

STEP File Analyzer User's Guide

Robert R. Lipman

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Validation Properties				
representation name	value name	value	units	exponent
surface area	surface area measure	60000	INCH	2
volume	volume measure	1000000	INCH	3
centroid	centre point	0.0 50.0 0.0		
surface area	surface area measure	60000	INCH	2
volume	volume measure	1000000	INCH	3
centroid	centre point	0.0 50.0 0.0		
number of views	number of views	1		
number of annotations	number of annotations	0		
	DESCRIPTION			
	MODELED_BY			
part user attributes	part user attributes	2		
centroid	centre point	50.0 50.0 -50.0		

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PREFACE

This guide describes how to use the STEP File Analyzer, a software tool that 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. Geometric, PMI (Product and Manufacturing Information), assembly, annotation, attribute, and tessellated validation properties are also reported.

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

The STEP File Analyzer was developed as part of the Model-Based Engineering project in the Engineering Laboratory's Systems Integration for Manufacturing and Construction Applications Program (SIMCA) and was first released in 2012.

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ACKNOWLEDGEMENTS

The author thanks Dr. Kent Reed, former leader of the Computer Integrated Building Process Group, for his guidance in the development of the IFC File Analyzer (<http://cic.nist.gov/ifc/>) 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: Screenshot of a Validation Properties spreadsheet report 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 generates a spreadsheet from a STEP (ISO 10303 – informally known as the STandard for Exchange of Product model data) [1,2,3] 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 (see section 4).

The STEP File Analyzer also reports validation properties (see section 5.2). The validation properties include geometric, PMI (Product and Manufacturing Information), assembly, annotation, attribute, and tessellated validation properties. Product and manufacturing information may include geometric dimensions and tolerances (GD&T), 3D text annotations, surface finish, and material specifications.

Validation properties are a type of recommended practice for implementing STEP in CAD software. The recommended practices for validation properties are defined by the CAx Implementor Forum (CAx-IF) where its objective is to advance CAx (mainly Computer-Aided Design and Engineering) software system translator development and to ensure that user requirements for interoperability are satisfied [5].

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

- AP203 – Configuration Controlled 3D Design of Mechanical Parts and Assemblies [6]
- AP209 – Structural Analysis Design [7]
- AP210 – Electronic Assembly Interconnect and Packaging Design [8]
- AP214 – Automotive Design [9]
- AP242 – Managed Model Based 3D Engineering [10]

2 Getting Started

2.1 Installing the STEP File Analyzer

The download request form for the STEP File Analyzer can be found at http://ciks.cbt.nist.gov/cgi-bin/ctv/sfa_request.cgi. 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 three 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, no GUI, (section 9 below)
3. `SFA-Users-Guide.pdf` – This user’s guide

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

Microsoft Excel is required to generate a spreadsheet.

2.2 Running the STEP File Analyzer

The STEP File Analyzer can run on any Windows computer. There are no minimum system requirements for running the software although as with any computer program, more memory and a fast computer processor are better. The software (`STEP-File-Analyzer.exe`) 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.

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 Disclaimers dialog is displayed.
2. The Crash Recovery dialog is displayed. See section 2.4 below.
3. 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. The STEP File Analyzer icon is a bluish circle with a frog. Creating the shortcut and icon facilitates running the software without having to remember where it is installed.
4. The Overview and What’s New information are displayed in the Status tab.
5. 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.
6. The IFCsvr toolkit is installed.

2.2.1 Installing the IFCsvr toolkit

The IFCsvr toolkit [11] is used to read and process STEP files. Although the toolkit was originally written to work with IFC (Industry Foundation Classes) data exchange files [12], used in the building and construction industry, it has been adapted to work with STEP files.

The installation of the IFCsvr toolkit is simple and straightforward. Two of the installation dialogs are shown in Figure 1 below. 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.

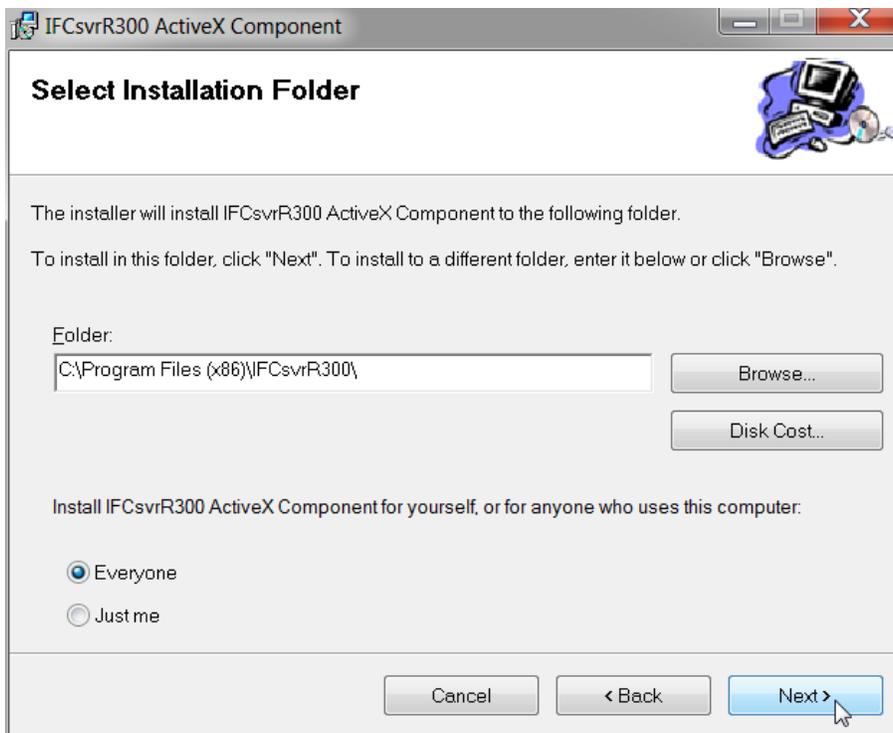


Figure 1: IFCsvr installation dialogs

2.3 Generating a spreadsheet from a STEP file

After the IFCsvr toolkit is installed, a spreadsheet can be generated from a STEP file that uses a supported Application Protocol (see section 1 above). Go to the File menu, select 'Open STEP File(s)', use the Open STEP File(s) dialog to 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 of the STEP File Analyzer

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. 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 8 below.

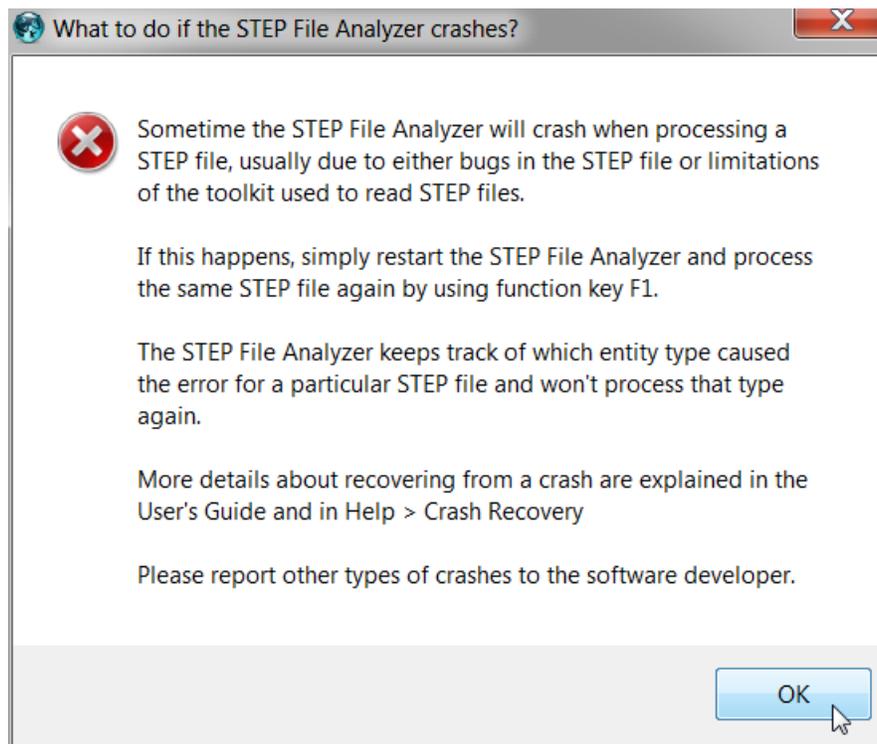


Figure 2: What to do if the STEP File Analyzer crashes

2.5 Uninstalling the STEP File Analyzer

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.

