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International Agreement Report

Contrast of RELAP5/MOD3.2 Results From Different Computing Platforms

Prepared by
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ABSTRACT

This work has focused in detecting (and, where possible, correcting) problems ocurred during the installation of Relap5/Mod 3.2 on different computing environments that encompass all major workstations (namely: DEC, HP, IBM, SGI and SUN), besides that of CONVEX, all of which run under the UNIX operating system. Once that the production version - that obtained with the supplied installation procedure - of Relap5 was obtained for each platform, it was run a common sample case and the results produced were analysed. As a result of that analysis, substantial differences were observed in the magnitude of the selected components (i.e., pressure, mass flow and temperature in the intact and broken loop, etc.), establishing as a possible cause for the discrepancies: the level of optimization adopted for compilation, the chosen maximum time step size, and the inherent precision of the platforms under consideration (32 or 64 bit architectures, compliance with IEEE-754, etc.). Those discrepancies, however, lay within acceptable limits when the results of the different machines are produced by non-optimised versions of Relap5 (only for some machines) and using a maximum time step size of about 0.125 s.. Hence, the recommendations are two-fold: to users, about the need to run the test (both, with and without optimisation) whenever a new version of Relap5, operating system and/or compiler level is installed, and to urge their system software providers to supply robust and reliable products, and to developers, about the need to deliver a code which is compliant with ANSI standards for Fortran, to establish a more rigid criteria to evaluate the maximum time step size and the convenience to put in place a test, or set of them, to be used as an acceptance/rejection criteria of the Relap5 version produced.

This work has been performed by Central Nuclear de Almaraz (CNA), a member of Unidad Eléctrica, S.A. (UNESA) that participates in the Code Application and Maintenance Project (CAMP), and is part of the "in kind" contribution of Spain to the CAMP Project.

Being the CAMP project of an international and multidisciplinary scope, this work reinforzes that nature for it is made out of contribution from the following groups: the Spanish PWR Plant Operators, the Spanish Nuclear Safety Council (CSN), the Turkish Atomic Energy Authority (TAEA) and the High Technical School of Mines of Madrid (ETSIMM). Their effort and suggestions are gathered here along with our deep gratitude.

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EXECUTIVE SUMMARY

The Relap5 code, as it is presently being distributed for installation on different platforms, consists of a common source code body and some installation procedures that use specific scripts tailored for the target platforms. One of the main concerns is the "portability" of the results produced, that is, the results produced for the same input data should be the same, regardless of the machine in which the were produced.

This work has focused in detecting (and, where possible, correcting) problems ocurred during the installation of Relap5/Mod 3.2 on different computing environments that encompass all major workstations (namely: DEC, HP, IBM, SGI and SUN), besides that of CONVEX, all of which run under the UNIX operating system. A common sample case was run in each platform using the production version - that obtained with the supplied installation procedure - of Relap5 and the results produced were analysed. As a result of that analysis, substantial differences were observed in the magnitude of the selected components (i.e., pressure, mass flow and temperature in the intact and broken loop, etc.), establishing as a possible cause for the discrepancies: the level of optimization adopted for compilation, the chosen maximum time step size, and the inherent precision of the platforms. Those discrepancies, however, lay within acceptable limits when the results of the different machines are produced by non-optimised versions of Relap5 (only for some machines) and using a maximum time step size of about 0.125 s..

Some recommendations are made: to users, about the need to run the test (both, with and without optimisation) whenever a new installation of Relap5 takes place, and to developers, about the need to deliver a robust code and to establish a more rigid criteria to evaluate the maximum time step size and the convenience to put in place a test, or set of them, to be used as an acceptance/rejection criteria of the Relap5 version produced.

1. INTRODUCTION

In the past recent years, there have been a number of advancements in computing technology - namely, the widespread use of open systems on high performance RISC workstations under the UNIX operating system - that have dramatically changed the scenario on which the Relap5 analysis code is operated. As far as the user/analyst is concerned, it has derived from a situation in which he/she was just a "code runner" - the code was on the corporate mainframe (CDC, CRAY, IBM or IBM-compatible) and somebody else took care of installing and quality controlling it - to a "do-it-yourself" situation in which he/she has to do everything from installing, to running, to quality controlling it on a departmental high performance workstation. That is due also, no doubt, to the way Relap5 is being disseminated (unique source code, simple media, i.e. diskette, etc., and simple installation procedures that use powerful and sophisticated scripts for the different platforms). However, that - in principle - leap forward achievement, poses serious concerns about the portability/independence of results being produced on different computing environments.

2. COMPUTING ENVIRONMENTS CONSIDERED

As depicted on Table 1, the choice of computing platforms under study encompass all major players in today's market of high performance RISC workstations. The exception to that is the CONVEX computer, a "one-of-a-kind" installation.

Table 1. HW/SW Configurations

Config.	Description
CNVX3440	CONVEX-3440, Unix 11.2, ftn77 v9.1, 128 MB
DEC-3100	DECStation 3100, Ultrix 4.3, ftn77 v3.2, 16 MB
DEC-5240	DECStation 5000/240 PX, Ultrix 4.2A, DECftn v3.1,32 MB
DECA2100	DEC-A-Ser 2100/500 MP, OSF/1 3.2, DECftn v3.5, 256 MB
	DEC-A-Ser 2100/500 MP, OSF/1 3.2, Fortran 90, 256 MB
	DEC-A-Sta 200 4/233, OSF/1 3.2 41 Alpha, DECftn for OSF/1 AXP v3.8, 256 MB
HP715/50	HP-715/50, HP/UX 9.03, ftn77, 64 MB
	HP-735/125, HP/UX 10.0, ftn77, 64 MB
IBM-6000	IBM R/S-6000, AIX 3.2, XL Fortran v1.1, 64 MB
SGI-INDY	SGI-INDY, IRIX 5.2, ftn77 v3.2, 32 MB
SGI-4D30	SGI-4D30, IRIX 4.05, ftn77 v3.4.1, 16 MB
SUN-ULSP	SUN-UltraSPARC 140, Solaris 2.5, ftn77 v4.0, 32 MB

The peculiarities occurred during the installation of Relap5/Mod 3.2 on the different platforms are described in Appendix I. As a general rule, the changes needed in the procedures can be labelled as very mild.

It should be pointed out that configuration "DECA2100" is representative of the DEC-Alpha Server 2100/500 and the DEC-Alpha Station, since all give (for the operating system level and compilers indicated in Table 1) identical results. Likewise happens with configuration "HP715/50", representative of platforms HP-715/50 and HP-735/125.

The results produced by the SGI-Indy are considered, all through this work and for comparison purposes only, as the reference ones. Although they seem to be smoother than the rest, that, by no means, should be taken as any claim to the accuracy and/or correctness of the results.

3. CASE UNDER STUDY

Whenever a new version of Relap5 is released, it is common practice within the Spanish group - it started when first involved in project ICAP and now has become a normal operating procedure - to run and check the results of the (modified) sample case "typpwr.i" (included along with the installation material). The modifications introduced extend the problem time from 100 to 650 sec. whereas the output units are changed from British to SI (mks) (See Table 2). Sample case "typpwr.i" presents a 4-loop PWR undergoing a 4" SBLOCA in the cold leg starting at 0.01 sec. and as far as evaluation purposes is concerned offers two good reasons to select it: first, it encompass a good number of components and phenomena, and second, it is known to all Relap5 users and, as such, provides a common ground for discussion and evaluation. The magnitudes and components, whose evolution over time are analysed, are depicted in Table 3. Due to the large number of potential figures, however, the representation of results have been restricted to those of mass flow rate in the cold leg of the intact loop (mflowj 116020000), the pressure in the steam generator (SG) secondary of the intact loop (p 180010000) and the temperature of the cold leg of the intact loop (tempf 114010000), for each calculational case considered. Also, the maximum time step selected has been depicted for the base case.

The analysis of the results (note: the "typpwr.i" uses a maximum time step size of 0.50 sec.), obtained on the Relap5 production versions on different platforms, show generalized discrepancies among them, starting at problem time of about 400 s. Those discrepancies affect to all magnitudes except "rktpow", that shows identical results for all platforms. For the sake of completeness - although they have been phased out by their respective users - the results from DEC-Stations 3100 and 5240 are included in this work, and depicted in Figures 1.1, 1.2 and 1.3 over the whole time span from 0 to 650 sec. (the observed discrepancies from time 0. and on, of the results produced on the DEC Stations 3100 and 5124 have been clearly identified with the compilation level chosen for two subroutines).

Table 2. Common test case run (modified "typpwr.i")

```
cna> diff typpwr.i typpwr.i.mod
12c12
< 102  british   british
---
> 102  british   si
21c21
< 201  100.0  1.0-7   0.50   7   2    40    160
---
> 201  650.0  1.0-7   0.50   7   2   260   1040
```

Table 3. Input for strip run

```
=typical pwr model -- 4 inch cold leg break
100  strip    fmtout
103  0
1001 mflowj   116020000    * cold leg, intact loop
1003 mflowj   212020000    * cold leg, broken loop
1005 mflowj   505000000    * cold leg, break
1011 p        180010000    * SG sec., intact loop
1013 p        280010000    * SG sec., broken loop
1015 p        345010000    * RV upper plenum
1020 rktpow   0
1021 tempf    114010000    * cold leg, intact loop
1023 tempf    210010000    * cold leg, broken loop
1025 mflowj   192000000    * SI, triple loop
1027 mflowj   190010000    * Accumulator
1029 p        190010000    * Accumulator
. end of case
```

Following suggestions received from some of the assistants at the Madrid meeting in May, 1996, the colleagues participating in this work, as well as those offered in Refs. [1]-[3], the search for the causes behind the said discrepancies was limited to the following aspects:

1. use of non-optimized versions of Relap5,

2. maximum time step size (MTSS) selected, and

3. inherent precision parameters of the platforms.

To cover aspects 1 and 2 above, several sets of calculations were performed on each of the platforms, namely:

a) with optimised version of Relap5/Mod 3.2, and MTSS dt=0.5 s (they are depicted in Figures 2.1, 2.2, 2.3, 3.1, 3.2 and 3.3 over the time span from 150 to 650 sec.). The time step size used during the calculations are depicted in Figures 4.1 and 4.2 over the whole time span from 0 to 650 sec.

b) with non-optimised version of Relap5/Mod 3.2, and MTSS dt=0.5 s (they are depicted in Figures 5.1, 5.2, 5.3, 6.1, 6.2 and 6.3 over the time span from 150 to 650 sec.).

c) with non-optimised version of Relap5/Mod 3.2, and MTSS dt=0.125 s (they are depicted in Figures 7.1, 7.2, 7.3, 8.1, 8.2 and 8.3 over the time span from 150 to 650 sec.).

d) with non-optimised version of Relap5/Mod 3.2, and MTSS dt=0.015625 s (they are depicted in Figures 9.1, 9.2 and 9.3 over the time span from 150 to 650 sec.).

Besides the calculations already described, some others were performed at the suggestion of the revision team (though only on two specific machines, i.e. SGI-Indy and SGI-4D30), namely:

1. using as input the reference one (modified "typpwr.i") but with the explicit introduction of the "d" descriptor for the floating point numbers (i.e. 0.24 is replaced by 0.24d0),

2. analizing the time step size vs. the Courant time step (see an extract of the modified input deck in Table 4),

3. analizing the mass error in the calculations (see an extract of the modified strip input deck in Table 5),

Table 4. Common test case run (for time step sizes)

```
cna> diff typpwr.i typpwr.i.mod.dt
12c12
< 102  british   british
---
> 102  british   si
21c21
< 201  100.0  1.0-7   0.50   7   2    40    160
---
> 201  650.0  1.0-7   0.50   7   2   260   1040
37a38,40
> 20800361 dt        0
> 20800362 dtcrnt    0
> *
```

Table 5. Input for strip run (time step sizes and mass error)

```
=typical pwr model -- 4 inch cold leg break
100  strip    fmtout
103  0
1001 mflowj   116020000    * cold leg, intact loop
1003 mflowj   212020000    * cold leg, broken loop
1005 mflowj   505000000    * cold leg, break
1011 p        180010000    * SG sec., intact loop
1013 p        280010000    * SG sec., broken loop
1015 p        345010000    * RV upper plenum
1020 rktpow   0
1021 tempf    114010000    * cold leg, intact loop
1023 tempf    210010000    * cold leg, broken loop
1025 mflowj   192000000    * SI, triple loop
1027 mflowj   190010000    * Accumulator
1029 p        190010000    * Accumulator
*
1031 dt       0
1032 dtcrnt   0
1033 emass    0
1034 tmass    0
. end of case
```

4. RESULTS

After pursuing the above mentioned three avenues, it was found that:

1. When comparing the results obtained on the same platform, from the current production version with those from the non-optimised one, it was observed that only for the DEC-Alpha and for the SGI-Indy those results were identical, that is, only for those platforms the results are independent of the compilation level selected. It was also observed that the non-optimised results from different platforms "don't differ as much" the optimised results do.

2. The study of the effect of the selected maximum time step size on the results showed two things: first, the time step sizes used are different (particularly from problem time 400 s. on) among platforms and, second, that the results and, even more the differences between them, are very sensitive to the maximum time step size. Obviously, the maximum time step size is problem dependent, and for this particular problem, "typpwr.i", it was found that for a maximum time step size of 0.125 s (= 1/8), most of the observed spikes in pressure, mass flow and temperature - present at larger maximum time step sizes, in all platforms results - dissapear and, what is more important, when that maximum time step size of 0.125 s. is used in conjunction with the non-optimised version of Relap5 the results produced by all platforms agree fairly well among themselves.

3. The analysis of the inherent precision parameters of the platforms involved was focused on three aspects:

a) analysis of three specific parameters, EPS, TIN and BIG, where:

   EPS ... the smallest number, accepted by the machine, to avoid unit round off:
   $(1 - EPS < 1 < 1 + EPS)$.

   TIN ... the smallest number (in absolute value), accepted by the machine, such that -TIN exists and TIN <> 0 and -TIN <> 0.

   BIG ... the largest number (in absolute value), accepted by the machine, such that -BIG exists and BIG <> Inf and -BIG <> Inf.

b) test LINPACK 100 x 100.

c) several iterative calculation tests:

$$A_i = \exp(\log(A_{i-1})), \text{ with } A_0 = 2., \text{ for } i = 1,2,...N,$$

$$B_i = \text{sqrt}((B_{i-1})^{**}C), \text{ with } B_0 = 3, C = 2, \text{ for } i=1,2,...N,$$

$$X_i = X_{i-1} / Z_{i-1} \text{ and } Y_i = Y_{i-1} / Z_{i-1}, \text{ for } i = 1,2,...N,$$

and with Z_{i-1} given by:

$$Z_{i-1} = \text{sqrt}((X_{i-1})^{**}2 + (Y_{i-1})^{**}2), \text{ with } X_0 = Y_0 = \text{sen}(Pi/4)$$

This analysis proved to be of not much help since, as shown in Table 4, the platforms analysed form a rather homogenous set, that is, although for some there is hardware support for 64-bits, the operating system and/or the compiler level only provides support for 32-bits, thus all platforms appear "as if they were" 32-bit ones.

