A concept for collection and presentation of material properties for diverse applications

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Outline

- Problem definition
- Terminology and characteristics
- Solution framework
- Conclusions

Problem

Why all this?

Except for simple cases….

- Material properties are not definitive!
- Handbook values are typical, not representative
- You cannot possibly measure all the possible nuances of a materials behavior- nor would you be interested

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Problem

Material properties differ…

- Properties depend on the application
  - on test conditions:
    - temperature
    - rate
    - time
    - environmental exposure
  - the samples
  - the test specimens

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Example

Case 1

- Automotive- Fuel Tank
  - Material : Polyethylene (PE)
  - Deformation: large, low temp failure
  - Model: *ELASTIC/*PLASTIC
  - Data needed: stress-strain curve at –40C
  - Typical data: taken on virgin resin at 23C

- Reality:
  - Data at –40C is needed
  - Much stiffer, brittle failure?

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Example

Case 2

- Bio-Implant Component
  - Material : Polyethylene (PE)
  - Deformation: large
  - Model: *ELASTIC/*PLASTIC
  - Data needed: stress-strain curve
  - Typical data: virgin resin, 23C
- Reality
  - 37C, saline environment
  - Large reduction in properties

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Problem

What's good for the goose…

- The correct material property for a particular use may not be the right one for another application
- Conversely, it is pointless developing properties outside the context of an application

is bad for the gander…

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Problem

Finding the right data

- Imagine wading through enormous swamps looking for the right data
  - Handbooks
  - Internet
  - Databases
  - File cabinets
  - Colleagues and co-workers

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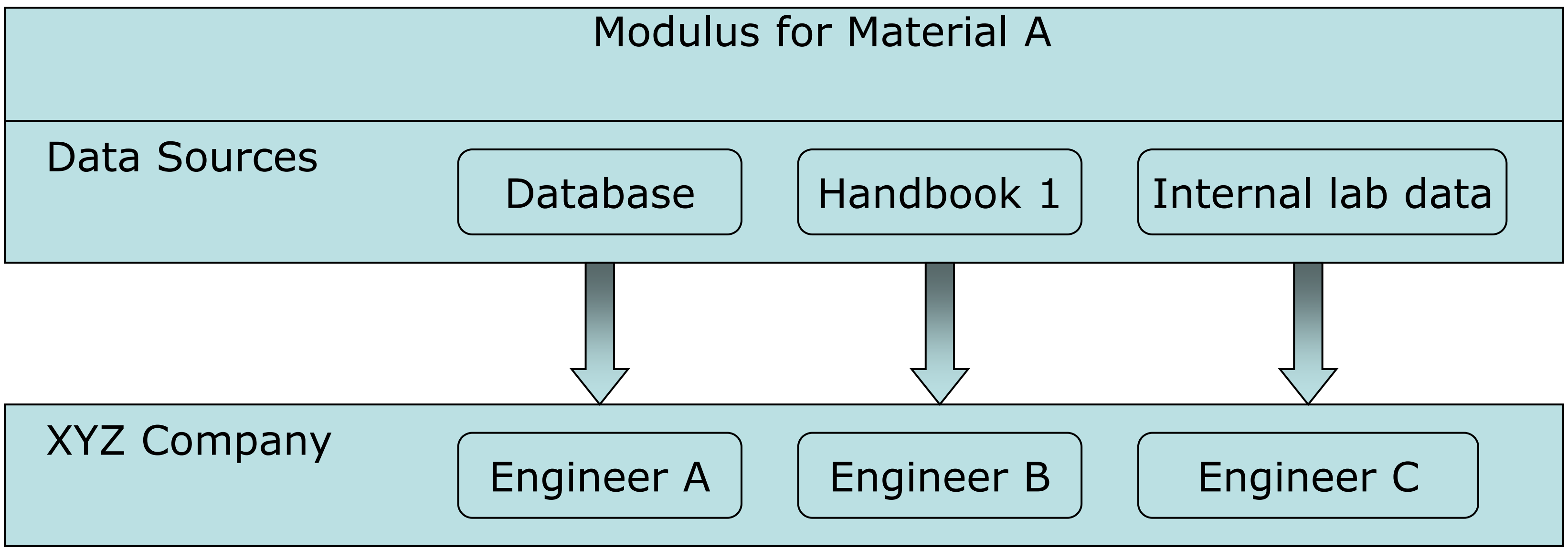
Problem