3 User Interface

Figure 3 shows the STEP File Analyzer user interface running on a Windows 7 computer. The appearance and functionality of the interface on a Windows XP computer is similar although different fonts are used.

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.

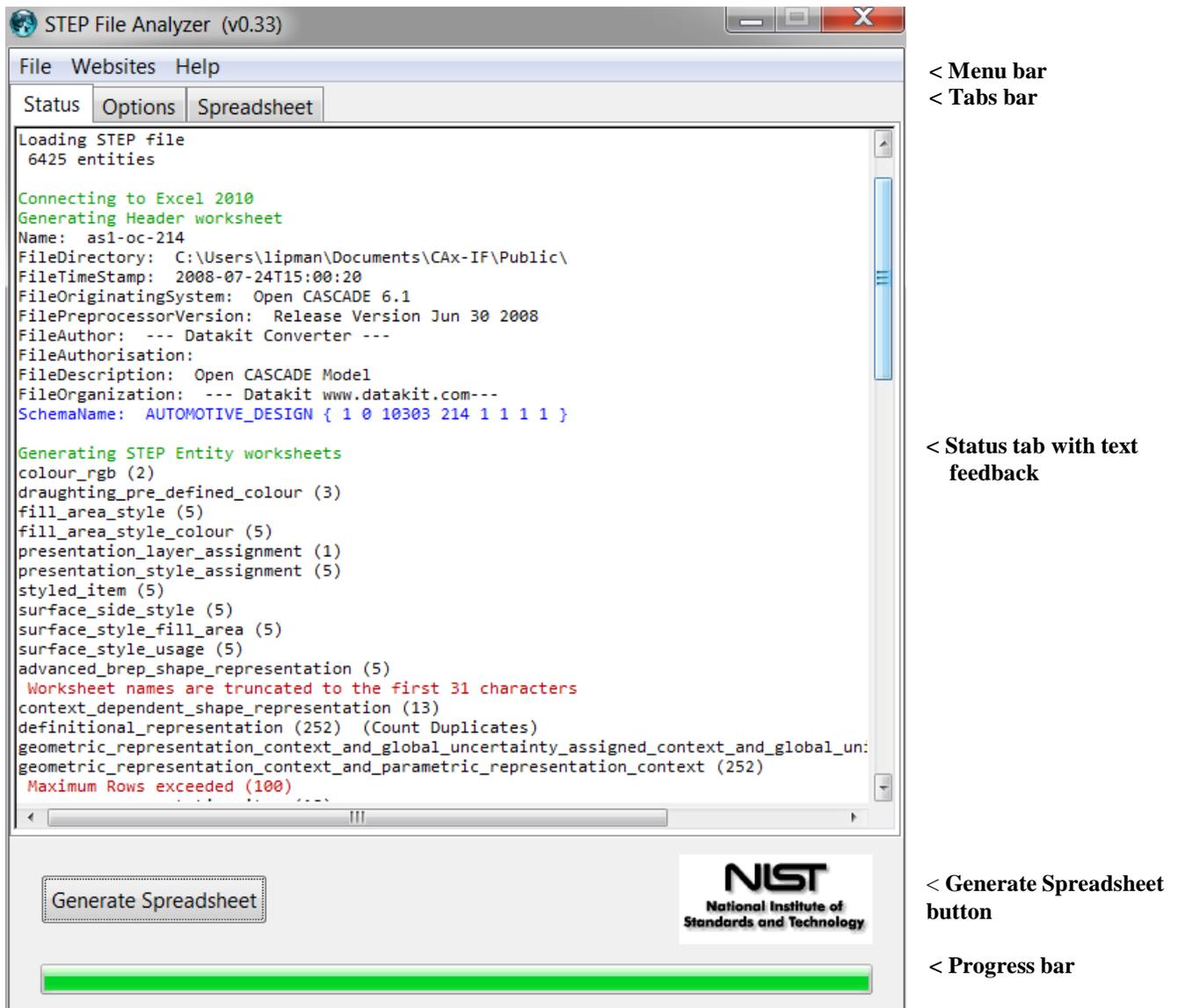


Figure 3: STEP File Analyzer user interface

3.1 Menu Bar

3.1.1 File Menu

From the File menu, shown in Figure 4, 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 .stp.Z are also recognized. Only STEP files using the supported Application Protocols can be processed (see section 1 above).

Multiple STEP files can also 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, which is described in section 7 below.

Below the first solid line in the File menu is a list of up to 20 of the most recently translated STEP files which can be opened directly. Function key F1 generates a spreadsheet from the STEP file that is first in the list. Function key F2 opens the last spreadsheet that was generated. Function key F3 opens the last File Summary spreadsheet when multiple STEP files were processed. Function key F4 generates multiple spreadsheets from the last directory selected.

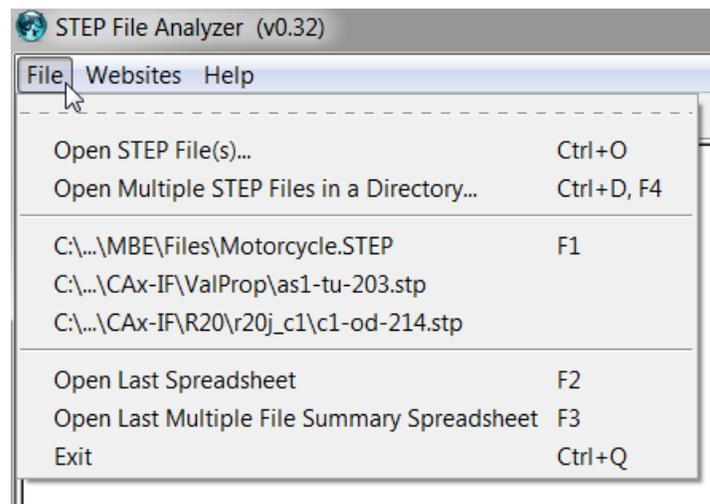


Figure 4: File menu

3.1.2 Websites Menu

The Websites menu, shown in Figure 5, provides links to useful resources related to STEP, organizations that are programmatically related to STEP, and to several websites with documentation for entities in STEP AP203, AP214, and AP242.

3.1.3 Help Menu

The Help Menu, shown in Figure 6, has four sections. In the first section, “User’s Guide” is a link to this document. “What’s New” displays information in the Status tab about new features in the STEP File

Analyzer. The “What’s New” 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. The “Check for Update” feature runs automatically if an update hasn’t been checked for in the last 30 days.

Selecting the other topics in the Help menu displays information related to them in the Status tab and is similar to information in this User’s Guide.