Table 6. Inherent precision parameters

Config.	Pre.	n1	n2	n3	n4	archit.	NOR. RES.	MACHEPS
CNVX3440	DP	52	53	1024	1022	HW32/SW32	9.58D-1	2.22D-16
DECA2100	DP	52	53	1074	1023	HW64/SW32	1.67D+0	2.22D-16
HP715/50	DP	52	53	1074	1023	HW32/SW32	1.67D+0	2.22D-16
IBM-6000	DP	52	53	1074	1023	HW32/SW32	1.28D+0	2.22D-16
SGI-INDY	DP	52	53	1074	1023	HW64/SW32	1.67D+0	2.22D-16
SGI-4D30	DP	52	53	1074	1023	HW32/SW32	1.67D+0	2.22D-16
SUN-ULSP	DP	52	53	1074	1023	HW64/SW32	1.67D00	2.22D-16

max n1, such that: $(1 + 2^{-n1}) > 1$

max n2, such that: $(1 - 2^{-n2}) < 1$

$\Rightarrow$ **EPS** $= 2^{-(\min(n1,n2))}$

max n3, such that: $2^{-n3} <> 0.$ **and** $-2^{-n3} <> 0.$ $\Rightarrow$ **TIN** $= 2^{-n3}$

max n4, such that: $2^{+n4} <> \mathrm{Inf.}$ **and** $-2^{+n4} <> \mathrm{Inf.}$ $\Rightarrow$ **BIG** $= 2^{+n4}$

The analysis of the tests of the inherent precision parameters showed:

a) values of parameter EPS are platform independent, whereas those of TIN and BIG are identical for all platforms except for CONVEX, that shows a more balanced values although within a narrower range.

b) test LINPACK 100 x 100 yields similar results for all machines except for CONVEX and IBM-6000 which give smaller normalised residue (NOR. RES.) values.

c) the iterative calculational tests, for N = 10000:

$A_N = 2.$, $(= A_0)$, $B_N = 3.$, $(= B_0)$, and

X_N = (except last digit) Y_N, (= cos(Pi/4)

give excellent results for all platforms involved.

It should be mentioned, that a rigorous precision analysis would require an exhaustive examination of the code - to see the range of validity of the expresions coded, i.e. exp(x)/sqrt(x), etc. - a task, however, that clearly exceeds the scope of this work.

4. As it was mentioned in Section 3 above, additional calculations were performed. Those calculations were carried out only on two specific machines, the SGI-Indy and the SGI-4D30, and the results obtained showed:

1. results obtained using the "d" descriptor in the input data and those obtained without using it are identical.

2. during most of the problem time, the time step size used is smaller than the Courant time step calculated. Only in a few instances (around problem times 300 and 400 sec.) and for a short time, the time step size used is slightly larger than the Courant time step calculated, however, it is never less than 80% of the Courant time step.

3. the relative mass error obtained in the calculations never exceeds 0.016 % (that translates into a maximum mass error of about 69 Kg in about 422000 Kg).

There is no reason to believe that the trend observed for the two SGI machines is not followed by the results from the rest of the platforms.

5. CONCLUSIONS

In analysing the possible causes for the discrepancies observed, three avenues were pursued, namely: the compilation level, the maximum time step size and the platforms inherent precision. The effect of the first two proved to be very important in justifying the observed discrepancies and in finding the corrections to them, whereas the third one was rather useless given the fact that the platforms considered constituted a rather homogeneous set (RISC hardware, UNIX operating system, "effective" 32-bits architecture) which produced very similar, if not identical, results for the numerical tests performed.

As a summary, it can be concluded that results for the magnitudes of the components of the problem under study are very sensitive to the time step size selected for all platforms considered. Likewise, results are dependent upon the compilation level chosen when generating the Relap5 executable (except for the DEC Alpha and the SGI Indy, which yield identical results for the optimised and non-optimised versions). Those results resemble more among themselves when the time step size decreases and even more so when they are produced with the non-optimised version. In fact, the agreement between the results - obtained on the platforms considered - from the non-optimised versions and with a maximum time step size of 0.125 s. can be considered to be reasonably good for some magnitudes whereas for others the agreement is excellent. Further analyses show that, for smaller (1/16 s., 1/32 s., 1/64 s.) time step sizes, the spikes dissapear and oscillations atenuate for all platforms considered.

6. RECOMMENDATIONS

From the experiences gathered during the course of this work, we dare to suggest a few recommendations to both, users and developers.

<u>To users</u>:

1. inform to the system SW suppliers about the discrepancies observed when the results are produced from non-optimised and optimised versions (a fact in itself unacceptable!), and demand from them robust and reliable products. It is important to notice that developers too have a say in this - avoiding possible causes of getting different results from non-optimised and optimised versions - by supplying a code compliant with ANSI standards for Fortran.

2. run the tests whenever a new version of Relap5 comes along, and a new operating system version and/or

compiler version is installed. Check for sensitivity of optimisation level and time step size.

To developers:

1. rework the criteria for calculating the time step size. It is clear that a more tight criteria is needed and, as is suggested in Ref [3], starting from the one implemented in Mod2 could point in the right direction.

2. work out a master case (or set of them) - to be included along with the installation material - to be used as a reference case to check the quality (acceptance/rejection) of the Relap5 executable. That master case should encompass the most important components and relevant phenomena as well, and it would be desirable also to count on experimental results.

