AREVA

Ref: AFS–12–0127

June 6, 2012

ATTN: Document Control Desk
Director, Spent Fuel Project Office
Office of Nuclear Material Safety and Safeguards
U. S. Nuclear Regulatory Commission
Washington, DC 20555–0001

SUBJECT: TRUPACT–III Amendment Request, Docket No. 71–9305, SAR Revision 14

AREVA Federal Services LLC (AFS) hereby submits Revision 14 of the Safety Analysis Report for the TRUPACT–III packaging, Docket No. 71-9305. This revision seeks approval for the optional use of 15 mm thick or 16 mm thick plate in certain locations indicated on the SAR drawing. The option is implemented in a new flag note 53 on sheet 2 of the SAR drawing. The new flag note is applied to item 23 (nominally 16 mm thick plate) in the list of materials on sheet 1. The change affects both the boxes that enclose the calcium silicate insulation boards in the overpack cover and front cheeks, and the outer and inner edges of the closure lid. Since the closure lid plates had been specified to be attached using an explicit full depth groove weld thickness of 16 mm for 16 mm plate, the weld symbol was changed to indicate a full depth groove weld of the plate thickness used, i.e., 15 mm or 16 mm (see sheet 14, Detail Y). A justification for the weld and plate thickness options is presented in a new Section 2.7.8.3 of the SAR.

Included with this letter is one paper copy of the revised pages and SAR drawings and one CD containing the entire SAR, Revision 14, in PDF file format. The CD is contained within an envelope labeled, "TRUPACT–III Docket 71–9305 Electronic Copy of Documents".

AFS appreciates the NRC's timely response to this matter, and requests that this revision be approved and the revised TRUPACT–III Certificate of Conformance be issued by June 22, 2012.

Should you have any questions regarding this submittal, please contact me at (253) 552–1321 or via E–mail (phil.noss@areva.com).

Very Truly Yours,
AREVA Federal Services LLC

Phil Noss

Phil Noss
Licensing Manager

cc: Jennivine Rankin, NRC (including six paper copies and one CD)
Robert Watkins, AFS Project Manager

NMSS01

AREVA

Contents of Electronic Media

This submission is composed of both paper copies and an electronic copy. The electronic copy is contained within an envelope labeled, "TRUPACT–III Docket 71–9305 Electronic Copy of Documents". The envelope contains one disc as follows:

Title	Media Type:	Contents
TRUPACT–III SAR	CD–R	One file of the complete text of the submittal: TRUPACT–III SAR, Complete, Rev. 14.pdf (17,191 kb) (580 pages)

Delete and Insert Instructions
for
Updating TRUPACT–III Safety Analysis Report
Docket Number 71–9305

SAR Section	Delete Rev. 13	Insert Rev. 14
Cover and Spline	Cover Page and Spine	Cover Page and Spine
Table of Contents	Pages i to ix	Pages i to ix
1.3.1	Pages 1.3.1-1 – 1.3.1-2	Pages 1.3.1-1 – 1.3.1-2
General Arrangement Drawings	51199–SAR, Rev. 13	51199–SAR, Rev. 14
2.7.8.2 – 2.7.8.3 (New Section)	Pages 2.7-41 – 2.7-42	Pages 2.7-41 – 2.7-44

