Open File OF96-7

Manitoba, Canada Float Glass Project Feasibility Study

Manitoba
Energy and Mines

Darren Praznik
Minister

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Manitoba
Energy and Mines
Marketing Branch

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Manitoba, Canada Float Glass Project Feasibility Study

by International Technologies Consultants, Inc.

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Report Summary and Conclusions

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Executive Summary

Introduction - International Technologies Consultants, Inc. (ITC) has prepared this report to document the results of its feasibility study to assess the viability of establishing a float glass manufacturing plant in Manitoba. The report presents realistic economic, marketing and technical analyses and information based upon an extensive collection of data derived from pertinent glass industry, consumer, service, and governmental sources. Considerable care has been taken to ensure that all input data and assumptions are accurate and conservative, and that sources are documented. All figures are reported in Canadian dollars and metric dimensions unless otherwise indicated.

Financial Results - ITC has developed a detailed Economic Model for the study, which is presented in Section 2. Analyses based upon this model indicate that a new float glass manufacturing facility located in southern Manitoba is financially viable. This is true both in terms of profitability and rentability.

- Profitability - Net income is positive from the fist year of operation and averages more than $22 million annually over 15 years yielding a return on total investment of 15%.
- Rentability - The project will pay for itself within 10 years of initial production. Net income will support the level of debt obtained to finance construction and initial operations and provide the owner with an attractive dividend resulting in a return on owner's equity investment of 49%.

Marketing Results - The market outlook is favorable for new manufacturing capacity in North America in general and for Canada in particular. Demand for flat glass through 1998 is forecast to rise by 4.2% per year in North America and by 5.3% per year in Canada, compared to the long term average of 4%. To keep supply and demand in balance, this means the addition of production equivalent to nearly two new float lines per year. A manufacturing plant located in southern Manitoba would be able to target and serve multiple market areas in both Canada and the United States. Thus, a Manitoba plant producing 140,000 metric tons of glass per year (400 tons / day) would not need to dominate any particular market in order to successfully sell its full production.

Technical Results - Sufficient quantities of raw materials of proper quality for float glass manufacture exist either in or relatively near to southern Manitoba. A number of satisfactory plant site locations, properly zoned and with good transportation facility access, exist in the area, including Selkirk to the north of Winnipeg and Morden / Winkler to the south. All required utility services are readily available in these locations and, generally, throughout the area. Construction and engineering companies as well as labor, both skilled and unskilled, needed to design, build and operate a new plant exist in the area. Most construction materials, such as fabricated steel and concrete, and a portion of the necessary capital equipment are available locally. Local and Provincial governments are supportive of industry and will facilitate the necessary permitting for plant construction and operation. Accordingly, it is ITC's belief that there is no technical reason which would prevent or significantly hinder the construction and operation of a float glass manufacturing facility in southern Manitoba.

Environmental Results - A float glass manufacturing plant is a quiet, clean, safe facility. There are no emissions which cannot be controlled within limits acceptable to Canadian environmental regulations. Jobs created are jobs which will pay a competitive wage for unskilled, self-reliant operators who will be trained on the job. It is common for float glass factories to work for millions of man-hours before experiencing a lost-time accident. Most of the raw materials and a portion of the finished product will be transported by rail, keeping truck traffic in and out of the facility to a minimum.

Consultant's Conclusion - Based upon the study results, it is ITC's conclusion that the establishment of a new float glass manufacturing facility in Manitoba is clearly feasible and viable. An investor should find the combination of a high potential financial reward and the reduced risk offered by a location central and accessible to multiple growing markets to be quite attractive.

With this as a premise, there are two principal ways for obtaining the necessary technology and project management to gain entry into the float glass manufacturing industry. The first is via an arrangement with one of a small number of global production firms dominating the industry who may be willing to provide entry by charging payment of either licensing fees, profit sharing, royalties on production and sales, or a combination. The second is to become an independent producer by obtaining the technology and management assistance from a qualified design and services company which is not a glass producer. This second, independent approach is much the more financially attractive method due to lower capital costs and the ability of the owner to keep all operating profits. For this reason, it is the independent approach which is used as the basis for the Economic Model results contained in this report.

It is ITC's opinion that a prospective investor seeking new entry in the float glass manufacturing business will find the added profitability and independence of this approach highly desirable.

Study Objective

The Manitoba Provincial Government, via the Ministry of Industry, Trade and Tourism, and the Federal Government of Canada, via Natural Resources Canada, (the "Client") has contracted with International Technologies Consultants, Inc. (ITC, the "Consultant") to conduct a feasibility study with the objective to assess the viability of establishing a float glass manufacturing plant in Manitoba.

In addition, the Client has specified certain desired parameters and outputs for the study, including:

- Identification of the required raw materials and review of the acceptability of locally available raw materials.
- Establishment of a recommended plant size and location.
- Definition of the structure and direction of float glass industry.
- Estimation of the present and future demand for float glass and of the market share available to a new manufacturer located in Manitoba.
- Estimation of the capital and operating costs, and expected profitability, for the proposed plant.

To satisfy these goals, ITC has made a fact finding visit to southern Manitoba and has held discussions in the offices of the Manitoba Ministry of Industry, Trade and Tourism. ITC has contacted a collection of regional float glass manufacturers, customers, provincial government agencies, capital equipment suppliers, and utility and transportation service companies. The information gained from these efforts, as well as that in ITC's extensive library, provide a sound basis for the data, statements and conclusions in the study report.

The report is presented in four sections:

- Section 1 - Report Summary and Conclusions

  Contains the highlights of the more detailed information which appears in the remaining sections, as well as ITC's conclusions.
- Section 2 - Economic Model Results

  Contains a detailed financial analysis of the pro forma results of the first fifteen years of plant operation. Information is provided concerning expected income, costs, pricing, markets, rate of return on investment (ROI), and ROI sensitivity.
- Section 3 - Flat Glass Marketing and Production

  Contains a detailed discussion of flat glass producers and consumers, industry structure, market trends, and the expected target market for a Manitoba plant.
- Section 4 - General and Background Information

  Contains supporting information including the Economic Model inputs and assumptions, project cost analysis, typical float plant characteristics, and a general discussion of float glass manufacturing technology.

Financial Summary

Analysis Method - ITC's approach to all aspects of the financial analysis has been to be realistic and conservative. This means that all of the inputs and assumptions used in the Economic Model are derived from authoritative and representative sources, are timely and accurate wherever possible, and are conservative if based upon estimations or a range of possible values. All figures are reported in Canadian dollars and metric dimensions unless otherwise indicated. Economic Model inputs and references are presented in Section 4.

Capital Cost and Project Budget - The total capital cost for construction of a float plant with a melting capacity of 500 metric tons / day is estimated to be $115.875 million. This cost can be broken down into major components as follows:

- Land, Civil Works, Buildings and Utility Systems $31.798 million.
- Process Equipment $74.256
- Project Administration, Engineering, Interest $ 9.821

The above costs are based upon a project budget developed by ITC using information gathered during the course of the study and from information contained in ITC's database of project and equipment pricing. Details of the project budget are presented in Section 4.

Project Financing - For purposes of the Economic Model, it has been assumed that the plant's owner will contribute an equity investment equal to 20% of the total capital cost less interest during construction ($22.136 million). The 80% balance ($93.739 million) is assumed to be funded by a commercial bank loan with a repayment period of ten years beginning with the first full year of plant operation. This is a rather conservative approach to project financing, since it is likely that a more attractive debt structure than straight commercial borrowing can be arranged for an actual project. A number of local, federal and provincial government economic development programs exist which may provide grants or part of the necessary debt funding at subsidized rates.

Project Income - The Economic Model calculates anticipated net income from plant operations over a 15 year period. (The results are presented in the Income Statement on page 6 of Section 2). The Model shows an average annual net income of over $22 million on a non-inflation adjusted basis, with positive net income being generated in every year of operations. Net income (profitability) averages more than $140 per ton of glass and is determined by the following considerations:

- **Sales Revenue -** The Economic Model assumes the plant will operate at a yield of 80% of melting capacity with 350 production days per year. These are realistic factors which allow for normal operational and warehouse product losses. Net production, then, is initially 140,000 metric tons per year (less in a rebuild year and greater after a rebuild due to the potential for increased capacity). Gross sales revenues are based upon an average glass selling price of approximately $660 per metric ton. Net sales revenue of approximately $560 per ton is determined after allowances for freight costs and returns, averaging $90 and $10 per ton respectively. Freight costs are based upon trucking rates. Utilization of some railcar transport would lower overall freight costs.

- **Production, Sales and Financial Costs -** The cost of production includes such fixed and variable costs as Raw Materials, Utilities, and Personnel. The Economic Model calculates these costs to be about $235 per metric ton of glass. Sales cost, which includes the costs of sales personnel and expenses as well as sales commissions to outside sales agents, is estimated at 2.5% of gross sales revenue, or about $16 per ton. Financial cost, which includes rebuild allowance, taxation, debt interest and debt repayment, averages about $166 per ton. (The Cost Structure Analysis is presented on page 13 of Section 2).

Net Cash Flow and Dividends - The Economic Model assumes that all of net income is applied to dividends payable to the owner after repayment of short-term working capital debt. This debt is paid down as quickly as possible to reduce short-term interest expense. Annual dividends average over $21 million and are paid in every year except the first.

Return on Owner's Equity and on Total Investment - The Economic Model calculates an internal rate of return (ROI) on the owner's equity of 49% after tax (61% before). The ROI on the total project investment amount is calculated at 15% after tax (22% before).

Plant Size Considerations - ITC has calculated, based upon its database, that a float plant with a melting capacity of 300 metric tons per day would have a capital cost of approximately $93 million. In other words, a plant with 60% of the production capacity of the proposed 500 ton per day size would carry a cost of 80% as much. Assuming the same percentage debt financing, results of the Economic Model for this size plant shows after tax ROI's of 13% and 2% on owner's equity and total plant investment respectively. Thus, considering the marketing view showing the ability to sell the full production of a 500 ton per day plant, it is not economically attractive to construct a smaller size plant.

Financial Conclusions

ITC believes that the study's financial results demonstrate that the proposed float glass project is financially viable, providing attractive levels of positive net income, cash flow and investment return to the owner from the beginning of production, with the ability to repay all financing costs from normal revenues within ten years of production.

Detailed financial results from the Economic Model are presented in Section 2.

Marketing Summary

Market Structure - The North American flat glass market is one of the largest regional markets in the world, accounting for over 30% of the world's production. Currently, there are a total of 46 operating float production lines owned by 6 producer companies. Of these lines, 39 are located in the United States, 4 in Mexico and 3 in Canada.

Market Trends - According to independent market research statistics, Canadian flat glass demand is forecast to grow at a rate of 5.3% through 1998, while that in North America is forecast to increase at a 4.2% rate. The current Canadian production of 400,000 metric tons per year is only about half the estimated 1998 Canadian demand of 775,000 tons.

Considering the current number of 46 operating float lines, and the many recent articles appearing in glass industry trade magazines describing the current glass shortage, two things can be reasonably concluded:

- that supply and demand are currently in balance
- that the equivalent of 1.8 new float lines must be built in North America on average every year in order to maintain the balance of supply and demand.

In fact, only 10 new float lines have been added and 3 removed from the North American supply in the last 10 years. This past rate of glass production increase is far from what will be needed in the future given the market demand trends.

Target Markets for a Manitoba Plant - ITC has analyzed the potential markets surrounding a southern Manitoba plant location. By considering population, glass consumption and existing supply by geographic area, the anticipated market is as follows:

Area	Sales (Tons per Year)	Market Percentage
Canadian Prairie Provinces	17,000	25%
British Columbia	11,000	20%
Central and Mountain US States	85,000	7%
North Western US States	17,000	13%

Market Pricing - ITC has conducted a survey by telephone, telefax and personal interview of glass manufacturers, glass consumers and trade organizations in order to establish realistic glass prices for a Manitoba float manufacturing facility. Although some difference in price by location was found, as expected, the result was an average selling price of $660 per metric ton.

Marketing Conclusions

ITC believes that additional float glass manufacturing capacity is needed to serve the market and, considering the already serious trade imbalance in flat glass between Canada and the United States, that at least one additional 500 ton per day float plant in the central or western provinces is justified.

Construction and Technical Summary

ITC has visited the Winnipeg and surrounding areas of Manitoba, conducting an assessment of potential float plant site locations, support and transportation facilities. In addition, ITC has reviewed information provided by the Energy and Mines and Industry Development departments of the Manitoba provincial government concerning raw material quality and availability, as well as engineering, construction and manufacturing labor availability.

It is apparent that sufficient quantities of raw materials of proper quality for float glass manufacture exist either in or relatively near to southern Manitoba. A number of satisfactory plant site locations, properly zoned and with good transportation facility access, exist in the area, including Selkirk to the north of Winnipeg and Morden / Winkler to the south. All required utility services are readily available in these locations and, generally, throughout the area. Construction and engineering companies as well as labor, both skilled and unskilled, needed to design, build and operate a new plant exist in the area. Most construction materials, such as fabricated steel and concrete, and a portion of the necessary capital equipment are available locally. Local and Provincial governments are supportive of industry and will facilitate the necessary permitting for plant construction and operation.

Technical Conclusion

It is ITC's belief that it is technically feasible to establish a modern, high quality float glass manufacturing facility in southern Manitoba, and that there is no apparent technical reason presenting a significant deterrent to the construction or operation of such a facility.

Economic Model Results

Section 2 | Page

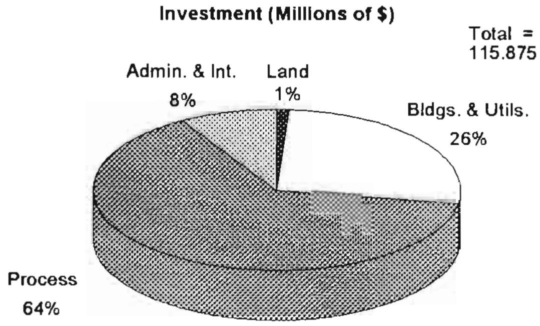
ITC has customized its proprietary economic forecasting model specifically for this Manitoba Float Glass Feasibility Study. All inputs and assumptions used in the model are realistic and conservative. Sources are documented in Section 4.

Capital Cost

ITC has calculated the estimated capital cost to construct a new 500 metric T/D float glass manufacturing plant located in southern Manitoba utilizing the highest quality industry standard facilities and equipment. The detailed analysis showing this estimate is presented in Section 4. All amounts are in Canadian dollars unless otherwise indicated.

A total capital cost of $115.875 million has been estimated with an expected distribution as follows:

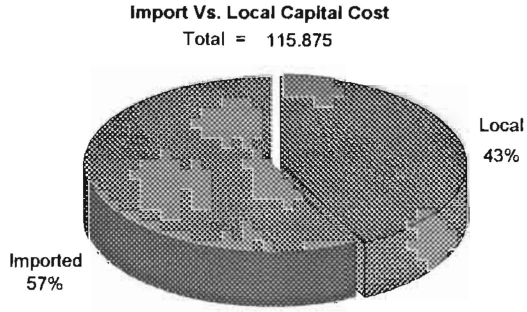
- Land $ 1.370 mil
- Bldgs. & Utilities $ 30.428
- Process Equipment $ 74.256
- Admin. & Interest $ 9.821



Local versus Imported Content

The total capital cost can be further categorized by items likely to be imported and those supplied locally. Generally, items which would be imported include:

- Specialized technology & equipment
- Most refractories
- Project management & consultants



Locally supplied items would include:

- Civil Works & Construction Labor
- Buildings & Fabricated Steel
- Some refractories
- Non-specialized equipment and services

The distribution of imported and local procurement is roughly estimated as follows:

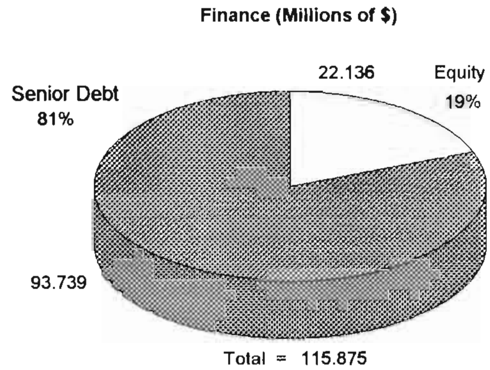
- Imported Content $49.340 mil
- Local (All Canada) Content $66.535 mil

Project Financing

For the Economic Model, a conservative financial structure assuming no cash grants or subsidized debt has been assumed regarding the funding of the project's capital cost:

- Owner's Equity Investment = 20% of Capital Cost (before constr. interest)
- Commercial Debt = 80%

It is likely, however, that more favorable debt financing than straight commercial borrowing can be arranged for an actual project. A number of local, federal and provincial government economic development programs exist which may provide part of the necessary debt funding at subsidized rates.



This conservative financial structure results in the following funding levels:

FINANCING

			Percent	$ Mil
EQUITY				
Investors			19.1%	22.136
Total Share Capital				22.136
Cash Grants			0.0%	0.000
Total Equity				22.136
DEBT				
Export Credit		(5 yr)	0.0%	0.000
Subsidized Loan		(10 yr)	0.0%	0.000
Commerial Debt	8.50%	(10 yr)	76.4%	88.547
(Inc.Constr. Int.)	8.50%	(10 yr)	4.5%	5.192
Total Debt				93.739
Project Total			100.0%	115.875
Working Capital (Years 1-2)	9.50%	(Credit Line)	**	13.470
Working Captial (Later Years)	9.50%	(Credit Line)	**	5.000

** Actual Working Capital Needs Depend on Cash Flow

Project Budget

The estimated capital cost stems from the following project budget breakdown:

CAPITAL PROJECT BUDGET

Item	Description		Cost		Mil C$
1	Land		1.370	Mil C$	1.370
2	Site Works:	Grading, Drainage, Excavation	1.878	Mil C$	1.878
		Foundations, Concrete Works	10.017	Mil C$	10.017
		Roads, Improvements, Fencing	0.435	Mil C$	0.435
10	Utilities:	Electrical Power	2.950	Mil US$	4.042
		Compressed Air	0.545	Mil US$	0.747
		Water - Cooling & Treatment	1.275	Mil US$	1.747
		Water - Fire, Potable, Sewage	0.540	Mil US$	0.740
		Fuel Oil & Storage	0.400	Mil US$	0.548
		HVAC	0.112	Mil US$	0.153
		Control System	0.534	Mil US$	0.732
20	Buildings:	Batch House (Bldg. Cover)	0.236	Mil C$	0.236
		Furnace	1.061	Mil C$	1.061
		Tin Bath	0.471	Mil C$	0.471
		Lehr	0.796	Mil C$	0.796
		Cutting Line	0.794	Mil C$	0.794
		Warehouse / Shipping Dock	3.571	Mil C$	3.571
		Power House / Utilities	0.972	Mil C$	0.972
		Office / Raw Materials / Misc.	1.489	Mil C$	1.489
30	Batch Plant:	Design & Equipment	2.040	Mil US$	2.795
		Structural Steel & Silos	1.843	Mil C$	1.843
		Material Handling & Conveyors	0.157	Mil C$	0.157
		Shipping, Install, Supervision	0.411	Mil C$	0.411
35	Cullet:	Design & Equipment	1.056	Mil US$	1.447
		Shipping, Install, Supervision	0.153	Mil C$	0.153
40	Furnace:	Design & Equipment	5.038	Mil US$	6.902
		Emmissions	2.750	Mil US$	3.768
		Refractories	9.405	Mil US$	12.885
		Steel & Ductwork	1.010	Mil C$	1.010
		Chimney	1.210	Mil C$	1.210
		Shipping, Install, Supervision	4.436	Mil C$	4.436
50	Float Bath:	Design & Equipment	5.300	Mil US$	7.261
		Refractories	1.900	Mil US$	2.603
		Steel	1.863	Mil C$	1.863
		Tin	1.370	Mil C$	1.370
		Shipping, Install, Supervision	2.303	Mil C$	2.303
60	Atmosphere:	Nitrogen & Hydrogen	0.480	Mil C$	0.480
70	Lehr:	Design & Equipment	4.958	Mil US$	6.792
		Shipping, Install, Supervision	0.533	Mil C$	0.533
80	Cutting:	Design & Equipment	5.973	Mil US$	8.183
		Shipping, Install, Supervision	1.947	Mil C$	1.947
85	Material:	Raw Materials	0.685	Mil C$	0.685
		Finished Products	1.302	Mil C$	1.302
		Misc. Vehicles	0.144	Mil C$	0.144
90	Equipment:	Admin., Maint., Lab.	1.774	Mil C$	1.774
		Subtotal Plant & Equipment			106.054
95	Project Management, Engr., Consultants		2.255	Mil C$	2.255
96	Client Staff & Development		2.000	Mil C$	2.000
99	Heat-Up Services		0.374	Mil C$	0.374
		Subtotal Administration			4.629
	Total Capital Cost Less Interest				110.683
	Interest During Construction				5.192
	Total Capital Cost of the Facility				115.875

Explanation of Budget Items (See Section 4 for additional details)

Item 1 - Land: Purchase price for project site.

Item 2 - Site Works: Cost of site improvements, excavation, foundations, and concrete works.

Item 10 - Utilities: Installed costs for all necessary utility systems, including piping, tubing and wiring as well as connections to outside utility providers. Connection to the electrical grid, natural gas, water and sewer services is assumed. Emergency back-up power generation for critical loads is included.

Item 20 - Buildings: Construction cost of all site buildings. Pre-engineered buildings are generally cost effective. Minimum on-site storage facilities for raw materials is assumed.

Item 30 - Batch Plant: Installed cost of silos, material handling and mixing equipment with sufficient elevated storage for 10 days supply of raw material and to weigh and mix the daily plant raw material requirements. Detailed engineering, critical controls, feeders, mixer, and load cells are likely to be imported with all other concrete and steel construction performed locally under supervision of the specialist contractor.

Item 35 - Cullet System: Installed cost of equipment for collection of cullet at Cutting Line and return to Batch Plant.

Item 40 - Melting Furnace, Emission Controls and Chimney: Installed cost of a regenerative melting furnace with state of the art natural gas fuel combustion controls. Includes electrostatic precipitator for emission control and a concrete chimney. Most furnace refractories are likely to be imported as well as the detailed design, specialized equipment and controls. Steel fabrication, piping, blowers and installation are assumed to be local.

Item 50 - Float Bath: Installed cost of a float bath by ITC, complete with all casings, refractories, flat roof, bottom cooling, electrical and mechanical equipment, and controls. Most items are likely to be imported, except for support steel and installation labor.

Item 60 - Atmosphere: Installed cost of hydrogen and nitrogen mixing and distribution. Supply of these gasses is assumed by contract purchase from an industrial gases supplier operating his own facility on-site. Supply cost is included in Operating fixed costs.

Item 70 - Annealing Lehr: Installed cost of annealing lehr for controlled glass cooling. The lehr modules, rolls, lineshaft drive, fans and controls are likely to be imported as a package including design. Installation is local under the supervision of the lehr contractor.

Item 80 - Cutting Line: Installed cost of a computerized glass cutting and stacking system capable of handling the full range of anticipated product sizes and glass thicknesses. This package system is imported. Installation is local under the contractor's supervision.

Item 85 - Material Handling: Cost for finished glass storage racks, shipping frames, lift trucks, and raw material handling vehicles and equipment. All is assumed to be locally procured.

Item 90 - Other Equipment: Cost of office equipment and furnishings, maintenance equipment and tools, and laboratory equipment.

Item 95 - Project Management, Engineering, and Consultants: Cost of non-staff project management and construction personnel, engineering design services, and consultants.

Item 96 - Client Staff & Development: Capitalized cost of early hire administrative, management, operations and maintenance personnel participating in project activities.

