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Industrial automation systems and integration — Product data representation and exchange —

Part 34: Conformance testing methodology and framework: Abstract test methods for application protocol implementations

Systèmes d'automatisation industrielle et intégration — Représentation et échange de données de produits —

Partie 34: Méthodologie et cadre général pour l'évaluation de la conformité: Méthodes d'évaluation abstraites pour les mises en application du protocole d'application

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Figures

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 10303 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 10303-34 was prepared by Technical Committee ISO/TC 184, *Industrial automation systems and integration*, Subcommittee SC 4, *Industrial data*.

This International Standard is organized as a series of parts, each published separately. The parts of ISO 10303 fall into one of the following series: description methods, integrated resources, application interpreted constructs, application protocols, abstract test suites, implementation methods, and conformance testing. The series are described in ISO 10303-1.

A complete list of parts of ISO 10303 is available from the Internet:

<http://www.nist.gov/sc4/editing/step/titles/>

Annex A forms a normative part of this part of ISO 10303.

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Introduction

ISO 10303 is an International Standard for the computer-interpretable representation and exchange of product data. The objective is to provide a neutral mechanism capable of describing product data throughout the life cycle of a product, independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving.

This part of ISO 10303 is a member of the conformance testing series.

This part of ISO 10303 specifies the test methods used in the conformance testing of implementations which read and write 10303 exchange structures or share information with SDAI implementations based on a given ISO 10303 application protocol.

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Industrial automation systems and integration – Product data representation and exchange – Part 34: Conformance testing methodology and framework: Abstract test methods for application protocol implementations

1 Scope

This part of ISO 10303 specifies the abstract test methods for conformance testing of an implementation of an ISO 10303 Application Protocol (AP). The scope is limited to the following implementation methods:

— preprocessors that claim to generate 10303 schema instances represented as exchange structures as defined by ISO 10303-21;

— postprocessors that claim to accept and process 10303 schema instances represented as exchange structures as defined by ISO 10303-21;

— preprocessors that claim to generate 10303 schema instances and use the SDAI interface as defined in ISO 10303-22 to populate an SDAI implementation with these schema instances;

— postprocessors that claim to accept 10303 schema instances and use the SDAI interface as defined in ISO 10303-22 to extract schema instances from an SDAI implementation.

The following are within the scope of this part of ISO 10303:

— the conformance assessment process undertaken to evaluate the conformity of an implementation of an ISO 10303 application protocol. The abstract test methods are independently applicable to implementation methods based on ISO 10303-21 and ISO 10303-22;

— the methods to be followed by the testing laboratory using executable test cases (ETC). The methods presented are abstract, that is, they are independent of the implementation under test (IUT). The method descriptions cover the different steps from abstract test case (ATC) selection to test case report production.

The following is outside the scope of this part of ISO 10303:

— the generation of executable test cases from abstract test cases. This part of ISO 10303 does not include abstract test methods for conformance testing of application protocol independent implementations of the Standard Data Access Interface (SDAI) -- ISO 10303-22.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 10303. For dated references, subsequent amendments to, or revision of, any of these publications do not apply. However, parties to agreements based on this part of ISO 10303 are encouraged to investigate the possibility of applying the most recent editions of the normative documents

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indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 10303-1:1994, *Industrial automation systems and integration - Product data representation and exchange - Part 1: Overview and fundamental principles*.

ISO 10303-11:1994, *Industrial automation systems and integration - Product data representation and exchange - Part 11: The EXPRESS language reference manual*.

ISO 10303-21:1994, *Industrial automation systems and integration - Product data representation and exchange - Part 21: Implementation methods: Clear text encoding of the exchange structure*.

ISO 10303-22:1998, *Industrial automation systems and integration - Product data representation and exchange - Part 22: Implementation methods: Standard data access interface*.

ISO 10303-31:1994, *Industrial automation systems and integration - Product data representation and exchange - Part 31: Conformance testing methodology and framework: General concepts*.

ISO 10303-32:1998, *Industrial automation systems and integration - Product data representation and exchange - Part 32: Conformance testing methodology and framework: Requirements on testing laboratories and clients*.

3 Terms, definitions and abbreviations

3.1 Terms defined in ISO 10303-1

For the purposes of this part of ISO 10303, the following terms defined in ISO 10303-1 apply.

