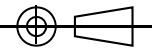


NAS9300-110

Long Term Archiving and Retrieval
of digital technical product documentation
such as 3D, CAD and PDM data

PART 110: Long Term Archiving and Retrieval
of CAD mechanical 3D Explicit geometry information

FORM 09-01

THIRD ANGLE PROJECTION 	CUSTODIAN ENGINEERING MANAGEMENT COMMITTEE	REVISION 1
PROCUREMENT SPECIFICATION NONE	TITLE LONG TERM ARCHIVING AND RETRIEVAL OF DIGITAL TECHNICAL PRODUCT DOCUMENTATION SUCH AS 3D, CAD AND PDM DATA PART 110: Long Term Archiving and Retrieval of CAD mechanical 3D Explicit geometry information	CLASSIFICATION STANDARD PRACTICE NAS9300-110 SHEET 1 OF 36

FOREWARD

1. This standard was prepared jointly by AIA, ASD-STAN, PDES, Inc. and the PROSTEP iViP Association.
2. The PROSTEP iViP Association is an international non-profit association in Europe. For establishing leadership in IT-based engineering it offers a moderated platform to its nearly 200 members from leading industries, system vendors and research institutions. Its product and process data standardization activities at European and worldwide levels are well known and accepted. The PROSTEP iViP Association sees this standard and the related parts as a milestone of product data technology.
3. PDES, Inc. is an international non-profit association in USA. The mission of PDES, Inc. is to accelerate the development and implementation of ISO 10303, enabling enterprise integration and PLM interoperability for member companies. PDES, Inc. gathers members from leading manufacturers, national government agencies, PLM vendors and research organizations. PDES, Inc. supports this standard as an industry resource to sustain the interoperability of digital product information, ensuring and maintaining authentic longevity throughout their product lifecycle.
4. Readers of this standard should note that all standards undergo periodic revisions and that any reference made herein to any other standard implies its latest edition, unless otherwise stated
5. The Standards will be published under two different standards organizations using different prefixes. ASD-STAN will publish the standard under the number EN 9300-110. AIA will publish the standard under the number NAS9300-110. The content in the EN9300 and NAS9300 documents will be the same. The differences will be noted in the reference documentation (i.e. for EN9300 Geometric Dimensioning & Tolerancing will be referenced in ISO 1101 and ISO 16792, and for NAS9300 the same information will be referenced in ASME Y14.5M and Y 14.41). The document formatting will follow that of the respective editorial rules of ASD-STAN and AIA.

REVISION

1

NAS9300-110
SHEET 2



Documents

Document Sharing Hub

TABLE OF CONTENTS

1	Scope.....	5
1.1	Introduction	5
1.2	In scope.....	5
1.3	Out of scope.....	5
2	Normative references	5
3	Terms, definitions and abbreviations	6
4	Applicability	6
5	Business Specifications for the long term archiving and retrieval of CAD mechanical 3D explicit geometry information	6
5.1	Introduction	6
5.2	Description of use cases for retrieval of CAD mechanical 3D explicit geometry.....	7
5.3	Description of file content	9
6	Essential Information of explicit geometry	9
7	Definition of Core Model for an explicit geometry	9
8	Verification rules of explicit geometry	9
8.1	Introduction	9
8.2	Level of Verification	10
8.3	Geometrical verification rules and appropriate thresholds	10
8.4	Results of the Verification.....	13
8.5	Status information	13
8.6	Verification reports left off review	13
9	Validation rules of an explicit geometry	14
9.1	Introduction	14
9.2	Level of Validation	14
9.3	Comparison of the Geometrical Validation Properties (GVP).....	15
9.4	Results of the Validation.....	15

FIGURES

FIGURE 1	– Illustration of the major generations of CAD systems	7
FIGURE 2	– Links between Use Cases, essential information and NAS9300 1xx parts.	8
FIGURE 3	– No_Edge_Gap.....	12
FIGURE 4	– Unacceptable_Edge_Gap	12
FIGURE B1	– Illustration of a manifold_solid_brep	22
FIGURE C1	– Illustration of a tessellated representation	25
FIGURE C2	– Illustration of the tessellated concept.....	25
FIGURE C3	– Illustration of fan and strip	26
FIGURE C4	– Illustration of watertight tessellation	26
FIGURE C5	– Watertight tessellation ensured by a common list of coordinate points	27
FIGURE D1	– Method used to define verification rules level 1 and 2	28
FIGURE F1	– Illustration of the Centre of gravity of solids	32
FIGURE F2	– Illustration of the Volume and Area	32

