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Installation of RELAP5/MOD3.2 on 80486 and Pentium Based Personal Computers

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Abstract

RELAP5/MOD3.2 has been installed on Intel Chip based personal computers at KNFC. This report is to present the installation procedures and test results for CPU time comparison and installation verification. Installation of RELAP5/MOD3.2 on PC has been done using Lahey Fortran F77L3 compiler under Windows 95 environment. The "dinstls" script with proper modifications was used to extract the source for conversion and then several modifications were done for installation on PC. Compilation and linking has been done using a MAKE utility and generation of TPFH2O has been done also. Four test cases were used to verify the conversion and installation of RELAP5/MOD3.2 on PC. CPU time benchmark calculation was also done. The results show that the use of PC version could be an option for the users based on the availability of hardware and the speed of CPU.

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Executive Summary

RELAP5/MOD3.2 PC version has been installed on IBM-compatible personal computers at Korea Nuclear Fuel Company(KNFC). The purpose of this report is to present the installation procedures and test results for installation verification. This report is submitted to USNRC as one of the in-kind contribution of Korea to Code Applications and Maintenance Program(CAMP) according to the TPC's approval at the eighth CAMP meeting in Spain.

Previously, there were several attempts to install the RELAP5 code on IBM-PC because the capability of the hardware based on Intel microprocessors such as 80486, Pentium, and Pentium pro has increased enough to run the RELAP5 code on IBM-PC. Frantisek Kolman's attempt of Nuclear Power Plants Research Institute(NPPRI) of Slovakia was one of them. He presented the installation of RELAP5/MOD3/5M5 on 32-bit PC with DOS based operating system in 1993. Steve Thomasson of Carolina Power & Light Company also described the installation procedures and requirements to install RELAP5/MOD3/5M5 on 80386 & 80486-based microcomputers in 1993. Akhil Gantayat and Mushtaque Habib of Vectra Technologies, Inc. presented a paper about steam-hammer analysis in 1994. It is said that RELAP5 PC version called RELAP5M2/RMA was used in their paper. Recently, A. Annunziato of Joint Research Center in Ispra published a report on implementation of RELAP5/MOD3.1 on PC in 1995 and Steve Thomasson of Enercon presented a paper on using RELAP5/MOD3.2 on a PC in 1996 RELAP5 International Users Seminar.

At KNFC, installation of RELAP5/MOD3.2 on PC has been done using Lahey Fortran F77L3 compiler under Microsoft Windows 95 environment. Extraction of the source for conversion and several modifications were done for porting RELAP5/MOD3.2 on PC.

Four test cases such as TYPPWR, Semiscale S-NC-8B, LOFT L9-1/L3-3, and LOFT L2-5 were used to verify the conversion and installation of RELAP5/MOD3.2 on PC. CPU time benchmark calculation was also done using TYPPWR case. In TYPPWR case results from PC version matched with those of HP version reasonably well until 400 sec. After 400 sec, the results from two versions start to diverge but overall trend was similar each other. An attempt was tried to improve the predictablity by using smaller time step. In S-NC-8B case, the results were quite good and there seems to be no difference in temperature and pressure prediction in the plots. In LOFT L9-1/L3-3 case, results from PC version follow the results from HP version by some time lag. In LOFT L2-5 case, no difference was found for the pressure prediction but there was about 40 K difference in peak cladding temp.(PCT) prediction after 20 sec into transient. In summary the overall prediction capability of PC version was good enough to be used as an option for the hardware choices but more efforts should be done to improve the numerics part of RELAP5.

1. Introduction

RELAP5/MOD3 was developed for the analysis of all transients and postulated accidents in light water reactor(LWR) systems, including both large- and small-break loss-of-coolant accidents as well as the full range of operational transients. The system models are so complicated that code execution was normally done on mainframe computers or workstations such as CRAY X-MP, DECstation 5000, DEC Alpha Workstation, IBM Workstation, SUN Workstations, HP Workstation, and etc.

There were several attempts to install the RELAP5 code on IBM-PC because the capability of the hardware based on Intel microprocessors such as 80386, 80486, Pentium, and Pentium Pro has increased enough to run the RELAP5 code on IBM-PC. Such activities can be found in the literature and are summarized as follows.

Frantisek Kolman[1] of Nuclear Power Plants Research Institute(NPPRI) of Slovakia presented the installation steps and code modifications of RELAP5/MOD3/5M5 on 32-bit PC with DOS based operating system at the second CAMP Meeting held in Belgium, 1993. The major parts of the code modifications are corrections in the memory management routines, correction in the subroutine *ICONVR*, declaration change in *STH2X6*, modifications for extracting an exponent part of a *REAL*8* variable in matrix inversion routines, and correction of the wrong formulas for the variable *AET* in subroutine *STATEP*. In 1994 RELAP5 International Users Seminar Akhil Gantayat and Mushtaque Habib of Vectra Technologies, Inc. presented a paper[2] about steam-hammer analysis in which RELAP5 PC version called RELAP5M2/RMA was used.

Steve Thomasson of Carolina Power & Light Company described the installation procedures and hardware and software requirements to install RELAP5/MOD3/5M5 on 80386 & 80486-based microcomputers in his transmittal letter[3], which has been released to Korea domestic CAMP members in Oct. 1994. He used *SELECTF* utility with four *DEFINE* options such as *$DEFINE HP, $DEFINE IN32, $DEFINE FOURBYT*, and *$DEFINE IEEE*. Some intrinsic function calls in the environmental library were replaced with the functions provided in the NDP-486 Fortran libraries. The required changes were modifications in the subroutines using a *%LOC* function, replacement of an *ABORT* function with a *STOP* statement in subroutine *FABEND*, the use of NDP function *SEC_1000* in routine *TIMSET*, and use of NDP *IDATE* and *TIME* functions in subroutines *DATE* and *CLOCK*, respectively. Comparison table of execution speeds of various machines is also included in the description.

A. Annunziato of Joint Research Center in Ispra submitted a report[4] on implementation of RELAP5/MOD3.1 on PC in 1995. He described the installation steps, the changes in some routines, and routines added. The *DEFINE* options used in the "*dinstls*" script are "*boront, decrisc, frifac, fourbyt, impnon, in32, losuboil, ondimk, mmfld, prizer, sphacc, threed,*

unix, and *vargrav*". The modifications are the removal of a *GOTO* statement at label 53 into a *IF-ENDIF* structure in subroutine *RPUMP*, change of variable *NULL* definition and change of value of status specifier in open statement in subroutine *GNINIT*, use of *UNKNOWN* instead of *NEW* for the status specifier in open statement in subroutine *RRSTD*, modifications in the read and write statements in subroutines *STGH2O* and *STREAD*. *ETIME, FTIME, ABORT, GETARG,* and *NARG* routines have been added to be compatible with Microsoft Fortran Power Station Compiler. Test runs were done using typpwr.i input included in RELAP5 transmittal package.

Steve Thomasson of Enercon presented a paper[5] on using RELAP5/MOD3.2 on a PC in 1996 RELAP5 International Users Seminar. He suggested OS/2.0 operating system and OS/2.0 Pentium-optimizing compiler as an option for software requirements. Pentium-based PC with 16 Megabytes or at least 8 megabytes was recommended as hardware requirements. Installation steps include choosing proper *DEFINE* statements, following same process as that performed by the Unix installation scripts, and changing compiler-dependent routines such as *CLOCK, DATE, LOCF*, and etc.

At Korea Nuclear Fuel Company(KNFC), one of Korea domestic CAMP members, installation of RELAP5/MOD3.2 on PC has been done using Lahey Fortran F77L3 compiler under Microsoft Windows 95 environment. This report, which describes the related works, is submitted to USNRC as one of Korean In-Kind Contribution upon '96 Spain CAMP TPC's decision.

The installation procedure is described as follows: The "*dinstls*" script with proper "**DEFINE*" statements was used to extract the source for conversion and several modifications have been done for porting RELAP5/MOD3.2 on PC. The modifications include adding a comma in the several format statements, fixing number of argument mismatch in *INP.FOR*, correction in subroutine *TIMSET.FOR*, change of lower temperature limit in subroutine *STACC.FOR*, and fixing unnecessary conversion done by *CNV32.X* in subroutine *AATL.FOR*. Compilation and linking have been done using a *MAKE* utility and steam property file, *TPFH2O* has been generated by the same procedure as script *DSTGXXX*.

Four test cases were used to verify the conversion and installation of RELAP5/MOD3.2 on PC. CPU time benchmark calculation has been performed also using TYPPWR case. The test results show that PC version predicts the overall thermal hydraulic phenomena reasonably well and PC may be used as an option for the hardware choices possibly.

2. Installation of RELAP5/MOD3.2 PC Version

The source code for creating RELAP5 PC version can be obtained using the "*dinstls*" script distributed with RELAP5 transmittal package. The "*ddefine*" of "*dinstls*" script for HP has been modified to include the following options.

$define laheyf77
$define blkdta
$define boront
$define crossfl
$define doebplu
$define doeitr
$define doption
$define erf
$define fourbyt
$define gesep
$define hconden
$define impnon
$define in32
$define level
$define losuboil
$define mmfld
$define nestle
$define loc
$define prizer
$define sphaccm
$define tfront
$define threed
$define vargrav

After "*dinstls*" script has been executed by typing the command, "*dinstls hp relap nonpa >& dinstls.out*" on HP, the source files for PC version generated under both *selap* and *envrl* directories were transferred to the PC, keeping the same directory structure. That is, files were appropriately copied to *c:\relap5\envrl* and *c:\relap5\selap*. Because the source files format is a fixed format, the source files with suffix "*.f*" have been renamed "*.for*" on PC.

2.1 Modifications of Source

Some modifications were necessary in order to compile RELAP5 with Lahey Fortran Compiler on PC. The modifications are summarized as follows.

2.1.1 Format Errors

There were several fatal errors due to missing a comma in the format statement. The related routine names and format numbers are given below;

SNPMD.FOR	*under ENVRL*	*: format 801*
SNPMI.FOR	*under ENVRL*	*: format 801*
SNPML.FOR	*under ENVRL*	*: format 801*
SNPTD.FOR	*under ENVRL*	*: format 802*
SNPTI.FOR	*under ENVRL*	*: format 802*
SNPTL.FOR	*under ENVRL*	*: format 802*
CMPCOM.FOR	*under SELAP*	*: format 2108*
IEDIT.FOR	*under SELAP*	*: format 2020*

2.1.2 Number of Arguments in *INP.FOR*

Seventh argument, *LPR* of the subroutine *INP.FOR* under *ENVRL* directory was deleted because the number of arguments is not matching with the calling statements.

Thus the line looks like as shown below before and after the modification.

subroutine inp(l1,nl1,hed,ncase,ndata,isw,lpr
--->subroutine inp(l1,nl1,hed,ncase,ndata,isw)

2.1.3 *TIMER* in Routine *TIMSET.FOR*

In subroutine *TIMSET, TIMER* was used as a function but it is only available as a subroutine in Lahey Fortran. The modified source is attached in Appendix A.

2.1.4 Lower Temperature Limit in Routine *STACC.FOR*

During running RELAP5 PC version with LOFT L2-5 input, an error has occurred. The message was "steam property error" in injecting accumulator water. In subroutine *STACC*, temperatures of gas and liquid are limited by *TTRIP* which is defined as 273.16 K. That temperature is lower limit in the steam table. It seems that the value of temperature in PC version was slightly smaller than 273.16 and then program stopped. Therefore an arbitrary small value was added to the limiter. That is, (*TTRIP+0.001D0*) was used instead of *TTRIP* in *STACC*. The changed lines are:

tliq=max(ttrip,tt) ---> tliq=max(ttrip+0.001d0,tt)
tt=max(ttrip,tempg(i)) ---> tt=max(ttrip+0.001d0,tempg(i))

2.1.5 Unnecessary Conversion by *CNV32.X* in Routine *AATL.FOR*

One of the warning messages was "character target length less than character constant

length" for the *PTITLE* character variables in subroutine *AATL*. During conversion process, *CNV32.X* did unnecessary conversion such that it added "*d0*" at the end of number,"*3.2*" in the character string of *PTITLE*. It has been modified to keep the original character string.

2.2 Compiler Options and Compilation

The Following options have been used for Lahey F77L/EM32 compiler:

n0 - *Standard Fortran 77 IMPLICIT*
n2 - *Generate 387 constants and code*
4 - *Optimize for 486 processor*
7 - *Get 80x87 items from memory*
A2 - *Allocatable array checking*
B - *Check array subscript bounds*
nC - *Ignore nonstandard usage*
nC1 - *INTEGER constants 4 bytes*
nD - *Direct files with headers*
nD1 - *(N/A)*
nF - *Standard-Format source file*
nH - *No hardcopy source listing*
I - *Check subprogram interfaces*
nK - *Generate 80x87 code*
L - *Line-number traceback table*
nO - *No options output*
P - *Protect constant argument*
nQ1 - *Assume infinite NDP stack*
nQ2 - *No protected-mode RPC module*
nQ3 - *No real-mode RPC module*
R - *Remember local variables*
nS - *No SOLD file created*
nT - *INTEGER*4, LOGICAL*4 default*
V - *VAX Fortran interpretation*
W - *Display warning messages*
nX - *No Xref listing*
Z1 - *Production optimizations*

Before doing compilation of RELAP5/MOD3.2, make sure that the directory containing the *F77L3*, *386LIB*, *386LINK*, and *RUN386* files is declared in the *PATH* variables, otherwise use full path names to the above files. The library file *ENVRL.LIB* can be created using a *MAKEFILE* which is attached in Appendix B. Let's assume that *ENVEL.LIB* is created under *c:\relap5\envrl* directory. Then, the RELAP5/MOD3.2 executable file, *RELAP5.EXE*, can be created by linking the object files under *SELAP* directory with the above *ENVRL.LIB*. The compilation and linking was done by typing "make" under directory *SELAP*. The related *MAKEFILE* is also attached in Appendix C. The size of RELAP5/MOD3.2 executable varies depending on the array size of *LFSIZ* in *FTBCOM.H* and *FAST.H*.

The water thermodynamic property file, *TPFH2O* was generated by the same procedure as script *DSTGXXX*. That is, the steam table main program *STGH2O.FOR* was compiled and linked with *ENVRL.LIB*. And then, the executable *STGH2O.EXE* was run using *STGH2O.I* as an input to generate *TPFH2O*. The procedure to produce steam table is given in Appendix D.

3. Test Cases and Results

Four test case inputs were chosen to be used for verification of the conversion and installation of RELAP5/MOD3.2 on PC. These are TYPPWR, Semiscale S-NC-8B, LOFT L9-1/L3-3, LOFT L2-5 cases. A Short description for each case is given in section 3.2. Results from HP workstation were used as a reference for comparison in this verification. Experimental data were not included in the plots for those comparisons. So, the accuracy of the inputs was not checked in this study. CPU time benchmark was also done by running TYPPWR case upto 100 sec.

3.1 CPU Time Benchmark

TYPPWR case was used for CPU time benchmark calculations. The tests were done on 33 MHz 80486, 75 MHz Pentium, 100 MHz Pentium, HP 715/50, and HP 9000/K200 workstations. As shown in Table 1, a high-end Pentium PC has a comparable speed over a HP workstation tested.

Table 1. CPU Time Benchmark

Machine	Speed(CPU Seconds)
HP 9000/K200	87.19
PC Clone 100 MHz Pentium/16 M Bytes	130.7
PC Clone 75 MHz Pentium/16 M Bytes	197.8
HP 715/50	205.6
PC Clone 33 MHz 486/8 M Bytes	690.1

3.2 Test Cases

TYPPWR is included in RELAP5 transmittal package, whose input is typpwr.i. This case simulated a 4 inch cold leg break in a four loop pressurized water reactor up to 1200 sec. A broken loop is simulated as a single loop and the other 3 intact loops are lumped into one loop. The nodalization includes 139 volumes, 142 junctions, and 83 heat structures.

Semiscale S-NC-8B[6] is to simulate a transient natural circulation induced by SBLOCA for 8000 sec. It was designed to provide data on natural circulation during a SBLOCA transient without high pressure and low pressure safety injection flows. Recovery actions

were S/G auxiliary feed and bleed, accumulator injection, and primary coolant vent through PORV. The nodalization includes 204 volumes, 208 junctions, and 264 heat structures.

LOFT L9-1/L3-3[7] is to simulate a loss of feedwater accident with multiple failures and a consequentially-induced small break loss-of-coolant accident in pressurized water reactor. The main objectives of this experiment was to evaluate uncertainty in thermal hydraulic response associated with S/G dryout, the adequacy of Power Operated Relief Valve(PORV) during Loss of Feedwater Accident(LOFA), uncertainty in system response during a PORV imposed small break with loss of heat sink, and the adequacy of modelling assumptions used in small break performance predictions. The simulation was done for 8000 sec with nodalization of 125 volumes, 134 junctions, and 136 heat structures.

LOFT L2-5[8] simulated a guillotine break in the cold leg of a commercial PWR simutaneous with a loss of site power. It was designed to provide experimental data to demonstrate that Appendix K assumptions result in a conservative prediction of peak cladding temperature and to determine system behavior and core thermal response during the reflood portion of a double-ended cold leg break experiment. The simulation was done for 40 sec with nodalization of 140 volumes, 148 junctions, and 47 heat structures.

3.3 Results

System pressure, void fraction in the core, and fluid temperature at broken loop hot leg for TYPPWR case are shown in Figures 1 to 3, respectively. These plots show that the results from PC match well the results from HP until around 400 sec. After 400 sec the two results start to diverge but PC version predicts an overall trend reasonably. It is very interesting to point that similar pressure trend was observed by other study[9]. They used SGI-INDY, HP715/50, and DEC2100 workstations for comparisons. In order to investigate the possible reasons for these differences, time step size used in the calculations are plotted as shown in Figures 4 and 5. These two plots show that the time step sizes are quite different from each other after 400 sec and the difference, though small, can be observed even before 400 sec. Maximum time step size was 0.5 sec. In order to demonstrate the effects of using different time step, another case with the same input but smaller maximum time step size of 0.05 sec have been run. The results are shown in Figures 6 to 9. It can be seen that there was improvement in the temperature and pressure prediction upto 600 sec and then void fraction started to diverge after 600 sec.

The pressures in the primary system, intact loop S/G, and broken loop S/G for Semiscale S-NC-8B are shown in Figures 11 and 12, respectively. No difference can be found in the plots. As shown in Figures 13 to 15, break flow rate, mass flow rates at intact and broken loop cold legs are very similar to those from HP. Fluid temperatures at intact loop hot leg and cold leg and fluid temperatures at broken loop hot leg and cold leg are given in Figures 16 to 19,

respectively. These results show that the difference between two versions is minimal. As shown in Figure 20 the cladding temperature at elevation 291 cm is also very close to the result of HP. The time step sizes for the two versions are given in Figures 21 to 22. It shows that there is difference but the effect of difference on results is small.

Pressures in the intact loop hot leg and in S/G steam dome for LOFT L9-1/L3-3 are given in Figures 24 and 25, respectively. It is shown that the pressure prediction by PC version follows that of HP version by some time difference. A similar trend is also found for temperature predictions as shown in Figures 25 and 26. As shown in Figure 27 PC version predicted similar mass flow rate through PORV as HP version with some time lag. Time step sizes for two versions are given in Figure 28.

System pressure for LOFT L2-5 is given in Figure 29, which shows that no difference can be found by eye. The PCT prediction is shown in Figure 30. This plot shows that the temperature prediction differs by around 40 K after around 20 sec into transient. This may be caused by the numerical instability due to rapid condensation after cold water from accumulator is injected into the cold leg. Mass flow rates at broken loop cold leg and hot leg are shown in Figures 31 and 32, respectively. Results from PC version match reasonably well with that of HP version. Finally time step sizes are shown in Figure 33.

4. Run Statistics

100 MHz Pentium PC/16 MB with Windows 95 was used to run TYPPWR case using RELAP5/MOD3.2 PC version compiled with Lahey F77L3 compiler. Time step size used in the calculation is shown in Figure 5. The minimum and maximum time step in the time step control cards are 1.E-7 sec and 0.5 sec, respectively. Grind time and computational efficiency can be summarized as follows:

CPU Time,	CPU	=1972.05 sec
Number of Time Step,	DT	=11904
Number of Volume,	C	=139
Real Transient Time,	RT	=1200 sec
Grind Time,	GT	=(CPU * 1000)/(C * DT)
		=(1972.05 * 1000)/(139 * 11904)
		= 1.192 msec/(vol-step)

5. Summary and Conclusions

RELAP5/MOD3.2 has been installed and tested on 486 and Pentium PCs. Code modifications and installation procedure were documented. The test cases include a LOFA transient, a small break accident, and a large break accident. The results from PC version were compared with those from HP version. It was found that the overall prediction capability of PC version was good enough to be used as a replacement or complement for a workstation version. However, the results show that some improvements in numerics are still needed to get better agreement between the results from two versions.

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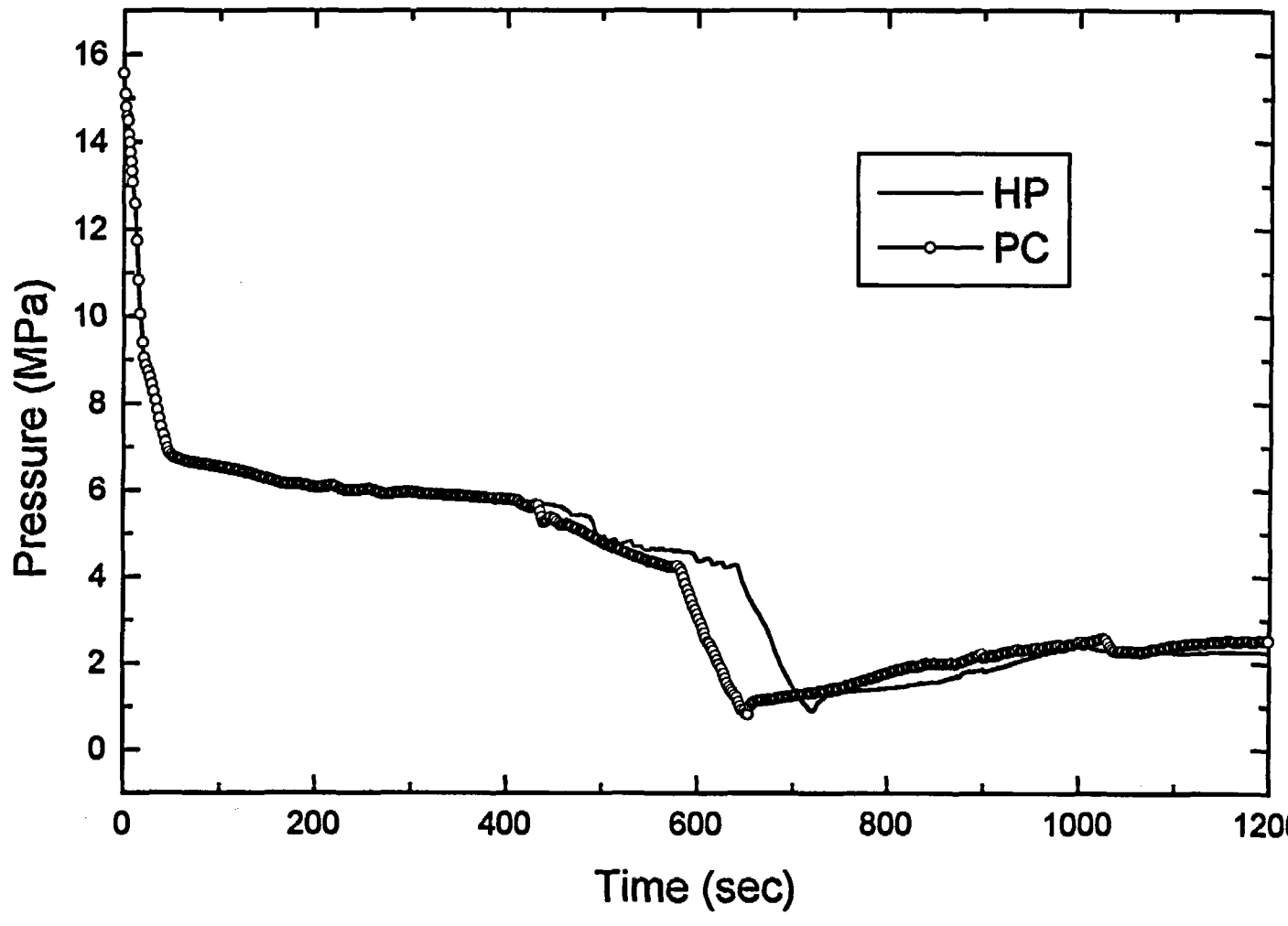

