# COMBAT RATION NETWORK

# FOR

# TECHNOLOGY IMPLEMENTATION

## Assessment of TAMU Rack Material in Poly Tray Racks using Spray Retort

**Final Technical Report STP#2022**

**Results and Accomplishments (September 2006 – June 2009)**

**Report No: FTR 215**

**CDRL Sequence: A003**

**May 2009**

**CORANET CONTRACT NO. SPO103-02-D-0024**

Sponsored by:
DEFENSE LOGISTICS AGENCY
8725 John J. Kingman Rd.
Fort Belvoir, VA 22060-6221

Contractor:
THE CENTER FOR ADVANCED FOOD TECHNOLOGY
The School of Enviromental and Biological Science
Rutgers, The State University of New Jersey
New Brunswick, New Jersey 08903

Principal Investigator:
Henderikus B Bruins

TEL: 732-445-6130
FAX: 732-445-6145

| REPORT DOCUMENTATION PAGE | *Form Approved* *OMB No. 0704-0188* |
|---|---|



| 1. REPORT DATE *(DD-MM-YYYY)* | 2. REPORT TYPE | 3. DATES COVERED *(From - To)* |
|---|---|---|
| July 2009 | Final | September 2006 - June 2009 |

| 4. TITLE AND SUBTITLE | |
|---|---|
| Assessment of TAMU Rack Material in Poly Tray Racks using Spray Retort | 5a. CONTRACT NUMBER<br>SP0103-02-D-0024 / 0012 |
| | 5b. GRANT NUMBER |
| | 5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S)<br>Mr. Henderikus B. Bruins | 5d. PROJECT NUMBER<br>STP # 2022 |
| | 5e. TASK NUMBER |
| | 5f. WORK UNIT NUMBER<br>A003 |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br>Rutgers, The State University of New Jersey<br>The Center for Advanced Food Technology<br>School of Enviromental and Biological Sciences<br>New Brunswick, NJ 08903 | 8. PERFORMING ORGANIZATION REPORT NUMBER<br>FTR 215 |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)<br>Defense Logistics Agency<br>8725 John J. Kingsman Rd<br>Fort Belvoir, VA 22060-6221 | 10. SPONSOR/MONITOR'S ACRONYM(S) |
| | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) |

**12. DISTRIBUTION/AVAILABILITY STATEMENT**

Approved for public release; distribution is unlimited.

**13. SUPPLEMENTARY NOTES**

**14. ABSTRACT**

The compound recommended by Texas A&M for retort racks that could lead to significant cost savings was compounded by Omni Plastics, Evansville IN and molded into retort racks by Allpax Products Inc, Franklin WI. The compound was more expensive then regular polypropylene/talc compounds but much cheaper then the currently used PPX compound. Each retort rack was molded with a unique ID# for traceability. The racks were tested by ration producers for the performance in spray retorts. So far, the rack has held up very well with little or no wear and tear. However, it is difficult to access the mean life cycle of the rack due to large fluctuations in rack use. The ration producers will keep using the rack and report on the expected mean life cycle at some time in the future.

**15. SUBJECT TERMS**

Ration, MRE, UGR, Retort, Rack

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT | b. ABSTRACT | c. THIS PAGE | | | Henderikus B. Bruins |
| Unclassified | Unclassified | Unclassified | Unclassified | | 19b. TELEPHONE NUMBER *(Include area code)*<br>732-445-6130 |

**Abstract:**
The compound recommended by Texas A&M for retort racks that could lead to significant cost savings was compounded by Omni Plastics, Evansville IN and molded into retort racks by Allpax Products Inc, Franklin WI. The compound was more expensive then regular polypropylene/talc compounds but much cheaper then the currently used PPX compound. Each retort rack was molded with a unique ID# for traceability. The racks were tested by ration producers for the performance in spray retorts. So far, the rack has held up very well with little or no wear and tear. However, it is difficult to access the mean life cycle of the rack due to large fluctuations in rack use. The ration producers will keep using the rack and report on the expected mean life cycle at some time in the future.

Index

# 1 Results and Accomplishments

## *1.1 Introduction and Background*

Under a CORANET Short Term Project, STP#2007, Texas A&M University recommended an improved compound for retort racks that would be cheaper and last longer than recently used materials. Retort racks for the polymeric tray were molded from a 75% BP APPRCO 9346[1] and 25% Talc Luzenac R-7 Talc compound and tested at SOPAKCO in a full water immersion Stock 1100 retort. While the results were positive, the current industrial base for polymeric trays is using larger spray type retorts, which is a harsher environment for retort rack than the full water immersion retorts due to the lack of container buoyancy and impingement of water droplets.

Under a separate CORANET Short Term Project, STP#2010, a new injection mold was developed for racks that would maximize the capacity of the much larger spray type retort. During the material selection process for this new rack, several materials were evaluated but the recommended "TAMU" compound could not be obtained in the qualities needed and within the short time frame of that project. Instead, a GE material for this rack was selected (PPX-15), which performed well. However, the cost of this compound is significant, not only due to the high raw material cost, the size of injection molding equipment needed (the molding pressure needed during the injection molding process requires a 3,500 ton injection molding machine), but also due to the relative small orders for racks that are being placed.

The cost of a PPX-15 molded polymeric tray retort rack for the 1400 style spray retorts is significant (~$75/rack) and the potential exist to reduce the cost of the rack by using a high quality polypropylene/talc blend that has performed extremely well in full water immersion retorts. The recommended compound has, however, never been tested in a spray retort and is not readily available as a compound for molding retort racks in small quantity.

Rack performance in a spray retort differs significantly from the performance in full water immersion retorts. Due to the lack of container buoyancy in spray retorts, retort racks are exposed to greater gravitational forces and tend to sag easier unless stiff materials are used and/or racks are designed with larger ribs to increase stiffness. Also, the impingement of water droplets on the rack has a significant impact on the longevity of the rack as plasticizers leach out and the rack becomes brittle.

This project assessed the availability of the recommended rack material by Texas A&M, identified a compounder that is willing and capable to compound the material, molded approximately 200 racks using the existing mold for the larger spray retorts and tested these racks in a commercial operation to determine the performance of the rack over time.

## *1.2 Objectives*

Analyze the performance of retort racks for polymeric trays in spray retorts that are molded from a compound that was identified and recommended by Texas A&M. This project will mold and test the retort rack in a FMC 1400 style spray retort by analyzing the sag and longevity of the rack in a commercial operation.

This project was jointly executed with Texas A&M. Rutgers University was responsible for sourcing the compounding, molding of the racks and in cooperation with Ameriqual and Wornick evaluated the performance of the racks as per established protocol. Texas A&M was responsible for the analysis of the physical properties of the current rack design, recommending the best ratio

[1] The BP APPRCO 9346 is currently marketed under the trade name: "Innovene H05H-00

of Innovene H05H-00 and Luzenac R-7 Talc, as well as validating the acceptability of the compound and molded material.

### *1.3 Results and Conclusions*

The compound that is recommended by Texas A&M is not an off the shelf item that can be purchased. Instead, it needs to be custom compounded upon request. Three compounders were contacted to quote on compounding the custom blend. One compounders, Omni Plastics, was interested in obtaining the ingredients and custom compounding a relative small amount. The compound was more expensive then regular polypropylene/talc compounds but much cheaper then the PPX compound that was used previously. The compound was then molded into retort racks by a subcontractor to Allpax who manages the injection mold. Each rack was molded with a unique ID# for traceability. No problems were encountered in the molding process. The racks were initially sent to Ameriqual for the initial performance test and later sent to Wornick for further retort testing. So far, the rack has held up very well with little or no wear and tear. However, it is difficult to access the mean life cycle of the rack due to large fluctuations in rack use. Wornick will keep using the rack once it has obtained a new contract for polymeric trays and report on the expected mean life cycle at some time in the future.

# 2 Program Management

The project was awarded on September 14, 2006, under SPO103-02-D-0024, delivery order 0012, with a full obligation of the total requested amount of $59,469. Performance period for this delivery order was initially set at 9 months from September 14 2006 through June 14, 2007. The objective of the project was as follows: "Analyze the performance of the TAMU recommended material compound for retort racks". This project would mold and test the retort rack for the polymeric tray in a FMC 1400 style spray retort by analyzing the sag and longevity of the rack during commercial operation and compare performance against the current used PPX-15 material from General Electric"

The following modifications were issued:

- May 16, 2007 0013/01 No cost extensions of performance period from June 14, 2007 through to November 30, 2007
- Nov 27, 2007 0012/02 No cost extension of the performance period through to June 30, 2008
- June 10, 2008 0012/03 No cost extension of the performance period through December 31, 2008.
- Dec 15, 2008 0012/04 No cost extension of the performance period through June 30, 2009

# 3 Short Term Project Activities

### *3.1 Product Availability and Required Formulation*

Due to design difference of the new rack and the environment in which the rack is being used, Dr H.J. Sue from Texas A&M re-evaluated the optimum compound formulation for the application. After some initial trials and evaluation, he recommended that the ideal ratio of polypropylene to talc would be 70% - 30%. The reasons for increasing the percentage of talc in this formulation, was to create a stiffer material than the previously tried compound for MRE and Poly Tray racks. This increased stiffness is required in spray retorts, where there is no buoyancy and the full weight of the container needs to be carried by the rack. A stiffer rack should be more resistant to rack sagging.

