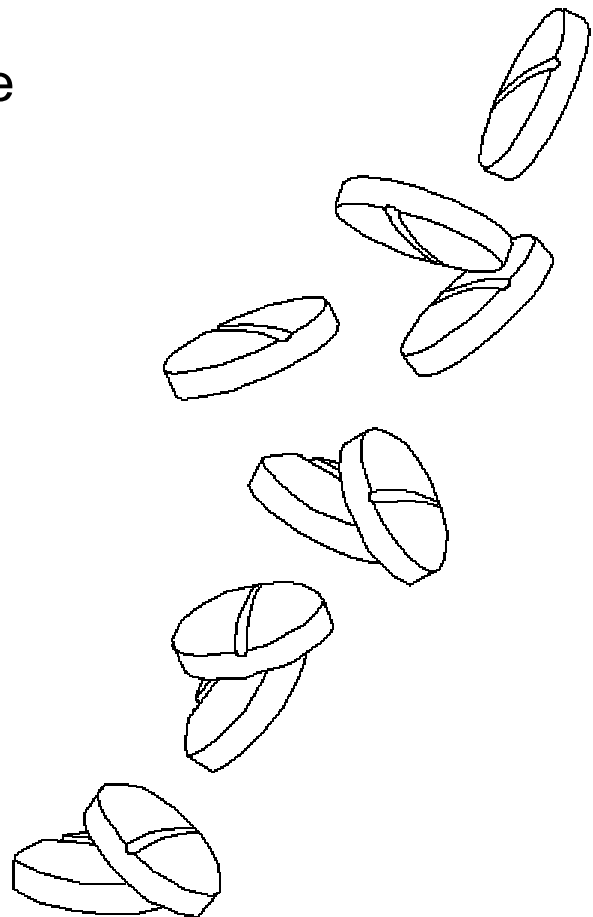


Thermodynamic Analysis of Aqueous Film Coating

Program User's Guide
Windows Version 1.0.0
SFW 01001W01



**THOMAS
ENGINEERING
INC.** 575 W. CENTRAL RD. HOFFMAN ESTATES IL 60195

INTRODUCTION

WHAT IS TAAC?

TAAC (pronounced 'tack') is an acronym for **T**hermodynamic **A**nalysis of **A**queous **C**oating. As its name implies, the model utilizes thermodynamic heat and mass transfer equations to accurately characterize the environmental conditions inside a coating pan during a steady state film coating process.

The purpose of TAAC is twofold. First, it allows a user to investigate the interrelationships between process variables. For example, the model can be used to determine how a change in spray rate will affect the exhaust air temperature. Second, TAAC provides the user with a measure of film drying rate which, once calculated for a given set of conditions, can be used to reproduce a desired quality under an entirely different set of conditions. It is the second feature of TAAC which is generally of greater interest to the user since it makes parameter variation studies and optimization possible.

A more detailed discussion of drying rate equivalency appears in the **DATA OUTPUT** section of this manual. A complete reprint of the *Pharmaceutical Technology* magazine article featuring the full mathematical and thermodynamic development of the model can be obtained by contacting Thomas Engineering's marketing department (see Help, About TAAC in program).

INSTALLING TAAC

This version of the TAAC program will run on IBM® and compatible computer systems with Microsoft Windows® 95, 98, or NT operating systems and 256 color, 800 x 600 screen resolution minimum.

INSTALLATION: CD ROM

1. Install the CD in your CD ROM drive.
2. Click on the Microsoft® **Start** button. Select **Run...** and click.
3. In the pop up dialog, enter the letter designation for your CD drive followed by **:\setup.exe** as the filename to open.
4. Click on the OK button and follow the prompts to complete installation.