Inconsistent use of data

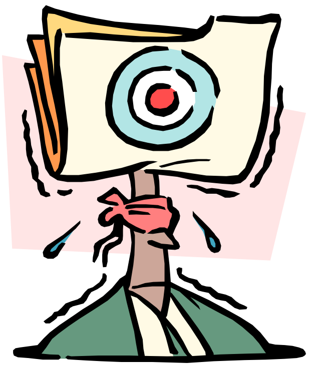


the six sigma killer…

Problem

Poor properties can be fatal

- Property no longer represents the behavior being simulated
- Can be a root cause of error in CAE
- Presents a serious credibility problem for analyst, CAE tool, and VPD



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Framework

How to avoid this?

- Understand the environment that is being simulated
- Translate the behaviors into a set of measurable property requirements
- Pay heed to the underlying assumptions
- Develop representative properties
- Use consistently across VPD platform

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Problem

The case in singular

- I need to store a variety of properties
- On the materials that I use most
- Which must be pertinent to my class of applications
- And appropriate for my CAE solution

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Problem

The big picture

- We need to store a multitude of varied properties
- Which depend on the end use application
- For diverse applications
- For diverse material types
- Useable in a variety of CAE solutions

a major mess…

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Definition

material (ma·te·ri·al)

(1) : the elements, constituents, or substances of which something is composed or can be made

(2) : matter that has qualities which give it individuality and by which it may be categorized

Merriam Webster Collegiate Dictionary

-Date: 1556

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Definition

reality (re·al·i·ty)

1: the quality or state of being real

2 a (1): a real event, entity, or state of affairs

2 a (2): the totality of real things and events

2 b : something that is neither derivative nor dependent but exists necessarily

Merriam Webster Collegiate Dictionary

-Date: 1550

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Definition

A new semantic definition

matereality (mat·e·re·al·ity)

1: collections of material properties that represent a particular behavioral reality

2: material properties used in virtual product development

3: a collection of properties pertinent to a particular stage of the product life cycle

-Date: 2002

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Framework

Characteristics of matereality

- A matereality is defined in the context of its end use
- A matereality is self-consistent
- Properties of one matereality may not be applicable to another matereality
- Misuse of properties in a matereality can fracture the matereality

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Framework

Features of matereality

- Pertinent
  - All properties represent the behavior under consideration
- Traceable
  - The source and quality of the data must be assessable
- Describes variability
  - An understanding of the statistical spread of the representative property

