

CURRENT ACTIVITIES OF THE ASME SUBGROUP NUPACK

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ABSTRACT

Current activities of the American Society of Mechanical Engineers (ASME), Section III Subgroup on Containment Systems for Spent Fuel and High-Level Waste Transport Packagings (also known as Subgroup NUPACK) are reviewed with emphasis on the recent revision of Subsection WB. Also, brief insights on new proposals for the development of rules for internal support structures and for a strain-based acceptance criteria are provided.

INTRODUCTION

Subgroup NUPACK (standing for nuclear packaging) was organized by the American Society of Mechanical Engineers (ASME) in 1982 in anticipation of a greatly increased need for the transportation of spent nuclear fuel to a Department of Energy (DOE) repository. ASME created a new Division 3 within Section III where these new construction rules for the design, fabrication, inspection and testing of transportation containments would be located. In 1997, the first version of Division 3 was issued. Since that start, Subgroup NUPACK has continued to improve and enhance the rules for transportation containments and has also expanded its scope to address storage containments as well. Subgroup membership is voluntary and consists of individuals from industry, Department of Energy (DOE) national laboratories, and the U.S. Nuclear Regulatory Commission. The current Chair is Mr. Gerald Foster.

The current rules in Division 3 address only the structural integrity of containments for transportation packagings and for storage canister systems. Currently, Division 3 does not address other items such as shielding, impact limiters, or outer barriers. Division 3 containments are typically not high pressure containments where the Design Pressure at Design Temperature controls the final design. It is the accidental drop events that are specified to have either Level A

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Service Limits (e.g., a one-foot drop) or Level D Service Limits (e.g., a 30-foot drop) that control the final design of the containment. Division 3 containments are designed with the expectation that leakage should be minimized (meeting any Design Specification criteria), with some designs even going as far as remaining leaktight. In addition, where appropriate, the container and associated internal support structures should be structurally designed to address any criticality concerns.

INDUSTRY USAGE

Subgroup NUPACK is aware that Section III, Division 3 has not gained full acceptance by the nuclear industry for a number of major reasons. These factors include difficulties with implementation of requirements as originally issued in 1997 and a lack of endorsement from the regulatory agency. Therefore, the goal of Subgroup NUPACK has been to consolidate appropriate rules for transportation and storage containments into one Division that are fully applicable to these types of containments, rather than having to take exceptions to rules established for nuclear reactor components. Hence, with past and on-going revision efforts that have included significant participation by industry representatives, the latest Section III, Division 3 rules [anticipated to be fully issued in the 2008 Addenda of the 2007 Edition of the ASME Boiler & Pressure Vessel (B&PV) Code] are expected to be rules that industry can effectively implement on new design efforts. In addition, the U.S. Nuclear Regulatory Commission's Division of Spent Fuel Storage and Transportation is planning to initiate a review of Section III, Division 3 starting in fiscal year 2008.

STATUS OF SUBSECTIONS WA, WB, AND WC

Division 3 currently consists of Subsection WA (General Requirements), Subsection WB (Class TC Transportation Containments), and Subsection WC (Class SC Storage Containments). Subgroup NUPACK is actively preparing (via a Task Group reporting to the Working Group on the Design of Division 3 Containments) a new Subsection WD that would consist of rules for internal support structures. This Working Group was instituted after lessons learned from writing Subsection WC in 2004. Subgroup NUPACK recognized that it was very important to fully specify all of the design rules (Article-3000) prior to starting to write the other rules for materials, fabrication, examination, and testing (Articles -2000, -4000, -5000, and -6000 respectively).

Subsection WA

After the initial issuance of Division 3 in 1997, one of the first major rewrite efforts for Subgroup NUPACK was the revision of the rules in Subsection WA. In order to better interface with the commercial nuclear industry, to improve the quality assurance aspects, and to have a framework of criteria more similar to Division 1, Subsection WA was significantly revised and was reissued in the 2001 Edition of the ASME B&PV Code.

One important aspect to recognize is that Division 3, although similar to Division 1, has taken a slightly different approach regarding the definition of conditions, loads, and associated stress limits. The requirements identified in Federal Regulations 10 CFR Part 71 and 10 CFR Part 72 have clearly guided the development of Subsections WB and WC, respectively. With regard to

transportation and storage containments, the Design Specification is mandated to identify the loadings and combination of loadings and the applicable Design and Service Limits for the stresses resulting from those loadings. WA-2123 has established that normal loadings result from normal conditions; off-normal loadings result from off-normal conditions (applicable to storage containments only); accident loadings result from accident conditions; and that test loadings include pressure and leak tests specified by the respective WB/WC-6000. WA-2123 then continues to discuss Design Loadings, Operating Loadings, and Test Loadings in WA-2123.1, WA-2123.2, and WA-2123.3, respectively. Finally, WA-2123.4 specifies that Design Limits shall be satisfied for design loadings, Level A Service Limits must be satisfied for all normal loadings (which for transportation containments can include a one-foot drop resulting in primary stresses), Level C Service Limits must be satisfied for all off-normal loadings (only applicable to storage containments of Subsection WC), Level D Service Limits must be satisfied for all accident loadings, and that Test Limits shall be satisfied for test loadings.

