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Accelerator Development Department

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SSC Technical Note No. 94

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PRESSURE RELIEF RADIAL PASSAGES FOR SSC

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Pressure relief radial passages for SSC

1. Introduction

In the 40mm SSC cross-section design radial helium venting passages located every 6 in were present. The purpose of these passages was to provide escape routes for helium from the coil cooling passage to the bypasses during a quench. The passages are introduced in the magnet by placing special yoke laminations with channels going from the bypasses to the inner radius.

The question as to whether the venting passages are still needed in the 50 mm design is addressed here. One might expect that they would be more needed here since the stored magnetic field energy increases considerably faster than the coil cooling passage cross-section, unless the width of the latter is increased.

Since the dimensions of the beam tube are not fixed at this time two cases are considered: a coil cooling passage gap of 1.3 mm and one of 5 mm.

An existing computer code developed at Brookhaven National Laboratory by R.P. Shutt and programmed by K. Jellet is applied to the present problem. The theoretical contents of the code are described in [SSC-N-266 No 59]. Pressures, helium, coil, and yoke temperatures, and mass flows are computed during a quench for one magnet with no venting occurring in the interconnect regions.

2. Results

The relief passages are one lamination deep, that is d=0.06 cm (1/16 in). The case where there are no passages is simulated with d=0.001 cm.

Of all the results produced by the calculations, that which is of most interest is the helium pressure around the beam tube, where the pressure is expected to be the highest. Figures 1 to 4 illustrate helium pressure (at the location where it is maximum) around the beam tube as a function of time, and the table summarizes the results.

Table 2.1: Pressures around the beam tube (* pressure still rising at end of time for which pressure is calculated)

coil cooling pass. gap mm	1.3	1.3	5	5
relief passages	yes	no	yes	no
max pressure around beam tube (atm)	12.6	29.4*	10.0*	8.5*

Figure 1 shows that the maximum pressure around the beam tube is 12.6 atm when the relief passages are present and when the coil cooling passage gap is 1.3 mm. In the absence of these passages Figure 2 shows that the pressure rises to 29.4 atm and above which is above the 20 atm design pressure. If the coil cooling passage gap were 5 mm then Figures 3 and 4 show that the presence of relief passages has little effect on the pressure around the beam tube. In Figures 2,3 and 4 pressures are still rising at the end of the shown time periods. However, in Fig. 2 the design pressure has already been exceeded, and at the end of the time periods in Figs.3 and 4 vent valves in interconnections would have opened, relieving the pressure fast. Concerning Fig.2, the maximum pressure in the interconnection is only 4.5 atm.

3. Buckling pressure

These pressures should be compared with the 20 atm design pressure and the critical pressure for buckling. A formula from "Roark's Formulas for stress and strain,W.C. Young, Mc–Graw Hill" gives the critical pressure of an externally pressurized tube:

$$p = \frac{t}{R}\frac{\sigma_y}{1 + \left(\frac{4\sigma_y}{E}\right)\left(\frac{R}{t}\right)^2}$$

For a beam tube of radius R=0.8 in (2.0 cm), thickness t=0.06 in (0.15 cm) and yield strength σ_y = 30000 psi then p=1314 psi=91.8 atm (9. MPa). If there are no relief passages for the 1.3 mm gap the safety factor for the beam tube is 3. Thus the beam tube would still be safe even while exceeding the design value of 20 atm.

On the other hand if the shell thickness is halved then p=292 psi=20 atm (2 MPa) and the beam tube will fail.

4. Conclusions

If the coil cooling passage gap is 1.3 mm as it was in the 40 mm design then relief passages are needed in order to remain below the design pressure of 20 atm for the beam tube.

For a 5 mm coil cooling passage gap relief passages are not needed.

