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REGULATORY GUIDE

Technical Lead
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REGULATORY GUIDE 1.129

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MAINTENANCE, TESTING, AND REPLACEMENT OF VENTED LEAD-ACID STORAGE BATTERIES FOR NUCLEAR POWER PLANTS

A. INTRODUCTION

Purpose

This regulatory guide describes methods and procedures that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use in complying with the agency's regulations with regard to the maintenance, testing, and replacement of vented lead-acid storage batteries in nuclear power plants. This revision of Regulatory Guide 1.129 endorses (with certain clarifying regulatory positions described in Section C of this guide) the Institute of Electrical and Electronics Engineers (IEEE) Standard (Std) 450-2010, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications" (Ref. 1).

Applicable Rules & Regulations

Specifically, the method described in this regulatory guide relates to General Design Criteria (GDC) 1, 17, and 18, as set forth in Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities" (Ref. 2).

- GDC 1, "Quality Standards and Records," requires that structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed.

- GDC 17, "Electric Power Systems," requires that an onsite electric power system and an offsite electric power system shall be provided to permit functioning of structures, systems, and components important to safety.

- GDC 18, "Inspection and Testing of Electric Power Systems," requires that electric power systems important to safety shall be designed to permit appropriate periodic inspection and testing of important areas and features, such as wiring, insulation, connections, and switchboards to assess the continuity of the systems and the condition of their components.

Written suggestions regarding this guide or development of new guides may be submitted through the NRC's public Web site under the Regulatory Guides document collection of the NRC Library at http://www.nrc.gov/reading-rm/doc-collections/reg-guides/contactus.html.

Electronic copies of this regulatory guide, previous versions of this guide, and other recently issued guides are available through the NRC's public Web site under the Regulatory Guides document collection of the NRC Library at http://www.nrc.gov/reading-rm/doc-collections/. The regulatory guide is also available through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html, under ADAMS Accession No. ML13170A112. The regulatory analysis may be found in ADAMS under Accession No. ML13170A116 and the staff responses to the public comments on DG-1269 may be found under ADAMS Accession No. ML13170A114.

In addition, Criterion XI, "Test Control," in Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 sets forth the following requirements:

- A test program shall be established to ensure that all testing is required to demonstrate that structures, systems, and components will perform satisfactorily in service and is identified and performed in accordance with written test procedures that incorporate the requirements and acceptance limits contained in applicable design documents.

- The program shall include, as appropriate, proof tests before the installation, preoperational tests, and operational tests during nuclear power plant or fuel reprocessing plant operation of structures, systems, and components.

- Test procedures shall include provisions for ensuring that all prerequisites for the given test have been met, adequate test instrumentation is available and used, and the test is performed under suitable environmental conditions.

- Test results shall be documented and evaluated to ensure that test requirements have been satisfied.

To augment those requirements, Criterion XII, "Control of Measuring and Test Equipment," in Appendix B to 10 CFR Part 50 sets forth the following requirements:

> Measures shall be established to ensure that tools, gages, instruments, and other measuring and testing devices used in activities affecting quality are properly controlled, calibrated, and adjusted at specified periods to maintain accuracy with necessary limits.

Related Guidance

- NUREG/CR-7148 "Confirmatory Battery Testing: The Use of Float Current Monitoring to Determine Battery State-of-Charge," (Ref. 3) provides information on confirmatory battery testing; specifically, the use of float current monitoring to determine battery state-of-charge.

- The Model Application for Plant-Specific Adoption of Technical Specification Task Force (TSTF) Traveler TSTF-500, Revision 2, "DC Electrical Rewrite-Update to TSTF-360" (Ref. 4) provides model Technical Specifications for verification of the capability of batteries used in nuclear power plants.

Purpose of Regulatory Guides

The NRC issues regulatory guides to describe to the public methods that the staff considers acceptable for use in implementing specific parts of the agency's regulations, to explain techniques that the staff uses in evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations and compliance with them is not required. Methods and solutions that differ from those set forth in regulatory guides will be deemed acceptable if they provide a basis for the findings required for the issuance or continuance of a permit or license by the Commission.

