

Report Concerning Space Data System Standards

|  |
| --- |
| CCSDS RFID Tag-Encoding Yellow Book |

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DOCUMENT CONTROL

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# Introduction

## Purpose

This report documents the interoperability testing conducted in support of the CCSDS RFID Tag-Encoding Standard. This document supports the CCSDS requirement that a Recommended Standard be accompanied by a report documenting interoperability between two independent prototypes or implementations.

The two implementations used for these tests were:

* The NASA JSC-EV8 RFID Tag-Encoding implementation;
* The FSA/University of St. Petersburg Tag-Encoding implementation.

## Scope

This document applies to the CCSDS Tag-Encoding (881x1r0) specification only.

## Applicability

This document supports the interoperability testing requirement needed for the CCSDS RFID Tag-Encoding Specification to be accepted by CCSDS as a Recommended Standard.

## Document Structure

Section 2 provides an overview of the testing purpose and goals.

Annex A provides the detailed Test Procedures.

Annexes B and C provided the Implementation Conformance Statements and test results (table B‑1).

Annex D provides a resource (test conductor) contact table.

Annex E provides the ECMA-113 / ISO 13456 Latin/Cyrillic allowable character set.

Annex F provides listings of the Software-Test Data Sets.

## References (INFORMATIVE)

The following publications are referenced in this document. At the time of publication, the editions indicated were valid. All publications are subject to revision, and users of this document are encouraged to investigate the possibility of applying the most recent editions of the publications indicated below. The CCSDS Secretariat maintains a register of currently valid CCSDS publications.

[1] *Spacecraft Onboard Interface Services—RFID-Based Inventory Management Systems*. Issue 1. Recommendation for Space Data System Practices (Magenta Book), CCSDS 881.0-M-1. Washington, D.C., CCSDS, May 2012.

[2] *Spacecraft Onboard Interface Services—RFID Tag Encoding Specification*. Issue 1. Proposed Draft Recommended Standard for Space Data System Practices (Red Book), CCSDS 881.0-R-0. Washington, D.C., CCSDS, March 2015.

[3] ECMA-113 / ISO 8859 Part 5 8-Bit Single-Byte Coded Graphic Character Sets: Latin/Cyrillic Alphabet, 1999.

[4] GS1 EPC Tag Data Standard, Document version 1.9, November 2014.

# Overview

Interoperability Testing is a formal requirement for the publication of any CCSDS Recommended Standard (a CCSDS “Blue Book”). The interoperability testing specified in this document is in support of CCSDS 881.0-R-0: “*Spacecraft Onboard Interface Services—RFID Tag Encoding Specification*” [2].

The RFID Tag-Encoding Interoperability Testing involves the following testing regimes:

1. **Software Testing**: Verification of the ability to generate (encode) and properly read (decode) RFID tag-encoding values via an independent Test Agency software artifact. Test values will include:
   1. **Test-Suite-01:** A FSA-generated Test Data Set for Software-Based Test.
   2. **Test-Suite-02:** A NASA-generated Test Data Set for Software-Based Test.
2. : Test Procedures
   1. Test Procedures Organization

NOTE – For a reference tag encoding example please see Annex C of the *Spacecraft Onboard Interface Services—RFID Tag Encoding Specification* [2].

* 1. RFID Tag-Encoding Requirements

Section 3.2 and Annex A of the *Spacecraft Onboard Interface Services—RFID Tag Encoding Specification* CCSDS 881.0-R-0 describes the Protocol Implementation Conformance requirements on RFID Tag Encoding for CCSDS implementations. The requirements are listed in the following table. To be classified as CCSDS RFID Tag-Encoding compliant the following tag encoding rules MUST be followed:

Table ‑ : RFID Tag-Encoding Requirements

|  |  |  |
| --- | --- | --- |
|  | **PICS Requirement [**2**]** | **Requirement Specification** |
| 1 | 3.2.a | All fields (Database-ID, Owner-ID, Program-ID, Object-ID and Serial-ID) MUST be valid and present in the order specified. |
| 2 | 3.2.b | All character fields (Database-ID, Owner-ID, Program-ID and Serial-ID) MUST be encoded per the ECMA-113/ISO 8859 Part 5 Standard for encoding Latin and Cyrillic characters. See [3] for the ECMA-113/ISO 8859 Part 5 allowable Latin and Cyrillic character sets. |
| 3 | 3.2.c | The Database-ID MUST be defined in the SANA RFID-TAG Database-ID Registry. |
| 4 | 3.2.d | The Object-ID MUST be an integer between [0 – 65535]. |
| 5 | 3.2.e | If the Object-ID is to be tracked across multiple Database-IDs and Owner-IDs, then the Object-ID MUST be in the range of “Common Object IDs” which is [32768 – 65535]. If the Object-ID exists in the SANA RFID-Tag Object-ID Registry then the existing registered Object-ID MUST be utilized. If a “Common Object ID” for a class of objects does not exist, then a request to add a NEW common Object-ID per the specified Registration Rule MUST be completed. |
| 6 | 3.2.f | If the Object-ID does not require common-object cross-referencing then the Object-ID MUST be in the range [0 – 32767] to indicate a unique agency test activity. |

