



**SPECTRUM TECHNOLOGIES** ®  
**UTILITIES SERVICES U.S.A., Inc.**

April 19, 2004

U.S. Nuclear Regulatory Commission  
ATTN: Document Control Desk  
Washington, D.C. 20555

Subject: Response to Notices of Nonconformance (NRC Inspection Report 99901350/2004-201)

Dear Sir/Madam:

The Nuclear Regulatory Commission (NRC) conducted an inspection at Spectrum Technologies Utilities Services USA, Incorporated (Spectrum), facility in Schenectady, New York, on February 2-5, 2004

The NRC inspectors concluded that Spectrum's QA program was generally effective in controlling dedication and equipment qualification activities, and they noted the pro-active manner in which Spectrum implemented continuing personnel training program, including communication of industry issues and enhancements to the QA program. However, instances were noted certain requirements of 10CFR50, Appendix B, were not being met resulting in four notices of nonconformance and one notice of unresolved item being documented.. This correspondence provides, in attachment A, Spectrum's response to these four nonconformances and one unresolved item.

We appreciate the NRC's critical assessment of our Quality Assurance Program. We are always striving to improve our program.

If you have any questions please don't hesitate to call, fax or e-mail us.

Assuring you of our best intentions.

Sincerely,

Brij M. Bharteey,  
President and CEO

*Spectrum Sets Standards Above The Standards*

SPECTRUM RESPONSES TO NOTICES OF NONCONFORMANCE AND UNRESOLVED ITEM

Notices Of Nonconformance 99901350/2004-201-01 and 99901350/2004-201-02:

Criterion II, "Quality Assurance Program," of 10 CFR Part 50, Appendix B, states, in part, that the quality assurance program shall provide control over activities affecting the quality of the identified structures, systems, and components, to an extent consistent with their importance to safety. Activities affecting quality shall be accomplished under suitably controlled conditions. Controlled conditions include assurance that all prerequisites for the given activity have been satisfied.

Criterion V, "Instructions, Procedures, and Drawings," of 10 CFR Part 50, Appendix B, states, in part, that activities affecting quality shall be prescribed by documented instructions, procedures, or drawings of a type appropriate to the circumstances and shall be accomplished in accordance with these instructions, procedures, or drawings. Instructions, procedures, or drawings shall include appropriate quantitative or qualitative acceptance criteria for determining that important activities have been satisfactorily accomplished.

Section 5.0, "Instructions, Procedures and Drawings," of Spectrum's Quality Assurance Manual (QAM), Revision 4, dated March 22, 1992, stated in part: "All activities affecting quality shall be prescribed and performed in accordance with documented instructions, procedures or drawings" and also stated in part: "Instructions, procedures or drawings shall include or reference appropriate quantitative or qualitative acceptance criteria for determining that prescribed activities have been satisfactorily accomplished."

Contrary to the above, as of February 5, 2004, Spectrum had not established any procedures or instructions officially to prescribe the utilization of and compliance with Spectrum "Policy Memoranda" which were intended to govern various activities affecting quality. Although Spectrum personnel were unofficially required to comply with the memoranda, the documents had not been formally incorporated into the QA program. Nonconformance 99901350/2004-201-01.

Spectrum Response:

Spectrum had implemented the Policy Memoranda system in order to immediately capture industry and Spectrum issues to support immediate implementation measures; however, it was never formally incorporated in Spectrum's Quality Assurance Procedures Manual. In response to this non-conformance, Quality Assurance Procedure #QAP/16/002 - "Policy Memoranda", Rev. 0, dated February 4, 2004, was issued. This procedure documents what has been instituted in practice since 1991.

Contrary to the above, as of February 5, 2004, Spectrum had not established adequate procedures or instructions to ensure that the quantitative and qualitative acceptance criteria, delineated in Spectrum's Policy Memoranda documents, were appropriately specified in Spectrum's "Acceptance Test Procedures."  
Nonconformance 99901350/2004-201-02.

Spectrum Response:

A formal copy of the Policy Memoranda File has been established in the inspection and test laboratory. In addition Generic Procedures are being revised, and any new acceptance test procedures will be written to reference policy memoranda when applicable.

Notice Of Nonconformance 99901350/2004-201-03:

Criterion III, "Design Control," of 10 CFR Part 50, Appendix B, requires in part, that measures be established to assure that applicable regulatory requirements and the design basis are correctly translated into specifications, drawings,

procedures, and instructions. These measures shall include provisions to assure that appropriate quality standards are specified and included in design documents and that deviations from such standards are controlled.

