FCRD-UFD-2012-000327
INL/EXT-12-27133

INL FY12 Submittals for the Can-In-Can Proposal

S. M. Birk

August 2012

The INL is a U.S. Department of Energy National Laboratory
operated by Battelle Energy Alliance

FCRD-UFD-2012-000327
INL/EXT-12-27133

INL FY12 Submittals for the Can-In-Can Proposal

S. M. Birk

August 2012

Idaho National Laboratory
Nuclear Materials Disposition and Engineering
Idaho Falls, Idaho 83415

http://www.inl.gov

Prepared for the
U.S. Department of Energy
Office of Nuclear Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

Nuclear Materials Disposition and Engineering

INL FY12
End of Year Submittals for the Can in Can Concept

FCRD-UFD-2012-000327
INL/EXT-12-27133

August 27, 2012

Approved by:

SM Birk 8-27-12

Sandra M. Birk
Manager, Nuclear Materials Disposition and Engineering

Date

ABSTRACT

This report provides all of the submittals required of the Idaho National Laboratory in completing the work requested in evaluating the viability and feasibility of the proposed Can-In-Can concept proposed by Oak Ridge National Laboratory. The detailed evaluations performed are contained in Appendices to this report. The summary recommendation is that the current proposed design concept be revised such that the construction and use of this proposed canister, including the potential for accidental drops, can be achieved with greater ease and increased safety.

CONTENTS

ACRONYMS

DOE	U.S. Department of Energy
INL	Idaho National Laboratory
ORNL	Oak Ridge National Laboratory

INL FY12 Submittals for the Can-In-Can Proposal

1. BACKGROUND

Oak Ridge National Laboratory (ORNL) has been assigned to take the project lead in developing a storage canister that could place the Department of Energy (DOE) in a better position for commercial used fuel to be ready for final dispositional. Although called a variety of project names, ORNL has currently suggested using the project name of Can-In-Can. Other DOE National Laboratories are supporting this effort by providing review comments on drawings, performing preliminary analyses of the proposed canister performance to various loads, including thermal and accidental drop, and other operational considerations. This team of national laboratory personnel first met on February 14, 2012 in Las Vegas, Nevada to discuss the project and to assign various tasks to each laboratory. Attendees included John Wagner from ORNL, Ken Sorenson from Sandia, Brady Hanson from PNNL, Rob Howard from ORNL, John Scaglione from ORNL, Ned Larson from DOE NV, and others. In preparation for this meeting, ORNL generated an initial set of draft drawings, which were briefly discussed at the meeting. Besides completing their assigned tasks, each laboratory was also requested to provide review comments on the initial set of draft drawings back to ORNL. ORNL would then incorporate those review comments as possible and distribute the updated drawings back to the laboratories for their use in the assigned tasks.

2. INL ASSIGNED TASKS

The Idaho National Laboratory (INL) was assigned four separate tasks at the February 14, 2012 meeting to support the Can-In-Can effort. The first task was to provide review comments on the initial set of draft drawings. The second task was to provide general design commentary on the updated set of drawings released by ORNL. The third task was to perform a scoping or preliminary drop analysis of the Can-In-Can design in order to assess its structural performance during an accidental drop event. Finally, the fourth task was to assess expected drying operations and provide any insights into expected advantages, expected problems, and any improvements that could be implemented to increase drying efficiency. A report addressing the first two tasks (providing drawing and design commentary) are presented in Appendix A. A report addressing the preliminary drop analysis task is presented is submitted in a separate attachment called Appendix B. This separate attachment is due to size of the file. Finally, a report addressing the operational assessment including drying issues is presented in Appendix C.

3. CONCLUSIONS

Each Appendix provides its own set of summarizing conclusions and recommendations. However, in terms of an overall summary, the INL believes that the current proposed concept needs to be redesigned due to the numerous concerns identified and serious consideration be given as to when this concept is actually implemented, preferably at the consolidated storage site(s).

Appendix A

Design Commentary on Proposed Can-In-Can Concept

Appendix A

Design Commentary on Proposed Can-In-Can Concept

BACKGROUND

This appendix addresses two Can-In-Can tasks assigned to the Idaho National Laboratory (INL). The first task was to provide review comments on the initial draft drawings prepared for the first Can-In-Can meeting held on February 14, 2012 in Las Vegas, Nevada. These initial drawings are provided in Attachment A of this Appendix. All participating national laboratory personnel were to provide review comments. INL review comments were provided to Oak Ridge National Laboratory (ORNL) (via email to John Wagner and John Scaglione) on February 29, 2012. For reader convenience, these review comments are provided in Attachment B.

Once the Can-In-Can drawings were updated (see Attachment C (the last three drawings were ignored per ORNL direction), the second task assigned to the INL was to review the updated drawings and provide general design comments along with American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (BPV) Code construction insights. The goal of this effort was to provide additional input to the process of determining if this proposed Can-In-Can concept is feasible.

This Appendix uses the phrase canister rather than can (per drawings) when referring to the larger or smaller used fuel container. This was done to better match industry terminology.

GENERAL DESIGN COMMENTARY

In order to provide structure to the Can-In-Can review comments generated, Tables 1 and 2 were developed. Table 1 addresses the smaller inner canister while Table 2 addresses the larger outer canister. These tables provide both pro and con comments in relation to the typical design consideration categories necessary to complete an ASME BPV Code, Section III, Division 3 construction effort as well as scope and operational use. Note that in Section III, the term 'construction' is defined as:

> *"…. an all-inclusive term comprising materials, design, fabrication, examination, testing, inspection, and certification required in the manufacture and installation of an item"*.

Hence, the tables have been organized to address the Can-In-Can design under material, design, fabrication, examination, and testing categories as well as scope and operational use commentary.

ASSUMPTIONS

Oak Ridge National Laboratory provided the following information regarding how the Can-In-Can system is envisioned to work.

- The smaller canisters will be loaded into the large canister prior to loading in the spent fuel pool so that multiple smaller canisters can be loaded at one time.
- The smaller canister lids will be welded on and the larger canister lid will be bolted on.
- The larger canister will then be placed in an over pack for storage or transportation similar to current functionality for dual purpose canisters (DPCs).
- The repository receipt facility or wherever the canisters are shipped would be where the larger canister would be unpacked and the smaller canisters either emplaced in repository specific over packs or directly disposed.

SUMMARY

The review comment**s** provided in Tables 1 and 2 are intended to help improve the design of the current Can-In-Can concept. These comments are also intended to increase the acceptability of the concept to users and regulatory authorities. However, more design and preliminary analysis work needs to be completed before this concept is sufficiently developed for outside review and acceptance.

Strong opposition to this current proposed concept is expected from the nuclear industry. From their perspective, it is believed that the current Can-In-Can concept simply involves more effort and more radiation exposure to plant personnel with longer plant outages reducing the ability to generate needed power. The reduced fuel capacity of the Can-In-Can concept, even though the outer diameter of the outer canister is much larger than nearly all other storage canisters in current use, means more efforts and more shipments. The nuclear industry has an established storage process. They simply want DOE to remove the storage canisters from their sites.

Rather than assuming this type of loading campaign must occur at the reactor plant, an alternative is to plan on this type of loading effort to occur later, when final disposition plans are actually known. This loading campaign can occur at the consolidated storage site(s) where preparations can be made to complete such a repackaging effort safer and more efficient, with less radiation dose to personnel. The consolidated storage site(s) will undoubtedly be required to develop a mitigation capability to address leaking, damaged, or significantly degraded storage systems. To address this defense-in-depth requirement, the consolidated storage site(s) should also construct a simple yet effective shielded dry cell facility (no rewetting concerns). An inert gas environment can be used to minimize any oxidation or corrosion effects on any exposed components, including fuel assemblies. If any final disposition path requires a fuel assembly evaluation (degraded or not degraded), this dry cell facility will be a necessity. In order to maximize the use of such a facility, during non-use periods, such a facility could even be used for additional nuclear research.

Table 1. Design Commentary on the Smaller Can-In-Can Canister

Item	Category	Subject	Pro	Con
1	Scope	Specified construction code on drawings is “ASME BPV Code 3”	Excellent choice for construction rules but callout is confusing. Most current storage canisters historically used Section III, Division 1 requirements but is Section III, Division 3 implied? ASME wrote Section III, Division 3 specifically for transportation and storage containments. NUREG-1617 identifies Section III, Division 3 as providing acceptable construction rules for transportation. Specifying ASME BPV Code, Section III, Division 3 criteria clarifies many construction details. NRC is currently reviewing Division 3 for future endorsement. New proposed Division 3 strain-based acceptance criteria would be applicable to these canisters, yielding a more efficient design. Division 3 has also nearly completed a new proposed subsection providing rules for internal support structures (baskets). Assuming transportation use, suggest specifying ASME BPV Code, Section III, Division 3, Subsection WB with both transportation and storage loadings evaluated (dual purpose). This would permit use of inner containment rules.	NRC endorsement is not yet achieved and the strain-based acceptance criteria are not yet approved (expected to be submitted to BPV III Standards Committee by August 2012). Would need to assure full Code compliance is achieved with authorized fabrication shop using certified design and construction documentation.

2	Scope	Moderator exclusion	Use of the construction rules identified above achieves a leaktight containment, allowing moderator exclusion to be achieved.	Would moderator exclusion be a functional requirement for the smaller canister? If yes, added safety margin is obviously achieved.
3	Materials	Choice of materials for containment	Good choice of material (316 SST) since it is reasonably economical, ASME Section III approved for Class TC construction, and is good for added pitting corrosion protection (better than 304 SST). 316 SST used by some storage canister vendors as preferred material in marine environments. However, ASME specification callouts (e.g., SA-240 for plate) and product form need to be made on drawings for all Code intended materials, not the UNS designation. Is dual stamped 316/316L acceptable, since chances are high that is what will be procured?	Still some potential concern for stress corrosion cracking with 316/316L. The 30.5-inch OD tube callout is questionable. It does not appear to satisfy the acceptable ASME tube specification callouts like SA-213, SA-249, or SA-688 due to the larger OD size. If not a standard size, more fabrication costs are involved and more welds. Is the product seamless or welded? Is the tube centrifugal cast? Can 30 or 32 NPS pipe be used?
4	Materials	Choice of materials for internal support structures (baskets)	Difficult to provide commentary when the function of some of the components is not identified. For example, is the borated stainless steel intended to carry structural loads or not? In the PWR canister, S30464 and aluminum are not Division 3 approved materials. For the BWR canister, just 'borated steel' called out.	Enhanced versions of borated stainless steel (e.g., UNS S30467 using powder metallurgy processing for more uniform dispersion of boron) can have improved neutron absorption performance over UNS S30464. Will final closure welding adversely affect the aluminum or is it far enough removed?
5	Materials	Multiple materials introducing galvanic corrosion concerns	NC	Is there a galvanic corrosion concern with having 316/316L, borated 304, aluminum, and fuel assemblies within the same containment?

6	Design	Canister geometry	Can-In-Can concept provides the potential for easier future disposition use but a final decision has not yet been made.	Final disposition requirements are still unknown at this time. Concept may get one closer to a disposition goal but at this time, no firm design basis exists. Without firm assurance of future disposition, the nuclear industry will likely oppose this concept. They simply want the existing storage canisters removed by DOE. Without assurance of a future disposition use, industry could see this as a wasted effort that likely increases personnel radiation exposure, potentially extends plant outages, and increases their efforts, especially with the increased number of shipments.
7	Design	Top head design	Top head provides added shielding for positions directly above the smaller canister.	Is sufficient shielding provided for a welder positioned at the side of the smaller canister? Is a shielded transfer cask needed to cover up to the bottom of the canister plug? More dimensions needed on canister plug. No weld details provided on drawings but if butt welding head (plug) shoulder to shell lip, this weld could be difficult to examine per Code requirements (volumetric examination). UT may work if proper UT test specimens can be developed that verify the weld geometry. Head length would put added moment loading on weld if accidently dropped or impacted. Head difficult to install remotely over pipe or is pipe welded to head?

8	Design	Access port	NC	No access port that is capable of being opened or closed remotely to aid in the drying or backfilling processes is called out.
9	Design	Bottom head design	Conflict between drawings where material lists indicate ½-inch thick but DWG No. 235-UFD-4000, Sheet 3 indicates 2-inch thick. For comment purposes, assume ½-inch thickness is proposed.	A small dip to capture water where siphon tube is located could be useful in the drying process. No weld details are provided on the drawings but if similar to the larger canister, this weld (Category C) could still be difficult to examine per Section III, Division 3 requirements (volumetric examination) if at the corner. Suggest moving welds away from shell/bottom plate interface and up the shell wall for easier full penetration butt weld examination and less potential of weld cracking or damage by potential drop or impact loads. Head thickness does not appear to be thick enough for proper lifting. Flexibility of lid may adversely load weld during lifting.
10	Design	Shell design	The ½-inch thick shell is reasonable. The assumed butt weld attaching the lid ring to the shell should be easy to examine.	No weld details are provided on the drawings for attaching the lid ring to the shell.
11	Design	Content capacity	Potentially makes final disposition easier to achieve, but no final disposition decision has yet been made.	There is a significant amount of wasted loading volume. This significantly increases the number of canisters and shipments, as well as probable increases in radiation exposure for plant personnel.

12	Design	Internal support structures (baskets)	Reasonable general design indicated.	Limited or no details are provided on how the internals and baskets are assembled. Separate Support Sections may displace and cause loading problems. Why not one piece? Drawing 235-UFD-4000 calls out steel while 235-UFD-4200 identifies aluminum. With lid ring, if 2-inch plate is used to make, high fabrication strains are expected, which can be avoided using other product forms such as pipe. Does small canister lid ring create basket loading problems with 28.5-inch ID restricted opening? Have dimensional compatibility checks been performed? Is sheath too long? Is pipe too long? On PWR sheath bottom, hole size not specified. On BWR Canister ASM drawing, Section AA, fuel baskets are not aligned. Drawing error or dimensional problems to be faced when loading? On BWR Sheath ASM drawing, no details are provided for Item 5, fuel spacer. Also, should stack-up drawing be redone to show proper sequence for Item 2? Finally, why is the PWR sheath bottom 5/16-inch thick while the BWR sheath bottom is 3/16-inch thick (unless governed by heavier PWR fuel assemblies)? On the BWR Absorber Section drawing, what is the cross-section shape of a BWR thermal piece and purpose?

13	Design	Response to potential accidental drop or impact loads – containment aspects	Specifying Section III, Division 3 criteria are expected to allow the use of strain-based acceptance criteria. The intent of the strain-based criteria is to yield efficient designs while still maintaining a leaktight containment, even with significant strain present.	Existing design places welds at the bottom corners. This is the most likely damage zone if the canisters are dropped or impact loaded. Modifying the design to remove the welds from the most likely damage zone (by using flanged heads) improves the design.
14	Design	Response to potential accidental drop or impact loads – retrievability aspects	Due to the geometries involved, significant deformations are not expected if inside of a transportation package during an accidental drop or impact so retrievability not expected to be an issue.	Due to the geometries involved, if lifted and handles by self, additional damage could cause retrievability issues during accidental drop or impact events.
15	Design	Amount of materials used in design	NC	There is a significant amount of costly and limited resource materials being used in comparison to the volumetric loading efficiency.
16	Fabrication	General commentary	NC	Suggested design changes could make the fabrication process easier.
17	Fabrication	Making final weld closure	NC	Not clear how or when the final closure weld is anticipated to be made after loading but the weld on the side of the small canister could result in high radiation exposures unless added shielding methods and remote welding are used (e.g., placing remote welding machine into shielded box that surrounds the weld region of the smaller canister). Radiation exposure to set-up personnel must still be considered.
18	Examination	Canister weld examination in shop	No problems expected if suggested design changes are made for bottom head.	Bottom head weld could be difficult to examine as previously described in Item #9.

19	Examination	Final closure weld examination	NC	Final closure weld examination could be problematic even if remote UT and Eddy Current examination methods (volumetric and surface examinations, respectively per Division 3 rules) are employed within a shielded enclosure that permits access to the weld region. Radiation exposure to set-up personnel should also be considered.
20	Testing	Pressure testing	Shop pressure testing of the containment boundary components can be accomplished. Pressure testing of the final closure weld not required per recent revision to WB-6120 rules expected to be published in the 2013 Edition of Section III, Division 3.	NC
21	Testing	Helium leak testing	Shop helium leak testing of the containment boundary components can be accomplished.	Access port needed with ability to open and close remotely. Helium leak testing of the final closure weld could again be problematic when trying to gain access to the weld region. Due to expected backfilling of the canister with helium, a vacuum on the exterior of the canister shell surrounding the weld region will be required to complete leak testing (similar to process used on Hanford's MCO canister). Radiation exposure to set-up personnel should also be considered.

22	Use	During initial preparation – lifting and handling	NC	No identified means to separately lift the bottom canister shell or top head or assembled canister, especially remotely. Is a separate carrier device needed? Unique hoisting and rigging equipment probably needed, with such equipment needing to be monitored and properly handled and stored at the plant. More overhead crane time probably needed, which is in great demand during outages.
23	Use	During initial preparation – proper fit-up	Proper fit-up should be required in order to minimize any remote loading problems and to assure the entire process can be completed as planned.	NC
24	Use	Amount of fuel loaded – efficient use of available space	NC	More canisters and shipments become necessary, with an expected corresponding radiation exposure increase for plant personnel.
25	Use	Ease of fuel loading – remote loading and tolerances (cross-sectional and longitudinal)	Expect sheaths to be pre-loaded into smaller canisters so this minimizes fuel assembly movement and loading time, which reduces radiation exposures for plant personnel.	Will fuel elements easily fit into the sheaths? Have previous high burnup fuel element deformations been monitored (axial bowing or other significant cross-sectional deformations) to provide expected dimensional tolerances?
26	Use	Access ports – dewatering, drying, and backfilling	½-inch drainage pipe is shown on drawings.	No access port that is capable of being opened or closed remotely to aid in the dewatering, drying or backfilling processes is called out. Fuel elements inside sheaths could trap water, increasing drying times, which potentially increases radiation exposure for plant personnel.

27	Use	ALARA considerations	Each individual Can-In-Can canister would not be as highly radioactive as the current storage canisters with a larger number of fuel elements.	More time in radiation zones due to more canisters, more loading steps, more dewatering and drying steps, more closure welding steps, more weld examination steps, more leak testing steps and more handling steps are expected to increase radiation exposures for plant personnel. Simultaneous operations may not reduce exposures, but does require more plant personnel. All this effort for less fuel than a current storage canister capacity, meaning more shipment steps.
28	Use	Shielding - need for transfer cask to provide access room to final weld closure region	This additional piece of equipment appears to be necessary at each plant in order to increase overall efficiency.	The use of a smaller transfer cask is inconsistent with the initial assumption for loading in the spent fuel pool but no realistic option was determined that would permit final closure welding, examination, or testing without the use of such a device. Need to provide distribution not only of canisters but also special equipment like this transfer cask just for smaller canisters and potentially unique hoisting and rigging, all needing to be monitored and properly handled and stored at the plant.
29	Use	Criticality – during pool loading and after drying	Reduced amount of fuel elements (less dense spacing) means less criticality concerns due to “leaking neutrons”.	If spent fuel pool is borated or has contaminants, have these effects been evaluated, is special rinsing needed, or are the effects insignificant?

30	Use	Thermal	Preliminary thermal analyses by other national laboratory personnel should provide good insights.	Sheaths could hamper heat transfer but number of fuel assemblies is limited.

General Notes:

(a) ASME - American Society of Mechanical Engineers
(b) BPV – Boiler and Pressure Vessel
(c) NRC – U.S. Nuclear Regulatory Commission
(d) SST – stainless steel
(e) TC – transportation containment
(f) OD – outer diameter
(g) NPS – nominal pipe size
(h) PWR – pressurized water reactor
(i) BWR – boiling water reactor
(j) UNS – Unified Numbering System
(k) NC – no comment
(l) DOE – U.S. Department of Energy
(m) UT – ultrasonic testing
(n) ID – inner diameter
(o) MCO – Multi-Canister Overpack
(p) ALARA – an acronym standing for ‘As Low As Reasonably Achievable’ referring to the means taken to reduce radiation exposure to personnel as far below dose limits as practical.

Table 2. Design Commentary on the Larger Can-In-Can Canister

Item	Category	Subject	Pro	Con
1	Scope	Specified construction code on drawings is “ASME BPV Code 3”	Excellent choice for construction rules but callout is confusing. Most current storage canisters historically used Section III, Division 1 requirements but is Section III, Division 3 implied? ASME wrote Section III, Division 3 specifically for transportation and storage containments. NUREG-1617 identifies Section III, Division 3 as providing acceptable construction rules for transportation. Specifying ASME BPV Code, Section III, Division 3 criteria clarifies many construction details. NRC is currently reviewing Division 3 for future endorsement. New proposed Division 3 strain-based acceptance criteria would be applicable to these canisters, yielding a more efficient design. Division 3 has also nearly completed a new proposed subsection providing rules for internal support structures (baskets). Assuming transportation use, suggest specifying ASME BPV Code, Section III, Division 3, Subsection WB with both transportation and storage loadings evaluated (dual purpose). This would permit use of inner containment rules.	NRC endorsement is not yet achieved and the strain-based acceptance criteria are not yet approved (expected to be submitted to BPV III Standards Committee by August 2012). Would need to assure full Code compliance is achieved with authorized fabrication shop using certified design and construction documentation.

2	Scope	Moderator exclusion	Use of the construction rules identified above achieves a leaktight containment, allowing moderator exclusion to be achieved except for the seal region where testing should supply that justification.	Would moderator exclusion be a functional requirement for the larger canister? Assuming yes for larger canister (since it is more readily inspectable), added safety margin is achieved.
3	Materials	Choice of materials for containment	Good choice of material (316 SST) since it is reasonably economical, ASME Section III approved for Class TC construction, and is good for added pitting corrosion protection (better than 304 SST). 316 SST used by some storage canister vendors as preferred material in marine environments. However, ASME specification callouts (e.g., SA-240 for plate) and product form need to be made on drawings for all Code intended materials, not the UNS designation. Is dual stamped 316/316L acceptable, since chances are high that is what will be procured?	Still some potential concern for stress corrosion cracking with 316/316L, especially in marine environments.
4	Materials	Choice of materials for internal support structures (baskets)	Difficult to provide commentary when the function of some of the components is not identified. For example, is the aluminum support basket (not ASME approved material for Division 3 use) intended to carry structural loads or not?	The support basket material thickness callout on Dwg. 235-UFD-2000, sheet 1 (2 inch) does not match the dimensions indicated on sheet 2. How is this fabricated and retain dimensional control? Welding reduces strength.
5	Materials	Multiple materials introducing galvanic corrosion concerns	NC	Is there a galvanic corrosion concern with having 316/316L and aluminum within the same containment?
6	Design	Access port	NC	No access port that is capable of being opened or closed remotely to aid in the dewatering, drying, or backfilling processes is called out.

7	Design	Canister geometry	Can-In-Can concept provides the potential for easier future disposition use but a final decision has not yet been made.	OD is indicated to be 88 inches, which is larger than most existing storage canisters. This adds fit concerns `and handling complexity at the plants. Can this size canister fit into a transportation package and be shipped? The 2-inch thickness over the entire length also complicates the fabrication efforts with hot rolling and extra care. This means having to address larger tolerances for fit of the smaller canisters and the support basket and more quality control measures to assure the established tolerances are sufficiently small to assure conformance with final dimensions. The thickness will also mean high fabrication generated strains that will probably need to be reduced by proper heat treatment (annealing and pickle?) after fabrication is completed. Final disposition requirements are still unknown at this time. Concept may get one closer to a disposition goal but at this time, no firm design basis exists. Without firm assurance of future disposition, the nuclear industry will likely oppose this concept. They simply want the existing storage canisters removed by DOE. Without assurance of a future disposition use, industry could see this as a wasted effort that likely increases personnel radiation exposure, potentially extends plant outages, and increases their efforts, especially with the increased number of shipments.