Table A‑2 specifies the allowable range of values for each field of the RFID Tag-ID.

Table ‑ : RFID Tag-Encoding Item Properties

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Item** | **Field**  **Description** | **Reference** | **Status** | **Values Allowed** |
| 1 | Database-ID | Section 3.2 of [2] | M | See Table A‑3 |
| 2 | Owner-ID Byte 0 | Section 3.2 of [2] | M | See Table A‑3 |
| 3 | Program-ID Byte 0 | Section 3.2 of [2] | M | See Table A‑3 |
| 4 | Program-ID Byte 1 | Section 3.2 of [2] | M | See Table A‑3 |
| 5 | Serial-ID Byte 0 | Section 3.2 of [2] | M | See Table A‑3 |
| 6 | Serial-ID Byte 1 | Section 3.2 of [2] | M | See Table A‑3 |
| 7 | Serial-ID Byte 2 | Section 3.2 of [2] | M | See Table A‑3 |
| 8 | Serial-ID Byte 3 | Section 3.2 of [2] | M | See Table A‑3 |
| 9 | Serial-ID Byte 4 | Section 3.2 of [2] | M | See Table A‑3 |
| 10 | Owner-ID Byte 1 | Section 3.2 of [2] | M | See Table A‑3 |
| 11 | Object-ID | Section 3.2 of [2] | M | 0 .. 65535 |

Table ‑ : ECMA-113 Valid & Blacklist Characters

|  |  |
| --- | --- |
| **ECMA-113**  **Blacklist Character Ranges** | **ECMA-113**  **Valid Character Ranges** |
| **00h .. 20h** | **21h .. 22h** |
| **23h .. 24h** | **25h .. 3Fh** |
| **40h** | **41h .. 5Ah** |
| **5Bh .. 5Eh** | **5Fh** |
| **60h** | **61h .. 7Ah** |
| **7Bh .. A0h** | **A1h** |
| **A2h .. A3h** | **A4h** |
| **A5h .. AFh** | **B0h .. BFh** |
| **C0h** | **C1h .. F1h** |
| **F2h .. F3h** | **F4h** |
| **F5h .. FCh** | **FDh** |
| **FEh .. FFh** |  |

* 1. Software-Based Testing

* + 1. Software-Based Test Configuration

General Requirements:

* A computer which can be programmed to read, interpret, and generate tab-delimited unicode-encoded text files;
* A means of accessing the Internet for the transmission and reception of those tab-delimited text files.

NOTE – The choice of the operating system and programming environment to generate test software artifacts is left to the Agency, provided that cross-platform tab-delimited text files can be read/written by the software artifact.

* + 1. Software-based Test Cases

Two sets of data will be used for each Agency’s test: A truth data set to validate correct performance of encoding software prior to inter-agency exchange and test data sets to be exchanged between participating agencies (**Test-Suite-01, Test-Suite-02)**. Data sets will be generated as Unicode-encoded files with each row representing a unique entry. Each field in a row will be separated by a Unicode tab character; tabs, rather than commas, are chosen as the field delimiter since the ECMA-113 comma character is part of the valid ECMA-113 character subset specified in Table A‑3. A Unicode newline character will indicate the end of one row and the beginning of the next.

The order of fields in each row of the file will be as follows and encoded in Unicode format:

1. Database-ID
2. Owner-ID
3. Program-ID
4. Serial-ID
5. Object-ID
6. Tag-ID

Test data sets (**Test-Suite-01, Test-Suite-02)** will be comprised ONLY of valid entries in these fields. Unicode characters in the test data set will be the Unicode representations of the valid subset of ECMA-113 characters specified in Table A‑3. The Database-ID will be comprised of one Unicode character drawn from the valid ECMA-113 subset. The Owner-ID will be comprised of two Unicode characters from the valid ECMA-113 subset. The Program-ID will be comprised of two Unicode characters from the valid ECMA-113 subset. The Serial-ID will be comprised of five Unicode characters from the valid ECMA-113 subset. The Object-ID will be comprised of 5 Unicode characters representing decimal integer values (‘0’ through ‘9’) and will encode in the range [0 – 65535]. The Tag-ID field will be comprised of 24 Unicode characters representing hexadecimal integer values (‘0’ through ‘9’ and ‘A’ through ‘F’).

