CHPRC-01550
Revision 0

Development of LA-10860 Database for CritView

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
Richland, Washington 99352

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P.O. Box 1600
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Prepared by: MB Murphy and SH Finfrock
for
CH2M HILL Plateau Remediation Company
Richland, Washington

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1.0 INTRODUCTION

The CritView Code (Finfrock, 2010) is an electronic handbook for criticality safety. The initial database for CritView consisted of the data taken from the scans of the ARH-600 (Carter et al., 1968) database. This was later supplemented with the data obtained by performing MCNP calculations to reproduce some of the ARH-600 data (Finfrock, 2010) . This report documents the addition of the data taken from the scans of another handbook, *Critical Dimensions of Systems Containing* ^{235}U, ^{239}Pu, *and* ^{233}U, (Paxton and Pruvost, 1986) – typically referred to as "LA-10860".

LA-10860 contains 70 graphs showing various critical parameters (e.g., critical mass versus concentration) for different scenarios (e.g., plutonium spheres). Some of these graphs contain parameters that are not compatible with the current version of CritView (e.g., surface separation) and have been omitted from this work.

The digitization was achieved by taking the scans of select curves from LA-10860, converting them to electronic format (jpg files), and then digitizing them with the Engauge code. Engauge is an "open source, digitizing software which converts an image file showing a graph or map, into numbers" (digitizer.sourceforge.net).

The main body of this report discusses the methodology for the digitization process. This is the method that is used to go from a hard copy graph to an electronic file which is useable by the CritView code. Appendix A contains a record of the peer review of this document, Appendix B contains the graphs showing the digitized data with straight lines, drawn between the points in most cases, overlaid on the original curves, and Appendix C provides a listing of the resultant CritView formatted data files.

2.0 METHODS

To create the CritView compatible output files, the graphs from LA-10860 were scanned into a PDF file. This PDF file was then taken and the figures separated out and saved as JPG files. The JPG files were loaded into Engauge and the digitization process began. The first step in digitizing a graph was to define the axis. This was done by clicking on three points on the graph axis (top of the Y axis, right most point of the X axis, and the X-Y intersection) and manually inputting the coordinates. Second, the individual curves (many of the graphs contain multiple curves) were selected manually using the curve point option in the taskbar at the top. When one curve was finished, "Curves.." was selected under the settings menu and a new curve was added. This process was repeated until the digitization was complete. Once a figure was complete, the digitization file was saved for future use and the data exported as raw X and Y points (Settings, Export Settings….) to a CSV (Comma Separated Values) file. Appropriate headers (as defined in the CritView documentation) were added to each CSV file to create a Critview compatible database file.

3.0 ERROR ANALYSIS

Although steps were taken to reduce the error involved in the digitization process, error was inevitably introduced. The first source of error involved selecting the three axis points, as defined above. It appeared that some of the graphs had axes that did not form a perfect right angle. It is not known if this was due to an error in the scanning process or if it traces back to the original graphs. This error was very small but noticeable in some cases.

The second source of error derived from the process of manually clicking on the points on the graph to enter the data. This error applied to both the process of defining the axis, and the actual digitization of the curves. Since minute movements of the mouse cause discrete jumps of the curser, selecting the desired point perfectly on the intended location was very difficult if not impossible. If the digitized point was within the thickness of the graph line, then it was deemed to be sufficient. Care was taken to define them as closely as possible and the error introduced was estimated to be in the 4^{th} or decimal place in most cases. It should be noted, however, that for log scale graphs, the magnitude of this error could become relatively large in the upper decades of the graph. This is because the effective line width also becomes large in those regions.

Figures 51 and 54 (from LA-10860) present a special case in that the X-axis parameter is "number of cylinders". The points on this graph represent whole numbers and, therefore, it doesn't make sense to draw a curve between the points. Thus, for these points, the point was placed as close as possible to the intersection of the line and the x=constant value. A percent error was not appropriate due to the varying slopes and scales used in the graphs.

All of the results presented in this report were subjected to peer review (see Appendix A) to insure that the curve displayed by CritView is a good match for the original curve in LA-10860. This prevents any of the above mentioned uncertainties leading to a large error.

Since the data contained herein, like any handbook data, should never be used without applying an appropriate safety margin, the digitized curves were deemed to have a sufficiently low error.

4.0 CONCLUSIONS

All of the graphs in LA-10860 have been digitized, and the resulting data presented in a format that is amenable to use with the CritView code. It is important to note that the current version of the CritView code (1.02) only supports standard parameters for graphs (e.g., mass, volume, density, radius, etc.). Most of the LA-10860 graphs use more specialized parameters (e.g., surface separation, ratios of critical masses, etc.) and cannot be displayed in the current version of CritView. It is anticipated that the next release of the code will work with all of the LA-10860 curves.

5.0 REFERENCES

Carter, R. D., G. R. Kiel, and K. R. Ridgeway, 1968, *Criticality Handbook*, ARH-600, 1980 Revision, Atlantic Richfield Hanford Company, Richland, Washington.

Finfrock, S. H., 2010, *CritView User's Guide*, CHPRC-00340, Revision 1, CH2M HILL Plateau Remediation Company, Richland, Washington.

Paxton, H. C. and N. L. Pruvost, 1986, *Critical Dimensions of Systems Containing ^{235}U, ^{239}Pu, and ^{233}U*, LA-10860-MS, Los Alamos National Laboratory, Los Alamos, New Mexico.

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APPENDIX A - INDEPENDENT REVIEW COMMENTS AND CHECKLIST

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CHPRC REVIEW CHECKLIST

Document Reviewed:
CHPRC-01550, Revision 0, Development of LA-10860 Database for CritView

Scope of Review:
Entire document

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

Harvey Goldberg Harvey Goldberg 31 August 2011
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.

A-6004-797 (REV 3)

Comments:

Listing of data was checked against original graphs. Several inconsistencies were found and corrected. Several suggestions were made for better presentation of the data and most were incorporated in the final document.

The final document accurately digitizes the graphs in LA-10860 and should provide an adequate database for input to CritView.

Harvey Goldberg

31 August 2011
Date

CHPRC REVIEW CHECKLIST

Document Reviewed:
Development of LA-10860 Database for CritView

Scope of Review:
Comparison of CritView library file data to LA-10860 Data

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

Raymond J Puigh II — Raymond J Puigh II (signature) — 9/19/2011
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.

A-6004-797 (REV 3)

A comparison of the CritView data library for LA-10860 data was made with the original data in LA-10860. The CritView data library included the curves from the following figures in LA-10860 (1986): Figures 20, 28, 31, 32, 33, 34, 35, 36, 37, 38, 39, and 44. For all figures except Figure 44, the curves generated by CritView were sized with the same axes and scales as copies of the Figures directly from the LA-10860 report on 8 ½ by 11 inch paper. The two plots were overlaid and visually compared. No differences between the curves were observed to the accuracy of the visual comparison. For Figure 44 discrete data points were extracted from the LA-10860 curve in the document and compared to the CritView curve for this Figure. The results agreed to within the accuracy of the comparison method (± 0.5 %).

The CritView data library was judged to be equivalent to the digitized data for the library presented in the report, "Development of LA-10860 Database for CritView."

Raymond J Puigh (signature) — 9/19/2011

Raymond Puigh — Date

APPENDIX B - DIGITIZED CURVES

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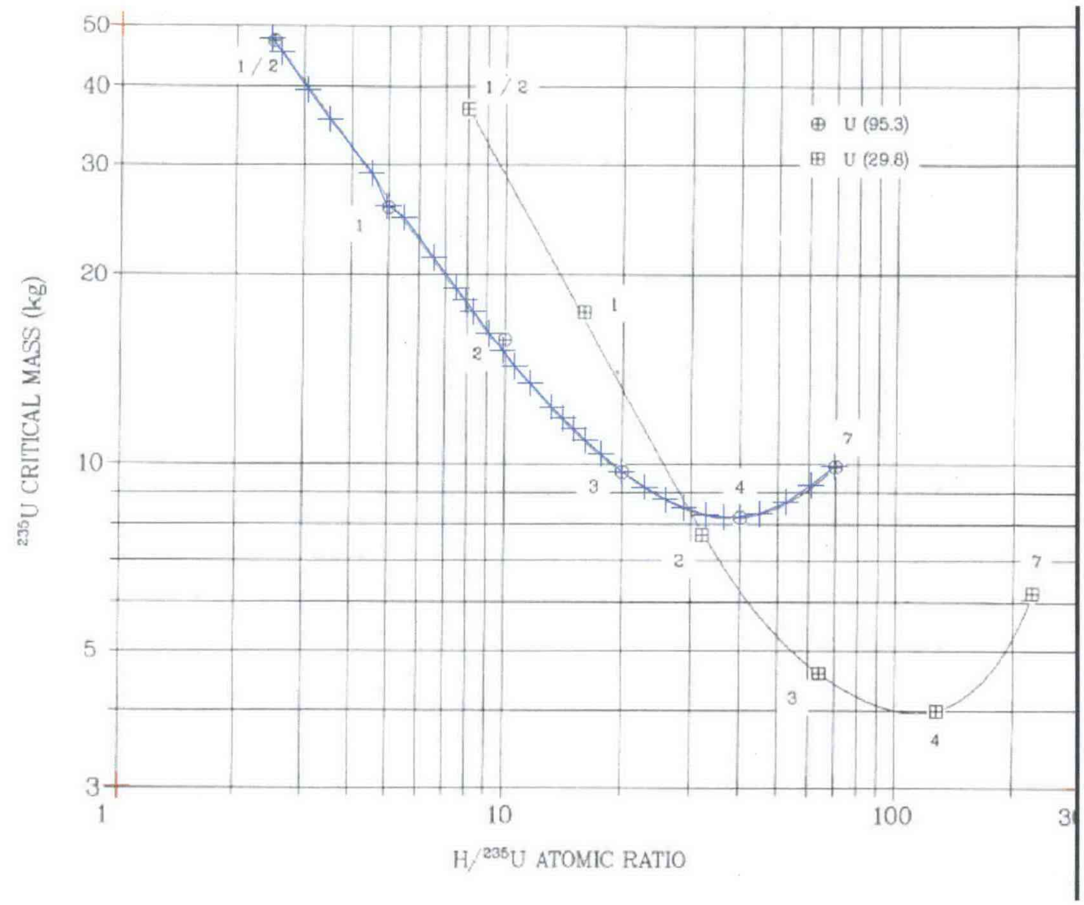
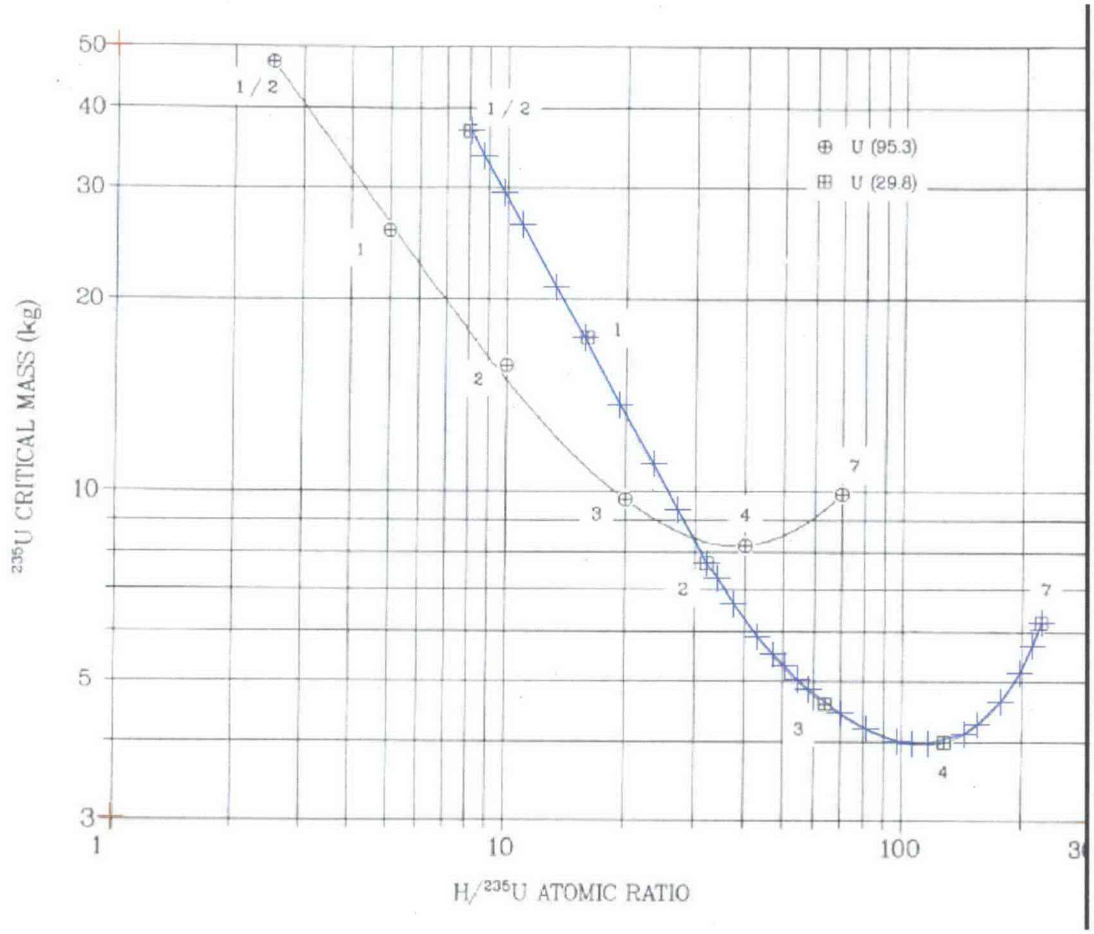
Figure B-1a. Critical Masses of Paraffin-Reflected Cubes Consisting of Intermixed One-inch Cubes of UF_6C and Polyethylene for U(95.3) and U(29.8) (Fig. 1 from LA-10860)



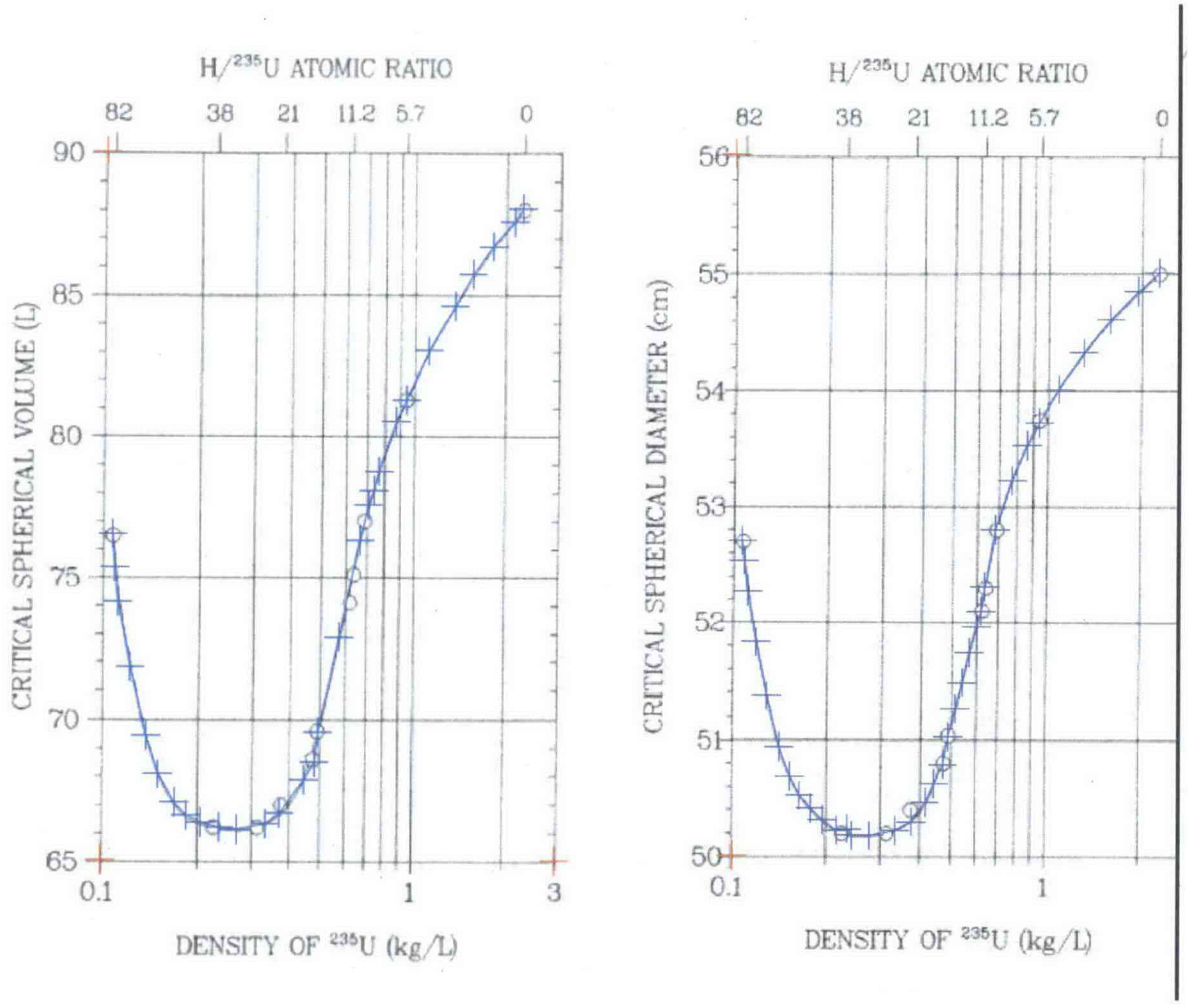
The ratios of polyethylene to UF_6C cubes are indicated.

Figure B-1b. Critical Masses of Paraffin-Reflected Cubes Consisting of Intermixed One-inch Cubes of UF6C and Polyethylene for U(95.3) and U(29.8) (Fig. 1 from LA-10860)



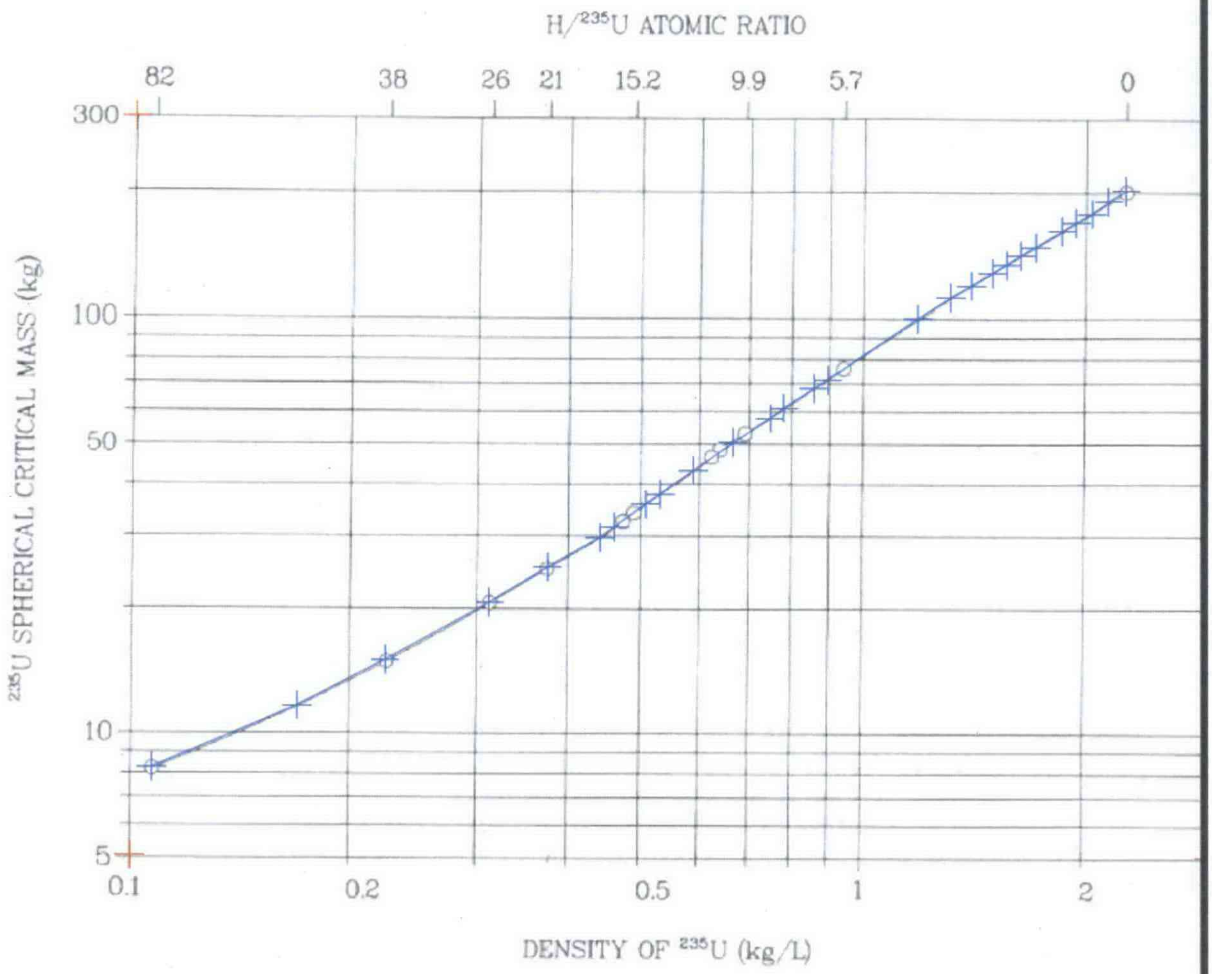
The ratios of polyethylene to UF_6C cubes are indicated.

Figure B-2. Critical Volume and Diameter of U(93) as Liquid UF_6-HF at 75°C as a Function of ^{235}U Density (Fig. 2 from LA-10860)



The system was contained in a water-reflected 0.4-cm-thick monel sphere.

Figure B-3. Critical Mass of U(93) as Liquid UF_6-HF at 75°C as a Function of ^{235}U Density (Fig. 3 from LA-10860)



The system was contained in a water-reflected 0.4-cm-thick monel sphere.

Figure B-4a. The Ratio of Cylindrical to Spherical Critical Masses of $U(93)O_2F_2$ Solutions, Unreflected and With Water reflector, as A function of Cylinder Height to Cylinder Diameter Ratio (Fig. 4 from LA-10860)

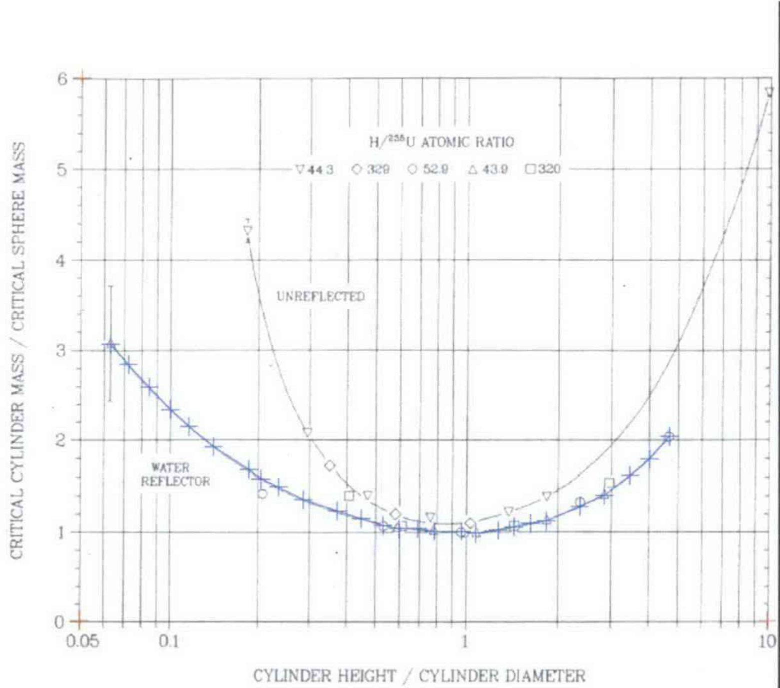


Figure B-4b. The Ratio of Cylindrical to Spherical Critical Masses of $U(93)O_2F_2$ Solutions, Unreflected and With Water reflector, as A function of Cylinder Height to Cylinder Diameter Ratio (Fig. 4 from LA-10860)

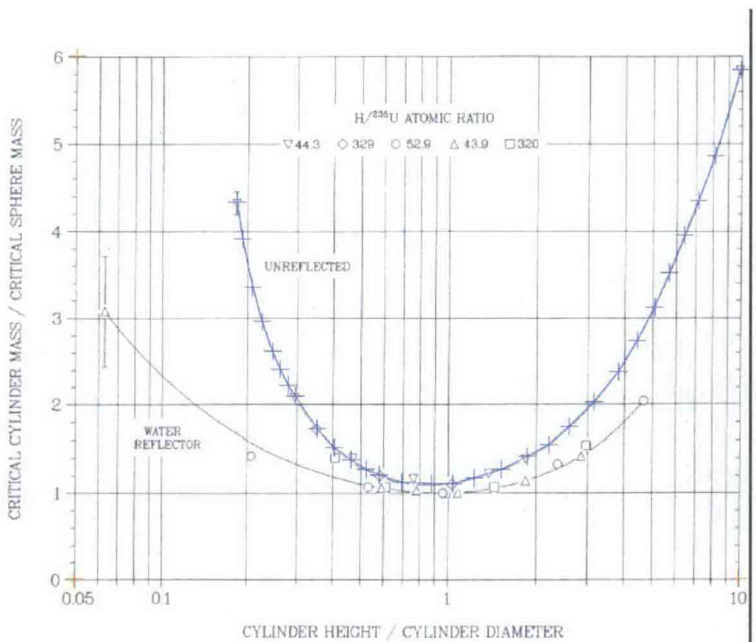


Figure B-5. The Ratio of Cylindrical to Spherical Critical Masses, for U(>90) Metal, Unreflected and With Hydrogenous Reflector, as a Function of Cylinder Height to Cylinder Diameter Ratio (Fig. 5 from LA-10860)

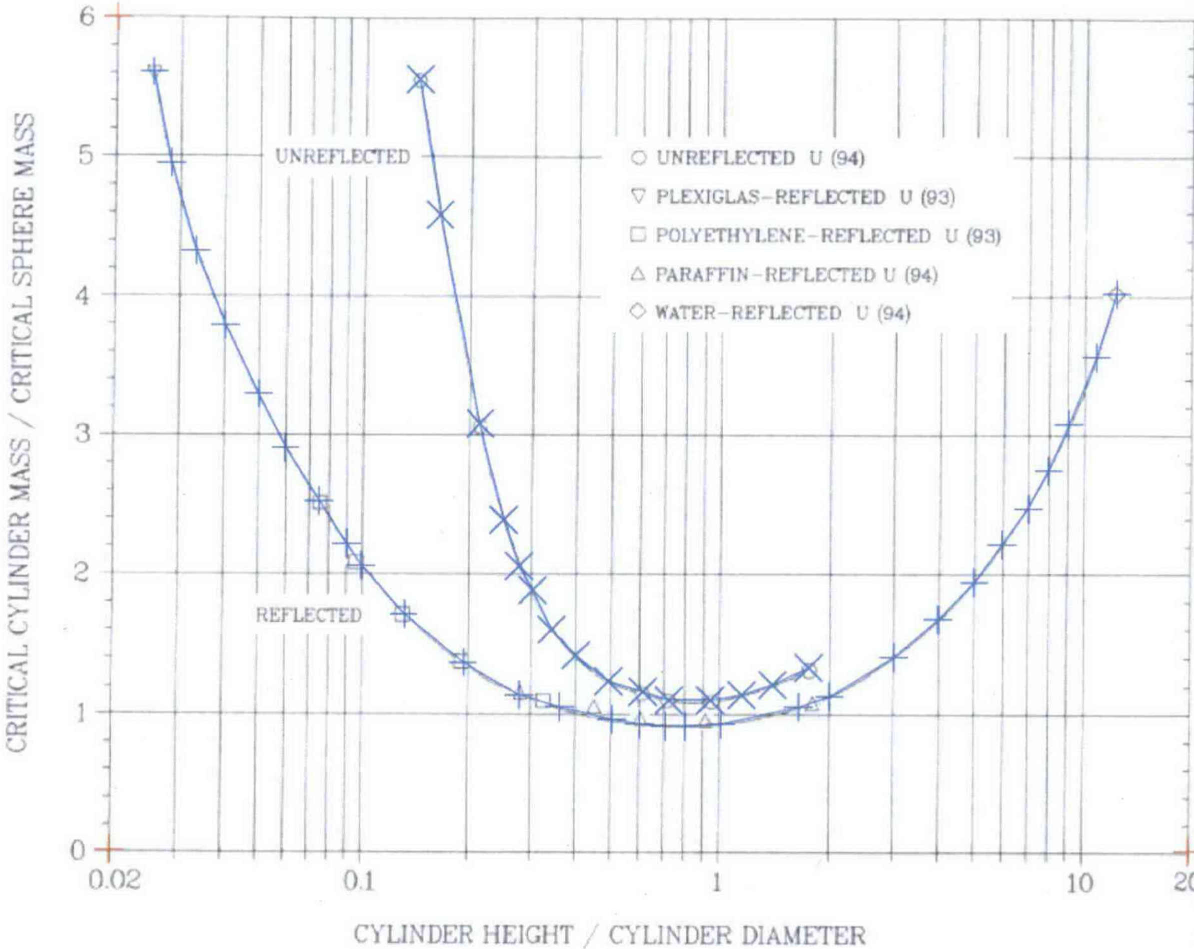
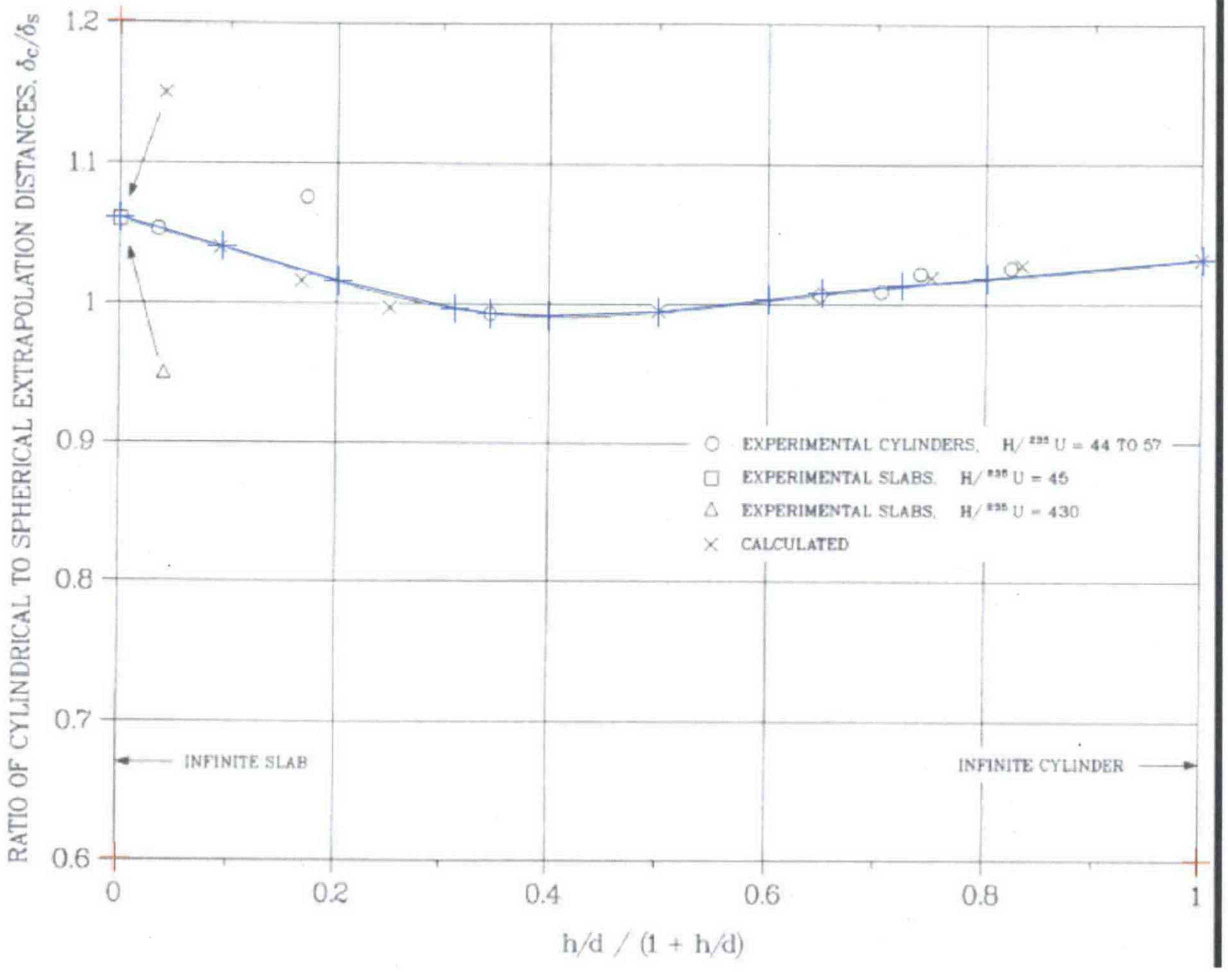
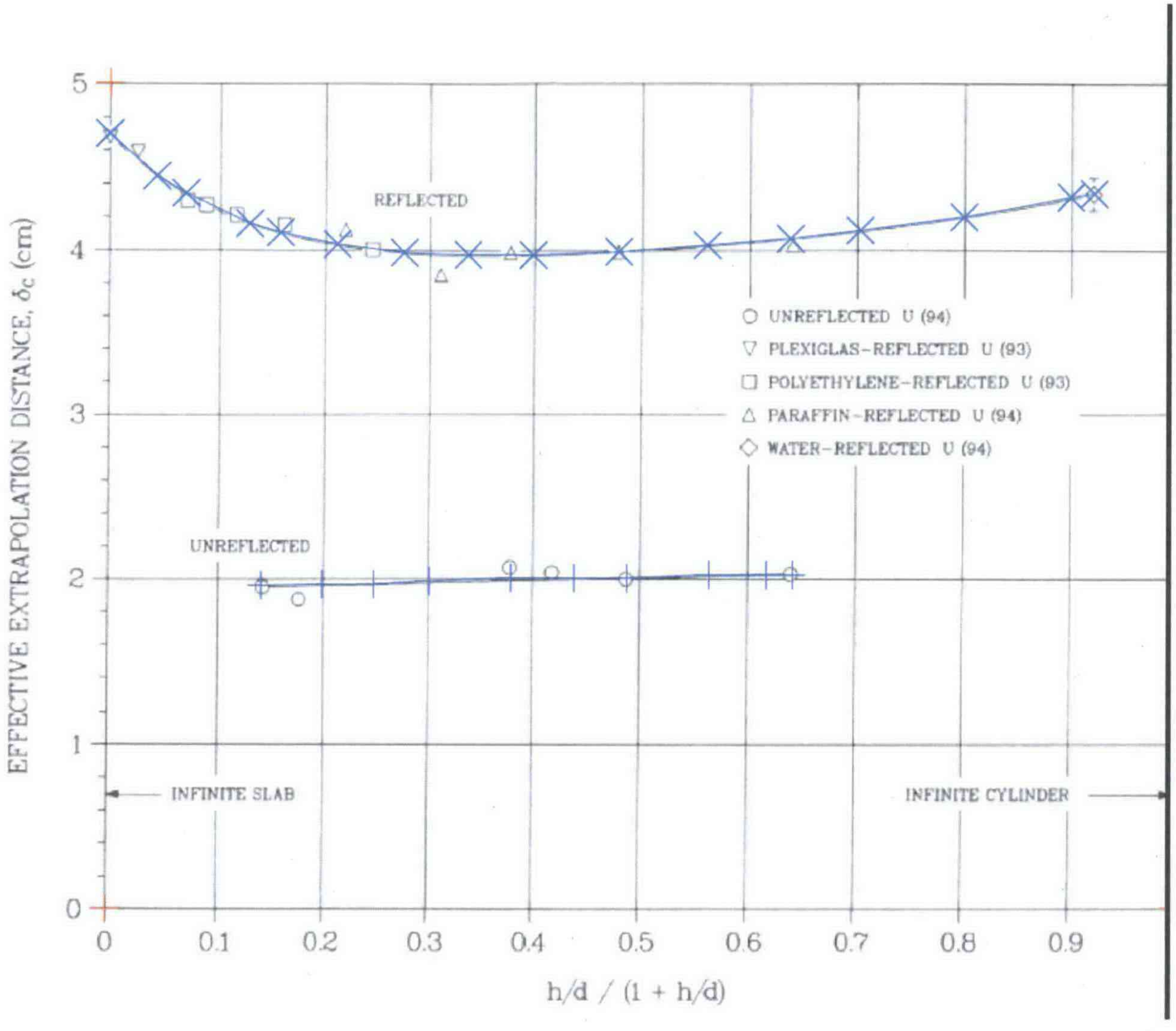


Figure B-6. Ratio of Cylindrical Extrapolation Distance to That of Sphere for Water Reflected $U(93)O_2F_2$ solutions (Fig. 6 from LA-10860)



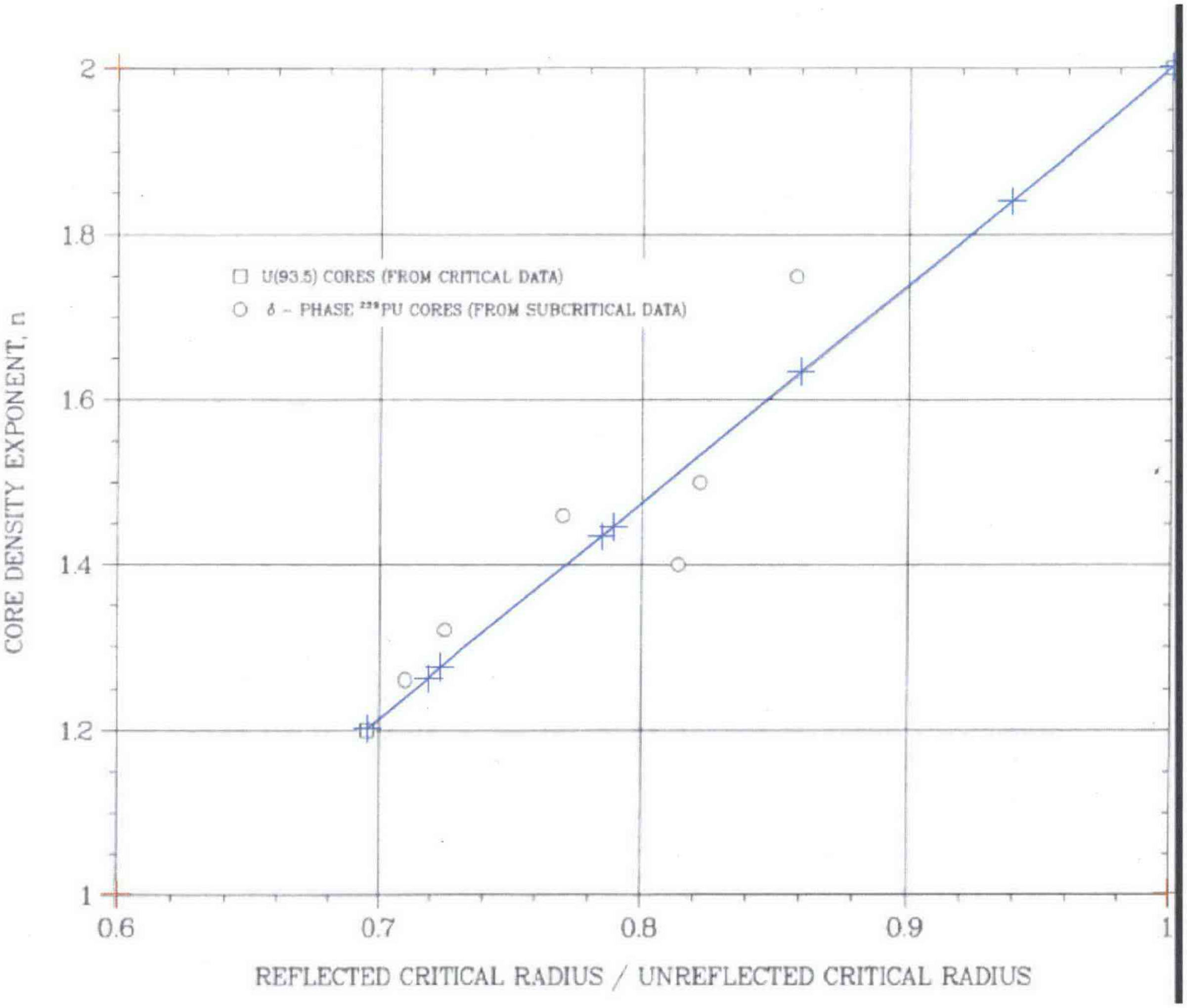
Cylinder height and diameter are h and d respectively.