REVISION

1

NAS9300-110

SHEET 3



Document Sharing Hub

USE OF OR RELIANCE UPON THIS DOCUMENT OR ANY NATIONAL AEROSPACE STANDARD IS ENTIRELY VOLUNTARY. AIA DOES NOT QUALIFY SUPPLIERS OR CERTIFY

CONFORMANCE OF ITEMS PRODUCED UNDER NATIONAL AEROSPACE STANDARDS. AIA MAKES NO REPRESENTATION OR CLAIM RESPECTING (1) THE SUITABILITY OF

ITEMS FOR ANY PARTICULAR APPLICATION OR (2) THE EXISTENCE OF OR APPLICABILITY HERETO OF PATENT OR TRADEMARKS RIGHTS.

No reproduction or networking permitted without license from IHS

Full document details: AIA NAS9300-110 2017

FIGURE F3 – Illustration of the surface area for a tessellated solid	34
FIGURE F4 – Illustration of the centroid for a tessellated solid	34
FIGURE F5 – Illustration of the number of facets for a tessellated solid	34
FIGURE F6 – Illustration of the Centre of Gravity, and Area for an exact independent surface	35
FIGURE F7 – Illustration of the Centre of Gravity and Area for a tessellated independent surface	35
FIGURE F8 – Illustration of the number of facets for a tessellated independent surface	35
FIGURE F9 – Illustration of the length and of the centroid for an independent curve	36
FIGURE F10 – Illustration of the length and of the centroid for an independent tessellated curve	36

TABLES

TABLE 1 – Validation properties level 1	14
TABLE D1 – Verification rules level 1	30
TABLE D2 – Verification rules level 2	30

ANNEXES

ANNEX A – Description of Use cases for Long Term Archiving and Retrieval of CAD 3D explicit geometry	17
ANNEX B – Definition of explicit 3D shape as advanced boundary representation according ISO 10303-514 (informative)	22
ANNEX C – Definition of tessellated 3D shape according ISO 10303-42 (Informative)	25
ANNEX D – Recommended verification rules level 1 and 2 (informative)	28
ANNEX E – Illustration of qualification reports (informative)	31

REVISION

1

NAS9300-110
SHEET 4



Documents
Document Sharing Hub

1 Scope

1.1 Introduction

This document defines the requirements on a digital archive to preserve for the long term the 3D explicit geometry of single CAD parts. The goal is to preserve the 3D information without loss with respect to the geometry produced by the original CAD system, following the principles laid down in NAS9300-003 'Fundamentals and Concepts', including the use of an open data format.

1.2 In scope

The following is in scope of this part of NAS9300:

- Business specification for long term archiving and retrieval of CAD 3D explicit geometry (ref. section 5);
- Essential information of CAD 3D explicit geometry (solids, curves, surfaces, and points) to be preserved (ref. section 6);
- Data structures detailing the main fundamentals and concepts of CAD 3D explicit geometry (ref. section 7);
- Verification rules to check CAD 3D explicit geometry for consistency and data quality (ref. section 8);
- Validation rules to be stored with the CAD 3D explicit geometry in the archive to check essential characteristics after retrieval (ref. section 9).

Note: This part includes the geometrical external shape resulting from CAD 3D entities (e.g., 3D Structural components, 3D Tubing, 3D electrical harness, 3D composite, etc.).

1.3 Out of scope

The following is outside the scope of this part of NAS9300:

- The formal definition of validation and verification rules to check 3D explicit geometry for consistency and data quality using a machine-readable syntax;
- Implicit or parametric geometry;
- Geometric Dimensioning & Tolerancing (GD&T), Product & Manufacturing Information (PMI);
- Assembly structures.
- Presentation of explicit geometry

2 Normative references

This Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NAS9300 (All parts), Aerospace series — LOTAR — LOnG Term Archiving and Retrieval of digital technical product documentation such as 3D, CAD and PDM data

ISO 10303-42:2003, Industrial automation systems and integration — Product data representation and exchange — Part 42: Integrated generic resource: Geometric and topological representation

ISO 10303-203:2011, Industrial automation systems and integration — Product data representation and exchange — Part 203: Application protocol: Configuration controlled 3D design of mechanical parts and assemblies