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Docket 71-9305

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TRUPACT-III

Safety Analysis Report

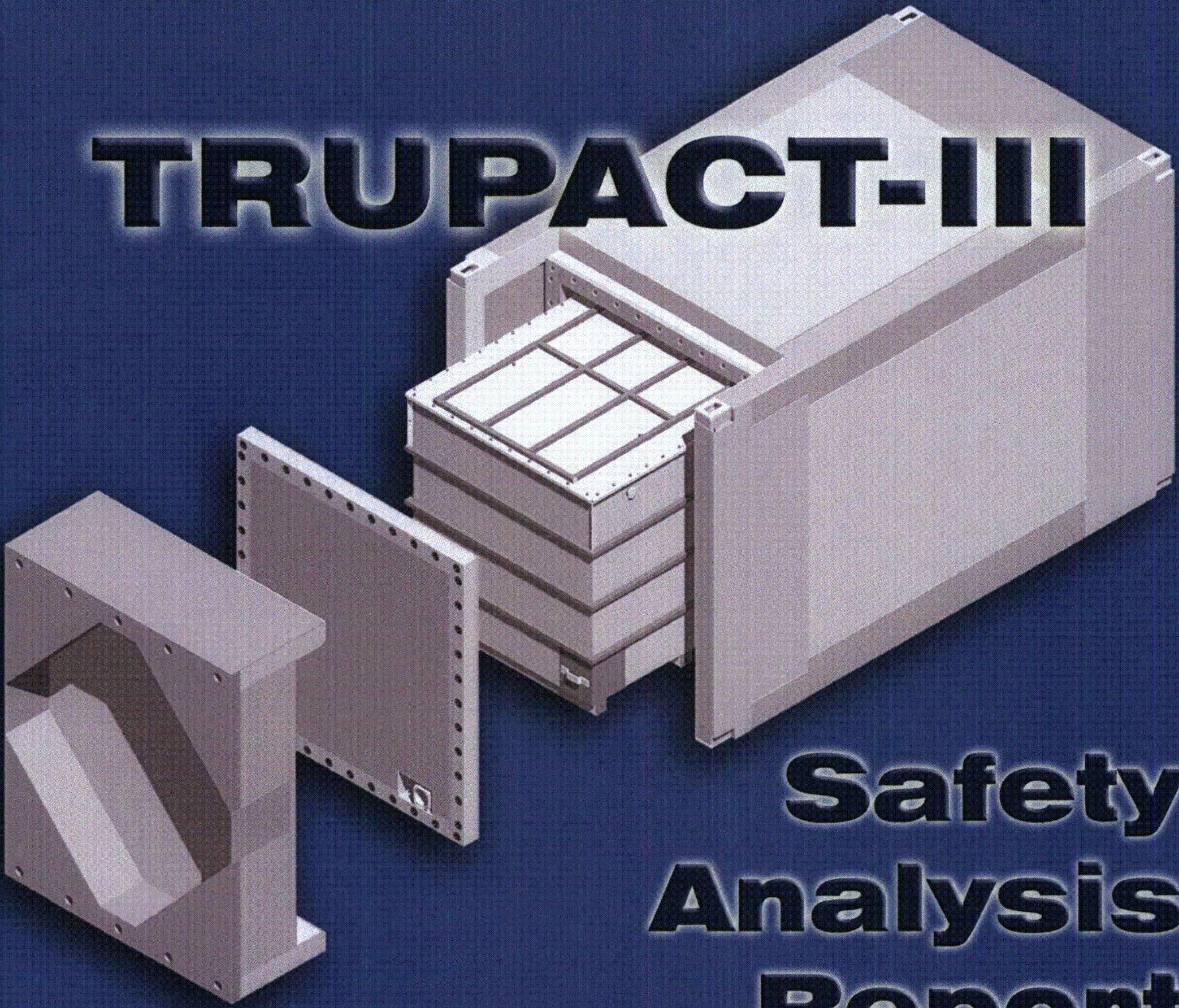
Revision 14
June 2012

AREVA Federal Services LLC

Docket 71-9305

AREVA

TRUPACT-III



Safety Analysis Report

Revision 14

June 2012

AREVA Federal Services LLC

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1.3.1 Packaging General Arrangement Drawings

This section presents the TRUPACT–III packaging general arrangement drawing[1], consisting of 21 sheets entitled, *TRUPACT–III Packaging SAR Drawing*, Drawing Number 51199–SAR, Rev. 14.

Within the packaging general arrangement drawing, dimensions important to the packaging's safety are dimensioned and toleranced (e.g., sealing regions on the seal flanges). All other dimensions are provided as a reference dimension, and are toleranced in accordance with the general tolerance block.

[1] The TRUPACT–III packaging general arrangement drawing utilizes the uniform standard practices of ASME Y14.5M–1994, *Dimensioning and Tolerancing*, American National Standards Institute, Inc. (ANSI).