Dr Sue also inquired on the availability of the two raw materials and contacted Ineos (formerly BP Chemical, then Innovene), and Rio Tinto (formerly Luzenac) to inquire about material availability. Both materials were readily available

## *3.2 Compounding*

Request for quotations were issued for the compound (appendix 4.2). Two of the three contacted compounders elected not to submit a quote. Reason was the small order quantity and the specific materials that needed to be compounded. Omni Plastics from Evansville did submit a quote for three order quantities (see appendix 4.3). Omni Plastic compounded 4,075 lbs of the material on January 9, 2007. The formulation was identified as HPPTF307HSBK500 and besides the polypropylene and talc, a color (black) and a heat stabilizer was added. The resulting formulations was:

- Innovene H05H-00, (Polypropylene Homo polymer) 68.8%
- Luzenac R-7, (Talc) 30%
- Color 1%
- Heat Stabilizer 0.2%

Routine Quality Assurance Measures were performed by Omni, which are attached in the appendix. The pelletized compounded was sent to the rack molder.
Test samples were also sent to Dr Sue @ TAMU who analyzed the properties of the compound. Dr Sue lab completed the initial evaluation on January 23, 2007 and found the material to be acceptable and released the compound for molding.

## *3.3 Rack Molding*

AllPax, who manages the injection mold, did submit a detailed quote for molding the retort racks. The quote spells out a cost to setup and cleanup the injection molding machine and a per mold cost (see appendix 4.4). Allpax scheduled the injection molding of the material on January 25, 2007. Rieks Bruins attended to observe the overall performance of the compound in the injection molding operation. A total of 200 racks were molded and each rack was individually labeled for tracking purposes. The racks were sent to Ameriqual, where they were received on 1/29/07.

## *3.4 Monitoring the Rack Performance*

The performance evaluation of the rack was divided in three phase:

- an initial evaluation when the racks were put into the production system,
- a medium range evaluation during which the rack is closely monitored for six month to assure that any defects or rapid deterioration are carefully studied
- a long range performance monitoring during which we will record when a rack fails and determine the expected life cycle of the rack.

The protocols for each of the three phases are in the appendix 4.5.

### 3.4.1 Initial Evaluation

The initial evaluation of the racks was executed on March 20-23, 2007. The evaluation consisted on evaluating deformation of a fully loaded retort stack after retorting and a drop test of selected racks on all corners and sides. The retort tests were run with and without extra support plate in the bottom of the retort. Results clearly indicated that the support plate reduces the stress and deformation of the rack. With the support plate, the sag of the rack was similar as measured when using the PPX material. The rack passed also the drop test. This made the rack similar in performance during the initial test as the PPX material.

Recommendations were made to Ameriqual to use the rack with support plate in order to maximize the life cycle of the rack before commencing the medium range test.

### 3.4.2 Medium Range Performance

After Ameriqual acquired the necessary perforated plates for their production retort pallets to support the racks in all the load bearing points, temperature distribution were made to validate this new configuration. The racks were put into use on July 27, 2007. Ameriqual kept track of the racks that were used and the number of retort cycles that they were exposed to. One rack was pulled every month and a sub section was sent to TAMU for evaluation.

The three month evaluation period was concluded on October 27, 2007. Ameriqual stopped using the racks, as the rack was not longer compatible with their operation. The racks were moved from Ameriqual to Wornick during the first week of January 2008. Wornick started using 144 racks in their production queue on March 10, 2008. The required medium range test period was completed end of June (6 month). Feedback received from Wornick at the end of the six month period indicated excellent performance of the racks and no known issues.

### 3.4.3 Long Range Performance

Wornick started the long range performance test in July 2008 and will continue this until 50% of the racks have failed. However production of polymeric trays halted in October 2008 as their contract was completed. A new contract might not be released until the fall of 2009. Until then the rack will be kept in storage and the long range evaluation will continue after production has re-started.

## *3.5 Cost Benefit Analysis*

The new rack material (HPPTF307HSBK500) can be used for retort racks that are designed for polymeric trays and replace the currently used material PPX-15 at a significant cost savings. It is expected that the savings can be in the order of 31% based on an estimate that was made in 2007. It is also expected that the life cycle time of the rack will be similar or slightly longer that that of PPX, based on observations made by the producer. Assuming that the industry currently buys per year about 1200 racks, this could results in $15,761 annual savings. Once the long range performance has been completed by Wornick, this number would need to be confirmed.

- Rack Molding Cost (February 2007 estimates)
  - Setup and Cleaning Cost: $2,150
  - Molding Cost: $21.20/rack (~10-15 racks/hr)
  - Material/Rack: 15.5 lbs @ $1.56 = $24.18/rack
  - Total Cost ~$56.13/rack (200 racks)
  - PPX-15: ~$81.50/rack (200 racks)
  - New Material yields a 31% savings

- H&S Racks
  - Assume that Industry has in use 1200 racks for H&S
  - Assume life cycle rack increases from 3 years to 4 years
  - Hence acquisition of 300 versus 400 racks/year
  - Cost/Rack: $56.13 vs $81.50
  - Cost Savings: $32,600 – $16,839=$15,761/year

However, the savings are not limited to the racks used for polymeric trays. The same rack material can also be used for MRE retort racks. Based on feedback from the Industry, it is assumed that the cost savings might be an order of magnitude larger for this application, as many more racks are being used for MRE's than for polymeric trays and the current material life cycle of MRE racks is limited to one year. It is estimated that the Industry replaces per year 12,000 racks at a cost of $31/rack. While the new rack material might be slightly more expensive than the currently used polypropylene, it is expected that the custom made rack material could double the life cycle of a rack. This could equate to an annual cost savings of $156,000/year

- MRE Racks
  - Assume that Industry has in use 12,000 racks
  - Assume life cycle rack increases from **1** years to **2** years
  - Hence acquisition 6,000 vs 12,000 racks/year
  - Cost/Rack: $36 vs $31/rack
  - Cost Savings: $372,000-$216,000=$156,000/year

Total savings of switching to this new material might therefore result in a total annual savings of $171,761/year

## 3.6 Meetings

A project kick-off meeting was held on October 27 at Ameriqual. The objective of the meeting was to discuss and agree on the recommended formulation and test protocols. The notes of the meeting can be found in the appendix 4.1;

# 4 Appendix:

## *4.1 Kick-Off meeting Notes*

## *4.2 Request for Quote*

## *4.3 Omni Quote*

## *4.4 AllPax Quote*

## *4.5 Rack Monitoring Protocols*

# Retort Rack Material

Kick-Off Meeting
10/27/06
Ameriqual, Evansville IN

Kick Off Meeting was held at Ameriqual IN.

Attendees were:

Mark Bradley, Quality System Administration Ameriqual, 812-867-1444
mbradley@ameriqual.com

Mark Thomas, VP Sales and Marketing Omni Plastics, 812-421-8900
mthomas@omnithermoplastics.com

Jim O'Risky, VP Processing Operations Ameriqual 812-867-1444
jorisky@ameriqual.com

Rieks Bruins, Associate Director CAFT, 732-445-6135,
bruins@aesop.rutgers.edu

Attended via Teleconference:

Hj Sue, Polymer Technology Center Texas A&M, 979-845-5024, hjsue@tamu.edu

Jesse Burns, Defense Supply Center Philadelphia, (215) 737-7436, jesse.l.burns@dla.mil

# Agenda

- Objective
- Project Outline
- Compound Formulation
- Material Availability
- Test Protocols
- Compounding/Molding
- Rack Testing
- Cost Benefit Analysis

Ameriqual hosted the teleconference with Jesse Burns and Dr Sue

Rieks Bruins initially reviewed the meeting agenda.

Jesse Burns started the meeting explaining the objective of the project and gave some of the back ground information

# Objective

- Analyze the performance of the TAMU recommended material compound for retort racks designed for the 1400 style spray retort

Rieks Bruins and Dr Sue explained the back ground and that the objective of the project is to evaluate the performance of the Innovene polypropylene based compound against the reference GE material with as ultimate goal to reduce the cost of retort racks

# Project Outline

- Analyze product availability and required formulation (Phase I)
- Developing Test Protocols (Phase II)
- Compounding and Molding Racks (Phase III)
- Monitor Performance of Rack (Phase IV)
- Cost Benefit Analysis

The project has four phases. Task I and II are running parallel. Rutgers started to develop the test protocols while Dr Sue conducted tests to determine the appropriate formulation for the rack

# Outline

1. Objective
2. Candidate Material (Innovene)
3. Reference Material (GE Plastics)
4. Tensile and Charpy/Izod impact
5. Summary and Recommendation

Dr Sue reviewed the background of past research and current analysis performed. Dr Sue will send a copy of the final report from STP2007 as a reference document in this project.

The above is the outline of Dr Sue's presentation

# Objective

1) Compare mechanical properties between the reference material and the candidate material

   1) Tensile modulus
   2) Tensile strength
   3) Charpy/Izod impact strength

2) Lower the cost of retort racks for CORANET members

To determine the formulation for this rack, comparisons of tensile modulus, tensile strength and Charpy/Izod impact properties of the current used rack material (PPX-15) were made with formulations under consideration in this project.

The goal of the project is to lower the "useage cost" of the retort rack. Dr Sue's expressed that the ingredient cost for the rack can be lowered significantly by using the material that he identified and tested under STP#2007. Cost of talc is about $0.50/lb and polypropylene about $1.00/lb if purchased in large quantities.

It was noted, however, that the cost of a rack is not only a function of the raw material cost but also a function of order size, the cost of compounding, molding and shipment.