Item 99 - Heat-Up Services: Cost of specialized furnace and float bath heat-up work.

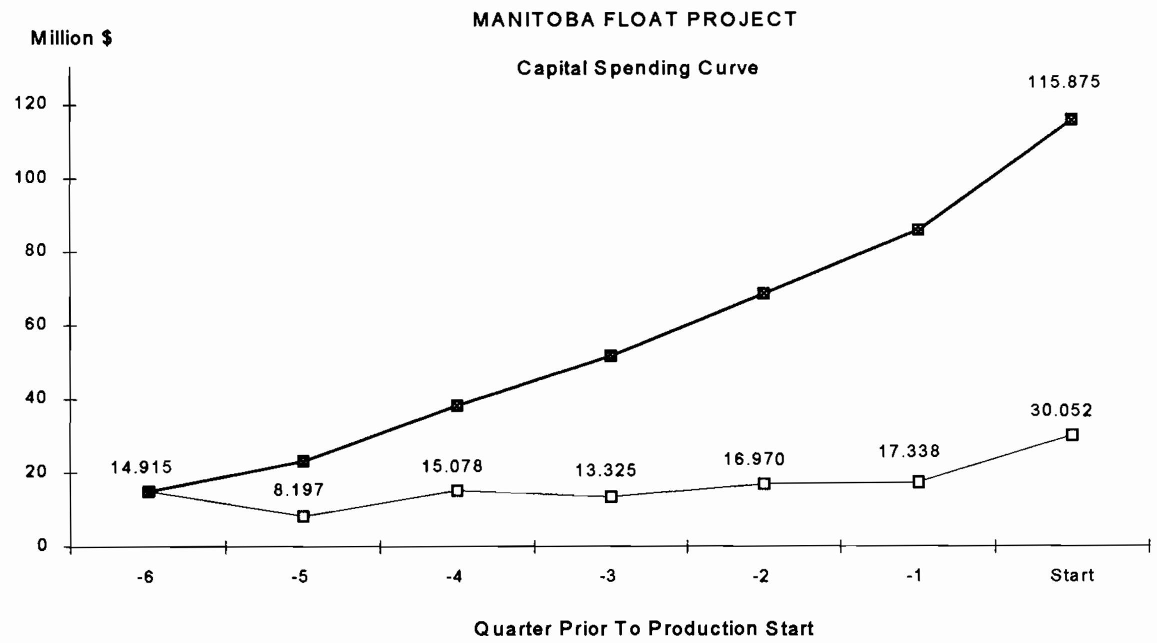
Cash Flow During Construction

Cash Flow During Construction

Quarter Prior to Production Start

Usage	-6	-5	-4	-3	-2	-1	Start	Total
Land	1.370							1.370
Site Prep.		4.110	4.110	4.110				12.330
Utility Systems		2.177	2.177	1.088	1.088	1.088	1.088	8.706
Buildings		2.348	2.348	1.174	1.174	1.174	1.174	9.392
Process Equip.	14.577		7.289	7.289	14.577	14.577	14.577	72.886
Retainage (10%)	-1.458	-0.864	-1.592	-1.366	-1.684	-1.684	8.648	0.000
Tin metal							1.370	1.370
Project Administration	0.226	0.226	0.226	0.226	0.451	0.451	0.451	2.257
Client Staff Development	0.200	0.200	0.200	0.200	0.400	0.400	0.400	2.000
Heat-Up Services							0.374	0.374
Financial & Legal								0.000
Interest Expense	0.000	0.000	0.320	0.604	0.964	1.333	1.971	5.192
Total Expenses	14.915	8.197	15.078	13.325	16.970	17.339	30.053	115.877
Cumulative	14.915	23.112	38.190	51.515	68.485	85.824	115.877	
Source								
Equity (Shareholders)	14.915	7.221	0.000	0.000				22.136
Cash Grant							0.000	0.000
Export Credit								0.000
Subsidized Loan								0.000
Commercial Debt	0.000	0.976	15.078	13.325	16.970	17.339	30.053	93.741
Total Revenue	14.915	8.197	15.078	13.325	16.970	17.339	30.053	115.877

Loan Balances:	Rate	-6	-5	-4	-3	-2	-1	Start
Equity		14.915	22.136	22.136	22.136	22.136	22.136	22.136
Export Credit	0.00%							
Subsidized Loan	0.00%							
Commercial Debt	8.50%			15.078	28.403	45.373	62.712	92.765
Interest:		0.000	0.000	0.320	0.604	0.964	1.333	1.971



Income Forecast

INCOME FORECAST
Before Inflation
(Million $)

		6 mo. 1998	1999	2000	2001	2002	2003	2004	2005	2006	2007 Rebuild	2008	2009	2010	2011	2012	2013	Average
1 Metric Tons Sold (000)		52.5	130.0	136.0	140.0	140.0	140.0	140.0	140.0	140.0	111.0	173.0	168.0	168.0	168.0	168.0	168.0	148.7
2 Total Gross Sales (Mil $)		34.8	86.1	90.1	92.8	92.8	92.8	92.8	92.8	92.8	73.6	114.6	111.3	111.3	111.3	111.3	111.3	98.5
3 Freight Cost		4.72	11.70	12.24	12.60	12.60	12.60	12.60	12.60	12.60	9.99	15.57	15.12	15.12	15.12	15.12	15.12	13.38
4 Returns and Allowances	1.5%	0.52	1.29	1.35	1.39	1.39	1.39	1.39	1.39	1.39	1.10	1.72	1.67	1.67	1.67	1.67	1.67	1.48
5 Ex-Works Sales		29.54	73.15	76.53	78.79	78.79	78.79	78.79	78.79	78.79	62.46	97.34	94.53	94.53	94.53	94.53	94.53	83.66
6 Inventory Change		0.00	2.35	0.94	0.00	0.00	0.00	0.00	0.00	0.00	1.18	-1.18	0.00	0.00	0.00	0.00	0.00	
7 Plant Turnover		29.54	75.50	77.47	78.79	78.79	78.79	78.79	78.79	78.79	63.64	96.16	94.53	94.53	94.53	94.53	94.53	83.88
8 Raw Material		4.54	12.11	12.11	12.11	12.11	12.11	12.11	12.11	12.11	10.04	14.53	14.53	14.53	14.53	14.53	14.53	12.94
9 Water & Sewer		0.04	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.10	0.14	0.14	0.14	0.14	0.14	0.14	0.13
10 Melting Fuel		1.21	3.24	3.24	3.24	3.24	3.24	3.24	3.24	3.24	2.68	3.89	3.89	3.89	3.89	3.89	3.89	3.46
11 Packing Materials		0.26	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.58	0.84	0.84	0.84	0.84	0.84	0.84	0.75
12 Production Personnel		2.39	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.38	5.29	7.66	7.66	7.66	7.66	7.66	7.66	6.82
13 Royalty Expense	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14 Total Variable Cost		8.44	22.55	22.55	22.55	22.55	22.55	22.55	22.55	22.55	18.69	27.06	27.06	27.06	27.06	27.06	27.06	24.10
15 Fixed Electricity		0.42	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
16 Atmosphere		1.75	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
17 Moving & Changing		0.00	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
18 Plant Admin. and O.H.		2.68	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35
19 Total Fixed Cost		4.85	10.39	10.39	10.39	10.39	10.39	10.39	10.39	10.39	10.39	10.39	10.39	10.39	10.39	10.39	10.39	10.39
20 Total Operating Cost		13.29	32.94	32.94	32.94	32.94	32.94	32.94	32.94	32.94	29.08	37.45	37.45	37.45	37.45	37.45	37.45	34.49
21 Operating Profit		16.25	42.56	44.53	45.85	45.85	45.85	45.85	45.85	45.85	34.56	58.71	57.08	57.08	57.08	57.08	57.08	49.39
22 Selling Expense	2.5%	0.87	2.15	2.25	2.32	2.32	2.32	2.32	2.32	2.32	1.84	2.87	2.78	2.78	2.78	2.78	2.78	2.46
23 Depreciation		14.42	28.84	28.84	24.24	1.31	1.31	1.31	1.31	1.31	7.31	6.68	6.02	2.02	0.02	0.02	0.02	7.37
24 Interest Expense		4.24	7.22	6.34	5.55	4.75	3.96	3.16	2.36	1.57	1.48	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	2.41
25 Taxable Income		-3.28	4.35	7.10	13.74	37.47	38.26	39.06	39.86	40.65	23.93	49.19	48.31	52.31	54.31	54.31	54.31	37.14
26 Income Tax	39.1%	0.00	1.70	2.78	5.37	14.66	14.97	15.28	15.59	15.90	9.36	19.24	18.90	20.46	21.24	21.24	21.24	14.53
27 Debt Service (Long-term)		0.00	9.37	9.37	9.37	9.37	9.37	9.37	9.37	9.37	9.37	9.37	0.04	0.00	0.00	0.00	0.00	6.25
28 Rebuild Cost											20.00							1.33
29 Add: Depreciation		14.42	28.84	28.84	24.24	1.31	1.31	1.31	1.31	1.31	7.31	6.68	6.02	2.02	0.02	0.02	0.02	7.37
30 Net Income (Profitability)		11.14	22.12	23.79	23.24	14.75	15.23	15.72	16.21	16.69	-7.49	27.26	35.39	33.87	33.09	33.09	33.09	22.40
31 Dividend Payable		0.00	9.28	22.34	22.90	14.75	15.23	15.72	16.21	16.69	0.00	14.98	35.39	33.87	33.09	33.09	33.09	21.11

32 **Rate of Return (ROI) on Owner's Equity After Tax = 49%** **Rate of Return (ROI) on Total Investment After Tax = 15%**

33 **Rate of Return (ROI) on Owner's Equity Before Tax = 61%** **Rate of Return (ROI) on Total Investment Before Tax = 22%**

Explanation of Income Lines

Line 1 - Tons Sold: From line 4, Net Tons/Day calculation, Production and Sales Volume (Page 18). An 80% yield of Tons/Day melted for 350 Days/Year is realistic and conservative, taking into account time lost for thickness changes, defects, breakdowns, and normal operational and warehouse losses. Production is assumed to begin in July 1998.

Line 2 - Gross Sales: From line 33, Total Sales calculation, Production and Sales Volume (Page 18).

Line 3 - Freight Cost: Calculated from average freight cost per ton, Net Selling Price (Page 9), applied to glass tons shipped, line 8 Production and Sales Volume (Page 18).

Line 4 - Returns and Allowances: Equal to 1.5% of gross sales (line 2).

Line 5 - Ex-Works Sales: Equal to line 2 less lines 3 & 4.

Line 6 - Inventory Change: Equal to tons of inventory built, line 6 Production and Sales Volume (Page 18), applied to inventory value per ton, which is the sum of fixed and variable costs per ton.

Line 7 - Plant Turnover: Equal to line 5 plus line 6.

Line 8 - Raw Material: Equal to total raw material cost per ton, from Raw Material Cost (Page 14), applied to annual production tonnage, line 5 Production and Sales Volume (Page 18).

Lines 9, 10 ,11 ,12 - Variable Costs: Equal to associated variable cost per ton, from Cost Structure (Page 13), applied to annual production tonnage, line 5 Production and Sales Volume (Page 18).

Line 13 - Royalty Expense: Not applicable due to independent manufacturing approach.

Line 14- Total Variable Cost: Equal to sum of lines 9 to 13.

Lines 15, 16, 17, 18 - Fixed Costs: Equal to fixed costs per year, from Cost Structure (Page 13).

Line 19 - Total Fixed Cost: Equal to sum of lines 15 to 18.

Line 20 - Total Operating Cost: Equal to line 14 plus line 19.

Line 21 - Operating Profit: Equal to line 7 less line 20.

Line 22 - Selling Expense: Equal to 2.5% of gross sales (line 2). This represents the cost of sales personnel and expenses as well as sales commissions to outside sales agents.

Line 23 - Depreciation: Depreciation allowance as calculated on Depreciation Schedule (Page 16).

Line 24 - Interest Expense: Interest cost on long-term debt and on working capital less interest earned on cash. From line 28 Balance Sheet (Page 11).

Line 25 - Taxable Income: Equal to line 21 less the sum of lines 22 to 26.

Line 26 - Income Tax: Combined federal and provincial corporate income tax at 39.12% of line 27.

Line 27 - Debt Service: Cost of repayment of long-term debt over 10 years beginning in first full year of operation (Year 2).

Line 28 - Rebuild Cost: Cost in year 10 for furnace and bath rebuild and misc. plant refurbishing.

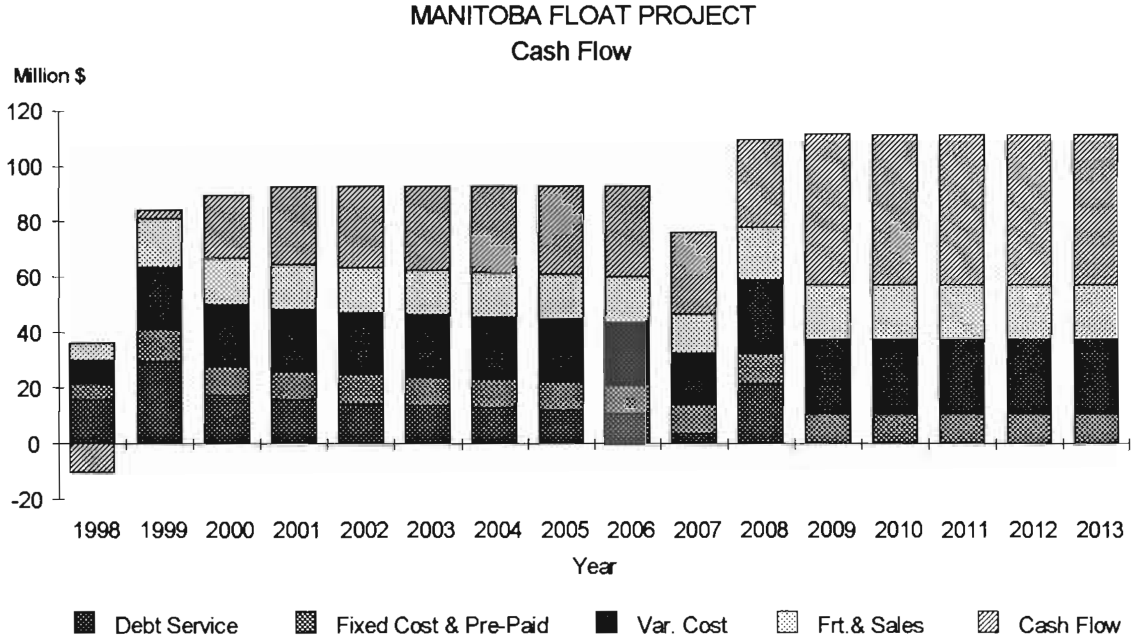
Line 30 - Net Income: Net income (profitability). Equal to line 25 less lines 26, 27, 28 plus line 29.

Line 31 - Dividend Payable: Equal to net income available after payment of working capital debt.

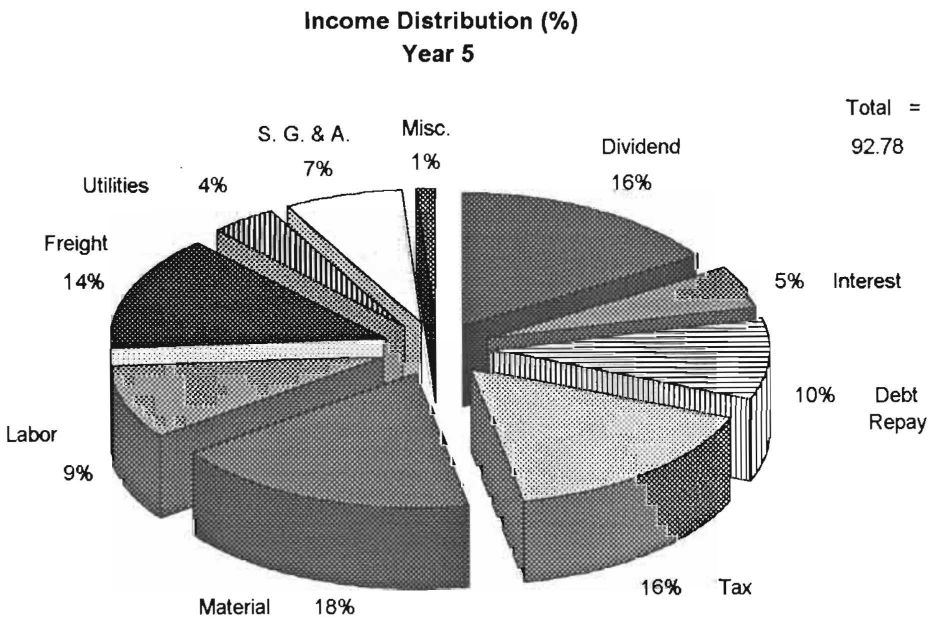
Lines 32, 33 - ROI: Rates of return on owner's equity and on total investment before and after tax.

Cash Flow and Income Distribution Charts

Breakdown of Income
From Annual Sales



Distribution of Each
Sales Income Dollar



Selling Price

NET SELLING PRICE

(Based on Best Buyer's Prices)

1.37 CAD / USD

Customer Location	Tons /Year	% of Total	Gross Price/TG	Local Cur	Cash Discount %	Net Price (Local)	Net Price (CAD)	Distance Km	Freight /T/Km	Freight /Ton	Net X Works Price
Eastern Canada (Montreal / Toronto)	10,000	7.1%	633.00	CAD	3.0%	614.01	614.01	2,250	0.0267	60.13	553.88
Central Canada (Winnipeg / So. MB & SK)	17,000	12.1%	723.00	CAD	3.0%	701.31	701.31	300	0.1169	35.07	666.24
Western Canada (Vancouver / So. BC	11,000	7.9%	700.00	CAD	3.0%	679.00	679.00	2,300	0.0403	92.69	586.31
Central USA (Chicago / Minneapolis)	50,000	35.7%	473.99	USD	3.0%	459.77	629.88	1,100	0.0774	85.18	544.70
Mountain USA (Denver / Salt Lake City)	35,000	25.0%	507.05	USD	3.0%	491.84	673.82	1,900	0.0659	125.26	548.56
North Western USA (Seattle / Portland)	17,000	12.1%	512.57	USD	3.0%	497.19	681.15	2,400	0.0428	102.71	578.44
	140,000	100%		Weighted Average =			657.84	1,536	0.0685	89.99	567.85

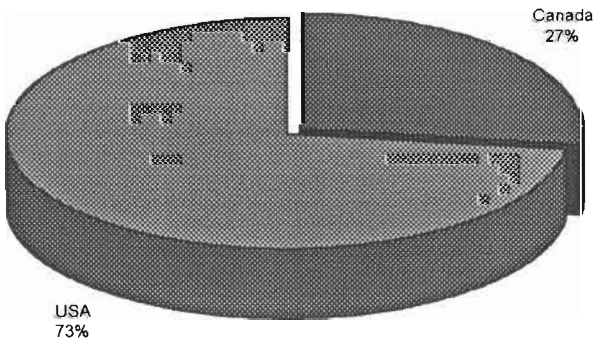
Average Price / Ton = 657.84 CAD/Ton = 596.79 CAD/sTon

Average Distance To Cust. = 1536 KM

Average Freight Cost = 89.99 CAD/Ton = 81.64 CAD/sTon

Sales by Country (Tons per Year)

Total = 140,000



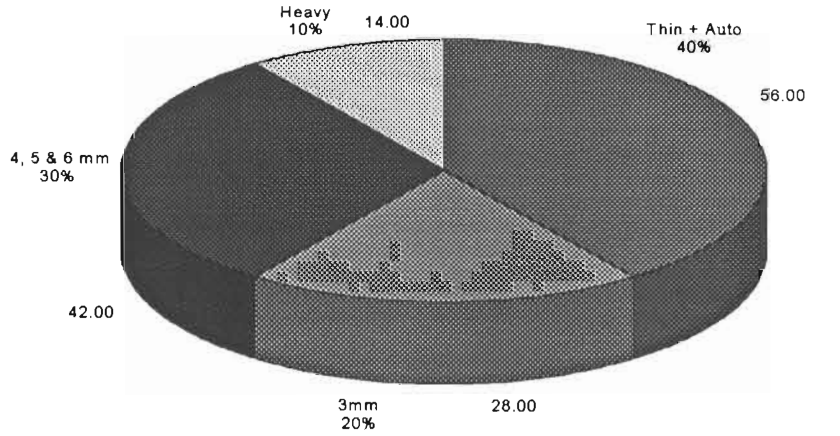
Sales Mix Forecast

SALES FORECAST

Product	Sales/Year Percent	Sales/Year 1000 Tons	Sq.M.	Market	Sales Price $/Sq M	Package Cost/Ton	Freight Per Ton	Net Price Per Ton Delivered	Kg. per Sq M	Net Sales Value
Thin Glass		0.00	0	Picture	3.53	5.00	89.99	611.01	5.00	0
Auto Open	15.0	21.00	3360	Auto OEM	4.11	5.00	89.99	562.61	6.25	11,814,810
"		0.00	0	Auto After Market	4.11	5.00	89.99	562.61	6.25	0
Open Window	25.0	35.00	6364	Window Market	4.11	5.00	89.99	652.28	5.50	22,829,800
	40.0	56.00	9724		4.11	5.00	89.99	618.65	5.78	34,644,610
Auto Box		0.00	0	Export Market	4.32	40.00	89.99	561.21	6.25	0
Window Box		0.00	0	Light Cases B+5%	4.32	40.00	89.99	561.21	6.25	0
	0.0	0.00	0		0.00	0.00	0.00	0.00	0.00	0
Tempered										
3 mm Temp.		0.00	0	Storm Doors	4.75	40.00	89.99	503.34	7.50	0
4 mm Temp		0.00	0	Commercial	4.75	40.00	89.99	345.01	10.00	0
	0.0	0.00	0		0.00	0.00	0.00	0.00	0.00	0
3mm Open	10.0	14.00	1867	Window	4.93	5.00	89.99	562.34	7.50	7,872,760
Glass	10.0	14.00	1867	Commercial	4.93	5.00	89.99	562.34	7.50	7,872,760
		0.00	0	End Cap	5.08	15.00	89.99	572.34	7.50	0
	20.0	28.00	3733		4.93	5.00	89.99	562.34	7.50	15,745,520
3mm Box		0.00	0	Export - B	5.08	40.00	89.99	547.34	7.50	0
& Export		0.00	0	Light Cases B+5%	5.18	40.00	89.99	560.68	7.50	0
	0.0	0.00	0		0.00	0.00	0.00	0.00	0.00	0
4, 5 & 6 mm	30.0	42.00	4200	Jumbo Size (4mm)	6.58	5.00	99.99	553.01	10.00	23,226,420
Glass		0.00	0	Disposable Racks	6.91	40.00	89.99	561.01	10.00	0
		0.00	0	Box Glass +5%	6.91	40.00	89.99	561.01	10.00	0
	30.0	42.00	4200		6.58	5.00	99.99	553.01	10.00	23,226,420
Heavy	10.0	14.00	933	Jumbo Size	7.40	5.00	99.99	388.34	15.00	5,436,760
Glass		0.00	0	Lehr end size	7.40	40.00	89.99	363.34	15.00	0
		0.00	0	Box Glass +5%	7.77	40.00	89.99	388.01	15.00	0
	10.0	14.00	933		7.40	5.00	99.99	388.34	15.00	5,436,760
6 mm Temp	0.0	0.00		Tempered	8.14	40.00	89.99	412.68	15.00	0
	100.0 %		18590	(1000) Sq.M./Year	5.34	5.00	93.99	564.67		79,053,310
			140.0	(1000) Tons/Year	7,000	Truck Loads / Year				

Sales by Product (1000 Tons per Year)

