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GRANTA
MATERIAL INTELLIGENCE

Exporting Data from Granta MI

Discussion with NEA&AWE, 2015-May-5

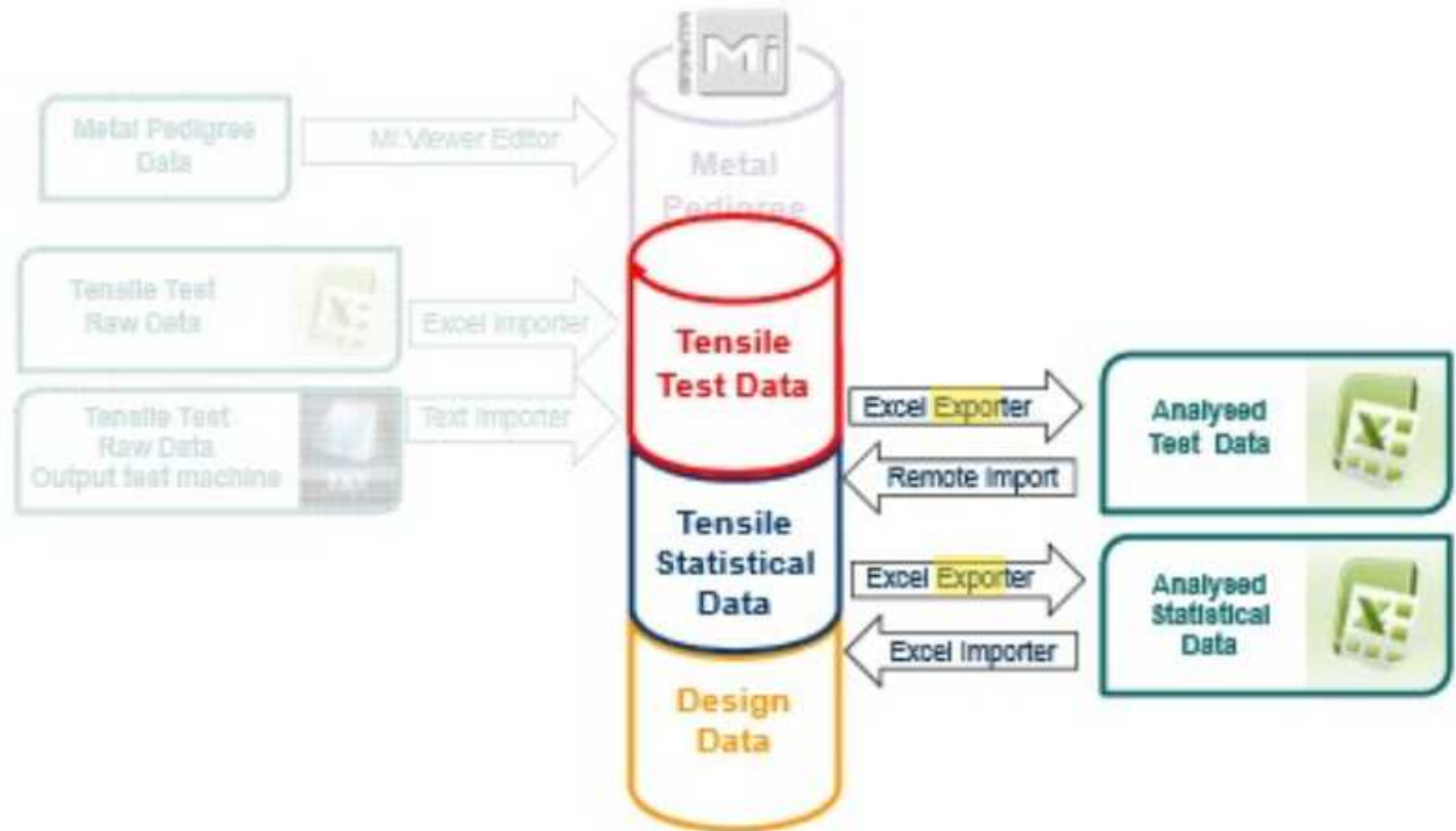