1.3mm gap maximum pressure around beam tube with venting

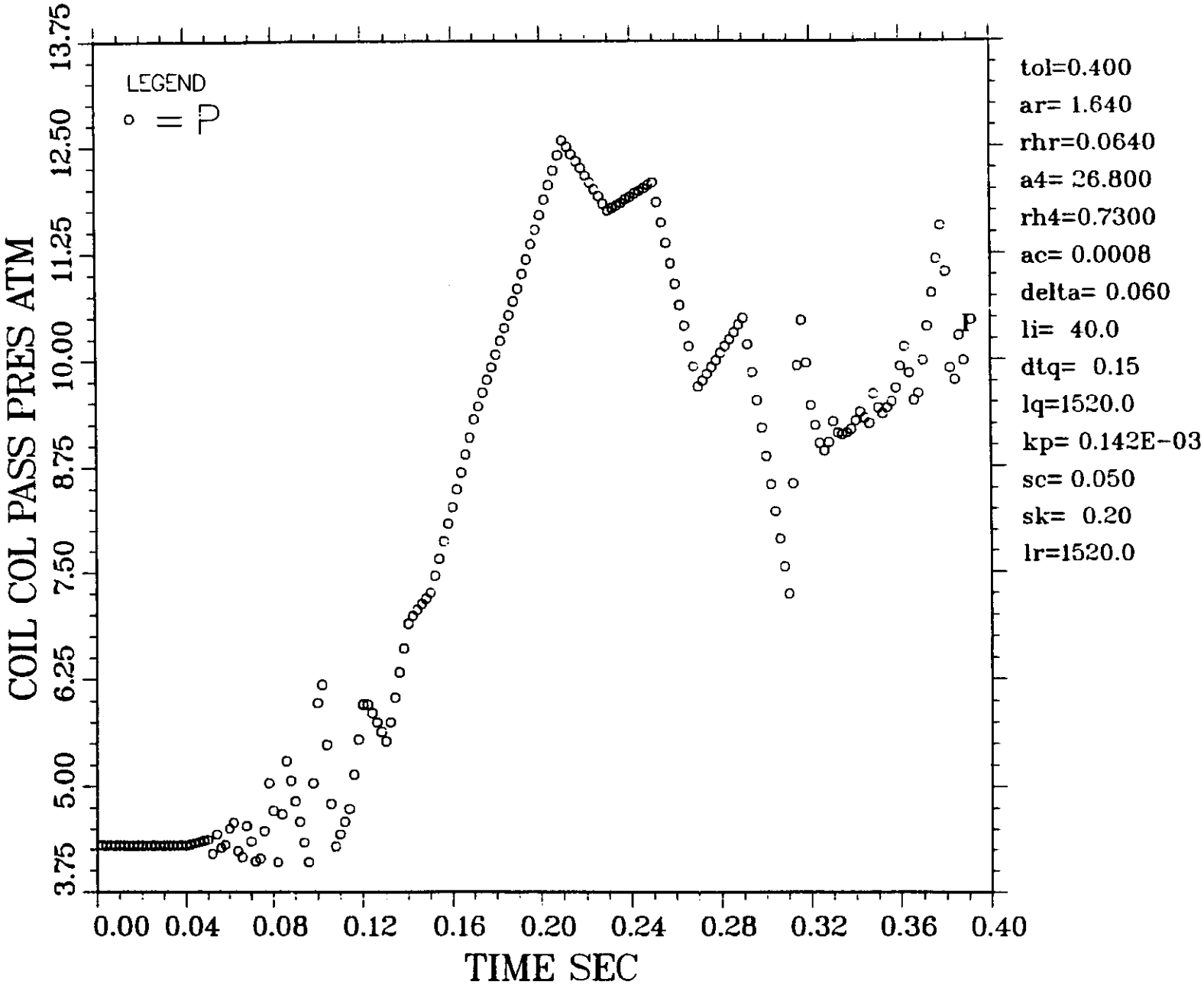

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Figure 1.

