CRITICALITY ACCIDENT CODE

IDENTIFICATION SHEETS

CRITEX

GENERAL INFORMATIONS
(1)

Designation of the code	CRITEX	
Summary (General purpose)	Models the transient criticality of a fissile solution contained in an open cylindrical vessel with vertical walls, so that the solution is able to expand vertically (thermal dilatation, production of radiolytic gas bubble). The solution vertical extent is divided with axial meshes into a number of volumes that allows to calculate the axial movement of the solution and the following reactivity effect. The energy deposited in the volumes is calculated based on the power profile (assuming fundamental neutronic mode), coupled with the central power calculated with the point kinetic equation.	
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Status of code	First version released (date and reference number)	CRITEX V4.3 (1993).
	Current version released (date and reference number)	CRITEX V6.1 (2001).
	Current development	
	Language program / Modularity	Fortran 90.
	Operating system (windows, linux, unix,…)	Windows.
	Software requirements (fortran compiler,…)	Fortran 90 compiler.

	Portability (PC / Workstation/Supercomputer))	PC. Workstation.
	Availability / web site (executable, source files, data files, …)	
	Typical running time (for one calculation)	10 s → 10 min.
Comments		

GENERAL INFORMATIONS
(2)

User Interface	Input data file for a CRITEX run can be built by INITAL code or manually
Calculated Standard Outputs / and Units Time step output : power, energy, pressure, temperature, … Main characteristics : first peak power, total energy release, maximum pressure, temperature, time of boiling,…	Time, central specific power, inverse period, total power, total energy released. Reactivity inserted, reactivity feedback (doppler, solution expansion), total reactivity of the solution. Solution temperature at top/mid/bottom level of the vessel. First peak power, first minimum, secondary peak powers and minimums. Time of radiolytic gas bubble formation (nucleation). Gas inverse time constant (diffusion).
Graphic editor	
Quality Assurance (data and code package)	Description of code modeling (report). Code production (report). Selection of Experimental Benchmarks (reports). Code qualification synthesis (report).
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Comments	

GENERAL DESCRIPTION (3)

Fissile Materials	Physical Forms				
	Solution (nitrate,fluorure, sulfate,…)	Powder (dry, wetted,…)	Metal (dry, wetted,…)	Fuel rods	…
Uranium (isotopic content %)	Nitrate (93%, 5%, 3.5%). Fluoride (1% → 8%).				
Plutonium (isotopic content %)	Nitrate (^{239}Pu/^{240}Pu/^{241}Pu = 95/5/0, 80/20/0, 67/20/13). Fluoride.				
Mixed Plutonium / Uranium (isotopic content %)	Nitrate ($\frac{Pu}{U+Pu} = 10$ ou 30%). Fluoride.				
Geometry description Cylindrical, spherical,… Space Dimension (1D, 2D,…), Meshing / Region, Finite Element Method, …	Cylindrical 1D with free upper surface allowing solution expansion. Axial meshing.				
Comments					

DESCRIPTION OF MODELS USED		
Neutronic Power / Kinetics	Point kinetic equation, transport or diffusion theory ….	Point kinetic equation.
Reactivity and Reactivity feedback	Transport or diffusion theory, mathematical formulas, input or calculated data (reactivity insertion, temperature coefficients : Doppler, dilatation,..)	Reactivity inserted by step, ramp or buckling formula. Reactivity feedback of the solution expansion is calculated with one group perturbation formula. Doppler coefficients are tabulated internal data.
Thermal – hydraulics Hydrodynamics	Thermal (heat conduction, convection, boiling…) / Meshing and region	Axial meshing, heat conduction, natural convection.
	Multi-phase flow	Radiolytic gas bubble formation and migration.
	Fluid motion / Meshing and region	
	Pressure modeling	
Radiolysis (for solutions)	Radiolytic formation and migration models	Radiolytic gas bubble migration is modeled by means of a conservation equation with bubble migration velocity and a source term.
Data libraries : External or/and Internal (constants, calculated / tabulated, experimental, bibliography, …) …	Neutronics – kinetics (cross sections libraries, k_∞, neutron lifetime, delayed neutrons)	k_∞ , neutron lifetime, delayed neutron constants and doppler coefficients are tabulated internal data , they have been calculated with WIMS or APOLLO deterministic neutronic codes.
	Thermal and hydrodynamics (heat capacity, conductivity,…)	Internal data determined from laboratory measurements.
	Radiolysis (yield, threshold formation, velocity,…)	Internal data determined from CRAC and SILENE experiments.

<table>
<tr><th colspan="3">VALIDATION BASE OF THE CODE</th></tr>
<tr><td>Summary of the main assumptions in the code</td><td colspan="2">The power is calculated with point kinetic equation and a power profile assuming fundamental neutronic mode. The reactivity feedback takes into account solution expansion (thermal dilatation , void effect of bubbles) and doppler effect.
Solution temperature is calculated using a thermal balance equation with heat capacity and natural convection.
Bubble migration is calculated using a conservation equation with bubble migration velocity and a source term.</td></tr>
<tr><td>Limitations to the use of the code</td><td colspan="2">Aqueous solution of fissile media.
No treatment of the boiling phase.</td></tr>
<tr><td>Experimental benchmarks
(reactor : fissile media, geometry, reactivity insertion, duration,…)</td><td colspan="2">CRAC, SILENE: Uranyl nitrate (93%, 22 g/l → 218 g/l, ∅=30 cm, 80 cm, 36 cm).
SHEBA: uranium fluoride (5%, 979 g/l, ∅=49 cm).

Reactivity pulse or ramp from 0.035 to 3 $.</td></tr>
<tr><td>Past Accidents
(simulations)</td><td colspan="2">Tokai-Mura (JCO , 1999).</td></tr>
<tr><td rowspan="2">Codes comparison</td><td>Validation of the modeling with standard codes
(neutronics, thermal,…)</td><td></td></tr>
<tr><td>Accidents code</td><td></td></tr>
<tr><td>Domain of validation and level of confidence</td><td colspan="2">Comparison with experimental benchmarks from SILENE , CRAC and SHEBA experiments show correct agreement for first peak power and total energy released (within 20 to 40%).</td></tr>
</table>

References (reports, communications, publications,…)	D. J. MATHER, A. M. BICKLEY, A. PRESCOTT “CRITEX – a code to calculate the fission release arising from transient criticality in fissile solutions” AEA/CS/R1007/R (1994) D. J. MATHER , A. M. BICKLEY, A. PRESCOTT F. BARBRY, P. FOUILLAUD, J.P. ROZAIN “Validation of the CRITEX code” Proceedings of the ICNC'91 P. GRIVOT, P. FOUILLAUD “Description du code CRITEX” CEA/IPSN/DPEA/SRSC n°96.02 (1996) P. GIROUD “Mise en production du code CRITEX version 6” CEA/IPSN/DPEA/SRSC n°01.09 (2001) P. GIROUD, P. GRIVOT “Accident de criticité en solution – Synthèse de la qualification du code CRITEX“ CEA/IPSN/DPEA/SRSC n°00.05 (2000)