

Standards for Sustainable Manufacturing

Part 2 Evaluating Environmental Sustainability for Manufacturing Process

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**Supported by grant 70NANB18H277 from the National Institute of Standards
and Technology**

Sustainable Manufacturing

- **ASTM E2987 / E2987M** Standard Terminology for Sustainable Manufacturing
- **ASTM E3096** Standard Guide for Definition, Selection, and Organization of Key Performance Indicators for Environmental Aspects of Manufacturing Processes
- **ASTM E2986** Standard Guide for Evaluation of Environmental Aspects of Sustainability of Manufacturing Processes
- **ASTM E2979** Standard Classification for Discarded Materials from Manufacturing Facilities and Associated Support Facilities
- **ASTM E3012** Standard Guide for Characterizing Environmental Aspects of Manufacturing Processes



ASTM is a not-for-profit organization that provides a forum for the development and publication of international voluntary consensus standards for materials, products, systems and services.

Source: <https://www.astm.org/ABOUT/faqs.html>

ASTM E2986 Standard Guide for Evaluation of Environmental Aspects of Sustainability of Manufacturing Processes

- Provide a reference to the manufacturing community for the evaluation of environmental sustainability aspects of manufacturing processes.
- Intend to improve efficiencies and consistencies of informal methods by providing procedures for consistent evaluations of manufacturing processes
- Describe a procedure to identify parameters and models for evaluating sustainability metrics for a particular process.
- Users of this guide will benefit from insight into the sustainability implications of selected processes as well as the contributing factors.

Methods for
Manufacturing
Process Evaluation

Evaluation
Procedure for
Sustainable
Improvement

Documentation and
Reporting

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Methods for Manufacturing Process Evaluation

1. Set Sustainability Objective

- A statement of the sustainability goals
- Opportunities to be addressed

2. Identify Indicator

- Attributes – name, definition, quantitative/qualitative, units, references, application level

3. Identify Process(es)

- Processes that contribute to the identified indicator
- Relevant documentations (e.g., safety data, draws).

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Methods for Manufacturing Process Evaluation

4. Identify Evaluation Metrics

- Provide measures for indicators to be evaluated
- Depends on processes, data availability, measurement equipment

5. Set Boundary Conditions

- Limit the scope and constraint the extent of the evaluation
- Physical boundaries/time-related boundaries

6. Identify Input and Output Parameters

- May be related to materials, energy, or intermediate products
- Can be measured, estimated, or calculated

7. Create a Process Model

- Empirical and/or theoretical models to support repeatable evaluation

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Evaluation Procedure for Sustainable Improvement



Methods:

- Data Collection
 - Direct Measurement
 - Theoretical computation
 - Estimation – measurement + estimates

- Decision-Making
 - Simulation – imitation of a real system over time.
 - Optimization – selection of a best value from a set of available alternatives
 - What-if analysis – compare data by varying inputs and recording changes in results.

Machine#	Material in kg	Material out kg	Energy in MJ	Energy out MJ
1				
2				

Uncertainty/Sensitivity Analysis

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Documentation and Reporting

- Sustainability measurement report includes
 - Purpose, objectives, and scope
 - Administrative data
 - Contextual information
 - Measurement results and quantification
- Effective documentation
 - Clear information on scopes, objectives, and processes,
 - Details of the procedural steps
 - Sufficient supporting data of any result
 - Results, performance metrics, decisions made

ASTM E3012 Standard Guide for Characterizing Environmental Aspects of Manufacturing Processes