8	Design	Top head design	Top head provides some additional shielding directly over the top of the canister.	Dwg. 235-UFD-2000, sheet 1 does not callout lid material but assumed to be 316/316L. More importantly, seal type and seal material are not called out. Metal seals were used by the storage vendors specifying bolted lids. Lid flexibility may adversely affect canister seal performance during lifting operations. The top head must be recessed for protection during drop events. Do the hoist rings require through lid thickness threading (indicated in drawings and catalog indicates thread length of 3 inches) to develop sufficient load capacity? If so, that could compromise the helium leak test. Have localized stresses around hoist rings been evaluated? Callout for holes for hoist rings appear too small. Lid thickness does not appear to be sufficiently thick enough for proper lifting. Bolts (no bolt or hole callout info provided other than catalog number) may not be adequate as designed, especially regarding thread engagement and number of bolts. ASME quality procurement required. Remotely installing UNC threaded bolts may prove difficult if radiation exposures are high. Acme threads may be easier to install remotely if necessary. What are required torque pre-loads? No top head penetrations for access ports are called out on the drawings.

9	Design	Bottom head design	NC	Head thickness does not appear to be thick enough for proper lifting support. Flexibility of lid may adversely load weld during lifting. No weld details provided on drawings but if full penetration welding plate to shell, this weld (Category C) could still be difficult to examine per ASME Code requirements (volumetric examination). UT may work if proper UT test specimens can be developed that verify the weld geometry. Very large weld to make with associated difficulties. A small dip to capture water where siphon tube is located could be useful in the drying process.
10	Design	Shell design	NC	The 2-inch thick shell may be thicker than needed. High fabrication strains expected. Weight savings could be achieved and heat dissipation improved.
11	Design	Content capacity	Potentially makes final disposition easier to achieve, but no final disposition decision has yet been made.	There is a significant amount of wasted loading volume. This significantly increases the number of canisters and shipments, as well as probable increases in radiation exposure for plant personnel.
12	Design	Response to potential accidental drop or impact loads – retrievability aspects	Due to the geometries involved, significant deformations are not expected if inside of a transportation package during an accidental drop or impact so canister retrievability is not expected to be an issue.	Due to the geometries involved, if lifted and handled by self, additional damage could cause retrievability issues during accidental drop or impact events.

13	Design	Response to potential accidental drop or impact loads – containment aspects	Specifying Section III, Division 3 criteria are expected to allow the use of strain-based acceptance criteria except for the seal region. The intent of the strain-based criteria is to yield efficient designs while still maintaining a leaktight containment, even with significant strain present.	Existing design places welds at the bottom corners. This is the most likely damage zone if the canisters are dropped or impact loaded. Modifying the design to remove the welds from the most likely damage zone (by using flanged heads) improves the design. Since lifting loads promote concern regarding lid flexibility and adequate design, accidental drop or impact loads are also a potential concern.
14	Design	Amount of materials used in design	NC	There is a significant amount of costly and limited resource materials being used in comparison to the volumetric loading efficiency.
15	Fabrication	General commentary	NC	Suggested design changes could make the fabrication process easier.
16	Fabrication	Making final bolted closure	NC	Uncertain what expected radiation field is in area but installing 16 large bolts and applying proper torque without shielding may not be feasible.
17	Examination	Canister weld examination in shop	No problems expected if suggested design changes are made for bottom head.	Bottom head weld could be difficult to examine as previously described in Item #9.
18	Examination	Final bolting examination	NC	No problems are expected with the exception of radiation dose concerns.

19	Testing	Pressure testing	Shop pressure testing of the containment boundary components can be accomplished. Pressure testing of the final closure weld not required per recent revision to WB-6120 rules expected to be published in the 2013 Edition of Section III, Division 3.	NC
20	Testing	Helium leak testing	Shop helium leak testing of the containment boundary components can be accomplished.	Helium leak testing of the final bolted closure could be problematic when trying to gain access to the seal region. Due to expected backfilling of the canister with helium, a vacuum on the exterior of the canister shell surrounding the bolted joint will be required to complete leak testing. Radiation exposure to set-up personnel should also be considered.
21	Use	During initial preparation – lifting and handling	NC	No identified means to separately lift the bottom canister shell. Is a separate carrier device needed? Unique hoisting and rigging equipment probably needed, with such equipment needing to be monitored and properly handled and stored at the plant. More overhead crane time probably needed, which is in great demand during outages. Hoist rings may require ASME quality assurance procurement. Have potential galvanic corrosion effects of hoist rings been considered on the canister lid?
22	Use	During initial preparation – proper fit up	Before loading, proper fit-up should be required to minimize remote loading problems and to assure the entire process can be completed as planned.	NC

23	Use	Amount of fuel loaded – efficient use of available space	NC	More canisters and shipments become necessary, with an expected corresponding radiation exposure increase for plant personnel.
24	Use	Ease of small canister loading – remote loading and tolerances (cross-sectional and longitudinal)	Expect smaller canisters to be pre-loaded into large canister so this minimizes loading time, which reduces radiation exposures for plant personnel.	Will small canisters fit into the available space? Geometry checks indicate very little tolerance for ovality and axial curvature of the smaller canisters.
25	Use	Access ports – dewatering, drying, and backfilling	Same type of generic process as currently used for storage canisters would be used for Can-In-Can concept.	No access port that is capable of being opened or closed remotely to aid in the dewatering, drying or backfilling processes is called out. Flat bottoms on smaller canisters may trap water, which potentially increases drying time and radiation exposure for plant personnel.
26	Use	ALARA considerations	Each individual Can-In-Can canister would not be as highly radioactive as the current storage canisters with a larger number of fuel elements.	More time in radiation zones due to more canisters, more loading steps, more dewatering and drying steps, more closure welding steps, more weld examination steps, more leak testing steps and more handling steps are expected to increase radiation exposures for plant personnel. All this effort for less fuel than a current storage canister capacity, meaning more shipment steps.
27	Use	Shielding - need for transfer cask to provide access room to final weld closure region	A transfer cask is probably needed similar to current transfer casks used but needs to be larger to fit 88-inch OD.	Need to provide distribution not only of large canisters but also special equipment like this larger transfer cask and potentially unique hoisting and rigging, all needing to be monitored and properly handled and stored at the plant. Could a more efficient shielding material sleeve be used rather than a 2-inch thick shell over the entire length?

28	Use	Criticality – during pool loading and after drying	Reduced amount of fuel elements (less dense spacing) means less criticality concerns due to “leaking neutrons”.	If spent fuel pool is borated or has contaminants, have these effects been evaluated, is special rinsing needed, or are the effects insignificant?
29	Use	Thermal	Preliminary thermal analyses by other national laboratory personnel should provide good insights.	The 2-inch thick shell retards heat loss ability to some degree as do smaller canisters inside of large canister.

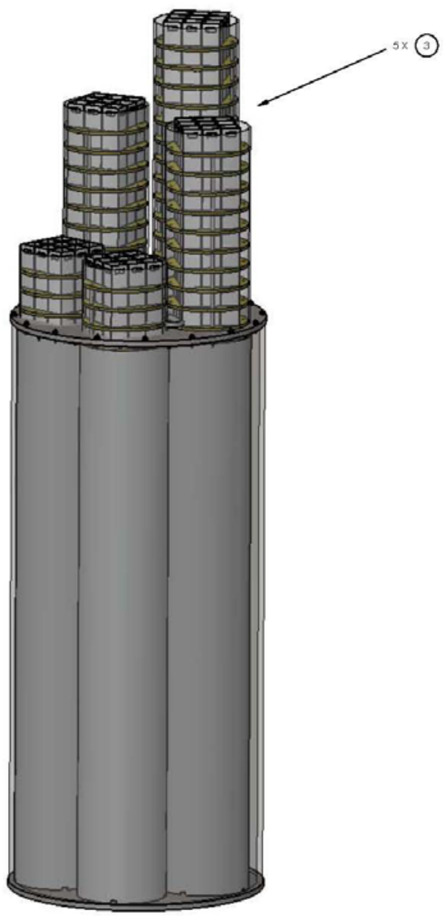
General Notes:

(a) ASME - American Society of Mechanical Engineers
(b) BPV – Boiler and Pressure Vessel
(c) NRC – U.S. Nuclear Regulatory Commission
(d) SST – stainless steel
(e) TC – transportation containment
(f) UNS – Unified Numbering System
(g) NC – no comment
(h) OD - outer diameter
(i) DOE – U.S. Department of Energy
(j) UNC – Unified National Coarse threading
(k) UT – ultrasonic testing
(l) ALARA – an acronym standing for ‘As Low As Reasonably Achievable’ referring to the means taken to reduce radiation exposure to personnel as far below dose limits as practical.

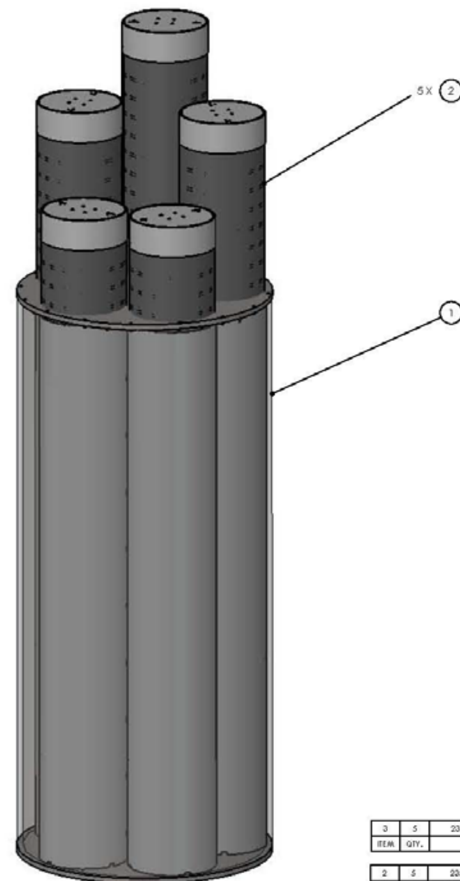
Attachment A

THIS DRAWING PRODUCED ON SOLIDWORKS

NOTES
1. MATERIAL CERTIFICATIONS REQUIRED.



BWR ASM



ITEM	QTY.	NAME	MATERIAL	DESCRIPTION	DWG
3	5	235-BWR canister asm	STEEL ASM	STEEL ASM	235-UFD-4000

ITEM	QTY.	NAME	MATERIAL	DESCRIPTION	DWG
2	5	235-PWR canister asm	STEEL ASM	STEEL ASM	235-UFD-3000
1	1	235-large can assembly	STAINLESS STEEL 316	STAINLESS STEEL WELDMENT	235-UFD-2000

THIRD-ANGLE PROJECTION

UNLESS OTHERWISE NOTED
1. ALL DIMENSIONS ARE IN INCHES
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M
3. MACHINED FINISH 125 MICRO-INCHES RMS
4. CONCENTRICITY .010 TIR
5. MACHINED ANGLES ±1/2° FORMED ANGLES ±1°
6. BREAK SHARP CORNERS AND REMOVE ALL BURRS
7. WHOLE NUMBERS AND FRACTIONS ±1/16
8. .X DECIMALS ±.030
9. .XX DECIMALS ±.010
10. .XXX DECIMALS ±.005

This drawing was prepared by ORNL solely for use in work performed under Department of Energy contract number DE-AC05-00OR22725 and applicable Work for Others Agreements and Cooperative Research and Development Agreements. This drawing is property of ORNL and must be returned upon request.

DRAWING APPROVALS		DATE
DES	D GIULIANO	01/12/2012
DRW	D GIULIANO	01/12/2012
CHK		
ENG		
QA		
-	-	-

OAK RIDGE NATIONAL LABORATORY
operated for the U.S. Department of Energy under contract DE-AC05-00OR22725 Oak Ridge, TN

REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION

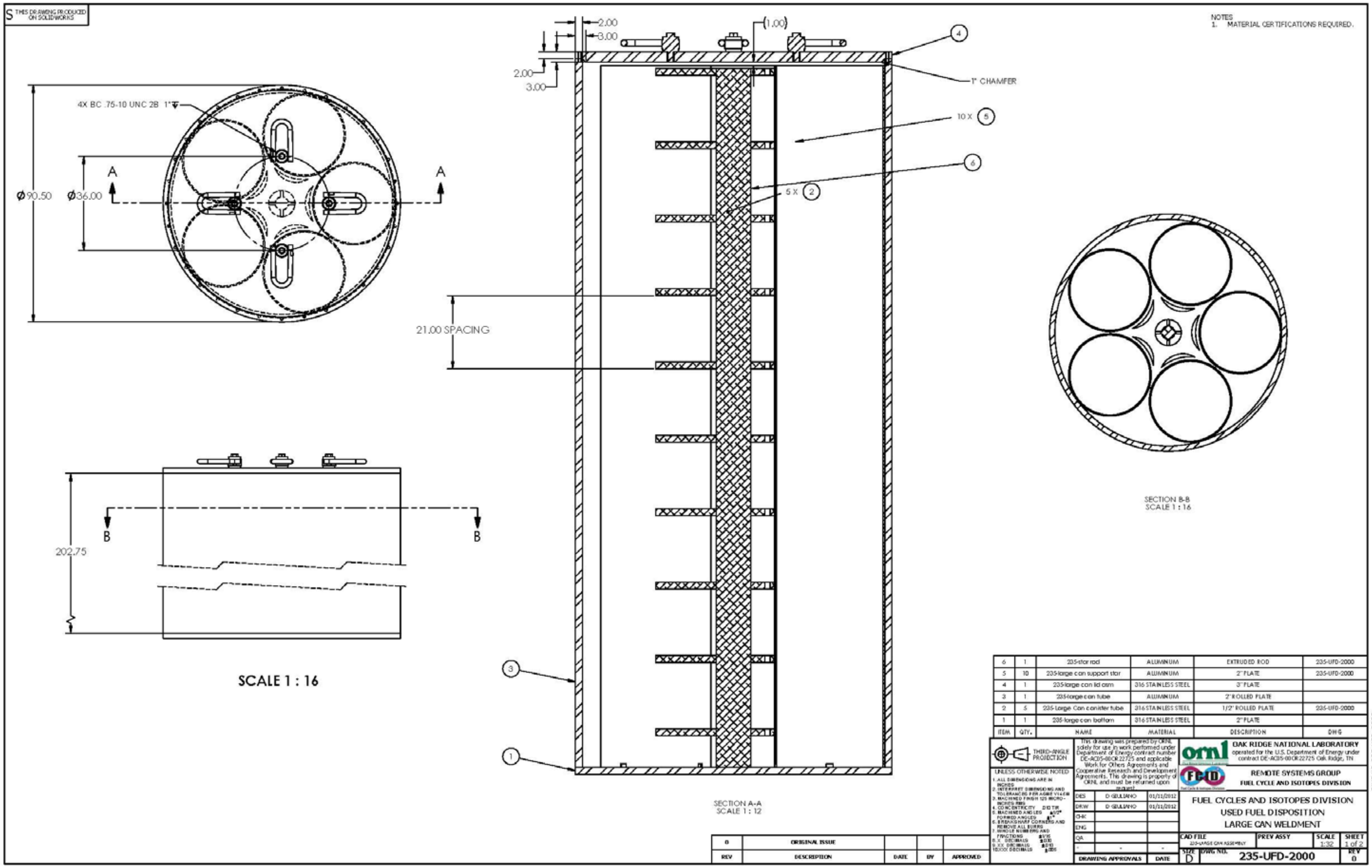
FUEL CYCLES AND ISOTOPES DIVISION
USED FUEL DISPOSITION
TOP LEVEL ASSEMBLIES

CAD FILE	PREV ASSY	SCALE	SHEET
235-BWR LARGE CAN ASM		1:20	1 of 1

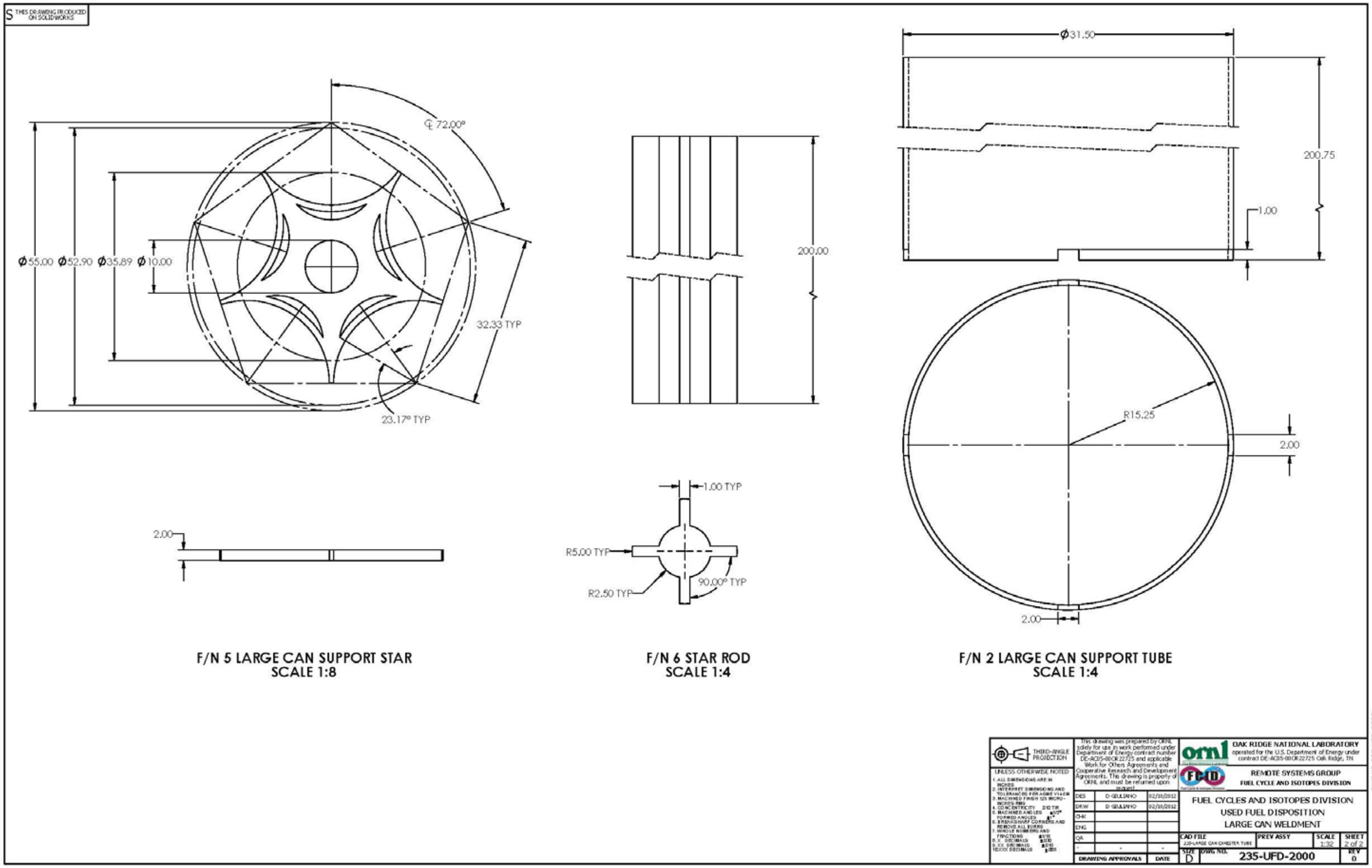
SIZE	DWG NO.	REV
D	235-UFD-1000	0

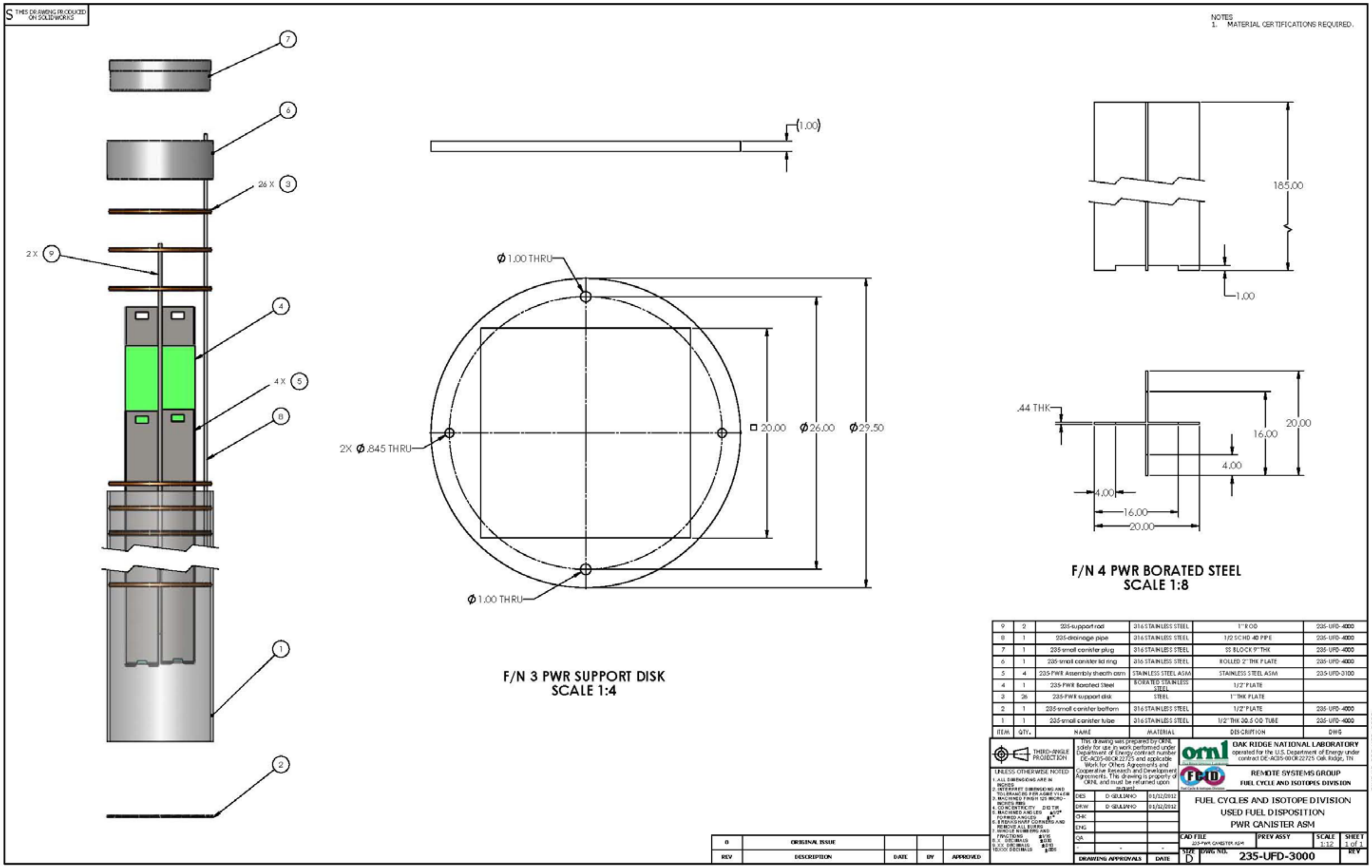
REV	DESCRIPTION	DATE	BY	APPROVED
0	ORIGINAL ISSUE			

DWG NO. 235-UFD-1000

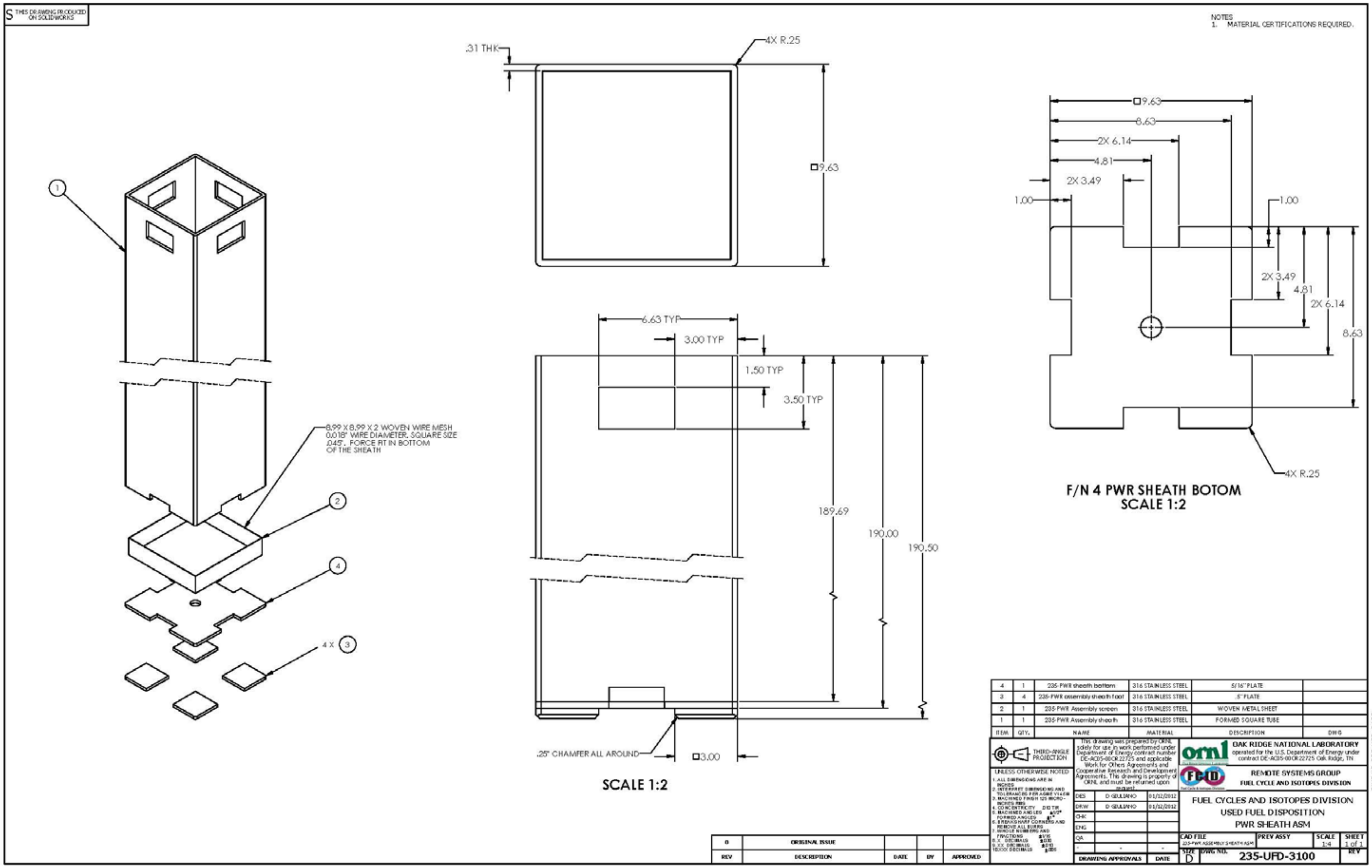


6	1	235-star rod	ALUMINUM	EXTRUDED ROD	235-UFD-2000
5	10	235-large can support star	ALUMINUM	2" PLATE	235-UFD-2000
4	1	235-large can lid asm	316 STAINLESS STEEL	3" PLATE	
3	1	235-large can tube	ALUMINUM	2" ROLLED PLATE	
2	5	235-Large Can canister tube	316 STAINLESS STEEL	1/2" ROLLED PLATE	235-UFD-2000
1	1	235-large can bottom	316 STAINLESS STEEL	2" PLATE	
ITEM	QTY.	NAME	MATERIAL	DESCRIPTION	DWG

