Cleaner Production Assessment

in

Glass Sector

सत्यमेव जयते

Department of Forests and Environment
(Government of Gujarat)

Submitted by:

Gujarat Cleaner Production Centre
(Established by Industries & Mines Department, Government of Gujarat)

March 2016

***Title**: Cleaner Production Assessment in Glass Sector*
***Prepared in:** March, 2016*

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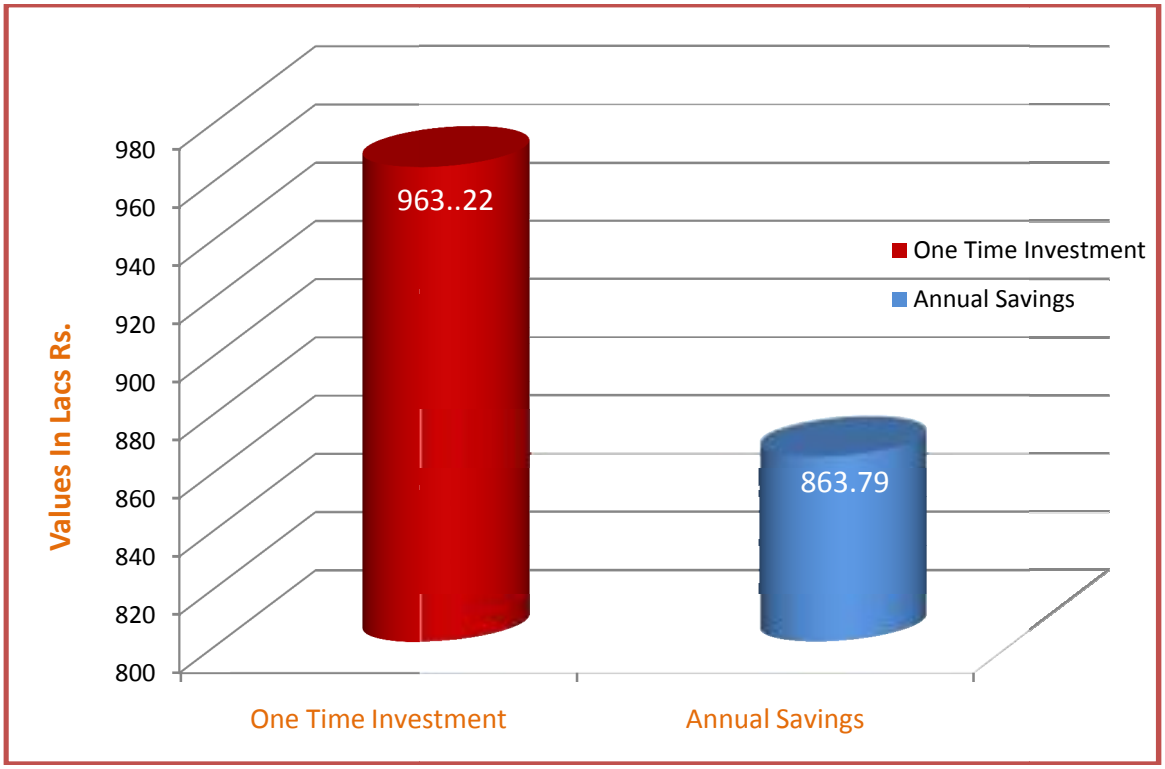
EXECUTIVE SUMMARY

Overall Achievable Financial Benefit from

'Cleaner Production Assessment in Glass Sector'

(One Time Investment vs. Annual Savings Indicator)

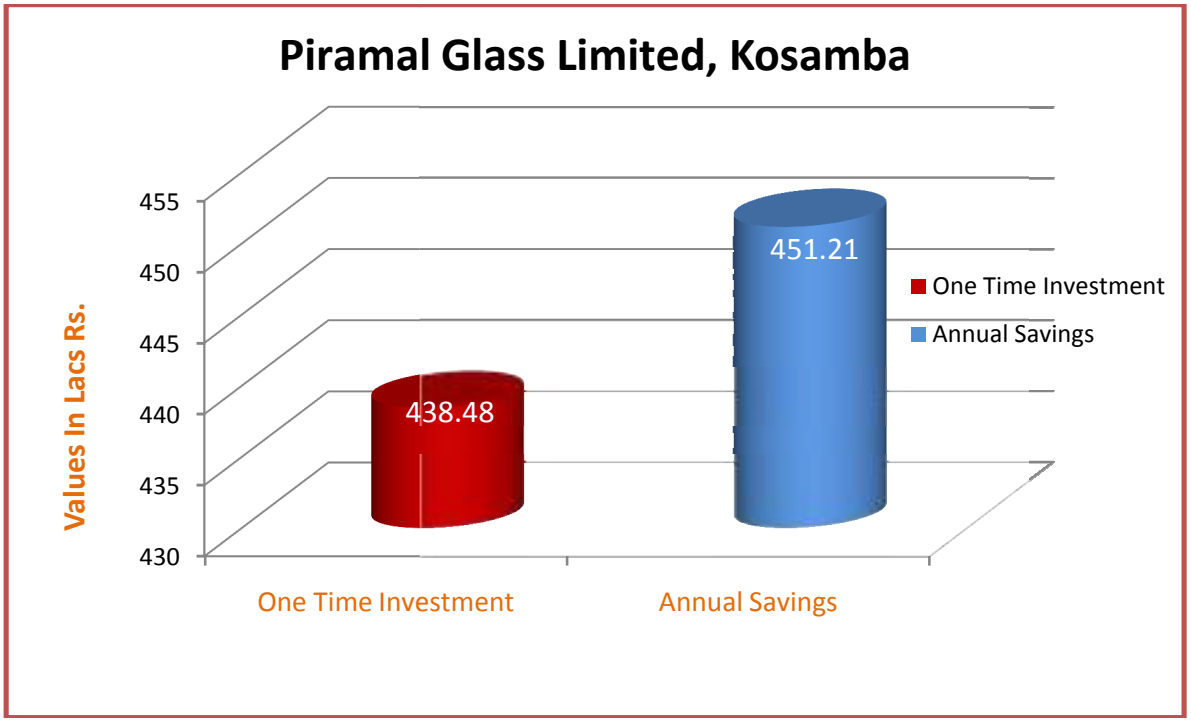


One Time Investment = 963.22 Lacs Annual Savings = 863.79 Lacs

Payback Period= 13 Months

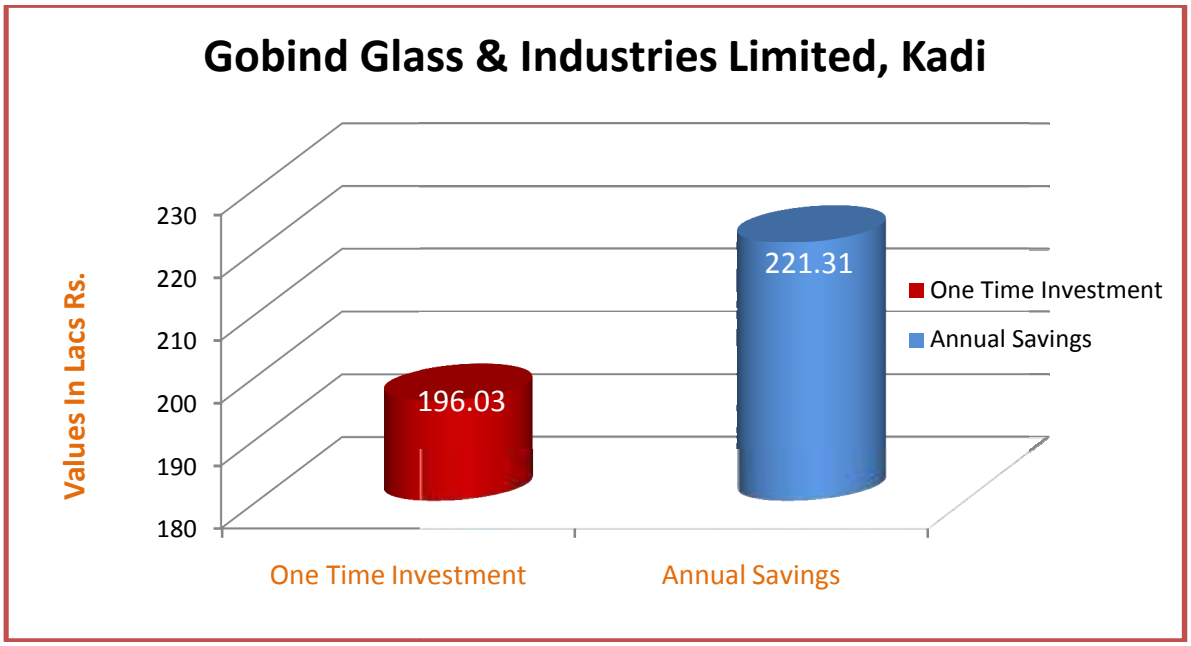
Industry wise achievable financial benefits

(One Time Investment vs. Annual Savings Indicator)



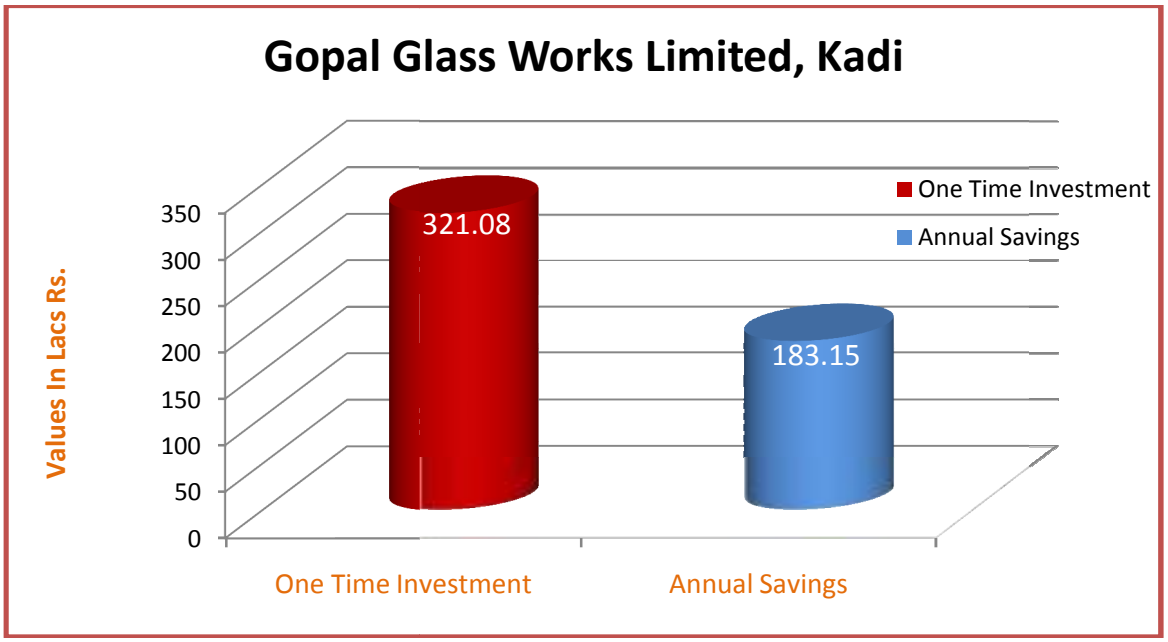
One Time Investment = 438.84 Lacs Annual Savings = 450.86 Lacs

Payback Period = 12 Months



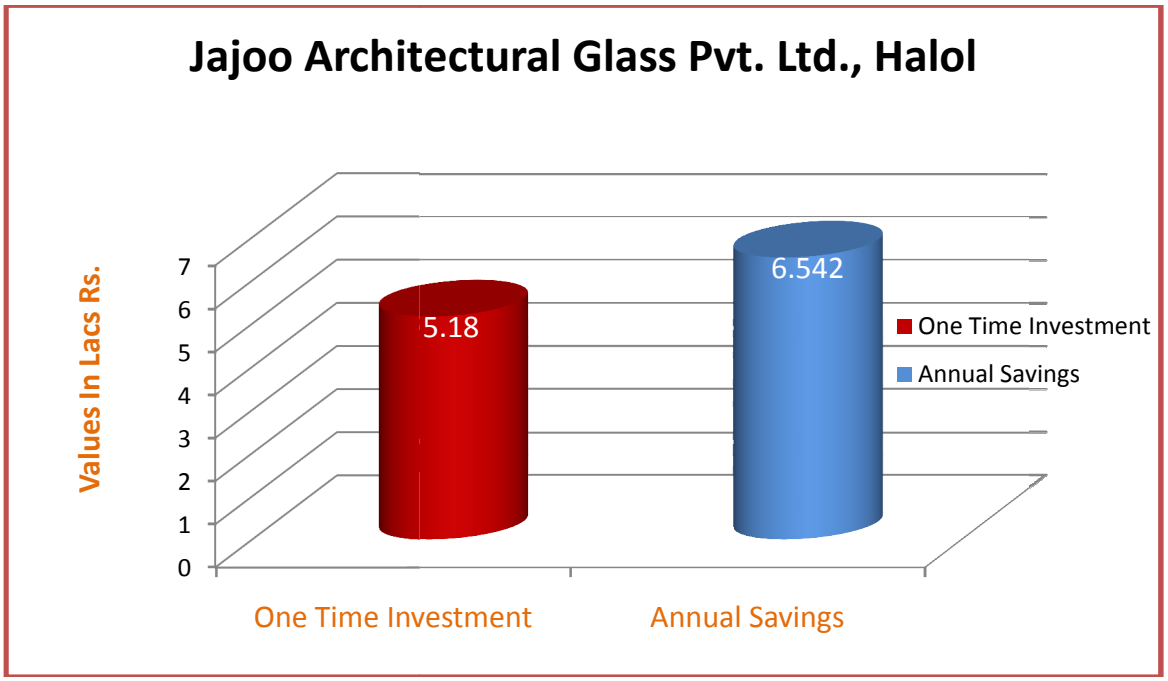
One Time Investment = 196.03 Lacs Annual Savings = 221.31 Lacs

Payback Period = 11 Months



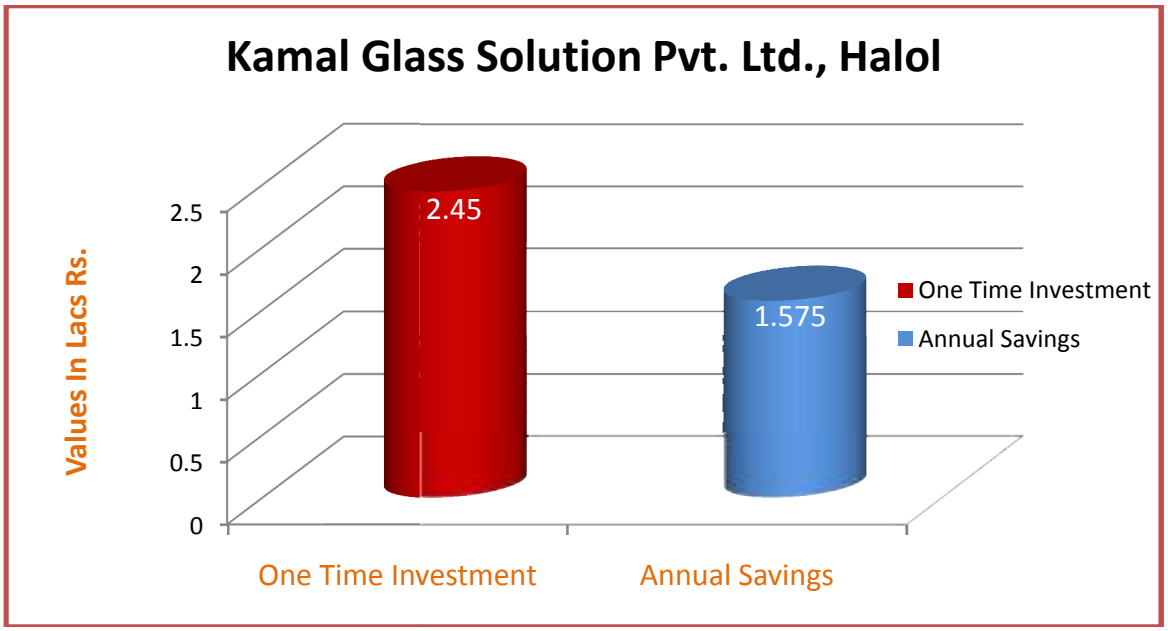
One Time Investment = 321.08 Lacs Annual Savings = 183.15 Lacs

Payback Period = 21 Months



One Time Investment = 5.18 Lacs Annual Savings =6.542 Lacs

Payback Period= 10 Months



One Time Investment = 2.45 Lacs Annual Savings = 1.575Lacs

Payback Period= 18 Months

Industry wise Regression Analysis of expected saving of resources from this Project							
Sr. No.	Suggested Energy Saving Option	Resource Saved	Quantity of Savings per annum (with unit)	One Time Investment (in INR)	Annual Savings (in INR)	Payback Period (in Months)	Reduction in GHG annually
1. Piramal Glass Limited, Kosamba, Surat							
1	Optimisation of ToU Charges by Rescheduling Non-critical Load	Electricity	N/A	Nil	18,31,000	Immediate	N/A
2	Availing Night Concession by Rescheduling Electrical Consumption in Night Hours	Electricity	N/A	Nil	1,91,31,000	Immediate	N/A
3	Compressed Air Saving Guns for Cleaning Stations per station)	Electricity	U/A	3,000	21,000	3	U/A
4	Reducing Fluctuating Compressed Air Demand	Electricity	U/A	6,00,000	4,97,000	15	U/A
5	Optimisation of	Natural	2,80,524 SCM	30,00,000	50,49,000	8	525.42 MT

	Combustion Efficiency at Melting Furnaces	Gas					GHG
6	Installation of Variable Frequency Drive (VFD) In Furnace Blower Motor	Electricity	U/A	2,45,000	2,80,800	10	U/A
7	Optimisation of Gas Consumption through Oxygen Enhanced Combustion in Furnaces	Natural Gas	7,18,063 SCM	2,50,00,000	1,29,25,000	24	1344.93 MT GHG
8	Optimisation of Gas Consumption through Batch & Cullet Preheating	Natural Gas	14,96,616 SCM	1,50,00,000	53,87,000	34	2803.16 MT GHG
2. Gopal Glass Works Limited, Kadi							
9	Optimisation of ToU Charges by Rescheduling Non-critical Load	Electricity	N/A	Nil	87,058	Immediate	N/A
10	Availing Night Concession by Rescheduling Electrical Consumption in Night Hours	Electricity	N/A	Nil	10,74,427	Immediate	N/A

11	Installation of Variable Frequency Drive (VFD) In Cooling Blower Motor	Electricity	9,450 KWh	50,000	71,253	9	8.13MT GHG
12	Compressed Air Saving Guns for Cleaning Stations per station)	Electricity	U/A	3,000	21,000	3	U/A
13	Optimise the Power Consumption at Cooling Water Pump	Electricity	50,400 KWh	55,000	3,80,016	2	43.34 MT GHG
14	Optimisation of Combustion Efficiency at Melting Furnaces	Natural Gas	3,46,149 SCM	20,00,000	51,92,000	5	648.34 MT GHG
15	Optimisation of Gas Consumption through Oxygen Enhanced Combustion in Furnaces	Natural Gas	5,74,513 SCM	2,20,00,000	86,17,695	30	1076.06 MT GHG
16	Optimisation of Gas Consumption through Batch & Cullet Preheating	Natural Gas	9,57,522 SCM	80,00,000	28,72,000	34	1793.44 MT GHG
3. Gobind Glass & Industries Limited, Kadi							

17	Optimisation of ToU Charges by Rescheduling Non-critical Load	Electricity	N/A	Nil	1,69,461	Immediate	N/A
18	Availing Night Concession by Rescheduling Electrical Consumption in Night Hours	Electricity	N/A	Nil	2,64,524	Immediate	N/A
19	Installation of Variable Frequency Drive (VFD) In Cooling Blower Motor	Electricity	5,208 kWh	25,000	39,000	8	4.48 MT GHG
20	Compressed Air Saving Guns for Cleaning Stations per station)	Electricity	U/A	3,000	21,000	3	U/A
21	Optimise the Power Consumption at Cooling Water Pump	Electricity	33,600 KWh	75,000	2,43,000	4	28.90 MT GHG
22	Optimisation of Combustion Efficiency at Melting Furnaces	Natural Gas& Furnace Oil	5,73,588 SCM & 1,05,813 Litre	25,00,000	1,10,00,000	3	1187.55 MT GHG
23	Optimisation of Gas Consumption through	Natural Gas &	4,30,191 SCM &	1,20,00,000	81,98,000	18	890.66 MT GHG

	Oxygen Enhanced Combustion in Furnaces	Furnace Oil	79,360 Litre				
24	Optimisation of Gas Consumption through Batch & Cullet Preheating	Natural Gas & Furnace Oil	1,43,397 SCM & 2,126 Litre	50,00,000	21,97,000	28	270.85 MT GHG
4. Jajoo Architectural Glass Pvt. Ltd., Halol, Panchmahal							
25	Avoid Compressed air usage for cleaning purposes	Electricity	U/A	3,000	21,000	3	U/A
26	Optimise the Electric Power at Washing Machine	Electricity	71,400 kWh	1,00,000	5,35,000	2	61.40 MT GHG
27	Optimise the Plant Lighting Load	Electricity	7,504 kWh	1,15,000	56,200	25	6.45 MT GHG
28	Solar Roof-Top System for Plant Lighting Load	Electricity	U/A	3,00,000	42,000	85	U/A
5. Kamal Glass Solution Pvt. Ltd., Halol, Panchmahal							
29	Optimise the Electric Power at Washing	Electricity	14,000 kWh	35,000	1,05,000	4	12.04 MT GHG

	Machine						
30	Optimise the Plant Lighting Load	Electricity	4,200 kWh	60,000	31,500	23	3.61 MT GHG
31	Solar Roof-Top System for Plant Lighting Load	Electricity	U/A	1,50,000	21,000	85	U/A

Abbreviations:

CP: Cleaner Production
INR: Indian Rupees
MT: Metric Ton
SCM: Standard Cubic Meter
KWh: Kilo Watt Hour
U/A: Unaccountable
N/A: Not Applicable
GHG: Green House Gas (CO_2)

TOTAL EXPECTED OUTCOME OF THE PROJECT

Cleaner Production Assessment in Glass Sector

Sr. No.	Resource Saved	Quantity of Savings per annum (with unit)	One Time Investment (in INR)	Annual Savings (in INR)	Average Payback Period (in Months)	Reduction in GHG
1	Natural Gas	55,20,563 SCM	7,20,00,000	6,14,37,695	14	10340 MT GHG
2	Furnace Oil	1,87,299Litre	1,95,00,000	2,46,76,368	10	639.70 MT GHG
3	Electricity	1,90,554 KWh	18,40,000	2,48,85,439	1	168.18 MT GHG

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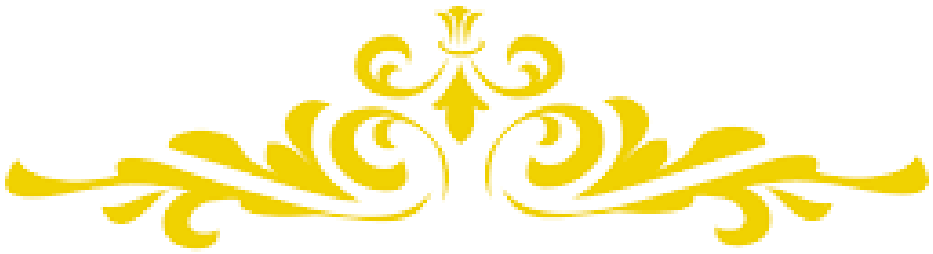

CHAPTER 1
ABOUT THE PROJECT

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Name of Project: Cleaner Production Assessment in Glass Sector

Project Target: Cleaner Production Assessment in 5 different industries from Glass Sector and prepare sector specific guidelines

Description: Glass manufacturing Industry is an inseparable part of the Indian Industrial Sector. Its contribution to the growth of the nation is noteworthy. The success stories are many, but the sector has still a long way to pass through for achieving a sustainable growth.

The Department of Forests and Environment, Government of Gujarat has awarded a Project "Cleaner Production Assessment in Glass Sector"to the Gujarat Cleaner Production Centre (GCPC), Gandhinagar, Gujarat, for carrying out Cleaner Production Assessment in the Glass Sector of Gujarat.

The objective of the project is to create Cleaner Production opportunities for improving resource efficiency and preventing the emissions to the air, water and land; with that, reducing the waste generation and creating better work environment. The target of the project is Cleaner Production Assessment in 5 different industries from Glass Sector; hence preparing sector specific guidelines.

In order to achieve the above mentioned objective, the activities to be undertaken are mentioned in the forthcoming part of the document.

CHAPTER 2
OBJECTIVE OF THE PROJECT

OBJECTIVE OF THE PROJECT

The purpose of Cleaner Production Assessment Project is to raise awareness of theenvironmental impacts associated with industrial and manufacturing processes, andto highlight the approaches that industry and government can take to avoid orminimize these impacts by adopting a Cleaner Production approach for achievingmultiplier effects.

The major focus area of CP studies will be reduction of the emissions to air, water and land and reducing the waste generation; hence creating cleaner and better work environment. Cleaner production is an ongoing, comprehensiveexamination of the operations of a facility; with the goal of minimizing all types ofwastes. This enhances economic growth and allows the industries to concentrate on providing better goods and services.

Glass industry has a huge scope of implementing cleaner production techniques. The increasing demand of glass products at global level has triggered the production rate of glass products in last a few years. To sustain in a global competitive market along with keeping environmental impacts in mind, industries have to implement techniques that may reduce the production cost, improve the production rate and most importantly, avoid waste generation.

The major environmental concern associated with the glass sector is the emissions to the air, water and generation of solid waste. Fortunately, the end products waste can be recycled successfully in this sector and industries have been practicing the same at well and good level, still scope of improvement is large. Emission to the air has been the most serious issue related to the glass sector. The air pollution is caused by the gases evolved during the combustion; however they contain harmful heavy metals too. This sector also requires tremendous amount of water for the cooling purposes, leading to the generation of waste water, and that too with high inorganic particles dissolved

in it. All such issues need to be resolved as soon as possible because the efficiency improvement of industries and prevention of the pollution are the two most important parameters attached with the sector.

Cleaner Production is an attractive approach to tackle environmental problemsassociated with industrial production and poor material efficiency. The cleanerproduction approaches were successfully implemented in other sectors also. It showsthat significant financial saving and environmental improvements can be made byrelatively low-cost and straightforward interventions. This improves the quality ofproducts and minimizes the cost of production, enabling the industry to compete inthe global market. Moreover, Cleaner Production also improves the company's publicimage by highlighting the steps it has taken to protect the environment.

The objectives specifically are as mentioned:

1. To perform cost saving through reduced wastage of both energy and materials
2. To perform cost saving on End-of-Pipe waste treatment
3. To improve operating efficiency of the plant
4. To increase product quality and consistency
5. To recover waste materials
6. To improve the work environment (Health and Safety of the workers)
7. To build capacity of glass industrial floor personnel
8. To develop new and improved market opportunities through waste exchange

CHAPTER 3
PROJECT ACTIVITIES

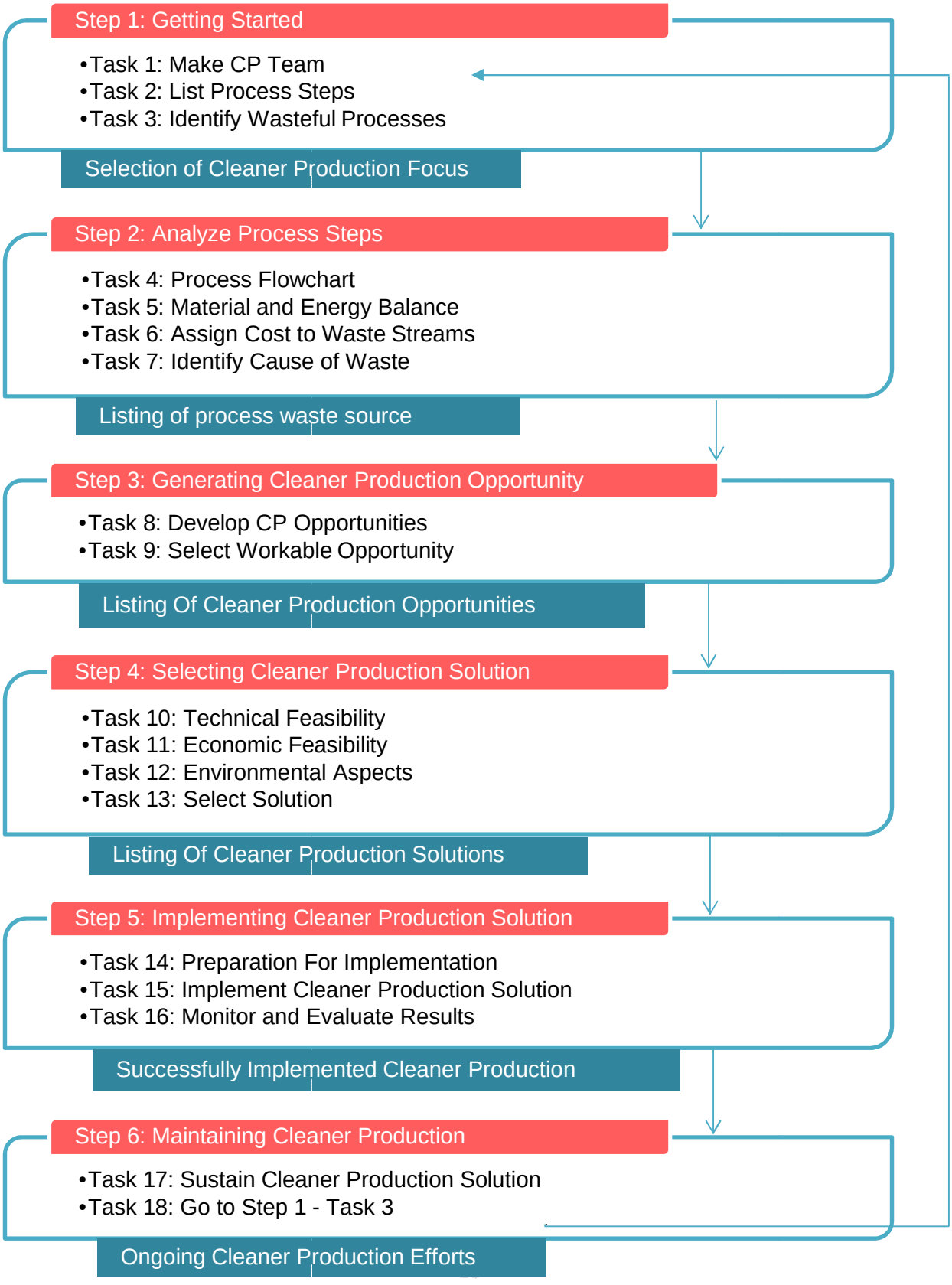
PROJECT ACTIVITIES

Scope of Work

Sr.No.	Activities
1.	Selection of Industrial Estate having glass sector
2.	Identification of sub-sector in glass industries
3.	Introductory meeting with Associations/Industries and identification of willing pilot industry for CP assessment
4.	Baseline Survey / Data Collection
5.	Detailed Cleaner Production Assessment
6.	Submission of Draft Assessment Report
7.	Submission of Final Report including Implementation Plan
8.	Dissemination of results

CHAPTER 4
METHODOLOGY FOR CP ASSESSMENT

METHODOLOGY FOR CLEANER PRODUCTION ASSESSMENT



CHAPTER 5
PRIMARY INTRODUCTION: GLASS SECTOR

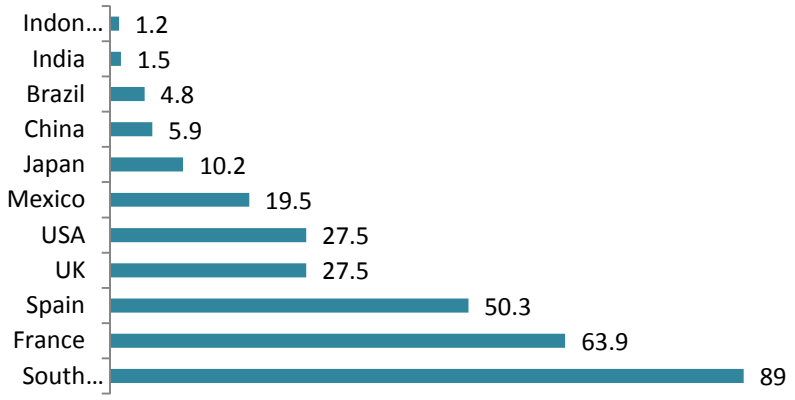
PRIMARY INTRODUCTION: GLASS SECTOR

Glass is an amorphous (non-crystalline) solid which is often transparent and has widespread practical, technological, and decorative usage in things like window panes, tableware, and optoelectronics. Mosttypes of glass are based on the chemical compound silica (silicon dioxide), the primary constituent of sand. Of the many silica-based glasses that exist, ordinary glass is formed from a specific type of composition, composed of approximately 75% silicon dioxide (SiO_2), sodium oxide (Na_2O)sodium carbonate (Na_2CO_3), calcium oxide (CaO), and several minor additives, mainly metallic oxides that serve as colouring agents. Glass products are used widely in households, construction, laboratories and consumer items such as bangles, beads, pearls, etc.