Figure B-7. Effective Extrapolation Distances of U(>90) Metal Cylinders, Unreflected and with Hydrogenous Reflectors (Fig. 7 from LA-10860)



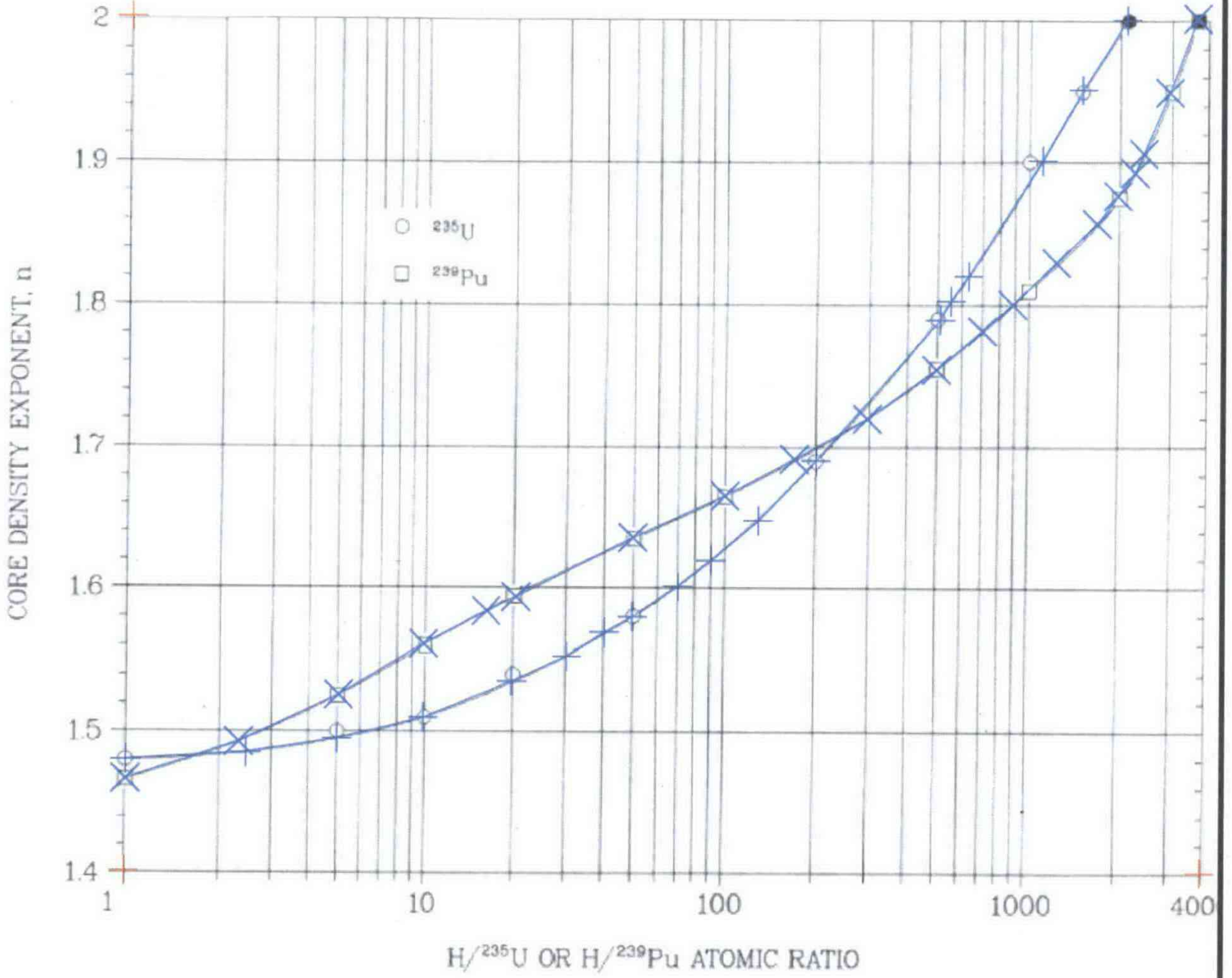
Cylinder height and diameter are h and d respectively.

Figure B-8. Density Exponents of Unmoderated Spherical Cores in Constant-Density Reflectors (Fig. 8 from LA-10860)



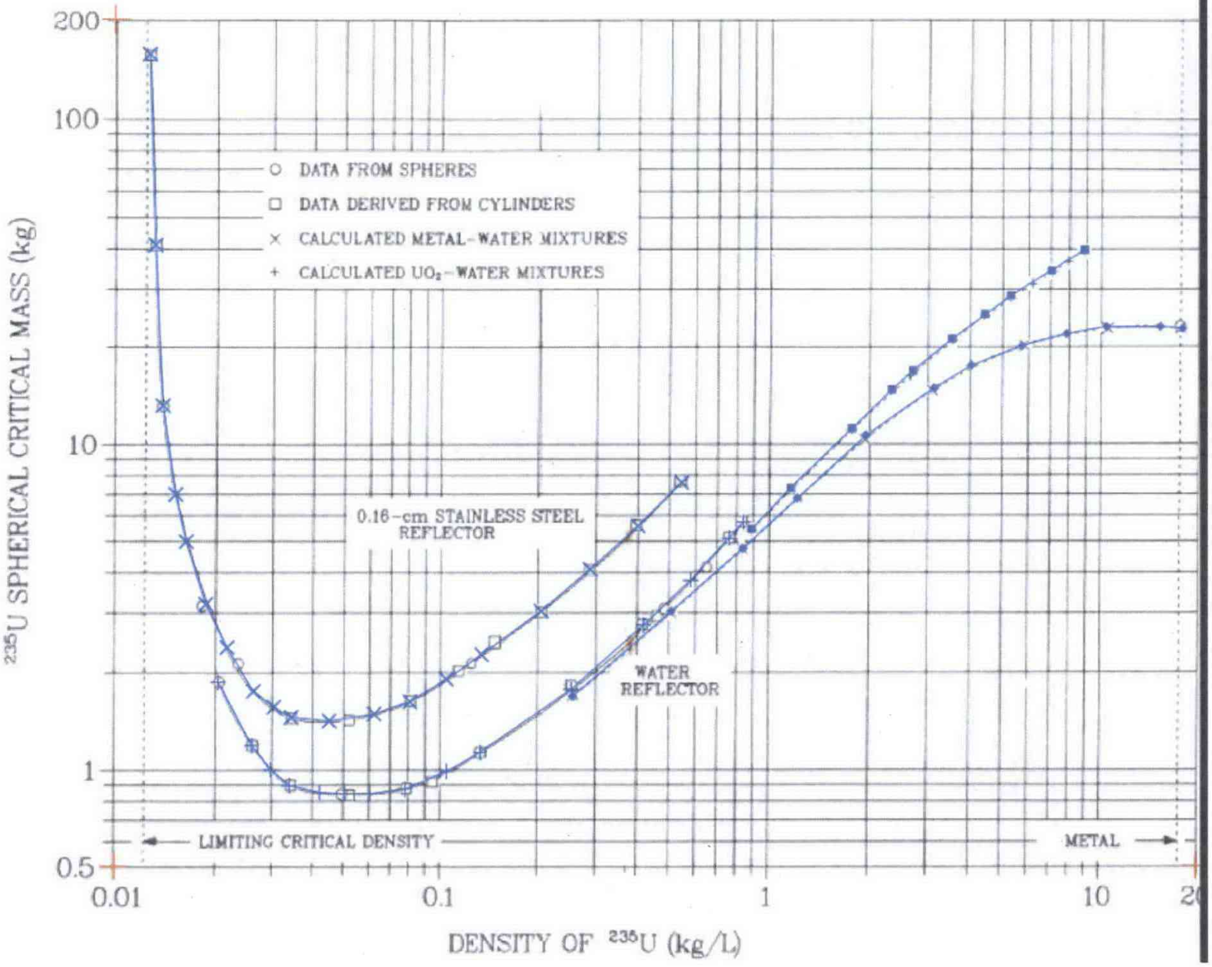
Critical Mass = constant (Core density)$^{-n}$.

Figure B-9. Calculated Core-Density Exponents for Water-Reflected Spheres of Homogeneous Metal-Water Mixtures (Fig. 9 from LA-10860)



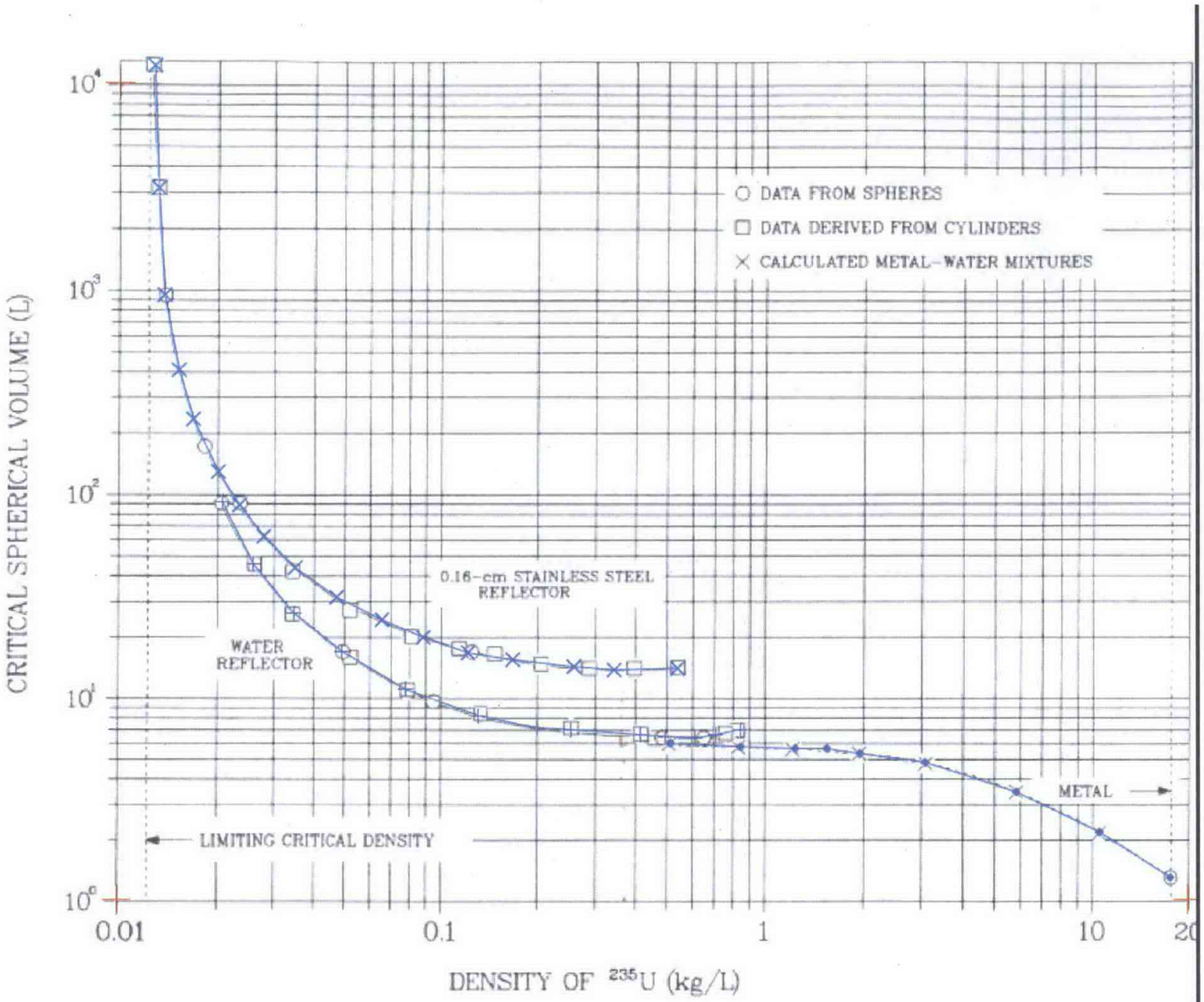
The solid symbols represent limiting conditions.

Figure B-10. Critical Masses of Homogeneous Water-Moderated U(93.2) Spheres (Fig. 10 from LA-10860)



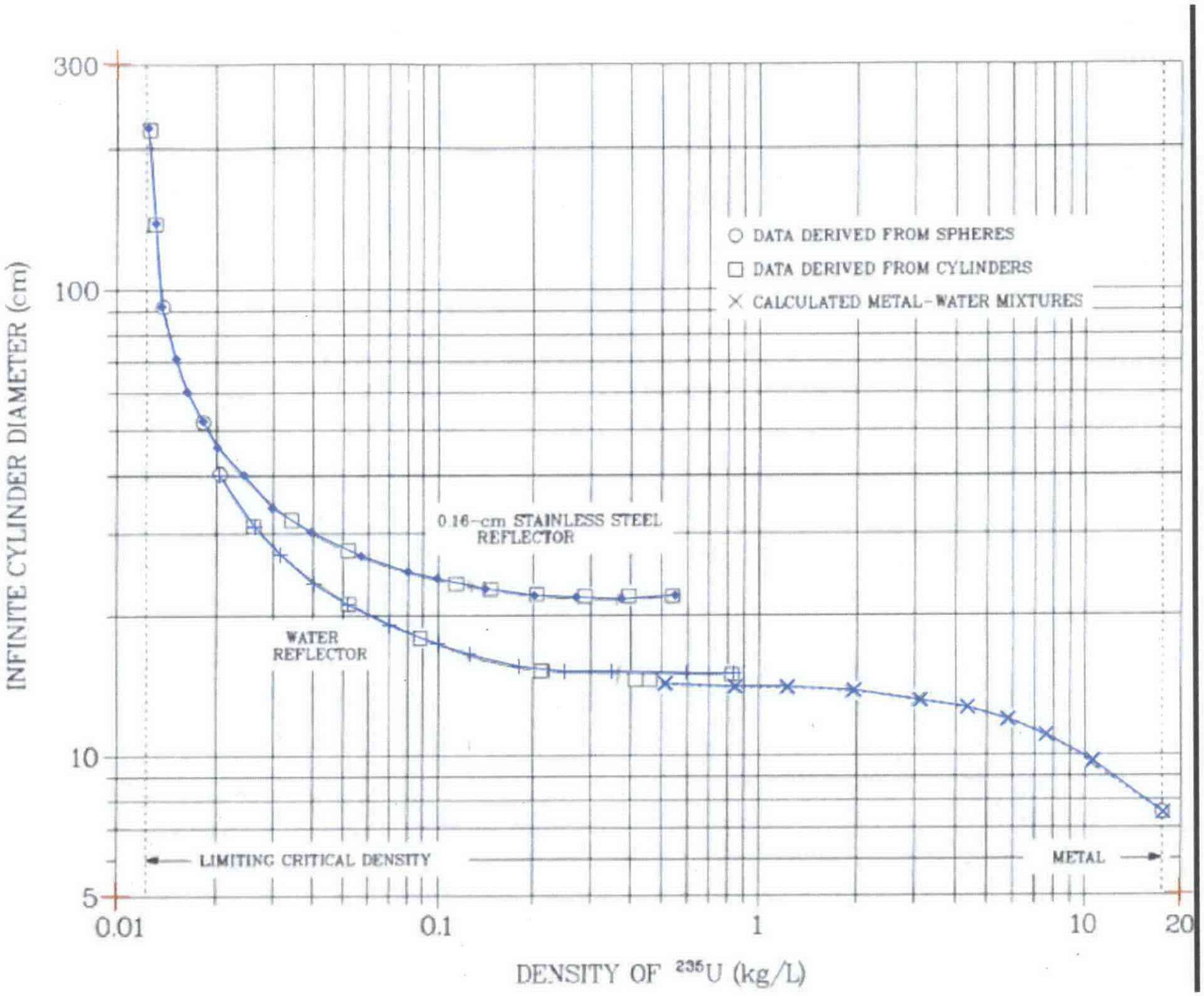
Solution data appear unless indicated otherwise.

Figure B-11. Critical Volumes of Homogeneous Water-Moderated U(93.2) Spheres (Fig. 11 from LA-10860)



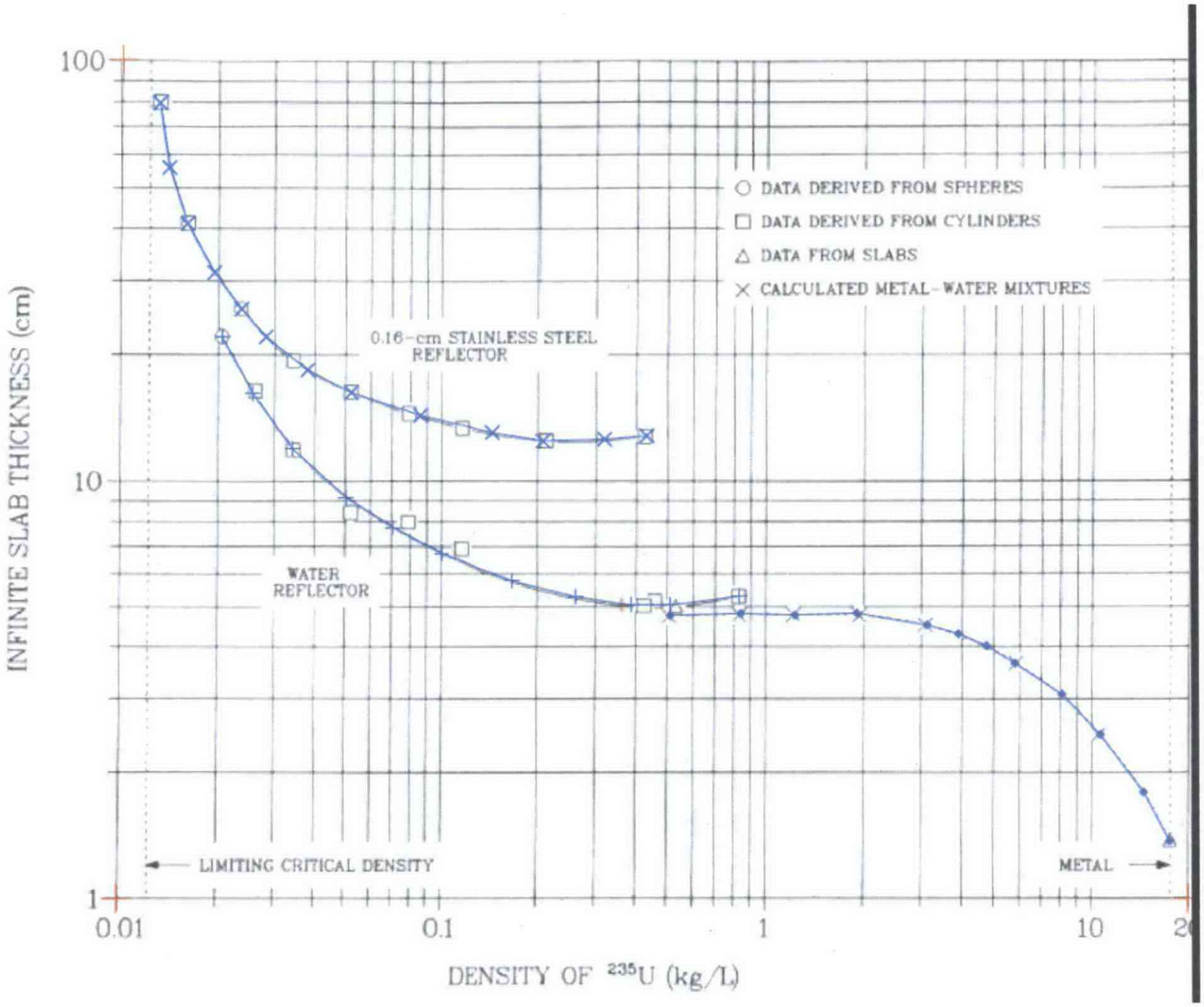
Solution data appear unless indicated otherwise

Figure B-12. Estimated Critical diameters of Infinitely Long Cylinders of Homogeneous Water-Moderated U(93.2) (Fig. 12 from LA-10860)



Solution data appear unless indicated otherwise.

Figure B-13. Estimated Critical Thicknesses of Slabs, Infinite in Other Dimensions, of Homogeneous Water-Moderated U(93.2) (Fig. 13 from LA-10860)



Solution data appear unless indicated otherwise. Unreflected infinite slabs are fictitious

Figure B-14. Critical Masses of Water-Reflected Spheres of Hydrogen-Moderated U(93), U(30.3), U(5.00), U(3.00) and U(2.00) (Fig. 14 from LA-10860)

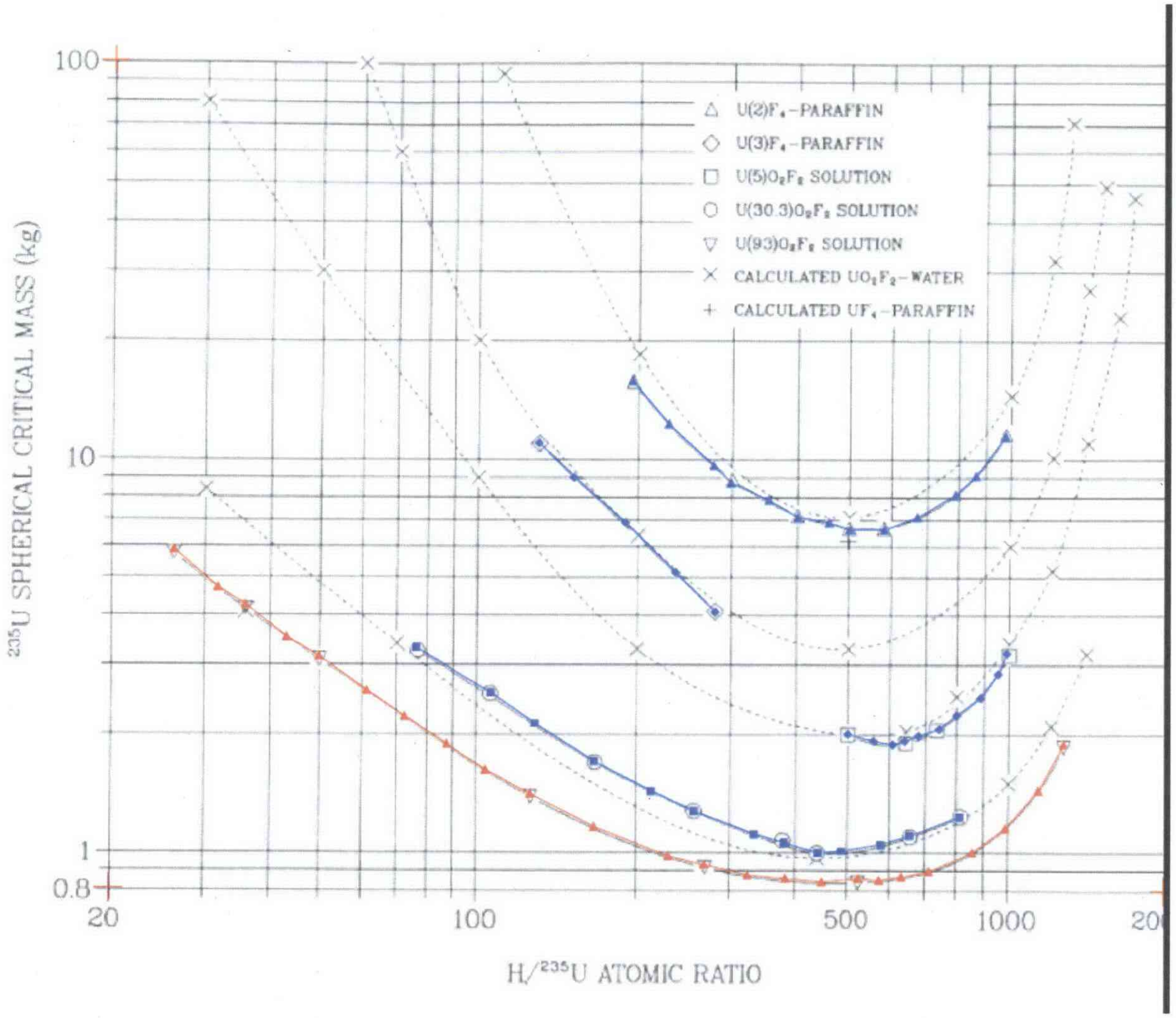


Figure B-15. Critical Volumes of Water-Reflected Spheres of Hydrogen-Moderated U(93), U(30.3), U(5.00), U(3.00) and U(2.00) (Fig. 15 from LA-10860)

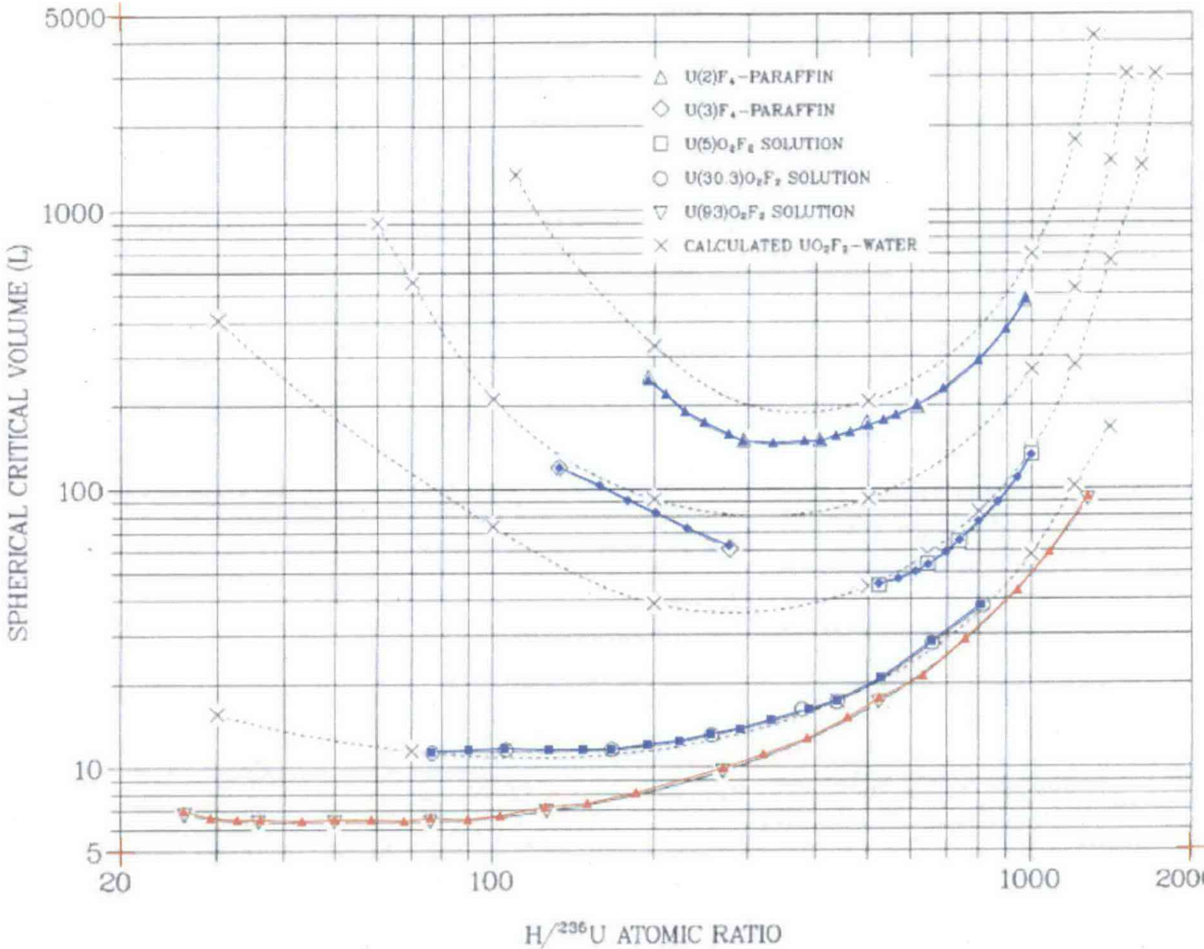


Figure B-16. Estimated Critical Diameters of Infinitely Long Water-Reflected Cylinders of Hydrogen-Moderated U(93), U(30.3), U(5.00), U(3.00) and U(2.00) (Fig. 16 from LA-10860)

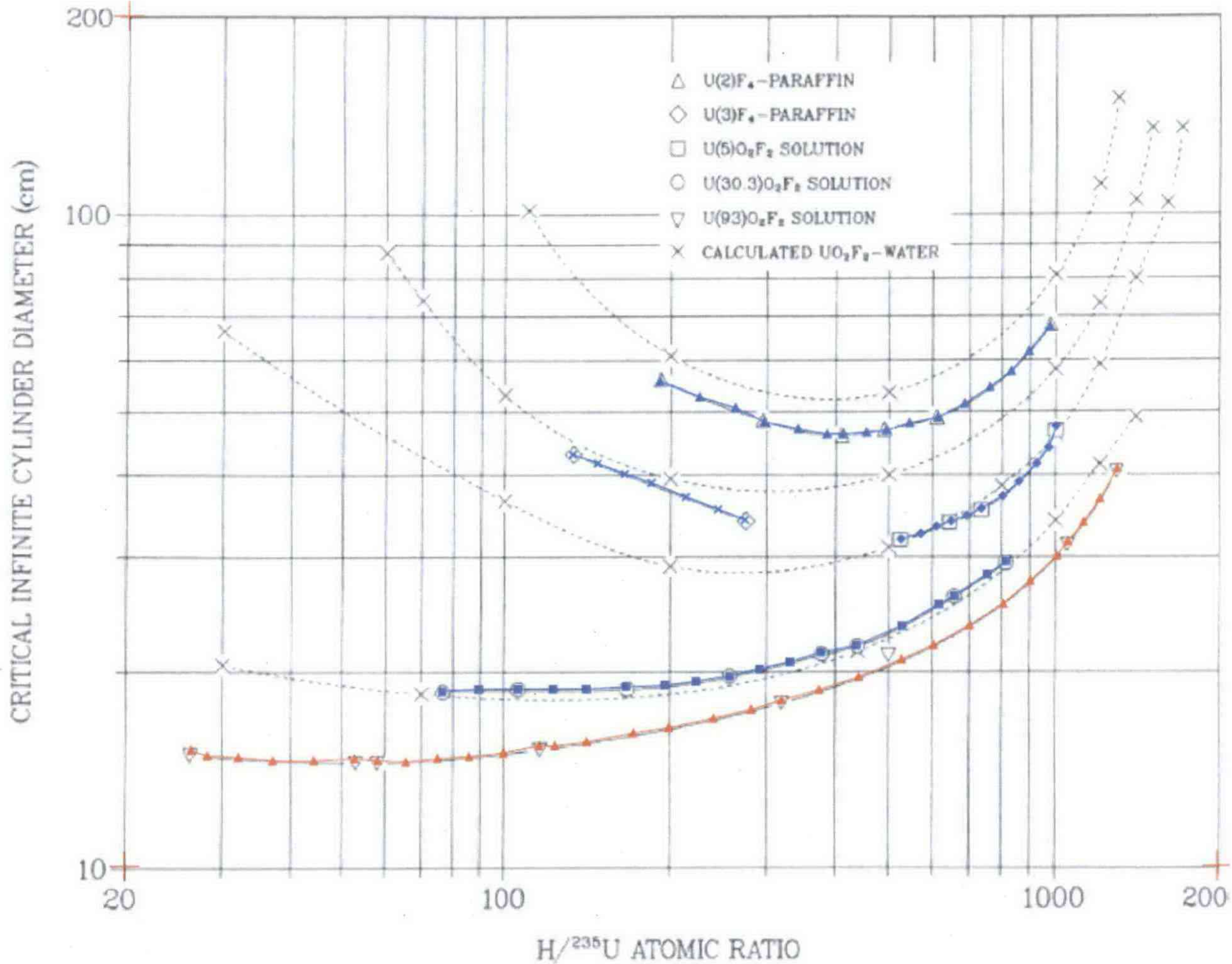


Figure B-17. Estimated Critical Thicknesses of Water-Reflected Slabs, Infinite in Other Dimensions of Hydrogen-Moderated U(93), U(30.3), U(5.00), U(3.00) and U(2.00) (Fig. 17 from LA-10860)

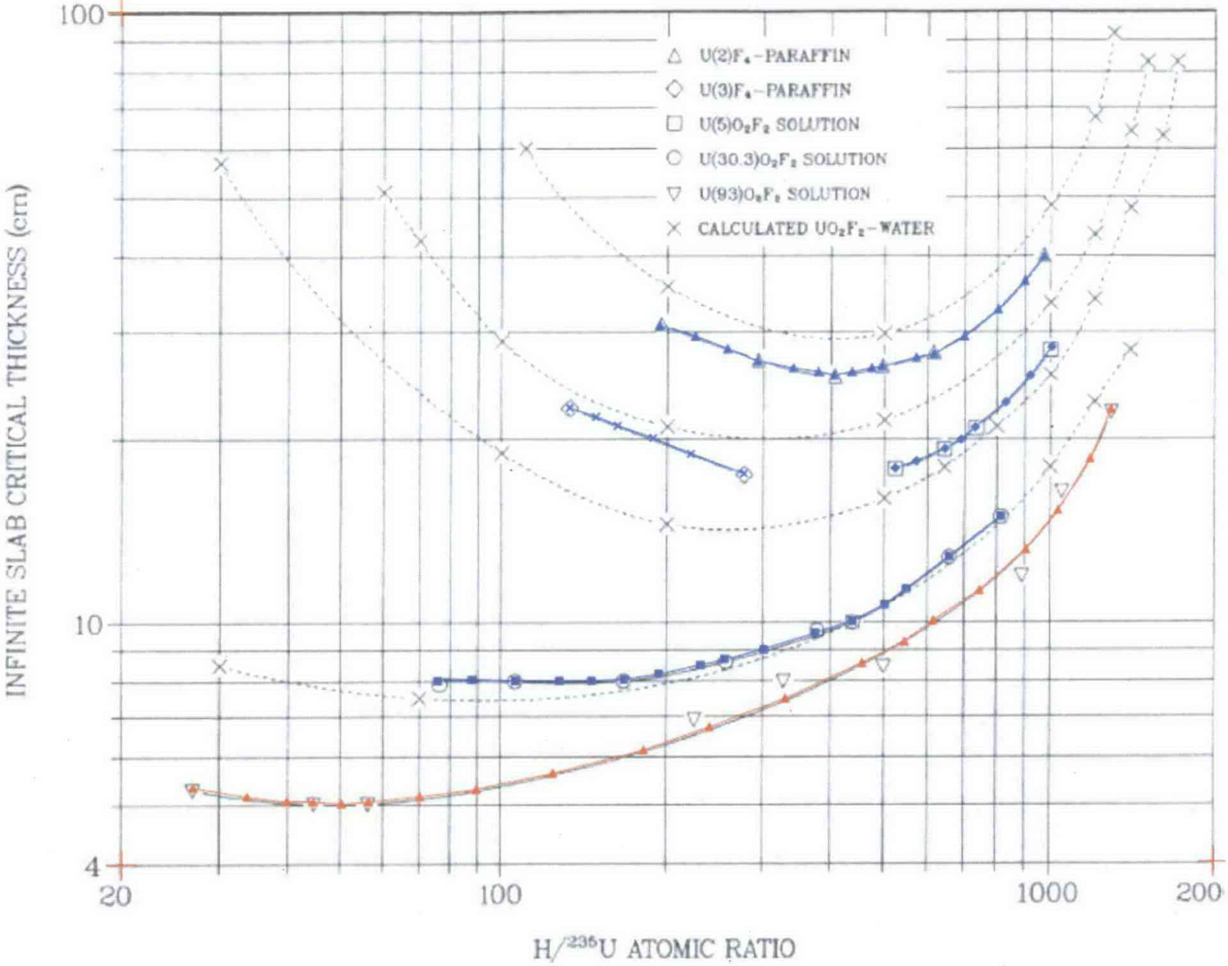
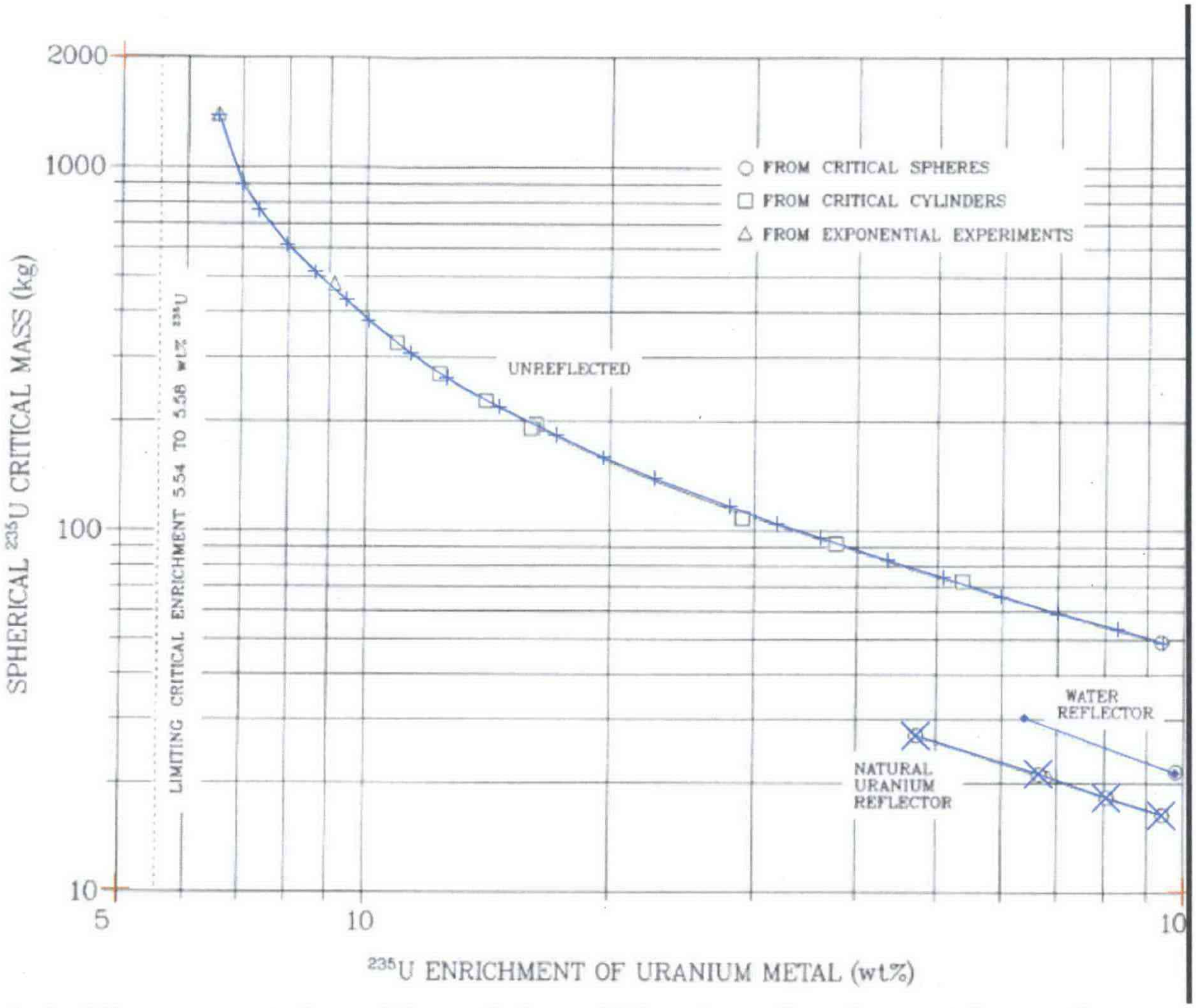
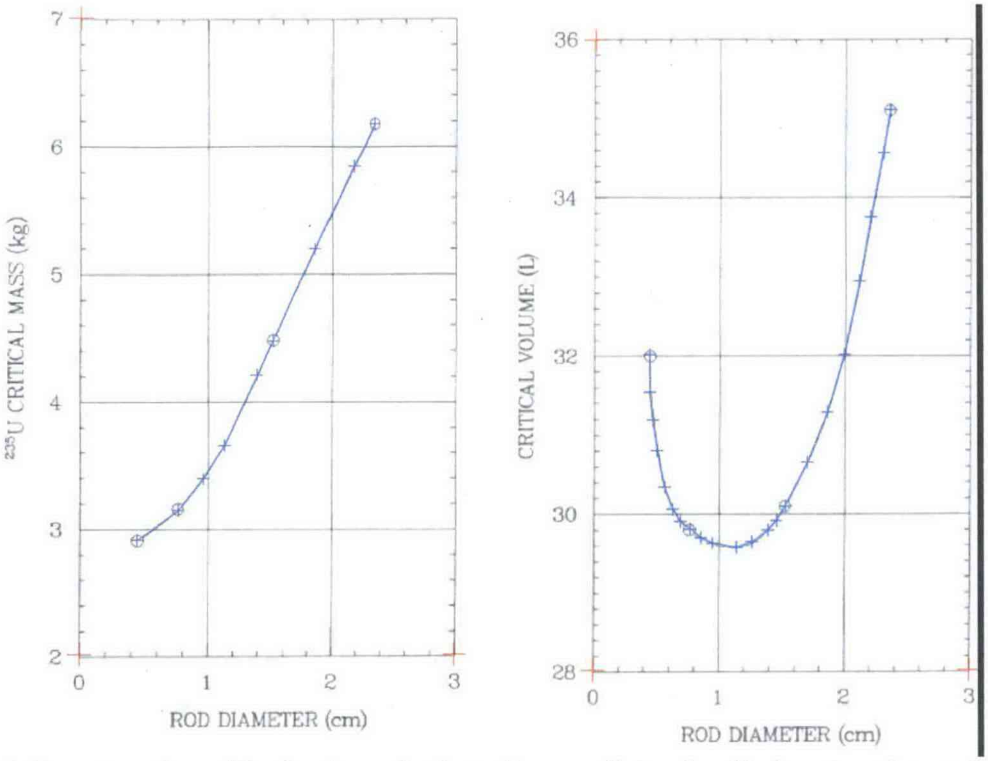