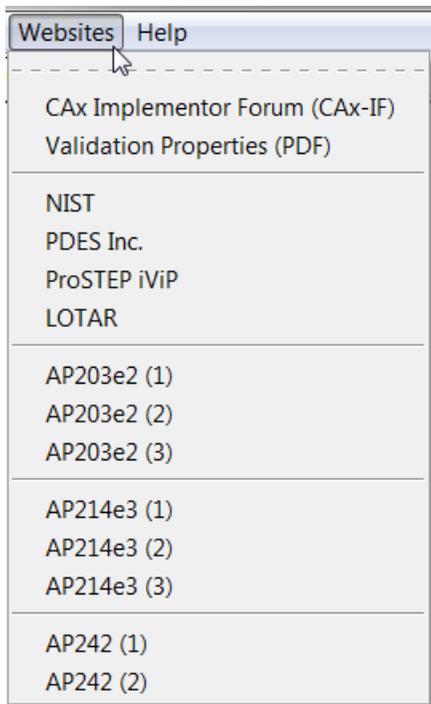


Figure 5: Websites menu

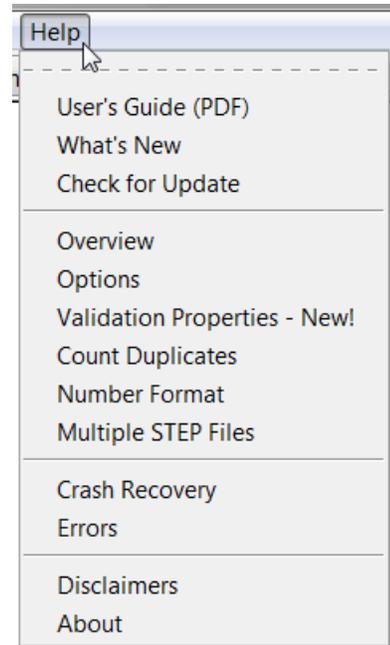


Figure 6: Help menu

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 7.

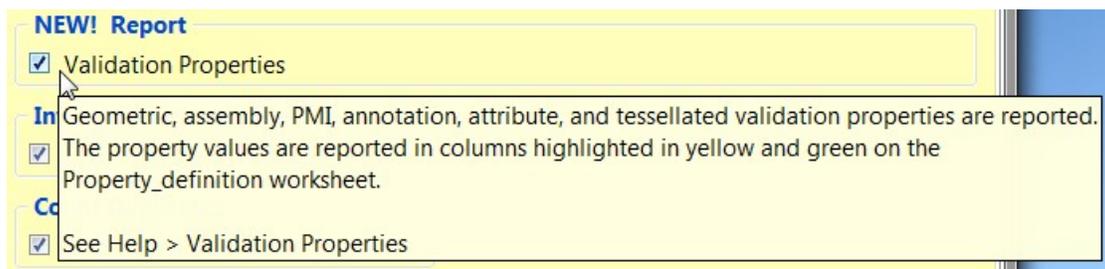


Figure 7: Tooltip help

3.2 Tabs Bar

The Tabs bar is located directly below the menu bar in Figure 3. Clicking on a tab will switch from the current tab to the selected tab. Except for the Status tab, the two other 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 the sections below.

3.3 Status Tab (Feedback)

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 text**, or **blue text**. A brief example of the information in the Status tab is shown in Figure 3.

The following general sequence of information 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 5.1 below)
- Messages about Closing IFCsvr, Adding Summary worksheet, Formatting spreadsheet, Adding links to STEP documentation
- Messages about Saving and Loading the spreadsheet

Function keys F5 and F6 can be used to decrease and increase the size of the text in the Status tab. Function key F7 can be used to toggle the text font in the Status tab.

4 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.

4.1 Summary Worksheet

An example of a Summary worksheet is shown in Figure 8. Rows 1-5 contain basic information about the STEP file. Starting with row 8, 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. In this example, the entity name in parentheses in cell A12 is for a complex entity (characterized_representation)(draughting_model). Column B is the number of each entity type. Column C is a link to STEP documentation for that entity type.

At the bottom of the spreadsheet are tabs for the Summary, Header, and entity worksheets. The 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 5.1 below. Selecting a tab, using the links in column A, or using the Control-PageUp and Control-PageDown keys will switch to a different worksheet.

	A	B	C	D	E	F	G
1	STEP File	pp3 oc 242.stp					
2	STEP Directory	C:\Users\lipman\Documents\CAX-IF\R29\r29j_pp3					
3	Application	Datakit CrossCadWare V72 Feb 16 2012					
4	Timestamp	2012-16-03T18:37:42					
5	Total Entities	5461					
6							
7	Entity	Count	AP242				
8	camera model d3 multi clipping	2	Doc				
9	integer representation item	4	Doc				
10	product category relationship	1	Doc				
11	characterized item within representation	3	Doc				
12	(characterized representation) (draughting model)	3	Doc				
13	leader directed callout	3	Doc				
14	colour rgb	7	Doc				
15	curve style	10	Doc				
16	(draughting annotation occurrence) (geometric representation item) (leader curve)	6	Doc				
17	draughting model item association	3	Doc				
18	draughting pre defined colour	12	Doc				
19	draughting pre defined curve font	10	Doc				
20	fill area style	4	Doc				
21	fill area style colour	4	Doc				
22	point style	5	Doc				
23	pre defined marker	5	Doc				
24	presentation style assignment	19	Doc				
25	styled item	13	Doc				
26	surface side style	4	Doc				
27	surface style fill area	4	Doc				
28	surface style usage	4	Doc				
29	advanced brep shape representation	1	Doc				
30	constructive geometry representation	3	Doc				

Figure 8: Summary worksheet

4.2 Entity Worksheets

An example of an entity worksheet is shown in Figure 9. Row 1 contains the name of the entity and the number of entities. It is also a link back to the File Summary worksheet. Row 2 contains a link to documentation for the entity.

Starting with row 4, each row contains the attribute values for an entity. Row 3 is the names of the entity attributes. The first column is the entity ID.

Column D is the of_shape attribute where, in this example, all of the values for the entities are product_definition_shape 37. This means that the of_shape attribute is a reference to the product_definition_shape entity with an ID of 37. 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 (7)					
2	Doc					
3	ID	name	description	of_shape	product_definitional	constituents
4	5814	DRF1		product_definition_shape 37	FALSE	(1) datum_reference_compartment 5815
5	6498	DRF2		product_definition_shape 37	FALSE	(2) datum_reference_compartment 6499 6500
6	8307	DRF3		product_definition_shape 37	FALSE	(3) datum_reference_compartment 8308 8309 8310
7	9073	DRF4		product_definition_shape 37	FALSE	(2) datum_reference_compartment 9074 9077
8	9398	DRF5		product_definition_shape 37	FALSE	(3) datum_reference_compartment 9399 9400 9401
9	9529	DRF6		product_definition_shape 37	FALSE	(2) datum_reference_compartment 9530 9533
10	9614	DRF7		product_definition_shape 37	FALSE	(2) datum_reference_compartment 9615 9616

Figure 9: Entity worksheet (datum_system)

In the example of an entity worksheet, shown in Figure 10, 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 is too much information for one worksheet cell.

	A	B	C
1	draughting_model (3)		
2	Doc		
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 10: Entity worksheet (draughting_model)

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. For example, Figure 11 shows question marks (???) in column E where the control_points_list attribute was skipped.