ISO 10303-214:2010, Industrial automation systems and integration — Product data representation and exchange — Part 214 — Application protocol: Core data for automotive mechanical design processes

ISO 10303-242:2014, Industrial automation systems and integration -- Product data representation and exchange ----- Part 242: Application protocol: Managed model-based 3D engineering

REVISION

1

NAS9300-110
SHEET 5



Document Sharing Hub

ISO 2768-1:1989, General Tolerances - Part 1: Tolerances for Linear and Angular Dimensions without Individual Tolerance Indications - First Edition

ISO 2768-2:1989, General Tolerances - Part 2: Geometrical Tolerances for Features without Individual Tolerance Indications -First Edition

ISO 16792:2006, Technical product documentation — Digital product definition data practices

ISO PAS 26183:2006, SASIG Product data quality guidelines for the global automotive industry

ASME Y14.5:2009, Dimensioning and Tolerancing

ASME Y14-41:2012, Digital Product Definition Data Practices

3 Terms, definitions and abbreviations

For the purposes of this standard, the terms, definitions and abbreviations given in NAS9300-007 and NAS9300-100 apply.

4 Applicability

Refer to applicability of NAS9300-001, paragraph 4.

5 Business Specifications for the long term archiving and retrieval of CAD mechanical 3D explicit geometry information

5.1 Introduction

General specifications for long term archiving of CAD mechanical design information are described in NAS9300-100, in the section "Fundamentals and concepts for Long Term Archiving of CAD 3D mechanical information"

According to the section "5.1 Different generations of CAD systems and associated methods of design", there are several methods of design:

- The first generation of CAD design method allowed the engineer to digitally create a 2D drawing (without a 3D model). The essential information as well as the Regulatory authority of the design intent is represented by the 2D drawing.
- The second generation of CAD design method is based primarily on the use of 3D models with the output being both 2D representation (drawings) and a 3D CAD dataset to drive CAM/CAI. The Regulatory authority of the design intent is represented by the 2D drawing.
- The third generation of CAD design method is based on the use of parametric and relational design. The essential information as well as the Regulatory authority of the design intent is represented by the 3D model.

NAS9300-110 part specifies long term archiving for CAD mechanical 3D explicit geometry generated in CAD systems of the second and third generation.