Figure B-18. Critical Mass vs ^{235}U Enrichment of Uranium Metal (Fig. 19 from LA-10860)



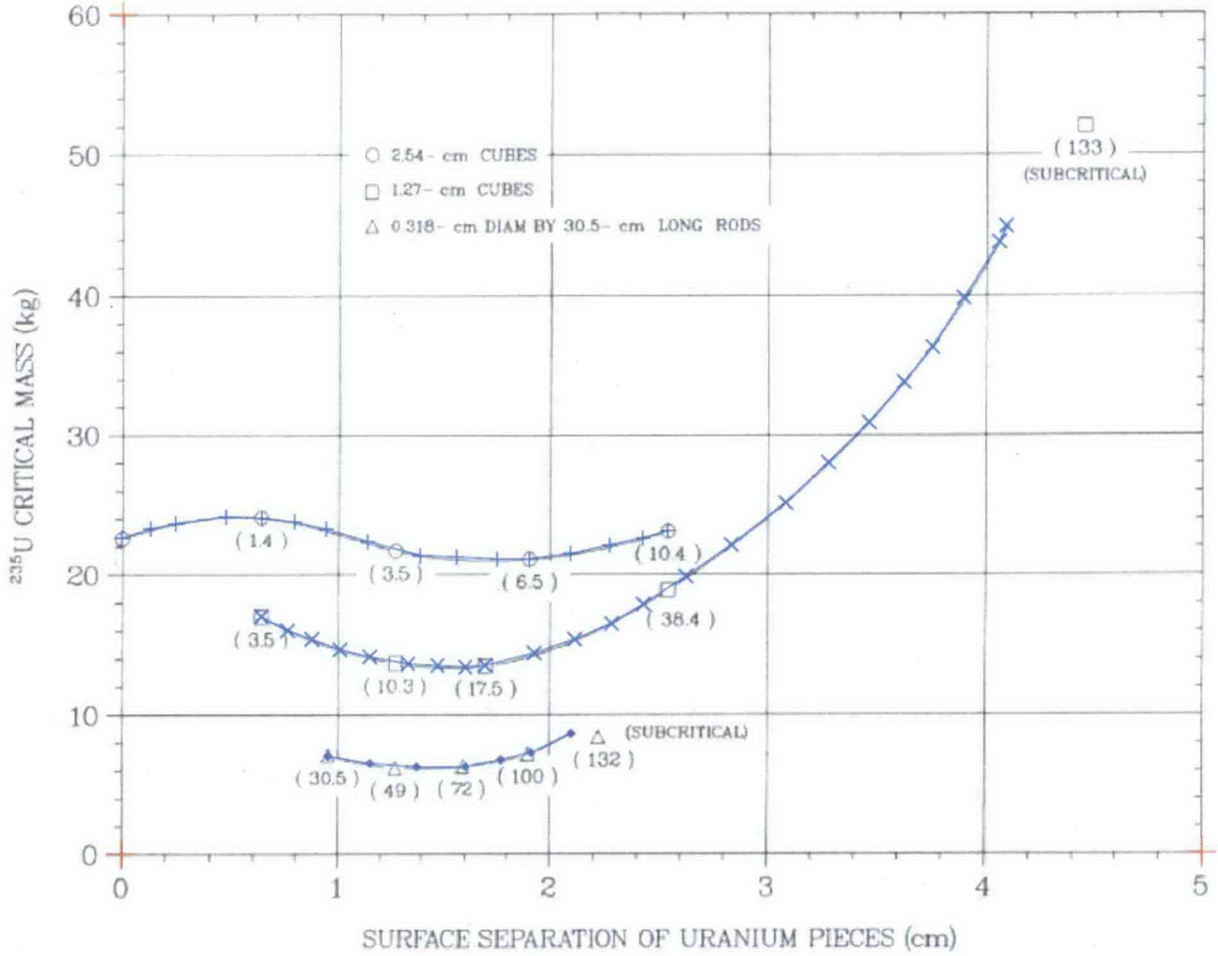
The dashed line represents the enrichment below which a piece of uranium metal cannot become critical, as determined by an international reactor physics program.

Figure B-19. Critical Mass and Volume for Lattices of U(3.063) Metal Rods In Water (Fig. 20 from LA-10860)



At each rod diameter, the critical volume is that of an equilateral cylinder at optimum lattice spacing, and the critical mass corresponds.

Figure B-20. Critical Masses of Water-Immersed U(94) Metal Lattices as Functions of Spacing Between Units (Fig. 21 from LA-10860)



Mean H/^{235}U ratios are in parenthesis.

Figure B-21. Minimum Spherical Critical Masses as Functions of ^{235}U Enrichment in Homogeneous and Heterogeneous Hydrogen-Moderated Systems (Fig. 22 from LA-10860)

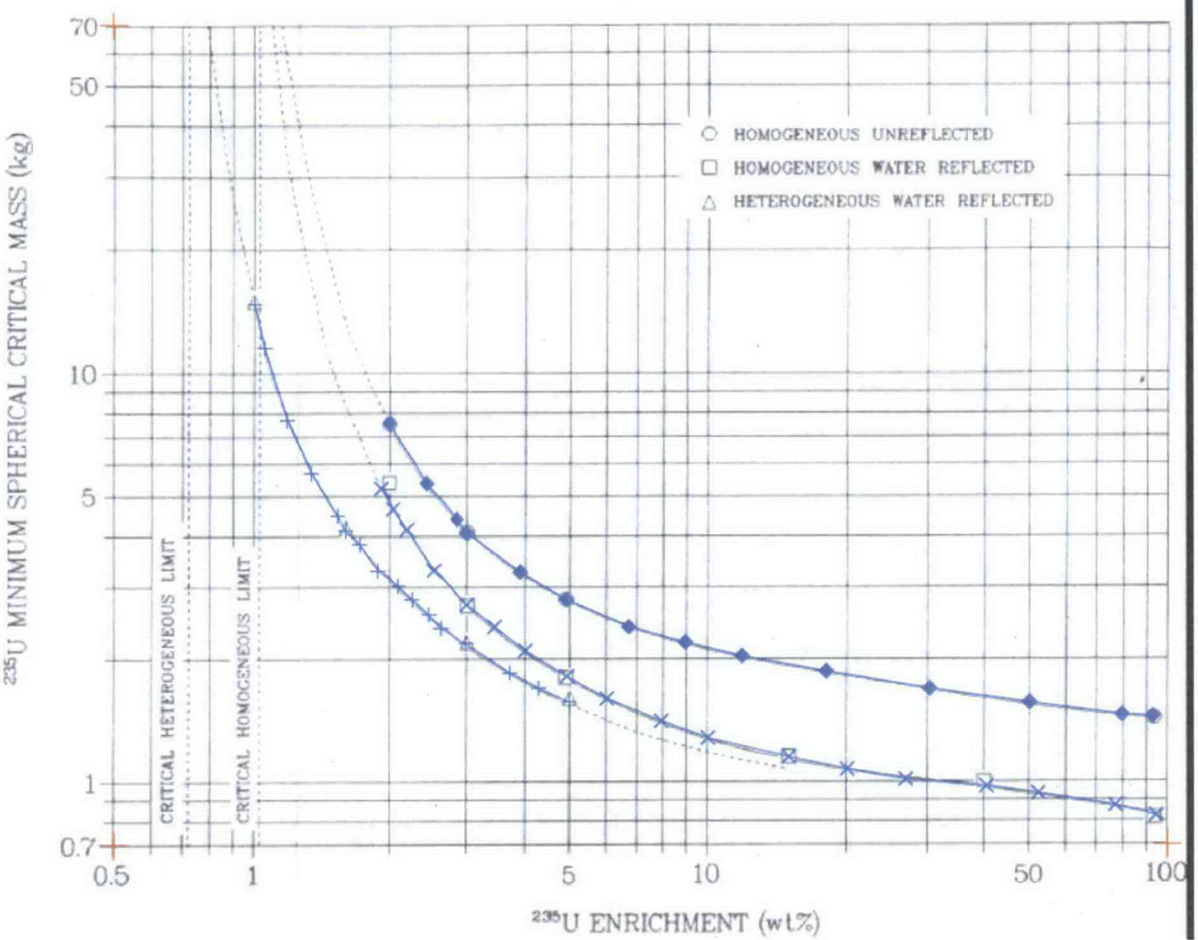


Figure B-22. Minimum Spherical Critical Volumes as Functions of ^{235}U Enrichment in Homogeneous and Heterogeneous Hydrogen-Moderated Systems (Fig. 23 from LA-10860)

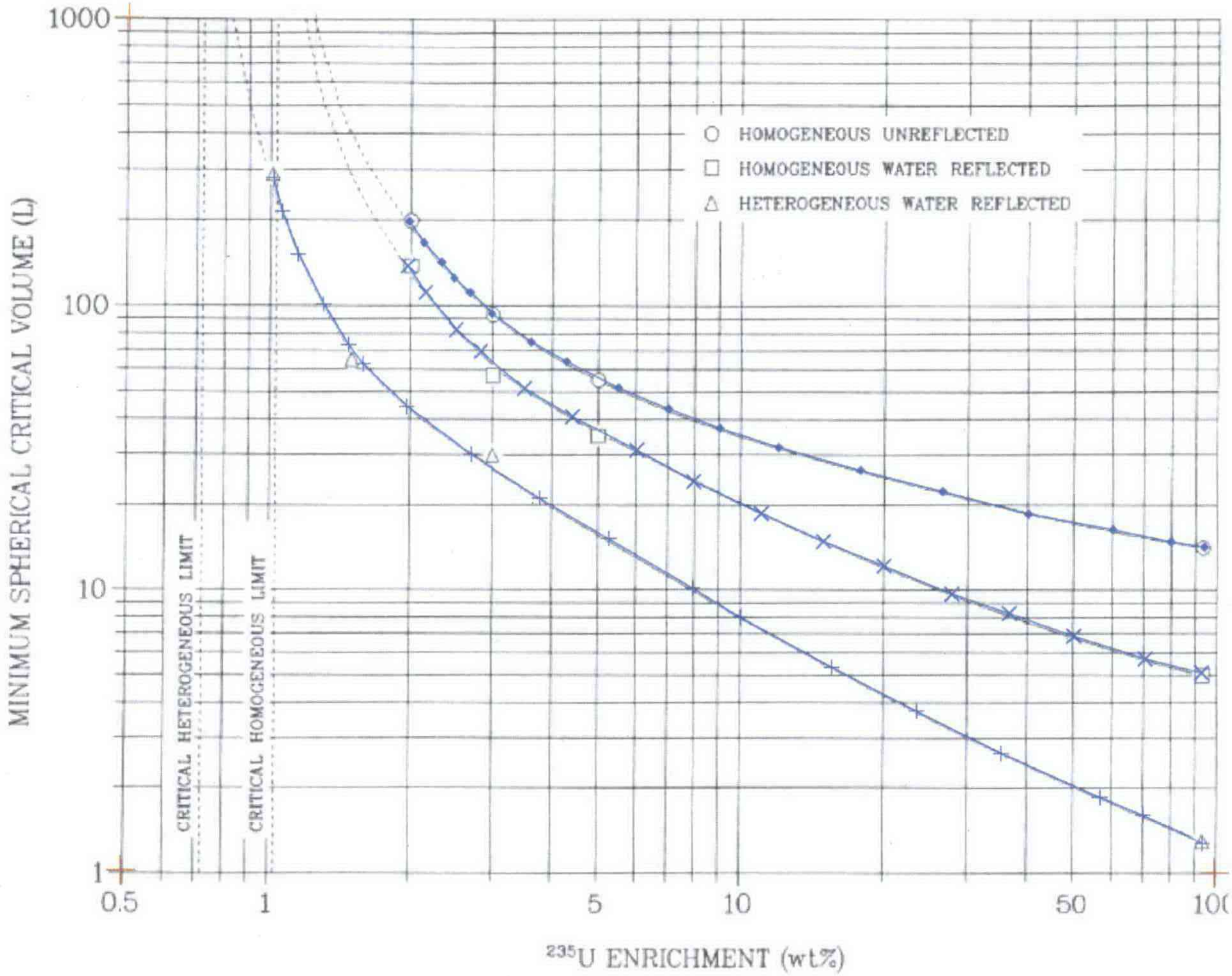


Figure B-23. Minimum Critical Infinite Cylinder Diameters as Functions of ^{235}U Enrichment in Homogeneous and Heterogeneous Hydrogen-Moderated Systems (Fig. 24 from LA-10860)

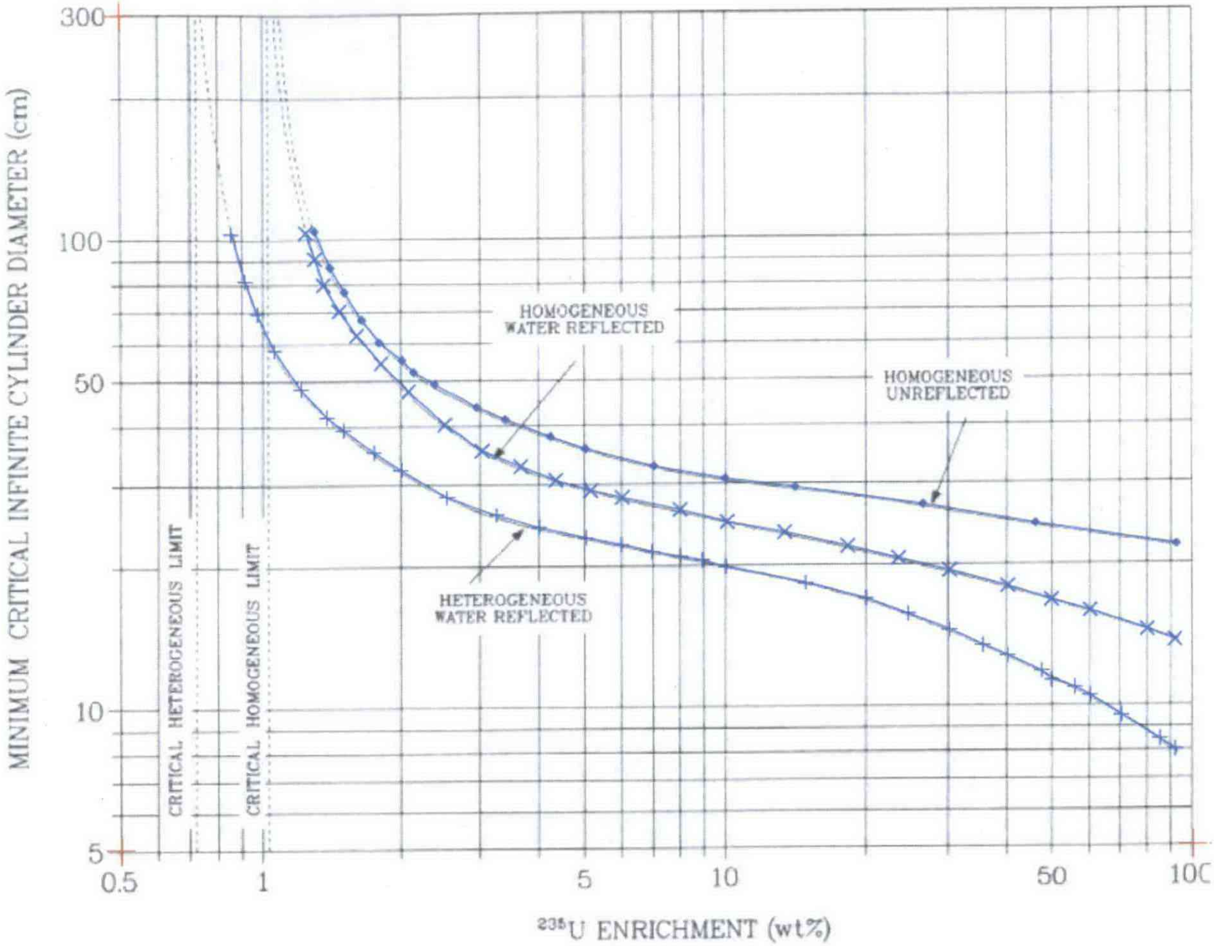
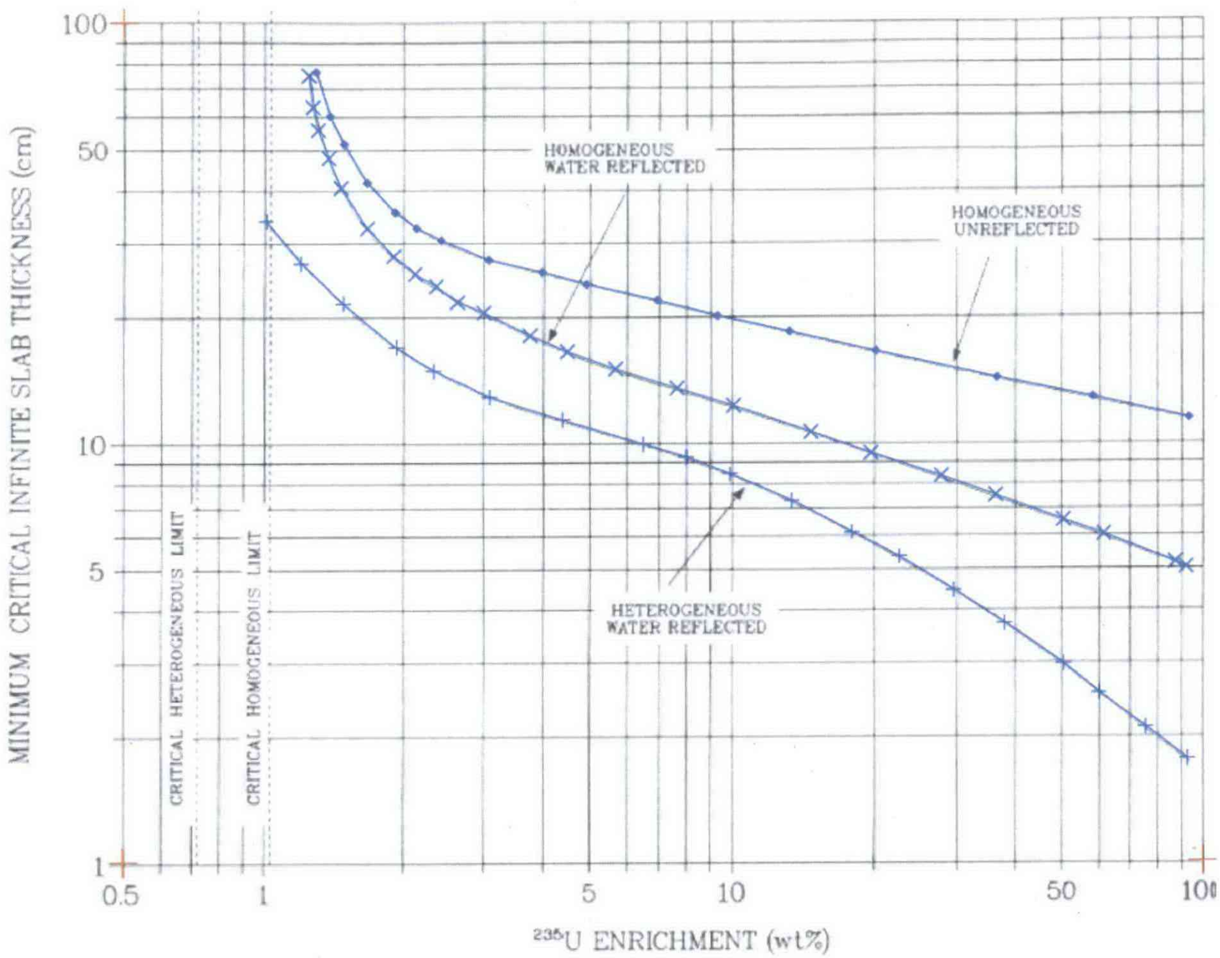


Figure B-24. Minimum Critical Infinite Slab Thicknesses as Functions of ^{235}U Enrichment in Homogeneous and Heterogeneous Hydrogen-Moderated Systems (Fig. 25 from LA-10860)



Unreflected infinite slabs are fictitious.

Figure B-25. Critical Thicknesses of 12.7- by 20.3-cm U(93) Metal Slabs Immersed in 24-cm-diam $U(93)O_2(NO_3)_2$ Solutions at Various ^{235}U Densities (Fig. 26 from LA-10860)

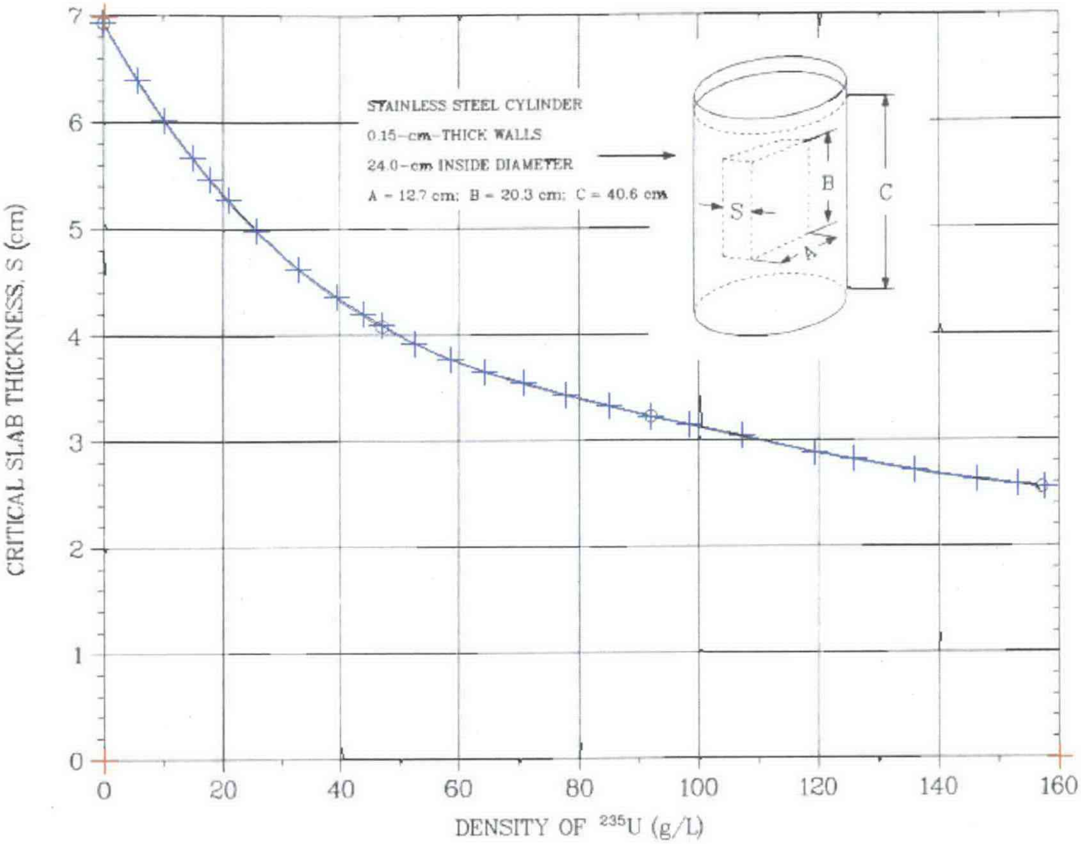


Figure B-26. Critical Thicknesses of 25.4- by 40.6-cm U(93) Metal Slabs Immersed in 76-cm-diam $U(93)O_2(NO_3)_2$ Solutions at Various ^{235}U Densities (Fig. 27 from LA-10860)

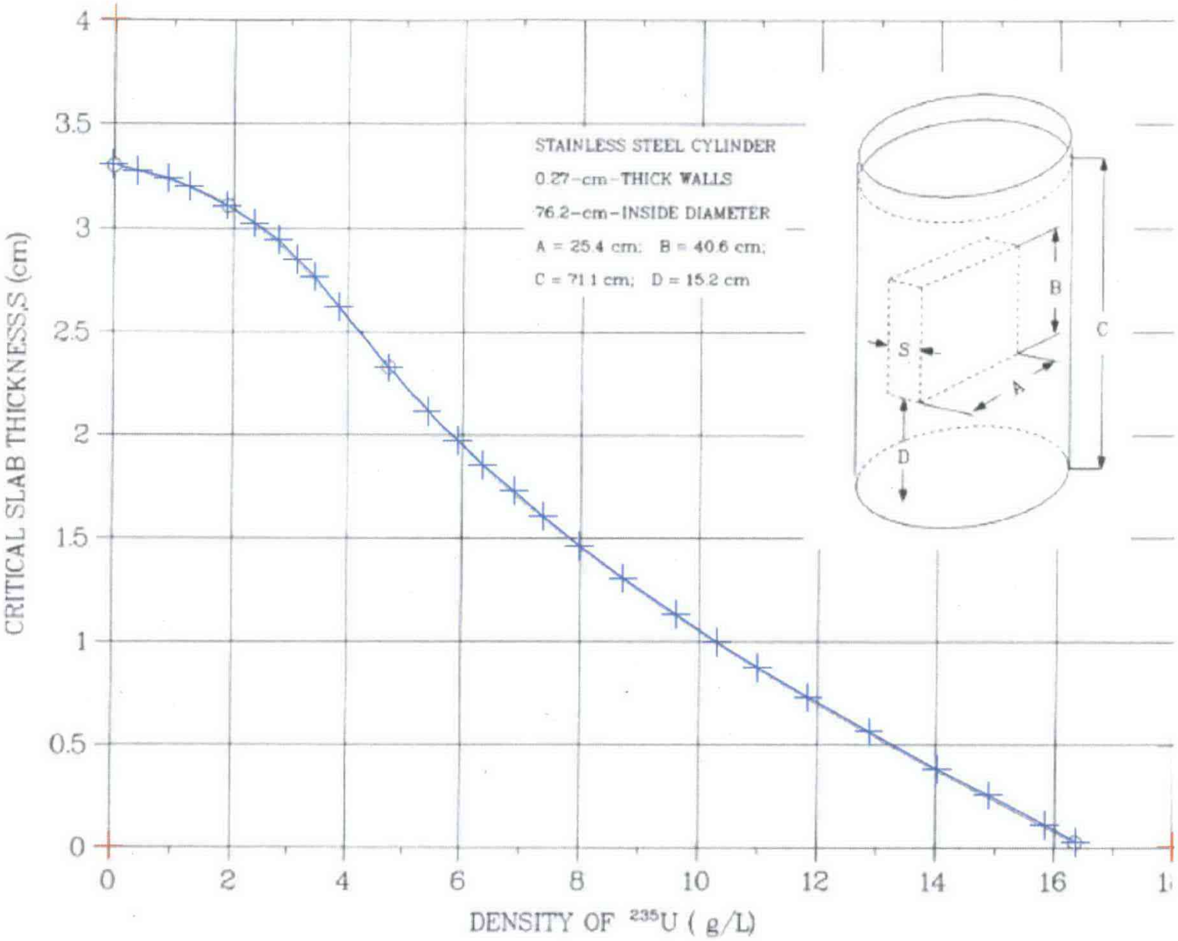


Figure B-27. Spherical Critical Masses and Volumes of Water-Reflected $Pu(NO_3)_4$ Solutions with Various Nitrate Densities (Fig. 28 from LA-10860)

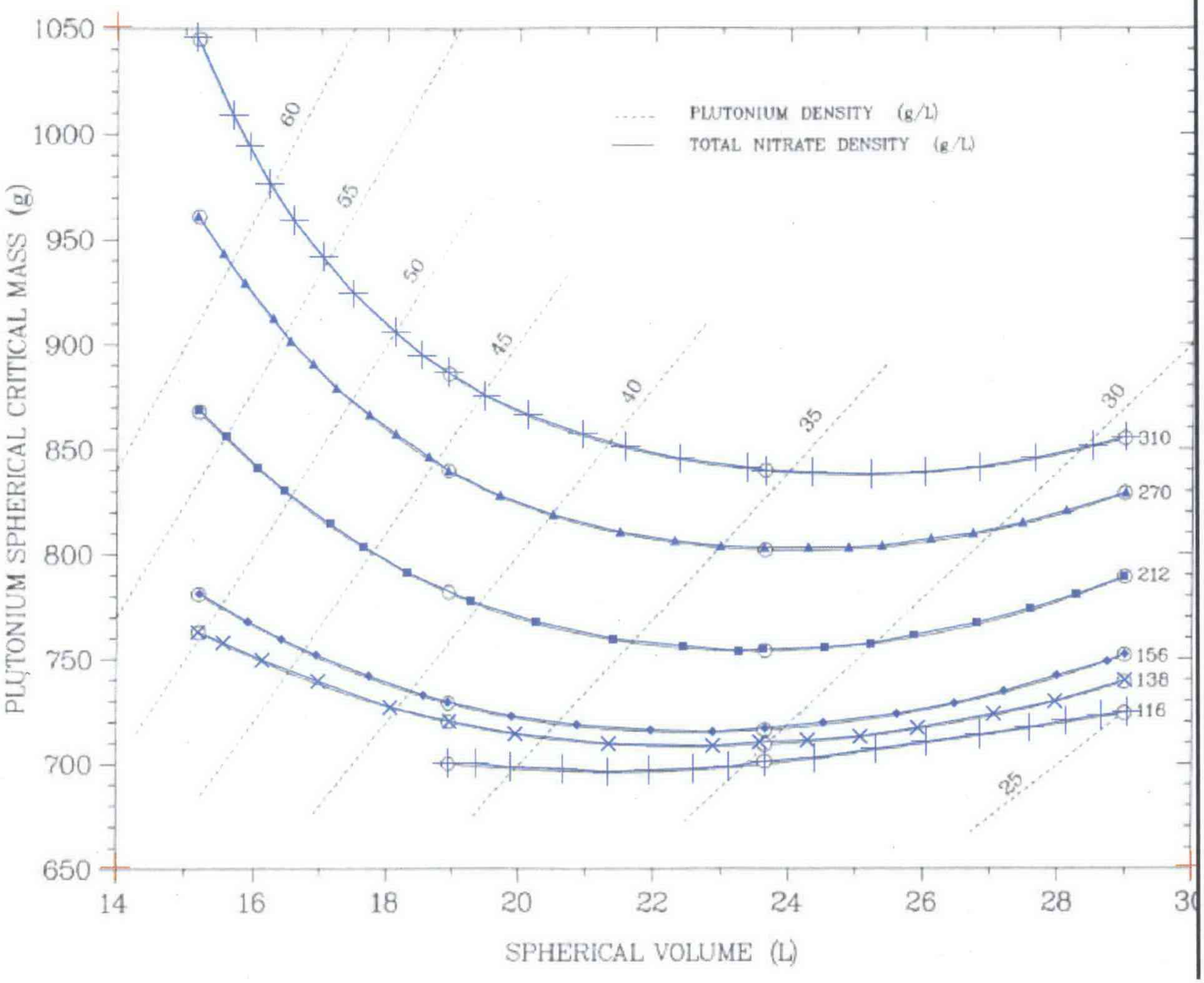


Figure B-28. Atomic Ratios H/Pu as Functions of Plutonium Density for $Pu(NO_3)_4$ Solutions Containing 4 M, 5.6 M, 7.5 M and 10 M HNO_3, and for Idealized Plutonium-Water Mixtures (Fig. 29 from LA-10860)

