U.S. Consumer Product Safety Commission

3D Printing: Potential Hazards and Risk Review

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CPSC's Risk Management Group

The Risk Management Group (RMG) is a division within the Office of Hazard Identification and Reduction (EXHR)

- Program Area Risk Managers (PARMs):
  - Rick McCallion – Mechanical, Recreational, Sports, and Seniors
  - Susan Bathalon – Children's Products
  - Rik Khanna – Fire and Combustion
  - Doug Lee – Electrical
  - Dr. Treye Thomas – Chemical, Nanotechnology, and Emerging Materials

- Voluntary Standards Coordinator – Patty Edwards
- Voluntary Standards Specialist – Scott Ayers
- FOIA and Product Safety Assessment (PSA) Coordinator – Dean LaRue
- Division Director – Patty Adair

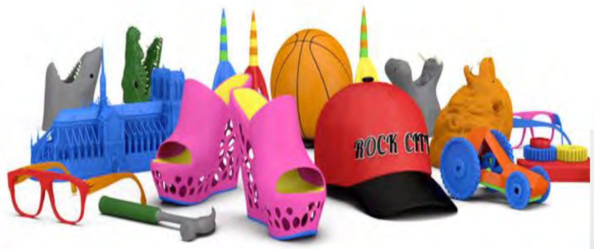
What Is 3D printing and Why a Concern?

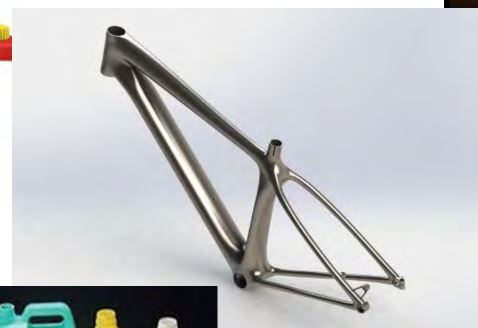
- “Building (printing)” of consumer products/parts by adding material
  - Vertical layering process
  - Many different methods and materials
    - Polymers, metals, ceramics, concrete, glass, organics

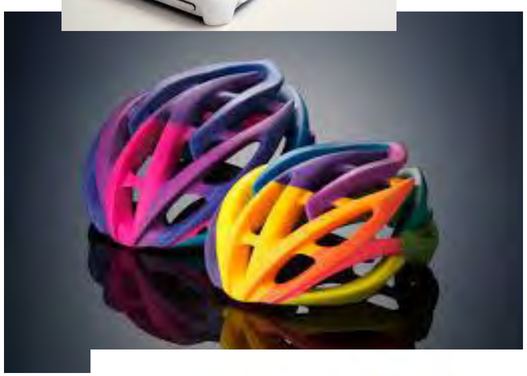
- Rapidly Growing Technology
  - Affordability/Ease of adaptation
  - Design/Engineering versatility
  - Printing time is decreasing (increase in production limits)
  - Expected increase in home and school environments
    - Every student will likely be exposed in the future
  - Manufacturers and small businesses are rapidly adopting this technology

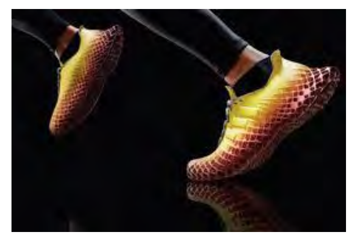
- Result: More consumer products will likely contain 3D printed parts

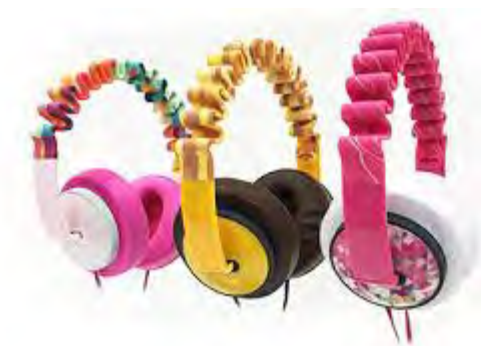
3D Printed Consumer Products

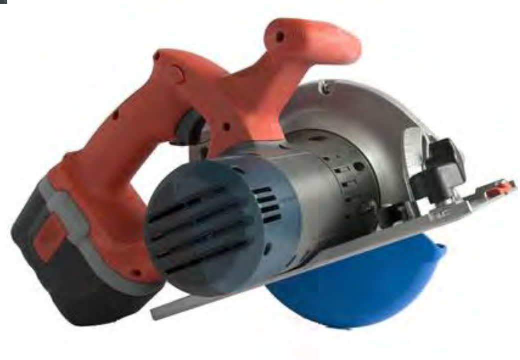


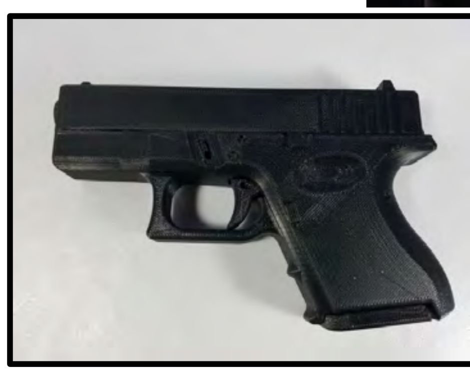












Terminology

- 3D printing
  - General common or lay term used to describe a device that constructs consumer products by laying down thin layers of materials
  - Used to describe small scale consumer use devices

