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Performance Evaluation of Rotating Pump Jet Mixing of Radioactive Wastes in Hanford Tanks 241-AP-102 and -104

Y. Onishi
K. P. Rechnagle

July 1998

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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Richland, Washington 99352

Summary

The purpose of this study was to examine the adequacy of a single mixer pump to fully mix wastes stored in Hanford Tanks 241-AP-102 and 241-AP-104 (AP-102 and AP-104). These tanks, located at the U.S. Department of Energy's Hanford Site in eastern Washington State, will be used as staging tanks to receive low-activity radioactive wastes from other Hanford double-shell tanks and will supply the wastes to vitrification facilities for eventual solidification. The diameter and operating depth of Tanks AP-102 and -104 are 23 m (75 ft) and 10.7 m (35 ft), respectively; operational storage capacities are 4,390 kL (1,160 kgal).

Three-hundred-hp mixer pumps are planned to be installed at the centers of Tanks AP-102 and AP-104. These pumps will rotate at 0.05 to 0.2 rpm and have two 6-inch nozzles injecting 60-ft/s jets to mix stored wastes, as part of the process of preparing feed to transfer to a private contractor's feed tanks, 241-AP-106 and -108.

Because Tank 241-AN-105 (AN-105) is scheduled to be the first double-shell tank to have its waste transferred to Tanks AP-102 and AP-104, and because it contains liquid, solid, and gaseous wastes representative of the other low-activity wastes that will be transferred to the AP tanks, AN-105 was selected to be modeled in this study. Tank AN-105 contains 4.270 million liters (1.129 million gallons) of waste, equivalent to a waste depth of 10.4 m (410 in.).

Six cases were studied that bound planned waste conditions after waste from Tank AN-105 is transferred to Tanks AP-102 and -104. Case 1 places the largest amount of solids and supernatant liquid in Tanks AP-102 and -104; Case 4 places the least amount of solids and supernatant liquid in those two tanks.

Case 1: 180% dilution of AN-105 waste by water without solid dissolution with solids initially deposited in the tank bottom

Case 2: 180% dilution without solid dissolution after solids are fully mixed

Case 3: 180% dilution with solids dissolution after solids are fully mixed

Case 4: 25% dilution with solids dissolution and solids initially deposited in the tank bottom

Case 5: 25% dilution with solids dissolution after solids are fully mixed

Case 6: 25% dilution without solids dissolution after solids are fully mixed.

We used two criteria to select the amount of diluent (water) that will be mixed with AN-105 waste in this assessment. One is that AN-105 waste will be diluted at least 25% by water. The other comes from restrictions imposed on the slurry pipeline transfer: that the mixture density must be less than 1.25 g/mL and the solid volume fraction less than 20%.

We applied the TEMPEST computer code to Tanks AP-102 and -104 to simulate the mixing induced by the 60-ft/s rotating jets in these six cases. TEMPEST is a time-dependent, three-dimensional code that simulates flow, mass and heat transfer, and chemical reactions (equilibrium and kinetic reactions) coupled together. TEMPEST was previously applied to Hanford double-shell tanks SY-102, AZ-101, AY-102, SY-101, and AY-102 to model tank waste mixing with rotating pump jets, gas rollover events, and waste transfer from one tank to another.

The Tank AP-102 and -104 modeling results over one simulation hour indicated that the mixer pump has the capacity to fully mix the wastes under the 180 and 25% dilution conditions tested. The study also confirmed that mixing is most difficult under Case 1 conditions and easiest under the Case 4 conditions used in the study. The model results demonstrate that the centrally located, 300-hp pump with rotating 60-ft/s jets can suspend the slurry and keep it in suspension within at least 94% uniformity over the entire tank. The 94% waste uniformity represents a waste distribution condition in which the minimum solid concentration is 94% at the point of maximum solid concentration in the tank. It would take a little over one hour to achieve this fully mixed condition in Case 1, starting from the solids deposited on AP-102 and -104 tank bottoms. Under Case 4 conditions, the mixer pump can achieve over 99% waste uniformity in about 20 minutes. The table below summarizes how well a single pump can mix the waste transferred from Tank AN-105 to Tanks AP-102 and AP-104 in each of these six cases.

Table S.1. Expected Waste Uniformity Achieved by Pump Jet Mixing in Tanks AP-102 and -104

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Waste Uniformity (%)	94.4	94.6	99.0	99.97	99.97	99.0

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1.0 Introduction

The purpose of this study was to confirm the adequacy of a single mixer pump to fully mix the wastes that will be stored in Tanks 241-AP-102 and -104. These Hanford double-shell tanks (DSTs) will be used as staging tanks to receive low-activity wastes from other Hanford storage tanks and, in turn, will supply the wastes to private waste vitrification facilities for eventual solidification. The diameter and operating depth of Tanks AP-102 and -104 are 23 m (75 ft) and 10.7 m (35 ft), respectively; their operational storage capacities are 4,390 kL (1,160 kgal) each. Mixer pumps of 300 hp are planned to be installed at the tank centers. These pumps will rotate at between 0.05 and 0.2 rpm and have two 6-inch nozzles injecting 60-ft/s jets to mix stored wastes made up of liquid and solids. WHC (1995) and Hanlon (1997) summarize DST waste content.

Tanks AP-102 and -104 will receive low-activity wastes from the DSTs. Because Tank 241-AN-105 is scheduled to be the first DST to have its waste transferred to AP-102 and -104, and because its waste is representative of the other wastes that will be transferred to the AP tanks, we selected AN-105 for modeling the efficacy of the single mixer pump.

The TEMPEST computer code (Trent and Eyler 1993) was applied to Tanks AP-102 and -104 to simulate waste mixing generated by the 60-ft/s rotating jets and to determine the effectiveness of the single rotating pump to mix the waste. TEMPEST simulates flow and mass/heat transport and chemical reactions (equilibrium and kinetic reactions) coupled together (Onishi et al. 1996a). For fluid mechanics computations, TEMPEST solves three-dimensional, time-dependent equations of flow, turbulence, heat, and mass transport, based on conservation of the following:

- fluid mass (the equation of continuity)
- momentum (the Navier-Stokes equations)
- turbulent kinetic energy and its dissipation
- thermal energy
- mass of dissolved constituents
- mass of solid constituents
- mass of gaseous constituents.

TEMPEST uses integral forms of the fundamental conservation laws applied in the finite volume formulation. It uses the k-ε turbulence model (Rodi 1984) to solve the turbulence of kinetic energy and its dissipation. TEMPEST can accommodate non-Newtonian fluids as well as fluids whose rheology depends upon solid concentrations (Mahoney and Trent 1995; Onishi and Trent 1998).

TEMPEST was applied previously to other Hanford DSTs, SY-102 (Onishi et al. 1996b), AZ-101 (Onishi and Recknagle 1997), AY-102 (Whyatt et al. 1996), SY-101 (Trent and Michener 1993), and AY-102 (Whyatt et al. 1996) to simulate mixing with rotating pump jets, gas rollover events, and transfer from one tank to another.

Section 2 describes the pump jet mixing conditions we evaluated, the modeling cases, and their parameters. Section 3 reports model applications and assessment results. The summary and conclusions are presented in Section 4, and cited references are listed in Section 5.

2.0 Selection of Pump Jet Mixing Evaluation Conditions

2.1 Tank Waste Conditions

In this study, we assumed that Tank AN-105 waste would be transferred to Tanks AP-102 and -104. AN-105 contains 4.270 million liters (1.129 million gallons) of waste, equivalent to a waste depth of 10.4 m (410 in.) (Jo et al. 1997). Within this waste, a nonconvective layer (solids-containing layer) occupies 4.1 to 4.6 m (160 to 180 in.), and a convective (supernatant liquid) layer, including up to 0.30 m (12 in.) of crust on the surface, occupies 5.8 to 6.4 m (230 to 250 in.) (Stewart et al. 1996; Steen 1997). The nonconvective layer also includes approximately 3.8 vol% of free gas (mostly H_2, N_2, N_2O), while the convective layer contains 0.5 vol% of free gas (Stewart et al. 1996; Shekarriz et al. 1997). The densities of the nonconvective (without gas) and convective layers are 1.59 and 1.42 g/mL, respectively (Jo et al. 1997). The former contains 46.1 vol% of solids whose average particle density is estimated to be 1.91 g/mL. Without gas, these solids account for 48% of the total volume of the nonconvective layer. The viscosity of the waste in the convective layer is reported to be 15–55 cP at a strain rate of less than 1 s^{-1} (Jo et al. 1997; Stewart et al. 1997). The viscosity of the waste in the nonconvective layer was measured to be as much as 360 cP at these low strain rates (Herting 1997). The AN-105 solid size distribution is shown in Figure 2.1 (Herting 1997).

Because many of the AN-105 tank solids can be dissolved with a solution of NaOH and water (Herting 1997), these diluents will be added to the waste to reduce the solid concentrations during the actual retrieval operations. Although both water and NaOH (likely 2 M) are being considered as potential diluents, we expect that water is more likely to be used because it is simple

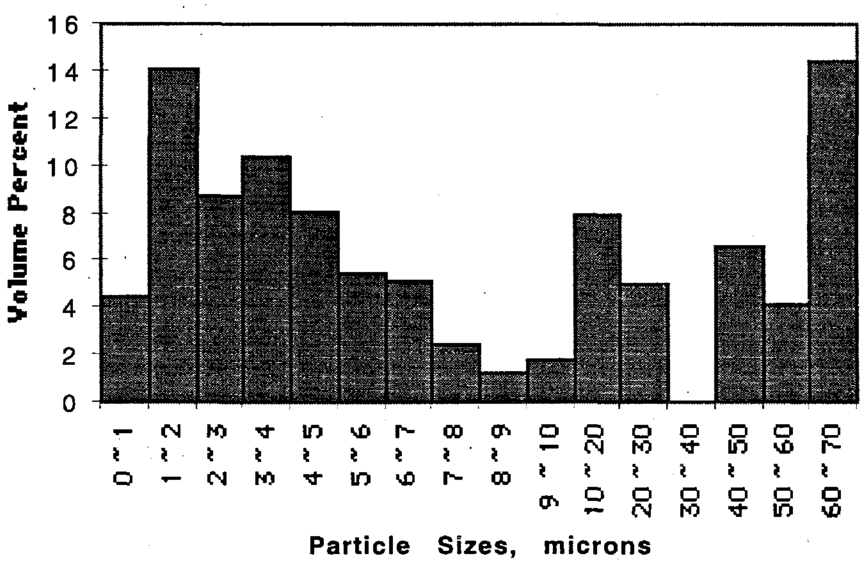

Figure 2.1. AN-105 Solid Size Distribution (Herting 1997)

and inexpensive. So we chose water to dilute the AN-105 waste in this assessment. Hot cell experiments with actual AN-105 tank waste have been conducted to evaluate potential solid dissolution by water and 2-M NaOH solution (Herting 1997). Test results on amounts of solids dissolved by water are summarized in Table 2.1. The dissolution kinetic time was very fast (on the order of seconds and minutes) (Herting 1997).

We used two criteria to select the amount of water to be mixed with AN-105 waste for this assessment. One criterion is that AN-105 tank waste will be diluted at least 25% by water, resulting in a mixture density of approximately 1.4 g/mL. The other criterion derives from restrictions imposed on the slurry pipeline transfer, which dictate that the mixture density be less than 1.25 g/mL and the solid volume fraction less than 20%. With these two criteria, we bounded a range of the assessment conditions with the smallest amounts of supernatant liquid and solids and the largest amounts of supernatant liquid and solids deposited in Tanks AP-102 and -104.

The smallest amounts of supernatant liquid and solids correspond to a case in which AN-105 waste is diluted by 25 vol% of water, resulting in 49% of the original AN-105 solids being dissolved (see Table 2.1). This case yields densities of 1.37 and 1.43 g/mL for the resulting supernatant liquid and the total mixture, respectively. The largest amounts of supernatant liquid and solids occurs in the case in which AN-105 waste is diluted by 180 vol% of water without any solids dissolved. This case results in 1.22 and 1.25 g/mL, respectively, of the resulting supernatant liquid and total mixture densities. The 25% dilution case also corresponds to very quick solid dissolution kinetic reactions, while the 180% dilution case corresponds to very slow kinetic reactions.

Because kinetic reaction testing was performed with small quantities (Herting 1997), it is not certain that chemical (dissolution/precipitation) reactions will be completed before the AN-105 tank waste is transferred to Tanks AP-102 and -104. Thus, we selected the solid and supernatant liquid conditions corresponding to the following four conditions:

- 180% dilution without accounting for AN-105 solids dissolution/precipitation reactions

- 180% dilution accounting for AN-105 solids dissolution

- 25% dilution accounting for AN-105 solids dissolution

- 25% dilution without accounting for AN-105 solids dissolution.

Table 2.1. Solid Dissolution of AN-105 Waste with Water (from Herting 1997)

Dilution by Water (%)	Solid Volume Remaining after Dilution (%)	Solid Volume Reduction after Dilution (%)	Resulting Supernatant Liquid Density (g/mL)
0	100	0	1.42
25	51.0	49.0	1.37
50	41.7	58.3	1.32
75	32.4	67.6	1.29

2.2 Selection of Test Cases

To bound these conditions, we selected the following six test cases:

Case 1: 180% dilution of AN-105 waste by water without solid dissolution with solids initially deposited in the tank bottom

Case 2: 180% dilution without solid dissolution after solids are fully mixed

Case 3: 180% dilution with solids dissolution after solids are fully mixed

Case 4: 25% dilution with solids dissolution and solids initially deposited on the bottom of the tank

Case 5: 25% dilution with solids dissolution after solids are fully mixed

Case 6: 25% dilution without solids dissolution after solids are fully mixed.

Cases 1 and 2 portray the largest amounts of solids and supernatant liquid deposited in AP-102 and -104. Case 1 examined whether the settled AN-105 solids can be suspended by the pump; Case 2 tested the pump's ability to maintain a fully mixed condition. Cases 4 and 5 have the smallest amounts of solids and supernatant liquid deposited in the two receiving tanks.

We selected initial waste conditions (e.g., solid volume, solid size distribution, viscosity, and density of supernatant liquid) to account for chemical reactions rather than simulating solid dissolution during the mixing. The TEMPEST code thus simulated physical movements of the waste induced by the rotating pump jet in these conditions. Table 2.2 shows waste properties for Cases 1 through 6. These values were estimated by the combined use of Tank AN-105 data (Jo et al. 1997; Steen 1997), dilution test data (Herting 1997), and empirical formulas of density and viscosity for Hanford tank wastes (Mahoney and Trent 1995). The density (1190 kg/m^3) of the convective layer in Case 3 (180% dilution accounting for solid dissolution effects) is probably the same or slightly higher than those (1220 kg/m^3) in Cases 1 and 2 (180% dilution, accounting for

Table 2.2. Assigned Test Conditions

	Density of Convective Layer (kg/m^3)	Viscosity of Convective Layer (cP)	Solid Concentration of Tank (vol%)	Total Waste Depth (m)
Case 1	1220	5.0	7.23	7.16
Case 2	1220	5.0	7.23	7.16
Case 3	1190	5.0 (14.0[(a)])	2.34	7.16
Case 4	1370	15.0	7.7	3.20
Case 5	1370	15.0	7.7	3.20
Case 6	1320	11.6 (37.0[(a)])	16.2	3.20

(a) The viscosities of fully mixed slurries were internally computed by the computer code.

for solid dissolution). This indicates there is potentially a small error (about 3%) in the density estimate. However, using the lower liquid density in Case 3 represents a condition of less mixing, making it a more conservative condition.

The viscosity of the slurry changes spatially and temporally during the mixing operation because of the mixing of the supernatant liquid and solids. The TEMPEST computer code internally calculates these varying viscosities during the simulation by Equation 2.1.

$$\mu = \mu_L \left\{ \frac{\mu_s}{\mu_L} \right\}^{\frac{C_V}{C_{Vmax}}} \tag{2.1}$$

where

- C_V = solid volume fraction of the slurry
- C_{vmax} = maximum solid volume fraction (= 0.48 based on Jo et al. 1997)
- μ = viscosity of slurry at solid concentration of C_V
- μ_L = viscosity of convective layer (supernatant liquid)
- μ_S = viscosity of nonconvective layer (saltcake).

The nonconvective layer in Tank AN-105 exhibits a yield stress of 40 to 180 Pa (Stewart 1997). However, our model assumed that the resulting nonconvective layers in AP-102 and -104 would not have yield stress, because the AN-105 waste will be fully disturbed by 1) pump jet mixing in that tank, 2) mixing in the 3,678-ft long, 3-in. transfer pipeline connecting AN-105 to AP-102 and AP-104, and 3) injection and deposition of the mixed slurry into AP-102 and -104.

Solid size distributions in AP-102 and -104 would vary, depending on the dissolution with water. Based on tank characterization data (Jo et al. 1997) and solid dissolution testing results (Herting 1997), we divided the AN-105 solids now in AP-102 and -104 into four size fractions (Solids #1, 2, 3, and 4). These size fractions and their associated unhindered fall velocities are shown in Tables 2.3 through 2.6 for Cases 1 through 6. Cases 1 and 2 have the largest particles, up to 70 μm, while Cases 4 and 5 have particles only up to 30 μm (Herting 1997).

Table 2.3. Solid Size Fractions, Concentrations, and Unhindered Fall Velocities, Case 1 (estimates based on the no-dilution case measured by Herting 1997)

	Particle Size (μm)	Solid Concentration in Nonconvective Layer (vol%)	Solid Concentration in Convective Layer (vol%)	Unhindered Fall Velocity (m/s)
Solid #1	0.0 ~ 4.0	13.2	0	1.7×10^{-7}
Solid #2	4.0 ~ 10	16.6	0	2.3×10^{-6}
Solid #3	10 ~ 30	6.2	0	2.3×10^{-5}
Solid #$4	40 ~ 70	12.0	0	2.1×10^{-4}
Total[(a)]		48.0	0	

(a) All solids for Case 1 are initially settled in Tanks AP-102 and 104.

Table 2.4. Solid Size Fractions, Concentrations, and Unhindered Fall Velocities, Case 2 (estimates based on the no-dilution case measured by Herting 1997)

	Particle Size (μm)	Solid Concentration in Nonconvective Layer (vol%)	Solid Concentration in Convective Layer (vol%)	Unhindered Fall Velocity (m/s)
Solid #1	0.0 ~ 4.0	1.98	1.98	1.7×10^{-7}
Solid #2	4.0 ~ 10	2.50	2.50	2.3×10^{-6}
Solid #3	10 ~ 30	0.94	0.94	2.3×10^{-5}
Solid #4	40 ~ 70	1.81	1.81	2.1×10^{-4}
Total[a]		7.23	7.23	
(a) All solids for Case 2 are initially distributed uniformly within Tanks AP-102 and 104.				

Table 2.5. Solid Size Fractions, Concentrations, and Unhindered Fall Velocities, Case 3 (estimates based on no dilution and 75% dilution cases measured by Herting 1997)

	Particle Size (μm)	Solid Concentration in Nonconvective Layer (vol%)	Solid Concentration in Convective Layer (vol%)	Unhindered Fall Velocity (m/s)
Solid #1	0.0 ~ 3.0	0.72	0.72	8.5×10^{-8}
Solid #2	3.0 ~ 5.0	0.58	0.58	4.3×10^{-7}
Solid #3	5.0 ~ 20	0.45	0.45	2.9×10^{-6}
Solid #4	20 ~ 50	0.59	0.59	2.8×10^{-5}
Total[a]		2.34	2.34	
(a) All solids for Case 3 are initially distributed uniformly within Tanks AP-102 and -104.				

Table 2.6. Solid Size Fractions, Concentrations, and Unhindered Fall Velocities, Case 4 (estimates based on 25% dilution case measured by Herting 1997)

	Particle Size (μm)	Solid Concentration in Nonconvective Layer (vol%)	Solid Concentration in Convective Layer (vol%)	Unhindered Fall Velocity (m/s)
Solid #1	0.0 ~ 2.0	5.5	0	1.9×10^{-8}
Solid #2	2.0 ~ 5.0	31.7	0	1.9×10^{-7}
Solid #3	5.0 ~ 10	8.9	0	9.7×10^{-7}
Solid #4	10 ~ 30	1.9	0	4.4×10^{-6}
Total[a]		48.0	0	

(a) All solids for Cases 4 are initially settled on the AP-102 and -104 tank bottoms.

Table 2.7. Solid Size Fractions, Concentrations, and Unhindered Fall Velocities, Case 5 (estimates based on 25% dilution case measured by Herting 1997)

	Particle Size (μm)	Solid Concentration in Nonconvective Layer (vol%)	Solid Concentration in Convective Layer (vol%)	Unhindered Fall Velocity (m/s)
Solid #1	0.0 ~ 2.0	0.88	0.88	1.9×10^{-8}
Solid #2	2.0 ~ 5.0	5.09	5.09	1.9×10^{-7}
Solid #3	5.0 ~ 10	1.42	1.42	9.7×10^{-7}
Solid #4	10 ~ 30	0.31	0.31	4.4×10^{-6}
Total[a]		7.70	7.70	

(a) All solids for Case 5 are initially distributed uniformly within Tanks AP-102 and 104.

Table 2.8. Solid Size Fractions, Concentrations, and Unhindered Fall Velocities, Case 6 (estimates based on no dilution case measured by Herting 1997)

	Particle Size (μm)	Solid Concentration in Nonconvective Layer (vol%)	Solid Concentration in Convective Layer (vol%)	Unhindered Fall Velocity (m/s)
Solid #1	0.0 ~ 4.0	4.44	4.44	1.7×10^{-7}
Solid #2	4.0 ~ 10	5.60	5.60	2.3×10^{-6}
Solid #3	10 ~ 30	2.11	2.11	2.3×10^{-5}
Solid #4	40 ~ 70	4.05	4.05	2.1×10^{-4}
Total[a]		16.20	16.20	

(a) All solids for Case 6 are initially distributed uniformly within Tanks AP-102 and 104.

