LOSS OF COOLANT ACCIDENT ANALYSIS

INDIAN POINT 3

JANUARY, 1980

The Loss of Coolant Accident (LOCA) has been reanalyzed for Indian Point Unit 3. The following information amends the Safety Analysis Report section on Major Reactor Coolant System Pipe Ruptures. The results are consistent with acceptance criteria provided in reference 1.

The description of the various aspects of the LOCA analysis is given in WCAP-8339[2]. The individual computer codes which comprise the Westinghouse Emergency Core Cooling System (ECCS) evaluation model are described in detail in separate reports [3-6] along with code modifications specified in references 7, 9 and 10. The analysis presented here was performed with the February 1978 version of the evaluation model which includes modifications delineated in references 11, 12, 13 and 14.

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Results

The analysis of the loss of coolant accident is performed at 102 percent of the licensed core power rating. The peak linear power and total core power used in the analysis are given in Table 2. Since there is margin between the value of peak linear power density used in this analysis and the value of the peak linear power density expected during plant operation, the peak clad temperature calculated in this analysis is greater than the maximum clad temperature expected to exist.

Table 1 presents the occurence time for various events throughout the accident transient.

Table 2 presents selected input values and results from the hot fuel rod thermal transient calculation. For these results, the hot spot is defined as the location of maximum peak clad temperatures. That location is specified in Table 2 for each break analyzed. The location is indicated in feet which presents elevation above the bottom of the active fuel stack.

Table 3 presents a summary of the various containment systems parameters and structural parameters which were used as input to the COCO computer code[6] used in this analysis.

Tables 4 and 5 present reflood mass and energy releases to the containment, and the broken loop accumulator mass and energy release to the containment, respectively.

The results of several sensitivity studies are reported[8]. These results are for conditions which are not limiting in nature and hence are reported on a generic basis.

Figures 1 through 17 present the transients for the principle parameters for the break sizes analyzed. The following items are noted:

Figures 1A - 3C: Quality, mass velocity and clad heat transfer coefficient for the hotspot and burst locations

Figures 4A - 6C: Core pressure, break flow, and core pressure drop. The break flow is the sum of the flowrates from both ends of the guillotine break. The core pressure drop is taken as the pressure just before the core inlet to the pressure just beyond the core outlet

Figures 7A - 9C: Clad temperature, fluid temperature and core flow. The clad and fluid temperatures are for the hot spot and burst locations

Figures 10A - 11C: Downcomer and core water level during reflood, and flooding rate

Figures 12A - 13C: Emergency core cooling system flowrates, for both accumulator and pumped safety injection

Figures 14A - 15C: Containment pressure and core power transients

Figures 16, 17: Break energy release during blowdown and the containment wall condensing heat transfer coefficient for the worst break

Conclusions - Thermal Analysis

For breaks up to and including the double ended severance of a reactor coolant pipe, the Emergency Core Cooling System will meet the Acceptance Criteria as presented in 10CFR50.46.[1] That is:

1. The calculated peak clad temperature does not exceed 2200°F based on a total core peaking factor of 2.17.

2. The amount of fuel element cladding that reacts chemically with water or steam does not exceed 1 percent of the total amount of Zircalloy in the reactor.

3. The clad temperature transient is terminated at a time when the core geometry is still amenable to cooling. The cladding oxidation limits of 17% are not exceeded during or after quenching.

4. The core temperature is reduced and decay heat is removed for an extended period of time, as required by the long-lived radioactivity remaining in the core.

References for Section 15.4.1

1. "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Cooled Nuclear Power Reactors", 10CFR50.46 and Appendix K of 10CFR50.46. Federal Register, Volume 39, Number 3, January 4, 1974.

2. Bordelon, F. M., Massie, H. W., And Zordan, T. A., "Westinghouse ECCS Evaluation Model-Summary," WCAP-8339, July 1974.

3. Bordelon, F. M., et al., "SATAN-VI Program: Comprehensive Space-Time Dependent Analysis of Loss-of-Coolant," WCAP-8302 (Proprietary Version), WCAP-8306 (Non-Proprietary Version), June 1974.

4. Bordelon, F. M., Et al., "LOCTA-IV Program: Loss-of-Coolant Transient Analysis," WCAP-8301 (Proprietary Version), WCAP-8305 (Non-Proprietary Version), June 1974.

5. Kelly, R. D., et al., "Calculational Model for Core Reflooding after a Loss-of-Coolant Accident (WREFLOOD Code)." WCAP-8170 (Proprietary Version), WCAP-8171 (Non-Proprietary Version), June 1974.

6. Bordelon, F. M., and Murphy E. T., "Containment Pressure Analysis Code (COCO)," WCAP-8327 (Proprietary Version), WCAP-8326 (Non-Proprietary Version), June 1974.

7. Bordelon F. M., et al., "The Westinghouse ECCS Evaluation Model: Supplementary Information," WCAP-8471 (Proprietary Version), WCAP-8472 (Non-Proprietary Version), January 1975.

8. Salvatori, R., "Westinghouse ECCS - Plant Sensitivity Studies," WCAP-8340 (Proprietary Version), WCAP-8356 (Non-Proprietary Version), July 1974.

9. "Westinghouse ECCS Evaluation Model, October, 1975 Versions," WCAP-8622 (Proprietary Version), WCAP-8623 (Non-Proprietary Version), November, 1975.

10. Letter from C. Eicheldinger of Westinghouse Electric Corporation to D. B. Vassalo of the Nuclear Regulatory Commission, letter number NS-CE-924, January 23, 1976.

11. Kelly, R. D., Thompson, C. M., et. al., "Westinghouse Emergency Core Cooling System Evaluation Model for Analyzing Large LOCA's During Operation With One Loop Out of Service for Plants Without Loop Isolation Valves," WCAP-9166, February, 1978.

12. Eicheldinger C., "Westinghouse ECCS Evaluation Model, February 1978 Version," WCAP-9220-P-A (Proprietary Version), WCAP-9221-A (Non-Proprietary Version), February, 1978.

13. Letter from T. M. Anderson of Westinghouse Electric Corporation to John Stolz of the Nuclear Regulatory Commission, letter number NS-TMA-1981, Nov. 1, 1978.

14. Letter from T. M. Anderson of Westinghouse Electric Corporation to John Stolz of the Nuclear Regulatory Commission, letter number NS-TMA-2014, Dec. 11, 1978.

APPENDIX A

As reported in Reference 15, Westinghouse has investigated the effects of fuel rod heatup rate prior to burst with respect to the Appendix K LOCA analyses. Westinghouse has evaluated this effect for Indian Point Unit 3 with the following results. For the worst break (1.0 DECLG), the appropriate heatup rate for the hot rod and adjacent rod is 22.1°F/sec and the appropriate heatup rate for the hot assembly average rod was 14.8°F/sec. The burst node location (6.25') still yielded the maximum clad temperature which was an increase of approximately 30°F over the results listed in Table 2 with a total core peaking factor of 2.17. The 30°F change does not incorporate the fuel rod models for burst and blockage presented in NUREG 0630 (DRAFT).

TABLE 1

LARGE BREAK - TIME SEQUENCE OF EVENTS

EVENT	OCCURENCE TIME (SECONDS)		
	DECLG, C_D = 0.6	DECLG, C_D = 0.8	DECLG, C_D = 1.0
Accident Initiation	0.0	0.0	0.0
Reactor Trip Signal	0.580	0.576	0.573
Safety Injection Signal	1.06	0.94	0.87
Start Accumulator Injection	16.5	14.4	13.9
End of ECC Bypass	26.36	25.94	24.96
End of Blowdown	30.11	28.47	28.34
Bottom of Core Recovery	42.00	41.91	40.84
Accumulators Empty	56.83	54.68	54.29
Start Pumped ECC Injection	26.06	25.94	25.87

TABLE 2

LARGE BREAK - ANALYSIS INPUT AND RESULTS

Quantities in the calculations:

Licensed core power rating	102% of 3025	MWt
Total core peaking factor	2.17	
Peak linear power	102% of 13.55	kw/ft
Accumulator water volume	800	cubic feet per tank
Accumulator pressure	600	PSIA
Number of Safety Injection Pumps Operating	2	
Steam Generator Tube Plugging Level	4	percent (uniform)
Fuel Parameters - Cycle 3	Region all	

Results	DECLG, C_D = 0.6	DECLG, C_D = 0.8	DECLG, C_D = 1.0
Peak clad temperature (°F)	2023.3	2026.5	2094.1
Location (feet)	6.0	6.25	6.25
Maximum local clad/water reaction (%)	4.98	5.22	6.18
Location (feet)	6.0	6.25	6.25
Total core clad/water reaction (%)	< 0.3	< 0.3	< 0.3
Hot rod burst time (seconds)	32.2	32.2	30.6
Location (feet)	6.0	6.25	6.25

TABLE 3

CONTAINMENT DATA (DRY CONTAINMENT)

Net Free Volume	2.61×10^6 ft^3
Initial Conditions	
Pressure	14.7 PSIA
Temperature	90.0 °F
RWST Temperature	40.0 °F
Service Water Temperature	35.0 °F
Outside Temperature	-20.0 °F
Spray System	
Number of Pumps Operating	2
Runout Flow Rate	3000 GPM
Actuation Time	20 SECS.
Safeguards Fan Coolers	
Number of Fan Coolers Operating	5
Fastest Post Accident Initiation of Fan Coolers	30 SECS.

TABLE 3 (Cont'd)

STRUCTURAL HEAT SINK DATA

	Thickness (in)	Material	Area, ft^2
1.)	0.0065	Paint	
	0.375	Steel	
	36.0	Concrete	49,838.
2.)	0.0065	Paint	
	0.500	Steel	
	36.0	Concrete	32,072.
3.)	12.0	Concrete	15,000.
4.)	0.375	Stainless Steel	
	12.0	Concrete	10,000.
5.)	12.0	Concrete	61,000.
6.)	0.0065	Paint	
	0.500	Steel	68,792.
7.)	0.0065	Paint	
	0.375	Steel	79,904.
8.)	0.0065	Paint	
	0.250	Steel	27,948.
9.)	0.0065	Paint	
	0.1875	Steel	69,800.
10.)	0.125	Steel	3,000.
11.)	0.138	Steel	22,000.

TABLE 3 (Cont'd)

PAINTED STRUCTURAL HEAT SINK DATA

	Thickness (in)	Material	Area, ft^2
12.)	0.0065	Paint	
	0.0625	Steel	10,000.
13.)	0.0065	Paint	
	0.75	Steel	
	36.0	Concrete	565.
14.)	0.019	Stainless Steel	
	1.25	Insulation	
	0.500	Steel	
	36.0	Concrete	7,634.
15.)	0.375	Steel	1,800.

TABLE 4

1.0 DECLG BREAK

REFLOOD MASS AND ENERGY RELEASE

Time (Sec)	Mass Flow (Lb/Sec)	Energy Flow (Lb/Sec)
40.84	0.0	0.0
41.6	5.0	6,478.
47.8	42.06	54,505.
55.9	271.42	237,180.
66.6	323.68	246,021.
79.8	342.47	244,480.
94.3	351.51	239,880.
109.9	357.72	234,227.
143.8	367.70	221,758.
181.4	376.82	208,131.

TABLE 5

1.0 DECLG BREAK

BROKEN LOOP ACCUMULATOR MASS AND ENERGY RELEASE

Time (Sec)	Mass Flow (Lb/Sec)	Energy Flow (Btu/Sec)
0.0	4,288.	255,679.
2.0	3,314.	197,608.
4.0	2,799.	166,882.
6.0	2,461.	146,723.
8.0	2,211.	131,847.
10.0	2,015.	120,152.
12.0	1,855.	110,618.
14.0	1,722.	102,670.
16.0	1,609.	95,941.
18.0	1,520.	90,616.
20.0	1,445.	86,153.
22.0	1,381.	82,335.
23.75	0.	0.

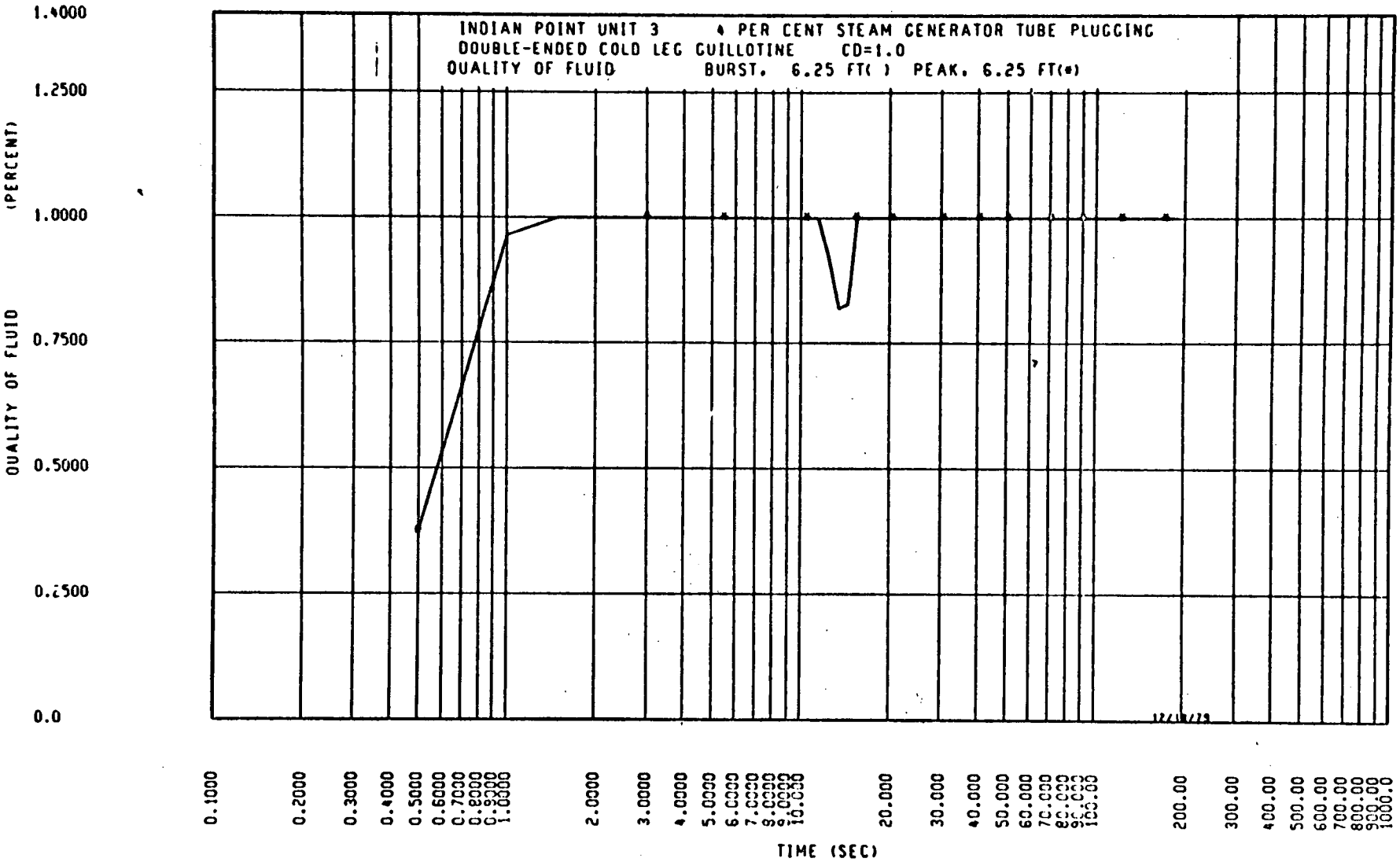
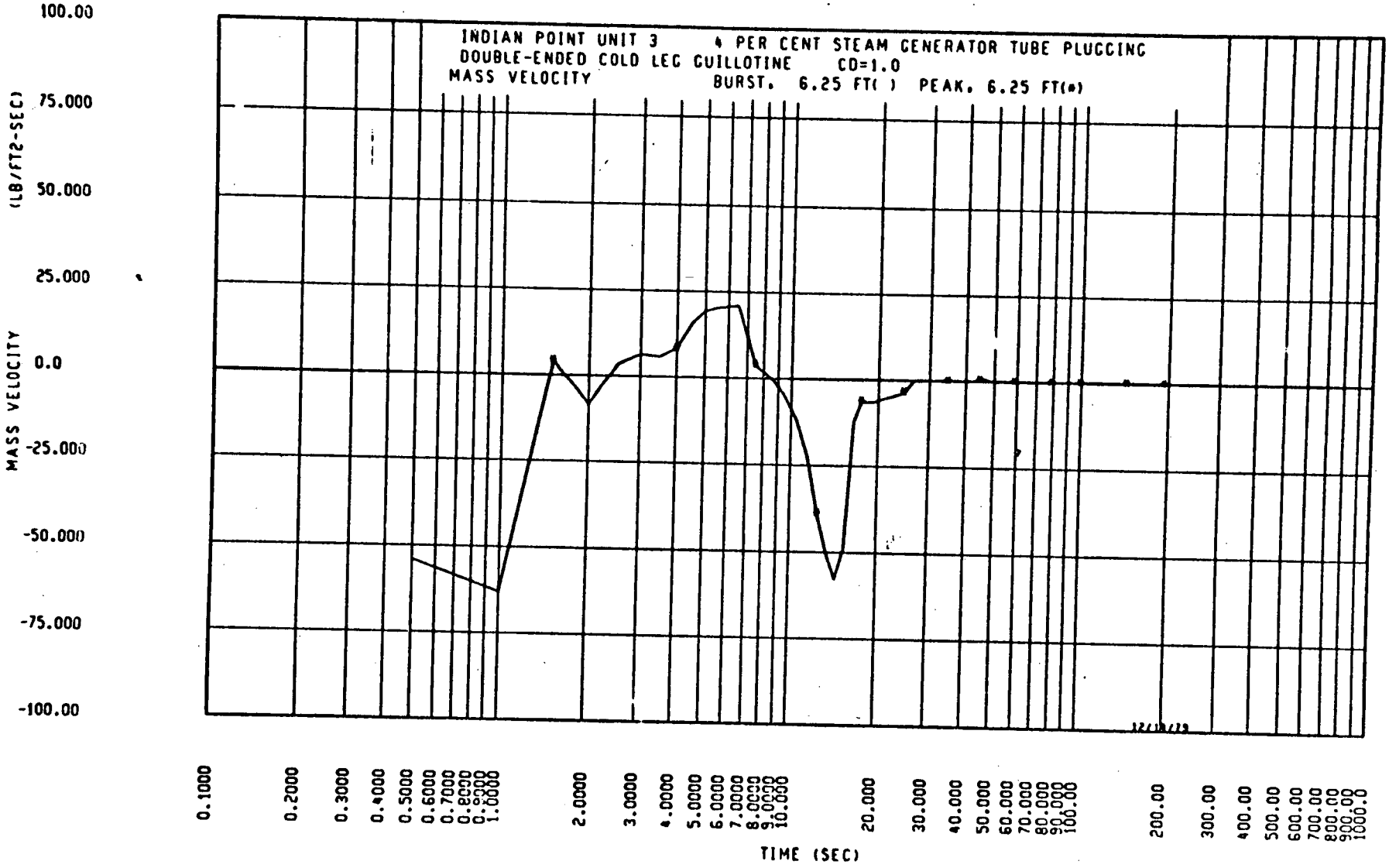

INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=1.0
QUALITY OF FLUID BURST. 6.25 FT( ) PEAK. 6.25 FT(*)
QUALITY OF FLUID (PERCENT)
1.4000
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
0.1000
0.2000
0.3000
0.4000
0.5000
0.6000
0.7000
0.8000
0.9000
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
20.000
30.000
40.000
50.000
60.000
70.000
80.000
90.000
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

FIG. 1A


INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=1.0
MASS VELOCITY BURST. 6.25 FT( ) PEAK. 6.25 FT(*)
MASS VELOCITY (LB/FT2-SEC)
100.00
75.000
50.000
25.000
0.0
-25.000
-50.000
-75.000
-100.00
TIME (SEC)
0.1000
0.2000
0.3000
0.4000
0.5000
0.6000
0.7000
0.8000
0.9000
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
20.000
30.000
40.000
50.000
60.000
70.000
80.000
90.000
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300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0

FIG. 2A

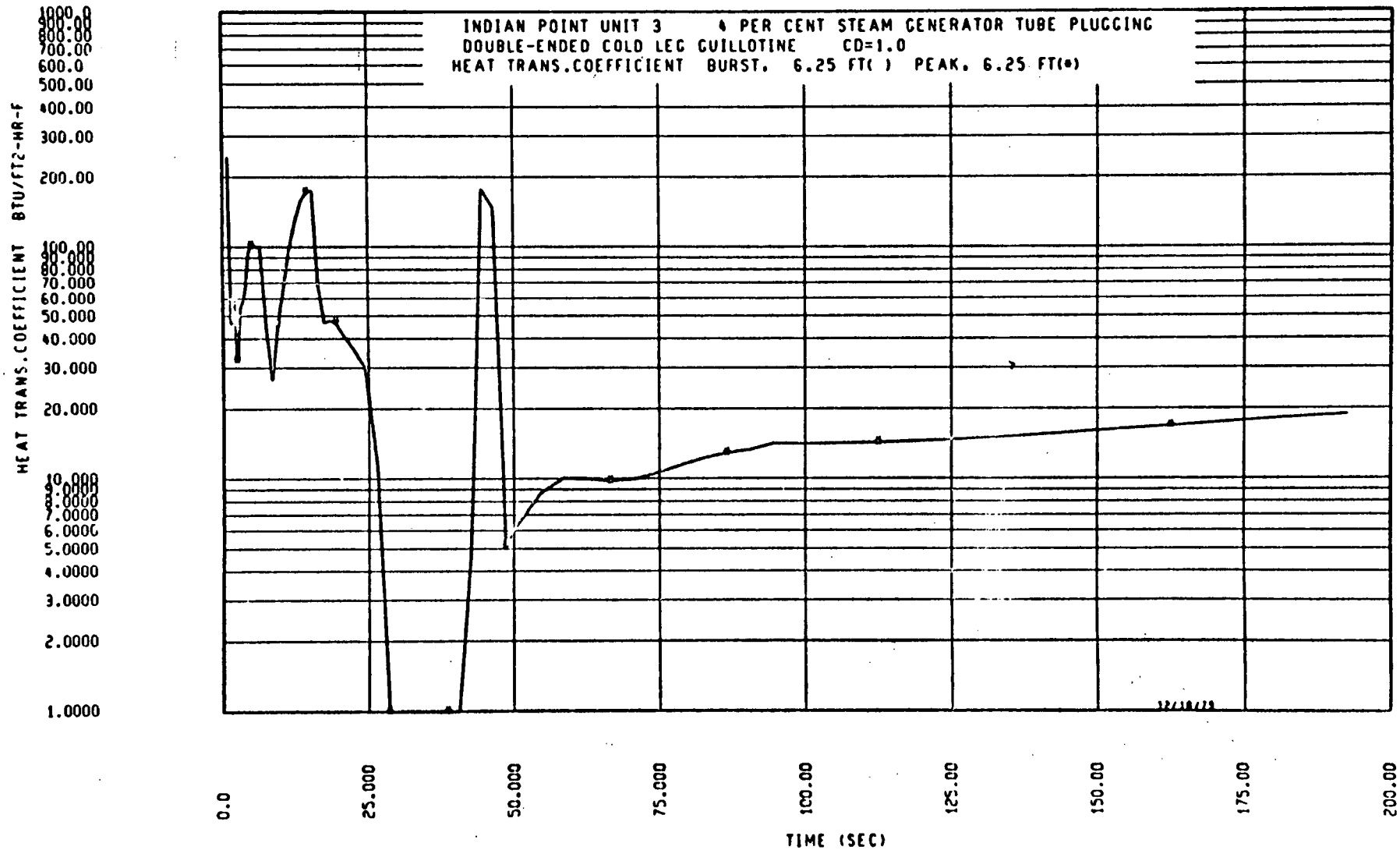
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=1.0
HEAT TRANS.COEFFICIENT BURST. 6.25 FT( ) PEAK. 6.25 FT(•)
HEAT TRANS.COEFFICIENT BTU/FT2-HR-F
1000.0
900.00
800.00
700.00
600.0
500.00
400.00
300.00
200.00
100.00
90.000
80.000
70.000
60.000
50.000
40.000
30.000
20.000
10.000
9.0000
8.0000
7.0000
6.0000
5.0000
4.0000
3.0000
2.0000
1.0000
0.0
25.000
50.000
75.000
100.00
125.00
150.00
175.00
200.00
TIME (SEC)

