AUG 2 8 1996
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(21) ENGINEERING DATA TRANSMITTAL

Page 1 of 1

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		10. System/Bldg./Facility: Tank Farms
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		13. Permit/Permit Application No.: N/A
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1	WHC-SD-WM-CN-065	N/A	0	Consequence Analysis of an Unmitigated NaOH Solution Spray Release During Addition to Waste Tank	N/A	1/2	1	1

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(G) Reason	(H) Disp.	(J) Name (K) Signature (L) Date (M) MSIN	(G) Reason	(H) Disp.	(J) Name (K) Signature (L) Date (M) MSIN
		Design Authority	1	1	Peer Rev. B.E. Hey [signature] 8/27/96 A3-34
		Design Agent			
1	1	Cog.Eng. D.A. Himes [signature] 8/27/96 A3-34			
1	1	Cog. Mgr. D.S. Leach [signature] 8/27/96 A3-34			
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		Env.			

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D.A. Himes [signature] 8/27/96 Signature of EDT Originator Date	N/A Authorized Representative Date for Receiving Organization	D.S. Leach [signature] 8/27/96 Design Authority/ Cognizant Manager Date	Ctrl. No. N/A [N/A] Approved [] Approved w/comments [] Disapproved w/comments

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Consequence Analysis of an Unmitigated NaOH Solution Spray Release During Addition to Waste Tank

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Westinghouse Hanford Company, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-87RL10930

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Abstract: Toxicological consequences were calculated for a postulated maximum caustic soda (NaOH) solution spray leak during addition to a waste tank to adjust tank pH. Although onsite risk guidelines were exceeded for the unmitigated release, site boundary consequences were below the level of concern. Means of mitigating the release so as to greatly reduce the onsite consequences were recommended.

AUG 28 1996
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STA: 15 RELEASE ID: 21

Karen L Noland 8/28/96
Release Approval Date Release Stamp

Approved for Public Release

CONSEQUENCE ANALYSIS OF AN UNMITIGATED NaOH SOLUTION SPRAY RELEASE DURING ADDITION TO WASTE TANK

D.A. Himes
8/21/96

Aqueous NaOH solutions are added as needed to Hanford waste tanks to adjust waste pH so as to minimize corrosion in the tanks. These additions are normally made from a tank truck through any of a variety of pipes, hoses and pumps. The lightest equipment considered to be suitable for NaOH solution transport is 1 inch schedule 10 commercial steel pipe with a wall thickness of 0.109 inches. The largest pipe or hose considered is 2 inch cross linked polyethylene hose with a wall thickness of 25/64 inch. The maximum pressure the system can be subjected to is 125 psig. The highest temperature at which the tank truck is loaded is 120^{0}F (49^{0}C). The solution concentration could be anywhere in the range 5 to 50% NaOH.

An evaluation is required of the maximum NaOH air concentrations which could occur at the onsite (100 m) and site boundary receptors due to a spray leak during a transfer to a waste tank.

Accident description:

A pressure of 125 psig is not expected to be able to cause schedule 10 steel pipe to fail. The most likely cause of a spray release is considered to be a loose connection, or possibly a cracked circumferential weld joining the pipe to a flange or fitting. In the case of a loose fitting, the leak could extend around the full circumference of the sealing surface. The depth (path length) of the opening in such a case, however, would be much greater than the wall thickness of the pipe and so would exhibit a much lower leak rate due to friction losses. Polyethylene is not stiff enough to maintain the fine crack width associated with an atomizing spray over a crack length sufficient to produce a significant leak rate. A split in the polyethylene hose large enough to cause a significant release rate would therefore produce a stream (with little production of small particles) rather than a fine spray. The worst case circumferential crack in a pipe weld able to maintain the narrow width associated with a fine aerosol spray is normally assumed to extend a distance around the pipe equal to one pipe diameter (inside).

The maximum spray leak was therefore assumed to be a crack with a minimum depth equal to the lightest (schedule 10) pipe wall thickness of 0.109 inches and a maximum length equal to one pipe diameter, i.e., 1 inch. The width of the crack was optimized to produce the highest respirable particle fraction using the SPRAY Code (Hey and Leach 1994).

Transport assumptions:

For a ground level release the onsite receptor is normally assumed to be at a distance of 100 m in the worst direction (WHC 1988). The site boundary receptor for purposes of this analysis is located at the site boundary or the near bank of the Columbia River, whichever is closer, in the worst direction. No receptor evacuation was assumed.