REVISION

1

NAS9300-110
SHEET 6



Documents
Document Sharing Hub

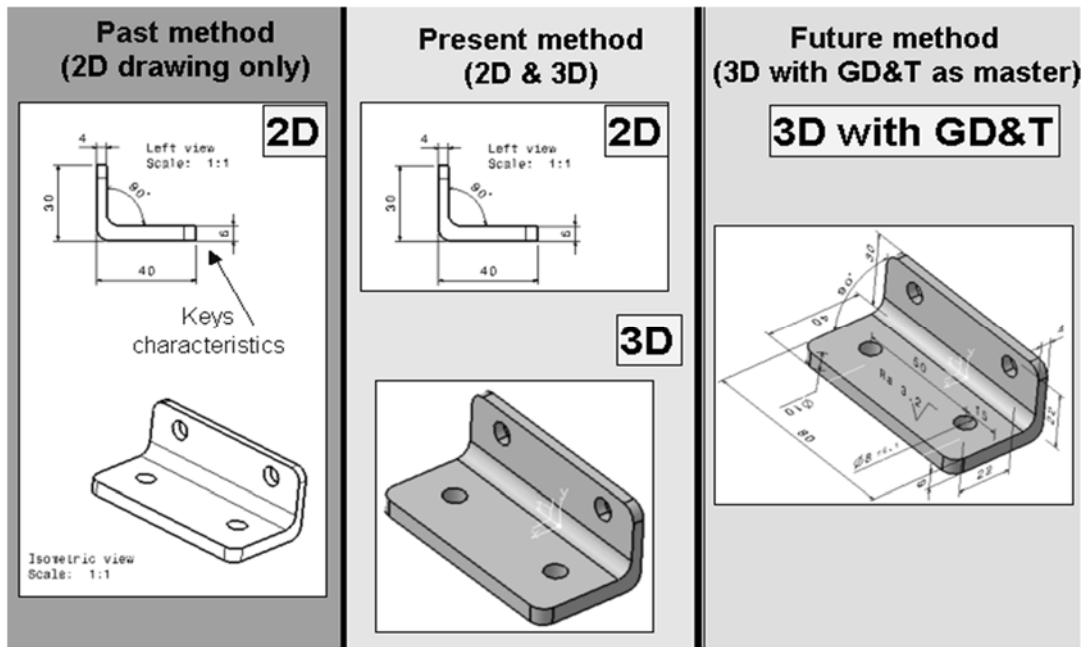


FIGURE 1 – Illustration of the major generations of CAD systems

5.2 Description of use cases for retrieval of CAD mechanical 3D explicit geometry

Use cases for long term archiving and retrieval of CAD mechanical 3D explicit geometry are used to verify that the specifications meet the business requirements, to identify any gaps that occur over time, and to fix them. This is illustrated in Figure 2, extracted from NAS9300-100 Figure 2: "Links between Use Cases, essential information and NAS9300 1xx parts".

REVISION

1

NAS9300-110
SHEET 7



Document Sharing Hub

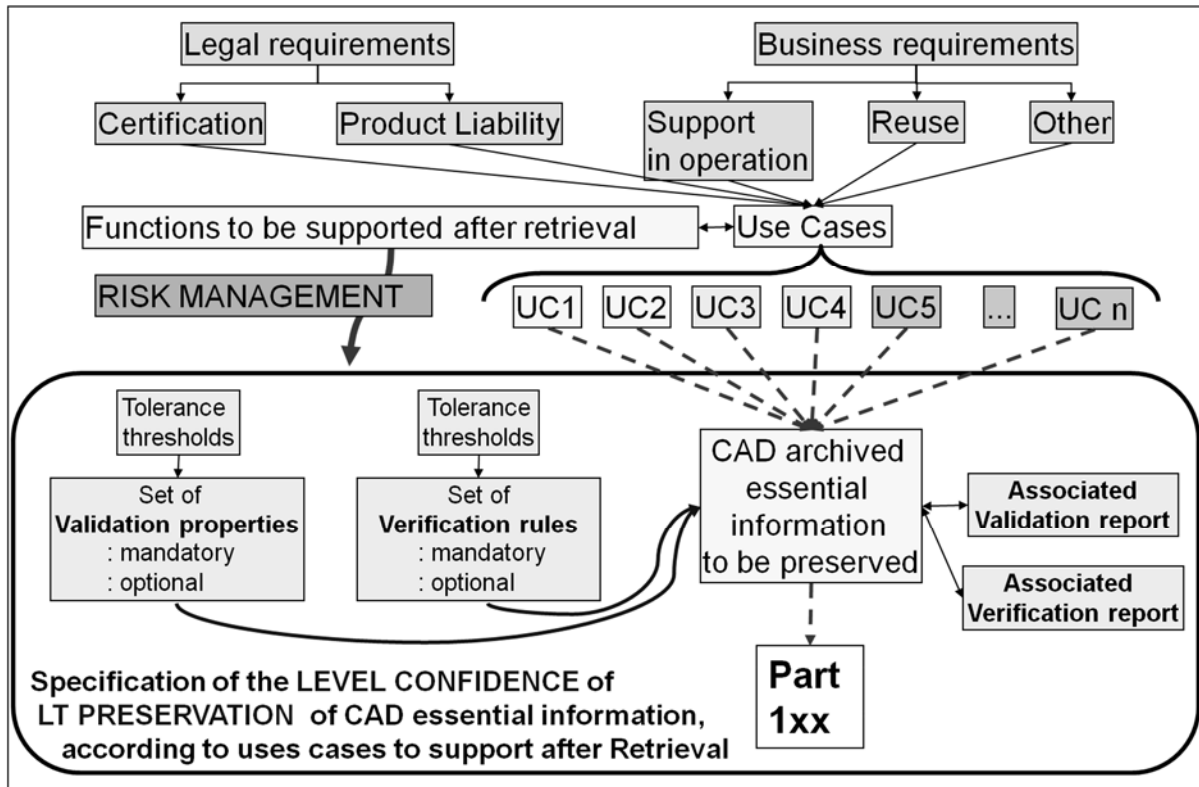


FIGURE 2 – Links between Use Cases, essential information and NAS9300 1xx parts.

This section sums up general requirements common to the Aerospace industries, for the preservation of the 3D external shape of the product. These requirements should be reviewed and adapted by each company, according to its products and its business practices.