— abstract test suite (ATS);

— application interpreted model;

— application protocol (AP);

— application reference model;

— conformance class;

— exchange structure;

— implementation method;

— Protocol Implementation Conformance Statement (PICS);

— PICS proforma.

3.2 Terms defined in ISO 10303-11

For the purposes of this part of ISO 10303, the following terms defined in ISO 10303-11 apply.

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— entity;

— entity instance.

3.3 Terms defined in ISO 10303-22

For the purposes of this part of ISO 10303, the following terms defined in ISO 10303-22 apply.

— schema instance;

— SDAI model.

3.4 Terms defined in ISO 10303-31

For the purposes of this part of ISO 10303, the following terms defined in ISO 10303-31 apply.

— abstract test case (ATC);

— abstract test method;

— conformance;

— conformance log;

— conformance test report;

— conformance testing;

— executable test case;

— fail (verdict);

— implementation under test (IUT);

— inconclusive (verdict);

— pass (verdict);

— PIXIT (Protocol Implementation eXtra Information for Testing);

— PIXIT proforma;

— preprocessor;

— postprocessor;

— system under test (SUT);

— test campaign;

— test case error;

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— testing laboratory;

— test report;

— test verdict;

— verdict criteria.

3.5 Other terms and definitions

For the purposes of this part of ISO 10303, the following terms and definitions apply.

3.5.1
application element
an application object, attribute, or assertion defining the information requirements in clause 4 of an application protocol.

3.5.2
semantic analysis
the evaluation as to whether or not the information content of a schema instance was maintained during either preprocessing or postprocessing.

3.5.3
structure analysis
the evaluation as to whether or not an IUT schema instance conforms to the AIM and conformance requirements of the ISO 10303 application protocol of interest.

3.5.4
SUT operator
a human or an automated component of the system under test that enables communication of instructions and query data between the test engine and the implementation under test.

3.5.5
syntax analysis
the evaluation as to whether or not an IUT schema instance is properly encoded in an exchange representation conforming to an implementation method of ISO 10303.

3.5.6
test case report
a report covering the identifiers, data, results, and verdicts associated with the execution of a test case.

3.5.7
test case verdict
a summarized verdict assigned to a test case derived from the individual verdicts assigned to the verdict criteria of a test case.

3.5.8
test engine
the component of a test system that, by observing test case instructions, prepares, controls, observes, and analyses an IUT.

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3.5.9
test system
the hardware, software, and data used by a testing laboratory to execute a test method.

3.6 Abbreviations

For the purposes of this part of ISO 10303, the following abbreviations apply.

AE	Application Element
AP	Application Protocol
ATC	Abstract Test Case
ATS	Abstract Test Suite
ETC	Executable Test Case
IUT	Implementation Under Test
PICS	Protocol Implementation Conformance Statement
PIXIT	Protocol Implementation eXtra Information for Testing
SDAI	Standard Data Acess Interface
SUT	System Under Test

4 Overview and assumptions

Two abstract test methods are defined in this part of ISO 10303. The first provides for testing of implementations that generate exchange structures, i.e., preprocessors. The second provides for testing of implementations that interpret exchange structures, i.e., postprocessors. These methods are defined in clauses 5 and 6 respectively. Both abstract test methods apply also to applications that interface with SDAI implementations in a data sharing environment.

General principles and an overall framework for conformance testing are provided in ISO 10303-31. Requirements on test laboratories are defined in ISO 10303-32. The methods for preparing, controlling, observing, and analyzing implementations during testing are defined in this part of ISO 10303. Specific abstract test cases associated with ISO 10303 application protocols are defined in corresponding ISO 10303 abstract test suite standards. A description of abstract test suites concepts and the requirements on their use are defined in each 10303 abstract test suite.

4.1 Components of exchange structure test methods

Exchange structure test methods are based on three principal components: the implementation to be tested, a test system, and a human or automated component between them. These are the Implementation Under Test (IUT), the Test Engine, and the System Under Test Operator (SUT Operator), respectively.

— The Test Engine represents the control and communication functions of a test system, directing the execution and analysis of tests. The Test Engine communicates directly with

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the IUT using a standard means (ISO 10303-21 or ISO 10303-22) and indirectly with the IUT via the SUT Operator.

