NISTIR 8122

STEP File Analyzer User's Guide (Version 3)

Robert R. Lipman

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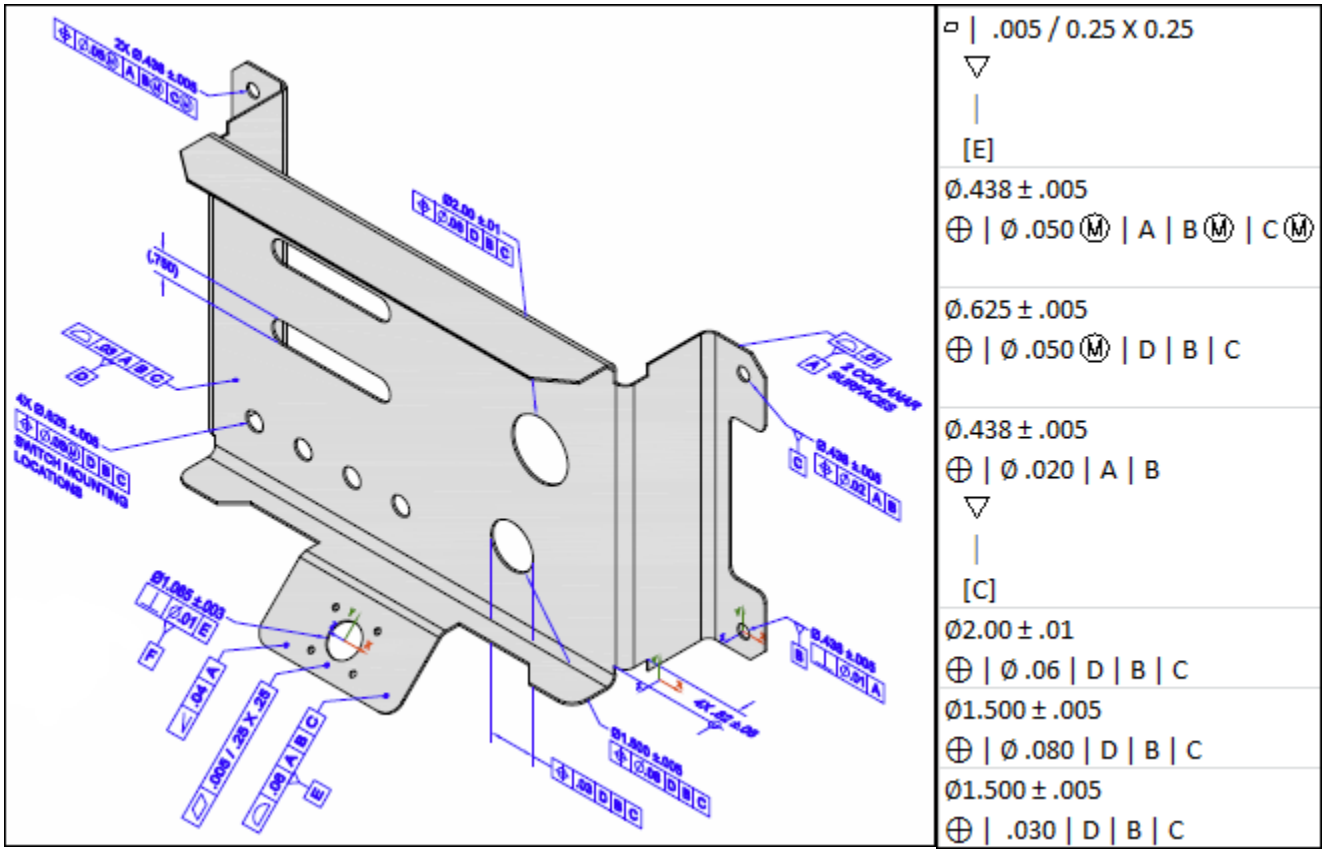
http://dx.doi.org/10.6028/NIST.IR.8122



National Institute of Standards and Technology
U.S. Department of Commerce

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Systems Integration Division
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April 2016

U.S. Department of Commerce
Penny Pritzker, Secretary

National Institute of Standards and Technology
Willie E. May, Under Secretary of Commerce for Standards and Technology and Director

PREFACE

This guide describes how to use the STEP File Analyzer, a software tool that analyzes and generates a spreadsheet from a STEP (STandard for the Exchange of Product model data) file. The spreadsheets simplify inspecting information in the STEP file at an entity and attribute level. STEP files can also be checked for conformance to recommended practices for Product and Manufacturing Information (PMI) representation, PMI presentation, and validation properties.

More information about the STEP File Analyzer and sample spreadsheets can be found at http://www.nist.gov/el/msid/infotest/step-file-analyzer.cfm.

The STEP File Analyzer is developed as part of the Digital Thread for Smart Manufacturing project in the Engineering Laboratory's Smart Manufacturing Operations Planning and Control Program (SMOPAC). The software was first released in 2012. This guide is based on version 1.60 of the software.

DISCLAIMERS

The STEP File Analyzer might not be up-to-date with the most recent recommended practices specified by the CAx Implementor's Forum. The software might also not check STEP files for conformance to every aspect of a recommended practice.

Any mention of commercial products in the STEP File Analyzer and this user's guide is for information purposes only; it does not imply recommendation or endorsement by NIST. For any of the web links in the software and this user's guide, NIST does not necessarily endorse the views expressed, or concur with the facts presented on those web sites.

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ACKNOWLEDGEMENTS

The author thanks Dr. Kent Reed, former leader of the NIST Computer Integrated Building Process Group, for his guidance in the development of the IFC File Analyzer (http://www.nist.gov/el/msid/infotest/ifc-file-analyzer.cfm) on which the STEP File Analyzer is based. The author also acknowledges the many software vendors and users who have provided invaluable feedback, suggestions, and bug reports about the software and supplied sample STEP files that were used to test and improve the capabilities of the software.

Cover image: Part with PMI annotations, part of a spreadsheet generated by the STEP File Analyzer

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1 Introduction

This guide describes how to use the STEP File Analyzer, a software tool that analyzes and generates a spreadsheet from a STEP (ISO 10303 – informally known as the STandard for Exchange of Product model data) [1-3] file. The spreadsheets simplify inspecting information from the STEP file at an entity and attribute level. In this report a "STEP file" refers to a file that is exported by CAD (Computer-Aided Design) software in a format described by ISO 10303-21[4] and typically known as a Part 21 file.

Typical STEP file viewers show a 3D visualization of the part or model represented by the STEP file. The viewers usually have a high-level hierarchical display of the information in the STEP file where the user can drill down to individual attributes of parts. However, there is no way to view all of the actual STEP entities and their attributes at once. The STEP File Analyzer provides this capability by creating a spreadsheet from the STEP file.

The STEP File Analyzer also checks for conformance to recommended practices for PMI (Product and Manufacturing Information) representation, PMI presentation, and validation properties [5]. Recommended practices are defined by the CAx Implementor Forum (CAx-IF) [6, 7]. The objective of the CAx-IF is to advance CAx (mainly Computer-Aided Design, Engineering, and Manufacturing) software system translator development and to ensure that user requirements for interoperability are satisfied. PMI may include geometric dimensions and tolerances (GD&T), 3D text annotations, surface finish, and material specifications. PMI representation includes all information necessary to represent GD&T without any graphical presentation elements, although an importing CAD system can attempt to recreate the visual presentation of the annotation. PMI presentation presents GD&T annotations as a visual representation of geometric elements such as lines and arcs as part of the CAD model. The validation properties include geometric, PMI, assembly, annotation, attribute, and tessellated validation properties.

The STEP File Analyzer supports current and some older versions of the following STEP Application Protocols (AP). An AP is the implementable part of ISO 10303 upon which translators are based for a particular engineering domain.

- AP203 – Configuration Controlled 3D Design of Mechanical Parts and Assemblies [8]
- AP209 – Structural Analysis Design [8]
- AP210 – Electronic Assembly Interconnect and Packaging Design [9]
- AP214 – Automotive Design [9]
- AP238 – Integrated CNC Schema [10]
- AP242 – Managed Model Based 3D Engineering [11-13]

2 Getting Started

2.1 Installing the Software

The STEP File Analyzer was developed for Windows computers. The software is a 32-bit application. The size of the STEP file that can be translated by the software depends on the amount of computer memory and the options selected when running the software. Microsoft Excel is required to generate a spreadsheet. The IFCsvr toolkit is required to read STEP files (section 2.2.1).

The link to the download request form for the STEP File Analyzer can be found on http://www.nist.gov/el/msid/infotest/step-file-analyzer.cfm. After submitting the download request, instructions about where to download the software is provided. The information is also emailed to the requestor. The software is downloaded as a zip file named `SFA.zip`.

The installation process does not require anything more than unzipping the file `SFA.zip`, which contains four files:

1. `STEP-File-Analyzer.exe` – STEP File Analyzer graphical user interface (GUI) version
2. `STEP-File-Analyzer-CL.exe` – STEP File Analyzer command-line version (section 8)
3. `SFA-Users-Guide.pdf` – This user's guide
4. `SFA-README-FIRST.pdf` – A readme file

There are no restrictions as to where the files are located in the computer's file system.

2.2 Running the Software

To run the STEP File Analyzer, simply double click on the icon for `STEP-File-Analyzer.exe`. Several setup functions are performed the first time the software is run:

1. The 'What's New' information is displayed in the Status tab.
2. The Disclaimers dialog is displayed.
3. This User's Guide is displayed.
4. The user is asked if a shortcut to the STEP File Analyzer can be created in the Start Menu and if an icon for the software can be placed on the Desktop.
5. The Crash Recovery dialog is displayed (section 2.4).
6. A file `STEP-File-Analyzer-options.dat` is created in the user's home directory that stores the current state of the STEP File Analyzer options. Do not edit this file.
7. The IFCsvr toolkit is installed.

2.2.1 Installing the IFCsvr toolkit

The IFCsvr toolkit [14, 15] is used to read and process STEP files[1]. The installation of the IFCsvr toolkit is simple and straightforward. Two of the installation dialogs are shown in Figure 1. The default installation folder should be used as shown in the second dialog. It is important to let the installation process complete before processing any STEP files with the STEP File Analyzer.

Figure 1: IFCsvr installation dialogs

[1] Although the toolkit was originally written to work with IFC (Industry Foundation Classes) data exchange files, used in the building and construction industry, it has been adapted to work with STEP files.

2.3 Generating a Spreadsheet

After the IFCsvr toolkit is installed, a spreadsheet can be generated from a STEP file that uses a supported AP. Go to the File menu, select 'Open STEP File(s)', select a STEP file on your computer, click Open in the dialog, and then click on the 'Generate Spreadsheet' button. Feedback will appear in the Status tab indicating the progress of processing the STEP file. The spreadsheet will be opened after it has been generated.

2.4 Recovering from a Crash

Sometimes the STEP File Analyzer will unexpectedly stop (crash) when processing a STEP file. This is usually due to either bugs in the STEP file or limitations of the IFCsvr toolkit. If this happens, simply restart the software and process the same STEP file again by using function key F1 or F4 if processing multiple STEP files. The software might also crash when processing very large STEP files. Figure 2 shows a dialog that is displayed the first few times the software is run.

The STEP File Analyzer keeps track of which entity type caused the crash for a particular STEP file and will not process that type again. More details about recovering from a crash are explained in section 7.

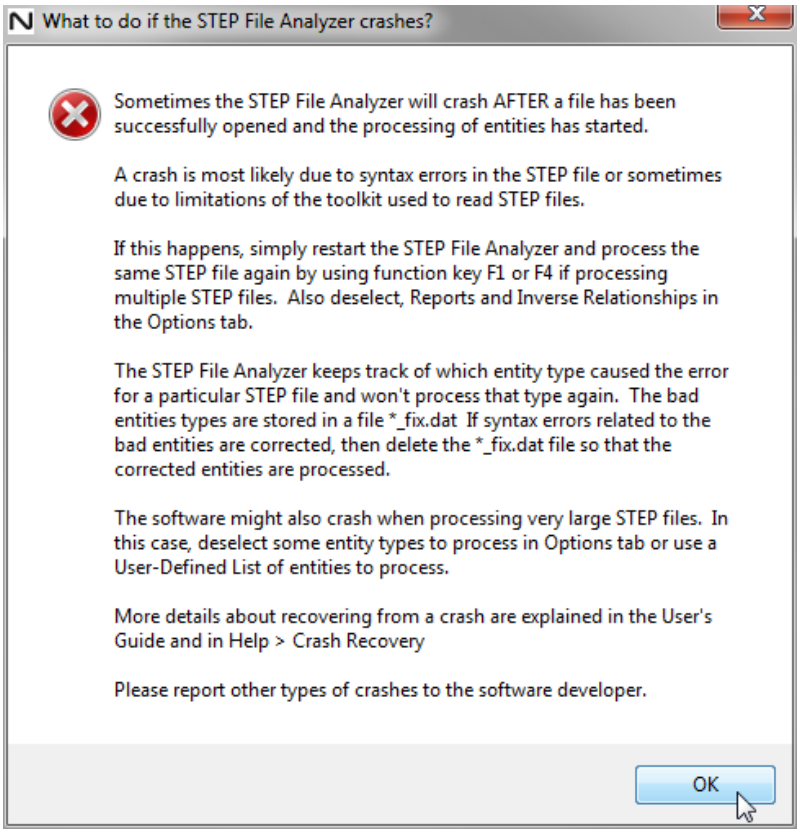


Figure 2: What to do if the STEP File Analyzer crashes

2.5 Uninstalling the Software

The STEP File Analyzer can be uninstalled by manually deleting the two executable files, the `STEP-File-Analyzer-options.dat` file in the user's home directory, and the desktop icon for the software. The IFCsvr toolkit can also be deleted from the Control Panel.

3 Sample Worksheets

The spreadsheet generated by the STEP File Analyzer contains several worksheets. There are Summary and Header worksheets, along with a worksheet for each entity type that was processed from the STEP file. The type of entities processed depends on the entities selected in the Process section of the Options tab. Links to sample worksheets are available on the STEP File Analyzer website http://www.nist.gov/el/msid/infotest/step-file-analyzer.cfm.

3.1 Summary Worksheet

An example of a Summary worksheet is shown in Figure 3. Rows 1-6 contain basic information about the STEP file including a link to documentation for the schema (AP214) used in the file. Starting with row 9, each row in column A is the name of an entity processed from the STEP file. The entity names are linked to their corresponding worksheet. Column B is the number of each entity type counted by the software.

	A	B	C	D
1	**STEP Directory**	C:\Users\lipman\Document		
2	**STEP File**	Vertical Plate.stp		
3	**Excel File**	Vertical Plate_stp.xlsx		
4	**Application**	Autodesk Inventor 2011		
5	**Total Entities**	1848		
6	**Schema**	AP214		
7				
8	**Entity**	**Count**		
9	draughting_pre_defined_colour	1		
10	fill_area_style	1		
11	fill_area_style_colour	1		
12	presentation_style_assignment	1		
13	styled_item	1		
14	surface_side_style	1		
15	surface_style_fill_area	1		
16	surface_style_usage	1		
17	advanced_brep_shape_representation	1		
18	mechanical_design_geometric_presentation_representation	1		
19	shape_definition_representation	1		
20	shape_representation	1		
21	shape_representation_relationship	1		
22	application_context	1		
23	application_protocol_definition	1		
24	product	1		
25	product_context	1		
26	product_definition	1		
27	product_definition_context	1		
28	product_definition_formation	1		
29	product_definition_shape	1		
30	product_related_product_category	1		
31	advanced_face	58		
32	axis2_placement_3d	99		
33	cartesian_point	311		
34	circle	40		
35	closed_shell	1		

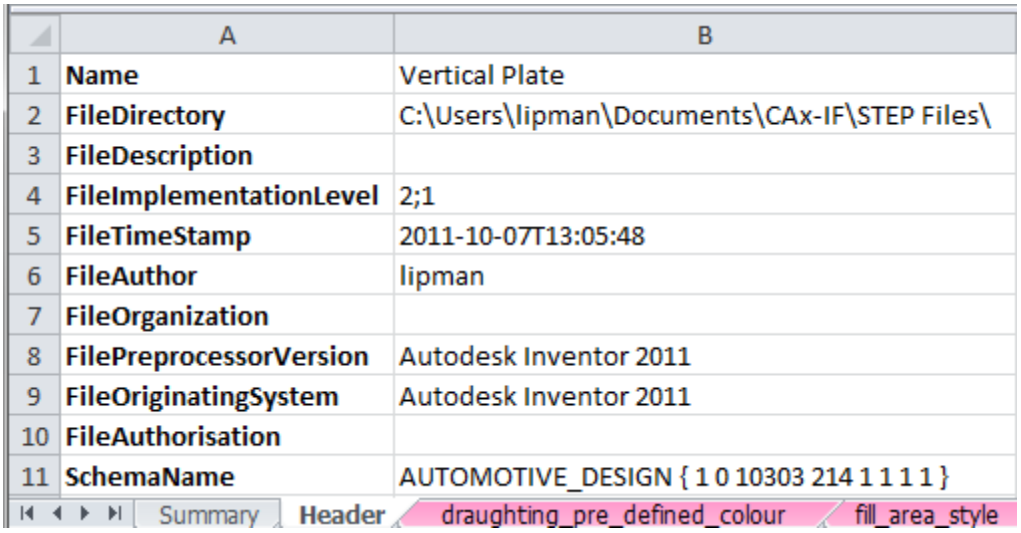
Summary | Header | draughting_pre_defined_colour | fill_area_style | fill_area_styl

Figure 3: Summary worksheet

At the bottom of the spreadsheet are tabs for the Summary, Header, and many entity worksheets. Entities in column A and in the worksheet tabs are grouped and colored according to the categories of entities in the Process section of the Options tab as described in section 4.4.1. Selecting a tab, using the links in column A, or using the Control-PageUp and Control-PageDown keys will switch to a different worksheet.

3.2 Header Worksheet

An example of the Header worksheet is shown in Figure 4. Rows 3-11 contain the information in a STEP file header section. Rows 1 and 2 are the STEP file name and directory.



	A	B
1	**Name**	Vertical Plate
2	**FileDirectory**	C:\Users\lipman\Documents\CAx-IF\STEP Files\
3	**FileDescription**	
4	**FileImplementationLevel**	2;1
5	**FileTimeStamp**	2011-10-07T13:05:48
6	**FileAuthor**	lipman
7	**FileOrganization**	
8	**FilePreprocessorVersion**	Autodesk Inventor 2011
9	**FileOriginatingSystem**	Autodesk Inventor 2011
10	**FileAuthorisation**	
11	**SchemaName**	AUTOMOTIVE_DESIGN { 1 0 10303 214 1 1 1 1 }

Figure 4: Header worksheet

3.3 Entity Worksheets

An example of a datum_system entity worksheet is shown in Figure 5. Row 1 contains the name of the entity and the number of entities. It is also a link back to the Summary worksheet. Row 3 is the names of the entity attributes. Column A is the entity ID.

Starting with row 4, each row contains the attribute values for an entity. Column B is the text string for the name attribute. Column C is the description attribute which is blank. Column D is the of_shape attribute where, in this example, all of the values for the entities are product_definition_shape 56. This means that the of_shape attribute is a reference to the product_definition_shape entity with an ID of 56. In column F, the constituents attribute refers to either single or multiple datum_reference_compartment entities. The number in parentheses is the number of entity references and the numbers after the entity name are the entity IDs that are referenced.