FIG. 3A

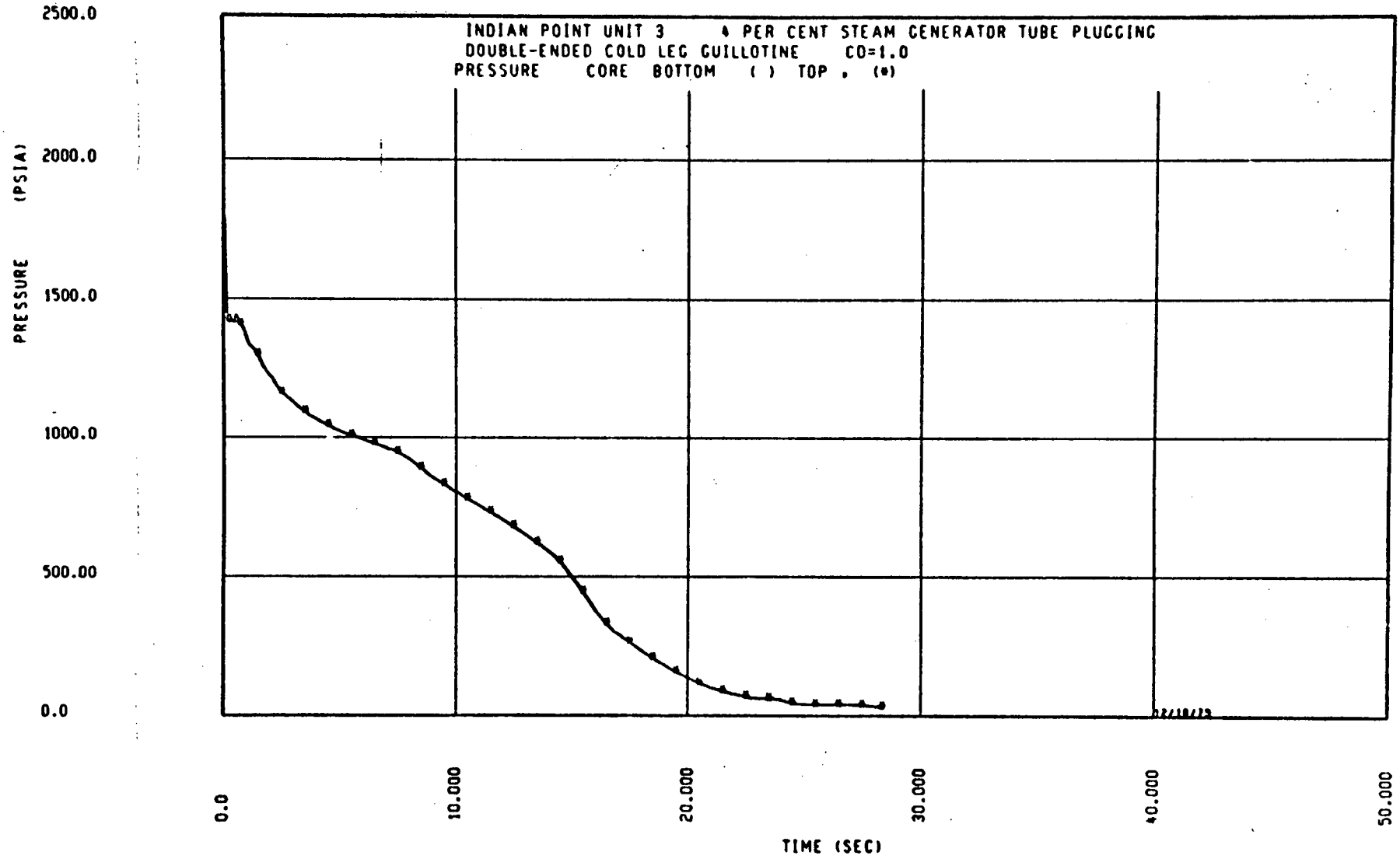
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=1.0
PRESSURE CORE BOTTOM ( ) TOP , (*)
PRESSURE (PSIA)
2500.0
2000.0
1500.0
1000.0
500.00
0.0
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 4A

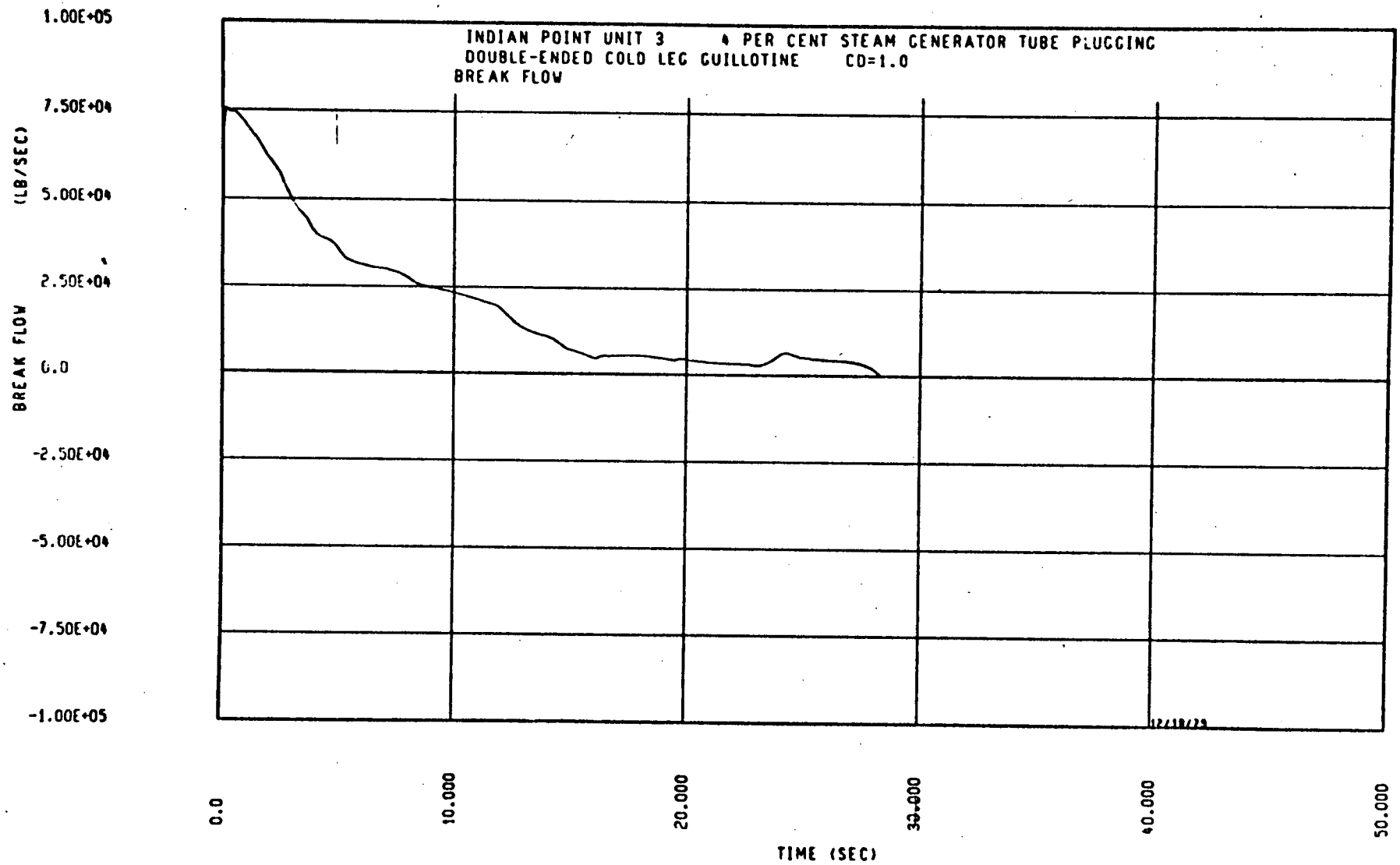
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=1.0
BREAK FLOW
BREAK FLOW (LB/SEC)
1.00E+05
7.50E+04
5.00E+04
2.50E+04
0.0
-2.50E+04
-5.00E+04
-7.50E+04
-1.00E+05
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 5A

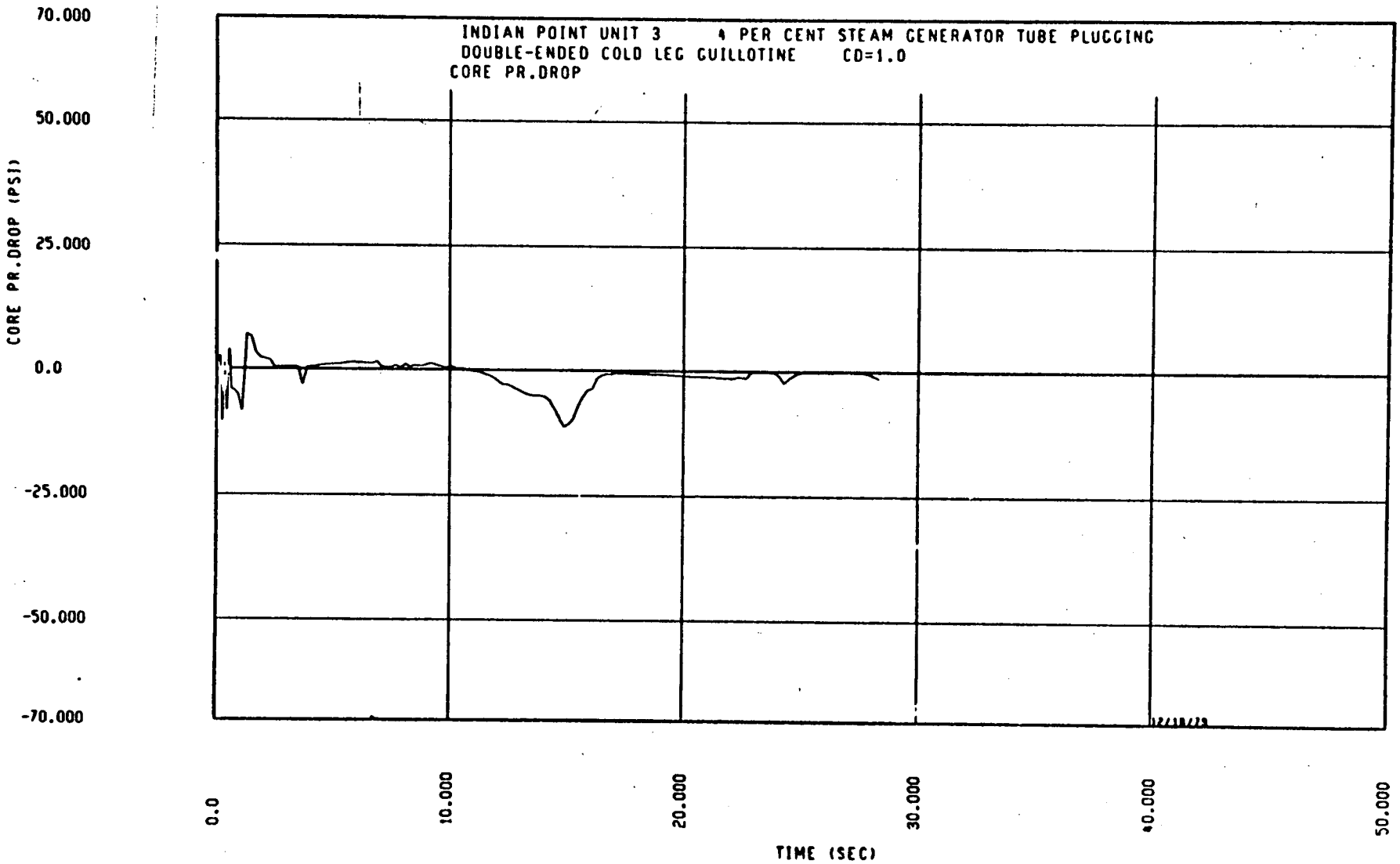
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=1.0
CORE PR.DROP
70.000
50.000
25.000
0.0
-25.000
-50.000
-70.000
CORE PR.DROP (PSI)
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 6A

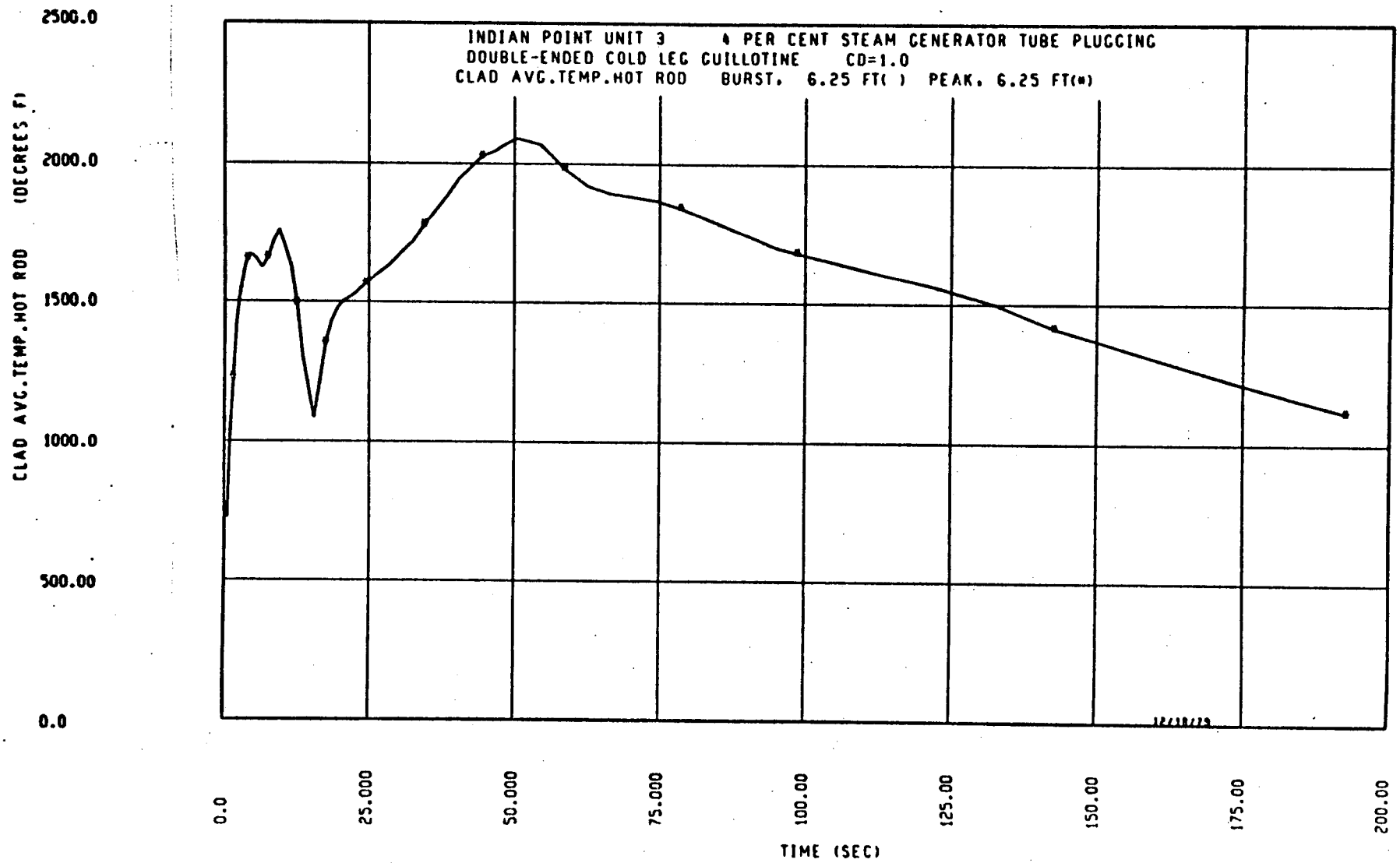
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=1.0
CLAD AVG.TEMP.HOT ROD BURST, 6.25 FT( ) PEAK, 6.25 FT(*)
CLAD AVG.TEMP.HOT ROD (DEGREES F)
2500.0
2000.0
1500.0
1000.0
500.00
0.0
0.0
25.000
50.000
75.000
100.00
125.00
150.00
175.00
200.00
TIME (SEC)

FIG. 7A

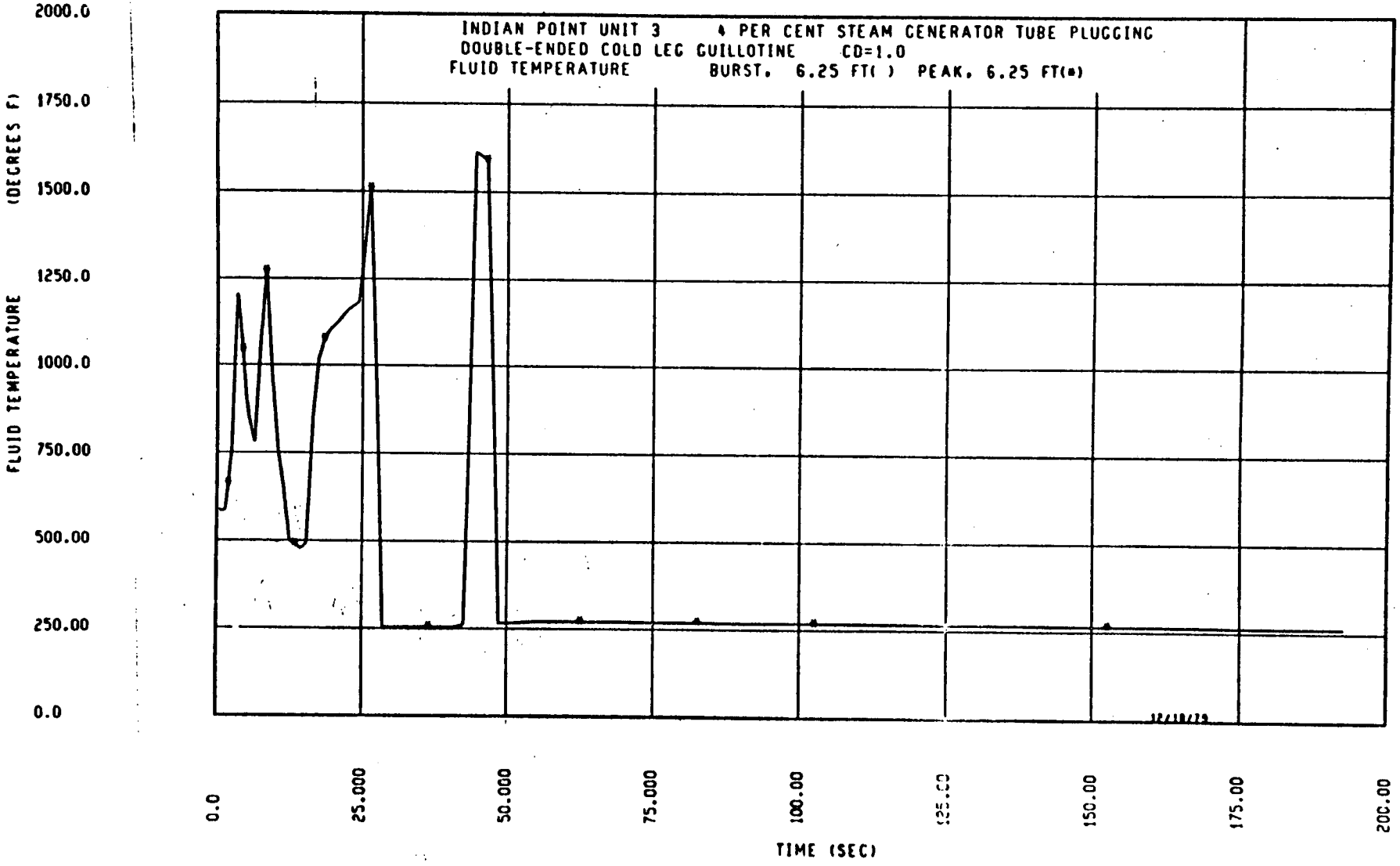
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=1.0
FLUID TEMPERATURE BURST, 6.25 FT( ) PEAK, 6.25 FT(*)
FLUID TEMPERATURE (DEGREES F)
2000.0
1750.0
1500.0
1250.0
1000.0
750.00
500.00
250.00
0.0
0.0
25.000
50.000
75.000
100.00
125.00
150.00
175.00
200.00
TIME (SEC)

FIG. 8A

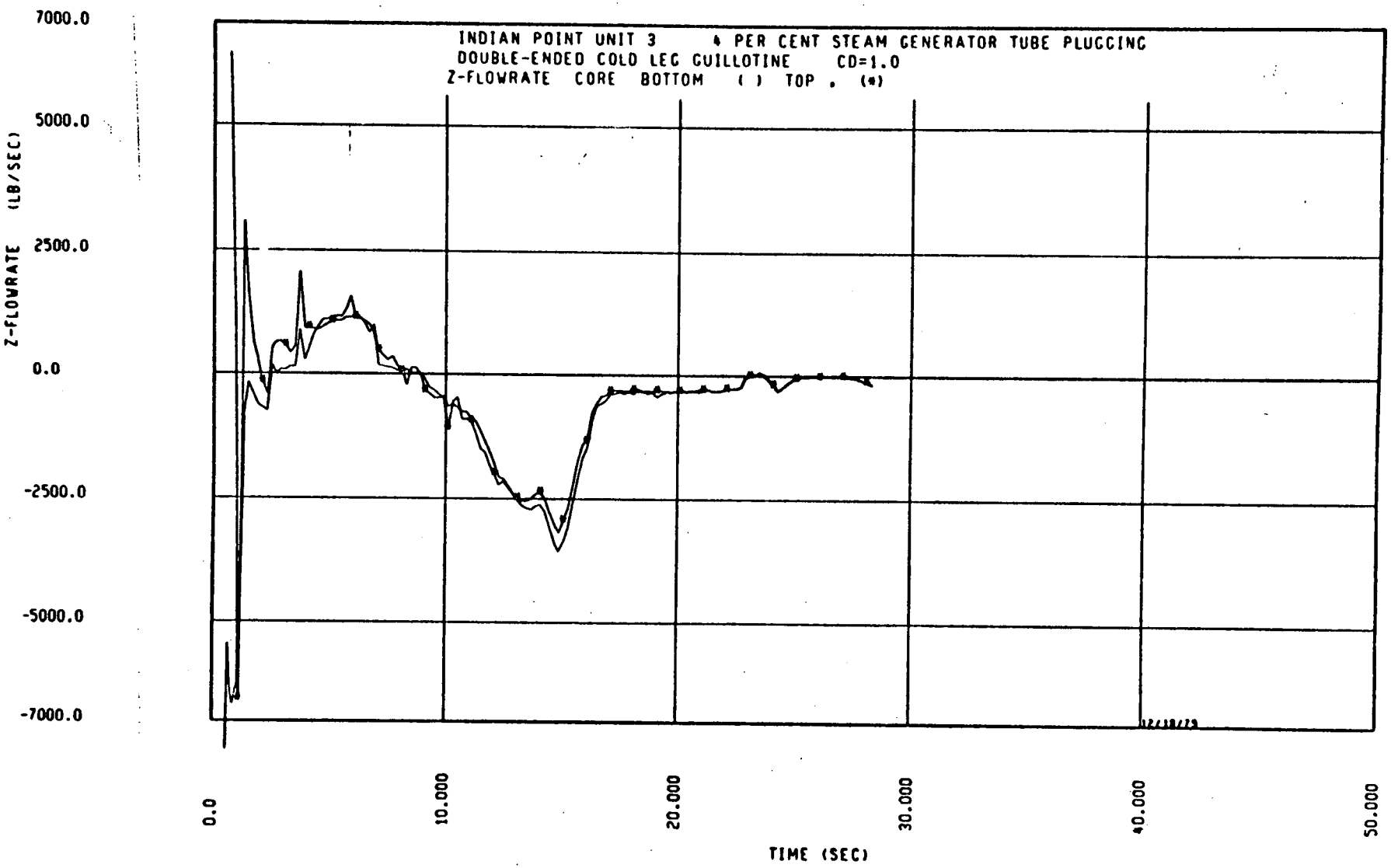
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=1.0
Z-FLOWRATE CORE BOTTOM ( ) TOP . (*)
7000.0
5000.0
2500.0
0.0
-2500.0
-5000.0
-7000.0
Z-FLOWRATE (LB/SEC)
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 9A

