



## FOUNDRY PRODUCTS: Technical Data Sheet

**PROCESS OVERVIEW: PHENOLIC URETHANE COLD BOX RAPIGURE™**

### THE COLD BOX SAND BINDER SYSTEM

#### INTRODUCTION

The cold box system was originally understood to be the phenolic/urethane/amine process, but now describes any core binder process that uses a gas or vaporized catalyst to cure resin coated sand while it is in contact with a room temperature pattern. Thus the phenolic SO<sub>2</sub>, phenolic ester, furan/SO<sub>2</sub>, epoxy/SO<sub>2</sub>, silicate/CO<sub>2</sub> and FRC/SO<sub>2</sub> systems are all in this category.

The cold box processes have eliminated the need for expensive, inconvenient heat curing. They offer advantages of dimensional accuracy, productivity and potentially higher quality than other core and mould systems. With the exception of the silicate/CO<sub>2</sub> process, all the cold box systems have the typical blow, gas, purging strip core making sequence. The cure cycle is relatively fast and can be completed within seconds.

The cold box processes are exceptionally precise during the coremaking stages as 1), no thermally related expansion and contraction of the tooling takes place and 2) core breakage is relatively low because the cores develop a substantial portion of their ultimate strength before they are ejected from the pattern.

Cold box binders provide a flowable sand mix that is easily blown into intricate core boxes. Tolling can be made of wood, metal or plastic. The size of cores and moulds produced in the cold box process is limited only by machine handling capacity. Cores in excess of 500 Kg. Have been blown. The process is especially well suited to blowing smaller cores with complex configurations since the system has excellent flow characteristics and good strippability. Because of the ambient cure, small, thin sections and protrusions are not overcures and burned during the time that thicker sections take to cure.

As cold box processes are not dependent on high temperature heat sources for curing, they yield reduced energy consumption and, through the advantages of productivity and quality, lower cost per finished casting.

#### THE PHENOLIC URETHANE PROCESS

The process is a three part binder system consisting of Part 1, a phenolic resin, Part 2 a polymeric isocyanate and an amine type Part 3 catalyst, capable of being vapourized.

Sand is coated with the part 1 and 2 components and compacted into a room temperature pattern. The catalyst is then vapourized and introduced through vents in the pattern to harden the contained sand mix instantly. The catalyst gassing cycle is normally followed by an air purge that forces the excess catalyst vapours throughout the sand mass and

**MANCUSO CHEMICALS LIMITED**

5725 Progress St.,

Niagara Falls ON

Canada L2E 6X8

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removes residual catalyst from the hardened core. It is preferable that the exhaust from the box be chemically scrubbed to remove the excess catalyst.

The reactive component of the part 1 is a phenolic resin. It is solubilized in organic solvents to yield a low viscosity resin solution so as to more easily coat the sand and allow easier blending with the part 2. The part 2 is usually a polymeric isocyanate solution in organic solvents. The hydroxyl components of the part 1 react with the isocyanate components of the part 2 in the presence of the catalyst to form a solid urethane polymer that bonds the sand grains together.

Both the part 1 and 2 solutions are essentially water free. The cross linking process releases no water or other by products. The system will contain a small (~3%) of Nitrogen, introduced via the isocyanate. The organic resins and solvents in the system give a high Carbon content which may contribute to the generation of lustrous carbon and a reducing mould atmosphere during casting.

Both parts 1 and 2 should be stored between 60 and 90°F in a dry area. Above 90°F there is a risk of pressure build-up and evaporative loss. Below 60°F the resin viscosity can build to the point of difficulty in pumping and mixing on the sand. Care must be taken to avoid water contaminating the part 2 resin as it will react to form a solid sludge or crust and generate CO<sub>2</sub> gas. The part 1 and 2 should not be “premixed” in bulk as they will react to form a solid mass and liberate significant heat. With proper storage, the shelf life of both components will be at least one year.

The catalysts are flammable liquids and must be kept away from open flame and other sources of ignition. All drums containing these liquids must be grounded and the liquids should only be handled in containers designed for flammable liquids. Do not store the catalysts in direct sunlight so as to ensure minimal pressure buildup. In sealed containers, the shelf life of the catalysts will be at least one year.