Acute 99.5 percentile ground level release dispersion factors (X/Q) have been generated for the Hanford tank farms using the GXQ code (Hey 1994) at each of the 16 sectors at 100 m and at the site boundary or the near bank of the Columbia River. Since maximum air concentrations are the primary concern for toxic releases, no plume meander was assumed. The resulting X/Qs are reported in WHC-SD-WM-SARR-016 (Savino 1996) as 3.41E-2 s/m^3 onsite (100 m E) and 2.83E-5 s/m^3 at the site boundary (8.76 km N).

In the case of a liquid spray release, care must be taken to account for evaporation during transit when estimating the small particle ("respirable") fraction. Particles less than about 10 µm tend to remain suspended in the air for long distances whereas particles larger than 10 µm released from a non-elevated source tend to fall out within the first 50 to 100 m of travel. (The term "respirable fraction" is often used in reference to particles less than 10 µm because this is the size range which can reach the lower lung.) The size of the liquid particles will decrease in transit due to evaporation of the liquid component finally leaving only a smaller particle of the solid material which had been in solution in the liquid. The initial diameter, D_r, of a solution particle with a solid fraction f_s which will evaporate to a particle with a diameter of 10 µm is given by (Hey and Leach 1995)

$$D_r = \frac{10\ \mu m}{f_s^{\frac{1}{3}}} \qquad (1)$$

The resulting initial particle diameters are shown in Table 1 along with solution viscosity and density (Perry and Green 1984) for a range of solid fractions of NaOH in water. The leak rate and atomization efficiency increase with decreasing viscosity and hence increasing temperature. The high end of the temperature range for this liquid (50°C) is therefore assumed.

Table 1: Concentration dependent parameters for caustic soda (NaOH) solutions at 50°C

% NaOH	Density (g/cm^3)	Viscosity (centipoise)	D_r (μm)
5	1.041	0.80	27.1
10	1.094	0.96	21.5
12	1.116	1.1	20.3
15	1.148	1.3	18.8
20	1.202	1.9	17.1
30	1.309	4.4	14.9
40	1.410	8.5	13.6
50	1.504	14.3	12.6

It is conservatively assumed here that the liquid fraction of the spray evaporates very quickly. In reality the initial large size of the "respirable" particles would cause rapid initial fallout.

Source term:

The SPRAY Code version 3.0 (Hey and Leach 1995) was used to calculate leak rates and small particle fractions for the assumed break in the liquid containment boundary. As previously developed, the assumed break is a crack with a maximum length of 6.28 inches and a minimum depth of 0.109 inches. (The release rate will decrease with increasing crack depth due to higher friction losses.) The crack width was optimized to maximize the release rate of particles with an initial size less than or equal to the size given as D_r in Table 1.

At low solution concentrations, the viscosity is low (approaching that of water) so that friction losses in the crack are low and solution release rates are relatively high. The NaOH release rate is low, however, due to the low concentration. As concentration increases, the NaOH respirable release rate initially stays fairly constant due to the competing effects of increasing concentration and decreasing initial particle size range due to effects of evaporation. However as concentration is increased further, the increase in solution viscosity causes a rapidly decreasing flow rate. There may also be an added effect due to a possible transition from turbulant flow at low viscosity to laminar flow at higher viscosities. It is expected, therefore, that the maximum small particle NaOH release rate will occur at some optimum solution concentration. A parametric study was performed using the SPRAY Code to determine this optimum solution concentration within the expected range of 5% to 50% NaOH to be used for tank additions. The small particle release rate was therefore calculated over a range of NaOH concentrations with the results shown in Table 2. Standard roughness and flow parameters for steel pipe were assumed as documented in the SPRAY Code output files shown in Attachment 1. For the cases where critical flow developed in the crack, friction factors for laminar flow were assumed for conservatism.

Table 2: Solution spray release parameters

% NaOH	Optimum Crack Width (m)	Flow Type	Respirable Fraction	Respirable NaOH Release Rate (g/s)
5	9.99E-5	Turbulent	7.10E-2	0.193
10	9.81E-5	Turbulent	3.76E-2	0.204
12	4.60E-5	Critical	4.12E-1	1.68
15	4.68E-5	Critical	3.00E-1	1.53
20	5.34E-5	Laminar	1.38E-1	1.07
30	7.77E-5	Laminar	2.19E-2	0.384
40	1.05E-4	Laminar	5.10E-3	0.166
50	1.35E-4	Laminar	1.55E-3	0.0840

As indicated in the table, the maximum small particle NaOH release rate corresponded to a solution concentration of 12%.

<u>Results</u>:

By the definition of the X/Q, the maximum air concentration of NaOH at a receptor location is just the product of the maximum release rate and the receptor X/Q. The resulting onsite and site boundary air concentrations of small particle NaOH is shown in Table 3.