Figure 1 System Pressure

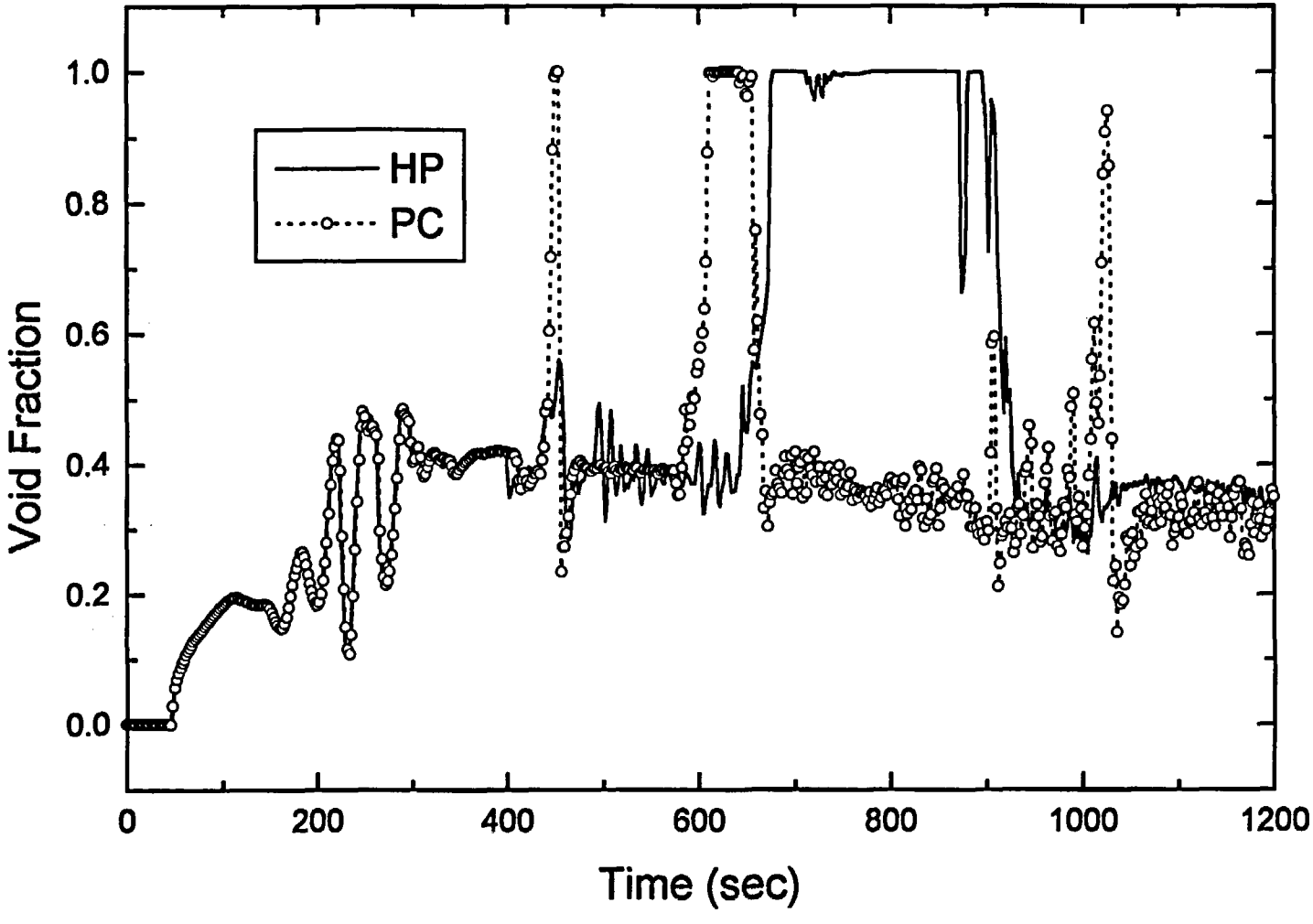

Figure 2 Void Fraction in the Core

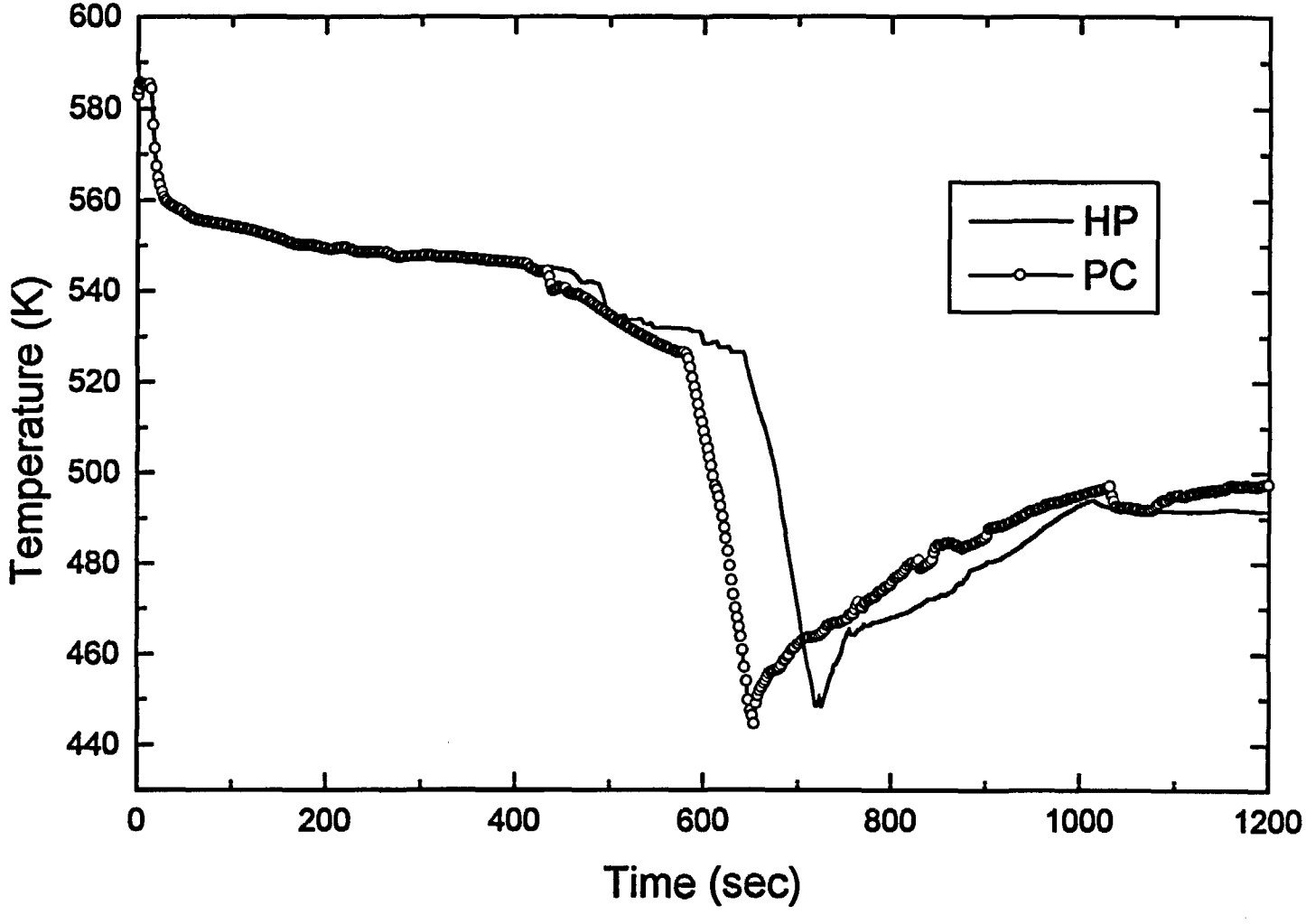

Figure 3 Fluid Temperature at Broken Loop Hot Leg

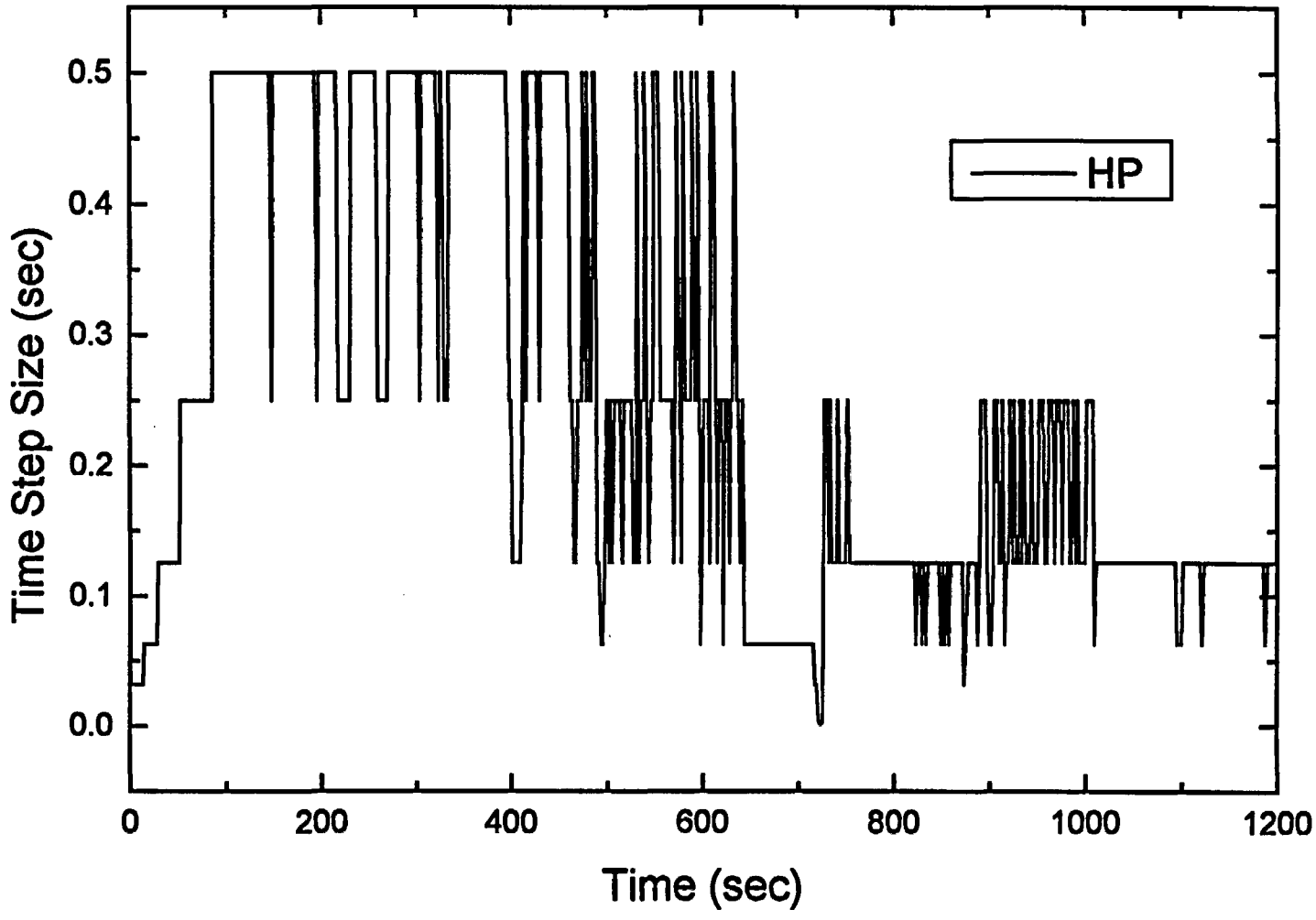

Figure 4 Time Step Size on HP

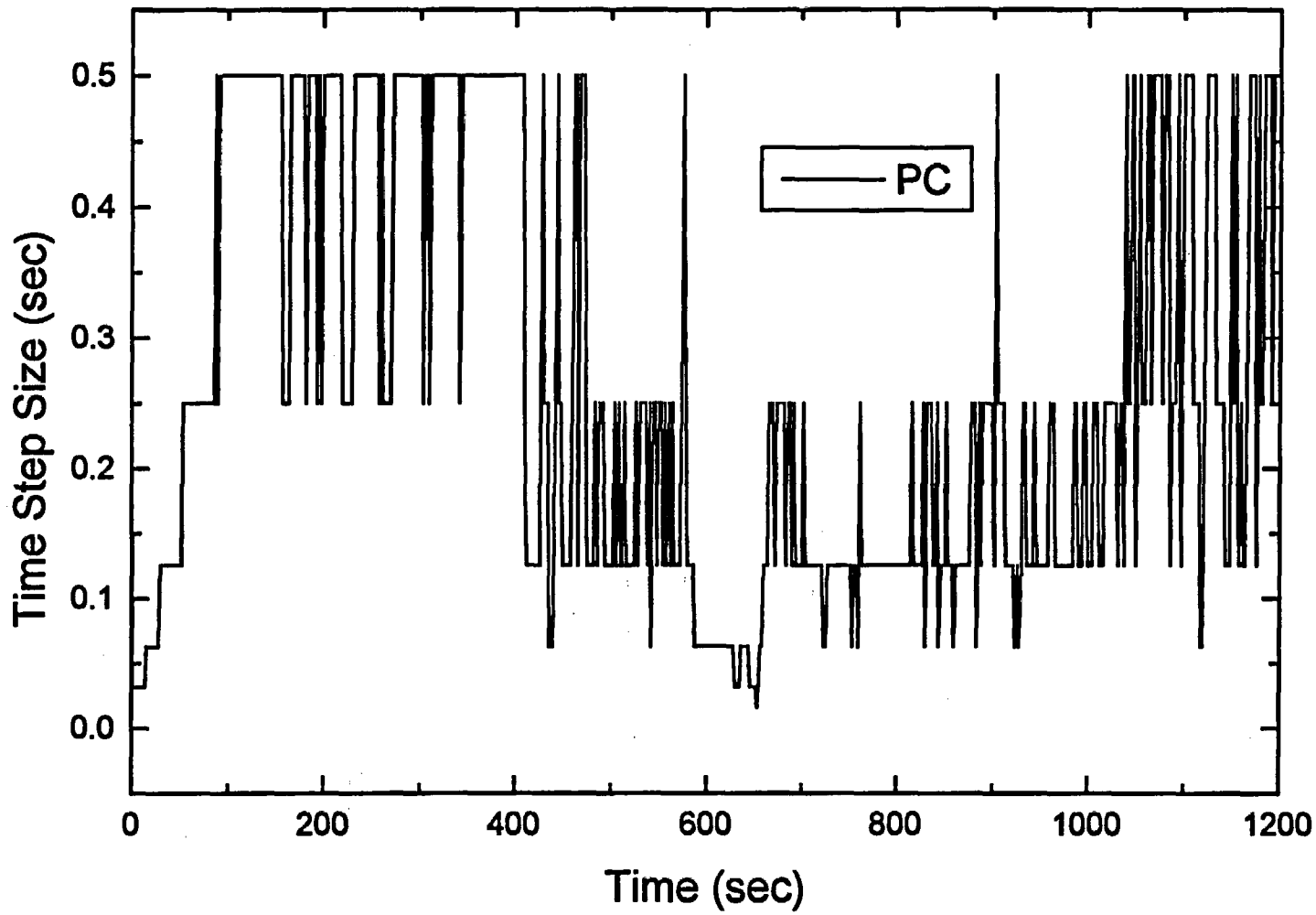

Figure 5 Time Step Size on PC

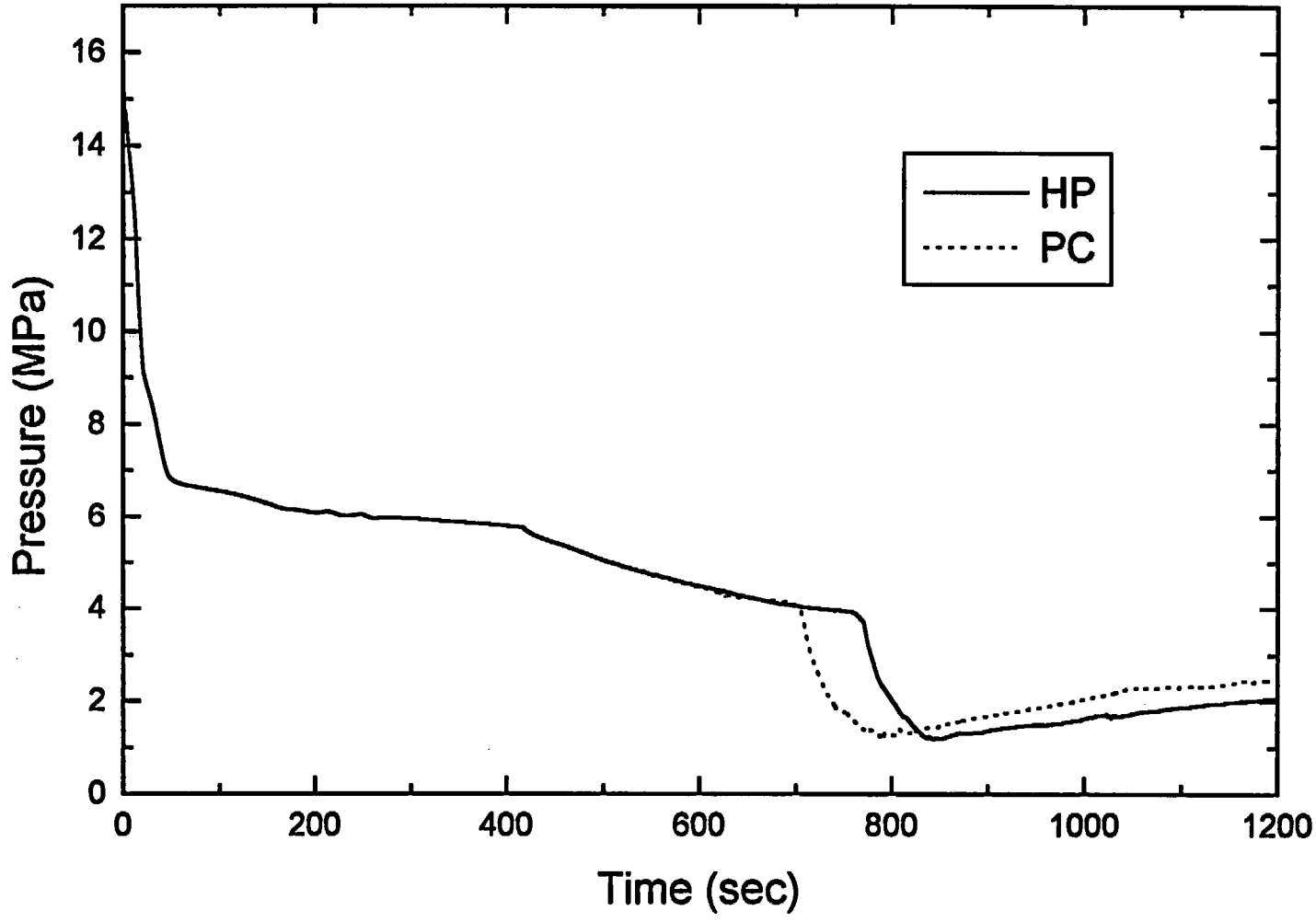

Figure 6 System Pressure

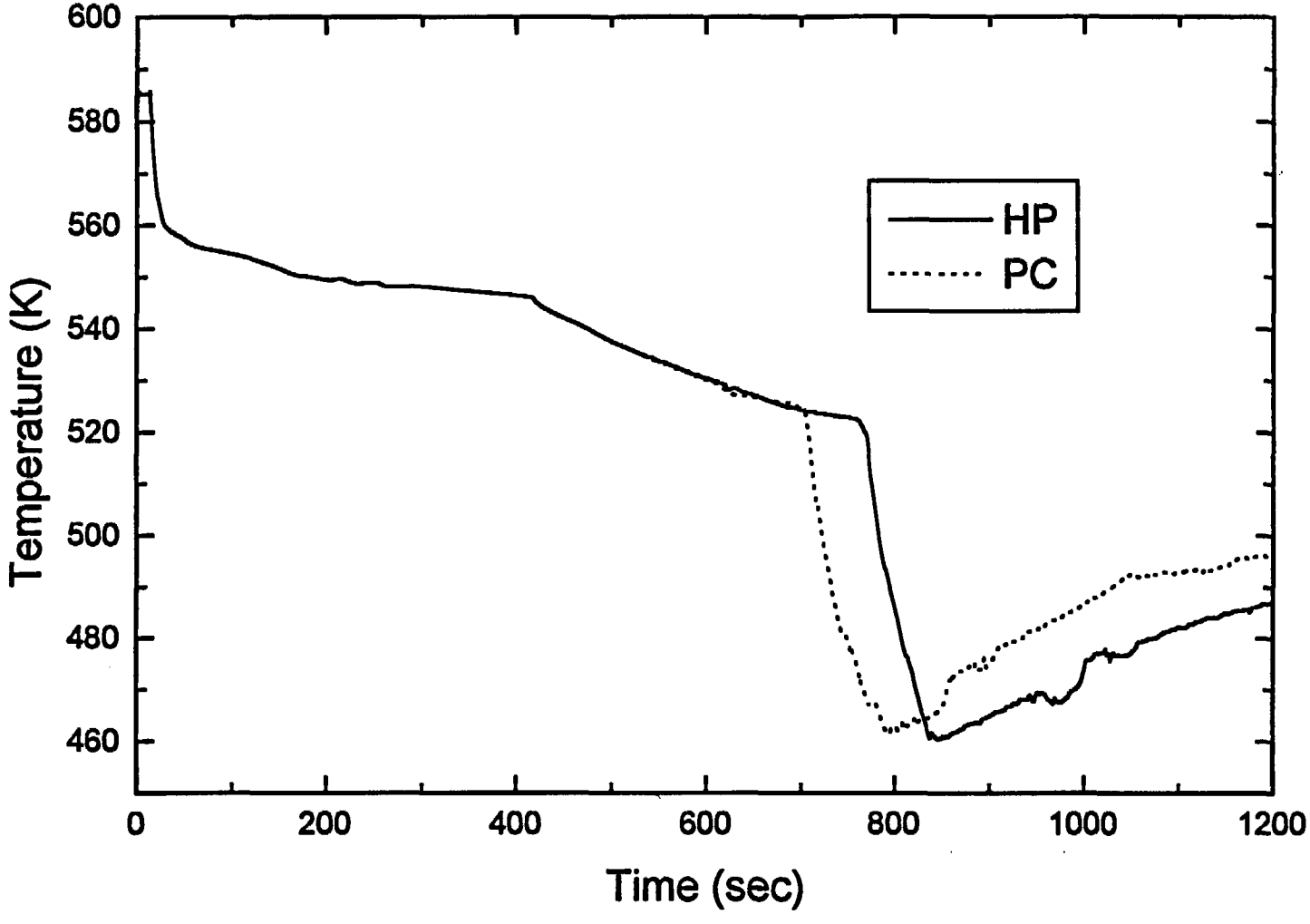

Figure 7 Fluid Temperature at Broken Loop Hot Leg

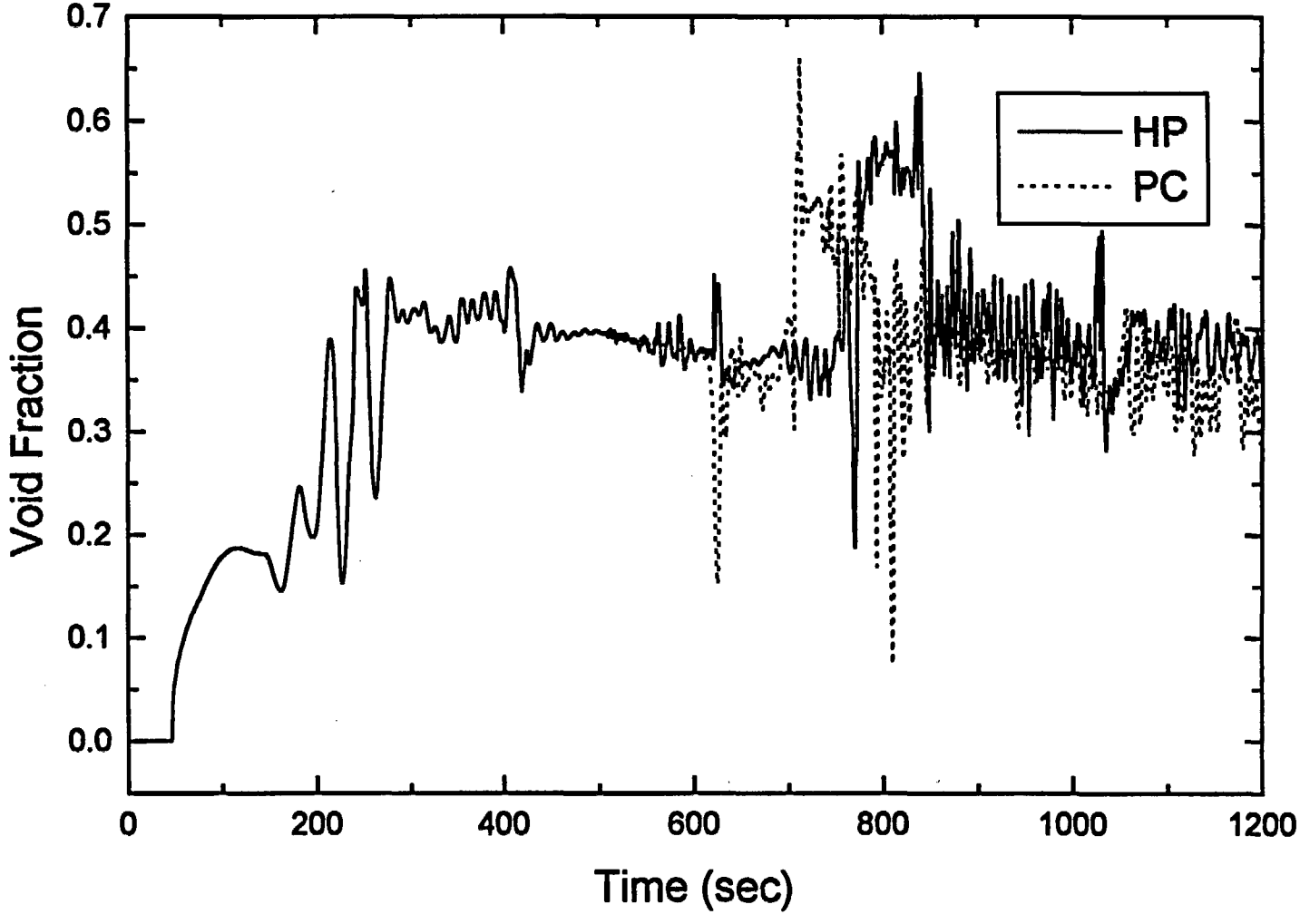

Figure 8 Void Fraction in the Core

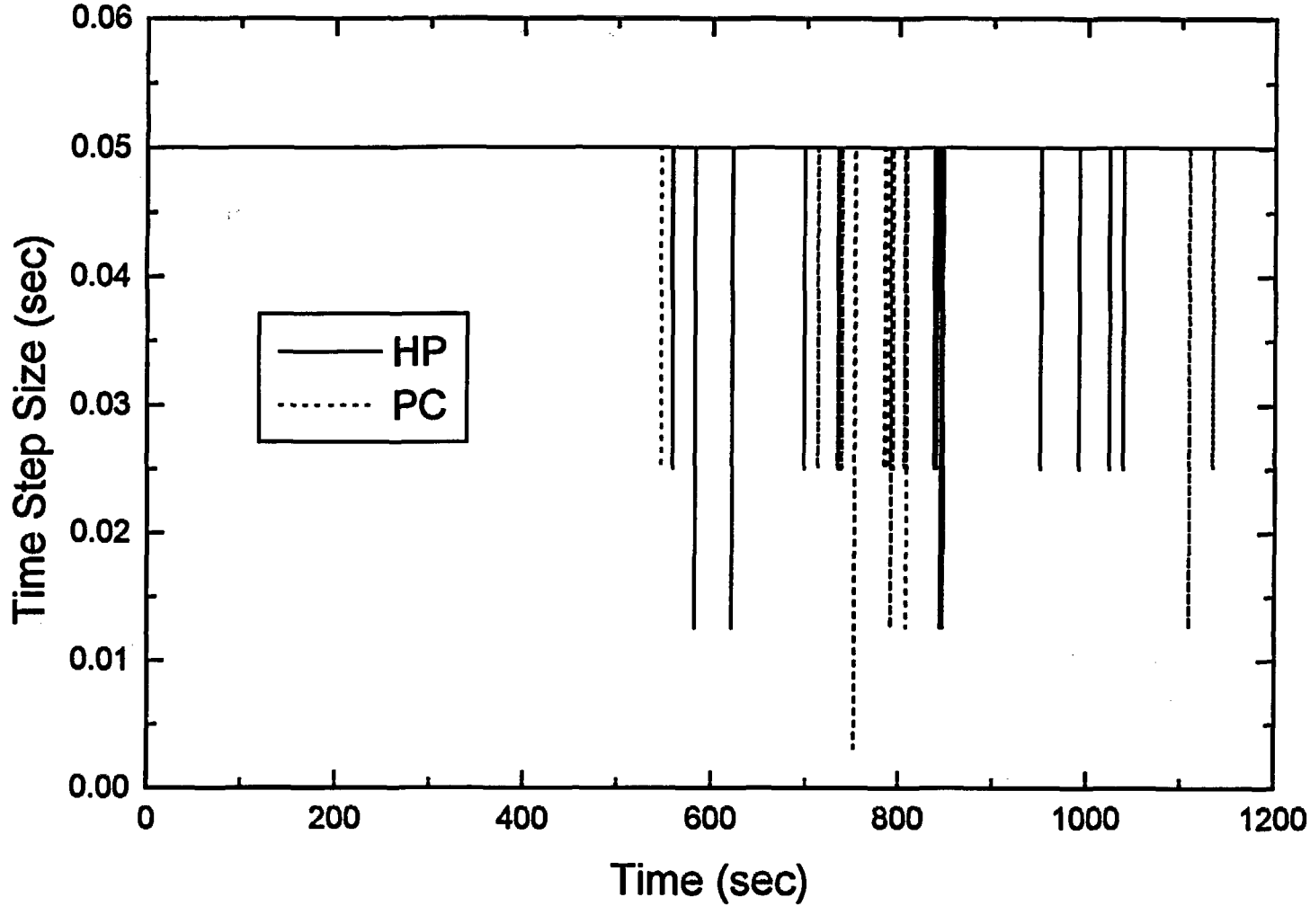

Figure 9 Time Step Size

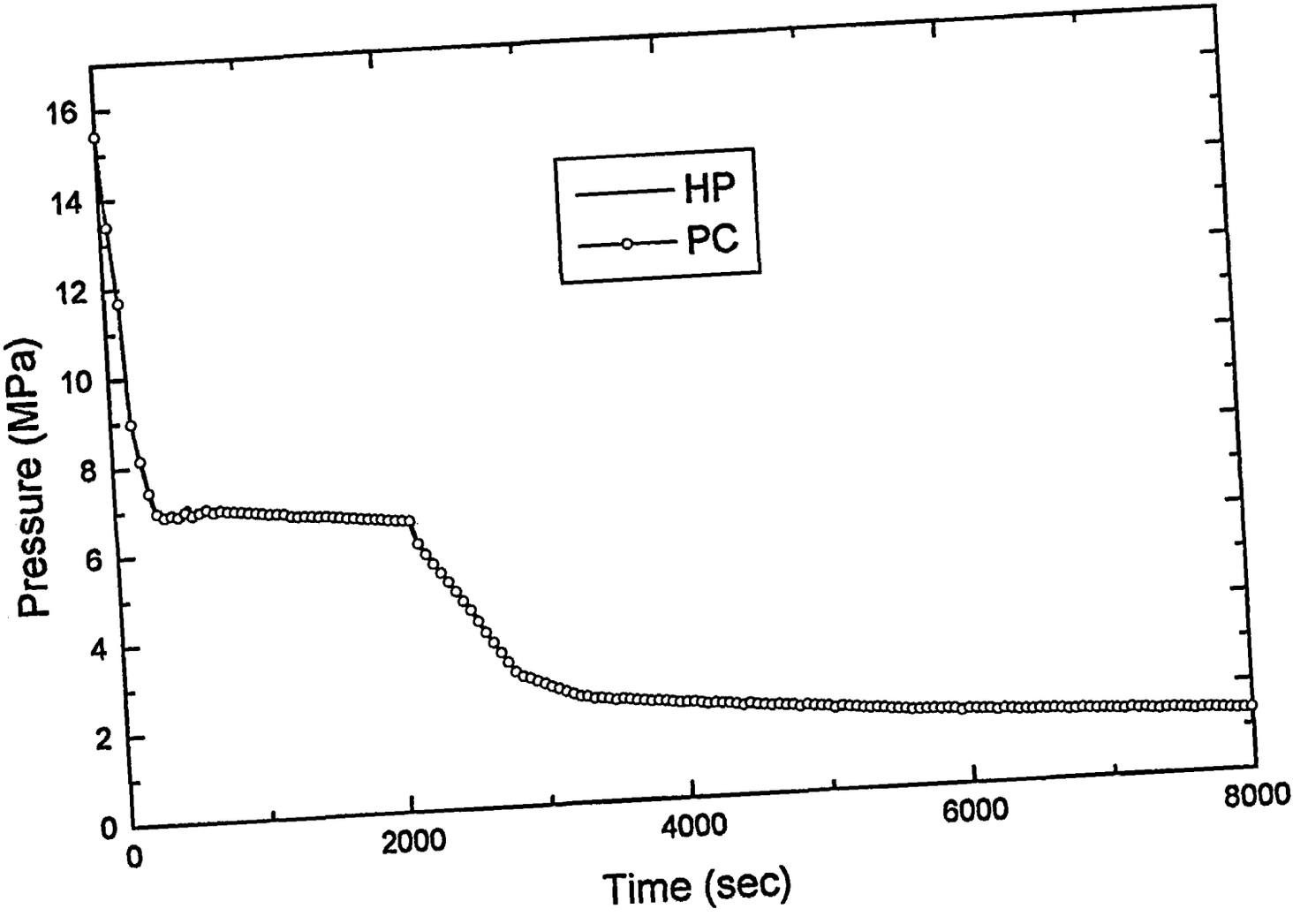

Figure 10 Primary System Pressure

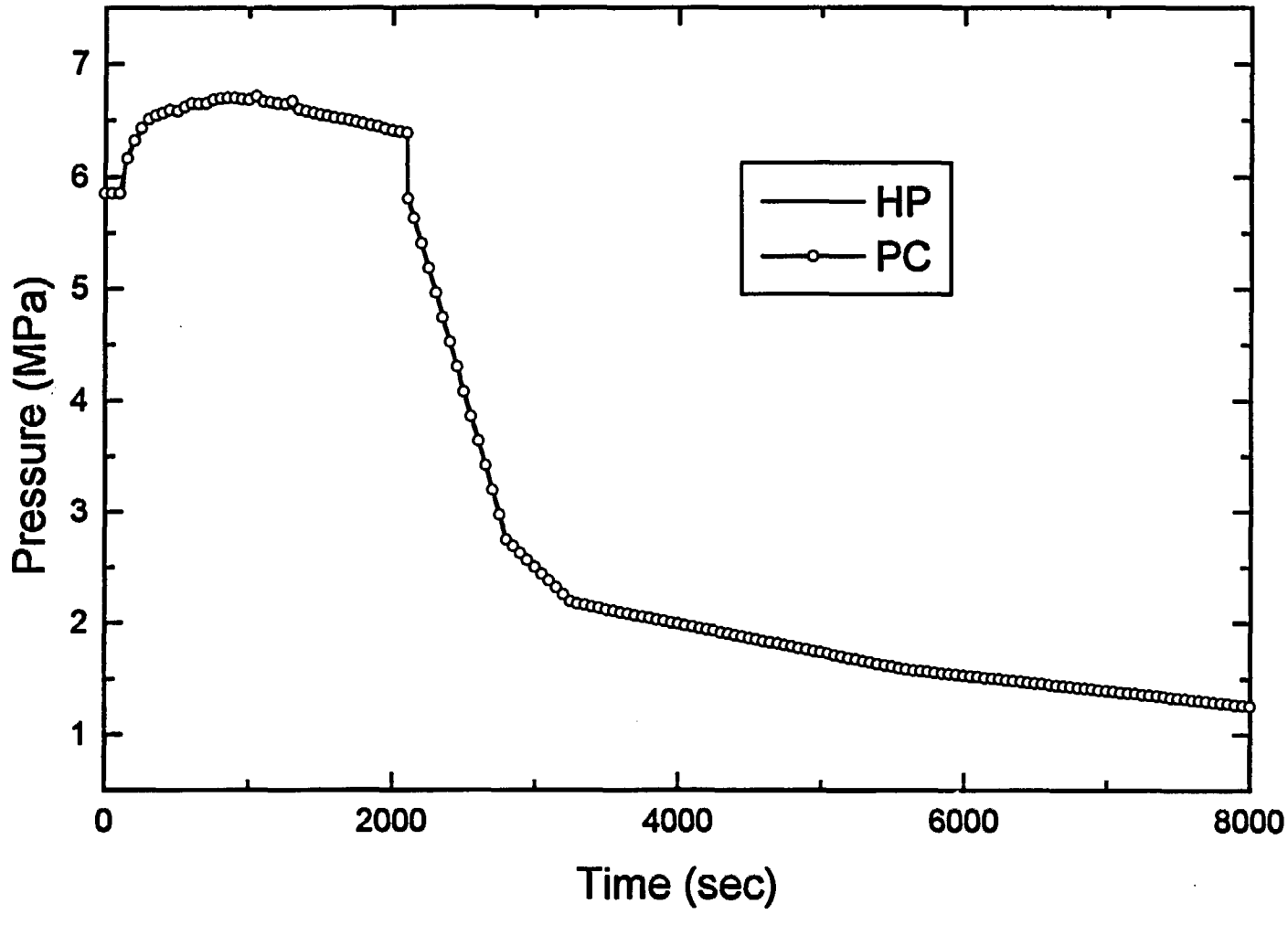

Figure 11 Pressure in Intact Loop S/G

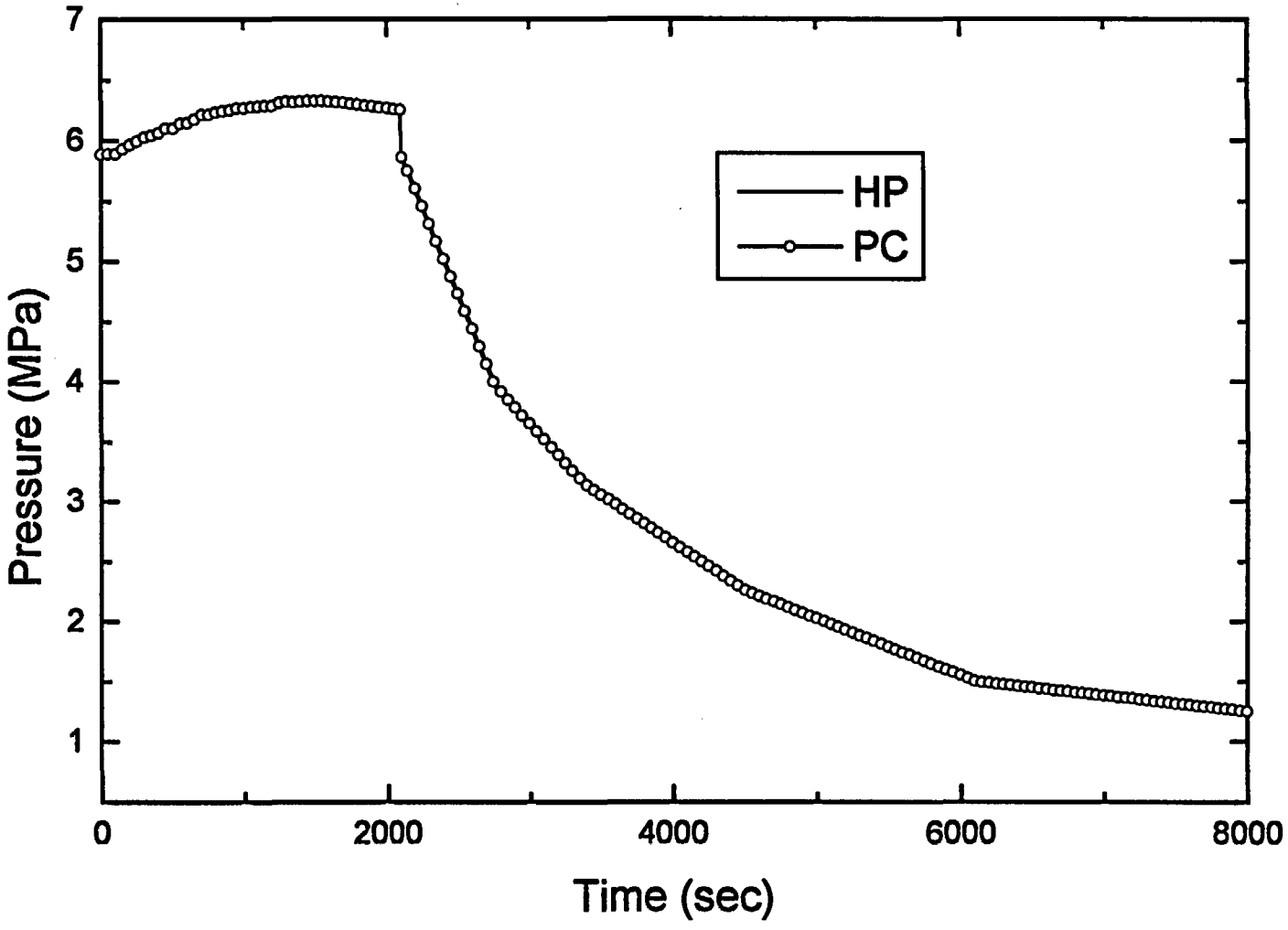

Figure 12 Pressure in Broken Loop S/G

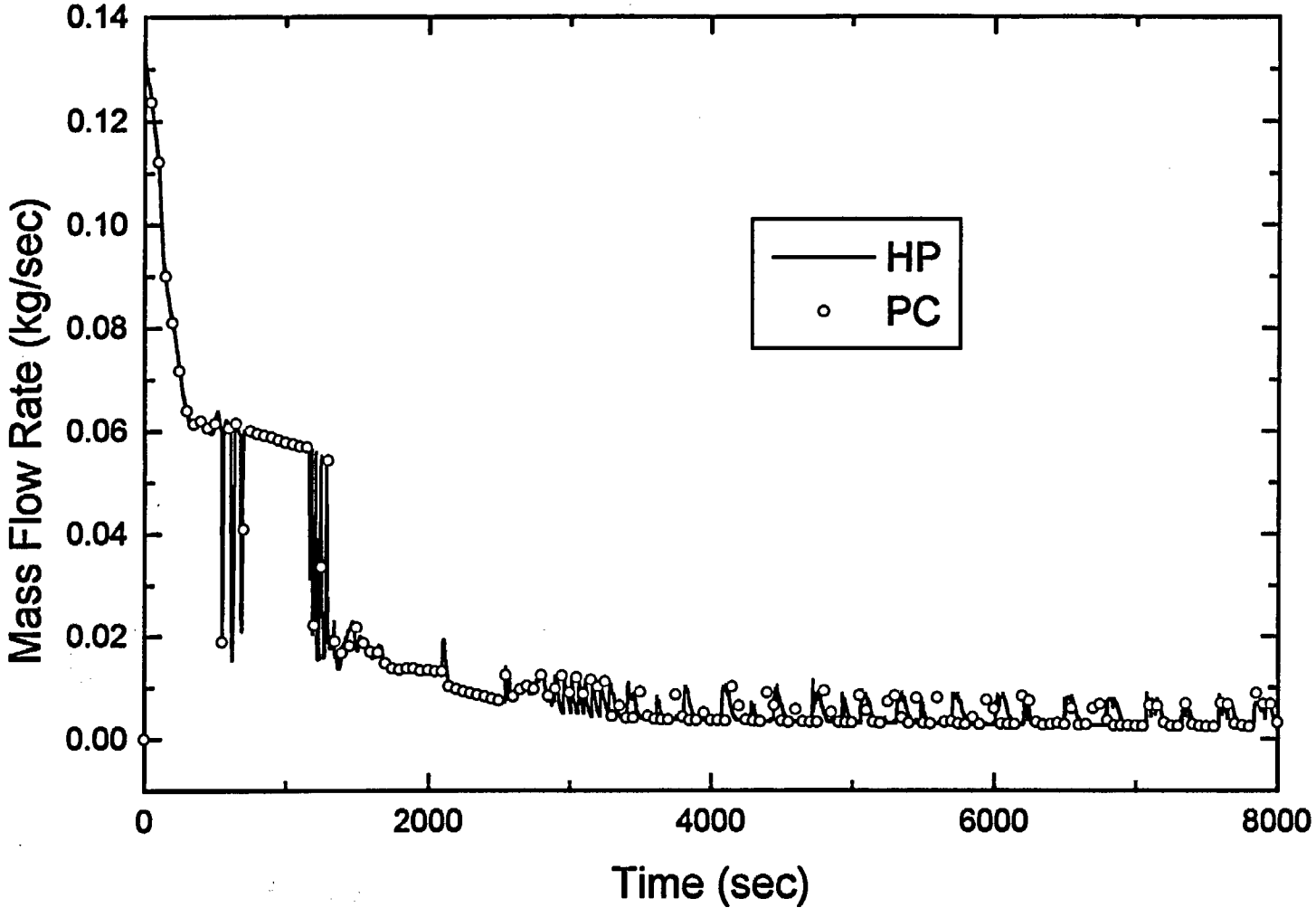

Figure 13 Break Flow Rate

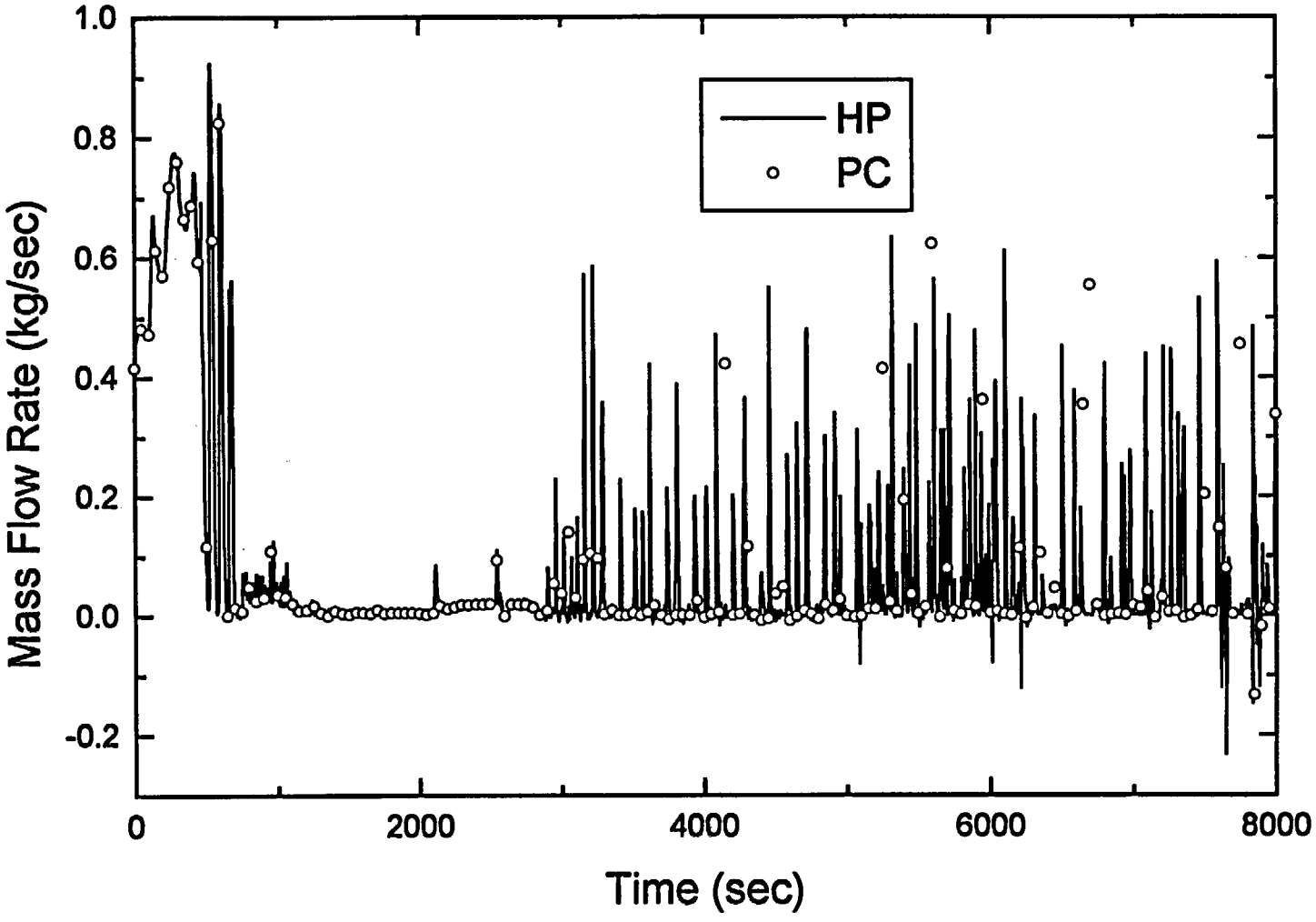

Figure 14 Mass Flow Rate at Intact Loop Cold Leg

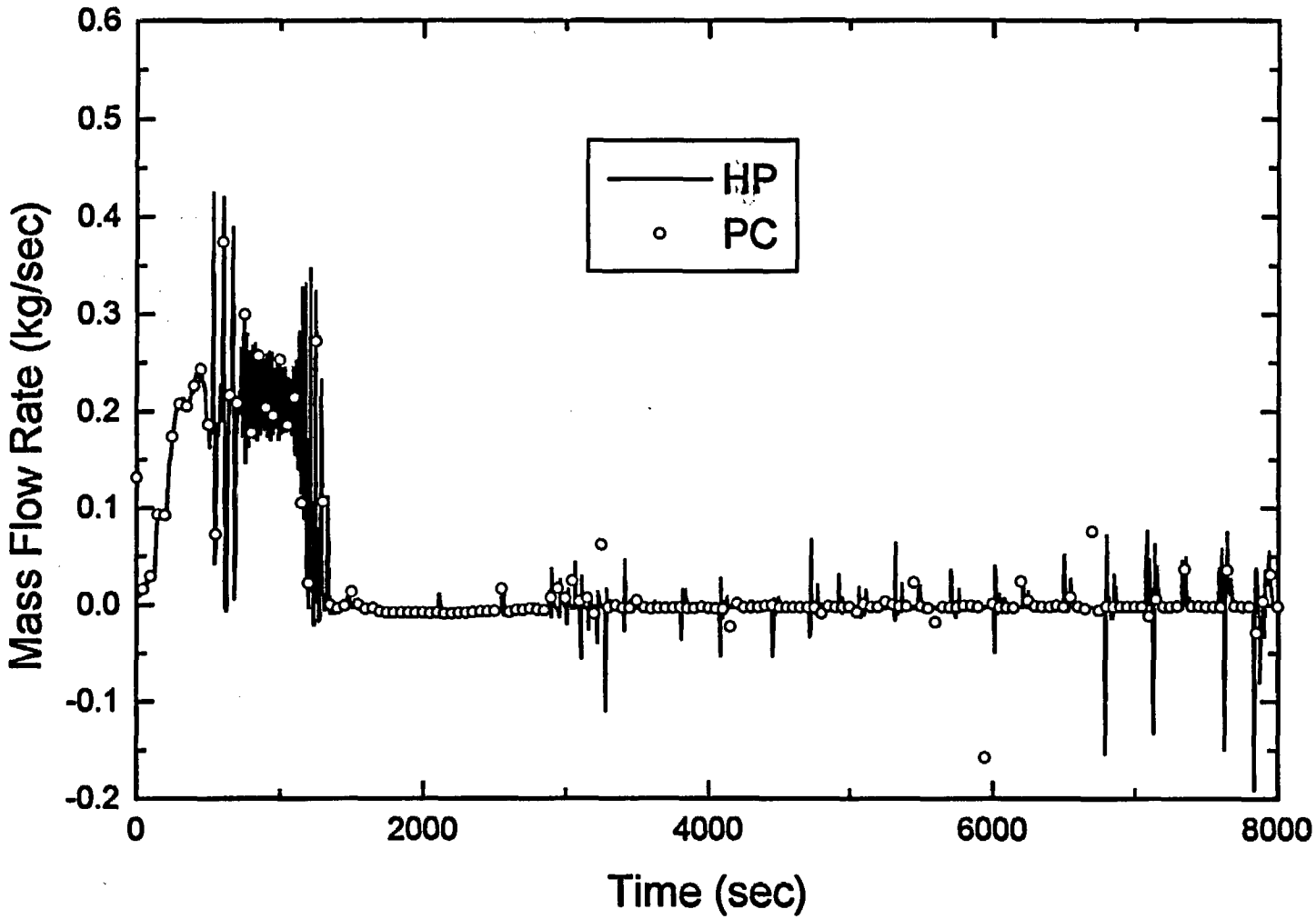

Figure 15 Mass Flow Rate at Broken Loop Cold Leg

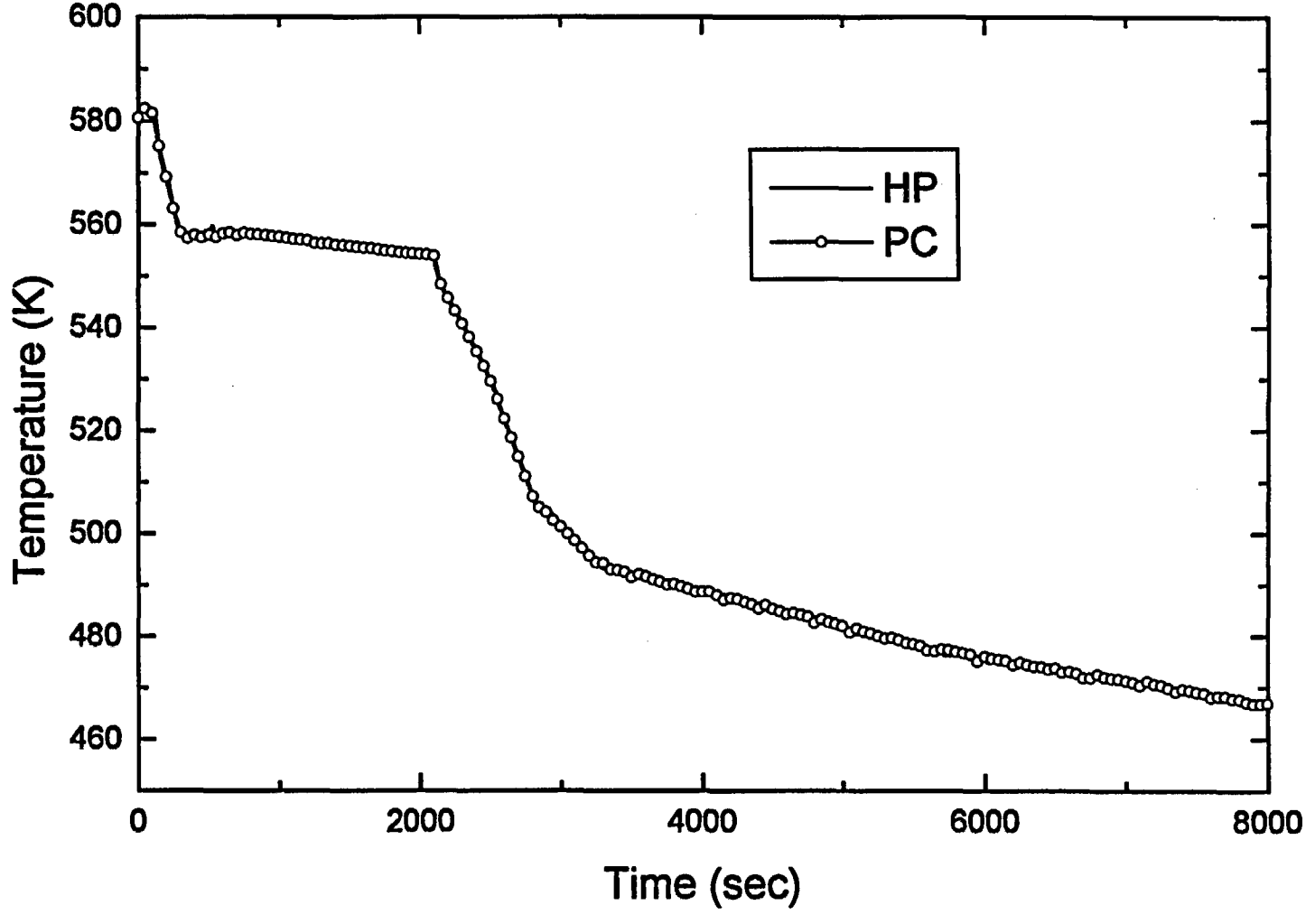

Figure 16 Fluid Temperature at Intact Loop Hot Leg

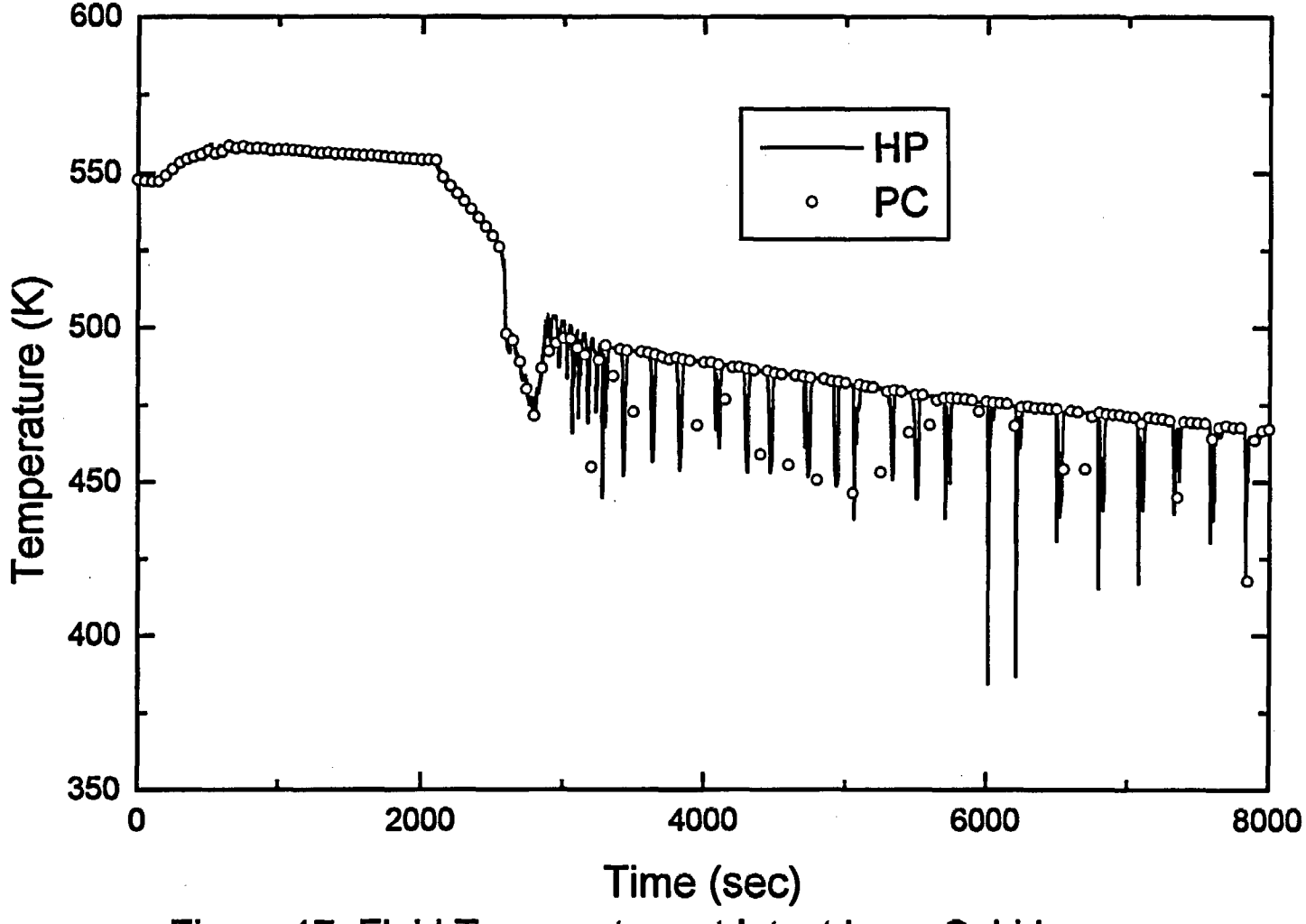

Figure 17 Fluid Temperature at Intact Loop Cold Leg

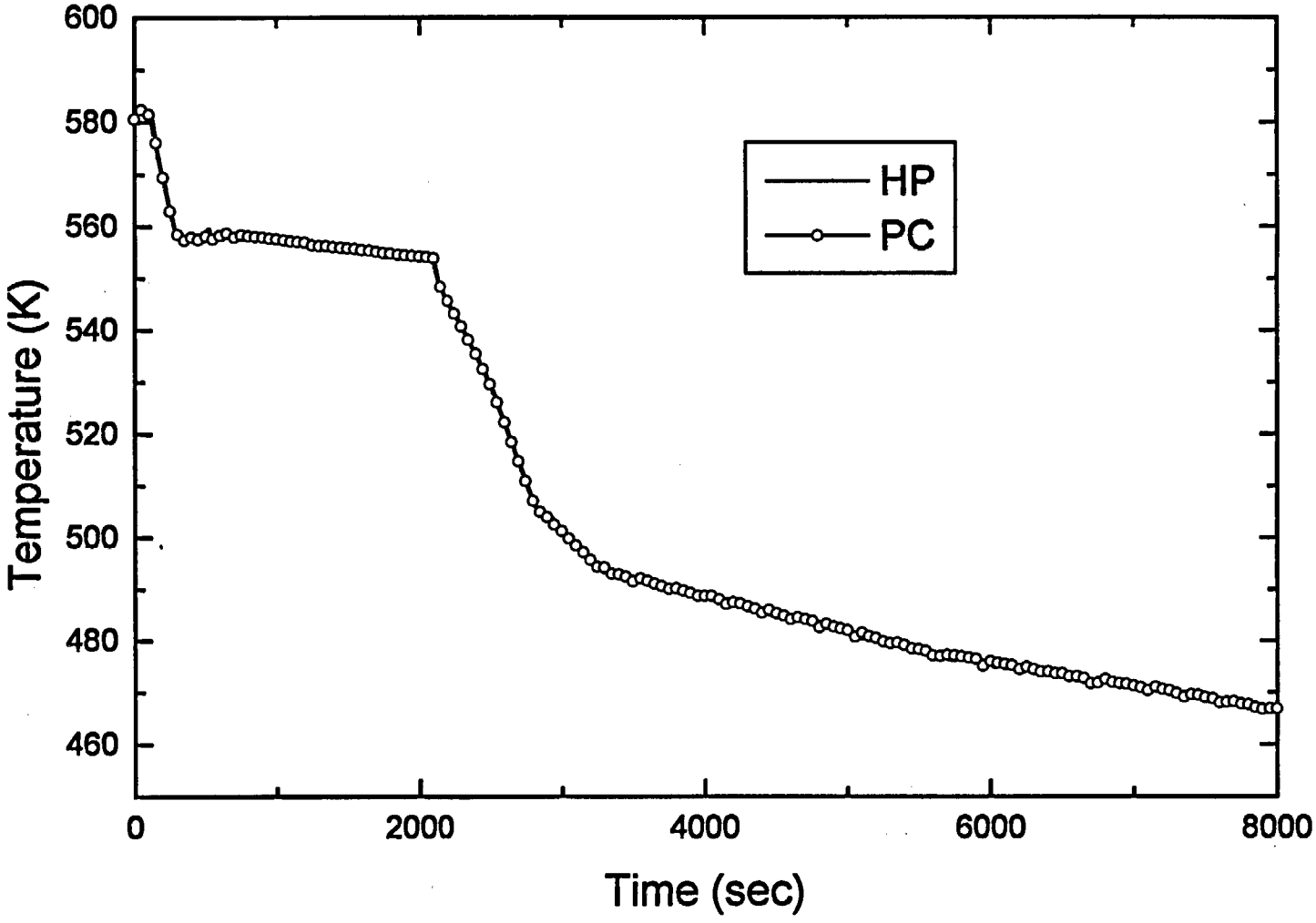

Figure 18 Fluid Temperature at Broken Loop Hot Leg

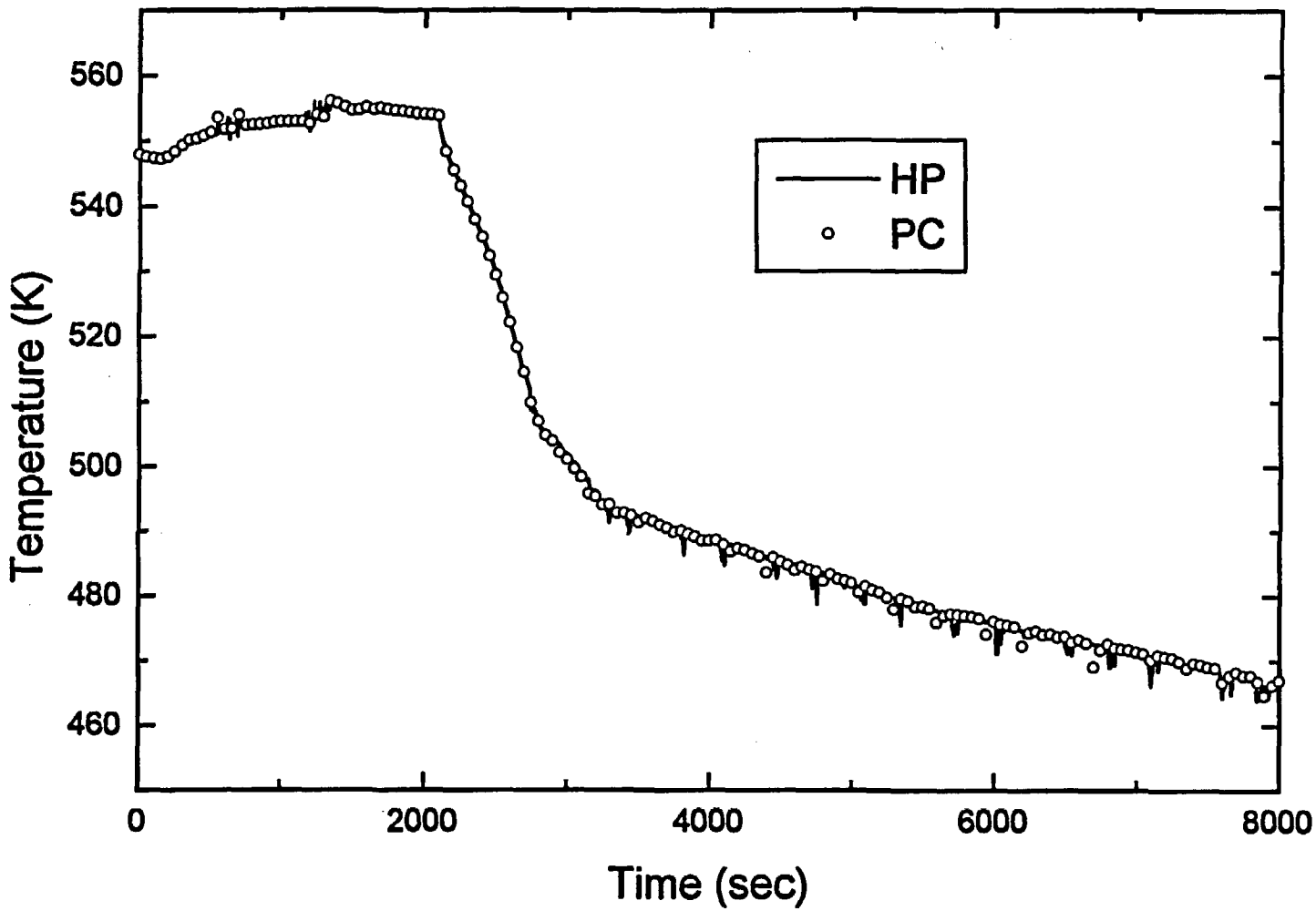

Figure 19 Fluid Temperature at Broken Loop Cold Leg

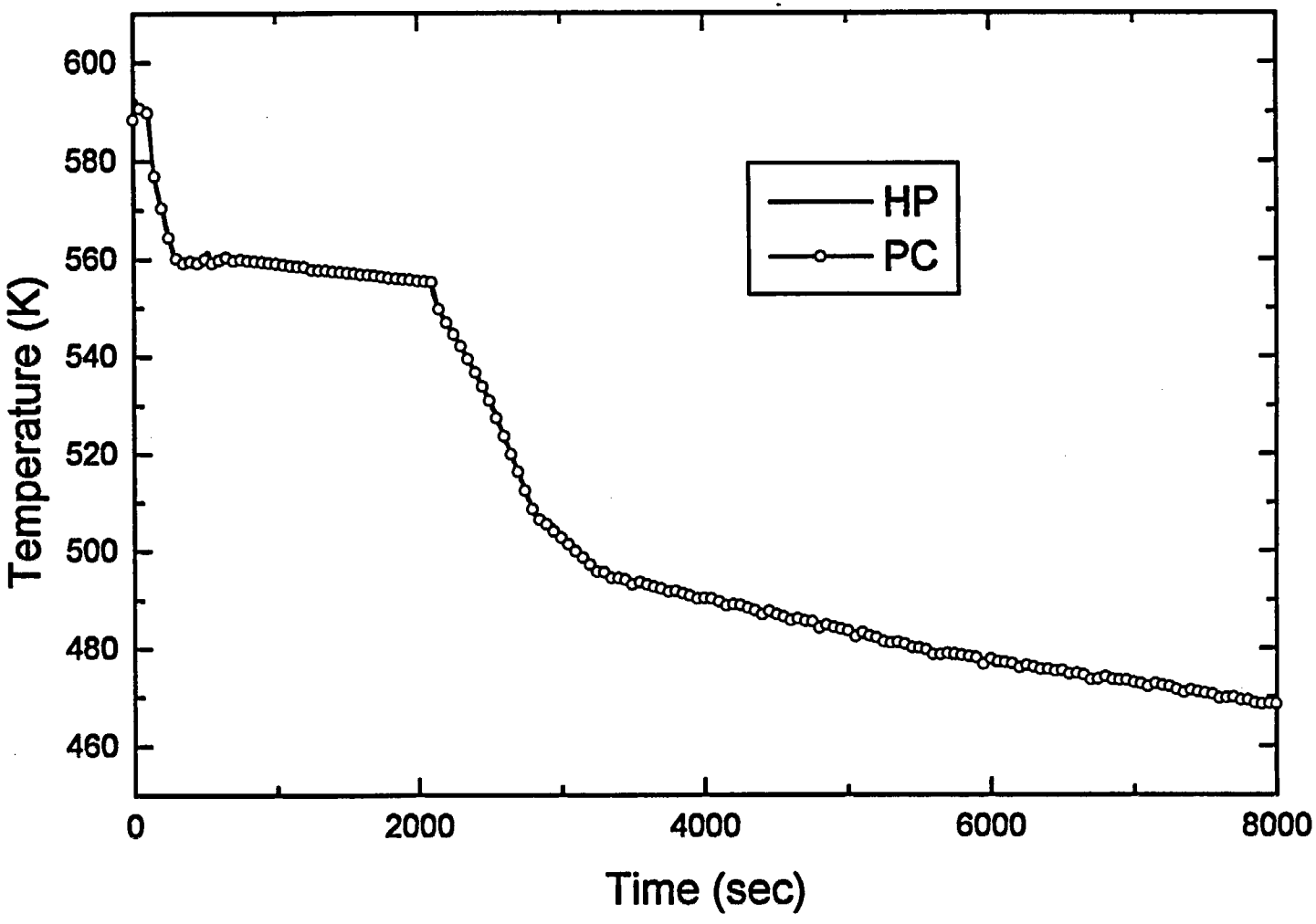

Figure 20 Cladding Temperature at Elevation 291 cm

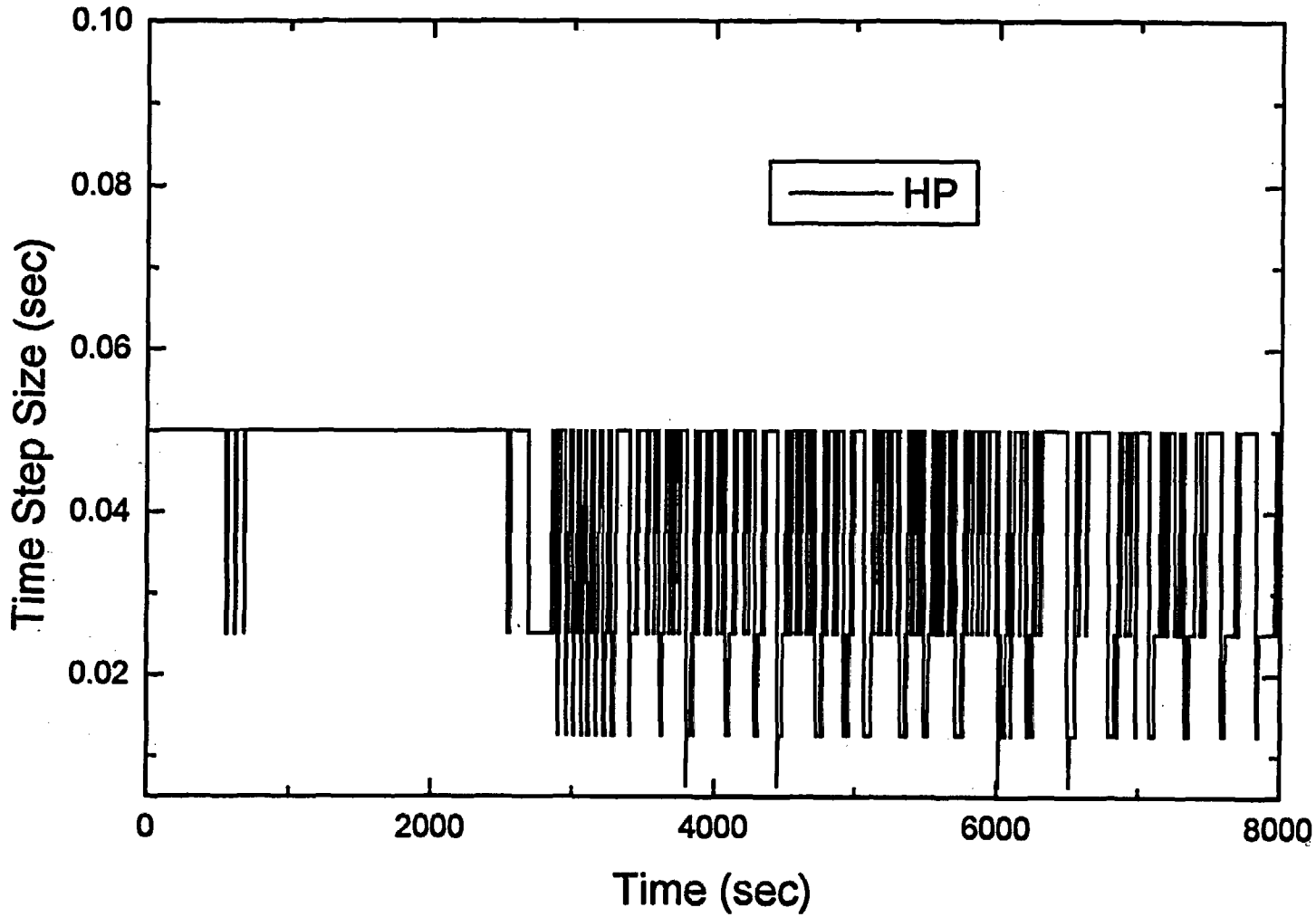

Figure 21 Time Step Size on HP

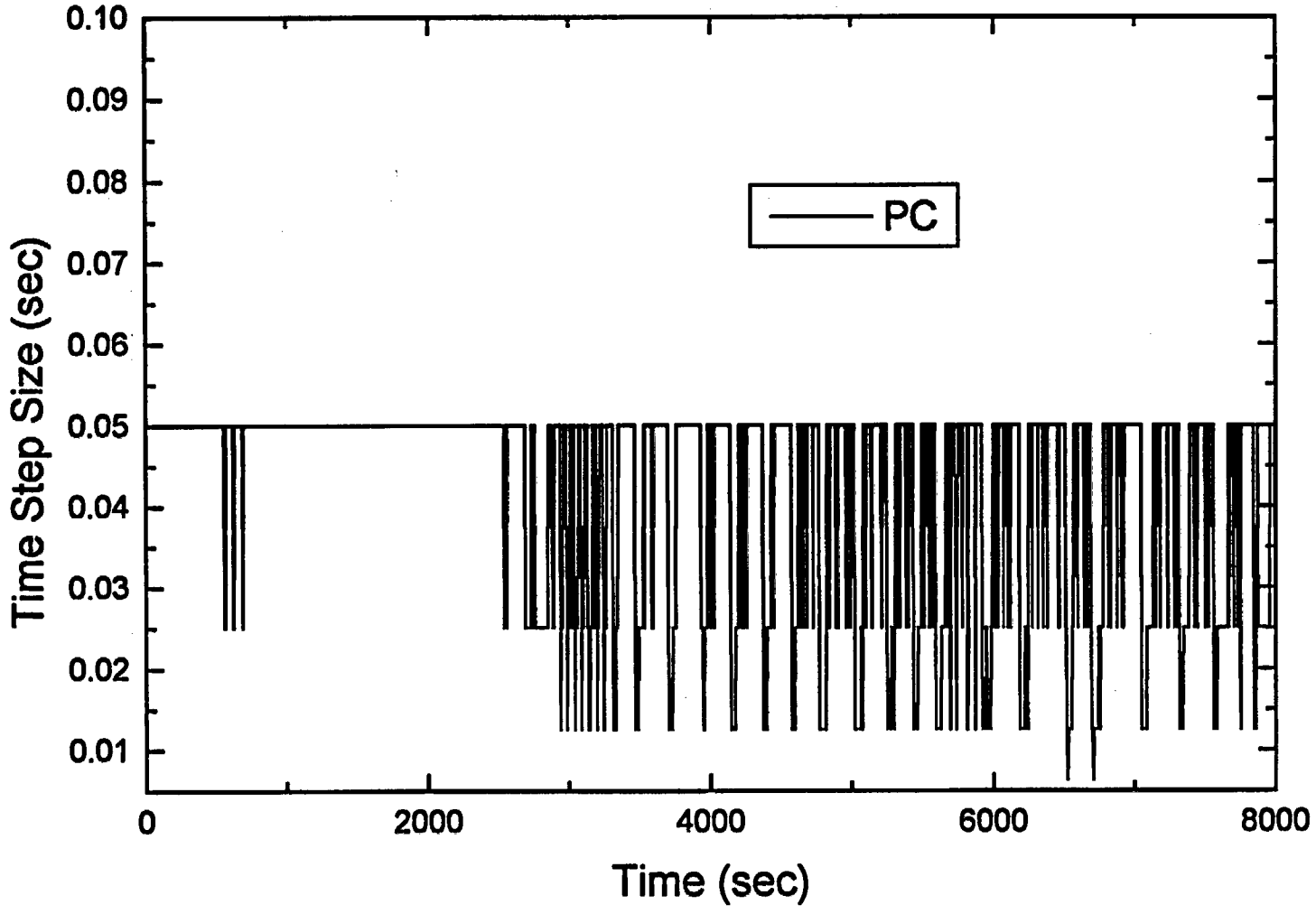

Figure 22 Time Step Size on PC

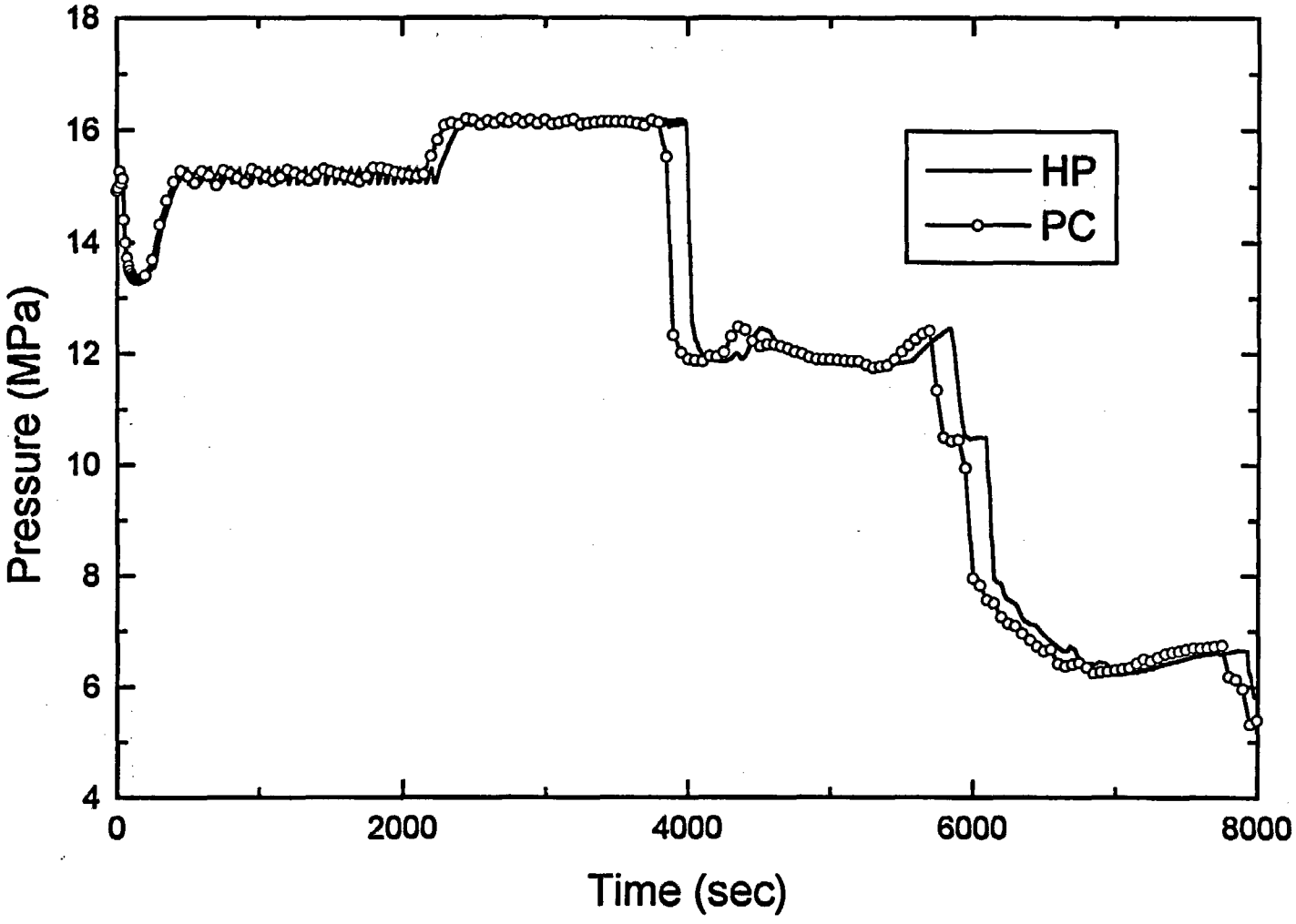

Figure 23 Pressure in the Intact Loop Hot Leg

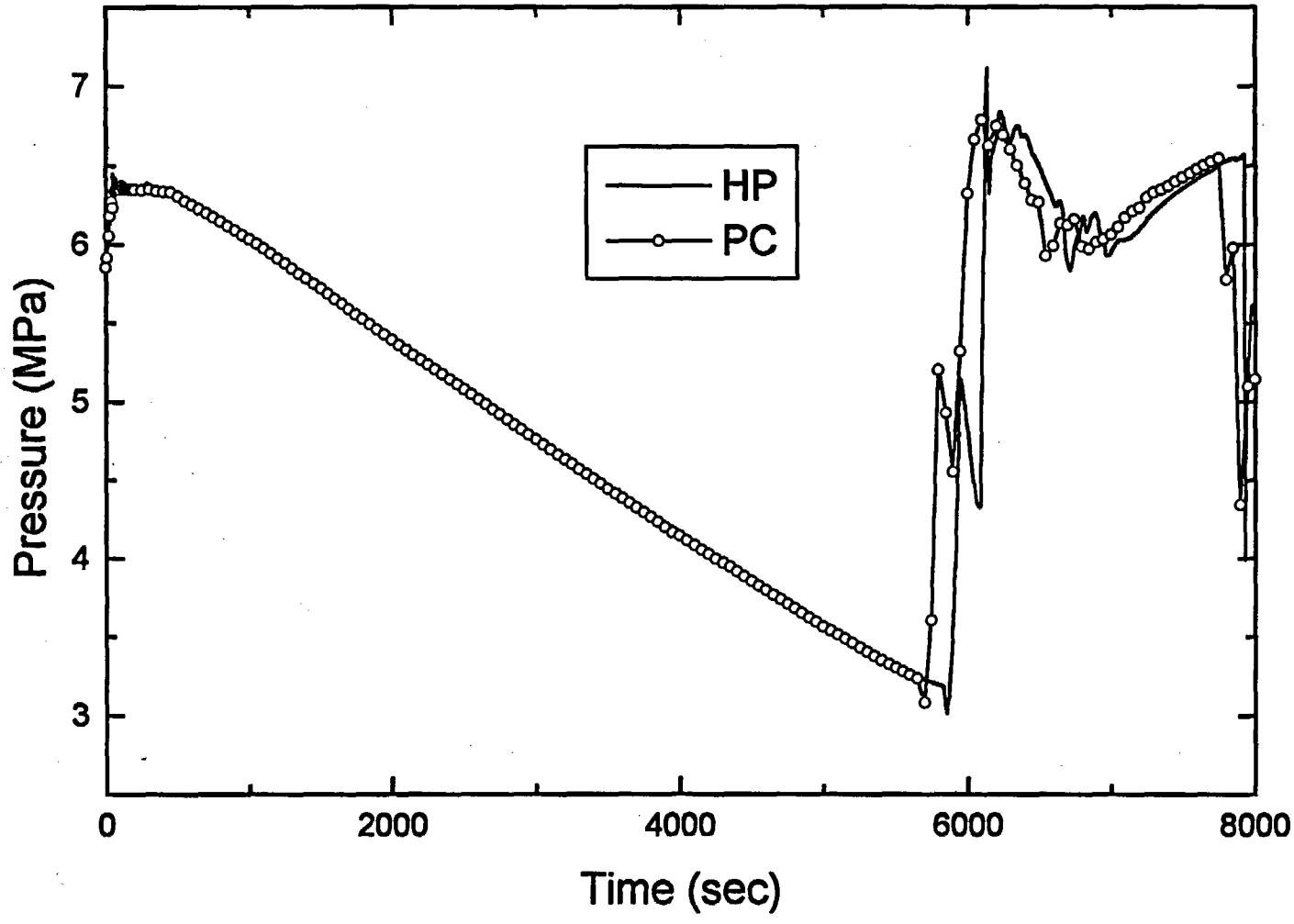

Figure 24 Pressure in S/G Steam Dome

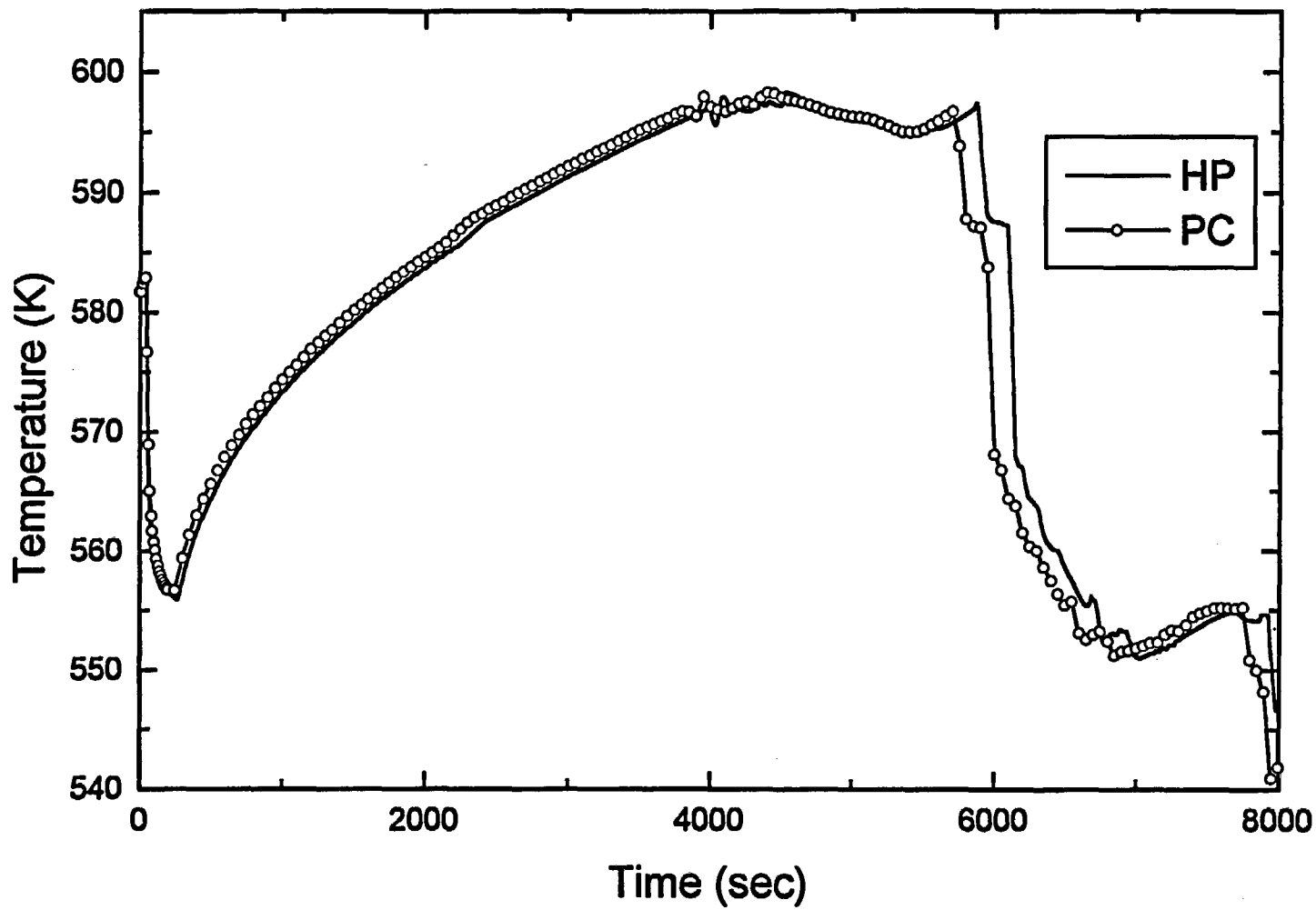

Figure 25 Fluid Temperature at the Intact Loop Hot Leg

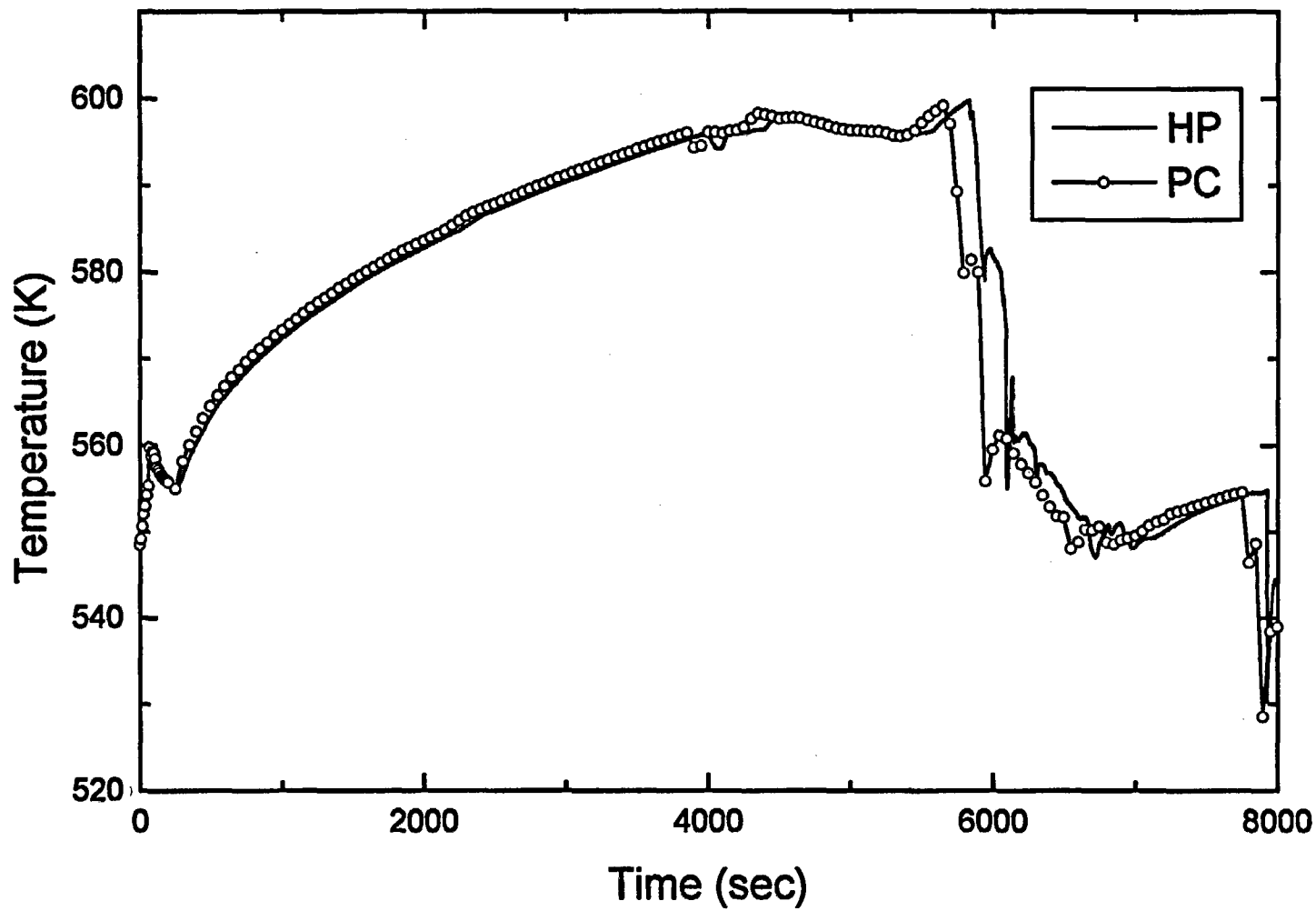

Figure 26 Fluid Temperature at S/G Secondary Side

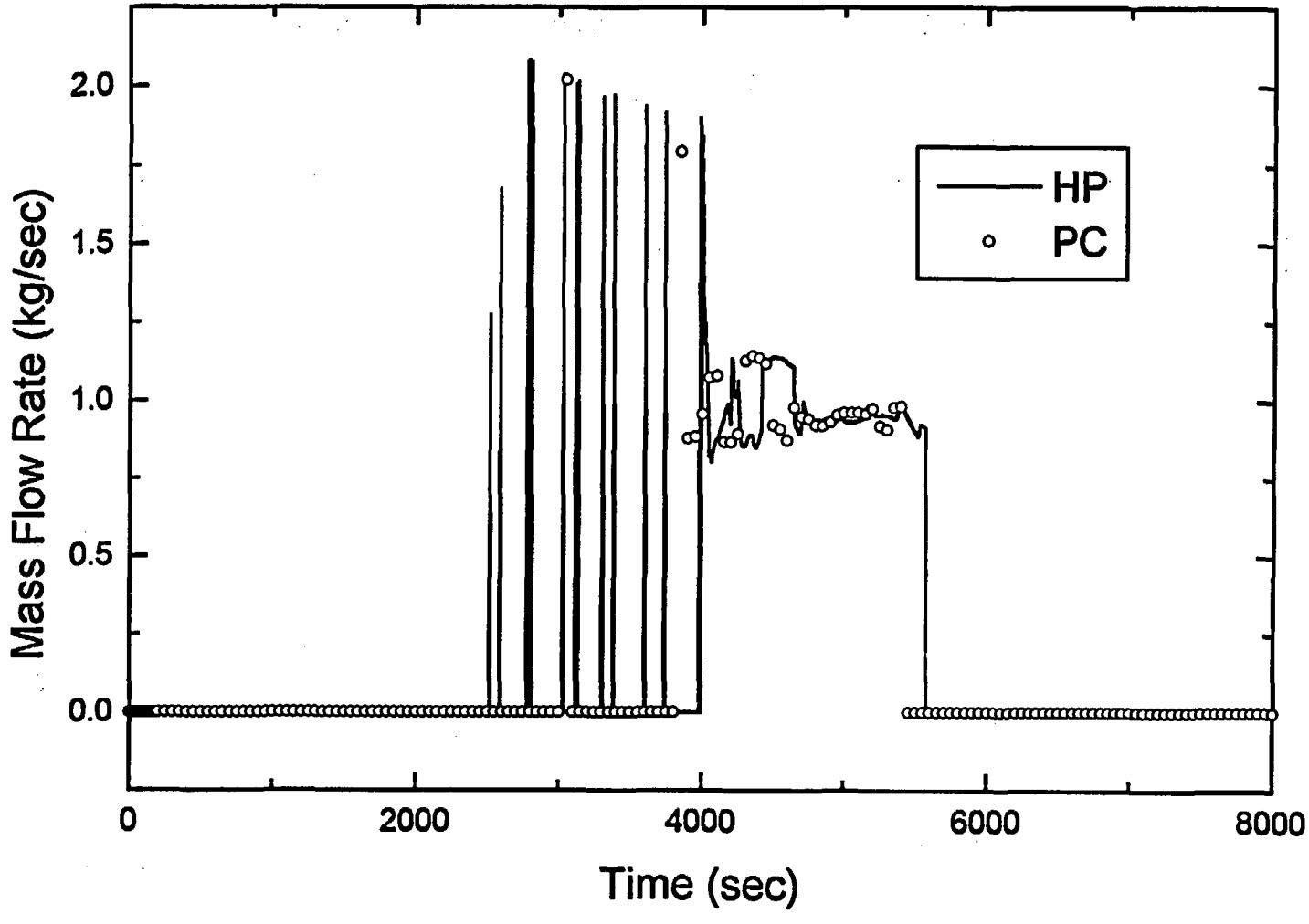