The process may be used with all sands commonly used for core making processes in the foundry. Consideration must be given to the effects of sand temperature, chemistry and moisture content on the resin performance. The ideal sand temperature is 70 to 80°F. Lower sand temperatures can reduce mixing efficiency and increase cure times. Higher sand temperatures will reduce gassing cycles and the amount of catalyst require but will also shorten the usable life of the coated sand mix.

The presence of high levels of alkaline impurities in the sand, as measured by acid demand value, (ADV), and pH, can shorten bench life. Moisture in the sand will reduce tensile strength and shorten bench life. A maximum sand moisture content of 0.2% is acceptable at normal sand temperatures, (~70°F), but when the sand temperature rises to ~90°F, the moisture content should be kept to below 0.1% for the process to function properly.

All types of popular sand mixing equipment can be used with the cold box system. A sand delivery system that causes the least amount of aeration is preferred.

Typically, 1.5% of combined parts 1 and 2 is used, with the ratios of components ranging from 50/50 to 55/45. A 50/50 ratio is most common in ferrous foundries. For casting

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Aluminum, magnesium and other low-pouring-temperature alloys, binder levels of 1% or lower are commonly used to facilitate shakeout.

The volatile catalysts are usually tertiary amines, such as triethylamine, (TEA), or dimethylethylamine, (DMEA). Both are volatile, flammable, corrosive liquids. The choice of which catalyst may be used will depend on the following differences in performance: DMEA cures the cores faster than TEA. Generally TEA has a less noticeable odour than DMEA. DMEA has a higher vapour pressure than TEA and is thus more easily vaporized in bulk generator systems. Various designs of generators are used to vaporize and blend these amines with inert carrier gases and deliver them to the core blowing machine. The best designs provide a consistent high concentration of catalyst to facilitate fast, predictable cure cycles. Typically, about 7 pounds of carrier gas will transport 1 pound of catalyst. Catalyst usage and cure rate depend largely on how efficiently the tooling is vented and on the geometry of the core or mould itself. In practice the use of about 1 to 2 pounds of catalyst per ton of mixed sand is the goal. Heated catalyst gas and air purge can reduce cycle times and decrease catalyst usage. Insulating and heat tracing the catalyst delivery lines between the generator and the pattern to give a 25°F step-up in temperature ensures optimum catalyst use and prevents catalyst vapours from condensing back to the liquid phase.

The exhaust from the corebox should be conveyed to a chemical scrubber where the excess catalyst is removed by reaction with a dilute acid, typically sulphuric, to form the equivalent sulphate salt. Depending on the volumes of scrubbed liquor. The catalyst is capable of being reclaimed.

Sand additives may be used in this process to correct casting defects. For example, veining in both ferrous and brass castings can be substantially reduced by the addition of 1 to 2% of proprietary clay/sugar blends or 1 to 3% of Iron Oxide.

Because of the high carbon content and the reducing mould atmosphere, soot or lustrous carbon developed during the binder decomposition will provide an excellent casting surface, although in excess it can cause surface wrinkles or other casting defects commonly known as lustrous carbon defects. Lustrous carbon can be controlled by lowering the resin content, increasing pouring temperature, reducing pouring time improving core and mould venting and using Iron Oxides at 1 to 3% to generate a richer oxidizing atmosphere in the cavity. Black or red iron oxide additions of 2 to 3% are recommended for steel castings Red iron oxide at levels as low as 0.25% can be effective in eliminating binder induced subsurface pinhole porosity in alloys prone to these defects. Care should be taken to study these additives in the specific foundry application, as they can negatively affect tensile strength/bench-life relationships.

Cores and moulds prepared with this process can be coated with all usual types of refractory coatings. Water based coatings should be applied as soon after moulding as possible, then dried immediately in a well exhausted oven that will minimize steam effects on the coating. Alcohol based coatings should preferably be applied after the cores or moulds have cured for at least 10 minutes. Usually, non water based coatings will increase ultimate binder

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strength, whereas water based systems will cause a loss of strength, worsening as the time between moulding and coating increases.

Used sand from the process is easily reclaimable, with the cold box system clearly being superior to other popular binders in the proportion of core removed as a function of vibration time. Sands from the cold box system are compatible with reclaimed sand from many other chemically bonded sand systems, with the exception of silicates, shell and ester-cured phenolics because of the alkaline nature of their reclaim which can drastically shorten cold box mix life time.

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