Table 3: Resulting NaOH air concentrations

% NaOH	Respirable Release Rate (mg/s)	Concentration (mg/m^3) Onsite (100 m)	Site Boundary
5	1.93E+2	6.58E+0	5.46E-3
10	2.04E+2	6.96E+0	5.77E-3
12	**1.68E+3**	**5.73E+1**	**4.75E-2**
15	1.53E+3	5.22E+1	4.33E-2
20	1.07E+3	3.65E+1	3.03E-2
30	3.84E+2	1.31E+1	1.09E-2
40	1.66E+2	5.66E+0	4.70E-3
50	8.40E+1	2.86E+0	2.38E-3

These results are considered very conservative in this case since they do not take credit for the initially rapid fallout rate of the large liquid particles prior to evaporation of the liquid fraction.

Conclusion:

The caustic spray leak analyzed here has been assigned a frequency of occurrence in the anticipated range (10^{-2} - 10^{+0}/y). The risk guidelines for onsite and site boundary receptors for this frequency range are ERPG-1 and PEL-TWA. Both criteria are 2 mg/m^3 for NaOH (Van Keuren 1995). The concentrations at the receptor points and the resulting sum of fractions of the risk guidelines are shown in Table 4.

Table 4: Receptor exposures to NaOH

Receptor	NaOH Concentration (mg/m3)	Sum of Fractions
Site Boundary at 8.76 km N	4.75E-2	0.024
Onsite at 100 m E	5.73E+1	29

The sum of fractions at the site boundary are far less than the toxicological risk criterion of 1. The criterion is exceeded at the onsite receptor location.

Note that these results are for standard schedule 10 steel pipe. Use of a thinner wall pipe such as schedule 5 (wall thickness 0.065 in.) would increase the maximum release rate and receptor concentrations shown in Tables 3 and 4 by about 30% (due to the smaller crack depth and decreased friction losses). There would be no changes in the conclusions.

Recommendations for mitigation:

Since the liquid being transferred is relatively cool (<50^{0}C) and is at relatively low pressure ($\leq$125 psig), containment of a possible spray release would be easy. Plastic sleeving or wrap taped in place around the fittings would be sufficient to contain the spray. Using the total optimal leak rate of 3.04E-5 m^3/s (see attached Spray Code run for 12% solution) and the crack area produces a maximum liquid spray velocity of 26 m/s. Even assuming the spray to come out in a parallel (rather than a radial) stream, the maximum resulting reaction force of the worst-case spray would be about 0.88 Nt (0.20 lb). Assuming the plastic to form a 90^0 corner under the impact of the spray, the maximum stress produced in 4 mil material would be about 35 psi. Standard 4 mil polyethylene (or similar material) sleeving or wrap would therefore have ample strength to contain the spray. The sleeving/wrap would not be expected to be pressure tight, however, and the solution would still leak out, producing a minor local cleanup problem, but there would be no significant aerosol release.

References:

Hey 1994, B.E. Hey, *GXQ Program User's Guide*, WHC-SD-GN-SWD-30002, Rev. 1, December 1994.

Hey and Leach 1994, B.E. Hey and D.S. Leach, *A Model for Predicting Respirable Releases from Pressurized Leaks*, WHC-SD-GN-SWD-20007 Rev 0, April 1994.

Perry and Green 1984, R.H. Perry and D. Green, *Perry's Chemical Engineers' Handbook*, Sixth Edition, McGraw-Hill, New York, 1984.

Savino 1996, A.V. Savino, *Tank Waste Compositions and Atmospheric Dispersion Coefficients for use in Accelerated Safety Analysis Consequence Assessments*, WHC-SD-WM-SARR-016 Rev 2, July 1996.

Van Keuren 1995, J.C. Keuren, J.S. Davis, and M.L. Dentler, *Toxic Chemical Considerations for Tank Farm Releases*, WHC-SD-WM-SARR-011 Rev 1, November 1995.

WHC 1996, *Safety Assessment for Tank 241-C-106 Waste Retrieval Project W-320*, WHC-SD-WM-SAD-024 Rev 0, May 1996.