— The SUT Operator represents a communication interface between the Test Engine and the IUT. It transmits commands and requests from the Test Engine to the IUT. It also transmits the IUT's responses back to the Test Engine. The SUT Operator communicates directly with the IUT using IUT-defined means.

Test laboratories specify the Test Engine to SUT Operator interface and the expected operations of the SUT Operator, but the SUT Operator implementation and SUT Operator-to-IUT interface is left to IUT suppliers. The SUT Operator may be a human being who follows instructions and performs translations.

An IUT is tested either as a preprocessor or postprocessor. To output its schema instance, the IUT may use the exchange structure as specified in ISO 10303-21 or the SDAI interface as specified in ISO 10303-22. To accept its schema instance, the IUT may use the exchange structure as specified in ISO 10303-21 or the SDAI interface as specified in ISO 10303-22. A system under test may be capable of supporting both preprocessing and postprocessing functions, but testing of each capability shall be independent. In both cases, the required function of an IUT is to translate product data representations. The basic approach of both test methods is that an IUT is supplied an ISO 10303 application protocol schema instance in one format and is expected to translate the schema instance into another format while observing the rules of the application protocol structures and maintaining schema instance semantics.

For a preprocessor, the input format is not defined by ISO 10303. For testing purposes, the input specification of a schema instance shall be provided in a human-readable format, for example, text and graphics. The expected output format of a schema instance is an exchange structure conforming to ISO10303-21 or the output of a set of SDAI operations conforming to ISO 10303-22.

For a postprocessor, the input schema instance shall be formatted in an ISO 10303-21 exchange structure or a set of SDAI operations input conforming to ISO 10303-22. The output format is undefined by ISO 10303.

For testing purposes, the output is expected to be a series of correct responses to human-interpretable queries on the schema instance. Though the postprocessor may provide the schema instance in a text and graphic format similar to the input format of preprocessor tests, this is not required.

The inputs to a preprocessor and the outputs of a postprocessor are implementation dependent. As such, the test methods require the use of a SUT Operator to support the communication of schema instances.

4.2 Processes of exchange structure test methods

4.2.1 Preparation for testing

A number of ISO 10303 options, parameter values for ETCs, and IUT-dependent variables and configurations, are identified, selected, and utilized in conformance testing. The test laboratory identifies the parameters that will be used, and the IUT supplier provides acceptable ranges for values of those parameters. These values are recorded in a PICS and a PIXIT. PICS and PIXIT proformas are provided to IUT suppliers in preparation for testing. The PICS and PIXIT are used to guide the selection of IUT configurations, test inputs, execution sequences, and test output evaluation.

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Abstract test cases (ATCs) are standardized in ISO 10303. A number of parameters of the ATCs may not, or cannot be, resolved until a specific IUT is prepared for conformance testing. Executable test cases (ETCs), for use with a specific IUT, are derived from the ATCs using PICS and PIXIT information to resolve ATC parameters. Conformance test campaign execution may proceed when all ETCs corresponding to required ATCs and a specific IUT are available.

NOTE - For a further description of conformance testing preparations and procedures, see ISO 10303-32.

4.2.2 Test campaign

A test campaign is a sequenced execution of all required ETCs with the objective of determining a verdict for each test purpose and ETC.

The execution of an ETC consists of three basic steps: first input a schema instance into the IUT, second translate it into a different format, and third analyze whether the resulting form is a valid representation of the input. These steps are different for preprocessors and postprocessors. They are described in clauses 5 and 6 respectively.

Modifications to the IUT during the test campaign are not permitted. Modifications to the ETC during the test campaign are not permitted, except in the situation where the ETC is determined to be in error. ETC errors shall be recorded in the test report and reported to ISO TC 184/SC4 for correction.

4.2.3 Analysis of results

A test campaign or ETC may terminate for any reason. An ETC shall be assigned a pass verdict if all verdict criteria in the ETC are assigned a pass verdict.

If an ETC is determined to be in error, a verdict of inconclusive shall be assigned to the test case, and the reason recorded, until the error is resolved and the test repeated. ISO problem resolution parties shall be consulted whenever an error in an executable test case is potentially the result of a defect in ISO 10303.

4.2.4 Report production

A conformance log shall be produced for each executed test campaign. The conformance log or logs shall be used to produce the conformance test report.