Paperwork Reduction Act

This regulatory guide contains information collection requirements covered by 10 CFR Part 50 and 10 CFR Part 52 that the Office of Management and Budget (OMB) approved under OMB control number 3150-0011 and 3150-0151, respectively. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number.

B. DISCUSSION

Reason for Change

NRC issued Regulatory Guide 1.129, Revision 2, in February 2007 to endorse (with certain clarifying regulatory positions) IEEE Std 450-2002. Since then IEEE has revised IEEE Std 450-2010 to refine the condition monitoring guidance and the use of rate-adjusted test methods for acceptance testing to ensure consistent performance. The revised IEEE standard provides a succinct document for the condition monitoring of batteries. The staff determined that, based on the revised IEEE standard, a revision to this regulatory guide is necessary for guidance to support new reactor license applications, design certifications, and applications for license amendments.

Background

This regulatory guide provides guidance to manage battery degradation such that a battery in service would retain its readiness for supporting design-basis events. It endorses with certain clarifying regulatory positions the Institute of Electrical and Electronics Engineers (IEEE) Std 450-2010, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications." This standard was developed by the IEEE Power Engineering Society Stationary Batteries Committee and approved by the IEEE Standards Association Standards Board on February 25, 2011. IEEE Std 450-2010 provides the recommended maintenance, test schedules, and testing procedures intended to optimize the life and performance of permanently installed, vented lead-acid storage batteries used for standby power applications. It also provides guidance to determine when batteries should be replaced. This standard applies to full-float stationary applications in which a battery charger normally maintains the battery fully charged and supplies the direct current (dc) loads. However, specific applications, such as emergency lighting units, semi portable equipment, and alternate energy applications, may have other appropriate practices that are beyond the scope of the recommended practice. This standard does not include any other components of the dc system, and it does not require inspection and testing of the dc system even though the battery is part of that system. Also, this standard does not specifically address Class 1E batteries in nuclear generating stations.

IEEE Std 450-2010 is an updated national consensus standard that adds new recommendations and requirements, as well as informative annexes, which reflect the current state of technology for vented lead-acid batteries. It is important to recognize that IEEE Std 450-2010 states that it should be used in conjunction with IEEE Std 484-2002, "IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications" (Ref. 5), and IEEE Std 485-2010, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications" (Ref. 6). Consequently, some of the test acceptance criteria in IEEE Std 450-2010 depend on having sized the batteries in accordance with IEEE Std 485-2010 and also on properly trending of battery capacity test data to predict the end of life. For example, the battery replacement criteria in IEEE Std 485-2010 are based on IEEE Std 450-2010, which recommends that the batteries be replaced when their actual performance reaches 80 percent of their rated performance. In addition, IEEE Std 485-2010 recommends that, to

ensure the batteries are capable of meeting their design loads throughout their service life, the batteries' rated capacity should be at least 125% (1.25 aging factor) of the load expected at the end of its service life.

IEEE Std 450-2010 also introduces the importance of monitoring battery parameters to maintain a fully operational battery, but cautions against the use of monitoring in lieu of periodic inspections.

IEEE Std 450-2010 recommends using stabilized charging (float) current as an indicator to determine a fully-charged condition for vented lead-calcium batteries. It states that after battery discharge, the recharge current is initially high (typically for a few hours) but rapidly decreases to a relatively constant value as the battery voltage approaches the charger voltage. When the charging current stabilizes at the charging voltage for three consecutive hourly measurements, the battery is near full charge. IEEE Std 450-2010 also states that some methods to determine the state of charge are better suited than others for some battery cell plate metallurgies. For vented lead-antimony batteries, IEEE Std 450-2010 recommends using electrolyte specific gravity and battery float voltage measurement readings for determining a fully-charged condition. The manufacturer should be consulted for the recommended charging method, as well as for the charging current and voltage parameters.