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

Figure 11: Entity worksheet (b_spline_surface_with_knots)

5 Options Tab

Figure 12 shows the Options tab, enabling the user to control which entities from the STEP file are written to the spreadsheet and to selectively add other supplemental information to some worksheets.

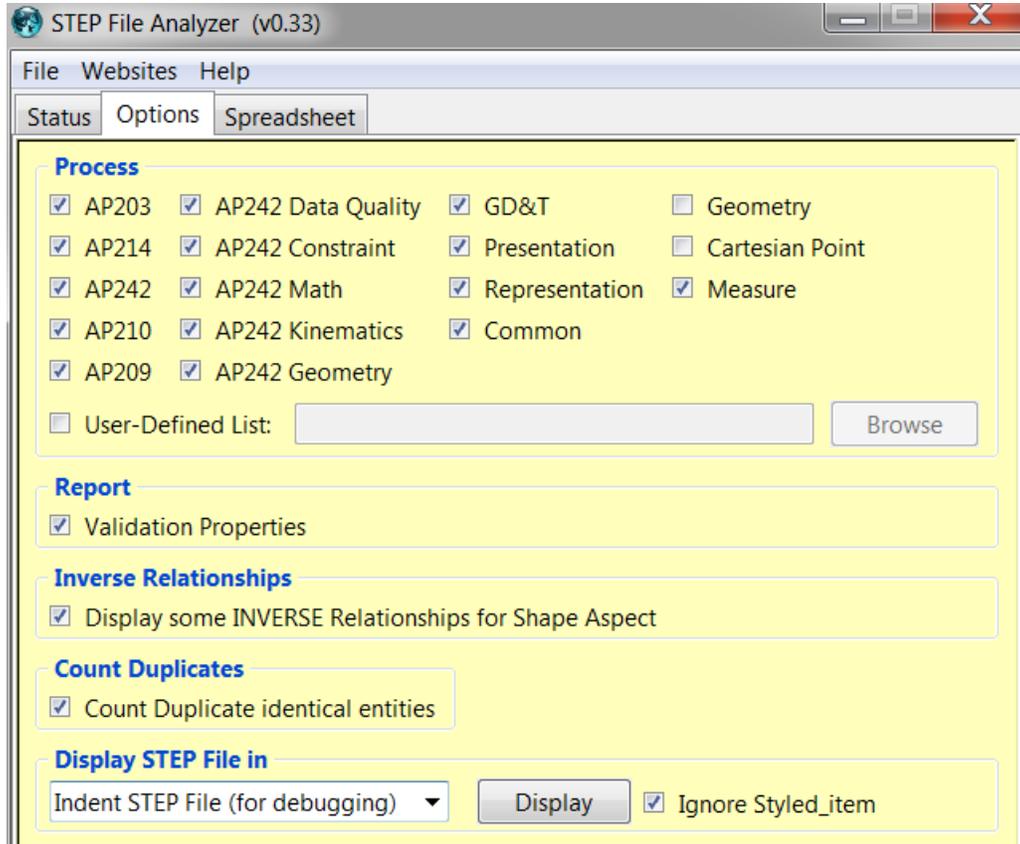


Figure 12: Options tab

5.1 Selectively Process Entity Types

The STEP File Analyzer can process any entity type from AP203, AP214, AP242, AP209, and AP210. 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 12, all entity types are processed except Geometry and Cartesian Point entities.

By processing only certain types of entities, the size 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 8. 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 13. The tooltip indicates that there are 66 entities in the GD&T category and which Application Protocol (AP) they are contained in. 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 text file with one entity type per line.

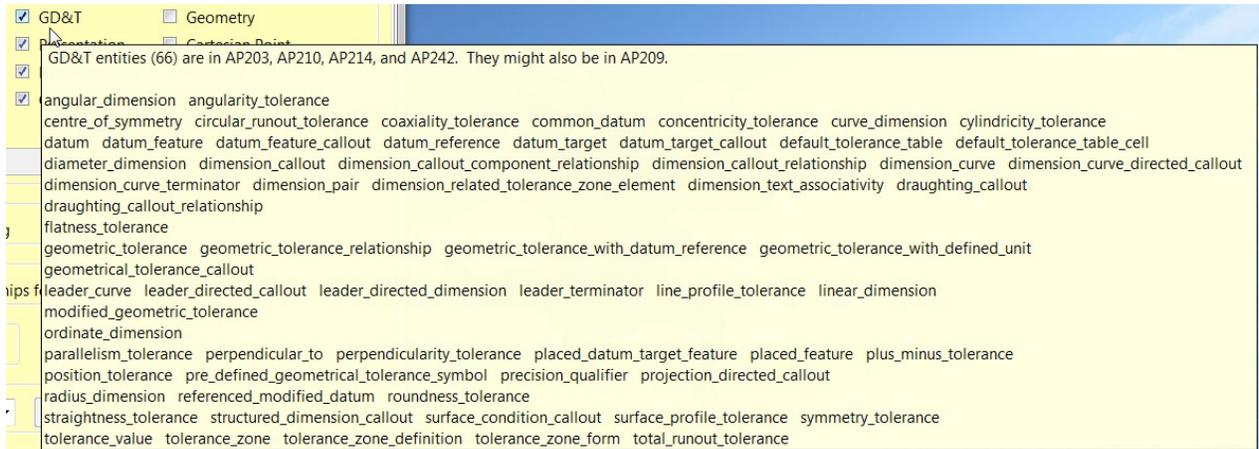


Figure 13: Tooltip help for GD&T entities

5.2 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 added 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.

Recommended practices for communicating validation properties in STEP files are published by the CAx-IF. Validation properties are not part of ISO 10303. Recommended practices for geometric, assembly, PMI (Product and Manufacturing Information), annotation, attribute, and tessellated validation properties have been documented by the CAx-IF [13] and implemented in several CAD systems.

Validation properties are reported by the STEP File Analyzer by inspecting how information on the STEP representation entity is related to property_definition through property_definition_representation. Figure 14 shows a graphical representation of this relationship. The boxes contain entity names and the entity attribute names are displayed next to the lines connecting the boxes. The property_definition_representation entity is connected to the property_definition entity through the definition attribute and to the representation entity through the used_representation attribute. The representation entity is connected to the measure_representation_item entity through the items S[1:?] attribute and to the volume attribute through the name attribute.

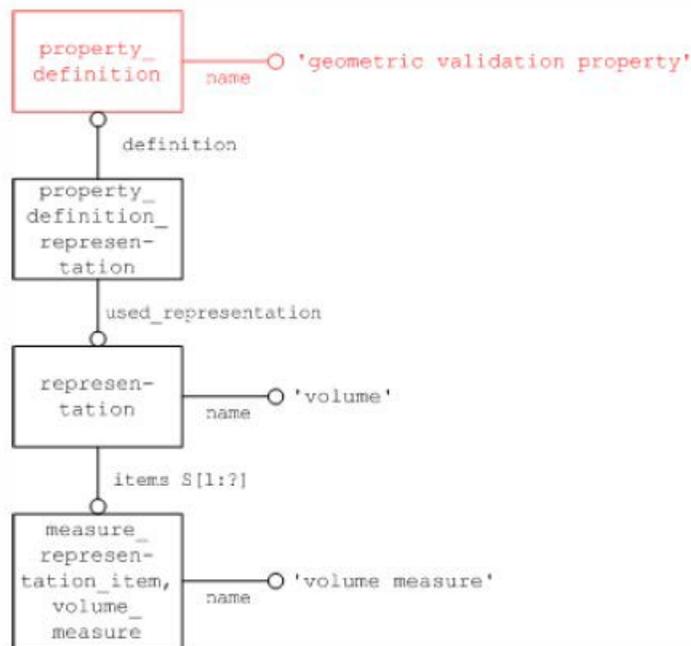


Figure 14: Graphical notation for the geometric validation property for volume [14]

Figure 15 shows an example of a validation properties report. The report is always on the `property_definition` worksheet. 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. The values in cells I6, I9, and I15 are cartesian coordinates. The empty cells E12 and E13 indicates 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.

