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FROM: C. L. CRAWFORD CLC

Results for the Third Quarter Calendar Year 2017 Tank 50 Salt Solution Sample

Approved by: ______________________ 10/25/2017
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SUMMARY

In this memorandum, the chemical and radionuclide contaminant results from the Third Quarter Calendar Year 2017 (CY17) sample of Tank 50 salt solution are presented in tabulated form. The Third Quarter CY17 Tank 50 samples [a 200 mL sample obtained 6" below the surface (HTF-50-17-62) and a 1 L sample obtained 66" from the tank bottom (HTF-50-17-63)] were obtained on July 17, 2017 and received at Savannah River National Laboratory (SRNL) on July 17, 2017.[1] Prior to obtaining the samples from Tank 50, a single pump was run at least 4.4 hours and the samples were pulled immediately after pump shut down.[1] All volatile organic analysis (VOA) and semi-volatile organic analysis (SVOA) were performed on the surface sample and all other analyses were performed on the variable depth sample. The information from this characterization will be used by Savannah River Remediation (SRR) for the transfer of aqueous waste from Tank 50 to the Saltstone Production Facility, where the waste will be treated and disposed of in the Saltstone Disposal Facility. This memorandum compares results, where applicable, to Saltstone Waste Acceptance Criteria (WAC) limits and targets.[2] The chemical and radionuclide contaminant results from the characterization of the Third Quarter CY17 sampling of Tank 50 were requested by SRR personnel[3] and details of the testing are presented in the SRNL Task Technical and Quality Assurance Plan (TTQAP).[4] This memorandum is part of Deliverable 2 from SRR request.[3] Data pertaining to the regulatory limits for Resource Conservation and Recovery Act (RCRA) metals will be documented at a later time per the TTQAP for the Tank 50 Saltstone task.[4]

The following facts pertaining to the WAC are drawn from the analytical results provided in this memorandum:

- WAC targets or limits were met for all analyzed chemical and radioactive contaminants for which the detection limits are below the WAC targets or limits.

- Isopar L has a higher detection limit[5] compared with the current Saltstone WAC[2] value of 11 ppm that has been in effect since revision 12 of the WAC dating back to July of 2013.[6]

- Minimum detection limits are reported for ^{94}Nb, ^{247}Cm, ^{249}Cf, and ^{251}Cf as determined from the minimum detectable activity associated with the radiochemical methods used for these radionuclides. The reported detection limits are above the requested SRR target minimum detection limit concentrations.[7] However, the reported minimum detection limits reported for the Third Quarter CY17 Tank 50 sample for these four radionuclides are all lower than the estimated detection limits initially established by SRNL in 2009.[8] Thus per guidance from SRR,[7] SRNL continues to achieve as low as practical detection limits for these radionuclides.

TABLES CONTAINING RESULTS

Unless otherwise stated, all of the concentrations presented in the tables (except upper limits) are averages based on triplicate analyses of the Third Quarter CY17 Tank 50 samples. A memorandum reporting the average Cs-137 value has been previously issued.[9] The standard deviation of each average is also presented. Several of the contaminants were either not detected in the slurry samples or detected at values below the method reporting limit (MRL). For contaminants not detected or detected below the MRL, the result is preceded by a "<", which indicates the result is an upper limit based on the sensitivity of the method used to analyze the individual analyte. If only one value out of the triplicate analysis is above the detection limit, then that single value is reported and noted in the tables. Also, if only two values out of the triplicate analyses are above the detection limit, then the average of those two values is reported and noted in the tables. Data reported for atomic absorption (AA), cold-vapor atomic absorption (CVAA), inductively coupled plasma atomic emission spectroscopy (ICP-AES) and inductively coupled plasma mass spectrometry (ICP-MS) are derived from the digested Tank 50 supernate by the aqua regia method. The tetraphenylborate anion was analyzed using High Performance Liquid Chromatography (HPLC). Plutonium isotopes were analyzed using alpha Pulse Height Analysis (alpha PHA). All analytical methods shown by the acronyms in the tables for this memorandum have been previously defined in the TTQAP.[4] Radionuclides reported in Table 3 and Table 4 using the ICP-MS method are converted from a reported mass per volume basis to activity per volume units using the specific activities (Ci/g) reported from the Department of Energy 1996 Integrated Data Base Report.[10]

