Automotive Electronics Council
Component Technical Committee

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QUALIFICATION REQUIREMENTS FOR COMPONENTS USING COPPER (Cu) WIRE INTERCONNECTIONS

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Text enhancements and differences made since the release of this document are shown as underlined areas.

1. SCOPE

This document contains a set of tests and defines the minimum requirements for qualification of components using bare and coated copper (Cu) and copper alloy (CuA) wire interconnections to be used in any automotive electronics application. While the set of tests highlighted here are replicated in AEC-Q100/Q101, this document details any different test conditions and/or durations plus the activity around these tests that are unique requirements for ensuring Cu wire reliability. Use of this document does not relieve the supplier of their responsibility to meet their own company's internal qualification program. All other AEC-Q100/Q101 test requirements shall be met. In this document, "user" is defined as all customers using a component qualified per this specification. The user is responsible to confirm and validate all qualification data that substantiates conformance to this document.

If a supplier has qualified a Cu wire technology family for automotive applications (as defined in table 2) prior to the publication of this document, they can provide evidence of robustness/reliability of this family, and it is in production with no Cu wire related issues, the supplier does not have to requalify components of this technology family again per this document.

A technology family is considered to be in production if there are regular shipments to users totalling more than 500k pieces per year or overall shipments of more than 2.3 million pieces.

A Cu wire related issue is defined as recurring Cu wire related failures with the same failure mechanism with an intrinsic systemic root cause (e.g., setup of wire bond process, selection of the bill of material or design of the chip metallization stack).

1.1 Purpose

The purpose of this specification is to determine that a component is capable of passing the specified stress tests and thus can be expected to give a certain level of quality/reliability in the application.

1.2 Reference Documents

Current revision of the referenced documents will be in effect at the date of agreement to the qualification plan. Subsequent qualification plans will automatically use updated revisions of these referenced documents.
Sections 1.2.2 and 1.2.3 provide references for the test methods used in this document and their abbreviations. Whenever the test method is referred to in this document it is implicitly referencing/referring to the standards stated in these sections.

1.2.1 Automotive

AEC-Q100 Failure Mechanism Based Stress Test Qualification for Integrated Circuits in Automotive Applications
AEC-Q101 Failure Mechanism Based Stress Test Qualification for Discrete Semiconductors in Automotive Applications

1.2.2 JEDEC

JESD22 Reliability Test Methods
JESD22-A104 Temperature Cycling (TC)
JESD22-A110 Highly Accelerated Stress Test (HAST)
JESD22-A101 Temperature Humidity Bias (THB) / High Humidity High Temperature Reverse Bias (H3TRB)
JESD22-A103 High Temperature Storage Life (HTSL)
JESD22-A108 Temperature, Bias and Operating Life (HTRB/HTGB)
J-STD-035 Acoustic Microscopy for Non-Hermetic Encapsulated Electronic Components (AM)
J-STD-020 Moisture/Reflow Sensitivity Classification for Nonhermetic Surface Mount Devices
JESD22-A113 Preconditioning of Nonhermetic Surface Mount Devices Prior to Reliability Testing (PC)
JEP122 Failure Mechanisms and Models for Semiconductor Devices

1.2.3 Military

MIL-STD-750, Method 1038 (condition A) High Temperature Reverse Bias (HTRB)

2. EQUIPMENT

Not applicable (see referenced documents)

3. DATA SUBMISSION

3.1 Certificate of Design and Construction

For qualification of components with Cu wire, a Certificate of Design and Construction per AEC-Q100/Q101 is required to determine whether available generic data can apply to the part in question for one or more of the required tests in this document.

If applicable, supplier must document the definition of Cu wire product or technology family. This document should explain the selection of family (worst-case) test vehicle(s). In the list in Section 7.1, critical product, construction, and material items for defining Cu wire product or technology families are given.

The relevant items in the Certificate of Design and Construction are highlighted in Section 7.1 for determination of what data is considered acceptable generically.

3.2 Test Results

The following data is to be submitted to the user for approval on request:

- Cu wire stress test qualification results
- Wire pull/ball shear – mean, min, max, standard deviation, T_0[1] limits
- AM images before/after stressing
- Electrical/ATE functional/parametric test results before/after stress tests
- Cross-sections of ball/wedge bonds (as needed per Section 5)

4. QUALIFICATION TESTS

The required set of qualification stresses, test conditions and test durations are shown in the following sections, with an enhanced qualification flow described in Table 3. Other tests not mentioned in Table 3 shall be performed as required per AEC-Q100/AEC-Q101.

