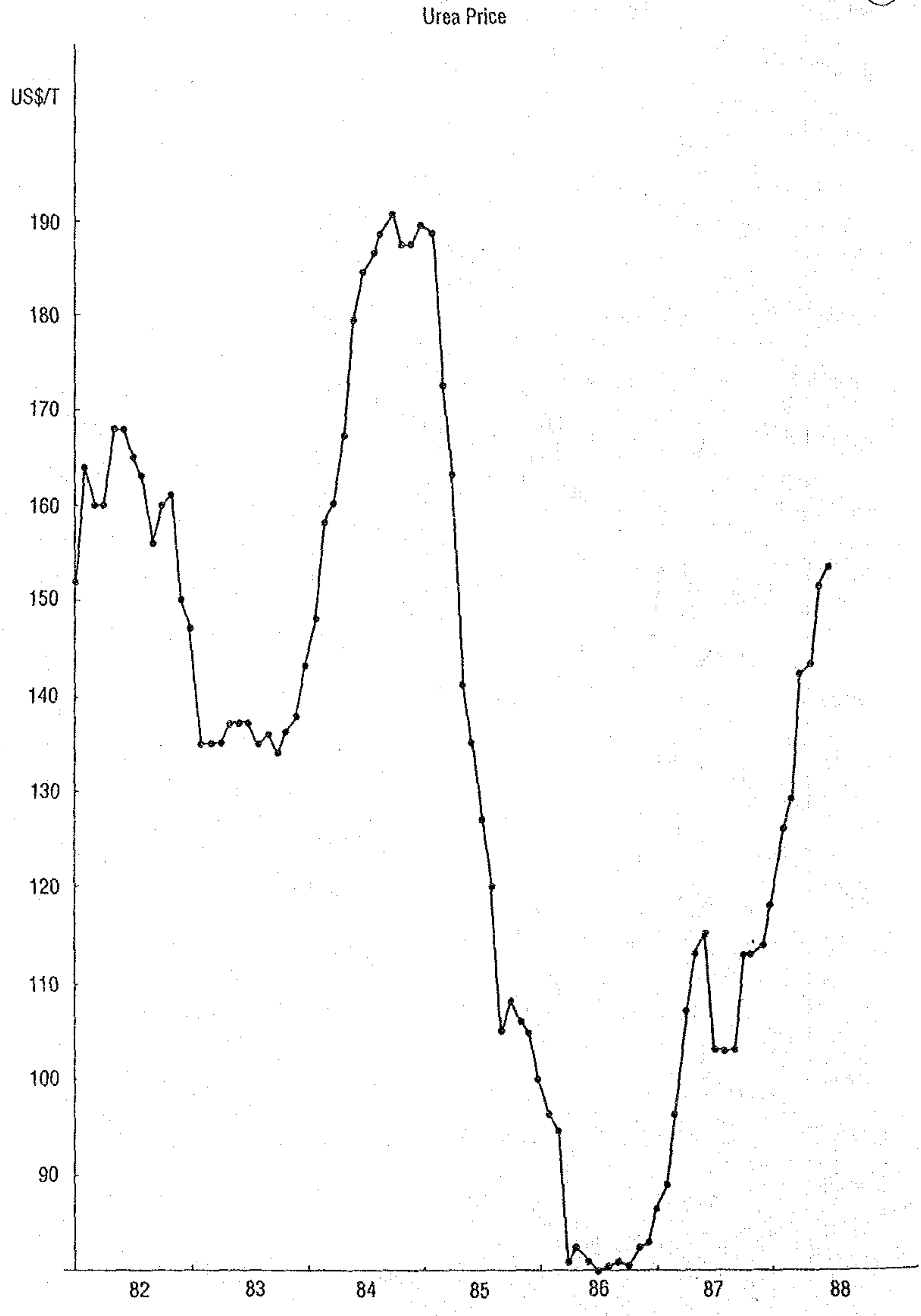
A-Fig. 4-2 Price Fluctuation of Ammonia Price



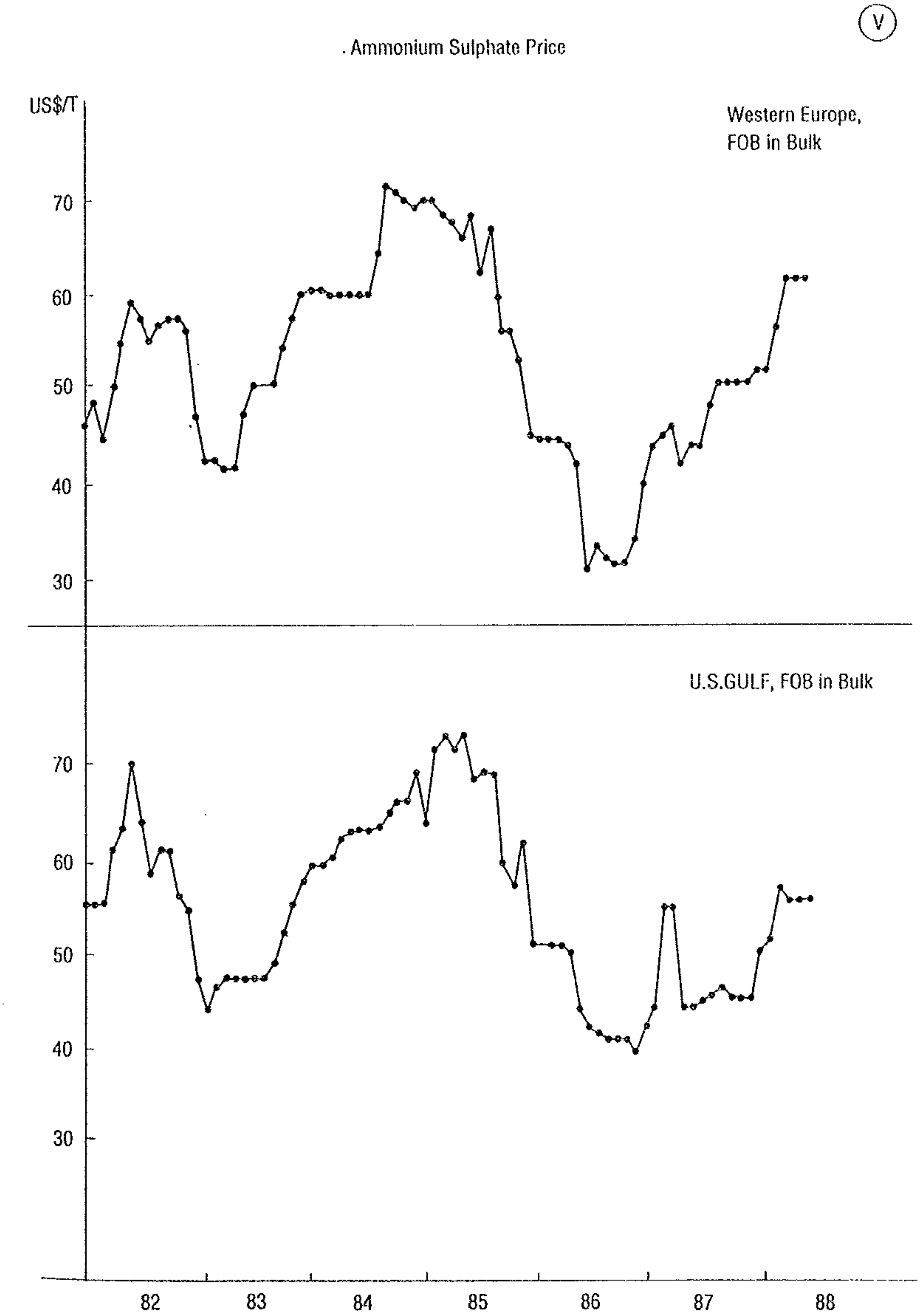
A-Fig. 4-3 Price Fluctuation of Urea Price

Middle East, FOB Bagged

(IV)



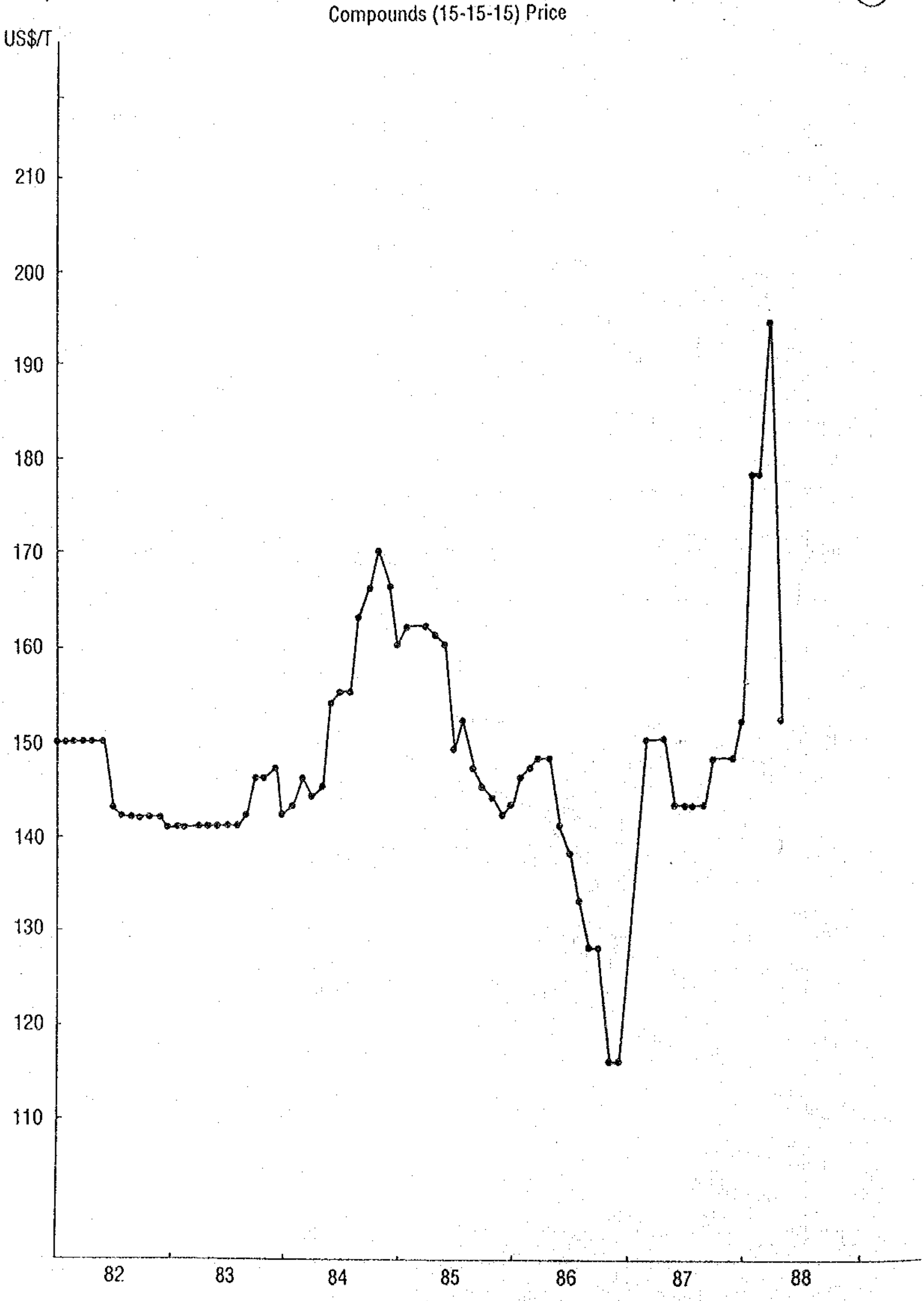
A-Fig. 4-4 Price Fluctuation of Urea Price