# Approach

- Analyze product availability and required formulation
  - Ingredients:
    - Innovene H05H-00 (Polypropylene Homopolymer)
    - Luzenac R-7 (Talc)
    - Formulation: 70/30
  - Determine
    - Compounder (Omni Plastics)
    - Rack Molder (AllPax)
  - Assess Material Availability

The first step in the project is the determination of the appropriate formulation. Because of the rack size( 30inch x 30”), container size (poly tray) and the retort environment (spray), the compound formulation used in STP2007 (75%/25%) might need to be adjusted.

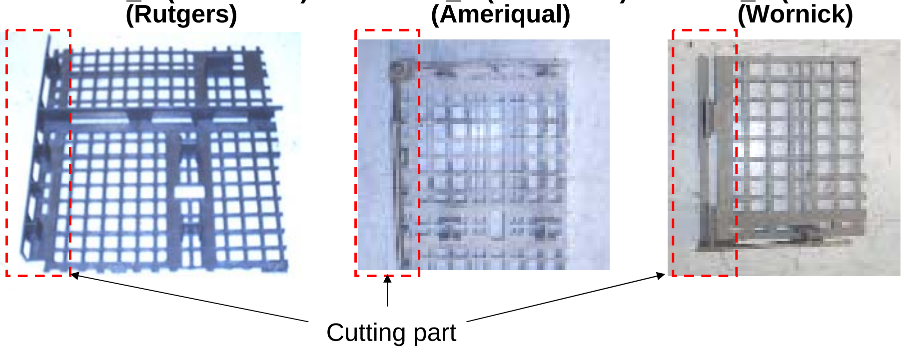
TAMU requested racks from Racks from Rutgers(original, not used), Ameriqual(frequent used in commericial process) and Wornick (used for H&S)

Mechanical properties of the three racks were measured and compared to lab test data of various H-PP/Talc formulations

# Preparation of Specimen

1. Rack (Order of package)

**RACK_A (14% Glass) (Rutgers)** | **RACK_B (17% Glass) (Ameriqual)** | **RACK_C (17% Glass) (Wornick)**




→Specimens prepared from the same location of each rack

In this slide we see samples of each of the racks.

The analysis of each rack indicated that the Rack A had less fiber glass than the racks B and C

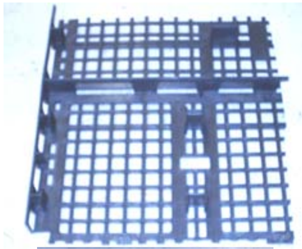
Samples for the tensile test and Izod test were taken from the rack section as indicated.

Mark Thomas commented that samples taken from a molded rack can yield different values as the properties are affect by the material flow in that section.

Dr Sue indicated that we would normally have molded the test pieces directly, but he had no access to the raw material in the short time frame

Rieks Bruins noted that the official records for all three racks indicated that they were molded with 15% medium size fiber glass

Mark Thomas also indicated that the variation in % fiber can be explained by batch to batch variation.



**Rack : A (Rutgers)**
-**Color : Black**
-**Type : D.E.I**
-**MOID # : 577**
-**Date (month/year) : 02/2003**

**Rack : B (Ameriqual)**
-**Color : White gray**
-**Type : D.E.I (same)**
-**MOID # : 577 (same)**
-**Date (month/year) : 01-04/2003**

**Rack : C (Wornick)**
-**Color : Dark gray**
-**Type : D.E.I (same)**
-**MOID # : 577 (same)**
-**Date (month/year) : 01-04/2003**

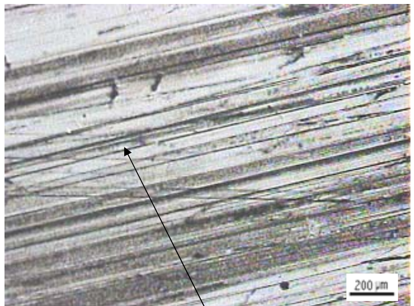
In the above picture the detail of each rack is given as indicated by the stamp in the center of the rack.

It should be noted that the color of Rack A is black. This rack was molded prior to the other racks as indicated by the mold date. It should also be noted that the color of the Ameriqual rack is lighter than the Wornick rack, indicating probably higher useage and thus leaching out some of the color.

Rutgers had a rack with the same mold date and a sample of this rack was send to TAMU for comparison. Test data of this sample is pending

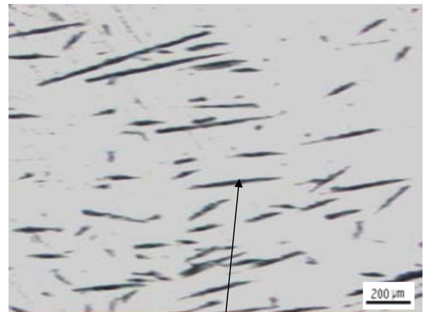
## Specimen Surfaces

**< Before Polishing >**




**Surface scratch on specimen**

**< After Polishing >**




**Micro glass fiber**

The above microscopic picture is from the surface of the rack. Once polished the glass fiber is clearly visible. The size of the fiber is around 200 µm, significant shorter than seen in the previous racks molded from an unknown polypropylene/long fiber glass for the Stock 1100 retorts and much better distributed

# Testing condition

1. Tensile test (ASTM D-638)

   1) 5 specimens

   2) Strain rate : 5mm/min

   3) Date acquisition from INSTRON and extensometer

< A >

< B >

< C >

Above pictures are of the test samples that were cut from the rack

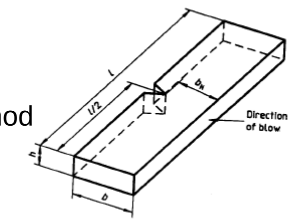
# Test condition

2. Izod impact test (ASTM D-256)

1) 5 specimens

2) Same dimension of charpy impact test method

3) $a_{cN}\ (a_{iN}) = \frac{W}{h \times b_N} \times 10^{3}$



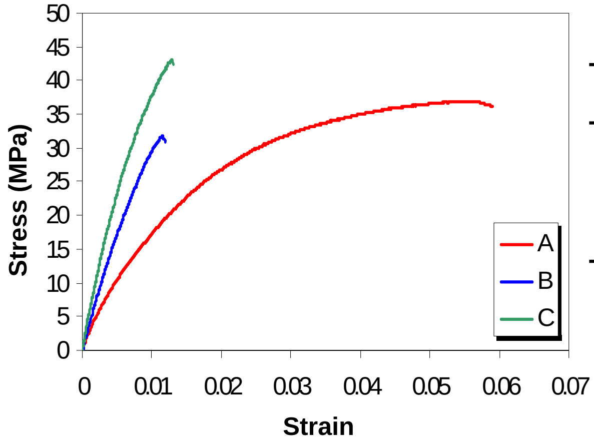

< A >

< B >

< C >

Above are pictures of samples that were cut from the rack for the impact test

## Tensile Behavior




| | Modulus (GPa) | T.S. (MPa) |
|---|---|---|
| A | 2.15±0.24 | 35 |
| B | 4.02±0.64 | 33 |
| C | 4.95±0.65 | 42 |

- Modulus : C > B > A
- Tensile strength : Rack C shows 20% higher than others
- Elongation at break : A(7.6%), B(1.2%), C(1.4%)

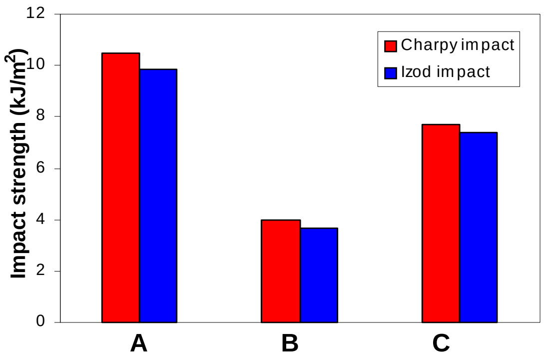
Above are the results of the tensile test. We can observe the following:

Rack A rack is more ductile

The B and C racks have lost their ductility. Is this caused by the age and use of the rack, or was the rack made with a different formulation, or a combination of both? [Sample A has less amount of glass fibers, as well]

The B rack has a lower tensile strength value than the C rack which might be due to the higher number of retort cycles that the B rack was exposed to. Ameriqual estimates that their rack might have seen as many 1,000 – 1,500 retort cycles

# Impact Strength




| | Impact strength ($kJ/m^2$) | |
|---|---|---|
| | Charpy | Izod |
| A | 10.5±0.82 | 9.83±1.41 |
| B | 4.0±0.49 | 3.67±1.07 |
| C | 7.7±0.20 | 7.39±2.24 |

- Impact strength : A > C > B
- Impact strength of charpy is higher than that of Izod
- Izod impact test result shows higher STDEV value than charpy

The Rutgers supplied rack (A) shows improved impact resistance (capability to absorb energy before breaking) than the “used” racks supplied by Wornick and Ameriqual.  This might be due to the number of retort exposures of the rack, indicating that the rack is becoming less impact resistant after use.

This observation is in contrast with the candidate material (STP 2007).  The candidate material actually has a slight improvement on impact strength after the retort exposure.