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Figure Withheld Under 10 CFR 2.390

AREVA

AREVA Federal Services LLC
Packaging Projects
Tacoma, WA 98402

TRUPACT–III PACKAGING
SAR DRAWING

SCALE: NONE	WT. N/A
REV: 14	SHEET 1 OF 21
DWG SIZE: D	DWG NO. 51199–SAR
CADFILE: 51199SAR0114.DWG	

Figure Withheld Under 10 CFR 2.390

REV: 14	SHEET 2 OF 21	
DWG SIZE D	DWG NO. 51199-SAR	CADFILE: 51199SAR0214.DWG

51199-SAR | 3 | 14

Figure Withheld Under 10 CFR 2.390

REV: 14	SHEET 3 OF 21
DWG SIZE: D	DWG NO. 51199-SAR
	CADFILE: 51199SAR0314.DWG

Figure Withheld Under 10 CFR 2.390

51199-SAR	5	14

Figure Withheld Under 10 CFR 2.390

REV: 14		SHEET 5 OF 21	
DWG SIZE	D	DWG NO. 51199-SAR	
		CADFILE: 51199SAR0514.DWG	

Figure Withheld Under 10 CFR 2.390

51199-SAR 7 14

Figure Withheld Under 10 CFR 2.390

REV: 14 SHEET 7 OF 21

DWG SIZE D DWG NO. 51199-SAR

CADFILE: 51199SAR0714.DWG

51199-SAR | 8 | 14

Figure Withheld Under 10 CFR 2.390

REV: 14 SHEET 8 OF 21
DWG SIZE D
DWG NO. 51199-SAR
CADFILE: 51199SAR0814.DWG

51199-SAR | 9 | 14

Figure Withheld Under 10 CFR 2.390

REV: 14		SHEET 9 OF 21
DWG SIZE D	DWG NO. 51199-SAR	
	CADFILE: 51199SAR0914.DWG	

51199-SAR 10 14

Figure Withheld Under 10 CFR 2.390

REV: 14	SHEET 10 OF 21	
DWG SIZE D	DWG NO. 51199-SAR	
	CADFILE: 51199SAR1014.DWG	

51199-SAR | 11 | 14

Figure Withheld Under 10 CFR 2.390

REV: 14 SHEET 11 OF 21
DWG SIZE D
DWG NO. 51199-SAR
CADFILE: 51199SAR1114.DWG

Figure Withheld Under 10 CFR 2.390

REV: 14	SHEET 12 OF 21
DWG SIZE D	DWG NO. 51199-SAR
CADFILE: 51199SAR1214.DWG	

Figure Withheld Under 10 CFR 2.390

51199-SAR 14 14

Figure Withheld Under 10 CFR 2.390

REV: 14 SHEET 14 OF 21
DWG SIZE D DWG NO. 51199-SAR
CADFILE: 51199SAR1414.DWG

51199-SAR 15 14

Figure Withheld Under 10 CFR 2.390

REV. 14 SHEET 15 OF 21

DWG SIZE D DWG NO. 51199-SAR

CADFILE: 51199SAR1514.DWG

Figure Withheld Under 10 CFR 2.390

REV: 14		SHEET 16 OF 21
DWG SIZE D	DWG NO. 51199-SAR	
	CADFILE: 51199SAR1614.DWG	

Figure Withheld Under 10 CFR 2.390

REV: 14	SHEET 17 OF 21	
DWG SIZE D	DWG NO. 51199-SAR	
CADFILE: 51199SAR1714.DWG		

Figure Withheld Under 10 CFR 2.390

REV. 14	SHEET 18 OF 21
DWG SIZE D	DWG NO. 51199-SAR
	CADFILE: 51199SAR1814.DWG

Figure Withheld Under 10 CFR 2.390

REV: 14		SHEET 19 OF 21
DWG SIZE	DWG NO.	
D	51199-SAR	
	CADFILE: 51199SAR1914.DWG	

51199-SAR | 20 | 14

Figure Withheld Under 10 CFR 2.390

REV: 14 SHEET 20 OF 21
DWG SIZE D DWG NO. 51199-SAR
CADFILE: 51199SAR2014.DWG

Figure Withheld Under 10 CFR 2.390

- The overpack cover is securely retained on both CTU-1 and CTU-2. At the conclusion of all testing, the overpack cover was still securely fastened to the body.
- Criticality assumptions regarding package reconfiguration are supported.
- Thermal fire event analysis assumptions regarding the integrity of thermal insulation and exposure of polyurethane foam are supported.