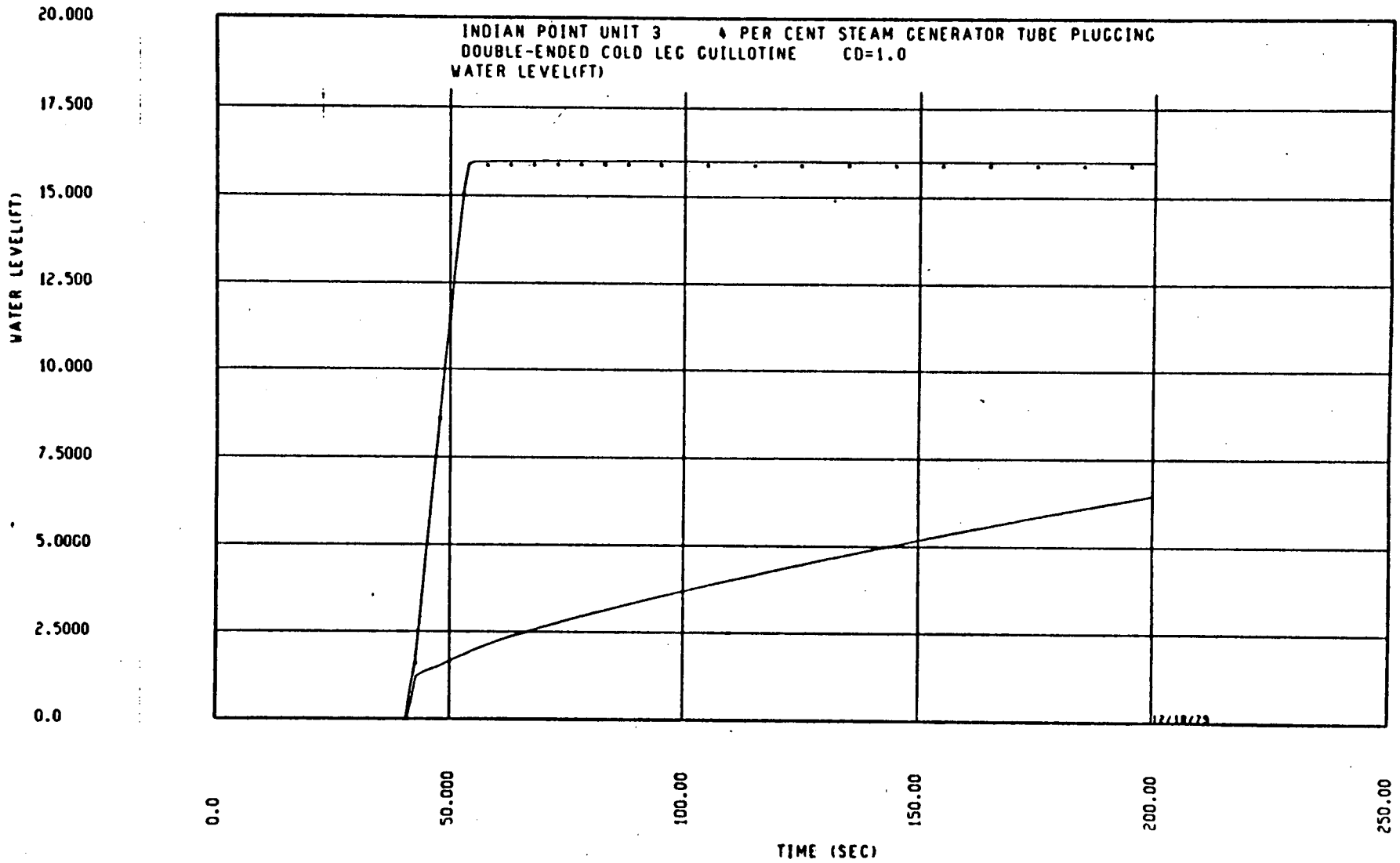
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=1.0
WATER LEVEL(FT)
20.000
17.500
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0
WATER LEVEL(FT)
0.0
50.000
100.00
150.00
200.00
250.00
TIME (SEC)

FIG. 10A

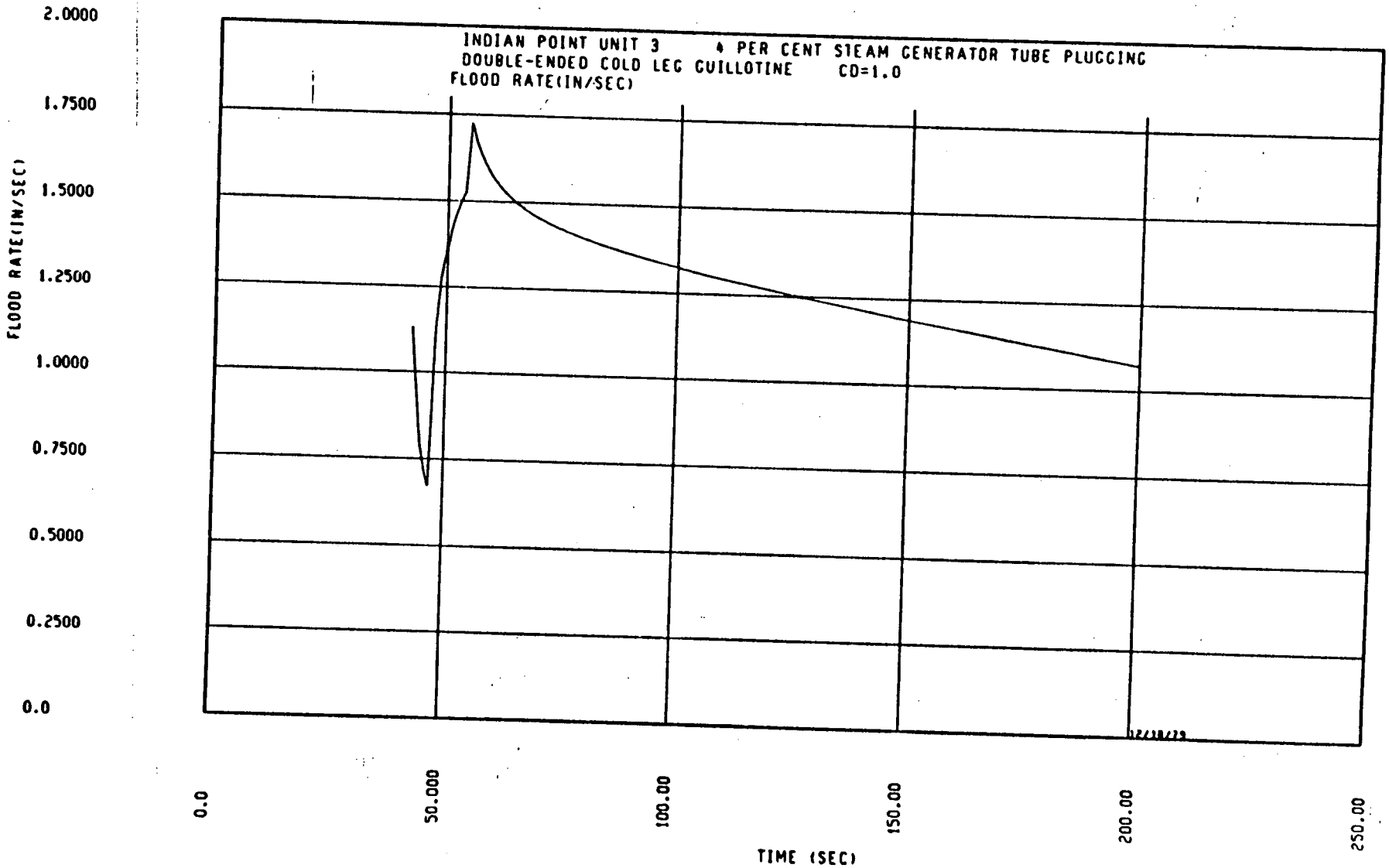
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=1.0
FLOOD RATE(IN/SEC)
FLOOD RATE(IN/SEC)
2.0000
1.7500
1.5000
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
0.0
50.000
100.00
150.00
200.00
250.00
TIME (SEC)

FIG. 11A

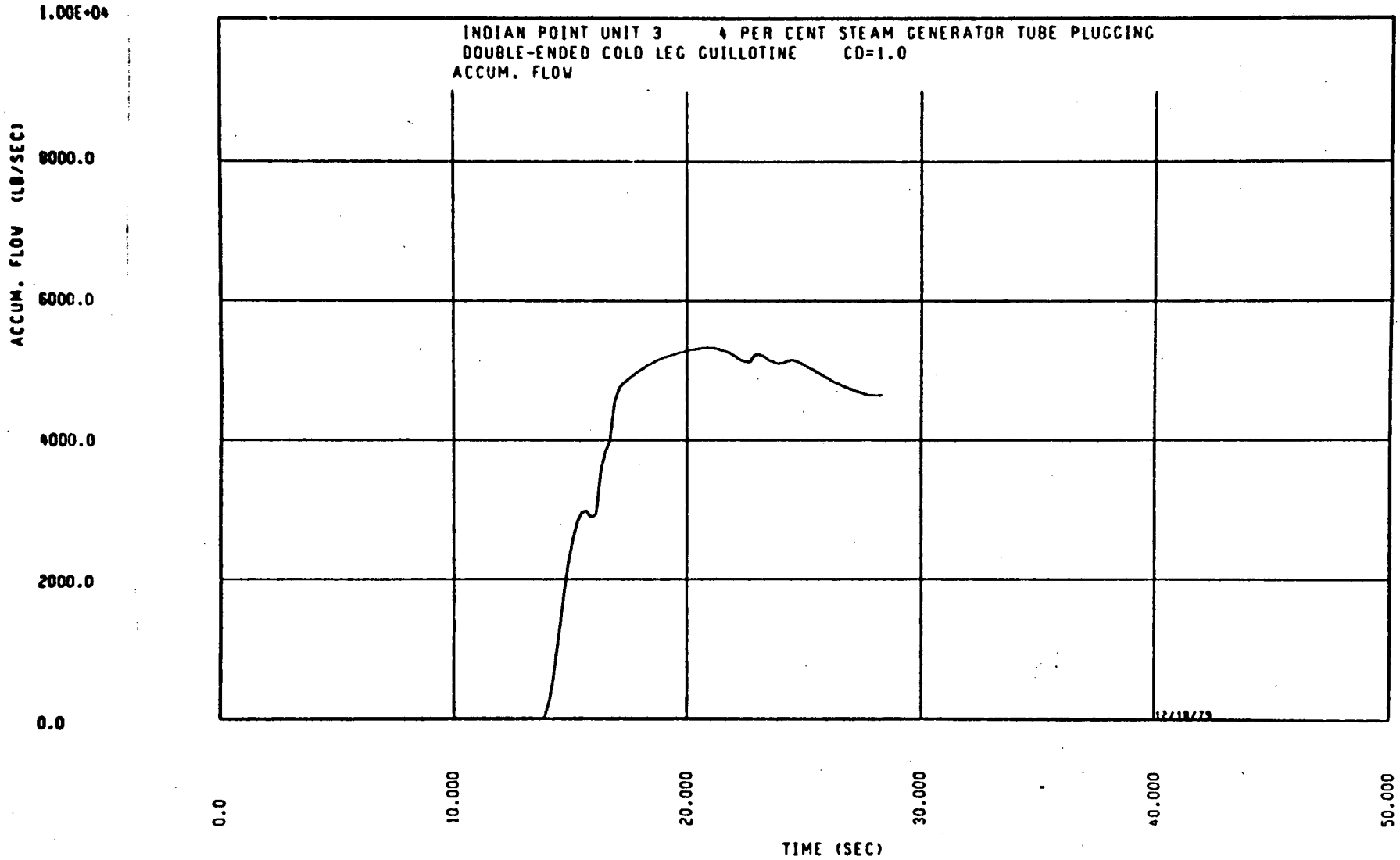
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=1.0
ACCUM. FLOW
ACCUM. FLOW (LB/SEC)
1.00E+04
8000.0
6000.0
4000.0
2000.0
0.0
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 12A

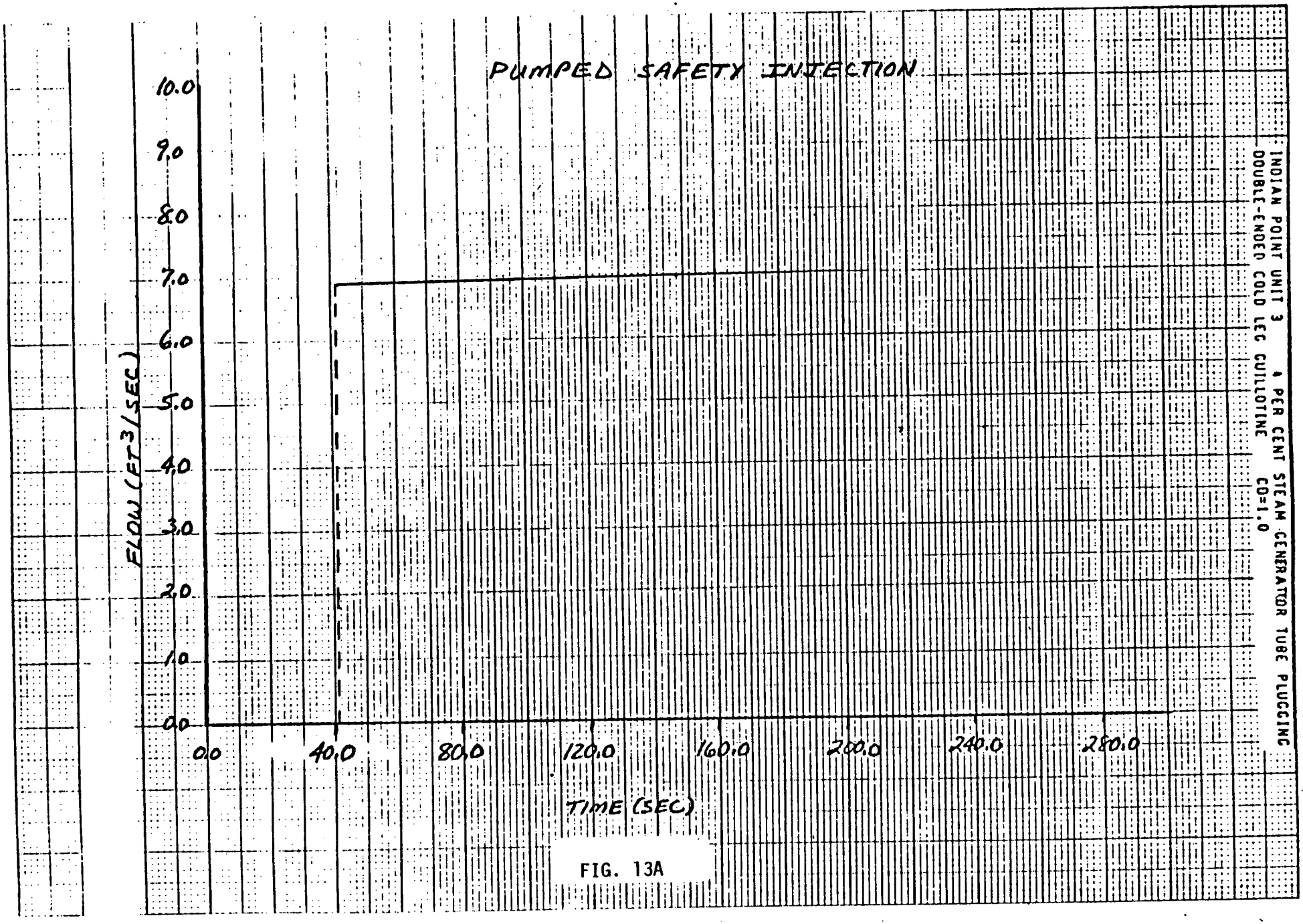
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=1.0
PUMPED SAFETY INJECTION
FLOW (FT³/SEC)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.0
40.0
80.0
120.0
160.0
200.0
240.0
280.0
TIME (SEC)

FIG. 13A

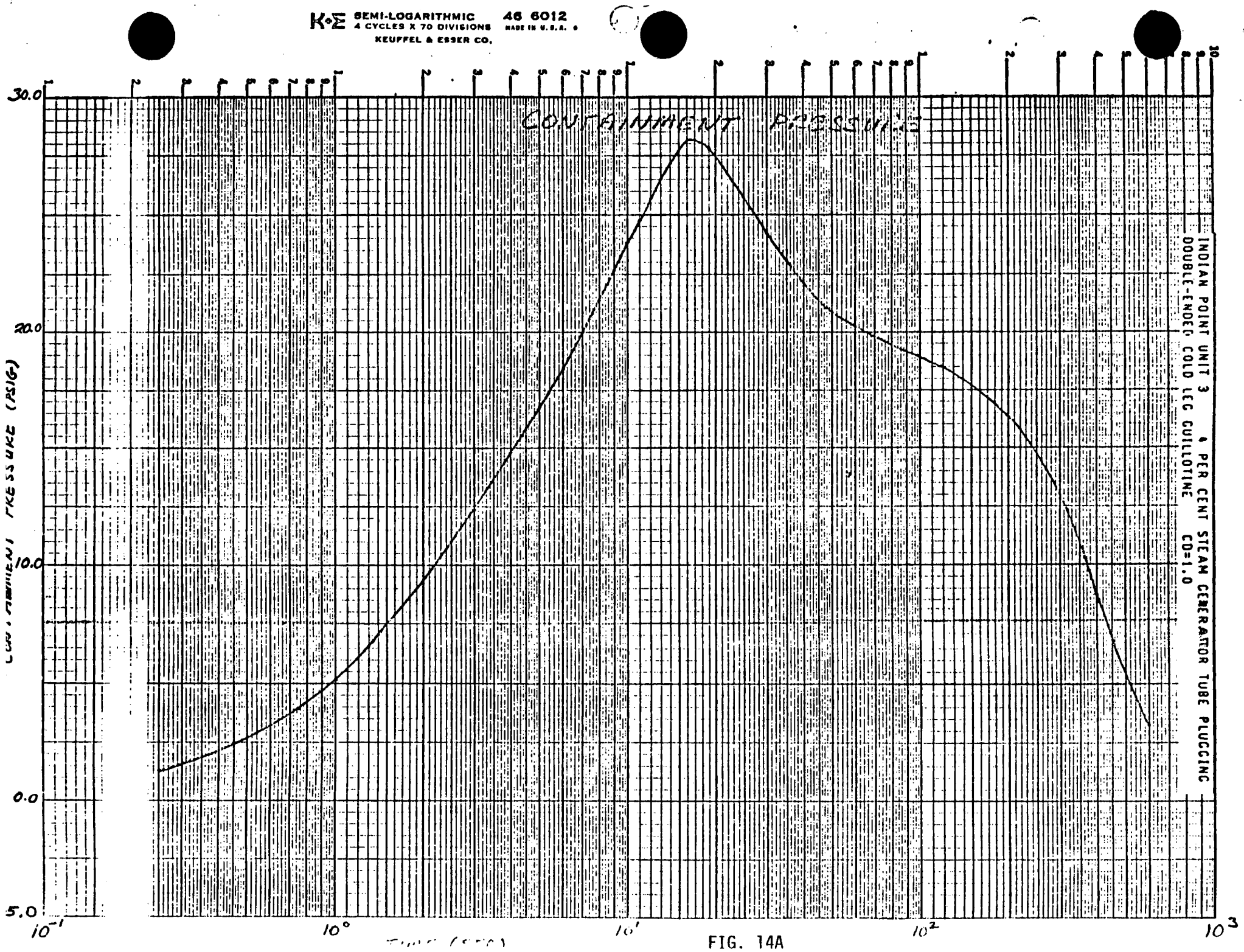
K+E SEMI-LOGARITHMIC 46 6012
4 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
CONTAINMENT PRESSURE
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=1.0
30.0
20.0
10.0
0.0
5.0
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}

FIG. 14A

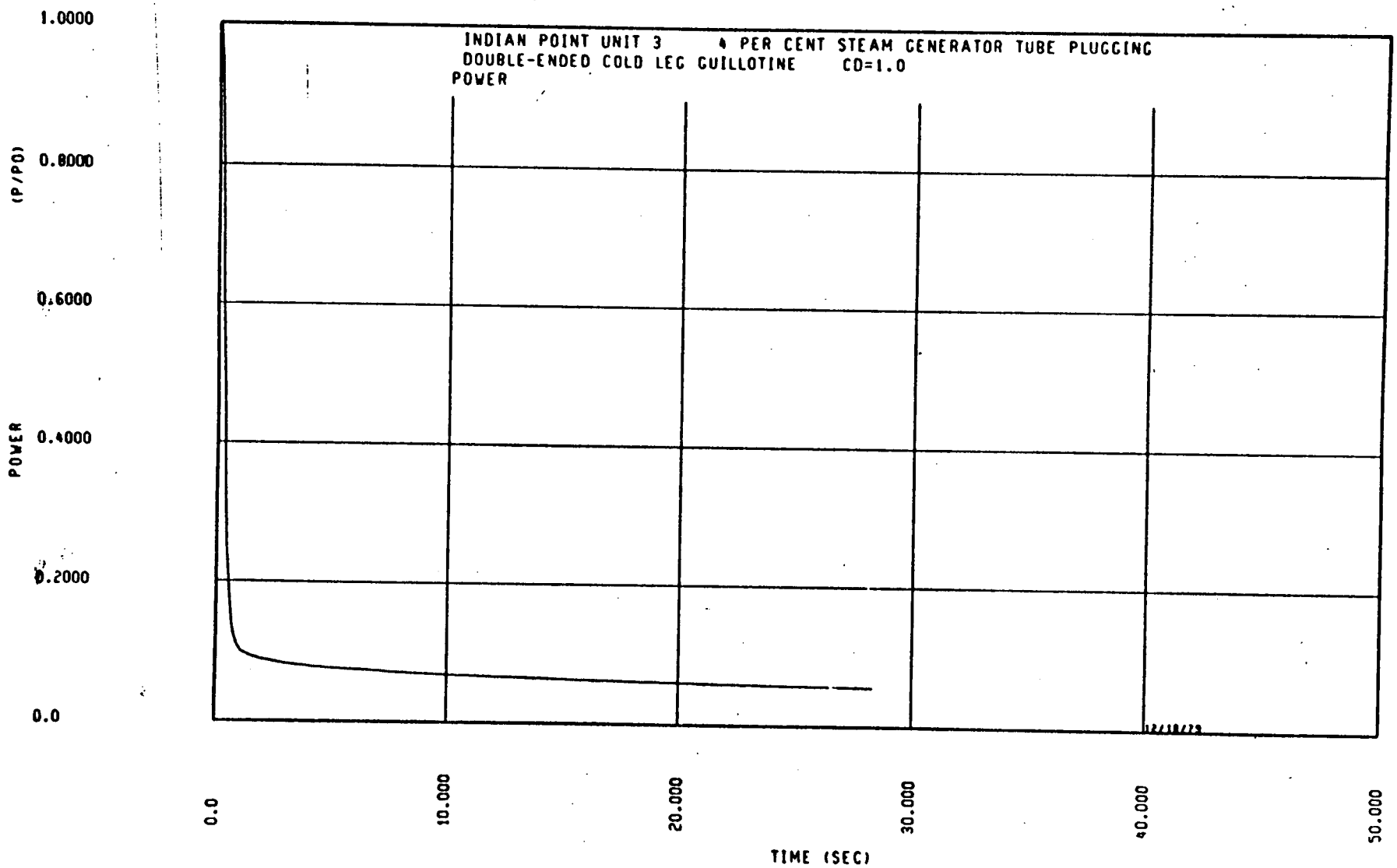
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=1.0
POWER
POWER (P/PO)
1.0000
0.8000
0.6000
0.4000
0.2000
0.0
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 15A

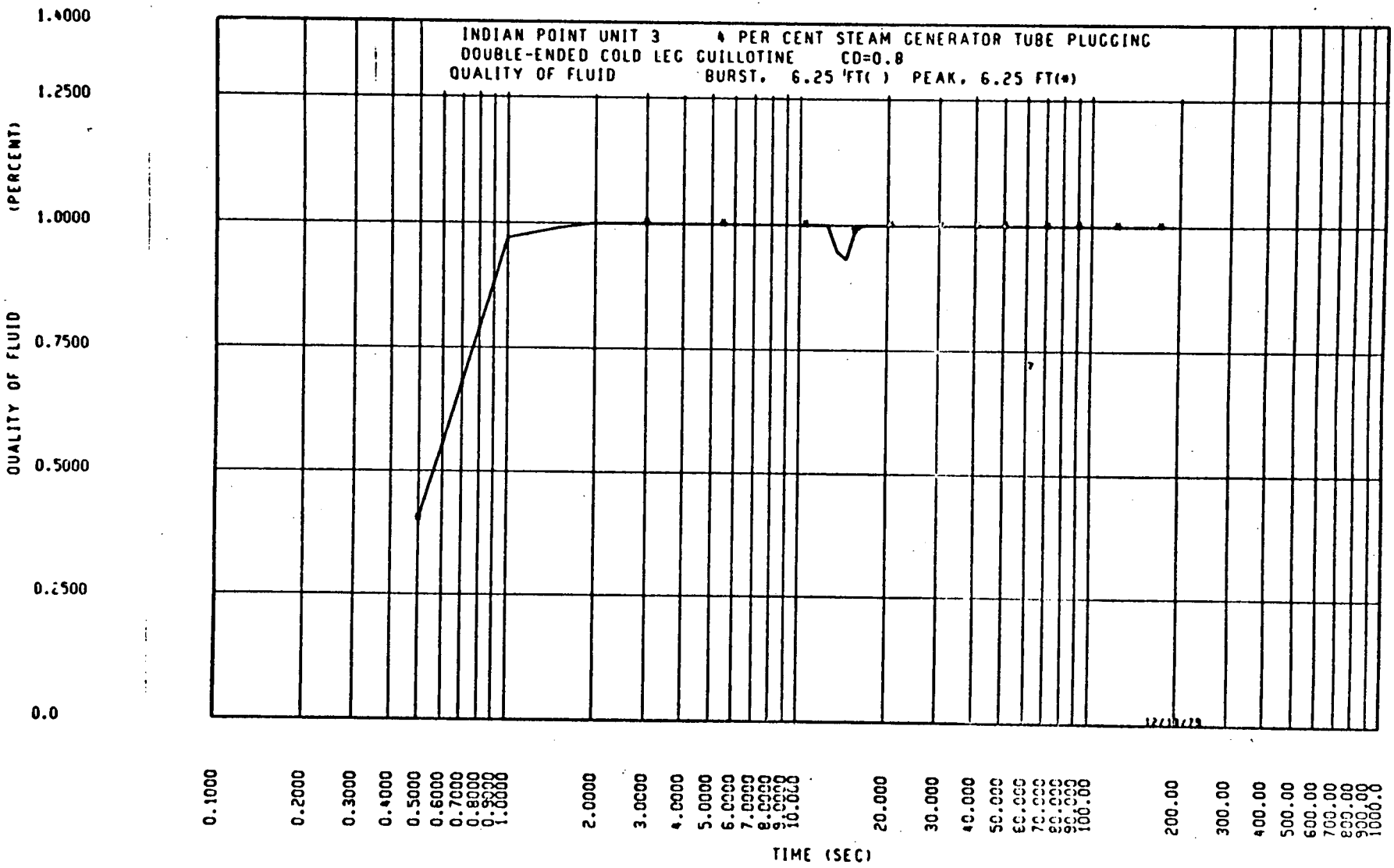
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.8
QUALITY OF FLUID BURST, 6.25 FT( ) PEAK, 6.25 FT(*)
QUALITY OF FLUID (PERCENT)
1.4000
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
0.1000
0.2000
0.3000
0.4000
0.5000
0.6000
0.7000
0.8000
0.9000
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
20.000
30.000
40.000
50.000
60.000
70.000
80.000
90.000
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

