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**GLOBAL EPOXY**

**RESIN MARKET**

**FORECAST & OPPORTUNITIES, 2030**

**MARKET INTELLIGENCE. CONSULTING**

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| **4.3.1 Target End-Use Applications (Grade wise application details of Epoxy Resin)**  There are many customised Epoxy Resin types commercially available from global manufacturers, compatible with a wide range of modifying resins, reactive and nonreactive diluents, curing agents, additives, rheology modifiers, and fillers.   |  |  |  | | --- | --- | --- | | **BISPHENOL-A BASED LIQUID EPOXY RESINS** | | | | **Application** | **EEW** | **Viscosity1 @ 25°C** | | **g/eq** | **mPa∙s** | | Multiple application including Adhesive, Coating, Construction, Electrical and Composites | 184 - 191 | 11,000 - 15,000 | | Coatings and Adhesive formulations | 213 - 233 | 20,000 - 26,000 | | Adhesives and Prepregs | 225 - 280 | 450 - 800 (70% solution in butyl corbitol) | | Multiple application including Adhesive, Coating, Construction, Electrical and Composites | 180 - 187 | 8,000 - 11,000 | | Coatings and Adhesives | 280 - 300 | 500 - 1,500 (70% solution in butyl corbitol) | |
| |  |  |  |  | | --- | --- | --- | --- | | **BISPHENOL-A BASED SOLID RESINS** | | | | | **Application** | **EEW (g/eg)** | **Viscosity^1 25°C (mPa∙s)** | **Softening point (°C)** | | Powder Coating formulation | 653 - 704 | 375 - 475 | 80 - 90 | | Powder Coating formulation with high glass transition temperature | 769 - 847 | 6,000 - 8,000 @ 150°C | Tg = Min 55 | | Hybrid powder coatings | 714 - 752 | 500 - 600 | 95 - 101 | | Powder Coating formulation | 781 - 855 | 480 - 580 | 85 - 90 | | Protective Coating | 450 - 465 | 160 - 190 | 65 - 75 | | Enamels and exterior coating of cans and tubes | 833 - 893 | 550 - 700 | 90 - 102 | | Internal coating of cans and tubes | 1,695 - 1,887 | 1,800 - 2,600 | 110 - 120 | | Tubes, Cans and Coil coatings | 2,381 - 2,941 | 5,000 - 10,000 | 125 - 140 |  |  |  |  | | --- | --- | --- | | **BISPHENOL-F BASED LIQUID EPOXY RESINS** | | | | **Application** | **EEW (g/eg)** | **Viscosity^1 25°C (mPa∙s)** | | Coating applications, Composites, Construction and Electrical casting | 159 - 175 | 2,000 - 5,000 | | 164 - 172 | 2,000 - 3,300 | | 164 - 172 | 3,300 - 4,100 | | 159 - 172 | 5,000 - 7,000 | | Coatings, Composites, Construction applications and Floor coatings. | 172 - 180 | 6,500 - 8,500 | | 174 - 182 | 4,500 - 6,500 | | High Solids coatings, Construction and Floor coatings. | 185 - 196 | 6 860 - 960 |  |  |  |  | | --- | --- | --- | | **CYCLOALIPHATIC RESINS** | | | | **Application** | **EEW (g/eg)** | **Viscosity^1 25°C (mPa∙s)** | | Electrical component castings, Potting and Outdoor coatings. | 159 - 182 | 500 - 1,100 | | Electrical cast components | 180 - 200 | 350 - 750 | | Outdoor coatings, Flooring, Electrical castings and composite parts | 220 - 240 | 2,000 - 4,000 | | Outdoor coatings, Flooring, Electrical castings and Composite | 210 - 230 | 1,300 - 2,500 | | Electrical component castings, Potting and Outdoor coatings | 130 - 143 | 250 - 450 |  |  |  |  | | --- | --- | --- | | **EPOXY PHENOL NOVOLAC RESINS** | | | | **Application** | **EEW (g/eg)** | **Viscosity^1 25°C (mPa∙s)** | | Composites, Electrical and Coating applications. | 172 - 179 | 1,100 - 1,700 @ 52°C | | Composites, Electrical, Chemical resistant coatings and Flooring | 175 - 182 | 20,000 - 50,000 @ 52°C | | Chemical resistant coatings, Electrical and Composite applications. | 215 - 231 | 150 - 350 | | Chemical resistant coatings, Electrical and Composite applications. | 215 - 231 | 800 - 1,500 | | Composites, Electrical and Coating applications. | 167 - 179 | 35,000 - 55,000 | | Composites, Electrical and Coating applications. | 167 - 182 | 25,000 - 35,000 |  |  |  |  |  | | --- | --- | --- | --- | | **GLYCIDYL AMINE BASED MULTIFUNCTIONAL RESINS** | | | | | **Application** | **EEW (g/eg)** | **Viscosity^1 25°C (mPa∙s)** | **HyCl %** | | High Performance Composites (aviation and marine) | 117 - 134 | 7,000 - 11,000^2 @ 50°C | Max 0.10 | | 118 - 134 | 7,000 - 19,000^2 @ 50°C | Max 0.10 | | 111 - 117 | 3,000 - 6,000 @ 50°C | Max 0.10 | | 118 - 133 | 7,000 - 12,000 | Max 0.10 | | 105 - 115 | 2,000 - 5,000 | Max 0.30 |  |  |  |  |  | | --- | --- | --- | --- | | **5. BROMINATED RESINS** | | | | | **Application** | **EEW (g/eg)** | **Viscosity^1 25°C (mPa∙s)** | **Bromine content %** | | Prepregs and Laminates | 450 - 500^2 | 2,200 – 3,000 | 19 - 23 | | Electrical | 250 - 280 | 700 – 1,100 @ 70°C | 21 - 26 | | Vinyl Ester and Electronic components. | 319 - 410 | – | 44 - 48 |   **4.3.2 Plant Process-description (Evaluation of major process commercially available for licensing:**  **Production process of Liquid Bisphenol-A Epoxy Resin**: The one-step process proceeds via polycondensation of reacting [epichlorohydrin](https://en.wikipedia.org/wiki/Epichlorohydrin) (ECH) with [bisphenol A](https://en.wikipedia.org/wiki/Bisphenol_A) (BPA),  resulted with different chemical liquid substance known as [bisphenol A diglycidyle ether](https://en.wikipedia.org/wiki/Bisphenol_A_diglycidyl_ether) (commonly known as BADGE or DGEBA). Bisphenol A-based resins are most widely commercialised resins (75-80%).  **Badge Process:**  Bisphenol A or 2,2'bis(p-hydroxyphenyl) propane is produced from acetone and phenol with an acid catalyst such as 75% sulphuric acid or dry hydrogen chloride. The reaction conditions will depend on the design of the production unit. The purity of the product is high, >95% p,p'-isomer (para-para); the other isomers formed are o,p'(ortho-para) and o,o (ortho- ortho)'. For resin manufacture the p,p' isomer (para-para) content should be at least 98%. The light-yellow colour of some Epoxy Resins may be due to trace impurities in the bisphenol A, such as iron, arsenic and highly coloured organic compounds. When a large excess of epichlorohydrin is reacted with bisphenol A with a stoichiometric amount of sodium hydroxide at about 65-70°C the resin produced contains about 50% diglycidyl ether of bisphenol A, DGEBA(BADGE) and the reaction may be represented formally as below:  Diagram  Description automatically generated  **Two Step Process**: The two-step process is the reaction of bisphenol A (BPA) and epichlorohydrin (ECH) in presence of a catalyst (such as a quaternary ammonium salt), the first step by an addition reaction is to form a diphenol-propane chlorohydrin ether as intermediate, and the second step is to be carried out in presence of Caustic, this closed loop reaction produces an Epoxy Resin.  **Production process of solid bisphenol A Epoxy Resin**  **Higher molecular weight bisphenol A resins:** Bisphenol A/epichlorohydrin ratio is important for control of the average molecular weight of the resins produced. Larger the value of n the smaller the epichlorohydrin / bisphenol A ratio required. The purity of the reactants is important and monofunctional reactants are chain terminators and hence their concentration has to be controlled. However, it is also necessary to optimize the reaction conditions to achieve the degree of polymerization required. For the production of oligomers with 1 ≤n ≤ 4, the so-called 'Taffy' process could be used but for much higher molecular weight polymers 3 ≤ n ≤ 20 the fusion or chain extension process (also called advancement process) is used.  **Taffy Process**:  In taffy process,1-3 bisphenol A is reacted at 85–95°C in a controlled excess of epichlorohydrin (ECH) (to give polymer molecules along with glycidyl ether groups, at both ends) in the presence of Caustic and an inert solvent. This reaction is used to produce lower molecular weight (MW) epoxides. The low molecular weight epoxides are polydisperse mix of epoxides with “n” values lies between 0 and 1 and have an average molecular weight of 340-600.  **Detail Description of Taffy Process:** A mixture of bisphenol A and 10% aqueous sodium hydroxide solution is introduced in a reactor equipped with high-speed powerful agitator. The mixture is heated up to 450 C and ECH is added rapidly with agitation, giving off heat. The temperature is allowed to rise to 950 C, where it is maintained for approx. 