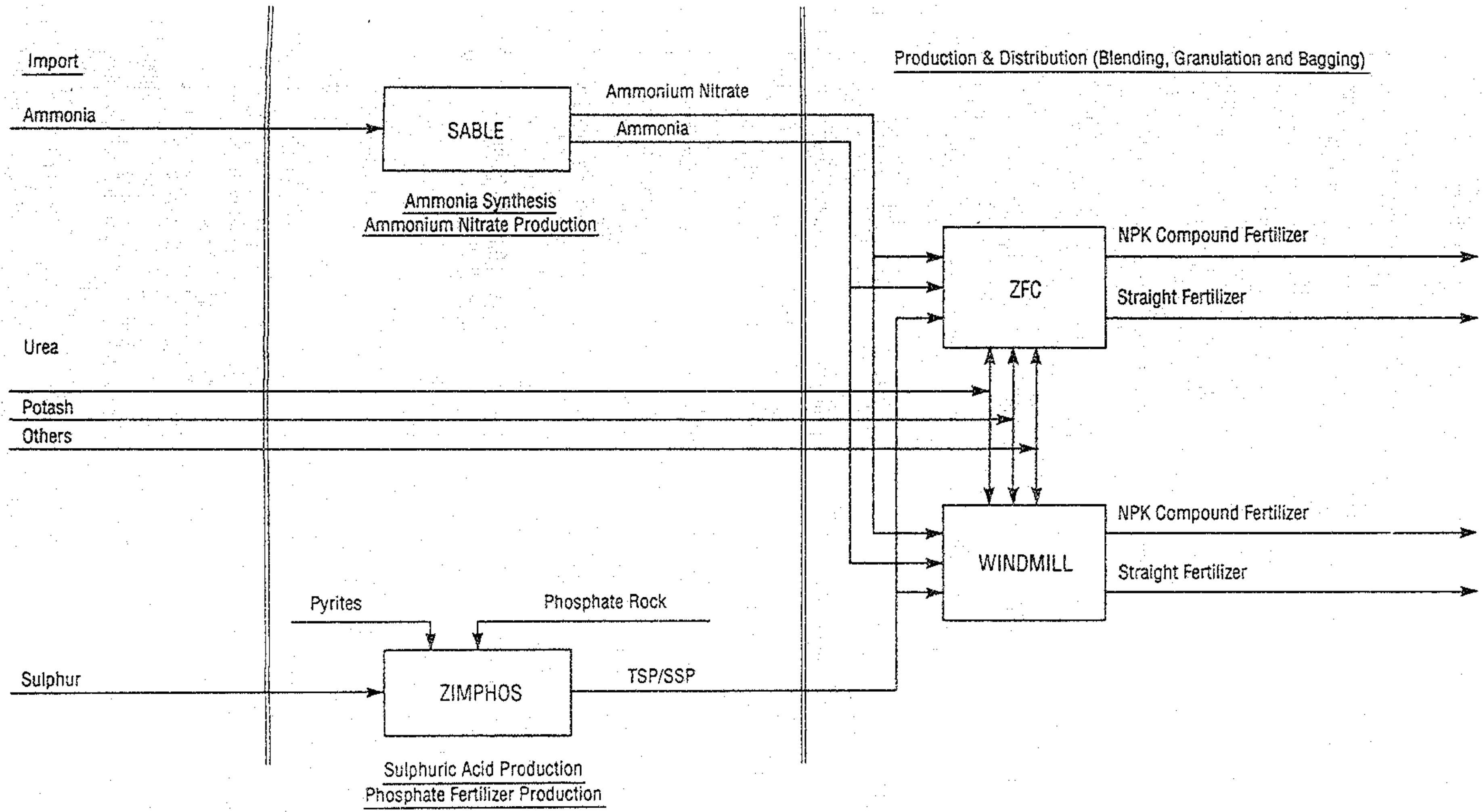
A-Fig. 4-5 Price Fluctuation of Ammonia Sulphate PriceA-Fig. 4-1 Price Fluctuation

Western Europe, FOB Bagged

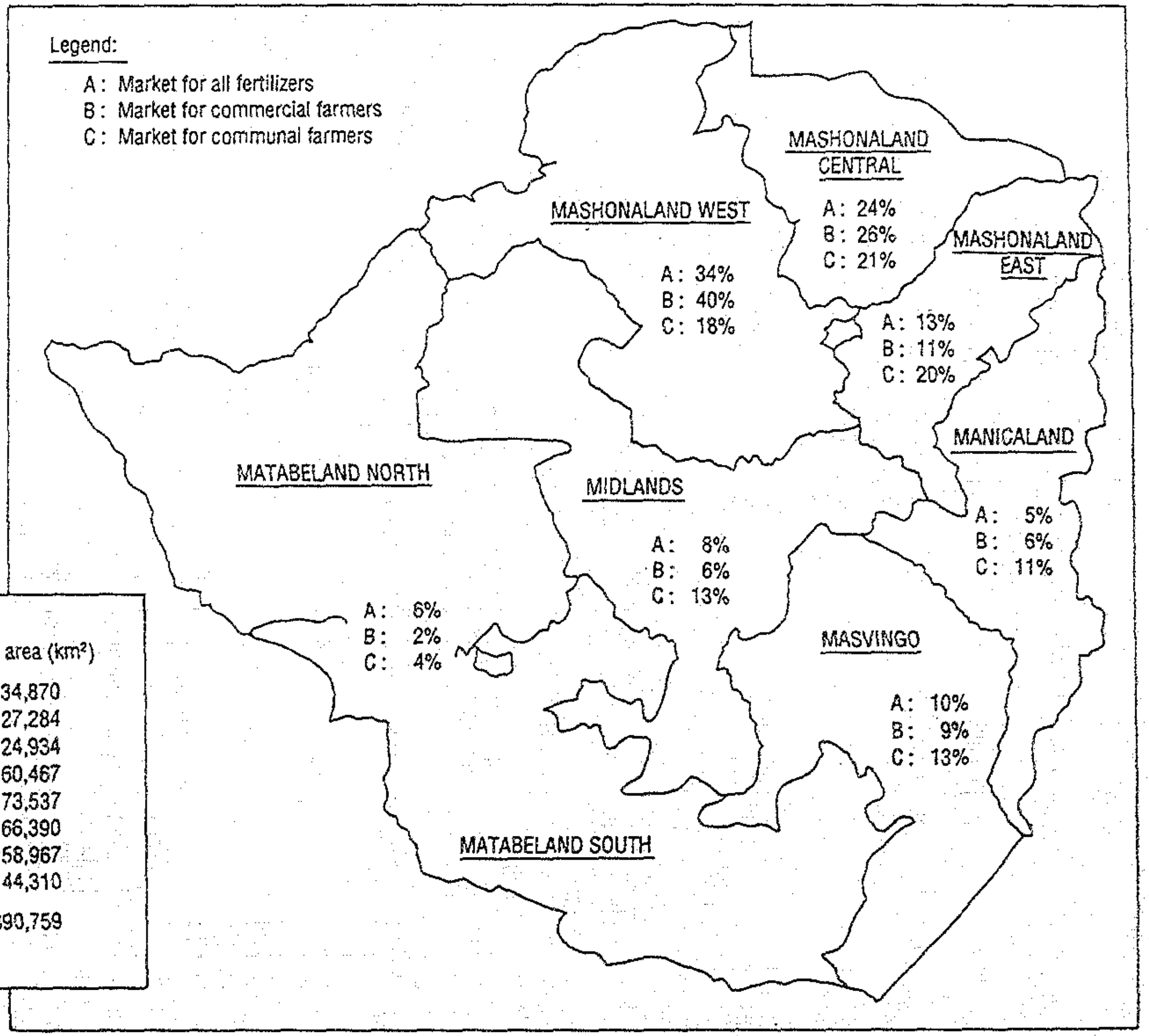
Ⓥ



A-Fig. 4-6 Price Fluctuation of Compound Fertilizer



A-Fig. 4-7 Schematic Flow of Fertilizer Production and Distribution in Zimbabwe



Land area by provinces	Land area (km²)
Manicaland	34,870
Mashonaland Central	27,284
Mashonaland East	24,934
Mashonaland West	60,467
Matebeleland North	73,537
Matebeleland South	66,390
Midlands	58,967
Masvingo	44,310
Total	390,759

A-Fig. 4-8 Fertilizer Shipment by Province

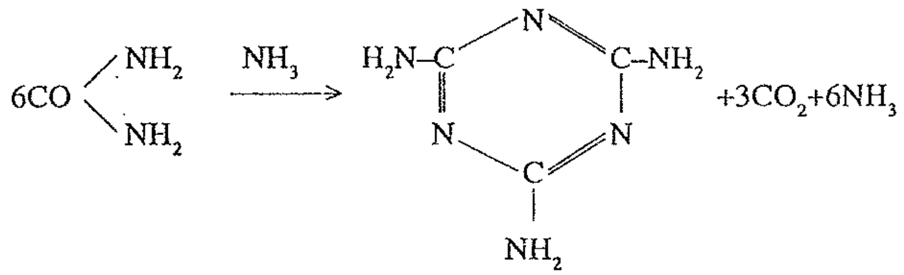
Appendix 1-2 Industrial Utilization of Urea

The major use of urea is for the agriculture, however it is also utilized commonly in the industries. In the chemical industry it is used as a raw material for several derivatives as below.