Attachment 1
SPRAY Code Files

```
                              SPRAY Version 3.0
                                 May 3, 1994

Spray Leak Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company


Run Date = 08/21/96/
Run Time = 08:03:04.56


INPUT ECHO:
c unmitigated caustic spray - 5% NaOH
c SPRAY Version 3 Input Deck
c   mode iflow iopt
     2    0     T
c
c MODEL OPTIONS:
c mode = 1 then orifice leak with friction assumed
c        2 then slit leak with friction assumed
c iflow= 0 Reynold's number determines friction relation (i.e. laminar or turb.
c      = 1 friction based on laminar relation
c      = 2 friction based on turbulent relation
c iopt = T then optimal diameter search performed
c      = F then no optimal search
c
c PARAMETER INPUT:
c
c   Initial Slit                   Slit or
c   Width or        Slit           Orifice
c   Orifice Dia.    Length         Depth
c   (in)            (in)           (in)
c
    1.00000E-03     1.00000E+00    1.09000E-01
c
c                   Absolute
c                   Surface
c                   Roughness      Contraction    Velocity
c                   (in)           Coefficient    Coefficient
c   Pressure        0.00006 tube   0.61    and    0.98  for sharp edge orifice
c   Differential    0.0018  steel  1.00    and    0.98  for rounded orifice
c   (psi)           0.0102  iron   1.00    and    0.82  for square edge orifice
c
    1.25000E+02     1.80000E-03    1.00000E+00    8.20000E-01
```

```
c
c   Fluid           Dynamic          Respirable      RR Fitting
c   Specific        Viscosity        Diameter        Constant
c   Gravity         (centi-poise)    (μm)            (q)
c
    1.04100E+00     8.00000E-01      2.71000E+01     2.40000E+00
```

MESSAGES:
Slit Model
Code search for optimal equivalent diameter.

OUTPUT:

```
     Liquid Velocity =  6.76E+01 ft/s      2.06E+01 m/s
     Reynolds Number =  5.33E+03 Turbulent Flow
Sauter Mean Diameter =  5.26E+01 μm
  Optimum Slit Width =  3.93E-03 in        9.99E-05 m
 Respirable Fraction =  7.10E-02
     Total Leak Rate =  8.28E-01 gpm       5.22E-05 m3/s      5.44E+01 g/s
Respirable Leak Rate =  5.88E-02 gpm       3.71E-06 m3/s      3.86E+00 g/s
```

SPRAY Version 3.0
May 3, 1994

Spray Leak Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Run Date = 08/21/96/
Run Time = 08:08:31.64

```
INPUT ECHO:
c unmitigated caustic spray - 10% NaOH
c SPRAY Version 3 Input Deck
c   mode iflow iopt
    2    0     T
c
c MODEL OPTIONS:
c mode = 1 then orifice leak with friction assumed
c        2 then slit leak with friction assumed
c iflow= 0 Reynold's number determines friction relation (i.e. laminar or turb.
c      = 1 friction based on laminar relation
c      = 2 friction based on turbulent relation
c iopt = T then optimal diameter search performed
c      = F then no optimal search
c
c PARAMETER INPUT:
c
c   Initial Slit                   Slit or
c   Width or       Slit            Orifice
c   Orifice Dia.   Length          Depth
c   (in)           (in)            (in)
c   ____________   ____________    ____________
    1.00000E-03    1.00000E+00     1.09000E-01
c
c                  Absolute
c                  Surface
c                  Roughness       Contraction     Velocity
c                  (in)            Coefficient     Coefficient
c   Pressure       0.00006 tube    0.61    and     0.98  for sharp edge orifice
c   Differential   0.0018  steel   1.00    and     0.98  for rounded orifice
c   (psi)          0.0102  iron    1.00    and     0.82  for square edge orifice
c   ____________   ____________    ____________    ______________________________
    1.25000E+02    1.80000E-03     1.00000E+00     8.20000E-01
```

```
c
c   Fluid           Dynamic          Respirable     RR Fitting
c   Specific        Viscosity        Diameter       Constant
c   Gravity         (centi-poise)    (μm)           (q)
c   ____________    ____________     ____________   ____________
    1.09400E+00     9.60000E-01      2.15000E+01    2.40000E+00
```

MESSAGES:
Slit Model
Code search for optimal equivalent diameter.

```
OUTPUT:
     Liquid Velocity =  6.53E+01 ft/s       1.99E+01 m/s
     Reynolds Number =  4.43E+03 Turbulent Flow
Sauter Mean Diameter =  5.48E+01 μm
  Optimum Slit Width =  3.86E-03 in         9.81E-05 m
 Respirable Fraction =  3.76E-02
     Total Leak Rate =  7.86E-01 gpm        4.96E-05 m3/s       5.42E+01 g/s
Respirable Leak Rate =  2.96E-02 gpm        1.87E-06 m3/s       2.04E+00 g/s
```