Glass Industry in India

According to Associated Chambers of Commerce and Industry of India (ASSOCHAM) The market size of Indian glass industry is expected to reach a worth Rs.340 billion by the end of 2015 as against estimated at Rs.225 billion in 2013. This is primarily fuelled by growth within the real estate, infrastructural development, retail sector, automotives sales and food & beverages sector.Per capita glass consumption has increased significantly in India from 0.58 kg to 1.5 kg; however it is still much lower as compared to other developing countries and much lower than China, where it stands at around 5.9 kg, USA 27.5 kg and South Korea 89 kg.

India's scenario: World Glass Container per capita consumption (in



(Source:http://www.derivatives.capitaline.com/newsdetails.aspx?sno=648664&opt=cn&secid=21&subsecid=155&SelDt=)

The glass industry in India is divided into two categories; viz.

1. Cottage Industry and
2. Factory industry

Under cottage industry, glass bangles, beads, pearls and other consumer items are made either in small furnaces either from glass blocks produced in factories; or from inferior glass manufactured from the impure sands of rivers and the efflorescent alkali. Flower pots, decorative glassware, tableware, lamps and lamp-ware are also produced under cottage industry. Cottage industry, though spread throughout the country, is mainly concentrated in Firozabad (UP) and Belgaum (Karnataka).

The factory industry is mostly confined to Uttar Pradesh, Maharashtra, West Bengal, Bihar, Jharkhand, Gujarat and Punjab. Glass industries in Uttar Pradesh mainly produce sheet glass, hollow and pressed wares (bulbs, chimneys, reflectors and motor headlights) while Bengal and Maharashtra are famous for glass tubes, test-tubes, beakers and flat glass. Punjab predominates in the production of hollowware and scientific and precision goods.

The consumption growth of glass in various sub-sectors, as expected, are: In construction 10-12%, Automotives20%, Consumer Goods 15-20% and Pharmaceuticals 15-18%.

The organized sector is dominated by large players like,

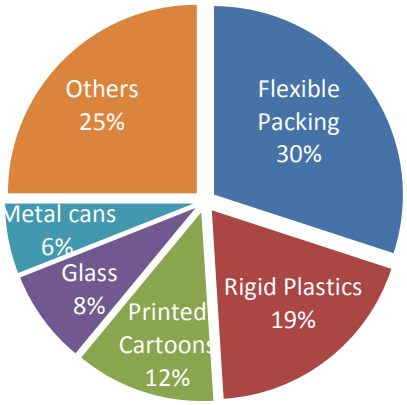
- ASAHI Glass India Ltd
- Hindustan National Glass & Industries ltd
- Piramal Glass
- Saint-Gobain India
- HSIL Ltd
- Owen Corning
- Triveni Glass
- Nippon Electric Glass
- Gujarat Borosil
- Sezal Glass

The organized sector of the glass industry employs about 3 million people directly and about half a million people indirectly. On the other hand, the unorganized sector employs around 5-6 lacs people largely consisting of unskilled workers. It is estimated that the overall glass industry employs more than 4 million people.

About 75% of the total glass industry is concentrated in Uttar Pradesh, Maharashtra, Gujarat, Karnataka and Andhra Pradesh. The highest share in the number of factories of the glass industry is secured by Uttar Pradesh with a share of 36.9%, followed by Gujarat at 15%, Andhra Pradesh and Tamil Nadu at 5.6% and Karnataka with 4%.

The glass packaging industry is facing tough competition from alternative medium. But with the key properties such as inertness, transparency, recyclability – glass will overcome the issues of fragility and bulkiness have which will enable the consumer to satisfying there changing needs.

Indian packaging industry is estimated to be Rs. 900 Billion, grown at 14-15% CAGR in past a few years. Indian glass market is only 8% of the overall Indian packaging industry and it is estimated to be around Rs. 7.2 billion. India is amongst the top 15 markets for glass packaging globally & 3rd fastest growing market after Turkey and Brazil. The following diagram depicts the use of glass products in the packaging industry in India. (Source: A study report on Evolution of Glass Industry in India: Challenges and Future Scenario by HNGIL, India)



The latest challenge being faced by Indian glass manufacturer is increasing prices of the raw material which is an important component in the process of glass manufacturing. The increase in the price of raw materials is affecting the bottom line of the glass manufacturing companies.

It further highlighted that around 1.3 pounds (0.58967 Kg) waste is generated per person per day in India, whereas it is 4.6 pounds(2.08652 Kg) in the US. Glass recycling was very high in developed countries at 70-80 per cent. In Denmark, 98 per cent of bottles are refillable and 98 per cent of those are returned to consumers. However, in India, only 40-45 per cent of the finished

product comes for recycling and the rest goes for land filing. Recycling saves 10-20 per cent energy, 30 per cent air pollution and improves furnace efficiency by 20 per cent.

The largest conglomerate of small scale glass manufacturing units is located in Firozabad. We have 3 clusters of glass beads which are located in Purdilnagar, Hathras (UP), Banaras (UP) and Nathdwara (Rajasthan).

Firozabad Cluster, Uttar Pradesh

Almost the entire small-scale glass industry in India is located within a single cluster in Firozabad, about 40 km from Agra. Each day, MSME units in Firozabad produce around 2000 tonnes of glass products, including 50 million bangles, and provide direct employment to an estimated 150,000 people. Besides having a near monopoly in the production of bangles, the Firozabad glass cluster also produces popular low-value glass products (bowls, tumblers, lamp shades, and so on). Glass for making bangles is melted mainly in open-pot furnaces. Till the mid-1990s, the 80-odd traditional pot furnaces in Firozabad were poor in design and coal-fi red, resulting in very low levels of operating efficiency and high levels of CO2 and particulate emissions.

In December 1996, when the Supreme Court ordered 292 industries located in the Taj Trapezium zone—including the coal fired pot furnace units in Firozabad—to switch over to natural gas (NG) to protect the Taj Mahal in Agra from environmental pollution. The Supreme Court also directed GAIL India Ltd to supply NG to industries in the region.

The coal-fired pot furnace units were plunged into a crisis following the Supreme Court's verdict, because there were no readily available designs for NG-fired pot furnaces at that point of time. Closure of these units would have disrupted the entire bangle-making industry, and threatened the livelihoods of thousands of workers.

Glass Beads in Purdilnagar(Hathras)

There is a growing demand for Glass Beads in the country in India. Glass Beads are being manufacture at Purdilnagar and Varanasi in U.P.; however some superior quality beads are imported. There is good scope talking up manufacture of Glass Beads in any part of the country. Glass Beads have good export potential, as demand for these beads is increasing in foreign countries.

Purdilnagar is famous for glass beads making not only in India but also all over the world. Purdilnagar is also known as Shrangar Nagar. Glass Beads of Purdilnagar are supplied all over India and abroad. They can start their work of glass bangles making for their living.

The beads of Purdilnagar are used for manufacturing of Jewelry, art ware goods and other decorative items. The manufacturing of Glass Beads in Purdilnagar is in unorganized sector. Approximately, more than 15000 individual small artisans are engaged in the manufacturing of glass beads and other glass products with traditional craft at their residence/homes.

Glass Industry in Gujarat

Majority of the glass manufacturing industries of Gujarat have evolved at a cottage industry level and then developed to organized level. Gujarat has some large industries like, Sezal Glass – Jhagadia – Bharuch, Haldyn Glass – Vadodara, Saint Gobain – Jhagadia, Hindustan Nation Glass & Industries Ltd. – Halol, Piramal Glass – Kosamba&Jambusar, Gujarat Guardian Ltd. – Ankleshwar.

HNG Float Glass Limited is a HNG group company incorporated in Halol (Gujarat) in 2006. The company has an installed capacity of 600 tonnes per day.

Piramal glass manufactures glass bottles for specialty food and beverages. In India, Piramal glass has two major facilities at Kosamba and Jambusar(Gujarat). The Kosamba facility with 6 furnaces has combined capacity of 340 tonnes per day. The Jambusar facility with a capacity of 355 tonnes per day is one of the world's largest installed capacity for pharmaceutical packaging in amber glass.

Gujarat Guardian Ltd., Ankleswar, Gujarat, is the first company to set up float glass plant in India produces 550 tons per day; it is a joint venture between Guardian Industries International Corporation of the United States and India's Modi Group.

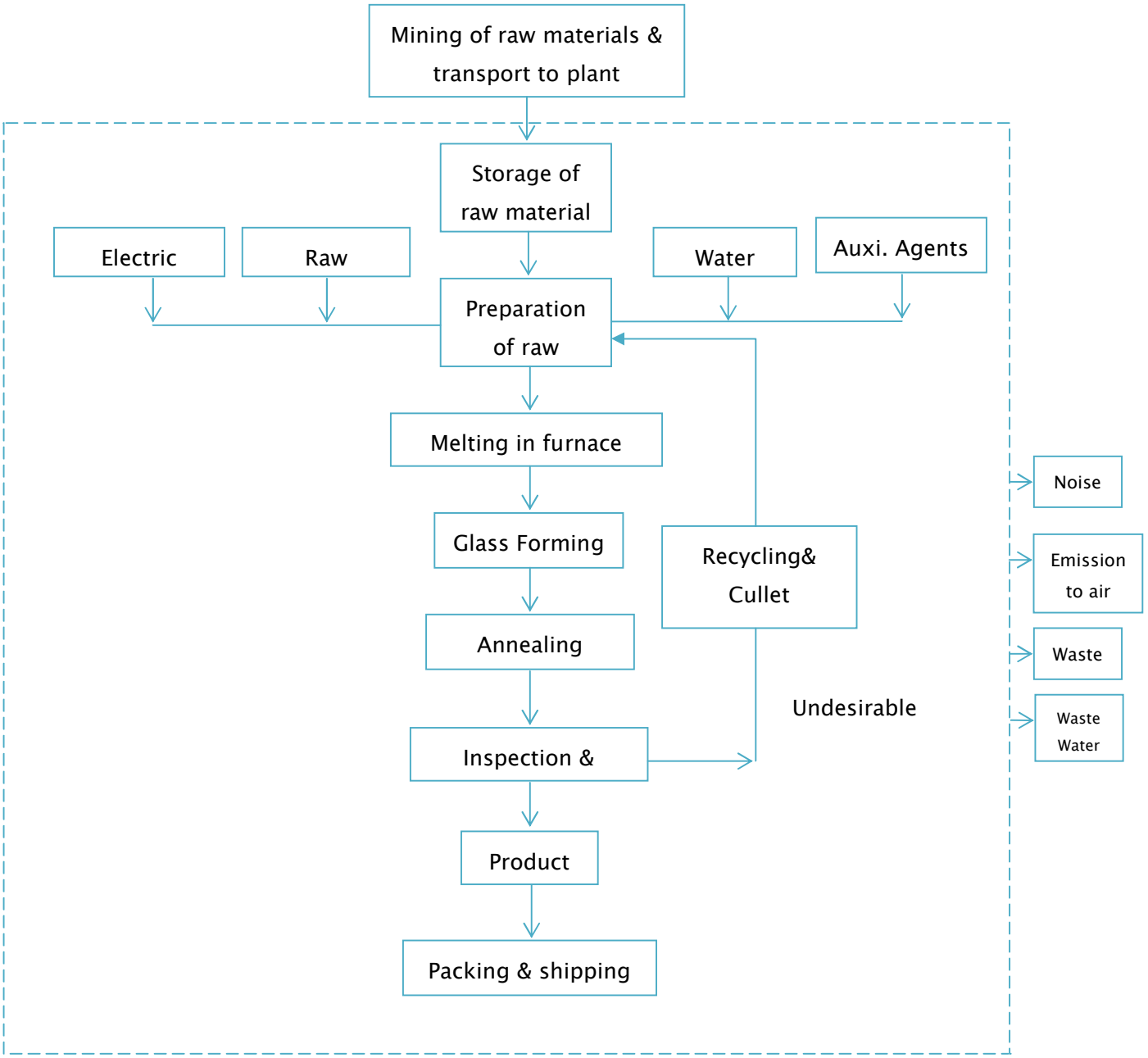
Sezal Glass Ltd at Jhagadia, Bharuch, Spread around an area of 150 acres, the plant produces 550 Metric Tons of float glass per day. The plant incorporates the best in class technology and it is one of the most advanced float glass plants in the country. Well connected to the railways and ports, the plant is in proximity to the raw material belt (silica sand, soda ash, etc.) Sezal glass product range includes Clear Float Glass from 2mm to 15mm thickness, Mirrors from 2mm to 8mm thickness, Dark Grey, Bronze & Green tinted along with hard coat & soft coat reflective range of architectural glass.

SUBSECTORS IN GLASS SECTOR

The glass industry represents a number of definable product segments:

- Flat glass including Float Glass
- Containers Glass and Hollowware
- Vacuum glass
- Domestic and industrial glassware
- Fiber glass
- Glass wool TV picture tube glass shells
- Laboratory glass
- Others

Manufacturing process



The manufacturing process of glass can be divided into four main phases, which are moreor less similar irrespective of the type of product to be manufactured.

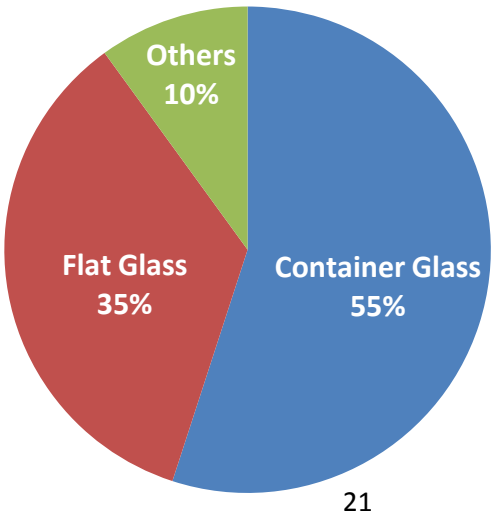
Phase 1: Preparation of raw material:The common raw materials used for themanufacture of glass are glass sand, recycled glass (cullet), feldspar and flux materials likesoda ash, dolomite, etc. which are crushed to 20–120 mesh and mixed with other additives toform a batch.

Phase 2: Melting in a furnace: The batch is introduced into the furnace for melting atabout 1500°C.

Phase 3: Forming:The glass is drawn from the furnace and blown (formed) into differentshapes. These products are then heated and cooled in a controlled manner, termed as annealing,to impart hardness to the glass.

Phase 4: Finishing:The products are subjected to various cutting and finishing operations and then packed for dispatch to the markets.

Indian Glass industry can be broadly classified into flat glass and container glass.



(Source: A study report on Evolution of Glass Industry in India, Challenges & future scenario by

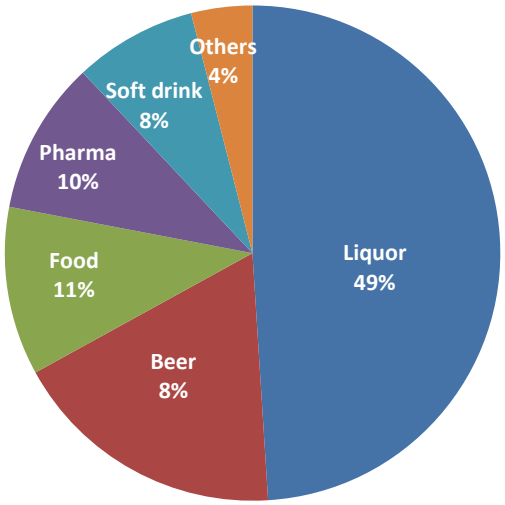
Container glass

Container glass is made from a basic soda-lime formulation and is melted in a fossil fuel fired furnace, or exceptionally an electrically heated furnace. The molten glass is generally formed into the products by automated individual section (IS) machines. Where appropriate, colouring agents are added to the glass and surface coatings are applied to the finished products.Container glass used in alcoholic beverage, food, soft drinks, jam, sauce, perfume, milk and milk product etc.

There are three broad customer industry sectors. The beverage sector accounts for approximately 75% of the total tonnage of glass packaging containers. This includes still and sparkling wines, fortified wines, spirits, beers and ciders, flavoured alcoholic beverages, soft drinks, fruit juices and mineral waters. The food sector accounts for about 20% of the tonnage (mostly jars). This covers a wide range of products, such as: wet and dry preserves, milk and milk products, jams and spreads, sauces and dressings, oil, vinegar, etc. perfumery/cosmetics, pharmaceuticals and technical product containers (bottles), which are generally small bottles, account for the remaining 5% of container glass tonnage.

This is one of the largest segments in the glass sector and comprises of glass packaging for beverages, food, perfumes and pharmaceuticals. India has an impressive performance in export of container glass products. It has persistently enjoyed a positive net trade value of an average of Rs 4.7 Billion between 2009 -2013years.

Consumption Pattern of Container Glass in India (2009-13)



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Flat Glass

Flat Glass or sheet glass is commonly used for windows, glass doors, transparent walls and windshields. Most flat glass is soda lime glass, produced by the float glass process. Flat glass segment comprises of float glass and rolled glass, which are mostly used in architectural and automotive applications.

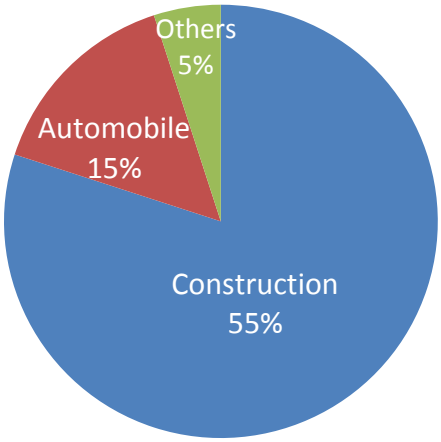
Global market for flat glass is approximately 62 million Tonnes. Flat glass market is growing at 6% per annum globally.Global demand of float glass – Europe, China & North America together accounts for approx 70% of high quality floats demand. India contributes approx. 0.19% of Global float glass demand. China is the largest country in terms of Demand as well as capacity, contributing approx. 50% of Global glass market in both demand & capacity.

Flat glass has created significant place in the glass industry not just in India but on a global level. Total size of Flat Glass industry in India is 1.10 Lakh Tonnes per Month. Indian Glass Industry consists of architectural, automotive, value

added glass, mirrors & furniture segment which has market share of 45%, 15%, 15%, 10% & 15% respectively.

Flat glass in India is majorly used for construction purpose, or by the automotive sector along with railways. In terms of value, the construction sector of the country held a majority share in sales of flat glass in the country. The recent infrastructural developments in the real estate sector of the country are majorly responsible for the majority share of construction sector in the end user analysis. The research and developments in the flat glass industry have led to production of highly specialized form of glass intended for production of different products and applications. All such developments are leading to positive growth in the flat glass market of India.

Consumption Pattern of Flat Glass in India



(Source: http://www.derivatives.capitaline.com/newsdetails.aspx?sno=648664&opt=cn&secid=21&subsecid=155&SelDt=)

Toughened glass

Toughened glass is treated to be far more resistant to breakage than simple annealed glass and to break in a more predictable way when it does break, thus providing a major safety advantage in almost all of its applications.

Toughened glass is made from annealed glass treated with a thermal tempering process. A sheet of annealed glass is heated to above its "annealing point" of 600°C; its surfaces are then rapidly cooled while the inner portion of the glass remains hotter. The different cooling rates between the surface and the inside of the glass produces different physical properties, resulting in compressive stresses in the surface balanced by tensile stresses in the body of the glass. These counteracting stresses give toughened glass its increased mechanical resistance to breakage, and are also, when it does break, what cause it to produce small, regular, typically square fragments rather than long, dangerous shards that are far more likely to lead to injuries. Toughened glass also has an increased resistance to breakage as a result of stresses caused by different temperatures within a pane.

Toughened glass has extremely broad applications in products for buildings and automobiles. Car windshields and windows, glass portions of building facades, glass sliding doors and partitions in houses and offices, glass furniture such as table tops, and many other products typically use toughened glass. Products made from toughened glass often also incorporate other technologies, especially in the building and automotive and transport sectors.

Fiberglass

Fibre glass consists of thin filaments of glass fibre that are used primarily as reinforcement material in polymer products. The resultant composite is called fibre Reinforced Polymer (FRP) or Glass Reinforced Plastic (GRP), commonly referred to as fibre glass. The products in this category also include fiberglass (glass wool) insulation for buildings, roofing and panels.

The Indian defense sector is expected to spend Rs 20,000 crore in a decade on products made out of fiberglass for use in the latest weaponry systems. The wings for the aircraft are now totally being made out of fiberglass

structures.Fibre glass is regularly used in protective equipment, such as helmets because of its light weight and durability. It is also used to make storage tanks, roofing laminate, door surrounds, chimneys and in pipe systems.

Photo-chromatic glass

Photo-chromic glass acquires a darker shade when exposed to bright light and returns to its original lighter shade in dim light. This happens because silver halides (iodide or chloride) are added to this glass. Plastic photo-chromic lenses rely on organic photo chromic molecules (such as oxazines and naphthopyrans) to achieve the reversible darkening effect.

Pyrex glass

Pyrex glass is highly heat resistant. In ordinary glass, silica is the main constituent. In pyrex glass some of the silica is replaced by boron oxide. Boron oxide expands very little when heated, thus, pyrex glass does not crack on strong heating. Pyrex glass is also called borosilicate glass. It has a high melting point and is resistant to many chemicals. Laboratory equipment and ovenware are made of Pyrex glass.

Flint Glass

Flint glass is softer than any other glass. It is clear and transparent. Potassium and lead silicates are used in making flint glass. The main use of flint glass is in the manufacture of lenses, prisms and other optical instruments.

Soda glass or soda-lime glass

It is the most common variety of glass. It is prepared by heating sodium carbonate and silica. It is used for making windowpanes, tableware, bottles and bulbs.

Safety glass

It is made by placing a sheet of plastic such as celluloid between sheets of glass.

Laminated glass

It can also be called bulletproof glass. Several layers of safety glass are bound together with a transparent adhesive.

Lead crystal glass

Lead crystal glass has high refractive index, and so has the maximum brilliance. It sparkles and is used for high quality art objects and for expensive glassware. It is also called cut glass because the surface of the glass objects is often cut into decorative patterns to reflect light. In order to increase the refractive index, lead oxide is used as flux in crystal glass; therefore it is also called lead crystal glass.

Colored glass

Small amounts of metallic oxides are mixed with the hot molten mixture of sand, sodium carbonate and limestone. The desired color determines the choice of the metallic oxide to be added, as different metallic oxides give different colors to the glass.

ENVIRONMENTAL ISSUES ASSOCIATED WITH GLASS SECTOR

The environmental issues in glass manufacturing sector primarily include:

Emission to Air

Glass manufacturing is a high temperature, energy intensive resulting in the emission of combustion of by-products (sulphur dioxide, carbon dioxide, carbon monoxide) and the high-temperature oxidation of atmospheric nitrogen.The main source of air pollution is the dust emission in the manufacture of special glasses like lead glass and Borosilicate glass. In lead glass the level of emission depends on the quantity of lead. The roots of emission to the air are particulate matters and heavy metals. The following part describes in detail various aspects of the emissions in glass industry.

Heavy Metals:

Heavy metals are present as minor impurities in some raw materials, in cullet, and in fuels. Lead and cadmium are used in fluxes and colouring agents in the frit industry. Particulates from lead crystal manufacture may have a lead content of 20–60 percent.

Raw materials:

Particulates are pollutants emitted by glass manufacturing facilities. Dust emissions are an expected result of raw materials transportation, handling, storage, and mixing. Dust generated by these processes is typically coarser than the particulates emitted from the hot processes, which have sizes below 1 µm, but the small particulates readily agglomerate into larger particles.

Whereas dust emitted from handling processes is mostly an occupational health and safety (OHS) issue.

All of the sectors within the glass industry involve the use of powdered, granular or dusty rawmaterials. The storage and handling of these materials represents a significant potential for dustemissions. The movement of materials through systems incorporating silos and blending vesselsresults in the displacement of air, which if uncontrolled, could contain very high dustconcentrations. This is particularly true if pneumatic transfer systems are used. The transfer ofmaterials using conveyor systems and manual handling can also result in significant dustemissions.

Many processes in the glass industry involve the use of cullet (either internal or external) whichmay require sorting and crushing prior to use in the furnace. Like all similar processes, this hasthe potential for dust emissions. The level of emissions will depend on factors such as thedesign of the facility, whether the extraction is filtered before discharge, how well buildings aresealed, etc. Some processes also involve the use of volatile liquids, which can result in releasesto air from tank breathing losses and from the displacement of vapours during liquid transfers.

Melting:

For many of the processes undertaken in the glass manufacturing industry, the greatest potential forenvironmental pollution arises from the melting activities. In general, the main environmentalpollutants arising from melting are:

- The products of fossil fuel combustion and the high-temperature oxidation of nitrogen inthe combustion atmosphere (i.e. sulphur dioxide, carbon dioxide, and nitrogen oxides)
- Particulate matter arising mainly from the volatilization and subsequent condensation ofvolatile batch materials

- Gases emitted from the raw materials and melt during the melting processes.

Emission	Source/Comments
Particulate matter	Volatilization of batch components from the moltenglass and subsequent condensationinto submicrondust particles, carryover of fine material in the batch, product of combustion of some fossil fuels
Nitrogen oxides	Thermal NOx due to high melting temperatures and prompt NOx formation, decomposition of nitrogen compounds in the batch materials, oxidation of nitrogen contained in fuels
Sulphur oxides	Sulphur in fuel, decomposition of sulphur compounds in the batch materials in particular from thefining process with sulphates, oxidation of hydrogen sulphide in hot blast cupola operations
Chlorides/HCl	Present as an impurity in some raw materials, particularly synthetic sodium carbonateand external cullet, NaCl used as a raw material (fining agent) in some special glasses
Fluorides/HF	Present as a minor impurity in some raw materials, including external cullet, added as a raw material in the production of enamel frit to add certain properties to thefinished product, added as a raw material in the continuous filament glass fibre sector to influence the forming process (surface tension) and in some glass batches to improve melting, or toproduce

	certain properties in the glass, e.g. opalescence, where fluorides are added to the batch, typically as fluorspar, uncontrolled releases canbe very high
Heavy metals (e.g. V, Ni, Cr, Se, Pb, Co, Sb, As, Cd)	Present as minor impurities in some raw materials, post-consumer cullet, and fuels used in fluxes and colouring agents in the frits sector, in particular for enamel frits(predominantly lead and cadmium), used in some special glass formulations (e.g. lead crystal and some coloured glasses). Selenium is used as a colourant (bronze glass), or as a decolourising agent in someclear glasses and may generate both gaseousand solid emissions
Carbon dioxide	Combustion product emitted after decomposition of carbonates in the batch materials (e.g. soda ash, limestone)
Carbon monoxide	Product of incomplete combustion, particularly in hot blast cupolas
Hydrogen sulphide	Formed from raw material or fuel sulphur in hot blast cupolas due to the reducingconditions found in parts of the furnace

Downstream activities:

This term is used to describe activities undertaken following melting, for example, forming,annealing, coating, processing, etc. The emissions from downstream activities can vary greatlybetween the different sub-sectors. Although many ofthe sub-sectors share some similar melting techniques, the

downstream activities tend to beexclusive to each one. In general, emissions to air can arise from:

- The coating application and/or drying (e.g. mineral wool, continuous filament glass fibre,container glass, and some flat glass)
- Any activities performed on the materials produced such as cutting, polishing, or secondary processing (e.g. mineral wool, domestic glass, special glass, HTIW)
- Some product-forming operations (e.g. mineral wool)

Diffuse/Fugitive emissions:

Diffuse and fugitive emissions may be associated with different operations of the glassmanufacturing process; however, in general, they do not represent a main concern for the sector.The main sources of diffuse/fugitive emissions common to all the sub-sectors of the glass industryare related to the following areas:

- Material storage and handling: Solid emissions may arise from sand and/or cullet deposited in open spaces and leakages from storage silos. Gaseous emissions may arise from the storage and handling of volatile liquids and/or gaseous chemicals, mainly related to downstream activities or flue-gas treatments (i.e. ammonia storage). In general, the impact of diffuse and fugitive emissions in the working area is managed by Health and Safety regulations at work, which include awareness and compliance.