FIG. 1B

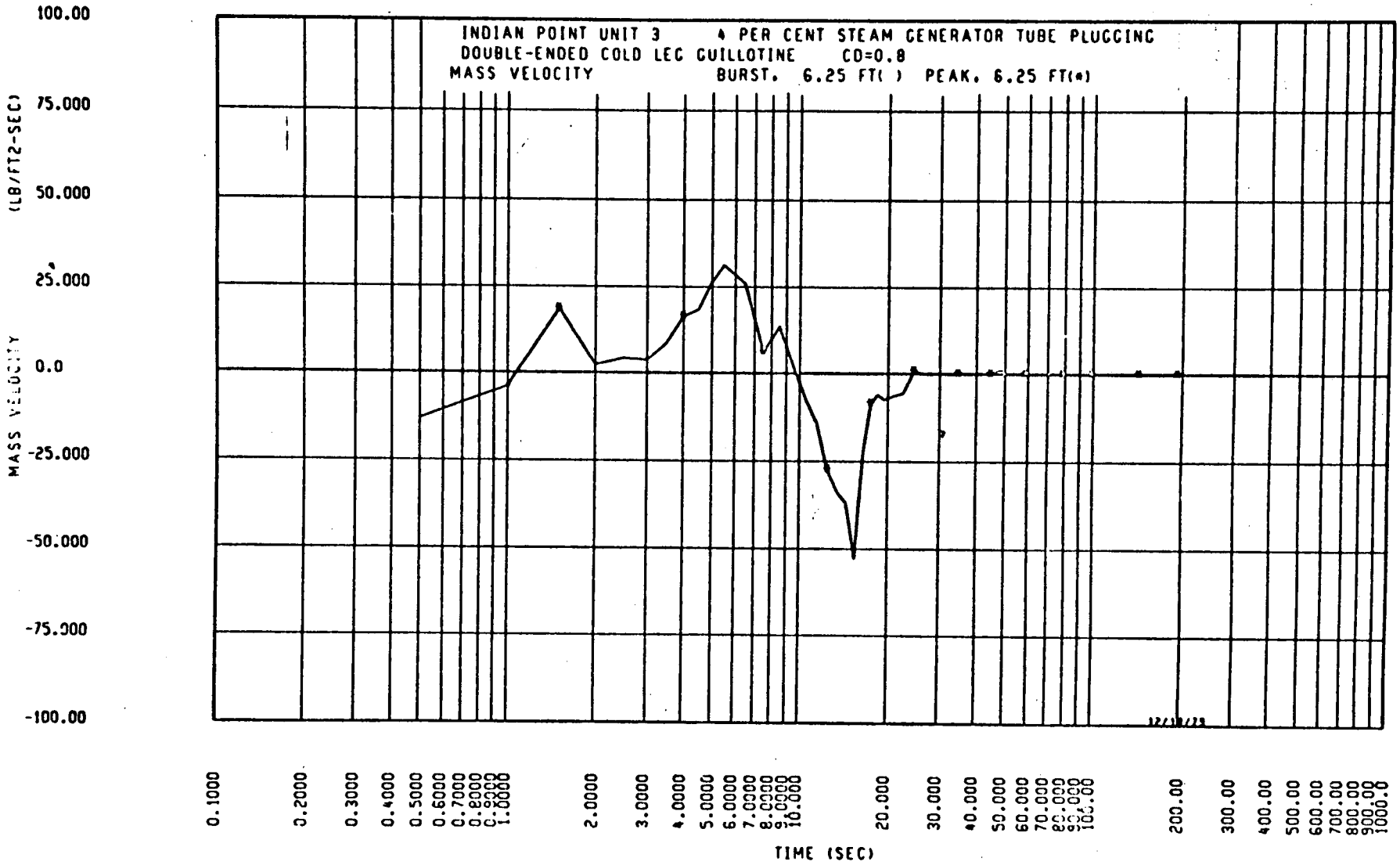
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.8
MASS VELOCITY BURST. 6.25 FT( ) PEAK. 6.25 FT(*)
MASS VELOCITY (LB/FT2-SEC)
100.00
75.000
50.000
25.000
0.0
-25.000
-50.000
-75.000
-100.00
0.1000
0.2000
0.3000
0.4000
0.5000
0.6000
0.7000
0.8000
0.9000
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
20.000
30.000
40.000
50.000
60.000
70.000
80.000
90.000
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

FIG. 2B

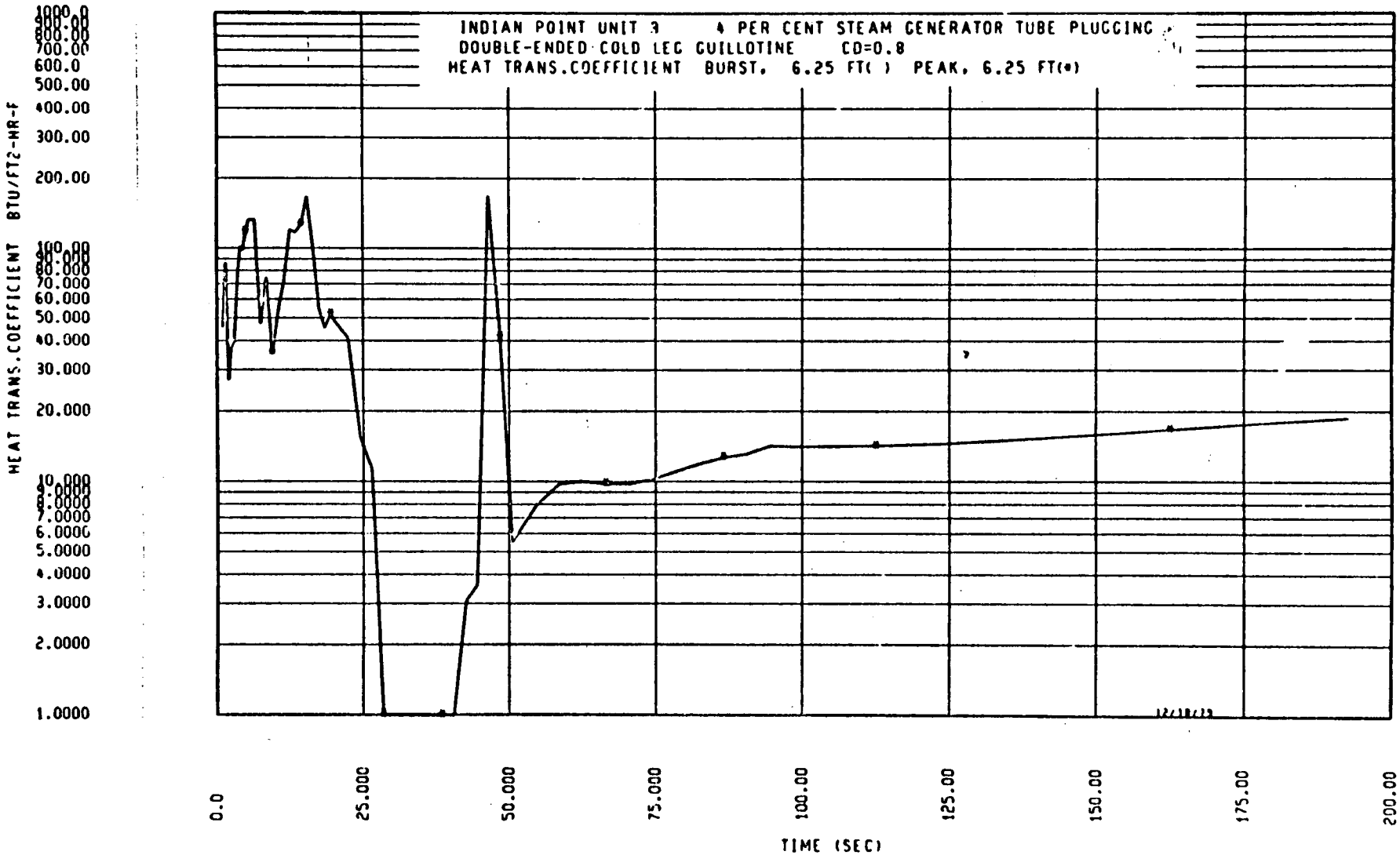
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.8
HEAT TRANS.COEFFICIENT BURST, 6.25 FT( ) PEAK, 6.25 FT(*)
HEAT TRANS.COEFFICIENT BTU/FT2-HR-F
1000.0
900.00
800.00
700.00
600.0
500.00
400.00
300.00
200.00
100.00
90.000
80.000
70.000
60.000
50.000
40.000
30.000
20.000
10.000
9.0000
8.0000
7.0000
6.0000
5.0000
4.0000
3.0000
2.0000
1.0000
0.0
25.000
50.000
75.000
100.00
125.00
150.00
175.00
200.00
TIME (SEC)

FIG. 3B

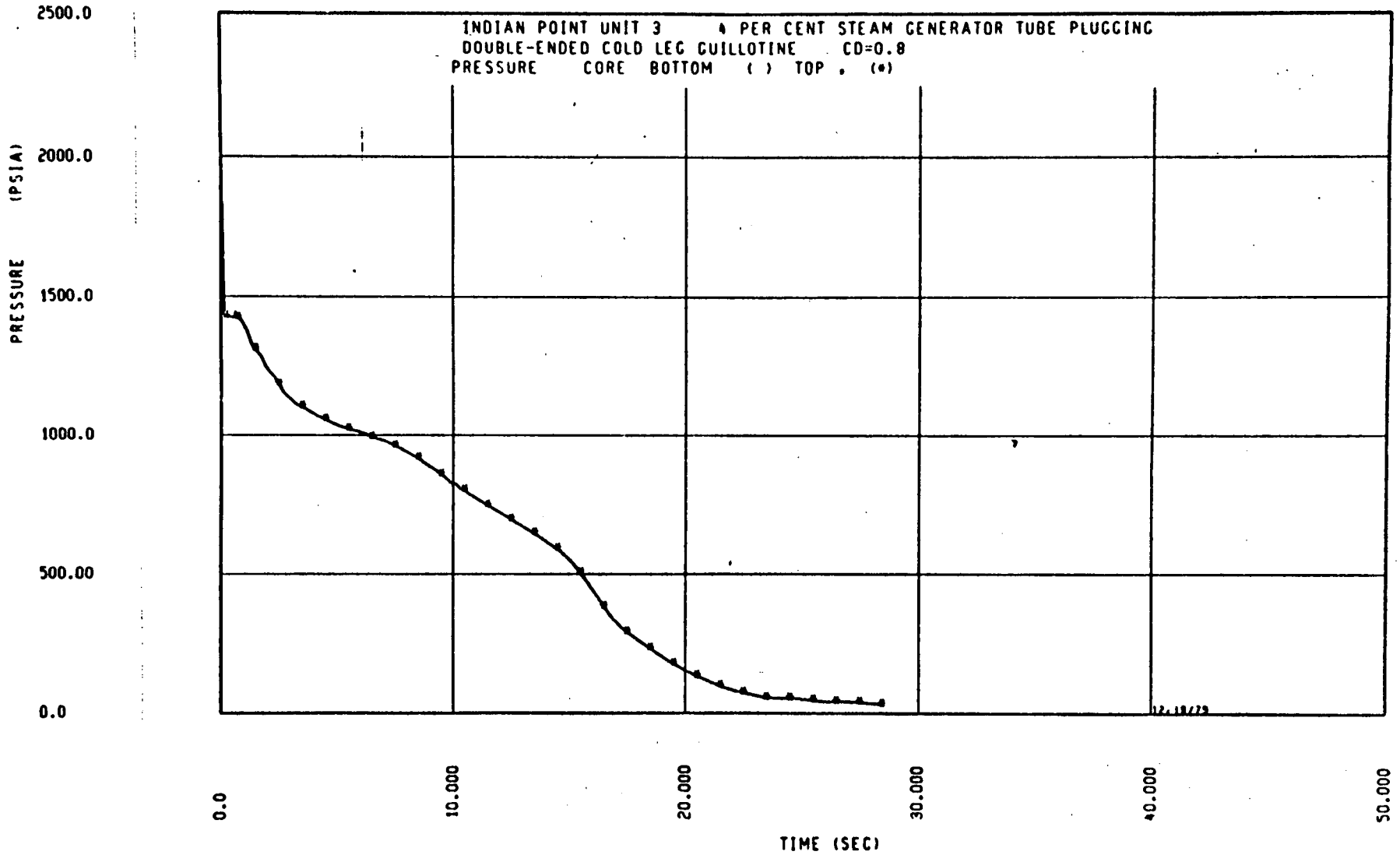
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.8
PRESSURE CORE BOTTOM ( ) TOP . (*)
PRESSURE (PSIA)
2500.0
2000.0
1500.0
1000.0
500.00
0.0
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 4B

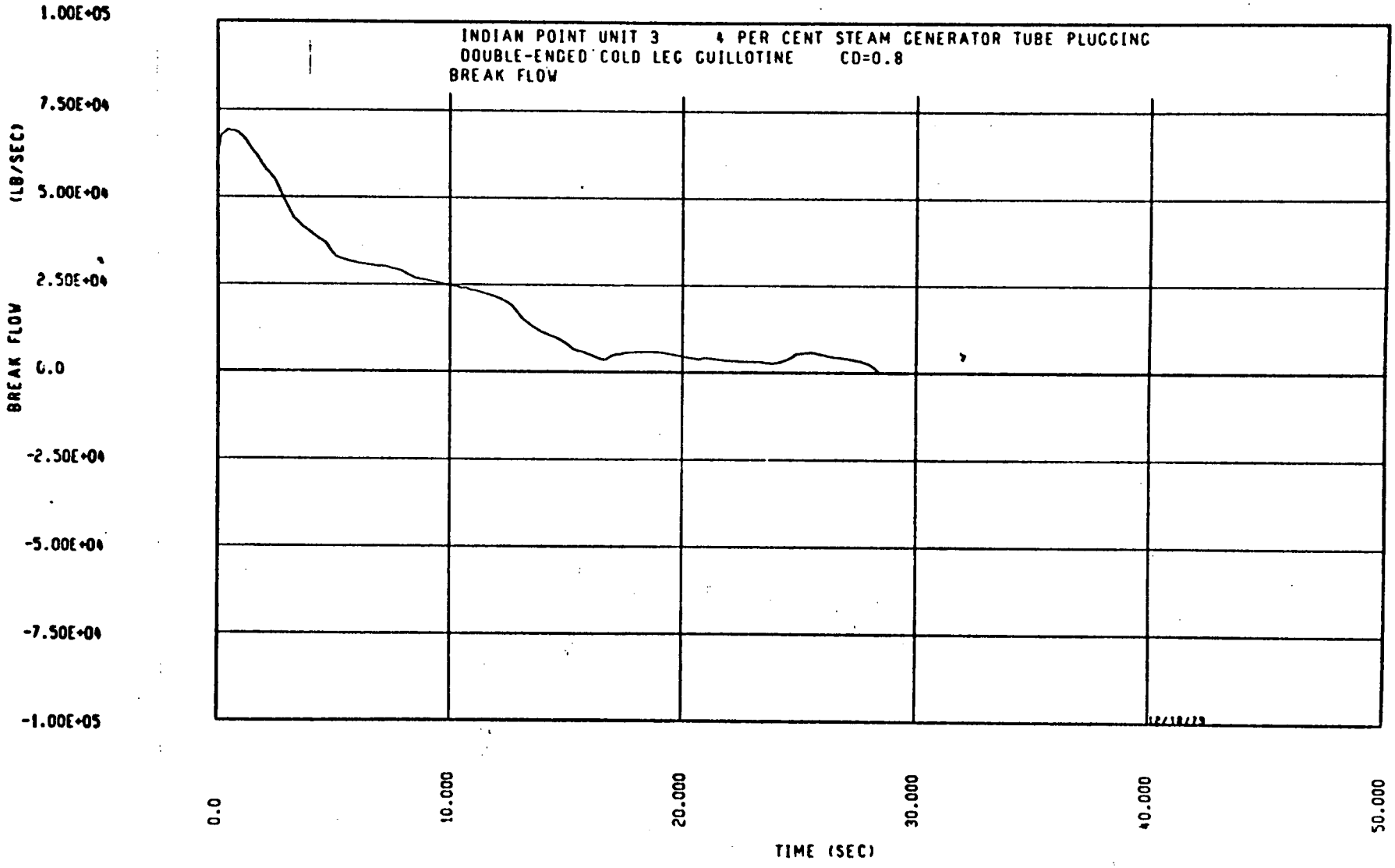
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.8
BREAK FLOW
BREAK FLOW (LB/SEC)
1.00E+05
7.50E+04
5.00E+04
2.50E+04
0.0
-2.50E+04
-5.00E+04
-7.50E+04
-1.00E+05
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 5B

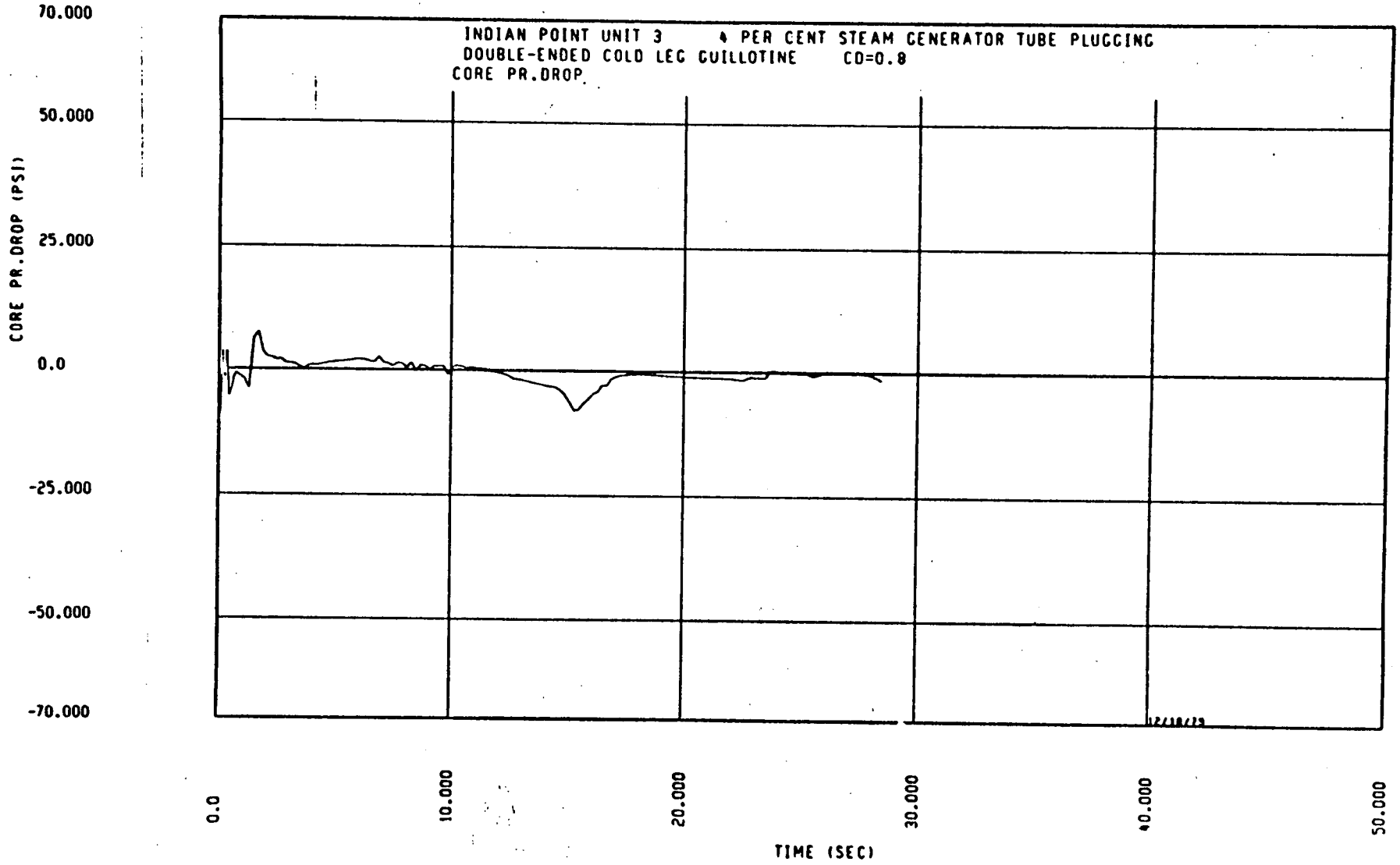
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.8
CORE PR.DROP
70.000
50.000
25.000
0.0
-25.000
-50.000
-70.000
CORE PR.DROP (PSI)
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 6B

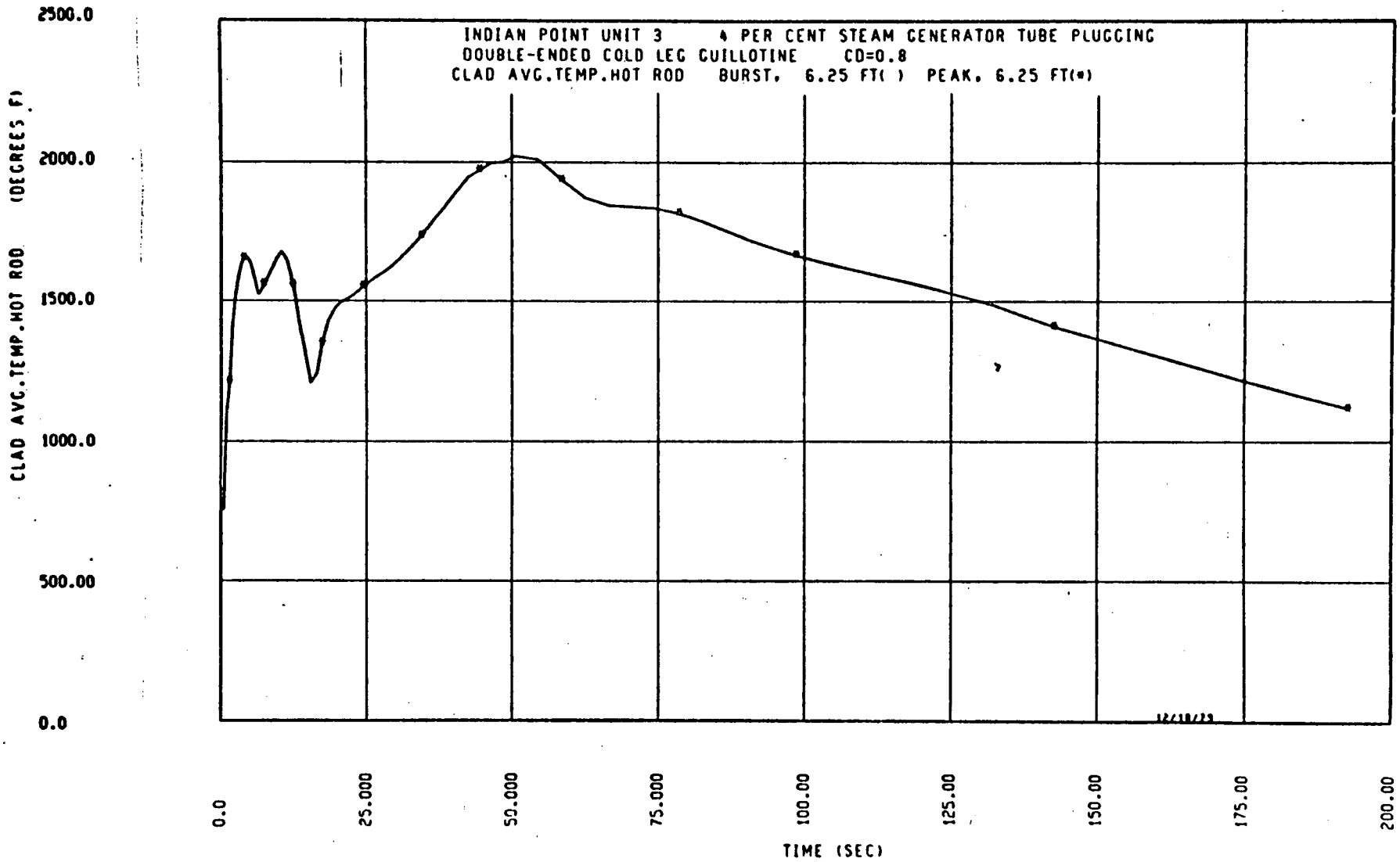
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.8
CLAD AVG.TEMP.HOT ROD BURST, 6.25 FT( ) PEAK, 6.25 FT(*)
CLAD AVG.TEMP.HOT ROD (DEGREES F)
2500.0
2000.0
1500.0
1000.0
500.00
0.0
0.0
25.000
50.000
75.000
100.00
125.00
150.00
175.00
200.00
TIME (SEC)