Figure 27 Mass Flow Rate through PORV

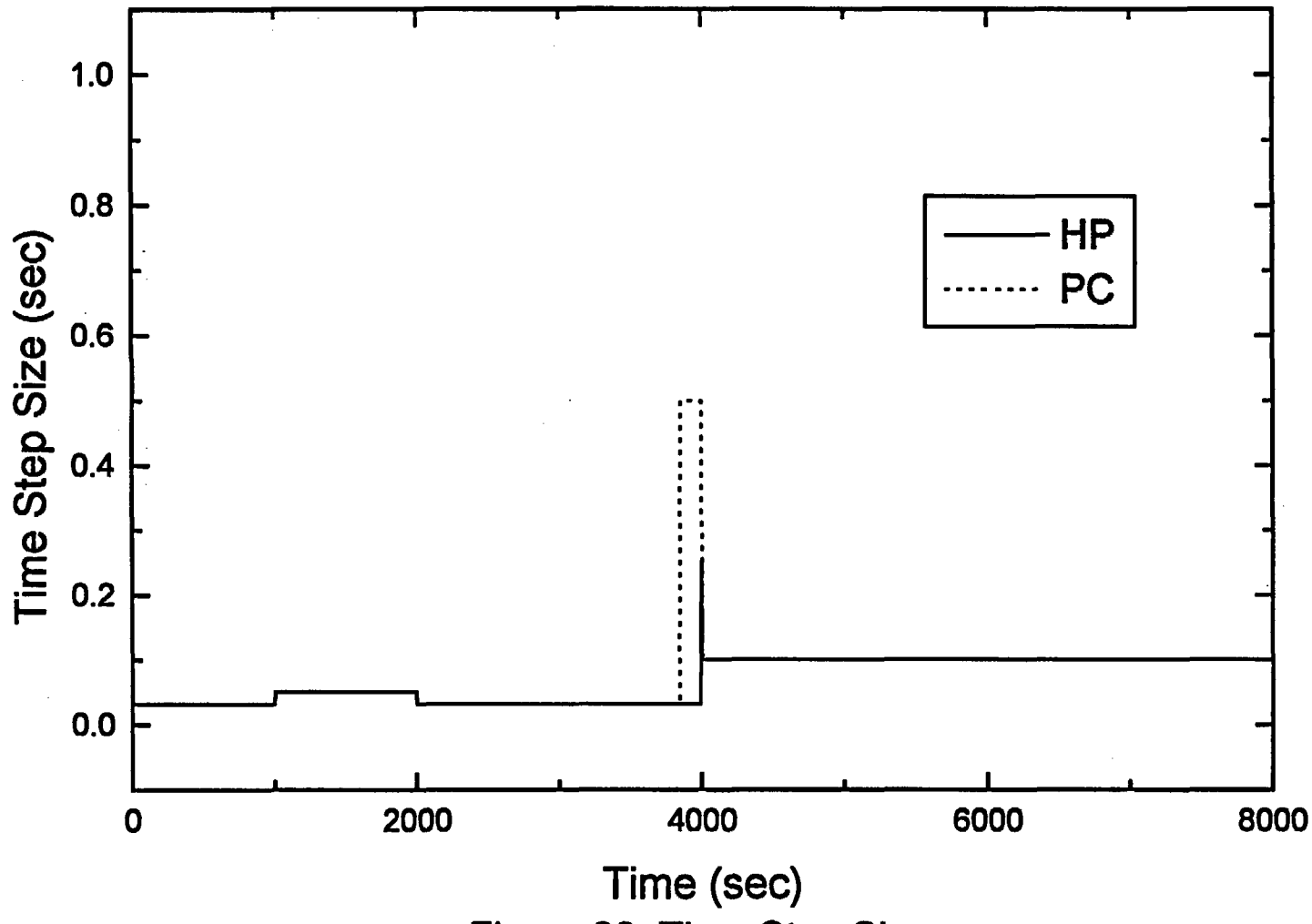

Figure 28 Time Step Size

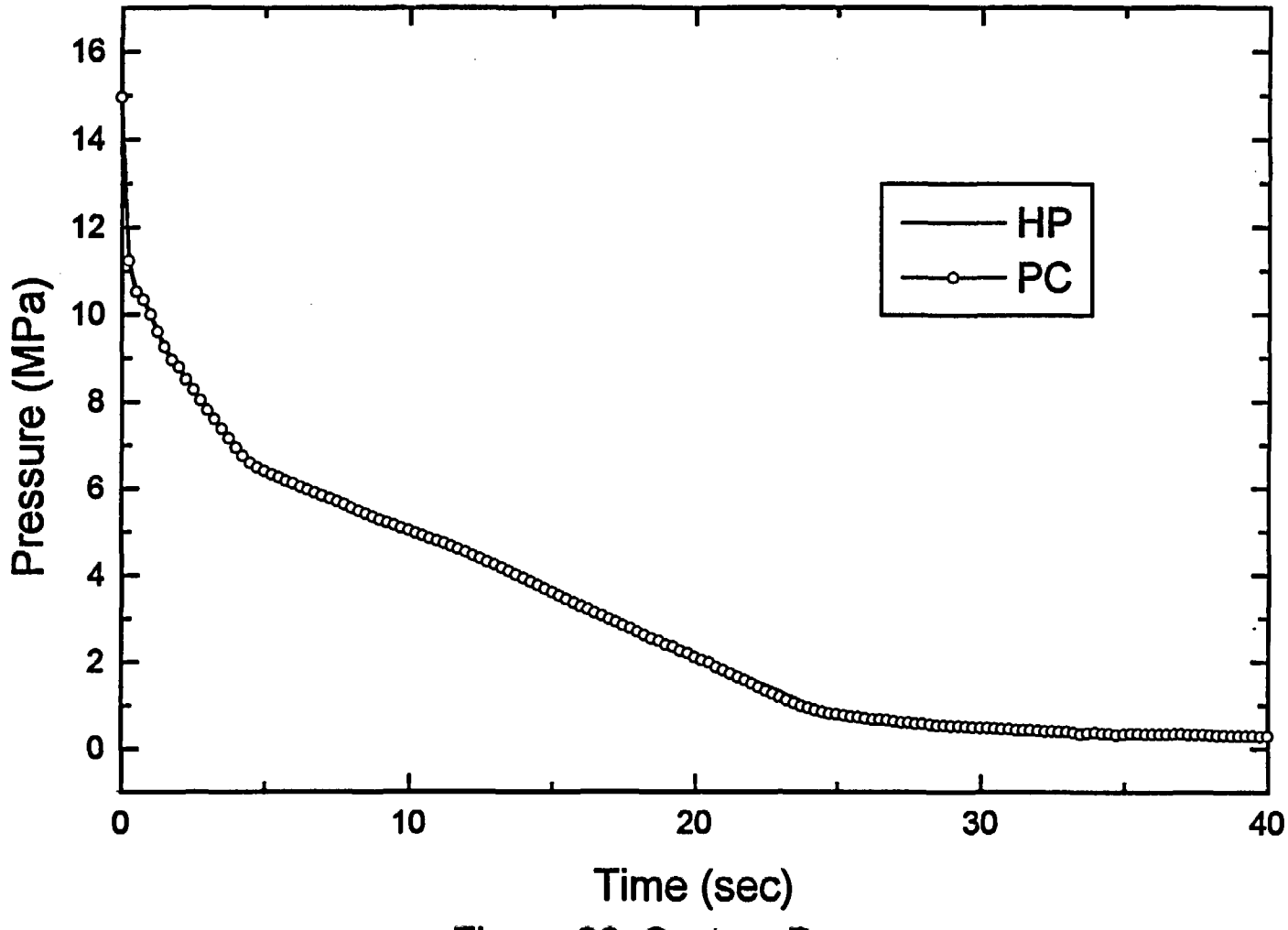

Figure 29 System Pressure

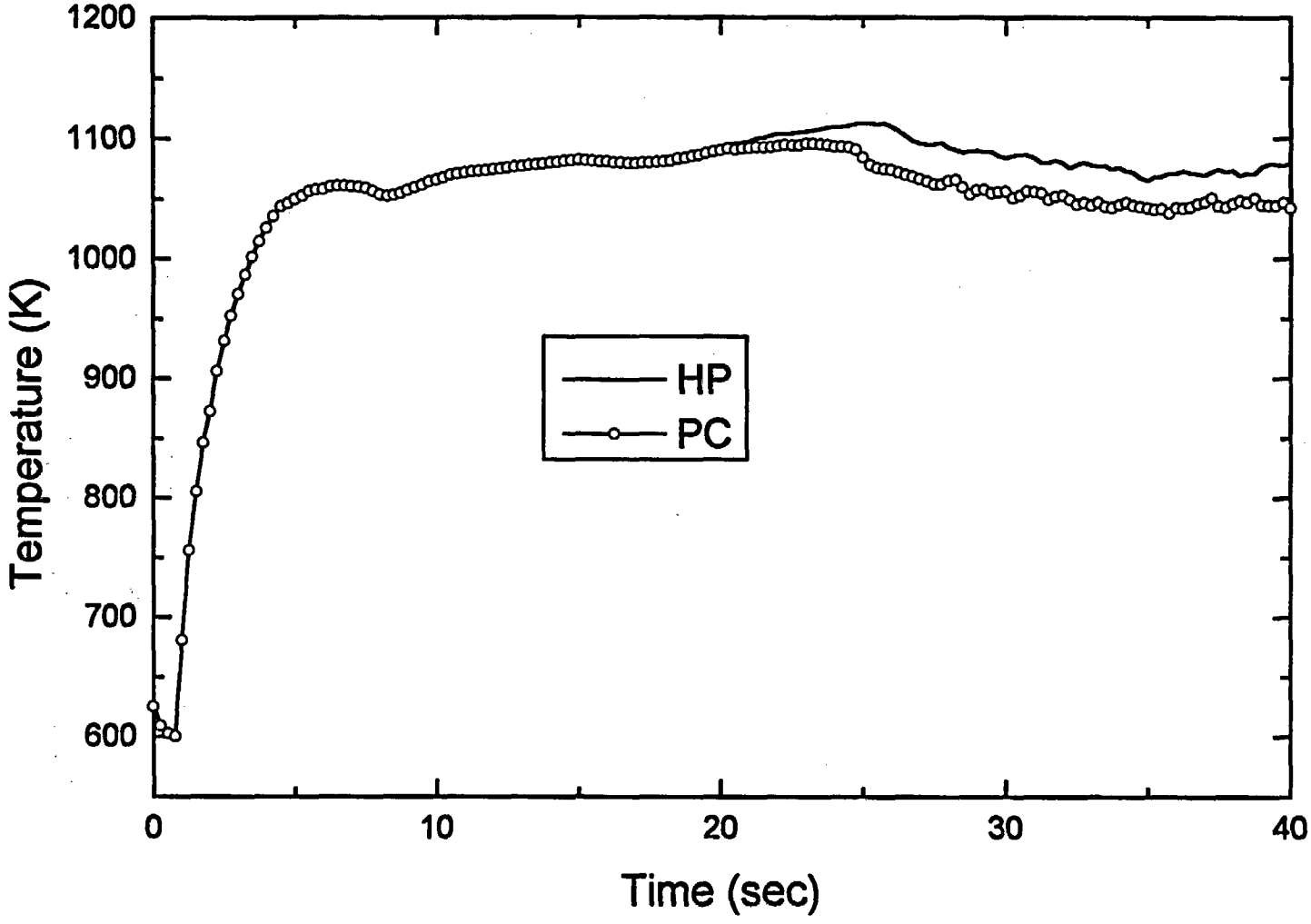

Figure 30 Peak Cladding Temperature

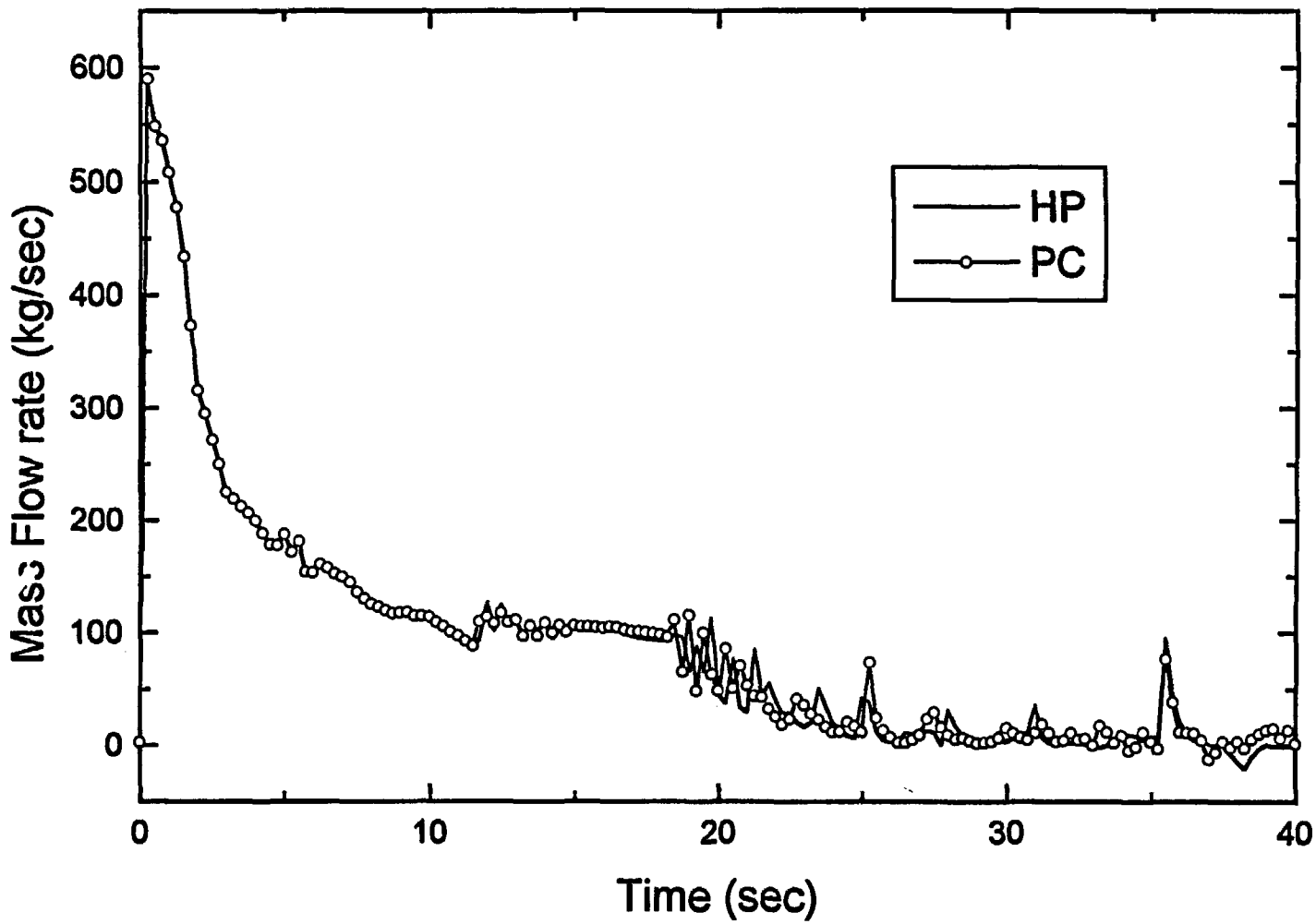

Figure 31 Mass Flow Rate at Broken Loop Cold Leg

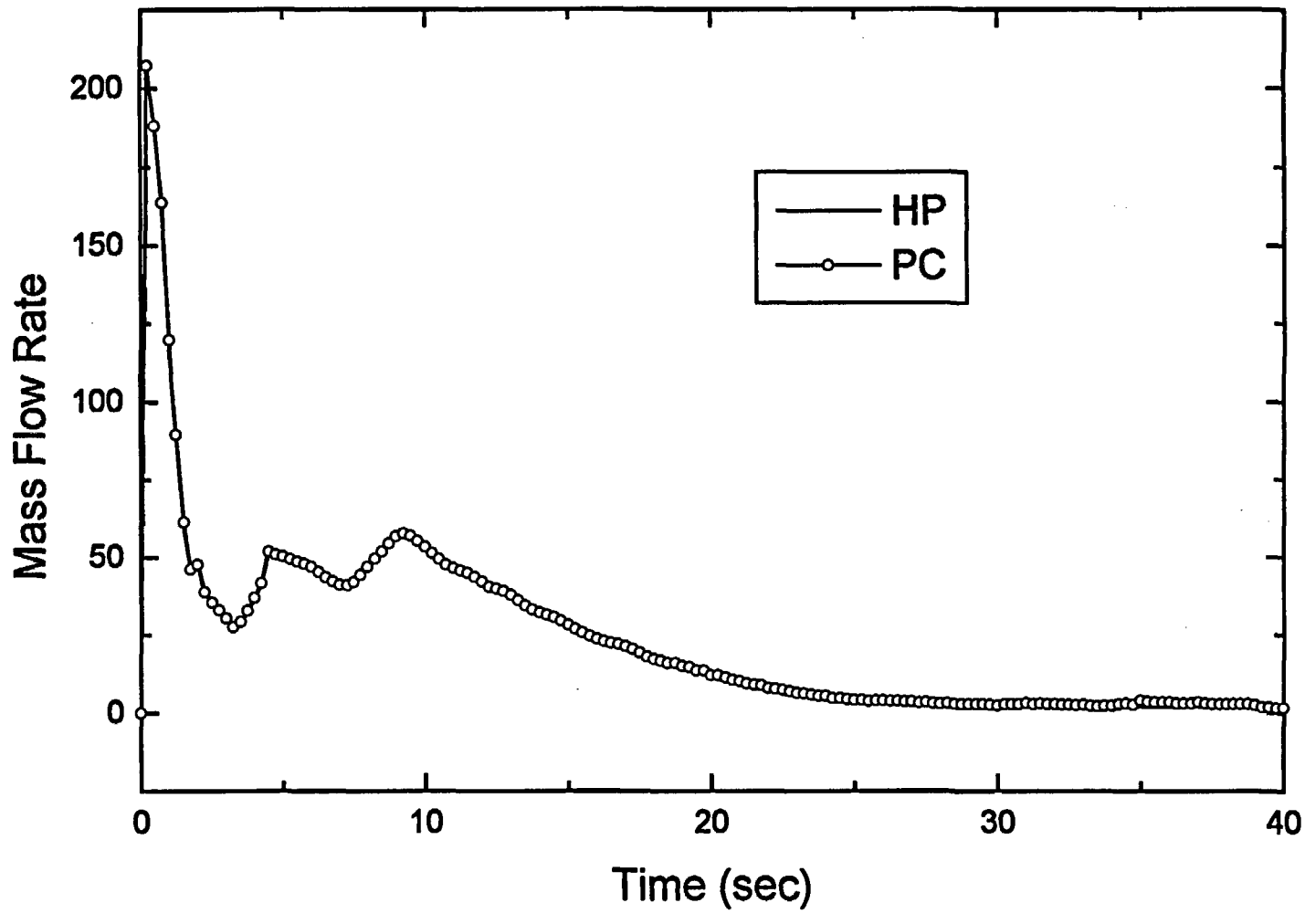

Figure 32 Mass Flow rate at Broken Loop Hot Leg

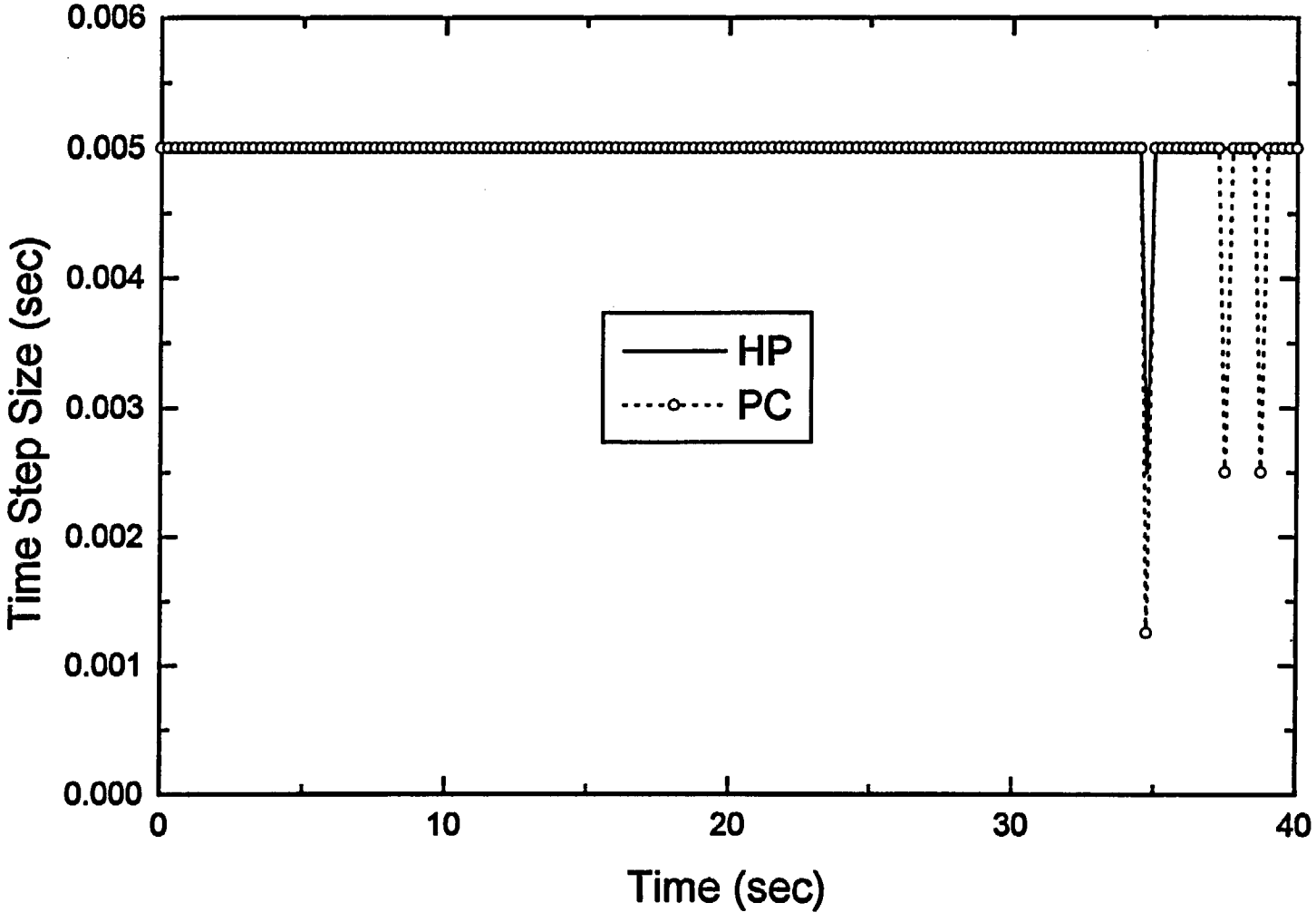

Figure 33 Time Step Size

Appendix A. A Modified Source for TIMSET.FOR

```
*deck timset
      subroutine timset (x)
c  Timing subroutine.  Maintains two nested timing measures.
c
*if def,in32,1
      real*8 x,x1,x2,xn
*if def,apollo,2
*     real*8 array(2),etime
*     external etime
*if def,decrisc,2
*     real*4 array(2),etime
*     external etime
*if def,decrisc2,2
*     real*4 array(2),etime
*     external etime
*if def,decalpha,2
*     real*4 array(2),etime
*     external etime
*if def,laheyf77,2
*      real*4 array(2),timer
*      external timer
      integer iticks
*if def,mass,1
*     real array(2)
*if def,stardent,2
*     real*4 array(2),etime
*     external etime
*if def,sun,2
*     real*4 array(2),etime
*     external etime
*if def,vax,2
*     real*8 array(2),etime
*     external etime
```

```
c
      data x1/0.0d0/,x2/0.0d0/,xn/0.0d0/
c
      i = 1
      go to 10
      entry time1 (x)
      i = 2
      go to 10
*if -def,laheyf77,1
*     entry timer (x)
*if def,laheyf77,1
      entry timerrbc (x)
      i = 3
*if def,apollo,1
*  10  xn = etime(array)
*if def,cdccra,1
*  10  xn = second(xn)
*if def,decrisc,1
*  10  xn = etime(array)
*if def,decrisc2,1
*  10  xn = etime(array)
*if def,decalpha,1
*  10  xn = etime(array)
*if def,hp,1
*  10  xn = etime()
*if def,ibm,1
*  10  xn = 0.0
*if def,ibmrisc,1
*  10  xn = etime(array)
*if def,laheyf77,2
*   10  xn = 100.0d0*timer(array)
   10  call timer(iticks)
       xn = iticks / 100.0d0
```

```
      if (xn .lt. x2) xn = xn + 86400.0d0
*if def,mass,1
*  10   xn = etime(array)
*if def,stardent,1
*  10   xn = etime(array)
*if def,sun,1
*  10   xn = etime(array)
*if def,vax,1
*  10   xn = etime(array)
      if (i-2) 11,13,14