4.1 Temperature Cycling (TC)

This test highlights the differences in the coefficient of thermal expansion of package materials with Cu along with the increased hardness of Cu with respect to gold (Au).

Perform per the test requirements in AEC-Q100/Q101.

4.2 Biased Humidity (HAST/THB/H3TRB)

This test can exacerbate corrosion along the Cu/bond pad intermetallic compound (IMC) interfaces.

Perform per the test requirements in AEC-Q100/Q101.

4.3 High Temperature Storage Life (HTSL) / High Temperature Gate Bias (HTGB) / High Temperature Reverse Bias (HTRB)

This test can accelerate IMC growth along the Cu/Aluminum (Al) interface to yield an open bond failure. It can also degrade the mechanical performance of the stitch (wedge/second bond) bond.

Perform per the test requirements in AEC-Q100/Q101.

For grade 0 products with an anticipated self heating under nominal operating conditions >10 °C in the application, HTSL shall be performed at 175 °C only.

[1] T_0 refers to the point in tlifetime of a component after final test but before mounting, usage or stress.

5. ANALYTICAL TESTS

5.1 Delamination Assessment

Delamination of the mold compound over the Cu ball or stitch bond could lead to joint fatigue failure at either weld joint. Typically Acoustic Microscope (AM) scans in C-Mode are used for the delamination assessment. Refer to IPC/JEDEC J-STD-035 for operation of acoustic microscope. The delamination criteria for various stages of qualification testing are shown in Table 1. Delamination of the mold compound at a wire bond location is an indicator of risk, but may not be a cause of failure within the useful life portion of the device. For example, there are many small discrete devices that may exhibit delamination at the stitch bond location at various points and in changing magnitudes in the test sequence or useful life but exhibit no reliability concerns in the field.

Table 1: Delamination Criteria

	Read Point	Mold Compound Delamination Acceptance Criteria	Electrical
Qualification Requirements	T_0	No delamination at first (ball) or second (stitch/wedge) bonds unless otherwise agreed between supplier and user. (1)	All components passing production test
	Post MSL PC	No delamination at first (ball) or second (stitch/wedge) bonds unless otherwise agreed between supplier and user. (1)	All components passing production test
	1X for AEC Q100 grade X or AEC Q101	Test specific delamination criteria after 1X are defined in section 7.2.1.	All components passing production test
Minimum AM sample size: 11 components per lot through each readpoint.			

Notes:

(1) Agreement between the supplier and user would be achieved via the exchange of data that demonstrates that the form of delamination seen is not an issue for this part based on supporting data (e.g., field, monitor, in-process, etc.).

5.2 Wire Bond Integrity Assessment

The tests described below and where they are performed are a good gauge of the bond strength and weld formation of the ball and stitch bonds. They are done to demonstrate adequate process control with acceptable bond integrity. The supplier shall specify appropriate T_0 limits (referring to AEC-Q100/101) for the acceptance of each wire bond integrity test and provide those with the pull and shear force data to the user upon request. The location of the hook for bond pull should be over the contact of interest (i.e., over the ball and over the stitch/wedge).

- Ball shear – ball bond area versus shear force (pre-packaged)
- Ball and Stitch/Wedge bond wire pull (pre-packaged)
- Perform wire pull/ ball shear on first bond and wire pull for stitch/wedge bond (post packaged at T_0)
- Pad cratering test (pre-packaged)

Wire pull / ball shear is also performed after stress testing and decapsulation. A recommended process flow is described below:

1. Select components per the sample size specified in AEC-Q100/Q101 for wire pull and shear. Selecting worst-case components based on AM after stress is desirable.

2. Carefully decapsulate these components so as to not damage or adversely affect the wire bonds but enough to be able to reliably conduct wire pulls and/or bond shears. Check for corrosion of pad, ball bond area or wire.

3. The wire pull hook should be situated as close as possible over the stitch/wedge bond for stitch/wedge bond pull and over the ball for ball bond pull.

4. Ball shear direction should be consistent for pre and post stress analysis. Typically, this can be ensured by selecting the same wires for pre and post stress analysis.