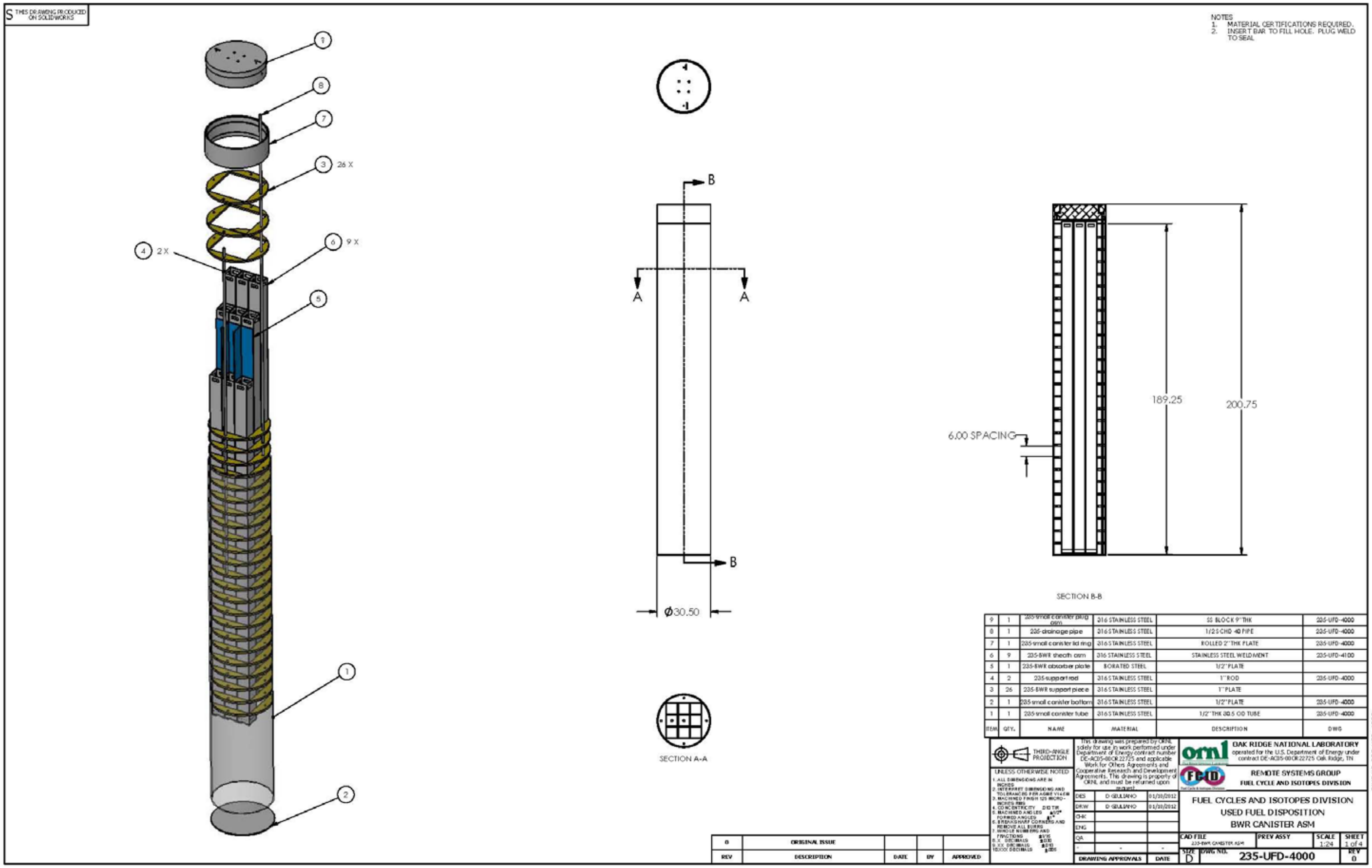

THIS DRAWING PRODUCED ON SOLIDWORKS
Ø31.50
200.75
1.00
Ø55.00 Ø52.90 Ø35.89 Ø10.00
72.00°
32.33 TYP
23.17° TYP
200.00
R15.25
2.00
2.00
1.00 TYP
R5.00 TYP
R2.50 TYP
90.00° TYP
2.00
F/N 5 LARGE CAN SUPPORT STAR
SCALE 1:8
F/N 6 STAR ROD
SCALE 1:4
F/N 2 LARGE CAN SUPPORT TUBE
SCALE 1:4
THIRD-ANGLE PROJECTION
UNLESS OTHERWISE NOTED
This drawing was prepared by ORNL solely for use in work performed under Department of Energy contract number DE-AC05-00OR22725 and applicable Work for Others Agreements and Cooperative Research and Development Agreements. This drawing is property of ORNL and must be returned upon request.
DES D GIULIANO 02/10/2012
DRW D GIULIANO 02/10/2012
CHK
ENG
QA
DRAWING APPROVALS
DATE
OAK RIDGE NATIONAL LABORATORY
operated for the U.S. Department of Energy under contract DE-AC05-00OR22725 Oak Ridge, TN
REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION
FUEL CYCLES AND ISOTOPES DIVISION
USED FUEL DISPOSITION
LARGE CAN WELDMENT
CAD FILE
PREV ASSY
SCALE 1:32
SHEET 2 of 2
SIZE D
DWG NO. 235-UFD-2000
REV 0
DWG NO. 235-UFD-2000



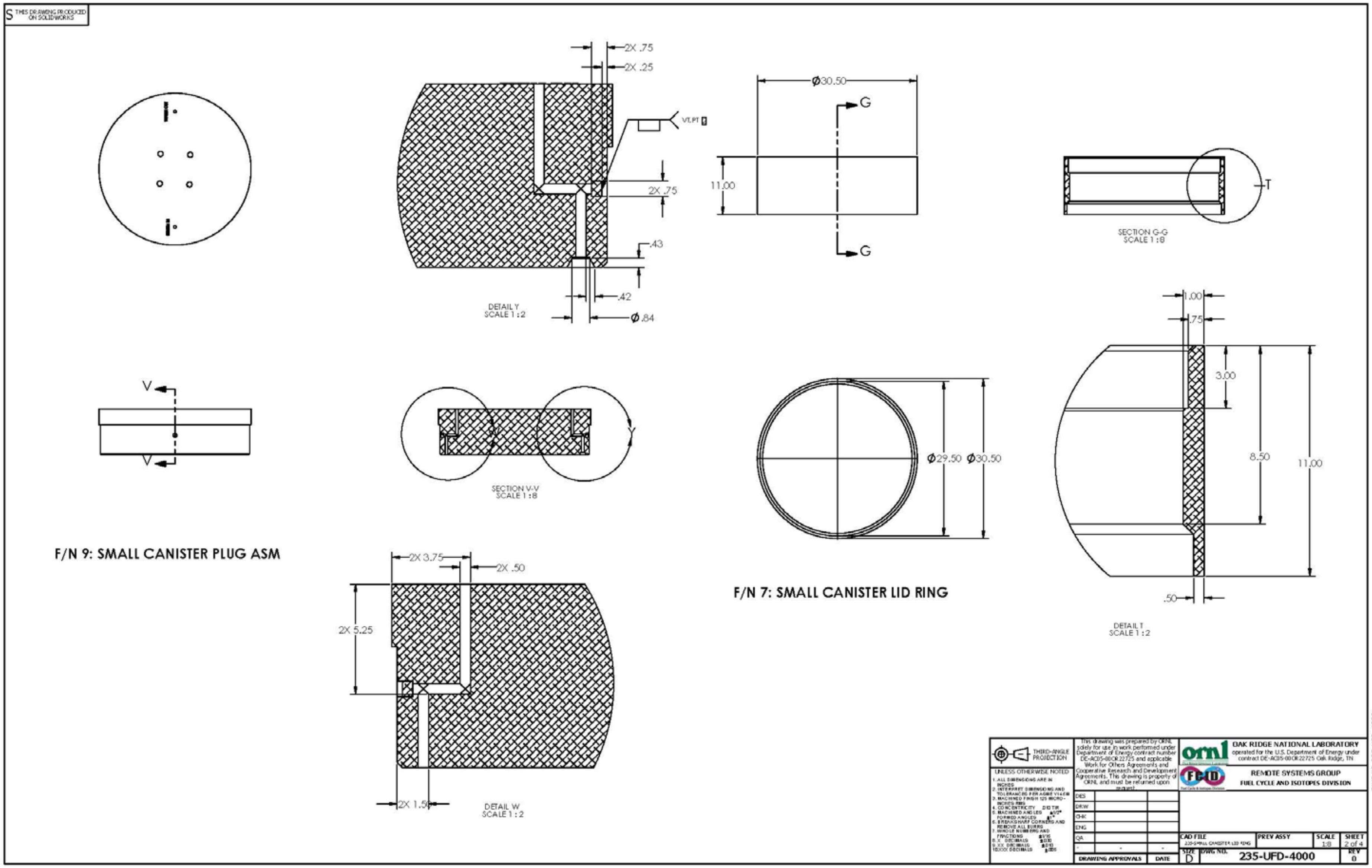
ITEM	QTY.	NAME	MATERIAL	DESCRIPTION	DWG
9	2	235-support rod	316 STAINLESS STEEL	1" ROD	235-UFD-4000
8	1	235-drainage pipe	316 STAINLESS STEEL	1/2 SCHD 40 PIPE	235-UFD-4000
7	1	235-small canister plug	316 STAINLESS STEEL	SS BLOCK 9" THK	235-UFD-4000
6	1	235-small canister lid ring	316 STAINLESS STEEL	ROLLED 2" THK PLATE	235-UFD-4000
5	4	235-PWR Assembly sheath asm	STAINLESS STEEL ASM	STAINLESS STEEL ASM	235-UFD-3100
4	1	235-PWR Borated Steel	BORATED STAINLESS STEEL	1/2" PLATE	
3	26	235-PWR support disk	STEEL	1" THK PLATE	
2	1	235-small canister bottom	316 STAINLESS STEEL	1/2" PLATE	235-UFD-4000
1	1	235-small canister tube	316 STAINLESS STEEL	1/2" THK 30.5 OD TUBE	235-UFD-4000



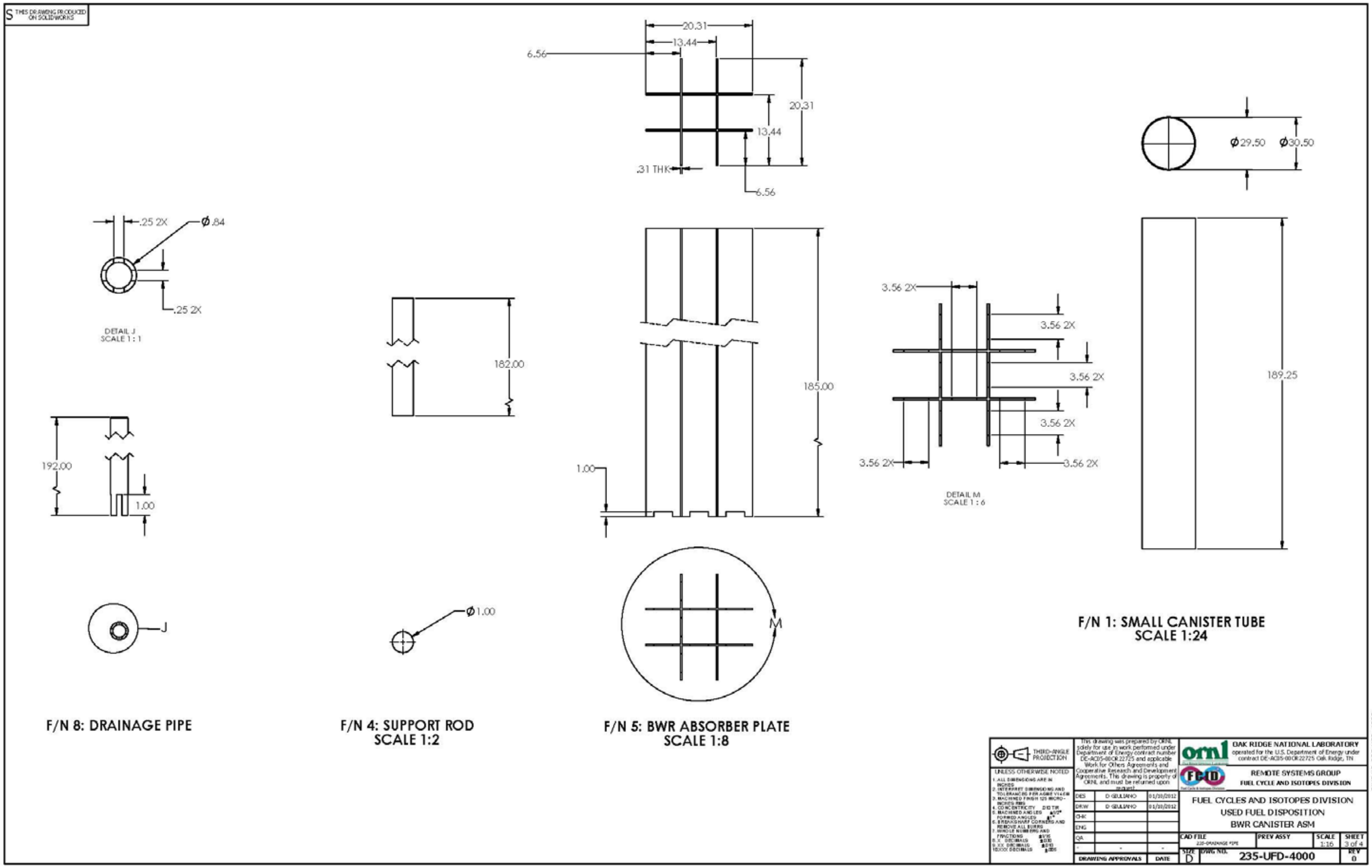
THIS DRAWING PRODUCED ON SOLIDWORKS
NOTES
1. MATERIAL CERTIFICATIONS REQUIRED.
.31 THK
4X R.25
□9.63
6.63 TYP
3.00 TYP
1.50 TYP
3.50 TYP
189.69
190.00
190.50
.25" CHAMFER ALL AROUND
□3.00
SCALE 1:2
8.99 X 8.99 X 2 WOVEN WIRE MESH 0.018" WIRE DIAMETER. SQUARE SIZE .045". FORCE FIT IN BOTTOM OF THE SHEATH
1
2
4
4 X 3
□9.63
8.63
2X 6.14
4.81
2X 3.49
1.00
1.00
2X 3.49
4.81
2X 6.14
8.63
4X R.25
F/N 4 PWR SHEATH BOTOM
SCALE 1:2
4 | 1 | 235-PWR sheath bottom | 316 STAINLESS STEEL | 5/16" PLATE
3 | 4 | 235-PWR assembly sheath foot | 316 STAINLESS STEEL | .5" PLATE
2 | 1 | 235-PWR Assembly screen | 316 STAINLESS STEEL | WOVEN METAL SHEET
1 | 1 | 235-PWR Assembly sheath | 316 STAINLESS STEEL | FORMED SQUARE TUBE
ITEM | QTY. | NAME | MATERIAL | DESCRIPTION | DWG
THIRD-ANGLE PROJECTION
UNLESS OTHERWISE NOTED
This drawing was prepared by ORNL solely for use in work performed under Department of Energy contract number DE-AC05-00OR22725 and applicable Work for Others Agreements and Cooperative Research and Development Agreements. This drawing is property of ORNL and must be returned upon request.
OAK RIDGE NATIONAL LABORATORY
operated for the U.S. Department of Energy under contract DE-AC05-00OR22725 Oak Ridge, TN
REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION
DES | D GIULIANO | 01/12/2012
DRW | D GIULIANO | 01/12/2012
CHK
ENG
QA
DRAWING APPROVALS | DATE
FUEL CYCLES AND ISOTOPES DIVISION
USED FUEL DISPOSITION
PWR SHEATH ASM
CAD FILE
235-PWR ASSEMBLY SHEATH ASM
PREV ASSY
SCALE 1:4
SHEET 1 of 1
SIZE D
DWG NO. 235-UFD-3100
REV
0 | ORIGINAL ISSUE
REV | DESCRIPTION | DATE | BY | APPROVED
DWG NO. 235-UFD-3100

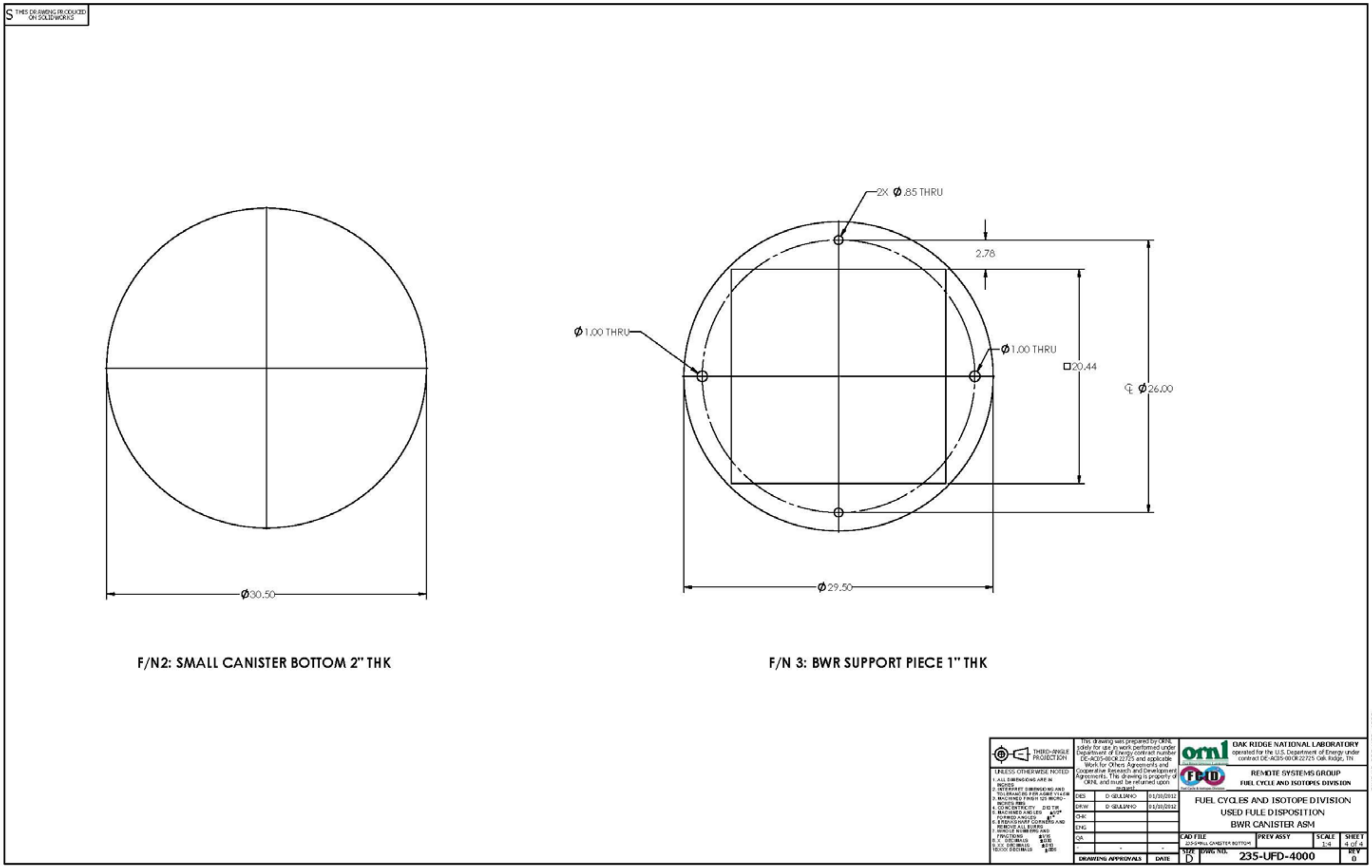


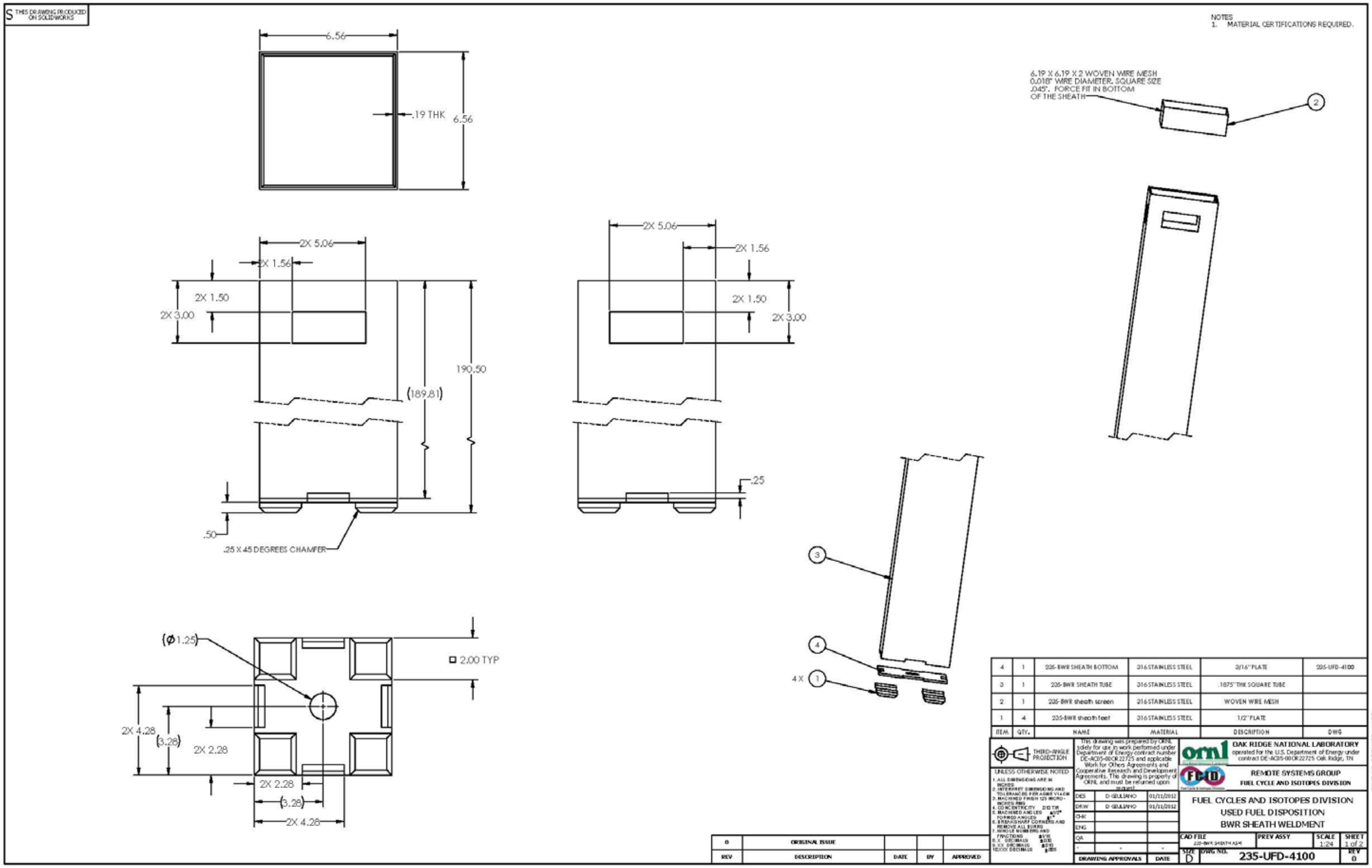
ITEM	QTY.	NAME	MATERIAL	DESCRIPTION	DWG
9	1	235-small canister plug asm	316 STAINLESS STEEL	SS BLOCK 9"THK	235-UFD-4000
8	1	235-drainage pipe	316 STAINLESS STEEL	1/2 SCHD 40 PIPE	235-UFD-4000
7	1	235-small canister lid ring	316 STAINLESS STEEL	ROLLED 2"THK PLATE	235-UFD-4000
6	9	235-BWR sheath asm	316 STAINLESS STEEL	STAINLESS STEEL WELDMENT	235-UFD-4100
5	1	235-BWR absorber plate	BORATED STEEL	1/2"PLATE	
4	2	235-support rod	316 STAINLESS STEEL	1"ROD	235-UFD-4000
3	26	235-BWR support piece	316 STAINLESS STEEL	1"PLATE	
2	1	235-small canister bottom	316 STAINLESS STEEL	1/2"PLATE	235-UFD-4000
1	1	235-small canister tube	316 STAINLESS STEEL	1/2"THK 30.5 OD TUBE	235-UFD-4000