Total 140.00



Balance Sheet

BALANCE SHEET
(Million $)

ASSETS		6 mo. 1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1 Plant & Equipment		100.1	71.3	42.4	18.2	16.9	15.6	14.2	12.9	11.6	24.3	17.6	11.6	9.6	9.6	9.6	9.5
2 Land		1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
3 Inventory		3.4	5.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	7.8	6.7	6.7	6.7	6.7	6.7	6.7
4 Acct.Receiv. (55 days)		8.9	11.0	11.5	11.9	11.9	11.9	11.9	11.9	11.9	9.4	14.7	14.2	14.2	14.2	14.2	14.2
5 Pre-paid Expenses		1.3	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
6 Cash		1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
7 Total Assets		116.0	93.9	66.5	42.6	41.3	39.9	38.6	37.3	36.0	47.4	44.8	38.4	36.4	36.3	36.3	36.3
LIABILITIES																	
8 Equity Capital		22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1
9 Cash Grant		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
10 Annual Income		11.1	22.1	23.8	23.2	14.7	15.2	15.7	16.2	16.7	-7.5	27.3	35.4	33.9	33.1	33.1	33.1
11 Retained Earnings		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
12 Dividend Payable		0.0	-9.3	-22.3	-22.9	-14.7	-15.2	-15.7	-16.2	-16.7	0.0	-15.0	-35.4	-33.9	-33.1	-33.1	-33.1
13 Working Capital Payable		-11.1	-12.8	-1.5	-0.3	0.0	0.0	0.0	0.0	0.0	7.5	-12.3	0.0	0.0	0.0	0.0	0.0
14 Equity Adjustment		-5.5	-15.4	-33.4	-48.0	-39.9	-31.8	-23.8	-15.7	-7.7	6.0	19.5	13.1	11.1	11.1	11.1	11.0
15 Owners Equity		16.6	6.7	-11.3	-25.8	-17.8	-9.7	-1.6	6.4	14.5	28.1	41.7	35.3	33.2	33.2	33.2	33.2
16 Loan - Export		0.0	0.0	0.0	0.0	0.0	0.0										
17 Loan - Subsidized		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
18 Loan - Commercial Debt		93.7	84.4	75.0	65.6	56.3	46.9	37.5	28.1	18.8	9.4	0.0					
19 Total Long-Term Debt		93.7	84.4	75.0	65.6	56.3	46.9	37.5	28.1	18.8	9.4	0.0	0.0	0.0	0.0	0.0	0.0
20 Working Capital Debt		4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.0	0.0
21 Acct. Payable (1 month)		1.1	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.4	3.1	3.1	3.1	3.1	3.1	3.1
22 Total Liabilities		116.0	93.9	66.5	42.6	41.3	39.9	38.6	37.3	36.0	47.4	44.8	38.4	36.4	36.3	36.3	36.3
Inerest Calculation:		6 mo.															
23 Earned on Cash (-)	4.0%	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
24 Export Credit	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
25 Subsidized Loan	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
26 Commercial Debt	8.5%	4.0	7.2	6.4	5.6	4.8	4.0	3.2	2.4	1.6	0.8	0.0	0.0	0.0	0.0	0.0	0.0
27 Working Capital	9.5%	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.8	0.1	0.1	0.1	0.1	0.1	0.1
28 Total Interest Expense		4.2	7.2	6.3	5.6	4.8	4.0	3.2	2.4	1.6	1.5	0.0	0.0	0.0	0.0	0.0	0.0

Source and Use of Funds

SOURCE AND USE OF FUNDS
(Million $)

Provided	6 mo. 1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1 Equity Capital	22.1															
2 Cash Grant	0.0															
3 Net Income (Inc. Rebuild Inv.)	11.1	22.1	23.8	23.2	14.7	15.2	15.7	16.2	16.7	12.5	27.3	35.4	33.9	33.1	33.1	33.1
4 Long-term Debt	93.7															
5 Short-term Debt (Working Capital)	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.0	0.0
6 Total Funds Provided	131.5	22.1	23.8	23.2	14.7	15.2	15.7	16.2	16.7	20.0	27.3	35.4	33.9	33.1	33.1	33.1
Applied																
7 Land, Plant and Equipment	115.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0
8 Dividend Payable	0.0	9.3	22.3	22.9	14.7	15.2	15.7	16.2	16.7	0.0	15.0	35.4	33.9	33.1	33.1	33.1
9 Working Capital	15.7	12.8	1.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	12.3	0.0	0.0	0.0	0.0	0.0
10 Total Funds Applied	131.5	22.1	23.8	23.2	14.7	15.2	15.7	16.2	16.7	20.0	27.3	35.4	33.9	33.1	33.1	33.1
Working Capital Change																
(+) = Source (-) = Use																
11 Cash and S.T. Invest.	-1.0	-1.0	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
12 Receivables	-8.9	-2.1	-0.5	-0.3	0.0	0.0	0.0	0.0	0.0	2.5	-5.3	0.4	0.0	0.0	0.0	0.0
13 Inventory	-3.4	-2.4	-0.9	0.0	0.0	0.0	0.0	0.0	0.0	-1.2	1.2	0.0	0.0	0.0	0.0	0.0
14 Pre-paid Expenses	-1.3	-1.3	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
15 Accounts Payable	-1.1	-1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	-0.7	0.0	0.0	0.0	0.0	0.0
16 Working Capital Change	-15.7	-8.3	-1.5	-0.3	0.0	0.0	0.0	0.0	0.0	1.6	-4.8	0.4	0.0	0.0	0.0	0.0

Cost Structure

COST STRUCTURE

140,000 Tons/Year

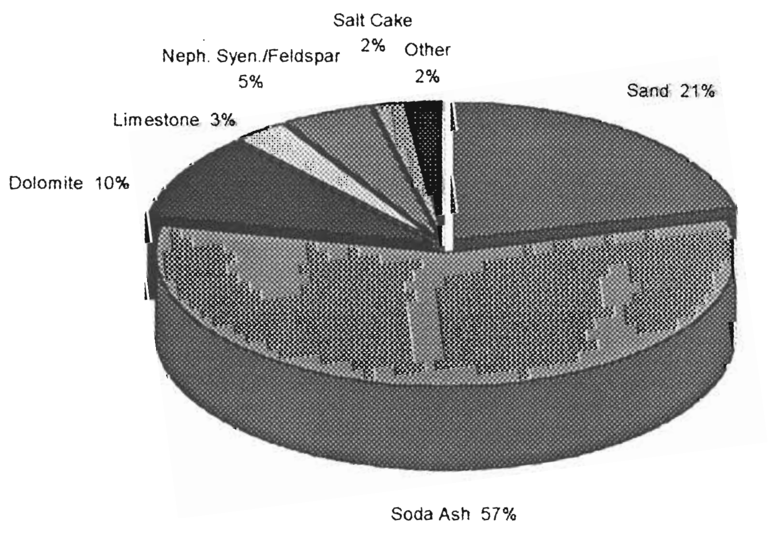
	Mil $/Year	$/Ton	Percent
1. Variable Cost - Production			
a. Raw Material	12.11	86.51	13.05
b. Melting Fuel			
1600 Kcal/Kg @0.1289 $/M3	3.24	23.14	3.49
c. Water			
400 M3 @ 0.6003 $/M3	0.09	0.64	0.10
d. Sewer			
100 M3 @ 0.8087 $/M3	0.03	0.21	0.03
e. Packing Materials	0.70	5.00	0.75
f. Production Personnel	6.38	45.57	6.88
Subtotal	22.55	161.07	24.30
2. Variable Cost - Sales			
a. Freight Cost	12.60	89.99	13.58
b. Returns and Allowances	1.39	9.93	1.50
c. Royalty Expense	0.00	0.00	0.00
Total Variable Cost	36.54	260.99	39.38
3. Fixed Cost			
a. Fixed Electricity			
24.455 MKWH/Yr @0.0201 $/KWH	0.49	3.50	0.53
4100 KW (Peak) @7.0890 $/KW/Mo.	0.35	2.50	0.38
b. Atmosphere (N2 & H2)	3.50	25.00	3.77
c. Moving & Changing & Misc.	0.70	5.00	0.75
d. Plant Admin. & General	5.35	38.24	5.77
	10.39	74.24	11.20
4. Total Cost Before Interest, Debt, Tax & Sales Exp.	46.93	335.23	50.58
Interest, Debt & Tax (Average)	23.19	165.64	24.99
Selling Exp. @ 2.5% of Gross Sales	2.32	16.57	2.50
Total Cash Cost	72.44	517.44	78.08

Raw Material Cost

RAW MATERIAL COST

Raw Material Ingredient	Price $ / Ton	Freight $ / Ton	Total $ / Ton	Formula / Ton	Cost / Ton Glass $ / TG
Sand	21.00	5.00	26.00	0.692	17.99
Soda Ash	158.56	77.16	235.72	0.210	49.50
Dolomite	33.47	16.53	50.00	0.177	8.85
Limestone	30.00	18.00	48.00	0.054	2.59
Neph. Syen./Feldspar	35.04	47.62	82.66	0.057	4.71
Salt Cake	102.23	22.60	124.83	0.012	1.50
			Subtotal		85.14
			Misc. (Carbon, Rouge)		1.37
			Total		86.51

Raw Material Cost (%)



Administrative, General and Personnel Costs

ADMINISTRATIVE AND GENERAL COST

	MIL $
Travel and Entertainment	0.70
Bank Charges	0.50
Accounting and D.P. Equip.	0.55
Property Tax	0.35
Insurance	0.50
Legal and Auditing Services	0.60
Salaried Personnel	2.15
Total	5.35

Total selling expenses are assumed to be equal to 2.5% of Gross Sales in line 22 of the Income Statement

PERSONNEL COST

	Salary per Year	Fringe Percent	Quantity	Annual Cost MIL $
Production	30,677	25.0%	140	5.368
Maintenance	33,744	25.0%	24	1.012
Total Hourly			164	6.380
Salaried				
Clerical	24,000	25.0%	9	0.270
Supervisory	36,000	25.0%	19	0.855
Engineers	42,000	25.0%	6	0.315
Dept. Heads	54,000	25.0%	7	0.473
Scheduling	36,000	25.0%	3	0.135
Plant Manager	84,000	25.0%	1	0.105
Total Salaried			45	2.153
Total Personnel			209	8.533

Depreciation

Depreciation is an accounting technique which allows certain capital and expense items to be amortized over their useful lives. This means that a portion of the original cost of an asset (or allowable capitalized expense) can be "written off" over a period of time as an expense against taxable income, resulting in a lower tax liability.

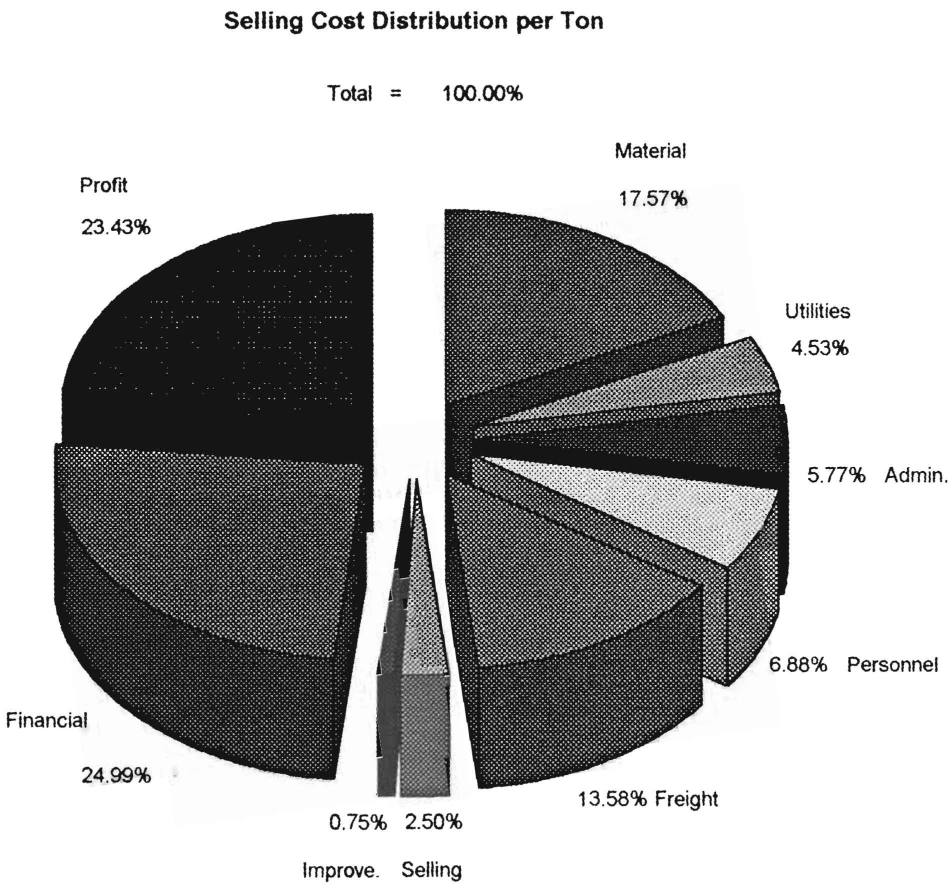
DEPRECIATION

	CCA Class	Dep. Rate	New Val.	Reduce Base	Depr. Base
Buildings	1	4.0%	9.4	100%	9.4
Const. Int. -Buildings	1	4.0%	0.5	100%	0.5
Site Improve.	6	10.0%	12.3	100%	12.3
Const. Int. -Site Improve.	6	10.0%	0.6	100%	0.6
Equipment& Utilities	43	30.0%	87.6	100%	87.6
Const. Int. -Equip. & Util.	43	30.0%	4.2	100%	4.2
Financial & Legal	43	30.0%	0.0	100%	0.0
Total			114.5		114.5
Rebuild Inv. (10th Year)	43	30.0%	20.0	100%	20.0

DEPRECIATION SCHEDULE

	Base	1998	6 mo. 1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Buildings	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
Const. Int. -Buildings	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1
Site Improve.	12.3	11.7	10.5	9.3	8.0	6.8	5.6	4.3	3.1	1.9	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Const. Int. -Site Improve.	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Equipment& Utilities	87.6	74.5	48.2	21.9	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
Const. Int. -Equip. & Util.	4.2	3.5	2.3	1.0	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
Financial & Legal	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
Rebuild Inv. (10th Year)	20.0										14.0	8.0	2.0	0.0	0.0	0.0	0.0
Total Asset Value	114.5	100.1	71.3	42.4	18.2	16.9	15.6	14.2	12.9	11.6	24.3	17.6	11.6	9.6	9.6	9.6	9.5
Depreciation		14.4	28.8	28.8	24.2	1.3	1.3	1.3	1.3	1.3	7.3	6.7	6.0	2.0	0.0	0.0	0.0

Cost Chart

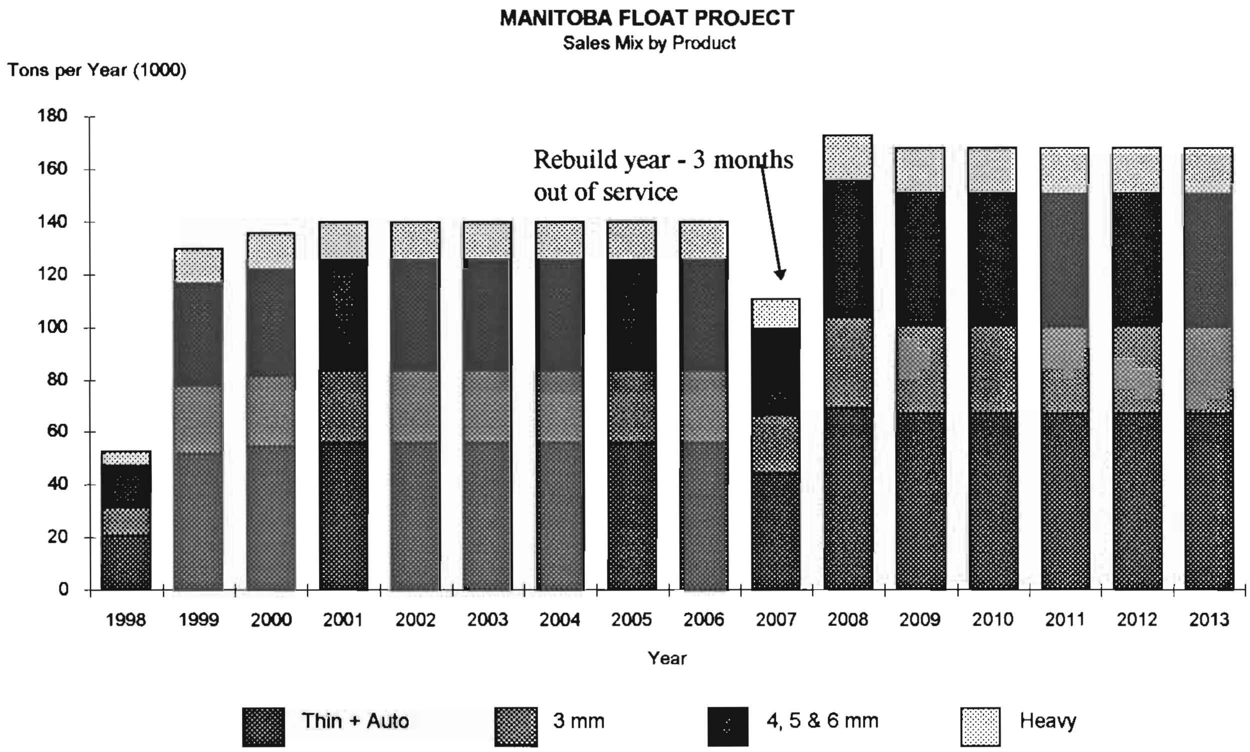

Selling Cost Distribution per Ton
Total = 100.00%
Material
17.57%
Profit
23.43%
Utilities
4.53%
5.77% Admin.
6.88% Personnel
Financial
24.99%
13.58% Freight
0.75% 2.50%
Improve. Selling

Production and Sales Volumes

PRODUCTION AND SALES VOLUME

	6 mo. 1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1 Days / Year	175	350	350	350	350	350	350	350	350	290	350	350	350	350	350	350
2 Tons Melted / Day	400	500	500	500	500	500	500	500	500	500	600	600	600	600	600	600
3 Line Yield	75%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
4 Net Tons / Day	300	400	400	400	400	400	400	400	400	400	480	480	480	480	480	480
5 Annual Prod.(1000 Tons)	52.5	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	116.0	168.0	168.0	168.0	168.0	168.0	168.0
6 Inven. Change (1000 Tons)	0.0	10.0	4.0							5.0	-5.0					
7 Total Available (1000 Tons)	52.5	130.0	136.0	140.0	140.0	140.0	140.0	140.0	140.0	111.0	173.0	168.0	168.0	168.0	168.0	168.0
8 Available after Temp. Loss	52.5	130.0	136.0	140.0	140.0	140.0	140.0	140.0	140.0	111.0	173.0	168.0	168.0	168.0	168.0	168.0
Sales Mix (Tons):																
9 Thin Glass	21.0	52.0	54.4	56.0	56.0	56.0	56.0	56.0	56.0	44.4	69.2	67.2	67.2	67.2	67.2	67.2
10 Auto Box	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
11 3 mm Temp.	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
12 4 mm Temp	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
13 3mm Open	10.5	26.0	27.2	28.0	28.0	28.0	28.0	28.0	28.0	22.2	34.6	33.6	33.6	33.6	33.6	33.6
14 3mm Box	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
15 4, 5 & 6 mm	15.8	39.0	40.8	42.0	42.0	42.0	42.0	42.0	42.0	33.3	51.9	50.4	50.4	50.4	50.4	50.4
16 Heavy	5.3	13.0	13.6	14.0	14.0	14.0	14.0	14.0	14.0	11.1	17.3	16.8	16.8	16.8	16.8	16.8
17 6 mm Temp	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
18 Total Sales (1000 Tons)	52.5	130.0	136.0	140.0	140.0	140.0	140.0	140.0	140.0	111.0	173.0	168.0	168.0	168.0	168.0	168.0
19 Total Thin & Auto	21.0	52.0	54.4	56.0	56.0	56.0	56.0	56.0	56.0	44.4	69.2	67.2	67.2	67.2	67.2	67.2
20 Total 3mm	10.5	26.0	27.2	28.0	28.0	28.0	28.0	28.0	28.0	22.2	34.6	33.6	33.6	33.6	33.6	33.6
21 Total 4,5 & 6	15.8	39.0	40.8	42.0	42.0	42.0	42.0	42.0	42.0	33.3	51.9	50.4	50.4	50.4	50.4	50.4
22 Total Heavy	5.3	13.0	13.6	14.0	14.0	14.0	14.0	14.0	14.0	11.1	17.3	16.8	16.8	16.8	16.8	16.8
23 Total Tempered	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
	52.5	130.0	136.0	140.0	140.0	140.0	140.0	140.0	140.0	111.0	173.0	168.0	168.0	168.0	168.0	168.0
Sales Revenue:																
24 Thin Glass	14.9	37.0	38.7	39.8	39.8	39.8	39.8	39.8	39.8	31.6	49.2	47.8	47.8	47.8	47.8	47.8
25 Auto Box	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
26 3 mm Temp.	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
27 4 mm Temp	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
28 3mm Open	6.9	17.1	17.9	18.4	18.4	18.4	18.4	18.4	18.4	14.6	22.7	22.1	22.1	22.1	22.1	22.1
29 3mm Box	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
30 4, 5 & 6 mm	10.4	25.7	26.9	27.6	27.6	27.6	27.6	27.6	27.6	21.9	34.2	33.2	33.2	33.2	33.2	33.2
31 Heavy	2.6	6.4	6.7	6.9	6.9	6.9	6.9	6.9	6.9	5.5	8.5	8.3	8.3	8.3	8.3	8.3
32 6 mm Temp	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
33 Total Sales (Mil $)	34.8	86.1	90.1	92.8	92.8	92.8	92.8	92.8	92.8	73.6	114.6	111.3	111.3	111.3	111.3	111.3

Production Distribution



Production Capacity - The tonnage calculation on Page 18 is straightforward and assumes operating at a normal, full capacity with the following considerations:

- In the first (partial) year of operation, a lower than normal operating efficiency is assumed in anticipation of a learning curve for the new facility and personnel.
- Inventory is built up to a level equal to slightly more than one month's production. More inventory is added just prior to the plant rebuild in year 10 to cover the time out of service.
- Production tonnage increases by 20% starting in year 11 after the rebuild.

Translation of tonnage into sales mix and sales revenue uses distribution and pricing shown on pages 9 and 10.

Capacity Reduction - If necessary, it is possible to reduce production by:

- Reducing the melt rate (up to 25%) from nominal.
- Reverting to a "soak" condition where the melter is maintained at an intermediate temperature. Time to recover is approximately one week.
- Draining and cooling the furnace. Variable costs may be substantially reduced. Time to recover is approximately one month.