After retrieval from the long term archiving system, the CAD 3D information may be not exactly the same as the original. This may result, for example, from the changes in mathematical representation of the CAD modeler ("change of generation of CAD systems"), or from the evolution of their internal data models through successive versions. The objective is to demonstrate that the process still preserves the essential information for the 3D shape of the product, as defined by the original CAD system the moment that the CAD information was released.

The type of CAD representation to be preserved differ according to the use cases (ref. NAS9300-100 Figure 4: Links between Use Cases, essential information and NAS9300 1xx parts). In the same way, the tolerance thresholds for the verification rules and geometric validation properties are related to the different use cases and to the specific requirements of each company. Such thresholds will not be normatively defined in this standard, but values will be proposed in associated recommended practices. Such tolerances depend on the precision of the CAD modeler; it is assumed that the precisions of the modelers will increase overtime. They are also related to the categories of parts and to their functions.

As mentioned in the NAS9300-002, there are 4 main use cases for long-term archiving and retrieval of CAD 3D exact geometry, and its complementary 2D drawings:

- Documentation of Aerospace & Defense Product Design for Regulatory and Contractual Compliance
- Aerospace & Defense Industry Incident Investigation (Product Liability)
- Design Re-use – Product modification,
- Product Lifecycle Support and Disposal.

These use cases are detailed in the context of long term preservation of CAD mechanical 3D explicit geometry information. For more information reference Annex A.

5.3 Description of file content

- Scenario 1: Part file with exact geometry only
- Scenario 2: Part file with tessellated geometry only
- Scenario 3: Part file with exact and tessellated geometry
- Scenario 4: Part file containing an Assembly mixing exact and tessellated geometry (ref. NAS9300-115 & NAS9300-125).

6 Essential Information of explicit geometry

Essential information of CAD mechanical 3D explicit geometry, captured in archive files, are defined as:

- The exact boundary representation shape of a single part within free tolerances of manufacturing (ref. ISO 2768 general tolerances).
- The tessellated boundary representation shape
- The exact representation of curves
- The tessellated representation of curves
- The exact representation of surfaces
- The tessellated representation of surfaces
- The representation of points

The EN9300-003 standard shall be applied to any additional information not covered by this standard.

7 Definition of Core Model for an explicit geometry

To preserve the essential information of explicit 3D geometry the shape should be represented at nominal size precisely and completely within the defined tolerances independent of tool specific generation functions for geometry. Therefore a boundary representation as an accumulative topological and geometric volume model has been chosen as core model for this part of NAS9300.

This core model is defined by ISO 10303-514 (Advanced boundary representation) and ISO 10303-42 (geometric and topological representation). This representation is used by ISO10303-203 (Configuration Controlled 3D Design of Mechanical Parts and Assemblies) CC08, ISO10303-214 (Core Data for Automotive Mechanical Design Processes) CC02 and ISO 10303-242 (Managed Model Based 3D Engineering). Therefore STEP physical files meeting ISO10303-203 CC08 or ISO 10303-214 CC02 or ISO 10303-242 may be used for the ingest of explicit geometry. The Descriptive Information of the AIP shall document the versions of both NAS9300-110 and ISO 10303 application protocol that are basis for the AIP

Other geometric information or information related to geometry such as design history, layer information, auxiliary geometry or technical attributes like roughness or tolerances as modelled in typical CAD systems may be maintained together with the 3D explicit geometry within the same STEP file, assuming that this information can be represented by the chosen application protocol of ISO 10303. In this case additional validation properties and verification rules defined in the respective parts of NAS9300 should be applied to ensure the preservation of this additional information.

8 Verification rules of explicit geometry

8.1 Introduction

As described in NAS9300-005 ("Authentication and Verification"), verification is one of the two basic qualification methods to reduce the risk of losing essential information during the Long Term Archiving process.

The verification of the source and the target CAD models are not required in this standard, but the quality of the exported file in the archival format is strongly dependent of the quality of the source CAD model and lack of verification creates a risk that the retrieval process will fail.

REVISION

1

NAS9300-110
SHEET 9



Documents
Document Sharing Hub

The verification for 3D explicit geometry described in this section concerns only the archival file during the ingest process (EN9300-012).

To improve the longevity of the archive, companies may decide to add new verification rules and to check a selection of the archived files. In this case the company may decide to archive the new verification report, and according to the result, carry out the appropriate action to ensure the long term preservation of the archived CAD 3D explicit geometry information.

