Test Suite for the CAx Implementor Forum Round 16J

March – October 2005

Release 0.2

(Draft)

May 13, 2005

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1.0 <u>Introduction</u>

This document describes the suite of test cases to be used for the sixteenth round of testing of the CAx Implementor Forum (CAx-IF). The CAx-IF is a joint testing forum organized by PDES, Inc. and the ProSTEP-iViP association. The test rounds of the CAx-IF concentrate primarily on testing the interoperability and conformance of STEP processors based on AP 203 and AP 214.

The test rounds in general combine testing of synthetic and production models. Production models will in most cases be provided by the member companies of the organizations PDES, Inc. and ProSTEP-iViP. When production models are not available from the member companies, "production-like" models will be solicited from the various CAx-IF participants.

This test suite includes synthetic models for testing the following capabilities: geometric and dimensional tolerances (GD&T), AP203 edition 2 migration, density and material names, AP209 interoperability, surface validation properties, and data exchange quality tracking.

Production models are provided for assemblies and piece parts. The basis for the production test cases is native CAD models. Each test case therefore originates from a single CAD system, and the set of test cases to be pre-processed (converted to STEP files) is unique for each CAD system. After pre-processing, the resulting STEP files are then to be imported/post-processed/read in by the rest of the participants.

1.1 Functionality tested in this round

Functionality tested in this round relates to: solid geometry exchange, geometric dimensioning and tolerancing, AP203 edition 2 migration, density and material names, AP209 interoperability, surface validation properties, and data exchange quality tracking.

Solid geometry exchange aims for validation and improvement of the results of the 8th Pro-STEP processor benchmark, using the same assembly. In addition to the basic STEP data transfer, all exchanges for this test case will be tracked by CADIQ in order to identify issues both within the model itself and during import / export of the STEP file.

Since a second edition of AP203 is now available, which shows significant differences in the data model compared to the first edition, extensive testing is needed to validate STEP data exchange with this new protocol.

The goal for GD&T is the ability to exchange tolerances for dimensions and geometry to drive downstream applications such as coordinate measuring and manufacturing.

The density and material names test case is designed to transfer these basic attributes using the 'material as property' or 'material as product' approach for informational uses between CAD systems.

AP209 interoperability testing focuses in ability to import geometry and the correct structure from AP209 files into AP203/AP214 processors, as well as transfer density and material information exported using the 'material as product' approach to AP209 systems.

Surface Validation Properties are used to validate the exchange of surface models. They are a specific subset of the Geometric Validation Properties, and will be tested to validate the updated Recommended Practices for this functionality.

In addition to synthetic models for the above capabilities, production models are included in this round of testing.

1.2 General test instructions for this round

The general procedures for communication of models and statistics are outlined in a separate document 'General Testing Instructions'. The general instructions can be retrieved from CAx Implementor Forum web sites. The latest version is v1.4, dated December 2004.

1.3 Preliminary testing schedule

Date	Action
May 4, 2005 **(Wed)**	**Test Suite available /** **1st CAx Implementor Forum conference call**
ASAP	**Production Models released**
July 8 (Fri)	**Initial STEP files and native statistics due**
July 29 (Fri)	**STEP files and native statistics frozen**
September 1 (Tue)	**Target statistics due / 2nd conference call**
September 30 (Fri)	**Target statistics frozen**
October 11 (Tue)	**Pre-release of final statistics / 3rd conference call**
October 18 (Tue)	**Review meeting for test round**
October 19 – 20 **(Wed – Thu)**	**CAx Implementor Forum meeting,** **Munich, Germany**

1.4 Copyrights on test cases

Not all of the production test cases which were provided by the PDES, Inc. and ProSTEP-iViP member companies are fully released for any purpose. The least common denominator is that the test cases can be freely distributed among the ProSTEP-iViP / PDES, Inc. Round Table participants and can be used for any purposes that are related to CAx-IF testing (i.e. testing, documentation of testing efforts), as long as a reference to the originating company is made.

The test cases must not be used for any purposes other than the CAx-IF testing or outside of PDES, Inc. and ProSTEP-iViP.