5. Compare these results with production or qualification data (i.e., before mold via WBP/WBS or after decap) to assess the level of degradation in the distribution of the data. If there are positively biased wires required in the test, ensure that they are included in this analysis, as they are thought to be more susceptible to corrosion. Include the highest bias level, in case there are several levels in the test. An accurate execution of steps 2 and 3 is essential for a meaningful conclusion on the strength of both ball and stitch/wedge from comparison of distributions.

6. In conjunction with pull/shear after decapsulation, a thorough inspection of the stitch/wedge bonds should take place to look for heel cracks or precursors for failure.

For temperature cycling, pulls and shears at corner locations of the die/package are preferable. For moisture stressing, selecting random balls/stitches is acceptable (uniform moisture penetration) but ensure that both biased and unbiased pins are selected. Determination of which wires per device undergo ball shear, ball pull or stitch/wedge pull is left to the supplier to determine as long as the intent of inspecting all types of bonds is adequately addressed.

5.3 Cross-Sectioning Inspection

The sample sizes and test conditions are specified in the overall process qualification flow shown in Table 3. It is recommended to perform the X-section at the center of the ball/stitch and for the stitch in the direction of the wire.

Areas of examination:

- Ball bond area
  - Amount and distribution of intermetallic - an alternative 2D planar analysis method to evaluate ball bond IMC formation is also acceptable
  - Crack initiation/propagation
  - Corrosion after 1X stress

- Stitch/Wedge bond area
  - Amount of contact
  - Wire angle to stitch/wedge
  - Crack initiation/propagation
  - Corrosion after 1X stress
  - Intermetallics formed in the bond area

6. COMPONENT CHANGES

6.1 Qualification Test Requirements for Cu Wire Changes

The requirements for qualification of changes to already qualified and released components can be found in AEC-Q100/Q101. Q006 requirements for the applicable tests should be considered for changes affecting the Cu wire interconnect system; including, but not limited to:

- Leadframe Plating
- Leadframe Dimension
- Wire Bonding
- Die Preparation / Clean
- Die Attach
- Mold Compound
- New Package

Reason for not applying Q006 requirements for a change affecting the Cu wire interconnect system should be given in the qualification plan or results.
In cases where wire is changing to copper (including coated copper wire), relevant stress tests and physical analysis steps must be performed per Q006 Table 3 conditions, unless internal and external data for already-qualified Cu wire parts is provided with technical justification to support the equivalent robustness of the material and design changes and is agreeable to the user.

7. QUALIFICATION REQUIREMENTS FOR Cu WIRE COMPONENTS

The sections below describe the individual steps required in a qualification flow for Cu wire components and the sample sizes required for each stress test.

7.1 Family Data Usage

The qualification can be performed on a technology basis, defined as sharing the same characteristics described below. Technology family is qualified using the technology driver (or lead product) most representative of the technology family. Product family is the subset of (functional specific) parts (or follow-on parts) under the technology driver part. Passage of the technology family allows subsequent components in the product family(ies) used for the technology qualification to then be qualified by association. See Table 2 for the qualification requirements per different cases of the technology family criteria.

Use of family generic data for new designs into the family requires a consideration of a combination of family attributes. This section provides a list of relevant items for consideration. In this case for use of Cu wire, a family consists of 1) silicon die related attributes, 2) package related attributes, and 3) assembly factory related attributes. Table 2 provides an overview of those attributes that characterize a Technology Family.

Table 2: Technology Family Criteria

The qualification requirements per different cases of the technology family criteria.

Note that in each case only the difference(s) is highlighted and all other attributes are the same unless specified otherwise.

Case	Silicon die related attributes	Package related attributes	Assembly site location related attributes	Requirements in addition to Q100/Q101
1	different	different	different	Q006 (Table 3), 3 lots
2a	different bond pad base/layered materials (e.g., Al vs. plated Al vs. Cu)	same	same	Q006 (Table 3), 3 lots
2b	new component has a die diagonal size of >115% of the technology qual vehicle	same	same	Q006 (Table 3 for TC), 3 lots
2c	different dielectric composition and thickness under the bond pad	same	same	Q006 (Table 3 for TC), 3 lots
3a	same	different mold compound materials	same	Q006 (Table 3), 3 lots
3b	same	different bond wire materials (e.g., bare Cu vs. coated Cu)	same	Q006 (Table 3), 3 lots
3c	same	different lead frame/ substrate material surface at stitch (e.g., NiPdAu vs. Cu vs. Alloy42 vs Ag strike)	same	Q006 (Table 3), 3 lots Analytical tests may be limited to the stitch side
3d	same	different package types (e.g., QFP vs. SOIC)	same	Q006 (Table 3), 3 lots
4a	same	same	Different assembly site locations	Q006 (Table 3), 3 lots [(1)]
5	new component has a die diagonal size of <115% of the technology qual vehicle	same	same	1 lot TC per Q100/Q101 requirements up to item #10 in Table 3 (generic or part-specific data)