SPRAY Version 3.0
May 3, 1994

Spray Leak Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Run Date = 08/21/96/
Run Time = 08:24:57.06

```
INPUT ECHO:
c unmitigated caustic spray - 12% NaOH
c SPRAY Version 3 Input Deck
c   mode iflow iopt
     2    1     T
c
c MODEL OPTIONS:
c mode = 1 then orifice leak with friction assumed
c        2 then slit leak with friction assumed
c iflow= 0 Reynold's number determines friction relation (i.e. laminar or turb.
c      = 1 friction based on laminar relation
c      = 2 friction based on turbulent relation
c iopt = T then optimal diameter search performed
c      = F then no optimal search
c
c PARAMETER INPUT:
c
c   Initial Slit                  Slit or
c   Width or        Slit          Orifice
c   Orifice Dia.    Length        Depth
c   (in)            (in)          (in)
c   ____________    ___________   ___________
    1.00000E-03     1.00000E+00   1.09000E-01
c
c                   Absolute
c                   Surface
c                   Roughness     Contraction    Velocity
c                   (in)          Coefficient    Coefficient
c   Pressure        0.00006 tube  0.61    and    0.98  for sharp edge orifice
c   Differential    0.0018  steel 1.00    and    0.98  for rounded orifice
c   (psi)           0.0102  iron  1.00    and    0.82  for square edge orifice
c   ___________     ____________  ___________    ____________________________
    1.25000E+02     1.80000E-03   1.00000E+00    8.20000E-01
```

```
c
c   Fluid            Dynamic          Respirable       RR Fitting
c   Specific         Viscosity        Diameter         Constant
c   Gravity          (centi-poise)    (µm)             (q)
c
    1.11600E+00      1.10000E+00      2.03000E+01      2.40000E+00
```

```
MESSAGES:
Slit Model
Code search for optimal equivalent diameter.
Friction factor based on laminar flow.
```

```
OUTPUT:
     Liquid Velocity =  8.54E+01 ft/s      2.60E+01 m/s
     Reynolds Number =  2.43E+03 Critical Flow
Sauter Mean Diameter =  1.73E+01 µm
  Optimum Slit Width =  1.81E-03 in        4.60E-05 m
 Respirable Fraction =  4.12E-01
     Total Leak Rate =  4.82E-01 gpm       3.04E-05 m3/s       3.40E+01 g/s
Respirable Leak Rate =  1.98E-01 gpm       1.25E-05 m3/s       1.40E+01 g/s
```

```
                    ___________________________
                       SPRAY Version 3.0
                          May 3, 1994
                    ___________________________

Spray Leak Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company


Run Date = 08/21/96/
Run Time = 08:28:44.89


INPUT ECHO:
c unmitigated caustic spray - 15% NaOH
c SPRAY Version 3 Input Deck
c   mode iflow iopt
    2    1     T
c
c MODEL OPTIONS:
c mode = 1 then orifice leak with friction assumed
c        2 then slit leak with friction assumed
c iflow= 0 Reynold's number determines friction relation (i.e. laminar or turb.
c      = 1 friction based on laminar relation
c      = 2 friction based on turbulent relation
c iopt = T then optimal diameter search performed
c      = F then no optimal search
c
c PARAMETER INPUT:
c
c   Initial Slit                    Slit or
c   Width or        Slit            Orifice
c   Orifice Dia.    Length          Depth
c   (in)            (in)            (in)
c   ____________    ___________     ___________
    1.00000E-03     1.00000E+00     1.09000E-01
c
c                   Absolute
c                   Surface
c                   Roughness       Contraction     Velocity
c                   (in)            Coefficient     Coefficient
c   Pressure        0.00006 tube    0.61    and     0.98  for sharp edge orifice
c   Differential    0.0018  steel   1.00    and     0.98  for rounded orifice
c   (psi)           0.0102  iron    1.00    and     0.82  for square edge orifice
c   ____________    _____________   ___________     ______________________________
    1.25000E+02     1.80000E-03     1.00000E+00     8.20000E-01
```

```
c
c   Fluid          Dynamic         Respirable     RR Fitting
c   Specific       Viscosity       Diameter       Constant
c   Gravity        (centi-poise)   (μm)           (q)
c
    1.14800E+00    1.30000E+00     1.88000E+01    2.40000E+00
```

```
MESSAGES:
Slit Model
Code search for optimal equivalent diameter.
Friction factor based on laminar flow.
```

```
OUTPUT:
     Liquid Velocity =  8.20E+01 ft/s      2.50E+01 m/s
     Reynolds Number =  2.06E+03 Critical Flow
Sauter Mean Diameter =  1.89E+01 μm
  Optimum Slit Width =  1.84E-03 in        4.68E-05 m
 Respirable Fraction =  3.00E-01
     Total Leak Rate =  4.71E-01 gpm       2.97E-05 m3/s      3.41E+01 g/s
Respirable Leak Rate =  1.41E-01 gpm       8.91E-06 m3/s      1.02E+01 g/s
```