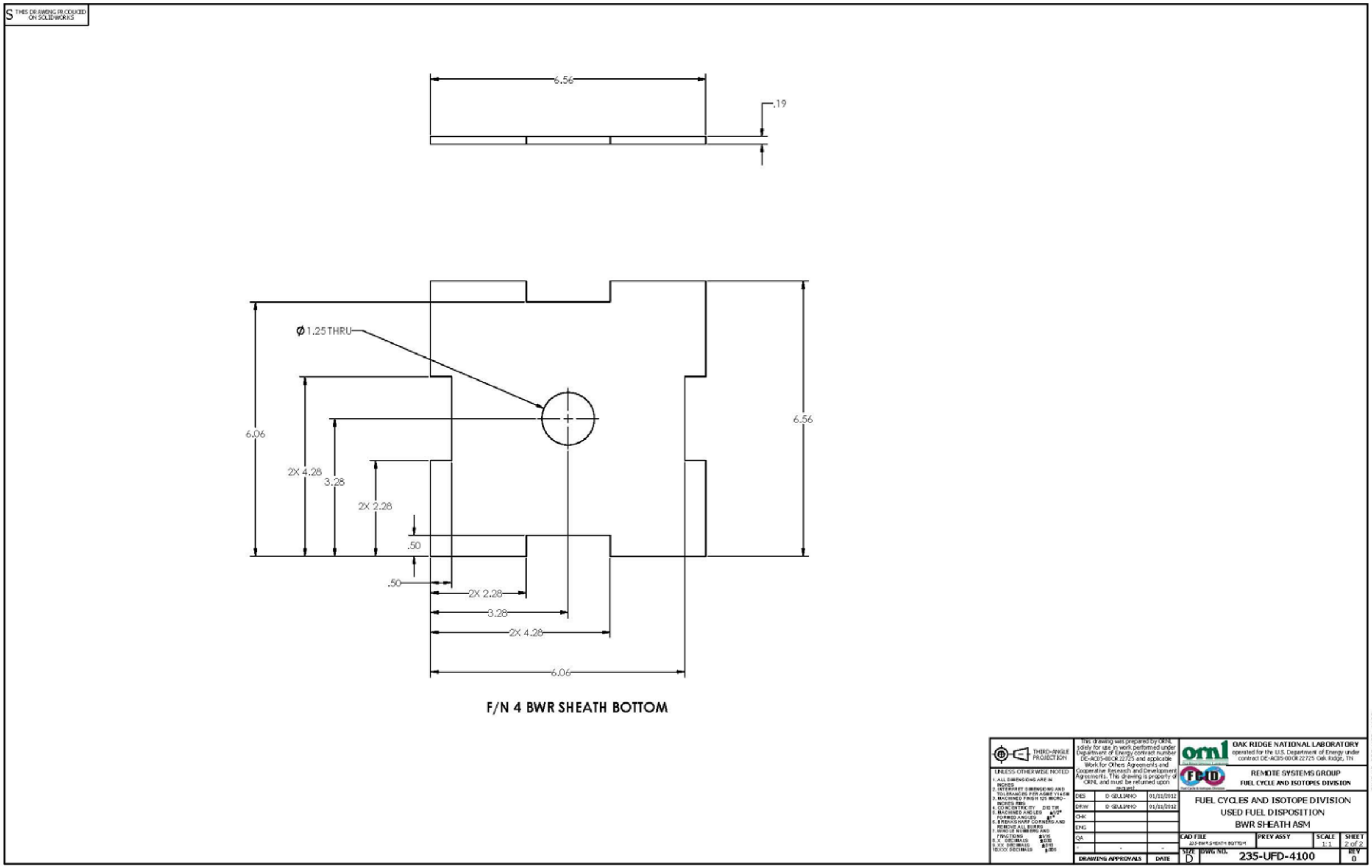


THIS DRAWING PRODUCED ON SOLIDWORKS
2X .75
2X .25
VI.PT
2X .75
.43
.42
Ø.84
DETAIL Y
SCALE 1 : 2
Ø30.50
G
11.00
SECTION G-G
SCALE 1 : 8
T
V
SECTION V-V
SCALE 1 : 8
Ø29.50 Ø30.50
1.00
.75
3.00
8.50
11.00
.50
DETAIL T
SCALE 1 : 2
F/N 9: SMALL CANISTER PLUG ASM
2X 3.75
2X .50
2X 5.25
2X 1.50
DETAIL W
SCALE 1 : 2
F/N 7: SMALL CANISTER LID RING
THIRD-ANGLE PROJECTION
UNLESS OTHERWISE NOTED
OAK RIDGE NATIONAL LABORATORY
REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION
DRAWING APPROVALS
DATE
SIZE D
DWG NO. 235-UFD-4000
SCALE 1:8
SHEET 2 of 4
REV 0
DWG NO. 235-UFD-4000


THIS DRAWING PRODUCED ON SOLIDWORKS
20.31
13.44
6.56
20.31
13.44
.31 THK
6.56
ϕ29.50
ϕ30.50
.25 2X
ϕ.84
.25 2X
DETAIL J
SCALE 1 : 1
182.00
185.00
3.56 2X
3.56 2X
3.56 2X
3.56 2X
3.56 2X
3.56 2X
189.25
192.00
1.00
1.00
DETAIL M
SCALE 1 : 6
J
ϕ1.00
M
F/N 1: SMALL CANISTER TUBE
SCALE 1:24
F/N 8: DRAINAGE PIPE
F/N 4: SUPPORT ROD
SCALE 1:2
F/N 5: BWR ABSORBER PLATE
SCALE 1:8
THIRD-ANGLE PROJECTION
This drawing was prepared by ORNL solely for use in work performed under Department of Energy contract number DE-AC05-00OR22725 and applicable Work for Others Agreements and Cooperative Research and Development Agreements. This drawing is property of ORNL and must be returned upon request.
OAK RIDGE NATIONAL LABORATORY
operated for the U.S. Department of Energy under contract DE-AC05-00OR22725 Oak Ridge, TN
REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION
UNLESS OTHERWISE NOTED
DES D GIULIANO 01/10/2012
DRW D GIULIANO 01/10/2012
CHK
ENG
QA
DRAWING APPROVALS
DATE
FUEL CYCLES AND ISOTOPES DIVISION
USED FUEL DISPOSITION
BWR CANISTER ASM
CAD FILE
PREV ASSY
SCALE 1:16
SHEET 3 of 4
SIZE D
DWG NO. 235-UFD-4000
REV 0
DWG NO. 235-UFD-4000


THIS DRAWING PRODUCED ON SOLIDWORKS
2X Ø.85 THRU
2.78
Ø1.00 THRU
Ø1.00 THRU
□20.44
℄ Ø26.00
Ø30.50
Ø29.50
F/N2: SMALL CANISTER BOTTOM 2" THK
F/N 3: BWR SUPPORT PIECE 1" THK
THIRD-ANGLE PROJECTION
UNLESS OTHERWISE NOTED
This drawing was prepared by ORNL solely for use in work performed under Department of Energy contract number DE-AC05-00OR22725 and applicable Work for Others Agreements and Cooperative Research and Development Agreements. This drawing is property of ORNL and must be returned upon request.
OAK RIDGE NATIONAL LABORATORY
operated for the U.S. Department of Energy under contract DE-AC05-00OR22725 Oak Ridge, TN
REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION
DES D GIULIANO 01/10/2012
DRW D GIULIANO 01/10/2012
CHK
ENG
QA
DRAWING APPROVALS
DATE
FUEL CYCLES AND ISOTOPE DIVISION
USED FULE DISPOSITION
BWR CANISTER ASM
CAD FILE
PREV ASSY
SCALE 1:4
SHEET 4 of 4
SIZE D
DWG NO. 235-UFD-4000
REV 0
DWG NO. 235-UFD-4000


THIS DRAWING PRODUCED ON SOLIDWORKS
NOTES
1. MATERIAL CERTIFICATIONS REQUIRED.
6.56
.19 THK
6.56
6.19 X 6.19 X 2 WOVEN WIRE MESH 0.018" WIRE DIAMETER, SQUARE SIZE .045". FORCE FIT IN BOTTOM OF THE SHEATH
2X 5.06
2X 1.56
2X 1.50
2X 3.00
190.50
(189.81)
.25
.50
.25 X 45 DEGREES CHAMFER
(Ø1.25)
2.00 TYP
2X 4.28
(3.28)
2X 2.28
4 X
ITEM | QTY. | NAME | MATERIAL | DESCRIPTION | DWG
4 | 1 | 235-BWR SHEATH BOTTOM | 316 STAINLESS STEEL | 3/16" PLATE | 235-UFD-4100
3 | 1 | 235-BWR SHEATH TUBE | 316 STAINLESS STEEL | .1075" THK SQUARE TUBE
2 | 1 | 235-BWR sheath screen | 316 STAINLESS STEEL | WOVEN WIRE MESH
1 | 4 | 235-BWR sheath feet | 316 STAINLESS STEEL | 1/2" PLATE
THIRD-ANGLE PROJECTION
UNLESS OTHERWISE NOTED
This drawing was prepared by ORNL solely for use in work performed under Department of Energy contract number DE-AC05-00OR22725 and applicable Work for Others Agreements and Cooperative Research and Development Agreements. This drawing is property of ORNL and must be returned upon request.
OAK RIDGE NATIONAL LABORATORY
operated for the U.S. Department of Energy under contract DE-AC05-00OR22725 Oak Ridge, TN
REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION
DES D GIULIANO 01/11/2012
DRW D GIULIANO 01/11/2012
CHK
ENG
QA
DRAWING APPROVALS DATE
FUEL CYCLES AND ISOTOPES DIVISION
USED FUEL DISPOSITION
BWR SHEATH WELDMENT
CAD FILE 235-BWR SHEATH ASM
PREV ASSY
SCALE 1:24
SHEET 1 of 2
SIZE D
DWG NO. 235-UFD-4100
REV 0
0 ORIGINAL ISSUE
REV DESCRIPTION DATE BY APPROVED
DWG NO. 235-UFD-4100


THIS DRAWING PRODUCED ON SOLIDWORKS
6.56
.19
Ø1.25 THRU
6.06
2X 4.28
3.28
2X 2.28
.50
.50
2X 2.28
3.28
2X 4.28
6.06
6.56
F/N 4 BWR SHEATH BOTTOM
THIRD-ANGLE PROJECTION
UNLESS OTHERWISE NOTED
This drawing was prepared by ORNL solely for use in work performed under Department of Energy contract number DE-AC05-00OR22725 and applicable Work for Others Agreements and Cooperative Research and Development Agreements. This drawing is property of ORNL and must be returned upon request.
OAK RIDGE NATIONAL LABORATORY
operated for the U.S. Department of Energy under contract DE-AC05-00OR22725 Oak Ridge, TN
REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION
DES D GIULIANO 01/11/2012
DRW D GIULIANO 01/11/2012
CHK
ENG
QA
DRAWING APPROVALS
DATE
FUEL CYCLES AND ISOTOPE DIVISION
USED FUEL DISPOSITION
BWR SHEATH ASM
CAD FILE
PREV ASSY
SCALE 1:1
SHEET 2 of 2
SIZE D
DWG NO. 235-UFD-4100
REV 0
DWG NO. 235-UFD-4100

Attachment B

Engineering Analysis Control Account Drawing Review Comments

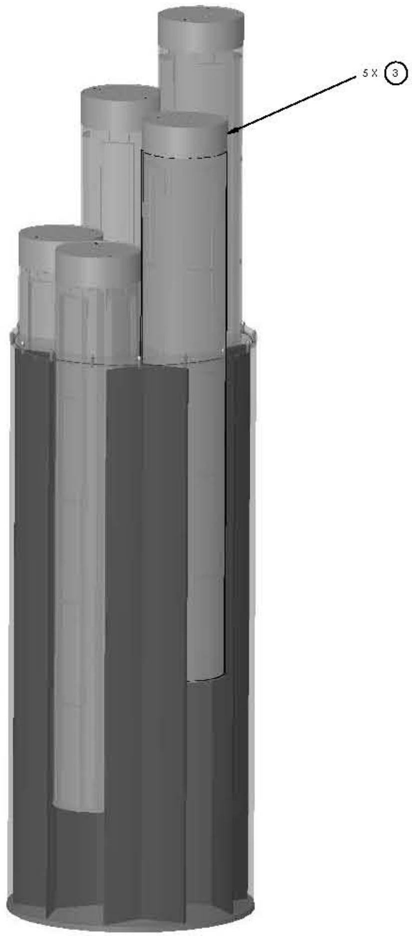
from D. K. Morton (Feb. 29, 2012)

Dwg. No.	Sheet	Comments
235-UFD-1000	1/1	Material call-outs have no detailed material specifications identified (i.e. ASME SA-240 or SA-312, etc.). *This comment is applicable throughout the series of drawings (see General Comment below).* Delete confusing ASM notations if referring to ASM International or if referring to an assembly, use some term more recognizable. *This comment is applicable throughout.*
235-UFD-1000	1/1	The note “material certifications required” is somewhat odd. Typical note would indicate “Certified Material Test Reports” (CMTR’s) required”. However, by indicating Section III compliance, that is already addressed in the Code. *This comment is applicable throughout the series of drawings.*
235-UFD-1000	1/1	Add notation under PWR canister
235-UFD-2000	1/2	There appear to be four swivel eyebolts on the lid of the can. However, there are no apparent detailed call-outs (rated load in material list) for these items nor any preload requirements identified.
235-UFD-2000	1/2	Item #3 (shell material) is identified as aluminum but should be 316 SST (previously noted at 2/14/2012 meeting). Is the shell expected to be fabricated from rolled plate or otherwise?
235-UFD-2000	1/2	Labeling font sizes are not consistent. *This comment is applicable throughout many of the drawings.* Larger font sizes are helpful for easier reading.
235-UFD-2000	1/2	If the top lid is to be bolted on (as indicated at the 2/14/2012 meeting), a reinforced ring at the top lip of the shell would be necessary in order to have sufficient material for the bolts to engage and carry the required loading. What size bolts would be used and preload info? Thread type is important if installed remotely.
235-UFD-2000	1/2	Have cathodic/anodic reactions been considered with the materials indicated?
235-UFD-2000	1/2	Indication for Item #2 location appears to be in error. Isn’t that the star rod?
235-UFD-2000	2/2	The support tube shows a 30.5 inch circular ID but the smaller fuel canisters have a 30.5 inch circular OD. There is no tolerance to account for ovality and curvature along the length. These components cannot be loaded into each other.
235-UFD-2000	2/2	What does “F/N” mean where a part is “detailed”? *This comment is applicable throughout many of the drawings.*
235-UFD-2000	2/2	Where are the detailed drawings for the can top and bottom lids?
235-UFD-2000	2/2	Not sure if sufficient dimensions are provided to fabricate the support star. What are the radius values? Can the support tubes physically fit between the support star and the wall of the larger canister, considering maximum tolerances? How are the support stars attached to the star rod?
235-UFD-3000	1/1	Is the borated steel divider all borated material? What are the 4-inch wide end pieces for?

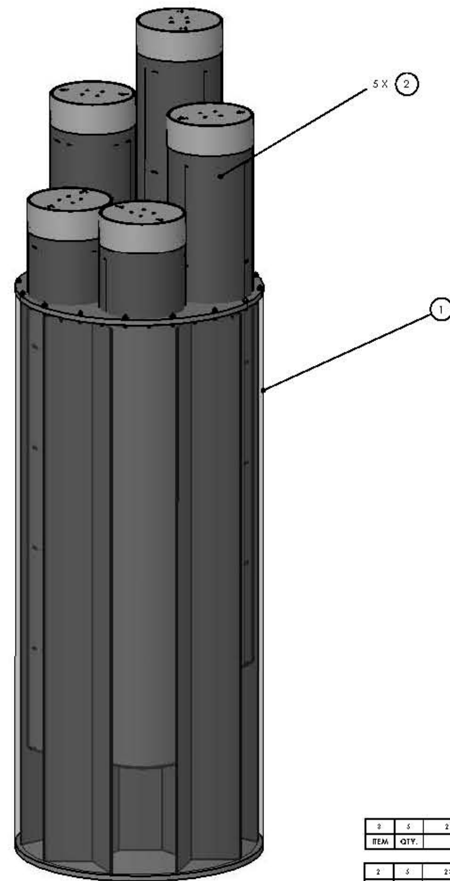
235-UFD-3000	1/1	The title given to components seems backwards. The larger component should be the canister and the smaller component (with fuel assemblies) should be a can. This change would then better match industry and regulatory terminology.
235-UFD-3000	1/1	What specific type of borated SST is being used? Does this provide any structural functions?
235-UFD-3000	1/1	Hole dimension of 0.845 seem very tight for ½ " NPS and over the length of the pipe.
235-UFD-3000	1/1	What is the spacing between Items 3 (quantity of 26) on this sheet? What type of steel?
235-UFD-3000	1/1	Minimal dimensional and fabrication details are provided for the PWR smaller can.
235-UFD-3100	1/1	Inconsistent dimensional call-outs: decimal versus fractional in material list.
235-UFD-3100	1/1	What is the hole diameter for the hole at the center of "F/N 4 PWR Sheath Botom"? (spelling error)
235-UFD-3100	1/1	On Item 1: it's not clear what the notch dimensions for the rectangular cut outs at the bottom of this item are.
235-UFD-4000	1/4	No comments.
235-UFD-4000	2/4	The curved faces of the plug cross-sections are misleading as drawn. Does the plug weld have any functions requiring rigorous examinations?
235-UFD-4000	3/4	It is not readily apparent what details are being provided in 'Detail M', the 3.56 wide segments?
235-UFD-4000	4/4	The thickness dimension of the bottom lid (2" thick) conflicts with callout on Sheet 1/4 (mentioned in 2/14/2012 meeting).
235-UFD-4100	1/2	No comments.
235-UFD-4100	2/2	No comments.
General Comment	#1	The details of these assemblies are not as clear as they need to be. Drawing must reflect the information necessary to fabricate and analyze these components.
General Comment	#2	The lack of detailed material specifications and welded or bolted connection details makes any valid structural analysis of this assembly currently impossible to complete.
General Comment	#3	The assumption has been made herein that construction will be per ASME BPV Code, Section III requirements (Division 3 is preferable). Drawings should so state in Notes.
General Comment	#4	316 stainless steel is identified but reality is that dual-stamped 316L/316 will be readily available. Is that material acceptable? If so, clarifying this on the drawings will improve later procurement efforts.
General Comment	#5	Do these drawings meet industry standards or are they conceptual drawings only?
General Comment	#6	Overall, it seems to be a very labor/fabrication intensive design. Perhaps with some resizing to address fit issues, standard components or off-the-shelf items can be incorporated.