Richard Karnesky, rakarne@sandia.gov



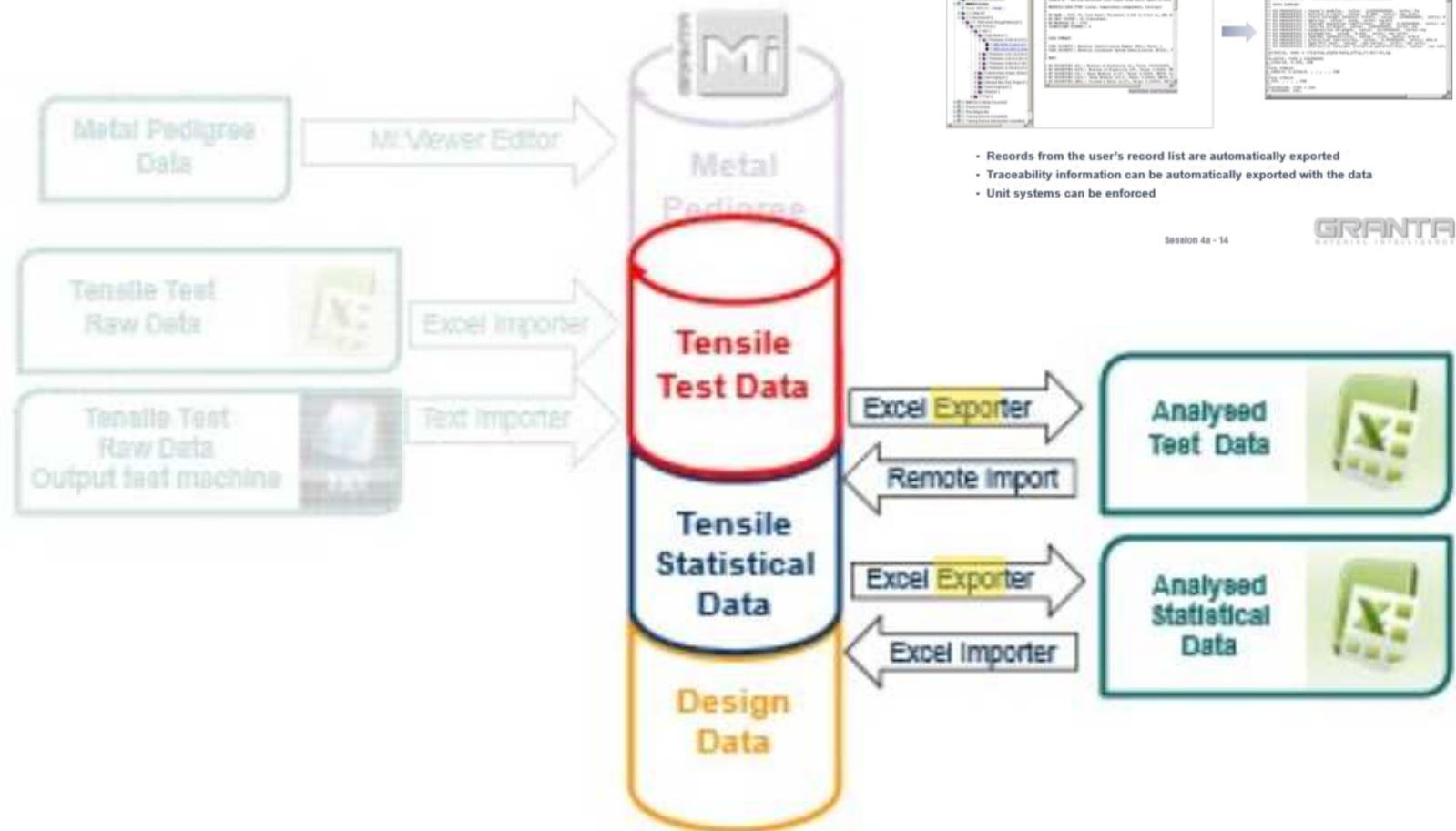
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First: A disclaimer