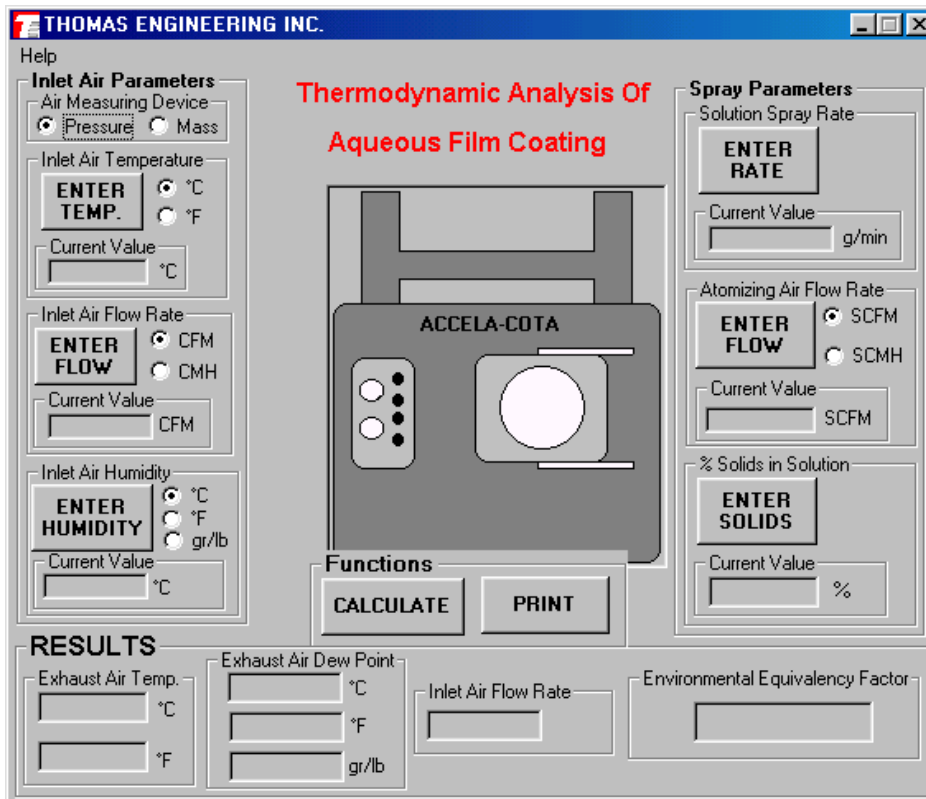
INSTALLATION : E-MAIL OR THE WEB

1. Unzip the three files (**setup.exe**, **setup.lst**, and **taac32.cab**) from **SFW01001W01.zip** to a folder on your hard drive.
3. Click on the Microsoft® **Start** button. Select **R**un... and click.
3. In the pop up dialog, enter the letter designation for your hard drive followed by **:\folder\setup.exe** where **folder** is the folder where the unzipped files are stored.
4. Click on the OK button and follow the prompts to complete installation.

RUNNING TAAC

To run the TAAC program, click on the Microsoft® **Start** menu box , select in turn, **Programs, TAAC Windows 32-bit, TEI TAAC Windows 32-bit**. The TAAC screen shown below will appear in the upper left corner of your monitor.

To move the TAAC screen to another area of your monitor, move the mouse cursor to the blue bar at the top of the screen. Hold the left mouse button in and drag the screen to the desired location.



HELP/ ABOUT TAAC

To contact Thomas Engineering for more information about TAAC, click on the Help, About TAAC button in the upper left corner of the TAAC screen. To remove the Thomas Engineering dialog box that appears, hit the **Esc** key on your keyboard.

DATA ENTRY

Along the left and right sides of the coating pan dialog are boxes labeled with user input parameters. Each box contains a button for entering parameter data and two or three option buttons for specifying the units to be used with each parameter value.

The **CALCULATE** button along the bottom edge of the coating pan is used to start program execution once all process parameters have been entered and the **PRINT** button is used to get a hard copy of the program results.

Values for the exhaust air conditions and the Environmental Equivalency (EE) factor are displayed in the **RESULTS** section at the bottom of the dialog.

Each button has a tool tip which appears when the cursor is moved onto the button. The tool tip indicates what action will occur if the button is selected.

To enter data, click on any of the individual parameter buttons and enter the desired value for the process variable in the pop up display. Units for each parameter are selected by clicking on the circular shaped option buttons next to the desired units. A solid dot indicates the units currently in effect.