Note:

(1) In case two assembly sites are copied exactly from a technical and process perspective, both sites may be qualified with 4 lots in total, either 3-1 or 2-2. For details on attributes which need to match, see Appendix 2.

7.2 Qualification Requirements

Table 3 below describes the test requirements and sequence for Cu wire qualification of integrated circuit and discrete devices in addition to, or replacement of, the normal qualification requirements per AEC-Q100 or AEC-Q101 (depending on which document is applicable for the device to be qualified). The sample sizes in the table define the number of lots times the number of samples per lot.

The qualification concept defined in this document demonstrates reliability margin by either extended analytical tests or extended stress duration compared to the underlying AEC-Q100/101 requirements. Therefore, there are two basic options to qualify a Cu wire technology family according to this document.

- **Option 1:** 1X stress duration (based on AEC-Q100/101 requirements) followed by ATE (test temperature requirements as per AEC-Q100/101) AND analytical tests as per items 8-11 of Table 3. The sequence of mandatory items in this case per Table 3 is 1-11. Analytical tests must prove to meet minimum requirements as per Section 7.2.1 of this document. If this is not the case a risk mitigation by executing additional items 12 and 13 is mandatory.

- **Option 2:** 2X stress duration (based on AEC-Q100/101 requirements) followed by ATE (test temperature requirements as per AEC-Q100/101). The sequence of mandatory items in this case per Table 3 is 1-7, 12, 13.

Table 3: Qualification Test Requirements based on AEC-Q100/Q101

A "●" in this table indicates that this item shall be executed if the respective option is selected.
A "○" indicates that the item shall only be executed if the criteria as per Section 7.2.1 are not met.

Sequence #	Qualification Step \ Stress Test	TC	HAST / THB / H3TRB	HTSL (8)	Option 1	Option 2
1	**Initial sampling**	Sample sizes as required			●	●
2	**AM @ T_0 (1,6)**	Sample sizes as required			●	●
3	**Preconditioning to MSLx**	3x77	3x77	---	●	●
4	**AM after PC (1,6)**	3x11	--	---	●	●
5	**ATE Test**	3x77	3x77	3x45	●	●
6	**Stress 1X**	3x77	3x77	3x45 (4)	●	●
7	**ATE Test**	3x77	3x77	3x45	●	●
Items 8-11 may be limited to Q100/101 requirements. In this case, continue at item 12.						
8	**AM post-1X stress (1)**	3x11	--	---	●	
9	**SEM inspection (stitch) (5)**	3x1	---	---	●	
10a	**Ball + Stitch/Wedge pull**	3x3 (3)	3x3 (3)	---	●	
10b	**Ball shear**	3x3 (3)	3x3 (3)	3x3 (3)	●	
11	**Cross-section (7)**	3x1	3x1	3x1	●	
Continue at item 12 if items 8-11 are not performed or if the criteria according to Section 7.2.1 are not met.						
12	**Stress 2X**	3x77 (9)	3x77 (9)	3x45 (4,9)	○	●
13	**ATE Test**	3x77 (2,9)	3x77 (2,9)	3x45 (2,9)	○	●
Items 14-17 are optional, but recommended. If item 13 (ATE Test) is pass, it is recommended but optional to perform items 14-17.						
14	**AM post-2X stress (1)**	Lot and sample sizes to be defined on a case by case decision depending on the target of the investigation.				
15	**SEM inspection (stitch)**					
16a	**Ball + Stitch/Wedge pull**					
16b	**Ball shear**					
17	**Cross-section (7)**					

Notes:

(1) 11 random picked samples. If samples are coated for AM analysis or desoldered from stress test boards these may not go back to stress. In this case, additional samples must be added at the beginning and taken out after PC and/or at the 1X readpoint.