Recently issued changes in the 2007 Edition of the ASME B&PV Code indicate that in WA-2123.1(c), Design Mechanical Loads are no longer required to bound loadings for which Level A Service Limits are designated (as in Division 1). This change was appropriate since Division 3 rules (both WB-3000 and WC-3000) have now incorporated rules for the evaluation of primary stresses under Level A Service Limits. This permits designers to address loads such as the transportation required one-foot drop event considering coincident pressure and temperature conditions.

The initial release of Subsection WB did not include the Dimensional Standards Table WB-3132-1 although it was referenced in the rules. In addition, many of the specifications identified in Subsection WB had their issue dates listed with the noted specifications (i.e., ASTM E-185-82 and SNT-TC-1A-1992). Subgroup NUPACK recognized that updating the issue dates of these standards and specifications throughout Division 3 would be much simpler (and with less error) if the dates were listed just once. Since multiple Subsections existed, it was decided to create a new Article WA-7000 where the Dimensional Standards Table could be placed as well as a Table that listed all of the Specifications and Standards listed in Division 3 and their respective issue dates. These dates could then be easily corrected as necessary in one place. This permitted the elimination of the issue dates throughout Division 3, especially in Articles -2000 and -5000. This change is expected to be issued with the 2008 Addenda of the ASME B&PV Code.

Subsection WB

Subsection WB (for transportation containments) has six Articles that following the Introduction (WB-1000), “establish rules” for Material (WB-2000), Design (WB-3000), Fabrication (WB-4000), Examination (WB-5000), and Testing (WB-6000). “The rules of Subsection WB cover the strength and containment integrity of items the failure of which would violate the containment boundary” (WB-1100).

Subsection WB has required significant revision since Subsection WA underwent the major rewrite and issuance in 2001. Reflecting an enhanced approval process within the Section III subcommittee and its pertinent reporting Subgroups, Subgroup NUPACK (addressing WB-1000 and with overall coordination responsibility), Subgroup on Materials, Fabrication and

Examination (addressing Articles -2000, -4000, -5000 and -6000), and Subgroup Design, including its reporting Working Group on the Design of Division 3 Containments, (addressing Article-3000) have combined their efforts to write, review, and approve a new Subsection WB, updating its rules, making it more compatible with Subsection WA, and making it more usable for the nuclear industry.

A summary of the major revisions recently made to Subsection WB, the first major revision to Subsection WB since 1997, follows. Common changes throughout the entire Subsection typically included replacing words such as “vessel”, “component”, and “systems” with “containment”. In addition, since the new WA-7000 was introduced, the dates of certain specifications and standards within the main body of Subsection WB were removed. These changes are expected to be published in the 2008 Addenda, changing the existing rules published in the 2007 Edition.

Article WB-1000 Introduction

Article WB-1000 has fundamentally remained the same, providing the scope for Subsection WB (WB-1100) and the rules for Class TC containments (WB-1120) and the description of the containment boundaries (WB-1131). However, much more details have been provided for the boundary between a containment and attachments (WB-1132).

Article WB-2000 Material

Article WB-2000 was updated with numerous editorial and errata changes and a limited number of technical changes. The choice of containment materials was limited to those listed in Tables 2A and 2B from Section II, Part D and the revision also placed an additional material limitation to those P numbers listed in Table WB-4622.1-1. The existing rules for castings and references to castings were removed and a statement added that these rules are in the process of development. References to brazing were deleted. A new Subarticle WB-2190 was added to specifically address “material not performing a containment function”. References to valves and electroslag welding were deleted throughout.

Article WB-3000 Design

Article WB-3000 was rewritten to reflect the changes made in Subsection WA regarding Design Loadings (Design Pressure, Design Temperature, and Design Mechanical Loads) as well as the revised Design, Service, and Test Limits (replacing just normal operating condition limits and hypothetical accident condition limits). Only Level A or D Service Limits (in addition to Design Limits and Testing Limits) are specified. Since Division 3 has elected to not specify a Level B Service Limit, primary stress evaluations for Level A Service loadings have been added (i.e., can be used for the one-foot drop at coincident pressure and temperature conditions). Nomenclature for MNOP/MNIP pressures have been replaced with Design Pressure (WB-3112) and operating pressure (WB-3113) rules. Rules for external pressure evaluation from Subsection WC-3133 (originally from Subsection NC-3133) were added as WB-3133 (including the rules for stiffening rings from NB-3133.5). The plastic analysis rules contained in Division 1, Appendix F may be used for the evaluation of loads that have Level D Service limits specified provided the

deformation limits (such as those necessary to limit leakage specified in the Design Specification) are satisfied and no yielding in the bolts or on the sealing surface is permitted when limiting leakage. The decision was made to eliminate Nelms' equation for puncture evaluation (originally in WB-3324). The above decision eliminated the need for WB-3310 and WB-3320 since the remaining paragraphs referenced back to existing rules in WB-3100 and WB-3200. In order to match current industry practices, the philosophy was taken that all design evaluations are performed by detailed analyses. Therefore, hand calculation-type methods for any size of opening and associated reinforcement per WB-3330 were no longer needed and WB-3330 was deleted. However, requirements for small (typically equal to or less than 2 NPS) nozzles and openings not requiring detailed analysis were added as WB-3240. This basically left existing WB-3340 and WB-3350 isolated so the decision was made to bring these two subsubarticles forward into WB-3200. This format is consistent with Subsection WC.

