
Testing Evaporators

Performance testing is a means to enable understanding of an evaporator system. Tests permit detection of unsatisfactory performance and often indicate methods to improve operation. Performance tests may also be required to establish that a new evaporator system has met performance guaranteed by the supplier. Tests may also serve to plan for maintenance or cleaning. Tests may be used to determine evaporator capacity under different operating conditions or to obtain data for designing a new evaporator system. Tests may also be necessary to establish base performance for evaluation of possible upgrading methods. The American Institute of Chemical Engineers has published a procedure entitled "AIChE Equipment Testing Procedure: Evaporators". This procedure covers methods for such performance tests and discusses several factors influencing performance and accuracy of test results.

Tests are conducted to determine capacity, heat transfer rates, steam economy, product losses, and cleaning cycles. Practically all the criteria of evaporator performance are obtained from differences between test measurements. Errors can result when measuring flow rates, temperatures and pressures, concentrations, and steam quality. Factors which can have a great effect on performance include: dilution, vent losses, heat losses, and physical properties of fluids.

PLANNING THE TEST

In setting up any performance test, the following principal steps should be taken:

- (1) establish the test objectives
- (2) plan the test and the test data log
- (3) check all instruments and measurement methods

- (4) check for leaks
- (5) take all steps necessary to ensure smooth operation, especially during the tests
- (6) conduct a preliminary test and evaluate the results to spot any possible discrepancies
- (7) select data for evaluation from a period of smooth and steady operation.

It is of great advantage that the person who will analyze plant data participate in the test program. Many factors should be evaluated during the test to determine the validity of the test data. Evaporator tests can be costly, especially if the data obtained are not sufficient to meet the test objectives. Adequate test personnel must be available to gather all necessary data over a relatively short period. Testing a sextuple-effect evaporator can require several hours for one data set at one operating point.

Diagnosis of plant data depends heavily upon actual physical inspection of the equipment, checking on conditions not apparent from any panel board or instrument readings. Included are:

- (1) vent temperatures (may be measured in some cases)
- (2) complete removal of condensate from heating elements
- (3) pump speeds and degree of wear
- (4) presence of scale on the inside or outside of tubes
- (5) obstructed circulating piping
- (6) obstructions in separator or vapor piping.

The test team must be completely familiar with the evaporator system. Flow sheets and instrument diagrams must be understood. Physical location of measuring devices must be known and evaluated.

Accuracy of the data required must be established. Errors in the interpretation of results may arise either from errors of measurement or from factors that are not normally subject to measurement. The effect of these errors depends to a large extent on the intended use of the test results. If test data are used to predict performance of the same evaporator under slightly different conditions, most of the normal errors are self-compensating. If test data for one effect of an evaporator are to be used in the design of a new evaporator, even minor errors can be of great importance. Accurate data is necessary when comparing actual performance to that expected.

CAUSES OF POOR PERFORMANCE

Evaporator system problems usually are evidenced by one or all of the following symptoms:

- (1) reduced evaporator capacity

- (2) reduced steam economy
- (3) loss of product
- (4) frequent cleaning cycles.

Frequent causes of poor performance of an evaporator system include the following:

- (1) low steam economy
- (2) low rates of heat transfer
- (3) excessive entrainment
- (4) short cleaning cycles.

Low Steam Economy

Steam economy with a fixed feed arrangement can be calculated from heat and material balances. Steam economies lower than that calculated during the design of the unit may be the result of one or more of the following:

- (1) leakage of pump gland seal water
- (2) excessive rinsing
- (3) excessive venting
- (4) flooded barometric condensers
- (5) dilution from condensate leakage
- (6) steam leakage
- (7) leaking across supposedly closed or sealed valves.

Low Rates of Heat Transfer

Poor heat transfer may occur for the following reasons:

- (1) salted, scaled, or fouled surfaces (both process and steam side)
- (2) inadequate venting
- (3) condensate flooding
- (4) inadequate circulation
- (5) inadequate liquid distribution
- (6) temperature differences that are too high or too low

Excessive Entrainment

Product losses through excessive entrainment may result from:

- (1) air leakage (especially below liquid surface)
- (2) excessive flashing
- (3) sudden pressure changes

- (4) inadequate liquid levels
- (5) inadequate pressure levels
- (6) operation at increased capacity
- (7) plugged drains

Short Cleaning Cycles

Downtime required for cleaning may not agree with the expected frequency of cleaning. Short cleaning cycles may be caused by:

- (1) sudden changes in operating conditions (such as pressure or liquid levels)
- (2) improper liquid level control
- (3) low velocities
- (4) introduction of hard water or other foulants during cleaning, rinsing, or from seal leaks
- (5) high temperature differences
- (6) improper cleaning procedures.