When solid concentrations are high, particle fall velocity will be less than the particle fall velocity in low solid concentrations (Vanoni 1975). This reduced (hindered) fall velocity was internally computed by Equation 2.2 (Vanoni 1975) during our AP-102 and -104 simulations.

$$V_s = V_{so}\left\{1 - \frac{C_V}{C_{Vmax}}\right\}^{4.65} \tag{2.2}$$

where

V_s = hindered fall velocity
V_{so} = unhindered fall velocity.

3.0 Pump Jet Mixing Evaluation

Tanks AP-102 and -104 will each have a single 300-hp rotating pump at the tank center to mix their stored wastes. The pump has a 15-in.-diameter suction opening positioned 7 in. above the tank bottom and has two 6-in.-injection nozzles located 17 in. above tank bottom. These injection nozzles discharge recirculating slurry into the tank with an exit velocity of 60 ft/s. To enhance uniform mixing of the wastes, these nozzles rotate a half circle each at 0.05 to 0.2 rpm.

To determine the effectiveness of the single rotating pump to mix tank wastes, we used the three-dimensional TEMPEST computer code (Trent and Eyler 1993; Onishi and Trent 1998) to simulate waste mixing induced by two 60-ft/s rotating jets injected from the pump. The pump speed was selected to be 0.2 rpm for the current simulation, because pump jet modeling conducted for other Hanford DSTs (Onishi et al. 1996; Whyatt et al. 1997; Onishi and Recknagle 1998) implies that 0.2 rpm will probably achieve a shorter mixing time than 0.05 rpm does. The 0.2-rpm speed is thus more likely to be used for the AP-102 and -104 pump jet mixing than the 0.05 rpm speed. Because Tanks AP-102 and -104 are exactly the same size and have the same waste conditions and pump configurations, AP-102 modeling can represent both tanks.

We selected six test cases to test the adequacy of the single mixer pump design, as discussed in Section 2.3. These cases are

Case 1: <u>180% dilution of AN-105 waste by water without solid dissolution with solids initially deposited in the tank bottom</u>

This case and Case 2 represent 180% dilution of AN-105 waste by water with very slow kinetic chemistry (no solid dissolution). Thus these cases have the largest amount of solids and supernatant liquid and the largest particle sizes (up to 70 μm) to be mobilized by the pump jets. Case 1 represents the most difficult conditions for uniform mixing among the cases examined here. The objective of this case was to examine how well the pump jets resuspend and mix the settled solids under this most difficult bounding condition.

Case 2: <u>180% dilution without solid dissolution after solids are fully mixed</u>

The objective of this case was to examine how well the pump jets keep the solids suspended once they are uniformly mixed under the bounding conditions of Case 1.

Case 3: <u>180% dilution with solids dissolution after solids are fully mixed</u>

The objective of this case was to examine how well the pump jets keep the solids in suspension, if kinetic chemistry is very quick to dissolve approximately 2/3 of solids as a result of 180% dilution by water (see Table 2.1). Because solid dissolution increases the viscosity of supernatant liquid (and probably its density) and reduces the amounts of solids to be suspended, it is expected that this case will more easily resuspend the solid particles and keep them in suspension than the cases with very slow kinetics (Cases 1 and 2).

Case 4: <u>25% dilution with solids dissolution and solids initially deposited in the tank bottom</u>

This case and Case 5 represent the 25% dilution of AN-105 waste by water with very fast kinetic chemistry. This condition dissolves half the solids (see Table 2.1), as reported by Herting (1997). Case 4 has 1) the smallest amount of solids and supernatant liquid, 2) only up to 30-μm solid particles to be mobilized by the pump jets, and 3) the most viscous supernatant liquid. Thus it is the easiest condition from which to achieve uniform mixing of the cases examined here. The objective of this case was to examine how well the pump jets resuspend and mix the settled solids under this easiest bounding condition.

Case 5: 25% dilution with solids dissolution after solids are fully mixed

The objective of this case was to examine how well the pump jets keep the solids in suspension once they are uniformly mixed for the 25% dilution case with the very fast kinetics (Case 4).

Case 6: 25% dilution without solids dissolution after solids are fully mixed

This case represents 25% dilution of AN-105 waste by water with very slow kinetic chemistry (no solid dissolution). Thus this case has a larger amount of solids and less viscous supernatant liquid than Cases 4 and 5. The objective of this case was to examine how well the pump keeps the solids in suspension if kinetic chemistry is very slow to dissolve the solids.

Specific test conditions for these six cases were described in Section 2 (see Tables 2.2 through 2.8). All six simulations covered a half-circle of the tank (180°), as covered by the centrally located pump.

3.1 Simulation Results of Case 1

The TEMPEST computer code simulated movements of supernatant liquid and the four size fractions of solids particles ranging from submicron to 70 μm (see Table 2.3) for 1 hour and 20 simulation minutes. Figure 3.1 shows the initial 1.12-m-thick nonconvective (solids-containing) layer at the tank bottom and the 6.04-m-thick convective (supernatant liquid) layer that make up 7.16 m of the waste in Tank AP-102. It also shows the positions of the rotating pump, the withdrawal inlet, and the nozzle injecting a 60-ft/s jet within the nonconvective layer. The Solid #4 concentration within the nonconvective layer is 12 vol%, as shown in this figure. Its concentration in the convective (supernatant liquid) layer was assigned a small value (0.01 vol%) rather than zero to handle the fall velocity for all solid concentrations.

The top of Figure 3.1 shows the time (0 simulation second in this plot) and constituent (Solid #4 in this case). The left side of the figure describes which plane it is showing (in this case the r-z plane, which is the Vertical Plane 2 (I=2) area of the plot coverage (in this case J=1 to 34, indicating the entire radial direction from the tank center to the wall, and K=1 to 19, indicating the vertical direction from the tank bottom to the waste surface at 7.16 m). The left side of the figure also shows concentrations (expressed in volume fractions) represented by lines 1 through 9. "Plane min and max" indicate minimum and maximum values (Solid #4 volume fractions of 1.0×10^{-4} [0.01 vol%] and 0.12 [12 vol%], respectively, in this case) within the plotted plane, while "array min and max" indicate minimum and maximum values (Solid #4 volume fractions of 1.0×10^{-4} and 0.12, respectively, in this case) encountered within the entire simulated area. At the left bottom, the maximum velocity encountered in this vertical plane is shown (in this case 16.1 m/s with its corresponding scale length). All velocity in the plot is scaled to this magnitude. Note that the jet velocity at the nozzle exit was assigned to be 18.3 m/s (60 ft/s) in all six cases. The maximum velocity of 16.1 m/s listed in this figure is the velocity within the nozzle, not at the nozzle exit.

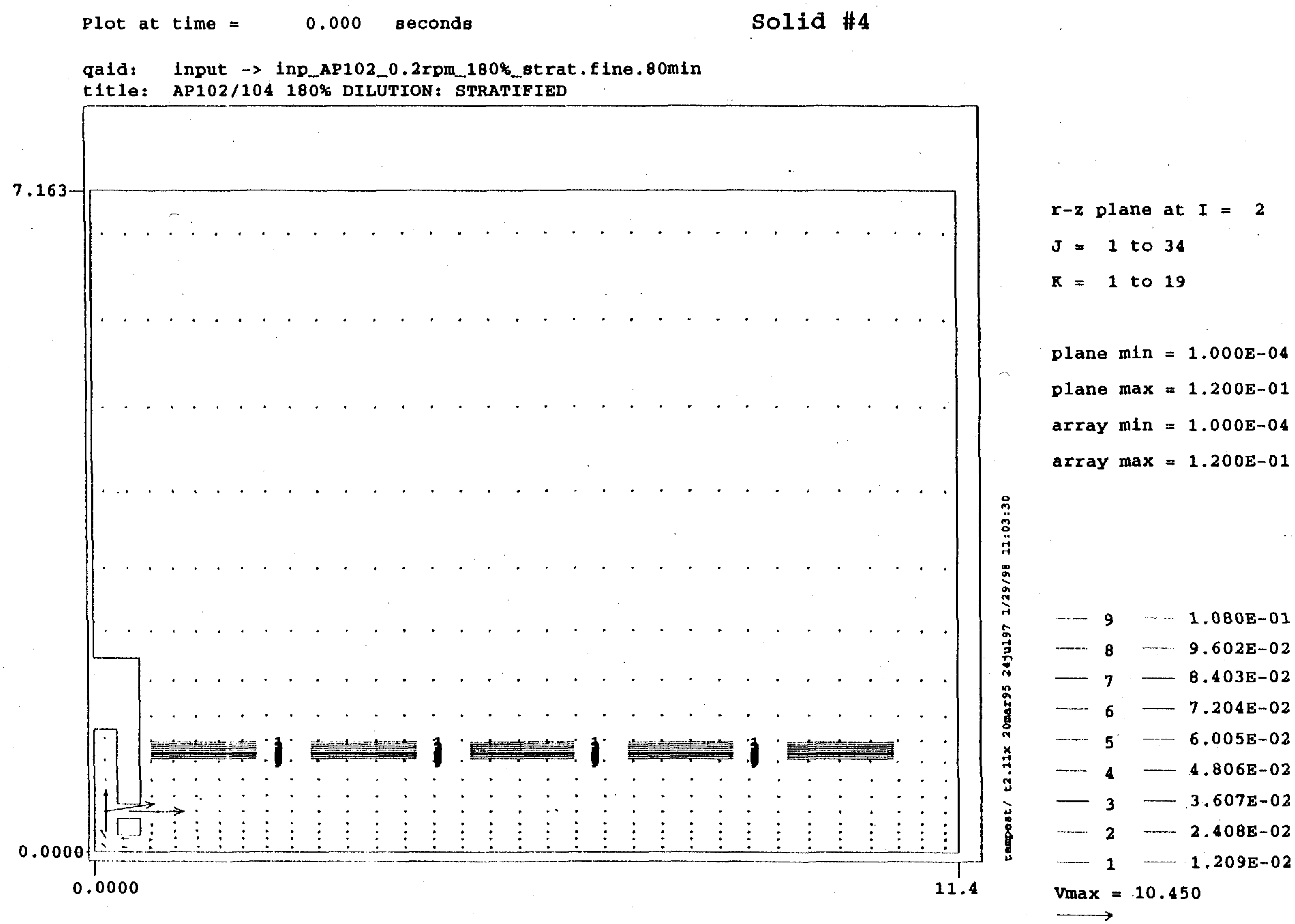

Figure 3.1. Initial Conditions of Convective Layer, Nonconvective Layer, and Solid 4 Concentrations in 3 O'Clock Position (vertical plane 2) for Case 1 (180% dilution without solid dissolution with solids initially deposited in the tank bottom)

One way to examine the mixing progress over time is to track the solid concentrations at fixed locations. We selected 16 locations in Tank AP-102 for this purpose. Of these, four locations along the tank wall are expected to take the longest time to become fully mixed. One is at the tank bottom along the wall (Location 1) in the 3 o'clock position (Vertical Plane 2); the second (Location 7) is at the supernatant liquid surface, 7.16 m above Location 1; the third (Location 10) is on the tank bottom in the 12 o'clock position (Vertical Plane 11), 90° from Location 1; the fourth (Location 12) is at the supernatant liquid surface, 7.16 m above Location 10 and 90° from Location 7. All figures showing time-varying solid concentrations are taken from these four locations.

Figures 3.2 through 3.5 present predicted volume fractions of Solids #1 through #4, respectively, versus time. Four lines in each figure represent solid concentrations at Locations 1 (tank bottom), 7 (supernatant surface), 10 (tank bottom), and 12 (supernatant surface). These figures show that the finer the solid, the faster it becomes fully mixed. All four solids achieve full mixing by about one simulation hour. Small oscillatory behavior exhibited by the three finer solids (Solids #1 through 3) before arriving at the fully mixed condition is due to the rotating jets, with 0.2 rpm hitting each specific tank location periodically. Once solids are fully mixed, there are no oscillatory variations on solid volume fractions, as indicated in Figures 3.2 through 3.4. However, the coarsest solid (Solid #4, with diameters of 40 to 70 μm) still exhibits a small oscillation after becoming fully mixed. This is because Solid #4 settles down toward the tank bottom between the times the periodic jet impinges on the waste at these locations.

The predicated distributions of velocity and Solid #1 (0 to 4 μm) volume fraction at 1 hour, 20 minutes of simulation time are shown in Figure 3.6, revealing uniform distribution throughout the tank. At that time, the jet happened to hit this particular vertical plane (2) in the 3 o'clock position. Solid #4 distribution on this same plane is shown in Figure 3.7, depicting a mostly uniform distribution with 5% concentration variation (1.76 vol% near the surface to 1.84 vol% near the tank bottom), while the impinging jet is mobilizing the solids. Predicted Solid #4 distribution on Vertical Plane 11 in the 12 o'clock position, which is 90° from the jet-impinging Vertical Plane 2, shows some solids settling and accumulating near the tank bottom, especially near the tank wall (see Figure 3.8). The minimum and maximum concentrations of Solid #4 in the whole tank are 1.76 and 2.13 vol%, respectively, while the tank average concentration is 1.81 vol%. This corresponds to a 21% variation of Solid #4 concentration within the tank. When the jet hits this plane, all solids will be resuspended, as shown in Figure 3.7.

Predicted velocity and Solid #4 concentration variation on the tank bottom are shown in Figure 3.9, depicting higher solid concentrations along the tank wall farthest from the rotating 60-ft/s jets in the 3 and 9 o'clock positions). The Solid #4 concentrations on the bottom range from 1.81 to 2.13 vol%, about the same degree of variation as in the overall tank.

The AP-102 model also predicted that variations of Solids #2 and 3 concentrations within the entire tank are 0.20 and 2.2%, respectively. Since Solids #1, 2, 3, and 4 represent 27.4, 34.6, 13.0, and 25.0 vol% of the solids in the tank, these variations result in approximately 5.6% nonuniformity of the total solid concentrations within the tank, as summarized in Table 3.1.

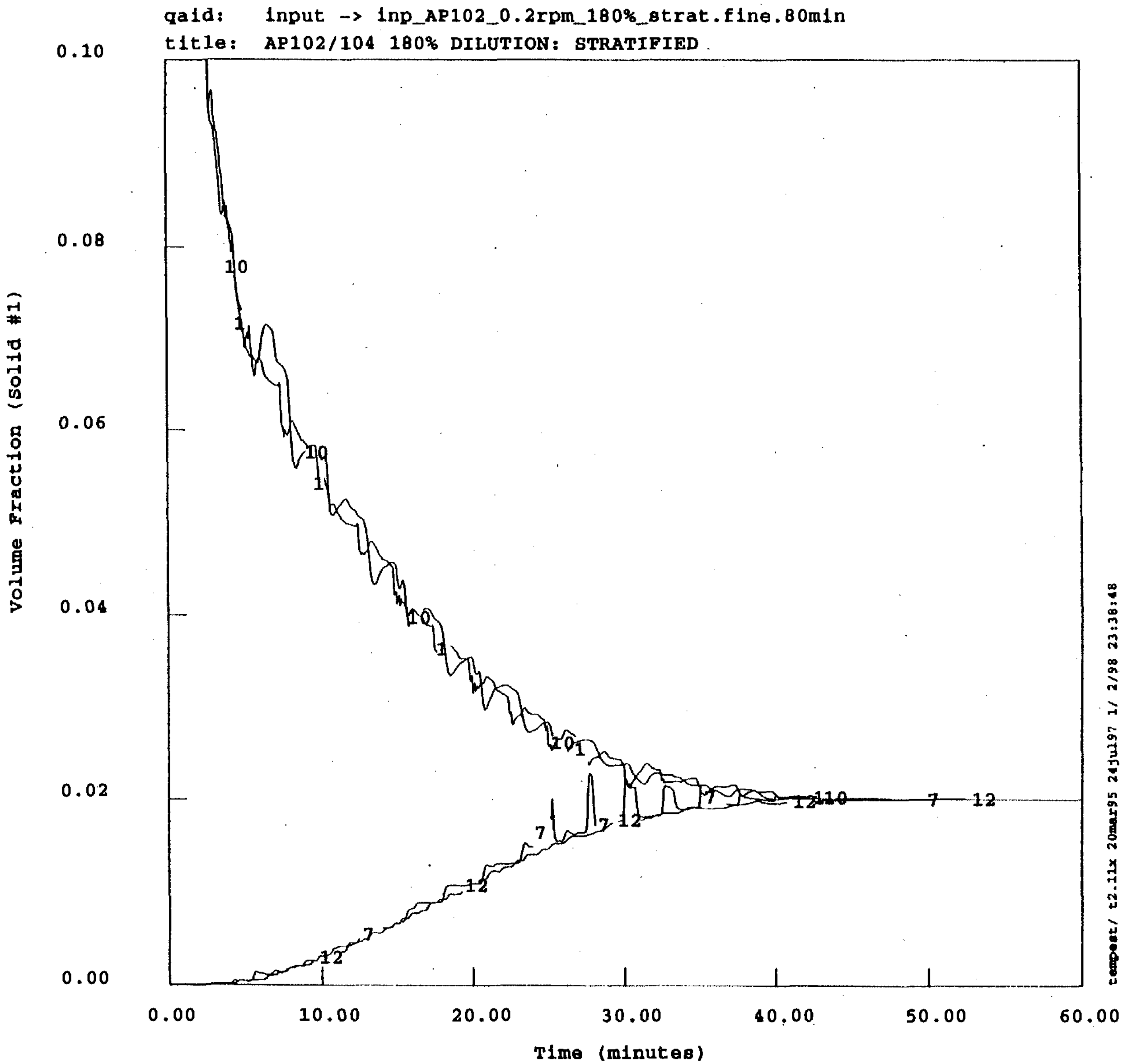

Figure 3.2. Predicted Solid 1 Concentrations (volume fraction) over One Simulation Hour for Case 1

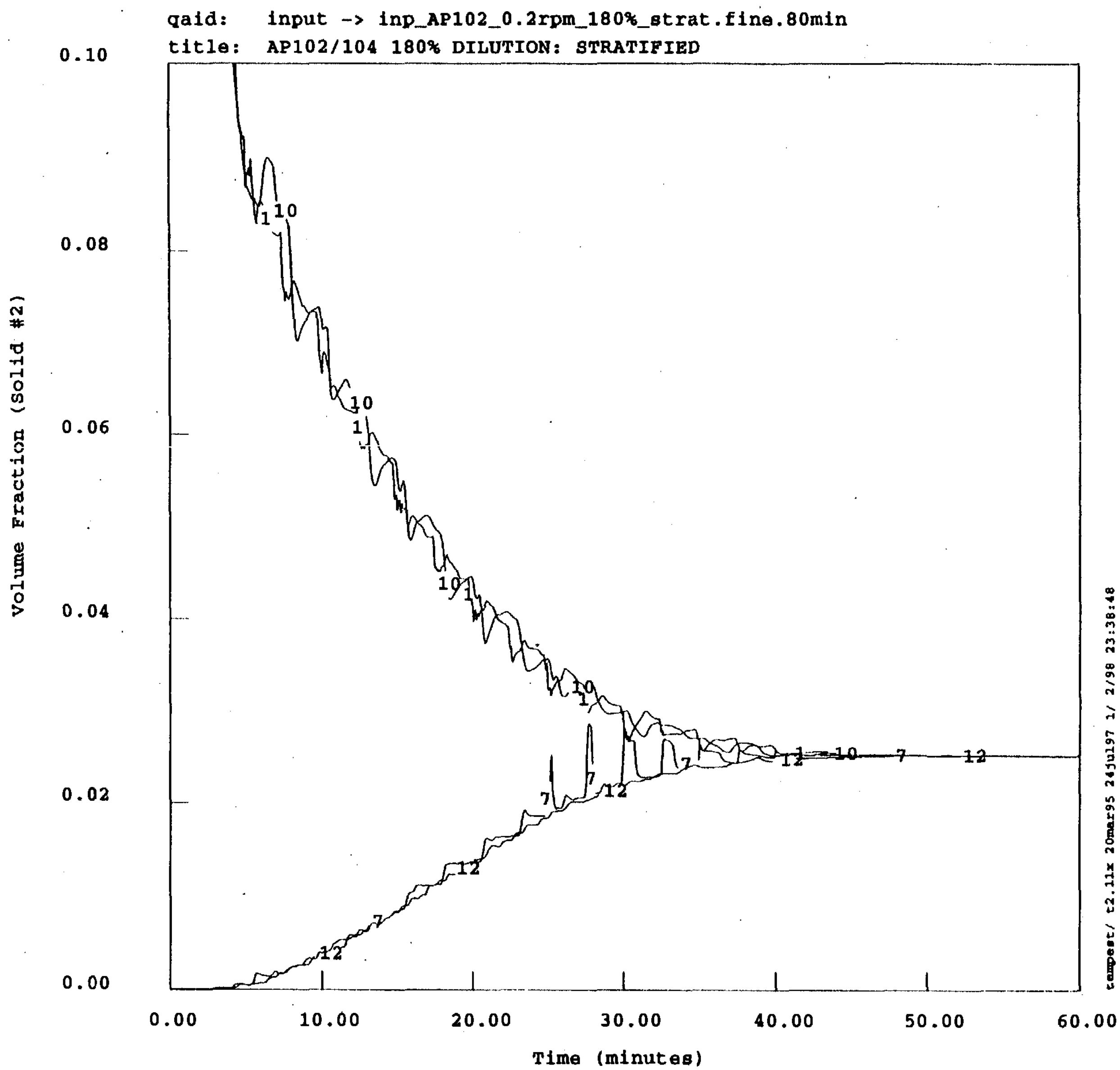

Figure 3.3. Predicted Solid 2 Concentrations (volume fraction) over One Simulation Hour for Case 1