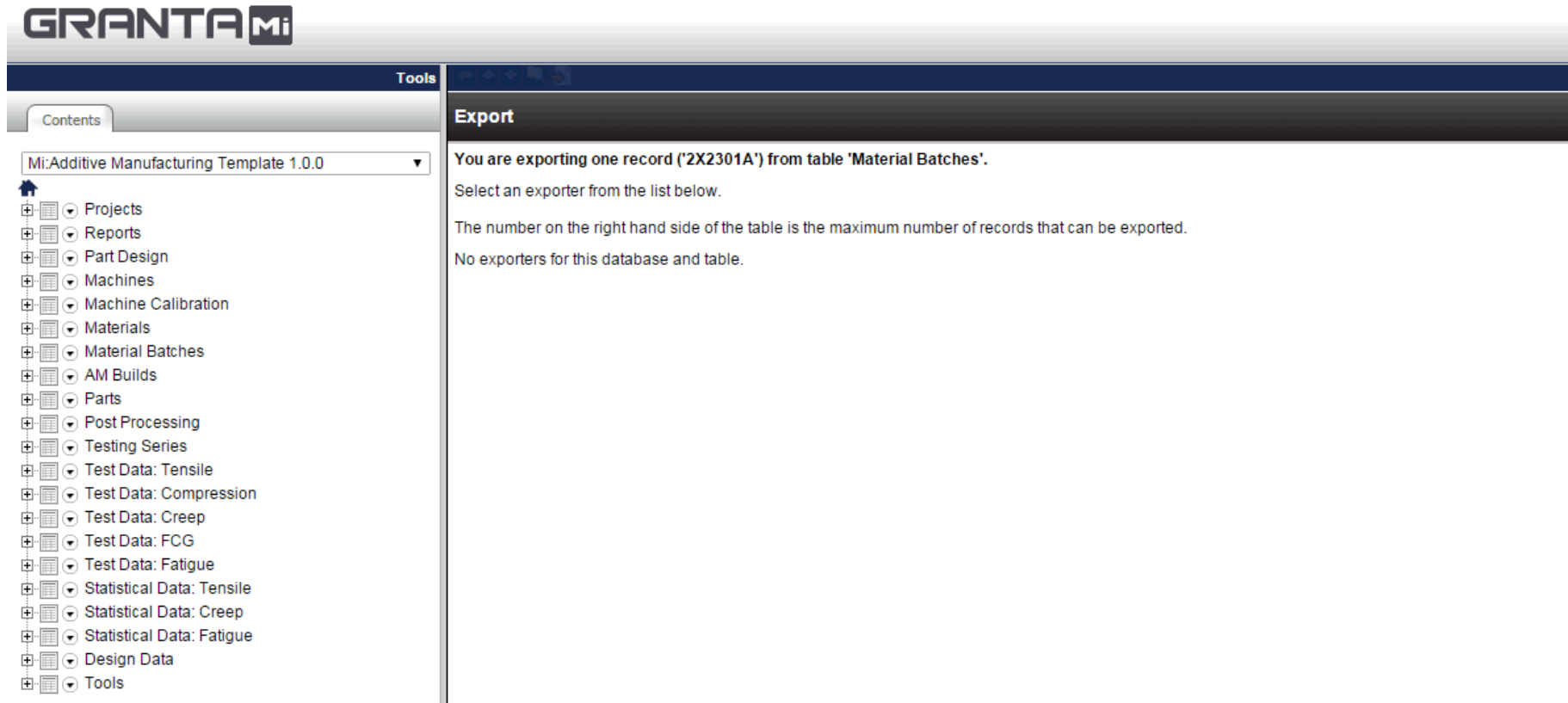
First: A disclaimer...Desired workflow



First: A disclaimer...Desired workflow



First: A disclaimer...Current workflow



Version 1.0.0 of the MI AM template has very few exporters “built-in”.
Granta and the AM working group will no doubt add more in the future.

That's not to say we can't already store useful data!