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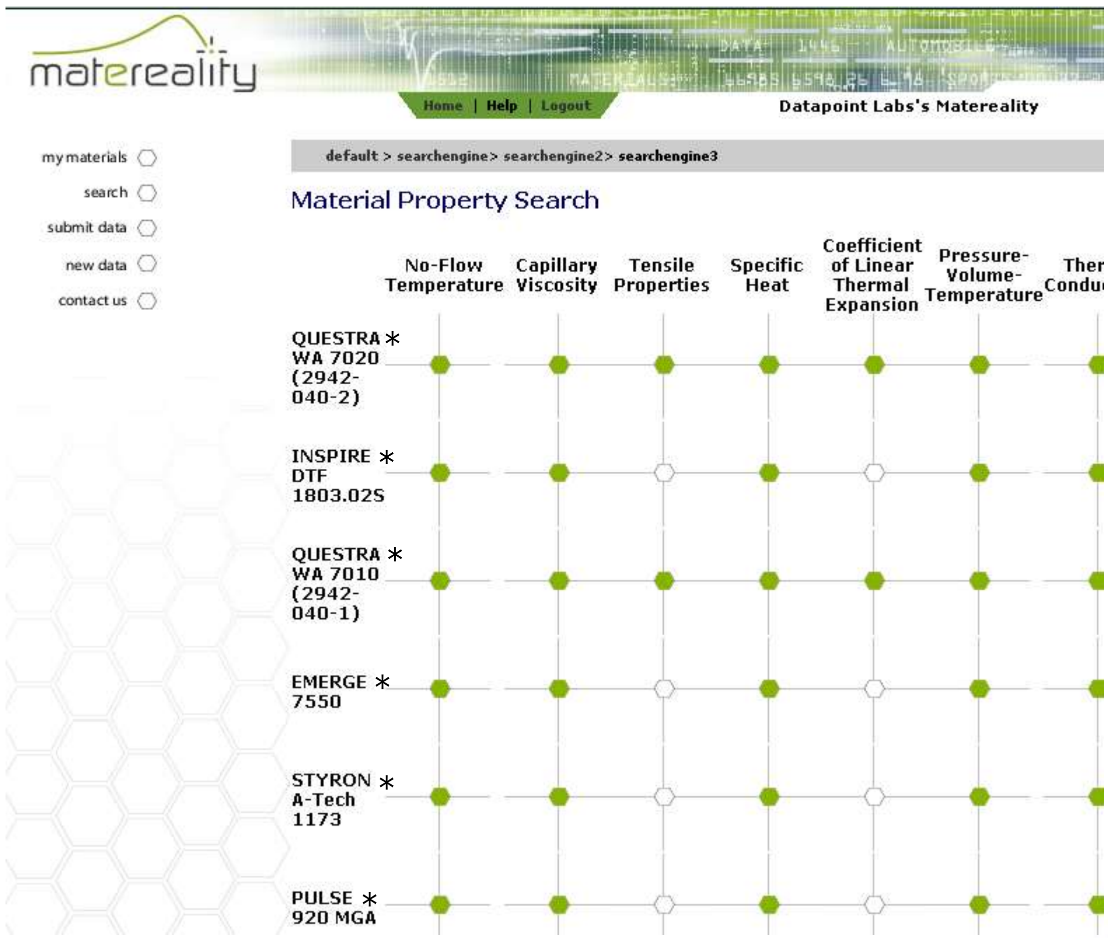
Framework

