

# Carsten Systems and Machine



Carsten Systems and Machine (CSM) located in Powell River, British Columbia, Canada (approximately 100 miles north of Vancouver) designs and builds tape casting systems and furnaces/kilns mainly for electronics applications. The employees of CSM have an accumulate 40 years of experience in the construction and production of tape casting systems. These systems are used for the following applications such as MLCC, piezoelectric components, electro-ceramic dielectric substrates, batteries, ferrites, SOFC, MCFC fuel cells, and LTCC manufacture. Typically these systems are built to customer specifications although standard modules are used whenever possible. These machines have an extraordinarily rugged design resulting in high reliability and excellent long-term stability.



# Tape Casting Systems



Tape casting systems are built in any length from approx. 7 m up to 30 m (20ft.-90ft.) in length. The drying oven consists of modules with a length of 1.8 to 2.4 m (6ft.-8ft.) which can be heated - depending on the customer's requirements - from above and/or underneath the belt as well as with heated air. Belts are supplied in standard widths ranging from 10"– 42" (25cm-106cm). The slurry is cast directly on the steel belt or on a PET (Mylar) film.

All systems shipped to Europe are EMC and CE certified. These tape-casting systems fulfill the safety requirements of NFPA-86.

All gauges and controls are in either English or metric measures depending on their destination and the customer's choice.

Please be aware that the items in the following description are in some cases either optional or customer specific. Most of the shown and listed features are only some typical examples and may be different for the actual customer requirements.

# Construction

The frame is a welded square tube construction. Lower recessed panels are provided for access to the electrical wiring and mechanical components. Efficient removal of solvent volatiles is done by baffled exhaust ducts, one for each zone through the oven floor. The ducts are “teed” together into a single outlet that is blower assisted for connection to the factory exhaust system.

The major zones of the oven are provided with hinged side doors containing double paned windows 60 inches (152cm) wide x 9 inches (23cm) high. The inner pane is of tempered glass and the outer of laminated safety glass. The hinged upper lids and side doors are equipped with blast relief safety latches as per NFPA-86 recommendations.

All metal surfaces are coated with polyurethane industrial finish in two-tone colors.



## Doors and Lids

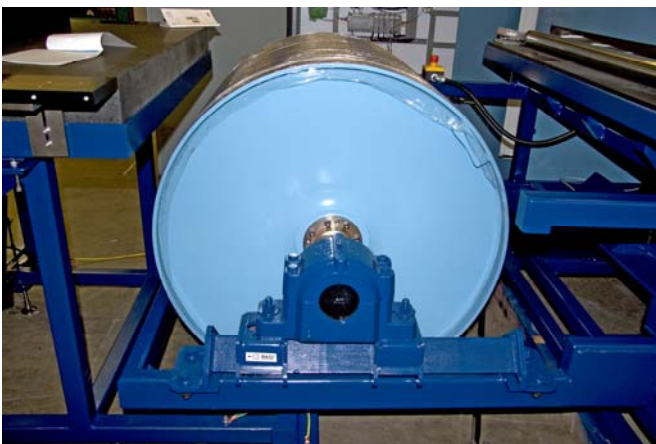
The hinged upper lids on the top of the system can be lifted upwards for maintenance. The major zones of the oven can be provided with optional hinged side doors containing double paned windows 60 inches (152cm) wide x 9 inches (23cm) high. The inner pane is of tempered glass and the outer of laminated safety glass. The hinged upper lids and side doors are equipped with blast relief safety latches as per NFPA-86 recommendations.



# Drive and Belt

The stainless steel belt with a width between 10” and 42” (25cm-106cm) wide is driven by a pre-tensioned pulley on which the belt centers itself. The belt is welded, ground and polished into an endless loop. Removable roof and lower frame components are provided for easy removal and replacement of a new belt if and when necessary.

