TECHNICAL REPORT TR-5364-1
REVISION 0

BOOK 1 OF 15

DONALD C. COOK NUCLEAR GENERATING PLANT

ANALYSIS OF PRESSURIZER SAFETY/RELIEF VALVES DISCHARGE PIPING SYSTEM PER NUREG 0737, ILD.1, UNIT 1

JUNE 6, 1983

AMERICAN ELECTRIC POWER SERVICE CORPORATION
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NEW YORK, NEW YORK 10004

TECHNICAL REPORT TR-5364-1
REVISION 0

BOOK 1 OF 15

DONALD C. COOK NUCLEAR GENERATING STATION

ANALYSIS OF PRESSURIZER SAFETY/RELIEF VALVES DISCHARGE PIPING SYSTEM PER NUREG 0737, II. D.1, UNIT 1

JUNE 6, 1983

TELEDYNE ENGINEERING SERVICES

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TELEDYNE ENGINEERING SERVICES

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1.0 INTRODUCTION

American Electric Power Service Corporation (AEP), purchase order number 02676-820-1N, authorized Teledyne Engineering Services (TES) to analyze the Pressurizer Safety/Relief Valve Discharge Piping per NRC NUREG-0737, Item II. D.1 for the Donald C. Cook Nuclear Power Plant, Unit #1.

This activity was performed in accordance with the TES Quality Assurance program which meets the requirements of 10CFR50, Appendix B, and ANSI N45.2.11 as interpreted by Regulatory Guide 1.64, Revision 2.

The scope of work for this effort is described in detail in Teledyne Engineering Services Technical Proposal PR-5653 (Reference 1), dated May 4, 1981 and modified as stated in AEP letter dated November 29, 1982, from Mr. Sam Ulan (AEP) to Mr. L. B. Semprucci (TES) and in AEP letter from Mr. Sam Ulan (AEP) to Mr. P. D. Harrison (TES) dated March 15, 1983 (References 2 and 3).

The majority of the analysis was performed after the receipt of AEP letters dated November 29, 1982 and March 15, 1983 (References 2 and 3), which were issued after more complete information was available from the EPRI data.

This analysis was performed using large digital computer programs supplemented with any necessary hand calculations. The RELAP5 MOD1 Cycle 14 computer program was used to do the thermal fluid transient analysis. The structural analysis, for all loading conditions, was done utilizing the TMRSAP computer program.

The size of the pressurizer safety/relief valve discharge piping system was so large that the computer models, for both RELAP and TMRSAP, strained the limits of the programs. This condition necessitated multiple RELAP runs in order to execute the thermal fluid transient analysis for the appropriate length of time. For the structural analysis it was necessary to expand the core of the TMRSAP program in order to avoid an overconservative overlap analysis.

2.0 CONCLUSIONS

The analysis performed by TES on the Pressurizer Safety/Relief Valve Discharge Piping System indicates that all criteria of NRC NUREG-0737, Item II.D.1 is met for normal and upset (PORV discharge) conditions and is not met for the emergency (SV discharge) condition.

Evaluation of normal and upset conditions required structural analysis for deadweight, thermal, OBE seismic, and PORV transient shock loading conditions. Details of the various loadings considered are provided in Section 5.

Based on preliminary SV thermal hydrodynamic transient analysis, excessive loads and stresses were anticipated and, therefore, it was decided, for economic reasons, that a quarter model SV thermal transient analysis (RELAP5) should be performed to check the adequacy of the system for the emergency condition. In addition, due to the similarities of the Unit 1 and Unit 2 geometries, it was determined that the results of one unit could be considered applicable to the other unit. The quarter model consisted of the piping from the pressurizer, through valve SV-45C, and continuing down to the quench tank, for Unit 2. The SV transient analysis considered only the effect of valve SV-45C opening. The results of the quarter model analysis indicated substantial failure of the entire quarter model geometry. Considering that TES is required to analyze for the simultaneous opening of all three SV valves (Reference 3), which is a more severe loading condition, it is evident that the quarter model analysis is sufficient to prove the failure, for the emergency condition, of both Units 1 and 2. Therefore, this report for Unit 1 contains no analysis or results for the SV thermal condition or the SV thermal transient shock condition. Results of the SV quarter model analysis performed for Unit 2 are contained in the Unit 2 report, TES Technical Report TR-5364-2 (Reference 6).

Section 6 contains a stress summary of all node points, a summary of support loads, valve acceleration calculations, a summary of pressurizer and quench tank nozzle loads, and a listing of the moments on the end of each valve for all loading conditions. It should be noted that valves NRV-151, NRV-152, NMO-151, NMO-152, and NMO-153 are in excess of the veritical acceleration criteria of 2g for the PORV thermal shock transient condition. These values are considered acceptable per the approval given by AEP in their letter of May 26, 1983 from Mr. Sam Ulan of AEP to Mr. P. D. Harrison of TES (Reference 7).

3.0 SYSTEM DESCRIPTION/DISCUSSION

The Pressurizer Safety/Relief Valve Discharge Piping consists of all of the piping from the pressurizer nozzles, down to the sparger in the quench tank. This information is depicted on TES drawing E-5763, Revision 2, generated from AEP drawings 1-GRC-6, sheets 1, 2, 3, 4; 1-GRC-7; 1-GRC-8; and 1-GRC-9.

The "Discharge" piping constitutes a very large system resulting in a large computer model. The size and geometrical complexity, which is due mainly to the sweeping curves around the pressurizer, complicates the modification effort in addition to causing longer run times..

Modification of this complex system, to attempt to secure satisfactory "Safety Valve Discharge" results, is limited to draining the SV loop seals. Heating the loop seals is not a viable "fix" because of the size of the loops. These long loops contain sufficient quantity of water such that on SV Discharge, the water seal does not "flash" completely enough to reduce the very high loads caused by the water slug. Modification to the support system is also a poor option because of the very limited space in the annulus around the pressurizer, which makes construction very difficult.

Another aspect of the system that could be improved is the setting of the constant spring supports. During the data extraction of the deadweight analysis results, it was observed that the supports in the PORV loop area were causing significant upward displacements of the piping system, as detailed in Section 6.2. The stresses in these regions are high and, although they do not exceed the allowable, they could be reduced by re-adjustment of the spring settings.

4.0 THERMAL FLUIDS ANALYSIS

4.1 Introduction

The following analysis determines the fluid forces which act on the pressurizer safety and relief valve discharge piping of the American Electric Power Donald C. Cook Nuclear Power Plant, Units 1 and 2. These forces are generated by the sudden opening of the pressurizer safety and relief valves during one or more of the pressurizer transients described in the AEP supplied 1982 letter to TES.

These forces, the resulting stresses they apply to the piping system, the resulting loads they impose on the pipe supports, and the loads they transmit to the safety and relief valves became of increased concern as a result of the incident at Three Mile Island.

Following the Three Mile Island incident, the NRC issued NUREG 0578 and NUREG 0737 which required that each utility determine the effect of safety/relief valve operation upon the valve and the discharge piping. An elaborate program involving both testing and analysis was established under the general management of the Electric Power Research Institute (EPRI). Intensive testing of safety and relief valves was performed at several locations across the country. A full scale model of the pressurizer and discharge piping was built at Combustion Engineering in Connecticut.

Simultaneously, an analytical program was initiated to choose and test a computer program which would predict the fluid forces; RELAP5 MOD1 was chosen. This is the latest in the family of RELAP programs developed at the Idaho National Engineering Laboratory.

In this analysis, TES has used RELAP5 MOD1 Version 2.11 as it is made available through Control Data Corp with a post-processor, REPIPE version 3.10, which calculates the fluid forces.

This version of RELAP5 MOD1 is identified by the following computer job control language at Control Data Corporation:

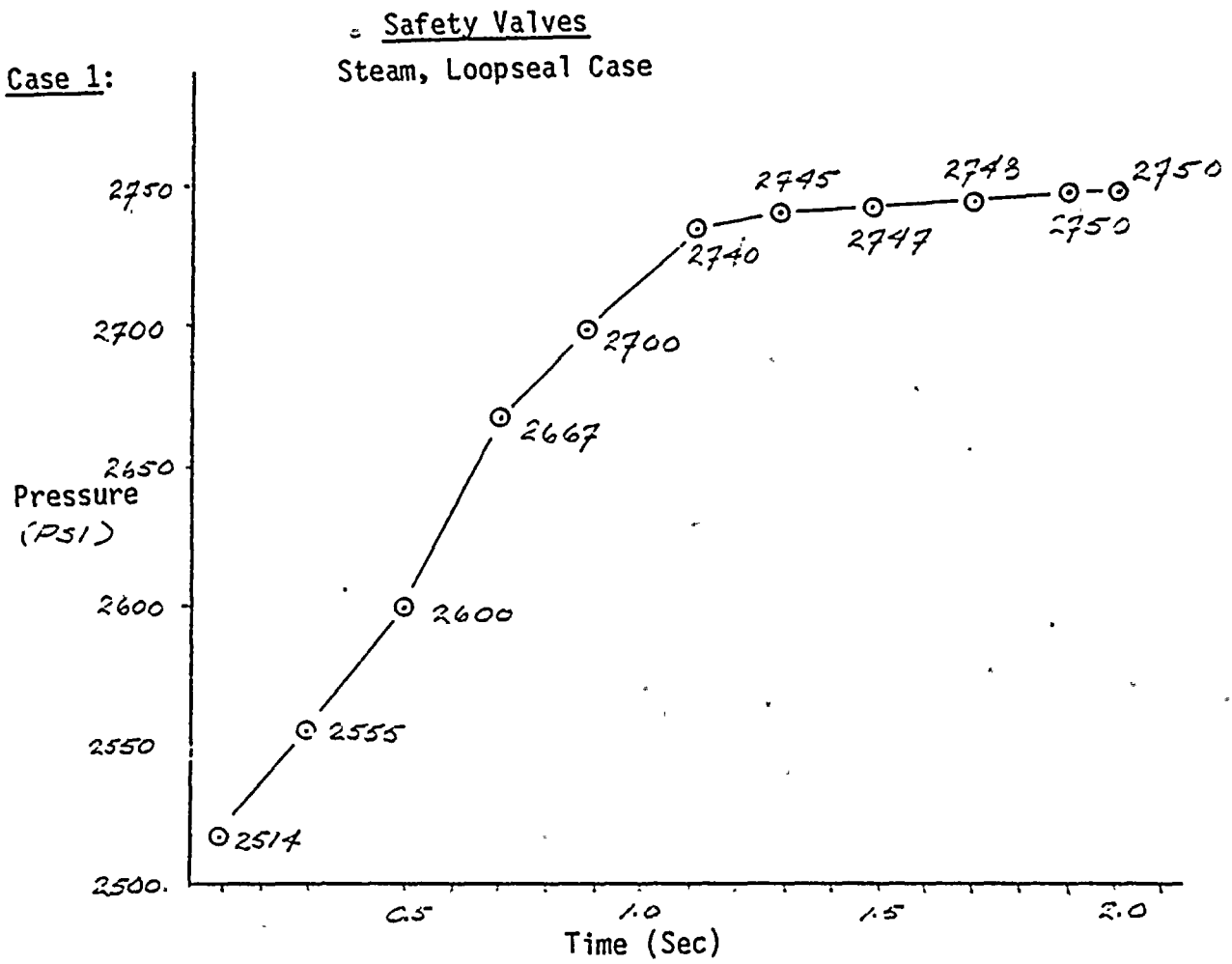
```
BEGIN, RELAP5, R5M2, INPUT=INPUTFILE, SCM=377000B
```

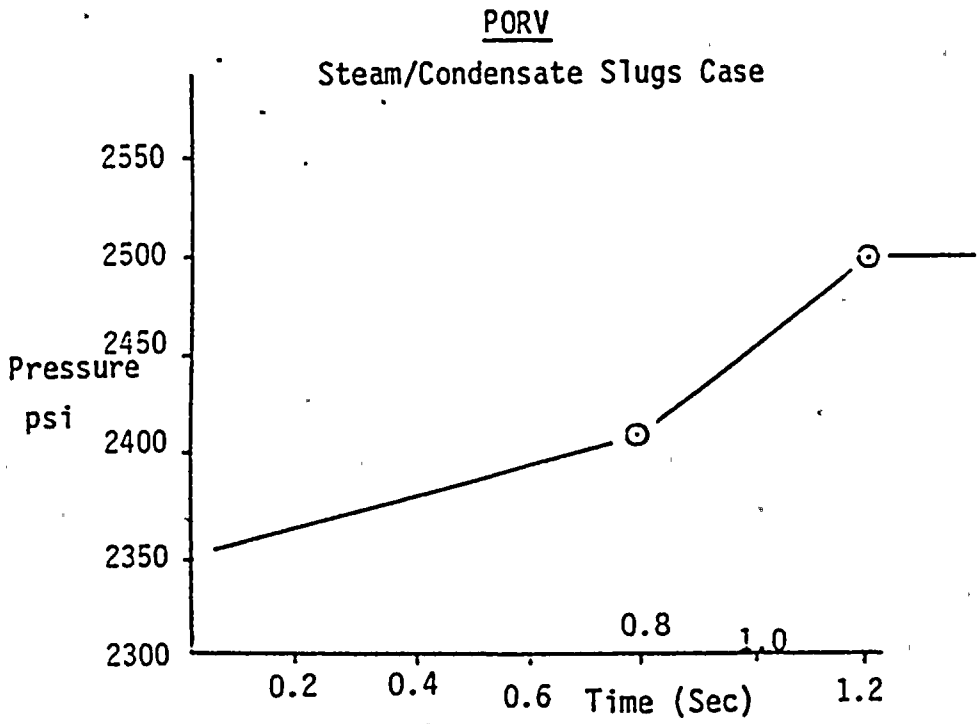
The computer analysis procedure for the thermal analysis portion is included in Appendix A.

RELAP5 calculates hydrodynamic data for control volumes in each segment of pipe. REPIPE then takes this data and defines two force time histories for a segment. One set of inlet junction forces, the other outlet junction forces. SAP2SAP adds these force time histories. Finally, one force time history for each segment of axial, unbalanced loads is analyzed structurally.

4.2 RELAP Model

4.2.1 The D.C. Cook pressurizer was modeled as a single time dependent volume with the following transient conditions as specified by the American Electric Power 11/29/82 letter to LBS, pages 1-7:





Case 2: Continuous Warm Water = 400°F (Same pressure as PORV, Case 1)

4.2.2 Safety valves and power operated relief valves were modeled as RELAP junctions using the following information:

Type	Manufacturer	Orifice Area	Opening Time
Safety Valve	Crosby HB-BP-86 (Ref. 13)	0.022 Ft^2	0.010 Sec.
PORV	Masoneilan NO-38-20721 (Ref. 14)	0.00806 Ft^2	1.0 Sec

Valve orifice areas were calculated using the EPRI Safety and Relief Valve Test Report (Reference 16) and RELAP (Run ID BAICDRO) implementing rated flows. Calculated values are included in Section 4.6.1.

4.2.3 Discharge piping was modeled from all safety and power operated relief valves to the quench tank. This discharge piping included the following pipe sizes:

3 inch, 12 inch	SCH 40
4 inch, 6 inch	SCH 40S
4 inch	SCH 120
3 inch, 6 inch	SCH 160

Friction factors for 1.5 D or short radius bends and reducers were taken from technical paper #410 by Crane. Calculations of these losses and constants are included in Appendix A. Segment lengths used are listed in Figures 4.2.1 and 4.2.2 for both models. The discharge piping defines segments with segments described as straight sections from elbow to elbow, valve to elbow, etc. Also, a listing of RELAP5 input is included in this report. The SRV model is modeled from one safety valve to the quench tank. This was determined to be an adequate representation of safety discharge piping for both units and will subsequently be referred to as "The Quarter Model". The Quarter Model is modeled utilizing Unit 2's geometry.

4.2.4 The Quench Tank was modeled in two parts: the sparger and the tank itself. The Quench Tank is modeled using cylindrical volumes containing water and air. The volume sizes are equal to quench tank volumes provided on Westinghouse Dwg. No. 110E272.

The sparger for D.C. Cook is a perforated pipe submerged in the water within the quench tank as indicated in Figure 4.2.3 of this report. It is represented in RELAP as a pipe equal in volume and similarly submerged.

BY CMM DATE 3-16-83
CHKD. BY KG DATE 5-24-83

1/4 MODEL LENGTHS & NODES. (SRV) ANALYSIS

SHEET NO. 1 OF 1
PROJ. NO. 5364

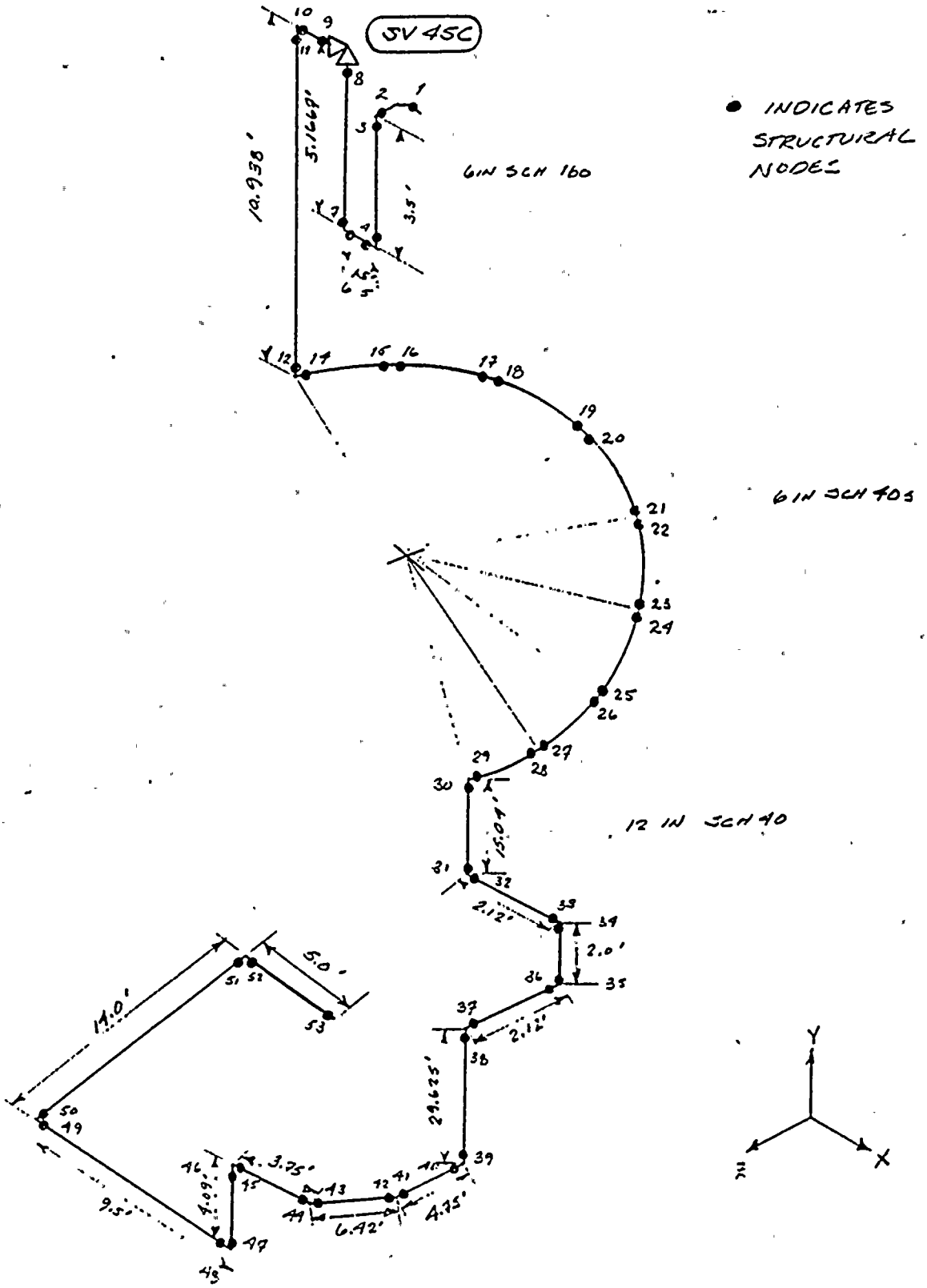


FIGURE 4.2.1

BY RAM DATE 4-14-83
CHKD. BY CHM DATE 5-23-83

UNIT 1
SEGMENT LENGTHS
PORV SECTION

SHEET NO. 1 OF 3
PROJ. NO. 5364

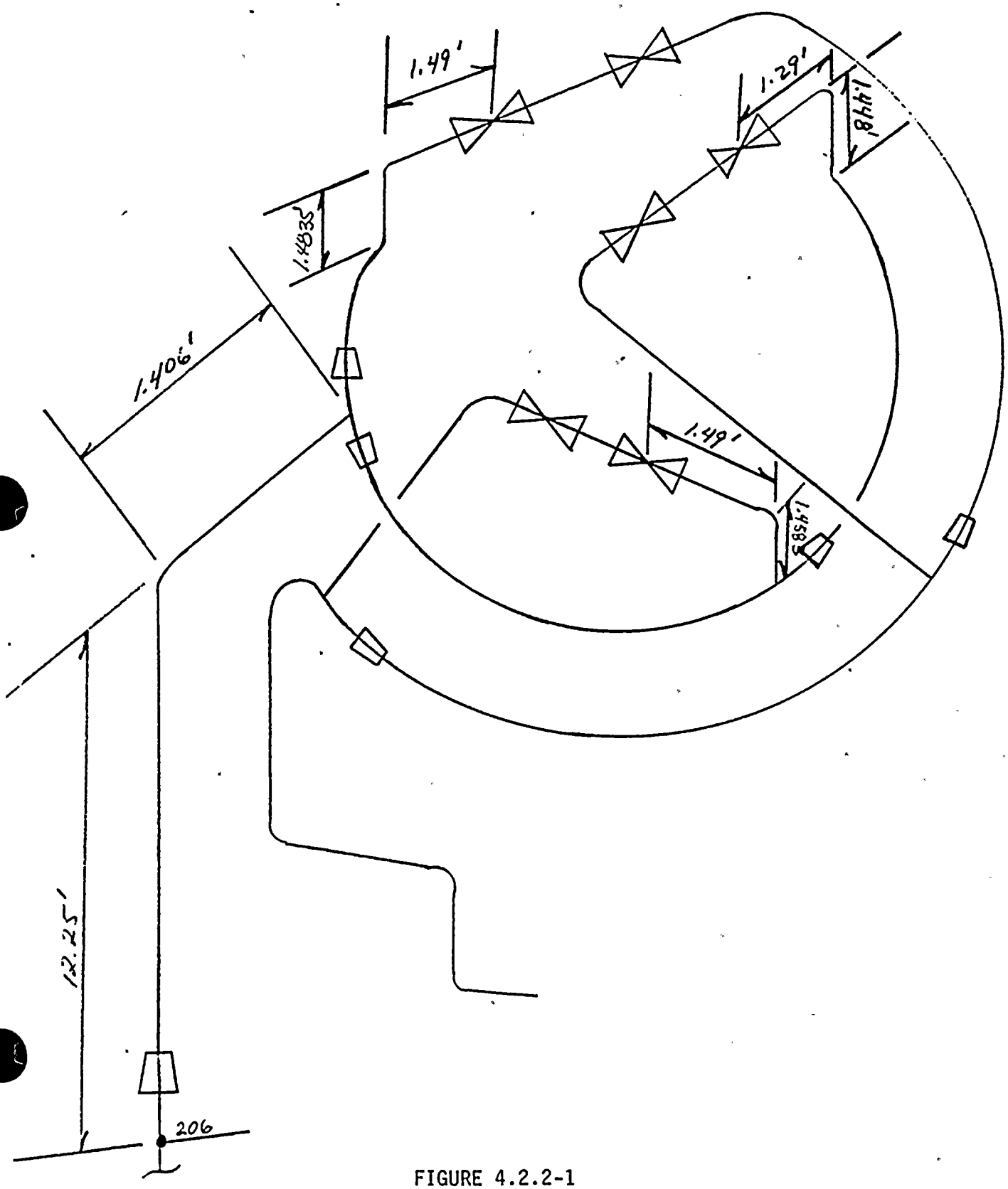


FIGURE 4.2.2-1

BY RAM DATE 4-14-83
CHKD. BY CNM DATE 5-23-83

UNIT 1
MAIN ARCS PORV ANALYSIS

SHEET NO. 2 OF 3
PROJ. NO. 5364

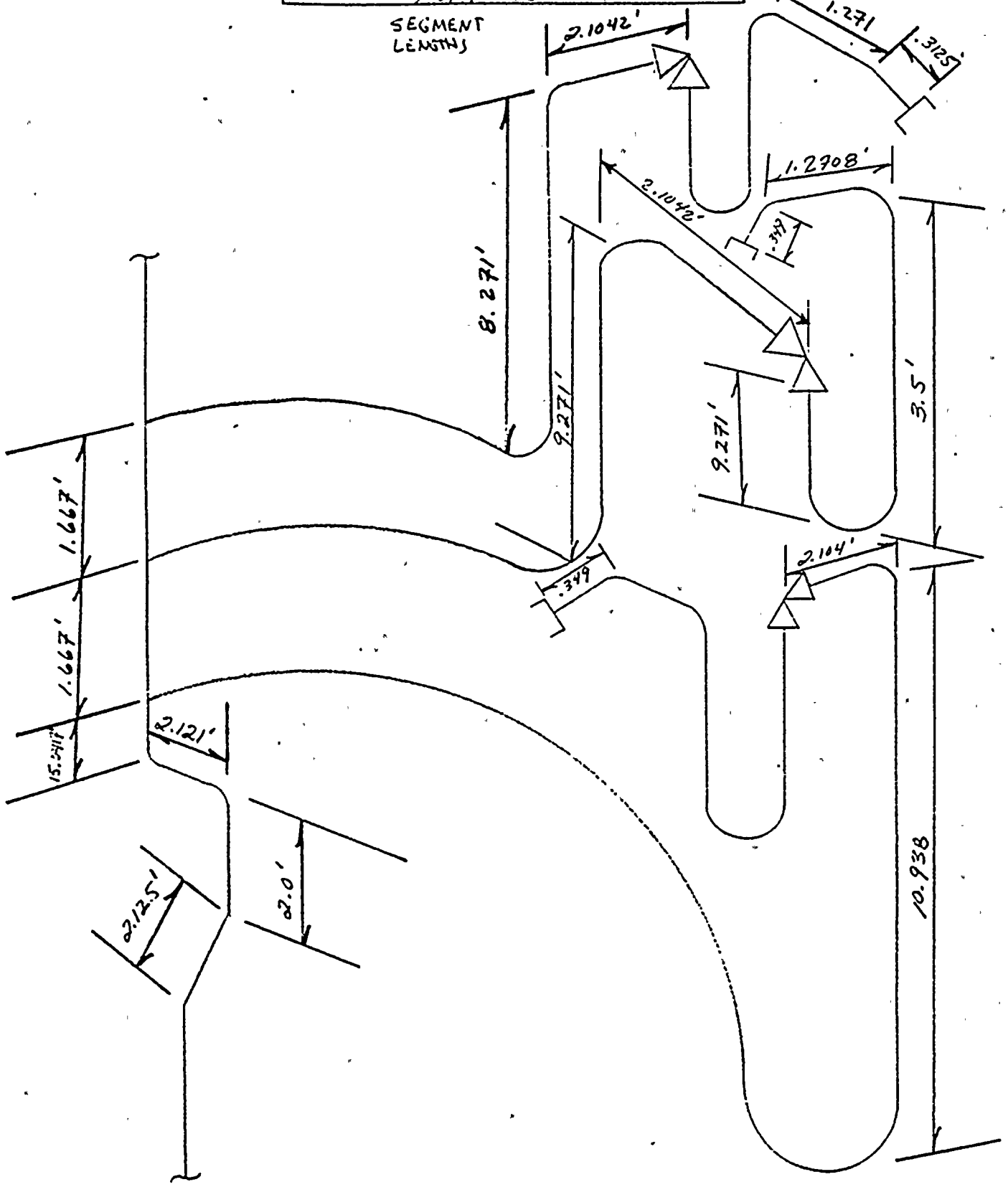


FIGURE 4.2.2-2

BY RAM DATE 4-14-83
CHKD. BY CHM DATE 5-23-83

UNIT 1
DOWNSTREAM (12IN) FORV ANALYSIS

SHEET NO. 3 OF 3
PROJ. NO. 5364

SEGMENT LENGTHS

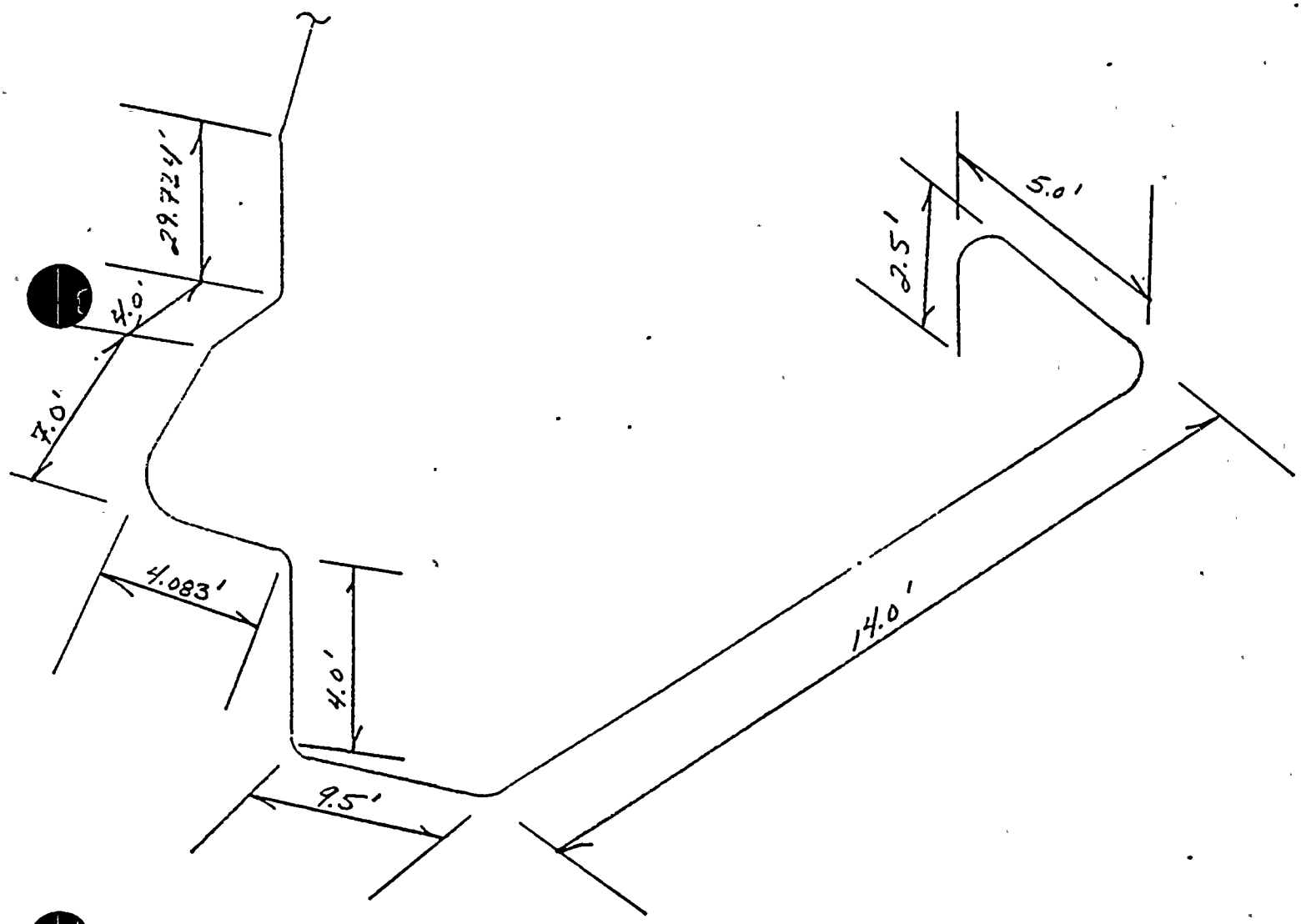


FIGURE 4.2.2-3

TELEDYNE ENGINEERING SERVICES

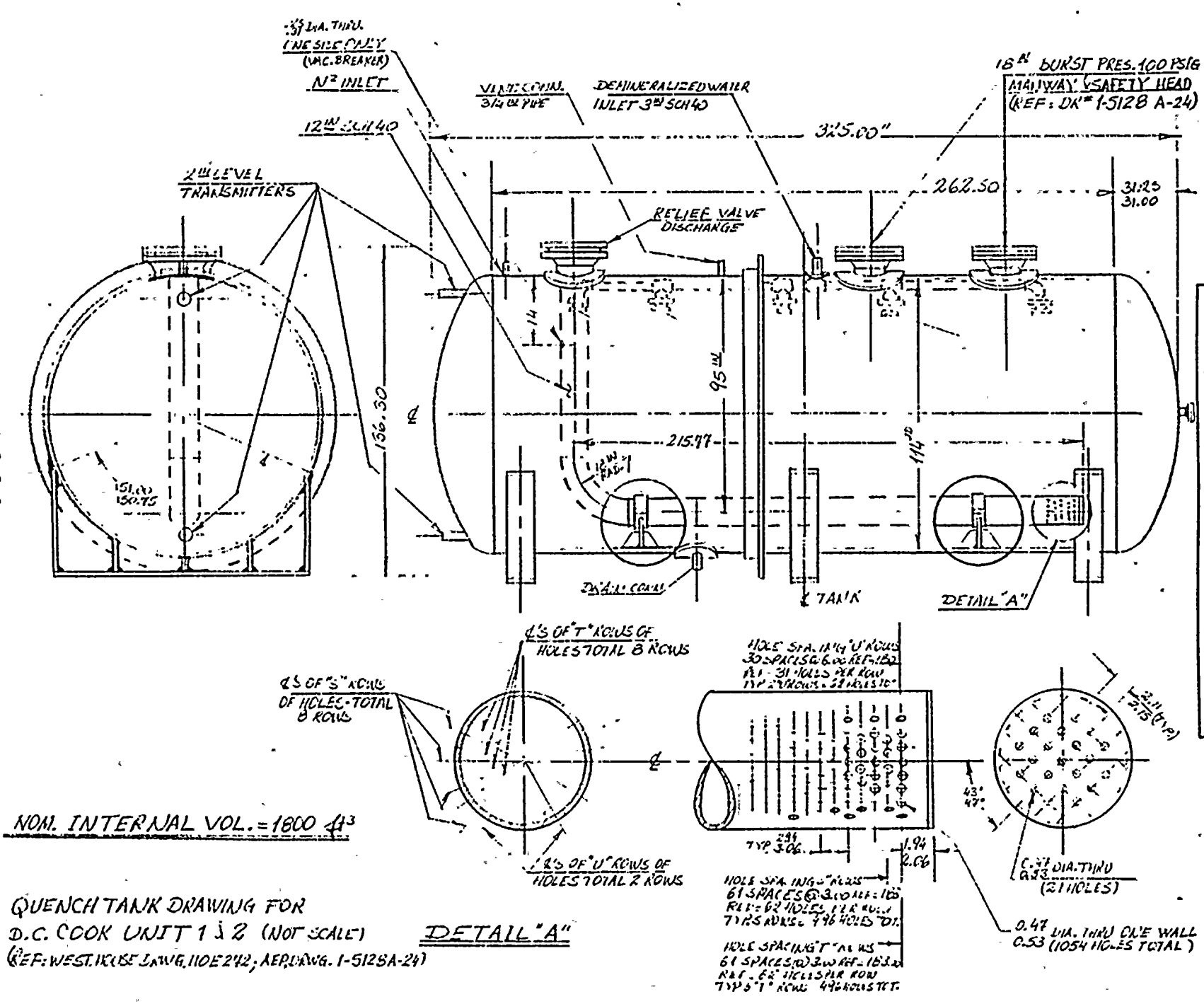


FIGURE 4.2.3-1

BY BAI DATE 1-17-83
CHKD. BY CHM DATE 3-11-83

DONALD C. COOK
NUCLEAR GEN. STATION UNITS 1&2
RELAP5 QUENCH TANK MODELING

SHEET NO. 2 OF 6
PROJ. NO. 5364

RELAP5 MODEL OF THE QUENCH TANK

REMARKS:

1. QUENCH TANK WAS MODELED AS A SERIES OF "PIPE COMPONENTS" WITH APPROPRIATE FLOW AREAS AND LOSS COEFFICIENTS.

2. WATER LEVEL IN THE QUENCH TANK. IS AT THE SAME HEIGHT AS THE WATER LEVEL IN THE SPARGER

3. THE SECTION OF THE SPARGER WITH DISCHARGE HOLES WAS MODELED AS A PIPE WITH ITS LENGTH EQUAL TO THE LENGTH OF THE SPARGER WITH THE TOTAL NUMBER OF HOLE AREAS EQUAL TO FLOW AREA OF THE SPARGER (REF. DETAIL DRW "A")

4. RUPTURE DISCS WERE MODELED AS A TRIP VALVE WHICH OPENS AT THE BURST PRESSURE OF 100 psig.

5. VACUUM BREAKER HOLE WITH DIA. = 0.25 - 0.31 IN AND LOCATED 14 INCHES FROM THE TOP OF THE QUENCH TANK WAS IGNORED IN THE MODELING.

V = NOMINAL INTERNAL VOLUME OF THE TANK = 1800 ft^3 (W.H. Dr. #110 E272)

TANK IS 82% FULL OF WATER. (REF. TELECON LBS WITH SAM ULAN DATED 1-14-83)

V_1 = WATER VOLUME IN THE QUENCH TANK = 1476 ft^3

V_2 = AIR VOLUME IN THE QUENCH TANK = 324 ft^3

FIGURE 4.2.3-2

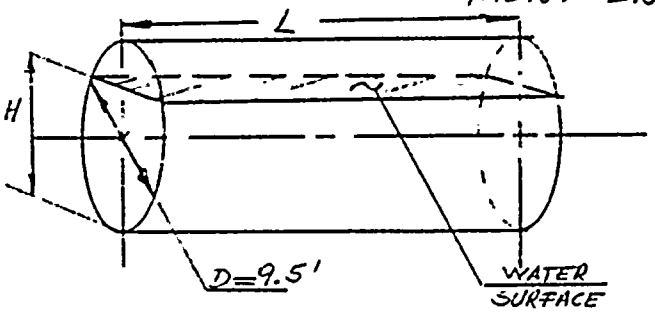
BY BAI DATE 1-17-83
CHKD. BY CMM DATE 3-11-83

DONALD C. COOK
NUCLEAR GEN. STATION UNITS 1 & 2
RELAP5 QUENCH TANK MODELING

SHEET NO. 3 OF 6
PROJ. NO. 5364

IF QUENCH TANK IS A CYLINDER WITH D = 114 IN INSIDE DIA.

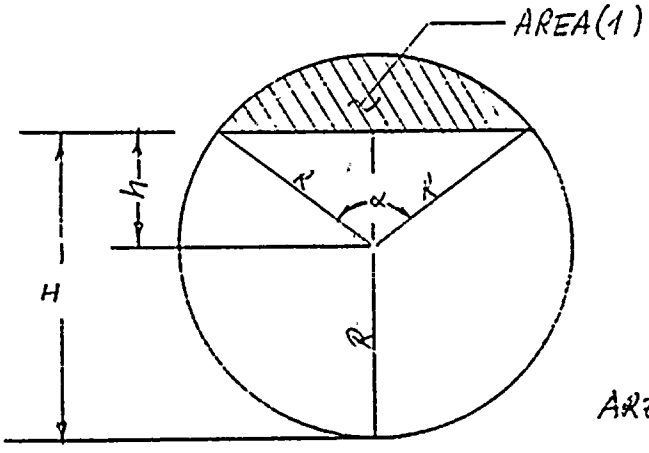
THEN: LENGTH $L = \dfrac{V}{\left(\frac{D}{2}\right)^2 \pi}$



$$L = \frac{1800}{\left(\frac{9.5}{2}\right)^2 \pi}$$

$$L = 25.3943 \text{ ft}$$

H – HEIGHT OF THE WATER LEVEL FROM BOTTOM OF THE TANK



$$AREA(1) = \frac{R^2}{2}(\hat{\alpha} - \sin\alpha) \qquad \text{EQN} - (1)$$

WHERE: $\hat{\alpha}$; IN RADIANS

α ; IN DEGREES

$$AREA(1) = \frac{\text{AIR VOLUME}}{\text{HEIGHT OF CYL.}} = \frac{V_2}{L} = \frac{324}{25.3943}$$

$$AREA(1) = 12.7588 \text{ ft}^2$$

SUBSTITUTING INTO EQN (1)

$$12.7588 = \frac{22.5625}{2}(\hat{\alpha} - \sin\alpha)$$

$$13.1310 = \hat{\alpha} - \sin\alpha$$

BY TRIAL AND ERROR:

$$\alpha \approx 116.5^\circ$$

FIGURE 4.2.3-3

TELEDYNE ENGINEERING SERVICES

BY BAI DATE 1-17-83
CHKD. BY CMM DATE 3-11-83

DONALD C. COOK
NUCLEAR GEN. STATION UNITS 1 & 2
RELAP5 QUENCH TANK MODELING

SHEET NO. 4 OF 6
PROJ. NO. 5364

$$h = R \cos \frac{\alpha}{2}$$

$$h = 4.75 \cos \frac{116.5}{2}$$

$$h = 2.4995$$

$$H = h + R = 4.75 + 2.4995$$

$H \approx 87^{IN} = 7.25$ ft HEIGHT OF WATER SURFACE FROM THE BOTTOM OF THE QUENCH TANK.

$D - H = 27^{IN} = 2.25$ ft FROM THE TOP OF THE QUENCH TANK TO THE WATER SURFACE.

FROM WATER SURFACE TO THE CENTER OF THE HORIZANTAL SECTION OF THE SPARGER $\approx 68^{IN} = 5.6667$ ft

HEIGHT OF WATER LEVEL IN QUENCH TANK MODEL MUST BE ALSO = 5.6667 ft.

VOLUME OF WATER IN QUENCH TANK = 1476 ft^3

SURFACE AREA BETWEEN WATER AND AIR = $\frac{1476}{5.6667} = 260.4706$ ft^2

VOLUME OF AIR IN QUENCH TANK = 324 ft^3

HEIGHT OF AIR VOLUME IN RELAP MODEL = $\frac{324}{260.4706} = 1.2439$ ft

FIGURE 4.2.3-4

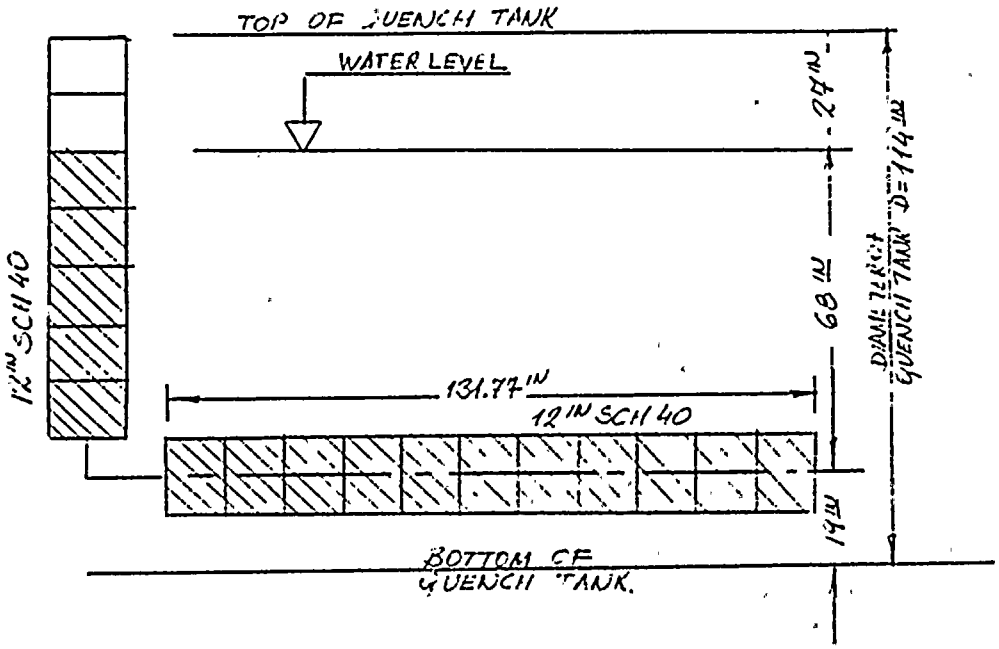
BY BAI DATE 1-17-83
CHKD. BY CMM DATE 3-11-83

DONALD C. COOK
NUCLEAR GEN. STATION UNITS 1 & 2
RELAP5 QUENCH TANK MODELING

SHEET NO. 5 OF 6
PROJ. NO. 5364

FIGURE 4.2.3-5

SPARGER MODELING



AREA OF EACH HOLE ON SPARGER SIDE = 0.1963 in² = 0.0014 ft²

TOTAL FLOW AREA OF ALL THE SIDE HOLES = 1054 × 0.0014 = 1.4368 ft²

FLOW AREA OF 12 IN SCH40 PIPE = 0.7773 ft²

ALL THE HOLES ARE DISTRIBUTED EVENLY @ 183 IN LENGTH FROM THE TIP OF THE SPARGER

AREA RATIOS = $\frac{0.7773}{1.4368}$ = 0.541 REPRESENTS THE SECTION OF THE SPARGER WHICH INCLUDES ALL THE HOLES WITH THE TOTAL AREAS EQUAL TO THE FLOW AREA OF THE 12 IN SCH40 PIPE.

1 − 0.541 = .459

183 × 0.459 = 83.9977 ≈ 84.0 IN = 7 ft THE LENGTH WHICH MUST BE EXCLUDED FROM THE TIP

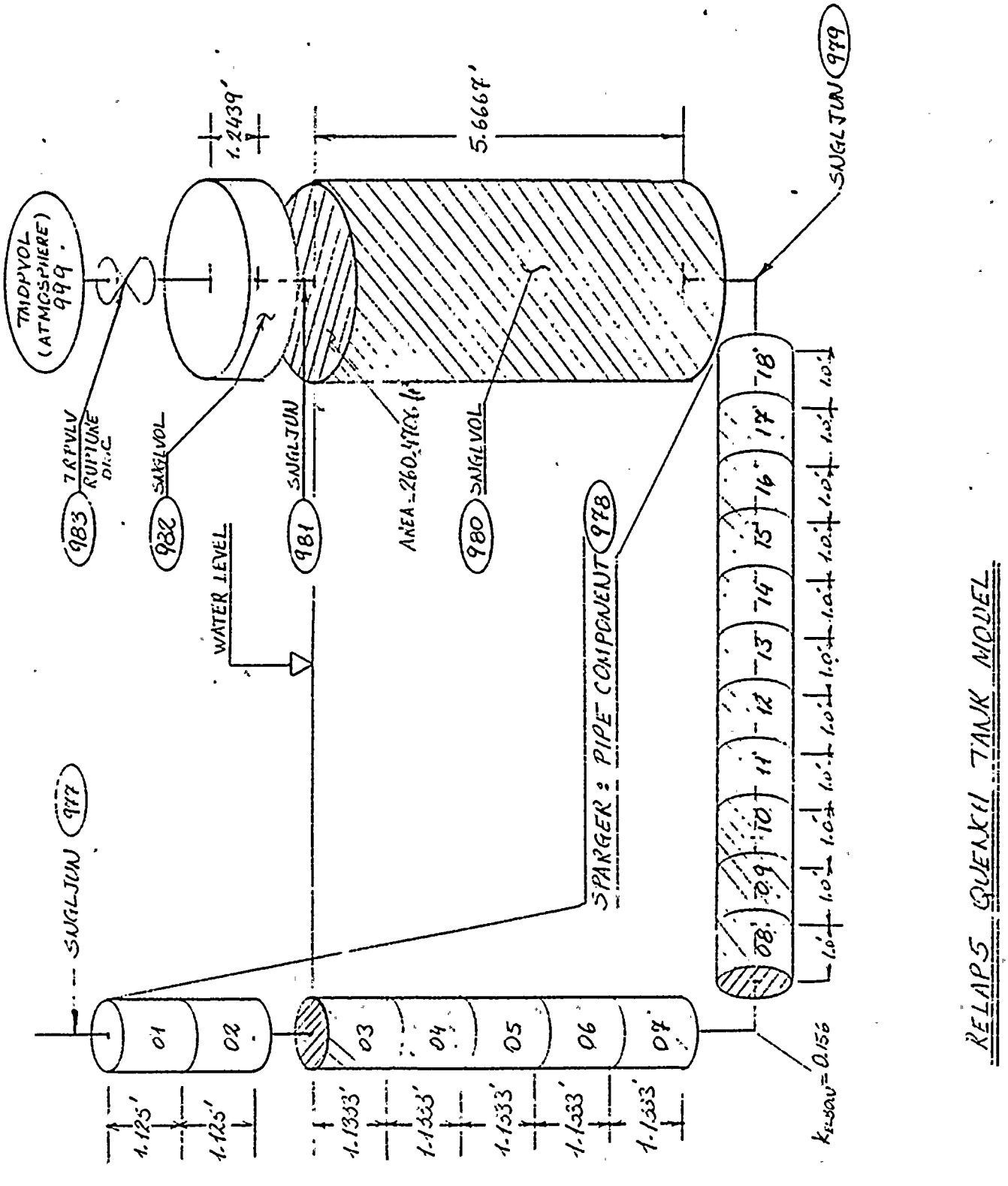
TOTAL LENGTH OF HORIZONTAL SECTION = 215.77 IN (REF DRW ON Page 1)

THIS LENGTH IN RELAP MODEL = 215.77 − 84 = 131.77 ≈ 11 ft

BY BAI DATE 1-17-83
CHKD. BY CMH DATE 3-11-83

DONALD C. COOK
NUCLEAR GEN. STATION UNITS 1 & 2
RELAP5 QUENCH TANK MODELING.

SHEET NO. 6 OF 6
PROJ. NO. 5364



RELAP5 QUENCH TANK MODEL

FIGURE 4.2.3-6

4.3 RELAP Model Control Volumes

The Evaluation of RELAP5/MOD1 for Calculation of Safety/Relief Valve Discharge Piping Hydrodynamic Loads report prepared by Intermountain Technologies, Inc. recommends using ten or more control volumes per bounded segment while avoiding significant control volume length differences to preserve pressure wave shapes. The ten control volume criteria recommended by ITI was adhered to except in piping arcs and in segments less than three feet in length. The D.C. Cook discharge piping is modeled using as few as one control volume per segment (pipe segments with lengths less than 0.5 feet) and up to thirty-two control volumes per segment.

Arc modeling for both units is represented in Figures 4.3.1 and 4.3.2. All arcs for Units 1 and 2 were modeled in RELAP as having no fluid losses. Essentially, RELAP calculates these as straight sections of pipe. REPIPE, however, distributes the calculated forces to pre-assigned node points matching the TES structural models.

Average control volume lengths used for the D.C. Cook RELAP Units 1 and 2 model were:

Pipe Size	Average C.V. Length
3 inch SCH 160	0.4644 feet
6 inch SCH 160	0.5264 feet
4 inch SCH 40S	0.4471 feet
6 inch SCH 40S	0.8614 feet
12 inch SCH 40	0.8064 feet
3 inch SCH 40	0.4744 feet
4 inch SCH 120	0.5056 feet

A schematic of the discharge systems modeled in RELAP for the PORV Unit 1 model and the SRV 1/4 model for Unit 2 are given in Figures 4.7.1 and 4.7.2, respectively.

Quench Tank modeling was achieved using twenty control volumes and twenty junctions. Eighteen volumes comprise the sparger model while the remaining two are single volumes modeling the water and air spaces of the quench tank. The water and air volumes as determined from Westinghouse Dwg. No. 110E272 were input to RELAP to insure proper quenching capacity. Eighteen control volumes forming the sparger are initially 88% full of water representing a submerged pipe. The discharge holes were modeled as a single hole of equivalent area at the end of the pipe (a conservative assumption).

Finally, the tank rupture disk is modeled as a pressure actuated valve placed on the air volume and set to blow out at 100 psig discharging to atmosphere. (Figure 4.2.3 represents the D.C. Cook Units' 1 and 2 Quench Tank).

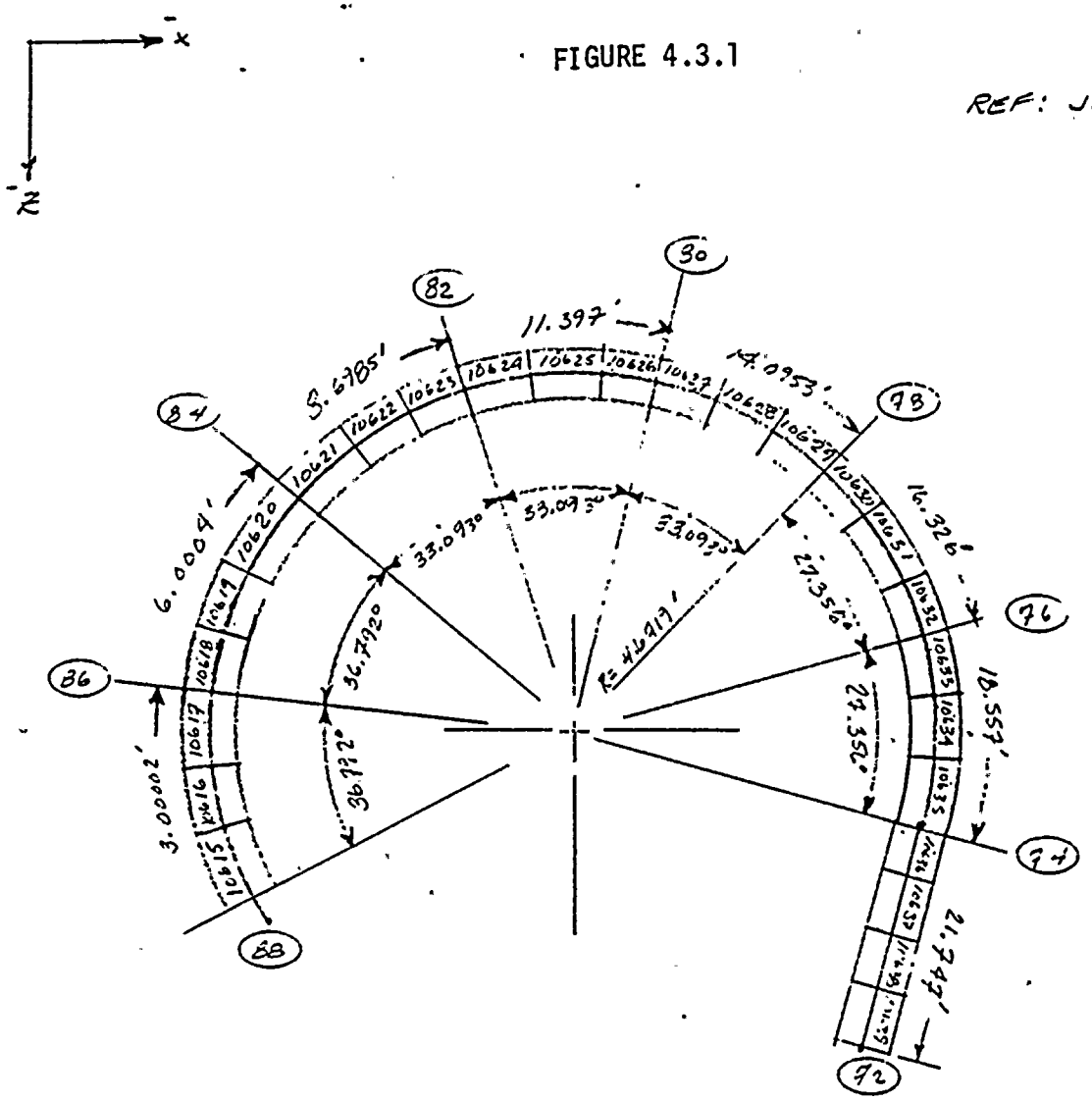
BY CMM DATE 1-17-83
CHKD. BY CJC DATE 2-17-83

RELAP MODEL 1/4 MODEL
ARC 1 LEVEL 669'-2" UNIT 2

SHEET NO. 1 OF 1
PROJ. NO. 5364

FIGURE 4.3.1

REF: JBM CALC
12-31-81



COMPONENT 106 6IN PIPE SCH 40S.

VOLUMES 10615 → 10639

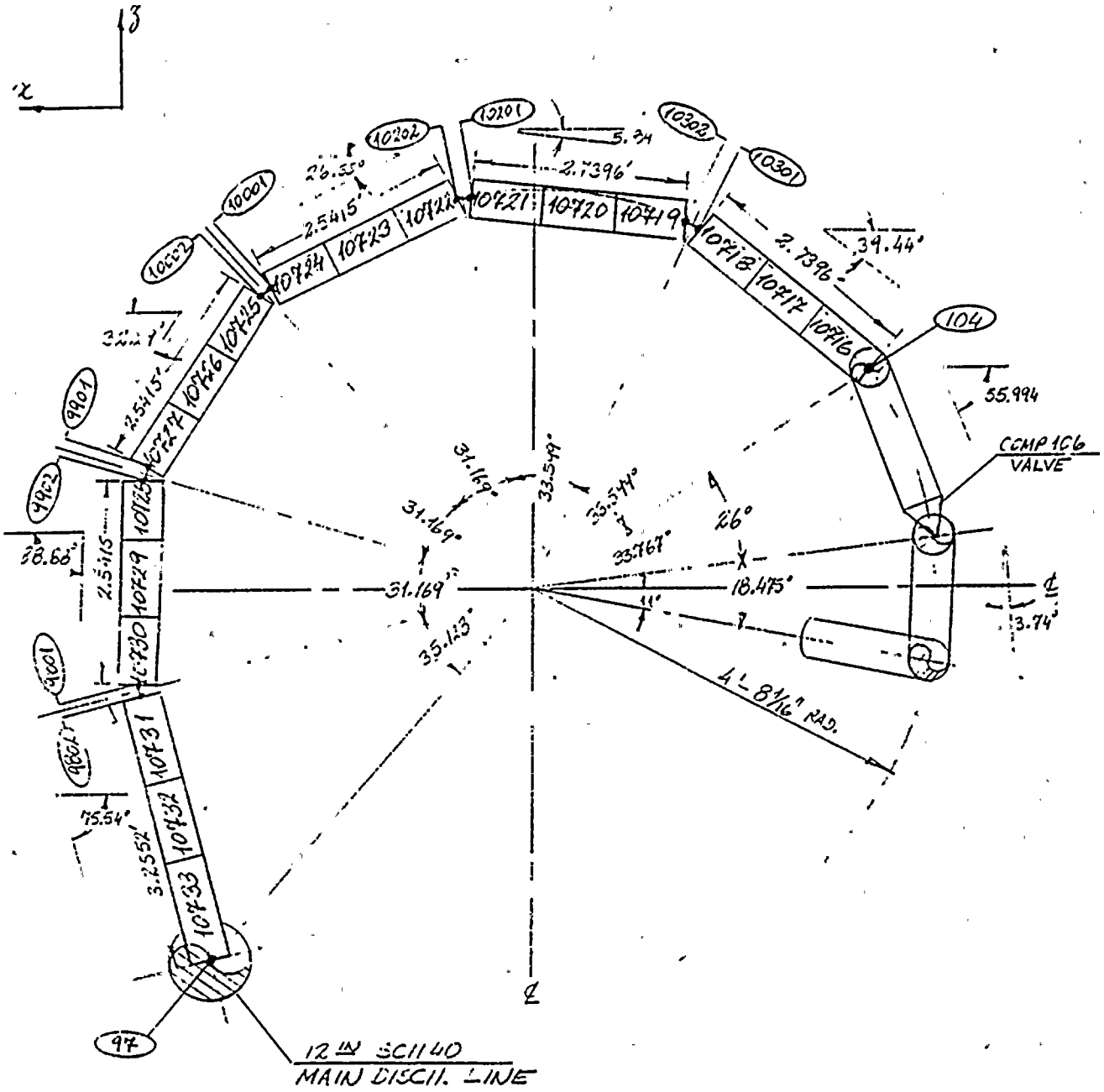
BY BAI DATE 2-8-83
CHKD. BY CJC DATE 2-15-83

D. C. COOK UNIT 1
ARC 1 GEOMETRY @ ELEV. 669'-2"

SHEET NO. 1 OF 5
PROJ. NO. 5364

FIGURE 4.3.2-1

RELAP5 MODEL OF ARC @ ELEVATION 669'-2" (ARC 1)



REMARKS:
NUMBERS IN ⬭ INDICATE STRUCTURAL NODES
DIMENSIONS BETWEEN NODES REPRESENT CORRESPONDING ARC LENGTHS.

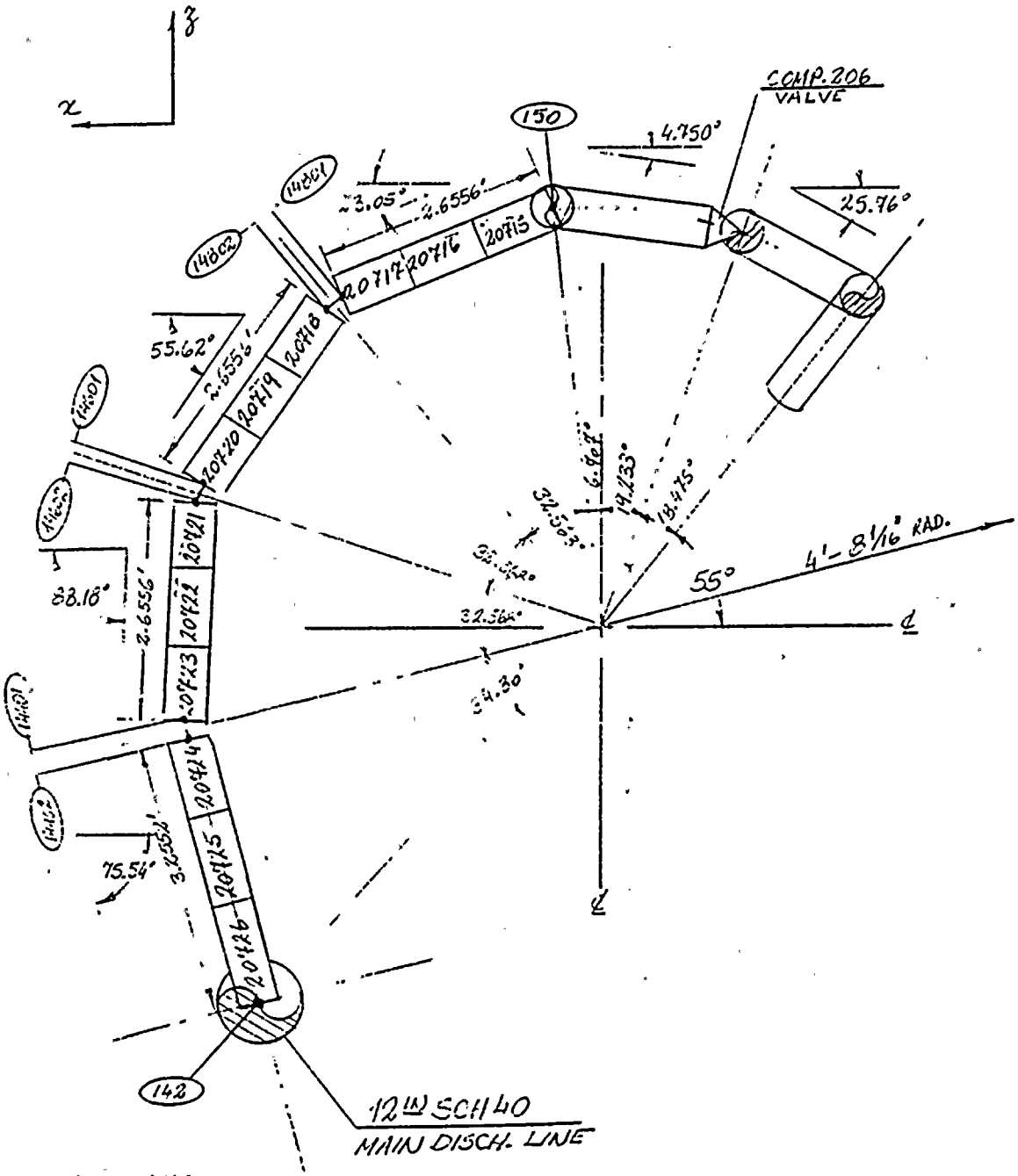
BY BAI DATE 2-8-83
CHKD. BY CJC DATE 2-15-83

D.C. COOK UNIT 1
ARC 2 GEOMETRY @ ELEV. 670'-10"

SHEET NO. 2 OF 5
PROJ. NO. 5364

FIGURE 4.3.2-2

RELAP5 MODEL OF ARC @ ELEVATION 670'-10" (ARC 2)



REMARKS:
NUMBERS IN ( ) INDICATE STRUCTURAL NODES
DIMENSIONS BETWEEN NODES REPRESENT CORRESPONDING ARC LENGTHS.

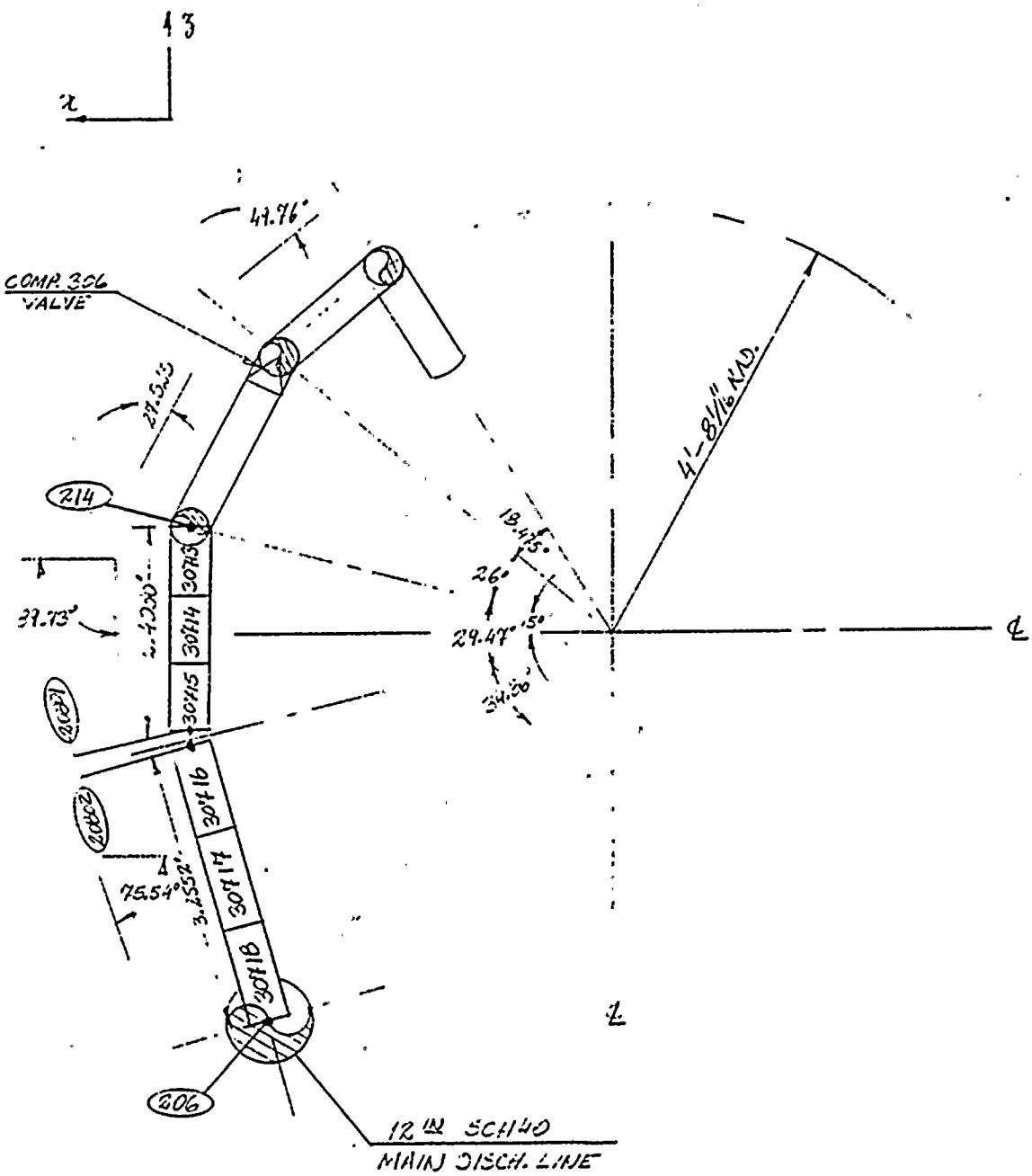
BY BAI DATE 2-8-83
CHKD. BY CJC DATE 2-15-83

D. C. COOK UNIT 1
ARC 3 GEOMETRY @ ELEV. 672'-6"

SHEET NO. 3 OF 5
PROJ. NO. 5634

FIGURE 4.3.2-3

RELAP5 MODEL OF ARC @ ELEVATION 672'-6" (ARC3)



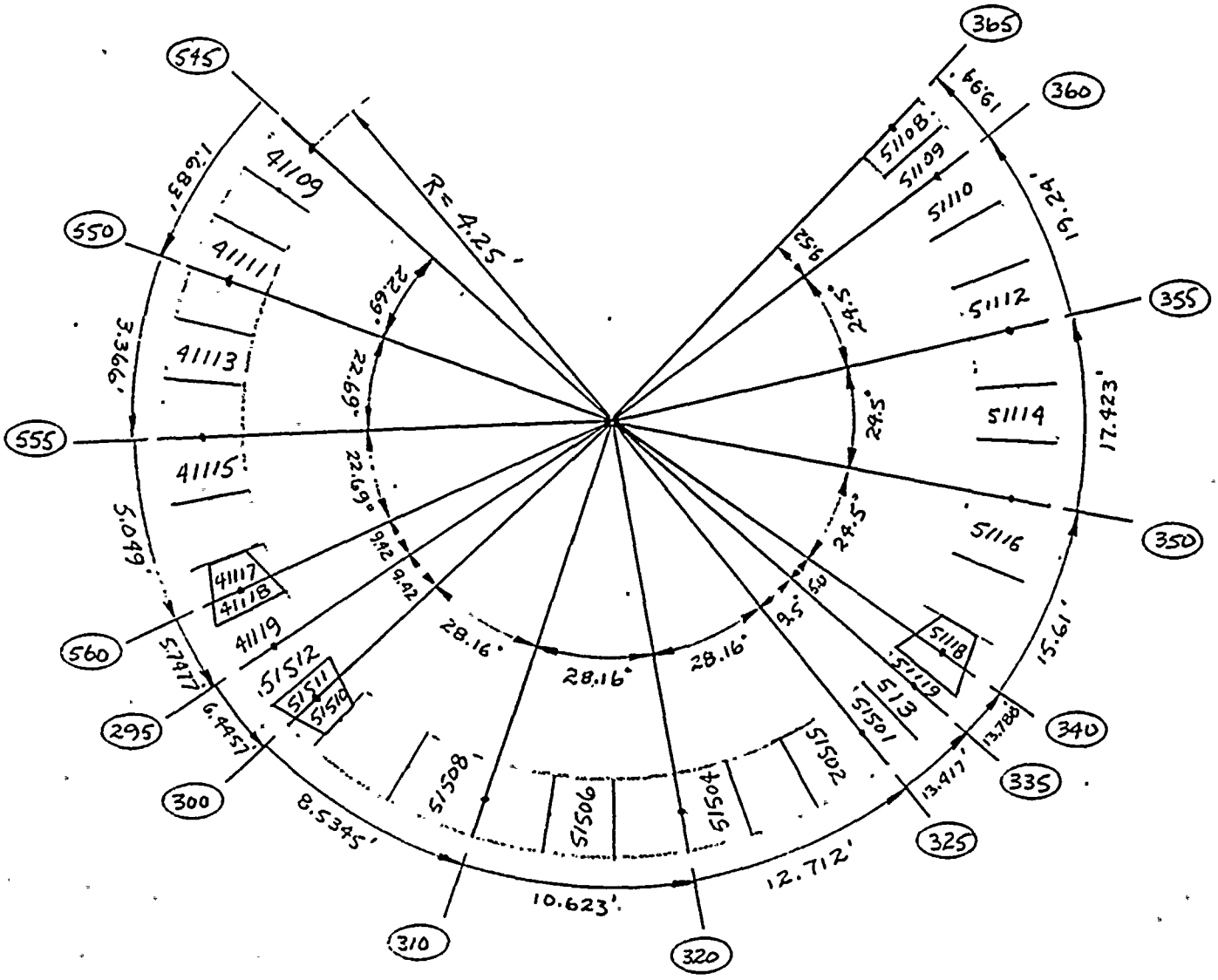
REMARKS:
NUMBERS IN ⬭ INDICATE STRUCTURAL NODES
DIMENSIONS BETWEEN NODES REPRESENT CORRESPONDING ARC LENGTHS.

BY CJC DATE 3-25-83
CHKD. BY CHM DATE 3-28-83

UNIT 1 PORV SECTION
RELAP MODEL (DOWNSTREAM)

SHEET NO. 4 OF 5
PROJ. NO. 5364

FIGURE 4.3.2-4

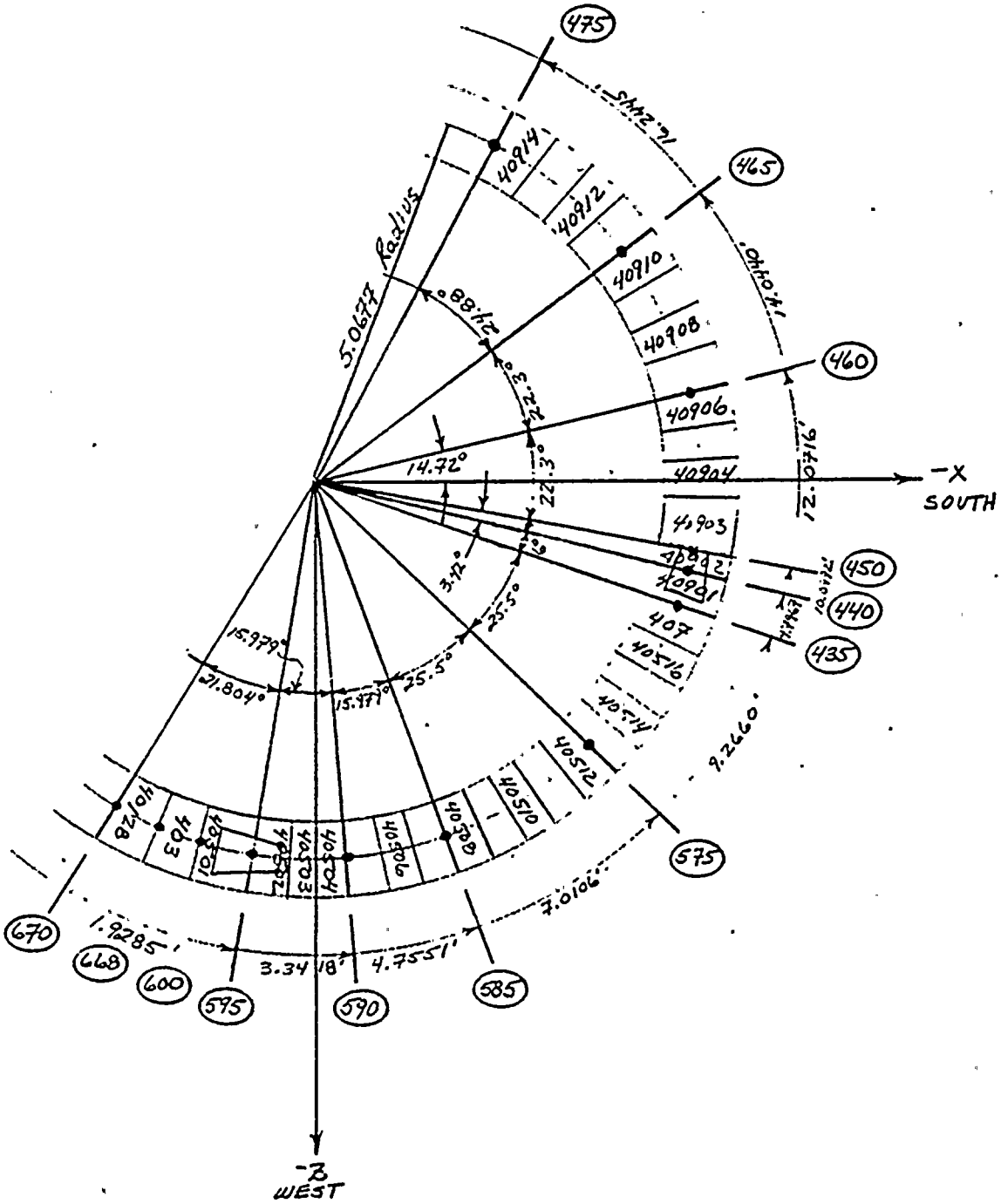


BY RAM DATE 5-12-83
CHKD. BY CHM DATE 5-23-83

UNIT 1 PORV
AIRC LEVEL 686'-6"

SHEET NO. 5 OF 5
PROJ. NO. 5364

FIGURE 4.3.2-5

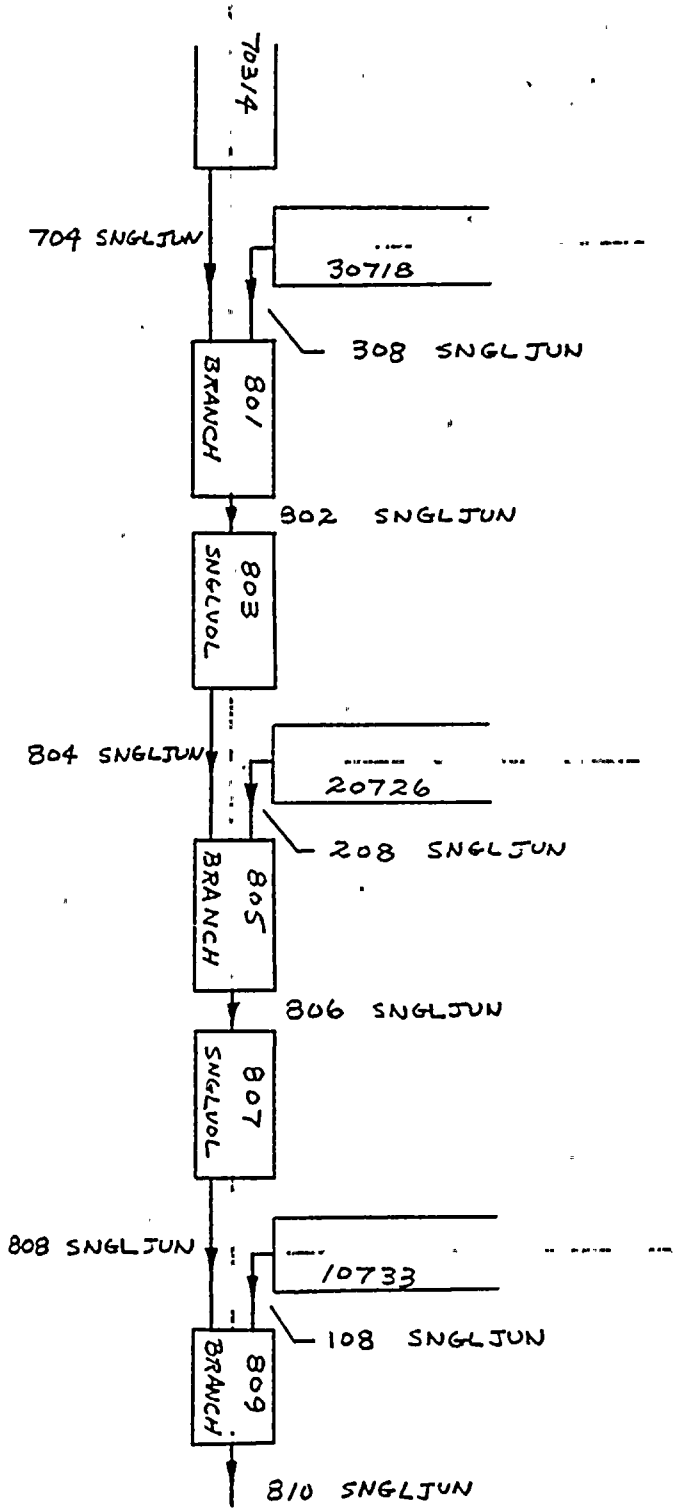


BY CJC DATE 3-25-83
CHKD. BY CHM DATE 3-28-83

UNIT 1 MAIN ARC CONNECTIONS
BRANCHES + TEES

SHEET NO. 1 OF 2
PROJ. NO. 5364

FIGURE 4.3.3-1

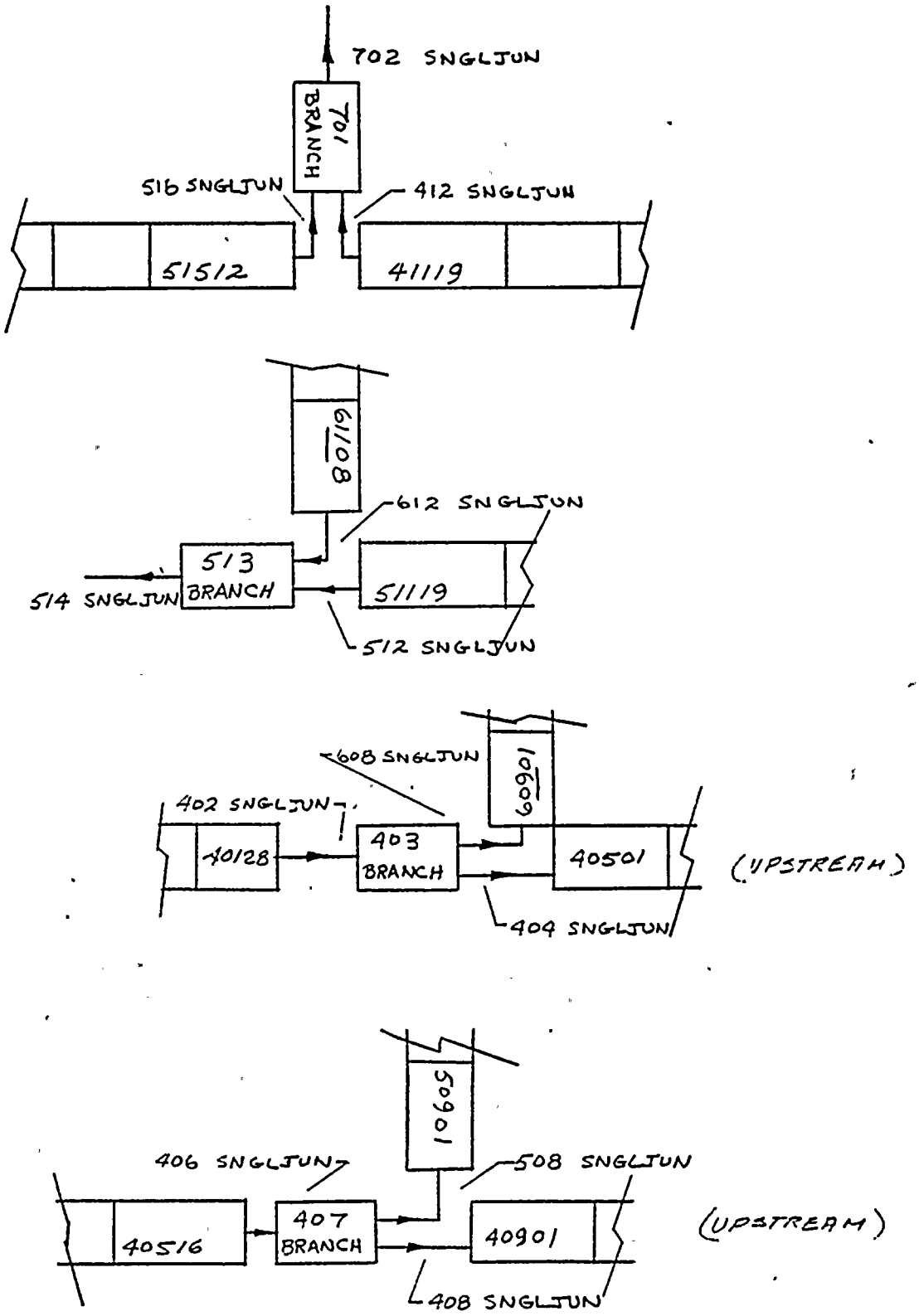


BY CJC DATE 3-25-83
CHKD. BY CHM DATE 3-28-83

UNIT 1 PORV SECTION
BRANCHES + TEES

SHEET NO. 2 OF 2
PROJ. NO. 5364

FIGURE 4.3.3-2



4.4 Quarter Model

Before beginning the as-built analysis for the safety valves, it was almost certain that the loads would fail the system. A review of the testing that was done at Combustion Engineering in Connecticut indicated this would be the case. The cold loop seal discharge test at C.E. produced loads of 175 Kips. The D.C. Cook Units 1 and 2 pressurizers have three safety valves each with a loop seal larger than the C.E. test facility loop seal. Therefore, it was decided to make a small RELAP model of the D.C. Cook Safety Valve discharge line. This model contains one safety valve (SV45C) including its loop seal piping and its discharge piping through arc level 669'-2" up to, but not including, the quench tank. This model would be less expensive to run than the full three valve model.

The results of this small (Quarter Model) confirmed our suspicion that the cold loop seal case would fail. It also allowed us to make a paremetric study of loop seal temperature in loads as is shown below. Only the steam discharge proved to be acceptable, therefore, TES has recommened to drain the loop seals.

Loop Seal Condition	Loop Seal Temperature (°F)	Position of Loop Seal	Valve Opening Time (Sec)	Max Load (LBF)
Cold	141°	Upstream	0.010	115,000
Cold	141°	Downstream	0.010	174,000
Hot	350°	Upstream	0.010	156,000
Hot	350°	Upstream	0.090	109,000
Hot	350°	Upstream	0.130	124,000
Hot (Sat. Water)	650°	Upstream	0.090	38,000
Steam	650°	Upstream	0.010	6,000

The loop seal temperature distribution was calculated to be input to RELAP and is included in the Appendix A. The temperatures used for the cold loop seal ranged from 584.4° at the pressurizer to 141.1° at the valve.

BY CMM DATE 3-22-83
CHKD. BY KJG DATE 3-23-83

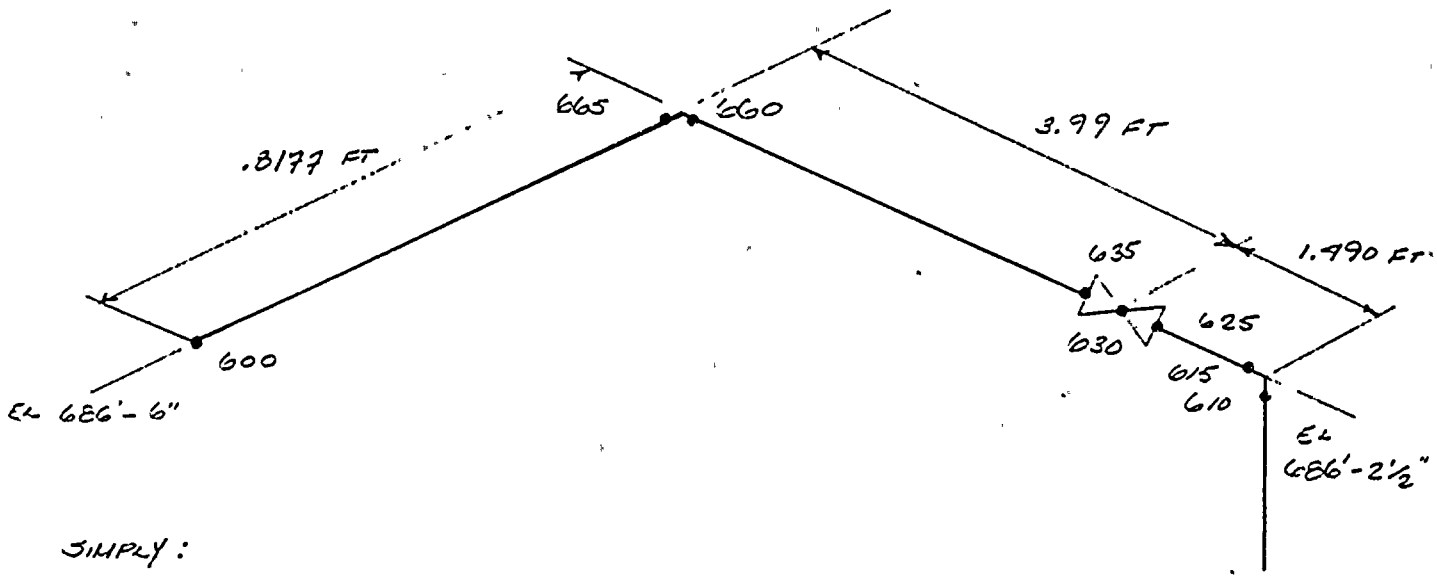
UNIT 1 FLUID VOLUME CALCULATION PORV INLET

SHEET NO. 1 OF 6
PROJ. NO. 5364

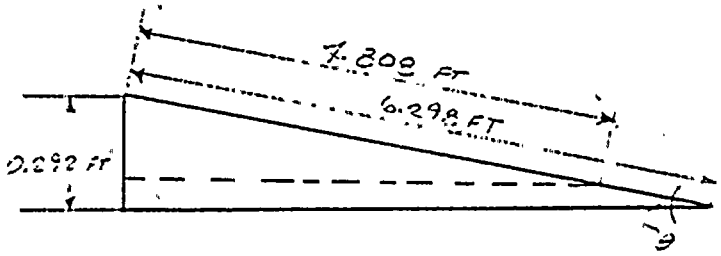
VALVE #1: NRV153

3 IN SCH 160 PIPING : AREA = 0.0376 FT²

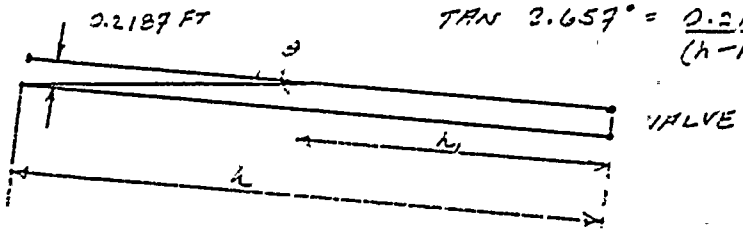
OVERALL SLOPE = (686.5 - 686.208) FT = 0.292 FT



SIMPLY:



SLOPE TO VALVE = 0.2229 FT, θ = 2.657°



$\tan 2.657° = \frac{0.2187}{(h-h_1)}$ $h-h_1 = 4.7127$ FT

FIG.4.4.1-1

BY CHM DATE 3-22-83
CHKD. BY KTG DATE 3-23-83

UNIT 1 FLUID VOLUME
CALCULATION FOR V. INLET

SHEET NO. 2 OF 6
PROJ. NO. 5364

VOLUME OF A FRUSTRUM:

$$V_{TOTAL} = 1.5708\, r^2 (h + h_1)$$

$$r = \frac{0.2187\ FT}{2} = 0.10935\ FT \qquad h_1 = (4.808 - 4.7127)\ FT$$

$$h = 4.808\ FT$$

$$V_{TOTAL} = 1.5708\,(0.10935\ FT)^2\,(4.808\ FT + (4.808\ FT - 4.7127\ FT))$$

$$V_{TOTAL} = 0.0921\ FT^3$$

EQUIVALENT SLUG LENGTH (PIPE FULL)

$$L_{EQ} = 3.749\ FT$$

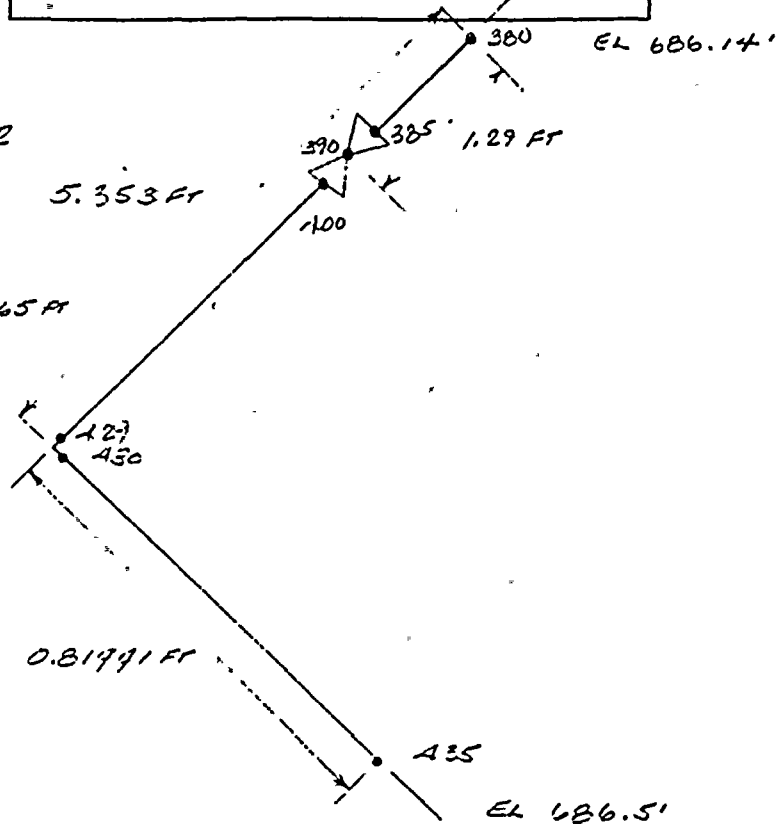
FIGURE 4.4.1-2

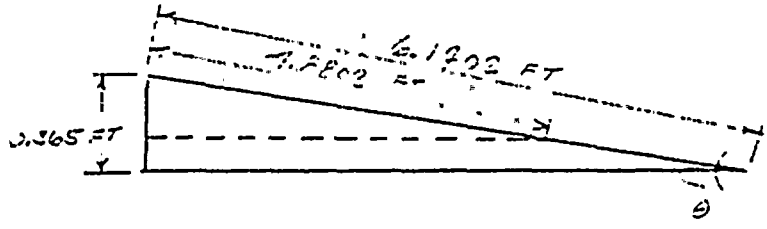
BY CMM DATE 3-22-83
CHKD. BY JG DATE 3-23-83

UNIT 1 FLUID VOLUME CALCULATION PORV INLET

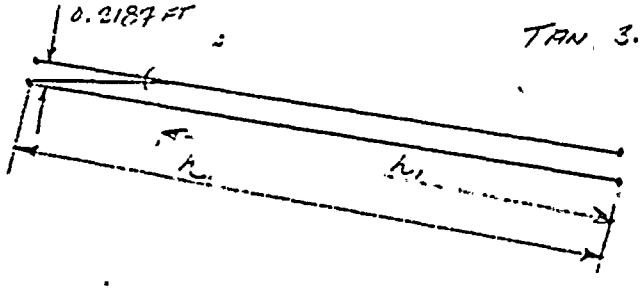
SHEET NO. 3 OF 6
PROJ. NO. 5364

VALVE #2: NRV 152
3IN SCH 160 PIPING
AREA = 0.0396 FT²
OVERALL SLOPE =
(686.5' - 686.14') = 0.365 FT





SLOPE TO THE VALVE = 0.2187 FT θ = 3.39°



$$\tan 3.39° = \frac{0.2187 \text{ FT}}{h - h_1}$$

$h - h_1 = 3.692$ FT

FIGURE 4.4.1-3

BY CMM DATE 3-22-83
CHKD. BY KJG DATE 3-23-83

UNIT 1 FLUID VOLUME CALCULATION PORV INLET

SHEET NO. 4 OF 6
PROJ. NO. 5364

VOLUME OF A FRUSTRUM:

$$V_{TOT} = 1.5708\ r^2 (h + h_1)$$

$r = 0.10935$ FT

$h_1 = 1.138$ FT

$h = 4.8802$ FT

$$V_{TOTAL} = 1.5708\ (0.10935\ FT)^2 (1.138\ FT + 4.8802\ FT)$$

$V_{TOTAL} = 0.1140$ FT^3

EQUIVALENT SLUG VOLUME LENGTH (PIPE FULL)

$L_{EQ} = 3.031$ FT.

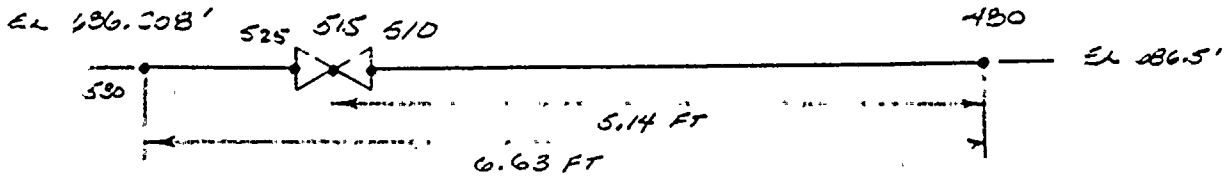
FIGURE 4.4.1-4

BY CHM DATE 3-22-83
CHKD. BY KJG DATE 3-23-83

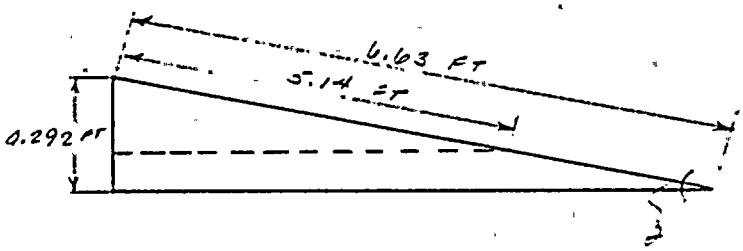
UNIT 1 FLUID VOLUME CALCULATION PORV INLET.

SHEET NO. 5 OF 6
PROJ. NO. 5364

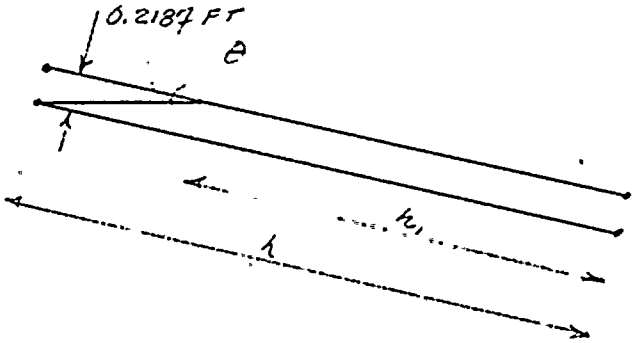
VALVE #3: NRV 151
3 IN SCH 160 PIPING AREA = 0.0376 FT²



OVERALL SLOPE: 0.292 FT



SLOPE TO THE VALVE = 0.226 FT $\theta = 2.524°$



$$\tan 2.524° = \frac{0.21874 \text{ FT}}{h - h_1}$$

$$h - h_1 = 4.96 \text{ FT}$$

FIGURE 4.4.1-5

BY CMM DATE 3-22-83
CHKD. BY KJG DATE 3-23-83

UNIT 1 FLUID VOLUME CALCULATION PORV INLET

SHEET NO. 6 OF 6
PROJ. NO. 5364

VOLUME OF FRUSTRUM

$$V_{TOT} = 1.5708\, r^2 (h_1 + h)$$

$$r = 0.10935 \text{ FT}$$

$$h_1 = 0.18 \text{ FT}$$

$$h = 5.14 \text{ FT}$$

$$V_{TOTAL} = 1.5708 (.10935 \text{ FT})^2 (0.18 \text{ FT} + 5.14 \text{ FT})$$

$$V_{TOTAL} = 0.0997 \text{ FT}^3$$

EQUIVALENT SLUG LENGTH (PIPE FULL)

$$L_{EQ} = 2.657 \text{ FT}$$

FIGURE 4.4.1-6

BY KJG DATE 3-23-83
CHKD. BY CLH DATE 3-24-83

PORV INLET SLUG MODELED FOR RELAP UNIT #1

SHEET NO. 1 OF 3
PROJ. NO. 5364

@ 2500 psia $v_g = .13068 \frac{ft^3}{lbm}$

$v_f = .02859 \; ft^3/lbm$

Valve #1
NRV 153

$Vol_{liquid} = .0921 \; ft^3$
$Vol_{vapor} = .0885 \; ft^3$

$m_{liquid} = (.0921 \; ft^3) / (.02859 \; ft^3/lbm)$
$= 3.221 \; lbm$

$m_{vapor} = (.0885 \; ft^3) / (.13068 \; ft^3/lbm)$
$= .677 \; lbm$

$$quality = \frac{.677}{3.221 + .677} = .174$$

Valve #2
NRV 152

$Vol_{liquid} = .1140 \; ft^3$
$Vol_{vapor} = .0694 \; ft^3$

$m_{liquid} = (.1140 \; ft^3) / (.02859 \; ft^3/lbm)$
$= 3.987 \; lbm$

$m_{vapor} = (.0694 \; ft^3) / (.13068 \; ft^3/lbm)$
$= .531 \; lbm$

$$quality = \frac{.531}{3.987 + .531} = .118$$

FIGURE 4.4.2-1

BY KJG DATE 3-23-83
CHKD. BY CMM DATE 3-24-83

PORV INLET SLUG MODELED FOR RELAP UNIT #1

SHEET NO. 2 OF 3
PROJ. NO. 5364

Valve #3

$$Vol_{liquid} = 0.0999 \ ft^3$$
$$Vol_{vapor} = 0.0932 \ ft^3$$

$$m_{liquid} = (0.0999 \ ft^3)/(.02859 \ ft^3/lbm)$$
$$= 3.494 \ lbm$$

$$m_{vapor} = (0.0932 \ ft^3)/(.13068 \ ft^3/lbm)$$
$$= .713 \ lbm$$

$$quality = \frac{.713}{3.494 + .713} = .169$$

FIGURE 4.4.2-2

TELEDYNE ENGINEERING SERVICES

BY KTG DATE 3-23-83
CHKD. BY CMM DATE 3-24-83

PORV INLET SLUG MODELED FOR RELAP UNIT #1

SHEET NO. 3 OF 3
PROJ. NO. 5364

VALVE I.D	QUALITY	LENGTH of SLUG	C.VOL	AREA	PIPE SIZE
#1 NRV 153	.174	4.808 FT	609	.0376 ft²	3 INCH SCH 160
#2 NRV 152	.118	4.882 FT	509	.0376 ft²	3 INCH SCH 160
#3 NRV 151	.169	5.14 FT	409	.0376 ft²	3 INCH SCH 160

FIGURE 4.4.2-3

4.5 Unit 1 PORV Model

The inlet piping to the PORV's is sloped toward the valves. Therefore, during normal operating conditions a saturated water (condensate) loop seal is formed at the inlet to the PORV.

As specified in American Electric Power's letter of November 29, 1982, referring to PORV transient conditions, the following cases were modeled:

Case	Transient
1	Condensate/Steam Discharge
2	400° Solid Liquid Discharge

4.5.1 The way in which the condensate/steam case loopseal was to be modeled was decided by using two methods on a small sample model.

a. Low Quality Steam Loop Seal (Saturated Conditions)
b. Solid Loop Seal (Saturated Conditions)

A low quality steam loop seal produced oscillatory mass flow rates through the valve. These oscillations were severe enough to cause rejection of this model and to choose the solid condensate case. These oscillations are the result of numerical instabilities in RELAP's choking correlation. This is due to the severe change in sonic velocities in the transition range between subcooled water and steam.

4.5.2 Both cases (loop seal and 400°F solid liquid discharge) were modeled and run on RELAP and REPIPE. The resulting force time histories were compared. It was not clear at this level which case was more severe. Therefore, the force time histories for both cases were input to the structural program. It could then be seen that the 400°F solid water discharge condition was the governing case.

Both the loop seal and the solid water case exhibited unstable behavior (oscillations in the flow rate). The loop seal case showed these oscillations in the transition region at the tail end of the loop seal as it passed through the valve. RELAP tends to cause flow rate oscillations because of the severe change in sonic velocities between subcooled water and low quality steam. These flow rate oscillations result in high forces which tend to be overly conservative.

In the 400°F subcooled water case, the reason for the flow rate oscillation was more obscure. At approximately .400 seconds the flow suddenly decreases approximately 30 lbm/sec in 1msec.

This can be seen in Section 4.7.2. A careful review of the RELAP output did not reveal a good physical reason for such behavior. Reasons for such behavior could be

1. A sudden reduction in the valve area vs. time data.

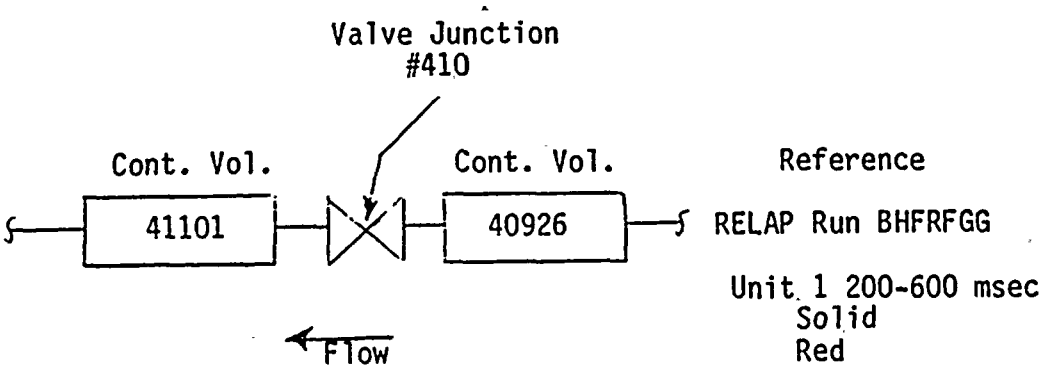
2. A build up of back pressure in the discharge line which will cause the valve flow rate to suddenly decrease.

3. A sudden decrease in pressure in the pressurizer boundary condition which would result in reduced-flow.

All these things were checked to see if they were possible sources of the flow rate fluctuation. But the review indicated that they were not the source of the problem.

A partial tabulation of this review is shown below:

UNIT 1



Time	Junction #410 Flow	Cont. Vol. #40926 Q	Cont. Vol. #41101 P	Cont. Vol. #40926 P
.408	111.18	0.0	248.89	2342.8
.409	83.424	0.0	245.55	3058.

It can be seen that the downstream pressure does not exhibit a sudden increase that would reduce the flow through the valve. The upstream quality remains zero so that the flow through the valve is subcooled.

The pressure increases upstream which corresponds to a sudden reduction in flow area. However, the flow area increases it does not decrease. The pressurizer time dependent volume does not exhibit any sudden change in pressure which would correspond to this flow change.

Past experience with the RELAP programs has shown problems with subcooled water and low quality steam flow. These problems have manifested themselves as severe oscillations in the flow rate. It is our opinion that the results from the RELAP run are highly conservative and overpredict the fluid forces.

When the fluid forces from this RELAP run are combined with the seismic, deadweight, and thermal expansion loads, the allowables were slighlty exceeded. Since the principal fluid loads appear to be a result of an instability in the flow rate predicted by RELAP and not a result of an actual physical phenomena, it was decided that these loads were overly conservative and could justifiably be reduced by 20%. The fluid forces presented in Section 4.8 and elsewhere in Section 4.0 are the as calculated loads and have not been reduced by 20%.

It should be noted that an alternative modeling practice that could have been employed in the solution of this problem would have been to make the PORV valves time dependent junctions and specify the valve flow rate. Had this been done, the flow rate oscillation and their resulting forces would never have occurred.

4.6 Valve Flow Rate Calculation

Valve Type	TES Flow Rate Calculated LBM/HR	Max Rating* For Steam @ 3% Accum.	Bore Area (IN^2)	Opening Time (Sec)
Crosby Safety Relief Valve	523,332	435,000	3.6 in^2	0.010 (Ref. 18)
Masoneilan Power Operated Relief Valve	199,000	--	--	1.0 (Ref. 16)

* The maximum rating for steam at 3% accumulation value is from the Crosby Valve and Gage Safety Valve Drawing No. H-51688, Revision A.

4.6.1 The valve flow rates used in RELAP analysis of the SRVs were obtained by increasing the ASME rated flow by 15%; 10% to consider the ASME underating of the theoretical flow and 5% to cover tolerances. TES flow rate calculations are included in Figure 4.6.1.

$W_T = 51.5\ AP$ Napier's Eq.

ASME rated flow:

$$W_R = 51.5A\ (1.03P + 14.7)(.9)(.975)C \qquad \text{(Ref. 17)}$$

where:

W_T = theoretical flow

W_R = rated flow

coefficients:

1.03 - applies 3% accumulation

0.975 - valve flow coefficient

0.9 - represents theoretical flow rate reduced 10% to equal ASME rating

The equation TES uses to calculate the valve flow rate is

$$Wmax = 1.05 \times 51.5A\ (1.03P + 14.7)C(0.975)$$

This is an increase of 15% above the ASME rated flow as explained above.

4.6.2 The Masoneilan PORV maximum flow rate for steam was taken from the EPRI Safety and Relief Valve Test Report as 199,000 lbm/hr (Table 4.5.1-1b). A valve opening time of 1.0 seconds is used based on total valve opening times of all Masoneilan valves tested listed in Table 4.5.2-1. Since full open times averaged 2.76 seconds, with a minimum value of 1.64 seconds, TES has assumed 100% opening in 1.0 second, because independent testing has shown that flow is not always directly proportional to stem travel. Most often full flow is obtained before full stem travel. Because 1 second is a very long opening time, this was not considered overly conservative.

BY KJG DATE 6-2-83
CHKD. BY CMM DATE 6-3-83

CROSBY 6M6 VALVE
RELAP5 MODEL FLOW AREA CALCULATIONS

SHEET NO. 1 OF 2
PROJ. NO. 5364

Ref. 1. ASME Sec III N.B. - 7731.1 and N.B. 7734.2 (1980)
2 CROSBY 6M6 Model HB-BP-86 Valve Drawing No. H-51688 Rev. A.
3 Computer Run BAICDRØ

CROSBY 6M6 Valve Properties

Manufacturer : CROSBY Valve & Gage Company
Type : Spring loaded Safety Valve
Drawing No : H-51688 Revision A
Bore Area : 3.600 in²
Design Setpoint Pressure : 2485 psig
Model No. HB-BP-86 6M6

Calculation of Max Flow Rate (W_{max})

The following assumptions and considerations are made in determining W_{max}.

1) This calculation is used only to determine a Relap5 orifice size and does not necessarily represent pressurizer input conditions.

2) The max flow W_{max} was increased by 5%. This accounts for the 5% flowrate tolerance discussed in NB-7734.2

USING Ref 1.

$$W_{max} = 1.05 \times 51.5 \times 3.600 (2485 \times 1.03 + 14.7) C (0.975)$$

$$C = \frac{0.1906\, P_{set} - 1000}{0.2292\, P_{set} - 1061} \qquad P_{set} = 2485 \text{ psig}$$

$C = 1.0711$ after substituting,

$$W_{max} = 523{,}340.55 \text{ lb/hr}$$

Fig.4.6.1-1

BY KJG DATE 6-2-83
CHKD. BY CYM DATE 6-3-83

CROSBY 6M6 VALVE
RELAP5 MODEL FLOW AREA CALCULATION

SHEET NO. 2 OF 2
PROJ. NO. 5364

SV

$$W_{max} = 523{,}340.55 \text{ lb/hr} = 145.37 \text{ lb/sec}$$

USING THE COMPUTER RUN BAICDRØ

Valve full open area in the run BAICDRØ = 0.0232 ft^2

Flow rate @ full opening = 153.19 lb/sec

Flow rate @ 90% opening of the valve = 138.01 lb/sec

RELAP5 flow area which delivers W_{max} = 145.37 lb/sec is calculated by interpolation.

$$A_{flow} = \left[0.9 + 0.1 \frac{145.37 - 138.01}{153.19 - 138.01}\right](0.0232)$$

$$= 0.022 \text{ ft}^2 \text{ (SV)}$$

PORV

Similarly,

$$W_{max} = 199{,}000 \text{ lb/hr} = 55.28 \text{ lb/sec}$$

Flow area to deliver 55.28 lb/sec

$$A_{flow} = \left[0.3 + 0.1 \frac{55.28 - 48.001}{63.4 - 48.001}\right] 0.0232$$

$$= 0.00806 \text{ ft}^2 \text{ (PORV)}$$

Fig.4.6.1-2

4.7 RELAP Plots

The following plots represent RELAP mass flows, pressures and qualities at various points along the discharge piping. Since RELAP had to be restarted, the plot time scales may vary (i.e. 0.0 - 0.2 seconds or 0.0 - 0.400 seconds). Also, the ordinate axis may not always be correct; many times multipliers will be off (CDC is aware of this problem in RELAP). However, they do depict the trend accurately and are calculated and reported in RELAP every 0.001 seconds. Correct peaks and times at which they occur are listed with each trace.

Plot Set	Transient
4.7.1 Unit 1	Condensate/Steam Case
4.7.2 Unit 1	400° Solid Liquid Case
4.7.3 Quarter Model	Cold Loop Seal/Steam Case

A RELAP volume schematic precedes each plot set.