Total mercury was analyzed by SRNL using the CVAA method. Other mercury (Hg) speciation data shown in Table 1, Table 2, and Table 5 are calculated from previous work as analyzed by Cold Vapor Atomic Fluorescence Spectroscopy (CVAFS).[11] These species include elemental mercury (Hg(0)), monomethyl mercury, ethyl mercury, and dimethyl mercury. Monomethyl, ethyl, and dimethyl mercury are organomercury species. The concentration values for the organomercury species are calculated from the Hg speciation data on a mg Hg/L basis.[11] As a sample calculation for monomethyl mercury, information from Reference 11 shows that the reported average monomethyl concentration on a mg Hg/L basis is 32.5 mg Hg/L. This value is then multiplied by the formula weight of monomethyl mercury from the WAC[2] (215.62 g monomethyl mercury/mol) divided by the molecular weight of Hg (200.6 g Hg/mol). Thus the calculated concentration of the species monomethyl mercury is 32.5 mg Hg/L x (215.62 g monomethyl mercury/mol / 200.6 g Hg/mol) = 34.9 mg monomethyl mercury/L.

Table 1. Chemical Contaminants from Third Quarter CY17 Tank 50 Samples and Saltstone WAC, Revision 17, Attachment 8.1 Limits[2]

Chemical Name (Formula)	Method	Average Concentration (mg/L)	Std. Dev.	WAC Limit (mg/L)
Aluminate ($Al(OH)_4^-$)	ICP-ES	1.69E+04 [a]	4.36E+01	**4.08E+05**
Ammonium (NH_4^+)	IC	< 1.00E+02	NA	**2.12E+02**
Carbonate (CO_3^{2-})	TIC	1.51E+04 [b]	2.88E+02	**1.20E+05**
Chloride (Cl^-)	IC	4.99E+02	3.61E+00	**7.95E+03**
Fluoride (F^-)	IC	< 1.00E+02	NA	**4.07E+03**
Free Hydroxide (OH^-)	Total Base	3.50E+04 [b]	4.50E+02	**1.58E+05**
Nitrate (NO_3^-)	IC	1.17E+05	5.77E+02	**4.37E+05**
Nitrite (NO_2^-)	IC	2.75E+04	4.04E+02	**2.14E+05**
Oxalate ($C_2O_4^{2-}$)	IC	5.42E+02	6.66E+00	**2.72E+04**
Phosphate (PO_4^{3-})	IC	2.76E+02	2.08E+00	**2.94E+04**
Sulfate (SO_4^{2-})	IC	3.94E+03	4.73E+01	**5.69E+04**
Arsenic (As)	AA	< 1.12E-01	NA	**2.30E+01**
Barium (Ba)	ICP-ES	< 1.52E+00	NA	**6.19E+02**
Cadmium (Cd)	ICP-ES	< 2.67E+00	NA	**3.10E+02**
Chromium (Cr)	ICP-ES	5.27E+01	9.66E-01	**1.24E+03**
Lead (Pb)	ICP-MS	4.35E-01	1.53E-02	**6.19E+02**
Total Mercury (Hg)	CVAA	6.77E+01	6.43E-01	**3.25E+02**
Elemental Mercury (Hg(0))	CVAFS	1.21E+00 [e]	5.81E-01	**1.82E+01**
Monomethyl Mercury (CH_3Hg)	CVAFS w/ Distillation	3.49E+01 [e]	1.08E+00	**3.50E+02**
Ethyl Mercury (C_2H_5Hg)	CVAFS w/ Distillation	< 1.95E-01 [e]	NA	**3.73E+02**
Selenium (Se)	AA	< 1.12E-01	NA	**4.46E+02**
Silver (Ag)	ICP-ES	< 2.72E+00	NA	**6.19E+02**
Aluminum (Al)	ICP-ES	4.80E+03	1.24E+01	**1.16E+05**
Potassium (K)	AA	4.00E+02	5.85E+00	**3.03E+04**
Butanol (C_4H_9OH)	VOA	< 5.00E-01 [c]	NA	**7.73E+00**
Propanol (C_3H_7OH)	VOA	< 2.50E-01 [c]	NA	**1.88E+00**
Phenol (C_6H_5OH)	SVOA	< 1.00E+01 [c]	NA	**7.50E+02**
Isopar L (----)	SVOA	< 2.67E+01 ppm [c,d]	NA	**1.10E+01 ppm**
Total Organic Carbon (----)	TOC	2.90E+02 [b]	2.00E+00	**5.00E+03**
Tetraphenylborate [TPB] ($B(C_6H_5)_4^-$)	HPLC	< 5.00E+00	NA	**5.00E+00**