   13 x = xn - x2
      go to 12
   14 x = xn - x1
   11 x1 = xn
   12 x2 = xn
      return
      end
```

Appendix B. A Makefile for Creating ENVRL.LIB library

```
#
# MKMF template makefile for protected mode executables.
#
FC          = f77l3
#LINKER      = 386link
#PROGRAM     = envrl.lib
LIBRARY     = envrl.lib
DEST        = .
EXTHDRS             =
FFLAGS      =
HDRS                = compr.h efilesd.h efiless.h ftbcom.h machaf.h machas.h \
                      machdf.h machds.h machef.h maches.h machlf.h machls.h \
                      machnf.h machns.h machof.h machos.h machsf.h machss.h
LDFLAGS     =
LDMAP       = nul
LIBS        =
MAKEFILE    = Makefile

OBJS                = aaetit.obj astem.obj cvic.obj cvirc.obj dmpfil.obj \
                      dmplst.obj eclock.obj edate.obj erf.obj fabend.obj \
                      ftbcls.obj ftbdel.obj ftbdsb.obj ftberr.obj ftbexp.obj \
                      ftbftb.obj ftbget.obj ftbint.obj ftblct.obj ftbmov.obj \
                      ftbnid.obj ftbopn.obj ftbout.obj ftbpr1.obj ftbpr2.obj \
                      ftbpr3.obj ftbpr4.obj ftbrdc.obj ftbrsv.obj ftbsft.obj \
                      ftbslk.obj ftbtnc.obj getarg.obj idfind.obj inp.obj \
                      inp10.obj inp2.obj inp5.obj inp6.obj inp7.obj inp8.obj \
                      inp9.obj inplnk.obj inpmod.obj inppck.obj inpupk.obj \
                      inxget.obj isfdes.obj ishft.obj issfrg.obj lavail.obj \
                      lcntgs.obj lcontg.obj lifopn.obj locf.obj locf4.obj \
                      locfi.obj locfi4.obj lucmpf.obj mxsets.obj nanvd.obj \
                      nfsets.obj nfsize.obj nfunit.obj pminv1.obj pminv4.obj \
                      pminvd.obj pminvf.obj pminvm.obj pminvr.obj remtim.obj \
                      s2psb1.obj s2psb2.obj s2psb3.obj s2psb4.obj s2psi1.obj \
                      s2psi2.obj s2psi3.obj s2psi4.obj s2psi5.obj s2psl1.obj \
                      s2psl2.obj s2psl3.obj s2psl4.obj s2psl5.obj s2pvi.obj \
                      s2pvib.obj s2pvl.obj search.obj setndf.obj snpb01.obj \
                      snpho.obj snpmd.obj snpmi.obj snpml.obj snpsb1.obj \