4.7.1 Unit 1 - Condensate/Steam Case

BY [illegible] DATE [illegible]
CHKD. BY CHM DATE 5-26-83

RELAP MODEL SCHEMATIC
UNIT 1 PORV INLET

SHEET NO. 1 OF 3
PROJ. NO. 5364

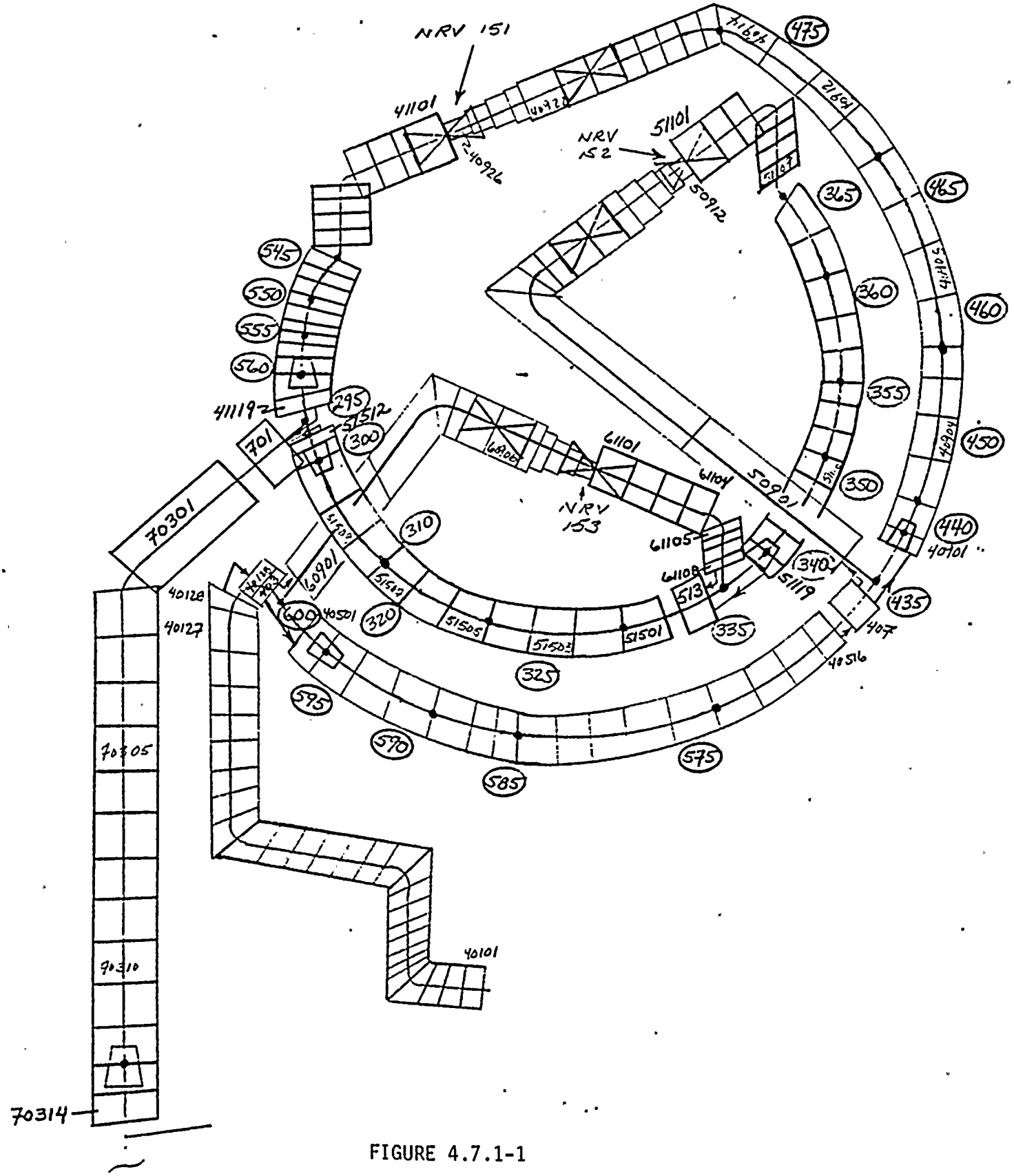


FIGURE 4.7.1-1

BY KAM DATE 4-14-83
CHKD. BY CHM DATE 5-23-83

RELAP MODEL SCHEMATIC
UNIT 1 MAIN ARCS

SHEET NO. 2 OF 3
PROJ. NO. 5364

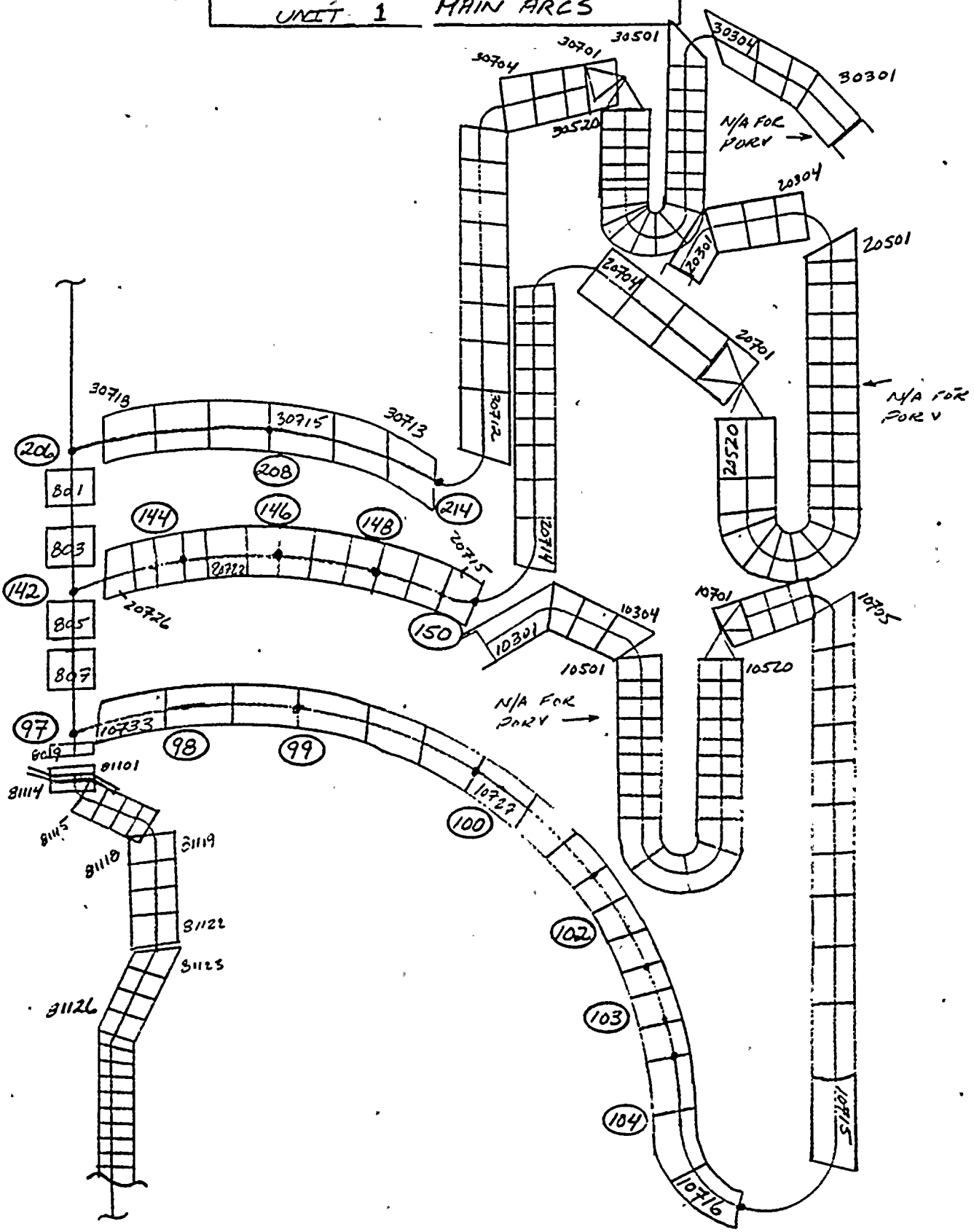


FIGURE 4.7.1-2

BY RAM DATE 4-14-83
CHKD. BY CHH DATE 5-23-83

RELAP MODEL SCHEMATIC
UNIT 1 DOWNSTREAM (12IN)

SHEET NO. 3 OF 3
PROJ. NO. 5364

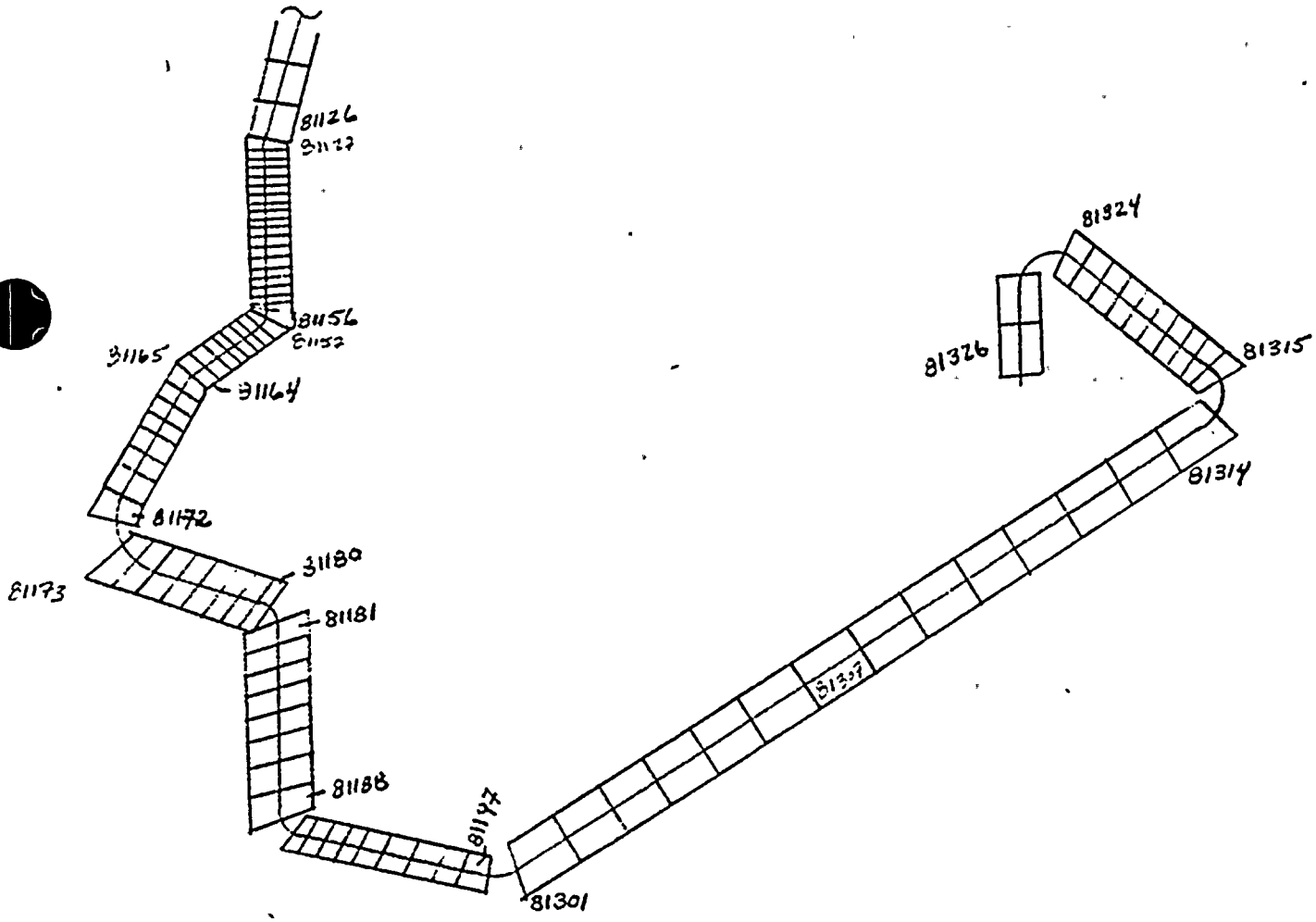


FIGURE 4.7.1-3

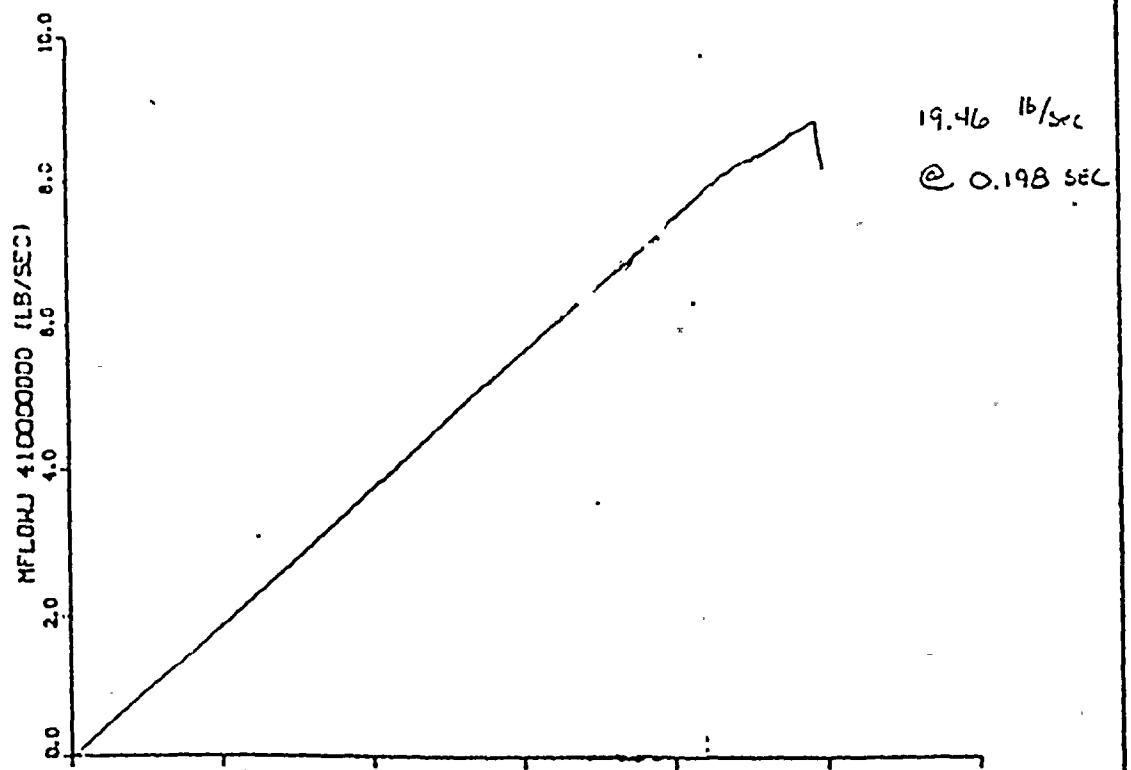
BY CMH DATE 4-29-83
CHKD. BY JBM DATE 4-29-83

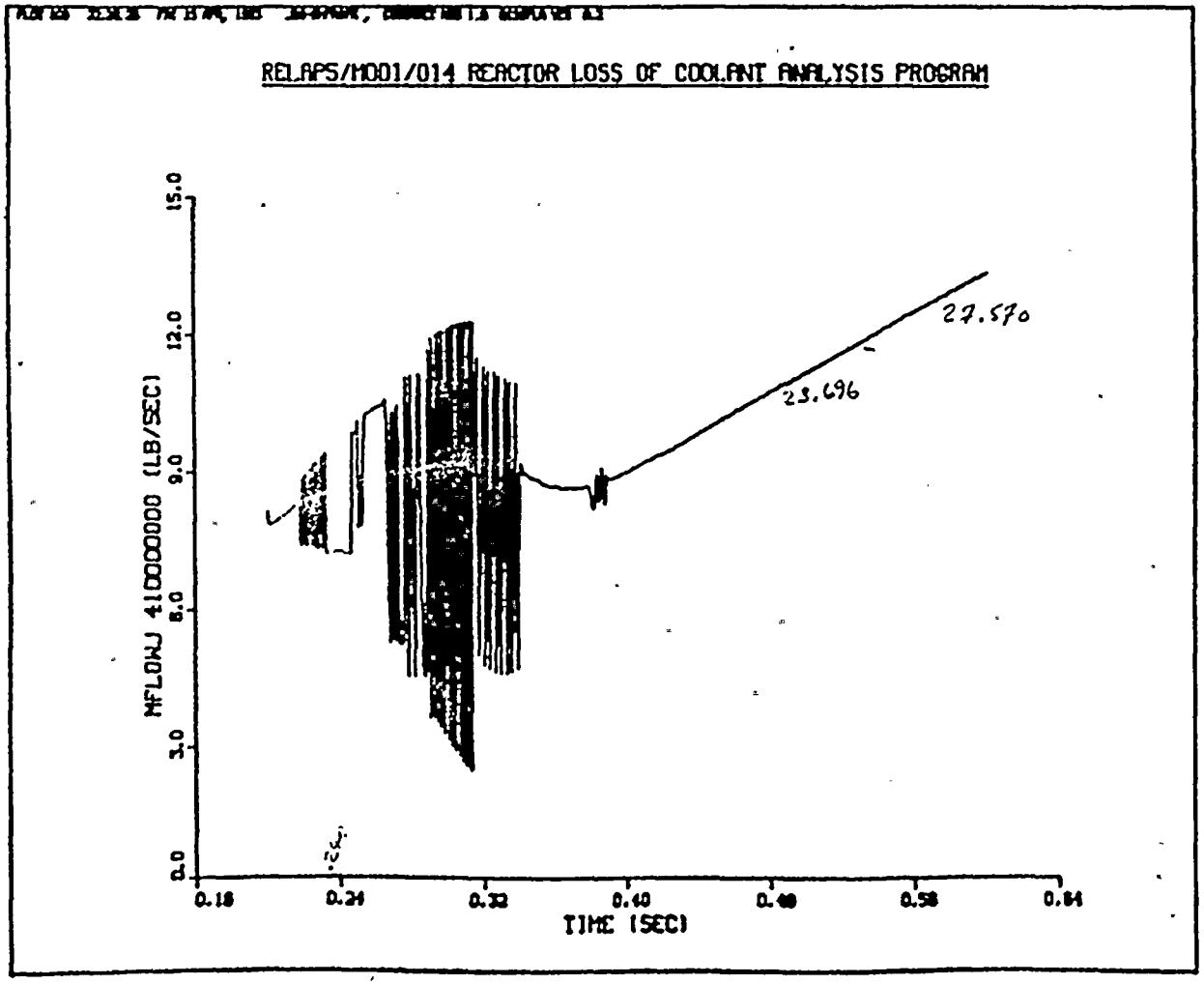
TELEDYNE ENGINEERING SERVICES

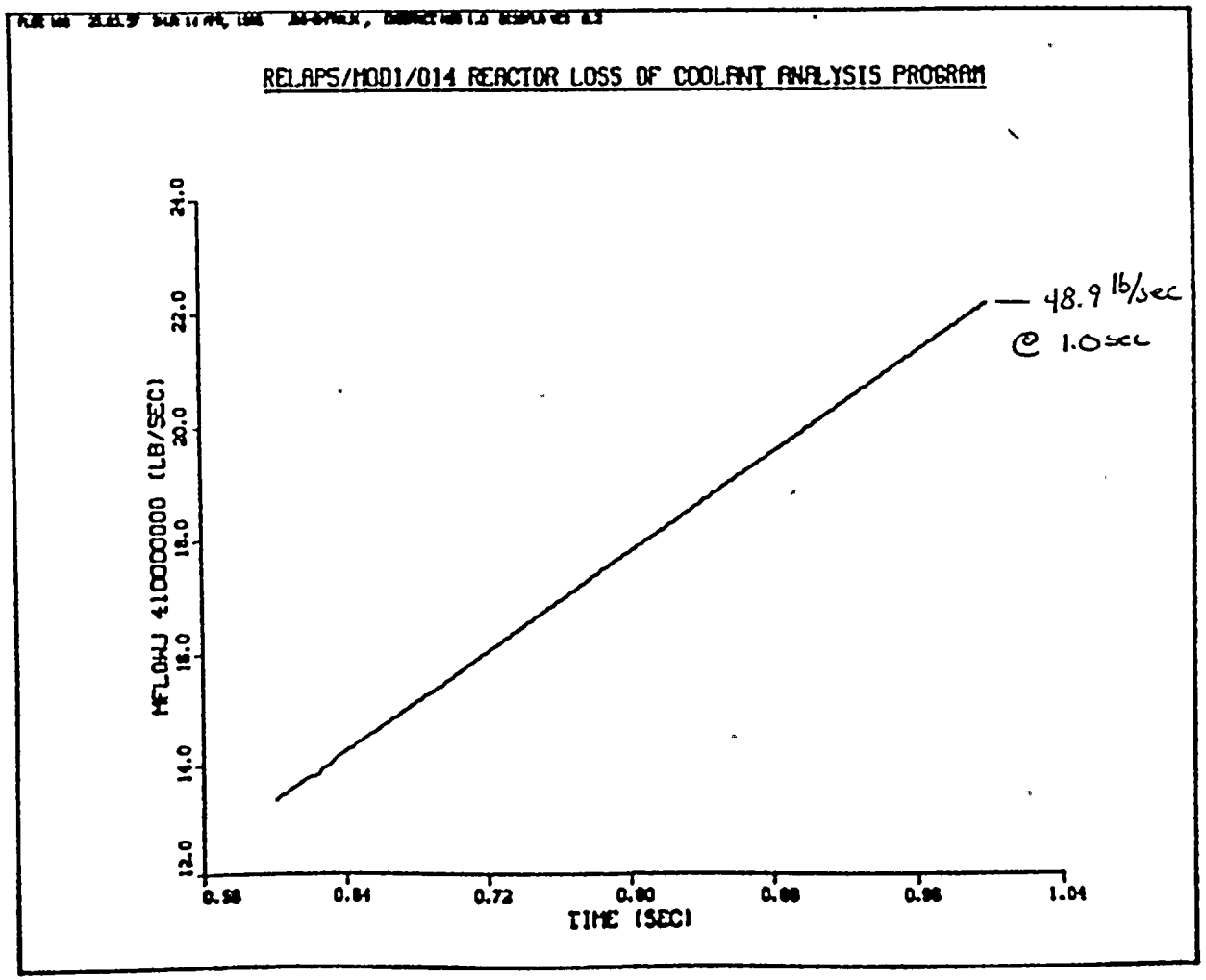
Technical Report
TR-5364-1
Revision 0

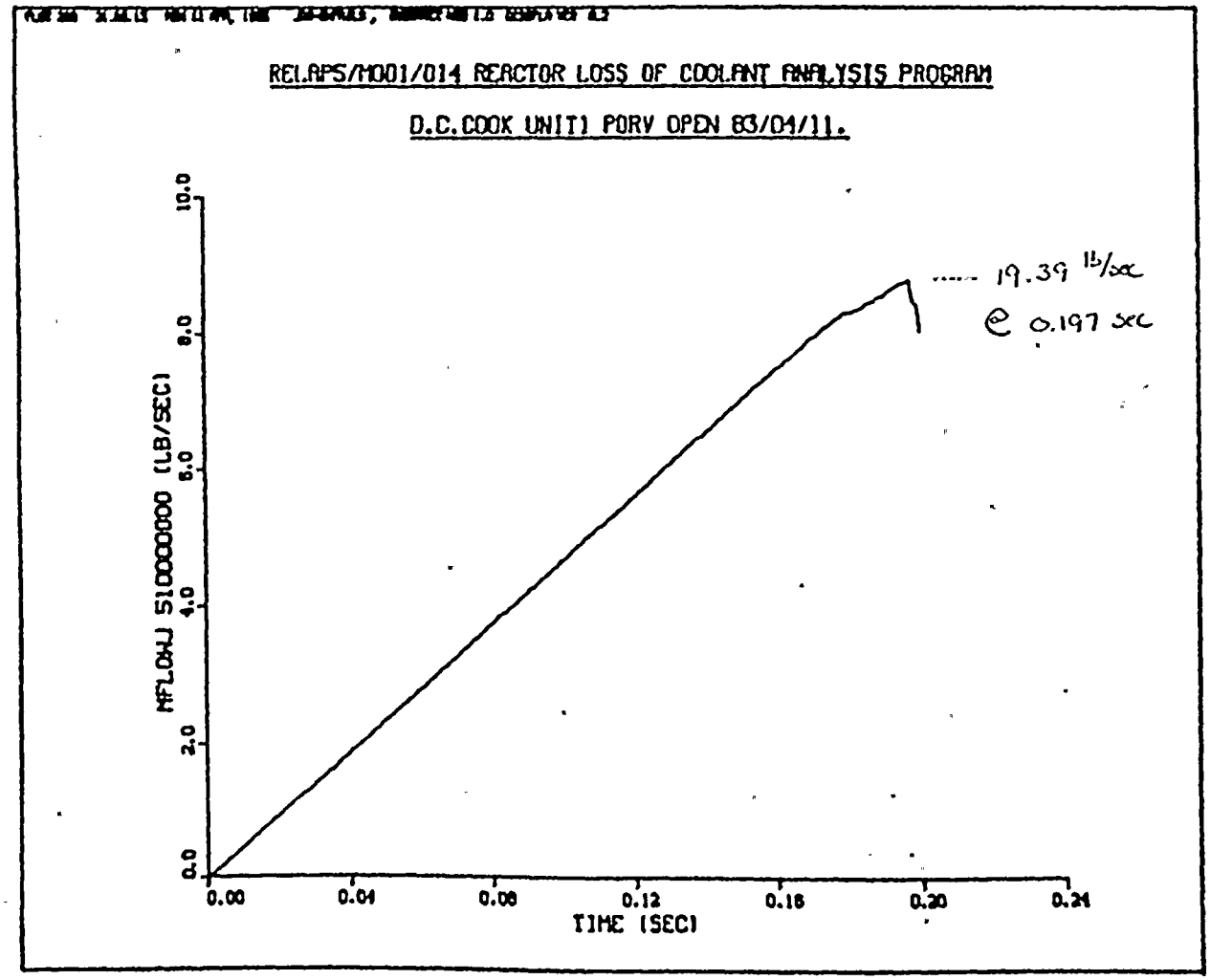
RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM

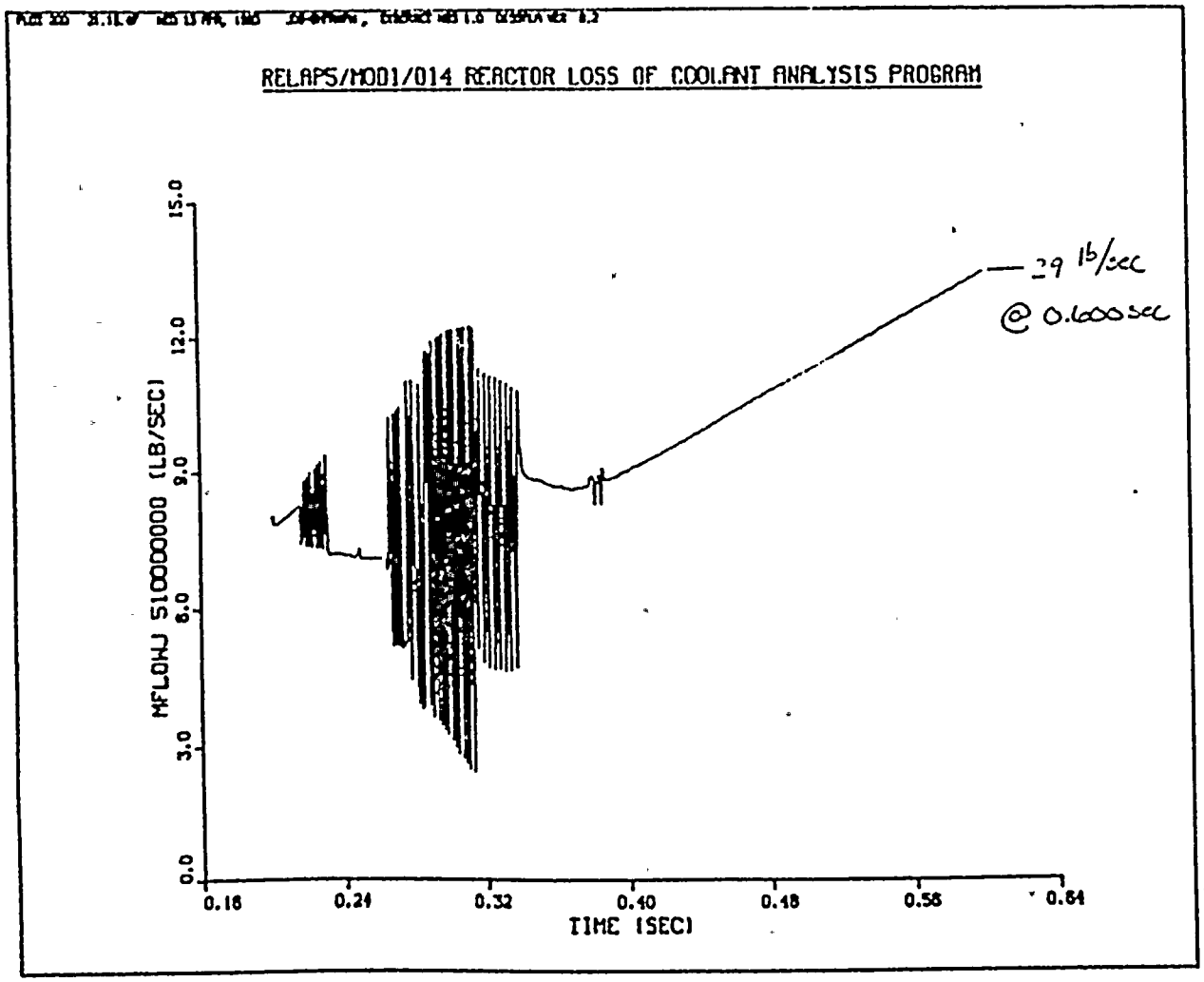
D.C.COOK UNIT1 PORV OPEN 83/04/11.

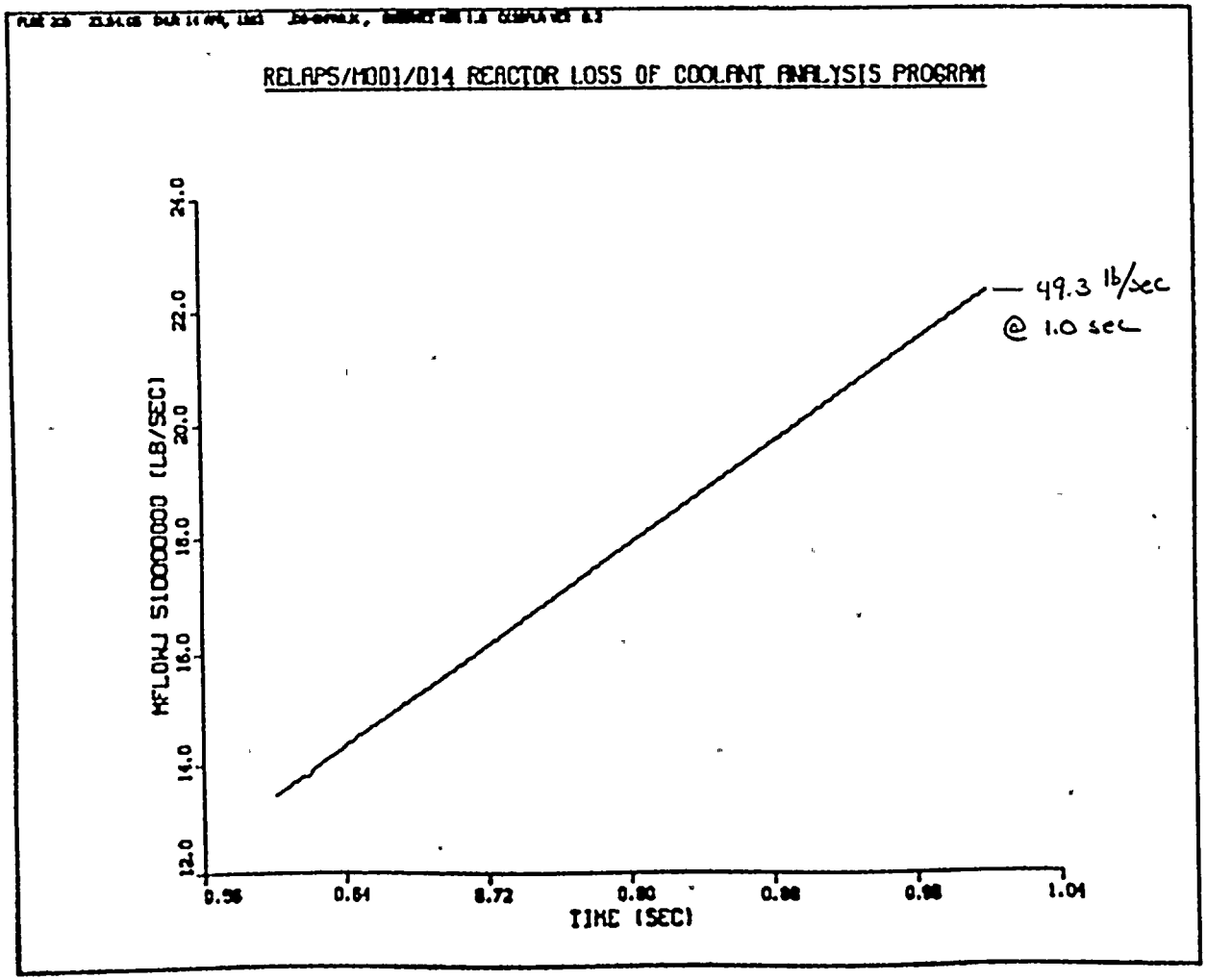


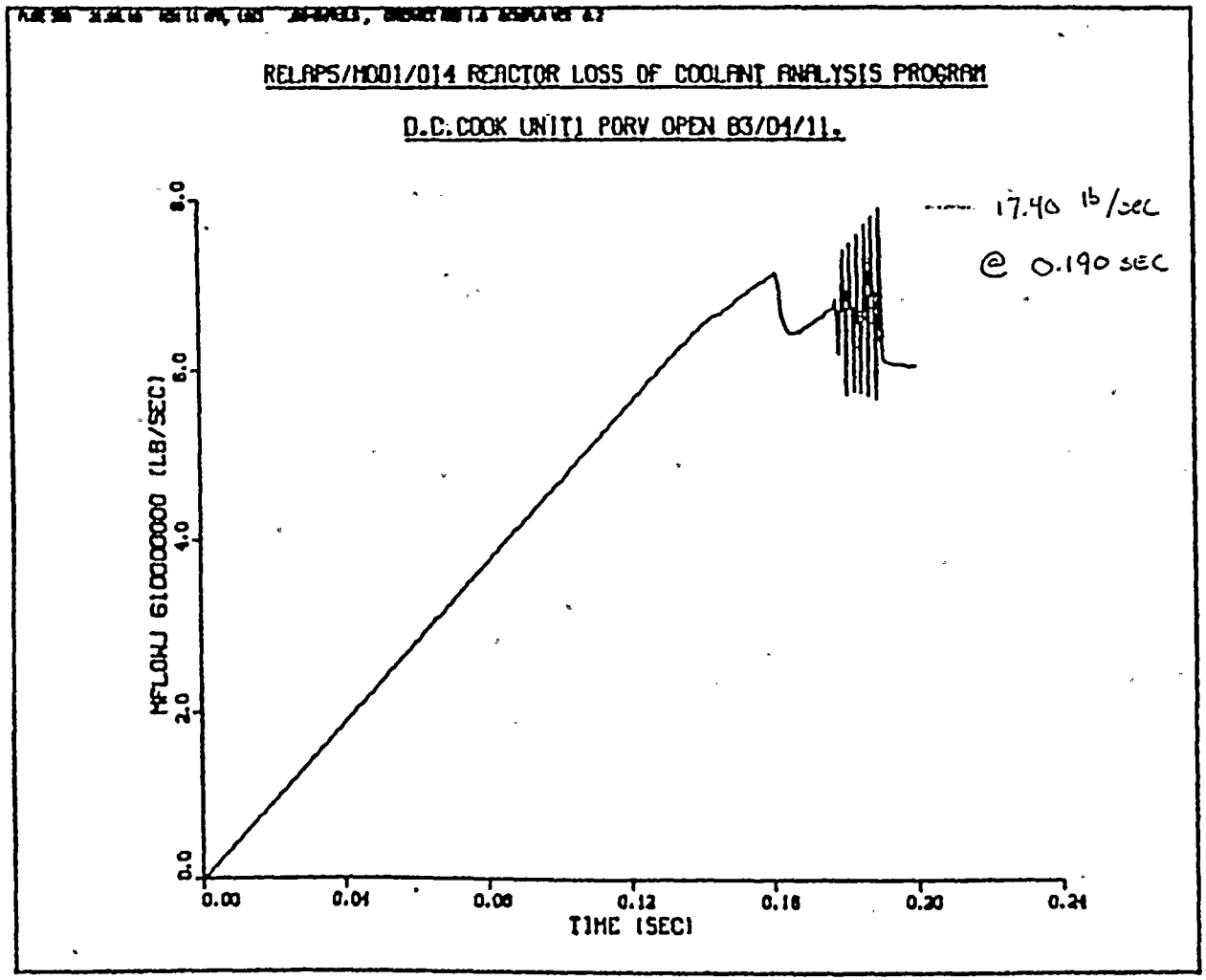

RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
MFLOWJ 41000000 (LB/SEC)
0.0
3.0
6.0
9.0
12.0
15.0
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)
27.570
23.696

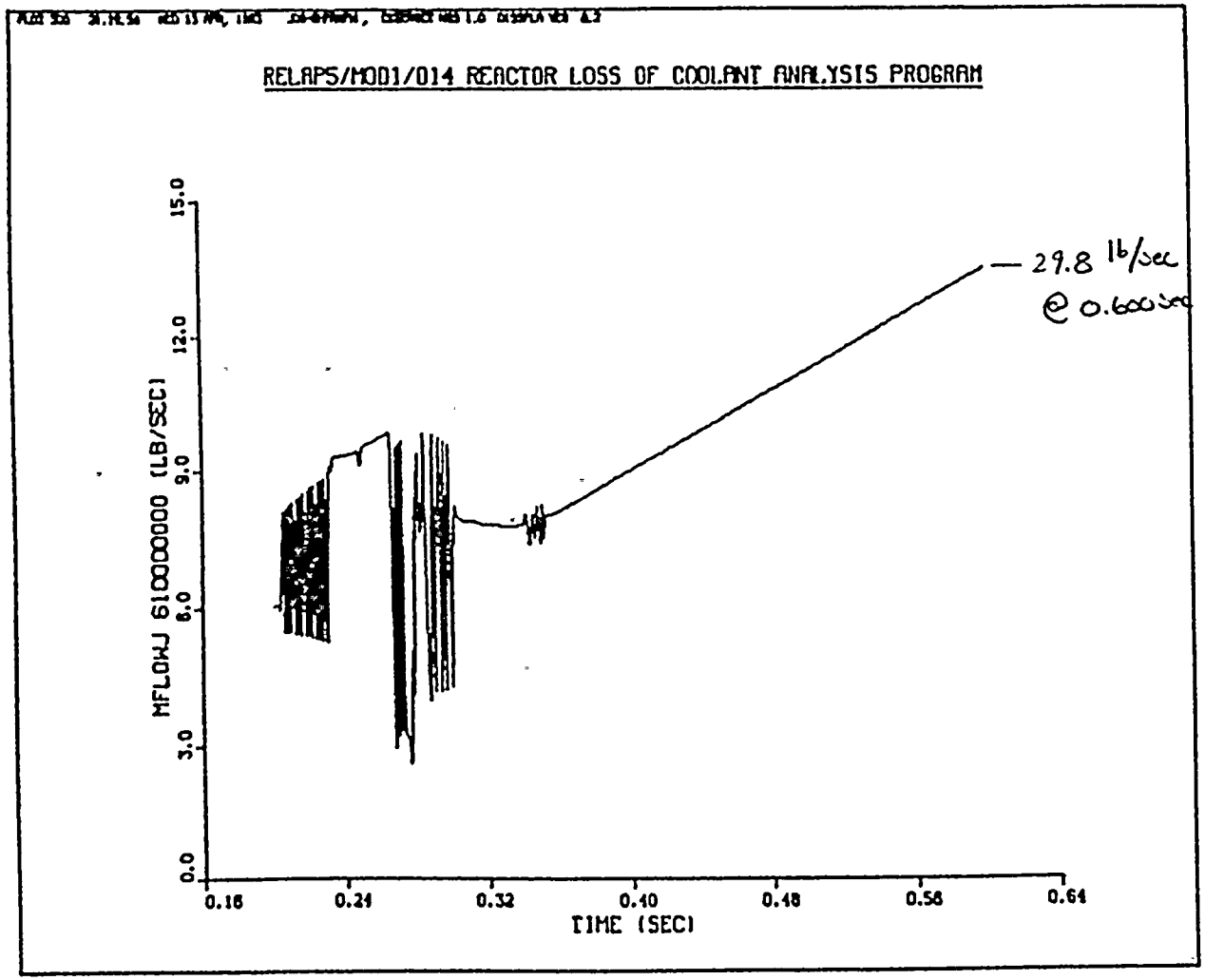

RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
MFLOWJ 41000000 (LB/SEC)
12.0
14.0
16.0
18.0
20.0
22.0
24.0
0.56
0.64
0.72
0.80
0.88
0.96
1.04
TIME (SEC)
48.9 lb/sec
@ 1.0 sec

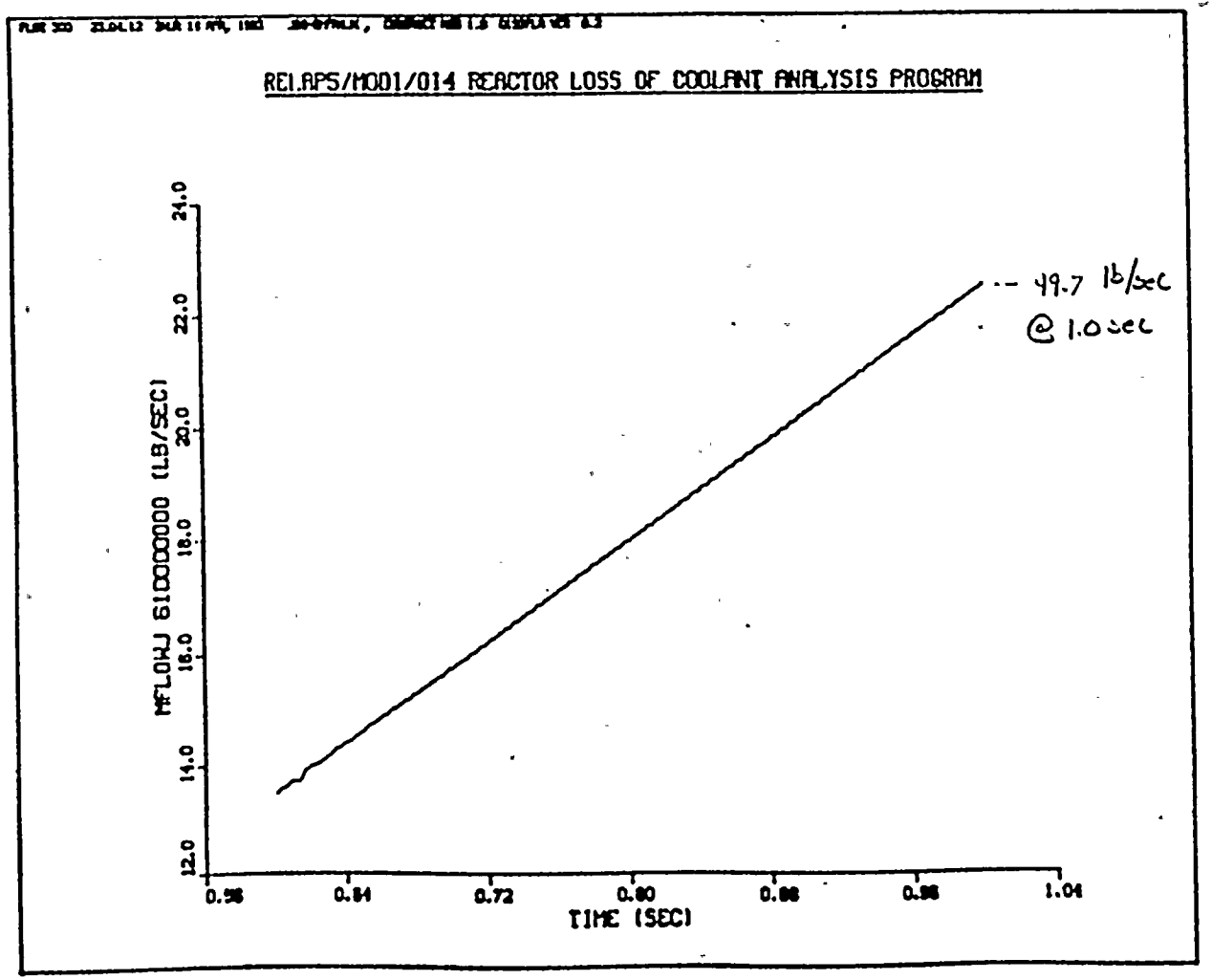

RELAPS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/11.
MFLOWJ 510000000 (LB/SEC)
0.0
2.0
4.0
6.0
8.0
10.0
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)
19.39 lb/sec
@ 0.197 sec


RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
MFLOWJ 51000000 (LB/SEC)
0.0
3.0
6.0
9.0
12.0
15.0
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)
29 lb/sec
@ 0.600 sec

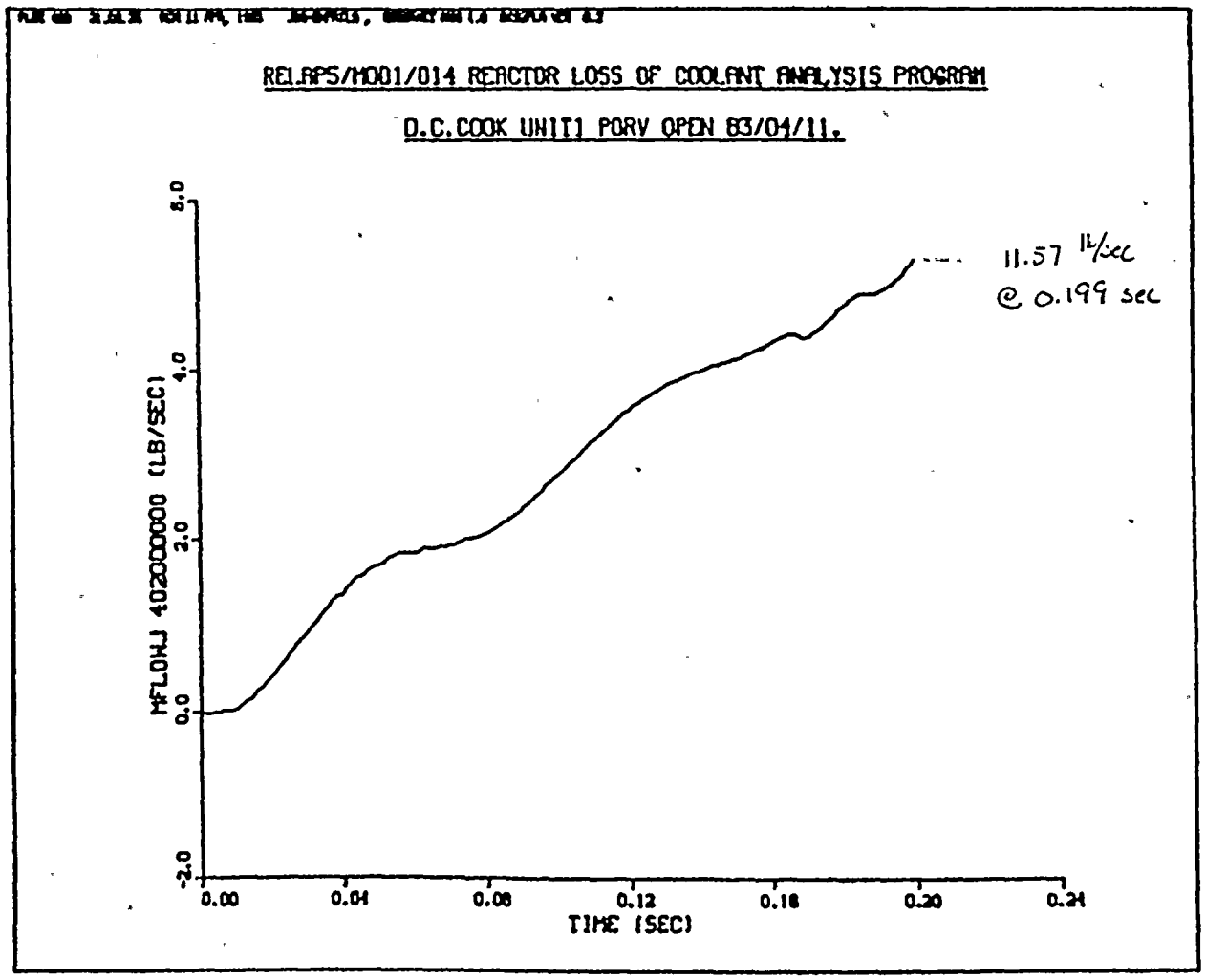

RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
MFLOWJ 510000000 (LB/SEC)
12.0
14.0
16.0
18.0
20.0
22.0
24.0
0.56
0.64
0.72
0.80
0.88
0.96
1.04
TIME (SEC)
49.3 lb/sec
@ 1.0 sec

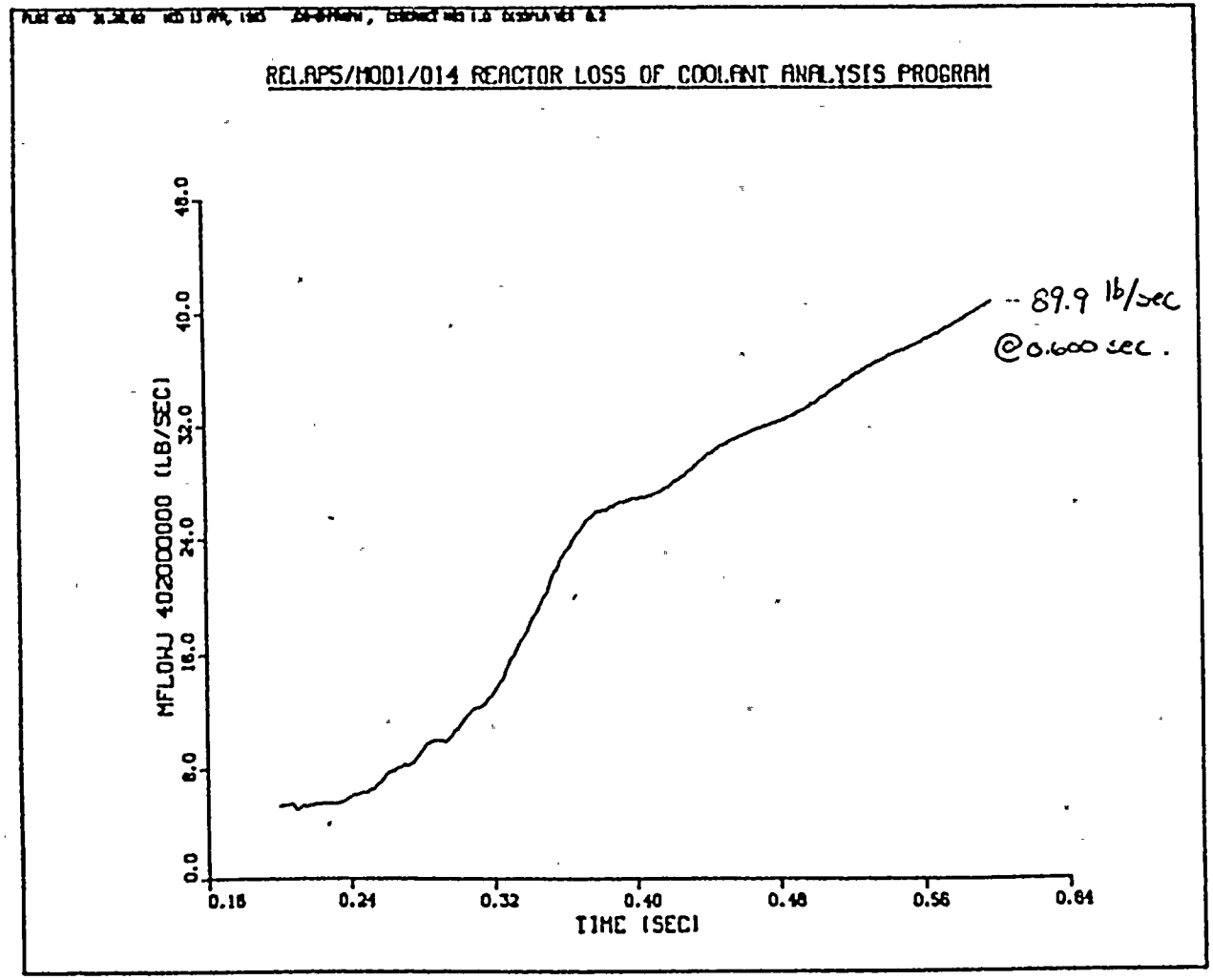

RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/11.
17.40 lb/sec
@ 0.190 SEC
MFLOWJ 610000000 (LB/SEC)
0.0
2.0
4.0
6.0
8.0
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)

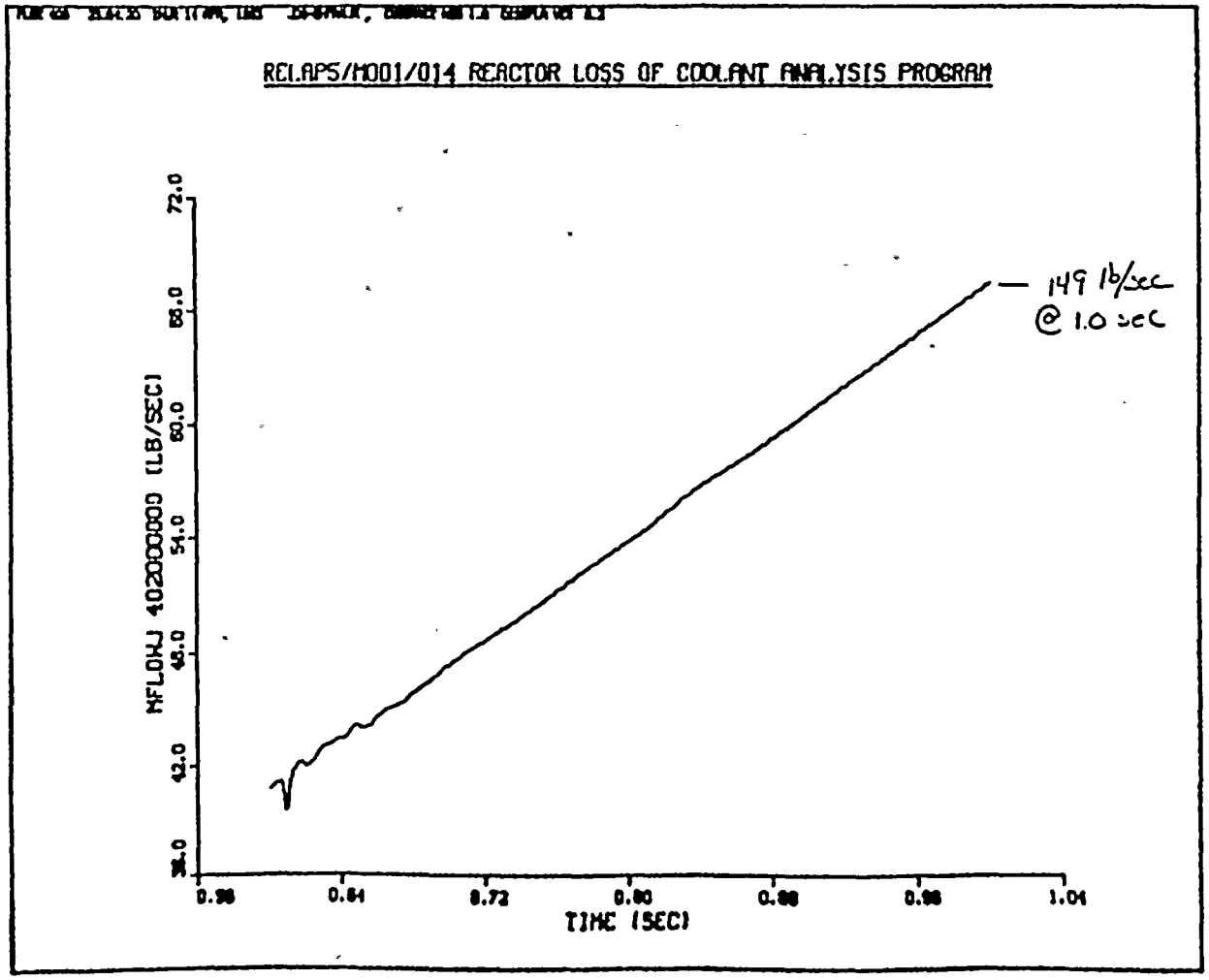

RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
MFLOWJ 61000000 (LB/SEC)
0.0
3.0
6.0
9.0
12.0
15.0
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)
29.8 lb/sec
@ 0.600 sec


REI.APS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
MFLOWJ 810000000 (LB/SEC)
12.0
14.0
16.0
18.0
20.0
22.0
24.0
0.56
0.64
0.72
0.80
0.88
0.96
1.04
TIME (SEC)
-- 49.7 lb/sec
@ 1.0 sec

BY UHM DATE 11-29-83
CHKD. BY JBV DATE 11-29-83




RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
MFLOWJ 40200000 (LB/SEC)
0.0
8.0
16.0
24.0
32.0
40.0
48.0
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)
89.9 lb/sec
@0.600 sec.


RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
MFLOWJ 40200000 (LB/SEC)
36.0
42.0
48.0
54.0
60.0
66.0
72.0
0.64
0.72
0.80
1.04
TIME (SEC)
149 lb/sec
@ 1.0 sec

BY JHM DATE 11-29-83
CHKD. BY JBL DATE 11-29-83

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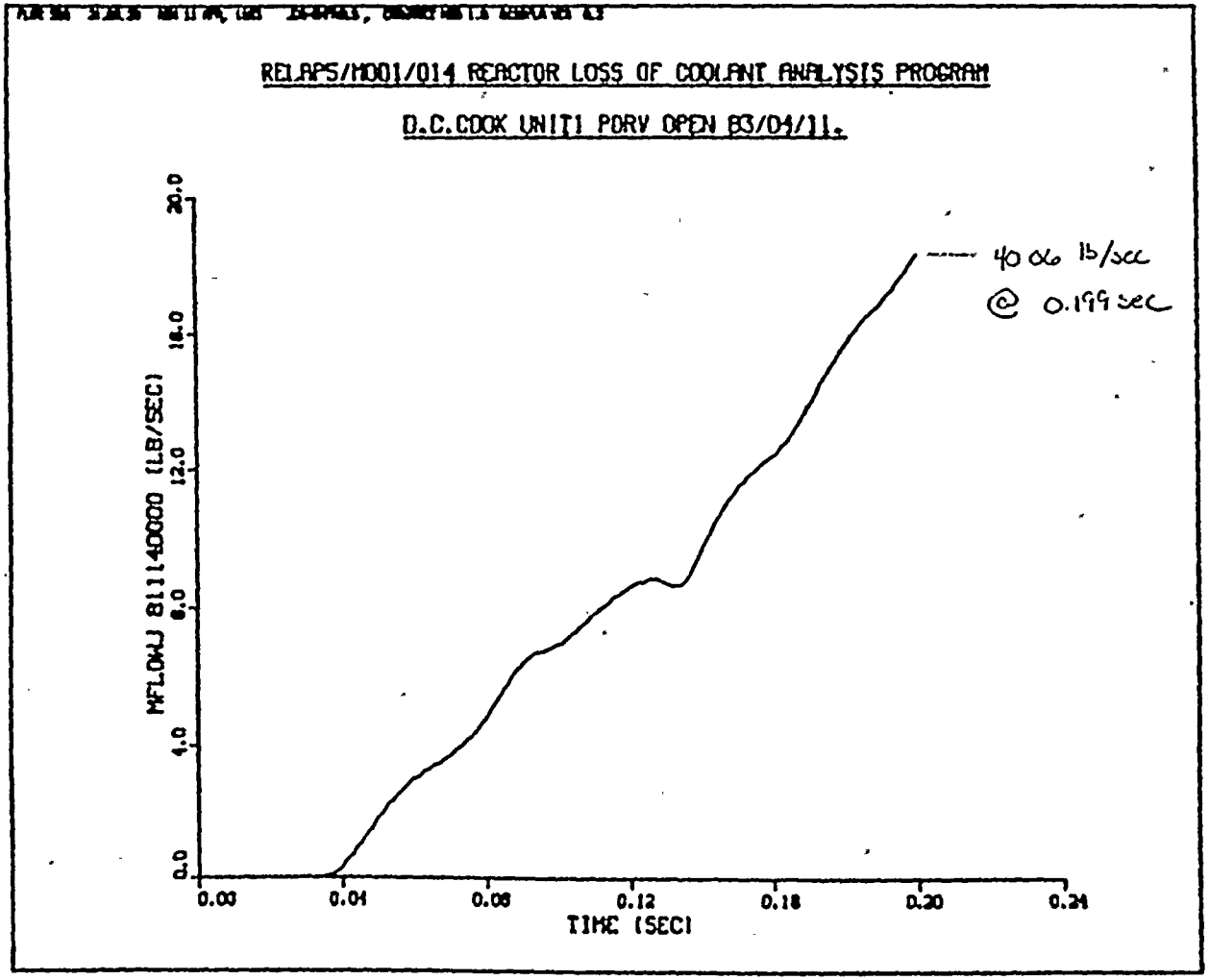
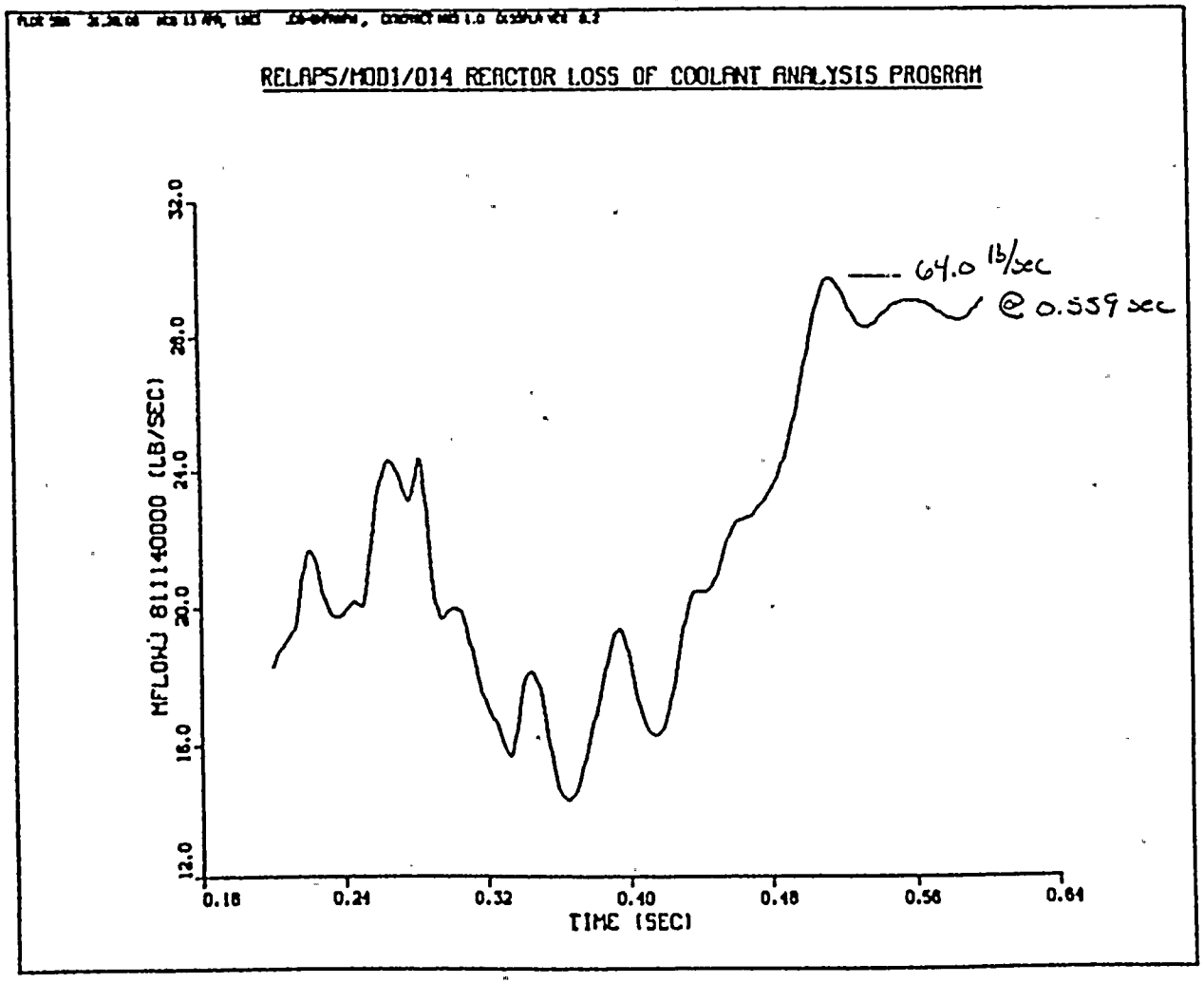
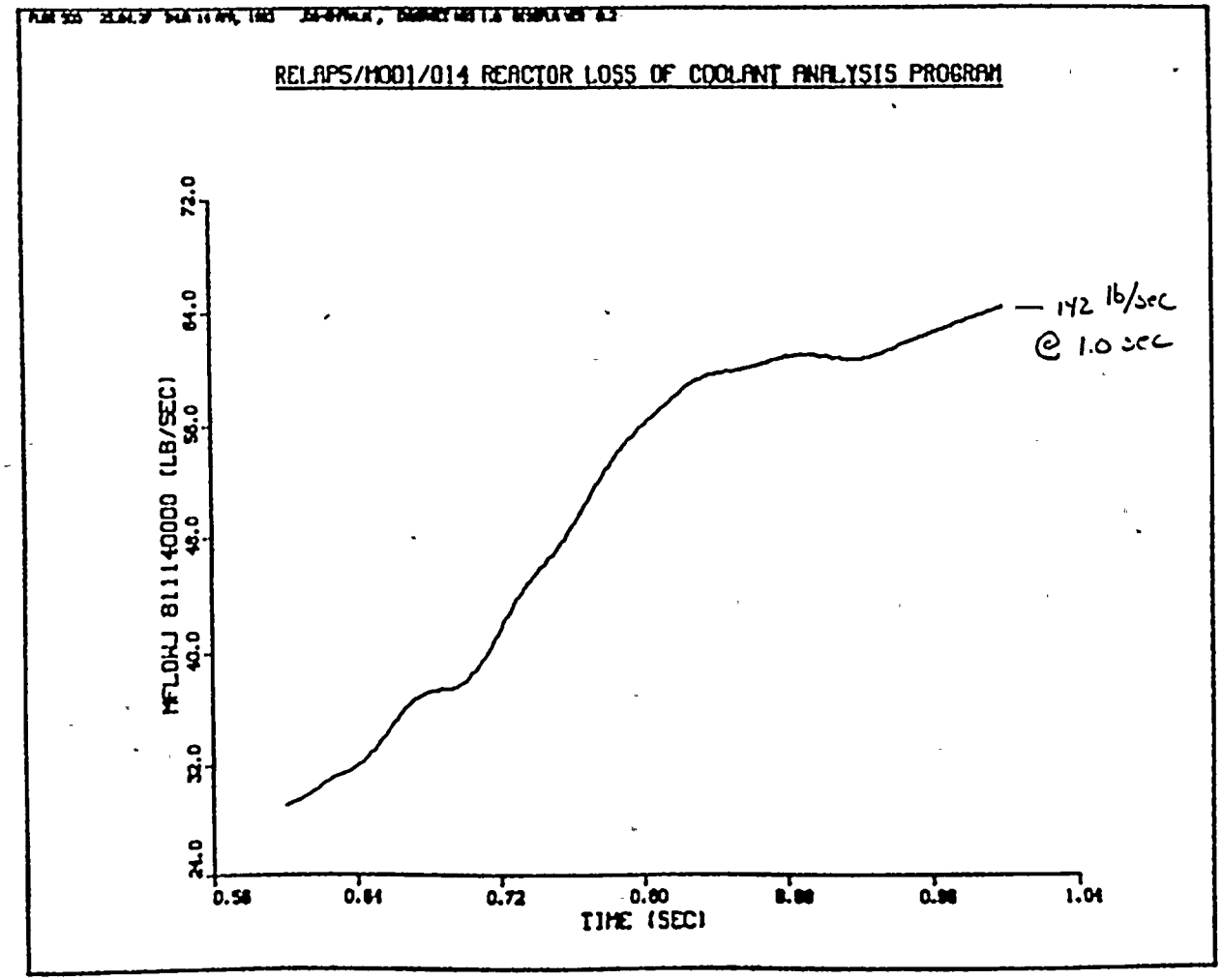



RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
MFLOWJ 81114000 (LB/SEC)
32.0
28.0
24.0
20.0
16.0
12.0
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)
64.0 lb/sec
@ 0.559 sec


RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
MFLOWJ 81114000D (LB/SEC)
24.0
32.0
40.0
48.0
56.0
64.0
72.0
0.56
0.64
0.72
0.80
0.88
0.96
1.04
TIME (SEC)
— 142 lb/sec
@ 1.0 sec

BY JHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83

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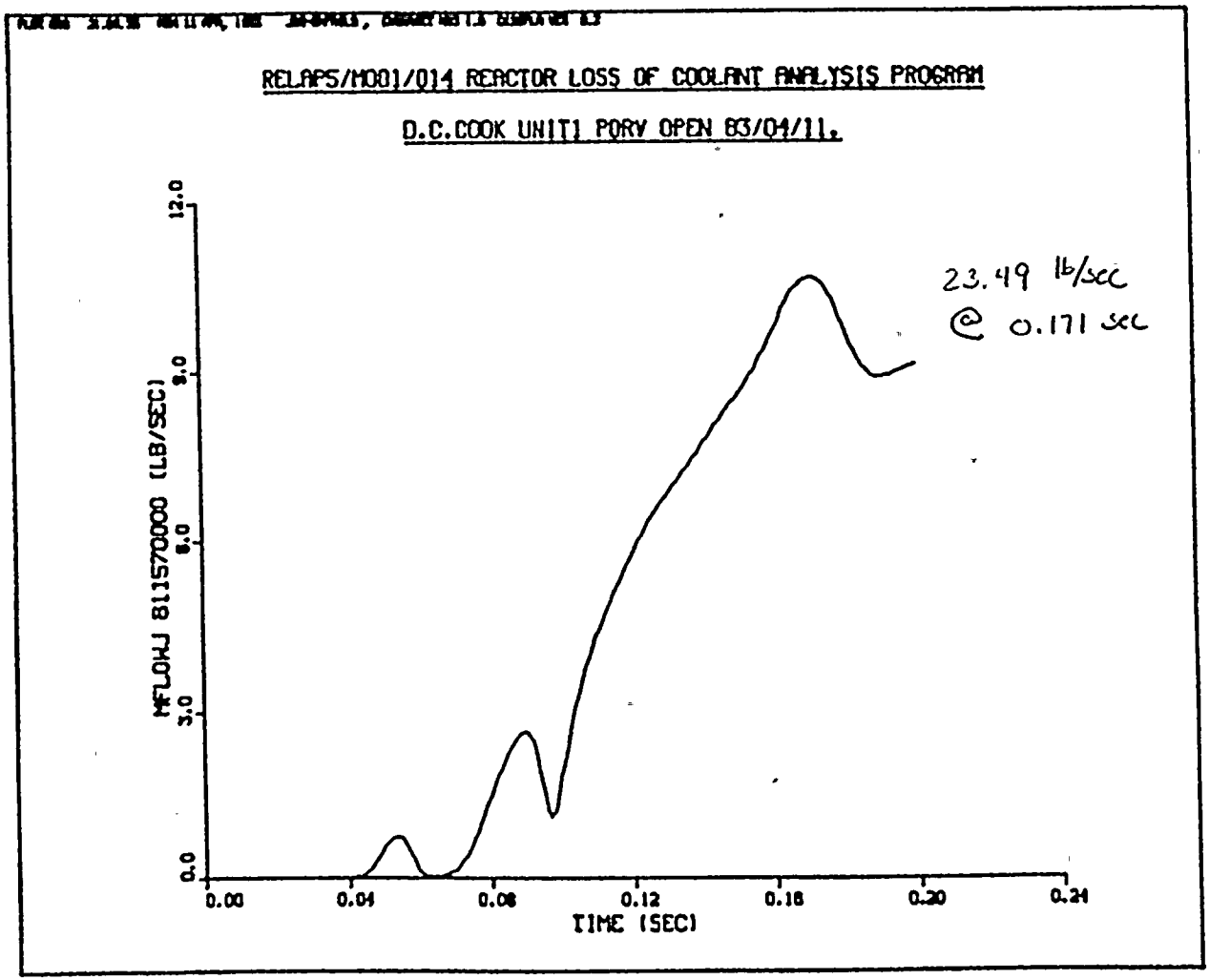
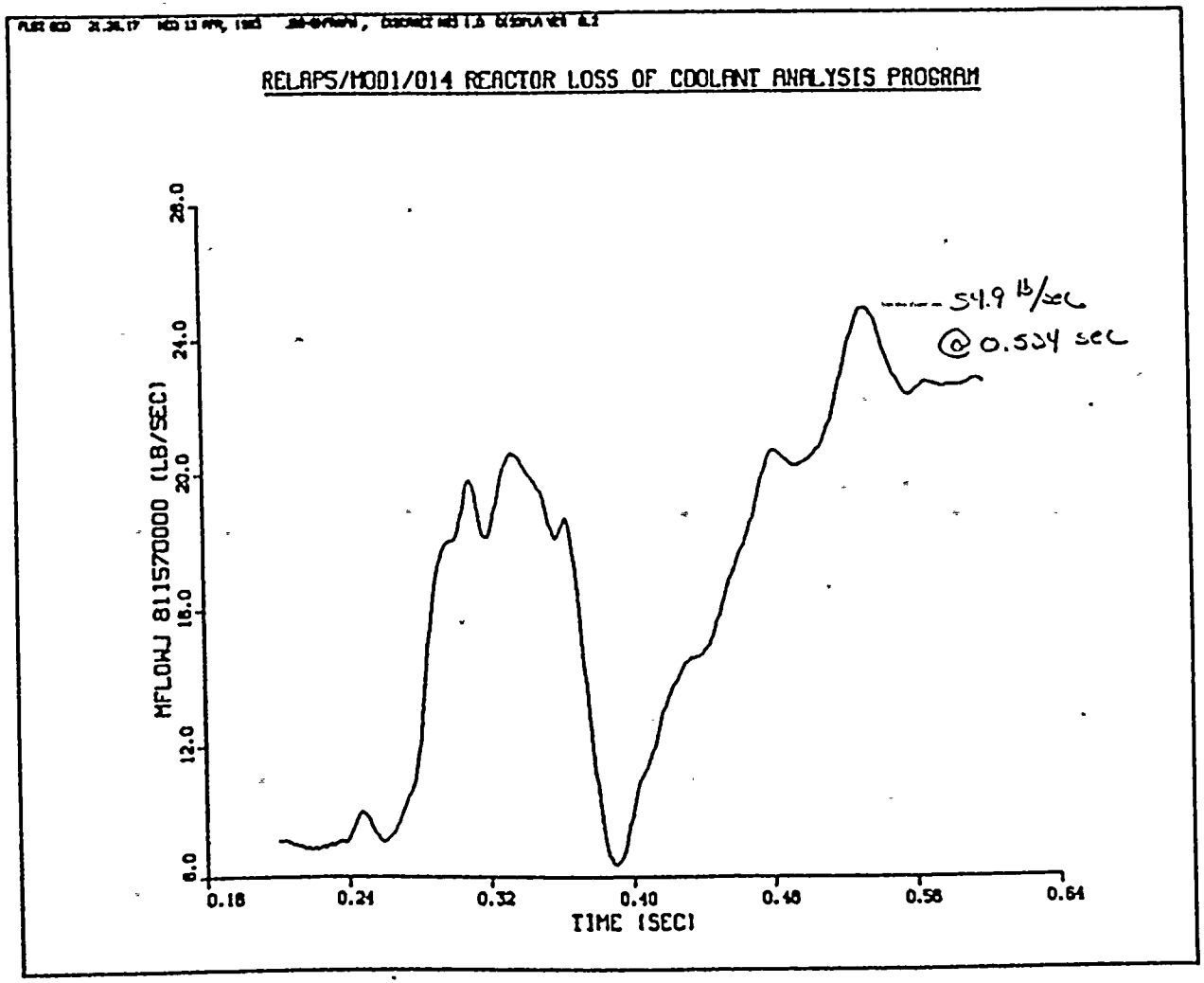
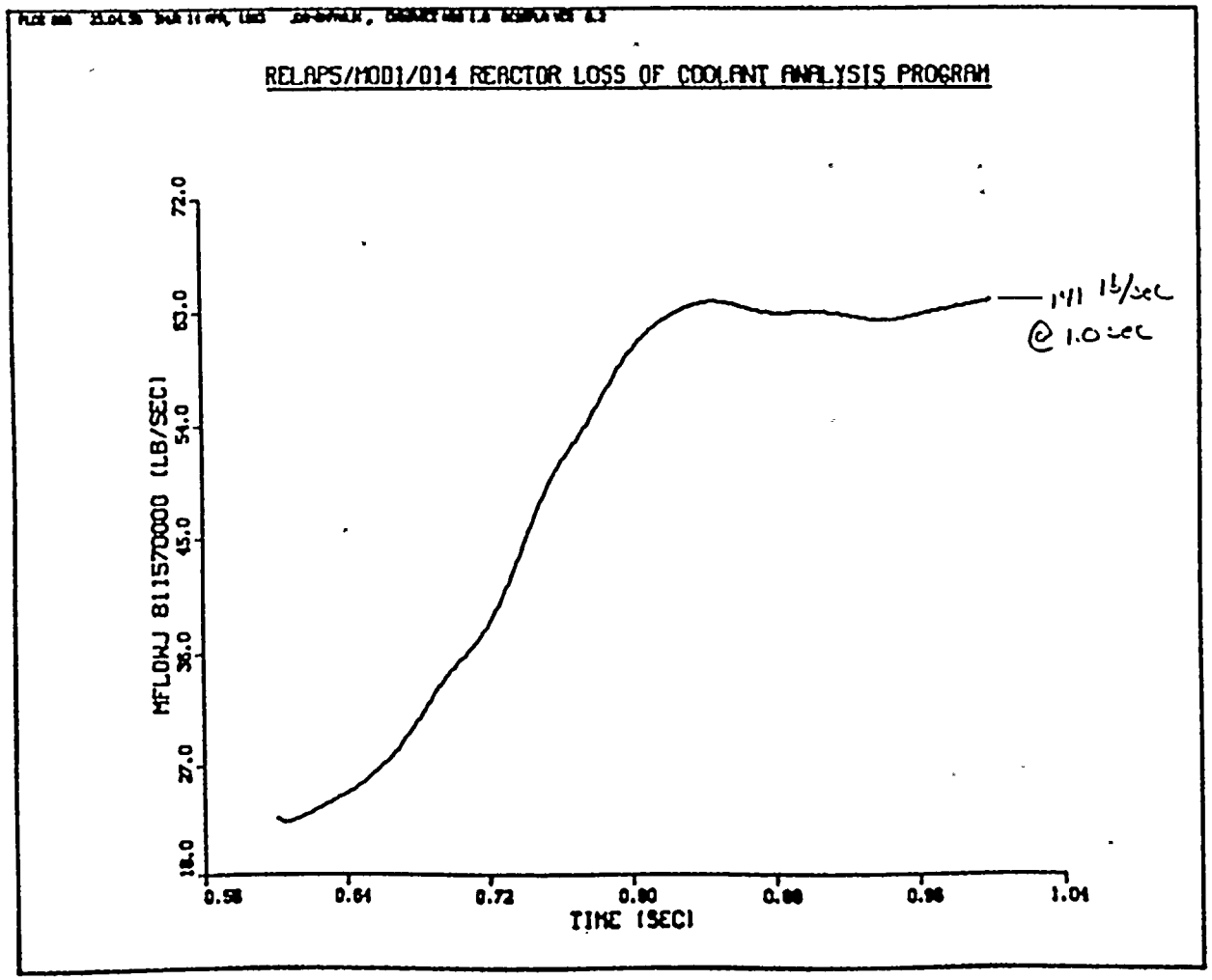



RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
MFLOWJ 81157000D (LB/SEC)
28.0
24.0
20.0
16.0
12.0
8.0
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)
54.9 lb/sec
@ 0.524 sec


RELAPS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
MFLOWJ 81157000D (LB/SEC)
18.0
27.0
36.0
45.0
54.0
63.0
72.0
0.56
0.64
0.72
0.80
0.88
0.96
1.04
TIME (SEC)
141 lb/sec
@ 1.0 sec

BY JHM DATE 11-29-83
CHKD. BY JBM DATE 11-29-83

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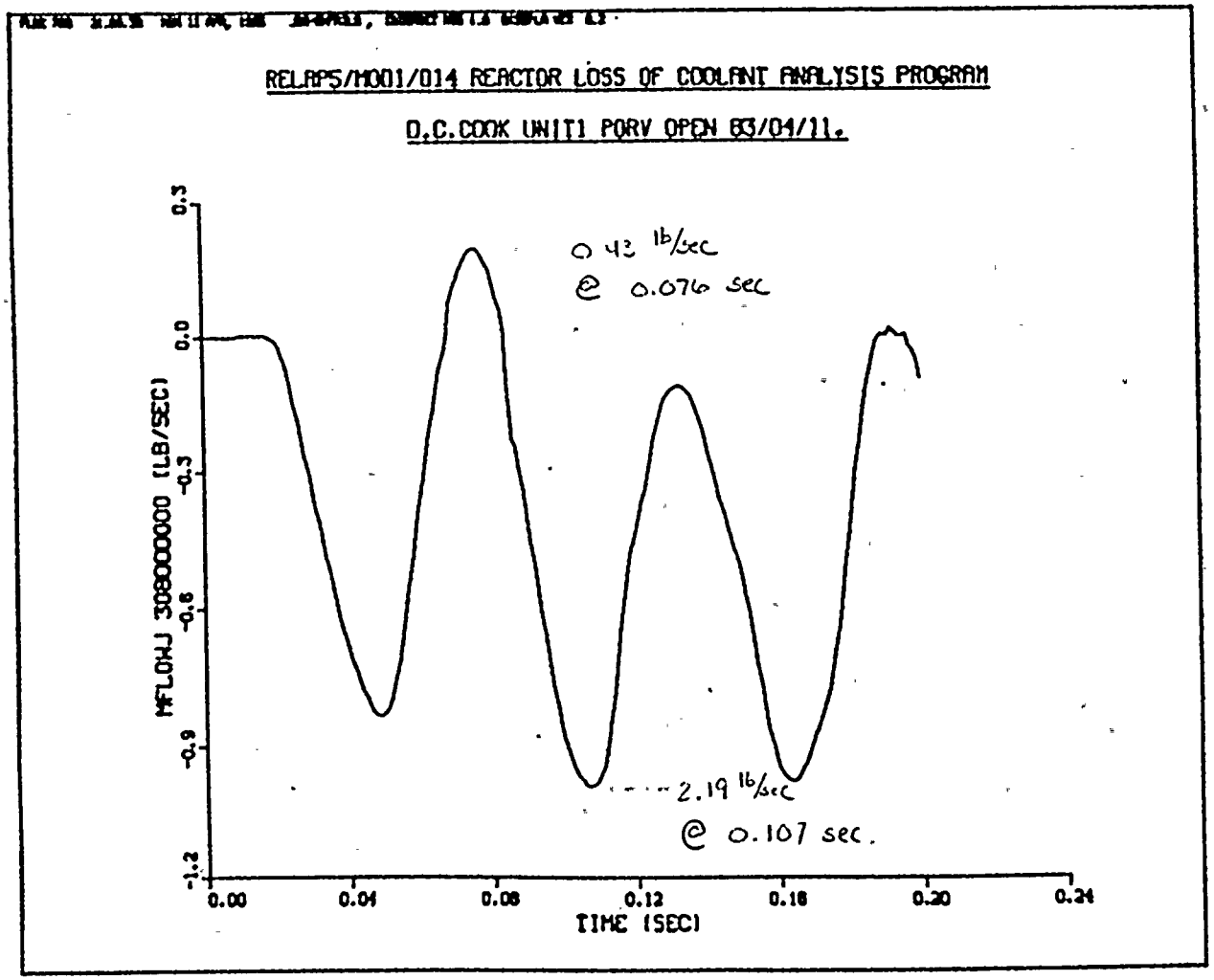
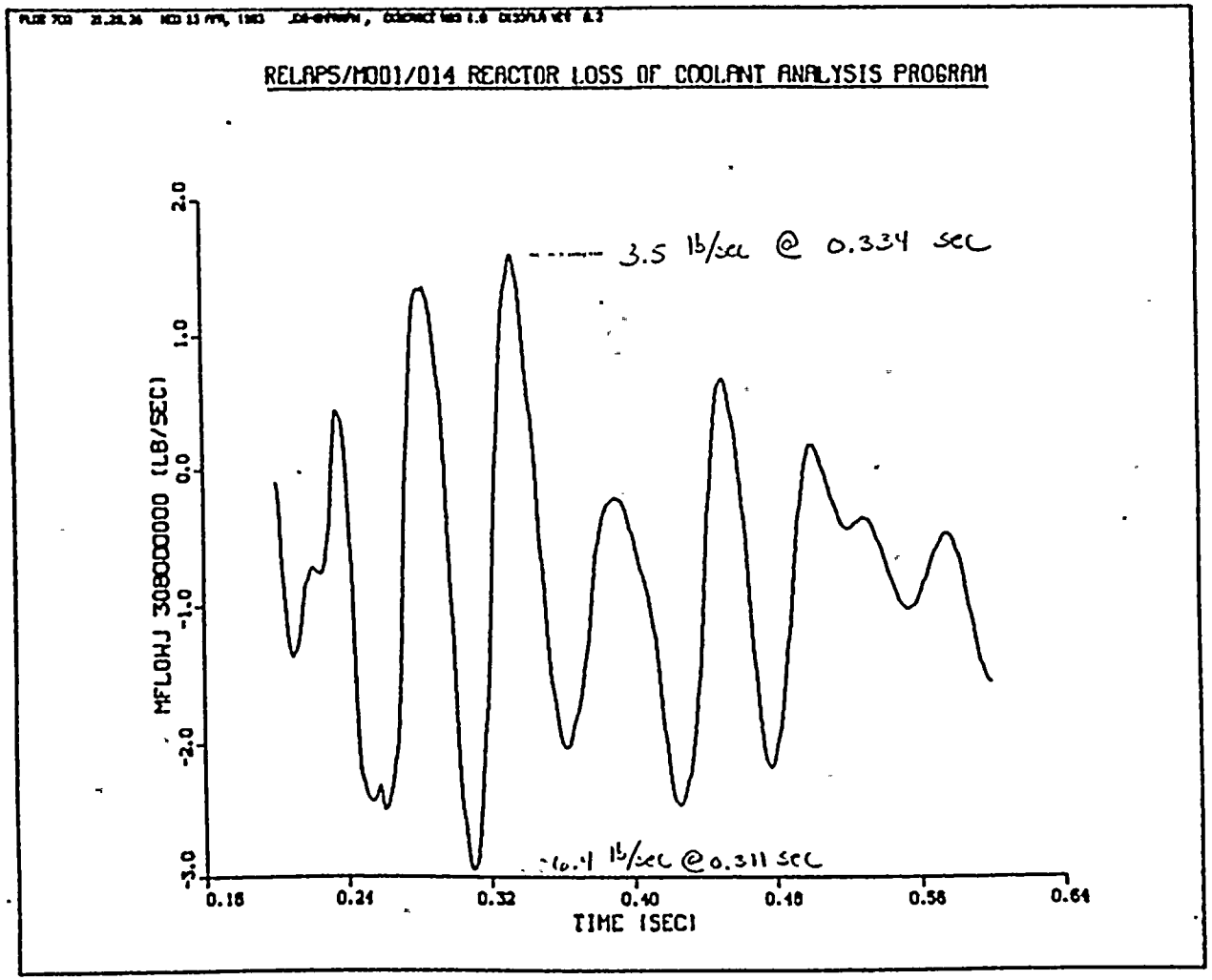
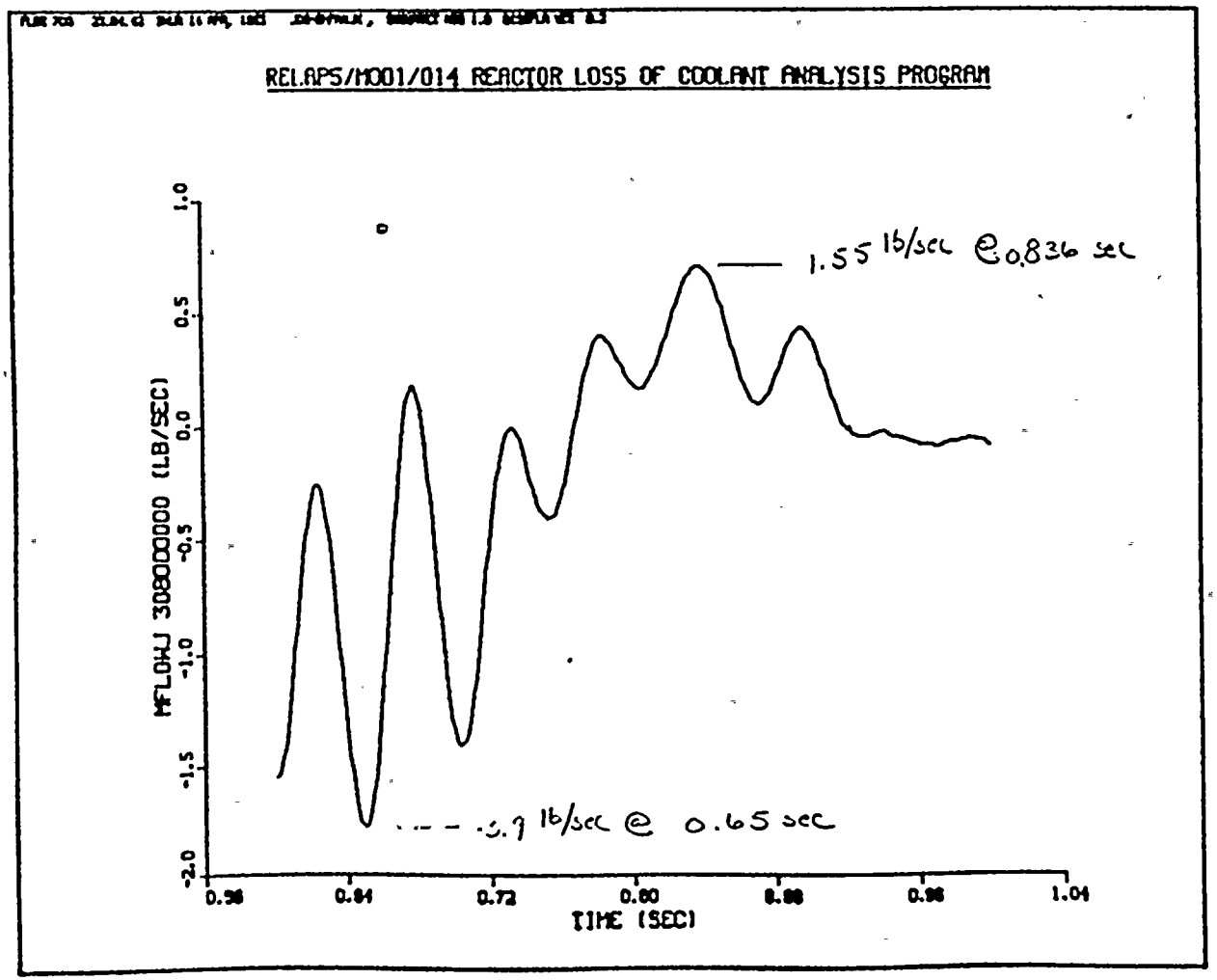
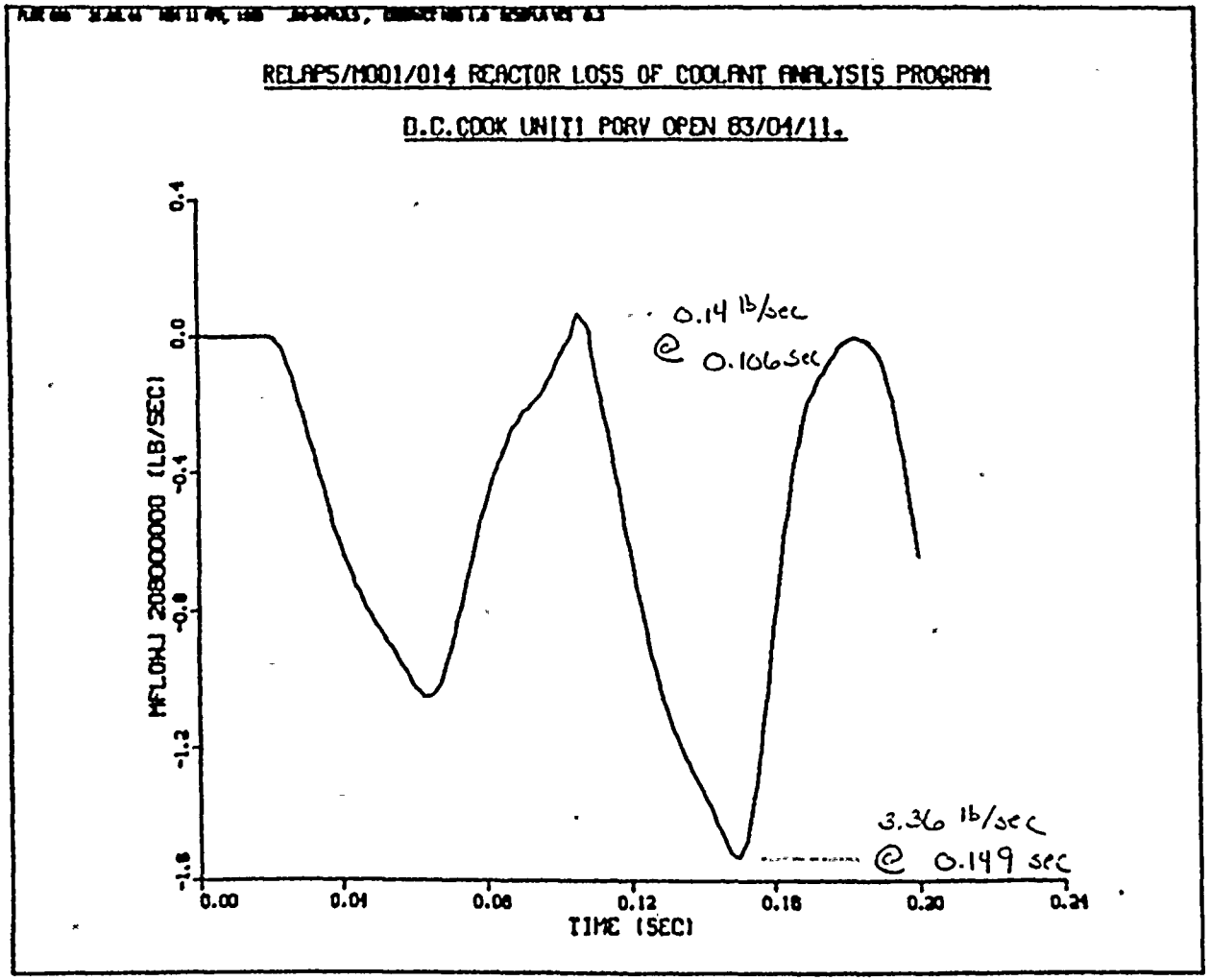
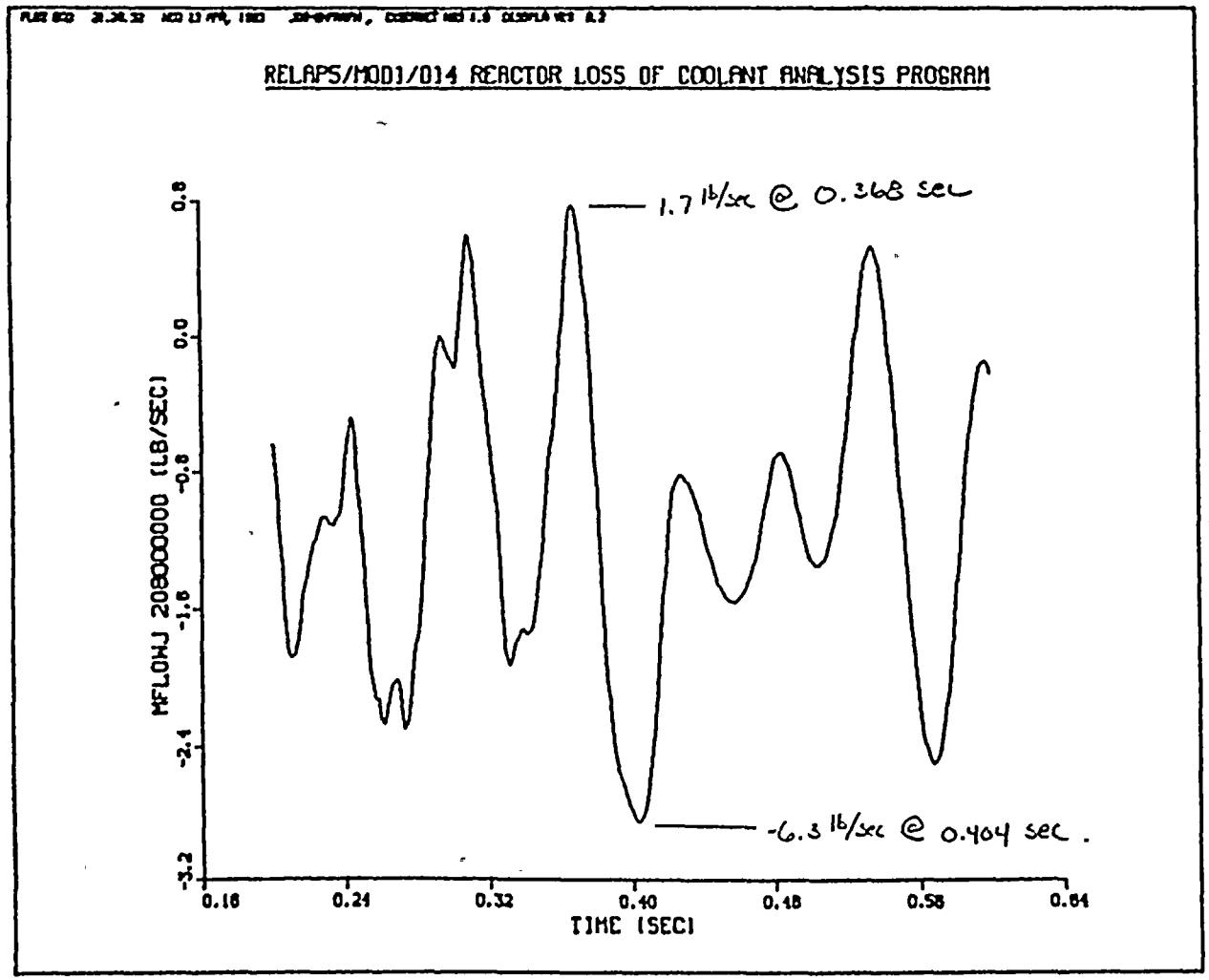
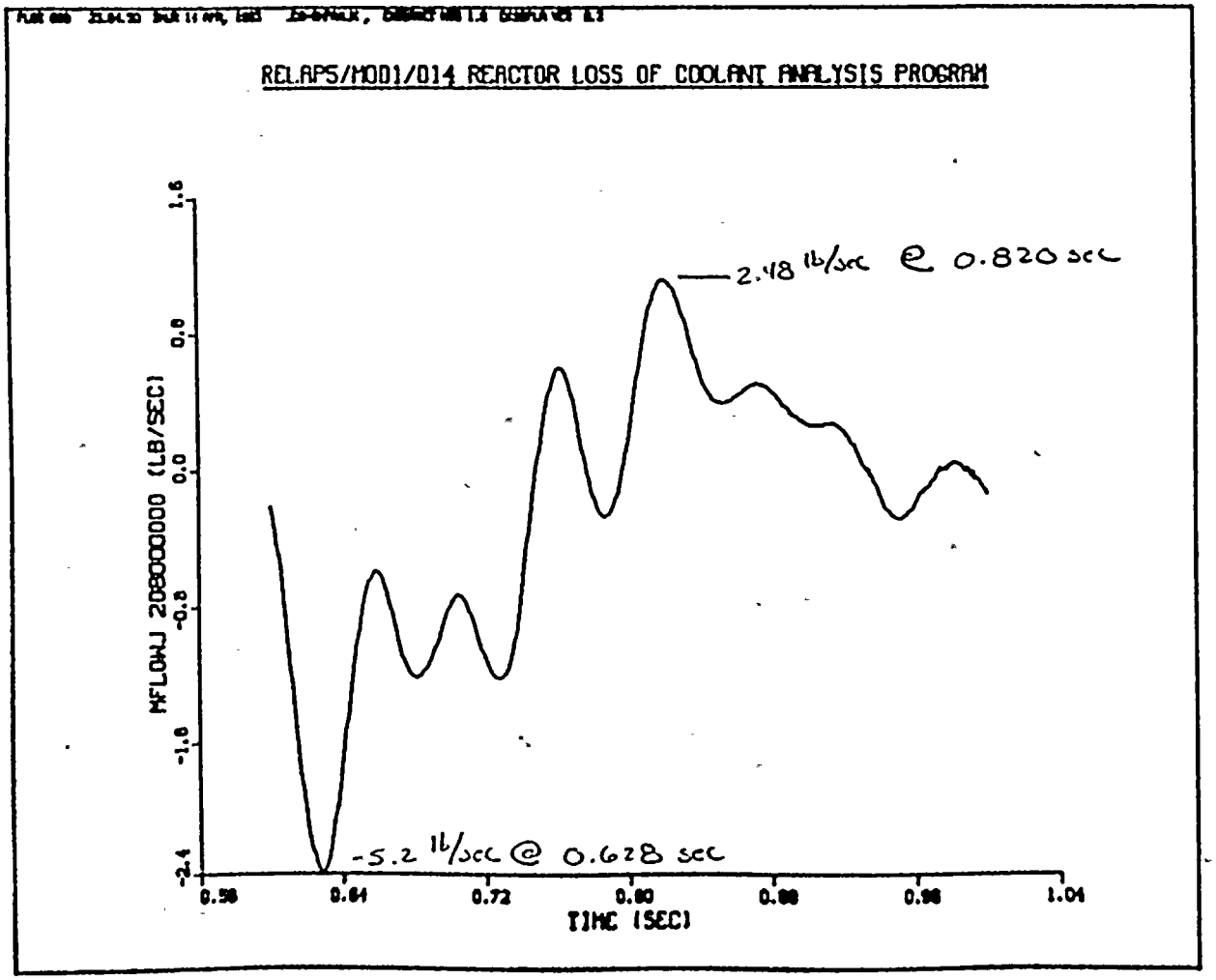


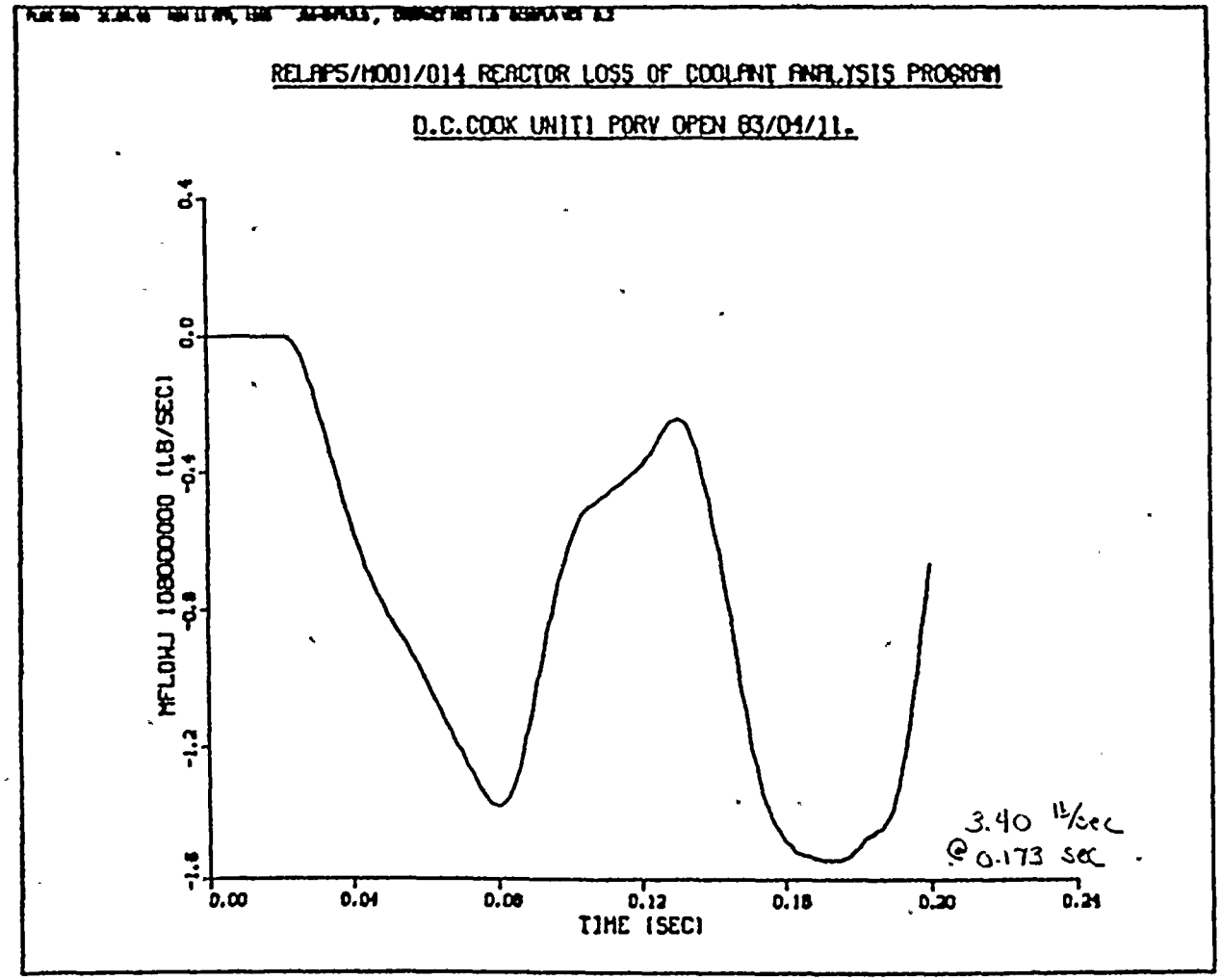

RELAPS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
3.5 lb/sec @ 0.334 sec
-10.4 lb/sec @ 0.311 sec
MFLOWJ 30800000 (LB/SEC)
2.0
1.0
0.0
-1.0
-2.0
-3.0
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)

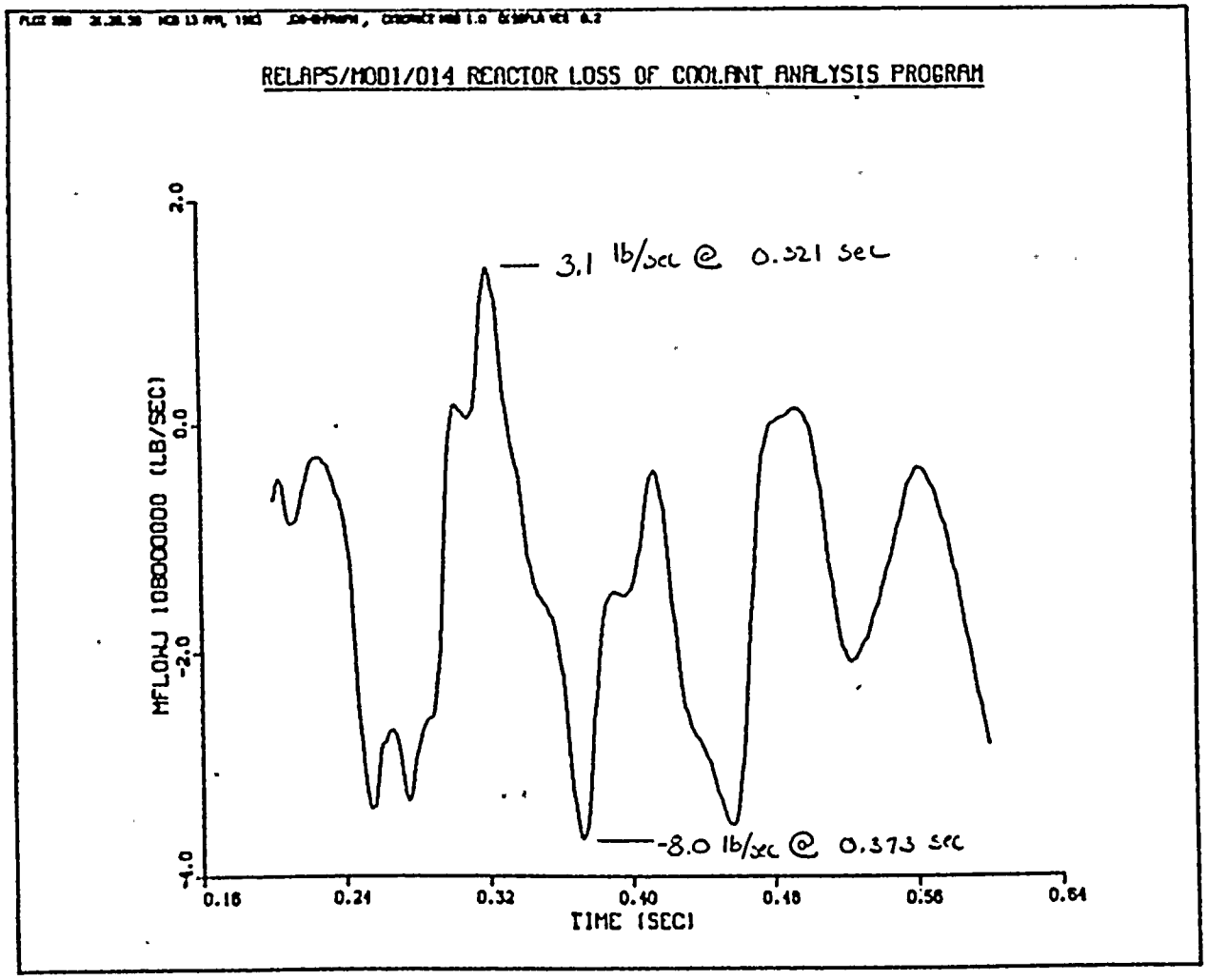

RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
MFLOWJ 30800000 (LB/SEC)
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0.56
0.64
0.72
0.80
0.88
0.96
1.04
TIME (SEC)
1.55 lb/sec @ 0.836 sec
-1.9 lb/sec @ 0.65 sec

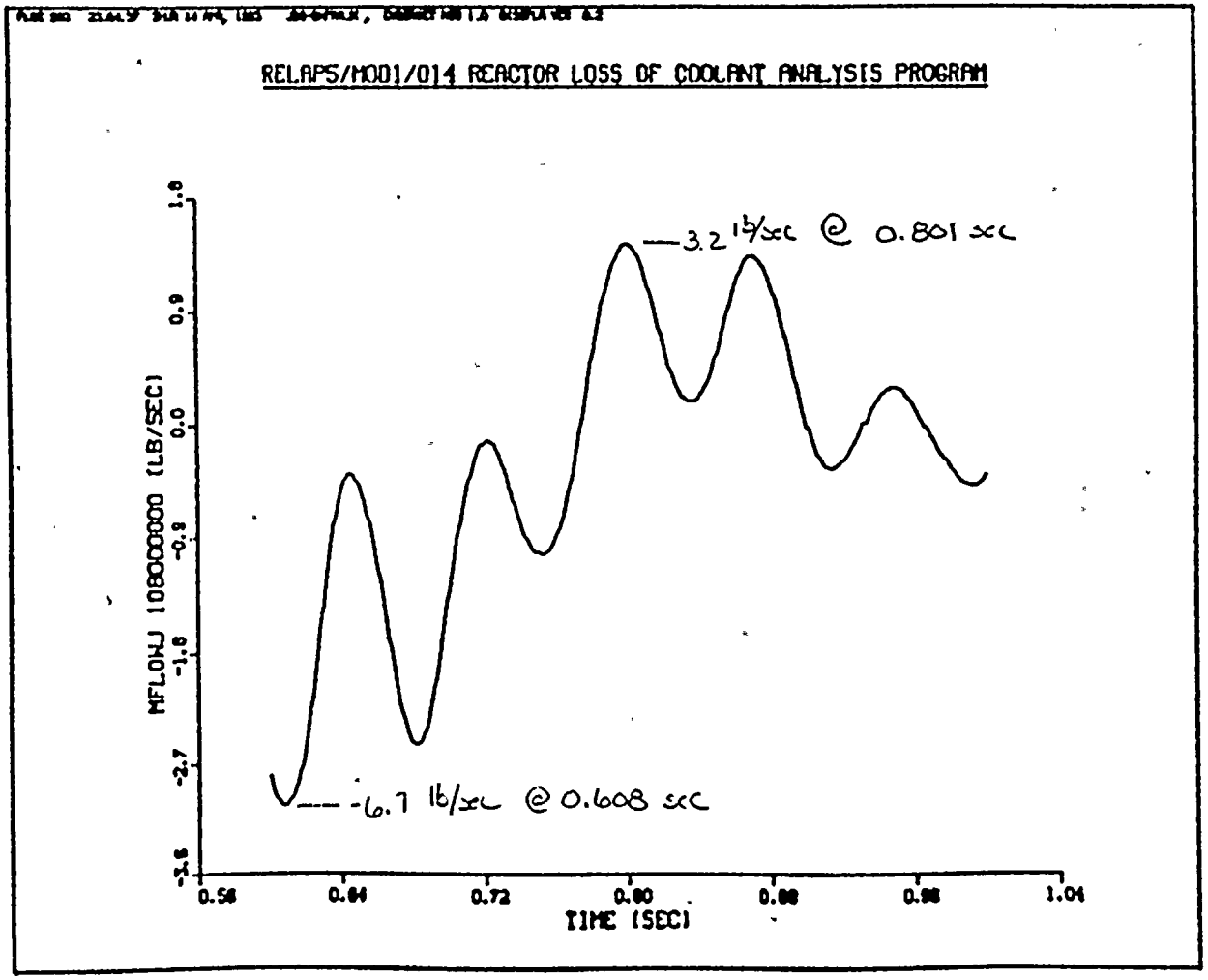

RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/11.
MFLOWJ 2080000000 (LB/SEC)
0.4
0.0
-0.4
-0.8
-1.2
-1.6
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)
0.14 lb/sec
@ 0.106 sec
3.36 lb/sec
@ 0.149 sec


RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
1.7 lb/sec @ 0.368 sec
-6.3 lb/sec @ 0.404 sec.
MFLOWJ 20800000 (LB/SEC)
0.8
0.0
-0.8
-1.6
-2.4
-3.2
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)


RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
MFLOWJ 208000000 (LB/SEC)
1.6
0.8
0.0
-0.8
-1.6
-2.4
0.64
0.72
0.80
0.88
0.96
1.04
TIME (SEC)
2.48 lb/sec @ 0.820 sec
-5.2 lb/sec @ 0.628 sec


RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/11.
MFLOWJ 10800000000 (LB/SEC)
0.4
0.0
-0.4
-0.8
-1.2
-1.6
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)
3.40 lb/sec
@ 0.173 sec


RELAPS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
MFLOWJ 108000000 (LB/SEC)
2.0
0.0
-2.0
-4.0
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)
3.1 lb/sec @ 0.321 sec
-8.0 lb/sec @ 0.373 sec


RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
MFLOWJ 10800000000 (LB/SEC)
1.8
0.9
0.0
-0.9
-1.8
-2.7
-3.6
0.56
0.64
0.72
0.80
0.88
0.96
1.04
TIME (SEC)
3.2 lb/sec @ 0.801 sec
-6.7 lb/sec @ 0.608 sec