If a verification of the native target CAD model is implemented in the retrieval process (EN9300-014), the CAD model shall pass the validation process before the model will be fully acceptable. Verification process is required to minimize the risk of data loss or unacceptable change between archival and retrieval. This process shall be applied to the STEP file during archival ingestion, to the STEP file after any archival preservation conversion. It is strongly recommended that this processes is also applied to the target CAD model after STEP import.

8.2 Level of Verification

Conversion of CAD models between different formats may lead to the loss of geometrical and topological elements.

To minimize this risk, companies shall choose one of the following three levels of verification:

- Verification level 0: no verification, which entails accepting the maximum risk of failure at retrieval;
- Verification level 1: a controlled risk with using the list of verification rules defined below;
- Verification level 2: a minimum risk with the use of verification level 1 rules, plus additional verification rules defined by the company.

For verification of exact solid and surface, the rules for the verification level 1 are a subset of the rules defined in the SASIG PDQ and ISO 10303-59, which provides a definition for each rule, an illustration of the defects detected by the rule, and, where possible, a method to fix the defects.

For verification of tessellated solid and surface, the verification rule level 1 can consist of a check such as a watertight tessellation.

For verification level 2, companies may check using their own verification rules. (Ref. ANNEX D -Recommended verification rules level 1 and 2 (informative)).

Example 1, multiple identical elements (points, curves, surfaces). This can be problematic for some business cases, and the distance between two identical elements need to be within a given tolerance that may change from one system to another system (e.g., change of generation of CAD modelers).

Example 2, specific rules for the verification of the structure of the CAD model (i.e. color and layers) may be added.

Some rules are parameterized by acceptance thresholds. For the long term retention of 3D explicit geometry, the verification level 1 shall be apply with appropriate thresholds in the ingest process. For the retrieval process, this is not required.

8.3 Geometrical verification rules and appropriate thresholds

8.3.1 Verification rules

Verification is applied to the B-REP-STEP-file according to of ISO10303-514 and ISO 10303-42.

The verification rules level 1 shall be applied by each company These are required to ensure a high rate of success for the import process of the archival file, and for retrieval of the shape of the parts without significant change,

The method used to define the verification rules (both level 1 and 2), and the initial set of the recommended verification rules for level 1 can be found in Annex C.

The set of verification rules may change over the time following successive upgrades of the CAD systems. To add new verification rules, the method in Annex C should be used.

REVISION

1

NAS9300-110
SHEET 10



Documents
Document Sharing Hub

Two ways to verify the quality of the STEP files have been identified:

- using a STEP checker which includes its own geometry kernel;
- using a CAD checker after import of the STEP file into a CAD system.

If a checker does not implement the verification rules level 1, a mapping with its own verification rules shall be documented and a qualification provided with appropriate test cases.

Following the change of CAD system and its STEP interfaces, the list of verification rules may be adapted using an adequate method as described in Annex C, otherwise the list of verification rules level 1 should be applied. A company may remove a verification rule from level 1 if it is demonstrated and documented that the users' methods or the operational CAD system does not allow the quality defects detected by the rule to occur in STEP files.

Before implementing the ingest processes, it is recommended that an analysis takes place of the CAD system interfaces export options and their consequences for the contents of STEP files. For example, an option to export the entities placed in a no show mode may have an impact on verification.

8.3.2 Evaluation of the values of thresholds

Verification may be done by checkers, which shall be compliant with the rules for verification levels 1 and 2.

Following the precision of the parts, the quality of the computation, and the precision of the source CAD systems, a threshold per types of CAD parts and per rule may be defined.

Note: As a result, the thresholds for each verification rule cannot be standardized. The thresholds in Annex C are informative.

If required for particular rules and categories of CAD parts, a second threshold may be defined to indicate a "warning" rather than a failure.

The example below illustrates that for the same rule, the "Edge Gap" thresholds are significant for import success:

- When there are only negligible gaps between connected edges in a STEP model, receiving CAD systems are able to import the geometry with negligible shape changes, including maintaining the BREP solid definition. (Ref. Figure 3 "No_Edge_Gap").
- When the gap between connected edges is too large in the STEP model, it is usually too difficult for the receiving CAD system to close it sufficiently to create a solid model. In this case, the model on the right was imported as an open shell. (Ref. Figure 4: "Unacceptable_Edge_Gap").

REVISION

1

NAS9300-110
SHEET 11



Documents
Document Sharing Hub