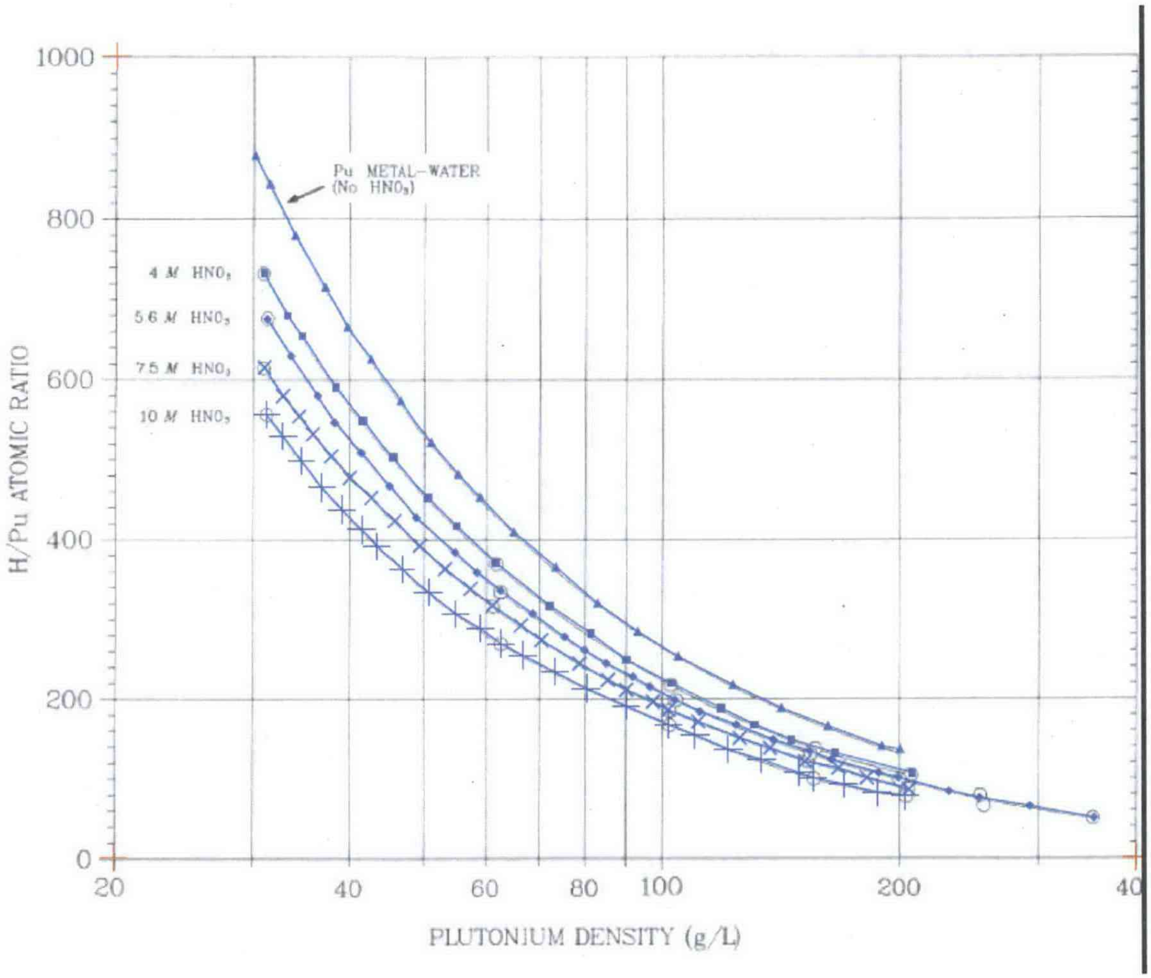
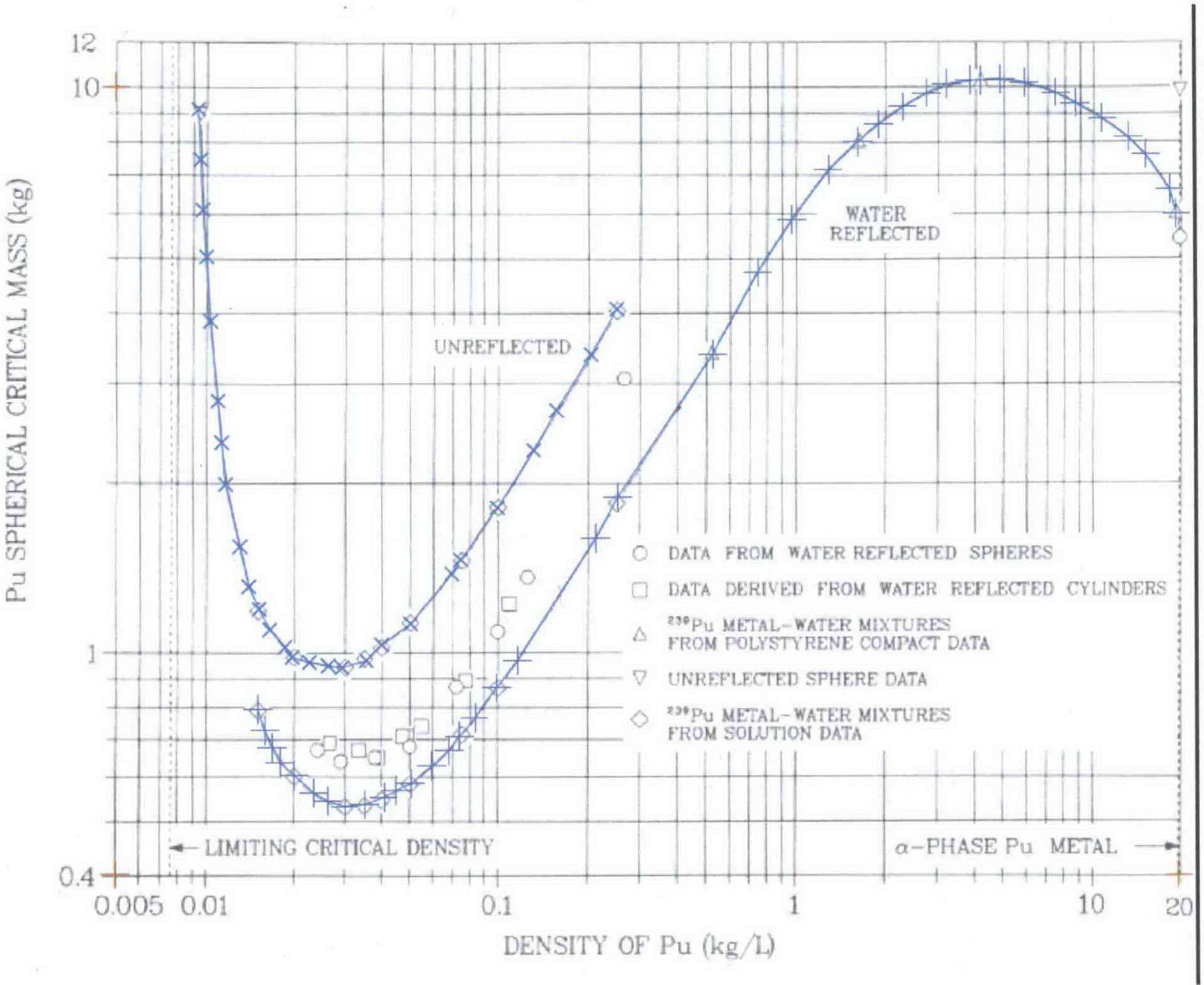
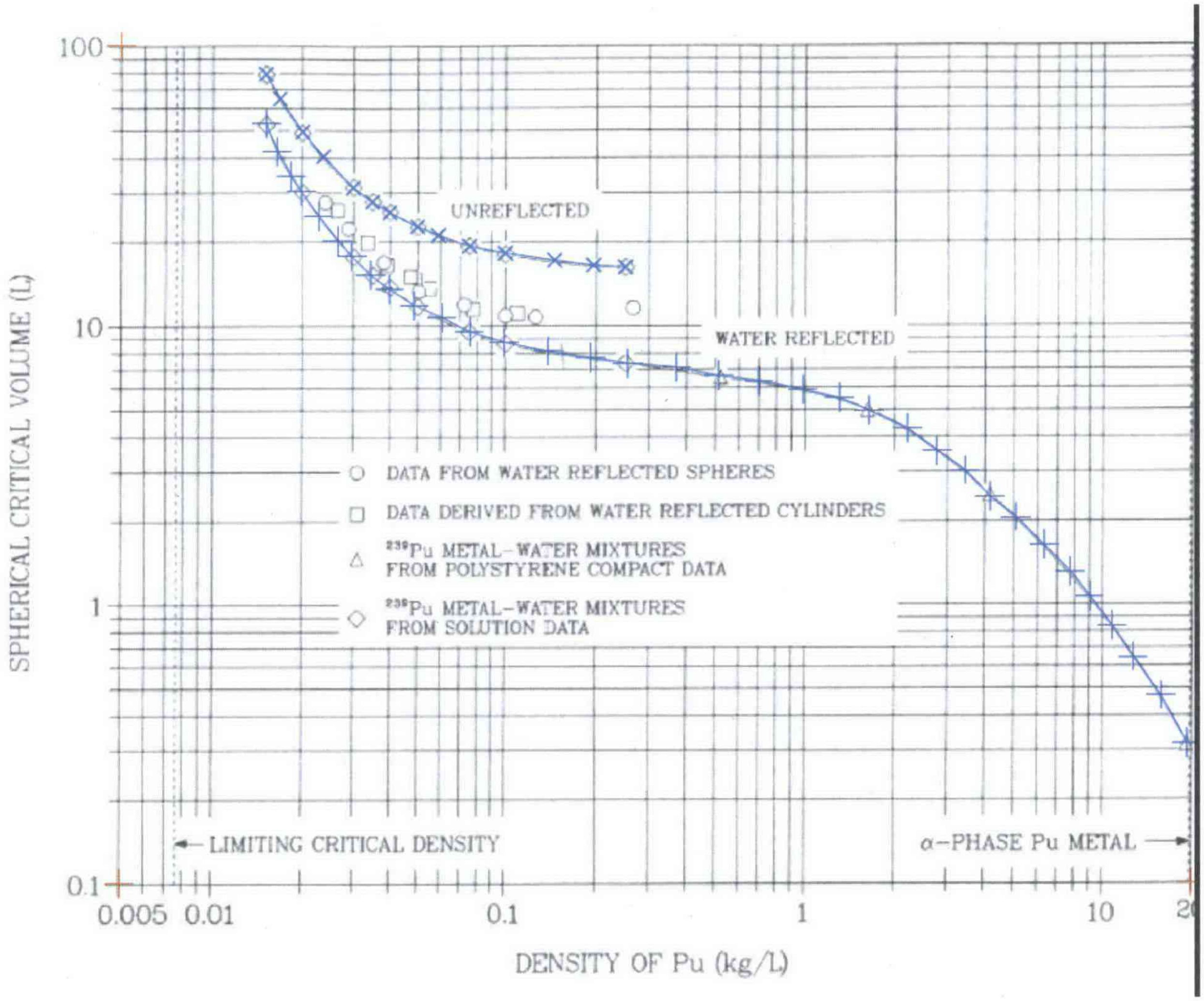


Figure B-29. Critical Masses of Homogeneous Water-Moderated Plutonium Spheres (Fig. 31 from LA-10860)



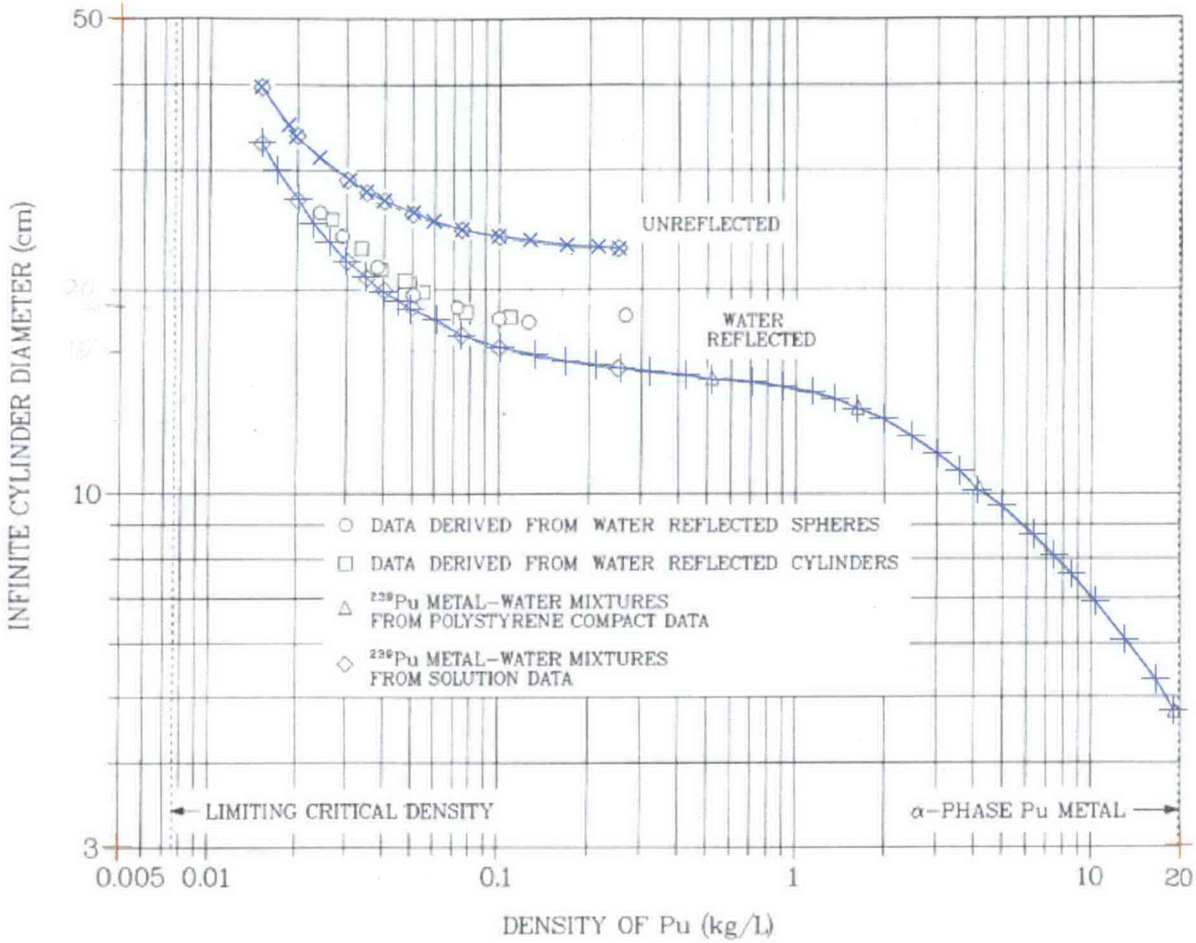
The points suggesting an intermediate curve apply to water-reflected $Pu(NO_3)_4$ solution with 1 N HNO_3, and 3.1% ^{240}Pu content of the plutonium.

Figure B-30. Critical Volumes of Homogeneous Water-Moderated Plutonium Spheres (Fig. 32 from LA-10860)



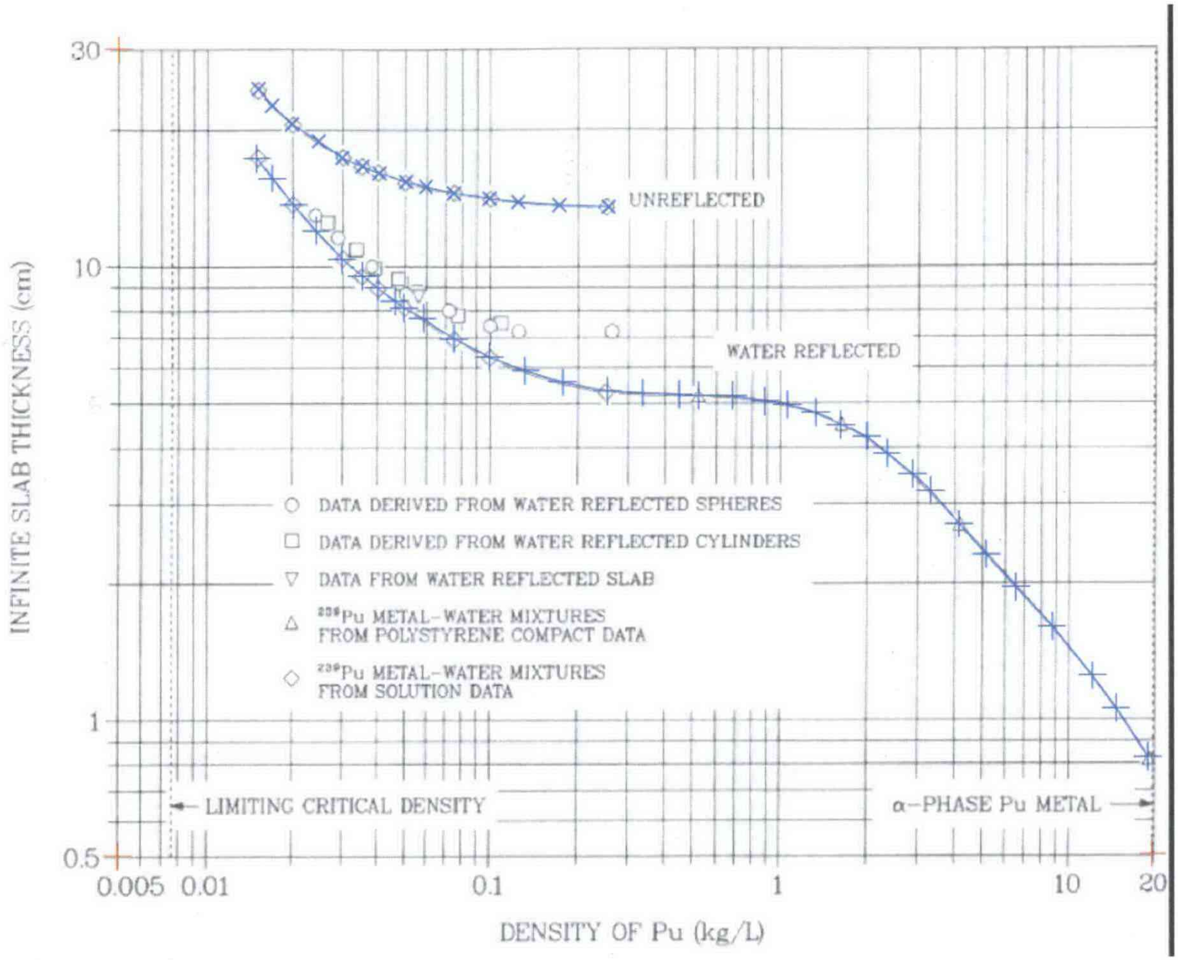
The points suggesting an intermediate curve apply to water-reflected $Pu(NO_3)_4$ solution with 1 N HNO_3, and 3.1% ^{240}Pu content of the plutonium.

Figure B-31. Estimated Critical Diameters of Infinitely Long Cylinders of Homogeneous Water-Moderated Plutonium (Fig. 33 from LA-10860)



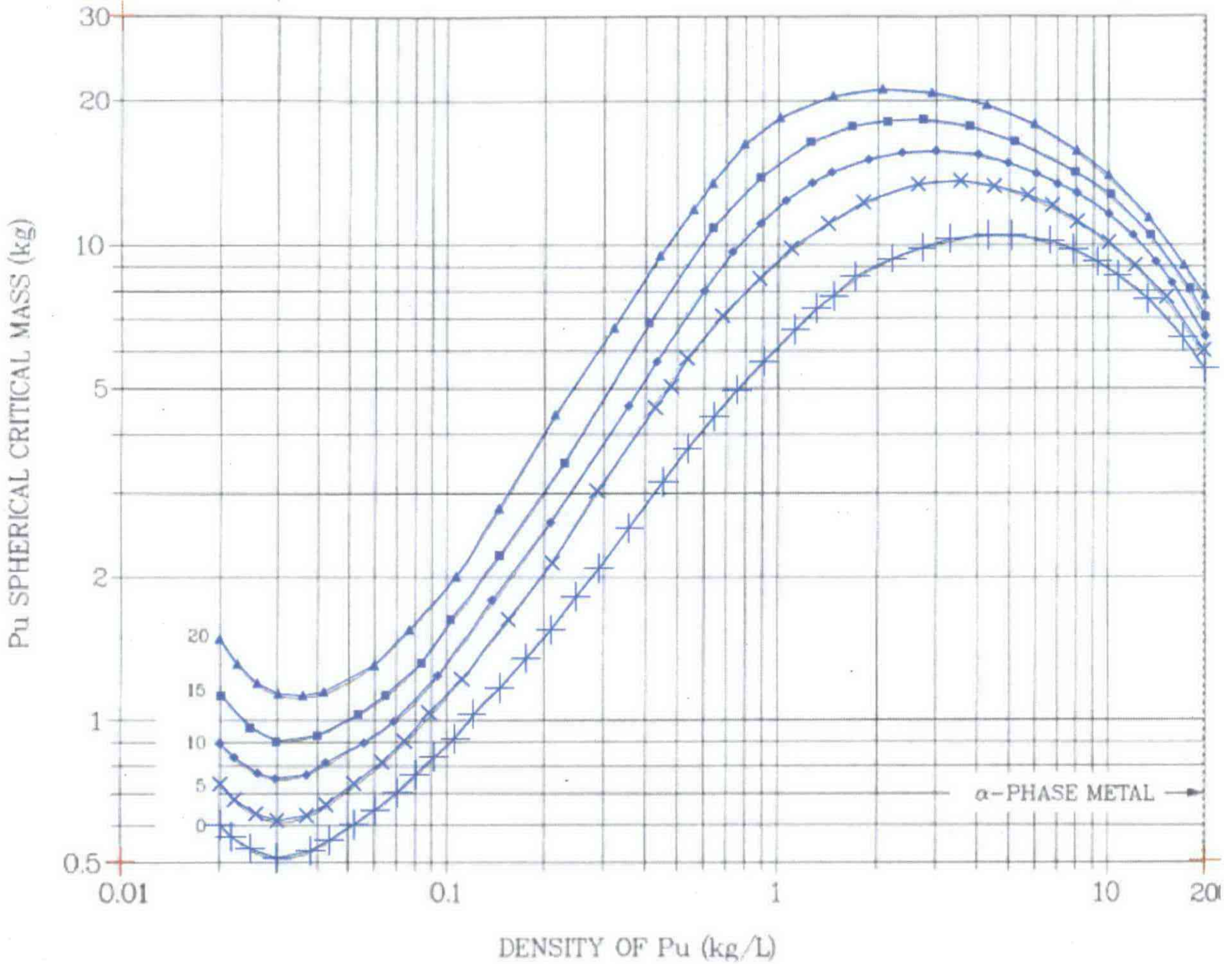
The points suggesting an intermediate curve apply to water-reflected $Pu(NO_3)_4$ solution with 1 N HNO_3, and 3.1% ^{240}Pu content of the plutonium.

Figure B-32. Estimated Critical Thicknesses of Slabs, Infinite in Other Dimensions, of Homogeneous Water-Moderated Plutonium (Fig. 34 from LA-10860)



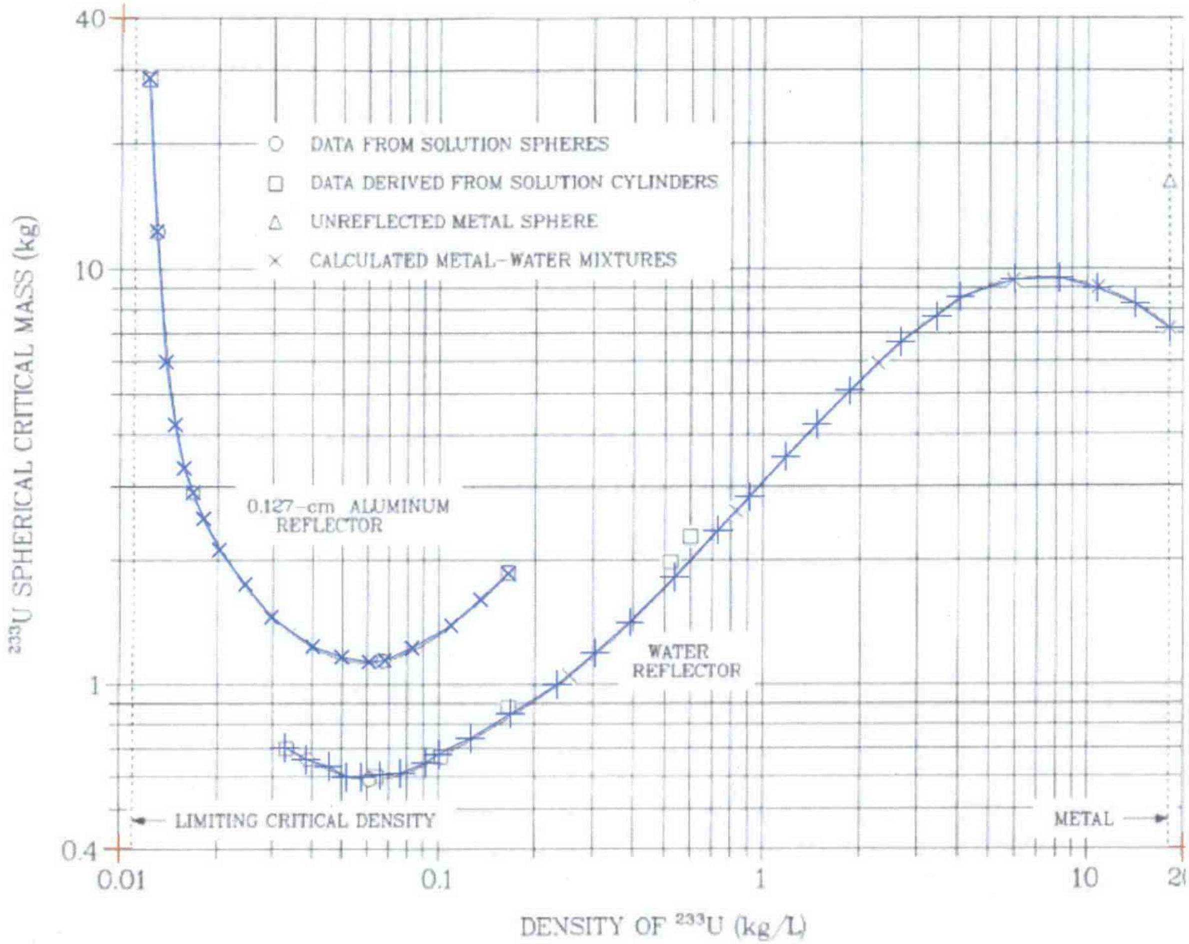
Unreflected infinite slabs are fictitious. The points suggesting an intermediate curve apply to water-reflected $Pu(NO_3)_4$ solution with 1 N HNO_3, and 3.1% ^{240}Pu content of the plutonium.

Figure B-33. Calculated Effect of ^{240}Pu Content on the Critical Mass of Water-Reflected Homogeneous plutonium Metal-Water Spheres (Fig. 35 from LA-10860)



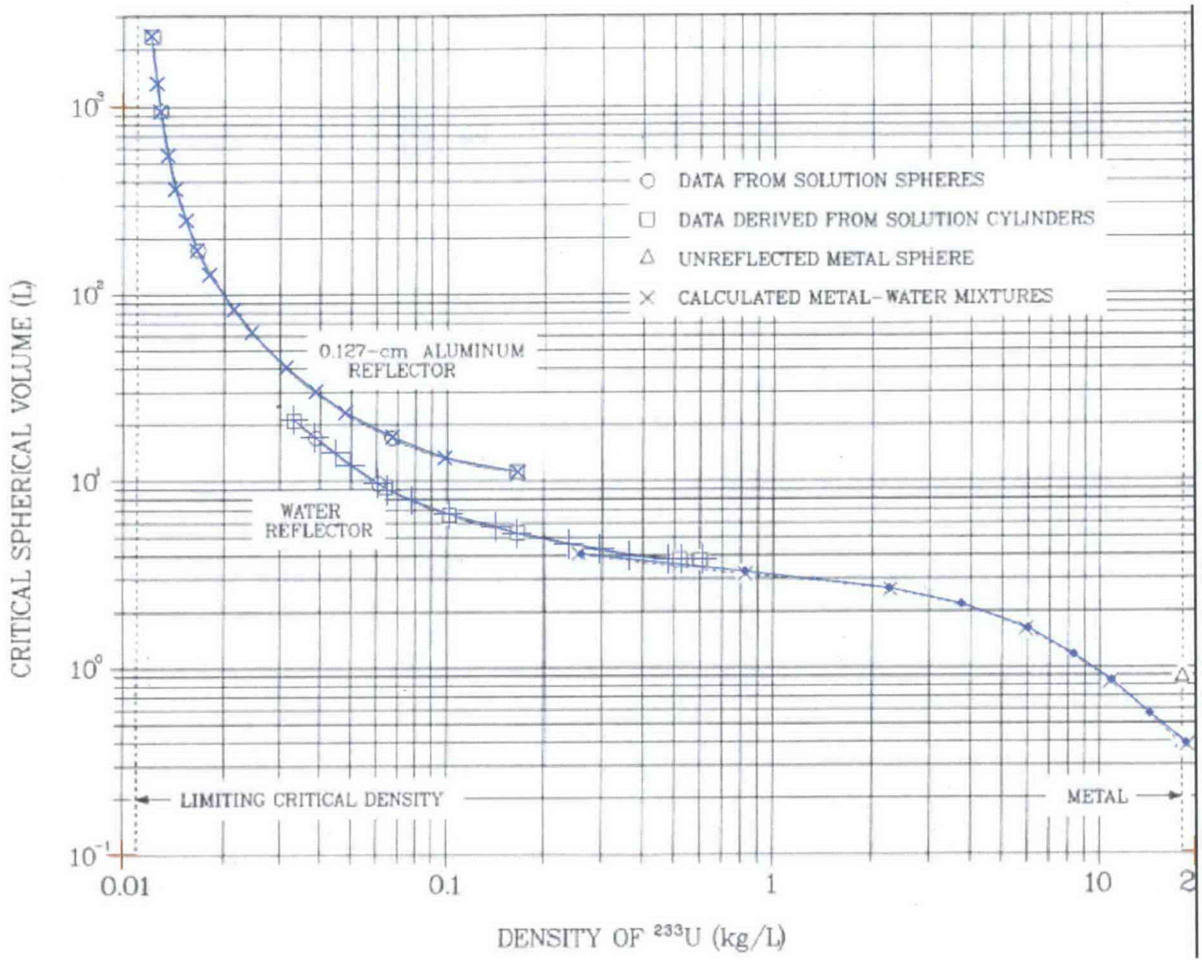
The ^{240}Pu content, in wt%, is indicated for each curve.

Figure B-34. Critical Masses of Homogeneous Water-Moderated ^{233}U Spheres (Fig. 36 from LA-10860)



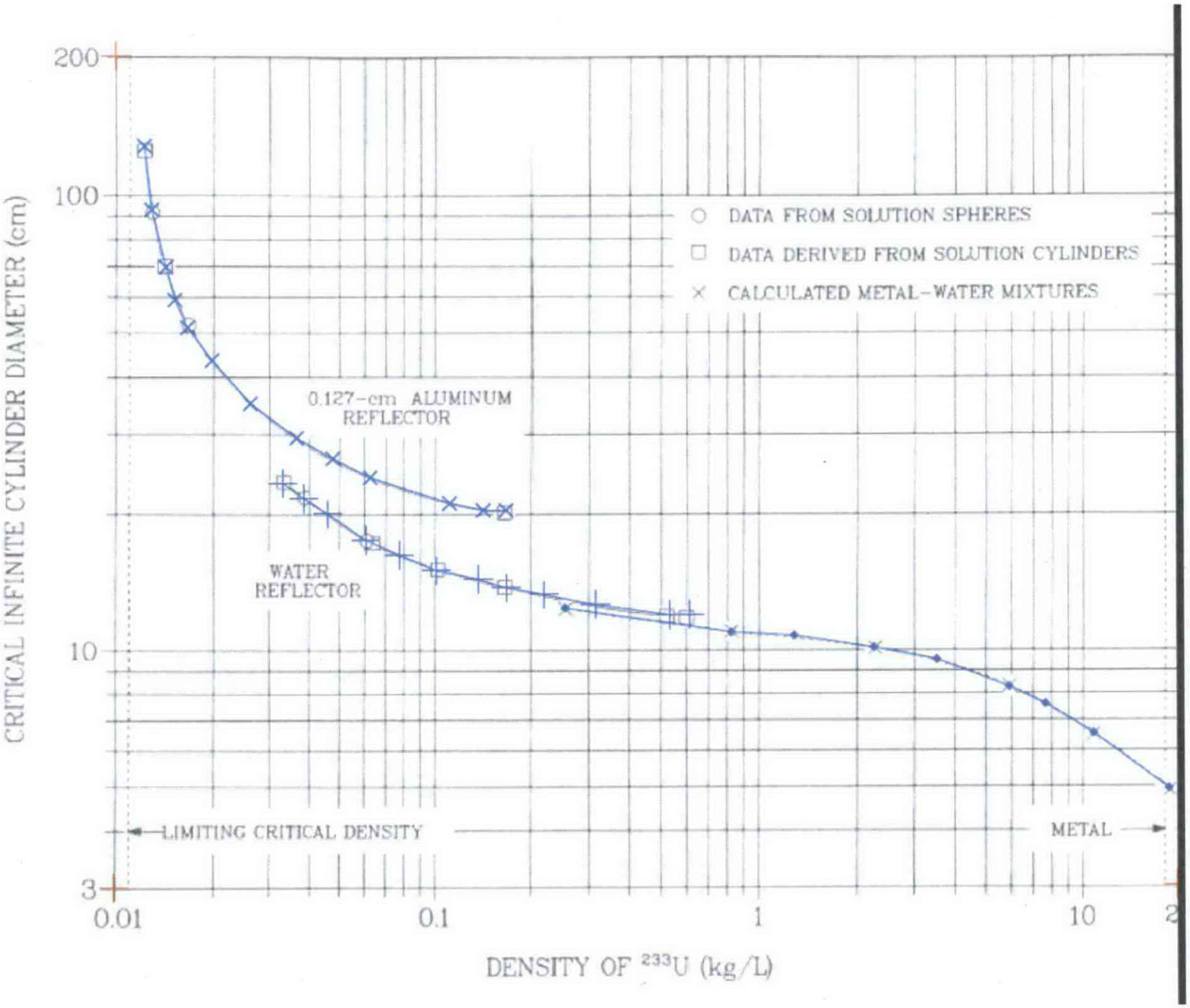
Solution data appear unless indicated otherwise.

Figure B-35. Critical Volumes of Homogeneous Water-Moderated ^{233}U Spheres (Fig. 37 from LA-10860)



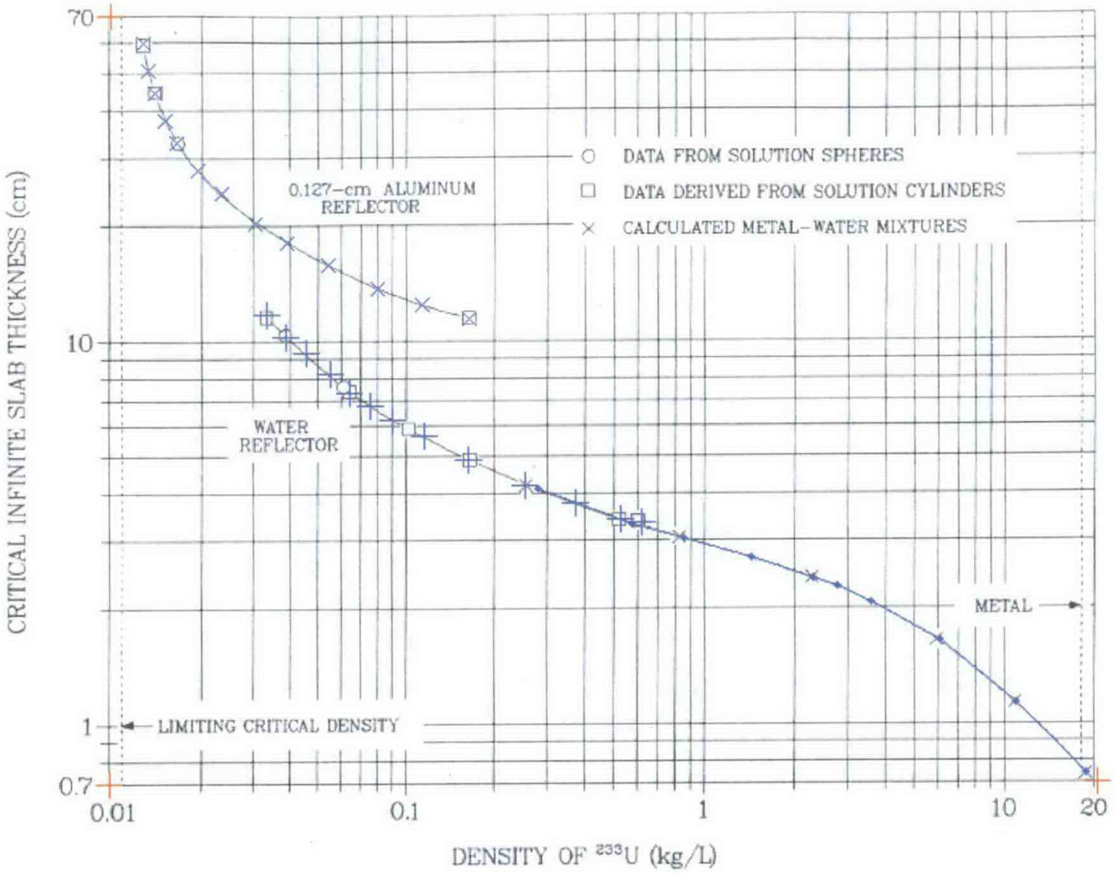
Solution data appear unless indicated otherwise.

Figure B-36. Estimated Critical Diameters of Infinitely Long Cylinders of Homogeneous Water-Moderated ^{233}U (Fig. 38 from LA-10860)



Solution data appear unless indicated otherwise.

Figure B-37. Estimated Critical Thicknesses of Slabs, Infinite in Other Dimensions, of Homogeneous Water-Moderated ^{233}U (Fig. 39 from LA-10860)



Unreflected infinite slabs are fictitious. Solution data appear unless indicated otherwise.