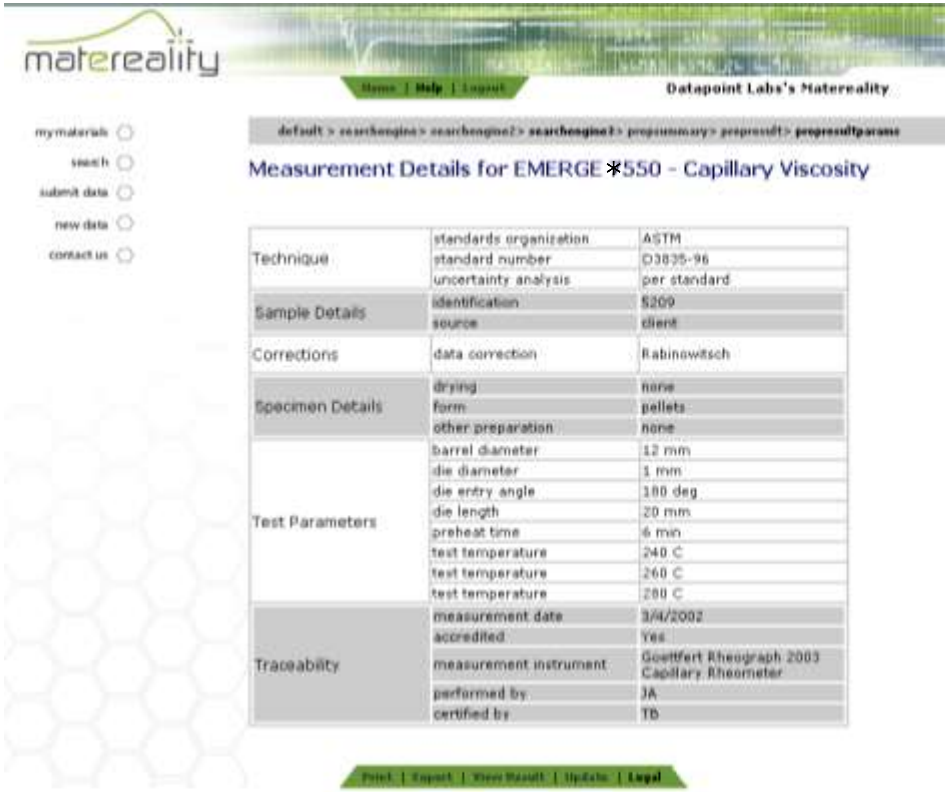
Pertinence



Material names are trademark of Dow Chemical

Framework

Traceability



Technique	standards organization	ASTM
	standard number	D3835-96
	uncertainty analysis	per standard
Sample Details	identification	5209
	source	client
Corrections	data correction	Rabinowitsch
Specimen Details	drying	none
	form	pellets
	other preparation	none
Test Parameters	barrel diameter	12 mm
	die diameter	1 mm
	die entry angle	180 deg
	die length	20 mm
	preheat time	6 min
	test temperature	240 C
	test temperature	260 C
	test temperature	280 C
Traceability	measurement date	3/4/2002
	accredited	Yes
	measurement instrument	Goettfert Rheograph 2003 Capillary Rheometer
	performed by	JA
	certified by	TB

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Framework

Variability

Tensile Modulus - Youngs

2223 MPa	1
2138 MPa	2
2229 MPa	3
2197 MPa	Average

Offset Yield Stress in Tension

44.27 MPa	1
46.04 MPa	2
41.07 MPa	3
43.79 MPa	Average

Offset Yield Strain in Tension

2.12 MPa	1
2.24 MPa	2

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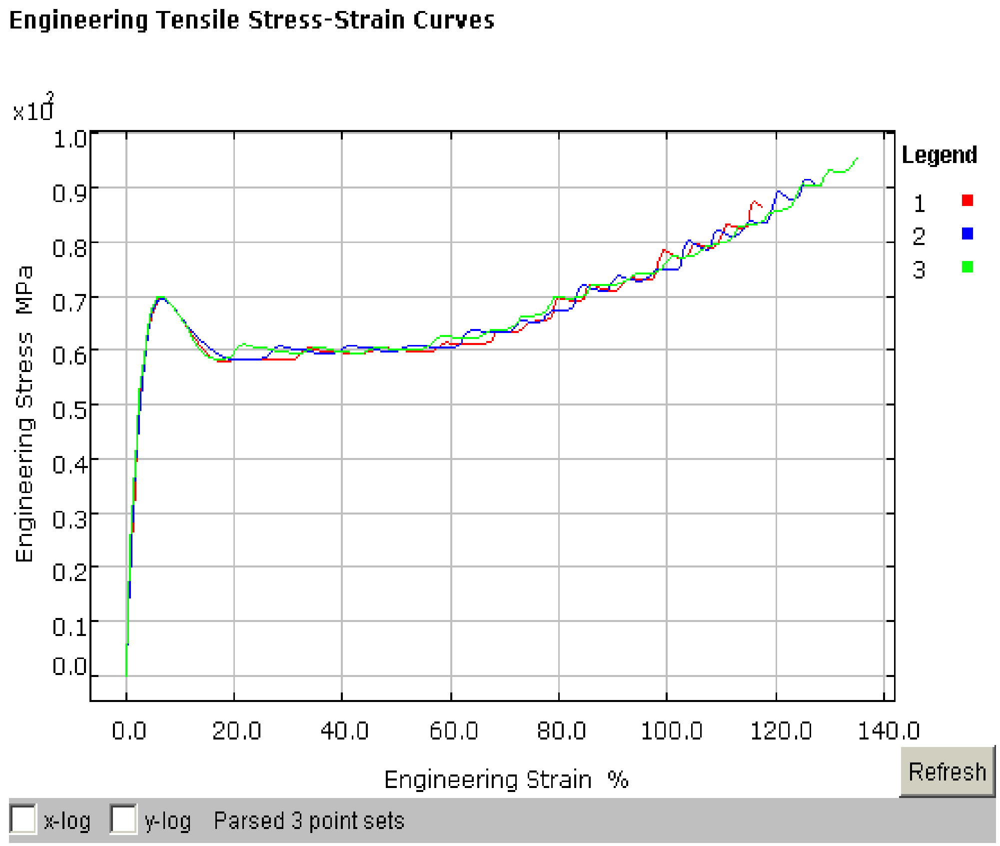
Framework