a. Result is calculated from the measured Al concentration assuming all the Al is present as the OH compound.
b. Measurement performed on filtered supernate samples.
c. Measurement performed on duplicate samples rather than triplicate samples.
d. Result is calculated from the reported concentration of < 33 mg/L and the density of the slurry sample listed in Table 8.
e. Mercury species calculated from data presented in Reference 11.

Table 2. Chemical Contaminants from Third Quarter CY17 Tank 50 Samples and Saltstone WAC, Revision 17, Attachment 8.2 Targets[2]

Chemical Name (Formula)	Method	Average Concentration (mg/L)	Std. Dev.	WAC Target (mg/L)
Boron (B)	ICP-ES	4.84E+01	3.46E+00	**7.43E+02**
Cobalt (Co)	ICP-MS [a]	< 2.23E-02	NA	**1.75E+02**
Copper (Cu)	ICP-ES	< 9.75E+00	NA	**7.43E+02**
Iron (Fe)	ICP-ES	< 4.22E+00	NA	**4.95E+03**
Lithium (Li)	ICP-ES	< 2.44E+01	NA	**7.43E+02**
Manganese (Mn)	ICP-ES	< 3.75E-01	NA	**7.43E+02**
Molybdenum (Mo)	ICP-ES	< 3.22E+01	NA	**7.43E+02**
Nickel (Ni)	ICP-ES	< 4.56E+00	NA	**7.43E+02**
Silicon (Si)	ICP-ES	2.67E+01	3.66E+00	**1.07E+04**
Strontium (Sr)	ICP-ES	< 7.53E-02	NA	**7.43E+02**
Zinc (Zn)	ICP-ES	6.60E+00	7.03E-02	**8.03E+02**
Benzene (C_6H_6)	VOA	< 1.50E-01 [b]	NA	**3.10E+02**
Methanol (CH_3OH)	VOA	c	NA	**1.88E+00**
Dibutylphosphate [DBP] ($C_8H_{19}O_4P$)	IC	< 2.50E+02	NA	**3.47E+02**
Tributylphosphate [TBP] ($(C_4H_9O)_3PO$)	SVOA	< 7.50E-01 [b]	NA	**7.50E+00**
Toluene ($C_6H_5CH_3$)	VOA	< 1.50E-01 [b]	NA	**3.10E+02**
EDTA ($C_{10}H_{12}N_2O_8^{4-}$)	HPLC	< 1.00E+02	NA	**3.10E+02**
NORPAR 13 (C_nH_{2n})	SVOA	< 7.50E-01 [b]	NA	**7.50E-01**
Dimethyl Mercury ($(CH_3)_2Hg$)	CVAFS	7.10E-02 [d]	4.75E-03	**1.00E+00**

a. Cobalt based on the stable Co-59 isotope.
b. Measurement performed on duplicate samples rather than triplicate samples.
c. Currently, a routine method for detecting this species does not exist in Analytical Development (AD).
d. Mercury species calculated from data presented in Reference 11.

Table 3. Radionuclide Contaminants from Third Quarter CY17 Tank 50 Samples and Saltstone WAC, Revision 17, Attachment 8.3 Limits[2]