Figure B-38. Boron Concentrations Required for $k_\infty = 1$ in Homogeneous Hydrogen-Moderated Uranium Enriched to 2% and 3% ^{235}U (Fig. 40 from LA-10860)

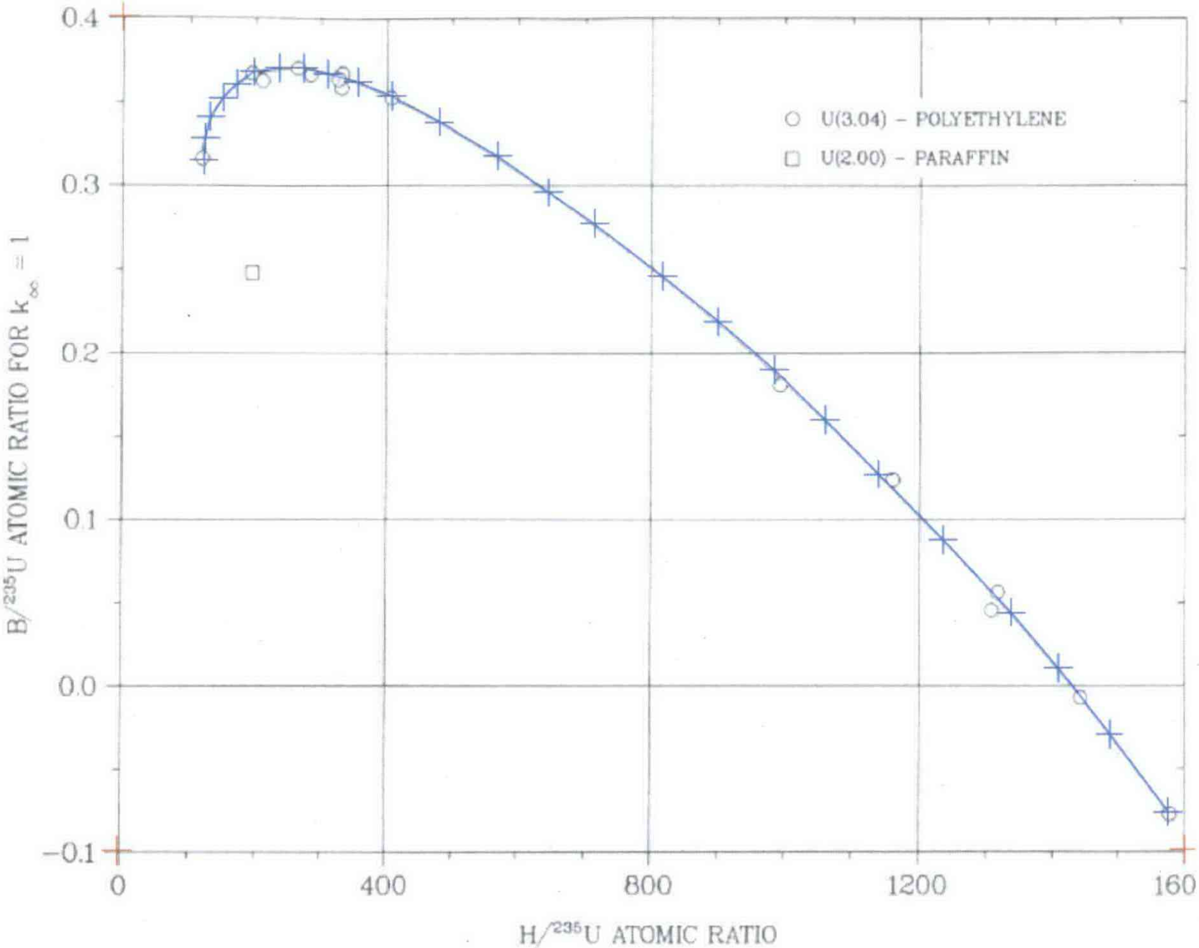


Figure B-39. Maximum Boron-to-Uranium Atomic Ratios Required for $k_\infty = 1$ vs ^{235}U Enrichment in Homogeneous Hydrogen-Moderated Uranium (Fig. 41 from LA-10860)

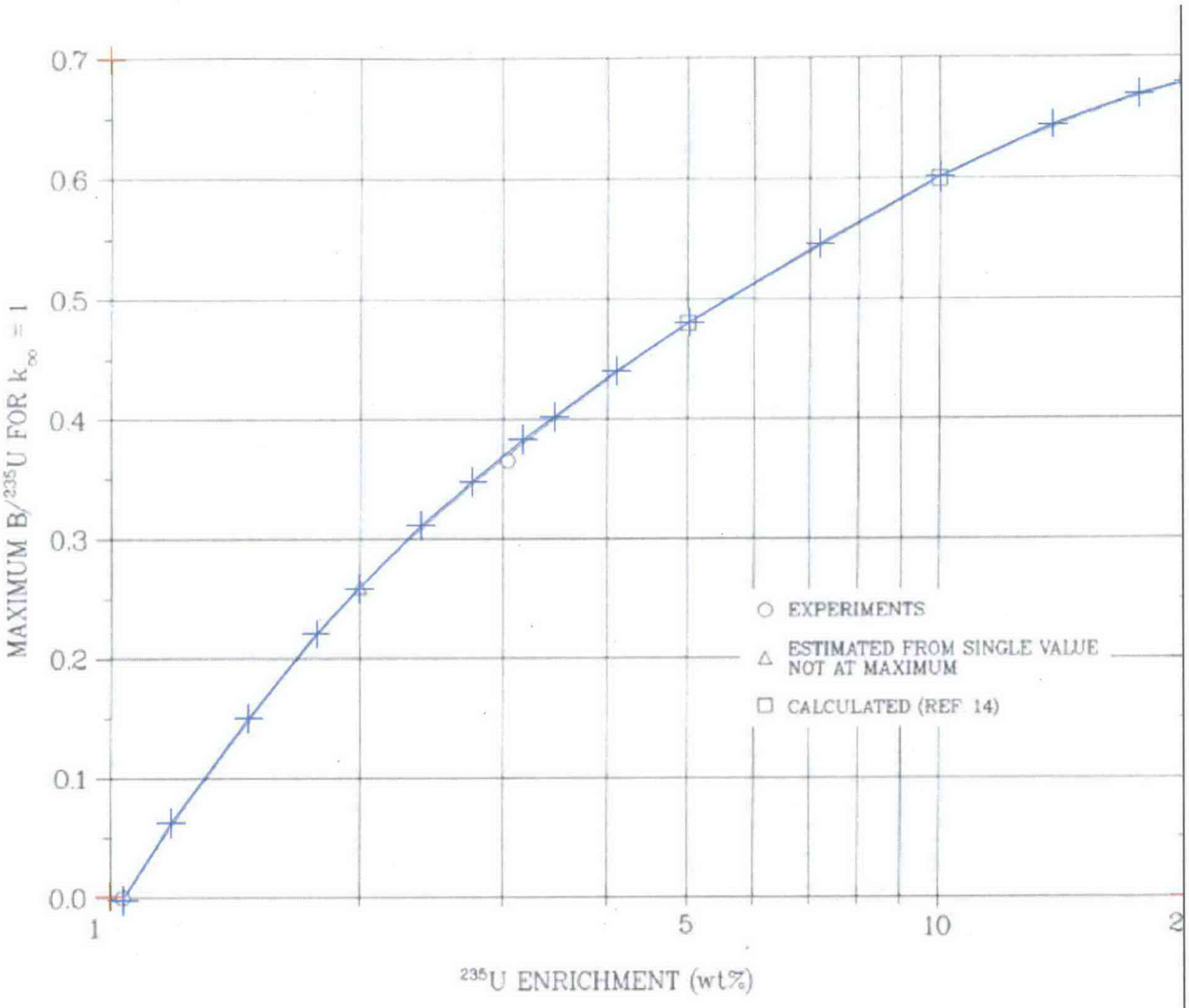
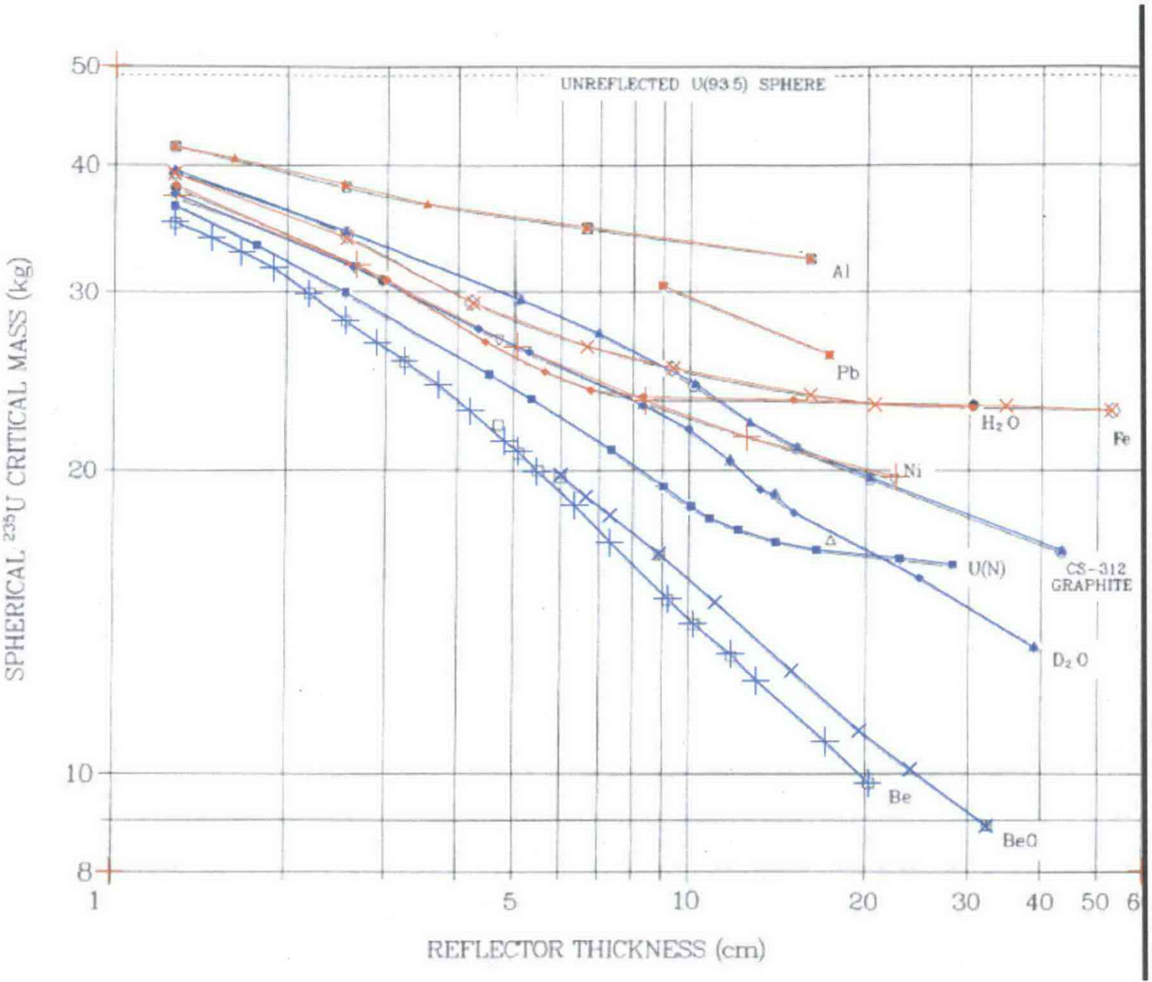
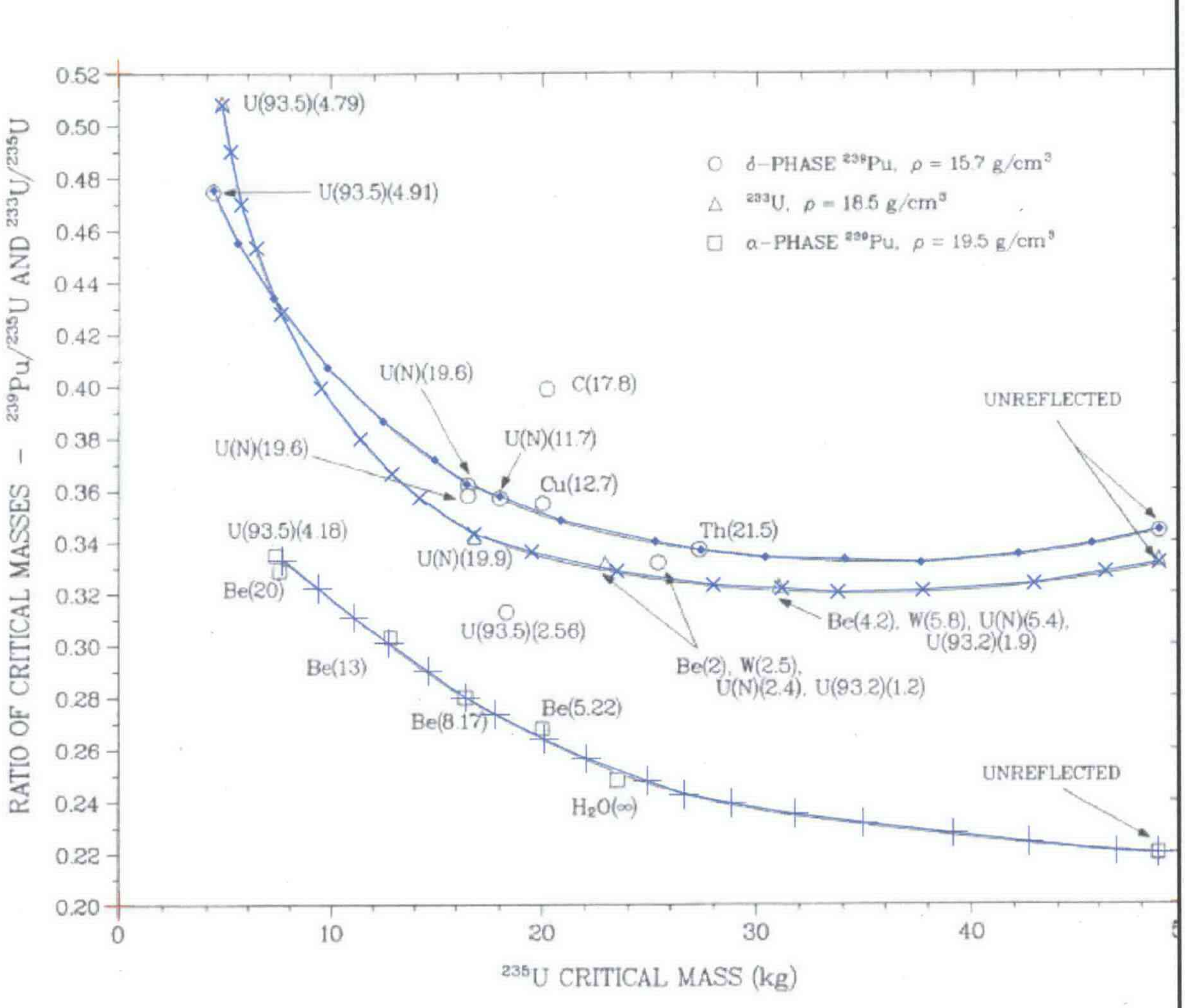


Figure B-40. Critical Masses of U(93.5) Metal Spheres in Various Reflectors (Fig. 42 from LA-10860)



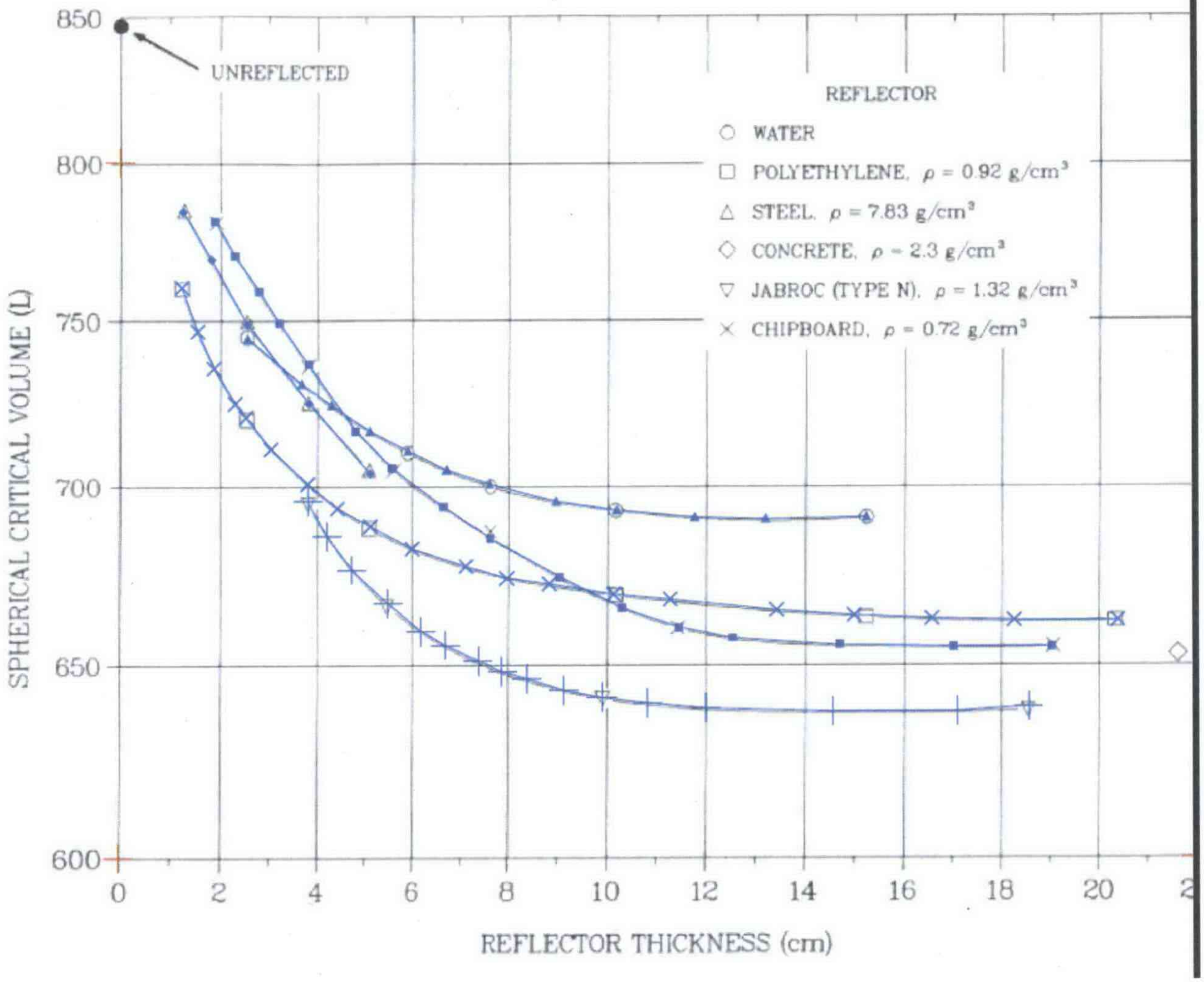
Uranium density = 18.8 g/cm^3.

Figure B-41. Critical Masses of Spheres of ^{239} Pu and ^{233} U Metal Relative to Those of U(93.5) Metal With the Same Reflector (Fig. 43 from LA-10860)



Indicated at each point are the reflector material and thickness in cm.

Figure B-42. Spherical Critical Volumes vs Thickness of Various Reflectors for $U(1.42)F_4$-paraffin at $H/^{235}U = 422$ and $\rho(U) = 2.5\ g/cm^3$ (Fig. 44 from LA-10860)



Jabroc is a wood product containing 45% carbon, 6% hydrogen, and 37% oxygen.

Figure B-43. Ratio of Water-Reflected to Unreflected Spherical Critical Volumes vs Reflector Thickness for Enriched Uranium (Fig. 45 from LA-10860)

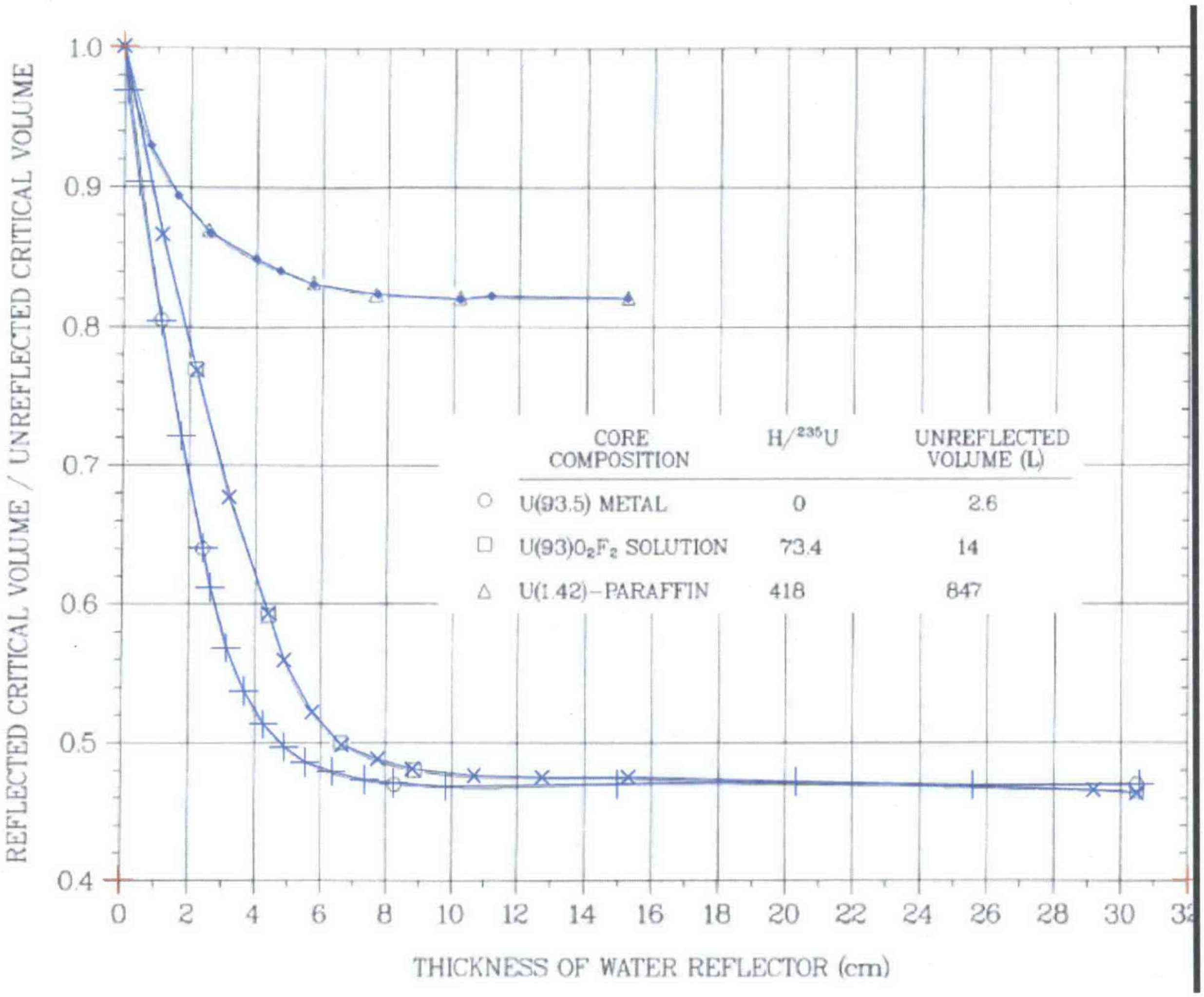


Figure B-44. Critical Masses of Unreflected Spheres of U(93) Diluted with Various Moderators (Fig. 46 from LA-10860)

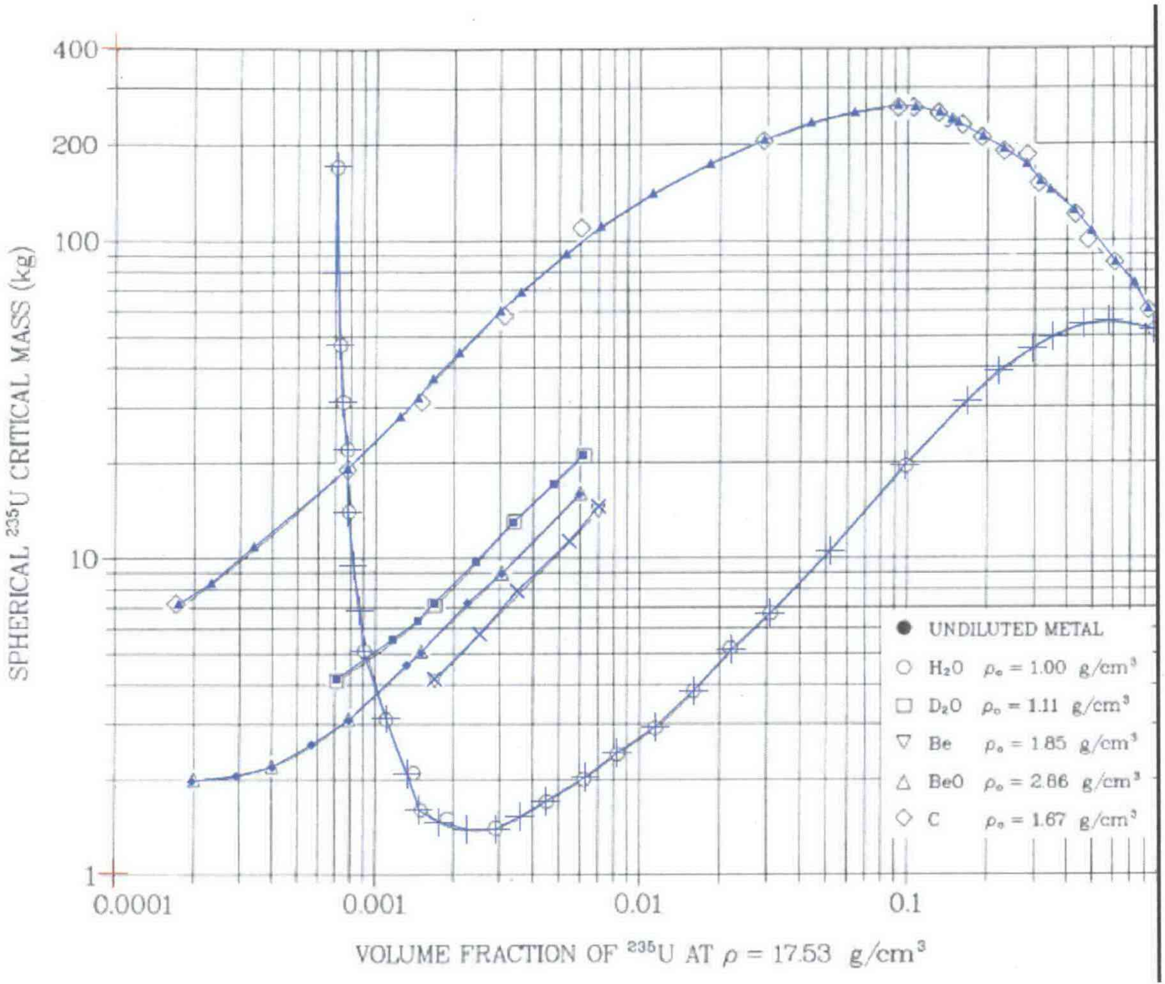


Figure B-45. Critical Heights of Cylindrical Annuli Containing $U(93)O_2F_2$ Solution at $H/^{235}U = 50.4$ as Functions of Thickness and Outside Diameter of Solution Annulus (Fig. 47 from LA-10860)

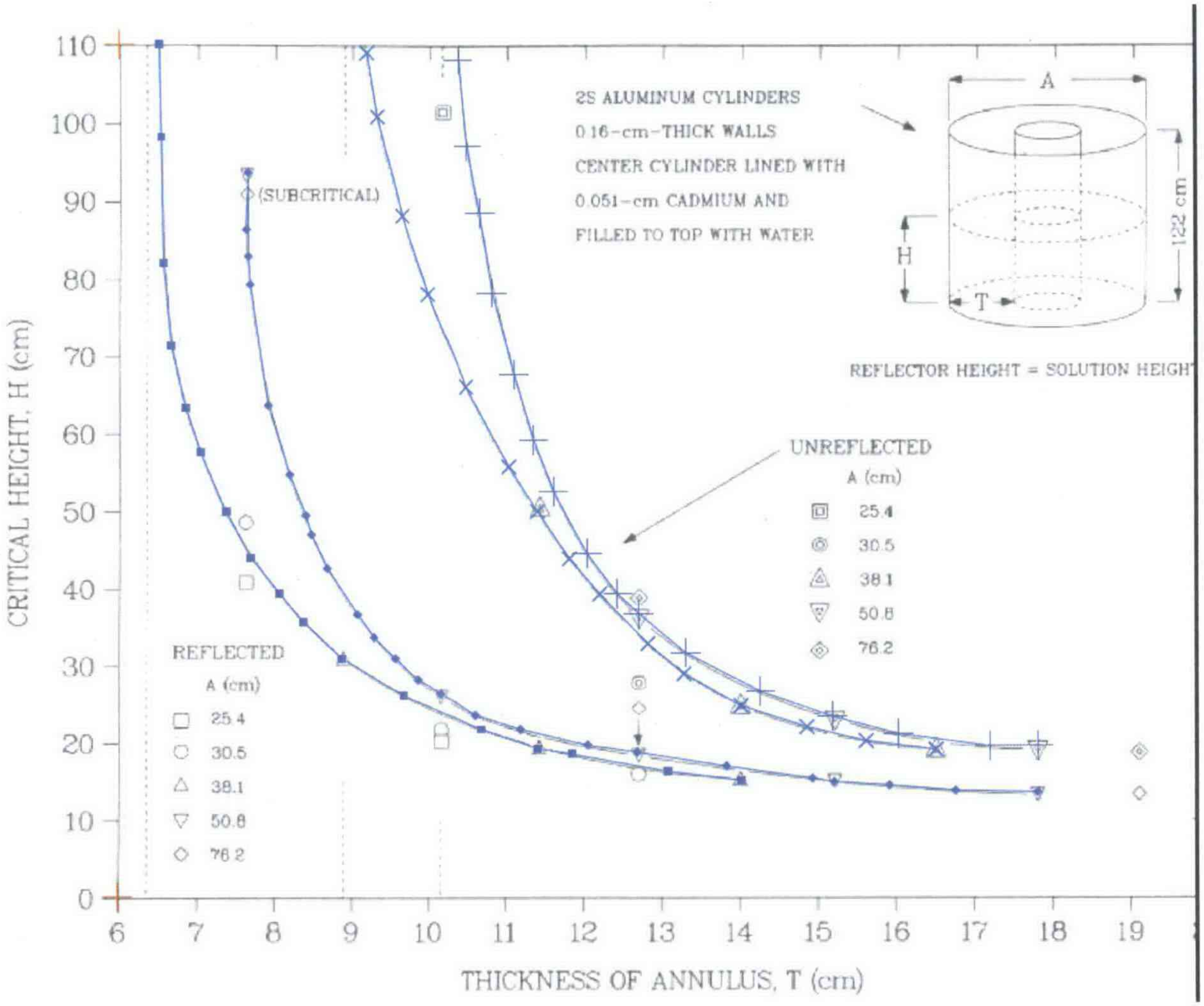


Figure B-46. Critical Heights of Cylindrical Annuli Containing $U(93)O_2F_2$ Solution at $H/^{235}U = 309$ as Functions of Thickness and Outside Diameter of Solution Annulus (Fig. 48 from LA-10860)

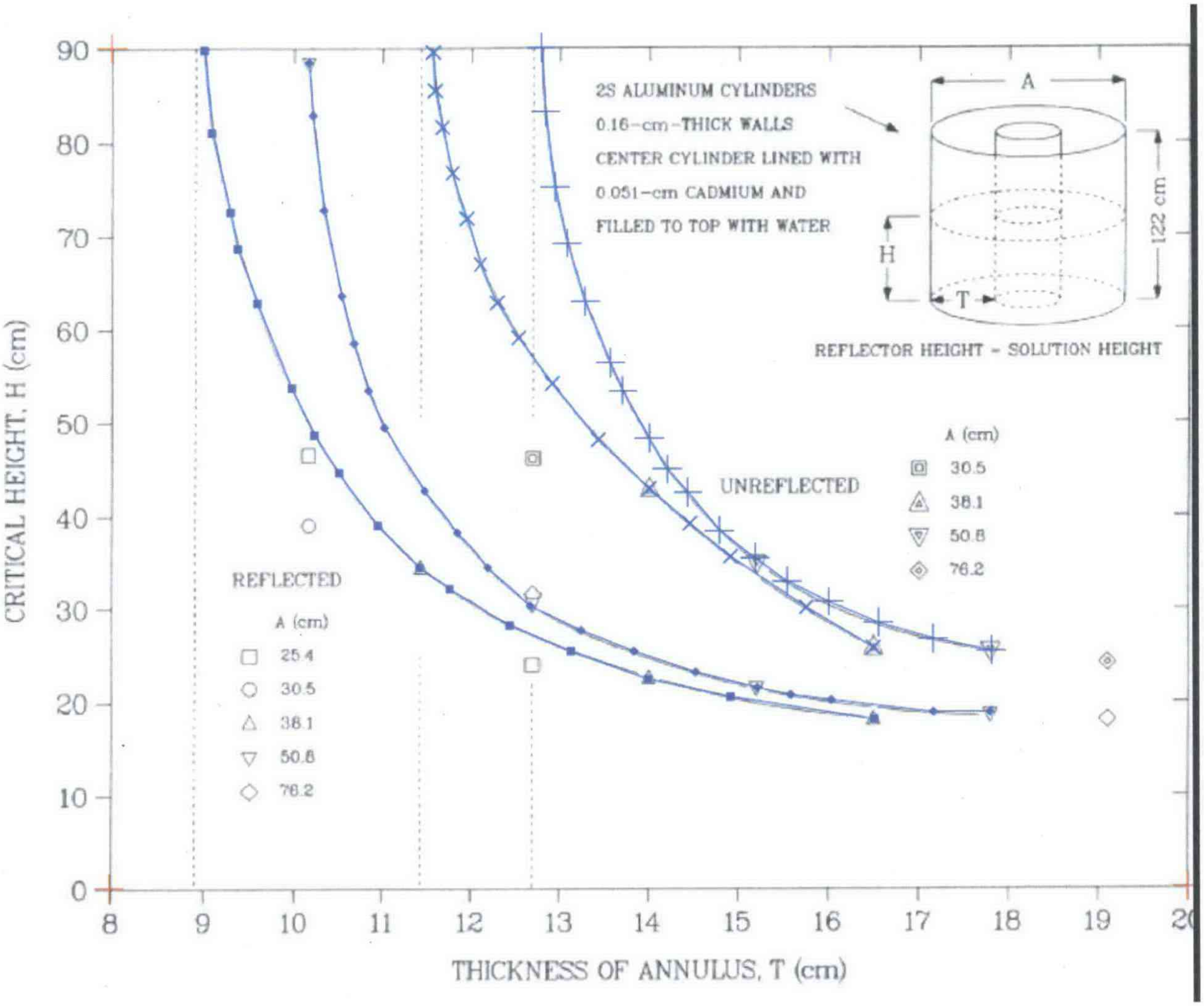
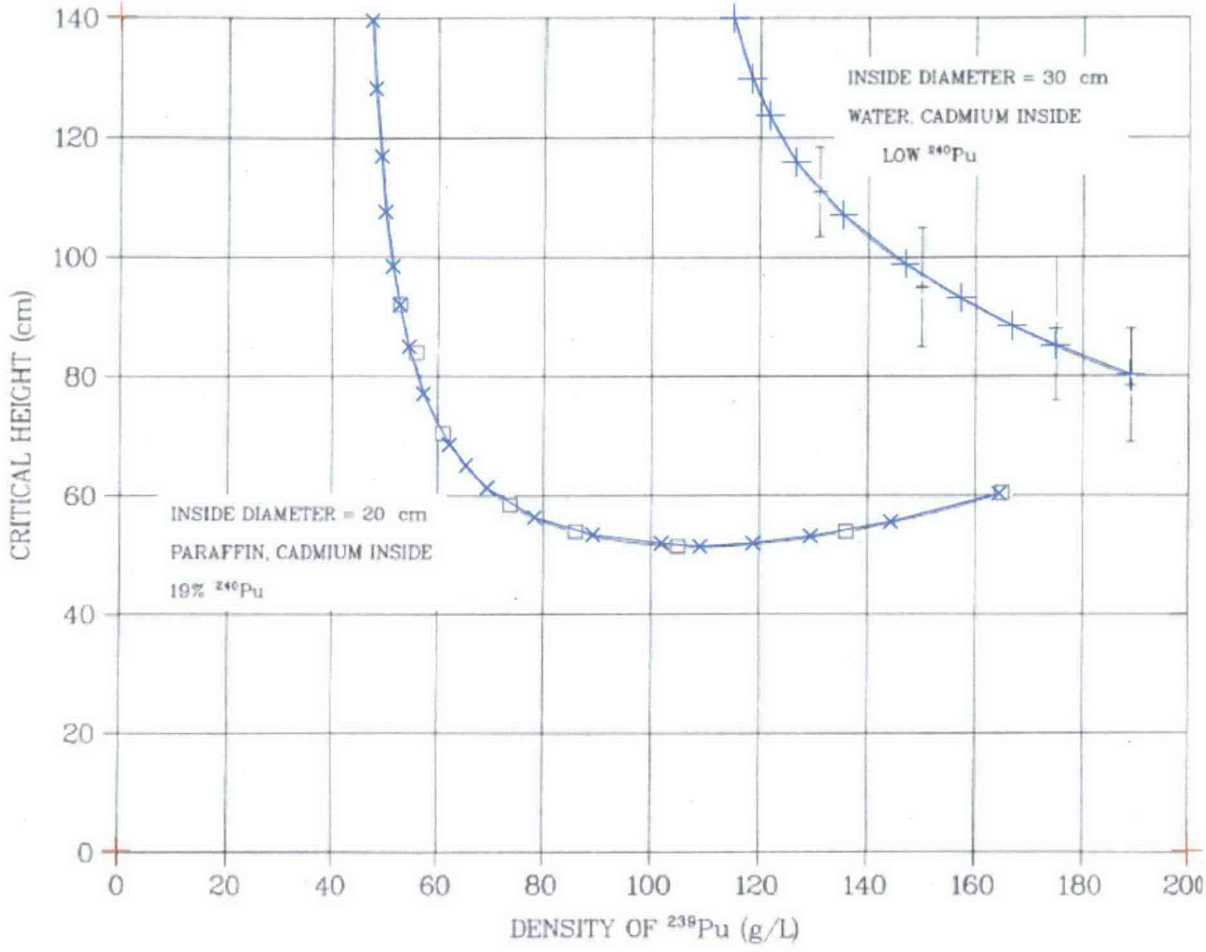
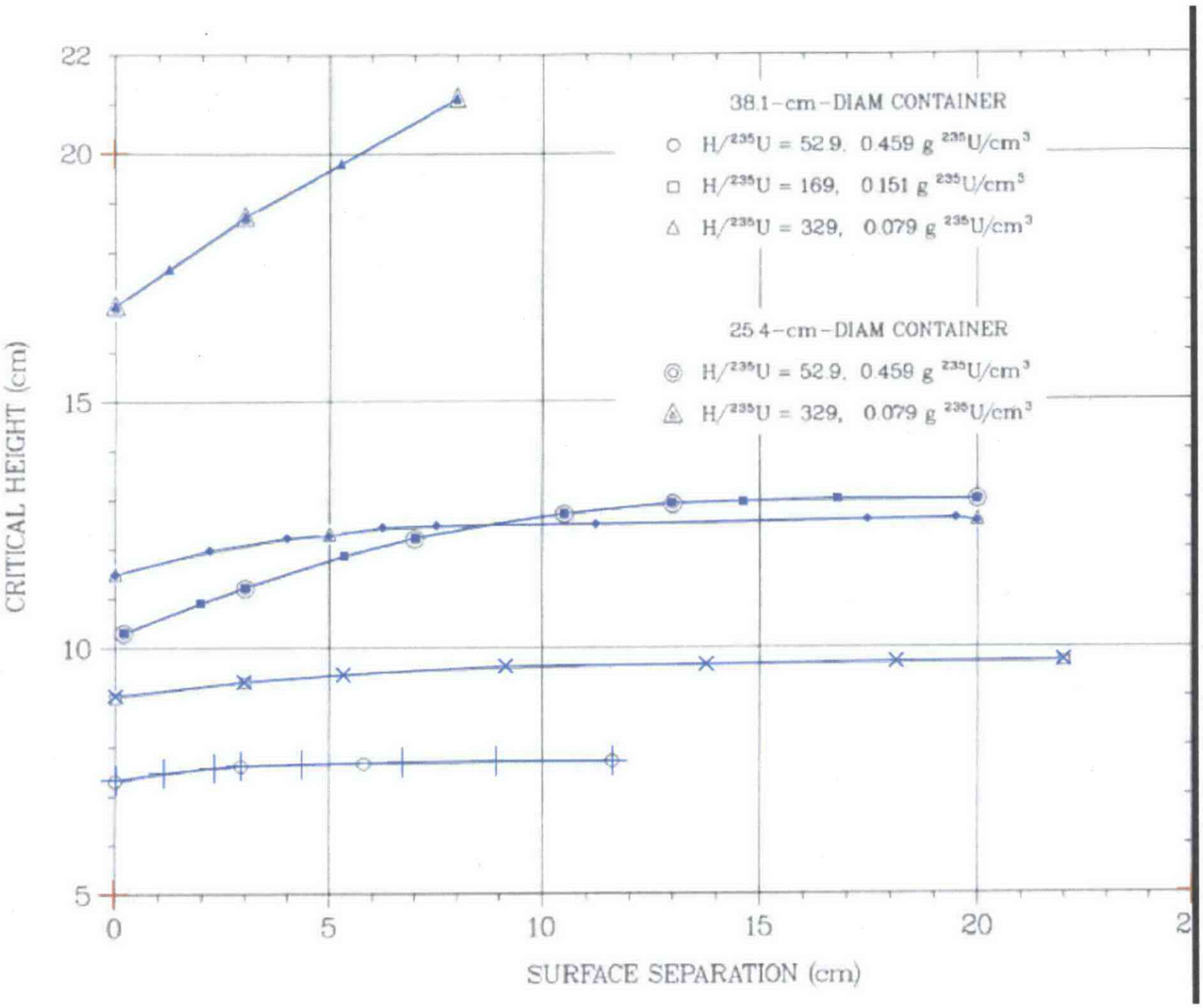


Figure B-47. Critical Heights of Plutonium Solution as Function of Plutonium Density in 50-cm-o.d. Annuli, Water-Reflected to Height of Solution (Fig. 49 from LA-10860)