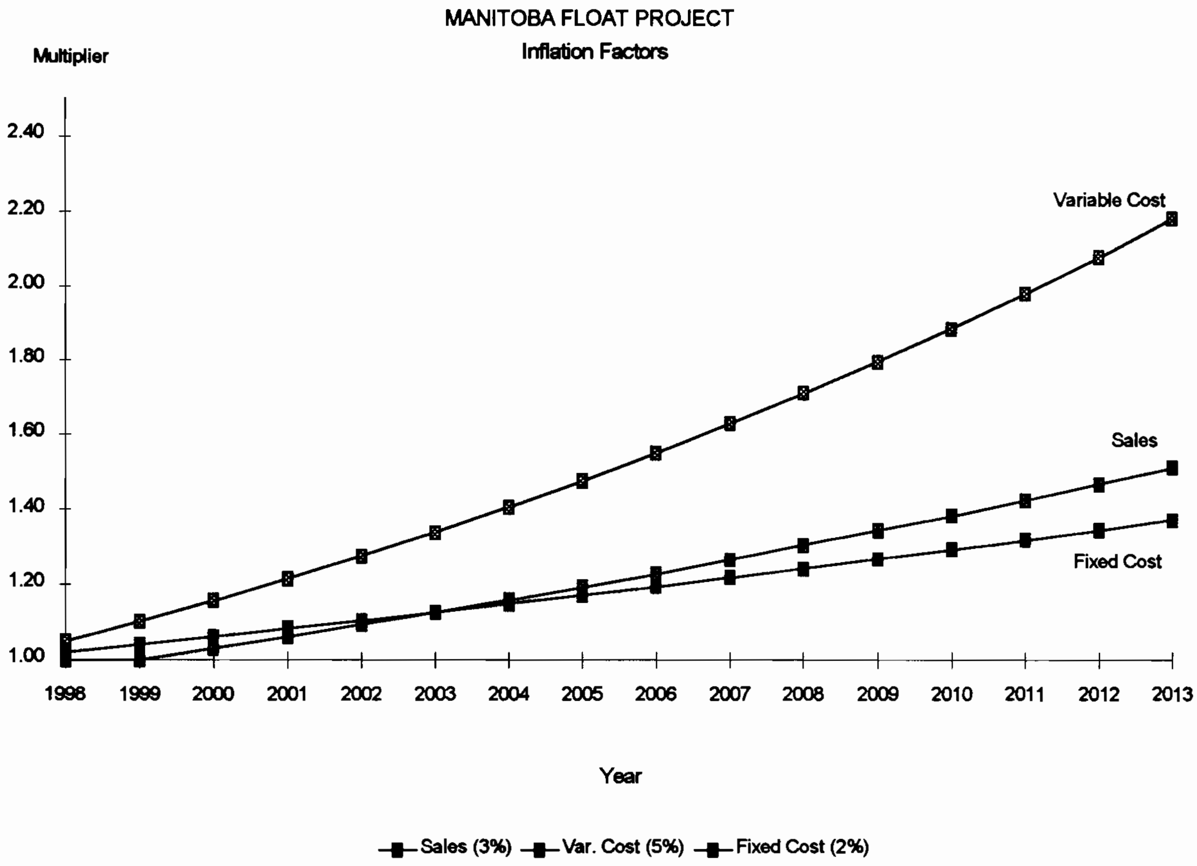
Working Capital Estimate

WORKING CAPITAL ESTIMATE

EXPENSES		Mil $
Heat-up Energy and Expense		0.60
Glass-Maker Consultants		0.45
Start-up Expense (Misc.)		0.30
		1.35
ASSETS		
Receivables (55 Day Payment Terms)		11.02
Payables (1 month)		-2.75
	Dif.:	8.27
Inventories		
Inventory : 10,000 T/Day @ $ 235.31		2.35
Raw Mat'l Inventory (30 Days)		1.01
Subtotal Inventory Items		3.36
Total Working Capital Line Required (Years 1 - 2)		12.98
Cost of Working Cap.Credit Line @ 1.0%		0.13
Total Working Capital Line Required (Later Years)		5.00
Cost of Working Cap.Credit Line @ 1.0%		0.05

Working Capital Requirements - Actual cash flow and working capital usage are calculated in the income statement and the balance sheet. Actual cash flow application towards dividends and working capital debt repayment will depend upon the terms negotiated with lenders and the corporate policy on dividends. In order to allow for adequate reserves, however, an over-draft facility or credit line of approximately $5 million is assumed for all years beyond the second.

Inflation Factors



Inflation Assumptions

In order to estimate the affect of inflation on the financial results of the Economic Model, the following assumptions were made:

- All variable cost items are subject to a compounded annual inflation rate of 5%, effective in the first year of operation.
- All fixed costs are subject to a compounded annual inflation rate of 2%, effective in the first year of operation.
- The average selling price of glass does not increase until the third year of operation, and then is subject to a compounded annual inflation rate of just 3%. Thus, an allowance is made for price competition or special introductory discounts.

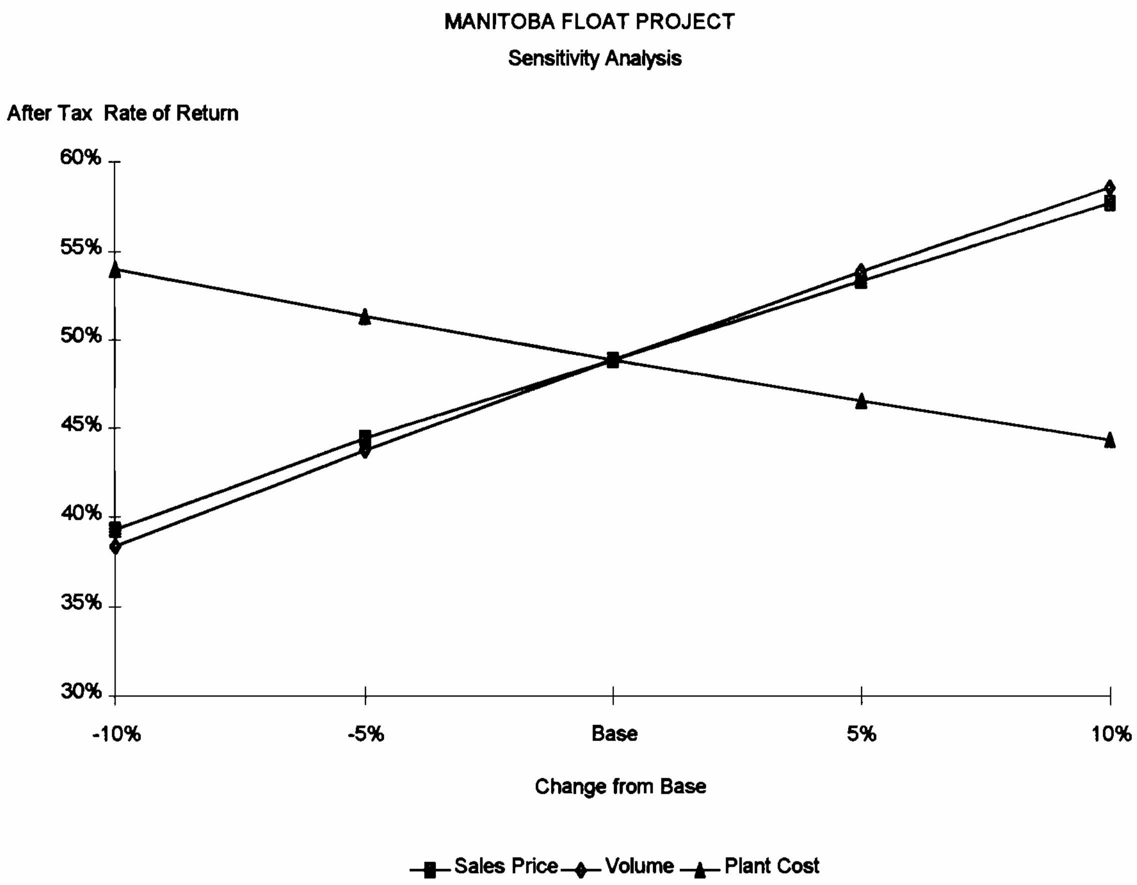
Calculation of the internal rate of return (ROI) on owner's equity indicates nearly the same result as before inflation. Thus, the investment return is not particularly sensitive to reasonable inflation which is fairly matched between costs and selling price.

Inflated Cash Flow Projection

CASH FLOW PROJECTION
After Inflation
(Million $)

		6 mo. 1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	15 Year Average
Inflation On Sales =	3.0%																	
Inflation On Variable Cost =	5.0%																	
Inflation On Fixed Cost =	2.0%																	
1 Sales Inflator		1.0	1.0	1.0	1.1	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.3	1.4	1.4	1.5	1.5	1.2
2 Var. Cost Inflator		1.1	1.1	1.2	1.2	1.3	1.3	1.4	1.5	1.6	1.6	1.7	1.8	1.9	2.0	2.1	2.2	1.6
3 Fixed Cost Inflator		1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.4	1.2
4 Gross Sales		34.8	86.1	92.8	98.4	101.4	104.4	107.6	110.8	114.1	93.2	149.6	149.6	154.1	158.7	163.5	168.4	123.5
5 Freight & Allowances		5.5	14.3	15.7	17.0	17.9	18.8	19.7	20.7	21.7	18.1	29.6	30.2	31.7	33.2	34.9	36.7	24.0
6 Net Sales		29.3	71.8	77.1	81.4	83.5	85.7	87.9	90.1	92.4	75.1	120.0	119.5	122.4	125.5	128.6	131.7	99.5
7 Inventory Change		0.0	2.4	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	-1.5	0.0	0.0	0.0	0.0	0.0	0.2
8 Plant Turnover		29.3	74.2	78.1	81.4	83.5	85.7	87.9	90.1	92.4	76.6	118.5	119.5	122.4	125.5	128.6	131.7	99.7
9 Variable Cost		8.9	24.9	26.1	27.4	28.8	30.2	31.7	33.3	35.0	30.4	46.3	48.6	51.0	53.6	56.3	59.1	38.8
10 Fixed Cost		5.0	10.8	11.0	11.3	11.5	11.7	11.9	12.2	12.4	12.7	12.9	13.2	13.4	13.7	14.0	14.3	12.5
11 Gross Margin		15.5	38.5	40.9	42.8	43.3	43.8	44.2	44.6	45.0	33.5	59.3	57.7	58.0	58.2	58.3	58.4	48.4
12 Selling Expense		0.9	2.2	2.3	2.5	2.5	2.6	2.7	2.8	2.9	2.3	3.7	3.7	3.9	4.0	4.1	4.2	3.1
13 Interest Expense		4.2	7.2	6.3	5.6	4.8	4.0	3.2	2.4	1.6	1.5	0.0	0.0	0.0	0.0	0.0	0.0	2.4
14 Depreciation		14.4	28.8	28.8	24.2	1.3	1.3	1.3	1.3	1.3	7.3	6.7	6.0	2.0	0.0	0.0	0.0	7.4
15 Income Before Tax		-4.1	0.3	3.4	10.5	34.7	35.9	37.0	38.2	39.3	22.4	48.9	47.9	52.1	54.2	54.3	54.2	35.6
16 Provision for Tax	39.1%	0.0	0.1	1.3	4.1	13.6	14.0	14.5	14.9	15.4	8.8	19.1	18.8	20.4	21.2	21.2	21.2	13.9
17 Net Income		-4.1	0.2	2.1	6.4	21.1	21.8	22.6	23.2	23.9	13.6	29.8	29.2	31.7	33.0	33.0	33.0	21.6
18 Add: Depreciation		14.4	28.8	28.8	24.2	1.3	1.3	1.3	1.3	1.3	7.3	6.7	6.0	2.0	0.0	0.0	0.0	7.4
19 Cash Available		10.4	29.0	30.9	30.6	22.4	23.2	23.9	24.6	25.2	20.9	36.4	35.2	33.8	33.0	33.1	33.0	29.0
Applied to:																		
20 Debt Service (Long-term)		0.0	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	0.0	0.0	0.0	0.0	0.0	6.3
21 Plant and Equipment											32.6							
22 Dividend Payable		0.0	9.3	22.3	22.9	14.7	15.2	15.7	16.2	16.7	0.0	15.0	35.4	33.9	33.1	33.1	33.1	21.1
23 Working Capital Payable		10.4	14.2	1.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	21.0	0.0	0.0	0.0	0.0	0.0	2.5
24 Excess Cash Flow		0.0	-3.8	-2.5	-2.0	-1.7	-1.4	-1.2	-1.0	-0.8	-21.0	-8.9	-0.2	-0.1	0.0	0.0	-0.1	Residual Equity)
25 Owner's Cash Flow		0.0	5.5	19.9	20.9	13.1	13.8	14.5	15.2	15.9	-21.0	6.1	35.2	33.8	33.0	33.1	33.0	50.2
26 Return (ROI) on Owner's Equity		43% Adjusted for Inflation																

Sensitivity Analysis



Base Case - In the above chart, the internal rate of return on owner's equity (49%)is recalculated for a variety of excursions from the Base Case for glass Sales Price, Production Volume, and Capital Cost as presented in the earlier pages of this section.

Sales Price Sensitivity - The average glass selling price is allowed to change by -10%, -5%, +5% and +10% from the Base Case with a new internal rate of return calculated for each change. The line marked "Sales Price" plots the results indicating a positive slope. For a price change of 5% from the anticipated price, the owner's ROI changes by 5%.

Volume Sensitivity - When the production volume is varied, a similar positive slope results. For a volume change of 5%, the owner's ROI changes by 5%.

Capital Cost Sensitivity - When the project's capital cost is varied, it is assumed that the percentage of the new amount funded by the owner stays constant. The results show an expected negative slope. For a cost change of 5%, the owner's ROI changes by 2.5%.

Flat Glass Marketing and Production

Section 3 | Page

Flat Glass Market

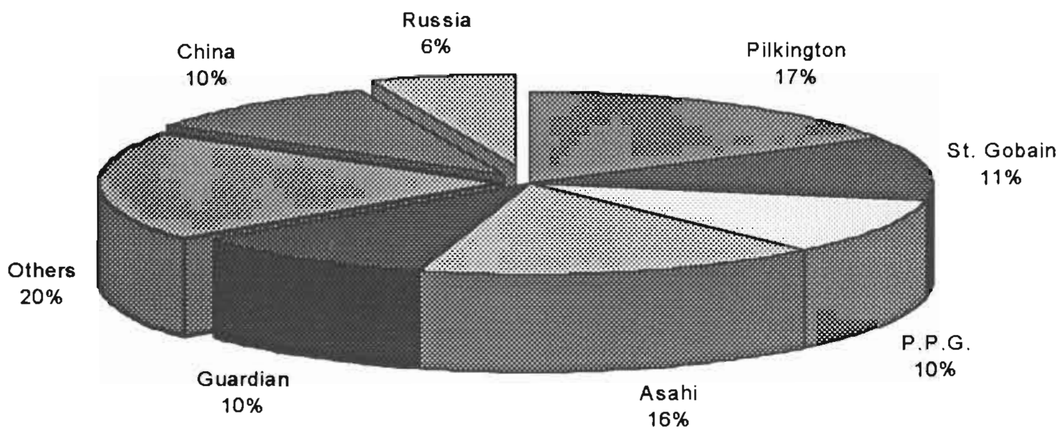
World Wide Market

Flat glass is a necessary, basic component in the construction of dwellings, commercial buildings, interior furnishings, and vehicles. Since glass is relatively heavy and fragile, it is difficult to transport economically over large distances. As a result, the manufacturing facilities for glass world-wide are generally distributed in the same pattern as the end users are themselves distributed.

Essentially all flat glass consumed in the developed countries of the world is produced by the float glass forming technique described in Section 4 of this report. A typical float glass manufacturing line makes about 500 tons of molten glass per day, yielding about 140,000 tons of finished product per year. Assuming normal product mixes, the typical facility makes approximately 15 million square meters of glass annually.

ITC maintains a database which lists the float glass manufacturing facilities around the world. From this list one may see that about 170 float glass lines are in production world-wide making about 18 million metric tons of glass annually.

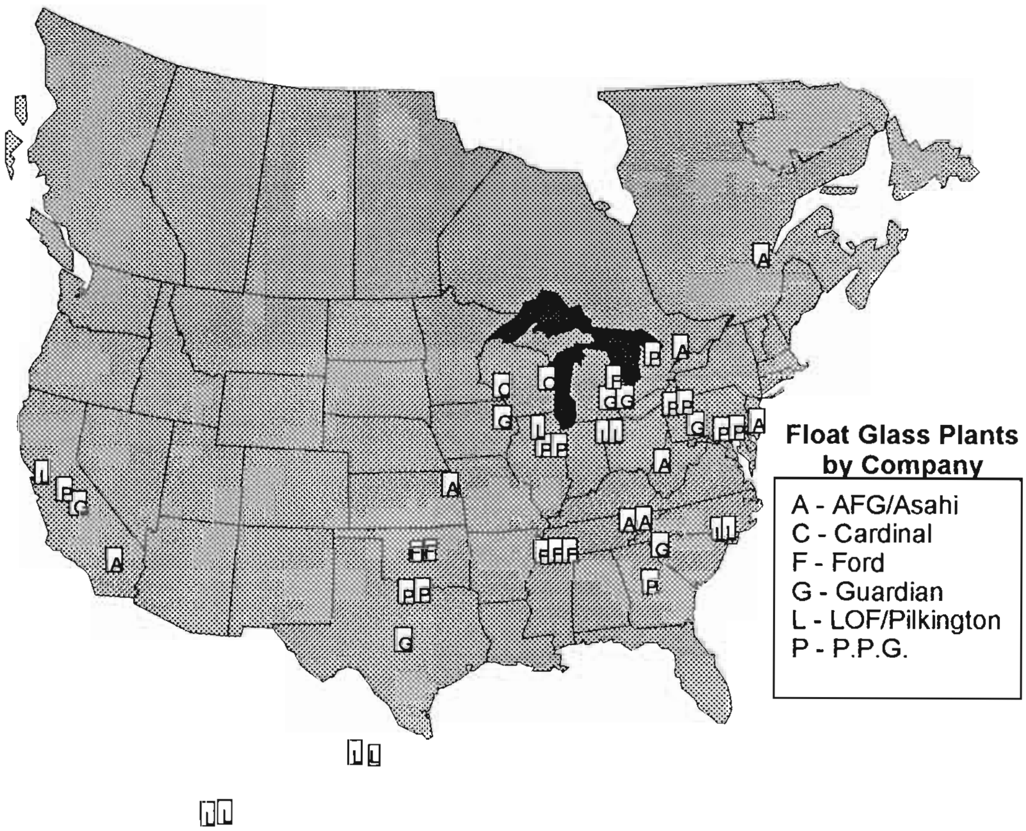
World Float Glass Capacity
by Company



As one can see from the above chart of market share by producer, the float glass market is dominated by 5 large producers. Pilkington, Asahi, Saint Gobain, PPG and Guardian control about 65% of the world's supply of float glass. If the glass produced by local companies in China and in Russia (neither of which is traded on the world flat glass market) is removed from consideration, the market share of the five large companies jumps to about 80%.

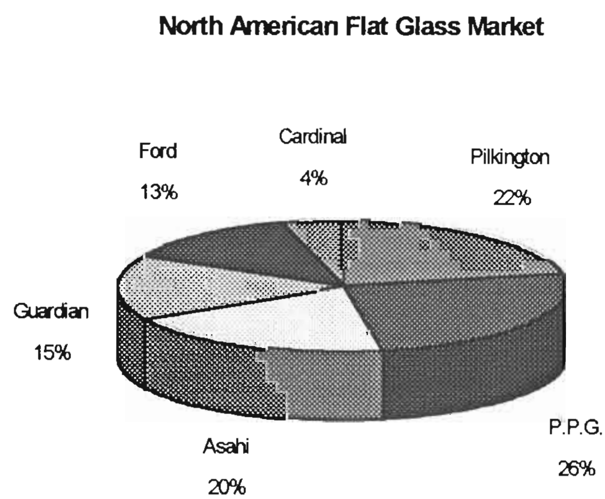
North American Market

The flat glass market in North America is served by 46 production lines, owned by 6 different companies. The plants are geographically located as shown on the map below.



The North American market is one of the largest regional markets in the world, accounting for over 30 percent of the world's glass production. The market is dominated by four large companies who enjoy a large share of the world-wide market described above. Pilkington owns 80% of Libbey-Owens-Ford and holds a large interest in Vidrio Plano in Mexico. AFG Industries in the United States and Glaverbec in Quebec are owned by the Japanese company, Asahi.

The chart at the right illustrates the market shares held by each producer. Together, they operate 46 production lines. Thirty nine of these lines are located in the United States, four in Mexico, and three in Canada.



Canadian Market

Of the three float glass manufacturing facilities located in Canada, two are owned by Asahi and operated by Asahi's United States subsidiary company, AFG Industries. One of these facilities in located in Scarborough, Ontario. This plant was originally built and operated as a two line facility by Pilkington in about 1967. Pilkington sold the plant to Ford Motor Company's glass division, who in turn, sold it to AFG. The second Asahi line was built in St. Augustine, Quebéc in 1991 by Glaverbel, the Belgian subsidiary of Asahi. AFG announced about two years ago that the marketing and operating control of both plants would be consolidated under their direction.

The only other float glass manufacturing facility in Canada is located in Owen Sound, Ontario. It was built by PPG in 1978 and remains under their ownership and operation.

According to statistics published by the Freedonia Group, a Cleveland, Ohio based market research company, the total flat glass demand in Canada stood at 64 million square meters in 1993. Canadian flat glass demand is forecast to grow at a rate of 5.3% (compared to the long-term growth rate of 4% in the United States) reaching a level of 83 million square meters in 1998.

The three production facilities in Canada only manufacture about 400,000 tons, equivalent to approximately 45 million square meters of glass annually. The short fall is equivalent to the combined output of over two Canadian float glass manufacturing facilities. Statistics Canada confirms that the vast majority of trade in glass is done with the United States. Imports into Canada from the United States for safety glass alone were valued at $372,051,000 in 1993 compared to exports of $239,738,000 for a shortfall of over $130,000,000. Trade in mirrors were reported to have a similar deficit of $130,000,000 with the United States.

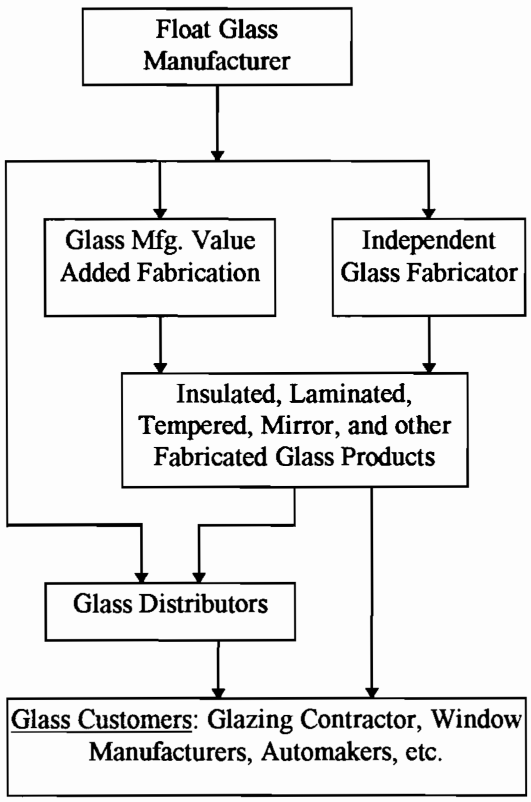
Industry Structure

The graphic below shows the principal pattern of distribution of flat glass products. Since very little glass is used by the end consumer without being further worked, the first step is to fabricate the raw glass into a value-added product such as:

- Insulated Glass for Windows
- Laminated Glass for Windshields
- Tempered Body Glass for Vehicles
- Tempered Patio Doors
- Reflective Coated Glass
- Mirrors
- Edge Ground Glass for Furniture
- Bent Architectural Glass

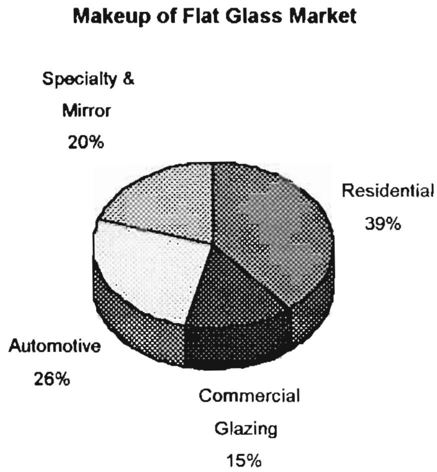
Sometimes this fabricating step is carried out by the same company who manufactures the raw glass and sometimes it is done by an independent fabricator who buys raw glass from the glass manufacturer then further works it.