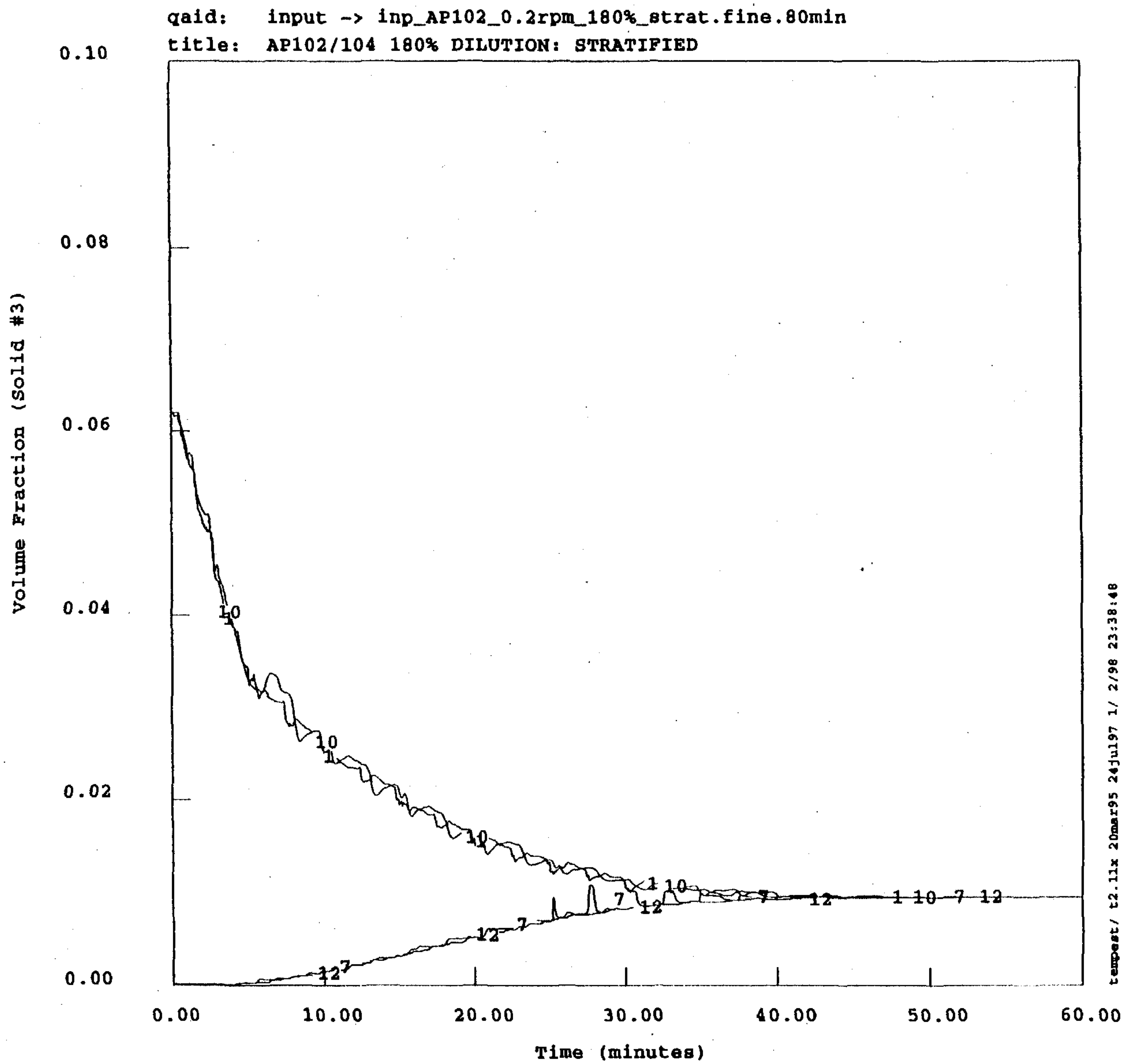

Figure 3.4. Predicted Solid 3 Concentrations (volume fraction) over One Simulation Hour for Case 1

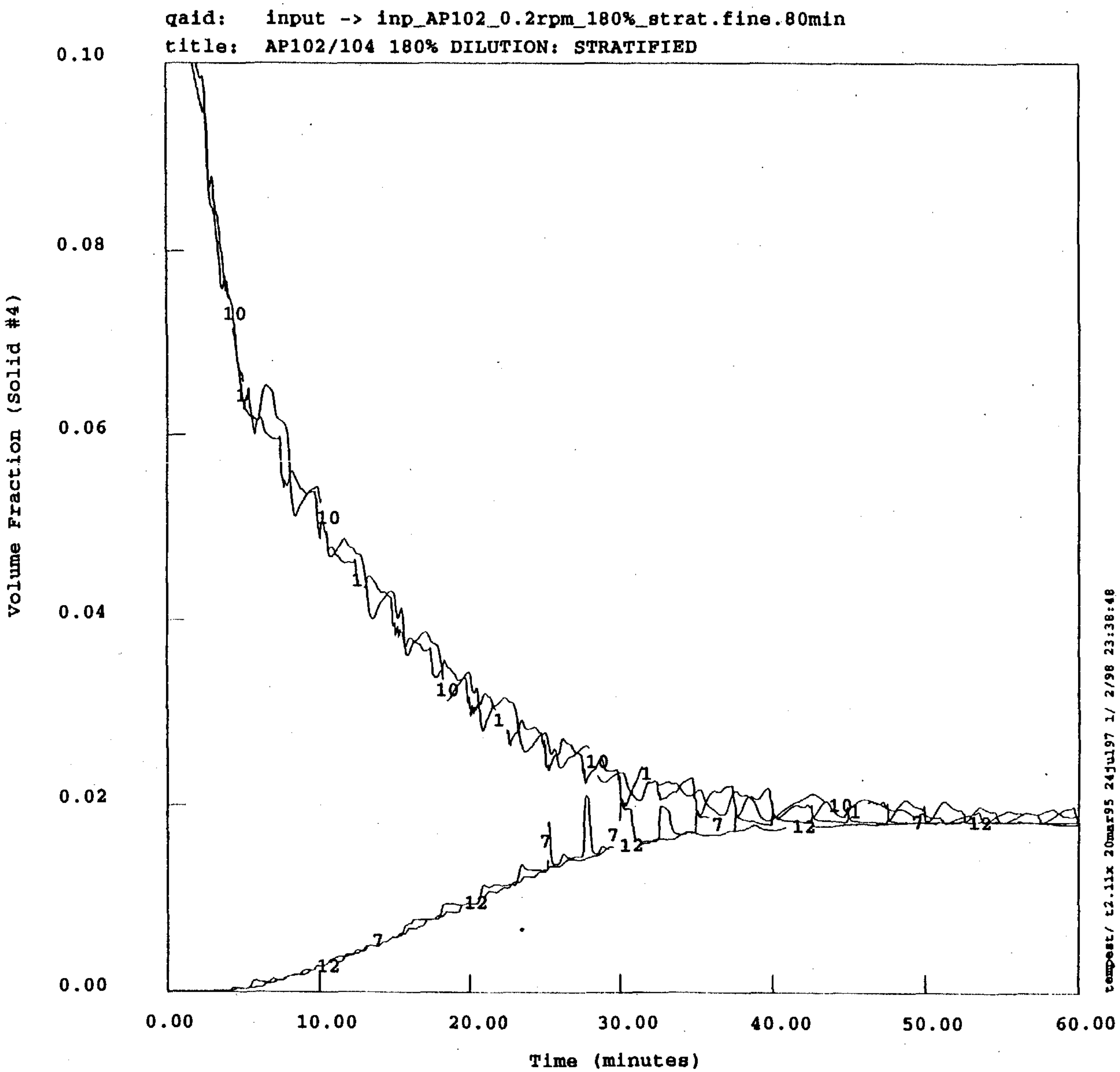

Figure 3.5. Predicted Solid 4 Concentrations (volume fraction) over One Simulation Hour for Case 1

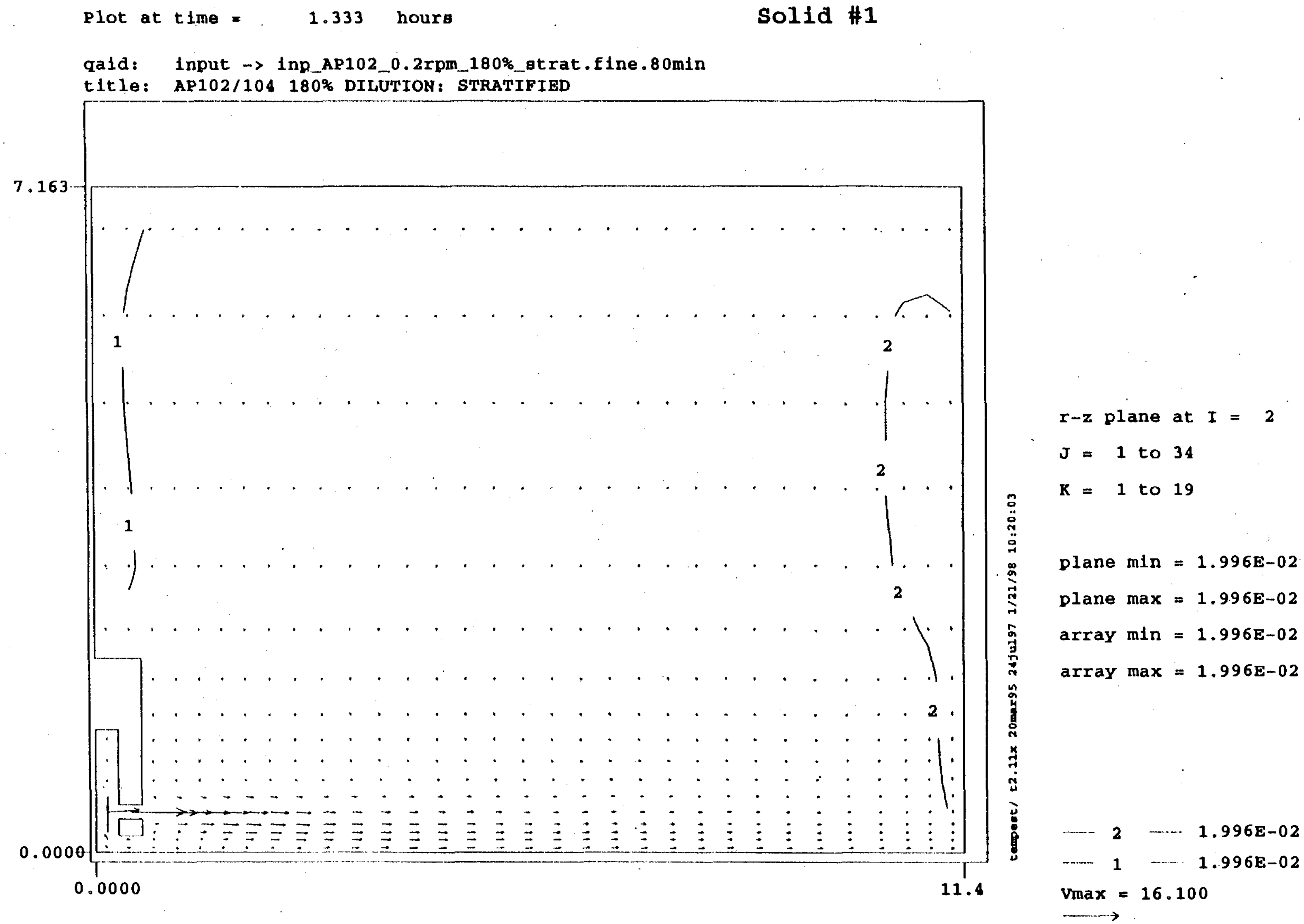

Figure 3.6. Predicted Distributions of Velocity (m/s) and Solid 1 Concentrations (volume fraction) in 3 O'Clock Position at 1 Hour and 20 Simulation Minutes for Case 1

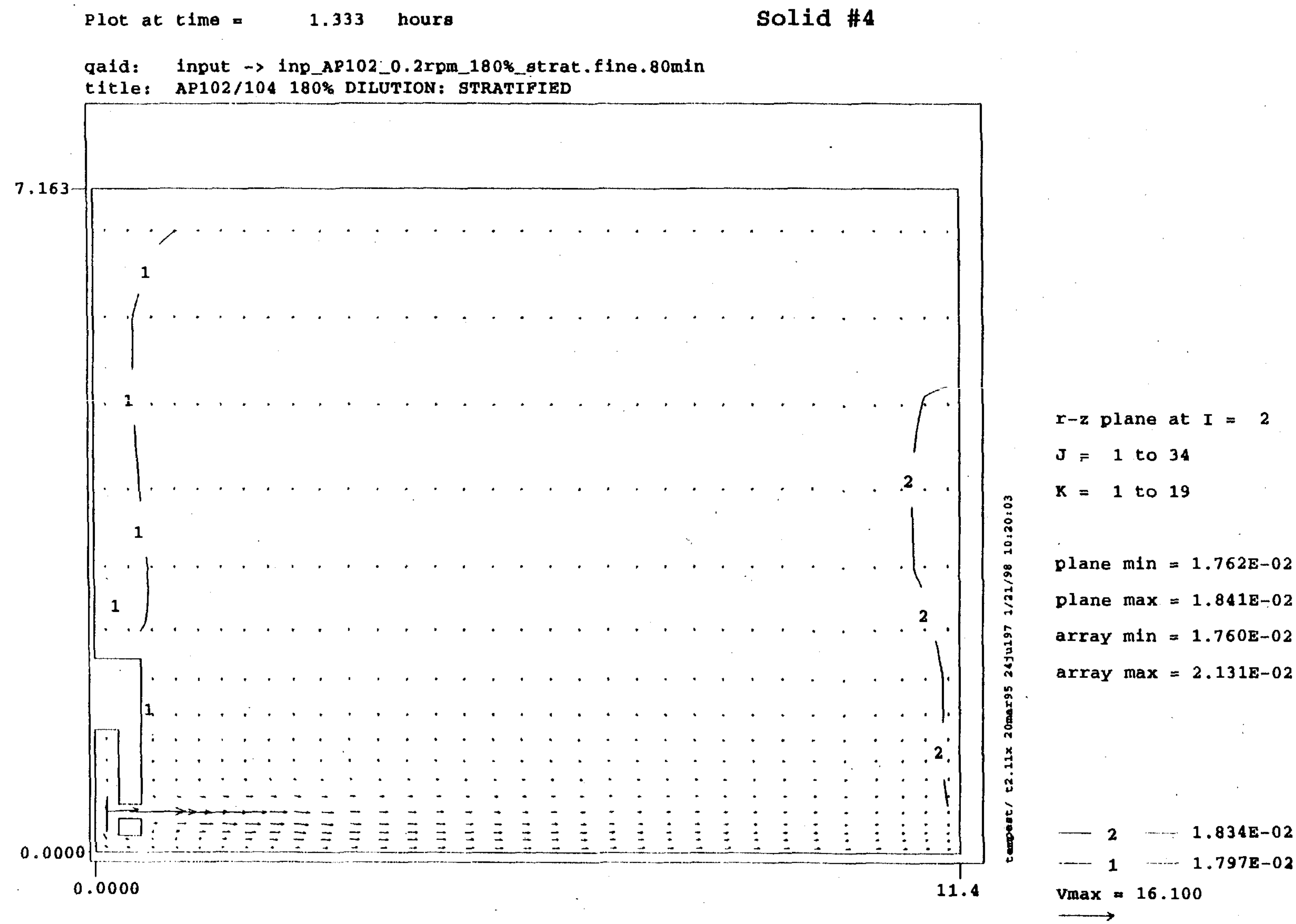

Figure 3.7. Predicted Distributions of Velocity (m/s) and Solid 4 Concentrations (volume fraction) in 3 O'Clock Position (vertical plane 11) at 1 Hour and 20 Simulation Minutes for Case 1

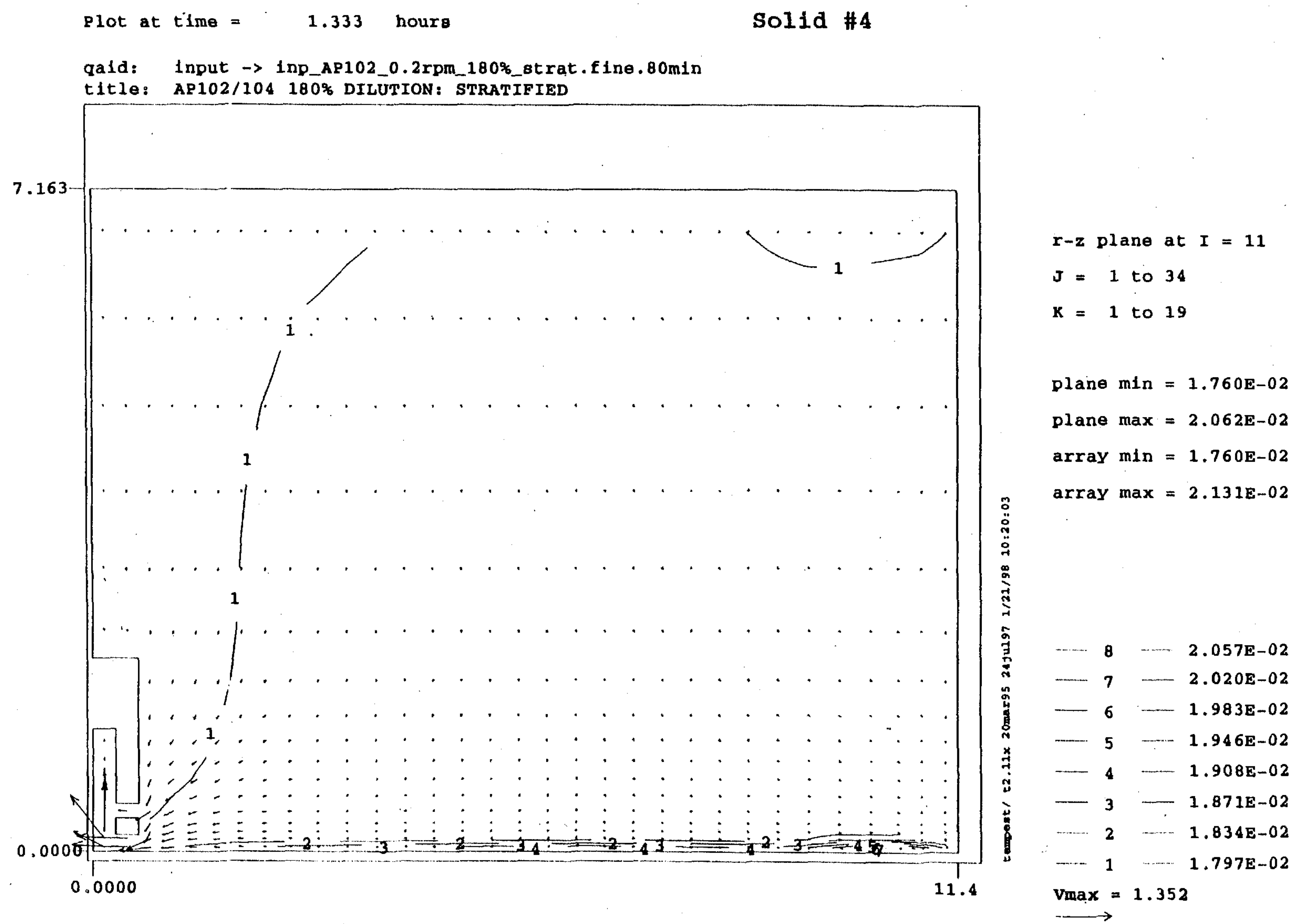

Figure 3.8. Predicted Distributions of Velocity (m/s) and Solid 4 Concentrations (volume fraction) in 12 O'Clock Position at 1 Hour and 20 Simulation Minutes for Case 1

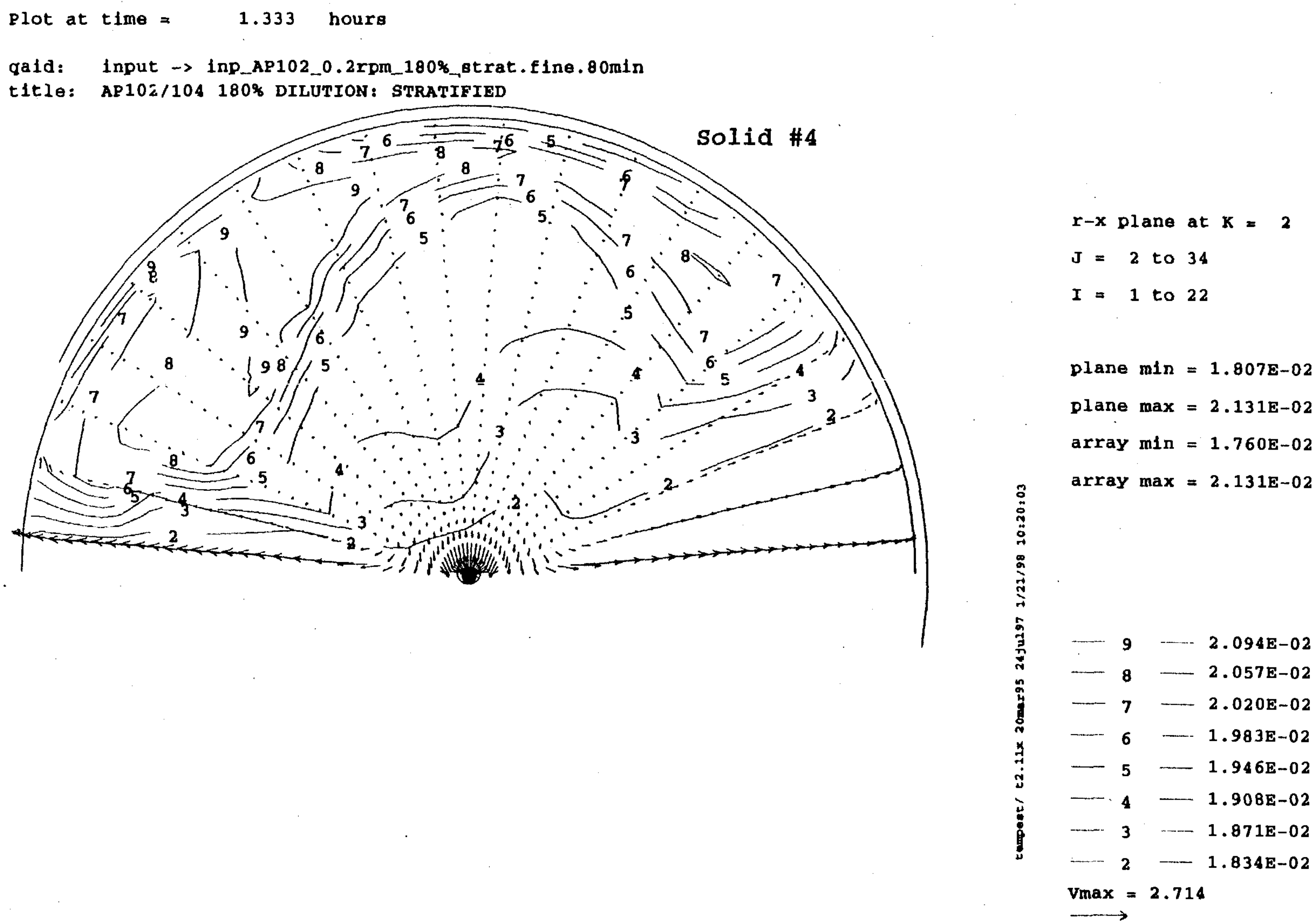

Figure 3.9. Predicted Distributions of Velocity (m/s) and Solid 4 Concentrations (volume fraction) on the Tank Bottom at 1 Hour and 20 Simulation Minutes for Case 1

Table 3.1. Expected Nonuniformity of Solid Concentrations in AP-102 Tank Resulting from Pump Jet Mixing, Case 1

	Volume Percent among Solids (vol%)	Predicted Final Solid Concentration (vol%)	Predicted Nonuniform Variation (%)
Solid #1	27.4	1.98	0.000
Solid #2	34.6	2.50	0.20
Solid #3	13.0	0.94	2.2
Solid #4	25.0	1.81	21.1
Total	100.0	7.23	5.6

These Case 1 modeling results show that the centrally located, 300-hp single pump can mix and suspend the AN-105 solids in Tanks AP-102 and 104 within 94.4% uniformity under the conditions of 180% dilution by water without accounting for the solid dissolution. They also indicate that it would take approximately one hour to fully mix the waste.