(2) Any failures beyond 1X must directly relate to the Cu wire bonding system for them to count as a legitimate failure requiring further evaluation (i.e., the projected lifetime of failure, effect of fail mode on product lifetime, corrective/preventive action). The method of approval is determined between the user and supplier.

(3) Pull/shear as many as is possible per the number of wires per device to be qualified up to a maximum of 30 wires/balls from the total sample size specified.

(4) For grade 0 products with an anticipated self heating under nominal operating conditions >10 °C in the application, HTSL shall be performed at 175 °C only.
(5) If there are any parts showing delamination at the stitch area it is highly recommended to use those for SEM inspection. In case the wire bond diagram includes ground bonds, one of these should be included in the inspection sample.
(6) Samples for this test can be set aside unless an issue is found at AM after 1X stress. In this case, additional samples must be added to maintain the required sample size of the subsequent tests.
(7) For alternatives to assess IMC coverage, see Section 5.3.
(8) Data from HTRB/HTGB may be used alternatively for devices qualified according to AEC-Q101.
(9) If Option 1 continues to 2X stress (risk mitigation), then sample sizes change to: TC – 3x69, HAST / THB / H3TRB – 3x70, HTSL – 3x41.

7.2.1 Release criteria after 1X stress

A qualification according to this document may be completed by performing 1X stress followed by additional physical analysis (items 1-11 per Table 3) if the analytical tests (items 8-11 in Table 3) prove that the criteria given in this section are met. Not meeting the criteria of items 8-11 or only executing these items according to AEC-Q100/101 requirements make it mandatory to continue until 2X stress followed by ATE test at test temperature requirements as per AEC-Q100/101 (items 12-13 per Table 3) are complete.

A WBS or WBP result of 0 gf is a FAIL. Such failure prohibits continuation to 2X stress.

7.2.1.1 Thermal Cycling

The following criteria must be met after 1X stress for TC, if 2Xstress is not performed:

- AM: no delamination allowed at 1st and 2nd bond area and at active side of the die corners
- SEM inspection: no heel cracks
- WBS Shear Codes: shall not include:
  - Bond lift: wire bond separated from bonding surface and no evidence of bond, i.e., IMC formation
  - Cratering: residual bonding surface and substrate (bulk) material attached to wire bond
- WBS Force Values: must be above T_0 specification limit
- WBP Pull Codes: for 1st and 2nd bond pull shall only include:
  - Wire breaks in any point of the wire
- WBP force values must be above T_0 specification limit
- Cross-Section: no cracks in BEoL stack for bond over active area

7.2.1.2 HAST/THB/H3TRB

The following criteria must be met after 1X stress for HAST/THB/H3TRB, if 2X stress is not performed:

- WBS Shear Codes: shall not include:
  - Bond lift: wire bond separated from bonding surface and no evidence of bond, i.e., IMC formation
  - Cratering: residual bonding surface and substrate (bulk) material attached to wire bond
- WBP Pull Codes: shall only include
  - Wire breaks in any point of the wire
- Cross-Section: any sign of corrosion needs to be assessed

7.2.1.3 HTSL

The following criteria must be met after 1X stress for HTSL, if 2X stress is not performed:

- WBS Shear Codes: shall not include:
  - Bond lift: wire bond separated from bonding surface and no evidence of bond, i.e., IMC formation
  - Cratering: residual bonding surface and substrate (bulk) material attached to wire bond
- WBS Force Values:
  - Must be above T_0 specification limit
  - Measured minimum individual value of shear force after 1X stress is more than 50% of T_0 measured minimum individual value (PASS > 0.5X T_0 measured minimum individual value)
- Cross-Section: any sign of corrosion needs to be assessed using stitch/ wedge pull and force values must be above T_0 specification limit.

APPENDIX 1: Cu Wire Process and Technology Characterization Guideline

This appendix is meant to be used as a guideline for users of components assembled using Cu wire for the internal interconnects. This guideline is a broad outline of generic items and issues suppliers should address to ensure a reliable Cu wire process in production.

This guideline is meant to illustrate the technical items that need discussion between supplier and user to determine the level of competence in the supplier's development process for Cu wire production. This discussion can involve data from design of experiments, stress tests, historical data, models, etc.