To see the hidden columns F, H, J, L, and N, click on the plus (+) signs above the columns or the “2” in the upper left corner as highlighted in red in Figure 15. 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, J, and L are shown below in Figure 16. Columns 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.

Figure 17 shows more examples of geometric, PMI, and tessellated validation properties. Sometimes the worksheet with validation properties will not be correctly formatted. In this case the width and height of the columns and rows can be manually adjusted. This is most likely to occur with the smooth sampling points in cells G8 and I8.

	A	B	C	D	E	G	I	K	M	O
1		property definition (35)								
2	Doc									
3	ID	name	description	definition	representation name	value name	value	units	exponent	
4	394	geometric validation property	area of C1_SOLID	shape_aspect 384	surface area	surface area measure	60000	INCH	2	
5	403	geometric validation property	volume of C1_SOLID	shape_aspect 384	volume	volume measure	1000000	INCH	3	
6	407	geometric validation property	centroid of C1_SOLID	shape_aspect 384	centroid	centre point	0.0 50.0 0.0			
7	416	geometric validation property	area of C1_SOLID	product_definition_shape 383	surface area	surface area measure	60000	INCH	2	
8	425	geometric validation property	volume of C1_SOLID	product_definition_shape 383	volume	volume measure	1000000	INCH	3	
9	429	geometric validation property	centroid of C1_SOLID	product_definition_shape 383	centroid	centre point	0.0 50.0 0.0			
10	482	pmi validation property	number of views of C1_SOLID	product_definition_shape 383	number of views	number of views	1			
11	486	pmi validation property	number of annotations of Default	characterized_object_and_draughting_model 434	number of annotations	number of annotations	0			
12	489	DESCRIPTION	user defined attribute	product_definition 382		DESCRIPTION				
13	495	MODELED_BY	user defined attribute	product_definition 382		MODELED_BY				
14	502	attribute validation property	part user attributes of C1_SOLID	product_definition_shape 383	part user attributes	part user attributes	2			
15	513	geometric validation property	centroid of C1_SOLID	product_definition_shape 511	centroid	centre point	50.0 50.0 -50.0			

Figure 15: Validation properties example (property_definition)

Validation Properties										
representation name	value name	value	units							
surface area	#395 representation.name	surface area measure	#393 measure_representation_item.name	60000	#393 measure_representation_item.value_component	INCH	#390 conversion_based_unit_and_le			
volume	#404 representation.name	volume measure	#402 measure_representation_item.name	1000000	#402 measure_representation_item.value_component	INCH	#399 conversion_based_unit_and_le			
centroid	#408 representation.name	centre point	#406 cartesian_point.name	0.0 50.0 0.0	#406 cartesian_point.coordinates					
surface area	#417 representation.name	surface area measure	#415 measure_representation_item.name	60000	#415 measure_representation_item.value_component	INCH	#412 conversion_based_unit_and_le			
volume	#426 representation.name	volume measure	#424 measure_representation_item.name	1000000	#424 measure_representation_item.value_component	INCH	#421 conversion_based_unit_and_le			
centroid	#430 representation.name	centre point	#428 cartesian_point.name	0.0 50.0 0.0	#428 cartesian_point.coordinates					
number of views	#483 representation.name	number of views	#481 value_representation_item.name	1	#481 value_representation_item.value_component					
number of annotations	#487 representation.name	number of annotations	#485 value_representation_item.name	0	#485 value_representation_item.value_component					
	#493 representation.name	DESCRIPTION	#492 descriptive_representation_item.name		#492 descriptive_representation_item.description					
	#499 representation.name	MODELED_BY	#498 descriptive_representation_item.name		#498 descriptive_representation_item.description					
part user attributes	#503 representation.name	part user attributes	#501 value_representation_item.name	2	#501 value_representation_item.value_component					
centroid	#514 representation.name	centre point	#512 cartesian_point.name	50.0 50.0 -50.0	#512 cartesian_point.coordinates					

Figure 16: Validation properties example with expanded columns

	A	B	C	D	E	G	I	K	M
1		property definition (100 of 4355)							
2		Doc							
3									
3	ID	name	description	definition	representation name	value name	value	units	exponent
4	137705	geometric validation property	Main:t2:::0	product_definition_shape 43	volume	volume measure	105.1380679	INCH	3
5	137721	geometric validation property	Main:t2:::0	product_definition_shape 43	centroid	centre point	-0.454667976545899 0.53787536491866 0.023995198699849		
6	137725	geometric validation property	Main:t2:::0	product_definition_shape 43	surface area	surface area measure	1728.486057	INCH	2
7	137745	geometric validation property	volume of solid	shape_aspect 137741	volume	volume	105.1409553	INCH	3
8	137759	geometric validation property		shape_aspect 137755	smooth sampling points (5 of 5)	(1) sampling point (2) sampling point (3) sampling point (4) sampling point (5) sampling point	10.113988020620653 1.006420893615678 4.293254962336012 10.11396612461185 1.009631340423488 4.293306546100149 10.113944228603046 1.012841787231298 4.293358129864288 10.1111001407560927 1.008026117019583 4.292017659340621 10.108036690510007 1.006420893615678 4.290728772581091		

	A	B	C	D	E	G	I	K
1		property definition (48)						
2		Doc						
3								
3	ID	name	description	definition	representation name	value name	value	units
13	11982	pmi validation property	centroid of AE_SYMBOL0	characterized_item_within_representation 11980	centroid	polyline curve centroid	69.51632922137 -2.698673248291 17.55111653224	
14	11987	pmi validation property	polyline curve length of AE_SYMBOL0	characterized_item_within_representation 11980	polyline curve length	polyline curve length	79.20645849	millimetre
15	12233	pmi validation property	centroid of AE_SYMBOL0	characterized_item_within_representation 12231	centroid	polyline curve centroid	59.26289617798 -2.698673248291 14.60382417057	
16	12238	pmi validation property	polyline curve length of AE_SYMBOL0	characterized_item_within_representation 12231	polyline curve length	polyline curve length	42.47388876	millimetre
17	15428	pmi validation property	centroid of AE_SYMBOL1	characterized_item_within_representation 15426	centroid	polyline curve centroid	-65.00318182046 -8.80285358429 24.20145145342	
18	15433	pmi validation property	polyline curve length of AE_SYMBOL1	characterized_item_within_representation 15426	polyline curve length	polyline curve length	75.99734158	millimetre
19	15780	pmi validation property	centroid of AE_SYMBOL1	characterized_item_within_representation 15778	centroid	polyline curve centroid	-59.21002034139 -8.80285358429 20.18248899104	
20	15785	pmi validation property	polyline curve length of AE_SYMBOL1	characterized_item_within_representation 15778	polyline curve length	polyline curve length	44.68662937	millimetre
21	15793	pmi validation property	number of annotations of R29J_SP3_CREO	product_definition_shape 7537	number of annotations	number of annotations	24	

	A	B	C	D	E	G	I	K	M
1		property definition (70)							
2		Doc							
3									
3	ID	name	description	definition	representation name	value name	value	units	exponent
4	176	tessellated validation property	centroid	shape_aspect 170	centroid	centre point	-186.917057986 80.2823927006 0.00143892067884		
5	182	tessellated validation property	surface area	shape_aspect 170	surface area	surface area measure	22999.10105	millimetre	2
6	186	tessellated validation property	number of facets	shape_aspect 170	number of facets	number of facets	174		
7	190	tessellated validation property	number of facets	product_definition_shape 38	number of facets	number of facets	174		
8	194	tessellated validation property	surface area	product_definition_shape 38	surface area	surface area measure	22999.10105	millimetre	2
9	198	tessellated validation property	centroid	product_definition_shape 38	centroid	centre point	-186.917057986 80.2823927006 0.00143892067884		

Figure 17: More validation property examples

5.3 Inverse Relationships

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 [15]. Inverse relationships are explicitly defined in a STEP schema, however, the only one currently reported by the STEP File Analyzer is associated with shape_aspect_relationship.