FIG. 7B

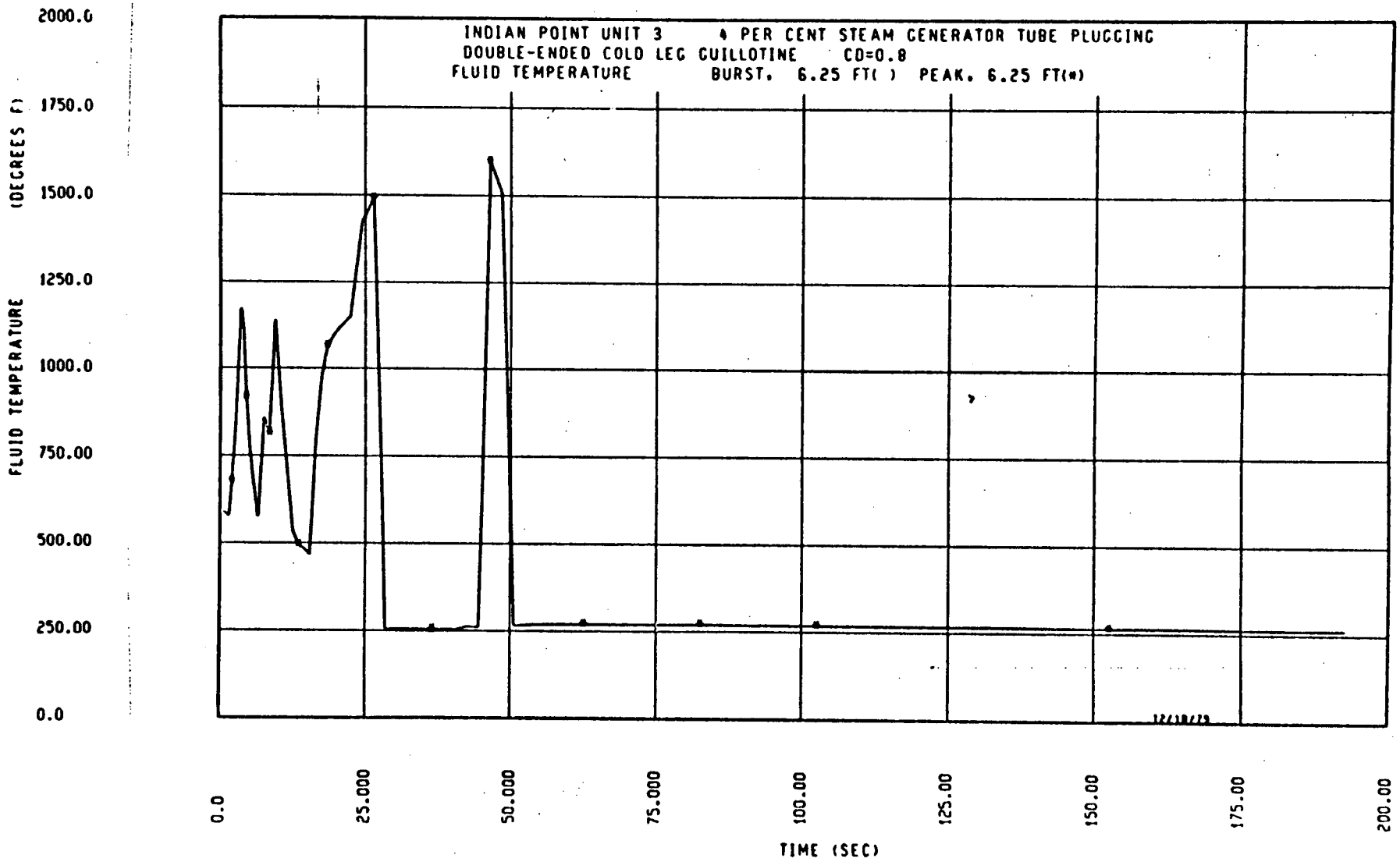
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.8
FLUID TEMPERATURE BURST. 6.25 FT( ) PEAK. 6.25 FT(*)
FLUID TEMPERATURE (DEGREES F)
2000.0
1750.0
1500.0
1250.0
1000.0
750.00
500.00
250.00
0.0
0.0
25.000
50.000
75.000
100.00
125.00
150.00
175.00
200.00
TIME (SEC)

FIG. 8B

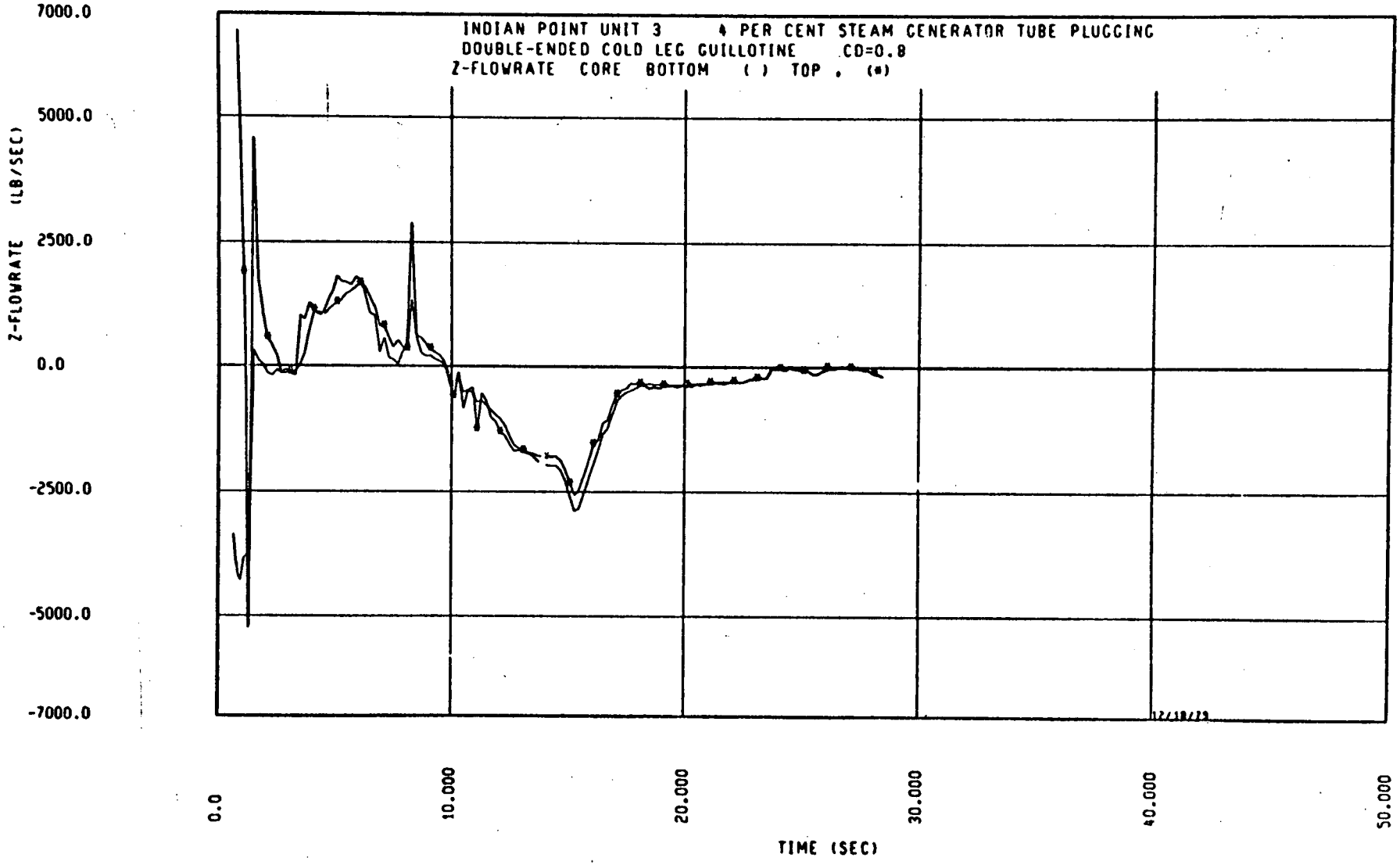
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.8
Z-FLOWRATE CORE BOTTOM ( ) TOP . (*)
7000.0
5000.0
2500.0
0.0
-2500.0
-5000.0
-7000.0
Z-FLOWRATE (LB/SEC)
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 9B

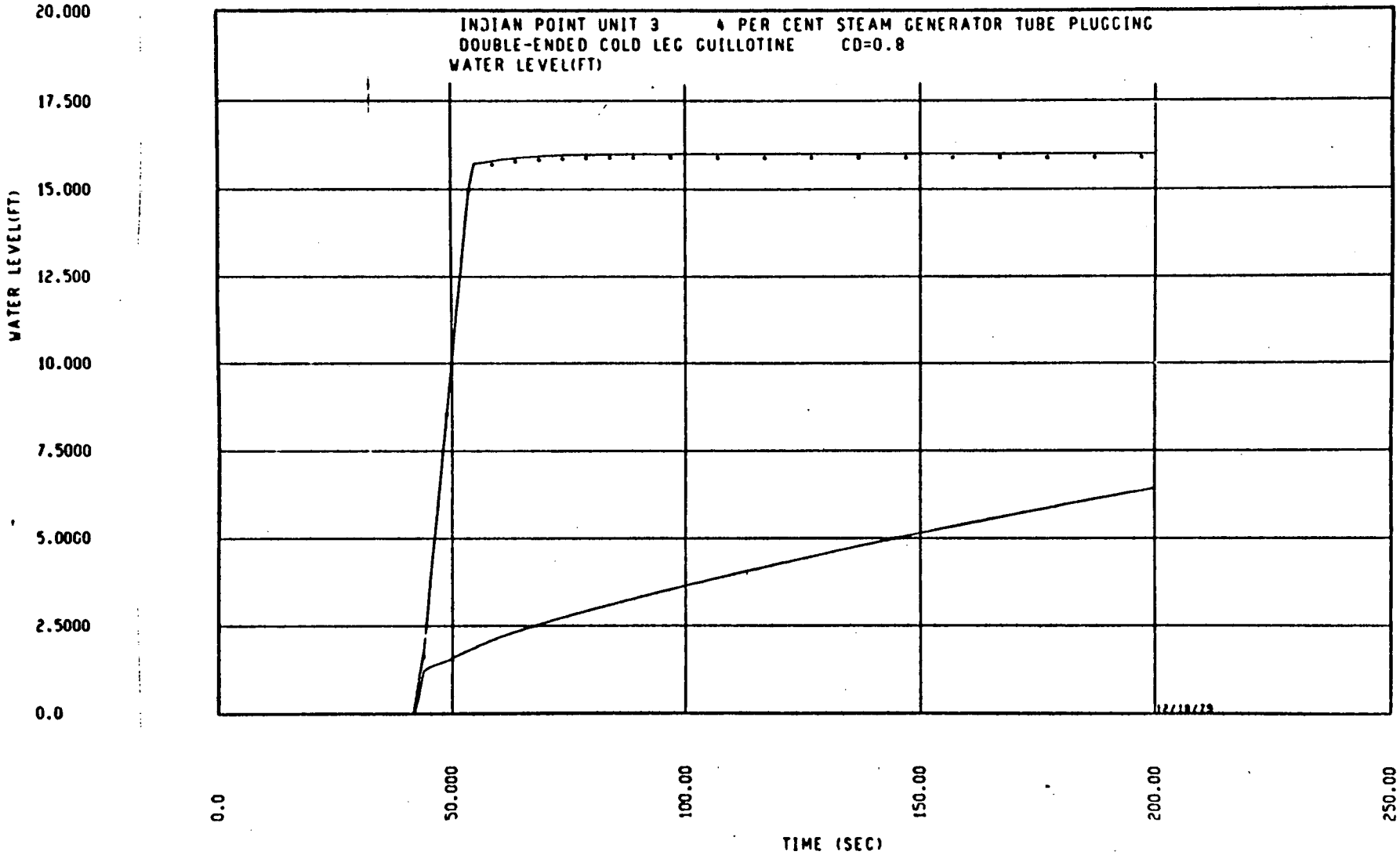
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.8
WATER LEVEL(FT)
20.000
17.500
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0
WATER LEVEL(FT)
0.0
50.000
100.00
150.00
200.00
250.00
TIME (SEC)

FIG. 10B

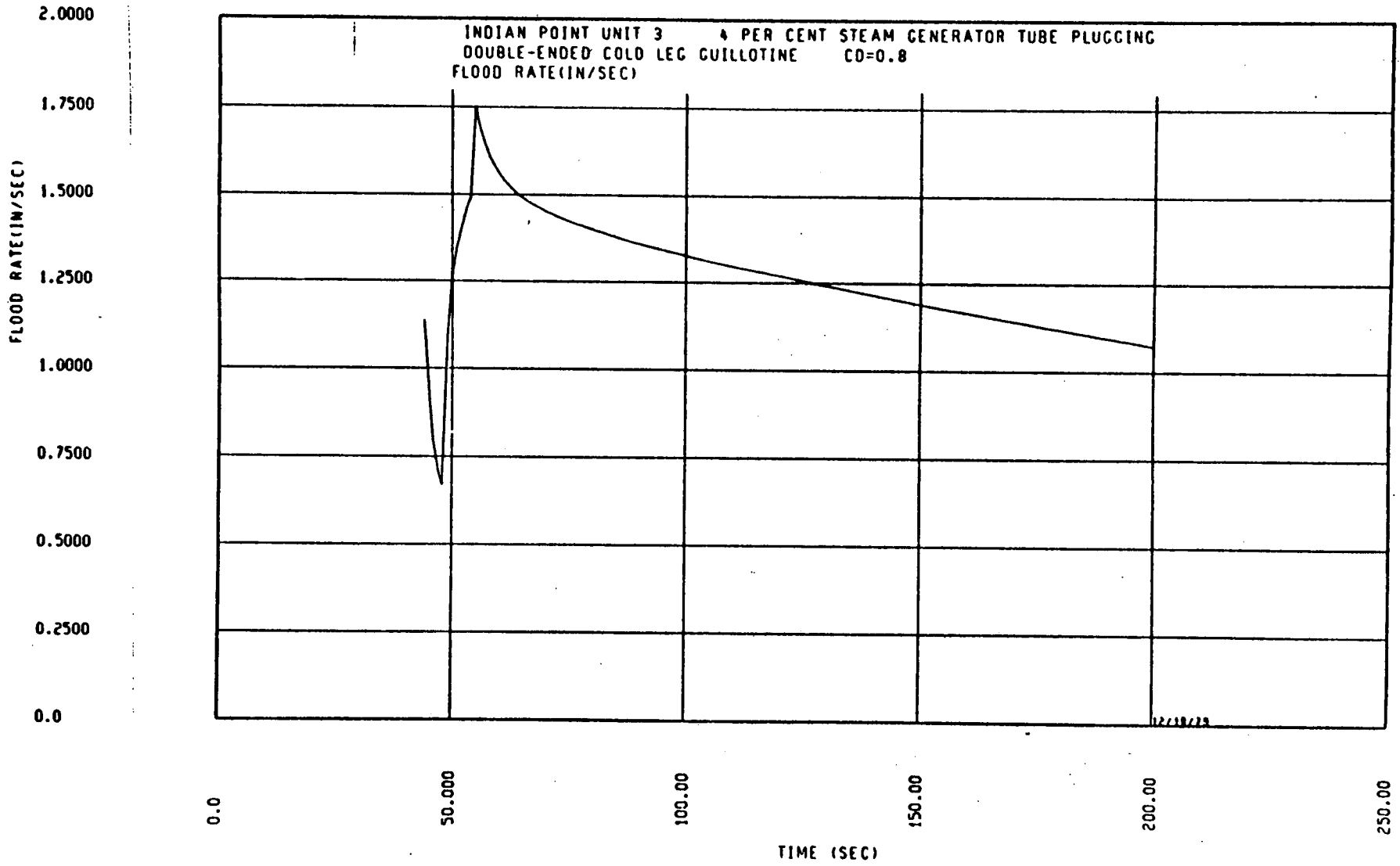
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.8
FLOOD RATE(IN/SEC)
2.0000
1.7500
1.5000
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
FLOOD RATE(IN/SEC)
0.0
50.000
100.00
150.00
200.00
250.00
TIME (SEC)

FIG. 11B

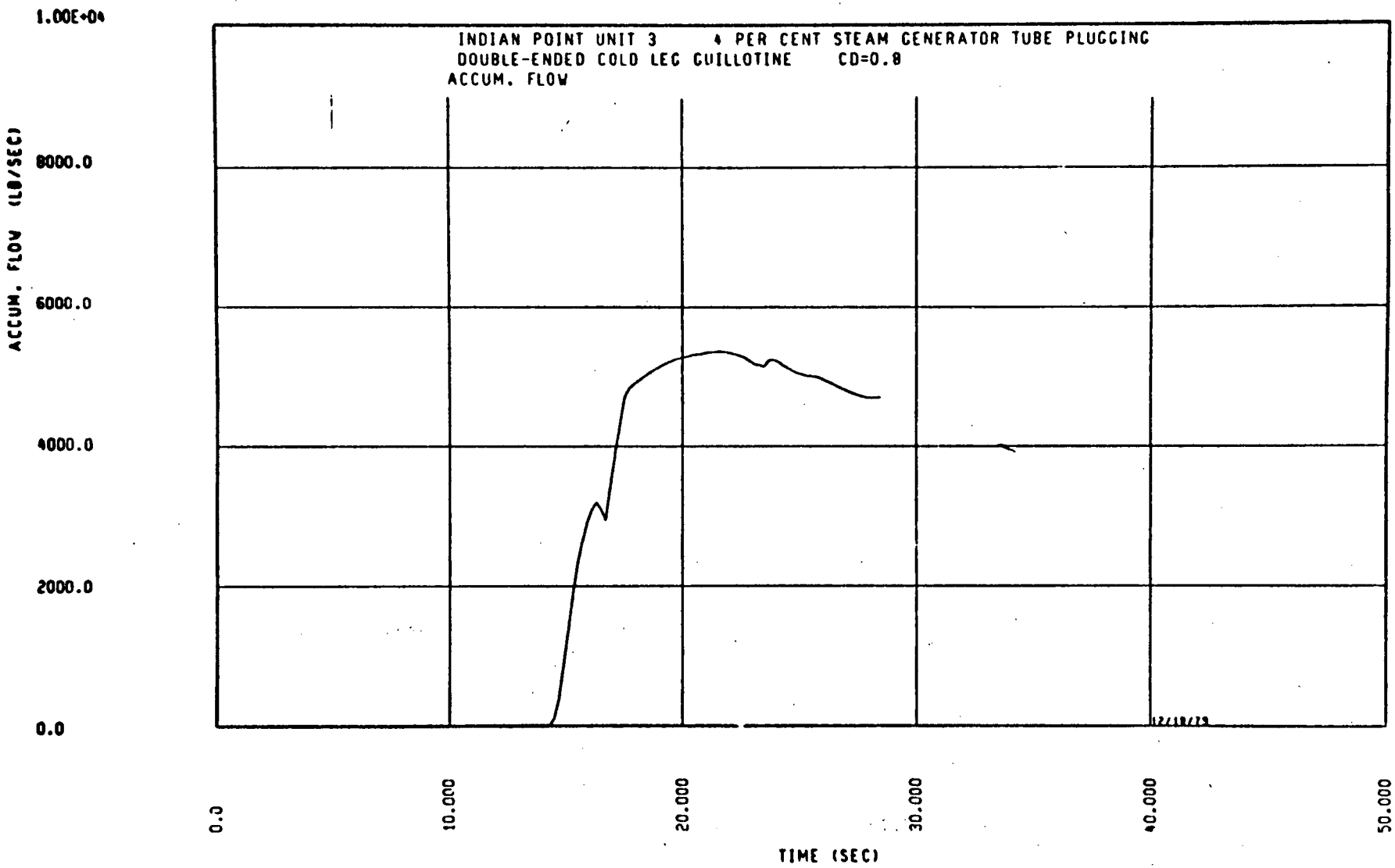
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.8
ACCUM. FLOW
ACCUM. FLOW (LB/SEC)
1.00E+04
8000.0
6000.0
4000.0
2000.0
0.0
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)
12/18/79

FIG. 12B

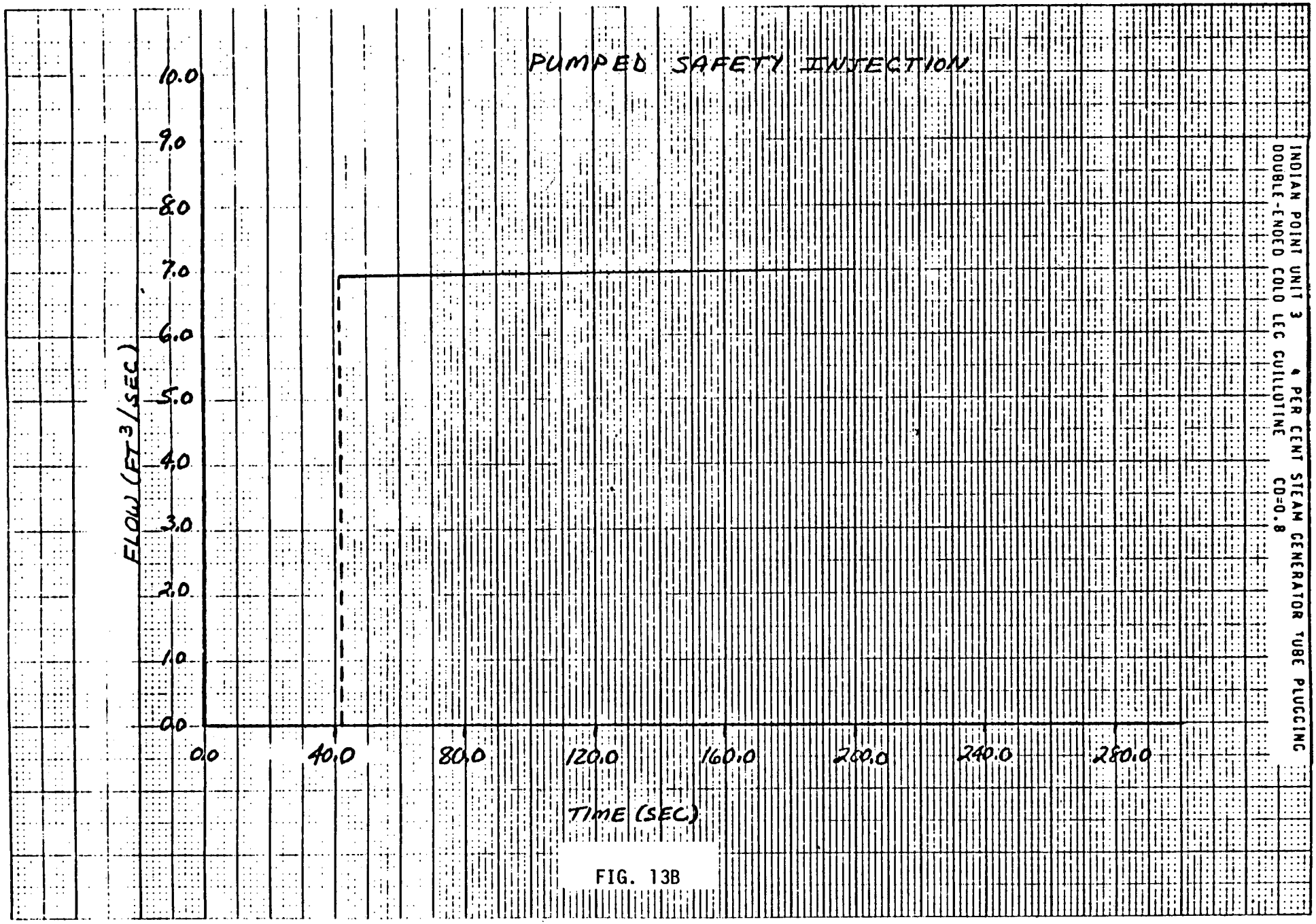
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.8
PUMPED SAFETY INJECTION
FLOW (FT³/SEC)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.0
40.0
80.0
120.0
160.0
200.0
240.0
280.0
TIME (SEC)