Figure 1.1

CAMP PROJECT

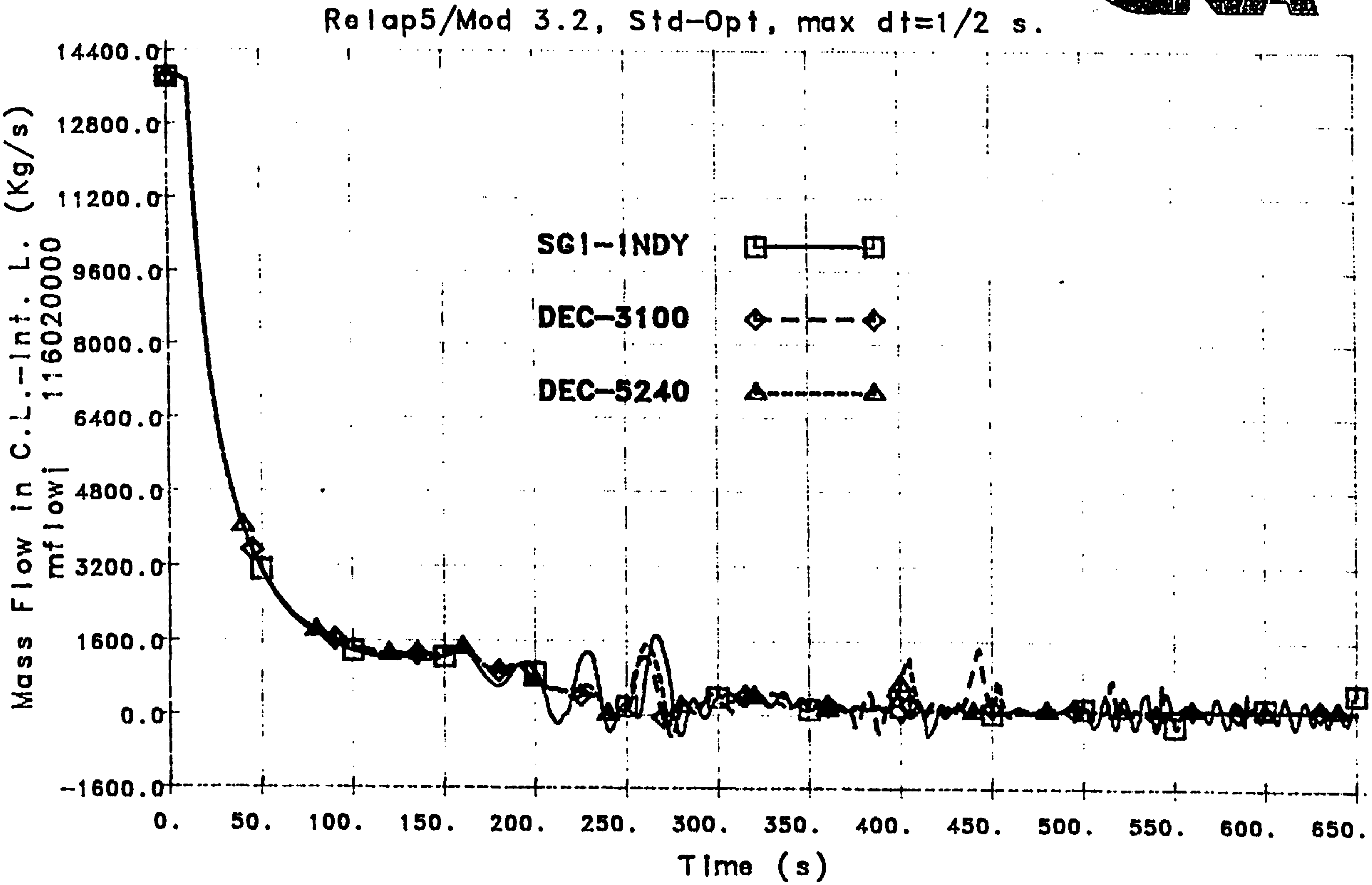


Figure 1.2

CAMP PROJECT

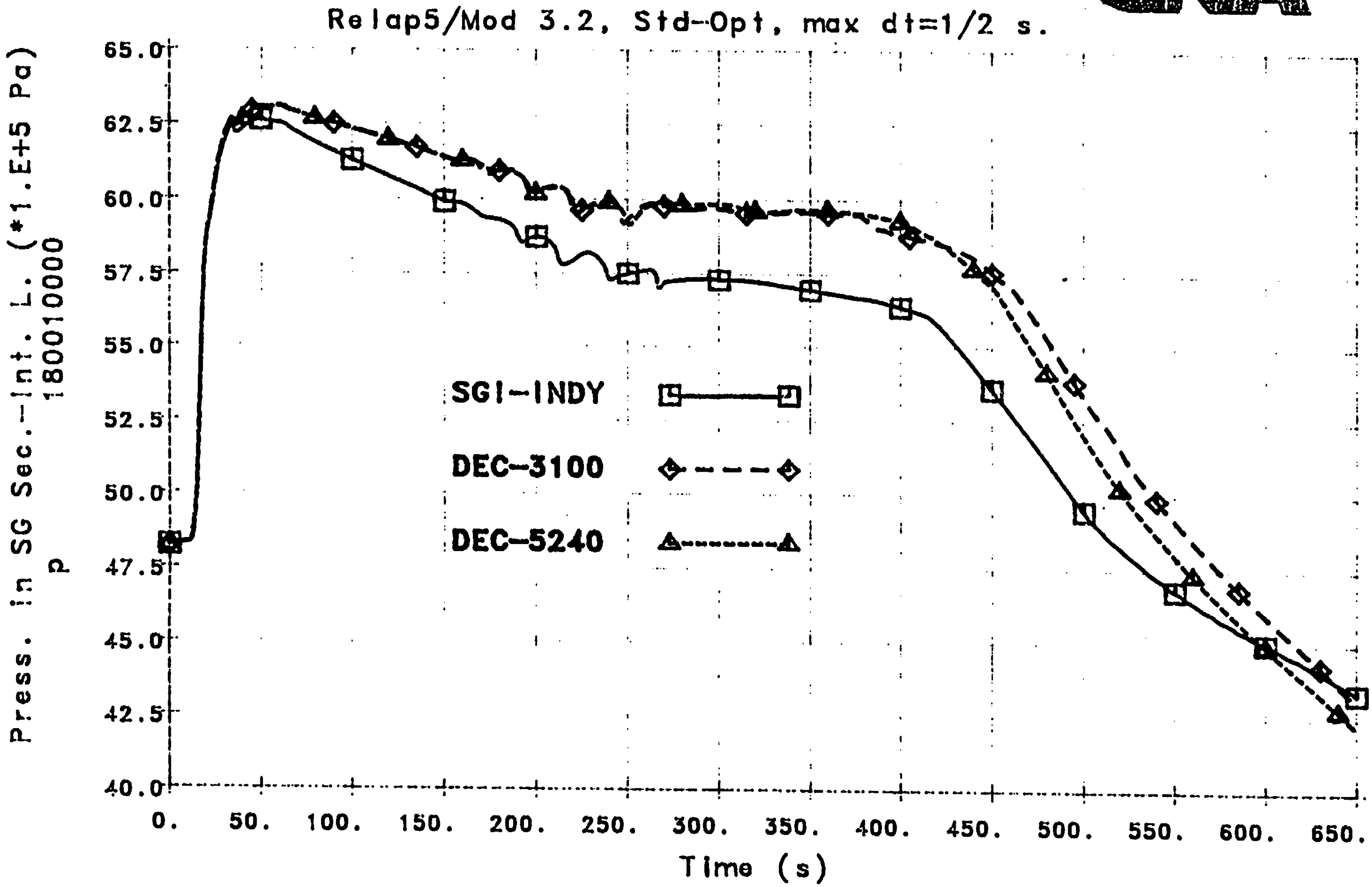


Figure 1.3

CAMP PROJECT

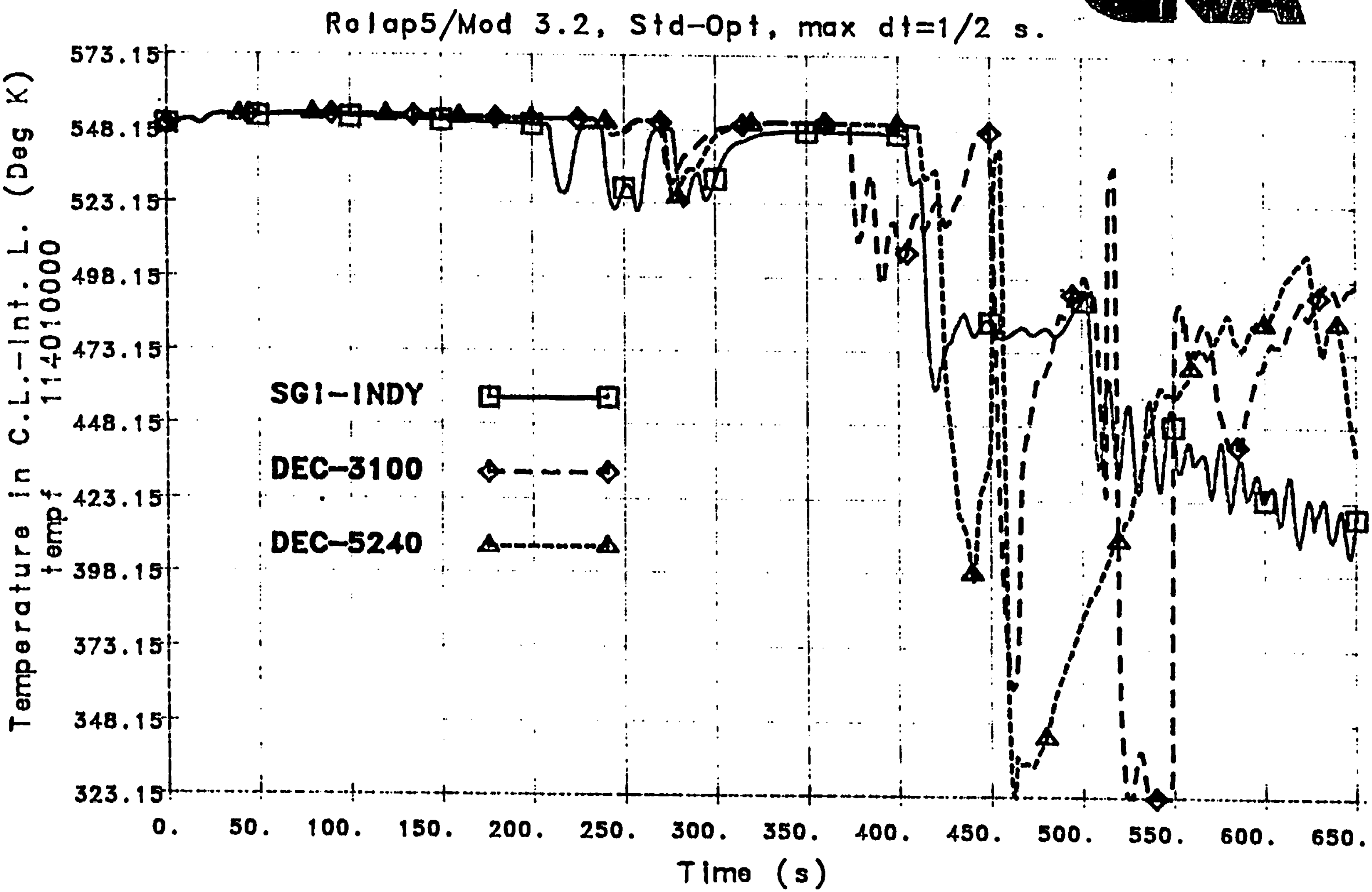


Figure 2.1

CAMP PROJECT

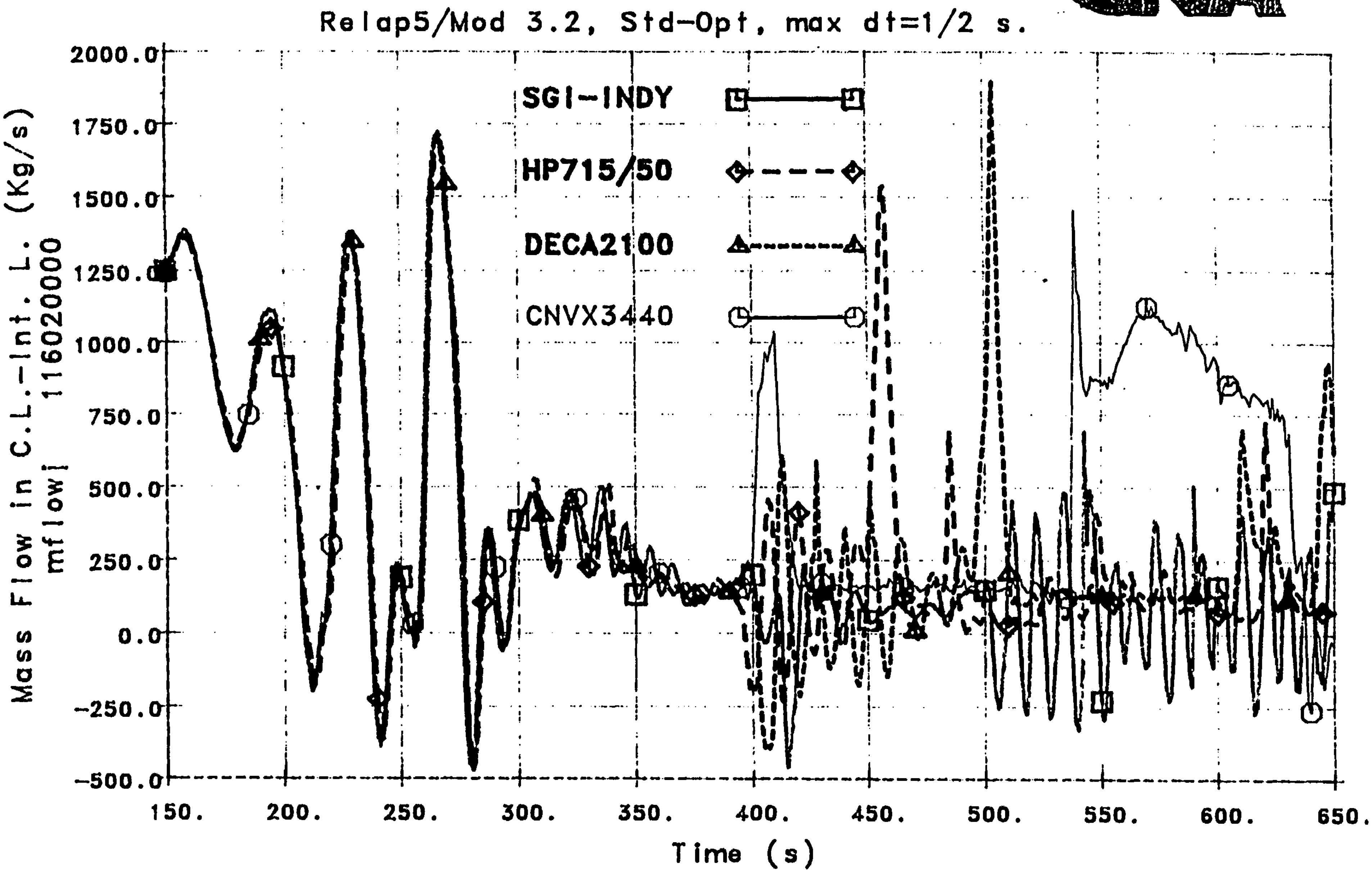


Figure 2.2

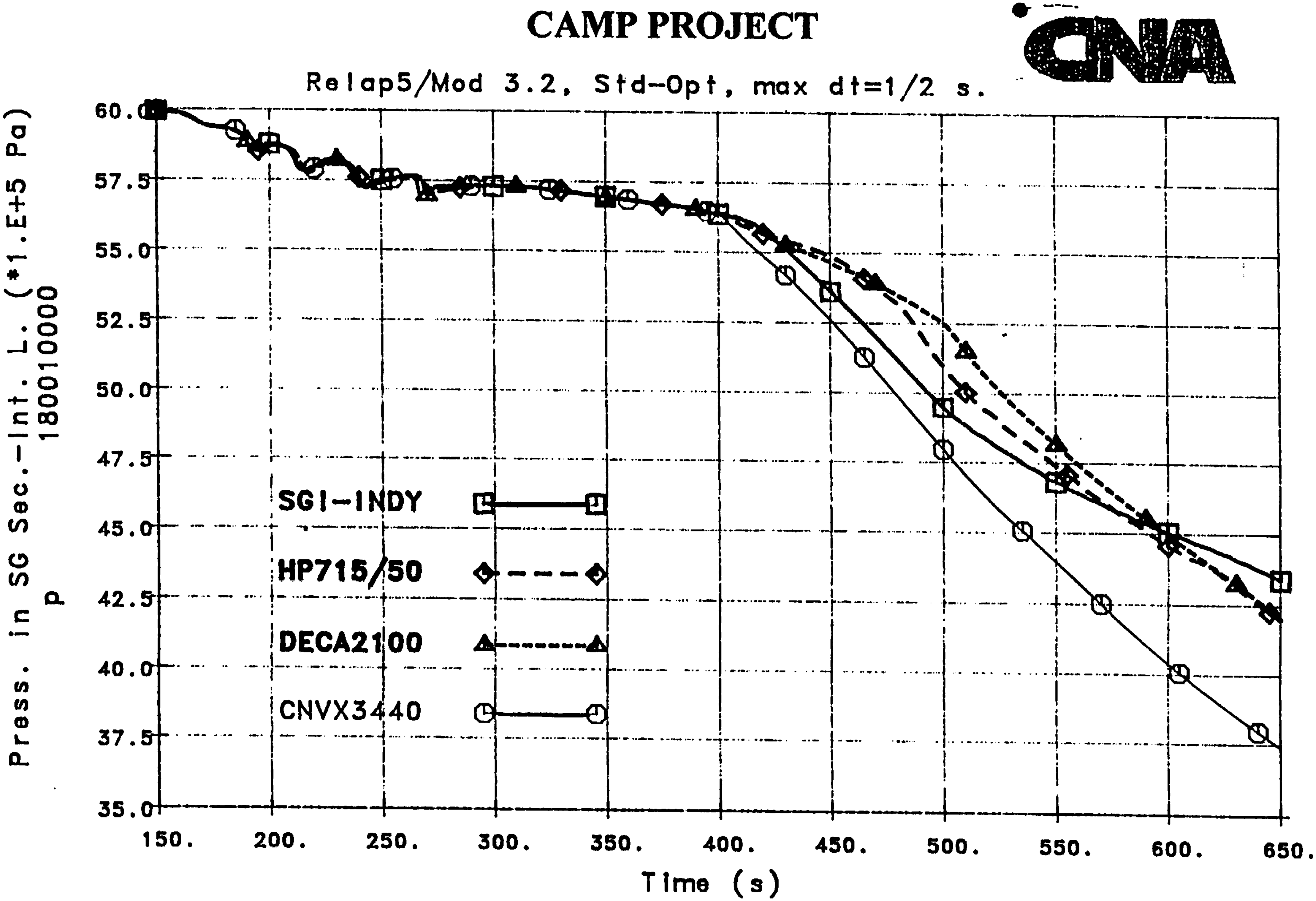

CAMP PROJECT
Relap5/Mod 3.2, Std-Opt, max dt=1/2 s.
Press. in SG Sec.-Int. L. (*1.E+5 Pa)
p 180010000
60.0
57.5
55.0
52.5
50.0
47.5
45.0
42.5
40.0
37.5
35.0
150.
200.
250.
300.
350.
400.
450.
500.
550.
600.
650.
Time (s)
SGI-INDY
HP715/50
DECA2100
CNVX3440

Figure 2.3

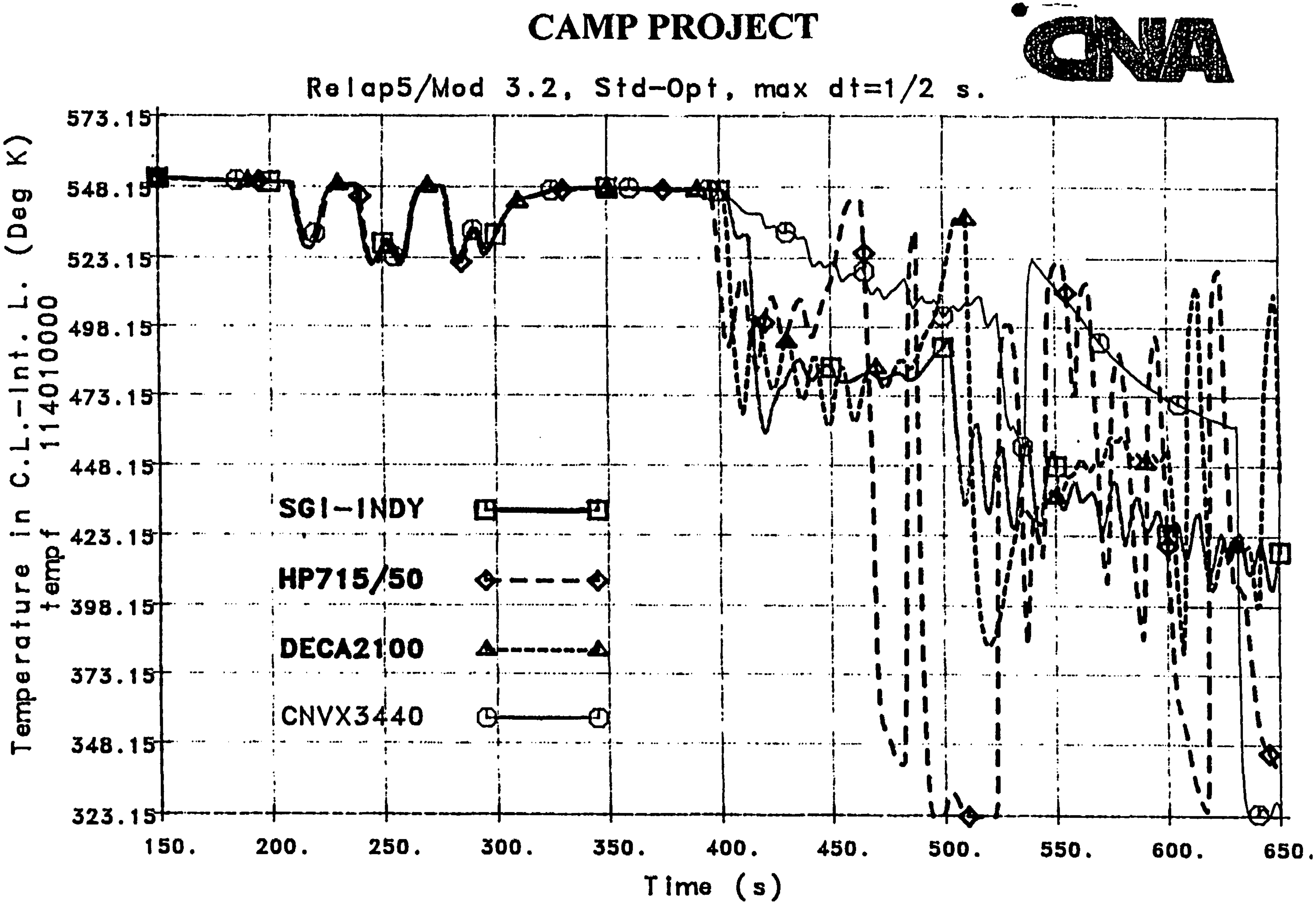

CAMP PROJECT
CNA
Relap5/Mod 3.2, Std-Opt, max dt=1/2 s.
Temperature in C.L.-Int. L. (Deg K)
114010000
tempf
573.15
548.15
523.15
498.15
473.15
448.15
423.15
398.15
373.15
348.15
323.15
150.
200.
250.
300.
350.
400.
450.
500.
550.
600.
650.
Time (s)
SGI-INDY
HP715/50
DECA2100
CNVX3440