	A	B	C	D	E	F
1	datum_system (6)					
2						
3	**ID**	**name**	**description**	**of_shape**	**product_definitional**	**constituents**
4	37106	Perpendicularity.1		product_definition_shape 56	TRUE	(1) datum_reference_compartment 37101
5	42046	Position.1		product_definition_shape 56	TRUE	(2) datum_reference_compartment 42036 42041
6	51481	Position.3		product_definition_shape 56	TRUE	(3) datum_reference_compartment 51466 51471 51476
7	53696	Position.4		product_definition_shape 56	TRUE	(3) datum_reference_compartment 53681 53686 53691
8	70801	Position Surfacic Profile.2		product_definition_shape 56	TRUE	(3) datum_reference_compartment 70786 70791 70796
9	84091	Perpendicularity.2		product_definition_shape 56	TRUE	(1) datum_reference_compartment 84086

Figure 5: Entity worksheet (datum_system)

In the example of a draughting_model entity worksheet, shown in Figure 6, cells C4 and C6 refer to multiple entity types. Cell C5 refers to multiple styled_item entities, however, the entity IDs are not displayed because there are too many entity IDs to fit in one worksheet cell.

	A	B	C
1	draughting_model (3)		
2			
3	**ID**	**name**	**items**
4	31471		(2) annotation_plane 29651 31466 (1) axis2_placement_3d 36
5	31941		(93) styled_item
6	32031	detail view	(1) axis2_placement_3d 36 (1) camera_model_d3_multi_clipping 32026

Figure 6: Entity worksheet (draughting_model)

3.3.1 Skipped Attributes

Sometimes the STEP File Analyzer skips certain entity attributes due to limitations of the IFCsvr toolkit. A message about skipping an entity attribute will be displayed in the Status tab and question marks are displayed in the worksheet. For example, Figure 7 shows question marks (???) in column E where the control_points_list attributes were skipped.

	A	B	C	D	E
1	b_spline_surface_with_knots (730)				
2					
3	**ID**	**name**	**u_degree**	**v_degree**	**control_points_list**
4	51332		5	5	???
5	51464		3	1	???

Figure 7: Entity worksheet (b_spline_surface_with_knots)

4 User Interface

Figure 8 shows the STEP File Analyzer user interface running on a Windows 7 computer. At the top of the user interface is the Menu bar with the File, Websites, and Help menus. Below that is the Tabs bar with tabs for Status, Options, and Spreadsheet. Below that is the Status window that displays text feedback when the STEP File Analyzer is running. Clicking on the Options and Spreadsheet tabs will switch to the user interface for those tabs. At the bottom of the user interface is the Generate Spreadsheet button, NIST logo, and Progress bar.

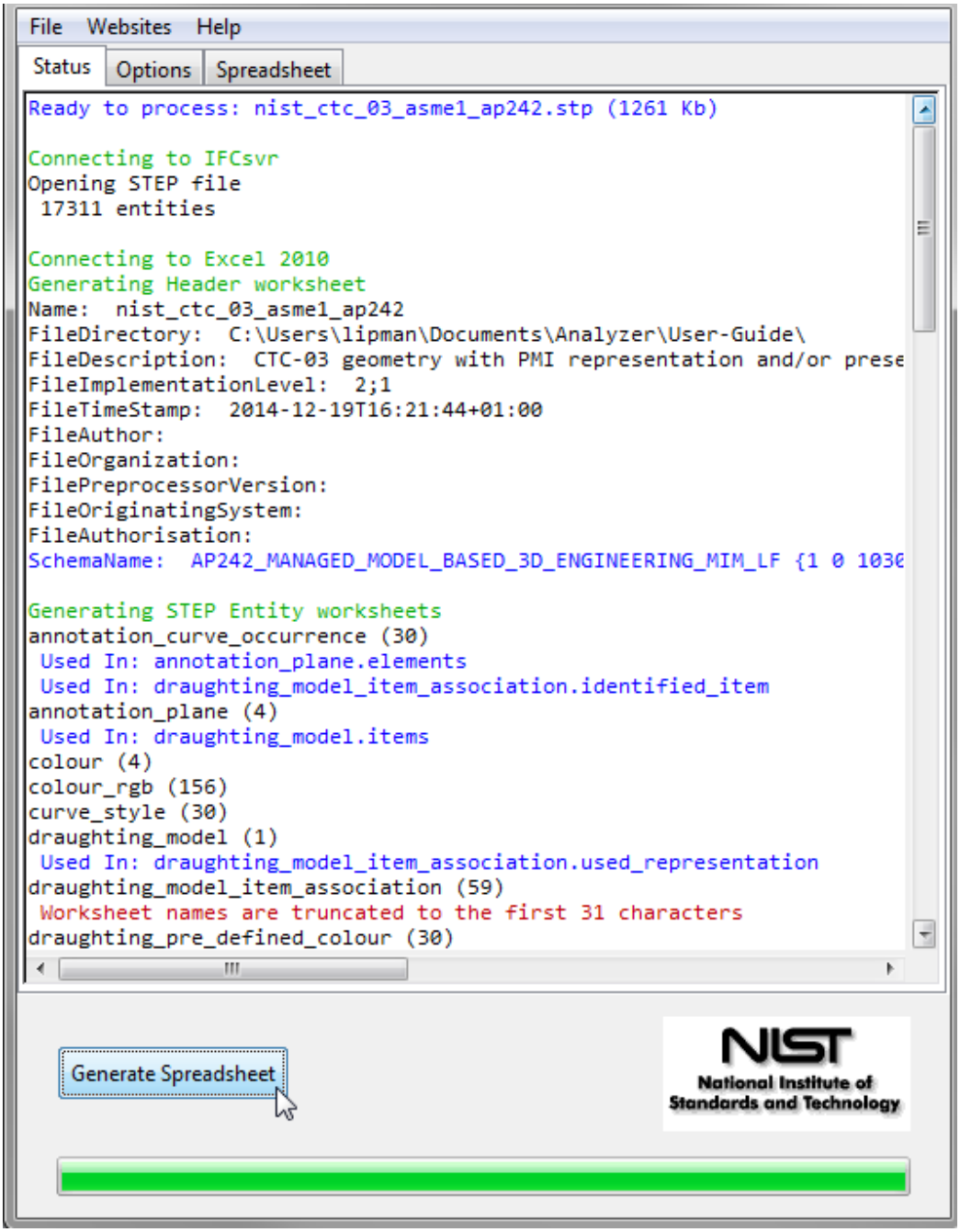


Figure 8: User interface

4.1 Menu Bar

The menu bar contains three items: the File menu, the Websites menu, and the Help menu.

4.1.1 File Menu

From the File menu, shown in Figure 9, the user can select a single STEP Part 21 file to process with "Open STEP File(s)…". STEP files with extensions of .stp, .step, and .p21 are recognized. Compressed STEP files with an extension of .stpZ are also recognized. Only STEP files using the supported AP's can be processed (section 1).

Multiple STEP files can be processed at one time by selecting the "Open Multiple STEP Files in a Directory…" option where the user will be asked to select a directory to search for STEP files. The search for multiple files can be restricted to only the selected directory or to include all subdirectories.

Multiple STEP files can also be selected in the "Open STEP File(s)" dialog by holding down the control or shift key when selecting files. When spreadsheets from multiple STEP files are generated a File Summary spreadsheet is also generated, as is described in section 6.

Below the first solid line in the File menu is a list of up to 20 of the most recently translated STEP files that can be opened directly. Several function keys can be used to access features of the File menu and in the software.

- F1 generates a spreadsheet from the STEP file that is first in the list.
- F2 opens the last spreadsheet that was generated.
- F3 opens the last File Summary spreadsheet when multiple STEP files were processed.
- F4 generates multiple spreadsheets from the last directory selected.
- F5 and F6 decrease and increase, respectively, the size of the text in the Status tab.

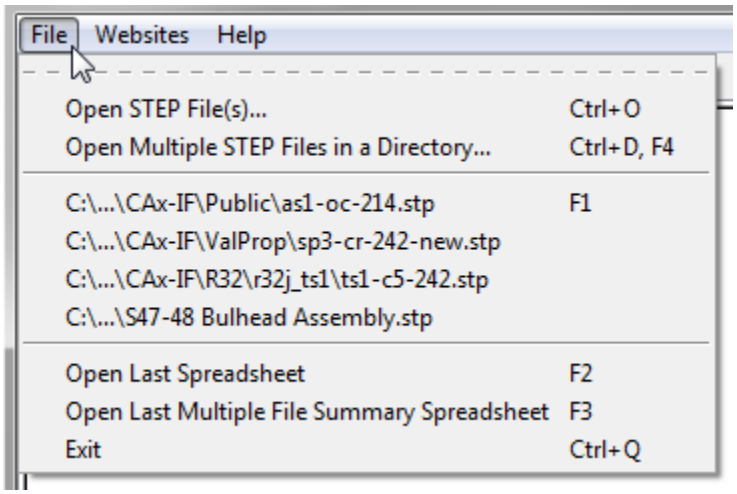


Figure 9: File menu

4.1.2 Websites Menu

The Websites menu, shown in Figure 10, provides links to useful resources related to the STEP File Analyzer, CAx-IF, NIST research, organizations that are programmatically related to STEP, and to several websites with documentation for entities in STEP AP203, AP214, and AP242.

4.1.3 Help Menu

The Help Menu, shown in Figure 11, has six sections. In the first two sections,

- "User's Guide (pdf)" is a link to this document.
- "What's New" displays information in the Status tab about new features in the software. This information is automatically displayed every time a new version of the software is run.
- "Check for Update" opens up a web page that checks for the latest version of the STEP File Analyzer. Follow the instructions on that web page to download a new version of the software if one is available. This feature runs automatically if an update hasn't been checked for in the last 30 days.
- "Sample STEP Files (zip)" are STEP files generated from the CAD models used in the NIST MBE PMI Validation and Conformance Testing Project [16].
- "Sample Output" are links to sample spreadsheets that contain many of the features described in this User's Guide.

The other topics in the Help menu display information in the Status tab and are similar to most information in this User's Guide.

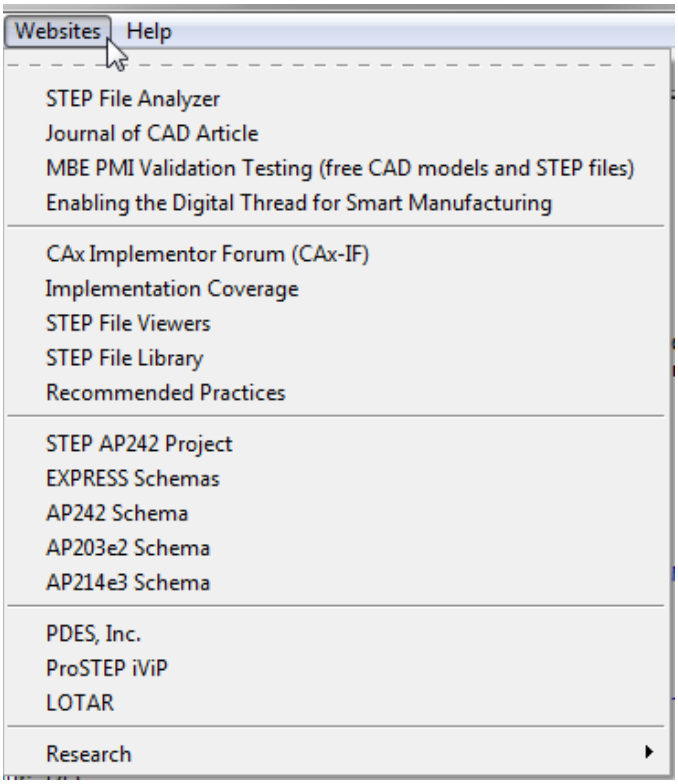


Figure 10: Websites menu

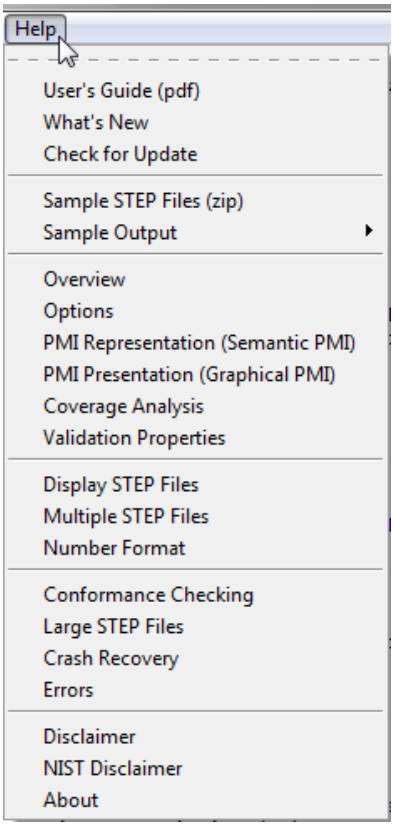


Figure 11: Help menu

Help is also available in the form of tooltips related to the display options in the tabs. Holding the mouse over any text in a tab for a second or two will display a tooltip. An example of the Validation Reports tooltip help in the Options tab is shown in Figure 12.

Features of the software that are not described in this User's Guide are explained in the Help menu topics or in tooltips.

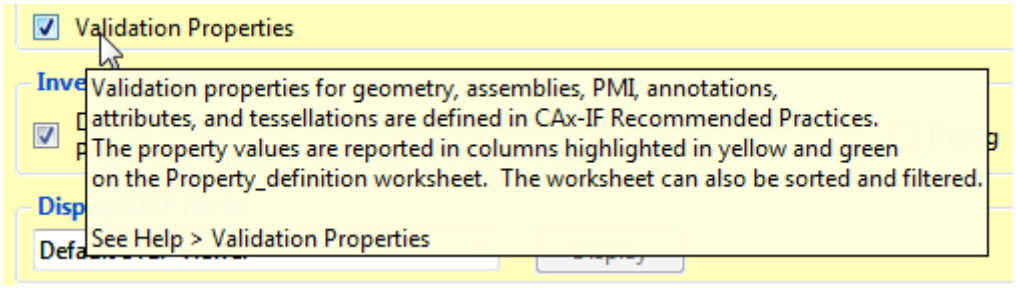


Figure 12: Tooltip help

4.2 Tabs Bar

The Tabs bar is located directly below the menu bar in Figure 8. Clicking on a tab will switch from the current tab to the selected tab. Except for the Status tab, the tabs contain the STEP File Analyzer display options that affect how a spreadsheet is generated from a STEP file. The options in the Options and Spreadsheet tabs are described in sections 4.4 and 4.5.

4.3 Status Tab

The Status tab displays important feedback during the generation of a spreadsheet from a STEP file. The feedback should not be ignored as it provides useful information related to the success in processing the STEP file. Some of the error, warning, or informational messages in the Status tab have a yellow background, red background, red, blue, or green text. Syntax error messages related to nonconformance to a recommended practice are highlighted with a red background. A brief example of the information in the Status tab is shown in Figure 8.

The following general sequence of status messages appears in the Status tab when a STEP file is processed:

- Messages about Connecting to IFCsvr, Loading STEP file, and Number of entities
  - The time to complete this step depends on the size of the STEP file
- Messages about Connecting to Excel and Generating Header worksheet
- Information from the STEP file header section
- STEP entities listed in the order they are processed
  - The number in parentheses is the number of entities of that type in the STEP file
  - The types of entities processed depends on the entities selected in the Process section of the Options tab (section 4.4.1)
- Possible messages about inverse relationships (section 0), checking recommended practices (section 4.4.2), and syntax errors
- Messages about Closing IFCsvr, Adding Summary worksheet, Formatting spreadsheet, Adding links to STEP documentation
- Messages about Saving and Loading the spreadsheet

4.4 Options Tab

Figure 13 shows the Options tab that enables the user to control which entities from the STEP file are written to the spreadsheet and to selectively add supplemental information to some worksheets.

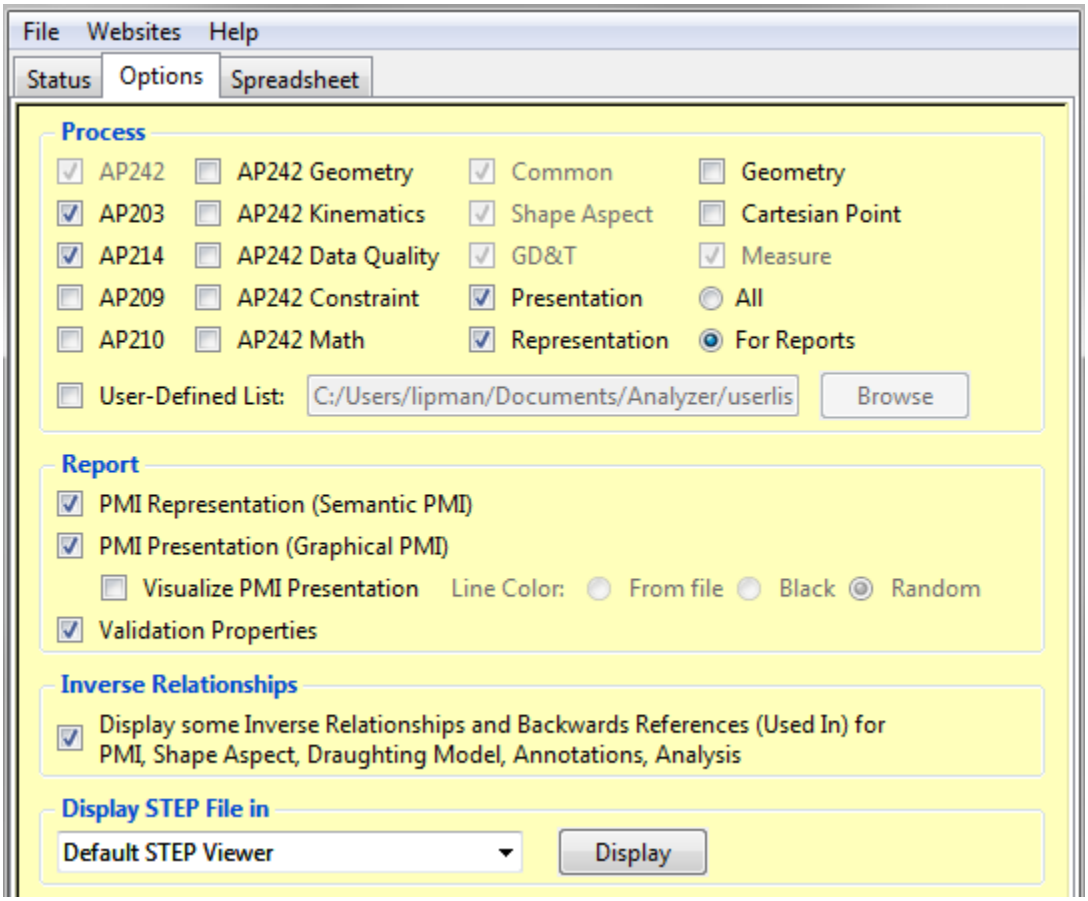


Figure 13: Options tab

4.4.1 Selectively Process Entity Types

The STEP File Analyzer can process any entity type from AP203, AP209, AP210, AP214, and AP242. The checkboxes in the Process section of the Options tab allow the user to selectively process different types of entities. Each checkbox corresponds to a category of entities. In the example in Figure 13, all entity types are processed except Geometry, Cartesian Point, AP209, AP210, and some AP242 entities.

The 'All' button selects all categories except Geometry, Cartesian Point, AP209, and AP210. The 'For Reports' button selects all three of the Report types for PMI Representation, PMI Presentation, and Validation Properties. Selecting any of the three Report types automatically includes the necessary entities related to that report. For example, selecting the report for PMI Representation automatically selects the entity categories for AP242, Common, Shape Aspect and GD&T and disables deselecting them.

By processing only certain types of entities, the size of and time to generate a spreadsheet can be reduced. The categories of entities are also used to order and color the entity names on the Summary worksheet

and tabs for the entity worksheets as shown in Figure 3. Each category of entities is assigned a different color and within each category the entities are listed in alphabetic order.