2.0 <u>Synthetic test case specifications</u>

2.1 Model B4 : Benchmark model 'torque converter assembly'

2.1.1 Motivation

After testing the torque converter housing in Rounds 12J to 15J, and resolving the majority of issues found in the 8th ProSTEP iViP Benchmark, the new focus of this test case is the data quality tracking for an assembly.

Therefore, in addition to the STEP files, the native models from both the source and the target system will be collected and analyzed using the "CADIQ" tool.

2.1.2 Approach

No new capability involved.

2.1.3 Testing Instructions

The assembly should be exported as a single STEP file in either AP214-IS or AP203e2 format.

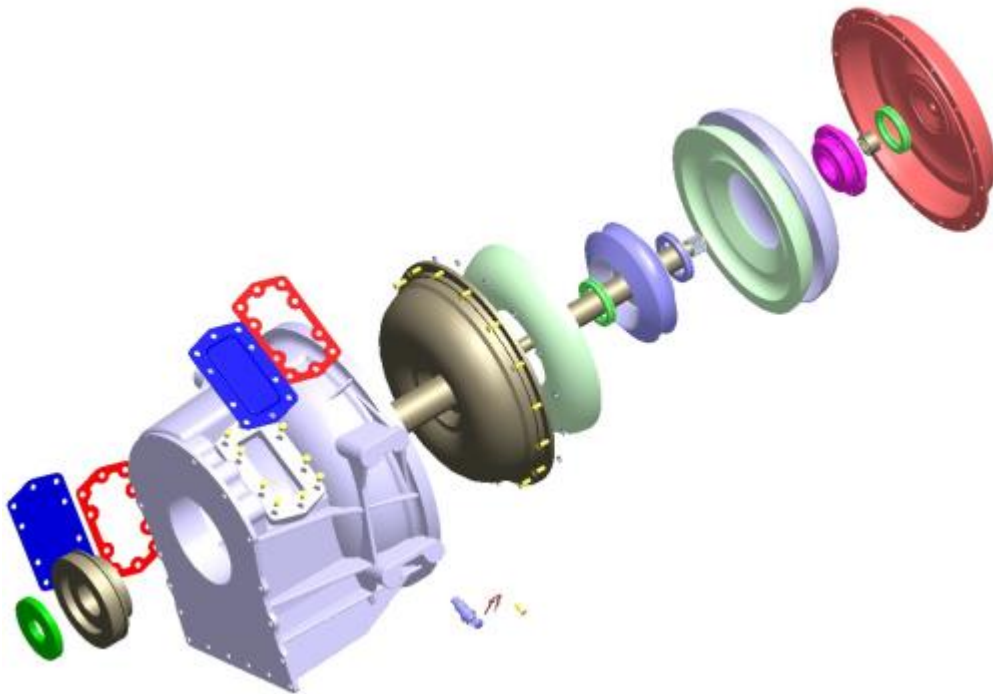### 2.1.3.1 Construction of the benchmark model

Figure 1: Exploded view of the B4 model (torque converter assembly)

Those vendors who participated in the ProSTEP iViP benchmark should re-use the torque converter assembly model which has been constructed for that purpose.

If vendors who wish to participate in this test but do not have a native model of the assembly, please contact jochen.boy@prostep.com for modeling instructions.

2.1.3.2 Results

For each STEP file imported for the B4 model, vendors need to submit at least one of the following:

- The native model from their system created by importing the STEP file. This is required for an end-to-end analysis of the data exchange with the "CADIQ" tool. The file name should clearly point out the source system which created the STEP file.

    If the resulting native model is submitted, no .CSV needs to be provided, since the results calculation can be done by CADIQ.

- A text file with the statistics in comma-delimited form (.CSV):

model	*b4*
system_n	*Native system code*
system_t	*Target system code (for native statistics use 'stp' for system_t)*
unit	*Units*
volume	*Total volume of all solids*
area	*Total surface area*
cx, cy, cz	*Centroid of all solids*
date	*Date submitted*
issues	*Short description of issues*

2.2 Model GD2: Geometric Dimensioning and Tolerancing

2.2.1 Motivation

Geometric and Dimensioning Tolerances are required for a number of business use case in the context of STEP data exchange. Among others, they are a prerequisite for long-term data archiving the way the aircraft industry plans to use it. In addition, the GD&T data can be used to drive downstream applications such as coordinate measuring and manufacturing

2.2.2 Approach

The functionality tested with this model is based on the harmonized approach for GD&T, described in detail in the updated GD&T Usage Guide (Version 2), which is available from the CAx-IF homepages under "Joint Testing Information".