3.2 Simulation Results of Case 2

Case 1 model testing shows that the 300-hp pump can suspend and mix the wastes in Tanks AP-102 and -104. To examine how well the pump jets can keep the solids suspended once they are uniformly mixed under the Case 1 conditions, Case 2 modeling was performed. In this case, all the solids were fully mixed at the beginning of the simulation (see Table 2.4). We ran this case for one simulation hour.

The AP-102 model predicted that solid concentrations, which are the same as those at the end of the Case 1 simulation, remain unchanged from the initial concentrations over the entire simulation period. Predicted Solid #1 concentrations at Locations 1, 7, 10, and 12 over one simulation hour are shown in Figure 3.10, confirming the constant Solid #1 concentration of 1.98 vol% over one simulation hour (compare Figures 3.10 and 3.2). Figure 3.11 presents the predicted Solid #4 concentration at these locations, displaying the small periodic variations of about 1.81 vol% caused by the coarse particles settling between the times pump jets hit there.

The predicted distribution of velocity and Solid #4 concentrations at one simulation hour are shown in Figure 3.12, with the impinging jet mobilizing the solids within Vertical Plane 2 (3 o'clock position). The figure shows that the concentration of Solid #4 varies from 1.74 vol% near the slurry surface to 1.83 vol% near the tank bottom, a 5% variation (same as Case 1). The minimum and maximum concentrations of Solid #4 in the entire tank are 1.74 and 2.09 vol%, respectively; the average is 1.81 vol%. This corresponds to a 21% variation of Solid #4 concentration in the tank. As shown in Figure 3.13, the predicted Solid #4 concentration on the tank bottom varies from 1.81 to 2.09 vol%, revealing concentration and velocity variations similar to those of Case 1 (see Figure 3.9).

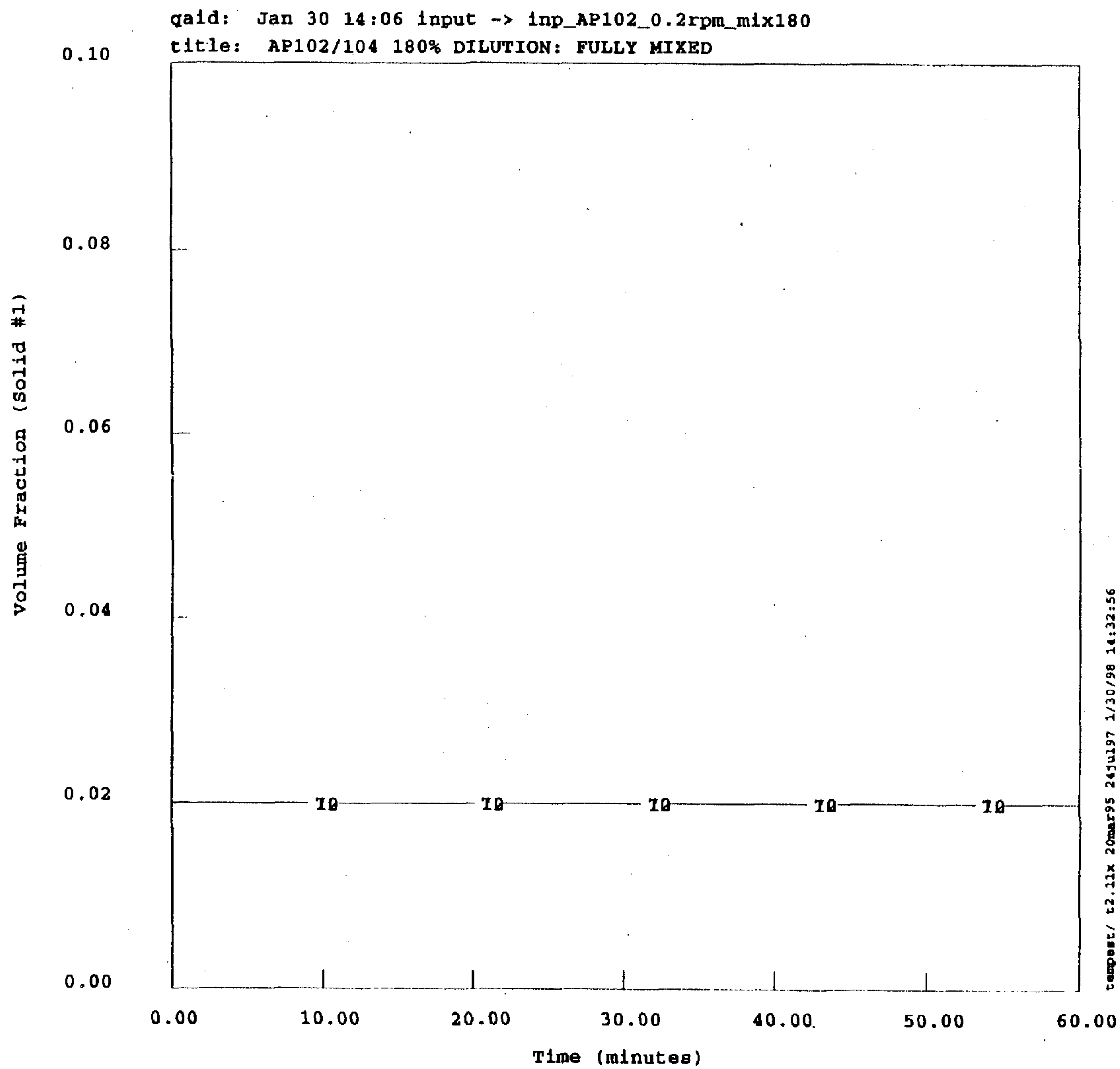

Figure 3.10. Predicted Solid 1 Concentrations (volume fraction) over One Simulation Hour for Case 2 (180% dilution without solid dissolution after solids are fully mixed)

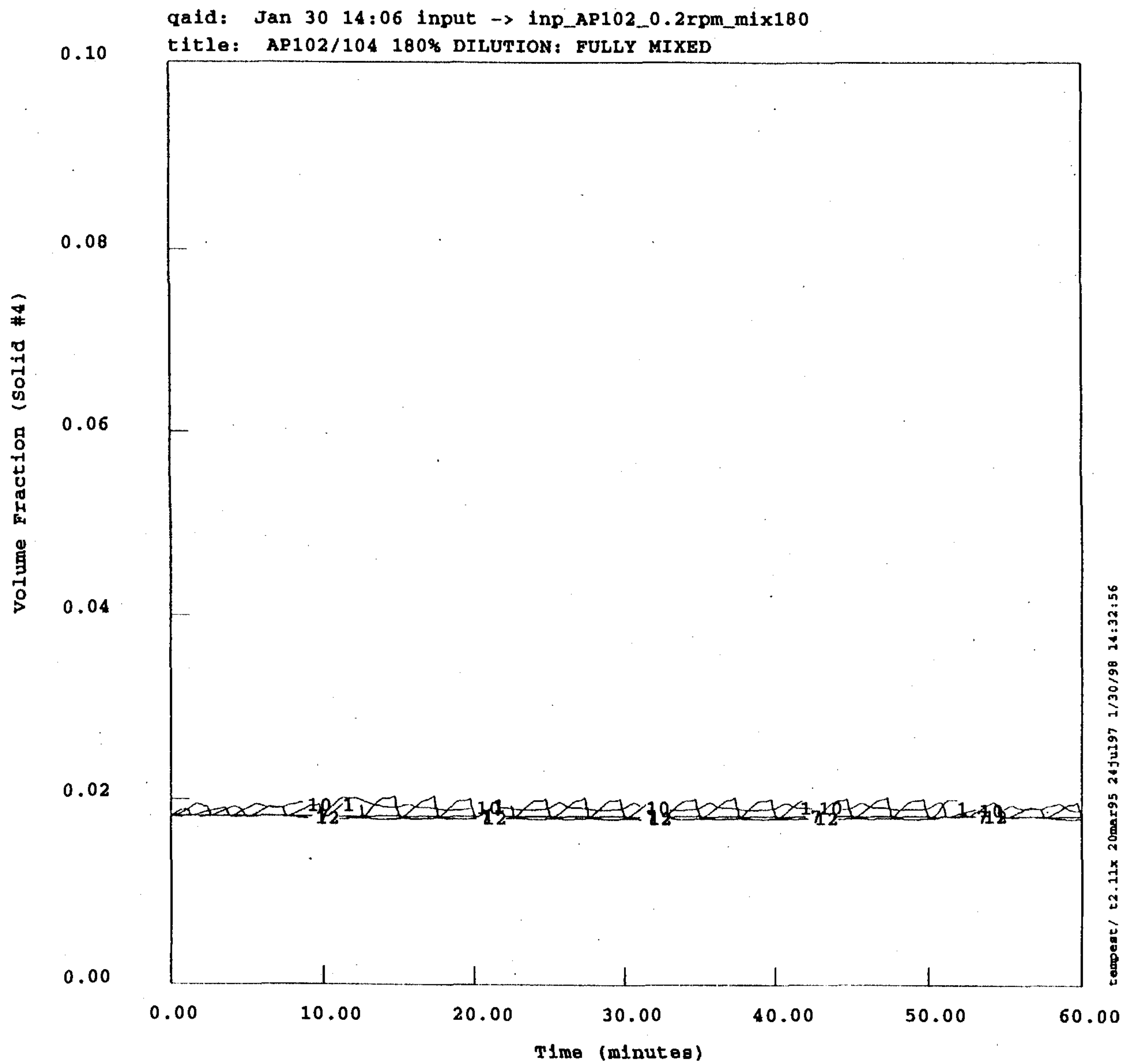

Figure 3.11. Predicted Solid 4 Concentrations (volume fraction) over One Simulation Hour for Case 2

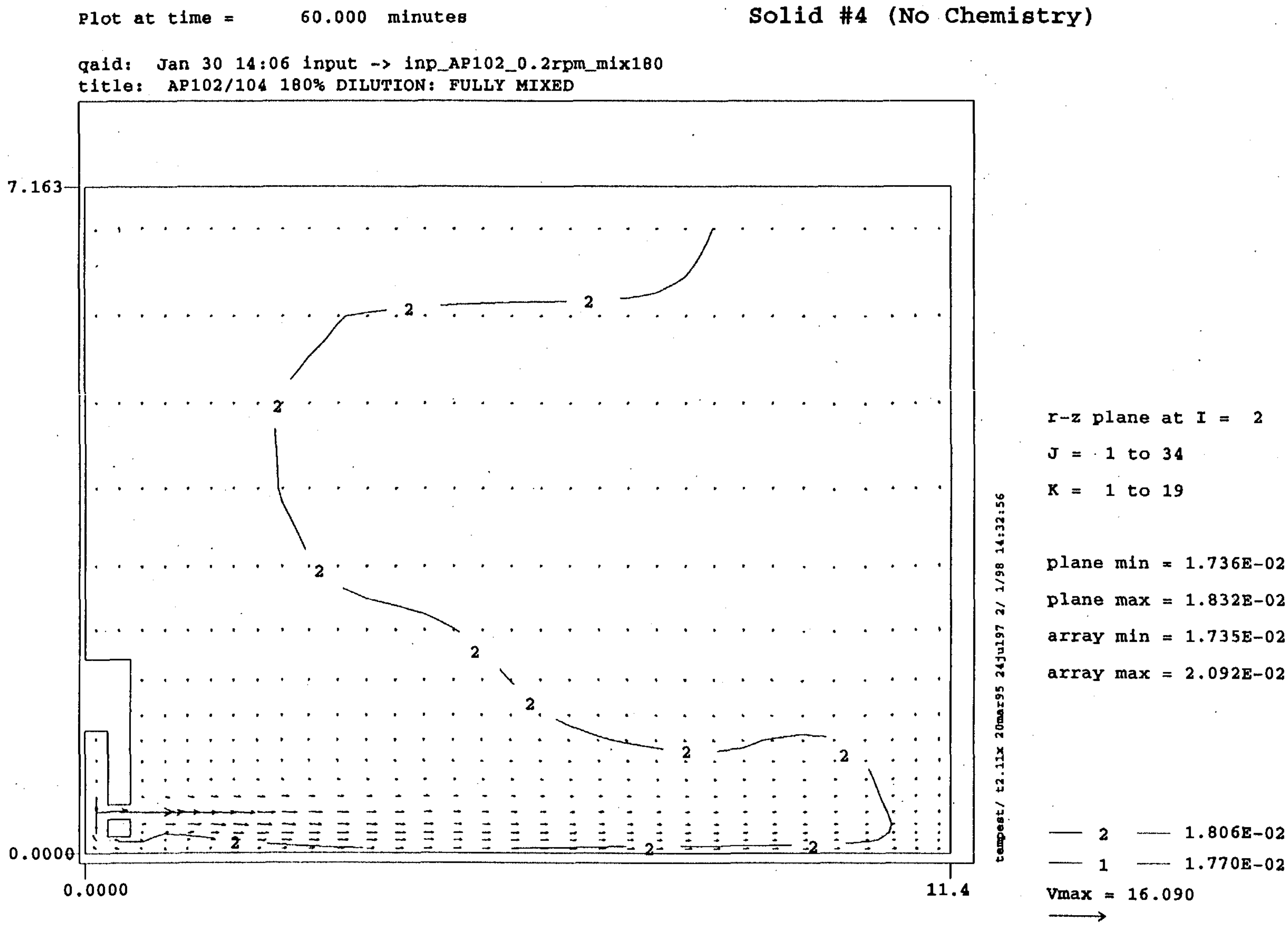

Figure 3.12. Predicted Distributions of Velocity (m/s) and Solid 4 Concentrations (volume fraction) in 3 O'Clock Position at One Simulation Hour for Case 2

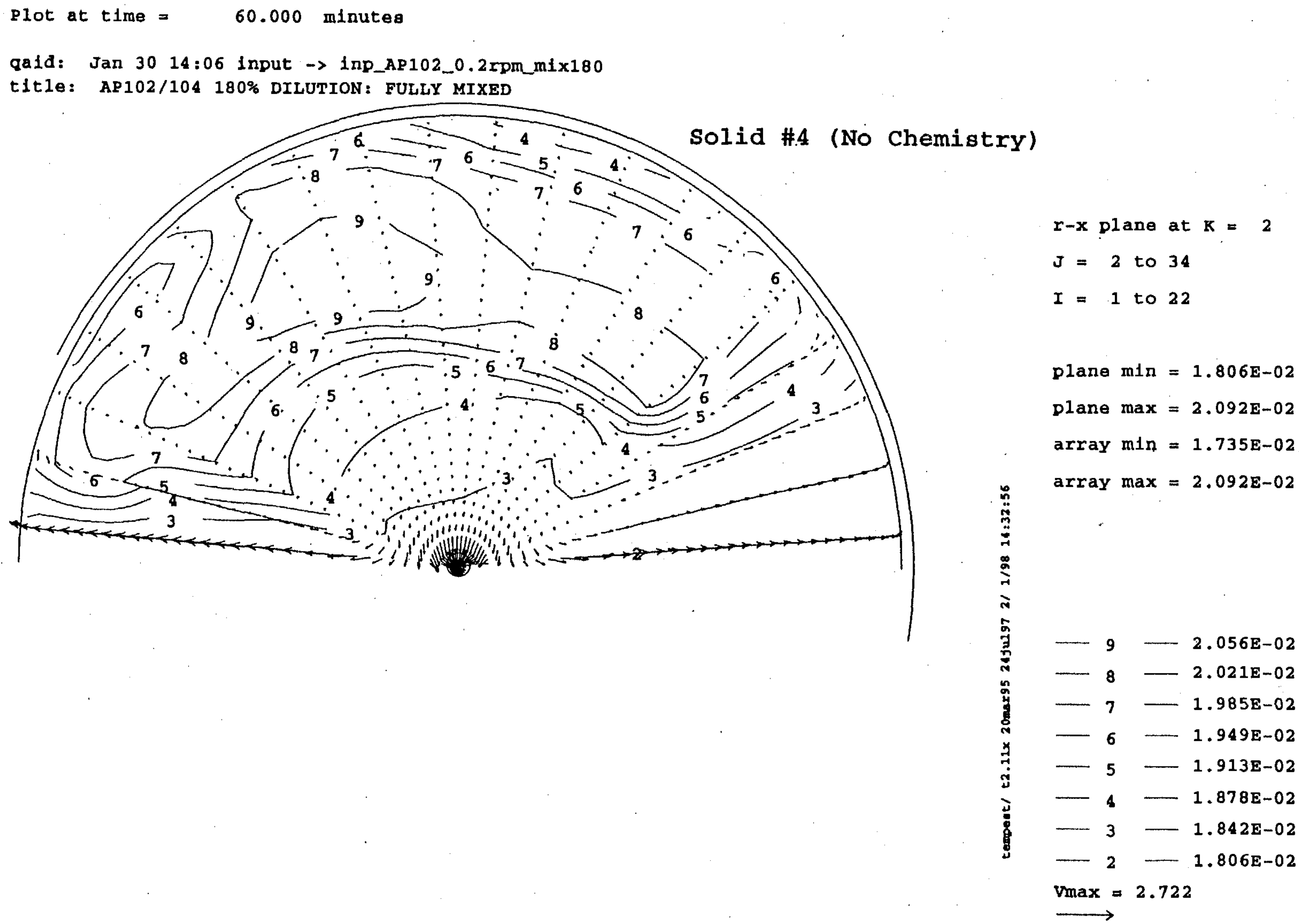

Figure 3.13. Predicted Distributions of Velocity (m/s) and Solid 4 Concentrations (volume fraction) on the Tank Bottom at One Simulation Hour for Case 2

Table 3.2 summarizes predicted variations in solid concentrations within Tank AP-102. These variations result in approximately 5.4% nonuniformity of the total solid concentrations.

These Case 2 modeling results show that the centrally located, 300-hp single pump can keep the AN-105 solids suspended in AP-102 and -104 within 94.6% uniformity once the solids are fully mixed under the condition of 180% dilution ofwaste without accounting for dissolution of solids.

Table 3.2. Expected Nonuniformity of Solid Concentrations in AP-102 Tank Resulting from Pump Jet Mixing, Case 2

	Volume Percent Among Solids (vol%)	Predicted Final Solid Concentration (vol%)	Predicted Nonuniform Variation (%)
Solid #1	27.4	1.98	0.00
Solid #2	34.6	2.50	0.20
Solid #3	13.0	0.94	2.1
Solid #4	25.0	1.81	20.6
Total	100.0	7.23	5.4

3.3 Simulation Results of Case 3

Cases 1 and 2 assume that the chemical kinetics are very slow to dissolve AN-105 solids during the dilution and subsequent mixing in Tanks AP-102 and-104. However, hot cell experiments with small AN-105 samples indicate that the dissolution of solids may be completed as quickly as within tens of seconds (Herting 1997). The dissolution also affects solid size distribution and slurry properties (viscosity and density), as shown in Tables 2.2 and 2.5. This case was tested to determine how well the pump jets kept the solids suspended if chemical kinetics quickly dissolve approximately two-thirds of the solids as a result of 180% dilution by water (see Table 2.1). We ran this case for one simulation hour.

The AP-102 model for Case 3 predicted that concentrations of all solids (including the coarsest solids) remain unchanged from the initial concentrations shown in Table 2.5 over the entire simulation period. Predicted Solids #1 and 4 concentrations at Locations 1, 7, 10, and 12 over one simulation hour are shown in Figures 3.14 and 3.15, displaying constant concentrations of 0.72 and 0.59 vol%. Unlike Cases 1 and 2, the predicted Solid #4 concentrations at these locations display hardly any periodic variation, because the largest solid particle size in this case is 50 µm, compared with 70 µm in Cases 1 and 2.

The predicted distributions of velocity and Solid #4 at one simulation hour also show more uniform Solid #4 distribution within Tank AP-102 than Cases 1 and 2 (compare Figures 3.16 and 3.17). The minimum and maximum concentrations of Solid #4 in the tank are 0.584 and 0.606 vol%, respectively, while the average concentration is 0.59 vol%. Although it is much less pronounced, Figure 3.17 still shows slightly higher Solid #4 concentrations along the tank wall, away from the area that the 60-ft/s jet is hitting.