1. Chemicals

1.1 Melamine

Melamine is derived from urea in the presence of ammonia under high pressure and high temperature or under the presence of certain catalyst in the following reaction formula.

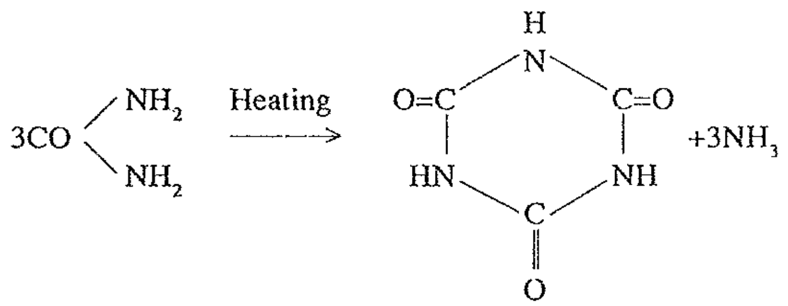


Melamine is mainly converted into a melamine resin combined with formaldehyde. Melamine resin is thermo-setting and used for glues, laminates, coatings and moldings. The investment cost for melamine plant is remarkably heavy. One ton of melamine requires more than three tonnes of urea.

Currently in the world 1.2~1.3 million tonnes of urea would have been consumed for the production of melamine.

1.2 Isocyanuric Acid

Urea is heated up to 300°C or higher, then a condensation reaction takes place releasing ammonia and isocyanuric acid is formed in the following formula.



Isocyanuric acid thus produced is purified, and then chlorinated to obtain di-chloride or tri-chloride. The chlorinated products are used mainly as a disinfectant for swimming pools. Some isocyanuric acid is used for the production of paints.

One ton of isocyamic acid requires 1.6~2.0 tonnes of urea. In the world 100 to 150 thousand tonnes of urea would have been consumed for the production of isocyanuric acid.

1.3 Sulfamic Acid

Sulfamic acid is manufactured by the reaction of urea and oleum (fuming sulfamic acid) in the following two steps reaction.

$$CO\left\langle\begin{array}{l}NH_2\\NH_2\end{array}\right. + SO_3 \longrightarrow HSO_3NHCONH_2$$

$$HSO_3NHCONH_2 + H_2SO_4 \rightarrow 2HSO_3NH_2 + CO_2$$

Sulfamic acid is a dry acid and highly stable. It is particularly well suited for scale removal and chemical cleaning of vessels with its less corrosive character.

A big problem of producing sulfamic acid is the disposal of waste sulphuric acid.

The more accessible utilization of urea is in the manufacture of urea resin which is extensively used in the manufacture of plywood, furniture, molded appliance, textile, paper, paint etc. Urea resin is the typical and the most common amino resin and is supplied to the market in a competitive price.

2. Urea Resins

2.1 Chemistry of Urea Resin

Urea resin is chemically a polymer of a condensate product of urea and formaldehyde. Urea itself comprises two amino radicals. And each amino radical reacts with one molecule of formaldehyde giving an addition product, dimethylolurea, as follows.

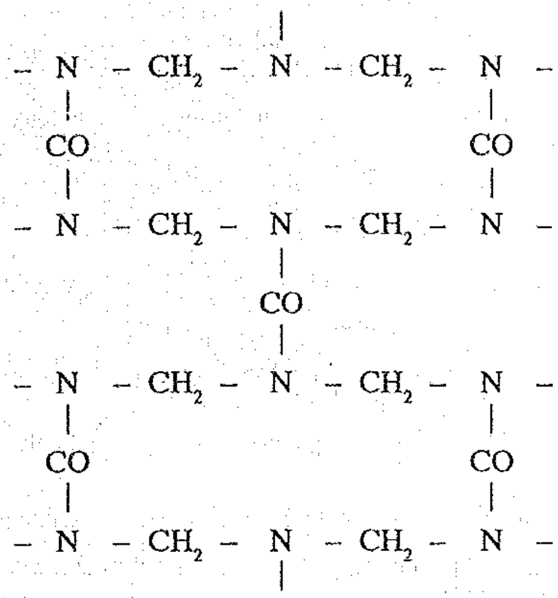
$$CO\left\langle\begin{array}{l}NH_2\\NH_2\end{array}\right. + 2CH_2O \longrightarrow CO\left\langle\begin{array}{l}NH-CH_2OH\\NH-CH_2OH\end{array}\right.$$

Then, under the controled conditions, condensation reaction takes place as follows for an example.

$$CO\left\langle\begin{array}{l}NH-CH_2OH\\NH-CH_2OH\end{array}\right. + CO\left\langle\begin{array}{l}NH_2\\NH_2\end{array}\right.$$

$$\rightarrow HOCH_2\text{-}NH\text{-}CO\text{-}NH\text{-}CH_2\text{-}NH\text{-}CO\text{-}NH_2 + H_2O$$

Finally a three dimensional net work complex is formed as a stable polymer as shown below.



In these reactions the control of mol ratio of urea and formaldehyde, pH, temperature, reaction time, type of catalysts, is most important to achieve the property of the resin suitable for the specific end use.

2.2 Uses

2.2.1 Adhesives

This is the largest use of urea resin.

The finished product resin is in a spray-dried powder form or in a liquid form containing 40% (concentrated) to 60% (unconcentrated) water depending to the uses. The majority is used for the manufacture of plywood and the rest is for the manufacture of particle board, chip board and furniture.

The adhesives must remain in the glue line on the surface between the layers. So the adhesives are made of high viscosity so that they remain in the glue line. In this purpose thickners such as finely ground pecan shells, wheat flour etc. are often used. An example prescription, 100 portion of finished product resin, 40 portion of barley or wheat flour, 1.5 portion of harder forms a glue, of which standard application is $120 g/m^2$ of inner surface.

A brochure of plywood making plant is attached to the end of this Appendix for a general reference.

2.2.2 Molding Compounds

This use is quite comparable to adhesives.

The mole ratio of formaldehyde to urea is normally in the range of 1.2~1.5 for preparation of this resin. After reaction in the presence of ammonia or alkaline catalyst for a couple of hours under 40-60°C, the reactant in a form of syrup is filtered and a chopped alpha cellulose filler is added to the syrup about 20 to 25% by weight.

The mixture is steam dried, then pigment, mold release agent and curing catalyst are added to it before milling. The urea resin mold has a good electrical properties. The molding compound is used for manufacture of bottle caps, tablewares, buttons, electric and mechanical parts, stationery etc.

2.2.3 Coatings

The urea resins are the cheapest and fastest curing. They are used in clear coatings for wood furniture setting under room temperature, baked enamels for appliances, and primer coats on automobiles.

The formulations of coatings are sophisticated. In many case the urea resins are assorted with methanol, n-butanol, iso-butanol or other alcohols for effecting alkylation which improves the nature of this resin curing too hard and brittle to be used alone. Usually the urea resin is upto 50% of the total resin solids in the formulation.

2.2.4 Textile Finishes

Mostly methylolated urea, the primary addition product of the urea resin reaction and monomeric, is used for furnishing textile fabrics.

The urea resins react with cellulosic fibres and change their physical properties. They do not react with synthetic fibres, such as nylon, polyester or acrylics, but may self-condense on the surface. This results in a change in the stiffness or resiliency of the fibre.

Processing of cotton fabric with the urea resin gives the garments made of it special features so called as "wash and wear" and "permanent press" according to the processing.

Since the methylolurea monomers have limited warer solubility of about 30%, they are usually marketed in dispersed form as soft pastes containing 55-65% active ingredient to save container and shipping cost.

2.2.5 Paper Industry

The urea resins are used by the paper industry in large volume for a variety of applications. The resins are divided into two classes according to the mode of application. The resins added to the fibre slurry before the sheet is formed are called wet end additive and are used to improve wet and dry strength and stiffness. The resins applied to the surface of formed paper or board, almost invariably together with other additives, are used to improve the water resistance of coatings, the sag resistance in ceiling boards, and the scuff resistance in cartons and labels.

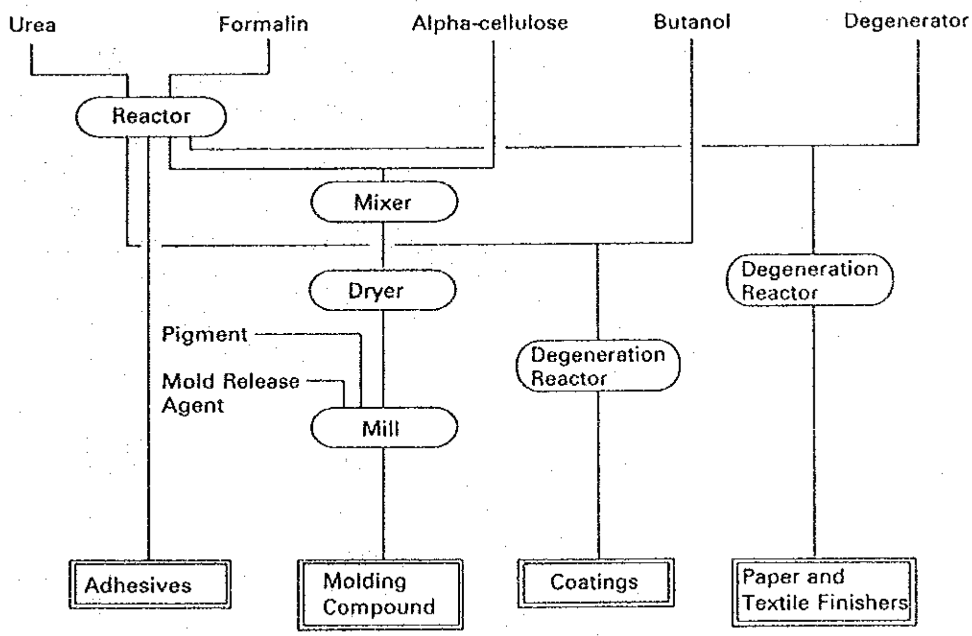
In the purpose of improving the water solubility of the urea-aldehyde polymer and of achieving better adhesion between fibres, application of the anionic polymer made by the reaction of urea resin with sodium bisulfite and application of the cationic polymer made by the reaction of urea resin with polyethylenepolyamines are most widely practiced.

The dosage of the resin is somewhat 0.3 to 2% of the fibre and the use of alum as a mordant is essential.