2.2.3 Testing Instructions

1. Use inches for units.

2. Create a rectangular block at the origin with dimensions x =4, y=2, z=1.

3. Remove two 1 inch diameter through holes parallel to the Z axis centered in the block. The centerlines of the holes are at (1, 1, 0) and (3,1,0)

4. Assign Datum plane A to the top face, i.e. the XY plane where Z=1.

5. Assign Datum plane B to the side face, i.e., the XZ plane where Y=2.

6. Assign Datum C to the end face, i.e., the YZ plane where X=3.

7. Assign a position tolerance to the pattern of holes diameter of .01 referencing Datum C and B in that order of precedence. See below.
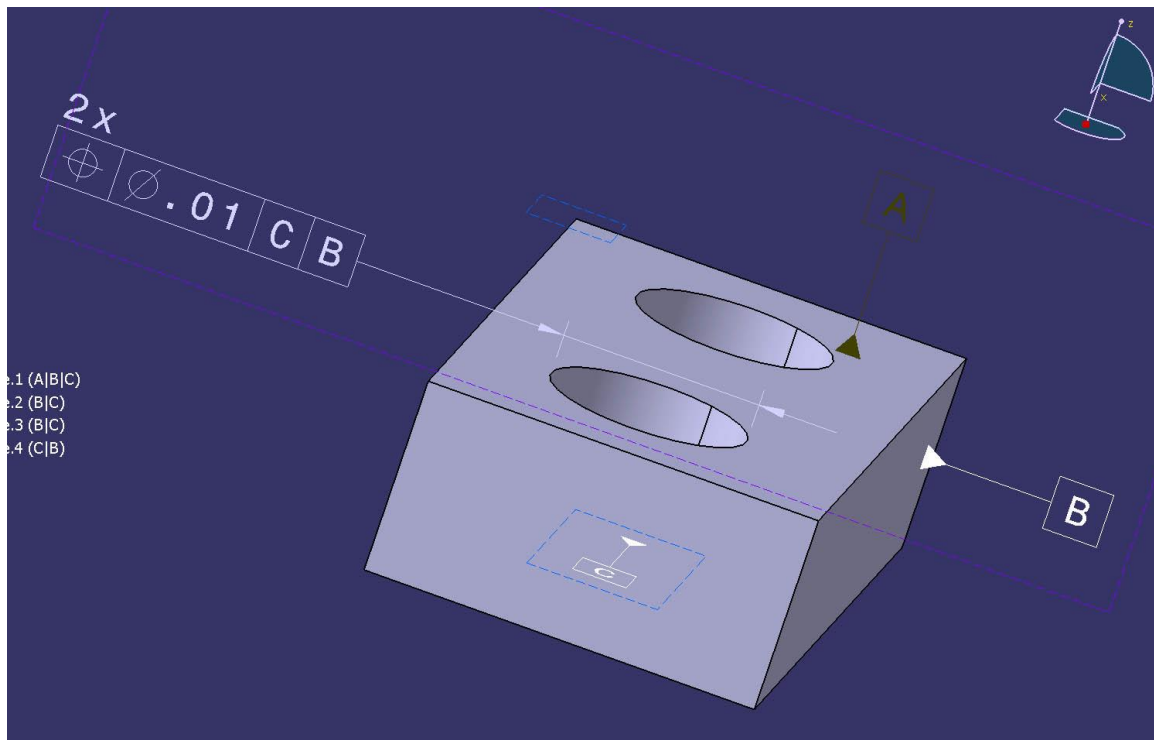

Figure 2: Shape of the GD2 model

8. Assign a perpendicularity tolerance of .01 on the top face (the same face as Datum A) referencing Datum B and Datum C in that order of precedence.