- Charging area of the furnace (doghouse): Solid and gaseous emissions may arise from carryover, evaporation and decomposition phenomena from the charging of the batch formulation into the melting furnace. In general, the charging area (doghouse) is kept closed as much as possible in order to prevent both air infiltration and diffuse emissions. In some cases the

doghouse area may be equipped with extraction systems that discharge outside or, less frequently, inside the building, close to the roof; in other cases, for specific types of furnaces, the doghouse is totally enclosed.

- Melting furnace: Diffuse emissions may arise from combustion gases of the fossil fuel and from evaporation/condensation phenomena of the volatile components in the batch formulation. The melting furnace may not be totally sealed due to inspection holes, burner ports, and slits between the refractory bricks.

Wastewater Generation

In general, emissions to the water environment are relatively low and there are few major issuesthat are specific to the glass industry. In general, water is used mainly for cleaning and coolingand can be readily recycled or treated using standard techniques.Most activities will use some liquids, often limited to water treatment chemicals, lubricants orfuel oil. All liquid raw materials pose a potential threat to the environment through spillage orcontainment failure. In many cases, basic good practice and design is sufficient to control anypotential emissions.The main sources of water pollution in a glass industry are:

Cullet washing:

The cullet contains dust, metal caps etc. To clean it, the material is introduced into a rotary drum washer. The through agitation of the dirty cullet with water cleans the cullet which is sent for crushing. The water principally containing mud and also the oil (used for cutting blade for cutting the glass) is the source for water pollution.

Cooling water:

Water for cooling purpose is used at different areas in the furnace operation. Some amount of bleed/blow down is necessary to keep the solids concentration within limits. This appears as waste water. Some treatment chemicals like dissolved salts and water treatment chemicals used for the cooling-water system also source of pollution.

The total water consumption per ton of glass produced varies considerably.Circulating systems should be installed so that only small quantity of additional fresh water is required.

The main water consuming areas in a glass works are:

- Cooling of the compressors required for generating compressed air
- Cooling of the diesel units sometimes used for power generation
- Quenching basins for excess glass
- Finishing and refining of glass by grinding, drilling etc.

Solid Waste Generation

Coarse sand from the sand screening:

The silica sand /quartz sand which is the main raw material for the glass making is screened through 30 to 80 meshes. The coarse sand is rejected as it cannot be usedin glass making andbecomes a solid waste.

Waste glass from furnace:

While drawing the molten glass from the furnace, certain amount of glass is wasted due to uneven heating conditions and lack if proper handling of material and when it gains cooling from air or water, it solidifies.

Ash and unburnt coal:

The ash and unburnt coal particles results from coal combustion. These are sold to the contractors and ash is used for land filling purposes.

A characteristic of most of the glass industry sub-sectors is that the great majority of internallygenerated glass waste is recycled back to the furnace. The main exceptions to this are thecontinuous filament sub-sector, the HTIW sub-sector and producers of very quality-sensitive products inthe special glass and domestic glass sub-sectors.

The mineral wool and frits sectors show a widevariation in the amount of waste recycled to the furnace ranging from nothing to almost 100%for some stone wool plants. Other waste production includes waste from raw materialpreparation and handling, waste deposits (generally sulphates) in waste gas flues, and wasterefractory materials at the end of the life of the furnace.

In some sub-sectors of the glass industry, refractories which contain chromium are used for the construction of upper walls, crowns and regenerators. The chromium when combined withmagnesia to form magnesium-chrome bricks is very resistant to batch carryover and combustion products at the high temperatures that exist in the regenerator chambers. The chromium used in the preparation of these materials, Cr^{3+}, is essentially non-hazardous, has low solubility and presents little risk. However, at high temperatures under alkaline and oxidizing conditions, smallamounts of the chromium will convert to Cr^{6+} during the furnace campaign. Cr^{6+} compounds arehighly soluble, toxic and carcinogenic.

Energy

Glass making is energy intensive and the choices of energy source, heating technique and heat recovery method are central to the design of the furnace.

The same choices are also some of the most important factors affecting the environmental performance and energy efficiency of the melting operation. Thus, one of the most important types of input to the glass making process is energy, and the three main energy sources are fuel oil, natural gas and electricity. The exception to this is the manufacture of stone wool where the predominant melting technique is the hot blast cupola, which is fuelled by coke.

Fuel oil and natural gas are the predominant energy sources for melting,with a small percentage of electricity. Forehearths and annealing lehrs are heated by gas orelectricity, and electrical energy is used to drive air compressors and fans needed for theprocess. General services include water pumping, steam generation for fuel storage and traceheating, humidification/heating of batch, and heating buildings. Some furnaces have beenequipped with waste heat boilers to produce part or all of the steam required.

In general, energy is supplied to the melting furnace by:

- Combustion of fuel
- Preheating of combustion air
- Electric power
- Sensible heat of fuels, oxygen or excess air
- (Preheated) batch

Because glass making is such energy intensive, high-temperature process, there is clearly ahigh potential for heat loss. And the heat loss is in such a large amount that can account for around 20% to 30% of the energy cost of a batch. The cause of above can be given as the design of the furnace and the operating procedure.

Some of the general factors affecting the energy consumption of fossil fuel fired furnaces are outlined below. For any particular installation, it is important

to take account of site-specific issues which will affect the applicability of the general information given below. These factors also affect the emissions per ton of glass of those substances which relate directly to the amount of fossil fuel burned, particularly CO_2, SO_2 and NOx. The main site-specific issues are given below.

a. The capacity of the furnace significantly affects the energy consumption per ton of glass melted, because larger furnaces are inherently more energy efficient due to thelower surface area to volume ratio.

b. The furnace throughput is also important, with most furnaces achieving the most energyefficient production at peak load. Variations in furnace load are largely market dependentand can be quite wide, particularly for some container glass and domestic glass products.

c. As the age of a furnace increases, its thermal efficiency usually declines. Towards the endof a furnace campaign, the energy consumption per tonne of glass melted may be up to20 % higher than at the beginning of the campaign.

d. The use of an electric boost improves the energy efficiency of the furnace. However,when the cost of electricity and the efficiency of electrical generation and distribution aretaken into account, the overall improvement is lower (or even negative). An electric boostis generally used to improve the melting capability of the furnace rather than to improveenergy efficiency.

e. The use of cullet can significantly reduce energy consumption because the chemicalenergy required to melt the raw materials has already been provided. As a general rule,every 10 % increase in cullet usage results in an energy savings of 2 – 3 % in the meltingprocess.

f. Oxy-fuel firing can also reduce energy consumption, particularly in smaller furnaces. Theelimination of the majority of the nitrogen from the combustion atmosphere reduces thevolume of the waste gases leaving the furnace by 60 – 70 %. Therefore, energy savingsare possible because it is not necessary to heat the atmospheric nitrogen to thetemperature of the flames; most oxy-fuel furnaces are not equipped with heat recoverysystems.

The site-specific issues reported above do not take into account some important off-site issueswhich affect the applicability of the different melting techniques, in particular the cost ofelectricity and the efficiency of electrical generation anddistribution.

Noise Pollution

In the glass manufacturing process, noise may be a significant issue for some sectors, particularly in the container and domestic glass production sectors. Prevention and reduction of noise is not always practicable and precautions are normally taken to protect workers where noise levels cannot be reduced. The noise levels within the installation represent mainly anoccupational health issue. The noise levels (in decibels) are equipment/plant-specific and may exceed the value of 85 dBAin some areas of the installation.
The significant sources of noise emissions are the following:

- Compressed air for cooling
- Fan for combustion air
- Fan for waste gas extraction
- Forming machines (e.g. Container, domestic and special glass sectors)
- Transport belts for glass products
- Cutting operations (e.g. Flat and special glass)
- Grinding, polishing operations (e.g. Domestic and special glass)

Industry Specific Standards – Glass Industry (Source: Central Pollution Control Board)

Category of glass manufacturing processes according to CPCB

- Manufacturing of glass, Fibre glass and processing (Excluding moulding):RED
- Glass manufacturing using oil or gas fired kiln, coating on glasses using cerium fluoride, magnesium fluoride etc, manufacture of mirror from sheet glass, printing or etching of glass sheet using hydrofluoric acid, producer gas plant using conventional up-drift coal gasification (linked to glass for dedicated fuel supply):ORANGE
- Glass ampules & vials making from glass tubes, glass putty and sealant, glass manufacturing using electrical kiln or not involving fossil fuel kilns: GREEN

The standards of emission are as shown in the table.

	Particulars	Emissions	Standards
A.	Sodalime& Borosilicate and other special Glass (other than Lead)		
	(a)Furnace : Capacity	Particulate Matter	2.0 kg/hr.
	(i) Upto a product draw capacity of 60 MT/Day	Particulate Matter	0.8 kg/MT of product drawn
	(ii) Product draw capacity more than 6 MT/Day	Stack height	H=14(Q)0.3 where Q is the emission rate of SO2 in Kg/hr. & H is Stack height in meters
	(iii) For all capacities		

		Total Fluorides Nox	5.0 mg/NM3 Use of low Nox burners in new plants
	(b) Implementation of the following measures for fugitive emission control from other sections : (i) Raw materials should be transported in leak proof containers. (ii) Cullet preparation should be dustfree using water spraying. (iii) Batch preparation section should be covered.		
B.	Lead Glass		
	(a) Furnaces : All capacities	Particulate Matter Lead	50 mg/NM3 20 mg/NM3
	(b) Implementation of the following measures for fugitive emission control from other sections: (i) Batch mixing, proportioning section and transfer points should be covered and it should be connected to control equipments to meet the following standards : Particulate Metter 50 mg/NM^3 Lead 20 mg/NM^3 (ii)Minimum Stack height should be 30 meters in lead glass units.		
	(c) Pot furnace at Firozabad Furnace :	Particulate matter	1200 mg/NM^3

Industry	Parameter	Standards
Glass Industries (for all categories)	EFFLUENTS: pH Total Suspended Solids Oil & Grease	 6.5 – 8.5 100 mg/l 10 mg/l
LIME KILN Capacity : Upto 5 T/day Above 5T/day More than 5T/day and up to 40 T/Day Above 40T/day	Stack Height Stack Height Stack Height Particulate matter Particulate matter	 A hood should be provided with a stack of 30 meter height from ground level (including kiln height). $H=14(Q)^{0.3}$ where Q is emission rate of SO_2 in kg/hr and H=Stack Height in meters. 500 mg/Nm^3 150 mg/Nm^3

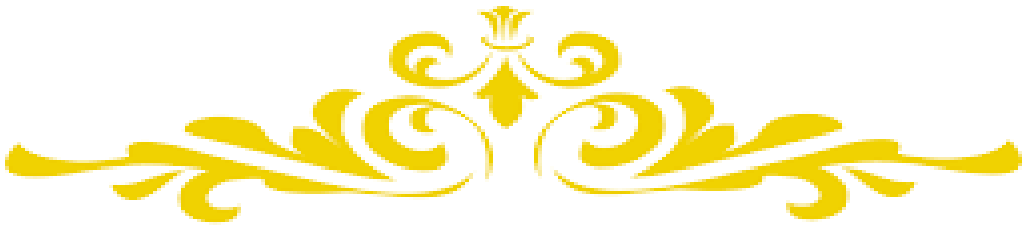
Standards of emissions to air

Pollutants	Time-weighted average	Concentration in ambient air			Method of measurement
		Industrial Areas	Residential Rural & other Areas	Sensitive Areas	

Sulphur Dioxide (SO_2)	Annual Average *	80 µg/m^3	60 µg/m^3	15 µg/m^3	-Improved West and Geake Method - Ultraviolet Fluorescence
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3	
Oxides of Nitrogen as (NO_2)	Annual Average *	80 µg/m^3	60 µg/m^3	15 µg/m^3	-Jacob & Hochheiser Modified (Na-Arsenite) Method -Gas Phase Chemi-luminescence
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3	
Suspended Particulate Matter (SPM)	Annual Average *	360 µg/m^3	140 µg/m^3	70 µg/m^3	- High Volume Sampling, (Average flow rate not less than 1.1 m3/minute).
	24 hours**	500 µg/m^3	200 µg/m^3	100 µg/m^3	
Respirable Particulate Matter (RPM) (size less than 10 microns)	Annual Average *	120 µg/m^3	60 µg/m^3	50 µg/m^3	- Respirable particulate matter sampler
	24 hours**	150 µg/m^3	100 µg/m^3	75 µg/m^3	
Lead (Pb)	Annual Average *	1.0 µg/m^3	0.75 µg/m^3	0.50 µg/m^3	-ASS Method after Sampling using EPM 2000 or equivalent Filter paper
	24 hours**	1.5 µg/m^3	1.00 µg/m^3	0.75 µg/m^3	
Ammonia1	Annual Average *	0.1 mg/ m^3	0.1 mg/ m^3	0.1 mg/m^3	
	24 hours**	0.4 mg/ m^3	0.4 mg/m^3	0.4 mg/m^3	
Carbon Monoxide (CO)	8 hours**	5.0 mg/m^3	2.0 mg/m^3	1.0 mg/ m^3	- Non Dispersive Infra Red (NDIR) Spectroscopy
	1 hour	10.0 mg/m^3	4.0 mg/m^3	2.0 mg/m^3	

Note: * Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

** 24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.



CHAPTER 6

DATA COLLECTION AND DETAILED ASSESSMENT

DATA COLLECTION AND DETAILED ASSESSMENT

For conducting the detailed Cleaner Production Assessment, Four of the sub-sectors were identified to cover a wider scope of assessment. They are –

1. Container Glass
2. Flat Glass
3. Tempered Glass

Industrial estates consisting of Glass units were identified. Major of the Glass units are located around Surat, Baroda, Kadi, Panchmahal etc. various units were invited to participate in the project through letters, emails and telephonic conversations, out of which following units were selected to conduct the detailed Cleaner Production Assessment –

1. Piramal Glass Limited, Kosamba, Surat, Manufacture of Container Glass
2. Gopal Glass Works, Kadi, Manufacture of Figure Glass
3. Gobind Glass and Industries, Kadi, Manufacture of Figure Glass
4. Jajoo Architectural Glass Pvt. Ltd., Halol, Panchmahal
5. Kamal Glass Solution Pvt. Ltd., Halol, Panchmahal

A detailed exercise was carried out using the methodology of data collection and detailed assessment, including on-site observations, waste stream identification, quantification, generation of Cleaner Production Scope, Suggestions to implement CP and possible outcomes of implementation. After suggesting the options, many of them have been taken under implementation, many of them are being planned to be implemented and

many of them are implemented successfully. The detail of the same is mentioned in the next parts of the document.

Selection of CP Assessment Focus

The focus of the project is generating Cleaner Production Scope by –

- Study of raw material to final product (Mass Balance)
- Study of usage of process water in overall processes (Water Balance)
- Study of source of waste water generation with its physical form and balancing the quantity from individual waste water generation to final effluent discharge/recycle from the industry
- Study of source of solid waste generation with its physical form and balancing the quantity from individual solid waste generation to final solid waste discharge/recycle from the industry
- Study of source of air and gaseous emission from the different processes and identifying the impacts and losses for the industries.

General description of information:

The details required for carrying out the assessment is presented in the following table:

Details	Purpose
Company profile	For general status and growth of industry
Plant layout	To gain an overview of plant design and equipment positions
Fuel (PNG) consumption data	To correlate fuel consumption with the production output
Electricity consumption	To correlate electricity consumption

	with the production output
Process flow sheet	To identify the individual process and relation between the processes
Material consumption data	To track the actual quantity of raw and auxiliary materials converted into final product.
Water consumption data	To track the water consumption in different processes and role of water in the process
Waste water generation data	To determine the quantity & quality of waste water generated in the process
Air & gaseous emission data	To determine air & gaseous emission sources

List of data source, authentication & reliability

All the data necessary for carrying out this activity was obtained from the industry employees at the discretion of the owner.

Data	Authentication	Reliability
Company profile	Industry personnel	High
Plant layout	Industry personnel	High
Fuel consumption data	Installed meter readings	High
Electricity consumption	Electricity bills from State Electricity Board	High
Process flow sheet	Industry personnel & verified in visit	High
Material consumption data	Industry personnel	Medium
Water consumption	Industry personnel & verified by	High

data	process parameters	
Waste water generation data	Industry personnel	Medium
Air & gaseous emission information	Visual during visit	Medium
Environment Consent	Gujarat Pollution Control Board	High
Domestic water consumption data	Industry personnel	Medium

Methodology of Data Collection

- Data collection, verification by visit to the industry and interaction with industry personnel.
- Study of collected data to assess how well the process systems and pollution control systems are performing, and identifying the operations of poor performance.
- Identifying potential cost savings which can be accrued through reduction in raw material consumption by way of waste minimization and adoption of recycle/recovery/reduction in pollution load.
- To identify the measures in order to enabling industry discharge in compliance with environmental laws and regulations.
- To make proper format of up-to-date environmental data base for use in-plant modifications, emergencies etc.
- Unraveling surprises and hidden liabilities due to which regulatory risk and exposure to litigation can be reduced and providing timely warning to management on potential future problems, and
- Providing inputs for strengthening environmental management structures within the industry.

Limitations

Some limitations were also faced by the team during the environmental assessment project. These are as below:

- Lack of data related to actual consumption of resources to verify and made calculations on actual consumption figures.
- Hesitation/reluctance on the part of industry persons to provide typical problem in the process resulting in loss of resources and generation of undesirable waste.
- Limitation of technical staff in the industries.
- Unavailability of technical details and process parameters.
- Lack of metering & data at critical processes.

CHAPTER 7

CASE STUDY OF CLEANER PRODUCTION IMPLEMENTATION

Piramal Glass Limited, Kosamba, Surat

Introduction- Piramal Glass Limited

Piramal Glass is the largest specialty glass player in Asia and has been the fastest growing glass company in the world for the last 10 years. It has 17 of the world's top 20 cosmetic companies as customers. Piramal Glass Limited (PGL) is ISO 9001, ISO 14001 & ISO 18001 certified container glass manufacturing company having plant at Kosamba, Jambusar in Gujarat, India. The Kosamba facility has a capacity of 340 tonnes per day and manufactures USP Type I, II and III amber and flint bottles and vials for the pharmaceuticals industry. It also makes containers for nail enamel, perfumes, skin care, foundation, aroma oils, miniatures etc (from 5 ml to 150 ml). The Kosamba facility is run on natural gas with furnace oil as a backup. The fact that every third nail polish bottle in the world is manufactured by us speaks volumes of our expertise as perfume and cosmetic bottle manufacturers. Production capacity of the plant is 11670 MT per month.

Cleaner Production Assessment Team

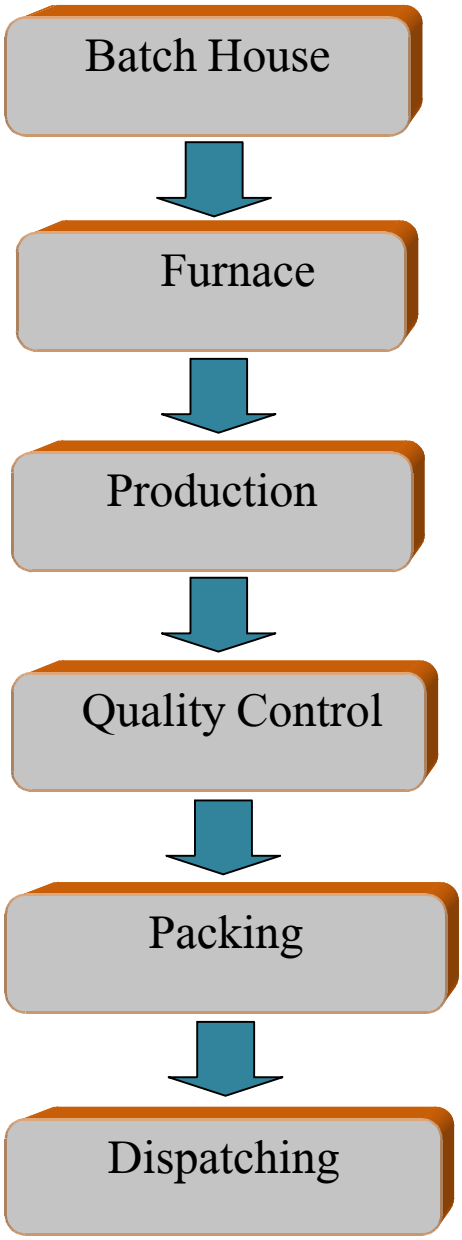
The team for conducting Cleaner Production Assessment includes the following members.

Name	Designation
Dr. Bharat Jain	Member Secretary, GCPC
Mr. PunamchandraRathod	Senior Project Engineer, GCPC
Mr. Abhi Patel	Assistant Project Engineer, GCPC
Mr. Paras Gojiya	Assistant Project Engineer, GCPC
Mr. Rakesh Khopkar	General Manager-HR, Piramal Glass Ltd.
Mr. Vipul Thakkar	Senior. Manager, Safety, Health and Environment, Piramal Glass Ltd.
Mr. Viral Atodaria	Senior Executive, Electrical Department,

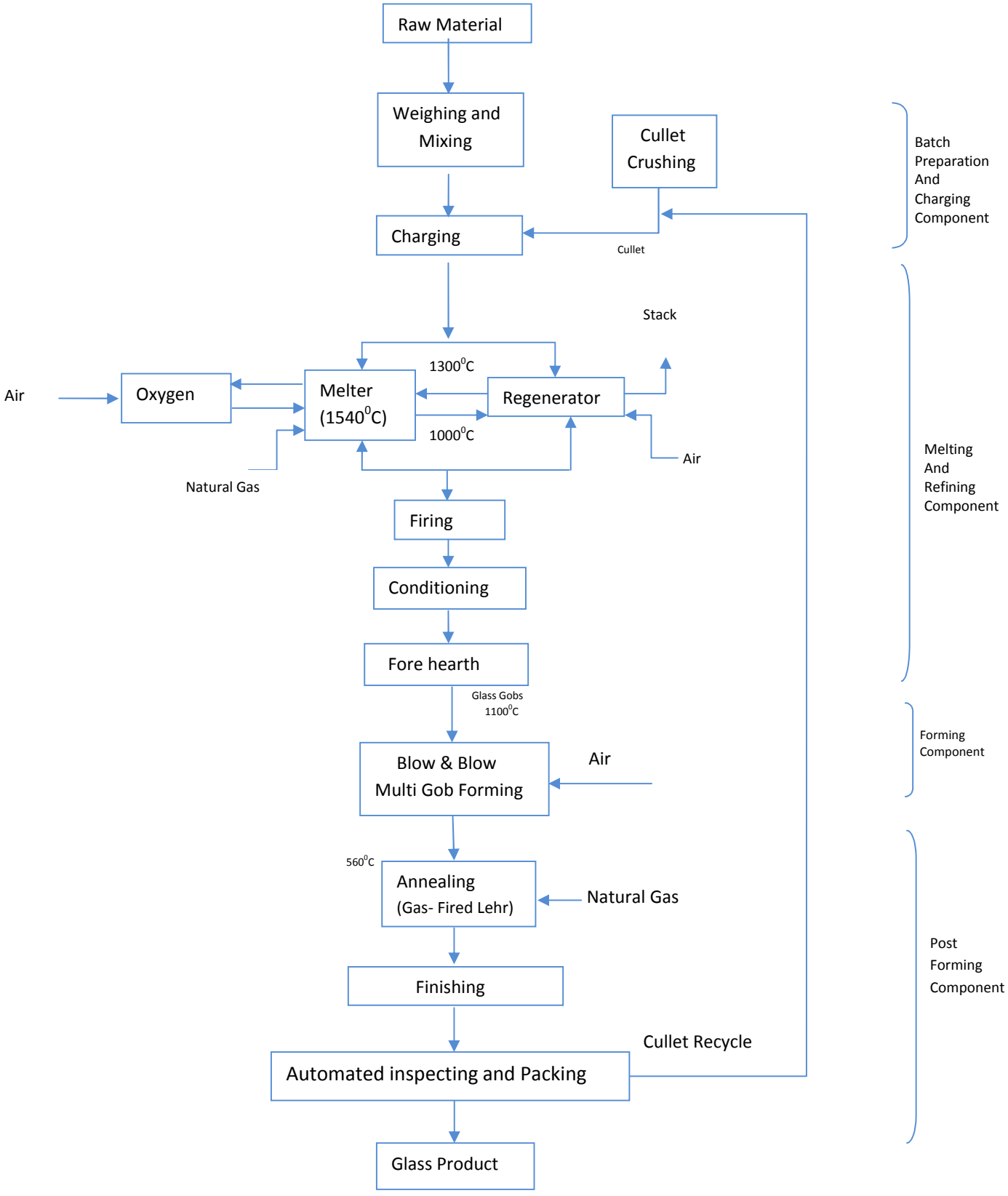
Manufacturing Process

Piramal Glass Limited, Kosamba, Surat manufacturing plant manufactures containers for nail enamel, perfumes, skin care, foundation, aroma oils, miniatures etc. The manufacturing process flow chart is as depicted below.

Manufacturing Process Steps



Manufacturing Process Flow Diagram



I. Raw- material

Glass for packaging is made from abundant natural raw materials like 71% silica (sand), 14% sodium in the form of sodium carbonate (soda ash), 11% calcium in the form of limestone, 4% other ingredients, including colorants.

Cullet is added to this mixture. Cullet is broken glass, either scrap from the manufacturing process, or from recycling centers, bottle banks collection systems. Use of cullet not only enables discarded packing to be valorized but also saves energy and raw materials.

II. Furnace

The mixture of raw materials and cullet is melted continuously in furnaces, heated to a temperature of around 1200 0C. Those furnaces operate 24 hours a day, seven days a week and have a lifespan of between eight and ten years. It takes around 24 hours for the raw materials entering the furnace to be converted into glass.

The molten glass is carried through a series of distribution channels – known as forehearths – to the forming machines. At the end of the forehearths, the glass flow is cut into gobs whose weight, shape and temperature are precisely controlled.

III. Forming

The forming process transforms the compact mass of the gobs into a hollow shape, using a metal plunger or blown air. Forming generally takes place in two stages:
The gob is transformed by pressing or blowing into an intermediate hollow pocket shape, with the opening fully formed.

A mechanical arm then transfers this partially formed shape over to a finishing mold for blowing into the final shape of the bottle or jar. The finished glass object is then taken out of the finish mold by tongs and held briefly over a cooling plate, before being conveyed away.

The bottles and jars are still at temperatures of over 1,060° F when they come out of the machine. The whole forming cycle only takes a few seconds.

IV. Annealing Lehr

To ensure the solidity of the freshly formed glass containers, they need to undergo a heat treatment and be cooled in a controlled way, inside a tunnel furnace known as an 'annealing lehr'. This process takes between 30 minutes and two hours.

To make the bottles and jars more resistant to scratches, they are usually treated with a surface coating applied when they are still hot, before entering the lehr, with a complementary coating when cooled at the lehr exit.

This completes the manufacturing process for glass containers.

V. Quality Control

To ensure the quality of our products, we check every item we make using a range of specialized equipment, using mechanical, video and light beam technology.

In particular, these check the neck area (for good closure), the dimensions, glass thickness and appearance.

Any container that does not come up to standard is automatically rejected and returned to the furnace to be re-melted.

VI. Dispatching

Before shipping, bottles and jars are grouped in industrial packaging made from reusable or recycled materials. Once a pallet of bottles, packs or cases is complete, it is totally encased in a plastic wrapper which protects the products during handling and storage.

The bottles and jars are then shipped out, to be filled or personalized using a number of decorative processes.

Data Collect from Piramal Glass Limited.