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1.3mm gap maximum pressure around beam tube without venting

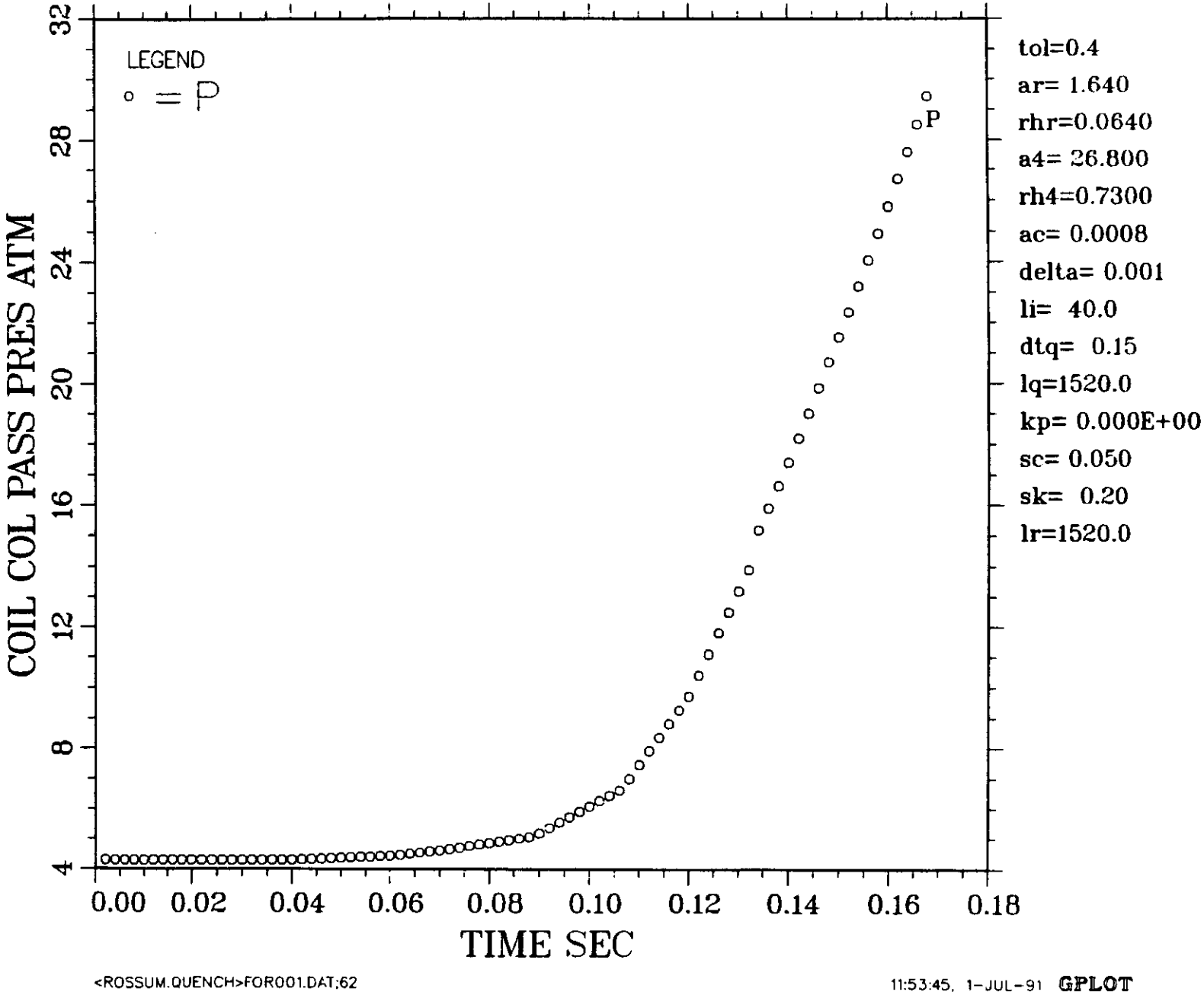

Figure 2.