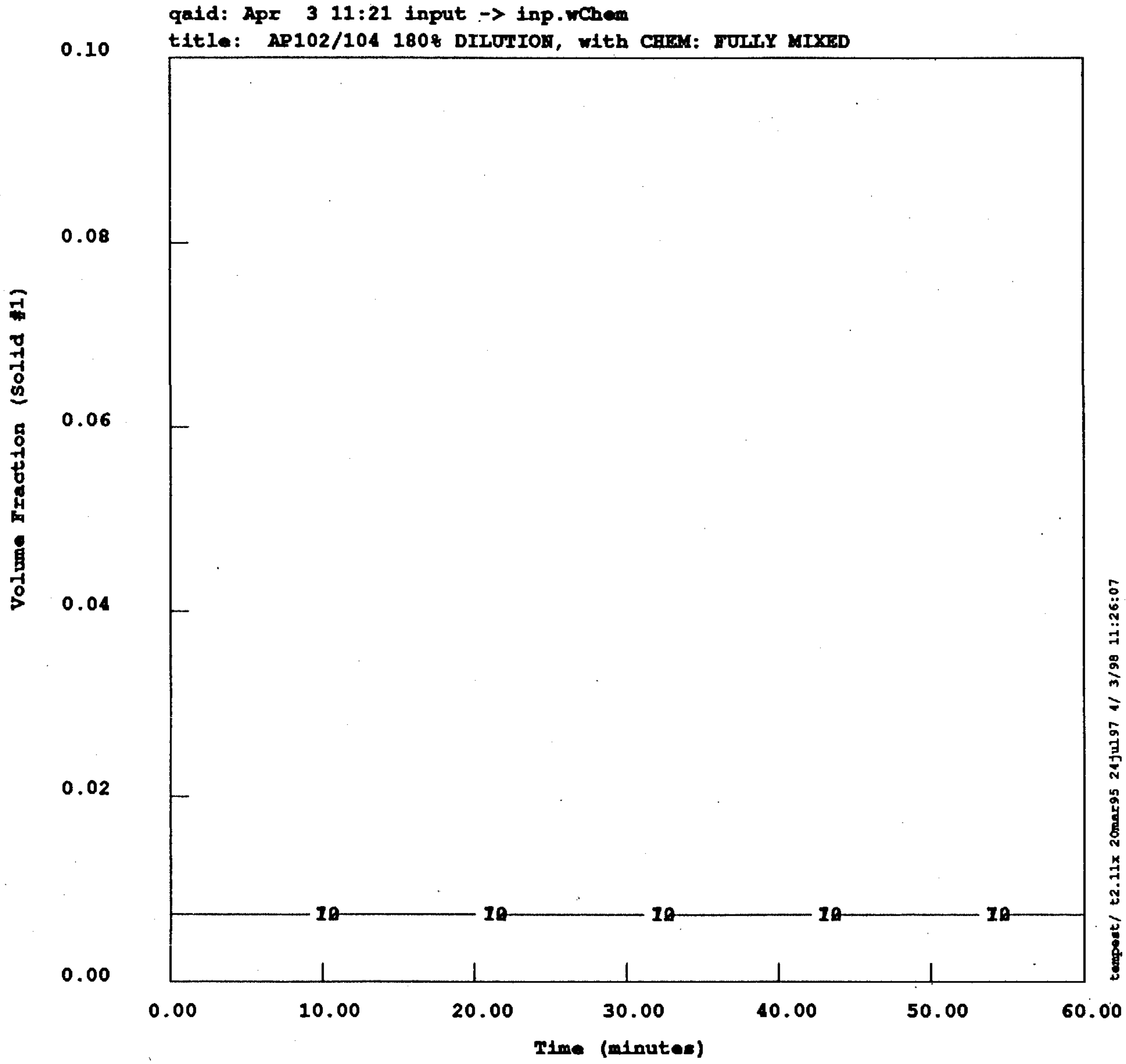

Figure 3.14. Predicted Solid 1 Concentrations (volume fraction) over One Simulation Hour for Case 3 (180% dilution with solid dissolution after solids are fully mixed)

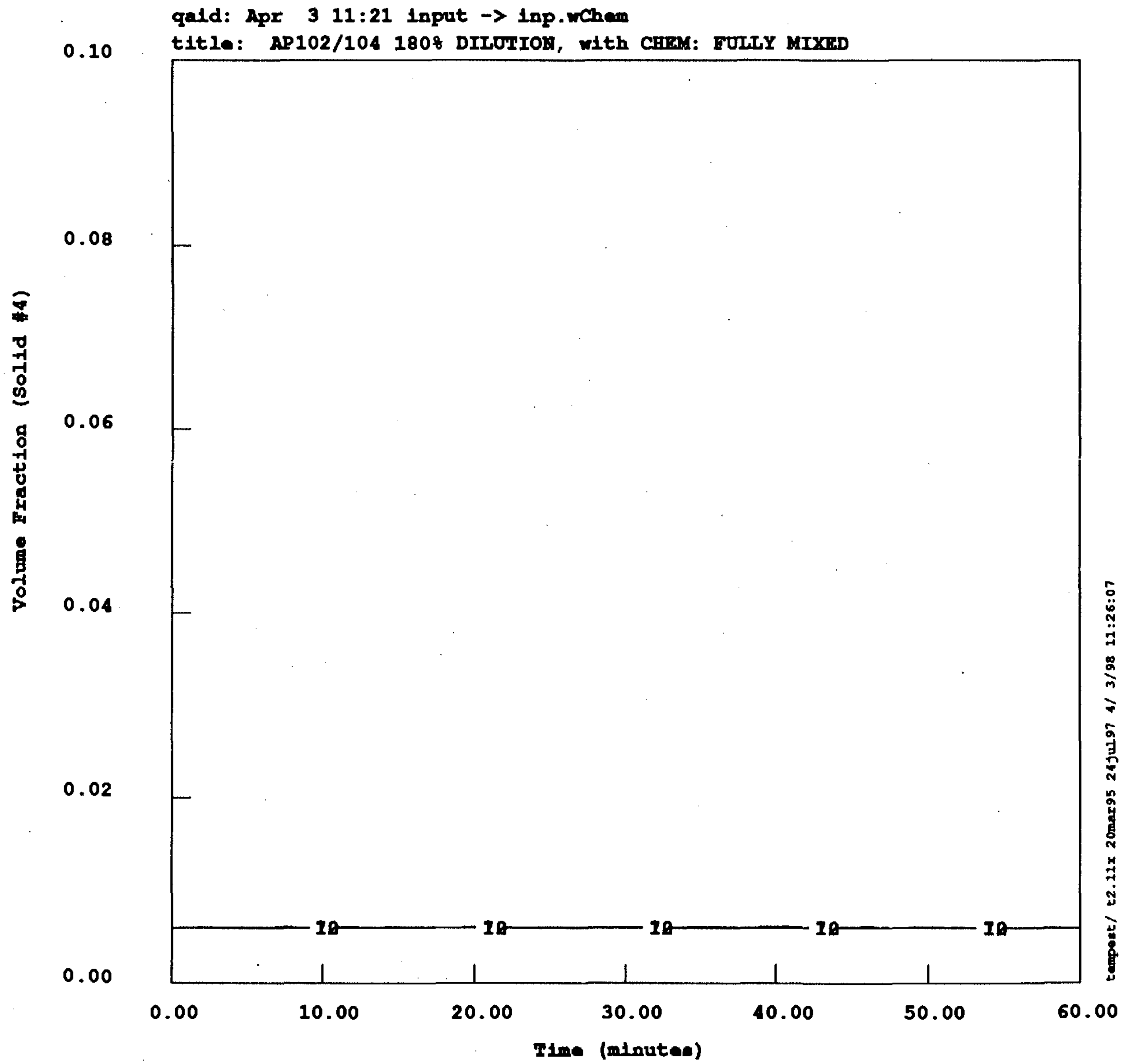

Figure 3.15. Predicted Solid 4 Concentrations (volume fraction) over One Simulation Hour for Case 3

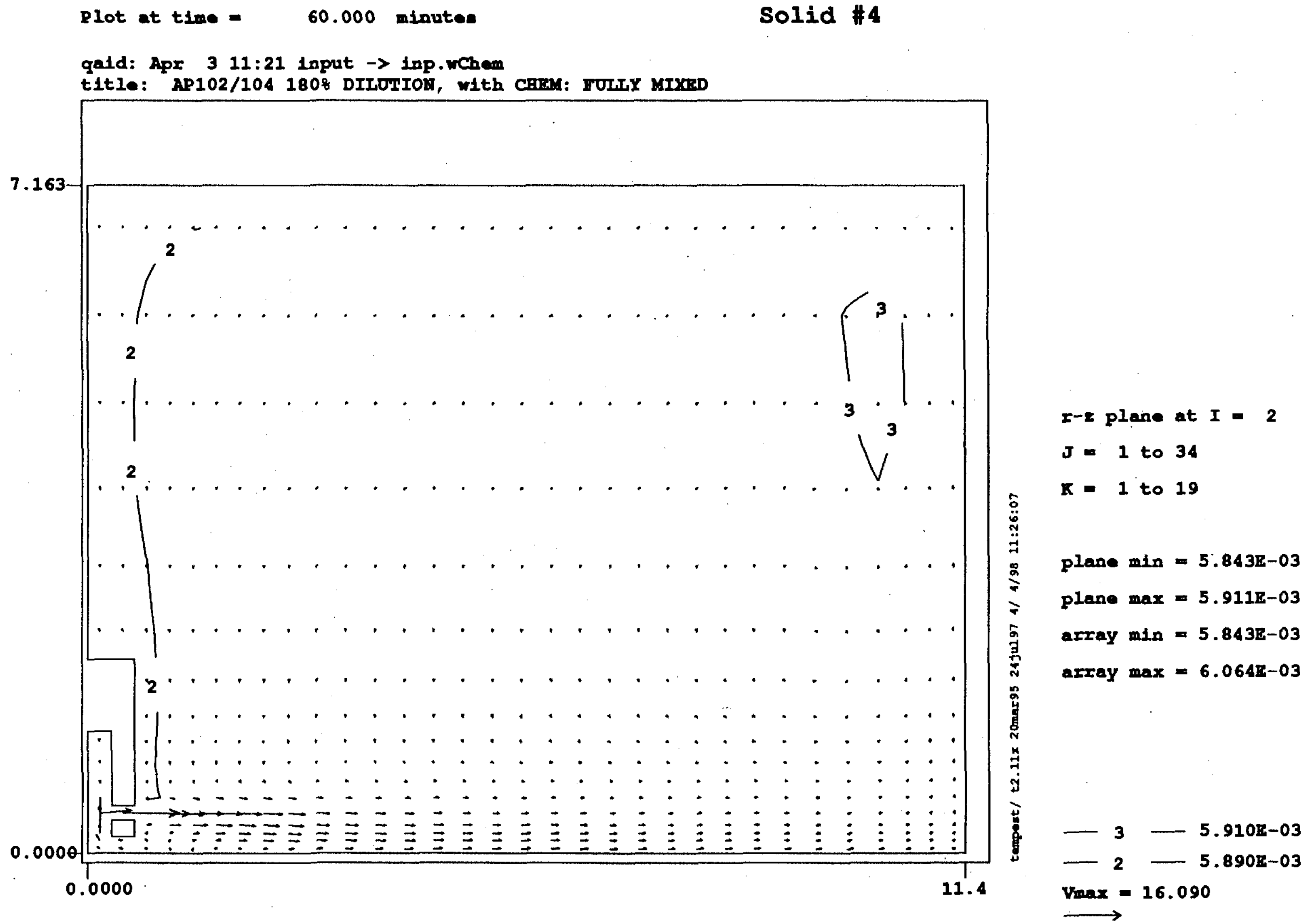

Figure 3.16. Predicted Distributions of Velocity (m/s) and Solid 4 Concentrations (volume fraction) in 3 O'Clock Position at One Simulation Hour for Case 3

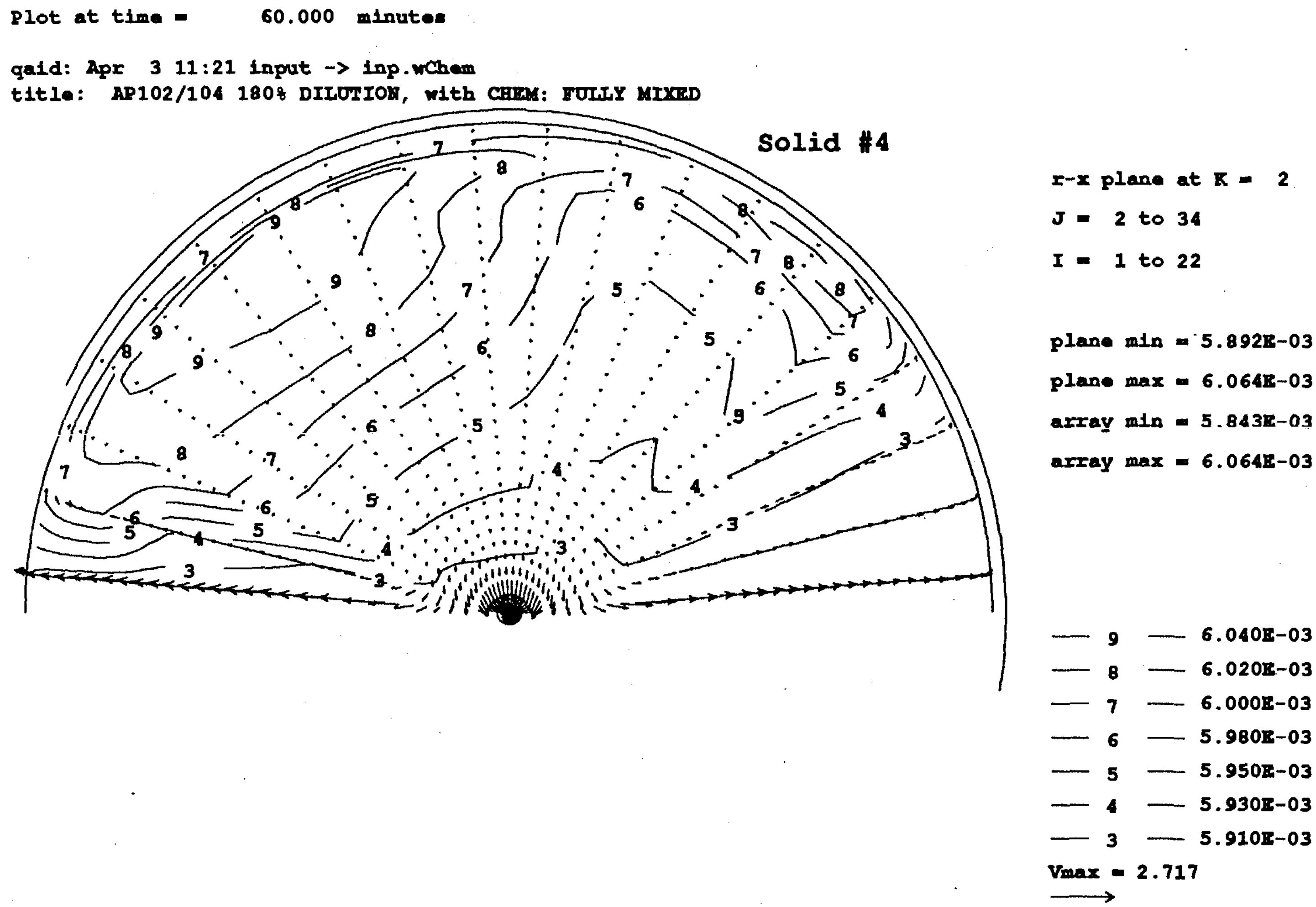

Figure 3.17. Predicted Distributions of Velocity (m/s) and Solid 4 Concentrations (volume fraction) on the Tank Bottom at One Simulation Hour for Case 3

Table 3.3 summarizes predicted solid concentration variations in AP-102. These variations result in 1% nonuniformity of the total solid concentrations within the tank.

Table 3.3. Expected Nonuniformity of Solid Concentrations in AP-102 Tank Resulting from Pump Jet Mixing, Case 3

	Volume Percent among Solids (vol%)	Predicted Final Solid Concentration (vol%)	Predicted Nonuniform Variation (%)
Solid #1	30.7	1.98	0.00
Solid #2	24.8	2.50	0.05
Solid #3	19.2	0.94	0.4
Solid #4	25.3	1.81	3.8
Total	100.0	7.23	1.0

The results from Case 3 modeling show that the centrally located, 300-hp single pump can keep suspending the AN-105 solids in Tanks AP-102 and -104 within 99.0% uniformity once the solids are fully mixed under the condition of 180% dilution and accounting for the solid dissolution.

Cases 1, 2 and 3 modeling results show that the centrally located, 300-hp pump with rotating 60-ft/s jets in Tanks AP-102 and -104 can suspend and keep in suspension the slurry resulting from the 180% dilution of AN-105 waste within 94.4 vol% uniformity.

3.4 Simulation Results of Case 4

Case 4 shows 25% dilution of AN-105 waste with water accounting for solids dissolution. Since 49% of the AN-105 solids are expected to be dissolved by 25% dilution with water (see Table 2.1), this case places the least amount of solids (0.57 m of the nonconvective layer) and resulting supernatant liquid (2.63 m of the convective layer) in Tanks AP-102 and -104 (see Figure 3.18). This compares with 1.12 m and 6.04 m of nonconvective and convective layers for Case 1 (see Figures 3.1 and 3.18). As a result, the supernatant liquid in this case has the highest viscosity and density, as indicated in Tables 2.2 and 2.6. Moreover, the dissolution occurs predominantly among the coarser solids, eliminating all particles larger than 30 μm (Herting 1997). This case forms the opposite end of the bounding condition from Case 1. We ran this case for one simulation hour.

Concentrations of Solids #1 through 4 over one simulation hour are shown in Figures 3.19 through 3.22, respectively. Because of the combination of small amounts of liquid and solid wastes, finer solid particles, and dense and viscous supernatant liquid, the mixing is very vigorous in this case, and all solids reached their fully mixed conditions in about 20 minutes. Unlike Case 1, because Solid #4 consists of particles of only 10–30-μm diameters, there is no oscillation of Solid #4 particles once the fully mixed stage is reached.

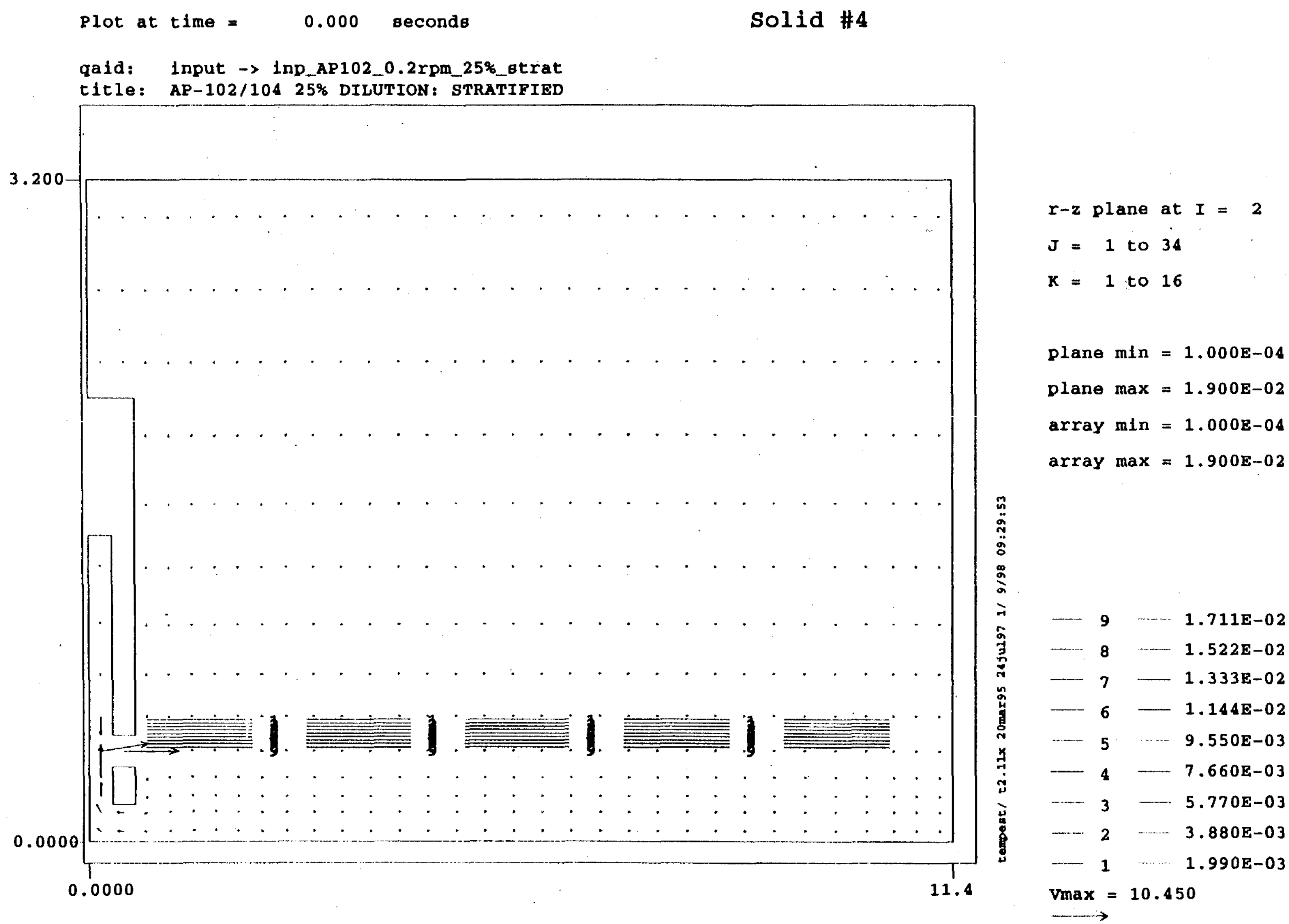

Figure 3.18. Initial Conditions of Convective Layer, Nonconvective Layer, and Solid 4 Concentrations in 3 O'Clock Position for Case 4 (25% dilution with solids dissolution and solids initially deposited in the tank bottom)