# Comparison

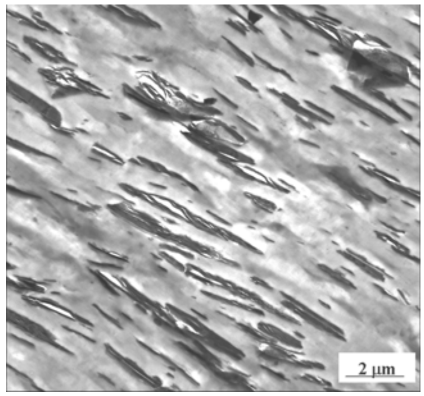
| Sample | Elastic Modulus (GPa) | Tensile Strength (MPa) | Izod Impact Strength ($kJ/m^2$) |
|---|---|---|---|
| **H-PP** | **2.08±0.11** | **38** | **2.5±0.13** |
| **35wt%_H-PP/talc** | **5.48±0.28** | **35** | **1.9±0.16** |
| ***30wt%_H-PP/talc*** | ***4.31±0.39*** | ***35*** | ***2.2±0.48*** |
| **25wt%_H-PP/talc** | **3.73±0.14** | **37** | **2.4±0.30** |
| **30wt%_H-PP/$CaCO_3$** | **2.84±0.10** | **31** | **2.5±0.35** |
| **RACK_A** | **2.15±0.24** | **35** | **9.83±1.41** |
| **RACK_B** | **4.02±0.64** | **33** | **3.67±1.07** |
| **RACK_C** | **4.95±0.65** | **42** | **7.39±2.24** |

Above table summarizes the mechanical properties of the three racks and compares the values to various formulations.

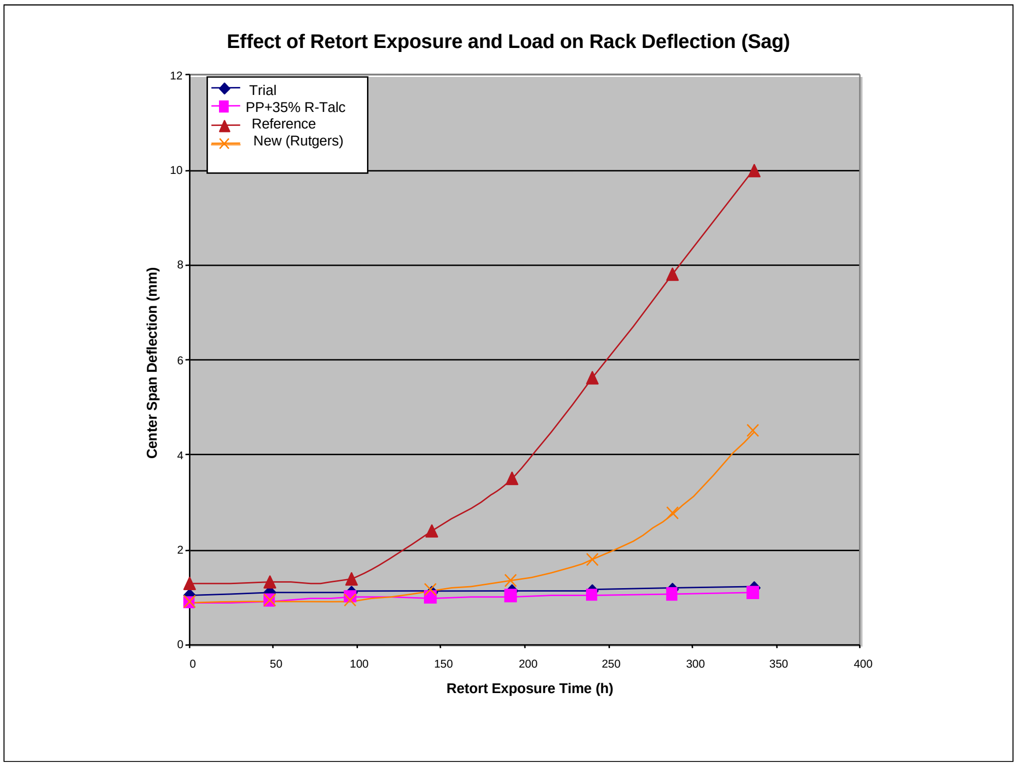
The recommended formula is a 70% H-PP and 30% Talc.

The reasons for selecting this formulation is that this formulation has a sufficient stiffness, as compared with Rack B and C. As a result, it should have good "sag" resistance. Also, the impact strength was not much an issue when SOPAKCO did the field trial for one year. They did not observe fracture on any of their racks. Therefore, the proposed formulation should work for the current needs.

Candidate Material @ 35wt%)



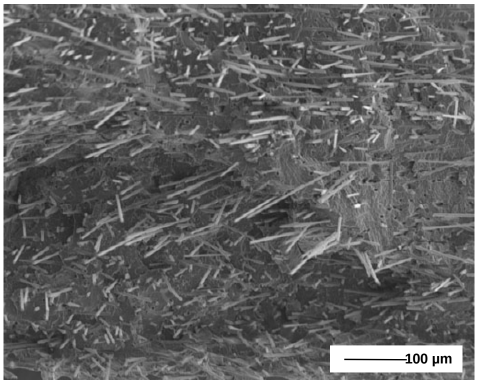

Above microscopic picture is of a test sample with 35% talc. The size of the talc particles (2 µm) is an order of magnitude smaller than the fiber glass used in the GE material (200 µm).



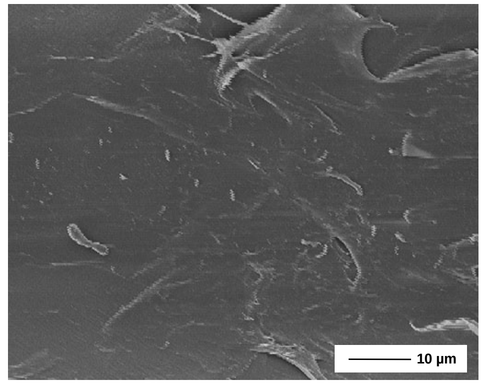

This graph depicts the deflection of test strips that are exposed to a steam environment (@ 120°C). The trial sample is H-PP with 25% talc and the 35% sample is H-PP with 35% talc. The New (Rutgers) is the GE PPX-15 material and the reference is the original material used in retort racks (unknown polypropylene with 15% long glass fiber). The last two samples were cut directly from a rack, the first two samples were molded into the test strips.

This information indicates that the proposed material has the potential to be significant better than the material so far used as it doesn't degrade over time. We should however note that 1) the test was done in a steam environment and not in a spray retort, 2) a difference exist in preparing the test samples.

## SEM Analysis of Exposed Surfaces




Reference Sample




Candidate @30%Wt

The above pictures are from the reference material (unknown polypropylene with 15% long glass fiber) and the proposed material (70%H-PP / 30% Talc). The first sample is taken from a molded rack. The second sample is taken from a molded test strip

# Summary and Recommendation

1. Mechanical Screening of the reference material and candidate material has been completed
2. The recommended formulation is 70% PP / 30% R7-Talc
3. There is still a need to validate the newly molded racks to confirm the rack mechanical properties and talc dispersion

The recommended test material is a 70%/30% based on the analysis of the reference rack and comparing it to candidate material.  Once the racks are molded, samples will be taken from these racks to compare the mechanical properties of the rack.  Also, the compounder will mold around 200 ASTM test strips from the compound

This concluded the presentation given by Dr Sue,

## Phase II: Test Protocols

- Initial Rack Performance
- Medium Range Rack Performance
- Long Range Rack Performance

Rieks Bruins continued the presentation by reviewing the proposed test protocols that would be used in evaluating the racks once molded.

Testing will consist of three phases as indicated above

# Initial Rack Performance

- Characterization New Rack
- Loaded with Polymeric Half Steam Table Tray
- One Pallet Retorted @ 260 F for 60 min (2 times)
- Test for Rack Sag
- Drop Test
  - 2 ft height
  - All corners and sides (10 drops)

The initial test phase is the Initial Rack Performance.

The racks will be characterized in regards to dimension and weight. Rutgers will supply adequate number of polymeric trays for this test. A single pallet load will be retorted at 260 F for 60 min. At the end of each retort step three racks will be selected for analysis of sag.

After completion of the two retort runs, the three selected racks will be tested in a drop test in which the rack will be dropped from a height of 2 ft. on all corners and sides for a total of 10 drops

Results will be compared to the results obtained from a similar test conducted at Stegner Foods with the reference GE-PPX15 material

## Medium Range Performance

- Load with production trays
- Each retort stack can only hold one type rack
- Keep log sheet on number of retort cycles
- Pull one rack every month for potential analysis by TAMU
- Keep Log when rack is no longer serviceable and reason.

After the initial test, the racks will be put into production at Ameriqual and Ameriqual will need to maintain a log on the number of retort cycles the racks are exposed to.

To keep track of the racks, each rack will be uniquely numbered and the date that a rack is placed in service will be logged

The proposed protocol requires that Ameriqual inspects the racks on a monthly basis and log any deficiencies in the rack.  Also Ameriqual will ask that one rack is removed from the production queue every month and set aside for analysis.

If a rack is not longer useable, it will be removed from the production queue and the reason for removal logged, including a picture of the deficiencies.

The removed rack will need to be replaced with a new rack to complete the stack height.  The ID of the new rack will be logged with the date of “placed in service”

# Long Range Performance

- Load with production trays
- Each retort stack can only hold one type rack
- Pull one rack every 6 month for potential analysis by TAMU
- Keep Log when rack is no longer serviceable and reason.