Criterion V, "Instructions, Procedures, and Drawings," of 10 CFR Part 50, Appendix 8, states, in part, that activities affecting quality shall be prescribed by documented instructions, procedures, or drawings of a type appropriate to the circumstances and shall be accomplished in accordance with these instructions, procedures, or drawings. Instructions, procedures, or drawings shall include appropriate quantitative or qualitative acceptance criteria for determining that important activities have been satisfactorily accomplished.

Section 5.0, "Instructions, Procedures and Drawings," of Spectrum's Quality Assurance Manual (QAM), Revision 4, dated March 22, 1992, stated in part: "All activities affecting quality shall be prescribed and performed in accordance with documented instructions, procedures or drawings" and also stated in part: "Instructions, procedures or drawings shall include or reference appropriate quantitative or qualitative acceptance criteria for determining that prescribed activities have been satisfactorily accomplished."

Criterion XI, "Test Control," of Appendix B to 10 CFR Part 50, requires, in part, that a test program be established to assure that all testing required to demonstrate that structures, systems, and components will perform satisfactorily in service is identified and performed in accordance with written test procedures which incorporate the requirements and acceptance limits contained in applicable design documents...Test procedures shall include provisions for assuring that all prerequisites for the given test have been met, that adequate test instrumentation is available and used, and that the test is performed under suitable environmental conditions.

Contrary to the above, as of February 5, 2004, some of Spectrum's generic test procedures lacked certain pertinent references, failed to specify appropriate measuring and test equipment, omitted certain pertinent tests, or lacked adequate specificity when prescribing certain test steps, test parameters or acceptance criteria. Nonconformance 99901350/2004-201-03.

#### Spectrum Response:

- Generic Procedures did not prescribe equipment identification by unique serial numbers or specimen numbers by which test data could be traced to individual items, nor did the memos or the GPs themselves refer to Spectrum QAP 008/001, Revision 2, dated December 4, 1993, which specified how items were to be marked or labeled upon receipt as would be expected under Equipment Identification.

Spectrum's Generic Procedures have been revised to add the following requirement: "Each item/container shall be identified as described in QAP/8/001", where container means the box or package in which items may be contained. Any additional or customer specific information required shall be included in the technical memo for dedication."

- Generic Procedures did not reference EPRI Report NP-6406, "Technical Evaluation of Replacement Items; nor did they all reference NRC Generic Letter 89-02 which endorsed the acceptance methods of NP-5652, but imposed restrictions and caveats on the use of Methods 2 and 4 alone. Also not referenced was NRC Generic Letter 91-05 which, among other things promulgated the NRC staff positions on critical characteristics and so-called "like-for-like" or "identical" determinations which are often essential in dedication for verification of the critical characteristics of seismic and/or environmental qualification of dedicated production items.

Reference to Generic Letter 91-05 and EPRI NP-6406 have been added to Spectrum's Generic Test Procedures and shall be included in all future Acceptance Test Procedures that are generated.

- The inspectors also noted that the G Ps' Section 4 specified critical characteristics for acceptance, as distinguished from critical characteristics for design. This distinction is contrary to the guidance of NRC Generic Letter 91-05; although it is defined in EPRI NP-6406.

The reference "for acceptance" has been deleted from Spectrum's Generic Test Procedures, and shall not be incorporated in any future Acceptance Test Procedures.

- Paragraph a, under Section 7, "Additional Dedication," of GP 0060 for similarity analysis, stated "Ordering identical parts using the same manufacturer and part number/catalog numbers provides assurance that these parts are the same as those previously qualified." This statement is inconsistent with the guidance in NRC Generic Letter 91-05 that only parts of the same manufacturer, part number, and same time frame of manufacture can be considered identical because even if form, fit and function of CGIs remain the same, there may have been in the interim important changes in manufacturing process and/or materials that were not reflected by a change in part number. Therefore, without having the same time of manufacture (e.g., as determined possibly by date code, lot or batch number, etc., provided lot or batch homogeneity can be established), one would need to determine from the manufacturer what changes have been made in the interim and then reconcile those changes with the performance and durability requirements of the plant application.