The final glass product is then sold either directly to the end user or to a wholesaler or distributor for future sale to the end user.



Consumers of Glass

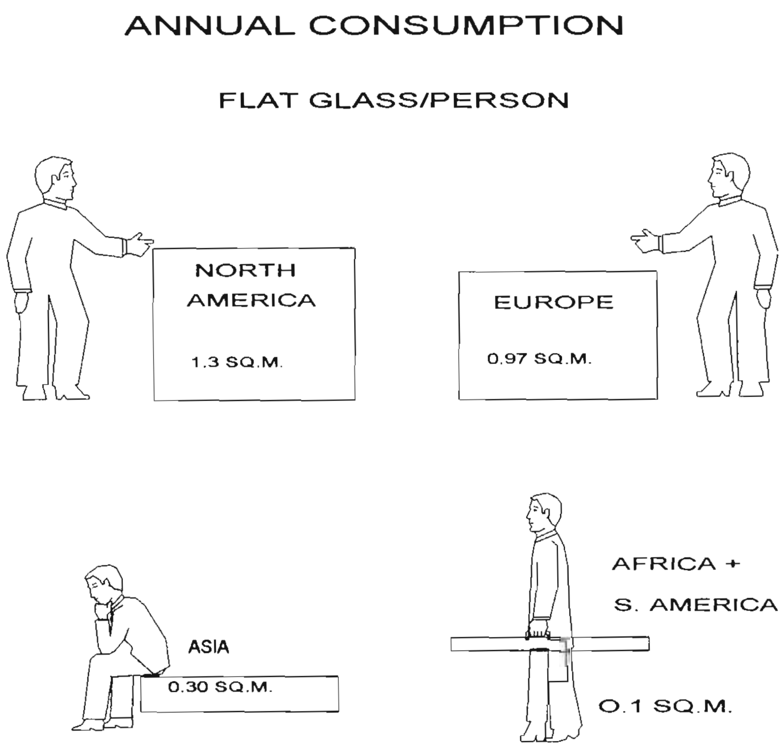
The most significant end uses of glass are for glazing and for use in vehicles. The pie chart at the right shows the make-up of the flat glass market as reported by a widely quoted industry expert, Rick Cunningham from AFG Industries. Another way to look at the market is to list the consumption by product type as shown in the table below:



Tempered Glass	17%
Insulated Glass	18%
Laminated Glass	2%
Gray/Bronze	5%
Reflective	2%
Low-E	3%
Mirror	8%
Automotive	26%
Other	19%

The preceding discussion on market format makes it obvious that manufacturers of flat glass are often in competition with their customers at the value-added level and at the distributor level. This situation often creates some conflict between the parties and has resulted in a demand for an independent supplier of flat glass in the market place.

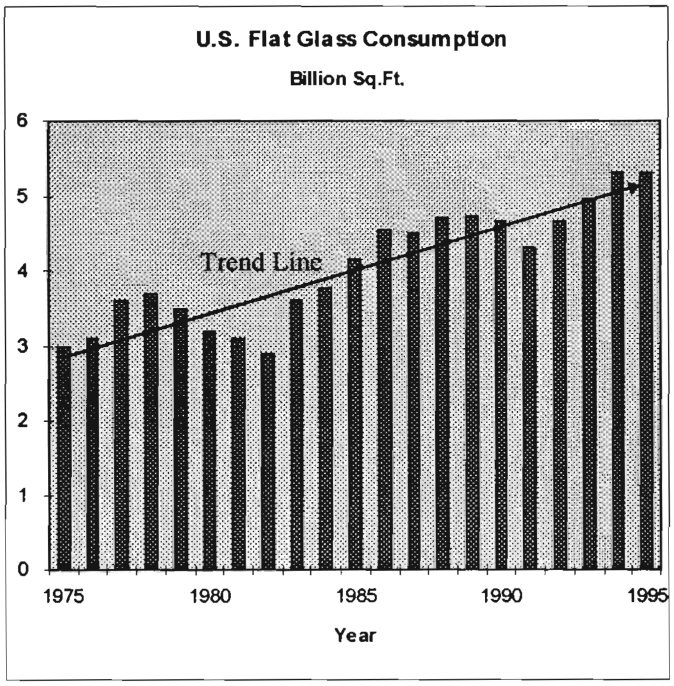
Another factor which influences the market structure and patterns of use is the relative development of a technical consumers' society. Consumption of glass in North America is in excess of 1 sq.m. per capita per annum. The market in other areas is only capable of absorbing a fraction of this amount.



The percentage of value added products such as coated glass, tempered and automotive products is also a function of the level of technological development.

Market Trends

The trend line for growth in the North American flat glass market has averaged about 4% per year for many years. Considerable fluctuation around this trend has been caused by cyclical variation in the number of housing starts, automotive manufacturing, and other macro economic factors.



The Freedonia Group predicts that flat glass demand in North America will rise 4.2 percent per year to 645 million square meters in 1998. Considering that 46 float glass production lines are currently in operation in North America, and further considering that many articles have appeared in glass industry trade magazines lamenting the current glass shortage, one may assume two things:

- that supply and demand are currently in balance
- that the equivalent of 1.8 new float lines must be built in North America on average every year in order to maintain the balance of supply and demand

In fact, relatively few float glass lines have been erected in North America during the last few years. The most recent plants constructed and idled are listed below:

New Float Lines Constructed

Cardinal Glass, Portage, WI	1996
Guardian Industries, Dewitt, IA	1996
Vidrio Plano, Mexico City,	1996
Vidrio Plan, Monterrey,	1993
Cardinal Glass, Menomonie, WI	1992
Glaverbec, St. Augustin, Quebéc,	1991
PPG Industries, Perry GA	1989
AFG Industries, Spring Hill, KA	1989
AFG Industries, Victorville, CA	1988
Guardian Industries, Richburg, SC	1988

Float Lines Permanently Idled

PPG Industries, Chehalis, WA	1991
PPG Industries, Crystal City, MO	1991
PPG Industries, Cumberland, MD	1988

From the table above, one can see that 10 new lines have been added and three removed from the North American flat glass supply during the last 10 years. This is far from the 15-18 lines of new capacity indicated by the long-established growth trend line.

Market Prices

ITC has conducted a survey by telephone, telefax, and personal interview of glass manufacturers, glass consumers, and trade organizations in the industry. While some of those surveyed declined to reveal typical glass pricing information, enough reliable, comparable responses were obtained to yield a satisfactory result for the Economic Model.

Individual respondents were promised that the information which they supplied would be maintained in confidence and not attributed to any specific person or firm. Representative results are shown below:

Single Strength 2.3mm window glass	0.23-0.27 USD / sq.ft	= avg. 404 USD / ston
3mm clear glass for tempering	0.33-0.36 USD / sq.ft.	= avg. 454 USD / ston
6mm clear glass in architectural sizes	0.56-0.63 USD / sq.ft.	= avg. 430 USD / ston
3/8 in. (10mm) glass in furniture sizes	1.30-1.40 USD / sq.ft.	= avg. 445 USD /ston
Canadian Statistics Import Information	563.70 CAD / mton	= equiv. 411 USD / ston

Some difference in price by location was found, as expected. In general, the price premium in the Canadian Prairie Provinces, in British Colombia, and in the NW United States is equal to the additional cost of freight from the location of the producers in the central U.S. and in California, respectively.

ITC has concluded, therefore, that additional float glass facilities are needed to serve the market and, considering the already serious trade imbalance in flat glass between Canada and the United States, that at least one additional float glass plant in the Central or Western Provinces of Canada is justified.

Target Markets for Manitoba

The map on page two of this section shows the location of existing float glass plants in North America. Clearly, the proposed float glass line in Manitoba would have a freight cost advantage for customers located in the Central and Western Provinces of Canada. In addition, the Manitoba facility would be located within two days trucking of the major cities in the mid-west and mountain states of the United States.

When the map showing location of existing producers is compared with the effective service area shown above, one may conclude that a deficiency of production capacity exists to serve glass consumers in Manitoba and surrounding areas. ITC has concluded that the following markets may be advantageously targeted by the Manitoba facility:

1. Canadian Prairie Provinces

By comparing the population of both Canada and the United States to the number of float glass manufacturing lines one may see that 7.3 million persons per float line exists in the United States at present and 9.3 million persons per float glass line in Canada. This may used as a simple index to compare existing float glass manufacturing capacity with the consuming population on a region by region basis.

Manitoba, Alberta, and Saskatchewan have a combined population of 4.6 million. Using the index of 8 million in population for each float line, a rough estimate of potential glass consumption of 60-80,000 tons per year may be estimated for this region. While the proposed facility in Manitoba would have an absolute transportation advantage over competing facilities, we have assumed that a market share of only 25% will be reached to avoid undo pricing pressure on the local market and considering that some locally based glass consumers are owned or controlled by competing glass companies. This market share is equivalent to 17,000 metric tons per year.

2. Central and Mountain States

The major U.S. Cities of Minneapolis/St. Paul, Denver, Kansas City, and Chicago are all bases for companies who are large consumers of glass. In addition, the states of Wisconsin, Minnesota and Iowa are the home bases for the largest wooden window manufacturers in North America.
Considering the population of the region of almost 70 million and the fact the Manitoba facility would be able to serve the region at least as well as the relatively few existing float glass manufacturing facilities located within a reasonable shipping distance, we have assumed a market share of 7% equivalent to 85,000 tons per year.

3. British Columbia

The rapidly growing city of Vancouver and its surrounding region is the most remote North American population center from any existing source of float glass. With a population of over 3 million and considering the excellent rail and road connection between Manitoba and British Columbia, we have considered that the Manitoba facility would be able to enjoy a 20% share of this small, but profitable glass market. This market share is equivalent to 11,000 tons per year.

4. Washington and Oregon States

ITC is aware that several glass manufacturers have considered locating manufacturing facilities in the northwestern United States. PPG did, if fact, build a small, highly complex float glass facility in Chehalis, Washington in 1988 but abandoned it because of technical difficulties with an experimental melting furnace a couple of years later. The problem with building a typical 500 ton per day float glass line in this market area is that the market is only large enough to reasonably accommodate a production facility about one-half as large as is considered economically feasible. Any amount of glass in excess of that reduced volume must be hauled east across the mountains to compete with mid-western based facilities.

The states of Washington, Oregon, and Idaho are the homes of a number of window manufacturers and boast a population of nearly 9 million. We expect that the Manitoba facility may obtain a 13% market share equivalent to 17,000 tons per year.

General and Background Information

Section 4 | Page

MANITOBA FLOAT PROJECT FEASIBILITY STUDY
DATA INPUTS & ASSUMPTIONS FOR ECONOMIC MODEL

LINE	INPUT / ASSUMPTION	VALUE for 500 T/D	UNITS	REF. CODE	COMMENT	RESPONSIBILITY	
						ITC	Manitoba
	COSTS:						
	Capital:						
1	Land	1.370	Mil C$	23	43 Acres @ C$31,860/Acre	X	X
	Sub-Total	1.000	Mil US$				
	Site Works:						
2	Grading, Drainage, Excavation	1.878	Mil C$	1		X	
3	Foundations, Concrete Works	10.017	Mil C$	1		X	
4	Roads, Improvements, Fencing	0.435	Mil C$	1		X	
	Sub-Total	12.330	Mil C$				
	Sub-Total	9.000	Mil US$				
	Utility Systems:						
5	Electrical Power	2.950	Mil US$	1		X	
6	Compressed Air	0.545	Mil US$	1		X	
7	Water - Cooling & Treatment	1.275	Mil US$	1		X	
8	Water - Fire, Potable, Sewage	0.540	Mil US$	1		X	
9	Fuel Oil & Storage	0.400	Mil US$	1		X	
10	HVAC	0.112	Mil US$	1		X	
11	Control System	0.534	Mil US$	1		X	
	Sub-Total	8.708	Mil C$				
	Sub-Total	6.356	Mil US$				
	Buildings:						
12	Batch House (Bldg. Cover)	0.236	Mil C$	1		X	
13	Furnace	1.061	Mil C$	1		X	
14	Tin Bath	0.471	Mil C$	1		X	
15	Lehr	0.796	Mil C$	1		X	
16	Cutting Line	0.794	Mil C$	1		X	
17	Warehouse / Shipping Dock	3.571	Mil C$	1		X	
18	Power House / Utilities	0.972	Mil C$	1		X	
19	Office / Raw Materials / Misc.	1.489	Mil C$	1		X	
	Sub-Total	9.390	Mil C$				
	Sub-Total	6.854	Mil US$				
	Batch Plant:						
20	Design & Equipment	2.040	Mil US$	1		X	
21	Structural Steel & Silos	1.843	Mil C$	1		X	
22	Material Handling & Conveyors	0.157	Mil C$	1		X	
23	Shipping, Install, Supervision	0.411	Mil C$	1		X	
	Sub-Total	5.206	Mil C$				
	Sub-Total	3.800	Mil US$				
	Cullet Return:						
24	Design & Equipment	1.056	Mil US$	1		X	
25	Shipping, Install, Supervision	0.153	Mil C$	1		X	
	Sub-Total	1.600	Mil C$				
	Sub-Total	1.168	Mil US$				
	Furnace, Emmisions & Chimney:						
26	Design & Equipment	5.038	Mil US$	1		X	
27	Emmissions	2.750	Mil US$	1		X	
28	Refractories	9.405	Mil US$	1		X	
29	Steel & Ductwork	1.010	Mil C$	1		X	
30	Chimney	1.210	Mil C$	1		X	
31	Shipping, Install, Supervision	4.436	Mil C$	1		X	
	Sub-Total	30.210	Mil C$				
	Sub-Total	22.051	Mil US$				

MANITOBA FLOAT PROJECT FEASIBILITY STUDY
DATA INPUTS & ASSUMPTIONS FOR ECONOMIC MODEL

LINE	INPUT / ASSUMPTION	VALUE for 500 T/D	UNITS	REF. CODE	COMMENT	RESPONSIBILITY ITC	RESPONSIBILITY Manitoba
	Float Bath:						
32	Design & Equipment	5.300	Mil US$	1		X	
33	Refractories & Roof	1.900	Mil US$	1		X	
34	Steel	1.863	Mil C$	1		X	
35	Tin	1.370	Mil C$	1		X	
36	Shipping, Install, Supervision	2.303	Mil C$	1		X	
	Sub-Total	15.400	Mil C$				
	Sub-Total	11.241	Mil US$				
	Atmosphere:						
37	Nitrogen & Hydrogen	0.480	Mil C$	1		X	
	Sub-Total	0.350	Mil US$				
	Lehr:						
38	Design & Equipment	4.958	Mil US$	1		X	
39	Shipping, Install, Supervision	0.533	Mil C$	1		X	
	Sub-Total	7.325	Mil C$				
	Sub-Total	5.347	Mil US$				
	Cutting Line:						
40	Design & Equipment	5.973	Mil US$	1		X	
41	Shipping, Install, Supervision	1.947	Mil C$	1		X	
	Sub-Total	10.130	Mil C$				
	Sub-Total	7.394	Mil US$				
	Material Handling & Other Equipment:						
42	Raw Materials	0.685	Mil C$	1		X	
43	Finished Products	1.302	Mil C$	1		X	
44	Misc. Vehicles	0.144	Mil C$	1		X	
45	Equip. - Admin., Maintenance, Lab.	1.774	Mil C$	1		X	
	Sub-Total	3.905	Mil C$				
	Sub-Total	2.850	Mil US$				
46	Project Management, Engr., Consultants	2.255	Mil C$	1		X	
47	Client Staff & Development	2.000	Mil C$	1		X	
48	Heat-Up Services	0.374	Mil C$	1		X	
	Sub-Total	4.629	Mil C$				
	Sub-Total	3.379	Mil US$				
	Total Capital Cost	110.683	Mil C$				
	Total Capital Cost	80.790	Mil US$				
	Construction Labor:						
49	Skilled	21.47	C$/Hr	24	High Wage + 5% + Burden		X
50	Unskilled	7.43	C$/Hr	24	Min. Wage + 10% + Burden		X
	Operating (Variable):						
	Raw Material Price (per Ton):						
51	Sand	21.00	C$ / T	21	From Selkirk, MB		X
52	Soda Ash	158.56	C$ / T	21	From Green River, WY	X	X
53	Dolomite	33.47	C$ / T	21	From Hilbre or Inwood, MB	X	X
54	Limestone	30.00	C$ / T	21	From Faulkner, MB	X	X
55	Nepheline Syenite / Feldspar	35.04	C$ / T	21	From Peterborough, ON	X	X
56	Salt Cake	110.23	C$ / T	21	From Chaplin, SK	X	X
57	Misc. (per Ton Glass)	1.37	C$ / TG	2	Delivered Price	X	

MANITOBA FLOAT PROJECT FEASIBILITY STUDY
DATA INPUTS & ASSUMPTIONS FOR ECONOMIC MODEL

LINE	INPUT / ASSUMPTION	VALUE for 500 T/D	UNITS	REF. CODE	COMMENT	RESPONSIBILITY: ITC	RESPONSIBILITY: Manitoba
	Raw Material Freight Cost (per Ton):						
58	Sand	5.00	C$ / T	22	From Selkirk, MB	X	
59	Soda Ash	77.16	C$ / T	22	From Green River, WY	X	
60	Dolomite	16.53	C$ / T	22	From Hilbre or Inwood, MB	X	
61	Limestone	18.00	C$ / T	22	From Faulkner, MB	X	
62	Nepheline Syenite / Feldspar	47.62	C$ / T	22	From Peterborough, ON	X	
63	Salt Cake	22.60	C$ / T	22	From Chaplin, SK	X	
	Raw Material Formula (per Ton Glass):						
64	Sand	0.692	T / TG	3		X	
65	Soda Ash	0.210	T / TG	3		X	
66	Dolomite	0.177	T / TG	3		X	
67	Limestone	0.054	T / TG	3		X	
68	Nepheline Syenite / Feldspar	0.057	T / TG	3		X	
69	Salt Cake	0.012	T / TG	3		X	
	Fuel / Furnace:						
70	Natural Gas Price	0.1289	C$ / M3	25			X
71	Calorific Value	8,900	Kcal / M3	25			X
72	Melter Efficiency	1,600	Kcal / Kg	4		X	
73	Raw Water Price	0.6003	C$ / M3	26	+ C$0.8087 / M3 Sewer		X
	Personnel Salaries (per Year):						
74	Production	30,677	C$ / Yr	27	C$13.28 / Hr + 10%		X
75	Maintenance	33,744	C$ / Yr	27	C$13.28 / Hr + 20%		X
	Personnel Quantities:						
76	Production	140	Persons	5		X	
77	Maintenance	24	Persons	5		X	
78	Benefits Factor (Hourly Emp.)	25.0	%	27			X
	Sales (Variable):						
79	Returns & Allowances Factor	1.5	%	6		X	
80	Selling Expense (% of Gross Sales)	2.5	%	6		X	
	Operating (Fixed):						
	Electricity:						
81	Avg. Cost (per KWH)	0.0201	C$ / KwH	28	+ C$7.089 / Kw(Peak) / Mo.		X
82	Consumption (per Year)	24.455	MKwH/Yr	7		X	
	Atmosphere:						
83	N2 & H2 (per Year)	3.500	MC$ / Yr	8		X	
84	Moving / Changing / Misc. Cost	0.700	MC$ / Yr	9		X	
	Administration & General Cost:						
85	Travel & Entertainment	0.700	MC$ / Yr	9		X	
86	Bank Charges	0.500	MC$ / Yr	9		X	
87	Accounting / Computer Equipment	0.550	MC$ / Yr	9		X	
88	Property Tax	0.350	MC$ / Yr	9		X	
89	Insurance	0.500	MC$ / Yr	9		X	
90	Legal & Auditing Services	0.600	MC$ / Yr	9		X	
	Personnel Salaries (per Year):						
91	Clerical	24,000	C$ / Yr	29		X	X
92	Supervisory	36,000	C$ / Yr	29		X	X
93	Engineers	42,000	C$ / Yr	29		X	X
94	Dept. Heads	54,000	C$ / Yr	29		X	X
95	Scheduling	36,000	C$ / Yr	29		X	X
96	Plant Manager	84,000	C$ / Yr	29		X	X

MANITOBA FLOAT PROJECT FEASIBILITY STUDY
DATA INPUTS & ASSUMPTIONS FOR ECONOMIC MODEL

LINE	INPUT / ASSUMPTION	VALUE for 500 T/D	UNITS	REF. CODE	COMMENT	RESPONSIBILITY	
						ITC	Manitoba
	Personnel Quantities:						
97	Clerical	9	Persons	10		X	
98	Supervisory	19	Persons	10		X	
99	Engineers	6	Persons	10		X	
100	Dept. Heads	7	Persons	10		X	
101	Scheduling	3	Persons	10		X	
102	Plant Manager	1	Person	10		X	
103	Benefits Factor (Management Emp.)	25.0	%	27			X
	Depreciation Rates:						
104	Buildings	4	% / Yr	11	CCA Class 1		X
105	Buildings - Constr. Interest	4	% / Yr	11	CCA Class 1		X
106	Site Improvements	10	% / Yr	11	CCA Class 6		X
107	Site Improvements - Constr. Interest	10	% / Yr	11	CCA Class 6		X
108	Equipment, Utilities, Admin.	30	% / Yr	11	CCA Class 43		X
109	Equipment - Constr. Interest	30	% / Yr	11	CCA Class 43		X
110	Financial & Legal	30	% / Yr	11	CCA Class 43		X
111	Rebuild	30	% / Yr	11	CCA Class 43		X
112	Rebuild Allowance	20.000	Mil C$	12		X	
	Financial / Production Assumptions:						
113	Income Tax Rate	39.12	%	30	Federal + Provincial Rate		X
114	Interest Rate Earned on Cash	4.0	%	30			X
	Tons Melted (per Day):						
115	Year 1 (6 Months)	400	T / Day	13		X	
116	Years 2 - 10	500	T / Day	14		X	
117	Years 11 - 16	600	T / Day	15		X	
	Line Yield:						
118	Year 1 (6 Months)	75	%	13		X	
119	Years 2 - 16	80	%	14		X	
120	Tempering Yield	N/A	%	16		X	
	Inventory Change (1000 TG / Yr):						
121	Year 1 (6 Months)	0	TG / Yr	13		X	
122	Year 2	10	TG / Yr	14		X	
123	Year 3	4	TG / Yr	14		X	
124	Year 10	5	TG / Yr	15		X	
125	Year 11	-5	TG / Yr	15		X	
	INCOME:						
	Sales:						
	Amount by Customer Location:						
126	Eastern Canada	10,000	TG / Yr	31	Montreal / Toronto	X	
127	Central Canada	17,000	TG / Yr	31	Winnipeg / So. MB & SK	X	
128	Western Canada	11,000	TG / Yr	31	Vancouver / So. BC	X	
129	Central US	50,000	TG / Yr	31	Chicago / Minneapolis	X	
130	Mountain US	35,000	TG / Yr	31	Denver / Salt Lake City	X	
131	North Western US	17,000	TG / Yr	31	Seattle / Portland	X	
	Price (Gross 4mm) by Customer Location:						
132	Eastern Canada	633.00	C$ / TG	31	Per Metric Ton of Glass	X	
133	Central Canada	723.00	C$ / TG	31	" " " "	X	
134	Western Canada	700.00	C$ / TG	31	" " " "	X	
135	Central US	430.00	US$ / sTG	31	Per Short Ton of Glass	X	