The screenshot displays the GRANTAMi software interface. The left-hand navigation tree shows a hierarchy of folders including Projects, Reports, Part Design, Machines, Machine Calibration, Materials, Material Batches, AM Builds, and a subset of Builds (Default). The main content area is titled '2013-04-15 CLAD-2321 01' and contains several sections:

- Beam Location with Respect to Additive Material**: 0 in
- Three-Dimensional Beam Profile**: A 3D visualization of the beam profile.
- Beam Diameter at Workpiece (Spot Size)**: 0.157 in
- Substrate Information**:
 - Substrate Material**: Ti-6Al-4V
 - Substrate Manufacturer**: Titanium Metal Supply, Inc.
- Powder Build Parameters**:
 - Powder Feed Calibration Date**: Thursday, March 07, 2013
- In-Process Analysis**:
 - Build Anomalities by Layer**: A table showing O2 sensor readings and notes for each layer.

Layer [#]	Pass [#]	Notes
0	0	O2 sensor reading 3.8ppm
10	1	O2 sensor reading 3.6ppm
20	1	O2 sensor reading 18.6 ppm
30	1	O2 sensor reading 17.5 ppm, nozzle plugged, »
40	1	O2 sensor reading 20.2 ppm
50	1	O2 sensor reading 21.7ppm

And there are some extremely basic exporters already

GRANTAMi

Tools

Contents

Mi: Additive Manufacturing Template 1.0.0

- Projects
- Reports
- Part Design
- Machines
- Machine Calibration
- Materials
- Material Batches
- AM Builds
- Parts
- Post Processing
- Testing Series
- Test Data: Tensile
- Test Data: Compression
- Test Data: **Creep**
- Test Data: FCG
- Test Data: Fatigue
- Statistical Data: Tensile
- Statistical Data: **Creep**
- Statistical Data: Fatigue
- Design Data
- Tools
 - Subset Tools (Default)
 - Export
 - Creep
 - Single Record
 - Creep (Imperial)
 - Creep (Metric)
 - Relaxation
 - Single Record
 - Relaxation (Imperial)
 - Relaxation (Metric)
 - Import

L13L12

Part Information

Part ID	L13L12
Part of Build	2013-04-15 CLAD-2321 01
Build ID	2013-04-15 CLAD-2321 01

Samples from this Part

Cut-off Diagram

Number of Samples Cut from Part: 9

Description of Tensile Samples cut from this Part [Hide table](#)

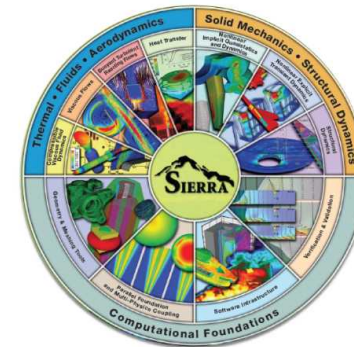
[Save To Excel \(CSV\)](#) [Copy To Clipboard](#)

Specimen ID	Specimen location	Specimen orientation
-------------	-------------------	----------------------

But: SNL already makes use of GRANTA MI data in design and analysis

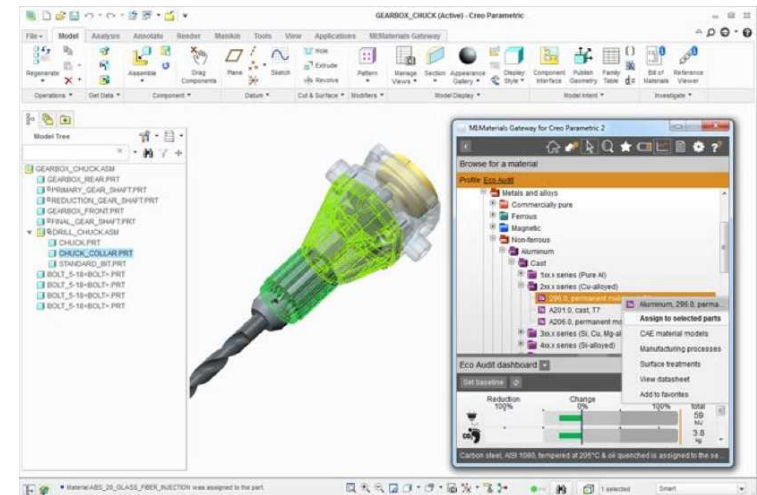
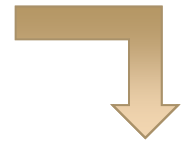
■ Sierra Mechanics Exporter (*J. Dike*)