This should create a part with a solid model, one dimensional tolerance, one position tolerance, one perpendicularity tolerance and three datums as shown below.
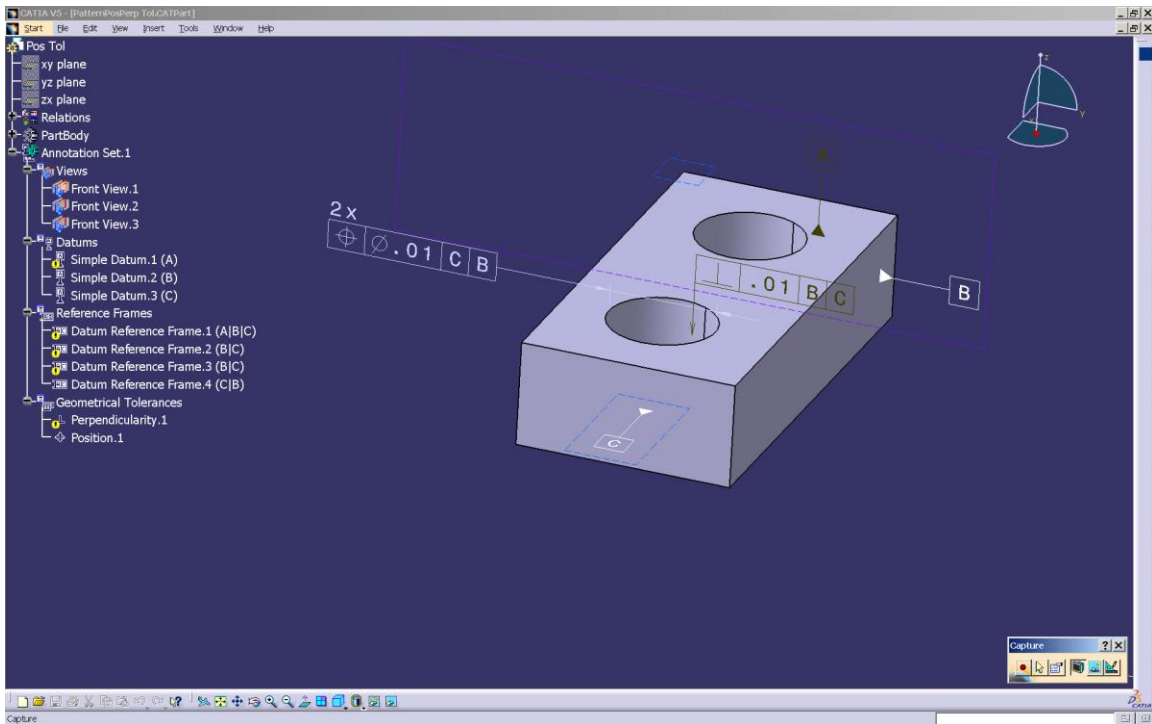
Figure 3: The GD2 model shown with the feature tree

2.2.3.1 Statistics

With each STEP file processed for the GD&T model, vendors must include a text file with the statistics in comma-delimited form (.CSV):

model	*gd2*
unit	*Units*
volume	*Total volume of all solids*
area	*Total surface area of all solids*
cx, cy, cz	*Centroid of all solids*
dim_found	*The number of dimensions processed.*
datum_found	*The number of datums processed.*
tol_processed	*The number of tolerances processed.*
date	*Date submitted*
issues	*Short description of issues*

2.3 Model DM1: Density and Material name

2.3.1 Motivation

Up to now, it has not been possible to transfer different materials via STEP. On export, a consistent density for all parts is assumed.

The scope of this test is to provide a first approach to transfer density values (as real values) and material names (as strings). Using the density information, the center of geometry of a model can be distinguished from the center of gravity. The material name can be used to receive further information about that material from a database.

2.3.2 Approach

It has been agreed that within the CAx-IF, the "simple approach" for exchanging Material and Density information will be used, i.e. the respective values will be mapped as general properties of the part. This is seen as a capability for basic information exchange between CAD systems. This approach is reflected in the current version of the Material and Density Recommended Practices.

For completeness, the Recommended Practices have been updated to also include the "detailed approach", where the material is represented as a product, and the density is attached to it either as general property or material property. This detailed approach is harmonized with the PDM schema, resp. AP209.

The new Recommended Practice document can be found on the CAx-IF web sites at http://www.cax-if.de/ and http://www.cax-if.org/ under "Joint Testing Information".