After six month, Ameriqual will be asked to continue to use the racks and keep a log when a rack is taken out of service. Every month Ameriqual will be asked to estimate the number of retort cycles that the racks that are in service were exposed to.

At month 12, 18 and 24 month, Ameriqual will be asked to remove one rack from the production queue and set aside for analysis

Once more than 50% of the racks have been taken out of service, the long range performance test will be concluded

# Compounding and Molding Racks (Phase III)

- Compounding
  - Quantity: 4,000 lbs
  - Color: Black
  - Need a updated quote
  - Recommended Injection Mold Setup Data
- Molding
  - Quantity: 200 racks
  - Color: Natural
  - Need an updated quote
  - Uniquely number each rack

To mold about 200 racks, we will need about 4,000 lbs of compound. Omni Plastics indicated that the pellet size of the compound will be about 1/8" diameter by 1/8" long. After some discussion with the Mark Thomas, we decided to add some carbon black to the compound for coloring purpose (<0.5%) and thermo stabilizer (<0.5%). The suggested formula additions were approved by Dr Sue.

To obtain a quote from Omni Plastics, Rutgers will issue a request for quotation, indicating the formulation and requested quantities. It was agreed that appropriate price breakpoints would be 4,000 lb, 20,000 lbs and 40,000 lbs. The quote would have a separate cost for molding the ASTM test strips

Rutgers will contact Scott Williams and request a quotation for molding the retort racks, including a breakdown of setup cost, molding cost, clean up cost. Rutgers will also ask if the racks can be embossed with a unique serial number for rack tracing

# Monitor Performance Rack

- Initial Evaluation: Rutgers/Ameriqual
- Medium Range Evaluation (6 month), Ameriqual/Rutgers
- Long Range Evaluation (till 50% of racks are non serviceable), Ameriqual

Once the racks are molded, once sample rack will be send to TAMU for evaluation and the remainder of the racks will be send to Ameriqual for testing in a 1400 spray retort.

The performance testing will follow the developed protocols for initial, medium range and long range evaluation as indicated above.

# Cost Benefit Analysis

- Compound Cost (function of order quantity)
- Molding Cost (function of order quantity)
- Expected Life Cycle
- Performance existing GE-PPX15 rack
- Other Benefits

Cost benefit calculations will be performed based on the cost information supplied by the compounder and molder

Typical reorder quantity will be 200 racks. Consideration will be given to either purchase additional raw materials and store it or compound it and store the compound and/or mold them into racks and store the racks.

The use cost of the rack is, however, not only a function of the purchase cost. Life cycle time of a rack is a second important factor.

Both Ameriqual and Wornick will be asked to estimate the life cycle time of the reference rack (GE-PPX15) in terms of the average number of retort cycles before a rack needs to be taken out of service.

CENTER FOR ADVANCED FOOD TECHNOLOGY

Food Manufacturing Technology Facility
120 New England Avenue
Piscataway, NJ 08854
732/445-6130 FAX: 732/445-6145

Omni Plastics, L.L.C.
Mark J. Thomas
Vice President of Sales & Marketing
2300 Lynch Road
Evansville, IN 47711

October 31, 2006

RE: Request for Quotation

Dear Mr. Thomas,

The Center for Advanced Food Technology is requesting a quotation for a specific compound at three different order levels.

Application:
Retort Racks, temperatures not to exceed 275 F.

Compound Description:

| | |
|---|---|
| Innovene H05H-00, (Polypropylene Homo polymer) | 70% |
| Luzenac R-7, (Talc) | 30% |
| Carbon Black for coloring | <0.5% |
| Heat Stabilizer | <0.5% |

Note: No substitution allowable for the Innovene H05H-00 and Luzenac R-7

Order Quantity:

| | |
|---|---|
| Option #1: | 4,000 lbs |
| Option #2: | 20,000 lbs |
| Option #3: | 40,000 lbs |

Please give me a call if you have any questions,

Sincerely,

Rieks Bruins

Omni PLASTICS

2300 Lynch Road
Evansville, IN 47711
812-421-8900
812-421-8915 (fax)

11-13-2006

Rieks Bruins
CAFT/FMT Facility
120 New England Avenue
Piscataway NJ 08854

Dear Rieks,

Per our meeting last week and your follow up notes, the Omni product code for the material we defined will be **HPP TF307 HS BK500**

Pricing per release quantity is as follows:

40000 lbs. @ $1.24
20000 lbs. @ $1.26
4000 lbs. @ $1.56

To set up and mold 200 test specimens for ASTM or ISO testing will be $450

Please give me a call if you have any questions.

Mark Thomas

VP of Sales
Omni Plastics, LLC

2300 Lynch Road
Evansville, IN 47711
812-421-8900
812-421-8915 (fax)

***Lot #:*** OM66997

***Product:*** HPP TF307 HS BK500

***Date / Time***
***Molded:*** 1/9/07 4:00 p.m.

***Date Tested:*** 1/12/07 8:00 a.m.

☐ REQUIRES C of A
☐ REFERENCE CUSTOMER SPECIFICATIONS
☐ REFERENCE INTERNAL SPECIFICATIONS

***Testing:***

| TEST | ASTM | UNITS | RESULTS |
|---|---|---|---|
| Tensile Strength | D638 | PSI | 5,630 |
| | | Mpa | 38.8 |
| | | | |
| Tensile Elongation | D638 | % | 7.2 |
| | | | |
| Flexural Strength | D790 | PSI | 9,500 |
| | | Mpa | 65.5 |
| | | | |
| Flexural Modulus | D790 | PSI | 605,000 |
| | | Mpa | 4,171 |
| | | | |
| Izod Impact Strength | D256 | ft.lbs / in | 0.61 |
| | | j/m | 32.56 |
| Specific Gravity | D792 | | - |
| Flow Rate * | D1238 | gr / 10 minutes | 8.2 |
| Ash * | D2584 | % | 28.4 |
| Moisture | n/a | % | 0.07 |

* = if applicable

***Tests Administered By:*** MRM

☐ ENTER IN ACCESS BY __________

***Sample Comments:***

Properties and values herein are based on laboratory test specimens and should not be used to establish minimum specification limits or fabricate tooling

Omni does not guarantee the accuracy of this information or the suitability of this product in any given application or usage situation.

ALLPAX

CORANET
QUOTE # Q-06--01-P1
Effective Date: November 28, 2006
Expiration Date: December 31, 2006


PROJECT PRICING

| ITEM | QTY | DESCRIPTION | EACH | TOTAL |
|---|---|---|---|---|
| 1 | 1 | Mold Set-up Cost – one time cost for setting the mold up in a molding machine to produce injection molded trays from PP based resin formulation. Cost includes purging the mold, setting up, testing, and tuning the process. After molding the mold is purged, cleaned, removed from molding center and returned to storage. | 2,150.00 | 2,150 |
| 2 | 200 | Injection Molded Poly Tray Racks produced from PP based material supplied by Coronet | 21.20 | 4,240 |
| 3 | 1 | Label Setup Charge – Produces unique individual serial numbers molded into the tray for identification and tracking purposes. | 690.00 | 690.00 |
| 4 | 1 | Mold Set-up Cost – one time cost for setting the mold up in a molding machine to produce injection molded trays from PPE/PP glass reinforced resin formulation. Cost includes purging the mold, setting up, testing, and tuning the process. After molding the mold is purged, cleaned, removed from molding center and returned to storage. | 2,950.00 | 2,950.00 |
| 5 | 200 | Injection Molded Poly Tray Racks produced from PPE/PE glass reinforced resin formulation. Material will be supplied by Allpax and cost of material is included in this line item. | 66.75 | 13,350 |
| 6 | 1 | Label Setup Charge – Produces unique individual serial numbers molded into the tray for identification and tracking purposes. | 690.00 | 690.00 |

**STP#2022 Test Protocol**
**Initial Rack Performance**

**Materials:**

**Racks:** 200 retort racks molded with Tamu material. The color of the rack will be "Black". Each rack will be uniquely numbered.

**Product:** 150 trays water filled polymeric trays from the Demo facility

**Retort:** FMC 1400 Spray Retort with six pallets. Bottom of pallet needs to be designed to support rack in load bearing points

**Retort Test Program:**
Come Up Phase: 15 minutes to 264 F and 41 psig
Hold Phase 60 min @ 261 F and 41 psig
Cool Phase: 60 min

**Retort Load:**
Single pallet with 13 layers @ 8 water filled trays/layer (maximum layers is a function of on pallet height)

**Test Methodology:**

Select at random 13 racks from the retort racks that were supplied by the molder. Number racks: 1 through 13.

**Characterization Original Rack**
Select rack 1, 7 and 13 and characterize
- Rack Length
- Rack Width
- Rack Height at load bearing points
- Pocket sag of bottom, middle and top rack

**Retort Run #1**
Load Retort with trays face down and process according to retort test program. Rack #1 at bottom, Rack #7 in the middle and rack #13 on top

**Characterization Rack (1)**
Pocket sag of bottom(#1), middle (#7) and top rack (#13)

**Retort Run #2**
Load retort racks in reverse order with trays face down and process according to retort test program. Rack #13 at bottom, Rack #7 in the middle and rack #1 on top

**Characterization of a Retorted Rack (2)**

Rack Length
Rack Width
Rack Height at weight bearing points
Pocket sag of bottom (#13), middle (#7) and top rack (#1)

**Drop Test**

**Test Protocol:** After the rack has been tested for deformation (see above test protocol), three racks (#1, #7 and #13) will be tested for impact resistance by dropping the each rack on all sides and corners from a 2 ft height on a concrete floor for a total of 10 drops in the following order: (1, 2, 3, 4) each corner of the rack; (5, 6, 7, 8) flat-wise drop on each side of the rack and (9,10) flat-wise drop on top and bottom of the rack. The 2 ft drop height is defined as the distance from the lowest point of the rack to the ground.