Attachment C

NOTES
1. ASME BPV CODE 3 COMPLIANCE REQUIRED



BWR ASM



PWR ASM

ITEM	QTY.	NAME	MATERIAL	DESCRIPTION	DWG
3	5	235-BWR canister asm	STEEL ASM	STEEL ASM	235-UFD-4000

ITEM	QTY.	NAME	MATERIAL	DESCRIPTION	DWG
2	5	235-PWR canister asm	STEEL ASM	STEEL ASM	235-UFD-3000
1	1	235-large can assembly	UNS S31603	STAINLESS STEEL WELDMENT	235-UFD-2000

THIRD-ANGLE PROJECTION

UNLESS OTHERWISE NOTED
DIMENSIONS ARE IN INCHES
INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M
BREAK SHARP CORNERS AND REMOVE ALL BURRS

DEFAULT TOLERANCES
LINEAR: .XX= ±.100, .XXX= ±.010, .XXXX= ±.005
ANGULAR: ±1/2°

DO NOT SCALE DRAWING

APPROVALS		DATE
DES	DR GIULIANO	4/18/2012
DRW	DR GIULIANO	4/18/2012
CHK		
ENG		
QA		

TOTAL WEIGHT LBS

THIS DRAWING PRODUCED USING SolidWorks

THIS DRAWING IS THE PROPERTY OF
OAK RIDGE NATIONAL LABORATORY
OPERATED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT DE-AC05-00OR22725 OAK RIDGE, TN

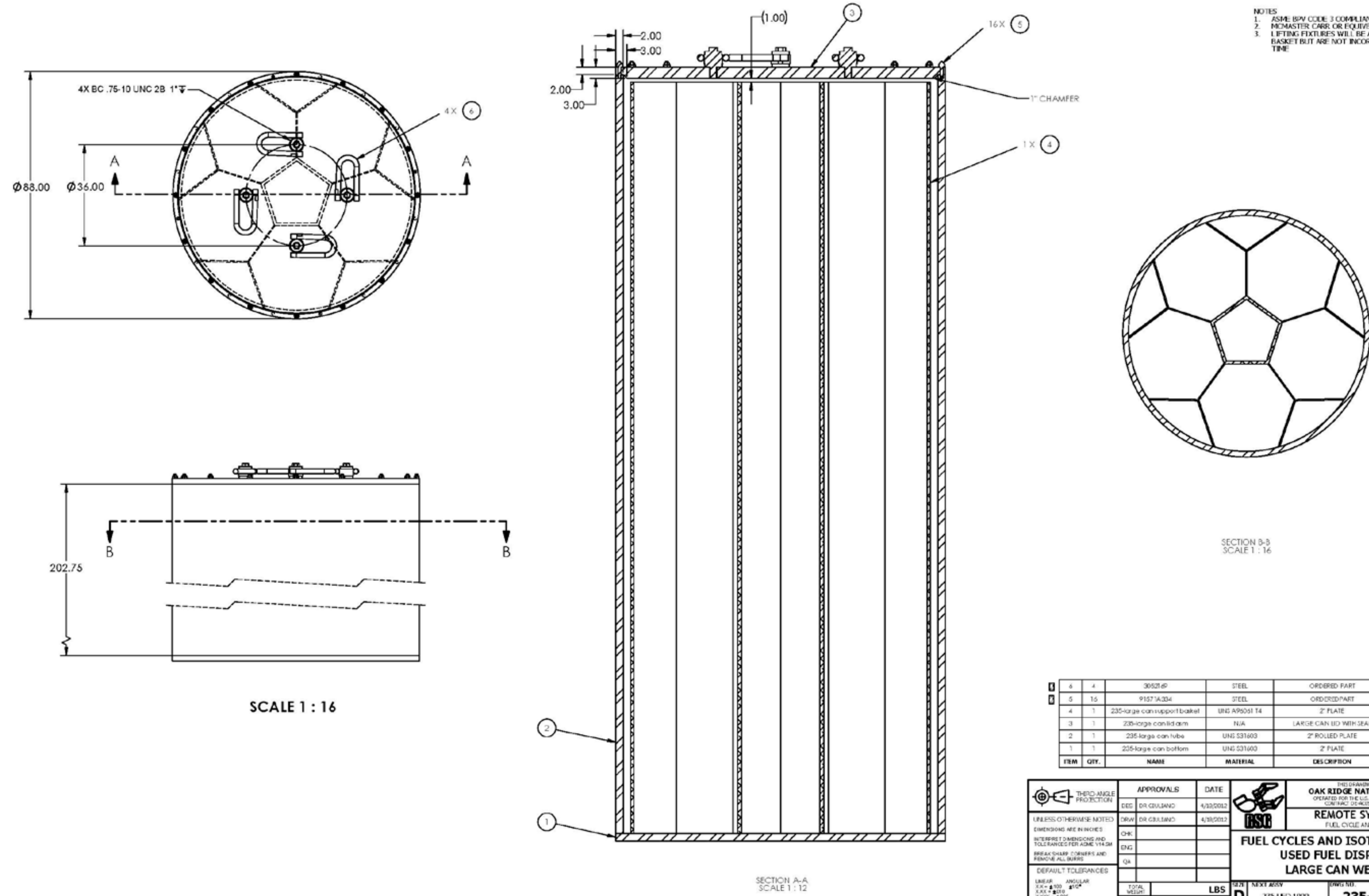
REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION

FUEL CYCLES AND ISOTOPES DIVISION
USED FUEL DISPOSITION
TOP LEVAL ASSEMBLIES

SIZE	NEXT ASSY	DWG NO.	REV
D	---	235-UFD-1000	1

SCALE 1:48 | CAD FILE 235-BWR large Can asm | SHEET 1 of 1

DWG NO. 235-UFD-1000



NOTES
1. ASME BPV CODE 3 COMPLIANCE REQUIRED
2. MCMASTER CARR OR EQUIVELANT
3. LIFTING FIXTURES WILL BE ADDED TO THE BASKET BUT ARE NOT INCORPORATED AT THIS TIME

ITEM	QTY.	NAME	MATERIAL	DESCRIPTION	DWG
6	4	3052T49	STEEL	ORDERED PART	N/A
5	16	91571A334	STEEL	ORDERED PART	N/A
4	1	235-large can support basket	UNS A96061 T4	2" PLATE	235-UFD-2000
3	1	235-large can lid asm	N/A	LARGE CAN LID WITH SEAL	235-UFD-2000
2	1	235-large can tube	UNS S31603	2" ROLLED PLATE	235-UFD-2000
1	1	235-large can bottom	UNS S31603	2" PLATE	235-UFD-2000

THIRD-ANGLE PROJECTION

UNLESS OTHERWISE NOTED
DIMENSIONS ARE IN INCHES
INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M
BREAK SHARP CORNERS AND REMOVE ALL BURRS

DEFAULT TOLERANCES
LINEAR X.X = ±.100, X.XX = ±.010, X.XXX = ±.005; ANGULAR ±1/2°

DO NOT SCALE DRAWING

APPROVALS		DATE
DES	DR GIULIANO	4/10/2012
DRW	DR GIULIANO	4/10/2012
CHK		
ENG		
QA		

TOTAL WEIGHT LBS

THIS DRAWING PRODUCED USING SolidWorks

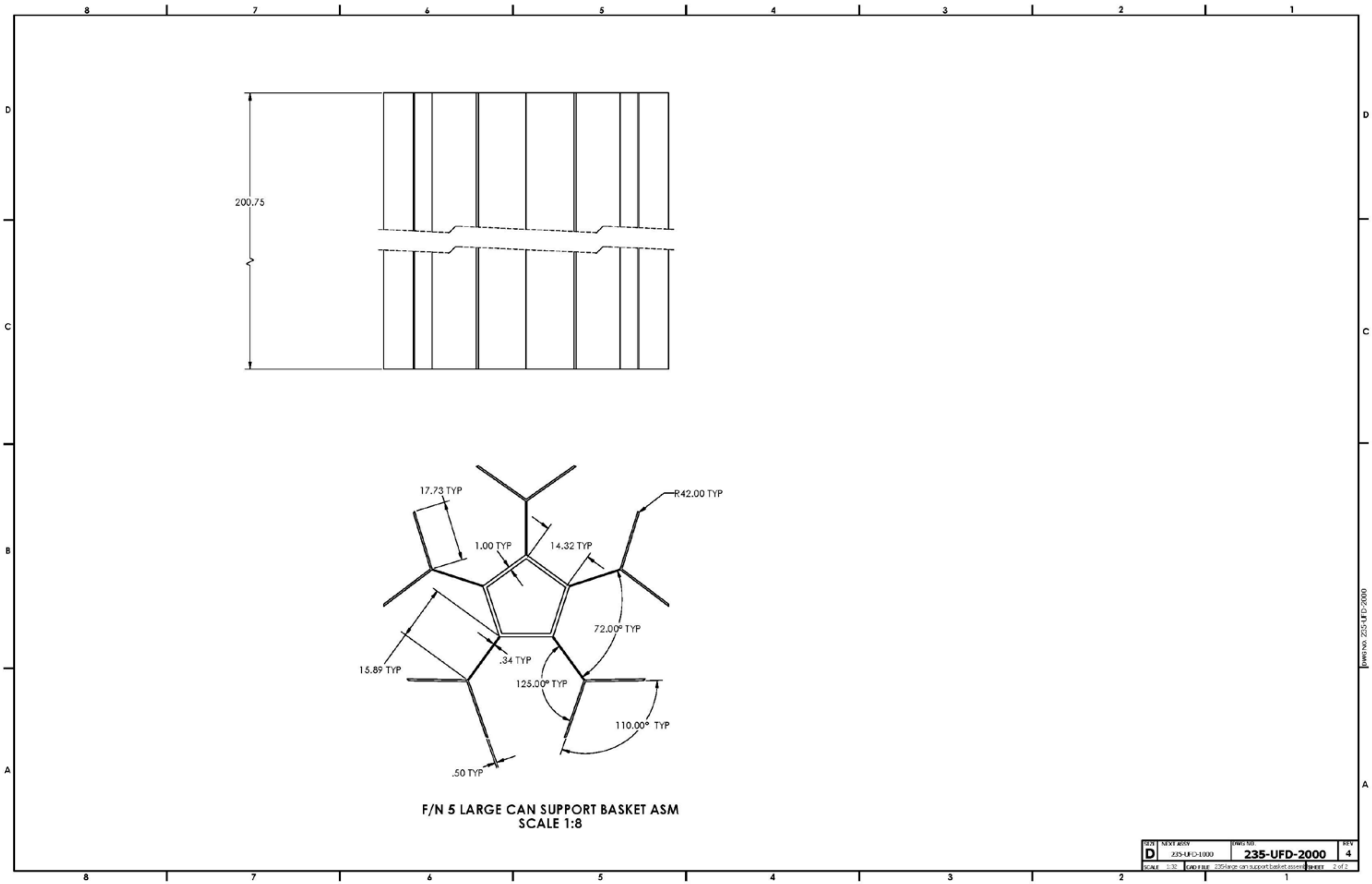
THIS DRAWING IS THE PROPERTY OF
OAK RIDGE NATIONAL LABORATORY
OPERATED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT DE-AC05-00OR22725 OAK RIDGE, TN

REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION

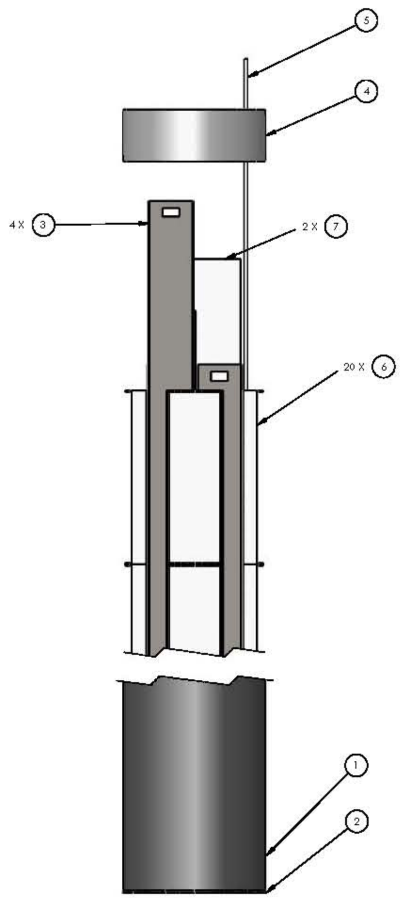
FUEL CYCLES AND ISOTOPES DIVISION
USED FUEL DISPOSITION
LARGE CAN WELDMENT

SIZE D | NEXT ASSY 235-UFD-1000 | DWG NO. 235-UFD-2000 | REV 4
SCALE 1:32 | CAD FILE 235-large can assembly | SHEET 1 of 2

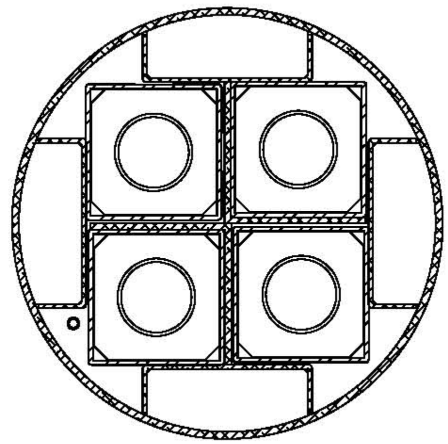
DWG NO. 235-UFD-2000


200.75
17.73 TYP
R42.00 TYP
1.00 TYP
14.32 TYP
72.00° TYP
15.89 TYP
.34 TYP
125.00° TYP
110.00° TYP
.50 TYP
F/N 5 LARGE CAN SUPPORT BASKET ASM
SCALE 1:8
SIZE D
NEXT ASSY 235-UFD-1000
DWG NO. 235-UFD-2000
REV 4
SCALE 1:32
CAD FILE 235-large can support basket assem
SHEET 2 of 2

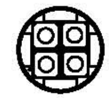
NOTES
1. ASME BPV CODE 3 COMPLIANCE REQUIRED

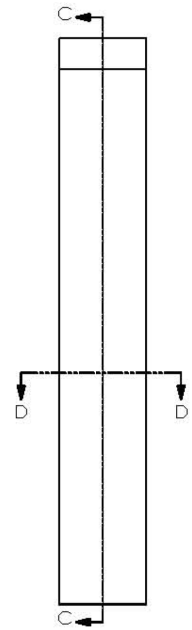


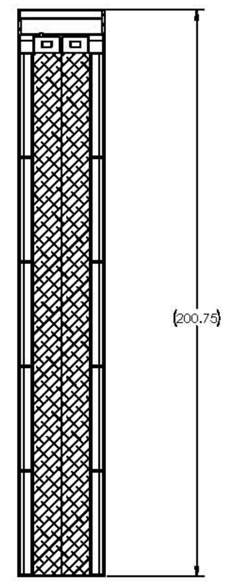
PWR CANISTER ASM
SCALE 1:12



SECTION D-D
SCALE 1 : 4







SECTION C-C
SCALE 1 : 20

ITEM	QTY.	NAME	MATERIAL	DESCRIPTION	DWG
7	2	235-pwr absorber piece BS	UNS S30464	.3125" BORATED STEEL SHEET	235-UFD-3300
6	20	235-pwr support frame section	N/A	ALUMINUM WELDMENT	235-UFD-3200
5	1	235-drainage pipe	UNS S31603	1/2 SCHD 40 PIPE	235-UFD-4000
4	1	235-small canister lid ring	UNS S31603	ROLLED 2" THK PLATE	235-UFD-4000
3	4	235-PWR Assembly sheath asm	STAINLESS STEEL ASM	STAINLESS STEEL ASM	235-UFD-3100
2	1	235-small canister bottom	UNS S31603	1/2" PLATE	235-UFD-4000
1	1	235-small canister tube	UNS S31603	1/2" THK 30.5 OD TUBE	235-UFD-4000

THIRD-ANGLE PROJECTION

UNLESS OTHERWISE NOTED
DIMENSIONS ARE IN INCHES
INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M
BREAK SHARP CORNERS AND REMOVE ALL BURRS

DEFAULT TOLERANCES
LINEAR: .XX= ±.100, .XXX= ±.010, .XXXX= ±.005
ANGULAR: ±1/2°

DO NOT SCALE DRAWING

APPROVALS		DATE
DES	DR GIULIANO	4/18/2012
DRW	DR GIULIANO	4/18/2012
CHK		
ENG		
QA		

TOTAL WEIGHT LBS

THIS DRAWING PRODUCED USING SolidWorks

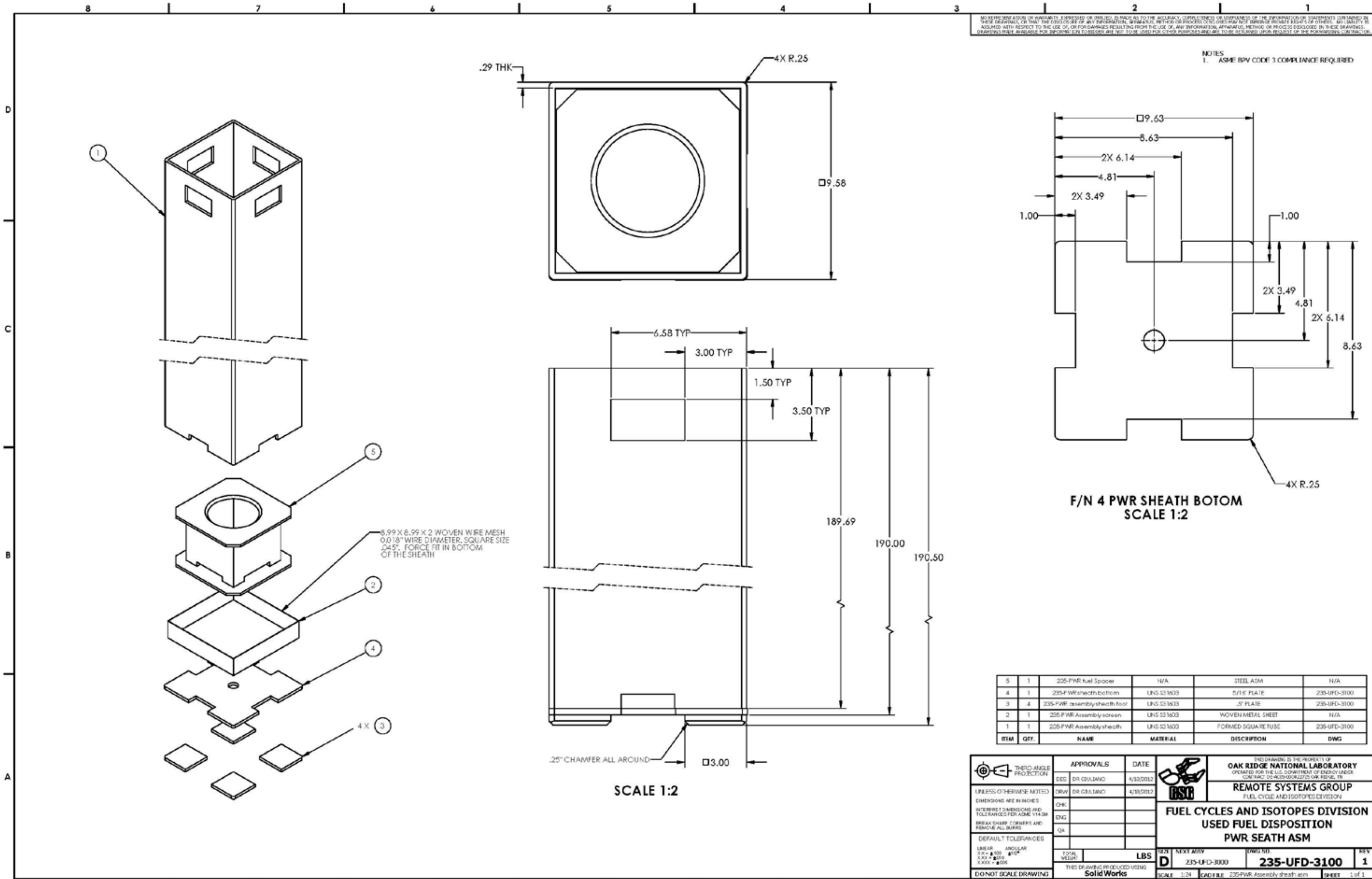
THIS DRAWING IS THE PROPERTY OF
OAK RIDGE NATIONAL LABORATORY
OPERATED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT DE-AC05-00OR22725 OAK RIDGE, TN

REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION

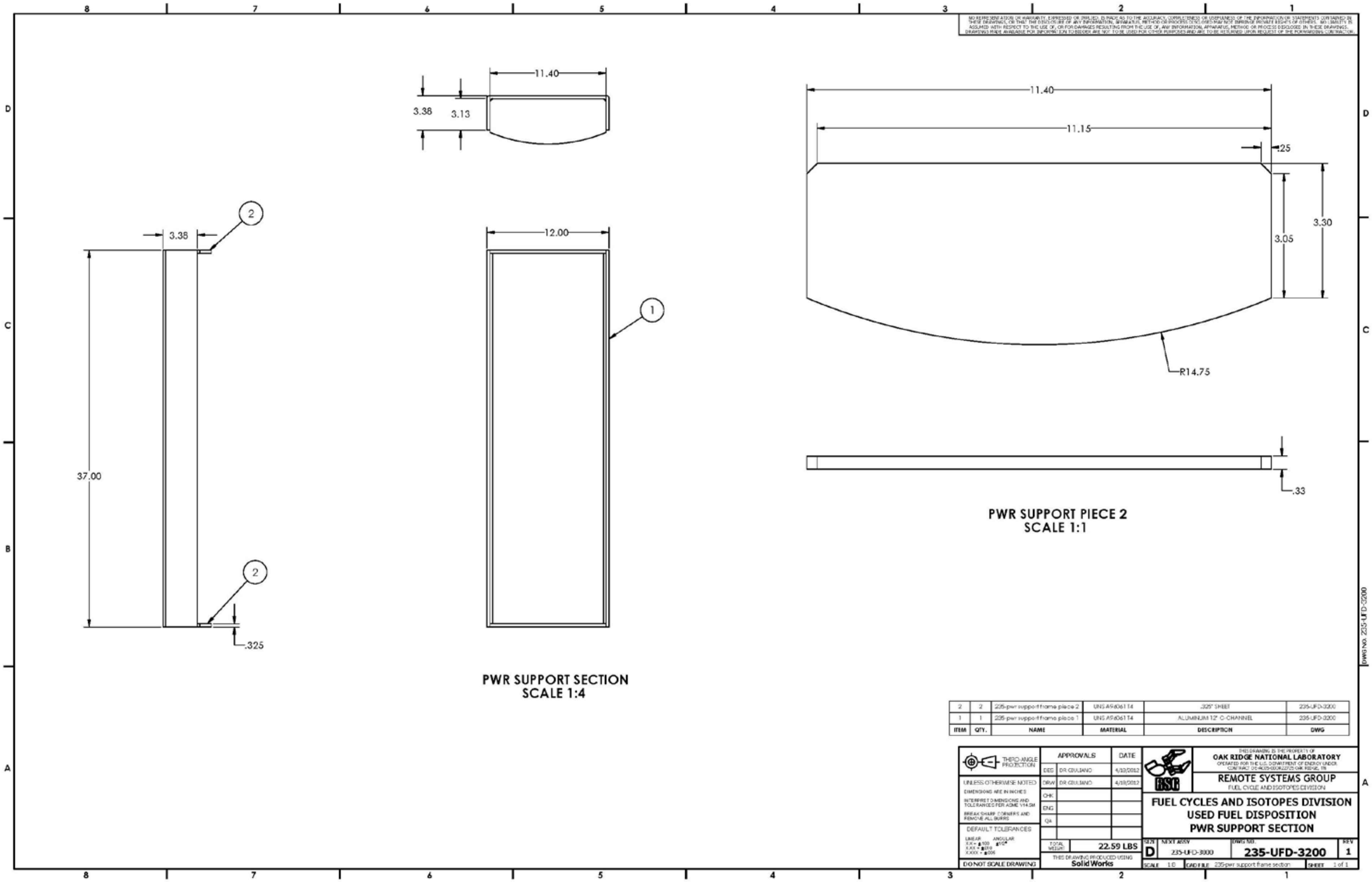
FUEL CYCLES AND ISOTOPES DIVISION
USED FUEL DISPOSITION
PWR CANISTER ASM

SIZE D | NEXT ASSY 235-UFD-1000 | DWG NO. 235-UFD-3000 | REV 3
SCALE 1:32 | CAD FILE 235-PWR canister asm | SHEET 1 of 1

DWG NO. 235-UFD-3000



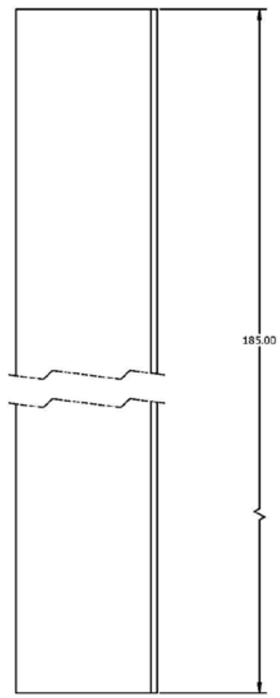
ITEM	QTY.	NAME	MATERIAL	DESCRIPTION	DWG
5	1	235-PWR fuel Spacer	N/A	STEEL ASM	N/A
4	1	235-PWR sheath bottom	UNS S31603	5/16" PLATE	235-UFD-3100
3	4	235-PWR assembly sheath foot	UNS S31603	.5" PLATE	235-UFD-3100
2	1	235-PWR Assembly screen	UNS S31603	WOVEN METAL SHEET	N/A
1	1	235-PWR Assembly sheath	UNS S31603	FORMED SQUARE TUBE	235-UFD-3100



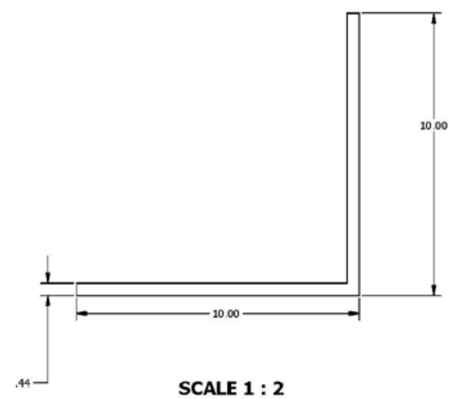
ITEM	QTY.	NAME	MATERIAL	DESCRIPTION	DWG
2	2	235-pwr support frame piece 2	UNS A96061 T4	.325" SHEET	235-UFD-3200
1	1	235-pwr support frame piece 1	UNS A96061 T4	ALUMINUM 12" C-CHANNEL	235-UFD-3200