5 Exchange structure test method - preprocessor

A sequence of testing preparation, execution, analysis, and reporting activities shall form the general procedure as described in clause 4. Test execution and analysis activities for an IUT claiming conformance as a preprocessor of ISO 10303-21 exchange structures or preprocessor of ISO 10303-22 SDAI operations output are further detailed in the remainder of this clause. Figure 1 depicts the functional components and interfaces that support the test method.

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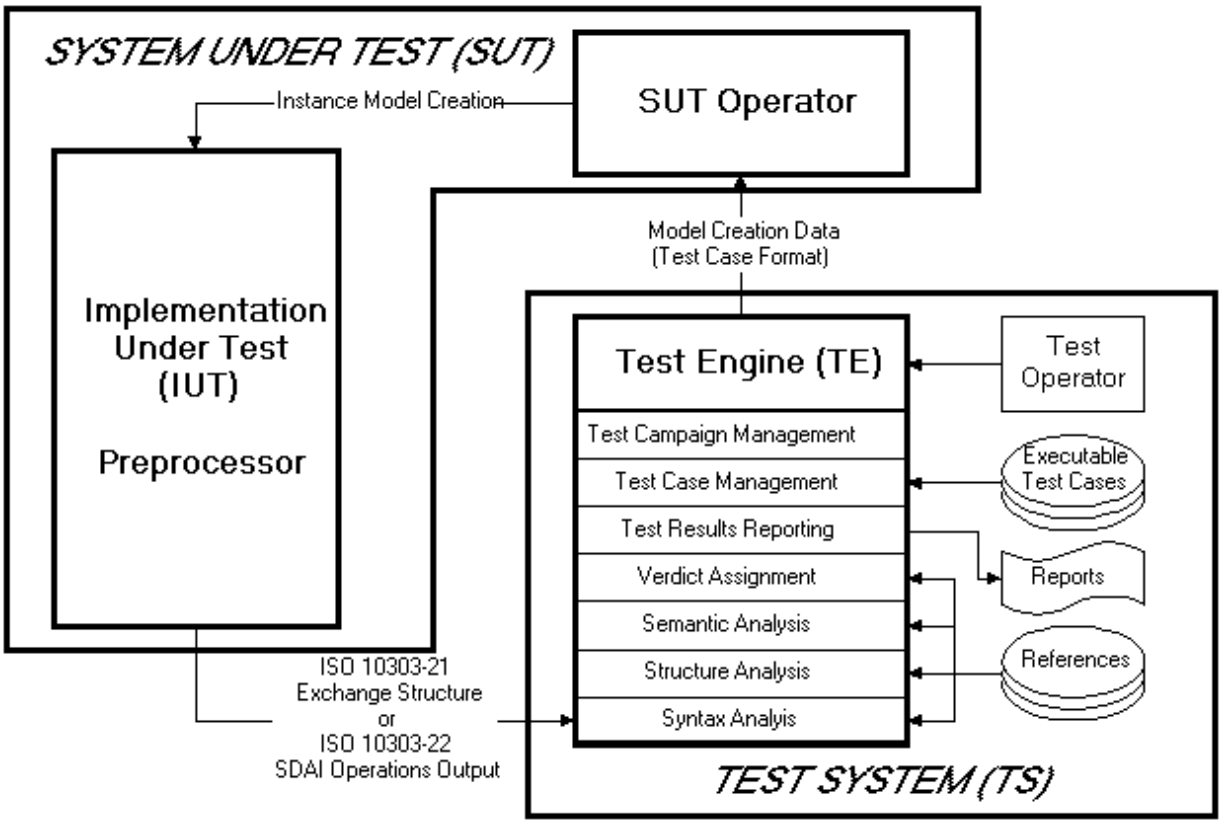

Figure 1 – Preprocessor testing components

5.1 Model creation

For preprocessor input, the test system provides a text, or both text and graphic, description, either paper or electronic, of the schema instance from an ETC. Optionally, a sequence of steps may be specified to determine how the model should be created in the IUT. These instructions are delivered to the SUT Operator for entry into the IUT.

The ETC describes specific actions and permissible interpretations. The IUT data entry process shall be monitored for accuracy throughout the test campaign or its integrity shall be established through another means and recorded in the conformance test report. Any deviation from expected entries shall be noted in the conformance log and analyzed by the SUT Operator for impact. If entered data differs from executable test case requirements, the data shall either be re-entered to remove deviations and the test re-run, or the test case result shall be reported as inconclusive.