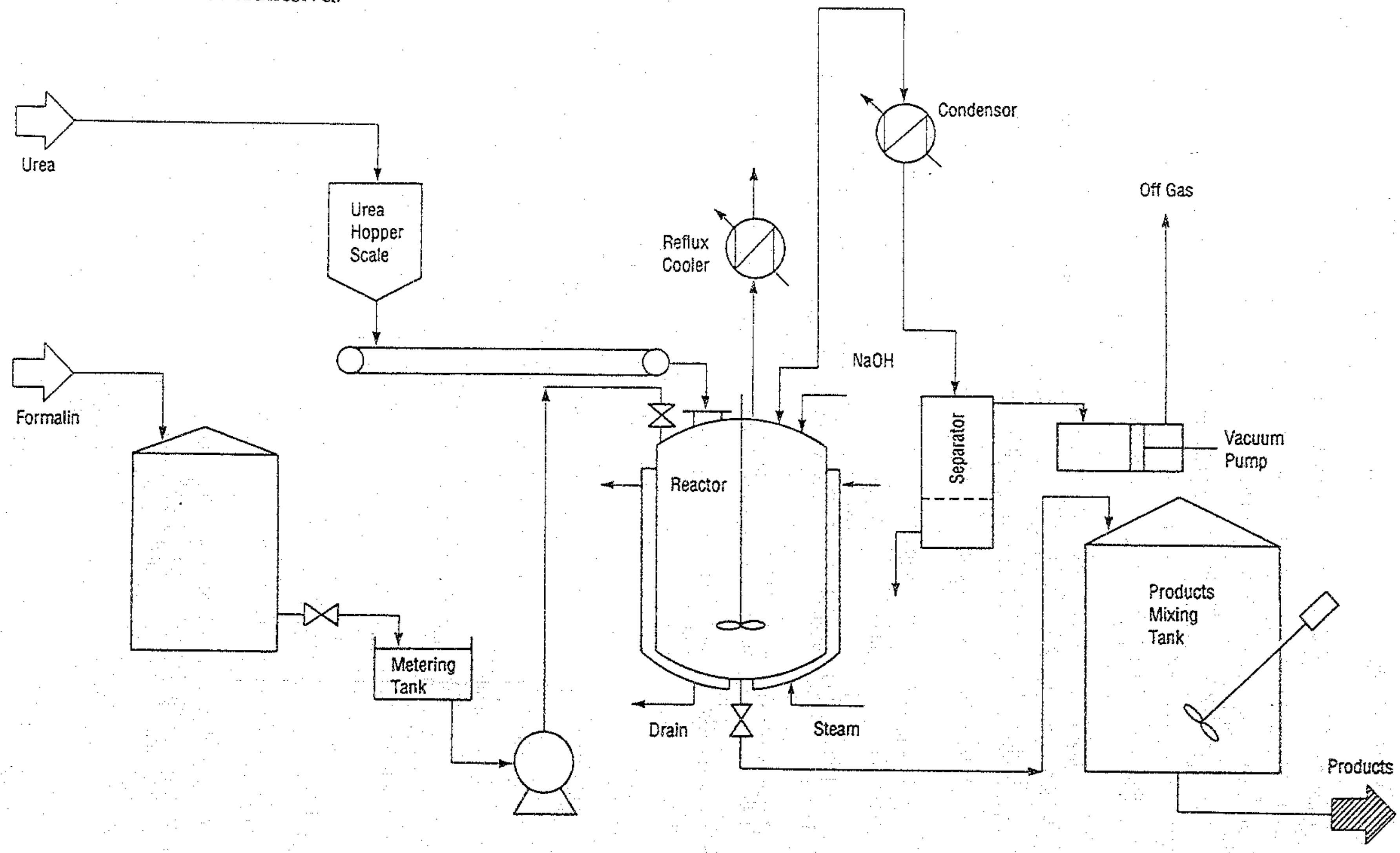
Melamine resins and phenolics are the competing thermo-setting resins with the urea resins.

2.3 Process Flow

2.3.1 Generalized Flow Sheet of Urea Resins



2.3.2 Flow Sheet for Adhesives



2.4 Outline of Process

Outline of the urea resin process is given below taking a case of manufacturing the adhesives as a typical example.

The plant is designed on a batch reaction basis. The main equipment comprise a reflux cooler provided with a condenser of $3\sim10m^3$, a reactor of $10\sim20m^3$ with a jacket/coil for steam heating and water cooling and an agitator and a vacuum condenser connected to the reactor. All the equipment are made of stainless steel. This is to prevent the contamination of products by iron ion and to protect equipment from corrosion by formalin. It is indispensable to provide a continuous measurement system of pH and temperature of reactant since those parameters dictates the product quality definitely. When powder adhesives are to be manufactured, provision of a spray dryer is necessary.

Formalin is metered and charged into the reactor and a catalyst of alkaline substance such as ammonia, caustic soda, sodium carbonate, sodium phosphate is added and pH of the liquid is adjusted to 7.5~8.0.

Then urea is charged under agitation and heating to the range of 80 to 90°C and the reaction liquid is kept for a couple of hours as required to effect the addition reaction. In the next step a weak organic acid such as acetic, oxalic, formic acid or an acidic inorganic salt such as zinc chloride, sodium hydrogen phosphate is added as an acidic catalyst to bring pH of the reactant to 5.0~6.0. The heating under agitation is continued for an appropriate time to achieve the condensation reaction. Again the alkaline catalyst is added to the condensate to adjust its pH to neutral and the excess water is removed under vacuum to the required concentration.

2.5 Plant Cost

A plant, for production of urea resin adhesive, 10,000 T/Y and within the scope of battery limit, would cost above Japanese Yen 200 million in 1988 in Japan.

2.6 Unit Consumption

The consumption of two main raw materials, urea and formalin, varies widely according to the product.

	Adhesive	Molding
Urea	300kg	800kg
37% formalin	700	1300
Mol ratio (formalin/urea)	1.73	1.20

The adhesive quoted here is an unconcentrated product containing less than 60% water. The molding resin here represents a dry product but alpha cellulose is not included.

An example of unit consumption is given below for the case of adhesive resin containing minimum 60% nonvolatile matter.

Urea	340-275kg
37% formalin	680-755kg
10% caustic soda	2.5-3.0kg
10% acetic acid	0.5-3.0kg
Water	5-15m^3
Power	10-50 kWh
Fuel	10-30 l

2.7 Product Specification

For a reference two copies of Japanese Industrial standard are attached to the end of this Appendix 1-2.

JIS K 6801 (1987)	Urea Resin Adhesives for Wood
JIS K 6916 (1975)	Urea Formaldehyde Molding Compounds

2.8 Price in Japan

In 1986 the delivered price of the urea resin molding compounds in Japan ranged Japanese Yen 440-480 per kg.

2.9 Production in Japan

In 1985 in Japan the production of the thermosetting resins comprising urea resin, melamine resin and phenolics, was 911,000 tonnes, in which urea resin amounted to 470,000 tonnes.

When the urea resins are manufactured, a supply of formalin is indispensable. Formalin is a water solution of formaldehyde and its concentration is normally 37% only. Formaldehyde in water is not stable beyond this concentration resulting polymerization. Methanol is added by 5 to 8% in formalin to stabilize the solution. Therefore a transportation of formalin in large quantity is often uneconomical. And the manufacture of formalin might be contemplated concurrently with the manufacture of urea resins. In this view a brief information on the formalin manufacture is given below.

3. Formalin

3.1 Process Flow

An example of flow producing formalin from methanol is given to the next page.

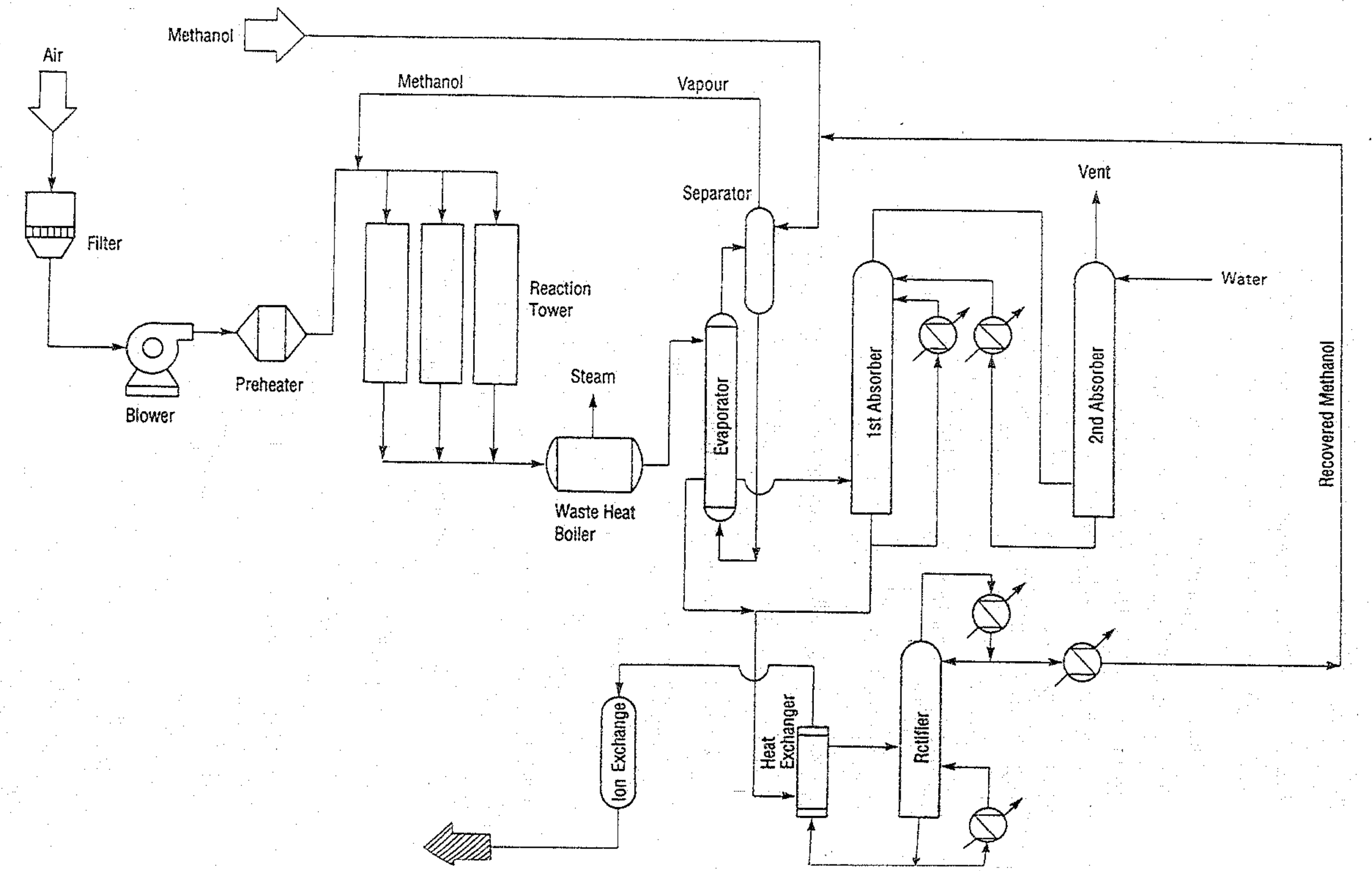
3.2 Plant Cost

Battery limit plant cost of 37% formalin of 18,000 T/y would be about Japanese Yen 1,000 million in 1988 in Japan.

