SAND2007-3621P

Plutonium Air Transport 1 (PAT-1) Criticality Analysis

Held at

U.S. Nuclear Regulatory Commission

Wednesday 13 June 2007

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Presentation Overview

- Establish “baseline” via reproduction of previous results
- Modify baseline configuration to model postulated “worst case” geometry
- Extend expected worst case by modifying fuel/moderator ratio seeking highest numerical value in “approach to criticality” search
- Summary, discussion and questions

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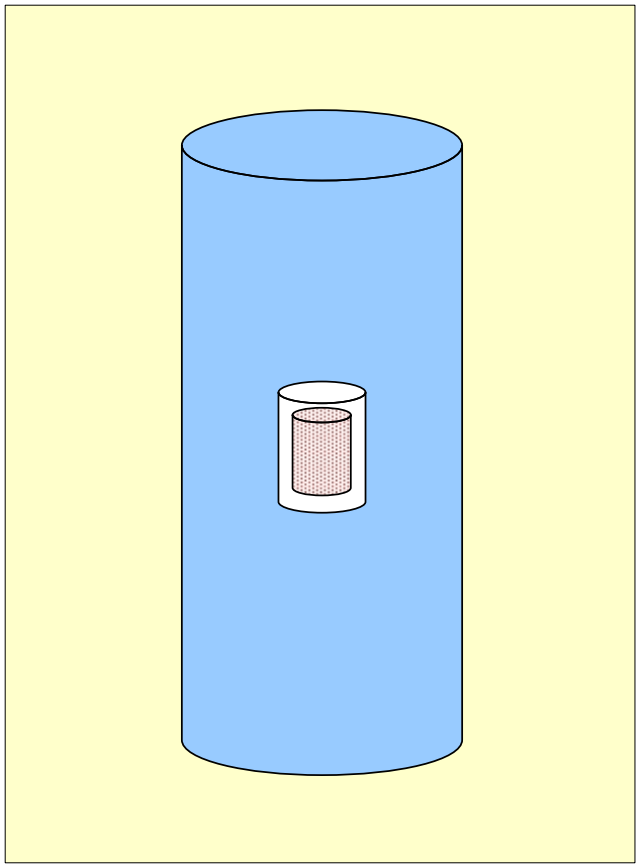
Baseline Confirmation of Previous Results

- Verification of new computational tool and platform
  - KENO IV to KENO VI
  - UNIX to PC
- Evaluate correctness of geometrical model and material composition constructs
- Establish “baseline” via reproduction of previous results
- Supports extension of analysis from verifiable foundation

Baseline Geometry



- PuO_2 powder fuel with water moderator
  - Leakage of TB-1
- Encased in martensitic steel (PH13-8Mo) reflector
  - TB-1 Vessel
- Immersed in water reflector
  - Redwood assemblies replaced with H_2O

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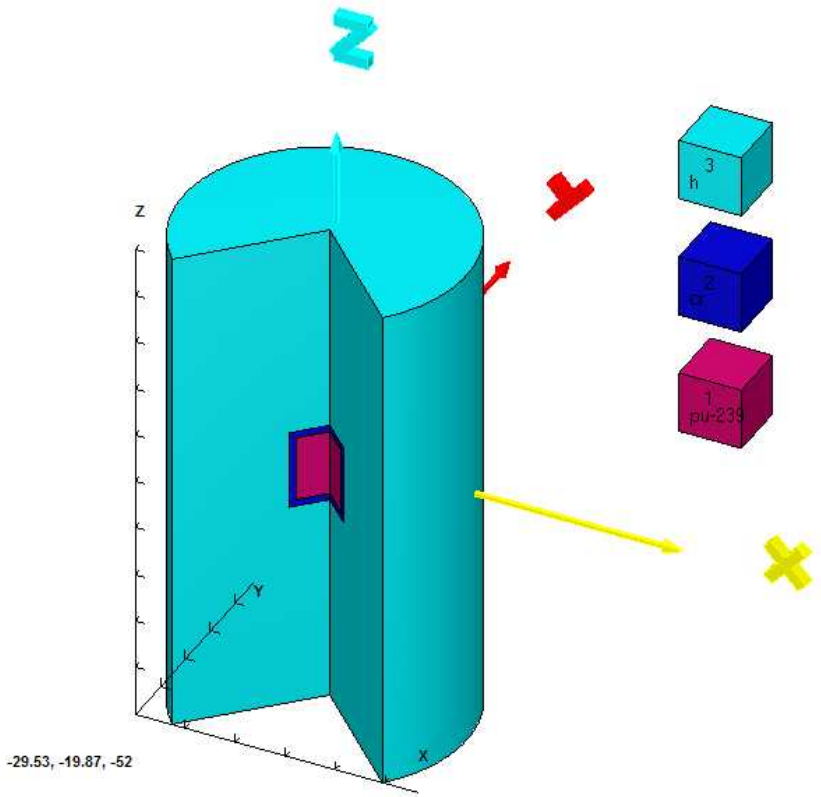
Actual Keno3d Geometry