Figure 3.1

CAMP PROJECT

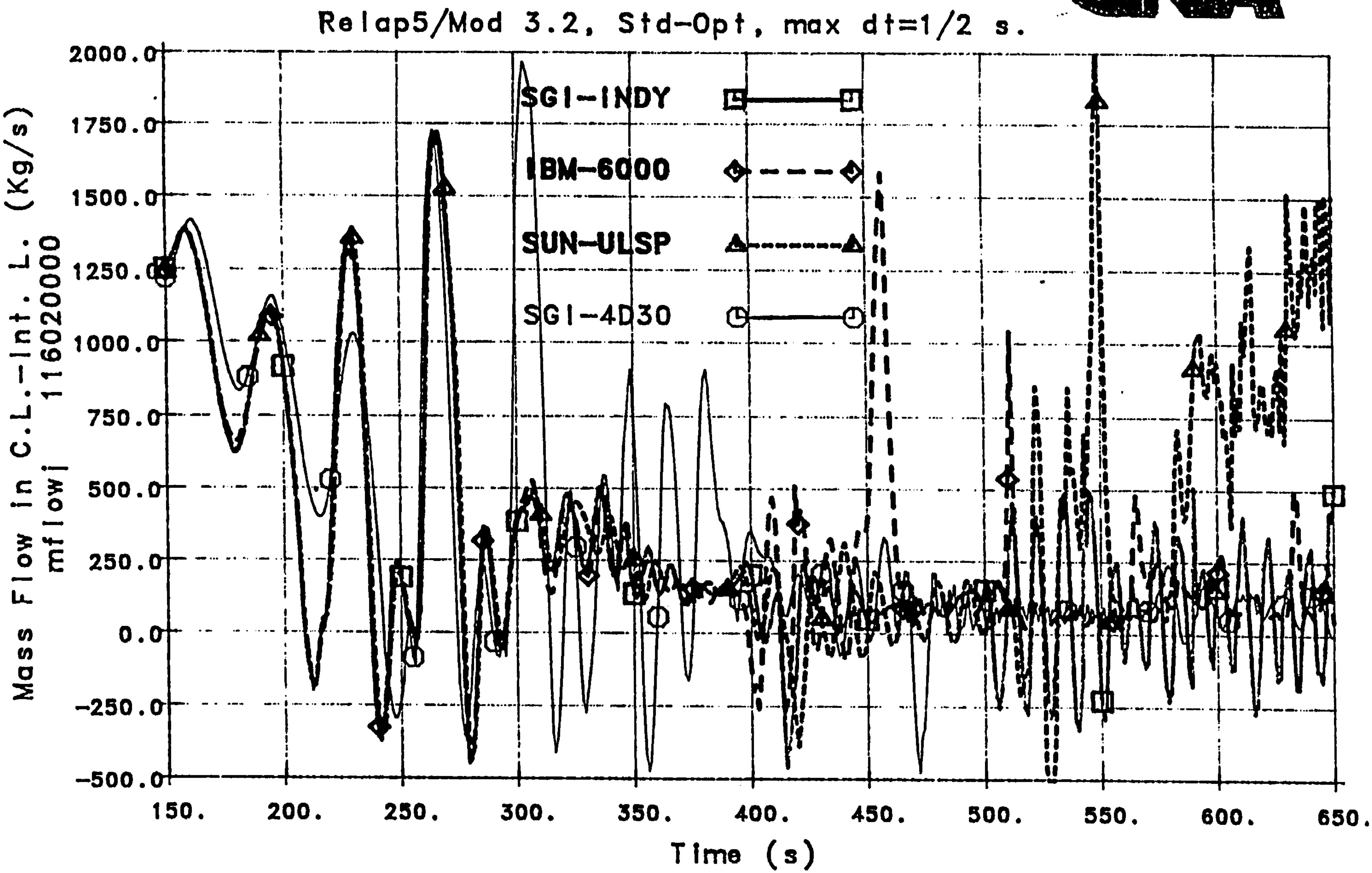


Figure 3.2

CAMP PROJECT

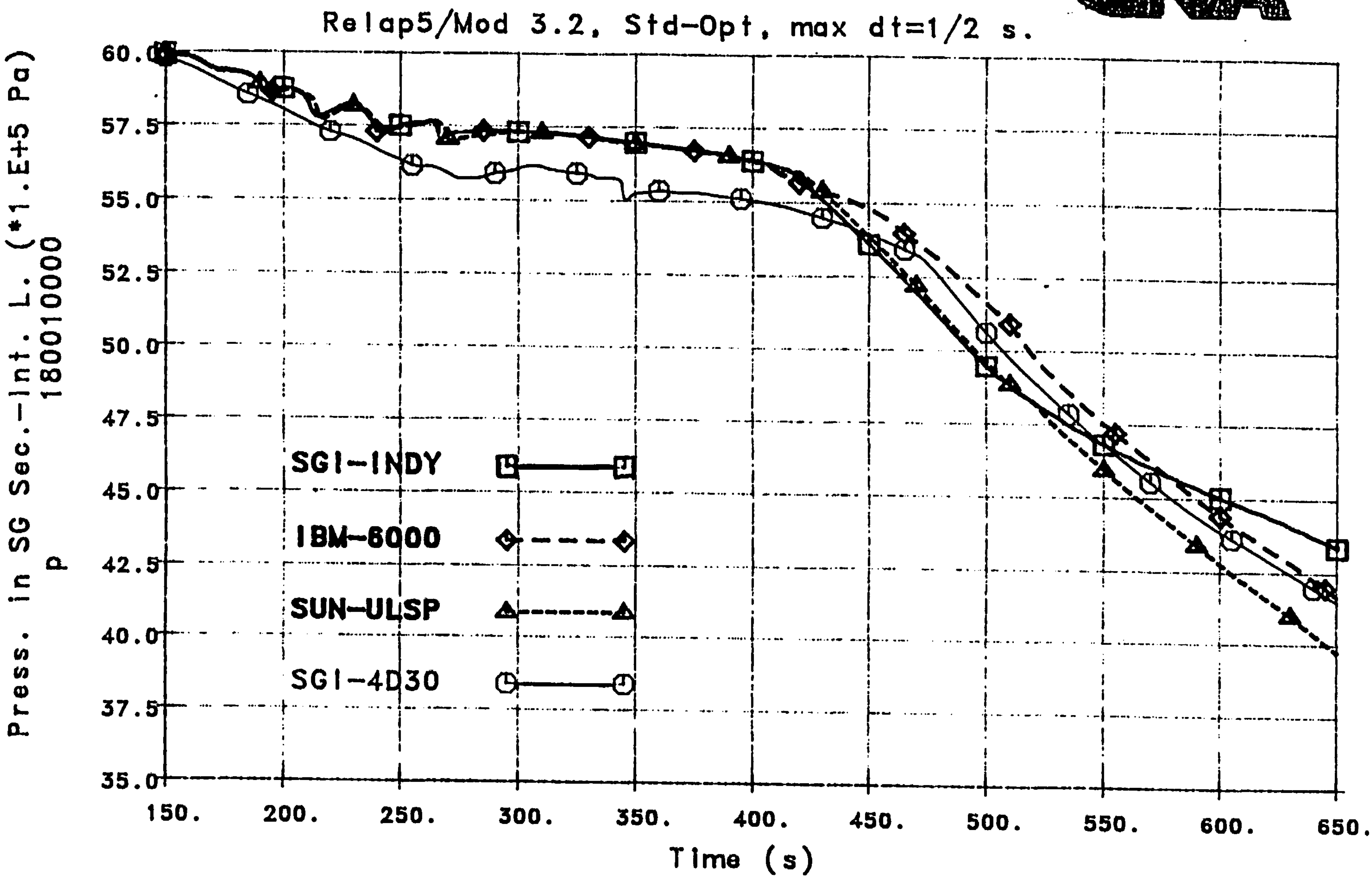


Figure 3.3

CAMP PROJECT

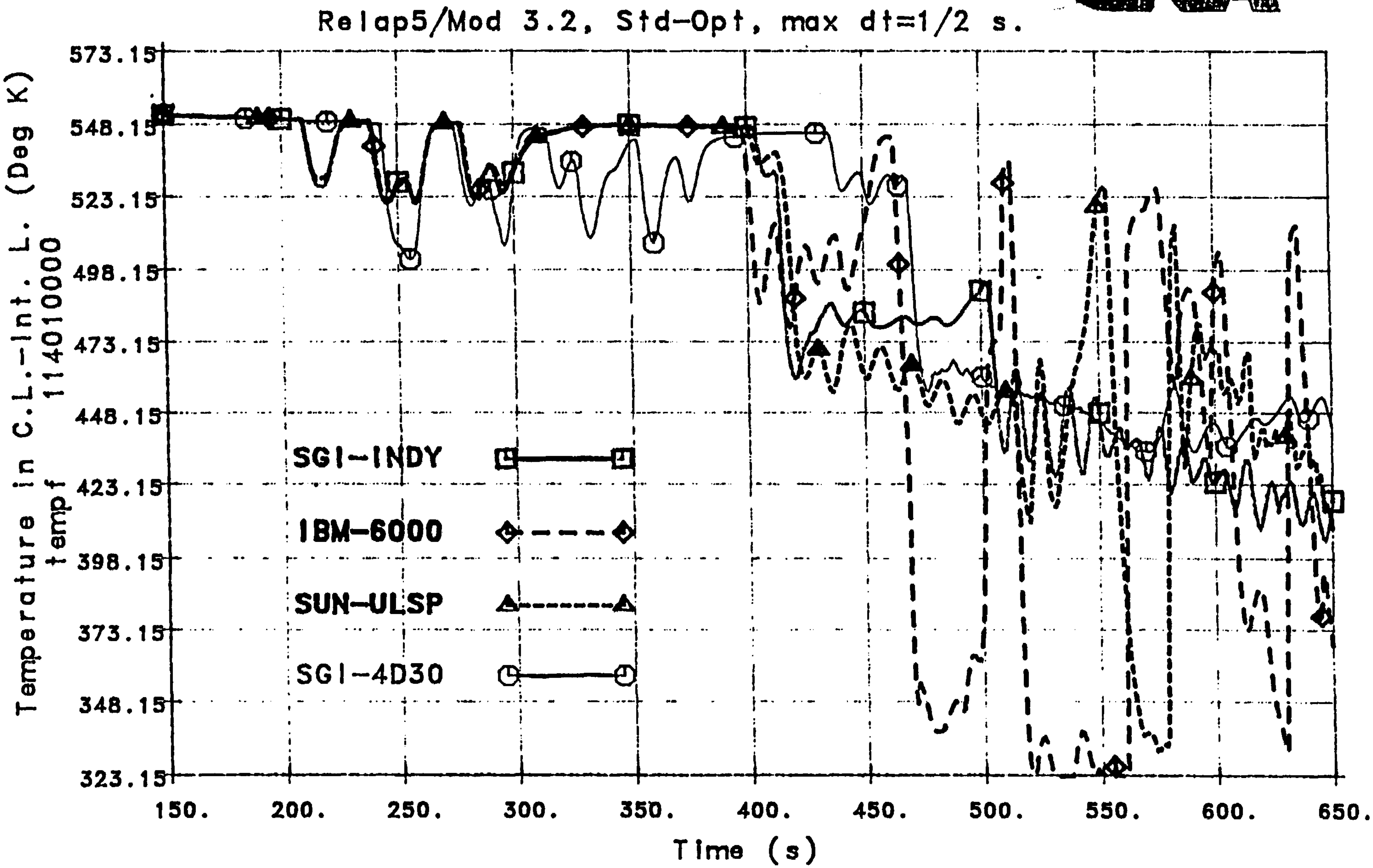


Figure 4.1

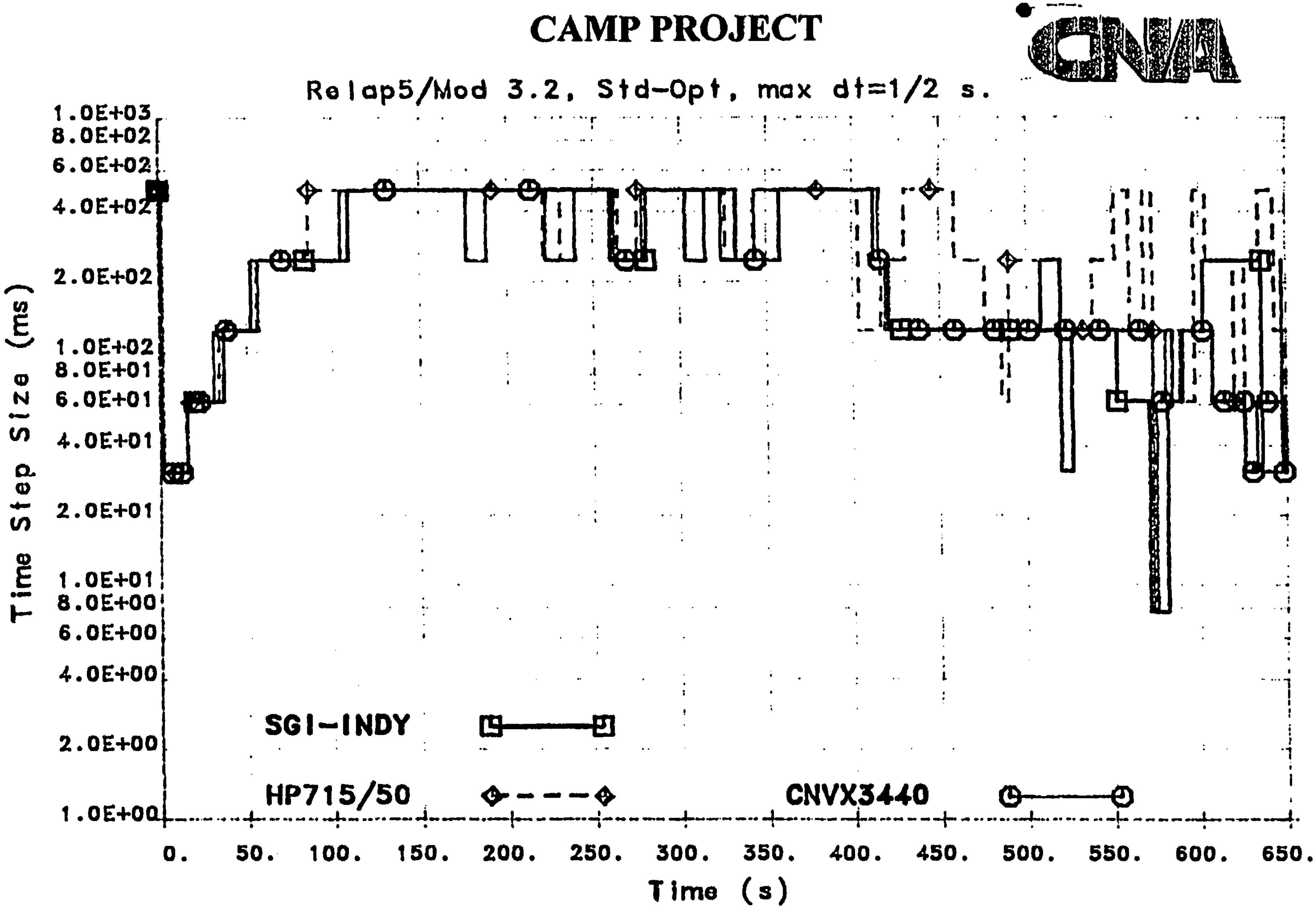

CAMP PROJECT
Relap5/Mod 3.2, Std-Opt, max dt=1/2 s.
Time Step Size (ms)
1.0E+03
8.0E+02
6.0E+02
4.0E+02
2.0E+02
1.0E+02
8.0E+01
6.0E+01
4.0E+01
2.0E+01
1.0E+01
8.0E+00
6.0E+00
4.0E+00
2.0E+00
1.0E+00
0. 50. 100. 150. 200. 250. 300. 350. 400. 450. 500. 550. 600. 650.
Time (s)
SGI-INDY
HP715/50
CNVX3440