                      snpsb2.obj snpsb3.obj snpsb4.obj snpsc1.obj snpsc2.obj \
                      snpsd1.obj snpsd2.obj snpsd3.obj snpsd4.obj snpsd5.obj \
                      snpsi1.obj snpsi2.obj snpsi3.obj snpsi4.obj snpsi5.obj \
                      snpsl1.obj snpsl2.obj snpsl3.obj snpsl4.obj snpsl5.obj \
                      snptd.obj snpti.obj snptl.obj snpvc.obj snpvd.obj \
                      snpvi.obj snpvib.obj snpvl.obj spl1d1.obj spl1d2.obj \
                      spl2d1.obj spl2d2.obj spln11.obj spln12.obj spln21.obj \
                      spln22.obj sqoz.obj stgd2o.obj stgh2o.obj sth2x0.obj \
                      sth2x1.obj sth2x3.obj sth2x4.obj sth2x5.obj sth2x6.obj \
```

```
                sth2xi.obj sth2xj.obj timset.obj trap.obj unsqoz.obj \
                zerout.obj
SRCS        = aaetit.for astem.for cvic.for cvirc.for dmpfil.for dmplst.for eclock.for \
              edate.for erf.for fabend.for ftbcls.for ftbdel.for ftbdsb.for ftberr.for \
              ftbexp.for ftbftb.for ftbget.for ftbint.for ftblct.for ftbmov.for \
              ftbnid.for ftbopn.for ftbout.for ftbpr1.for ftbpr2.for ftbpr3.for \
              ftbpr4.for ftbrdc.for ftbrsv.for ftbsft.for ftbslk.for ftbtnc.for \
              getarg.for idfind.for inp.for inp10.for inp2.for inp5.for inp6.for \
              inp7.for inp8.for inp9.for inplnk.for inpmod.for inppck.for inpupk.for \
              inxget.for isfdes.for ishft.for issfrg.for lavail.for lcntgs.for \
              lcontg.for lifopn.for locf.for locf4.for locfi.for locfi4.for lucmpf.for \
              mxsets.for nanvd.for nfsets.for nfsize.for nfunit.for pminv1.for \
              pminv4.for pminvd.for pminvf.for pminvm.for pminvr.for remtim.for \
              s2psb1.for s2psb2.for s2psb3.for s2psb4.for s2psi1.for s2psi2.for \
              s2psi3.for s2psi4.for s2psi5.for s2psl1.for s2psl2.for s2psl3.for \
              s2psl4.for s2psl5.for s2pvi.for s2pvib.for s2pvl.for search.for \
              setndf.for snpb01.for snpho.for snpmd.for snpmi.for snpml.for \
              snpsb1.for snpsb2.for snpsb3.for snpsb4.for snpsc1.for snpsc2.for \