80-85 min for the completion of reaction. Agitation is stopped, and mixture gets separate in two layers. The heavier aqueous layer is drawn off from bottom and the molten, taffy-like product is washed with hot water until the wash water gets neutral PH. The taffy-like product is dried at 1350 C, gives solid resin with softening point of 70-750 C and an EEW value of 500. Alternatively, epichlorohydrin are removed by vacuum distillation at temperatures up to 1800 C approx. The crude resin is then dissolved in a secondary solvent (Toluene) to facilitate water washing and salt removal. This secondary solvent is then recovered via vacuum distillation in order to obtain the resin product.  **Cons of Taffy Process**: In this process insoluble polymers are formed, which create handling and disposal problem.  **Advancement Process**: For manufacturing of higher molecular weight Epoxy Resins, liquid Epoxy Resin (LER) is reacted with calculated amount of bisphenol A, further catalyst solution is added to boost the reaction and the temperature is maintained at approx. 160 °C. This process is known as "Advancement process". The high molecular weight epoxides are manufactured by “Advancement” process using Benzyl trimethyl ammonium hydroxide as a catalyst.  Diagram  Description automatically generated **Detail Description of Advancement Process**  Advancement process is widely practiced by coating producers to facilitate the handling of the high molecular weight, highly viscous Epoxy Resins used in many paint & coating formulations. The degree of polymerization is calculated by ratio of LER (formed from BADGE Process) to bisphenol A; an excess of the former provides epoxy terminal groups. The actual molecular weight obtained depends on purity of the starting materials, solvents & catalyst used. Reactive mono-functional groups are used as chain terminators to control MW and viscosity build. The below formula is used to calculate the amount of bisphenol A that is to be reacted with Epoxy Resin (LER) to obtain an advanced Epoxy Resin of predetermined EEW value. (EEW is Epoxy Equivalent Weight) is a measure of compounds which epoxy containing groups. The epoxy equivalent weight describes the mass in grams which one mole of epoxy groups contains.)  BisA = EEWi – 1 – EEWf – 1 EEWi – 1 + PEW - 1  where Bis A is mass fraction of bisphenol A in the mixture at initial stage, EEWi is the EEW of the Epoxy Resin that is to be advanced (i stands for initial), EEWf is the EEW (f stand for Final) of the advanced Epoxy Resin, and PEW is the phenol equivalent weight of the bisphenol, its value is 115.1 g per equivalent for bisphenol A. In an advancement process, bisphenol A and a liquid BADGE resin (170–180 EEW) are heated to 155–199 0C in the presence of a catalyst and reacted (i.e., advanced) to form a high MW resin. This oligomerisation process is exothermic and proceeds rapidly to completion. The exotherm temperatures depends on the reaction mass and targeted EEW. In the cases of higher MW resins, exotherm temperature can reach >190-205 0C. Reaction catalysts facilitate the rapid preparation of medium to high MW linear resins, also control side reactions inherent with Epoxy Resin preparations, e g, chain branching, by addition of the alcohol group generated in the chain-lengthening process to the epoxy group. Nuclear Magnetic Resonance (NMR) spectroscopy Methodcan be used to determine the extent of branching.  **Bisphenol F based Epoxy Resin**: Any multifunctional, f ≥ 2, phenolic compound is a potential starting material for the manufacture of Epoxy Resins, these are 'formulated' to meet specific requirements. Also, some monofunctional phenols have been reacted with epichlorohydrin to produce monofunctional reactants for use as modifying diluent agents. The dihydric phenol which is produced by reaction of phenol with formaldehyde is called bisphenol F.  