FIG. 13B

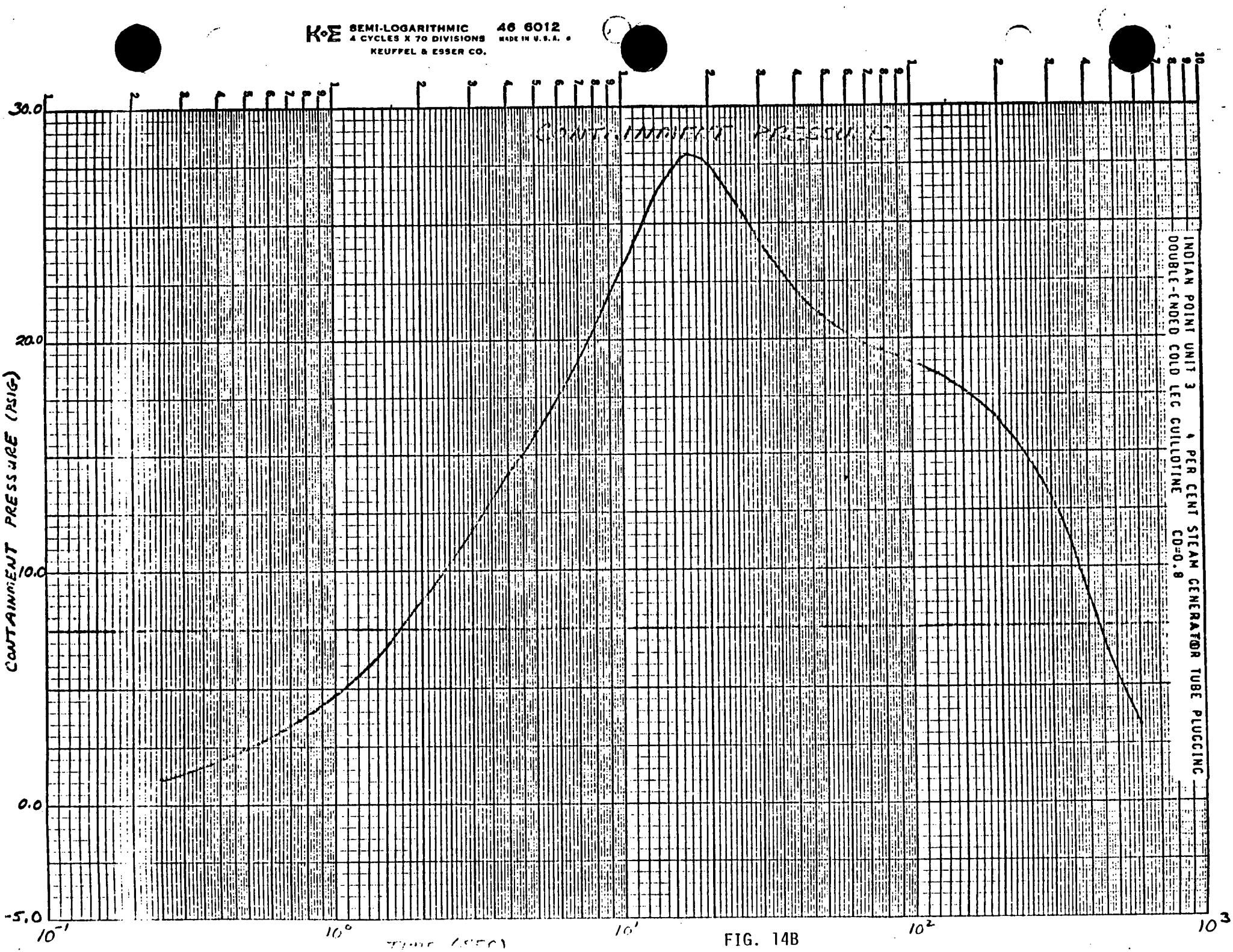
K+E SEMI-LOGARITHMIC 46 6012
4 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.8
CONTAINMENT PRESSURE
CONTAINMENT PRESSURE (PSIG)
30.0
20.0
10.0
0.0
-5.0
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
TIME (SEC)

FIG. 14B

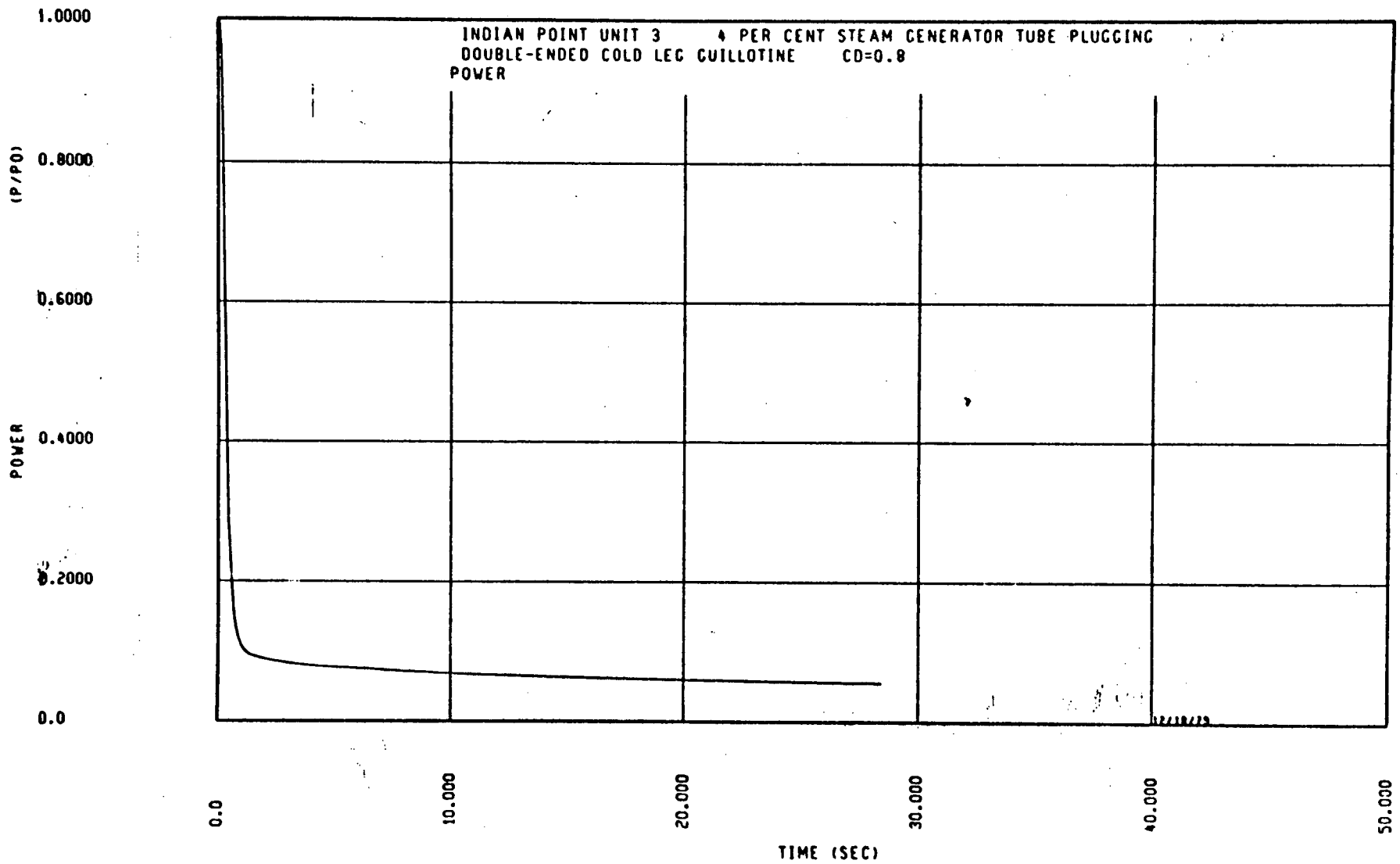
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.8
POWER
POWER (P/PO)
1.0000
0.8000
0.6000
0.4000
0.2000
0.0
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 15B

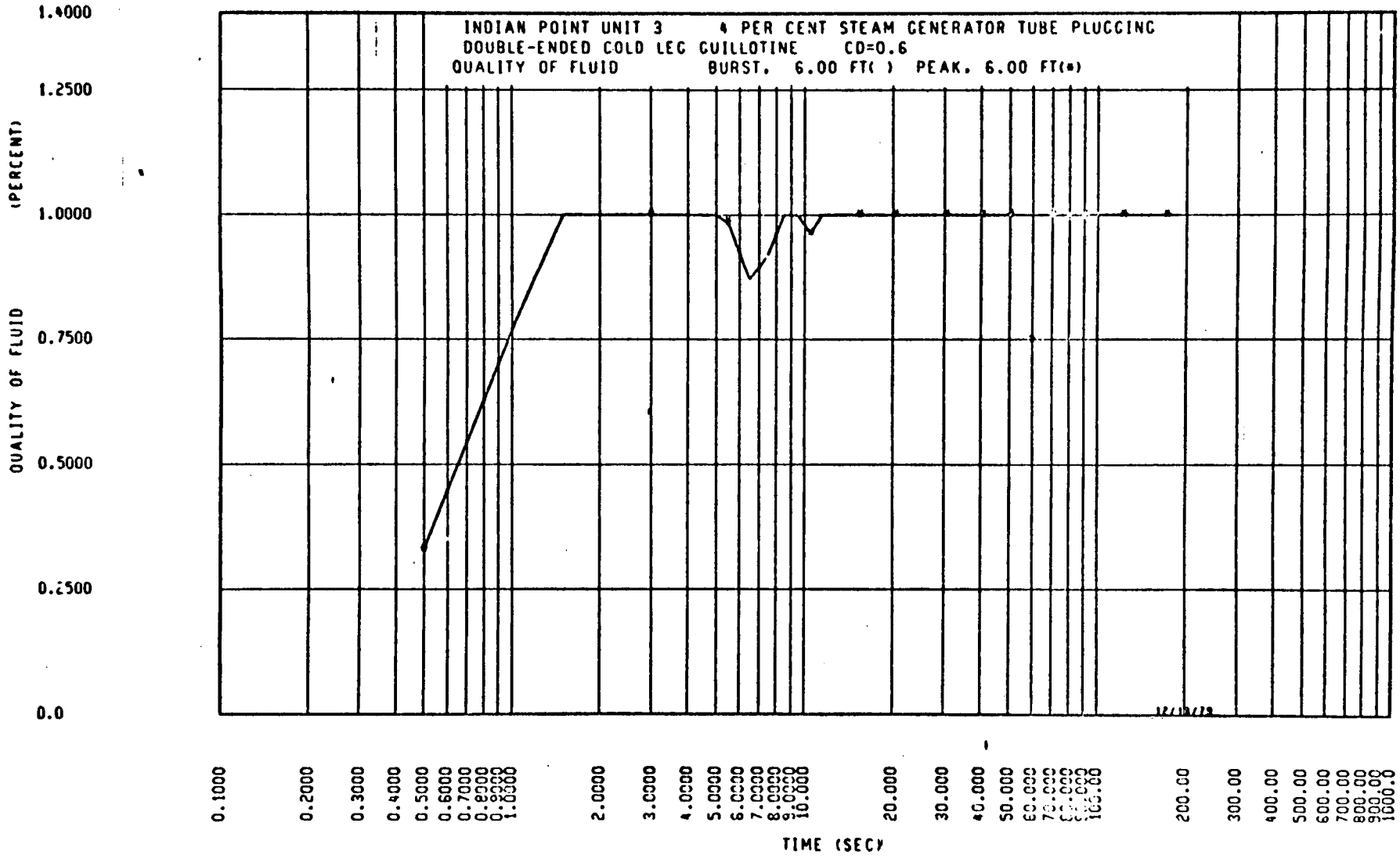
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.6
QUALITY OF FLUID BURST. 6.00 FT( ) PEAK. 6.00 FT(*)
QUALITY OF FLUID (PERCENT)
1.4000
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
0.1000
0.2000
0.3000
0.4000
0.5000
0.6000
0.7000
0.8000
0.9000
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
20.000
30.000
40.000
50.000
60.000
70.000
80.000
90.000
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

FIG. 1C

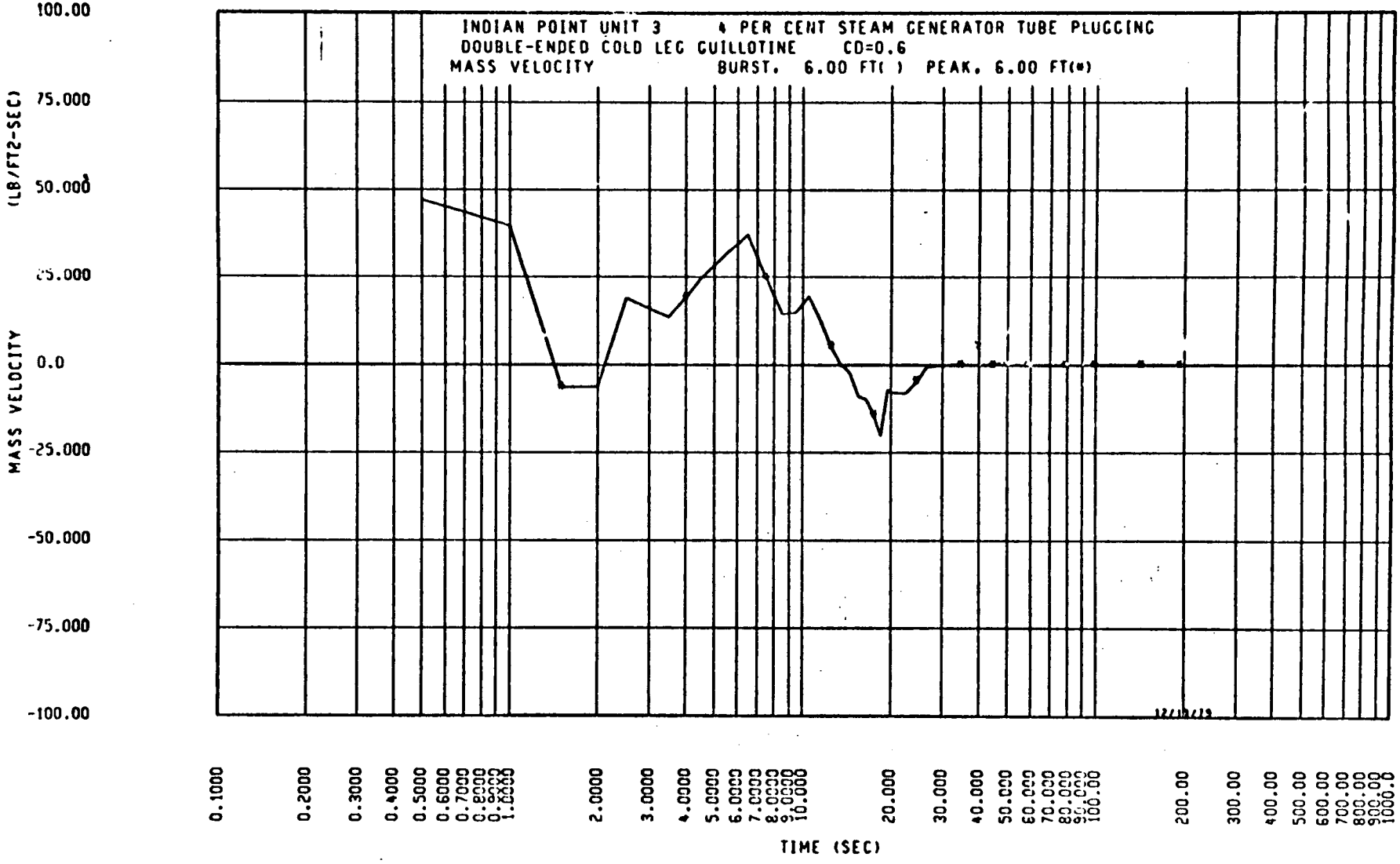
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.6
MASS VELOCITY BURST. 6.00 FT( ) PEAK. 6.00 FT(*)
MASS VELOCITY (LB/FT2-SEC)
100.00
75.000
50.000
25.000
0.0
-25.000
-50.000
-75.000
-100.00
TIME (SEC)
0.1000
0.2000
0.3000
0.4000
0.5000
0.6000
0.7000
0.8000
0.9000
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
20.000
30.000
40.000
50.000
60.000
70.000
80.000
90.000
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0

FIG. 2C

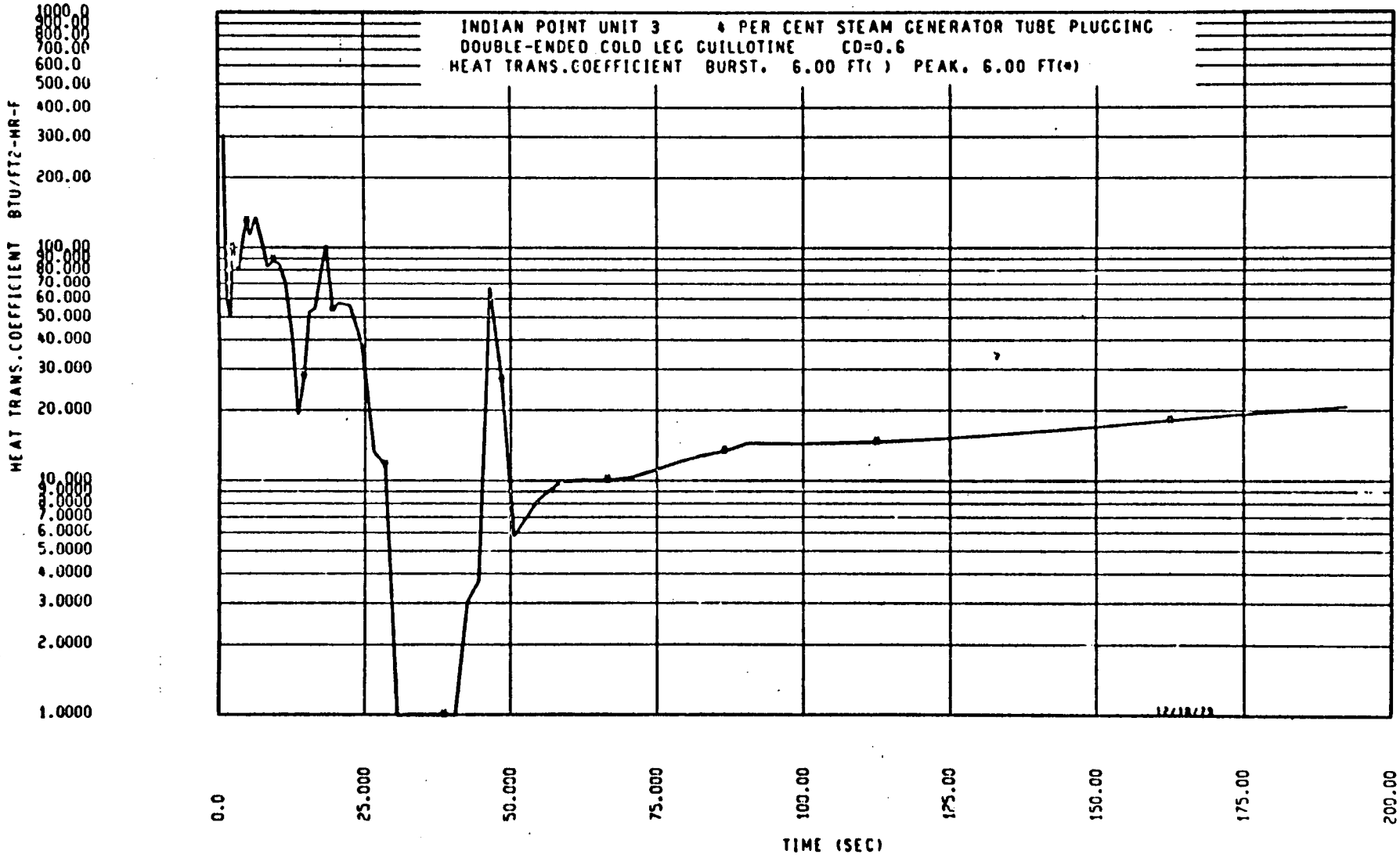
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.6
HEAT TRANS.COEFFICIENT BURST. 6.00 FT( ) PEAK. 6.00 FT(*)
HEAT TRANS.COEFFICIENT BTU/FT2-HR-F
1000.0
900.00
800.00
700.00
600.0
500.00
400.00
300.00
200.00
100.00
90.000
80.000
70.000
60.000
50.000
40.000
30.000
20.000
10.000
9.0000
8.0000
7.0000
6.0000
5.0000
4.0000
3.0000
2.0000
1.0000
0.0
25.000
50.000
75.000
100.00
125.00
150.00
175.00
200.00
TIME (SEC)

FIG. 3C

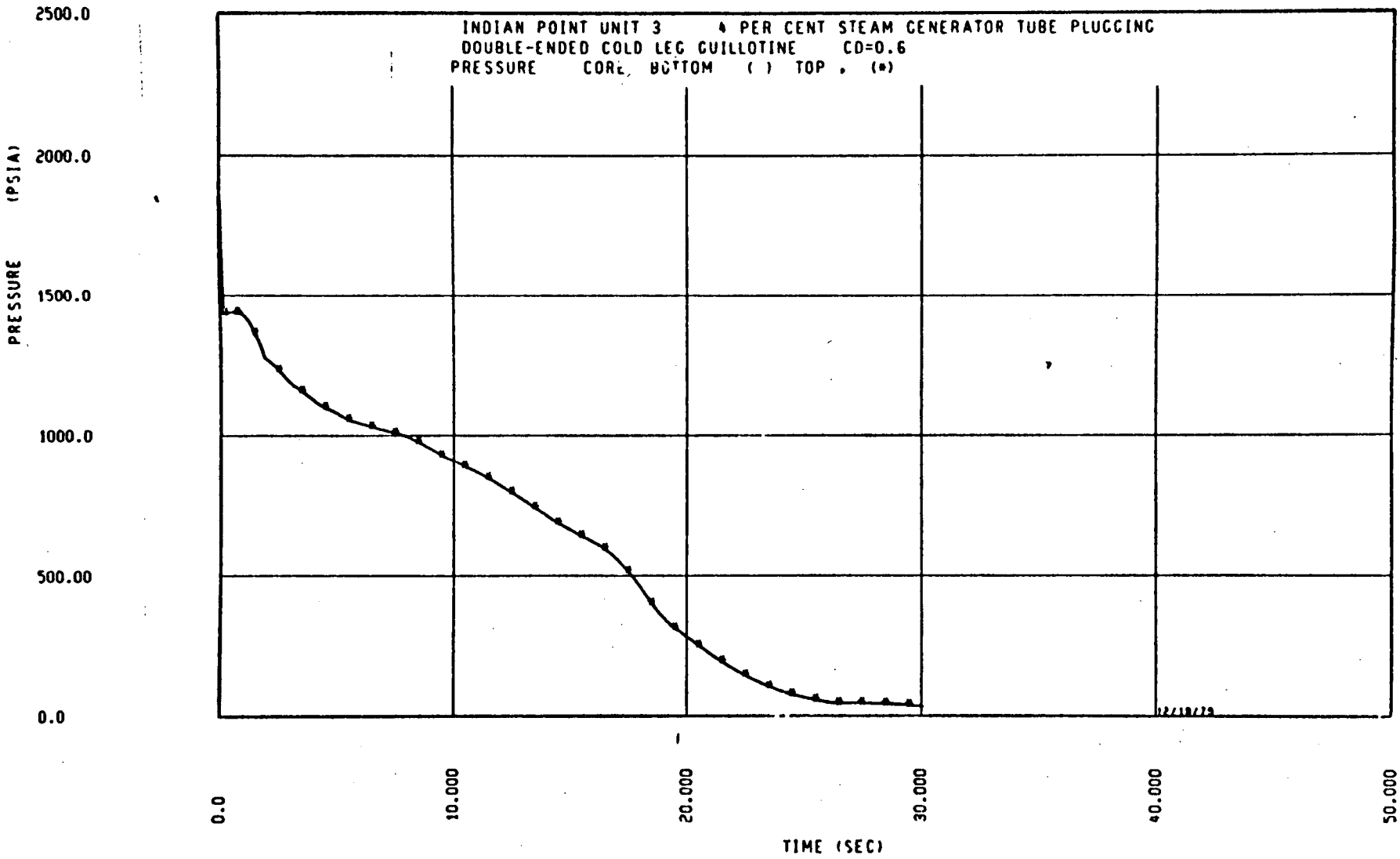
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.6
PRESSURE CORE BOTTOM ( ) TOP , (*)
PRESSURE (PSIA)
2500.0
2000.0
1500.0
1000.0
500.00
0.0
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 4C