The conveyor drive consists of a three-phase gear motor that is controlled by a variable frequency inverter supplied with a digitally read tachometer. The belt speed will be 1-9 ft/minute (30-275cm/min.) with an accuracy of 1%. The speed can range from a few cm per minute up to several meters per minute and can be changed by making changes on the frequency converter or by using a different ratio in the gearbox.



# Mylar-System

An alternative to casting on the steel belt can also be accomplished on a PET carrier like Mylar film or other materials. This system consists of an unwind frame and a rewind frame located at opposite ends of the casting machine. The rewind unit is prepared to accept coils with an inner diameter of 3"-6" (please specify). Gear motor driven magnetic particle clutches maintain proper Mylar web tension.

An ultrasonic sensor measures the increasing diameter of the rewind spool synchronizing the speed of the rewind spool with the conveyor drive pulley. Anti-static bars are also provided at both ends of the Mylar system.

The system is supplied with a cover for the Mylar film to guarantee an enriched atmosphere. The whole unit is not covered, only the belt between the doctor blade and the drying section is covered. The doctor blade and the gauges always remain accessible. This cover is made from stainless steel.

In conjunction with the Mylar film, casting is usually done on a granite plate that gives a solid support to the casting surface area.



# Slurry Reservoir and Stirrer

The slurry reservoir consists of a pressurized tank available in different volumes and is equipped with a pressure gauge and a regulator. With small machines the volume can be in the 2-2.5 gals (7.5-10 Liters) range. The stirrer with a variable speed consists of a magnetic mixer moving a Teflon coated ball (egg) in the slurry.

Larger systems come with a slurry container of 15 gals (60 Liters) or more. Some tanks can use “disposable Tank-Liners“. These are rigid polyethylene inserts making the cleaning much easier and convenient. These inserts fit exactly into the pressure tank. Therefore the inside of the stainless steel tank remains clean during operation. After tape casting the tank liners are removed and a new liner - e.g. with a different slurry formulation – can be used. This means production can go on without losing cleaning time. Meanwhile the used tank liner can be cleaned. The material is antistatic and therefore minimizes the electro-static charge caused by friction.

The mixer consists of an air pressure driven agitator and has two pressure gauges and two regulators.

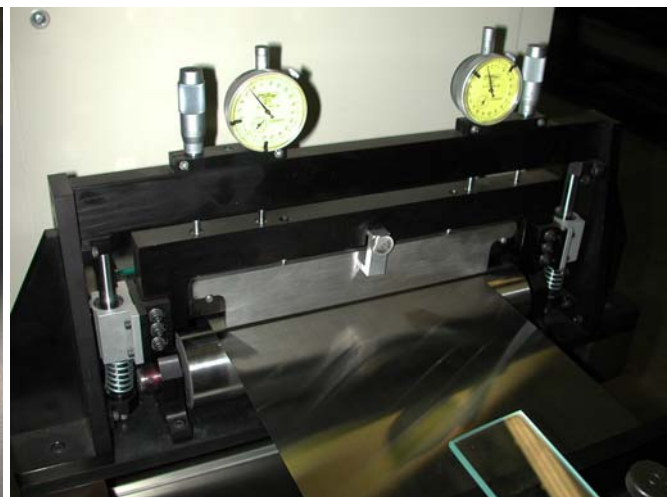
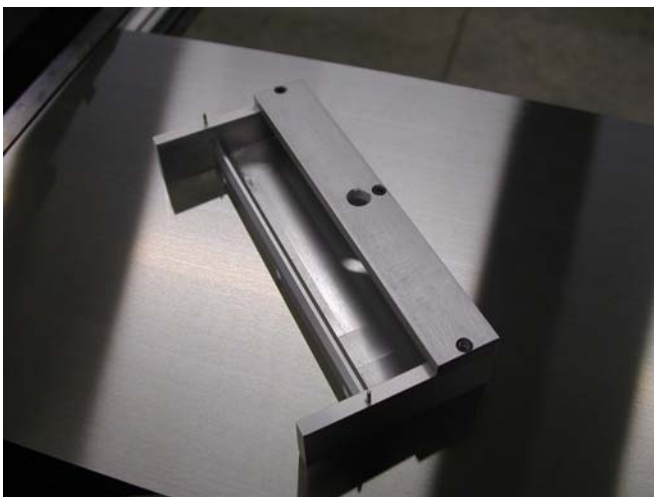