2.3.3 Testing Instructions

The test model is based on a sub-assembly of the well-known AS1 model, i.e. one of the "L-bracket assemblies":
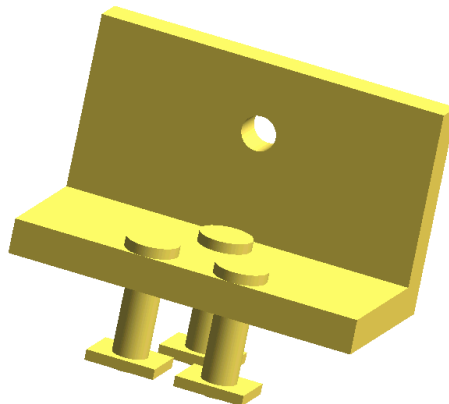
Figure 4: Shape of the DM1 model

This sub-assembly is composed of three individual parts, each of which should be assigned a different density and material name. Suggested values are:

Part	Density	Material name
L-bracket	.160 lb/cu in	AMS 4928; Titanium 6-4
Bolt	.285 lb/cu in	AMS 5613; Greek Ascoloy
Nut	.297 lb/cu in	AMS 5662; Inconel 718

Due to the different densities, the center of gravity will differ from the center of geometry. These coordinates, besides the transferred values for density and material, will be the focus of this test.

2.3.3.1 Statistics

With each STEP file submitted for the dm1 model, vendors must include a text file with the statistics in comma-delimited form (.CSV):

model	*dm1*
system_n	*Native system code*
system_t	*Target system code (for native statistics use 'stp' for system_t)*
unit	*Units*
volume	*Total volume of all solids*
area	*Total surface area*
geoX, geoY, geoZ	*Geometric centroid of all solids*
gravX, gravY, gravZ	*Center of gravity for all solids*
densityLB, densityNut, densityBolt	*Density values for the three parts*
materialLB, materialNut, materialBolt	*Material names for the three parts*
date	*Date submitted*
issues	*Short description of issues*

2.4 Model K1 : Surface Model with Validation Properties

2.4.1 Motivation

Previous findings indicated that the exchange of surface models may need some enhancement. To take into account the latest issue resolution processes in the CAx-IF, and to give new participants a chance to measure their improvements, this model is tested again.

2.4.2 Approach

The STEP files should be exported in **AP203e2** format, including Geometric Validation Properties for Surface Models as described in the draft updated Recommended Practices for GVP, which are available in the "Member Area" of the CAx-IF internet homepages.

The reason for this test is that inconsistencies have been found in the definition of where to attach the GVP information to surface models, since there are several ways to do it. For details please the draft Recommended Practices mentioned above.

2.4.3 Testing Instructions

2.4.3.1 Model construction
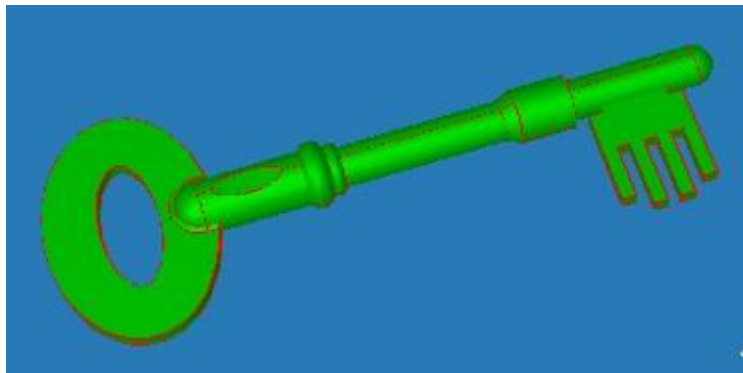
Figure 5 : Shape of the K1 model.

The detailed modeling instructions are available as PDF document from the member areas of the CAx-IF web sites, http://www.cax.if.de/secure/ and http://www.cax-if.org/secure/ , under 'Information on Round4J of Testing'. It has been agreed that only topologically bounded surface models shall be exchanged

There are several degrees of freedom when implementing this test case:

▪ The first point is how two construct the model according to Theorem's test suite. There are two approaches (sweeping/revolving vs. union/intersection). Vendors may choose the approach which fits best with their system capabilities, the model should be constructed only once.