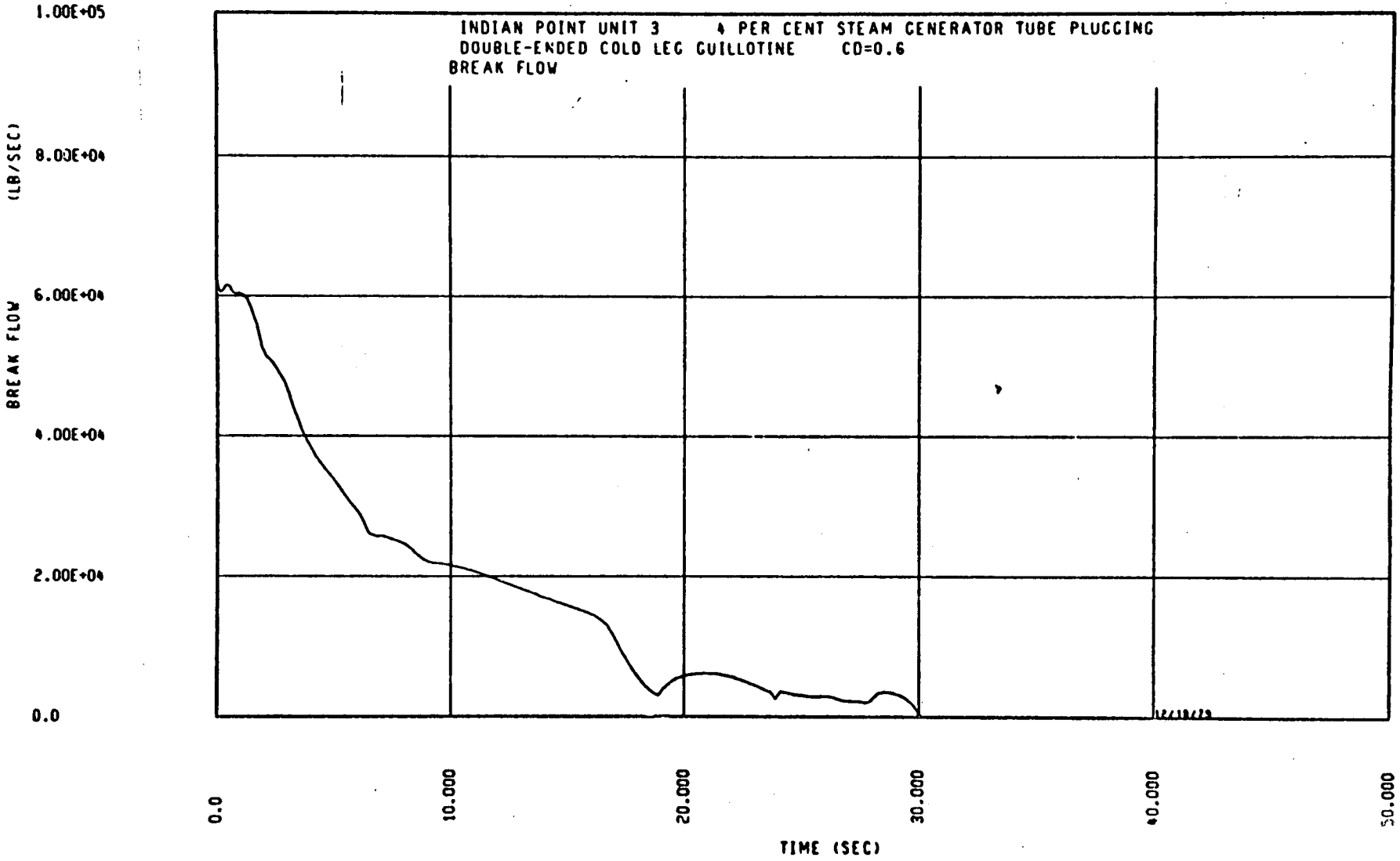
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.6
BREAK FLOW
BREAK FLOW (LB/SEC)
1.00E+05
8.00E+04
6.00E+04
4.00E+04
2.00E+04
0.0
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 5C

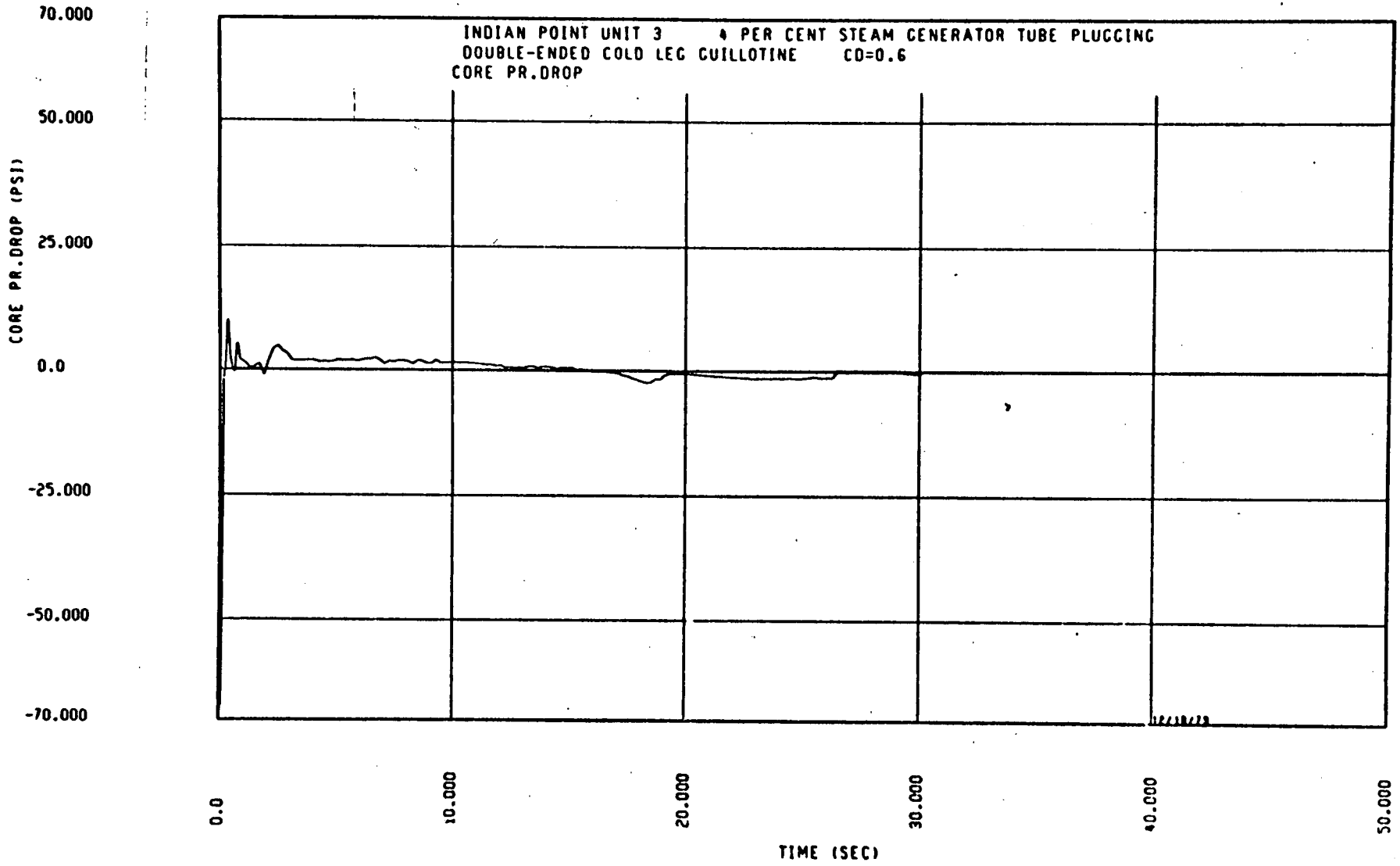
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.6
CORE PR.DROP
70.000
50.000
25.000
0.0
-25.000
-50.000
-70.000
CORE PR.DROP (PSI)
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 6C

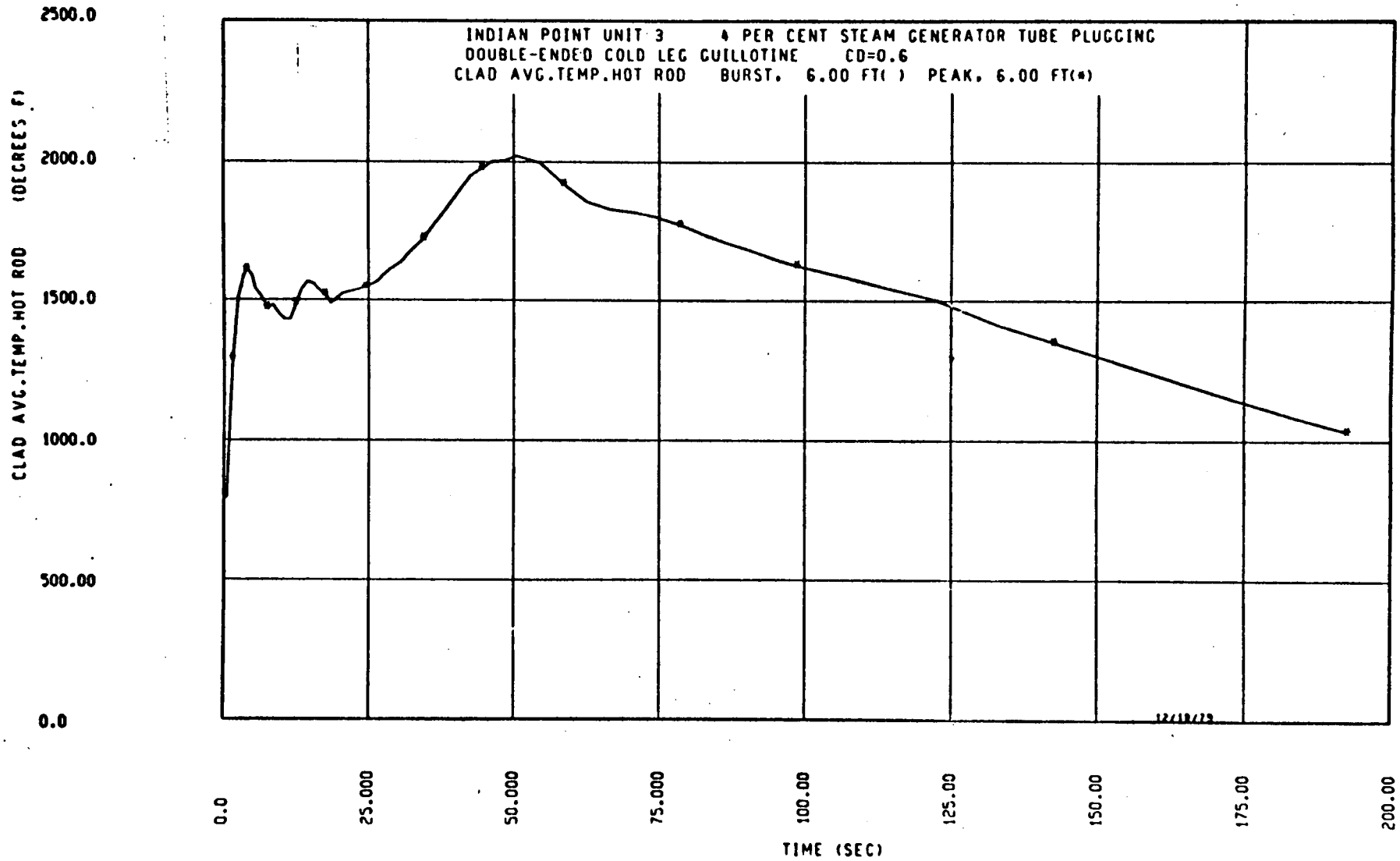
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.6
CLAD AVG.TEMP.HOT ROD BURST, 6.00 FT( ) PEAK, 6.00 FT(*)
CLAD AVG.TEMP.HOT ROD (DEGREES F)
2500.0
2000.0
1500.0
1000.0
500.00
0.0
0.0
25.000
50.000
75.000
100.00
125.00
150.00
175.00
200.00
TIME (SEC)

FIG. 7C

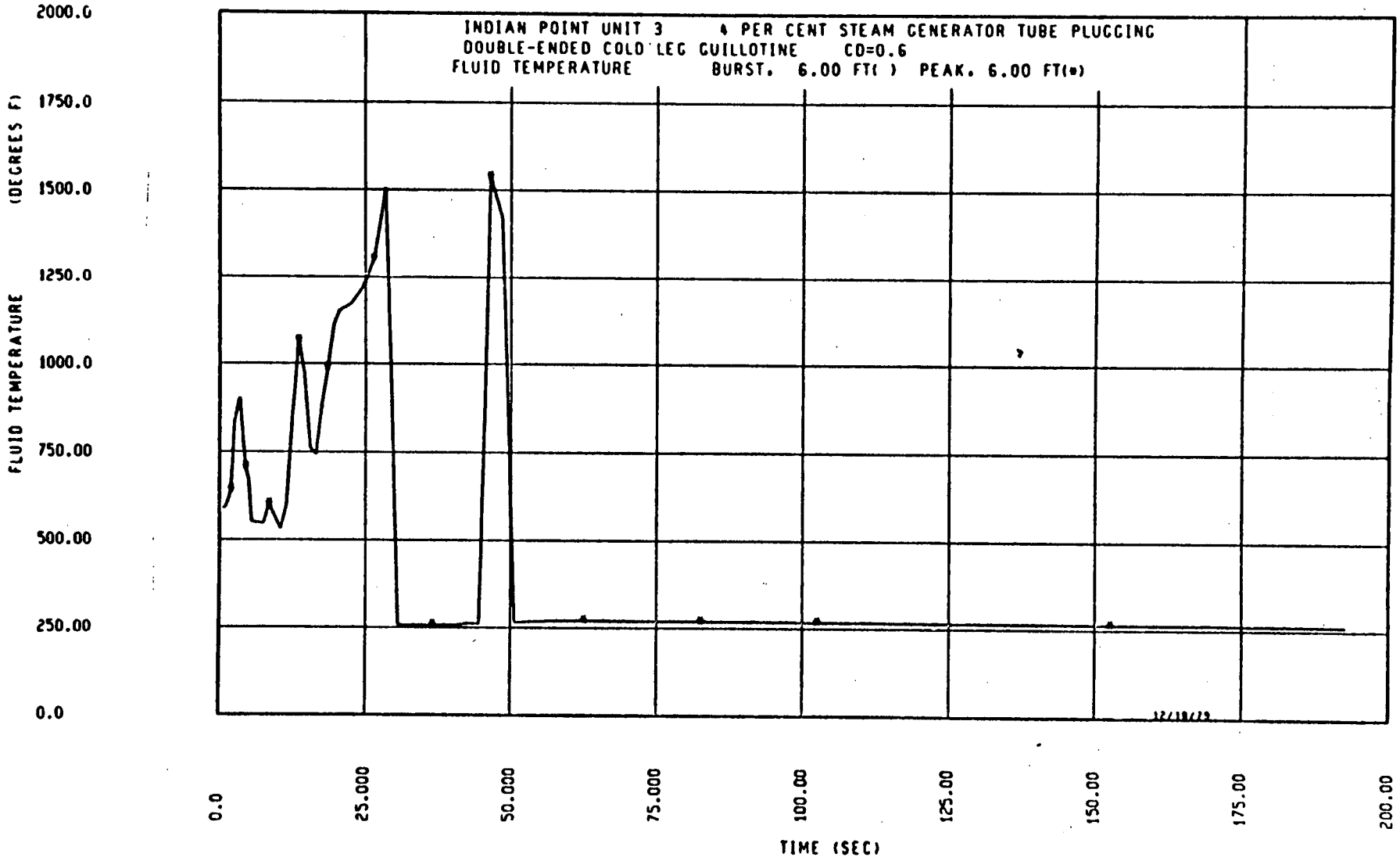
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.6
FLUID TEMPERATURE BURST. 6.00 FT( ) PEAK. 6.00 FT(*)
FLUID TEMPERATURE (DEGREES F)
2000.0
1750.0
1500.0
1250.0
1000.0
750.00
500.00
250.00
0.0
0.0
25.000
50.000
75.000
100.00
125.00
150.00
175.00
200.00
TIME (SEC)

FIG. 8C

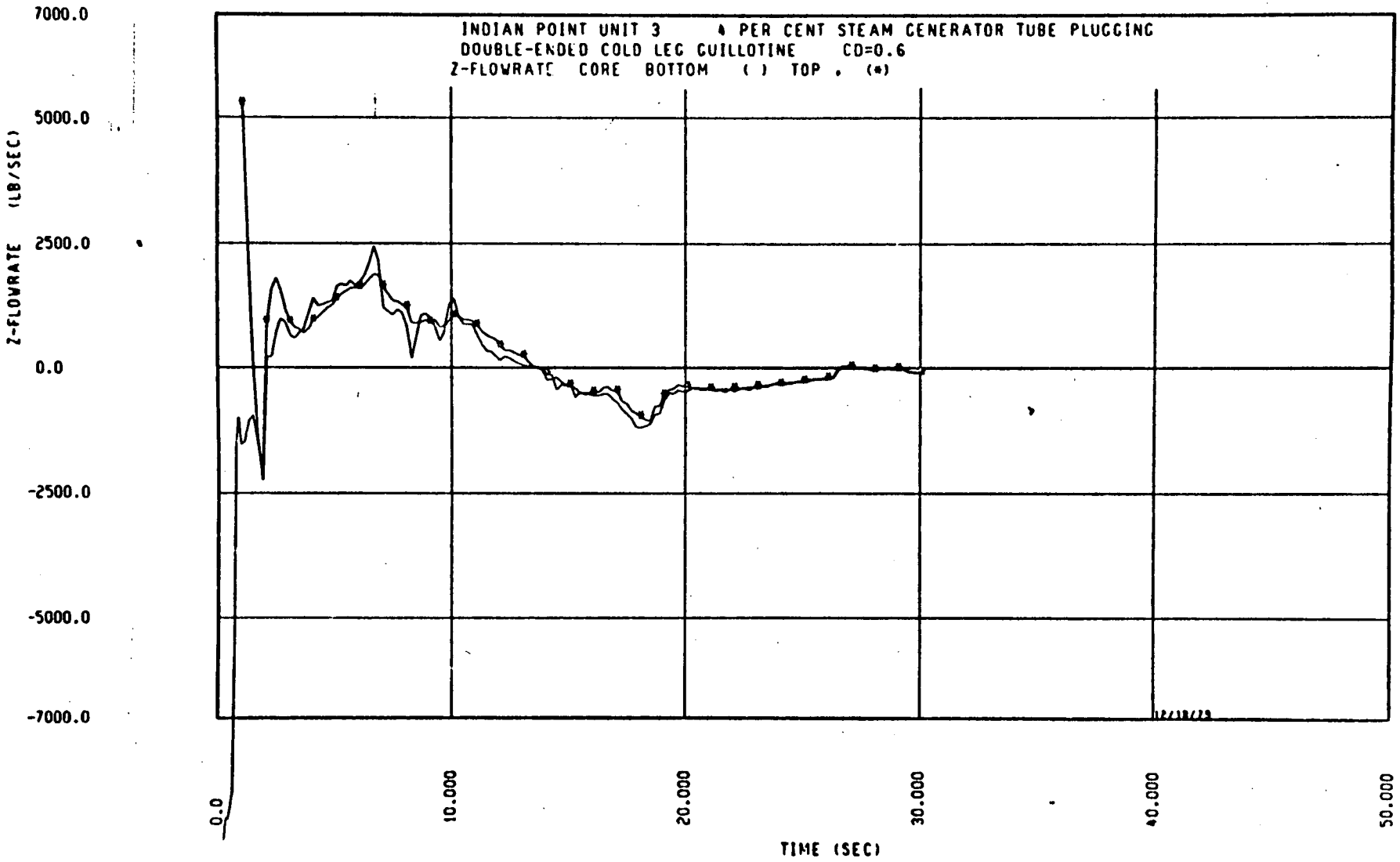
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.6
Z-FLOWRATE CORE BOTTOM ( ) TOP , (*)
Z-FLOWRATE (LB/SEC)
7000.0
5000.0
2500.0
0.0
-2500.0
-5000.0
-7000.0
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 9C

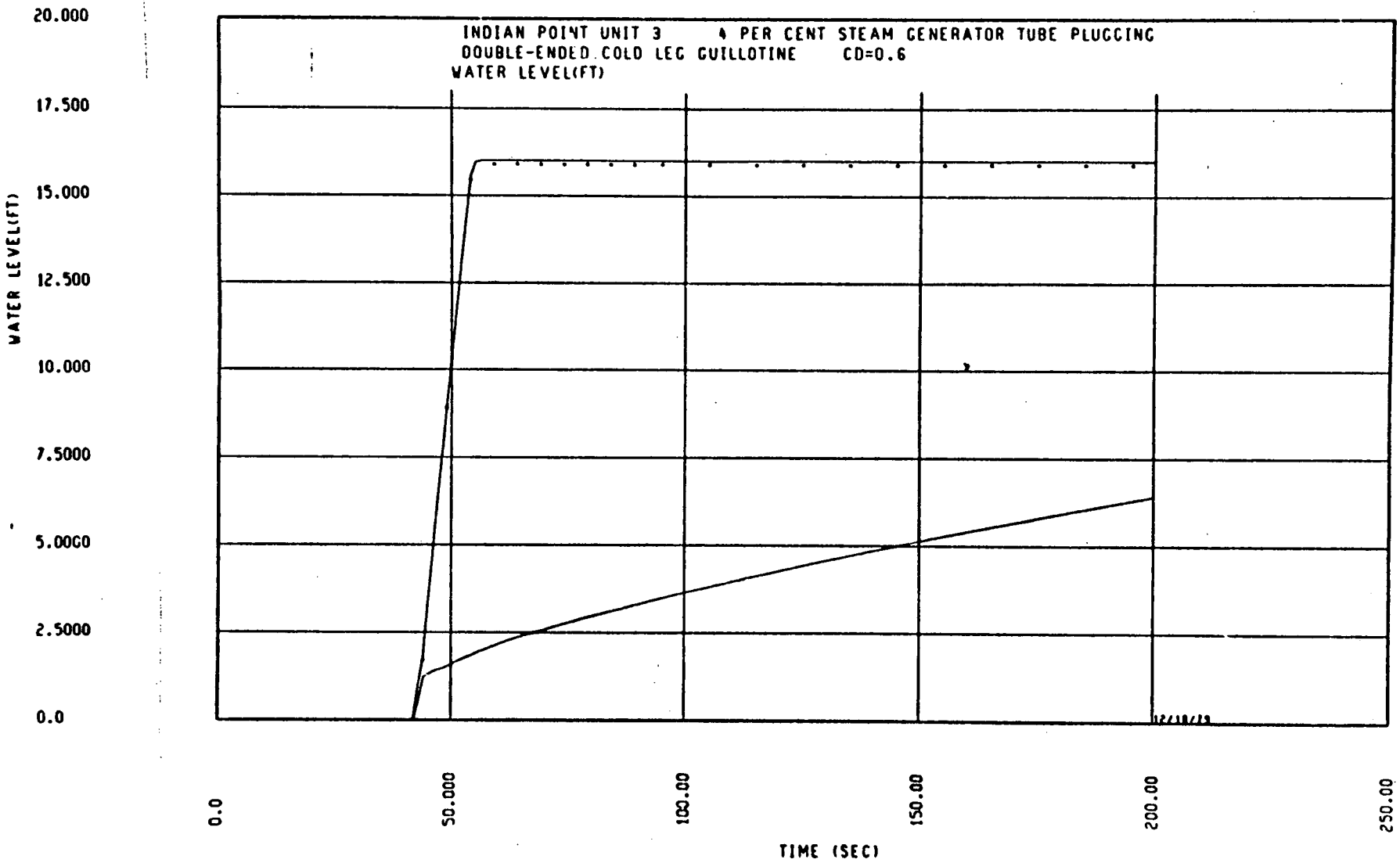
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.6
WATER LEVEL(FT)
20.000
17.500
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0
WATER LEVEL(FT)
0.0
50.000
100.00
150.00
200.00
250.00
TIME (SEC)

FIG. 10C

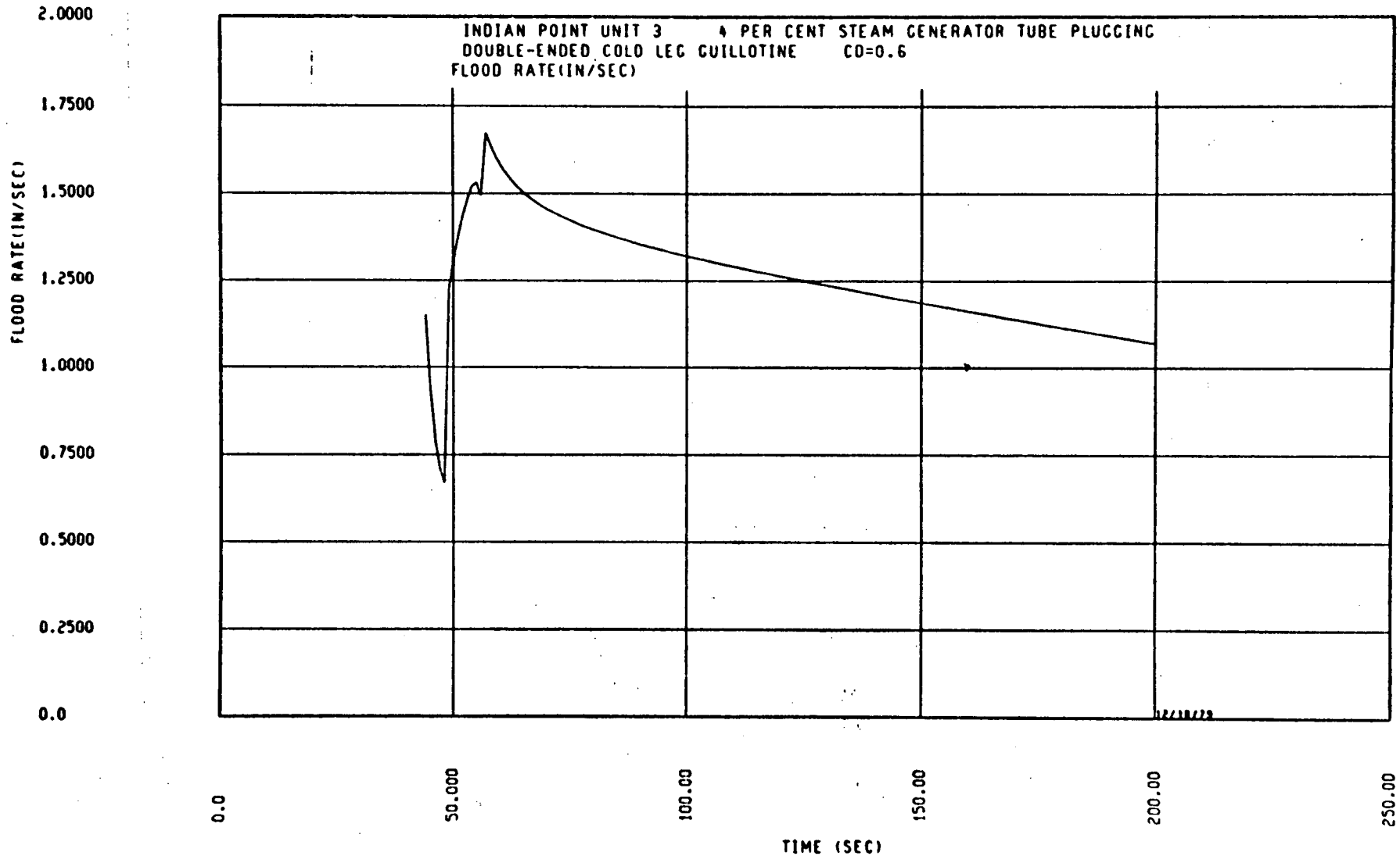
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.6
FLOOD RATE(IN/SEC)
FLOOD RATE(IN/SEC)
2.0000
1.7500
1.5000
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
0.0
50.000
100.00
150.00
200.00
250.00
TIME (SEC)