Variability



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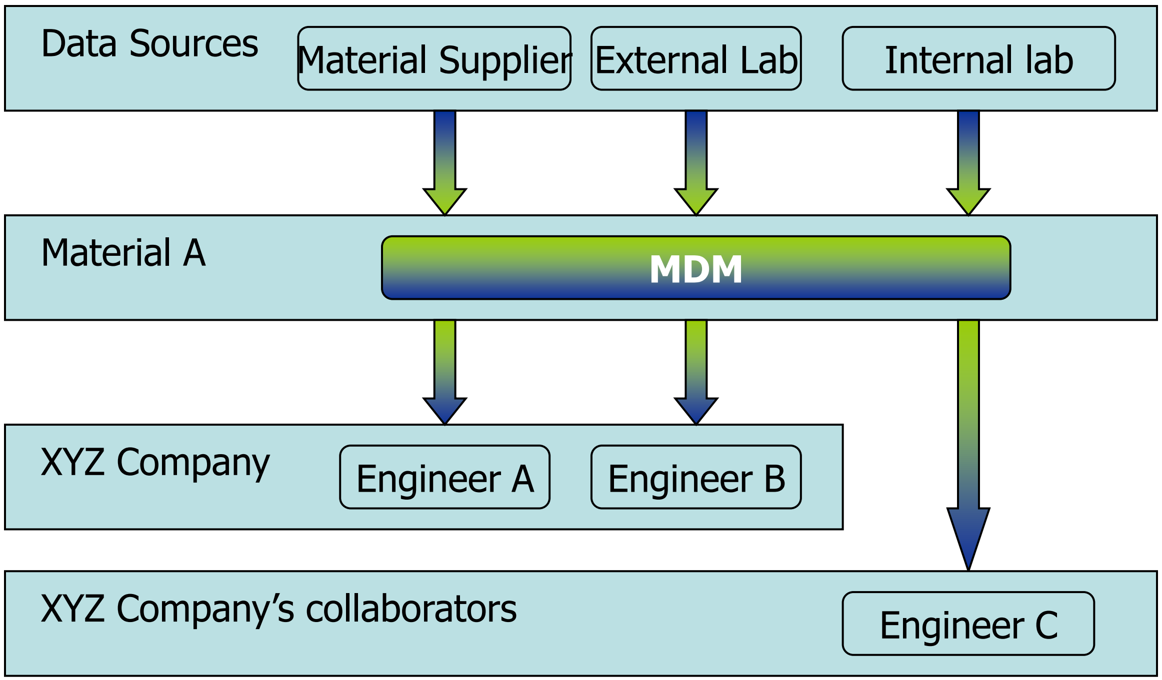
Framework

Matereality applied consistently



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Example

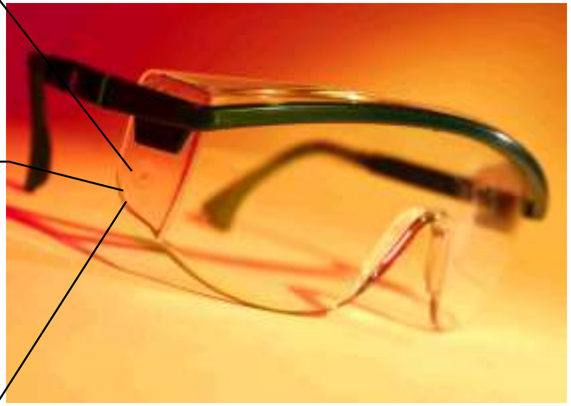
Examples of matereality

Part designer's matereality
- Stress-strain data
- Impact data
- Refractive index

Moldflow analyst's matereality
- Viscosity
- Thermal conductivity
- Melt density
- Specific heat
- No-flow temperature

Molder's matereality
- Melt flow rate
- Izod strength

Product: safety glasses



Material: polycarbonate

one material, many materealities

Moldflow is a trademark of Moldflow Corp.

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Cost savings

- Only the properties needed are measured
- Once measured, properties are shared by all stakeholders
- Reduced risk- no searching in dubious places for data

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Conclusions

- Defines a collection of properties pertinent to a particular stage of the product life cycle
- Authoritatively defines the manner in which a particular behavior is described.
- Used to classify property collections for different applications

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