NOTES

1. BPV CODE 3 COMPLIANCE REQUIRED



SCALE 1 : 4



SCALE 1 : 2

ITEM	QTY.	NAME	MATERIAL	DESCRIPTION	DWG
1	2	235-pwr absorber BS	UNS S30464	.3125 BORATED STEEL SHEET	235-UFD-3300

QUALITY VERIFICATION REQUIREMENTS DOCUMENTS	
MATERIAL MILL TEST REPORT	
LEAK TEST REPORT	
CLEANING CERT	
WELD / BRAZE INSPECTION REPORT	
HEAT TREAT REPORT	
DIMENSIONAL REPORT	
MATERIAL SELLER CERT	
FUNCTIONAL TEST REPORT	
DEVIATION REQUEST	
NONCONFORMANCE REPORT	

THIRD ANGLE PROJECTION

UNLESS OTHERWISE NOTED
DIMENSIONS ARE IN INCHES
INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M
BREAK SHARP CORNERS AND REMOVE ALL BURRS

DEFAULT TOLERANCES
LINEAR: X.XX = ±.100, X.XXX = ±.010, X.XXXX = ±.005
ANGULAR: ±1/2°

DO NOT SCALE DRAWING

	APPROVALS	DATE
DES	DR GIULIANO	4/10/2012
DRW	DR GIULIANO	4/10/2012
CHK		
ENG		
QA		

TOTAL WEIGHT: 154.44 LBS

THIS DRAWING PRODUCED USING SolidWorks

THIS DRAWING IS THE PROPERTY OF
OAK RIDGE NATIONAL LABORATORY
OPERATED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT DE-AC05-00OR22725 OAK RIDGE, TN

REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION

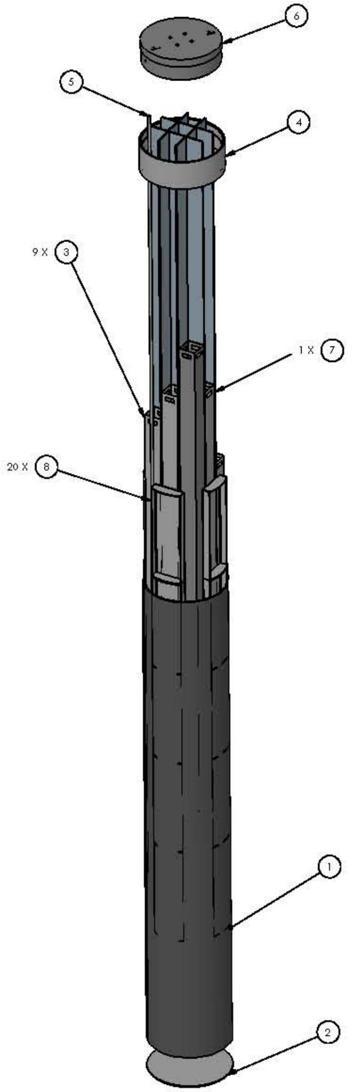
FUEL CYCLES AND ISOTOPES DIVISION
USED FUEL DISPOSITION
PWR ABSORBER SECTION

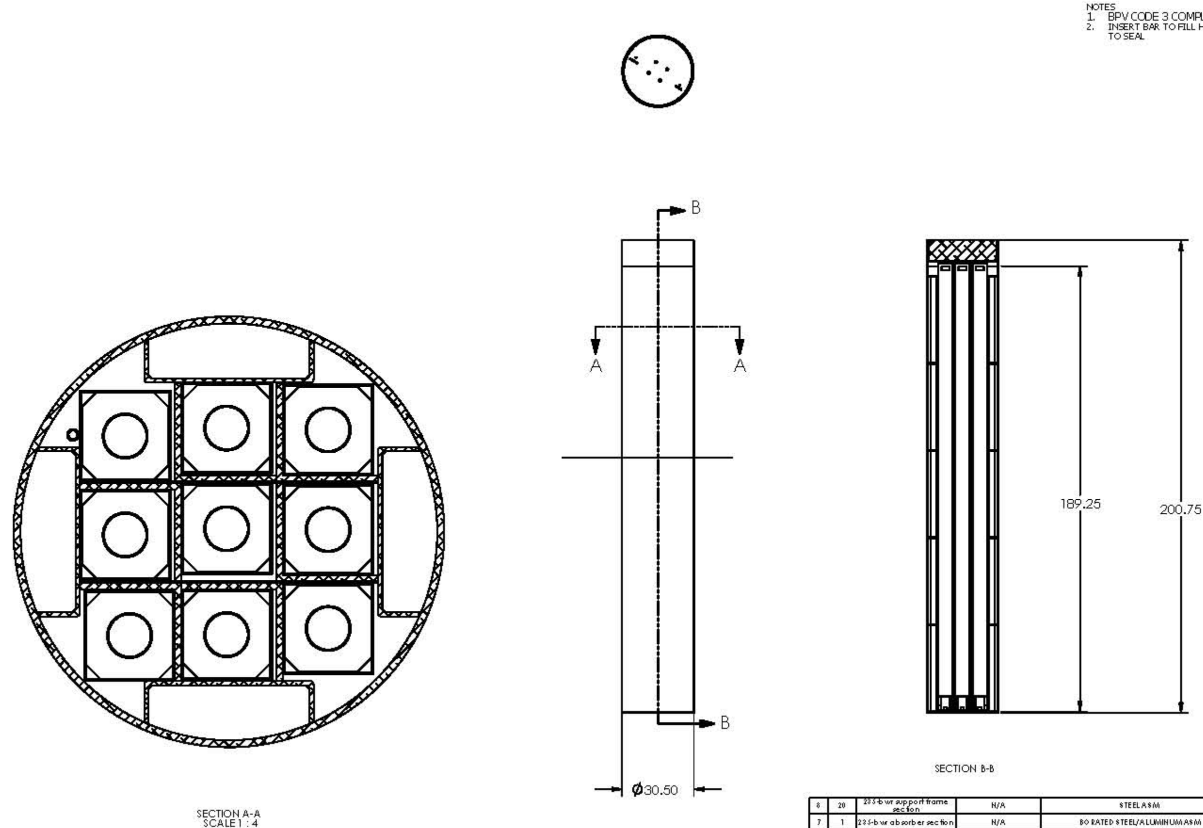
SIZE	NEXT ASSY	DWG NO.	REV
D	235-UFD-3000	235-UFD-3300	1

SCALE 1:8 | CAD FILE 235-pwr absorber piece BS | SHEET 1 of 1

DWG NO. 235-UFD-3300

NOTES
1. BPV CODE 3 COMPLIANCE REQUIRED
2. INSERT BAR TO FILL HOLE. PLUG WELD TO SEAL





ITEM	QTY.	NAME	MATERIAL	DESCRIPTION	DWG
8	20	235-bwr support frame section	N/A	STEEL ASM	235-UFD-4200
7	1	235-bwr absorber section	N/A	BORATED STEEL/ALUMINUM ASM	235-UFD-4300
6	1	235-small canister plug asm	UNS S31603	SS BLOCK 9" THK	235-UFD-4000
5	1	235-drainage pipe	UNS S31603	1/2 SCHD 40 PIPE	235-UFD-4000
4	1	235-small canister lid ring	UNS S31603	ROLLED 2" THK PLATE	235-UFD-4000
3	9	235-BWR sheath asm	UNS S31603	STAINLESS STEEL WELDMENT	235-UFD-4100
2	1	235-small canister bottom	UNS S31603	1/2" PLATE	235-UFD-4000
1	1	235-small canister tube	UNS S31603	1/2" THK 30.5 OD TUBE	235-UFD-4000

THIRD-ANGLE PROJECTION

UNLESS OTHERWISE NOTED
DIMENSIONS ARE IN INCHES
INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M
BREAK SHARP CORNERS AND REMOVE ALL BURRS

DEFAULT TOLERANCES
LINEAR: XX= ±.100, XXX= ±.010, XXXX= ±.005
ANGULAR: ±1/2°

DO NOT SCALE DRAWING

APPROVALS		DATE
DES	DR GIULIANO	4/18/2012
DRW	DR GIULIANO	4/18/2012
CHK		
ENG		
QA		

TOTAL WEIGHT LBS

THIS DRAWING PRODUCED USING **SolidWorks**

THIS DRAWING IS THE PROPERTY OF
OAK RIDGE NATIONAL LABORATORY
OPERATED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT DE-AC05-00OR22725 OAK RIDGE, TN

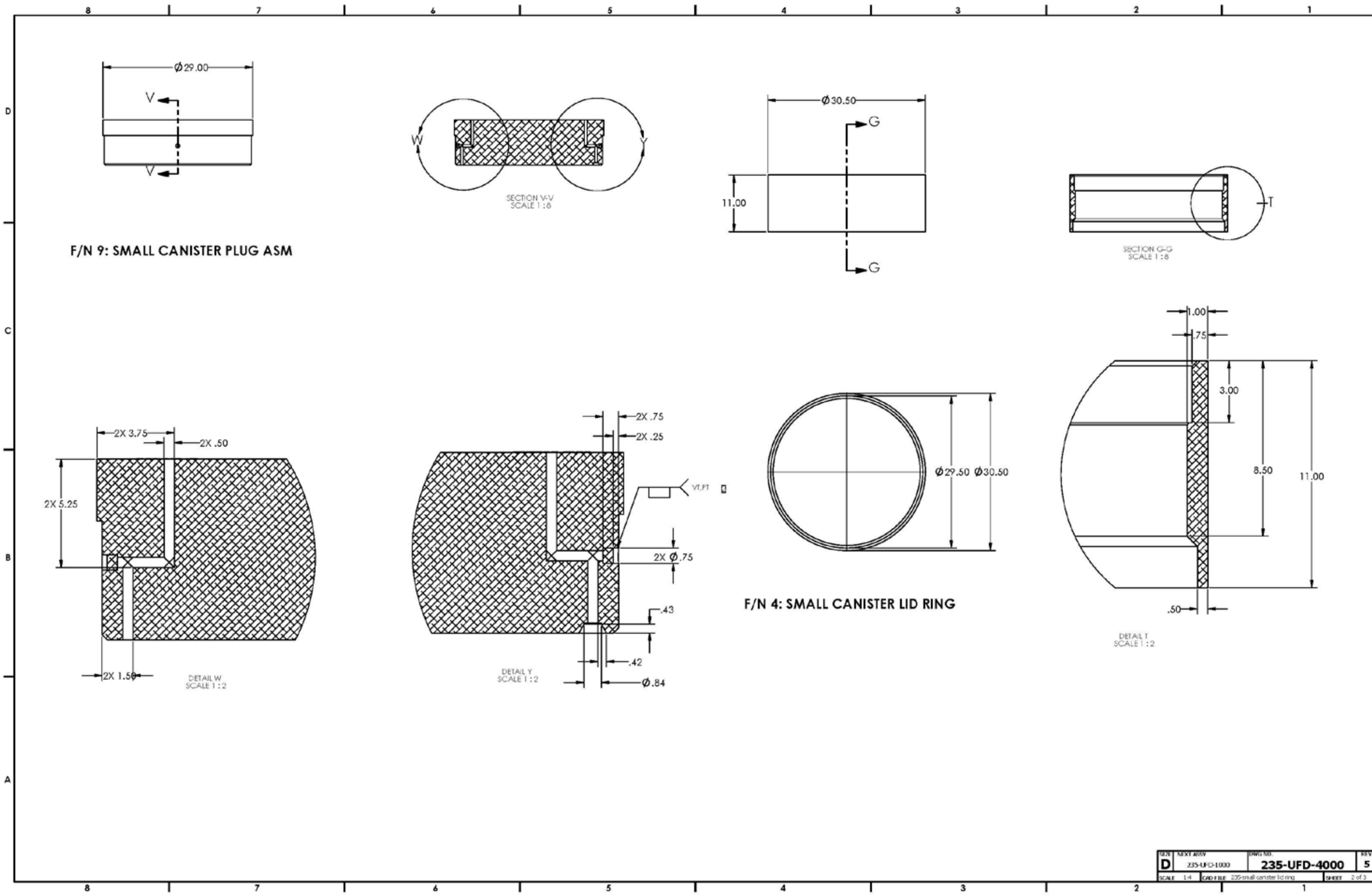
REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION

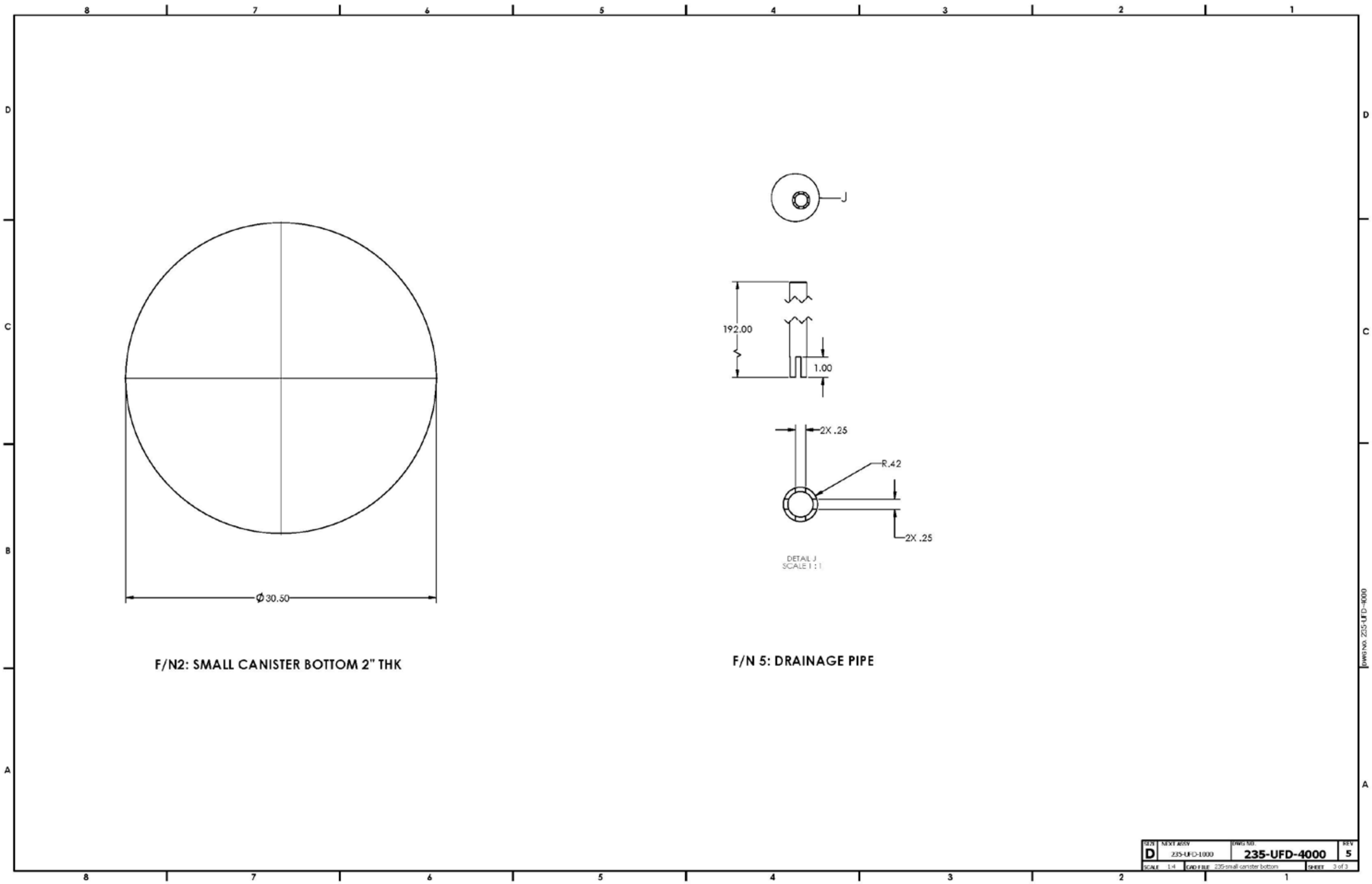
FUEL CYCLES AND ISOTOPES DIVISION
USED FUEL DISPOSITION
BWR CANISTER ASM

SIZE: D | NEXT ASSY: 235-UFD-1000 | DWG NO.: 235-UFD-4000 | REV: 5

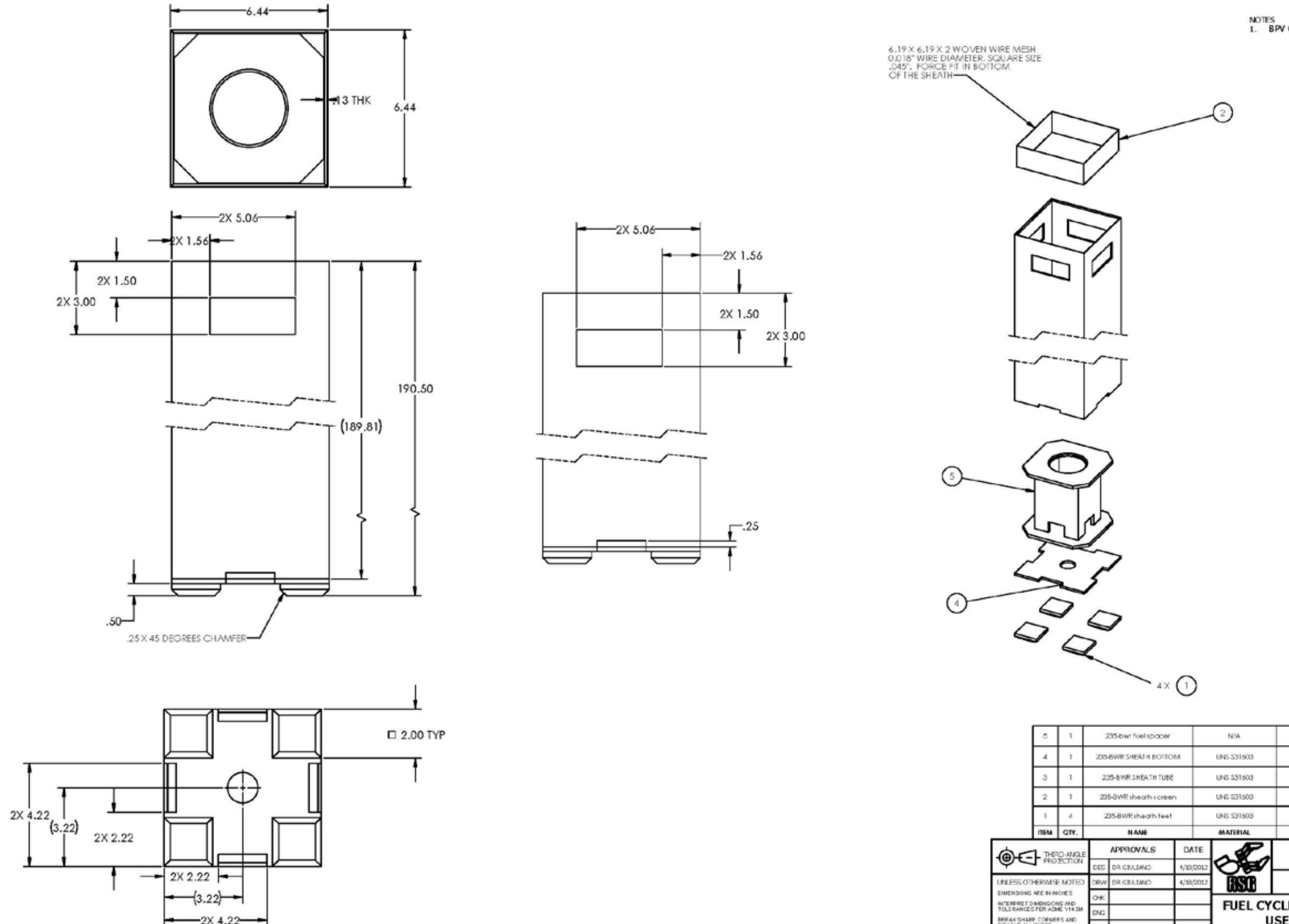
SCALE: 1:24 | CAD FILE: 235-BWR canister asm | SHEET 1 of 3

DWG NO. 235-UFD-4000


F/N 9: SMALL CANISTER PLUG ASM
Ø29.00
SECTION V-V
SCALE 1 : 8
DETAIL W
SCALE 1 : 2
2X 3.75
2X .50
2X 5.25
2X 1.50
DETAIL Y
SCALE 1 : 2
2X .75
2X .25
2X Ø.75
.43
.42
Ø.84
F/N 4: SMALL CANISTER LID RING
Ø30.50
11.00
SECTION G-G
SCALE 1 : 8
Ø29.50 Ø30.50
1.00
.75
3.00
8.50
11.00
.50
DETAIL T
SCALE 1 : 2
D
235-UFD-1000
235-UFD-4000
5


192.00
1.00
2X .25
R.42
2X .25
DETAIL J
SCALE 1 : 1
J
Ø30.50
F/N2: SMALL CANISTER BOTTOM 2" THK
F/N 5: DRAINAGE PIPE
SIZE D
NEXT ASSY 235-UFD-1000
DWG NO. 235-UFD-4000
REV 5
SCALE 1:4
CAD FILE 235-small canister bottom
SHEET 3 of 3
DWG No. 235-UFD-4000

NOTES
1. BPV CODE 3 COMPLIANCE REQUIRED.