NRC-sponsored research on batteries is documented in NUREG/CR-7148 (Brookhaven National Laboratory) and it confirmed the effectiveness of float current monitoring to verify the state-of-charge of lead-calcium batteries. The research further determined that using float current as an indicator over specific gravity has an advantage in determining a battery's state-of-charge in that float current provides an indication of the entire battery string, while specific gravity is measured on a cell by cell basis. However, using specific gravity is still an acceptable approach to determine a battery's state-of-charge even though it is no longer a recommendation in the revised IEEE Std 450-2010. The test monitoring equipment used for the research program included a calibrated shunt connected to a data acquisition system and a more sophisticated device that was based on the principles of the Hall Effect. These monitoring devices were used to enhance data collection trending and record battery parameters. Due to the low float current levels and the importance of needing to know when a battery has the required capacity and capability to perform its design function, it is extremely important to use precise, calibrated instrumentation when taking float current measurements for determining a battery's state-of-charge.

NUREG/CR-7148 used two different monitoring methods for determining a battery's state-of-charge. The first method relies on stabilized charging (float) current to determine a fully-charged condition as recommended in IEEE Std 450-2010. For the first method, the research testing demonstrated that the battery strings were able to meet their capacity and capability requirements at the point where the float current was stable for three consecutive hours. The research testing determined that the tested batteries reached a stable float current in the 0.5-2.0 amp range depending on the battery type and recharge characteristics. Specifically, the testing demonstrated the adequacy of using stabilized float current to determine the state-of-charge of vented lead-calcium batteries. However, the specific point at which a battery can be considered fully charged needs to be established by the end user on a battery-by-battery basis.

The second method was a three time constant approach. The method relies on the exponential pattern of charging current delivered by a conventional voltage-regulated charger after a discharge to be able to evaluate when the battery can be considered fully charged. The three time constant method is explained in Appendix A of NUREG/CR-7148. Battery testing during the research determined that float current reached a value equivalent to three time constants on the exponentially shaped recharge/float current curves as illustrated in Appendix A of NUREG/CR-7148. Using this method, the research determined that the tested batteries reached a fully charged state in the 1.6-18.4 amp range depending on the battery type and recharge characteristics. NUREG/CR-7148 cautions that the calculated time

constants are not equal for all battery types. Therefore, the end user will need to establish its own values for calculating the return-to-service float current limit on a battery-by-battery basis.

The NRC recognizes both float current monitoring methods for determining a battery's state of charge. However, the differences between these methods will require the end user to analyze its own plant dc system design. In addition, the manufacturer should be consulted in determining the appropriate current monitoring method, recharge voltage level, charging current range, and charge duration to ensure optimal battery performance. It is important to note that charging batteries at elevated voltages for inappropriately long periods can cause a premature failure.

IEEE Std 450-2010 allows the use of a modified performance test in lieu of a service test or a performance test. A service test is a periodic test of the as-found condition of a battery to meet its duty cycle, and its results reflect the effectiveness of maintenance practices. A performance test is a periodic test of the battery capacity, and its results are used to trend battery aging and to determine when the battery needs to be replaced. By contrast, a modified performance test is a test of the battery capacity with the discharge rate modified according to the rules in normative Annex I, "Modified Performance Testing Methods and Examples," of IEEE Std 450-2010. These provisions ensure that the modified performance testing is of sufficient magnitude and duration to envelop every portion of the battery duty cycle, the service test, and the performance test.

The guidance in this regulatory guide is consistent with the Model Application for Plant-Specific Adoption of Technical Specification Task Force (TSTF) Traveler TSTF-500, Revision 2, "DC Electrical Rewrite-Update to TSTF-360."