FLUE GAS ANALYSIS DATA

95 TPD Furnace			
Parameters	Reading		
	1	2	3
NET	484	489	491
O2	12.4	12.6	12.8
CO	821	408	146
Efficiency	44	42	420
CO2	4.8	4.6	4.6
Flue Gases	518	522	525
Ambient	33	33.2	33.4
Access Air	148	144.8	151.8
Pressure	0.18	0.20	0.21

55 TPD Furnace		
Parameters	Reading	
	1	2
NET	485	485
O2	13	12.1

CO	0	0
Efficiency	42.8	46
CO2	4.6	4.9
Flue Gases	525	525
Ambient	40	40.4
Access Air	151	140
Pressure	0.17	0.21

ELECTRIC ANALYZER DATA

75 TPD Furnace	
BT- 11 Throat Cooling Blower (30 HP)	
Parameters	**Reading**
V	412
A	16
KW	3.46
COSΦ	0.30
BD- 12 Distribution Blower (30 HP)	
Parameters	**Reading**
V	418
A	5.66
KW	1.15
COSΦ	0.28

55 TPD Furnace	
BB- 3 Block Cooling Blower (50 HP)	
Parameters	**Reading**
V	420
A	26.7
KW	9.89
COSΦ	0.51
BD- 31 Blower (50 HP)	
Parameters	**Reading**
V	419
A	21.2
KW	15.0
COSΦ	0.98

95 TPD Furnace	
BD- 41 Fore hearth Distribution Blower (60 HP)	
Parameters	**Reading**
V	422
A	17.2
KW	12.5
COSΦ	1.00
BT- 41 Throat Cooling Blower (60 HP)	

Parameters	Reading
V	421
A	56.1
KW	40.5
COSΦ	0.99
BM- 42 Starter (270 HP)	
Parameters	**Reading**
V	418
A	219
KW	142
COSΦ	0.90

100 TPD Furnace	
BB- 63 Block Cooling Blower (60 HP)	
Parameters	**Reading**
V	420
A	34.1
KW	11.0
COSΦ	0.44
BT- 61 Throat Cooling Blower (50 HP)	
Parameters	**Reading**
V	424

A	33.4
KW	24.4
COSΦ	0.99

Electricity Bills

Month	Electricity Bills (INR)
Jan'15	37399059
Feb'15	35294123
March'15	39262823
April'15	36893600
May'15	39294757
June'15	37746180
July'15	41281065
Aug'15	40892293
Sep'15	39154173
Oct'15	39497461
Nov'15	37549048
Dec'15	39273049

Details of Raw- Material

Material Description	Total Qty
DOLOMITE	96,041.00
DOLOMITE (COSMETICS)	6,056,615.00
LIME STONE POWDER	12,185,054.00
MANGANESE DIOXIDE	172,117.00
RED OXIDE	15,184.82
SEMI SNOW WHITE QUARTZ	43,607,169.00
SNOW WHITE QUARTZ	24,910,918.00
Feldspar 2nd Grade	1,529,901.00
LITHIUM CARBONATE	50,678.00
BORAX	2,963,988.00
COBALT OXIDE	78.79
SELENIUM	568.54
ALUMINA HYDRATE FDH GRADE	2,999,275.00
BARIUM CARBONATE	820,893.00
SODIUM NITRATE	185,282.00
SODIUM SILICATE FLUORIDE	704,332.00
SODIUM SULPHATE	503,438.30

ZINC SELENITE	427.16
COKE POWDER	2,934.09
SULPHUR	1,278.56
POTASSIUM NITRATE	1,040,440.00
SODA ASH DENSE	18,038,030.20
RAW CULLET AMBER	358,398.00
SILICA SAND	1,018,346.00
SILICA SAND E	1,801,938.00
Total	119,063,325.46

Option Adopted For Environment Protection

Sr.No.	Option adopted for Environment protection
1	Stack provided to all flue gases outlet as per requirement
2	Natural Gas is used as fuel for emission control
3	Treated water is completely recycled as feed water
4	Dedusting system installed in the Batch house
5	Normal Lights replaced with LED lights
6	Energy efficient motors are installed.
7	ETP area modified as model area to work.

8	Monthly water leakages are identified and controlled
9	All forklifts are converted to battery operated from diesel.
10	Solar power project is planned to execute.

Sr.No.	Option adopted for Safety
1	Induction is mandatory for all employee, contractor, customers & visitors
2	PPE's are provided to all employee working in hazardous area
3	Safety Training is mandatory for all once in year
4	Dedusting system installed in the batch house
5	Monthly audit is carried out for entire plant.
6	Medical checkup is conducted for all employee once in 2 year
7	Work permit system for all non routine activities
8	SOP prepared to perform the job at all area.
9	Fire Fighting system installed i.e. fire hydrant, fire tender, fire extinguishers, sprinkler etc
19	All rotating parts are properly guarded.
11	Emergency drill carried out frequently

Cleaner Production Opportunities

<table>
<tr><th>Intervening Technique</th><th>Optimization of Combustion Efficiency of Melting Furnace</th></tr>
<tr><td>Before CP</td><td>
Flue gas exhaust at the furnace was monitored. %O2 in flue gas varies from 12 % to 13 %.

Flue gas temperature also varies from 518oC to 525oC.% O2 in flue gases should be between 3- 4%.

Flue Gas Monitoring Parameters at 95 TPD Furnace
<table>
<tr><th>Parameters</th><th>Reading 1</th><th>Reading 2</th><th>Reading 3</th></tr>
<tr><td>Oxygen (%)</td><td>12.4</td><td>12.6</td><td>12.8</td></tr>
<tr><td>Carbon Monoxide (ppm)</td><td>821</td><td>408</td><td>146</td></tr>
<tr><td>Combustion Efficiency (%)</td><td>44</td><td>42</td><td>42</td></tr>
<tr><td>Carbon Dioxide (%)</td><td>4.8</td><td>4.6</td><td>4.6</td></tr>
<tr><td>Flue Gas Temperature (0C)</td><td>518</td><td>522</td><td>525</td></tr>
<tr><td>Access Air (%)</td><td>148</td><td>144.8</td><td>151.8</td></tr>
<tr><td>Pressure (mBar)</td><td>0.18</td><td>0.20</td><td>0.21</td></tr>
</table>
Flue Gas Monitoring Parameters at 55 TPD Furnace
</td></tr>
</table>

	<table><tr><th>Parameters</th><th>Reading 1</th><th>Reading 2</th></tr><tr><td>Oxygen (%)</td><td>13</td><td>12.1</td></tr><tr><td>Carbon Monoxide (ppm)</td><td>0.0</td><td>0.0</td></tr><tr><td>Combustion Efficiency (%)</td><td>42.8</td><td>46</td></tr><tr><td>Carbon Dioxide (%)</td><td>4.6</td><td>4.9</td></tr><tr><td>Flue Gas Temperature (ºC)</td><td>525</td><td>525</td></tr><tr><td>Access Air (%)</td><td>151</td><td>140</td></tr><tr><td>Pressure (mBar)</td><td>0.17</td><td>0.21</td></tr></table>
After CP	The same can be maintained by regular monitoring of flue gas sample with the help of a portable flue gas analyzer or by installing O_2 sensor at the furnace exhaust for flue gases and a modulating motorized damper for combustion air control. The sensor will provide constant feedback of O_2% to the damper which will in turn regulate the flow of combustion air to maintain the combustion efficiency at optimum level of 80 – 90% (Achievable combustion efficiency). Thus, it is recommended to operate the furnaces at optimum efficiency by controlling (manual/auto) air fuel ratio so that to get maximum combustion efficiency, the fluidised bed furnaces are known for generating maximum combustion efficiency in principal more than 80 %, thus

	plant should target to achieve the same initially manual adjustment through frequency adjustment and monitoring oxygen percentage in flue gases and then putting the drives in auto with online O_2 sensor in exhaust and feedback to supply air, although caution need to be considered with setting of minimum air requirement for pressure & draft control within furnace. By maintaining optimum combustion efficiency even upto 75 % from existing (average 45 %) in these two furnaces, plant can save approximately 280524 SCM per annum.
Benefit	
Environmental	• Reduction in the natural gas consumption by 280524 SCM per year • Per Year Reduction in Greenhouse Gas (CO_2) emission: 525.42 tCO_2/yr
Economical	Investment: **Rs. 30,00,000**/-for 2 nos. of Furnace Annual Savings: **Rs. 50,49,000**/- per annum Payback Period: **8 months**

Intervening Technique	Electricity Consumption Planning for Reducing Electricity Cost
Benefits	• DGVCL charges Time of Use (TOU) surcharge. This is applicable for different periods of the day i.e. normal period, two peak hour periods. The surcharge on energy charges according to the period of

consumption shall be as per following:

TOU Period

Sr. No.	Peak Period
1.	Morning peak load period (7 AM to 11 AM)
2.	Evening peak load period (6 PM to 10 PM)

- The Time of Use charges for the energy consumption during these peak periods are as following:

TOU Charges

Sr. No.	Billing Demand	TOU Charges
1.	For billing demand upto 500 kVA	Rs. 0.45 per unit
2.	For billing demand above 500 kVA	Rs. 0.85 per unit

- Plant is consuming average 18, 66,995 kWh per month during ToU duration and thus it is contributing to average Rs. 15, 26,151 per month additional electricity charges.

- Although due to continuous production it is not possible to avoid critical load running during the TOU (peak load period) but plant can optimize the TOU surcharges in the bill by identifying few non-critical loads and keeping them off during the TOU duration (i.e., 7 AM to 11 AM & 6 PM to 10 PM) mentioned in

	the above table or if possible rescheduling of critical load to operate during 11 AM to 6 PM & 10 PM to 6 AM. Even 10 % load reduction during ToU duration will save approximately Rs. 18, 31,000 p.a. without any investment. CONCESSION FOR USE OF ELECTRICITY DURING NIGHT HOURS: • For the consumer eligible for using supply at any time during 24 hours, entire consumption shall be billed at the energy charges specified above. However, the energy consumed during night hours of 10.00 PM to 06.00 AM next morning as is in excess of one third of the total energy consumed during the month, shall be eligible for concession at the rate of 85 Paise per unit. Plant is not consuming which contributed loss of rebate. • Thus plant should inventorize the list of electrical loads which are critical for production and non-critical load which can be operated in night hours only in view to maximize the benefits of night usage rebate, even if plant maintains night usage more than to its 1/3rd of total average consumption i.e., 18, 75,605 kWh per month, plant will save approximately Rs. 1,91,31,000 p.a. additionally.

Intervening Technique	Avoid Compressed air usage for cleaning purposes
Before CP	During the visit it was observed that compressed air is used for cleaning purposes at some workstations to clean the components with open hose of 5 mm diameter and at 6 kg/cm²g pressure.
After CP	Usually, cleaning can be done at lower pressure (around 2-3 kg/cm²g). So, the first step would be to reduce the pressure and energy saving would be around 8% at drop of each bar for that hose if generated separately. From our past experience the company can save Rs. 21,000 per year (from one workplace) by installing compressed air saving gun. The compressed air is a costly utility and the less critical purposes like cleaning can be achieved by installing air saver nozzles at the tip of these cleaning devices or shall be replaced with new one. The special design of these improved cleaning nozzles allows ambient air to get entrained in the path due to vacuum created by compressed air and delivers the air with similar velocity and thrust giving to desired cleaning effect. However, the amount of compressed air uses is only 20-25% which reduces the compressed air requirement and thus resulting in energy savings. In addition, these nozzles also

	reduce the noise level.  
Environmental	Reduction in the electricity consumption to generate the compressed air, with that, also reducing Noise Pollution of the surrounding, making the site easy to work
Economical	Investment: **3,000**/- per gun Annual Savings: **Rs. 21,000**/- per station Payback Period: **3 months**

<table>
<tr><th>Intervening Technique</th><th>Installation of Variable Frequency Drive (VFD) In Furnace Blower Motor</th></tr>
<tr><td>Before CP</td><td>
Plant is operating 6 nos. Of furnace with common connection to 30 HP to 60 Hp motor. The motor load test conducted while operating all 4 nos. blower simultaneously is shown in table below:

Table: Electrical Parameters Measured at Ball Mill Motor (4 nos. Motor)

<table>
<tr><th rowspan="2">Parameter</th><th colspan="2">75 TPD Furnace</th><th>55 TPD Furnace</th><th>100 TPD Furnace</th></tr>
<tr><th>BT-11 Throat Cooling Blower (30 HP)</th><th>BD-12 Distribution Blower (30 Hp)</th><th>BB-3 Block Cooling Blower (50 HP)</th><th>BB-663 Block Cooling Blower (60 HP)</th></tr>
<tr><td>Voltage (V)</td><td>412</td><td>418</td><td>420</td><td>420</td></tr>
<tr><td>Ampere (A)</td><td>16</td><td>5.66</td><td>26.7</td><td>34.1</td></tr>
<tr><td>Power (kW)</td><td>3.46</td><td>1.15</td><td>7.98</td><td>11.0</td></tr>
<tr><td>Power Factor (Cos Ø)</td><td>0.30</td><td>0.28</td><td>0.51</td><td>0.44</td></tr>
</table>

The load survey conducted on the blower shows that the maximum loading on blower motor are between 15 to 50 %. The load variation recorded during normal operation of blower motor is

• 3.46 kW for BT-11 Throat Cooling Blower, while the rated capacity of motor is 22.2 kW
• 1.15 kW for BD-12 Distribution Blower, while the
</td></tr>
</table>

	rated capacity of motor is 22.2 kW • 7.98 kW for BB-3 Block Cooling Blower, while the rated capacity of motor is 37 kW • 11.0 kW for BB-663 Block Cooling Blower, while the rated capacity of motor is 44.4 kW. The load survey during all blower operation is shown in table above: • It could be observed that all the motors are running below 50% of the rated load; however, this does not consume less electricity than required at full load, on the contrary, the motor efficiency decreases dramatically.
After CP	• Cooling blowers are critical equipments for glass industries and they keep on running for 24 hours all the day, hence there is a huge scope of saving the electricity. • The speed of the motor can be reduced by installing variable frequency drive on Blower motor and operating speed can be programmed accordingly. • This will result in reduction in electricity consumption to the tune of 15% saving in electricity consumption in blowers. This concept is applicable to all the motors in the plant above 5 HP. • Approximate total one time investment will be Rs.2, 45,000 for all four VFD.

Benefit	
Economical	Investment: **Rs. 2,45,000**/-for 4 nos. of VFD Annual Savings: **Rs. 2,80,000**/- per annum Payback Period: **10 months**

Intervening Technique	Optimisation of Gas Consumption through Oxygen Enhanced Combustion in Furnaces
Description	Glass manufacturing is a very energy intensive industrial process. Glass is produced by heating the raw materials like silica (Silicon dioxide), sand (Quartz), iron oxide, and other Materials to about 1500 to 200 ^{0}C. Glass manufacturers who need to increase pull rate (pull rate is the velocity of the glass sheet) and improve quality, consistency, and thermal efficiency while decreasing NOx emissions can use Oxy-Fuel technology. Oxy-Fuel technology has proved to be one of the most energy efficient combustion processes for glass melting furnaces. Ideal burners for any furnace would have the following characteristics: • Flexibility with respect to flame length and heat transfer. • Continuity of operations, which can be adjusted during use. • Multiple fuel usage.

- Robust and compact design.

The Oxy-Fuel burners have most of the above characteristics. It has been observed by a major company in combustion technology that in Oxy-Fuel combustion the volume of the flue gases is approximately 20% of that in the Air-Fuel combustion resulting in a reduction of the amount of heat lost through flue gases. They have developed their own-patented burners and found it to be one of the most efficient ways of reducing NOxs, achieve maximum efficiency, and reduce particulate emissions from glass furnaces. Additional advantages of Oxy-Fuel Combustion in the glass industry are:

- Better glass quality.
- Very low NOx and particulate emissions.
- No air preheating necessary.
- Suitability at higher pull rate.
- Better sequencing of the furnace.

Thus with oxygen enrichment, more heat is transferred to the product, less heat is lost in the exiting combustion gases, and the combustion process becomes more efficient. With proper furnace design and burner selection, reduction of NOx by 50-70%, as compared to regenerator furnace is achievable. In addition, reduction of batch carry over is possible.

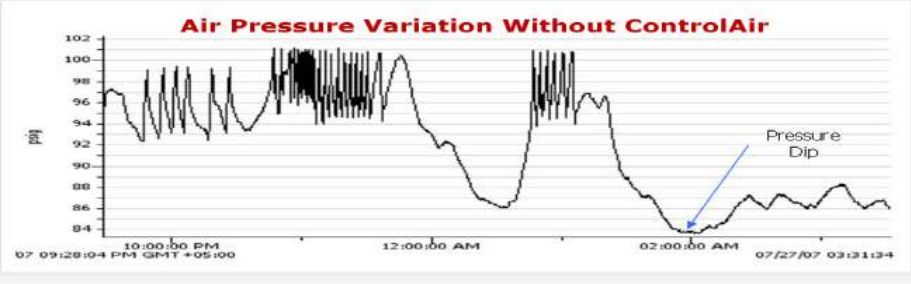
Depending on the furnace operation and the efficiency of the operation, fuel savings can range from slightlyover 50% to only 10%, so all the variables need to be reviewed prior to

	deciding if oxy combustion is a viable option.It is possible to convert specific zones of existing furnaces to oxy-fuel, or to add oxy-boosting burners asrequired at strategic locations in addition to air-fired burners. The conversion from an air-fuel combustions system to an oxy-fuel system willrequire a complete burner replacement. "Oxy-fuel burners are of a different design than air-fuel burners; it is not possible tosimply insert an oxy-fuel element into an air-fuel burner. Oxy-fuel combustion is not the answer to all applications, so it is very important to determine if it is a viable alternative. That said, in some processes that cycle, whereloads are taken from cold to hot and melted, going from air combustion to oxy combustion not only reduces fuel use but can reduce cycle and heat-up time. This is where the operator can see significant cost reductions. Add to this the potential for reduction in total NOx emissions and the ability to reduce the plant's carbon footprint by reductionin fuel use, and the benefits of oxy-fuel can be important. Before replacing or adding air-fuel combustion systems, it can bevaluable to take a look at the oxy-fuel option. Depending on the furnace operation and the efficiency of the operation, fuel savings can range from slightly over 50% to only 10%, so all the variables need to be reviewed prior to deciding if oxy combustion is a viable option. It is possible to convert specific zones of existing furnaces to oxy-fuel, or

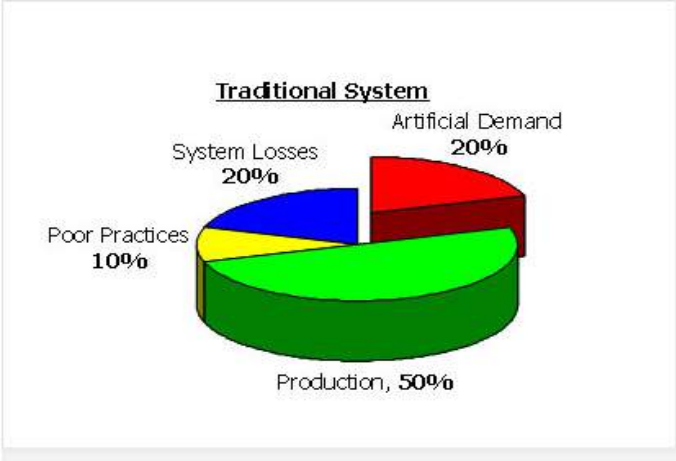
	to add oxy-boosting burners as required at strategic locations in addition to air-fired burners. Considering even 10 % fuel saving by converting air-fuel system into oxy-fuel system plant can save approximately 718063 SCM per annum.
Benefit	
Environmental	• Reduction in the natural gas consumption by 718063 SCM per year • Per Year Reduction in Greenhouse Gas (CO2) emission: 1344.93 tCo_2/Year
Economical	Investment: **Rs. 2,50,00,000**/-for 2 nos. of Furnace Annual Savings: **Rs. 1,29,50,000**/- per annum Payback Period: **24** months

Intervening Technique	Reducing Fluctuating Compressed Air Demand
Description	• Plant is operating various air compressors for process application, while 2 nos, air compressors of 75 kW rated power and 484 CFM free air delivery capacity each were operating for instrumentation air purpose. • Industry usually have problem of fluctuating air pressure. This is caused by intermittent use of several pneumatic equipments. It begins with sudden air demand pulling down pressure at the point of use. The only way for the Air Compressors to know about it, is when it travels to upstream through distribution

network. The capacity control mechanism of the Air Compressor in the form of Load/Unload or VSD then starts delivering compressed air in the system. Practically it takes a while for the entire air system to fill up to the required pressure.



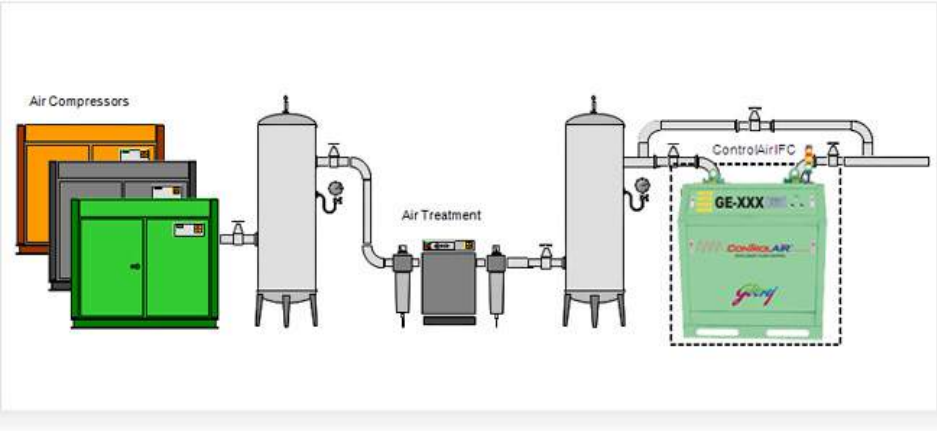
- This lag in response time between demand & supply, force the Compressor operators to maintain higher level of pressure in the air system to sustain a sudden demand. Thus more Compressors are needed to meet the artificial demand along with real air demand. This causes wastage of compressed air & leads to an energy inefficient system. This translates into high energy bills. Isn't it time, you controlled the cost of energy for your Air Compressors?

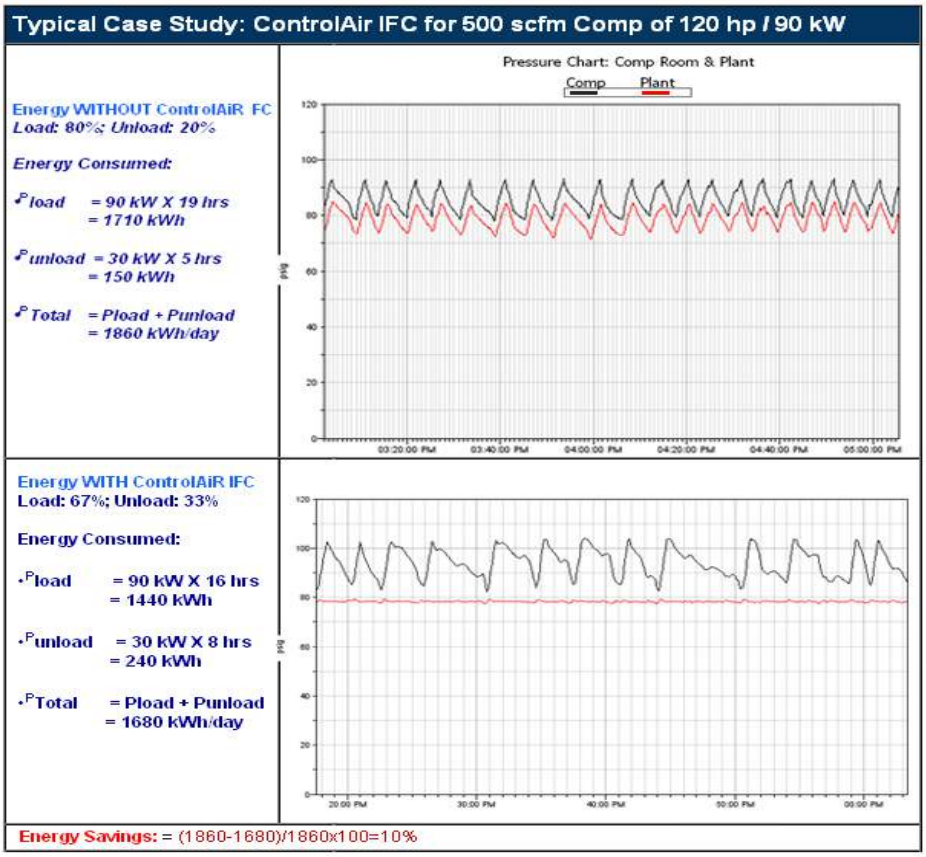


BENEFITS of ControlAir IFC System:

- Constant Air Pressure throughout the plant
- Artificial Demand Reduction
- Reduced Compressed Air leaks
- Satisfy Peak Demand with Useful Storage
- Improved product quality
- Increased productivity
- Reduction in Comps operating & maintenance costs
- 80% depreciation under prevailing income tax laws in India
- Payback between 7 to 22 months

- The ControlAir IFC is designed to operate at the intermediate point of the compressed air system; i.e. on the downstream of Dryers / Receivers & upstream of the main piping distribution system. ControlAir IFC creates useful storage which isolates Compressors from demand side peaks & troughs to provide a stable air supply at optimum pressure. It monitors demand side rate of change of pressure & releases only required amount of storage air to satisfy the peak demands instead of starting additional Compressors. Thus energy is saved through reduction in mass of air & reduction in load period of Compressors.





Thus, it is suggested to install the ControlAir system for instrumentation air supply, this will save approximately 10 % of electricity consumption by air compressor.

Benefit

Environmental	• Reduction in Greenhouse Gas (CO_2) emission
Economical	Investment: **Rs. 6,00,000/-** Annual Savings: **Rs. 4,97,000/-** per annum Payback Period: **15 months**

Intervening Technique	Optimisation of Gas Consumption through Batch & Cullet Preheating
Description	Batch and cullet is normally introduced cold into the furnace, but by using the residual heat ofthe waste gases to preheat the batch and cullet, significant energy savings can be possible. Preheating temperatures should preferably not be lower than 270 ^{0}C but should not exceed500 – 550 ^{0}C. In practice, most batch and cullet preheaters operate at batch preheat temperaturesbetween 275 and 325 ^{0}C. The available systems are described below: • Direct preheating – this type of preheating involves direct contact between the flue-gas and the raw material (cullet and batch) in a cross-counter flow. The waste gases are supplied to the preheater from the waste gas duct behind the regenerator. They pass through the cavities in the preheater, thereby coming into direct contact with the raw material. The outlet

temperature of the cullet and batch is about 300 0C and could go up to 400 ^{0}C. The system incorporates a bypass that allows furnace operations to continue whenpreheater use is either inappropriate or impossible.

- Indirect preheating – the indirect preheater is, in principle, a cross-counter flow, plate heat exchanger, in which the material is heated indirectly. It is designed in a modular form and consists of individual heat exchanger blocks situated above each other. These blocks are again divided into horizontal waste gas and vertical material funnels. In the material funnels, the material flows from the top to the bottom by gravity. Depending on the throughput, the material reaches a speed of 1 – 3 m/h and will normally be heated from ambient temperature up to approximately 300 ^{0}C. The flue-gases will be let into the bottom of the preheater and flow into the upper part by means of special detour funnels.The waste gases flow horizontally through the individual modules. Typically the flue gases will be cooled down by approximately 270 – 300 ^{0}C.

These techniques have a number of environmental effects, which can vary from case to case. Ingeneral, the benefits given below have been experienced.

- Specific energy savings of between 10 and 20 % with a consequent reduction of CO_2 emissions.
- Reduction in NOX emissions (due to lower fuel

	requirements and lower furnace temperatures). However, in most cases the energy savings are used to increase the pull of the furnace. • An increase of pull rate of up to 10 – 15 %, is possible for applications to existing glass furnaces, with preheating of the batch to 300 ^{0}C. By implementing the batch & cullet preheating plant can save approximately 299316 SCM per annum with only cullet preheating (considering 20% cullet), while plant can save approximately 1496616 SCM per annum with batch & cullet preheating.
Benefit	
Environmental	• Reduction in Natural Gas Consumption by1496616 SCM per annum. • Reduction in Greenhouse Gas (CO_2) emission = 2803.16tCo2/Year
Economical	Investment: **Rs. 1,50,00,000**/-(for 2 nos. of furnace) Annual Savings: **Rs. 53,87,000**/- per annum (for cullet Preheating) Payback Period: **34** months

Gopal Glass Works Limited, Kadi

Introduction: Gopal Glass Works Limited

Gopal Glass Works Ltd., located at Kadi City Industrial Estate, Mehsana district, is a well-known manufacturer of Float Glass. Gopal Glass Works has beenstartedsince 1978. It was first gas based furnace in India which was established in 1989. It started manufacturing of Patterned (figure) glass, Rolled Glass and Wired glass in both Flint and tinted form with variety of design. Gopal Glass has a Consultancy Provider for establishing the Turkey Project of Patterned (Figure) glass Manufacturing. It was also a best seller brand in Indian Patterned (Figure) glass Market. It has an only company which Spread in 90 % of the Indian Figured Glass Market. They use GAIL Gas, Sabarmati Gas, Furnace Oil and Sometimes use Petcock as a fuel in Furnace. Gopal Glass was Pioneer in Manufacturing 2 mm Anti Glair Rolled Glass, which widely used in the Photo Framing. Starting with production Capacity of 50 tonne per day, Now Gopal Glass has Production Capacity of more than 240 tonne per day. Total Production of Gopal Glass works ltd. has 3708744Sqm. / Annum.

Cleaner Production Assessment Team

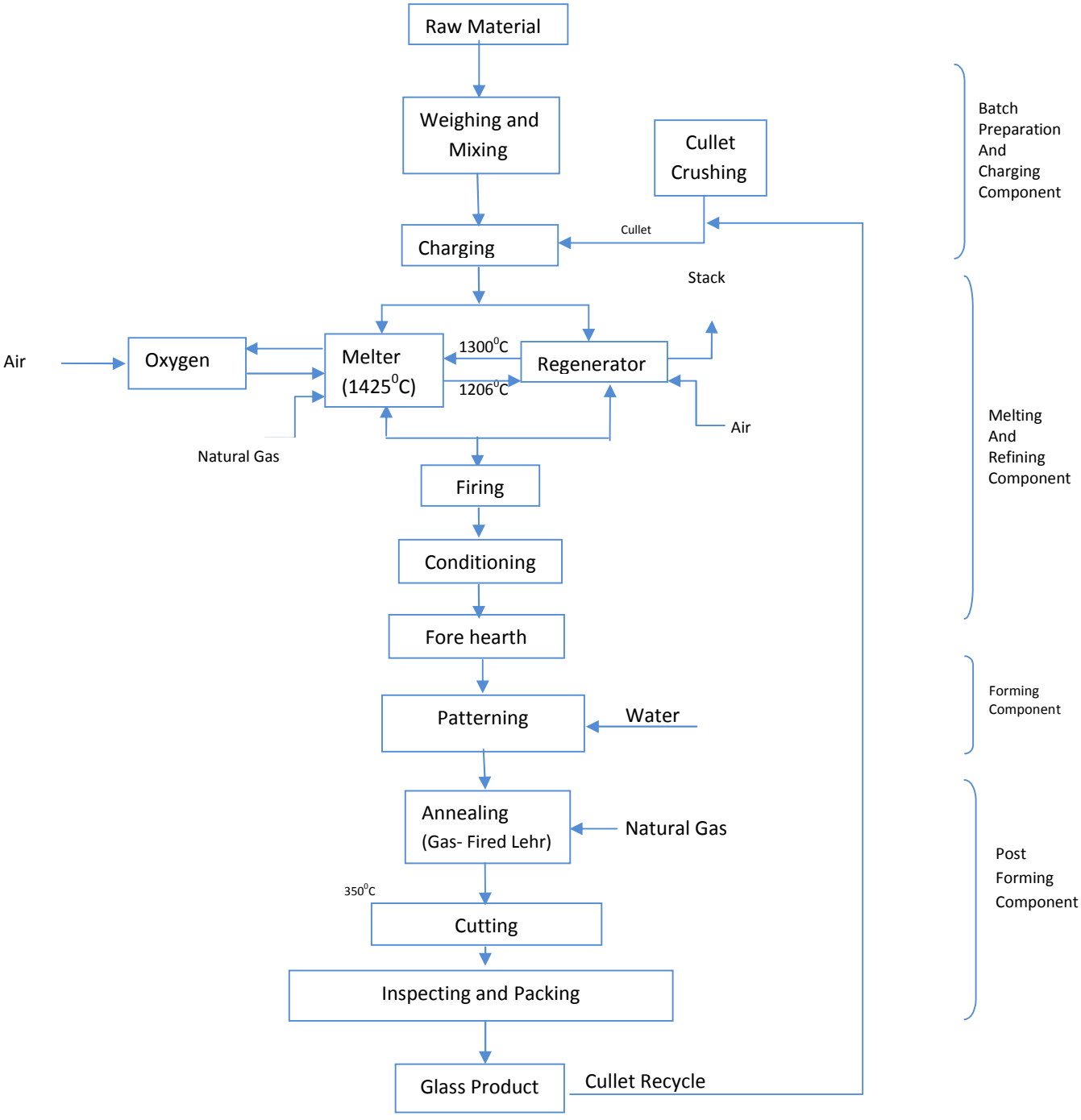
The team for conducting Cleaner Production Assessment includes the following members.