NOTE - One means of establishing IUT data entry integrity may be through the variation of a small sample of model values for each run of a campaign.

5.2 Exchange structure generation

After the ETC specified schema instance is input, created in the IUT, the IUT shall generate an ISO 10303-21 exchange structure or ISO 10303-22 SDAI operations output corresponding to the input model.

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Preprocessor parameters identified in the ATC and resolved during testing preparations shall be applied to the IUT.

5.3 Analysis

Preprocessor output, the IUT generated exchange structure, is analyzed and examined for elements that are expected and searched for elements that are disallowed. Verdicts (see 5.4) are assigned as appropriate during analysis. A single fail verdict during any analysis step may terminate further analysis and shall result in an overall fail verdict being assigned to the test case.

5.3.1 Syntax analysis

The observed exchange structure shall be analyzed for conformance to the syntax defined by ISO 10303-21 or a language binding of ISO 10303-22 as appropriate. If a fail or inconclusive verdict results, relevant portions of the analysis shall be included in the test report.

5.3.2 Structure analysis

The schema instance contained in the observed exchange structure shall be analyzed for conformance to the AIM (clause 5 of the AP) and the conformance requirements (clause 6 of the AP).

EXAMPLE 1- Requirements may include informal propositions, quantitative limits, and error responses.

The structure analysis objective is to decide whether the instance elements and their structuring, represented in the schema instance, are those permitted as defined in the Application Interpreted Model and conformance classes of the AP. Valid element value domains and element structures are specified in the AP through the type and relationship mechanisms defined in ISO 10303-11.

EXAMPLE 2 - Type and relationship mechanisms may be elements, attributes, supertypes, subtypes, rules, functions, and procedures.

Valid elements in invalid relationships are considered to be errors.

EXAMPLE 3 - Valid elements in invalid relationships include correctly constructed entities which violate an AIM rule, an informal proposition, or a conformance class constraint.

Constraints that shall be checked are identified in the ATS, by test purposes and include:

— local constraints;

— global constraints;

— uniqueness constraints;

— existence constraints (INVERSE);

— cardinality constraints resulting from aggregate definitions;

— informal propositions.

Violation of the AIM or AP conformance requirements shall result in assignment of a test verdict of fail.

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5.3.3 Semantic analysis

The schema instance contained in the observed exchange structure shall be analyzed for accuracy with respect to the ETC-defined input schema instance. The objective is to decide whether semantics supported by the application protocol of interest, and selected for instantiation in a particular ETC, are accurately conveyed as output in the schema instance of the observed exchange structure. The supported semantics are identified in the Application Elements (AEs) of an AP, their encodings as defined in the Application Reference Model to Application Interpreted Model mappings. Additional specification or clarification may be provided in the conformance clause.

An ETC may specify a value as part of the input and expect that value to appear in the exchange structure output. Permutation of that value into another AP-valid value shall result in a fail verdict.

> EXAMPLE 1 - An AP may allow the values red and blue for curves. If the ETC specifies that a particular instance of curve is red, the exchange structure must carry this same value, and not blue (although blue is an allowed value in the AP) for a pass verdict to be assigned.

An ETC may specify a concept to be conveyed in an exchange structure that allows the use of more than one AP-defined mechanism (not necessarily using specific entities or values). If the schema instance in the observed exchange structure contains the general information concept, then a pass verdict is assigned to the analysis of this semantic.

> EXAMPLE 2 - An AP may allow geometric surfaces to be planar or non-planar. This property may be implicit in the specification of surfaces (and not explicit as in example 1). A **pass** verdict will be assigned only after determining that the planarity property of a surface specified in the ETC has been maintained in the exchange structure.

The level of detail of a semantic, whether it is a general concept or a specific numerical value, shall be specified in the verdict criteria, and shall be analyzed accordingly.

The ETC identifies which semantics to observe and analyze, and the means for discerning whether an observed semantic is acceptable. These selected semantics shall be captured in the specification of ETC verdict criteria. The specification of verdict criteria may include the specification of numerical accuracy, i.e., mathematical precision, that shall be maintained between input and output schema instances, classification categories to which observations shall be assigned, computations or operations that shall be performed on output schema instances, or other specific measurement techniques to be employed.

