THERMAL SHOCK

"Thermal Shock" is a term often used to define a type of boiler failure. The analogy often given is that of a heated glass cracking when filled with ice cubes. This is not what is happening in boiler failures of this type. Steel is a material that is very resistant to the type of temperature extremes present in boilers. During the welding process the steel experiences temperatures greater than 2000 °F. Additionally, every time the burner fires the pressure vessel material is subjected to temperature extremes. These "thermal shock" failures are caused by return water that is below 140 °F. If the return water is 140 °F failure will not occur but if it is at 120 °F failure will occur. This small change in temperature will not cause thermal shock.

The real cause of this type of failure is flue gas condensation. When fuel is burned water is a primary combustion product. Normally this water is in vapour form due to high temperature inside the appliance and the vent. However when return water is below 140 °F it can chill the flue gasses enough for condensation to occur. There is sulphur in the fuel and when this combines with the water sulphuric acid is formed. The sulphuric acid attacks the steel. This attack is enhanced when mechanical stress is present. Therefore the most likely location for failure is an area where condensation is occurring and where the stress is the highest.

Condensation will occur in all boiler systems at certain times. When the system first starts condensation will occur in the boiler since it is not up to temperature. With low thermal mass systems the temperature quickly rises above the dew point and

there is not a problem. A radiant slab goes through a “cold start” at the beginning of each cooling / heating cycle at the beginning of the heating season or after thermostat set back. Additionally the slab can cool to room temperature due to solar gain or other sources of heat. Zones such as the garage or basement that will occasionally be raised several degrees will cause a “cold start”.

It is extremely important to maintain the return water temperature above 140 °F.

Cast-iron, steel and even copper heat exchangers can be severely damaged in a short period of time if exposed to **sustained condensation.** Systems used to have low thermal mass, were equipped with tankless coils and were over-sized. Today we have high mass/low temperature systems operating with low mass boilers. Flue gas condensation causes scale formation and aggressive corrosion.

To prevent “thermal shock” failures keep the boiler operating above the dew point of the flue gasses. If the system heat emitters can extract heat faster than the boiler can generate it, the water temperature in the entire system will lower. Start up of a radiant slab is an excellent example of this. **Active** mixing controls must be used to solve this problem. Controls must sense the return temperature and modulate flow to maintain the return temperature above the dew point. If there is no return temperature sensing, there is **no** boiler protection. Manual four-way valve do not assure boiler protection. A bypass pump between supply and return cannot assure boiler protection.

Most residential systems are not at risk of “thermal shock” if it is properly designed.