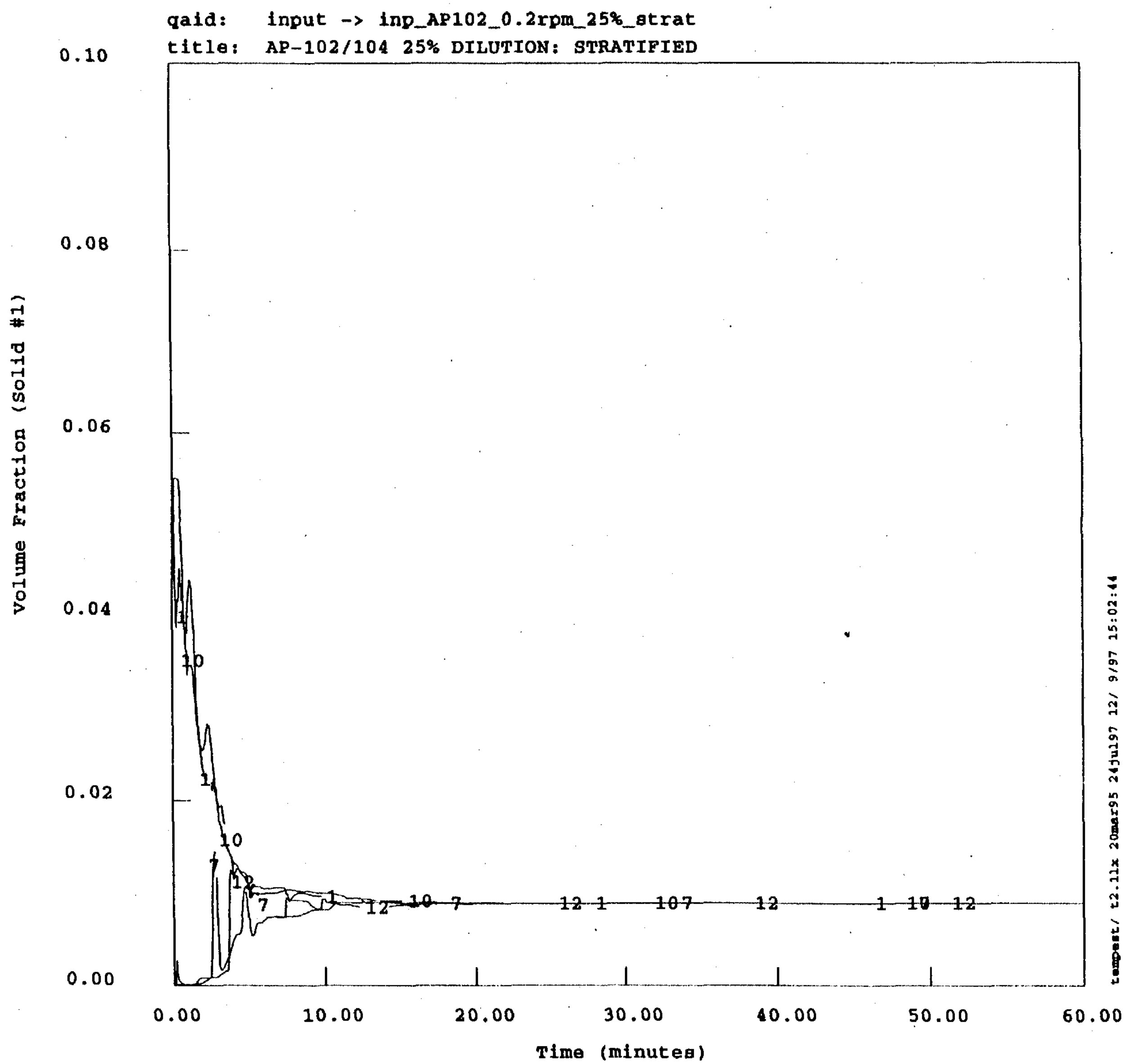

Figure 3.19. Predicted Solid 1 Concentrations (volume fraction) over One Simulation Hour for Case 4

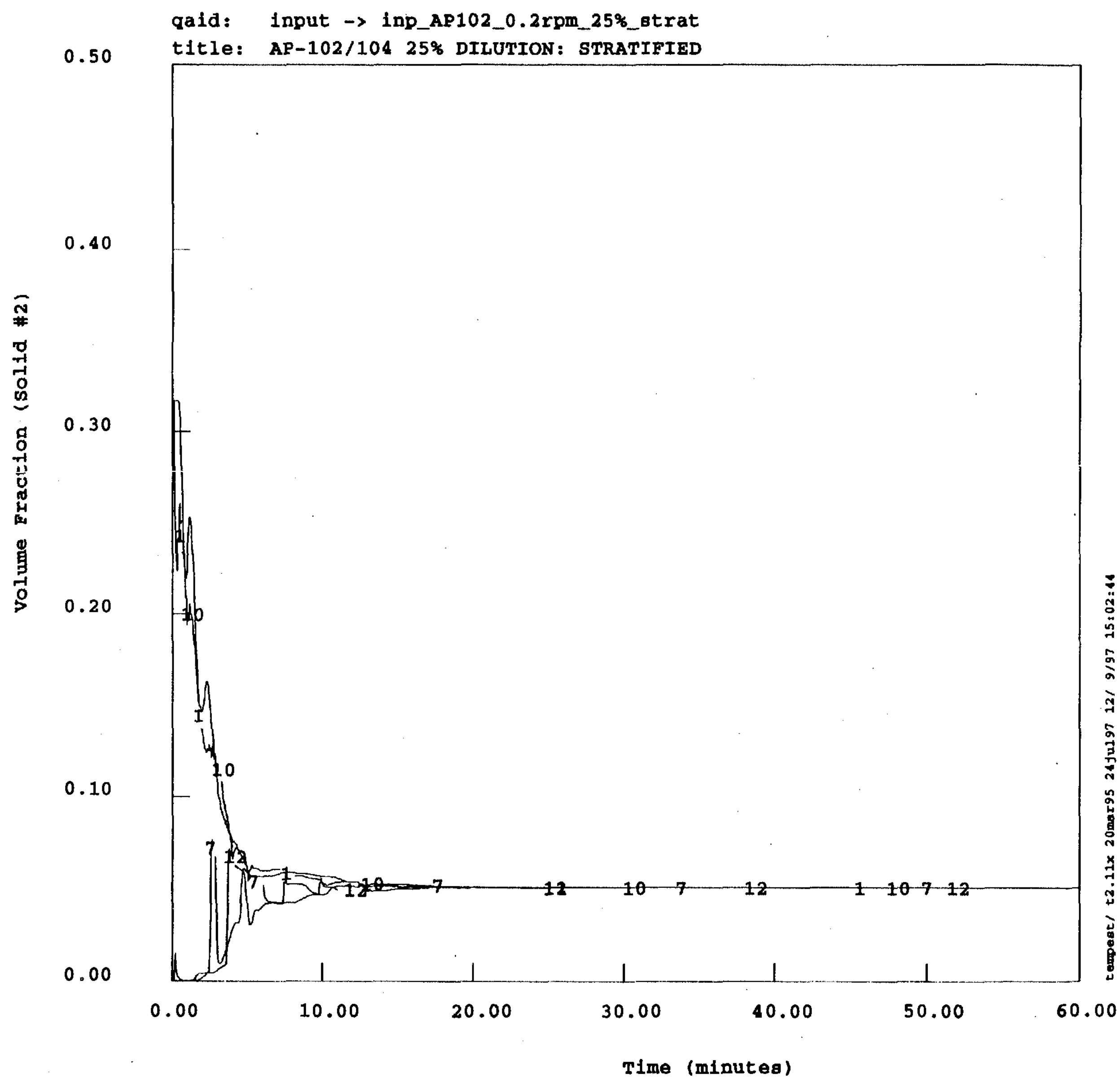

Figure 3.20. Predicted Solid 2 Concentrations (volume fraction) over One Simulation Hour for Case 4

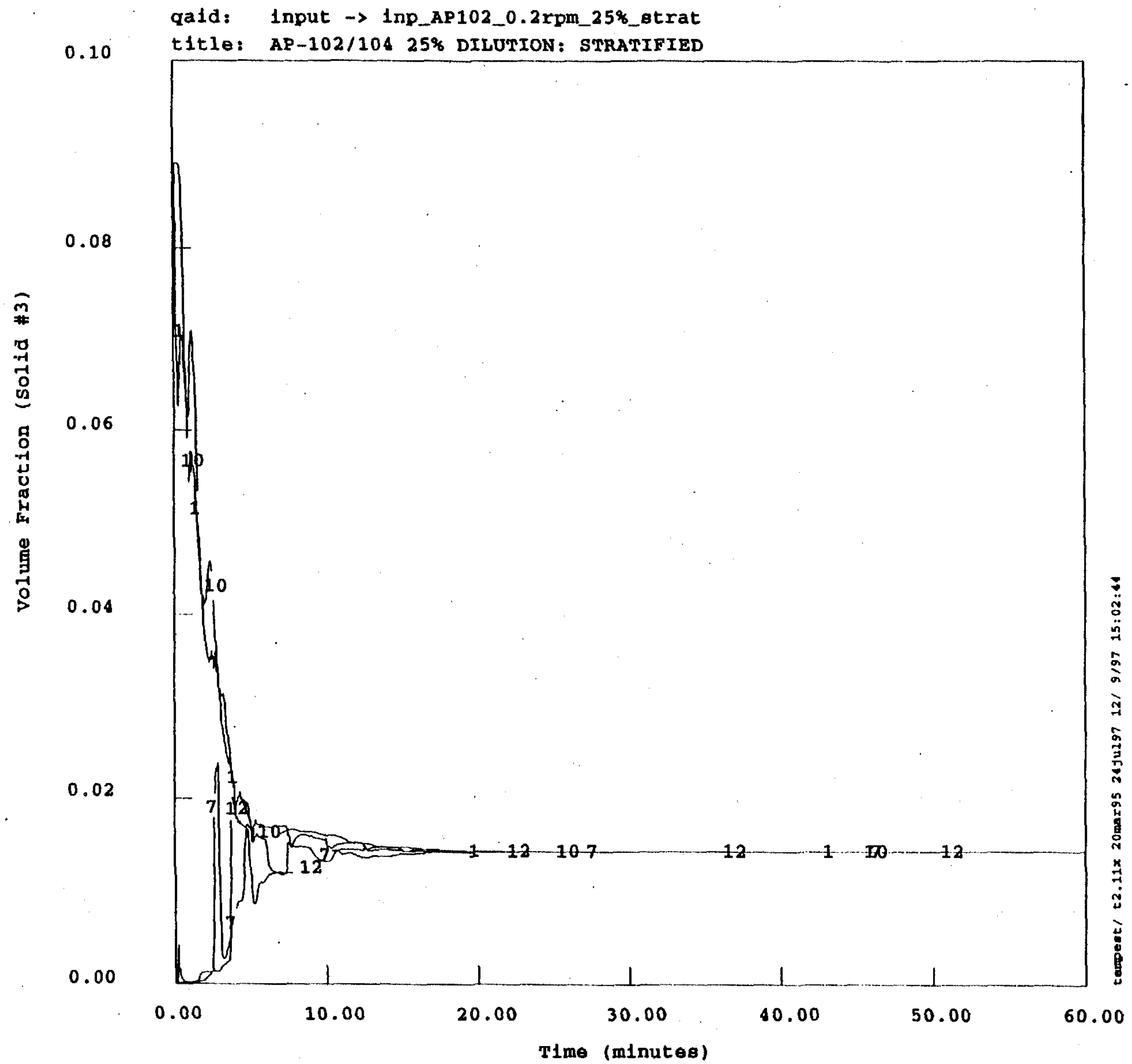

Figure 3.21. Predicted Solid 3 Concentrations (volume fraction) over One Simulation Hour for Case 4

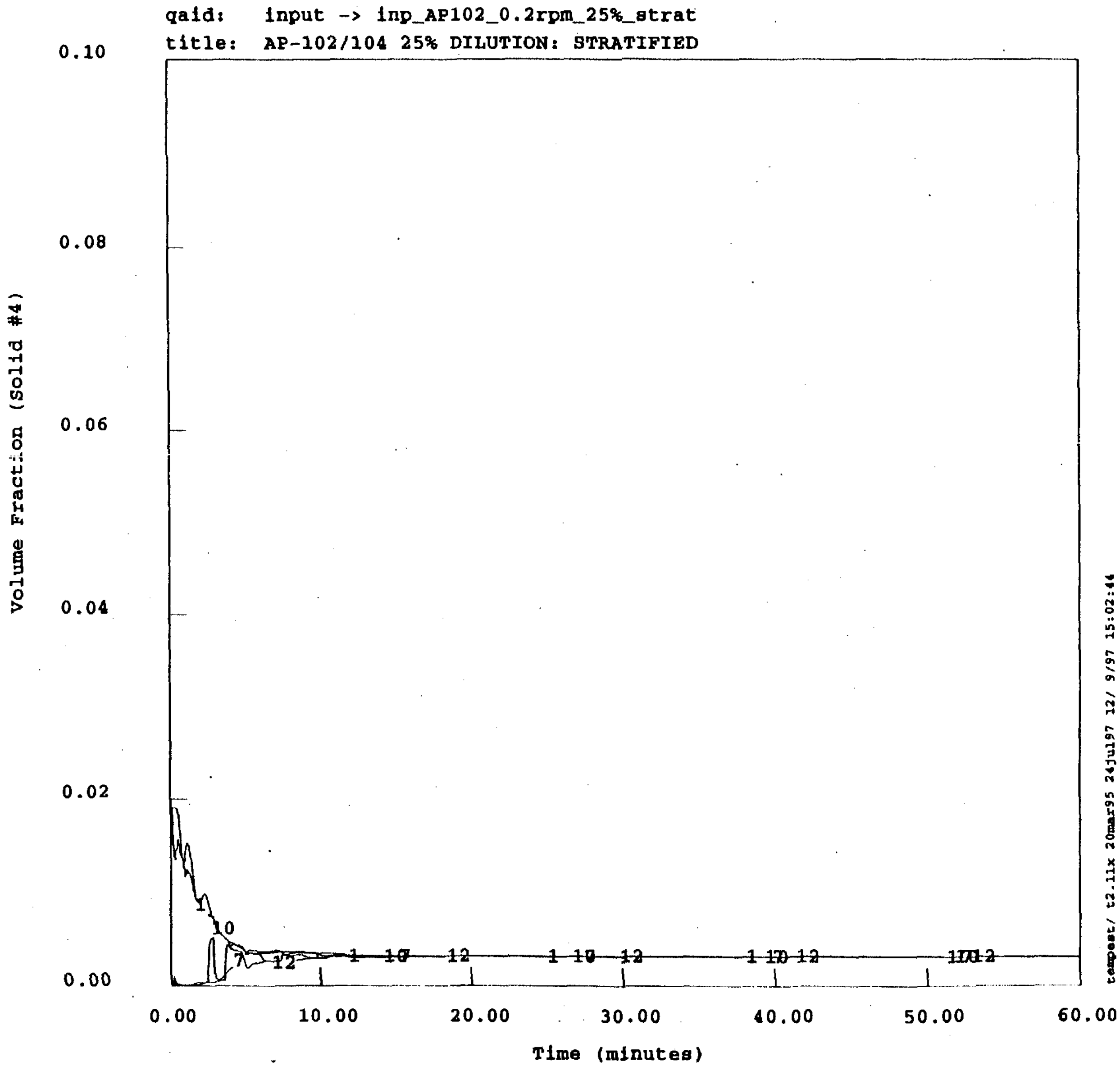

Figure 3.22. Predicted Solid 4 Concentrations (volume fraction) over One Simulation Hour for Case 4

The predicted distribution of velocity and Solid #1 concentrations at one simulation hour show a uniform concentration of 0.88 vol% everywhere in Tank AP-102, as shown in Figure 3.23. Figures 3.24 and 3.25 show very uniform vertical and horizontal distributions of Solid #4 concentrations. The minimum and maximum concentrations of Solid #4 within the entire tank are 0.3097 and 0.3110 vol%, respectively, while the average concentration is 0.310 vol%.

Table 3.4 summarizes predicted solid concentration variations within Tank AP-102. These variations result in only 0.03% nonuniformity of the total solid concentrations within that tank.

Table 3.4. Expected Nonuniformity of Solid Concentrations in AP-102 Tank Resulting from Pump Jet Mixing, Case 4

	Volume Percent among Solids (vol%)	Predicted Final Solid Concentration (vol%)	Predicted Nonuniform Variation (%)
Solid #1	11.4	1.98	0.000
Solid #2	66.1	2.50	0.000
Solid #3	18.5	0.94	0.070
Solid #4	4.0	1.81	0.420
Total	100.0	7.23	0.030

The modeling results from Case 4 show that the centrally located, 300-hp single pump can suspend the deposited AN-105 solids and mix them in Tanks AP-102 and -104 within 99.97% uniformity in about 20 minutes under the condition of 25% dilution and accounting for the solid dissolution.

3.5 Simulation Results of Case 5

This case examines whether the 300-hp pump can keep suspending all the solids once they are resuspended by the rotating jets for the 25% dilution condition (Case 4). Initial solid concentrations are shown in Table 2.7.

As expected, concentrations of all solids remain unchanged over one simulation hour, as shown in Figures 3.26 and 3.27 for Solids #1 and 4 at the same four locations. Uniformity of solid concentration throughout the tank is shown in Figures 3.28 and 3.29, depicting vertical and horizontal distributions of Solid #4 concentrations at one simulation hour. As in Case 4, these variations in solid concentrations cause only a 0.03% nonuniformity of the total solid concentrations within Tank AP-102.

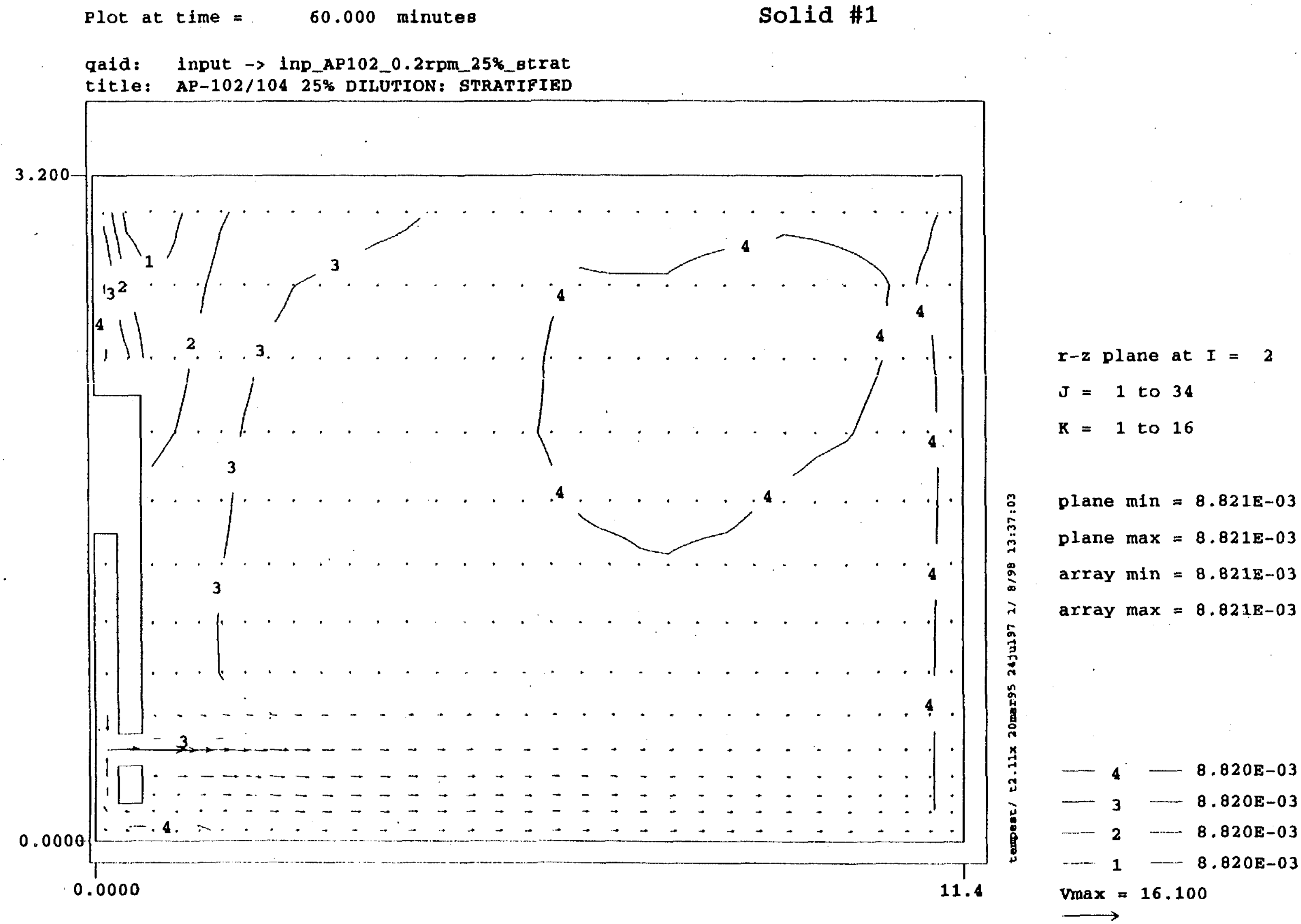

Figure 3.23. Predicted Distributions of Velocity (m/s) and Solid 1 Concentrations (volume fraction) in 3 O'Clock Position at One Simulation Hour for Case 4