- Supply Temperature Dependent Response
- Multiple Alloys
- For use in statics code



■ Drafting via MI:Materials Gateway Tool (*A. Machado*)

- Direct access to public and SNL-specific materials information
- Direct insertion into CAD models



Envisioned modes of data sharing

- Contribute to external database that uses Granta (e.g. ASM)
- Provide a raw database dump to other Granta users
- Allow web-based access to MI
 - We already do this for users of the SRN (can include non-Sandians)
 - We plan to do this for the SON for a “proof-of-principle” project
- Internally, we will allow integration with CREO
- We will use the export functionality built by the AM working group and in-house

The MMPDS database gives an example of the rich export possibilities

GRANTAMi

Tools

Contents Search

13 results

Search Criteria

Profile
MMPDS-08 Database

Search term
304

Save search | Refine search

Results By Table
2 Tables

Hide data

- MMPDS-08 Data
- MMPDS-08 Subset
- MMPDS-08 Database
- MMPDS-08 Master Document
- MMPDS-08 Subset
- MMPDS-08 Database

Export

The number on the right hand side of the table is the maximum number of records that can be exported.

Category	Material Type	Description	Maximum Records
▼ Abaqus 6			
<input type="radio"/>	Linear, temperature-dependent, isotropic, thermal, plastic	Exports temperature dependent, isotropic data to the Abaqus format. If temperature dependent data is not available then room temperature data will be exported.	50
<input type="radio"/>	Linear, temperature-independent, isotropic, thermal, plastic	Exports temperature independent, isotropic data to the Abaqus format.	50
▼ ANSYS MAPDL v15 (ANSYS Classic)			
<input type="radio"/>	Linear, temperature-independent, isotropic	Exports isotropic data to ANSYS MAPDL format.	50
<input type="radio"/>	Linear, temperature-dependent, isotropic	Exports temperature dependent, isotropic data to ANSYS MAPDL format.	50
▼ ANSYS Workbench v12 onwards			
<input type="radio"/>	Linear, temperature-dependent, isotropic, thermal, plastic	Exports isotropic data to ANSYS Workbench format. Where temperature dependent data is available it will be exported, if not room temperature data will be exported. Where stress-strain curves are available they will be exported to the plastic hardening model.	50
▼ MatML			
<input type="radio"/>	Basic material data	Exports basic material data to the MatML format.	50
<input type="radio"/>	Linear, isotropic	Exports linear, temperature-independent, isotropic data to the MatML format.	200
<input type="radio"/>	Linear, temperature-dependent, isotropic	Exports linear, temperature-dependent, isotropic data to the MatML format.	200
▼ NastranNX			
<input type="radio"/>	MAT1 (temperature-independent, isotropic, with MATS1)	Exports data to the NastranNX MAT1 format. If a record contains a stress-strain curve it will be exported in the MATS1 format.	1000
<input type="radio"/>	MAT1/MAT11 (temperature-dependent, isotropic, with MATS1)	Exports data to the NastranNX MAT1/MAT11 format. If a record contains a stress-strain curve it will be exported in the MATS1 format.	1000
▼ Pro/ENGINEER Wildfire 5.0			
<input type="radio"/>	Linear, temperature-independent, isotropic, thermal, plastic	Exports temperature independent, isotropic data to the Pro/ENGINEER Wildfire 5.0 format.	1
▼ Pro/ENGINEER Wildfire 4.0			
<input type="radio"/>	Linear, temperature-independent, isotropic, thermal, plastic	Exports temperature independent, isotropic data to the Pro/ENGINEER Wildfire 4.0 format.	1
▼ SolidWorks 2011			
<input type="radio"/>	Linear, elastic, isotropic	Exports isotropic data to a SolidWorks material library file.	50
▼ Sierra Mechanics			
<input type="radio"/>	Multilinear elastic-plastic hardening (temperature-dependent, isotropic)	Exports temperature dependent, isotropic data to the Sierra Mechanics format. If temperature dependent data is not available then room temperature data will be exported.	50

