Calibration Concepts

A computer model is mostly ineffective until it is calibrated. This is due to the fact that even though the engineer may have gone to great lengths of ensuring data accuracy, there will still exist subtle nuances in the distribution system that have gone undetected. Such nuances may consist of partially shut or closed valves, incorrect data on pumps and system valves (PRV's, etc.), or erroneous GIS data that was used in the model creation. None of these items will be discovered until the model has been through a series of calibration runs that effectively match what is occurring on the computer to what is occurring in the system. Depending on the system, a correlation of 5% to 10% between field data and simulation results is desired.

Ultimately, a calibrated model creates confidence by allowing the engineer to predict, with some level of certainty, how the system will react to operational changes. Such changes may include the addition of a pumping station, a new pressure zone, a new tank or the replacement of a well. Without a calibrated model, system modifications and the subsequent results generated from the hydraulic model will contain a variable degree of uncertainty.

Fire Flow Testing

One of the ways to calibrate a model is through a series of fire hydrant tests that measure flow and residual pressure at a hydrant. In addition to these flow tests, pressure recording devices will also need to be strategically placed in the system to record pressure changes during the fire flow test. The size and configuration of the water distribution system network will determine the number and location of fire flow tests.

The key in selecting fire test hydrants is to strategically identify those areas of the system that will "tell the story" of system operation. The figure below demonstrates the concept of hydrant selection and fire-flow testing. As depicted in this figure, the location of hydrant tests was determined by identifying source locations and testing those hydrants furthest from the source. The reason for selecting distant hydrants is to maximize headloss across the system. Logically, it is of little use to test a hydrant right down the street from a tank or well. In such a situation, headloss is minimal and will not provide useful data for the entire system. It should be noted that minor (local) losses due to bends, meters and fittings are generally neglected for municipal applications since the friction headloss in the pipes are generally much larger than the local losses.

For calibration, it is necessary to have a full complement of system data while a fire flow test is occurring. This would include all available SCADA and circle charts for booster stations, tanks, and pumps. Encapsulated with this data would be the types and number of pumps operating, the levels and flow rates of tanks, and spot pressures across the system. In the course of model calibration, there is no such thing as too much information. Unfortunately, with regards to data required for model calibration, the opposite condition of too little information is usually the case. It is for this reason that the engineer will need to document those facilities for which SCADA (Supervisory Control And Data Acquisition) and other system data is not available and prepare a contingency plan. This plan would usually consist of installing temporary gauges and meters or sending an individual to a water tank to measure tank levels at set time intervals. It cannot be stressed enough that if a portion of a water system is critical to model calibration, then data must be acquired via the necessary means.

Performing the Calibration

When calibrating a hydraulic model, it is important to select a day during the year that experiences high water demand (stressed condition). By reviewing historical water consumption records, the engineer is able to select a day in which water production has been above average (usually a summer day). Once a day has been identified and scheduled, the engineer will need to work with the Operations department in order to gather the resources (equipment, personnel, etc.) necessary for fire flow testing and recording system pressures. Prior to calibration day, the engineer must ensure that all relevant field devices are being recorded and that good data is available. After the calibration day, the engineer will once again need to work with those involved to accumulate all of the relevant information and begin the compilation process.

Adjusting Parameters

With the completion of the test day and the accumulation of system data, the next step is to correlate the hydraulic model with the results generated from the field. However, prior to changing any model parameters, the engineer should use due diligence in reviewing the test data against the hydraulic model. In this review, the engineer is specifically looking for distinct discrepancies that would be the direct result from operational issues, unknown to the engineer. Again, these issues may consist of closed valves, incorrect pump curves, incorrect valve settings, and logical control settings. Other issues may arise from input error by the engineer. These would consist of incorrect pipe diameters, node elevations, system demands, etc. The goal of the cursory check is to ensure data integrity prior to model calibration.

Once the cursory check has been completed and the model data fairly resembles the results from the hydraulic model, the last step is to adjust pipe roughness coefficients to bring the model results in line with the field results. With the Calibrator, you can also adjust nodal demands and pipe status for a steady state simulation. Such optimization tools can significantly reduce the amount of time required for system calibration and the cost for acquiring such a program like the Calibrator pays for itself.

Model accuracy can be greatly improved by calibrating for multiple loading conditions. In addition to a stressed condition, the network model should be calibrated under average and slack demand conditions. The latter is normally used to check for HGL accuracy to ensure proper node elevation data. Using SCADA data, the model can be further refined using an Extended Period Simulation (EPS) run to check for proper dynamic operations such as accurate tank water levels.