ITEM	QTY.	NAME	MATERIAL	DESCRIPTION	DWG
5	1	235-bwr fuel spacer	N/A	STEEL ASM	N/A
4	1	235-BWR SHEATH BOTTOM	UNS S31603	3/16" PLATE SA-240	235-UFD-4100
3	1	235-BWR SHEATH TUBE	UNS S31603	.1875" SQUARE TUBE	235-UFD-4100
2	1	235-BWR sheath screen	UNS S31603	WOVEN WIRE MESH	N/A
1	4	235-BWR sheath feet	UNS S31603	1/2" PLATE SA-240	235-UFD-4100

THIRD-ANGLE PROJECTION

UNLESS OTHERWISE NOTED
DIMENSIONS ARE IN INCHES
INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M
BREAK SHARP CORNERS AND REMOVE ALL BURRS

DEFAULT TOLERANCES
LINEAR: X.X = ±.100, X.XX = ±.010, X.XXX = ±.005
ANGULAR: ±1/2°

DO NOT SCALE DRAWING

APPROVALS		DATE
DES	DR GIULIANO	4/10/2012
DRW	DR GIULIANO	4/10/2012
CHK		
ENG		
QA		

TOTAL WEIGHT: LBS

THIS DRAWING PRODUCED USING SolidWorks

THIS DRAWING IS THE PROPERTY OF
OAK RIDGE NATIONAL LABORATORY
OPERATED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT DE-AC05-00OR22725 OAK RIDGE, TN

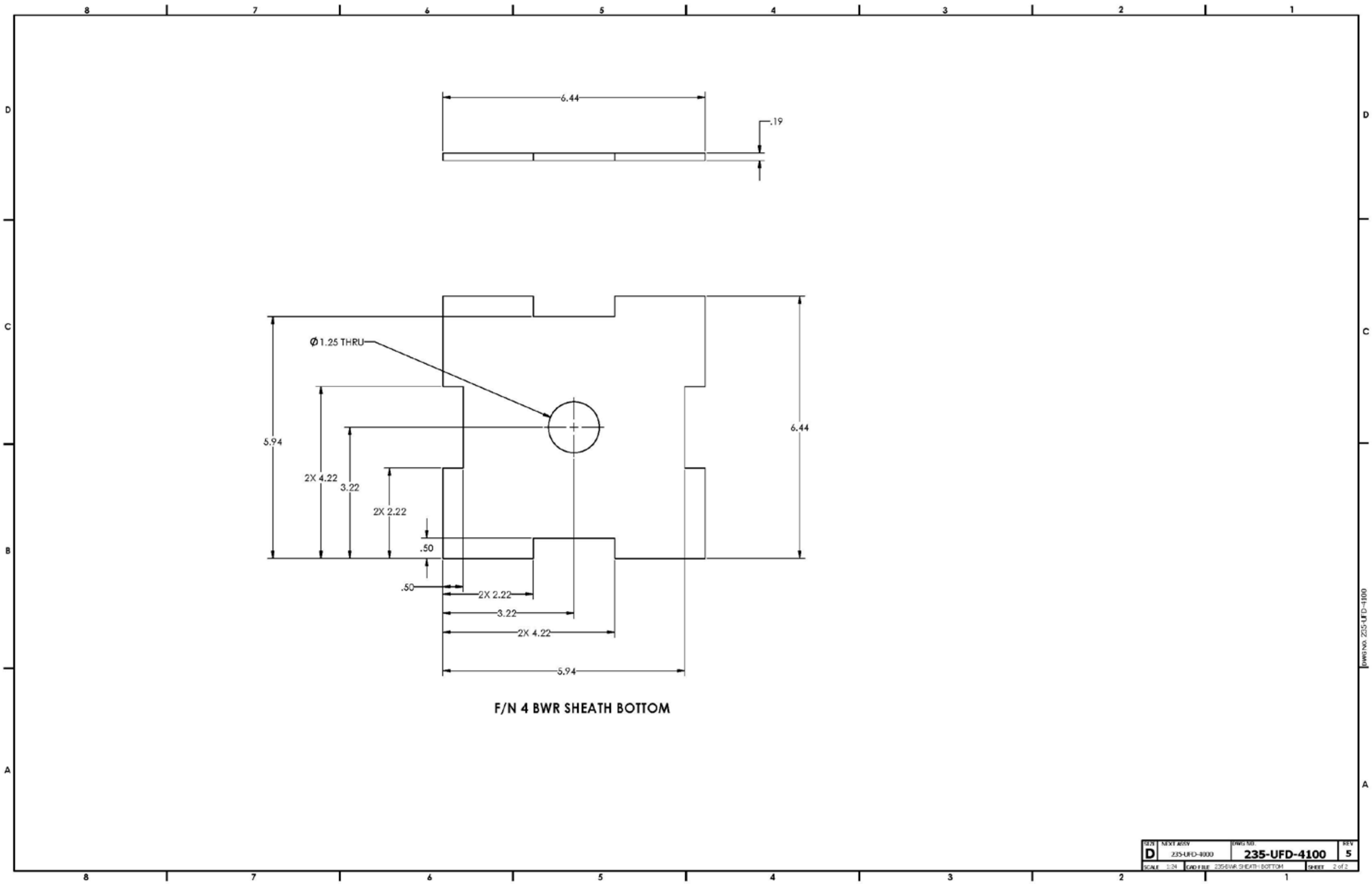
RSG
REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION

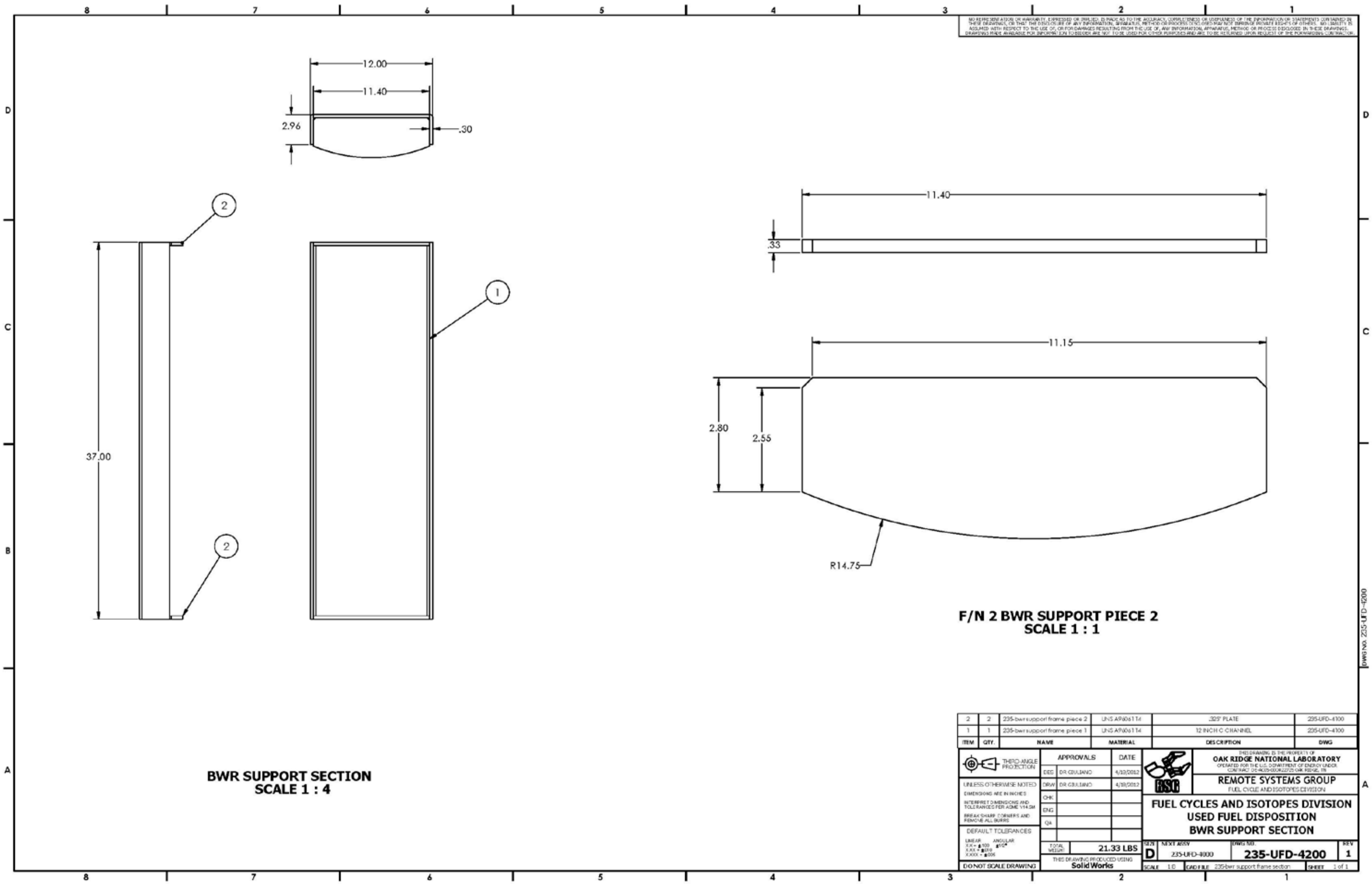
FUEL CYCLES AND ISOTOPES DIVISION
USED FUEL DISPOSITION
BWR SHEATH ASM

SIZE	NEXT ASSY	DWG NO.	REV
D	235-UFD-4000	235-UFD-4100	5

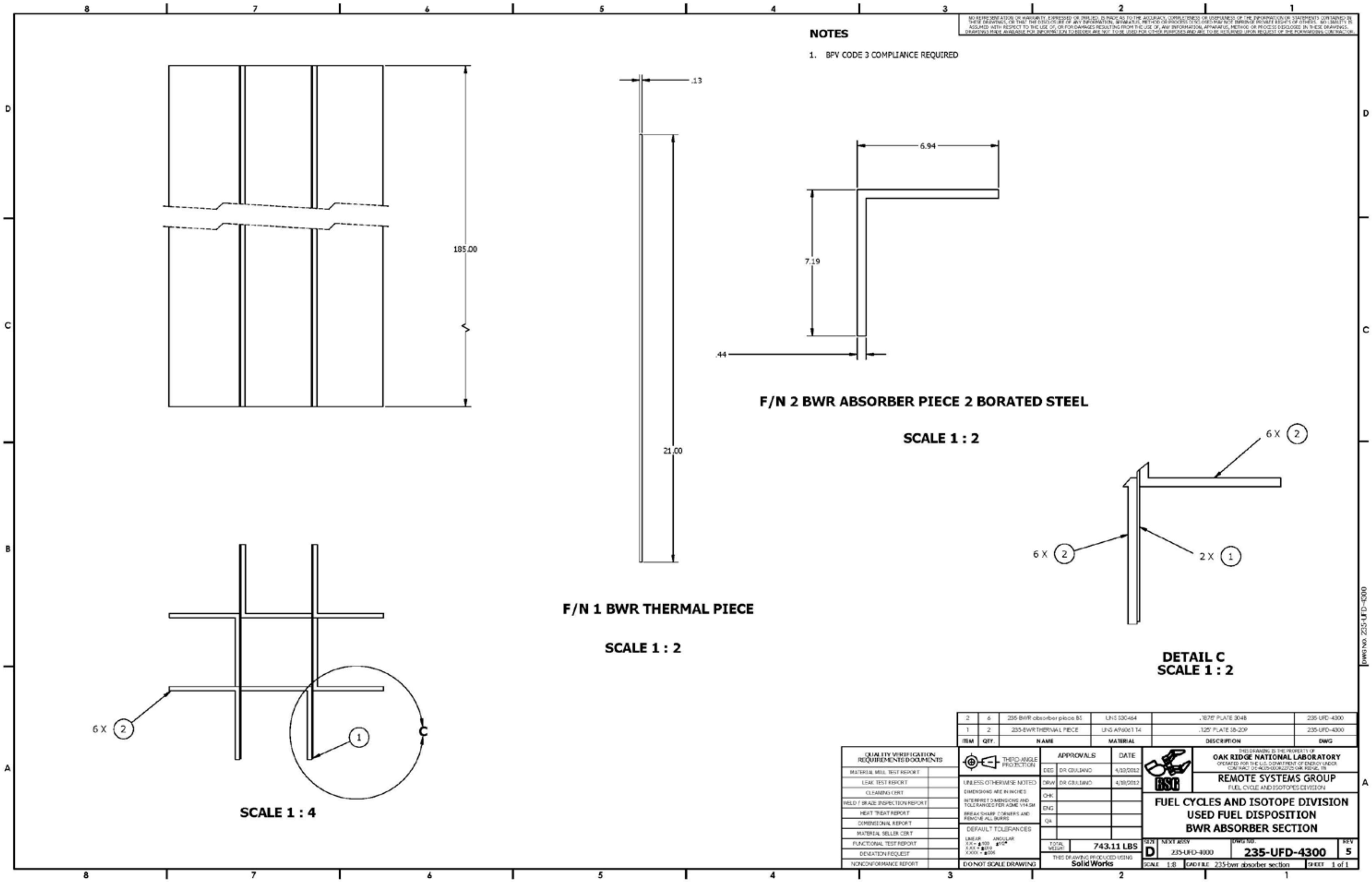
SCALE 1:24 | CAD FILE 235-BWR sheath asm | SHEET 1 of 2

DWG NO. 235-UFD-4100


6.44
.19
Ø1.25 THRU
5.94
2X 4.22
3.22
2X 2.22
.50
6.44
.50
2X 2.22
3.22
2X 4.22
5.94
F/N 4 BWR SHEATH BOTTOM
SIZE
D
NEXT ASSY
235-UFD-4000
DWG NO.
235-UFD-4100
REV
5
SCALE 1:24
CAD FILE 235-BWR SHEATH BOTTOM
SHEET 2 of 2

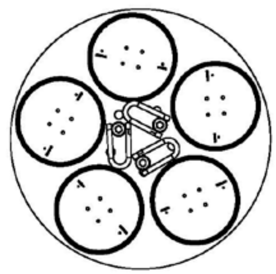


12.00
11.40
2.96
.30
37.00
2
1
2
11.40
.33
11.15
2.80
2.55
R14.75
F/N 2 BWR SUPPORT PIECE 2
SCALE 1 : 1
BWR SUPPORT SECTION
SCALE 1 : 4
2 | 2 | 235-bwr support frame piece 2 | UNS A96061T4 | .325" PLATE | 235-UFD-4100
1 | 1 | 235-bwr support frame piece 1 | UNS A96061T4 | 12 INCH C CHANNEL | 235-UFD-4100
ITEM | QTY. | NAME | MATERIAL | DESCRIPTION | DWG
THIRD ANGLE PROJECTION
APPROVALS
DATE
DES DR GIULIANO 4/10/2012
DRW DR GIULIANO 4/10/2012
CHK
ENG
QA
UNLESS OTHERWISE NOTED
DIMENSIONS ARE IN INCHES
INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M
BREAK SHARP CORNERS AND REMOVE ALL BURRS
DEFAULT TOLERANCES
TOTAL WEIGHT 21.33 LBS
THIS DRAWING PRODUCED USING
SolidWorks
DO NOT SCALE DRAWING
THIS DRAWING IS THE PROPERTY OF
OAK RIDGE NATIONAL LABORATORY
REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION
FUEL CYCLES AND ISOTOPES DIVISION
USED FUEL DISPOSITION
BWR SUPPORT SECTION
SIZE D
NEXT ASSY 235-UFD-4000
DWG NO. 235-UFD-4200
REV 1
SCALE 1:8
CAD FILE 235-bwr support frame section
SHEET 1 of 1

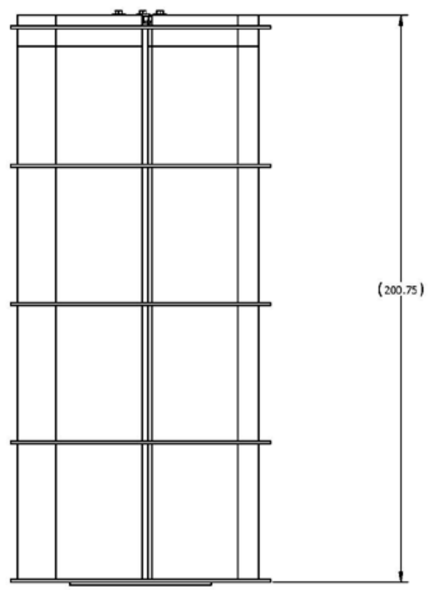

NOTES
1. BPV CODE 3 COMPLIANCE REQUIRED
185.00
.13
21.00
6.94
7.19
.44
F/N 2 BWR ABSORBER PIECE 2 BORATED STEEL
SCALE 1 : 2
F/N 1 BWR THERMAL PIECE
SCALE 1 : 2
6 X 2
2 X 1
DETAIL C
SCALE 1 : 2
6 X 2
1
C
SCALE 1 : 4
2 | 6 | 235 BWR absorber piece BS | UNS S30464 | .1875 PLATE 304B | 235-UFD-4300
1 | 2 | 235-BWR THERMAL PIECE | UNS A96061 T4 | .125 PLATE 38-20P | 235-UFD-4300
ITEM | QTY. | NAME | MATERIAL | DESCRIPTION | DWG
QUALITY VERIFICATION REQUIREMENTS DOCUMENTS
MATERIAL MILL TEST REPORT
LEAK TEST REPORT
CLEANING CERT
WELD / BRAZE INSPECTION REPORT
HEAT TREAT REPORT
DIMENSIONAL REPORT
MATERIAL SELLER CERT
FUNCTIONAL TEST REPORT
DEVIATION REQUEST
NONCONFORMANCE REPORT
THIRD-ANGLE PROJECTION
UNLESS OTHERWISE NOTED
DIMENSIONS ARE IN INCHES
INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M
BREAK SHARP CORNERS AND REMOVE ALL BURRS
DEFAULT TOLERANCES
DO NOT SCALE DRAWING
APPROVALS
DATE
DES DR GIULIANO 4/10/2012
DRW DR GIULIANO 4/18/2012
CHK
ENG
QA
TOTAL WEIGHT 743.11 LBS
THIS DRAWING PRODUCED USING SolidWorks
THIS DRAWING IS THE PROPERTY OF
OAK RIDGE NATIONAL LABORATORY
REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION
FUEL CYCLES AND ISOTOPE DIVISION
USED FUEL DISPOSITION
BWR ABSORBER SECTION
SIZE D
NEXT ASSY 235-UFD-4000
DWG NO. 235-UFD-4300
REV 5
SCALE 1:8
CAD FILE 235-bwr absorber section
SHEET 1 of 1

NOTES

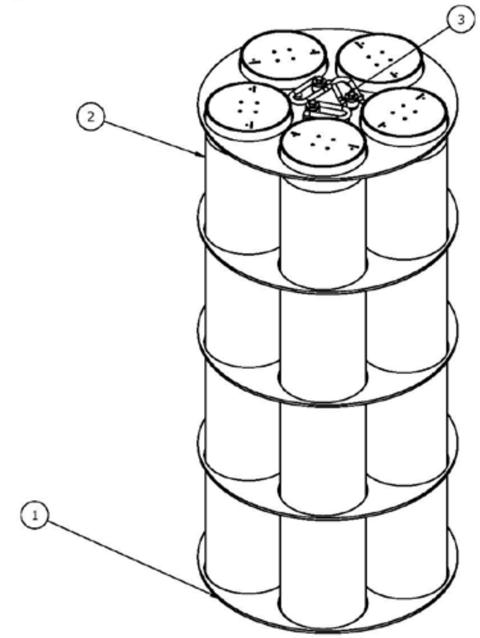
1. BPV CODE 3 COMPLIANCE REQUIRED



SCALE 1 : 20



SCALE 1 : 20



SCALE 1 : 20

ITEM	QTY.	NAME	MATERIAL	DESCRIPTION	DWG
3	3	3052T69	STEEL	ORDERED PART	N/A
2	5	235-BWR canister asm	STEEL ASM	STEEL ASM	235-UFD-4000
1	1	235-large can inner support cartridge	UNS S31603	WELDED STEEL CONSTRUCTION	235-UFD-5100

QUALITY VERIFICATION REQUIREMENTS DOCUMENTS	
MATERIAL MILL TEST REPORT	
LEAK TEST REPORT	
CLEANING CERT	
WELD / BRAZE INSPECTION REPORT	
HEAT TREAT REPORT	
DIMENSIONAL REPORT	
MATERIAL SELLER CERT	
FUNCTIONAL TEST REPORT	
DEVIATION REQUEST	
NONCONFORMANCE REPORT	

THIRD ANGLE PROJECTION

UNLESS OTHERWISE NOTED
DIMENSIONS ARE IN INCHES
INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M
BREAK SHARP CORNERS AND REMOVE ALL BURRS

DEFAULT TOLERANCES
LINEAR: X.XX = ±.100; X.XXX = ±.010; X.XXXX = ±.005 — ANGULAR: ±1/2°

DO NOT SCALE DRAWING

APPROVALS		DATE
DES	DR GIULIANO	4/19/2012
DRW	DR GIULIANO	4/19/2012
CHK		
ENG		
QA		

TOTAL WEIGHT: 22893.36 LBS

THIS DRAWING PRODUCED USING SolidWorks

THIS DRAWING IS THE PROPERTY OF
OAK RIDGE NATIONAL LABORATORY
OPERATED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT DE-AC05-00OR22725 OAK RIDGE, TN

RSG
REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION

FUEL CYCLES AND ISOTOPES DIVISION
USED FUEL DISPOSTION
BWR CARTRIDGE TOP LEVEL

SIZE	NEXT ASSY	DWG NO.	REV
D	N/A	235-UFD-5000	1

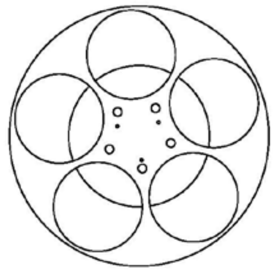
SCALE 1:32 | CAD FILE 235-BWR cartridge asm | SHEET 1 of 1

DWG NO. 235-UFD-5000

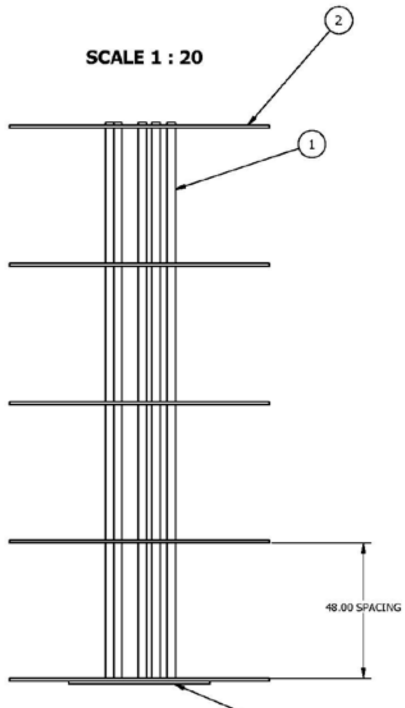
NO REPRESENTATION OR WARRANTY, EXPRESSED OR IMPLIED, IS MADE AS TO THE ACCURACY, COMPLETENESS OR USEFULNESS OF THE INFORMATION OR STATEMENTS CONTAINED IN THESE DRAWINGS, OR THAT THE DISCLOSURE OF ANY INFORMATION, APPARATUS, METHOD OR PROCESS DISCLOSED MAY NOT INFRINGE PRIVATE RIGHTS OF OTHERS. NO LIABILITY IS ASSUMED WITH RESPECT TO THE USE OF, OR FOR DAMAGES RESULTING FROM THE USE OF, ANY INFORMATION, APPARATUS, METHOD OR PROCESS DISCLOSED IN THESE DRAWINGS. DRAWINGS MADE AVAILABLE FOR INFORMATION TO BIDDER ARE NOT TO BE USED FOR OTHER PURPOSES AND ARE TO BE RETURNED UPON REQUEST OF THE FORWARDING CONTRACTOR.