In addition, calculations have shown that the stress criteria of Table 2.1-1 are satisfied for the thermal and immersion events (see Section 2.7.4.4, *Comparison With Allowable Stresses* and Section 2.7.6, *Immersion – All Packages*, respectively).

Therefore, the TRUPACT–III package satisfies all of the requirements of 10 CFR §71.73.

2.7.8.1 Debris Contamination of the Containment Seal on CTU-1

As discussed in Section 2.12.5.2, *Contamination of the Containment O-ring Seal During Certification Testing*, the initial helium leakage rate test performed on the closure lid containment O-ring seal of CTU-1 at the conclusion of the certification test was not successful due to contamination of the sealing nip. The contamination was found to be in the form of small shards and flakes of aluminum, which were generated by the numerous collisions of the aluminum round bars which made up the CTU simulated payload. As a result of free drop impact, a transient gap can open between the CSA body and closure lid flanges. In certification testing, the debris from the simulated payload was transported across the containment seal with the aid of the internal air pressure, equal to MNOP. Even though the flanges returned to contact after only a few milliseconds, the seal was not leaktight per the criterion of 1×10^{-8} Pa-m^3/s, air, per ANSI N14.5. Since small amounts of grit or dirt could be present in the payload cavity in normal operation, a debris shield is utilized to ensure maintenance of a leaktight containment seal under all free drops and puncture drops. The debris shield shown in the drawings of Appendix 1.3.1, *Packaging General Arrangement Drawings*, is effective in preventing containment seal contamination, as demonstrated by the tests performed on CTU-2. A discussion of how the debris contaminated the CTU-1 containment seal, the design considerations for the debris shield, and an analytical evaluation of the effectiveness of the shield, are presented in Section 2.12.5, *Closure Lid Debris Shield.*

2.7.8.2 Closure Bolts

During the post-test disassembly of CTU-2, all of the closure bolts were found to be in good condition, having an average residual loosening torque of 79% of the initial tightening torque. The loosening torque is generally expected to be on the order of 75% of the tightening torque, even if no external loads are applied to the joint. Therefore, an average residual torque of 79% after application of HAC test loads is in the expected range. None of the bolts showed any bending deformation, nor was there evidence of any bolt heads being contacted by the overpack cover recess cups. Many of the closure bolt washers did show evidence of contact with the overpack cover recess cups, (evident also in the corresponding cups). However, evidence of contact of a washer with a cup did not correlate to lower residual loosening torque for the corresponding bolt. Details of the CTU-2 post-test results are given in Section 2.12.6.8, *Leakage Rate Tests and Post-Test Measurements*.

During post-test disassembly of CTU-1, it was discovered that some of the closure bolts, particularly on the right flange, had a residual torque which was significantly below the average for all bolts. The bolts having below-average residual torque were found to be bent. There was strong correlation between the amount of bending and the lowness of the residual torque. The greatest bending and lowest residual torque occurred close to the center of the right side of the lid. Moving towards each end of the right side (i.e., the top right corner and the lower right corner), bolt bending approached the as-fabricated average runout, and the residual torque approached the non-bent average value. Each of the affected bolts was bent in two opposite directions, with the axes of the threaded portion and of the bolt head nearly parallel, but with an offset. These bolts showed evidence of having been struck laterally on the bolt head, and the location of the strike aligned with the direction of bending. It was noted that the direction of bending, relative to the CTU, generally aligned with the 11:00 o'clock azimuth. The right side of the lid moved upward along the same orientation, and the guide pin on the right side was sheared by approximately 4.3 mm in the same direction. More details regarding the CTU-1 post-test findings are provided in Section 2.12.3.8.2.1, *Body Flange and Closure Lid Observations*, and Section 2.12.3.8.2.2, *Closure Lid Bolt Removal Torque and Related Observations*. It is apparent that the bolt bending was caused by the side impact on the bolt heads from the overpack cover recess cups, that struck the heads during a lateral translation of the overpack cover, which in some cases also struck the edge of the washer. Contact may have occurred in more than one free drop, but most likely the primary case was free drop LD4, the CG-over-corner orientation, based on the direction of bending. Because of the number of tests performed on CTU-1 (four HAC free drops and four puncture drops), the condition of the bolts was likely caused by, or at least exacerbated by, over-testing.