Figure 18 is an entity worksheet for shape_aspect_relationship that shows the relationship 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 (7)		
2	Doc				
3	ID	name	description	relating_shape_aspect	related_shape_aspect
13	12256			datum_feature 5583	datum 5618
14	12257			centre_of_symmetry_and_datum_feature 5827	datum 5932
15	12258			centre_of_symmetry_and_datum_feature 6648	datum 6650
16	12259			centre_of_symmetry_and_datum_feature 8319	datum 8320
17	12260			centre_of_symmetry_and_datum_feature 8829	datum 8935
18	12261			placed_datum_target_feature 9908	datum 9907
19	12262			placed_datum_target_feature 9953	datum 9907

Figure 18: Entity worksheet (shape_aspect_relationship)

Figure 19 shows the inverse relationship, in column G, between datum and other entities as established by shape_aspect_relationship. There are similar inverse relationships displayed on the datum_feature, centre_of_symmetry_and_datum_feature, and placed_datum_target worksheets.

	A	B	C	D	E	F	G	H
1	datum (6)							
2	Doc							
3	ID	name	description	of_shape	product_definitional	identification	INV-established_by_relationships	
4	5618		product_definition_shape 37	FALSE	A	(1) datum_feature 5583		
5	5932		product_definition_shape 37	FALSE	B	(1) centre_of_symmetry_and_datum_feature 5827		
6	6650		product_definition_shape 37	FALSE	C	(1) centre_of_symmetry_and_datum_feature 6648		
7	8320		product_definition_shape 37	FALSE	D	(1) centre_of_symmetry_and_datum_feature 8319		
8	8935		product_definition_shape 37	FALSE	E	(1) centre_of_symmetry_and_datum_feature 8829		
9	9907		product_definition_shape 37	FALSE	F	(2) placed_datum_target_feature 9908 9953		

Figure 19: Inverse Relationships example

5.4 Count Duplicates

The option to count duplicates identifies entities with identical values for all attributes and reduces the number of rows in the worksheet for that entity type. Figure 20 shows part of a cartesian_point worksheet where duplicates have been counted. In this example, the name and coordinates attributes in columns B and C must be identical for duplicates to be counted. The number (count) of duplicate entities, for a particular combination of name and coordinates attributes, is shown in column D. Row 1 indicates that of 178 total cartesian_point entities, 70 are unique. The IDs in column A are for the first entity with those attribute values.

Duplicates are counted only for a small set of mostly geometric entities. A list of those entities can be displayed in the tooltip help for counting duplicates. Duplicates are not counted if there are less than 100 of an entity type.

	A	B	C	D
1	cartesian_point (70 of 178)			
2	Doc			
3	ID	name	coordinates	Count
4	16		-50.0 0.0 50.0	4
5	24		-50.0 0.0 0.0	5
6	31		-50.0 60.0 0.0	4
7	38		-50.0 60.0 10.0	4
8	57		12.99038105677 0.0 42.5	2
9	73		-12.99038105677 0.0 42.5	2
10	96		0.0 0.0 20.0	2
11	349		5.0 0.0 20.0	1
12	350		-5.0 0.0 20.0	1
13	357		-7.990381056767 0.0 42.5	1
14	358		-17.99038105677 0.0 42.5	1
15	707	centre point	-9.66746115407e-6 20.20271778233 14.59456028609	3
16	1436	centre point	0.0 -1.5 0.0	2
17	1490	centre point	0.0 31.5 0.0	1
18	1494		0.0 33.0 0.0	1
19	1545	centre point	0.0 18.02056353271 0.0	1
20	1551	centre point	0.0 -8.020563532713 20.0	1
21	1564	centre point	12.99038105677 -8.020563532713 42.5	1
22	1577	centre point	-12.99038105677 -8.020563532713 42.5	1

Figure 20: Count Duplicates example (cartesian_point)

5.5 Display a STEP File in Other Applications

The “Display STEP File in” option is a convenient way to display a STEP file in other applications. Figure 21 shows the pull-down menu, listing some of the applications that can display a STEP file on the author’s computer. The Notepad or WordPad text editors will always appear in the menu, along with the option to “Indent STEP File (for debugging)” which is described in section 5.5.1 below. 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.