              snpsd1.for snpsd2.for snpsd3.for snpsd4.for snpsd5.for snpsi1.for \
              snpsi2.for snpsi3.for snpsi4.for snpsi5.for snpsl1.for snpsl2.for \
              snpsl3.for snpsl4.for snpsl5.for snptd.for snpti.for snptl.for snpvc.for \
              snpvd.for snpvi.for snpvib.for snpvl.for spl1d1.for spl1d2.for \
              spl2d1.for spl2d2.for spln11.for spln12.for spln21.for spln22.for \
              sqoz.for stgd2o.for stgh2o.for sth2x0.for sth2x1.for sth2x3.for \
              sth2x4.for   sth2x5.for sth2x6.for sth2xi.for sth2xj.for timset.for \
              trap.for   unsqoz.for zerout.for

$(LIBRARY):     $(OBJS)
                386lib $@ -pagesize 32 -create $(OBJS)

clean::         @del -f $(OBJS)

depend::    @mkmf -f $(MAKEFILE) LIBRARY=$(LIBRARY) DEST=$(DEST)

install:    $(LIBRARY)
                @echo Installing $(LIBRARY) in $(DEST)
                @if not $(DEST)x==.x copy $(LIBRARY) $(DEST)
### OPUS MKMF:   Do not remove this line!   Automatic dependencies follow.

astem.obj: efilesd.h efiless.h
cvic.obj: machaf.h machas.h machef.h maches.h machnf.h machns.h machof.h \
          machos.h machsf.h machss.h

cvirc.obj: efilesd.h efiless.h

dmpfil.obj: efilesd.h efiless.h ftbcom.h machdf.h machds.h
```

dmplst.obj: efilesd.h efiless.h ftbcom.h machdf.h machds.h

ftbcls.obj: ftbcom.h machdf.h machds.h

ftbdel.obj: ftbcom.h machdf.h machds.h

ftbdsb.obj: ftbcom.h machdf.h machds.h

ftberr.obj: efilesd.h efiless.h ftbcom.h

ftbexp.obj: ftbcom.h machdf.h machds.h

ftbftb.obj: ftbcom.h

ftbget.obj: ftbcom.h machdf.h machds.h

ftbint.obj: efilesd.h efiless.h ftbcom.h machdf.h machds.h

ftblct.obj: ftbcom.h machdf.h machds.h

ftbnid.obj: efilesd.h efiless.h ftbcom.h machdf.h machds.h

ftbopn.obj: ftbcom.h machdf.h machds.h

ftbout.obj: ftbcom.h

ftbpr1.obj: ftbcom.h machdf.h machds.h

ftbrdc.obj: ftbcom.h machdf.h machds.h

ftbrsv.obj: ftbcom.h machdf.h machds.h

ftbsft.obj: ftbcom.h machdf.h machds.h

ftbslk.obj: ftbcom.h machdf.h machds.h

ftbtnc.obj: ftbcom.h machdf.h machds.h

idfind.obj: ftbcom.h machdf.h machds.h

inp.obj: efilesd.h efiless.h machaf.h machas.h machlf.h machls.h machnf.h \
machns.h machof.h machos.h machsf.h machss.h