Name	Designation
Dr. Bharat Jain	Member Secretary, GCPC
Mr. PunamchandraRathod	Senior Project Engineer, GCPC
Mr. Abhi Patel	Assistant Project Engineer, GCPC
Mr. Paras Gojiya	Assistant Project Engineer, GCPC
Mr. SammerGautam	General Manager, Gopal Glass Works Ltd., Kadi
Mr. Purvish Shah	Director, Gopal Glass Works Ltd., Kadi
Mr. Gaurav Sharma	Production Department, Gopal Glass Works Ltd., Kadi
Mr. Jigarbhai	Utility Department, Gopal Glass Works Ltd., Kadi

Manufacturing Process

Piramal Glass Limited, Kosamba, Surat manufacturing plant manufactures containers for nail enamel, perfumes, skin care, foundation, aroma oils, miniatures etc. The manufacturing process flow chart is as depicted below.

Manufacturing Process Flow Diagram



INTRODUCTION

The Float process became standard during the sixties. This technique involves discharging a ribbon of molten glass from the furnace and then floating it across a bath of molten tin to produce a perfectly flat, flawless surface of uniform thickness and viscosity. The ribbon is pulled through the float to the lehr, resulting in a continuous supply of glass that requires no grinding or polishing.

i. BATCHING OF RAW MATERIALS:

The main components, namely, soda lime glass, silica sand (73%), calcium oxide (9%), soda (13%), magnesium (4%), and 25 % cullet (broken glass) are weighed and mixed into batches to which recycled glass (cullet) is added. The use of 'cullet' reduces the consumption of natural gas. The materials are tested and stored for later mixing under computerized control. For certain glass type metallic oxides to add a coloured tint to the glass. Magnesium or Aluminum to increase its resistance to atmospheric agents.

ii. FURNACE

The batched raw materials pass from a mixing silo to a five-chambered furnace where they become molten at a temperature of approximately 1500°C to remove any impurities and bubbles. The furnace is a wide tank made of refractory materials and holds up to 75 tonnes of molten glass. The glass is fired from above from alternating sides using natural gas, furnace oil, PETCO and waste gases, which are re-used to preheat the air on the opposite side.

iii. PATTERNED GLASS

The glass, now at 12000C, passes between two horizontal rollers positioned several millimeters apart. A ribbon of textured glass is created by the revolving rollers embossed with a pattern on one face.

iv. ANNEALING LEHR:

On leaving the bath of molten tin, the glass – now at a temperature of 600°C – has cooled down sufficiently to pass to an annealing chamber called a lehr. The glass is now hard enough to pass over rollers and is annealed, which modifies the internal stresses enabling it to be cut and worked in a predictable way and ensuring flatness of the glass. As both surfaces are fire finished, they need no grinding or polishing.

v. CUTTING

Once cooled, the glass ribbon is ready to continue to the cutting area. First the glass thickness and presence of faults are monitored by an online laser detection system. Then the ribbon is automatically cut across (once the roller marked edges have been removed and recycled) into standard sheet dimensions of approximately 1830 x 1830 mm.

vi. STOCKING AND TRANSPORT

After the Cutting of the sheet in standard dimension, its sheet is lifted by the person who is stand nearer the Cutting Section and put in the specific place where the sheets are then loaded in packs onto a stillage, the base of which forms the actual floor of the delivery vehicles ready to be sent to the customer.

Data Collected from Gopal Glass Works Ltd.

Total Production of Glass and Fuel Consumption

Production	Unit 1	Unit 2	Total Production	Fuel			
	Production	Production		GAIL GAS	Sabarmati Gas	Furnace Oil	PETCOKE
Total	3708744	3415717	7124462	5198817	550315	1969477	1027838

Where, Production in Sqm. /Annum
Gas in Standard Cubic Meter
Furnace Oil in Liter
PETCOKE in KG

Details of Raw-material

Sr. No.	Raw Material	Total (In tonnes)
1	S/SAND	27177
2	DOLOMITE	5669
3	SODA ASH	8706
4	L/STONE	2709
5	S/SULPHATE	468
6	S/NITRATE	182
7	CARBON	27
8	FELSPAR	572
9	SLAG POWDER	81
10	ROUGE POWDER	24

Cleaner Production Opportunities

<table>
<tr><td>Intervening Technique</td><td>Electricity Consumption Planning for Reducing Electricity Cost</td></tr>
<tr><td>Benefits</td><td>

The source of outside power for the plant is from UGVCL (Uttar Gujarat Vij Company Limited) grid at 66 kV.
The below table indicates, maximum registered demand, average power factor, average load factor and average unit's consumption for the reference period. Refer Annexure –I for analysis of monthly electricity consumption parameters as per UGVCL electricity bills.

Table 1: Electricity Bill Analysis Summary
<table>
<tr><td rowspan="2">Sr. No.</td><td rowspan="2">Items</td><td colspan="3">January 2015 – December 2015</td></tr>
<tr><td>Minimum</td><td>Maximum</td><td>Average</td></tr>
<tr><td>1.</td><td>Contract demand (kVA)</td><td colspan="3">700</td></tr>
<tr><td>2.</td><td>Maximum demand (kVA)</td><td>473</td><td>698</td><td>573058</td></tr>
<tr><td>3.</td><td>Power factor</td><td>0.993</td><td>0.999</td><td>0.997</td></tr>
<tr><td>4.</td><td>Monthly units consumption (kWh)</td><td>220176</td><td>323088</td><td>262482.667</td></tr>
<tr><td>5.</td><td>Avg. unit rate, (Rs./kWh)</td><td colspan="3">7.54</td></tr>
</table>

Average maximum demand is more than 85 % (Minimum Billing Demand) of contract demand i.e., 700 KVA

</td></tr>
</table>

throughout year, although it is varying month to month but the variation is in between 103 KVA and is below contract demand.

- Average power factor maintained by the company is around 0.997, although company has centralised APFC which are maintaining the power factor up to 0.998 thus availing maximum PF incentive from the electricity distribution company. Although in few months the power factor dipped due to less demand in respective months, thus fine tuning of capacitor banks will improve and maintain the power factor up to 0.99 in order to avail maximum rebate of PF incentive.

- UGVCL charges Time of Use (TOU) surcharge. This is applicable for different periods of the day i.e. normal period, two peak hour periods. The surcharge on energy charges according to the period of consumption shall be as per following:

Table 2: TOU Period

Sr. No.	Peak Period
1.	Morning peak load period (7 AM to 11 AM)
2.	Evening peak load period (6 PM to 10 PM)

- The Time of Use charges for the energy consumption during these peak periods are as following:

Table 3: TOU Charges

Sr. No.	Billing Demand	TOU Charges
1.	For billing demand upto 500 kVA	Rs. 0.45 per unit
2.	For billing demand above 500 kVA	Rs. 0.85 per unit

- Plant is consuming average 89,286.667 kWh per month during ToU duration and thus it is contributing to average Rs. 75893.667 per month additional electricity charges.

- Although due to continuous production it is not possible to avoid critical load running during the TOU (peak load period) but plant can optimize the TOU surcharges in the bill by identifying few non-critical loads and keeping them off during the TOU duration (i.e., 7 AM to 11 AM & 6 PM to 10 PM) mentioned in the above table or if possible rescheduling of critical load to operate during 11 AM to 6 PM & 10 PM to 6 AM. Even 10 % load reduction during ToU duration will save approximately Rs. 87,058.4 p.a. without any investment.

CONCESSION FOR USE OF ELECTRICITY DURING NIGHT HOURS:

- For the consumer eligible for using supply at any time during 24 hours, entire consumption shall be billed at the energy charges specified above. However, the energy consumed during night hours of 10.00 PM to 06.00 AM

	next morning as is in excess of one third of the total energy consumed during the month, shall be eligible for concession at the rate of 85 Paise per unit. Plant is not consuming which contributed loss of rebate. • Thus plant should inventorize the list of electrical loads which are critical for production and non-critical load which can be operated in night hours only in view to maximize the benefits of night usage rebate, even if plant maintains night usage to its maximum recorded for month of January- 2015 upto 1, 05,336 kWh per month, plant will save approximately Rs. 10,74,427 p.a. additionally.

Intervening Technique	Installation of VFD on Throat Cooling Blower Motor
Before CP	Most electric motors are designed to run at 50% to 100% of rated load. Maximum efficiency is usually near 75% of rated load. Thus, a 10-horsepower (hp) motor has an acceptable load range of 5 to 10 hp; peak efficiency is at 7.5 hp. A motor's efficiency tends to decrease dramatically below about 50% load. However, the range of good efficiency varies with individual motors and tends to extend over a broader range for larger motors, as shown in Figure 6. A motor is considered under loaded when it is in the range where efficiency drops significantly with decreasing load. Figure shows that power factor tends to drop off sooner, but less steeply than efficiency, as load decreases.

Electrical load survey was conducted on major motors in the plant, the parameters measured are shown in following table:

Motor Name	Voltage (V)	Current (A)	Power Factor	Power (kW)	Rated Power (kW)	Loading (%)
Unit No. 2 (75 TPD Furnace Area)						
Throat Cooling Blower	412	8.57	0.64	3.94	9.32	42
Unit No. 1 (84 TPD Furnace)						
Throat Cooling Blower	416	6.32	0.78	3.55	9.32	38

Loading on both the motors is less than 50 %, thus they are running at lower efficiency of around 75 %, thus it is recommended to replace these motors with appropriate size on next failure, the motor need to be selected so that the loading on motor is more than 80 % to have more than 90 % efficiency.

After CP

- Replacement of these motors with energy efficient motors will save approximately 9450 kWh per annum.

Benefits

Environmental

- Reduction in the Electricity consumption by 9450 KWh per year
- Reduction in the green-house gases = 8.08 tCO_2/Year

Economical

Investment: **50,000/-** (for 2 nos. of Furnace)

	Annual Savings: **Rs. 71,253**/- per annum Payback Period: **9 months**

Intervening Technique	Avoid Compressed air usage for cleaning purposes
Before CP	During the visit it was observed that compressed air is used for cleaning purposes at some workstations to clean the components with open hose of 5 mm diameter and at 6 kg/cm²g pressure.
After CP	Usually, cleaning can be done at lower pressure (around 2-3 kg/cm²g). So, the first step would be to reduce the pressure and energy saving would be around 8% at drop of each bar for that hose if generated separately. From our past experience the company can save Rs. 21,000 per year (from one workplace) by installing compressed air saving gun. The compressed air is a costly utility and the less critical purposes like cleaning can be achieved by installing air saver nozzles at the tip of these cleaning devices or shall be replaced with new one. The special design of these improved cleaning nozzles allows ambient air to get entrained in the path due to vacuum created by compressed air and delivers the air with similar velocity and thrust giving to desired cleaning effect. However, the amount of compressed air uses is only 20-25%

	which reduces the compressed air requirement and thus resulting in energy savings. In addition, these nozzles also reduce the noise level.  
Benefits	
Environmental	Reduction in the electricity consumption to generate the compressed air, with that, also reducing Noise Pollution of the surrounding, making the site easy to work
Economical	Investment: **3,000**/- per gun Annual Savings: **Rs. 21,000**/- per station Payback Period: **3 months**

Intervening Technique	Optimization of Combustion Efficiency of Melting Furnace
Before CP	Plant is operating 2 nos. furnaces for melting the glass with natural gas as fuel. Thus, the flue gas analysis for the furnaces was carried out, at the exhaust of individual furnaces, the measured parameters are shown in table below: **Table: Flue Gas Monitoring Parameters at Unit 2 Furnace**

Parameters	Right Side Firing	Left Side Firing
Oxygen (%)	3.0	6.8
Carbon Monoxide (ppm)	0	78
Carbon Dioxide (%)	10.3	7.9
Access Air (%)	15.4	47.1
Pressure (mBar)	0.46	0.23

Table: Flue Gas Monitoring Parameters at Unit 1 Furnace

Parameters	Right Side Firing	Left Side Firing
Oxygen (%)	4.0	10.4
Carbon Monoxide (ppm)	0	0
Carbon Dioxide (%)	9.6	6.0
Access Air (%)	26.6	95.3
Pressure (mBar)	-0.04	-0.10

It can be observed that the combustion parameters are maintained properly with oxygen percentage in flue gases 3 to 4 % while right side firing and 6 to 12 % while left side firing. Thus, there is loss of combustion efficiency during left side firing and need to be optimized by following combustion efficiency indicators.

Combustion Efficiency Indicator:

1. As a rule, the most efficient and cost-effective use of fuel takes place when CO_2 concentration in the

	exhaust is maximized. Theoretically, this occurs when there is just enough O_2 in the supply air to react with all the carbon in the fuel. 2. The absence of any O_2 in the flue gas directly indicates deficient combustion air while presence indicates excess air. Ideally, the O_2 level shall be maintained 2 % to 6 %, CO_2 level shall be maintained 8 % to 11 %, CO level shall be maintained 80 ppm – 100 ppm and excess air shall be maintained 5 % to 7 % (high pressure burner) for gas. 3. Carbon monoxide (CO) is a sensitive indicator of incomplete combustion; its levels should range from 0 to 400 ppm by volume. The presence of a large amount of CO in flue gas is a certain indicator of deficient air. Excessive draft allows increased volume of air into the furnace. The large amount of flue gas moves quickly through the furnace, allowing less time for heat transfer to the material side. The result is that the exit temperature decreases with increase in heat quantity along with larger volume of flue gas leaving the stack contributes to higher heat loss.
After CP	The same can be maintained by regular monitoring of flue gas sample with the help of a portable flue gas analyzer or by installing O_2 sensor at the furnace exhaust for flue gases and a modulating motorized damper or RPM of combustion air blower through VFD for combustion air control. The sensor will provide constant feedback of O_2 % to the damper

	/ VFD which will in turn regulate the flow of combustion air to maintain the combustion efficiency at optimum level of 80 – 90% (Achievable combustion efficiency). Thus, it is recommended to operate the furnaces at optimum efficiency by controlling (manual/auto) air fuel ratio so that to get maximum combustion efficiency, the fluidised bed furnaces are known for generating maximum combustion efficiency in principal more than 80 %, thus plant should target to achieve the same initially manual adjustment through frequency adjustment and monitoring oxygen percentage in flue gases and then putting the drives in auto with online O_2 sensor in exhaust and feedback to supply air, although caution need to be considered with setting of minimum air requirement for pressure & draft control within furnace. By maintaining optimum combustion efficiency even up to 75 % for left side firing of particularly unit 1 furnace from existing (average 40 % as per oxygen percentage in flue gases) in these two furnaces, plant can save approximately 346149 SCM per annum.
Benefit	
Environmental	• Reduction in the natural gas consumption by 346149 SCM per year • Reduction in the green-house gases = 648.34 tCO_2/Year
Economical	Investment: **Rs. 20,00,000** /- (for complete automation of

	furnace) Annual Savings: **Rs. 51,92,000** /- per annum Payback Period: **5 months**

Intervening Technique	Optimise the Power Consumption at Cooling Water Pump
Before CP	• Plant is operating cold water pump of 9.32 kW rated power with rated discharge of 151 m^3/hr, with rated head of 15 m. Cooling water is being used for different cooling application, the suction head of the cooling water was found 3 m. The discharge line has flow control valve which was only 30 % open, indicates that the pump installed is over capacity. • The pump is not operating at the optimum efficiency due to shift in flow rate from design parameter. The pump is consuming 9.5 kW power while the hydraulic power required for pumping water (@ 60 m /hr flow as per valve position) at total head of 20 m (assumed) is only 4.5 kW.
After CP	• Thus it is recommended to install a Variable Frequency Drive with pressure feedback on this pump to optimize the power consumption without replacing the pump as well as keeping option of load increment in future; the VFD will save approximately 21000 kWh per annum.

	• Plant is operating hot water pump of 15 kW rated power with rated discharge of 120 m^3/hr, with rated head of 28 m. Water is being pumped to the cooling tower, the suction head of the cooling water was found 1.5 m. The discharge line has flow control valve which was only 50 % open, indicates that the pump installed is over capacity. The pump is not operating at the optimum efficiency due to shift in flow rate from design parameter. The pump is consuming 15 kW power while the hydraulic power required for pumping water (@ 72 m^3/hr flow as per valve position) at total head of 30 m (assumed) is only 7.8 kW. • Thus it is recommended to install a Variable Frequency Drive with pressure feedback on this pump to optimise the power consumption without replacing the pump as well as keeping option of load increment in future; the VFD will save approximately 29400 kWh per annum.
Benefit	
Environmental	• Reduction in the natural gas consumption by 50,400 KWh per year • Reduction in the green-house gases = 43.34 tCO_2/Year
Economical	Investment: Rs. **Rs. 55,000** /-(for 2 VFD) Annual Savings: **Rs. 3,80,016**/- per annum

	Payback Period:2 Months

Intervening Technique	Optimisation of Gas Consumption through Oxygen Enhanced Combustion in Furnaces
Description	Glass manufacturing is a very energy intensive industrial process. Glass is produced by heating the raw materials like silica (Silicon dioxide), sand (Quartz), iron oxide, and othermaterials to about 1500 to 200 ^{0}C. Glass manufacturers who need to increase pull rate (pull rate is the velocity of the glass sheet) and improve quality, consistency, and thermal efficiency while decreasing NOx emissions can use Oxy-Fuel technology. Oxy-Fuel technology has proved to be one of the most energy efficient combustion processes for glass melting furnaces. Ideal burners for any furnace would have the following characteristics: ▪ Flexibility with respect to flame length and heat transfer. ▪ Continuity of operations, which can be adjusted during use. ▪ Multiple fuel usage. ▪ Robust and compact design. The Oxy-Fuel burners have most of the above characteristics. It has been observed by a major company in combustion technology that in Oxy-Fuel combustion the

	volume of the flue gases is approximately 20% of that in the Air-Fuel combustion resulting in a reduction of the amount of heat lost through flue gases. They have developed their own-patented burners and found it to be one of the most efficient ways of reducing NOx, achieve maximum efficiency, and reduce particulate emissions from glass furnaces. Additional advantages of Oxy-Fuel Combustion in the glass industry are: ▪ Better glass quality. ▪ Very low NOx and particulate emissions. ▪ No air preheating necessary. ▪ Suitability at higher pull rate. ▪ Better sequencing of the furnace. Thus with oxygen enrichment, more heat is transferred to the product, less heat is lost in the exiting combustion gases, and the combustion process becomes more efficient. With proper furnace design and burner selection, reduction of NOx by 50-70%, as compared to regenerator furnace is achievable. In addition, reduction of batch carry over is possible. Depending on the furnace operation and the efficiency of the operation, fuel savings can range from slightly over 50% to only 10%, so all the variables need to be reviewed prior to deciding if oxy combustion is a viable option. It is possible to convert specific zones of existing furnaces to oxy-fuel, or to add oxy-boosting burners as required at strategic locations in addition to air-fired burners.

	The conversion from an air-fuel combustions system to an oxy-fuel system will require a complete burner replacement. "Oxy-fuel burners are of a different design than air-fuel burners; it is not possible to simply insert an oxy-fuel element into an air-fuel burner. Oxy-fuel combustion is not the answer to all applications, so it is very important to determine if it is a viable alternative. That said, in some processes that cycle, where loads are taken from cold to hot and melted, going from air combustion to oxy combustion not only reduces fuel use but can reduce cycle and heat-up time. This is where the operator can see significant cost reductions. Add to this the potential for reduction in total NOx emissions and the ability to reduce the plant's carbon footprint by reduction in fuel use, and the benefits of oxy-fuel can be important. Before replacing or adding air-fuel combustion systems, it can be valuable to take a look at the oxy-fuel option. Depending on the furnace operation and the efficiency of the operation, fuel savings can range from slightly over 50% to only 10%, so all the variables need to be reviewed prior to deciding if oxy combustion is a viable option. It is possible to convert specific zones of existing furnaces to oxy-fuel, or to add oxy-boosting burners as required at strategic locations in addition to air-fired burners. Considering even 10 % fuel saving by converting air-fuel system into oxy-fuel system plant can save approximately 574513 SCM per annum.

Benefit	
Environmental	• Reduction in the natural gas consumption by 574513 SCM per year • Per Year Reduction in Greenhouse Gas (CO2) emission: 1076.06 tCO_2/Year
Economical	Investment: **Rs. 2,20,00,000**/-for 2 nos. of Furnace Annual Savings: **Rs. 86,17,695**/- per annum Payback Period: **30** months

Intervening Technique	Optimisation of Gas Consumption through Batch & Cullet Preheating
Description	Batch and cullet is normally introduced cold into the furnace, but by using the residual heat of the waste gases to preheat the batch and cullet, significant energy savings can be possible. Preheating temperatures should preferably not be lower than 270 ^{0}C but should not exceed 500 – 550 ^{0}C. In practice, most batch and cullet preheaters operate at batch preheat temperatures between 275 and 325 ^{0}C. The available systems are described below: ▪ Direct preheating – this type of preheating involves direct contact between the flue-gas and the raw material (cullet and batch) in a cross-counter flow.

	The waste gases are supplied to the preheater from the waste gas duct behind the regenerator. They pass through the cavities in the preheater, thereby coming into direct contact with the raw material. The outlet temperature of the cullet and batch is about 300 ^{0}C and could go up to 400 ^{0}C. The system incorporates a bypass that allows furnace operations to continue when preheater use is either inappropriate or impossible. ▪ Indirect preheating – the indirect preheater is, in principle, a cross-counter flow, plate heat exchanger, in which the material is heated indirectly. It is designed in a modular form and consists of individual heat exchanger blocks situated above each other. These blocks are again divided into horizontal waste gas and vertical material funnels. In the material funnels, the material flows from the top to the bottom by gravity. Depending on the throughput, the material reaches a speed of 1 – 3 m/h and will normally be heated from ambient temperature up to approximately 300 0C. The flue-gases will be let into the bottom of the preheater and flow into the upper part by means of special detour funnels. The waste gases flow horizontally through the individual modules. Typically the flue gases will be cooled down by approximately 270 – 300 ^{0}C. These techniques have a number of environmental effects, which can vary from case to case. In general, the benefits

	given below have been experienced. ▪ Specific energy savings of between 10 and 20 % with a consequent reduction of CO2 emissions. ▪ Reduction in NOX emissions (due to lower fuel requirements and lower furnace temperatures). However, in most cases the energy savings are used to increase the pull of the furnace. ▪ An increase of pull rate of up to 10 – 15 %, is possible for applications to existing glass furnaces, with preheating of the batch to 300 ^{0}C. ▪ By implementing the batch & cullet preheating plant can save approximately 191504 SCM per annum with only cullet preheating (considering 20% cullet), while plant can save approximately 957522 SCM per annum with batch & cullet preheating.
Benefit	
Environmental	• Reduction in the natural gas consumption by 957522 SCM per year • Reduction in Greenhouse Gas (CO2) emission = 1793.44tCo2/Year
Economical	Investment: **Rs. 80,00,000**/-(for 2 nos. of furnace) Annual Savings: **Rs. 28,72,000**/- per annum (for batch &cullet Preheating) Payback Period: **30** months

GobindGlass& Industries Limited, Kadi

Introduction: Gobind Glass & Industries Limited, Kadi

Gobind Glass & Industries Limited, GIDC, Tal: Kadi, in Mehsana district is a well-known manufacturer of Float Glass. It was first gas based furnace in India which was established in 1989. It started manufacturing of Patterned (figure) glass, Rolled Glass and Wired glass in both Flint and tinted form with variety of design. They use GAIL Gas, Sabarmati Gas, Furnace Oil and Sometimes use Petcock as a fuel in Furnace. Gobind Glass was Pioneer in Manufacturing 2 mm Anti Glair Rolled Glass, which widely used in the Photo Framing. Starting with production Capacity of 50 tonne per day, Now Gobind Glass has Production Capacity of more than 2700 MT/Month.

Cleaner Production Assessment Team

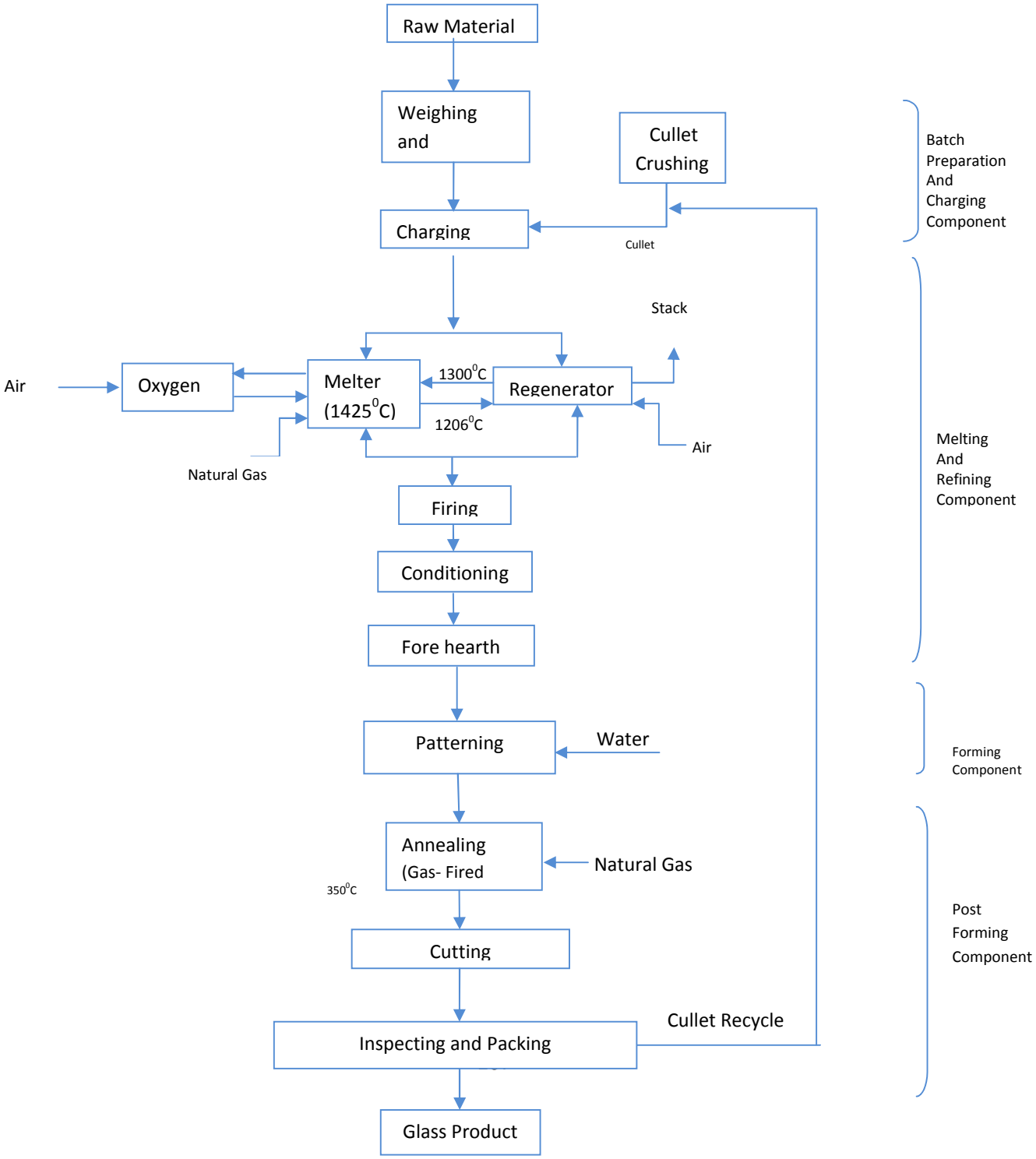
The team for conducting Cleaner Production Assessment includes the following members.

Name	Designation
Dr. Bharat Jain	Member Secretary, GCPC
Mr. PunamchandraRathod	Senior Project Engineer, GCPC
Mr. Abhi Patel	Assistant Project Engineer, GCPC
Mr. Paras Gojiya	Assistant Project Engineer, GCPC
Mr. M. A. Khan	Production Manager, Gobind Glass & Industries ltd.
Mr. Roshansingh	Utility Department, Gobind Glass & Industries ltd.

Manufacturing Process

Gobind Glass & Industries Limited, Kadi in Mehsana district has manufacturing plant manufactures of Patterned (figure) glass, Rolled Glass and Wired glass in both Flint and tinted form with variety of design. The manufacturing process flow chart is as depicted below.