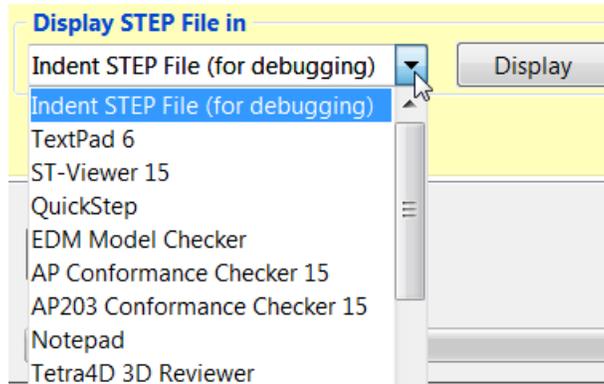


Figure 21: Display STEP File in Other Applications

5.5.1 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 22 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 such as cartesian_point and direction are usually not included in the “indented” 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');
#29=APPLICATION_CONTEXT('automotive design');
```

Figure 22: Indented STEP file

6 Spreadsheet Tab

The Spreadsheet tab, shown in Figure 23, contains several more options that affect how information is written to the spreadsheet.

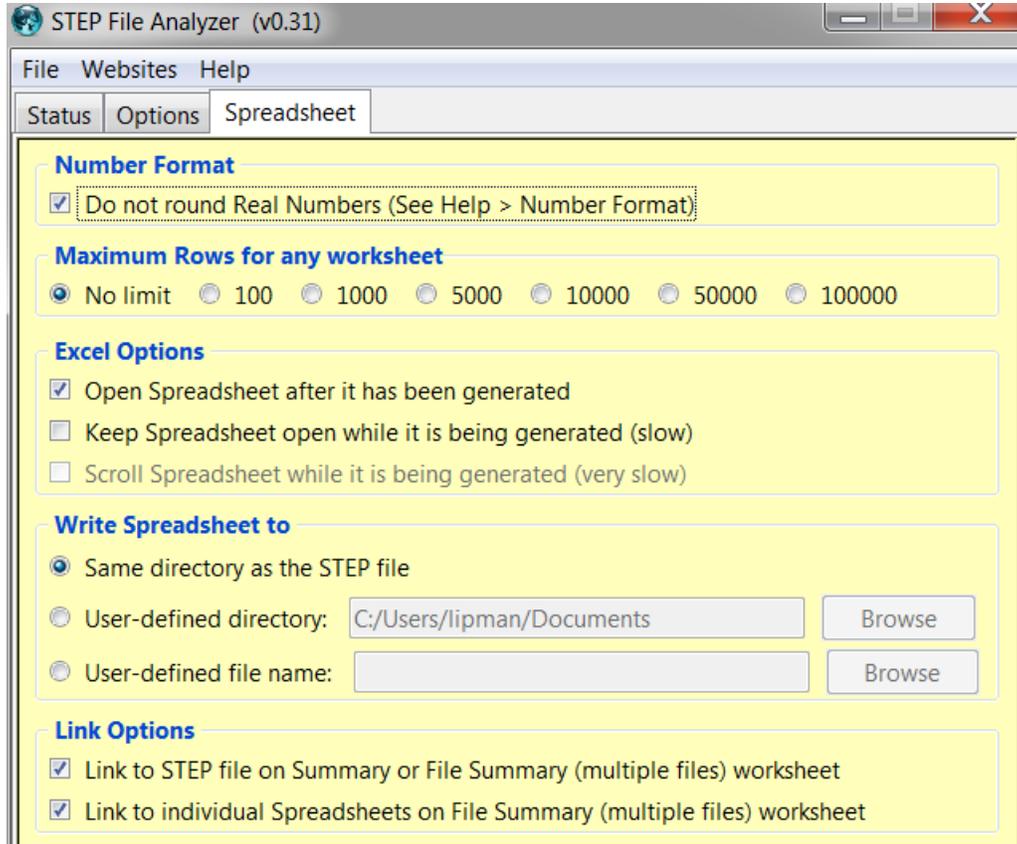


Figure 23: Spreadsheet tab

6.1 Rounding Numbers

By default, when the STEP File Analyzer adds a single real number to a worksheet cell, Excel might round the number. Figure 24, 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	Doc			
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	Doc			
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 24: Circle worksheet, with rounding (left) and without rounding (right)

Figure 25 shows the effect of counting duplicates on the values for radius shown in Figure 24. Counting duplicates looks for identical attribute values in the STEP file, not as they might be rounded by Excel. Therefore, in the worksheet on the left, it appears as if the radius values of 3 have not been correctly counted. However, not rounding the radius values, as shown on the right, verifies that the count is in fact correct.

	A	B	C	D	E
1	circle	(139 of 146)			
2	Doc				
3	ID	name	position	radius	Count
4	86		axis2_placement_3d	3	4
5	128		axis2_placement_3d	3	2
6	212		axis2_placement_3d	3	2
7	358		axis2_placement_3d	3.375	2

	A	B	C	D	E
1	circle	(139 of 146)			
2	Doc				
3	ID	name	position	radius	Count
4	86		axis2_placement_3d	2.999999999999695	4
5	128		axis2_placement_3d	2.999999999999792	2
6	212		axis2_placement_3d	2.999999999999803	2
7	358		axis2_placement_3d	3.375	2

Figure 25: Counting duplicates on circle worksheet, with rounding (left) and without rounding (right)

6.2 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 26 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	Doc				
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 26: Maximum rows example (cartesian_point)

6.3 Other Options

The other options on the Spreadsheet tab control are: (1) opening the spreadsheet after or while it is being generated, (2) specifying where to write the spreadsheet, and (3) generating links on the File Summary worksheet when multiple STEP files are processed.

7 Processing Multiple STEP Files

The capability to process 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 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 4. 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.

When processing multiple STEP files a second spreadsheet is generated, in addition to the individual spreadsheets for each STEP file. The second spreadsheet is a summary of the entities found in the multiple files as shown in Figure 27. In this example five STEP files were processed. Starting with row 10, column A lists all of the entity types in all five files with links to entity documentation. 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 5.1 above. 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 Link Options. Rows 5 through 9 contain, respectively, the file timestamp, software that generated the STEP file, the STEP application protocol (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\CAX-IF\R29\r29j_c2						
2								
3		Link (1)	Link (2)	Link (3)	Link (4)	Link (5)		
4		c2-c5-214.stp	c2-id-203.stp	C2_3de_203.stp	c2_cr_214.stp	c2_oc_242.stp		
5		12-01-30	12-01-23	12-02-06	12-02-09	12-02-14		
6		CATIA V5	I-DEAS	CT	ProE	DATAKIT		
7		AP214	AP203	AP203	AP214	AP242		
8		19 Kb	28 Kb	21 Kb	55 Kb	27 Kb		
9	Entity	387	535	433	1104	414	Total Entitie	Total Files
10	design context			1			1	1
11	mechanical context			1			1	1
12	product category relationship	1				4	5	2
13	area in set				4		4	1
14	(camera image 3d with scale (geometric representation item)				4		4	1
15	camera model d3 with hlhsr				4		4	1
16	camera usage				4		4	1
17	colour rgb	3		10	14	1	28	4
18	curve style	1	8	1	40	1	51	5
19	draughting model		4	1			5	2
20	draughting pre defined colour	5	8		5	6	24	4
21	draughting pre defined curve font	1	4	1	1	1	8	5
22	fill area style	9	8	6	14	3	40	5
23	fill area style colour	9	8	6	14	3	40	5
24	over riding styled item	7	9	2	6	1	25	5

Figure 27: File Summary worksheet when processing multiple STEP files

8 Crash Recovery

As explained in 2.4 above, sometimes the STEP File Analyzer will crash when processing a STEP file. This is usually due to either bugs in the STEP file or limitations of the IFCsvr toolkit (see section 2.2.1 above). If a crash occurs, one or more of the dialogs in Figure 28 might be displayed. If this happens, simply close the dialog(s), restart the software, and process the same STEP file again by using function key F1. 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, the *_fix.dat can be deleted or edited.

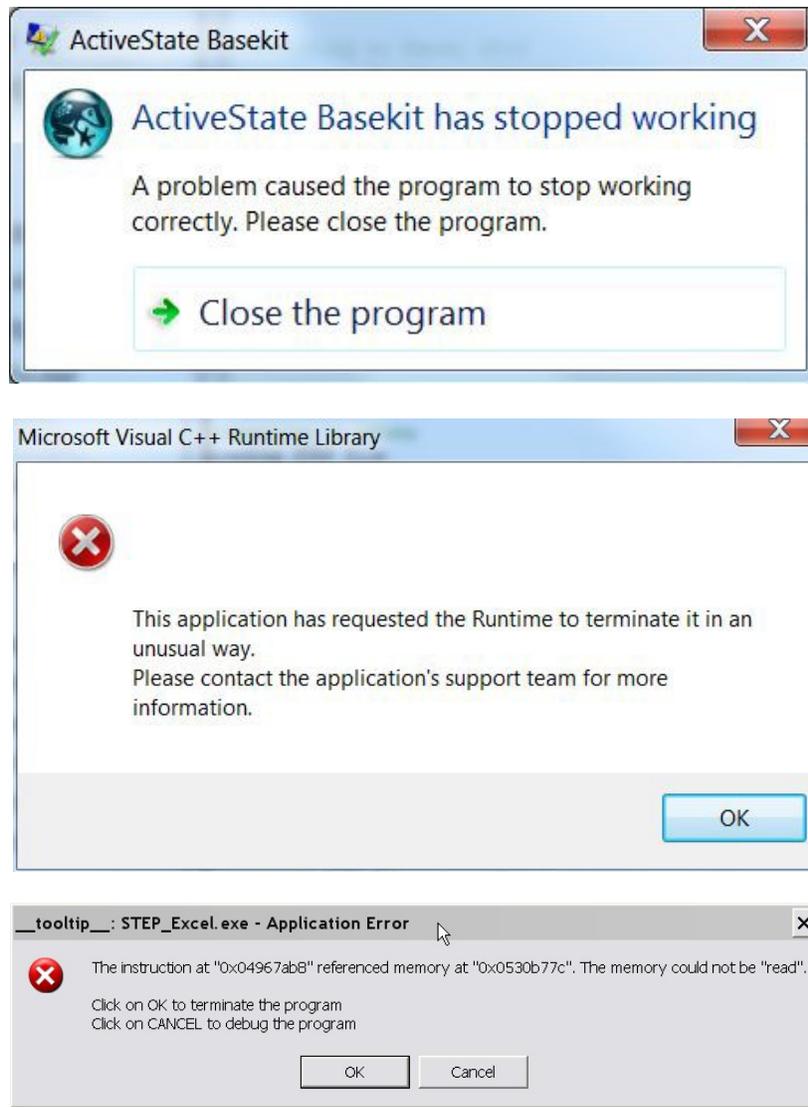


Figure 28: Dialogs that might be displayed when the STEP File Analyzer crashes

If the STEP File Analyzer crashes, the user can also see which entity type caused the crash. Figure 29 shows that the software crashed when processing a trimmed_curve entity. 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 entities of that category.

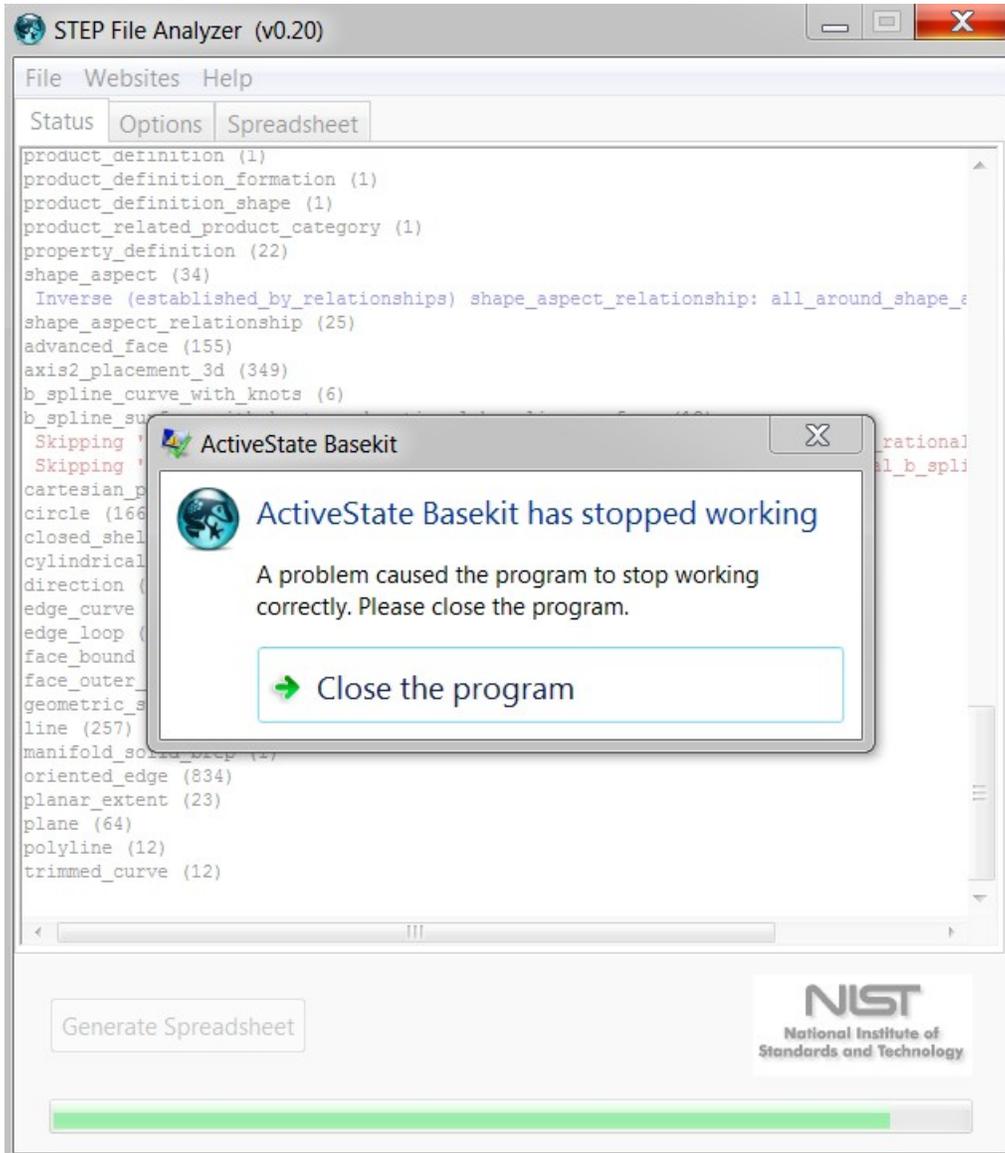


Figure 29: Determining which entity the STEP File Analyzer caused a crash

9 Command-line Version

A command-line (console) version of the STEP File Analyzer is available (section 2.1 above). `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 30.

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 3.3 above) as shown in Figure 30.

10 Other

Feedback about any aspect of the STEP File Analyzer can be emailed to the author.

Plans for a future version of the software include reports for presentation and semantic PMI and checking for other CAx-IF recommended practices [13].