Radionuclide	Method	Average Concentration (pCi/mL)	Std. Dev.	WAC Limit (pCi/mL)
Tritium (^{3}H)	Tritium Counting	1.38E+03	8.54E+01	**5.63E+05**
Carbon-14 (^{14}C)	C-14 Liquid Scintillation	6.52E+02	1.38E+01	**1.13E+05**
Nickel-63 (^{63}Ni)	Ni-59/63	< 4.43E+00	NA	**1.13E+05**
Strontium-90 (^{90}Sr)	Sr-90 Liquid Scintillation	2.89E+04	1.51E+03	**3.15E+06**
Technetium-99 (^{99}Tc)	Tc-99 Liquid Scintillation	4.39E+04	6.47E+02	**2.11E+05**
Iodine-129 (^{129}I)	I-129 (w/ separation) Liquid Scintillation	3.23E+01	2.05E+00	**6.30E+01**
Cesium-137 (^{137}Cs)	Gamma Scan	8.90E+05	3.88E+04	**3.96E+06**
Uranium-233 (^{233}U)	ICP-MS	< 2.16E+02	NA	**1.13E+04**
Uranium-235 (^{235}U)	ICP-MS	2.13E-01	9.13E-04	**1.13E+02**
Plutonium-241 (^{241}Pu)	Pu238/241 Liquid Scintillation	8.95E+03	6.47E+02	**8.38E+05**
Total Alpha	Liquid Scintillation Counting (Cs removed)	< 2.24E+04	NA	**2.13E+05**

Table 4. Radionuclide Contaminants from Third Quarter CY17 Tank 50 Samples and Saltstone WAC, Revision 17, Attachment 8.4 Targets[2]

Radionuclide	Method	Average Concentration (pCi/mL)	Std. Dev.	WAC Target (pCi/mL)
Aluminum-26 (^{26}Al)	Gamma Scan (Cs removed)	1.15E-01 [a]	NA	**2.88E+03**
Cobalt-60 (^{60}Co)	Gamma Scan (Cs removed)	2.39E-01	4.50E-02	**9.75E+02**
Potassium-40 (^{40}K)	Gamma Scan (Cs removed)	< 2.34E+00	NA	**1.00E+02**
Nickel-59 (^{59}Ni)	Ni-59/63	< 5.90E+00	NA	**1.13E+03**
Selenium-79 (^{79}Se)	Se-79	2.72E+01	6.32E+00	**1.90E+04**
Yttrium-90 (^{90}Y)	Secular Equilibrium w/ 100% of Sr-90	2.89E+04	1.51E+03	**3.15E+06**
Zirconium-93 (^{93}Zr)	ICP-MS	< 1.12E+02	NA	**1.00E+05**
Niobium-94 (^{94}Nb)	Nb-94	< 3.36E-01	NA	**1.53E+02**
Rhodium-106 (^{106}Rh)	Secular Equilibrium w/ 100% of Ru-106	< 2.58E+00	NA	**1.13E+06**
Ruthenium-106 (^{106}Ru)	Gamma Scan (Cs removed)	< 2.58E+00	NA	**1.13E+06**
Antimony-125 (^{125}Sb)	Gamma Scan (Cs removed)	1.01E+01	7.24E-01	**7.99E+03**
Tellurium-125m (^{125m}Te)	Secular Equilibrium w/ 100% of Sb-125	1.01E+01	7.24E-01	**1.83E+03**
Tin-126 (^{126}Sn)	Gamma Scan (Cs removed)	4.72E+02	3.65E+01	**1.80E+04**
Cesium-134 (^{134}Cs)	Gamma Scan	< 7.88E+01	NA	**1.82E+04**
Cesium-135 (^{135}Cs)	ICP-MS	< 5.14E+01	NA	**2.50E+02**
Barium-137m (^{137m}Ba)	Calculation (Secular Equilibrium w/ 94.6% of Cs-137)	8.42E+05	3.67E+04	**3.75E+06**
Cerium-144 (^{144}Ce)	Gamma Scan (Cs removed)	< 3.86E+00	NA	**1.13E+05**
Promethium-147 (^{147}Pm)	Pm-147/Sm-151 Liquid Scintillation	< 1.99E+01	NA	**5.63E+06**
Samarium-151 (^{151}Sm)	Pm-147/Sm-151 Liquid Scintillation	< 1.59E+01	NA	**2.25E+04**
Europium-154 (^{154}Eu)	Gamma Scan (Cs removed)	< 3.77E-01	NA	**1.62E+03**
Europium-155 (^{155}Eu)	Gamma Scan (Cs removed)	< 2.15E+00	NA	**1.13E+04**
Radium-226 (^{226}Ra)	Ra-226	< 2.61E+00	NA	**1.00E+03**
Radium-228 (^{228}Ra)	Gamma Scan (Cs removed)	< 1.05E+00	NA	**1.00E+04**
Actinium-227 (^{227}Ac)	Th-229/230	< 1.40E-02	NA	**1.00E+04**
Thorium-229 (^{229Th})	Th-229/230	4.93E-02 [b]	3.35E-02	**1.63E+05**
Thorium-230 (^{230Th})	Th-229/230	2.12E-02 [a]	NA	**6.26E+03**
Thorium-232 (^{232}Th)	ICP-MS	< 2.45E-03	NA	**2.88E+03**
Protactinium-231 (^{231}Pa)	Pa-231	< 1.33E-01	NA	**1.00E+03**
Uranium-232 (^{232}U)	U-232	1.19E+00	2.45E-01	**9.06E+03**
Uranium-234 (^{234}U)	ICP-MS	< 1.39E+02	NA	**1.13E+04**
Uranium-236 (^{236}U)	ICP-MS	< 1.44E+00	NA	**1.13E+04**
Uranium-238 (^{238}U)	ICP-MS	3.68E+00	6.68E-02	**1.13E+04**