Holding the mouse over any checkbox for a second or two will display a tooltip that lists all of the entities in that category. An example of the tooltip for the GD&T (Geometric Dimensioning and Tolerancing) entities is shown in Figure 14. The tooltip indicates that there are 63 entities in the GD&T category. Some of the categories contain hundreds of entities and the tooltip might not fit on the screen.

A User-Defined List can also be used to set which entities will be processed. The list is defined in a plain text file with the name of one entity type per line in lower case. When the User-Defined List option is selected, the Browse button will be activated to select the file that contains the list of entities. This option is useful when processing very large STEP files to process only the required entity types to be analyzed.

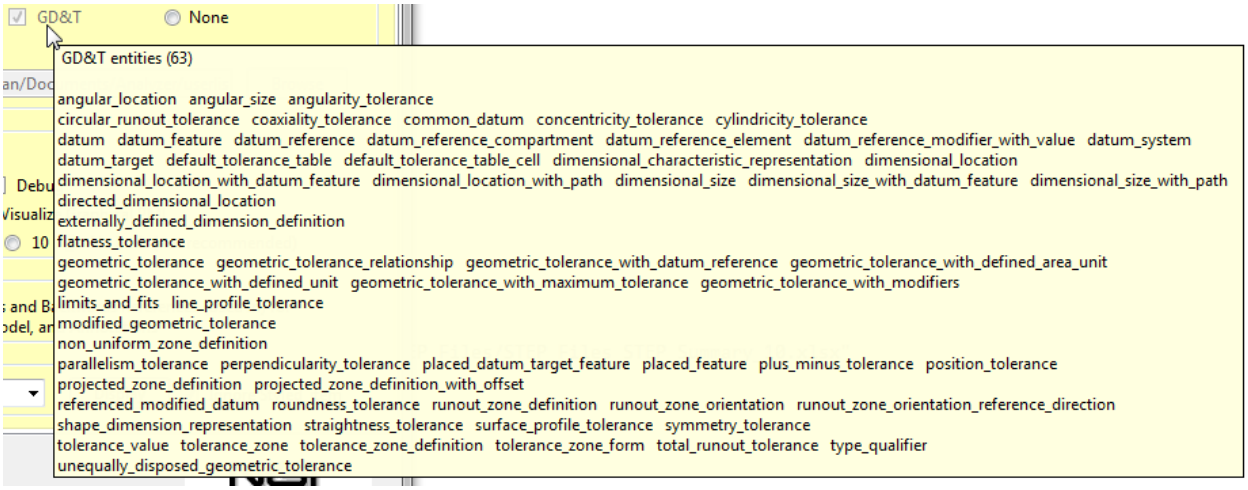


Figure 14: Tooltip help for GD&T entities

4.4.2 Reports for Recommended Practices

Recommended practices are specifications that provide common implementation guidance associated with specific functionalities for data exchange. The CAx-IF has published recommended practices for communicating PMI representation, PMI presentation, and validation properties in STEP files [7]. Recommended practices are not part of ISO 10303.

The STEP File Analyzer checks the STEP file for conformance to those recommended practices. Details about entity attribute values that indicate conformance are reported on various worksheets. Non-conformance is indicated by messages in the Status tab and spreadsheet cells are highlighted in red.

Section 5.1 discusses the report for PMI representation. Section 5.2 discusses the report for PMI presentation. Section 5.3 discusses the report for validation properties.

4.4.3 Inverse Relationships and Used In

In a STEP schema, an entity attribute whose value consists of entity references, in which the referenced entity has attributes referring to the referencing attribute's entity is called an inverse attribute. This establishes an inverse relationship [17]. Inverse relationships are explicitly defined in a STEP schema and reporting of some of those relationships has been implemented in the STEP File Analyzer.

Figure 15 is an entity worksheet for shape_aspect_relationship that shows the entity relationships established between the attribute values for relating_shape_aspect and related_shape_aspect in columns D and E.

	A	B	C	D	E
1	shape	aspect_relationship (71)			
2					
3	**ID**	**name**	**description**	**relating_shape_aspect**	**related_shape_aspect**
4	35781	Linear Size.1		composite_group_shape_aspect 35766	shape_aspect 35771
5	35796	Linear Size.1		composite_group_shape_aspect 35766	shape_aspect 35786
6	36201	Simple Datum.2		datum_feature 36202	datum 36203
7	37076	Perpendicularity.1		composite_group_shape_aspect 37061	shape_aspect 37066
8	37091	Perpendicularity.1		composite_group_shape_aspect 37061	shape_aspect 37081
9	40151	Linear Size.2		composite_group_shape_aspect 40136	shape_aspect 40141
10	40166	Linear Size.2		composite_group_shape_aspect 40136	shape_aspect 40156
11	40516	Simple Datum.3		datum_feature 40517	datum 40518
12	42016	Position.1		composite_group_shape_aspect 42001	shape_aspect 42006
13	42031	Position.1		composite_group_shape_aspect 42001	shape_aspect 42021

Figure 15: Entity worksheet (shape_aspect_relationship)

Figures 16 and 17 show how inverse relationships are displayed on the datum entity based on shape_aspect_relationship shown in Figure 15. Column G shows the relationship between datum and other entities. Column H, with the Used In header, shows where datum is referred to from other entity attributes although not by an inverse relationship established by a STEP schema. The tooltip in the Options tab for the Inverse Relationships selection will show the list of Inverse and Used In relationships that are processed.

	A	B	C	D	E	F
1	datum (6)					
2						
3	**ID**	**name**	**description**	**of_shape**	**product_definitional**	**identification**
4	36203	Simple Datum.2	Simple Datum.2	product_definition_shape 56	TRUE	B
5	40518	Simple Datum.3	Simple Datum.3	product_definition_shape 56	TRUE	C
6	70983	Simple Datum.5	Simple Datum.5	product_definition_shape 56	TRUE	E
7	37096	Simple Datum.1	Simple Datum.1	product_definition_shape 56	TRUE	A
8	53676	Simple Datum.4	Simple Datum.4	product_definition_shape 56	TRUE	D
9	84273	Simple Datum.6	Simple Datum.6	product_definition_shape 56	TRUE	F

Figure 16: Inverse Relationships and Used In example (columns A-F)

	G	H
1		
2		
3	**INV-relating_shape_aspect**	**Used In**
4	(1) datum_feature 36202	(8) datum_reference_compartment.base 42041 51471 53686 62416 66846 68581 70791 77256
5	(1) datum_feature 40517	(7) datum_reference_compartment.base 51476 53691 62421 66851 68586 70796 77261
6	(1) datum_feature 70982	(1) datum_reference_compartment.base 84086
7	(1) datum_feature 75912	(6) datum_reference_compartment.base 37101 42036 51466 70786 73696 77251
8	(1) datum_feature 77502	(4) datum_reference_compartment.base 53681 62411 66841 68576
9	(1) datum_feature 84272	

Figure 17: Inverse Relationships and Used In example (columns G-H)

4.4.4 Display STEP File in Other Applications

The "Display STEP File in" option is a convenient way to display a STEP file in other applications. Figure 18 shows the pull-down menu listing some of the applications that can display a STEP file on the author's computer. The pull-down menu will always contain the Notepad text editor, "Default STEP Viewer", and "Indent STEP File (for debugging)" which is described below. The "Default STEP Viewer" is whichever application is associated with STEP files. In this example, several STEP file viewers and conformance checkers also appear in the pull-down menu. Applications will appear in the pull-down menu if they are installed in their default location. To display a STEP file in one of the applications, select the application from the pull-down menu and click the Display button.

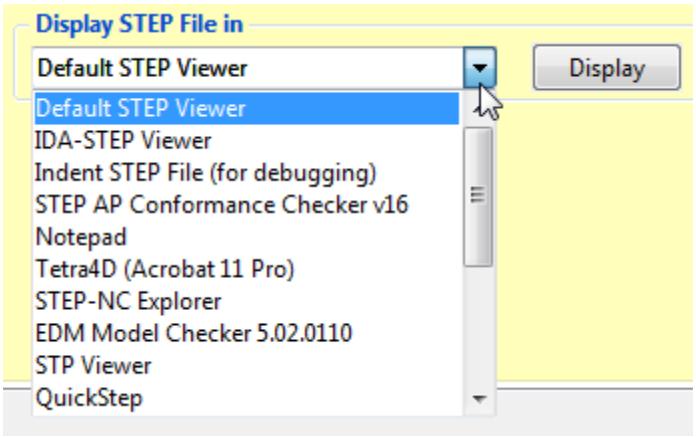


Figure 18: Display STEP File in other applications

4.4.4.1 Indent STEP File

The option to "Indent STEP File" will display the STEP file in a text editor; however, the STEP entities will be rearranged and indented to show the hierarchy of information in the STEP file. This is a useful feature to help debug a STEP file, but is not recommended for large STEP files. Figure 19 shows a sample of the "indented" output. In this sample, it is easy to see how flatness_tolerance (#5584) refers to length_measure_with_unit (#5585) and datum_feature (#5583). An "indented" portion of the STEP file starts with entities that will generate useful output and stops with other entities to prevent the "indented" file from getting too large. Basic geometric entities can optionally be included in the "indented" file which will increase the size of the file.

```
#5584=FLATNESS_TOLERANCE('GT1',$,#5585,#5583);
  #5585=LENGTH_MEASURE_WITH_UNIT(LENGTH_MEASURE(0.02),#24);
    #24=(LENGTH_UNIT()NAMED_UNIT(*)SI_UNIT(.MILLI.,.METRE.));
  #5583=DATUM_FEATURE('F116',$,#37,.T.);
    #37=PRODUCT_DEFINITION_SHAPE('None','None',#36);
      #36=PRODUCT_DEFINITION('None','None',#34,#35);
        #34=PRODUCT_DEFINITION_FORMATION('','None',#32);
          #32=PRODUCT('GDT_Test_Part_2011_1-id','','None',(#12273));
            #12273=PRODUCT_CONTEXT('part',#29,'');
              #29=APPLICATION_CONTEXT('automotive design');
        #35=PRODUCT_DEFINITION_CONTEXT('part definition',#29,'design');
```

Figure 19: Indented STEP file

4.5 Spreadsheet Tab

The Spreadsheet tab, shown in Figure 20, contains several more options that affect how information is written to the spreadsheet.

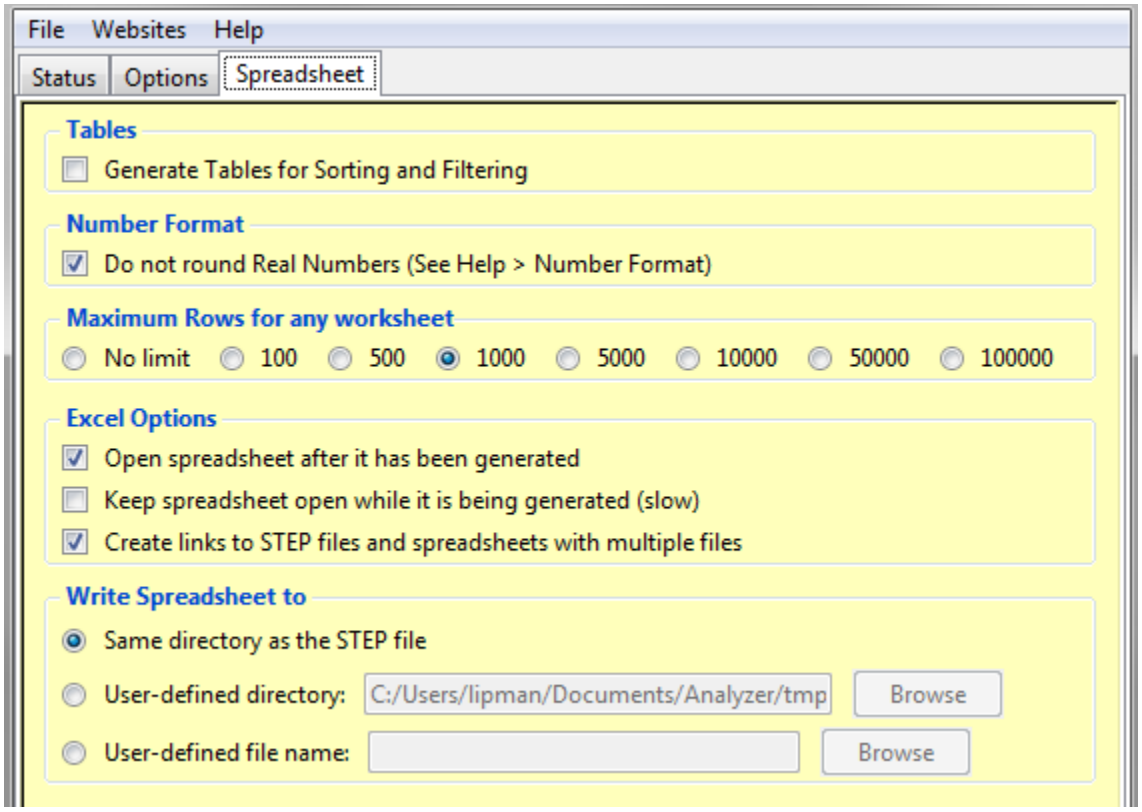


Figure 20: Spreadsheet tab

4.5.1 Tables

Figure 21 shows the shape_aspect worksheet with the option for generating tables turned on. With this option, pull-down menus (selector on the right of each cell in row 3) are displayed with the column headers in row 3 that access functions to sort and filter the rows. In this example, the table is sorted by the name attribute in column B. This is evident by the order of the entity IDs in column A. The worksheet containing validation properties (section 5.3) is always sorted.

	A	B	C	D	E
1	shape	aspect (69)			
2					
3	ID	name	descriptio	of_shape	product_definitiona
4	73686	Angularity.1		product_definition_shape 56	TRUE
5	73091	Flatness.1		product_definition_shape 56	TRUE
6	35771	Linear Size.1		product_definition_shape 56	TRUE
7	35786	Linear Size.1		product_definition_shape 56	TRUE
8	66951	Linear Size.10		product_definition_shape 56	TRUE
9	66966	Linear Size.10		product_definition_shape 56	TRUE
10	69381	Linear Size.11		product_definition_shape 56	TRUE
11	69396	Linear Size.11		product_definition_shape 56	TRUE
12	40141	Linear Size.2		product_definition_shape 56	TRUE

Figure 21: Entity worksheet (shape_aspect) with tables for sorting

4.5.2 Number Format

By default, when the STEP File Analyzer adds a single real number to a worksheet cell, Excel might round the number. Figure 22, on the left, shows values of radius in column D that are rounded. Using the Number Format option in the Spreadsheet tab to not round real numbers, results in the radius values displayed with full precision in the worksheet on the right. The non-rounded real numbers are the actual values that appear in a STEP file. The non-rounded real numbers are indicated by the small green triangle in the upper left corner of a cell. The non-rounded real numbers are also left justified as opposed to the rounded real numbers that are right-justified. Real numbers that appear in pairs or triplets, such as cartesian points, are never rounded.

	A	B	C	D
1	circle (146)			
2				
3	ID	name	position	radius
4	86		axis2_placement_3d 85	3
5	103		axis2_placement_3d 102	3
6	128		axis2_placement_3d 127	3
7	145		axis2_placement_3d 144	3
8	170		axis2_placement_3d 169	3
9	187		axis2_placement_3d 186	3
10	212		axis2_placement_3d 211	3
11	229		axis2_placement_3d 228	3
12	358		axis2_placement_3d 357	3.375
13	388		axis2_placement_3d 387	3.375

	A	B	C	D
1	circle (146)			
2				
3	ID	name	position	radius
4	86		axis2_placement_3d 85	2.999999999999695
5	103		axis2_placement_3d 102	2.999999999999695
6	128		axis2_placement_3d 127	2.999999999999792
7	145		axis2_placement_3d 144	2.999999999999792
8	170		axis2_placement_3d 169	2.999999999999695
9	187		axis2_placement_3d 186	2.999999999999695
10	212		axis2_placement_3d 211	2.999999999999803
11	229		axis2_placement_3d 228	2.999999999999803
12	358		axis2_placement_3d 357	3.375
13	388		axis2_placement_3d 387	3.375

Figure 22: Rounding numbers example

4.5.3 Maximum Rows

The maximum rows option in the Spreadsheet tab limits the maximum numbers of rows in any spreadsheet to the selected value. This is a way to reduce the size of the spreadsheet and speed processing of the STEP file. Figure 23 is an example where only the first 100 of 43681 rows for the cartesian_point entities are written to the worksheet.

	A	B	C
1	cartesian_point (100 of 43681)		
2			
3	**ID**	**name**	**coordinates**
4	18	#18	-0.9881 1.634176638 18.017717023
5	20	#20	-0.9881 1.547763978 17.548888756
6	22	#22	-0.892674976425 1.568442637 17.469469568
7	24	#24	-0.247174976425 1.828113272 17.582158424
8	26	#26	-0.1846 1.864882875 17.656001817
9	28	#28	-0.1846 1.961858223 18.18213751
10	30	#30	0.3089 2.140780414 18.161940186

Figure 23: Maximum rows example

4.5.4 Other Options

The other options on the Spreadsheet tab control:

- opening the spreadsheet after or while it is being generated
- generating links from entity worksheets to the Summary worksheet and entity documentation
- generating links on the File Summary worksheet when multiple STEP files are processed
- specifying where to write the spreadsheet

5 Reports

Product and manufacturing information (PMI) are annotations and attributes that define product geometry and product specifications [18]. PMI includes 3D annotations to specify Geometric Dimensioning and Tolerancing (GD&T), as well as non-geometric data such as surface texture specifications, finish requirements, process notes, material specifications, and welding symbols. GD&T is a symbolic language used to communicate tolerances on manufactured parts. The industry standards for presentation of GD&T in axonometric views in 3D space are ASME Y14.41-2003 [19] and ISO 16792:2006 [20]. Some common tolerances include dimensional tolerances on length and diameter, and geometric tolerances on flatness, position, surface profile, and circular runout.

Figure 24 shows a part with typical PMI annotations including dimensions, geometric and dimensional tolerances, and datum features. Most of these types of annotations are processed by the STEP File Analyzer.