Two helium leakage rate tests were performed on CTU-1 to determine whether the non-leaktight condition of the closure lid O-ring seal was due to the reduced clamping load of the bolts on the right side, or due to the debris on the seal. For the first test, the seal surfaces were wiped clean of debris (without removing them from the lid), and the lid was reinstalled with all 44 closure bolts tightened to the lowest residual tightening torque of all bolts, equal to 149 N-m (see Table 2.12.3-4). This was very conservative since it represented only one-sixth of the average measured residual tightening torque of all 44 bolts of 898 N-m. Upon repeating the standard helium leakage rate test for the CTU, the testing criterion of a leakage rate less than 1×10^{-8} Pa-m^3/s, air, per ANSI N14.5, was achieved. For the second test, the lid was removed and reinstalled with only the four corner bolts installed and tightened to 149 N-m. This configuration represented a hypothetical case of the loss of preload on all four sides of the lid. The standard helium leakage rate test for the closure lid seal was repeated, and was again successful to the same criterion. These two tests demonstrated that only a negligible clamping force is required to obtain a leaktight seal between the lid and body of the TRUPACT–III, and that a significant preload reduction due to closure bolt damage can be sustained without affecting the leaktight condition of the closure O-ring seal as long as the seal is not contaminated by debris. With the implementation of the debris shield that was successfully demonstrated in CTU-2, the TRUPACT-III package will remain leaktight in the presence of any damage to the closure bolts that could credibly occur.

2.7.8.3 Structural Steel Plates of 15 mm and 16 mm Thickness

As shown on the drawings in Appendix 1.3.1, *Packaging General Arrangement Drawings*, nominally 16 mm thick, ASTM A240, UNS31803 stainless steel plate, item 23, is specified for two different structures. One is the structure that encloses the calcium silicate insulating boards. The plates that are associated with these boards in the front cheeks are shown on sheet 10 of the drawings, in zone B/C-6. For the calcium silicate boards in the overpack cover, the plates are shown on sheet 17, Section AF-AF, and in the detail located in zone B/C-1/2. The second structure is the closure lid flange, where the item 23 plates form the inner and outer edge, as shown on sheet 14, Detail Y. The following analysis demonstrates that plates that are nominally 15 mm thick may be used in lieu of nominally 16 mm thick plates, with no effect on the margin of safety, provided the material strength of the 15 mm plates and of the weld filler metal exceeds the minimum ASTM values by an amount that is identified in the analysis.

The minimum thickness of the nominally 16 mm plate is $T_{min16} = 15.7$ mm, and the minimum thickness of the nominally 15 mm plate is $T_{min15} = 14.7$ mm, per ASTM A480/A480M. Three types of loading of the plates are considered: tension, shear, and bending.