Article WB-4000 Fabrication

Article WB-4000 was updated with numerous editorial and errata changes and a limited number of technical changes. The Article title was changed to reflect the case that transportation packagings are not "installed" like a piping system would be in a nuclear power plant. References to conical and spherical containments were deleted. Although pipe material can be used for containment, rules for forming or bending pipe were removed. Category C weld joints were incorporated. References to "run piping" or "branch piping" were removed. Rules for specially designed welded seals were also deleted. References to brazing were deleted. Finally, references to valves, inertia and continuous drive friction welding and electroslag welding were deleted throughout.

Article WB-5000 Examination

Article WB-5000 was updated with numerous editorial and errata changes and a limited number of technical changes. References to "run piping" or "branch piping" were removed. Rules for specially designed welded seals were also deleted. References to brazing were deleted. Finally, references to valves, inertia and continuous drive friction welding and electroslag welding were deleted throughout.

Article WB-6000 Testing

Article WB-6000 is a revision of the existing WC-6000, updating as necessary for transportation containments. WB-6120 has been revised to address leak testing. Both hydrostatic (WB-6221) and pneumatic (WB-6321) test pressures as well as the external pressure test requirements of WB-6610 have been increased to 1.5 times Design Pressure due to requirements in 10 CFR Part 71. Finally, WB-6700 was added to provide for helium leak testing requirements with a clarification that final closure welds on inner containments constructed to the requirements of Subsection WB may be helium leak tested in lieu of being pressure tested.

Subsection WC

Subsection WC, Class SC Storage Containments, was added to the Division 3 rules in the 2005 Addenda to the ASME B&PV Code. A paper (Reference 1) presented at the 10th International

Conference on Environmental Remediation and Radioactive Waste Management provides additional details on this past Subgroup NUPACK development activity.

SUBSECTION WD: ANOTHER NEW SUBSECTION IN PROGRESS

Subsection WD will establish rules for the construction of internal support structures (e.g., baskets, spacers, dividers, etc.) for transportation or storage containments. The rules of Subsection WD cover the requirements for strength integrity of items, the failure or excessive deformation of which would cause loss of geometric configuration of the containment contents. Geometric configuration is defined as maintaining geometry of the contents as required by the Design Specification to maintain the physical location of the contents in order to maintain criticality control and limit damage from physical contact during accident events. Current committee discussions are focusing on how to provide flexibility in the rules for internal support structures that may not require complete structural integrity but only need to assure certain inelastic deformations are not exceeded while still establishing rules that yield other internal support structure designs that can withstand all of the required loads, resulting only in small deformations.

A draft of Article WD-1000 was completed in 2006 that focuses on small deformation rules and development of Article WD-3000 is ongoing. A draft of WD-3000 is planned for submittal to Subgroup NUPACK at the end of the 2007 summer. Drafting of the remaining WD Articles is anticipated to begin in the late fall of 2007. No date for issuing Subsection WD has been established.

STRAIN-BASED ACCEPTANCE CRITERIA

Hypothetical accidents considered for transport packages include a 30-foot free drop onto an essentially unyielding target and a 40-inch free fall onto a 6-inch diameter puncture bar. For storage casks, accident conditions can include drops, tip-over, and aircraft impact. All of these accident events are energy-limited rather than load-limited, as is typically the case for boilers and pressure vessels. Therefore, it makes sense to have analysis acceptance criteria that are more closely related to absorbed energy than to applied load. Current nonlinear finite element codes used in the design of transportation packagings and storage canisters can accurately predict the high strain response of these containments. Strain-based acceptance criteria are the best way to meet this objective.

As transportation and storage containment vendors' ability to perform non-linear impact analysis has improved, the need for an improved code-based method to interpret the results of this type of analysis efforts has grown. Recognizing this fact, Subgroup NUPACK and the Working Group on the Design of Division 3 Containments are proceeding with efforts to develop strain-based acceptance criteria for use within Division 3 of the ASME B&PV Code. The Working Group on Design Methodology has been requested by the Working Group on the Design of Division 3 Containments to develop the technical details of the strain-based acceptance criteria. It will then be the task of the Working Group on the Design of Division 3 Containments to codify these details. One very important factor that will help this effort to succeed is the support of the U.S.

Nuclear Regulatory Commission's Spent Fuel Project Office in the development of these strain-based acceptance criteria.

CONCLUSION

Since the first issuance of Division 3 of Section III in 1997, the volunteer members of Subgroup NUPACK have devoted a significant amount of time updating, improving, and developing entirely new construction rules for spent nuclear fuel and radioactive waste containments. With the issuance of the revised Subsection WB and other recent improvements to Subsections WA and WC, the nuclear industry and the regulatory agencies now have useful and relevant rules in place that can be readily used to support needs for the future.

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