A.1 Failure Mechanisms Related to Copper Wire and Causes/Risk Factors:

- Chipout under ball bond (AEC Q100-001)
  - The pad and underlying structures have higher risk of damage/cracking due to the extra ball bonding force required for Cu wire
  - Bonding over layered active area circuitry
  - Thin passivation layer under bond pad
- Corrosion along Cu/Al IMC interface
  - Trace contaminants/additives in mold compound in presence of moisture
- Insufficient Cu/Al IMC
  - Al bondpad splash from overbonding force
  - Poorly optimized bonding parameters for bonding temperature/<u>ultrasonic power</u>/force during thermosonic bonding
  - Oxidation of free air ball during ball bonding
- Crack at stitch/wedge heel
  - Delamination at/near the lead tip where stitch/wedge located
    - Mold compound cure
    - Mold lock techniques
  - Large CTE mismatch among package materials
  - Mismatch of material properties (e.g., Tg, CTE, elastic modulus) of component and with customer circuit boards
- Wire neck severance
  - Die/mold compound delamination near/at the ball bond

A.2 Best Practices:

- Inert environment around Cu wire
  - During wire storage
  - During free air ball formation
  - (Pd) Plated Cu wire
- Tighter controls/limits for wire pull/shear metrics
  - USL/UCL and LSL/LCL
  - Ball shear and wire pull near/over stitch
  - Production monitor using unmolded parts
  - Pull/shear after stress testing and careful decapsulation
- Capillary
  - More frequent replacement/maintenance
  - Designed specifically for Cu wire
- Thermosonic bonding
  - Tighter parameters for <u>ultrasonic power</u>, temperature, force
  - Reliability data collection at bond recipe corners of <u>force</u> and <u>ultrasonic power</u>

- Mold Compound Material Requirements
  - Sufficiently high pH (generally greater than 5)
  - Cl extracted content (generally less than 15ppm)
  - If the application or process temperatures exceed the decomposition temperature of S containing ingredients, the suitability of the mold compound & wire combination should be demonstrated based on HTSL data and physical analysis (e.g., cross-sections or planar analysis of the IMC).
- Safe Launch (i.e., initial production period) period for new Qualification and Changes
  - Sample first lots for reliability test
- Bond Pad Construction including active circuits under pad if applicable
  - Selecting the most sensitive bond pad known for analysis
- Ball Bond: IMC contact area after wire bonding
  - Quantify smallest contact area below which there would be a bonding problem
  - Supplier should use standardized methods to determine IMC contact area
- Stitch/Wedge Bond: delamination response after TC
  - Quantify the largest amount of delamination change allowed

APPENDIX 2: Criterion for Extended Referencing Between Different Assembly Site Locations

This appendix is meant to be used as a guideline to assess the technical similarity of the processes and tooling at two different assembly site locations. If processes and tools at different assembly site locations are considered as technically identical, extended referencing of qualification results between these sites may be allowed, as per Table 2. The relevant attributes and criteria to be considered include, but are not limited to:

Materials:

- Package bill of materials shall be the same
- Leadframe strip layout shall be the same

Assembly Process & Equipment:

For the following processes, equipment incl. process settings shall be the same:

- Wire bond process
- Wire bond surface treatment (e.g., cleaning)
- Die attach process

For the following processes, equipment incl. process settings OR process responses shall be the same:

- Molding process

Tools:

- Capillary type shall be the same
- Clamping tool design shall be the same

Revision History

Rev #	Date of change	Brief summary listing affected sections
-	June 8, 2015	Initial Release.
A	July 1, 2016	Complete Revision. Revised sections 3.1, 4, 4.1, 4.2, 4.3, 4.4, 5.1, 5.2, 5.3, 6.1, and 7, Tables 1, 3a, and 3b, Appendix 1, and Revision History. Added new sections 7.1, 7.2, and 7.3, and Table 2.
B	June 30, 2025	Complete Revision. Revised sections 1, 1.2.2, 1.2.3, 3.2, 4, 4.1, 4.4, 5.1, 5.2, 5.3, 6.1, and 7.2, Tables 1, 2, and 3, Appendix 1, and Revision History. Added new sections 7.2.1, 7.2.1.1, 7.2.1.2, and 7.2.1.3, Table 1 Note 1 and Table 3 Notes 4-9. and Appendix 2. Deleted sections 4.3, 4.5, and 7.3, and Table 3b.