GP0060 involves the destructive analysis of newly purchased items to specimens that had been previously qualified by performance of seismic and/or environmental testing. Spectrum does not have design control over equipment provided by the OEMs; therefore, the whole purpose of GP0060 is to independently destructively verify that a representative specimen from the newly purchased items is, in fact, the same in form fit and function to the one that was previously qualified. This is also supported by the functional testing performed during the dedication testing in accordance with the applicable generic test procedure or acceptance test procedure. Along with verifying all of the applicable critical characteristics, the dedication testing also compares physical dimensions and configuration and functional attributes among the newly purchased items so as to establish homogeneity prior to randomly selecting the specimen for destructive testing in accordance with GP0060. Spectrum considers that this practice conservatively applies the guidance in NRC Generic Letter 91-05. To remove any confusion and misinterpretation, GP0060, Rev. 2, dated March 1, 2004, was issued to remove Section 7 "Additional Dedication" since the dedication process will have been completed prior to starting the analysis specified in GP0060.

- The inspectors also noted that the GPs did not reference any of the item-specific EPRI Joint Utility Task Group (JUTG) Technical Evaluations or manufacturers' specifications in Section 3.1; although some of the memos provided for identifying certain manufacturer data such as MCCB time-current characteristics to be listed on the memo for GP 0010 on MCCBs. Section 3.1 of the GPs did not list EPRI Report NP-7218 on sampling as a reference, yet its provisions were sometimes specified in Section 5.

Spectrum's Generic Procedures have been revised to include reference to the applicable EPRI JUTG Technical Evaluations, and to reference EPRI Report NP-7218. Manufacturer specifications are included in the technical memoranda that are generated for each application of a Generic Procedure.

- Section 4 of the GPs listed the critical characteristics to be verified for acceptance of the items being dedicated. However, in some cases, not all critical characteristics were addressed. For example, GP0010 for MCCBs, did not address individual pole resistance (although temperature rise was addressed). It also did not address interrupting capacity which must be verified; even if by indirect means for dedication of production item purposes.

All Spectrum's Generic Procedure have been reviewed, and upgraded, where necessary, to specifically identify all applicable critical characteristics. Individual pole resistance and interrupting capacity were added to section 4 of GP0010.

- The GPs did not address published industry operating experience (OE) documents relevant to dedication and qualification of commercial-grade items. These would include component or component-type-specific NRC generic communications, notifications pursuant 10 CFR Part 21,

manufacturers' technical/service bulletins, or various OE publications and data sources from the Institute for Nuclear Power Operations (INPO). Vendors such as Spectrum often obtain these documents, as they do EPRI documents, through their nuclear utility customers.

Spectrum is very proactive in reviewing NRC generic communications, part 21 notifications, manufacturer's technical/service bulletins and any other publications that relate to the equipment and process included in our dedication/qualification process. Such issues are identified and discussed at weekly all hands meetings, and Our Qualification Engineer is responsible incorporating pertinent information into applicable dedication and qualification procedures. We consider that it would be impractical to specifically reference all sources of such information in the procedures.

- Section 3.1 of GP 0010 for MCCBs appropriately listed Underwriters' Laboratories (UL) Standard UL-489 and National Electrical Manufacturers Association (NEMA) Standard AB 4 1996, but omitted pertinent references such as EPRI NP-7410, Volume III, which contains important guidance on MCCB testing, the GE MCCB Applications guide, NEMA Standards AB 1 or AB 3, and NUMARC 90-14, the counterfeit MCCB recognition guide published by the former Nuclear Management and Resources Council (now the Nuclear Energy Institute or NEI). None of the numerous NRC generic communications on MCCBs (except for Bulletin 88-10) were addressed.

GP0010, Generic Test Procedure for Acceptance Testing and Dedication of Molded Case Circuit Breakers, has been revised to include reference to EPRI NP7410, NEMA AB 1, NEMA AB 3, and NRC Generic Letters 89-02 and 91-05. Much of the guidance in NUMARC 90-14 is out of date (e.g., NUMARC 90-14 specifies that Westinghouse molded case circuit breakers should have a factory seal with a "circle W" printed on it between the body and cover. Cutler-Hammer now provides these Westinghouse breakers, and the "circle W" is no longer printed on the factory seals). The NUMARC information that is still valid are identified in Spectrum Generic Procedure #GP0010.