5 mm gap maximum pressure around beam tube with venting

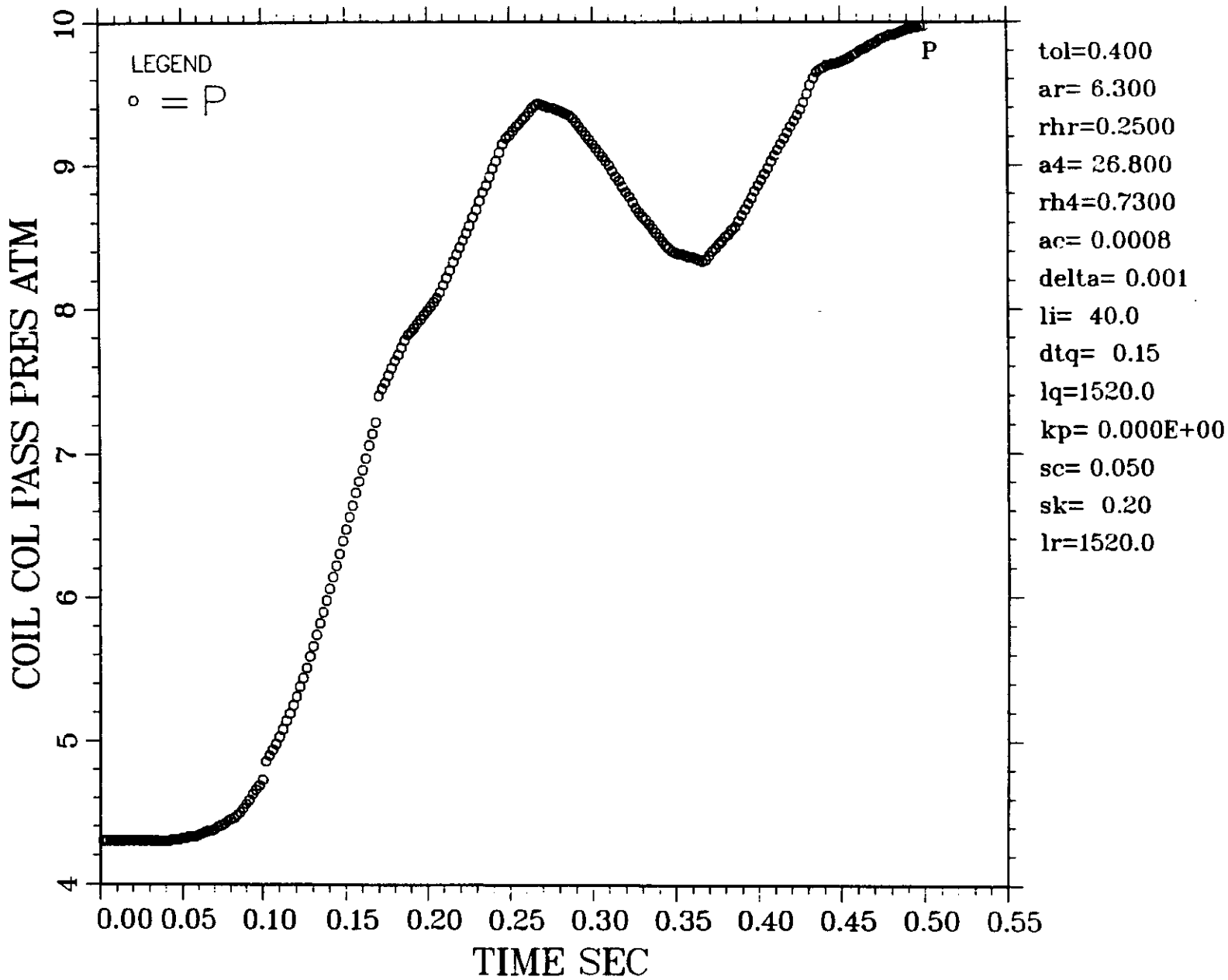

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Figure 3.