# Casting Head and Doctor-Blade

This unit is either placed before the entrance of the dryer or on the upper part of the Mylar unwind frame if it is supplied with a granite surface plate. Double doctor blades are provided. The blades are made from austenitic stainless steel or fused quartz. The doctor blades are adjusted with two micrometer handles for precise thickness adjustment and dial indicators to an accuracy of 0.0001" (2.54microns).

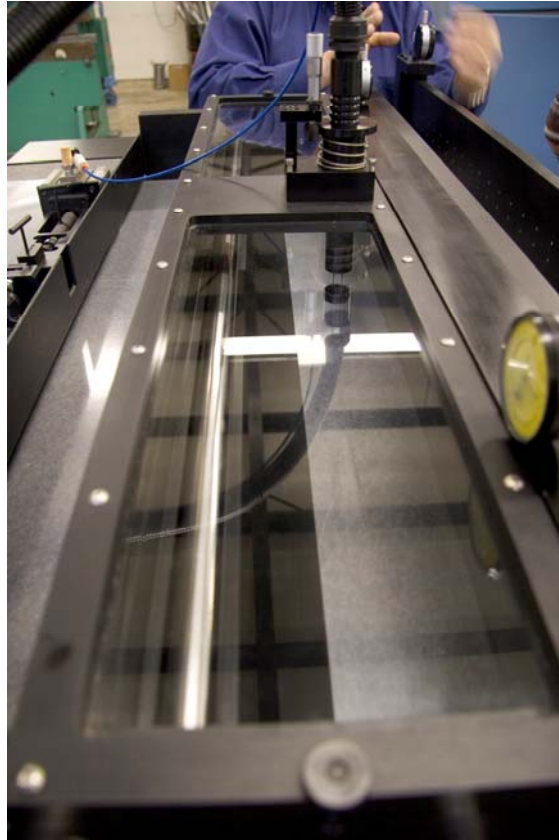
The casting head consists of a reservoir with uniform flow and level control. The casting head is covered by glass to ensure an enriched atmosphere.

In very wide casting systems the second doctor-blade is made from fused quartz for dimensional precision and stability. In all cases a flow control valve distributes the slurry equally over the whole width of the slurry box.



# Automatic Slurry Level Control

The automatic slurry level control uses a sensor (closed loop regulation) that detects the height of the slurry in the reservoir of the slurry box. The generated signal controls a proportional valve in the slurry feed from the slurry container to the slurry box for an accurate, continuous height control.



# Drying

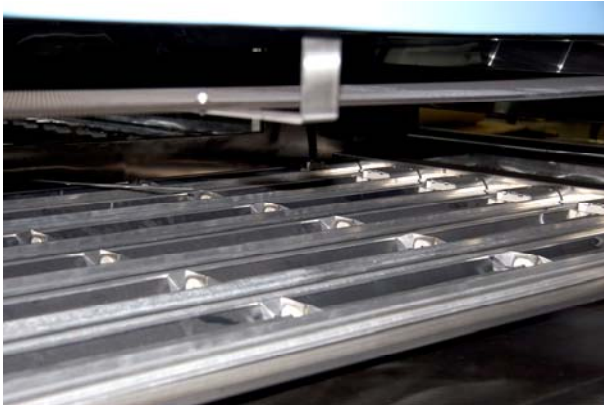
The oven chamber is divided into equal 6-foot long zones, each heated from beneath and over the belt by I.R. reflective heater assemblies. In addition, each of the zones has a forced heated air assembly that directs the flow of heated air contra the direction of the conveyor belt. Power control to the heater assemblies is by solid state contactors with time proportioning on/off control, and the thermocouples are type “J”.