Figure 4.2

CAMP PROJECT

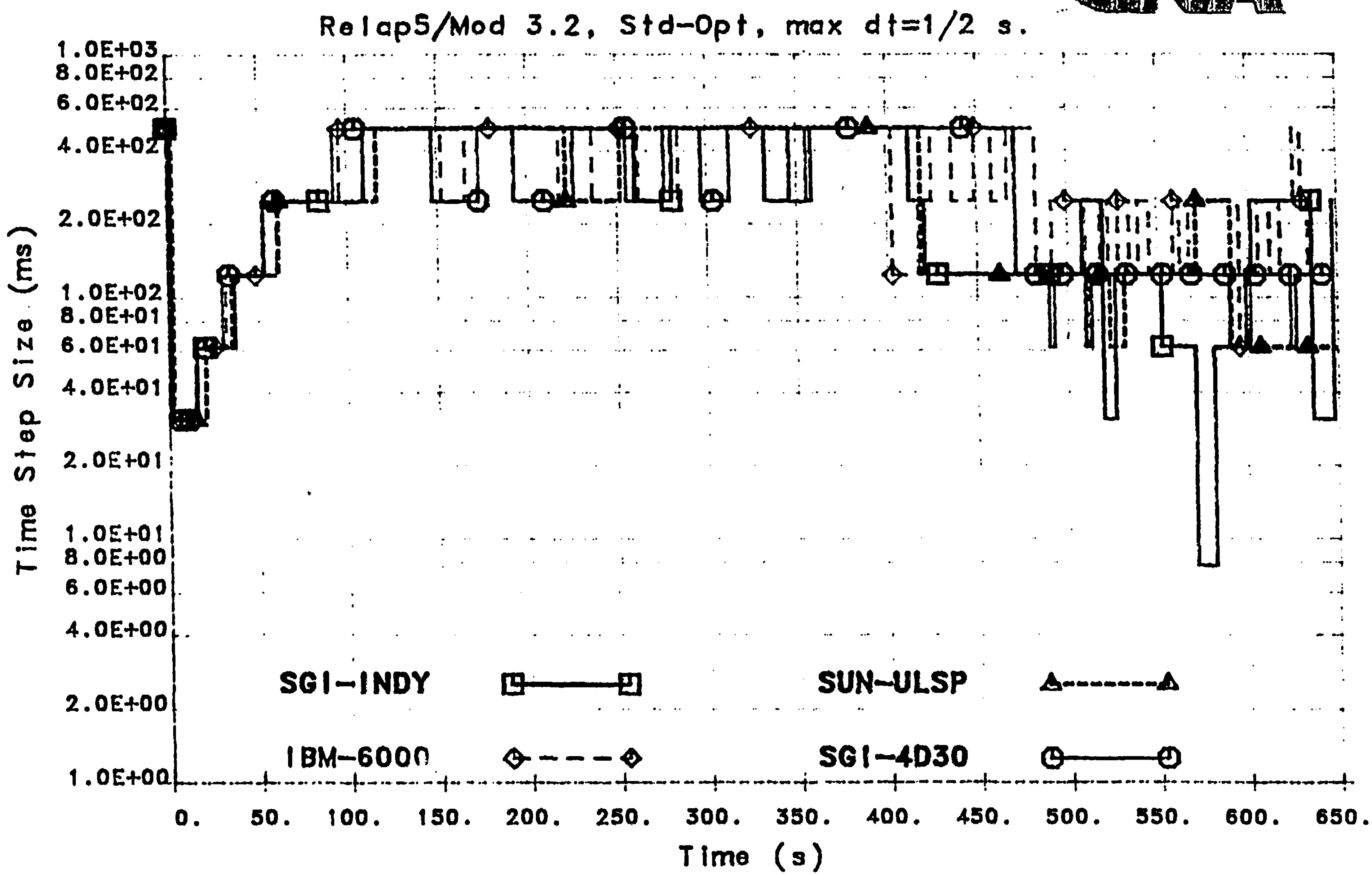


Figure 5.1

CAMP PROJECT

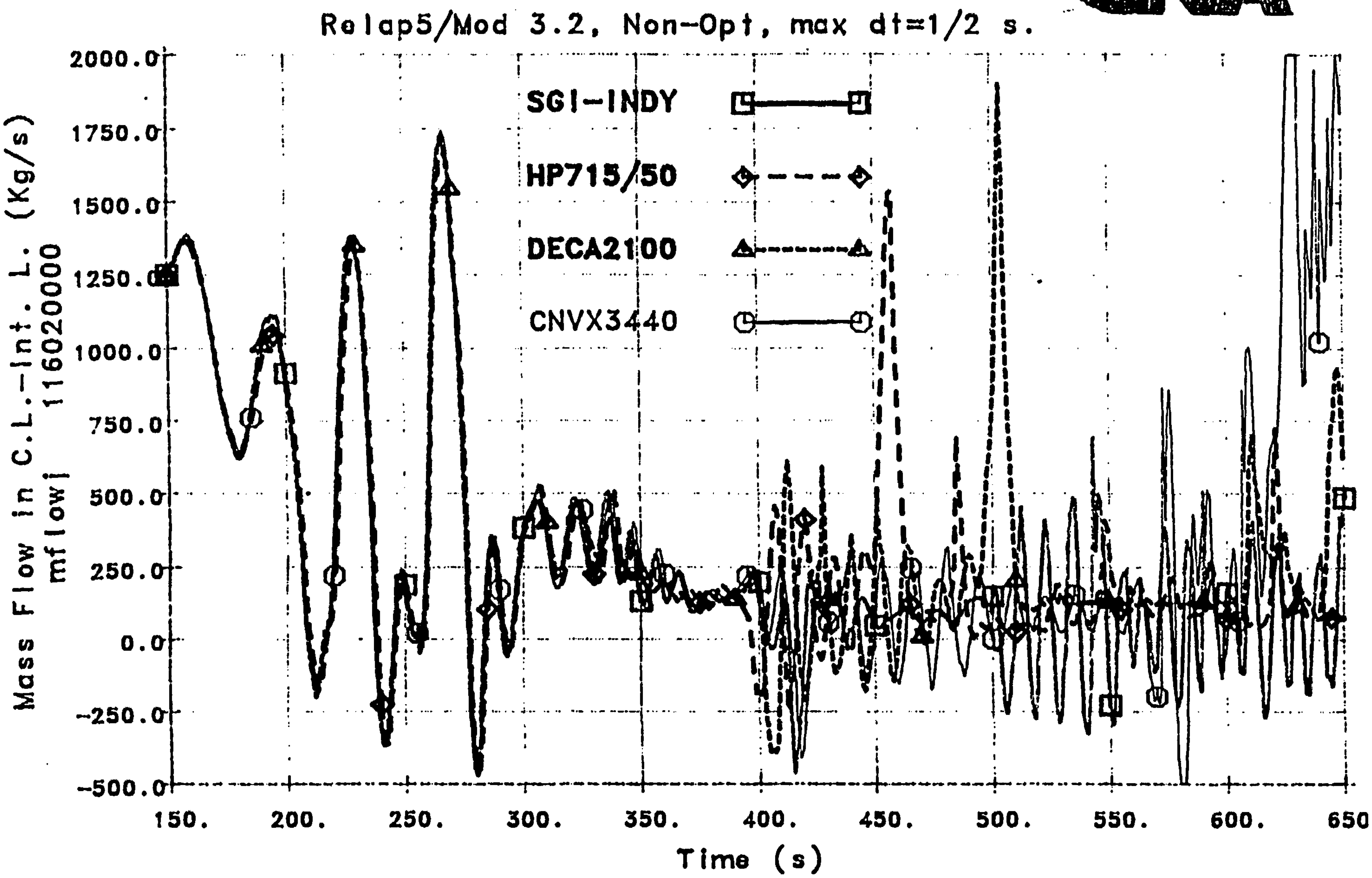


Figure 5.2

CAMP PROJECT

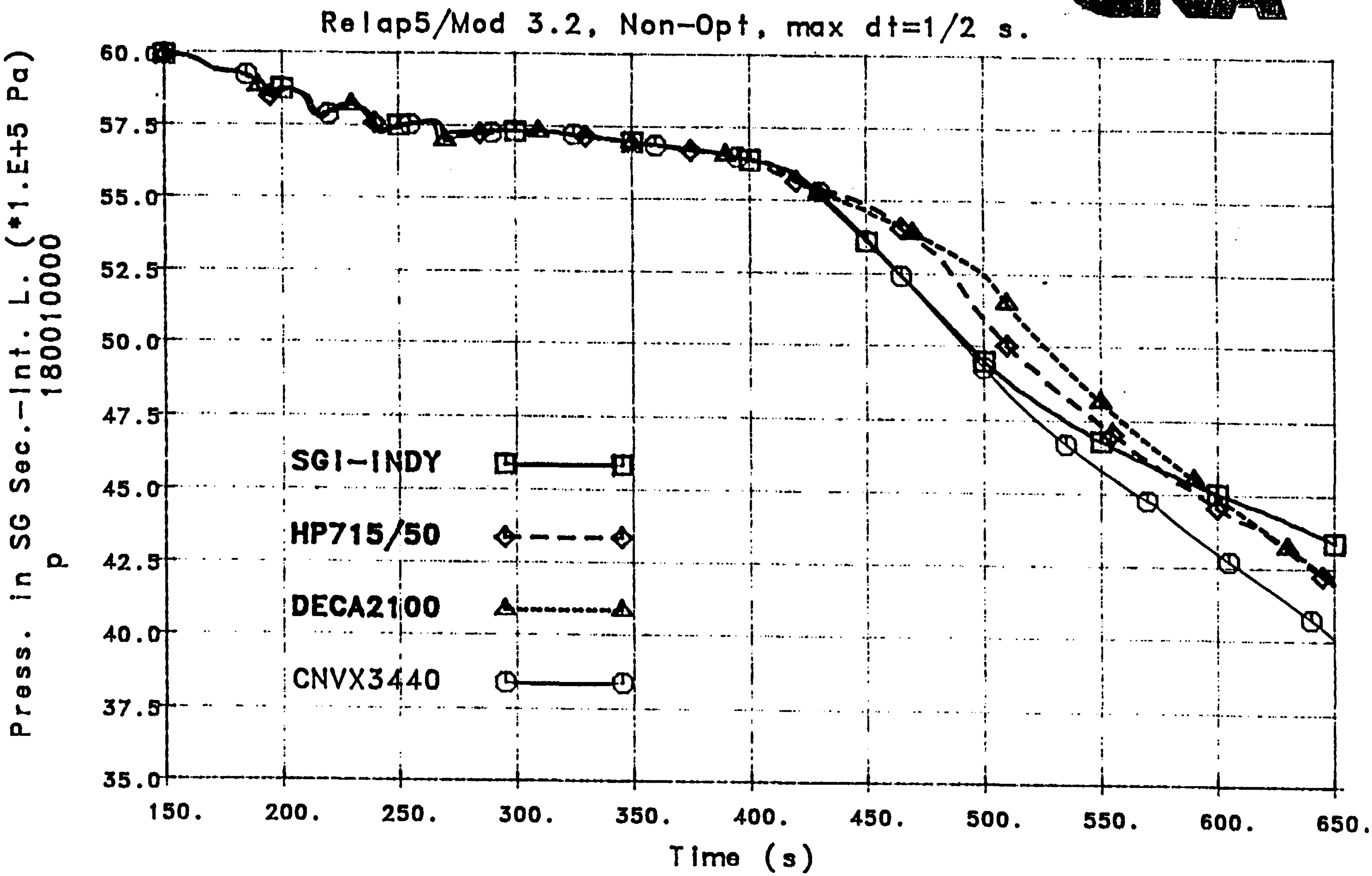


Figure 5.3

CAMP PROJECT

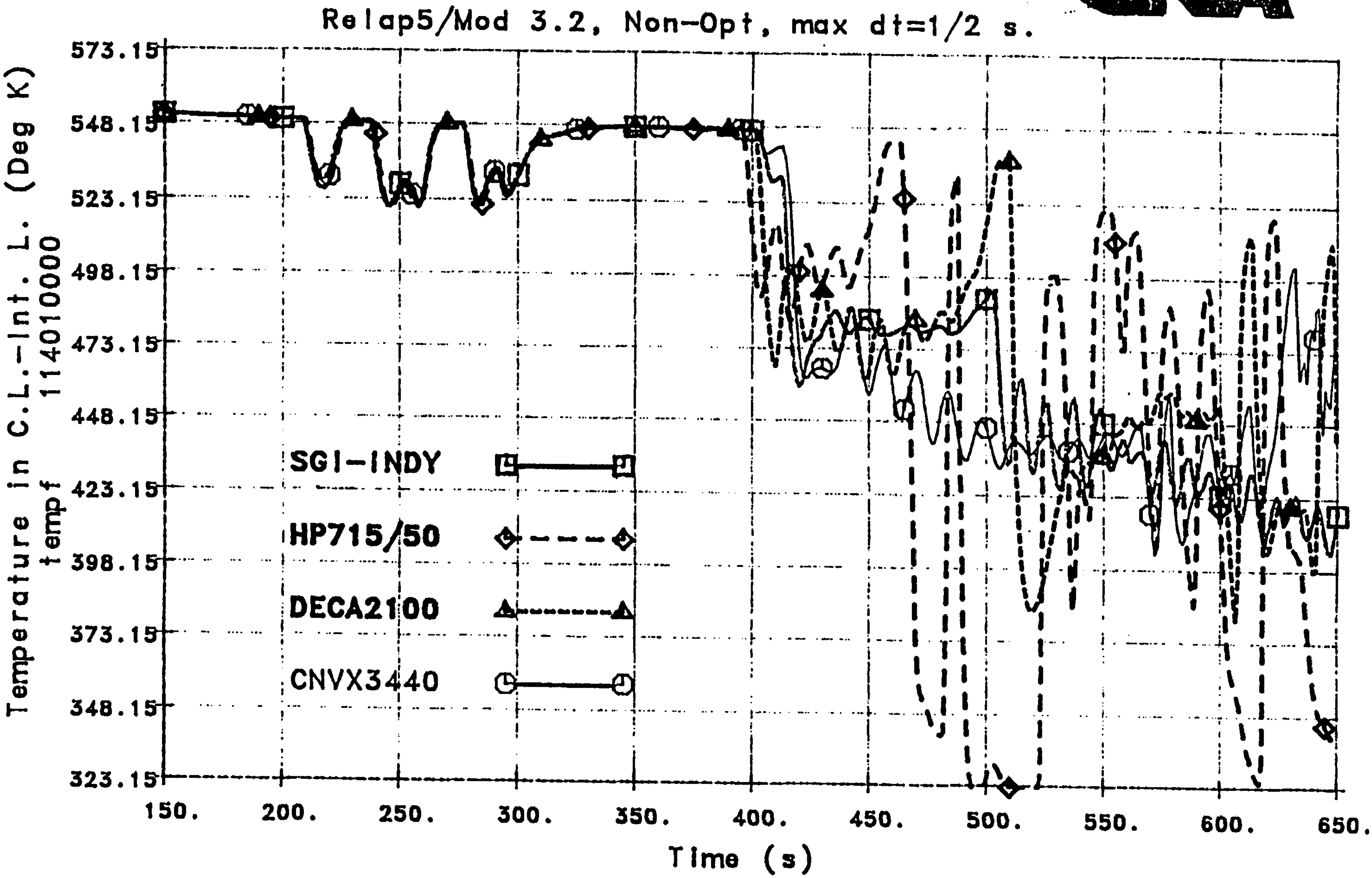


Figure 6.1

CAMP PROJECT

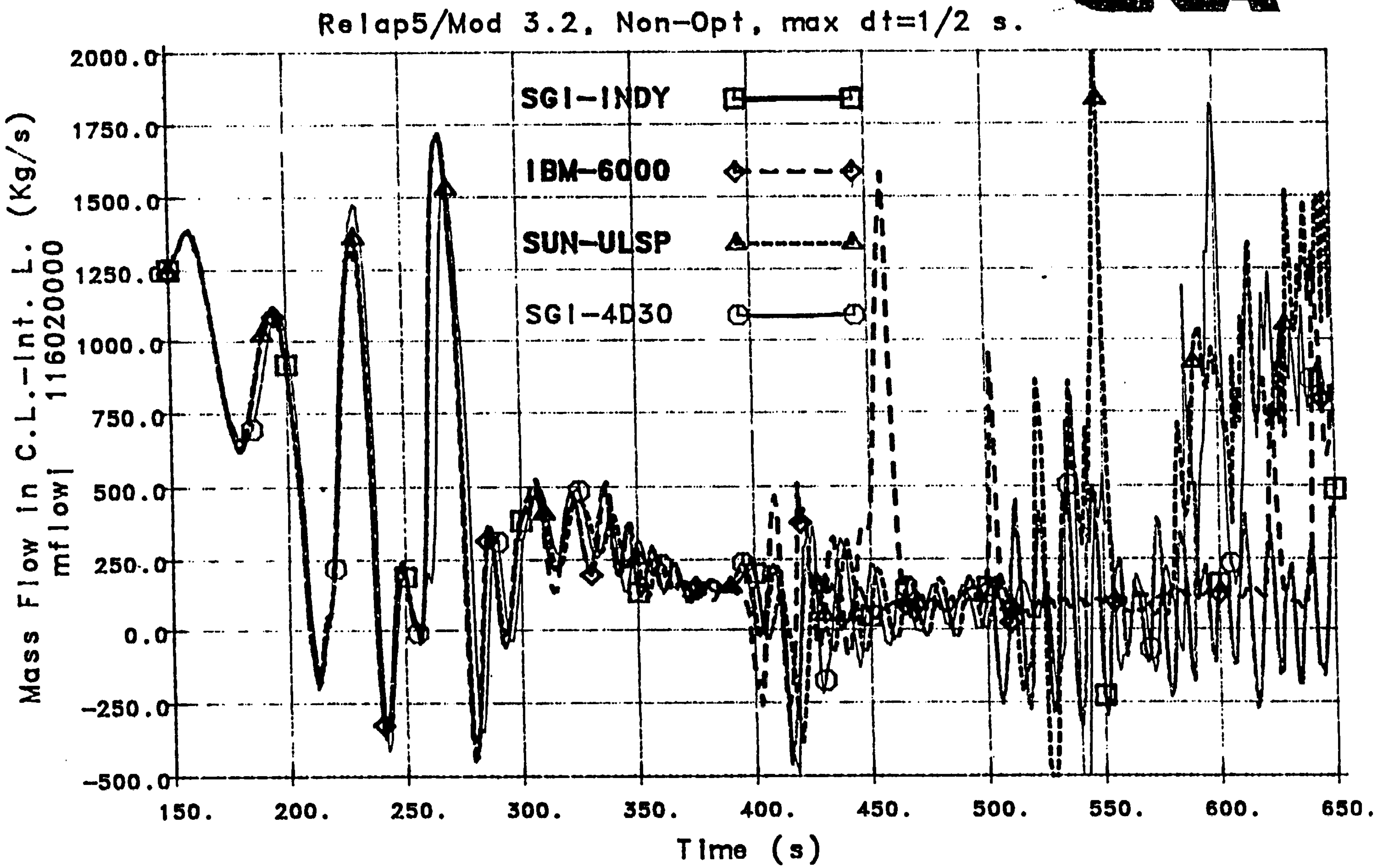


Figure 6.2

CAMP PROJECT

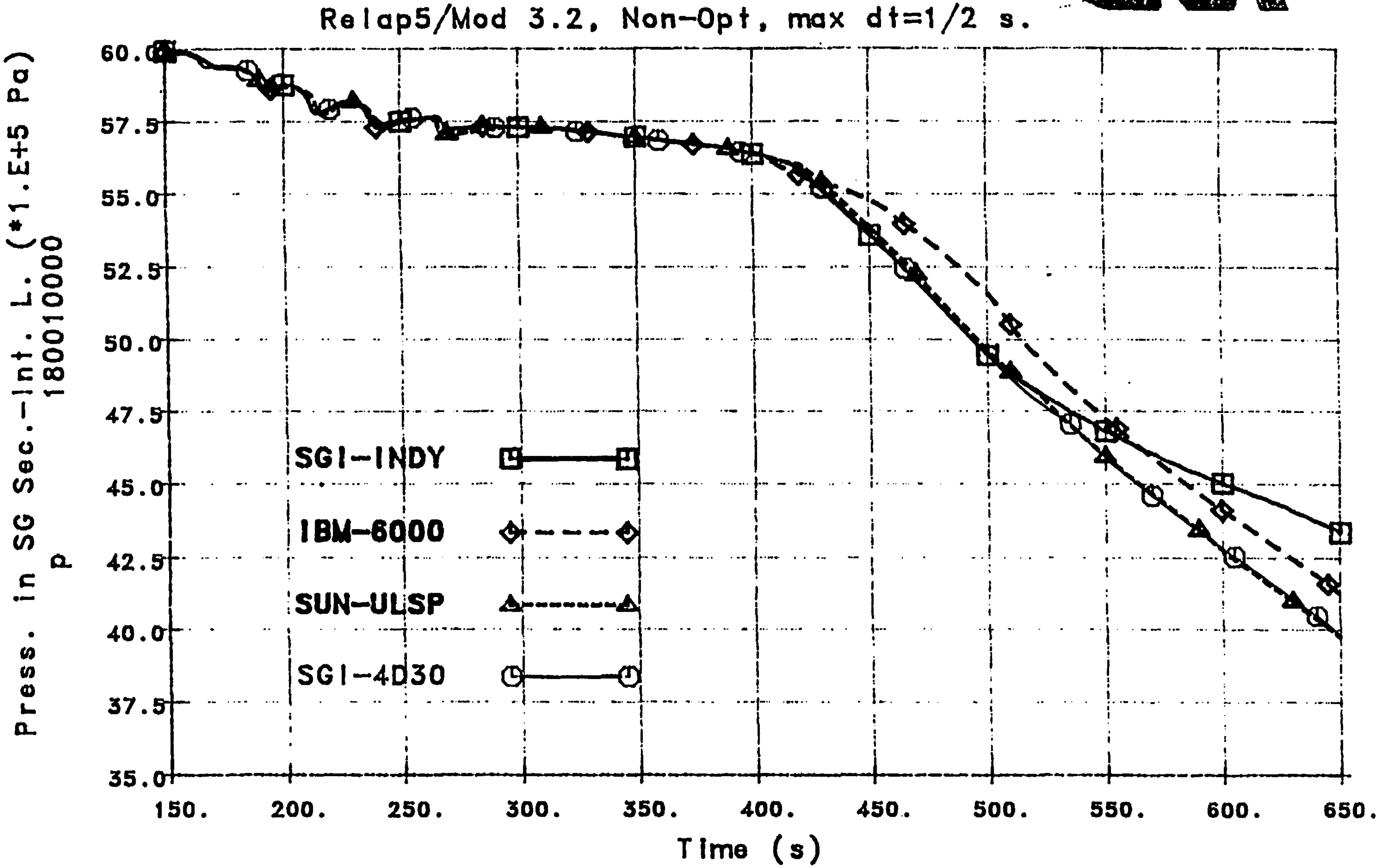


Figure 6.3

CAMP PROJECT

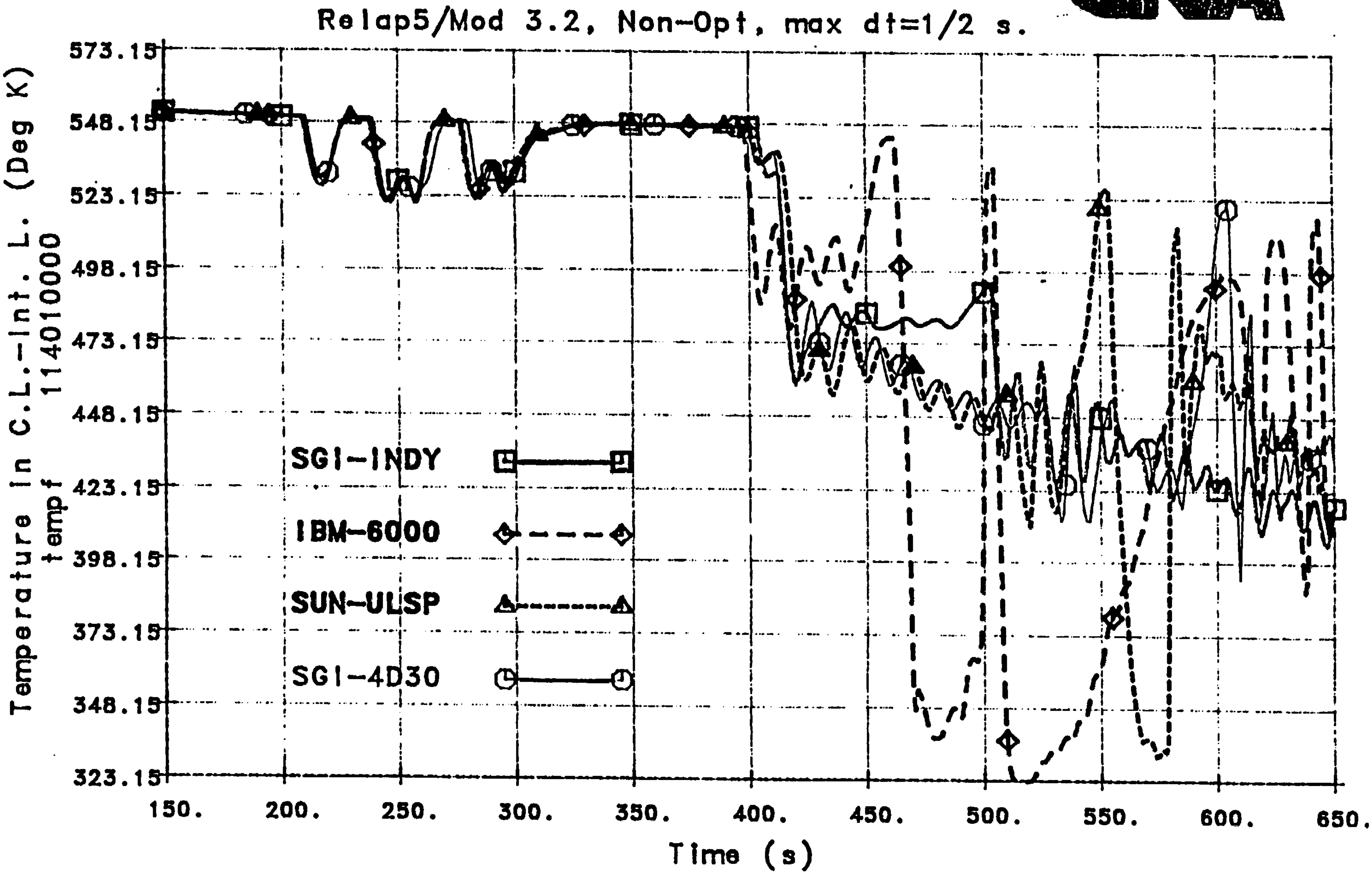


Figure 7.1

CAMP PROJECT

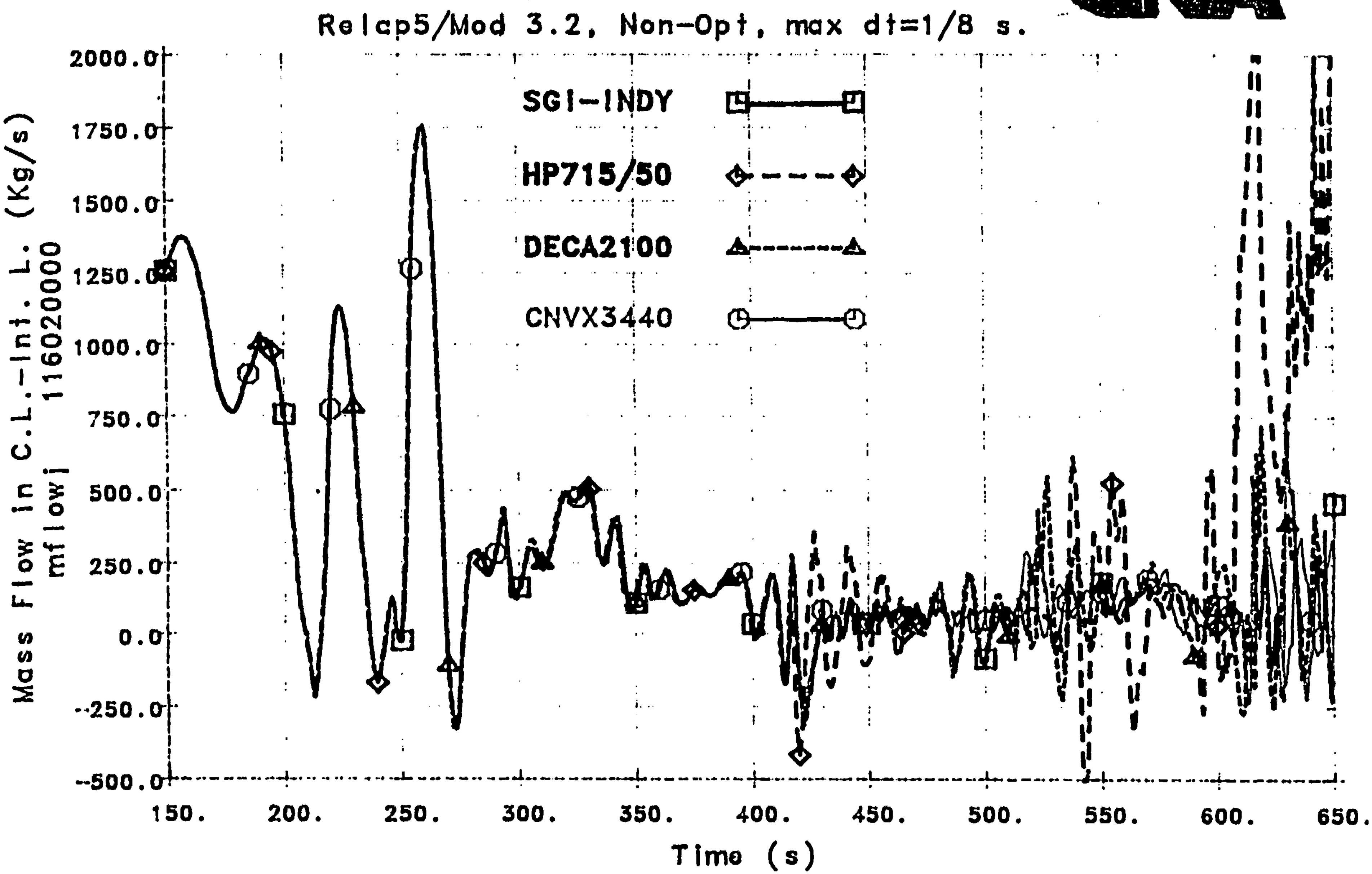


Figure 7.2

CAMP PROJECT

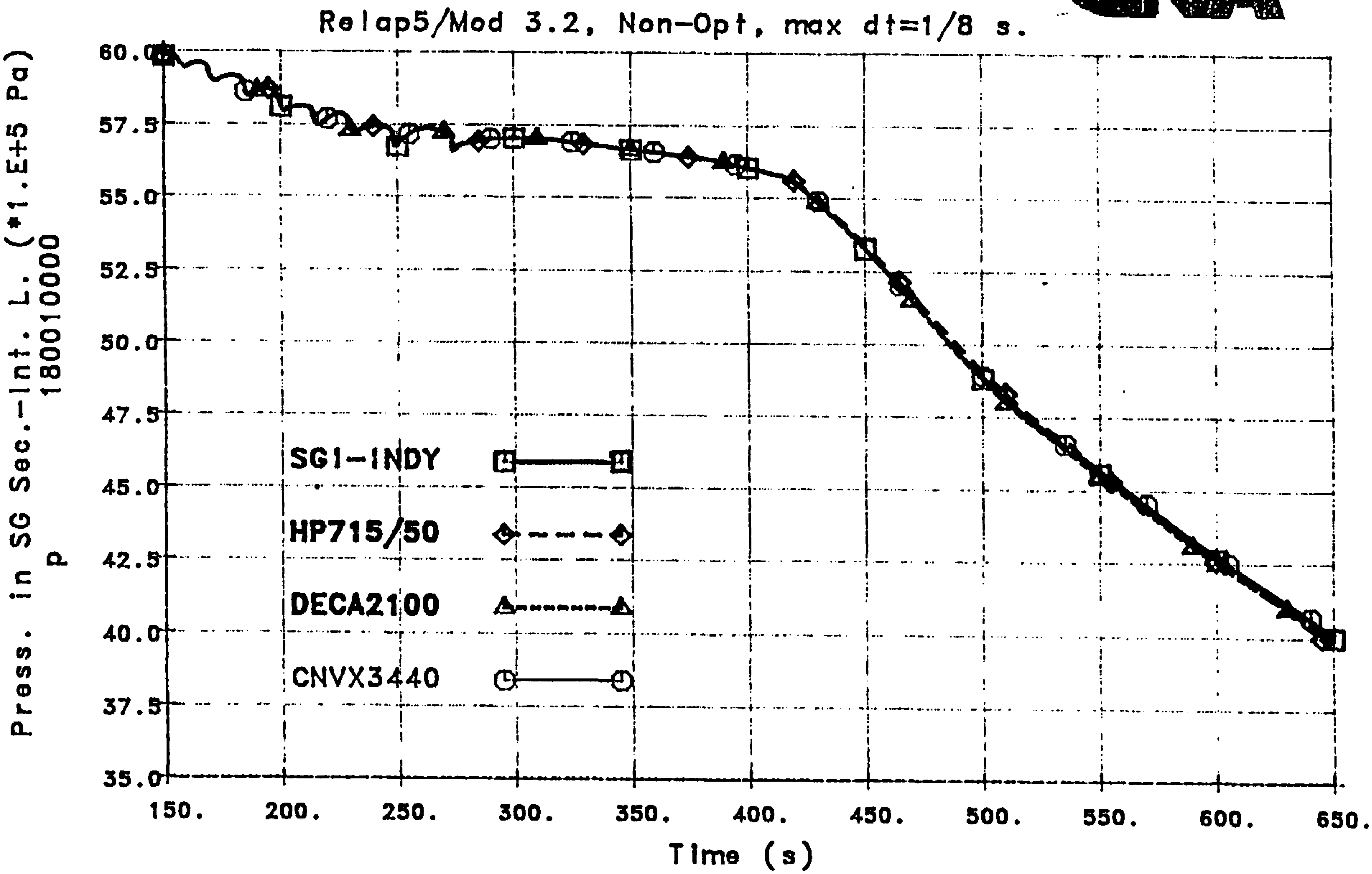


Figure 7.3

CAMP PROJECT

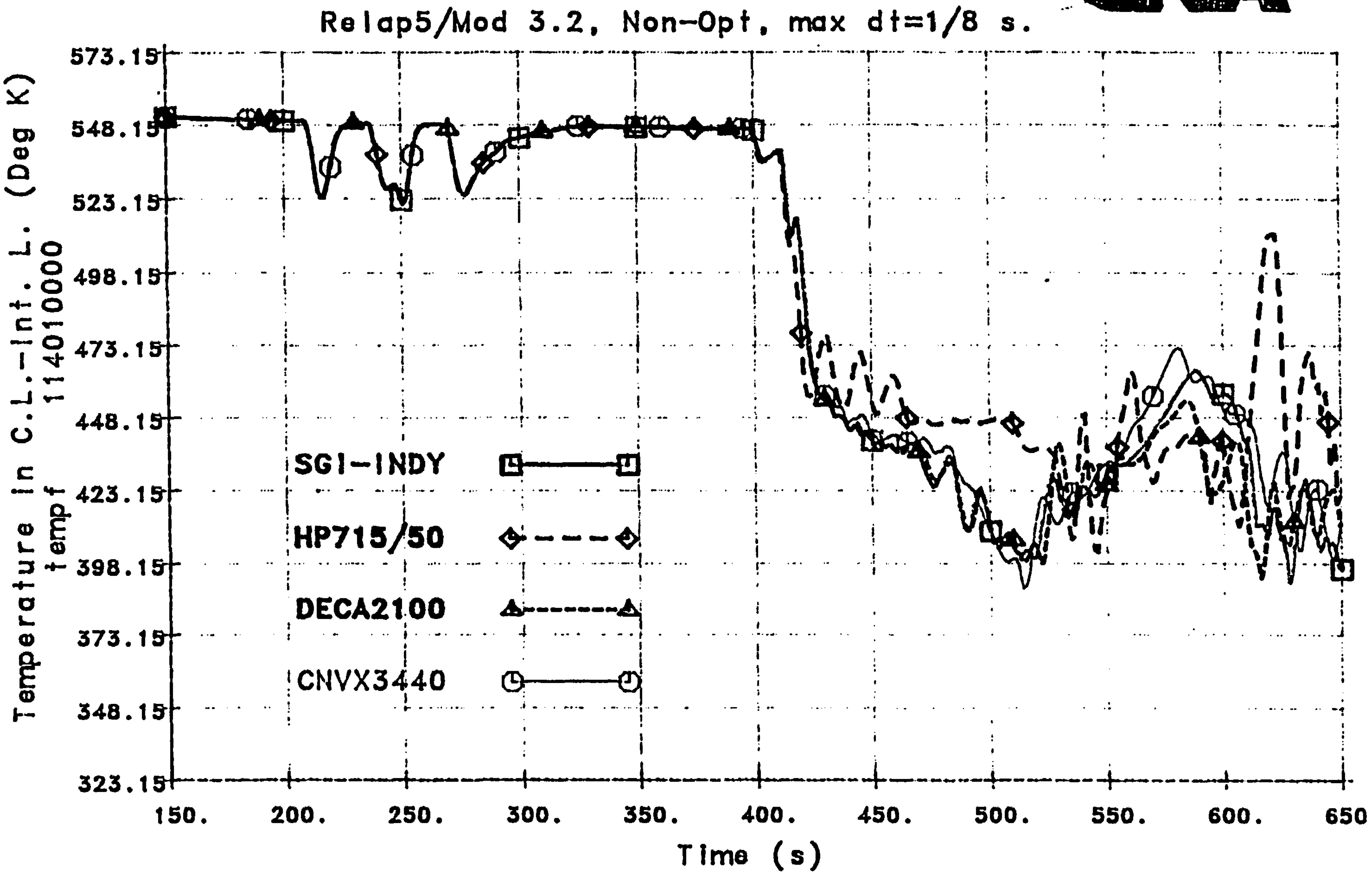


Figure 8.1

CAMP PROJECT

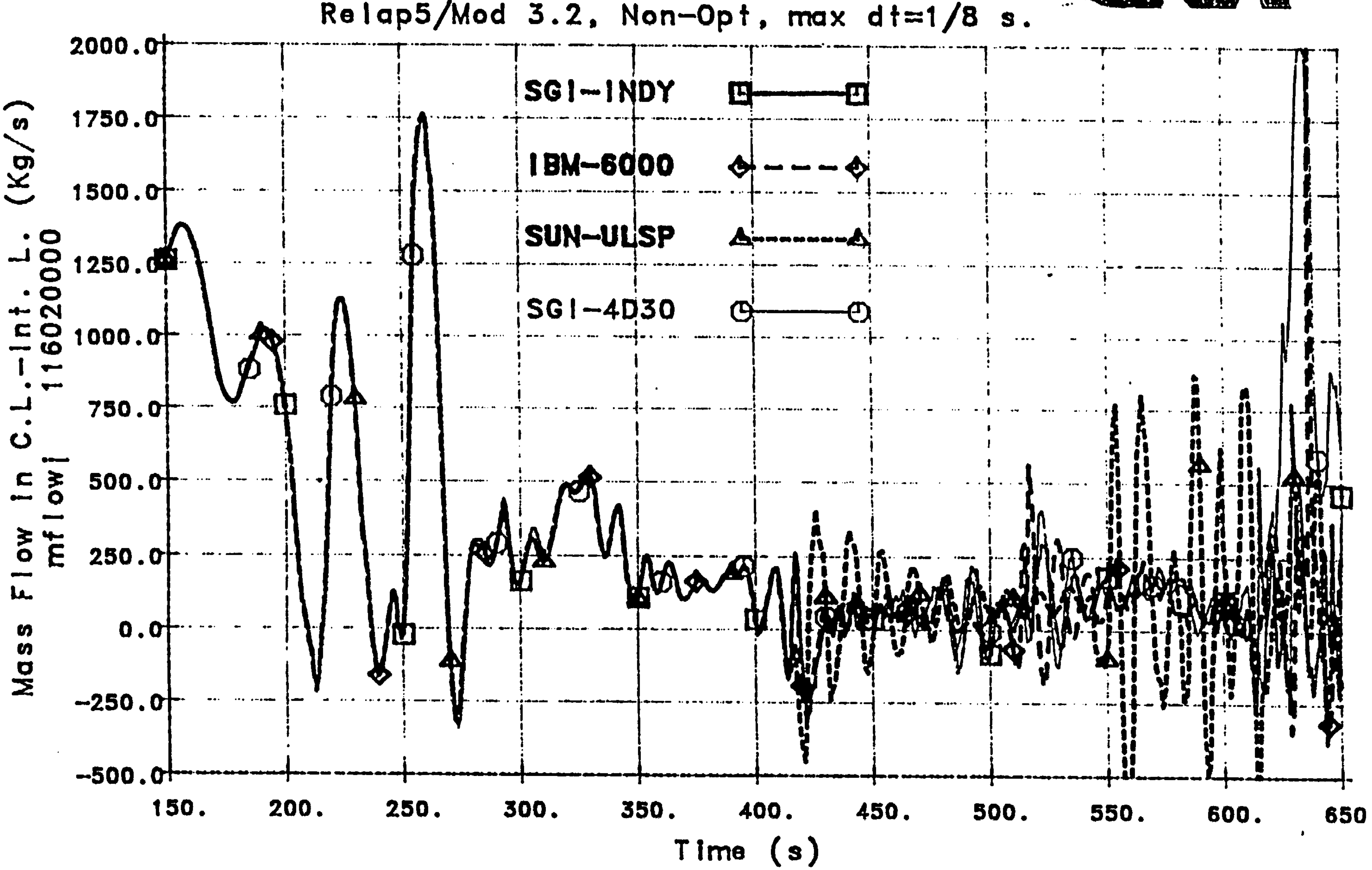


Figure 8.2

CAMP PROJECT

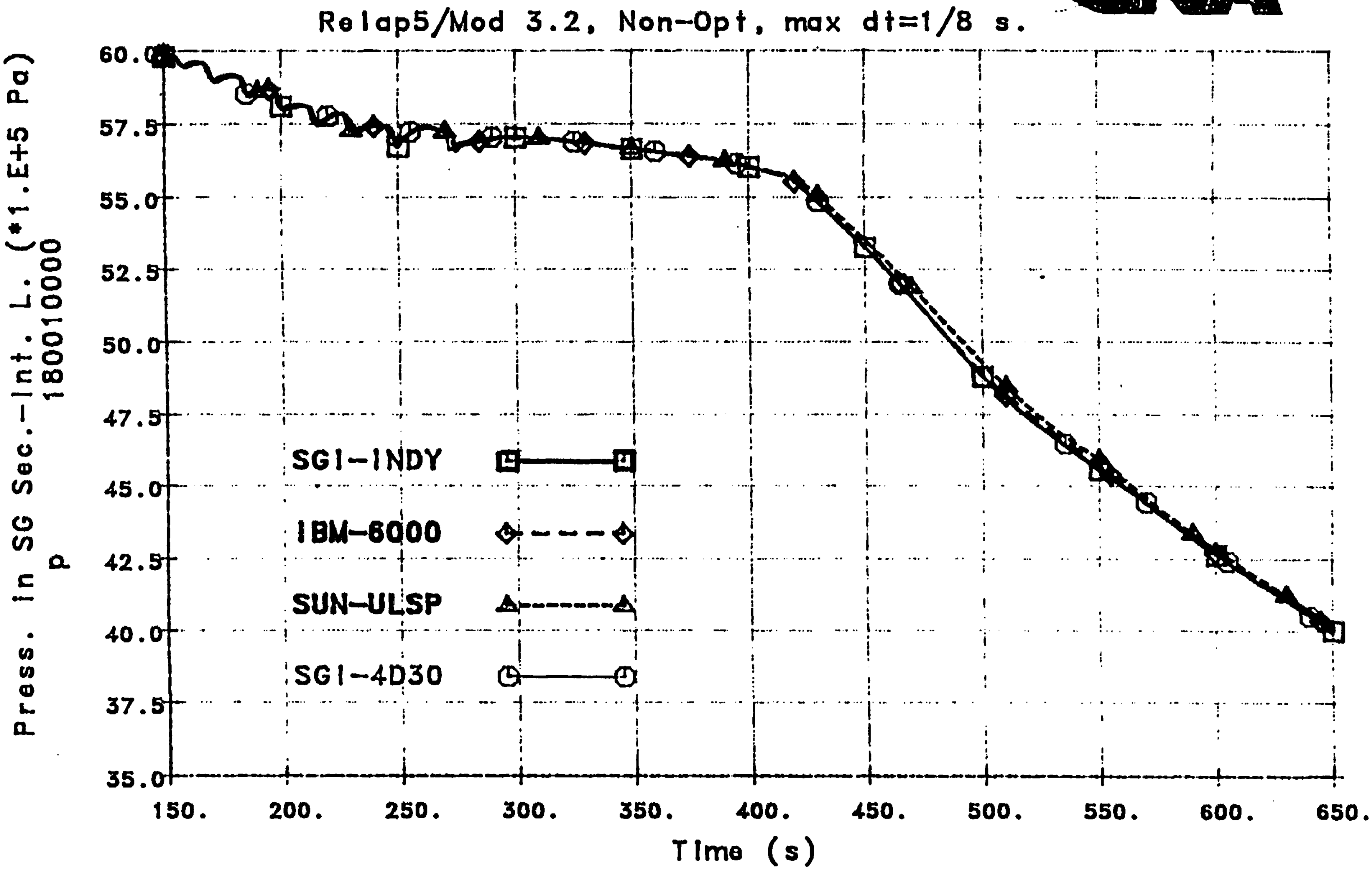


Figure 8.3

CAMP PROJECT

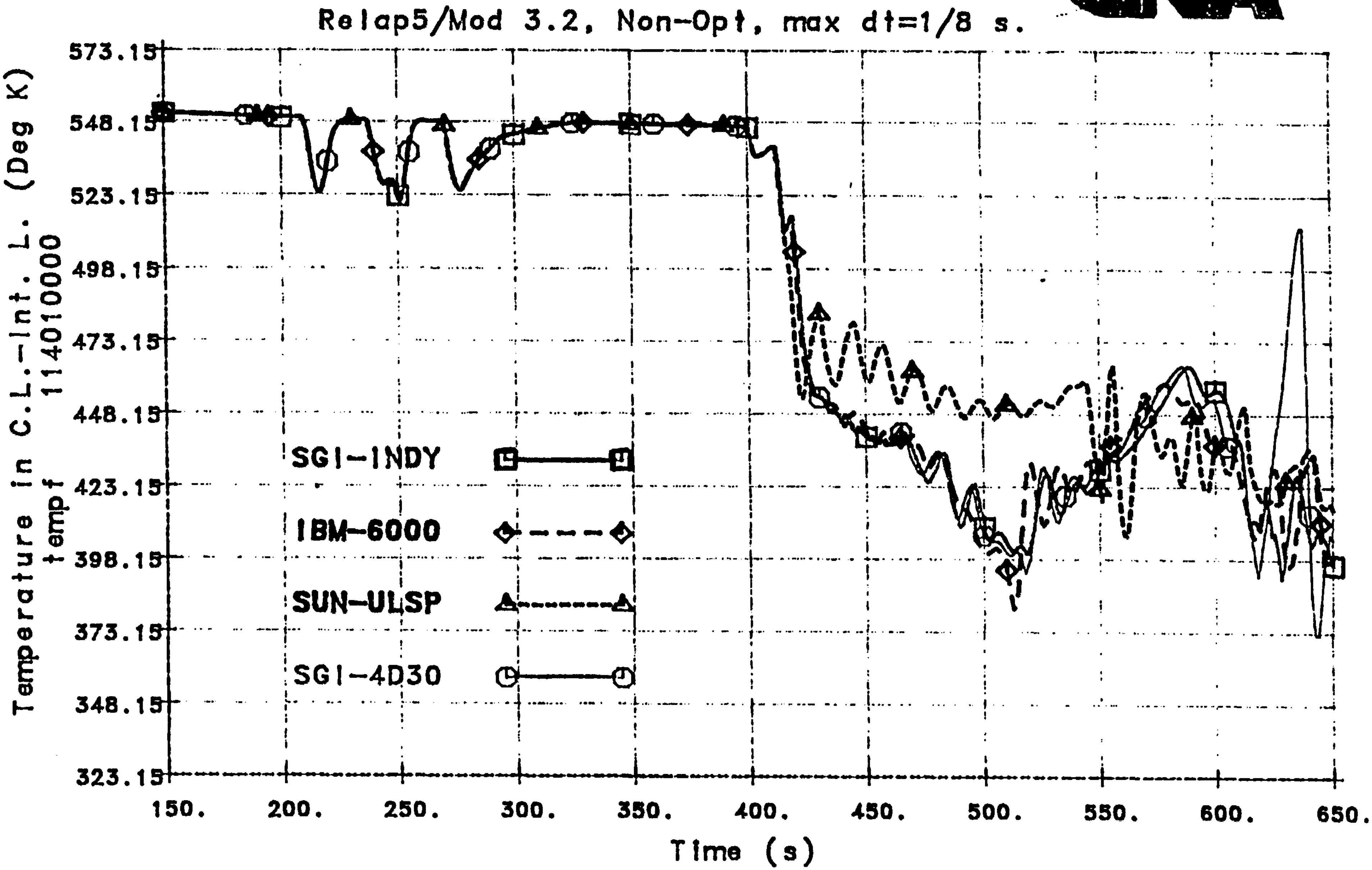


Figure 9.1

CAMP PROJECT

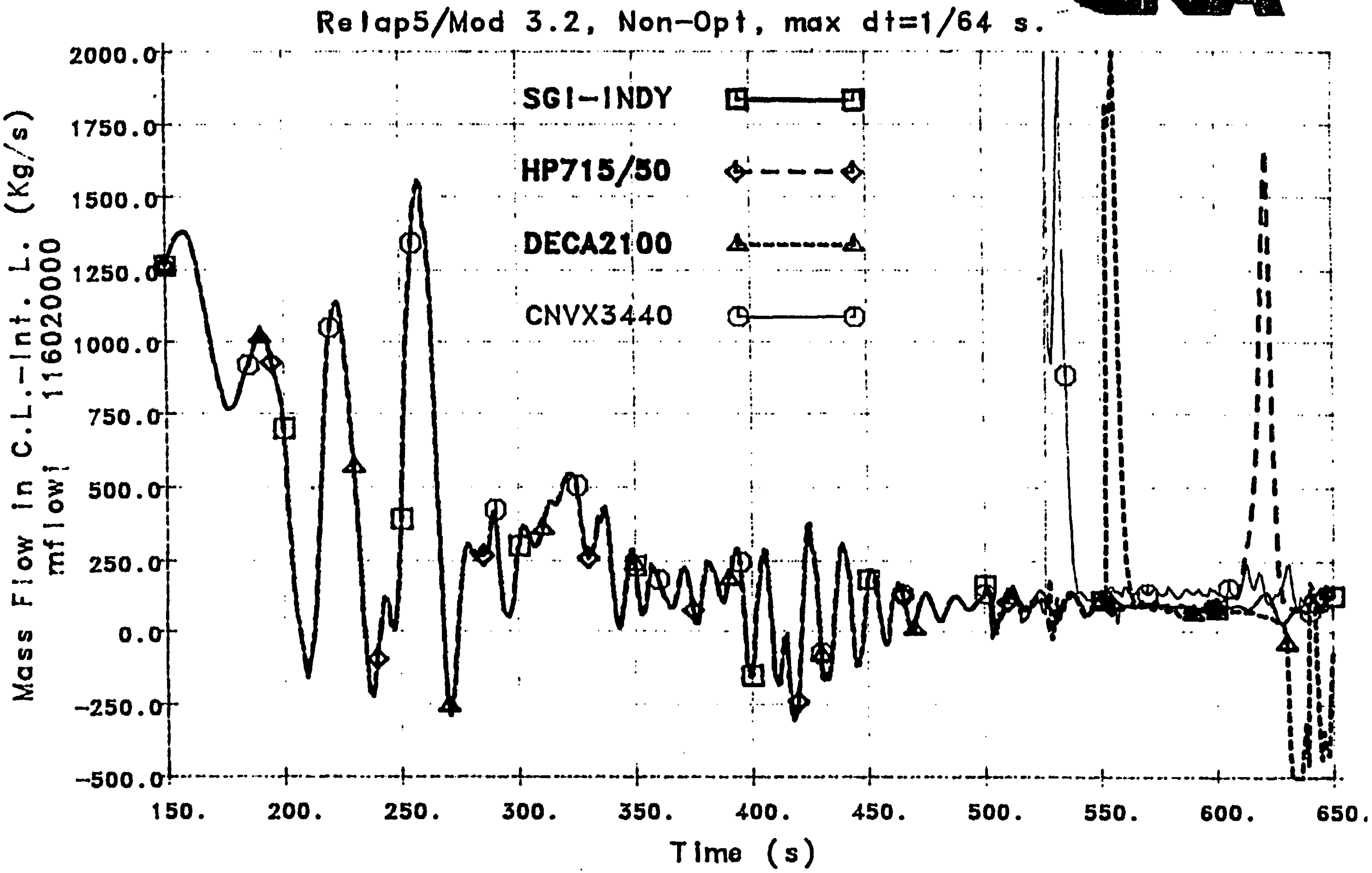


Figure 9.2

CAMP PROJECT

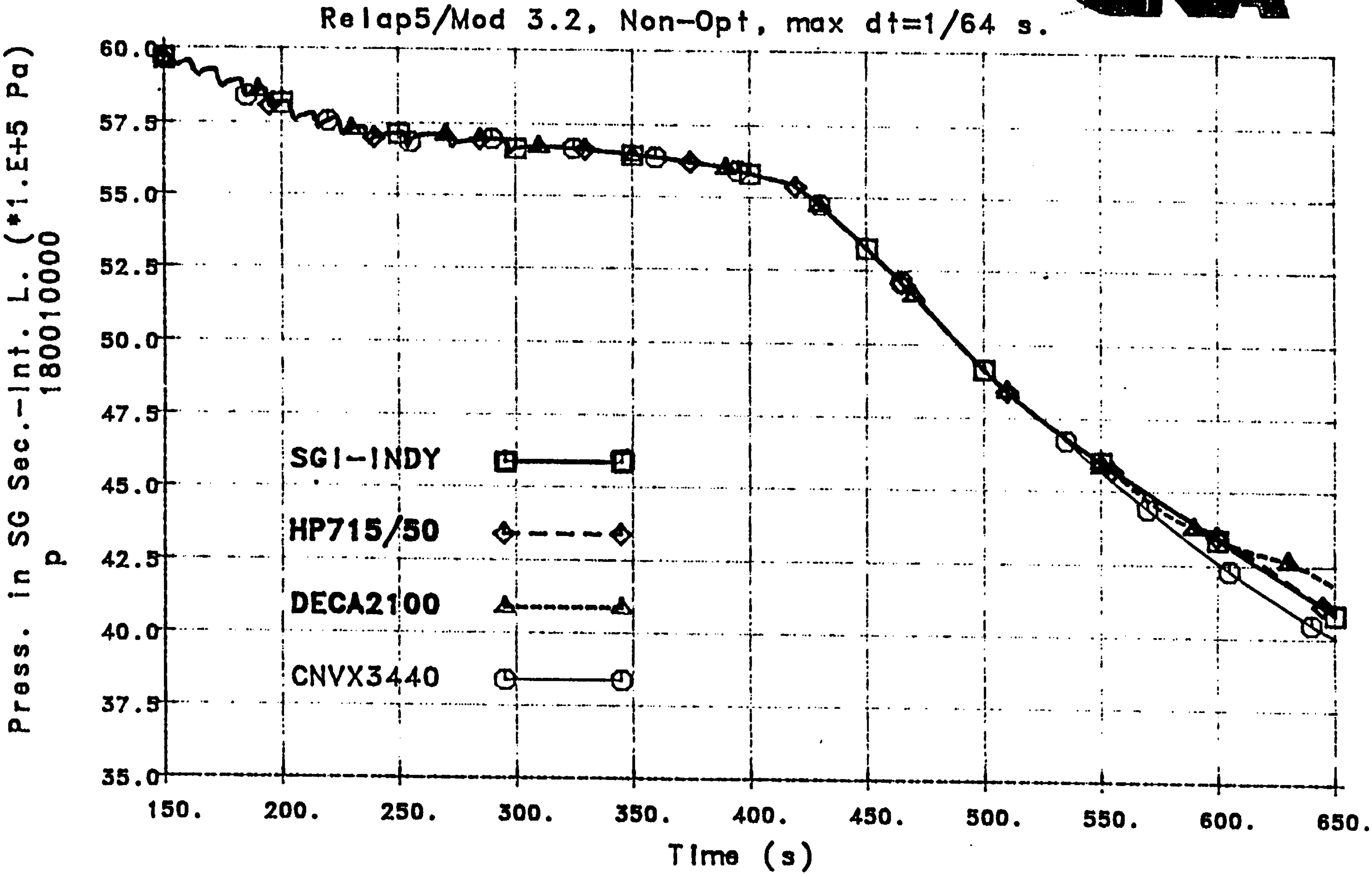
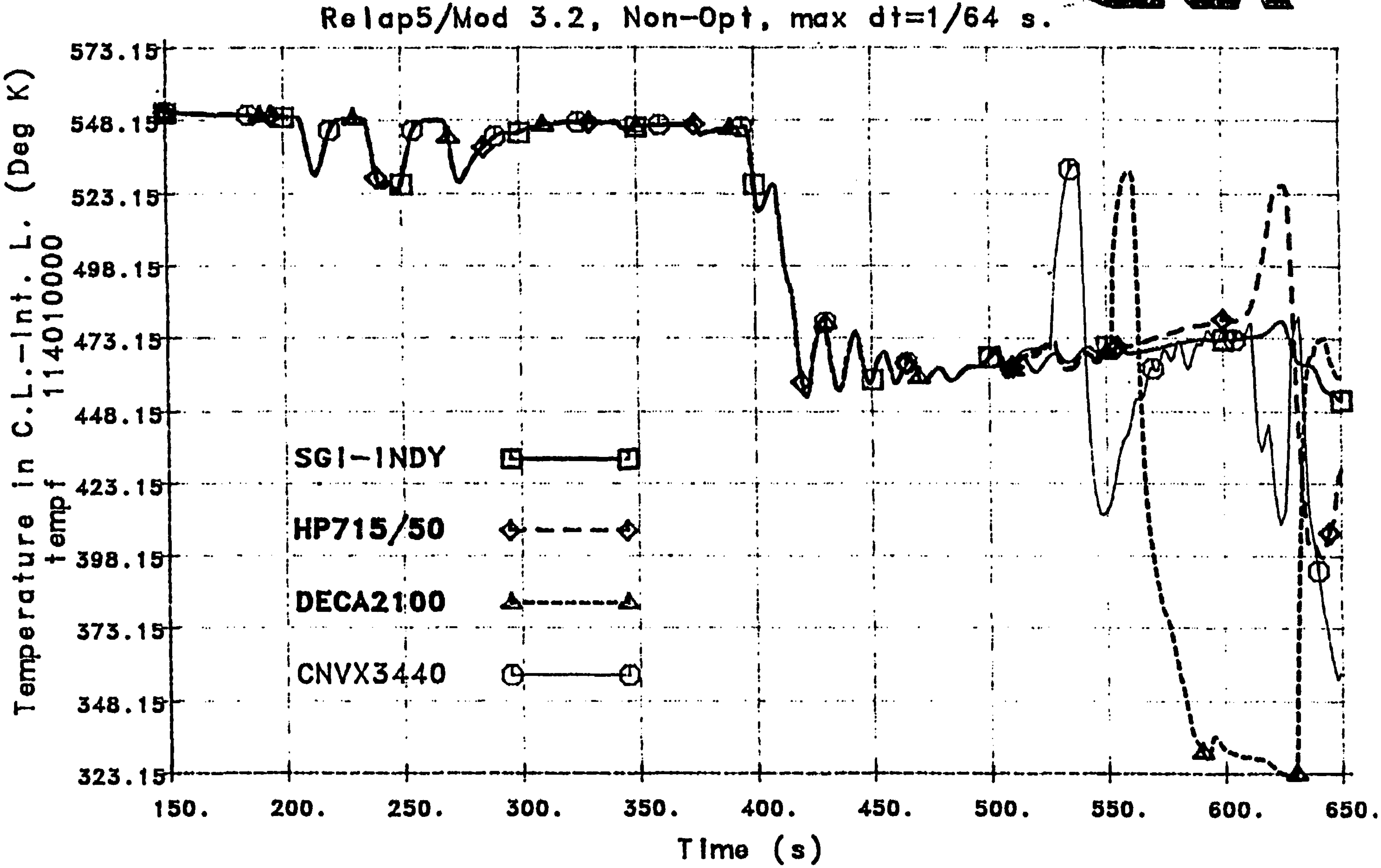


Figure 9.3

CAMP PROJECT



7. ACKNOWLEDGEMENTS

This work is part of the Spanish contribution to the CAMP project. The authors want to express their gratitude and appreciation to the following colleagues that kindly volunteered to provide both, suggestions and data from which this work was made, especifically: Miguel Sánchez-Perea from CSN, Arturo López-Cedillo from CNT, Emilio Moralo from CNJC, Francesc Reventós from ANA, Carlos Llopis from ANV-II, Ali Tanrikut from TAEA, and César Queral from ETSIMM. Our deep appreciation goes also to José Vicente López from CNG who carefully revised and gave meaninful comments to enrich this work.

8. REFERENCES

[1] Lynn R. Feinauer, "Compiler Issues Associated with Safety-related Software", Nucl. Tech., Vol. 93, pp. 116-122.