Each Agency’s Truth Data Set will be composed of both valid and invalid entries in these fields to test both proper encoding of valid input data and rejection of invalid input data. The Database-ID, Owner-ID, Program-ID, and Serial-ID fields will be drawn from the complete set of Unicode characters with no field-specific length requirements. The Object-ID can encode an arbitrarily large integer value. When values in the valid ranges for Database ID, Owner ID, Program ID, Serial ID, and Object ID are chosen, a Tag-ID field will be generated as in the case of test data sets. When values are chosen outside the valid ranges, the Tag-ID will be represented by the Unicode character string ‘invalid’ rather than a set of 24 Unicode hexadecimal integer characters.

For each of the cases in Table A‑4, a set of truth data mixing both valid and invalid inputs (according to the particulars of the test cases) can be found as referenced in the annex. The examples contained in this Annex are intended to be informative and should not be considered a statistically significant sample or a comprehensive subset of input/output classes for validating test software. The Truth Data Set will be used to validate Agency software artifacts for correct operation prior to encoding Agency software test data for exchange.

* + - 1. Test Data Set Generation

Test data sets will be generated by the software artifact generated by each participating Agency. Each agency will be required to generate at least 1000 test data entries. Characters for Database-ID, Owner-ID, Program-ID, and Serial-ID fields will be randomly drawn from the ECMA-113 character set. Integers for the Object-ID field will be drawn from the range [0 – 65535].

NOTE – Only valid selections of Database-ID, Owner-ID, Program-ID, and Serial-ID will be permitted for generation of test data (**Test-Suite-01, Test-Suite-02**), as we can safely assume that data encoded for the Tag-ID has already been subject to rejection filters for invalid input parameters.

* + - 1. Truth Data Test Cases

Table ‑ : Truth Data Test Case Descriptions

|  |  |  |  |
| --- | --- | --- | --- |
| Test Case | Test Basis | Test File | Requirement Satisfied |
| 1 | All 8-bit characters MUST be ECMA-113 / ISO 8859-Part 5 compatible | Test-Suite-01.txt | 3.2.b |
| 2 | Character strings of improper length MUST be rejected: (Database-ID.length != 1); (Owner-ID.length != 2); (Program-ID.length != 2); (Serial-ID.length != 5) | Test-Suite-01.txt | 3.2.a |
| 3 | The Object-ID MUST be a 16-bit unsigned integer between [0 – 65535] | Test-Suite-01.txt | 3.2.d |
| 4 | The Database-ID MUST be defined in the SANA RFID-TAG Database-ID Registry. NOTE – Test 4 may be safely waived if the SANA Registry has not yet been approved. | n/a | 3.2.c |
| 5 | Test Object-IDs above and below the value 32767: | Test-Suite-01.txt | 3.2.d, 3.2.e, 3.2.f |

* 1. Software-Based Test Procedures

Once an Agency’s encoding software artifact is written, it SHALL be validated internally against Truth Data Set cases to verify that it both (1) correctly encodes the truth data cases with valid input ranges and (2) rejects Truth Data Set cases with invalid input ranges.

Similarly, an Agency’s decoding software artifact should be validated against truth data cases with valid input ranges, correctly recovering the Database-ID, Owner-ID, Program-ID, Serial-ID, and Object-ID fields from the Tag-ID.

Following this, at least 1000 test input sets (**Test-Suite-01, Test-Suite-02**) should be drawn from the range of valid values for Database-ID, Owner-ID, Program-ID, Serial-ID, and Object-ID, and a tab-delimited text file encoding these values into Tag-IDs should be formatted as specified in A3.2 and sent electronically to the peer Agency participating in this interoperability test.

The peer Agency, upon receiving this file, should first pass the tab-delimited text file to their decoding software artifact. The decoding software will iterate through each line in the file, taking the Tag-ID for that line as input and decoding the Database-ID, Owner-ID, Program-ID, Serial-ID, and Object-ID associated with that Tag-ID; Each of those fields will then be compared with the corresponding entry on that line, and any discrepancies will be flagged.