Tensile stress is equal to load over area. A characteristic stress may be identified in which the area used is based on a unit length of one mm and the thickness of the plate. Therefore, the characteristic tensile stress in the 16 mm plate is:

$$\sigma_{16} = \frac{P}{(1)T_{min16}}$$

where P is the tensile load occurring in the HAC free drop or puncture drop events. From Table 2.1-1, the allowable stress under HAC for general membrane stress is the lesser of $2.4S_m$ or $0.7S_u$, which for UNS 31803 material is $0.7S_u$. The resulting margin of safety is:

$$MS_{16} = \frac{0.7S_u}{\sigma_{16}} - 1 = \frac{0.7S_u T_{min16}}{P} - 1$$

Similarly, the tensile stress in the 15 mm plate is:

$$\sigma_{15} = \frac{P}{(1)T_{min15}}$$

where the load P is the same as before. The margin of safety is:

$$MS_{15} = \frac{0.7F_T S_u}{\sigma_{15}} - 1 = \frac{0.7F_T S_u T_{min15}}{P} - 1$$

where the factor F_T has been introduced to indicate that the allowable stress must be higher in the case of 15 mm plate, if the margin of safety is to be the same as for 16 mm plate. Setting the two margins of safety equal,

$$MS_{15} = MS_{16} \quad => \quad \frac{0.7F_T S_u T_{min15}}{P} - 1 = \frac{0.7S_u T_{min16}}{P} - 1$$

Solving for F_T,

$$F_T = \frac{T_{min16}}{T_{min15}} = \frac{15.7}{14.7} = 1.07$$

In other words, if the 15 mm thick plate material is 7% stronger than the minimum strength permitted by the ASTM standard, the margin of safety under tensile loading will be the same as for a 16 mm plate that has the same minimum strength.

Shear stress in the plates will have the same formula as tensile stress, just by substituting the shear area for the tensile area, and shear area will be based on the same plate thicknesses as for the tensile load case. Although the allowable stress is equal to $0.42S_u$ instead of $0.7S_u$ (see Table 2.1-1), it can be seen that this will have no effect on the allowable factor, F. Therefore, $F_S = F_T = 1.07$.

The bending stress in a typical flat plate subjected to moment loading is proportional to M/t^2, where M is a general moment loading term and t is the plate thickness, as shown in the various stress cases listed in Table 26 of Roark[8]. The characteristic bending stress in the 16 mm plate is:

$$\sigma_{16} = \frac{M}{T^2_{\min 16}}$$

where M is the moment load term resulting from the HAC free drop or puncture drop events. From Table 2.1-1, the allowable stress under HAC for primary membrane plus bending stress is the lesser of $3.6S_m$ or S_u, which for UNS 31803 material is S_u. The resulting margin of safety is:

$$MS_{16} = \frac{S_u}{\sigma_{16}} - 1 = \frac{S_u T^2_{\min 16}}{M} - 1$$

Similarly, the bending stress in the 15 mm plate is:

$$\sigma_{15} = \frac{M}{T^2_{\min 15}}$$

where the load M is the same as before. The margin of safety is:

$$MS_{15} = \frac{F_B S_u}{\sigma_{15}} - 1 = \frac{S_u F_B T^2_{\min 15}}{M} - 1$$

where the factor F_B has been introduced to indicate that the allowable stress must be higher in the case of a 15 mm plate, if the margin of safety is to be the same as a 16 mm plate. Setting the two margins of safety equal,

$$MS_{15} = MS_{16} \quad => \quad \frac{F_B S_u T^2_{\min 15}}{M} - 1 = \frac{S_u T^2_{\min 16}}{M} - 1$$

Solving for F_B,

$$F_B = \frac{T^2_{\min 16}}{T^2_{\min 15}} = \left(\frac{15.7}{14.7}\right)^2 = 1.14$$

In other words, if the 15 mm thick plate material is 14% stronger than the minimum strength permitted by the ASTM standard, the margin of safety under moment loading will be the same for a 16 mm plate that has the same minimum strength.

Therefore, the minimum strength requirement for any 15 mm plate that has been substituted for 16 mm plate in the calcium silicate protection structures or in the closure lid is governed by moment loading, and is equal to +14% or a factor of 1.14. SAR drawing flag note 53 requires that any 15 mm plate which is used in the place of 16 mm plate have a tensile ultimate strength of at least 744 MPa. This requirement also applies to the weld filler metal. Since this is equal to 1.2 times the ASTM A240/A240M minimum value of 620 MPa, this requirement is conservatively met.

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[8] Young, Warren C., *Roark's Formulas for Stress and Strain*, Sixth Edition, McGraw-Hill, 1989.