

April 2020

Revision 20B

NAC-UMS

Universal MPC System

SAFETY ANALYSIS REPORT

Supplement to Damaged BWR
Amendment 8

Non-Proprietary Version

Docket No. 72-1015



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Enclosure 1

Supporting Calculation

for the

**NAC-UMS FSAR
Supplement to Damaged BWR Amendment 8
Revision 20B
(Docket No 72-1015)**

NAC International

April 2020

List of Calculations

1. EA790-2521, Revision 1

CALCULATION WITHHELD IN ITS ENTIRETY PER 10 CFR 2.390

Enclosure 2

List of Changes

for the

**NAC-UMS FSAR
Supplement to Damaged BWR Amendment 8
Revision 20B
(Docket No 72-1015)**

NAC International

April 2020

List of Changes for the NAC-UMS FSAR, Revision 20B

Chapter/Page/ Figure/Table	Description of Change
Note: The List of Effective Pages and the Chapter Table of Contents, List of Figures and List of Tables have been revised accordingly to reflect the list of changes detailed below, if needed.	
<u>Chapter 1</u>	
Page 1.8-2	Modified Section 1.8.1 where indicated.
<u>Chapter 2 – no changes</u>	
<u>Chapter 3</u>	
Pages 3.9-12 thru 3.9-14	Modified and added text at the end of Section 3.9.2.2 where indicated.
Pages 3.9-15 thru 3.9-17	Text flow changes.
<u>Chapter 4 – no changes</u>	
<u>Chapter 5 – no changes</u>	
<u>Chapter 6 – no changes</u>	
<u>Chapter 7 – no changes</u>	
<u>Chapter 8 – no changes</u>	
<u>Chapter 9 – no changes</u>	
<u>Chapter 10 – no changes</u>	
<u>Chapter 11 – no changes</u>	
<u>Chapter 12 – no changes</u>	
<u>Chapter 13 – no changes</u>	

Enclosure 3

List of Drawing Changes

for the

**NAC-UMS
Supplement to Damaged BWR Amendment 8
Revision 20B
(Docket No 72-1015)**

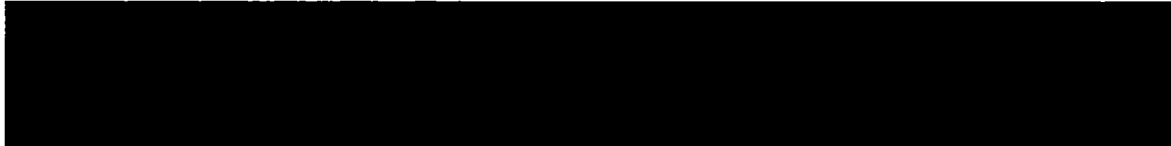
NAC International

April 2020

List of Drawing Changes, NAC-UMS SAR, Revision 20B

Drawing 790-601, Sheet 1, Revision 2P

Sheet 1:



Drawing 790-601, Sheet 1, Revision 1NP

Sheet 1:

1. Clouded out B.O.M. details indicating them as proprietary.
2. Clouded out Note details indicating them as proprietary.
3. Clouded out Assembly 99 identification balloon and title.

Enclosure 4

FSAR Changed Pages

for the

**NAC-UMS
Supplement to Damaged BWR Amendment 8
Revision 20B
(Docket No 72-1015)**

NAC International

April 2020

April 2020

Revision 20B

NAC-UMS

Universal MPC System

FINAL SAFETY ANALYSIS REPORT

for the UMS Universal Storage System

Non-Proprietary Version

Docket No. 72-1015



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1.8 License Drawings

This section presents the list of License Drawings for the Universal Storage System.