Semantic analysis procedures that are not identified in the ATC, but used in the determination of a verdict, shall be recorded in the conformance log.

5.4 Verdict assignment

During the different steps of the analysis phase, information is gathered on the observed results and verdicts are generated. Test purpose verdicts are generated as sub-results in test case analysis as required by the verdict criteria specified by the test case. These test purpose verdicts contribute to a single test case verdict.

For each test case, all applicable verdict criteria shall be evaluated and test purpose verdicts of pass, fail, or inconclusive are to be assigned to each verdict criterion. The assignment of a test case verdict reflects the conclusion of a test case analysis. A test case verdict shall be assigned based on the following:

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— If at least one test purpose verdict is **fail**, a test case verdict of **fail** shall be assigned.

— If no test purpose verdicts are **fail** and at least one test purpose verdict is **inconclusive**, a test case verdict of **inconclusive** shall be assigned.

— If all test purpose verdicts are **pass**, a test case verdict of **pass** shall be assigned.

Inconclusive verdicts arise when an anomaly occurs during the testing process that prevents resolution of a verdict criterion into pass or fail. It is recommended that a test laboratory and client work to resolve an inconclusive verdict into a pass or fail in an expedient and cost effective manner.

EXAMPLE - Anomalies may be events such as test equipment failure, test case error, unexpected IUT output, or resource limits being exceeded during testing.

A pass verdict at any level indicates no observed non-conformance of an IUT. A fail verdict indicates non-conformance.

5.5 Test case results reporting

The test case verdict shall be recorded in a test case report. Detailed information and results of analysis phases, such as sub-verdicts, may also be collected in a test case report. Supporting information such as selected values for the ETC schema instance (i.e., parameters resolved in creating an ETC) shall be included.

The test case reports shall be included in the conformance test report. ISO 10303-32 describes the conformance test report.

6 Exchange structure test method - postprocessor

A sequence of testing preparation, execution, analysis, and reporting activities shall form the general procedure as described in clause 4. Test execution and analysis activities for a IUT claiming conformance as a postprocessor of ISO 10303-21 exchange structures or postprocessor of ISO 10303-22 SDAI operations input are further detailed in the remainder of this clause. Figure 2 depicts the abstract components and interfaces that support the test method.

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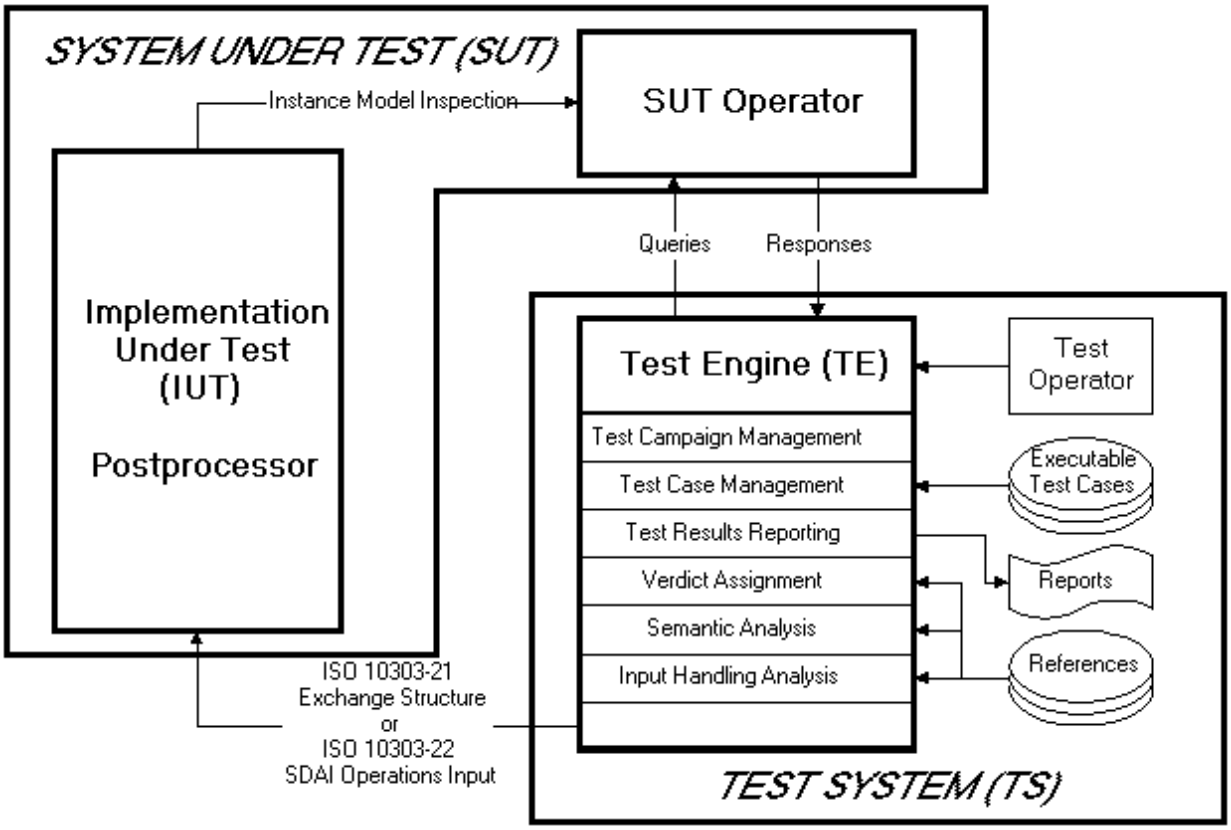