SPRAY Version 3.0
May 3, 1994

```
Spray Leak Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company


Run Date = 08/21/96/
Run Time = 08:36:42.36


INPUT ECHO:
c unmitigated caustic spray - 20% NaOH
c SPRAY Version 3 Input Deck
c   mode iflow iopt
    2    1     T
c
c MODEL OPTIONS:
c mode = 1 then orifice leak with friction assumed
c        2 then slit leak with friction assumed
c iflow= 0 Reynold's number determines friction relation (i.e. laminar or turb.
c      = 1 friction based on laminar relation
c      = 2 friction based on turbulent relation
c iopt = T then optimal diameter search performed
c      = F then no optimal search
c
c PARAMETER INPUT:
c
c   Initial Slit                   Slit or
c   Width or       Slit            Orifice
c   Orifice Dia.   Length          Depth
c   (in)           (in)            (in)
c   ____________   ___________     ___________
    5.00000E-03    1.00000E+00     1.09000E-01
c
c                  Absolute
c                  Surface
c                  Roughness       Contraction     Velocity
c                  (in)            Coefficient     Coefficient
c   Pressure       0.00006 tube    0.61     and    0.98  for sharp edge orifice
c   Differential   0.0018  steel   1.00     and    0.98  for rounded orifice
c   (psi)          0.0102  iron    1.00     and    0.82  for square edge orifice
c   ___________    _____________   ___________     _____________________________
    1.25000E+02    1.80000E-03     1.00000E+00     8.20000E-01
```

```
c
c   Fluid           Dynamic          Respirable      RR Fitting
c   Specific        Viscosity        Diameter        Constant
c   Gravity         (centi-poise)    (μm)            (q)
c   ___________     ____________     ___________     ___________
    1.20200E+00     1.90000E+00      1.71000E+01     2.40000E+00
```

MESSAGES:
Slit Model
Code search for optimal equivalent diameter.
Friction factor based on laminar flow.

OUTPUT:

```
     Liquid Velocity =  7.83E+01 ft/s      2.39E+01 m/s
     Reynolds Number =  1.61E+03 Laminar Flow
Sauter Mean Diameter =  2.48E+01 μm
  Optimum Slit Width =  2.10E-03 in        5.34E-05 m
 Respirable Fraction =  1.38E-01
     Total Leak Rate =  5.14E-01 gpm       3.24E-05 m3/s      3.90E+01 g/s
Respirable Leak Rate =  7.07E-02 gpm       4.46E-06 m3/s      5.36E+00 g/s
```

```
SPRAY Version 3.0
   May 3, 1994

Spray Leak Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company


Run Date = 08/21/96/
Run Time = 08:39:43.06


INPUT ECHO:
c unmitigated caustic spray - 30% NaOH
c SPRAY Version 3 Input Deck
c   mode iflow iopt
    2    0     T
c
c MODEL OPTIONS:
c mode = 1 then orifice leak with friction assumed
c        2 then slit leak with friction assumed
c iflow= 0 Reynold's number determines friction relation (i.e. laminar or turb.
c      = 1 friction based on laminar relation
c      = 2 friction based on turbulent relation
c iopt = T then optimal diameter search performed
c      = F then no optimal search
c
c PARAMETER INPUT:
c
c   Initial Slit                   Slit or
c   Width or        Slit           Orifice
c   Orifice Dia.    Length         Depth
c   (in)            (in)           (in)
c   ____________    ___________    ___________
    5.00000E-03     1.00000E+00    1.09000E-01
c
c                   Absolute
c                   Surface
c                   Roughness      Contraction    Velocity
c                   (in)           Coefficient    Coefficient
c   Pressure        0.00006 tube   0.61    and    0.98  for sharp edge orifice
c   Differential    0.0018  steel  1.00    and    0.98  for rounded orifice
c   (psi)           0.0102  iron   1.00    and    0.82  for square edge orifice
c   ____________    ___________    ___________    __________________________
    1.25000E+02     1.80000E-03    1.00000E+00    8.20000E-01
```

```
c
c   Fluid            Dynamic          Respirable      RR Fitting
c   Specific         Viscosity        Diameter        Constant
c   Gravity          (centi-poise)    (µm)            (q)
c   ___________      ____________     ___________     ___________
    1.30900E+00      4.40000E+00      1.49000E+01     2.40000E+00
```

```
MESSAGES:
Slit Model
Code search for optimal equivalent diameter.
```

```
OUTPUT:
     Liquid Velocity =  7.40E+01 ft/s      2.26E+01 m/s
     Reynolds Number =  1.04E+03 Laminar Flow
Sauter Mean Diameter =  4.77E+01 µm
  Optimum Slit Width =  3.06E-03 in        7.77E-05 m
 Respirable Fraction =  2.19E-02
     Total Leak Rate =  7.06E-01 gpm       4.45E-05 m3/s      5.83E+01 g/s
Respirable Leak Rate =  1.54E-02 gpm       9.74E-07 m3/s      1.28E+00 g/s
```

```
                    ________________________

                     SPRAY Version 3.0
                        May 3, 1994
                    ________________________

Spray Leak Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company


Run Date = 08/21/96/
Run Time = 13:50:03.03


INPUT ECHO:
c unmitigated caustic spray - 40% NaOH
c SPRAY Version 3 Input Deck
c   mode iflow iopt
    2    0     T
c
c MODEL OPTIONS:
c mode = 1 then orifice leak with friction assumed
c        2 then slit leak with friction assumed
c iflow= 0 Reynold's number determines friction relation (i.e. laminar or turb.
c      = 1 friction based on laminar relation
c      = 2 friction based on turbulent relation
c iopt = T then optimal diameter search performed
c      = F then no optimal search
c
c PARAMETER INPUT:
c
c   Initial Slit                  Slit or
c   Width or        Slit          Orifice
c   Orifice Dia.    Length        Depth
c   (in)            (in)          (in)
c   ____________    ____________  ____________
    5.00000E-03     1.00000E+00   1.09000E-01
c
c                   Absolute
c                   Surface
c                   Roughness     Contraction    Velocity
c                   (in)          Coefficient    Coefficient
c   Pressure        0.00006 tube  0.61    and    0.98  for sharp edge orifice
c   Differential    0.0018  steel 1.00    and    0.98  for rounded orifice
c   (psi)           0.0102  iron  1.00    and    0.82  for square edge orifice
c   ____________    _____________ ____________   ______________________________
    1.25000E+02     1.80000E-03   1.00000E+00    8.20000E-01
```

```
c
c   Fluid            Dynamic          Respirable      RR Fitting
c   Specific         Viscosity        Diameter        Constant
c   Gravity          (centi-poise)    (μm)            (q)
c   ____________     ____________     ____________    ____________
    1.41000E+00      8.50000E+00      1.36000E+01     2.40000E+00
```

```
MESSAGES:
Slit Model
Code search for optimal equivalent diameter.
```

```
OUTPUT:
     Liquid Velocity =  7.09E+01 ft/s      2.16E+01 m/s
     Reynolds Number =  7.48E+02 Laminar Flow
Sauter Mean Diameter =  8.02E+01 μm
  Optimum Slit Width =  4.13E-03 in        1.05E-04 m
 Respirable Fraction =  5.10E-03
     Total Leak Rate =  9.12E-01 gpm       5.75E-05 m3/s      8.11E+01 g/s
Respirable Leak Rate =  4.65E-03 gpm       2.93E-07 m3/s      4.14E-01 g/s
```

