



*Institute For Thermal Processing Specialists*

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## **TEMPERATURE DISTRIBUTION PROTOCOL FOR PROCESSING IN STILL, WATER IMMERSION RETORTS, INCLUDING AGITATING SYSTEMS OPERATED IN A STILL MODE**

Various methods and equipment may be employed to achieve and verify the temperature distribution conditions in a retort that ensures all areas of the retort receive the scheduled process. **The following recommendations are to be considered voluntary guidelines.** While this does not preclude the application of other methods and equipment for determining whether adequate temperature distribution is achieved in a retort to ensure delivery of the scheduled process, these guidelines have been developed by consensus of the Institute For Thermal Processing Specialists and should be given serious consideration for adoption as methodology by individuals performing temperature distribution studies on still, water immersion retorts, including agitating systems operated in the still mode.

### **1. PROCESSING EQUIPMENT SURVEY**

It is important to establish proper documentation during the survey of the processing room, so that a valid evaluation can be made in the process of selecting the test retort(s) (see Note 1). This survey should include examination of the following:

#### **1.1 Steam supply to the retorts**

- 1.1.1** Boiler capacity (horsepower or Btu rating), pressure, and method of firing (gas, oil, coal or dual capacity).
- 1.1.2** Header pressure. This is important to determine that adequate steam pressure and volume is available for the retorting system. This part of the survey should be performed during both peak use and off load hours.
- 1.1.3** Pipe size and length, valve size and types, from the main steam line to the test retort(s).
- 1.1.4** Size of all connecting steam pipes to the main line, noting all equipment using steam (e. g., blanchers, exhaust boxes, etc.).

#### **1.2 Retort room**

Pipe sizes and locations, valve sizes and types, instrumentation locations on each retort, construction details, process controls (if any) and installation variations (if any) from one retort to another located with the selected test retort(s).

## 1.3 Air supply to the retorts

- 1.3.1 Compressor type, capacity and operating pressure.
- 1.3.2 Type and size of filter, dryer and tank.
- 1.3.3 Line size, pressure, filters and dryers for instrument air.
- 1.3.4 Process air header line size(s), pressure and pressure regulation, if used.

## 1.4 Water supply to the retorts

- 1.4.1 Process water supply source, temperature, and controls, if any.
- 1.4.2 Cooling water supply source, temperature, and controls, if any.

## 1.5 Overflow/purge (air removal)

Valve type and size, pipe size and connections to drain headers or channels.

## 1.6 Drain

Valve type and size, pipe size and length; also note if check valves are used.

## 1.7 Retort loading considerations

- 1.7.1 Container information: material, size and dimensions; orientation for processing (vertical or horizontal); and loading configuration (layered, nested, compartmented, or offset).
- 1.7.2 Type of product heating (convection, conduction, or broken).
- 1.7.3 Maximum number of containers per layer; maximum number of crates, baskets or racks per retort.
  - 1.7.3.1 Partial load arrangement.
  - 1.7.3.2 Water displacement requirements (ballast).
  - 1.7.3.3 Crate, basket or rack dimensions.
- 1.7.4 Hole size, configuration and spacing in the base plate and sides of crates, baskets or racks and in separator sheets used in same.
- 1.7.5 Distance between crates, baskets or racks, where applicable.
- 1.7.6 Orientation of the crates, baskets or racks in the retort during come-up and processing.

**Note 1.** While retort room surveys are not a part of temperature distribution per se, they are important in identifying retorts to be tested, documenting the conditions of the temperature distribution study, as well as helping plant management realize that projects outside the retort room may have an effect on retort operations. Surveys should be periodically performed on all retorts to ensure that they remain consistently and properly installed to previously documented conditions, regardless of whether or not temperature distribution testing is to be performed.

## 2. SELECTION OF THE TEST RETORT(S)

In general, all of the information taken in the retort room survey should be used to select the retort(s) that will be tested for temperature distribution. The retort(s) selected should represent the one(s) identified as having the greatest potential for diminished delivery of the scheduled process. Factors that may help identify the test retort(s) include: retort position (at the beginning or end of a line of retorts), container configuration, divider style, and partial loads. New retorts can be presumed to require temperature distribution studies. Similarly, retorts that have undergone extensive repair or redesign can be expected to require temperature distribution studies. It would not be unusual for all retorts in a retort room to be tested on a regular basis because of the mechanical nature in which temperature distribution is established, especially in horizontal retorts. The replacement or normal wear of components associated with establishing acceptable temperature distribution also warrant consideration for performing temperature distribution studies. These components may include: water circulating pumps, valves and pipes associated with steam/water flow, steam injectors (fishtails), air orifices, and overflow/pressure regulating valves.