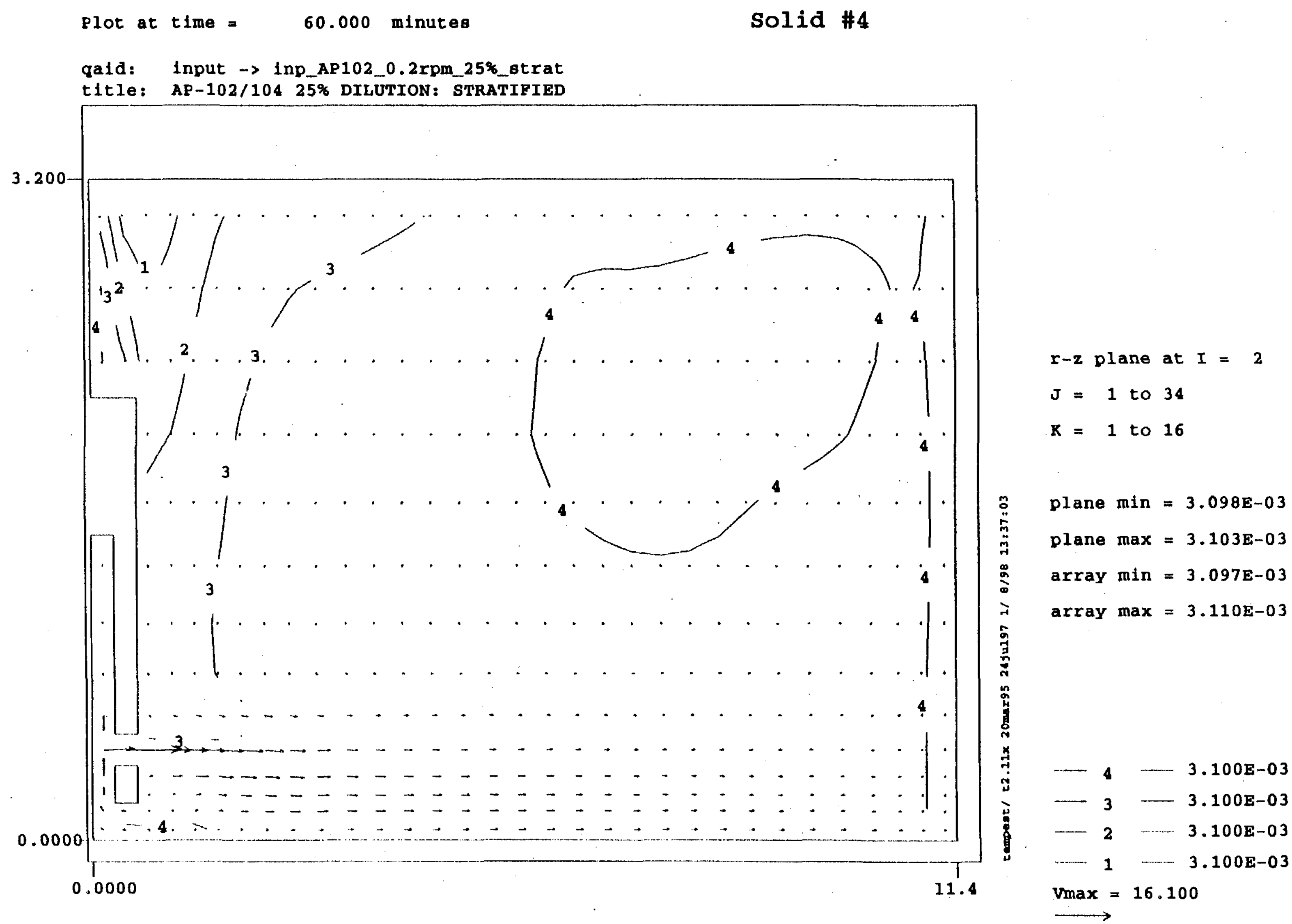

Figure 3.24. Predicted Distributions of Velocity (m/s) and Solid 4 Concentrations (volume fraction) in 3 O'Clock Position at One Simulation Hour for Case 4

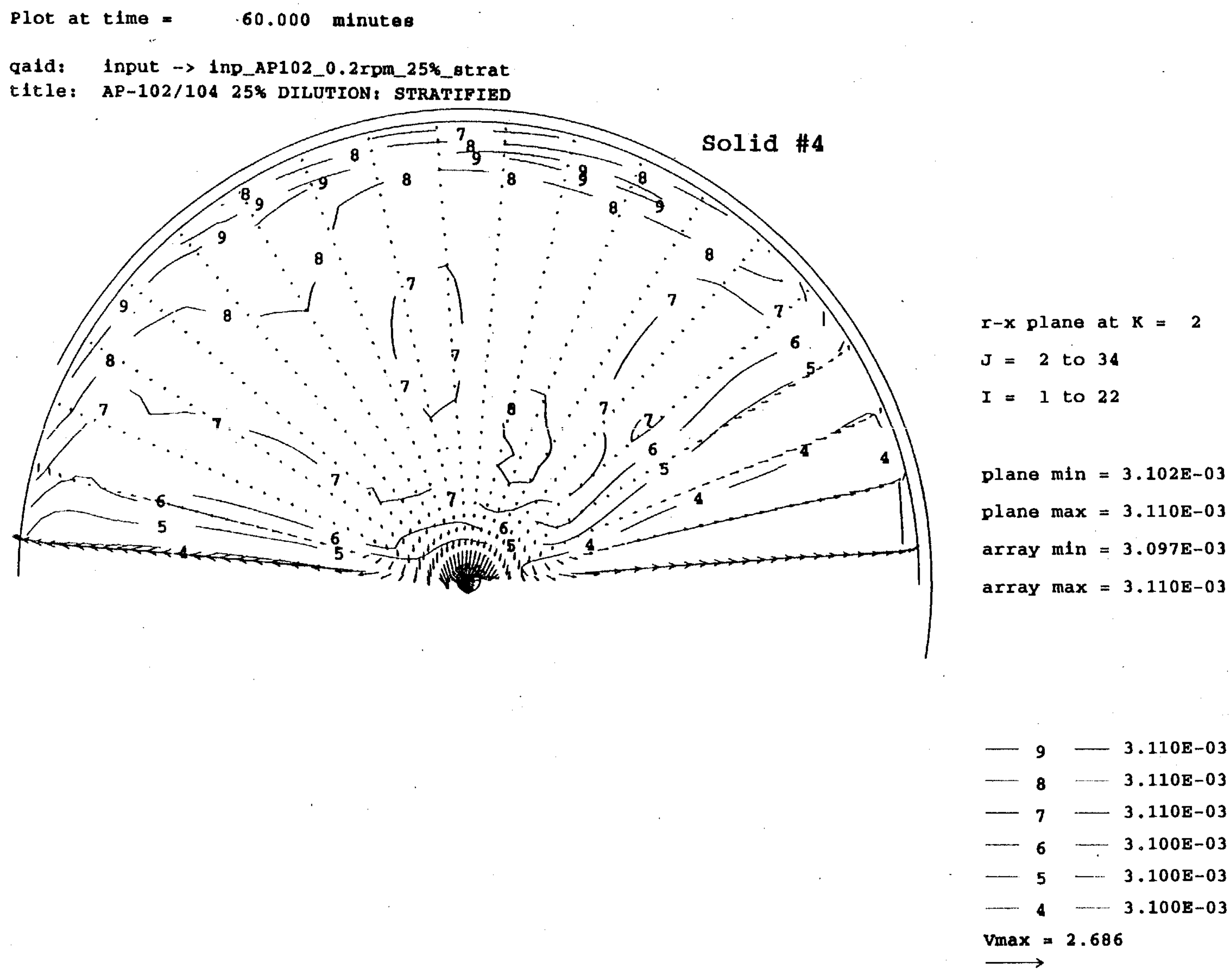

Figure 3.25. Predicted Distributions of Velocity (m/s) and Solid 4 Concentrations (volume fraction) on the Tank Bottom at One Simulation Hour for Case 4

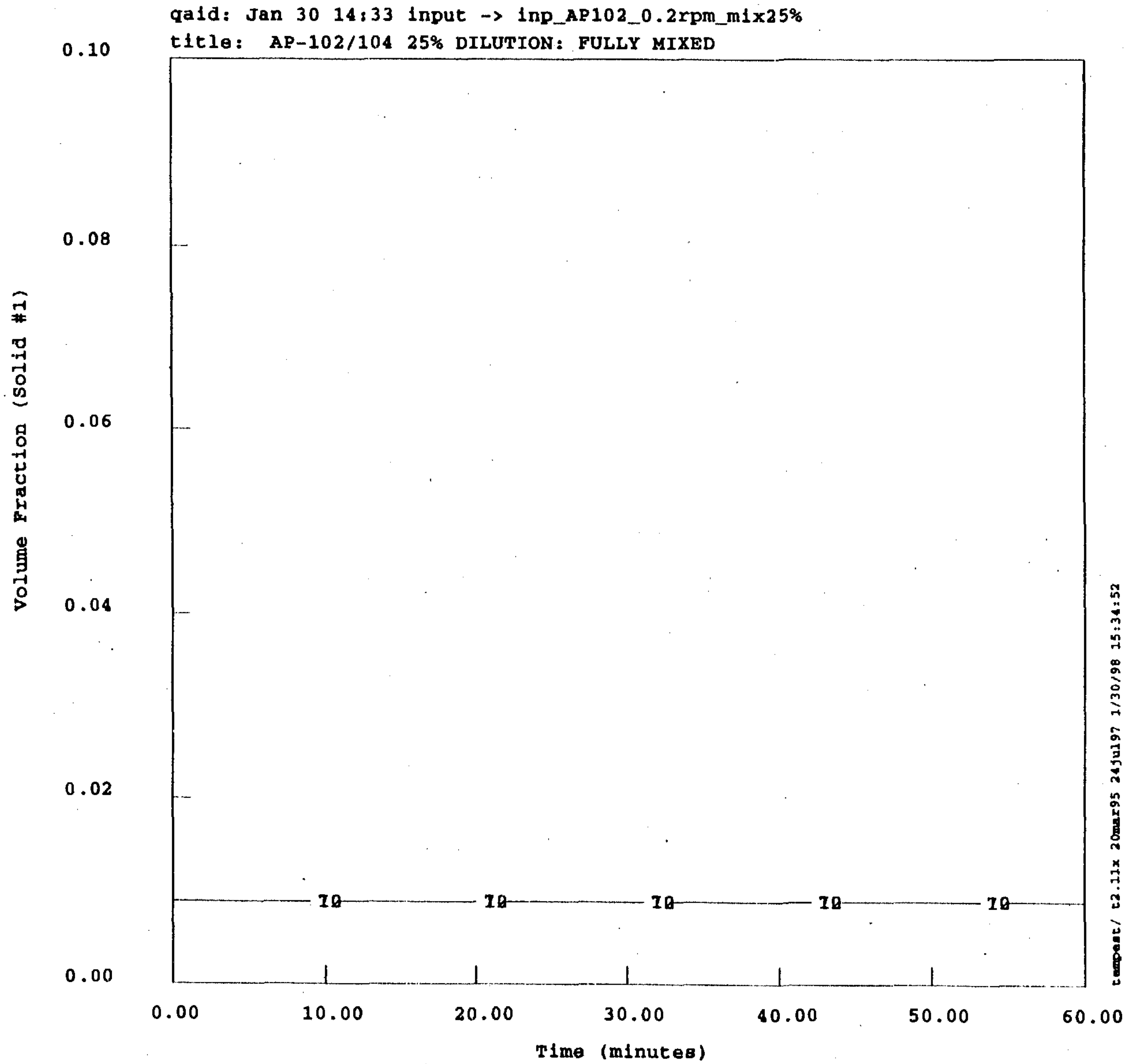

Figure 3.26. Predicted Solid 1 Concentrations (volume fraction) over One Simulation Hour for Case 5 (25% dilution with solids dissolution after solids are fully mixed)

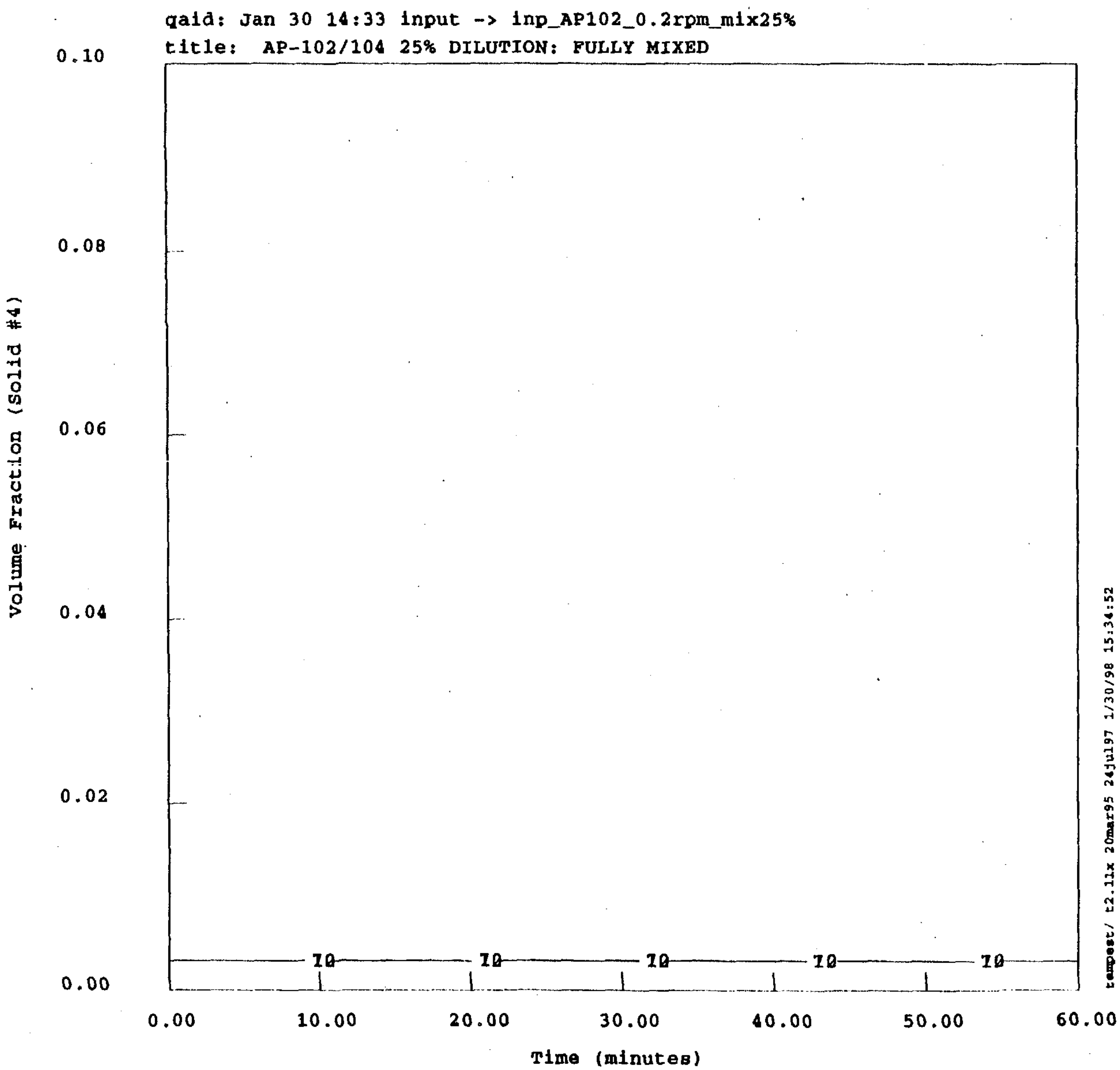

Figure 3.27. Predicted Solid 4 Concentrations (volume fraction) over One Simulation Hour for Case 5

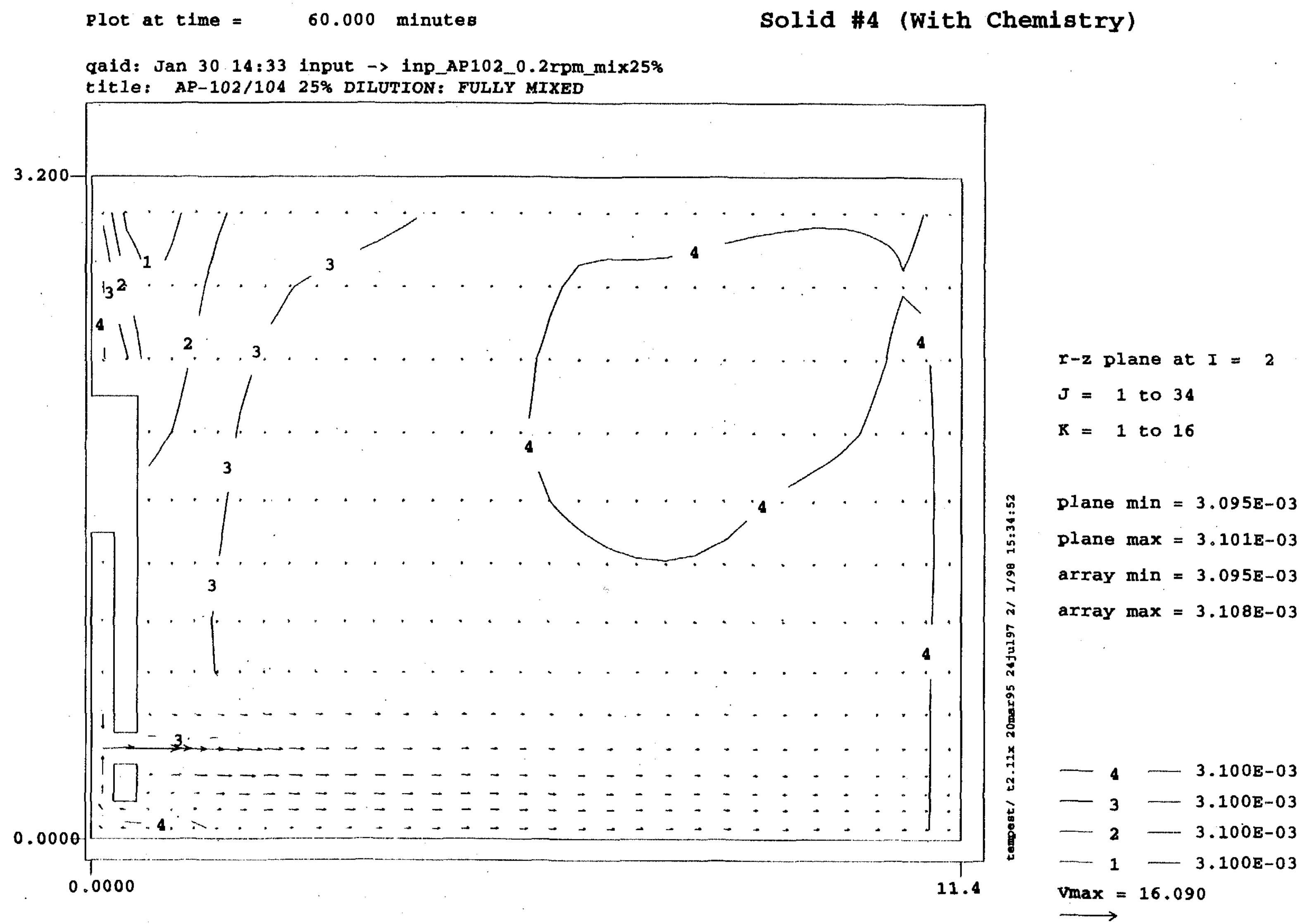

Figure 3.28. Predicted Distributions of Velocity (m/s) and Solid 4 Concentrations (volume fraction) in 3 O'Clock Position at One Simulation Hour for Case 5

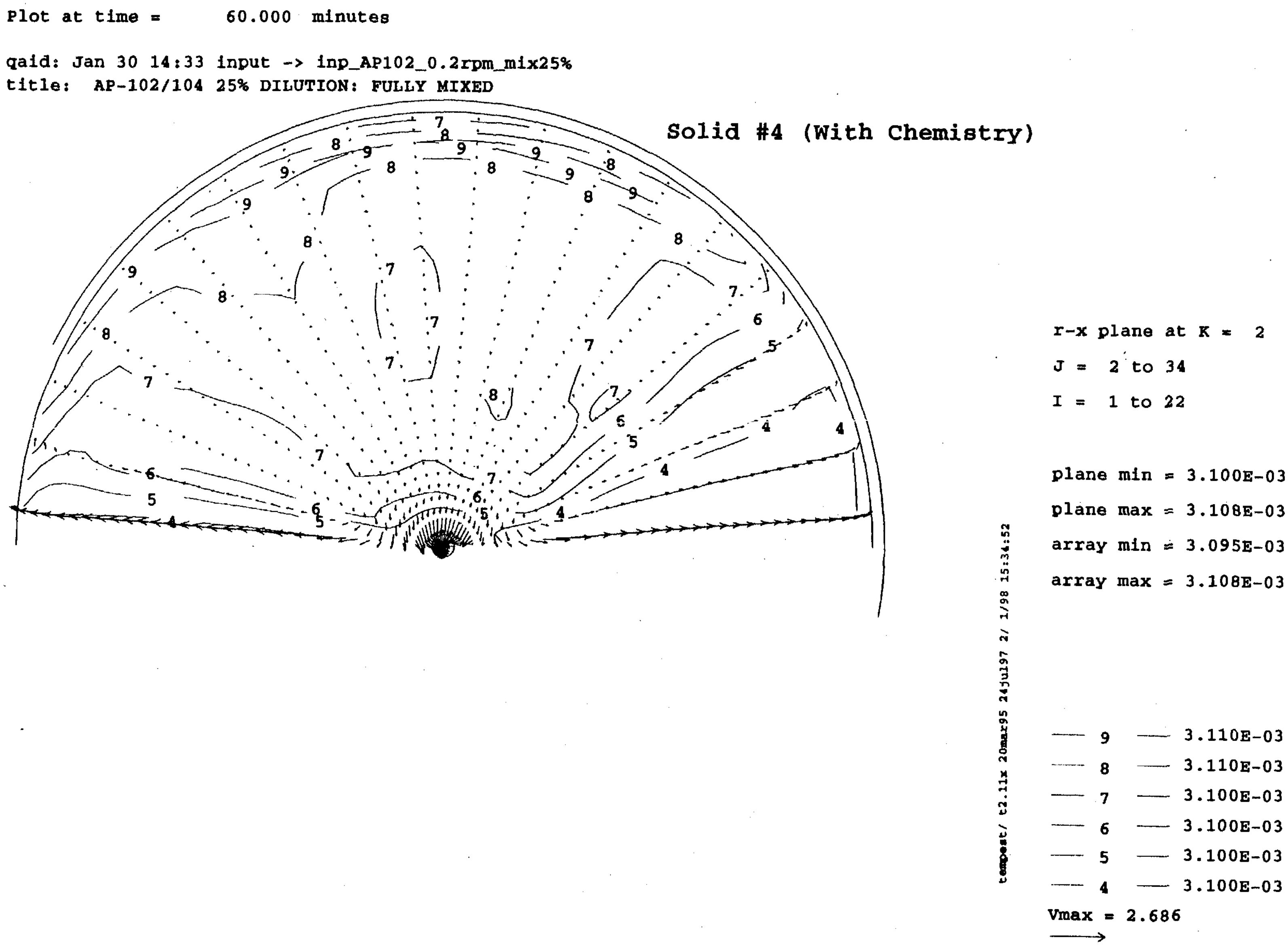

Figure 3.29. Predicted Distributions of Velocity (m/s) and Solid 4 Concentrations (volume fraction) on the Tank Bottom at One Simulation Hour for Case 5

Table 3.5. Expected Nonuniformity of Solid Concentrations in AP-102 Tank Resulting from Pump Jet Mixing, Case 5

	Volume Percent among Solids (vol%)	Predicted Final Solid Concentration (vol%)	Predicted Nonuniform Variation (%)
Solid #1	27.4	0.88	0.000
Solid #2	34.6	5.09	0.020
Solid #3	13.0	1.42	0.070
Solid #4	25.0	0.31	0.420
Total	100.0	7.70	0.030

These Case 5 model results show that the centrally located, 300-hp single pump can keep the solids fully mixed and suspended with 99.97% uniformity.