3.3 Unit Consumption

An example of unit consumption for 37% formalin is as follows.

3.1 Example Flow of Formalin



Methanol	430kg
Steam	0.5T
Cooling Water	$31 m^3$
Power	44 kWh
Catalyst	Nominal amount

3.4 Product Specification

Formaldehyde (wt%)	37.0±0.5
Formic acid (g/100 ml)	0.03 or under
Ash (g/100 ml)	0.01 or under

Above is in accordance with Japanese Industrial Standards, JIS K-1502.

3.5 Price in Japan

In 1986 37% formalin price in Japan was;

for the resin use	Japanese yen 45-50/kg
for general use	Japanese yen 55-65/kg

3.6 Production in Japan

In 1985 total production of 37% formalin in Japan was 1,200 thousand tonnes.

Plywood Making Plant

Plywood is a product in which several even numbers of boards are plied with glue to dissipate or compensate respective particular defects and to offer a wide size. Plywood thus produced has the particular features of being a wood with the least defects, wide size, long length and high strength mechanically (physically). Plywood is widely used in our daily life and contributes much to the development of culture and welfare. Its demand is ever on the increase.

Insofar as Japan is concerned, Nara (Quercus serrata T.), Shina (Tilia japonica S.), Tamo (Fraxinus var. japonica M.), Sen (Kalopanax Pictus N.), Kaba (Betula: Birch) and Buna (Fagus crenate: Beech) among native woods and Lauan, Mayapis, Kapor, Tanguil and Bagtikan of imported types can be used as peeler log.

In Southeast Asia, wood having the same quality as the exotic timber which Japan imports are used for plywood production and besides those mentioned above Apitong and Teak are included.

In North America, Douglas fir, Hemlock, and Spruce are used for this purpose and in Europe, Birch, Spruce, Poplar and in Africa, Okume is used. Thus, the typical woods of the world are almost entirely used as plywood material.

Outline of the Plant

This plant aims to use logs produced in tropical and semi-tropical regions and it is planned to utilize most effectively logs of large diameter class, straight and 0.45–0.55 of absolute dry specific gravity.

Type and quality of products are as follows, with a daily output capacity of 4,000 sheets (8 hrs.).

Size:	122 cm x 244 cm x 4 mm (4' x 8' x 4 mm)
Quality:	Type II AA (1st class), AB (2nd class) and BB (3rd class)

The product is used for general construction purposes such as interior material for housing, ships, vehicles, and furniture, and secondary processing is done on the face and used for similar purposes.

During the course of production of plywood, edge of logs, peeled core, and other waste from plywood and veneer are produced, and these wastes are chipped and used as materials for paper, fibreboard, and particle board. At this plant, they are also used as fuel for the boiler. Some of the edge wood and peeled core are collected and together with unqualified veneer logs, they are sawed into lumber and sold.

Process Description

Preparation of Logs

1. Cutting of logs

Logs stored in a pond are conveyed to the factory yard and are cut by the chain saw to the desired length for feeding to the veneer lathe or to the length of the veneer sheets to be produced.

2. Cooking or steaming

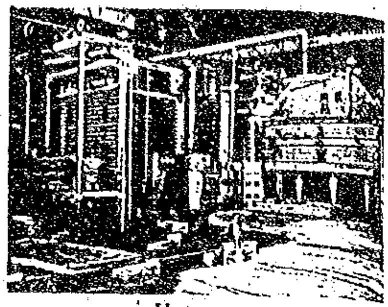
High-density logs require pre-treatment by cooking vats or steam chambers because they are hard and frequently too resinous to permit fresh cutting.

Veneer Manufacturing

1. Veneer cutting

1) Rotary cutting

In automated mills, log chargers with log centering devices are usually installed for speedly, automatic feeding of logs to the veneer lathe. As the log is centered by the centering device before feeding, it can immediately be fixed on the spindles of the veneer lathe and peeled in an endless sheet by utilizing veneer reeling and unreeling machines. The speed of the cutting and reeling is fully synchronized. Full reels are so stored on the deck of the system.



Hot press

2) Slicing

The "edge-grain" veneer required for the production of decorative plywood is cut by the veneer slicer, which slice across the grain of the log.

Fig. 2: Process Flow Sheet for Plywood Manufacturing Plant

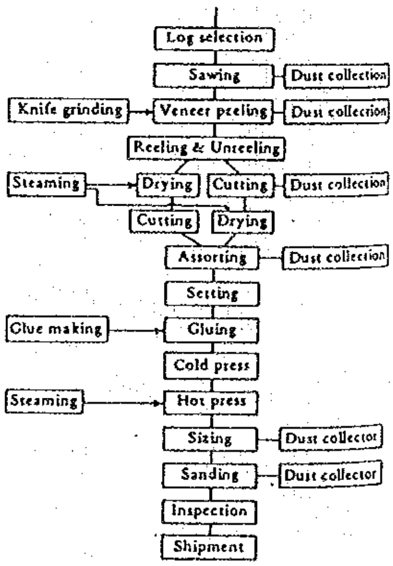
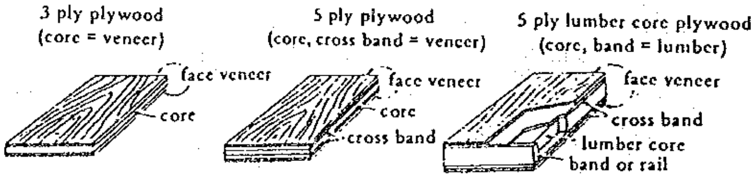


Fig. 1: Construction of Plywood



2. Green veneer clipping

The sheet of green veneer peeled by the veneer lathe is cut by the automatic or manual veneer clipper into the desired dimensions. Full rolls of the reeling machine are transferred to the unreeling unit, and the veneer is unrolled and cut by the veneer clipper.

Where the tray deck system is used the veneer can be sent directly front the tray deck to the veneer clipper of dryer.

3. Veneer drying

In order to ensure the maximum bonding effect of adhesive, veneer sheets must be dried adequately before gluing them together. The moisture content of veneer sheets is the most important factor in gluing. There are two types of veneer dryers, – namely roller and continuous veneer dryers.

4. Veneer Preparation

Narrow strips of veneer are joined together into full size by the following methods.

1) Veneer jointing

For the practical use of narrow on irregular pieces of veneer, the edges must be cut straight for precise jointing. The Arisun clipper or the veneer guillotine jointer are used for this purpose.

2) Veneer taping

After the veneer is processed by the veneer jointer, the veneer taping machine is used to join the veneer edge to edge to prescribed dimensions. This machine is usually used for the jointing of the back veneer sheet.

3) Veneer edge gluing

The veneer edge gluer is used for continuous glue-coating and splicing of the edges of veneer pieces which are carried with the grain at right angle to the direction of the feeding, automatically cutting the veneer to the desired length. Thermo-setting or thermo-plastic glue can be used with this machine. The veneer splicer is used to join the edges of veneer with glue instead of tape and is suitable for both back and core veneer sheets.

Manufacture of Plywood

1. Glue mixing

The glue mixer is used to mix the liquid or powder with the proper amount of water, hardener, filler and other ingredients.

2. Glue spreading

The glue spreader spreads the glue uniformly on the core veneer sheets in the first process to produce plywood from veneer sheets.

3. Pre-pressing

Veneer sheets glued together are stacked and pre-pressed by the cold press. Pre-pressing minimizes overlapping or gapping of the center core veneer which may occur during the carrying of the glued veneer sheets to the hot-pressing process.

4. Hot pressing

After pre-pressing, the plywood is fed to the hot press, where it is put under pressure of 10 – 15 kg/cm^2 in a temperature of 110 – 120°C.

Finishing

1. Sizing

After being hot pressed, the plywood is cut to prescribed specifications by the double sizer, which consists of rip-saw and cross-cut machine.

2. Sanding

The wide belt sander is generally used to finish plywood panels. It utilizes an abrasive belt which runs on serrated rubber contact rollers or platens. The number of heads, the combination of contact rollers and platens and the hardness of the rubber are determined by the kind and grade of finish desired.

3. Grading and inspection

After sanding, the plywood panels are carried by an automatic conveyor for grading and inspection. The panels are inspected and selected for delivery while they are on the conveyor.

Required Plant Site Area

The required building site is 32,000 m^2 (400 x 80 m) plus 10,000 m^2 for future expansion.

The detailed description of machinery and equipment required for 4,000 sheets/day plant are omitted here. However, the FOB price of machinery and equipment which should be imported is ¥1,180,000,000 while the machinery and equipment locally procurable would cost ¥350,000,000.

Locational Condition

1. Site where collection of logs is easy and storing is available.
   (1) Site facing unfrozen rivers, lakes and sea.
   (2) If there is no available water surface, site must be convenient for log collection.
2. Convenient site for sale and transportation of products.
3. Site where labour force is available.
4. Site where procurement of utilities is convenient.

Table 1: Requirement of Raw, Sub Materials & Utilities

Item	Spec.	Quantity
Logs	Suitable for plywood	106 m^3/day
Gum tape	For veneer lathe	23,000 m/day
	For patching	7,000 m/day
Urea resin		3,220 kg/day
Wheat flour		705 kg/day
Ammonium chloride		0.65 kg/day
Electricity		980 kWh
Steam		10 tons/hr.
Water		20 m^3/hr.
Nitrogen gas		150 ℓ/50 hr.
Lubricating oil	JIS No. 1 turbine oil	5,000 ℓ/300 days

Table 2: Required Manpower

Item	No.
Engineer	13
Skilled worker	54
Ordinary worker	96
Odd job man	9
Senior clerical worker	1
Junior clerical worker	7
Total	180

How To Start Smaller Industries

Japan Consulting Institute (JCI)

Hibiya Park Bldg., 1-8-1, Yuraku-cho, Chiyoda-ku, Tokyo, Japan
Cable Address: JACOINST TOKYO
Tel: (03) 213-8551-6, 271-9308, 271-1886

Revised date: March 1978.