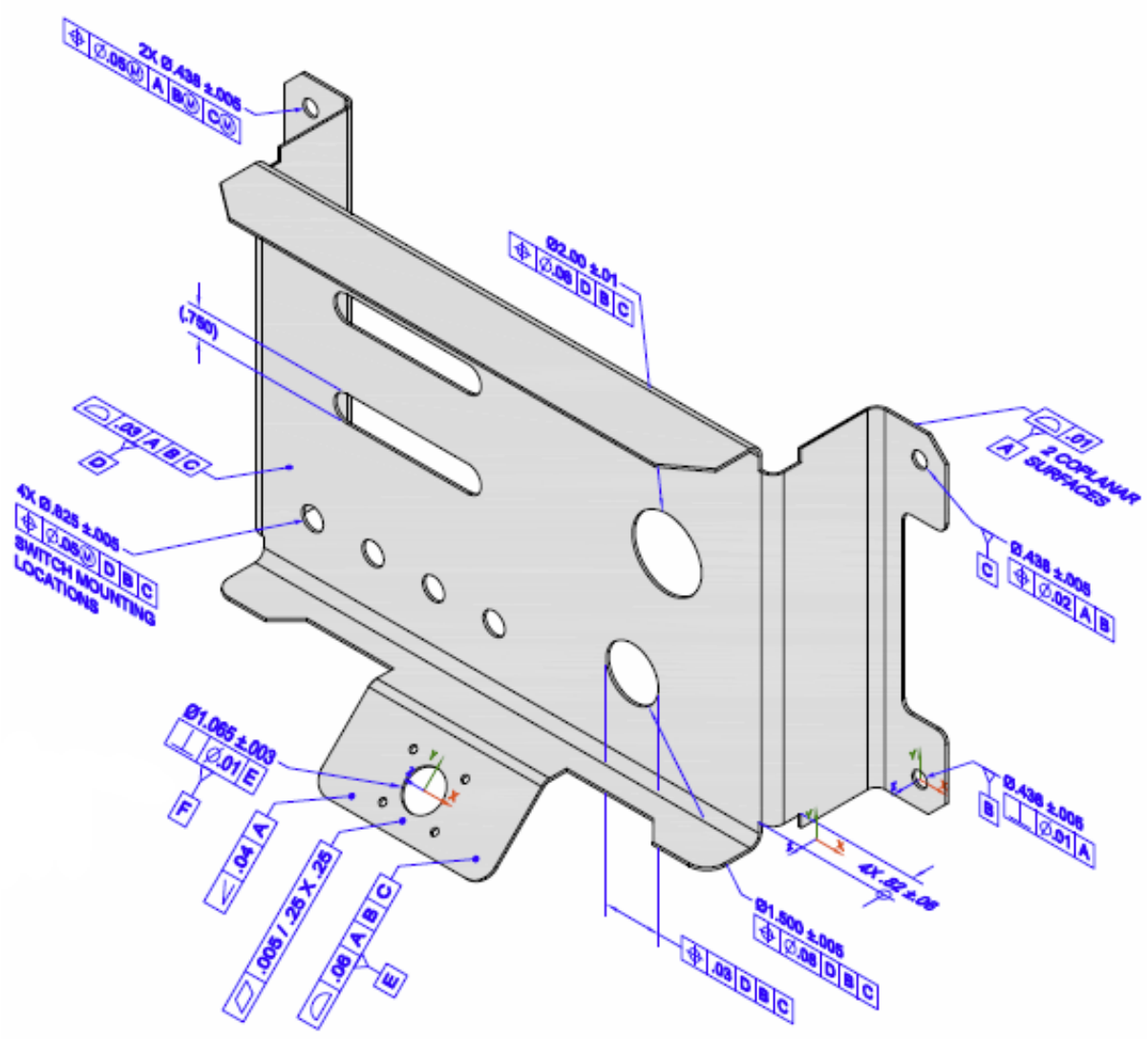


Figure 24: Part with PMI annotations

Figure 25 shows the summary worksheet, similar to Figure 3, with entities highlighted that have information related to PMI Representation and PMI Presentation. Rows 10-13 are entities related to the datum reference frame. Row 14 is the dimensional_characteristic_representation entity which is associated with all dimensional tolerances. Rows 9 and 17-24 are entities related to geometric tolerances. Row 28 is the annotation_curve_occurrence entity which is associated with PMI presentation. The entity name in parentheses in cell A17 is for a complex entity (flatness_tolerance)(geometric_tolerance_with_defined_unit_area). All of the worksheets for the highlighted entities will have extra columns with PMI information.

	A	B
1	**STEP Directory**	C:\Users\lipman\Documents\Analyzer\User-Guide
2	**STEP File**	nist_ctc_03_asme1_ap242.stp
3	**Excel File**	nist_ctc_03_asme1_ap242_stp.xlsx
4	**Total Entities**	17311
5	**Schema**	AP242
6	**Dimension Units**	INCH
7		
8	**Entity**	**Count**
9	angularity_tolerance [PMI Representation]	1
10	datum	6
11	datum_feature	6
12	datum_reference_compartment [PMI Representation]	26
13	datum_system [PMI Representation]	6
14	dimensional_characteristic_representation [PMI Representation]	10
15	dimensional_location	2
16	dimensional_size	8
17	(flatness_tolerance) (geometric_tolerance_with_defined_area_unit) [PMI Representation]	1
18	(geometric_tolerance_with_datum_reference) (geometric_tolerance_with_modifiers) (position_tolerance) [PMI Representation]	2
19	(geometric_tolerance_with_datum_reference) (position_tolerance) [PMI Representation]	4
20	(geometric_tolerance_with_datum_reference) (surface_profile_tolerance) [PMI Representation]	2
21	perpendicularity_tolerance [PMI Representation]	2
22	plus_minus_tolerance	8
23	shape_dimension_representation	10
24	surface_profile_tolerance [PMI Representation]	1
25	tolerance_value	8
26	tolerance_zone	7
27	tolerance_zone_form	7
28	annotation_curve_occurrence [PMI Presentation]	30
29	annotation_plane	4
30	colour_rgb	156

Summary | Header | PMI Representation Summary | PMI Representation Coverage | PMI Presentation Coverage

Figure 25: Summary worksheet with entities highlighted for PMI

5.1 PMI Representation

PMI representation (also known as semantic PMI) includes all information necessary to represent GD&T without any graphical presentation elements. PMI representation is associated with CAD model geometry and is computer-interpretable to facilitate automated consumption by downstream applications for manufacturing, measurement, inspection, and others. PMI representation does not contain any information regarding its visual appearance although an importing CAD system can attempt to recreate the visual presentation of the annotation. The CAx-IF defines recommended practices for PMI representation [21].

5.1.1 Visual Presentation of PMI Representation

Sections 5.1.2 through 5.1.4 show three examples of how PMI representation is reported. The report includes a visual presentation of the semantic PMI information that can be used for visual verification of that information. The visual presentation should correspond to the expected PMI annotations similar to those on Figure 24. If the visual presentation does not look right, then the semantic PMI information might be wrong. The visual presentation is limited by the characters and symbols available in the spreadsheet.

5.1.2 Datum Reference Frame Example

The following figures show how a datum reference frame is modeled in a STEP file. Figure 26 shows the datum worksheet that defines datum labels in column F.

	A	B	C	D	E	F
1	datum (6)					
2						
3	**ID**	**name**	**description**	**of_shape**	**product_definitional**	**identification**
4	36203	Simple Datum.2	Simple Datum.2	product_definition_shape 56	TRUE	B
5	40518	Simple Datum.3	Simple Datum.3	product_definition_shape 56	TRUE	C
6	70983	Simple Datum.5	Simple Datum.5	product_definition_shape 56	TRUE	E
7	37096	Simple Datum.1	Simple Datum.1	product_definition_shape 56	TRUE	A
8	53676	Simple Datum.4	Simple Datum.4	product_definition_shape 56	TRUE	D
9	84273	Simple Datum.6	Simple Datum.6	product_definition_shape 56	TRUE	F

Figure 26: Entity worksheet (datum)

Figure 27 shows the datum_reference_compartment worksheet with information for the compartments of a datum reference frame. The compartments are constructed from the base attribute that refers to the datum entity above and the modifiers attribute. The visual presentation of the compartments is shown in column H. The parenthetic notation in cell H3 indicates the section number in the CAx-IF recommended practice for PMI representation related to that information [21].

	A	B	C	D	E	F	G	H
1	datum_reference_compartment (26)							
2								**PMI Representation**
3	**ID**	**name**	**description**	**of_shape**	**product_definitional**	**base**	**modifiers**	**compartment (Sec. 6.9.7, 6.9.8)**
4	37101	Perpendicularity.1		product_definition_shape 56	TRUE	datum 37096		A
5	42036	Position.1		product_definition_shape 56	TRUE	datum 37096		A
6	42041	Position.1		product_definition_shape 56	TRUE	datum 36203		B
7	51466	Position.3		product_definition_shape 56	TRUE	datum 37096		A
8	51471	Position.3		product_definition_shape 56	TRUE	datum 36203	maximum_material_requirement	B Ⓜ
9	51476	Position.3		product_definition_shape 56	TRUE	datum 40518	maximum_material_requirement	C Ⓜ
10	53681	Position.4		product_definition_shape 56	TRUE	datum 53676		D

Figure 27: Entity worksheet (datum_reference_compartment)

Figure 28 shows the datum_system worksheet with information to combine the datum reference compartments, defined by the constituents attribute, to create a datum reference frame. The visual presentation of the datum reference frames is shown in column G.

	A	B	C	D	E	F	G
1	datum_system (6)						
2							PMI Representation
3	ID	name	description	of_shape	product_definitional	constituents	Datum Reference Frame (Sec. 6.9.7, 6.9.8)
4	37106	Perpendicularity.1		product_definition_shape 56	TRUE	(1) datum_reference_compartment 37101	A
5	42046	Position.1		product_definition_shape 56	TRUE	(2) datum_reference_compartment 42036 42041	A | B
6	51481	Position.3		product_definition_shape 56	TRUE	(3) datum_reference_compartment 51466 51471 51476	A | B Ⓜ | C Ⓜ
7	53696	Position.4		product_definition_shape 56	TRUE	(3) datum_reference_compartment 53681 53686 53691	D | B | C
8	70801	Position Surfacic Profile.2		product_definition_shape 56	TRUE	(3) datum_reference_compartment 70786 70791 70796	A | B | C
9	84091	Perpendicularity.2		product_definition_shape 56	TRUE	(1) datum_reference_compartment 84086	E

Figure 28: Datum reference frame example

5.1.3 Dimensional Tolerance Example

The following figures show how a dimensional tolerance is modeled in a STEP file. Figures 29 and 30 shows the dimensional_characteristic_representation worksheet where information related to dimensional tolerances is reported.

- Column B is the type of dimension, either dimensional_size or dimensional_location.
- Column C is a reference to shape_dimension_representation which refers to information for the dimension name and value.
- Column D shows the name attribute of the entity type shown in column B.
- Column E shows the name attribute of the entity type shown in column C.
- Column F shows the dimension (length value) associated with the shape_dimension_representation entity in column C.
- Column G shows the name of the length value in column F.
- Column H shows the plus-minus bounds associated with the dimensional tolerance. The bounds are defined by plus_minus_tolerance entities.
- Column I shows the visual presentation of the dimensional tolerances that correspond to the PMI annotations in Figure 24.
- Column J shows the geometric entities associated with the dimensional tolerances. In this case, the association is through shape_aspect entities which refer to advanced_face entities. The geometry entities cylindrical_surface and plane are referred to by the advanced_face attribute face_geometry.
- Not shown are columns for dimension modifiers and a value to specify the number of decimal places for the dimension.

The parenthetic notation in row 3 indicates the section number in the CAx-IF recommended practice for PMI representation related to that piece of information. For example, sections 5.1.1 (column D) and 5.2.1 (column E) in the recommended practice specify allowable attribute values shown in those columns.

The visual presentation can be used to do a semantic analysis of the PMI representation information. The dimension '0.75' in cell I11 appears as a basic dimension '(.750)' in Figure 24. In this case, the STEP file is missing the dimension modifier for a basic dimension. The visual presentation of the dimension shows that parentheses for a basic dimension are missing.

The feature count for a dimension, e.g. '2X', can be derived from the number of geometric surfaces in the associated geometry in column J. In this example, the feature count is half the number of geometric surfaces. For example, the dimensional tolerance in cell I6 would have a feature count of '4X' because there are eight cylindrical surfaces associated with it. This is confirmed in Figure 24.

	A	B	C
1	dimensional_characteristic_representation (10)		
2			
3	**ID**	**dimension**	**representation**
4	35831	dimensional_size 35801	shape_dimension_representation 35826
5	40201	dimensional_size 40171	shape_dimension_representation 40196
6	45336	dimensional_size 45306	shape_dimension_representation 45331
7	48741	dimensional_size 48711	shape_dimension_representation 48736
8	60541	dimensional_size 60511	shape_dimension_representation 60536
9	64886	dimensional_size 64856	shape_dimension_representation 64881
10	67011	dimensional_size 66981	shape_dimension_representation 67006
11	69441	dimensional_location 69411	shape_dimension_representation 69436
12	80071	dimensional_location 80041	shape_dimension_representation 80066
13	83181	dimensional_size 83151	shape_dimension_representation 83176

Figure 29: Dimensional tolerance example (columns A-C)

	D	E	F	G	H	I	J
1							
2	PMI Representation						
3	dimension name (Sec. 5.1.1, 5.1.5)	representation name (Sec. 5.2.1)	length/angle (Sec. 5.2.1)	length/angle name	plus minus bounds (Sec. 5.2.3)	Dimensional Tolerance	Associated Geometry (Sec. 5.1.1, 5.1.5)
4	diameter		0.438	nominal value	-0.005 0.005	Ø.438 ± .005	(2) cylindrical_surface 23661 23771 (2) advanced_face 23746 23806 (2) shape_aspect 35771 35786 (1) composite_group_shape_aspect 35766
5	diameter		0.438	nominal value	-0.005 0.005	Ø.438 ± .005	(2) cylindrical_surface 23831 23941 (2) advanced_face 23916 23976 (2) shape_aspect 40141 40156 (1) composite_group_shape_aspect 40136
6	diameter		0.625	nominal value	-0.005 0.005	Ø.625 ± .005	(8) cylindrical_surface 10716 10826 10886 10996 11056 11166 11226 11336 (8) advanced_face 10801 10861 10971 11031 11141 11201 11311 11371 (8) shape_aspect 45186 45201 45216 45231 45246 45261 45276 45291 (1) composite_group_shape_aspect 45181
7	diameter		0.438	nominal value	-0.005 0.005	Ø.438 ± .005	(4) cylindrical_surface 24571 24681 24741 24851 (4) advanced_face 24656 24716 24826 24886 (4) shape_aspect 48651 48666 48681 48696 (1) composite_group_shape_aspect 48646
8	diameter		2.0	nominal value	-0.01 0.01	Ø2.00 ± .01	(2) cylindrical_surface 9696 9806 (2) advanced_face 9781 9841 (2) shape_aspect 60481 60496 (1) composite_group_shape_aspect 60476
9	diameter		1.5	nominal value	-0.005 0.005	Ø1.500 ± .005	(2) cylindrical_surface 10546 10656 (2) advanced_face 10631 10691 (2) shape_aspect 64826 64841 (1) composite_group_shape_aspect 64821
10	diameter		1.5	nominal value		Ø1.5	(2) cylindrical_surface 10546 10656 (2) advanced_face 10631 10691 (2) shape_aspect 66951 66966 (1) composite_group_shape_aspect 66946
11	linear distance		0.75	nominal value		.750	(2) plane 9866 10061 (2) advanced_face 9951 10121 (2) shape_aspect 69381 69396
12	linear distance		0.82	nominal value	-0.06 0.06	.82 ± .06	(2) plane 11621 13991 (2) advanced_face 11711 14051 (2) shape_aspect 79966 79981
13	diameter		1.065	nominal value	-0.003 0.003	Ø1.065 ± .003	(2) cylindrical_surface 2556 2666 (2) advanced_face 2641 2701 (2) shape_aspect 83121 83136 (1) composite_group_shape_aspect 83116

Figure 30: Dimensional tolerance example (columns D-J)

5.1.4 Geometric Tolerance Examples

The following figures show how geometric tolerances are modeled in a STEP file. Figures 31 and 32 show the flatness_tolerance worksheet with the reconstructed visual presentation for the flatness tolerance.

- Column D is the magnitude of the flatness tolerance zone which is a reference to a length_measure_with_unit. As a convenience the value of the length measure "0.005" is also displayed.
- Column E is a reference to the toleranced shape_aspect.
- Columns F and G define the unit-basis size and type for the flatness tolerance. Another unit-basis parameter in column H is not shown.
- Column I shows the visual presentation of the flatness tolerance with the corresponding unit-basis and datum feature. It corresponds to the PMI annotations in Figure 24.
- Column J is the datum feature associated with the flatness tolerance.
- Column K shows the toleranced geometry associated with the flatness tolerance which comes from the toleranced_shape_aspect attribute in column E. The advanced_face entity references the plane entity.

The reconstructed visual presentation of the PMI representation is limited by the character set available in the spreadsheet. The flatness tolerance symbol (parallelogram) appears somewhat small and misshapen. The lines for the compartments of the feature control frame are not shown. The combination of the inverted triangle, vertical line, and 'E' in brackets represents the reference to datum feature 'E'.

	A	B	C	D	E	F	G
1	(flatness_tolerance)(geometric_tolerance_with_defined_area_unit) (1)						
2							
3	ID	name	description	magnitude	toleranced_shape_aspect	unit_size	area_type
4	73111	Flatness.1	_Geometric tolerance for feature_	0.005 (length_measure_with_unit 73101)	shape_aspect 73091	0.25 (length_measure_with_unit 73106)	square

Figure 31: Flatness tolerance example (columns A-H)

	I	J	K
1			
2	PMI Representation		
3	GD&T Annotation	Datum Feature (Sec. 6.5)	Toleranced Geometry (column E)
4	⏥ | .005 / 0.25 X 0.25 ▽ | [E]	datum_feature 70982	(1) plane 1081 (1) advanced_face 1696

Figure 32: Flatness tolerance example (columns I-K)

Figures 33 and 34 show the position_tolerance worksheet with the reconstructed visual presentations of two position tolerances.

- Column D is the magnitude of the position tolerance zone. As a convenience the value of the length measure "0.005" is also displayed.
- Column E is a reference to the toleranced shape_aspect.
- Column F is a reference to the associated datum reference frame.
- Column G is the modifier applied to the tolerance zone.
- Column H shows the visual presentation of the position tolerances with their associated dimensional tolerances.
- Column I shows the dimensional tolerance, defined in Figure 30, associated with the position tolerance.
- Column J shows the geometry, defined by the toleranced_shape_aspect attribute in column E, associated with the position tolerance.

	A	B	C	D	E	F	G
1	(geometric_tolerance_with_datum_reference)(geometric_tolerance_with_modifiers)(position_tolerance) (2)						
2							
3	ID	name	description	magnitude	toleranced_shape_aspect	datum_system	modifiers
4	51491	Position.3	Geometric tolerance for feature	0.05 (length_measure_with_unit 51486)	composite_group_shape_aspect 51401	(1) datum_system 51481	maximum_material_requirement
5	53706	Position.4	Geometric tolerance for feature	0.05 (length_measure_with_unit 53701)	composite_group_shape_aspect 53551	(1) datum_system 53696	maximum_material_requirement

Figure 33: Position tolerance example (columns A-G)

	H	I	J
1			
2	PMI Representation		
3	GD&T Annotation	Dimensional Tolerance (Sec. 6.2)	Toleranced Geometry (column E)
4	Ø.438 ± .005 ⌖ | Ø .050 Ⓜ | A | B Ⓜ | C Ⓜ	dimensional_size 48711	(4) cylindrical_surface 24571 24681 24741 24851 (4) advanced_face 24656 24716 24826 24886 (4) shape_aspect 51406 51421 51436 51451 (1) composite_group_shape_aspect 51401
5	Ø.625 ± .005 ⌖ | Ø .050 Ⓜ | D | B | C	dimensional_size 45306	(8) cylindrical_surface 10716 10826 10886 10996 11056 11166 11226 11336 (8) advanced_face 10801 10861 10971 11031 11141 11201 11311 11371 (8) shape_aspect 53556 53571 53586 53601 53616 53631 53646 53661 (1) composite_group_shape_aspect 53551

Figure 34: Position tolerance example (columns H-J)

5.1.5 PMI Representation Summary and Limitations

As a convenience, all of the visual presentations of the datum reference frames, dimensional tolerances, and geometric tolerances are collected on the PMI Representation Summary worksheet shown in Figure 35. The annotations in column C are collected from column G in Figure 28, column I in Figure 32, and column H in Figure 34. The annotations in column C correspond to the annotations shown in Figure 24.