BY [illegible] DATE 11-29-83
CHKD. BY JBM DATE 4-29-83

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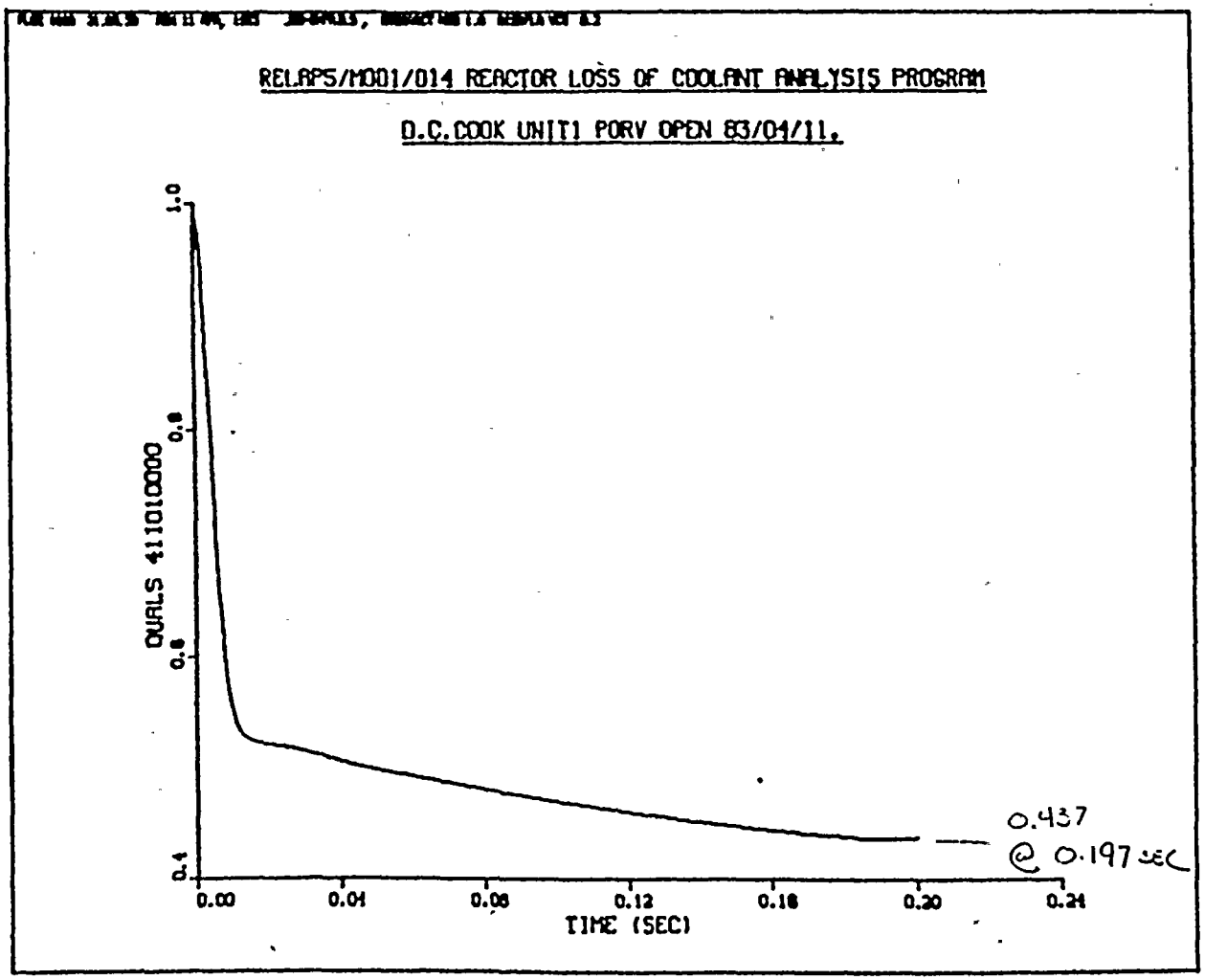
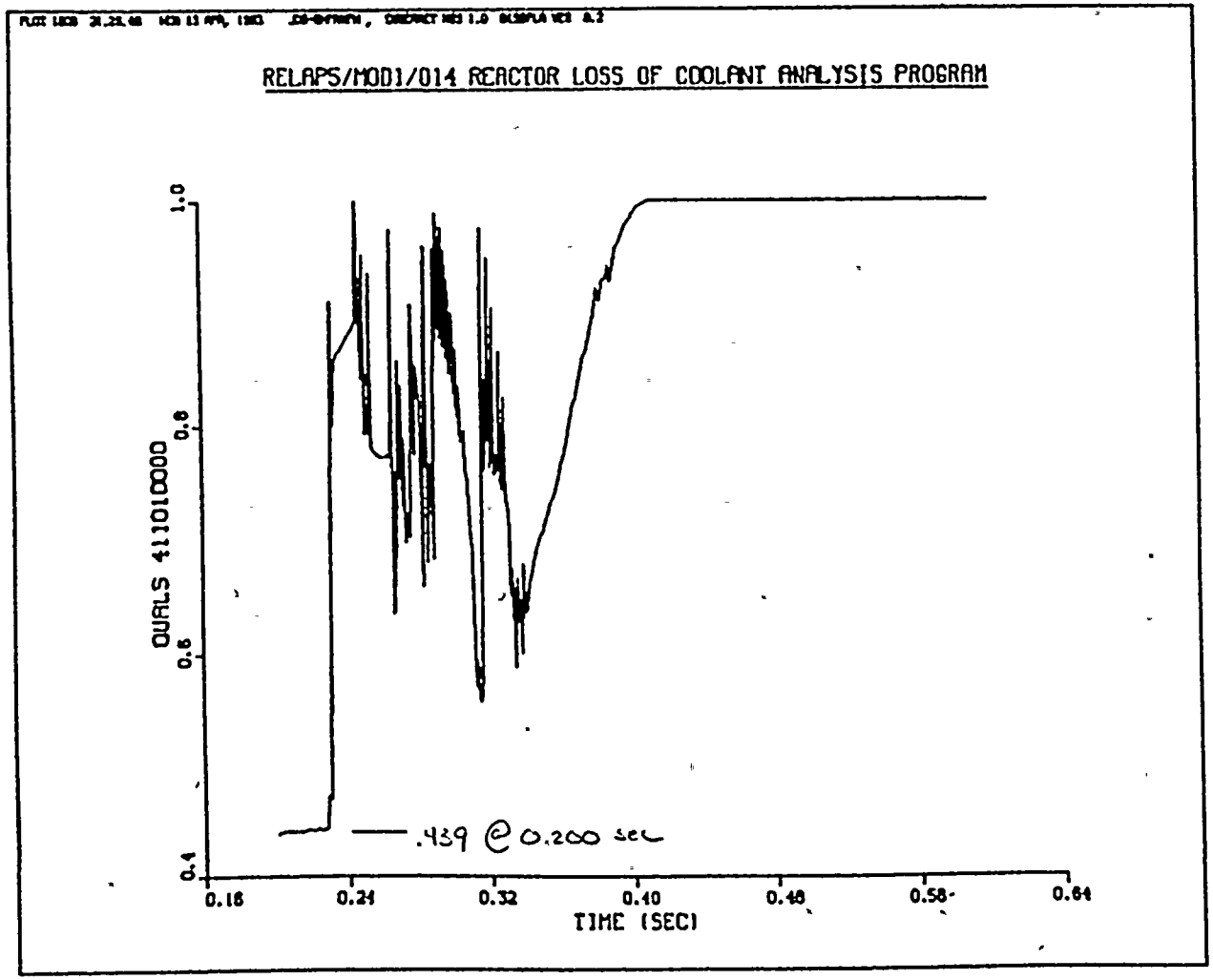
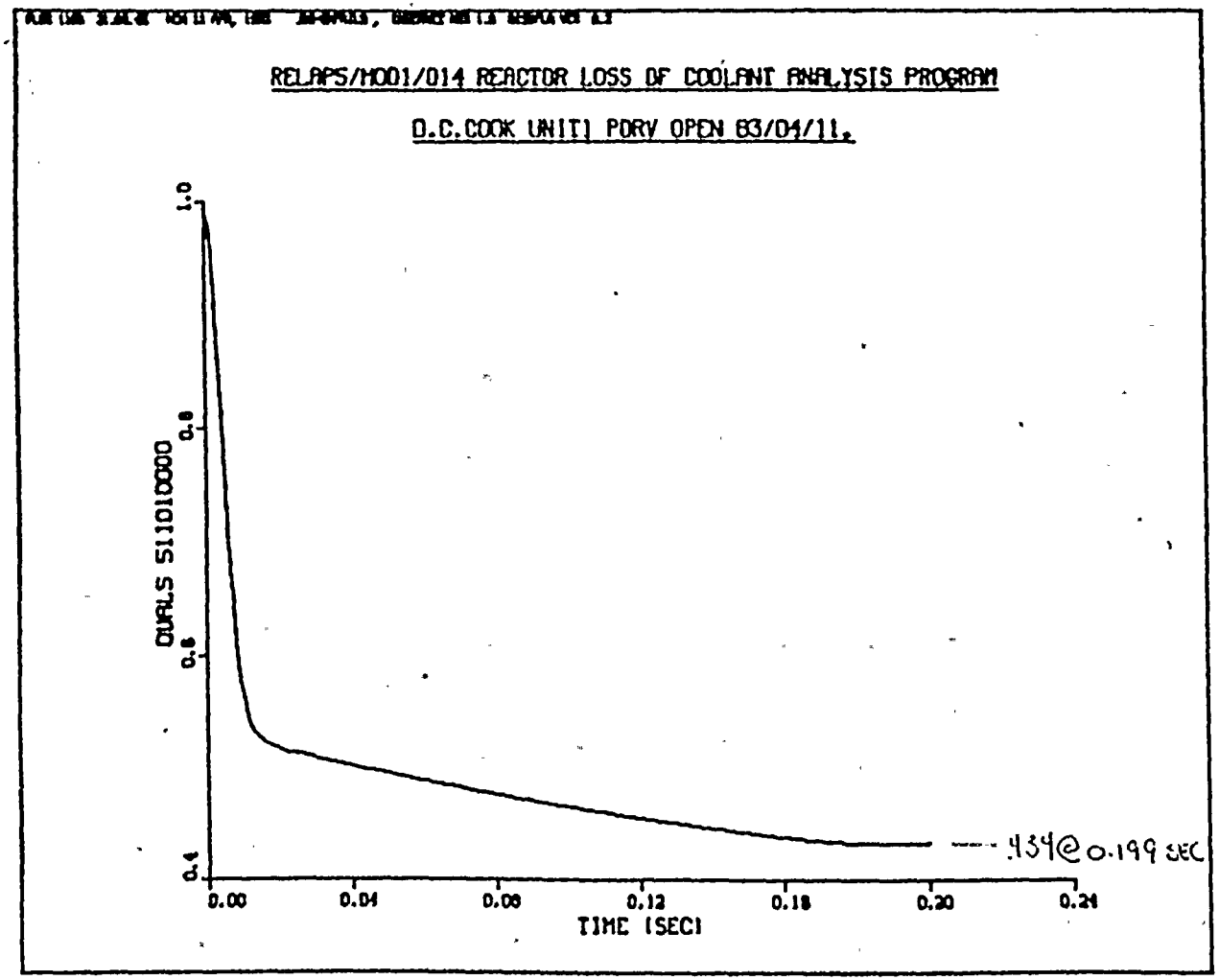
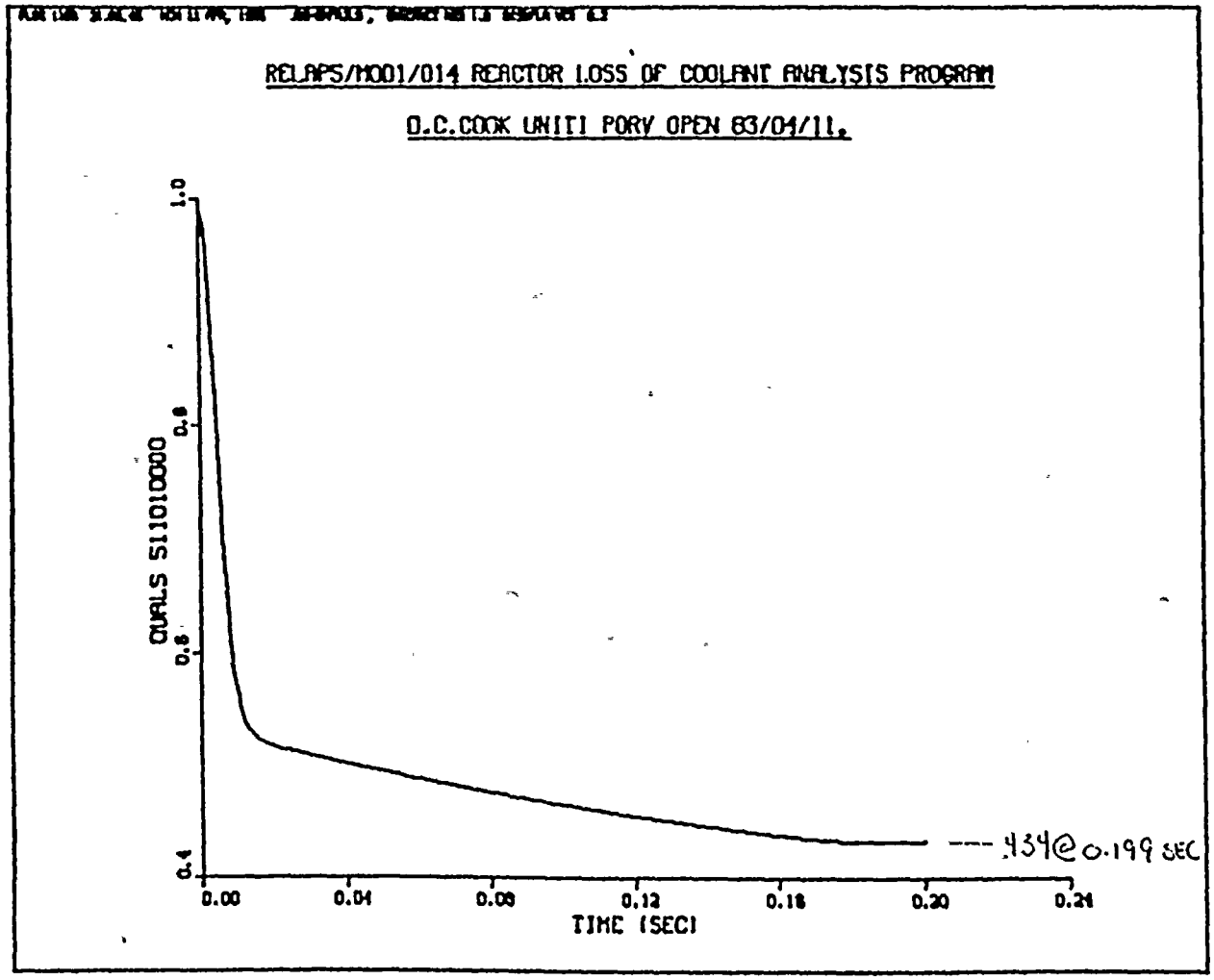
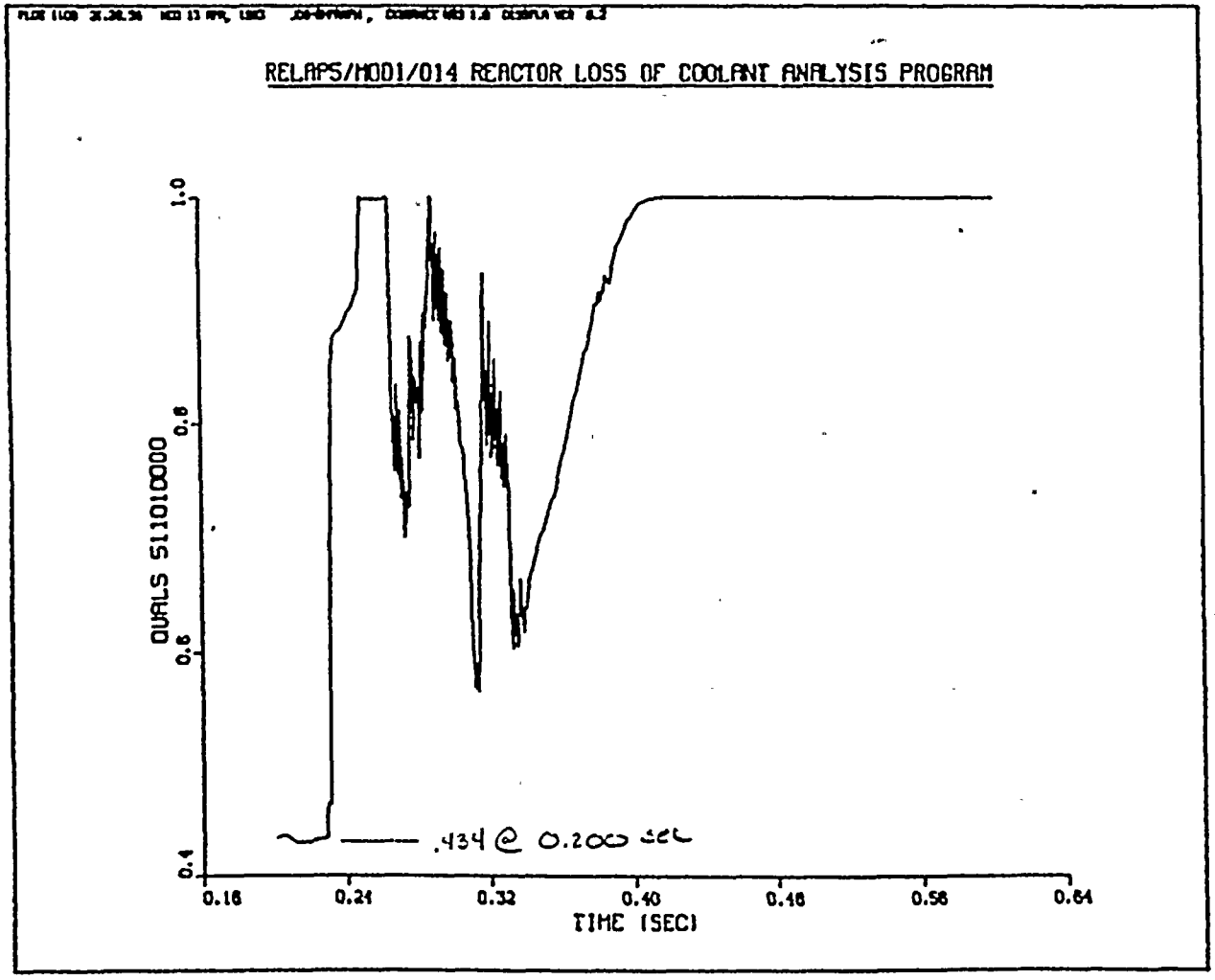



RELAPS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
QUALS 41101C000
1.0
0.8
0.6
0.4
.439 @ 0.200 sec
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)


RELAPS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/11.
CURLS 51101000D
1.0
0.8
0.6
0.4
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)
.434@0.199 SEC


RELAPS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/11.
CURLS 51101D000
1.0
0.8
0.6
0.4
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)
--- .434 @ 0.199 SEC


RELAPS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
QUALS 51101000
1.0
0.8
0.6
0.4
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)
.434 @ 0.200 sec

BY UMM DATE 4-29-83
CHKD. BY JBM DATE 4-29-83

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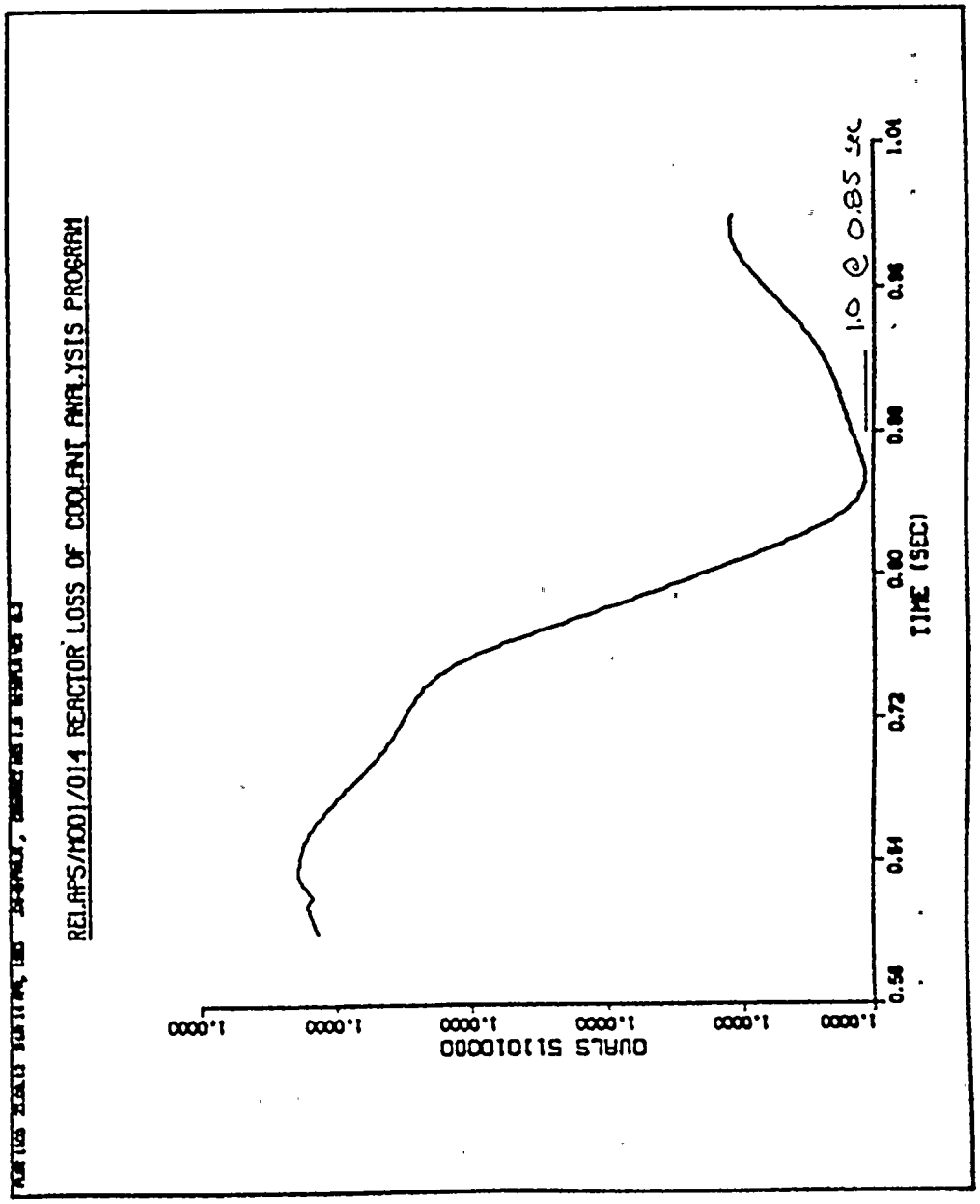
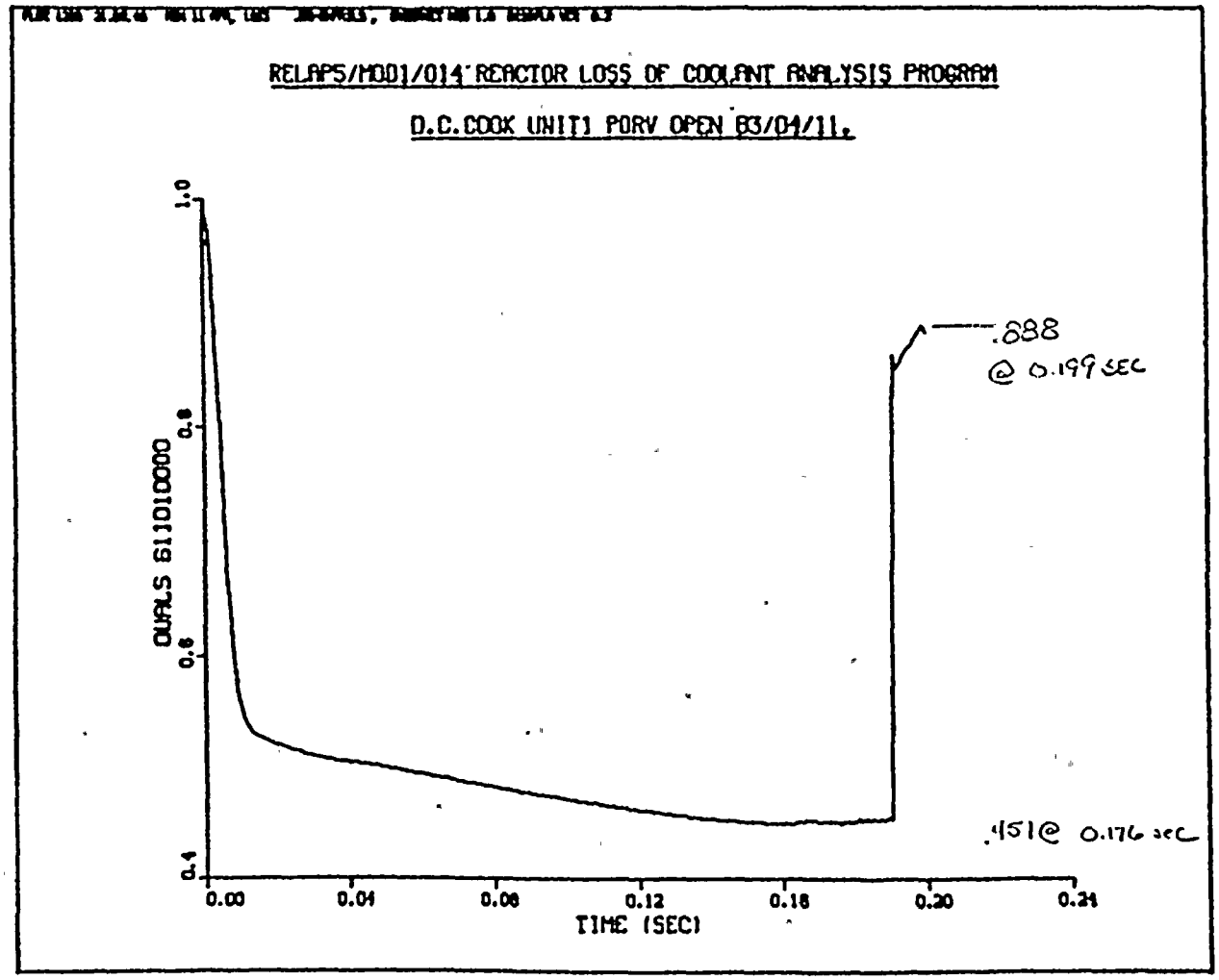
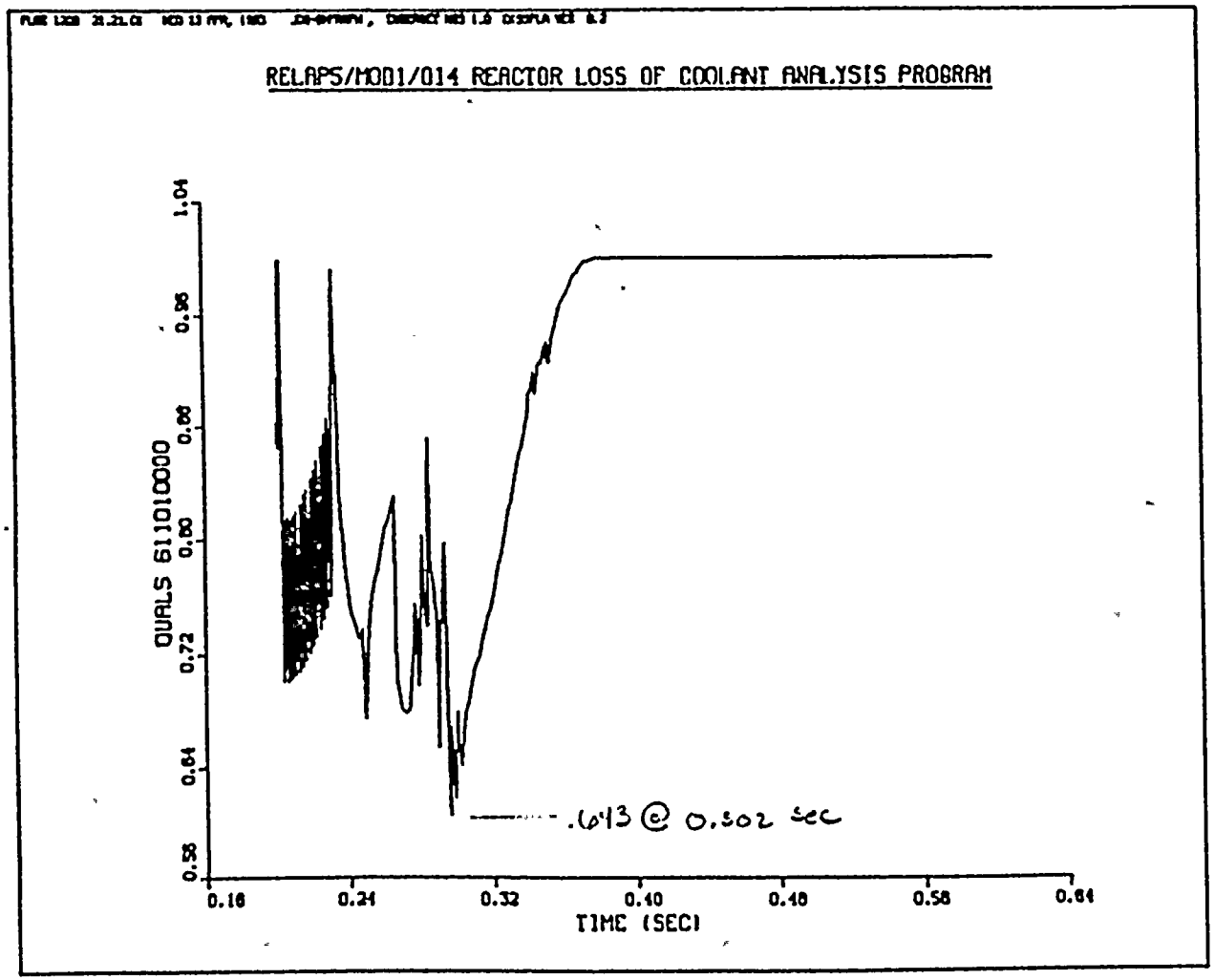



RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/11.
QUALS 61101000
1.0
0.8
0.6
0.4
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)
.888
@ 0.199 SEC
.451 @ 0.176 sec


RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
QUALS 61101000
1.04
0.96
0.88
0.80
0.72
0.64
0.56
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)
.643 @ 0.302 sec

BY UMM DATE 11-29-83
CHKD. BY JBM DATE 9-29-83

TELEDYNE ENGINEERING SERVICES

Technical Report
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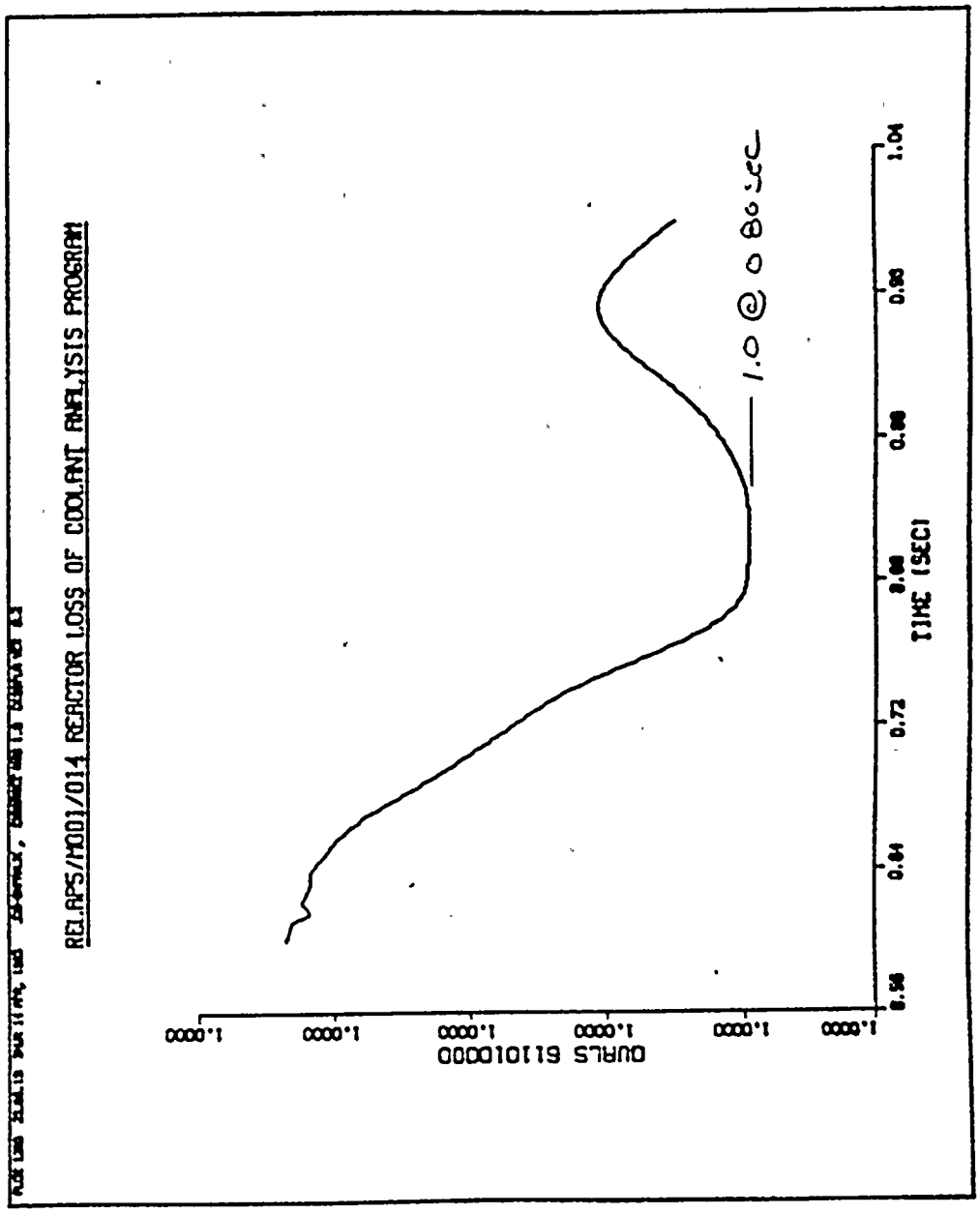

BY [illegible] DATE 4-29-83
CHKD. BY [illegible] DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

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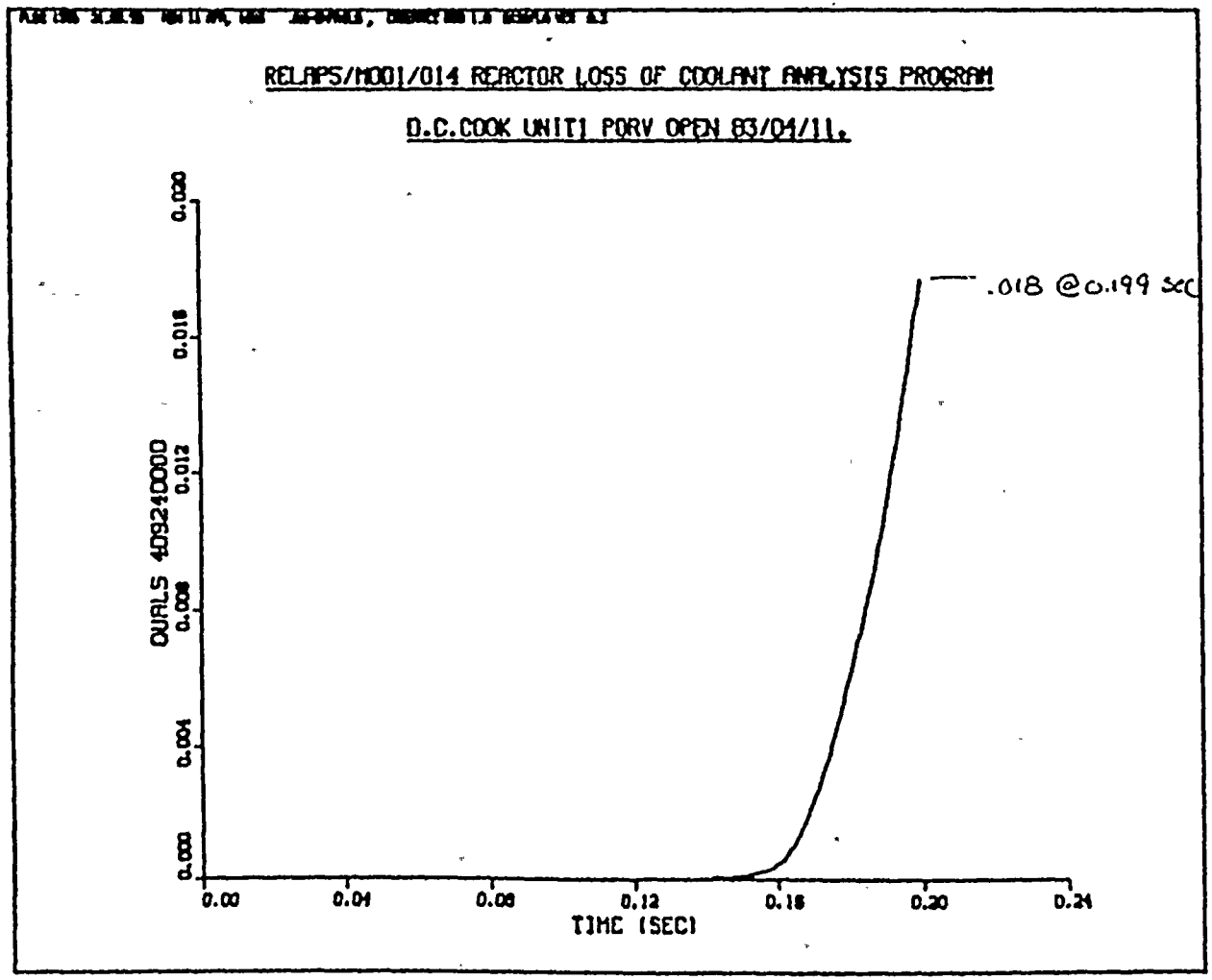
4-86



BY UHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

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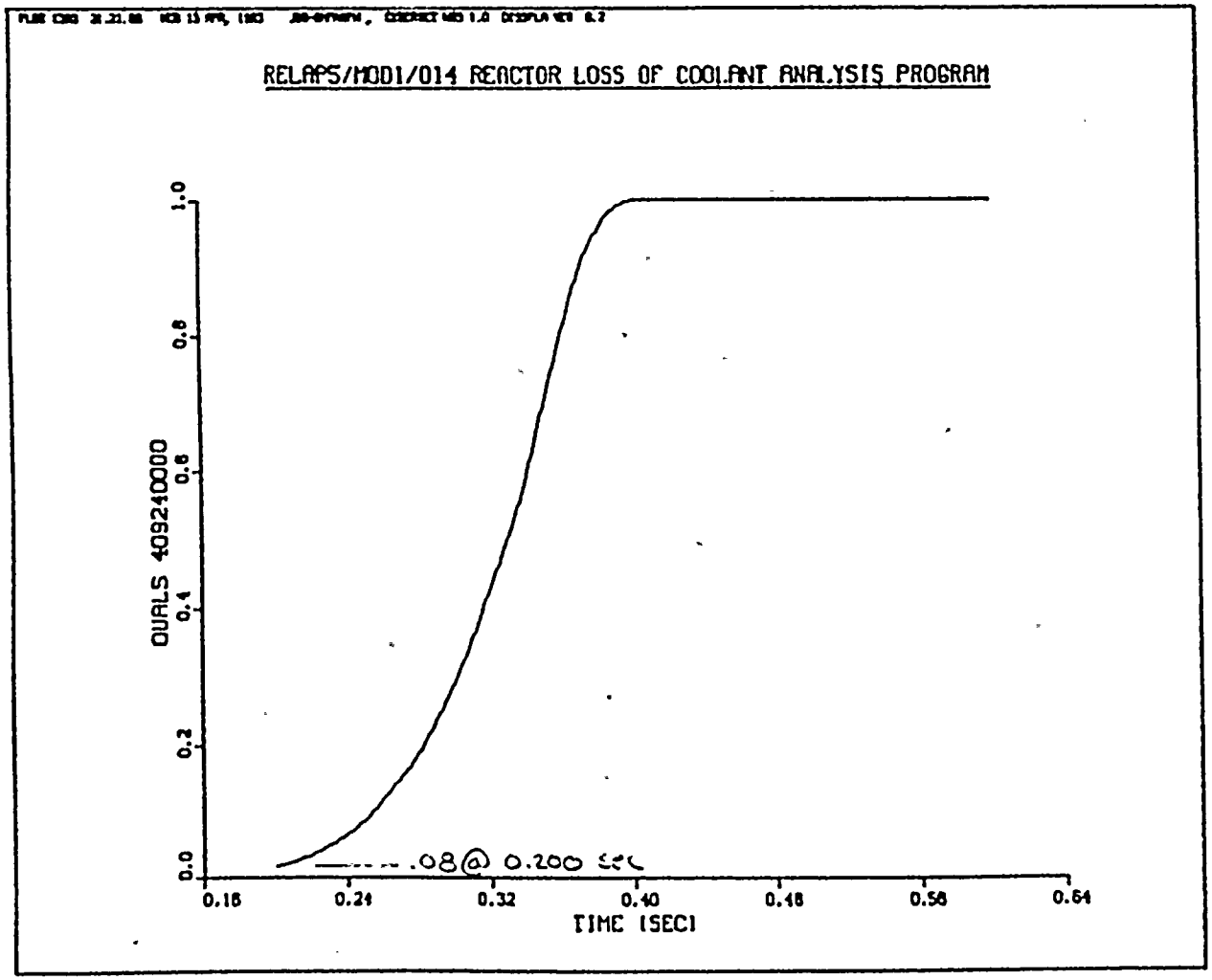
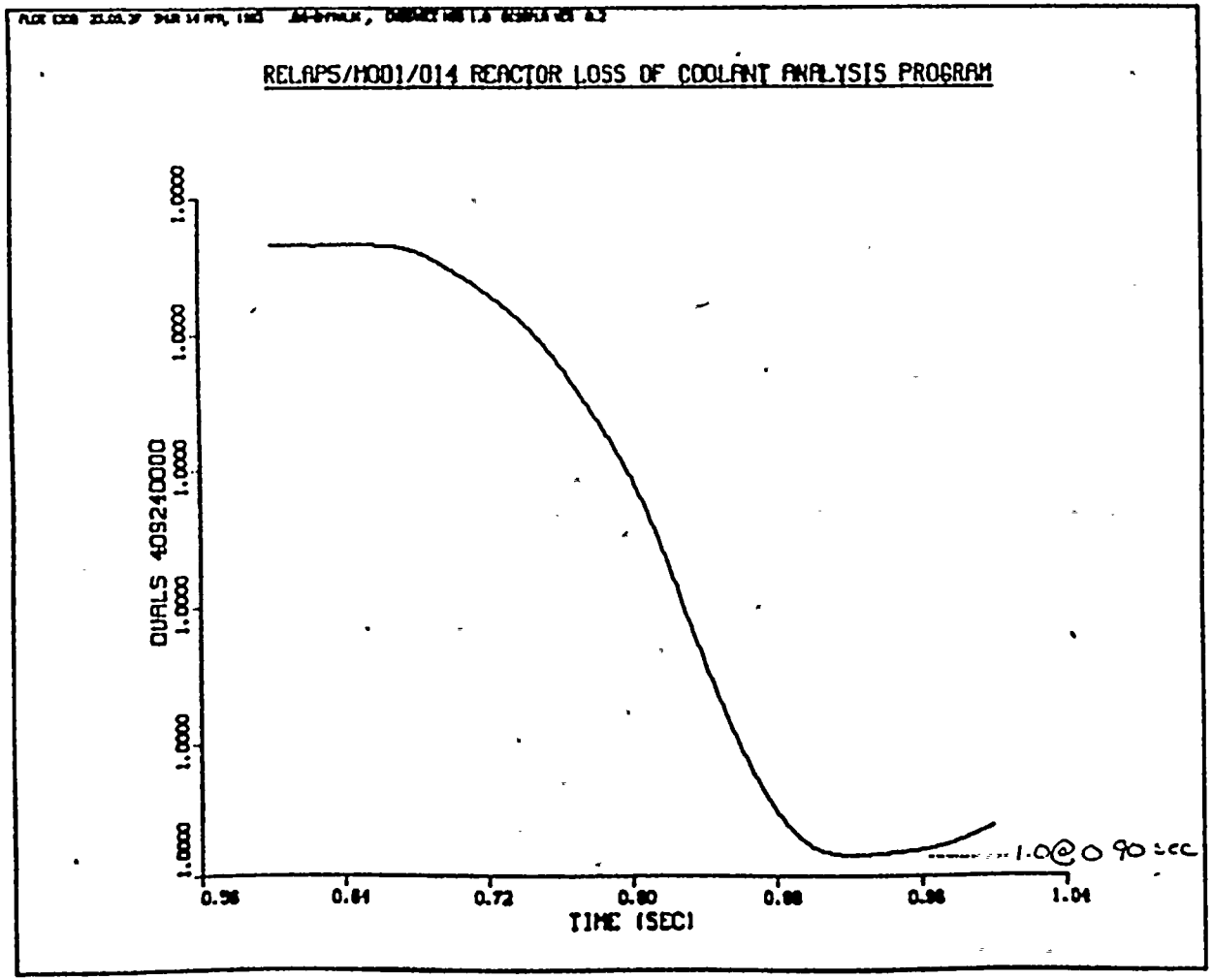
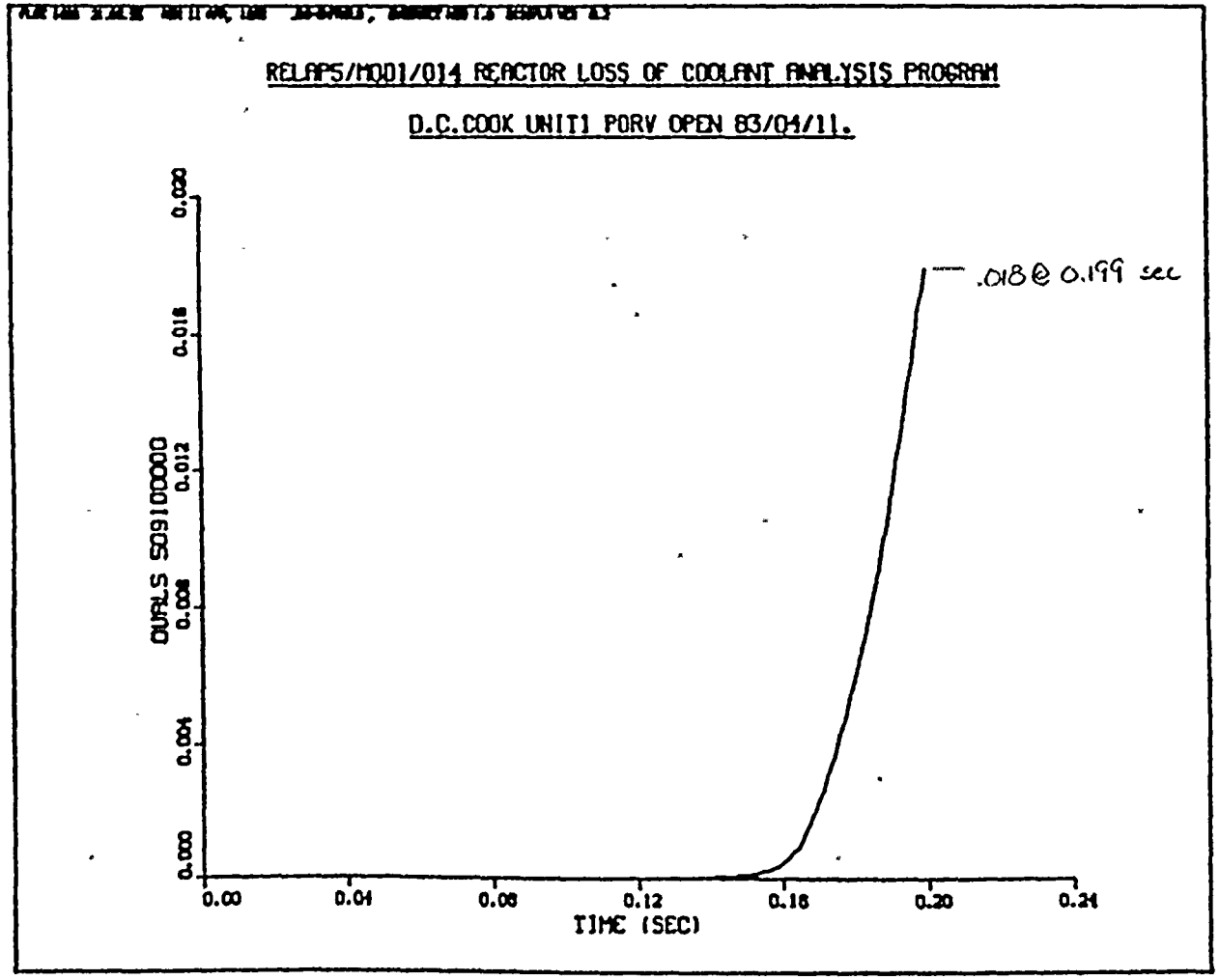
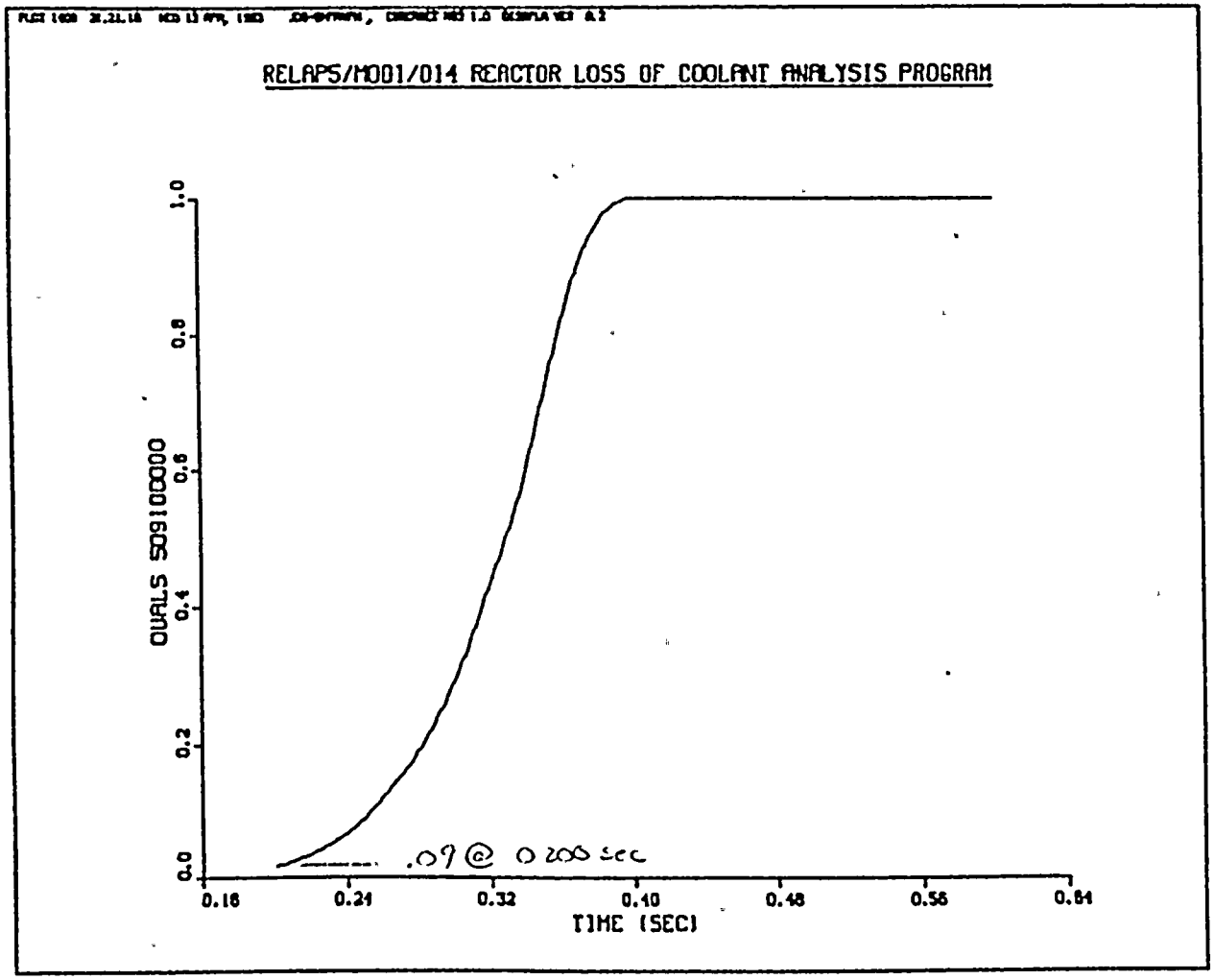



RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
DVALS 409240000
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000
0.56
0.64
0.72
0.80
0.88
0.96
1.04
TIME (SEC)
1.0@0.90 sec

BY JHM DATE 11-29-83
CHKD. BY JBJ DATE 4-29-83

TELEDYNE ENGINEERING SERVICES




RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
QUALS 50910000
0.0
0.2
0.4
0.6
0.8
1.0
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)
.09 @ 0.200 sec

BY UMM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

Technical Report
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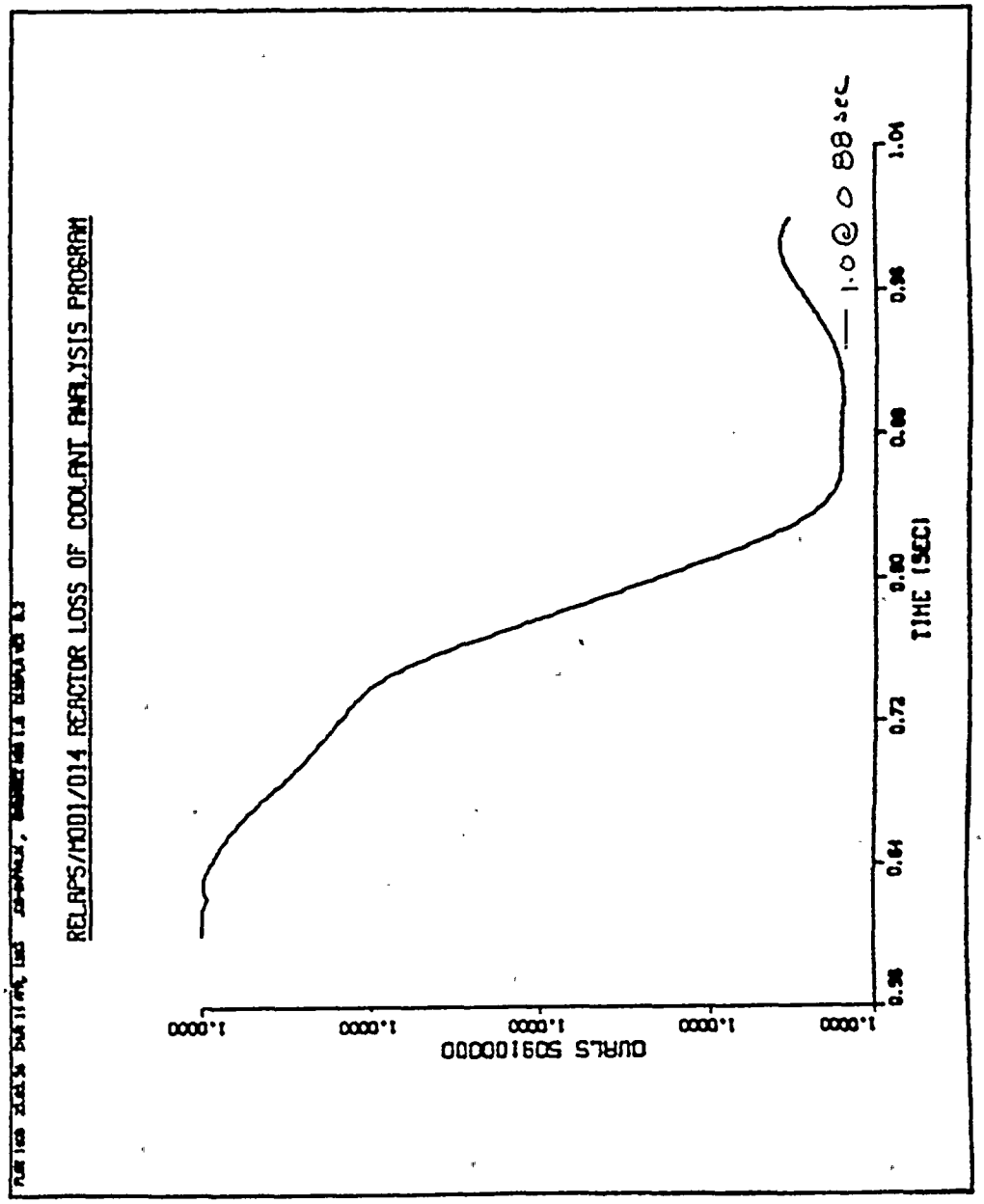
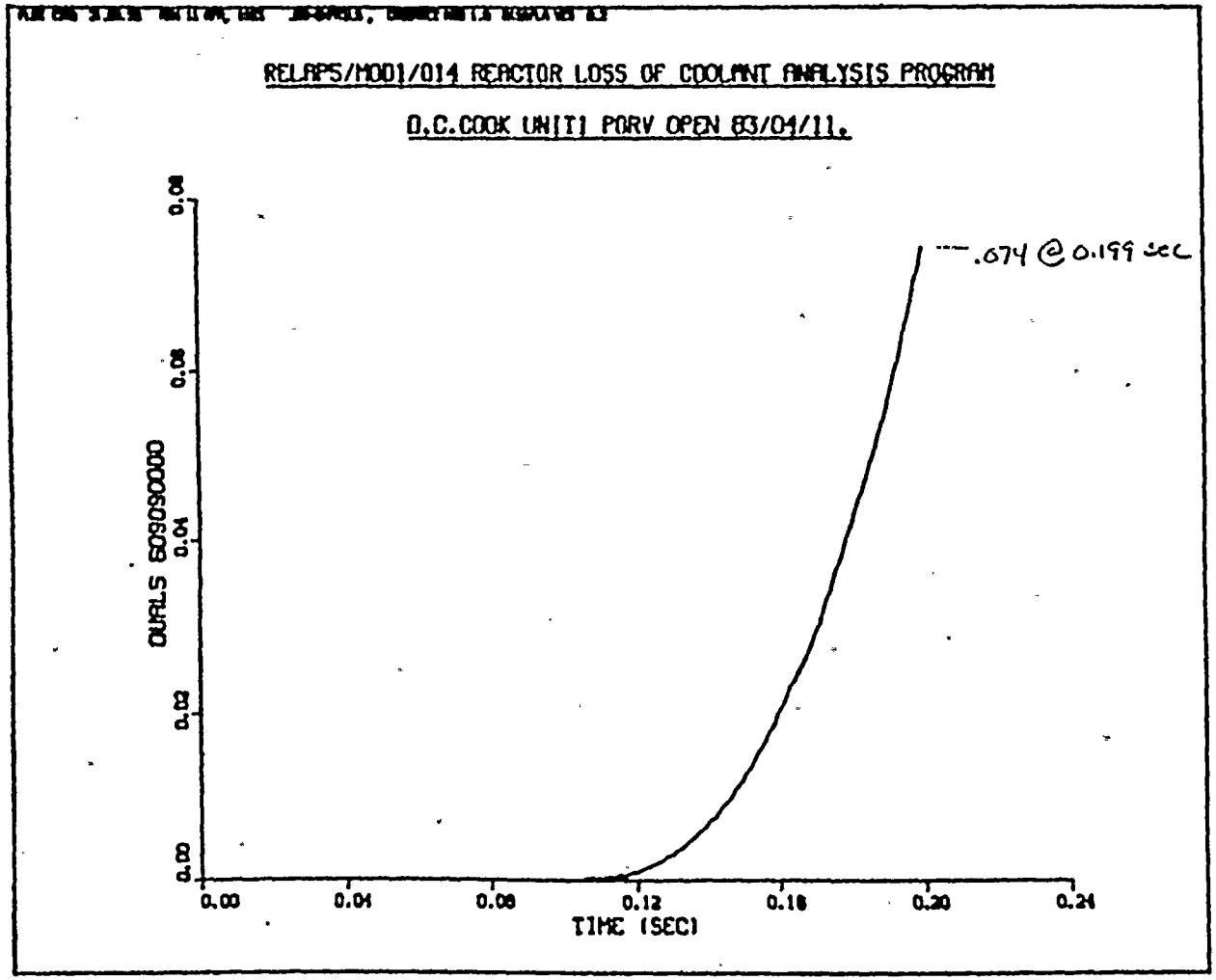
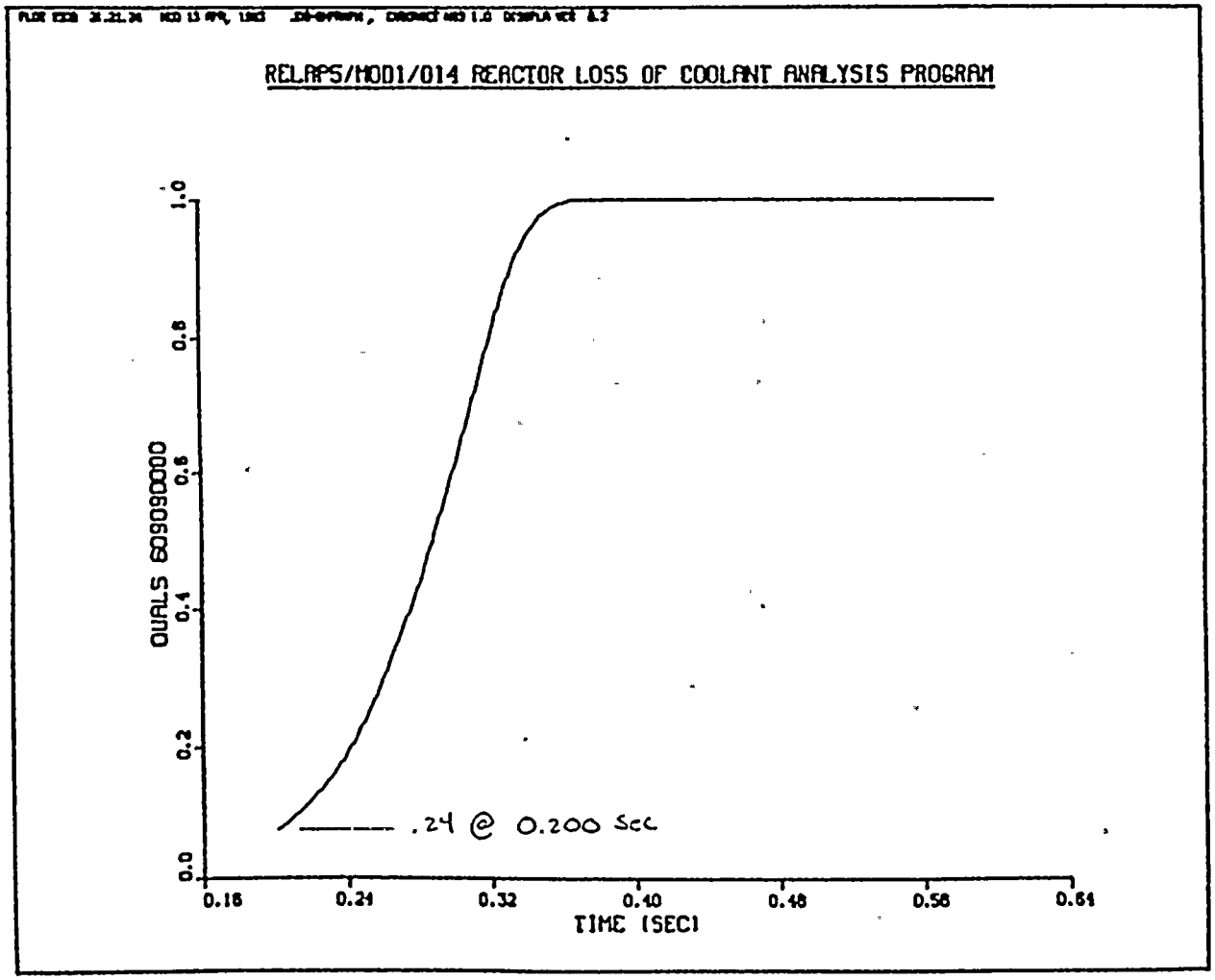


BY JHM DATE 11-29-83
CHKD. BY [illegible] DATE 4-29-83

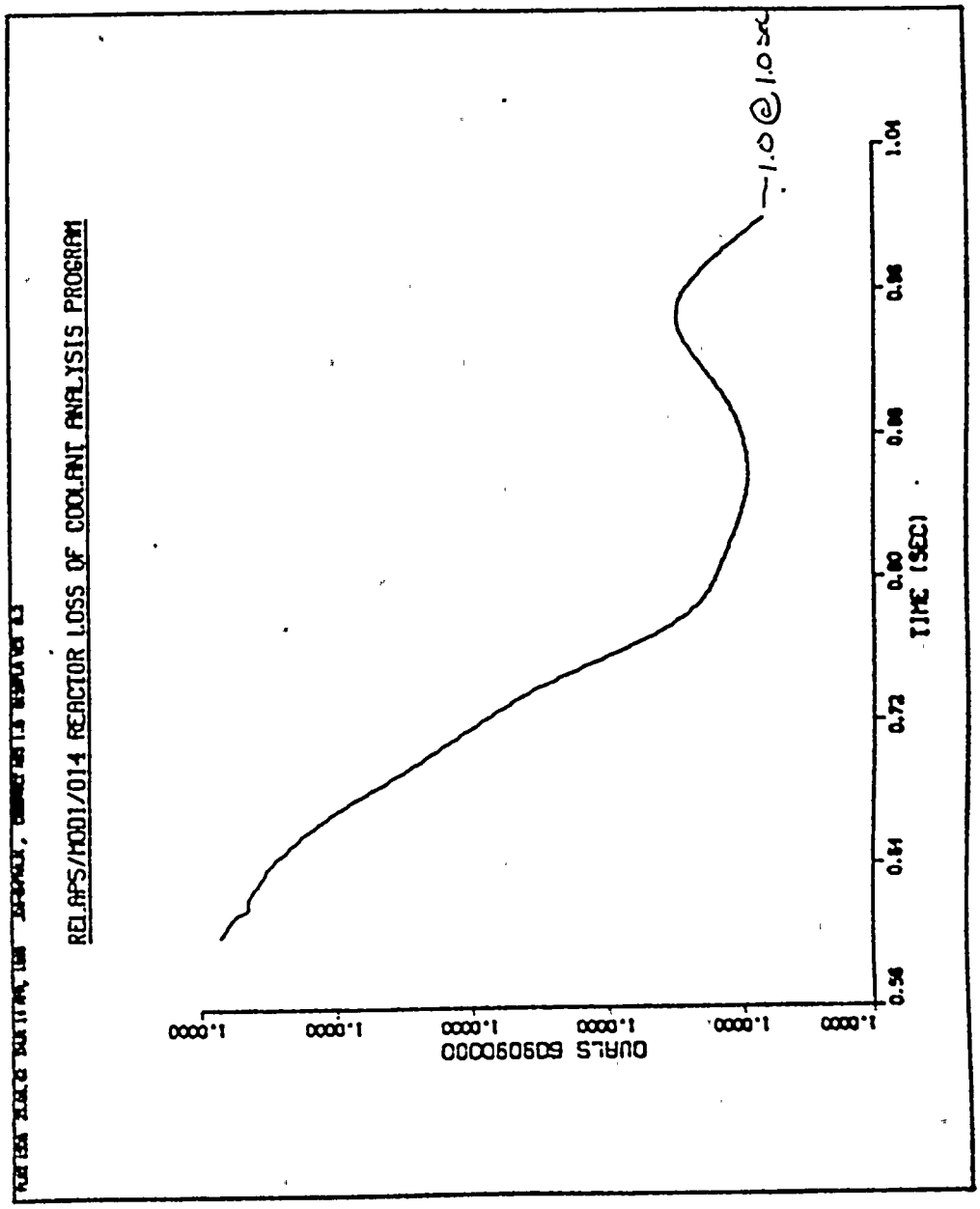



RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
QUALS 60909000
0.0
0.2
0.4
0.6
0.8
1.0
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)
.24 @ 0.200 sec

BY OHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

Technical Report
TR-5364-1
Revision 0



BY JHM DATE 4-29-83
CHKD. BY JBM DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

Technical Report
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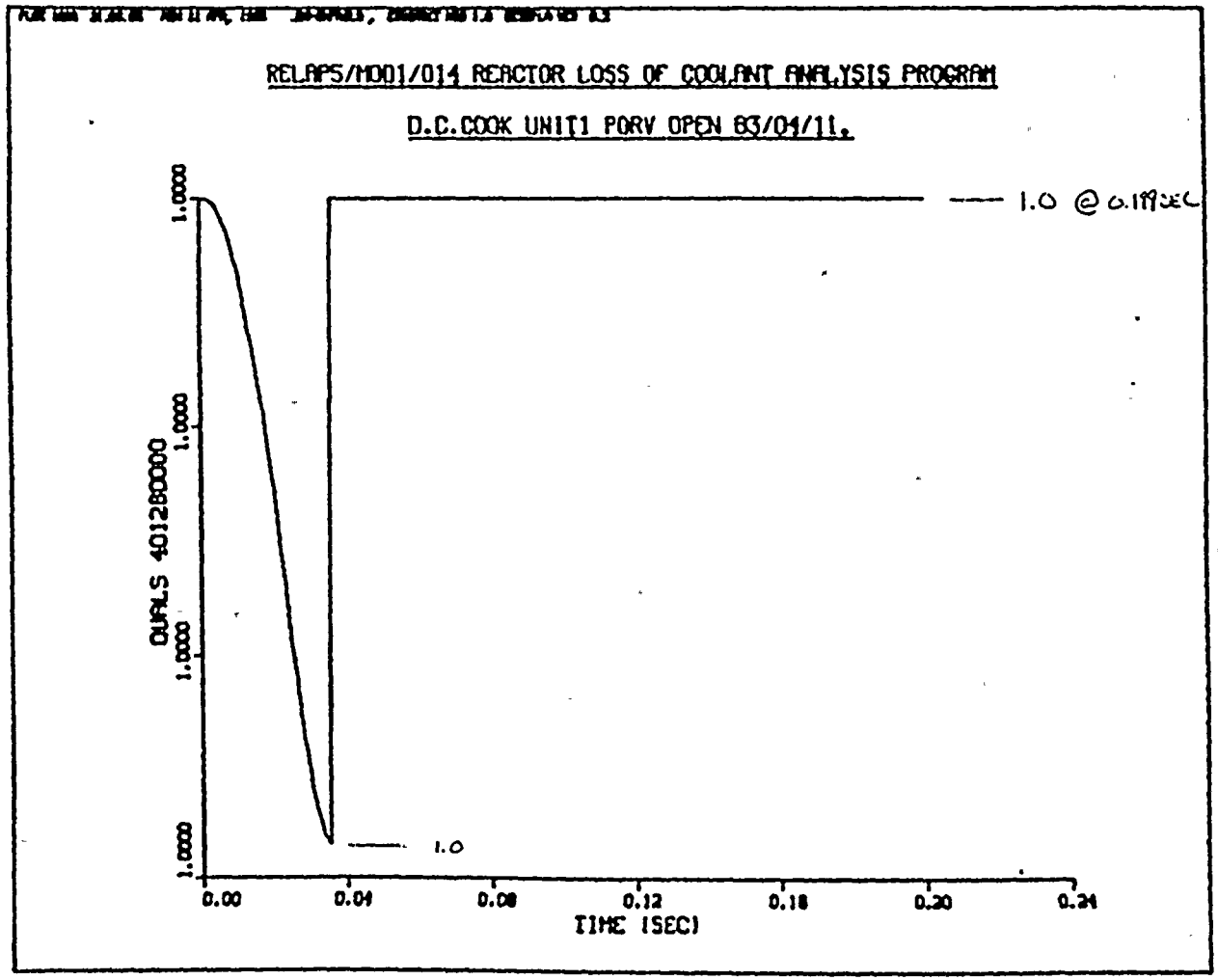
Revision 0



BY [illegible] DATE 11-29-83
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TELEDYNE ENGINEERING SERVICES

Technical Report
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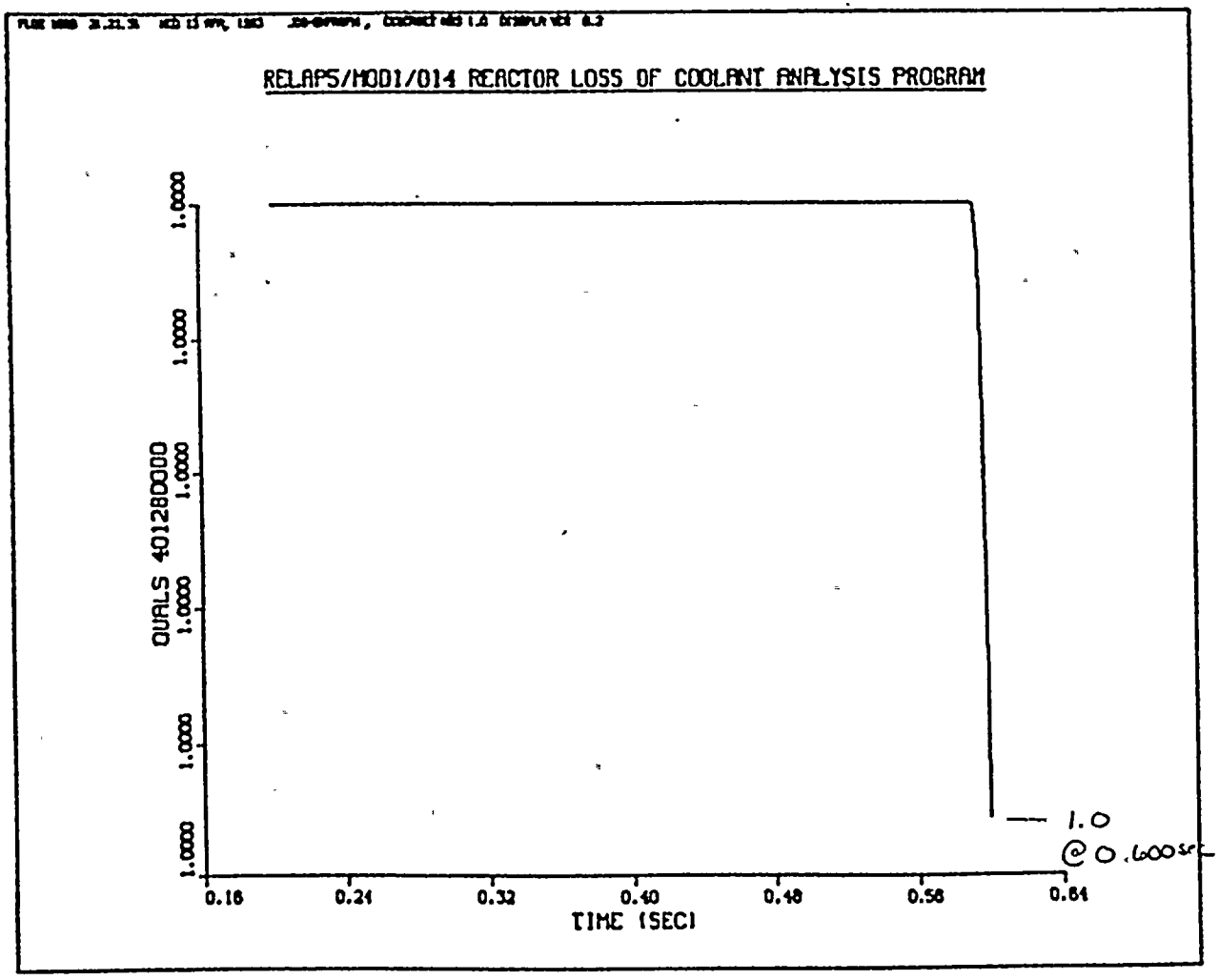
Revision 0



BY UHM DATE 11-29-83
CHKD. BY JBM DATE 9-29-83

TELEDYNE ENGINEERING SERVICES

Technical Report
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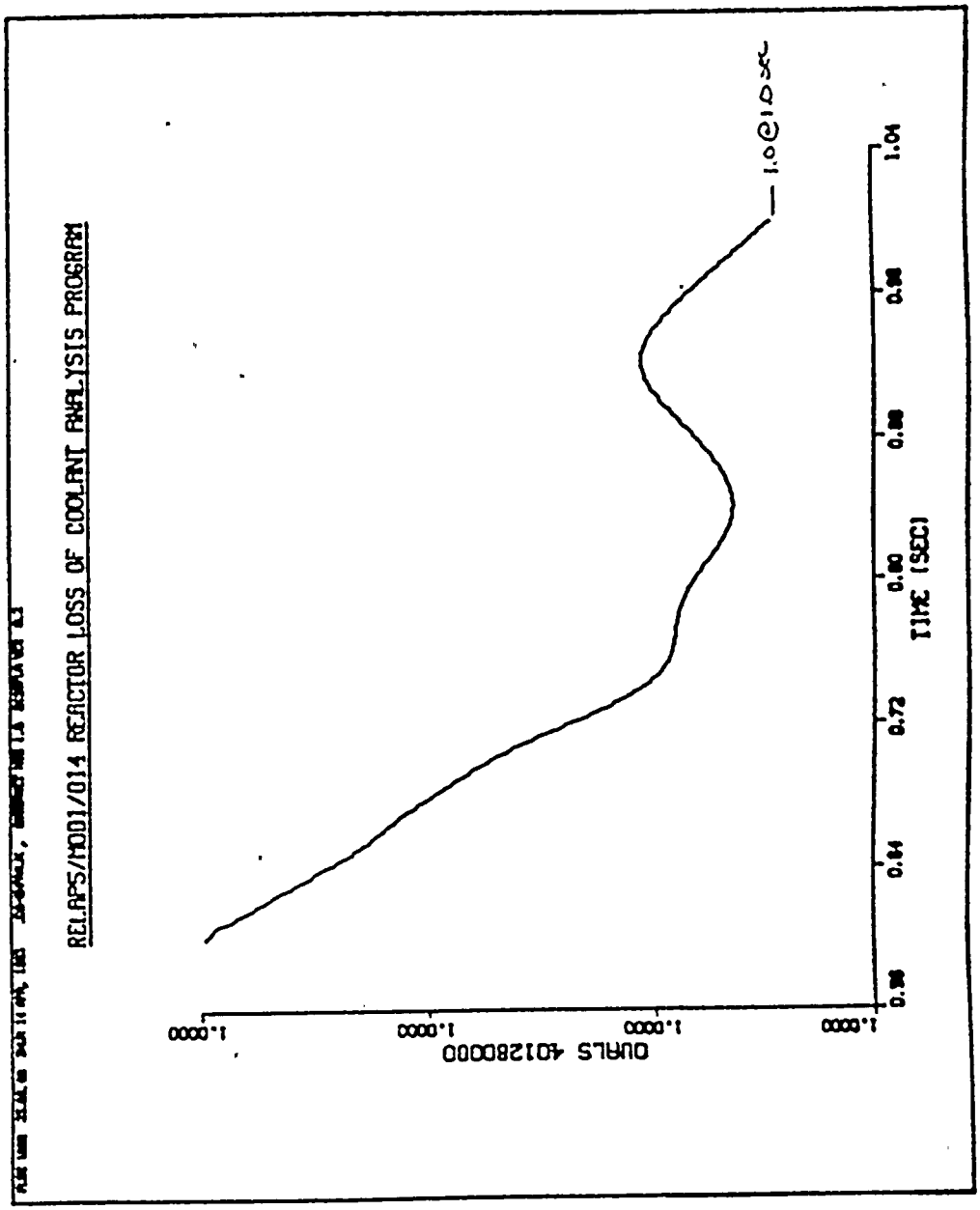
Revision 0



BY [illegible] DATE 11-29-83
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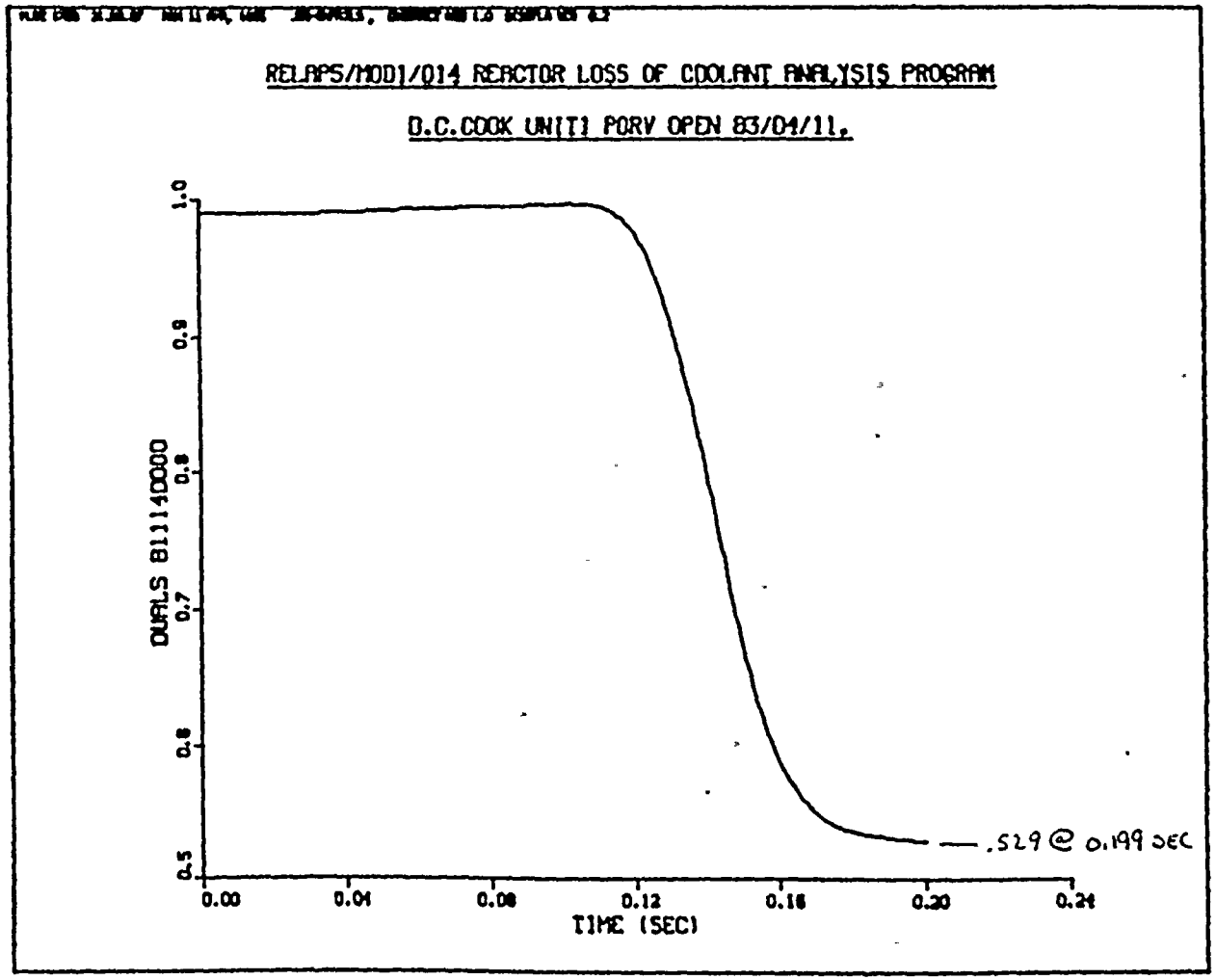
TELEDYNE ENGINEERING SERVICES

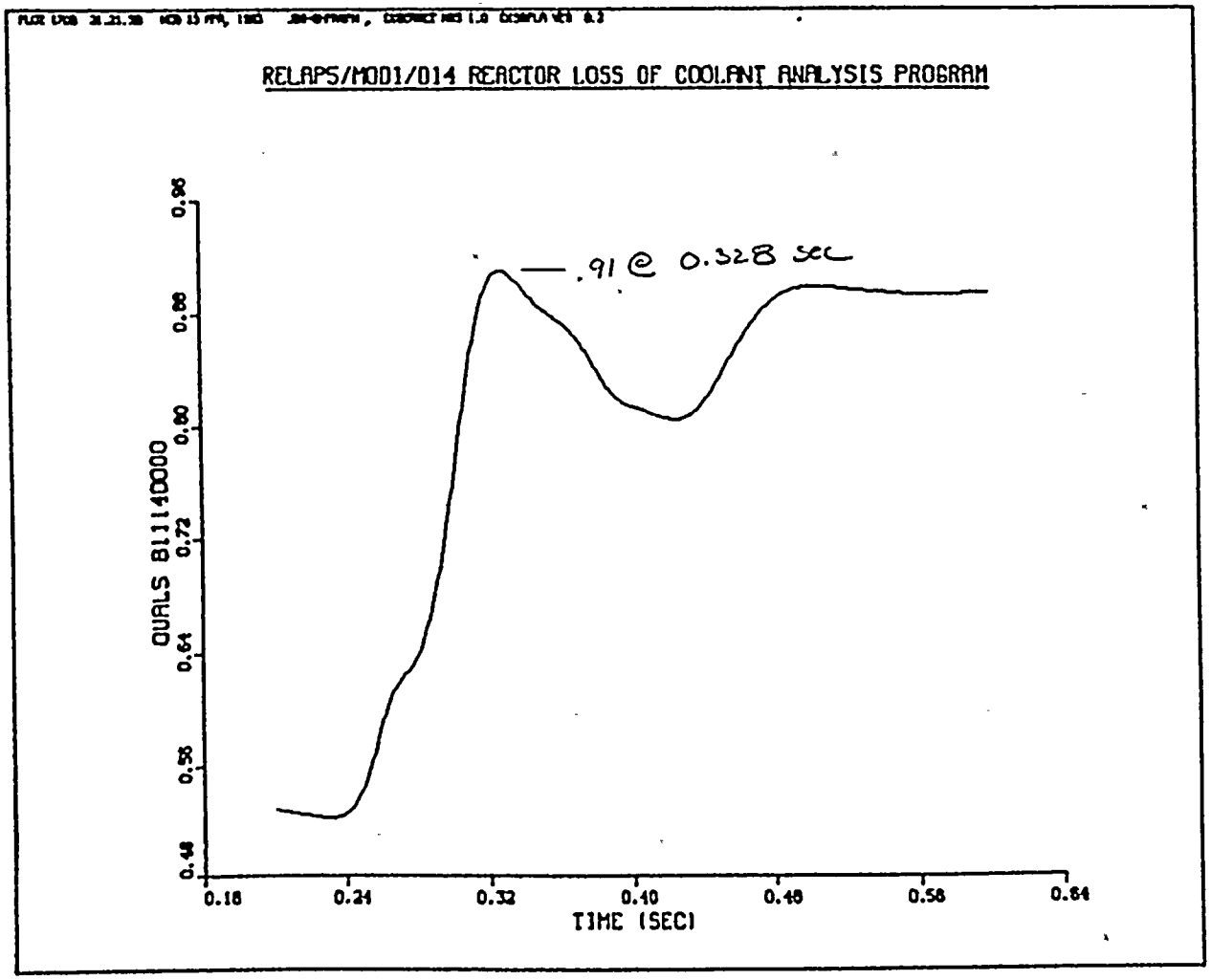
Technical Report
TR-5364-1
Revision 0



BY [illegible] DATE 11-29-83
CHKD. BY [illegible] DATE 4-29-87

TELEDYNE ENGINEERING SERVICES

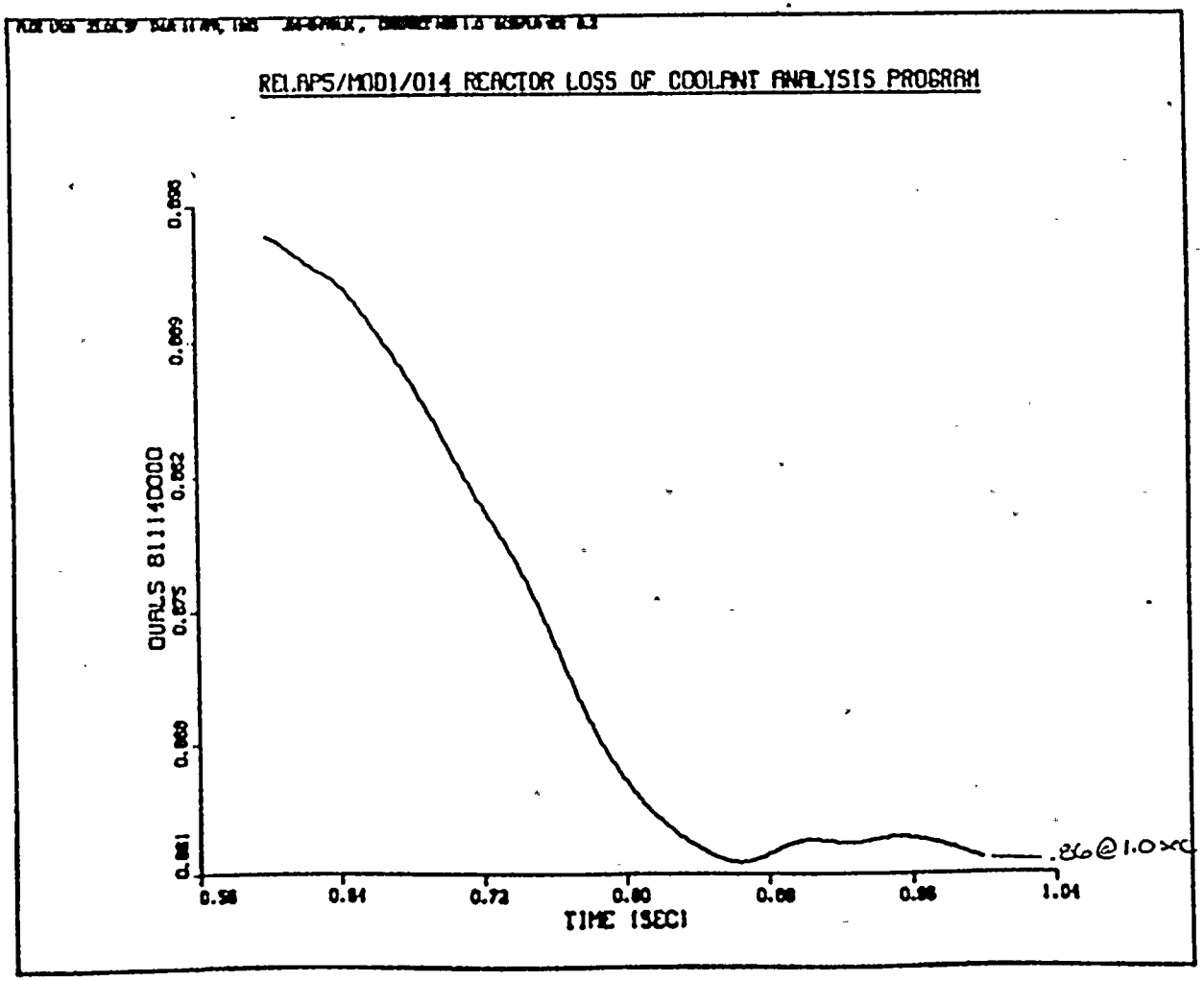
Technical Report
TR-5364-1
Revision 0



BY UHH DATE 11-29-83
CHKD. BY JBW DATE 11-29-83

TELEDYNE ENGINEERING SERVICES

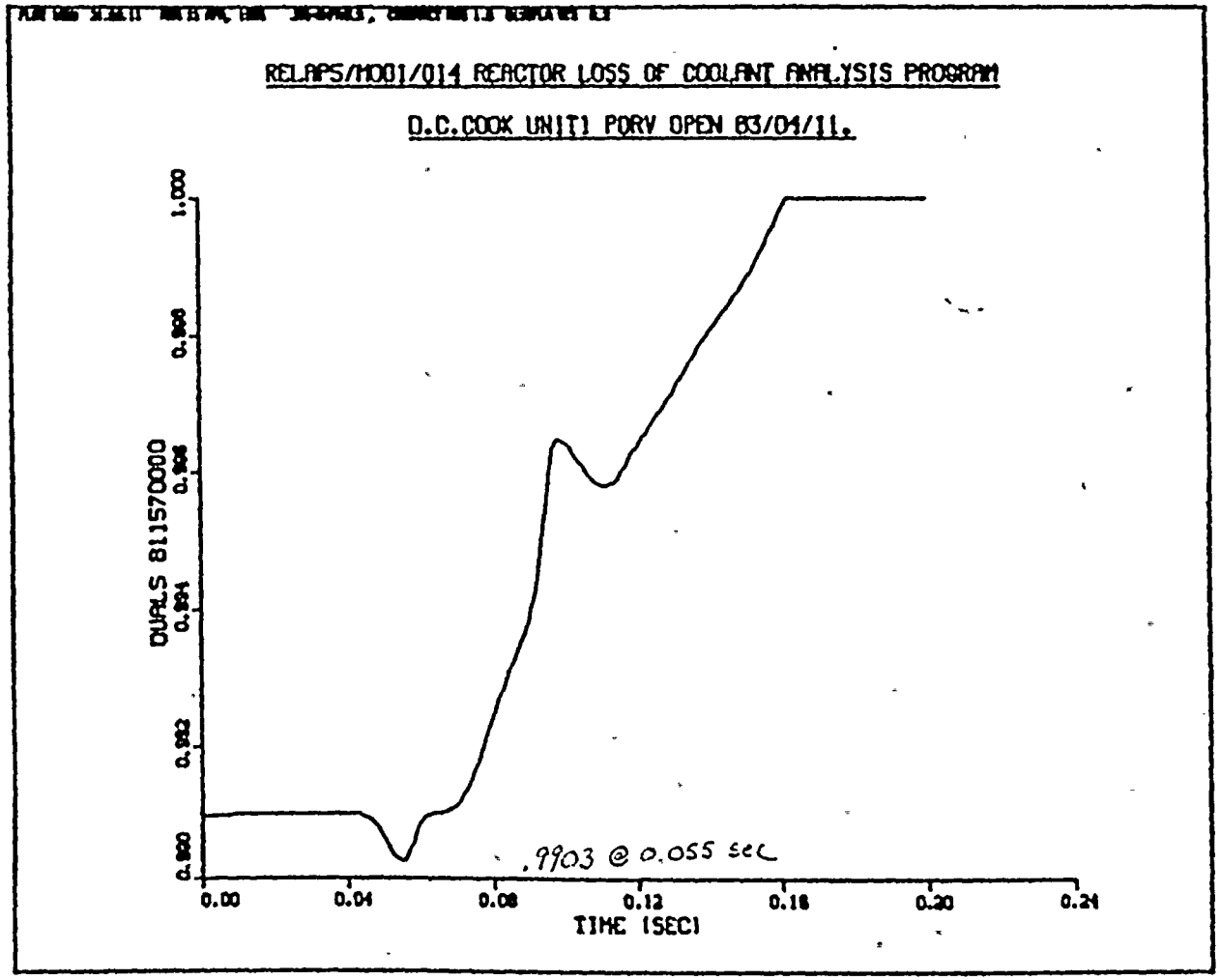
Technical Report
TR-5364-1
Revision 0



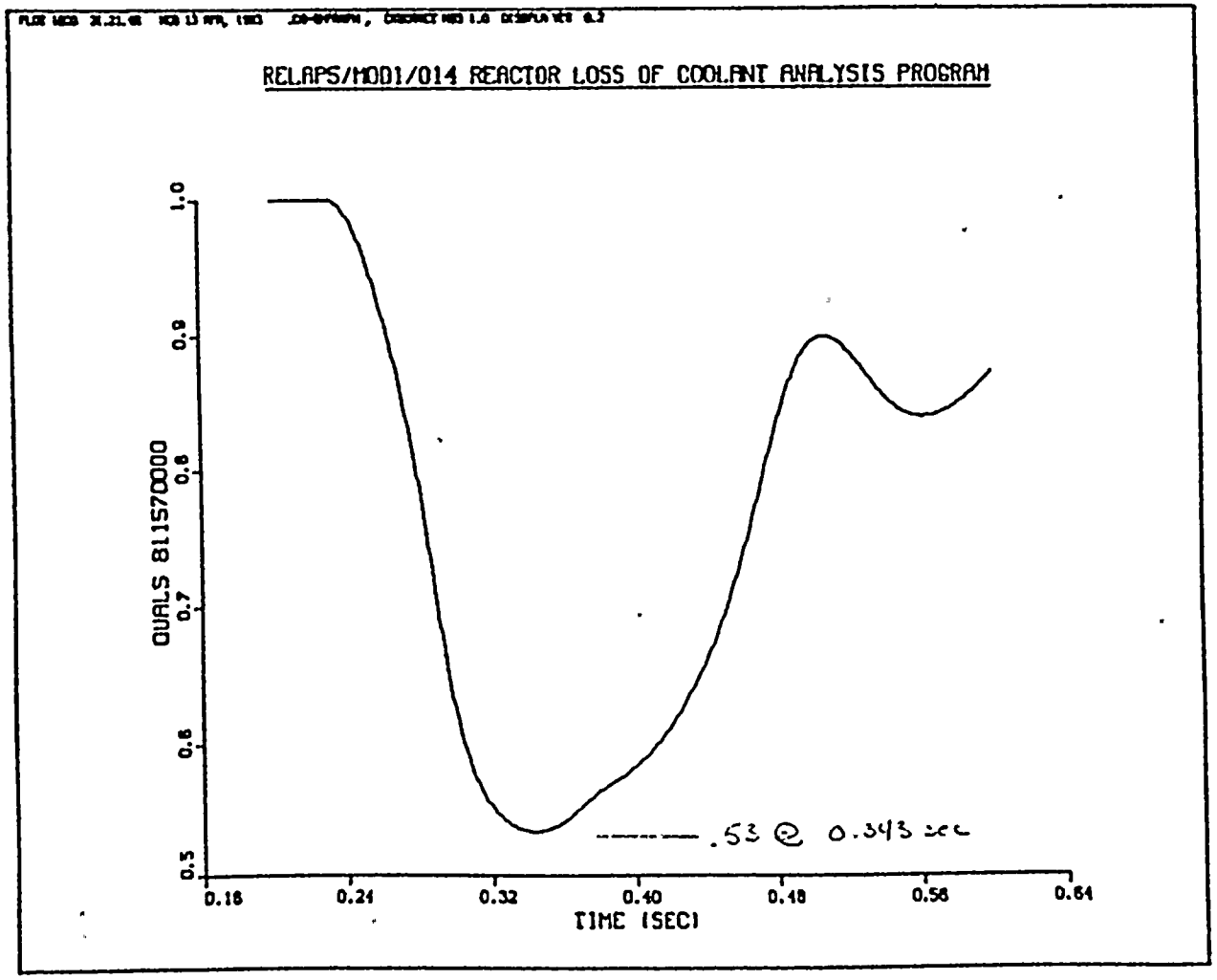
BY [illegible] DATE 11-29-83
CHKD. BY [illegible] DATE 4-29-83

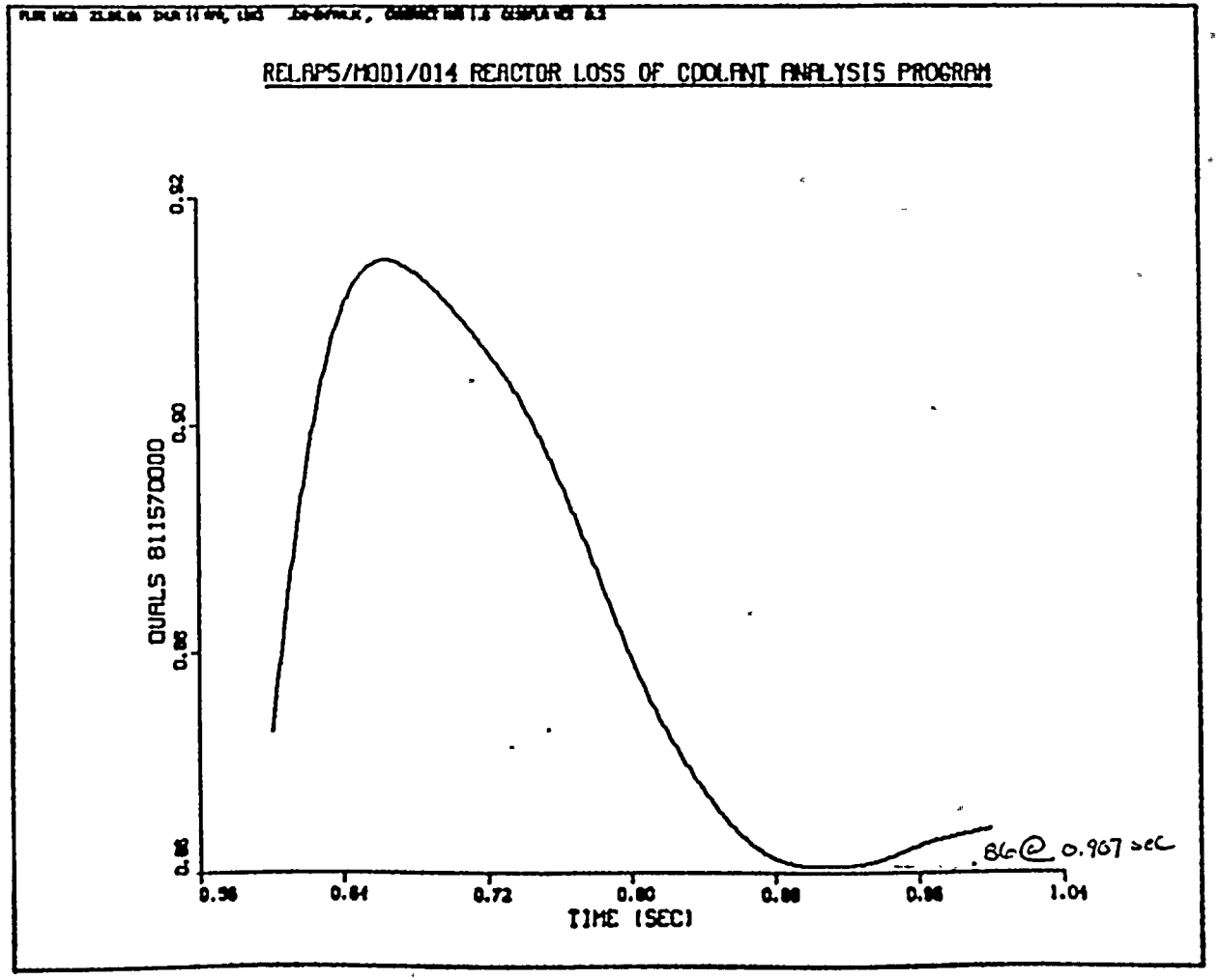
TELEDYNE ENGINEERING SERVICES

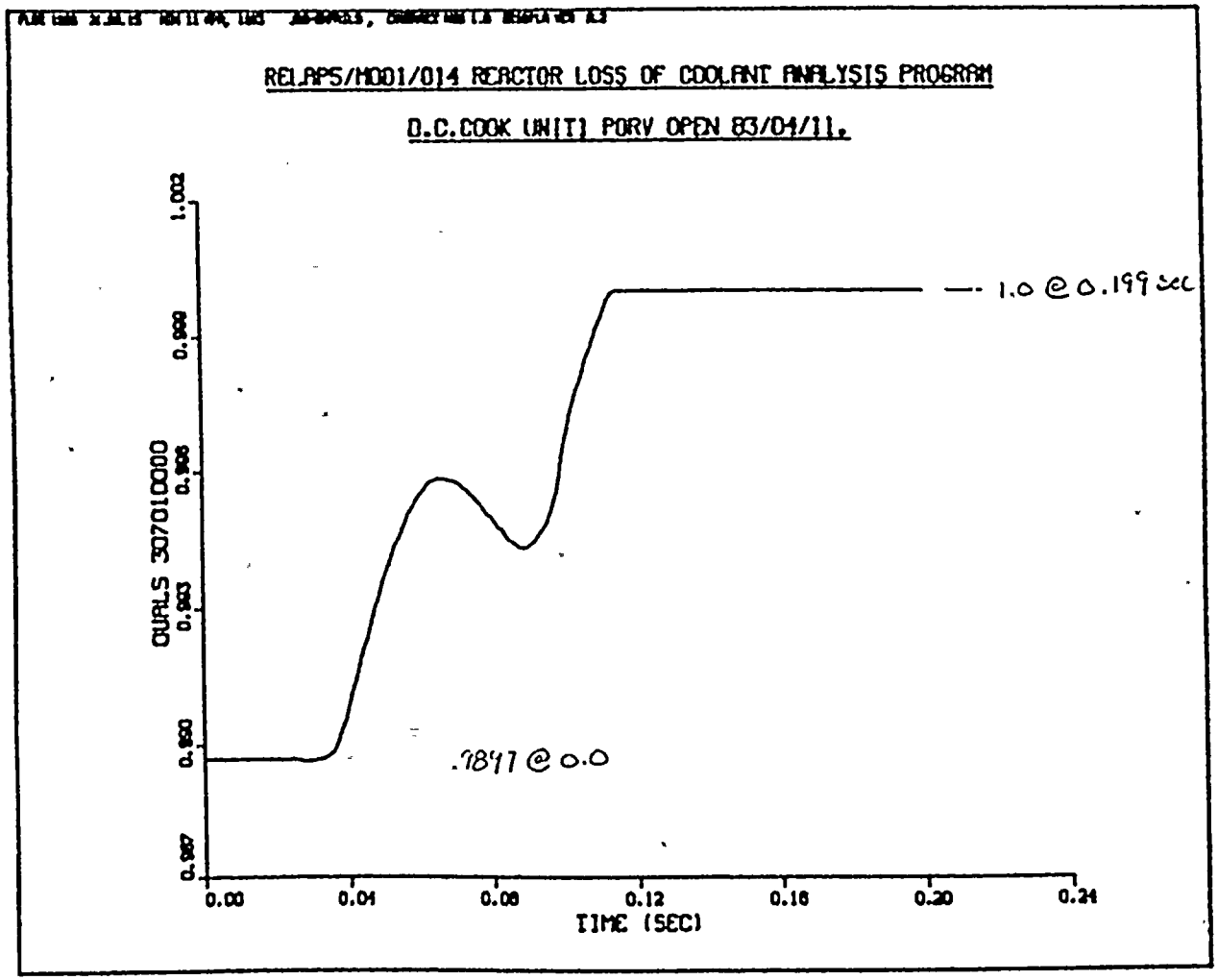
Technical Report
TR-5364-1
Revision 0



BY UHM DATE 11-29-83
CHKD. BY JBM DATE 11-29-83




RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
QUALS 81157000D
0.92
0.90
0.88
0.86
0.56
0.64
0.72
0.80
0.88
0.96
1.04
TIME (SEC)
86 @ 0.907 sec


RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/11.
CWALS 30701000D
1.002
0.999
0.996
0.993
0.990
0.987
1.0 @ 0.199 sec
.9847 @ 0.0
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)

BY UHM DATE 11-29-83
CHKD. BY [illegible] DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

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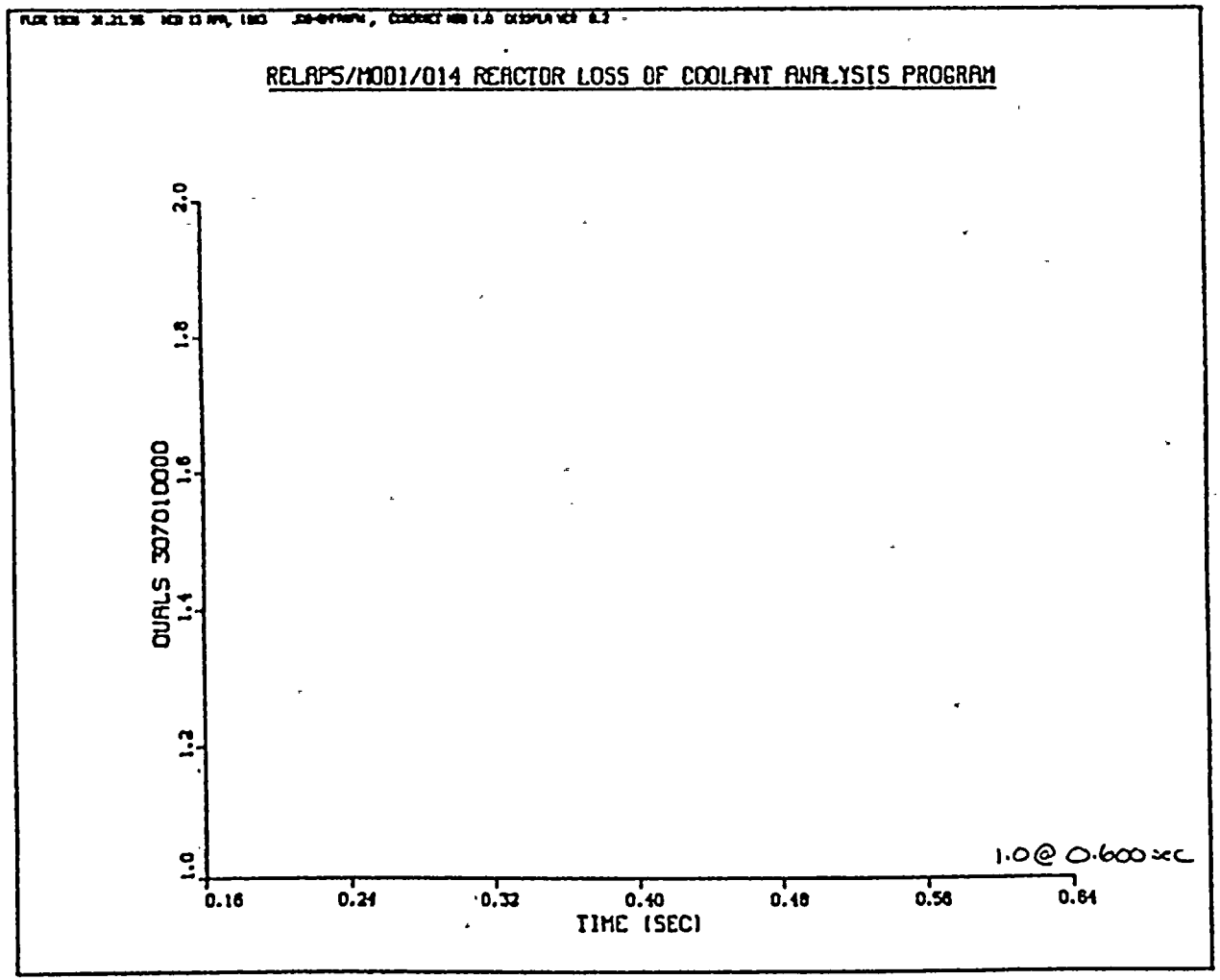
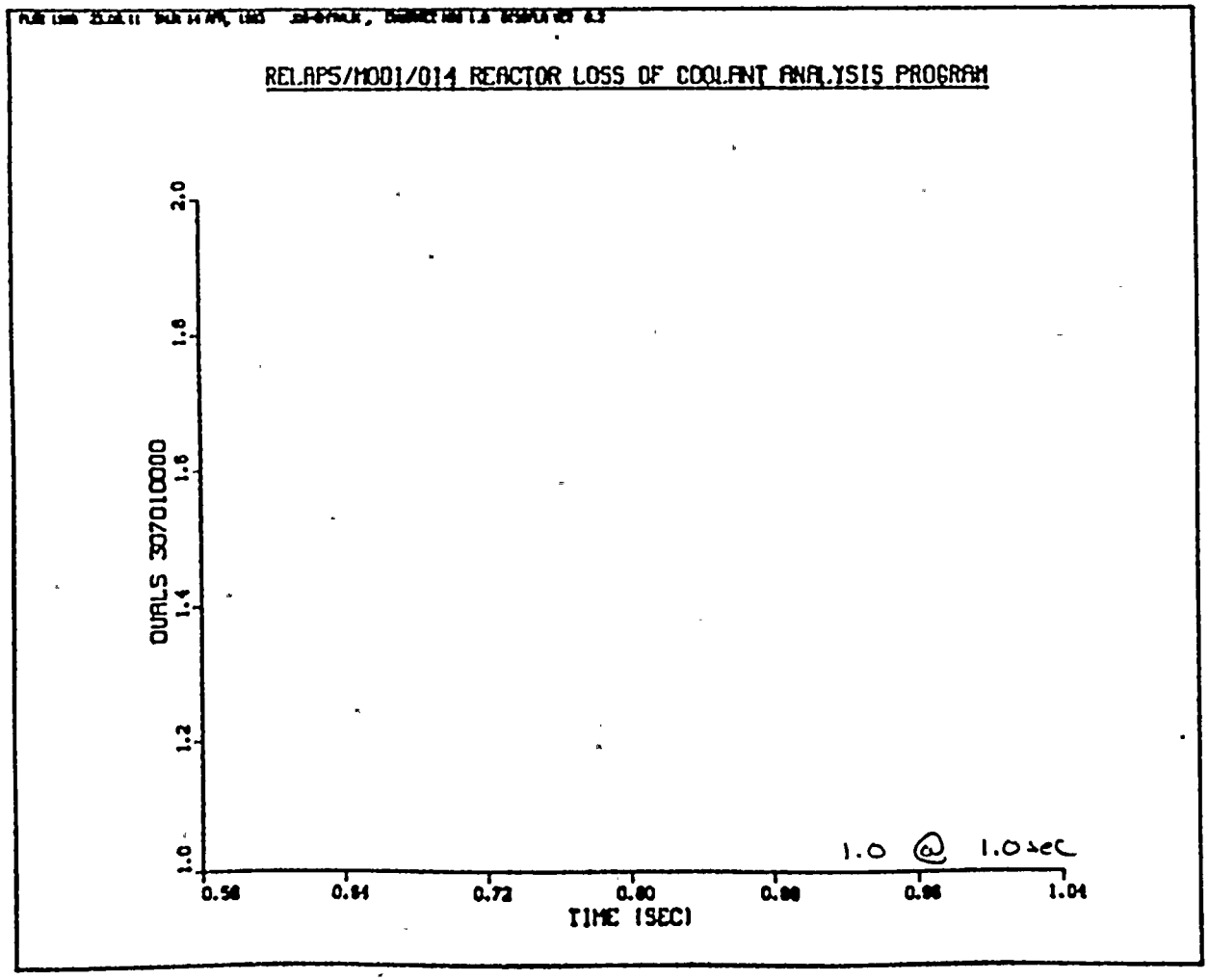
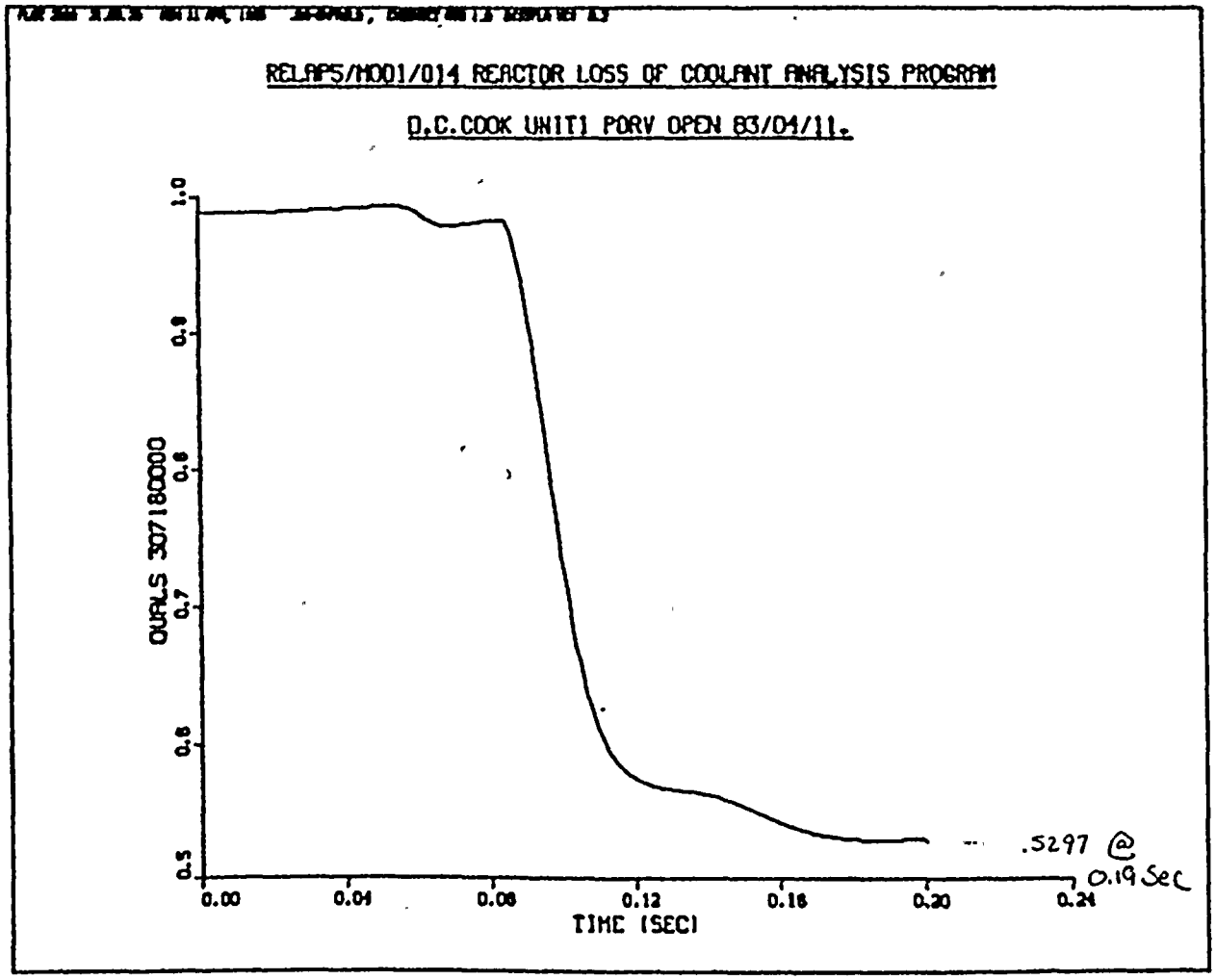
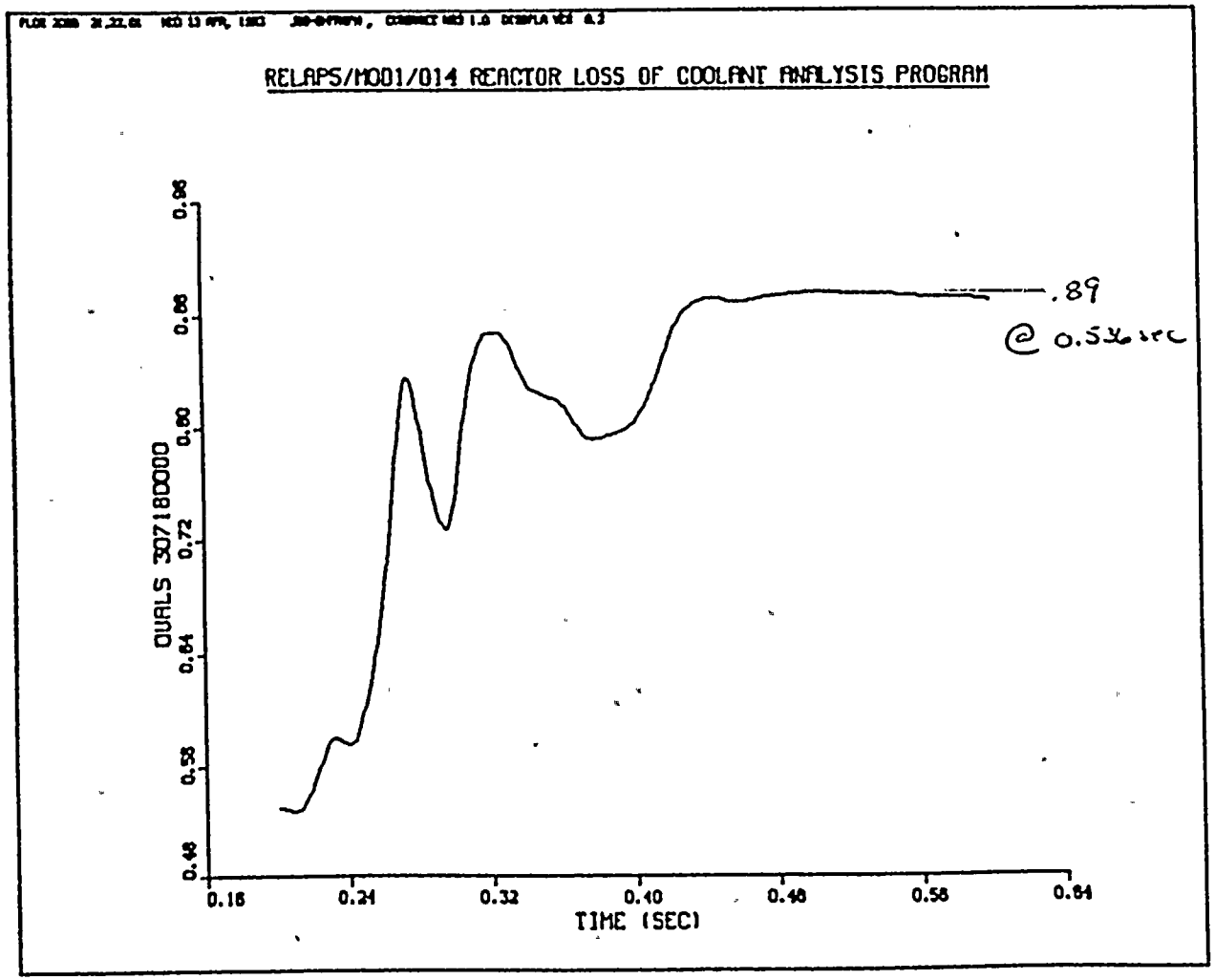
Revision 0