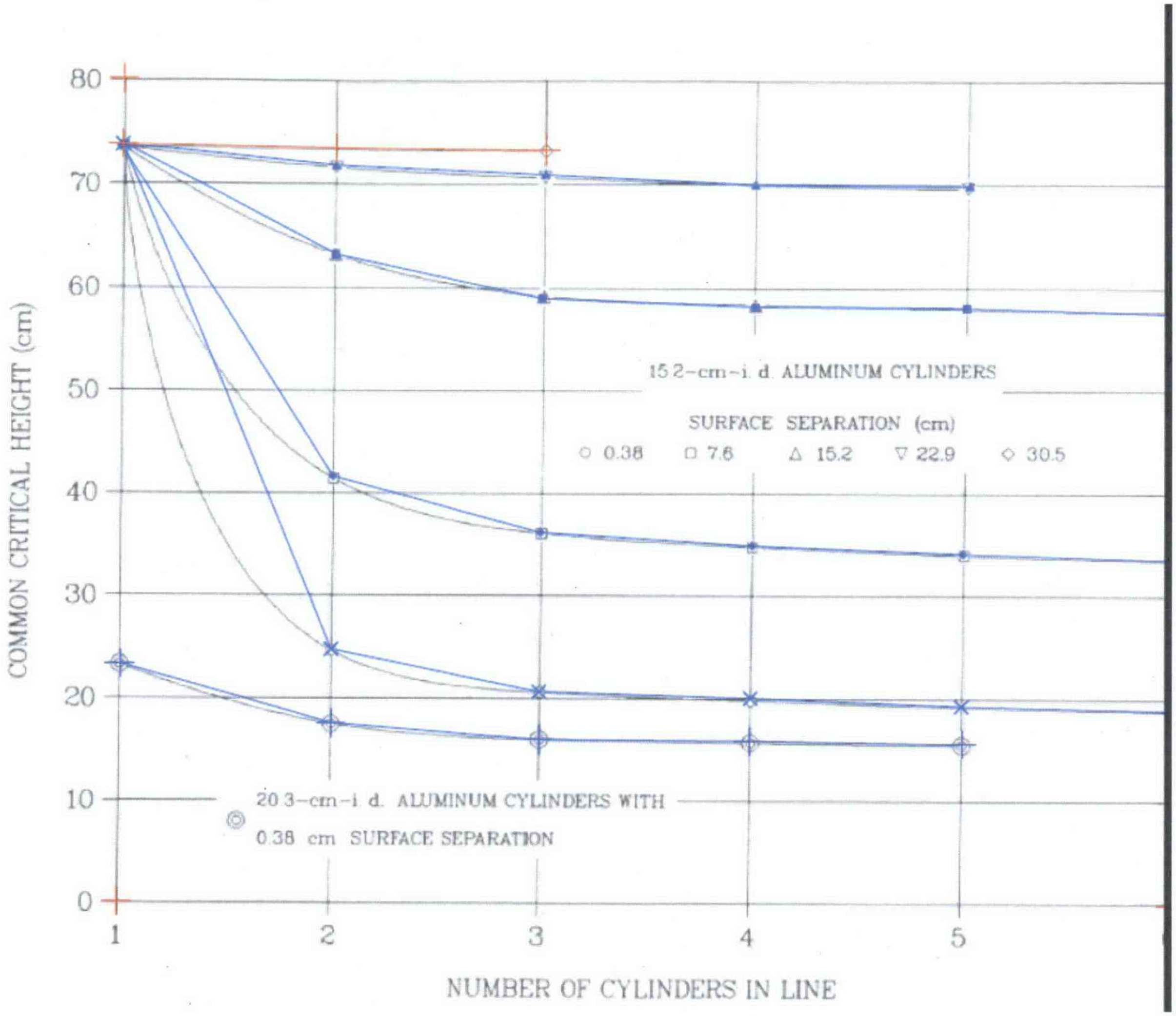
4

Figure B-48. Common Critical Height of Two Interacting U(93.4)O_2F_2 Solution Cylinders In Water (Fig. 50 from LA-10860)



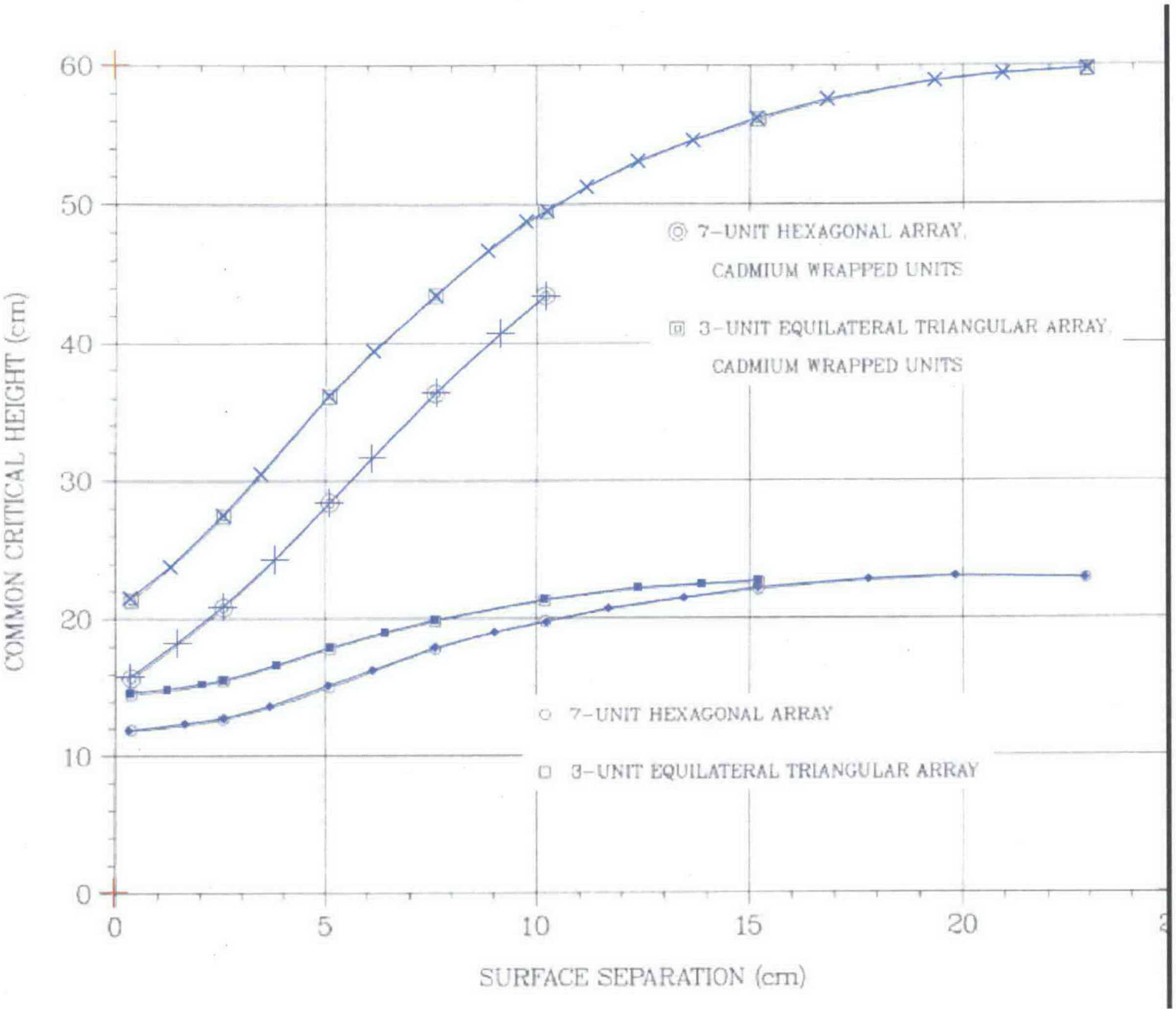
Aluminum containers with 0.15-cm walls.

Figure B-49. Common Critical Height of Interacting In-line $U(93.4)O_2F_2$ Solution Cylinders In Water, $H/^{235}U = 44.3$, 0.533 g $^{235}U/cm^3$ (Fig. 51 from LA-10860)



Aluminum containers with 0.15-cm walls.

Figure B-50. Common Critical Height of Planar Arrays of Three-and Seven-Unit Triangular Patterns of $U(93.4)O_2F_2$ Solution Cylinders In Water, $H/^{235}U$ = 44.3, 0.538 g $^{235}U/cm^3$, 20.3-cm-i.d. (Fig. 52 from LA-10860)



Aluminum Containers with 0.15-cm Walls

Figure B-51. Common Critical Height of Two Interacting U(93.2)O_2F_2 Solution Cylinders In Air, $H/^{235}U$ = 329, 0.0787 g $^{235}U/cm^3$ (Fig. 53 from LA-10860)

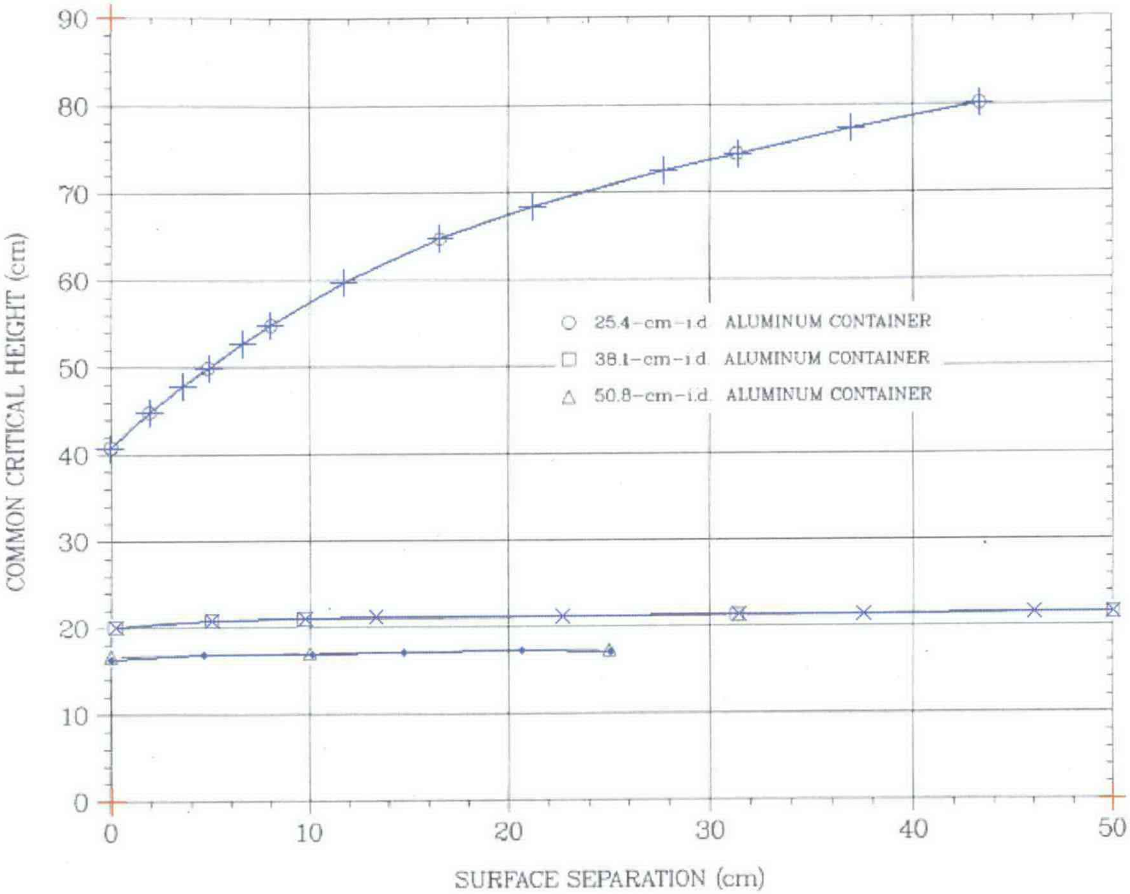
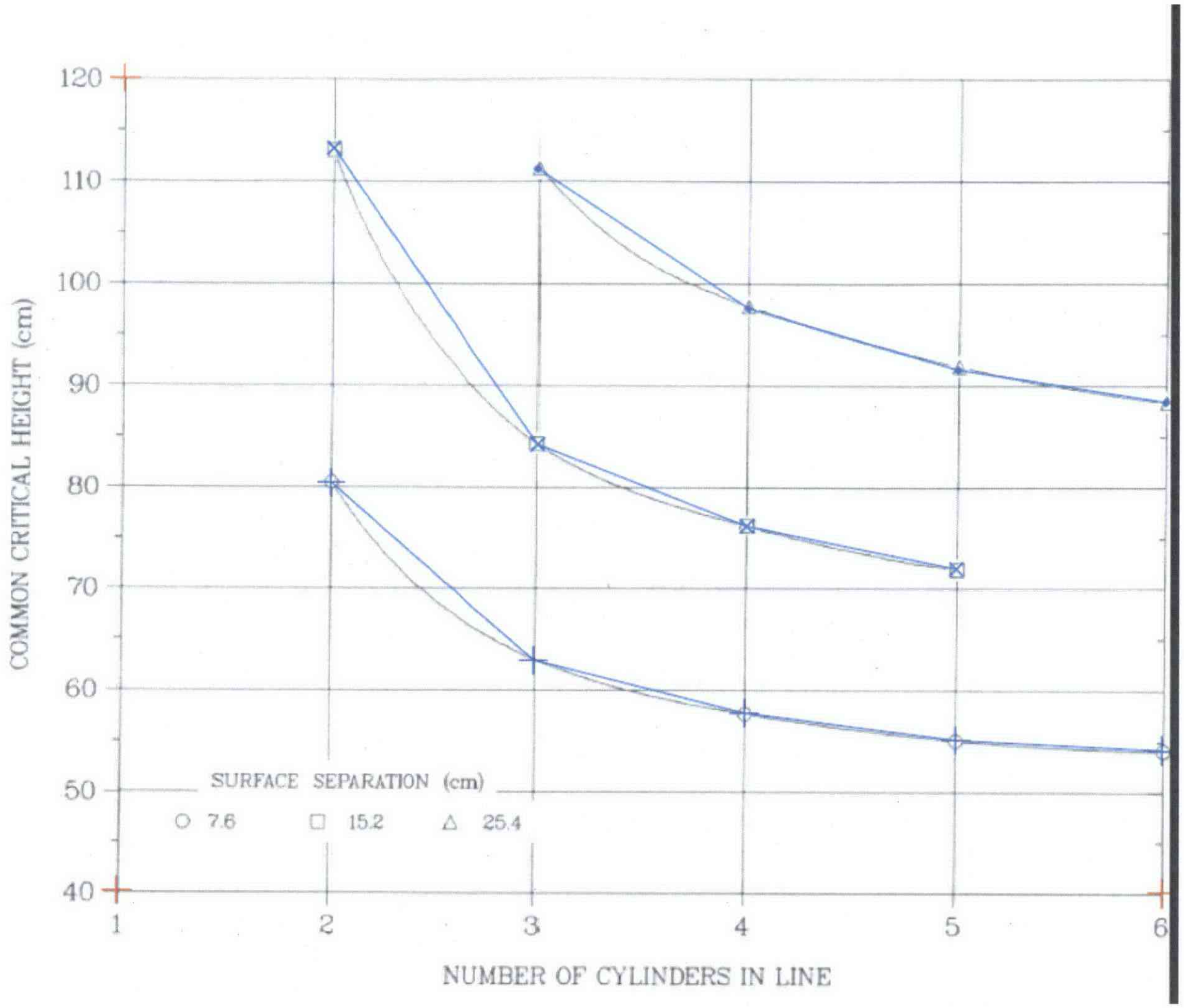


Figure B-52. Common Critical Height of Interacting In-Line $U(93.2)O_2F_2$ Solution Cylinders In Air, $H/^{235}U = 297$, 0.087 g $^{235}U/cm^3$, 24.1-cm-i.d. (Fig. 54 from LA-10860)



Aluminum containers with 0.15-cm-thick walls

Figure B-53. Common Critical Height of Two and Three Parallel $U(93.2)O_2F_2$ Solution Slabs In Air, 0.32-cm-thick Aluminum Containers (Fig. 57 from LA-10860)

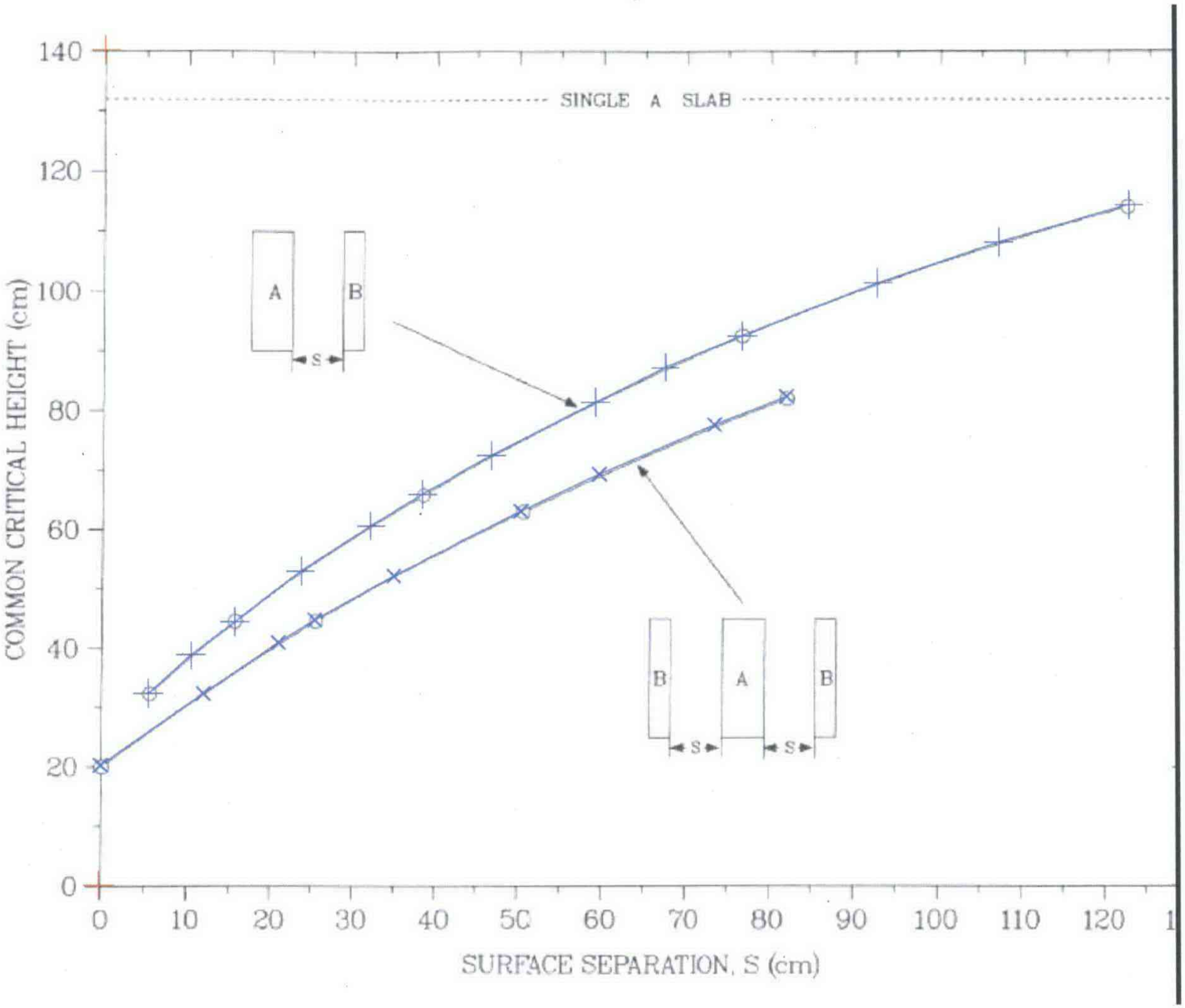


Figure B-54. Common Critical Height of Two and Three Parallel $U(93.2)O_2F_2$ Solution Slabs In Air, $H/^{235}U = 337$, 0.076 g $^{235}U/cm^3$, 0.32-cm-thick Aluminum Containers (Fig. 58 from LA-10860)

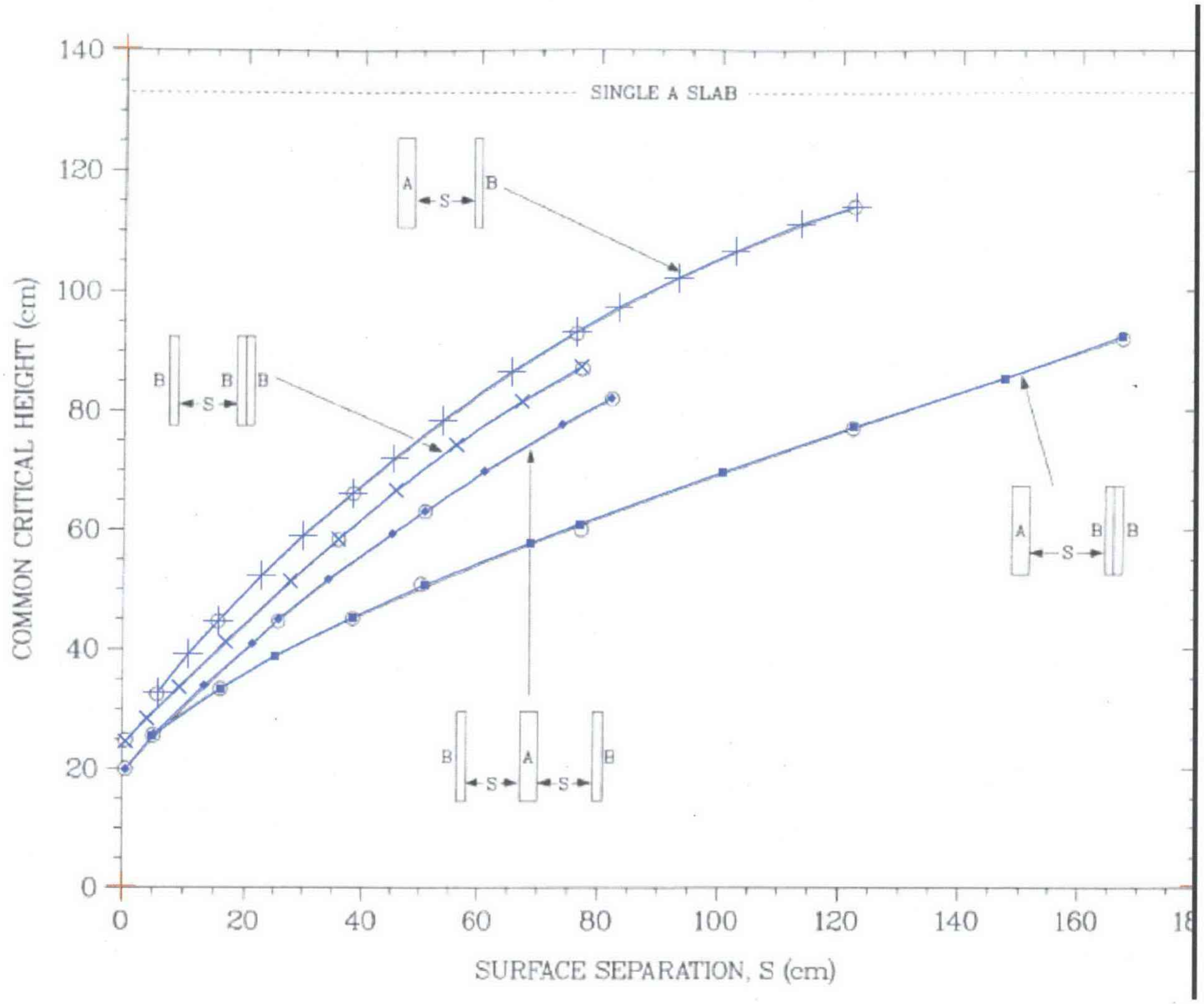
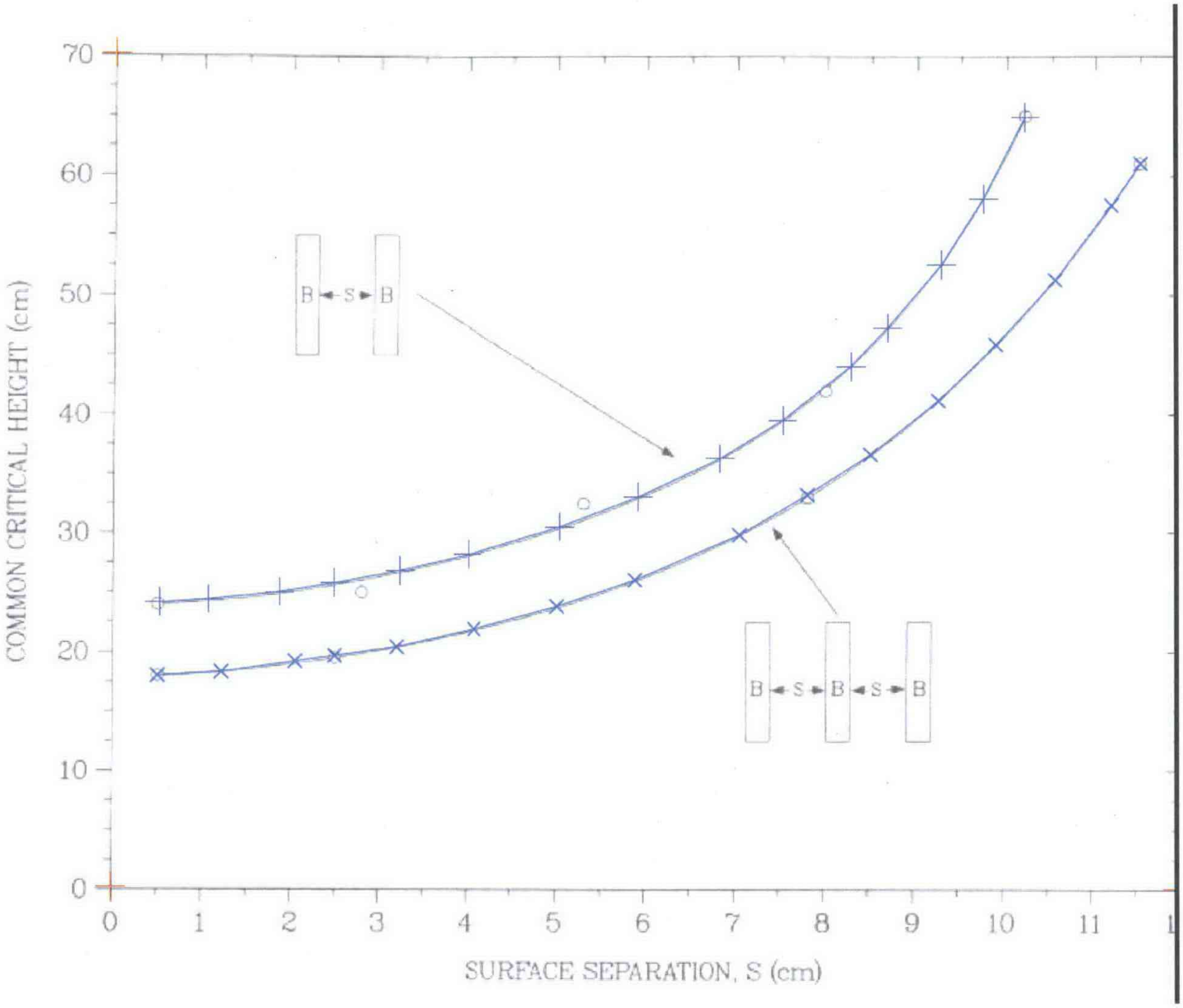


Figure B-55. Common Critical Height of Two and Three Parallel $U(93.2)O_2F_2$ Solution Slabs In Water, $H/^{235}U = 337$, 0.076 g $^{235}U/cm^3$ (Fig. 59 from LA-10860)



Aluminum containers with 0.32-cm-thick walls and 120.6-cm-wide by 7.6-cm-thick inside dimensions. Reflection consisted of immersion to height of solution.

Figure B-56. Common Critical Height of Two Parallel U(93.2)O_2F_2 Solution Slabs In Partial Water Reflection, 0.32-cm-thick Aluminum Containers (Fig. 60 from LA-10860)

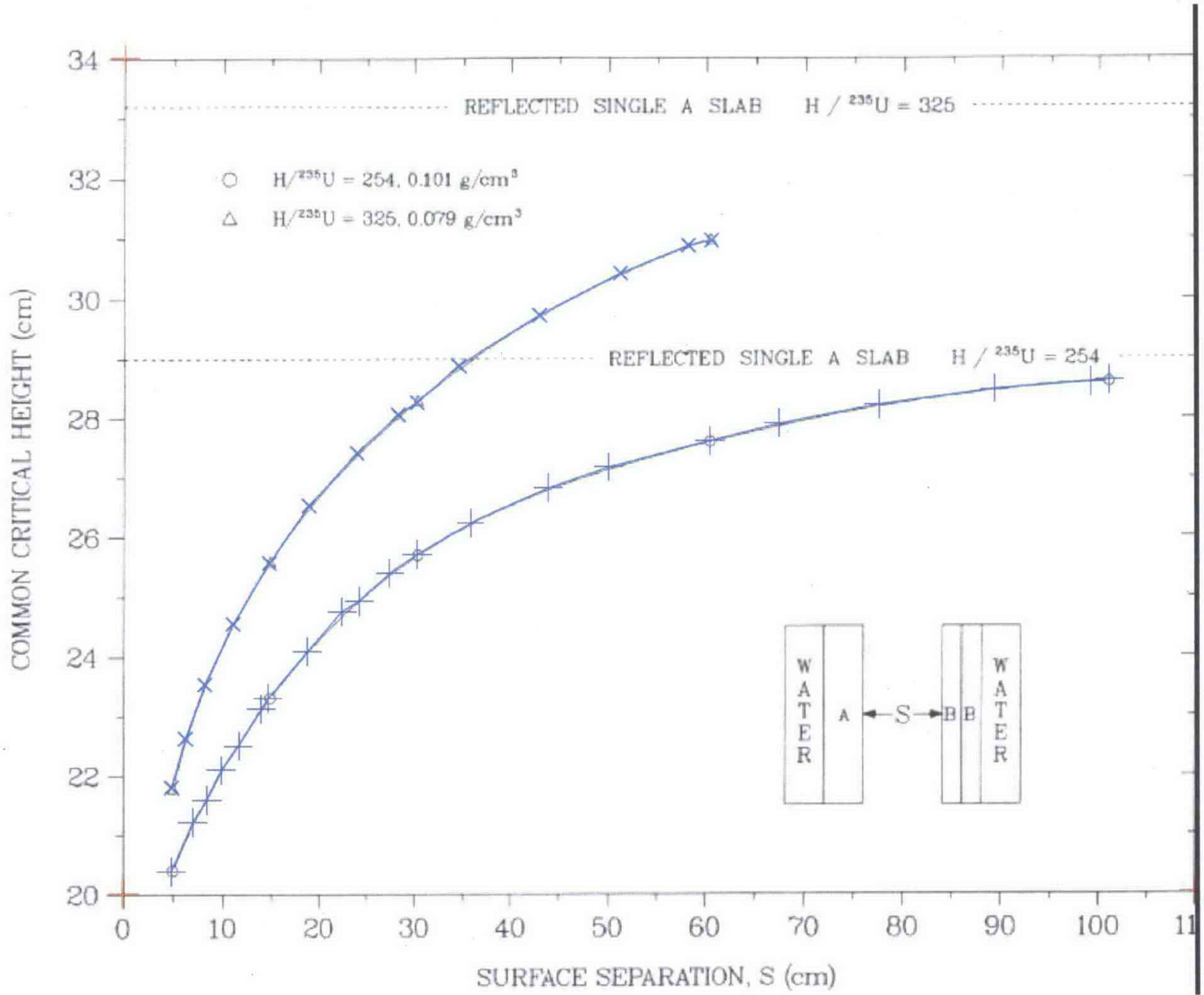


Figure B-57. Common Critical Heights of Pairs of Perpendicular $U(93.2)O_2F_2$ Solution Slabs In Air; $H/^{235}U = 325$, 0.079 g $^{235}U/cm^3$ Solution; 0.32-cm-thick Aluminum Containers (Fig. 61 from LA-10860)

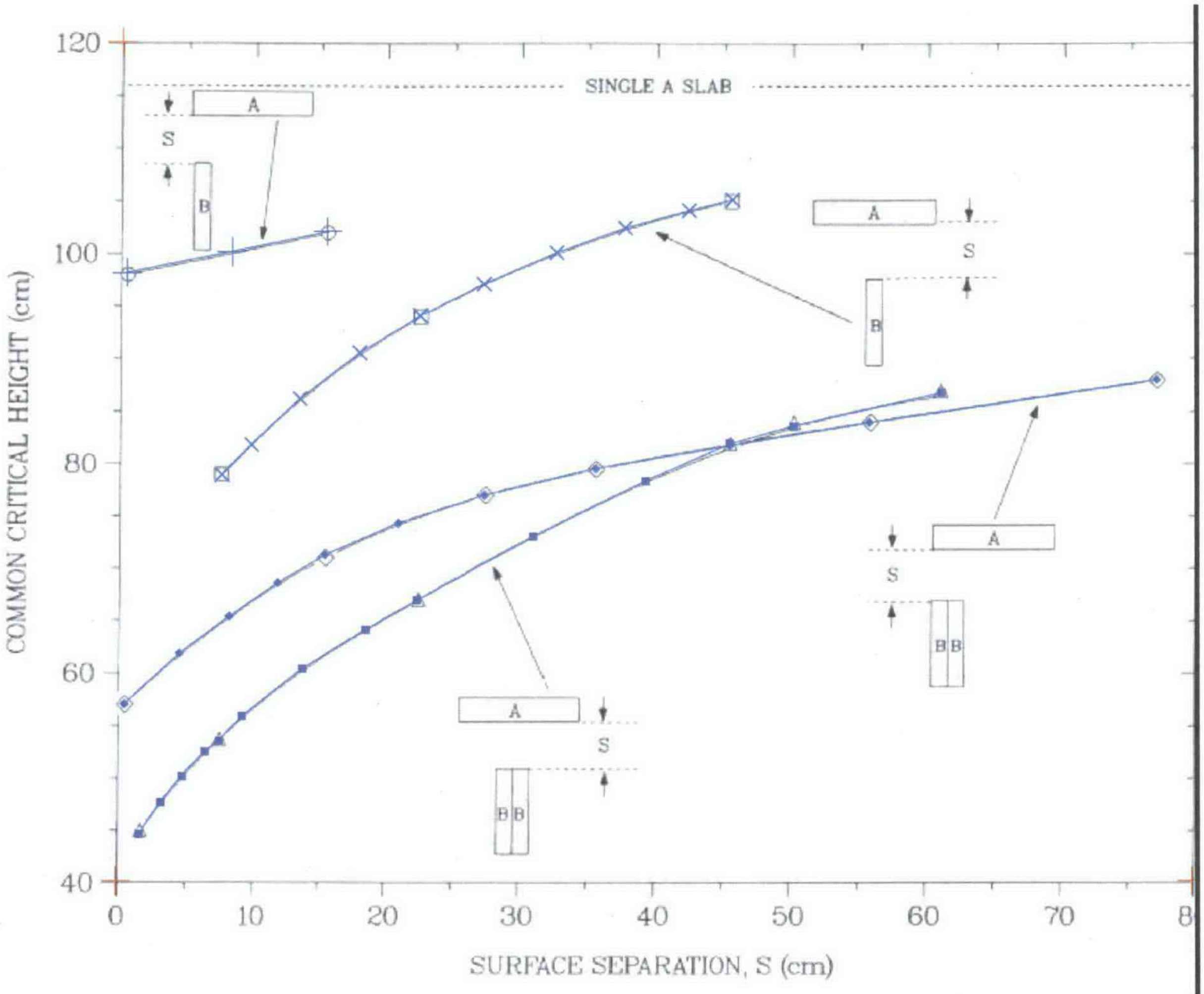


Figure B-58. Common Critical Heights of Two Parallel U(93.2)O_2F_2 Solution Slabs Separated By Plexiglas; $H/^{235}U$ = 293, 0.88 g $^{235}U/cm^3$; 0.32-cm-thick Aluminum Containers (Fig. 62 from LA-10860)

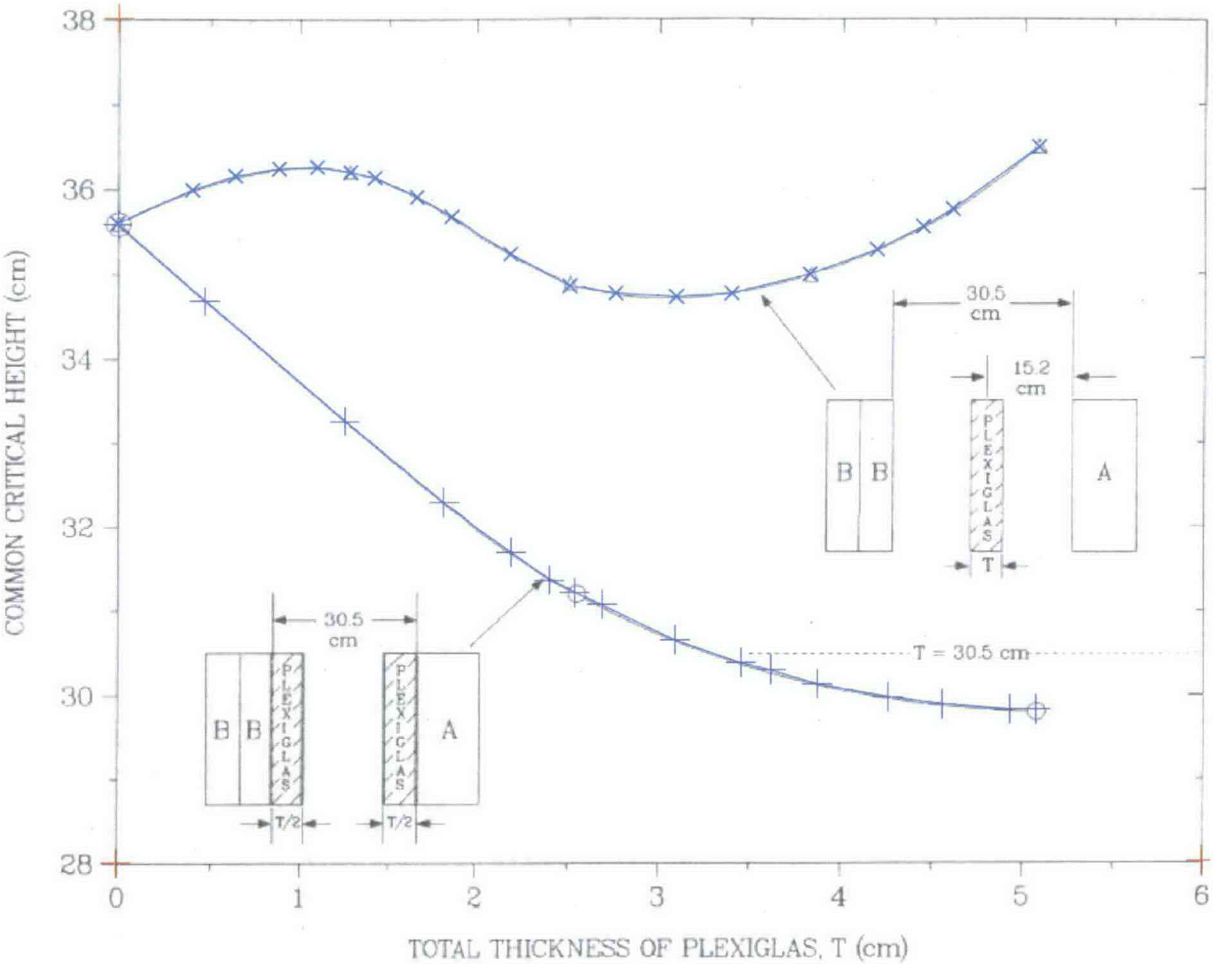


Figure B-59. Common Critical Height of Parallel $U(93.2)O_2F_2$ Solution Slabs and Cylinder, Unreflected and with Partial Water Reflection; $H/^{235}U = 331$, 0.078 g $^{235}U/cm^3$ (Fig. 63 from LA-10860)