Subsequently, the peer Agency should pass the tab-delimited text file to their encoding software artifact. The encoding software will iterate through each line in the file, taking the Database-ID, Owner-ID, Program-ID, Serial-ID, and Object-ID as input and producing a Tag-ID. That Tag-ID will be compared with the corresponding entry on that line, and any discrepancies will be flagged.

If no discrepancies are flagged in either the encoding or decoding processes, the interoperability test should be considered a success; otherwise, interoperability testing against existing software artifacts should be considered a failure. After Agency diagnostics to determine and address the root cause of such a failure, the test should be repeated.

Expected Results:

1. Validation of encoding software artifact against truth data
   1. Validation of encoding with valid input ranges
   2. Validation of rejection of invalid input ranges
2. Validation of decoding software artifact against truth data
   1. Validation of decoding Tag-IDs corresponding to valid input ranges
3. Validation of decoding software artifact against peer Agency’s tab-delimited text file containing that Agency’s (Database-ID, Owner-ID, Program-ID, Serial-ID, and Object-ID) and Tag-ID associations.
4. Validation of encoding software artifact against peer Agency’s tab-delimited text file containing that Agency’s (Database-ID, Owner-ID, Program-ID, Serial-ID, and Object-ID) and Tag-ID associations.
   1. Software-based Test Report

The Software-Based Testing Results are summarized in tables B‑1 and C‑1.

Add any special Test Notes here to complete the Test Report. A positive Test summary will be documented and indicated in the completion of the PICS in Annex B.

1. : Implementation Conformance Statement
   1. PICS for RFID Tag-Encoding (NASA)
      1. General Information
         1. Identification of PICS

|  |  |
| --- | --- |
| Date of Statement (DD/MM/YYYY) | 28/04/2017 |
| PICS Serial Number (e.g., 880x0R1.0001) | 881x1r0 |

* + - 1. Identification of Implementation Under Test (IUT)

|  |  |
| --- | --- |
| Implementation Agency | NASA |
| Implementation name | encoding.py |
| Implementation version | v. 1.4 |
| Special configuration | n/a |
| Other information | n/a |

* + - 1. Identification of Specification

|  |  |
| --- | --- |
| CCSDS 881.1-R-1 |  |
| Addenda implemented (yes/no) | No |
| Amendments implemented (yes/no) | No |
| Have any exceptions been required?  (Note: A YES answer means that the implementation does not conform to the Recommended Standard. Non-supported mandatory capabilities are to be identified in the PICS, with an explanation of why the implementation is non-conforming. | Yes \_\_\_\_\_ No \_\_X\_ |

* 1. RFID Tag-Encoding Requirements

To be classified as CCSDS RFID Tag-Encoding compliant the following tag encoding rules MUST be followed:

1. All fields (Database-ID, Owner-ID, Program-ID, Object-ID and Serial-ID) MUST be valid and present in the order specified.
2. All character fields (Database-ID, Owner-ID, Program-ID and Serial-ID) MUST be encoded per the ECMA-113 / ISO 8859 Part 5 Standard for encoding Latin and Cyrillic characters. See [3] for the ECMA-113 / ISO 8859 Part 5 allowable Latin and Cyrillic character sets.
3. The Database-ID must be defined in the SANA RFID-TAG Database-ID Registry.
4. The Object-ID must be an integer between [0 – 65535].
5. If the Object-ID is to be tracked across multiple Database-IDs and Owner-IDs, then the Object-ID must be in the range of “Common Object IDs” which is [32768 – 65535]. If the Object-ID exists in the SANA RFID-Tag Object-ID Registry then the existing registered Object-ID MUST be utilized. If a “Common Object ID” for a class of objects does not exist, then a request to add a NEW common Object-ID per the specified Registration Rule must be completed.
6. If the Object-ID does not require common-object cross-referencing then the Object-ID must be in the range [0 – 32767] to indicate a unique agency test activity.
   * 1. Test report

Example: As the test results, all test suites passed.