1.8.1 License Drawings for the UMS® Universal Storage System

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790-561	Weldment, Structure, Vertical Concrete Cask (VCC), NAC-UMS®	16	4
790-562	Reinforcing Bar and Concrete Placement, Vertical Concrete Cask (VCC), NAC-UMS®	20	8
790-563	Lid, Vertical Concrete Cask (VCC), NAC-UMS®	6	1
790-564	Shield Plug, Vertical Concrete Cask (VCC), NAC-UMS®	8	3
790-565	Nameplate, Vertical Concrete Cask (VCC), NAC-UMS®	5	1
790-570	Fuel Basket Assembly, 56 Element BWR, NAC-UMS®	6	3
790-571	Bottom Weldment, Fuel Basket, 56 Element BWR, NAC-UMS®	3	1
790-572	Top Weldment, Fuel Basket, 56 Element BWR, NAC-UMS®	4	1
790-573	Support Disk and Misc. Basket Details, 56 Element BWR, NAC-UMS®	8	1
790-574	Heat Transfer Disk, Fuel Basket, 56 Element BWR, NAC-UMS®	3	1
790-575	BWR Fuel Tube, NAC-UMS®	11	2
790-581	PWR Fuel Tube, NAC-UMS®	9	2
790-582	Shell Weldment, Canister, NAC-UMS®	13	2
790-583	Assembly, Drain Tube, Canister, NAC-UMS®	9	1
790-584	Details, Canister, NAC-UMS®	20	3
790-585	Transportable Storage Canister (TSC), NAC-UMS®	25	3
790-587	Spacer Shim, Canister, NAC-UMS®	1	1
790-590	Loaded Vertical Concrete Cask (VCC), NAC-UMS®	9	2
790-591	Bottom Weldment, Fuel Basket, 24 Element PWR, NAC-UMS®	6	2

License Drawings (continued)

Drawing Number	Title	Revision No.	No. of Sheets
790-592	Top Weldment, Fuel Basket, 24 Element PWR, NAC-UMS®	8	1
790-593	Support Disk and Misc. Basket Details, 24 Element PWR, NAC-UMS®	7	2
790-594	Heat Transfer Disk, Fuel Basket, 24 Element PWR, NAC-UMS®	2	1
790-595	Fuel Basket Assembly, 24 Element PWR, NAC-UMS®	10	2
790-601	Damaged Fuel Can (DFC), BWR, NAC-UMS®	1NP*	1
790-605	BWR Fuel Tube, Over-Sized Fuel, NAC-UMS®	12	2
790-613	Supplemental Shielding, VCC Inlets, NAC-UMS®	2	1
790-617	Door Stop, NAC-UMS®	4	2
790-671	Bottom Weldment, Fuel Basket, 56 Element BWR DF, NAC-UMS®	1	1
790-672	Top Weldment, Fuel Basket, 56 Element BWR DF, NAC-UMS®	1	1

*Proprietary Drawing Removed

1.8.3 Site Specific Spent Fuel License Drawings

Drawing Number	Title	Revision No.	No. of Sheets
412-501	Spent Fuel Can Assembly, Maine Yankee (MY), NAC-UMS®	4	2
412-502	Fuel Can Details, Maine Yankee (MY), NAC-UMS®	6	6

REV	CHANGE
ONP	INITIAL ISSUE - DCR A
INP	INC DCR ONPA

PROPRIETARY INFORMATION
REMOVED

1

NOTES:

96	97	98	99	ITEM	NAME	MATERIAL	SPEC	DRAWING NO.	DESCRIPTION			
ASSY	ASSY	ASSY	ASSY	QUANTITY								
UNLESS OTHERWISE STATED					GROUP	NAME	DATE	DAMAGED FUEL CAN (DFC) BWR, NAC - UMS®				
DIMENSIONING AND TOLERANCING SHALL BE PER ASME Y14.5M-94					PREPARED	<i>Th. V. L.</i>	3/19/20					
ALL THREAD DEPTH CALLOUTS ARE TO BE CONSIDERED AS A MIN DEPTH OF PERFECT THREADS					CHECKER	<i>Leif M.</i>	3-19-20					
					PROJECT MANAGER	<i>JR Bangs</i>	3-19-20					
					ENGINEERING	<i>Leif M.</i>	3-19-20					
ALL DIMENSIONS ARE IN INCHES					LICENSING	<i>Th. V. L.</i>	3/20/20	PROJECT 790				
MACHINED SURFACES SHALL BE ☒ OR BETTER					QUALITY	<i>W. M. G.</i>	3/20/20	DRAWING 601				
NEXT ASSEMBLY 790-585										REV 1NP		
DRAWING TYPE: LICENSE										SH 1 OF 1 3/19/2020		