	A	B	C
1		nist_ctc_03_asme1_ap242.stp	See CAx-IF Recommended Pract
2			
3	ID	Entity	PMI Representation
4	73706	angularity_tolerance	∠ | .04 | A ▽ | [E]
5	37106	datum_system	A
6	42046	datum_system	A | B
7	51481	datum_system	A | B Ⓜ | C Ⓜ
8	53696	datum_system	D | B | C
9	70801	datum_system	A | B | C
10	84091	datum_system	E
11	35831	dimensional_characteristic_representation	Ø.438 ± .005
12	40201	dimensional_characteristic_representation	Ø.438 ± .005
13	45336	dimensional_characteristic_representation	Ø.625 ± .005
14	48741	dimensional_characteristic_representation	Ø.438 ± .005
15	60541	dimensional_characteristic_representation	Ø2.00 ± .01
16	64886	dimensional_characteristic_representation	Ø1.500 ± .005
17	67011	dimensional_characteristic_representation	Ø1.5
18	69441	dimensional_characteristic_representation	.750
19	80071	dimensional_characteristic_representation	.82 ± .06
20	83181	dimensional_characteristic_representation	Ø1.065 ± .003
21	73111	(flatness_tolerance) (geometric_tolerance_with_defined_area_unit)	▱ | .005 / 0.25 X 0.25 ▽ | [E]
22	51491	(geometric_tolerance_with_datum_reference) (geometric_tolerance_with_modifiers) (position_tolerance)	Ø.438 ± .005 ⌖ | Ø .050 Ⓜ | A | B Ⓜ | C Ⓜ
23	53706	(geometric_tolerance_with_datum_reference) (geometric_tolerance_with_modifiers) (position_tolerance)	Ø.625 ± .005 ⌖ | Ø .050 Ⓜ | D | B | C
24	42056	(geometric_tolerance_with_datum_reference) (position_tolerance)	Ø.438 ± .005 ⌖ | Ø .020 | A | B ▽ | [C]
25	62431	(geometric_tolerance_with_datum_reference) (position_tolerance)	Ø2.00 ± .01 ⌖ | Ø .06 | D | B | C
26	66861	(geometric_tolerance_with_datum_reference) (position_tolerance)	Ø1.500 ± .005 ⌖ | Ø .080 | D | B | C
27	68596	(geometric_tolerance_with_datum_reference) (position_tolerance)	Ø1.500 ± .005 ⌖ | .030 | D | B | C
28	70811	(geometric_tolerance_with_datum_reference) (surface_profile_tolerance)	⌓ | .06 | A | B | C ▽ | [E]

Figure 35: PMI Representation Summary worksheet

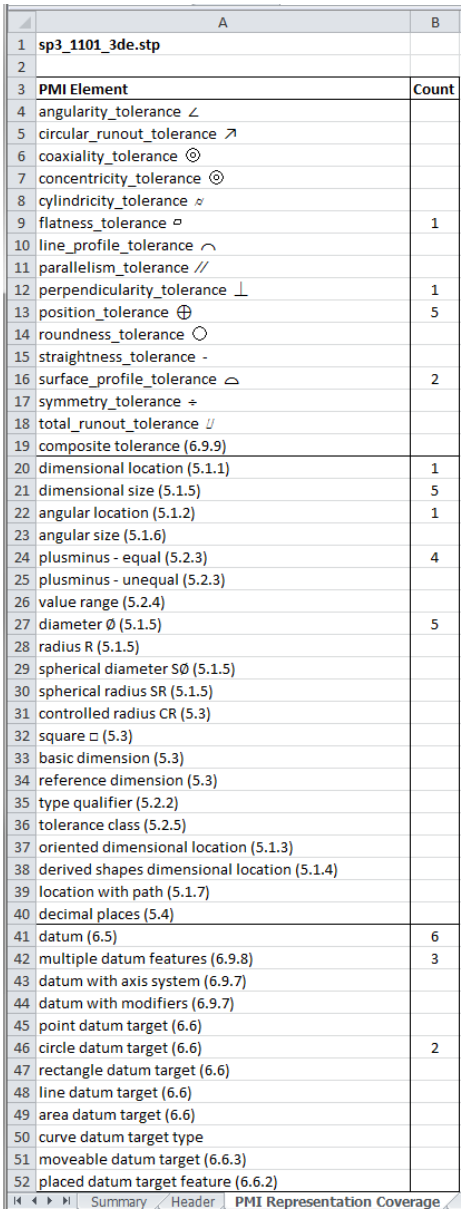
The reporting of PMI representation in the spreadsheet is still under development at NIST and depends on updates to CAx-IF recommended practices. The results presented here might change with future versions of the software. The reconstruction of the visual presentation of PMI representation might not correspond exactly to the PMI presentation modeled in the STEP file.

The semantic association of the datum feature with a geometric tolerance is based on each referring to the same geometric face in the STEP file. In Figure 24 datum feature 'E' is associated with a surface profile tolerance. Datum feature 'E' is the surface of the tab. However, in Figure 35, datum feature 'E' is associated with two geometric tolerances shown in cells C21 and C28. Semantically both are correct since both tolerances refer to the same surface. There is no semantic information in the STEP file to indicate which tolerance the datum feature is presented with.

Sometimes the software does not find an expected association between a dimensional tolerance and a geometric tolerance. The association is found by each tolerance referencing the same geometric face. In that case, the dimensional tolerance will not be displayed above the geometric tolerance.

5.1.6 PMI Representation Coverage Analysis

Coverage analysis counts the number of occurrences of a PMI element in a STEP file. Figure 36 shows the worksheet that is generated for coverage analysis of PMI Representation. Column A in rows 4 through 52 contain different types of PMI elements related to geometric and dimensional tolerances and datums. Rows 53 through 125 are not shown and contain PMI elements related to tolerance zones and tolerance modifiers. The other PMI elements are shown in Figures 38 and 39. The tolerances in rows 4 through 18 show their associated symbol. The numbers in parentheses refer to the sections in the CAx-IF recommended practice for the representation of PMI [21] where there is implementation guidance for that type of PMI element. Column B contains the number of occurrences of that type of PMI element in the file. Comparing the count to the number of expected PMI elements is a way to verify the PMI in the STEP file and resolve and modeling issues.



	A	B
1	**sp3_1101_3de.stp**	
2		
3	**PMI Element**	**Count**
4	angularity_tolerance ∠	
5	circular_runout_tolerance ↗	
6	coaxiality_tolerance ◎	
7	concentricity_tolerance ◎	
8	cylindricity_tolerance ⌭	
9	flatness_tolerance ⏥	1
10	line_profile_tolerance ⌒	
11	parallelism_tolerance //	
12	perpendicularity_tolerance ⊥	1
13	position_tolerance ⌖	5
14	roundness_tolerance ○	
15	straightness_tolerance -	
16	surface_profile_tolerance ⌓	2
17	symmetry_tolerance ⌯	
18	total_runout_tolerance ⌰	
19	composite tolerance (6.9.9)	
20	dimensional location (5.1.1)	1
21	dimensional size (5.1.5)	5
22	angular location (5.1.2)	1
23	angular size (5.1.6)	
24	plusminus - equal (5.2.3)	4
25	plusminus - unequal (5.2.3)	
26	value range (5.2.4)	
27	diameter Ø (5.1.5)	5
28	radius R (5.1.5)	
29	spherical diameter SØ (5.1.5)	
30	spherical radius SR (5.1.5)	
31	controlled radius CR (5.3)	
32	square □ (5.3)	
33	basic dimension (5.3)	
34	reference dimension (5.3)	
35	type qualifier (5.2.2)	
36	tolerance class (5.2.5)	
37	oriented dimensional location (5.1.3)	
38	derived shapes dimensional location (5.1.4)	
39	location with path (5.1.7)	
40	decimal places (5.4)	
41	datum (6.5)	6
42	multiple datum features (6.9.8)	3
43	datum with axis system (6.9.7)	
44	datum with modifiers (6.9.7)	
45	point datum target (6.6)	
46	circle datum target (6.6)	2
47	rectangle datum target (6.6)	
48	line datum target (6.6)	
49	area datum target (6.6)	
50	curve datum target type	
51	moveable datum target (6.6.3)	
52	placed datum target feature (6.6.2)	

Figure 36: PMI Representation Coverage worksheet (rows 1-44)

5.1.6.1 Color-coding Coverage Analysis Results

If a STEP file is processed that was generated from a NIST CAD model from the MBE PMI Validation and Conformance Testing Project [16] and the file can be recognized as having been generated from one of the CAD models, then the PMI Representation Coverage worksheet is color-coded by the expected number of PMI elements. The expected number of PMI elements was determined by manually counting them in each test case drawing, similar to Figure 24, for the NIST CAD models. The color-coded worksheet is shown in Figures 37 through 39. A similar worksheet without color-coding is shown in the previous section.

If more or less than the expected number of PMI elements was found, then the first value of two is the number found and the second is the expected number. For example, '2/3' means that three of that type of PMI element was expected, but only two were found. Counting of some modifiers, e.g. maximum material condition in row 59, does not differentiate whether they appear in the tolerance zone definition or datum reference frame.

A legend describing the colors is in column D of Figure 37.

- Green is a match to the expected number of PMI elements.
- Yellow means that more were found, e.g. '4/3'.
- Red means that less was found, e.g. '2/3'.
- Magenta means that none of an expected PMI element was found, e.g. '0/3'.
- Gray means that a PMI element is in a test case definition but there is no CAx-IF Recommended Practice to model it.

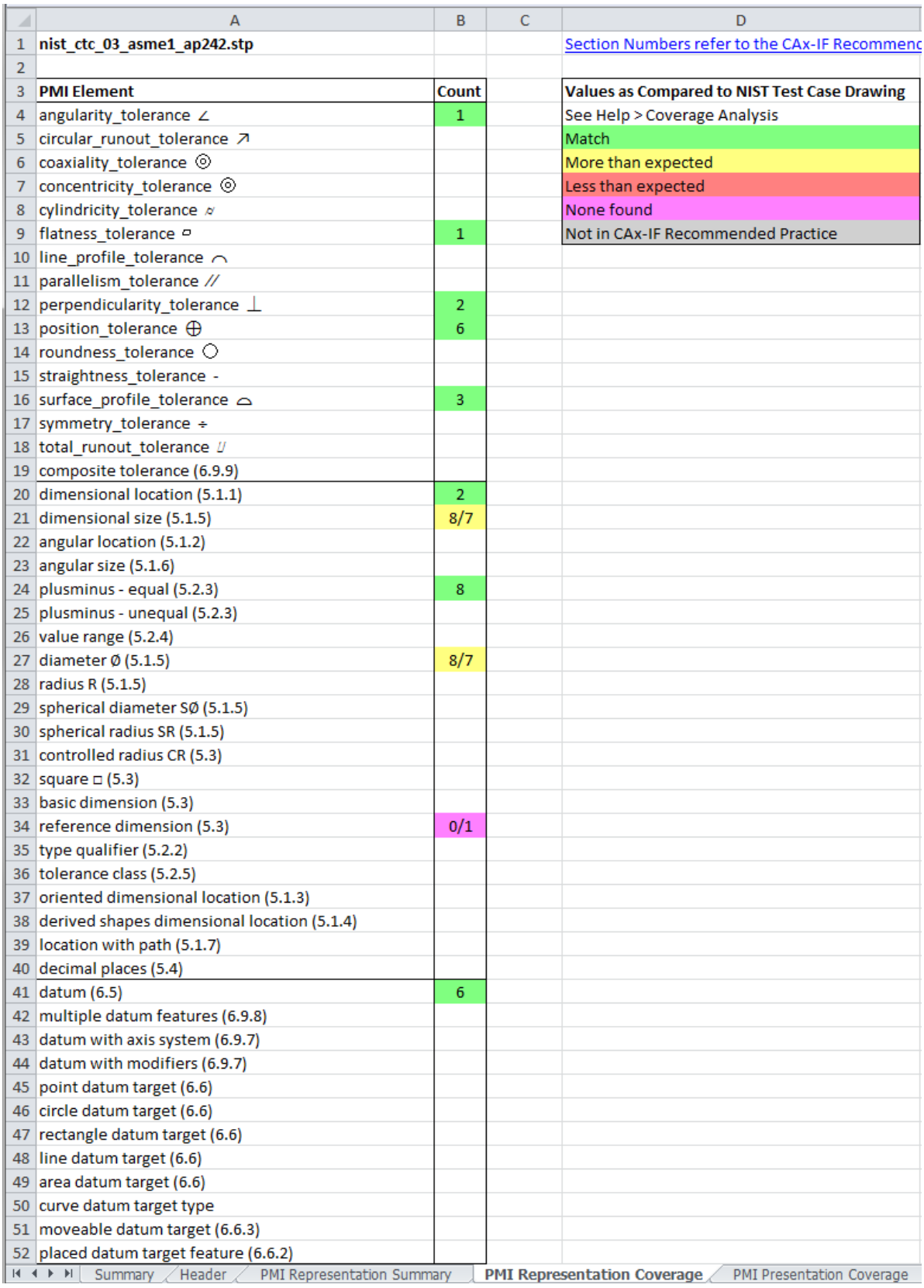
As an example of how to interpret the color-coding, a required spherical radius dimension might have been modeled as a radius in the CAD model. In the coverage analysis worksheet, the missing spherical radius would appear red or magenta, while the extra radius would appear yellow.

If a test case drawing contains hole depth, counterbore, and countersink, then the cell for those is colored gray because there currently is no recommended practice for those PMI elements. This means that those types of hole dimensions are not associated with a dimension type such as diameter and radius in the STEP file, although the dimension value is still represented semantically. This does not affect the PMI presentation (graphics) for those PMI elements.

In Figure 37, cell B34 is colored magenta because of a missing reference dimension as described in section 5.1.3. In Figure 38, cell B70 is gray because a dimension origin appears in the test case drawing but there is no recommended practice to model it in STEP.

Red, magenta, or yellow cells might mean that a CAD system or translator

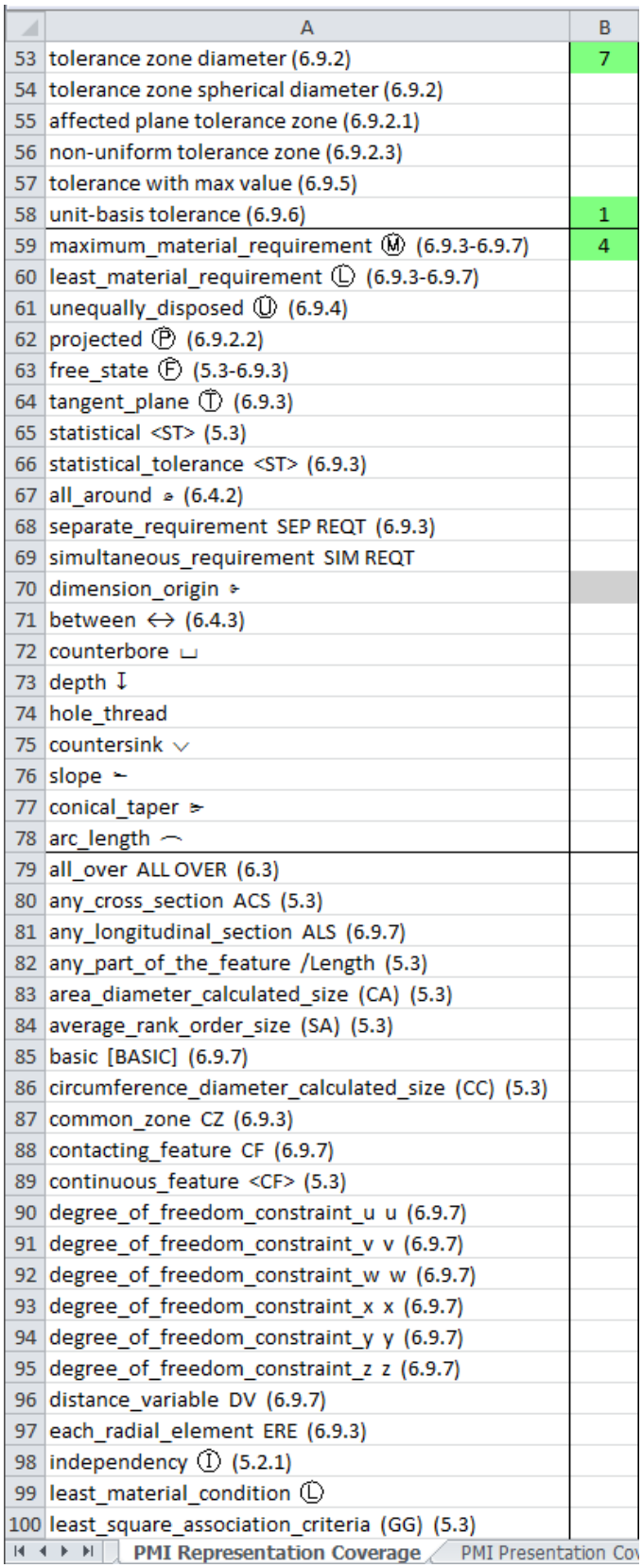
- mapped an internal PMI element to the wrong STEP PMI element,
- has not implemented exporting a PMI element to a STEP file,
- does not support a type of PMI element, or
- did not correctly model a PMI element defined in a test case.



	A	B	C	D
1	**nist_ctc_03_asme1_ap242.stp**			Section Numbers refer to the CAx-IF Recommend
2				
3	**PMI Element**	**Count**		**Values as Compared to NIST Test Case Drawing**
4	angularity_tolerance ∠	1		See Help > Coverage Analysis
5	circular_runout_tolerance ↗			Match
6	coaxiality_tolerance ◎			More than expected
7	concentricity_tolerance ◎			Less than expected
8	cylindricity_tolerance ⌭			None found
9	flatness_tolerance ▱	1		Not in CAx-IF Recommended Practice
10	line_profile_tolerance ⌒			
11	parallelism_tolerance //			
12	perpendicularity_tolerance ⊥	2		
13	position_tolerance ⌖	6		
14	roundness_tolerance ○			
15	straightness_tolerance -			
16	surface_profile_tolerance ⌓	3		
17	symmetry_tolerance ⌯			
18	total_runout_tolerance ⌰			
19	composite tolerance (6.9.9)			
20	dimensional location (5.1.1)	2		
21	dimensional size (5.1.5)	8/7		
22	angular location (5.1.2)			
23	angular size (5.1.6)			
24	plusminus - equal (5.2.3)	8		
25	plusminus - unequal (5.2.3)			
26	value range (5.2.4)			
27	diameter Ø (5.1.5)	8/7		
28	radius R (5.1.5)			
29	spherical diameter SØ (5.1.5)			
30	spherical radius SR (5.1.5)			
31	controlled radius CR (5.3)			
32	square □ (5.3)			
33	basic dimension (5.3)			
34	reference dimension (5.3)	0/1		
35	type qualifier (5.2.2)			
36	tolerance class (5.2.5)			
37	oriented dimensional location (5.1.3)			
38	derived shapes dimensional location (5.1.4)			
39	location with path (5.1.7)			
40	decimal places (5.4)			
41	datum (6.5)	6		
42	multiple datum features (6.9.8)			
43	datum with axis system (6.9.7)			
44	datum with modifiers (6.9.7)			
45	point datum target (6.6)			
46	circle datum target (6.6)			
47	rectangle datum target (6.6)			
48	line datum target (6.6)			
49	area datum target (6.6)			
50	curve datum target type			
51	moveable datum target (6.6.3)			
52	placed datum target feature (6.6.2)			

Summary | Header | PMI Representation Summary | **PMI Representation Coverage** | PMI Presentation Coverage