For convenience, a default set of the most commonly used units are loaded at startup. You need only change them if other units are desired. Units may be set before or after parameter values are entered and only take affect after the **CALCULATE** button is pressed.

A description of each process parameter for which data must be entered and the allowable units for that parameter appear below. You should note that some parameters have minimum or maximum valid values. These limitations are imposed to prevent program execution errors (i.e. division by zero) from occurring.

Air Measuring Device

In order for the model to accurately calculate the mass of air entering the coating pan, it is necessary to specify the type of measuring device used to obtain air flow readings. Two general classes of devices are commonly used for measuring air flow:

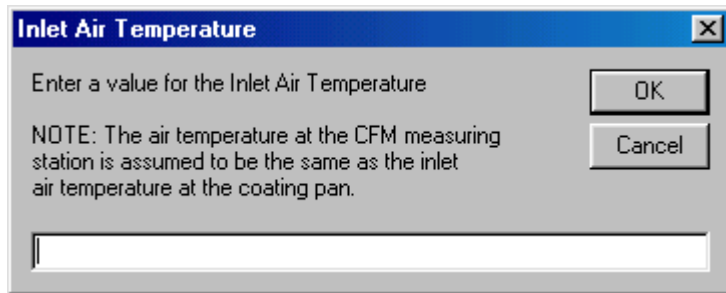
- Pressure-based devices (i.e. pitot tubes, flow nozzles, and venturi tubes)
- Mass-based devices (hot wire anemometers).

Move the cursor to the appropriate measurement device option button inside the Air Measuring Device box and click.

(Note: All Thomas Engineering lab coating pans and air handler units supplied by Thomas Engineering for production coating systems use pitot tubes to measure air flow.)

Inlet Air Temperature

Click on the **ENTER TEMP.** button inside the Inlet Air Temperature box. A pop up dialog will appear.



Type in the inlet air temperature and click the **OK** button.

Allowable units are:

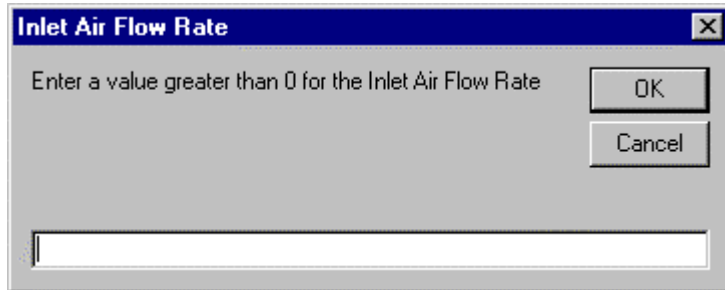
- °C - degrees Centigrade
- °F – degrees Fahrenheit

Note: Air density, which is needed to determine the actual mass of air flowing through the coating pan is a function of inlet air humidity and temperature. The Windows© version of TAAC assumes that the temperature at the point where the air flow is measured is the same as the inlet air temperature to the coating pan. This is a valid assumption for virtually all coating systems since the air flow measurement device is typically located down stream from the heating elements.

If your air handler is configured to measure inlet air flow rate prior to the heating elements, the DOS© version of TAAC, which allows either configuration, must be used.

Inlet Air Flow

Click on the **ENTER FLOW** button inside the Inlet Air Flow Rate box. Type in the inlet air flow rate and click the **OK** button. The entered value appears in the Current Value box along with the current units label.



Allowable units are:

- CFM** – cubic feet per minute
- CMH** – cubic meters per hour

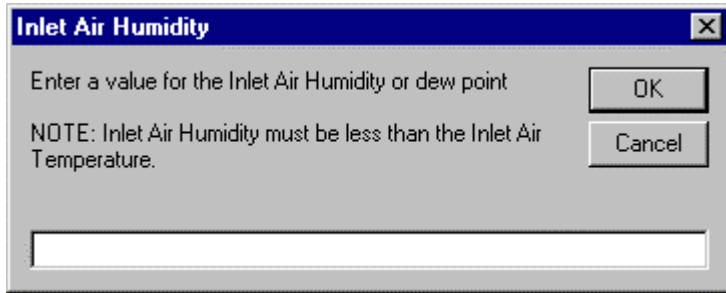
Note: You must enter a value greater than zero or an error message will appear.