▪ The next point is how to downgrade the model. It has been agreed that any number of shells is allowed. The information how many shells are used will be collected with the native stats, but will not be an exchange success criteria.

2.4.3.2 Statistics

With each STEP file submitted for K1, vendors must include a text file with the stats in comma-delimited form (.csv):

model	*k1*
system_n	*Native system code*
system_t	*Target system code (for native stats use 'stp' for system_t)*
unit	*Units*
shells	*Number of shells in the model (not a success criteria).*
area	*Total surface area (wetted)*
validation_area	*Total surface area as received via the GVP capability*
valid_area	*pass/fail – if the instantiation of the 'area' property is conforming the GVP Recommended Practices*
cx, cy, cz	*Center of area*
validation_cx, validation_cy, validation_cz	*Center of area as received via the GVP capability*
valid_cent	*pass/fail – if the instantiation of the 'center of area' property is conforming the GVP Recommended Practices*
date	*Date submitted*
issues	*Short description of issues*

2.5 Joint Test case with AP209 (EA) Group

2.5.1 Motivation

Since the number of APs used in every day data exchange is constantly increasing, the subject of AP interoperability is of growing interest. The focus of this test is on extracting the geometry (design shape) from a 209 file and converting it to an AP203 or AP214 detail/part or assembly.

2.6 Import of old STEP and Native Files

2.6.1 Motivation

In the light of the Long-Term Archiving (LOTAR / LTDR) efforts, the goal is to get an idea of how old CAD models behave when they are being imported into the current versions of the respective systems. The CAx-IF with its extensive file archives, which, including preceding activities, reach back as far as ten years, offers the chance to import both the native model and the STEP file originally created from it.

2.6.2 Testing Instructions

All participating vendors are asked to import the old STEP files provided in the file vault in the member area of the CAx-IF homepage, and report their findings. The basic set of target statistics (see Production Models, section 3.3.2, below) is welcome.

All vendors maintaining STEP processors for the originating system of the old native model are asked to try and import the old part into their system and report their findings.

3.0 <u>Production models: PM14</u>

3.1 Motivation

In an attempt to test the STEP processors on real world models, the CAx Implementor Forum will be testing production parts in this round and future rounds of CAx-IF testing. These production models are characteristic for components and assemblies that are encountered in the aerospace and automotive industries. PDES, Inc. and ProSTEP member companies and vendors have supplied these models.

3.2 Approach

Testing of Production Models focuses mainly on data quality, not on specific functionalities. Assemblies should therefore be exported as a single STEP file. Vendors are encouraged to include (extended) validation properties as far as supported. The file format should be either AP214-IS or AP203e2.

All source system native models and STEP files will be analyzed for data quality by the "CADIQ" developers. STEP syntax and structure will be checked by the CAx-IF facilitators. In order to enable an end-to-end analysis of the data exchange, all vendors importing Production Model STEP files are asked to submit the resulting native model from their system along with or instead of the target statistics.

3.3 Testing Instructions

3.3.1 List of available models

Model name	Exporting System	AP	Filename	Remarks
Brake Test Stand	CATIA V5 (Dassault)	AP203-E2	pm14-ab-ct-203.stp	
Car Body	Alias	AP203-E2	pm14-al-203.stp	Surface Model
		AP214-IS	pm14-al-214.stp	Surface Model
Casing	Pro/Engineer			
Dashboard	CATIA V5 (Dassault)	AP214-IS	pm14-vw-ct-214.stp	Surface Model
Vane Cluster	Unigraphics			

3.3.2 Results

For each STEP file imported for the Production Models, vendors need to submit at least one of the following:

- The native model from their system created by importing the STEP file. This is required for an end-to-end analysis of the data exchange with the "CADIQ" tool. The file name should clearly point out the source system which created the STEP file.

  If the resulting native model is submitted, no .CSV file is needed, since these results can be generated by CADIQ.

- A text file with the statistics in comma-delimited form (.CSV):

model	*pm14*
unit	*Units*
volume	*Total volume of all solids*
area	*Total surface area of all solids*
cx, cy, cz	*Centroid of all solids*
date	*Date submitted*
issues	*Short description of issues*