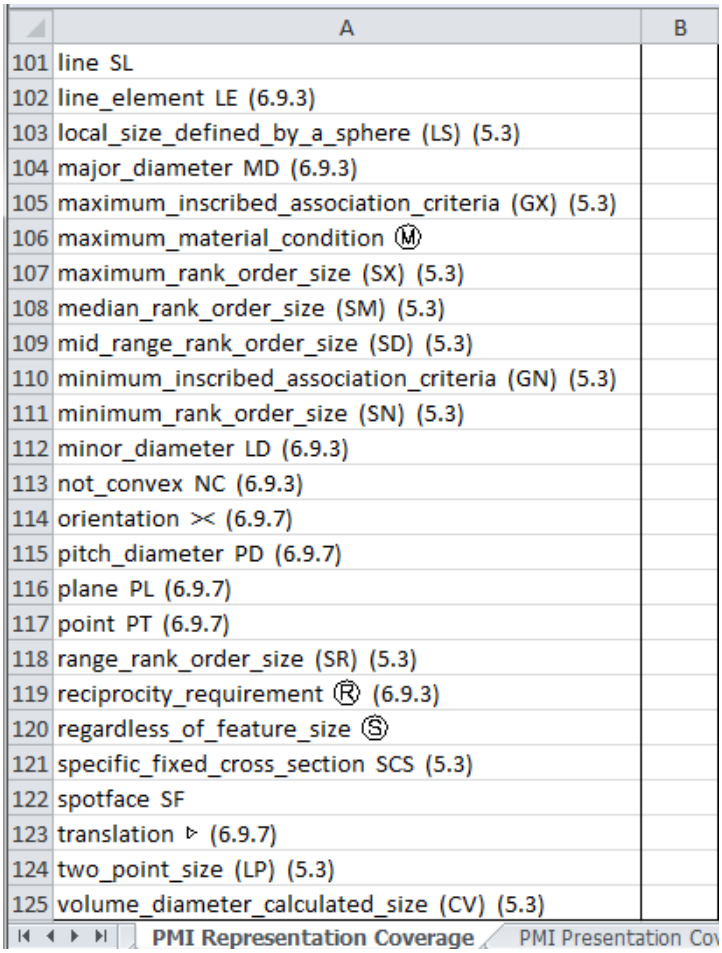
Figure 37: Color-coded PMI Representation Coverage worksheet (rows 1-52)



	A	B
53	tolerance zone diameter (6.9.2)	7
54	tolerance zone spherical diameter (6.9.2)	
55	affected plane tolerance zone (6.9.2.1)	
56	non-uniform tolerance zone (6.9.2.3)	
57	tolerance with max value (6.9.5)	
58	unit-basis tolerance (6.9.6)	1
59	maximum_material_requirement Ⓜ (6.9.3-6.9.7)	4
60	least_material_requirement Ⓛ (6.9.3-6.9.7)	
61	unequally_disposed Ⓤ (6.9.4)	
62	projected Ⓟ (6.9.2.2)	
63	free_state Ⓕ (5.3-6.9.3)	
64	tangent_plane Ⓣ (6.9.3)	
65	statistical <ST> (5.3)	
66	statistical_tolerance <ST> (6.9.3)	
67	all_around ⌀ (6.4.2)	
68	separate_requirement SEP REQT (6.9.3)	
69	simultaneous_requirement SIM REQT	
70	dimension_origin ⌖	
71	between ↔ (6.4.3)	
72	counterbore ⌴	
73	depth ↧	
74	hole_thread	
75	countersink ⌵	
76	slope ⏥	
77	conical_taper ⧐	
78	arc_length ⌒	
79	all_over ALL OVER (6.3)	
80	any_cross_section ACS (5.3)	
81	any_longitudinal_section ALS (6.9.7)	
82	any_part_of_the_feature /Length (5.3)	
83	area_diameter_calculated_size (CA) (5.3)	
84	average_rank_order_size (SA) (5.3)	
85	basic [BASIC] (6.9.7)	
86	circumference_diameter_calculated_size (CC) (5.3)	
87	common_zone CZ (6.9.3)	
88	contacting_feature CF (6.9.7)	
89	continuous_feature <CF> (5.3)	
90	degree_of_freedom_constraint_u u (6.9.7)	
91	degree_of_freedom_constraint_v v (6.9.7)	
92	degree_of_freedom_constraint_w w (6.9.7)	
93	degree_of_freedom_constraint_x x (6.9.7)	
94	degree_of_freedom_constraint_y y (6.9.7)	
95	degree_of_freedom_constraint_z z (6.9.7)	
96	distance_variable DV (6.9.7)	
97	each_radial_element ERE (6.9.3)	
98	independency Ⓘ (5.2.1)	
99	least_material_condition Ⓛ	
100	least_square_association_criteria (GG) (5.3)	

PMI Representation Coverage | PMI Presentation Cov

Figure 38: Color-coded PMI Representation Coverage worksheet (rows 53-100)



	A	B
101	line SL	
102	line_element LE (6.9.3)	
103	local_size_defined_by_a_sphere (LS) (5.3)	
104	major_diameter MD (6.9.3)	
105	maximum_inscribed_association_criteria (GX) (5.3)	
106	maximum_material_condition Ⓜ	
107	maximum_rank_order_size (SX) (5.3)	
108	median_rank_order_size (SM) (5.3)	
109	mid_range_rank_order_size (SD) (5.3)	
110	minimum_inscribed_association_criteria (GN) (5.3)	
111	minimum_rank_order_size (SN) (5.3)	
112	minor_diameter LD (6.9.3)	
113	not_convex NC (6.9.3)	
114	orientation >< (6.9.7)	
115	pitch_diameter PD (6.9.7)	
116	plane PL (6.9.7)	
117	point PT (6.9.7)	
118	range_rank_order_size (SR) (5.3)	
119	reciprocity_requirement Ⓡ (6.9.3)	
120	regardless_of_feature_size Ⓢ	
121	specific_fixed_cross_section SCS (5.3)	
122	spotface SF	
123	translation ▷ (6.9.7)	
124	two_point_size (LP) (5.3)	
125	volume_diameter_calculated_size (CV) (5.3)	

PMI Representation Coverage | PMI Presentation Co

Figure 39: PMI Representation Coverage worksheet (rows 101-125)

5.2 PMI Presentation

PMI presentation presents GD&T annotations as a visual representation of geometric elements such as lines and arcs as part of the CAD model, i.e., how the annotation is drawn on the model. PMI presentation is not intended to be computer-interpretable and does not carry any semantic representation information although it can be linked to its corresponding semantic representation. The CAx-IF defines recommended practices for PMI presentation [21].

Figures 40 through 42 show an example of how PMI presentation is reported in the spreadsheet. The report for PMI presentation only contains information about the graphical elements (points, lines, colors) needed to display PMI annotations. PMI presentation information is always reported on the annotation_curve_occurrence (as in this example), tessellated_annotation_occurrence, or annotation_occurrence worksheets.

- Columns B, C, and D show the entity attributes.
- Column E shows the name attribute of the geometric_curve_set in column D.
- Column F shows the element attributes of the geometric_curve_set. In this case, the elements refer to polyline entities.
- Column G shows the curve_style associated with the presentation_style_assignment in column C.
- Column H shows the color associated with the curve_style in column G.
- Column I shows the annotation plane associated with the annotation.
- Column J shows the geometry that the annotation is attached to. If associated geometry is missing then there is no cross-highlighting between the annotation and geometry.
- Column K shows the associated PMI representation entities.
- Not shown are columns for PMI presentation validation properties (section 5.3) and Saved Views.

	A	B	C	D
1	annotation_curve_occurrence (30)			
2				
3	**ID**	**name**	**styles**	**item**
4	35736	Linear Size.1	(1) presentation_style_assignment 35731	geometric_curve_set 35726
5	36196	Simple Datum.2	(1) presentation_style_assignment 36191	geometric_curve_set 36186
6	37056	Perpendicularity.1	(1) presentation_style_assignment 37051	geometric_curve_set 37046
7	40131	Linear Size.2	(1) presentation_style_assignment 40126	geometric_curve_set 40121
8	40511	Simple Datum.3	(1) presentation_style_assignment 40506	geometric_curve_set 40501

Figure 40: PMI presentation example (columns A-D)

	E	F	G	H
1				
2				PMI Presentation
3	name (Sec. 8.4)	elements (Sec. 8.1.1)	presentation style (Sec. 8.5)	color (Sec. 8.5)
4	diameter dimension	(35) polyline 32921 32996 33061 33151 33241 33271 33296 33361 33636 33726 33896 33986 34016 34106 34196 34226 34316 34406 34496 34586 34786 34856 34946 35036 35066 35156 35246 35336 35426 35626 35651 35676 35691 35706 35721	curve_style 35732	draughting_pre_defined_colour 35734
5	datum	(6) polyline 35941 36006 36111 36141 36156 36181	curve_style 36192	draughting_pre_defined_colour 36194
6	perpendicularity	(13) polyline 36281 36311 36491 36566 36631 36661 36751 36841 36906 36936 36961 37011 37041	curve_style 37052	draughting_pre_defined_colour 37054
7	diameter dimension	(35) polyline 37316 37391 37456 37546 37636 37666 37691 37756 38031 38121 38291 38381 38411 38501 38591 38621 38711 38801 38891 38981 39181 39251 39341 39431 39461 39551 39641 39731 39821 40021 40046 40071 40086 40101 40116	curve_style 40127	draughting_pre_defined_colour 40129
8	datum	(4) polyline 40426 40456 40471 40496	curve_style 40507	draughting_pre_defined_colour 40509

Figure 41: PMI presentation example (columns E-H)

	I	J	K
1			
2			
3	plane (Sec. 9.1)	Associated Geometry (Sec. 9.3.1)	Associated Representation (Sec. 7.3)
4	annotation_plane 69461 (ProjView.1)	(2) cylindrical_surface 23661 23771 (2) advanced_face 23746 23806 (2) shape_aspect 35771 35786 (1) composite_group_shape_aspect 35766	dimensional_size 35801
5	annotation_plane 69461 (ProjView.1)	(2) cylindrical_surface 23661 23771 (2) advanced_face 23746 23806 (1) datum_feature 36202	datum_feature 36202
6	annotation_plane 69461 (ProjView.1)	(2) cylindrical_surface 23661 23771 (2) advanced_face 23746 23806 (2) shape_aspect 37066 37081 (1) composite_group_shape_aspect 37061	perpendicularity_tolerance 37116
7	annotation_plane 69461 (ProjView.1)	(2) cylindrical_surface 23831 23941 (2) advanced_face 23916 23976 (2) shape_aspect 40141 40156 (1) composite_group_shape_aspect 40136	dimensional_size 40171
8	annotation_plane 69461 (ProjView.1)	(2) cylindrical_surface 23831 23941 (2) advanced_face 23916 23976 (1) datum_feature 40517	datum_feature 40517

Figure 42: PMI presentation example (columns I-K)

5.2.1 PMI Presentation Visualization

The PMI presentation annotations can also be visualized by selecting the option in the Options tab. The graphics for the annotations are visualized with an X3DOM file [22] that can be viewed in any web browser that supports WebGL [23]. The X3DOM file only contains the line segments that make up the PMI presentation and not the part geometry to which it is applied. The X3DOM file contains the line segments defined by the polylines in column F of Figure 41. Segments of annotations constructed with circles, instead of polylines, are not displayed. Filled characters are displayed only by their outer boundary and not filled. PMI presentation annotations specified by tessellated geometry are not displayed.

Figure 43 is a screenshot from a web browser displaying the X3DOM file generated from the PMI presentation. The PMI corresponds to some of annotations shown in Figure 24. In this example, the annotations are assigned a random color to help differentiate them from each other.

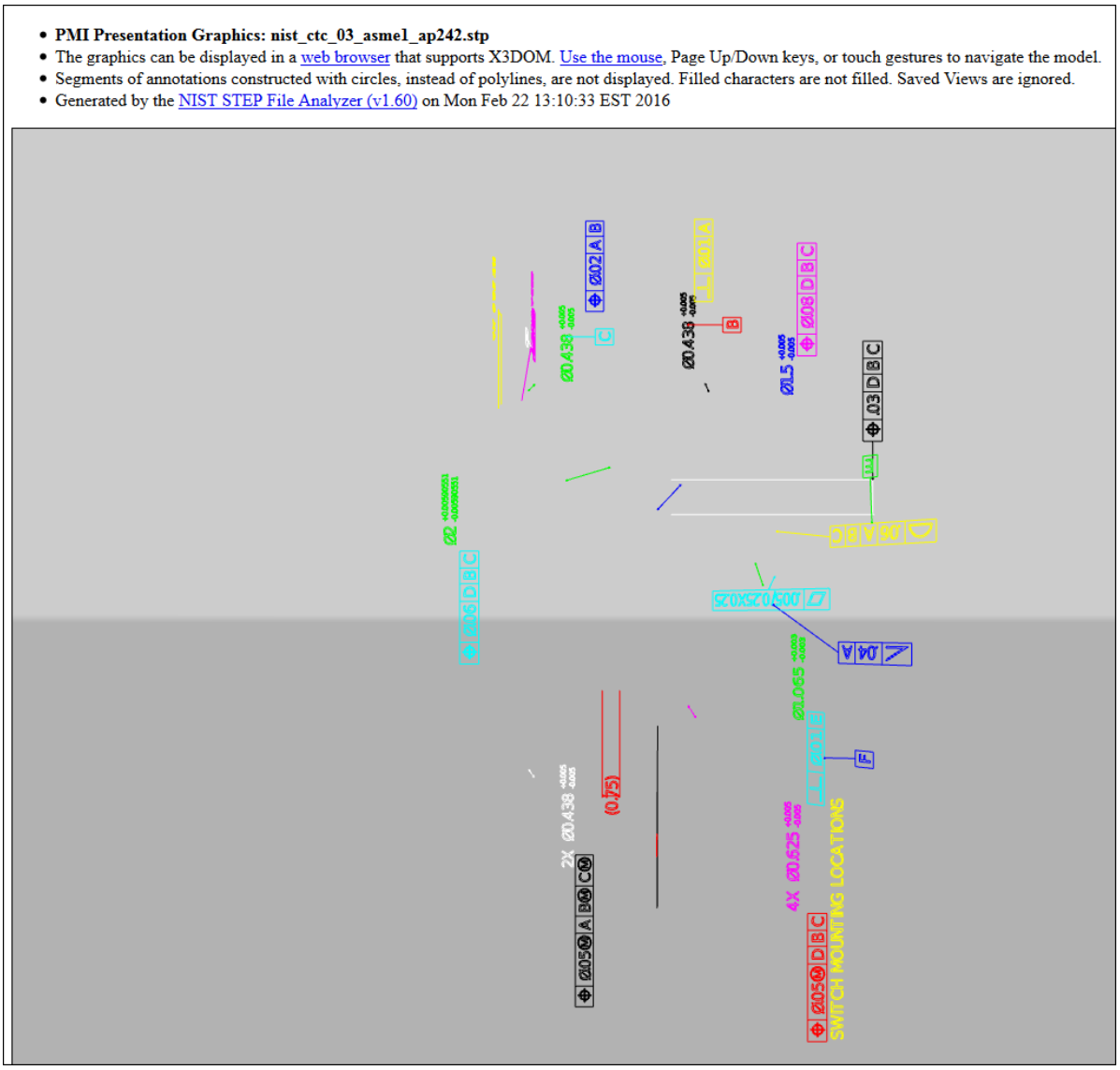


Figure 43: Visualization of PMI presentation

5.2.2 PMI Presentation Coverage Analysis

Coverage analysis counts the number of occurrences of a PMI element in a STEP file. Figure 44 shows the worksheet that is generated for coverage analysis of PMI presentation. Rows 4 through 33 of column A contain the allowable names [21] that can be associated with a PMI annotation. The names correspond to the values in column E in Figure 41. There is no semantic meaning associated with the names. PMI presentation assumes a semantic meaning through its association with a PMI representation as shown in column K of Figure 42.

	A	B
1	**nist_ctc_03_asme1_ap242.stp**	
2		
3	**PMI Presentation Names**	**Count**
4	angularity	1
5	circular runout	
6	circularity	
7	coaxiality	
8	concentricity	
9	cylindricity	
10	flatness	1
11	parallelism	
12	perpendicularity	2
13	position	6
14	profile of line	
15	profile of surface	3
16	roundness	
17	straightness	
18	symmetry	
19	total runout	
20	general tolerance	
21	linear dimension	2
22	radial dimension	
23	diameter dimension	8
24	angular dimension	
25	ordinate dimension	
26	curve dimension	
27	general dimension	
28	datum	6
29	datum target	
30	note	1
31	label	
32	surface roughness	
33	weld symbol	

PMI Presentation Coverage

Figure 44: PMI Presentation Coverage worksheet

5.3 Validation Properties

Validation properties are an important tool to verify the information in a STEP file. For example, geometric validation properties are characteristics of solid and surface models, such as area, volume, and centroid. Geometric validation properties could be written to a STEP file when it is exported from a CAD system. When the STEP file is imported to a receiving CAD system, that system can compute the same validation properties and compare them to the values from the originating system in the STEP file. If the computed validation properties are within an agreed tolerance to the original validation properties, then the exchange of geometric information has been validated. The CAx-IF defines recommended practices for validation properties [24].

Figures 45 and 46 show an example of a validation properties report. The report always appears on the property_definition worksheet. The rows can be sorted by any of the column attributes. The validation properties are shown in the yellow and green columns E, G, I, K, and M. Row 3 contains the names of the type of value in those columns. Properties not colored yellow and green are not validation properties as defined by the recommended practice. The values in cells I7, I10, and I16 are cartesian coordinates. Empty cells E13 and E14 indicate that values for those attributes were not specified in the STEP file. If no values for units and exponent appear in rows K and M, then none are required based on the type of value in row I.

The hidden columns F, H, J, L, and N can be shown by clicking on the plus (+) signs above the columns or the "2" in the upper left corner. Those columns contain the entity attribute name and ID for the corresponding validation property value in the column to the left. Displaying the hidden columns shows where the validation property values come from in the STEP file. The hidden columns F, H, and J are shown in Figure 47. Columns L, M, and N are not shown. For example, the value in cell G4 "surface area measure" comes from the measure_representation_item name attribute of entity ID 393. The expanded columns can be hidden again by clicking on the minus (-) signs above the columns or the "1" in the upper left corner.

	A	B	C	D
1	property_definition (35)			
2				
3	ID	name	description	definition
4	385		shape for solid data with which properties are associated	shape_aspect 384
5	394	geometric validation property	area of C1_SOLID	shape_aspect 384
6	403	geometric validation property	volume of C1_SOLID	shape_aspect 384
7	407	geometric validation property	centroid of C1_SOLID	shape_aspect 384
8	416	geometric validation property	area of C1_SOLID	product_definition_shape 383
9	425	geometric validation property	volume of C1_SOLID	product_definition_shape 383
10	429	geometric validation property	centroid of C1_SOLID	product_definition_shape 383
11	482	pmi validation property	number of views of C1_SOLID	product_definition_shape 383
12	486	pmi validation property	number of annotations of Default	(characterized_object) (draughting_model) 434
13	489	DESCRIPTION	user defined attribute	product_definition 382
14	495	MODELED_BY	user defined attribute	product_definition 382
15	502	attribute validation property	part user attributes of C1_SOLID	product_definition_shape 383
16	513	geometric validation property	centroid of C1_SOLID	product_definition_shape 511

Figure 45: Validation properties example (columns A-D)

	E	G	I	K	M
1					
2		Validation Properties			
3	representation name	value name	value	units	exponent
4	(1) shape_definition_representation.definition 387				
5	surface area	surface area measure	60000	INCH	2
6	volume	volume measure	1000000	INCH	3
7	centroid	centre point	0.0 50.0 0.0		
8	surface area	surface area measure	60000	INCH	2
9	volume	volume measure	1000000	INCH	3
10	centroid	centre point	0.0 50.0 0.0		
11	number of views	number of views	1		
12	number of annotations	number of annotations	0		
13		DESCRIPTION			
14		MODELED_BY			
15	part user attributes	part user attributes	2		
16	centroid	centre point	50.0 50.0 -50.0		

Figure 46: Validation properties example (columns E-O)

	E	F	G	H	I	J
1						
2				Validation Properties		
3	representation name	attribute	value name	attribute2	value	attribute3
4	(1) shape_definition_representation.definition 387					
5	surface area	#395 representation.name	surface area measure	#393 measure_representation_item.name	60000	#393 measure_representation_item.value_component
6	volume	#404 representation.name	volume measure	#402 measure_representation_item.name	1000000	#402 measure_representation_item.value_component
7	centroid	#408 representation.name	centre point	#406 cartesian_point.name	0.0 50.0 0.0	#406 cartesian_point.coordinates
8	surface area	#417 representation.name	surface area measure	#415 measure_representation_item.name	60000	#415 measure_representation_item.value_component
9	volume	#426 representation.name	volume measure	#424 measure_representation_item.name	1000000	#424 measure_representation_item.value_component
10	centroid	#430 representation.name	centre point	#428 cartesian_point.name	0.0 50.0 0.0	#428 cartesian_point.coordinates
11	number of views	#483 representation.name	number of views	#481 value_representation_item.name	1	#481 value_representation_item.value_component
12	number of annotations	#487 representation.name	number of annotations	#485 value_representation_item.name	0	#485 value_representation_item.value_component
13		#493 representation.name	DESCRIPTION	#492 descriptive_representation_item.name		#492 descriptive_representation_item.description
14		#499 representation.name	MODELED_BY	#498 descriptive_representation_item.name		#498 descriptive_representation_item.description
15	part user attributes	#503 representation.name	part user attributes	#501 value_representation_item.name	2	#501 value_representation_item.value_component
16	centroid	#514 representation.name	centre point	#512 cartesian_point.name	50.0 50.0 -50.0	#512 cartesian_point.coordinates

Figure 47: Validation properties example with expanded columns (columns E-J)

6 Processing Multiple STEP Files

Processing multiple STEP files at once is an easy way to process many STEP files with only a few mouse clicks and to compare entity usage and coverage of PMI representation and presentation across multiple STEP files.