BY [illegible] DATE 11-29-83
CHKD. BY [illegible] DATE 11-29-83




RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/11.
OURLS 307180000
1.0
0.9
0.8
0.7
0.6
0.5
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)
.5297 @ 0.19 Sec


RELAPS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
QUALS 30718D000
0.48
0.56
0.64
0.72
0.80
0.88
0.96
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)
.89
@ 0.536 sec

BY [illegible] DATE 11-29-83
CHKD. BY JBM DATE 4-29-87

TELEDYNE ENGINEERING SERVICES

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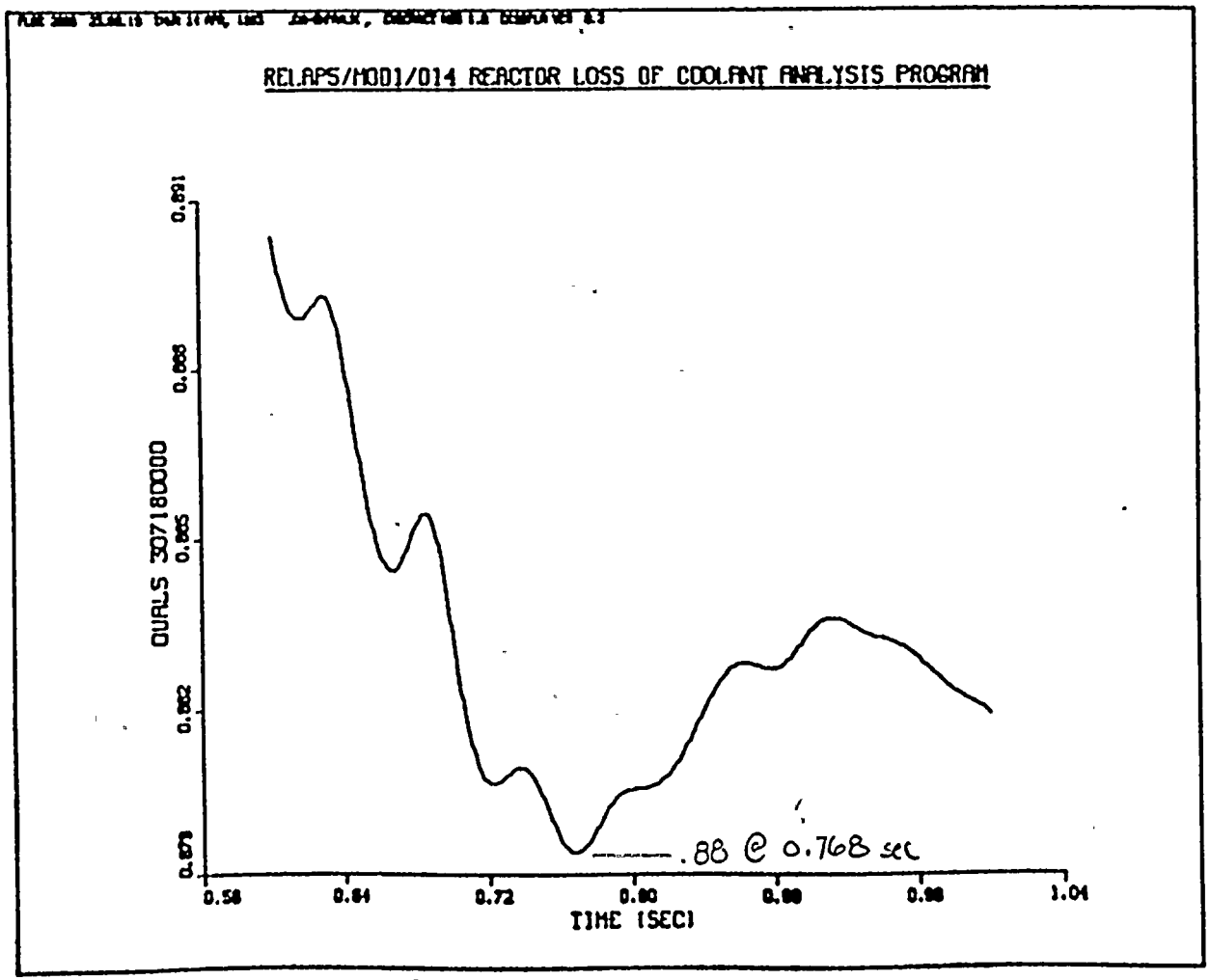
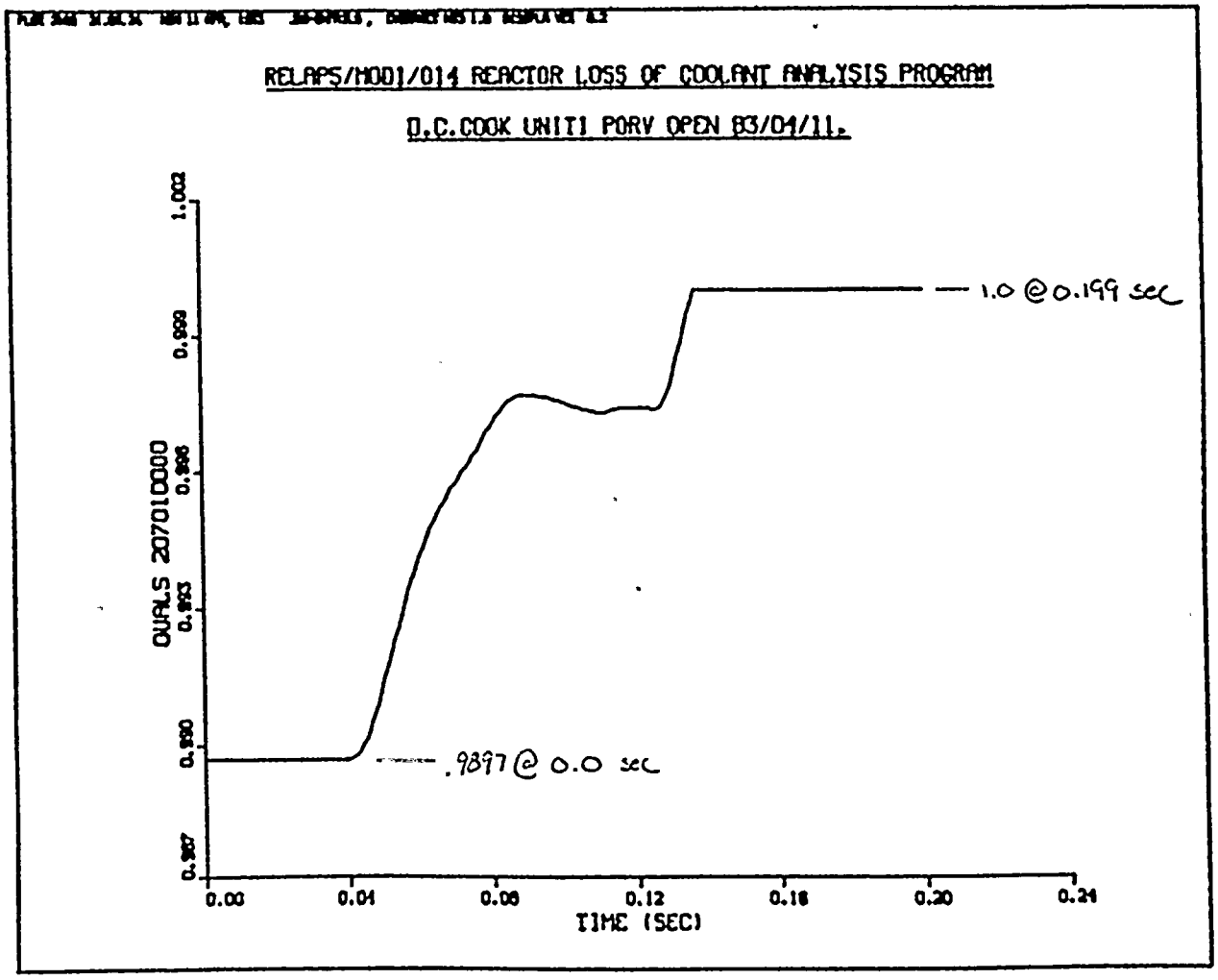


BY JHM DATE 11-29-83
CHKD. BY JBW DATE 4-29-83

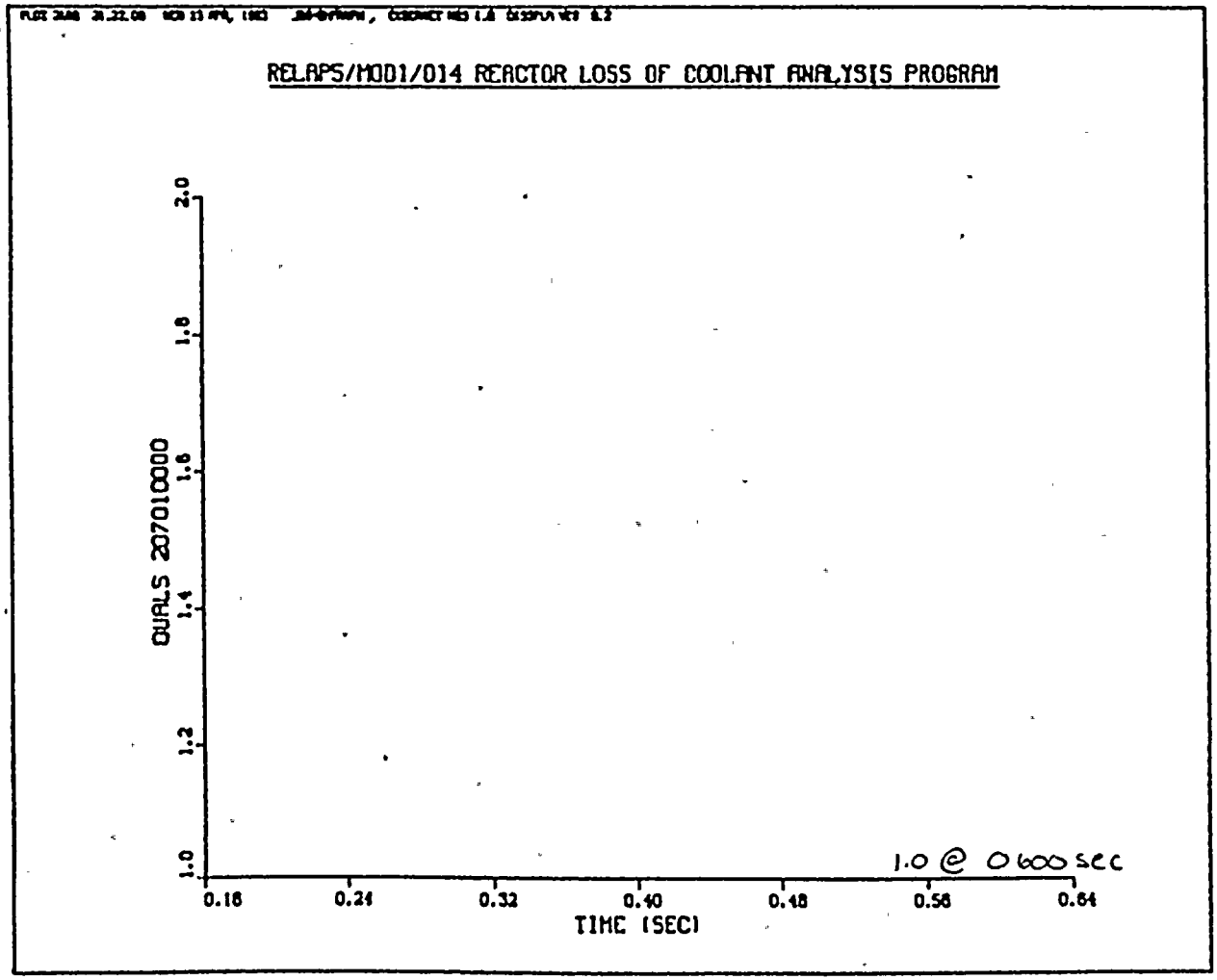
TELEDYNE ENGINEERING SERVICES



BY JHH DATE 11-29-83
CHKD. BY JBK DATE 4-29-85

TELEDYNE ENGINEERING SERVICES

Technical Report
TR-5364-1
Revision 0



BY JHM DATE 11-29-83
CHKD. BY [illegible] DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

Technical Report
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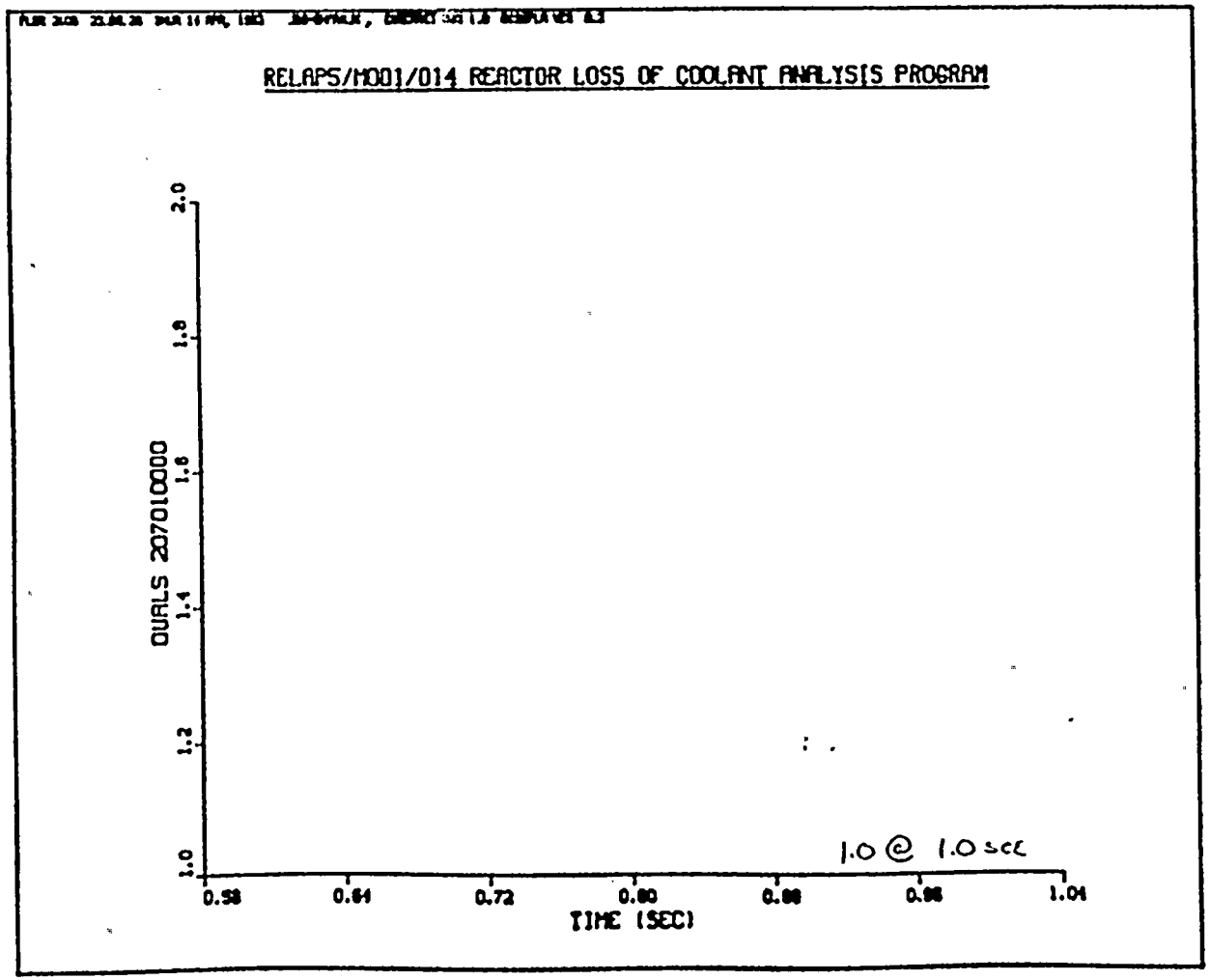
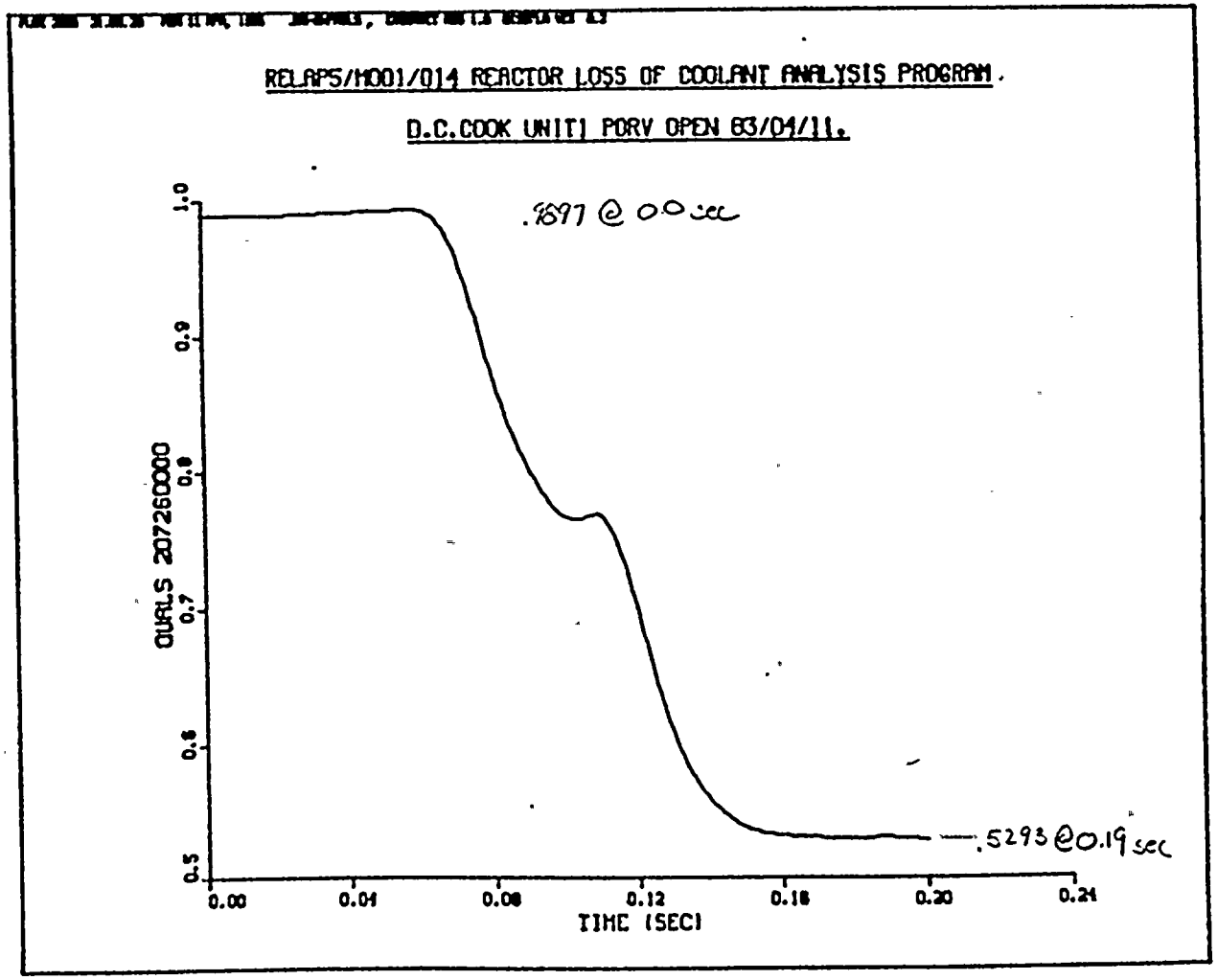
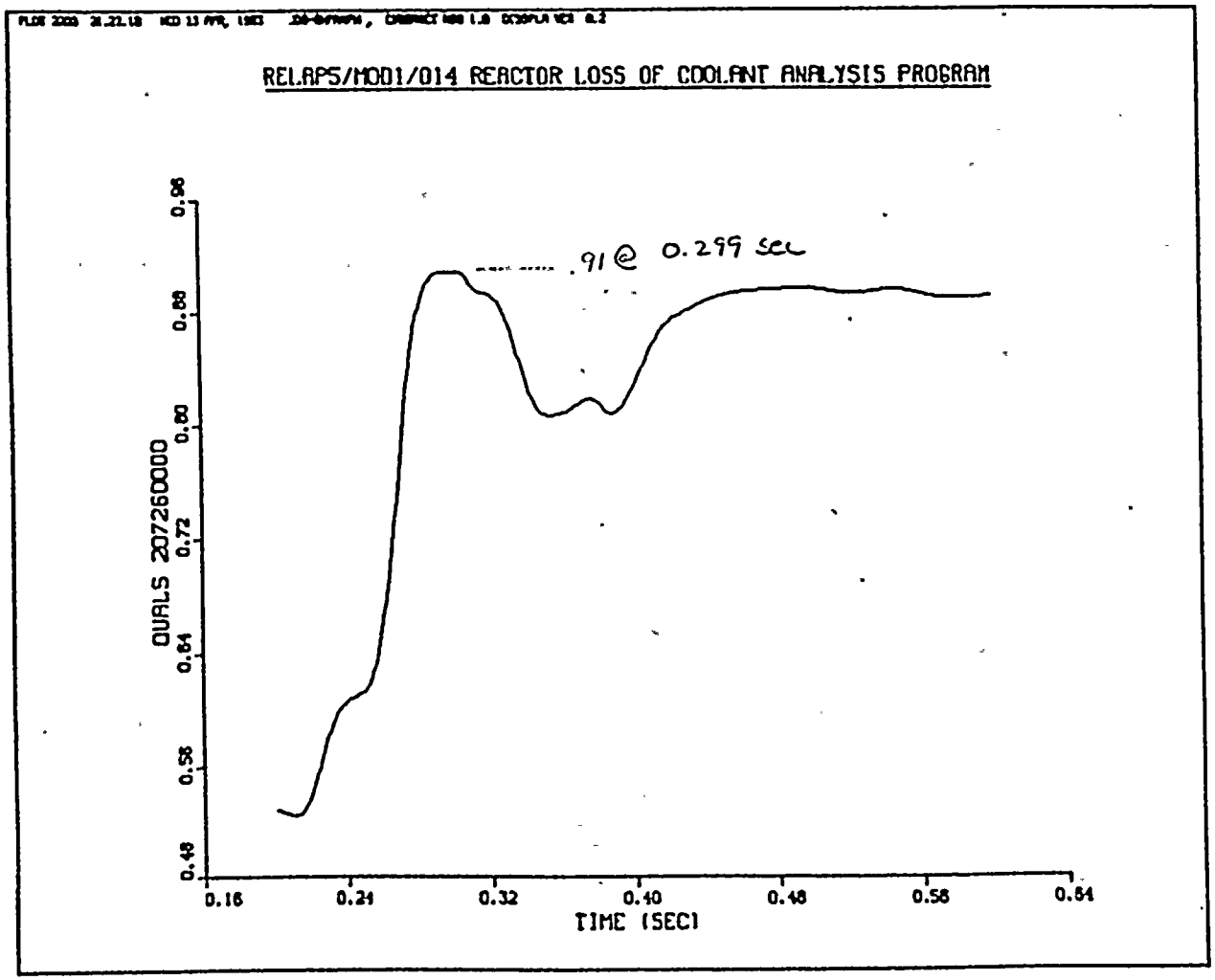


BY JHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83

TELEDYNE ENGINEERING SERVICES



BY UHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83



TELEDYNE ENGINEERING SERVICES

BY JHH DATE 11-29-83
CHKD. BY JBW DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

Technical Report
TR-5364-1
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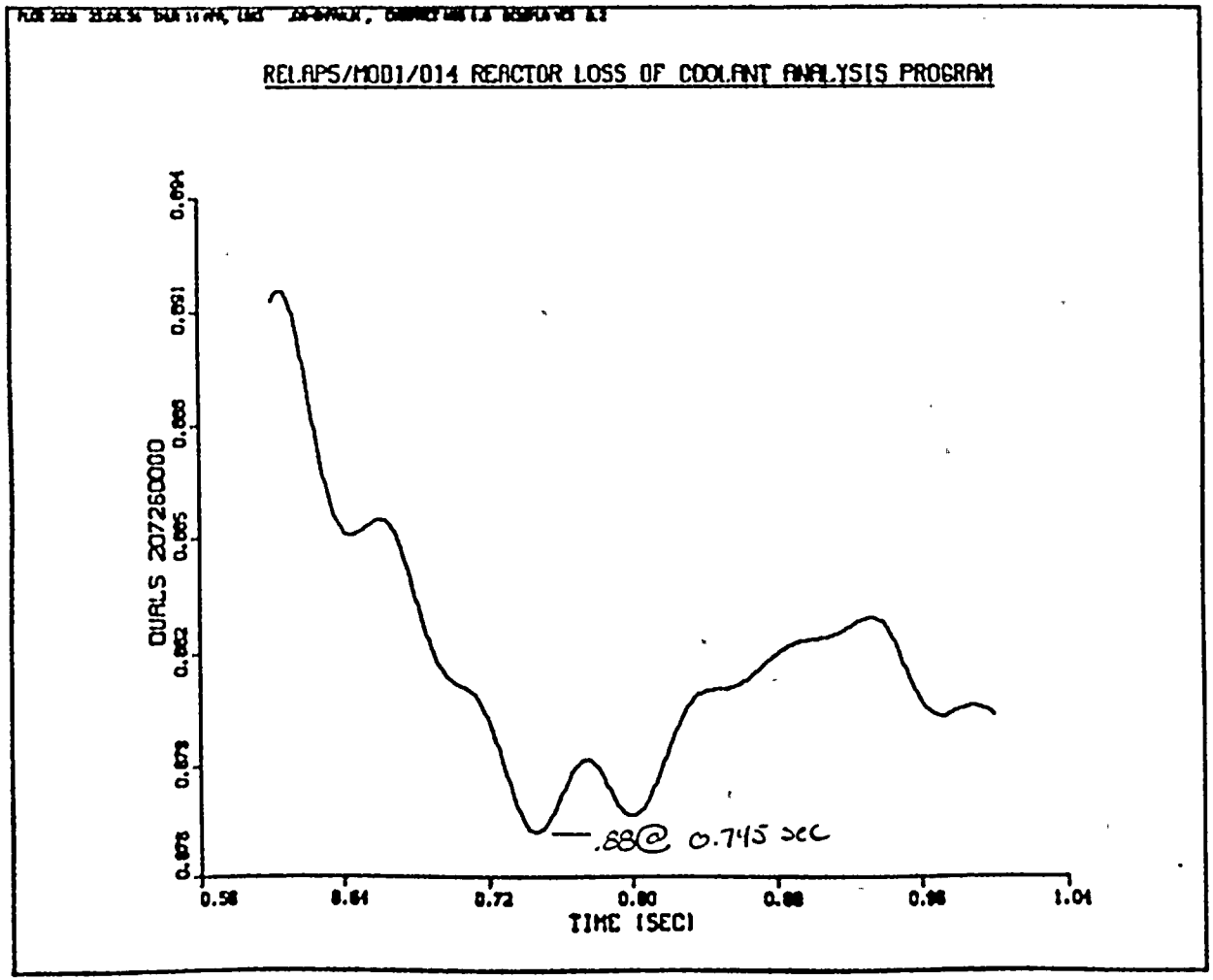

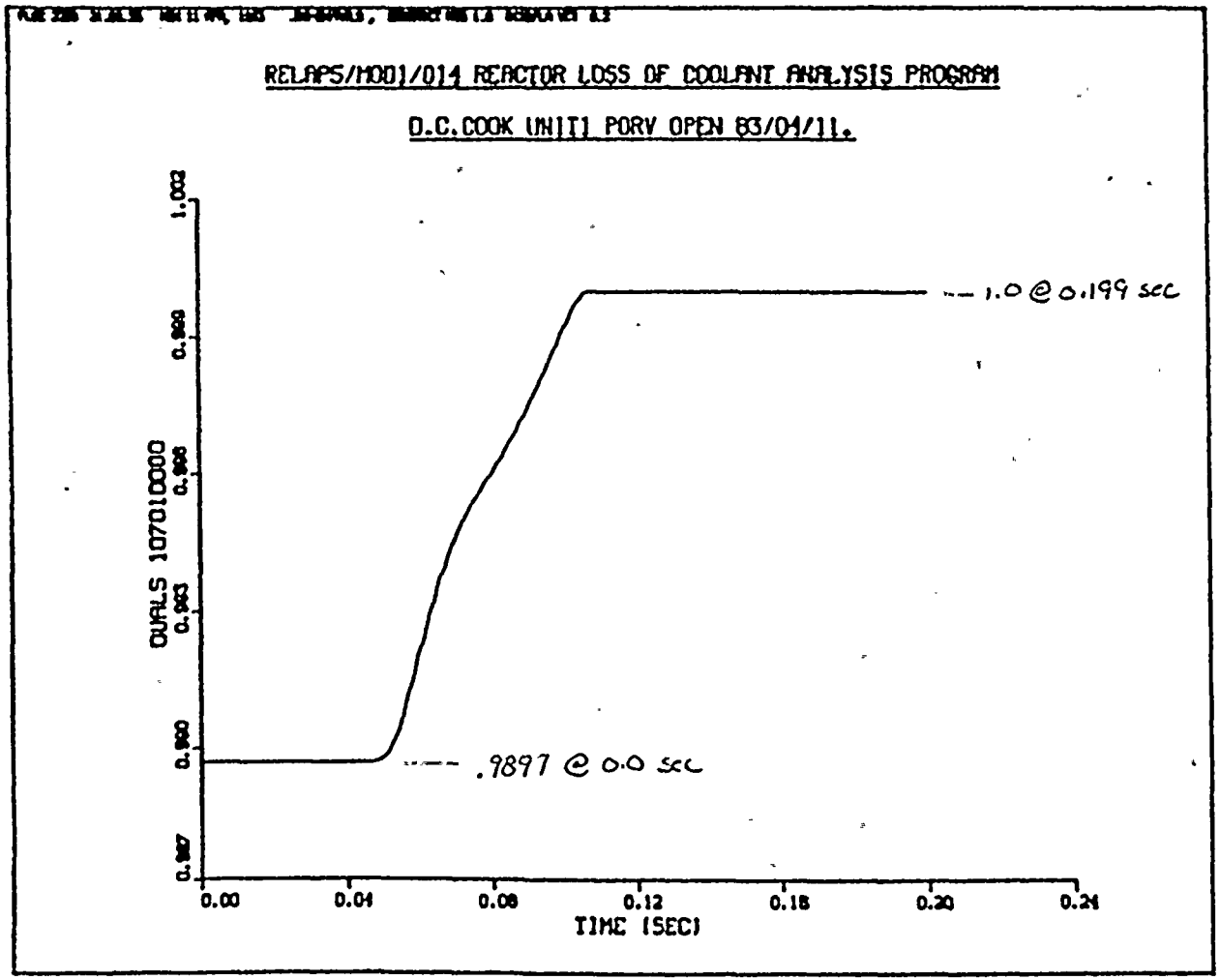
RELAPS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/11.
QUALS 1070100000
1.000
0.998
0.996
0.993
0.990
0.987
1.0 @ 0.199 sec
.9897 @ 0.0 sec
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)

BY [illegible] DATE 11-29-83
CHKD. BY [illegible] DATE 4-29-87

TELEDYNE ENGINEERING SERVICES

Technical Report
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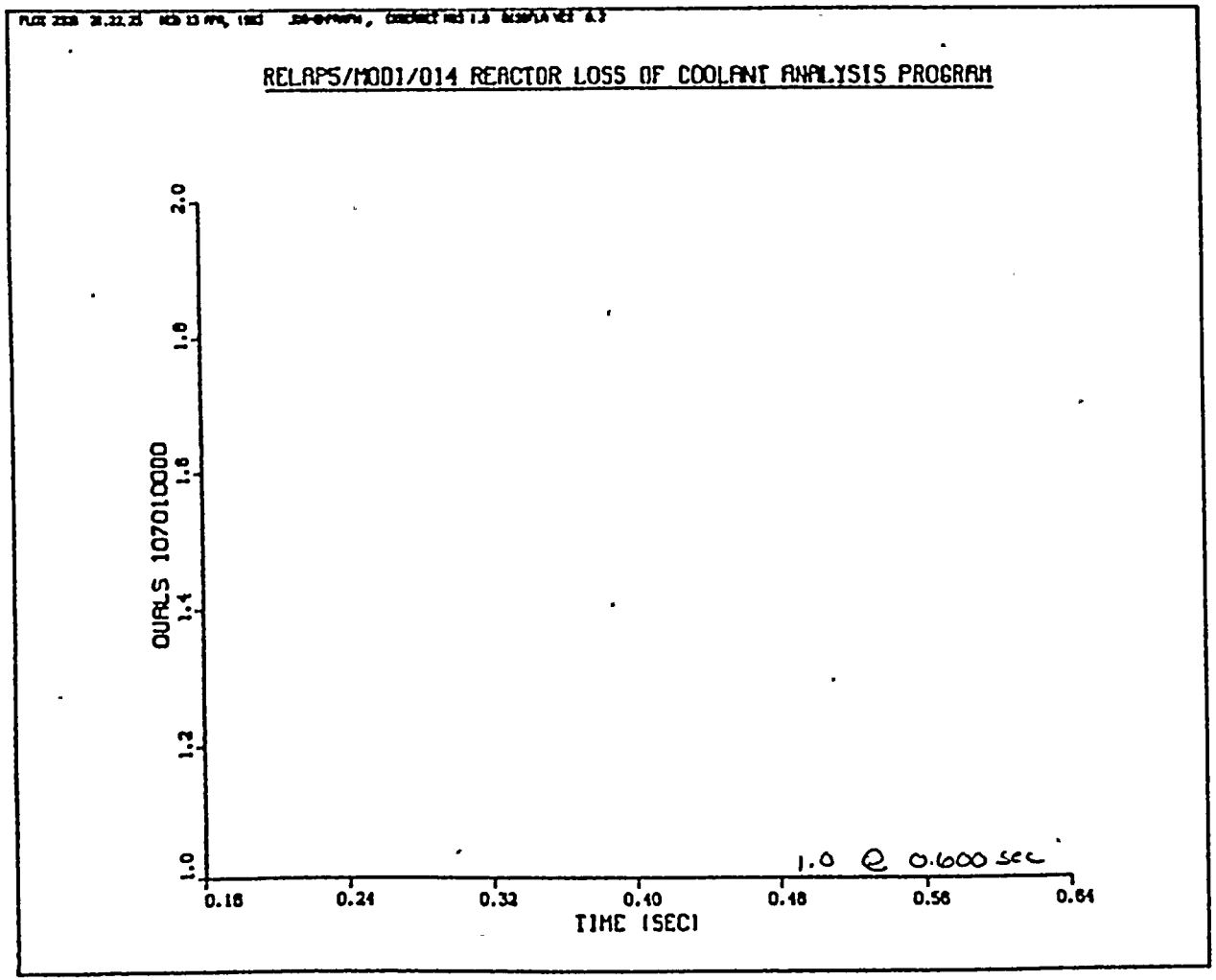
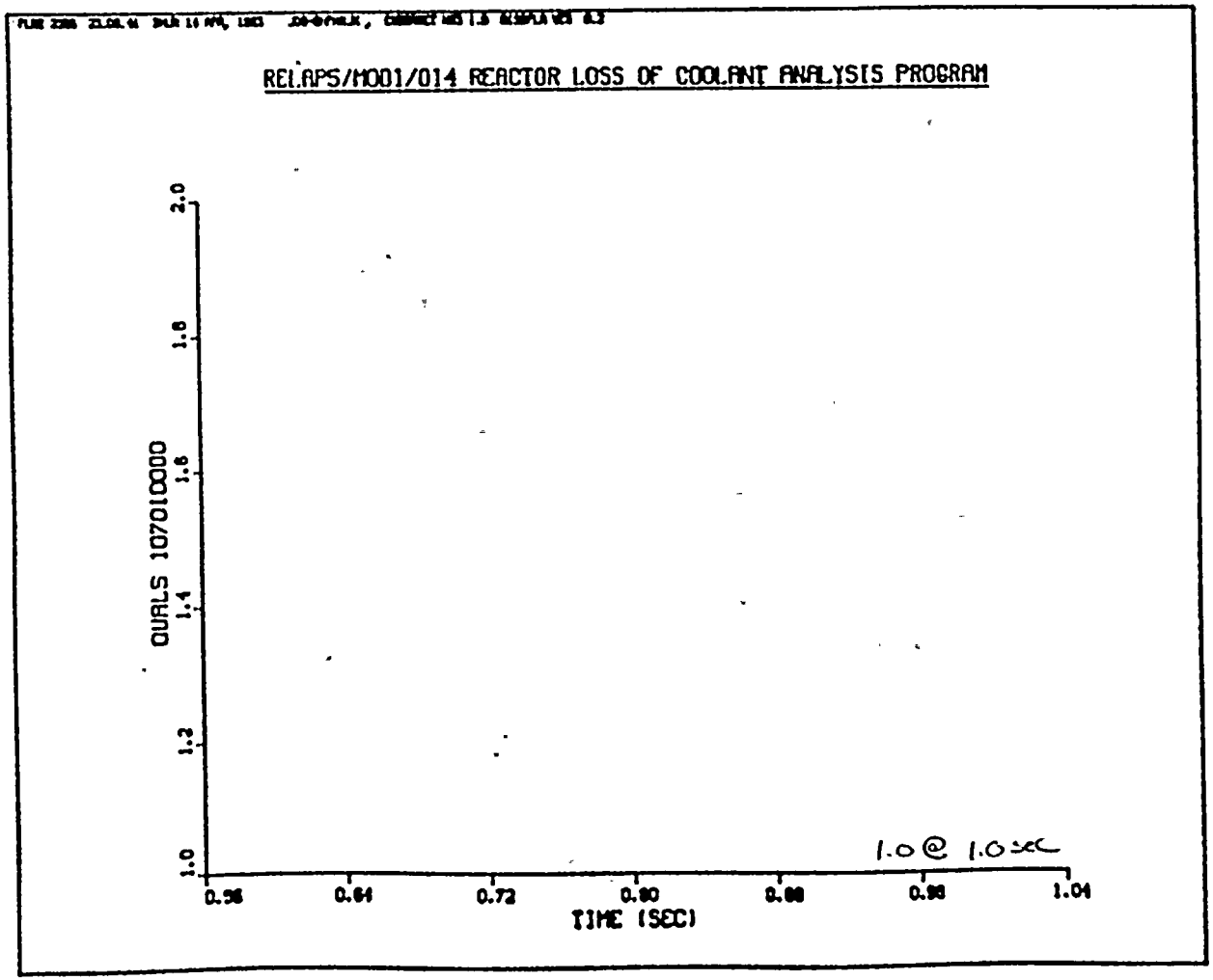
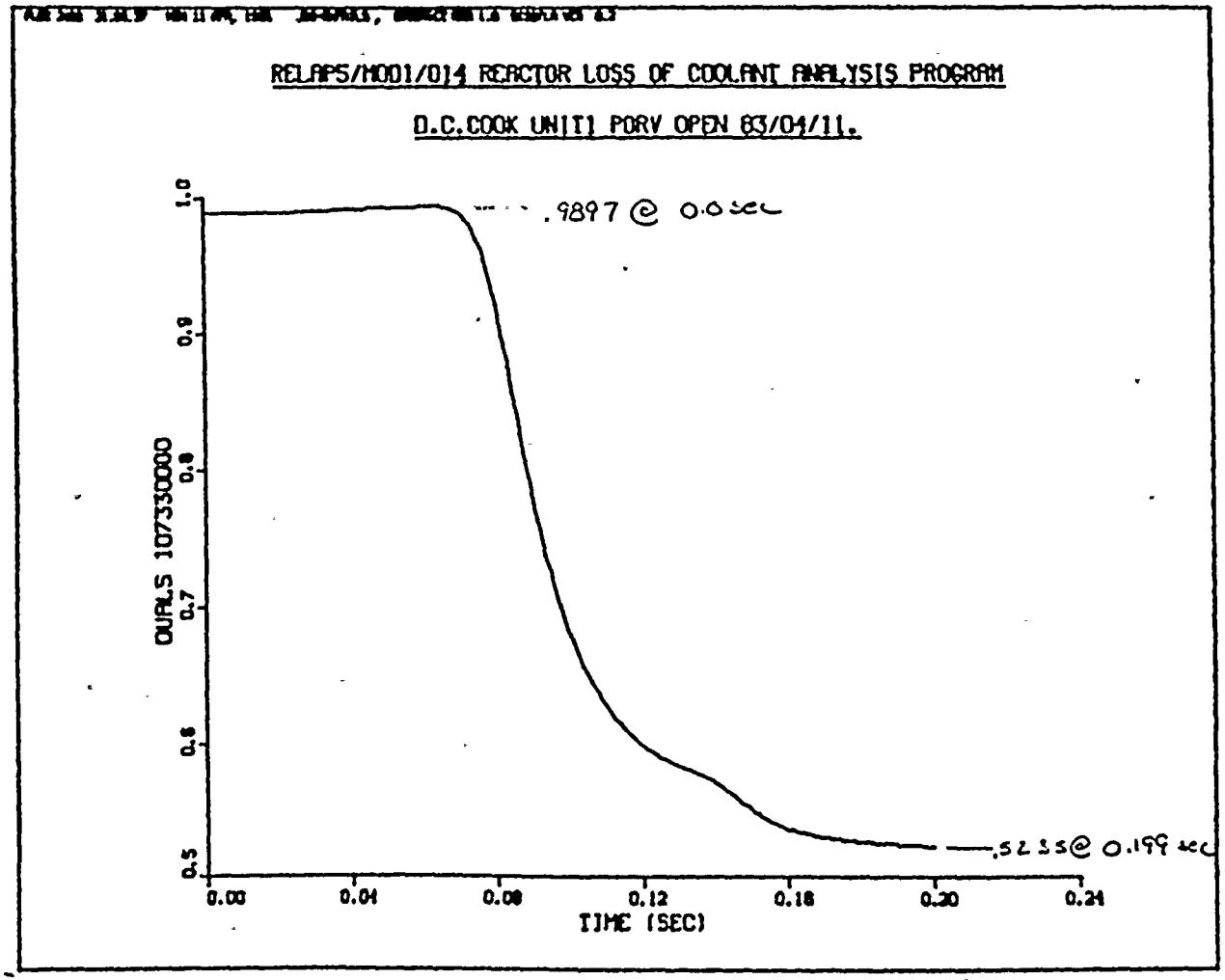


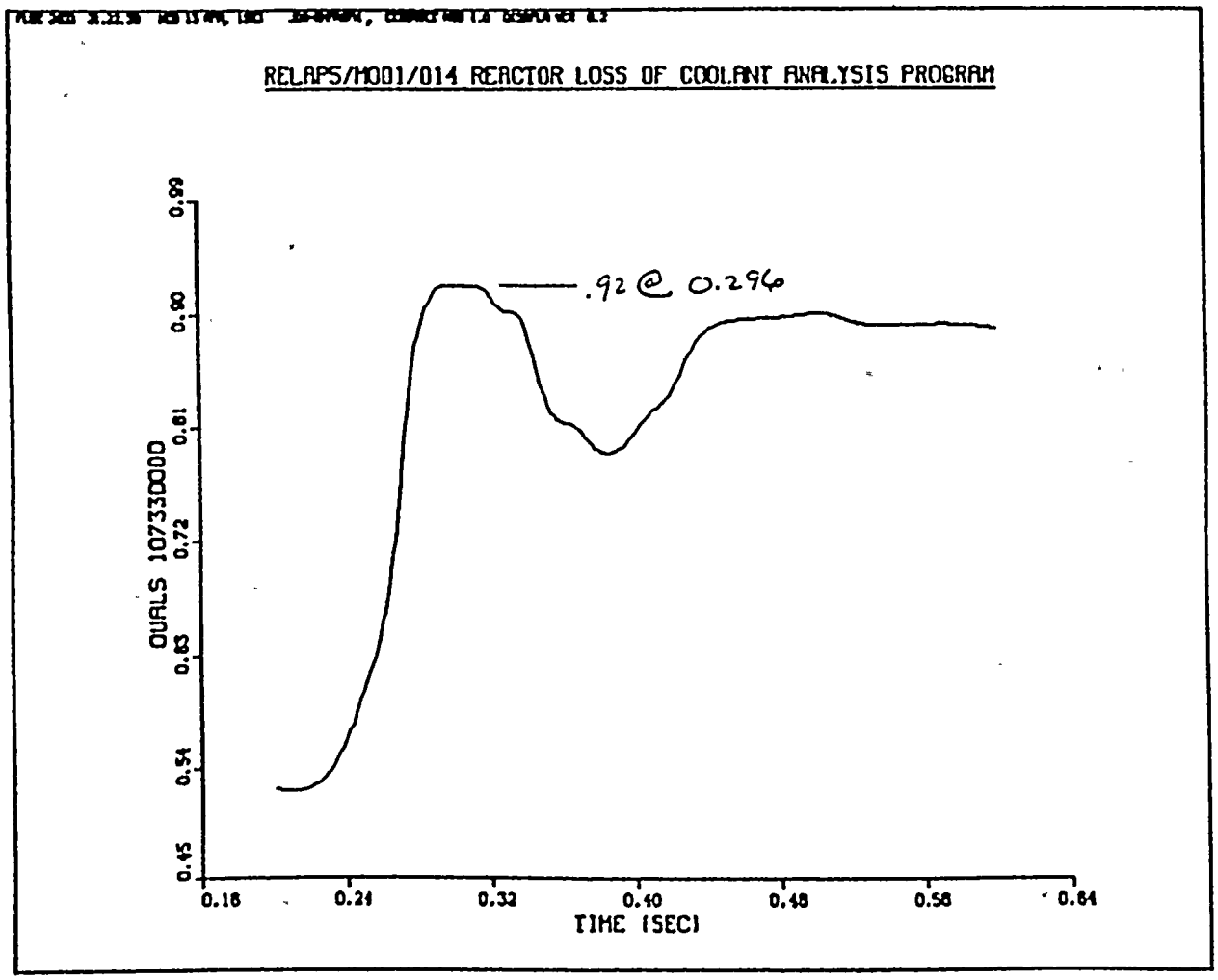
BY UHM DATE 11-29-83
CHKD. BY JBV DATE 11-29-83

TELEDYNE ENGINEERING SERVICES

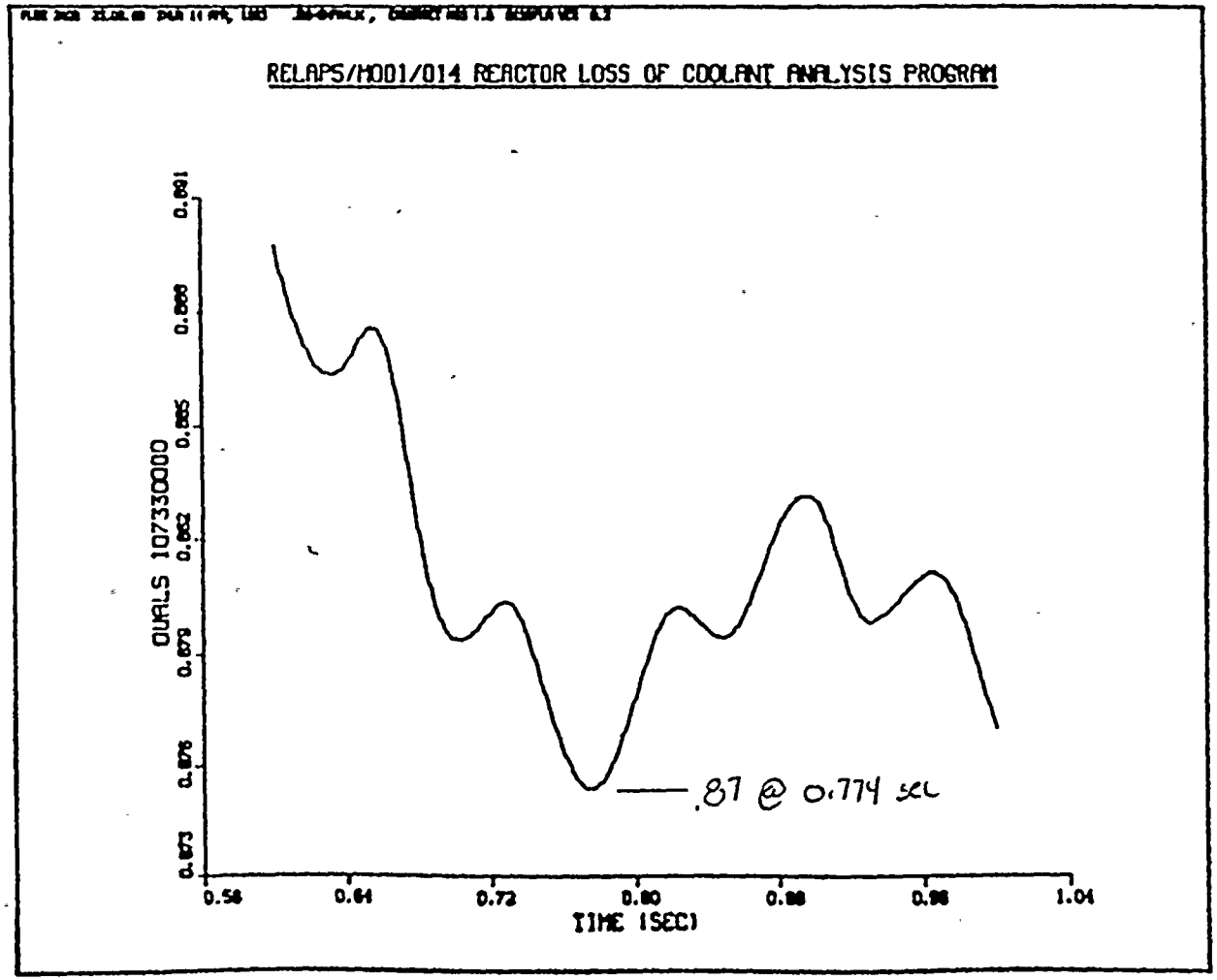
Technical Report
TR-5364-1
Revision 0



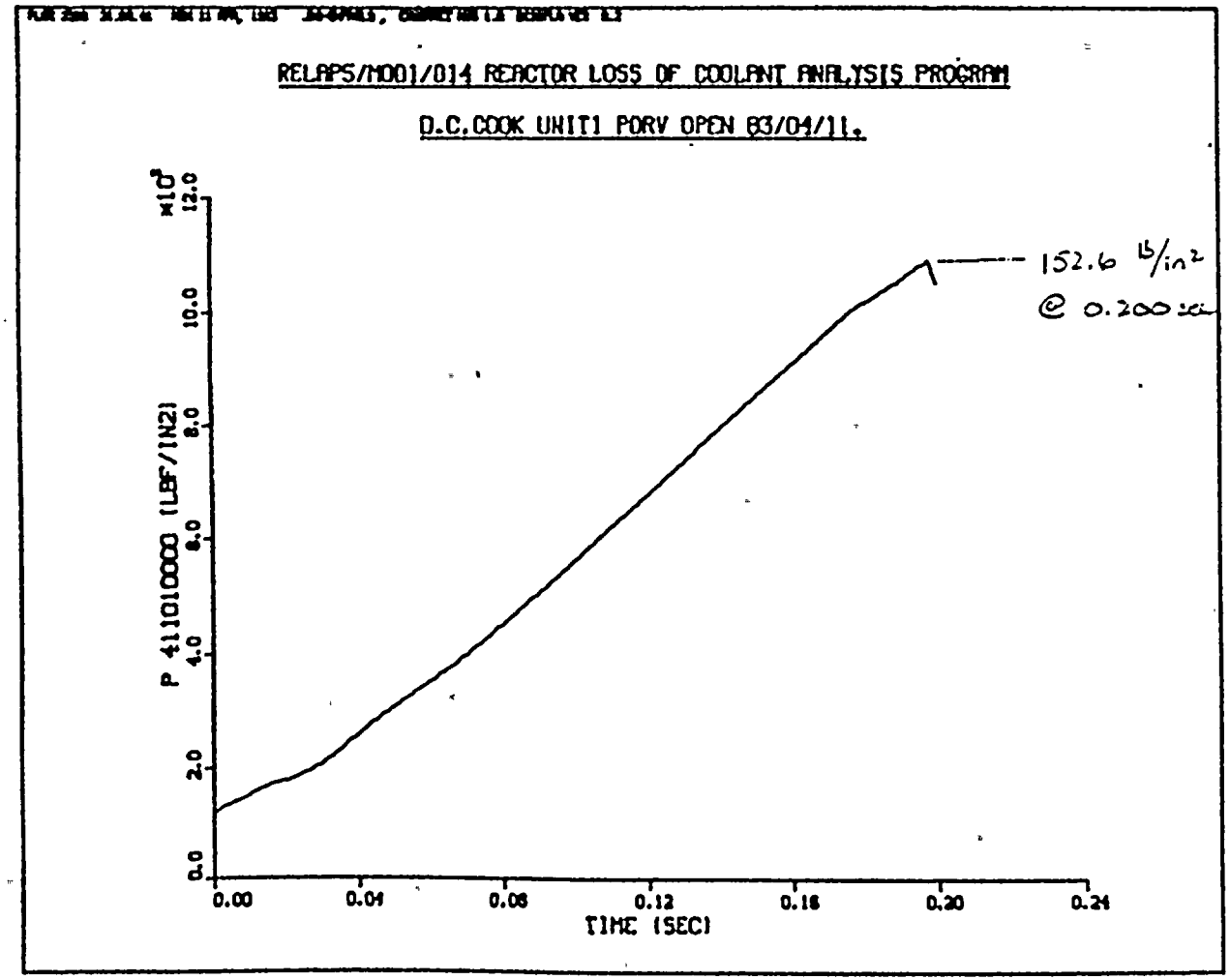

RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/11.
.9897 @ 0.0 sec
.5255 @ 0.199 sec
OUALS 1073300000
1.0
0.9
0.8
0.7
0.6
0.5
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)


RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
.92 @ 0.296
QUALS 10733000
0.45
0.54
0.63
0.72
0.81
0.90
0.99
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)

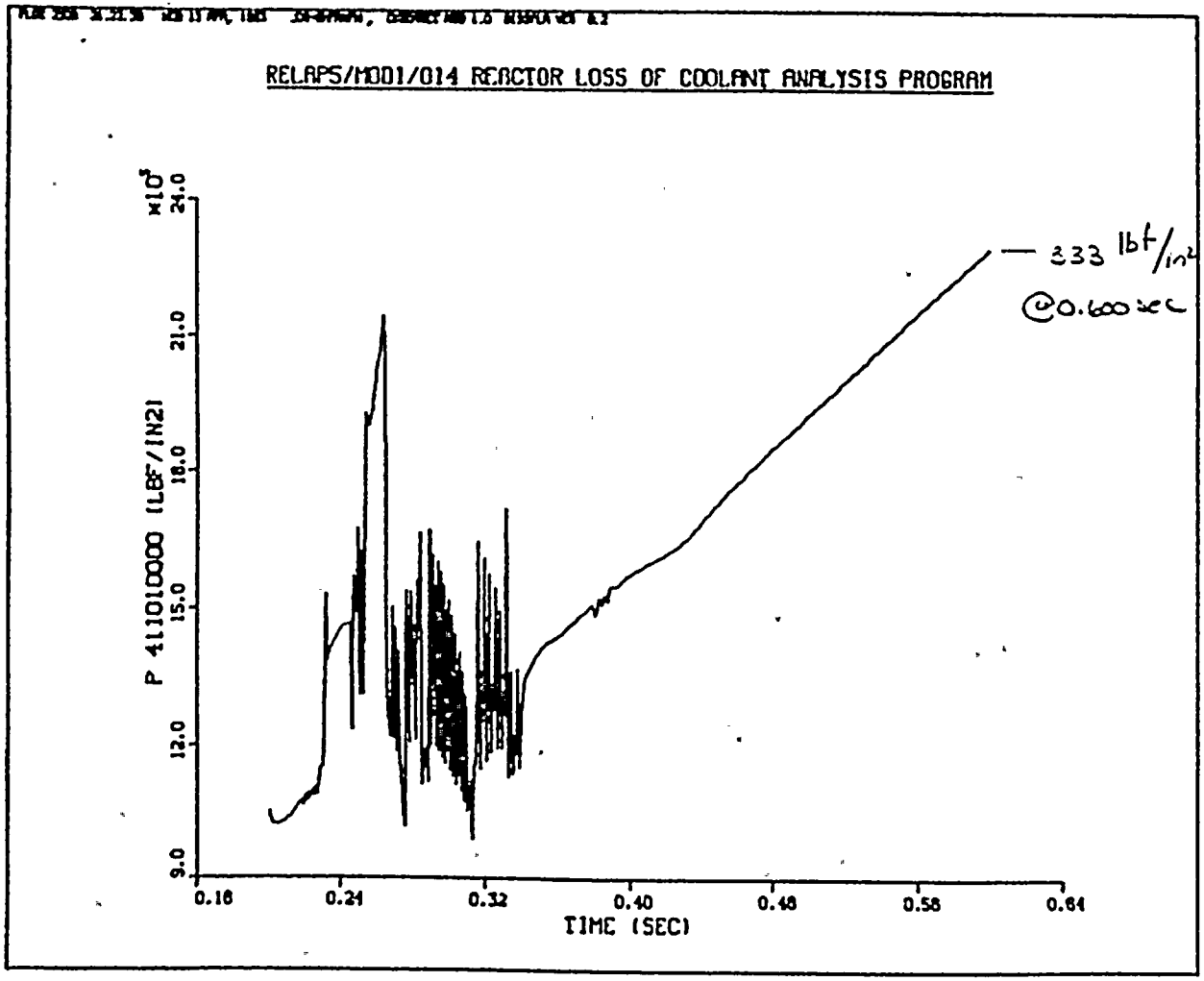
BY UHM DATE 11-29-83
CHKD. BY JBM DATE 11-29-83



BY [illegible] DATE 11-29-83
CHKD. BY [illegible] DATE 11-29-83



BY UHM DATE 11-29-83
CHKD. BY JBV DATE 4-29-87



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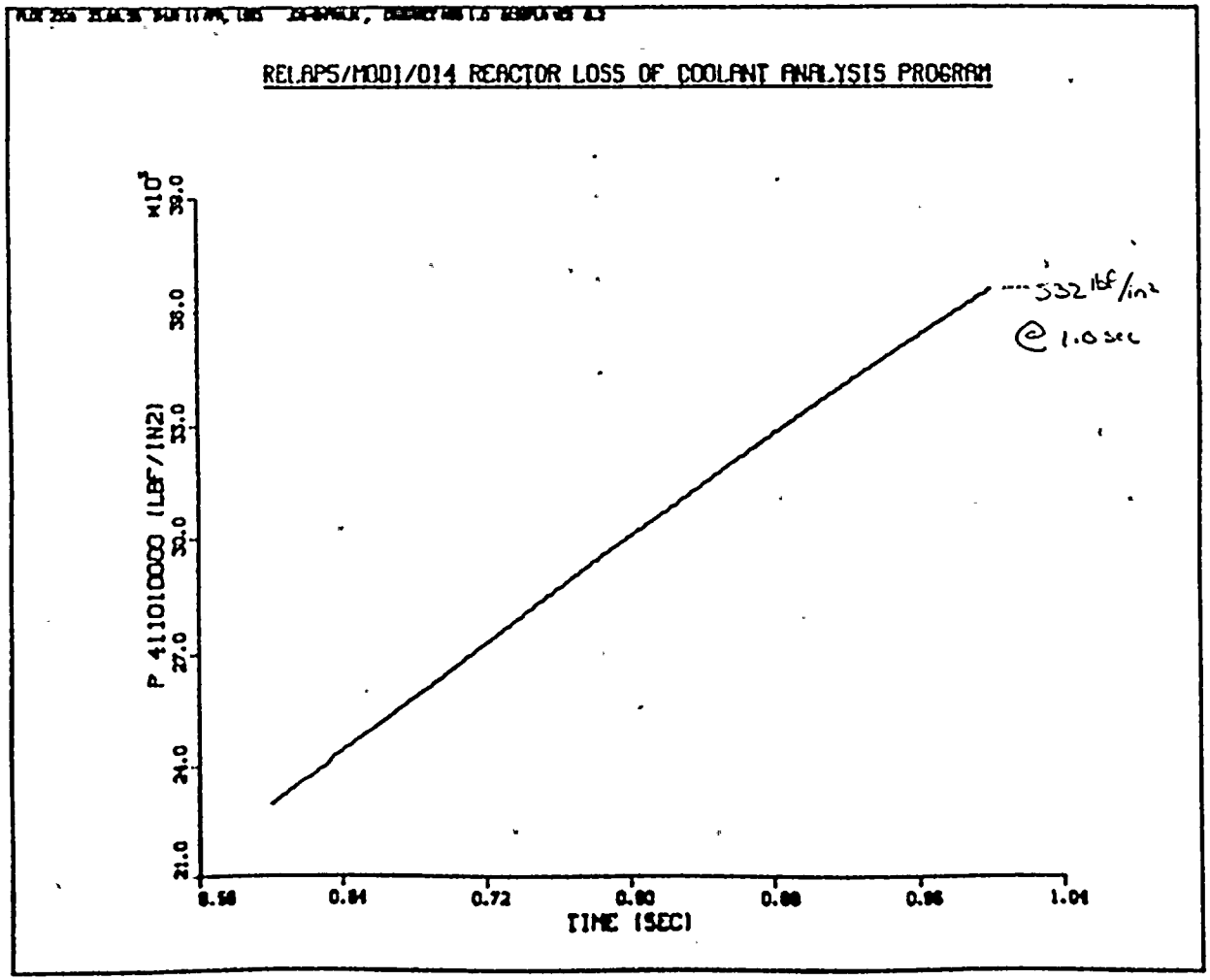
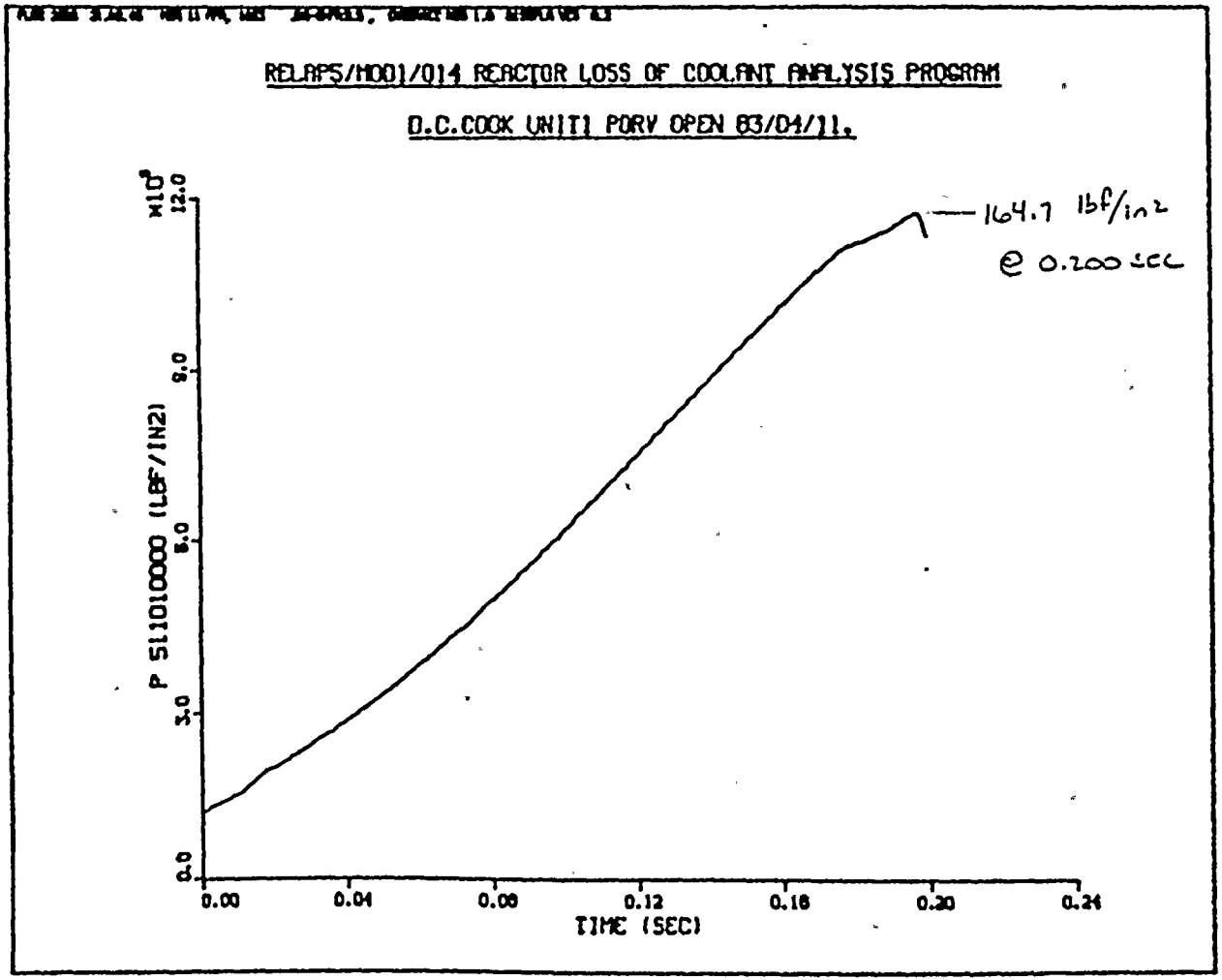
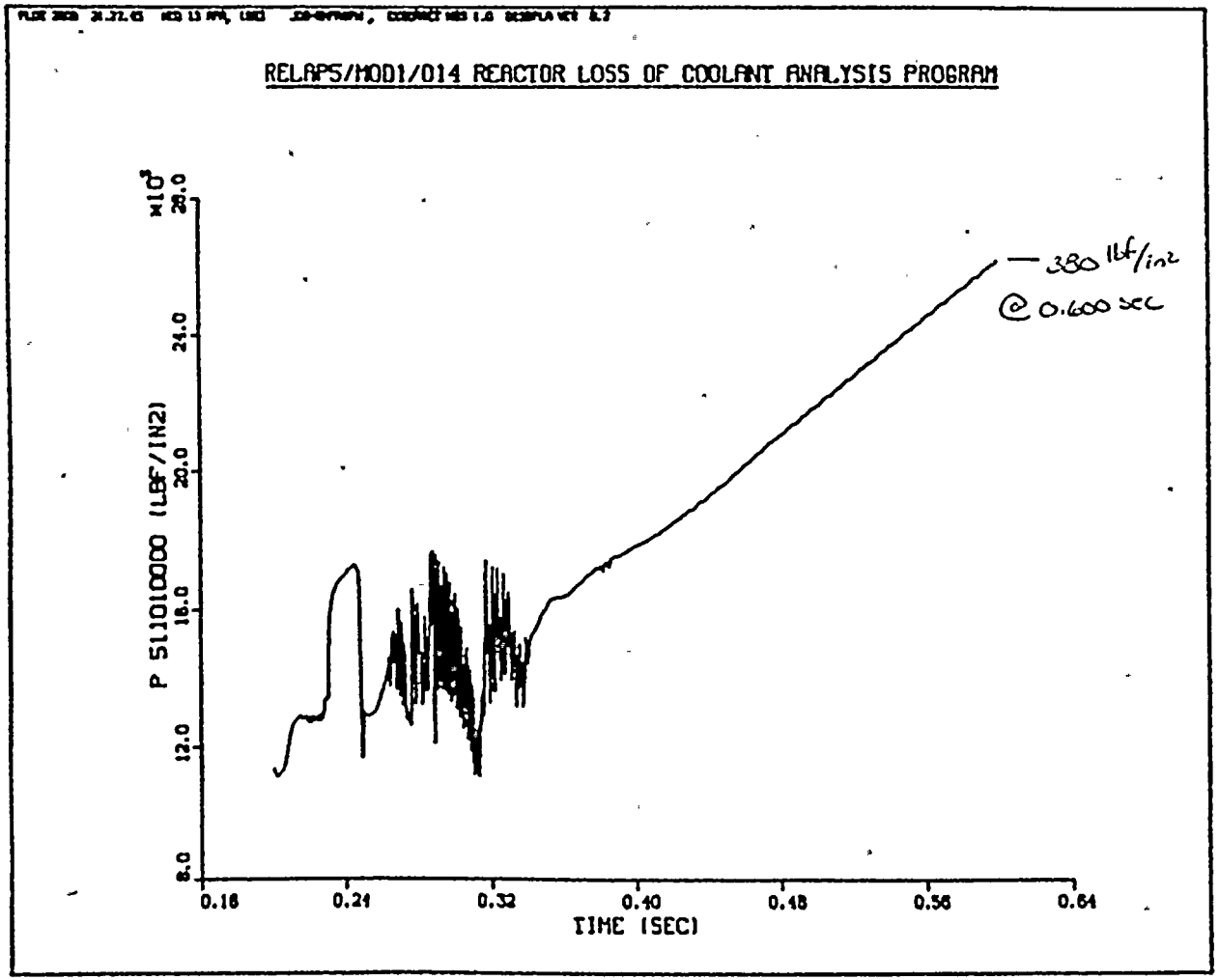
Revision 0


RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
P 411010000 (LBF/IN2)
x10^3
39.0
38.0
33.0
30.0
27.0
24.0
21.0
0.56
0.64
0.72
0.80
0.88
0.96
1.04
TIME (SEC)
532 lbf/in²
@ 1.0 sec

BY JHM DATE 11-29-83
CHKD. BY JBM DATE 11-29-83

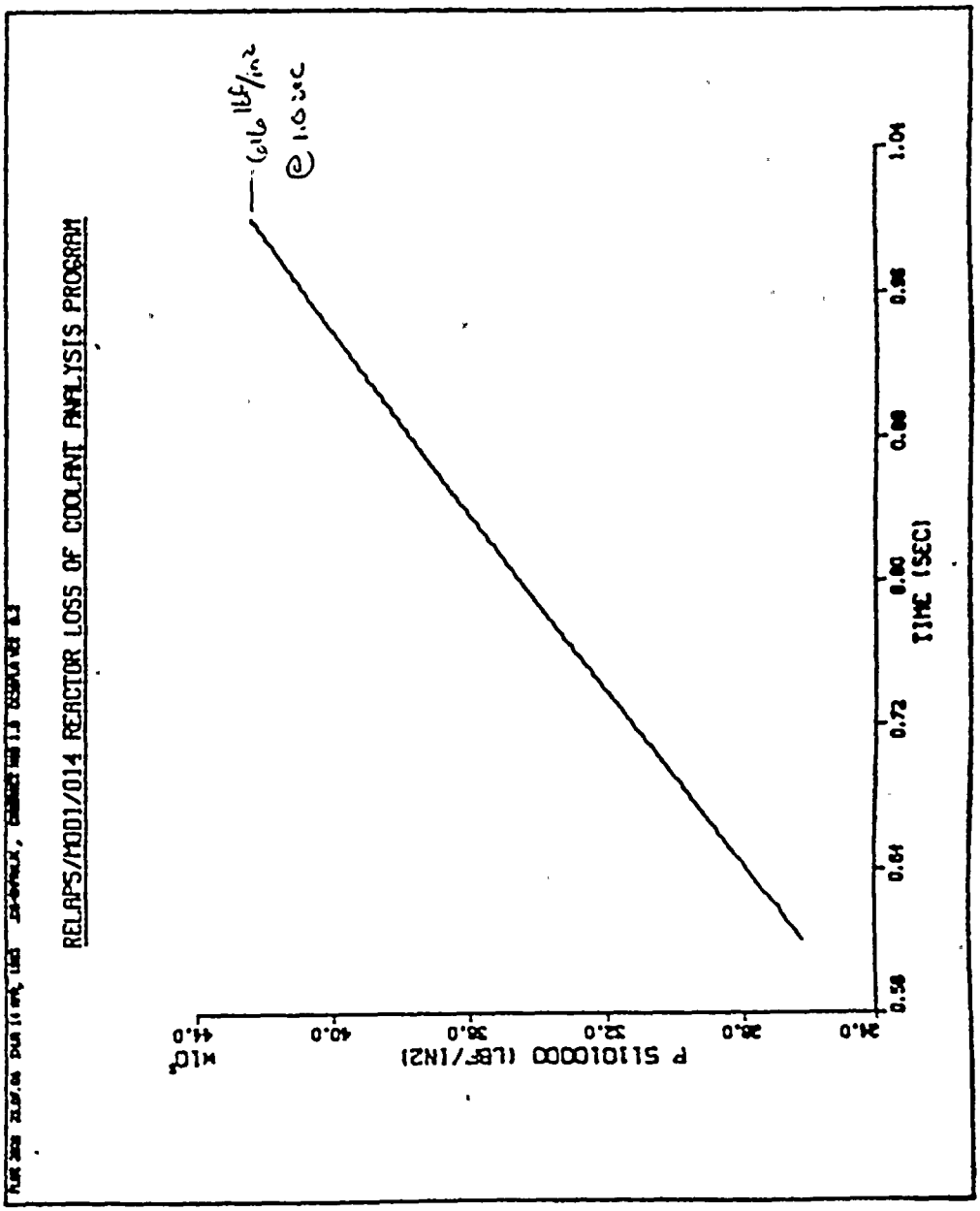



RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
P 51101000 (LBF/IN2)
x10³
28.0
24.0
20.0
16.0
12.0
8.0
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)
380 lbf/in²
@ 0.600 sec

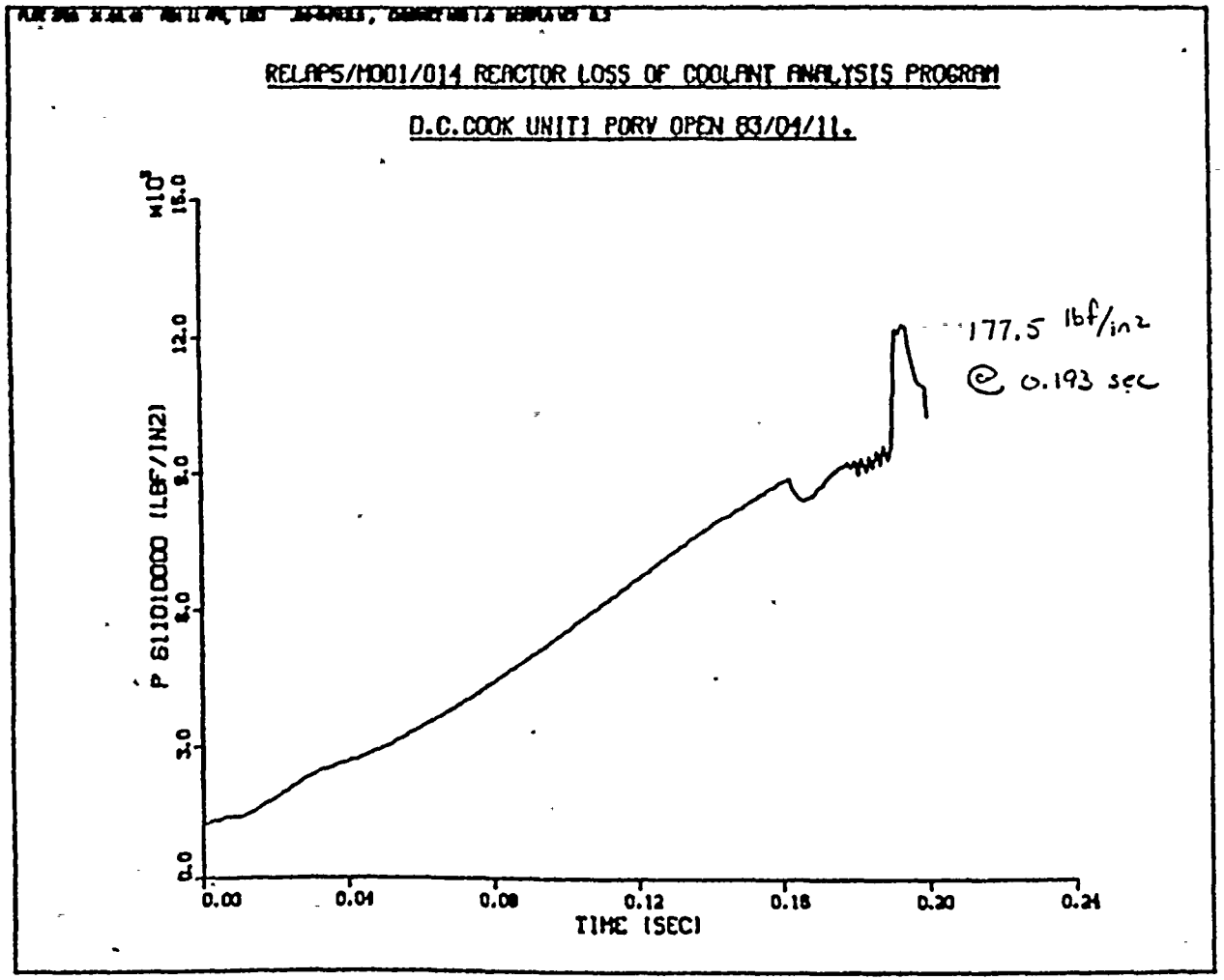
BY UMM DATE 11-29-83
CHKD. BY JBM DATE 9-29-83

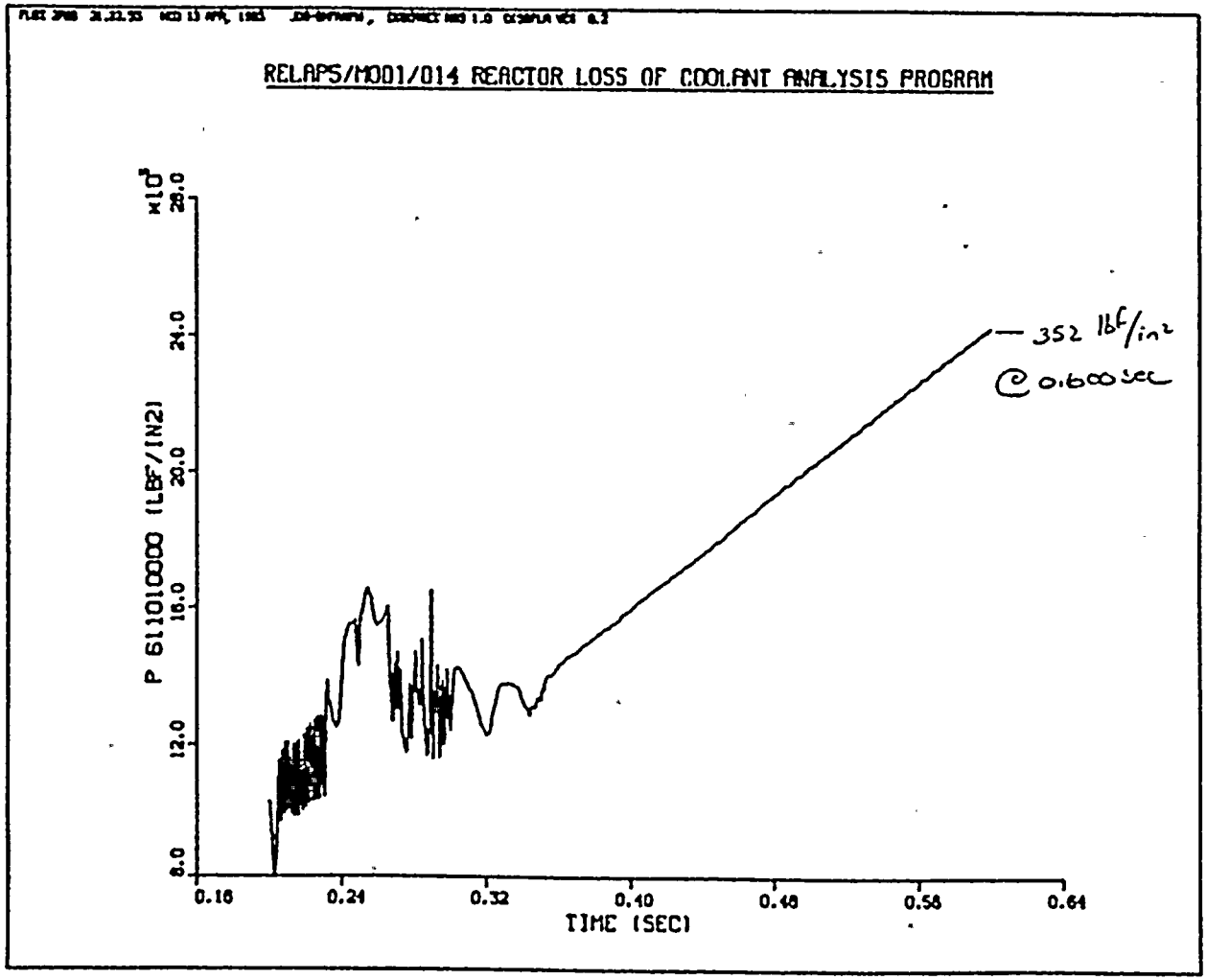
TELEDYNE ENGINEERING SERVICES

Technical Report
TR-5364-1
Revision 0

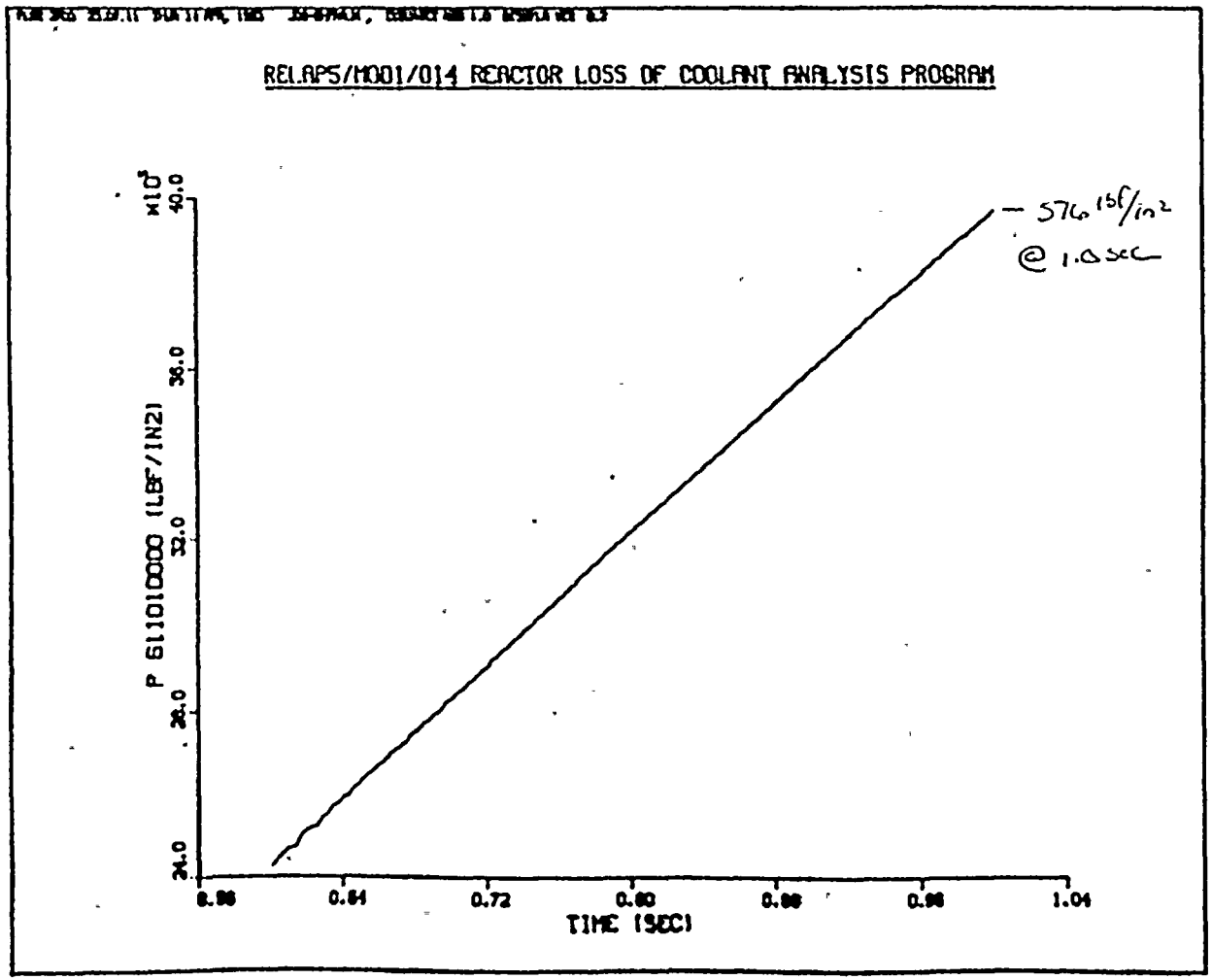


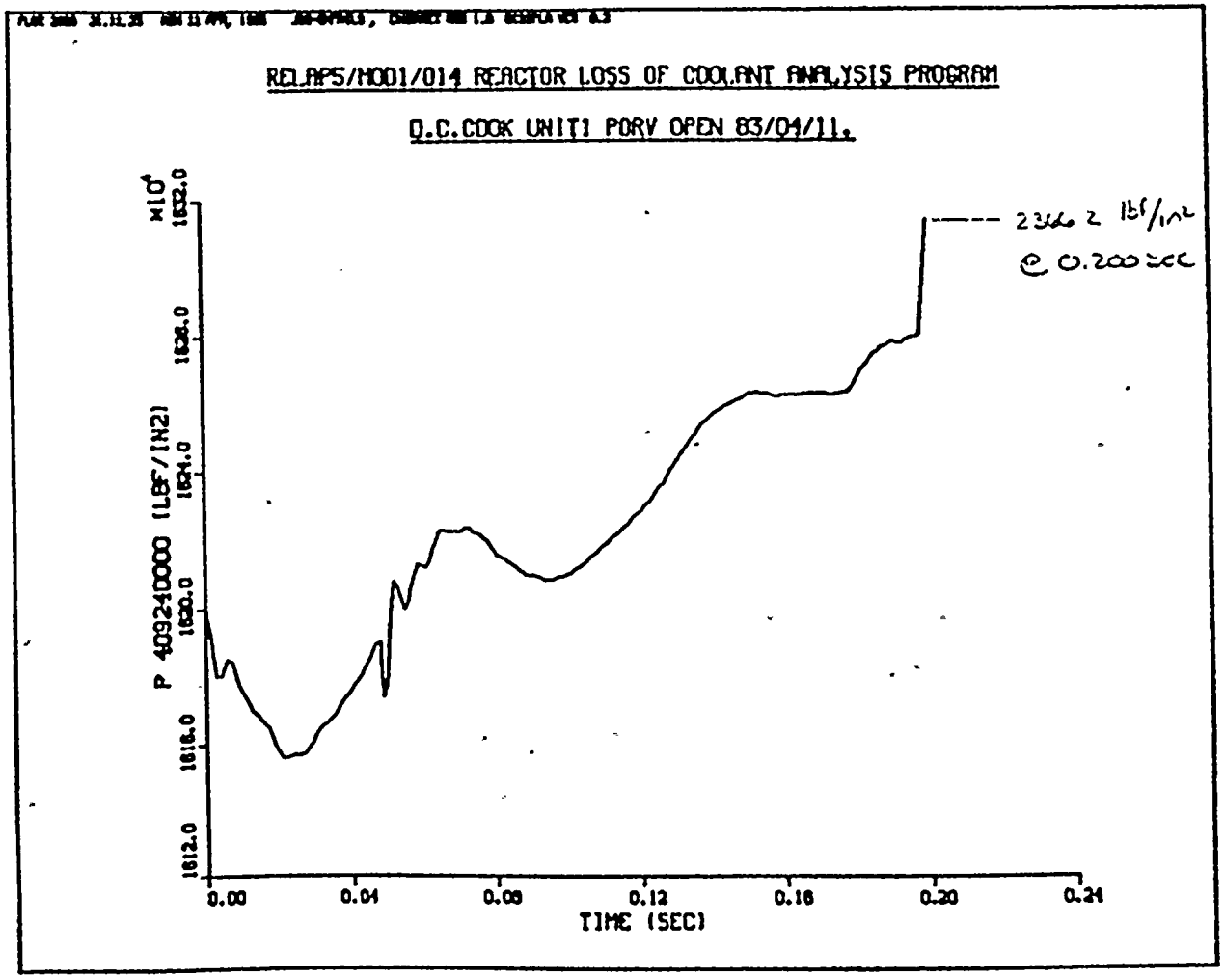
BY JHM DATE 11-29-83
CHKD. BY JBM DATE 11-29-83



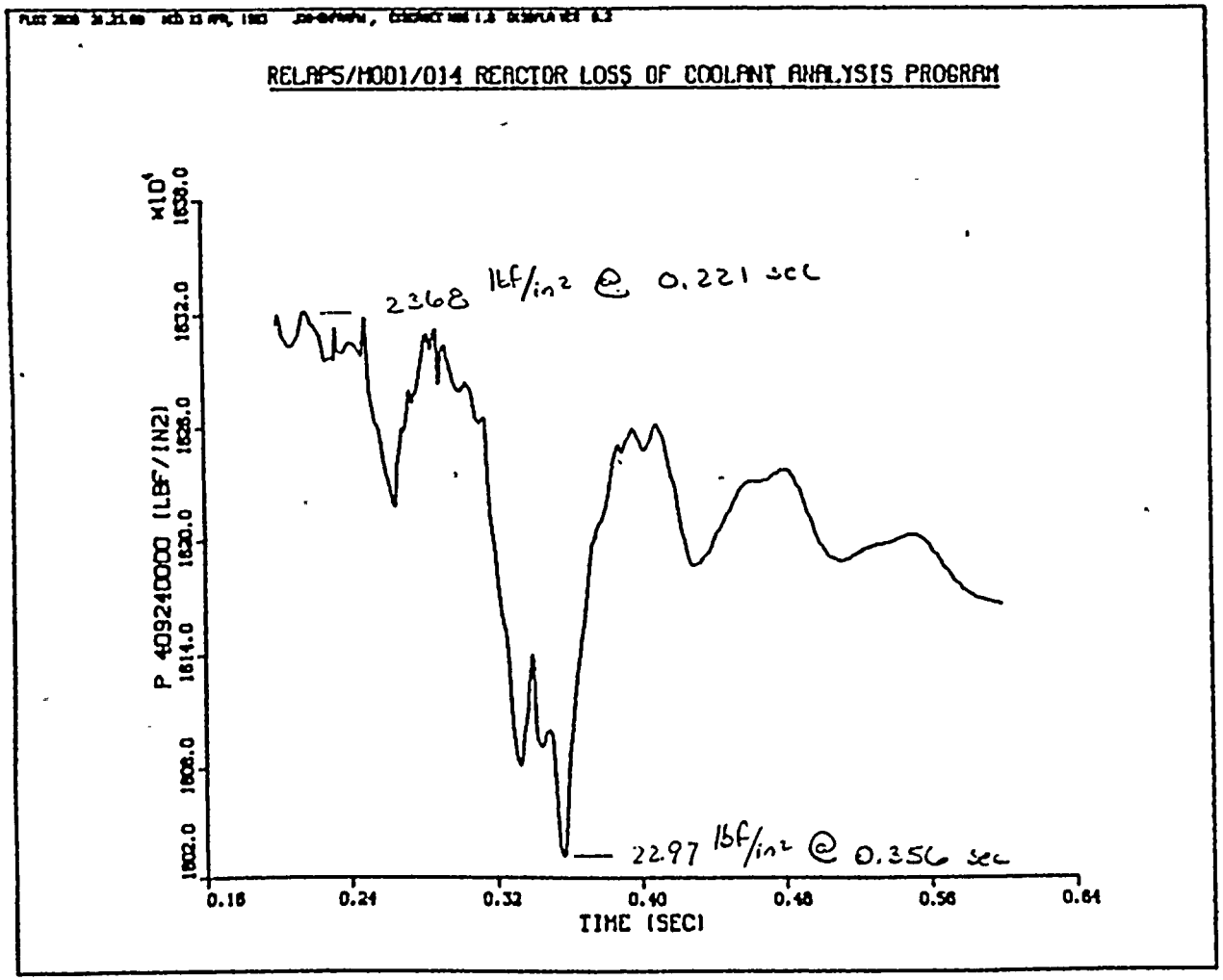

RELAPS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
P 61101000 (LBF/IN2)
×10³
28.0
24.0
20.0
16.0
12.0
8.0
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)
352 lbf/in²
@ 0.600 sec

BY JHM DATE 11-29-83
CHKD. BY JBM DATE 11-29-83

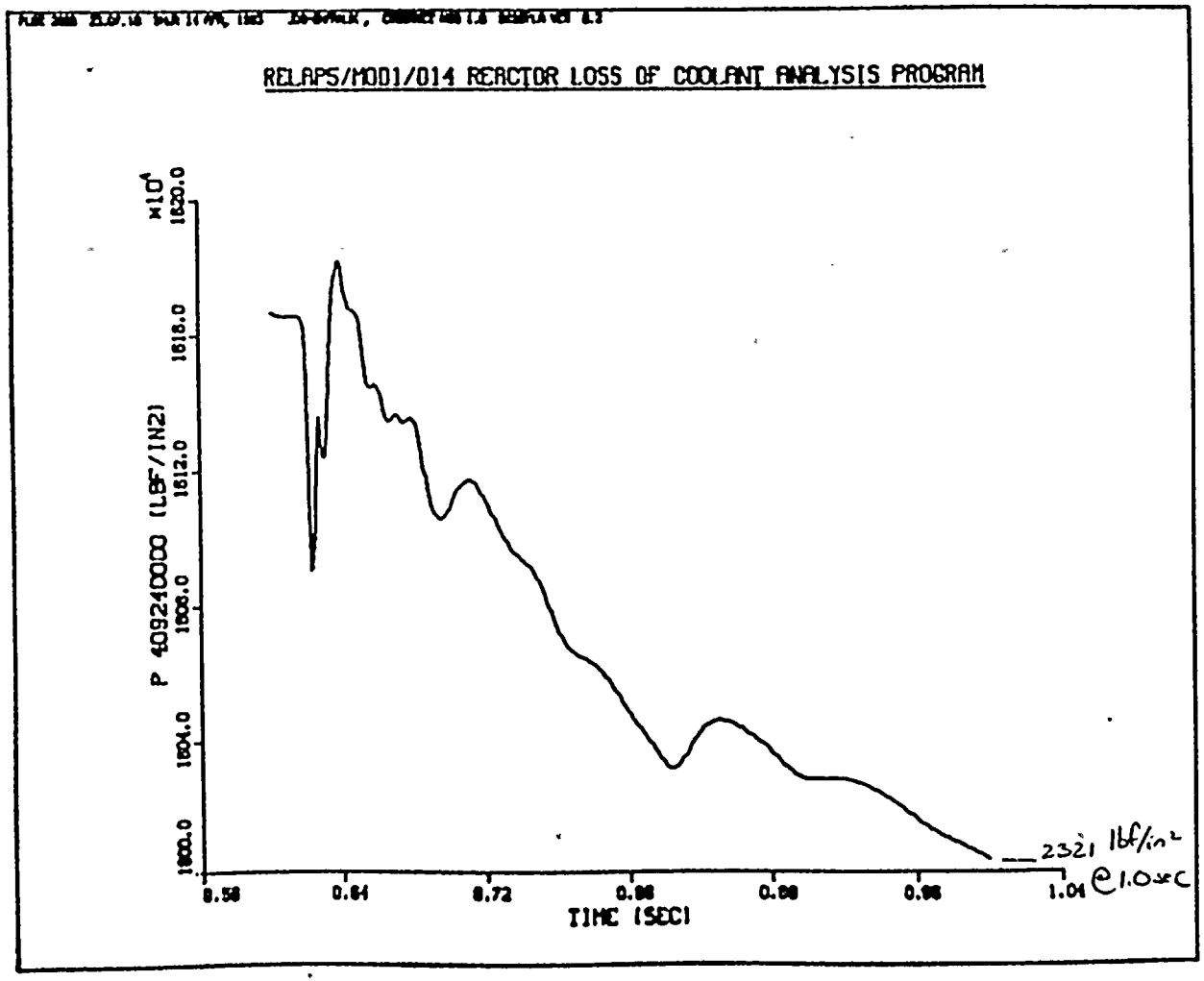



RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/11.
P 409240000 (LBF/IN2)
x10⁴
1632.0
1628.0
1624.0
1620.0
1616.0
1612.0
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)
2366.2 lbf/in²
@ 0.200 sec

BY UHM DATE 11-29-83
CHKD. BY JBV DATE 11-29-83



BY UMM DATE 11-29-83
CHKD. BY [illegible] DATE 11-29-83



BY UHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83

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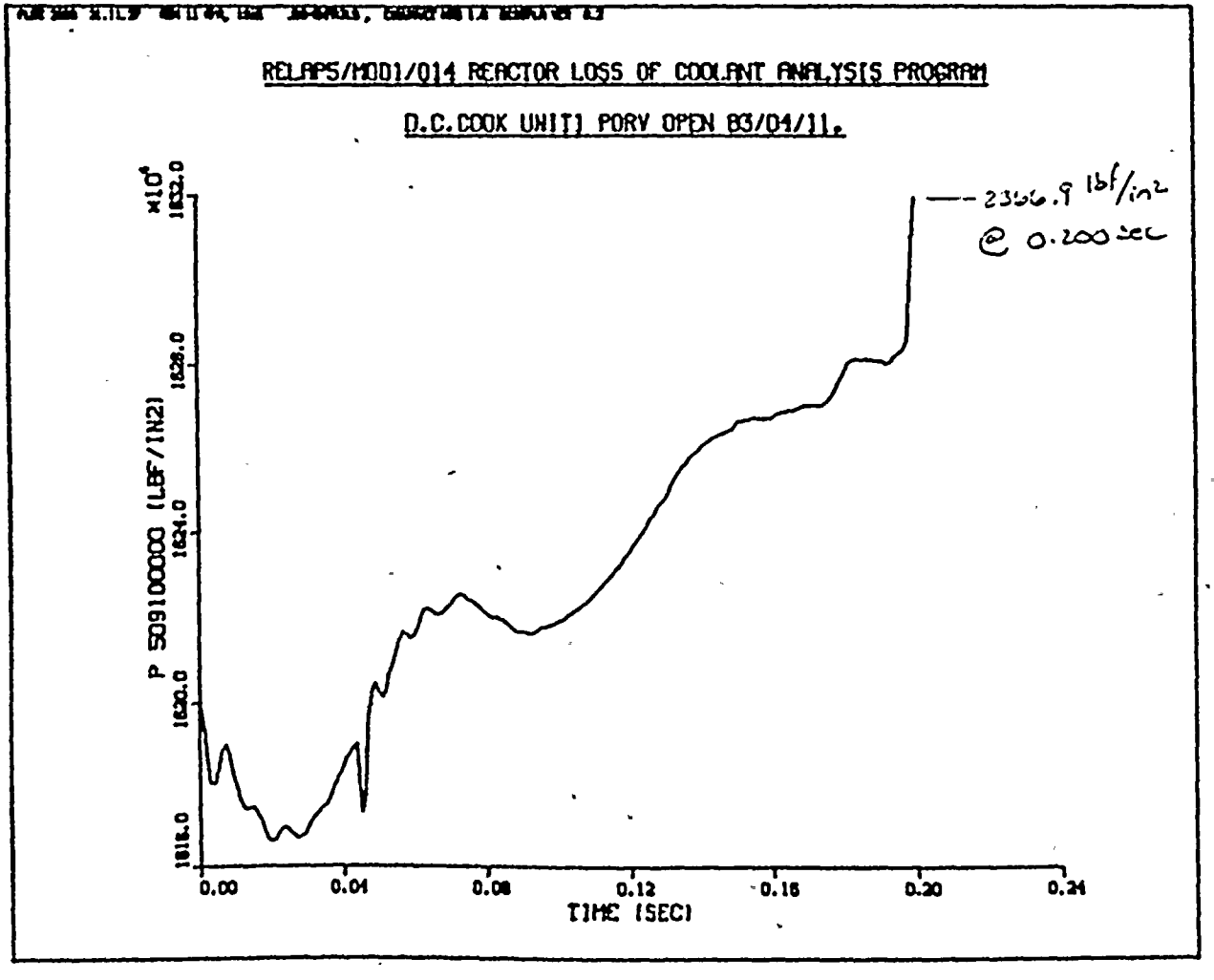
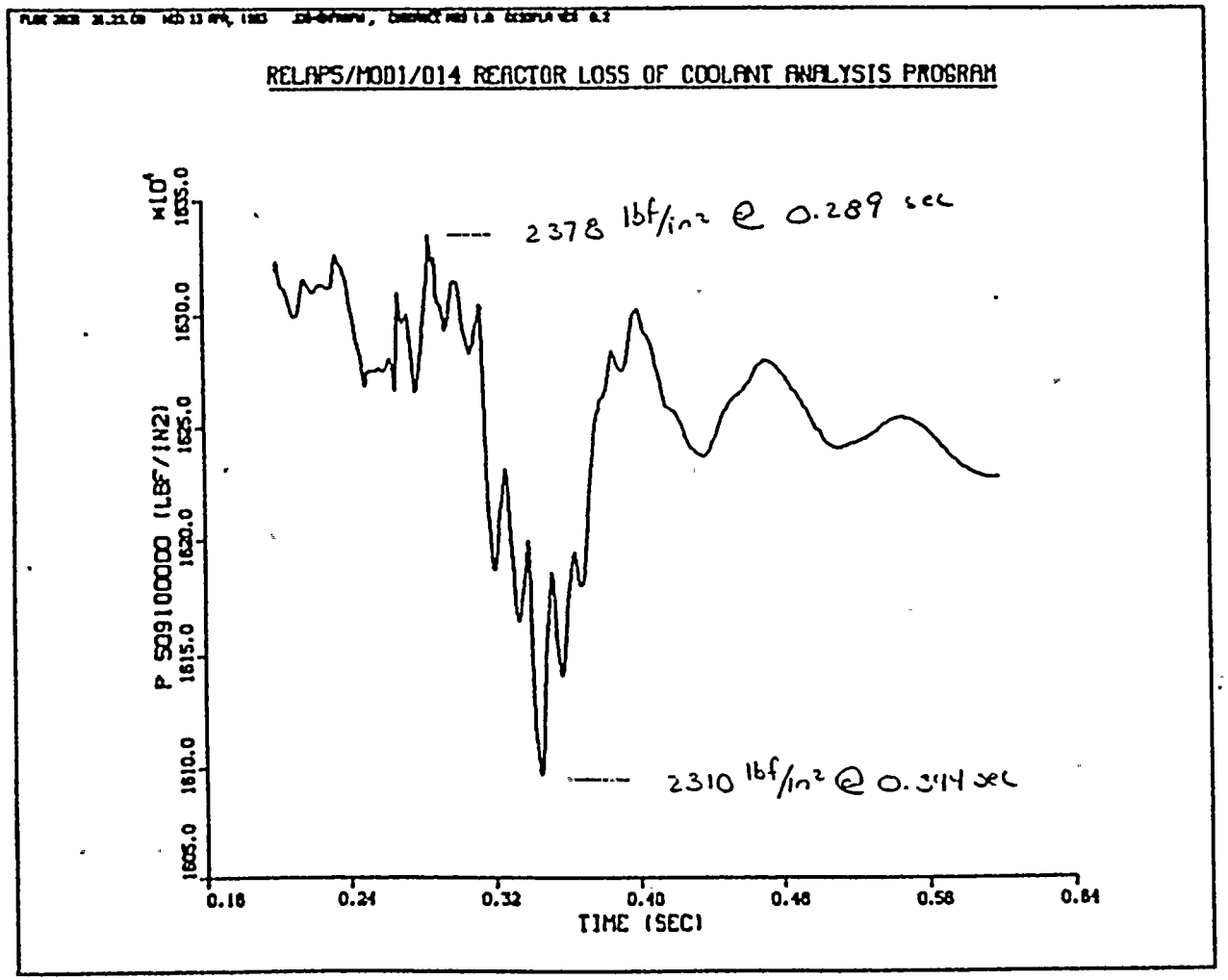
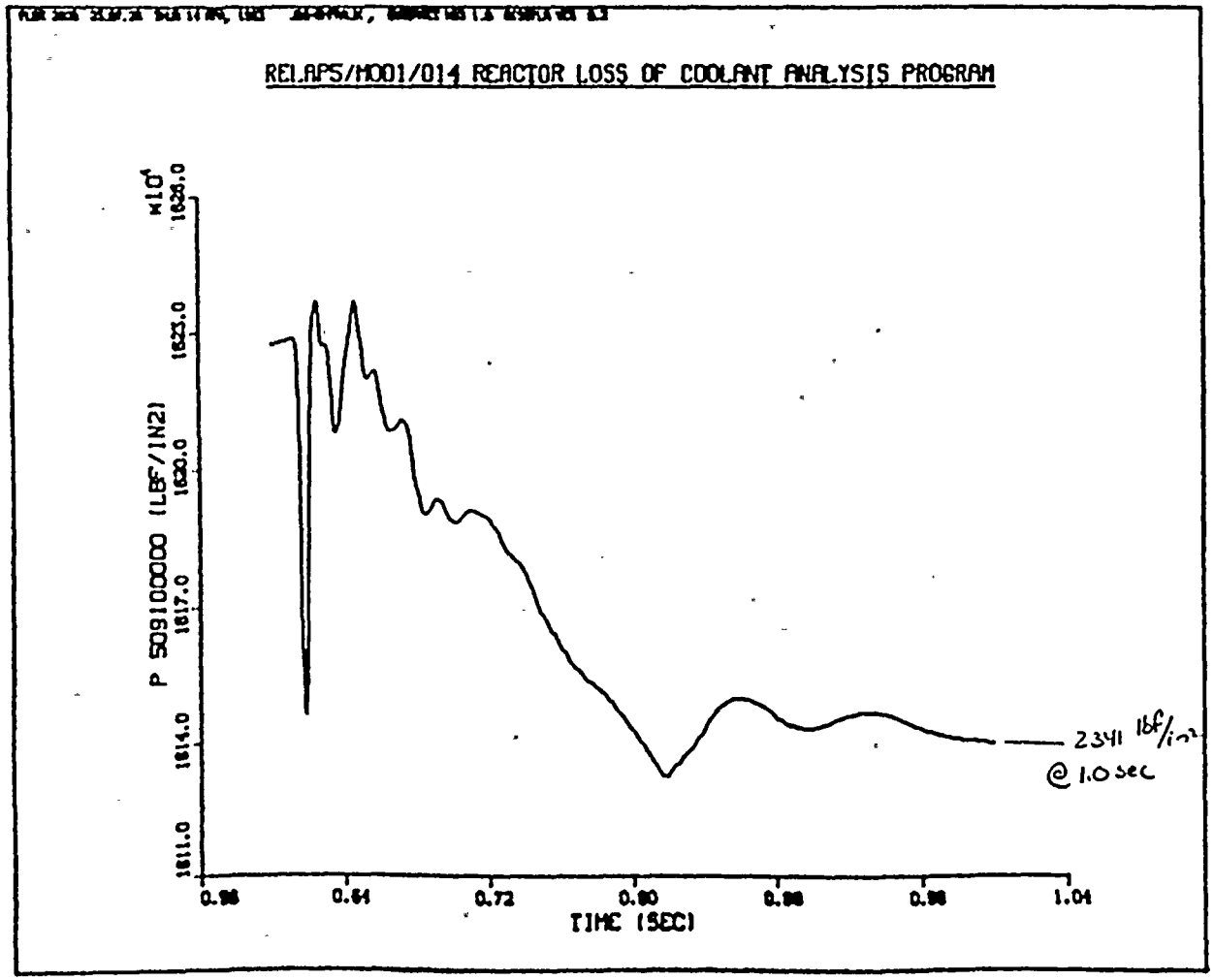
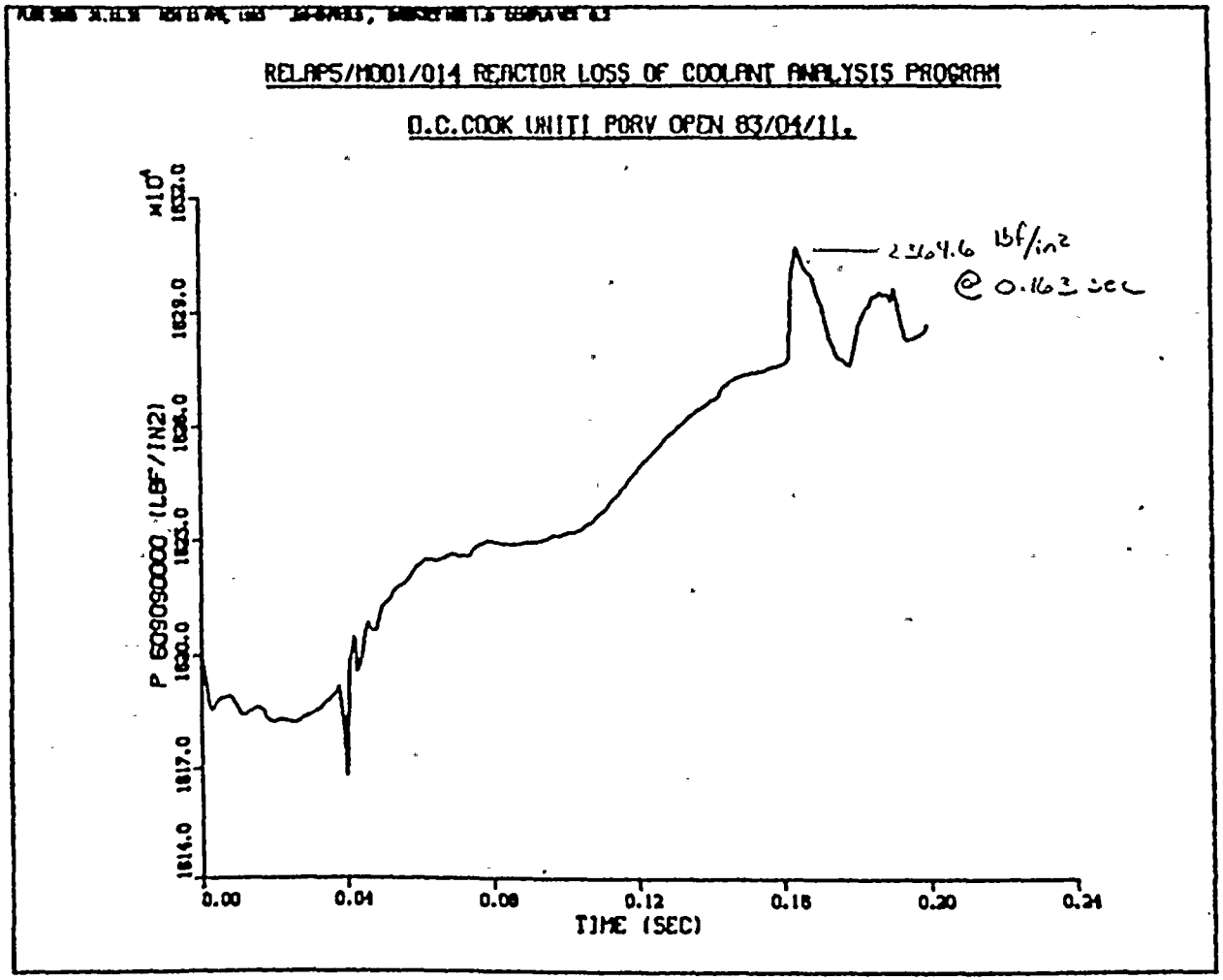



RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
2378 lbf/in² @ 0.289 sec
2310 lbf/in² @ 0.314 sec
P 50910000D (LBF/IN2)
×10⁴
1635.0
1630.0
1625.0
1620.0
1615.0
1610.0
1605.0
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)


RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
P SOBIDOOOO (LBF/IN2)
x10^4
1626.0
1623.0
1620.0
1617.0
1614.0
1611.0
0.56
0.64
0.72
0.80
0.88
0.96
1.04
TIME (SEC)
2341 lbf/in²
@ 1.0 sec

BY UHM DATE 11-29-83
CHKD. BY JBK DATE 11-29-83



TELEDYNE ENGINEERING SERVICES

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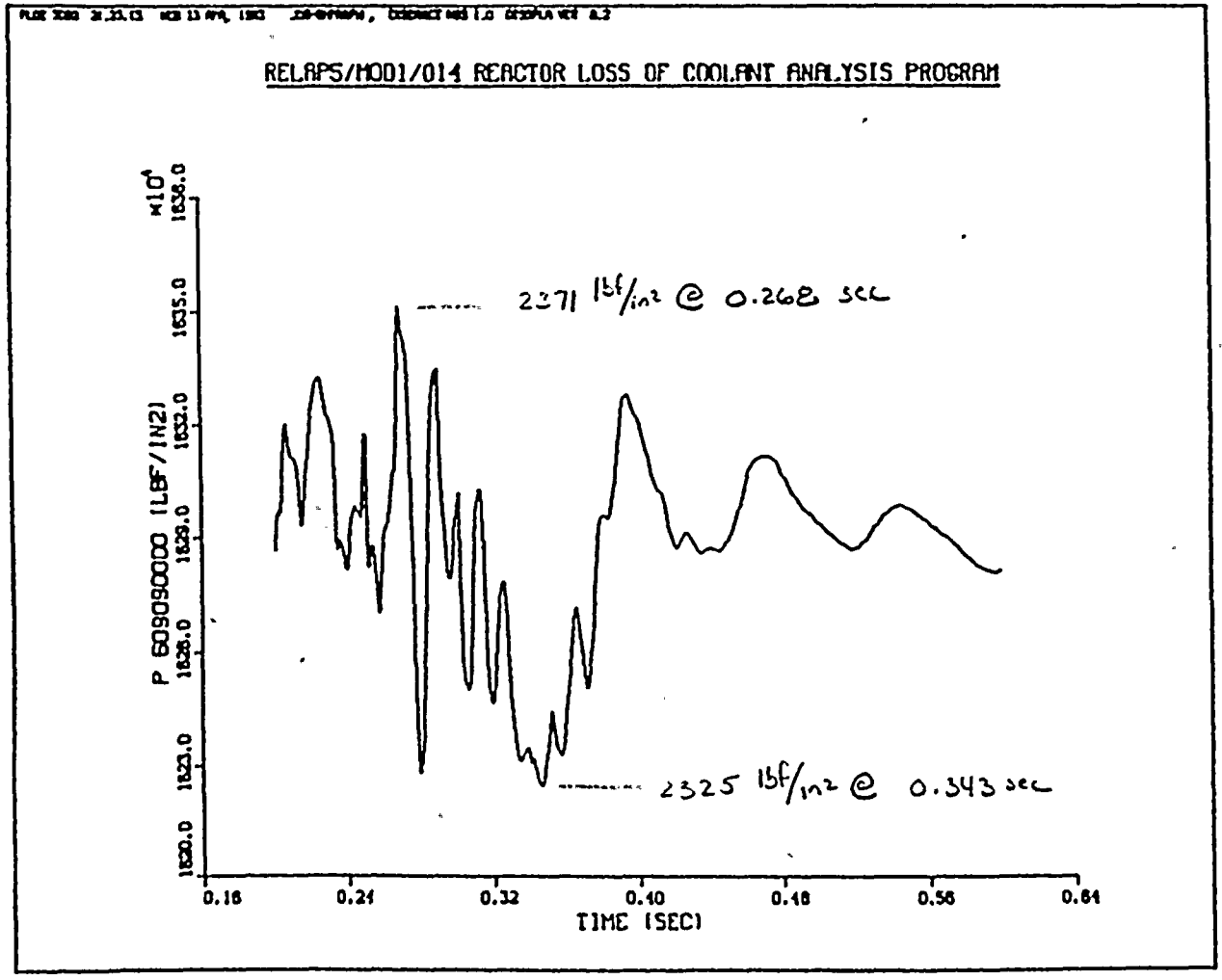
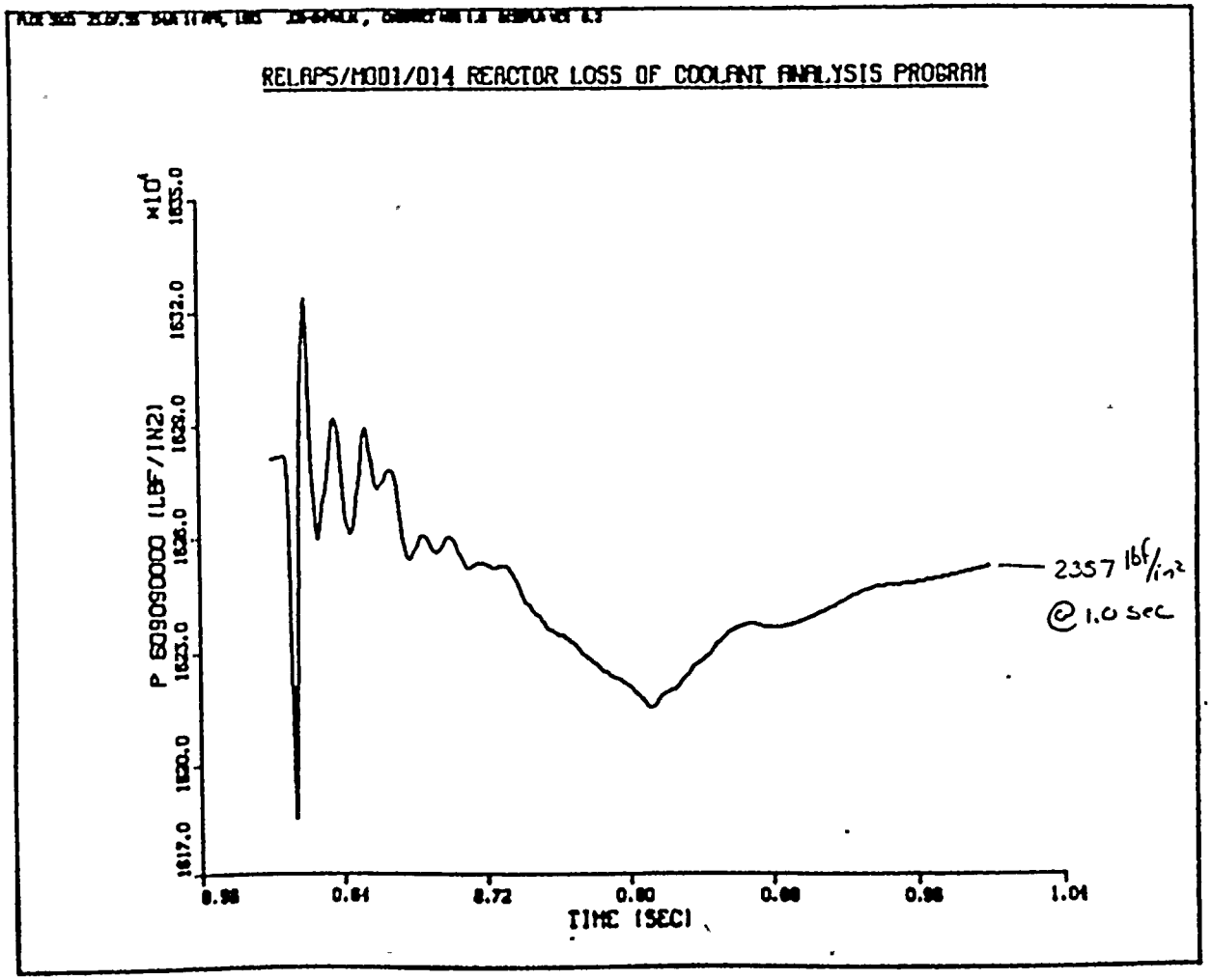
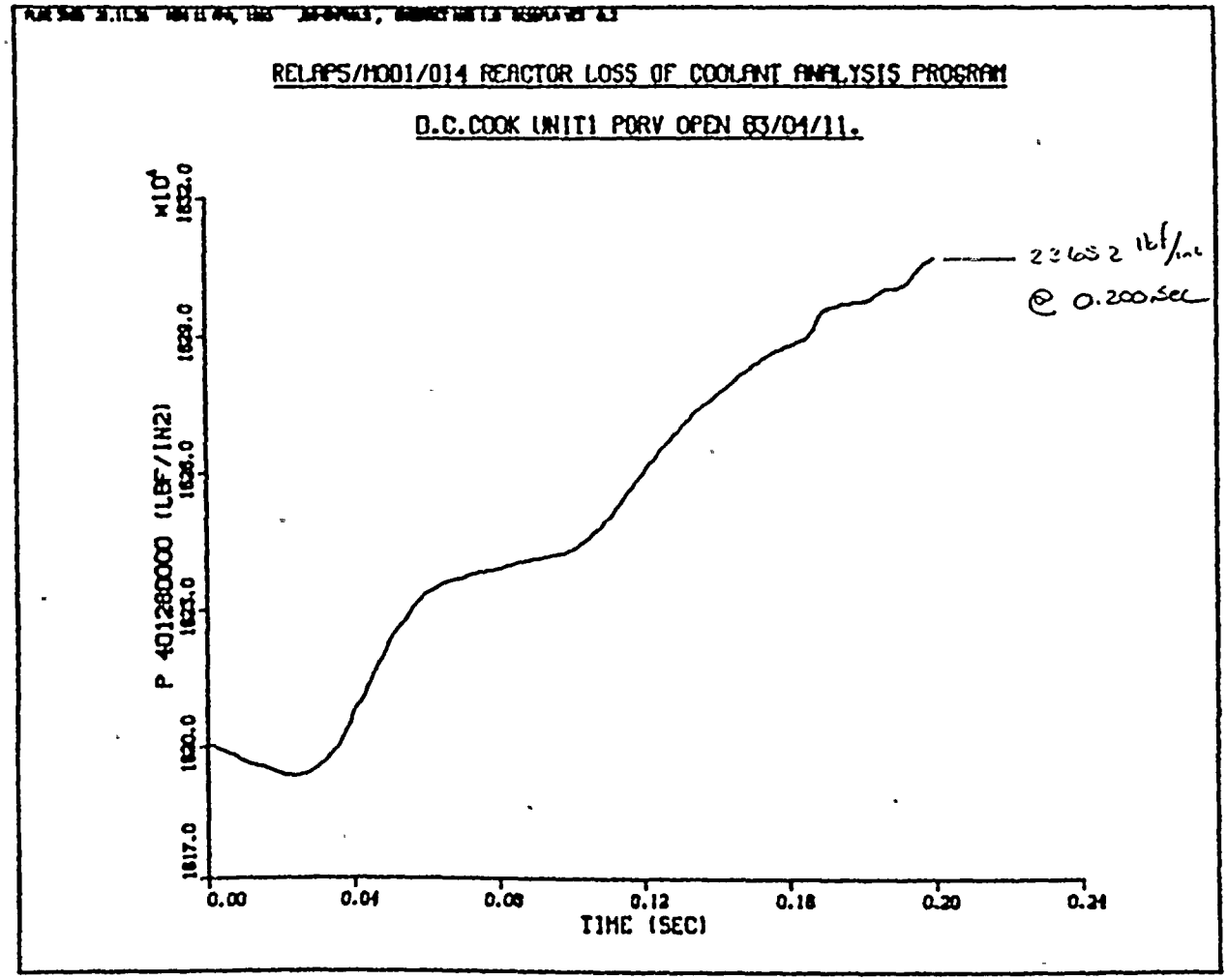

RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
P 60908000 (LBF/IN2)
×10⁴
1636.0
1635.0
1632.0
1629.0
1626.0
1623.0
1620.0
2371 lbf/in² @ 0.268 sec
2325 lbf/in² @ 0.343 sec
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)

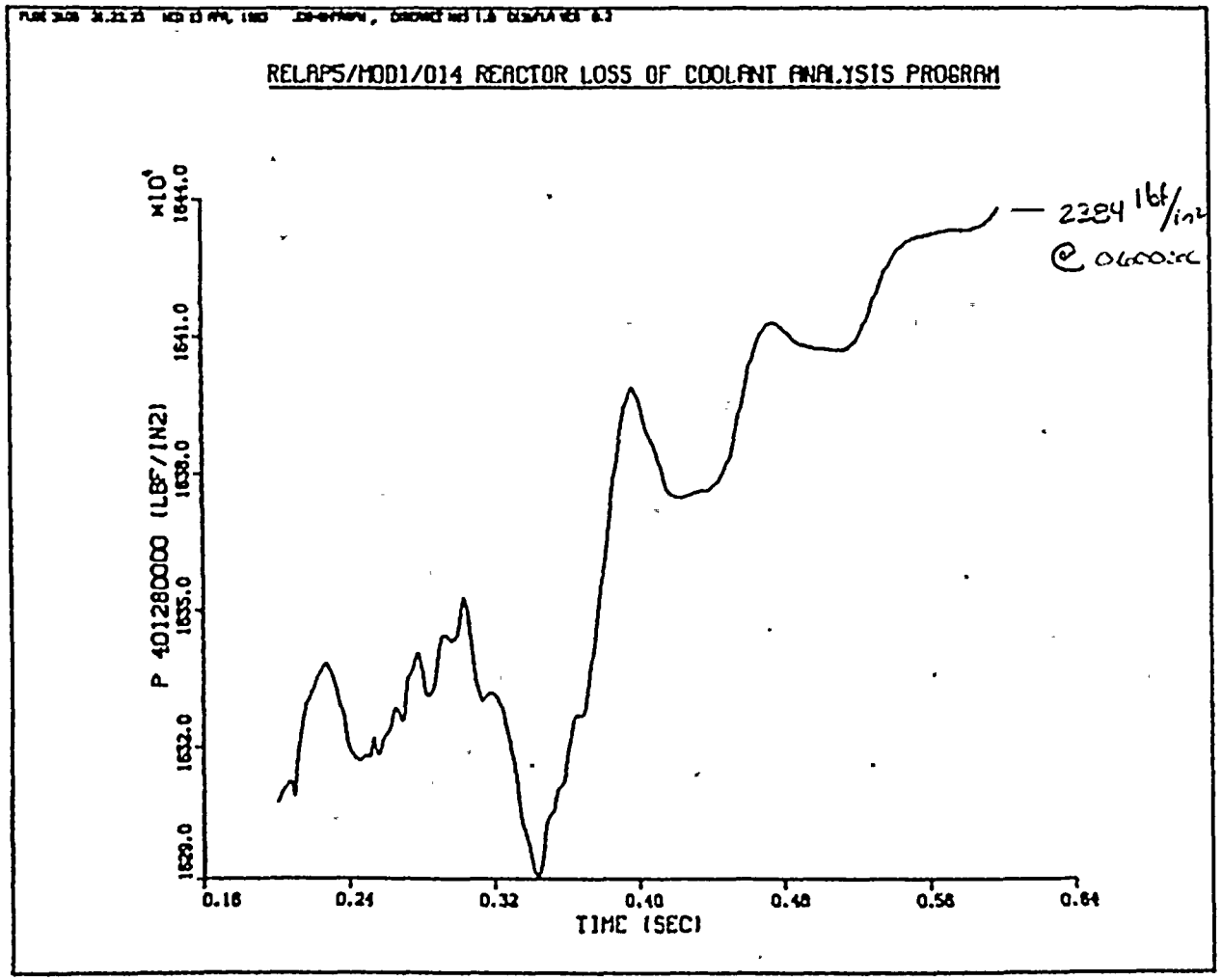
BY UHM DATE 11-29-83
CHKD. BY JBM DATE 11-29-83

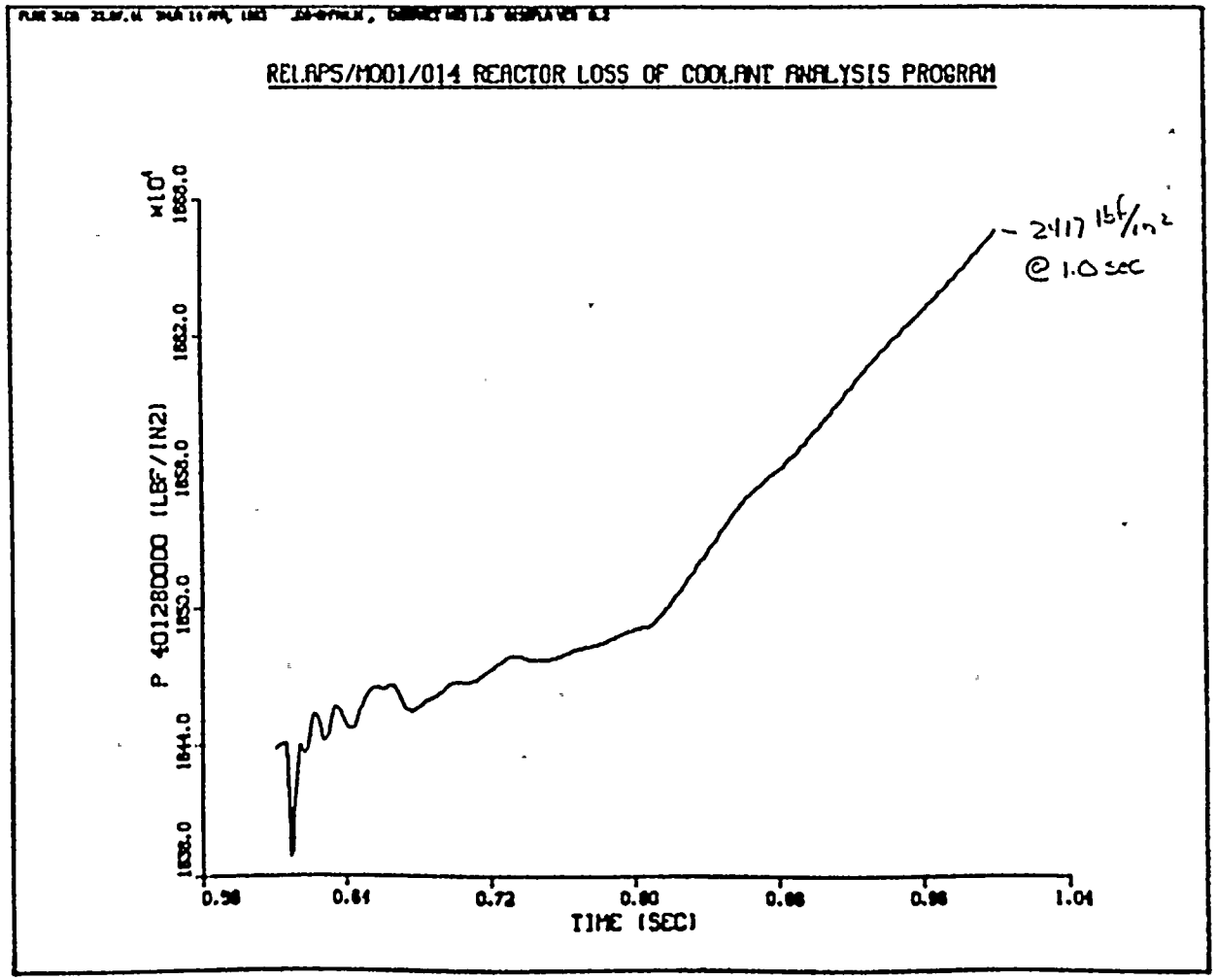


BY UHM DATE 11-29-83
CHKD. BY [illegible] DATE 11-29-83

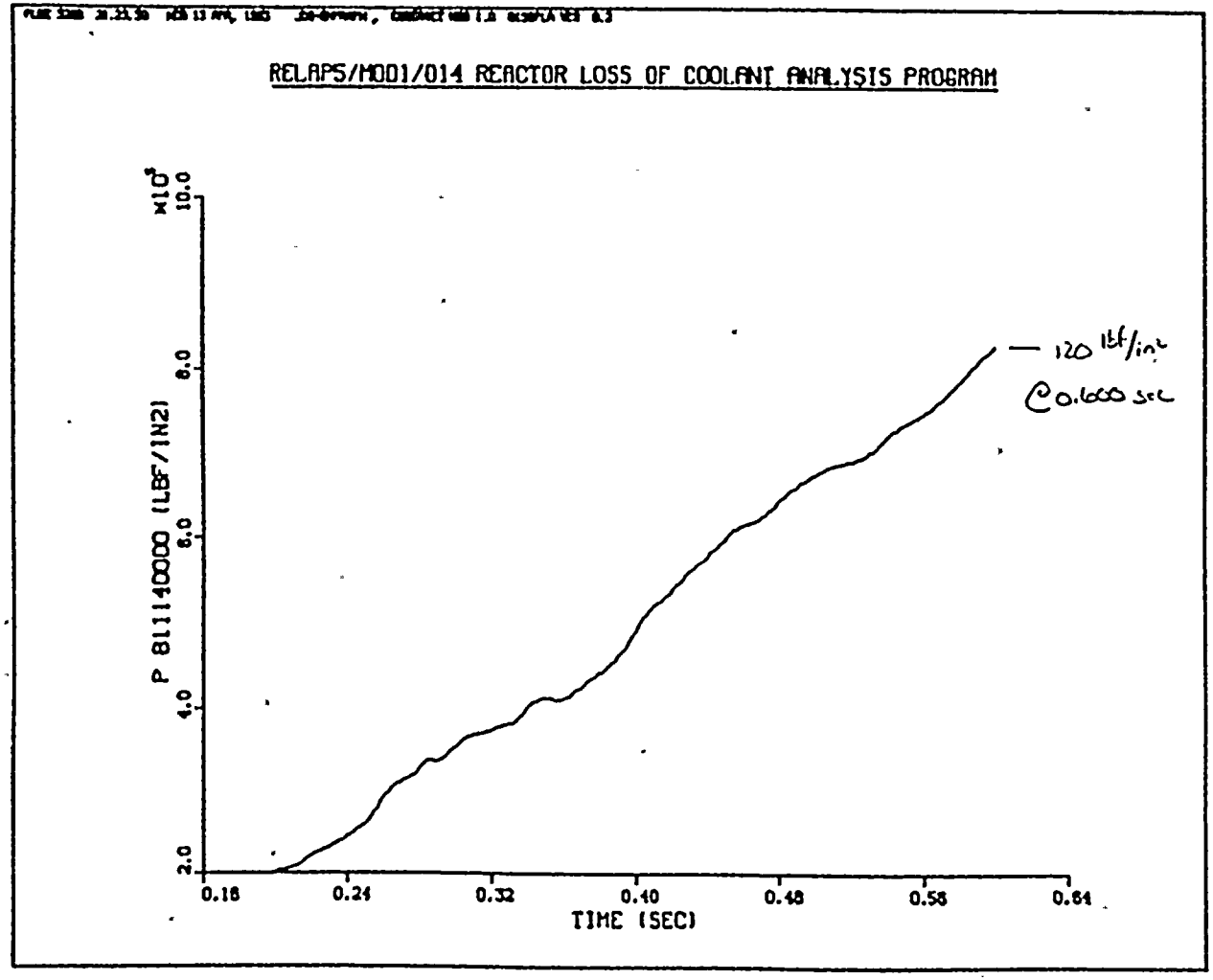


BY [illegible] DATE 11-29-83
CHKD. BY [illegible] DATE 4-29-83

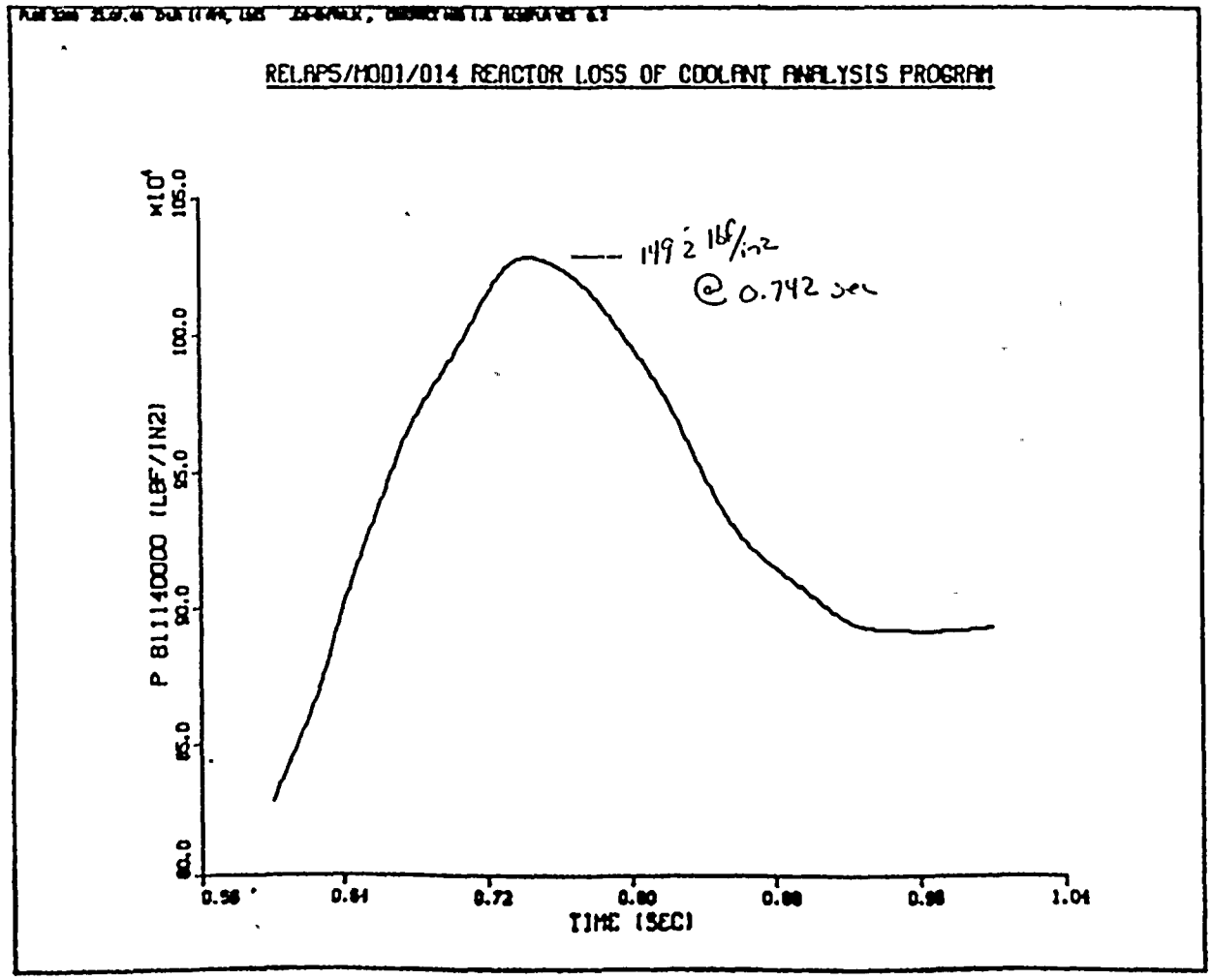


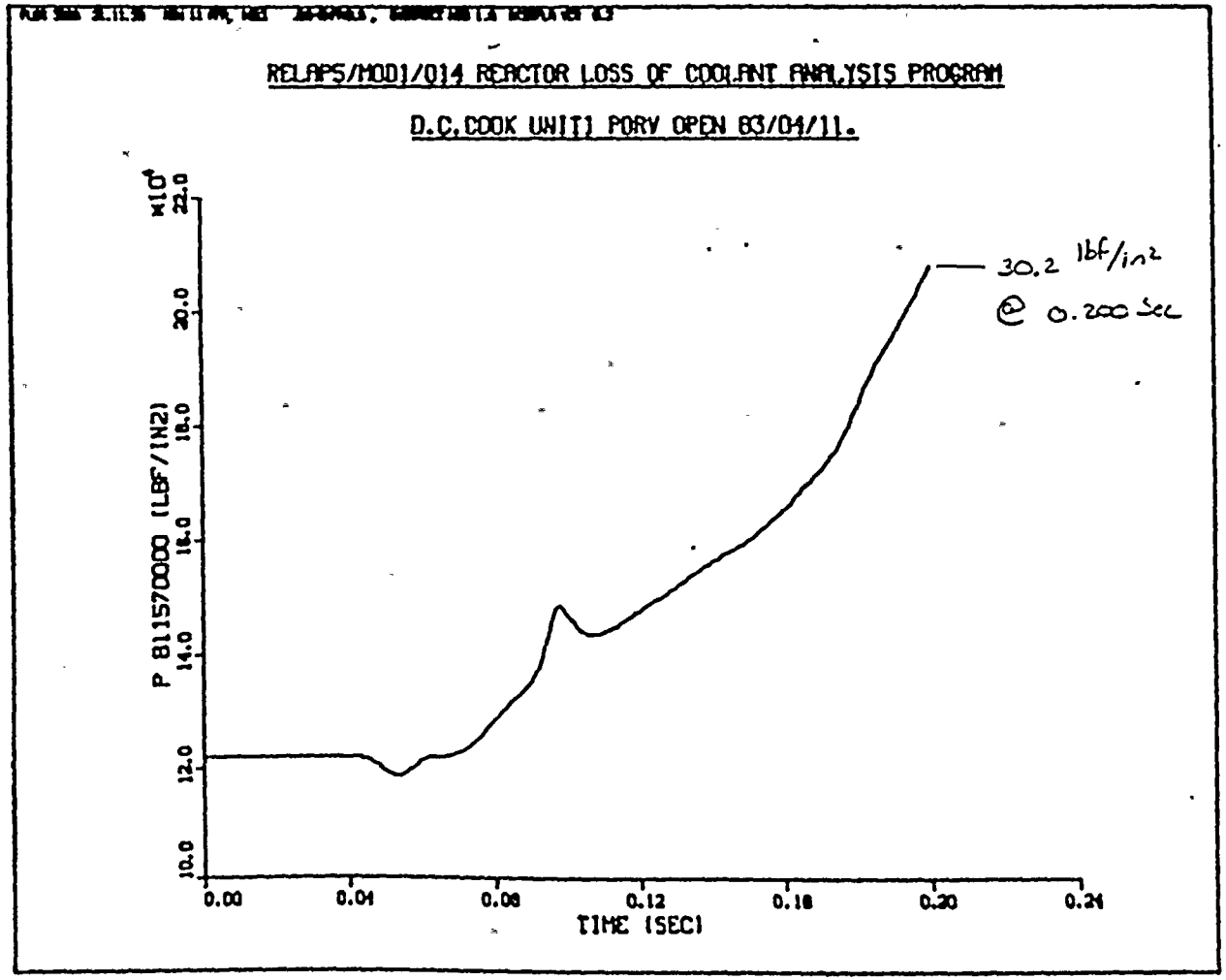

RELAPS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
P 40128000 (LBF/IN2)
x10^4
1856.0
1852.0
1850.0
1848.0
1844.0
1838.0
0.56
0.64
0.72
0.80
0.88
0.96
1.04
TIME (SEC)
~ 2417 lbf/in²
@ 1.0 sec

BY JHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83

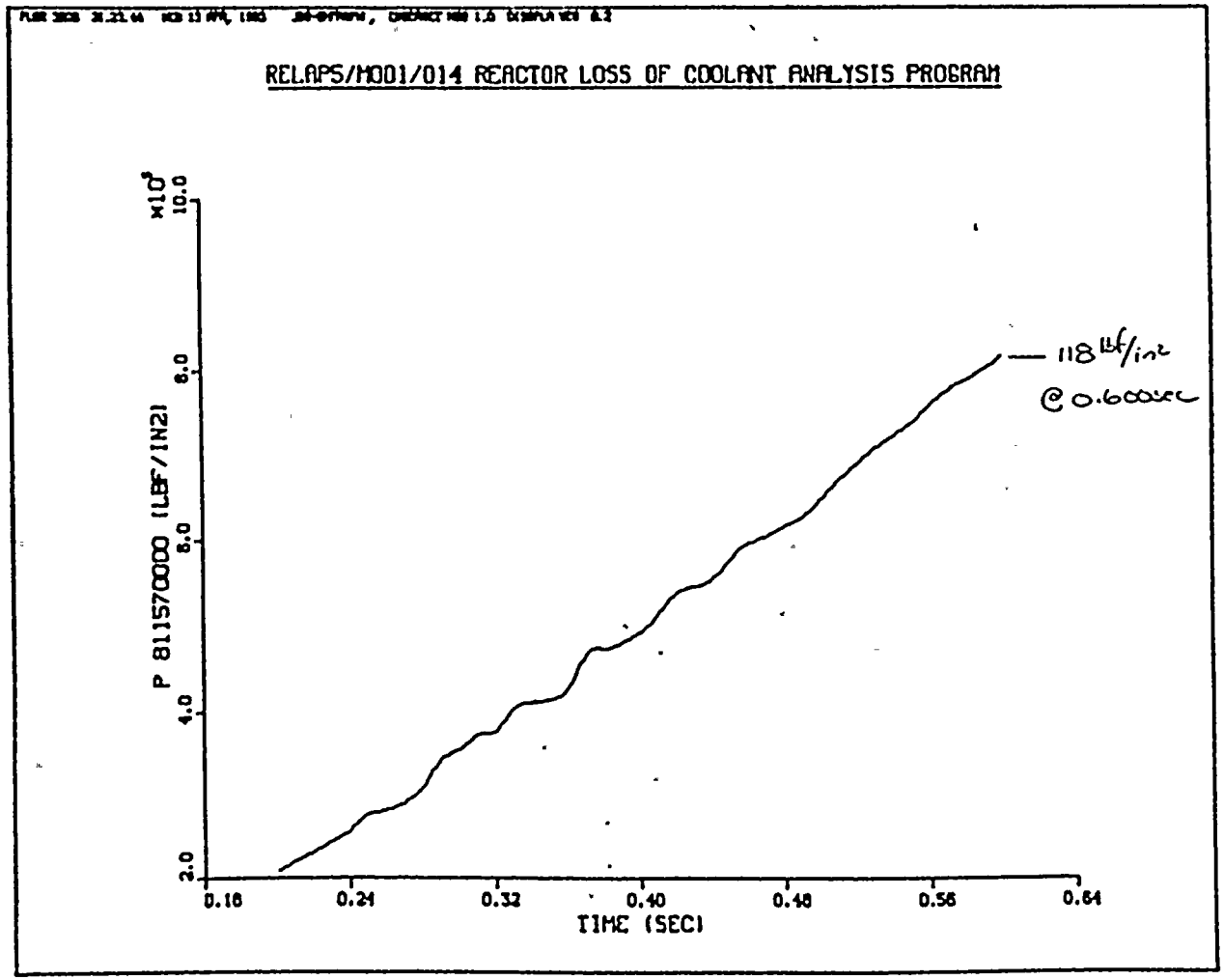


BY JHM DATE 11-29-83
CHKD. BY JBM DATE 11-29-83

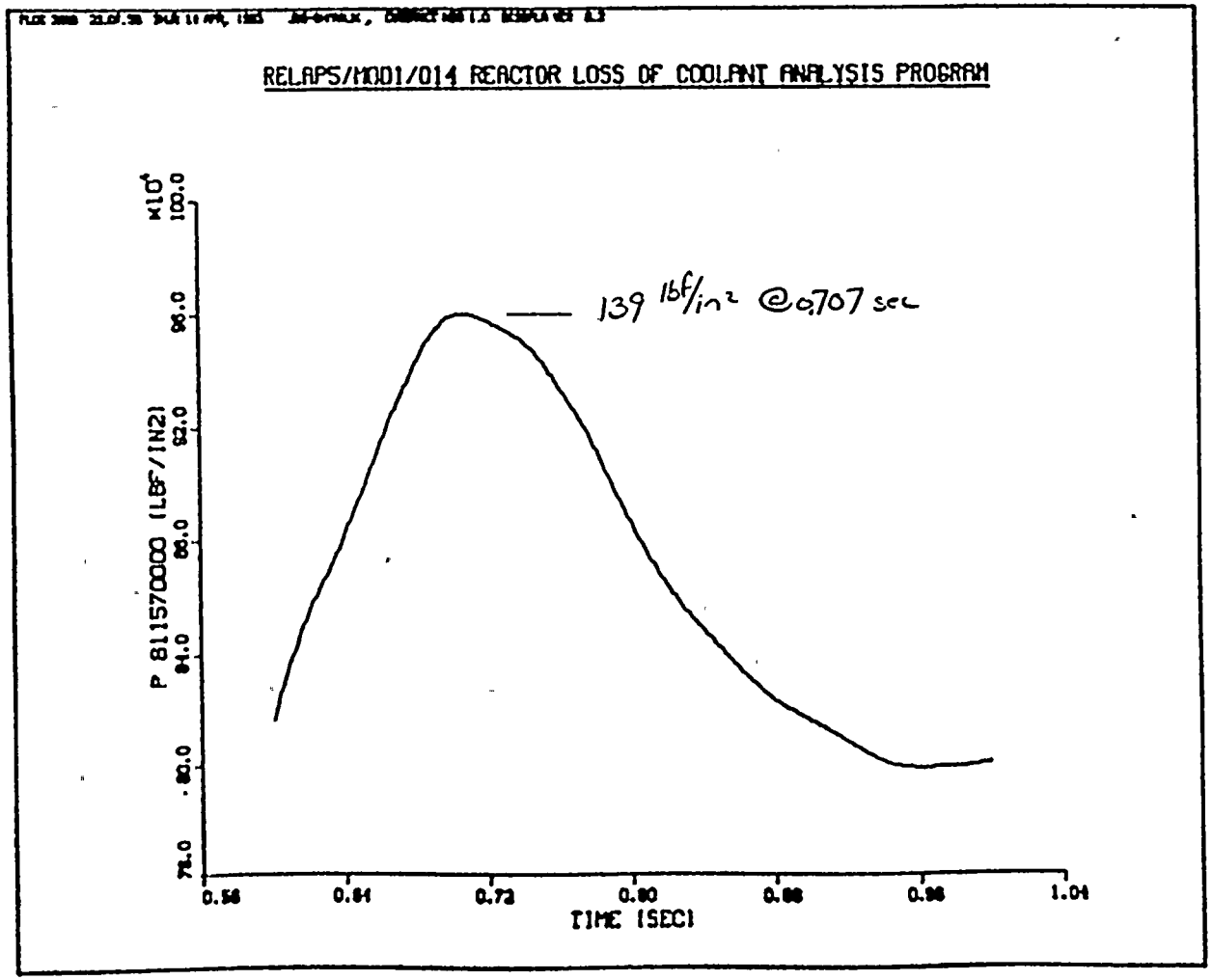



RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/11.
P B1157000 (LBF/IN2)
x10⁴
22.0
20.0
18.0
16.0
14.0
12.0
10.0
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)
30.2 lbf/in²
@ 0.200 sec

BY UHH DATE 11-29-83
CHKD. BY JBM DATE 11-29-83



BY UHM DATE 11-29-83
CHKD. BY JBM DATE 11-29-83



BY [illegible] DATE 11-29-83
CHKD. BY [illegible] DATE 4-29-83

TELEDYNE ENGINEERING SERVICES
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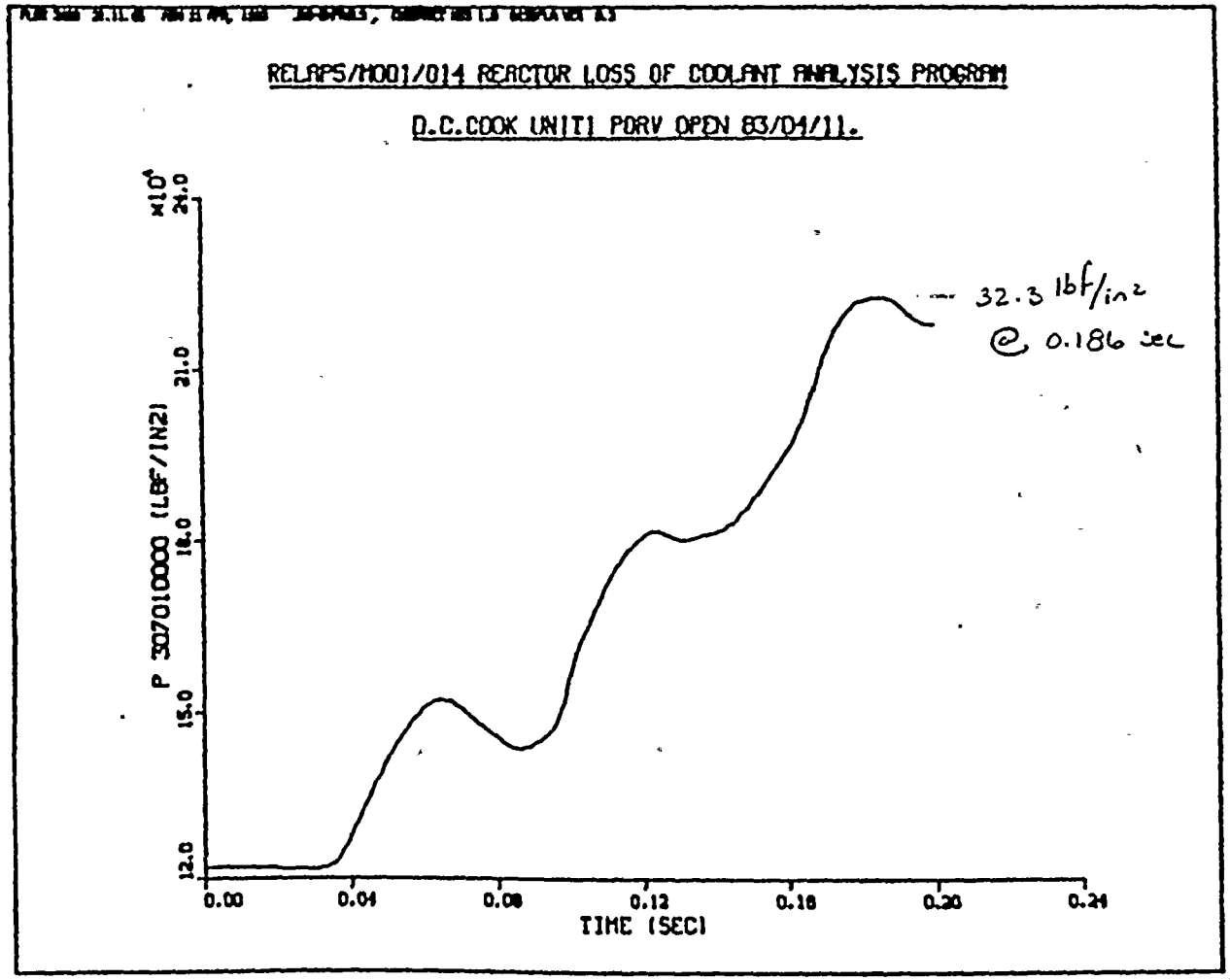
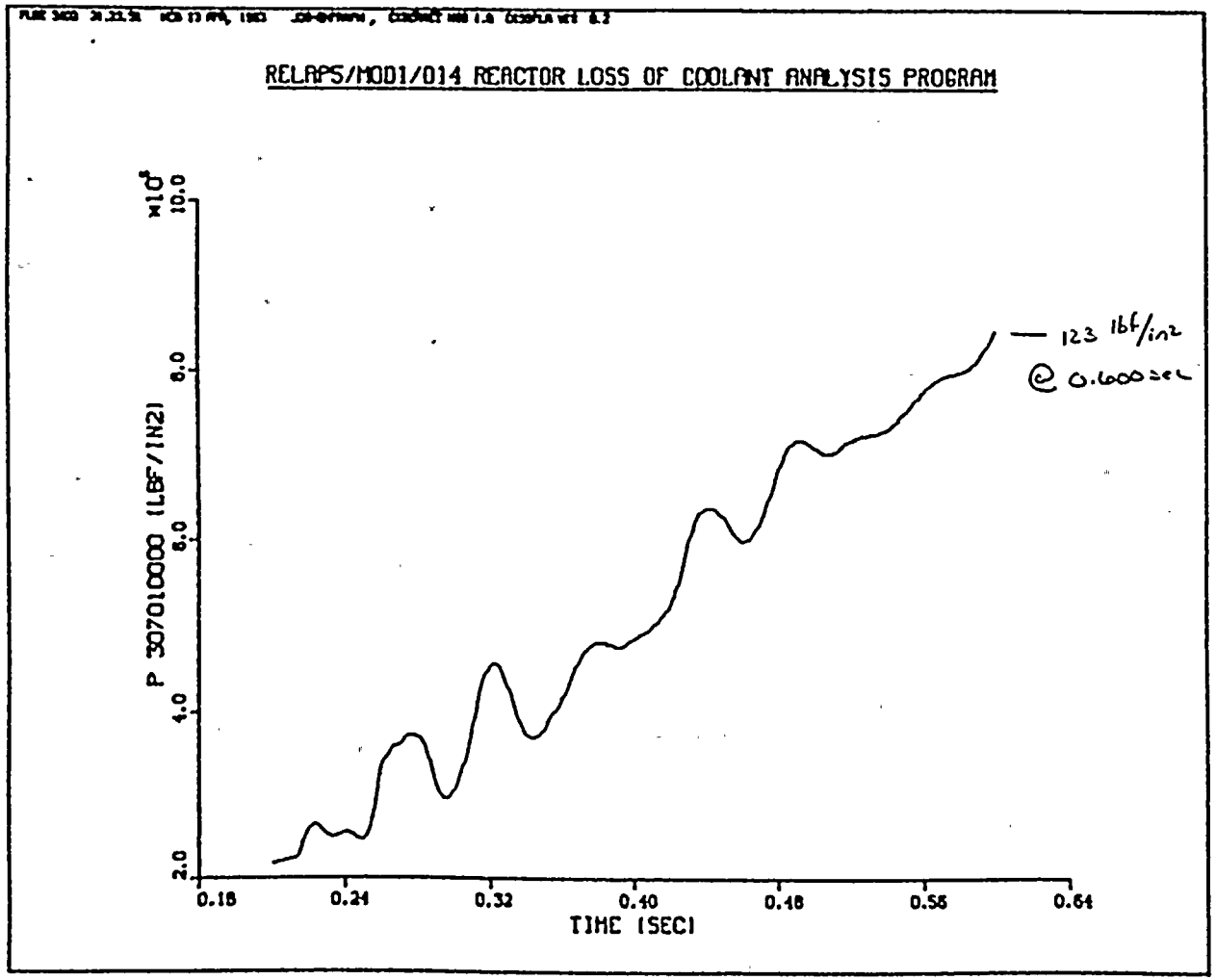
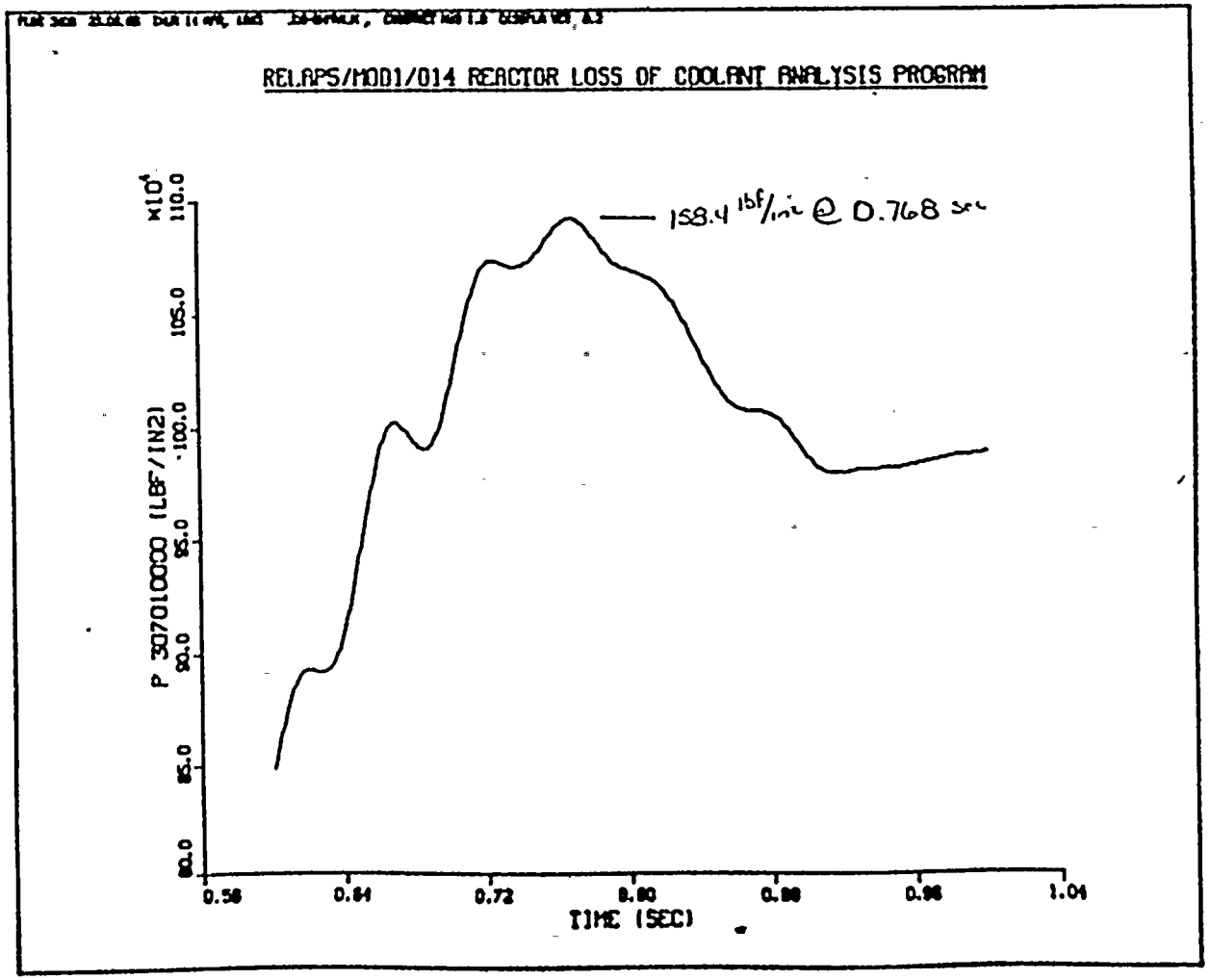


BY JHM DATE 11-27-83
CHKD. BY JBV DATE 4-29-83



BY UHM DATE 11-29-83
CHKD. BY JBK DATE 11-29-83



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CHKD. BY JBM DATE 11-29-83

TELEDYNE ENGINEERING SERVICES
Technical Report
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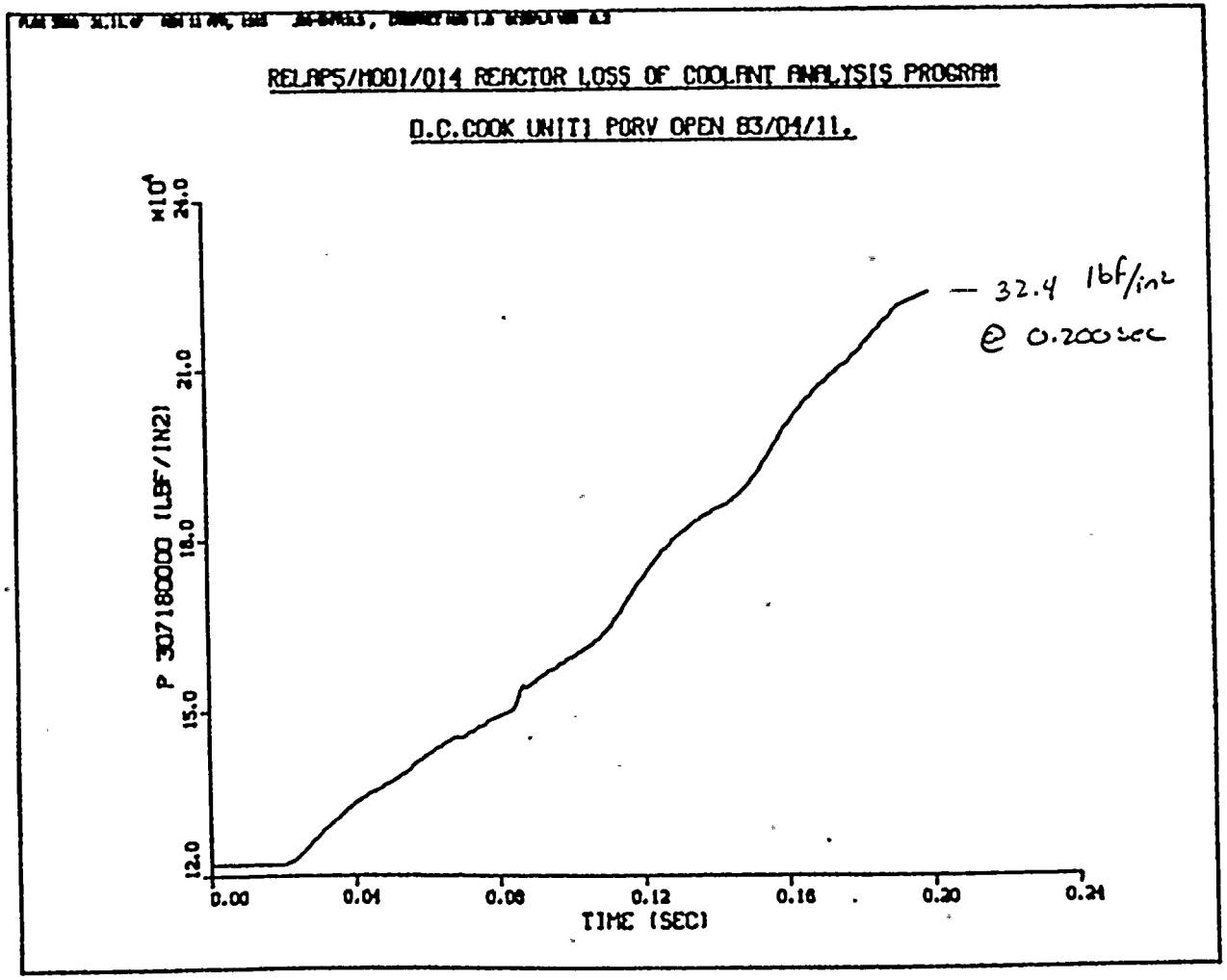
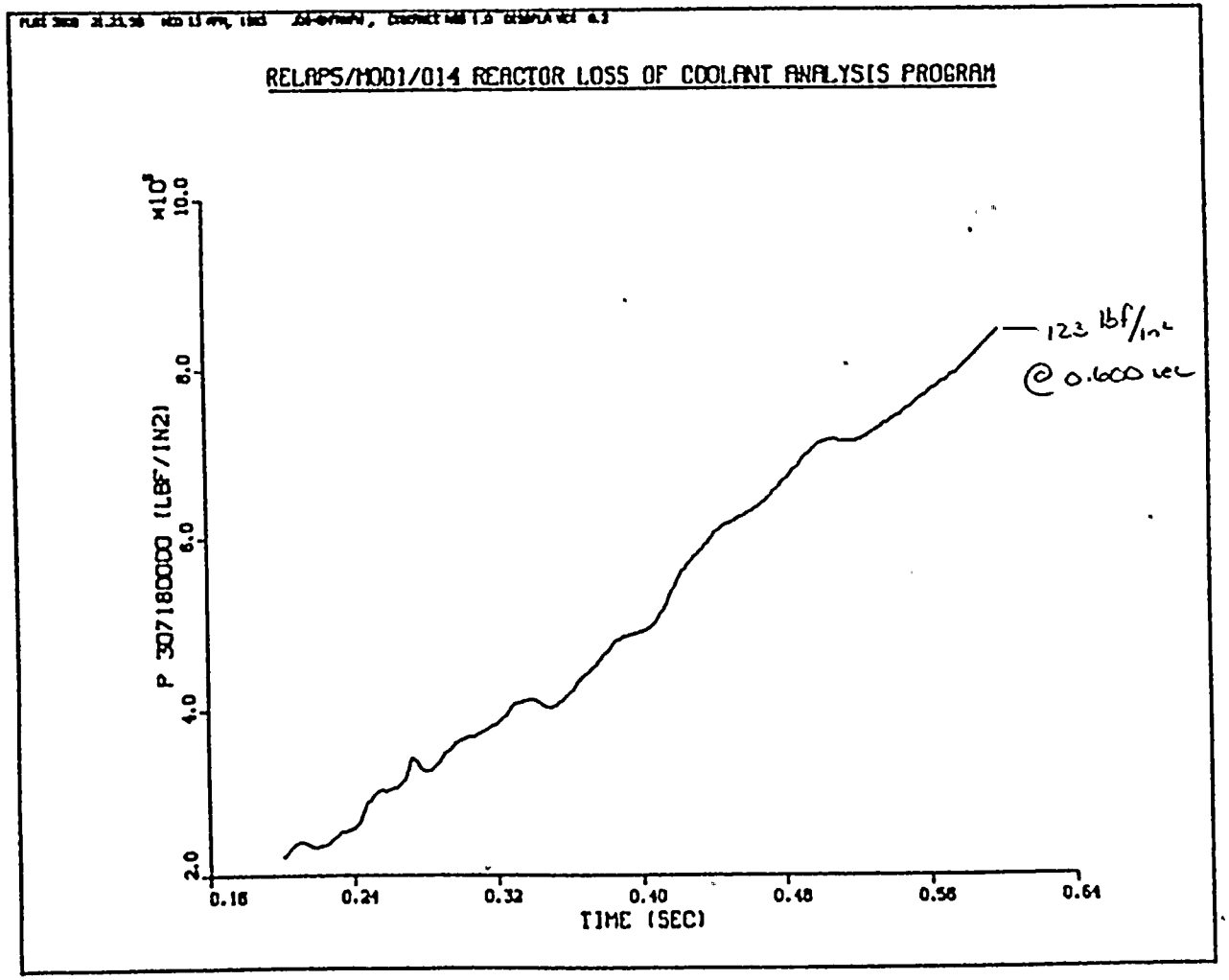
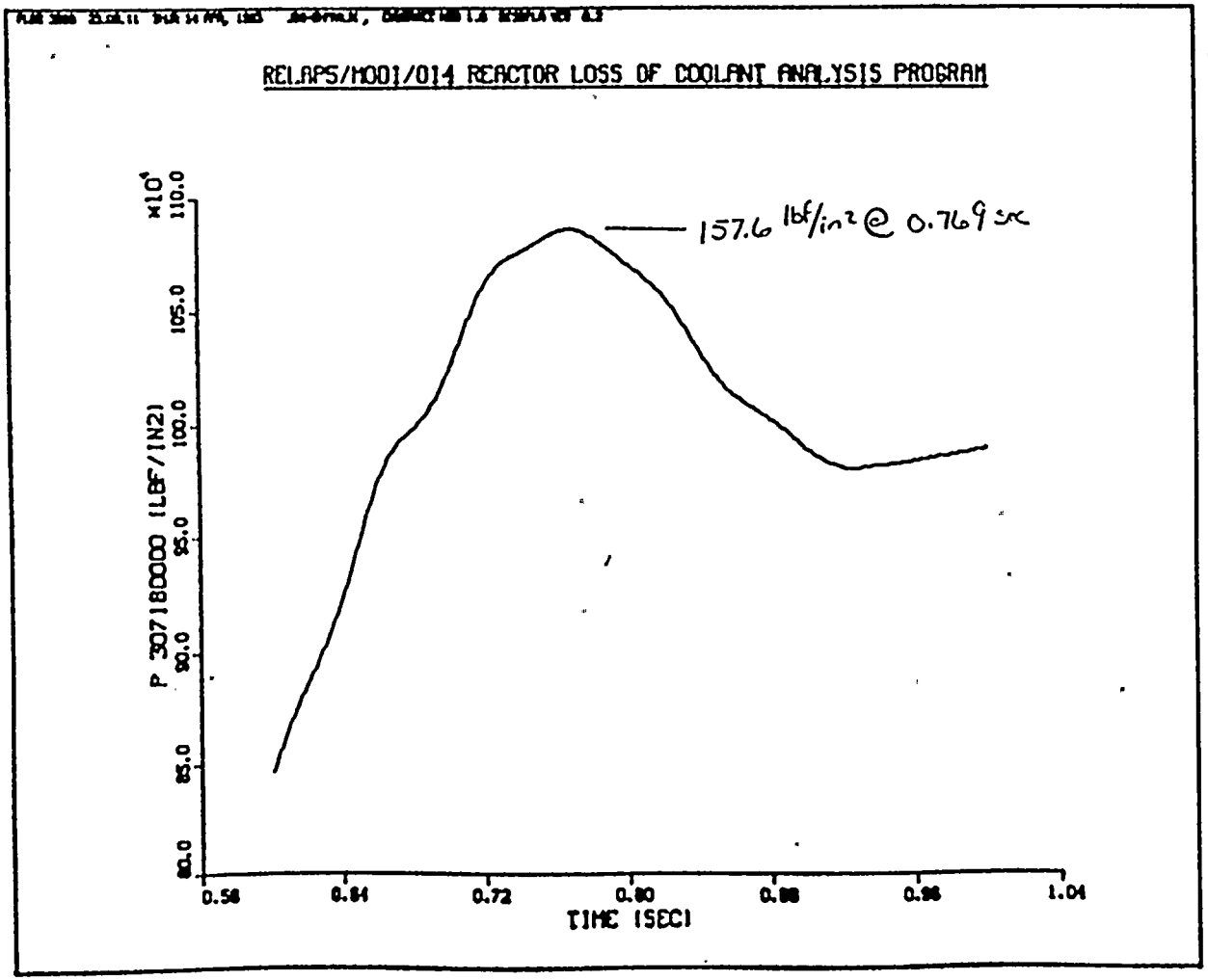


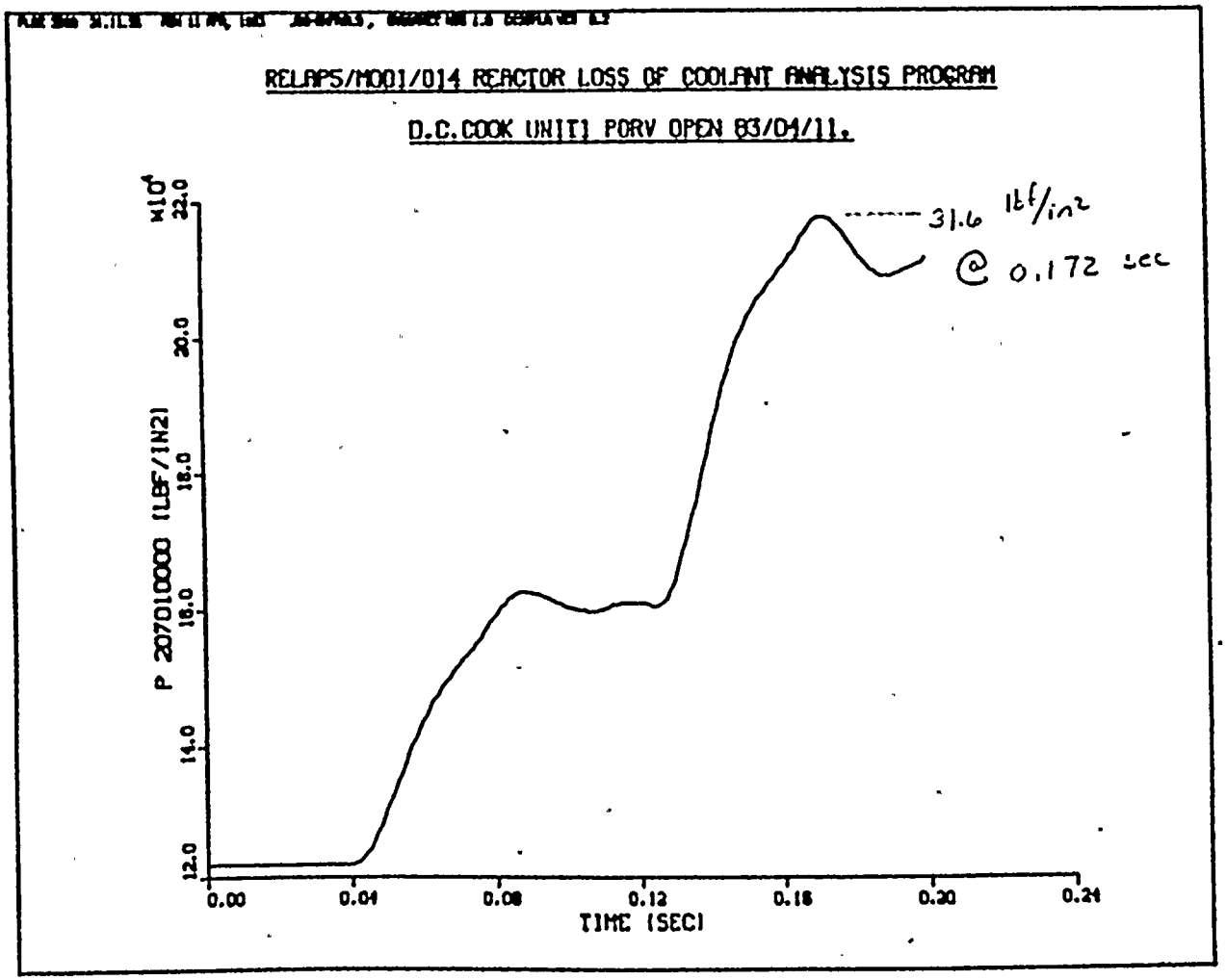
BY JHM DATE 11-29-83
CHKD. BY JBM DATE 11-29-83



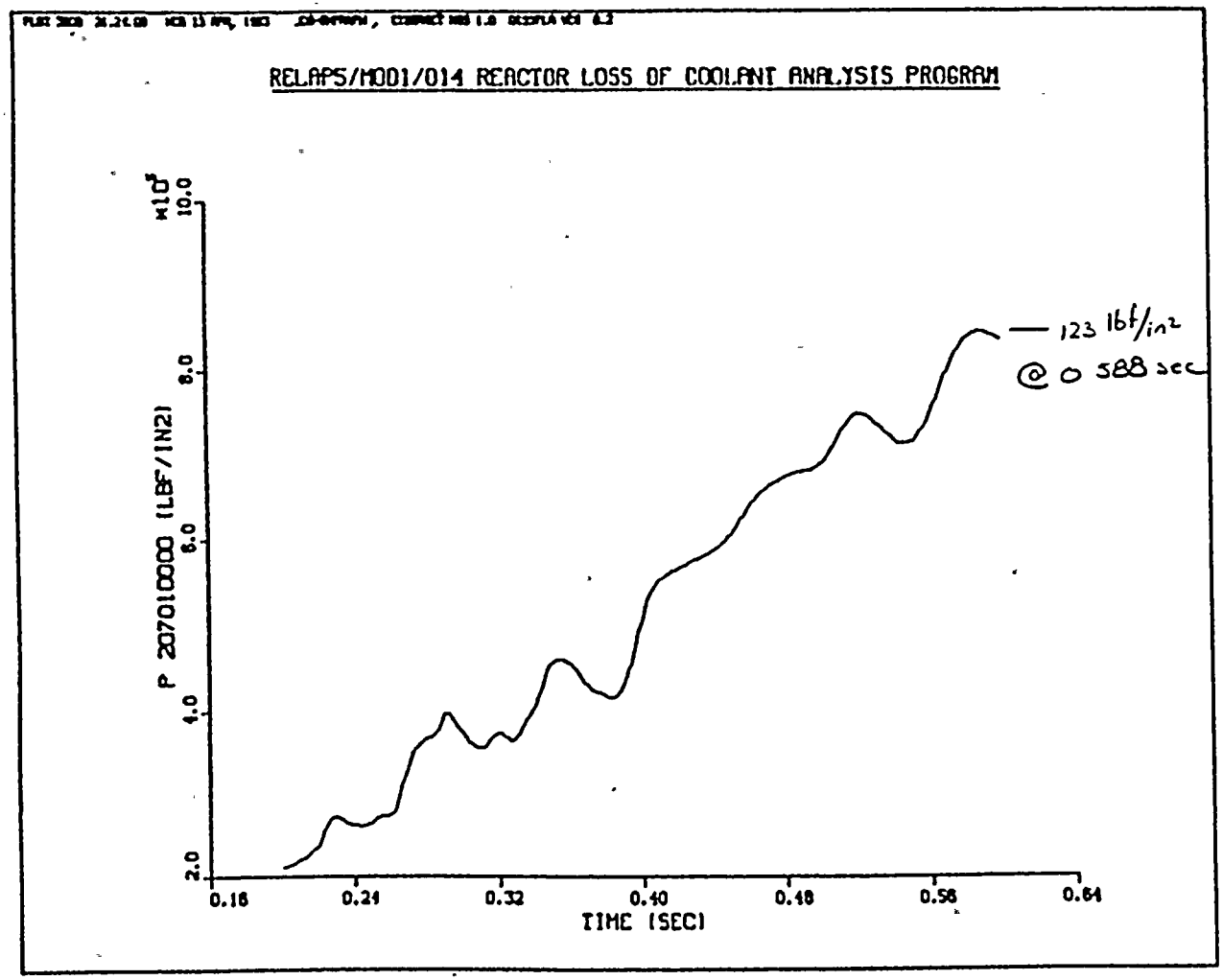
BY UHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83



BY CHH DATE 11-29-83
CHKD. BY JBM DATE 4-29-83



BY [illegible] DATE 11-29-83
CHKD. BY [illegible] DATE 4-29-83



BY UMM DATE 11-29-83
CHKD. BY JBN DATE 4-29-87

TELEDYNE ENGINEERING SERVICES

Technical Report
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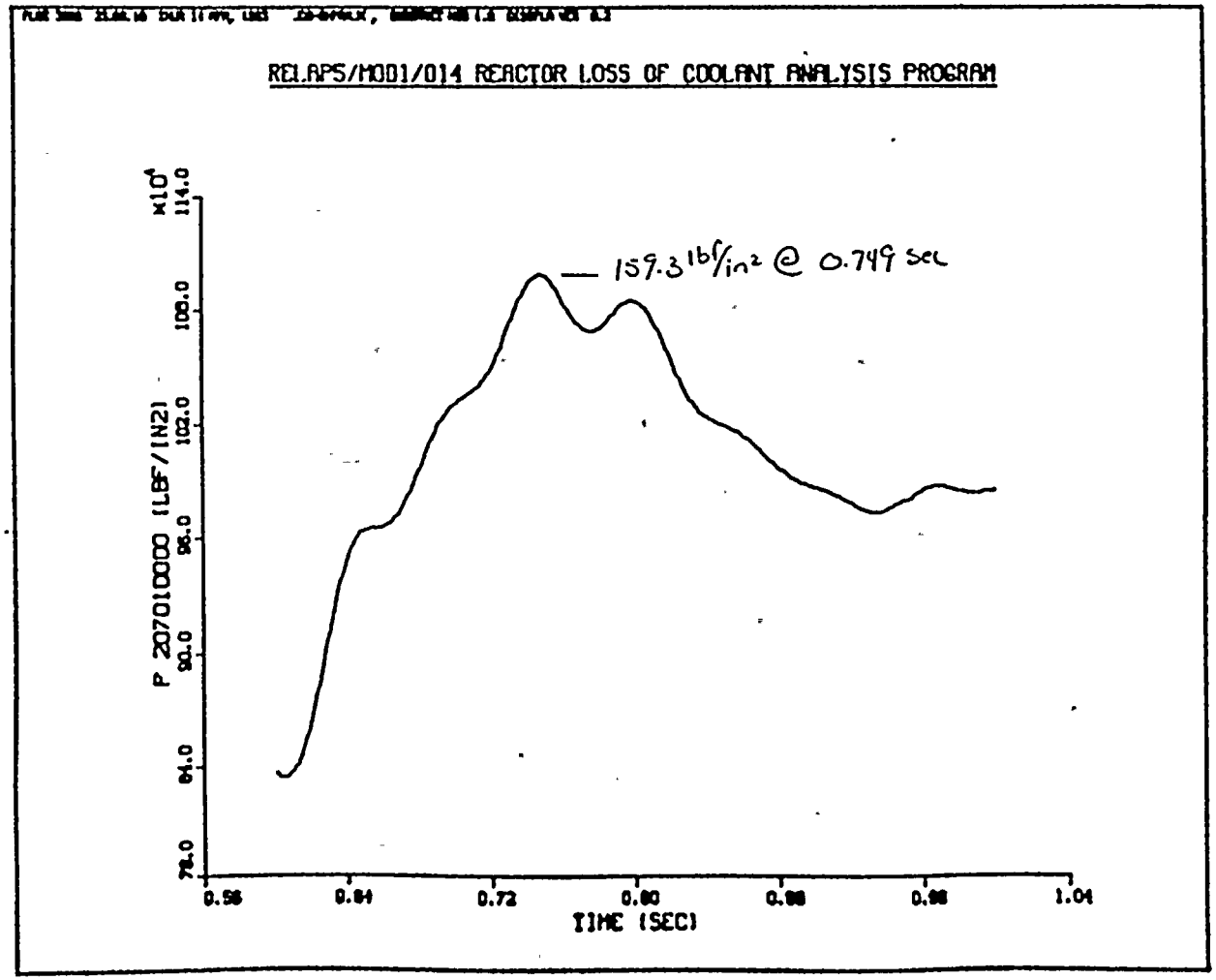
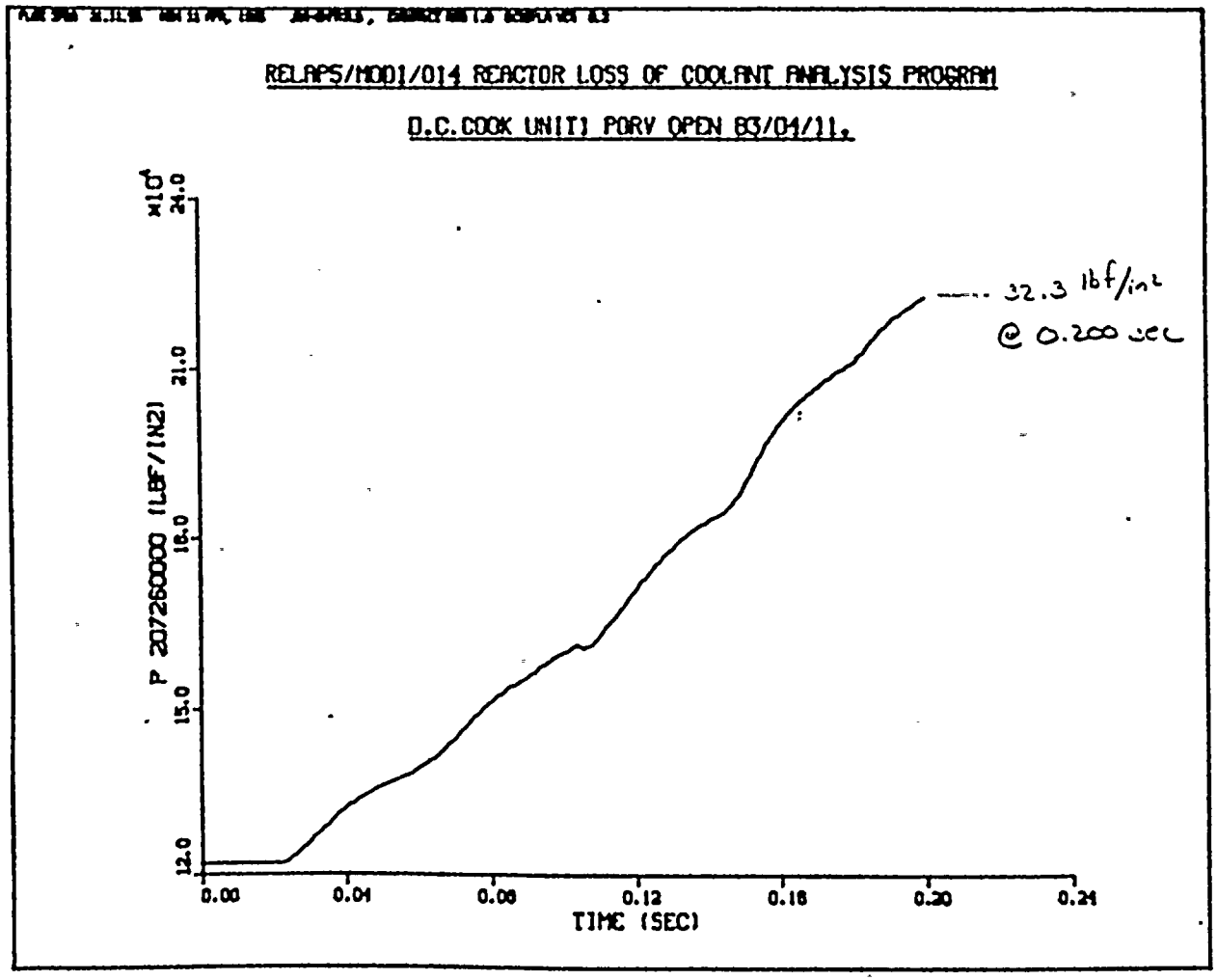


BY UHM DATE 4-29-83
CHKD. BY JBM DATE 4-29-83



BY [illegible] DATE 11-29-83
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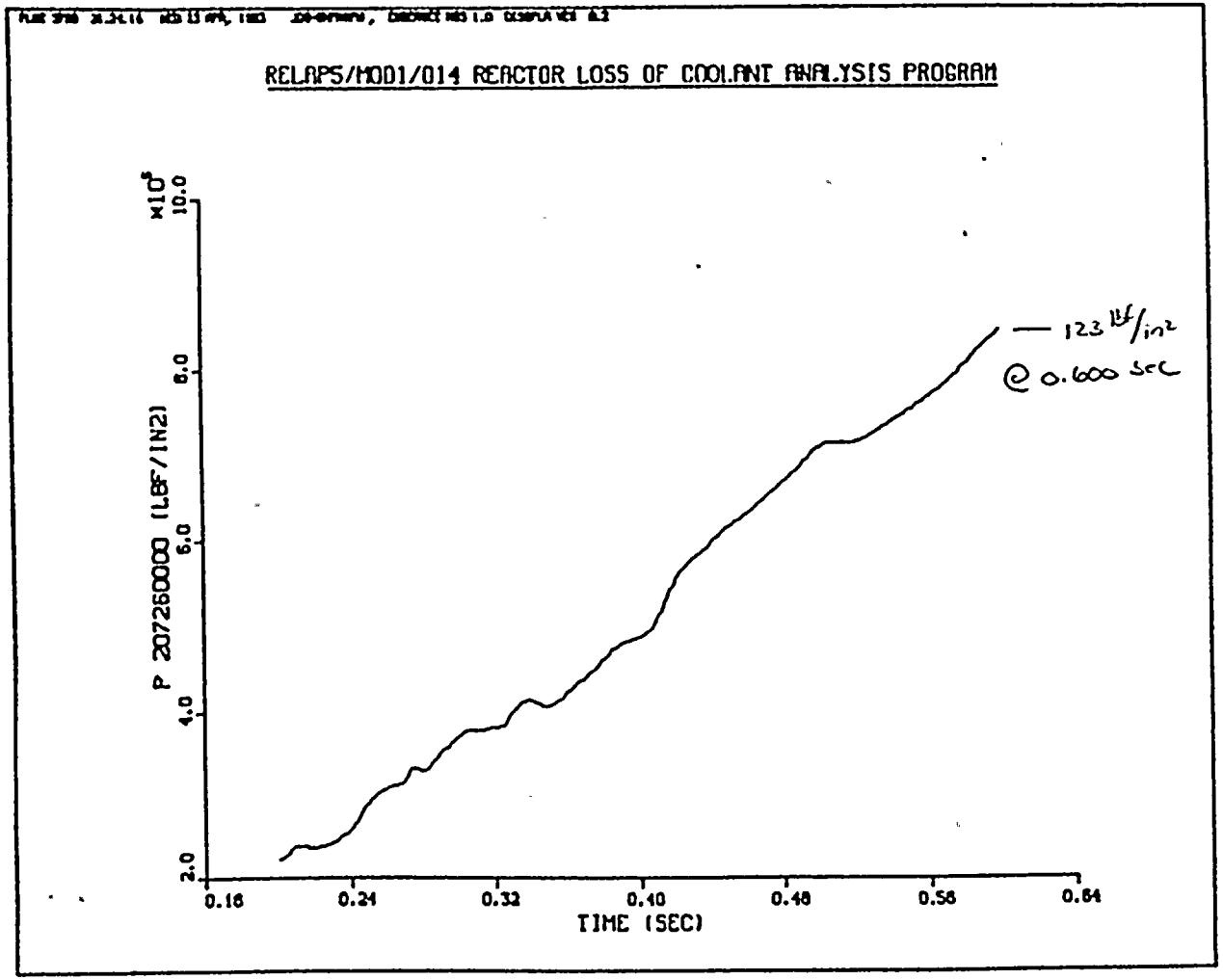
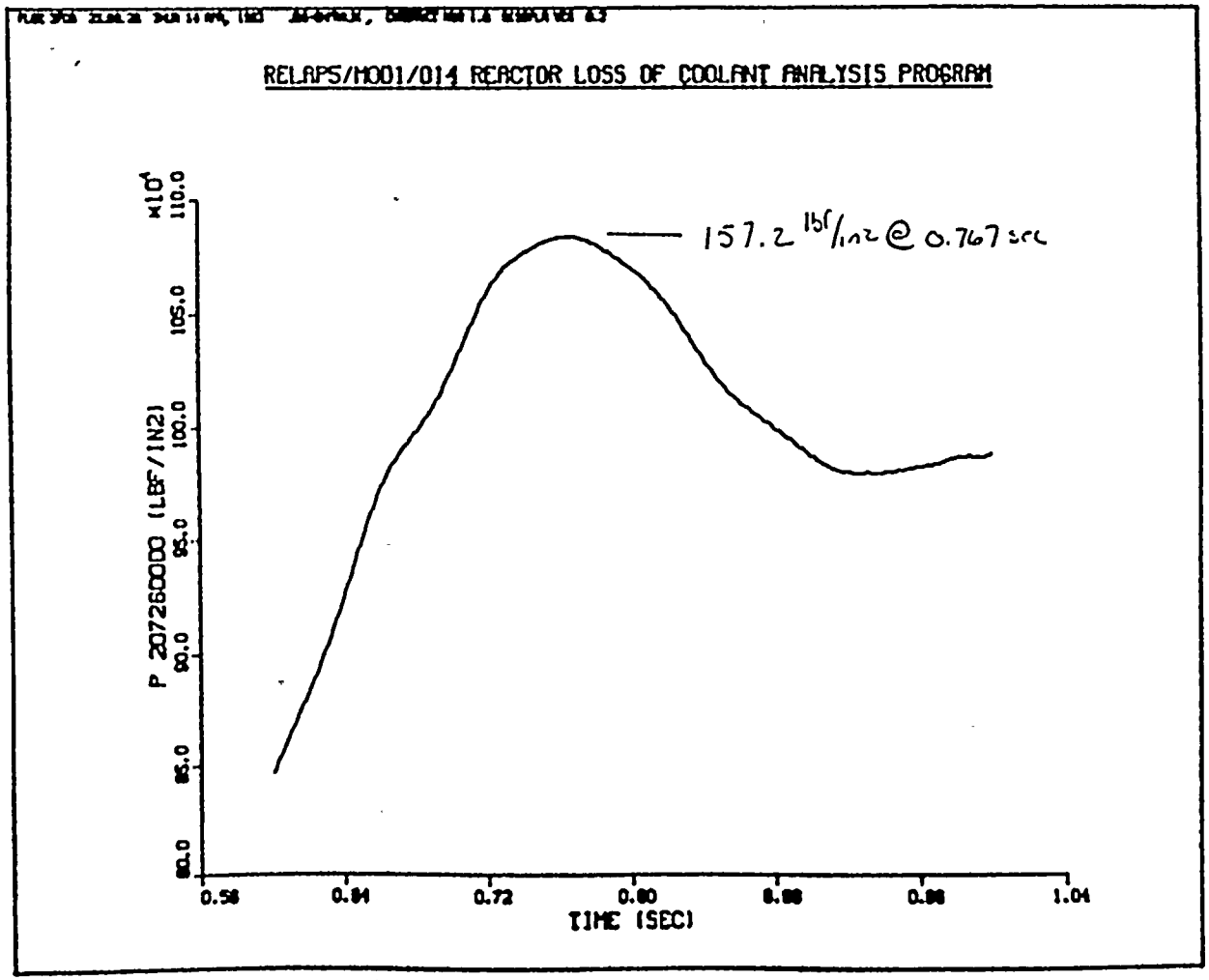
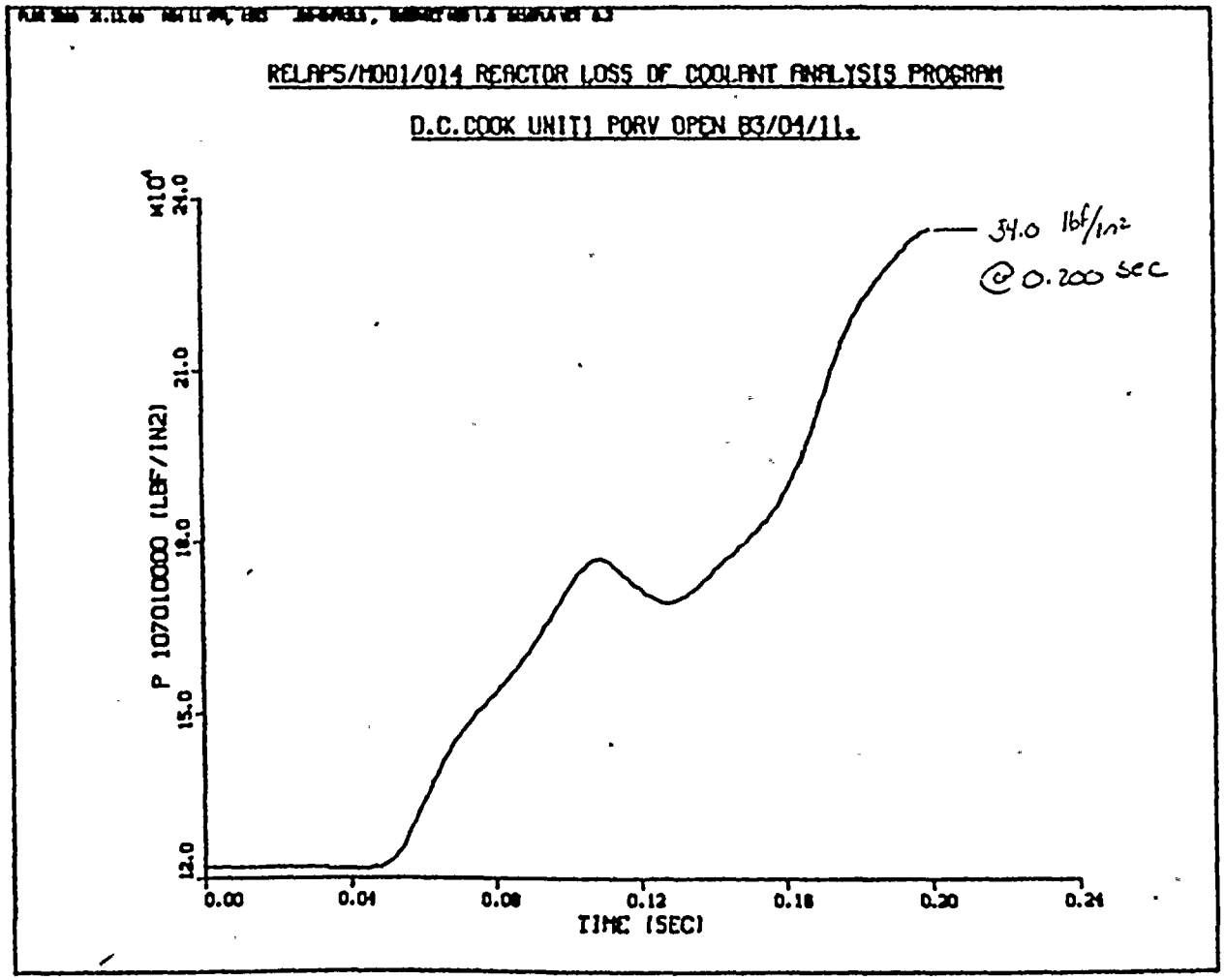
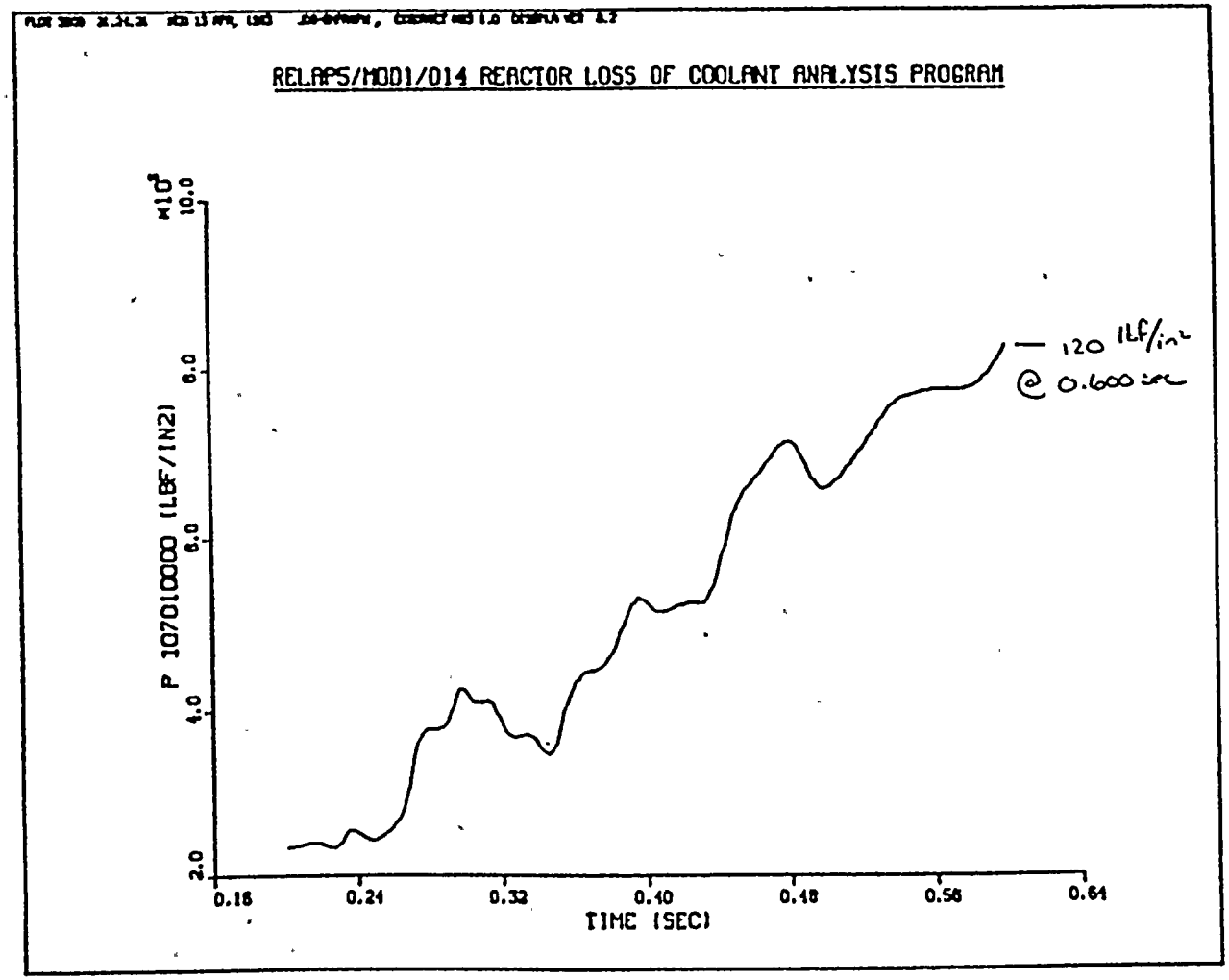


BY JHM DATE 11-29-83
CHKD. BY JBK DATE 11-29-83




RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/11.
P 10701000 (LBF/IN2)
x10⁴
24.0
21.0
18.0
15.0
12.0
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)
34.0 lbf/in²
@ 0.200 sec

BY [illegible] DATE 4-29-83
CHKD. BY [illegible] DATE 4-29-83



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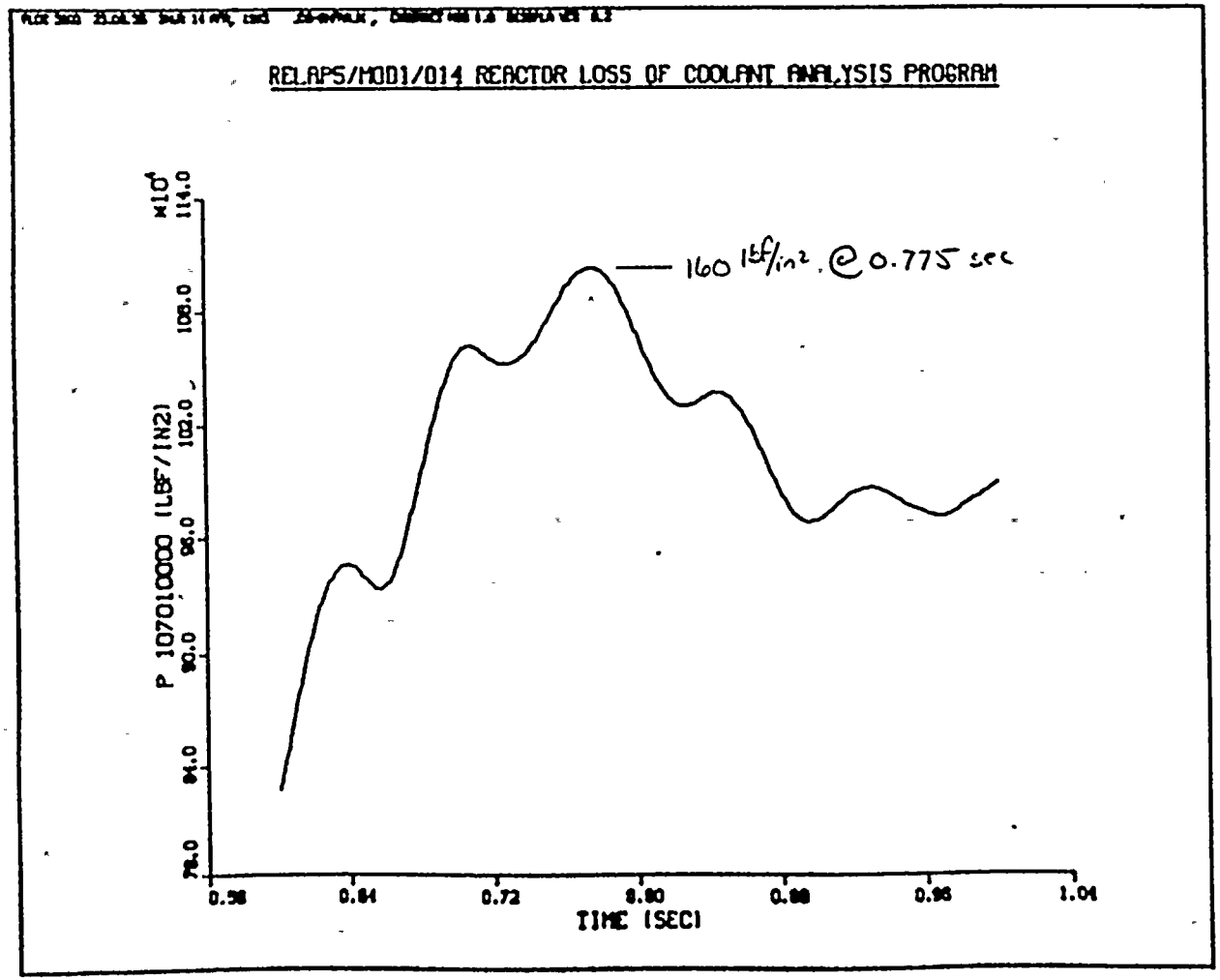
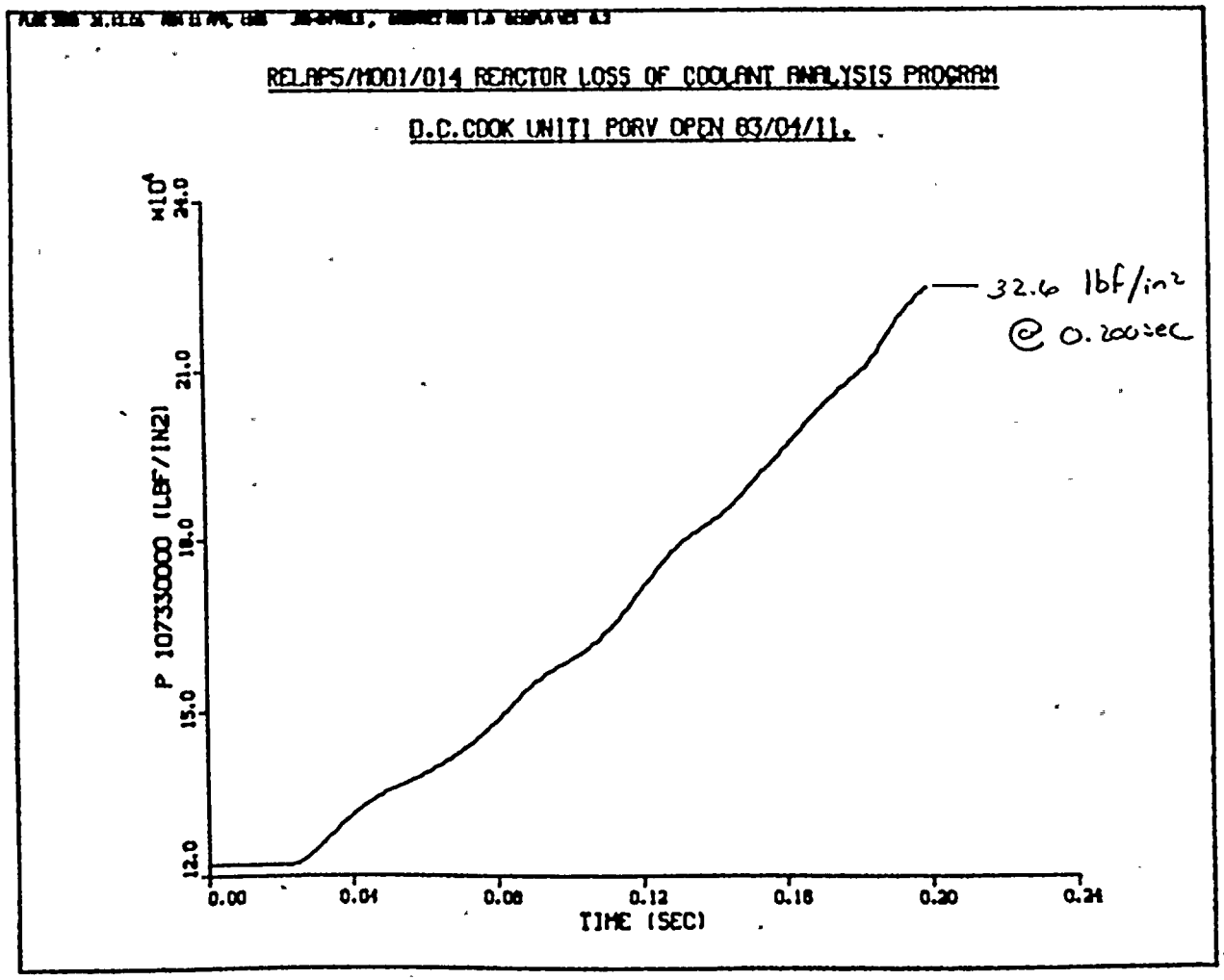
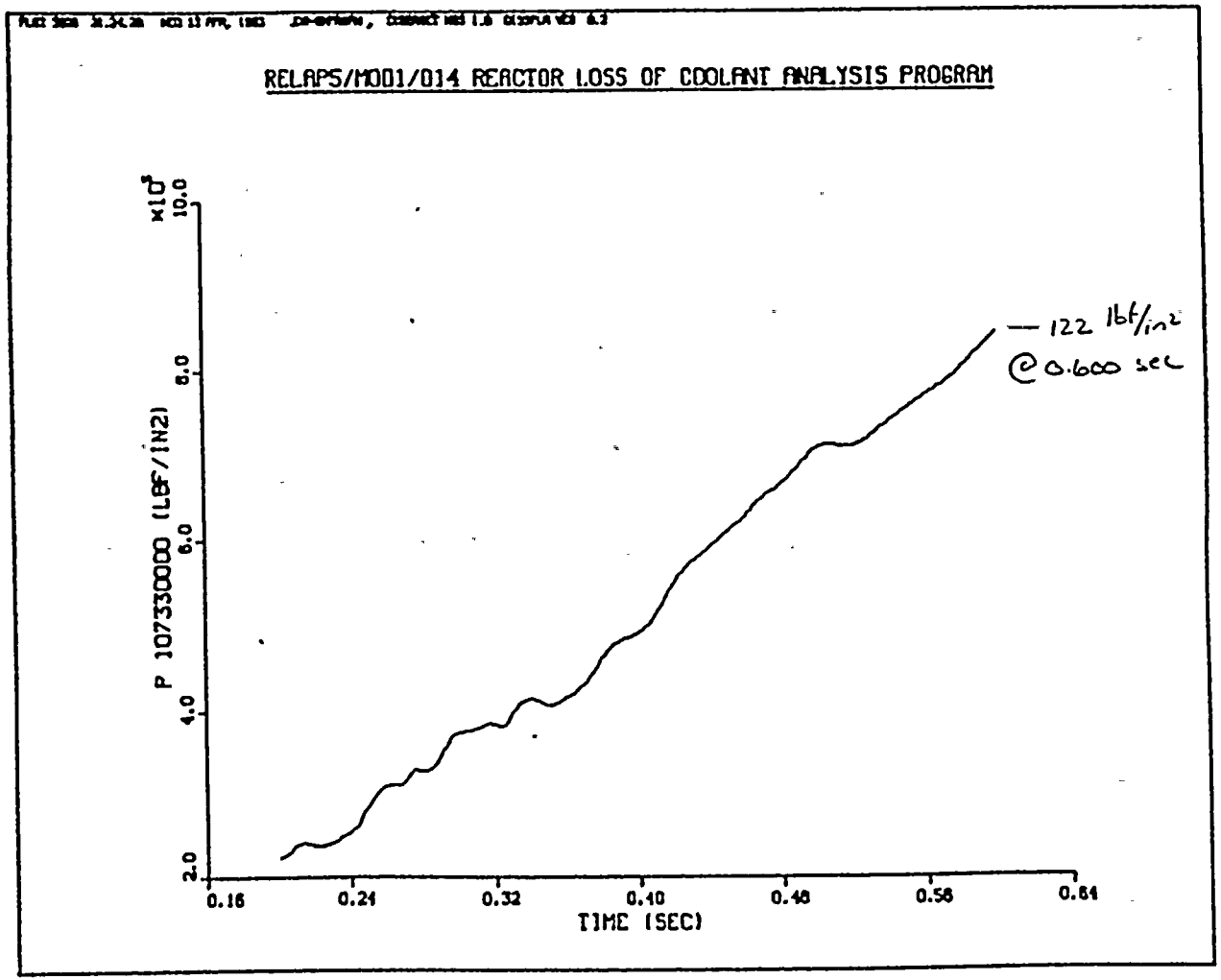
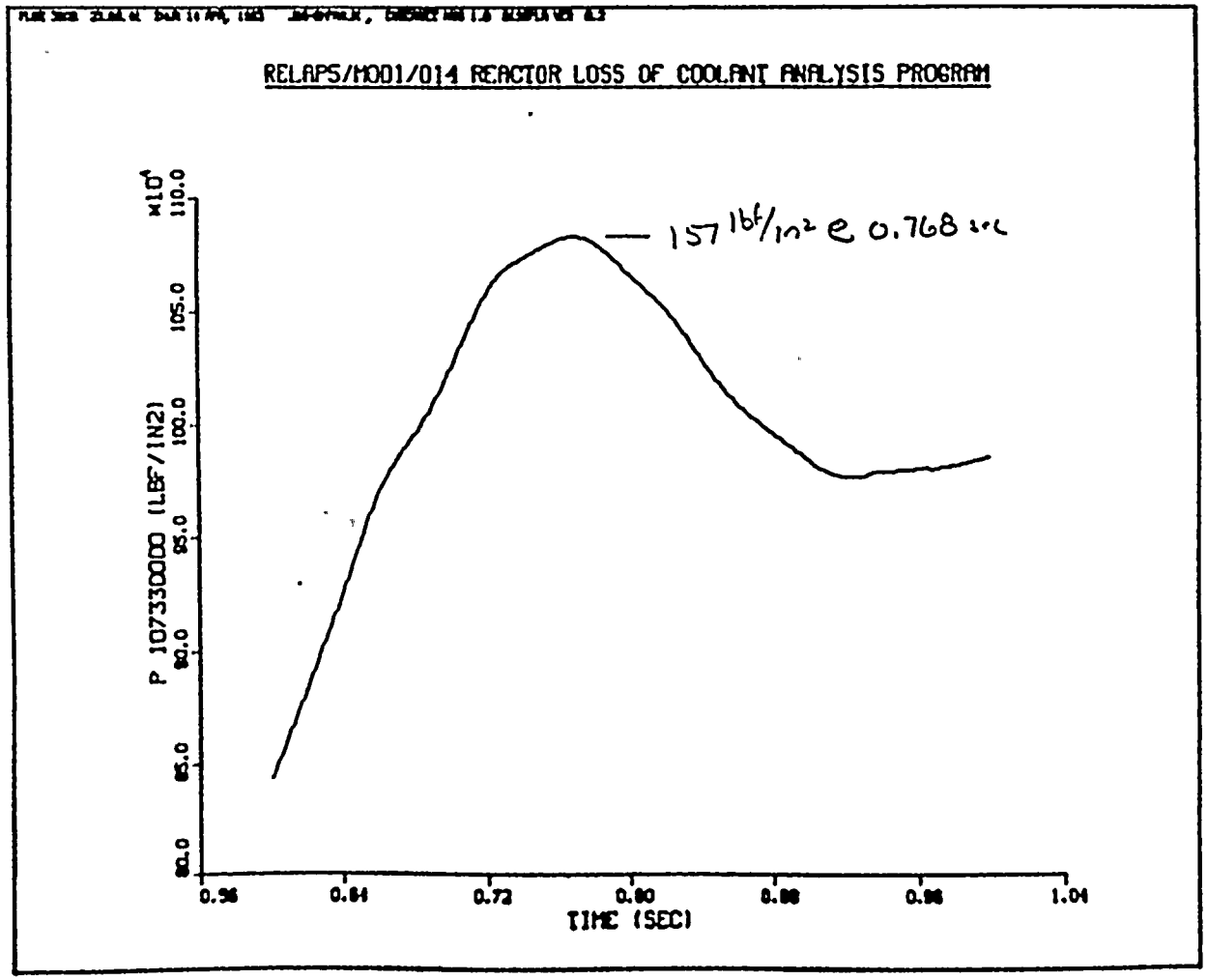
CHKD. BY [illegible] DATE 11-29-83




RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/11.
P 107330000 (LBF/IN2)
x10^4
24.0
21.0
18.0
15.0
12.0
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)
32.6 lbf/in²
@ 0.200 sec


RELAPS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
P 10733000 (LBF/IN2)
×10⁸
10.0
8.0
6.0
4.0
2.0
0.16
0.24
0.32
0.40
0.48
0.56
0.64
TIME (SEC)
— 122 lbf/in²
@ 0.600 sec


RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
P 10733000 (LBF/IN2)
×10⁴
110.0
105.0
100.0
95.0
90.0
85.0
80.0
0.56
0.64
0.72
0.80
0.88
0.96
1.04
TIME (SEC)
157 lbf/in² @ 0.768 sec

4.7.2 Unit 1 - 400° Solid Liquid Case

BY JHH DATE 11-29-83
CHKD. BY JBM DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

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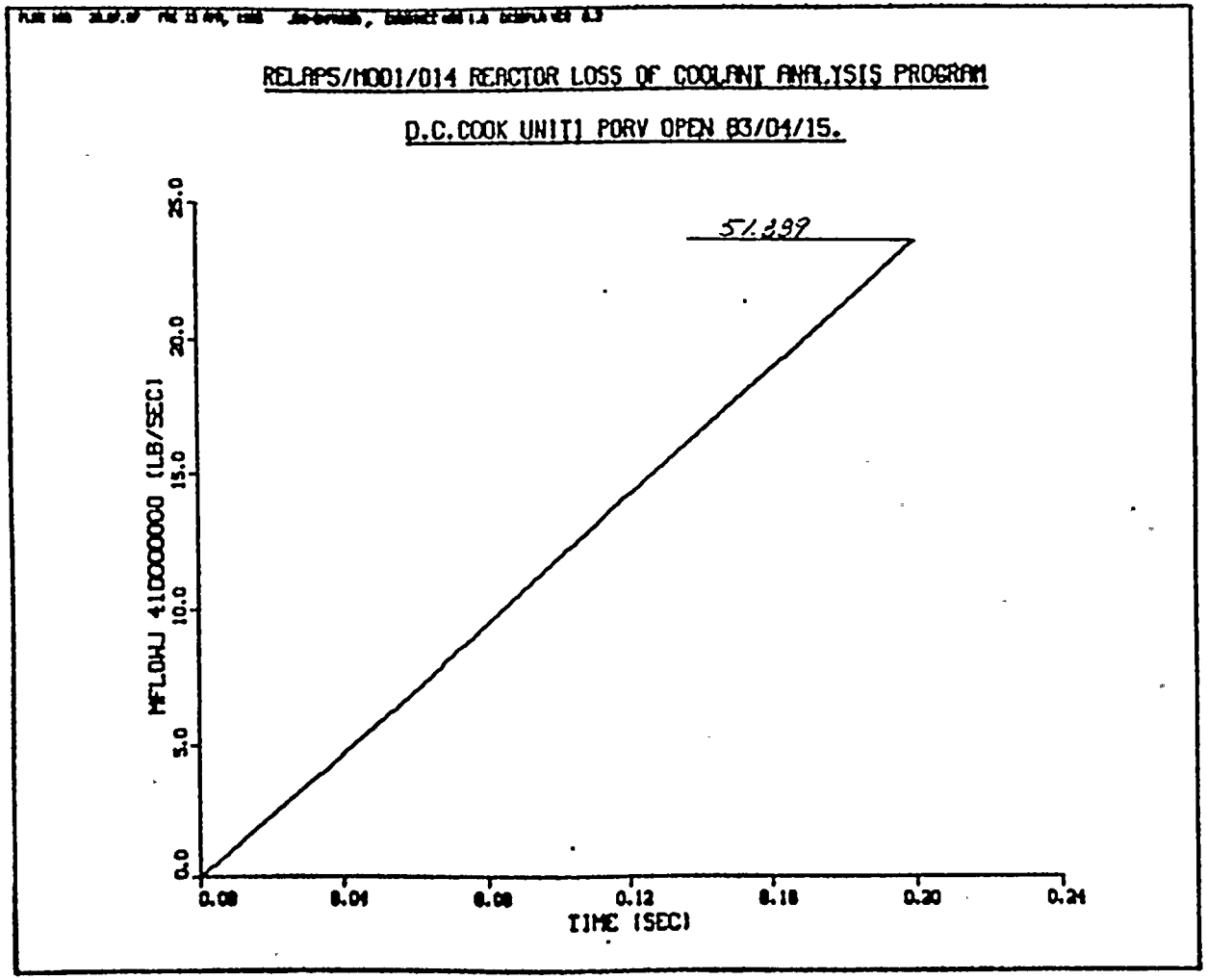
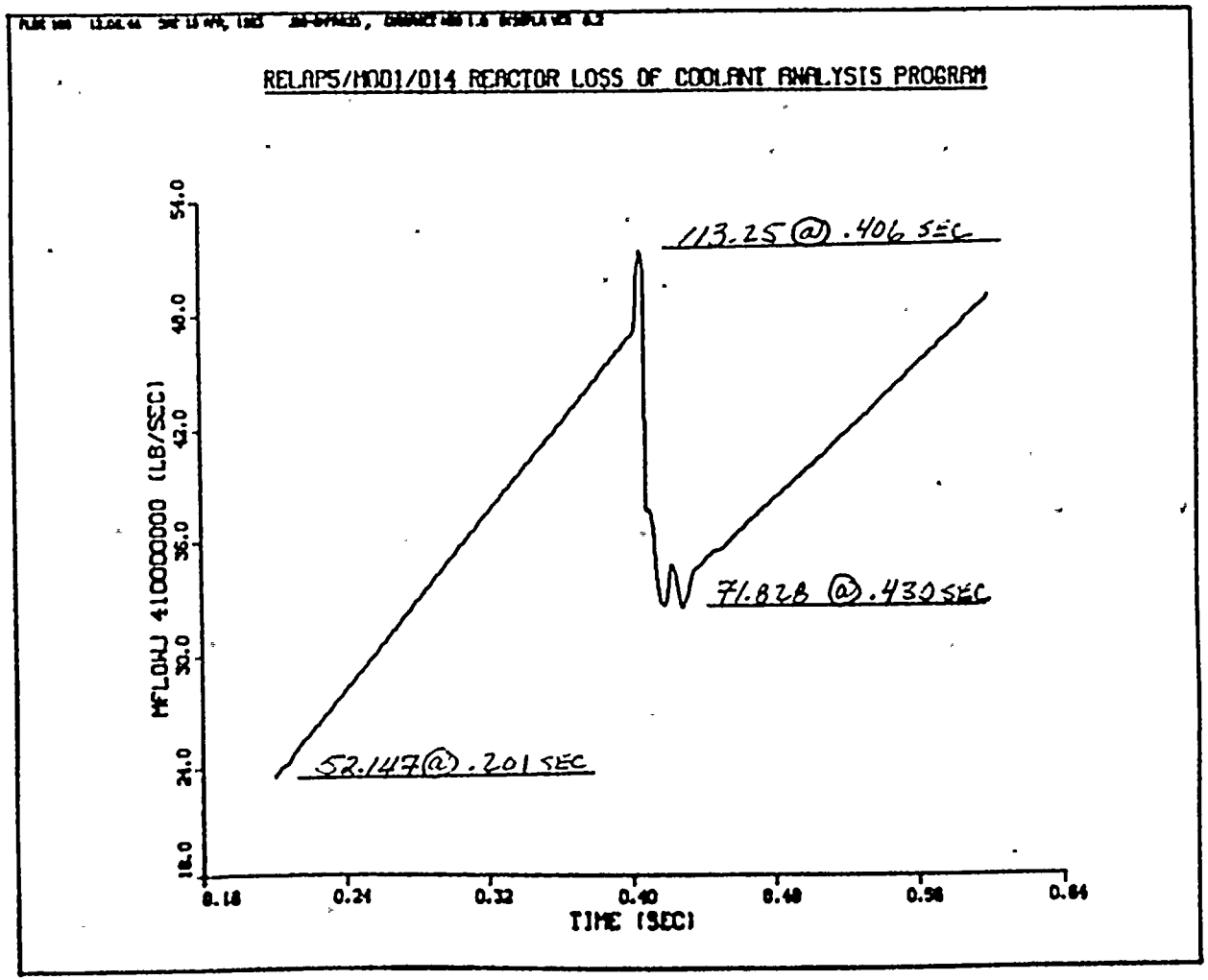