Inlet Air Humidity

Inlet air humidity is designated by dew point or humidity ratio (grains of water per pound of dry air). Since the TAAC model deals with absolute humidity (rather than relative humidity) it doesn't matter whether the humidity reading is made before or after the air is heated.

Humidity data may be obtained by means of electronic dew point measuring instruments (i.e. chilled mirror hygrometers), hand held sling psychrometers, or data from a nearby weather reporting station. Data in the form of dry bulb/ wet bulb temperature readings or dry bulb temperature plus relative humidity (%) must be converted to absolute humidity using a psychrometric chart.

Click on the **ENTER HUMIDITY** button inside the Inlet Air Humidity box. Type in the inlet air humidity and click the **OK** button.



Allowable units are:

- °C – dew point in degrees Centigrade
- °F – dew point in degrees Fahrenheit
- gr/ lb – humidity in grains per pound

Note: The inlet air dew point temperature can never exceed the inlet air temperature. Such a condition would indicate a relative humidity greater than 100%, which cannot occur. If you enter a dew point value higher than the inlet temperature, or otherwise enter conditions which result in an exhaust air dew point which exceeds the exhaust air temperature, an error message will appear when the **CALCULATE** button is activated.

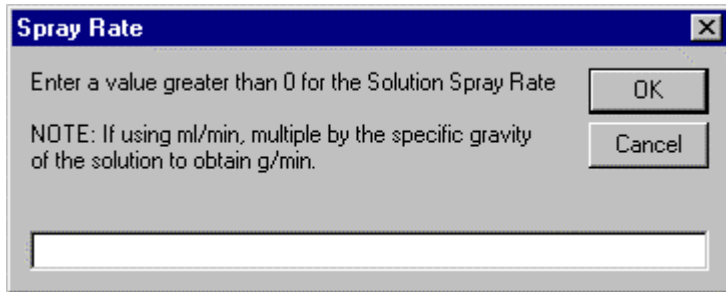
Solution Spray Rate

Solution spray rate is entered having units of grams per minute. If you work with measurements of milliliters per minute, the ml/ min measurements must be multiplied by the specific gravity of the solution to obtain units of grams per minute. Most film coating solutions have specific gravities in the range of 1.01 to 1.04.

Click on the **ENTER RATE** button inside the Solution Spray Rate box. Type in the solution spray rate and click the **OK** button.

Allowable units are:

g/min – grams per minute



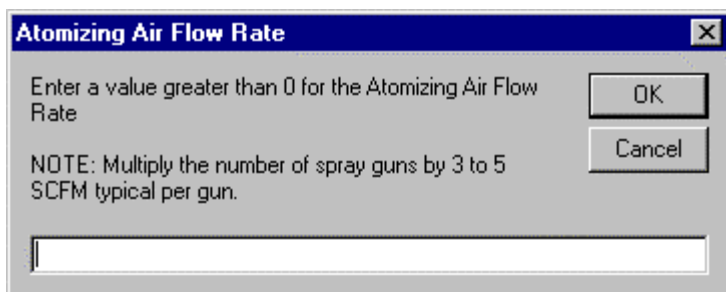
Note: You must enter a value greater than zero or an error message will appear.

Atomizing Air Flow Rate

The air used to atomize the coating solution as it is discharged from spray guns adds to the overall mass flow of air through the coating pan. Although its affect is generally insignificant when compared to the amount of heated inlet air, there are instances, particularly in small lab size coating units, where it can have a noticeable affect.

Spray guns supplied by Thomas Engineering (Spraying Systems®) have air usages in the range of 2 to 5 SCFM (standard cubic feet per minute) per gun. Rates as high as 15 SCFM per gun are typical of some other types.