Table 4. Radionuclide Contaminants from Third Quarter CY17 Tank 50 Samples and Saltstone WAC, Revision 17, Attachment 8.4 Targets[2], continued

Radionuclide	Method	Average Concentration (pCi/mL)	Std. Dev.	WAC Target (pCi/mL)
Neptunium-237 (^{237}Np)	ICP-MS	< 1.57E+01	NA	**1.00E+04**
Plutonium-238 (^{238}Pu)	Pu238/241 Pu alpha PHA	2.56E+04	2.08E+03	**2.13E+05**
Plutonium-239 (^{239}Pu)	Pu238/241 Pu alpha PHA	5.89E+02	2.13E+01	**2.13E+05**
Plutonium-240 (^{240}Pu)	Pu238/241 Pu alpha PHA	5.89E+02	2.13E+01	**2.13E+05**
Plutonium-242 (^{242}Pu)	ICP-MS	< 8.52E+01	NA	**2.13E+05**
Plutonium-244 (^{244}Pu)	ICP-MS	< 3.96E-01	NA	**7.02E+04**
Americium-241 (^{241}Am)	Am/Cm	6.04E+00	4.34E-01	**2.13E+05**
Americium-242m (^{242m}Am)	Am/Cm	< 2.32E-02	NA	**4.50E+05**
Americium-243 (^{243}Am)	Am/Cm	< 2.94E-01	NA	**2.13E+05**
Curium-242 (^{242}Cm)	Am/Cm	< 1.92E-02	NA	**1.13E+04**
Curium-244 (^{244}Cm)	Am/Cm	1.49E+00	5.91E-01	**2.13E+05**
Curium-245 (^{245}Cm)	Am/Cm	< 8.02E-01	NA	**2.25E+05**

a. Only one detectable value from the analyzed triplicate set.
b. Only two detectable values from the analyzed triplicate set.

Table 5. Chemical Contaminants Impacting Saltstone Disposal Unit (SDU) Flammability from Third Quarter CY17 Tank 50 Samples and Saltstone WAC, Revision 17, Table 2 Limits and Targets[2]

Chemical Name (Formula)	Method	Average Concentration (mg/L)	Std. Dev.	WAC Limit/Target
Isopar L (----)	SVOA	< 2.67E+01 ppm [a,b]	NA	**1.10E+01 ppm (Limit)**
Tetraphenylborate [TPB] ($B(C_6H_5)_4^-$)	HPLC	< 5.00E+00	NA	**5.00E+00 mg/L (Limit)**
Ammonium (NH_4^+)	IC	< 1.00E+02	NA	**2.12E+02 mg/L (Limit)**
Total Mercury (Hg)	CVAA	6.77E+01	6.43E-01	**3.25E+02 mg/L (Limit)**
Monomethyl Mercury (CH_3Hg)	CVAFS w/ Distillation	3.49E+01 [c]	1.08E+00	**3.50E+02 mg/L (Limit)**
Dimethyl Mercury ($(CH_3)_2Hg$)	CVAFS	7.10E-02 [c]	4.75E-03	**1.00E+00 mg/L (Target)**

a. Measurement performed on duplicate samples rather than triplicate samples.
b. Result is calculated from the reported concentration of < 33 mg/L and the density of the slurry sample listed in Table 8.
c. Mercury species calculated from data presented in Reference 11.