Next

The Sierra Mechanics exporter was built for us by Granta

GRANTA Mi

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MMPDS-08 Database

▼ MMPDS-08 Master Document
MMPDS-08 Subset
MMPDS-08 Database

Exported Data

The export file for Sierra Mechanics (model 'Multilinear elastic-plastic hardening (temperature-dependent, isotropic)') is shown below

```
#Model Type: Linear, temperature-dependent, isotropic
#Unit System: SI (Consistent)
#Export User: SANDIA\rakarne
#Export DateTime: 2015-04-29T15:37:12.9217283-06:00
#Database Name: MMPDS-08 Database
#Table Name: MMPDS-08 Data
#Material Record History Id: 251049
#
BEGIN PROPERTY SPECIFICATION FOR MATERIAL "AISI_304_Annealed_Plate_Sheet_Strip_AMS_5513_S_Basis"
  DENSITY = 7.91645e+3 #kg/m^3
  BEGIN PARAMETERS FOR MODEL MULTILINEAR EP
    YOUNGS MODULUS = 1.99948e+11 #Pa
    POISSONS RATIO = 2.70000e-1 #[No Unit]
    YIELD STRESS = 1.79264e+8 #Pa
    BETA = 1
    HARDENING FUNCTION = hardening_function_"AISI_304_Annealed_Plate_Sheet_Strip_AMS_5513_S_Basis" #Pa
    YOUNGS MODULUS FUNCTION = youngs_modulus_function_"AISI_304_Annealed_Plate_Sheet_Strip_AMS_5513_S_Basis" #Pa
    POISSONS RATIO FUNCTION = poisson_ratio_function_"AISI_304_Annealed_Plate_Sheet_Strip_AMS_5513_S_Basis" #[No Unit]
    YIELD STRESS FUNCTION = yield_stress_function_"AISI_304_Annealed_Plate_Sheet_Strip_AMS_5513_S_Basis" #Pa
  END PARAMETERS FOR MODEL MULTILINEAR EP
END PROPERTY SPECIFICATION FOR MATERIAL "AISI_304_Annealed_Plate_Sheet_Strip_AMS_5513_S_Basis"
#
BEGIN DEFINITION FOR FUNCTION yield_stress_function_"AISI_304_Annealed_Plate_Sheet_Strip_AMS_5513_S_Basis"
  TYPE = PIECEWISE LINEAR
  ABSCISSA = temperature_K scale = 1 offset = 0
  ORDINATE = yield_stress_Pa offset = 0
  BEGIN VALUES
    -1.83333e-1,2.33097e+8
    1.09278e+1,2.32756e+8
    2.20389e+1,2.32272e+8
    3.31500e+1,2.31500e+8
```