UDC 678.652'41'21:665.939.56:674

JAPANESE INDUSTRIAL STANDARD — J I S

Urea Resin Adhesives for Wood — K 6801-1987

1. Scope

This Japanese Industrial Standard specifies the liquid urea resin adhesives [1], hereinafter referred to as the "adhesives", used for plywood, glue laminated wood, laminated veneer lumber, particle board, middle class fiber board, general wood working, etc.

Note [1] Urea resin adhesives for wood, as they are called here, are limited to the liquid synthetic resin adhesives prepared by using urea and formaldehyde as the main components. They include the copolymers prepared by replacing a portion of urea by melamine, phenols, and others.

Remark: The units and numerical values given in { } in this Standard are based on the traditional unit system and are currently the criteria in force.

2. Classification

Adhesives shall be classified according to the fields of use as given in Table 1.

Table 1. Type of Adhesives

Type	Use
Class 1 (For use at normal temperature)	Mainly for general wood working and glue laminated wood
Class 2 (For use by thermal treatment)	Mainly for plywood and particle board

Remark: Class 2 shall be subdivided into A and B according to the content of free aldehyde (refer to Table 2).

3. Quality

The adhesives, when being tested in accordance with the description in 6., shall conform to the requirements given in Table 2.

Table 2. Quality of Adhesives

Test item			Quality			Test condition	Applicable test clause
			Class 1 (for normal temperature)	Class 2 (for thermal treatment)			
				A	B		
Appearance			No alien matter considered to be harmful			–	6.1
Nonvolatile matter		%	60 min.	43 min.		E-3 h/105 (2) ± 1.5°C	6.2
Preservativeness		h	10 min.			70 ± 2°C	6.3
Miscibility with water		times	2 min.			25 ± 1°C	6.4
pH		–	6.5 to 10.5	6.5 to 11.5		25 ± 1°C	6.5
Free formaldehyde		%	3 max.	Under 1	2 max.	–	6.6
Compressive shearing adhesive strength	Normal state	N/mm² {kgf/cm²}	9.81 {100} min.	–		–	6.7.1
	Warm-water resistance	N/mm² {kgf/cm²}	5.88 {60} min.	–		D-3 h/60 (2) ± 3°C	6.7.1
Wood tensile shear adhesive strength	Normal state	N/mm² {kgf/cm²}	–	1.18 {12} min.		–	6.7.2
	Warm-water resistance	N/mm² {kgf/cm²}	–	0.98 {10} min.		D-3 h/60 (2) ± 3°C	6.7.2

Table 2 (Continued)

Test item			Quality			Test condition	Applicable test clause
			Class 1 (for normal temperature)	Class 2 (for thermal treatment)			
				A	B		
Reference test	Viscosity	Pa·s {P}	0.3 to 15 {3.0 to 150}	0.01 to 15 {0.1 to 150}		25 ± 0.5°C	Reference Test 1.
	Gelation time	min	5 to 150	10 min.		25 ± 0.5°C (3)	Reference Test 2.
	Miscibility with vinyl acetate		Good miscibility	–		23 ± 2°C	Reference Test 3.

Notes (2) Letter "D" means treatment in warm water, and "E" in an air thermostat.

(3) For the Class 2 with the gelation time of not less than 100 min, measurement may be taken at 40 ± 1°C or 50 ± 1°C.

4. Method of Sampling

Sampling of products shall be carried out for each lot in accordance with the sampling method prescribed below:

4.1 Lot The definition of a lot shall be in accordance with 4.1 in JIS K 6833.

4.2 Number of Samples In accordance with 4.2 in JIS K 6833.

4.3 Sampling In accordance with 4.3 in JIS K 6833.

4.4 Sample for the Test Mix the samples taken from the product so that they represent the mean properties and use the admixture for the test, hereinafter referred to as the "sample". Its amount shall be about twice that required for the test.

5. Standard Condition of Laboratory

The condition of a laboratory shall be principally the standard temperature condition Grade 2 and standard humidity condition Grade 2 (23 ± 2°C in temperature and 50 ± 5 % in relative humidity) specified in JIS K 7100.

If there is a special circumstance, however, the standard temperature condition Grade 5 (20 ± 5°C) and standard humidity condition Grade 20 (65 ± 20 %) may be adopted instead. In this case, the temperature and humidity in the laboratory adopted for testing shall be recorded in the test report.

6. Test Method

6.1 Appearance Spread the sample uniformly in a thin film on a clean glass plate with a glass rod and immediately examine with the naked eye for the presence of foreign matters harmful to adhesion such as coarse particles, sand, dust and rust.

6.2 Nonvolatile Matter (Evaporation Residue) Shall be in accordance with 6.4 in JIS K 6833.

6.3 Preservativeness

6.3.1 Apparatus Apparatuses shall be as follows:

(1) Thermostatic Bath Use one capable of keeping the temperature of the bath liquid at 70 ± 2°C.

(2) Test Tube Use a 18 by 165 mm test tube prescribed in JIS R 3503.

(3) Balance Use one with a reciprocal sensibility of 100 mg or coarser

(4) Thermometer Use a 100-degree thermometer prescribed in JIS B 7411.

6.3.2 Procedure Weigh out 10 g of the sample with the balance into a test tube, stopper lightly with a cork or a rubber stopper, then dip the tube in the bath liquid kept at 70 ± 2°C so that the surface of the sample is approximately 2 cm below the surface of the bath liquid, and read the start time. After about 10 minutes, stopper firmly and measure the time required until the sample is gelatinized and stops flowing by slanting the test tube at every 1 hour's lapse from the start time.

6.4 Miscibility with Water

6.4.1 Apparatus Apparatuses shall be as follows:

(1) Balance Use one with a reciprocal sensibility of 100 mg or coarser.

(2) Erlenmeyer Flask Use a 200 ml Erlenmeyer flask prescribed in JIS R 3503.

(3) Burette Use a burette or a measuring cylinder prescribed in JIS R 3505.

(4) Thermometer Use a 50-degree thermometer prescribed in JIS B 7411.

(5) Thermostatic Bath Use one which can maintain temperature at 25 ± 1°C.

6.4.2 Procedure Weigh out approximately 5 g of the sample in the Erlenmeyer flask, put the thermometer in it and immerse it in the bath liquid kept at 25 ± 1°C to make the temperature of the sample 25 ± 1°C. Gradually add the water previously kept at 25 ± 1°C from the burette and stir to mix the water with the resin well. After stirring thoroughly, again add the water while stirring, and read in the unit of ml the amount of water which has been added till the resin becomes immiscible and sticks to the inside walls of the flask as an insoluble matter. Then calculate the miscibility with the water from the following formula in integral multiples. This measurement shall be performed until water is added 20 times and the frequency exceeding it shall be denoted as 20 times or more.

$$L = \frac{W}{S} \qquad \cdots\cdots (1)$$

where L : multiples denoting the miscibility with water

W : amount of water added (ml)

S : weight of the sample (g)

6.5 pH In accordance with 6.2 in JIS K 6833.

6.6 Free Formaldehyde

6.6.1 Apparatus Apparatuses shall be as follows:

(1) Balance Use one with a reciprocal sensibility of 10 mg or coarser.

(2) Ground-Stoppered Erlenmeyer Flask Use a 200 to 300 ml Erlenmeyer flask prescribed in JIS R 3503.

(3) Burette Use a 25 ml burette prescribed in JIS R 3505.

6.6.2 Reagents Reagents shall be as follows:

(1) Methyl Red-Methylene Blue Use the solution prepared according to 4.3 in JIS K 8001.

(2) 0.1 mol/l {0.1 N} and 1 mol/l {1 N} Hydrochloric Acid Use the hydrochloric acid prepared by the dilution of the acid prescribed in JIS K 8180 and standardized in accordance with JIS K 8001.

(3) 0.1 mol/l {0.1 N} and 1 mol/l {1 N} Sodium Hydroxide Solution Use the sodium hydroxide solution prepared in accordance with JIS K 8001 by dissolving sodium hydroxide prescribed in JIS K 8576, and standardized with 0.1 mol/l {0.1 N} and 1 mol/l {1 N} hydrochloric acid prepared in (2).

(4) 10 % Aqueous Solution of Ammonium Chloride Use the solution prepared by using ammonium chloride prescribed in JIS K 8116.

6.6.3 Procedure Weigh out accurately the sample containing approximately 0.1 to 0.3 g of formaldehyde into the ground-stoppered Erlenmeyer flask, and add 50 ml of water and stir.

Add 2 drops of indicator and after neutralizing the solution with 0.1 mol/l {0.1 N} hydrochloric acid or 0.1 mol/l {0.1 N} sodium hydroxide solution, add 10 ml each of ammonium chloride solution and 1 mol/l {1 N} sodium hydroxide solution. Then stopper, shake and allow it to stand for 30 min at 25°C with occasional shaking. Then titrate it with 1 mol/l {1 N} of hydrochloric acid taking the point as the end point where the colour of the solution changes from green to grayish blue in the process of the colour change from green to grayish blue and then to reddish purple.

Carry out a blank test and obtain the free formaldehyde from the following formula (2). Carry out at least two tests on the same sample, and obtain their average to the second decimal point.

$$H = \frac{0.045\,0\,(A-B)\,f}{S} \times 100 \qquad \cdots\cdots (2)$$

where H : free formaldehyde (%)

A : amount of 1 mol/l {1 N} hydrochloric acid consumed in the blank test (ml)

B : amount of 1 mol/l {1 N} hydrochloric acid consumed by the sample (ml)

f : factor of 1 mol/l {1 N} hydrochloric acid

S : weight of the sample (g)

6.7 Adhesive Strength   Class 1 shall be tested by the testing method for compressive shearing adhesive strength described in 6.7.1 and Class 2 by the testing method for wood tensile shear adhesive strength described in 6.7.2. In either case, the test shall be performed in normal state and for warm water resistance.

6.7.1 Compressive Shearing Adhesive Strength   Compressive shearing adhesive strength shall be tested as follows:

(1) Material of Test Piece   Use a straight grained birch block ([4]) dried to a water content of 6 to 15 % and having a volume density of 500 to 800 kg/m^3 {0.5 to 0.8 g/cm^3} and a thickness of 10 ± 0.5 mm, with the surface for adhesion finished flat. Make the direction of its main fibers parallel with the axis of material as shown in Fig. 1.