Harmonization with International Standards

The International Atomic Energy Agency (IAEA) has established a series of safety guides and standards constituting a high level of safety for protecting people and the environment. IAEA safety guides present international good practices and increasingly reflects best practices to help users striving to achieve high levels of safety. Pertinent to this regulatory guide is International Atomic Energy Agency Safety Guide NS-G-1.8, "Design of Emergency Power Systems for Nuclear Power Plants" (Ref. 7), which addresses design provisions for the inspection, testing, and maintenance of the emergency power systems—such as battery equipment in sections 5.1-5.8—as part of the overall periodic testing and maintenance of specific equipment in nuclear power plants. This regulatory guide incorporates similar design and preoperational testing guidelines and is consistent with the basics safety principles provided in IAEA Safety Guide NS-G-1.8.

Documents Discussed in Staff Regulatory Guidance

This regulatory guide endorses, in part, the use of one or more codes or standards developed by external organizations, and other third party guidance documents. These codes, standards and third party guidance documents may contain references to other codes, standards or third party guidance documents ("secondary references"). If a secondary reference has itself been incorporated by reference into NRC regulations as a requirement, then licensees and applicants must comply with that standard as set forth in the regulation. If the secondary reference has been endorsed in a regulatory guide as an acceptable approach for meeting an NRC requirement, then the standard constitutes a method acceptable to the NRC staff for meeting that regulatory requirement as described in the specific regulatory guide. If the secondary reference has neither been incorporated by reference into NRC regulations nor endorsed in a regulatory guide, then the secondary reference is neither a legally-binding requirement nor a "generic" NRC approval as an acceptable approach for meeting an NRC requirement. However, licensees and applicants may consider and use the information in the secondary reference, if appropriately justified and

consistent with current regulatory practice, consistent with applicable NRC requirements such as 10 CFR 50.59.

C. STAFF REGULATORY GUIDANCE

The staff finds that IEEE Std 450-2010 provides methods for maintenance, testing, and replacement of vented lead-acid storage batteries for stationary applications that are acceptable for use in demonstrating compliance with the requirements set forth in GDCs 1, 17, and 18 of Appendix A to 10 CFR Part 50, as well as Criterion XI and XII of Appendix B to 10 CFR Part 50 as they relate to testing the operability and functional performance of the components of large lead storage battery systems, subject to the following regulatory positions:

1. Section 2, "References," of IEEE Std 450-2010 recommended practices should be supplemented with the following:

    - IEEE Std 308, "Criteria for Class IE Power Systems for Nuclear Power Generating Stations," as endorsed by Regulatory Guide 1.32;

2. Section 5.2, "Inspections," of IEEE Std 450-2010 recommended practices should be supplemented with the following:

    - For nuclear power generating station Class 1E batteries, battery float current and voltage should be measured and recorded weekly. Where reference is made to the pilot cell, the pilot cell shall be based on the lowest voltage cell in the battery. If the temperature differential across the battery exceeds more than 5 degrees Fahrenheit (°F), it is appropriate to include average cell temperature in the selection criteria.

3. Section 5.4.1, "State of Charge Indicator," of IEEE Std 450-2010 recommended practices should be supplemented with the following:

    - For nuclear power generating stations, the manufacturer should be consulted in determining the appropriate current monitoring method, voltage level, charging current range, and charge duration to ensure optimal battery performance. Also, vendor recommendations may be considered for determining these parameters.

    - For nuclear power generating station Class 1E batteries, the use of stabilized charging current or the three time constant method to determine a fully charged condition should be limited to lead-calcium batteries, and the use of the stabilized charging current should be verified by measurements during charging. As there is wide variation in the initial and end charging currents, the instrumentation used to measure charging currents should have the appropriate range and sensitivity.

4. Section 6, "Test Schedule," of IEEE Std 450-2010 recommended practices should be supplemented with the following:

    - For nuclear power generating station Class 1E batteries, the battery service test discussed in Section 6.4, "Service," and described in Section 7.6, "Service Test," should be performed in addition to the battery performance test described in

Section 6.3, "Performance." The battery service test should be performed with intervals not to exceed 24 months.