Graphical user interface, diagram, text  Description automatically generated  Resins can be manufactured from bisphenol F by similar methods to those used for bisphenol A and epichlorohydrin with a catalyst such as NaOH. These resins have lower viscosities than the equivalent DGEBA.  **Bisphenol-F and Bisphenol-A/F Blends:** One can go with pure Bisphenol -F, Bisphenol A or Bisphenol A/F based Epoxy Resin. Bisphenol-F based resins are best known for low viscosity, chemical resistance and low crystallisation tendency in cold conditions. Bisphenol-F based pure and Bisphenol-A/F blend resins are recommended in varying viscosities for several applications like coatings, composites, floor coatings and construction applications.  **Epoxy Phenol Novolac (EPN) resins:** Graphical user interface, text, application, Word  Description automatically generated  These are generally referred to as multifunctional epoxy resins as they consist of more than two epoxy groups per molecule. EPN resins are produced by reaction of phenolic novolac with epichlorohydrin. After curing they result in a mesh like structure possessing high cross-linking density.  The mechanism of formation involves reaction of phenolic novolac with epichlorohydrin in alkaline medium (sodium hydroxide). Initially phenol hydroxyl group is deprotonated by hyroxide ions (OH-) of NAOH, thereby producing nucleophilic phenyl hydroxide (R-O-).  Further, the chloride of epichlorohydrin is substituted with the hydroxide of phenol hydroxyl group resulting in linking of phenolic unit with the epoxide.  Text  Description automatically generated  **Phenol Formaldehyde Epoxy Resin (Basic Chemistry)**   1. **Methylol monomer formation:**   Diagram  Description automatically generated   1. **Linear Polymer**   Text  Description automatically generated with low confidence   1. **Cross-linked tridimensional polymer**   Diagram  Description automatically generated  Phenolics are low-cost polymers with excellent physical & electrical properties and fast curing characteristics. Their poor colour characteristic can be partially overcome by adding pigment, dyes & fillers.  The main uses fall in these classes:   * Resin in solvent—coatings varnishes & laminated structure. * Resins in water solutions – adhesive bonding * Solid resin—all types of thermoset molded solid forms.   Phenol  Autoclave Reaction Vessel  Formaldehyde  Caustic Flakes  Stirring & heating up to 600 C  Dilution  Product: Phenol Formaldehyde Resin  Cooling  Vacuum Distillation  Reflux for 30-40 min.  Water  Methanol    **Cycloaliphatic Epoxy Resin:** These epoxy resins are produced by reacting cyclic alkene with a peracid (acid which consist of an acidic -OOH group)  Properties of Cycloaliphatic epoxy resin:   1. Higher resistance to UV and moisture 2. Excellent electrical properties 3. Superior deflection temperature 4. Low viscosity   **Glycidyl Amine Based Multifunctional Resins:** These are high-performance multifunctional epoxy resins that are produced by the reaction of aromatic amines with epichlorohydrin.  They are commonly of two types:   1. triglycidyl para-aminophenol (TGPAP) 2. triglycidyl of 4-(4-aminophenoxy) phenol (TGAPP)   They are increasingly used in the manufacturing of high-performance composites, adhesives and coatings in aircraft and aerospace industry.  **Brominated Epoxy Resin**  Brominated epoxy Resin is resin-based retardant with high bromine content compared to traditional TBBA- based flame retardant, products treated with brominated epoxy resin will have better thermal stability and chemical resistance.  **4.3.3&4. Process Flow Diagram & Technology Licensor**  **Technology licensor**   * **Tohto Kasei (Japan) (Now known as Nippon Steel & Simikin Chemical Co Ltd.),** leader in resin producer, have its own epoxy licensing technology arrangements with numerous resin manufacturers in Asia. In India Grasim, Vilayat use this technology. * **Olin Systems:** Olin Coorporation is the leading manufacturer & distributor of Epoxy Resin, which offers highly advanced Epoxy & leading customer support worldwide. The company doesn’t share their inhouse technology. * **Kukdo’s System** (Korean Technology)**:** Kukdo’s system is leading the global market through customized products and R&D. This companies all branches use their own technology. * The following table denotes the major licensors and manufacturers of Epoxy Resins. Only two of the following licensors i.e., Ciba-Geigy AG and Tohto Kasei Co., Ltd are open to share the technologies with new entrants. * Kukdo Chemical Co., Ltd and Olin Corporation do not share the technological process and process parameters and employ the manufacturing process in its own specific plants. * According to the primary research, the quality of product provided by Kukdo Chemical Co., Ltd is very superior in comparison to other technology licensors and it provides crystal clear liquid epoxy resin to the clients. * Ciba- Geigy AG has low solvent requirements than the Tohto Kasai Co., Ltd.      |  |  | | --- | --- | | **Technology** | **Open for Third Party Licensing** | | **Ciba-Geigy AG** | Badge Tick1 with solid fill | | **Tohto Kasei Co. Ltd.** | Badge Tick1 with solid fill | | **Kukdo Chemical Co., Ltd** | Badge Cross with solid fill | | **Olin Corporation** | Badge Cross with solid fill | | **Dow Chemicals** | Badge Cross with solid fill |   **Synthesis of Epoxy Resin**: The Epoxy Resin has been synthesized by the bulk polymerization by the continuous process of polymerization. The material is available commercially at 98% purity & colourless mobile liquid. Many commercial liquid resin consist essentially of low molecular weight diglycidyl ether of Bis-phenol A (BADGE) together with small quantity of higher mol Wt polymer. During the reaction hydrochloric acid has release. HCl has reacted with caustic & salt has form. As per reaction stoichiometry, the molar ratio of the BPA to ECH is 1:2 i.e., 1 mole of BPA & 2 mole of ECH but in actual practice this ratio is 1:5 or 1:6 of BPA to ECH.  **Technology 1: Nippon Steel & Simikin Chemical Co Ltd. (formerly Tohto Kasei Co. Ltd.) (Japanese firm)**    **Process Detail:**  **Pre-reaction Section**  Reaction starts with adding Excessive quantity of Epichlorohydrin (Fresh & recovered) with prescribed quantity of Bisphenol-A by using NaOH as catalyzer. As result of this reaction, Bisphenol-A chlorohydrin intermediate is formed.  Diagram  Description automatically generated  **Reactor**  Bisphenol-A chlorohydrin intermediate formed from the pre-reaction section is further changed to liquid Epoxy Resin by reaction with NaOH. Optimum process conditions are maintained in the reactor. Which minimizes hydrolysis of ECH and formation of by-product waste polymer and enables the production of high-quality Epoxy Resin of the required viscosity at high yields    **Resin + 2 NaCl + 2 H2O**  **Evaporator**  After the reaction process done, excessive quantities of unrelated ECH are separated from the product by increasing the temp and recovered through a vaporizer, same is returned to the ECH day tank for reuse. The crude epoxy is then sent to the next refining section. In order to protect the Epoxy Resin from thermal effect, vaporization of ECH is done under vacuum conditions, at the lowest possible temperature and in the shortest possible time.  **Refining**  In this section washing is done, toluene is added to dissolve resin in it. With continuous stirring & allowed salt solution to settle in the gravity settler, salt solution is separated from the resin manually by adding water. Again, DM water is added to wash the resin and remove the traces of salt from it.  **Filtration**  After refining, filtration is done to remove the impurities, suspended particles and rest of waste polymer by passing through the multilayer paper filter.  **Product Finishing Section:** Finally, Epoxy Resin is filtered to remove suspended filter cake via sparkler filter and is sent to the product tank through mixing tank.  **De solvent:** In this section, dissolvent is done to remove the solvent, toluene from the resin by passing through falling film thin evaporator & Rotary film thin evaporator under vacuum.  **ECH Stripping:** ECH Evaporated during reaction contains ECH along with water,  water is stripped off in the distillation unit, recovered pure ECH is recycled for next batch.  **ECH Distillation:** ECH vapours from the ECH detachment section are recovered and distilled in this section to recover pure ECH which is recycled.  **Process Flow Diagram:**  **Reactor Vessel**  **Accumulator**  **Phase Separator**  **Evaporator**  **Final Reactor**  **Phase Separator**  **Wash Process**  **Evaporator**  **Unreacted ECH**  **ECH Product**  **Reacted ECH**  **Liquid Epoxy Resin**  **H2O Brine**  **H2O Brine**  **Solid Epoxy Resin:**  **Pre-Reaction Section:** In this section, Liquid Epoxy Resin, Bisphenol A & Catalyst is added in to the reactor (BPA & Catalyst is added in 2 Stages i.e. With progress of the reaction, 2nd lot of BPA & catalyst is added. To avoid side reactions and unwanted products, reactants are added in lots to improve yield.)  **Reaction Section:** Here reaction mixture from the pre reaction section is added with a solvent in control range of pressure (5-7 Bar) & temp (70-750 C) approximately.  **Solidification Section:** Here Epoxy Resin (i.e. formed in reaction section) is passed through the flaker (with required utilities (chilled water & steam)) & further pass through the crusher to collect the final solid product.  For the suppression of catalytic reaction, a few amount of Methanol is added in reactor.  **Process Flow Diagram:**  **Jacketed Reactor.**  **Pre-Reaction Section**  **Reactor2**  **Reaction Section 70°C-80°C, 4 hrs**  **Flaker, 15°C chilled water**  **Crusher**  **Packer**  **Dust Collector**  **BPA, Liquid Epoxy Resin, NaOH, Methanol, Catalyst**  **180°C -190°C**  **Xylene**  **Hot Oil, 220°C**  **Oil, 50°C**  **5-7 Bar**  **Solid Epoxy Resin**      **Formulated Resins:**  **Mixing:** Different grade Liquid Epoxy Resin is mixed with various types of additives or Reactive Diluents to meet customer specific applications or other special Resin.    Mixing  Reactive Diluents / Additives: Solid Waste  LER:  Formulated Product  **Example**: amine cured epoxy coating is an epoxy coating where an anime-based hardener was used in the curation process.   |  | | --- | | **Hardeners:** As the name suggest, hardener is one who, or that which, hardens. The process is called curing of epoxy resin. Hardeners are required to make an epoxy resin useful for its intended purpose. The correct type of hardener must be selected to ensure the epoxy mixture will meet the requirements of the application. Mixing epoxy resin and hardener begins a chemical reaction that transforms the combined liquid ingredients to a solid. The time it takes for this chemical transformation from liquid to solid is called cure time. As it cures, the epoxy passes from the liquid state, through a gel state, before it reaches a solid state. Common examples of epoxy hardeners are anhydride-based, amine-based, polyamide, aliphatic and cycloaliphatic. |  Diluents or Diluting Agent: Diluents are low-molecular-weight, low-viscosity compounds that are used to reduce the viscosity or enhance the solubility of a resin and/or hardener, Diluents may be either reactive or non-reactive. However, the reactive types are more desirable since they combine chemically with the main resin during cure and are not free to outgas or leach. Examples of diluents for epoxy resins include: phenylglycidyl ether, butylglycidyl ether, allylglycidyl ether, [butanediol](https://www.sciencedirect.com/topics/engineering/butanediol) diglycidyl ether and glycerol-based epoxy resinAdditives: Epoxy resin additives are often used for multiple purposes. They can enhance the appearance of given resin and can even strengthen the resin. resin additives include metallic powders, liquid epoxy dye, spray paints, and glitter adhesives.Fillers: Major fillers include Graphene, Poly(2-butylaniline) functionalized Graphene & Waste Tire Rubber Particles. Fillers are used to affect the tensile strength, compressive strength impact resistance, viscosity, and shrinkage.  |  |  | | --- | --- | | **Fillers** | **Dispersion technique** | | Graphene | Epoxy Resin + graphene is dispersed by mechanical blending for 10 min + ultrasonic dispersion for 30 min. | | Poly(2-butylaniline) functionalized Graphene | Poly(2-butylaniline) + Tetrahydrofuran (THF) sonicated for 30 min. Addition of epoxy with 10 min stirring. Removal of THF by rotary evaporation; addition of curing agent followed by blending at 4000 rpm for 5 min; room temperature degassing in vacuum oven. | | Waste Tire Rubber Particles | Epoxy Resin + (1–20 wt%) Micronized Tire Rubber Manual Stirring for 10 min; Addition of curing agent followed by manual stirring for 5 min. |   **Technology-2: Ciba-Geigy AG**  **Process Detail:**  **Pre-reaction Section**  Reaction starts with adding Excessive quantity of Epichlorohydrin (Fresh & recovered) with prescribed quantity of Bisphenol-A by using NaOH as catalyzer. As result of this reaction, Bisphenol-A chlorohydrin intermediate is formed.  Graphical user interface, text, application  Description automatically generated  **Reaction Section**  Bisphenol-A chlorohydrin intermediate formed from the pre-reaction section is further changed to liquid Epoxy Resin by reaction with NaOH. Optimum process conditions are maintained in the reactor. Which minimizes hydrolysis of ECH and formation of by-product waste polymer and enables the production of high-quality Epoxy Resin of the required viscosity at high yield  Graphical user interface, text, application  Description automatically generated  **ECH Stripping & Recovery:** ECH Evaporated during reaction contains ECH and water, water is stripped off in the distilled unit, pure ECH is recycled for next batch  **Refining:** In this section, toluene is added to dissolve resin in it and salt solution is separated from the resin manually by adding water. There are 3 layers are formed, the resin and toluene stay in the upper layer (called Organic layer) &NaCl water in the lower layer & centre one is unreacted BPA, it is called Emulsion layer. Again, DM water is added to wash the resin and remove the traces of salt from it.  **De-solvent:** After filtration section, Epoxy Resin is sent to reboiler & vacuum distillation column for Toluene recovery.  **Product Finishing Section:** Epoxy Resin is finally filtered to remove traces of impurities  **Process Flow Diagram:**  **Pre-Reactor**  **Reactor**  **Evaporator**  **Washing/Gravity Separation**  **Condensate with stirrer at 60 RPM**  **Filtration Unit**  **ETP Treatment**  **Sludge**  **Salt Packaging**  **Solid Disposal**  **Packer**  **BPA, ECH, NaOH**  **Unreacted ECH**  **NaOH 48%**  **Dehydrated H2O**  **Toluene**  **Water**  **Steam 100°C**  *Note\*: process for Solid & Formulated Resin is same for Technology 2.* | | |
|  | | |
| **43.6. Utilities Overview (Cooling Water System, DM Water Plant, Compressed Air System, power, steam & effluent processing details):**  **For 100 KT Plant (per annum)**  Fresh water requirement will be 923 KLD. 710 KLD treated water after UF/RO system will be reused/recycled  back in process. Water will be sourced from the near water supply system.   |  |  | | --- | --- | | Typical Common Utility to be use | | | 1 | Electricity | | 2 | Gas | | 3 | Fuel Oil | | 4 | Steam | | 5 | Cooling tower Water | | 6 | Process Water | | 7 | Recycled process water | | 8 | Recycled cooling tower water | | 9 | Softened Water | | 10 | Demineralized water | | 11 | Instrumentation Air | | 12 | Inert Gas | | 13 | Nitrogen, purchased | | 14 | Refrigeration |   **Water Consumption:**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Water Consumption in KLD** | | | | | | **S. No.** | **Description** | **Fresh/ Permeate** | **Recycled water** | **Remark** | | 1 | Primary RO | **908** |  |  | | A | RO Permeate | 678 |  | RO permeate water will be used in utility & domestic | | a1 | Domestic | 15 |  |  | | a2 | Cooling Tower | 528 | 530 | 528 KLD Fresh + 530 KLD recycled water after UF/RO system | | a3 | Boiler | 130 | - |  | | a4 | Plant Washing | 5 |  |  | | 2 | Process | 0 | 180 | 180 KLD recycled water after UF/RO system | | 3 | Gardening | **15** |  |  | |  | **Water Required** | **923** | **710** |  | |  | **Total** | **1633** | | **923 KLD Fresh water from GIDC and 710 KLD recycled water after UF/RO System** |   **Detail of Wastewater Generation**   |  |  |  |  | | --- | --- | --- | --- | | **S. No.