Table B‑ : RFID Tag-Encoding TEST REPORT

|  |  |  |
| --- | --- | --- |
| Test suite ID | Purpose | Result  (PASS / FAIL) |
| Test-Suite-01 | Software-Based Verification of FSA Tag-ID Test Data Set by NASA | PASS |
| Test-Suite-02 | Software-Based Verification of NASA Tag-ID Test Data Set by FSA |  |

1. : Implementation Conformance Statement
   1. PICS for RFID Tag-Encoding (FSA)
      1. General Information
         1. Identification of PICS

|  |  |
| --- | --- |
| Date of Statement (DD/MM/YYYY) | 27/04/2017 |
| PICS Serial Number (e.g., 880x0R1.0001) | 880x1r0.0003 |

* + - 1. Identification of Implementation Under Test (IUT)

|  |  |
| --- | --- |
| Implementation Agency | FSA |
| Implementation name | encoding |
| Implementation version | v. 1.1 |
| Special configuration | n/a |
| Other information | n/a |

* + - 1. Identification of Specification

|  |  |
| --- | --- |
| CCSDS 881.1-R-1 |  |
| Addenda implemented (yes/no) | No |
| Amendments implemented (yes/no) | No |
| Have any exceptions been required?  (Note: A YES answer means that the implementation does not conform to the Recommended Standard. Non-supported mandatory capabilities are to be identified in the PICS, with an explanation of why the implementation is non-conforming. | Yes \_\_\_\_\_ No \_\_X\_ |

* 1. RFID Tag-Encoding Requirements

To be classified as CCSDS RFID Tag-Encoding compliant the following tag encoding rules MUST be followed:

1. All fields (Database-ID, Owner-ID, Program-ID, Object-ID and Serial-ID) MUST be valid and present in the order specified.
2. All character fields (Database-ID, Owner-ID, Program-ID and Serial-ID) MUST be encoded per the ECMA-113 / ISO 8859 Part 5 Standard for encoding Latin and Cyrillic characters. See [3] for the ECMA-113 / ISO 8859 Part 5 allowable Latin and Cyrillic character sets.
3. The Database-ID must be defined in the SANA RFID-TAG Database-ID Registry.
4. The Object-ID must be an integer between [0 – 65535].
5. If the Object-ID is to be tracked across multiple Database-IDs and Owner-IDs, then the Object-ID must be in the range of “Common Object IDs” which is [32768 – 65535]. If the Object-ID exists in the SANA RFID-Tag Object-ID Registry then the existing registered Object-ID MUST be utilized. If a “Common Object ID” for a class of objects does not exist, then a request to add a NEW common Object-ID per the specified Registration Rule must be completed.
6. If the Object-ID does not require common-object cross-referencing then the Object-ID must be in the range [0 – 32767] to indicate a unique agency test activity.
   * 1. Test report

Example: As the test results, all test suites passed.

Table C‑ : RFID Tag-Encoding TEST REPORT

|  |  |  |
| --- | --- | --- |
| Test suite ID | Purpose | Result  (PASS / FAIL) |
| Test-Suite-01 | Software-Based Verification of FSA Tag-ID Test Data Set by NASA |  |
| Test-Suite-02 | Software-Based Verification of NASA Tag-ID Test Data Set by FSA | PASS |