Each of the major zones is provided with high limit over-temperature protection.

For a uniform temperature distribution over the whole belt width there are baffles between the upper IR-heaters and the belt.

The heated air can be adjusted for temperature and the amount of air flow. Air switches are provided in order to automatically shut off power to the heaters, the drive belt, and the slurry supply if the air flow is interrupted. This safety mechanism avoids a high solvent concentration and potential damage to the system.

As flatness and support of the belt is critical in zone 1, larger systems have additional rollers under the belt in the first zone as well as a glass cover just above the belt to maintain the enriched atmosphere. Usually no IR-heaters (either from above or from underneath) or forced air are needed in the first zone.



IR-Heaters



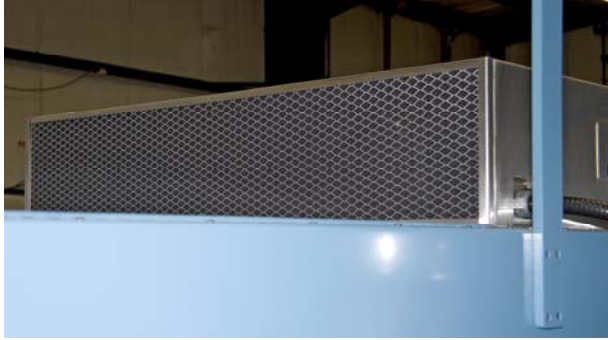
Baffle for uniform temperature distribution



Rollers to support belt



Glass cover for enriched atmosphere



Intake for heated air flow



Pressure gauge for airflow

# Exhaust

Each zone uses baffles below the belt and a center opening which leads to the exhaust duct. Because solvents are heavier than air they fall directly into the exhaust duct. The exhaust duct under each zone has a damper to regulate the exhaust flow individually for each zone.

The exhaust ducts of each drying zone are connected together in the lower part of the system and lead to a blower supported common exhaust that is designed to be connected to the customer's factory exhaust system. The blowers are equipped with air flow switches which turn off the drive belt, heaters and slurry feed if the air flow is interrupted.

An exhaust over the belt, as is often used in competitor's machines, would only disturb the air flow in the drying oven and interfere with proper process control.