inp10.obj: machdf.h machds.h

inp2.obj: efilesd.h efiless.h machdf.h machds.h

inp5.obj: efilesd.h efiless.h

inp7.obj: efilesd.h efiless.h

inp8.obj: efilesd.h efiless.h machdf.h machds.h

inp9.obj: machdf.h machds.h

inplnk.obj: machdf.h machds.h

inpmod.obj: machdf.h machds.h

inppck.obj: machdf.h machds.h

inpupk.obj: machdf.h machds.h

inxget.obj: ftbcom.h machdf.h machds.h

isfdes.obj: ftbcom.h

issfrg.obj: ftbcom.h

lavail.obj: ftbcom.h

lcntgs.obj: ftbcom.h machdf.h machds.h

lcontg.obj: ftbcom.h

lifopn.obj: ftbcom.h machdf.h machds.h

mxsets.obj: ftbcom.h machdf.h machds.h

nfsets.obj: ftbcom.h

nfsize.obj: ftbcom.h machdf.h machds.h

nfunit.obj: ftbcom.h machdf.h machds.h

pminv1.obj: machdf.h machds.h

pminvd.obj: efilesd.h efiless.h machdf.h machds.h

pminvf.obj: efilesd.h efiless.h machdf.h machds.h

pminvm.obj: efilesd.h efiless.h

pminvr.obj: efilesd.h efiless.h

sqoz.obj: machdf.h machds.h

sth2x1.obj: machdf.h machds.h

sth2x3.obj: machdf.h machds.h

sth2x4.obj: machdf.h machds.h

sth2x5.obj: machdf.h machds.h

sth2x6.obj: efilesd.h efiless.h machsf.h machss.h

sth2xi.obj: efilesd.h efiless.h

sth2xj.obj: efilesd.h efiless.h

unsqoz.obj: machdf.h machds.h

Appendix C. A Makefile for Creating RELAP5 Executable

```
#
# MKMF template makefile for protected mode executables.
#
FC          = f77l3
LINKER      = 386link
PROGRAM     = relap5.exe
DEST        = .
EXTHDRS             =
FFLAGS      =
HDRS                = alcm.h axtrns.h balfar.h bconds.h bcons.h bcs.h bder.h \
                      blageo.h blinit.h blkage.h bln2wk.h blonab.h bloond.h \
                      bplu1.h bsize.h buntim.h bwcons.h bwgeom.h bwprop.h \
                      bwtrns.h cboilx.h cdfinc.h cdfinv.h cmatp.h cmp3dt.h \
                      cmpalf.h cmpdac.h cmpdacc.h cmpdat.h cmpdatc.h cmpdtv.h \
                      cmpdtvc.h cmptim.h cnvtpa.h cnvtpad.h comctl.h comctlc.h \
                      comlst.h cons.h contrl.h contrx.h convarc.h convarx.h \
                      cora.h coupl.h cpmdat.h cprdat.h cprops.h cr2.h cvals.h \
                      dbacct.h dcon.h debcom.h debout.h eccmxc.h eccmxcc.h \
                      effprp.h eht0.h ehtc0.h farays.h fast.h fastc.h fecom.h \
                      fginvc.h fgrcom.h fparm1.h fparm2.h fpbin.h fpcoef.h \
                      fpctrl.h fpdkht.h fpfast.h fpfastc.h fpinsc.h fpinsh.h \
                      fplim.h fpmas.h fpmdl.h fpnonv.h fpvol.h ftbcom.h ftbfet.h \
                      gapvar.h genrl.h genrlc.h gentblc.h gentblx.h grscgr.h \
                      grsparg.h grsprg.h hardpn.h hfuson.h htrcom.h htrflb.h \
                      htrflbc.h htscr.h htscr1.h htscr2.h htsrcm.h htsrcmc.h \
                      hydprp.h intcom.h intrac.h intracc.h invhtb.h invtbl.h \
                      invtblc.h iocom.h iparm.h iparmc.h iparmm.h jundat.h \
                      k3all.h k3cc.h k3point.h lcntrl.h lcntrlc.h lpdat.h \
                      lpdatc.h lvectr.h machaf.h machas.h machef.h maches.h \
                      machlf.h machls.h machnf.h machns.h machof.h machos.h \
                      machsf.h machss.h madatc.h matdat.h matsrs.h maxmem.h \
                      maxmemc.h miedtc.h miedtcl.h miscon.h mtblc.h mtbls.h \
                      mxnfcd.h nbtim.h ndxara.h nhtara.h noval.h npacom.h \
                      nrcom.h oldcom.h oxcom1.h oxcom2.h oxcom3.h \
                      parm.h parmc.h \
                      parmm.h plndat.h pltloc.h pltput.h prdat.h propts.h \
                      przdat.h przdatc.h ptscom.h pumpblk.h pumpblx.h pvmvr5.h \
                      r5pvmcp.h radata.h radhtc.h radhtcc.h rcompc.h rflhtc.h \
                      rgacct.h rkinc.h rkincc.h rknatb.h rmadac.h rrkinc.h \
                      rupt.h rvoldt.h scdcom.h scddat.h scddatc.h scdout.h \
                      scdpow.h scrtch.h scrtchc.h separ.h separc.h slbcom.h \
                      slumpv.h solcom.h speed.h sscntr.h sscntrc.h ssiblk.h \
                      statc.h statcc.h statec.h statecc.h stcblk.h stcblkc.h \
                      stcom.h stcom2.h stmprp.h sysdatc.h sysdatm.h tblsp.h \
                      tdpptr.h temp3d.h thplot.h tmsrcm.h trnhlp.h trnhlpc.h \
```

```
                trnot1.h trnot2.h trpblk.h trpblkc.h tsctlc.h tsctlcc.h \
                tstpct.h tstpctc.h ttpsc.h turbin.h turbinc.h ufilef.h \
                ufiles.h ufilesc.h uoxcom.h uphdpn.h usrvar.h vel.h \
                voldat.h voldatc.h vreqd.h vreqs.h za.h zalfag.h
LDFLAGS    =c:\relap5\envrl\envrl.lib
LDMAP      =
LIBS       =
MAKEFILE   = Makefile
OBJS            = aatl.obj accum.obj adechk.obj amux.obj blkdta.obj \
                borbnd.obj bplu.obj bppram.obj bpsqlu.obj bpsqsl.obj \
                bpsub.obj brntrn.obj brycej.obj ccfl.obj celmdr.obj \
                cheby1.obj chebytr.obj chfcal.obj chfkut.obj cmpcom.obj \
                cntrlc.obj coev3d.obj conden.obj condn2.obj convar.obj \
                conver.obj cplexp.obj cramer.obj cthxpr.obj daxpy.obj \
                ddot.obj detmnt.obj dir16.obj dir2full.obj dir2x2.obj \
                dir4full.obj direct4.obj direct8.obj direct8b.obj \
                dittus.obj dlaydn.obj dmpcom.obj dnrm2.obj dryer.obj \
                dtstep.obj eccmxj.obj eccmxv.obj eprij.obj eqfinl.obj \
                eqfinm.obj errorn.obj fidis.obj fidis2.obj fidisj.obj \
                fidisv.obj figout.obj fildmp.obj flostj.obj flostv.obj \
                flux3d.obj fmvlwr.obj ftbmem.obj fwdrag.obj gapcon.obj \
                gascatc.obj gascath.obj gasthc.obj gedry.obj geometry.obj \
                gesep.obj gesub.obj getsec.obj gninit.obj grdnrj.obj \
                griftj.obj helphd.obj hifbub.obj hloss.obj ht1inp.obj \
                ht1sst.obj ht1tdp.obj ht2tdp.obj htadv.obj htcond.obj \
                htcsol.obj htfilm.obj htfinl.obj htheta.obj htrc1.obj \
                htrc2.obj htrcn2.obj hydro.obj hzflow.obj i3dcmp.obj \
                icmpf.obj icmpn1.obj icompn.obj iconvr.obj iedit.obj \
                ielvtn.obj igntbl.obj ihtcmp.obj ijprop.obj ilut.obj \
                imiedt.obj imlp.obj inital.obj inputd.obj interi.obj \
                invhts.obj invjt.obj ipipe.obj ipump.obj ir5pvmc.obj \
                iradht.obj irflht.obj irkin.obj irotat.obj isngj.obj \
                issi.obj istate.obj itrip.obj itrscn.obj itstck.obj \
                iusrvr.obj ivelst.obj ivlvel.obj jchoke.obj jprop.obj \
                k3dss.obj k3dtr.obj k3pntr.obj katokj.obj kloss.obj \
                komexp.obj level.obj lsorb.obj lsorb0.obj lusol0.obj \
                madata.obj majout.obj mapmat.obj mdata2.obj mhdfwf.obj \
                mirec.obj mover.obj nansca.obj nanscj.obj nanscv.obj \
                ncfilm.obj ncprop.obj ncwall.obj noncnd.obj nonnemc.obj \
                nonnemh.obj nonnetc.obj nonneth.obj nononec.obj \
                nononeh.obj nonplmc.obj nonplmh.obj nontwoc.obj \
                nontwoh.obj nonz.obj norm.obj normfsp.obj outin.obj \
                outintr.obj outpoint.obj outputss.obj outputtr.obj \
                packer.obj pcontrl.obj petukv.obj pgmres.obj phantj.obj \
                phantv.obj pimplt.obj pintfc.obj pjundat.obj plpdat.obj \
```

```
plstrn.obj pltrec.obj pltwrt.obj pminvx.obj pol8.obj \
polat.obj polatr.obj prebun.obj precr.obj prednb.obj \
preseq.obj prntfa.obj prntia.obj prseqm.obj psatpd.obj \
pscrtch.obj pset.obj pstdnb.obj pstpd2.obj pump.obj \
pump2.obj pvmfxrec.obj pvmput.obj pvmrcv.obj pvmset.obj \
pvmsnd.obj pvoldat.obj qfhtrc.obj qfmove.obj qfsrch.obj \
qmwr.obj qsplit.obj r3dcmp.obj raccum.obj radht.obj \
rbrnch.obj rcards.obj rcdelt.obj rchng.obj rcompn.obj \
rconvr.obj rdredt.obj reedit.obj relap5.obj relpower.obj \
reord.obj rgntbl.obj rhelp.obj rhtcmp.obj rintrv.obj \
rkin.obj rkinh.obj rkino.obj rmadat.obj rmblnk.obj \
rmflds.obj rmiedt.obj rmtplj.obj rnewp.obj rnoncn.obj \
rpipe.obj rpmpdc.obj rpmpmd.obj rpmvnj.obj rpump.obj \
rr5pvmc.obj rradht.obj rrestf.obj rrkin.obj rrkinh.obj \
rrkino.obj rrkinp.obj rrkioh.obj rrotat.obj rrstd.obj \
rsngj.obj rsngv.obj rssi.obj rstrec.obj rstrip.obj \
rtmdj.obj rtmdv.obj rtrip.obj rtsc.obj rturb.obj \
ruplas.obj rusrvr.obj rvalve.obj scnreq.obj seta.obj \
setspt.obj setup0.obj sgigrf.obj simplt.obj simul.obj \
snapit.obj sorce.obj sorce0.obj sqlu.obj srestf.obj \
sstchk.obj stacc.obj state.obj statep.obj stcset.obj \
std2x0.obj std2x1.obj std2x3.obj std2x6.obj stdry.obj \
stdsp.obj stgodu.obj stpu00.obj stpu0p.obj stpu2p.obj \
stpu2pu.obj stpu2t.obj stpupu.obj stputp.obj stread.obj \
strip.obj strpu.obj strpu1.obj strpu2.obj strpvm.obj \
strpx.obj strsat.obj strtp.obj strtx.obj strx.obj \
stvrpx.obj suboil.obj surftn.obj svh2x2.obj svpu2p.obj \
svpupu.obj sysitr.obj syssol.obj tcnvsl.obj tfront.obj \
thcond.obj tran.obj tridia.obj tridia0.obj trip.obj \
trnctl.obj trnfin.obj trnset.obj trotat.obj tsetsl.obj \
tstate.obj turbst.obj update.obj valve.obj vexplt.obj \
vfinl.obj vimplt.obj viscos.obj vlvela.obj volvel.obj \
wrplid.obj xsfdbk.obj zbrent.obj zfslgj.obj
SRCS = aatl.for accum.for adechk.for amux.for blkdta.for \
borbnd.for bplu.for bppram.for bpsqlu.for bpsqsl.for \
bpsub.for brntrn.for brycej.for ccfl.for celmdr.for \
cheby1.for chebytr.for chfcal.for chfkut.for cmpcom.for \
cntrlc.for coev3d.for conden.for condn2.for convar.for \
conver.for cplexp.for cramer.for cthxpr.for daxpy.for \
ddot.for detmnt.for dir16.for dir2full.for dir2x2.for \
dir4full.for direct4.for direct8.for direct8b.for \
dittus.for dlaydn.for dmpcom.for dnrm2.for dryer.for \
dtstep.for eccmxj.for eccmxv.for eprij.for eqfinl.for \
eqfinm.for errorn.for fidis.for fidis2.for fidisj.for \
fidisv.for figout.for fildmp.for flostj.for flostv.for \
```

flux3d.for fmvlwr.for ftbmem.for fwdrag.for gapcon.for \
gascatc.for gascath.for gasthc.for gedry.for geometry.for \
gesep.for gesub.for getsec.for gninit.for grdnrj.for \
griftj.for helphd.for hifbub.for hloss.for ht1inp.for \
ht1sst.for ht1tdp.for ht2tdp.for htadv.for htcond.for \
htcsol.for htfilm.for htfinl.for htheta.for htrc1.for \
htrc2.for htrcn2.for hydro.for hzflow.for i3dcmp.for \
icmpf.for icmpn1.for icompn.for iconvr.for iedit.for \
ielvtn.for igntbl.for ihtcmp.for ijprop.for ilut.for \
imiedt.for imlp.for inital.for inputd.for interi.for \
invhts.for invjt.for ipipe.for ipump.for ir5pvmc.for \
iradht.for irflht.for irkin.for irotat.for isngj.for \
issi.for istate.for itrip.for itrscn.for itstck.for \
iusrvr.for ivelst.for ivlvel.for jchoke.for jprop.for \
k3dss.for k3dtr.for k3pntr.for katokj.for kloss.for \
komexp.for level.for lsorb.for lsorb0.for lusol0.for \
madata.for majout.for mapmat.for mdata2.for mhdfwf.for \
mirec.for mover.for nansca.for nanscj.for nanscv.for \
ncfilm.for ncprop.for ncwall.for noncnd.for nonnemc.for \
nonnemh.for nonnetc.for nonneth.for nononec.for \
nononeh.for nonplmc.for nonplmh.for nontwoc.for \
nontwoh.for nonz.for norm.for normfsp.for outin.for \
outintr.for outpoint.for outputss.for outputtr.for \
packer.for pcontrl.for petukv.for pgmres.for phantj.for \
phantv.for pimplt.for pintfc.for pjundat.for plpdat.for \
plstrn.for pltrec.for pltwrt.for pminvx.for pol8.for \
polat.for polatr.for prebun.for precr.for prednb.for \
preseq.for prntfa.for prntia.for prseqm.for psatpd.for \
pscrtch.for pset.for pstdnb.for pstpd2.for pump.for \
pump2.for pvmfxrec.for pvmput.for pvmrcv.for pvmset.for \
pvmsnd.for pvoldat.for qfhtrc.for qfmove.for qfsrch.for \
qmwr.for qsplit.for r3dcmp.for raccum.for radht.for \
rbrnch.for rcards.for rcdelt.for rchng.for rcompn.for \
rconvr.for rdredt.for reedit.for relap5.for relpower.for \
reord.for rgntbl.for rhelp.for rhtcmp.for rintrv.for \
rkin.for rkinh.for rkino.for rmadat.for rmblnk.for \
rmflds.for rmiedt.for rmtplj.for rnewp.for rnoncn.for \
rpipe.for rpmpdc.for rpmpmd.for rpmvnj.for rpump.for \
rr5pvmc.for rradht.for rrestf.for rrkin.for rrkinh.for \
rrkino.for rrkinp.for rrkioh.for rrotat.for rrstd.for \
rsngj.for rsngv.for rssi.for rstrec.for rstrip.for \
rtmdj.for rtmdv.for rtrip.for rtsc.for rturb.for \
ruplas.for rusrvr.for rvalve.for scnreq.for seta.for \
setspt.for setup0.for sgigrf.for simplt.for simul.for \
snapit.for sorce.for sorce0.for sqlu.for srestf.for \

```
                    sstchk.for stacc.for state.for statep.for stcset.for \
                    std2x0.for std2x1.for std2x3.for std2x6.for stdry.for \
                    stdsp.for stgodu.for stpu00.for stpu0p.for stpu2p.for \
                    stpu2pu.for stpu2t.for stpupu.for stputp.for stread.for \
                    strip.for strpu.for strpu1.for strpu2.for strpvm.for \
                    strpx.for strsat.for strtp.for strtx.for strx.for \
                    stvrpx.for suboil.for surftn.for svh2x2.for svpu2p.for \
                    svpupu.for sysitr.for syssol.for tcnvsl.for tfront.for \
                    thcond.for tran.for tridia.for tridia0.for trip.for \
                    trnctl.for trnfin.for trnset.for trotat.for tsetsl.for \
                    tstate.for turbst.for update.for valve.for vexplt.for \
                    vfinl.for vimplt.for viscos.for vlvela.for volvel.for \
                    wrplid.for xsfdbk.for zbrent.for zfslgj.for

$(PROGRAM):     $(OBJS) $(LIBS)
            $(LINKER) $(OBJS) -EXE $@   -LIB $(LIBS) $(LDFLAGS)

clean::;            @del -f $(OBJS)

depend::;   @mkmf -f $(MAKEFILE) PROGRAM=$(PROGRAM) DEST=$(DEST)

install:    $(PROGRAM)
                    @echo Installing $(PROGRAM) in $(DEST)
                    @if not $(DEST)x==.x copy $(PROGRAM) $(DEST)
### OPUS MKMF:   Do not remove this line!   Automatic dependencies follow.

aatl.obj: genrl.h ufiles.h

accum.obj: cmpdac.h cmpdat.h comctl.h contrl.h fast.h jundat.h lpdat.h \
           lvectr.h machaf.h machas.h machnf.h machns.h machof.h machos.h \
           machsf.h machss.h scrtch.h statec.h stcom.h trnhlp.h trpblk.h \
           ufiles.h voldat.h

adechk.obj: ufiles.h

blkdta.obj: cmpalf.h comctl.h contrl.h fast.h fparm1.h fparm2.h fpctrl.h \
           fpinsc.h fpinsh.h fplim.h fpmdl.h ftbcom.h maxmem.h mxnfcd.h \
           npacom.h rcompc.h rknatb.h rmadac.h tsctlc.h ufilef.h ufiles.h

bppram.obj: bplu1.h

brntrn.obj: cmpdat.h comctl.h contrl.h fast.h invtbl.h jundat.h lpdat.h \
           lvectr.h machaf.h machas.h machof.h machos.h scrtch.h statec.h \
           stcom.h trnhlp.h tsctlc.h ufiles.h voldat.h
```

```
brycej.obj: comctl.h fast.h jundat.h voldat.h

ccfl.obj: comctl.h contrl.h fast.h jundat.h lpdat.h machaf.h machas.h \
        machnf.h machns.h machof.h machos.h scrtch.h trnhlp.h ufiles.h \
        voldat.h

chfcal.obj: contrl.h fast.h htrcom.h machaf.h machas.h stcblk.h ufiles.h \
        voldat.h

chfkut.obj: contrl.h fast.h htrcom.h machas.h machss.h stcblk.h stcom.h \
        ufiles.h voldat.h

cmpcom.obj: comctl.h comlst.h contrl.h fast.h genrl.h machaf.h machas.h \
        machlf.h machls.h machsf.h machss.h maxmem.h ufilef.h ufiles.h

conden.obj: contrl.h fast.h htrcom.h stcblk.h stcom.h ufiles.h voldat.h

condn2.obj: contrl.h fast.h htrcom.h stcblk.h stcom.h ufiles.h voldat.h

convar.obj: comctl.h contrl.h convarc.h fast.h gentblc.h machaf.h machas.h \
        machsf.h machss.h pumpblk.h trpblk.h turbin.h ufiles.h

cramer.obj: ufiles.h

dittus.obj: contrl.h fast.h htrcom.h mxnfcd.h ufiles.h voldat.h

dmpcom.obj: comctl.h contrl.h fast.h genrl.h lpdat.h machaf.h machas.h \
        machlf.h machls.h machnf.h machns.h machsf.h machss.h trnhlp.h \
        ufilef.h ufiles.h

dryer.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h lpdat.h lvectr.h \
        machaf.h machas.h machnf.h machns.h przdat.h separ.h statec.h \
        trnhlp.h ufiles.h voldat.h

dtstep.obj: cmpdat.h comctl.h contrl.h convarc.h coupl.h cpmdat.h fast.h \
        intrac.h jundat.h lcntrl.h machaf.h machas.h machef.h maches.h \
        machnf.h machns.h machof.h machos.h machsf.h machss.h ndxara.h \
        npacom.h pvmvr5.h scddat.h scdout.h slumpv.h statc.h statec.h \
        tblsp.h trnhlp.h trpblk.h tsctlc.h tstpct.h ufiles.h voldat.h

eccmxj.obj: comctl.h cons.h contrl.h eccmxc.h fast.h invtbl.h jundat.h \
        scrtch.h trnhlp.h ufiles.h voldat.h

eccmxv.obj: comctl.h cons.h contrl.h eccmxc.h fast.h invtbl.h jundat.h \
        scrtch.h trnhlp.h ufiles.h voldat.h
```

```
eprij.obj: comctl.h contrl.h fast.h jundat.h stcom.h voldat.h

eqfinl.obj: comctl.h contrl.h fast.h jundat.h lpdat.h lvectr.h machaf.h \
        machas.h machof.h machos.h scrtch.h statec.h stcom.h trnhlp.h \
        tsctlc.h ufiles.h voldat.h

fidis.obj: contrl.h fast.h stcom.h voldat.h

fidis2.obj: comctl.h contrl.h fast.h jundat.h stcom.h voldat.h

fidisj.obj: comctl.h contrl.h fast.h jundat.h machaf.h machas.h machsf.h \
        machss.h scrtch.h voldat.h

fidisv.obj: contrl.h fast.h stcom.h voldat.h

fildmp.obj: comctl.h ufiles.h

flostj.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h machaf.h machas.h \
        machnf.h machns.h machof.h machos.h machsf.h machss.h separ.h \
        statec.h ufiles.h voldat.h

flostv.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h lpdat.h machaf.h \
        machas.h machof.h machos.h machsf.h machss.h mxnfcd.h pumpblk.h \
        statec.h stcblk.h stcom.h ufilef.h ufiles.h voldat.h

fmvlwr.obj: comctl.h machaf.h machas.h machnf.h machns.h machof.h machos.h \
        machsf.h machss.h

ftbmem.obj: fast.h machlf.h machls.h

fwdrag.obj: comctl.h contrl.h debcom.h fast.h htsrcm.h invhtb.h jundat.h \
        lpdat.h lvectr.h machaf.h machas.h machnf.h machns.h scddat.h \
        scrtch.h stcblk.h trnhlp.h ufiles.h voldat.h

gapcon.obj: fast.h gapvar.h htscr.h htsrcm.h

gedry.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h lpdat.h lvectr.h \
        machaf.h machas.h machnf.h machns.h przdat.h separ.h statec.h \
        trnhlp.h ufiles.h voldat.h

gesep.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h lpdat.h lvectr.h \
        machas.h machns.h przdat.h separ.h statec.h trnhlp.h ufiles.h \
        voldat.h
```

```
gesub.obj: contrl.h

gninit.obj: alcm.h axtrns.h balfar.h bconds.h bcs.h blageo.h blinit.h \
        blkage.h bln2wk.h blonab.h bloond.h buntim.h bwcons.h bwgeom.h \
        bwprop.h bwtrns.h cboilx.h cdfinc.h cdfinv.h cmatp.h cmptim.h \
        comctl.h comlst.h cons.h contrl.h cora.h coupl.h cpmdat.h cprdat.h \
        cprops.h cr2.h cvals.h dbacct.h debcom.h debout.h effprp.h eht0.h \
        ehtc0.h farays.h fecom.h fginvc.h fgrcom.h fpbin.h fpcoef.h \
        fpctrl.h fpdkht.h fpinsh.h fplim.h fpmas.h fpmdl.h fpnonv.h \
        fpvol.h ftbfet.h genrl.h grscgr.h grsparg.h grsprg.h hardpn.h \
        hfuson.h hydprp.h intcom.h iocom.h iparm.h iparmm.h k3all.h \
        k3point.h machlf.h machls.h madatc.h matdat.h maxmem.h miscon.h \
        mxnfcd.h nbtim.h ndxara.h nhtara.h noval.h nrcom.h oldcom.h \
        oxcom1.h oxcom2.h oxcom3.h parm.h parmm.h plndat.h prdat.h \
        propts.h ptscom.h radata.h rgacct.h rupt.h scdcom.h scddat.h \
        scdout.h scdpow.h slbcom.h slumpv.h solcom.h speed.h statec.h \
        stcblk.h stmprp.h tblsp.h thplot.h trnot1.h trnot2.h ttpsc.h \
        ufilef.h ufiles.h uoxcom.h uphdpn.h za.h

grdnrj.obj: comctl.h contrl.h fast.h jundat.h voldat.h

helphd.obj: contrl.h fast.h lpdat.h trnhlp.h ufiles.h

hifbub.obj: contrl.h fast.h scrtch.h statec.h voldat.h

hloss.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h lpdat.h lvectr.h \
        machaf.h machas.h machsf.h machss.h scrtch.h statec.h trnhlp.h \
        voldat.h

ht1inp.obj: comctl.h cons.h contrl.h fast.h htsrcm.h machaf.h machas.h \
        machnf.h machns.h machof.h machos.h machsf.h machss.h ufiles.h

ht1sst.obj: comctl.h contrl.h convarc.h fast.h gapvar.h gentblc.h htrcom.h \
        htscr.h htsrcm.h rkinc.h trpblk.h ufiles.h voldat.h

ht1tdp.obj: comctl.h contrl.h convarc.h fast.h fpfast.h gapvar.h gentblc.h \
        htrcom.h htscr.h htsrcm.h machaf.h machas.h machof.h machos.h \
        machsf.h machss.h rkinc.h trnhlp.h trpblk.h ufiles.h voldat.h

ht2tdp.obj: comctl.h contrl.h convarc.h fast.h gentblc.h htrflb.h htscr1.h \
        htscr2.h htsrcm.h machaf.h machas.h machsf.h machss.h radhtc.h \
        rflhtc.h rkinc.h statec.h tmsrcm.h trpblk.h ufiles.h voldat.h

htadv.obj: comctl.h contrl.h fast.h fpfast.h htscr.h htsrcm.h machaf.h \
        machas.h radhtc.h scrtch.h trnhlp.h voldat.h
```