Click on the **ENTER FLOW** button inside the Atomizing Air Flow Rate box. Type in the atomizing air flow rate and click the **OK** button.



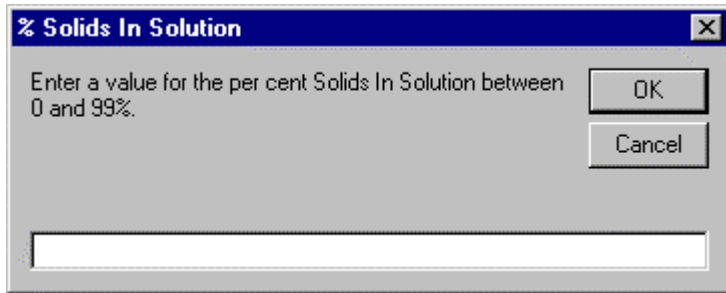
Allowable units are:

SCFM – standard cubic feet per minute
SCMH – standard cubic meters per hour

Note: You must enter a value greater than zero or an error message will appear.

% Solids in Solution

Click on the **ENTER SOLIDS** button inside the % Solids in Solution box. Enter the solids content in percent.



Note: You must enter a value between 0 and 99% or an error message will appear.

PROGRAM EXECUTION

Once all data values have been entered, move the cursor to the **Calculate** button and click. The TAAC program will begin execution. Program execution will halt and an error message will appear if the conditions you have selected result in saturated exhaust air.

Saturated exhaust air can result from the following conditions:

- The inlet air temperature is too close to the inlet air dew point.
- The spray rate selected is too high for the inlet air flow rate or inlet temperature.
- The inlet air temperature is too close to the resulting exhaust air temperature.

Correct any values as necessary and click on the **CALCULATE** button.

DATA OUTPUT

If program execution is successful, exhaust air conditions, the inlet air flow rate (temperature compensated), and the Environmental Equivalency Factor will appear in the **RESULTS** section.

EXHAUST AIR TEMPERATURE

Exhaust air temperature is displayed in both degrees Centigrade and Fahrenheit.

This is the exhaust air temperature that results from the given inlet air conditions and spray rate. The theoretical exhaust air temperature predicted by the TAAC model will be slightly higher (usually 2° to 5° C) than observed exhaust temperatures. Several factors are responsible for this difference:

- The calculated exhaust air temperature is based on an idealized system. It assumes a completely closed coating vessel without any heat loss to the environment or infiltration of room air into the coating pan.
- Inlet air temperatures are normally measured with single point temperature probes located in the center of ducts where the air temperature is the highest. The mixed inlet air temperature will be a few degrees lower than measured values. This discrepancy directly affects the exhaust air temperature reading.
- There is a change in the kinetic energy of the process air and the water evaporated from the tablet bed which is ignored due to its dependency on the exact configuration of the duct work and air handling equipment being used.
- The tablet bed acts like a large heat sink, slowly absorbing heat during coating, causing a lower exhaust air temperature.

Except for some slight dependency on inlet air temperature, the difference between calculated and observed exhaust air temperatures will remain constant for a given pan installation. Thus, if it is noted for a particular installation that the measured exhaust air temperature is 3° C lower than the predicted value, this difference can be expected to remain relatively constant even though parameter variations are implemented.

If you wish to empirically quantify the observed temperature difference, conduct a “dry” coating run. Set all coating pan/ air handler operating conditions to the values typically used during normal coating operation. This can be done without or without the pan loaded with tablets. Spray should not be used.

Allow about one half hour for the system to stabilize. You will note that the measured exhaust air temperature is lower than the measured inlet air temperature. This difference should closely match the difference between the temperature predicted by TAAC and the temperature observed during coating.

EXHAUST AIR HUMIDITY

The exhaust air has a higher moisture content (dew point) than the inlet air since it contains water evaporated from the coating solution. Exhaust air humidity is displayed in all three systems of units.

INLET AIR FLOW RATE

The inlet air flow rate is displayed in SCFM (standard cubic feet per minute) or SCMh (standard cubic meters per hour) depending upon which units were used to specify inlet air flow rate in the parameter section. This is the temperature corrected air flow.