### **3. TEST RETORT DOCUMENTATION**

Provide a diagram and description, including comments on condition, for the following, if applicable.

#### **3.1 Retort shell**

Physical dimensions and number of crates used in each test, for vertical retorts note the presence of centering guides.

#### **3.2 Steam supply from main line to the retort**

Pipe size, valve size, valve type, and pressure regulator(s).

#### **3.3 Steam introduction into the retort**

**3.3.1** Type and specification of the steam distribution system including: configuration (e.g. fishtail, cross, in line, etc.), steam flow piping, size, number, and location of steam injection perforations, if applicable.

**3.3.2** Steam injection chamber, if applicable.

**3.3.3** Use of any alternate methods of heating the processing water.

#### **3.4 Temperature control sensing device**

Type and location of the temperature measuring device (note relation of sensing devices to steam distributor).

#### **3.5 Type of instrument well(s)**

Size, shape and location of well(s) used to locate sensing devices (list devices).

#### **3.6 Water level indicator(s)**

Type (sight glass, petcock or electronic) and location.

### **3.7 Pressure Sensing Device(s)**

Type, range and location.

### **3.8 Reference temperature measuring device (TMD)**

**3.8.1** Mercury-in-glass (MIG) thermometer location, range and scale, date of calibration, and length of bulb insertion.

**3.8.2** Electronic TMD type (RTD, thermocouple, thermistor, etc.), range, response time, location, date of calibration and length of probe insertion

### **3.9 Temperature controller or recorder/controller**

**3.9.1** Process timing method (automatic or manual).

**3.9.2** If microprocessor-controlled, describe tuning parameter values (PID) used for come-up and cook phases, and the amount of offset applied to the control variable, if any.

**3.9.3** If computer-controlled, describe the name of the system and the program/file used to control the process, including program/file name, date, and the revision number, if applicable.

### **3.10 Air purge**

Valve types, sizes and location with piping connections, if applicable.

### **3.11 Drain**

Size, type, location, and piping connections.

### **3.12 Water circulation**

**3.12.1** Processing water: sizes, types, and location of valves and piping, if applicable.

**3.12.2** Method of water circulation.

**3.12.2.1** Pump specifications, including rated output (e.g., gpm), at retort operating temperature and pressure conditions, if applicable.

**3.12.2.2** Air flow: orifice size, pressure sensing device, pressure setting and flow rate (during test).

**3.12.2.3** Flow sensing device (water): type and location, if applicable.

**3.12.2.4** Pressure and/or flow switches: type, location, and trip point setting.

### **3.13 Overpressure**

Location and size of pipes and valves and method of application.

### 3.14 Other equipment

Other control or functional equipment installed that might affect the temperature distribution.

## 4. TEST EQUIPMENT

### 4.1 Data acquisition system

The calibrated system should be equipped with sufficient channels to accurately monitor and record temperature/ pressure within the process delivery system. Manual recording of data may be used if a sufficient sampling frequency can be maintained.

### 4.2 Temperature measuring devices (TMDs)

Use thermocouples or other devices of sufficient accuracy in sufficient quantity to adequately monitor the process water temperatures within the retort.

### 4.3 Pressure indicating device(s)

Operational gauges and electronic indicators may be used to monitor pressures associated with the retort operation during the test, but they should be of recent calibration. Separate test devices may be used if desired. Typical measurements would include retort vessel pressure, steam line pressure, sparge air line pressure and cooling water line pressure.

### 4.4 Reference TMD

Include if the test retort TMD is not going to be used.

### 4.5 Packing gland (stuffing box)

Neoprene or other synthetic materials soft enough to provide a tight seal without over-tightening and damaging the leads should be used for entry of lead wires into the retort, if applicable.

### 4.6 Flow meters

**4.6.1** May be used to measure flow of process water in those systems using circulation pumps.

**4.6.2** May be used to measure volume of air flow in those systems using air for agitation of process water.

## 5. STANDARDIZATION OF TEST EQUIPMENT

### 5.1 Retort thermometer/TMD

The retort MIG thermometer/TMD must conform to applicable regulations and shall have been checked for accuracy against a certified TMD within the past year, preferably more recently.