$$FS_u = \frac{S_u}{\sigma_{\max}} = \frac{63,300}{1659} = 38.2 > 10$$

DFC tube body welds evaluation

The welds joining the tube body to the flange and bottom assembly are full penetration welds (ASME, Section III, Subsection NG, Type III, paragraph NG-3352.3). Per Subsection NG, Table NG-3352-1, the weld quality factor (n) for a Type III weld with visual surface inspection is 0.5.

The weld stress (σ_w) is:

$$\sigma_w = \frac{1.1(P)}{A} = \frac{1.1(809)}{1.097} = 811 \text{ psi}$$

where:

P = the combined weight of the tube body, the neutron absorber weight, bottom assembly, the cladding weight, and can contents;

$$62 + 26 + 7 + 12 + 702 = 809 \text{ lb.}$$

A = cross sectional area of thinner member joined = 1.097 in²

The factors of safety on material yield strength (FS_y) and ultimate strength (FS_u) of Type 304 Stainless Steel at 600°F are:

$$FS = \frac{n \cdot S_y}{\sigma_w} = \frac{0.5(18,600)}{811} = 11.5 > 6$$

$$FS = \frac{n \cdot S_u}{\sigma_w} = \frac{0.5(63,300)}{811} = 39.0 > 10$$

Therefore, the criteria of NUREG-0612 and ANSI N14.6 for the lifting of non-redundant systems are satisfied.

DFC tube body tensile stress evaluation

The tube body will be subjected to tensile loads during lifting operations. The load (P) includes the can contents (702 lb design weight), the tube body weight (62 lb), the neutron absorber weight

(26 lb), the cladding weight (12 lb) and the bottom assembly weight (7 lb) for a total of 809 lb. A load of 809 lb with a 10% dynamic load factor is used for the analysis.

The tensile stress (σ_t) is then:

$$\sigma_t = \frac{1.1P}{A} = \frac{1.1(809 \text{ lb})}{1.097 \text{ in.}^2} = 811 \text{ psi}$$

where:

$$A = 6.14^2 - 6.05^2 = 1.097 \text{ in.}^2$$

The margin of safety (MS) based on allowable for primary membrane (tensile) stress (S_m) for Type 304 Stainless Steel at 600°F is: M

$$MS = 1.0 S_m / \sigma_t - 1 = 16,700 / 811 - 1 = + 19.6$$

Bottom Plate Evaluation

The DFC bottom plate is evaluated for the lift condition using ASME Boiler and Pressure Vessel Code, Section III, Subsection NG [6]. Since the DFC lifting operations always occur underwater, material properties are evaluated at 200°F.

Bending Stress

The controlling stress in the DFC bottom plate is the bending stress occurring in the 0.17-inch thick disk located in the middle of the bottom plate. Case No. 17 in Table 24 of Roark's Formulas for Stress and Strain [26] provides the expression for the moment for a uniform load over a circular area at the center of a uniform thick disk with fixed boundary conditions around its perimeter. This is applicable for the evaluation of the 0.17-inch thick disk located in the middle of the bottom plate. Therefore, the maximum bending moment occurring at the center of the bottom plate disk ($M_{\max,c}$) is calculated:

$$M_{\max,c} = \frac{W \times DLF}{4\pi} \times (1 + \nu) \times \ln \left(\frac{a}{r_o'} \right) = 171 \text{ in-lb}$$

where:

W = 702 lb, weight of BWR fuel assembly

DLF = 1.1, dynamic load factor (10%)

