Best Practice Recommendations for Local Manufacturing of Ceramic Pot Filters for Household Water Treatment

Justine Rayner
Daniele Lantagne, PE
The Ceramics Manufacturing Working Group
Outline

• Introduction
• Filter Efficacy
• Overview of Filter Production & Current Practices
• Summary of Manufacturing Recommendations & Guidelines
• Areas for Further Research
• Conclusions
Introduction

• International Ceramic Pot Workshop
  – Disinfection 2009, February
  – Independent workshop organized by Delft University
  – 74 attendees

• Ceramic Manufacturing Working Group
  – Series of conference calls
  – Survey filter factories
  – Best practice recommendations
Ceramics Manufacturing Working Group

Goal:

*Provide guidance to assist filter factories in producing the most effective ceramic filters possible at the lowest cost.*

Objectives:

- Summarize existing knowledge
- Identify lessons learned
- Make production recommendations
- Identify future research
Filter Efficacy

• Effective at removing:
  – > 99% of protozoa
  – 90-99% of bacteria

• Associated with reduction in diarrheal disease

• High user acceptability & potential for long-term use
Survey

35 Factories in 18 countries identified (July 2009)
18 Factories participated in the survey
- considers 8 Myanmar factories as 1 (25 total)
Filter Production

• Prepare Raw Materials
  – Water, Clay, Burn-out Material, Additional Materials (Grog, Sand, Laterite)
• Prepare Filter Mixture (pre-established ratio)
• Press Filter Shape
• Drying & Surface Finishing
• Stack and Fire Kiln
• Quality Control Inspections and Testing
• Apply Silver
• Package for Sale
Production Consistency

• Prototype filters
  – filter mixture ratio
  – specific flow rate
  – microbiological testing

• Flow rate
  – indicator of filter quality
  – production consistency

*With consistent materials and production, filters that pass flow rate testing should be representative of prototype filters.*
Flow Rate is also affected by:

- Clay characteristics
- Burn-out material
  - type
  - particle size
- Mixture ratio
  - including water & additional materials
- Firing conditions
  - location in kiln & heat distribution
  - firing profile & peak temperature
  - atmosphere
Clay

“Poor quality clay can result in a failure rate of over 20%”

Most factories get clay from the same source, 17% (3 of 18) do not.

- source
- location in the mine

Clay evaluation: consistency & characteristics

- shrinkage
- porosity
- maturation range
Burn-out Material

“Sawdust from different woods have different effects on filters: some pass on color and odor to the filters”

• Sawdust
  – The type of wood varies at 45% of the factories that use sawdust (5 of the 11)

• Rice husks
  – inner rice husks (bran)
  – outer rice husks

Monitoring & evaluation of burn-out material
  – consistent source
  – consistent processing
  – humidity
80% (13 of 16) of factories adjust their formula regularly or as needed depending on:

- where in the mine the clay comes from
- clay source
- burn-out characteristics
- based on experience
- the climate and the humidity of materials
- to achieve the desired flow rate
- other quality control issue

*When the filter mixture ratio is changed, efficacy should be confirmed with microbiological testing*
Firing

“Success depends on the person firing the kiln”

To monitor firings, factories use
- a pyrometer (50%)
- pyrometric cones (28%)
- both (22%)
- only one factory uses the 3 cone method

Monitoring and controlling firings:
- temperature range of clay
  - strength & porosity
- firing profile
- even heat distribution in the kiln
  - kiln characteristics
  - firing technique
- complete combustion of burn-out material
Production Logs

“We have introduced SPC and check all process parameters including: filter weight, drying time, kiln temperature, visual faults and filtration rates”

72% (13 of 18) always maintain production logs, the information recorded varies.

Production logs can aid in:

– calling attention to process details
– repeatability of process
– troubleshooting
– research
Failure Rates

Number one reason for filter rejection at 60% (9 of 15) of the factories: Flow rate

Standardization of quality control tests

- visual & auditory inspections
- pressure & flow rate tests
### Factory Established Flow Rates

#### Flow rate testing guidelines
- 100% of filters
- Saturation time
- Determining flow rate

#### Filter Flow Rates

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<th>Factory</th>
<th>Filter Capacity (L)</th>
<th>Filter Depth (cm)</th>
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**Disinfection 2011**
Microbiological Testing

• 72% (13 of 18) report carrying out microbiological testing regularly
  – 61% test between 0.2%-15% of filters at a laboratory, at the factory or both

Testing Guidelines
  – indicator selection
  – in-house testing methods
  – frequency of testing & percentage of filters
Summary of Recommendations

• Raw materials evaluations & consistent materials processing
• Consistent filter production
  – mixture preparation, pressing, drying
• Consistent firing
  – monitoring & controlling firing temperature & firing curve
• Quality control
  – visual & auditory inspections and pressure & flow rate tests
• Silver dilution and application
  – 64mg of colloidal silver applied by brushing, to each filter
• Microbiological testing
  – 0.1% of filters at a laboratory & 1% at the factory (minimum)
• Information to document & sample logs
  – materials characteristics, manufacturing processes, firing, results of inspections and tests
• Key points to include in the O & M instructions
• Health and Safety recommendations
Main Areas for Further Research

• Materials characteristics
  – clay, burn-out characteristics (type, size, residue) on flow rate, porosity & microbiological efficacy

• Variables that affect filter strength
  – filter shape, pressure, firing profile, processing, ratio & materials characteristics

• Firing temperature & profile
  – strength, porosity, black core

• Silver
  – optimum concentration & quantity, how long it lasts, what influences disassociation, effects of chlorine

• Filter lifespan and influences

• Strength of the relationship between porosity, flow rate & microbiological efficacy: additional low-cost tests
Conclusions

• Designed to be able to accommodate some variation in production
  – Consistent materials characteristics & processing
  – Consistent production processes
  – Standardized quality control testing
  – Documentation of production processes

• Voluntary Implementation of Recommendations
  – theory explained
  – adaptation based on local circumstances

• We hope to receive feedback!
Dedicated to Ron Rivera and Mickey Sampson

Thank you!