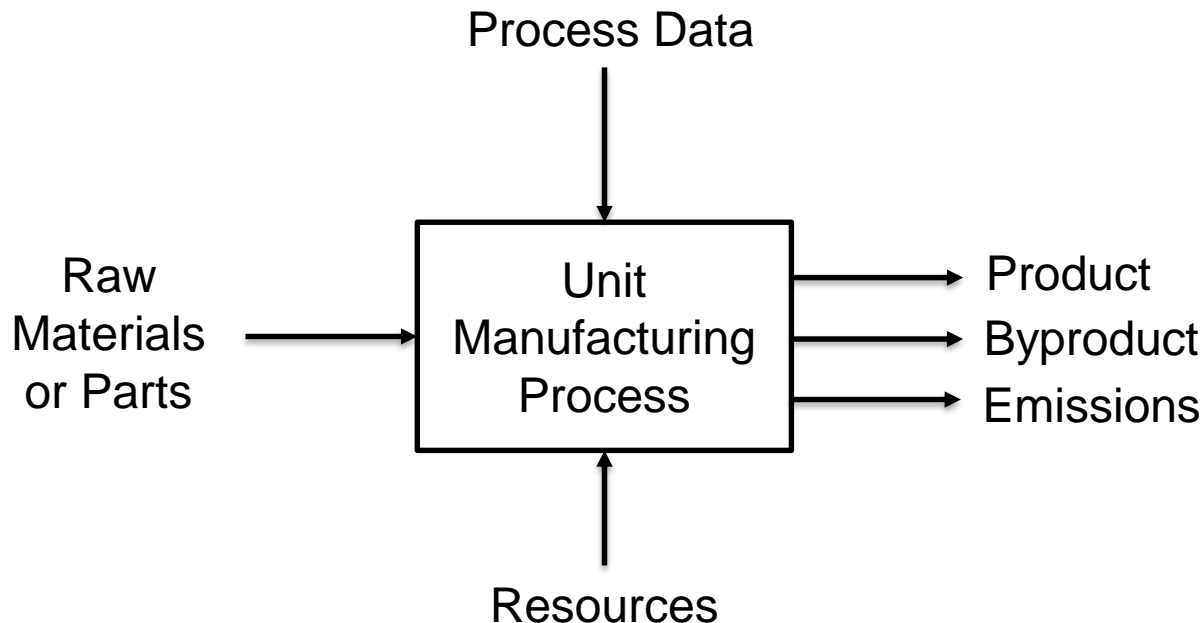
- Provides manufacturers a systematic approach for characterizing the environmental aspects of manufacturing
- Provides the required structure and formalism to ensure consistency in characterizing manufacturing processes in a computer-interpretable way enabling effective communication, computational analytics, and exchange of performance information.
- Supports the development of tools to improve decision support capabilities while facilitating the development and extension of standardized data and information bases such as Life Cycle Inventory (LCI) (ISO 14040 series).

Terminology

ASTM E2987 / E2987M Standard Terminology for Sustainable Manufacturing

Unit Manufacturing Process

“The individual operation or subset of operations necessary to convert, modify, or add value from a defined initial state to a defined end state”.



Examples:

- Casting
- Machining
- Mixing
- Surface treatment
- Preparation for shipping

Process Data Unit

“Smallest element of a unit manufacturing process for which discrete data are collected”.

ASTM E3012 Unit Manufacturing Process Representation (UMP)

“The UMP representation utilizes *graphical and formal methods* in constructing UMP information models for characterizing the environmental aspects of manufacturing processes.”

Product and Process Information

- Specifications of materials, processes, equipment, product.
- Production and quality plans
- Sustainability plans and safety information

Input

Output

Feedback

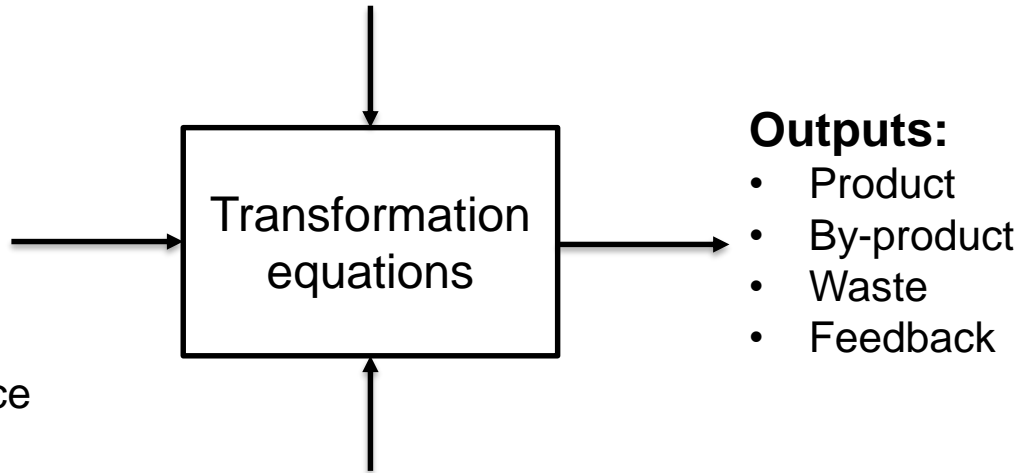
Products and process information

Resource

Transformation

Inputs:

- Energy
- Materials
- Outside factors
- Disturbance



Outputs:

- Product
- By-product
- Waste
- Feedback

Resources

Equipment, human, software, tooling

An Example of Graphic Representation

ASTM E3012 Process Characterization Methodology

Step 1: Identify UMPs and KPIs

- Need to specific boundary (e.g., one or multiple UMPs)
- Product process information can be similar or unique

Key Performance Indicator (KPI)

ASTM E2987 / E2987M Standard Terminology for Sustainable Manufacturing

“A quantifiable attribute that a company or industry uses to gauge or compare performance for meeting operational and strategic goals”.