Tick Mark Gap
10.4 cm



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Actual SCALE 5.1/KENO V.a Input File

```
'Input generated by GeeWiz SCALE 5.1 Compiled on November 9, 2006
'batch_args \-p\-m
=csas25 parm=(nitawl)
pat1, single package, baseline cylindrical geomerty
238groupndf5
read composition
 pu-239      1 0 0.0035751 300   end
 h           1 0 0.057497 300   end
 o           1 0 0.035898 300   end
 cr          2 0 0.01745 300   end
 ni          2 0 0.007728 300   end
 fe          2 0 0.06021 300   end
 h           3 0 0.06688 300   end
 o           3 0 0.03344 300   end
end composition
read celldata
  multiregion cylindrical left_bdy=reflected right_bdy=vacuum end
          1         5.36
          2         6.79
          3        29.53
      end zone
end celldata
read geometry
global unit 1
com='baseline cylindrical geometry, puo2, pu: 2000g, o: 16g'
 zcylinder 1 1    5.36     6.89    -6.89
 zcylinder 2 1    6.79     8.32    -8.32
 zcylinder 3 1   29.53       52      -52
end geometry
end data
end
```

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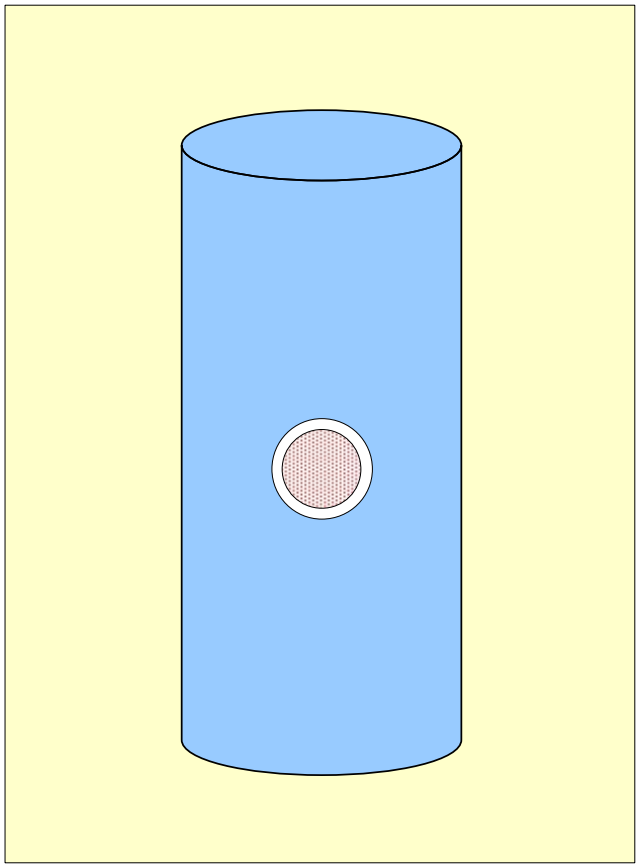
Criticality Results ($k_{effective}$)

- Baseline Single Package Cylindrical Geometry
  - February 1978 Safety Analysis Report: 0.584 + or - 0.006
  - May 2007 Preliminary Results: 0.6107 + or - 0.0016 (vacuum boundary); 0.6111 + or - 0.0023 (specular boundary)
  - Excellent agreement: <5% Relative (Fractional Error); attributable to cross-section libraries