5. Section 6.5, "Modified Performance Test" of IEEE Std 450-2010 recommended practices. The last paragraph states that a modified performance test can be used in lieu of a service test or a performance test at any time and, if the battery has been sized in accordance with IEEE Std 485-2010, a modified performance test is acceptable if the battery delivers a tested capacity of 80 percent or greater. This statement should be replaced with the following:

    - For nuclear power generating station Class 1E batteries, a modified performance test can be used in lieu of a service test or a performance test at any time. The modified performance test should follow the "Rules for Modified Performance Tests" in Annex I, "Modified Performance Testing Methods and Examples," to IEEE Std 450-2010. If the battery has been sized in accordance with IEEE Std 485-2010, the battery is acceptable if (1) it delivers a tested capacity of greater than 80 percent, and (2) there is no indication of degradation as indicated in Section 6.3 of IEEE Std 450-2010. The modified performance test/service test should be performed with intervals not to exceed 24 months. However, when modified performance test/service test results show that the battery has degraded or has reached 85 percent of its expected life with a capacity lower than 100 percent of the manufacturer's rating, modified performance testing should be performed on an annual basis.

6. Section 7.7, "Restoration," of IEEE Std 450-2010 recommended practices should be supplemented with the following:

    - Following the test, record the float voltage of each cell of the string.

D. IMPLEMENTATION

The purpose of this section is to provide information on how applicants and licensees[1] may use this guide and information regarding the NRC's plans for using this regulatory guide. In addition, it describes how the NRC staff complies with 10 CFR 50.109, "Backfitting" and any applicable finality provisions in 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

Use by Applicants and Licensees

Applicants and licensees may voluntarily [2] use the guidance in this document to demonstrate compliance with the underlying NRC regulations. Methods or solutions that differ from those described in this regulatory guide may be deemed acceptable if they provide sufficient basis and information for the NRC staff to verify that the proposed alternative demonstrates compliance with the appropriate NRC regulations. Current licensees may continue to use guidance the NRC found acceptable for complying with the identified regulations as long as their current licensing basis remains unchanged**.**

1 In this section, "licensees" refers to licensees of nuclear power plants under 10 CFR Parts 50 and 52; and the term "applicants," refers to applicants for licenses and permits for (or relating to) nuclear power plants under 10 CFR Parts 50 and 52, and applicants for standard design approvals and standard design certifications under 10 CFR Part 52.

2 In this section, "voluntary" and "voluntarily" means that the licensee is seeking the action of its own accord, without the force of a legally binding requirement or an NRC representation of further licensing or enforcement action.

Licensees may use the information in this regulatory guide for actions which do not require NRC review and approval such as changes to a facility design under 10 CFR 50.59, "Changes, Tests, and Experiments." Licensees may use the information in this regulatory guide or applicable parts to resolve regulatory or inspection issues.

Use by NRC Staff

The NRC staff does not intend or approve any imposition or backfitting of the guidance in this regulatory guide. The NRC staff does not expect any existing licensee to use or commit to using the guidance in this regulatory guide, unless the licensee makes a change to its licensing basis. The NRC staff does not expect or plan to request licensees to voluntarily adopt this regulatory guide to resolve a generic regulatory issue. The NRC staff does not expect or plan to initiate NRC regulatory action which would require the use of this regulatory guide. Examples of such unplanned NRC regulatory actions include issuance of an order requiring the use of the regulatory guide, requests for information under 10 CFR 50.54(f) as to whether a licensee intends to commit to use of this regulatory guide, generic communication, or promulgation of a rule requiring the use of this regulatory guide without further backfit consideration.

During regulatory discussions on plant specific operational issues, the staff may discuss with licensees various actions consistent with staff positions in this regulatory guide, as one acceptable means of meeting the underlying NRC regulatory requirement. Such discussions would not ordinarily be considered backfitting even if prior versions of this regulatory guide are part of the licensing basis of the facility. However, unless this regulatory guide is part of the licensing basis for a facility, the staff may not represent to the licensee that the licensee's failure to comply with the positions in this regulatory guide constitutes a violation.