BY CHM DATE 4-29-83
CHKD. BY KTG DATE 4-29-83



BY UHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

Technical Report
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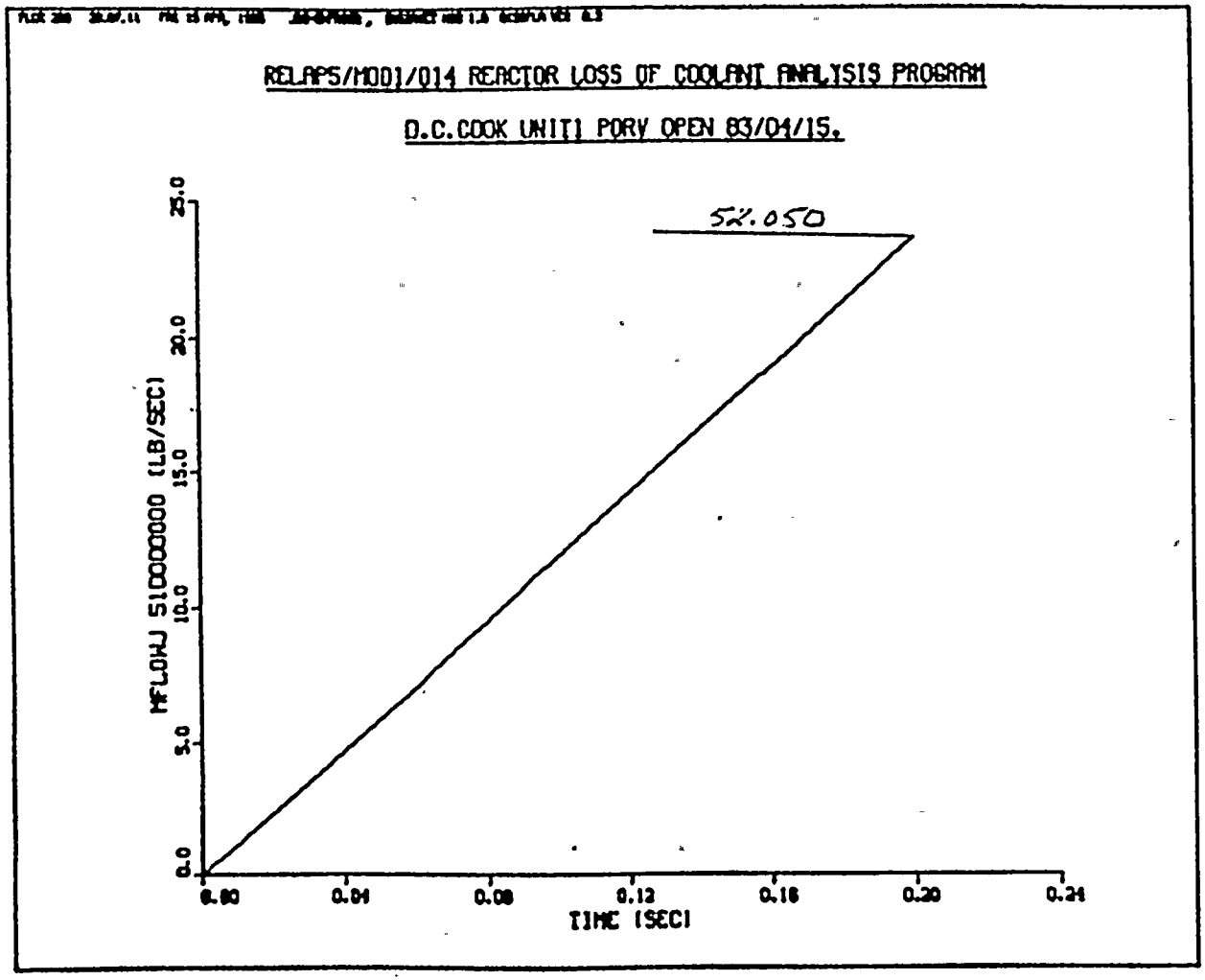
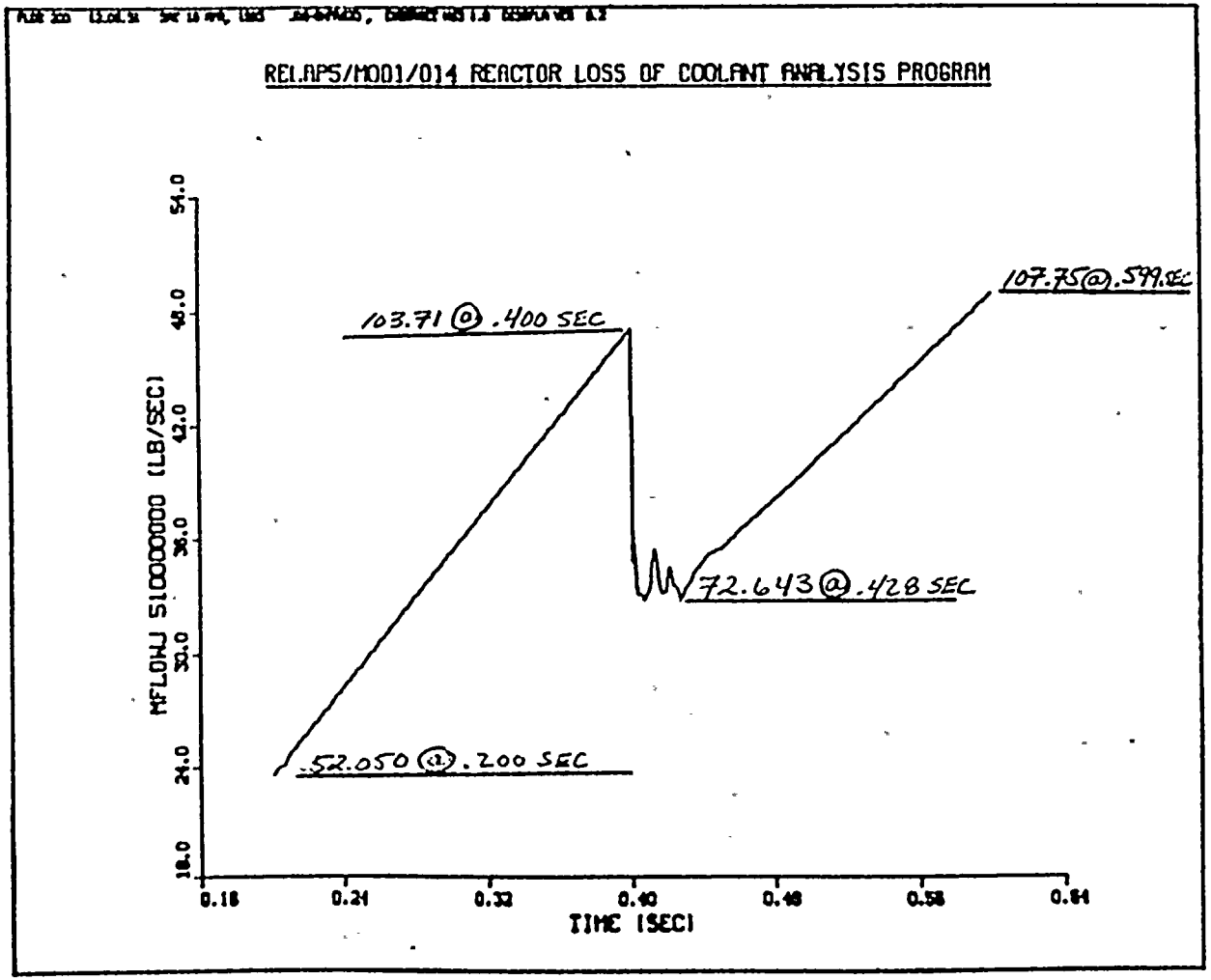
Revision 0



BY CHM DATE 4-29-83
CHKD. BY KTG DATE 4-27-83



TELEDYNE ENGINEERING SERVICES

Technical Report
TR-5364-1
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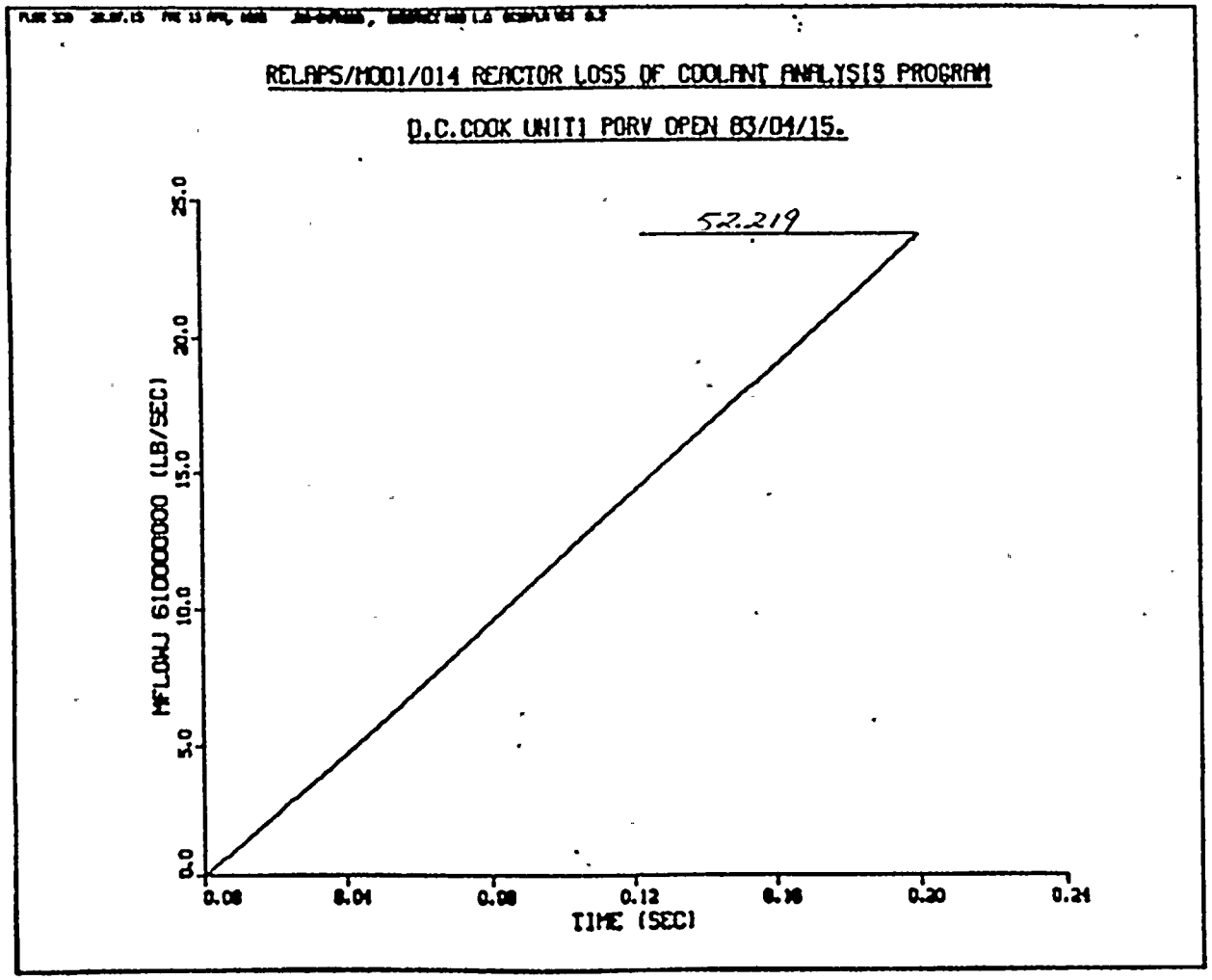
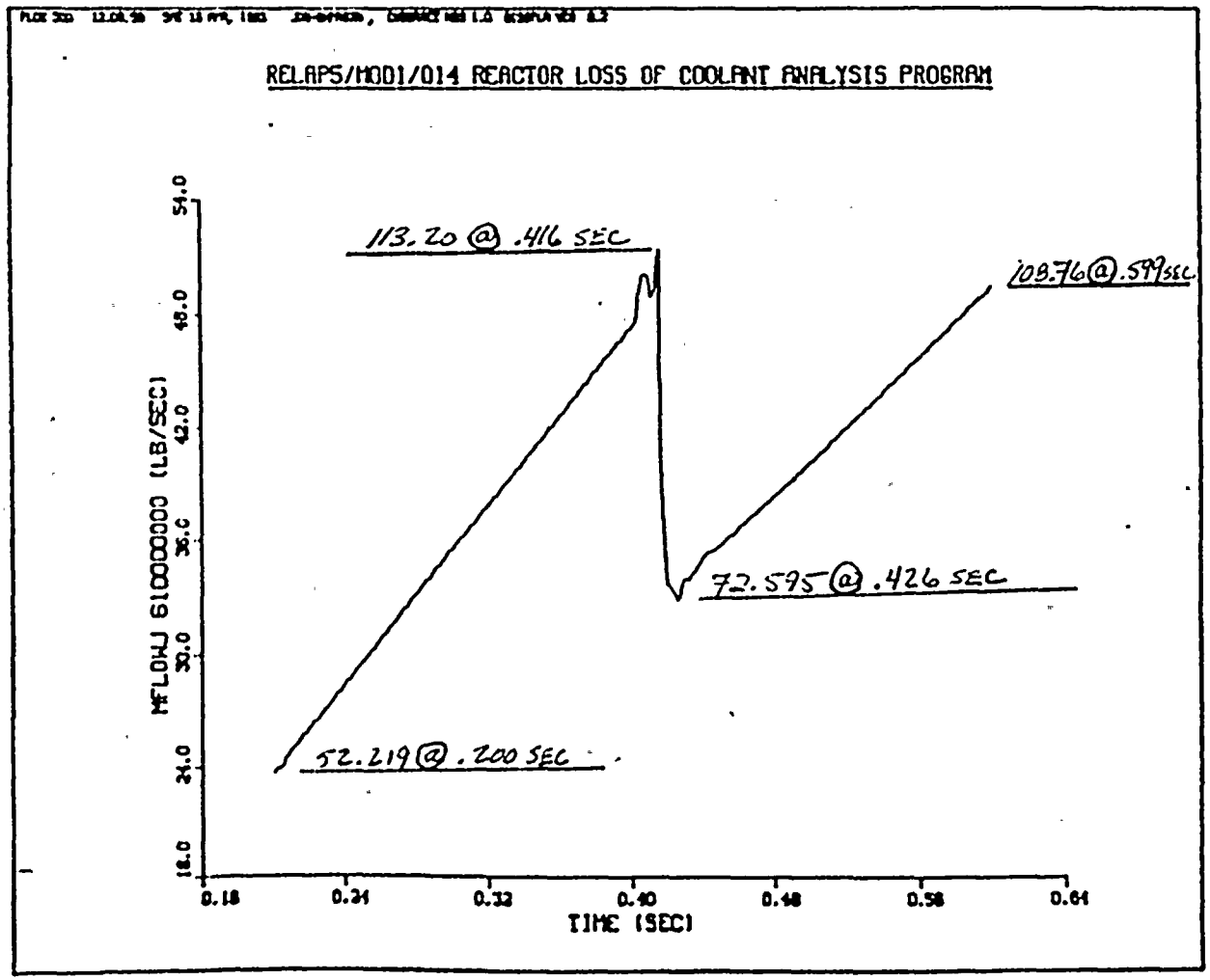

RELAPS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/15.
52.219
MFLOWJ 610000000 (LB/SEC)
0.0
5.0
10.0
15.0
20.0
25.0
0.08
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)

BY CHM DATE 4-29-83
CHKD. BY KTG DATE 4-29-83



BY UMM DATE 11-29-83
CHKD. BY JBM DATE 9-29-83

TELEDYNE ENGINEERING SERVICES

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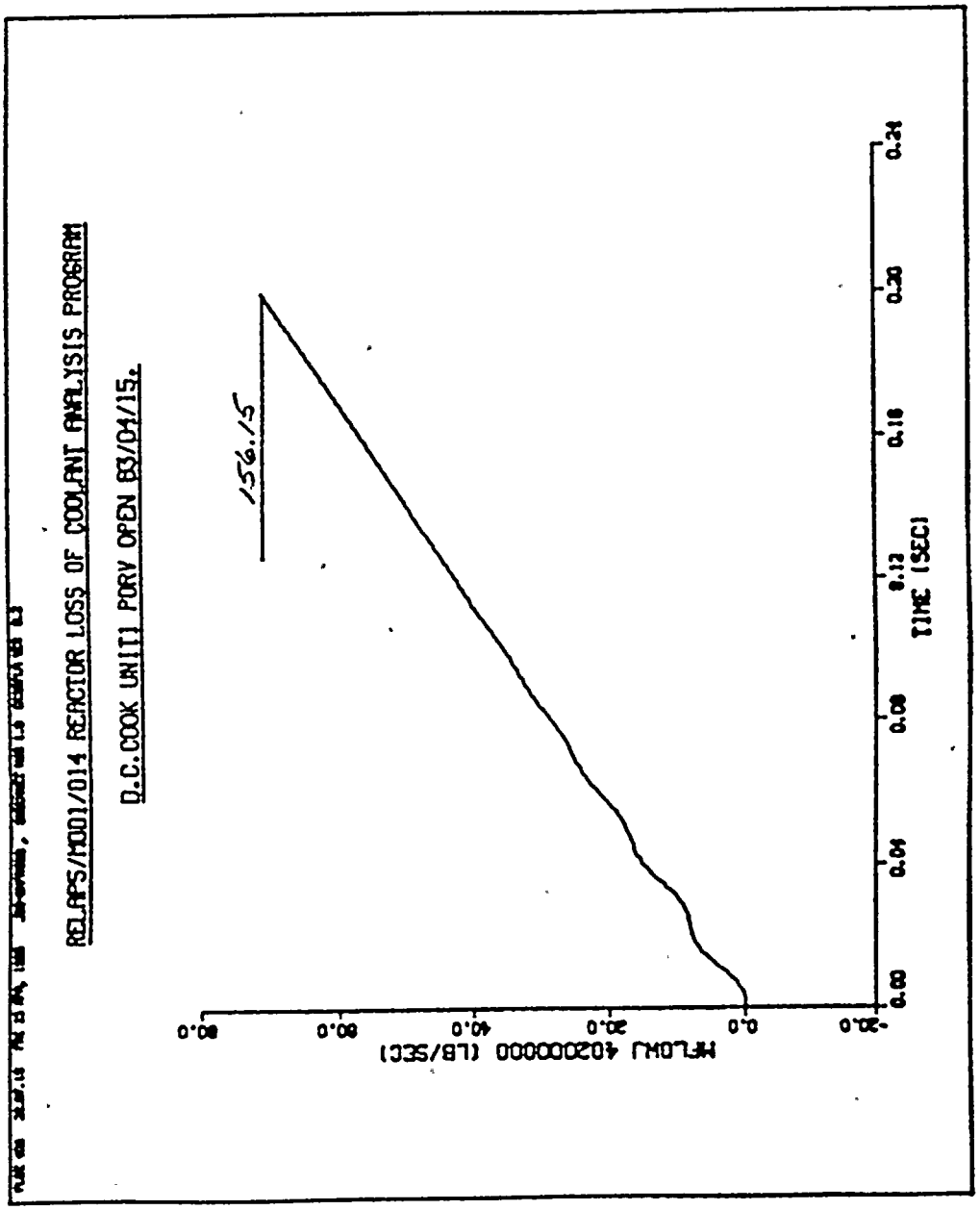
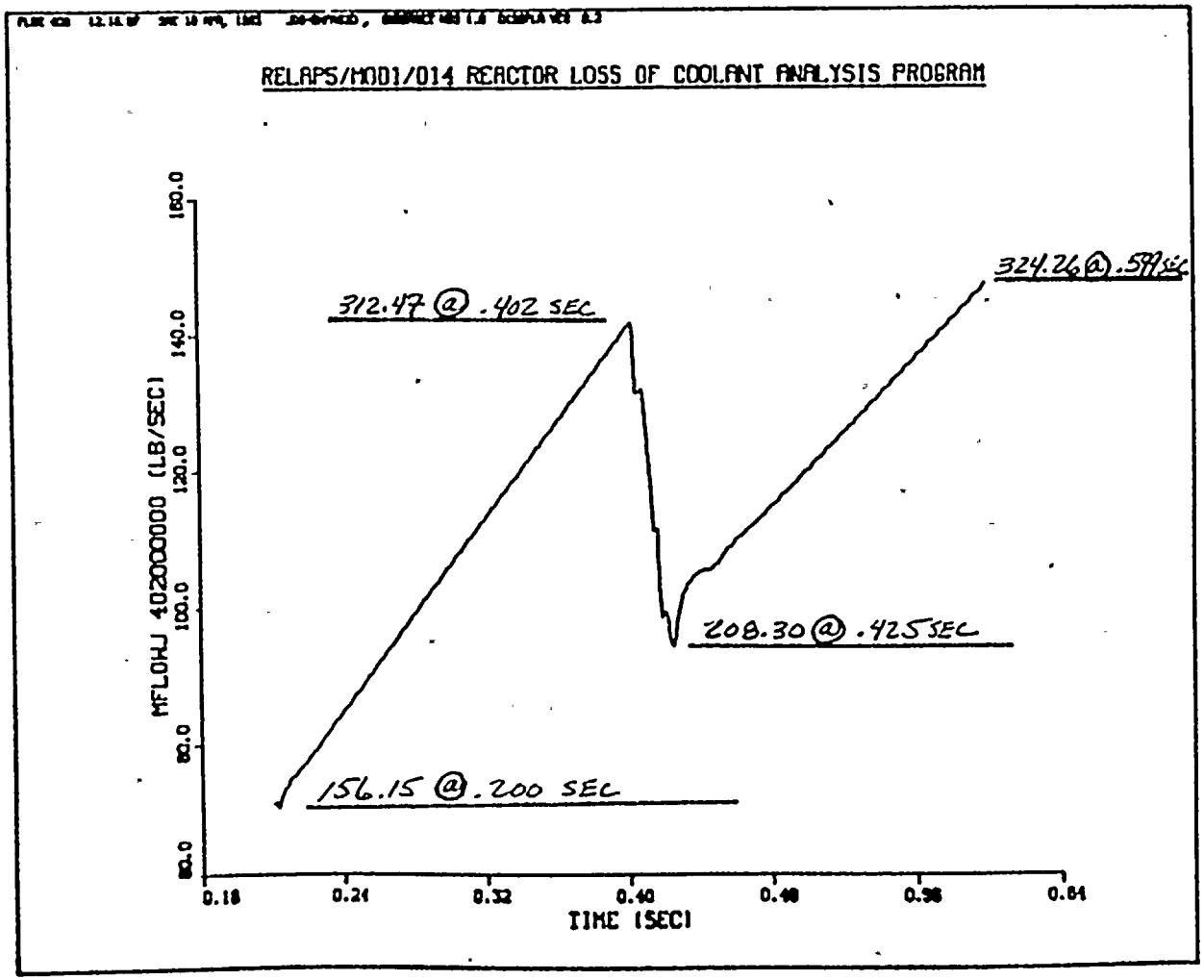
TR-5364-1
Revision 0



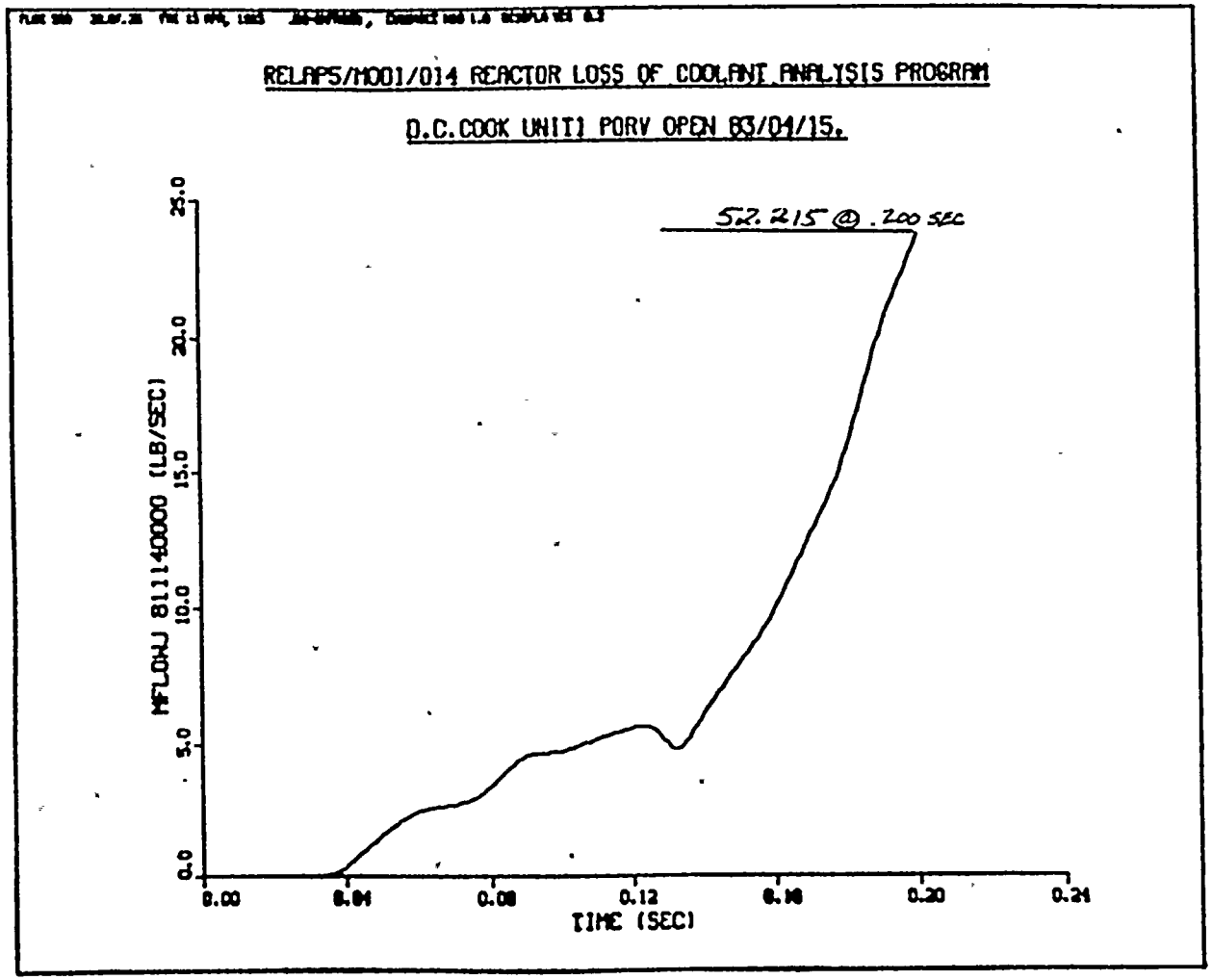
BY CMM DATE 4-29-83
CHKD. BY KTG DATE 4-29-83



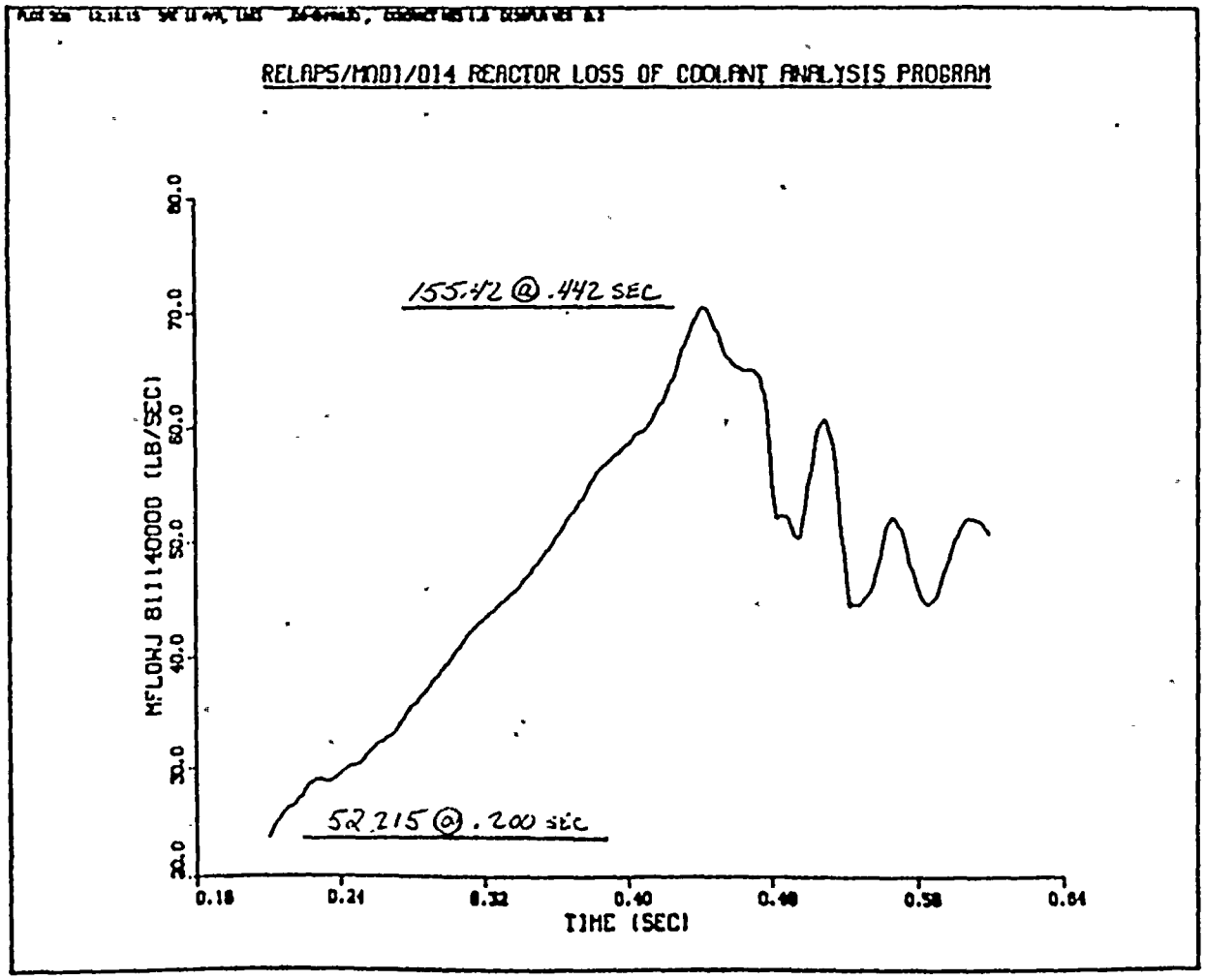
BY UHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

Technical Report
TR-5364-1
Revision 0



BY CHM DATE 4-29-83
CHKD. BY KTG DATE 11-29-83



BY UHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-84

TELEDYNE ENGINEERING SERVICES

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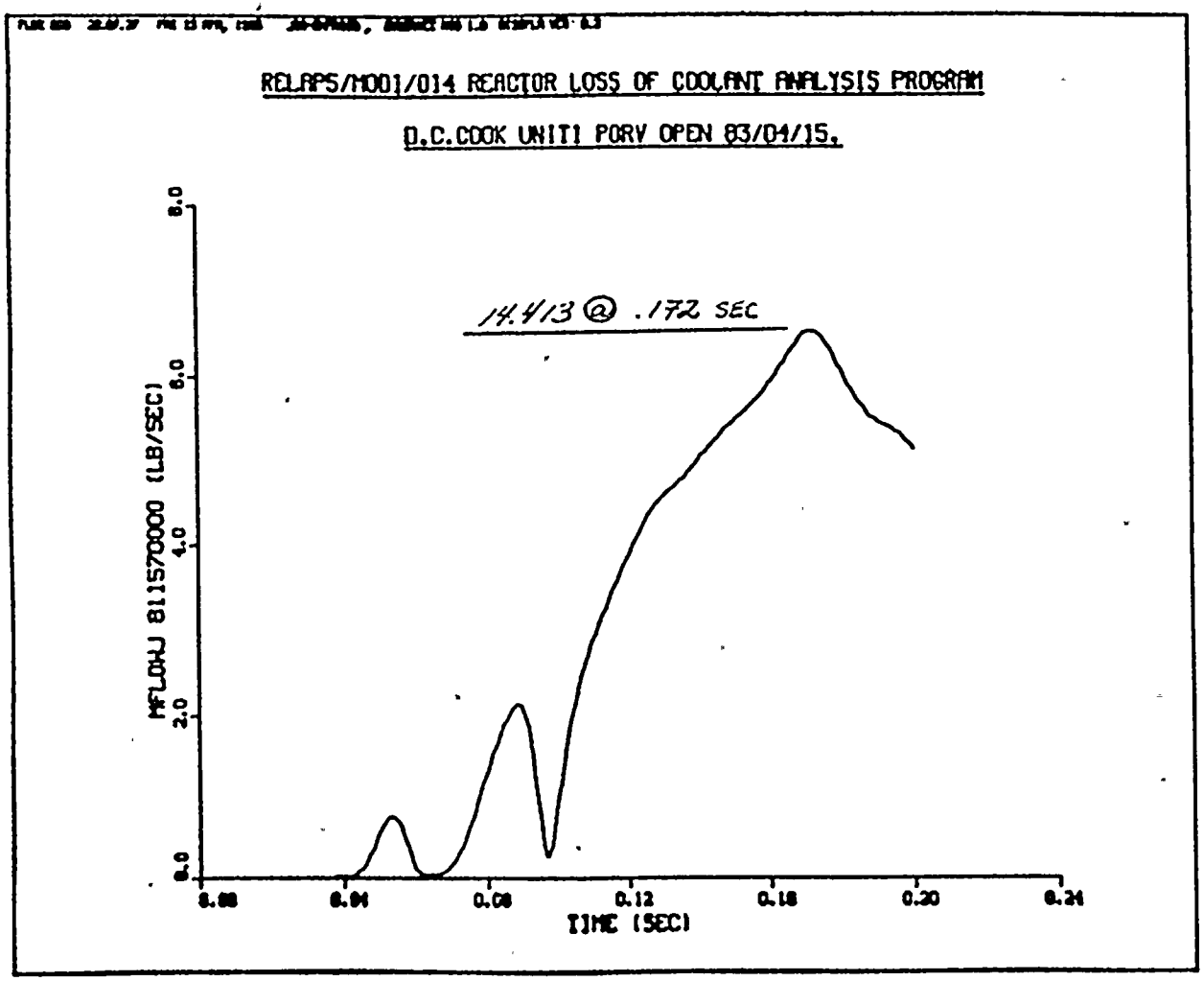
Revision 0



BY CHM DATE 4-29-83
CHKD. BY KTG DATE 4-29-83

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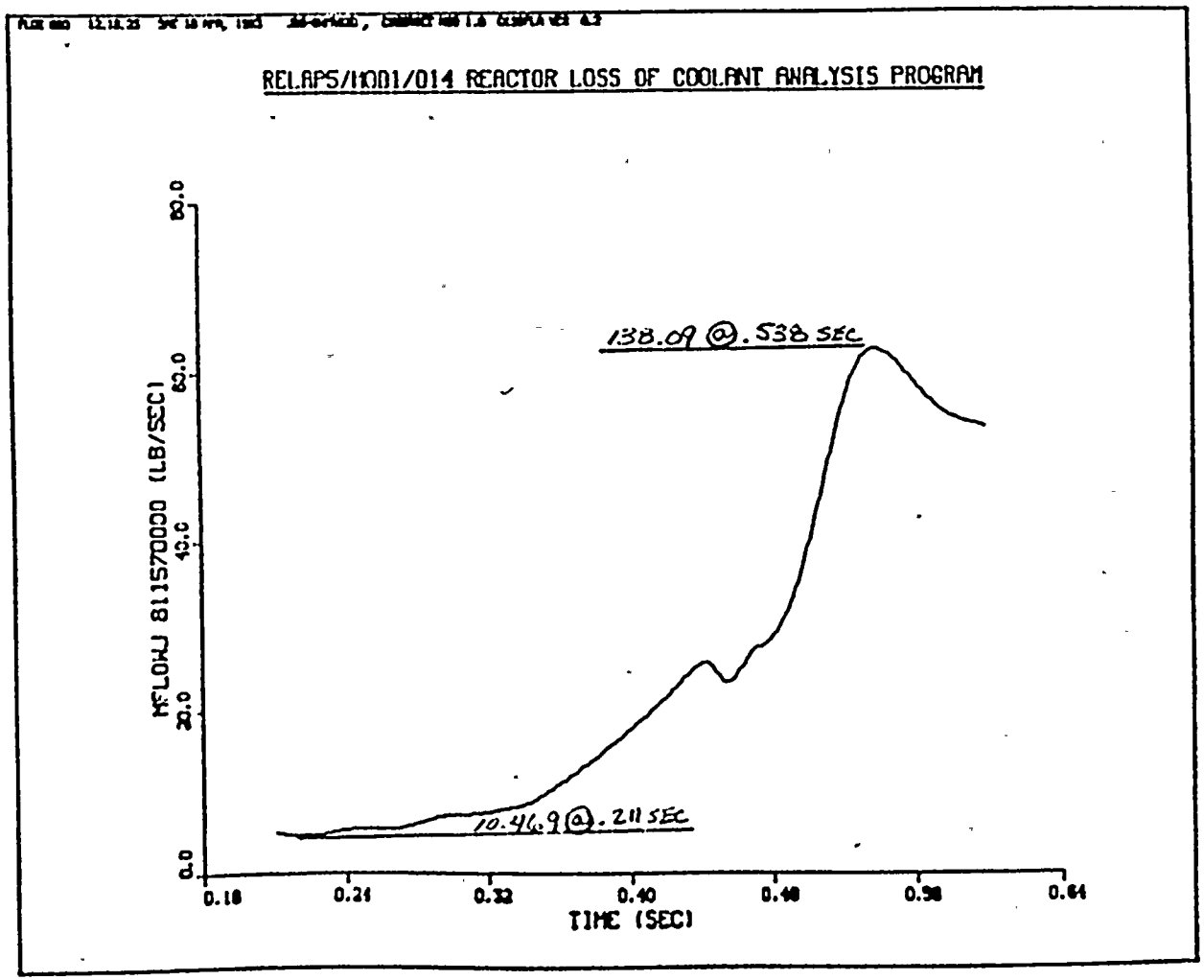
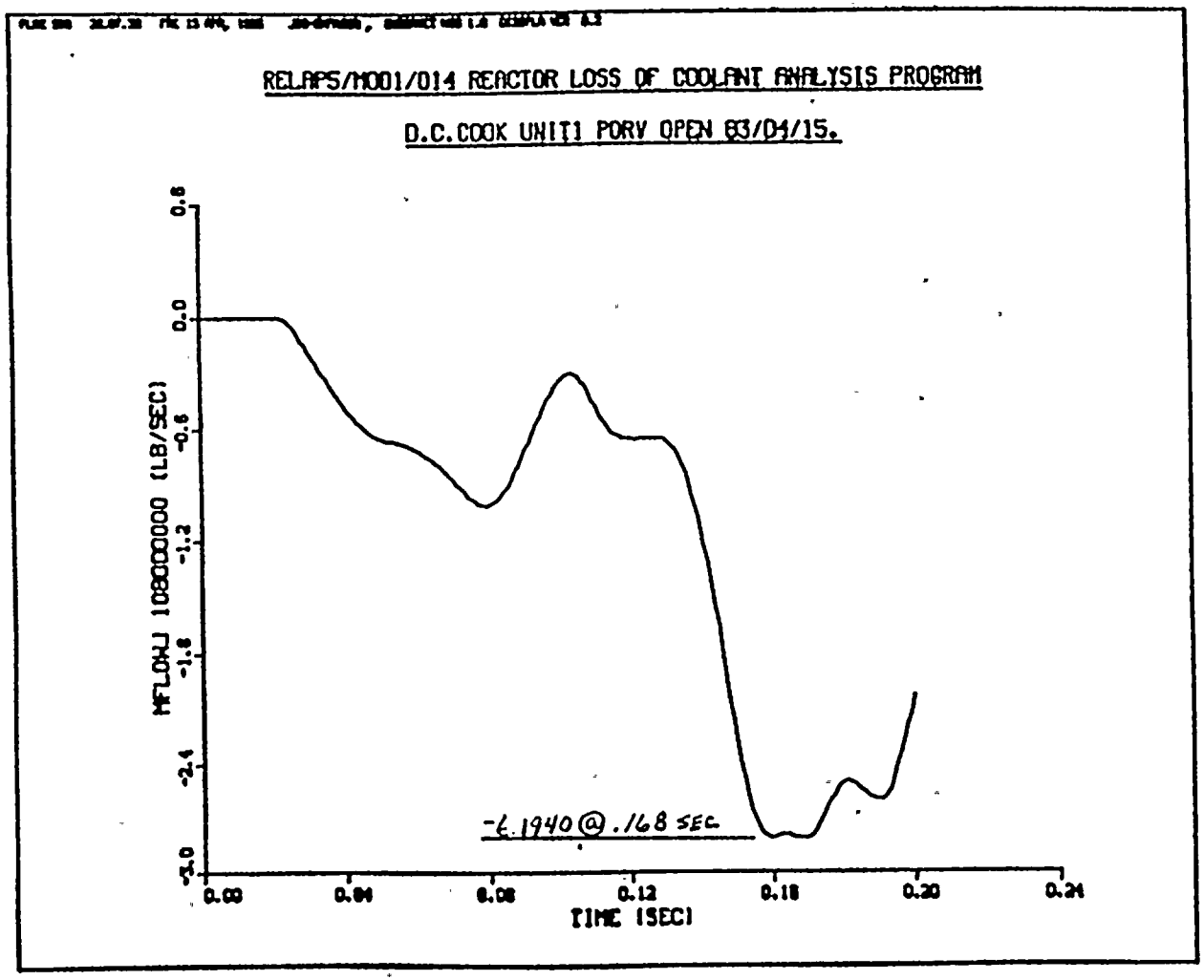
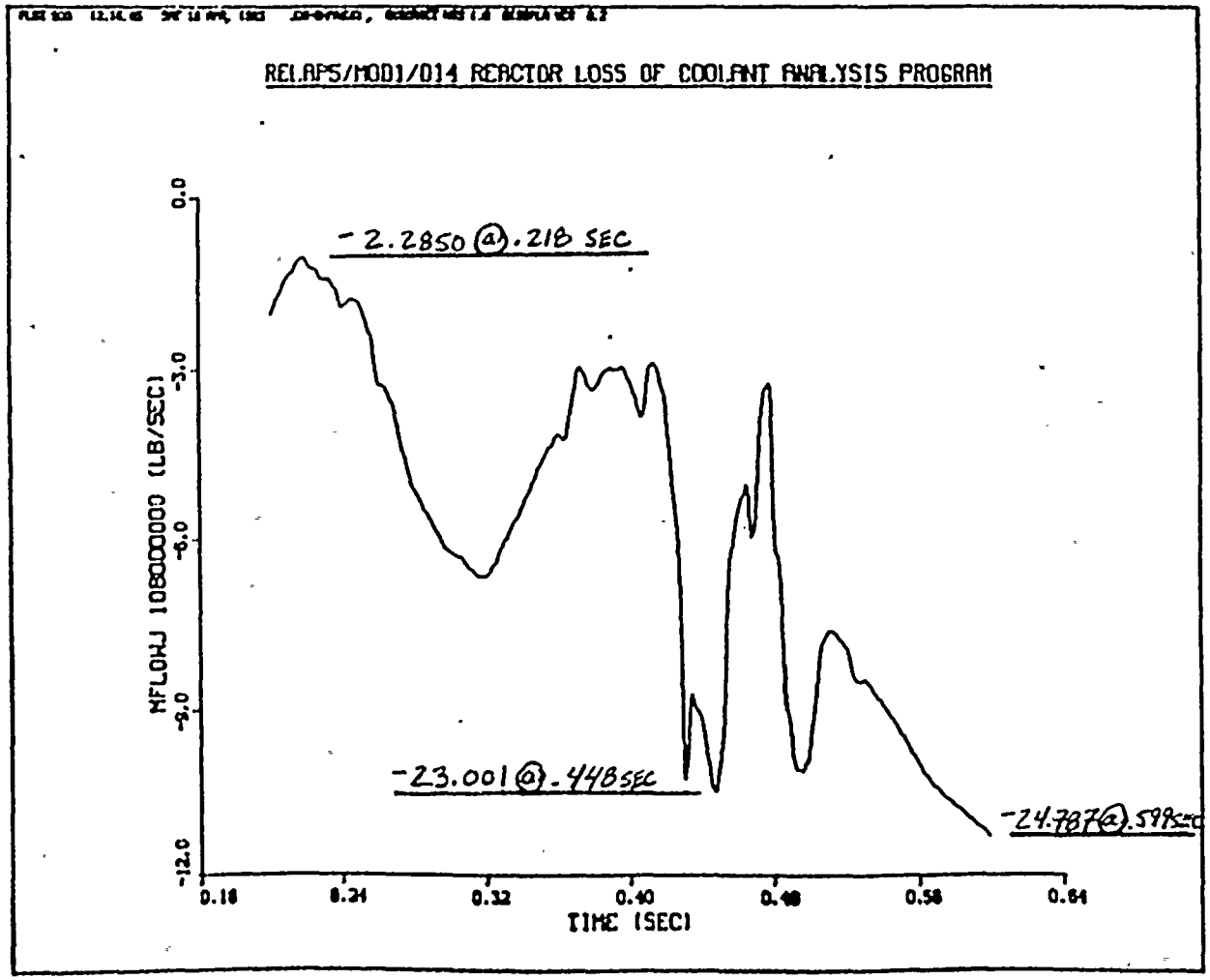
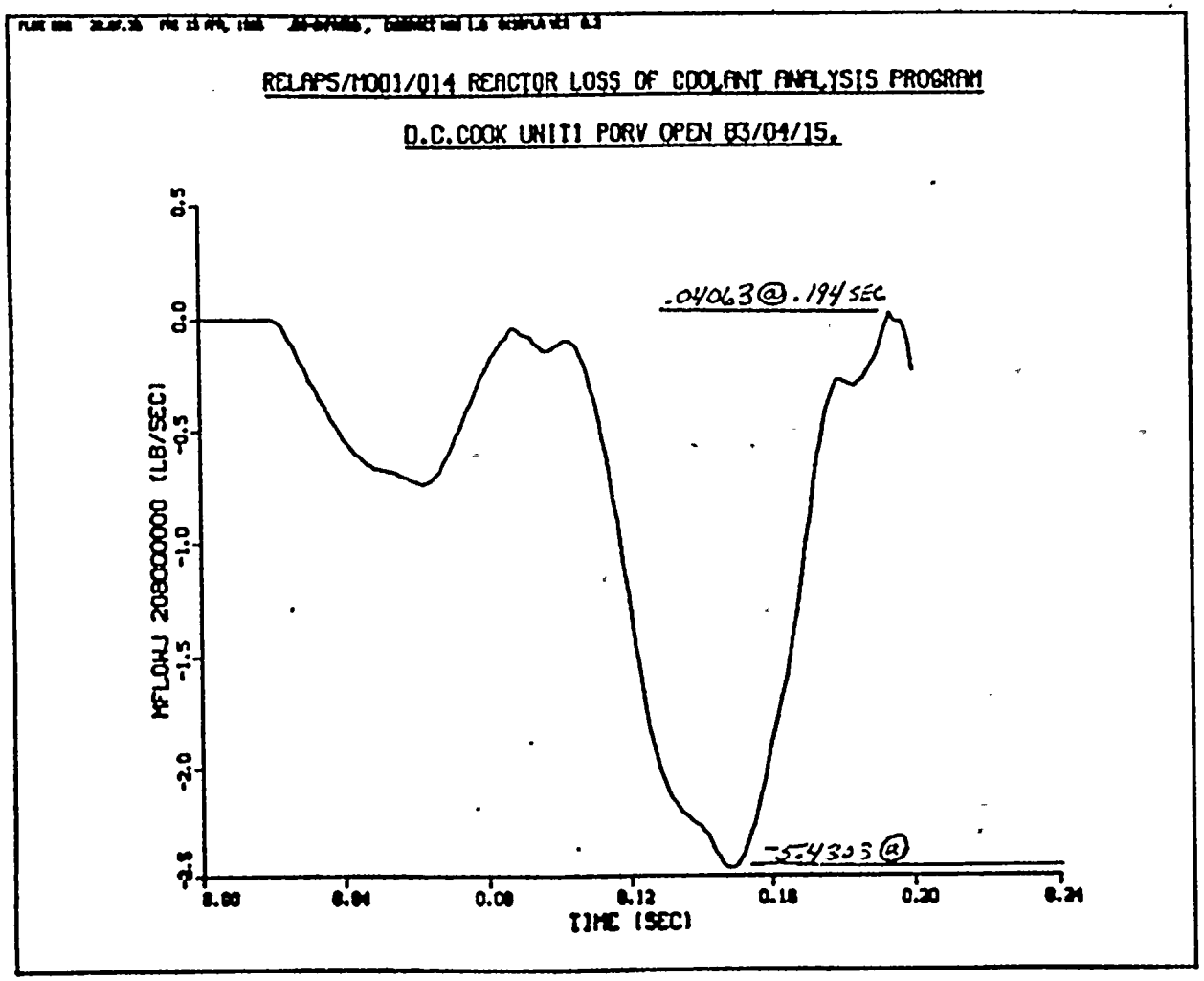


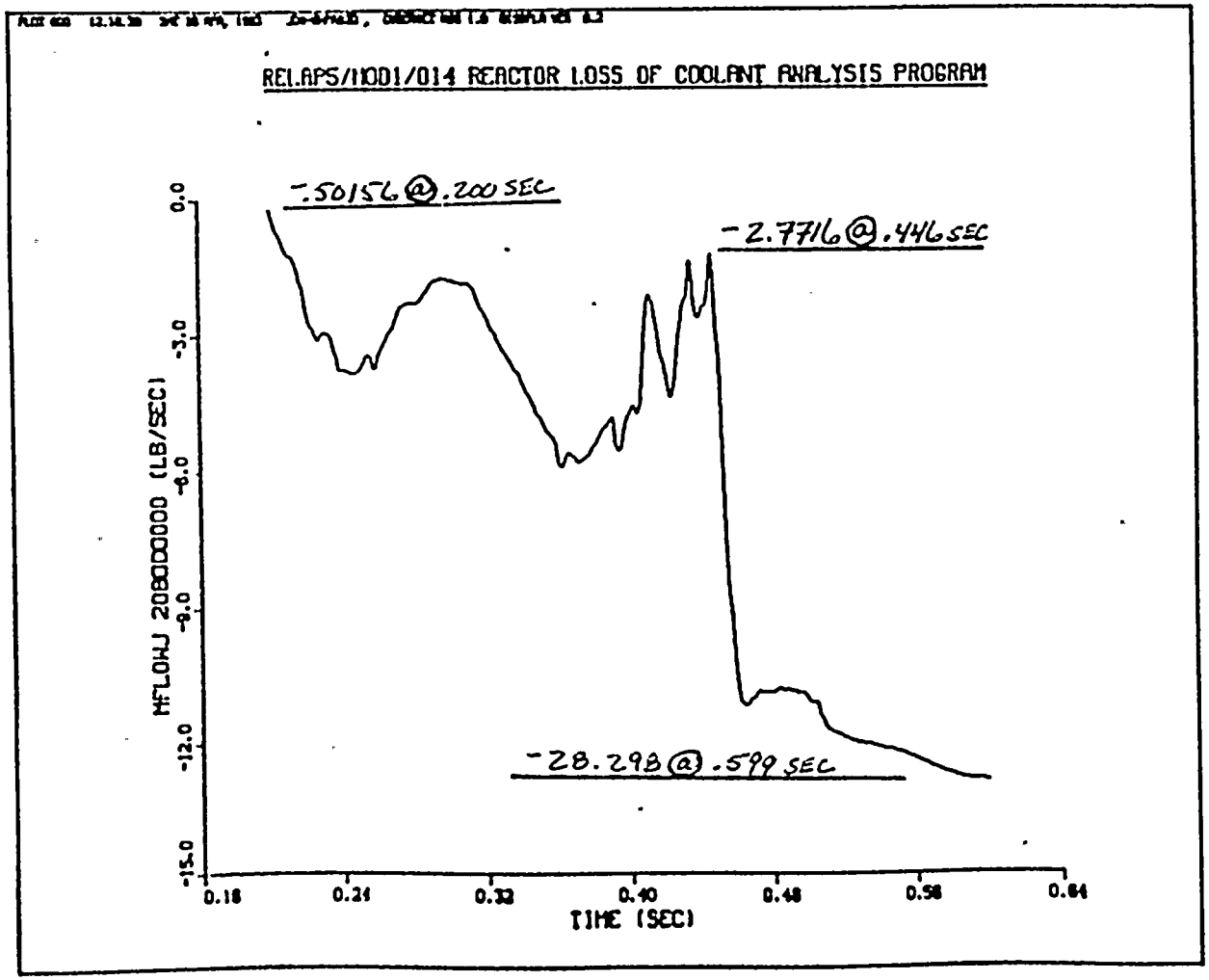

RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/15.
MFLOWJ 108000000 (LB/SEC)
0.8
0.0
-0.8
-1.6
-2.4
-3.0
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)
-6.1940 @ .168 SEC

BY CHM DATE 4-29-83
CHKD. BY KKG DATE 4-29-83

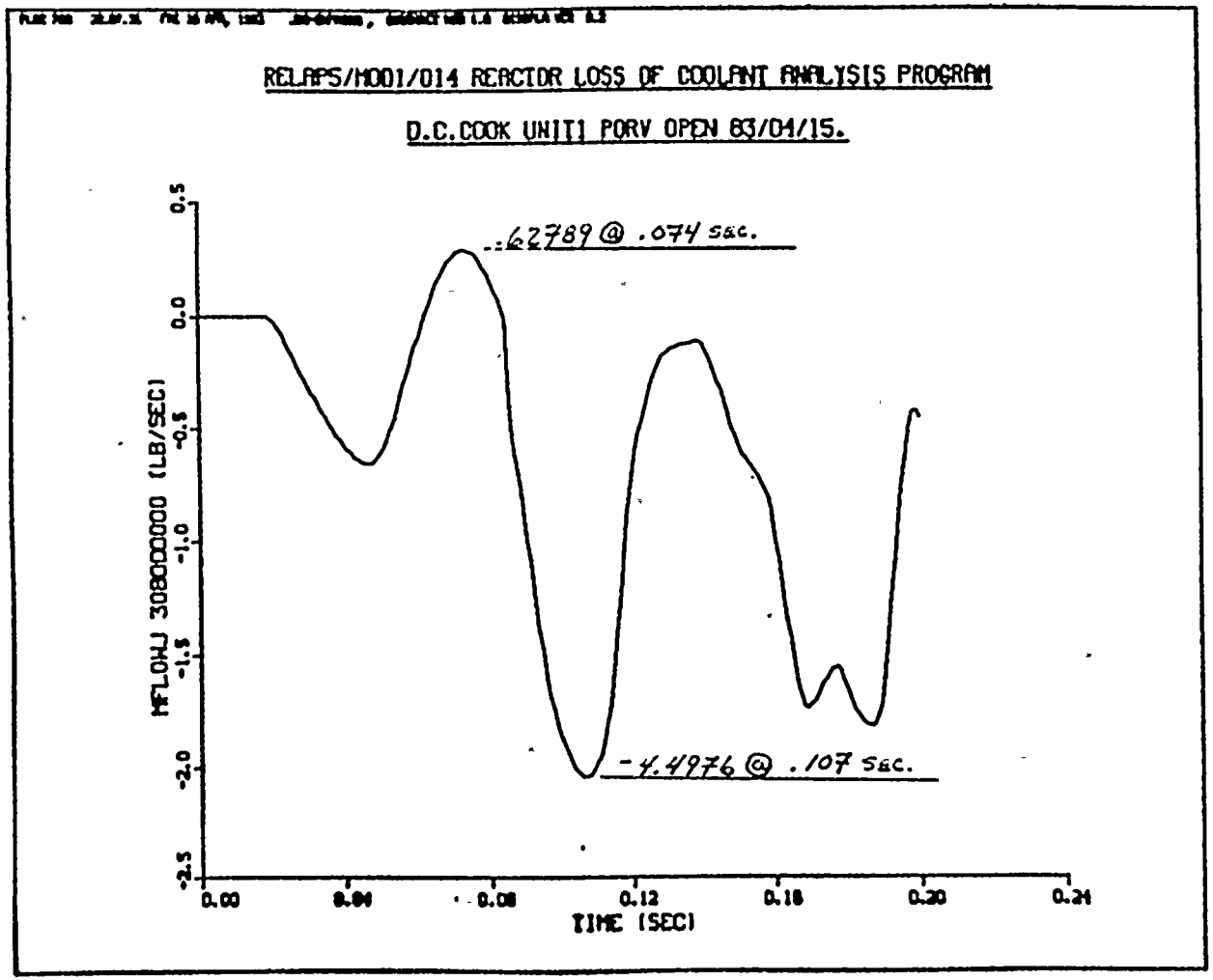



RELAPS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/15.
.04063@.194 SEC
-5.4303@
MFLOWJ 208000000 (LB/SEC)
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)

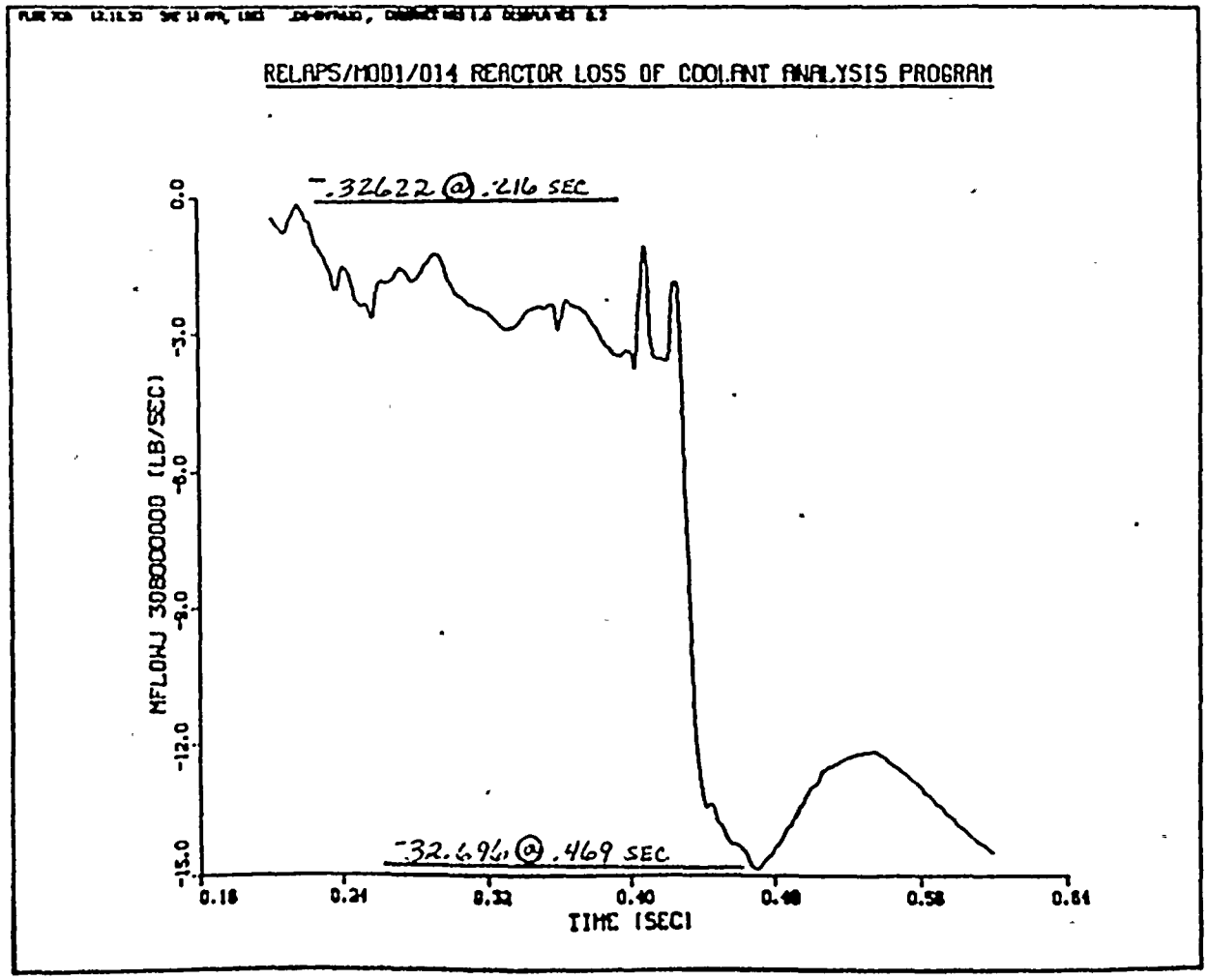
BY CHM DATE 4-29-83
CHKD. BY KTG DATE 4-29-83



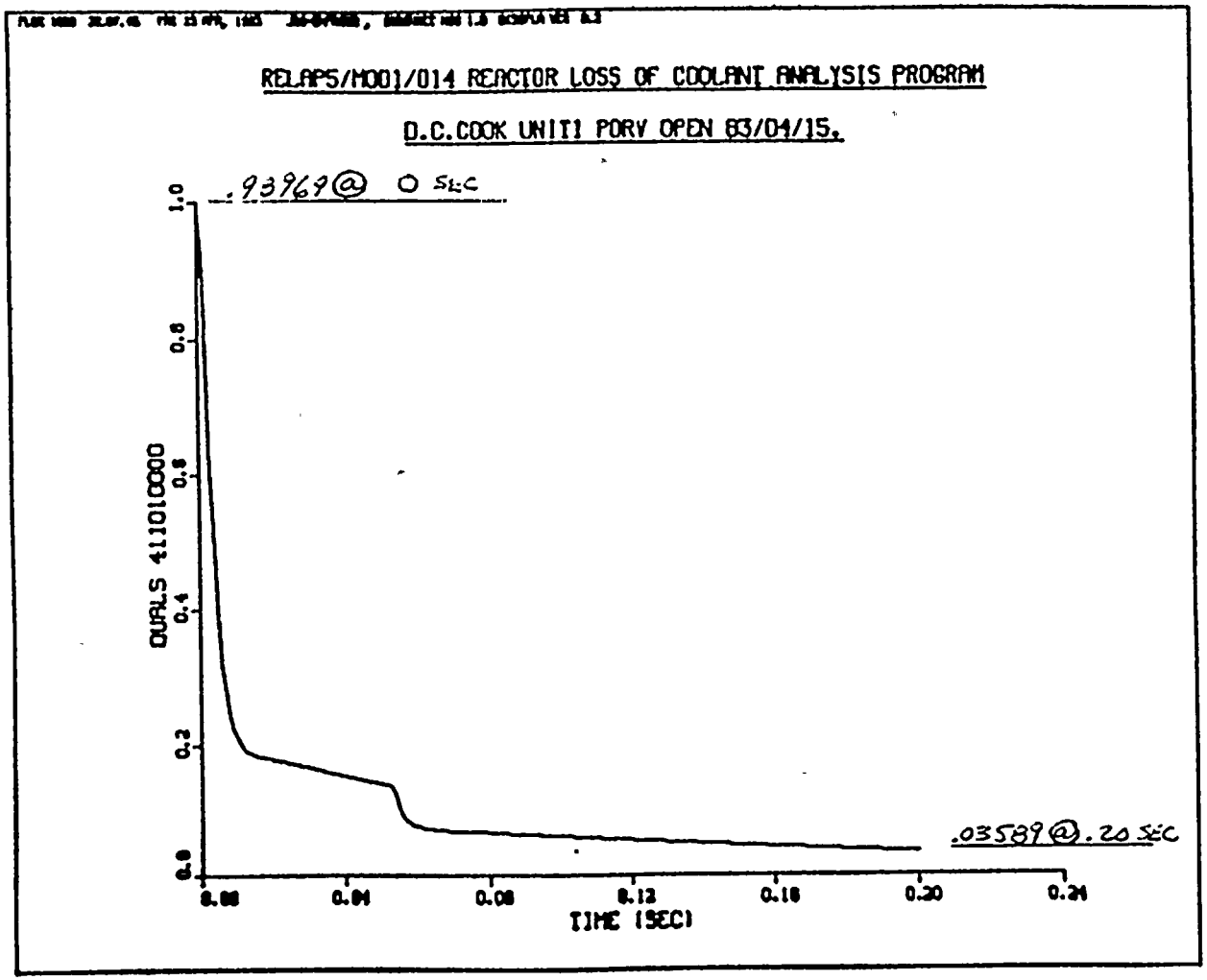
BY CMM DATE 4-29-83
CHKD. BY KKG DATE 4-27-83



BY CMM DATE 4-29-83
CHKD. BY KG DATE 4-27-83



BY UHM DATE 11-29-83
CHKD. BY JBK DATE 4-29-87



BY CHM DATE 4-29-83
CHKD. BY KTG DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

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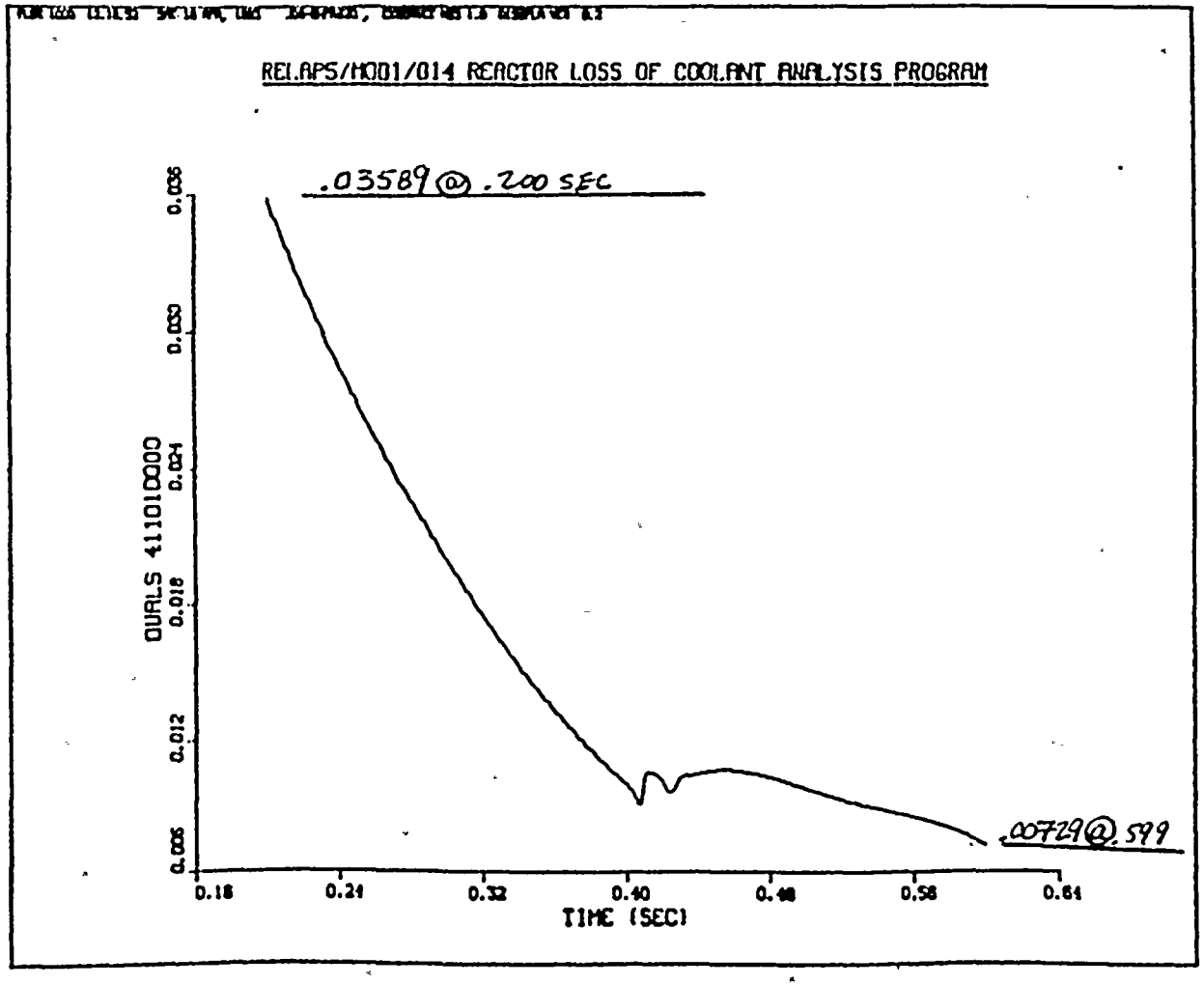
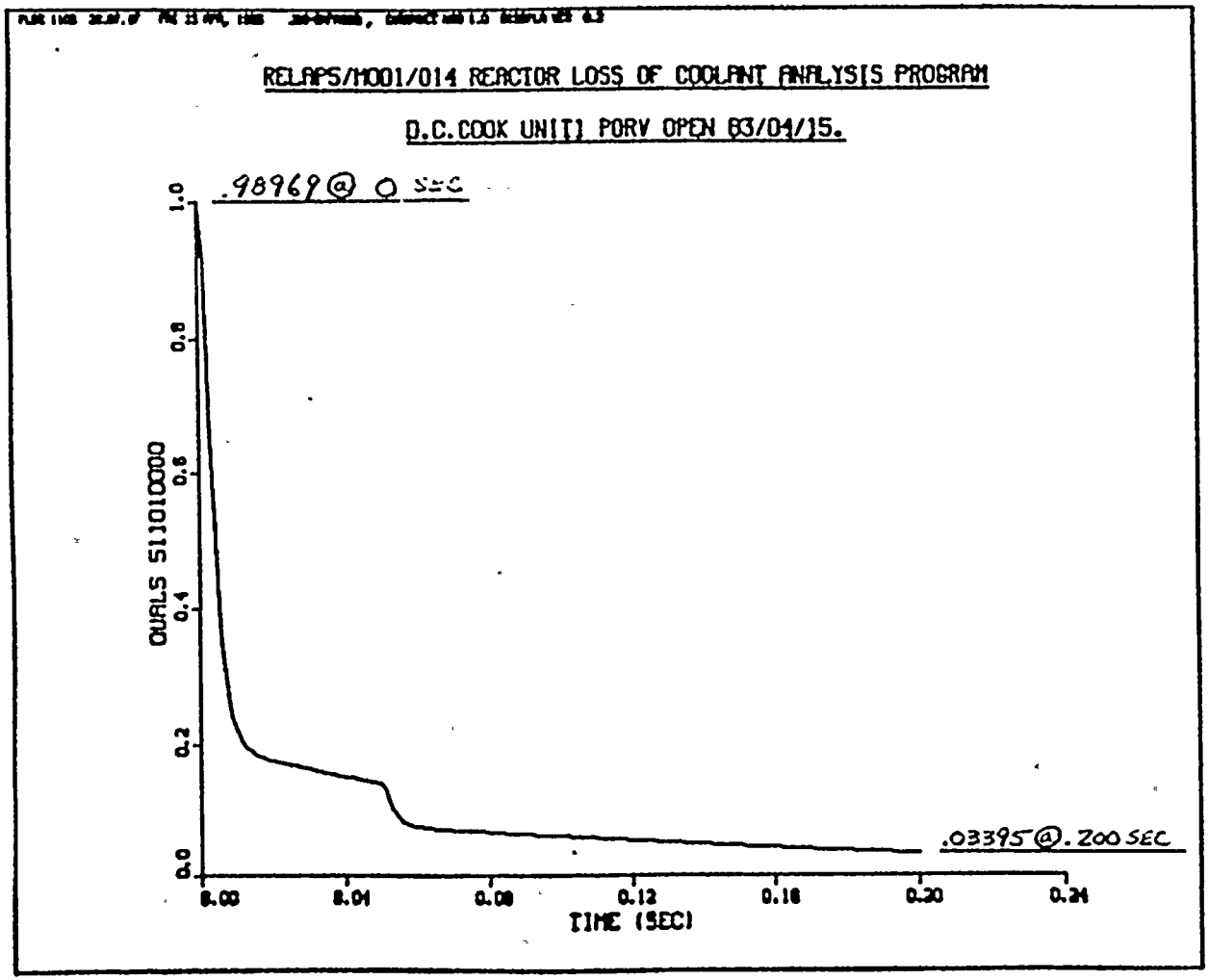
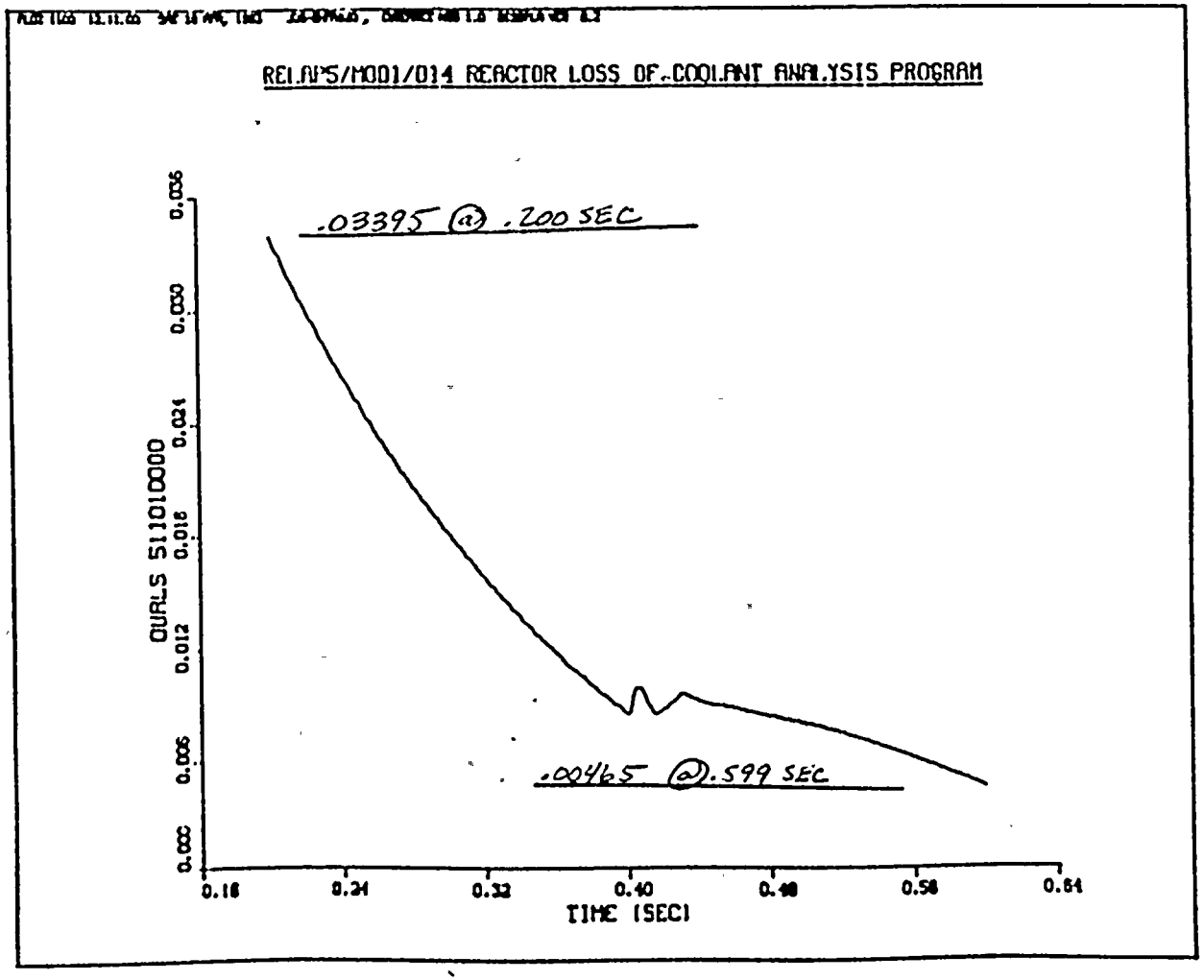


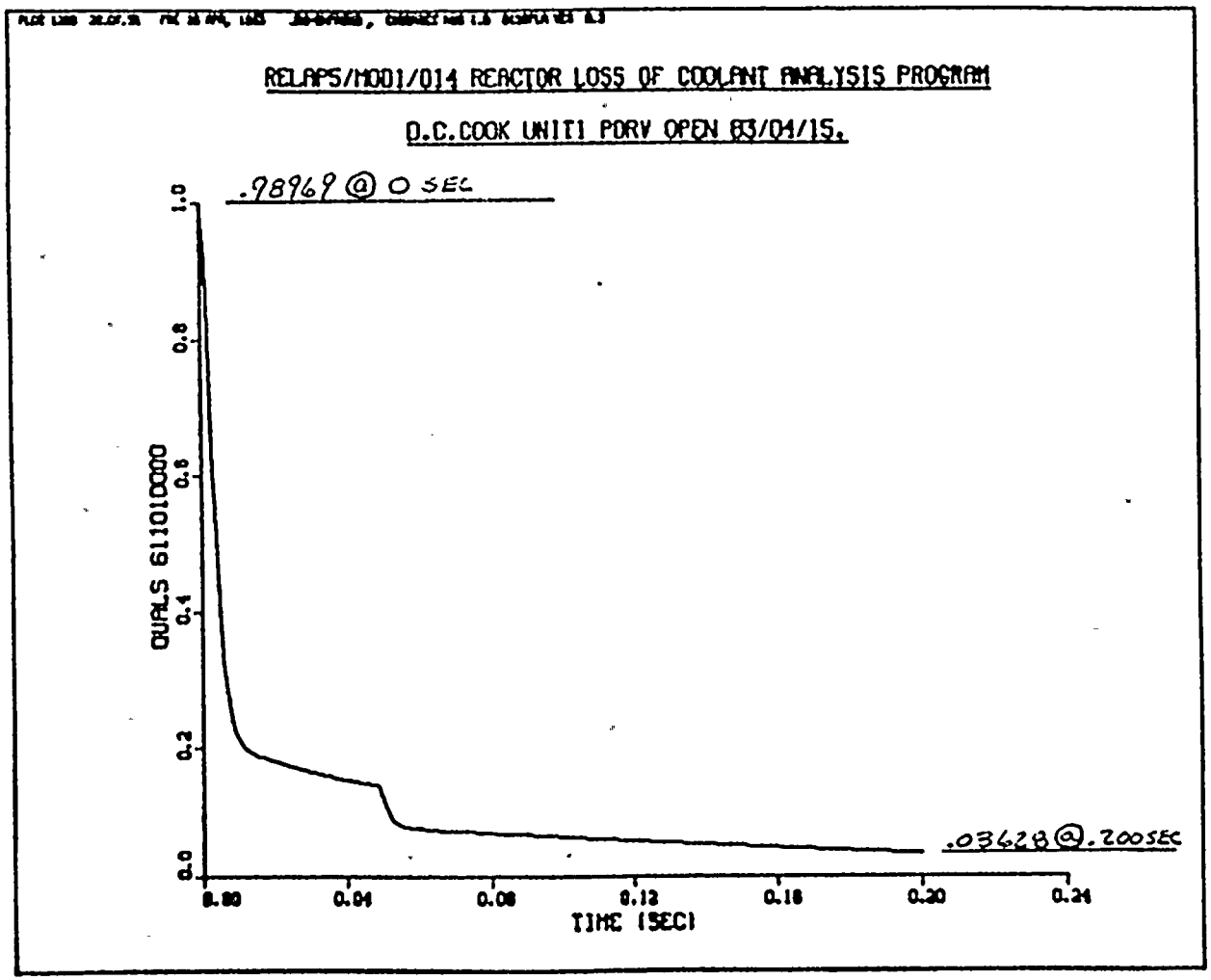
BY UHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83



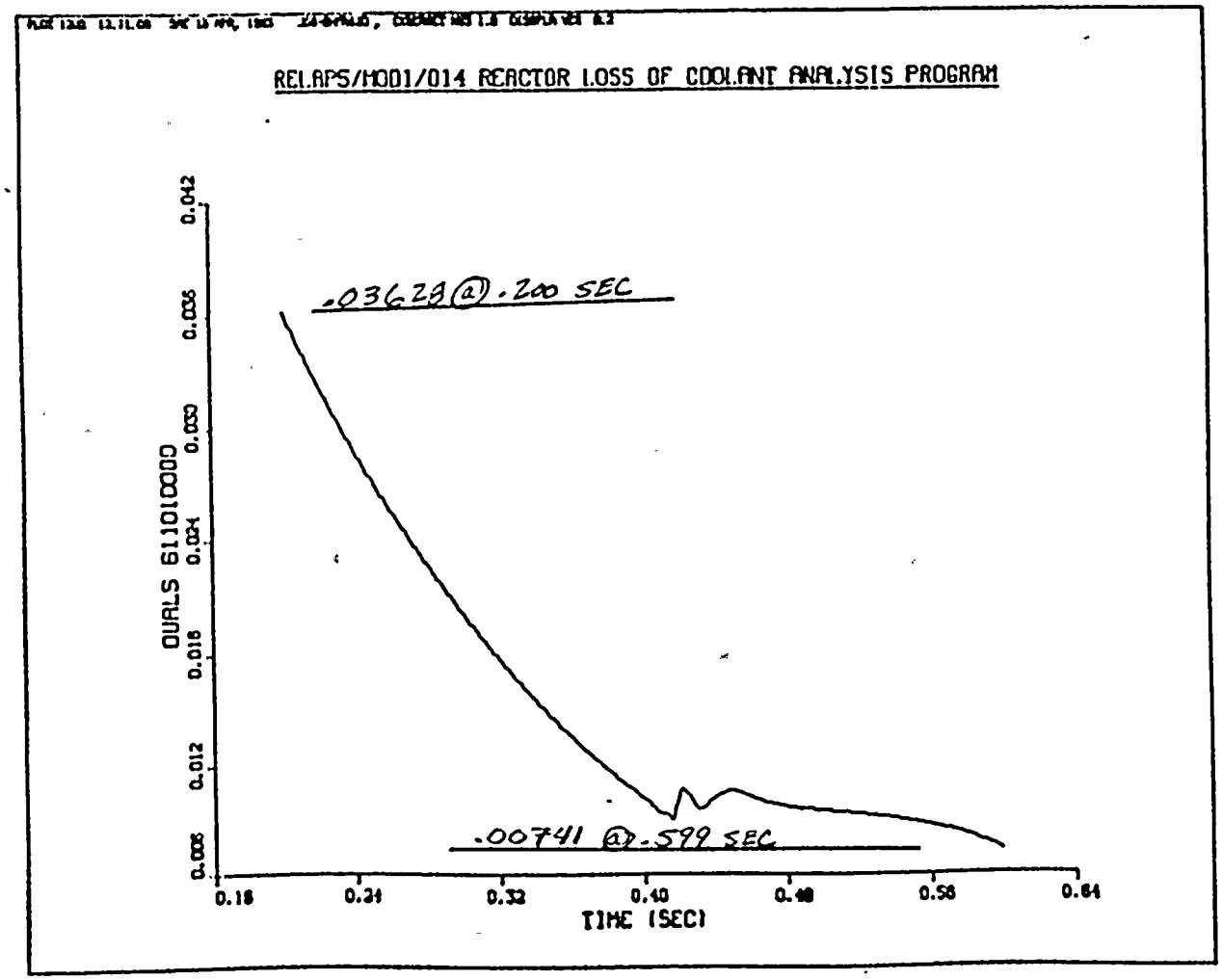
BY CHM DATE 4-29-83
CHKD. BY KTC DATE 4-29-83



BY JHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83



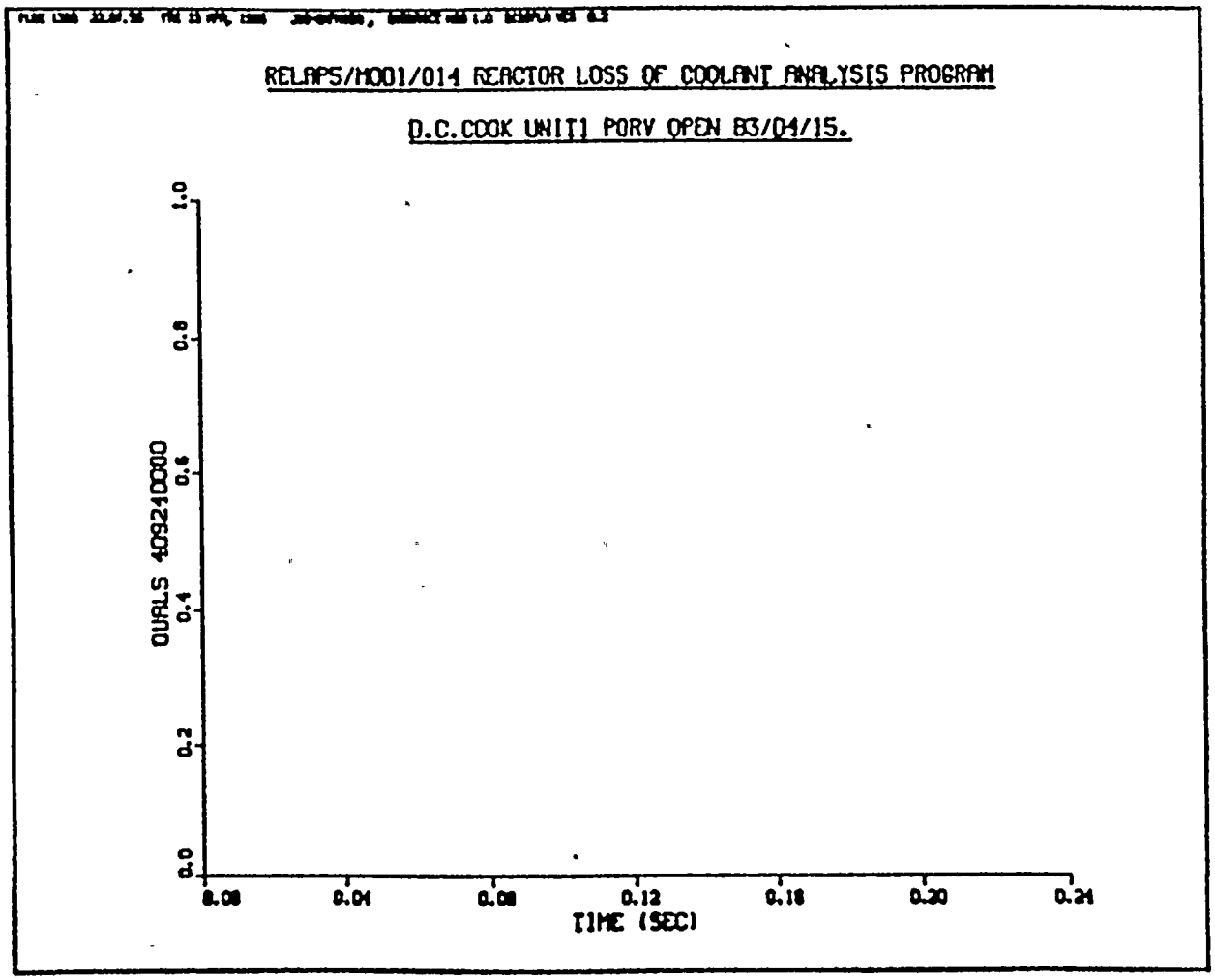
BY CHM DATE 4-29-83
CHKD. BY KTG DATE 4-27-83



BY UHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

Technical Report
TR-5364-1
Revision 0



BY CHM DATE 4-29-83
CHKD. BY KG DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

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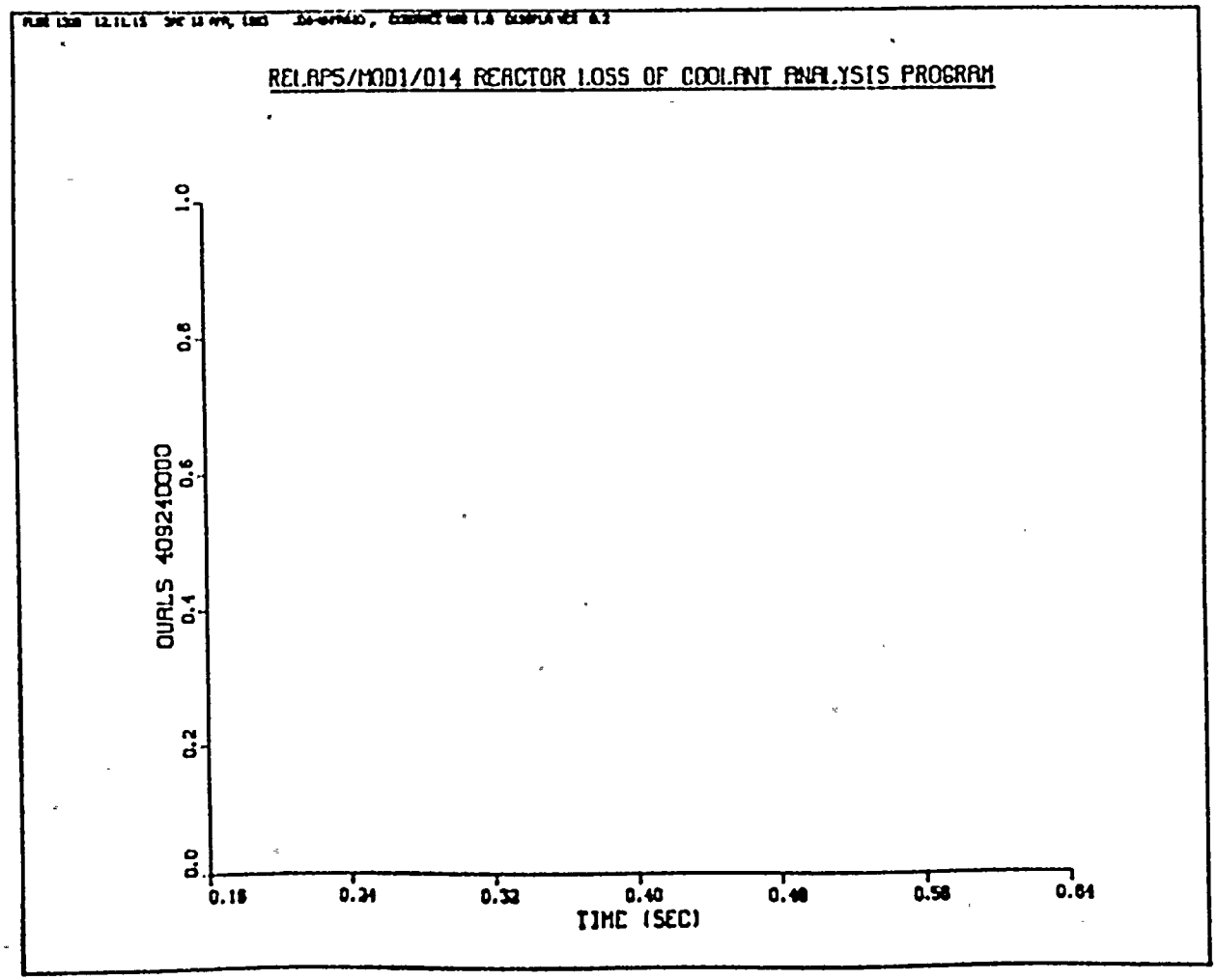

BY UHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-87

TELEDYNE ENGINEERING SERVICES

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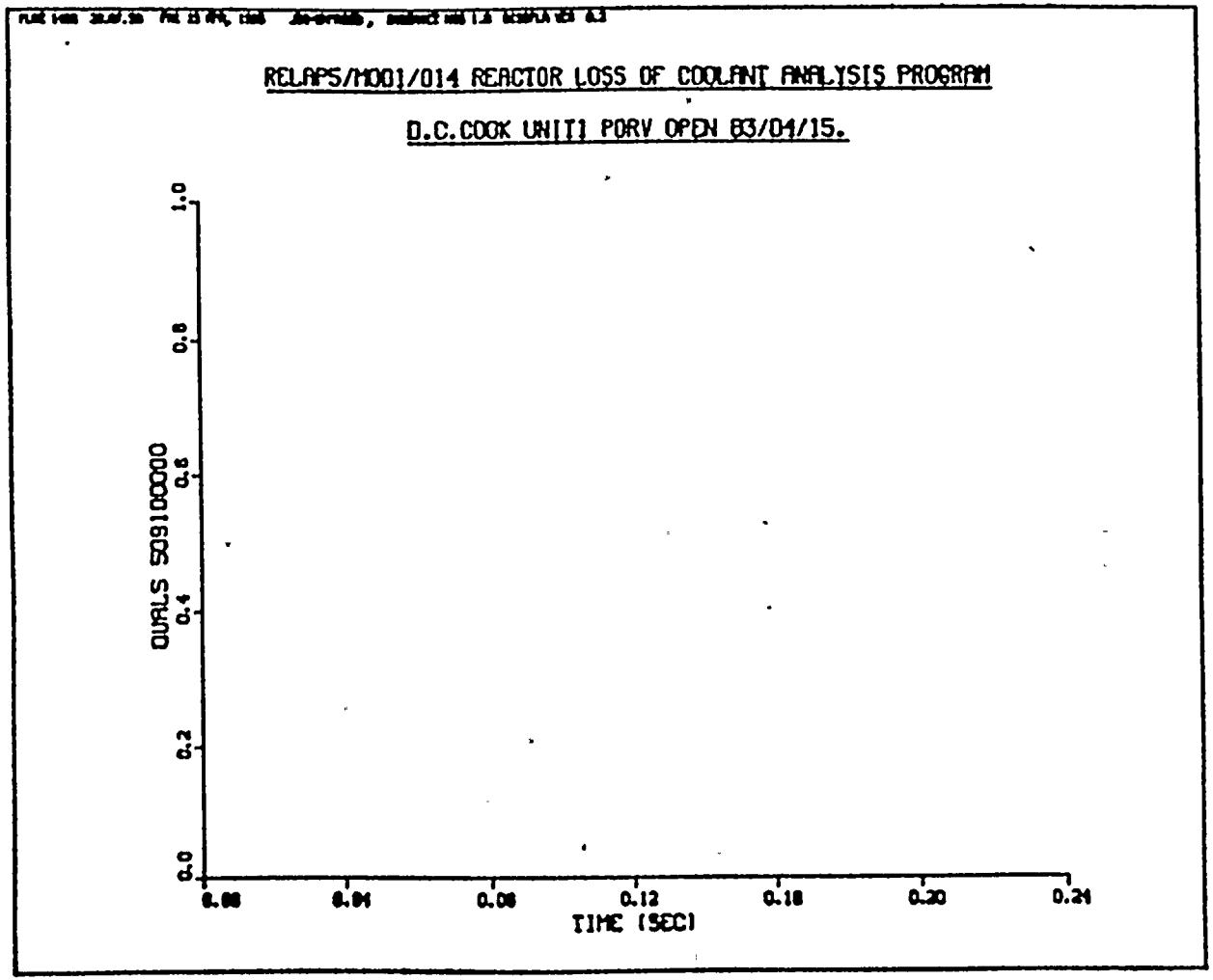

BY CMM DATE 4-29-83
CHKD. BY KTG DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

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TR-5364-1
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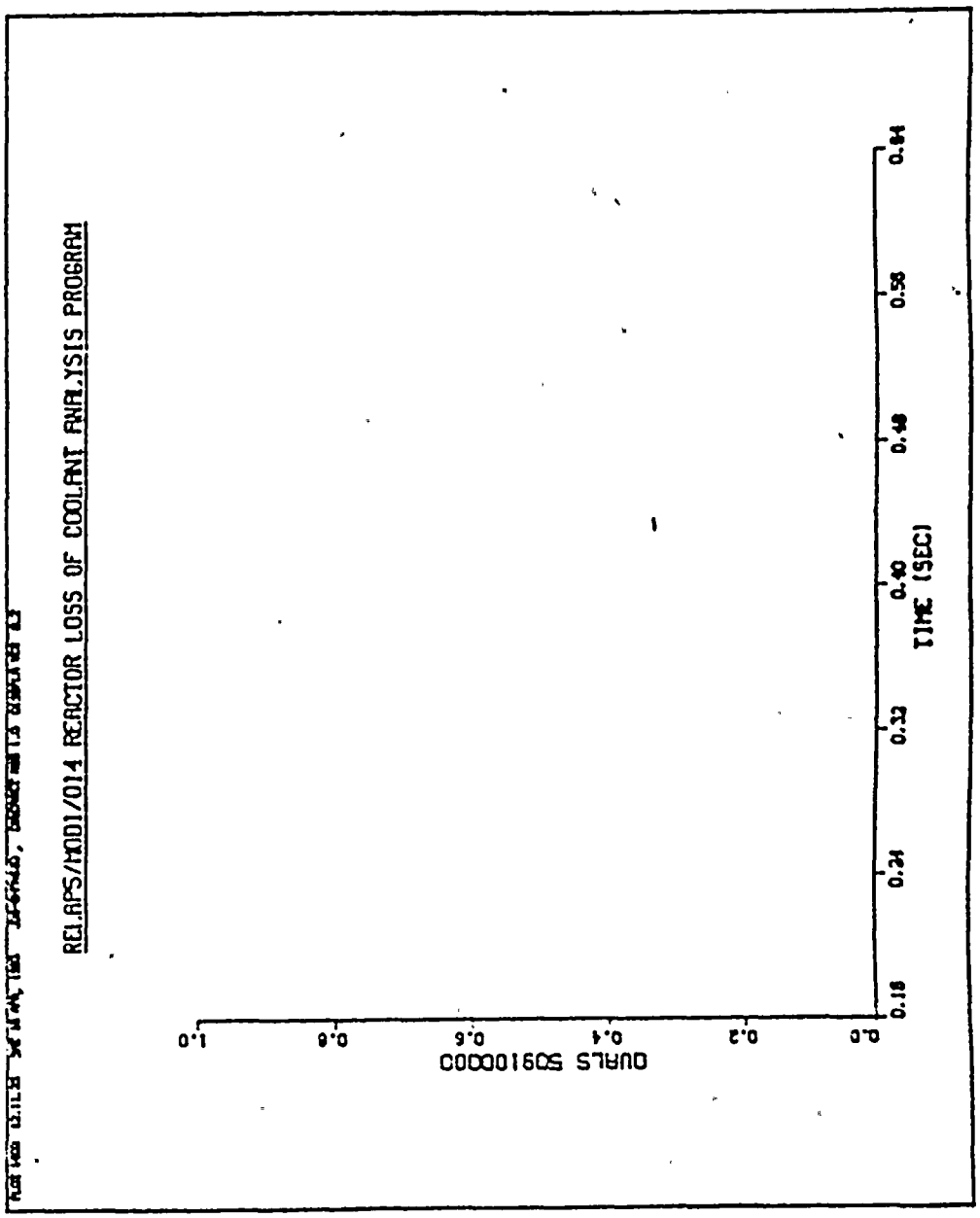

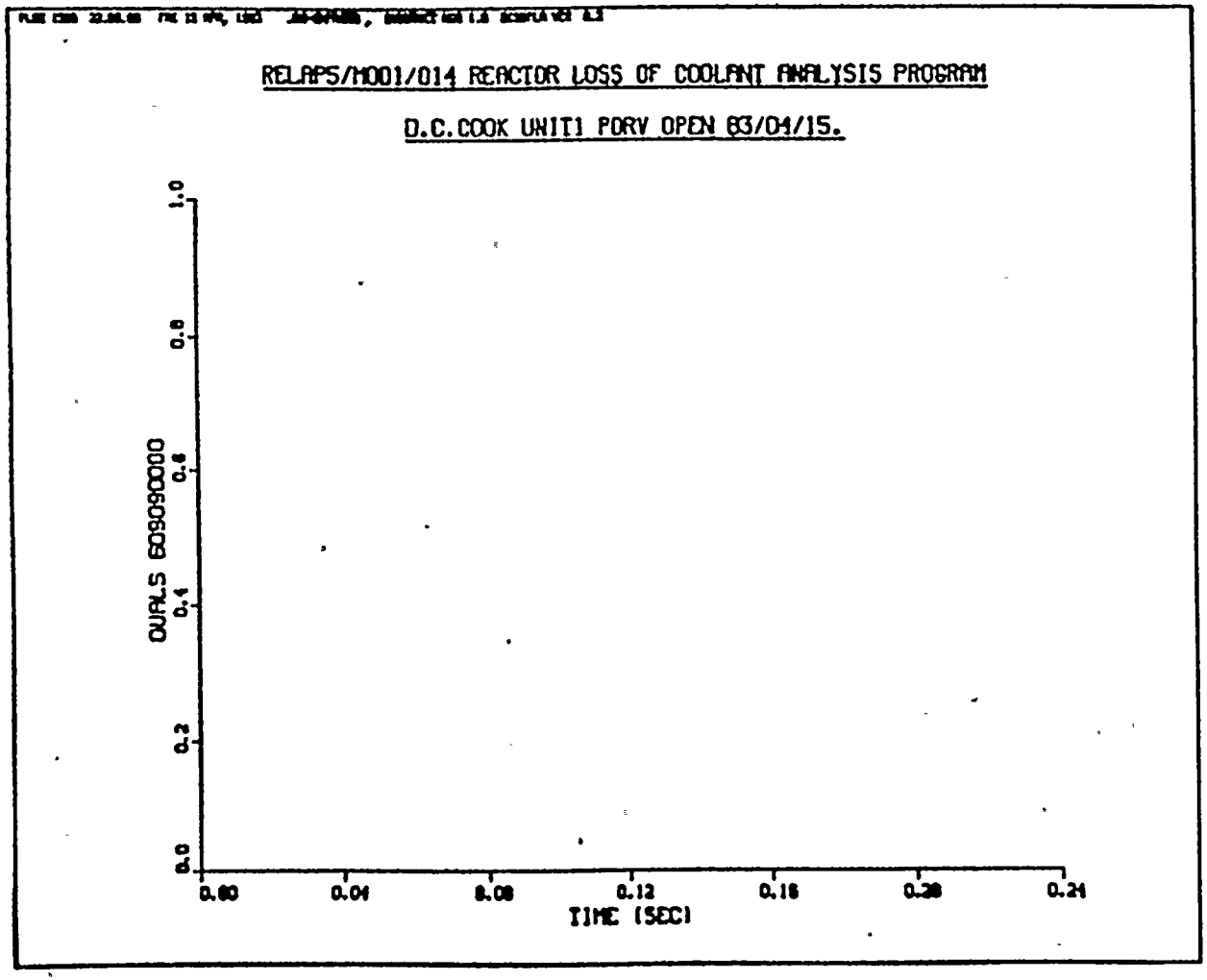
RELAP5/M001/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/15.
QUALS 60909000
1.0
0.8
0.6
0.4
0.2
0.0
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)

BY CMM DATE 4-29-83
CHKD. BY KJG DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

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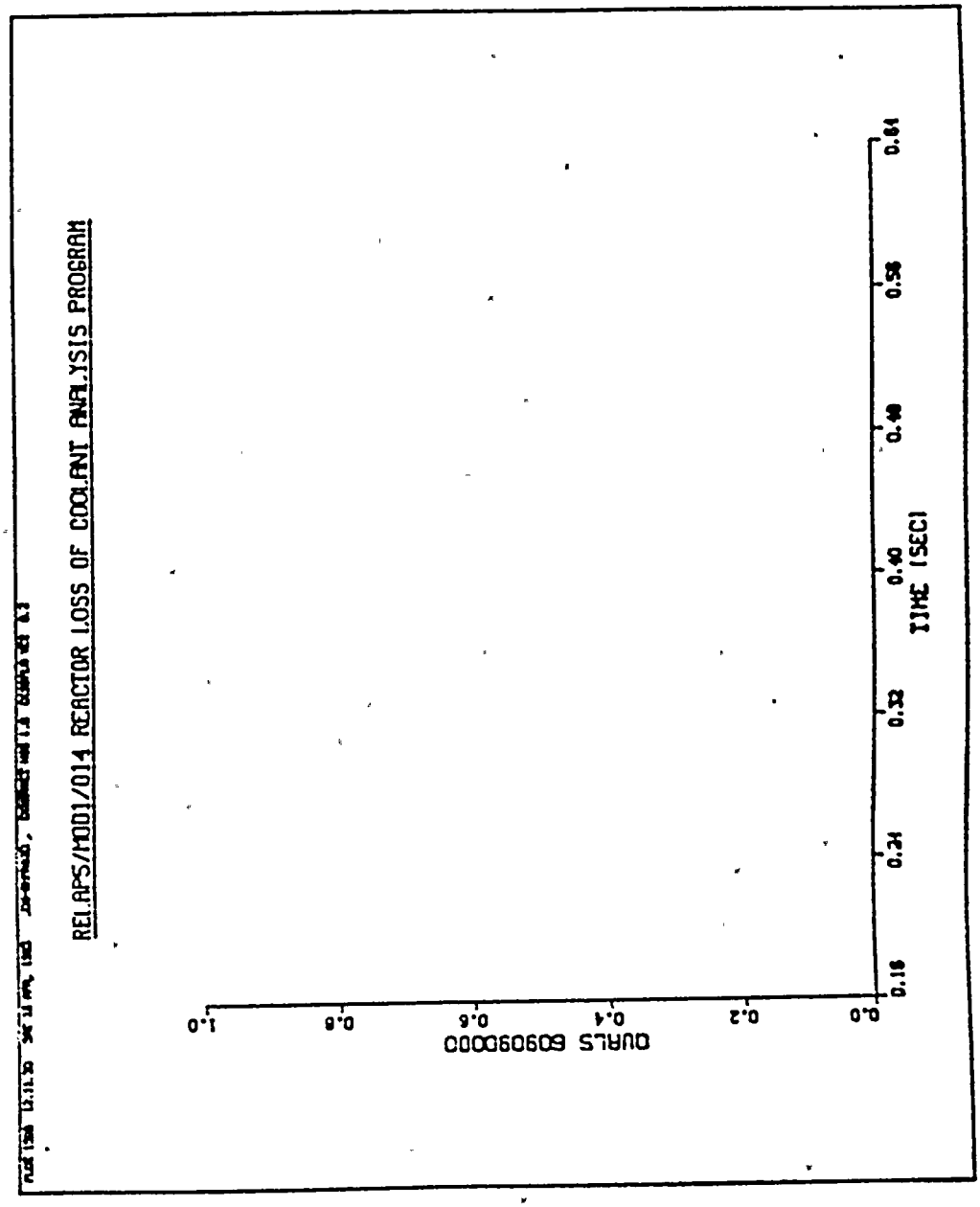

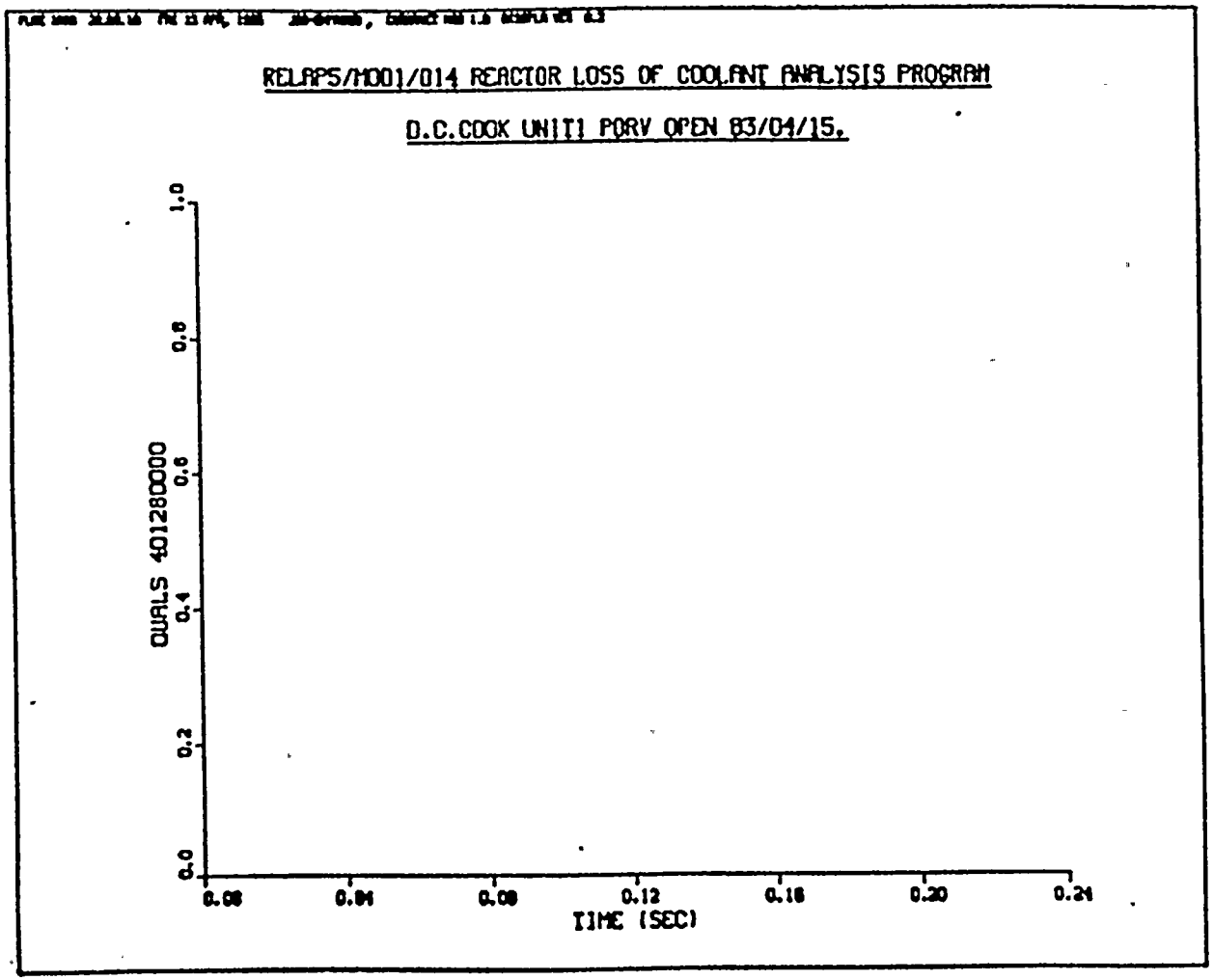
RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/15.
QUALS 401280000
0.0
0.2
0.4
0.6
0.8
1.0
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)

BY CHM DATE 4-29-83
CHKD. BY KIC DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

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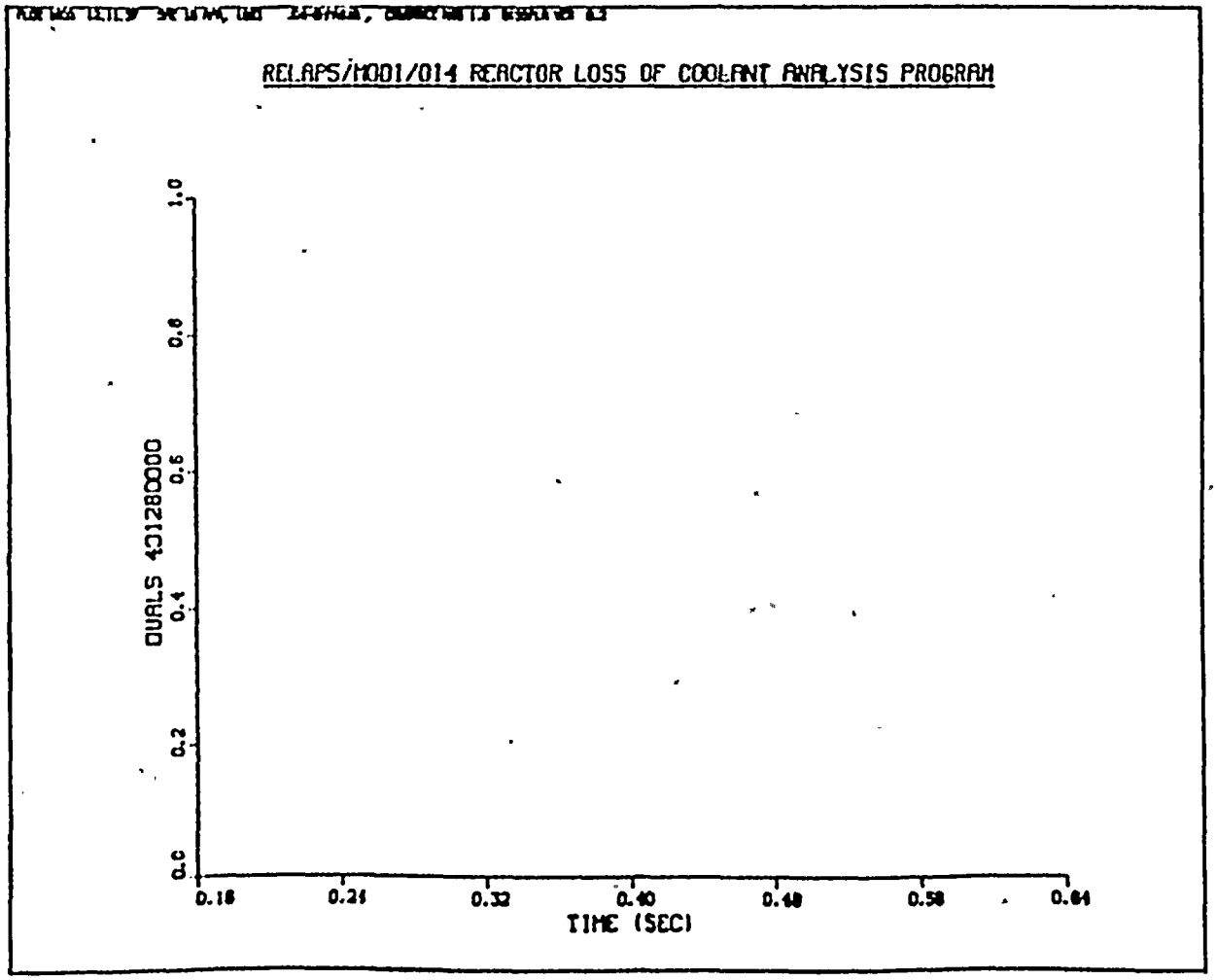