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5 mm gap maximum pressure around beam tube without venting

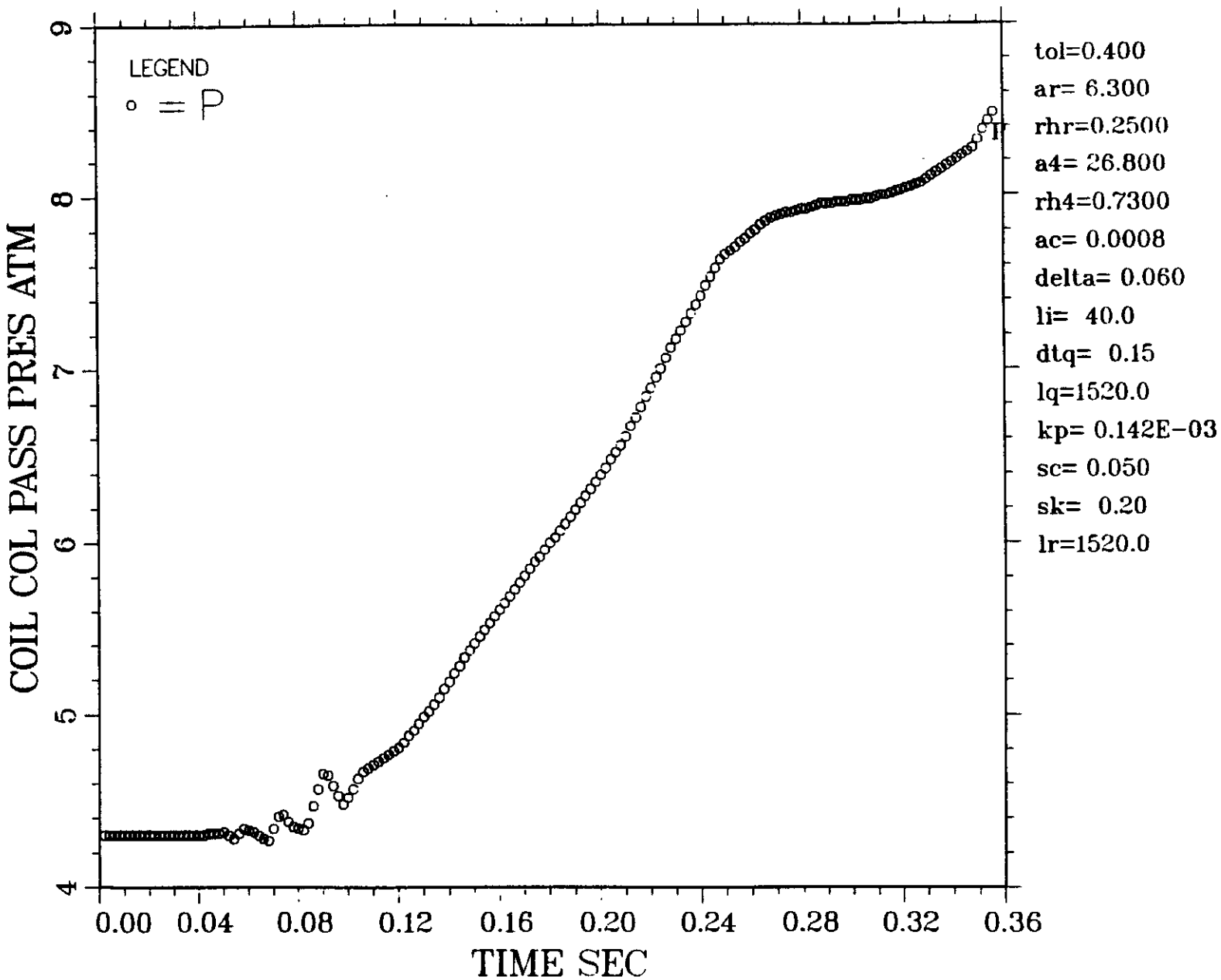

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Figure 4.

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