FIG. 11C

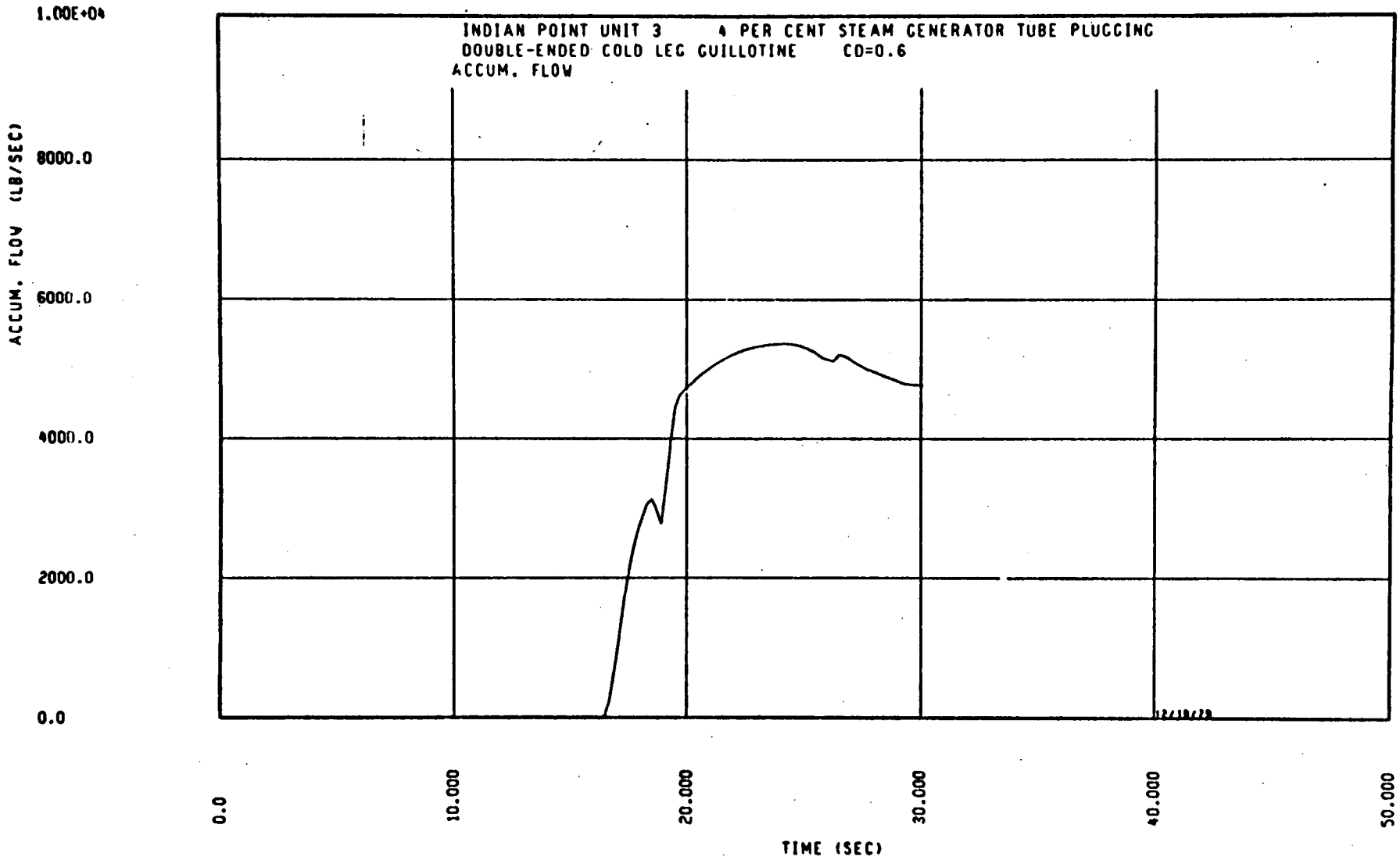
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.6
ACCUM. FLOW
ACCUM. FLOW (LB/SEC)
1.00E+04
8000.0
6000.0
4000.0
2000.0
0.0
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 12C

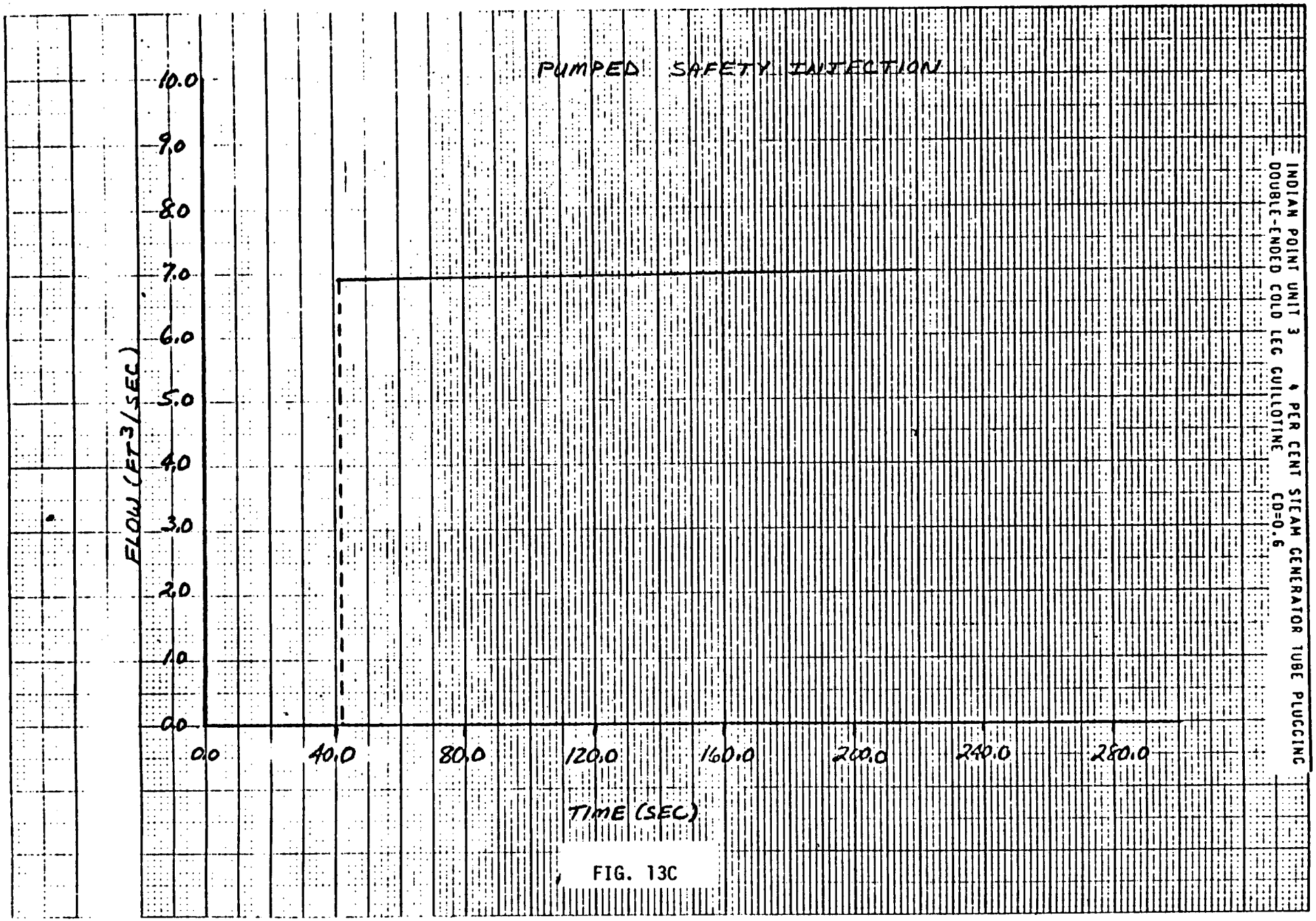
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.6
PUMPED SAFETY INJECTION
FLOW (FT3/SEC)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.0
40.0
80.0
120.0
160.0
200.0
240.0
280.0
TIME (SEC)

FIG. 13C

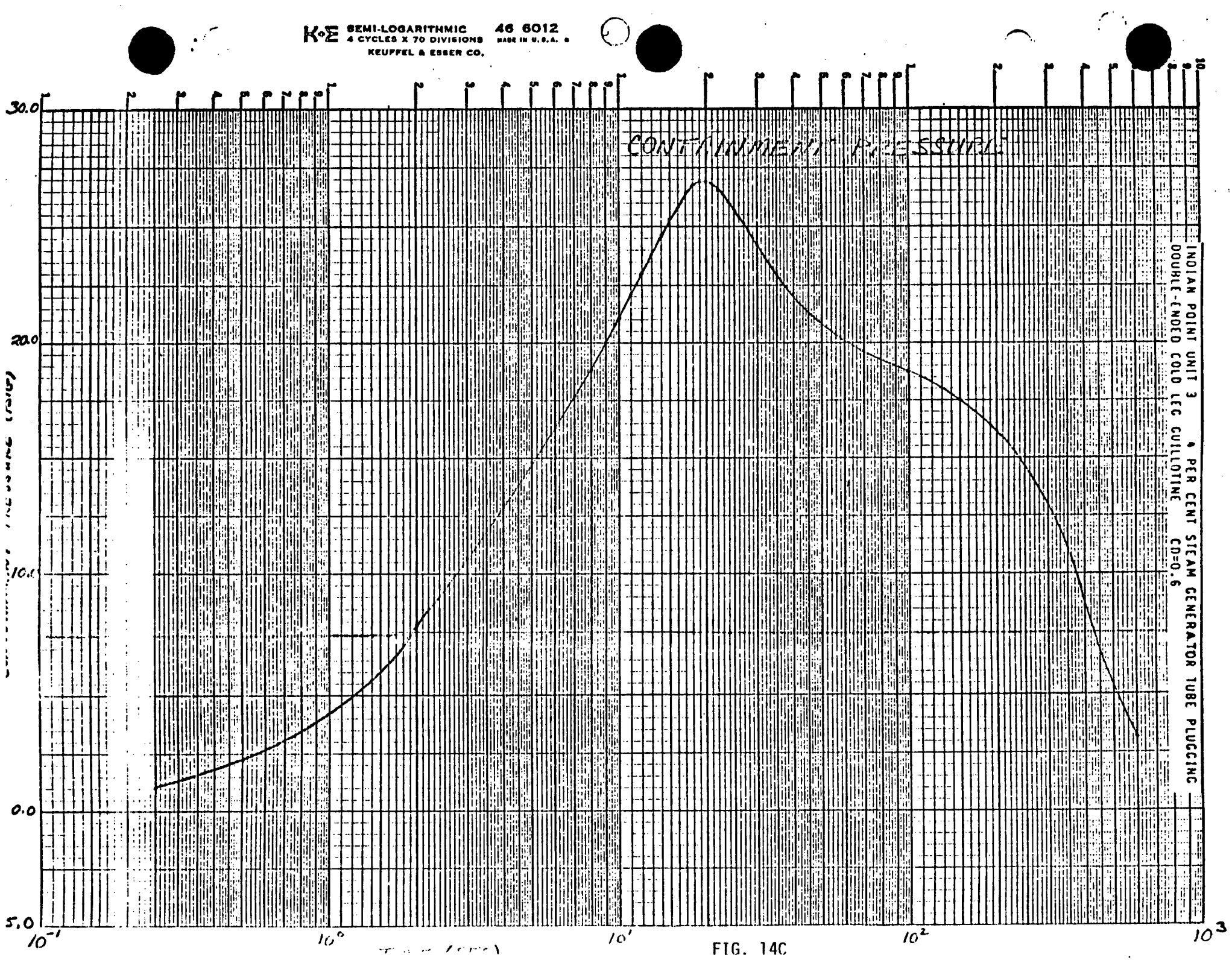
K+E SEMI-LOGARITHMIC 46 6012
4 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.6
CONTAINMENT PRESSURE
30.0
20.0
10.0
0.0
5.0
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}

FIG. 14C

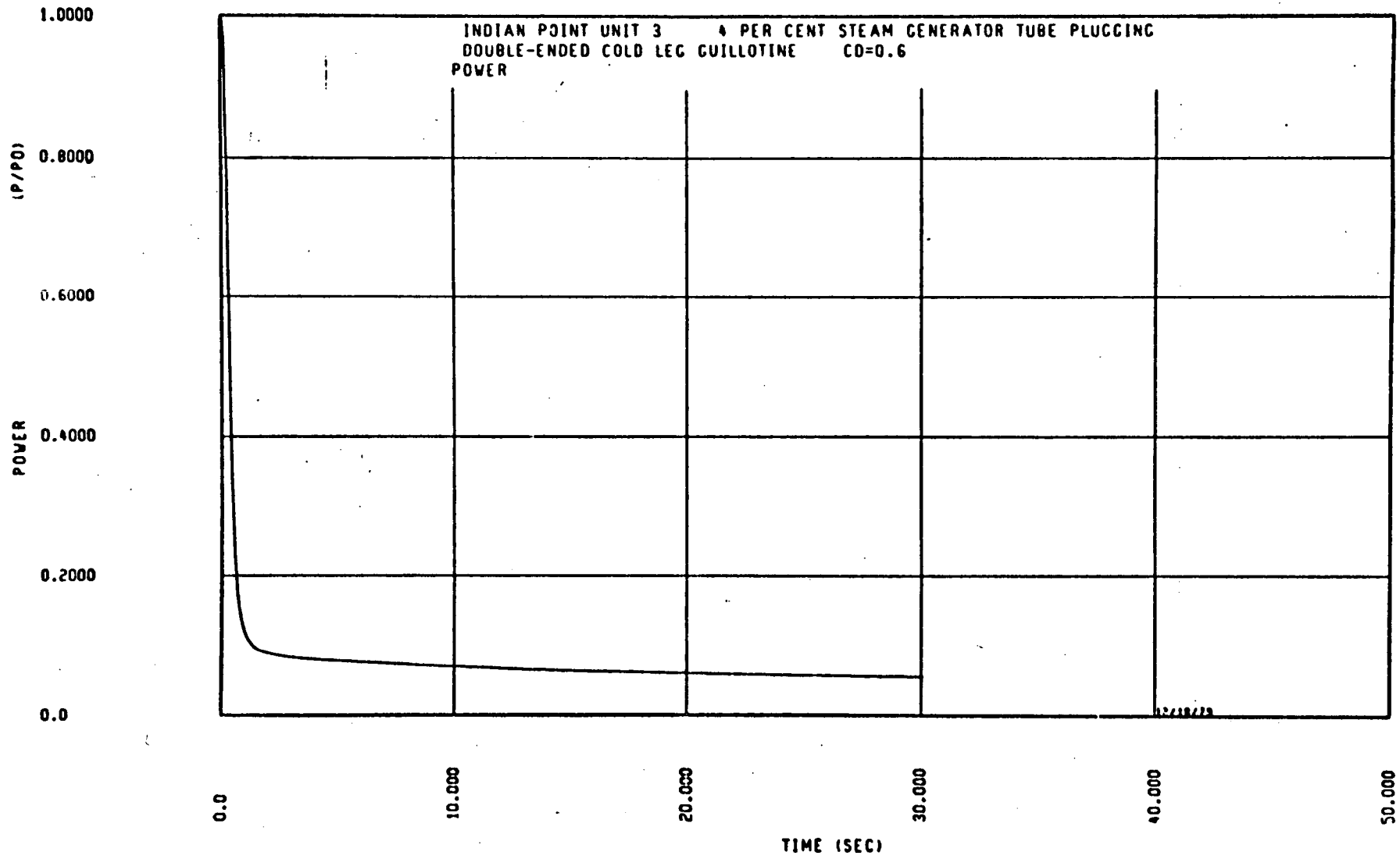
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=0.6
POWER
POWER (P/PO)
1.0000
0.8000
0.6000
0.4000
0.2000
0.0
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 15C

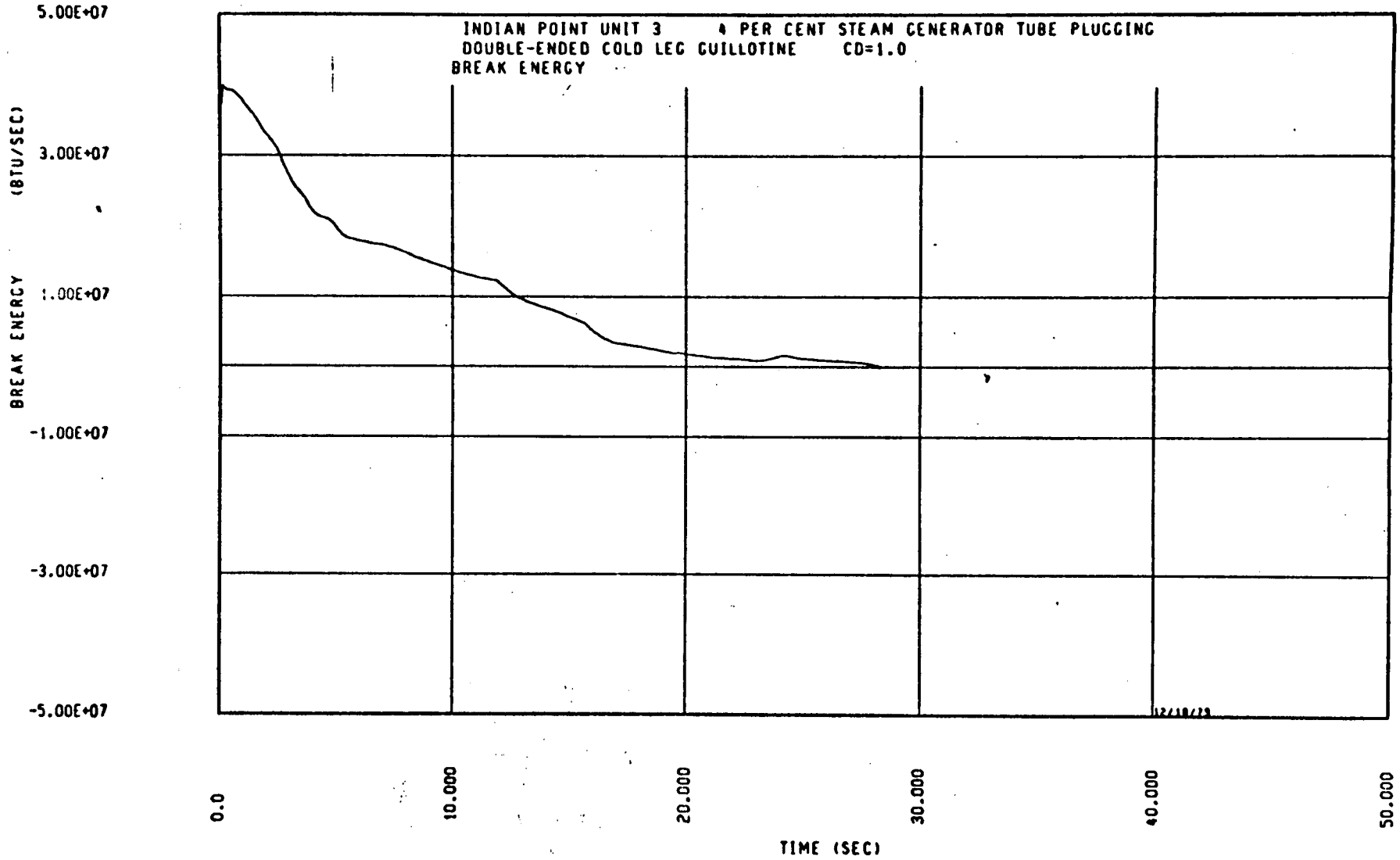
INDIAN POINT UNIT 3 4 PER CENT STEAM GENERATOR TUBE PLUGGING
DOUBLE-ENDED COLD LEG GUILLOTINE CD=1.0
BREAK ENERGY
5.00E+07
3.00E+07
1.00E+07
-1.00E+07
-3.00E+07
-5.00E+07
BREAK ENERGY (BTU/SEC)
0.0
10.000
20.000
30.000
40.000
50.000
TIME (SEC)

FIG. 16

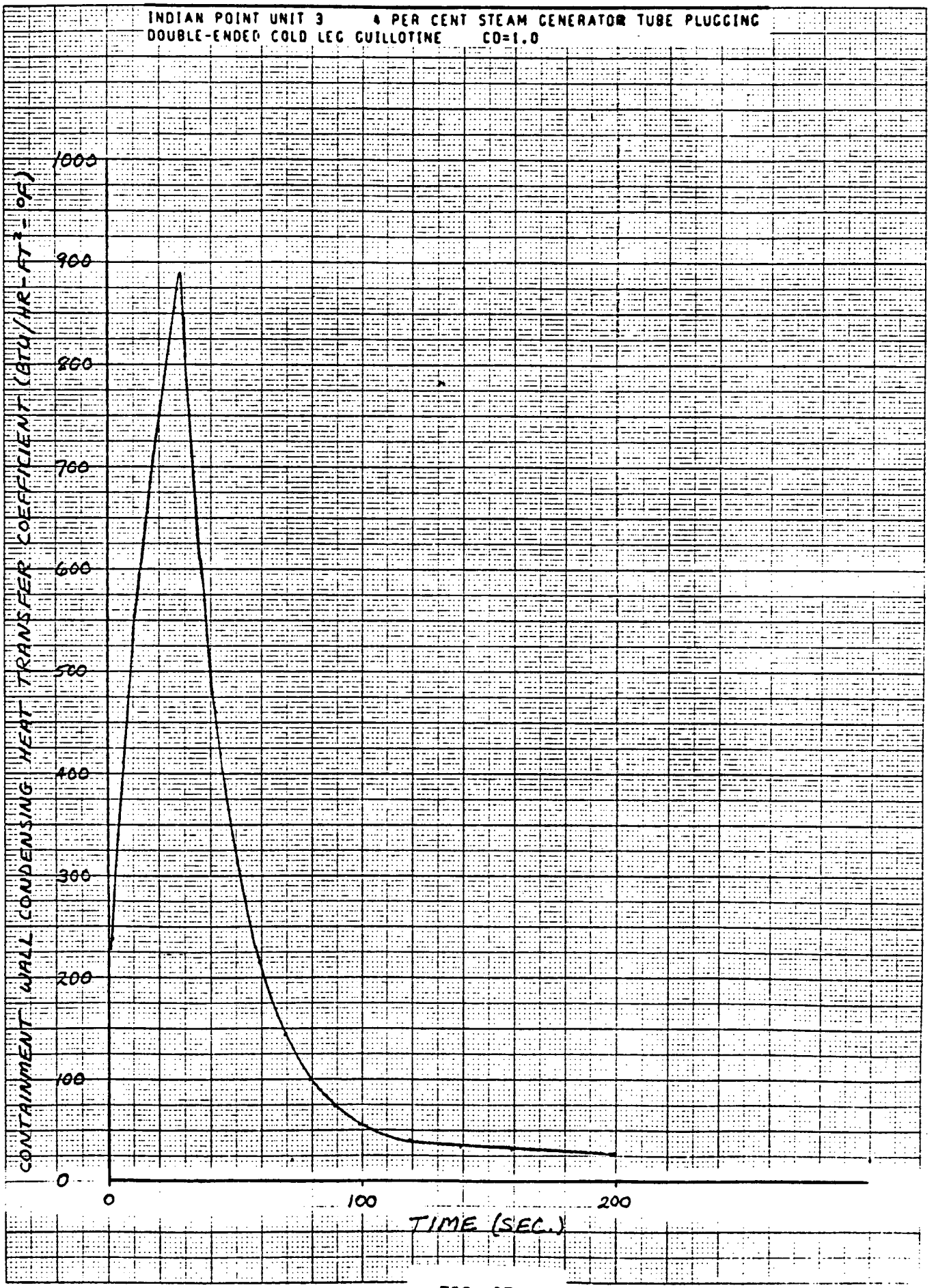

FIG. 17

461510
K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.