[2] K. Trambauer, "Computer and Compiler Effects on Code Results", Status Report, GRS Garching. NEA/CSNI/R(96)15.

[3] R.J. Preece and J.M. Putney, "Preliminary Assessment of PWR Steam Generator Modeling in Relap5/Mod3", NUREG/IA-0113, USNRC, September 1993.

Appendix I

Problems ocurred during the installation of Relap5/Mod 3.2 on the different platforms and actions taken to overcome them and produce Relap5 executables.

On CONVEX

Given the fact that it is a one-of-a-kind installation, extensive conversion effort had to be done, the description of which lies beyond the scope of this work.

On DecStations (DEC-3100, DEC5240)

No problem with DECftn v3.2, using script decrisc or decrisc2, however, v3.1 does not support dimensioning of the type: A(*).

On DEC-Alpha under OSF/1 v3.2

In the different Make files it is needed to append the continuation character, \, to each line in order to get every subprogram compiled.

Using DECftn v3.6, it was observed that when executing procedure dselap (within Makeq), the compiler was unable to compile subprograms stpupu.f and svpupu.f. The errors are localized in:

line 90 of stpupu.f (which reads as follows):

```
     if (s(2,n) .lt. ptrip) uin = max(uin,tphtbl(3,1))
```

line 94 of svpupu.f (which reads as follows):

```
     if (s(2,n) .lt. ptrip) s(12,n) = max(s(12,n),tphtbl(3,1))
```

in both cases the error message given is:

GEM ASSERTION, compiler internal error - please submit problem report. Fatal error in: /usr/lib/cmplrs/fort/decfort

Apparently, this type of error is linked to the compiler level (it has not been detected for DECftn v3.3).

Note: The problem was reported to DEC and corrected in upper level compiler versions.

On HP under HP/UX 9.03

The installation run smoothly except for the fact that file "icompn.f" had to be compiled with optimization deactivated.

On IBM under AIX 3.2