ENVIRONMENTAL EQUIVALENCY FACTOR

The Environmental Equivalency (EE) factor is the most important piece of data output by the TAAC program. It is a dimensionless number proportional to the ratio of the dry area of the tablet bed to the wetted area and as such, is indicative of the drying rate of the film being applied.

The underlying principle of the TAAC model is that any processes which result in the same drying rate will also produce the same film coating quality. Thus, any coating conditions (temperature, humidity, flow rate, and spray rate) which yield identical Environmental Equivalency Factors will also result in equivalent film coatings.

Experience has shown that the Environmental Equivalency factor will generally fall between 2 and 5, with 3.3 being a typical production value. Appendix A contains some examples of equivalent processes.

Obviously, some coating/ tablet combinations can be coated over a wide range of conditions with acceptable results, while other products may be more sensitive to changes in drying rates. The purpose of the TAAC program is not to predict whether or not a given set of conditions will produce a specific coating quality. Rather, it is a tool which can be used to determine how a successful coating applied under known conditions can be achieved under an entirely different set of conditions.

Some of the most common uses for TAAC are:

- Scaling up from laboratory size coating equipment to product size pans.
- Transferring processes from one size coating pan to another or from one manufacturer's equipment to another.
- Investigating the effects of inlet air humidity (summer vs. winter) on the film drying rate. (This is a particularly useful exercise if dehumidification is not used.)
- Optimizing a new or existing coating process.

GETTING A HARD COPY OF OUTPUT DATA

To get a print out of the output data, move the cursor to the **PRINT** button and click.

ENTERING NEW DATA

To enter new data, click on the appropriate parameter buttons and type in the new values. Move the cursor to the **CALCULATE** button and click. The **RESULTS** section will now show the new exhaust conditions and Environmental Equivalency Factor.

HOW CHANGES IN PROCESS VARIABLES AFFECT THE ENVIRONMENTAL EQUIVALENCY FACTOR

Since the Environmental Equivalency factor is proportional to the ratio of the dry area of the tablet bed to the wetted area, high values indicate dry conditions while lower numbers are representative of wetter tablet beds. Thus, any change in a process variable which would tend toward dryer conditions will cause the EE factor to increase. For reference, the table listed below summarizes how changes in any given process variable will affect the EE factor.

INCREASING VARIABLE VALUE

**ENVIRONMENTAL
EQUIVALENCY FACTOR**

Inlet Air Temperature

Increases

Inlet Air Humidity

Decreases

Inlet Air Flow Rate

Increases

Spray Rate

Decreases

% Solids In Solution

Increases (minimally)

APPENDIX A: EXAMPLE OF EQUIVALENT PROCESSES

** THERMODYNAMIC ANALYSIS OF AQUEOUS FILM COATING **
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PARAMETERS:

Air Measurement Device Type = Velocity Pressure
Inlet Air Temperature = 68.0° C
Inlet Air Flow Rate = 1850 CFM (1722 SCFM)
Inlet Air Dew Point = 14.0° C
Solution Spray Rate = 400 g/min
Atomizing Air flow Rate = 12.0 SCFM
% Solids In Solution = 12.0%

RESULTS:

Exhaust Temperature = 53.1° C (127.6° F)
Exhaust Air Dew Point = 21.3° C (70.3° F)
Environmental Equivalency Factor = 3.008

** THERMODYNAMIC ANALYSIS OF AQUEOUS FILM COATING **
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PARAMETERS:

Air Measurement Device Type = Velocity Pressure
Inlet Air Temperature = 63.0° C
Inlet Air Flow Rate = 1700 CFM (1592 SCFM)
Inlet Air Dew Point = 2.0° C
Solution Spray Rate = 350 g/min
Atomizing Air flow Rate = 12.0 SCFM
% Solids In Solution = 12.0%

RESULTS:

Exhaust Temperature = 48.9° C (120.1° F)
Exhaust Air Dew Point = 14.0° C (57.2° F)
Environmental Equivalency Factor = 3.018