- Section 3.1 of GP 0036 on auxiliary/control relays listed UL-508, a general standard on industrial control equipment, but failed to list the two most important references specifically for relays, NEMA Standard ICS 1 and Institute of Electrical and Electronic Engineers (IEEE) Standard C37.90. None of the numerous NRC generic communications on relays were addressed.

The references to NEMA ICS 1, IEEE C37.90 and applicable NRC generic communications has been added to GP0036.

- Section 5 of the GPs specified the actual acceptance testing. However, some pertinent tests were omitted or the necessary range of test parameters was not adequate. For example, GP0010 for MCCBs did not specify a trip-free function test, an overvoltage withstand test for accessory devices, or all the necessary tests for proper function of undervoltage trip devices. GP0030 for starters and contactors appropriately specified checking pickup and dropout voltages, but did not verify the capability of the contactor to operate continuously at the maximum DC control voltage to which the coil might be exposed for some time during an equalizer battery charge. A maximum dropout voltage test specifying dropout voltage  $\leq 70\%$  of rated voltage was appropriate, but the GP did not specify a minimum dropout value, i.e., the voltage below which the contactor must dropout. The maximum dropout voltage demonstrates adequate force developed by the coil/electromagnet at reduced voltage, but the minimum dropout test demonstrates adequate return spring strength and positive freedom of operation at reduced forces. Finally, the GP did not specify that the functional tests be conducted with the coil at its maximum continuous operating temperature at which coil winding resistance is highest and hence coil current and resultant magnetic force are lowest.

GP0010 has been revised to include a trip-free function test, operation of accessory devices at maximum voltage. Functional testing of undervoltage trip devices is included in GP0010.

Minimum coil dropout voltage is seldom specified by the manufacturer or required by the customer. In cases where minimum dropout is required, the technical memo will include a test and specificatoin

for verification of this parameter. In accordance with GP0030, contactors and starters are tested at maximum rating. Testing to maximum DC control voltage is performed as required by the customer. GP0030 has been revised to specifically required that functional testing be performed immediately following current carrying capacity/temperature rise testing.

- GP0036 for auxiliary/control relays did not address the critical characteristics of mechanical function, i.e., state of normally open and normally closed contacts, interlocks, armature overtravel, and contact wipe, where applicable. In addition, the GP specified an insulation resistance test of 1000 Vdc for one minute with  $\leq 1$  megohm. However, the applicable industry standards, NEMA ICS-1 and IEEE C37.90 call for hi-pot testing (dielectric withstand) at twice rated voltage plus 1000 Vdc for example. In functional tests, maximum dropout was specified at  $\leq 70\%$  of rated coil voltage, but there was no minimum dropout voltage verified. As with starters, the relay GP did not address hot-coil functional tests as prescribed by the industry standards.

Response:

Mechanical functional critical characteristics for auxiliary/control relays has been included in verification of the relay configuration. In addition, ICS-1 and IEEE37.9 have been added to the list of references, and hi-pot testing has been incorporated in GP0036. Minimum coil dropout voltage is seldom specified by the manufacturer or required by the customer. In cases where minimum dropout is required, the technical memo will include a test and specification for verification of this parameter. Also, GP0036 has been revised to specifically require that functional testing be performed immediately following current carrying capacity/temperature rise testing.

- With regard to specifying the appropriate measuring and test equipment (M&TE), the GPs did not do so; nor did the attached memos. Section 3.3, "Instrumentation," of all the GPs reviewed simply contained a blanket statement requiring calibration per MIL-STD-45662 and traceable to the National Institute of Standards and Technology (NIST), or other recognized and documented standards or basis. While these requirements are appropriate, they are very general and incomplete. MIL-STD-45662 (no longer in effect) describes a calibration quality control program. The GPs did not specify calibration requirements, such as those of industry standards (e.g., ASTM) or M&TE manufacturers, pertinent to the types of M&TE that would or should be used for the testing the types of components being dedicated. The inspectors noted that a previous NRC inspection of Spectrum identified that the company had used a calibration service contractor that had a nuclear QA program, but was not competent or properly equipped to perform the calibration for which it was hired (nonconformance closed), in that case, Spectrum's Rockwell hardness tester. The inspectors determined that selection and use of M&TE was left largely to the skill and discretion of the technicians, which even with supervision, is contrary to QA requirements. The inspectors recognized that in many cases, the only M&TE available was of the proper type, but in other cases, technicians would need to choose among more than one piece of M&TE, not all of which might be optimum or even appropriate, not to mention the various settings and modes of use available without documented guidance in the GPs. For example, in performing a test of the instantaneous magnetic trip function of MCCBs, there was no requirement to ensure that the test set to be used was capable of sensing the phase angle of the input voltage or current in order to time the shutting of its contacts and initiate current flow with the minimum asymmetrical current or "DC offset" which can introduce significant error into the test results. Not all of Spectrum's MCCB test sets had this capability.