Manufacturing Process Flow Diagram



INTRODUCTION

The Float process became standard during the sixties. This technique involves discharging a ribbon of molten glass from the furnace and then floating it across a bath of molten tin to produce a perfectly flat, flawless surface of uniform thickness and viscosity. The ribbon is pulled through the float to the lehr, resulting in a continuous supply of glass that requires no grinding or polishing.

i. BATCHING OF RAW MATERIALS

The main components, namely, soda lime glass, silica sand (73%), calcium oxide (9%), soda (13%), magnesium (4%), and 25 % cullet (broken glass) are weighed and mixed into batches to which recycled glass (cullet) is added. The use of 'cullet' reduces the consumption of natural gas. The materials are tested and stored for later mixing under computerized control. For certain glass type metallic oxides to add a coloured tint to the glass. Magnesium or Aluminum to increase its resistance to atmospheric agents.

ii. FURNACE

The batched raw materials pass from a mixing silo to a five-chambered furnace where they become molten at a temperature of approximately 1500°C to remove any impurities and bubbles. The furnace is a wide tank made of refractory materials and holds up to 75 tonnes of molten glass. The glass is fired from above from alternating sides using natural gas, furnace oil, PETCO and waste gases, which are re-used to preheat the air on the opposite side.

iii. PATTERNED GLASS

The glass, now at 12000C, passes between two horizontal rollers positioned several millimeters apart. A ribbon of textured glass is created by the revolving rollers embossed with a pattern on one face.

iv. ANNEALING LEHR

On leaving the bath of molten tin, the glass – now at a temperature of 600°C – has cooled down sufficiently to pass to an annealing chamber called a lehr. The glass is now hard enough to pass over rollers and is annealed, which modifies the internal stresses enabling it to be cut and worked in a predictable way and ensuring flatness of the glass. As both surfaces are fire finished, they need no grinding or polishing.

v. CUTTING

Once cooled, the glass ribbon is ready to continue to the cutting area. First the glass thickness and presence of faults are monitored by an online laser detection system. Then the ribbon is automatically cut across (once the roller marked edges have been removed and recycled) into standard sheet dimensions of approximately 1830 x 1830 mm.

vi. STOCKING AND TRANSPORT

After the Cutting of the sheet in standard dimension, its sheet is lifted by the person who is stand nearer the Cutting Section and put in the specific place where the sheets are then loaded in packs onto a stillage, the base of which forms the actual floor of the delivery vehicles ready to be sent to the customer.

Details of Fuel Consumption

Month	All Unit Fuel Consumption		
	Natural Gas	Furnace Oil	Total
January-2015	391079	35120	426199
February-2015	312594	73693	386287
March-2015	372265	58497	430762
April-2015	374323	54299	428622
May-2015	365965	72139	438104
Jun-2015	371696	47891	419587
July-2015	339666	93522	433188
August-2015	370835	62099	432934
September-2015	350562	65348	415910
Octomber-2015	348802	84138	432940
November-2015	327183	83068	410251
December-2015	376940	63785	440725

Cleaner Production Opportunities

Intervening Technique	Optimization of Combustion Efficiency of Melting Furnace
Before CP	Plant is operating one furnace for melting the glass with natural gas and furnace oil as fuel. Thus, the flue gas analysis for the furnaces was carried out, at the exhaust of furnace, the measured parameters are shown in table below:

Table: Flue Gas Monitoring Parameters at Unit 2 Furnace

Parameters	Right Side Firing	Left Side Firing
Oxygen (%)	0.2	0.6
Carbon Monoxide (ppm)	O/R	O/R

Carbon Dioxide (%)	11.5	11.4
Access Air (%)	0.4	3.4
Pressure (mBar)	0.02	0.06

It can be observed that the combustion parameters are not maintained properly with carbon monoxide level in flue gases over 10,000 ppm, indicating air deficient combustion. Thus, there is loss of combustion efficiency during firing and need to be optimized by following combustion efficiency indicators.

Combustion Efficiency Indicator:

- As a rule, the most efficient and cost-effective use of fuel takes place when CO2 concentration in the exhaust is maximized. Theoretically, this occurs when there is just enough O2 in the supply air to react with all the carbon in the fuel.
- The absence of any O2 in the flue gas directly indicates deficient combustion air while presence indicates excess air. Ideally, the O2 level shall be maintained 2 % to 6 %, CO2 level shall be maintained 8 % to 11 %, CO level shall be maintained 80 ppm – 100 ppm and excess air shall be maintained 5 % to 7 % (high pressure burner) for gas.
- Carbon monoxide (CO) is a sensitive indicator of incomplete combustion, its levels should range from 0 to 400 ppm by volume. The presence of a large amount of CO in flue gas is a certain indicator of

	deficient air. Reduced combustion air resulted in incomplete combustion and thus unburnt carbon, leading to carbon monoxide generation resulting in lower combustion efficiency and loss of fuel
After CP	The same can be maintained by regular monitoring of flue gas sample with the help of a portable flue gas analyzer or by installing O2 sensor at the furnace exhaust for flue gases and a modulating motorized damper or RPM of combustion air blower through VFD for combustion air control. The sensor will provide constant feedback of O2% to the damper / VFD which will in turn regulate the flow of combustion air to maintain the combustion efficiency at optimum level of 80 – 90% (Achievable combustion efficiency). Thus, it is recommended to operate the furnaces at optimum efficiency by controlling (manual/auto) air fuel ratio so that to get maximum combustion efficiency, the fluidised bed furnaces are known for generating maximum combustion efficiency in principal more than 80 %, thus plant should target to achieve the same initially manual adjustment through frequency adjustment and monitoring oxygen percentage in flue gases and then putting the drives in auto with online O2 sensor in exhaust and feedback to supply air, although caution need to be considered with setting of minimum air requirement for pressure & draft control within furnace.

	By maintaining optimum combustion efficiency even upto 75 % from existing (average 65 % as per oxygen percentage in flue gases) in the furnace, plant can save approximately 573588 SCM of gas as well as 105813 litre of furnace oil per annum.
Benefit	
Environmental	• Reduction in the natural gas consumption by 573588 SCM per year and Furnace Oil Consumption by 105813 litre per Year. • Reduction in the green-house gases = 1187.55 tCO_2/Year
Economical	Investment: Rs. **Rs. 25,00,000** /- (for complete automation of furnace) Annual Savings: **Rs. 1,10,00,000** /- per annum Payback Period: **3 months**

Intervening Technique	Installation of VFD on Cooling Blower Motor
Before CP	• Most electric motors are designed to run at 50% to 100% of rated load. Maximum efficiency is usually near 75% of rated load. Thus, a 10-horsepower (hp) motor has an acceptable load range of 5 to 10 hp; peak efficiency is at 7.5 hp. A motor's efficiency tends to decrease dramatically below about 50% load. However, the range of good efficiency varies with individual motors and tends to extend over a broader range for larger motors. A motor is considered under loaded when it is in the range where efficiency drops

significantly with decreasing load. Power factor tends to drop off sooner, but less steeply than efficiency, as load decreases.

Electrical load survey was conducted on major motors in the plant, the parameters measured are shown in following table:

Motor Name	Voltage (V)	Current (A)	Power Factor	Power (kW)	Rated Power (kW)	Loading (%)
100 TPD Furnace Area						
Glass Cooling Lower Blower	412	5.27	0.64	2.40	5.5	43
Throat Cooling Blower (with VFD)	411	9.02	0.78	5.02	11.2	45

- Loading on both the motors is less than 50 %, although throat cooling blower motor is driven through VFD still showing low power factor, indicating the opportunity to reduce the frequency of the VFD and optimise the power consumption.

- The Glass cooling lower blower motor is running at lower efficiency of around 75 %, thus it is recommended to replace motor with appropriate size

	on next failure, the motor need to be selected so that the loading on motor is more than 80 % to have more than 90 % efficiency.
After CP	• Reducing the frequency of the throat cooling blower motor frequency and replacement of the glass cooling lower blower motor with energy efficient motor will save approximately 5208 kWh per annum.
Benefits	
Environmental	• Reduction in the Electricity consumption by 5208 KWh per year • Reduction in the green-house gases = 4.48 tCO_2/Year
Economical	Investment: **50,000**/- (for 2 nos. of Furnace) Annual Savings: **Rs. 71,253**/- per annum Payback Period: **9 months**

Intervening Technique	Optimise the Power Consumption at Cooling Water Pump
Before CP	• Plant is operating cold water pump of 19.70 kW rated power with rated discharge of 150 m3/hr, with rated head of 35 m. Cooling water is being used for different cooling application, the suction head of the cooling water was found 2 m. The discharge line has flow control valve which was only 50 % open, indicates that the pump installed is over capacity. • The pump is not operating at the optimum efficiency due to shift in flow rate from design parameter. The

	pump is consuming 20 kW power while the hydraulic power required for pumping water (@ 90 m3/hr flow as per valve position) at total head of 40 m (assumed) is only 13.5 kW.
After CP	• Thus it is recommended to install a Variable Frequency Drive with pressure feedback on this pump to optimise the power consumption without replacing the pump as well as keeping option of load increment in future, the VFD will save approximately 27300 kWh per annum. • Plant is operating hot water pump of 8.12 kW rated power with rated discharge of 150 m3/hr, with rated head of 15 m. Water is being pumped to the cooling tower, the suction head of the cooling water was found 2 m. The discharge line has flow control valve which was only 70 % open, indicates that the pump installed is over capacity. The pump is not operating at the optimum efficiency due to shift in flow rate from design parameter. The pump is consuming 8.2 kW power while the hydraulic power required for pumping water (@ 120 m3/hr flow as per valve position) at total head of 15 m (assumed) is only 6.6 kW. • Thus it is recommended to install a Variable Frequency Drive with pressure feedback on this pump to optimise the power consumption without replacing the pump as well as keeping option of load increment

	in future; the VFD will save approximately 6300 kWh per annum.
Benefit	
Environmental	• Reduction in the Electricity consumption by 33600 KWh per year • Reduction in the green-house gases = 28.90 tCO_2/Year
Economical	Investment: Rs. **Rs. 75,000** /- (for complete automation of furnace) Annual Savings: **Rs. 2,43,000** /- per annum Payback Period: **4 months**
Intervening Technique	Electricity Consumption Planning for Reducing Electricity Cost
Benefits	• The source of outside power for the plant is from UGVCL grid at 66 kV. • The below table indicates, maximum registered demand, average power factor, average load factor and average unit's consumption for the reference period. Refer Annexure –I for analysis of monthly electricity consumption parameters as per UGVCL electricity bills.

Table: Electricity Bill Analysis Summary

Sr. No.	Items	January 2015 – December 2015		
		Minimum	Maximum	Average
1.	Contract demand (kVA)	400		

2.	Maximum demand (kVA)	201	285	249.58
3.	Power factor	0.993	0.999	0.997
4.	Monthly units consumption (kWh)	77124	152454	100244
5.	Avg. unit rate, (Rs./kWh)	7.26		

- Average maximum demand is less than 85 % (Minimum Billing Demand) of contract demand i.e., 400 kVA throughout year, although it is varying month to month but the variation is in between 84 kVA and is below contract demand.

- Average power factor maintained by the company is around 0.997, although company has centralised APFC which are maintaining the power factor upto 0.998 thus availing maximum PF incentive from the electricity distribution company. Although in few months the power factor dipped due to less demand in respective months, thus fine tuning of capacitor banks will improve and maintain the power factor upto 0.99 in order to avail maximum rebate of PF incentive.

- UGVCL charges Time of Use (TOU) surcharge. This is applicable for different periods of the day i.e. normal period, two peak hour periods. The surcharge on energy charges according to the period of consumption shall be as per following:

Table: TOU Period

Sr. No.	Peak Period

1	Morning peak load period (7 AM to 11 AM)
2	Evening peak load period (6 PM to 10 PM)

- The Time of Use charges for the energy consumption during these peak periods are as following:

Table: TOU Charges

Sr. No.	Billing Demand	TOU Charges
1.	For billing demand upto 340 kVA	Rs. 0.45 per unit
2.	For billing demand above 340 kVA	Rs. 0.85 per unit

- Plant is consuming average 38,319.33 kWh per month during ToU duration and thus it is contributing to average Rs. 14121.783 per month additional electricity charges.

- Although due to continuous production it is not possible to avoid critical load running during the TOU (peak load period) but plant can optimize the TOU surcharges in the bill by identifying few non-critical loads and keeping them off during the TOU duration (i.e., 7 AM to 11 AM & 6 PM to 10 PM) mentioned in the above table or if possible rescheduling of critical load to operate during 11 AM to 6 PM & 10 PM to 6 AM. Even 10 % load reduction during ToU duration will save approximately Rs. 1,69,461.4 p.a. without any investment.

CONCESSION FOR USE OF ELECTRICITY DURING NIGHT

	HOURS: • For the consumer eligible for using supply at any time during 24 hours, entire consumption shall be billed at the energy charges specified above. However, the energy consumed during night hours of 10.00 PM to 06.00 AM next morning as is in excess of one third of the total energy consumed during the month, shall be eligible for concession at the rate of 45 Paise per unit. Plant is not consuming which contributed loss of rebate. • Thus plant should inventorize the list of electrical loads which are critical for production and non-critical load which can be operated in night hours only in view to maximize the benefits of night usage rebate, even if plant maintains night usage to its maximum recorded for month of March- 2015 upto 48,986 kWh per month, plant will save approximately Rs. 2,64,524 p.a. additionally.

Intervening Technique	Optimisation of Gas Consumption through Oxygen Enhanced Combustion in Furnaces
Description	Glass manufacturing is a very energy intensive industrial process. Glass is produced by heating the raw materials like silica (Silicon dioxide), sand (Quartz), iron oxide, and othermaterials to about 1500 to 200^{0}C. Glass manufacturers who need to increase pull rate (pull

rate is the velocity of the glass sheet) and improve quality, consistency, and thermal efficiency while decreasing NOx emissions can use Oxy-Fuel technology. Oxy-Fuel technology has proved to be one of the most energy efficient combustion processes for glass melting furnaces. Ideal burners for any furnace would have the following characteristics:

- Flexibility with respect to flame length and heat transfer.
- Continuity of operations, which can be adjusted during use.
- Multiple fuel usage.
- Robust and compact design.

The Oxy-Fuel burners have most of the above characteristics. It has been observed by a major company in combustion technology that in Oxy-Fuel combustion the volume of the flue gases is approximately 20% of that in the Air-Fuel combustion resulting in a reduction of the amount of heat lost through flue gases. They have developed their own-patented burners and found it to be one of the most efficient ways of reducing NOxs, achieve maximum efficiency, and reduce particulate emissions from glass furnaces. Additional advantages of Oxy-Fuel Combustion in the glass industry are:

- Better glass quality.
- Very low NOx and particulate emissions.
- No air preheating necessary.
- Suitability at higher pull rate.

	• Better sequencing of the furnace. Thus with oxygen enrichment, more heat is transferred to the product, less heat is lost in the exiting combustion gases, and the combustion process becomes more efficient. With proper furnace design and burner selection, reduction of NOx by 50-70%, as compared to regenerator furnace is achievable. In addition, reduction of batch carry over is possible. Depending on the furnace operation and the efficiency of the operation, fuel savings can range from slightlyover 50% to only 10%, so all the variables need to be reviewed prior to deciding if oxy combustion is a viable option.It is possible to convert specific zones of existing furnaces to oxy-fuel, or to add oxy-boosting burners asrequired at strategic locations in addition to air-fired burners. The conversion from an air-fuel combustions system to an oxy-fuel system willrequire a complete burner replacement. “Oxy-fuel burners are of a different design than air-fuel burners; it is not possible tosimply insert an oxy-fuel element into an air-fuel burner. Oxy-fuel combustion is not the answer to allapplications, so it is very important to determine if it is a viable alternative. That said, in some processes that cycle, whereloads are taken from cold to hot and melted, going from air combustion to oxy combustion not only reduces fuel use but canreduce cycle and heat-up time. This is where the

	operator can see significant cost reductions. Add to this the potential for reduction in total NOx emissions and the ability to reduce the plant's carbon footprint by reductionin fuel use, and the benefits of oxy-fuel can be important. Before replacing or adding air-fuel combustion systems, it can bevaluable to take a look at the oxy-fuel option. Depending on the furnace operation and the efficiency of the operation, fuel savings can range from slightly over 50% to only 10%, so all the variables need to be reviewed prior to deciding if oxy combustion is a viable option. It is possible to convert specific zones of existing furnaces to oxy-fuel, or to add oxy-boosting burners as required at strategic locations in addition to air-fired burners. Considering even 10 % fuel saving by converting air-fuel system into oxy-fuel system plant can save approximately 430191 SCM gas as well as 79360 litre furnace oil per annum.
Benefit	
Environmental	• Reduction in the natural gas consumption by 430191 SCM per year and Furnace Oil Consumption by 79360 litre per Year • Per Year Reduction in Greenhouse Gas (CO_2) emission: 890.66 tCO_2/Year
Economical	Investment: **Rs. 1,20,00,000/-** Annual Savings: **Rs. 81,98,000/-** per annum Payback Period: **18** months

Intervening Technique	Optimisation of Gas Consumption through Batch & Cullet Preheating
Description	Batch and cullet is normally introduced cold into the furnace, but by using the residual heat ofthe waste gases to preheat the batch and cullet, significant energy savings can be possible. Preheating temperatures should preferably not be lower than 270 ^{0}C but should not exceed500 – 550 ^{0}C. In practice, most batch and cullet preheaters operate at batch preheat temperaturesbetween 275 and 325 ^{0}C. The available systems are described below: • Direct preheating – this type of preheating involves direct contact between the flue-gas and the raw material (cullet and batch) in a cross-counter flow. The waste gases are supplied to the preheater from the waste gas duct behind the regenerator. They pass through the cavities in the preheater, thereby coming into direct contact with the raw material. The outlet temperature of the cullet and batch is about 300 0C and could go up to 400 0C. The system incorporates a bypass that allows furnace operations to continue whenpreheater use is either inappropriate or impossible. • Indirect preheating – the indirect preheater is, in

principle, a cross-counter flow, plate heat exchanger, in which the material is heated indirectly. It is designed in a modular form and consists of individual heat exchanger blocks situated above each other. These blocks are again divided into horizontal waste gas and vertical material funnels. In the material funnels, the material flows from the top to the bottom by gravity. Depending on the throughput, the material reaches a speed of 1 – 3 m/h and will normally be heated from ambient temperature up to approximately 300 0C. The flue-gases will be let into the bottom of the preheater and flow into the upper part by means of special detour funnels.The waste gases flow horizontally through the individual modules. Typically the flue gases will be cooled down by approximately 270 – 300 ^{0}C.

These techniques have a number of environmental effects, which can vary from case to case. Ingeneral, the benefits given below have been experienced.

- Specific energy savings of between 10 and 20 % with a consequent reduction of CO2 emissions.
- Reduction in NOX emissions (due to lower fuel requirements and lower furnace temperatures). However, in most cases the energy savings are used to increase the pull of the furnace.
- An increase of pull rate of up to 10 – 15 %, is possible for applications to existing glass furnaces, with preheating of the batch to 300 ^{0}C.

	By implementing the batch & cullet preheating plant can save approximately 716985 SMC gas as well as 132266 litre furnace oil per annum with only cullet preheating (considering 20% cullet), while plant can save approximately 143397 SCM gas as well as 2126 litre furnace oil per annum with batch & cullet preheating.
Benefit	
Environmental	• Reduction in the natural gas consumption by 143397 SCM per year and Furnace Oil Consumption by 2126 litreper Year • Reduction in Greenhouse Gas (CO2) emission = 270.85tCo2/Year
Economical	Investment: **Rs. 50,00,000/-** Annual Savings: **Rs. 21,97,000/-** per annum (for cullet Preheating) Payback Period: **28** months

Jajoo Architectural Glass Pvt. Ltd., Halol

Introduction: Jajoo Architectural Glass Pvt. Ltd., Halol

Jajoo Architectural Glass Pvt. Ltd., located at Halol City Industrial Estate, Panchmahal district, is a well-known manufacturer of Tempered Glass. Jajoo Architectural Glass Pvt. Ltd was established in 1999. It started manufacturing of Reflective glass, tinted glass, clear glass & decorative glass, processing glass, toughens/ tempering glass, laminated glass, architectural glass. They use Electric Furnace for heating the Glass. The industry is spread in 12000 sq. meters with a building up area of around3000 sq. meters.

Journey of Jajoo Architectural Glass Pvt. Ltd.

YEAR	INITIATIVE
2004	Initiative taken for Setting up safety Glass Processing
2005	Conceived fully fledged Glass Processing Unit with ultra modern Facility. Started with land area 10,400sqm. With Building of 3000sqm.
2007	• Building expansion of another 1400sqm. • Installation of Insulated Glass unit Line and Double Edger Line With Online Washing Machine
2008	Achieved ISO Certificate
2009	Furnace upgraded to forced Convection and addition of edge deletion line for low-e glass
2010	Installation of Vertical Drilling and Milling Centre (CNC) with online Vertical Washing Machine
2011	• Installation of 4 station Jumbo Cutting line • Installation of Edge Seeming line with Online Washing

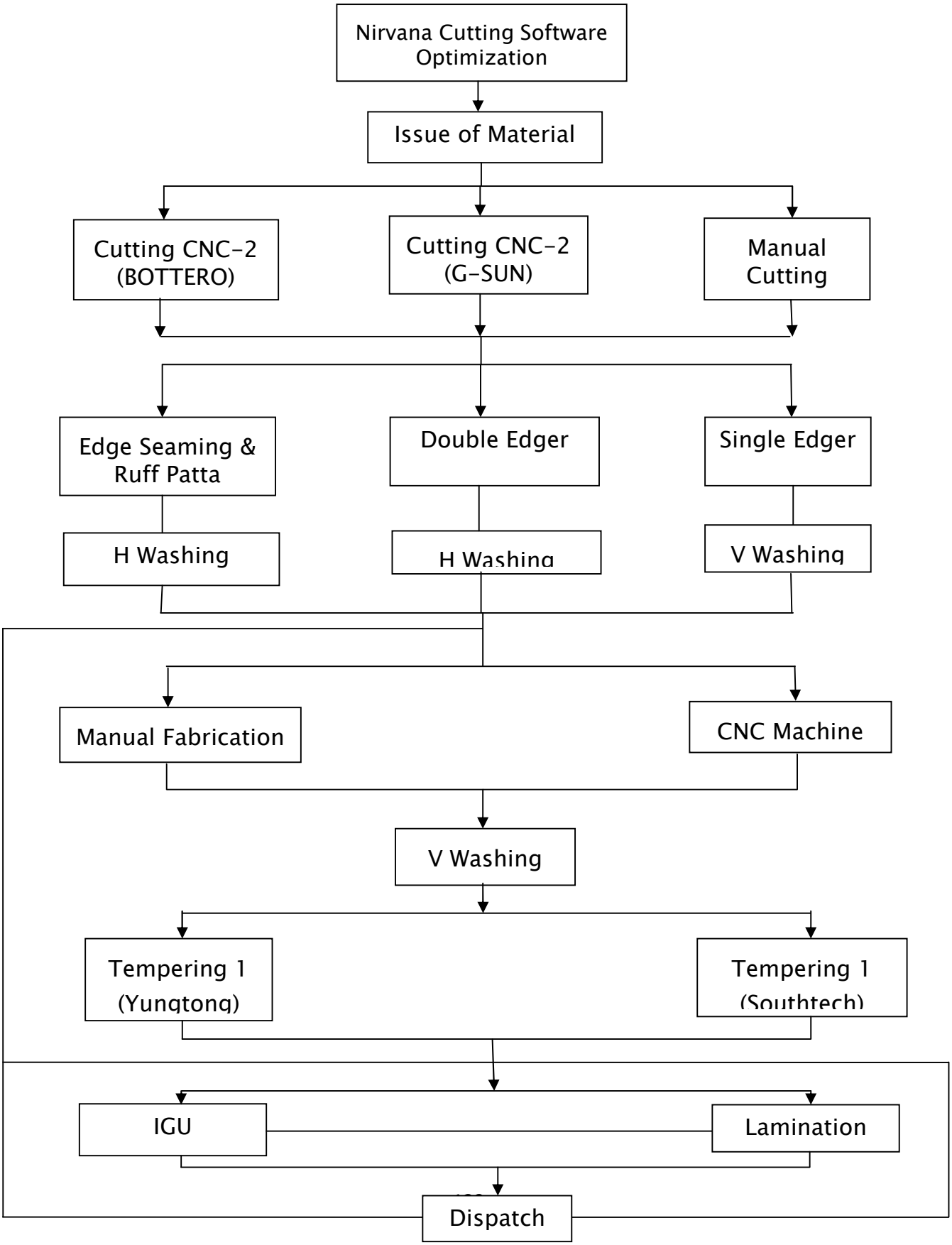
	Machine Specially for Hi-Performance Glass • Awarded with SGC membership and got 1 star rating certification.
2012	• Another building expansion of 900 sqm. • Installation of 2nd Tempering Unit with Double forced Convection Line. • Installation of Automatic Lamination Line. • Awarded with 2 Star rating from SGC.

Cleaner Production Assessment Team

The team for conducting Cleaner Production Assessment includes the following members.

Name	Designation
Dr. Bharat Jain	Member Secretary, GCPC
Mr. PunamchandraRathod	Senior Project Engineer, GCPC
Mr. Abhi Patel	Assistant Project Engineer, GCPC
Mr. Paras Gojiya	Assistant Project Engineer, GCPC
Mr. Dharmendrabhai	Director, Jajoo Architectural Glass Pvt. Ltd.,
Mr. Rohitbhai	HR Department, Jajoo Architectural Glass Pvt. Ltd.,

Manufacturing Process Flow Chart



INTRODUCTION

Toughened glass is a heat processed glass which is produced by heating an annealed glass to approximately 650°C (1202°F), at which point it begins to soften. The surfaces of this heated glass are then cooled and quenched rapidly. The toughening process results in the powerful compressive stress of the outer skin. The interior of the glass secures tensile stress.

At EMMVEE,a highly sophisticated machinery is used for the toughening process.

The processing is carried out at different stages

I. GLASS CUTTING

At this stage, the raw glass is cut as per the requirement, using ceramic wheel cutting technology. Any type of glass can be cut using highly efficient machinery from Italy.

II. GLASS POLISHING

After cutting, the glass is polished to remove the sharp edges. Nine types of polishing can be done depending upon the requirements and design features of the project.

III. DRILLING AND MILLING

After polishing, the glass is processed through the drilling and milling machines to make holes and notches.
Facility is well equipped with sophisticated machines which can process all irregular shapes.
The raw plate glass sheet which is free from waviness, distortion etc., is cut to required size and shape and then all the edges are ground and polished as per

end use of the product. This is called edge 4 grinding and polishing and is very important for toughening because it will lead to breakages during process. No glass sheet can be toughened without edge grinding and polishing.

IV. GLASS WASHING

The glass is then washed using normal plain water to clean any dust particles. The glass is finally air dried using air blowers.

After the edge grinding and polishing the glass sheets are washed manually or by machine and then dried. The glass sheets are fed into the furnace (Electrically operated). The sheets are kept in the furnace above its softening point, which varies according to the composition of glass. After attaining required temperature the glass sheets are removed out of the furnace and placed in the air blowing quenching boxes for 20 to 25 seconds. After quenching glass sheet is toughened.

V. Toughening or Tempering

After washing, the glass is now ready for tempering.

In this process, the glass is subjected to a temperature of around 700°C in an electric furnace depending upon the thickness of the glass. Such heated glass is then subjected to uniform controlled cooling by air blowers.

The tempered glass is four times stronger than the normal or annealed glass.

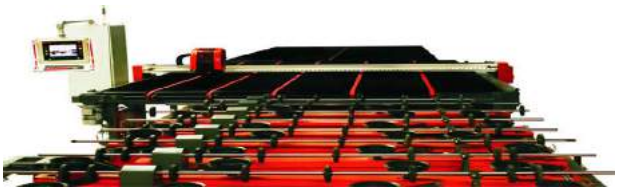
VI. STOCKING AND TRANSPORT

After Cooling of the sheet, it is lifted by the machine and put in the specific place where the sheets are then loaded in packs onto a stillage, the base of which forms the actual floor of the delivery vehicles ready to be sent to the customer.