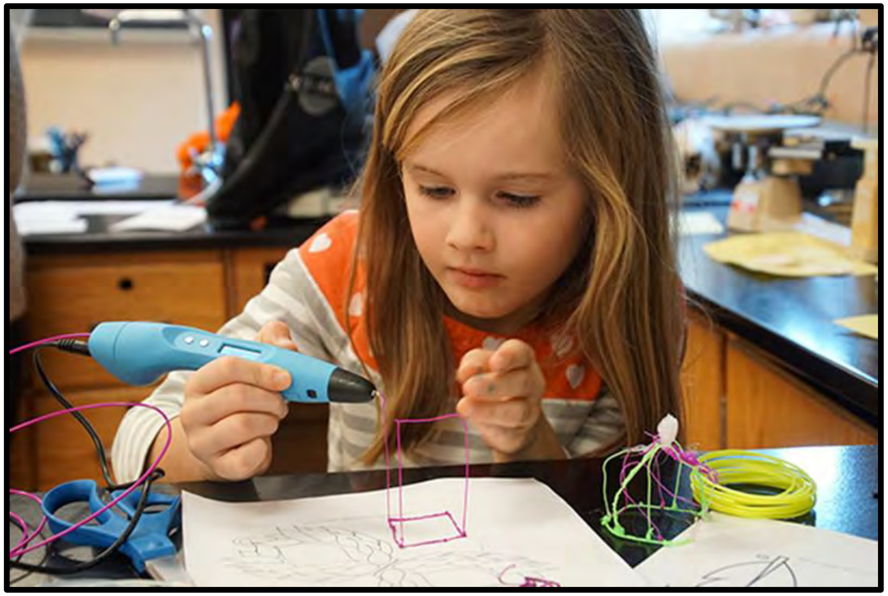
- Additive manufacturing
  - More technical term to describe a device that can construct a complete product.
  - Used to describe large scale production

- Small-Scale/Large-Scale manufacturing
  - Size and scope of the process from the purchase of raw materials, storage, production, finishing and product use.
  - Small Scale Printers can also be used in Large Manufacturing environments

- Product Lifecycle
  - Series of events ranging from the purchase of raw material to the use and disposal of a home-manufactured product

Small-Scale Printing

Children and 3D Printers



- STEM education curriculum
- Expect an increase in home, library, and school use
- Every student will likely be exposed in the future

Distributed Manufacturing

- Distributed Manufacturing (Local product production)
  - Rapidly growing trend
    - Financial support to purchase advanced equipment
  - Small Businesses in the local environment
    - Concerns about lack of training on equipment use and safety
    - Concerns about lack of Science/Engineering expertise in "Good Manufacturing Practices"
      - Quality control of materials, finished products, testing protocols?
  - Safe storage of materials
  - Will printed products meet mandatory and voluntary standards?
    - Products (e.g., pacifiers, toys, bike helmets, lead, phthalates)

3D Technology

3D printing Processes

- ✓ *Material*
- ✓ *Cost*
- ✓ *Speed*
- ✓ *Function/Purpose*

FDM/FFF – Fused Deposition Modeling/Fused Filament Fabrication
SLA – Stereo lithography
DLP – Digital Light Processing
SLS – Selective Laser Sintering
DMLS – Direct Laser Sintering
SLM – Selective Laser Melting
EBM – Electron Beam Melting
Material Jetting
DOD – Drop on Demand
Sand Binder Jetting/Metal Binder Jetting

Two Broad Hazard Areas

3D Printers

and

3D Printed Parts & Products

Fire and Combustion Hazards

3D Printer Fire Hazards

- Thermal runaway error
- Max and Min temperature check failure
- Cooling fan failure
- Lack of fire suppression and detection at printer location
- Unsupervised printing
- Combustible/explosive dust generation

3D Printer Product & Part Hazards

- Noncompliance with flammability standards
- Material compatibility concerns
- Durability/performance degradation

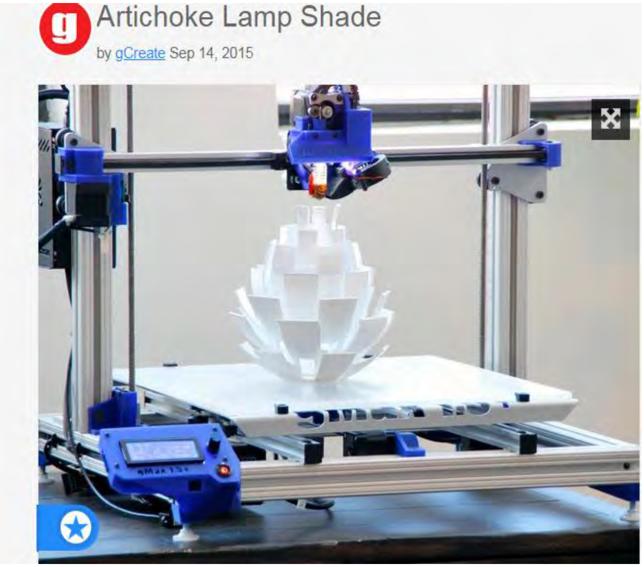
Electrical Hazards

Fire, electrical shock and mechanical hazards are possible from the 3D-printer

- Hazards are mitigated with product certification to the voluntary standard

Fire and Electrical shock hazards are likely if components or products are 3D printed using:

- improper flame retardants
- Improper UV inhibitors
- insufficient mechanical barriers



Chemical Hazards

Material Composition

- Must understand the types of materials (metals, nanomaterials, thermoplastics, etc.) used for various additive/3D technologies.
- Are they toxic under FHSA? What are the exposure limits? Can they be used safely in the home environment?

Exposures during storage and production

- Are materials safely stored and packaged (PPPA)?
- What is released during product construction?
- Do released chemicals accumulate in the indoor environment?
- What type of engineering controls or PPE should be used by the consumer to reduce health risks?

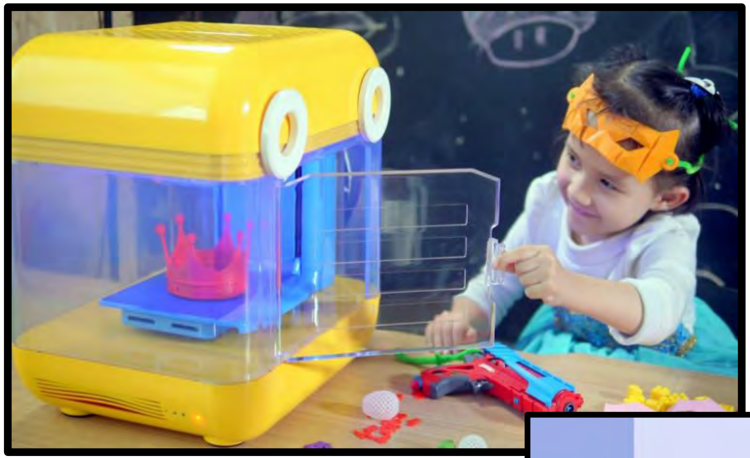
Types of finishing processes used

- Do they fall under CPSC regulations?

Durability of product

- Are 3D constructed products as durable as traditionally manufactured products? Or will they degrade and release chemicals during product lifecycle?

Children's Hazards



Printing process hazards:

- burns
- exposure to additives or chemicals

3D printed product hazards:

- Mandatory regulation compliance uncertainty
  - Choking hazards
    - Small parts, pacifiers, rattles, small balls, figurines, toys
  - Exposure to phthalates
  - Replica toy guns (proper marking)
- Durability

Mechanical Hazards

Additive manufacturing removes barriers to mechanical design that can affect product safety

- 3D printing allows designs impossible to produce using traditional manufacturing methods
- Redefining material and mechanical engineering roles in product development

Materials

- Raw materials can have different mechanical properties
- Limited post-production product treatment (e.g. heat treating metals)

Manufacturing

- QA/QC of parts – each produced part a prototype
- Process changes to managing unsafe products

  (Corrective actions for multiple similar prototypical products)

Staff Activities on 3D Printing

- **Research**
- **Engagement**
- **Voluntary Standards**

Research Activities

- Developed interagency agreement with NIST, EPA and DOD
  - Carbon nanotubes in 3D printers research completed
  - Researching toxicity of 3D materials with DOD ACE ERDC and Duke University

- Signed research agreement with EPA and NIOSH
    - VOCs, particulates, metals
    - Health effects

Staff Engagement

- Presentations and discussions with state, federal and international stakeholders
  - Letters to SDOs
  - Indo-US meeting follow-up planned for ~2020
  - German Regulator/UK research contacts
  - Initiated federal interagency teleconference on research activities
  - Hosted federal interagency meeting on August 20, 2019
  - Recent public meeting on UL research: *Influence of 3D Printing by Material Extrusion on UL 94 and UL746A Material Properties*

Voluntary Standards Activities

- UL Printer Safety Committee
  - CPSC staff on advisory board
  - UL 2904 Methods for detecting VOCs and particulates
- ISOJG68/ASTMF42 Joint Committee
  - Development of mechanical and emissions testing methods
- ASTM/ISO Additive Manufacturing Center of Excellence
  - Intended to coordinate R&D efforts for standards development
- ANSI America Makes Roadmap
  - Identified existing standards and areas of need for additive manufacturing
- UL 60950 Information Technology Equipment Standard (staff on UL STP)
- UL/CSA/IEC 62368-1 Audio/Video Information and Communication Technology Equipment Standard (staff on UL STP)

Challenges and Opportunities

- International collaboration
  - Research and development is global, not US-centric
- Material properties, production and performance
  - Lack of understanding of new technologies
- Durability of products is a concern across risk areas
- Educating users on Good Manufacturing Practices and Environmental, Health and Safety Practices
- Open source software – circumvent expertise
- Supply Chain changes – TBD impact on safety
- Consumer as Manufacturer – Bypass traditional safety

Thank You