Table 6. Other Organics Impacting SDU Flammability from Third Quarter CY17 Tank 50 Samples and Saltstone WAC, Revision 17, Table 3 Concentrations[2]

Chemical Name (Formula)	Method	Average Concentration (mg/L)	Std. Dev.	WAC Concentrations (mg/L)
Butanol (C_4H_9OH)	VOA	< 5.00E-01	NA	**0.75**
Tributylphosphate[TBP] ($(C_4H_9O)_3PO$)	SVOA	< 7.50E-01	NA	**1.0**
Isopropanol (C_3H_7OH)	VOA	< 2.50E-01	NA	**0.25**
Methanol (CH_3OH)	a	NA	NA	**0.05**
NORPAR 13 (C_nH_{2n})	SVOA	< 7.50E-01	NA	**0.75**

a. Currently, a routine method for detecting this species does not exist in AD.

Table 7. Processing Constituents from Third Quarter CY17 Tank 50 Samples and Saltstone WAC, Revision 17, Table 4 Limits[2]

Processing Constituents	Method	Value	Std. Dev.	WAC Limit
pH	Calculated	> 13	NA	**> 10**
Sodium Concentration	ICP-ES & AA	5.09M	2.25E-01	**2.5 M < [Na^+] < 7.0 M**
Total Insoluble Solids	Calculated	~0 wt%	NA	**< 15 wt%**

Table 8 contains additional measured constituents per the TTQAP.[4] This table also includes formate analysis and the Total Organic Carbon (TOC) (minus formate & oxalate) as shown in Appendix 1 of the WAC. The average and standard deviation that may be used to determine the 95% confidence interval for the Third Quarter CY17 are shown. These standard deviations include the variance in each triplicate analysis set as well as the one-sigma instrument uncertainty of 10% reported for each value. These values were calculated using the Guide for the Expression of Uncertainty in Measurement (GUM) Workbench statistical package.[12] These data indicate that, at the 95% confidence interval, the calculated TOC (minus formate & oxalate) could be in the approximate range of 22 to 154 mg/L for the Third Quarter CY17 sample, i.e., the average ± 2X Std. Dev.

Table 8. Additional Measured Constituents[4]

Constituent	Method	Average Value	Std. Dev.
Density (slurry)	Measured (21.3ºC)	1.2369 g/mL	0.0002
Specific Gravity	a	1.2396	0.0002
Total Solids	Measured	27.37 wt%	0.08
Total Beta	LSC	1.32E+06 pCi/mL	1.19E+04
Total Gamma	b	8.43E+05 pCi/mL	2.12E+04 [c]
Thorium-228 (^{228}Th)	Gamma scan (Cs removed)	< 1.23E+01 pCi/mL	NA
Curium-247 (^{247}Cm) [d]	Am/Cm	< 1.09E+00 pCi/mL	NA
Californium-249 (^{249}Cf) [d]	Am/Cm	< 1.20E+00 pCi/mL	NA
Californium-251 (^{251}Cf) [d]	Am/Cm	< 9.28E-01 pCi/mL	NA
Beryllium (Be) [e]	ICP-ES	2.14E-01	NA
Formate (HCO_2^-) [f]	IC	2.03E+02 mg/L	1.73E+00
Total Organic Carbon (minus formate & oxalate) [g]	Calculated	8.80E+01 mg/L	3.30E+01 [h]

a. Calculated from the measured density of slurry and density of water at 22.0 °C.[13]
b. Calculated from the sum of gamma emitters (Sb-126, Sn-126, Sb-125, Eu-154, Am-241, Co-60 and Ba-137m).
c. Value is the “standard error of the mean” rather than the standard deviation of the measurements since its calculation involves multiple radionuclides.
d. Reported values are all below the estimated detection limits of 90.1 pCi/mL established by SRNL.[8]
e. Only single value detectable from triplicate analysis for Be.
f. Formate is not required by the WAC but is used in the Total Organic Carbon (minus formate & oxalate) calculation.[2]
g. Total Organic Carbon (minus formate & oxalate) as shown in Appendix 1 of the WAC.[2]
h. Standard deviation includes uncertainty in the triplicate analysis and the one-sigma instrument uncertainty.

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