Infrastructure

I. Glass Cutting Line

- (Capable of cutting Low-e Glass)
- Size – 2700 mmX 3660 mm



II. Jumbo Glass Cutting Line : with Four Station

- Size – 3300 mm X 5100 mm

III. Edge Seaming line: with on line cutting and washing

- Specially for low-e glass
- The glass edges are automatically grinded on this CNC Machine.
- The grinding quality is much better and glass comes out clean after Washing

IV. Double Edger Line : with online Washing Machine

V. CNC Work Station

- Size – 2500 mm X 3210 mm

VI. Forced Convection Tempering Line: (For Flat and Bent Toughened Glass)

- This machine is capable of processing high Performance Low-e glass
- Thickness – 4 mm to 19mm
- Minimum Size – 300 mm X 100 mm, Maximum Size – 3900 mm x 2440 mm
- Bend : Maximum Size 1530 mm X 2440 mm
- Production Capacity: 1200 sqm./ day * on 6 mm basis

VII. Forced Convection Top and Bottom Tempering Line:

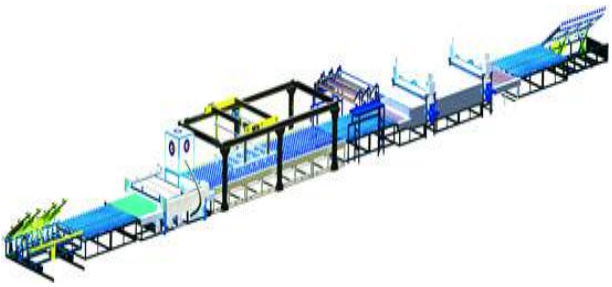
- Can Process High performance Glass

- Small Pitch of Rollers so that Minimum glass distortion achieved
- Thickness – 2.8 mm to 19 mm
- Minimum Size – 300 mm x 100 mm, Maximum Size – 4200 mmx 1700 mm
- Production Capacity : 1200sqm / day * on 6mm basis

VIII. Fully Automatic Insulating Line with edge Deletion:

- IGU Thickness – Minimum 10 mm, Maximum – 50 mm
- Minimum Size – 200 mm x 450 mm,Maximum Size – 3500 mm x 2440 mm
- Production Capacity : 300 Sqm ./ day

IX. Automatic Lamination Line : with clean room of class 1000



- Minimum Size – 420 mm x 300 mm, Maximum Size – 6000 mm x

2440 mm

- Production Capacity : 300sqm / day
- Laminated Glass Thickness – Minimum 6 mm, Maximum. 80 mm

- Autoclave

  Autoclave with infrared Heaters

Cleaner Production Opportunities

Intervening Technique	Avoid Compressed air usage for cleaning purposes
Before CP	During the visit it was observed that compressed air is used for cleaning purposes at some workstations to clean the components with open hose of 5 mm diameter and at 6 kg/cm²g pressure.
After CP	Usually, cleaning can be done at lower pressure (around 2-3 kg/cm²g). So, the first step would be to reduce the pressure and energy saving would be around 8% at drop of each bar for that hose if generated separately. From our past experience the company can save Rs. 21,000 per year (from one workplace) by installing compressed air saving gun. The compressed air is a costly utility and the less critical purposes like cleaning can be achieved by installing air saver nozzles at the tip of these cleaning devices or shall be replaced with new one. The special design of these improved cleaning nozzles allows ambient air to get entrained in the path due to vacuum created by compressed air and delivers the air with similar velocity and thrust giving to desired cleaning effect. However, the amount of compressed air uses is only 20-25%

	which reduces the compressed air requirement and thus resulting in energy savings. In addition, these nozzles also reduce the noise level.  
Environmental	Reduction in the electricity consumption to generate the compressed air, with that, also reducing Noise Pollution of the surrounding, making the site easy to work.
Economical	Investment: **3,000**/- per gun Annual Savings: **Rs. 21,000**/- per station Payback Period: **3 months**

Intervening Technique	Optimise the Electric Power at Washing Machine
Before CP	Plant is operating 3 nos. washing machine having air blower of 22 kW on 2 nos. machine while 7 kW on one machine. These blowers are running continuously even though the frequency of glass on conveyor is varying, also frequent ON/OFF of the blower motor is not practical as it will generate frequent and sudden load increment which is not advisable.
After CP	Thus it is advisable to install the Variable Frequency Drive (VFD) on these motors with speed variation feedback through material movement sensor on the conveyor. This intervention will save approximately 71400 kWh per annum.
Environmental	• Reduction in the Electricity consumption by 71400 KWh per year. • Reduction in Greenhouse Gas (CO_2) emission = 61.40 tCo_2/Year
Economical	Investment: **1,00,000**/- per Annum (for 3 nos. of VFD) Annual Savings: **Rs. 5,35,000**/- per Annum Payback Period: **3 months**

<table>
<tr><th>Intervening Technique</th><th>Optimise the Plant Lighting Load</th></tr>
<tr><td>Before CP</td><td>Plant is operating 15 nos. High Pressure Mercury Vapour Lamp (HPMV) of 250 watt each, for 8 hrs. Per day. Also, approximately 20 nos. CFL of 32 watt in admin department as well which also operated almost 8 hrs. Per day.</td></tr>
<tr><td>After CP</td><td>The comparison between different light types is shown in following table:

Table: Comparison of Lights (LED/Fluorescent/Incandescent)
<table>
<tr><th>Energy Efficiency</th><th>Incandescent Light Bulbs</th><th>Fluorescent (CFL)</th><th>LED</th></tr>
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power plants and lower electric bills			
Environmental	Incandescent Light Bulbs	Fluorescent (CFL)	LED
Contains the TOXIC Mercury. A silvery-colored poisonous elemental metal that is liquid at room temperature.	No	Yes - Toxic for your health and the environment.	No
RoHS Compliant (Reduction Of Hazardous Substances).The maximum concentration limits on hazardous materials used in electrical and electronic equipment. Enforced by the European Union.	Yes	No - contains 1mg-5mg of Mercury and is a major risk to the environment	Yes
Important Facts	Incandescent Light	Fluorescent (CFL)	LED

	Bulbs		
Sensitivity to low temperatures	Some	Yes – may not work under negative 10 degrees Fahrenheit or over 120 degrees Fahrenheit	None
Sensitive to humidity	Some	Yes – canhave a higher failure rate in more humid climates/weather.	No
On/off Cycling.Switching a CFL on/off quickly, in a closet for instance, may decrease the lifespan of the bulb.	Some	Yes – can reduce lifespan drastically	No Effect
Turns on instantly	Yes	No – takes time to warm up the Mercury to achieve	Yes

		maximum light output.	
Durability	Not Very Durable – glass or filament can break easily	Not Very Durable – glass can break easily	Very Durable – LEDs can handle jarring and bumping
Heat Emitted.Incandescent bulbs emit large amounts of heat which can increase air conditioning costs and energy consumption while using air conditioning.	85 btu's/hour	30 btu's/hour	3.4 btu's/hour
Possibility of Mechanical Failure	Some	Yes – may catch on fire, smoke, or omit an odor	Not typical
Minimum Light Output	Incandescent Light Bulbs	Fluorescent (CFL)	LED
Lumens Measures luminous	Watts The unit of power.The amount of energy		

flux or total packets of light produced by a light source	transferred in one second			
250	25	4-9	3	
450	40	9-13	4-5	
800	60	13-15	6-8	
1,100	75	18-25	9-13	
1,600	100	23-30	16-20	
2,000	125	28-40	20-25	
2,600	150	30-55	25-28	
Streetlight	90 LED	250W Mercury-vapour		
Light source	1W LED (90pcs)	(OSRAM)HQL 250W		
Central luminance	15-16Lux at 7m	15-16Lux at 7m		
Beam angle	120°	150°		
Life Span	100,000 hours	15,000 hours		
Energy consumption per	442kWh	1068kWh /year		

	year	/year		
	Ultraviolet hazards	No ultraviolet emission	Emits ultraviolet	
	LED Streetlight		Mercury-vapour Streetlight	
		Lumen	OSRAM HQL	Lumen
	28 LEDs - 28W	2300	50W~80W	1800~3800
	56 LEDs - 56W	5000	80W~125W	3800~6300
	112 LEDs-112W	10000	125W~250W	6300~13000
	168 LEDs-168W	14000	250W~400W	13000~22000
	Thus, by replacing the conventional light with LEDs (250 watt HPMV with 90 watt LED and 32 watt CFL with 18 watt LED) plant can save approximately 7504 kWh per annum.			
Environmental	• Reduction in the Electricity consumption by 7504 KWh per year. • Reduction in Greenhouse Gas (CO2) emission = 6.45 tCo_2/Year			
Economical	Investment: **1,15,000/- for LED** Annual Savings: **Rs. 56,200** /- per Annum			

	Payback Period: **25 months**

Intervening Technique	Solar Roof-Top System for Plant Lighting Load
Before CP	Plant is operating 15 nos. High Pressure Mercury Vapour Lamp (HPMV) of 250 watt each, for 8 hrs. per day. Also, approximately 20 nos. CFL of 32 watt in admin department as well which also operated almost 8 hrs. Per day.
After CP	After replacing conventional lighting system to LEDs plant lighting load will come down to 1.8 kW from 4.5 kW at present. Plant can install a battery assisted solar PV power generation system of 2 kW for the plant lighting load.
Economical	Investment: **Rs.3, 00,000**/- for solar PV system with battery. Annual Savings: **Rs. 42,000**/- per Annum Payback Period: **85 months**

Kamal Glass Solution Pvt. Ltd., Halol

Introduction: Kamal Glass Solution Pvt. Ltd.

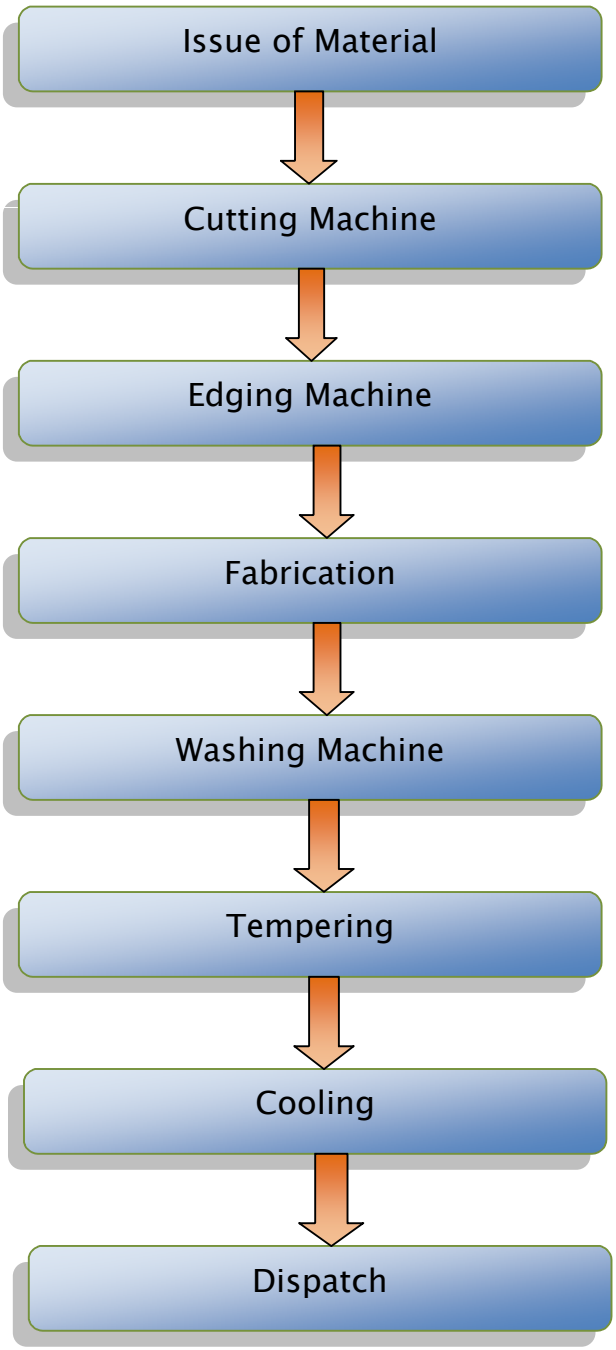
Kamal Glass Solution Pvt. Ltd., located at Halol City Industrial Estate, Panchmahal district, is a well-known manufacturer of Tempered Glass. Kamal Glass Solution Pvt. Ltd was established in 2013. It is classified as Indian Non-Government Company and is registered at Registrar of Companies. It started manufacturing of Tempered glass. They use Electric Furnace for heating the Glass.

Cleaner Production Assessment Team

The team for conducting Cleaner Production Assessment includes the following members.

Name	Designation
Dr. Bharat Jain	Member Secretary, GCPC
Mr. PunamchandraRathod	Senior Project Engineer, GCPC
Mr. Abhi Patel	Assistant Project Engineer, GCPC
Mr. Paras Gojiya	Assistant Project Engineer, GCPC
Mr. DIneshbhai Ahuja	Director, Kamal Glass Solution Pvt. Ltd.
Mr. SanjaybhaiParmar	Maintenance Department, Kamal Glass Solution Pvt. Ltd.

Manufacturing Process Flow Diagram



INTRODUCTION

Toughened glass is a heat processed glass which is produced by heating an annealed glass to approximately 650°C – 700°C (1202°F), at which point it begins to soften. The surfaces of this heated glass are then cooled and quenched rapidly.

The toughening process results in the powerful compressive stress of the outer skin. The interior of the glass secures tensile stress.

A highly sophisticated machinery is used for the toughening process.

The processing is carried out at different stages

I. GLASS CUTTING

At this stage, the raw glass is cut as per the requirement, using ceramic wheel cutting technology. Any type of glass can be cut using highly efficient machinery from Italy.

II. GLASS POLISHING

After cutting, the glass is polished to remove the sharp edges. Nine types of polishing can be done depending upon the requirements and design features of the project.

III. DRILLING AND MILLING

After polishing, the glass is processed through the drilling and milling machines to make holes and notches.

Facility is well equipped with sophisticated machines which can process all irregular shapes.

The raw plate glass sheet which is free from waviness, distortion etc., is cut to required size and shape and then all the edges are ground and polished as per

end use of the product. This is called edge 4 grinding and polishing and is very important for toughening because it will lead to breakages during process. No glass sheet can be toughened without edge grinding and polishing.

IV. GLASS WASHING

The glass is then washed using normal plain water to clean any dust particles. The glass is finally air dried using air blowers.

After the edge grinding and polishing the glass sheets are washed manually or by machine and then dried. The glass sheets are fed into the furnace (Electrically operated). The sheets are kept in the furnace above its softening point, which varies according to the composition of glass. After attaining required temperature the glass sheets are removed out of the furnace and placed in the air blowing quenching boxes for 20 to 25 seconds. After quenching glass sheet is toughened.

V. TOUGHENING OR TEMPERING

After washing, the glass is now ready for tempering.

In this process, the glass is subjected to a temperature of around 700°C in an electric furnace depending upon the thickness of the glass. Such heated glass is then subjected to uniform controlled cooling by air blowers.

The tempered glass is four times stronger than the normal or annealed glass.

VI. STOCKING AND TRANSPORT

After Cooling of the sheet, it is lifted by the machine and put in the specific place where the sheets are then loaded in packs onto a stillage, the base of which forms the actual floor of the delivery vehicles ready to be sent to the customer.

Cleaner Production Opportunities

Intervening Technique	Optimise the Electric Power at Washing Machine
Before CP	Plant is operating 1 nos. washing machine having air blower of 20 kW. This blower is running continuously even though the frequency of glass on conveyor is varying, also frequent ON/OFF of the blower motor is not practical as it will generate frequent and sudden load increment which is not advisable.
After CP	Thus it is advisable to install the Variable Frequency Drive (VFD) on these motors with speed variation feedback through material movement sensor on the conveyor. This intervention will save approximately 14,000 kWh per annum.
Environmental	• Reduction in the Electricity consumption by 14000 KWh per year. • Reduction in Greenhouse Gas (CO_2) emission = 12.04 tCo_2/Year
Economical	Investment: **35,000**/- per Annum for VFD Annual Savings: **Rs. 1,05,000**/- per Annum Payback Period: **4 months**

<table>
<tr><th>Intervening Technique</th><th>Optimise the Plant Lighting Load</th></tr>
<tr><td>Before CP</td><td>Plant is operating 8 nos. High Pressure Mercury Vapour Lamp (HPMV) of 250 watt each, for 8 hrs. per day. Also, approximately 10 nos. CFL of 28 watt as well, which also operates almost 8 hrs. Per day.</td></tr>
<tr><td>After CP</td><td>The comparison between different light types is shown in following table:

Table: Comparison of Lights (LED/Fluorescent/Incandescent)
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<tr><th>Energy Efficiency</th><th>Incandescent Light Bulbs</th><th>Fluorescent (CFL)</th><th>LED</th></tr>
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Environmental	Incandescent Light Bulbs	Fluorescent (CFL)	LED
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RoHS Compliant (Reduction Of Hazardous Substances).The maximum concentration limits on hazardous materials used in electrical and electronic equipment. Enforced by the European Union.	Yes	No - contains 1mg-5mg of Mercury and is a major risk to the environment	Yes
Important Facts	**Incandescent Light Bulbs**	**Fluorescent (CFL)**	**LED**
Sensitivity to low temperatures	Some	Yes - may not work under negative 10	None

	degrees Fahrenheit or over 120 degrees Fahrenheit		
Sensitive to humidity	Some	Yes – canhave a higher failure rate in more humid climates/weather.	No
On/off Cycling.Switching a CFL on/off quickly, in a closet for instance, may decrease the lifespan of the bulb.	Some	Yes – can reduce lifespan drastically	No Effect
Turns on instantly	Yes	No – takes time to warm up the Mercury to achieve maximum light output.	Yes
Durability	Not Very	Not Very Durable	Very Durable

	Durable – glass or filament can break easily	– glass can break easily	– LEDs can handle jarring and bumping
Heat Emitted.Incandescent bulbs emit large amounts of heat which can increase air conditioning costs and energy consumption while using air conditioning.	85 btu's/hour	30 btu's/hour	3.4 btu's/hour
Possibility of Mechanical Failure	Some	Yes – may catch on fire, smoke, or omit an odor	Not typical
Minimum Light Output	Incandescent Light Bulbs	Fluorescent (CFL)	LED
Lumens Measures luminous flux or total packets of light	Watts The unit of power.The amount of energy transferred in one second		

produced by a light source				
250	25	4-9	3	
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Streetlight	90 LED	250W Mercury-vapour		
Light source	1W LED (90pcs)	(OSRAM)HQL 250W		
Central luminance	15-16Lux at 7m	15-16Lux at 7m		
Beam angle	120°	150°		
Life Span	100,000 hours	15,000 hours		
Energy consumption per year	442kWh /year	1068kWh /year		

	Ultraviolet hazards	No ultraviolet emission	Emits ultraviolet	
	LED Streetlight		Mercury-vapour Streetlight	
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	28 LEDs - 28W	2300	50W~80W	1800~3800
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	168 LEDs-168W	14000	250W~400W	13000~22000

Thus, by replacing the conventional light with LEDs (250 watt HPMV with 90 watt LED and 32 watt CFL with 18 watt LED) plant can save approximately 4200 kWh per annum.

Environmental	• Reduction in the Electricity consumption by 4200 KWh per year. • Reduction in Greenhouse Gas (CO_2) emission = 3.61 tCo_2/Year

Economical	Investment: **60,000/- for LED** Annual Savings: **Rs. 31,500** /- per Annum Payback Period: **23 months**

Intervening Technique	Solar Roof-Top System for Plant Lighting Load
Before CP	Plant is operating 8 nos. High Pressure Mercury Vapour Lamp (HPMV) of 250 watt each, for 8 hrs. Per day. Also, approximately 10 nos. CFL of 28 watt as well, which also operates almost 8 hrs. Per day.
After CP	After replacing conventional lighting system to LEDs plant lighting load will come down to 1 kW from 2.5 kW at present. Plant can install a battery assisted solar PV power generation system of 1 kW for the plant lighting load
Economical	Investment: **Rs.1, 50,000**/- for solar PV system with battery. Annual Savings: **Rs. 21,000** /- per Annum Payback Period: **85 months**

Intervening Technique	Install A Double Edging machine to Reduce the Overall Process time
	Before CP:- Single Edging Machine is used to cut and polish the edges of glass. It is used for grinding straight edges and corners of different sizes and thickness of flat glass, rough edging, fine edging and polishing of straight line; rough edging, fine edging of corners. It works on a Vertical Position. There are total 9 nos. of motors for cutting and polishing of the edges of glass. Single Edging machine can perform cutting and polishing of only one side of the glass out of four sides at a time. For cutting and polishing on other sides, it's manually rotated, thereby repeating the exercise for three more times. New Technology: Double edging machine has the same application as the Single Edging Machine has. Glass Straight Line Double Edger Line is combined with a double edger, a transferring table and second double edger. New generation automatic double edger line can detect glass size automatically.Its working and alignment adjustment is automatic. The main advantage of this machine is to cut and polish the two sides of the glass at a time and then rotate the glass through transferring tableand pass through the another double edger machine for the rest two sides.

Advantage of Double Edging Machine:

- Reduction in Overall Process Time
- Save Labor cost
- Save Energy
- Reduce the overall footprint.

CHAPTER 8
GENERAL GUIDANCE

GENERAL GUIDENCE

❖ Occupational Health and Safety

Fire Precautions

- The workplace should be designed to prevent the start of fires through the implementation of fire codes applicable to industrial settings. Other essential measures include:
- Equipping facilities with fire detectors, alarm systems, and fire-fighting equipment. The equipment should be maintained in good working order and be readily accessible. It should be adequate for the dimensions and use of the premises, equipment installed, physical and chemical properties of substances present, and the maximum number of people present.

- Provision of manual firefighting equipment that is easily accessible and simple to use
- Fire and emergency alarm systems that are both audible and visible

Lavatories and Showers

- Adequate lavatory facilities (toilets and washing areas) should be provided for the number of people expected to work in the facility and allowances made for segregated facilities, or for indicating whether the toilet facility is "In Use" or "Vacant". Toilet facilities should also be provided with adequate supplies of hot and cold running water, soap, and hand drying devices.

- Where workers may be exposed to substances poisonous by ingestion and skin contamination may occur, facilities for showering and changing into and out of street and work clothes should be provided.

Potable Water Supply

- Adequate supplies of potable drinking water should be provided from a fountain with an upward jet or with a sanitary means of collecting the water for the purposes of drinking
- Water supplied to areas of food preparation or for the purpose of personal hygiene (washing or bathing) should meet drinking water quality standards.

Clean Eating Area

- Where there is potential for exposure to substances poisonous by ingestion, suitable arrangements are to be made for provision of clean eating areas where workers are not exposed to the hazardous or noxious substances

Lighting

- Workplaces should, to the degree feasible, receive natural light and be supplemented with sufficient artificial illumination to promote workers' safety and health, and enable safe equipment operation. Supplemental 'task lighting' may be required where specific visual acuity requirements should be met.
- Emergency lighting of adequate intensity should be installed and automatically activated upon failure of the principal artificial light source to ensure safe shut-down, evacuation, etc.

Safe Access

- Passageways for pedestrians and vehicles within and outside buildings should be segregated and provide for easy, safe, and appropriate access
- Equipment and installations requiring servicing, inspection, and/or cleaning should have unobstructed, unrestricted, and ready access
- Hand, knee and foot railings should be installed on stairs, fixed ladders, platforms, permanent and interim floor openings, loading bays, ramps, etc.
- Openings should be sealed by gates or removable chains
- Covers should, if feasible, be installed to protect against falling items
- Measures to prevent unauthorized access to dangerous areas should be in place

First Aid

- The employer should ensure that qualified first-aid can be provided at all times. Appropriately equipped first-aid stations should be easily accessible throughout the place of work
- Eye-wash stations and/or emergency showers should be provided close to all workstations where immediate flushing with water is the recommended first-aid response

- Where the scale of work or the type of activity being carried out so requires, dedicated and appropriately equipped first A id room(s) should be provided. First aid stations and rooms should be equipped with gloves, gowns, and masks for protection against direct contact with blood and other body fluids
- Remote sites should have written emergency procedures in place for dealing with cases of trauma or serious illness up to the point at which patient care can be transferred to an appropriate medical facility.

Air Supply

- Sufficient fresh air should be supplied for indoor and confined work spaces. Factors to be considered in ventilation design include physical activity, substances in use, and process related emissions. Air distribution systems should be designed so as not to expose workers to draughts
- Mechanical ventilation systems should be maintained in good working order. Point-source exhaust systems required for maintaining a safe ambient environment should have local indicators of correct functioning.
- Re-circulation of contaminated air is not acceptable. Air inlet filters should be kept clean and free of dust and microorganisms. Heating, ventilation and air conditioning (HVAC) and industrial evaporative cooling systems should be equipped, maintained and operated.

Work Environment Temperature

- The temperature in work, rest room and other welfare facilities should, during service hours, be maintained at a level appropriate for the purpose of the facility.

Site layout and drainage plan

Needs to include an accurate and up-to-date plan of your site showing the layout of key areas and drainage. Drainage includes private (site) and public (council) storm-water and sanitary sewer / trade-waste. This information will help you develop other aspects of your EMP (especially identifying risk areas of your site and how contaminants can enter receiving environments). The 'site layout and drainage plan' will also become an essential part of your Spill Response Plan.

A site layout and drainage plan needs to show:

- buildings and all outdoor activity areas
- storage areas – particularly for environmentally hazardous substances or materials
- storm water flow paths and areas of ponding,
- private and public drains / pipework, manholes, catch pits and soak holes
- private and public sewer and trade waste drains, manholes, pipework and cesspits

To create plan or confirm the accuracy of an existing plan you may need to involve a specialist to investigate your drainage systems (e.g., using CCTV or dye tests). For large or complicated sites, you may prefer to separate out the layout and drainage information and create two separate but linked plans (e.g. by including building outlines and site boundaries on your drainage plan).

OHS Training

- Provisions should be made to provide OHS orientation training to all new employees to ensure they are apprised of the basic site rules of work at / on the site and of personal protection and preventing injury to fellow employees.
- Training should consist of basic hazard awareness, site specific hazards, safe work practices, and emergency procedures for fire, evacuation, and natural disaster, as appropriate. Any site-specific hazard or color coding in use should be thoroughly reviewed as part of orientation training.

Visitor Orientation

- If visitors to the site can gain access to areas where hazardous conditions or substances may be present, a visitor orientation and control program should be established to ensure visitors do not enter hazard areas unescorted.

New Task Employee and Contractor Training

- The employer should ensure that workers and contractors, prior to commencement of new assignments, have received adequate training and information enabling them to understand work hazards and to protect their health from hazardous ambient factors that may be present.

The training should adequately cover:

- Knowledge of materials, equipment, and tools
- Known hazards in the operations and how they are controlled
- Potential risks to health
- Precautions to prevent exposure
- Hygiene requirements
- Wearing and use of protective equipment and clothing
- Appropriate response to operation extremes, incidents and accidents

Basic OHS Training

- A basic occupational training program and specialty courses should be provided, as needed, to ensure that workers are oriented to the specific hazards of individual work assignments. Training should generally be provided to management, supervisors, workers, and occasional visitors to areas of risks and hazards.
- Workers with rescue and first-aid duties should receive dedicated training so as not to inadvertently aggravate exposures and health hazards to themselves or their coworkers. Training would include the risks of becoming

infected with blood-borne pathogens through contact with bodily fluids and tissue.

- Through appropriate contract specifications and monitoring, the employer should ensure that service providers, as well as contracted and subcontracted labor, are trained adequately before assignments begin.

Area Signage

- Hazardous areas (electrical rooms, compressor rooms, etc), installations, materials, safety measures, and emergency exits, etc. should be marked appropriately.
- Signage should be in accordance with international standards and be well known to, and easily understood by workers, visitors and the general public as appropriate.

Labeling of Equipment

- All vessels that may contain substances that are hazardous as a result of chemical or toxicological properties, or temperature or pressure, should be labeled as to the contents and hazard, or appropriately color coded.
- Similarly, piping systems that contain hazardous substances should be labeled with the direction of flow and contents of the pipe, or color coded whenever the pipe passing through a wall or floor is interrupted by a valve or junction device.

Rotating and Moving Equipment

- Injury or death can occur from being trapped, entangled, or struck by machinery parts due to unexpected starting of equipment or unobvious movement during operations. Recommended protective measures include:
- Designing machines to eliminate trap hazards and ensuring that extremities are kept out of harm's way under normal operating conditions. Examples of

proper design considerations include two-hand operated machines to prevent amputations or the availability of emergency stops dedicated to the machine and placed in strategic locations. Where a machine or equipment has an exposed moving part or exposed pinch point that may endanger the safety of any worker, the machine or equipment should be equipped with, and protected by, a guard or other device that prevents access to the moving part or pinch point. Guards should be designed and installed in conformance with appropriate machine safety standards.64

- Turning off, disconnecting, isolating, and de-energizing (Locked Out and Tagged Out) machinery with exposed or guarded moving parts, or in which energy can be stored (e.g. compressed air, electrical components) during servicing or maintenance, in conformance with a standard such as CSA Z460 Lockout or equivalent ISO or ANSI standard
- Designing and installing equipment, where feasible, to enable routine service, such as lubrication, without removal of the guarding devices or mechanisms

Noise

- No employee should be exposed to a noise level greater than 85 dB (A) for a duration of more than 8 hours per day without hearing protection. In addition, no unprotected ear should be exposed to a peak sound pressure level (instantaneous) of more than 140 dB(C).
- The use of hearing protection should be enforced actively when the equivalent sound level over 8 hours reaches 85 dB(A), t he peak sound levels reach 140 dB(C), or the average maximum sound level reaches 110dB(A). Hearing protective devices provided should be capable of reducing sound levels at the ear to at least 85 dB (A).

- Although hearing protection is preferred for any period of noise exposure in excess of 85 dB(A), an equivalent level of protection can be obtained, but less easily managed, by limiting the duration of noise exposure. For every 3 dB(A) increase in sound levels, the 'allowed' exposure period or duration should be reduced by 50 percent.65
- Prior to the issuance of hearing protective devices as the final control mechanism, use of acoustic insulating materials, isolation of the noise source, and other engineering controls should be investigated and implemented, where feasible
- Periodic medical hearing checks should be performed on workers exposed to high noise levels

Vibration

- Exposure to hand-arm vibration from equipment such as hand and power tools, or whole-body vibrations from surfaces on which the worker stands or sits, should be controlled through choice of equipment, installation of vibration dampening pads or devices, and limiting the duration of exposure. Exposure levels should be checked on the basis of daily exposure time and data provided by equipment manufacturers.

Electrical

- Exposed or faulty electrical devices, such as circuit breakers, panels, cables, cords and hand tools, can pose a serious risk to workers. Overhead wires can be struck by metal devices, such as poles or ladders, and by vehicles with metal booms. Vehicles or grounded metal objects brought into close proximity with overhead wires can result in arcing between the wires and the object, without actual contact. Recommended actions include:
- Marking all energized electrical devices and lines with warning signs

- Locking out (de-charging and leaving open with a controlled locking device) and tagging-out (warning sign placed on the lock) devices during service or maintenance
- Checking all electrical cords, cables, and hand power tools for frayed or exposed cords and following manufacturer recommendations for maximum permitted operating voltage of the portable hand tools
- Double insulating / grounding all electrical equipment used in environments that are, or may become, wet; using equipment with ground fault interrupter (GFI) protected circuits
- Protecting power cords and extension cords against damage from traffic by shielding or suspending above traffic areas
- Appropriate labeling of service rooms housing high voltage equipment ('electrical hazard') and where entry is controlled or prohibited
- Rubber tired construction or other vehicles that come into direct contact with, or arcing between, high voltage wires may need to be taken out of service for periods of 48 hours and have the tires replaced to prevent catastrophic tire and wheel assembly failure, potentially causing serious injury or death;
- Conducting detailed identification and marking of all buried electrical wiring prior to any excavation work

Eye Hazards

Solid particles from a wide variety of industrial operations, and / or a liquid chemical spray may strike a worker in the eye causing an eye injury or permanent blindness. Recommended measures include:

- Use of machine guards or splash shields and/or face and eye protection devices, such as safety glasses with side shields, goggles, and/or a full face shield. Specific Safe Operating Procedures (SOPs) may be required for use of sanding and grinding tools and/or when working around liquid chemicals.

Frequent checks of these types of equipment prior to use to ensure mechanical integrity is also good practice. Machine and equipment guarding should conform to standards published by organizations such as CSA, ANSI and ISO.