SPRAY Version 3.0
May 3, 1994

```
Spray Leak Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company


Run Date = 08/21/96/
Run Time = 13:52:17.92


INPUT ECHO:
c unmitigated caustic spray - 50% NaOH
c SPRAY Version 3 Input Deck
c   mode iflow iopt
    2     0    T
c
c MODEL OPTIONS:
c mode = 1 then orifice leak with friction assumed
c        2 then slit leak with friction assumed
c iflow= 0 Reynold's number determines friction relation (i.e. laminar or turb.
c      = 1 friction based on laminar relation
c      = 2 friction based on turbulent relation
c iopt = T then optimal diameter search performed
c      = F then no optimal search
c
c PARAMETER INPUT:
c
c   Initial Slit                   Slit or
c   Width or        Slit           Orifice
c   Orifice Dia.    Length         Depth
c   (in)            (in)           (in)
c   ____________    ___________    ___________
    5.00000E-03     1.00000E+00    1.09000E-01
c
c                   Absolute
c                   Surface
c                   Roughness      Contraction    Velocity
c                   (in)           Coefficient    Coefficient
c   Pressure        0.00006 tube   0.61    and    0.98  for sharp edge orifice
c   Differential    0.0018  steel  1.00    and    0.98  for rounded orifice
c   (psi)           0.0102  iron   1.00    and    0.82  for square edge orifice
c   ___________     ___________    ___________    ______________________________
    1.25000E+02     1.80000E-03    1.00000E+00    8.20000E-01
```

```
c
c   Fluid           Dynamic          Respirable      RR Fitting
c   Specific        Viscosity        Diameter        Constant
c   Gravity         (centi-poise)    (μm)            (q)
c
    1.50400E+00     1.43000E+01      1.26000E+01     2.40000E+00
```

```
MESSAGES:
Slit Model
Code search for optimal equivalent diameter.
```

```
OUTPUT:
     Liquid Velocity =  6.88E+01 ft/s      2.10E+01 m/s
     Reynolds Number =  5.91E+02 Laminar Flow
Sauter Mean Diameter =  1.22E+02 μm
  Optimum Slit Width =  5.30E-03 in        1.35E-04 m
 Respirable Fraction =  1.55E-03
     Total Leak Rate =  1.14E+00 gpm       7.18E-05 m3/s      1.08E+02 g/s
Respirable Leak Rate =  1.77E-03 gpm       1.11E-07 m3/s      1.68E-01 g/s
```