Save To Disk | Copy To Clipboard

Exporters are coded in XSLT and can be shared

```
1 <?xml version="1.0" encoding="utf-8"?>
2 <!--$Rev: 50662 $-->
3 <xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform" xmlns:fe="http://www.grantadesign.com/Granta-MI/exports" xmlns:xtn="http://www.grantadesign.com/xmlns/xtension">
4
5 <xsl:import href="CommonUtilities.xsl"/>
6 <xsl:include href="SierraMechanicsFunctions.xsl"/>
7
8 <xsl:output method="text"/>
9
10 <!--Some useful constants-->
11 <xsl:param name="nSigFigs" select="6"/>
12 <xsl:param name="noValue" select="'[No Value]'" />
13 <xsl:param name="noUnit" select="'[No Unit]'" />
14
15 <xsl:template match="tab">
16 <xsl:text>&#x09;</xsl:text>
17 <xsl:apply-templates select="tab"/>
18 <xsl:copy-of select="self::node()[not(tab) and not(*[tab])]" />
19 </xsl:template>
20
21 <!-- Output the boiler-plate that we put at the start of each record section in the Sierra Mechanics file -->
22 <xsl:template name="writeRecordHeader">
23 <xsl:param name="modelName"/>
24 #GRANTA Material Name: <xsl:value-of select="xtn:escapeApos(string(@fullName))"/>
25 #Model Type: <xsl:value-of select="xtn:escapeApos(string($modelName))"/>
26 #Unit System: <xsl:value-of select="xtn:escapeApos(string(/fe:FEAExport/fe:definitions/fe:info/fe:UnitSystem))"/>
27 #Export User: <xsl:value-of select="xtn:escapeApos(string(/fe:FEAExport/fe:definitions/fe:info/fe:user))"/>
28 #Export Date/Time: <xsl:value-of select="/fe:FEAExport/fe:definitions/fe:info/fe:date"/>
29 #Database Name: <xsl:value-of select="xtn:escapeApos(string(/fe:FEAExport/fe:definitions/fe:volumeDetails/@name))"/>
30 #Table Name: <xsl:value-of select="xtn:escapeApos(string(/fe:FEAExport/fe:definitions/fe:info/fe:table))"/>
31 #Material Record History Id: <xsl:value-of select="@recordHistoryIdentity"/>
32 #
33 </xsl:template>
34
35 <!-- Writes one of the MI PROPERTIES sections as part of the human readable pedigree attribute: Granta name of the attribute to look up in the initial XML -->
36 <xsl:template name="writePropertyValue">
37 <xsl:param name="attribute"/>
38 <xsl:param name="modelAttributeName"/>
39 <xsl:param name="functionName"/>
40
41 <xsl:variable name="attrDefinition" select="/fe:FEAExport/fe:definitions/fe:attributes/fe:attribute[fe:Name = $attribute]"/>
42 <xsl:variable name="attr" select="fe:attributes/fe:attribute[@attributeID = $attrDefinition/@id]"/>
43
44 <xsl:variable name="outputText">
45 <xsl:value-of select="$modelAttributeName"/><xsl:text> = </xsl:text>
46 <xsl:choose>
47 <xsl:when test="$attr/fe:simpleValue"><xsl:apply-templates select="$attr/fe:simpleValue"/></xsl:when>
48 <xsl:when test="$attrDefinition/@CESAttributeType='functional'"><xsl:value-of select="$functionName"/></xsl:when>
49 <xsl:otherwise><xsl:value-of select="$noValue"/></xsl:otherwise>
50 </xsl:choose>
51 <xsl:text> #</xsl:text>
52 <xsl:choose>
53 <xsl:when test="$attrDefinition/fe:Units/@name"><xsl:value-of select="$attrDefinition/fe:Units/@name"/></xsl:when>
54 <xsl:otherwise><xsl:value-of select="$noUnit"/></xsl:otherwise>
55 </xsl:choose>
56 <xsl:text>&#x0D;&#xA;</xsl:text>
57 </xsl:variable>
58
59 <xsl:value-of select="xtn:escapeApos(string($outputText))"/>
60 </xsl:template>
61
62
63 <xsl:template name="writeFunction">
64 <xsl:param name="functionName"/>
65 <xsl:param name="functionalValues"/>
66 <xsl:param name="parameterValues"/>
67 <xsl:param name="ordinateName"/>
68
69 <!-- Write the yield stress function -->
70 <xsl:text>BEGIN DEFINITION FOR FUNCTION </xsl:text>
71 <xsl:value-of select="$functionName"/>
72 <xsl:text>&#x0D;&#xA;</xsl:text>
73
74 <xsl:choose>
```

Summary

- We are not yet exporting AM data
 - Nobody else really seems to be either!
- ...But we ARE exporting data in other databases
- We will use this experience to carefully critique the AM schema and how we add/use data
- The exporters are likely being built, and we may have the ability to help build them
- In addition to the technical aspects of coding an exporter that is most useful to end users, we are cognizant of other modes of data sharing and of the administrative/permission concerns