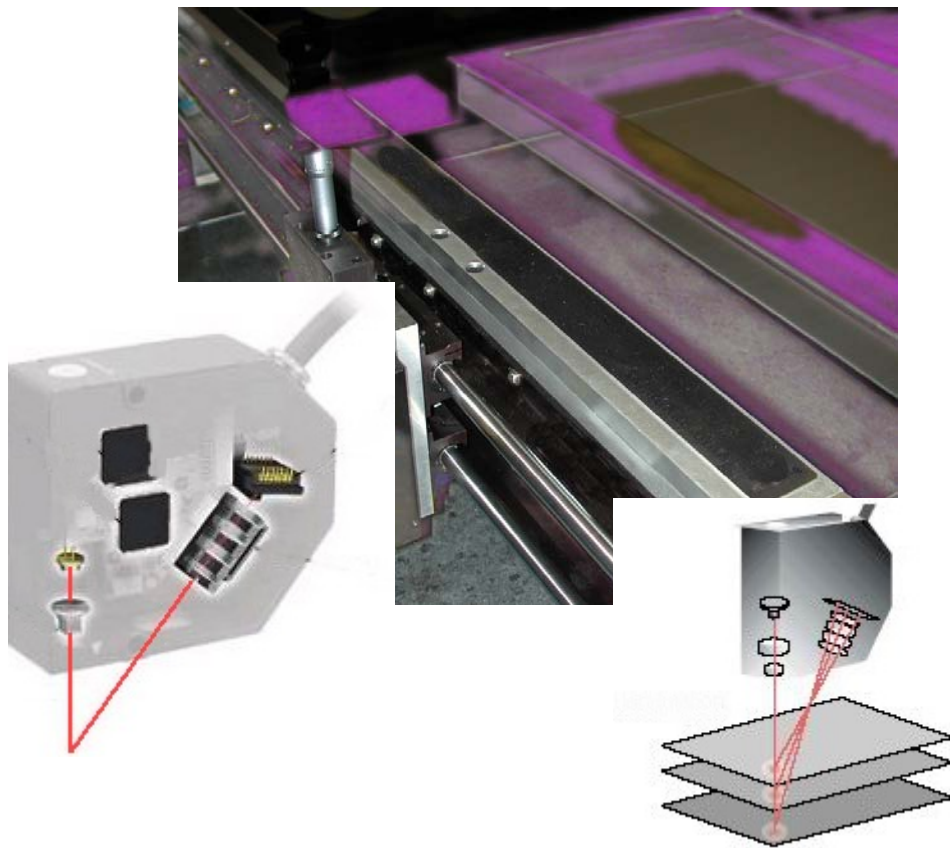
# Laser Thickness Measurement

The laser thickness measurement system is available as an option. The laser head will be mounted onto a precision ball bearing slide mechanism which is attached to a machined aluminum bridge frame which is mounted to the casting machine frame with travel over the belt carrying the tape.

Thickness can be measured either on wet tape, e.g. just after the casting head, or on dry tape at the end of the drying section. This system is universal and works not only on different colors, but also on light and on dark tape.

Wet and dry thickness measurement  $< 0.5$  microns.

When used for slurry level control it regulates the slurry level within 4 microns.

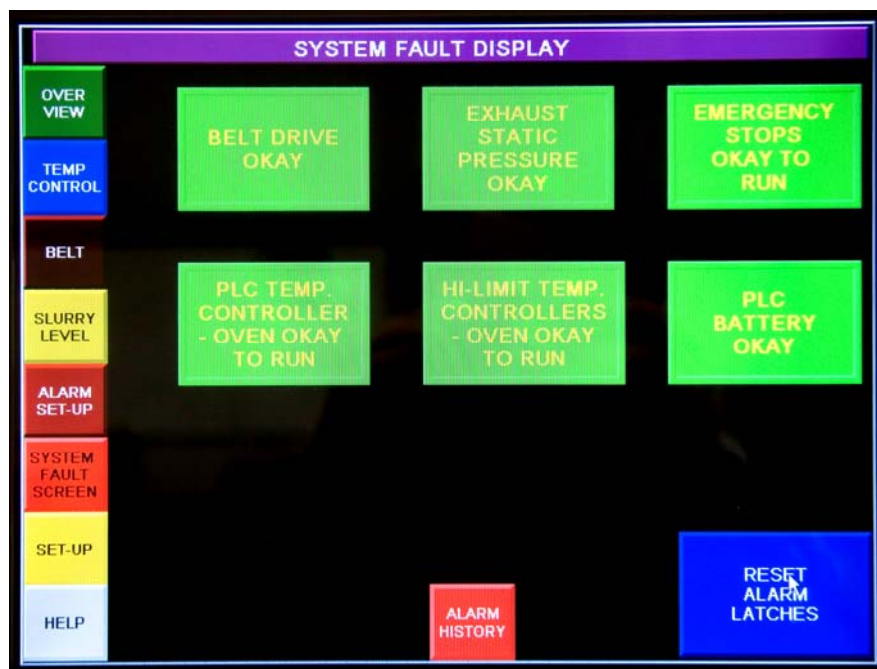


# System Control

Depending on the chosen option, the tape casting system can either be controlled by individual Eurotherm controllers (Closed Loop) or by an Allen-Bradley SLC 5/04 PLC controller which uses a processor, I/O-Chassis, each with power supply and interconnecting cables, digital input and output cards, analog input and output cards, and thermocouple input software retention. The SLC 5/04 will also be configured to control the conveyor belt speed.