All Generic Test Procedures have been revised to include the following statement in section 3.3: "Test measuring equipment shall be capable of monitoring the required parameters of this procedure with the proscribed accuracy. If a specific model or special instrument is required, it shall be stated in the text of the procedure or on the technical memo." In accordance with Spectrum's Quality Assurance Manual, it is the responsibility of the Inspection and Test Lab Supervisor to assure that his technicians use the proper type, range, accuracy and tolerance for measuring and test equipment used during testing. He is actively involved in such decisions. The following statement has been added to GP0010 - Test Procedure for Acceptance Testing and Dedication of Molded Case Circuit

Breakers, section 5.6 - Instantaneous Overcurrent Trip Test: "This test shall be performed with a Multi-Amp Model PS600 circuit breaker tester, or another model if capable of sensing the phase angle of the input voltage or current in order to time the shutting of the contacts and initiate current flow with the minimum asymmetrical current of DC offset.

Notice Of Nonconformance 99901350/2004-201-04:

Criterion VIII, "Identification and Control of Materials, Parts, and Components," of Appendix B to 10 CFR Part 50, requires, in part, that measures be established for the identification and control of materials, parts, and components, including partially fabricated assemblies. These measures shall assure that identification of the item is maintained by heat number, part number, serial number, or other appropriate means, either on the item or on records traceable to the item, as required throughout fabrication, erection, installation, and use of the item. These identification and control measures shall be designed to prevent the use of incorrect or defective material, parts, and components.

Contrary to the above, as of February 5, 2004, Spectrum had not uniquely or adequately identified some components in its dedication and qualification specimen library such that the components were no longer traceable to their item-specific performance records.

Nonconformance 99901350/2004-201-04.

The inspectors found several components that were inadequately identified such that with multiple specimens in a test, the results could not be attributed to a particular specimen. For example, MCCB parts in a bag from Job No. 02P1240 were marked as Line Item 1, parts 7 of 8 and 8 of 8. There were tags in the bag marked seismic specimens 1 and 2, but they were not attached to the parts. Fortunately, in this case, Data Sheet 11, Page 1 of 7, associated seismic specimen No.1 with part No.7 and specimen 2 with part 8. However, in another case, Job 02P2030, the data sheet indicated that PO line item 7, piece or item nos. 8 and 9 of 15 were seismic specimens 10A and 10B, but upon examining the library specimens themselves, the inspector found that the parts had green stickers marked "seismic specimen", but no tags to uniquely identify them. Nevertheless, in the instances in question, all the test results were satisfactory and comparable; so that traceability of particular sets of results to a specific item was less important with regard to their use in comparison to production items for verification on one or more critical characteristics.

Spectrum Response:

Traditionally, Spectrum had been using green tags, attached with string, to identify qualification specimens. Because these green tags are sometimes removed to facilitate actual testing, Spectrum recently implemented the practice of also identifying the specimen numbers on a more permanent green adhesive sticker (or metal tag for harsh environment specimens) applied directly to the specimen. Although this sticker/tag identified the job number, line item number and specimen number, it did not identify the item with in the line item (e.g., Line Item 1, Item 3 of 10). We have initiated the practice of including the item number of the line item on the specimen stickers and tags. This has been formally implemented in revision 3 to Spectrum's Quality Assurance Procedure #QAP/8/001 "Identification and Control of Items.

Unresolved Item 99901350/2004-201-05:

While observing verification and documentation of certain critical characteristics for seismically qualified circuit breaker retrofit kits for the Clinton Power Station, the inspectors noted that one item in the retrofit kits was lock washers that were specified as ASTM Grade-5-to-8. However, neither the shop traveler, nor the associated acceptance test procedure, No. AP04P0130/1, had any documented requirements for verification of the ASTM Grade-5-to-8 designation. Instead, Spectrum technicians stated that they relied upon a so-called "standing order" that required routine verification of ASTM Grade 5 or better "fasteners." A binder at the Inspection and Test Supervisor's work area contained several such standing orders, called "policy memoranda", that required verification of various attributes by testing and inspections.