```
Command Prompt
C:\Documents and Settings\lipman\My Documents\Analyzer>STEP-File-Analyzer-CL test-step.stp
-----
NIST STEP File Analyzer (v0.33 - Updated: 22 Sep 2012)
Options last used in the GUI version are being used. Some of them are:
  Count Duplicates
  Inverse Relationships
Connecting to IFCsvr
                        ST-DEVELOPER
                        System Release v10
                        Copyright (c) 1991-2003 by
                        STEP Tools Inc., Troy, New York
                        All Rights Reserved
-----
Loading STEP file
Reading: C:\Documents and Settings\lipman\My Documents\Analyzer\test-step.stp
Reading: C:\PROGRA~1\IFCSUR~1\dll\header_section_schema.rose
Reading: C:\PROGRA~1\IFCSUR~1\dll\automotive_design.rose
Reading: C:\PROGRA~1\IFCSUR~1\dll\keystone_extensions.rose
  11 entities
Connecting to Excel 2010
Generating Header worksheet
Name: test-step
FileDirectory: C:\Documents and Settings\lipman\My Documents\Analyzer\
FileTimeStamp: 2003-12-27T11:57:53
FileOriginatingSystem: IDA-STEP
FilePreprocessorVersion:
FileAuthor: Lothar Klein
FileAuthorisation:
FileDescription: A minimal AP214 example with a single part
FileOrganization: LKSoft
SchemaName: AUTOMOTIVE_DESIGN < 1 0 10303 214 2 1 1 >
Generating STEP Entity worksheets
application_context (1)
application_protocol_definition (1)
applied_organization_assignment (1)
organization (1)
organization_role (1)
product (1)
product_context (1)
product_definition (1)
product_definition_context (1)
product_definition_formation (1)
product_related_product_category (1)
Worksheet names are truncated to the first 31 characters
Closing IFCsvr
Adding Summary worksheet
Formatting Spreadsheet
Adding links on Summary to STEP documentation
Processing time: 9 seconds
Saving Spreadsheet as:
  C:\...\Analyzer\test-step_stp.xlsx
Closing Excel
Starting Excel
Loading Spreadsheet: test-step_stp.xlsx (30 Kb)
```

Figure 30: Feedback when running the command-line version

11 References

All websites were successfully accessed in November 2012.

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