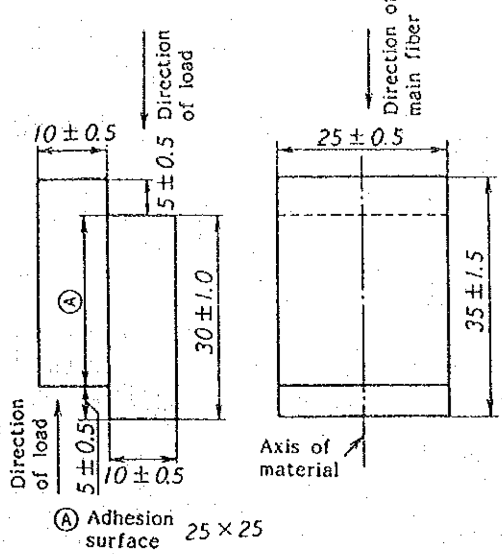
Note ([4]) Woods other than birch may be used. However, in such a case, a statement to that effect must be made in the report.

(2) Preparation of Test Piece   Add water and flour of Hakuriki Grade 3 so as to obtain the ratio of 55 % between the amount of nonvolatile matter of the sample and the total amount of the compound and also to adjust its viscosity to be suitable for coating. Then the compound adhesives are prepared by adding ammonium chloride prescribed in JIS K 8116 by the amount equal to 0.5 to 2.0 % of the sample to the above mixture.

Immediately spread the prepared compound adhesives uniformly over each of the surfaces for adhesion of (1) at a rate of approximately 100 g per 1 m^2, and cause each surface for adhesion to come into close contact in such a way that both sides parallel to the axis of material coincide with each other. Then press the test piece with a load of 0.98 to 1.47 GPa {10 to 15 kgf/cm^2} and allow it to stand under the load for 24 h at 20 to 25°C, and then remove the load. Further allow it to stand at the same temperature for 48 to 72 h, finish it to the shape and dimensions shown in Fig. 1, then scrape off the excessive adhesives from the periphery of the surfaces for adhesion and prepare twelve test pieces for each treatment. In this process, measure each of the actual adhesion areas.

Fig. 1. Shape and Dimensions of Test Piece

Unit: mm



(3) Treatment of Test Piece

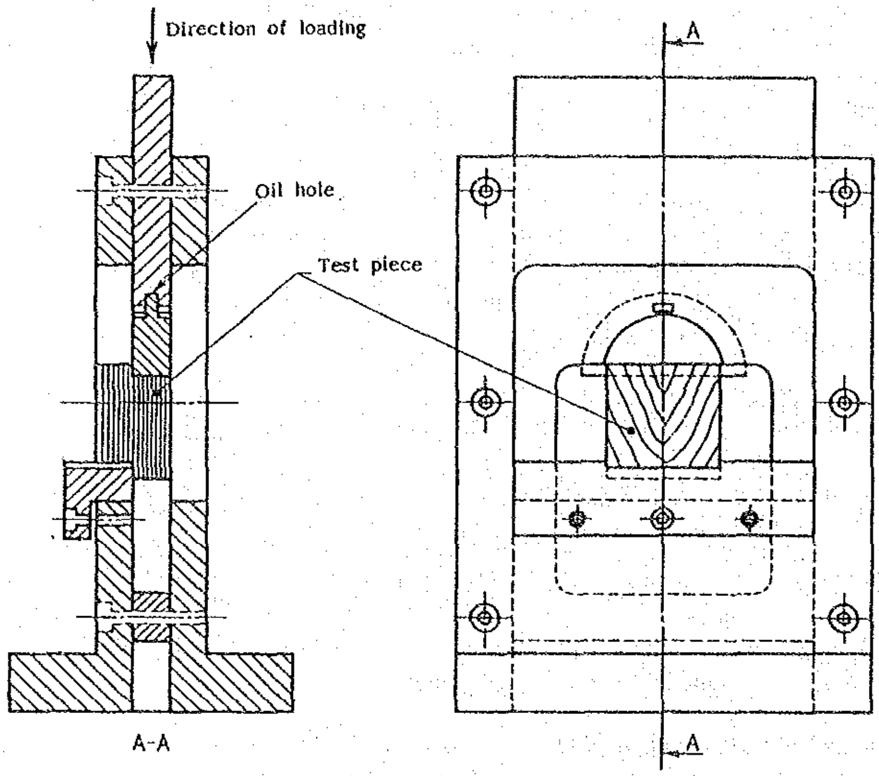
(a) Normal State Submit the test piece to a test in normal state immediately after the test piece is prepared.

(b) Warm-water Resistance After immersing 12 test pieces in warm water at 60 ± 3°C for three hours and then dipping them in room temperature water to cool down, subject them to the test while still wet.

(4) Testing Machine The testing machine shall be so selected that the breaking load of the test piece falls in the range of 15 to 85 % of its loading capacity and its standard error is ± 1 % of its standard load. Its loading rate shall be not more than 9.8 kN {1000 kgf} per minute, or else the moving speed of its crosshead be 0.5 to 2.0 mm per minute.

(5) Fixture Use a fixture which can concentrate the stress on the adhesion surface as shown in Fig. 2.

Fig. 2. Fixture



(6) Measurement Attach the test piece to the fixture so that its surface to be loaded is in alignment with the direction of load, then measure the maximum load N {kgf} shown till the breaking of the test piece takes place with the tester of (4), and calculate the adhesive strength N/mm^2 $\{kgf/cm^2\}$ by dividing the load by the adhesion area that was measured actually. In this operation, obtain the ratio of the broken area in the wood part to the sheared area by a multiple of 10 %, and record it as the percentage of wood failure (%). Test 12 test pieces in turn, and take the respective mean values as the compressive shearing adhesive strength and the percentage of wood failure.

Represent the mean percentage of wood failure by a multiple of 5 % by counting fraction of 0.3 or over as a unit and cutting away the rest. Concerning the compressive shearing adhesive strength, calculate the standard deviation from the following formula (3).

$$S=\sqrt{\frac{n\Sigma x^2-(\Sigma x)^2}{n\cdot(n-1)}} \quad \cdots\cdots (3)$$

where S : standard deviation (N/mm^2) $\{kgf/cm^2\}$

x : individual adhesive strength (N/mm^2) $\{kgf/cm^2\}$

n : number of test pieces

When the mean percentage of wood failure is 50 % or more and the mean adhesive strength is the standardized value or less, carry out a retest with newly prepared test pieces.

In the test report of adhesive strength, the following items shall be stated.

(a) Standard condition of the laboratory

(b) Blending percentage of adhesives

(c) Kinds of tree, volumetric density, and water content of test piece

(d) Type of test

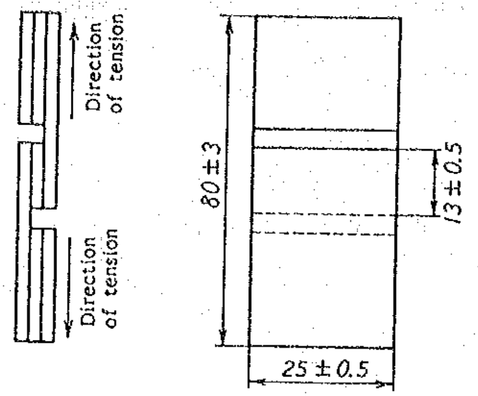
6.7.2 Wood Tensile Shear Adhesive Strength Wood tensile shear adhesive strength shall be tested as follows:

(1) Material of Test Piece Use a rotary veneer of South Sea Island lumber having a thickness of 1.2 to 1.5 mm, water content of 8 ± 2 % and a volume density of 450 to 600 kg/m^3 {0.45 to 0.60 g/cm^3} as the material of the test piece.

(2) Preparation of Test Piece Compound adhesives are prepared by adding to the sample the flour of Hakuriki No. 3, water and ammonium chloride prescribed in JIS K 8116 whose amount is equal to 0.2 to 1.0 % of the sample so as to make the amount of the nonvolatile matter in the sample 35 % of the total amount of the compound and also to make its viscosity suitable for coating.

Immediately spread the prepared compound adhesive on both surfaces of the core veneer of (1) to be tested at a rate of 160 ± 10 g per 1 m^2, overlap the front veneer and the back veneer on it so as to make the sap-side of the veneer face outward and, at the same time, arrange the direction of the fiber to be at right angles with the core veneer. Then apply to them uniformly the pressure of 0.98 ± 0.10 N/mm^2 {10 ± 1 kgf/cm^2} at room temperature for 30 ± 10 minutes, place them between hot press kept at 115 ± 2°C, apply uniformly the pressure 0.78 ± 0.10 N/mm^2 {8 ± 1 kgf/cm^2} for about 2 minutes to prepare three sheets of sample plywood each of which is composed of three veneers, and then allow them to stand to cool to room temperature. Each of these three sheets of sample plywood shall be given cuts having shapes and dimensions shown in Fig. 3 and fitting individual treatments of test pieces so as to facilitate the application of shearing force in the same direction as the reverse check of the core veneer and in the opposite direction, thus to provide 5 test pieces for each direction, or 10 pieces in all. The total sum of test pieces out of the three sheets shall be 30.

Fig. 3. Shape and Size of Test Piece



(3) Treatment of Test Piece The treatment of test pieces shall be as follows:

(a) Normal State Submit the test pieces to the normal state test after allowing them to stand for not less than 48 hours after preparing them.

(b) Warm-water Resistance After immersing test pieces in warm water of 60 ± 3°C for three hours and then dipping them in room-temperature water to cool down, subject them to the test while still wet.

(4) Testing Machine The testing machine shall be so selected that the breaking load of the test piece falls in the range of 15 to 85 % of its loading capacity and its standard error is ± 1 % of its standard load.

Its loading rate shall be not more than 5.88 kN {600 kgf}, or else the moving speed of its crosshead be 0.5 to 2.0 mm per minute.

(5) Fixture Use a fixture of structure that will giving no stress such as twisting or peeling.

(6) Measurement After tightly attaching both ends of the test piece to grips, measure the maximum load N {kgf} shown until the breaking of the test piece takes place with the tester of (4), and obtain adhesive strength N/mm^2 {kgf/cm^2} by dividing the load by adhesion area which was measured actually between two cuts.

In this operation, obtain the ratio of the broken area in the wood part to the sheared area by a multiple of 10 %, and record it as the percentage of wood failure (%). Test 30 test pieces in turn, and take the respective mean values as the wood tensile shear adhesive strength and the percentage of wood failure.

