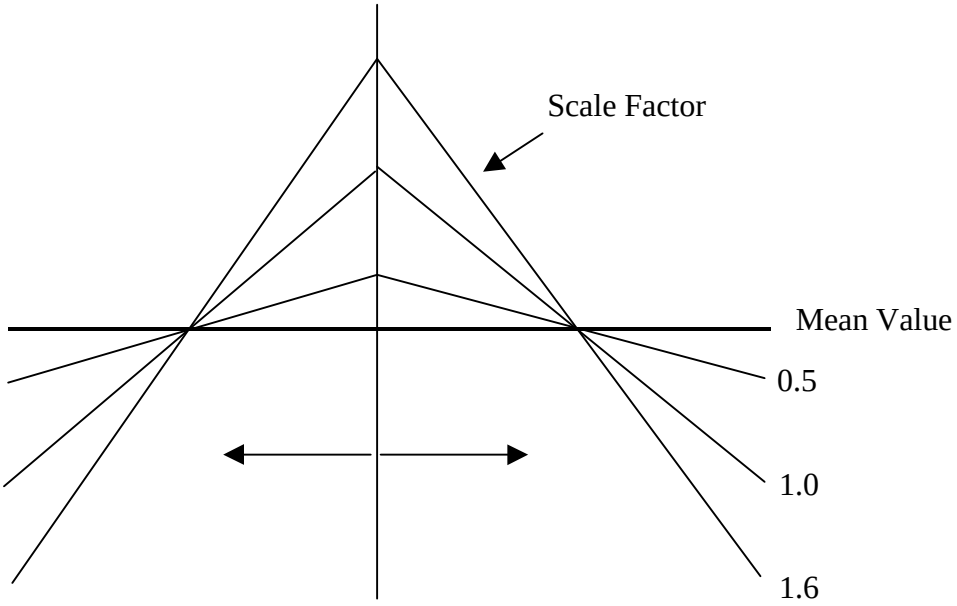
TMS 2000 - Theory of Operation

This is a brief discussion of the theory behind the TMS 2000 Isothermal mapping algorithm. It will provide the reader with a fundamental understanding of how TMS 2000 generates Isothermal surface maps from a given set of average path temperatures. In addition it addresses mapping accuracy and limitations.

The Isothermal Mapping Program begins with a known set of average temperatures that are received from the Processor Control Unit (PCU). The PCU obtains these temperatures from a series of path measurements that cross a planar section of a boiler or furnace. The process of selecting and configuring these paths is described in the Boilerwatch MMP Technical Manual.

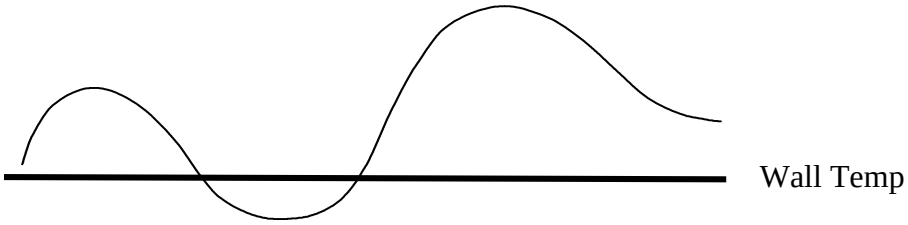
It is initially assumed that each path has a bi-linear profile (i.e. two lines meet to form a peak similar to the cross section of a pup tent). Thus the maximum temperature would be at the peak and the minimum (wall) temperatures at either end. The distance from the transmit end point to the point at which the peak is located is determined by the midpoint scale. The midpoint scale is set to 50% of the path length by default. The end points are assumed to be constant and are held at a constant level by the program algorithm relative to a Wall Temperature variable. The Wall Temperature variable may be set to one of three values: 1) A user selectable fixed value. 2) A percentage of the average path temperature. 3) A percentage of the minimum path temperature. The estimated path profile is calculated based on a Bi-linear integration from the Transmit point (Wall Temperature) up to the Mid-Point (Measured Path Temperature * Iteratively Computed Scale Factor) and back down to the Receive point (Wall Temperature). Initially, the scale factor is set to the value of two times the average path temperature.

Bi Linear Temperature Distribution



Mid-Point Scale

The estimated path profile is next plotted into a two dimensional grid representing the planar area of the boiler or furnace. This process is repeated for each path. When all temperatures have been plotted onto the grid, it will contain a sparse matrix (i.e. there are missing points on the grid between paths). The Bezier function is then used to transform the set of known points into a polynomial approximation of the actual temperature curve at discrete points on the grid. After the grid is smoothed, line integrations are performed along line paths and compared to measured data. The result of this comparison is used to adjust the scale factor for the next iteration to minimize the error between measured and estimated temperatures.



Bezier Curve Fit

This iterative process may be repeated between 3 and 20 times to produce a surface with the least error when compared to the original measured average path temperatures. Although there is no specification for absolute error or accuracy of the generated Isothermal map, an Average Path Error value is calculated to provide a confidence factor for any given map. The Average Path Error will range from 0 to 10% for a typical system in normal operation.

Several factors can affect the accuracy of an Isothermal map. The most significant is the physical configuration of the mapping plane, and the number and placement of acoustic transceivers. If an adequate number acoustic paths is not provided, The accuracy of the generated map may be suspect. TMS-2000 has a built-in Simulator to test TMS 2000's ability to accurately generate a known gaussian surface based on any desired geometry and path configuration. In addition the user may create a user-defined surface, and conduct the same tests. Configurations where acoustic transceivers cannot be placed on all four walls should be avoided. Another factor that can affect mapping accuracy is the actual acoustic performance of the Boilerwatch MMP system. If acoustic paths are erratic due to excessive soot-blowing noise, steam tube leaks, or thermal sheering due to flame impingement, accuracy of the maps generated by TMS 2000 will be reduced.

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