$\nu = 0.31$, Poisson's Ratio

$a = \frac{2.5}{2} = 1.25$ in, radius of 0.17" thick disk

$r'_o = r_o = 0.15$ in, because $r_o > 0.5t$

$r_o = \frac{d_o}{2} = 0.15$ in, radius of the applied load

$d_o = 0.3$ in, bearing area diameter of the applied load

$t = 0.17$ in, thickness of the middle disk

The maximum bending moment that occurs around the outer radius (1.25-inch) of the 0.17-inch thick disk ($M_{max,r}$) is calculated:

$$M_{max,r} = \frac{W \times DLF}{4\pi} = 61 \text{ in-lb}$$

The maximum bending moment at the center of the disk is greater than that at the outer radius; therefore, the maximum disk bending moment (in units of kip-inch) corresponds to the center of the disk.

$$M_{max} = \frac{M_{max,c}}{1000} = 0.171 \text{ kip-in}$$

The maximum bending stress (σ_{max}) at the center of the disk is calculated:

$$\sigma_{max} = 6 \times \frac{M_{max}}{t^2} = 35.4 \text{ ksi}$$

The margin of safety for the maximum bending stress of the disk is calculated as follows. Note that the allowable membrane plus bending stress is $1.5S_m$.

$$MS = \frac{1.5S_m}{\sigma_{max}} - 1 = +0.4$$

where:

$S_m = 33.1$ ksi, design stress intensity of SA-240 Type XM-19 at 200°F

Bearing Stress

The bearing stress ($\sigma_{bearing}$) from the BWR fuel assembly on the DFC bottom plate is calculated:

$$\sigma_{bearing} = \frac{W \times DLF}{\pi \times r_o^2} = 10.9 \text{ ksi}$$

where:

$W = 702$ lb, weight of BWR fuel assembly

$DLF = 1.1$, dynamic load factor (10%)

$r_o = \frac{d_o}{2} = 0.15$ in, radius of the applied load

$d_o = 0.3$ in, bearing area diameter of the applied load (see Figure 5.4)

The margin of safety (MS) for bearing stress is calculated based on the allowable bearing stress of S_y .

$$MS = \frac{S_y}{\sigma_{bearing}} - 1 = +3.3$$

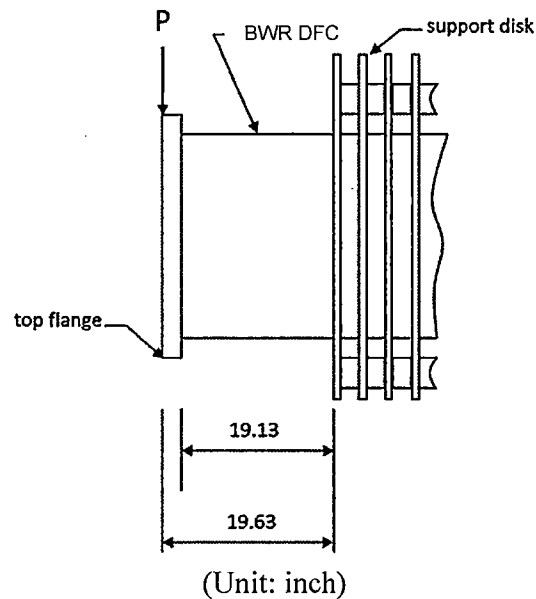
where:

$S_y = 47.1$ ksi, yield strength of SA-240 Type XM-19 at 200°F

3.9.2.3 BWR Damaged Fuel Can Tube Body-Side Impact

The governing side impact condition corresponding to the hypothetical cask tip-over accident is evaluated in this section. The majority of the BWR damaged fuel can (DFC) tube body is contained in the basket assembly. Because both the tube body and the support disks of the basket have square cross sections, they will be in full contact (for 158.83 inches longitudinally) during the side impact and no significant bending stress will be introduced into the support disk. The last 19.63 inches (tube body and top flange) will be unsupported past the support disk in the side impact configuration.

The tube body will be evaluated as a cantilevered beam with the combined weight (P) of the overhanging tube body, top flange, and lid assembly multiplied by the appropriate acceleration factor and, conservatively, concentrated at the top end of the top flange.