Extension to Postulated Worst Case

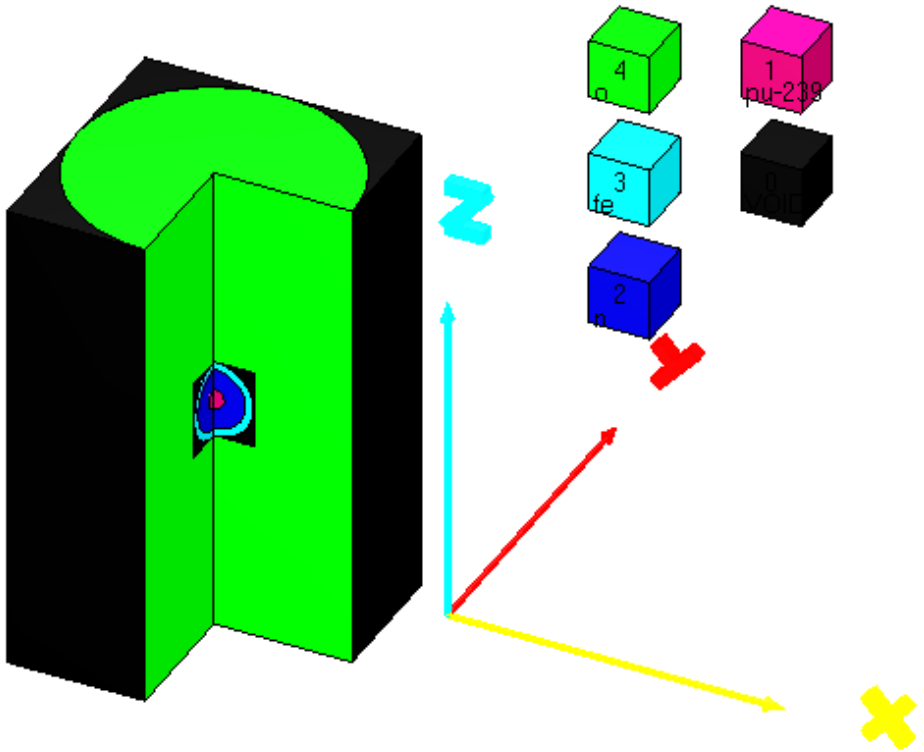
- Assume Pu metal forms perfect sphere as most conducive configuration to neutron economy
- Enhance neutron conservation by modeling TB-1 vessel as deforming to perfectly encase Pu metal as reflector
- Further neutron reflection is added by assuming redwood assemblies subjected to full water intrusion
- Although not considered in original analysis, will model and evaluate effect of AQ-1 stainless steel overpack

Postulated Worst Case Geometry

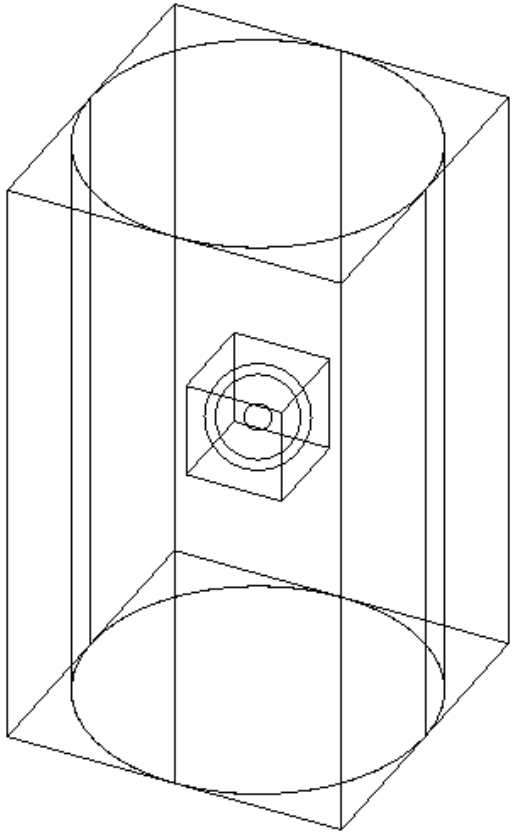


- Pu sphere fuel
  - Metal
- Surrounded by martensitic steel (PH13-8Mo) reflector
  - TB-1 Vessel
- Immersed in water reflector
  - Redwood assemblies replaced with H_2O

Actual Keno3d Geometry



Actual Keno3d Geometry (Wireframe)



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Criticality Results ($k_{effective}$)

- Postulated "Worse Case" Pu Metal Single Package Spherical Geometry
  - June 2007 Preliminary Results: 0.4930 + or - 0.0018 (vacuum boundary); 0.4920 + or - 0.0019 (specular boundary)
  - Substantial decrease from Baseline cylindrical geometry case; attributable to significant mass reduction
  - To achieve critical mass requires mass

Extend Analysis in "Approach To Criticality" Search

- Retain Pu metal form in spherical geometry as most conducive configuration with respect to neutron economy
- Continue modeling TB-1 as perfectly encasing Plutonium metal fuel as a reflector
- Include the further reflection provided by assuming redwood assemblies fully converted to water
- Modify fuel/moderator ratio by homogenous addition of H_2O in attempt to attain highest value of criticality ($k_{effective}$)

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Summary

- Outlined reasonable and reproducible approach to assess PAT-1 criticality response:
  - Duplicate earlier results to establish foundational baseline
  - Modify to examine postulated worst case geometry
  - Expand investigation by performing search for optimum fuel/moderator mixture to approach criticality
- Present status:
  - Received latest version (November 06) on Wed 02 May 07
  - Successfully executed baseline case on Wed 30 May 07
  - Successfully executed metal spherical case on Tue 05 June 07
  - Presently developing “approach to criticality” case models