- Moving areas where the discharge of solid fragments, liquid, or gaseous emissions can reasonably be predicted (e.g. discharge of sparks from a metal cutting station, pressure relief valve discharge) away from places expected to be occupied or transited by workers or visitors. Where machine or work fragments could present a hazard to transient workers or passers-by, extra area guarding or proximity restricting systems should be implemented, or PPE required for transients and visitors.
- Provisions should be made for persons who have to wear prescription glasses either through the use over glasses or prescription hardened glasses.

Welding / Hot Work

- Welding creates an extremely bright and intense light that may seriously injure a worker's eyesight. In extreme cases, blindness may result. Additionally, welding may produce noxious fumes to which prolonged exposure can cause serious chronic diseases. Recommended measures include:
- Provision of proper eye protection such as welder goggles and/or a full-face eye shield for all personnel involved in, or assisting, welding operations. Additional methods may include the use of welding barrier screens around the specific work station (a solid piece of light metal, canvas, or plywood designed to block welding light from others). Devices to extract and remove noxious fumes at the source may also be required.
- Special hot work and fire prevention precautions and Standard Operating Procedures (SOPs) should be implemented if welding or hot cutting is undertaken outside established welding work stations, including 'Hot Work

Permits, stand-by fire extinguishers, stand-by fire watch, and maintaining the fire watch for up to one hour after welding or hot cutting has terminated. Special procedures are required for hot work on tanks or vessels that have contained flammable materials.

Working Environment Temperature

Exposure to hot or cold working conditions in indoor or outdoor environments can result temperature stress-related injury or death. Use of personal protective equipment (PPE) to protect against other occupational hazards can accentuate and aggravate heat-related illnesses. Extreme temperatures in permanent work environments should be avoided through implementation of engineering controls and ventilation. Where this is not possible, such as during short-term outdoor work, temperature-related stress management procedures should be implemented which include:

- Monitoring weather forecasts for outdoor work to provide advance warning of extreme weather and scheduling work accordingly
- Adjustment of work and rest periods according to temperature stress management procedures provided by ACGIH67, depending on the temperature and workloads
- Providing temporary shelters to protect against the elements during working activities or for use as rest areas
- Use of protective clothing
- Providing easy access to adequate hydration such as drinking water or electrolyte drinks, and avoiding consumption of alcoholic beverages

Working at Heights

Fall prevention and protection measures should be implemented whenever a worker is exposed to the hazard of falling more than two meters; into operating

machinery; into water or other liquid; into hazardous substances; or through an opening in a work surface. Fall prevention / protection measures may also be warranted on a case-specific basis when there are risks of falling from lesser heights. Fall prevention may include:

- Installation of guardrails with mid-rails and toe boards at the edge of any fall hazard area
- Proper use of ladders and scaffolds by trained employees
- Use of fall prevention devices, including safety belt and lanyard travel limiting devices to prevent access to fall hazard area, or fall protection devices such as full body harnesses used in conjunction with shock absorbing lanyards or self retracting inertial fall arrest devices attached to fixed anchor point or horizontal life-lines
- Appropriate training in use, serviceability, and integrity of the necessary PPE
- Inclusion of rescue and/or recovery plans, and equipment to respond to workers after an arrested fall

Illumination

Work area light intensity should be adequate for the general purpose of the location and type of activity, and should be

Sr. No.	Minimum Limits For Workplace Illumination Intensity	
	Location / Activity	Light Intensity
1	Emergency light	10 lux
2	Outdoor non working areas	20 lux

3	Simple orientation and temporary visits (machine storage, garage, warehouse)	50 lux
4	Workspace with occasional visual tasks only (corridors, stairways, lobby, elevator, auditorium, etc.)	100 lux
5	Medium precision work (simple assembly, rough machine works, welding, packing, etc.)	200 lux
6	Precision work (reading, moderately difficult assembly, sorting, checking, medium bench and machine works, etc.), offices.	500 lux
7	High precision work (difficult assembly, sewing, color inspection, fine sorting etc.)	1,000 – 3,000 lux

Supplemented with dedicated work station illumination, as needed. The minimum limits for illumination intensity for a range of locations/activities appear in Table.

Controls should include:

- Use of energy efficient light sources with minimum heat emission
- Undertaking measures to eliminate glare / reflections and flickering of lights
- Taking precautions to minimize and control optical radiation including direct sunlight. Exposure to high intensity UV and IR radiation and high intensity visible light should also be controlled

- Controlling laser hazards in accordance with equipment specifications, certifications, and recognized safety standards. The lowest feasible class Laser should be applied to minimize risks.

Chemical Hazards

Chemical hazards represent potential for illness or injury due to single acute exposure or chronic repetitive exposure to toxic, corrosive, sensitizing or oxidative substances. They also represent a risk of uncontrolled reaction, including the risk of fire and explosion, if incompatible chemicals are inadvertently mixed. Chemical hazards can most effectively be prevented through a hierarchical approach that includes:

- Replacement of the hazardous substance with a less hazardous substitute
- Implementation of engineering and administrative control measures to avoid or minimize the release of hazardous substances into the work environment keeping the level of exposure below internationally established or recognized limits
- Keeping the number of employees exposed, or likely to become exposed, to a minimum
- Communicating chemical hazards to workers through labeling and marking according to national and internationally recognized requirements and standards, including the International Chemical Safety Cards (ICSC), Materials Safety Data Sheets (MSDS), or equivalent. Any means of written communication should be in an easily understood language and be readily available to exposed workers and first-aid personnel
- Training workers in the use of the available information (such as MSDSs), safe work practices, and appropriate use of PPE

Air Quality

Poor air quality due to the release of contaminants into the work place can result in possible respiratory irritation, discomfort, or illness to workers. Employers should take appropriate measures to maintain air quality in the work area. These include:

- Maintaining levels of contaminant dusts, vapors and gases in the work environment. Concentrations to which most workers can be exposed repeatedly (8 hours/day, 40 hrs/week, week-after week), without sustaining adverse health effects.
- Developing and implementing work practices to minimize release of contaminants into the work environment including:
- Direct piping of liquid and gaseous materials
- Minimized handling of dry powdered materials
- Enclosed operations
- Local exhaust ventilation at emission / release points
- Vacuum transfer of dry material rather than mechanical or pneumatic conveyance
- Indoor secure storage, and sealed containers rather than loose storage
- Where work shifts extend beyond eight (8) hours, calculating adjusted workplace exposure

Fire and Explosions

Fires and or explosions resulting from ignition of flammable materials or gases can lead to loss of property as well as possible injury or fatalities to project workers. Prevention and control strategies include:

- Storing flammables away from ignition sources and oxidizing materials. Further, flammables storage area should be:

    - Remote from entry and exit points into buildings
    - Away from facility ventilation intakes or vents
    - Have natural or passive floor and ceiling level ventilation and explosion venting
    - Use spark-proof fixtures

- Be equipped with fire extinguishing devices and self closing doors, and constructed of materials made to withstand flame impingement for a moderate period of time
- Providing bonding and grounding of, and between, containers and additional mechanical floor level ventilation if materials are being, or could be, dispensed in the storage area
- Where the flammable material is mainly comprised of dust, providing electrical grounding, spark detection, and, if needed, quenching systems
- Defining and labeling fire hazards areas to warn of special rules (e.g. prohibition in use of smoking materials, cellular phones, or other potential spark generating equipment)
- Providing specific worker training in handling of flammable materials, and in fire prevention or suppression

Corrosive, oxidizing, and reactive chemicals

Corrosive, oxidizing, and reactive chemicals present similar hazards and require similar control measures as flammable materials. However, the added hazard of these chemicals is that inadvertent mixing or intermixing may cause serious adverse reactions. This can lead to the release of flammable or toxic materials and gases, and may lead

directly to fires and explosions. These types of substances have the additional hazard of causing significant personal injury upon direct contact, regardless of any intermixing issues. The following controls should be observed in the work environment when handling such chemicals:

- Corrosive, oxidizing and reactive chemicals should be segregated from flammable materials and from other chemicals of incompatible class (acids vs. bases, oxidizers vs. reducers, water sensitive vs. water based, etc.), stored in ventilated areas and in containers with appropriate secondary containment to minimize intermixing during spills
- Workers who are required to handle corrosive, oxidizing, or reactive chemicals should be provided with specialized training and provided with, and wear, appropriate PPE (gloves, apron, splash suits, face shield or goggles, etc).
- Where corrosive, oxidizing, or reactive chemicals are used, handled, or stored, qualified first-aid should be ensured at all times. Appropriately equipped first-aid stations should be easily accessible throughout the place of work, and eye-wash stations and/or emergency showers should be provided close to all workstations where the recommended first-aid response is immediate flushing with water

Asbestos Containing Materials (ACM)

The use of asbestos containing materials (ACM) should be avoided in new buildings or as a new material in remodeling or renovation activities. Existing facilities with ACM should develop an asbestos management plan which clearly identifies the locations where the ACM is present, its condition (e.g. whether it is in friable form with the potential to release fibers), procedures for monitoring its condition, procedures to access the locations where ACM is present to avoid

damage, and training of staff who can potentially come into contact with the material to avoid damage and prevent exposure. The plan should be made available to all persons involved in operations and maintenance activities.

Personal Protective Equipment (PPE)

Personal Protective Equipment (PPE) provides additional protection to workers exposed to workplace hazards in conjunction with other facility controls and safety systems. PPE is considered to be a last resort that is above and beyond the other facility controls and provides the worker with an extra level of personal protection. Table presents general examples of occupational hazards and types of PPE available for different purposes. Recommended measures for use of PPE in the workplace include:

- Active use of PPE if alternative technologies, work plans or procedures cannot eliminate, or sufficiently reduce, a hazard or exposure
- Identification and provision of appropriate PPE that offers adequate protection to the worker, co-workers, and occasional visitors, without incurring unnecessary inconvenience to the individual
- Proper maintenance of PPE, including cleaning when dirty and replacement when damaged or worn out. Proper use of PPE should be part of the recurrent training programs for employees
- Selection of PPE should be based on the hazard and risk ranking described earlier in this section, and selected according to criteria on performance and testing established by recognized organizations.

Summary of Recommended Personal Protective Equipment According to Hazard		
Objective	Workplace Hazards	Suggested PPE
Eye and face protection	Flying particles, molten metal, liquid chemicals, gases or vapors, light radiation	Safety Glasses with side-shields, protective shades, etc.
Head protection	Falling objects, inadequate height clearance, and overhead power cords.	Plastic Helmets with top and side impact protection.
Hearing protection	Noise, ultra-sound.	Hearing protectors (ear plugs or ear muffs).
Foot protection	Falling or rolling objects, pointed objects. Corrosive or hot liquids.	Safety shoes and boots for protection against moving & falling objects, liquids and chemicals.
Hand protection	Hazardous materials, cuts or lacerations, vibrations, extreme temperatures.	Gloves made of rubber or synthetic materials (Neoprene), leather, steel, insulating materials, etc.
Respiratory protection	Dust, fogs, fumes, mists, gases, smokes, vapors.	Facemasks with appropriate filters for dust removal and air purification (chemicals, mists, vapors and gases). Single or multi-gas

		personal monitors, if available.
	Oxygen deficiency	Portable or supplied air (fixed lines). On-site rescue equipment.
Body/leg protection	Extreme temperatures, hazardous materials, biological agents, cutting and laceration.	Insulating clothing, body suits, aprons etc. of appropriate materials.

Monitoring

Occupational health and safety monitoring programs should verify the effectiveness of prevention and control strategies. The selected indicators should be representative of the most significant occupational, health, and safety hazards, and the implementation of prevention and control strategies. The occupational health and safety monitoring program should include:

- Safety inspection, testing and calibration: This should include regular inspection and testing of all safety features and hazard control measures focusing on engineering and personal protective features, work procedures, places of work, installations, equipment, and tools used. The inspection should verify that issued PPE continues to provide adequate protection and is being worn as required. All instruments installed or used for monitoring and recording of working environment parameters should be regularly tested and calibrated, and the respective records maintained.
- Surveillance of the working environment: Employers should document compliance using an appropriate combination of portable and stationary sampling and monitoring instruments. Monitoring and analyses should be conducted according to internationally recognized methods and standards.

Monitoring methodology, locations, frequencies, and parameters should be established individually for each project following a review of the hazards. Generally, monitoring should be performed during commissioning of facilities or equipment and at the end of the defect and liability period, and otherwise repeated according to the monitoring plan.

- Surveillance of workers health: When extraordinary protective measures are required (for example, against biological agents Groups 3 and 4, and/or hazardous compounds), workers should be provided appropriate and relevant health surveillance prior to first exposure, and at regular intervals thereafter. The surveillance should, if deemed necessary, be continued after termination of the employment.
- Training: Training activities for employees and visitors should be adequately monitored and documented (curriculum, duration, and participants). Emergency exercises, including fire drills, should be documented adequately. Service providers and contractors should be contractually required to submit to the employer adequate training documentation before start of their assignment.

Accidents and Diseases monitoring

- The employer should establish procedures and systems for reporting and recording:

    - Occupational accidents and diseases
    - Dangerous occurrences and incidents

- These systems should enable workers to report immediately to their immediate supervisor any situation they believe presents a serious danger to life or health.
- The systems and the employer should further enable and encourage workers to report to management all:

  - Occupational injuries and near misses
  - Suspected cases of occupational disease
  - Dangerous occurrences and incidents

- All reported occupational accidents, occupational diseases, dangerous occurrences, and incidents together with near misses should be investigated with the assistance of a person knowledgeable/competent in occupational safety. The investigation should:
  - Establish what happened
  - Determine the cause of what happened
  - Identify measures necessary to prevent a recurrence

Noise Monitoring

Noise monitoring will be carried out inside the units near the high noise generating areas once in a month. Ambient noise monitoring just outside the plant limit will be conducted monthly. Noise levels monitored will include Leq day & night, Lmax, and Lmin.

Quality Assurance

A quality assurance plan should be developed which will include all references methods for monitoring, relevant analytical techniques, calibration of equipment, standard of reagents, collection and presentation of results etc. All monitoring activities will be reviewed to find out the implementation of all the required norms. Periodic environmental audit may be arranged to make quality assurance a success.

Safety & Health

Periodic monitoring of the health of the workers will be carried out as required by Factories Act. For safety, mock drill of the concerned employees for handling the emergency situation will be carried out, as a part of On-Site Emergency Plan. Air Quality at the work place will be measured intermittently.

Rainwater Harvesting

Rainwater harvesting is now an important component of wise resource use and environmental management. During operation of the plant following approach will be taken to implement the Rainwater harvesting plan. Rainwater from the roofs of all the Station Buildings of the units, storm water drains adjoining the roads of Cooling Towers, ESP / Boiler areas of the plant shall be collected in a rainwater collection tank. All storm water drains of the main plant area shall be connected to the rainwater collection tank. Rainwater collected in the rainwater tank is to be utilized for further use. This is achieved by installing a suitable pump at one end of the tank. This shall pump the collected water to the synthetic PVC tank installed on the roof of superstructures like Station Building, etc. The size of the synthetic tank shall be suitably sized based on the rainfall intensity and the runoff there-of. Additional tanks could be installed as and when the underground tanks are added. PVC pipe is proposed for pumping water from the rainwater collection tank to the tanks on top of the buildings.

Collected water from the synthetic tank is distributed by gravity to desired locations for non-potable use like gardening, cleaning etc. Excess water will be discharged through CMB (Chloride mass balance).

Training

Training is of much importance in environmental management. Environmental science is a developing subject and the people implementing environmental strategies should remain up to date with the environmental control processes. The person in charge of the environmental jobs should attend suitable training courses. Besides, there shall be training programme for the general employees at different level.

Documentation

Documentation is an important step in implementing Environmental Management Plan. All statutory norms should be kept at one place for quick references. All monitoring results should be kept at selected folders which can be easily accessed. The presentation of the results should also be planned. Graphs and diagrams can be used to show the trend in environmental quality or achievement. Documents should be kept at a declared position.
Documentation will include

- Major technical information in operation
- Organizational Charts
- Environmental Monitoring Standards
- Environmental and related legislation
- Operational Procedure
- Monitoring Records
- Quality Assurance Plan for Monitoring
- Emergency Plan

Environmental Management Cell

A separate environmental management cell should be established to implement the management plan. The cell shall report to the Plant manager. The cell shall ensure the suitability, adequacy and effectiveness of the Environment

Management Programme. The management review process will ensure that the necessary information is collected to allow management to carry out its evaluation. This review will be documented.

Environmental Component	Remedial Measures	Time frame	Responsibility
Water			
Ground Water	No extraction of groundwater	Throughout Construction Phase	Supervising
Surface water sources	No disposal of any wastewater outside.	Throughout Construction Phase	Contractor, Supervising Engineer
Drinking Water Requirement	Arrange water without affecting local requirement	Throughout Construction Phase	Contractor, Supervising Engineer
Wastewater from Workers' camp	Ensure proper sanitation and drainage. No direct wastewater discharge in water bodies or the rivers.	Throughout Construction Phase	Design Consultant, Contractor, Supervising Engineer
Air & Noise			
Dust Generation	Spraying of water wherever required	Throughout Construction Phase	Contractor, Supervising Engineer
Gaseous Emission from Construction work vehicles	Ensure checking of vehicular emission and obtaining Pollution Under Control Certificate	Throughout Construction Phase	Contractor, Supervising Engineer
Noise from	Ensure machineries	Throughout	Contractor,

machineries and construction	meeting noise level standards	Construction Phase	Supervising Engineer
Land			
Land Development	Preserve the excavated topsoil to be used for green belt development.	Throughout Construction Phase	Design Consultant, Contractor, Supervising Engineer
Solid Waste from construction work	Ensure dumping at preselected location	Throughout Construction Phase	Design Consultant, Contractor, Supervising Engineer
Others			
Occupational Health	Ensure necessary facilities according to Factories Act	Throughout Construction Phase	Design Consultant, Contractor, Supervising Engineer
Wastewater	No discharge of untreated wastewater outside the plant	Throughout Operation Phase	Manager Environment
Gaseous Emission	Pollution Control Equipments and Dispersion through stack	Throughout Operation Phase	Manager Production and Manager Environment
Air Quality	Regular Monitoring according to schedule	Throughout Operation Phase	Manager Environment
Emission Quality	Regular Stack emission monitoring	Throughout Operation Phase	Manager Environment

	according to schedule		
Water Quality	Monitoring of wastewater quality before and after discharge Ground water around ash pond monitoring	Throughout Operation Phase	Manager Environment
Noise	All machineries would follow relevant noise regulations. Regular Monitoring according to schedule	Throughout Operation Phase	Manager Production and Manager Environment
Solid Waste	Disposal at preselected site within the plant premises and in ash pond	Throughout Operation Phase	Manager Environment
Safety	Maintain all safety provisions	Throughout Operation Phase	Manager Production and Manager Environment
Statutory Requirements	Meet all Statutory Requirements within time schedule	Throughout Operation Phase	Manager Production and Manager Environment

PREPARE MATERIAL SAFETY DATA SHEET (MSDS)

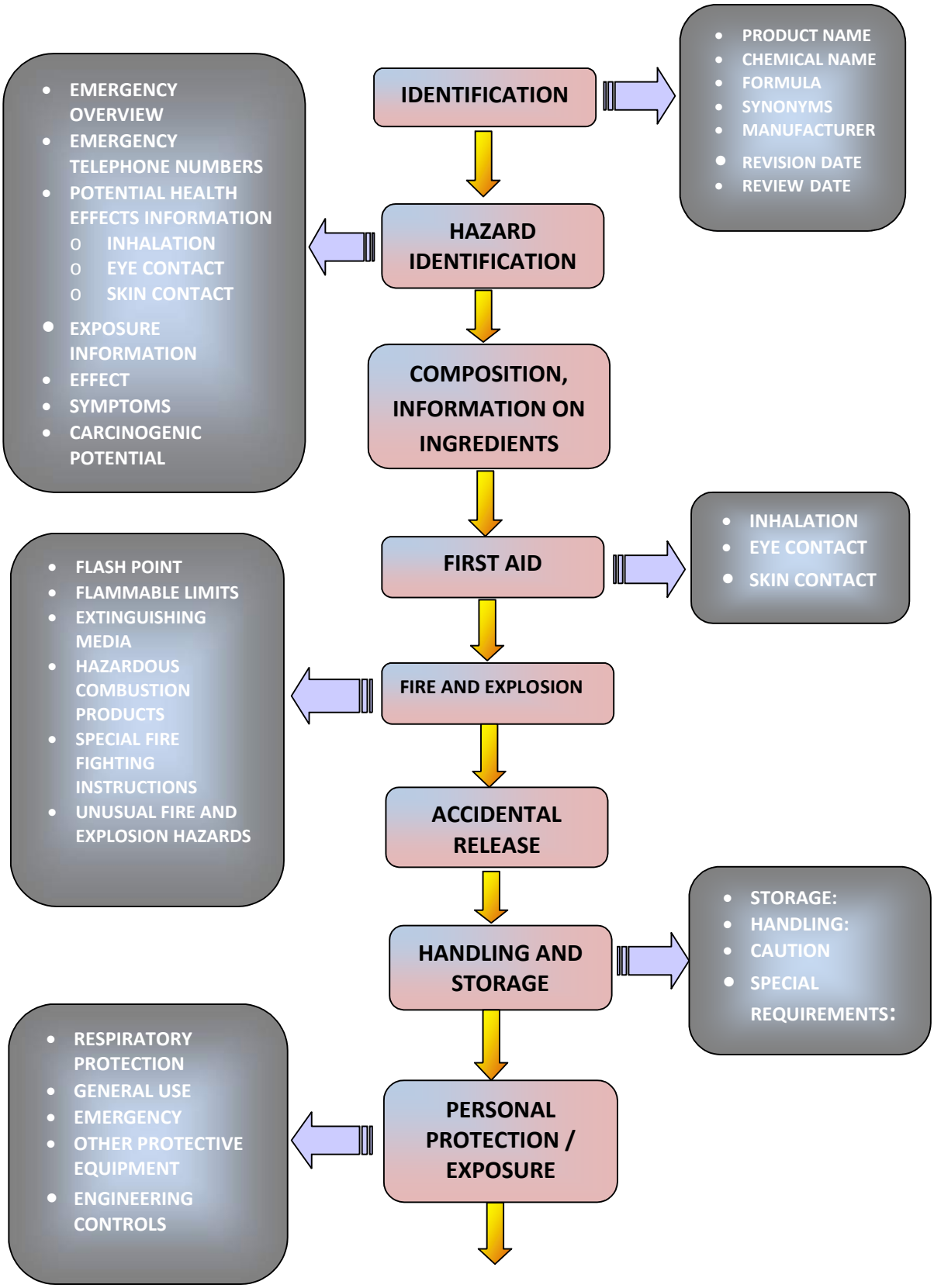
Safety Data Sheet (SDS) should be produce for all substances and mixtures which meet the harmonized criteria for physical, health or environmental hazards under the GHS and for all mixtures which contain ingredients that meet the criteria for carcinogenic, toxic to reproduction or target organ toxicity in concentration s exceeding the cut- off limit for SDS specified by the criteria for mixtures. The component authority may also require SDS for mixtures not meeting the criteria for classification as hazardous but which contain hazardous ingredients in certain concentrations. The CA may also require SDS for substances or mixtures that meet the criteria for classification as hazardous for non-GHS classes/ end-points. An SDS is a well-accepted and effective method for the provision of information for the substances or mixtures that do not meet or are not included in the GHS Classification criteria.

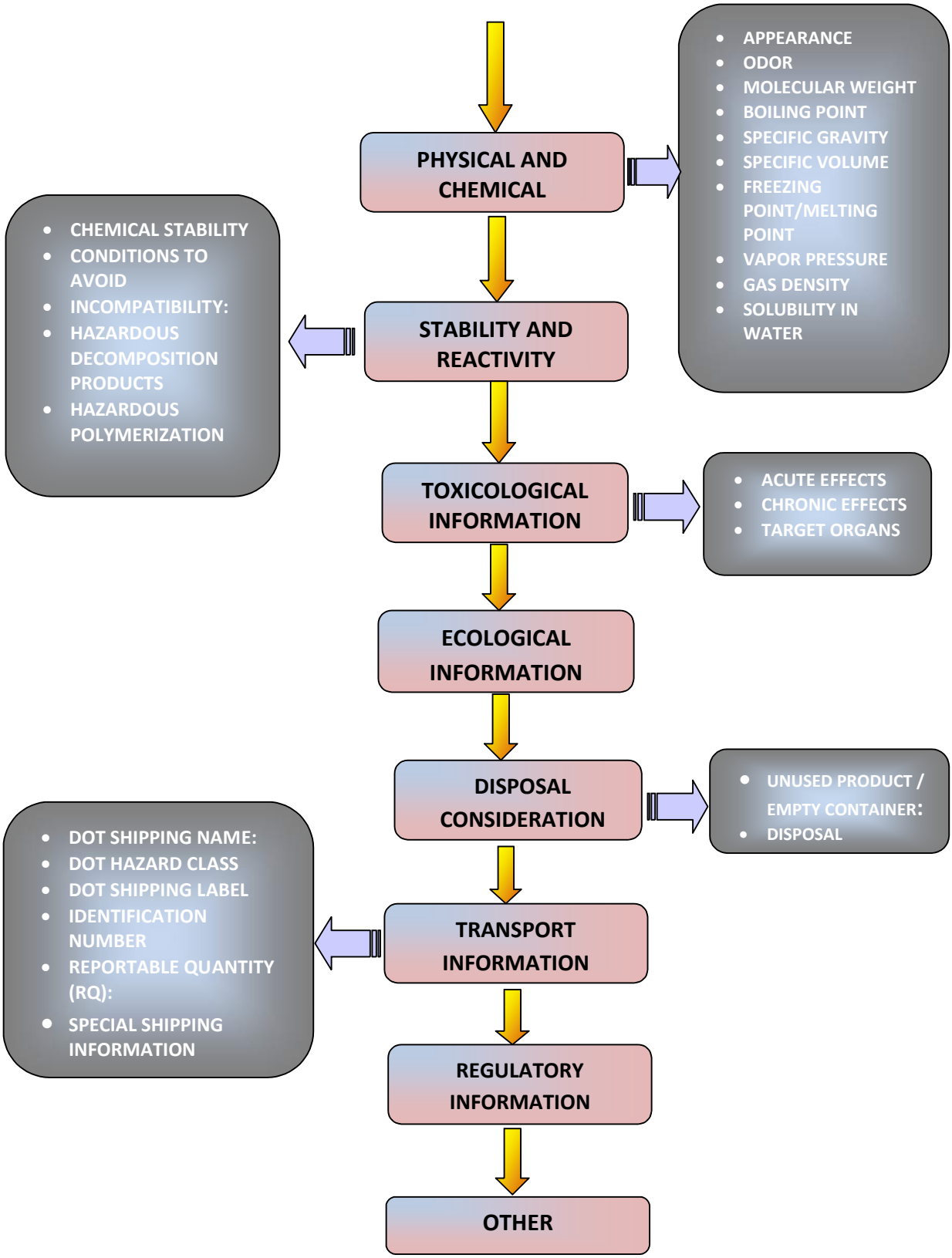
SDS format

The Information in the SDS should be presented using the following 16 headings in the given below.

i. Identification
ii. Hazard Identification
iii. Composition/ information on ingredients
iv. First-aid measures
v. Fire and Explosion
vi. Accident release measures
vii. Handling and Storage
viii. Exposure control/ personal protection
ix. Physical and Chemical properties
x. Stability and Reactivity
xi. Toxicological Information

xii. Ecological Information
xiii. Disposal Consideration
xiv. Transport Information
xv. Regulatory Information
xvi. Other Information


IDENTIFICATION
PRODUCT NAME
CHEMICAL NAME
FORMULA
SYNONYMS
MANUFACTURER
REVISION DATE
REVIEW DATE
HAZARD IDENTIFICATION
EMERGENCY OVERVIEW
EMERGENCY TELEPHONE NUMBERS
POTENTIAL HEALTH EFFECTS INFORMATION
INHALATION
EYE CONTACT
SKIN CONTACT
EXPOSURE INFORMATION
EFFECT
SYMPTOMS
CARCINOGENIC POTENTIAL
COMPOSITION, INFORMATION ON INGREDIENTS
FIRST AID
INHALATION
EYE CONTACT
SKIN CONTACT
FIRE AND EXPLOSION
FLASH POINT
FLAMMABLE LIMITS
EXTINGUISHING MEDIA
HAZARDOUS COMBUSTION PRODUCTS
SPECIAL FIRE FIGHTING INSTRUCTIONS
UNUSUAL FIRE AND EXPLOSION HAZARDS
ACCIDENTAL RELEASE
HANDLING AND STORAGE
STORAGE:
HANDLING:
CAUTION
SPECIAL REQUIREMENTS:
PERSONAL PROTECTION / EXPOSURE
RESPIRATORY PROTECTION
GENERAL USE
EMERGENCY
OTHER PROTECTIVE EQUIPMENT
ENGINEERING CONTROLS


PHYSICAL AND CHEMICAL
APPEARANCE
ODOR
MOLECULAR WEIGHT
BOILING POINT
SPECIFIC GRAVITY
SPECIFIC VOLUME
FREEZING POINT/MELTING POINT
VAPOR PRESSURE
GAS DENSITY
SOLUBILITY IN WATER
STABILITY AND REACTIVITY
CHEMICAL STABILITY
CONDITIONS TO AVOID
INCOMPATIBILITY:
HAZARDOUS DECOMPOSITION PRODUCTS
HAZARDOUS POLYMERIZATION
TOXICOLOGICAL INFORMATION
ACUTE EFFECTS
CHRONIC EFFECTS
TARGET ORGANS
ECOLOGICAL INFORMATION
DISPOSAL CONSIDERATION
UNUSED PRODUCT / EMPTY CONTAINER:
DISPOSAL
TRANSPORT INFORMATION
DOT SHIPPING NAME:
DOT HAZARD CLASS
DOT SHIPPING LABEL
IDENTIFICATION NUMBER
REPORTABLE QUANTITY (RQ):
SPECIAL SHIPPING INFORMATION
REGULATORY INFORMATION
OTHER

For More Details:

Gujarat Cleaner Production Centre

(Established by Industries & Mines Department, Government of Gujarat)

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