The maximum bending stress (f_b) is determined as follows.

$$f_b = \frac{M_{\max} c}{I} = \frac{11,778(3.07)}{6.793} = 5,322 \text{ psi}$$

where:

$$M_{\max} = P \times a \times L = 20(30)(19.63) = 11,778 \text{ lb}\cdot\text{in}$$

$$a = 30\text{g}$$

$$P = 20 \text{ lb; (lid plate, 2 lb + lid wall, 2 lb + top flange, 2 lb + tube body (62 lb} \times 19.13/177.57 \text{ in/in} = 6.68 \text{ lb) + cladding (12 lb} \times 19.13/177.1 \text{ in/in} = 1.3 \text{ lb) + neutron absorber (26 lb} \times 19.13/176.3 \text{ in/in} = 2.82 \text{ lb), which is equal to 16.8 lb; use 20 lb bounding)}$$

$$L = 19.63 \text{ in (total overhang length of the tube body and top flange)}$$

$$c = 6.14/2 = 3.07 \text{ in}$$

$$I = \frac{bh^3 - b_i h_i^3}{12} = \frac{6.14^4 - 6.05^4}{12} = 6.793 \text{ in}^4$$

The shear stress (τ) is:

$$\tau = \frac{Pg}{A} = \frac{20(30)}{1.097} = 547 \text{ psi}$$

where:

$$A = 6.14^2 - 6.05^2 = 1.097 \text{ in}^2$$

$$\sigma_1, \sigma_2 = \frac{1}{2} \left(f_b \pm \sqrt{f_b^2 + 4\tau^2} \right) = \frac{1}{2} \left(5,322 \pm \sqrt{5,322^2 + 4(547)^2} \right) = 5,378. \text{ psi and } -56 \text{ psi}$$

The stress intensity ($\sigma_{\max}$) = $|\sigma_1 - \sigma_2| = 5,434 \text{ psi}$

The margin of safety (MS) is:

$$MS = \frac{1.0 S_u}{\sigma_{\max}} - 1 = \frac{1.0(63,300)}{5,434} - 1 = +10.6$$

3.9.2.4 BWR Damaged Fuel Can Tube Body-End Impact

The DFC is evaluated for a bottom end impact corresponding to the cask 24-inch drop accident in this section. For the bottom end drop, the top flange, the lid assembly (Lid plate + Lid wall), neutron absorber, cladding and the tube body act against the bottom assembly (Bottom plate weldment + Collar + Bottom lid). The total weight is conservatively used for tube body compression.

DFC tube body compressive stress evaluation

For the end impact accident conditions, the tube is evaluated for a 60g acceleration. The compressive load (P) on the tube is the combined weight of the lid assembly, top flange, and tube body times 60g:

The compressive load (P) is:

$$P = 113 \text{ lb} \times 60g = 6,780 \text{ lb};$$

The compressive stress (S_c) in the tube body is:

$$S_c = \frac{P}{A} = \frac{6,780 \text{ lb}}{1.097 \text{ in}^2} = 6,180 \text{ psi}$$

The margin of safety (MS) is then:

$$MS = \frac{0.7 S_u}{S_c} - 1 = \frac{0.7(63,300) \text{ psi}}{6,180 \text{ psi}} - 1 = +6.2 \text{ for accident conditions at } 600^\circ\text{F}.$$

DFC tube body buckling evaluation

The tube is evaluated, using the Euler formula, to determine the critical buckling load (P_{cr}):

$$P_{cr} = \frac{\pi^2 EI}{L_e^2} = \frac{\pi^2 (25.2 \times 10^6) (6.793)}{[2(177.57)]^2} = 13,396 \text{ lb}$$

where:

$$E = 25.2 \times 10^6 \text{ psi}$$

$$I = \frac{6.14^4 - 6.05^4}{12} = 6.793 \text{ in.}^4$$

$$L_e = 2L \text{ (worst case condition)}$$

$$L = \text{tube body length (177.57 in)}$$

Because the maximum compressive load (6,780 lb under the accident condition) is much less than the worst-case critical buckling load (13,396 lb) and the support disks also provide lateral constraints to the body tube, the tube has adequate resistance to buckling.

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