There are two ways to select multiple STEP files. The first is to use the "Open Multiple STEP Files in a Directory" option from the File menu as shown in Figure 9. The user can select a directory in which all STEP files in that directory will be processed. Subdirectories of the selected directory can also be searched. The other way is to select multiple individual STEP files when using the "Open STEP File(s)" option from the File menu. Multiple STEP files can be selected in the Open File(s) dialog by holding down the control or shift key when selecting files.

6.1 Summary Worksheet

When processing multiple STEP files a second spreadsheet is generated, in addition to the individual spreadsheets for each STEP file. The second spreadsheet contains a summary worksheet of the entities found in the multiple files and possible coverage worksheets for PMI representation and presentation as shown in Figure 48. In this example five STEP files were processed. Starting with row 10, column A lists all of the entity types in all five files. The entities in column A are grouped and colored according to the categories of entities in the Process section of the Options tab as described in section 4.4.1. Columns B through F contain the entity counts for each of the five STEP files. Column G is the total entity count for all of the files and column H is the total number of files that an entity appears in.

Row 1 is the top-level directory where all of the STEP files are located. Row 3 contains links to the individual spreadsheets. Row 4 contains the name of the STEP file and a link to it. The file name can also contain the file's subdirectory. Clicking on the STEP file link will display it in whatever program is registered to display STEP files on the user's computer. The links in rows 3 and 4 can be turned off in the Spreadsheet tab with the selections for Excel Options. Rows 5 through 9 contain, respectively, the file timestamp, software that generated the STEP file, the STEP AP from the file, the size of the STEP file, and the number of entities in the STEP file.

	A	B	C	D	E	F	G	H
1	STEP Directory	C:\Users\lipman\Documents\Analyzer\User-Guide						
2								
3		Link (1)	Link (2)	Link (3)	Link (4)	Link (5)		
4		nist_ctc_01_asme1_ap242.stp	nist_ctc_02_asme1_ap242-1.stp	nist_ctc_03_asme1_ap242.stp	nist_ctc_04_asme1_ap242.stp	nist_ctc_05_asme1_ap242-1.stp		
5		15-02-16	15-02-17	14-12-19	15-02-16	14-12-19		
6								
7		AP242	AP242	AP242	AP242	AP242		
8		389 Kb	3548 Kb	1261 Kb	1073 Kb	851 Kb		
9	Entity	6137	48665	17311	17926	13058	Total Entities	Total Files
10	coordinates_list	55			65		120	2
11	tessellated_curve_set	55			65		120	2
12	tessellated_geometric_set	55			65		120	2
13	angular_location	1			1		2	2
14	angularity_tolerance			1			1	1
15	circular_runout_tolerance					3	3	1
16	coaxiality_tolerance					1	1	1
17	(composite_group_shape_aspect) (datum_feature)	1					1	1
18	(composite_shape_aspect) (datum_feature)	2			2		4	2
19	datum	3	10	6	8	4	31	5
20	datum_feature		7	6	6	2	21	4
21	datum_reference_compartment	11	34	26	15	8	94	5
22	datum_reference_element					6	6	1
23	datum_system	5	14	6	6	5	36	5
24	dimensional_characteristic_representation	8	7	10	9	2	36	5
25	dimensional_location			2	2	2	6	3
26	dimensional_size	7	7	8	6		28	4
27	flatness_tolerance	1	1				2	2
28	(flatness_tolerance) (geometric_tolerance_with_defined_area_unit)			1			1	1

File Summary | PMI Presentation Coverage | PMI Representation Coverage

Figure 48: File Summary worksheet, multiple files

6.2 Coverage Analysis Worksheets

If PMI representation or presentation is found in the STEP file, then coverage analysis worksheets are generated.

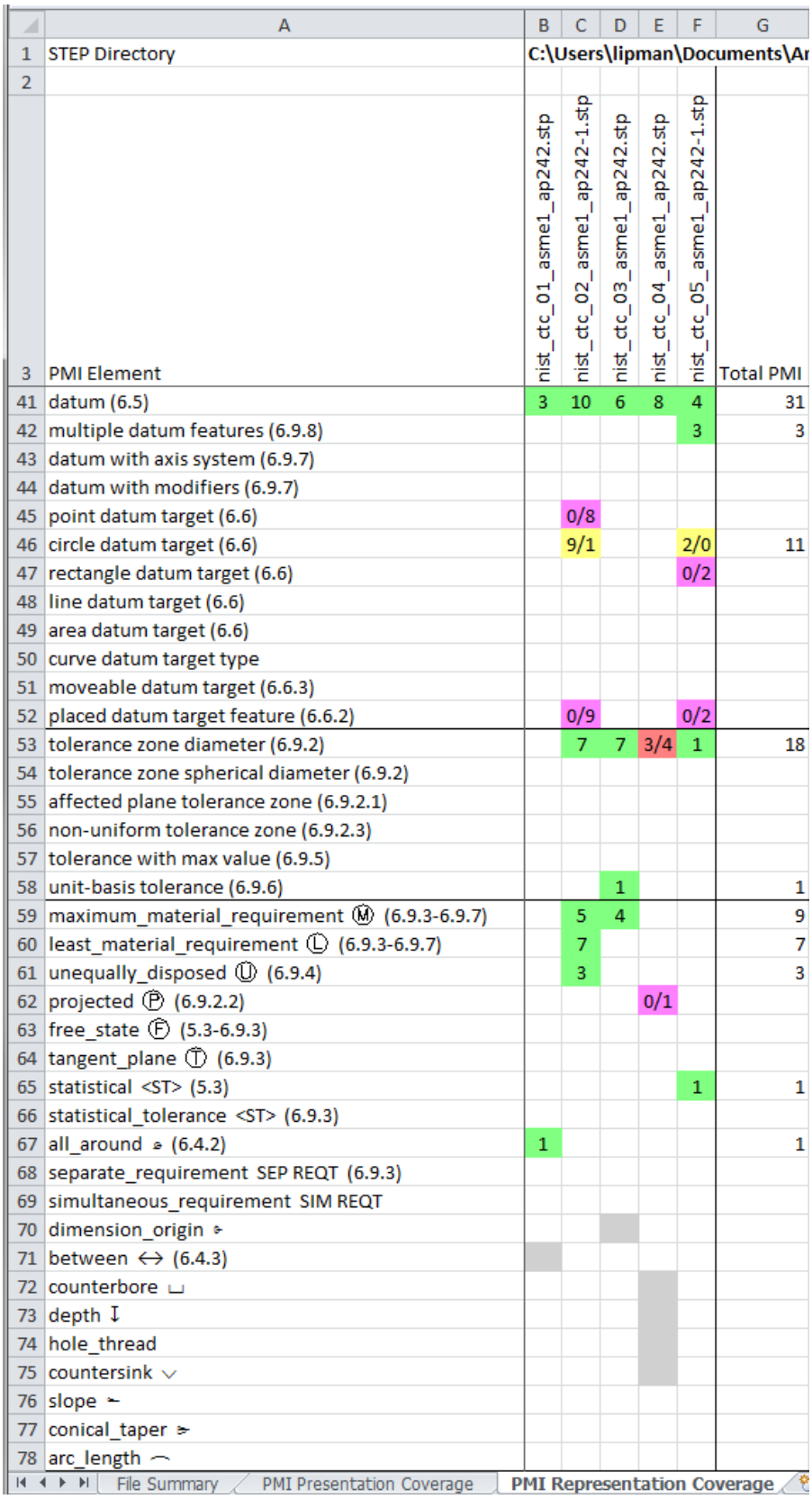
6.2.1 PMI Representation Coverage Analysis

Figures 49 through 52 show the worksheet that is generated for coverage analysis of PMI representation. The information on the worksheet is the same as described in section 5.1.6. Columns B through F refer to five STEP files and contain the number of occurrences of that PMI element. Column G counts the total number of occurrences for all STEP files that contain that type of PMI element. In this example the cells are color-coded, as described in section 5.1.6.1, because all five STEP files were generated from the NIST CAD models.

	A	B	C	D	E	F	G
1	STEP Directory	C:\Users\lipman\Documents\Ar					
2							
3	PMI Element	nist_ctc_01_asme1_ap242.stp	nist_ctc_02_asme1_ap242-1.stp	nist_ctc_03_asme1_ap242.stp	nist_ctc_04_asme1_ap242.stp	nist_ctc_05_asme1_ap242-1.stp	Total PMI
4	angularity_tolerance ∠			1			1
5	circular_runout_tolerance ↗					3	3
6	coaxiality_tolerance ◎					1	1
7	concentricity_tolerance ◎						
8	cylindricity_tolerance ⌭						
9	flatness_tolerance ▱	1	1	1			3
10	line_profile_tolerance ⌒		1				1
11	parallelism_tolerance //						
12	perpendicularity_tolerance ⊥	1	3	2		2	8
13	position_tolerance ⌖	2	4	6	3/4		15
14	roundness_tolerance ○					1	1
15	straightness_tolerance -					1	1
16	surface_profile_tolerance ⌓	2	13	3	3		21
17	symmetry_tolerance ⌯						
18	total_runout_tolerance ⌰					2	2
19	composite tolerance (6.9.9)				2		2
20	dimensional location (5.1.1)			2	2	2/5	6
21	dimensional size (5.1.5)	7	7	8/7	6	0/1	28
22	angular location (5.1.2)	1			1		2
23	angular size (5.1.6)						
24	plusminus - equal (5.2.3)	2	7	8	7	2	26
25	plusminus - unequal (5.2.3)	4					4
26	value range (5.2.4)	2					2
27	diameter Ø (5.1.5)	7	7	8/7	5	0/1	27
28	radius R (5.1.5)						
29	spherical diameter SØ (5.1.5)						
30	spherical radius SR (5.1.5)						
31	controlled radius CR (5.3)						
32	square □ (5.3)						
33	basic dimension (5.3)				2	0/4	2
34	reference dimension (5.3)			0/1			
35	type qualifier (5.2.2)						
36	tolerance class (5.2.5)						
37	oriented dimensional location (5.1.3)						
38	derived shapes dimensional location (5.1.4)						
39	location with path (5.1.7)						
40	decimal places (5.4)						

File Summary | PMI Presentation Coverage | **PMI Representation Coverage**

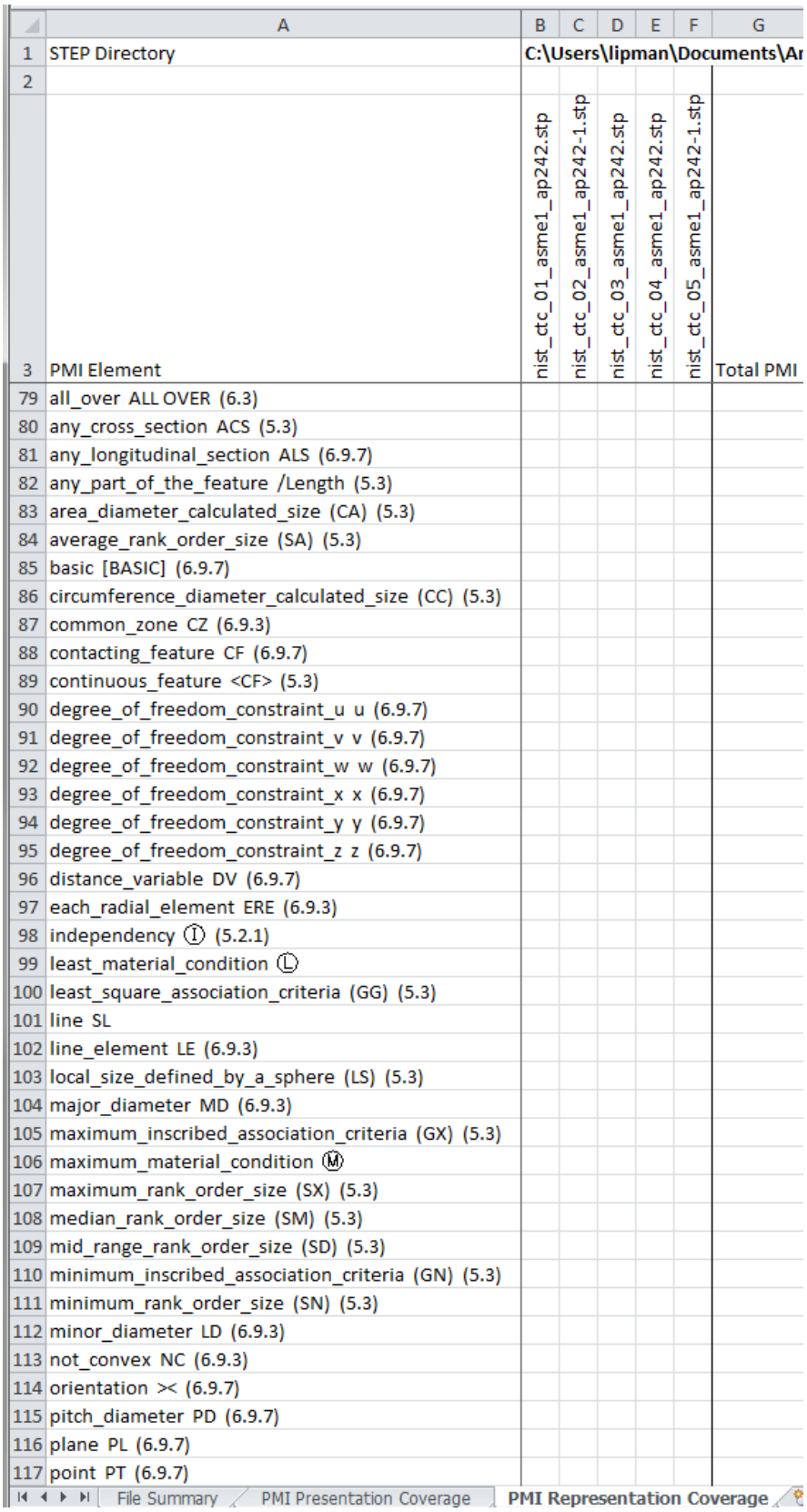
Figure 49: PMI Representation Coverage worksheet, multiple files (rows 1-40)



	A	B	C	D	E	F	G
1	STEP Directory	C:\Users\lipman\Documents\Ar					
2							
3	PMI Element	nist_ctc_01_asme1_ap242.stp	nist_ctc_02_asme1_ap242-1.stp	nist_ctc_03_asme1_ap242.stp	nist_ctc_04_asme1_ap242.stp	nist_ctc_05_asme1_ap242-1.stp	Total PMI
41	datum (6.5)	3	10	6	8	4	31
42	multiple datum features (6.9.8)					3	3
43	datum with axis system (6.9.7)						
44	datum with modifiers (6.9.7)						
45	point datum target (6.6)		0/8				
46	circle datum target (6.6)		9/1			2/0	11
47	rectangle datum target (6.6)					0/2	
48	line datum target (6.6)						
49	area datum target (6.6)						
50	curve datum target type						
51	moveable datum target (6.6.3)						
52	placed datum target feature (6.6.2)		0/9			0/2	
53	tolerance zone diameter (6.9.2)		7	7	3/4	1	18
54	tolerance zone spherical diameter (6.9.2)						
55	affected plane tolerance zone (6.9.2.1)						
56	non-uniform tolerance zone (6.9.2.3)						
57	tolerance with max value (6.9.5)						
58	unit-basis tolerance (6.9.6)			1			1
59	maximum_material_requirement Ⓜ (6.9.3-6.9.7)		5	4			9
60	least_material_requirement Ⓛ (6.9.3-6.9.7)		7				7
61	unequally_disposed Ⓤ (6.9.4)		3				3
62	projected Ⓟ (6.9.2.2)				0/1		
63	free_state Ⓕ (5.3-6.9.3)						
64	tangent_plane Ⓣ (6.9.3)						
65	statistical <ST> (5.3)					1	1
66	statistical_tolerance <ST> (6.9.3)						
67	all_around ⌀ (6.4.2)	1					1
68	separate_requirement SEP REQT (6.9.3)						
69	simultaneous_requirement SIM REQT						
70	dimension_origin ⌖						
71	between ↔ (6.4.3)						
72	counterbore ⌴						
73	depth ↧						
74	hole_thread						
75	countersink ⌵						
76	slope ⏥						
77	conical_taper ⌲						
78	arc_length ⌒						