Trip Report Rack Project (STP#2022)
Date 3/20-23/07
Location: Ameriqual Foods Evansville

**Objective**

The objective of the trip was to conduct an initial stress test on the retort rack. The retort racks (200) were molded by Allpax from the material compounded by Omni Plastics (HPP TF307 HS BK500), based on a formulation that was recommended by Dr Sue from Texas A&M. The racks were received by Ameriqual on and about 1/27/07 and placed in storage. Polymeric Trays, filled with water, were produced at the CORANET Demo Site were used to fully load each rack during the initial stress test. Ameriqual developed a high temperature retort program for their FMC 1400 spray retort (unit #12) that was similar to the one executed by Stegner in the validation and evaluation of the PPX-615 material..

Ameriqual normally uses pallet bottom to directly support the retort rack. Upon inspection of the bottom, it was determined that the frame does not support the rack in the load bearing points, which could increase stresses in the rack and cause unintended deformation of the rack. It was recommended to use a metal perforated plate on top of the pallet bottom to remedy this situation.

**Initial Rack Height and Dimension Measurement**

One rack was selected for an initial dimension analysis of width, length and height. The initial rack dimension was 98.0 cm long and 94.5 cm wide. If we compare this to the dimension of the mold (99.1 cm by 95.7 cm), we can see that some shrinkage of the rack has taken place during the de-molding process. The results of the height analysis can be seen in the appendix. There exist slight height variations in the rack, the “I” beams are slightly higher than the outside walls. This is the opposite as was observed when the rack was molded from the PPX-615 material, at which time the “I” beams were slightly less in height than the rest of the rack. The overall rack has however enough flexibility to compensate for these height variations and still assure that the weight of the rack is distributed over the load bearing points.

**Initial Retort Test**

For the initial retort test, Ameriqual constructed a perforated steel plate that fitted on top of the pallet bottom and supported the rack in all load bearing points. This setup was used for the initial performance testing of the rack in which a fully loaded stack of racks (12). The stack was processed in a FMC 1400 spray retort for 1 hr at 260 F, followed by a pressure cool to bring the product temperature back to ambient temperature. In the first retort cycle the trays were loaded up-side-down. The order of the racks in the stack was as follow:

| **80: Top** |
|---|
| 79 |
| 78 |
| 77 |
| 76 |

| |
|---|
| 75 |
| **74: Middle** |
| 73 |
| 72 |
| 71 |
| 70 |
| **69: Bottom** |

After the first retort run three racks (80, 74 & 69) were selected for sag measurements. The sag was determined in both directions by laying a straight edge (12 inch) across each pocket and measure the sage of the rack in the middle of this straight edge. The measurements were recorded in millimeters together with the pocket number. The following pocket numbering code was used:

| | | |
|---|---|---|
| 1 | Back<br>2 | 3 |
| Left 4 | | 5 Right |
| 6 | 7<br>Front | 8 |

Pocket Numbering Protocol

| Retort | Container | Plate | Layer | ID | Pocket | Deflection F-B | Deflection L-R |
|---|---|---|---|---|---|---|---|
| 1 | Down | Yes | Top | 80 | 1 | 0.8 | 1 |
| 1 | Down | Yes | Top | 80 | 2 | 0.6 | 1 |
| 1 | Down | Yes | Top | 80 | 3 | 1.2 | 1 |
| 1 | Down | Yes | Top | 80 | 4 | 0.4 | 1 |
| 1 | Down | Yes | Top | 80 | 5 | 1.3 | 1.4 |
| 1 | Down | Yes | Top | 80 | 6 | 1.5 | 0.7 |
| 1 | Down | Yes | Top | 80 | 7 | 0.4 | 0.7 |
| 1 | Down | Yes | Top | 80 | 8 | 1.7 | 0.7 |
| 1 | Down | Yes | Middle | 74 | 1 | 1.3 | 1.1 |
| 1 | Down | Yes | Middle | 74 | 2 | 0.8 | 0.3 |
| 1 | Down | Yes | Middle | 74 | 3 | 1.7 | 1.4 |
| 1 | Down | Yes | Middle | 74 | 4 | 0.8 | 1.2 |
| 1 | Down | Yes | Middle | 74 | 5 | 0.8 | 1.9 |
| 1 | Down | Yes | Middle | 74 | 6 | 2.3 | 1.2 |
| 1 | Down | Yes | Middle | 74 | 7 | 1.2 | 0.5 |
| 1 | Down | Yes | Middle | 74 | 8 | 1.7 | 2.2 |
| 1 | Down | Yes | Bottom | 69 | 1 | 0.6 | 0.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | Down | Yes | Bottom | 69 | 2 | 1.2 | 0.9 |
| 1 | Down | Yes | Bottom | 69 | 3 | 0.7 | 1.1 |
| 1 | Down | Yes | Bottom | 69 | 4 | 1.1 | 0.6 |
| 1 | Down | Yes | Bottom | 69 | 5 | 0.7 | 0.7 |
| 1 | Down | Yes | Bottom | 69 | 6 | 1 | 0.6 |
| 1 | Down | Yes | Bottom | 69 | 7 | 2 | 1.4 |
| 1 | Down | Yes | Bottom | 69 | 8 | 0.9 | 0.4 |

"Deflection F-B" is the deflection in the direction Front to Back. "Deflection L-R" is the deflection in the direction Left to Right. The average sag in the pocket was 1.1 mm (F-B direction) and 0.9 mm (L-R direction). Most of the deflection was observed in the middle layer.

The retort racks were then reloaded in reverse order, but now with the lid stock up. The order of the racks in the stack was as follow:

| |
|---|
| **69: Top** |
| 70 |
| 71 |
| 72 |
| 73 |
| **74: Middle** |
| 75 |
| 76 |
| 77 |
| 78 |
| 79 |
| **80: Bottom** |

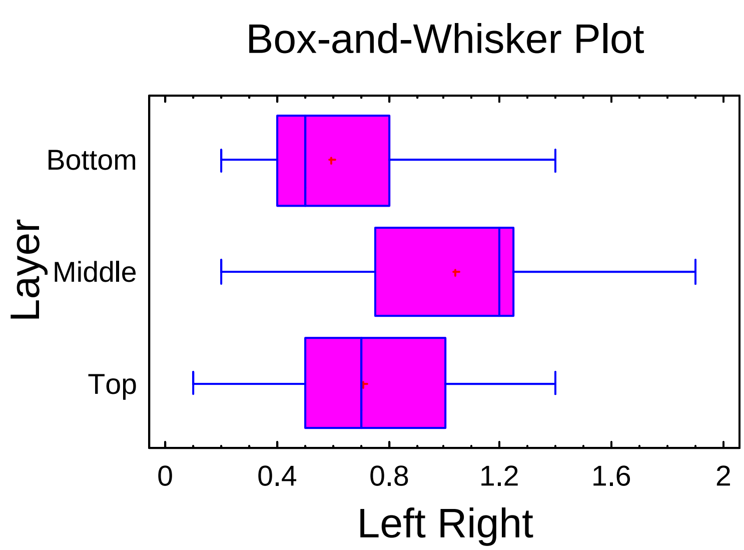
The single stack of racks was then reprocessed in a FMC spray retort for 1 hr at 260 F, after which the stack was removed from the retort. Again rack 69, 74 and 80 were inspected for sag. The sag was determined in both directions by laying a straight edge (12 inch) across each pocket and measure the sage of the rack in the middle of this straight edge. The measurements were recorded in millimeters.