If an existing licensee voluntarily seeks a license amendment or change and (1) the NRC staff's consideration of the request involves a regulatory issue directly relevant to this new or revised regulatory guide and (2) the specific subject matter of this regulatory guide is an essential consideration in the staff's determination of the acceptability of the licensee's request, then the staff may request that the licensee either follow the guidance in this regulatory guide or provide an equivalent alternative process that demonstrates compliance with the underlying NRC regulatory requirements. This is not considered backfitting as defined in 10 CFR 50.109(a)(1) or a violation of any of the issue finality provisions in 10 CFR Part 52.

Additionally, an existing applicant may be required to comply with new rules, orders, or guidance if 10 CFR 50.109(a)(3) applies.

If a licensee believes that the NRC is either using this regulatory guide or requesting or requiring the licensee to implement the methods or processes in this regulatory guide in a manner inconsistent with the discussion in this Implementation section, then the licensee may file a backfit appeal with the NRC in accordance with the guidance in NUREG-1409, "Backfitting Guidelines," (Ref. 8) and the NRC Management Directive 8.4, "Management of Facility-Specific Backfitting and Information Collection" (Ref. 9).

REFERENCES[3]

1. Institute of Electrical and Electronics Engineers, (IEEE) Standard 450-2010, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications," Piscataway, NJ, 2011[4].

2. *U.S. Code of Federal Regulations*, "Domestic Licensing of Production and Utilization Facilities," Part 50, Chapter I, Title 10, "Energy."

3. U.S. Nuclear Regulatory Commission (NRC), "Confirmatory Battery Testing: The Use of Float Current Monitoring to Determine Battery State-of-Charge," NUREG/CR-7148, Washington, DC, Agencywide Document Access and Management System (ADAMS) Accession No. ML12284A296.

4. Technical Specifications Task Force (TSTF) – A Joint Owners Group,[5] "DC Electrical Rewrite-Update to TSTF-360," TSTF-500, Revision 2, ADAMS Accession No. ML092670242.

5. IEEE, Standard 484-2002, "IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications," Piscataway, NJ, 2003.

6. IEEE Standard 485-2010, "IEEE Recommended Practice for Sizing Lead Acid Batteries for Stationary Applications," Piscataway, NJ, 2011.

7. International Atomic Energy Agency (IAEA), Safety Standards Series, "Design of Emergency Power Systems for Nuclear Power Plants," Safety Guide No. NS-G-1.8," Vienna, Austria, 2004[6].

8. NRC, "Backfitting Guidelines," NUREG-1409, July 1990, ADAMS Accession No. ML032230247.

9. NRC, "Management of Facility-specific Backfitting and Information Collection," Management Directive 8.4.

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3 All publicly available NRC documents are available electronically through the NRC Library on the NRC's public Web site at: http://www.nrc.gov/reading-rm/doc-collections. The documents also can be viewed online or printed for a fee in the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone 301-415-4737 or 800-397-4209; fax 301-415-3548; and e-mail pdr.resource@nrc.gov.

4 Copies of Institute of Electrical and Electronics Engineers (IEEE) documents may be purchased from the Institute of Electrical and Electronics Engineers Service Center, 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855 or through the IEEE's public Web site at http://www.ieee.org/publications_standards/index.html.

5 Administered by EXCEL Services Corporation, 11921 Rockville Pike, Suite 100, Rockville, MD 20852. https://www.excelservices.com/

6 Copies of International Atomic Energy Agency (IAEA) documents may be obtained through their Web site: WWW.IAEA.Org/ or by writing the International Atomic Energy Agency P.O. Box 100 Wagramer Strasse 5, A-1400 Vienna, Austria. Telephone (+431) 2600-0, Fax (+431) 2600-7, or E-Mail at Official.Mail@IAEA.Org