ASTM E3012 Process Characterization Methodology

Step 2: Identify UMP specific elements

- Inputs
- Outputs
- Resources.
- Transformation equations/functions

Material Transformation

- Mass/phase/structure change, deformation, consolidation

Energy Transformation

- Chemical, electrical, thermal, mechanical, and electromagnetic

Information Transformation

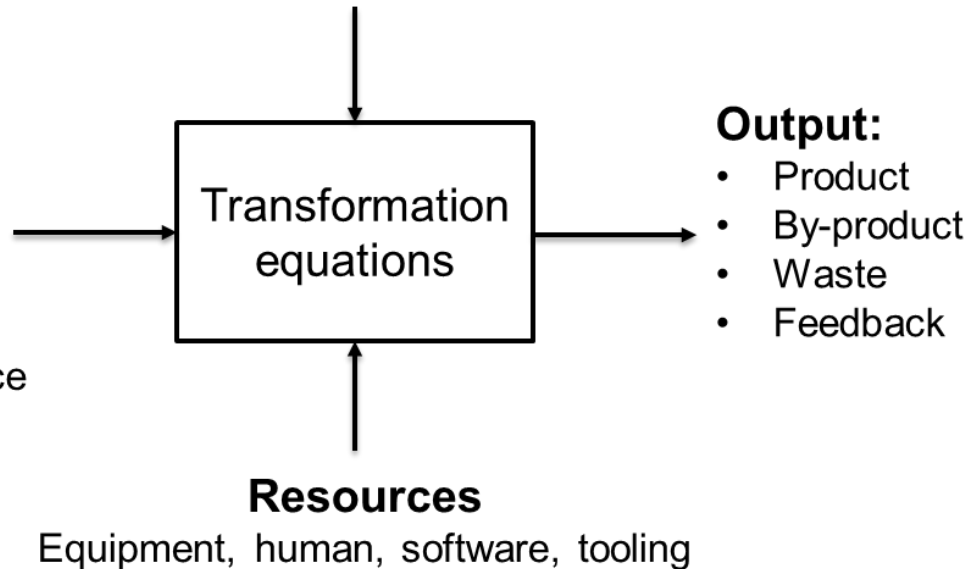
- Production and environmental metrics

Product and Process Information

- Specifications of materials, processes, equipment, product.
- Production and quality plans
- Sustainability plans and safety information

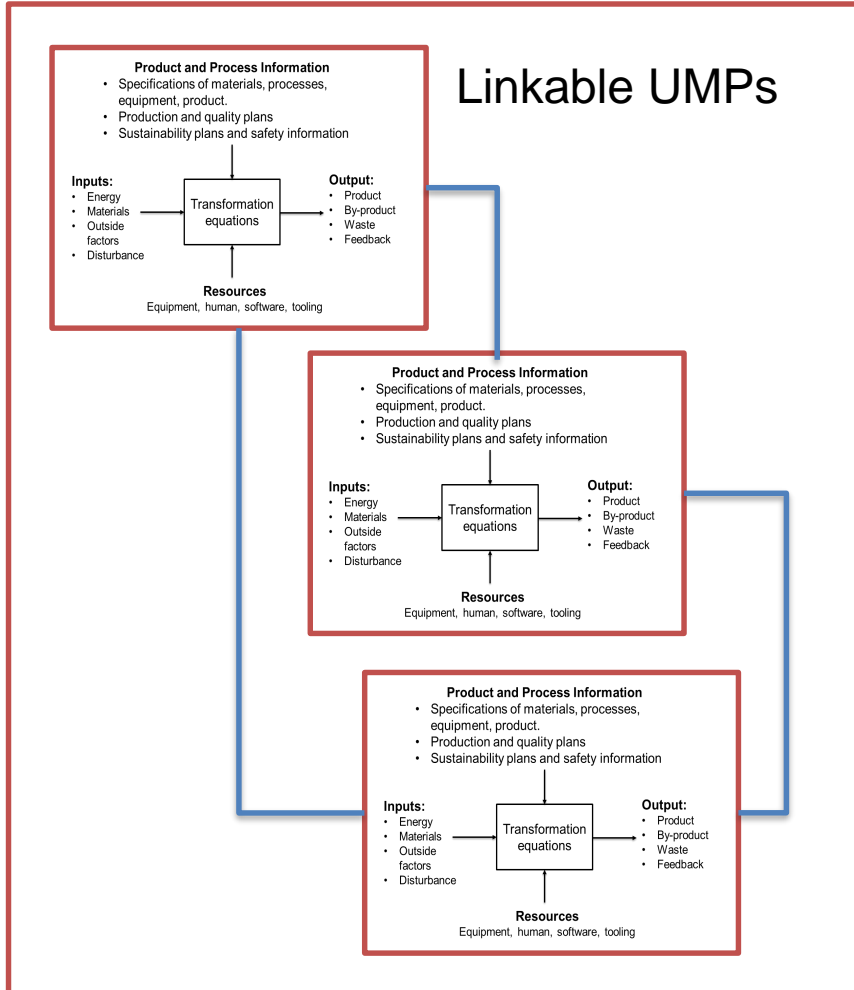
Inputs:

- Energy
- Materials
- Outside factors
- Disturbance



An Example of Graphic Representation

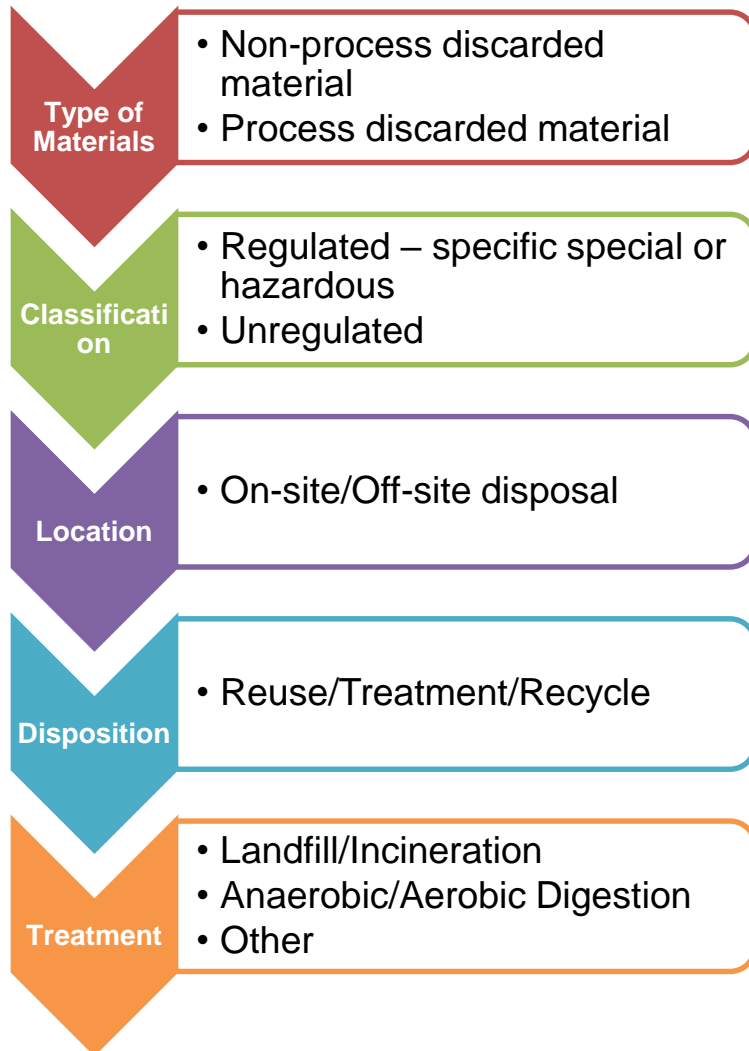
ASTM E3012 Composability of Unit Manufacturing Processes



“Composability, n —the ability to link individual unit manufacturing processes together to create a network or system of UMPs that can characterize the environmental aspects of a production system or product”

- Linking variables are used to define a composed system
- The composed system can be computed when all links have been defined by assigning values to the undefined inputs and outputs
- Common name convention or classifiers for the UMP model parameters.

ASTM E2979 Standard Classification for Discarded Materials from Manufacturing Facilities and Associated Support Facilities



- Classify material outputs from manufacturing facilities and associated support facilities. This classification does not include classification of emissions to air or water.
- Classify discarded materials for marketing claims associated with discarded materials generation and development of consistent tracking metrics for manufacturing facilities.

Visit Our Project Website

<https://faculty.cnr.ncsu.edu/yuanyao/green-buildings-and-sustainable-materials/>

This presentation and video were prepared by the project team (Yuan Yao, Stephen Kelley, Traci Rider, and Adam Scouse) at North Carolina State University using Federal funds under award 70NANB18H277 from the National Institute of Standards and Technology, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the National Institute of Standards and Technology or the U.S. Department of Commerce.