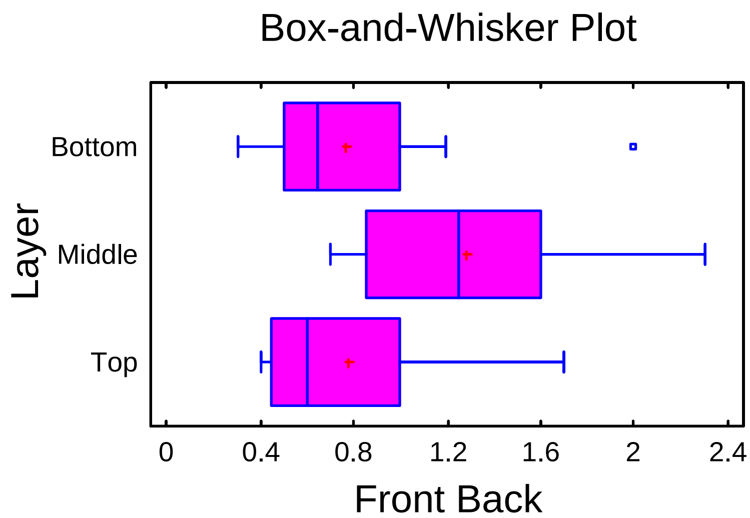
| Retort | Container | Plate | Layer | ID | Pocket | Deflection F-B | Deflection L-R |
|---|---|---|---|---|---|---|---|
| 2 | Up | Yes | Top | 69 | 1 | 0.8 | 0.1 |
| 2 | Up | Yes | Top | 69 | 2 | 0.6 | 0.5 |
| 2 | Up | Yes | Top | 69 | 3 | 0.6 | 0.6 |
| 2 | Up | Yes | Top | 69 | 4 | 0.5 | 0.9 |
| 2 | Up | Yes | Top | 69 | 5 | 0.5 | 0.4 |
| 2 | Up | Yes | Top | 69 | 6 | 0.4 | 0.6 |
| 2 | Up | Yes | Top | 69 | 7 | 0.4 | 0.5 |
| 2 | Up | Yes | Top | 69 | 8 | 0.7 | 0.6 |
| 2 | Up | Yes | Middle | 74 | 1 | 1.8 | 1.2 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2 | Up | Yes | Middle | 74 | 2 | 0.9 | 0.2 |
| 2 | Up | Yes | Middle | 74 | 3 | 1.3 | 1.1 |
| 2 | Up | Yes | Middle | 74 | 4 | 1.2 | 1.4 |
| 2 | Up | Yes | Middle | 74 | 5 | 1.1 | 1 |
| 2 | Up | Yes | Middle | 74 | 6 | 1.5 | 1.2 |
| 2 | Up | Yes | Middle | 74 | 7 | 0.7 | 0.4 |
| 2 | Up | Yes | Middle | 74 | 8 | 1.5 | 1.3 |
| 2 | Up | Yes | Bottom | 80 | 1 | 0.3 | 0.4 |
| 2 | Up | Yes | Bottom | 80 | 2 | 0.5 | 0.5 |
| 2 | Up | Yes | Bottom | 80 | 3 | 0.4 | 0.5 |
| 2 | Up | Yes | Bottom | 80 | 4 | 0.5 | 0.4 |
| 2 | Up | Yes | Bottom | 80 | 5 | 0.4 | 0.2 |
| 2 | Up | Yes | Bottom | 80 | 6 | 0.5 | 0.2 |
| 2 | Up | Yes | Bottom | 80 | 7 | 1 | 0.9 |
| 2 | Up | Yes | Bottom | 80 | 8 | 0.5 | 0.2 |

The average sag in the pocket was 0.8 mm (F-B direction) and 0.6 mm (L-R direction), somewhat less than observed with the lid stock down. Most of the deflection was again observed in the middle layer.

Summarizing the sag measurements of both retort runs, we can visually show the average sag in each of the three layers and demonstrate that the sag in the middle layer is the greatest. The sag in the bottom layer is comparable to the sag in the top layer, an indication of the positive effect of the perforated plate in supporting the bottom rack.






Based on the above observations, it is concluded that the selection of the rack material in combination with the use of the perforated plate to fully support the bottom rack seem to be adequate to assure that the sag of the rack is limited to less than 3mm. This performance is as good as the PPX-615 material during the same test at the acceptance test of the rack at Stegner Foods. Performance of the rack during the next six month will need to confirm if the longer but at lower retort temperature and continuous exposure to the spray environment exposure causes additional sag and/or hardening of the rack material due to the leasing out of the plasticizer.

It should be noted that the flow ribs on the underside of the rack have a significant function in supporting the rack. Damage of these flow/support ribs can cause the rack to weaken and cause additional sagging of the rack. Especially if one of the flow channel ribs breaks in any of the load bearing points, then incremental sag can be expected in the racks above this defective rack, and possibly lead to problems with temperature distribution

**Post Retort Rack Dimension Analysis**
Three racks (69, 74 and 80) were evaluated for post retort width and length analysis. The corner dimensions of all three racks had shrunk slightly (from 98.0 cm by 94.5 cm) to 97.5 cm by 94.3 cm. The shrinkage of the rack is such that they will not longer mate with an un-retorted rack. Therefore all retort racks should be retorted once to induce this shrinkage and be available to go into production at any time. The after retort dimensions are also such that they should not be mated with rack that are molded from the PPX material as the expansion and contraction differences between these two materials can cause permanent damage.

**Drop Test**
Three racks (69, 74 & 80) were used for a 2 ft drop test on all sides and corners. Racks were then evaluated for cracks. None were found. This performance was similar to the observations of the PPX-615 material

**Conclusion:**

- The sag that was measured in the racks was less than 3 mm, which was the performance criteria used when the rack was initially designed.
- The sag of the rack is similar to the sag in the rack molded from PPX-615.
- The sag of the top and bottom rack were less than the sag in the middle rack, but did not increase when exposed to a second retort cycle
- Three racks were exposed to a drop test and all racks passed

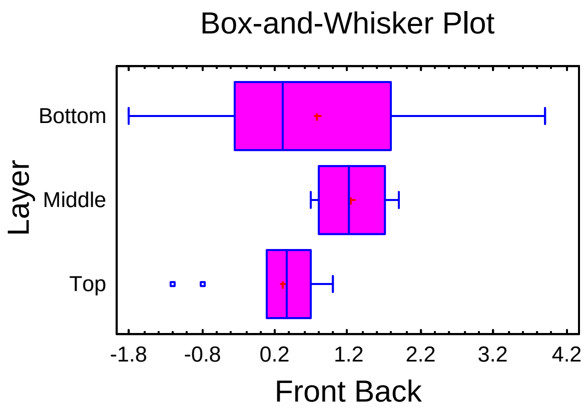
**Evaluation of the Rack Deformation without supporting plate**

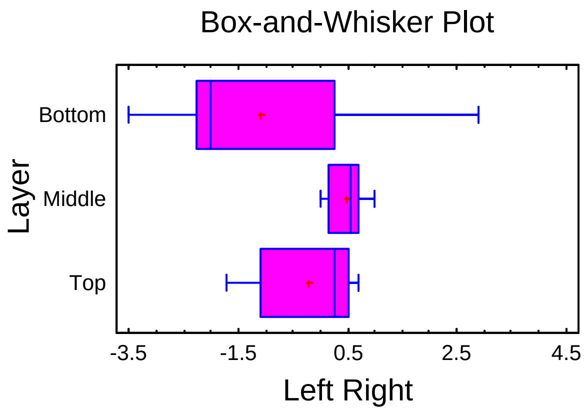
A second initial performance test was performed at the request of Ameriqual. The objective of this test was to determine the sag of the rack if it is supported by the pallet frame without the perforated plate. A new set of racks was used for this test. The same test protocol as previously discussed was used. Data is recorded in the two tables below.

| Retort | Container | Plate | Layer | ID | Pocket | Deflection F-B | Deflection L-R |
|---|---|---|---|---|---|---|---|
| 1 | Down | No | Top | 61 | 1 | 0.5 | 0.5 |
| 1 | Down | No | Top | 61 | 2 | 0.1 | 0.3 |
| 1 | Down | No | Top | 61 | 3 | 1 | 0.5 |
| 1 | Down | No | Top | 61 | 4 | 0.8 | 0.2 |
| 1 | Down | No | Top | 61 | 5 | 0.8 | 0.3 |
| 1 | Down | No | Top | 61 | 6 | 0.6 | 0.3 |
| 1 | Down | No | Top | 61 | 7 | 0.2 | 0.2 |
| 1 | Down | No | Top | 61 | 8 | 1 | 0.5 |
| 1 | Down | No | Middle | 67 | 1 | 1.5 | 0.6 |
| 1 | Down | No | Middle | 67 | 2 | 1 | 0.1 |
| 1 | Down | No | Middle | 67 | 3 | 1.8 | 0.7 |
| 1 | Down | No | Middle | 67 | 4 | 0.7 | 0.5 |
| 1 | Down | No | Middle | 67 | 5 | 0.7 | 0.2 |
| 1 | Down | No | Middle | 67 | 6 | 1.9 | 0.7 |
| 1 | Down | No | Middle | 67 | 7 | 0.8 | 0.1 |
| 1 | Down | No | Middle | 67 | 8 | 1.4 | 0.6 |
| 1 | Down | No | Bottom | 19 | 1 | 0.3 | -2.3 |
| 1 | Down | No | Bottom | 19 | 2 | 3.9 | 2.7 |
| 1 | Down | No | Bottom | 19 | 3 | 0.3 | -2.1 |
| 1 | Down | No | Bottom | 19 | 4 | -1.1 | -3.2 |
| 1 | Down | No | Bottom | 19 | 5 | -1.8 | -3.5 |
| 1 | Down | No | Bottom | 19 | 6 | 0.7 | -2.1 |
| 1 | Down | No | Bottom | 19 | 7 | 3.7 | 2.9 |
| 1 | Down | No | Bottom | 19 | 8 | 0.3 | -2.5 |