MANITOBA FLOAT PROJECT FEASIBILITY STUDY
DATA INPUTS & ASSUMPTIONS FOR ECONOMIC MODEL

LINE	INPUT / ASSUMPTION	VALUE for 500 T/D	UNITS	REF. CODE	COMMENT	RESPONSIBILITY	
						ITC	Manitoba
136	Mountain US	460.00	US$ / sTG	31	" " " "	X	
137	North Western US	465.00	US$ / sTG	31	" " " "	X	
	Distance by Customer Location:						
138	Eastern Canada	2250	Km	32	Montreal / Toronto	X	
139	Central Canada	300	Km	32	Winnipeg / So. MB & SK	X	
140	Western Canada	2300	Km	32	Vancouver / So. BC	X	
141	Central US	1100	Km	32	Chicago / Minneapolis	X	
142	Mountain US	1900	Km	32	Denver / Salt Lake City	X	
143	North Western US	2400	Km	32	Seattle / Portland	X	
	Freight Cost by Customer Location:						
144	Eastern Canada	60.13	C$ / TG	32	Montreal / Toronto	X	
145	Central Canada	35.07	C$ / TG	32	Winnipeg / So. MB & SK	X	
146	Western Canada	92.69	C$ / TG	32	Vancouver / So. BC	X	
147	Central US	85.18	C$ / TG	32	Chicago / Minneapolis	X	
148	Mountain US	125.26	C$ / TG	32	Denver / Salt Lake City	X	
149	North Western US	102.71	C$ / TG	32	Seattle / Portland	X	
150	Cash Sales Price Discount	3.0	%	17		X	
	Product Mix Forecast:						
151	Thin Glass		%	33		X	
152	Auto Open (for OEM)	15	%	33		X	
153	Auto Open (for After Market)		%	33		X	
154	Window Open	25	%	33		X	
155	Auto Box		%	33		X	
156	Window Box		%	33		X	
157	Tempered - 3mm		%	16		X	
158	Tempered - 3mm		%	16		X	
159	3 mm Open (for Window)	10	%	33		X	
160	3 mm Open (for Commercial)	10	%	33		X	
161	3 mm Open (for End Cap)		%	33		X	
162	3 mm Box (for Export)		%	33		X	
163	3 mm Box (for Light Cases)		%	33		X	
164	4, 5, 6mm (Jumbo Size 4mm)		%	33		X	
165	4, 5, 6mm (Disposable Racks)		%	33		X	
166	4, 5, 6mm (Box Glass)	30	%	33		X	
167	Heavy Glass (Jumbo Size)		%	33		X	
168	Heavy Glass (Lehr End Size)	10	%	33		X	
169	Heavy Glass (Box Glass)		%	33		X	
170	Tempered - 6mm		%	16		X	
	Packaging Cost:						
171	Open	5.00	C$ / TG	34		X	
172	Open (for End Cap)	15.00	C$ / TG	34		X	
173	Box, Disp. Racks, Lehr End	40.00	C$ / TG	34		X	
174	Packing Material per Ton Glass	12.5	Kg / TG	18		X	
175	Glass Delivery Truck Size	20	T / Truck	18		X	
176	Inventory Value (per Ton Glass)	***	C$ / TG	19	Calculated Value	X	
	Exchange Rates:						
177	USD / CAD	1.37	US$ / C$	20		X	

MANITOBA FLOAT PROJECT FEASIBILITY STUDY
DATA INPUTS & ASSUMPTIONS FOR ECONOMIC MODEL

LINE	INPUT / ASSUMPTION	VALUE for 500 T/D	UNITS	REF. CODE	COMMENT	RESPONSIBILITY	
						ITC	Manitoba
	Financing:						
	Equity:						
178	Investor "A"	22.136	Mil C$	35	20% of Total Capital Cost	X	
179	Investor "B"	0	Mil C$	35		X	
180	Cash Grants	0	Mil C$	35		X	
	Debt:						
181	Export Credit (5 Yr)	0	Mil C$	35		X	
182	Subsidized Loan (10 Yr)	0	Mil C$	35		X	
183	Commercial Debt (10 Yr)	93.739	Mil C$	35	Inc. Interest During Constr.	X	
	Interest Rates (% APR):						
184	Export Credit		%		N/A		X
185	Subsidized Loan		%		N/A		X
186	Commercial Debt	8.50	%	36	Canada Prime + 1.0 %		X
187	Working Capital Debt	9.50	%	36	Canada Prime + 2.0 %		X

MANITOBA FLOAT PROJECT FEASIBILITY STUDY
SOURCE / REFERENCE FOR DATA INPUTS & ASSUMPTIONS

REFERENCE CODE	REFERENCE / SOURCE
1	ITC Library: Estimated Values from Actual Vendor Quotes & Project Costs Dated Jun 1993 to Dec 1994.
2	ITC Estimate of US$1.00 / Ton Glass for Rouge, Carbon.
3	Actual Float Plant Batch Composition Calculation Dated Sep 1992.
4	Typical Melter Efficiency Specification as Guaranteed by a Furnace Supplier.
5	ITC Recommended Production / Maintenance Employee Staffing Based Upon Four Shifts at 42 Hrs per Week.
6	ITC Library: Typical Float Plant Sales Factors.
7	ITC Library: Estimate Based Upon 67,000 KwH Average Consumption per Day per 365 Day Year.
8	ITC Estimate Based Upon Typical Fixed Delivery Supply Contract
9	ITC Library: Typical Float Plant Administrative and General Costs.
10	ITC Library: Typical Salaried Staffing Levels.
11	Manitoba Department of Finance - January 30, 1996. Canadian Capital Cost Allowance Rates.
12	ITC Estimated Cost for Furnace / Bath Rebuild with a 20% Capacity Increase.
13	Assumed Production Start in July 1998 (6 Months) at a Reduced Start-Up Yield and No Inventory Build.
14	Assumed 10 Year Campaign at a Standard Yield with Inventory Build of 25 Days inYear 2 plus 10 Days in Year 3.
15	Assumed 20% Production Capacity Increase After Rebuild with Corresponding Inventory Build and Drawdown.
16	Assumed No Tempering Process.
17	Typical Industry Cash Sale Discount.
18	Typical Packing Material Weight Factor and North American Truck Size.
19	Calculated as Equal to the Average Variable and Fixed Costs of Production per Ton Glass.
20	Commercial Bank Exchange Rate Dated 11 Dec 1995.
21	Prices per Manitoba Energy & Mines Letter (01/23/96) on Raw Material Prices and per Supplier Quotations.
22	Quoted and Estimated Shipping Costs from Various Transport Companies.
23	The Manitoba Advantage Report, 1995 (3rd Edition) - Production Costs, Page 29. ITC Estimated Land Size.
24	The Manitoba Advantage Report, 1995 (3rd Edition) - Human Resources, Pages 39-40.
25	Natural Gas Price and Calorific Value per Centra Gas Ltd. - January 30, 1996.
26	The Manitoba Advantage Report, 1995 (3rd Edition) - Production Costs, Page 22.

MANITOBA FLOAT PROJECT FEASIBILITY STUDY
SOURCE / REFERENCE FOR DATA INPUTS & ASSUMPTIONS

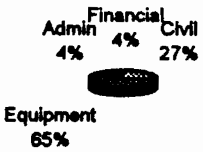
REFERENCE CODE	REFERENCE / SOURCE
27	The Manitoba Advantage Report, 1995 (3rd Edition) - Human Resources, Page 34.
28	Electricity Price and Demand Charge per Manitoba Hydro Ltd. - January 30, 1996.
29	ITC Estimates Based Upon The Manitoba Advantage Report, 1995 (3rd Edition) - Human Resources, Page 40.
30	Manitoba Department of Finance - January 30, 1996.
31	ITC Estimates for Glass Sales and Pricing Based Upon Customer Surveys, Dec 1995 - Jan 1996
32	ITC Identified Market Nodes and Shipping Costs Based Upon Supplier Quotes
33	ITC Estimate of Product Mix Based Upon Identified Market and Customer Surveys
34	ITC Library: Typical Packaging Costs
35	Financing Based Upon Assumption of 20% Investor Equity with Balance as 10Yr Commercial Bank Loan
36	Interest Rates Suggested by Manitoba Department of Finance - January 30, 1996.

MANITOBA FLOAT PLANT STUDY

ESTIMATE

Budget Summary **Budget Summary**

Item	Description	Local Source (CAD)	Imported (USD)	TOTAL (CAD)	TOTAL USD
	Civil & Infrastructure				
00	Land & Civil Works	$13,700,000	$0	$13,700,000	$10,000,000
10	Utilities	4,856,930	2,811,000	8,708,000	6,356,204
20	Buildings	9,390,000	0	9,390,000	6,854,015
	Subtotal	$27,946,930	$2,811,000	$31,798,000	$23,210,219
	Process Equipment				
30	Batch Plant	$2,191,000	$2,200,000	$5,205,000	$3,799,270
35	Cullet Return System	273,840	968,000	1,600,000	1,167,883
40	Melting Furnace & Emmissions	4,164,640	18,128,000	29,000,000	21,167,883
49	Chimney	1,190,820	14,000	1,210,000	883,212
50	Float Bath	4,508,500	7,950,000	15,400,000	11,240,876
60	Atmosphere Supply	480,000	0	480,000	350,365
70	Annealing Lehr	365,400	5,080,000	7,325,000	5,346,715
80	Cutting Line	1,231,165	6,495,500	10,130,000	7,394,161
85	Material Handling Equipment	890,500	800,000	1,986,500	1,450,000
90	Administration Equipment	143,000	0	143,000	104,380
91	Maintenance Equipment	320,000	0	320,000	233,577
92	Laboratory Equipment	9,500	950,000	1,311,000	956,934
93	Misc. Vehicles	144,000	0	144,000	105,109
	Subtotal	$15,912,365	$42,585,500	$74,254,500	$54,200,365
	Management & Adminstration				
95	Project Management	$0	$1,500,000	$2,055,000	$1,500,000
96	Client Staff & Development	2,000,000	0	2,000,000	1,459,854
97	Civil, M&E Design Engr.	150,000	0	150,000	109,489
98	Heat-Up Equip. & Services	100,000	200,000	374,000	272,993
99	Consultants/ Tech. Assist.	50,000	0	50,000	36,496
	Subtotal	$2,300,000	$1,700,000	$4,629,000	$3,378,832
	Subtotal Project	$46,159,295	$47,096,500	$110,681,500	$80,789,416
	Financial Costs				
410	Interest During Construction	$5,192,000	$0	$5,192,000	$3,789,781
420	Contingency	0	0	0	0
	Subtotal	$5,192,000	$0	$5,192,000	$3,789,781
	TOTAL BUDGET	$51,351,295	$47,096,500	**$115,873,500**	**$84,579,197**



MANITOBA FLOAT PLANT STUDY ESTIMATE

BASE DATA

Interest Rate / Equity Pct.	8.50%	20.00%
Equity Amount	CAD	$22,136,000
Local Tax Rate	N/A	
Calculate Local Costs in	CAD	
Local Currency Abbreviation	CAD	
Local Currency Name	Dollars	
Country Name	Canada	
Local Labor Factor	100%	(Productivity)
Project Number	227	

LOCAL COSTS	CAD	USD
Unskilled Manhour	7.43	5.42
Skilled Manhour	21.47	15.67
Technician Manhour	30.00	21.90
Supervision Daily Expenses	62.00	45.26
Supervision Air Fares	1,000.00	729.93

CURRENCY EXCHANGE per USD		DATE
BEF		
USD	1	2-Jan-96
FRF		
DEM		
CAD	1.37	2-Jan-95
SIN		
YEN		
AUS		
NZD		
STR		
HKD		
CHF		
LIR		

MANITOBA FLOAT PLANT STUDY

ESTIMATE

30 Batch Plant	Bid 1	Bid 2	Bid 3	Sel	**Batch Plant** Selected Bid
Supplier					
Quotation Date	15-Nov-94				
Foreign Content	USD				CAD
01 Contract Package	$1,980,000			1	$2,712,600
02 Site Supervision	160,000			1	219,200
03 Spare Parts	60,000			1	82,200
Subtotal	$2,200,000				$3,014,000
Local Content	CAD				CAD
11 Steel Fabrication & Erection	$1,394,660			1	$1,394,660
12 Wear Plates	376,750			1	376,750
13 Engineering	71,240			1	71,240
14 Conveyors	73,980			1	73,980
15 Raw Material Handling	83,022			1	83,022
41 Shipping/Importation Costs	26,400			1	26,400
42 Installation Materials	13,700			1	13,700
43 Installation Labor	109,600			1	109,600
44 Supervision Travel & Living	41,648			1	41,648
Subtotal	$2,191,000				$2,191,000
Unskilled Manhour	4,731				
Skilled Manhour	2,366				
Technician Manhour	789				
Batch Plant Total				**CAD**	**$5,205,000**

MANITOBA FLOAT PLANT STUDY

ESTIMATE

		Bid 1	Bid 2	Bid 3	Sel	Selected Bid
35	**Cullet Return System**					**Cullet Return System**
	Supplier					
	Quotation Date	28-Nov-94				
	Foreign Content	USD				CAD
01	Basic Contract	$438,000			1	$600,060
02	Conveyors	480,000			1	657,600
03	Spare Parts	30,000			1	41,100
04	Site Supervision	20,000			1	27,400
	Subtotal	$968,000				$1,326,160
	Local Content	CAD				CAD
11	Contractor	$82,000			1	$82,000
12	Wear Plates	65,760			1	65,760
41	Shipping/Importation Costs	19,180			1	19,180
42	Installation Materials	27,400			1	27,400
43	Installation Labor	65,800			1	65,800
44	Supervision Travel & Living	13,700			1	13,700
	Subtotal	$273,840				$273,840
	Unskilled Manhour	2,840				
	Skilled Manhour	1,420				
	Technician Manhour	473				
Cullet Return System Total					**CAD**	**$1,600,000**

MANITOBA FLOAT PLANT STUDY

ESTIMATE

40 Melting Furnace & Emmissions	Bid 1	Bid 2	Bid 3	Sel	Melting Furnace & Emmissions Selected Bid
Supplier					
Quotation Date	7-Oct-94				
Foreign Content	USD				CAD
01 Contract Package	$4,400,000			1	$6,028,000
02 Refractories	9,020,000			1	12,357,400
03 Steel	385,000			1	527,450
04 Process Equipment	225,500			1	308,935
05 Site Supervision	935,000			1	1,280,950
06 Emmission Controls (ESP)	2,750,000			1	3,767,500
07 Spare Parts & Tools	412,500			1	565,125
Subtotal	$18,128,000				$24,835,360
Local Content	CAD				CAD
11 Refractories	$527,450			1	$527,450
12 Steel	331,540			1	331,540
13 Tools	105,490			1	105,490
14 Ductwork	150,700			1	150,700
15 Equipment Rental	170,560			1	170,560
16 Special Installation Material	126,650			1	126,650
41 Shipping/Importation Costs	685,000			1	685,000
42 Installation Materials	75,350			1	75,350
43 Installation Labor	1,827,500			1	1,827,500
44 Supervision Travel & Living	164,400			1	164,400
Subtotal	$4,164,640				$4,164,640
Unskilled Manhour	78,891				
Skilled Manhour	39,445				
Technician Manhour	13,148				
Melting Furnace & Emmissions Total				**CAD**	**$29,000,000**

MANITOBA FLOAT PLANT STUDY

ESTIMATE

49 Chimney	Bid 1	Bid 2	Bid 3	Sel	**Chimney** Selected Bid
Supplier					
Quotation Date	18-Nov-94				
Foreign Content	USD				CAD
01 Engineering	$14,000			1	$19,180
Subtotal	$14,000				$19,180
Local Content	CAD				CAD
11 Chimney Concrete	$548,000			1	$548,000
12 Chimney Lining	274,000			1	274,000
13 Electrical	122,600			1	122,600
14 Installation & Equipment	246,220			1	246,220
41 Shipping/Importation Costs				1	0
42 Installation Materials				1	0
43 Installation Labor	0			1	0
44 Supervision Travel & Living	0			1	0
Subtotal	$1,190,820				$1,190,820
Unskilled Manhour	0				
Skilled Manhour	0				
Technician Manhour	0				
Chimney Total				**CAD**	**$1,210,000**

MANITOBA FLOAT PLANT STUDY **ESTIMATE**

50 Float Bath

	Bid 1	Bid 2	Bid 3	Sel	Float Bath Selected Bid
Supplier	ITC				
Quotation Date	18-Dec-95				
Foreign Content	USD				CAD
01 Contract Package & Design	$3,000,000			1	$4,110,000
02 Refractories, Canal, Roof	$1,900,000			1	2,603,000
03 Mechical, Electrical & Instr.	2,200,000			1	3,014,000
04 Spare Parts	100,000			1	137,000
05 Site Supervision	750,000			1	1,027,500
Subtotal	$7,950,000				$10,891,500
Local Content	CAD				CAD
11 Fabricated Steel	$1,822,100			1	$1,822,100
12 Side Seals	41,100			1	41,100
13 Tools	68,500			1	68,500
14 Installation Material & Equip	440,000			1	440,000
15 Tin	1,370,000			1	1,370,000
41 Shipping/Importation Costs	137,000			1	137,000
42 Installation Materials	30,000			1	30,000
43 Installation Labor	494,000			1	494,000
44 Supervision Travel & Living	105,800			1	105,800
Subtotal	$4,508,500				$4,508,500
Unskilled Manhour	21,325				
Skilled Manhour	10,663				
Technician Manhour	3,554				
Float Bath Total				CAD	$15,400,000

MANITOBA FLOAT PLANT STUDY

ESTIMATE

60 Atmosphere Supply	Bid 1	Bid 2	Bid 3	Sel	**Atmosphere Supply** Selected Bid
Supplier					
Quotation Date	5-May-95				
Foreign Content	USD				CAD
01				1	$0
Subtotal	$0				$0
Local Content	CAD				CAD
11 N2 & H2 Supply Contract	$205,500			1	$205,500
12 Piping & Electrical	$164,400			1	164,400
13 Instrumentation	54,800			1	54,800
41 Shipping/Importation Costs				1	0
42 Installation Materials	7,350			1	7,350
43 Installation Labor	47,950			1	47,950
44 Supervision Travel & Living	0			1	0
Subtotal	$480,000				$480,000
Unskilled Manhour	2,070				
Skilled Manhour	1,035				
Technician Manhour	345				
Atmosphere Supply Total				**CAD**	**$480,000**

MANITOBA FLOAT PLANT STUDY ESTIMATE

70 Annealing Lehr	Bid 1	Bid 2	Bid 3	Sel	Annealing Lehr Selected Bid
Supplier					
Quotation Date	5-Nov-94				
Foreign Content	USD				CAD
01 Contract Package & Equip.	$2,460,000			1	$3,370,200
02 Lehr Drive	870,000			1	1,191,900
03 Lehr Rollers	1,272,000			1	1,742,640
04 Speed Control Panel	144,000			1	197,280
05 Instrumentation	90,000			1	123,300
06 Site Supervision	144,000			1	197,280
07 Spare Parts	100,000			1	137,000
Subtotal	$5,080,000				$6,959,600
Local Content	CAD				CAD
11 Ductwork	$13,700			1	$13,700
12 Insulation	6,850			1	6,850
13 Grease and Oils	9,590			1	9,590
41 Shipping/Importation Costs	137,000			1	137,000
42 Installation Materials	20,550			1	20,550
43 Installation Labor	150,310			1	150,310
44 Supervision Travel & Living	27,400			1	27,400
Subtotal	$365,400				$365,400
Unskilled Manhour	6,489				
Skilled Manhour	3,244				
Technician Manhour	1,081				
Annealing Lehr Total				**CAD**	**$7,325,000**

MANITOBA FLOAT PLANT STUDY

ESTIMATE

80 Cutting Line	Bid 1	Bid 2	Bid 3	Sel	**Cutting Line** Selected Bid
Supplier					
Quotation Date	5-Nov-94				
Foreign Content	USD				CAD
01 Contract Package	$5,335,000			1	$7,308,950
02 Site Supervision	522,500			1	715,825
03 Thickness Measuring	517,000			1	708,290
04 Spare Parts	121,000			1	165,770
Subtotal	$6,495,500				$8,898,835
Local Content	CAD				CAD
11 Control Room	$34,250			1	$34,250
12 Steel Structure	20,550			1	20,550
41 Shipping/Importation Costs	750,000			1	750,000
42 Installation Materials	36,365			1	36,365
43 Installation Labor	375,000			1	375,000
44 Supervision Travel & Living	15,000			1	15,000
Subtotal	$1,231,165				$1,231,165
Unskilled Manhour	16,188				
Skilled Manhour	8,094				
Technician Manhour	2,698				
Cutting Line Total				**CAD**	**$10,130,000**

MANITOBA FLOAT PLANT STUDY

ESTIMATE

85 Material Handling Equipment	Bid 1	Bid 2	Bid 3	Sel	**Material Handling Equipment** Selected Bid
Supplier					
Quotation Date	1-Dec-94				
Foreign Content	USD				CAD
01 Overhead Cranes	$300,000			1	$411,000
02 Front End Loaders	250,000			1	342,500
03 Forktrucks	250,000			1	342,500
Subtotal	$800,000				$1,096,000
Local Content	CAD				CAD
11 Storage and Handling Racks	800,000			1	$800,000
12 Local Assembly	$90,500			1	90,500
41.00 Shipping/Importation Costs				1	0
42.00 Installation Materials				1	0
43.00 Installation Labor	0			1	0
44.00 Supervision Travel & Living	0			1	0
Subtotal	$890,500				$890,500
Unskilled Manhour	0				
Skilled Manhour	0				
Technician Manhour	0				
Material Handling Equipment Total				**CAD**	**$1,986,500**

MANITOBA FLOAT PLANT STUDY

ESTIMATE

Equipment Summary

Equipment Summary

Item	Description	Local Source (CAD)	Imported (USD)	TOTAL CAD	TOTAL USD
90	Administration Equipment	$143,000	$0	143,000	$104,380
91	Maintenance Equipment	320,000	0	320,000	233,577
92	Laboratory Equipment	9,500	950,000	1,311,000	956,934
93	Misc. Vehicles	144,000	0	144,000	105,109
	TOTAL	$616,500	$950,000	1,918,000	$1,400,000

MANITOBA FLOAT PLANT STUDY

ESTIMATE

90 Administration Equipment **Administration Equipment**

	Bid 1	Bid 2	Bid 3	Sel	Selected Bid
Supplier					
Quotation Date	26-Sep-94				
Foreign Content	USD				CAD
01				1	$0
Subtotal	$0				$0
Local Content	CAD				CAD
11 Office Furniture	$23,000			1	$23,000
12 Computer Equipment	60,000			1	60,000
13 Telephone Equipment	30,000			1	30,000
14 Office Equipment	30,000			1	30,000
41 Shipping/Importation Costs				1	0
42 Installation Materials				1	0
43 Installation Labor	0			1	0
44 Supervision Travel & Living	0			1	0
Subtotal	$143,000				$143,000
Unskilled Manhour	0				
Skilled Manhour	0				
Technician Manhour	0				
Administration Equipment Total					$143,000

MANITOBA FLOAT PLANT STUDY ESTIMATE

91 Maintenance Equipment — Maintenance Equipment

	Bid 1	Bid 2	Bid 3	Sel	Selected Bid
Supplier					
Quotation Date	1-Dec-94				
Foreign Content	USD				CAD
01 Maintenance Machinery	$0			1	$0
Subtotal	$0				$0
Local Content	CAD				CAD
11 Maintenance Equipment	$270,000			1	$270,000
12 Maintenance Tools	50,000			1	50,000
41 Shipping/Importation Costs				1	0
42 Installation Materials				1	0
43 Installation Labor	0			1	0
44 Supervision Travel & Living	0			1	0
Subtotal	$320,000				$320,000
Unskilled Manhour	0				
Skilled Manhour	0				
Technician Manhour	0				
Maintenance Equipment Total					$320,000