NOTES

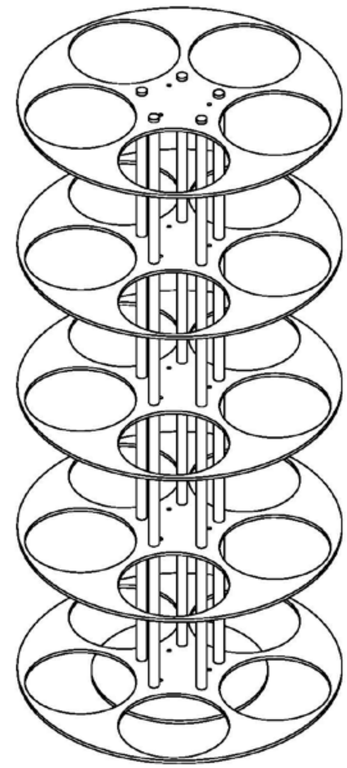
1. BPV CODE 3 COMPLIANCE REQUIRED



SCALE 1 : 20



SCALE 1 : 20



SCALE 1 : 16

DWG NO. 235-UFD-5100

ITEM	QTY.	NAME	MATERIAL	DESCRIPTION	DWG
3	1	235-large can inner support cartridge bottom	UNS S31603	1" STEEL PLATE	235-UFD-5100
2	5	235-large can inner support piece	UNS S31603	1" PLATE	235-UFD-2000
1	5	235-large can inner support rod	UNS S31603	3 INCH ROD	235-UFD-5100

QUALITY VERIFICATION REQUIREMENTS DOCUMENTS	
MATERIAL MILL TEST REPORT	
LEAK TEST REPORT	
CLEANING CERT	
WELD / BRAZE INSPECTION REPORT	
HEAT TREAT REPORT	
DIMENSIONAL REPORT	
MATERIAL SELLER CERT	
FUNCTIONAL TEST REPORT	
DEVIATION REQUEST	
NONCONFORMANCE REPORT	

THIRD-ANGLE PROJECTION

UNLESS OTHERWISE NOTED
DIMENSIONS ARE IN INCHES
INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M
BREAK SHARP CORNERS AND REMOVE ALL BURRS

DEFAULT TOLERANCES
LINEAR: X.X = ±.100, X.XX = ±.010, X.XXX = ±.005
ANGULAR: ±1/2°

DO NOT SCALE DRAWING

	APPROVALS	DATE
DES	DR GIULIANO	4/19/2012
DRW	DR GIULIANO	4/19/2012
CHK		
ENG		
QA		

TOTAL WEIGHT: 6511.84 LBS

THIS DRAWING PRODUCED USING **SolidWorks**

THIS DRAWING IS THE PROPERTY OF
OAK RIDGE NATIONAL LABORATORY
OPERATED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT DE-AC05-00OR22725 OAK RIDGE, TN

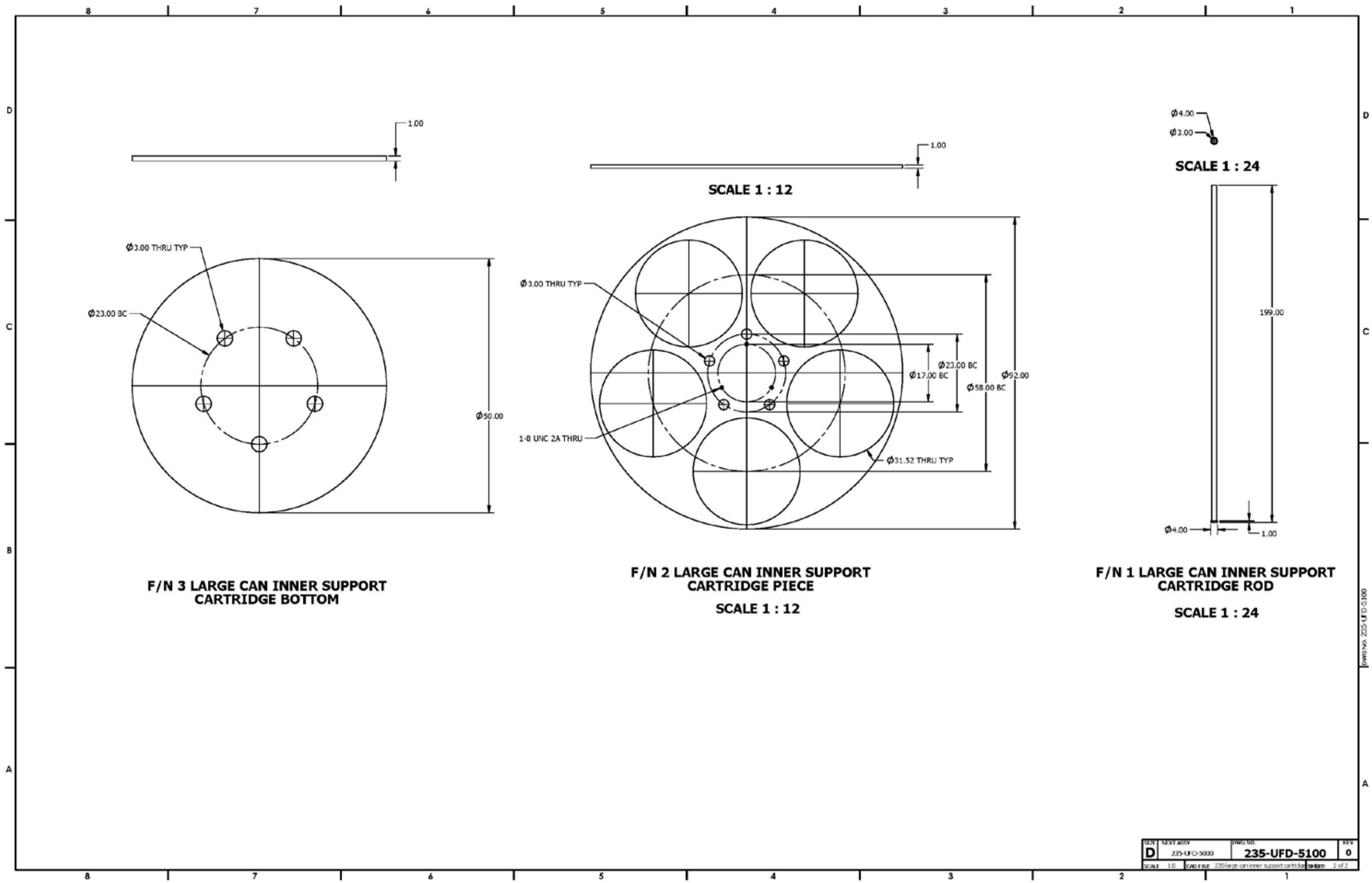
RSG

REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION

FUEL CYCLES AND ISOTOPE DIVISION
USED FUEL DISPOSITION
LARGE CAN INNER SUPPORT CARTRIDGE

SIZE	NEXT ASSY	DWG NO.	REV
D	235-UFD-5000	235-UFD-5100	0

SCALE 1:32 | CAD FILE 235-large can inner support cartridge | SHEET 1 of 2


1.00
Ø3.00 THRU TYP
Ø23.00 BC
Ø50.00
F/N 3 LARGE CAN INNER SUPPORT CARTRIDGE BOTTOM
1.00
SCALE 1 : 12
Ø3.00 THRU TYP
Ø23.00 BC
Ø17.00 BC
Ø92.00
Ø58.00 BC
1-8 UNC 2A THRU
Ø31.52 THRU TYP
F/N 2 LARGE CAN INNER SUPPORT CARTRIDGE PIECE
SCALE 1 : 12
Ø4.00
Ø3.00
SCALE 1 : 24
199.00
Ø4.00
1.00
F/N 1 LARGE CAN INNER SUPPORT CARTRIDGE ROD
SCALE 1 : 24
SIZE
D
NEXT ASSY
235-UFD-5000
DWG NO.
235-UFD-5100
REV
0
SCALE 1:0
CAD FILE 235-large can inner support cartridge
SHEET 2 of 2

Appendix B

ORNL Proposed Can-In-Can Design Structural Evaluation for Selected Accidental Drop Events

(Note submitted under separate cover due to size)

Appendix C

Drying Commentary on Proposed Can-In-Can Concept

Nuclear Materials Disposition and Engineering

INL FY12
Submittals for the
Operational Assessment of the Can in Can Concept

FCRD-UFD-2012-000326

June 2012

Approved by:

S.M Birk — 6.28.12

Sandra M. Birk
Manager, Nuclear Materials Disposition and Engineering

Date

DOE/NE Fuel Cycle Technologies Program
Office of Used Fuel Disposition Research and Development

Operational Assessment of the Can-In-Can Concept

Idaho National Laboratory
June 28, 2012

Objective

This paper considers the motivations for the proposed can-in-can packaging concept for used commercial nuclear fuel, assesses the operational challenges to implementation, and examines the implications and timing of a decision to employ the can-in-can concept.

Background

The can-in-can concept is to design cans for used commercial nuclear fuel that are small enough to enable flexible storage and transport configurations and robust enough to be suitable for direct disposal. Expanding on this idea, the intent is for a larger outer can to be designed to accept a number of these small cans and optimize the materials and configuration to meet storage and transportation requirements.[1] The concept of a standardized disposal can is not new. The U.S. Navy has a standard can to allow for uniform handling of its fuel. The INL also developed a standard can to accept the broad range of DOE fuel, and the approach offers some applicable insights.[2]

The envisioned benefits of the can-in-can concept are 1) standardized packaging that could comply with a wide range of storage, transportation, and disposal requirements while simplifying future facility requirements, 2) a versatile small can that minimizes the need for bare fuel handling, and 3) a single storage and transportation package design that accommodates a broad range of current and future fuels supported by demonstration confirming storage and transportation safety over extended storage periods. To take full advantage of these aforementioned benefits, the can-in-can concept has been proposed for implementation at the utilities. The can-in-can concept has been postulated as an alternative should direct disposal of used fuel prove untenable.

Generic Repository Requirements

In the absence of a selected repository site, generic repository options broadly define the repository environment. International efforts have identified several credible alternatives such as mined crystalline, mined clay/shale, mined bedded salt, and deep borehole. In combination with U.S. efforts to research and license a repository at Yucca Mountain, Nevada, these efforts provide the basis for likely disposal requirements. Reconsidering waste forms in the context of a range of potential disposal media helps define disposal requirements based on practical physical options and limitations independent from site selection. The small can is intended for use as or within the disposal waste package based upon heat transfer calculations forfuel loads that satisfy thermal constraints on container integrity for several identified geologic media.

Without decay times in excess of ~100 years or more, thermal considerations severely limit the packing density for used light water reactor fuel in many of the potential disposal environments. Thermal analysis indicates that a disposal package containing no more than 4 PWR assemblies per can or 9 BWR assemblies per can is compatible with most repository options of interest.[3] On this basis, the can has been tentatively sized to accommodate no more than 4 PWR or 9 BWR assemblies.[4] However, such repository packing density restrictions may become unnecessary with the extended interim storage. Storage terms of 100 years or more are being contemplated. Accordingly, acquisition of supporting data to extend existing dry storage licenses and efforts to provide for prolonged dry storage while accounting for trends in increasing fuel burnup are industry priorities.[5, 6]

The loading constraint is motivated by the need to limit thermal output per disposal package, but the choice has a secondary effect of a lower maximum temperature during the drying cycle compared to existing cask loads with a similar nominal burnup. (The smaller fuel load of the small can more readily satisfies the thermal constraints on drying under NRC-SFST-ISG-11.[7] However, the potential benefit in preventing hydride cracking of the cladding may be offset by residual moisture given reduced heat available to facilitate drying.) A risk associated with committing to the can-in-can concept is that the ‘generalized repository requirements may be overly restrictive if, for example, long storage periods times and/or a more heat tolerant repository. Or the generalized repository requirements could be not restrictive enough if deep borehole disposal requiring packages sized for individual assemblies. Future disposition paths could obviate reliance on the can altogether (e.g. reprocessing or other future disposal technologies).

Pathways to Disposal

In order for used fuel to be moved from an operating reactor to any disposal destination, several intervening operations are expected to occur: underwater handling and pool storage, drying and packaging for dry storage, on-site transfer, cask configuration or repackaging to meet off-site transportation requirements, and transfer to consolidated storage or disposition site. Figure 1 illustrates with a block diagram the general pathway to disposal both for existing fuel handling operations and for the can-in-can concept.

The existing operations have already been approved within the existing licensing envelope as defined by 10 CFR 71[8] and 10 CFR 72[9] and the NRC guidance documents NUREG-1536[10], NUREG-1567[11], and NUREG-1927[12]. Fuel movements have been analyzed. Shielding and worker locations have been considered. Facility space, handling capacity, and the available equipment are adequate to support the existing processes and configurations. Hazards have been identified and mitigated. Personnel have been trained. Infrastructure and protocols have been established to satisfy licensing requirements: changes are strictly controlled. Retrofit to accommodate the can-in-can concept would be financially expensive and would 1) take time, 2) require physical upgrades, and 3) require additional regulatory review for alterations to approved configurations and processes. And an additional effort to re-package the used fuel currently in dry storage would still be needed to achieve full standardization.

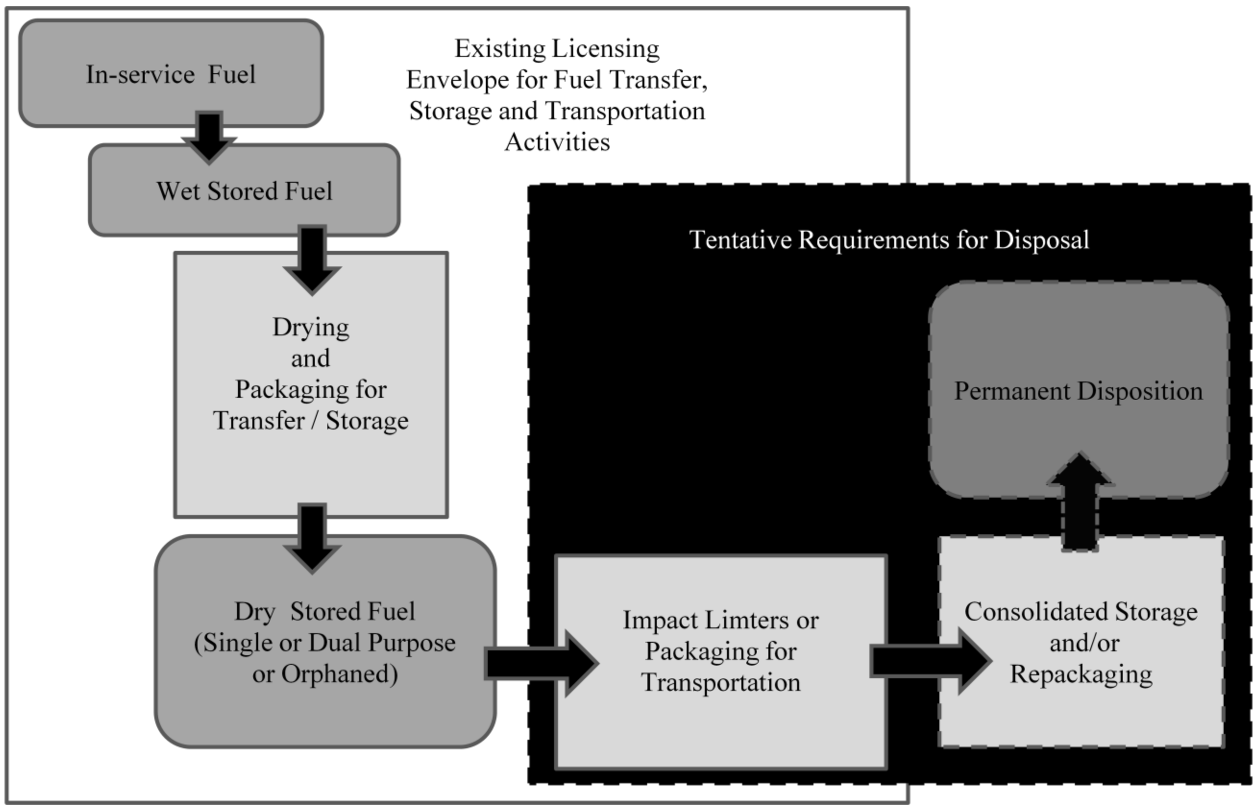


Figure 1. Generic Pathway to Disposal

Transportation of commercial fuel has long been accommodated by commercial cask vendors. Storage bunkers could be designed to accommodate the small cans, and the cask vendors can readily develop inserts to accommodate the small cans in their existing transportation casks. The size of the larger can appears to be inefficiently small for handling and storage purposes and unwieldy large for transportation.

While many of the fuel or fuel package degradation mechanisms have been identified, the rates and limiting conditions for degradation in a disposal environment remain to be determined. The grey box at the end of the generic path in Figure 1 represents the uncertainty associated with future requirements for final disposition of used nuclear fuel. The Yucca Mountain licensing experience demonstrates the level at which used fuel policy may be reversed; however, 10 CFR 60 can be tentatively applied to the disposal of used fuel.

Note that the "Impact Limiters or Packaging" step between dry storage and consolidated storage and/or repackaging is within both the existing licensing envelope and the boundary of tentative requirements. This is intended to suggest that while existing regulation allows for fuel transportation, more efficient engineering design beyond the scope of existing practices may take advantage of radiologic decay and demonstrate improvements that may be acceptable for future use.

Existing Practices

If standardized packaging occurs at the utility at the time of transfer from wet storage to dry storage, the anticipated benefit is the elimination of later potential bare-fuel handling. However three considerations make this a weak argument: 1) any future change in strategy that leads to repackaging precludes the benefit, 2) increasing the duration of can use increases material aging prior to repository placement, and 3) any requirement to retrofit existing facilities to accommodate the can-in-can concept is expected to be prohibitively expensive and is likely to be resisted by the utilities to the extent that it interferes with other plant operations. A brief examination of conventional drying protocol illustrates some of the investment these utilities have in their existing systems.

Most used fuel is being placed in canister-based storage systems – which place the fuel in a canister which is dried, inerted, and seal welded. The following process is typical for storage canisters (and bolted storage casks) accepting bare fuel assemblies.

The empty canister and transfer cask (or bolted storage cask) are (is) submerged in fuel storage pool. Fuel is loaded into the canister (or cask) underwater. Primary shielding is provided by the depth of the water. Shielding lid (or secondary/temporary shielding for transfer) is installed. Loaded (flooded) cask is removed from water. The exterior surfaces are decontaminated. Canister (or cask) is staged for drying process and drained with inert cover gas applied to address ISG-22 (limiting potential for fuel oxidation during handling and drying operations). Load is dried (usually under vacuum, but use of forced helium gas is also an accepted practice). Canister is seal-welded, place in a transfer cask, and transferred to dry storage (accepted into another cask or vault). (Or bolted cask is sealed and transferred to storage location.) Planning may or may not include a mechanism for off-site (truck or rail) transportation.

One major loss of fuel handling efficiency comes with the change in fuel loading. Because the small can in the can-in-can concept is sealed with the intent of controlling the storage, transportation, and disposal environment, it becomes the vessel that needs to be (decontaminated and) dried and sealed. Drying a can of just a few assemblies (4 PWR or 9 BWR) may proceed more quickly than drying a full storage canister or cask (24-37 PWR or 52-89 BWR assemblies), but there will be many more vessel sealing operations and the need to stage partially filled larger cans throughout those operations. Even if the small can could be dried more efficiently on a per assembly basis, the change in loading reflects a 6- to 10-fold increase in the number of container handling operations.

Facility constraints may or may not allow for concurrent drying of multiple cans, and such an option introduces somewhat more complicated operating protocol. A small can is not a cask (in the transfer or transport sense) and may need different or additional shielding or different operating protocol for radiation protection. And workers tend to receive a greater radiological dose during handling operations than during the stationary and remotely operated drying process.

Also, the drying process for these small cans may require multiple adaptations to account for retained water or other configuration-specific limitations. For example, the ½" Schd. 40 lines marked "drainage pipe" on both PWR and BWR small cans are a nominal 185" long.[4] Such a long constrained "drain" may plug easily and seems reminiscent of the narrow drain tube and "dashpot" impediments to drainage inherent to and overcome by some of the earlier commercial industry drying efforts.[13, 14] There is not yet adequate detail to assess how much water might be inaccessible to the drainpipe, but such small drying loads set up a critical path serial process, where space constraints may make multiple parallel drying operations impractical.

Regardless of the cost and schedule uncertainty, the additional fuel handling time and operator radiation exposure are compelling arguments against imposing a standardized can-in-can packaging operation on existing reactor facilities.

Summary

Implementation is complicated by existing utility facilities and licensed fuel handling practices that have evolved to account for storage and transportation requirements in the absence of disposal considerations. The can-in-can concept aspires to take a longer view of commercial used fuel disposition to consolidate the necessary processes and eliminate potentially redundant ones. Given the government obligation to take custody of the fuel for disposal, the utilities are divested of responsibility for these longer term issues, and they lack an incentive to embrace the can-in-can packaging concept.

Specific disposal requirements as associated with the, as yet undefined repository and waste package design, could preclude use of the proposed canister, requiring another repackaging operation. The 4 PWR / 9 BWR small can fuel load is intended to maximize repository options while providing for standardization. However, other delaying repackaging could allow a higher payload by capitalizing on decay time in extended storage. Depending on the disposition criteria, repackaging for disposal after dry storage may be inefficient in terms of materials and labor. Even so, development and use of a dry-to-dry transfer option in conjunction with repackaging would allow for positive determination of dryness.

Economy of scale for standardized packaging would be best achieved at a consolidated location compared to standardized packaging at utilities. Existing drying and dry storage operations have already been approved within a defined, achievable operating envelope. Retrofit is time-consuming, costly, and may be hampered by location-specific challenges and conflict with ongoing operations. Facility space, handling capacity, and the available equipment are adequate to support the existing processes and configurations. The number and type of handling iterations to load and dry small cans and place and seal five small cans in a large can are likely to increase worker dose (associated with handling a 5- to 10-fold increase in the number of packages). Work around to handle small cans individually (in the event that a large can does not fit within space constraints) would be particularly inefficient and complicated by the need to stage a partly-filled large can.

The can-in-can design is not sufficiently mature to enable a detailed evaluation of the drying operation. The loading process is presumed to involve submerging the small cans within the large can, raising questions regarding decontamination and how to dry and seal each can (in parallel or in series). And none of the large can drawings appear to indicate a mechanism for drainage. Small cans tentatively show a long, small diameter, single drain line that should be expanded (if possible within practical constraints) and duplicated to allow for flow reversal to alleviate plugging and to facilitate the aspiration of water from the can.

Table 1. Pros and Cons for the Can-In-Can Concept Proposed for Implementation at the Utilities

Pros	**Cons**
Uniform handling requirements for future facilities (with potential for economies of scale)	Forces package configuration to reduce thermal output for disposition purposes without credit for decay over the duration of dry storage
Provides a single, standard demonstration prototype for storage, transportation and disposal	Competing size/load constraints for can-in-can life cycle versus DOT transportation and existing facility capabilities
Efficiency (number and duration) in handling operations and waste minimization	Expensive to transition from current practices
Minimizes packaging waste	Maximizes material aging prior to disposition
Reduces need for bare fuel handling	Increases ALARA worker radiological dose over current practices

Table 1 summarizes the pros and cons associated with implementing the can-in-can concept at the utilities by comparison to existing practices based on the assumption that existing practices employ non-standard packages not suitable for final disposition. Ultimately, the caveat in this analysis is that can-in-can package configuration choices may or may not support downstream disposition strategies.

Conclusion

In principle, standardization has value when future activities can capitalize on the uniform features provided. However, the costs of implementation are high. There is no incentive for industry and little incentive for government agencies to change current practices in the absence of defined requirements. Again, costs are high and benefits may be easily negated by future decisions. In the absence of a safety or economic driver to justify the costs of transition, the can-in-can concept is not suited to implementation by retrofit at the utilities. However, several of the benefits can be attained while many of the disadvantages can be avoided by storing fuel bare (i.e. postponing packaging until disposition criteria are defined). This approach would be feasible if the increased storage capacity were made available at a centralized facility, thus eliminating the capital investment needed to build such a storage facility at each site.

Selected References

1 Williams, Jeff, *Compatibility of Commercial Storage Containers with the Waste Management System*, Fuel Cycle Technologies, Office of Used Nuclear Fuel Disposition, U.S. Department of Energy – Nuclear Energy, to Nuclear Waste Technical Review Board, Arlington, VA, January 9, 2012.

2 Morton, D. K., Preliminary Design Specification for Department of Energy Standardized Spent Nuclear Fuel Canisters, Volume I – Design Specification & Volume II – Rationale Document, DOE/SNF/REP-011, Rev. 0, National Spent Nuclear Fuel Program, United States Department of Energy, August 19, 1998.

3 Hardin, Ernest, (Sandia National Laboratory); Max Fratoni, Jim Blink, Harris Greenberg, Mark Sutton, (Lawrence Livermore National Laboratory); Joe Carter, Mark Dupont, (Savannah River National Laboratory); and Rob Howard, (Oak Ridge National Laboratory), *Generic Repository Concepts and Thermal Analysis*, SAND2011-9422C, U.S. Department of Energy – Nuclear Energy, to Nuclear Waste Technical Review Board, Arlington, VA, January 9, 2012. Also, called FCRD-USED-2011-000143 Rev. 0, August 2011. *Generic Repository Design Concepts and Thermal Analysis (FY11),* August 2, 2011, FCRDUSED-2011-000143, Rev 0 under SAND2011-6202.

4 Giuliano, D., *Preliminary used fuel disposition drawings: 235-UFD-1000, 235-UFD-2000, 235-UFD-3000, 235-UFD-3100, 235-UFD-4000, and 235-UFD-4100*, Remote Systems Group, Fuel Cycle and Isotopes Division, Oak Ridge National Laboratory, January – February 2012.

5 B. Hanson, H., Alsaed, C. Stockman, D. Enos, R. Meyer, and K. Sorenson, *Gap Analysis to Support Extended Storage of Used Nuclear Fuel*, Rev. 0, FCRD-USED-2011-000136, PNNL-20509, Used Fuel Disposition Campaign, Fuel Cycle Research & Development, January 31, 2012.

6 U.S. Nuclear Regulatory Commission, Plan For the Long-Term Update to the Waste Confidence Rule and Integration with the Extended Storage and Transportation Initiative, SECY-11-0029, February 28, 2011, http://pbadupws.nrc.gov/docs/ML1102/ML110260244.pdf.

7 U. S. Nuclear Regulatory Commission, Spent Fuel Storage and Transportation, Interim Staff Guidance - 11, Rev. 3, Cladding Considerations for the Transportation and Storage of Spent Fuel, November 2003. Full text at http://www.nrc.gov/reading-rm/doc-collections/isg/isg-11R3.pdf.

8 10 CFR Part 71, *Packaging and Transportation of Radioactive Material*, U.S. Nuclear Regulatory Commission, Washington, D.C.

9 10 CFR Part 72, *Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste*, U.S. Nuclear Regulatory Commission, Washington, D.C.

10 NUREG-1536, Rev. 1, *Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility*, U.S. Nuclear Regulatory Commission, Washington, D.C., 2010.

11 NUREG-1567, *Standard Review Plan for Spent Fuel Dry Storage Facilities*, U.S. Nuclear Regulatory Commission, Washington, D.C., 2000.

12 NUREG-1927, *Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance*. NUREG-1927, U.S. Nuclear Regulatory Commission, Washington, D.C., 2011.

13 Marston, M. J., *Commercial Power Experience in Getting Fuel From Wet to Dry Storage*, TSSD Services, Inc., September 14, 2010.

14 Tjserland, Gary, *NAC Drying Experience* presented by Gary Tjersland 1/31/2012.