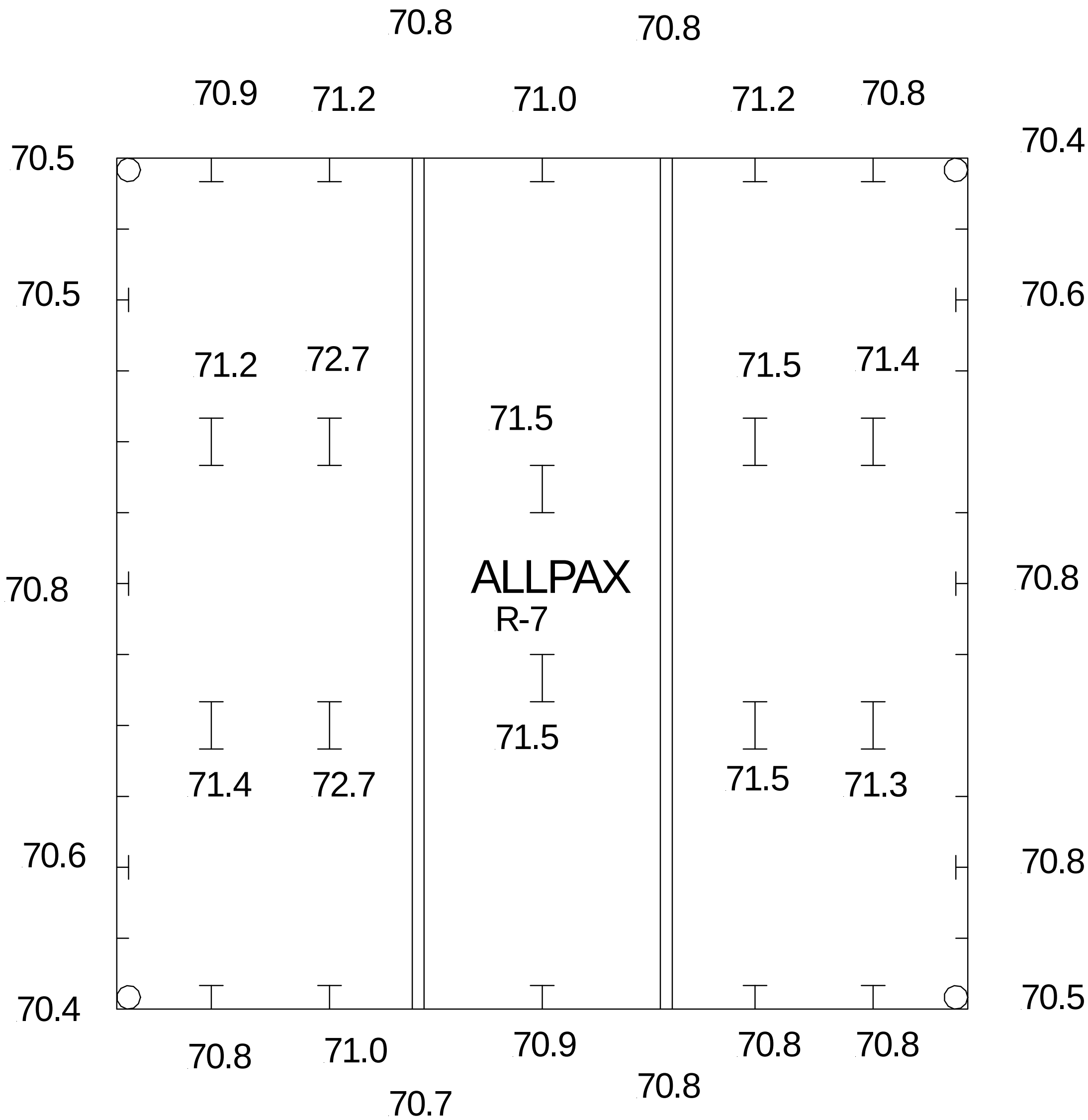
| Retort | Container | Plate | Layer | ID | Pocket | Deflection F-B | Deflection L-R |
|---|---|---|---|---|---|---|---|
| 2 | Up | No | Top | 19 | 1 | 0.2 | -1.2 |
| 2 | Up | No | Top | 19 | 2 | 0.6 | 0.7 |
| 2 | Up | No | Top | 19 | 3 | 0.2 | -1.3 |
| 2 | Up | No | Top | 19 | 4 | -0.8 | -1.3 |
| 2 | Up | No | Top | 19 | 5 | -1.2 | -1.7 |
| 2 | Up | No | Top | 19 | 6 | 0.1 | -1 |
| 2 | Up | No | Top | 19 | 7 | 0.6 | 0.5 |
| 2 | Up | No | Top | 19 | 8 | 0.1 | -1 |
| 2 | Up | No | Middle | 67 | 1 | 1.6 | 1 |
| 2 | Up | No | Middle | 67 | 2 | 0.7 | 0 |
| 2 | Up | No | Middle | 67 | 3 | 1.6 | 0.7 |
| 2 | Up | No | Middle | 67 | 4 | 0.8 | 0.5 |
| 2 | Up | No | Middle | 67 | 5 | 0.8 | 0.4 |
| 2 | Up | No | Middle | 67 | 6 | 1.8 | 1 |
| 2 | Up | No | Middle | 67 | 7 | 0.9 | 0.1 |
| 2 | Up | No | Middle | 67 | 8 | 1.8 | 0.6 |
| 2 | Up | No | Bottom | 61 | 1 | 0.1 | -1.9 |
| 2 | Up | No | Bottom | 61 | 2 | 2.9 | 2.4 |
| 2 | Up | No | Bottom | 61 | 3 | 0.3 | -2 |
| 2 | Up | No | Bottom | 61 | 4 | -0.9 | -2.2 |
| 2 | Up | No | Bottom | 61 | 5 | -0.8 | **-2** |
| 2 | Up | No | Bottom | 61 | 6 | 0.4 | -1.7 |
| 2 | Up | No | Bottom | 61 | 7 | 3.4 | 2.2 |
| 2 | Up | No | Bottom | 61 | 8 | 0.6 | -2 |

We observed in this test that some of the rack pockets in the bottom layer had negative sag (bowed up) due to the shape of the pallet frame and not supporting the rack in the load bearing points. The two graphs below summarize the pocket sag as measured after each retort run. One can see the much larger spread in sag data and well beyond the 3 mm acceptance criteria. Some of the sag is reversed by reverse stacking the racks. However, this bending back of the rack can quickly lead to problems fatigue cracks in the rack, problems with temperature distribution and overall shortening of the life cycle of the rack. The significant sag in the bottom layer actual caused the bottom three rack layers to deform such that when they were reversed stacked that they were not longer properly seating. We can therefore conclude that the perforated plate has very significant effect on maintaining the straightness of the rack and should be used at all times in order to maximize the life cycle of a rack


Box-and-Whisker Plot
Bottom
Middle
Top
Layer
-1.8
-0.8
0.2
1.2
2.2
3.2
4.2
Front Back


Box-and-Whisker Plot
Bottom
Middle
Top
Layer
-3.5
-1.5
0.5
2.5
4.5
Left Right

Appendix


70.8
70.8
70.9
71.2
71.0
71.2
70.8
70.5
70.4
70.5
70.6
71.2
72.7
71.5
71.4
71.5
70.8
ALLPAX
R-7
70.8
71.5
71.4
72.7
71.5
71.3
70.6
70.8
70.4
70.5
70.8
71.0
70.9
70.8
70.8
70.7
70.8

**STP#2022 Test Protocol.**
**Medium Range Rack Performance (0-6 month)**

**Materials:**

**Racks:** 200 retort racks molded with Tamu material. The color of the rack will be "Black". Each rack will be uniquely numbered

**Product:** Polymeric Half Steam table Tray, 4 containers/rack.

**Retort:** FMC 1400 Spray Retort

**Retort Program:**
Come Up Phase: TBD
Hold Phase: 250 F for TBD minutes
Cool Phase: TBD

**Retort Load:**
Six pallet with 13 or 12 layers/pallet, fully loaded with product. Each pallet can ONLY hold one type of retort rack material. Each pallet needs to have a supporting plate on the pallet frame to minimize rack sag.
**Note:** Due to difference in rack shrinkage and contraction, it is not permissible to mix multiple rack materials on the same pallet

**Test Methodology:**
Retorter will be asked to use 195 retort racks with TAMU material in their production process (15 pallet loads @ 13 racks/pallet load)
Company will need to keep a log sheet on the number of retort cycles and number of pallets within that load with the Tamu material, or as an alternative, keep a log sheet at time of filling when the Tamu racks are used.
On a monthly basis, the stack of Tamu racks will be carefully inspected by Ameriqual and any deficiencies noted (as function of the rack ID #)
Each time that a rack fails and needs to be removed, a log will be made of the rack ID# removed and the reason of removal.
A removed rack can be replaced by a new rack. A record will be maintained the new rack ID# that was added to the production queue

**Characterization Rack**
After each month, one rack will be pulled from the production queue and set aside for possible analytical analysis by either Rutgers and/or TAMU (total of 6 racks).

**STP#2022 Test Protocol**
**Long Range Rack Performance (7- till at least 50% of the racks have failed)**

**Materials:**

**Racks:** 200 retort racks molded with Tamu material. The color of the rack will be “Red”. Each rack will be uniquely numbered.

**Product:** polymeric half steam table tray containers, 4 containers/rack

**Retort:** FMC 1400 Spray Retort

**Retort Program:**
Come Up Phase: TBD
Hold Phase: 250 F for TBD minutes
Cool Phase: TBD

**Retort Load:**
Six pallet with 13 or 12 layers/pallet, fully loaded with product. Each pallet can ONLY hold one type of retort rack material. Each pallet needs to have a supporting plate on the pallet frame to minimize rack sag.
**Note:** Due to difference in rack shrinkage and contraction, it is not permissible to mix multiple rack materials on the same pallet

**Test Methodology:**
Retort Company will be asked to monitor the performance of the Tamu racks on an ongoing basis, following their in-house protocols.
Company will be asked to maintain a log of when a rack (including rack ID#) is removed from the production queue and the reason of removal/failure.
Company will be asked to estimate the number of retort cycle the Tamu racks see on a monthly basis

**Characterization Rack**
After 12, 18 and 24 month, one rack will be pulled from the production queue and set aside for possible analytical analysis by either Rutgers and/or TAMU (3 racks)