MANITOBA FLOAT PLANT STUDY **ESTIMATE**

92 Laboratory Equipment **Laboratory Equipment**

	Bid 1	Bid 2	Bid 3	Sel	Selected Bid
Supplier					
Quotation Date	1-Dec-94				
Foreign Content	USD				CAD
01 Lab Equipment	$950,000			1	$1,301,500
Subtotal	$950,000				$1,301,500
Local Content	CAD				CAD
11				1	$0
41 Shipping/Importation Costs	9,500			1	9,500
42 Installation Materials				1	0
43 Installation Labor	0			1	0
44 Supervision Travel & Living	0			1	0
Subtotal	$9,500				$9,500
Unskilled Manhour	0				
Skilled Manhour	0				
Technician Manhour	0				
Laboratory Equipment Total					$1,311,000

MANITOBA FLOAT PLANT STUDY

ESTIMATE

93 Misc. Vehicles **Misc. Vehicles**

		Bid 1	Bid 2	Bid 3	Sel	Selected Bid
	Supplier					
	Quotation Date	11-Nov-94				
	Foreign Content	USD				CAD
01					1	$0
	Subtotal	$0				$0
	Local Content	CAD				CAD
11	Water Tank Truck	$60,000			1	$60,000
12	Car / Van	50,000			1	50,000
13	Handtrucks	34,000			1	34,000
41	Shipping/Importation Costs				1	0
42	Installation Materials				1	0
43	Installation Labor	0			1	0
44	Supervision Travel & Living	0			1	0
	Subtotal	$144,000				$144,000
	Unskilled Manhour	0				
	Skilled Manhour	0				
	Technician Manhour	0				
	Misc. Vehicles Total					**$144,000**

MANITOBA FLOAT PLANT STUDY

ESTIMATE

Civil Works Summary

Civil Works Summary

Item	Description	Local Source (CAD)	Imported (USD)	TOTAL CAD	TOTAL USD
01	Cost of Land	$1,370,000		1,370,000	$1,000,000
02	Clearing and Grading	121,200		121,200	88,467
03	Fencing	22,500		22,500	16,423
04	Roadways	412,500		412,500	301,095
05	Drainage	544,500		544,500	397,445
06	Excavation	813,400		813,400	593,723
07	Piling	1,335,000		1,335,000	974,453
08	Excavation Protection	61,400		61,400	44,818
09	Basements RC Work	3,529,800		3,529,800	2,576,496
10	Imported Soil	337,600		337,600	246,423
11	Chimney Foundation	84,200		84,200	61,460
12	Cullet Tunnels	848,000		848,000	618,978
13	Building Foundations	1,412,500		1,412,500	1,031,022
14	Floor Slabs	2,148,300		2,148,300	1,568,102
15	Material Storage RC Work	374,800		374,800	273,577
16	Cullet Storage RC Work	284,300		284,300	207,518
		$13,700,000	$0	$13,700,000	$10,000,000

MANITOBA FLOAT PLANT STUDY

ESTIMATE

Buildings Summary

Buildings Summary

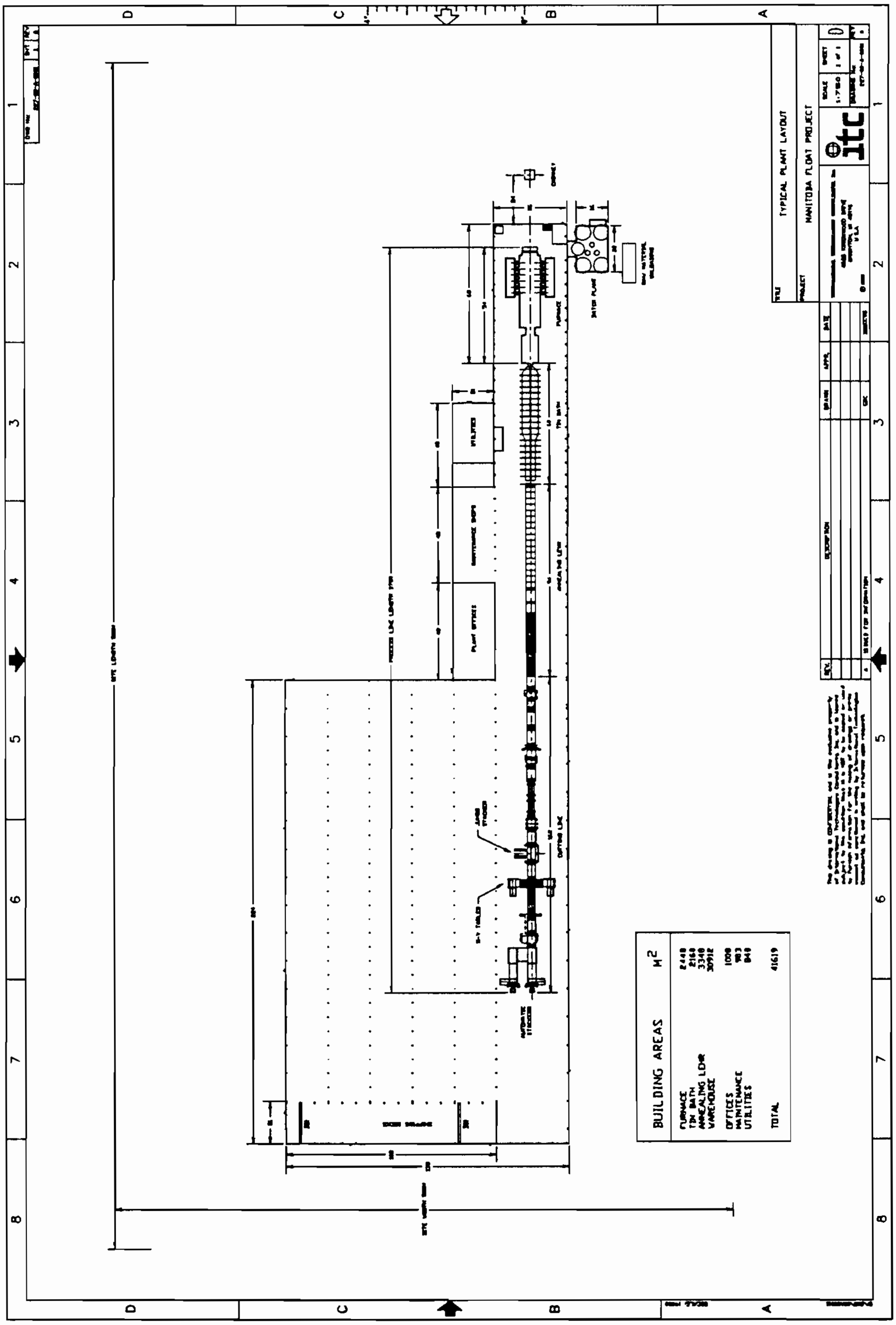
Item	Description	Local Source (CAD)	Imported (USD)	TOTAL CAD		TOTAL USD
21	Utilities Buildings	$972,000	$0	972,000		$709,489
22	Office/ Raw Materials/ Misc	1,489,000	0	1,489,000		1,086,861
23	Batch House	236,000	0	236,000		172,263
24	Furnace Building	1,061,000	0	1,061,000		774,453
25	Bath Building	471,000	0	471,000		343,796
26		0	0	0		0
27	Lehr Building	796,000	0	796,000		581,022
28	Cutting Line Building	794,000	0	794,000		579,562
29	Warehouse/Shipping	3,571,000	0	3,571,000		2,606,568
	TOTAL	$9,390,000	$0	9,390,000	0	$6,854,014

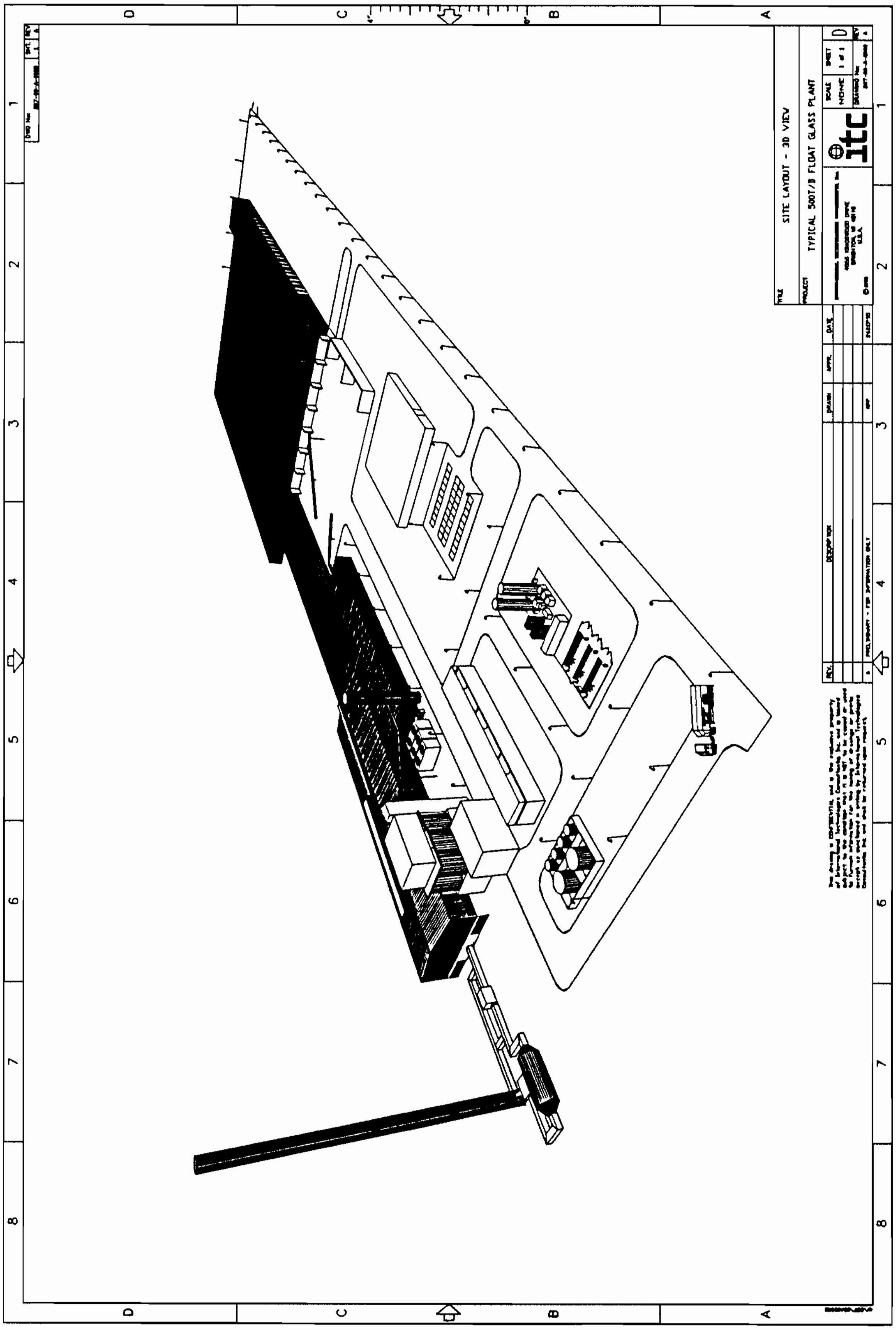
MANITOBA FLOAT PLANT STUDY

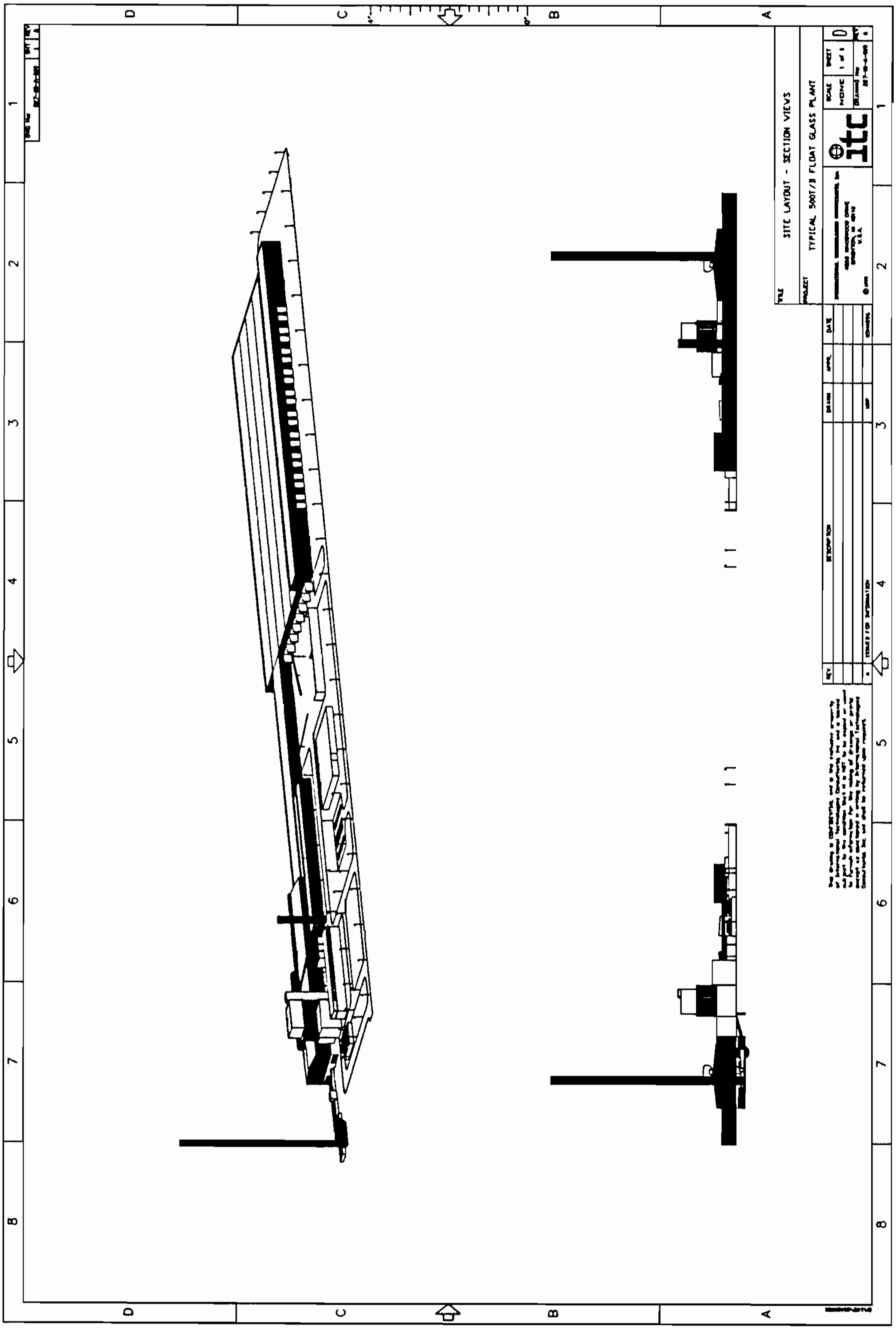
ESTIMATE

Utilities Summary **Utilities Summary**

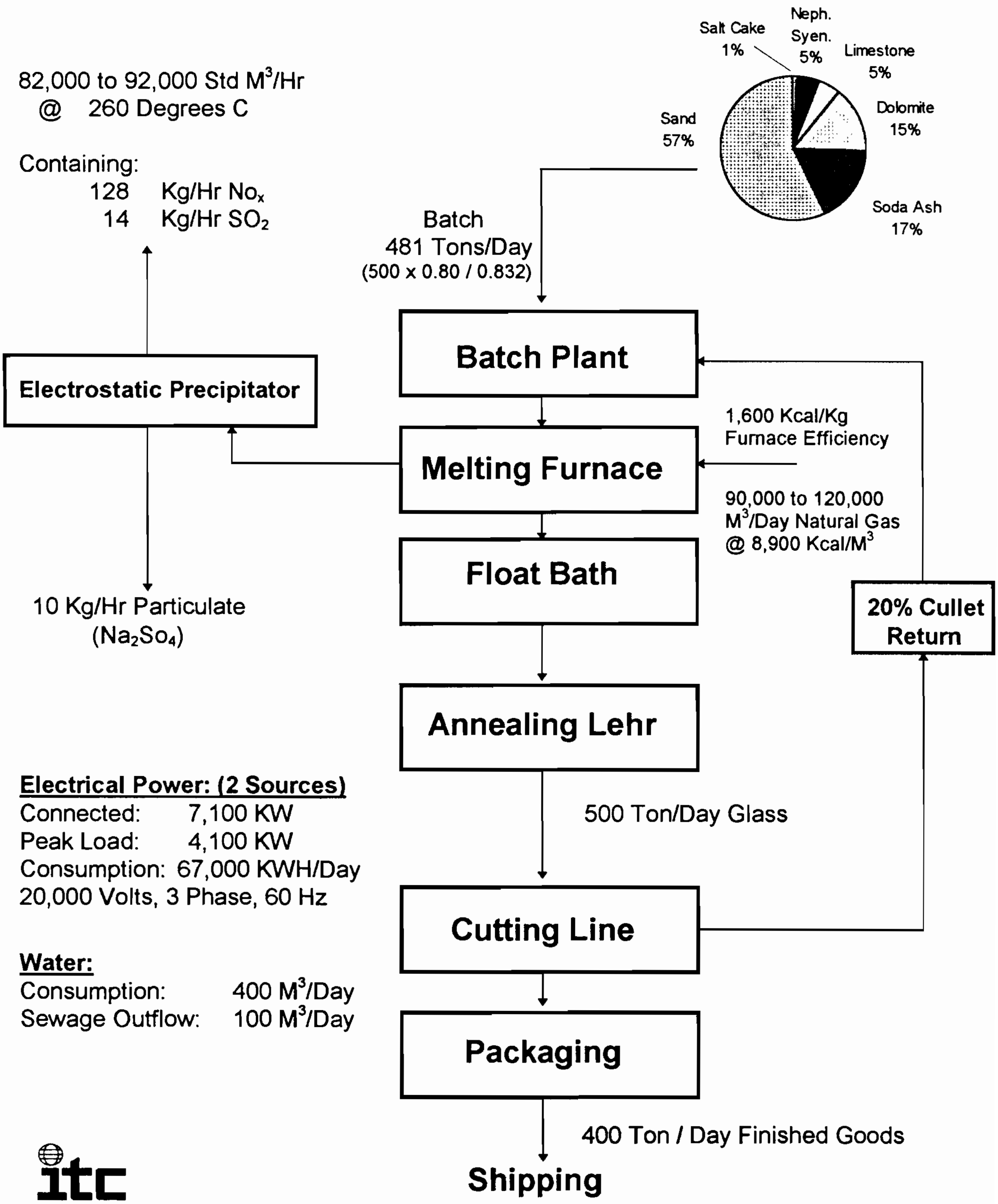
Item	Description	Local Source (CAD)	Imported (USD)	TOTAL CAD	TOTAL USD
10	Electric Systems	$2,616,700	$1,040,000	4,041,500	$2,950,000
11	Compressed Air System	369,900	275,000	746,650	545,000
12	Cooling Water	787,750	700,000	1,746,750	1,275,000
13				0	0
14	Potable Water/Treatment	141,110	200,000	415,110	303,000
15	Fuel Systems	489,090	43,000	548,000	400,000
16	Fire Protection	117,820	20,000	145,220	106,000
17	Drainage and Sewage (Not Including Civil Works)	131,800	35,000	179,750	131,204
18	HVAC	153,440	0	153,440	112,000
19	Plant Control System	49,320	498,000	731,580	534,000
	TOTAL	$4,856,930	$2,811,000	8,708,000	$6,356,204


TYPICAL PLANT LAYOUT
MANITOBA FLOAT PROJECT
itc
BUILDING AREAS
M2
FURNACE
TIN BATH
ANNEALING LEHR
WAREHOUSE
OFFICES
MAINTENANCE
UTILITIES
TOTAL
41619


SITE LAYOUT - 3D VIEW
TYPICAL 500T/D FLOAT GLASS PLANT
itc


SITE LAYOUT - SECTION VIEWS
TYPICAL 500T/D FLOAT GLASS PLANT

Process Flow Diagram



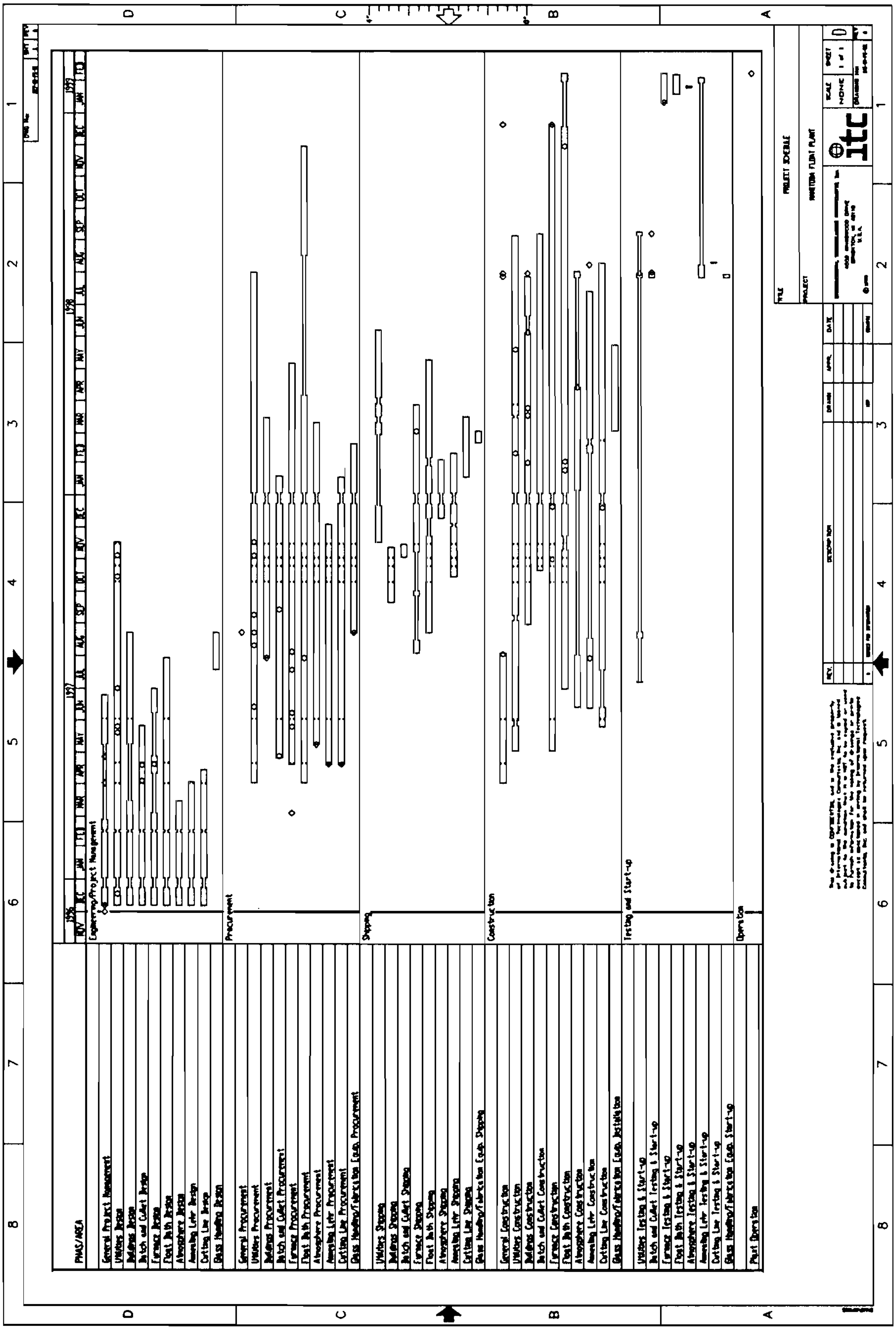
Batch Components in % for Flat Glass Production