In the basic version about 50 different programs can be stored. The controller can be extended by hardware and software in a way that more programs can be stored.

The PLC controller uses a touch screen and can display either metric or English units.



# Data Logging

A Pentium PC with Rockwell-RS-View software enables complete data logging. It communicates via E-Net (Ethernet) with the Allen-Bradley SLC 5/04 PLC controller.

The PC-software (Rockwell RS-View) is configured so that temperature profiles, temperature offsets (alarms), drive belt speed, slurry level height and optional thickness measurement when available, can be displayed. A password-protected version will be supplied, so that data and adjustments cannot be changed by unauthorized personal.

# Safety

All systems are built according to the known norms and safety standards. All systems for Europe are built to the current European norms and requirements and are EMC and CE certified. The tape casting systems from Carsten System and Machine meet all applicable safety and hazard laws.

## Emergency Off

Emergency off buttons are located at both ends of the system. Larger systems have an additional cord over the full length of the drying chamber that is coupled with the Emergency Off system as well.



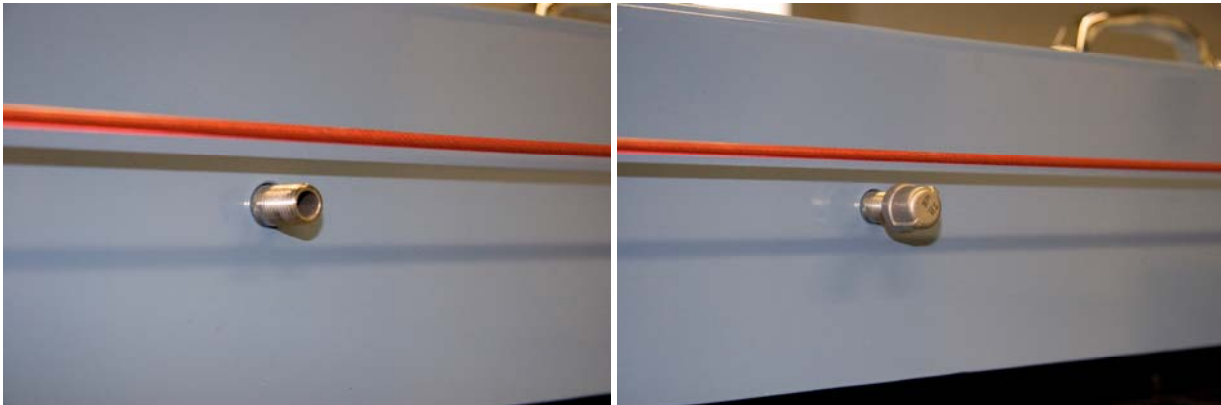
## Over Pressure

Lids and doors (windows) are equipped with 'Safety Blast Relief' latches. In case of an over pressure in the drying section the lids and doors open automatically. The latches are adjustable and are factory adjusted to an opening force of approximately 15 lbs (7kg).



### **Sampling Ports for solvent vapour concentration**

The side walls of the drying section have fittings with removable caps through which a sensor to measure solvent vapour concentration can be introduced during operation to spot check solvent vapour concentration.



### **Explosion Protection**

- All systems for Europe fulfill the CE and EMC certifying standards and address explosion protection by means of an operation setting at 12.5 –25% of the lower explosive limit (L.E.L.).
- Prior to starting the casting operation when the caster is initially turned on, the fans in the heated air assemblies and the exhaust duct will operate for 3 minutes in order to purge the oven and duct system of any volatiles prior to turning on the heaters.
- At the end of operation when the system is shut down, the fans will run for five minutes to exhaust remaining solvents.
- Air flow switches are provided at all fan and blower locations. In the event of a loss or interruption of air flow, the heaters, slurry feed, and conveyor belt are automatically shut off and an audible alarm sounds.
- The same procedure is followed in the event of an over-temperature event.