The hardness testing requirements for ASTM Grade 5 or better fasteners were prescribed by Spectrum's Policy Memorandum 92-4, Revision 4, dated July 31, 1996. It required that Grade 5 fasteners or better be used wherever

structural or load-bearing considerations are involved. It also required that all Grade 5 or better (e.g. Grade 8) fasteners obtained from commercial sources be checked by performance of a Rockwell hardness test upon receipt. However, the acceptance test procedure did not reference any of the policy memoranda, including No. 92-4.

Discussion with Spectrum personnel regarding control of these policy memoranda within the OA program revealed some additional weaknesses. First, Spectrum inspection and testing technicians stated that acceptance test procedures typically did not prescribe tests or inspections covered by policy memoranda, nor did they typically reference applicable policy memoranda. Further, the policy memoranda in the binder were not officially part of Spectrum's documented QA program. The policy memoranda were actually stand-alone documents and were not controlled within Spectrum's OA procedures or instructions.

One additional issue that was not fully dispositioned by the inspectors was Spectrum's use of the term "fasteners," and what that actually encompassed. Spectrum stated that the intent of the policy memorandum was that only bolts and nuts were required to be tested. However, the inspectors pointed out that in critical bolting applications, it is typical industry practice to verify the quality and suitability and material or material properties, including, hardness, strength, and often corrosion resistance and compatibility, as required for the application, of all the associated hardware, including flat and lock washers or other locking devices. The inspectors found that if Policy Memorandum 92-4 was only supposed to cover nuts and bolts, then it was, at best, ambiguous in that it did not specify which types of hardware, commonly considered to come under the heading of "fasteners", were required to be tested and which were not. The inspectors did not verify whether any additional objective evidence may have been available at Spectrum to confirm that interpretation. Therefore, Unresolved Item 99901350/2004-201-05 was identified in this area.

**Spectrum Response:**

As specified above in Spectrum's response to Nonconformance 99901350/2004-201-01, Quality Assurance Procedure QAP/16/002, formally institutes the Policy Memoranda system. Also, as specified above in Spectrum's response to Nonconformance 99901350/2004-201-02, Spectrum's Qualification Engineer has been directed to reference any and all applicable policy memoranda in dedication and qualification procedures that he generates. This will be monitored by QA.

The fasteners for which Spectrum is involved are used for assembly of equipment being qualified by Spectrum. In all cases, after establishing homogeneity among purchased fasteners through single purchase batches, visual inspection and, for grade 5 and higher screws/bolts and nuts, hardness testing, specimens are randomly selected for assembly of the equipment specimens to be subjected to qualification testing. This establishes a confidence level based on these representative fastener specimens having survived and functioned properly through the qualification testing. Spectrum has researched requirements for flat washers and lock washers. Based on this research a new policy memorandum "04-1" has been issued. This policy memorandum now includes hardness requirements for flat and lock washers, as follows:

| <u>SIZE</u>                           | <u>HARDNESS RANGE</u>   | <u>SIZE</u>                    | <u>HARDNESS RANGE</u> |
|---------------------------------------|-------------------------|--------------------------------|-----------------------|
| <u>Grade 5 Screws/Bolts:</u>          |                         | <u>Grade 8 Screws/Bolts:</u>   |                       |
| 1/4" through 3/4"                     | RC25 - RC34             | 1/4" through 1"                | RC33 - RC39           |
| Greater than 3/4" up to 1"            | RC19 - RC30             | <u>Grade 8 Nuts:</u>           |                       |
| Grade 5 Nuts (ALL)                    | Less Than RC32          | 1/4" through 5/8"              | RC24 - RC32           |
| Unhardened Flat Washers               | No Hardness Spec. Given | 3/4" through 1"                | RC26 - RC34           |
| <u>Through Hardened Flat Washers:</u> |                         | Carbon Steel Split Lockwashers | RC45 - RC51           |
| Un-Coated                             | HRC38 - HRC45           | Carbon Steel Tooth Lockwashers | RC40 - RC50           |
| Zinc Coated by Hot Dip Process        | HRC26 - HRC45           |                                |                       |

Washer hardness values are taken from the Industrial Fastener Institute Fastener Standards, Sixth Edition.