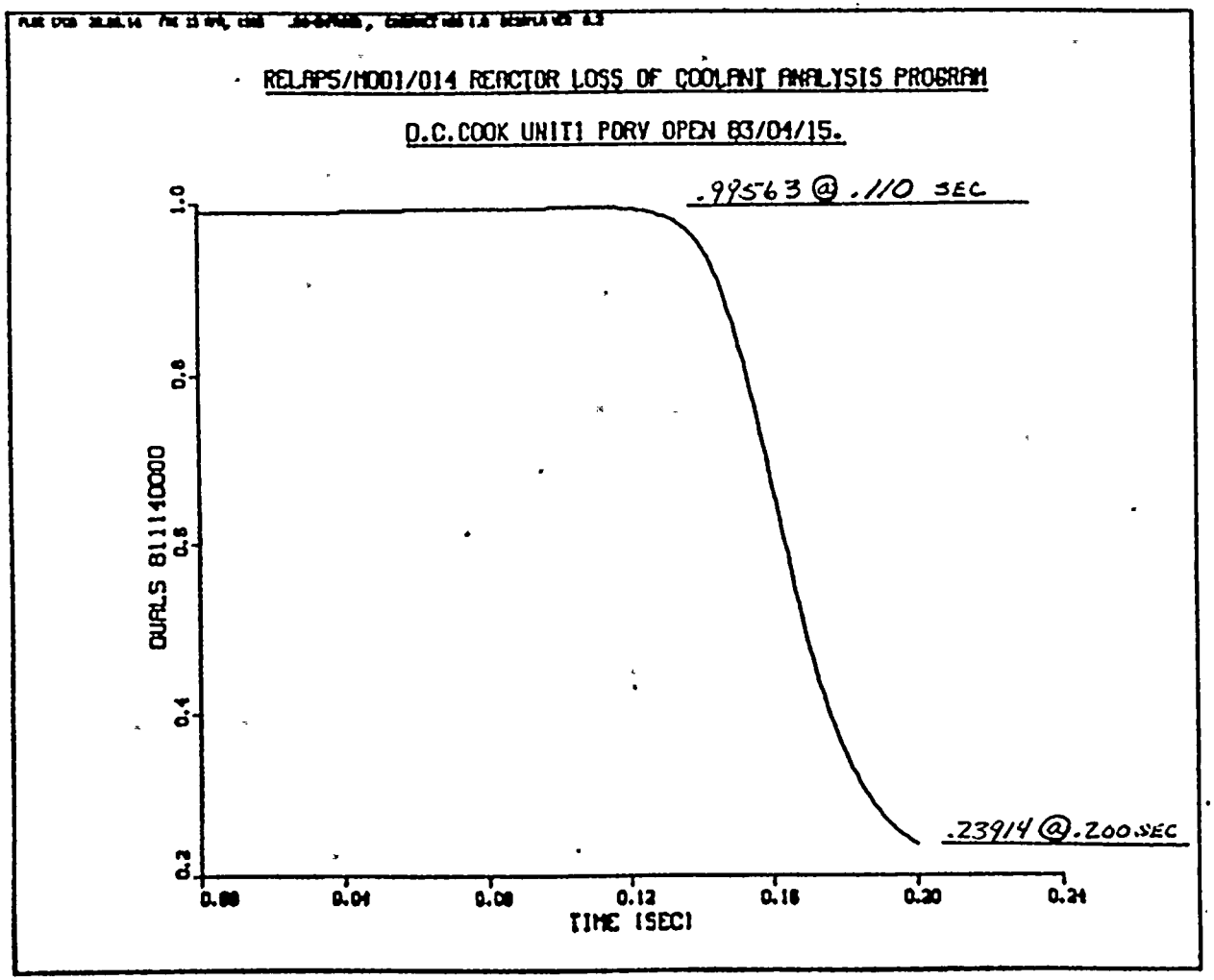
RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/15.
.99563 @ .110 SEC
.23914 @ .200 SEC
DVALS 811140000
1.0
0.8
0.6
0.4
0.2
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)

BY CHM DATE 4-29-83
CHKD. BY KJG DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

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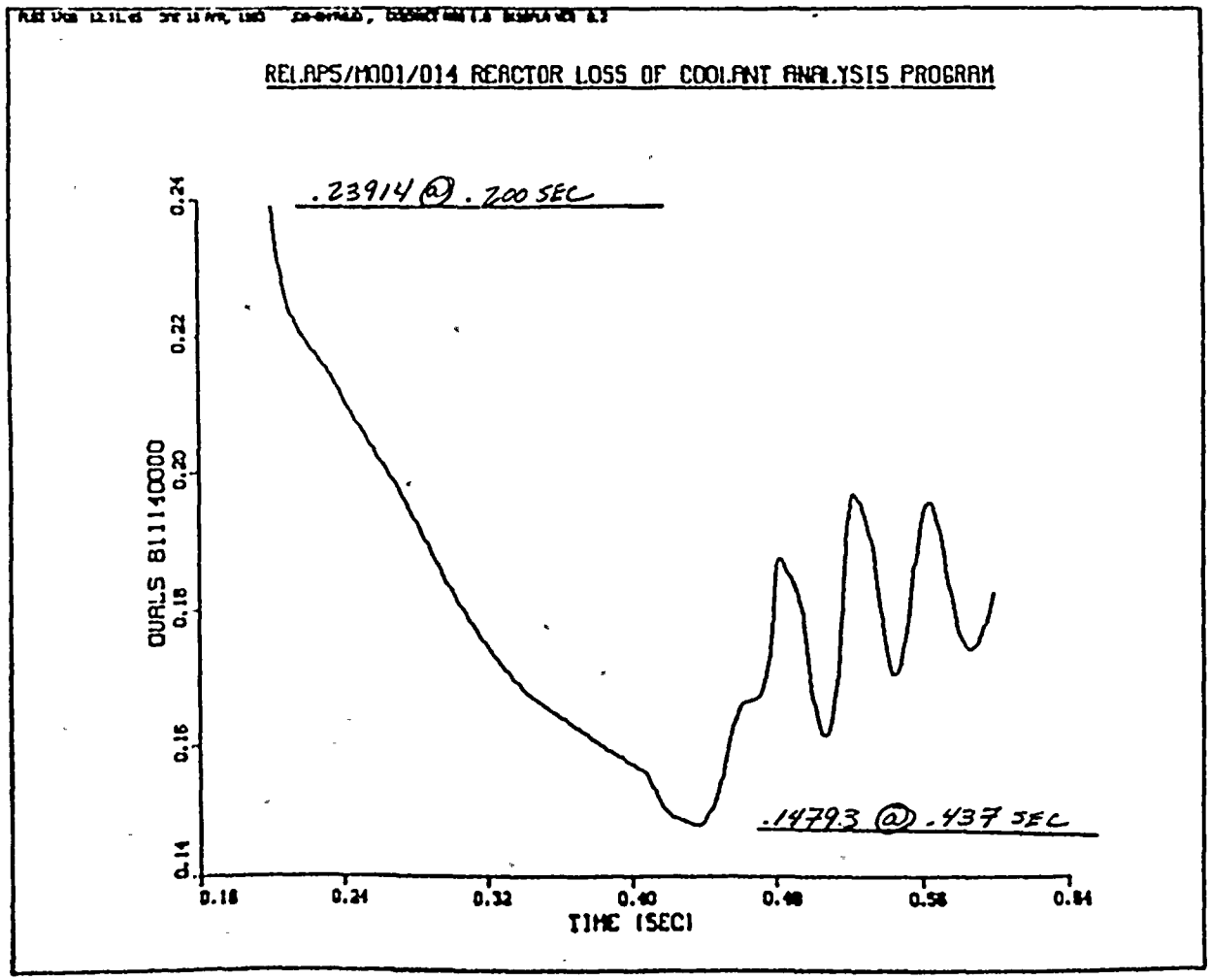
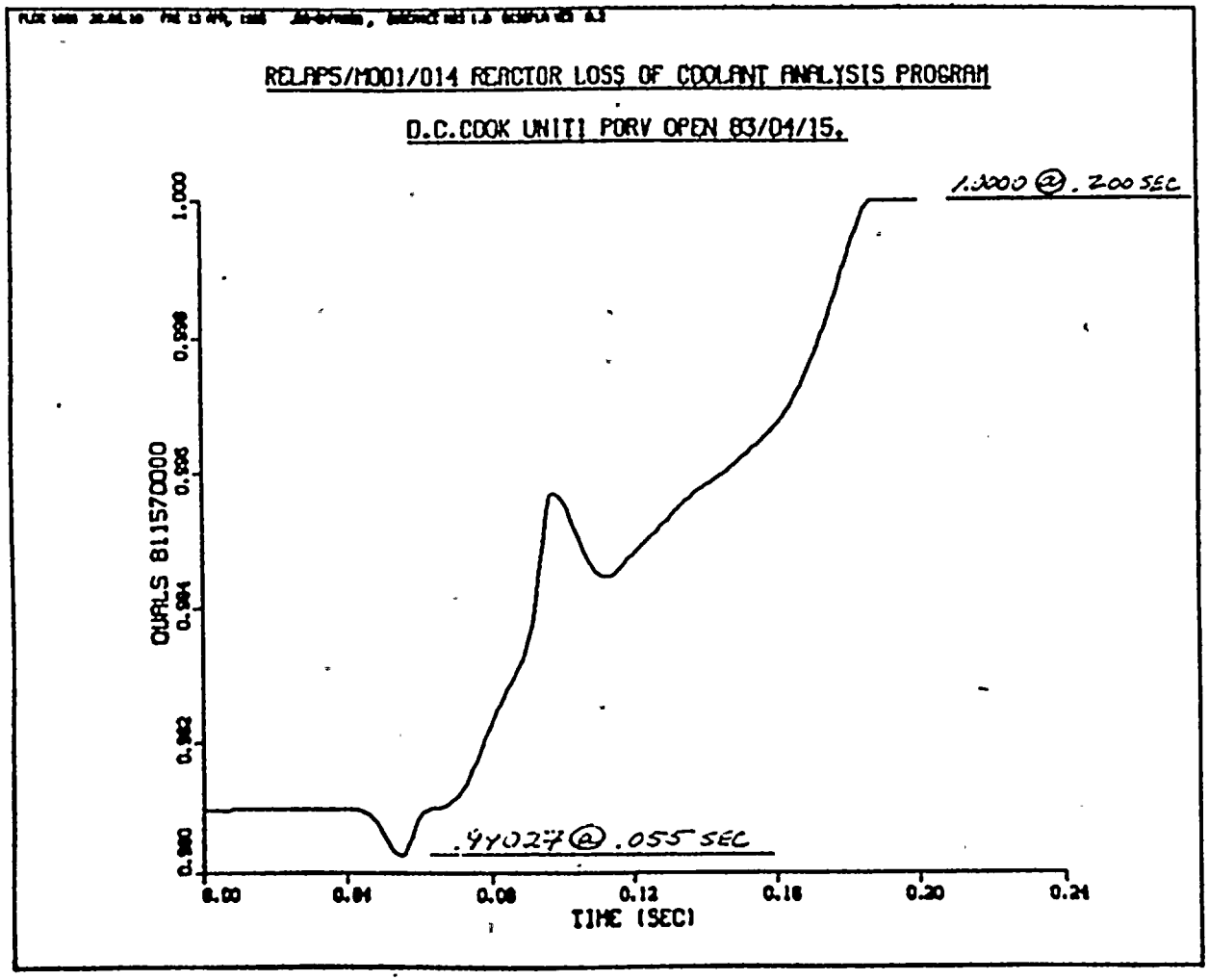
4-200



BY JHM DATE 11-29-83
CHKD. BY JBV DATE 4-29-83



BY CHM DATE 4-29-83
CHKD. BY NG DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

Technical Report
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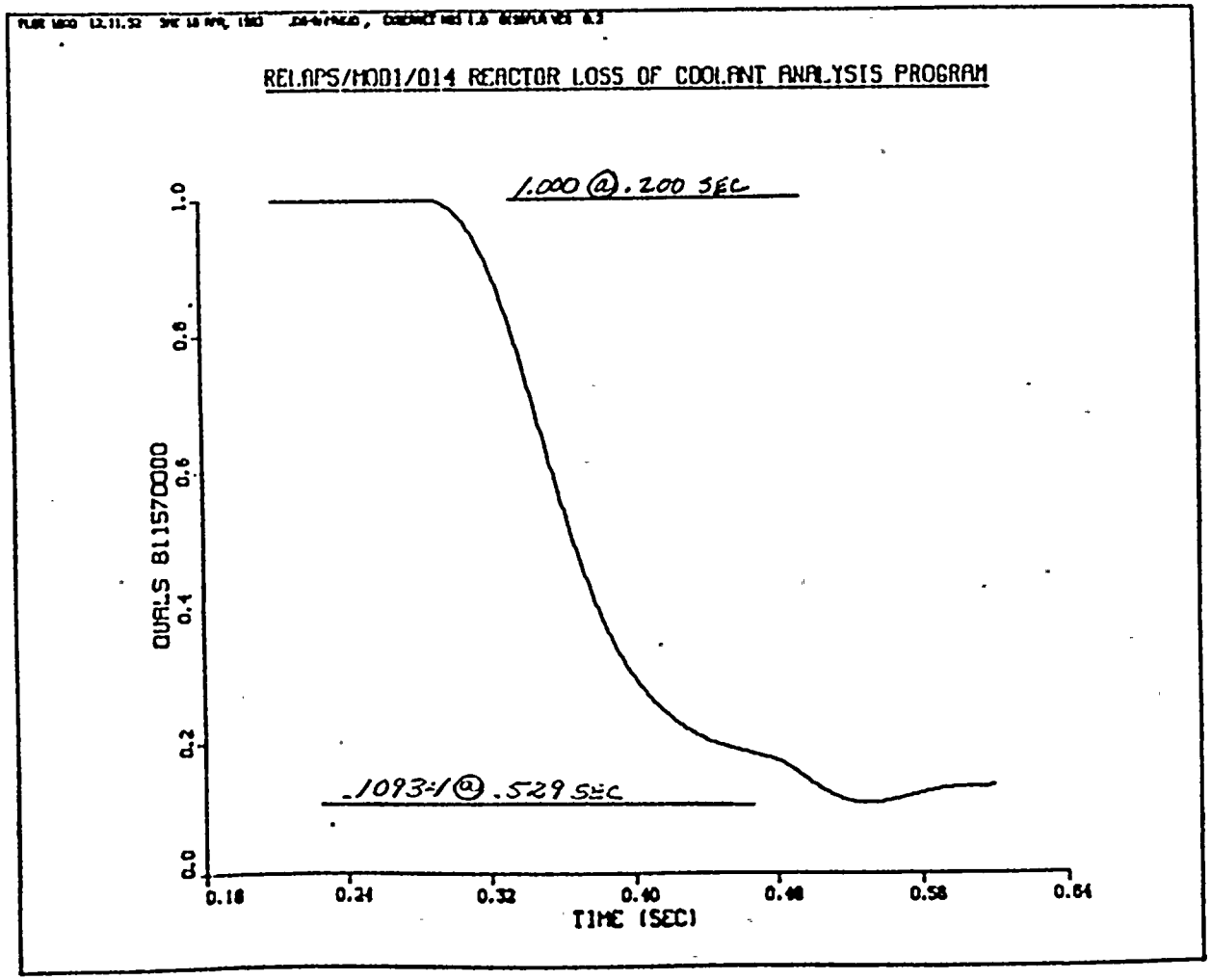
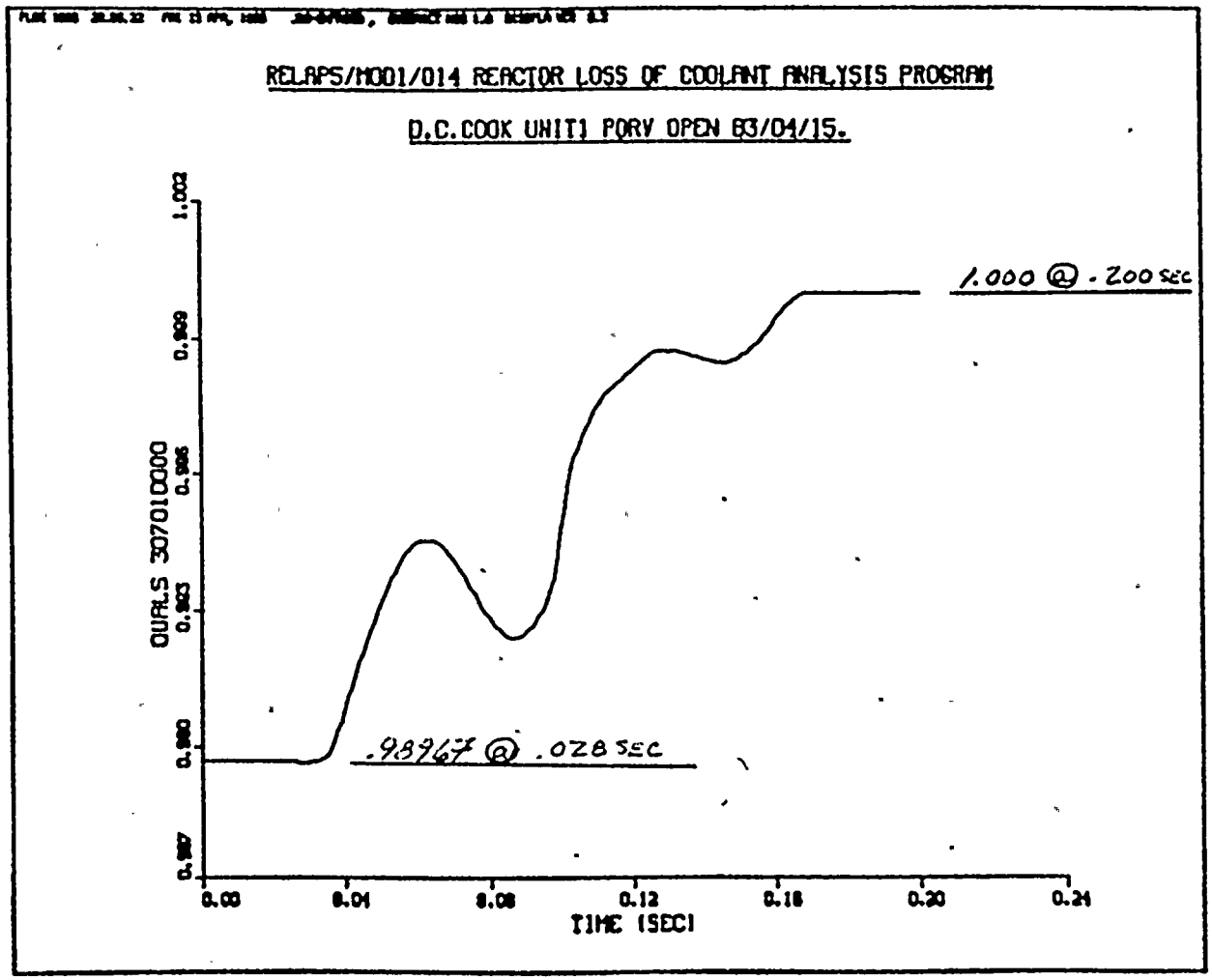
Revision 0



BY UMM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83



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BY CHM DATE 4-29-83
CHKD. BY KJG DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

Technical Report
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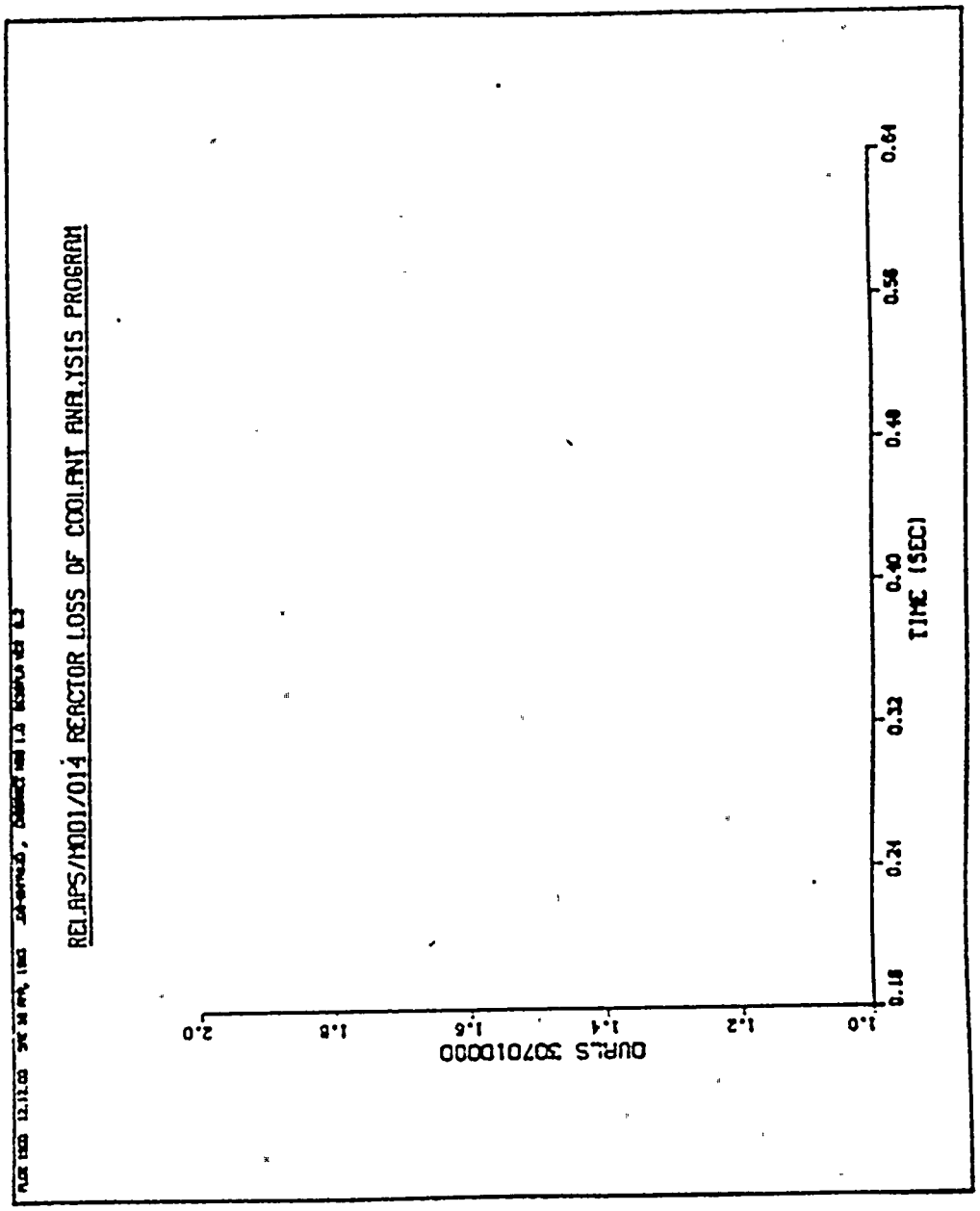
Revision 0



BY UHM DATE 11-29-83
CHKD. BY JBW DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

Technical Report
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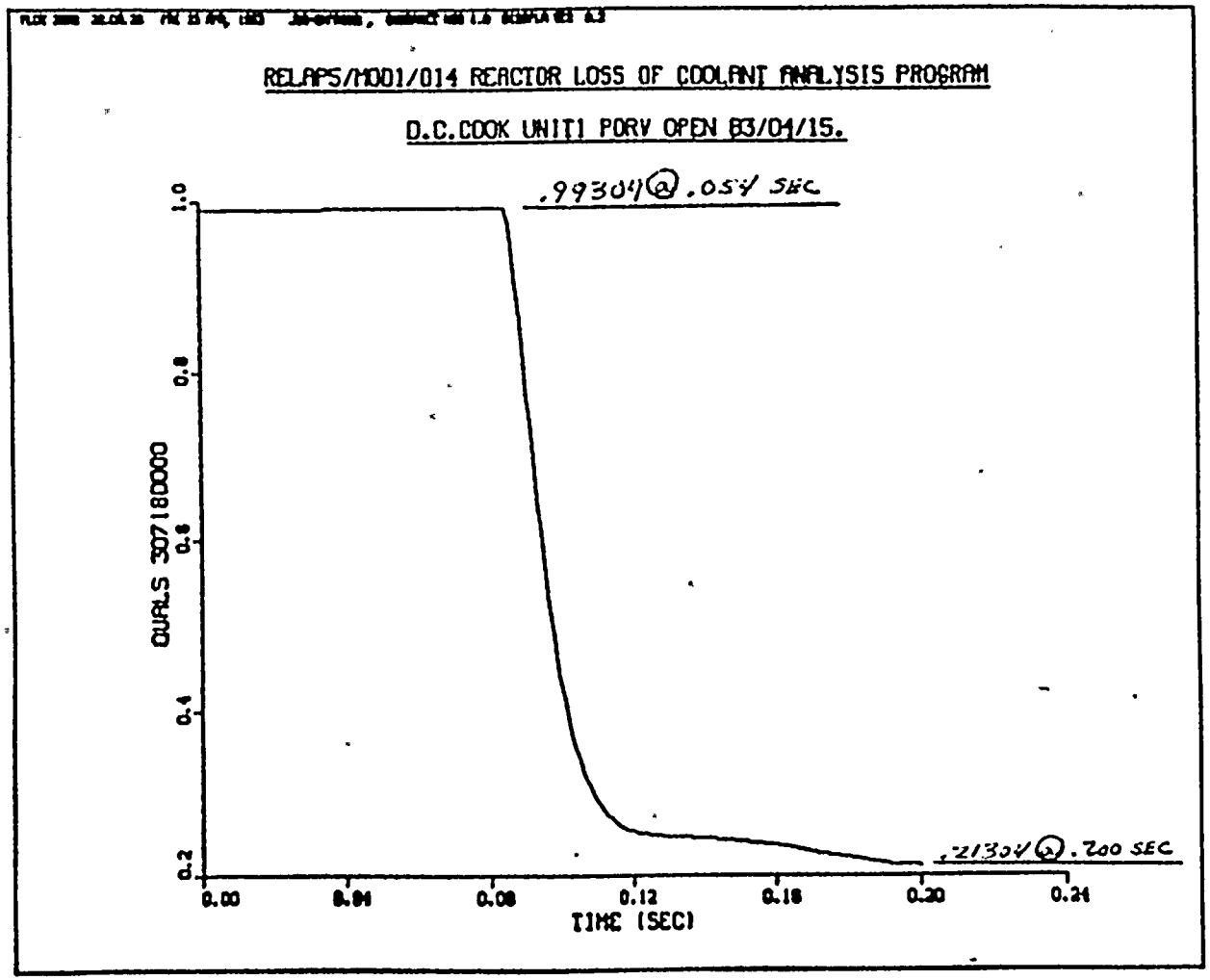
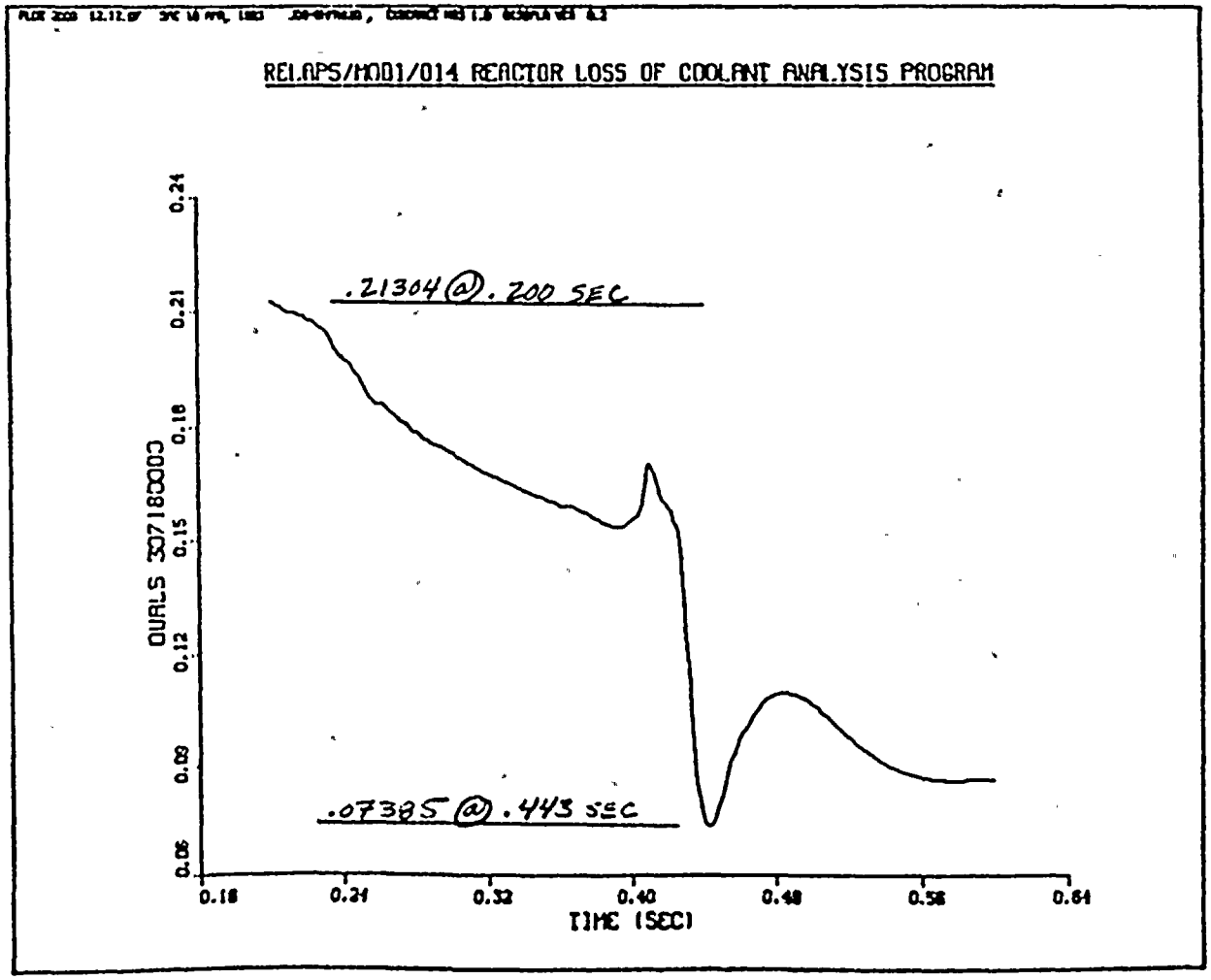
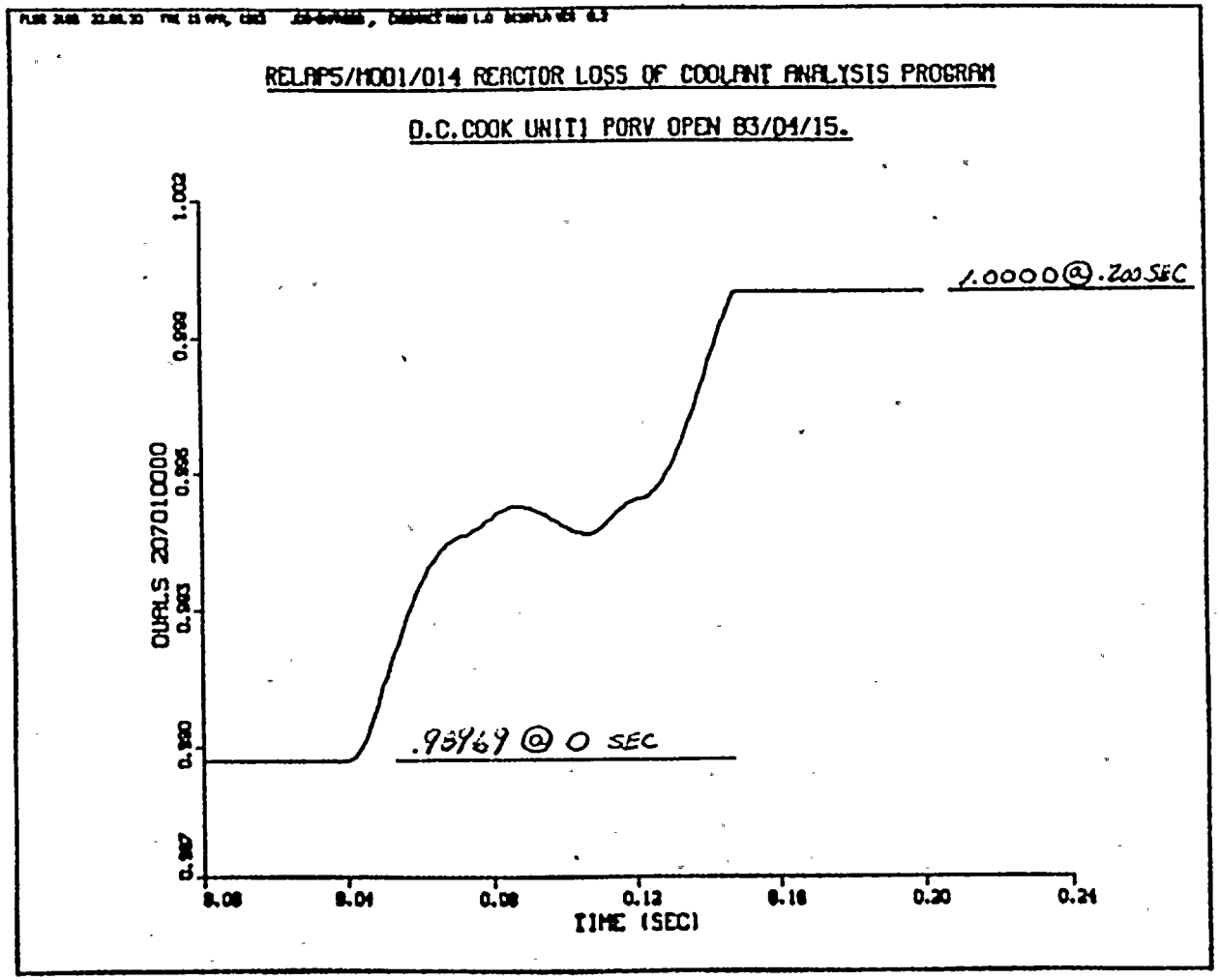
Revision 0



BY CHM DATE 4-29-83
CHKD. BY KIC DATE 4-29-83



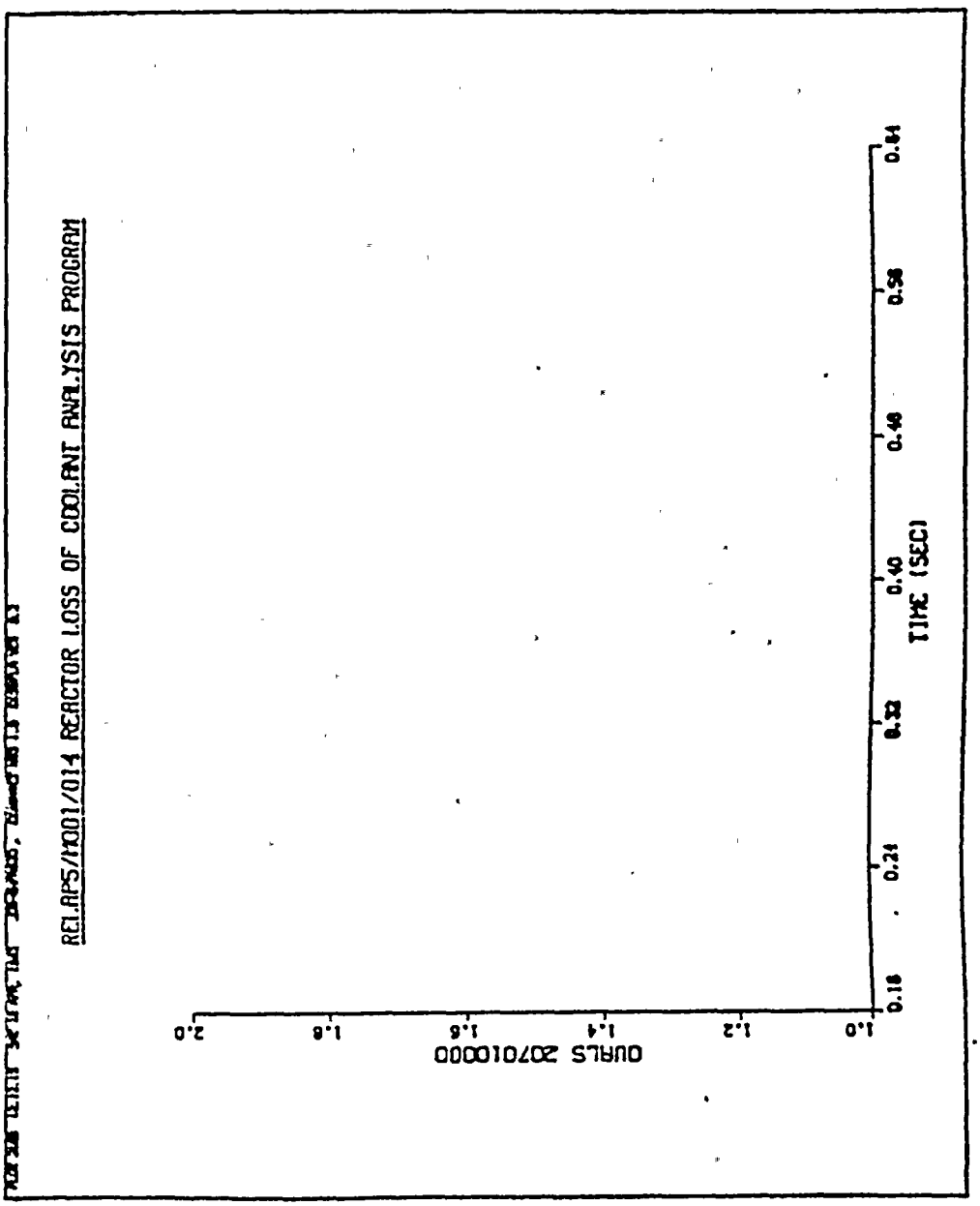
BY UHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83



BY CHM DATE 4-29-83
CHKD. BY KJG DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

Technical Report
TR-5364-1
Revision 0



BY UHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

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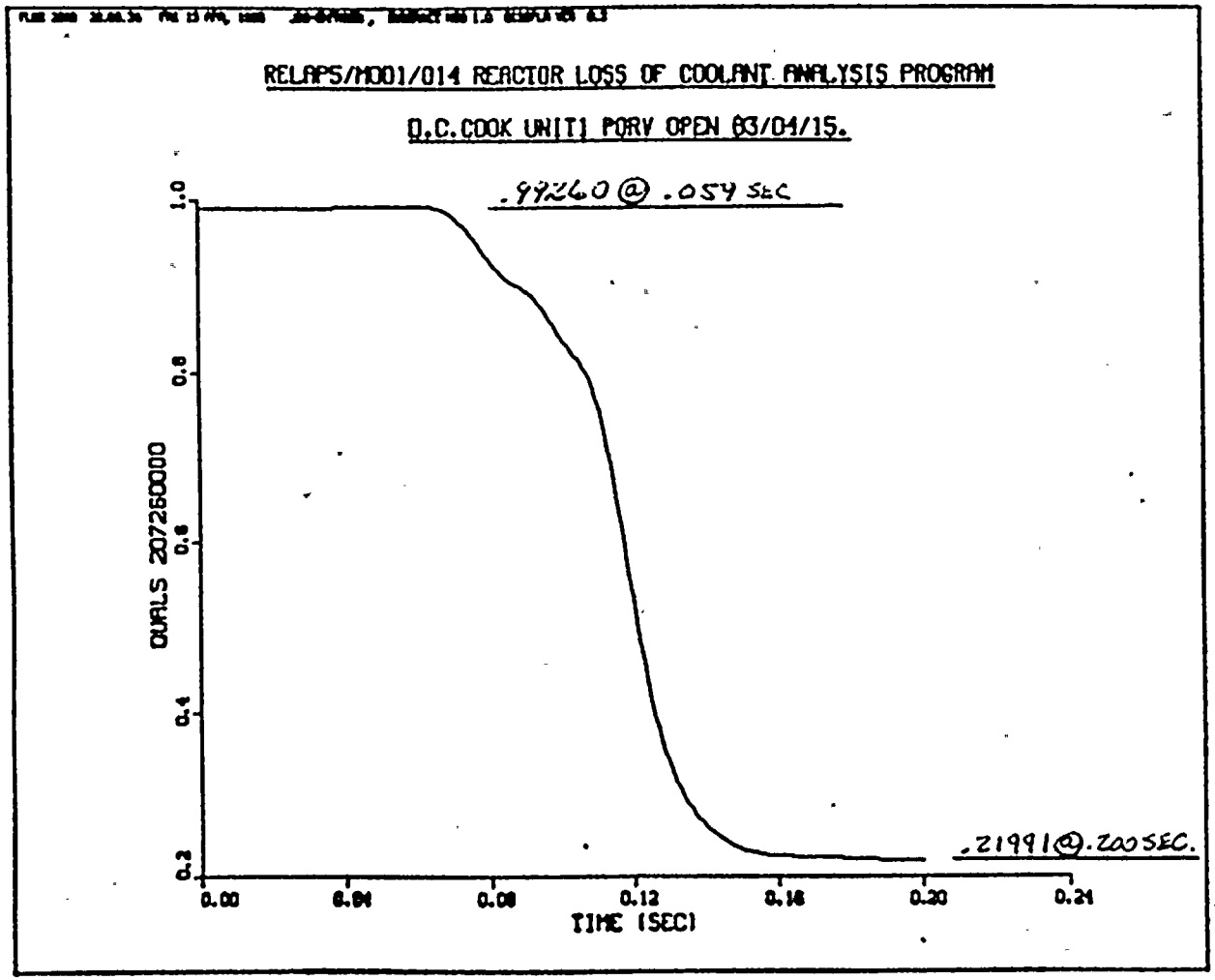
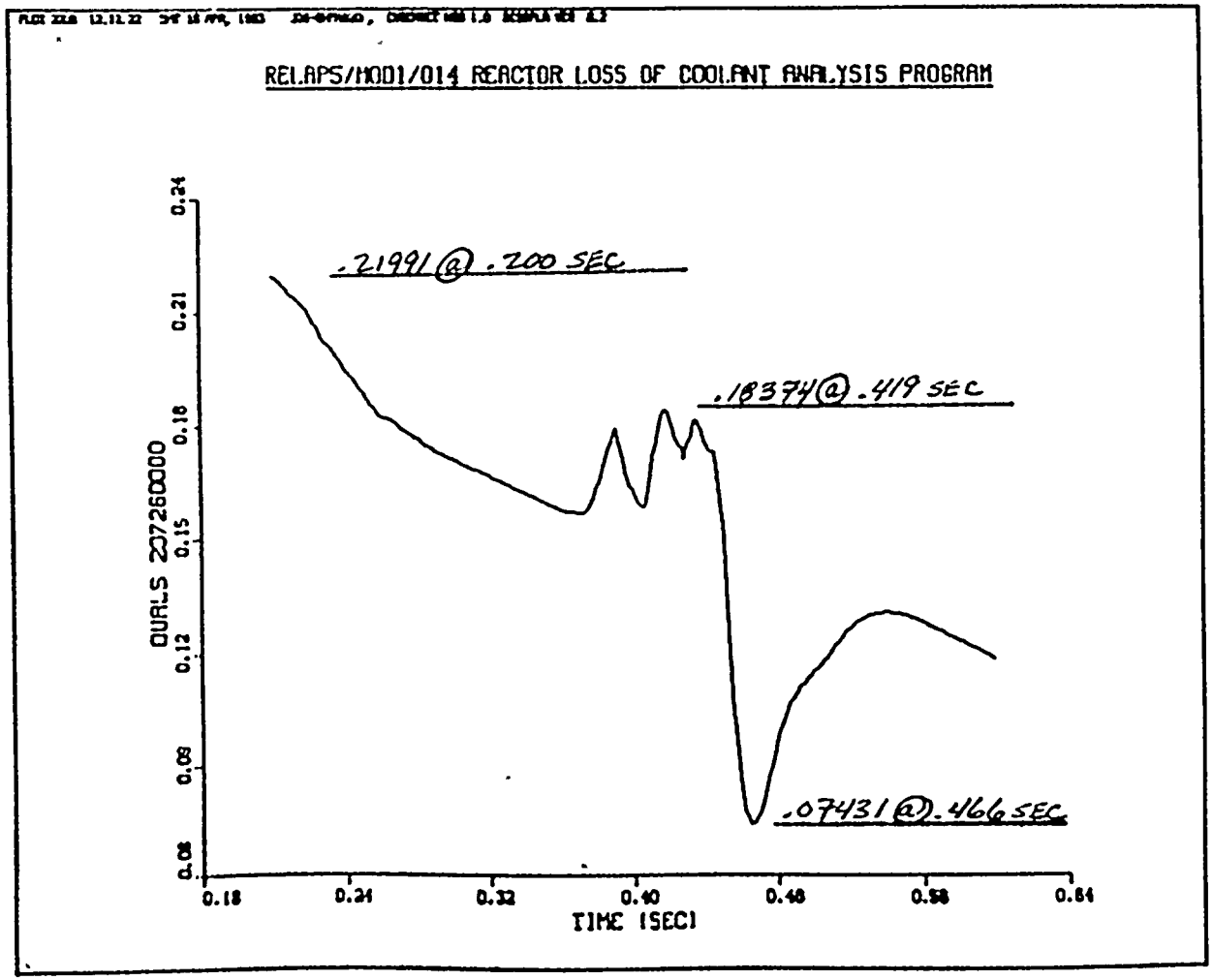
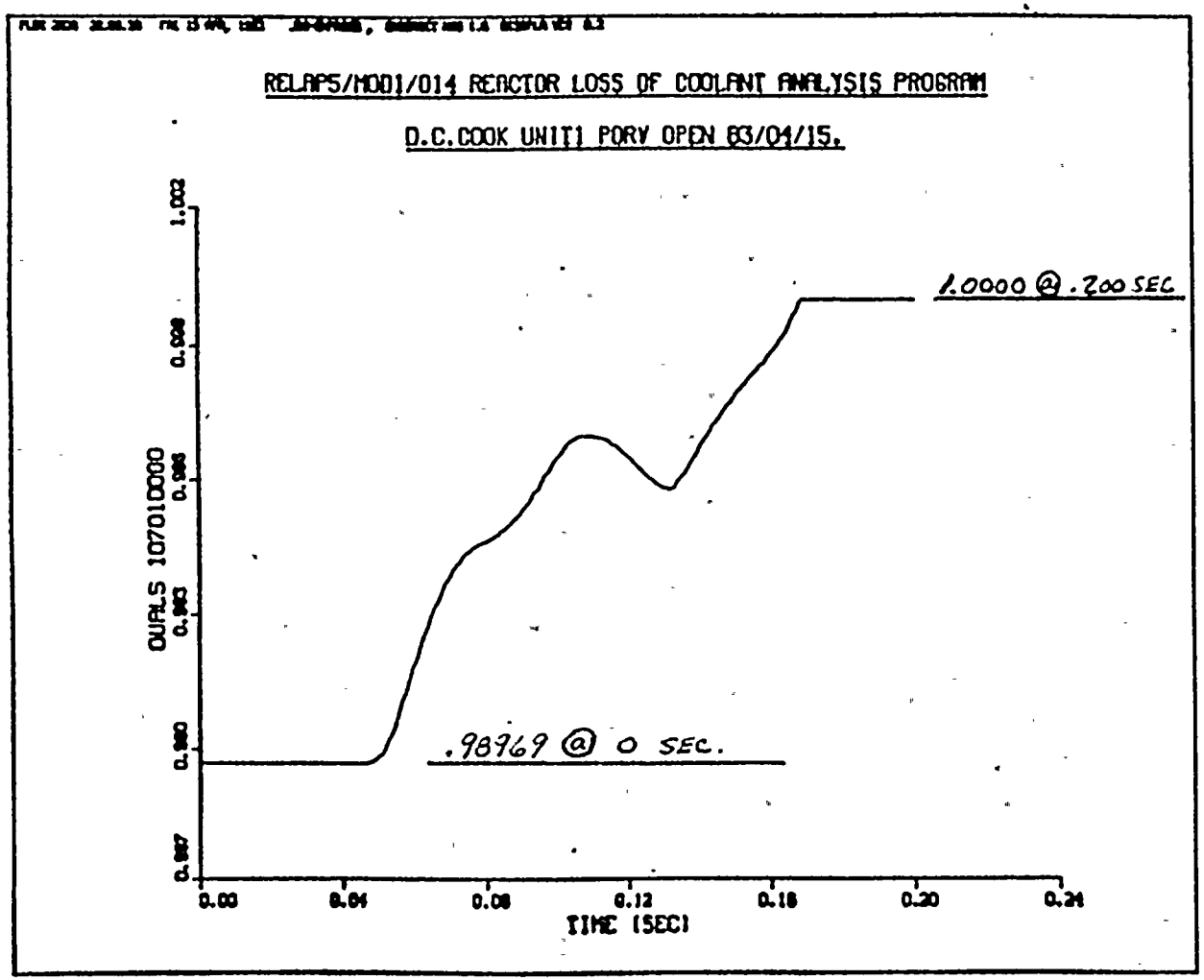


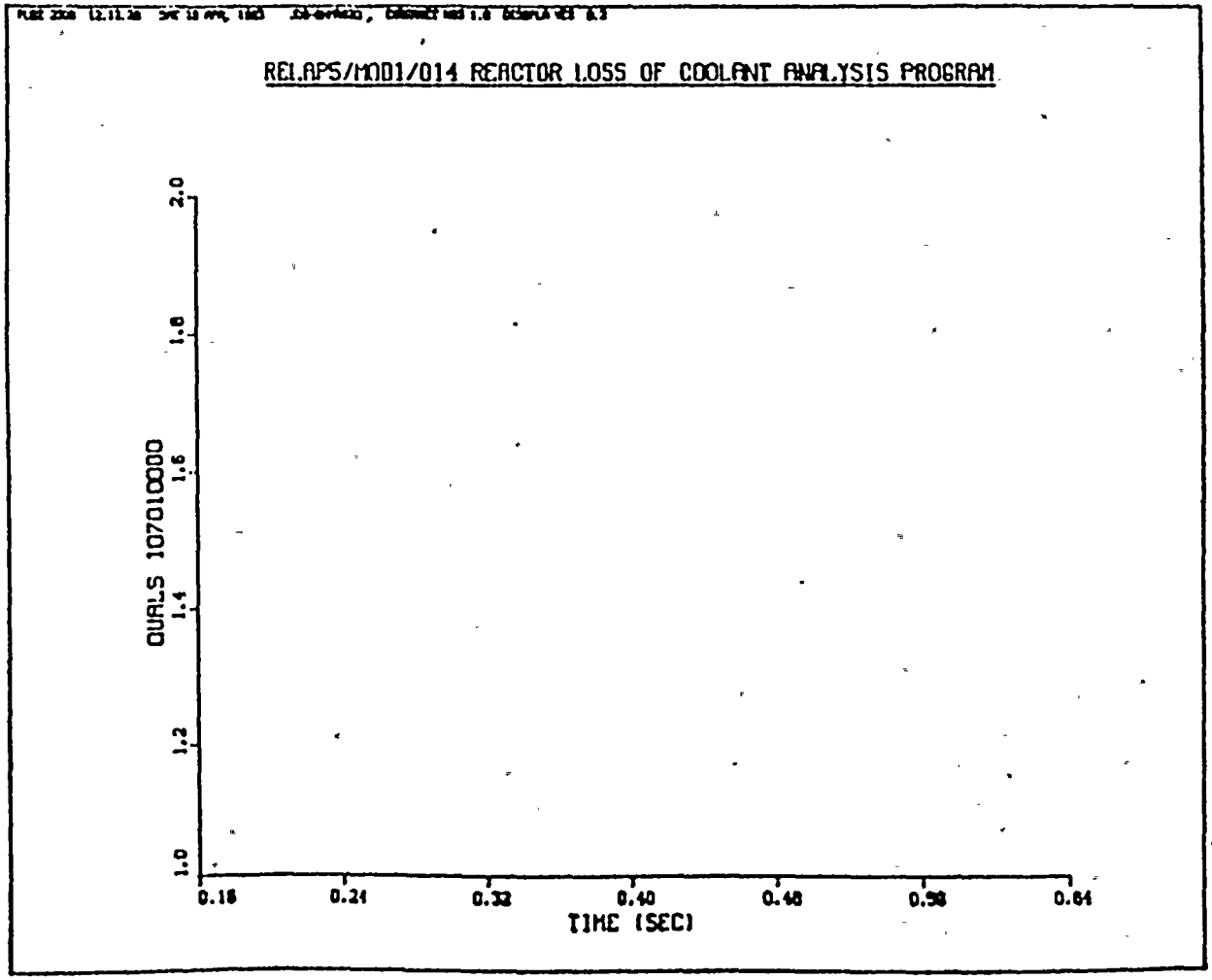
BY CHM DATE 4-29-83
CHKD. BY KG DATE 1-27-83



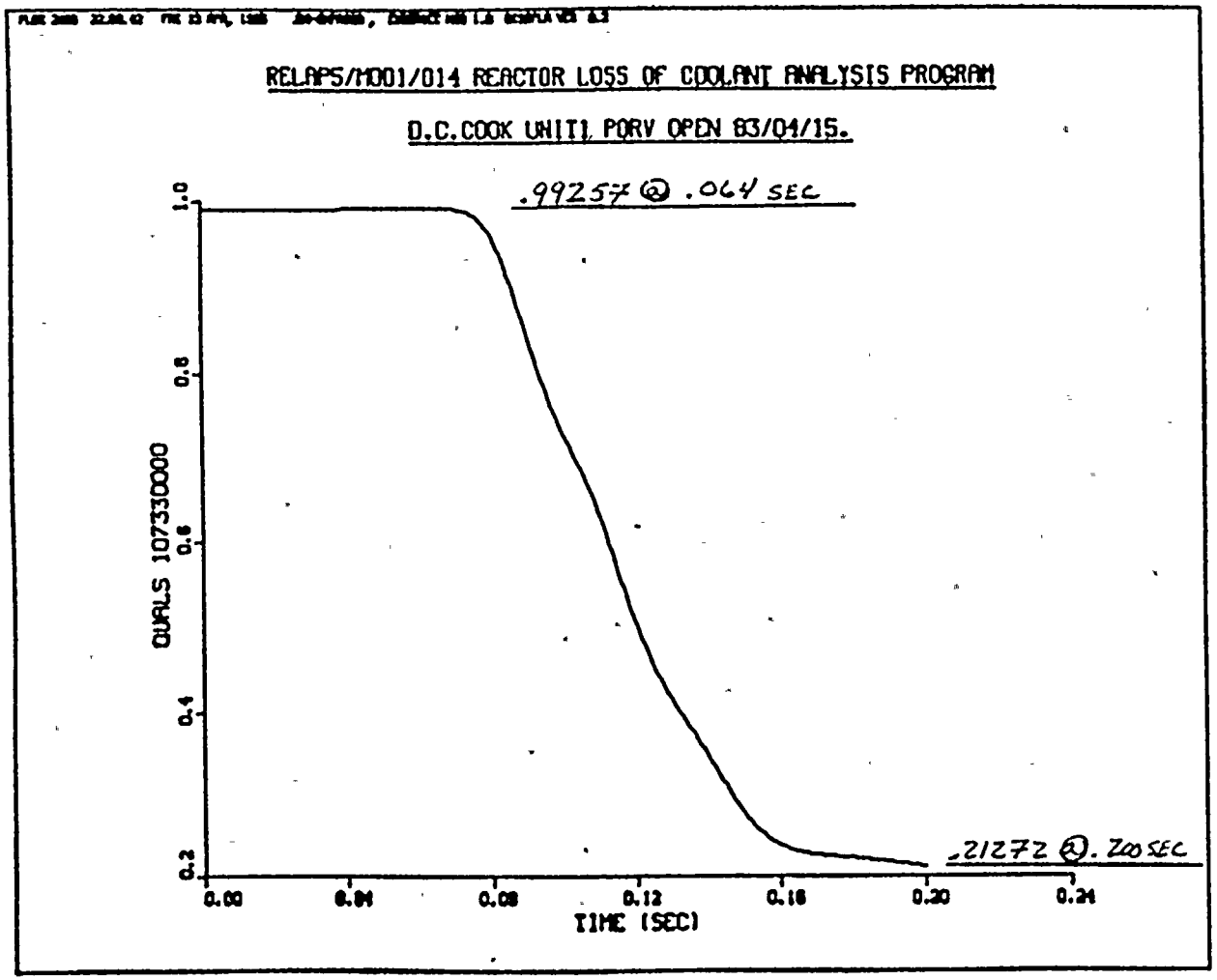
BY UHM DATE 11-29-83
CHKD. BY JBV DATE 4-29-83



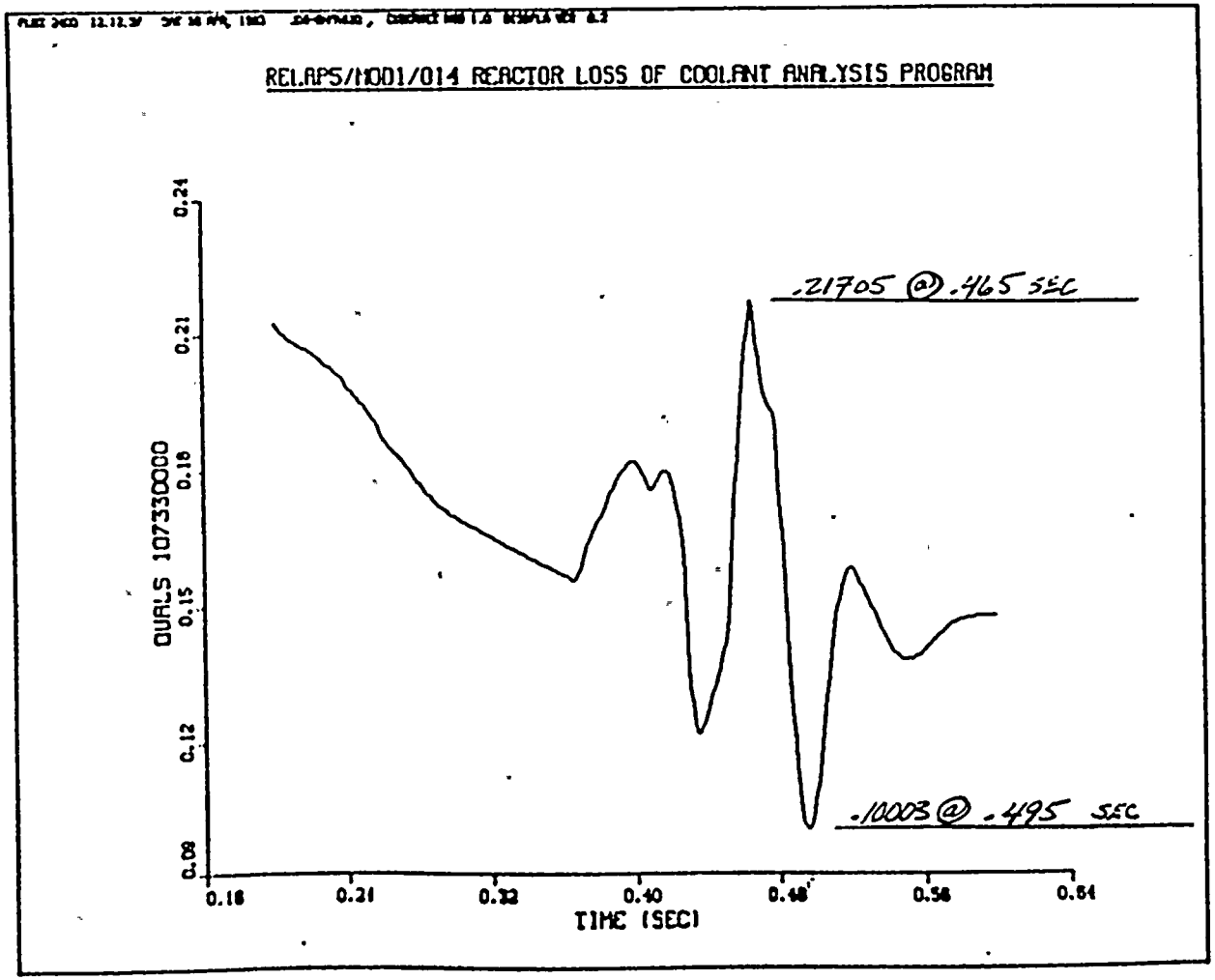
BY CHM DATE 4-29-83
CHKD. BY KTG DATE 4-27-83



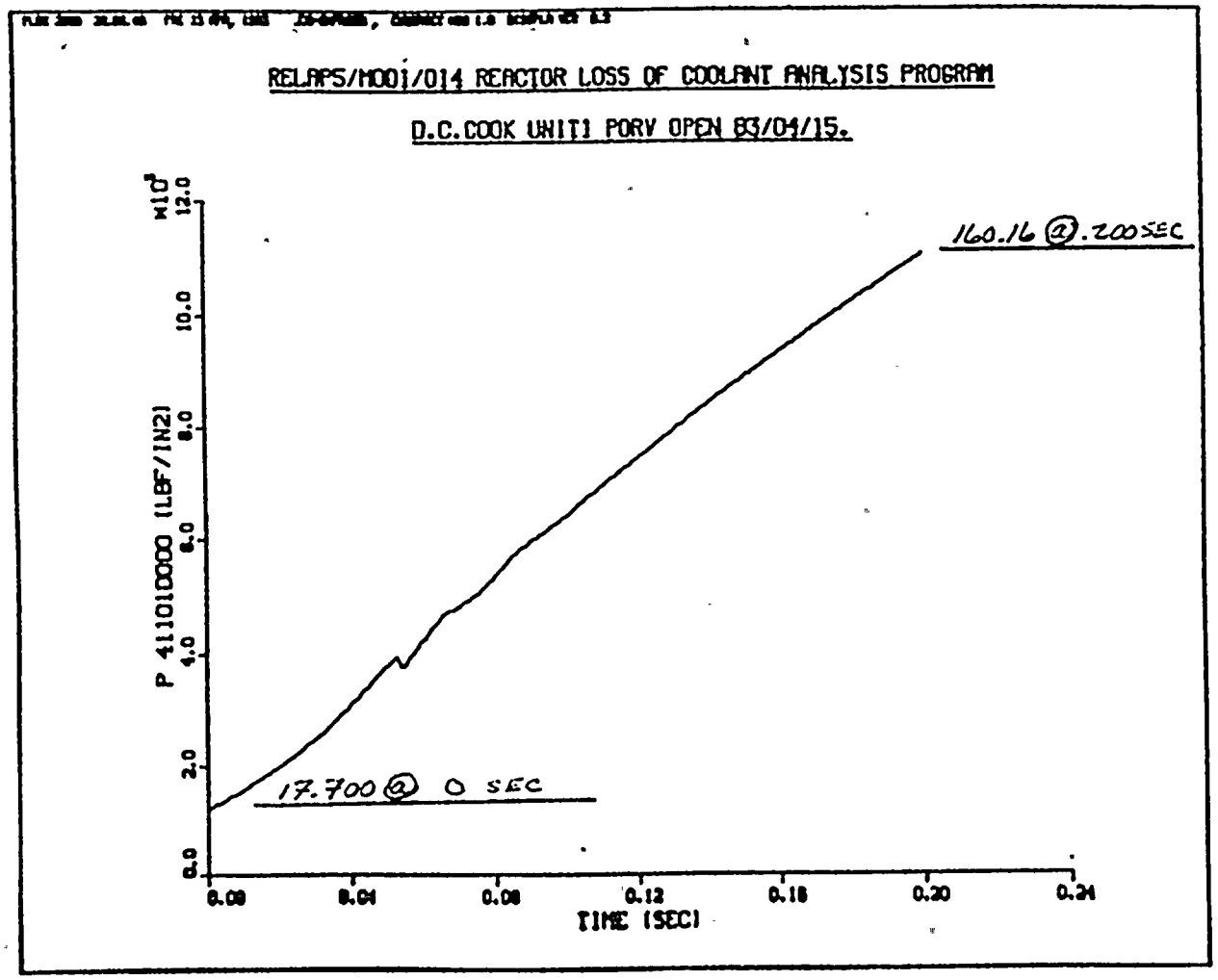
BY [illegible] DATE 4-29-83
CHKD. BY JBK DATE 4-29-83



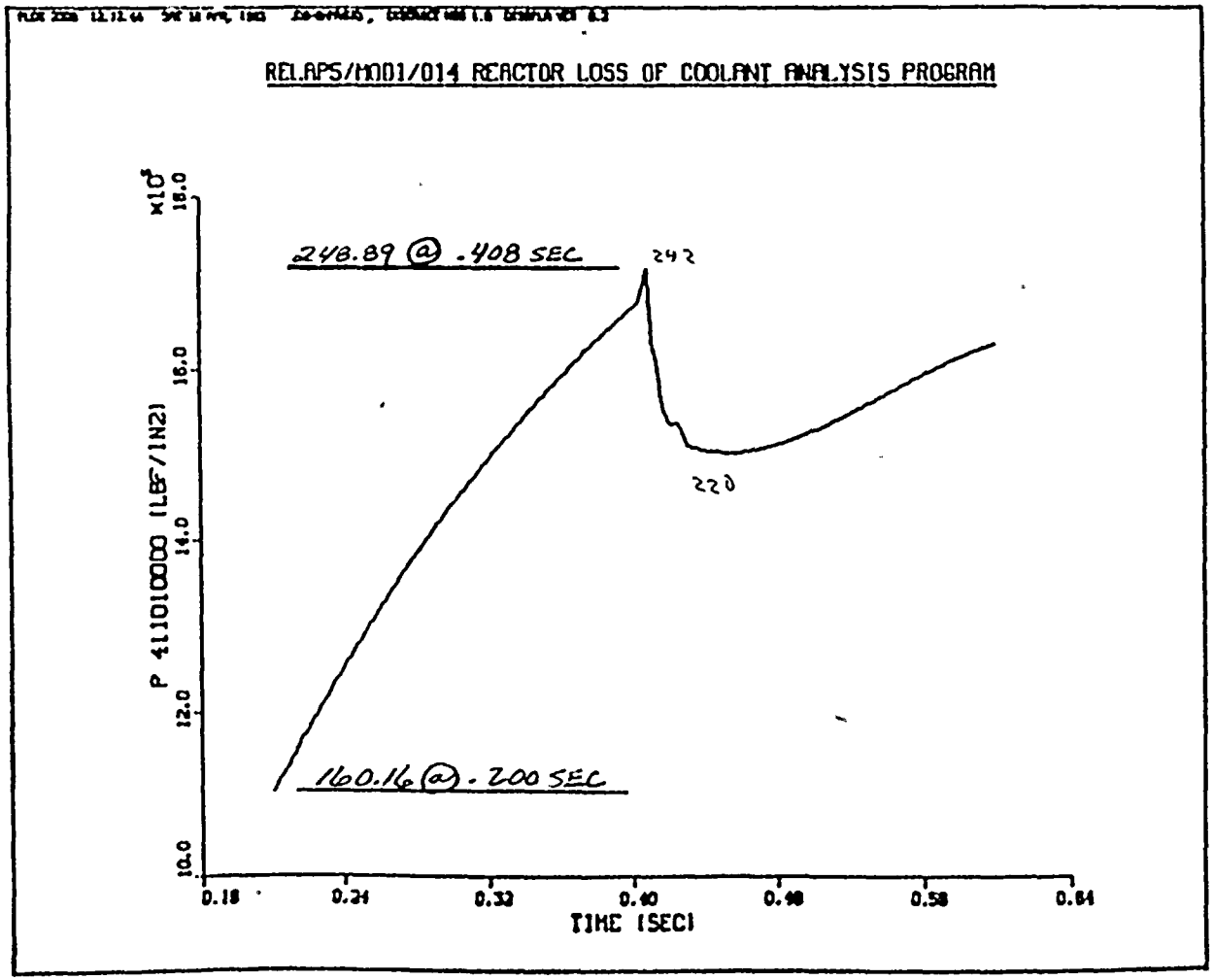
BY CHM DATE 4-29-83
CHKD. BY KG DATE 11-29-83



BY UHH DATE 11-29-83
CHKD. BY JBM DATE 4-29-83



BY CMM DATE 4-29-83
CHKD. BY KTG DATE 4-29-83



BY UHM DATE 11-29-83
CHKD. BY JBM DATE 4-29-83

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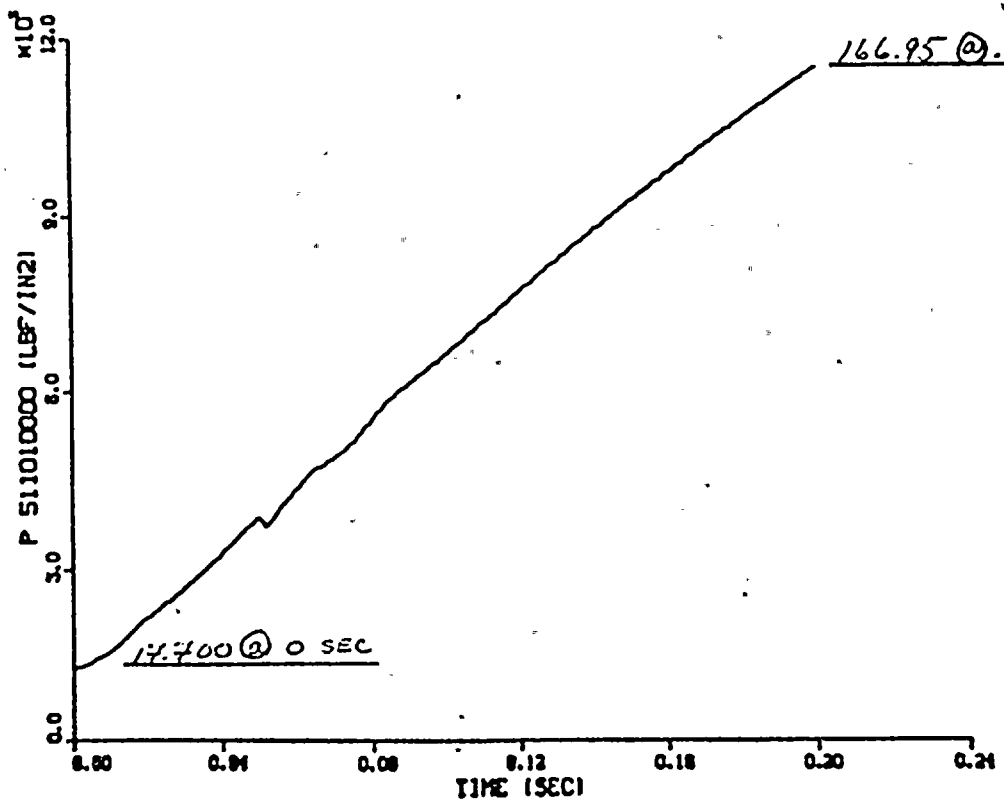
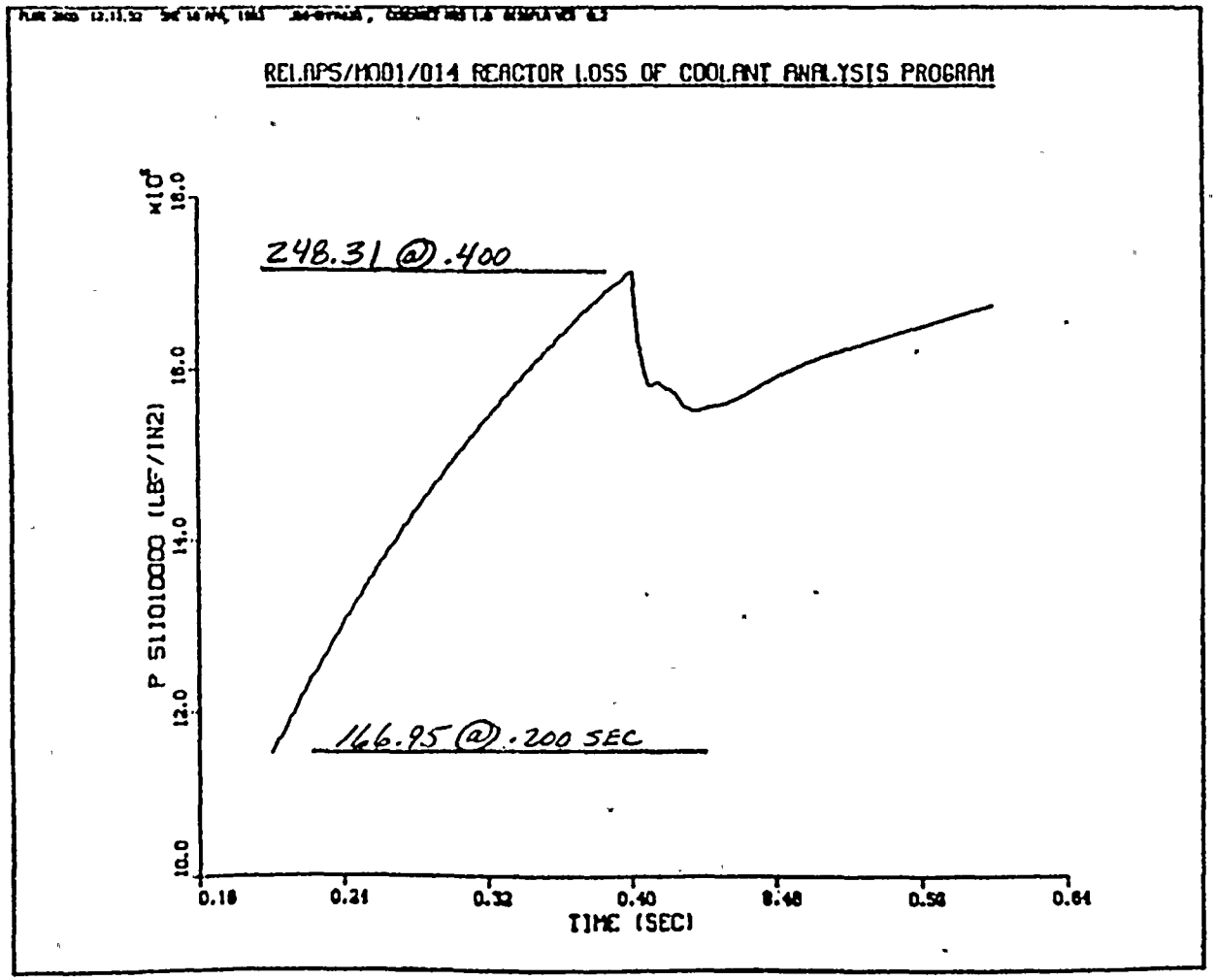
RELAPS/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM

D.C.COOK UNIT1 PORV OPEN 83/04/15.



BY CHM DATE 4-29-83
CHKD. BY KIG DATE 4-29-83



BY [illegible] DATE 11-29-83
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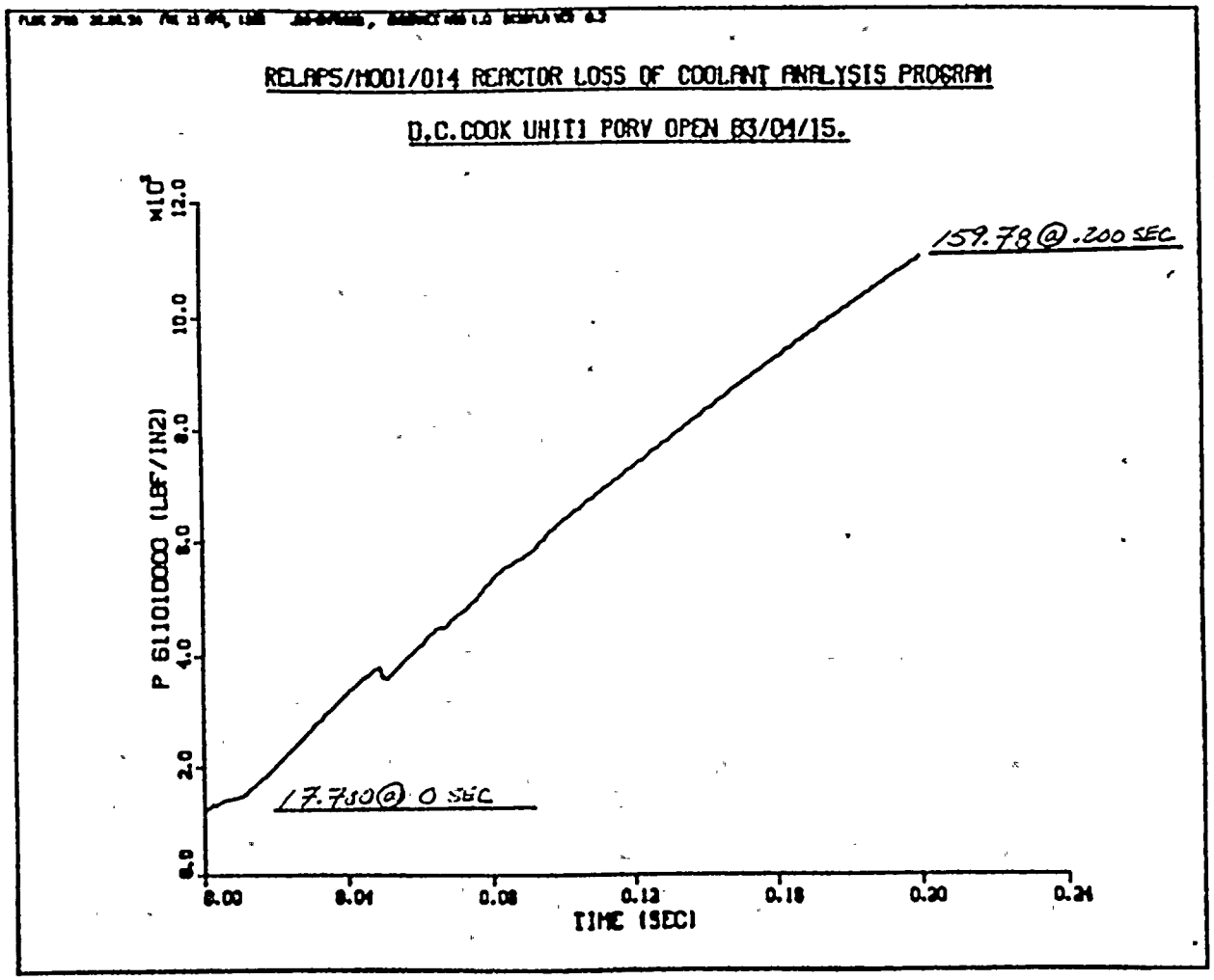
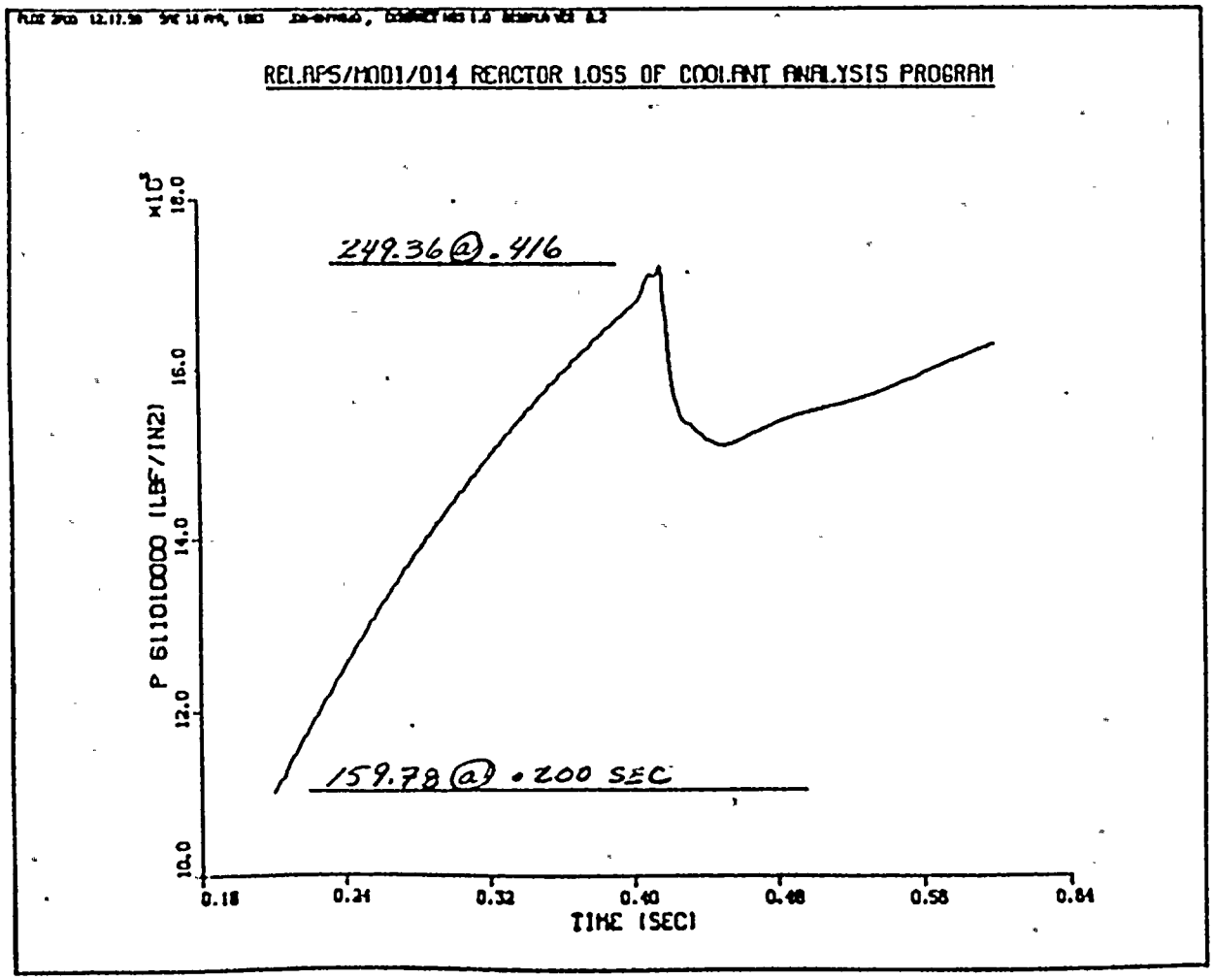
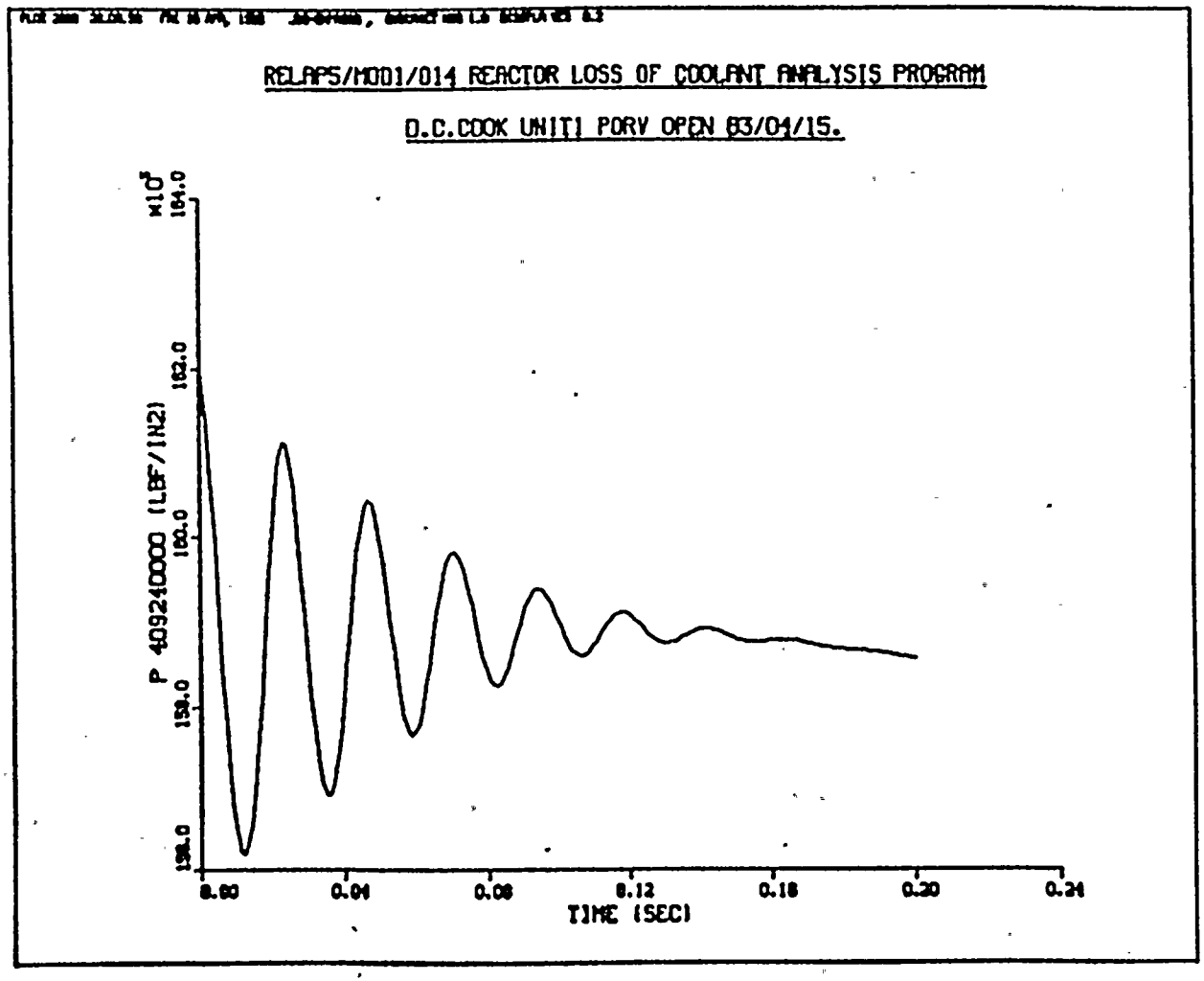


BY CHM DATE 4-29-83
CHKD. BY KTG DATE 11-27-83




RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/15.
P 409240000 (LBF/IN2)
×10²
184.0
182.0
180.0
178.0
176.0
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)

BY CHM DATE 4-29-83
CHKD. BY KJG DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

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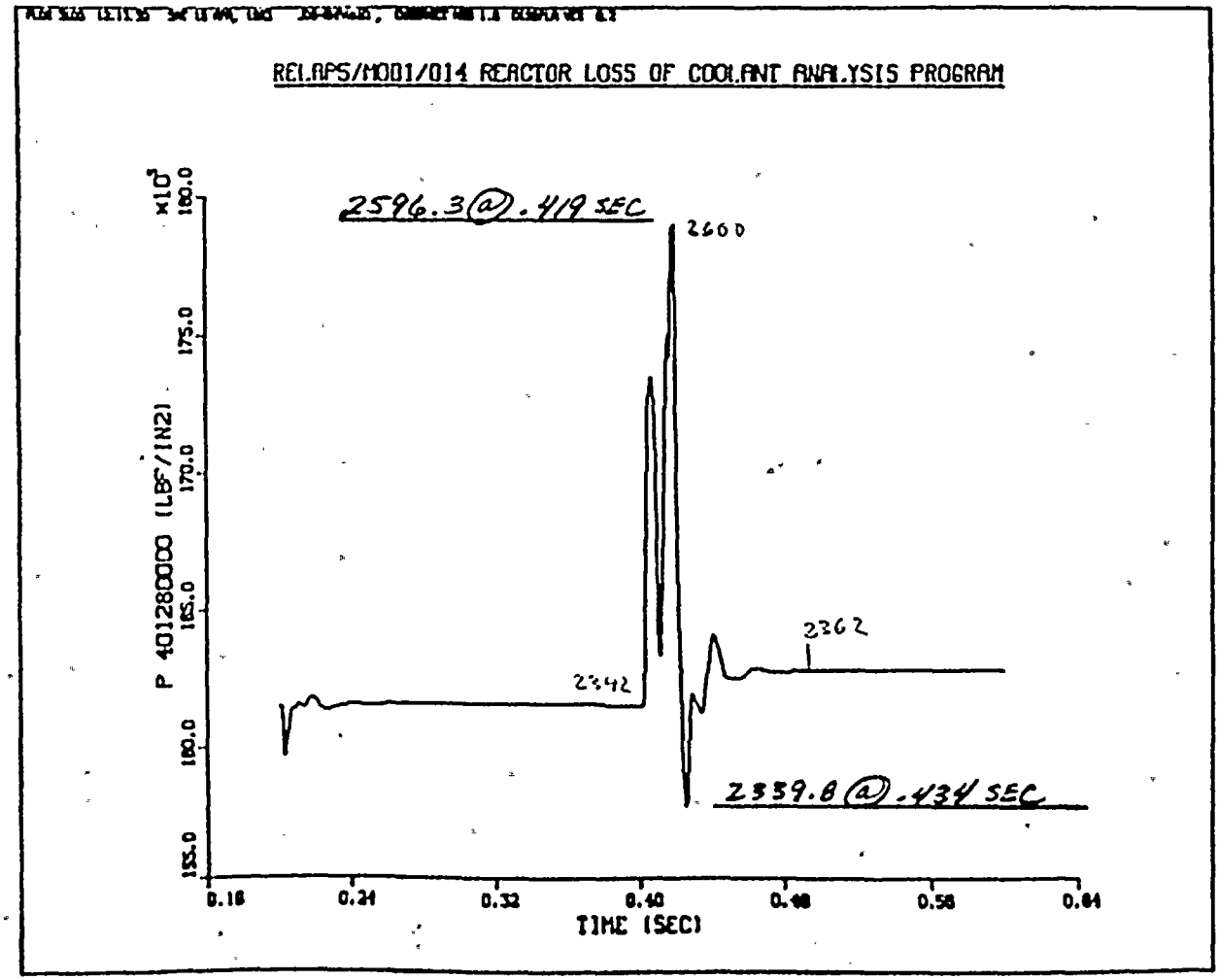

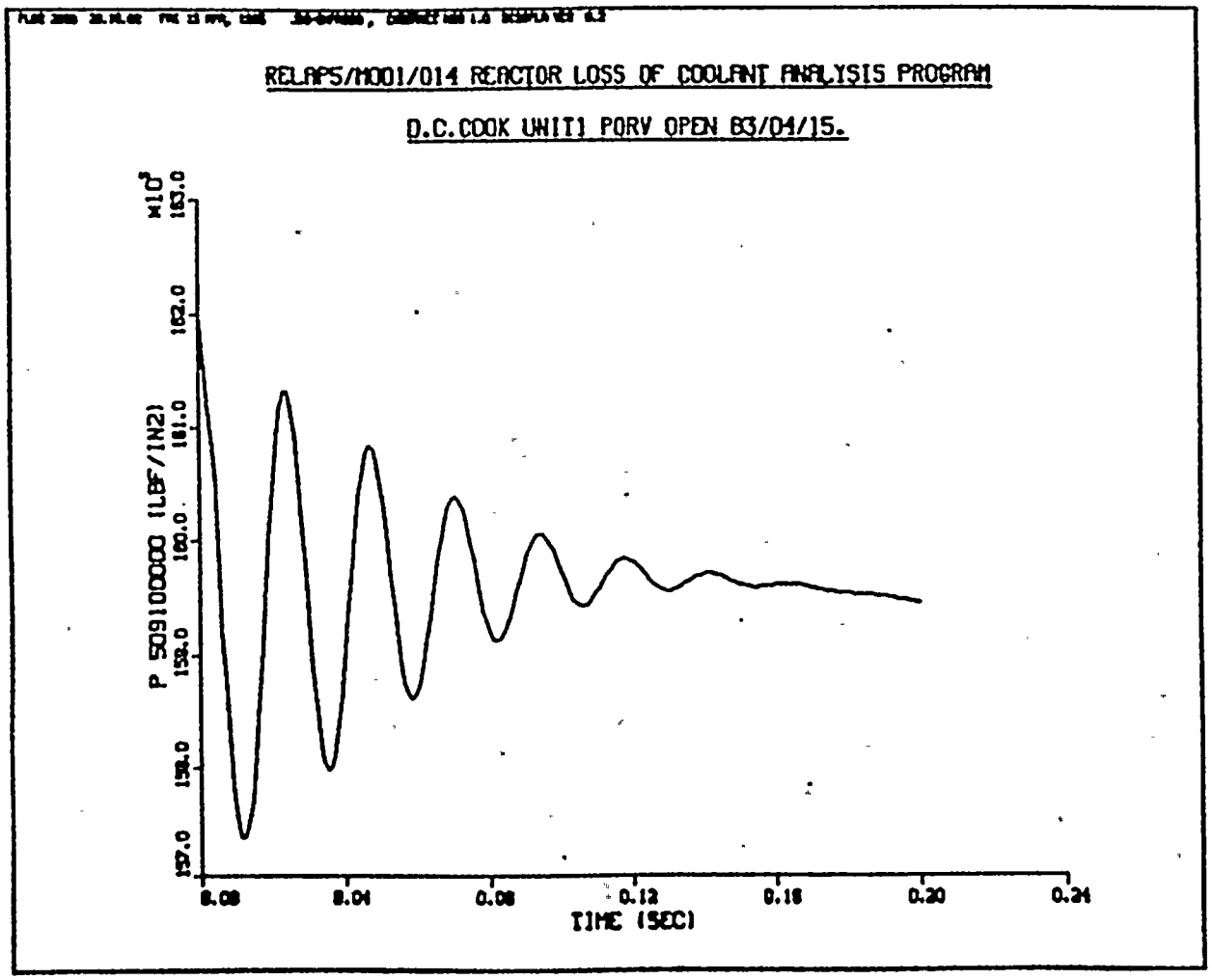
RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/15.
P 509100000 (LBF/IN2)
×10³
183.0
182.0
181.0
180.0
179.0
178.0
177.0
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)

BY CMM DATE 4-29-83
CHKD. BY KJG DATE 4-29 83

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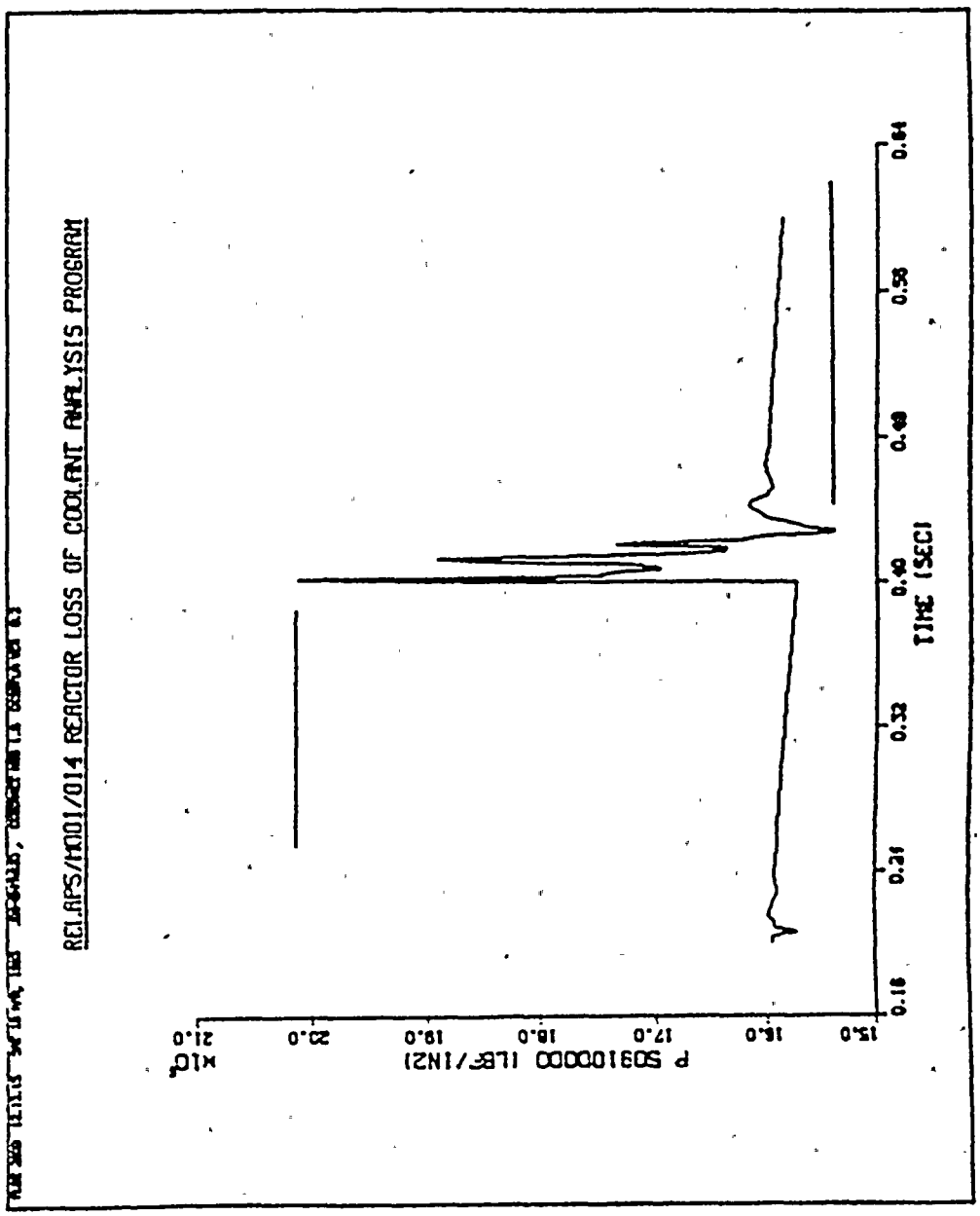
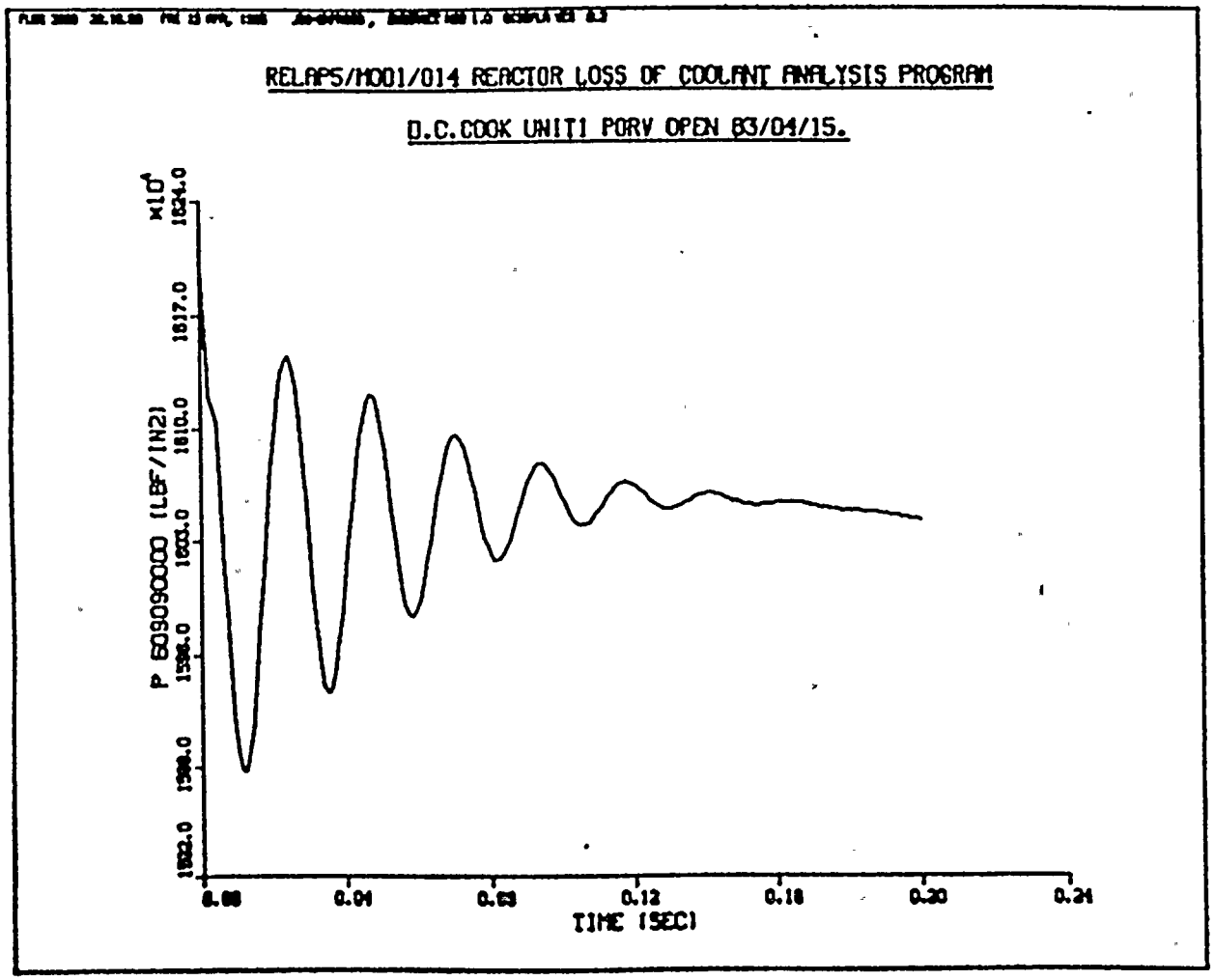
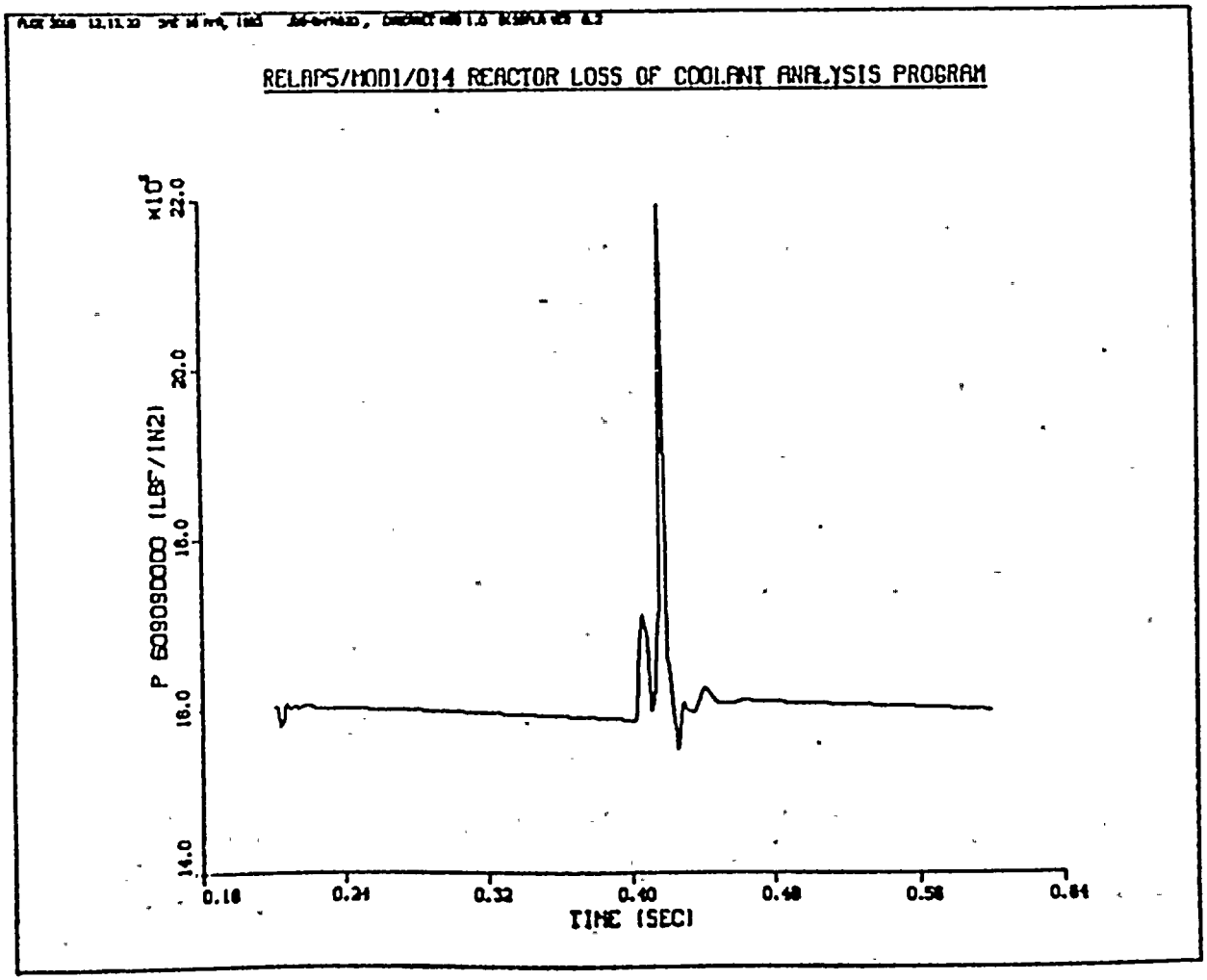



RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/15.
P 80909000 (LBF/IN2)
×10⁴
1824.0
1817.0
1810.0
1803.0
1796.0
1789.0
1782.0
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)

BY CHM DATE 4-29-83
CHKD. BY KTG DATE 4-29-83



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BY [illegible] DATE 11-29-83
CHKD. BY [illegible] DATE 11-29-83

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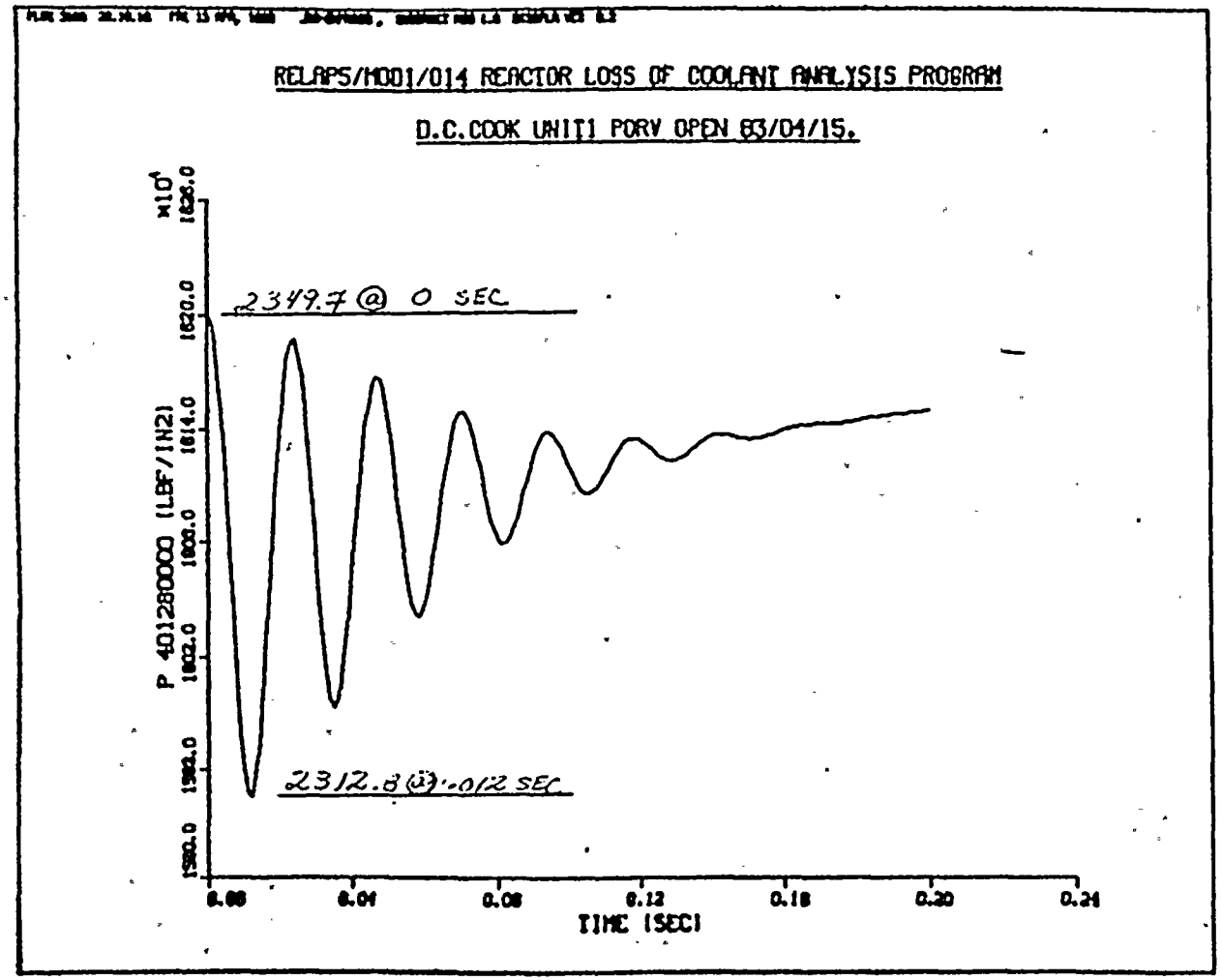
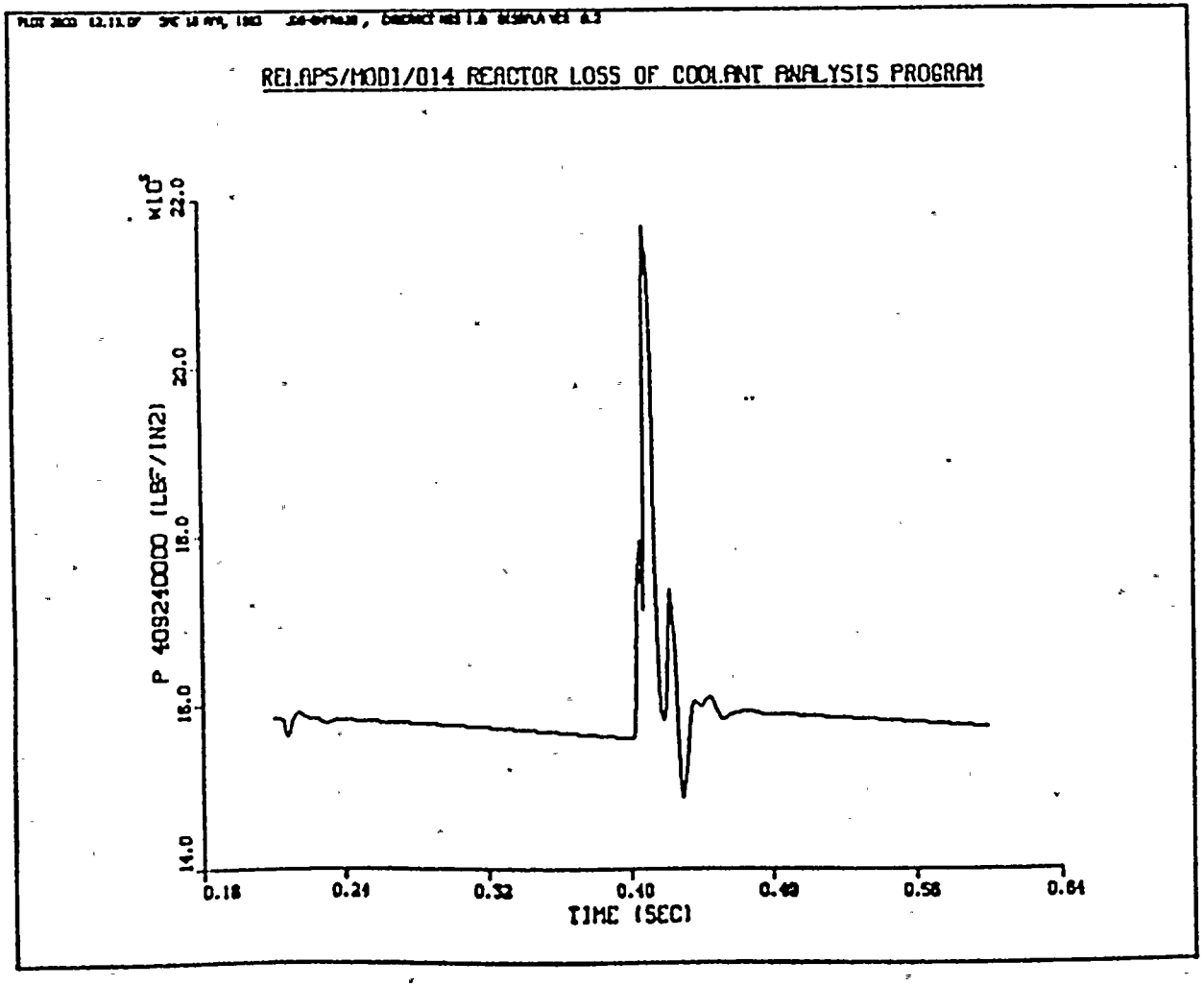
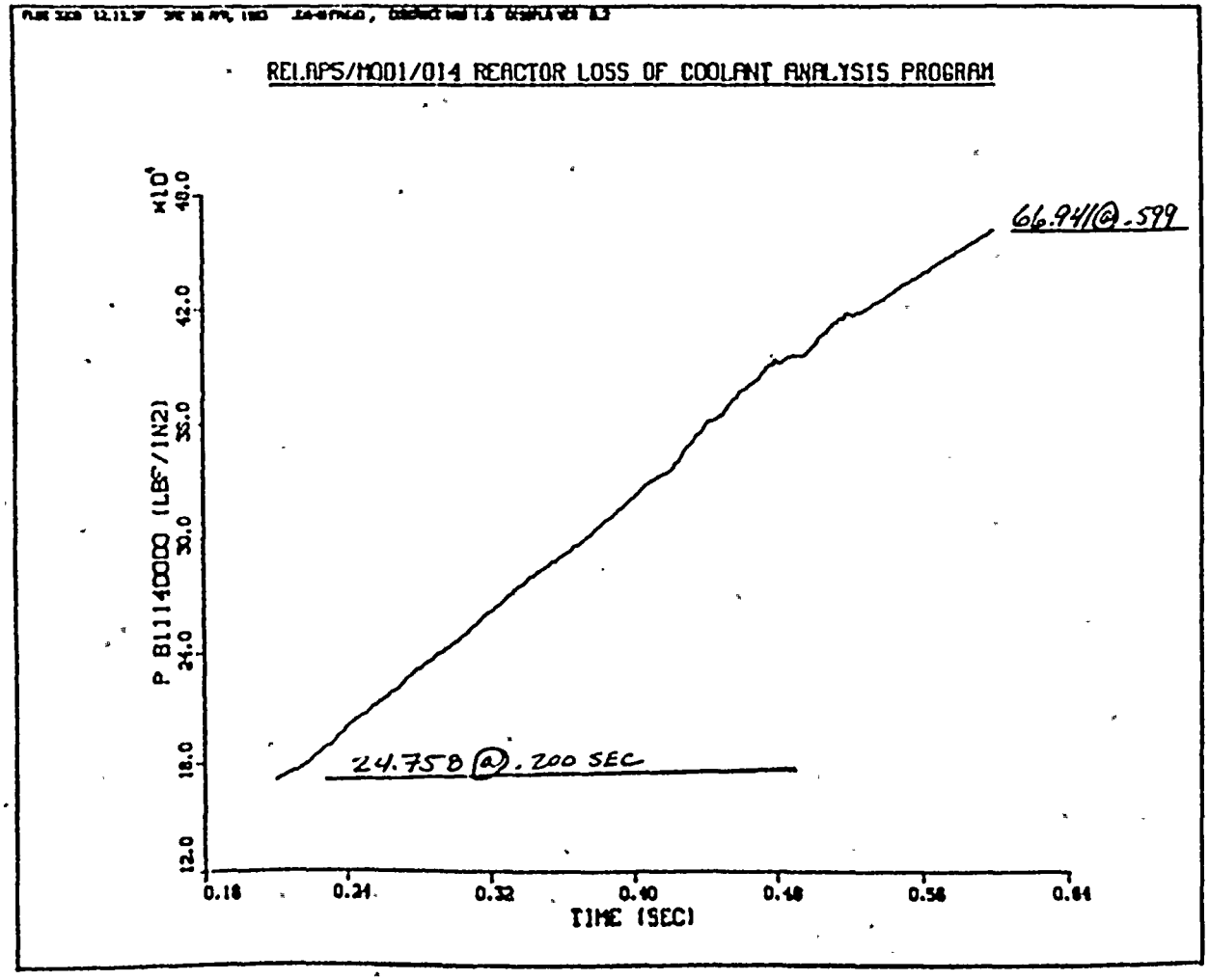