## 5.2 Temperature measurement system

**5.2.1** Prior to conducting the actual temperature distribution study, standardization or calibration of the test equipment should be performed in the test retort (as defined in Section 2) with all leads, extensions and connections assembled as they will be used under actual test conditions. The use of wired sensors normally requires a method of signal grounding. Follow the recommendations of the datalogging equipment manufacturer or consult with an instrument professional if you are unsure about the correct grounding technique to use.

**5.2.2** One acceptable method of calibration is to bundle all TMDs and locate them in close proximity to the known accurate MIG thermometer/ reference TMD, taking care not to inhibit the water flow past the reference probe.

**5.2.3** Bring the retort up to the same temperature and pressure as designed for the distribution test and allow temperatures in the vessel to equilibrate.

**5.2.4** Check the accuracy of the TMDs against the known accurate reference instrument. Any single TMD should agree to within 0.5°F (0.3°C) of the reference TMD/MIG thermometer. The range for all TMDs should be not more than 1°F (0.6°C). Any TMD which deviates from the above criteria should not be used until corrective action is taken that results in the TMD meeting the criteria. The TMD in closest agreement with the reference TMD should be attached to the reference probe and becomes the secondary reference TMD for data evaluation.

**5.2.5** To meet the calibration criteria above, and to ensure the accuracy of the test results, consideration should be given to minimizing errors inherent in any component of the temperature measuring system. For example, the use of special limits of error, premium grade thermocouple wire from the same spool to make thermocouple leads, or 3 or 4 wire high accuracy RTDs can help to reduce intrinsic error.

**5.2.6** The use of less restrictive criteria is acceptable, but may affect the control offset amount needed in the operation of the retort.

## 6. PLACEMENT OF THE TEMPERATURE, PRESSURE AND FLOW MEASURING DEVICES

### 6.1 Location of the TMDs in the retort

TMDs should be placed in the following locations:

**6.1.1** Attached or in close proximity to the reference TMD probe.

**6.1.2** Attached or in close proximity to the temperature controller probe, unless the reference TMD and the controller probe are located together.

**6.1.3** Located in a minimum of two (2) containers filled with test medium for the purpose of determining initial product temperatures (If there are data available that correlate temperatures measured by free leads to a specific initial product temperature - prior to making the TD study - such correlation may be used in lieu of measuring actual initial product temperature.)

**6.1.4** A minimum of three (3) leads should be used, each located in different layers or otherwise separated in each basket/crate/rack; leads should be placed so that measuring junctions are not in direct contact with containers or other internal material surfaces.

**6.1.5** Depending on the processing system, it may be necessary to place additional TMDs at other locations in the retort to adequately monitor cold spot(s).

## **6.2 Location of pressure sensor(s)**

At least one (1) pressure sensing device should be located in the retort shell. If the operational pressure sensing device has been recently calibrated, it can be used in place of a test device. Pressure gauges should also be used to monitor line pressures of steam, air and cooling water during a test.

## **6.3 Location of flow meter(s)**

**6.3.1** A flow meter (or alternate method) should be located in a manner to provide an accurate record of the water circulation flow during the process cycle on systems using circulation pumps.

**6.3.2** A flow meter (or alternate method) should be located in a manner to provide an accurate record of the air flow during the process cycle in systems using air for agitation of process water.

# **7. PREPARING RETORT WITH CONTAINERS**

## **7.1 Container size**

Select the container size processed in the retorts that will yield the worst-case condition for the commercial operation from a temperature distribution standpoint. In many cases, this will be the smallest container in use. In some cases, each container size, type, offset configuration, position and orientation will have to be tested.

## **7.2 Container contents**

Containers may be filled with water, or the fastest heating product, for studying retorts that process convection heating products. For conduction heating products, the containers should be filled with actual product, a stable starch solution, or other material that closely simulates the thermal diffusivity of the production products. Water may also be used, but the come-up times will be somewhat longer than will occur with product.

## **7.3 Container placement**

Containers are placed in the crates, etc. in a manner that is equivalent to the worst-case situation as seen in the commercial operation. This may need to be determined through additional observation and testing. If separator or divider sheets are used between the layers of containers, then the dividers with the smallest percent open area should be used for the tests. If additional dividers are used either on the top or the bottom of the container load, this procedure must be duplicated for the test.

## **7.4 Operating procedures**

Normal commercial operating procedures should be followed, e.g., if the crates, etc. are rotated during come-up or repositioned for thermal processing.