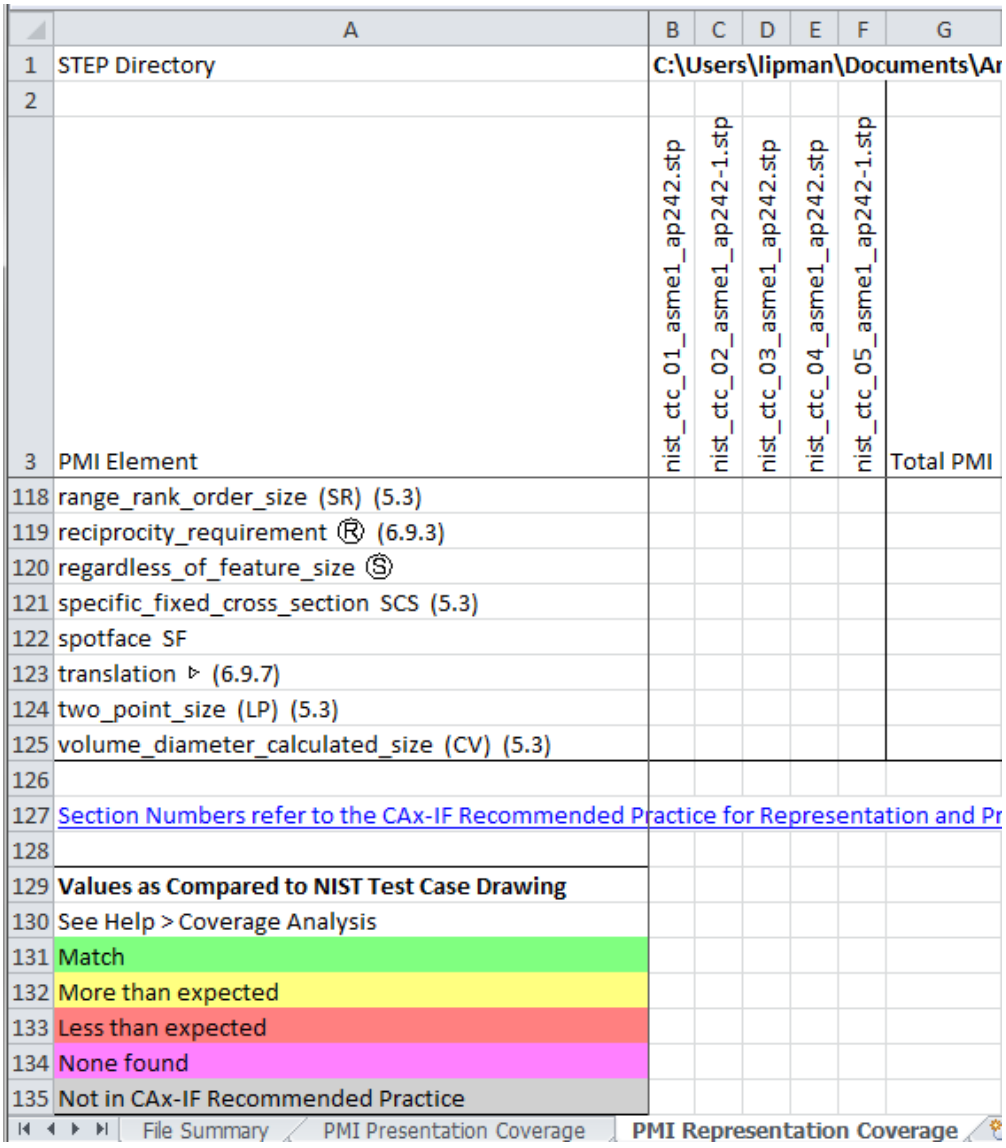
File Summary | PMI Presentation Coverage | **PMI Representation Coverage**

Figure 50: PMI Representation Coverage worksheet, multiple files (rows 41-78)



	A	B	C	D	E	F	G
1	STEP Directory	C:\Users\lipman\Documents\Ar					
2							
3	PMI Element	nist_ctc_01_asme1_ap242.stp	nist_ctc_02_asme1_ap242-1.stp	nist_ctc_03_asme1_ap242.stp	nist_ctc_04_asme1_ap242.stp	nist_ctc_05_asme1_ap242-1.stp	Total PMI
79	all_over ALL OVER (6.3)						
80	any_cross_section ACS (5.3)						
81	any_longitudinal_section ALS (6.9.7)						
82	any_part_of_the_feature /Length (5.3)						
83	area_diameter_calculated_size (CA) (5.3)						
84	average_rank_order_size (SA) (5.3)						
85	basic [BASIC] (6.9.7)						
86	circumference_diameter_calculated_size (CC) (5.3)						
87	common_zone CZ (6.9.3)						
88	contacting_feature CF (6.9.7)						
89	continuous_feature <CF> (5.3)						
90	degree_of_freedom_constraint_u u (6.9.7)						
91	degree_of_freedom_constraint_v v (6.9.7)						
92	degree_of_freedom_constraint_w w (6.9.7)						
93	degree_of_freedom_constraint_x x (6.9.7)						
94	degree_of_freedom_constraint_y y (6.9.7)						
95	degree_of_freedom_constraint_z z (6.9.7)						
96	distance_variable DV (6.9.7)						
97	each_radial_element ERE (6.9.3)						
98	independency Ⓘ (5.2.1)						
99	least_material_condition Ⓛ						
100	least_square_association_criteria (GG) (5.3)						
101	line SL						
102	line_element LE (6.9.3)						
103	local_size_defined_by_a_sphere (LS) (5.3)						
104	major_diameter MD (6.9.3)						
105	maximum_inscribed_association_criteria (GX) (5.3)						
106	maximum_material_condition Ⓜ						
107	maximum_rank_order_size (SX) (5.3)						
108	median_rank_order_size (SM) (5.3)						
109	mid_range_rank_order_size (SD) (5.3)						
110	minimum_inscribed_association_criteria (GN) (5.3)						
111	minimum_rank_order_size (SN) (5.3)						
112	minor_diameter LD (6.9.3)						
113	not_convex NC (6.9.3)						
114	orientation >< (6.9.7)						
115	pitch_diameter PD (6.9.7)						
116	plane PL (6.9.7)						
117	point PT (6.9.7)						

Figure 51: PMI Representation Coverage worksheet, multiple files (rows 79-117)



	A	B	C	D	E	F	G
1	STEP Directory	C:\Users\lipman\Documents\Ar					
2							
3	PMI Element	nist_ctc_01_asme1_ap242.stp	nist_ctc_02_asme1_ap242-1.stp	nist_ctc_03_asme1_ap242.stp	nist_ctc_04_asme1_ap242.stp	nist_ctc_05_asme1_ap242-1.stp	Total PMI
118	range_rank_order_size (SR) (5.3)						
119	reciprocity_requirement Ⓡ (6.9.3)						
120	regardless_of_feature_size Ⓢ						
121	specific_fixed_cross_section SCS (5.3)						
122	spotface SF						
123	translation ▷ (6.9.7)						
124	two_point_size (LP) (5.3)						
125	volume_diameter_calculated_size (CV) (5.3)						
126							
127	Section Numbers refer to the CAx-IF Recommended Practice for Representation and Pr						
128							
129	**Values as Compared to NIST Test Case Drawing**						
130	See Help > Coverage Analysis						
131	Match						
132	More than expected						
133	Less than expected						
134	None found						
135	Not in CAx-IF Recommended Practice						

File Summary | PMI Presentation Coverage | **PMI Representation Coverage**

Figure 52: PMI Representation Coverage worksheet, multiple files (rows 118-135)

6.2.2 PMI Presentation Coverage Analysis

Figure 53 shows the worksheet that is generated for coverage analysis of PMI presentation. The information in the worksheet is the same as described in section 5.2.2. Columns B through F refer to five STEP files and contain the number of occurrences of that PMI presentation name. Column G counts the total number of occurrences for all STEP files that contain that name.

	A	B	C	D	E	F	G
1	STEP Directory	C:\Users\lipman\Documents\A					
2							
3	PMI Presentation Names	nist_ctc_01_asme1_ap242.stp	nist_ctc_02_asme1_ap242-1.stp	nist_ctc_03_asme1_ap242.stp	nist_ctc_04_asme1_ap242.stp	nist_ctc_05_asme1_ap242-1.stp	Total PMI
4	angularity			1			1
5	circular runout					3	3
6	circularity					1	1
7	coaxiality						
8	concentricity					1	1
9	cylindricity						
10	flatness	1	1	1			3
11	parallelism						
12	perpendicularity	1	3	2		2	8
13	position	2	4	6	3		15
14	profile of line		1				1
15	profile of surface	2	13	3	2		20
16	roundness						
17	straightness					1	1
18	symmetry						
19	total runout					2	2
20	general tolerance						
21	linear dimension	2		2	4	6	14
22	radial dimension						
23	diameter dimension	7	7	8	6		28
24	angular dimension	1			1		2
25	ordinate dimension						
26	curve dimension						
27	general dimension						
28	datum	3	15	6	8	2	34
29	datum target					2	2
30	note			1			1
31	label	3	1		1		5
32	surface roughness						
33	weld symbol						

Figure 53: PMI Presentation Coverage worksheet, multiple files

7 Crash Recovery

As explained in section 2.4, sometimes the STEP File Analyzer will crash when processing a STEP file. This is most likely due to either syntax errors in the STEP file or due to limitations of the IFCsvr toolkit (section 2.2.1). If a crash occurs, one or more of the dialogs in Figure 54 might be displayed in Windows 7. If this happens, simply close the dialog(s), restart the software, and process the same STEP file again by using function key F1 or F4 if processing multiple files. The software keeps track of which entity type caused the crash for a particular STEP file and won't process that type again. A message will be displayed in the Status tab if a particular type of entity won't be processed.

The entity types that won't be processed again are stored in a file *_fix.dat where '*' is the name of the STEP file. No matter what the reason is for the crash, that file will always be generated. Even if the user stops the STEP File Analyzer in the middle of processing a STEP file, the file *_fix.dat will be generated. Therefore, the next time the software is run, the entity type that was being processed when the user stopped the software will not be processed. In this case, or if the syntax errors related to the bad entity are corrected, the *_fix.dat file can be deleted or edited.

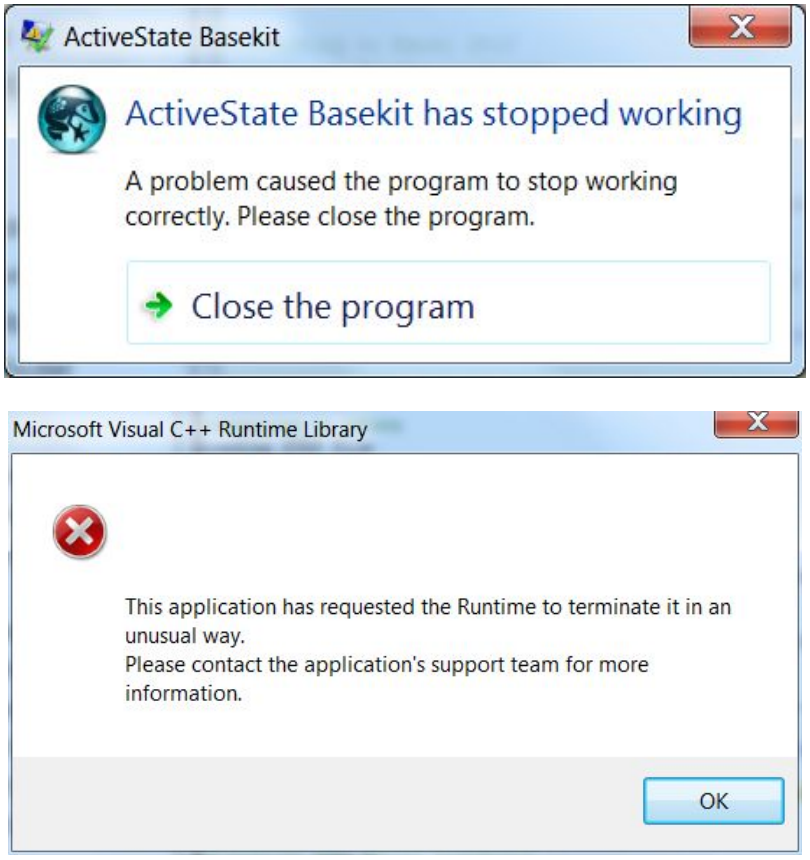


Figure 54: Dialogs displayed when the software crashes

The software might also crash when processing very large STEP files. Popup dialogs might appear that say "unable to alloc xxx bytes". In this case, deselect some entity types to process in the Options tab or use a User-Defined List of entities to process (section 4.4.1).

If the STEP File Analyzer crashes, the user can also see which entity type caused the crash. Figure 55 shows that the software crashed when processing an annotation_plane entity. The entities of the type that caused a crash should be checked for syntax errors.

Another way to prevent that entity type from being processed is to deselect, in the Process section of the Options tab, the category of entity that contains the entity that caused the crash. That will prevent that entity from being processed along with all other entities of that category.

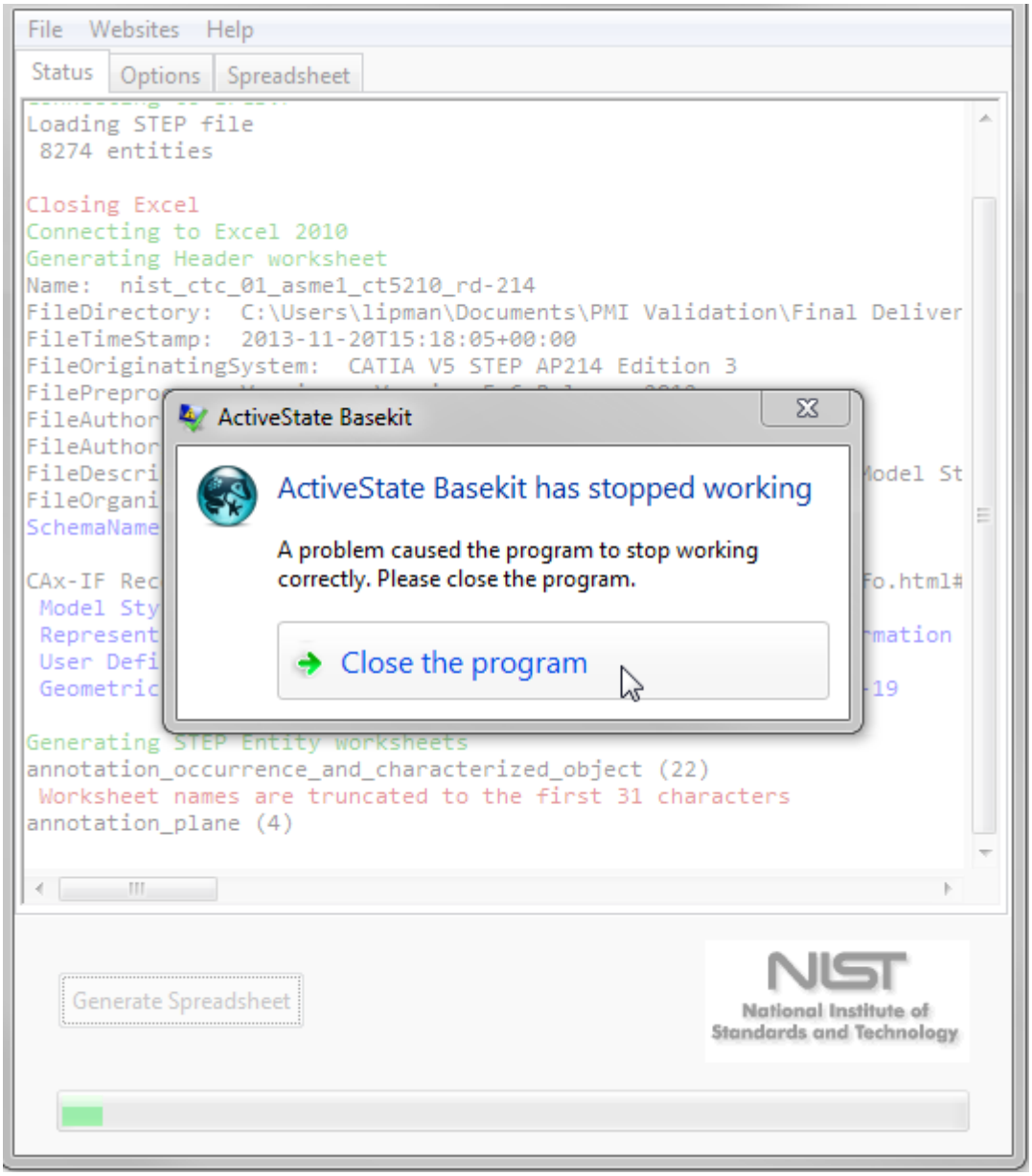


Figure 55: Which entity caused a crash

8 Command-line Version

A command-line (console) version of the STEP File Analyzer is available.
`STEP-File-Analyzer-CL.exe` can be run from a Windows command prompt by going to the Windows start menu, selecting Run, and entering "cmd". This will open up the command prompt window. To run the command-line version, change to the directory where the program is located. Then enter the name of the program and the name of the STEP file to translate as shown in Figure 56.

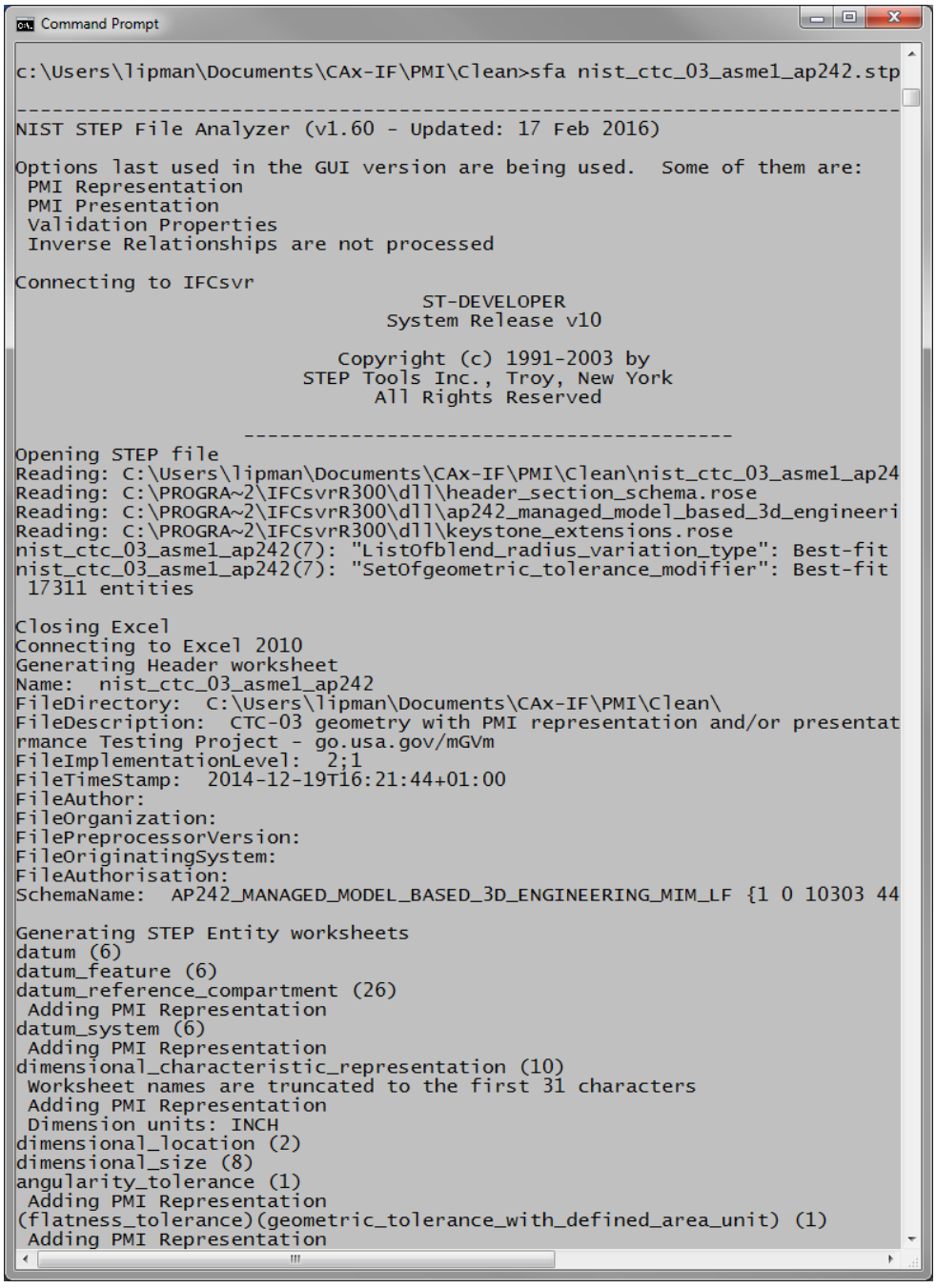


Figure 56: Command-line version

To facilitate running the command-line version, the PATH environment variable can be set to include the directory where the command-line executables are located. A batch file can also be created to run the command-line executable. If the STEP file is not located in the same directory as the command-line executable, then the STEP file name should also include the directory pathname for the file.

Entering the name of the program without a STEP file name will display the command-line options. The program will use whatever options were last used when the GUI version was run.

When the command-line version is run, feedback is provided that is similar to what is displayed in the Status tab (section 4.3) as shown in Figure 56.

9 References

All websites were successfully accessed in March 2016.

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