Represent the mean percentage of wood failure by a multiple of 5 % after counting fraction of 0.3 or over as a unit and cutting away the rest.

Concerning the wood tensile shear adhesive strength, calculate the standard deviation from the formula (3) in 6.7.1 (6).

When the mean percentage of wood failure is 50 % or more and the mean adhesive strength is the standardized value or less, carry out a retest with newly prepared test pieces.

In the test report of adhesive strength, the same items as given in 6.7.1 (6) shall be stated.

7. Marking

Each container shall be marked with the following information.

In the case of large-sized transportation container such as a tank truck and tank lorry, the accompanying "weight document of product" or "test report of product", if equipped with the following items from (1) to (7), may go as the regular markings.

(1) Name

(2) Class

(3) Nonvolatile matter

(4) Net mass

(5) Date of manufacture (or its abbreviation)

(6) Lot number

(7) Manufacturer's name or its abbreviation

8. Caution for Handling

Adhesives, because of its changeable tendency, should be stored in cold and dark places at about 20°C of temperature.

Reference Test:

1. Viscosity

Follow the description in 6.3 of JIS K 6833.

2. Gelation Time

2.1 Apparatus Apparatuses shall be as follows:

(1) Thermostat Capable of keeping 25 ± 0.5°C at bath temperature.

(2) Test Tube Measuring 18 by 165 mm, specified in JIS R 3503.

(3) Glass Stirring Rod Measuring 4 mm in diameter and about 30 cm in length.

(4) Balance With a reciprocal sensibility of 100 mg or coarser.

(5) Thermometer Thermometer (TAG 50) for tag-type low flash point tester specified in JIS B 7410.

2.2 Operation The test tube, sample, and stirring rod to be used in the test shall be maintained at 25 ± 0.5°C in advance.

Weigh 10 g of the sample in a test tube, and add 1 ml of 20 % solution of ammonium chloride specified in JIS K 8116. Stir quickly with a stirring rod and at the same time record the time when it starts. Immediately immerse the test tube in a thermostatic bath kept at 25 ± 0.5°C so that the sample level is about 2 cm below the liquid level of the bath. Stir the sample from time to time, and measure time interval to the time point when threads no longer take place as the rod dipped a little in the sample is pulled up. Carry out the operation at least two times and express the gelation time in minutes by the mean value of these measurements.

3. Miscibility with Vinyl Acetate

Miscibility test with vinyl acetate shall be carried out on Class 1.

3.1 Apparatus Apparatuses shall be as follows:

(1) Balance With a reciprocal sensibility of 100 mg or coarser.

(2) Beaker A 100-ml beaker specified in JIS R 3503.

(3) Glass Plate A transparent and flat glass plate measuring about 10 by 10 cm.

(4) Glass Rod About 5 mm in diameter.

3.2 Material Materials shall be as follows:

(1) Adhesive Conforming to Class 2 specified in JIS K 6804.

(2) Hardener 20 % solution of ammonium chloride specified in JIS K 8116.

3.3 Operation Operation, classified into the case of hardener added and that of hardener not added, shall be carried out principally at 23 ± 2°C of temperature.

(1) Case of Hardener Added Weigh out 20 g of vinyl acetate resin emulsion adhesive for wood in a beaker, add 20 g of sample, immediately stir well with a glass rod, and further add 1 g of hardener, followed by stirring similarly. After letting it stand for 10 minutes, place about 2 g of the mixture on the glass plate, and observe the miscibility when it is spread all over the plate. When the mixture looks uniform and flows smoothly, pass a judgment of adequate miscibility.

(2) Case of Hardener Not Added Weigh out 20 g of vinyl acetate resin emulsion adhesive for wood in a beaker, and add 20 g of the sample, immediately stir well with a glass rod and, after letting it stand it for 6 h, place about 2 g of the mixture on the glass plate. After spreading the mixture all over the plate, judge the miscibility similarly to (1) by ascertaining if it looks uniform and can flow smoothly.

Applicable Standards:

JIS B 7411-Etched-Stem Liquid-in-Glass Thermometers, Total Immersion Type

JIS K 6833-General Testing Methods for Adhesives

JIS K 7100-Standard Atmospheres for Conditioning and Testing of Plastics

JIS K 8001-General Rules of Testing Methods for Reagents

JIS K 8116-Ammonium Chloride

JIS K 8180-Hydrochloric Acid

JIS K 8576-Sodium Hydroxide

JIS R 3503-Glass Apparatus for Chemical Analysis

JIS R 3505-Volumetric Glassware

JIS Z 8703-Standard Atmospheric Conditions for Testing

Reference Standards:

JIS B 7410-Liquid-in-Glass Thermometers for Testing of Petroleum Products

JIS K 6804-Polyvinyl Acetate Emulsion Adhesives for Woods

JIS Z 8203-SI Units and the Use of their Multiples and of Certain other Units

UDC 678.652'41.072

JAPANESE INDUSTRIAL STANDARD

JIS

Urea-Formaldehyde Molding Compounds

K 6916-1975

1. Scope

This Japanese Industrial Standard specifies the urea-formaldehyde molding compounds, hereinafter referred to as the "molding compound". Molding compound mentioned in this standard shall be that which is composed of urea resin as the main binder and pulp and other fibrous materials as the main basic material and can be hardened by hot compression after putting it in a mold to make molded goods.

2. Classification and Mark

Classifications and marks of the molding compounds shall be as shown in Table 1.

Table 1. Classifications and Marks of Urea-Formaldehyde Molding Compounds

Classification	Mark	Main use
For general use	UM-G	Suitable for the manufacture of molded goods for general use.
For electrical and mechanical uses	UM-E	Suitable for the manufacture of molded goods of which primary object is their electrical and mechanical properties.

Applicable Standard:

JIS K 6911-Testing Methods for Thermosetting Plastics

Reference Standards:

JIS Z 8203-SI Units and Recommendations for the Use of Their Multiples and of Certain Other Units

JIS Z 8438-Kilogram Force-Newton Conversion Tables

3. Quality

Qualities of the molding compound shall be tested by the methods described under 4 and the results should conform to the specifications shown in Table 2. But a part of the tests may be omitted according to the agreement between the parties concerned.

Table 2. Qualities of Urea-Formaldehyde Molding Compound

Testing item	Unit	Treatment(1)	UM-G	UM-E
Plasticity	—	—	It can be easily detachable from mold and its appearance is good.	
Voltage resistance	—	C-90/20/65	—	To withstand the test voltage corresponding to potential gradient in Table 3 for 1 minute.
Insulation resistance (normal state)	Ω	C-90/20/65	10^9 and over	10^9 and over
Insulation resistance (after boiling)	Ω	C-90/20/65 +D-2/100	—	10^5 and over
Arc-proof property	Second	C-90/20/65	—	80.0 and over
Bending strength (normal state)	kgf/mm^2 $\{N/mm^2\}$(2)	A	6.0 and over {58.8 and over}	8.0 and over {78.4 and over}
Charpy impact strength	$kgf \cdot cm/cm^2$ $\{N \cdot cm/cm^2\}$(2)	A	2.0 and over {19.6 and over}	2.0 and over {19.6 and over}
External appearance after heating	—	A	No marked change in appearance is observed at test temperature given in Table 4.	
Water absorption	%	E-24/50 +D-24/23	2.0 and under	1.5 and under
Specific gravity(3)	—	A	(1.45 ~ 1.55)	

Note (1) (i) The letters of alphabet show the classifications of treatments of the test piece.

A : Leave intact as it is accepted and no treatment is performed.

C : Perform the treatment in the air kept at constant temperature and humidity.

D : Perform the steeping treatment in the water maintained at constant temperature.

E : Perform the treatment in the air maintained at constant temperature.

(ii) First figure shows the time required for treatment.

(iii) Second figure shows the temperature of treatment.

(iv) Third figure shows the relative humidity of treatment.

(v) Letter of alphabet and figure are separated by a cross line and figure and figure are separated by an oblique line.

(vi) When more than 2 kinds of treatments are performed, connect them with (+) sign and perform treatment according to their order.

Example: C-90/20/65+D-2/100

Treatment is performed in the air maintained at 20°C and 65 % RH for 90 hours. Then the steeping in the boiling water is performed at 100°C for 2 hours.

(2) Numerical value enclosed in the braces shows the expression and reduced value according to the international system of units.

(3) Numerical value of the specific gravity enclosed in the brackets is that shown as the reference.

4. Testing Method

4.1 Sampling Method Refer to that described under 2 in JIS K 6911-Testing Methods for Thermosetting Plastics.

4.2 Preparation of Test Piece Refer to that deseribed under 3 in JIS K 6911.

4.3 General Conditions of the Test Refer to that described under 5.1 in JIS K 6911.

4.4 Plasticity Refer to that described under 5.4.1 in JIS K 6911. But, it may be permitted to substitute the molding of the real thing for this test.

4.5 Voltage Resistance Refer to that described under 5.8.2 in JIS K 6911. But, the test voltage shall be that obtained by multiplying the potential gradient in Table 3 by the thickness (mm) of the test piece.

Table 3. Potential Gradient in Voltage Resistance Test of Urea-Formaldehyde Molding Compounds

Mark	UM-E
Potential gradient (kV/mm)	10

4.6 Insulation Resistance Refer to that described under 5.12.2 in JIS K 6911.

4.7 Arc-Proof Property Refer to that described under 5.15.2 in JIS K 6911.

4.8 Bending Strength Refer to that described under 5.17.2 in JIS K 6911.

4.9 Charpy Impact Strength Refer to that described under 5.20.2 in JIS K 6911. But the notch of the test piece shall be made by molding.

4.10 External Appearance after Heating Refer to that described under 5.23.1 in JIS K 6911. But the temperature of the test shall be as shown in Table 4 and the change in the external appearance shall be inspected with the naked eye.

Table 4. Temperature of the Test for the External Appearance of Urea-Formaldehyde Molding Compounds after Heating

Mark	UM-G	UM-E
Temperature of test (°C)	110 ± 2	110 ± 2

4.11 Water Absorption Refer to that described under 5.26.2 in JIS K 6911.

4.12 Specific Gravity Refer to that described under 5.28.1 in JIS K 6911.

5. Packaging and Packing and Marking

Molding compounds shall be packed to avoid the possibility of the moisture absorption and the following items shall be marked at a place on the container where it can be easily seen.

(1) Nomenclature

(2) Classification and mark

(3) Color

(4) Net weight

(5) Date of manufacture and lot of manufacture or mark

(6) Manufacturer's name or mark