## 8. THE TEMPERATURE DISTRIBUTION TEST

### 8.1 Set up

**8.1.1** Verify the results of the retort survey.

**8.1.2** Establish the initial product temperature. The initial product temperature for a test run is the warmest of the temperatures measured in an instrumented container at the start of the test. The range of initial temperatures to be encountered during regular commercial operation should be taken into account in establishing temperature distribution. If instrumented containers are not used, there should be some other means of determining the initial temperature. The initial temperature measured should be considered in the context of retort shell, crate, and/or process water temperatures, which may be lower or higher than the measured initial temperature. This could affect the length of come-up time required to bring the retort to a uniform processing temperature.

### 8.2 Data collection points

The following are critical and should be monitored and recorded during the test :

**8.2.1** Temperature controller set point, including if there is an overshoot set point for come-up and a lower set point for processing.

**8.2.2** Initial product temperature.

**8.2.3** Time steam on or zero ("0") time.

**8.2.4** Temperature of process water supply, if preheated.

**8.2.5** Fill time (displacement) in those systems dropping water from a storage drum or tank into the working processing vessel.

**8.2.6** Water level in process vessel in relation to the top surface of containers, stated as a minimum or an actual level throughout the process.

**8.2.7** Time when the reference TMD/MIG achieves the process set point temperature.

**8.2.8** Time when the end of come-up, start of cook phase has been achieved, as indicated by either the phase change in a control program or the achievement of scheduled process temperature at both the reference TMD/MIG and the recorder/controller.

**8.2.9** MIG/ reference TMD readings at sufficient intervals, including the point in time it reaches the process temperature setpoint.

**8.2.10** Air flow in scfm or lpm (if applicable and available).

**8.2.11** Line steam pressure at the time of the test and before, during, and after come-up, if possible.

**8.2.12** Line air pressure at the time of the test and before, during, and after come-up, if possible.

**8.2.13** Retort overpressure, throughout test cycle at sufficient intervals or on continuous chart.

**8.2.14** Time of end of cook, start of cool.

**8.2.15** Actual crate/ container orientation in the retort.

### 8.3 Miscellaneous non-critical observations



**8.3.1** Number of other retorts in operation at the time of the study.

**8.3.2** Other retorts entering come-up during the study.

**8.3.3** Temperature of retort cooling water, especially if general method or modeling calculations are performed as part of the temperature distribution study.

## **9. CONDUCTING THE TEST**

### **9.1 Datalogger**

The datalogger should record the temperature of each TMD at sufficient intervals, never to exceed one (1) minute, throughout the length of the study. The data-logger record is part of the permanent records for the temperature distribution study.

### **9.2 Critical points**

Critical points should be recorded at intervals of sufficient frequency to describe and verify retort operating parameters during the test. These recordings are part of the permanent test record and should include the temperature recording chart, the pressure readings or chart, flow rate records, MIG thermometer/reference TMD readings, and other data gathered that have been identified as critical data collection points. The test retort process control generated records may be used to supplement manual test observations and recordings.

### **9.3 Testing time duration**

Testing time duration depends upon:

**9.3.1** The precision of temperature and pressure control and whether the retort has stabilized and a definitive temperature profile has been established.

**9.3.2** Normal production process times, except that tests should be extended to include a minimum of fifteen (15) minutes at process temperature.

**9.3.3** Retort cooling phase temperatures being recorded until test product temperatures fall below 200°F (94°C). This is especially important if product cooling lethality will be based upon actual retort cooling profiles in developing scheduled processes.

### **9.4 Replication**

On new or modified retorts, temperature distribution studies should be performed, at a minimum, in duplicate.

### **9.5 Post-test inspection**

The condition of the measuring sensors, the test containers, and other attributes of the retort load should be examined after the completion of the test to determine if the test results may have been affected by movement or other changes to the desired test.

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  - Part of the mandate of the IFTPS Committees is to develop protocols to be used as guides for carrying out the work of thermal processing specialists. This is the first such protocol prepared by the Committee on Temperature Distribution and reviewed extensively by members of the Institute. The protocol has been approved by the Board of Directors. **This document may be photocopied in its entirety for use.**
  - Single copies of the protocol, as well as information on membership in IFTPS may be obtained from: Institute for Thermal Processing Specialists, 304 Stone Rd. W. Ste. 301, Guelph, ON N1G 4W4 Phone: (519) 824 6774 Fax: (519) 824 6642, E-Mail: [info@iftps.org](mailto:info@iftps.org)
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