No incidences reported.

On SGI under IRIX 5.2

The following reflects the proposed changes in file 'goodies'.

NOTE: The files with appended '.ori' in their names are the INEL supplied ones, whereas the (modified) ones used in the actual installation keep their original names.

The below changes in 'goodies' are necessary to compile correctly and generate binary libraries and executables.

```
cna> diff goodies.ori goodies
1712,1713c1712,1713
<   set F1 = 'F1="-c -O2 -Olimit 2000 -onetrip -Nq1500 -Nn4000
-trapuv -G 0"'
<   set F2 = 'F1="-c -O2 -Olimit 2000 -Nq1500 -Nn4000 -trapuv -G 0"'
---
>   set F1 = 'F1="-c -O2 -Olimit 2000 -onetrip -Nq1500 -Nn9500
-trapuv -G 0"'
>   set F2 = 'F1="-c -O2 -Olimit 2000 -Nq1500 -Nn9500 -trapuv -G 0"'
```

The below changes in 'goodies' are necessary to avoid warning messages.

```
cna> diff goodies.ori goodies
679c679
<   set TOUCH = 'TOUCH=ranlib'
---
>   set TOUCH = 'TOUCH=touch'
993c993
<   set TOUCH = 'TOUCH=ranlib'
---
>   set TOUCH = 'TOUCH=touch'
1715c1715
<   set TOUCH = 'TOUCH=ranlib'
---
>   set TOUCH = 'TOUCH=touch'
```

On SUN under Solaris 2.5

The following changes in source files 'stgh2o.f' and 'stgd2o.f' are necessary to correctly read the steam tables.

NOTE: The files with appended '.ori' in their names are the INEL supplied ones, whereas the (modified) ones used in the actual installation keep their original names.

```
minas> diff stgh2o.f.ori stgh2o.f
422c422
<        parameter   ( maxlen = 5000 )
---
>        parameter   ( maxlen = 50000 )
460c460
<        open (2,status='scratch')
---
>        open (2,file='TEMPRES',status='unknown')
475c475
<        if (record.ne.blnkln)  write (2,1000) record
---
> C      if (record.ne.blnkln)  write (2,1000) record
481c481
<        rewind 2
---
> C      rewind 2
522c522,525
<        read (2,*,iostat=ios) (tables(i),i=next,next+np-1)