Figure 2 – Postprocessor testing components

For a postprocessor, an ETC defines input in terms of an ISO 10303-21 exchange structure containing a schema instance. The exchange structure is supplied by the testing laboratory based on information specified in the ATS, PICS, PIXIT, and the application protocol.

6.1 Exchange structure interpretation

ATC parameters identified during the preparation for testing shall be applied to the IUT and the exchange structure input to the IUT. The IUT shall answer queries indirectly via the SUT Operator about the information communicated in the exchange structure. Each deviation or problem in exchange structure interpretation shall be reported in the conformance log.

6.2 Analysis

In analysis, postprocessor output is evaluated using a method of semantic queries, human-interpretable questions, about the information contained in the exchange file. These queries are used since no standard encoding of postprocessor output are defined in ISO-10303. Verdicts are assigned as appropriate during analysis (see 5.4). A single fail verdict during any analysis step may terminate further analysis and shall result in an overall fail verdict assigned to the test case.

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6.2.1 Input handling analysis

Postprocessor handling of the input ISO 10303-21 exchange structure or ISO 10303-22 SDAI operations input is analyzed. If a valid input file is supplied, the input shall be postprocessed with no error responses observed.

An invalid input may be supplied only if it is based on requirements specified or referenced in an AP. If a syntactically invalid input is supplied, the error response shall be observed and documented in the test report. If the exchange structure is syntactically correct, but carries information elements or structures not permitted by the application protocol of interest, an error response shall be observed and documented in the test report.

IUT-specific error responses not identified in the AP shall be identified in the PIXIT and recorded in the test report if the execution of a test case generates such an error response.

6.2.2 Semantic analysis

Semantics that are expected to be found in postprocessor output are identified as verdict criteria. These semantics are permitted by the information requirements clause of each AP and qualified by the conformance requirements clause. Semantic queries, that provide a structured means of searching postprocessor output for expected semantics, are executed and allow a verdict to be assigned to each verdict criterion. These queries require the support of a SUT Operator to assist execution, since postprocessor output is not required to be bound to any particular encoding (syntax).

The analysis technique is further described in 5.3.3. The difference between semantic analysis for preprocessors and postprocessors is that a SUT Operator is required to assist in the postprocessor semantic analysis. The Test Engine provides semantic queries to the SUT Operator, which in turn, interacts with the IUT to resolve those queries. The SUT Operator then returns the results to the Test Engine in a Test Engine defined format.

6.3 Verdict assignment

Verdict assignment for postprocessor tests is identical to that for preprocessors (see 5.4).

6.4 Test case results reporting

Test case results reporting for postprocessor tests is identical to that for preprocessors (see 5.5)

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Annex A
(normative)
Information object registration

To provide for unambiguous identification of an information object in an open system, the object identifier

{ iso standard 10303 part(34) version(1) }

is assigned to this part of ISO 10303. The meaning of this value is defined is ISO/IEC 8824-1, and is described in ISO 10303-1.

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