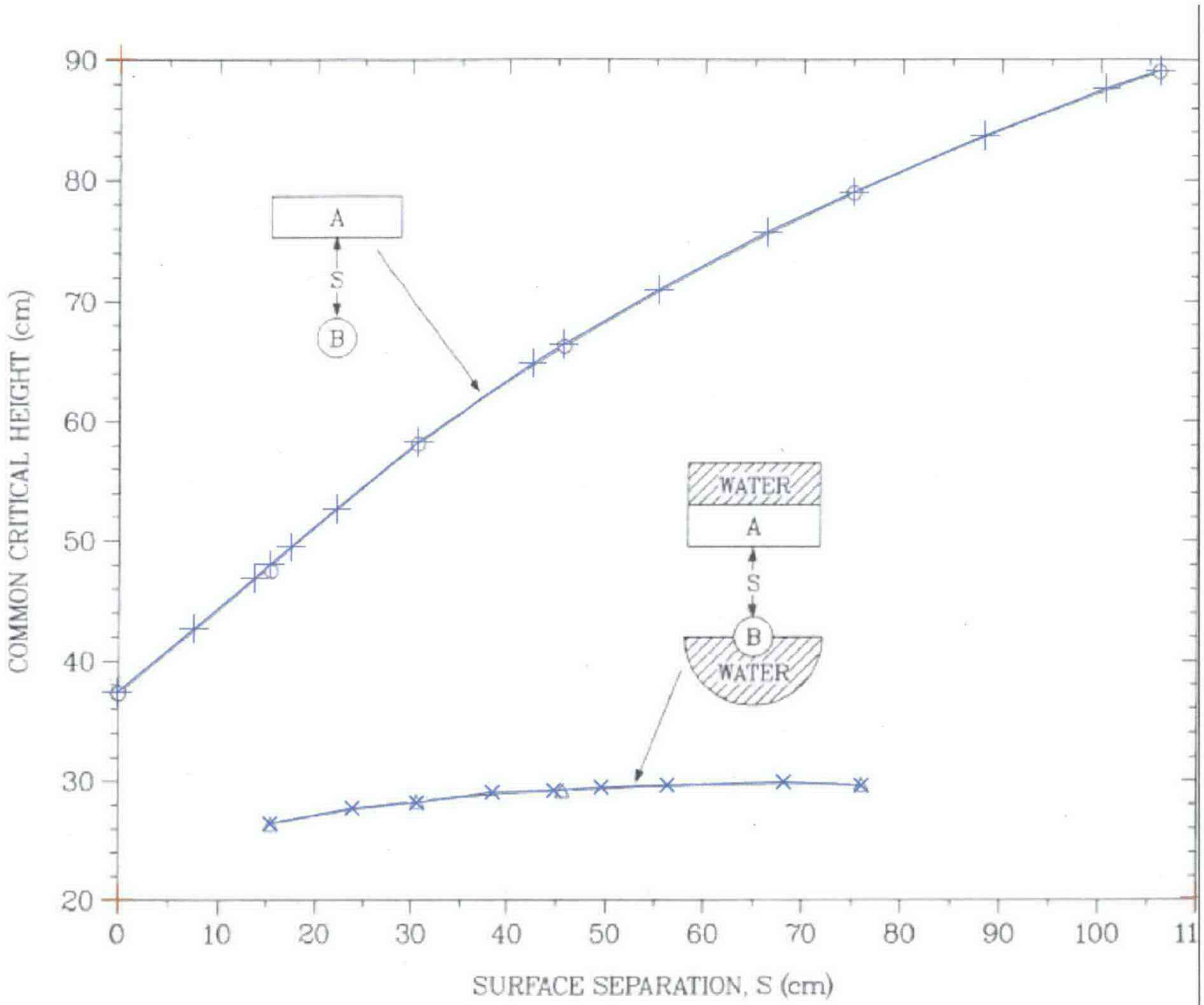
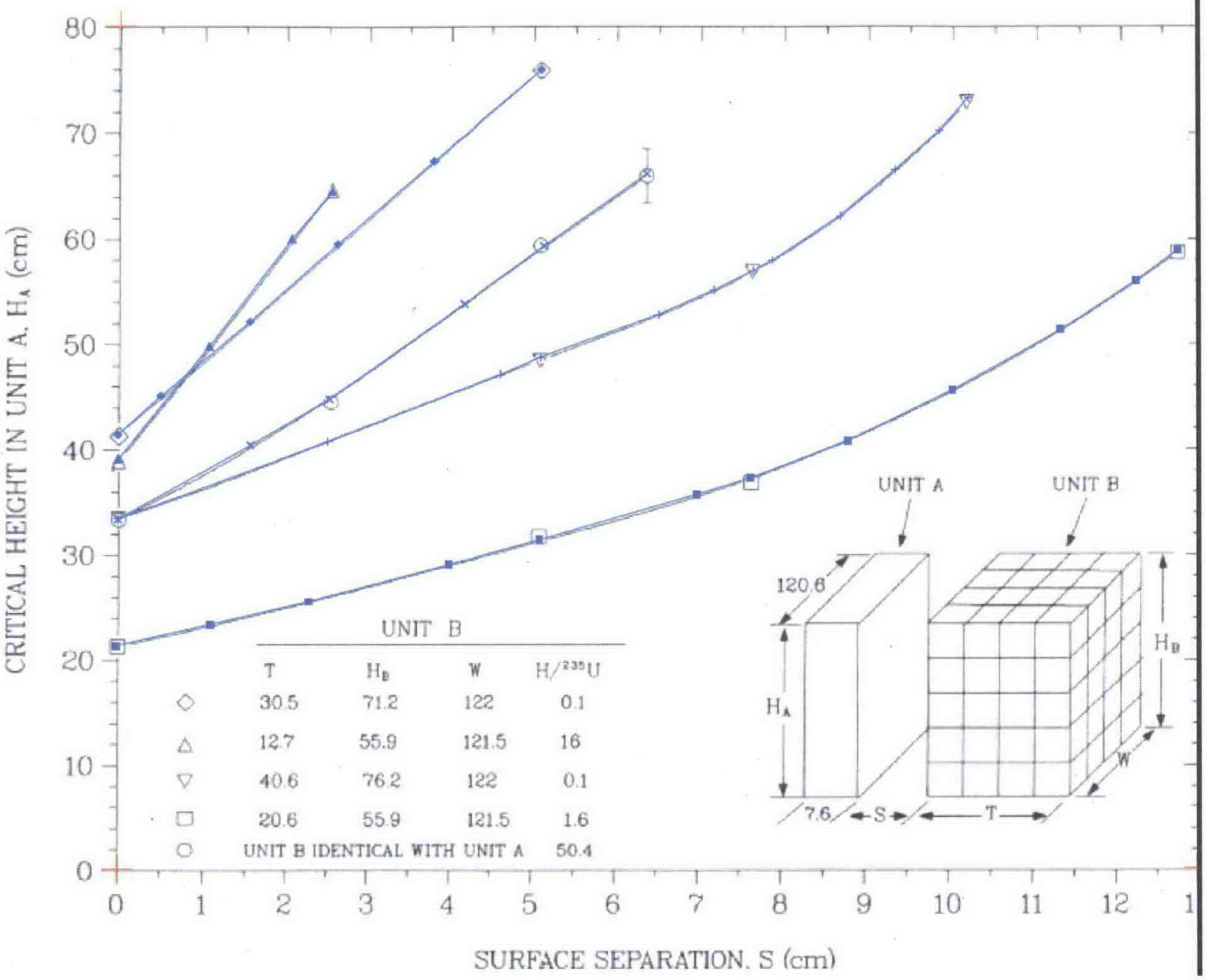
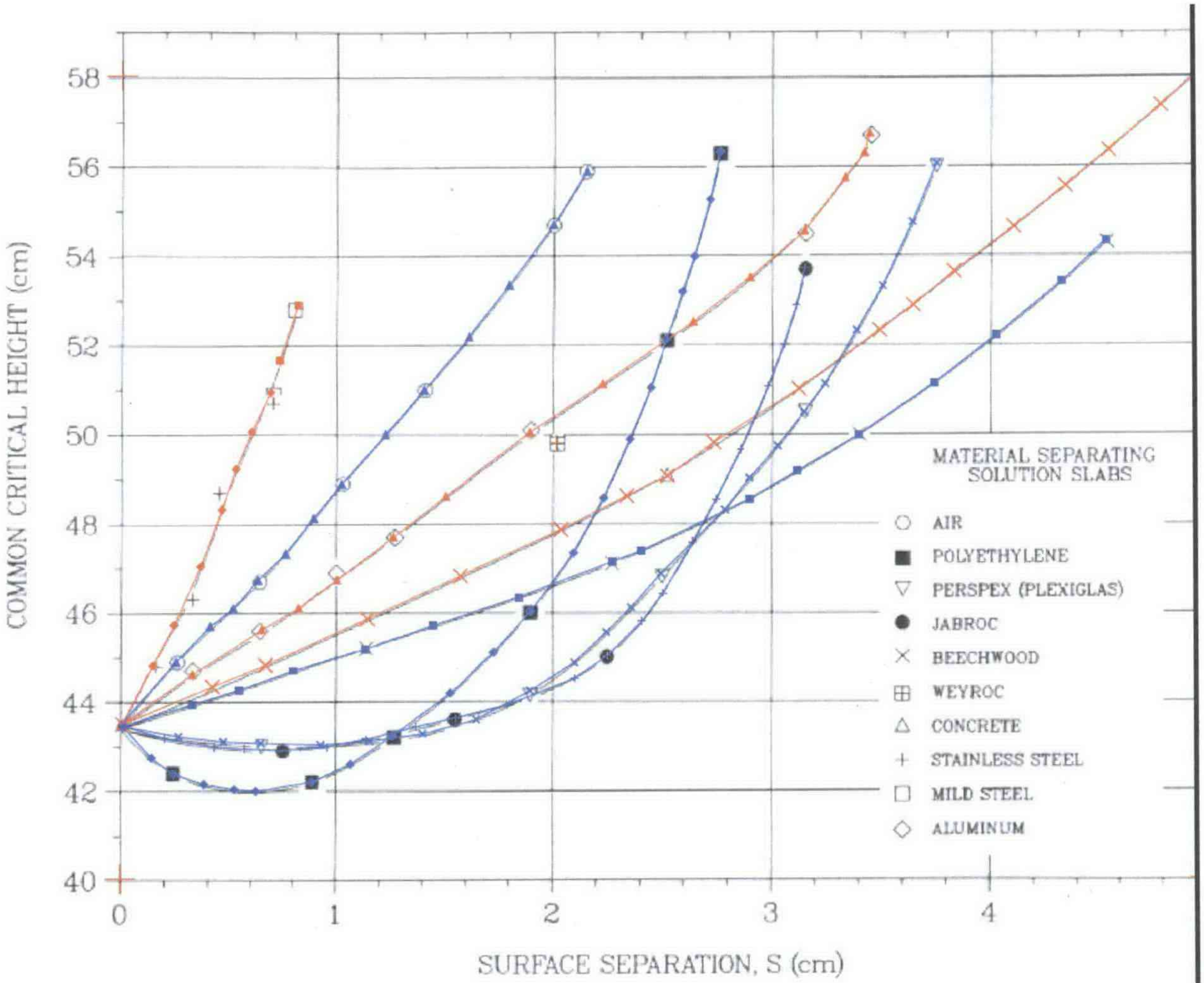


Figure B-60. Critical Height of A $U(93.2)O_2F_2$ Solution Slab Interacting With A Parallel Slab of $U(37)F_4$-CF_2 Blocks in Air (Fig. 64 from LA-10860)



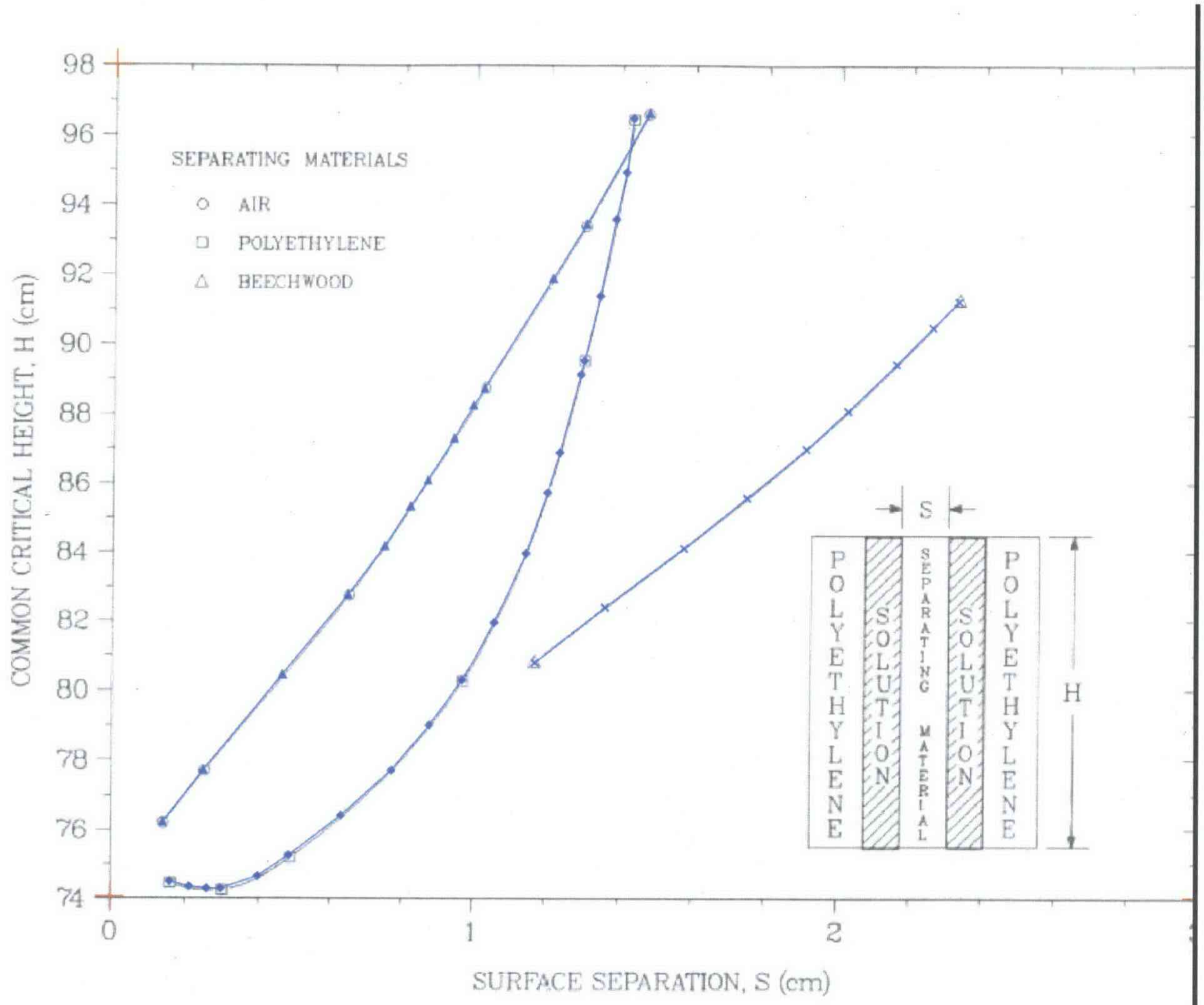
Unit A was solution in 0.32-cm-thick aluminum container. All dimensions in cm.

Figure B-61. Common Critical Height of Two Parallel $U(30.45)O_2F_2$ Solution Slabs With Thick Polyethylene Reflectors On Outer Faces and Separated by Various Materials; $H/^{235}U$ = 130, 0.182 g $^{235}U/cm^3$ (Fig. 65 from LA-10860)



Slabs 120-cm wide by 6.1-cm thick. Jabroc is a wood product containing about 45% carbon, 6% hydrogen, and 37% oxygen, at a density of 1.32 g/cm^3. Weyroc is also a wood product with a density of 0.72 g/cm^3.

Figure B-62. Common Critical Height of Two Parallel U(30.45)O_2F_2 Solution Slabs With Thick Polyethylene Reflectors On Outer Faces and Separated by Air, Polyethylene, or Beechwood; H/^{235}U = 214, 0.117 g ^{235}U/cm^3 Solution (Fig. 66 from LA-10860)



Slabs 120-cm wide by 6.1 thick.

Figure B-63. Total Critical Mass of Two Identical U(30.14)O_2-Paraffin Parallelepipeds With External Polyethylene Reflection and Separated By Air; H/^{235}U = 81.8, 0.331 g ^{235}U/cm^3 (Fig. 67 from LA-10860)

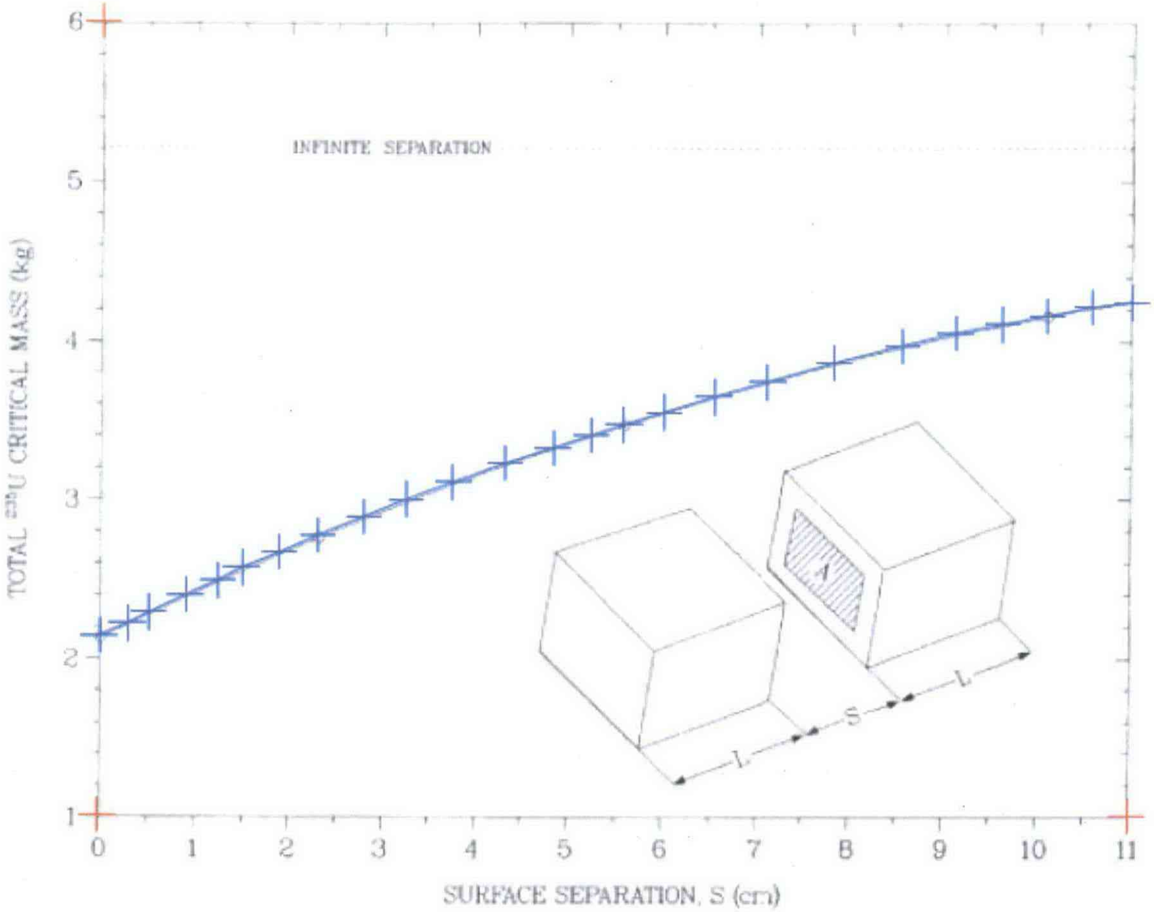


Figure B-64. Total Critical Mass of Two Identical U(1.42)F_4-Paraffin Parallelepipeds With 20.3-cm-thick Polyethylene Reflector Except on Facing Areas (Fig. 68 from LA-10860)

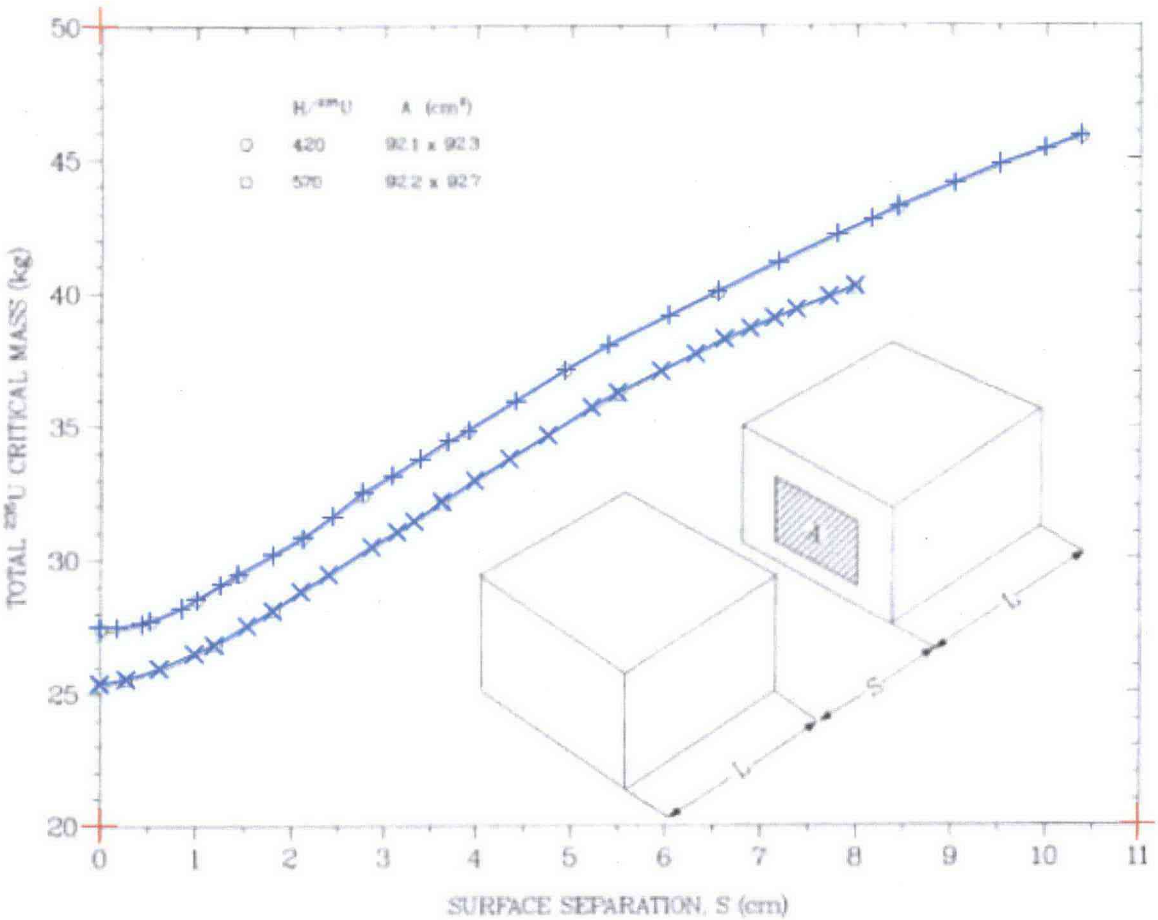
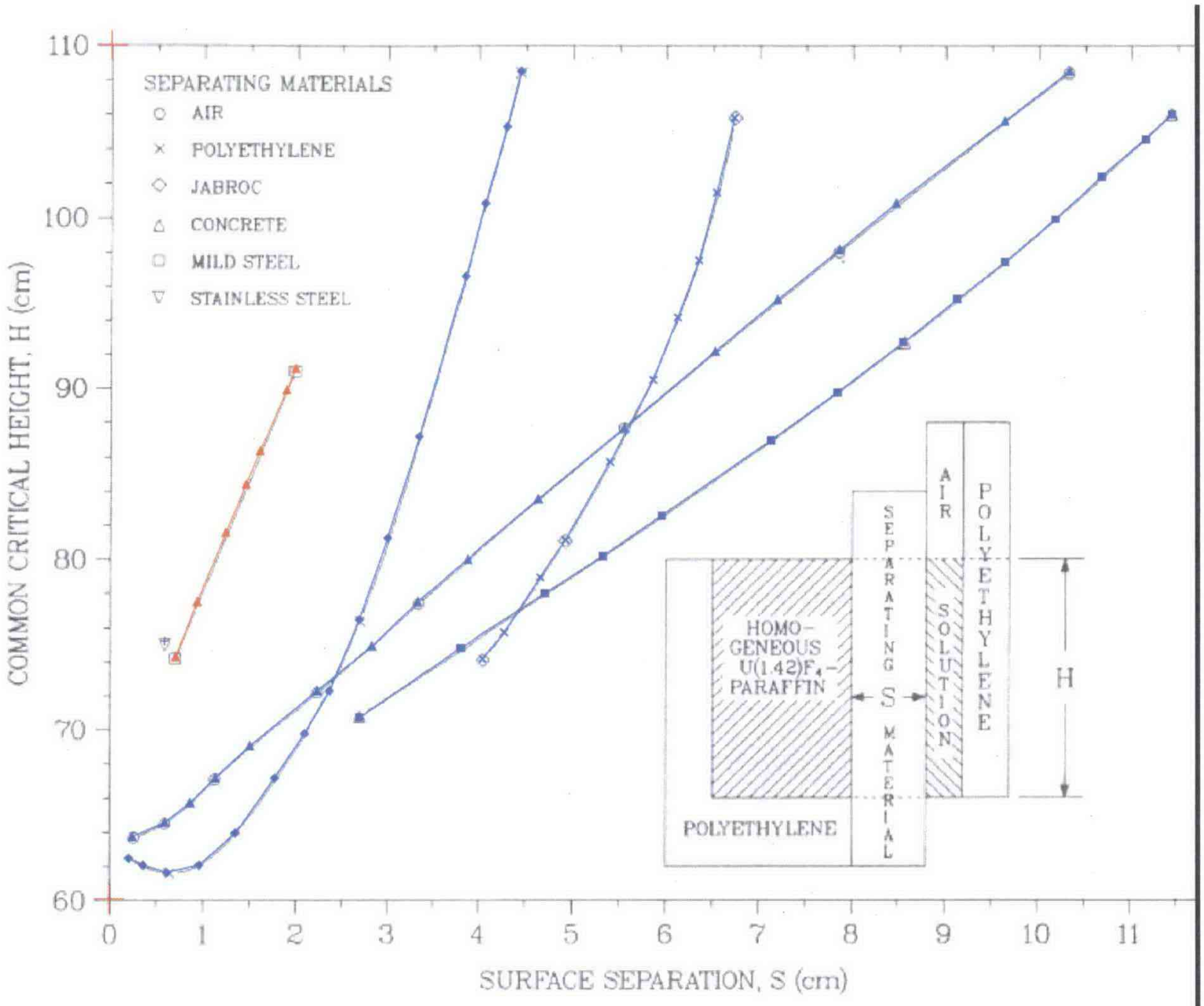


Figure B-65. Common Critical Heights of A U(30.45)O_2F_2 Solution Slab and A Facing U(1.42)F_4-Paraffin Parallelepiped, External Polyethylene Reflectors, and Various Materials Between components (Fig. 69 from LA-10860)



Solution at H/^{235}U = 112, 0.204 g ^{235}U/cm^3 in the 6.09-cm-thick by 120-cm-wide slab. Parallelepiped 62-cm thick and 123-cm wide.

Figure B-66. Common Critical Heights of Two, Three, or Four Unreflected $Pu(NO_3)_4$ Solution cylinders at 0.146 g/cm^3 of ^{239}Pu + ^{241}Pu; 30-cm-o.d. Stainless-Steel Containers With 0.3-cm-thick Walls (Fig. 70 from LA-10860)

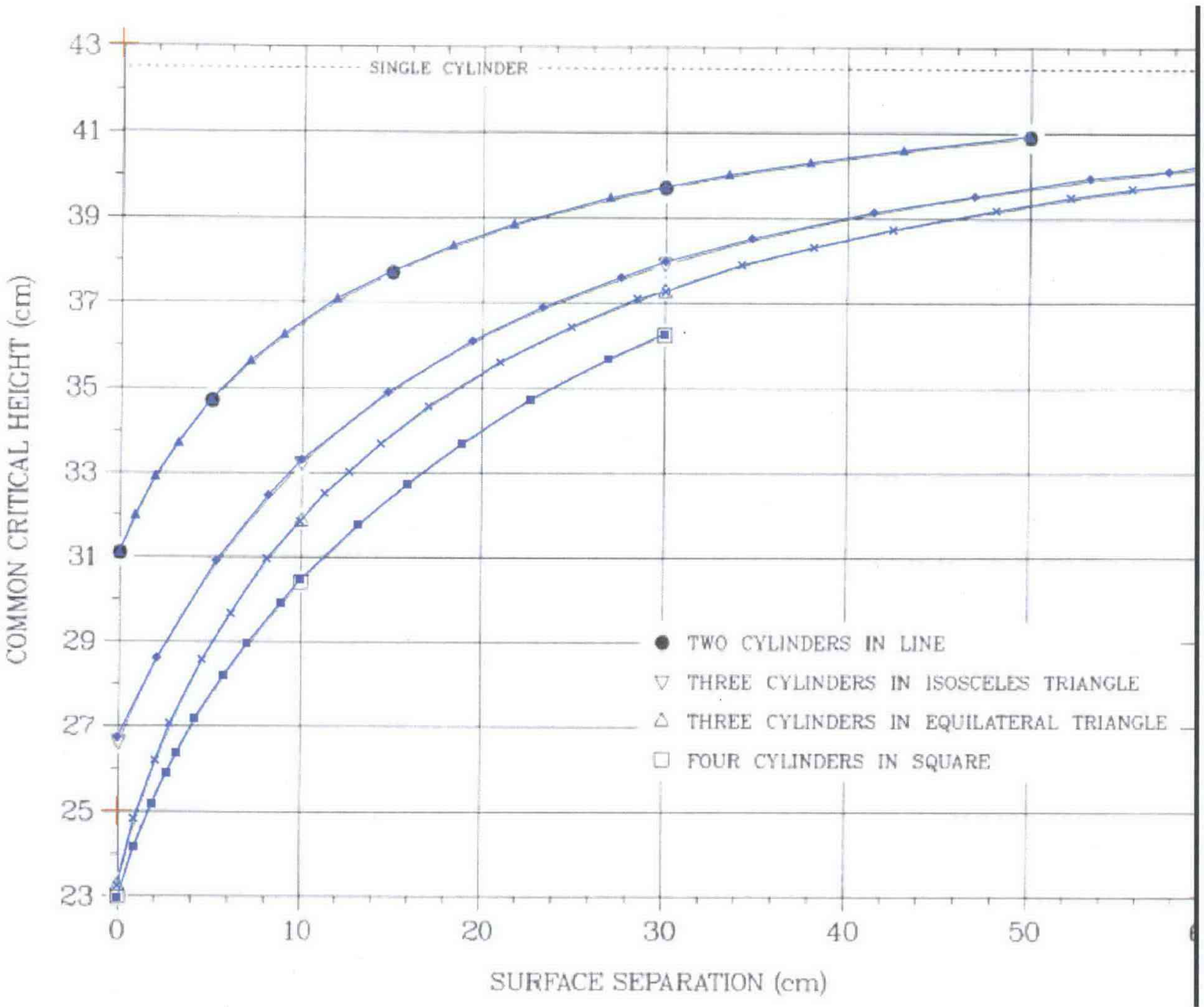


Figure B-67. Common Critical Heights of Two, Three, or Four Unreflected $Pu(NO_3)_4$ Solution Cylinders or Two $U(90)O_2(NO_3)_2$ Solution Cylinders; Concentration of Fissile Element = 0.110 g/cm^3 (Fig. 71 from LA-10860)

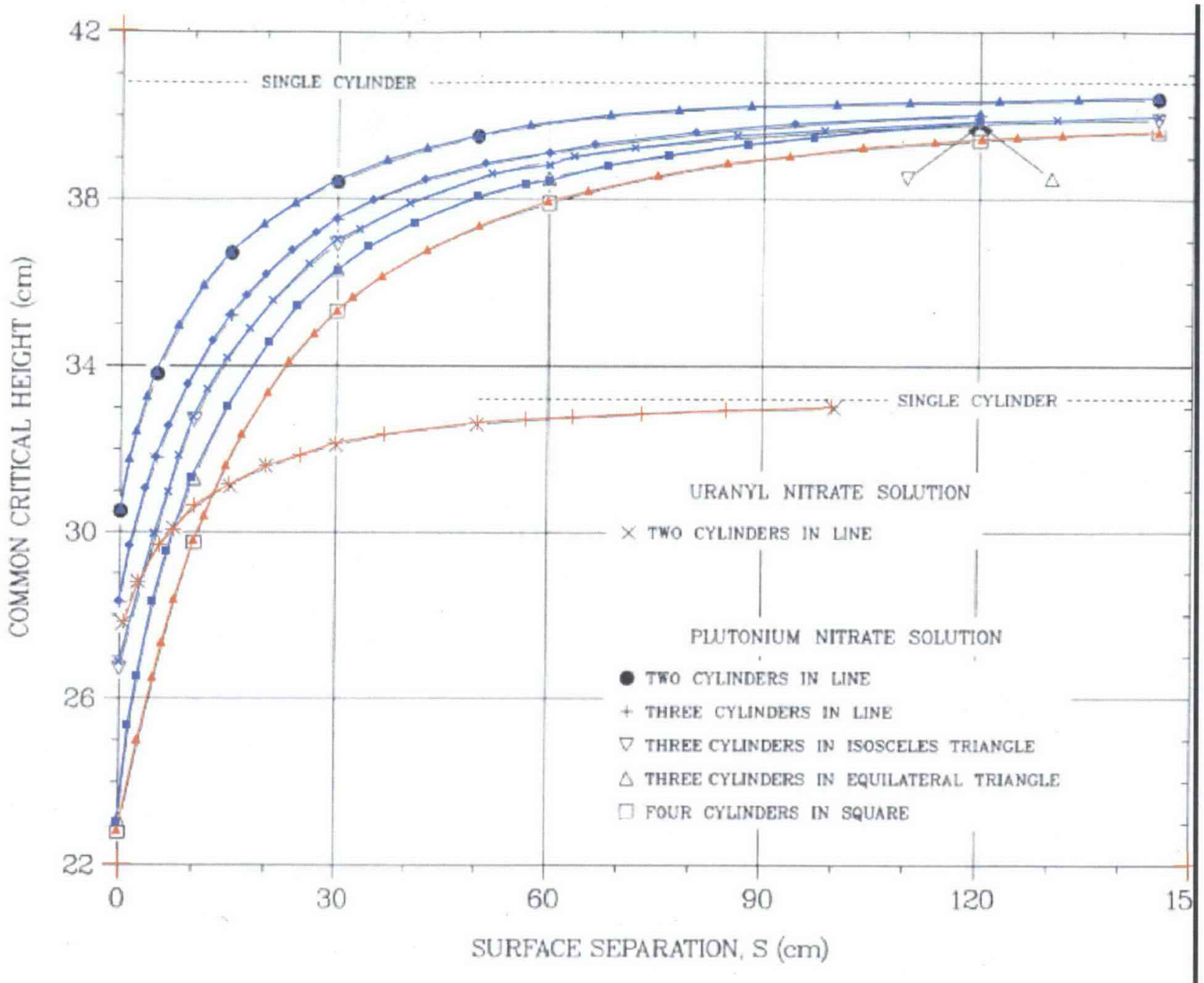
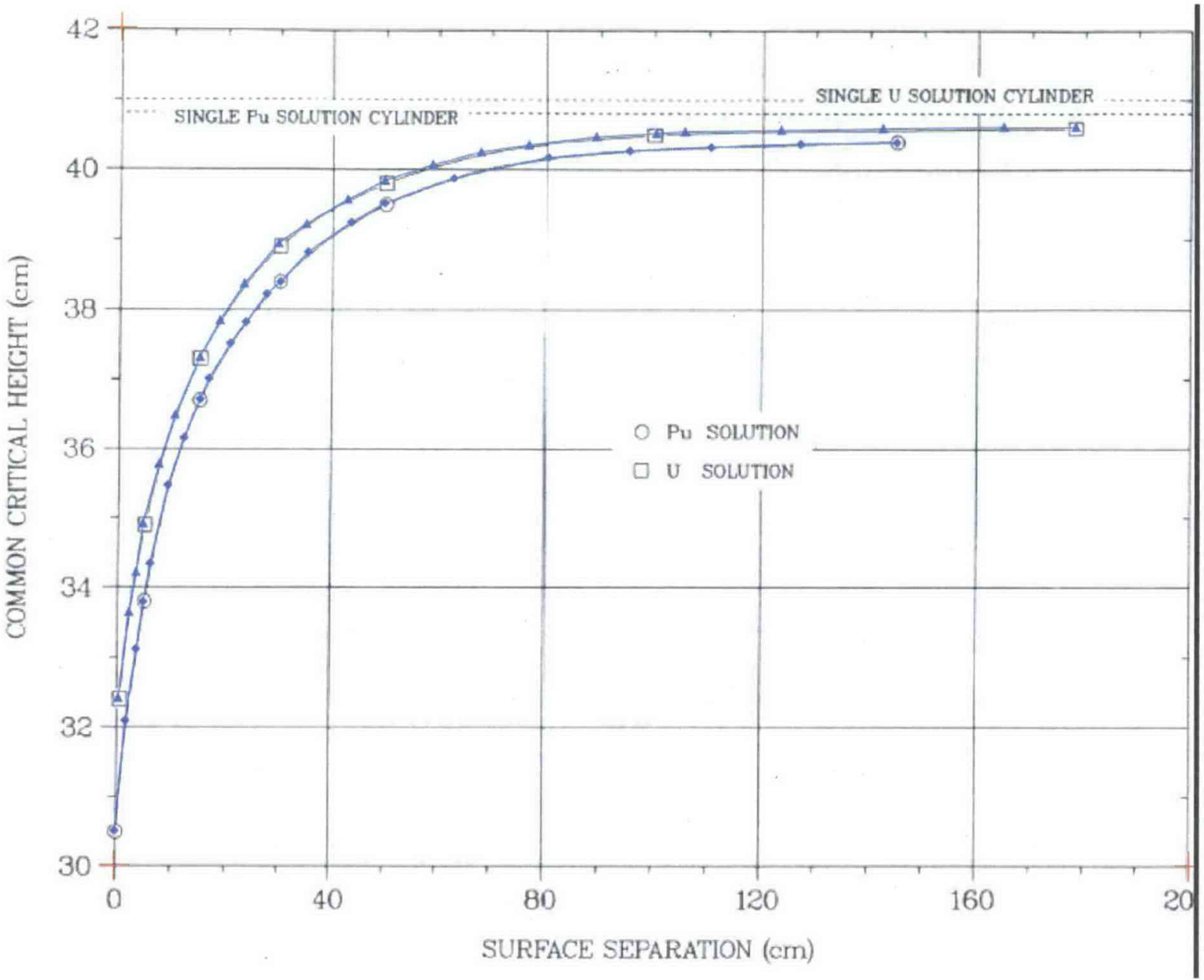


Figure B-68. Common Critical Heights of Two Unreflected $Pu(NO_3)_4$ Solution Cylinders at 0.110 g/cm^3 of ^{239}Pu + ^{241}Pu or Two $U(90)O_2(NO_3)_2$ Solution Cylinders At The Equivalent concentration of 0.081 g $^{235}U/cm^3$ (Fig. 72 from LA-10860)



Stainless steel containers 30-cm-o.d. with 0.3-cm-thick walls.