---
>        do i=next, next+np-1
>           read (2,*,iostat=ios) tables(i)
>        end do
> C      read (2,*,iostat=ios) (tables(i),i=next,next+np-1)


minas> diff stgd2o.f.ori stgd2o.f
214c214,217
<        read (2,*) (a(i),i=next,next+np-1)
---
>        do i= next, next+np-1
>           read(2,*) a(i)
>        end do
> C      read (2,*) (a(i),i=next,next+np-1)
```

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10. SUPPLEMENTARY NOTES

T. Lee, NRC Project Manager

11. ABSTRACT *(200 words or less)*

RELAP5/MOD3.2 was installed in all major UNIX workstations that include DEC, HP, IBM, SGI and SUN, besides that of CONVEX, and a common sample case was run on each of them. When these results were analyzed, substantial differences were observed in the magnitudes of selected parameters such as; pressure, mass flow, temperature, etc. The level of optimization adopted for compilation, the chosen maximum time step size and the inherent precision of the platforms under consideration are identified as possible causes for the discrepancies. Those discrepancies, however, lied within acceptable limits when results of different machines were produced by non-optimized version of RELAP5 and a maximum time step of about 0.125 seconds was used. To the users, it is recommended that a test be run whenever a new version of the code, operation system and/or compiler level is installed. The code developer needs to deliver a code which is compliant with ANSI standard for FORTRAN. The developer is also urged to evaluate the maximum time step size and provide a (or a set of) test to be used as an acceptance/rejection criterion for the new version of RELAP5.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*

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Different Platforms

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