** | **Description** | **Wastewater Generation in KLD** | **Remark** | | 1 | RO Reject | 230 |  | | 2 | Domestic | 15 |  | | 3 | Cooling Tower | 200 |  | | 4 | Boiler | 117 | To ETP | | 5 | Plant Washing | 5 |  | | 6 | Process | 243 | 304 KLD process effluent will be sent to MEE. From that 61 KLD will convert to Salt and 243 KLD MEE condensate will sent to ETP for further treatment | |  | **Total Wastewater Generation** | **810** | **Treatment in ETP** | |  | Recycled Water | 710 | After treatment in recycling UF and RO system | |  | **Treated Wastewater going to nearest drain/ CETP** | **100** | **RO reject will be disposed off into deep sea via nearest drain/CETP** |   **Nitrogen:** The reaction is carried out in reactor is under ‘nitrogen' blanket' to minimize oxidative degradative reactions.  **Power Requirement**  Nearest State Electricity Board will supply power through grid in that area. The peak demand of power would be approx. 5500 kVA. DG sets will be installed as a backup arrangement.   |  |  |  |  | | --- | --- | --- | --- | | **S No.** | **Stack Attached to** | **No. of working hrs** | **Type of Fuel used** | |  | |  |  |  | Coal / Biomass or |  | | 1 | Boiler-1 | 24 | Natural Gas |  | | 2 | Thermic Fluid Heater | 24 | Natural Gas |  | | 3 | Boiler-2 | 24 | Coal / Biomass or Natural Gas |  | | 4 | DG Set-1 | As per requirement | Diesel |  | | 5 | DG Set-2 | As per requirement | Diesel |  | | | |
| * + 1. **Waste generation, Management, and disposal:**   Wastewater generation from capacity of 84 KT which includes processes like Badge, Taffy, Advancement and manufacturing of standard and specialized epoxy resin, wastewater generation will be around 700 KLD. From that, 615 KLD will be recycled and 85 KLD will be discharged to CETP after achieving desired norms. Unit will provide 750 KLD capacity of ETP followed by RO & UF. High TDS (Total Dissolved Solids) stream will be treated in MEE/MVR (Multi Effect Evaporator/ Mechanical Vapor Re-compressor).  Hazardous wastes like resin sludge with polymers, resin-soaked cotton waste / gloves & chemical contaminated saw dust, office garbage, filter material, waste glycerine, spent solvent, spent oil, activated carbon, ETP (Effluent Treatment Plant) sludge, and waste barrel will be generated during the production. MEE/MVR salts (i.e., NaCl Salt) need to be send to authorized vendors & to managed as per the Hazardous Wastes (Management, Transport and Transboundary) Rules 2016 as amended till date.   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **S No** | **Type of Waste** | **Source** | **Quantity per Year (MT)** | **Method of collection** | **Treatment/Disposal** | | 1 | ETP Sludge + Evaporation residue | Process | 2.1 | Bag | Collection, storage and Disposal at Approved TSDF Site | | 2 | Resin-Soaked Cotton Waste/ Gloves, Chemical, Contaminated Saw dust, Office Garbage | Process | 0 | Bag | Incineration | | 3 | Filter Material | Process | 1.46 | Bag | Incineration | | 4 | Waste Glycerine | Maintenance | 10.95 | Drum | Incineration | | 5 | Spent Solvent | Process | 87.6 | Drum | Collection, storage and Disposal at Approved TSDF Site | | 6 | Spent Oil | Maintenance | 0 | Drum | Via Register Recycler | | 7 | Activated Carbon | Process | 0.43 | Bag | Via Register Recycler | | 8 | ETP Sludge | ETP | 0 | Bag | Via TSDF | | 9 | Discarded Container | Process | 534.6 | Drum | Via Authorised Vendor | | 10 | Process Residue | Process | 0 | Drum | Via CHWIF | | 11 | Salt (NaCl) | Process | 15149.2 | Bag | Sell to Authorised Vendor | | | |
| **TSDF:** Treatment, Storage, & Disposal Facility.  **CHWIF:** Common Hazardous waste Incineration facility.  **CETP:** Common Effluent Treatment Plant | | |