Figure B-69. Critical Separations of $U(2.35)O_2$ Rod Clusters In Water As Functions of Distance To Reflecting Walls of Steel, Lead, or Depleted Uranium; Clusters Were at Near-Optimum Moderation (Fig. 73 from LA-10860)

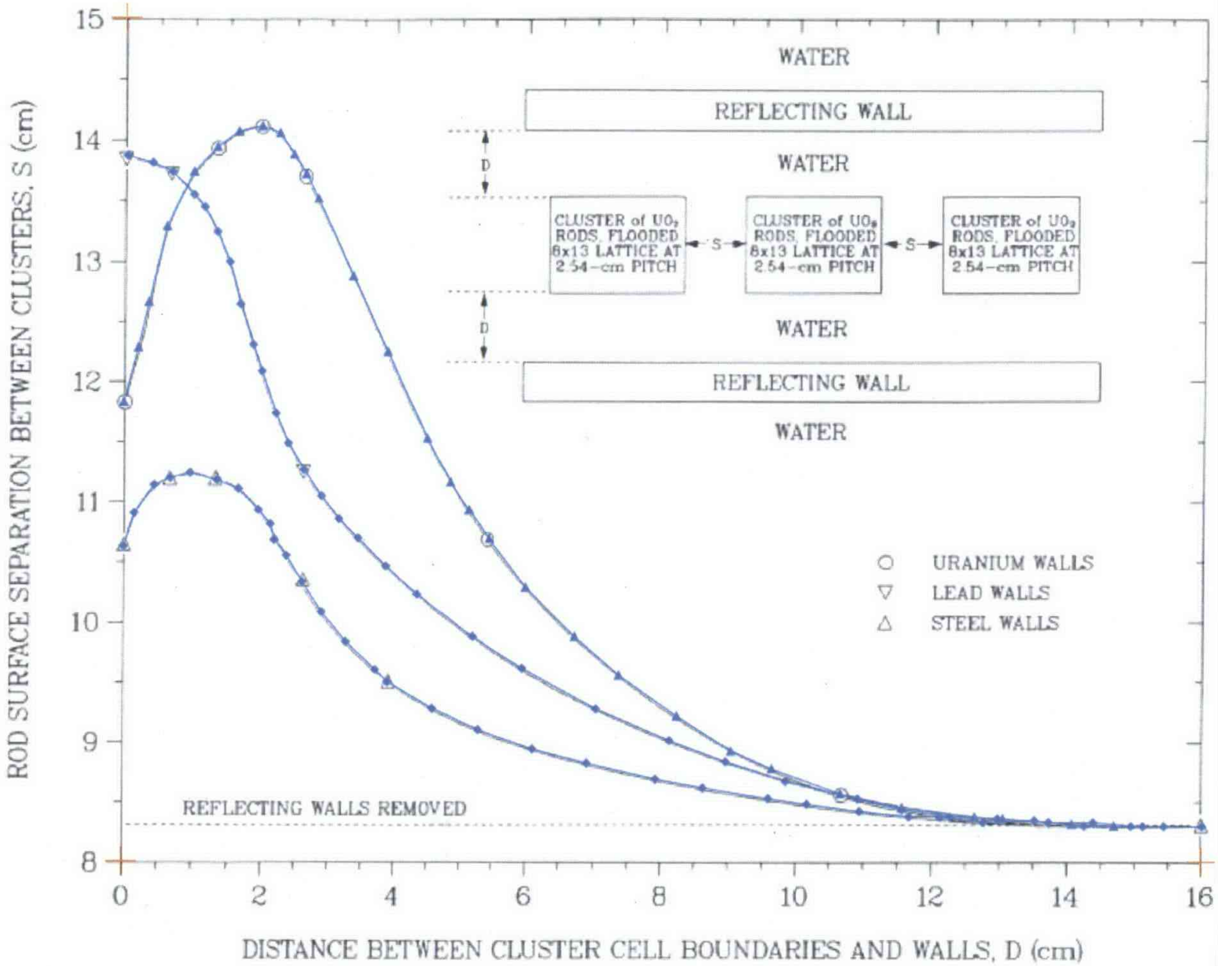
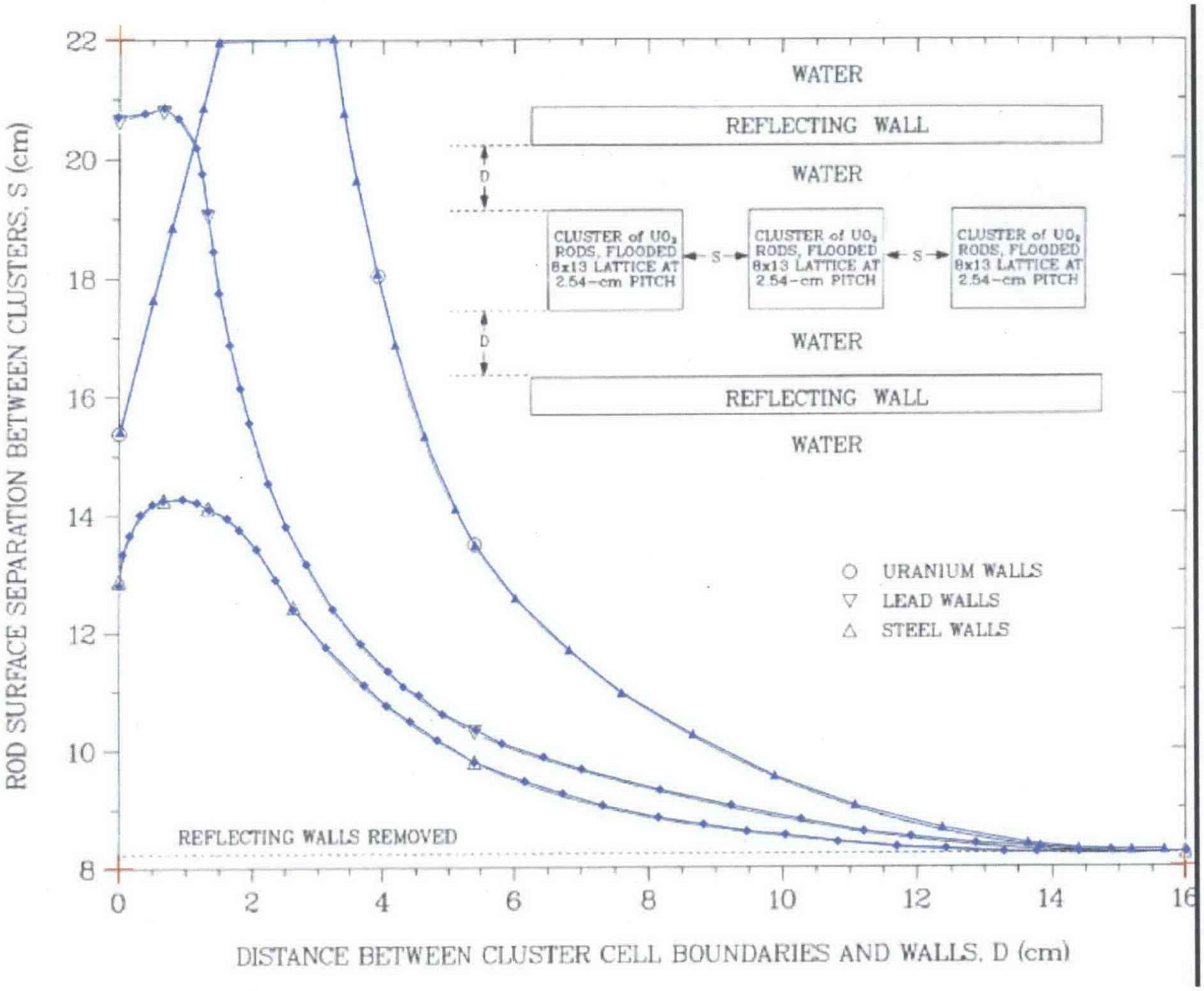


Figure B-70. Critical Separations of U(4.31)O_2 Rod Clusters In Water As Functions of Distance To Reflecting Walls of Steel, Lead, or Depleted Uranium; Clusters Were at Near-Optimum Moderation (Fig. 74 from LA-10860)



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APPENDIX C - LISTING OF THE RESULTANT CRITVIEW FORMATTED DATA FILES

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! LA-10860 partial database - CritView 1.02 compatible only

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title: LA-10860 Fig. 20b Critical volume of lattices of uranium metal rods in water
reference: LA-10860 Figure 20b
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: lattice of rods
modmat: H2O
critmat: Uranium
isomat: U235 0.03063 U238 0.96937
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: diameter cm
var: volume L
    0.4448   32.0090
    0.4475   31.5395
    0.4724   31.1783
    0.5088   30.7991
    0.5685   30.3296
    0.6384   30.0587
    0.6964   29.8962
    0.7768   29.8059
    0.8572   29.6975
    0.9489   29.6253
    1.1431   29.5711
    1.2682   29.6433
    1.3928   29.7878
    1.4606   29.9142
    1.5280   30.0948
    1.7073   30.6546
    1.8634   31.2867
    1.9962   32.0090
    2.1163   32.9481
    2.2029   33.7607
    2.3009   34.5734
    2.3549   35.1151
reset:
title: LA-10860 Fig. 28 Critical mass of Pu(NO3)4 spheres (116 g/L nitrate)
reference: LA-10860 Figure 28
set: LA-10860 set
source: LA-10860
```

created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: Pu(NO3)4 116 g/L nitrate
isomat: Pu239 1.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: volume L
var: critmass g

18.9315	699.2690
19.3498	699.2690
19.8730	697.5990
20.6575	696.7640
21.3114	695.0940
21.9387	695.9290
22.5921	696.7640
23.1148	697.5990
23.6634	700.1040
24.3951	701.7750
25.3093	705.9500
26.0668	709.2900
26.8505	712.6300
27.5818	715.9710
28.1302	719.3110
28.6526	721.8160
29.0444	723.4860

reset:
title: LA-10860 Fig. 28 Critical mass of Pu(NO3)4 spheres (138 g/L nitrate)
reference: LA-10860 Figure 28
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: Pu(NO3)4 138 g/L nitrate
isomat: Pu239 1.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: volume L
var: critmass g

15.2068	761.9000
15.5738	756.8890
16.1506	748.5390
16.9892	738.5180

18.0635	725.9920
18.9537	719.3110
19.9483	713.4660
21.3349	708.4550
22.8776	707.6200
23.5831	709.2900
24.2889	710.1250
25.0729	711.7950
25.9348	715.9710
27.0577	722.6510
27.9715	728.4970
29.0153	738.5180

reset:
title: LA-10860 Fig. 28 Critical mass of Pu(NO3)4 spheres (156 g/L nitrate)
reference: LA-10860 Figure 28
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: Pu(NO3)4 156 g/L nitrate
isomat: Pu239 1.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: volume L
var: critmass g

15.2294	780.2710
15.9379	766.9100
16.4362	758.5590
16.9606	751.0440
17.7469	741.0230
18.5591	731.8370
18.9258	728.4970
19.8944	721.8160
20.8626	717.6410
21.9611	715.1360
22.8763	714.3010
23.6603	715.9710
24.5225	718.4760
25.6197	722.6510
26.4815	727.6620
27.2124	733.5070
27.9952	741.0230
28.7521	747.7040
29.0129	751.0440

reset:
title: LA-10860 Fig. 28 Critical mass of Pu(NO3)4 spheres (212 g/L nitrate)
reference: LA-10860 Figure 28
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: Pu(NO3)4 212 g/L nitrate
isomat: Pu239 1.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: volume L
var: critmass g

15.2122	867.9540
15.6068	855.4280
16.0803	840.3970
16.4746	829.5410
17.1574	813.6740
17.6563	802.8180
18.3124	790.2920
19.2562	776.9310
20.2516	766.9100
21.4036	758.5590
22.4238	755.2190
23.2609	752.7140
23.6268	753.5490
24.5416	754.3840
25.2210	756.0540
25.8738	760.2300
26.8138	766.0750
27.5968	772.7560
28.2753	779.4360
29.0057	787.7870

reset:
title: LA-10860 Fig. 28 Critical mass of Pu(NO3)4 spheres (270 g/L nitrate)
reference: LA-10860 Figure 28
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: Pu(NO3)4 270 g/L nitrate
isomat: Pu239 1.0
reflmat: H2O

reflthick: 10 in
keff: 1.0
var: volume L
var: critmass g

15.1942	959.8120
15.5636	942.2760
15.8801	928.0790
16.3017	911.3780
16.5653	900.5220
16.9073	889.6660
17.2494	877.9750
17.7486	865.4490
18.1426	856.2630
18.6414	845.4070
18.9303	838.7270
19.7169	827.0350
20.5030	817.8500
21.4981	809.4990
22.3094	805.3240
22.9896	802.8180
23.6434	801.9830
24.2970	801.9830
24.8983	801.9830
25.3949	802.8180
26.1262	806.1590
26.7532	808.6640
27.4842	813.6740
28.1367	819.5200
29.0239	827.8710

reset:
title: LA-10860 Fig. 28 Critical mass of Pu(NO3)4 spheres (310 g/L nitrate)
reference: LA-10860 Figure 28
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: Pu(NO3)4 310 g/L nitrate
isomat: Pu239 1.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: volume L
var: critmass g

15.1775	1044.9900
15.7075	1008.2500

15.9458	993.2150
16.2368	975.6780
16.6062	958.1420
17.0541	940.6050
17.5020	923.0690
18.1331	904.6970
18.5274	893.8410
18.9211	885.4910
19.4984	874.6350
20.1277	865.4490
20.9399	856.2630
21.5685	850.4180
22.3801	844.5720
23.3744	840.3970
23.6623	838.7270
24.3422	837.8910
25.2313	837.0560
26.0416	837.8910
26.8516	840.3970
27.6612	844.5720
28.5228	850.4180
29.0187	854.5930

reset:
title: LA-10860 Fig. 31 Critical mass of Pu spheres (H2O reflected)
reference: LA-10860 Figure 31
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: Plutonium
isomat: Pu239 1.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: critconc g/cc
var: critmass kg

0.0150	0.7860
0.0159	0.7219
0.0168	0.6726
0.0179	0.6311
0.0200	0.6006
0.0232	0.5597
0.0259	0.5403
0.0296	0.5290
0.0348	0.5329

0.0404	0.5484
0.0444	0.5643
0.0501	0.5806
0.0589	0.6234
0.0674	0.6647
0.0730	0.7036
0.0824	0.7608
0.0980	0.8585
0.1151	0.9619
0.2101	1.5817
0.2499	1.8756
0.5214	3.3588
0.7377	4.6898
0.9639	5.8041
1.2767	7.1324
1.6040	7.9923
1.8846	8.5819
2.2749	9.2154
2.7465	9.7564
3.1851	10.1110
3.8474	10.2587
4.1723	10.2601
4.8402	10.3358
5.8488	10.1935
7.4627	9.7731
8.6629	9.3684
10.7615	8.7926
13.1915	8.1357
15.1129	7.5806
18.2916	6.5806
19.3313	5.9593

reset:
title: LA-10860 Fig. 31 Critical mass of Pu spheres (unreflected)
reference: LA-10860 Figure 31
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: Plutonium
isomat: Pu239 1.0
reflmat: none
reflthick: 0 in
keff: 1.0
var: critconc g/cc
var: critmass kg

0.0094	9.1294
0.0096	7.4329
0.0098	6.0517
0.0100	4.9976
0.0104	3.8446
0.0110	2.7750
0.0113	2.3409
0.0116	1.9747
0.0130	1.5301
0.0139	1.3001
0.0151	1.1858
0.0164	1.0892
0.0186	1.0149
0.0196	0.9796
0.0225	0.9524
0.0261	0.9393
0.0290	0.9328
0.0351	0.9599
0.0401	1.0162
0.0497	1.1123
0.0686	1.3699
0.0733	1.4501
0.0984	1.7946
0.1303	2.2688
0.1550	2.6715
0.2025	3.3533
0.2475	4.0335

reset:
title: LA-10860 Fig. 32 Critical volume of Pu spheres (H2O reflected)
reference: LA-10860 Figure 32
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: Plutonium
isomat: Pu239 1.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: critconc g/cc
var: volume L

0.0152	52.9159
0.0165	42.0064
0.0184	34.3203
0.0200	30.1385

0.0229 24.6227
0.0266 20.1159
0.0296 17.6641
0.0344 15.0690
0.0399 13.4235
0.0483 11.7857
0.0600 10.6500
0.0745 9.4860
0.0977 8.6956
0.1371 8.0859
0.1897 7.6284
0.2521 7.3018
0.3683 7.0895
0.5097 6.5926
0.6959 6.3100
0.9763 5.8676
1.2976 5.4567
1.6338 4.9308
2.2015 4.2664
2.7729 3.5356
3.4452 3.0158
4.1673 2.4284
5.1084 2.0418
6.3489 1.6204
7.7841 1.3048
9.0404 1.0660
10.7894 0.8339
12.7043 0.6431
15.7947 0.4681
19.3783 0.3170
reset:
title: LA-10860 Fig. 32 Critical volume of Pu spheres (unreflected)
reference: LA-10860 Figure 32
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: Plutonium
isomat: Pu239 1.0
reflmat: none
reflthick: 0 in
keff: 1.0
var: critconc g/cc
var: volume L
0.0152 79.2415

0.0169	64.7422
0.0202	49.2103
0.0238	40.2022
0.0300	30.9985
0.0348	27.6137
0.0398	25.3188
0.0495	22.5515
0.0582	20.9767
0.0743	19.2298
0.0988	18.1429
0.1443	17.1147
0.1944	16.3816
0.2480	16.1402

reset:
title: LA-10860 Fig. 33 Critical diameter of infinite cylinders of Pu-H2O (H2O reflected)
reference: LA-10860 Figure 33
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: infcyl
modmat: H2O
critmat: Plutonium
isomat: Pu239 1.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: critconc g/cc
var: diameter cm

0.0149	32.7828
0.0168	29.8449
0.0199	27.0120
0.0225	24.8819
0.0254	23.3272
0.0291	21.8698
0.0338	20.7459
0.0388	19.6797
0.0438	19.1118
0.0482	18.5599
0.0591	17.9198
0.0725	16.9996
0.0976	16.3183
0.1280	15.9424
0.1633	15.5749
0.2055	15.3956
0.2484	15.2178
0.3126	15.0425

0.4152	14.8699
0.5087	14.6122
0.6941	14.5299
0.8855	14.2785
1.1146	14.0314
1.3293	13.7073
1.5858	13.2343
1.9436	12.7779
2.4159	12.0509
2.9627	11.3651
3.5365	10.7181
4.0542	10.0485
4.9044	9.5324
6.2694	8.6281
7.3851	8.0418
8.4664	7.5394
10.2519	6.8641
12.9385	6.0330
16.5534	5.2716
18.9957	4.7432

reset:
title: LA-10860 Fig. 33 Critical diameter of infinite cylinders of Pu-H2O (unreflected)
reference: LA-10860 Figure 33
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: infcyl
modmat: H2O
critmat: Plutonium
isomat: Pu239 1.0
reflmat: none
reflthick: 0 in
keff: 1.0
var: critconc g/cc
var: diameter cm

0.0148	39.5613
0.0184	34.7712
0.0195	33.3719
0.0236	31.1050
0.0297	28.8231
0.0341	27.6647
0.0390	26.8667
0.0491	25.7887
0.0578	25.0452
0.0728	24.3244
0.0967	23.7643

0.1234	23.4908
0.1640	23.0852
0.2091	22.9540
0.2460	22.8222

reset:
title: LA-10860 Fig. 34 Critical thickness of infinite slabs of Pu-H2O (H2O reflected)
reference: LA-10860 Figure 34
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: infplane
modmat: H2O
critmat: Plutonium
isomat: Pu239 1.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: critconc g/cc
var: height cm

0.0152	17.3199
0.0171	15.6261
0.0204	13.6223
0.0244	11.9777
0.0303	10.3523
0.0356	9.5009
0.0402	8.9468
0.0460	8.3531
0.0499	8.0711
0.0579	7.6656
0.0749	6.9150
0.0995	6.2913
0.1321	5.8730
0.1779	5.5295
0.2528	5.2957
0.3357	5.2490
0.4458	5.2027
0.5243	5.1575
0.6869	5.1560
0.8880	5.0239
1.0585	4.9377
1.3320	4.7295
1.6315	4.4534
1.9983	4.1933
2.3507	3.8485
2.8796	3.4718
3.3419	3.1863

```
    4.2070   2.6840
    5.2246   2.3000
    6.5769   1.9541
    8.8589   1.5905
    12.2612   1.2403
    14.8217   1.0538
    19.1743   0.8218
reset:
title: LA-10860 Fig. 34 Critical thickness of infinite slabs of Pu-H2O (unreflected)
reference: LA-10860 Figure 34
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: infplane
modmat: H2O
critmat: Plutonium
isomat: Pu239 1.0
reflmat: none
reflthick: 0 in
keff: 1.0
var: critconc g/cc
var: height cm
    0.0154   24.6070
    0.0171   22.5845
    0.0201   20.5503
    0.0250   18.8591
    0.0302   17.3076
    0.0355   16.5792
    0.0407   16.0185
    0.0505   15.3435
    0.0594   14.9518
    0.0747   14.4447
    0.0992   14.0742
    0.1248   13.8318
    0.1726   13.5923
    0.2554   13.4710
reset:
title: LA-10860 Fig. 35 Calculated critical mass of Pu spheres with 0 wt% Pu240 (H2O
reflected)
reference: LA-10860 Figure 35
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: Plutonium
```

isomat: Pu239 1.0 Pu240 0.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: critconc g/cc
var: critmass kg

0.0200	0.5986
0.0215	0.5639
0.0247	0.5313
0.0297	0.5092
0.0376	0.5270
0.0431	0.5548
0.0512	0.5992
0.0593	0.6416
0.0696	0.6989
0.0787	0.7612
0.0902	0.8291
0.1045	0.9031
0.1182	1.0178
0.1439	1.1569
0.1730	1.3378
0.2055	1.5337
0.2440	1.8039
0.2863	2.0680
0.3527	2.5168
0.4453	3.1426
0.5288	3.6962
0.6358	4.3105
0.7459	4.8997
0.8970	5.6173
1.1194	6.5512
1.2974	7.2584
1.4676	7.7061
1.7012	8.4656
2.2046	9.2221
2.7197	9.7086
3.3141	10.1339
4.2974	10.3113
5.1106	10.3133
6.6294	10.0556
7.8869	9.6377
9.2690	9.0807
10.7601	8.4831
13.2938	7.5945
17.0574	6.2969
19.8152	5.4478

reset:
title: LA-10860 Fig. 35 Calculated critical mass of Pu spheres with 5 wt% Pu240 (H2O reflected)
reference: LA-10860 Figure 35
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: Plutonium
isomat: Pu239 0.95 Pu240 0.05
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: critconc g/cc
var: critmass kg

0.0199	0.7283
0.0220	0.6745
0.0256	0.6302
0.0297	0.6091
0.0366	0.6251
0.0419	0.6580
0.0511	0.7291
0.0622	0.8078
0.0730	0.8950
0.0867	1.0261
0.1095	1.2070
0.1526	1.6137
0.2074	2.1208
0.2818	3.0098
0.4224	4.4962
0.4718	4.9814
0.5267	5.7106
0.6734	7.0098
0.8719	8.3874
1.0881	9.6986
1.4096	10.9320
1.8040	12.1136
2.6458	13.1979
3.5606	13.4295
4.5057	13.0936
5.7027	12.5503
6.7850	11.9264
8.0746	11.0473
10.0994	9.9749
12.1724	8.9298

15.2319	7.6608
19.7998	5.9329

reset:
title: LA-10860 Fig. 35 Calculated critical mass of Pu spheres with 10 wt% Pu240 (H2O reflected)
reference: LA-10860 Figure 35
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: Plutonium
isomat: Pu239 0.90 Pu240 0.10
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: critconc g/cc
var: critmass kg

0.0199	0.8861
0.0220	0.8278
0.0258	0.7668
0.0293	0.7475
0.0365	0.7605
0.0419	0.8075
0.0549	0.8872
0.0677	0.9830
0.0921	1.2275
0.1364	1.7722
0.2045	2.5805
0.3508	4.5338
0.4268	5.6127
0.5944	7.8978
0.7233	9.5302
0.8807	10.9262
1.0463	12.2099
1.2588	13.2999
1.4417	14.0004
1.8687	14.8661
2.3636	15.3862
2.9901	15.5221
4.0251	15.2646
4.9698	14.6307
6.0612	13.9039
7.0352	13.2124
8.0646	12.6627
10.0869	11.4336

12.0069	10.3232
14.1196	9.0850
15.7984	8.2021
20.0341	6.3519

reset:
title: LA-10860 Fig. 35 Calculated critical mass of Pu spheres with 15 wt% Pu240 (H2O reflected)
reference: LA-10860 Figure 35
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: Plutonium
isomat: Pu239 0.85 Pu240 0.15
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: critconc g/cc
var: critmass kg

0.0201	1.1157
0.0245	0.9571
0.0296	0.8941
0.0393	0.9176
0.0528	1.0168
0.0636	1.1171
0.0823	1.3029
0.1014	1.6129
0.1430	2.1935
0.2252	3.4491
0.4055	6.7708
0.6306	10.7374
0.8789	13.6391
1.2411	16.1824
1.6693	17.4795
2.1377	17.9375
2.7380	18.0962
3.7788	17.4955
5.2172	16.2085
7.9580	14.0273
10.2039	12.5585
13.5891	10.3246
17.8845	7.9960
20.0170	6.9768

reset:

title: LA-10860 Fig. 35 Calculated critical mass of Pu spheres with 20 wt% Pu240 (H2O reflected)
reference: LA-10860 Figure 35
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: Plutonium
isomat: Pu239 0.80 Pu240 0.20
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: critconc g/cc
var: critmass kg

0.0198	1.4658
0.0224	1.3010
0.0257	1.1846
0.0299	1.1257
0.0355	1.1164
0.0412	1.1358
0.0589	1.2913
0.0754	1.5319
0.1051	1.9794
0.1427	2.7616
0.2113	4.3420
0.3166	6.5979
0.4355	9.3637
0.5499	11.6917
0.6293	13.2895
0.7851	16.0367
1.0045	18.2307
1.4549	20.2040
2.0569	20.9134
2.9095	20.5676
4.2728	19.3839
5.9737	17.6545
8.0497	15.5393
10.0698	13.7936
13.4116	11.2437
17.2151	8.9333
19.9985	7.7287

reset:
title: LA-10860 Fig. 36 Critical mass of U233 spheres (H2O reflected)
reference: LA-10860 Figure 36
set: LA-10860 set

source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: U233 solution
isomat: U233 1.0 U235 0.0 U238 0.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: critconc g/cc
var: critmass kg

0.0326	0.7005
0.0379	0.6549
0.0445	0.6303
0.0504	0.5950
0.0563	0.5951
0.0646	0.6009
0.0749	0.6069
0.0901	0.6431
0.0982	0.6749
0.1241	0.7363
0.1648	0.8429
0.2298	0.9933
0.2975	1.1818
0.3803	1.4060
0.5233	1.8070
0.7111	2.3448
0.8868	2.8165
1.1474	3.5164
1.4310	4.2239
1.8069	5.0739
2.5797	6.6480
3.3404	7.6841
3.9680	8.5450
5.8181	9.4138
8.0264	9.5088
10.5454	8.9778
13.8595	8.2350
17.7787	7.1982

reset:
title: LA-10860 Fig. 36 Critical mass of U233 spheres (unreflected)
reference: LA-10860 Figure 36
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere

modmat: H2O
critmat: U233 solution
isomat: U233 1.0 U235 0.0 U238 0.0
reflmat: none
reflthick: 0 in
keff: 1.0
var: critconc g/cc
var: critmass kg

0.0121	28.5575
0.0128	12.2335
0.0137	5.9399
0.0147	4.1994
0.0156	3.3008
0.0167	2.8846
0.0180	2.4967
0.0201	2.0995
0.0243	1.7319
0.0293	1.4426
0.0395	1.2251
0.0488	1.1566
0.0595	1.1239
0.0665	1.1350
0.0811	1.2145
0.1076	1.3770
0.1326	1.5915
0.1614	1.8394

reset:
title: LA-10860 Fig. 37 Critical volume of U233 spheres (H2O reflected)
reference: LA-10860 Figure 37
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: U233 solution
isomat: U233 1.0 U235 0.0 U238 0.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: critconc g/cc
var: volume L

0.0333	21.0467
0.0387	16.9632
0.0449	13.9701
0.0503	12.0123
0.0606	9.6816

```
    0.0653   8.8813
    0.0777   7.8032
    0.1008   6.5664
    0.1409   5.6462
    0.1635   5.1795
    0.2371   4.5507
    0.2928   4.2656
    0.3615   3.9130
    0.4747   3.7477
    0.5241   3.7477
    0.6081   3.7477
reset:
title: LA-10860 Fig. 37 Critical volume of U233 spheres (unreflected)
reference: LA-10860 Figure 37
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: U233
isomat: U233 1.0 U235 0.0 U238 0.0
reflmat: none
reflthick: 0 in
keff: 1.0
var: critconc g/cc
var: volume L
    0.0121   2369.7800
    0.0126   1323.6700
    0.0130   937.3400
    0.0137   546.6440
    0.0144   362.8430
    0.0155   246.0940
    0.0167   170.5490
    0.0183   126.0960
    0.0218   81.9123
    0.0247   61.8827
    0.0316   40.1990
    0.0391   29.7213
    0.0483   22.9433
    0.0676   16.9632
    0.0981   13.0947
    0.1650   11.0193
reset:
title: LA-10860 Fig. 37 Calculated critical volume of U233 spheres (H2O reflected)
reference: LA-10860 Figure 37
set: LA-10860 set
```

source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: H2O
critmat: U233 metal-h2o mixture
isomat: U233 1.0 U235 0.0 U238 0.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: critconc g/cc
var: volume L

0.2587	3.9983
0.8189	3.2225
2.2619	2.5973
3.7605	2.1390
6.0266	1.5815
8.3257	1.1443
10.9463	0.8280
14.3967	0.5496
18.6985	0.3809

reset:
title: LA-10860 Fig. 38 Critical diameter of infinite cylinders of U233 solution (H2O reflected)
reference: LA-10860 Figure 38
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: infcyl
modmat: H2O
critmat: U233 solution
isomat: U233 1.0 U235 0.0 U238 0.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: critconc g/cc
var: diameter cm

0.0330	23.1435
0.0383	21.3944
0.0455	19.7776
0.0598	17.3498
0.0767	16.0387
0.0994	14.8266
0.1355	14.1932
0.1652	13.5869
0.2169	13.1206
0.3105	12.4510
0.5286	11.8155

    0.6055   11.8155
reset:
title: LA-10860 Fig. 38 Critical diameter of infinite cylinders of U233 solution (unreflected)
reference: LA-10860 Figure 38
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: infcyl
modmat: H2O
critmat: U233 solution
isomat: U233 1.0 U235 0.0 U238 0.0
reflmat: none
reflthick: 0 in
keff: 1.0
var: critconc g/cc
var: diameter cm
    0.0122   127.0140
    0.0129   91.9496
    0.0143   68.9314
    0.0152   58.3943
    0.0166   50.7809
    0.0198   43.0184
    0.0260   34.5825
    0.0363   29.0414
    0.0471   26.1526
    0.0619   23.7577
    0.1095   20.8413
    0.1402   20.1260
    0.1646   20.1260
reset:
title: LA-10860 Fig. 38 Calculated critical diameter of infinite cylinders of U233 solution (H2O reflected)
reference: LA-10860 Figure 38
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: infcyl
modmat: H2O
critmat: U233 metal-h2o mixture
isomat: U233 1.0 U235 0.0 U238 0.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: critconc g/cc
var: diameter cm
    0.2517   12.2354

```
    0.8152    10.8276
    1.2723    10.6402
    2.2476    10.0093
    3.5091    9.4159
    5.9042    8.1883
    7.6598    7.5036
    10.8411    6.4686
    18.7205    4.8918
reset:
title: LA-10860 Fig. 39 Critical thickness of infinite slab of U233 solution (H2O reflected)
reference: LA-10860 Figure 39
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: infplane
modmat: H2O
critmat: U233 solution
isomat: U233 1.0 U235 0.0 U238 0.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: critconc g/cc
var: height cm
    0.0332    11.7079
    0.0385    10.2335
    0.0452    9.2955
    0.0545    8.2034
    0.0632    7.3095
    0.0743    6.7684
    0.0884    6.2073
    0.1132    5.6384
    0.1601    4.8811
    0.2468    4.1852
    0.3622    3.7652
    0.5120    3.4201
    0.6012    3.3549
reset:
title: LA-10860 Fig. 39 Critical thickness of infinite slab of U233 solution (unreflected)
reference: LA-10860 Figure 39
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: infplane
modmat: H2O
critmat: U233 solution
isomat: U233 1.0 U235 0.0 U238 0.0
```

reflmat: none
reflthick: 0 in
keff: 1.0
var: critconc g/cc
var: height cm

0.0128	59.4452
0.0133	50.4819
0.0140	44.1246
0.0151	37.4713
0.0165	32.7525
0.0194	27.8140
0.0233	24.3113
0.0303	20.2524
0.0388	18.0456
0.0535	15.7731
0.0786	13.6548
0.1111	12.4032
0.1610	11.3751

reset:
title: LA-10860 Fig. 39 Calculated critical thickness of infinite slab of U233 solution (H2O reflected)
reference: LA-10860 Figure 39
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: infplane
modmat: H2O
critmat: U233 metal-h2o mixture
isomat: U233 1.0 U235 0.0 U238 0.0
reflmat: H2O
reflthick: 10 in
keff: 1.0
var: critconc g/cc
var: height cm

0.2725	4.1055
0.5584	3.3228
0.8292	3.0474
1.3937	2.7153
2.2296	2.3963
2.6839	2.2839
3.4805	2.0745
5.9276	1.6470
10.6182	1.1321
18.3365	0.7416

reset:
title: LA-10860 Fig. 44 Critical volume of U(1.42)F4-paraffin (Jabroc reflected)

reference: LA-10860 Figure 44
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: paraffin
critmat: UF4
isomat: U235 0.0142 U238 0.9858
!*H/X: 422
critconc: 2.5 g/cc
reflmat: Jabroc
keff: 1.0
var: reflthick cm
var: volume L

3.82083	695.341
4.22104	685.312
4.72866	675.917
5.48749	666.652
6.17374	658.948
6.67836	655.129
7.3627	650.86
7.86678	648.029
8.37031	646.149
9.12588	642.871
9.88064	641.006
10.8146	639.61
11.9997	638.218
14.5843	637.291
17.0965	637.291
18.3526	637.291

reset:
title: LA-10860 Fig. 44 Critical volume of U(1.42)F4-paraffin (Polyethylene reflected)
reference: LA-10860 Figure 44
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: paraffin
critmat: UF4
isomat: U235 0.0142 U238 0.9858
!*H/X: 422
critconc: 2.5 g/cc
reflmat: polyethylene
keff: 1.0
var: reflthick cm
var: volume L

```
   1.23953  759.783
   1.56933  746.108
   1.89804  734.812
   2.33415  724.213
   2.55166  720.016
   3.059    710.662
   3.81811  700.411
   4.43203  693.324
   5.11664  688.305
   5.98151  681.835
   7.09679  676.9
   7.96003  673.467
   8.82219  672
   10.1158  669.078
   11.2651  667.621
   13.4201  664.717
   15.0     663.27
   16.5797  662.307
   18.2667  661.826
   20.3842  661.826
reset:
title: LA-10860 Fig. 44 Critical volume of U(1.42)F4-paraffin (steel reflected)
reference: LA-10860 Figure 44
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: paraffin
critmat: UF4
isomat: U235 0.0142 U238 0.9858
!*H/X: 422
critconc: 2.5 g/cc
reflmat: steel
keff: 1.0
var: reflthick cm
var: volume L
   1.26373  783.891
   1.8453   768.665
   2.57314  748.279
   3.84149  724.213
   5.10848  703.471
reset:
title: LA-10860 Fig. 44 Critical volume of U(1.42)F4-paraffin (chipboard reflected)
reference: LA-10860 Figure 44
set: LA-10860 set
source: LA-10860
```

created: Thur 08/18/2011
geometry: sphere
modmat: paraffin
critmat: UF4
isomat: U235 0.0142 U238 0.9858
!*H/X: 422
critconc: 2.5 g/cc
reflmat: chipboard
keff: 1.0
var: reflthick cm
var: volume L
  1.91109 781.049
  2.31131 769.783
  2.8192 758.68
  3.21887 748.823
  3.83551 735.88
  4.81485 715.844
  5.57423 705.006
  6.62099 693.828
  7.59489 684.814
  9.03643 673.956
  10.2974 665.2
  11.4489 659.906
  12.5272 657.036
  14.7175 655.129
  17.0147 654.653
  19.0245 654.653
reset:
title: LA-10860 Fig. 44 Critical volume of U(1.42)F4-paraffin (H2O reflected)
reference: LA-10860 Figure 44
set: LA-10860 set
source: LA-10860
created: Thur 08/18/2011
geometry: sphere
modmat: paraffin
critmat: UF4
isomat: U235 0.0142 U238 0.9858
!*H/X: 422
critconc: 2.5 g/cc
reflmat: H2O
keff: 1.0
var: reflthick cm
var: volume L
  2.57531 743.943
  3.69494 730.023
  4.30832 723.687

5.10196	715.844
5.89451	710.146
6.68706	704.494
7.58646	700.411
8.95296	695.341
10.1746	692.82
11.7548	690.81
13.1906	690.308
15.236	690.81