CHECKLIST FOR PEER REVIEW

Document Reviewed: **CONSEQUENCE ANALYSIS OF AN UNMITIGATED NaOH SOLUTION SPRAY RELEASE DURING ADDITION TO WASTE TANK**, D.A. Himes, 8/21/96

Scope of Review: entire document

Yes	No	NA		
[ ]	[ ]	[X]	*	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
[X]	[ ]	[ ]		Problem completely defined.
[X]	[ ]	[ ]		Accident scenarios developed in a clear and logical manner.
[X]	[ ]	[ ]		Necessary assumptions explicitly stated and supported.
[X]	[ ]	[ ]		Computer codes and data files documented.
[X]	[ ]	[ ]		Data used in calculations explicitly stated in document.
[X]	[ ]	[ ]		Data checked for consistency with original source information as applicable.
[X]	[ ]	[ ]		Mathematical derivations checked including dimensional consistency of results.
[X]	[ ]	[ ]		Models appropriate and used within range of validity or use outside range of established validity justified.
[X]	[ ]	[ ]		Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
[X]	[ ]	[ ]		Software input correct and consistent with document reviewed.
[X]	[ ]	[ ]		Software output consistent with input and with results reported in document reviewed.
[ ]	[ ]	[X]		Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
[X]	[ ]	[ ]		Safety margins consistent with good engineering practices.
[X]	[ ]	[ ]		Conclusions consistent with analytical results and applicable limits.
[X]	[ ]	[ ]		Results and conclusions address all points required in the problem statement.
[ ]	[ ]	[X]		Format consistent with appropriate NRC Regulatory Guide or other standards
[ ]		[X]	*	Review calculations, comments, and/or notes are attached.
[X]	[ ]	[ ]		**Document approved.**

Brit Hey   Brit Hey   8/27/96

Reviewer (Printed Name and Signature)   Date

* Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

HEDOP REVIEW CHECKLIST
for
Radiological and Nonradiological Release Calculations

Document reviewed (include title or description of calculation, document number, author, and date, as applicable):

CONSEQUENCE ANALYSIS OF AN UNMITIGATED NaOH SOLUTION SPRAY RELEASE DURING ADDITION TO WASTE TANK, D.A. Himes, 8/21/96

Submitted by: D.A. Himes   Date Submitted:

Scope of Review: entire document

YES	NO*	N/A	
[X]	[ ]	[ ]	1. A detailed technical review and approval of the environmental transport and dose calculation portion of the analysis has been performed and documented.
[X]	[ ]	[ ]	2. Detailed technical review(s) and approval(s) of scenario and release determinations have been performed and documented.
[ ]	[ ]	[X]	3. HEDOP-approved code(s) were used.
[ ]	[ ]	[X]	4. Receptor locations were selected according to HEDOP recommendations.
[X]	[ ]	[ ]	5. All applicable environmental pathways and code options were included and are appropriate for the calculations.
[X]	[ ]	[ ]	6. Hanford site data were used.
[X]	[ ]	[ ]	7. Model adjustments external to the computer program were justified and performed correctly.
[ ]	[ ]	[X]	8. The analysis is consistent with HEDOP recommendations.
[ ]		[X]	9. Supporting notes, calculations, comments, comment resolutions, or other information is attached. (Use the "Page 1 of X" page numbering format and sign and date each added page.)
[X]	[ ]		**10. Approval is granted on behalf of the Hanford Environmental Dose Overview Panel.**

* All "NO" responses must be explained and use of nonstandard methods justified.

Brit Hey [signature]   8/27/96
HEDOP-Approved Reviewer (Printed Name and Signature)   Date

COMMENTS (add additional signed and dated pages if necessary):

DISTRIBUTION SHEET

To	From	
Consequence Analysis 8M400	Consequence Analysis 8M400	Page 1 of 1
		Date 8/15/96
Project Title/Work Order: Consequence Analysis of an Unmitigated NaOH Solution Spray Release During Addition to Waste Tank		EDT No. 142249
		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
C. Carro	A2-34	X			
G.W. Ryan	A3-37	X			
B.E. Hey	A3-34	X			
D.A. Himes (2)	A3-34	X			
Central Files (original + 3)	A3-88	X			
Docket Files (2)	B1-17	X			
TWRS S & L Files (2)	A2-26	X			