3.6 Simulation Results for Case 6

This case examined the condition of very slow kinetic chemistry, such that no solids will be dissolved during the 25% dilution and subsequent pump jet mixing in Tanks AP-102 and -104 The waste properties and solid concentrations are shown in Tables 2.2 and 2.8. In this case, the lighter and less viscous supernatant liquid needs to suspend solids that contain up to 70 μm size particles in a total concentration of 16.2 vol%, compared with up to 30 μm size particles and 7.7 vol% for Case 5.

All solids nearly maintained their initial fully mixed concentrations throughout the one-hour simulation period, like the Solid #1 concentrations shown in Figure 3.30. However, Solid #4 concentrations display a very small oscillation around the uniform value of 4.05 vol% due to the settling velocity, as shown in Figure 3.31. This oscillation is less than those shown in Cases 1 and 2 because of the heavier and more viscous supernatant liquid in this case, even though the solid concentrations are higher in this case. This minor variation of Solid #4 concentrations in time and space also appears in Figures 3.32 and 3.33, which show slightly higher concentrations near the tank bottom along the wall. The variation in solid concentrations in this case results in only 0.97% nonuniformity in the concentration in the tank. The results of modeling Case 6 show that the centrally located, 300-hp single pump can maintain the solids in the fully mixed and suspended condition within 99% uniformity.

Cases 4, 5 and 6 modeling results show that the centrally located, 300-hp pump in Tanks AP-102 and -104 can suspend and keep in suspension the slurry resulting from the 25% dilution of AN-105 wastes within to 99% uniformity.

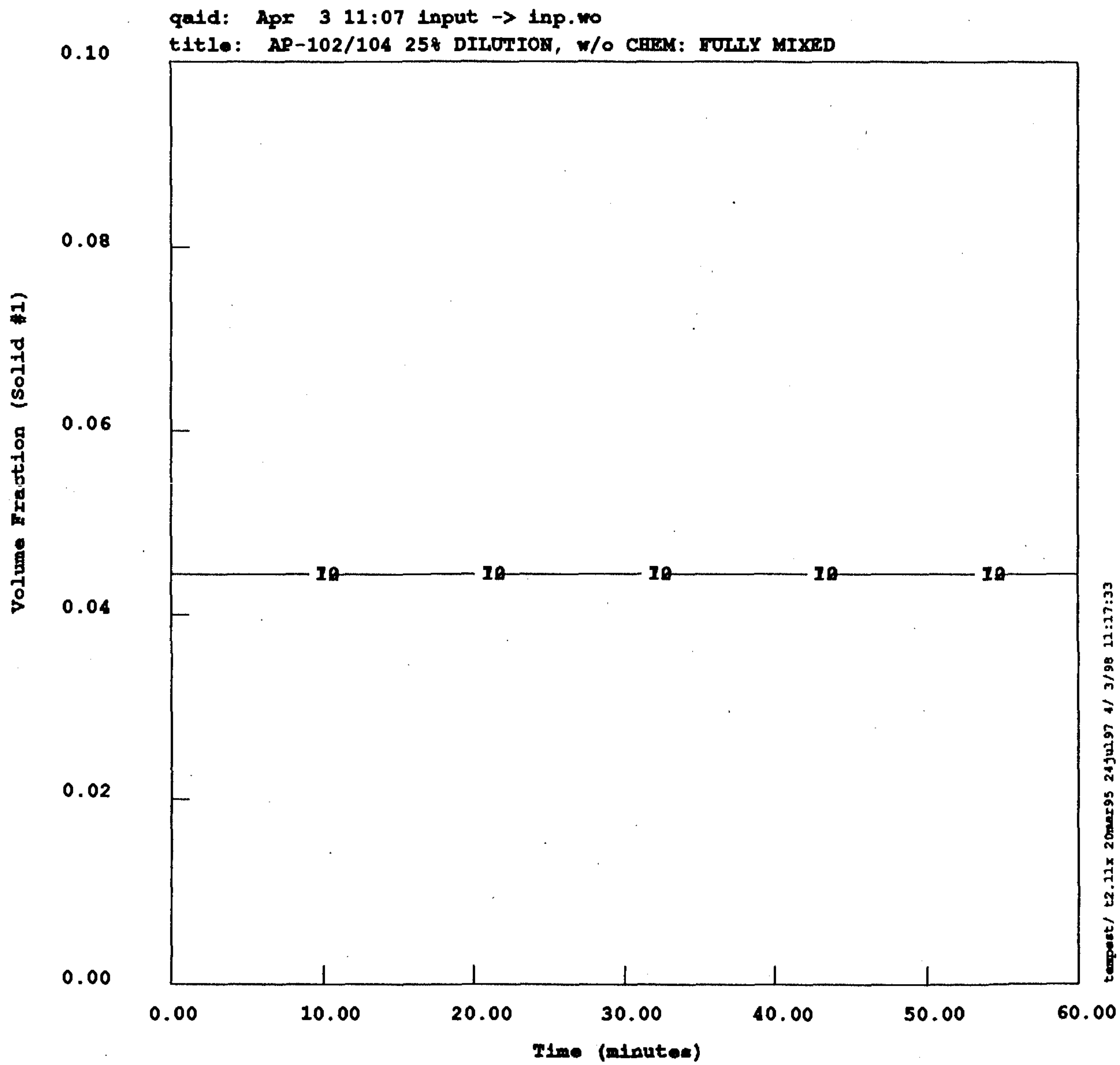

Figure 3.30. Predicted Solid 1 Concentrations (volume fraction) over One Simulation Hour for Case 6 (25% dilution without solids dissolution after solids are fully mixed)

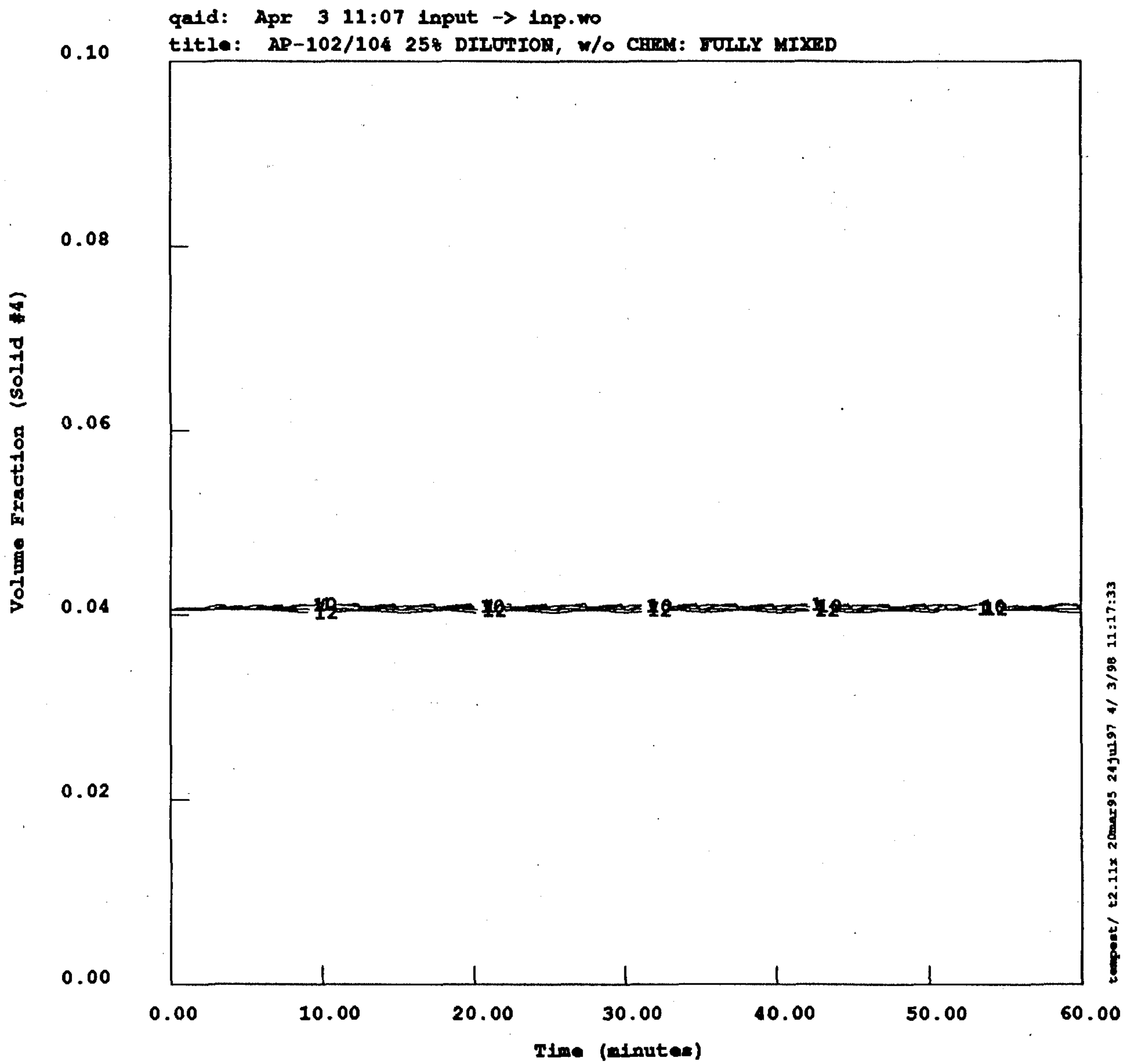

Figure 3.31. Predicted Solid 4 Concentrations (volume fraction) over One Simulation Hour for Case 6

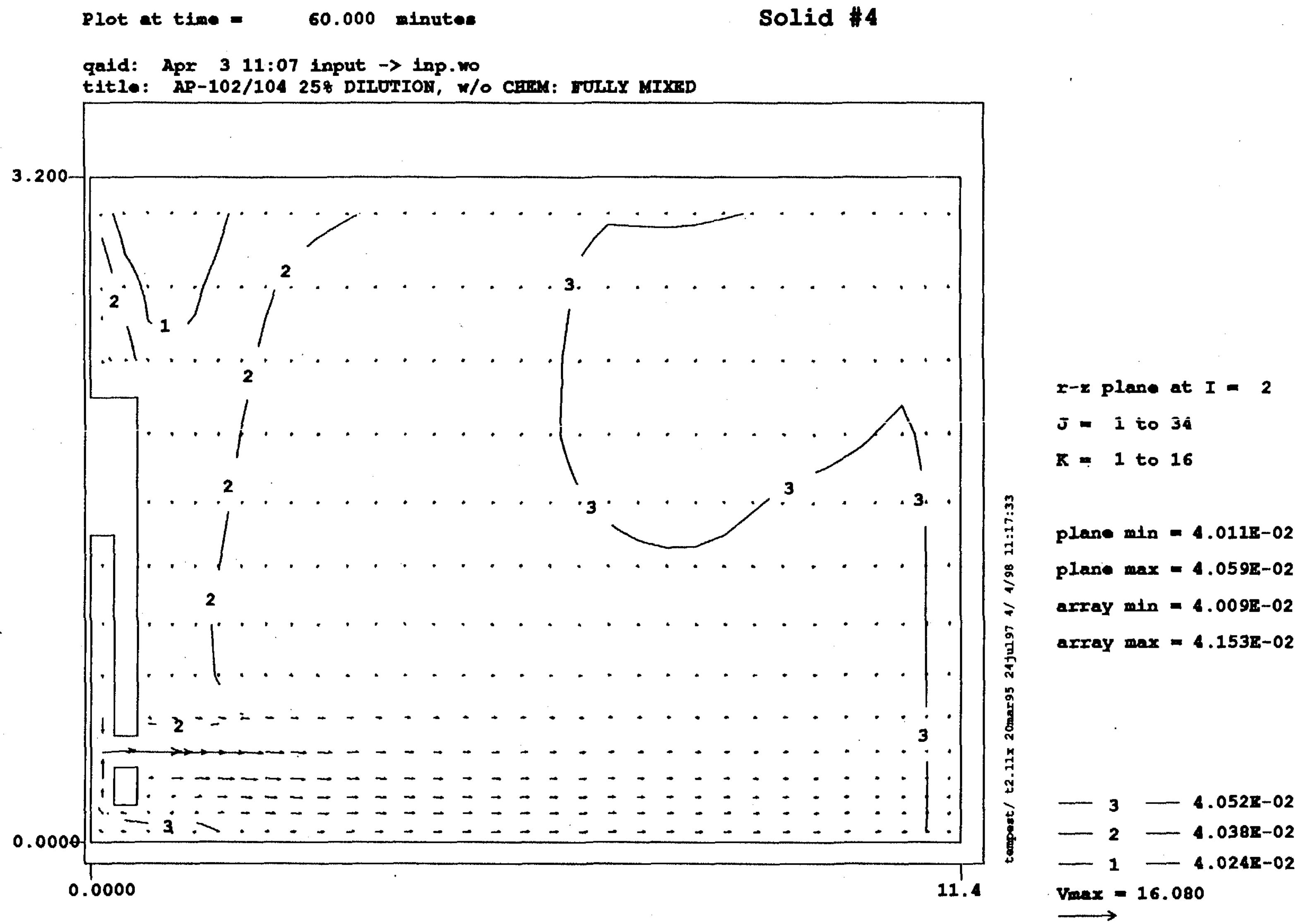

Figure 3.32. Predicted Distributions of Velocity (m/s) and Solid 4 Concentrations (volume fraction) in 3 O'Clock Position at One Simulation Hour for Case 6

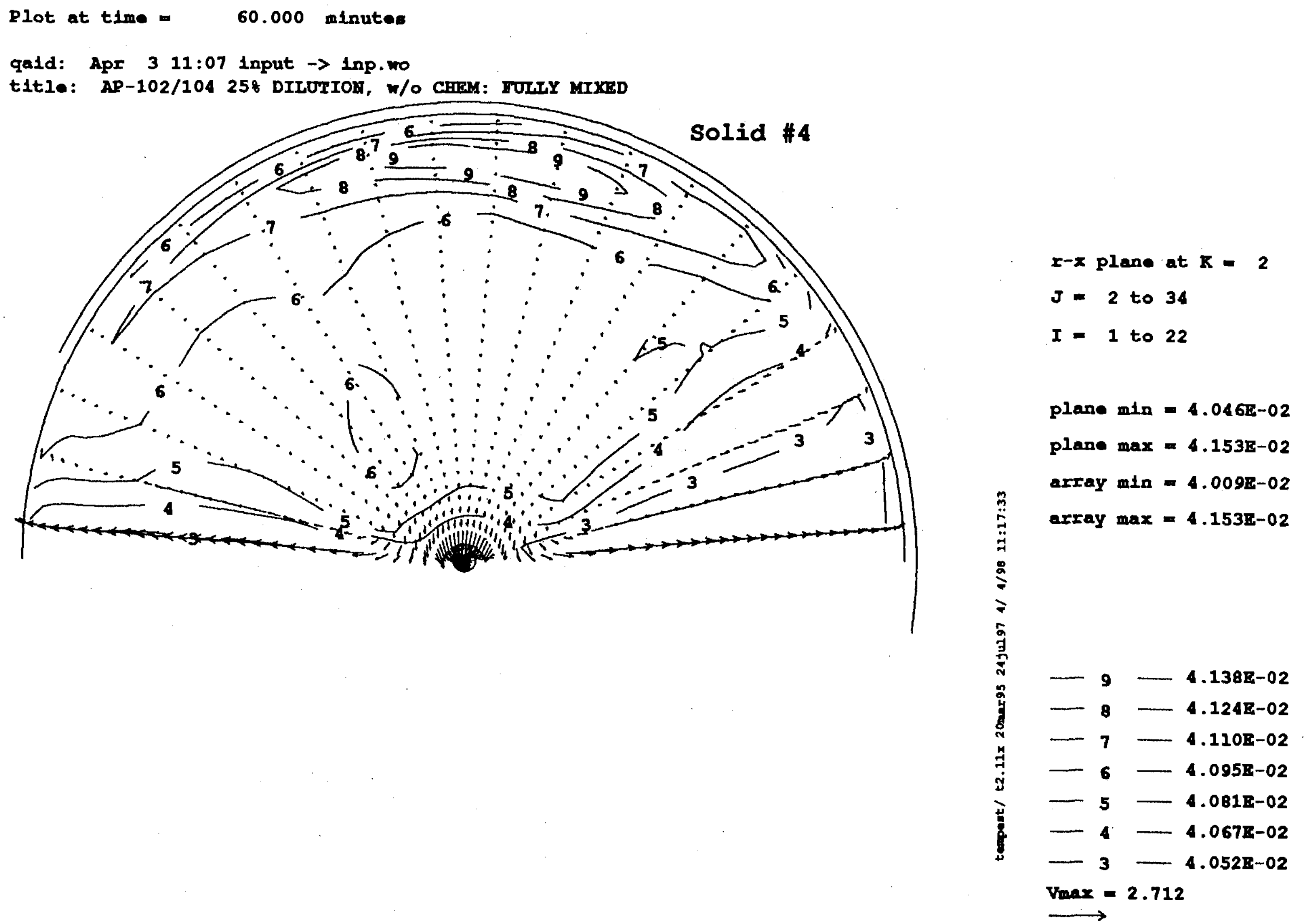

Figure 3.33. Predicted Distributions of Velocity (m/s) and Solid 4 Concentrations (volume fraction) on the Tank Bottom at One Simulation Hour for Case 6

Table 3.6. Expected Nonuniformity of Solid Concentrations in AP-102 Tank Resulting from Pump Jet Mixing, Case 6

	Volume Percent among Solids (vol%)	Predicted Final Solid Concentration (vol%)	Predicted Nonuniform Variation (%)
Solid #1	27.4	4.44	0.00
Solid #2	34.6	5.60	0.05
Solid #3	13.0	2.11	0.38
Solid #4	25.0	4.05	3.60
Total	100.0	16.20	0.97

4.0 Summary and Conclusions

Tanks AP-102 and -104 are each expected to have a single 300-hp rotating pump located at the tank center to mix the low-activity wastes stored within them. This modeling study, performed with the TEMPEST computer code, evaluated how well the pump mixes the wastes, which have been retrieved from other Hanford DSTs. We selected Tank AN-105 waste to be modeled because AN-105 will be the first DST to have its wastes transferred to Tanks AP-102 and -104 and because its waste is representative of the low-activity wastes that will be transferred to the AP tanks.

The following six cases were studied that bound planned waste conditions after waste from AN-105 is transferred to AP-102 and -104. Case 1 has the largest amount of solids and supernatant liquid in AP-102 and -104; Case 4 has the least amount of solids and supernatant liquid in the tanks.

Case 1: 180% dilution without solid dissolution with solids initially deposited in the tank bottom

Case 2: 180% dilution without solid dissolution after solids are fully mixed

Case 3: 180% dilution with solids dissolution after solids are fully mixed

Case 4: 25% dilution with solids dissolution and solids initially deposited in the tank bottom

Case 5: 25% dilution with solids dissolution after solids are fully mixed

Case 6: 25% dilution without solids dissolution after solids are fully mixed.

Simulation results over one simulation hour indicated that the mixer pump is adequate to fully mix the wastes under the 180 and 25% dilution conditions tested. The study also confirmed that mixing is most difficult under the Case 1 conditions and easiest under the Case 4 conditions used in the study. These modeling results indicate that the centrally located, 300-hp single pump with rotating 60-ft/s jets can suspend and keep suspending the slurry within at least 94% uniformity over the entire tank. It would take a little over one hour to achieve this fully mixed condition for Case 1, starting from the solids deposited on the AP-102 and -104 tank bottoms. Under Case 4 conditions, the mixer pump can achieve over 99% waste uniformity in about 20 minutes. Table 4.1 summarizes how well the single pump mixes the waste in each of these six conditions.

Table 4.1. Expected Waste Uniformity Achieved by Pump Jet Mixing in AP-102 and -104

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Waste Uniformity (%)	94.4	94.6	99.0	99.97	99.97	99.0

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