Sep. 1992

Material	Chemical Designation	Batch %	Prime Content	SiO2	Al2O3	Fe2O3	CaO	MgO	Na2O	K2O	SO3	TiO2	BaO	SrO	L.O.I.								Total L.O.I
															SO3	P2O5	N	F	CO2	H2O	NaCl	Minor	
Sand	SiO2	57.50	99.473	99.473	0.200	0.025	0.020	0.100	0.100	0.050		0.022										0.100	0.100
Soda Ash	Na2CO3	17.50	99.200			0.007	0.011	0.005	58.018						0.011				41.190		0.198	0.560	41.959
Dolomite	Ca Mg CO3	14.70	98.000	0.240	0.050	0.230	30.500	21.200											46.300	1.000		0.480	47.780
Nepheline Syenite	SiO2-Al2O3	4.70	56.000	56.000	23.800	0.100	1.300		7.900	9.000		0.100	0.300	0.300		0.100		0.004			0.016	1.080	1.200
Limestone	CaCO3	4.50	98.000	0.420	0.110	0.090	54.910	0.470							0.040				43.100			0.860	44.000
Salt Cake	Na2SO4	1.03	99.800			0.003	0.003	0.002	43.542		22.524				33.585					0.100	0.100		33.785
Rouge	Fe2O3	0.04	97.500	1.500	0.700	97.500	0.020	0.020				0.050										0.210	0.210
Carbon	C	0.03	98.200												0.800		1.000		98.200				100.000
Batch (fictituous)	%	100.00		59.884	1.246	0.097	7.029	3.196	11.030	0.452	0.232	0.017	0.014	0.014	0.350	0.005	0.0003	0.0002	15.983	0.148	0.036	0.316	16.839
Batch (converted)	%	120.25		72.011	1.498	0.117	8.452	3.843	13.264	0.544	0.279	0.020	0.017	0.017	0.421	0.006	0.0004	0.0002	19.220	0.178	0.043	0.380	20.249
Batch	T / Day	481.00		288.04	5.992	0.468	33.808	15.372	53.056	2.176	1.116	0.080	0.068	0.068	1.684	0.024	0.002	0.001	76.880	0.712	0.172	1.520	80.995

Float Batch Physical Characteristics

Material		% (Typical) Composition	Sieve Analysis	% Retained
Sand (SiO2)	SiO2	99.71	20	---
	Al2O3	0.108	30	0.5
	Fe2O3	0.109	40	4.9
	TiO2	0.012	50	17.6
	Cr	---	70	32.7
	CaO	0.008	100	28.3
	MgO	0.004	140	12.4
			200	2.8
			Pan	0.8
Soda Ash (Na2CO3)	Na2CO3	99.7	20	0.24
	Na2O	58.4	30	1.2
	NaCl	0.002	40	14.55
	Na2SO4	0.003	70	60.86
	Fe	2 ppm	100	17.77
	H2O	0.15	200	1.64
			Pan	0.91
Dolomite (CaO, MgO)	CaO	30.81	10	0.77
	MgO	21.04	12	7.59
	SiO2	0.18	16	35.4
	Fe2O3	0.06	20	29.45
	Al2O3	0.05	30	13.79
			40	4.22
			70	5.51
			100	1.27
			140	0.69
			200	0.56
			Pan	0.86
Limestone (CaCO3)	CaO	54.7	16	0.18
	MgO	0.58	20	6.25
	SiO2	0.45	50	58.57
	Al2O3	0.17	100	23.74
	Fe2O3	0.08	200	9.73
	SO3	0.08	Pan	1.53
	Na2O	0.04		
	K2O	0.03		
	TiO2	0.02		
Aragonite (CaCO3)	CaO	54.3	20	2.0
	SiO2	0.04	30	3.0
	Fe2O3	0.02	40	15.0
	Al2O3	0.02	50	18.0
	MgO	0.23	70	20.0
	Mn	0.005	100	20.0
	Sr	0.1 - 1.0	140	15.0
	S	0.14	200	6.0
	NaCl	0.25	Pan	1.0
Salt Cake (Na2SO4)	NaO2	43.62	20	0.7
	ZnO	0.142	40	0.8
	NaCl	0.033	60	0.7
	NaHCO3	0.037	100	11.7
	Na2CO3	0.038	200	41.7
	MgO	0.005	Pan	44.4
	H2O	0.018		



Float glass manufacturing

Dean E Wiley and Larry D Borman
International Technologies Consultants Incorporated

History of glass

If one were to take a handful of dirt, apply enough heat to cause it to melt, then allow it to cool, a crude form of glass would be produced. The earliest glass was most likely created accidentally by the burning of grain and the subsequent fusion of the ash, as the result of a fire caused by lightning. Although the dates are disputed by archeologists sometime between 12 000 BC and 4000 BC man first made glass for use as a decorative glaze for small beads. Later, around 2500 BC small solid glass objects were first made.

The first glass containers were made by the Egyptians in about 1000 BC by forming the glass around a clay mould and then chipping away the clay, a very difficult and time consuming procedure. For this reason these items were considered a luxury and were carefully preserved from generation to generation. It took the invention of the blowpipe, which occurred between 300 BC and 20 BC, to reveal the true capabilities of glass and make possible the quantity production of glass articles in shapes and designs which were not previously possible.

Window glass was first produced at the end of the 3rd Century by casting glass on top of a large flat stone. In principle, this "batch" production of flat glass changed little until the 20th Century when two technological revolutions occurred. The first, which started in 1913, was the invention of the continuous draw sheet glass process. The second, which we will later discuss in detail, was the development of float glass technology which first appeared commercially in the late 1950's.

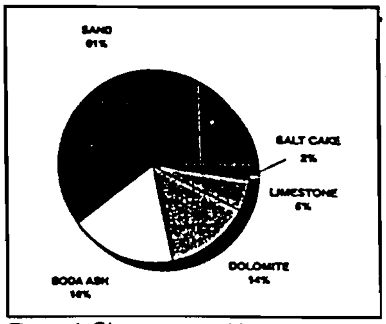


Figure 1. Glass composition.

Properties

Glass, as understood and recognised by the general public, is a hard transparent, brittle material with a relatively high softening point, substantially insoluble in water and organic solvents, and non-inflammable in the usual sense. From a more technical point of view glass is defined as an inorganic product of fusion which has been cooled to a rigid condition without crystallisation. This definition emphasises the point that glass is noncrystalline with a random molecular orientation at normal temperature. Although this molecular structure resembles a fluid, glass displays the hardness and rigidity of a solid.

When heated glass does not show a melting point like crystalline materials. Glass gradually softens into a fluid as the bonds between the atoms break at different temperatures instead of all breaking at the same temperature, which happens in a crystalline material. Because there is no single melting point, the behaviour of glass is often discussed in terms of viscosity or resistance to flow.

Composition

There are over a thousand chemical formulations for glass, each with its own combination of properties. However, all glasses have some properties in common — they are hard, perfectly elastic, brittle, non-conductors of electricity and chemically stable.

Most glass, including flat glass, contains three types of constituents — formers, fluxes, and network modifiers. Sand (silicon dioxide SiO_2) is used as the former which is the basis of the glassy, non-crystalline structure. In order to form a mixture with the silica which has a lower melting point than silica alone, soda ash (Na_2CO_3) is used as a flux. Lime ($CaCO_3$) and dolomite

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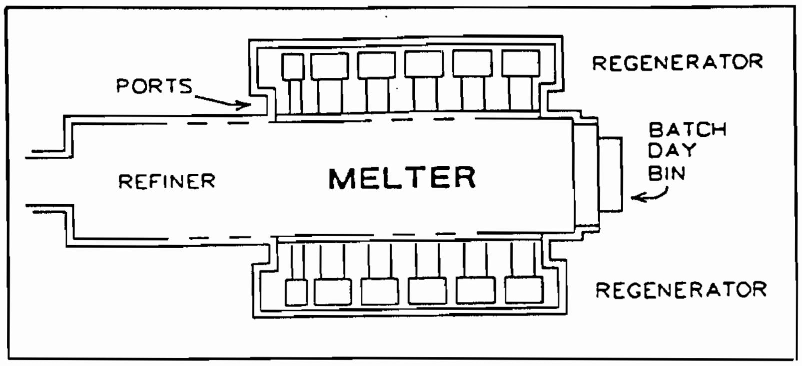

Figure 2. Typical melting furnace.

($CaCO_3$-$MgCO_3$) are the network modifiers which are used to stabilise the chemical properties of the glass.

Glassmaking

There has been little change in the basic steps of glassmaking over the past few centuries, only refinements in the techniques. These basic steps are mixing, melting, forming and annealing. For flat glass production an additional step, cutting of the glass, is necessary.

Mixing

The batch plant is the centre of all activity relating to the raw materials. First, the raw materials are unloaded from the delivery trucks and are stored in large vertical silos by a system of conveyors and an elevator. The batch plant will typically have enough storage capacity to support between 7 and 28 days of production.

Using an automatic, computer controlled batch system, the raw materials are weighed and gathered into batches according to preset formulas. Electronic scales with accuracy within 1 per cent provide a consistent mix of raw materials which is important to producing a high quality product. During the mixing process the ingredients are combined in a mechanical mixer in which all ingredients become uniformly distributed. Recycled scrap glass called cullet is added to aid in the melting process by softening at a temperature lower than the melting point of the batch ingredients. A batch will normally contain 20 per cent cullet.

After mixing the batch is conveyed to the furnace building on a conveyor and stored in a day bin above the batch charger. This day bin stores enough batch for 8 hours production to allow for normal maintenance or repairs to the batch plant equipment.

Melting

The typical melting furnace is a Six Port Cross Fired Regenerative furnace with a capacity of 500 metric tons per day. Major sections of the furnace — melter, refiner, regenerators, and ports, are shown in Figure 2.

Constructed of specialised refractory material with an outside steel framework, the melter has an area measuring 15m x 7.5m (112.5m²) with a glass depth of 1100mm. The melter operates at an internal temperature of approximately 1550°C (2822°F) to melt the raw materials. During normal operation the mixed raw materials are fed into the melter from the blanket batch charger at the charging end. The raw materials float on top of the molten glass melting as the flow moves forward towards the refiner. Convection, currents, which arise in the glass through the heating of the flames and cooling by side walls and batch, help make the melt homogeneous by stirring action.

Melter combustion

A regenerative furnace is designed to utilise the waste heat gas developed during the burning of fuel to preheat the air required for combustion. This operation, which results in a substantial improvement in fuel economy, is accomplished by the use of regenerators.

For this example we shall start with the melter firing from the North side. The fuel, which can be either natural gas or fuel oil, is ignited in special burners located under each port. In the North firing cycle only the burners located on the North side are used. The fuel is mixed with combustion air entering the ports from the North regenerator at a controlled fuel/air ratio.

As the fuel leaves the burners it is ignited by the intense heat of the melter and burns in continuous flames extending into the melter area from each port (on the North side). This combustion above the pool of glass maintains the melter at a controlled temperature for melting the batch.

The waste combustion products flow across the melter and exit through the South ports into the South regenerator. Regenerators are refractory structures with an area of 11m x 3m and a height of 10m. Inside the regenerators a matrix of refractory bricks is stacked from the bottom up to the port level. The waste gasses enter the South regenerator from the top and pass through the matrix of bricks to the bottom. At the bottom a refractory lined canal carries the waste gases through a reversing valve which is open to the chimney for exhaust. As the waste gases pass through the regenerator bricks (called checkers), the bricks are heated reaching a temperature in excess of 650°C (1200°F) at the bottom of the regenerators and up to 1320°C (1950°F) at the top.

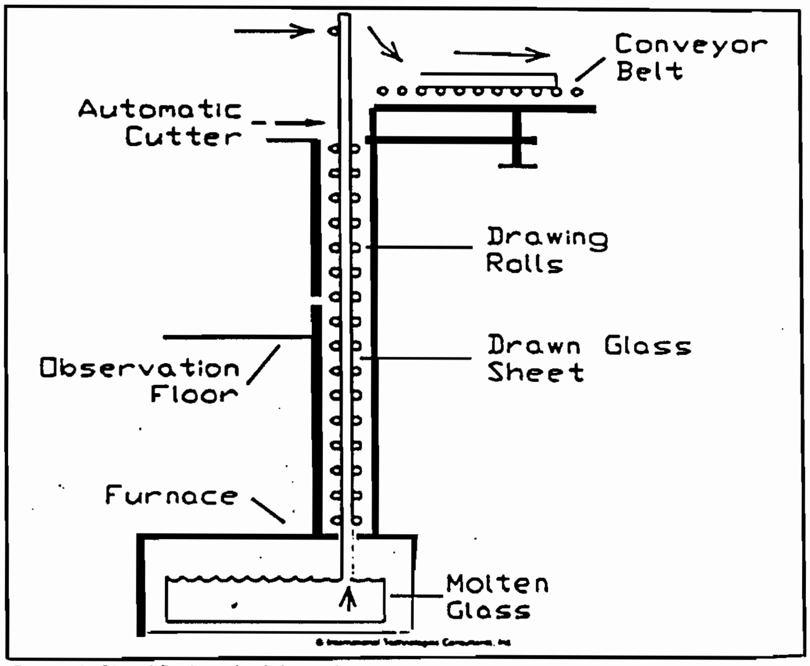

Figure 3. Simplified vertical draw sheet process.

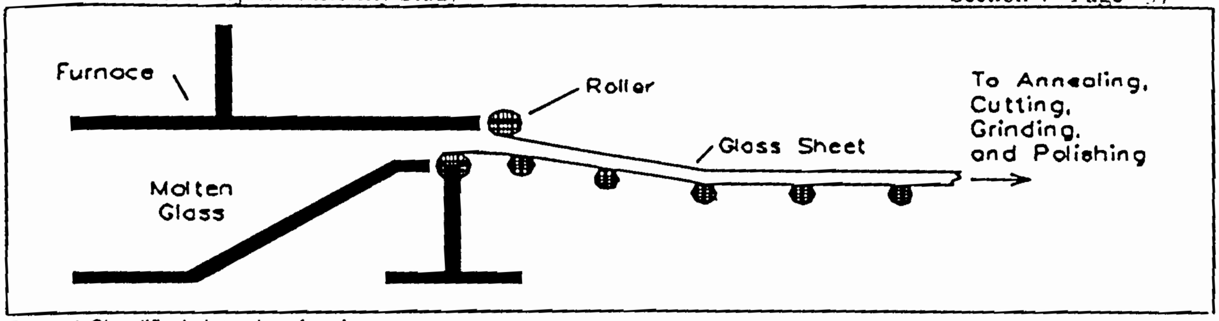

Figure 4. Simplified plate glass forming process.

Once the checkers on the South side have reached their maximum temperature, the firing of the melter is reversed to utilise this stored heat. First the fuel to the North burners is shut-off by reversal fuel valves. After a few seconds delay to purge the melter of waste gas, the reversing valve located in the canal changes position. In the new position the bottom of the South regenerator will be opened to outside air, and the bottom of the North regenerator will be opened to the chimney. Fresh air will now be drawn up through the heated South checkers into the melter from the South ports. Fuel will be turned on for the South burners for combustion with the preheated air now taking place from the South side and the waste gases exiting into the North regenerator and checkers and subsequently out to the chimney.

Thus the operation of a regenerative furnace is to periodically change the direction of firing from side to side to utilise the waste gases of combustion to preheat the air required for further combustion. The furnace will reverse its firing direction every 20 minutes. The total reversing cycle is completed in less than 30 seconds and has no effect on the glass temperature.

Refiner

The refiner is an extension of the melter with an area of 12m × 7.5m (93.75m^2). The purpose of the refiner is to start a gradual cooling and stabilisation of the glass as it passes to the working end.

Working End

The working end is a separate refractory chamber with an area of 12m × 6.5m (78.0m^2) and a glass depth of 950mm. The molten glass passes from the refiner into the working end via a waist connecting the two chambers. This is to prevent any carryover of batch particles or combustion contaminants from the melter into the working end and to establish the all important horizontal, laminar flow pattern.

The purpose of the working end is to condition the glass for the forming process by controlled cooling of the glass temperature from 1315°C at the entrance to 1065°C at the exit.

Forming technology

Flat glass is formed by one of three manufacturing methods: Sheet Glass, Plate Glass or Float Glass. The first two will be briefly reviewed before Float Glass is examined in detail.

Sheet Glass

Sheet Glass refers to clear flat transparent glass with a fire finish which is produced by a vertical drawing process. It is commonly known in the industry as "window glass" or "machine glass". Prior to the invention of the float process sheet glass was the most common method for production of glass for glazing in windows in domestic buildings and in the production of laminated and heat strengthened glass products.

Sheet glass is produced by a vertical draw process. For drawing sheet glass, a rod called a bait, is pulled upward from a pool of molten glass in the working end. A sheet of glass follows the bait, and drawing rollers pull the sheet until it is of the desired thickness. The sheet hardens to a fire-polished finish as it is pulled upwardly to the drawing rolls. It is gradually cooled, or annealed, as it passes through the drawing rolls to the cutting equipment at the top of the draw. Once the sheet glass emerges from the drawing machine it is a finished product with no further operations necessary prior to shipment. Thicknesses from 2mm to 6mm can be produced by the vertical draw process.

Plate Glass

Plate Glass is defined as transparent flat glass having plane polished surfaces and showing no distortion of vision in transmitted or reflected light. The rolling, grinding and polishing operations distinguish plate glass from sheet or float glass. Plate glass was traditionally used for higher quality applications including automotive wind screens, mirrors, and glazing for commercial applications.

For rolling a stream of molten glass is squeezed between rollers. Even with the smoothest possible rollers the surface quality of rolled glass is not adequate for high quality use. Hence, the rolled glass is transported through a laborious grinding and polishing operation to restore the smooth, plane and parallel surfaces and transparency required for plate glass.

Float Glass

Float Glass is produced by floating the molten glass on a bath of heavy metal. During the passage over the length of the bath the hot glass assumes the perfect flatness of the bath and develops excellent thickness uniformity. In pure economic terms manufacturing by way of the float glass process is the only viable method of producing flat glass, and the method has completely replaced the other production methods.

Float Glass Technology

The float bath is a refractory lined steel chamber containing over 150 tons of pure tin. The bath is 6m wide and 50m in length. The molten tin is at an average temperature of 800°F (1472°F), heated primarily by the latent heat of glass entering the bath. Electric heating elements are located in the roof of the bath to heat the tin during start-up operations and to provide makeup heating as required.

Several different metals were investigated for use in the bath with tin having the best results. The criteria for the selection of the bath metal are:

- The metal must be liquid in a temperature range from 1100°C to 530°C — the temperature range in which glass is formed from a molten state to a nearly hardened state
- It must be denser than glass so the glass will float on top of the metal, and
- It must be relatively unreactive with glass and must not "wet" the glass. This is to prevent a carryover of the metal out of the float tank by adhering to the glass.

Although tin meets all of the above criteria, there is one problem associated with tin — it rapidly oxidises when exposed to oxygen in its molten state. To solve this problem the bath atmosphere is carefuly controlled at a positive pressure with nitrogen. As a precaution a small amount of hydrogen is also added to the bath atmosphere. The hydrogen will change any oxygen which enters the bath into water vapour. At the exit end of the bath a curtain is placed jsut over the surface of the glass ribbon to restrict the flow of the positive atmosphere from the bath. Even with this small opening there is enough escape to completely change the bath atmosphere several times an hour.

The metal walls of the float bath are cooled by cooling fans to keep the temperature below 93°C (200°F). As this is far below the 232°C (450°F) freezing point of tin, any tin leaking through the refractory lining will freeze and prevent any further leakage.

Float Forming

The basic float process is to pour the molten glass onto the tin bath surface at the front of the bath and gently pulling the ribbon out the other end. During the transition through the bath the temperature of the glass is gradually reduced from the entering temperature of 1095°C (2003°F) to a temperature of 600°C (1110°F) at the exit. At the exit of the bath the glass is cooled to a point where dimensional stability is obtained.

When molten glass is poured on the tin surface an interesting phenomenon occurs. Gravitational force tends to spread the glass over the surface while at the same time a surface tension effect tends to contract it. The equilibrium of these two forces produces a constant glass thickness of just over 6mm. Thus little additional effort is required to produce glass of 6mm.

For other thicknesses the speed at which the ribbon is pulled through the bath is changed. For glass thicknesses less than 6mm the speed is increased to stretch the glass as it is pulled through the bath. Unfortunately as the ribbon is pulled at a greater speed, in addition to forming thinner glass the ribbon tends to become narrower as it is stretched. To solve this problem top roll machines are placed at several locations along the bath.

The water-cooled toothed wheel of each top roll machine grips the ribbon near each edge. The wheels are positioned at an angle with the ribbon to present a vectorial force on the ribbon to stretch it both lengthwise and horizontally thus controlling both the thickness and width of the ribbon.

During the production of glass less than 4mm the rapid movement of the glass over the tin does tend to create a movement of the tin through the bath. This is undesirable for two reasons. Firstly, the tin will flow into the far end of the float tank causing streams of different temperatures in the tin which in turn causes temperature differences (and thickness variations) in the glass. Secondly, the movement of the tin toward the end causes the temperature at the exit end to become excessively high. To counteract this problem submerged dams, weirs and deep tin pockets as well as linear motors are used to control the movement of tin through the bath.

To produce glass with a thickness greater than 6mm the flow through the bath is slowed creating the effect of a dam. Water cooled graphite guides and 'reverse stretch', or altering the angle and speed of the top rolls are used along the sidewalls to prevent outward flow of the glass. Using this process, glass up to 25mm has been produced and glass of 12-18mm is produced routinely.

Annealing

When the ribbon leaves the float bath the glass is at a temperature of 600°C. If this newly formed glass were allowed to cool freely, the surfaces would cool more rapidly than the interior. As a result, at a certain temperature the surfaces would become rigid while the interior remains somewhat fluid. As the interior cools further, it cannot adjust to the surfaces, which are already hard and shrunken through thermal contraction. This condition will cause a harmful stress to be present in the glass. To avoid this condition an annealing lehr is used to cool the glass from 600°C to 70°C in a controlled manner.

The annealing lehr is a metal structure 6m wide and 120m long. Special rollers and a sophisticated temperature control system are provided to accomplish the controlled cooling. Electric heaters are used within the lehr to help keep the edges of the ribbon from cooling more rapidly than the centre.

The end result of the annealing process is glass which has been carefully cooled to 70°C without the induction of temporary or residual stresses.

Cutting System

The final manufacturing process for float glass is the automatic cutting equipment which cuts the glass ribbon into pre-specified sizes. The ribbon is cut in both length and width by the system which scores the glass with oil-lubricated metal wheel cutters. The glass is then broken along the score with snap rollers to make a clean "cut".

The largest sizes produced by a typical float plant are called Jumbo's and measure 3.2 by 6 metres, after allowing for trim loss of the edge from the 3.5 metres ribbon.

Included in the cutting system is a computer controlled defect monitor which locates defects in the ribbon before they reach the cutters. The computer will optimise the cutting in the area of the defect to reduce waste.

The final function of the cutting system is to stack the finished sheets on frames or cases for transport to the warehouse or shipping trucks. Shipping methods vary by region and product. The large sheets of glass which are the most common product in central Europe are shipped on 'A' frames inside specially designed "Innenladers of Freightlines". In Scandinavia transportation of goods relies more heavily on ships where there container based 'A' frame system is designed for water transport. □

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