BY CHM DATE 4-29-83
CHKD. BY KTG DATE 4-27-83



BY CHM DATE 4-29-83
CHKD. BY KTC DATE 4-27-83



TELEDYNE ENGINEERING SERVICES

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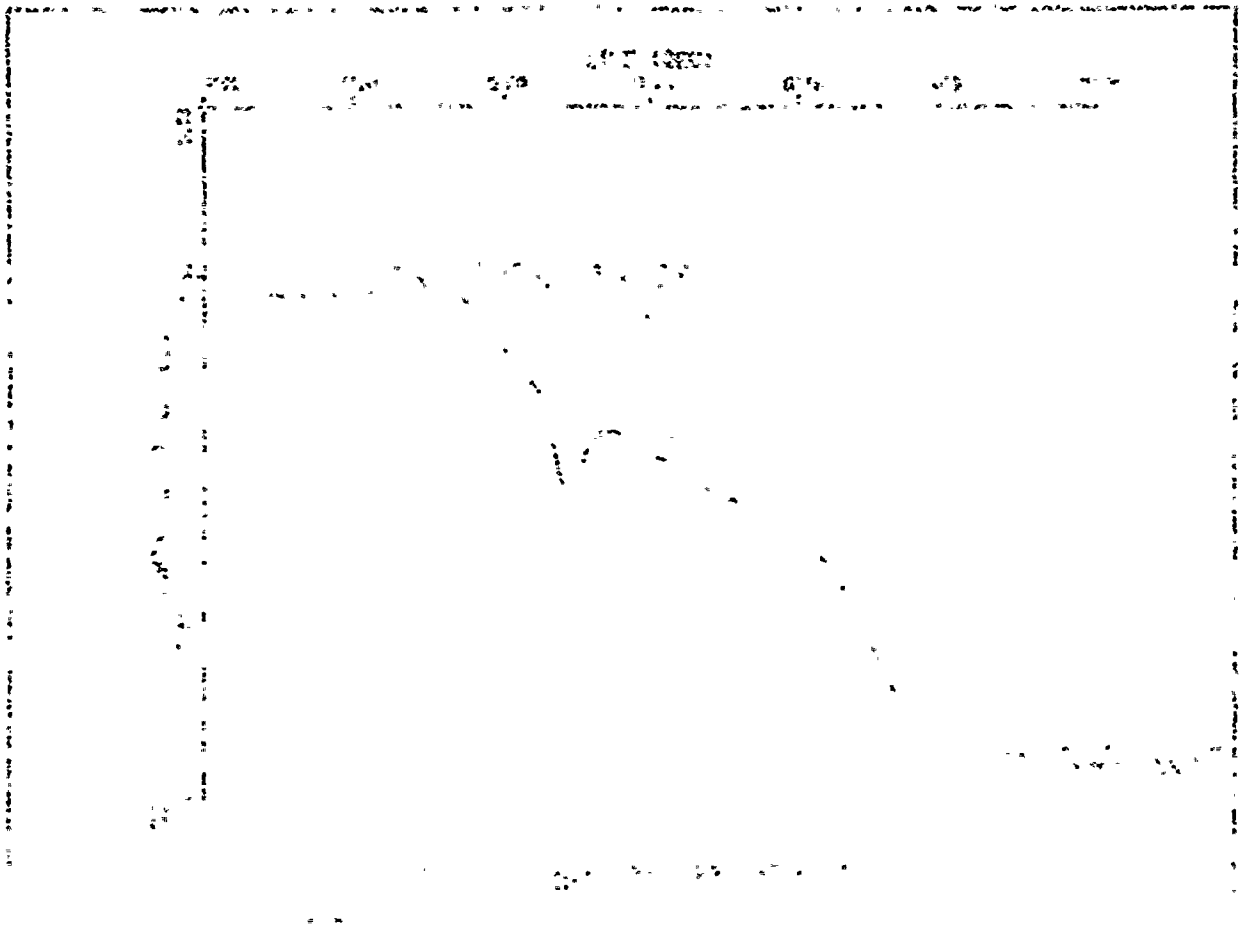
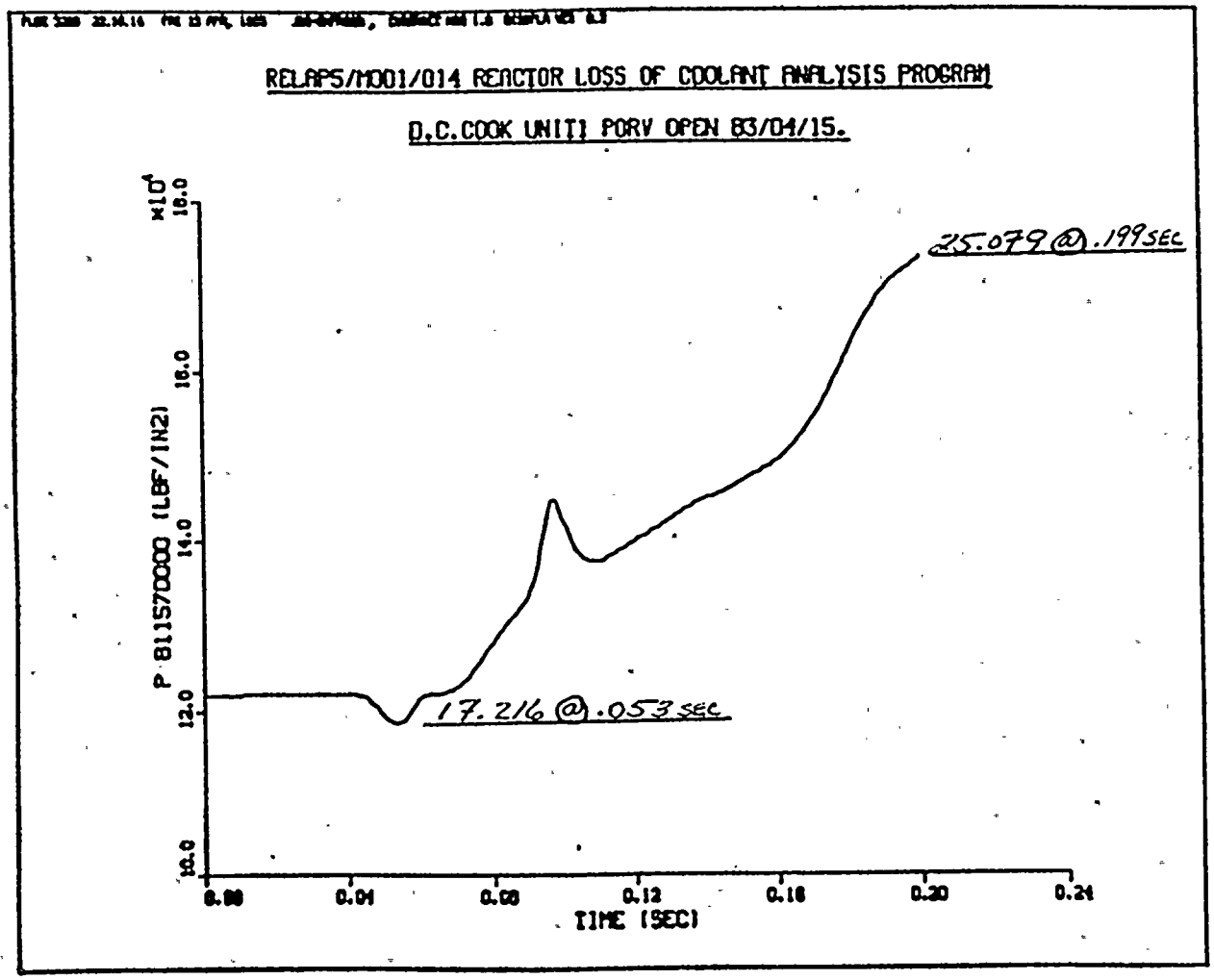
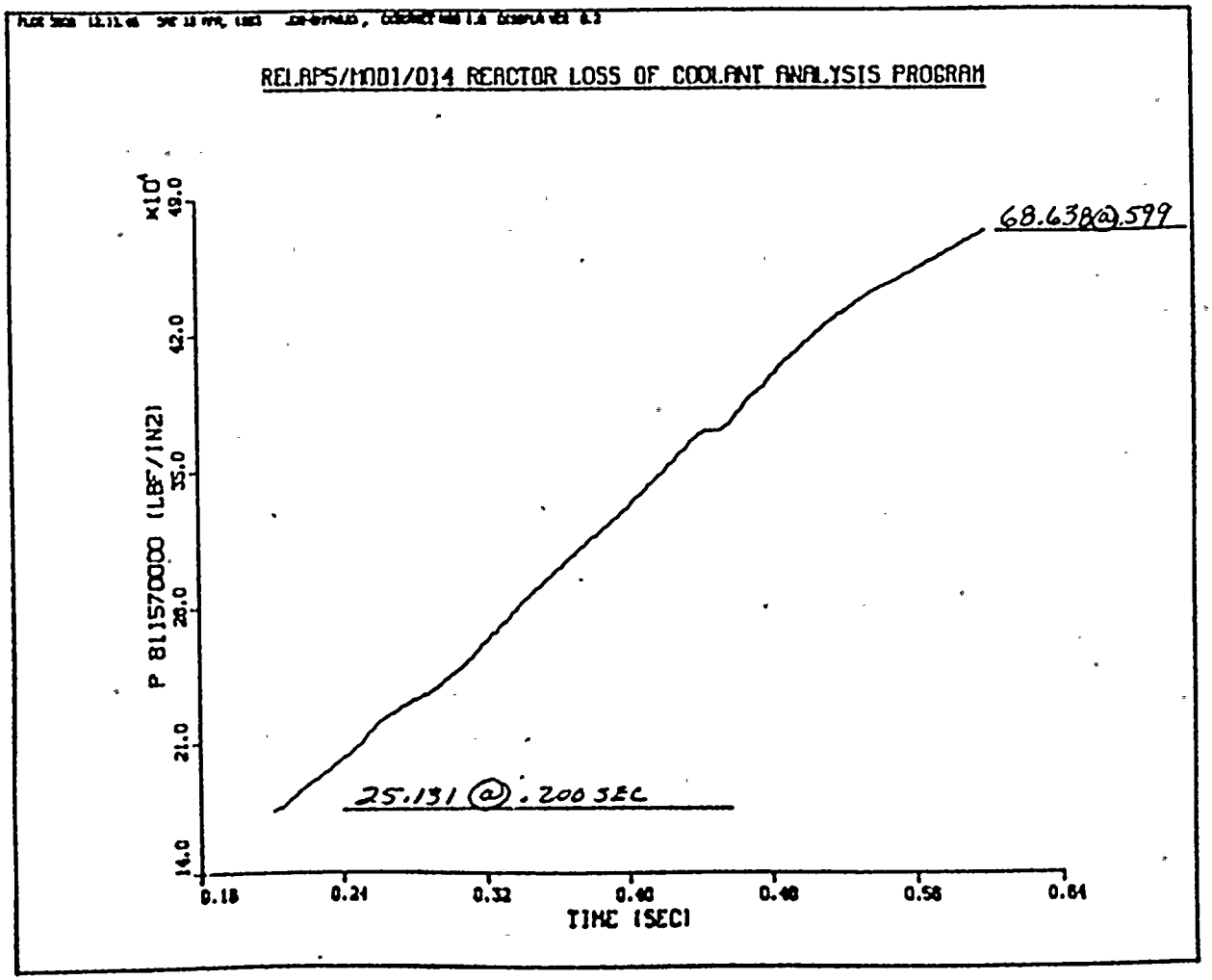
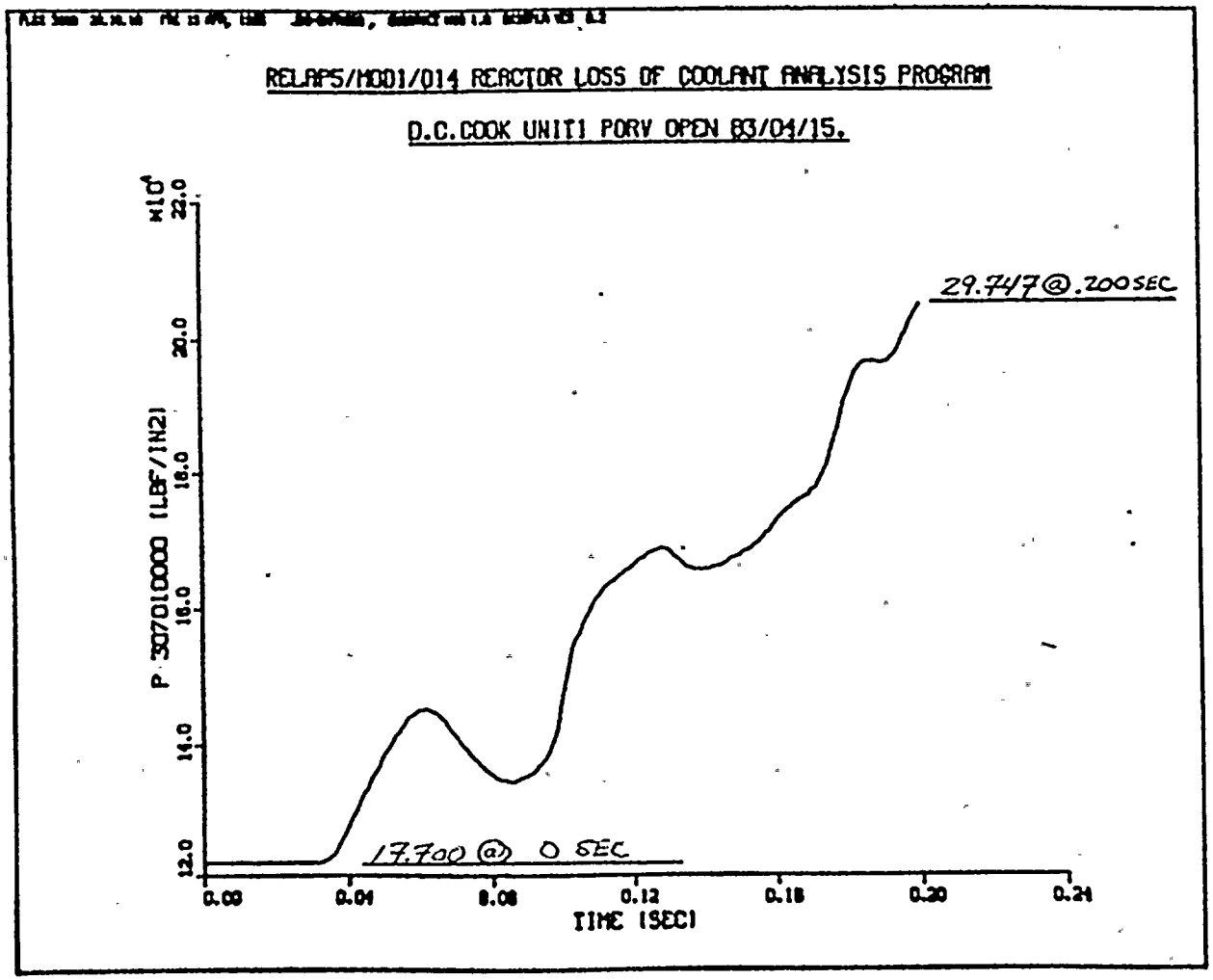


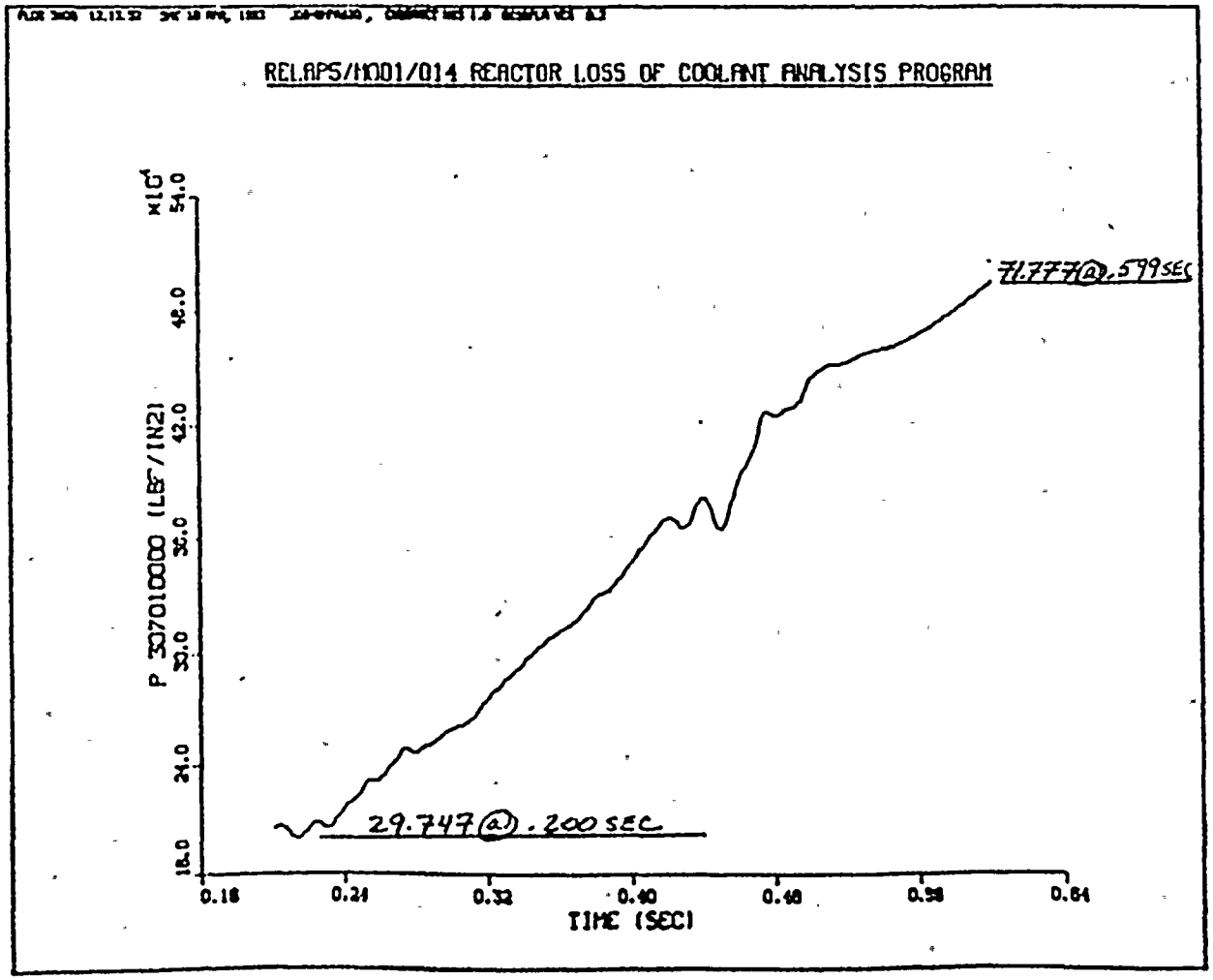

RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/15.
P B115/0000 (LBF/IN2)
×10⁴
18.0
16.0
14.0
12.0
10.0
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)
25.079 @ .199 SEC
17.216 @ .053 SEC

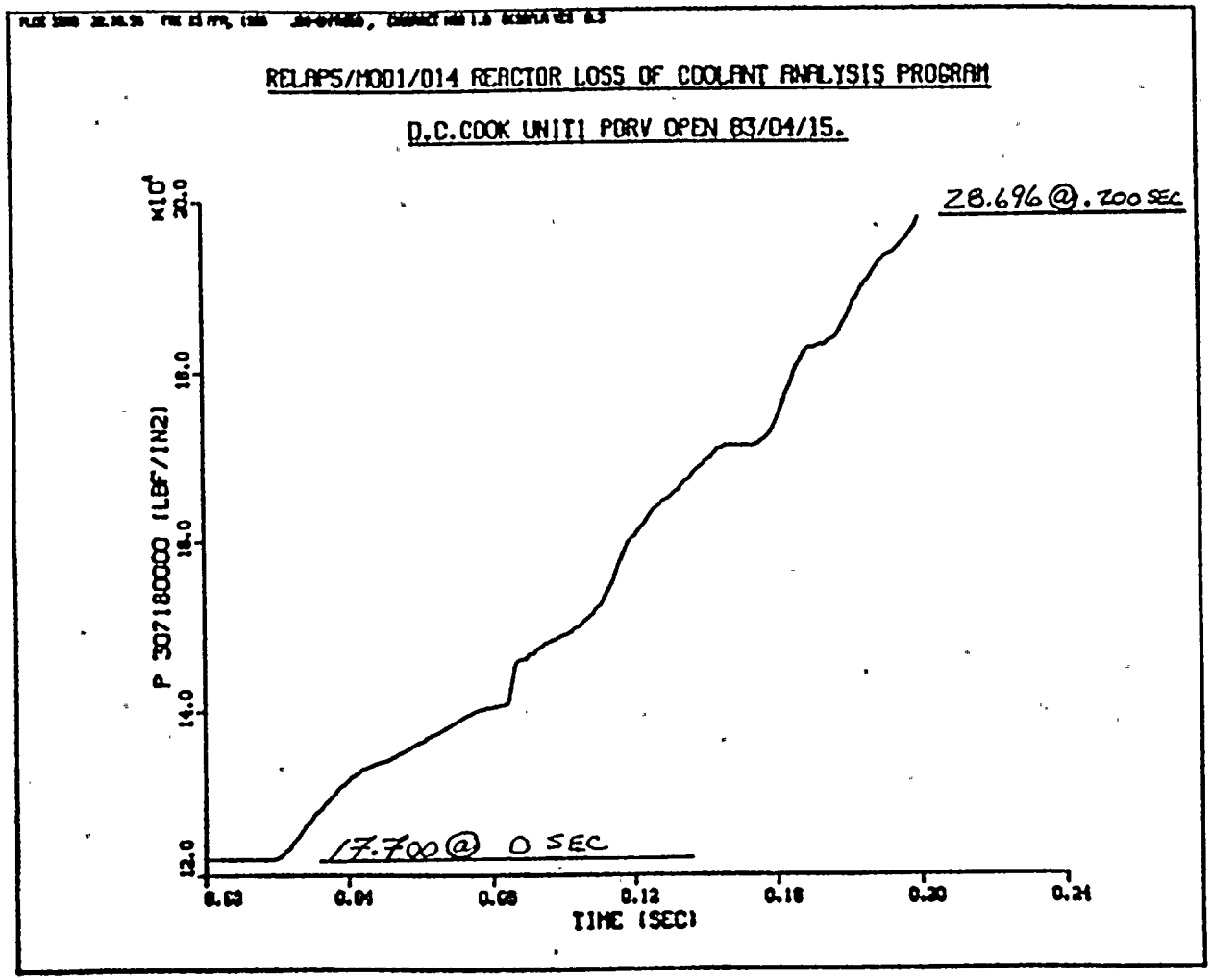
BY CHM DATE 4-29-83
CHKD. BY KJG DATE 4-29-83



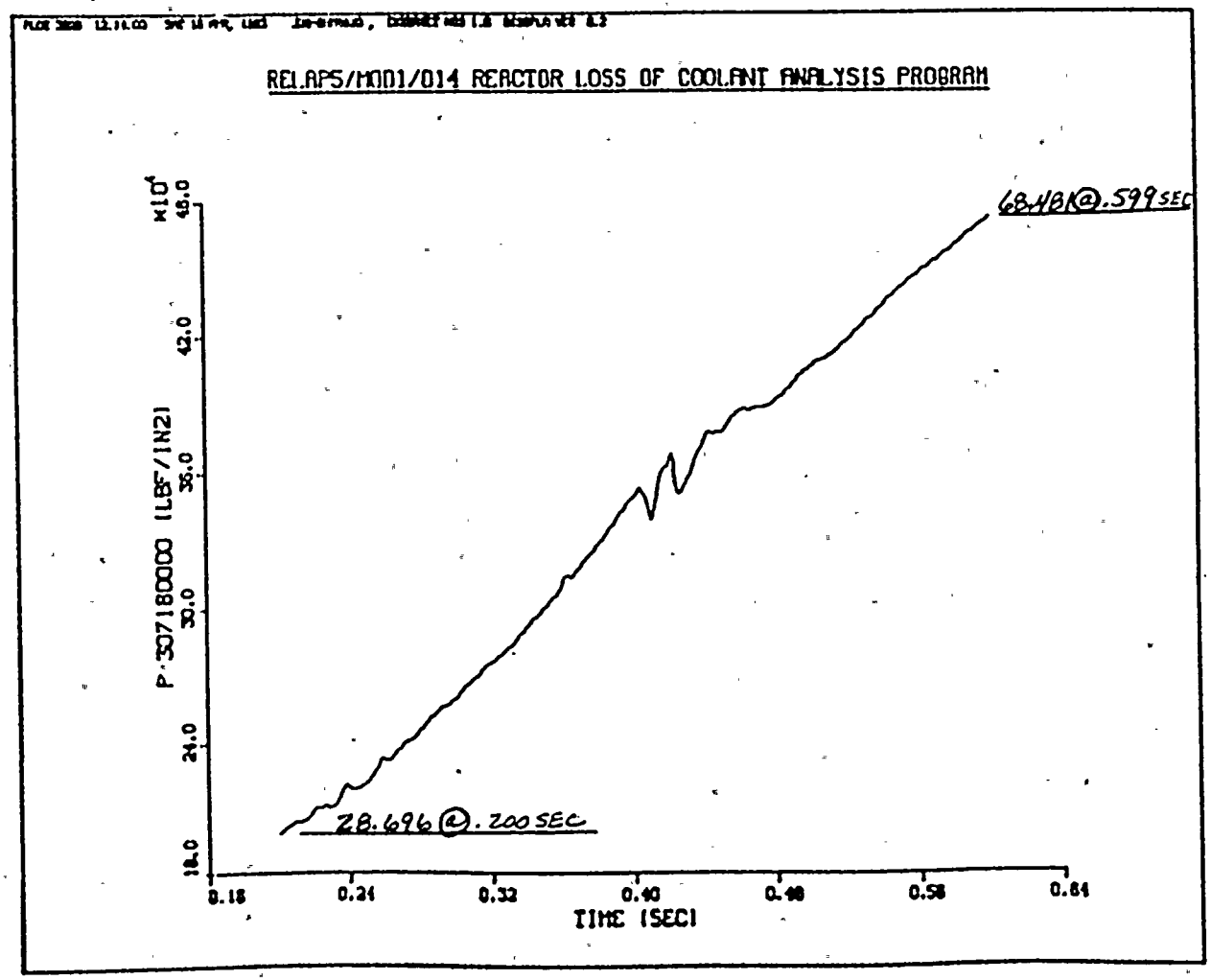

RELAP5/MOD1/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/15.
P 30701 0000 (LBF/IN2)
x10^4
22.0
20.0
18.0
16.0
14.0
12.0
29.747@.200SEC
17.700 @ 0 SEC
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)

BY CHM DATE 4-29-83
CHKD. BY KJG DATE 4-29-83




RELAP5/M001/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/15.
28.696 @ .200 SEC
17.700 @ 0 SEC
P 307180000 (LBF/IN2)
x10⁴
20.0
18.0
16.0
14.0
12.0
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)

BY CHM DATE 4-29-83
CHKD. BY KTC DATE 4-29-83



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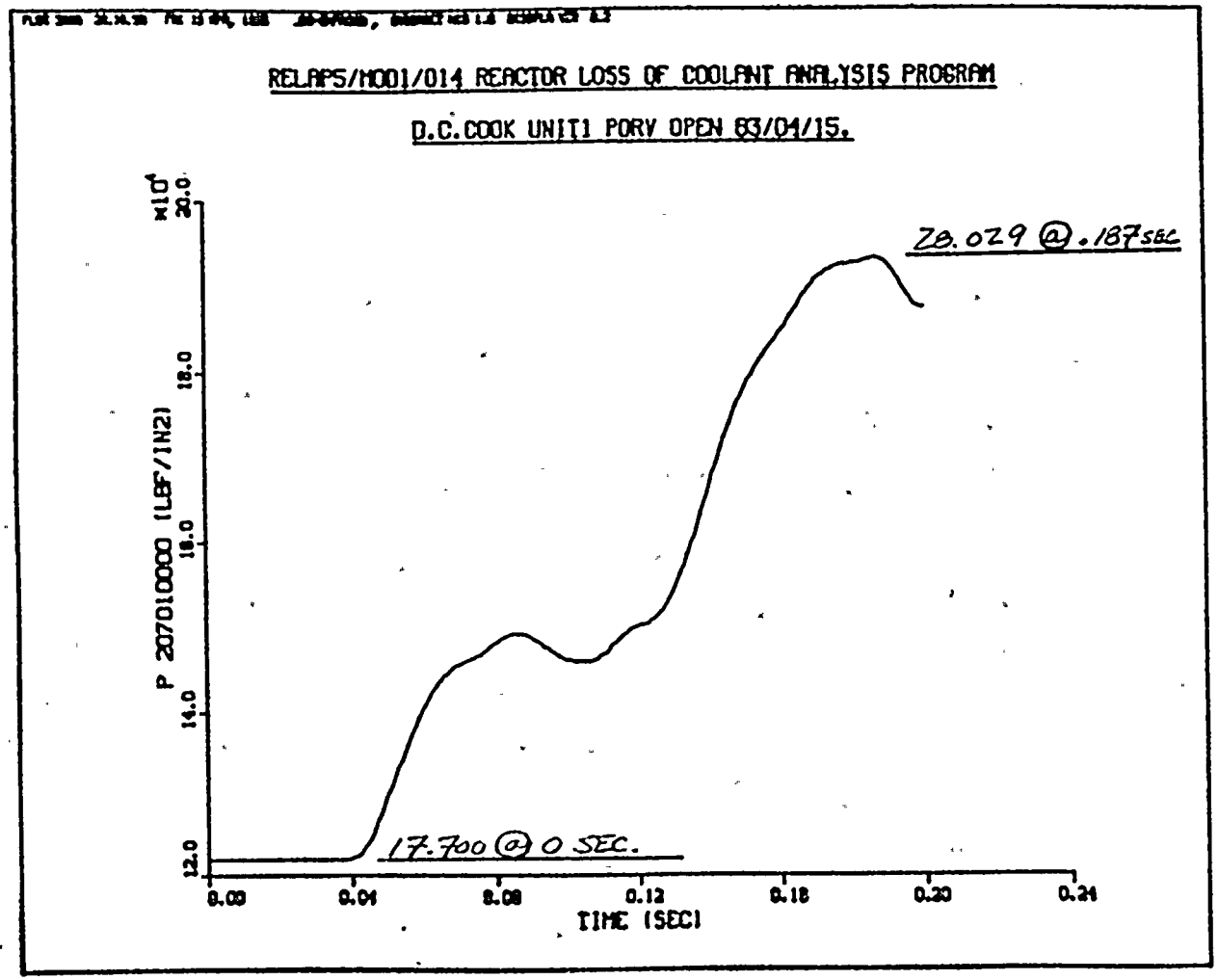
BY CHM DATE 11-27-83
CHKD. BY JBK DATE 11-29-83



BY CMM DATE 4-29-83
CHKD. BY KJG DATE 4-29-83

TELEDYNE ENGINEERING SERVICES

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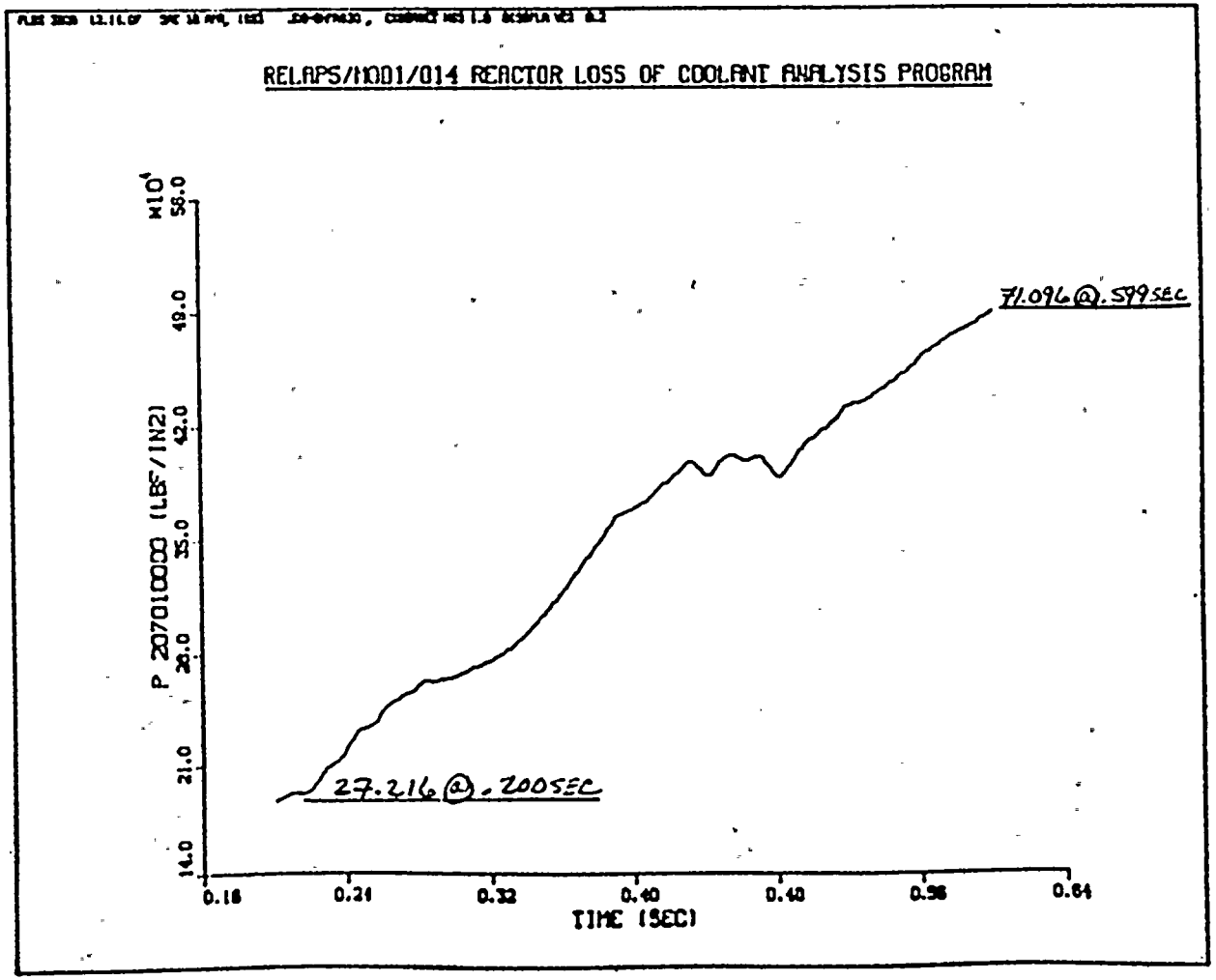
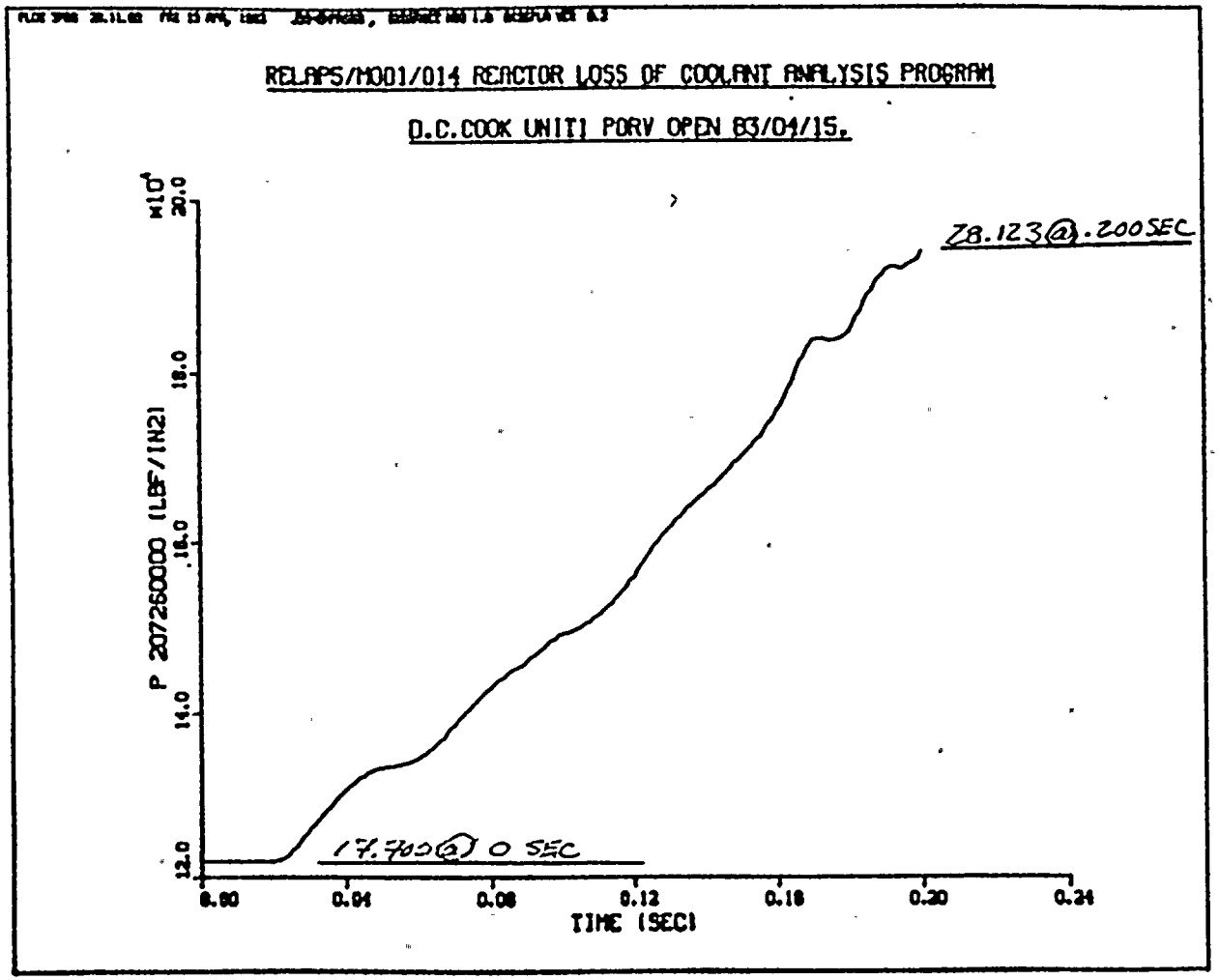
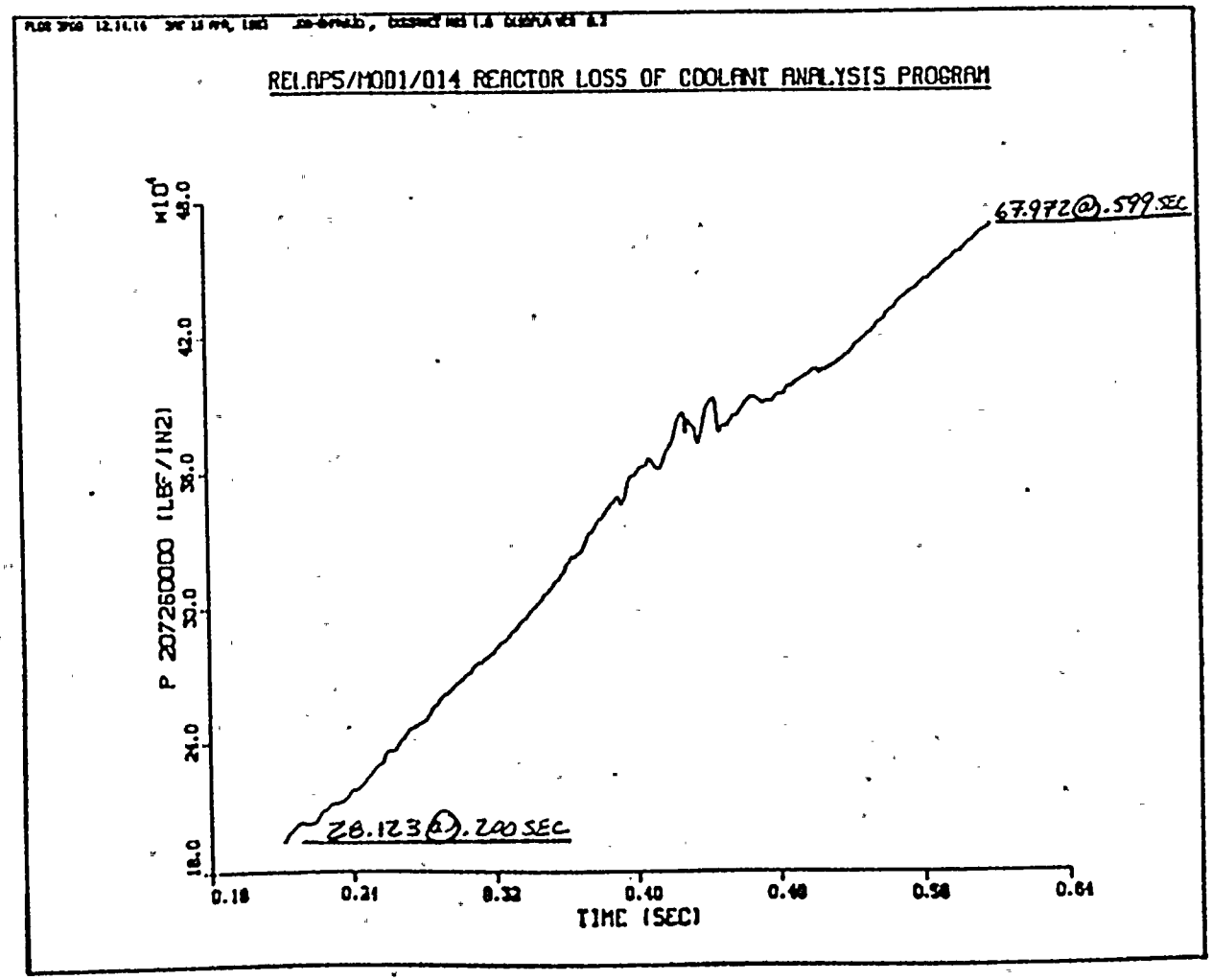
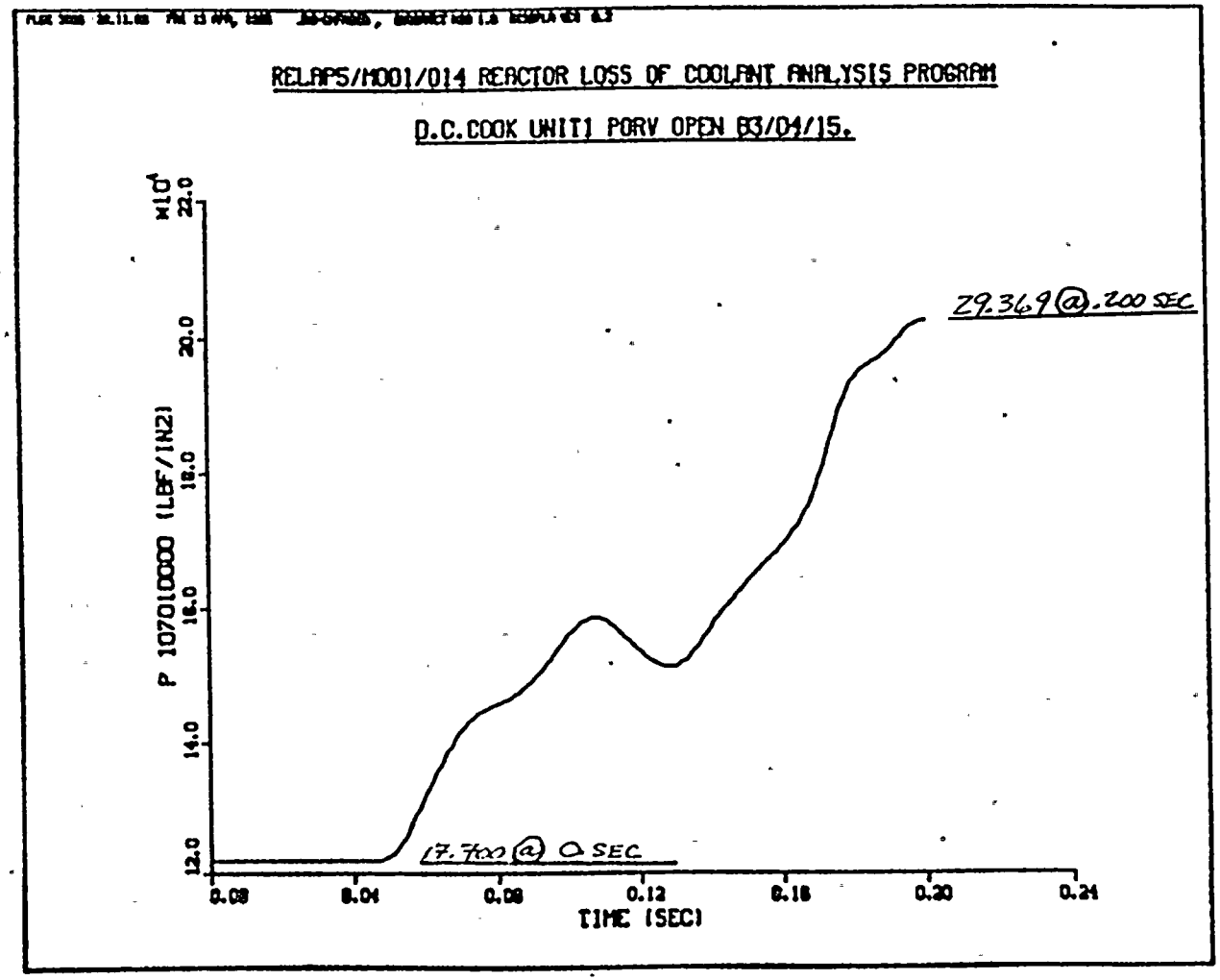


BY UHH DATE 11-29-83
CHKD. BY JBM DATE 4-29-83



BY CHM DATE 4-29-83
CHKD. BY KTG DATE 4-29-83




RELAP5/M001/014 REACTOR LOSS OF COOLANT ANALYSIS PROGRAM
D.C.COOK UNIT1 PORV OPEN 83/04/15.
P 10701000 (LBF/IN2)
x10^1
22.0
20.0
18.0
16.0
14.0
12.0
0.00
0.04
0.08
0.12
0.16
0.20
0.24
TIME (SEC)
29.369 @ .200 SEC
17.700 @ 0 SEC

BY CHM DATE 4-29-83
CHKD. BY KTG DATE 4-29-83

TELEDYNE ENGINEERING SERVICES
Technical Report
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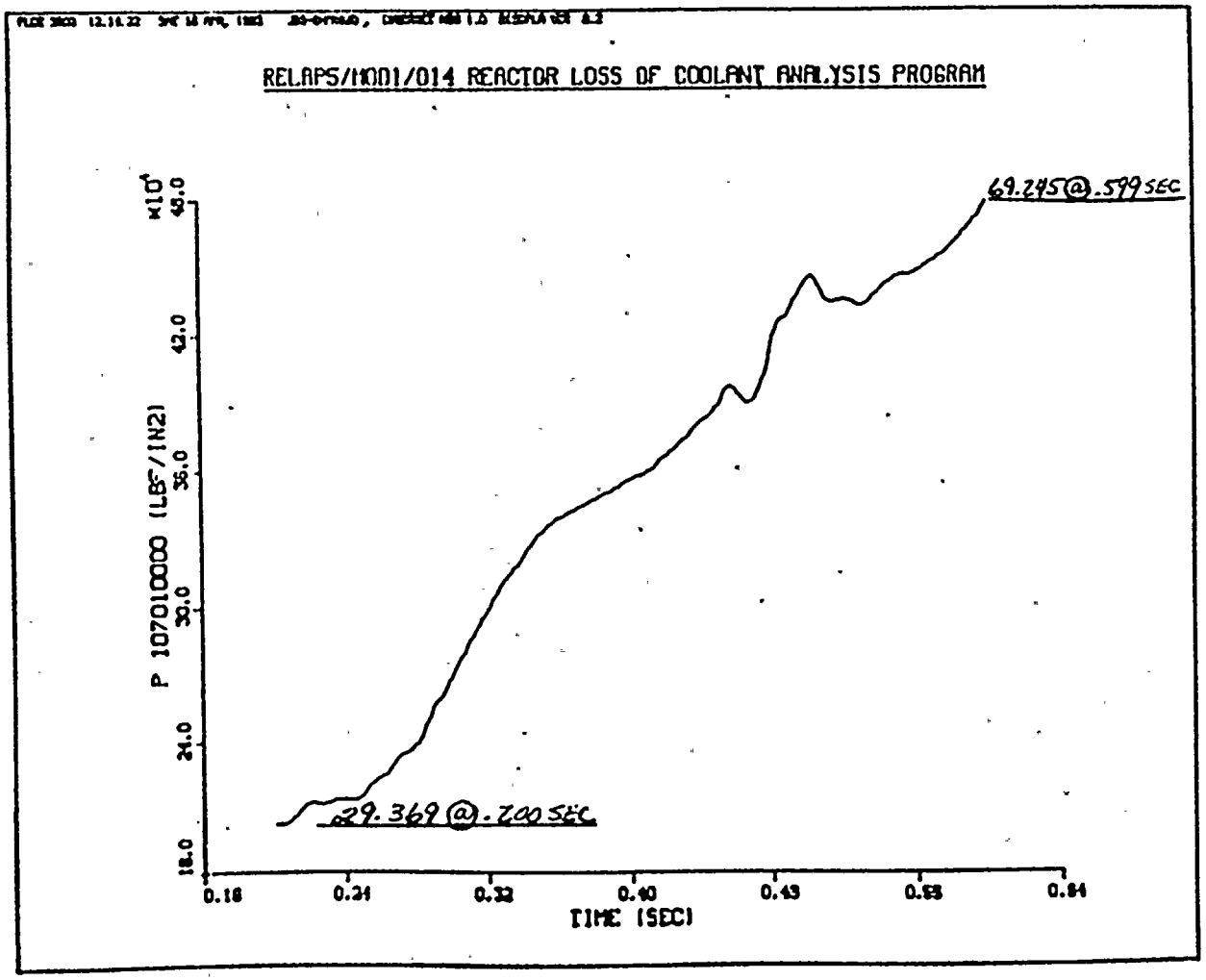
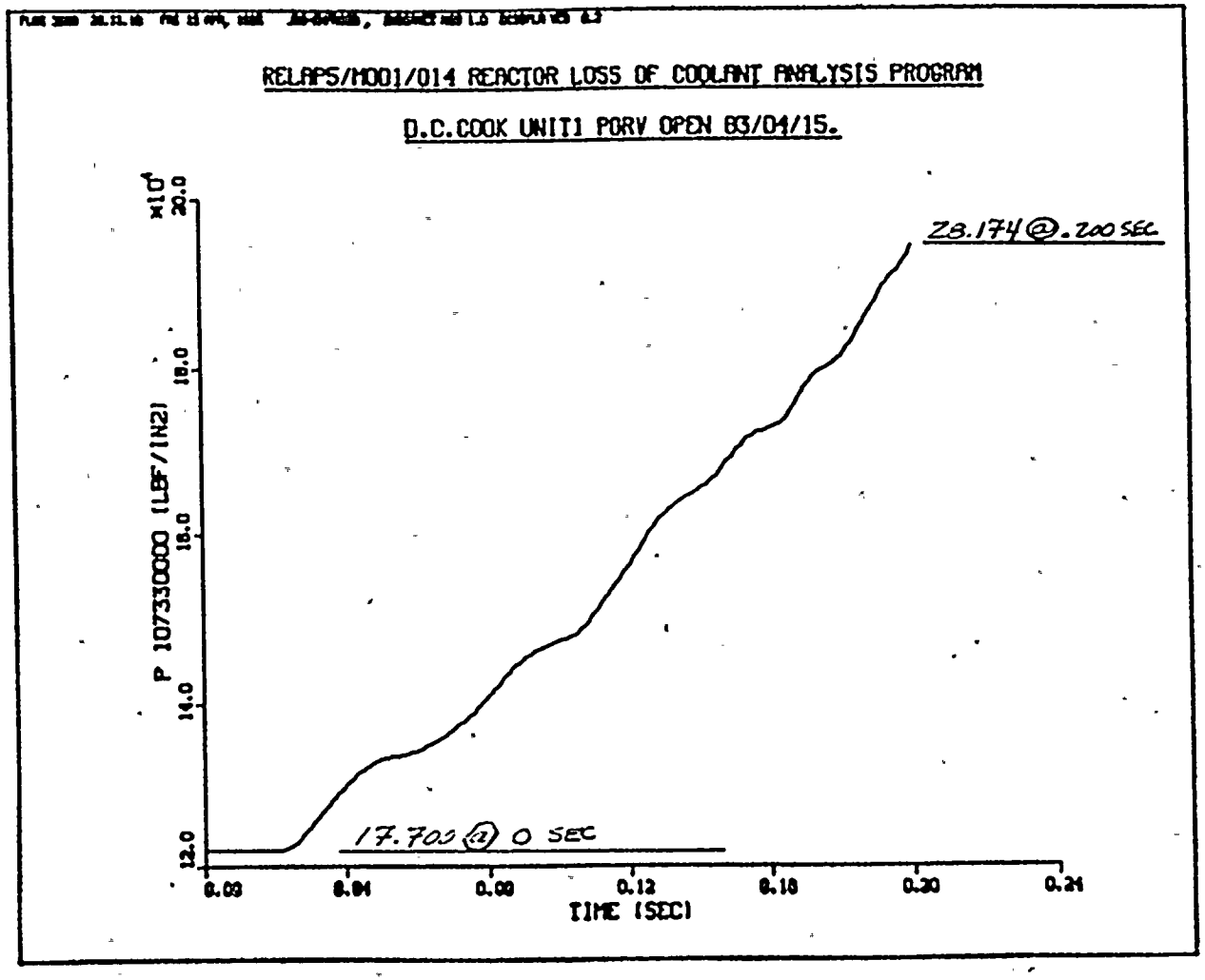
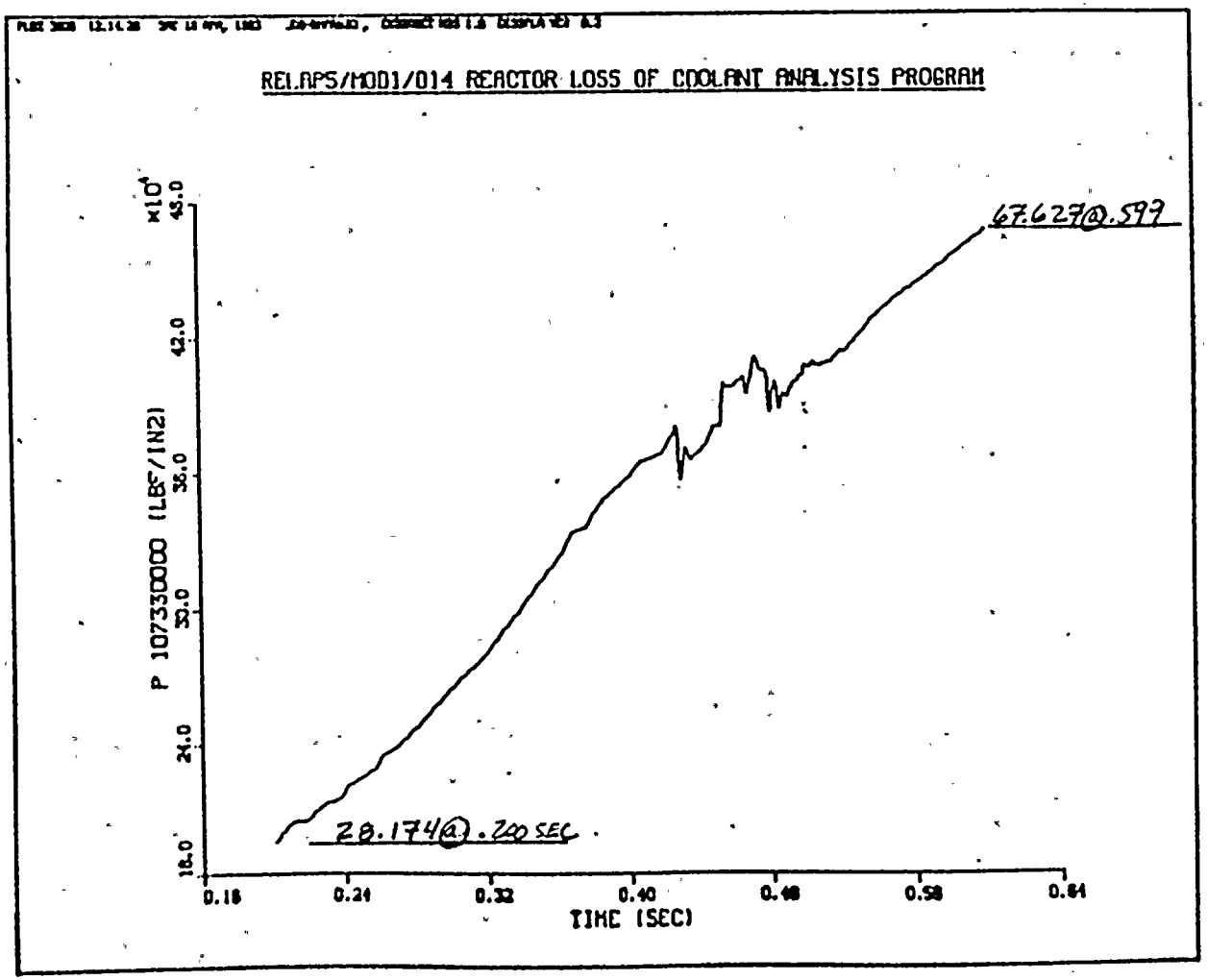


BY JHH DATE 11-29-83
CHKD. BY JBM DATE 4-29-83

TELEDYNE ENGINEERING SERVICES
Technical Report
TR-5364-1
Revision 0



BY CHM DATE 4-29-83
CHKD. BY KJG DATE 4-29-83



4.7.3 Quarter Model - Cold Loop Seal/Steam Case

BY CMM DATE 1-12-83
CHKD. BY RG DATE 5-24-83

1/4 MODEL SRV DISCHARGE
LINE - UNIT 2

SHEET NO. 1 OF 1
PROJ. NO. 5364

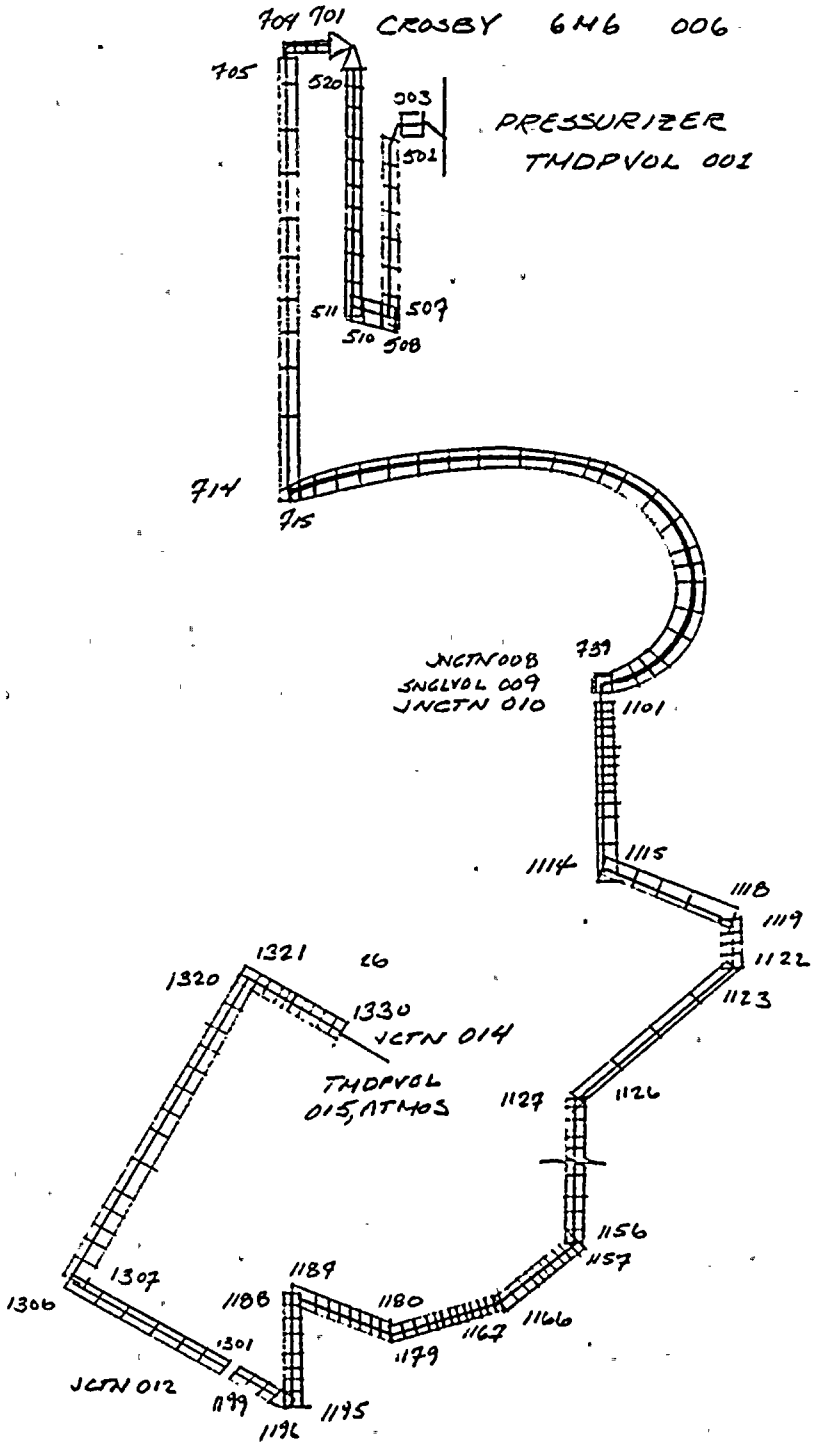
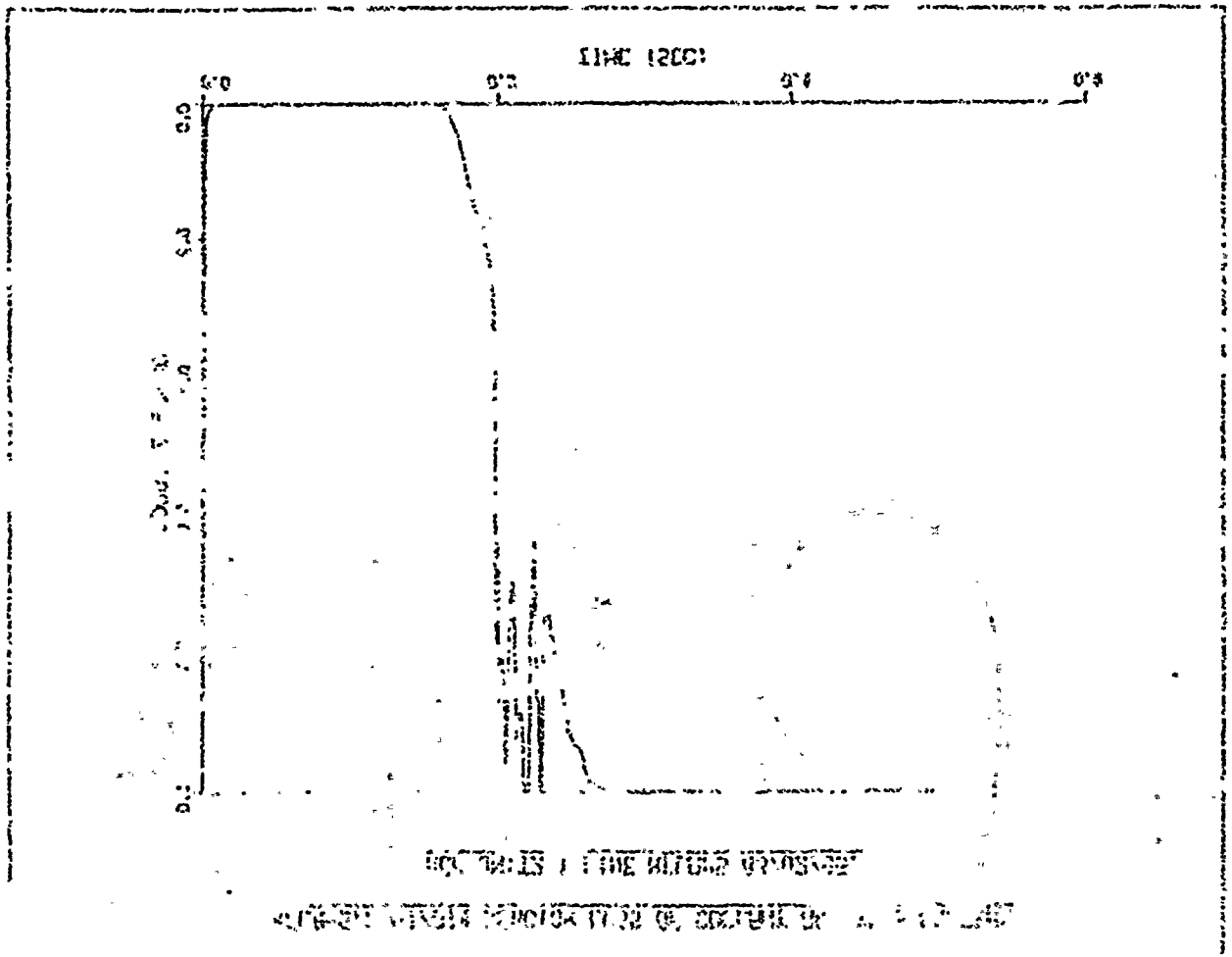


FIGURE 4.7.2-1


0.0
0.2
0.4
0.6
0.8
1.0
TIME (SEC)

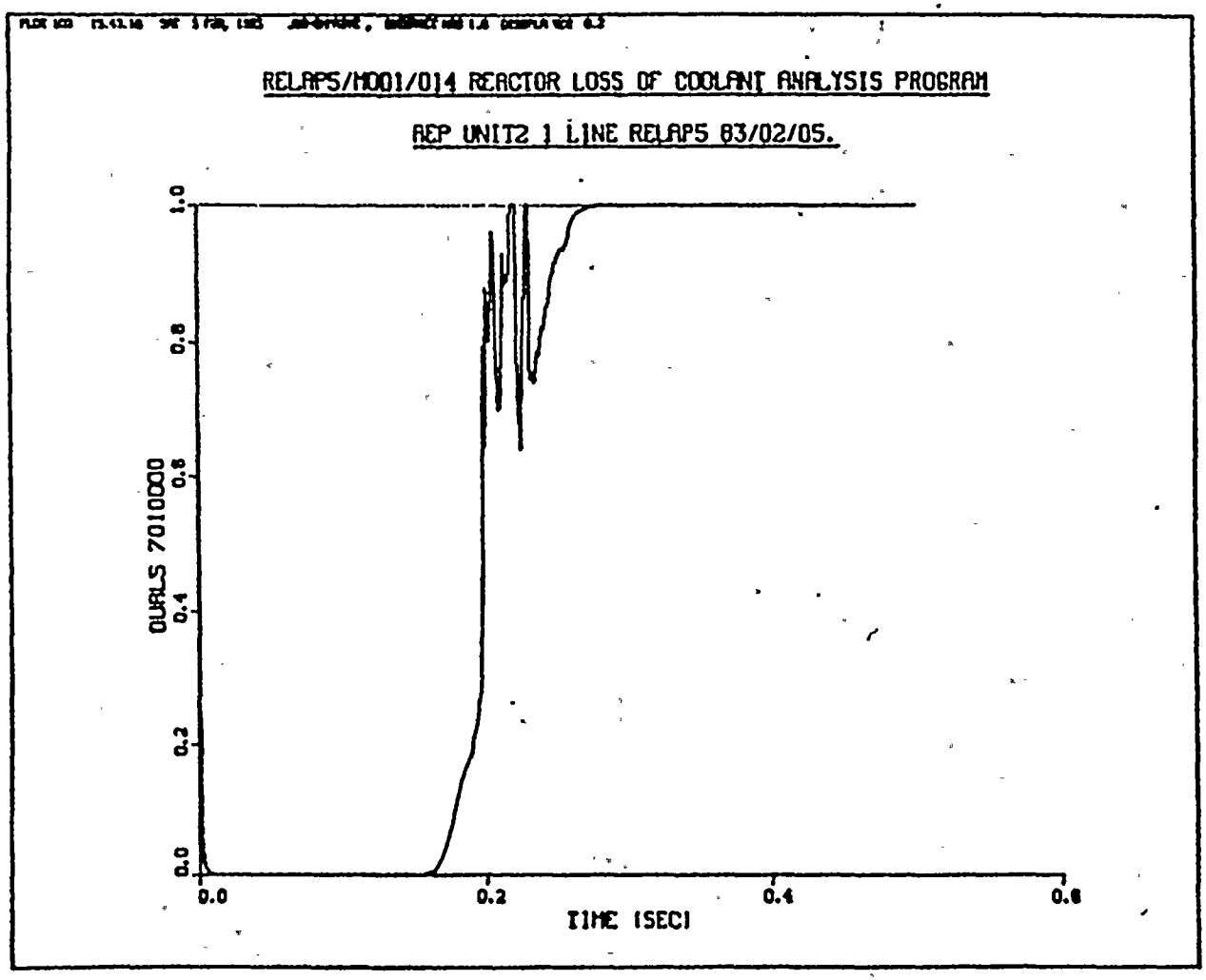
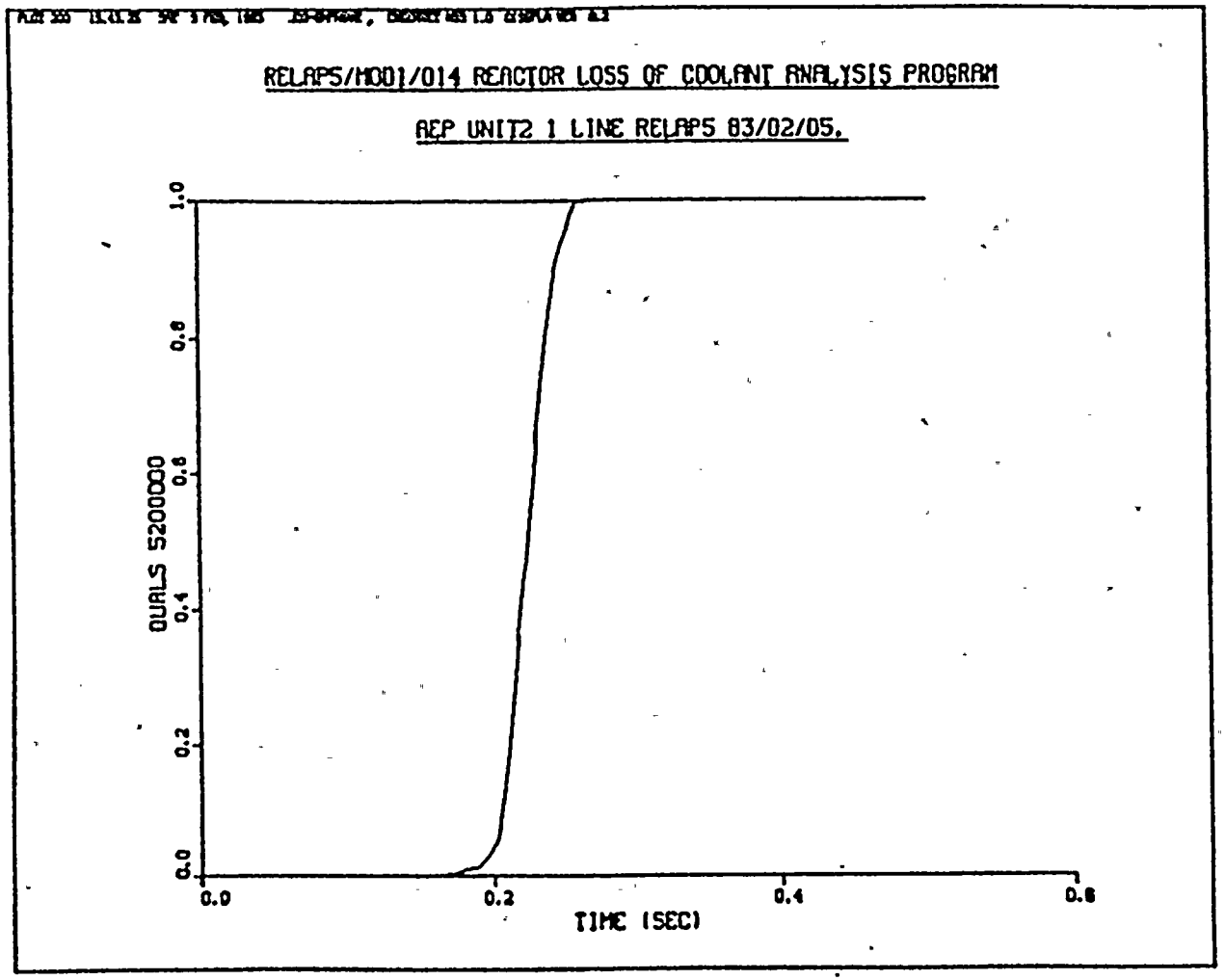
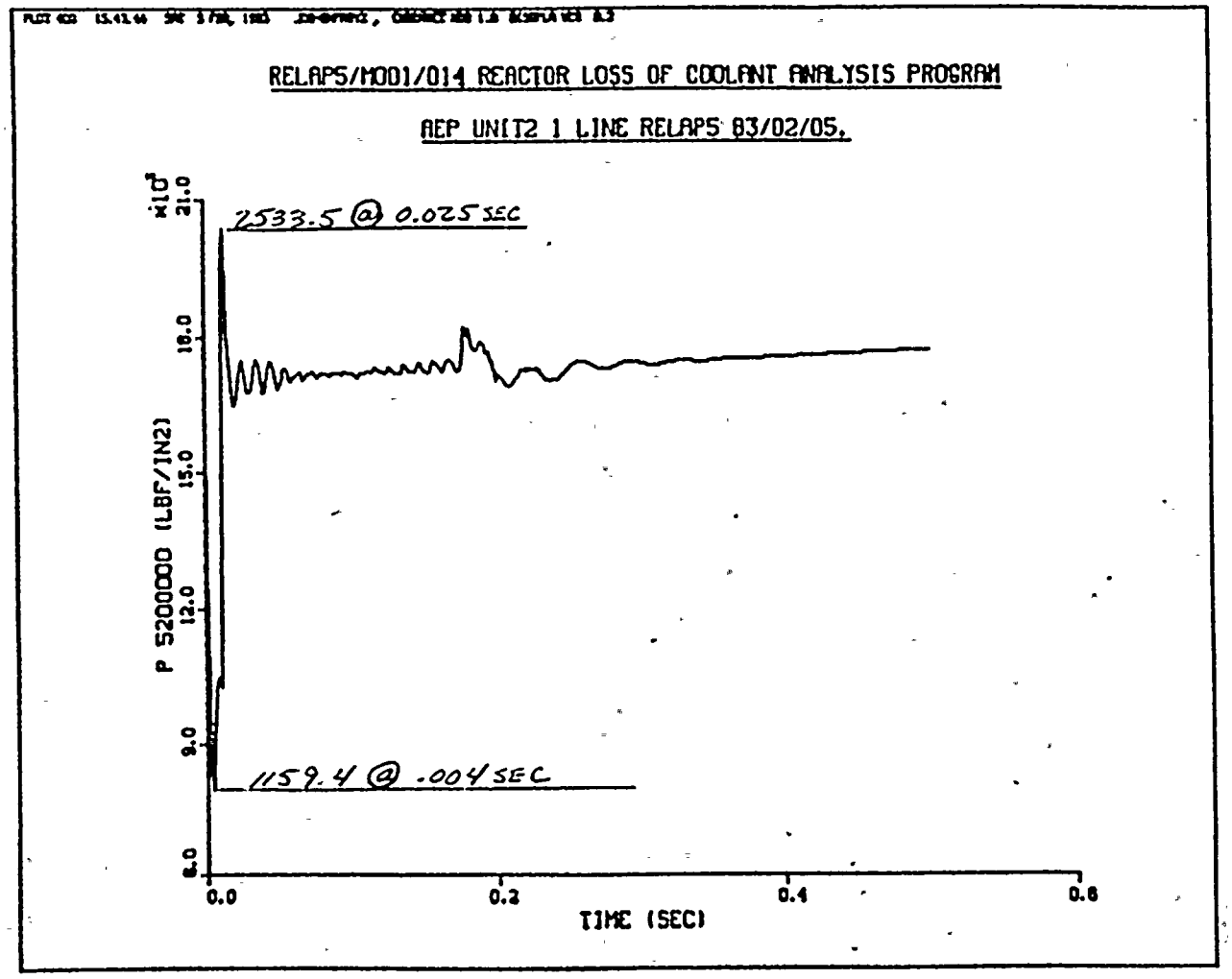
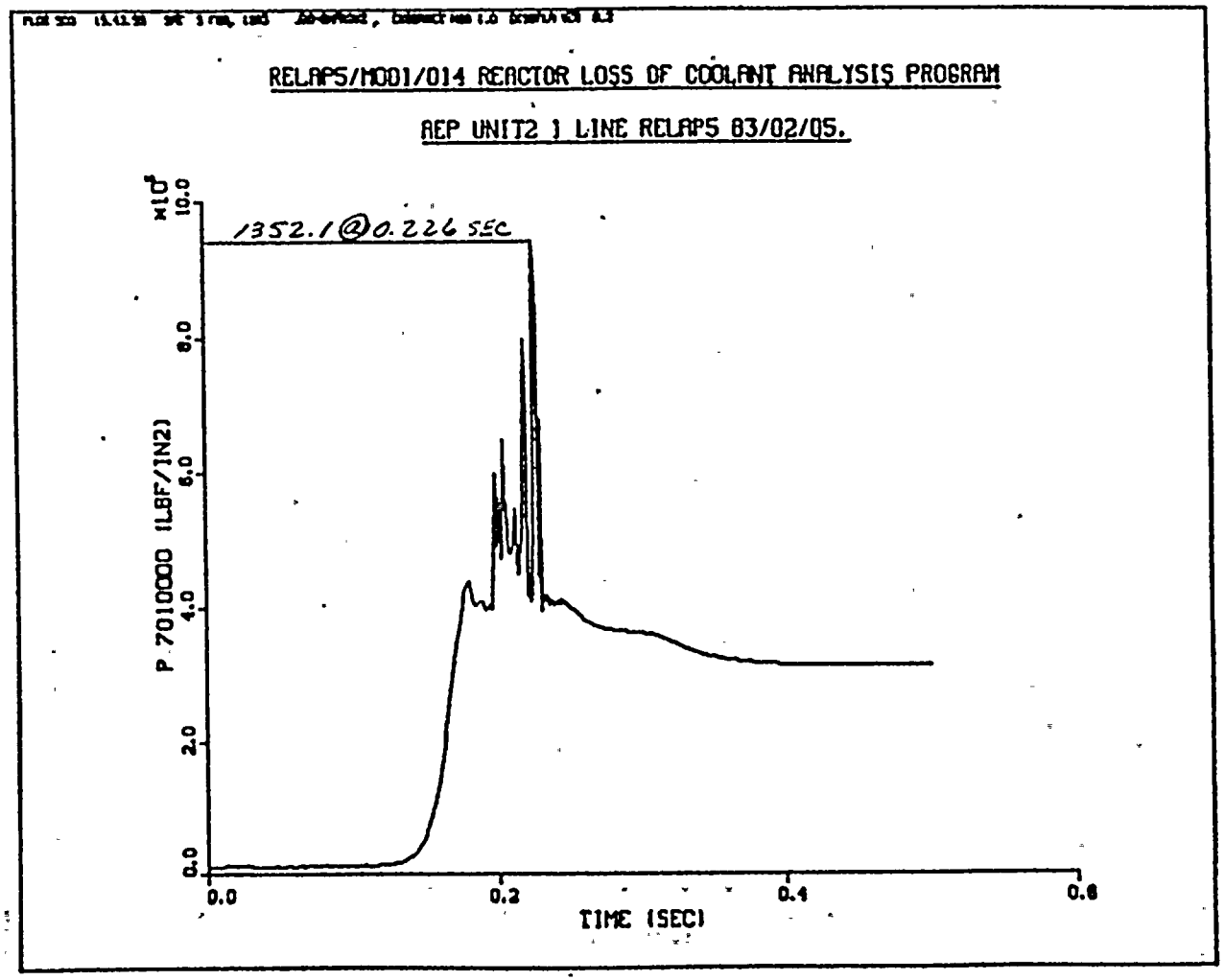
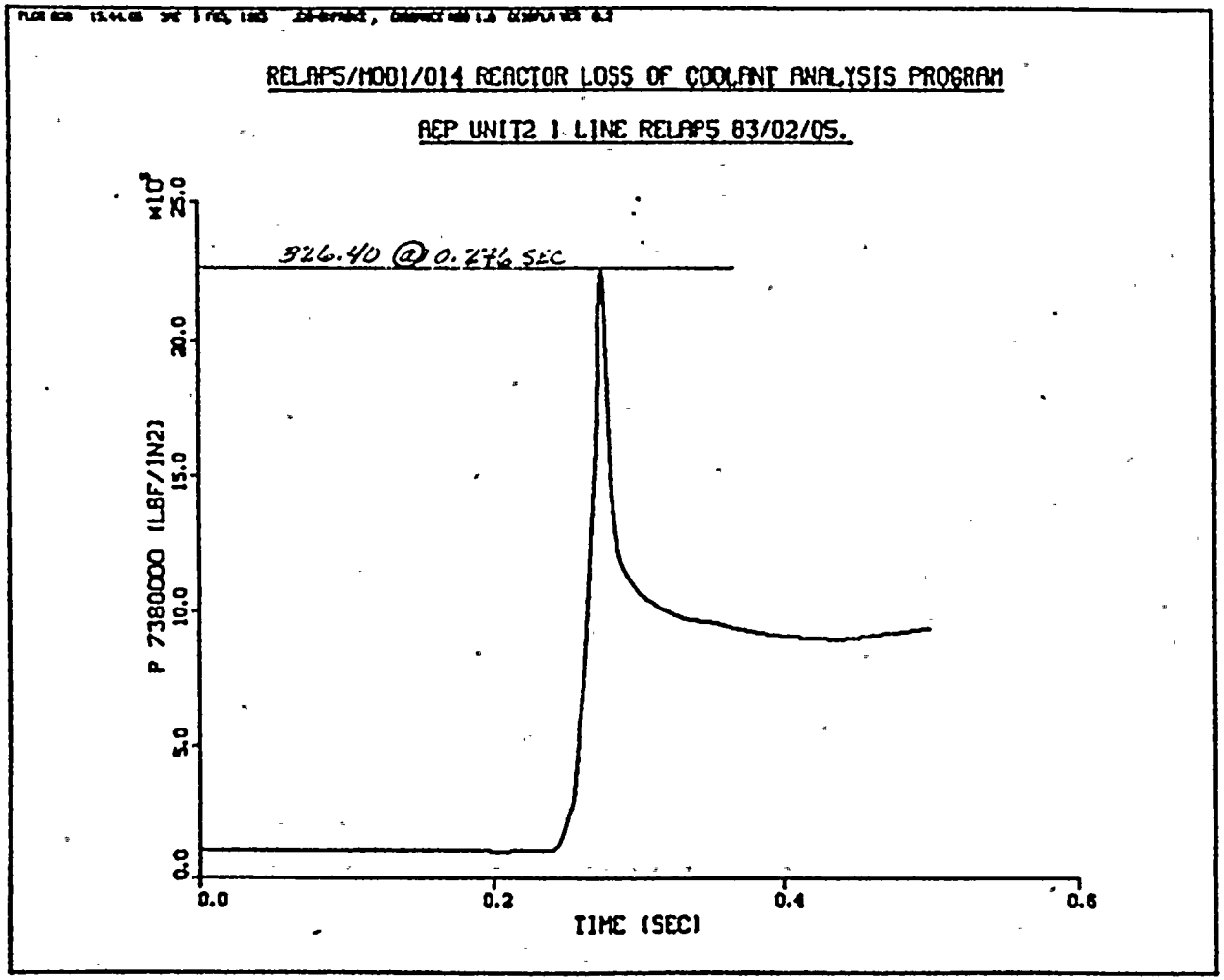


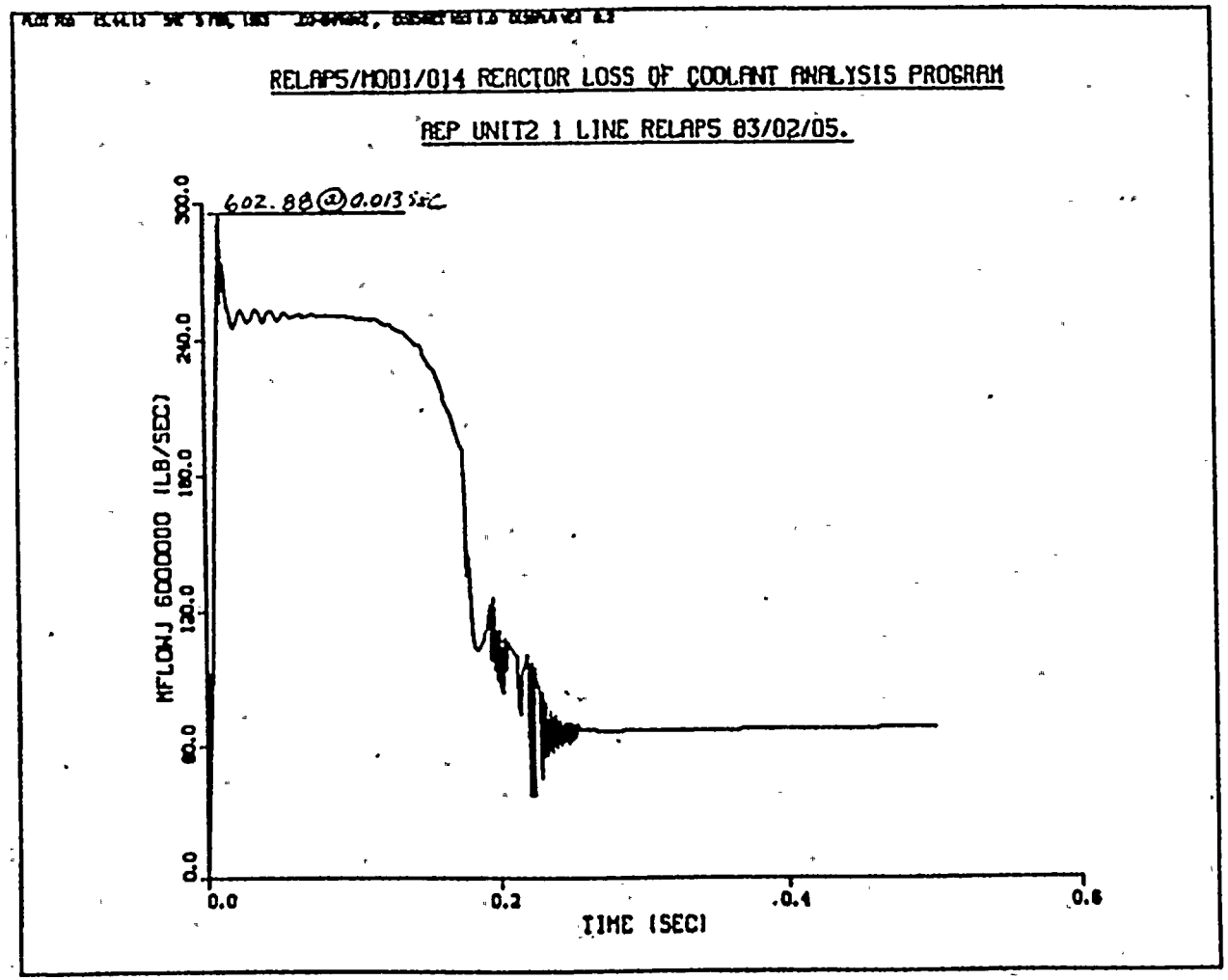
FIG. 7

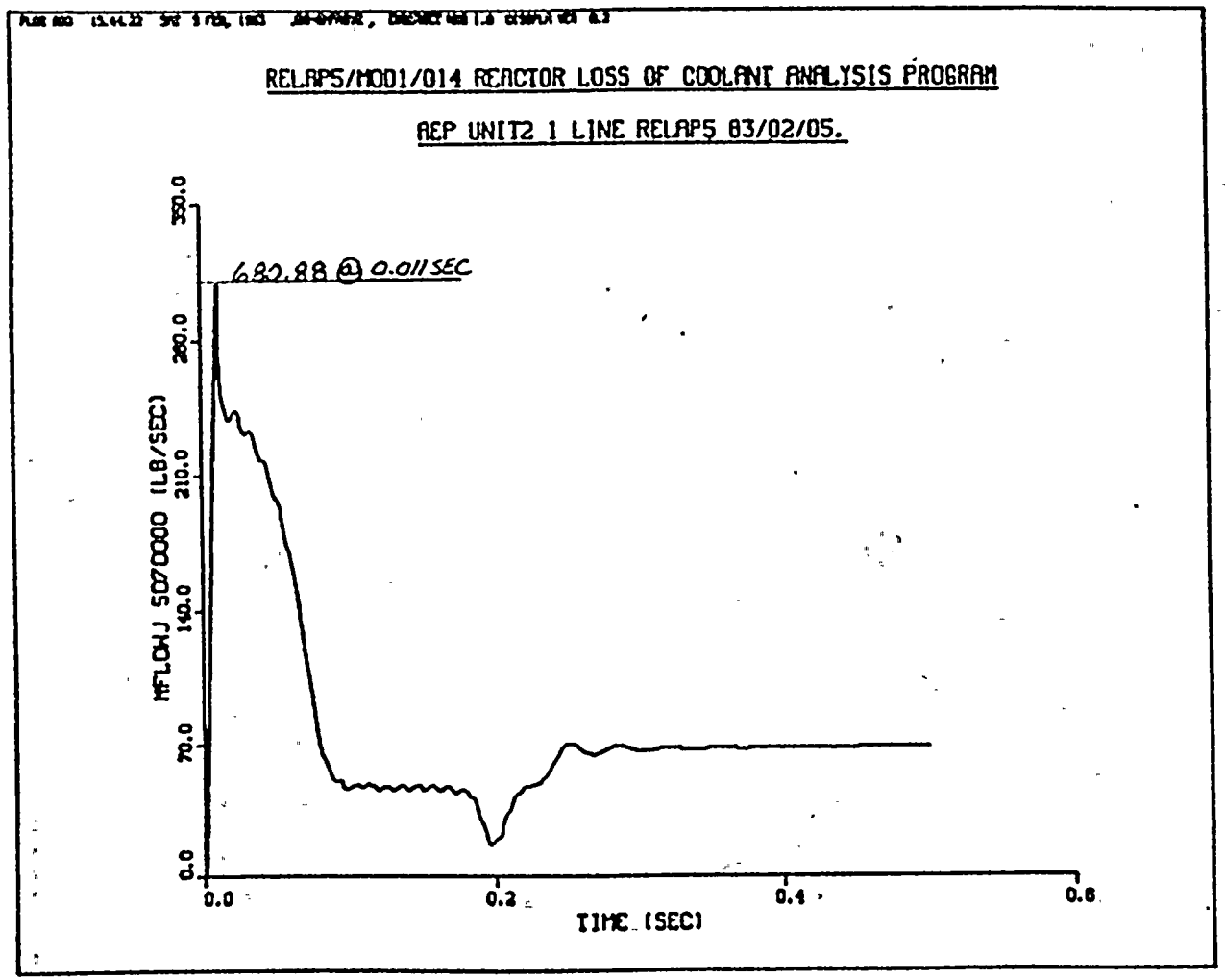


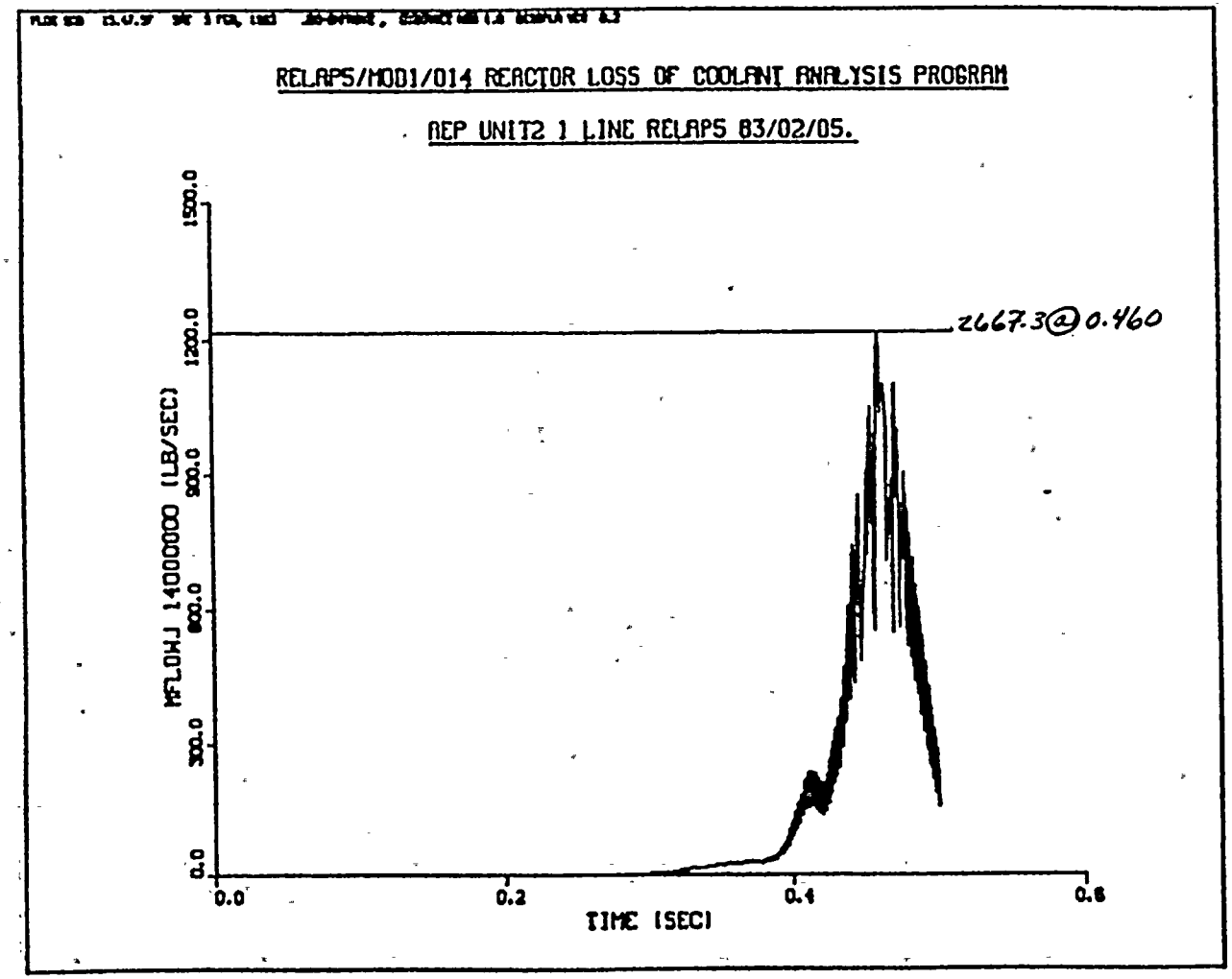


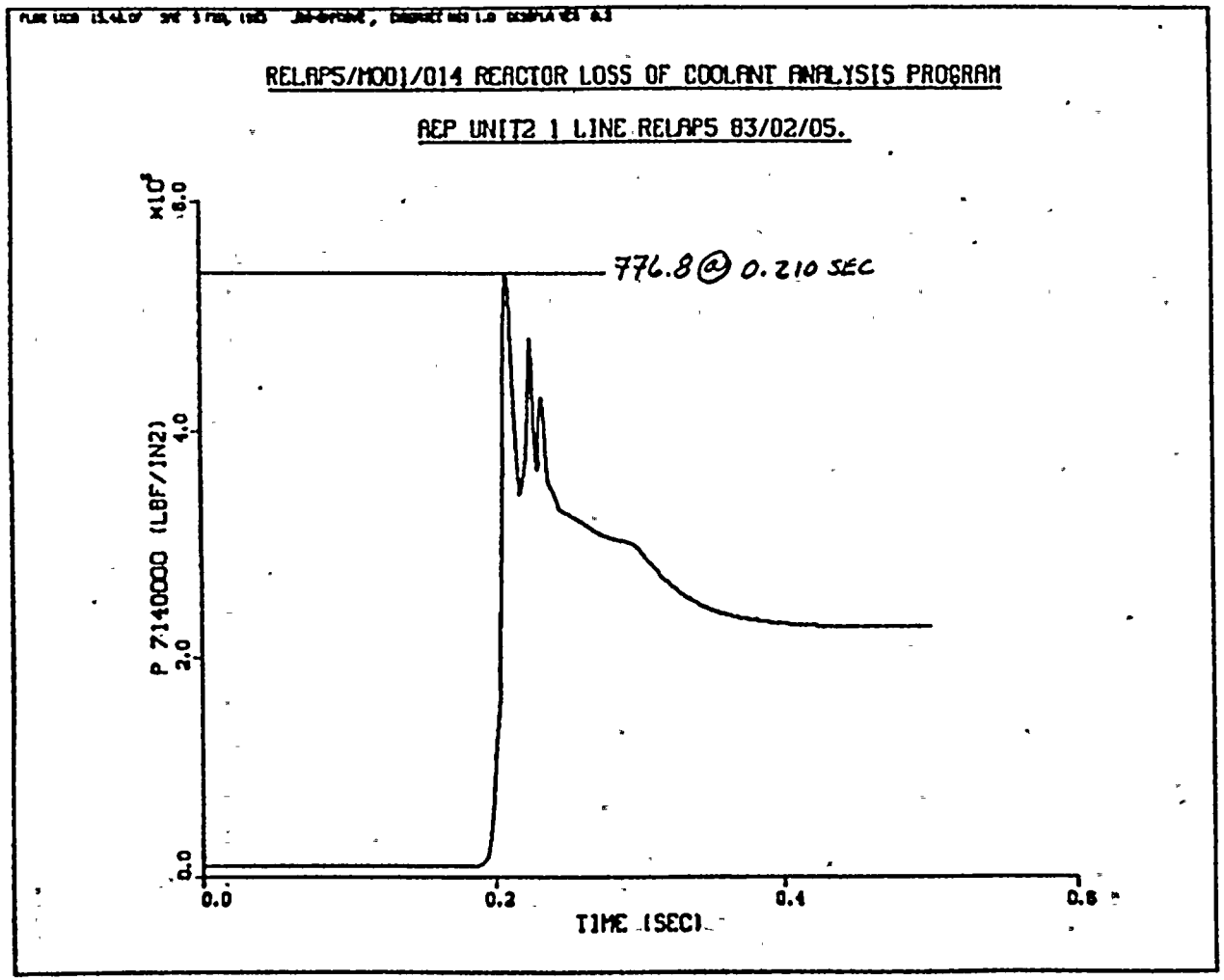


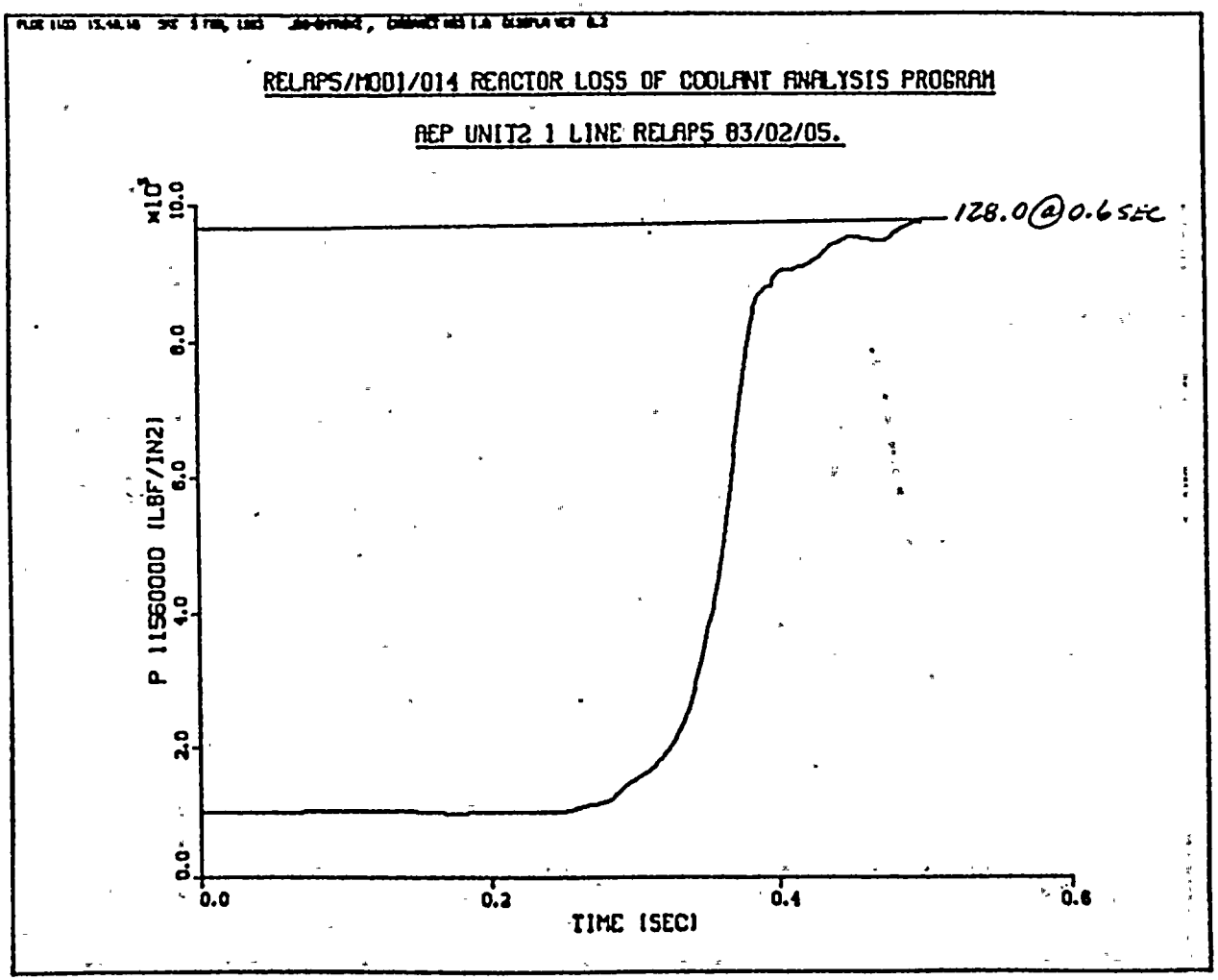




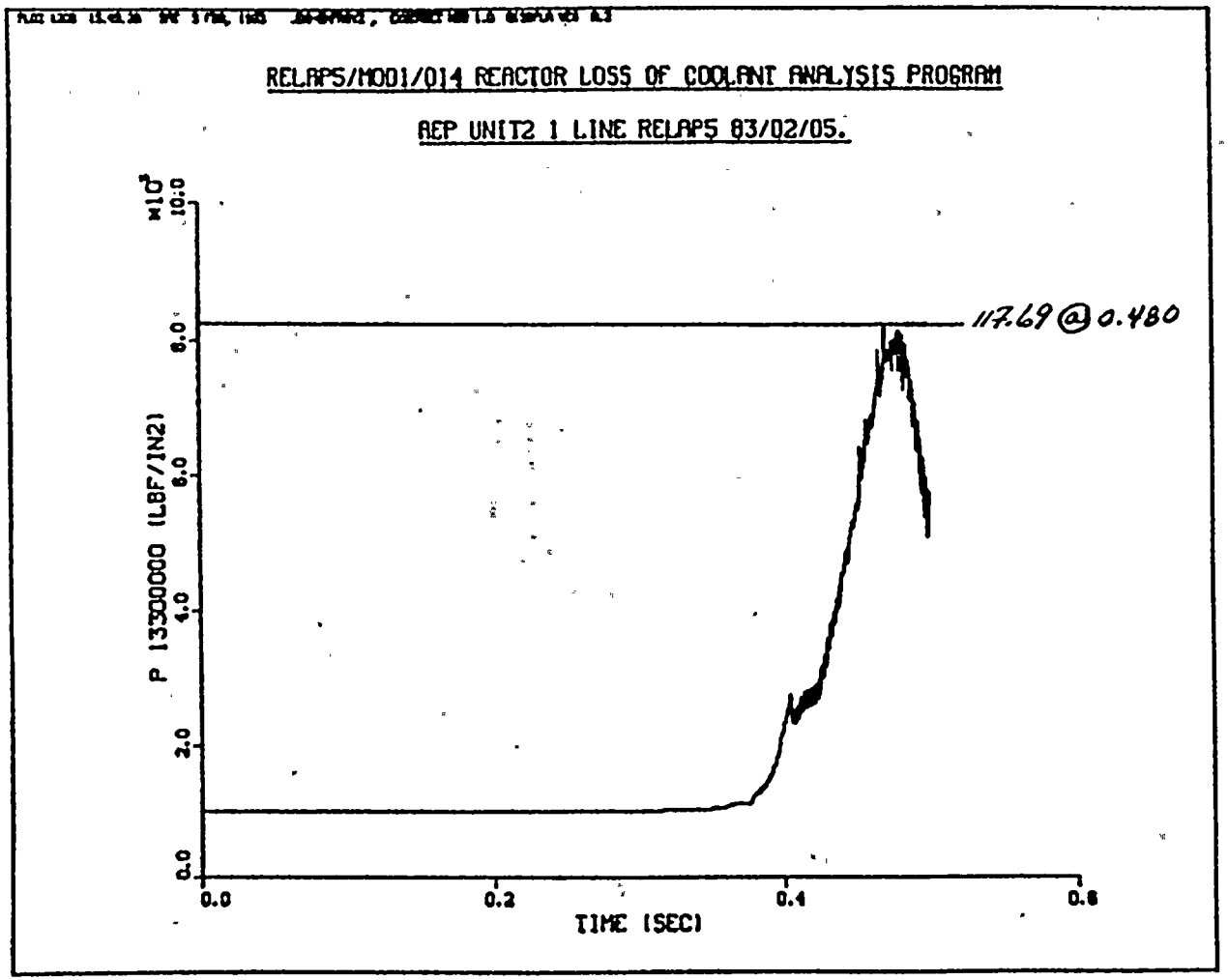




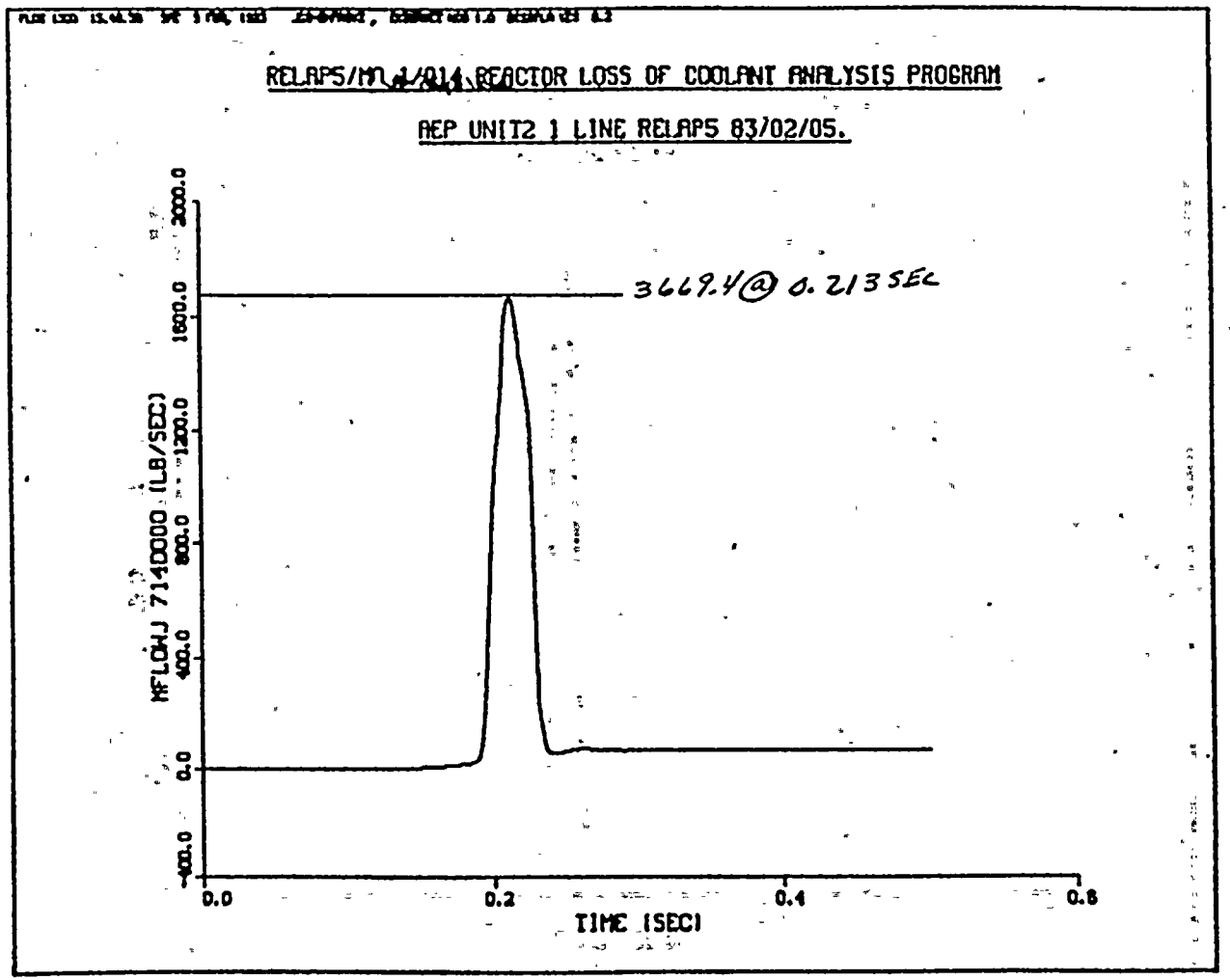




0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0.0
0.1
0.2
0.3
0.4
0.5



TIME (SEC)
0.0
0.5
1.0
1.5
2.0



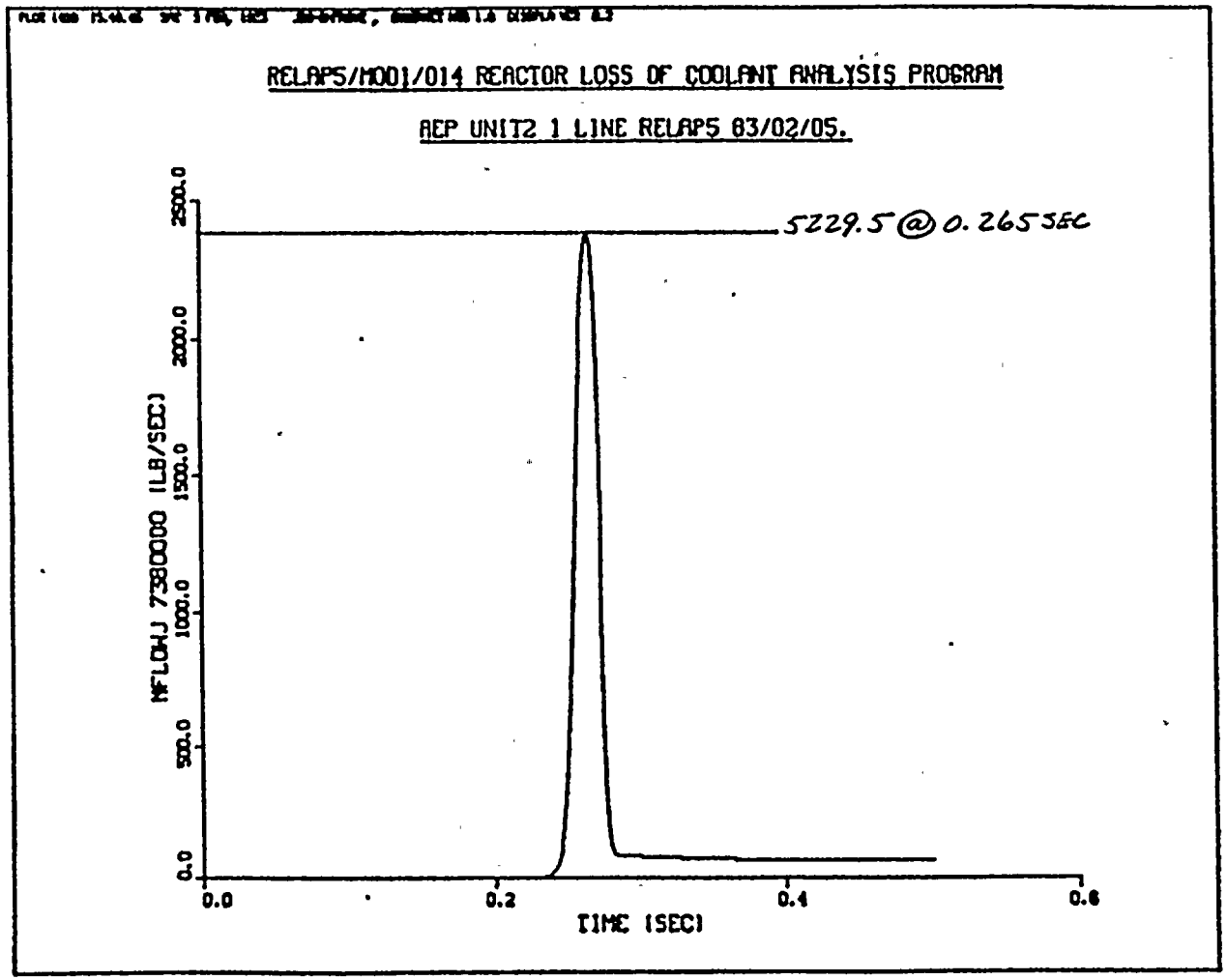


FIG. 4.12 SINE 1 LINE SOURCE 50/50 TO 1000 HZ MOTOR VEHICLE VIBRATION
FREQUENCY SPECTRUM PROBE
2.2E-2 @ 52.5
FREQ. CHAN
1000 HZ
0.0
0.5
1.0
1.5
2.0
0.0000
0.0001
0.0002
0.0003
0.0004
VOLTAGE (DIMENSIONLESS)

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