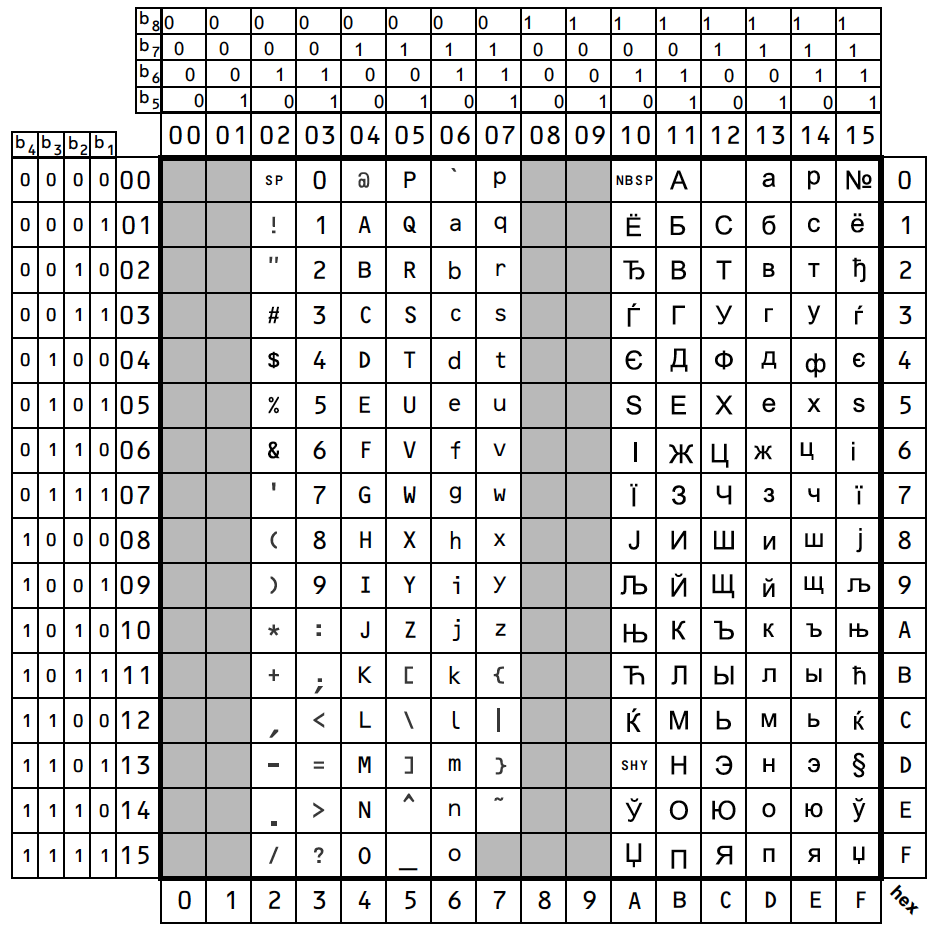
1. : Resource Contact Table

Table ‑ : Resource Contact Information

|  |  |  |
| --- | --- | --- |
| **Name** | **Agency** | **Resource Email** |
| Yuriy Sheynin | FSA | [sheynin@aanet.ru](mailto:sheynin@aanet.ru) |
| Vladimir Fetisov | FSA | [fet1@aanet.ru](mailto:fet1@aanet.ru) |
| Raymond Wagner | NASA | [raymond.s.wagner@nasa.gov](mailto:raymond.s.wagner@nasa.gov) |

1. : ECMA-113 / OSI 13456 Latin/Cyrillic Character Table

Table ‑ : ECMA-113 / OSI 8859 Part 5 Character Table



1. : Software Test Data
   1. Software Test: FSA Test Data Set

The Software-Based Testing FSA Test Data Set (Test-Suite-01) composed by FSA with each test entry formatted as described in Annex A-3.

Table ‑ : Software Test – FSA Data Set

|  |  |  |  |
| --- | --- | --- | --- |
| **Entry**  **#** | **Test Entry** | **Entry**  **#** | **Test Entry** |
| **1** |  | **31** |  |
| **2** |  | **32** |  |
| **3** |  | **33** |  |
| **4** |  | **34** |  |
| **5** |  | **35** |  |
| **6** |  | **36** |  |
| **7** |  | **37** |  |
| **8** |  | **38** |  |
| **9** |  | **39** |  |
| **10** |  | **40** |  |
| **11** |  | **41** |  |
| **12** |  | **42** |  |
| **13** |  | **43** |  |
| **14** |  | **44** |  |
| **15** |  | **45** |  |
| **16** |  | **46** |  |
| **17** |  | **47** |  |
| **18** |  | **48** |  |
| **19** |  | **49** |  |
| **20** |  | **50** |  |
| **21** |  | **51** |  |
| **22** |  | **52** |  |
| **23** |  | **53** |  |
| **24** |  | **54** |  |
| **25** |  | **55** |  |
| **26** |  | **56** |  |
| **27** |  | **57** |  |
| **28** |  | **58** |  |
| **29** |  | **59** |  |
| **30** |  | **60** |  |

* 1. Software Test: NASA Test Data Set

The Software-Based Testing NASA Test Data Set (Test-Suite-02) composed by NASA with each test entry formatted as described in Annex A-3.

Table ‑ : Software Test – NASA Data Set

|  |  |  |  |
| --- | --- | --- | --- |
| **Entry**  **#** | **Test Entry** | **Entry**  **#** | **Test Entry** |
| **1** |  | **31** |  |
| **2** |  | **32** |  |
| **3** |  | **33** |  |
| **4** |  | **34** |  |
| **5** |  | **35** |  |
| **6** |  | **36** |  |
| **7** |  | **37** |  |
| **8** |  | **38** |  |
| **9** |  | **39** |  |
| **10** |  | **40** |  |
| **11** |  | **41** |  |
| **12** |  | **42** |  |
| **13** |  | **43** |  |
| **14** |  | **44** |  |
| **15** |  | **45** |  |
| **16** |  | **46** |  |
| **17** |  | **47** |  |
| **18** |  | **48** |  |
| **19** |  | **49** |  |
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