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htcond.obj: comctl.h contrl.h fast.h gentblc.h htrcom.h htscr.h htsrcm.h \
        trpblk.h voldat.h

htcsol.obj: fast.h htrflb.h htscr1.h htscr2.h rflhtc.h

htfilm.obj: comctl.h contrl.h fast.h genrl.h htsrcm.h invhtb.h statec.h \
        stcblk.h stcom.h ufiles.h voldat.h

htfinl.obj: comctl.h contrl.h fast.h htscr.h htsrcm.h machaf.h machas.h \
        scrtch.h trnhlp.h voldat.h

htrc1.obj: contrl.h fast.h htrcom.h machaf.h machas.h machsf.h machss.h \
        stcblk.h stcom.h ufiles.h voldat.h

htrc2.obj: comctl.h fast.h gentblc.h htrcom.h htrflb.h htscr1.h htscr2.h \
        htsrcm.h rflhtc.h trpblk.h voldat.h

htrcn2.obj: contrl.h fast.h htrcom.h htsrcm.h statec.h stcom.h ufiles.h \
        voldat.h

hydro.obj: comctl.h contrl.h fast.h jundat.h lpdat.h lvectr.h machaf.h \
        machas.h scrtch.h statc.h statec.h trnhlp.h tsctlc.h ufiles.h \
        voldat.h

hzflow.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h lpdat.h machaf.h \
        machas.h machnf.h machns.h machof.h machos.h machsf.h machss.h \
        scrtch.h trnhlp.h ufiles.h voldat.h

icmpf.obj: cmpdat.h comctl.h fast.h

icmpn1.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h lpdat.h machaf.h \
        machas.h machof.h machos.h machsf.h machss.h mxnfcd.h pumpblk.h \
        statec.h stcblk.h stcom.h ufilef.h ufiles.h voldat.h

icompn.obj: cmpdac.h cmpdat.h cmpdtv.h comctl.h cons.h contrl.h fast.h \
        gentblc.h jundat.h machaf.h machas.h machnf.h machns.h machof.h \
        machos.h przdat.h pumpblk.h statc.h stcblk.h trpblk.h turbin.h \
        ufiles.h voldat.h

iconvr.obj: cmpdat.h cnvtpa.h cnvtpad.h comctl.h contrl.h convarc.h fast.h \
        gentblc.h machaf.h machas.h machsf.h machss.h pumpblk.h trpblk.h \
        turbin.h ufiles.h

iedit.obj: cmpalf.h cmpdac.h cmpdat.h comctl.h contrl.h fast.h jundat.h \
```

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        lpdat.h machaf.h machas.h machsf.h machss.h przdat.h pumpblk.h \
        trnhlp.h turbin.h ufiles.h voldat.h

ielvtn.obj: comctl.h contrl.h fast.h jundat.h lpdat.h machaf.h machas.h \
        machnf.h machns.h machof.h machos.h machsf.h machss.h ufiles.h \
        voldat.h

igntbl.obj: comctl.h contrl.h fast.h gentblc.h ufiles.h

ihtcmp.obj: comctl.h contrl.h convarc.h fast.h fpfast.h gentblc.h htscr.h \
        htsrcm.h machaf.h machas.h machlf.h machls.h machnf.h machns.h \
        machof.h machos.h machsf.h machss.h mtbls.h rkinc.h scddat.h \
        ufiles.h voldat.h

ijprop.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h machaf.h machas.h \
        machnf.h machns.h machof.h machos.h machsf.h machss.h separ.h \
        statec.h voldat.h

imiedt.obj: comctl.h contrl.h fast.h miedtc.h stcblk.h ufiles.h

imlp.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h lcntrl.h lpdat.h \
        machaf.h machas.h machnf.h machns.h machof.h machos.h mxnfcd.h \
        statec.h stcblk.h sysdatc.h ufiles.h voldat.h

inputd.obj: comctl.h contrl.h fast.h genrl.h machaf.h machas.h machof.h \
        machos.h machsf.h machss.h scddat.h ufiles.h

interi.obj: comctl.h contrl.h fast.h intrac.h machaf.h machas.h npacom.h \
        trnhlp.h ufiles.h

invhts.obj: cmpdat.h comctl.h contrl.h fast.h htsrcm.h invhtb.h ufiles.h \
        voldat.h

invjt.obj: cmpdat.h comctl.h contrl.h fast.h invtbl.h jundat.h machaf.h \
        machas.h machof.h machos.h ufiles.h voldat.h

ipipe.obj: cmpdat.h comctl.h fast.h jundat.h voldat.h

ipump.obj: cmpdat.h comctl.h contrl.h fast.h machaf.h machas.h machnf.h \
        machns.h machof.h machos.h pumpblk.h ufiles.h voldat.h

iradht.obj: comctl.h contrl.h fast.h htsrcm.h radhtc.h ufiles.h voldat.h

irflht.obj: comctl.h contrl.h fast.h htrflb.h htsrcm.h machaf.h machas.h \
        rflhtc.h ufiles.h
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irkin.obj: comctl.h contrl.h convarc.h coupl.h cpmdat.h fast.h gentblc.h \
        htsrcm.h k3all.h k3cc.h k3point.h machaf.h machas.h machlf.h \
        machls.h machnf.h machns.h machof.h machos.h machsf.h machss.h \
        ndxara.h rkinc.h rkincc.h scddat.h scdpow.h trpblk.h ufiles.h \
        voldat.h

isngj.obj: cmp3dt.h cmpdat.h comctl.h contrl.h fast.h jundat.h machaf.h \
        machas.h machnf.h machns.h machof.h machos.h ufiles.h voldat.h

issi.obj: cmpalf.h cmpdat.h cmpdtv.h cnvtpa.h cnvtpad.h comctl.h contrl.h \
        convarc.h fast.h gentblc.h pumpblk.h ssiblk.h stcblk.h trpblk.h \
        turbin.h ufiles.h

istate.obj: cmpdac.h cmpdat.h comctl.h contrl.h fast.h lpdat.h machaf.h \
        machas.h machnf.h machns.h machof.h machos.h machsf.h machss.h \
        mxnfcd.h statec.h stcblk.h stcom.h trnhlp.h trpblk.h ufiles.h \
        voldat.h zalfag.h

itrip.obj: comctl.h contrl.h fast.h machaf.h machas.h machof.h machos.h \
        machsf.h machss.h stcblk.h trpblk.h ufiles.h

itrscn.obj: comctl.h contrl.h fast.h machlf.h machls.h trpblk.h ufiles.h

itstck.obj: comctl.h contrl.h convarc.h fast.h tstpct.h ufiles.h

iusrvr.obj: comctl.h contrl.h fast.h usrvar.h

ivelst.obj: cmpdat.h comctl.h cons.h contrl.h fast.h jundat.h machaf.h \
        machas.h statec.h trpblk.h ufiles.h voldat.h

ivlvel.obj: comctl.h contrl.h fast.h invtbl.h jundat.h machaf.h machas.h \
        machsf.h machss.h statec.h stcom.h ufiles.h voldat.h

jchoke.obj: comctl.h contrl.h fast.h jundat.h lpdat.h machaf.h machas.h \
        machnf.h machns.h machof.h machos.h machsf.h machss.h scrtch.h \
        statec.h stcblk.h stcom.h trnhlp.h ufiles.h voldat.h

jprop.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h lpdat.h lvectr.h \
        machaf.h machas.h machnf.h machns.h przdat.h scrtch.h separ.h \
        statec.h trnhlp.h ufiles.h voldat.h

katokj.obj: comctl.h contrl.h fast.h jundat.h scrtch.h voldat.h

kloss.obj: comctl.h fast.h htsrcm.h invtbl.h jundat.h machaf.h machas.h \
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        voldat.h

level.obj: cmpdat.h comctl.h contrl.h eccmxc.h fast.h invtbl.h jundat.h \
        lpdat.h machaf.h machas.h machnf.h machns.h machof.h machos.h \
        machsf.h machss.h przdat.h scrtch.h statec.h stcblk.h stcom.h \
        trnhlp.h ufiles.h voldat.h

madata.obj: comctl.h contrl.h fast.h gapvar.h htscr.h htsrcm.h mtbls.h \
        ufiles.h

majout.obj: cmpalf.h cmpdac.h cmpdat.h cnvtpa.h cnvtpad.h comctl.h contrl.h \
        convarc.h coupl.h cpmdat.h fast.h fpfast.h genrl.h htrflb.h \
        htsrcm.h jundat.h lpdat.h machaf.h machas.h machsf.h machss.h \
        przdat.h pumpblk.h radhtc.h rflhtc.h rkinc.h rupt.h rvoldt.h \
        scddat.h slumpv.h statc.h statec.h trnhlp.h trpblk.h tstpct.h \
        turbin.h ufiles.h voldat.h

mdata2.obj: comctl.h contrl.h fast.h gapvar.h htrflb.h htscr1.h htscr2.h \
        htsrcm.h machaf.h machas.h machof.h machos.h machsf.h machss.h \
        mtbls.h rflhtc.h trnhlp.h ufiles.h voldat.h

mirec.obj: comctl.h contrl.h fast.h miedtc.h ufiles.h

mover.obj: comctl.h contrl.h fast.h jundat.h lpdat.h lvectr.h machaf.h \
        machas.h machnf.h machns.h machof.h machos.h machsf.h machss.h \
        scddat.h statec.h trnhlp.h voldat.h

ncfilm.obj: comctl.h contrl.h fast.h genrl.h statec.h stcblk.h stcom.h \
        ufiles.h voldat.h

ncprop.obj: comctl.h contrl.h fast.h genrl.h statec.h stcblk.h stcom.h \
        ufiles.h voldat.h

ncwall.obj: comctl.h contrl.h fast.h genrl.h statec.h stcblk.h stcom.h \
        ufiles.h voldat.h

noncnd.obj: comctl.h contrl.h fast.h genrl.h htrcom.h htsrcm.h statec.h \
        stcblk.h stcom.h ufiles.h voldat.h

nonz.obj: bplu1.h

packer.obj: comctl.h contrl.h fast.h invtbl.h jundat.h lpdat.h machaf.h \
        machas.h machsf.h machss.h scrtch.h trnhlp.h ufiles.h voldat.h

pcontrl.obj: comctl.h contrl.h fast.h
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petukv.obj: contrl.h fast.h htrcom.h stcblk.h ufiles.h voldat.h

phantj.obj: cmpdat.h comctl.h contrl.h eccmxc.h fast.h invtbl.h jundat.h \
            lpdat.h machaf.h machas.h machnf.h machns.h machof.h machos.h \
            machsf.h machss.h scrtch.h statec.h stcblk.h stcom.h trnhlp.h \
            ufiles.h voldat.h

phantv.obj: cmpdat.h comctl.h contrl.h eccmxc.h fast.h invtbl.h jundat.h \
            lpdat.h machaf.h machas.h machnf.h machns.h machof.h machos.h \
            machsf.h machss.h przdat.h scrtch.h statec.h stcblk.h stcom.h \
            trnhlp.h ufiles.h voldat.h

pimplt.obj: cmpdac.h cmpdat.h comctl.h contrl.h fast.h jundat.h lpdat.h \
            lvectr.h machaf.h machas.h scrtch.h statec.h stcom.h trnhlp.h \
            ufiles.h voldat.h

pintfc.obj: comctl.h contrl.h fast.h genrl.h htrcom.h htsrcm.h statec.h \
            stcblk.h stcom.h ufiles.h voldat.h

pjundat.obj: comctl.h contrl.h fast.h jundat.h

plpdat.obj: comctl.h contrl.h fast.h lpdat.h

plstrn.obj: ufiles.h

pltrec.obj: comctl.h contrl.h fast.h lpdat.h pltloc.h pltput.h trnhlp.h \
            ufiles.h

pltwrt.obj: cmpdac.h cmpdat.h cmpdtv.h comctl.h contrl.h convarc.h fast.h \
            htsrcm.h jundat.h przdat.h pumpblk.h rkinc.h statc.h trnhlp.h \
            turbin.h usrvar.h voldat.h

prebun.obj: comctl.h contrl.h fast.h htrcom.h statec.h stcblk.h stcom.h \
            ufiles.h voldat.h

prednb.obj: comctl.h contrl.h fast.h htrcom.h statec.h stcblk.h stcom.h \
            ufiles.h voldat.h

preseq.obj: cmpdac.h cmpdat.h comctl.h contrl.h fast.h jundat.h lpdat.h \
            lvectr.h machaf.h machas.h scrtch.h statec.h stcom.h trnhlp.h \
            ufiles.h voldat.h

prntfa.obj: fast.h
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prntia.obj: fast.h

pscrtch.obj: comctl.h contrl.h fast.h jundat.h lpdat.h scrtch.h trnhlp.h \
        voldat.h

pset.obj: fast.h lpdat.h scrtch.h trnhlp.h

pstdnb.obj: comctl.h contrl.h fast.h htrcom.h radhtc.h statec.h stcblk.h \
        stcom.h ufiles.h voldat.h

pump.obj: cmpdat.h comctl.h contrl.h fast.h lpdat.h lvectr.h machaf.h \
        machas.h machof.h machos.h pumpblk.h scrtch.h trnhlp.h trpblk.h \
        ufiles.h voldat.h

pump2.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h machaf.h machas.h \
        machnf.h machns.h machof.h machos.h machsf.h machss.h pumpblk.h \
        ufiles.h voldat.h

pvoldat.obj: comctl.h contrl.h fast.h voldat.h

qfhtrc.obj: comctl.h contrl.h fast.h htrcom.h htrflb.h htscr1.h htscr2.h \
        htsrcm.h machaf.h machas.h machsf.h machss.h rflhtc.h statec.h \
        tmsrcm.h ufiles.h voldat.h

qfmove.obj: comctl.h contrl.h fast.h htrflb.h htscr1.h htscr2.h htsrcm.h \
        machaf.h machas.h machof.h machos.h machsf.h machss.h rflhtc.h \
        statec.h tmsrcm.h trpblk.h ufiles.h voldat.h

qfsrch.obj: comctl.h contrl.h fast.h htrflb.h htsrcm.h rflhtc.h statec.h \
        tmsrcm.h ufiles.h voldat.h

qmwr.obj: comctl.h cons.h fast.h htsrcm.h machaf.h machas.h

r3dcmp.obj: cmp3dt.h cmpdat.h comctl.h contrl.h fast.h jundat.h machaf.h \
        machas.h machof.h machos.h machsf.h machss.h rcompc.h ufiles.h \
        voldat.h

raccum.obj: cmpdac.h cmpdat.h comctl.h cons.h contrl.h fast.h jundat.h \
        machaf.h machas.h machof.h machos.h machsf.h machss.h rcompc.h \
        ufiles.h voldat.h

radht.obj: comctl.h contrl.h fast.h htsrcm.h radhtc.h voldat.h

rbrnch.obj: cmpdat.h comctl.h cons.h contrl.h eccmxc.h fast.h jundat.h \
        machaf.h machas.h machof.h machos.h machsf.h machss.h rcompc.h \
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        separ.h statec.h ufiles.h voldat.h

rcards.obj: comctl.h contrl.h fast.h genrl.h ufiles.h

rcdelt.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h rcompc.h ufiles.h \
        voldat.h

rchng.obj: comctl.h contrl.h fast.h ufiles.h

rcompn.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h machaf.h machas.h \
        machof.h machos.h rcompc.h ufiles.h voldat.h

rconvr.obj: cnvtpa.h cnvtpad.h comctl.h contrl.h convarc.h fast.h machaf.h \
        machas.h machnf.h machns.h machof.h machos.h machsf.h machss.h \
        ufiles.h
rdredt.obj: contrl.h ufiles.h

reedit.obj: contrl.h ufiles.h

relap5.obj: alcm.h balfar.h bconds.h bcons.h bder.h bln2wk.h blonab.h \
        bloond.h bsize.h buntim.h bwcons.h bwgeom.h bwprop.h bwtrns.h \
        cdfinc.h cdfinv.h cmatp.h cmpdac.h cmpdacc.h cmpdat.h cmpdatc.h \
        cmpdtv.h cmpdtvc.h cmptim.h comctl.h comctlc.h cons.h contrl.h \
        contrx.h convarc.h convarx.h coupl.h cpmdat.h cprdat.h dbacct.h \
        dcon.h debcom.h debout.h eccmxc.h eccmxcc.h effprp.h eht0.h \
        ehtc0.h farays.h fast.h fastc.h fecom.h fginvc.h fgrcom.h fpbin.h \
        fpcoef.h fpctrl.h fpfast.h fpfastc.h fpinsc.h fpinsh.h fplim.h \
        fpmas.h fpmdl.h fpnonv.h fpvol.h ftbcom.h ftbfet.h genrl.h \
        genrlc.h gentblc.h gentblx.h grscgr.h grsparg.h grsprg.h hardpn.h \
        hfuson.h htrflb.h htrflbc.h htsrcm.h htsrcmc.h intcom.h intrac.h \
        intracc.h invtbl.h invtblc.h iocom.h iparm.h iparmc.h jundat.h \
        k3all.h k3point.h lcntrl.h lcntrlc.h lpdat.h lpdatc.h machaf.h \
        machas.h madatc.h matdat.h matsrs.h maxmem.h maxmemc.h miedtc.h \
        miedtcl.h miscon.h mtblc.h mtbls.h mxnfcd.h nbtim.h ndxara.h \
        nhtara.h nrcom.h oxcom1.h oxcom2.h oxcom3.h parm.h parmc.h \
        plndat.h prdat.h przdat.h przdatc.h ptscom.h pumpblk.h pumpblx.h \
        pvmvr5.h radata.h radhtc.h radhtcc.h rgacct.h rkinc.h rkincc.h \
        rmadac.h rupt.h scdcom.h scddat.h scddatc.h scdout.h scdpow.h \
        scrtchc.h separ.h separc.h slbcom.h slumpv.h solcom.h sscntr.h \
        sscntrc.h statc.h statcc.h statec.h statecc.h stcblk.h stcblkc.h \
        sysdatc.h sysdatm.h tblsp.h tdpptr.h thplot.h trnhlp.h trnhlpc.h \
        trnot1.h trnot2.h trpblk.h trpblkc.h tsctlcc.h tstpct.h tstpctc.h \
        turbin.h turbinc.h ufilef.h ufiles.h ufilesc.h uoxcom.h vel.h \
        voldat.h voldatc.h
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rgntbl.obj: comctl.h contrl.h fast.h gentblc.h ufiles.h

rhelp.obj: comctl.h contrl.h fast.h ufiles.h

rhtcmp.obj: comctl.h contrl.h fast.h htrflb.h htsrcm.h machaf.h machas.h \
        machnf.h machns.h machof.h machos.h machsf.h machss.h ufiles.h \
        voldat.h

rintrv.obj: comctl.h contrl.h fast.h genrl.h intrac.h machaf.h machas.h \
        machnf.h machns.h machsf.h machss.h ufilef.h ufiles.h

rkin.obj: comctl.h contrl.h convarc.h fast.h gentblc.h htsrcm.h machaf.h \
        machas.h machnf.h machns.h machof.h machos.h machsf.h machss.h \
        rkinc.h rknatb.h trnhlp.h trpblk.h ufiles.h voldat.h

rmadat.obj: comctl.h contrl.h fast.h machlf.h machls.h mtbls.h rmadac.h \
        ufiles.h

rmflds.obj: comctl.h contrl.h fast.h machaf.h machas.h machof.h machos.h \
        machsf.h machss.h mxnfcd.h sysdatc.h ufiles.h

rmiedt.obj: comctl.h contrl.h fast.h machof.h machos.h miedtc.h ufiles.h

rmtplj.obj: cmpdat.h comctl.h cons.h contrl.h fast.h jundat.h machaf.h \
        machas.h machof.h machos.h machsf.h machss.h rcompc.h statec.h \
        ufiles.h voldat.h

rnewp.obj: comctl.h contrl.h coupl.h cpmdat.h fast.h machaf.h machas.h \
        machof.h machos.h machsf.h machss.h scddat.h ufiles.h

rnoncn.obj: comctl.h contrl.h fast.h scddat.h statec.h ufiles.h

rpipe.obj: cmpdat.h comctl.h cons.h contrl.h fast.h jundat.h machaf.h \
        machas.h machof.h machos.h machsf.h machss.h przdat.h rcompc.h \
        statec.h ufiles.h voldat.h

rpmpdc.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h machof.h machos.h \
        machsf.h machss.h pumpblk.h ufiles.h voldat.h

rpmpmd.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h pumpblk.h ufiles.h \
        voldat.h

rpmvnj.obj: cmpdat.h comctl.h cons.h contrl.h fast.h jundat.h machaf.h \
        machas.h machof.h machos.h machsf.h machss.h pumpblk.h rcompc.h \
        statec.h ufiles.h voldat.h
```

```
rpump.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h machaf.h machas.h \
        machof.h machos.h pumpblk.h rcompc.h ufiles.h voldat.h

rradht.obj: comctl.h contrl.h fast.h htsrcm.h machaf.h machas.h machlf.h \
        machls.h machof.h machos.h radhtc.h ufiles.h

rrestf.obj: comctl.h contrl.h fast.h genrl.h machaf.h machas.h machlf.h \
        machls.h machnf.h machns.h machof.h machos.h machsf.h machss.h \
        maxmem.h ufilef.h ufiles.h


rrkin.obj: comctl.h contrl.h fast.h k3all.h k3point.h machof.h machos.h \
        machsf.h machss.h rkinc.h rknatb.h rrkinc.h ufiles.h

rrkinh.obj: contrl.h fast.h machaf.h machas.h rkinc.h rrkinc.h ufiles.h

rrkinp.obj: comctl.h contrl.h fast.h machaf.h machas.h machsf.h machss.h \
        rkinc.h rrkinc.h ufiles.h

rrstd.obj: comctl.h contrl.h fast.h genrl.h machof.h machos.h machsf.h \
        machss.h ufilef.h ufiles.h

rsngj.obj: cmpdat.h comctl.h cons.h contrl.h fast.h jundat.h machaf.h \
        machas.h machof.h machos.h machsf.h machss.h rcompc.h statec.h \
        ufiles.h voldat.h

rsngv.obj: cmpdat.h comctl.h cons.h contrl.h fast.h jundat.h machaf.h \
        machas.h machof.h machos.h machsf.h machss.h rcompc.h ufiles.h \
        voldat.h

rssi.obj: comctl.h contrl.h fast.h ssiblk.h ufiles.h

rstrec.obj: comctl.h contrl.h fast.h genrl.h lpdat.h machaf.h machas.h \
        machlf.h machls.h machnf.h machns.h machsf.h machss.h trnhlp.h \
        ufiles.h

rstrip.obj: comctl.h contrl.h fast.h ufiles.h

rtmdj.obj: cmpdat.h comctl.h cons.h contrl.h fast.h jundat.h rcompc.h \
        ufiles.h voldat.h

rtmdv.obj: cmpdat.h comctl.h cons.h contrl.h fast.h jundat.h machaf.h \
        machas.h machof.h machos.h machsf.h machss.h rcompc.h ufiles.h \
        voldat.h
```

```
rtrip.obj: comctl.h contrl.h fast.h machaf.h machas.h machof.h machos.h \
        machsf.h machss.h trpblk.h ufiles.h

rtsc.obj: comctl.h contrl.h fast.h machof.h machos.h machsf.h machss.h \
        tstpct.h ufiles.h

rturb.obj: cmpdat.h comctl.h cons.h contrl.h fast.h jundat.h machaf.h \
        machas.h machof.h machos.h machsf.h machss.h rcompc.h turbin.h \
        ufiles.h voldat.h

rusrvr.obj: comctl.h contrl.h fast.h machof.h machos.h ufiles.h usrvar.h

rvalve.obj: cmpdat.h cmpdtv.h comctl.h cons.h contrl.h fast.h jundat.h \
        machaf.h machas.h machof.h machos.h machsf.h machss.h rcompc.h \
        statec.h ufiles.h voldat.h

scnreq.obj: alcm.h buntim.h cmpdac.h cmpdat.h cmpdtv.h cnvtpa.h cnvtpad.h \
        comctl.h contrl.h convarc.h coupl.h cpmdat.h debout.h fast.h \
        fpfast.h hardpn.h htrflb.h htsrcm.h intcom.h intrac.h iparm.h \
        jundat.h k3all.h k3point.h lpdat.h machaf.h machas.h machlf.h \
        machls.h miscon.h ndxara.h plndat.h przdat.h pumpblk.h rkinc.h \
        rupt.h rvoldt.h scdcom.h scddat.h scdout.h separ.h slumpv.h \
        statc.h tblsp.h thplot.h turbin.h ufiles.h voldat.h vreqd.h \
        vreqs.h

simplt.obj: cmpdac.h cmpdat.h comctl.h contrl.h fast.h jundat.h lpdat.h \
        machaf.h machas.h machof.h machos.h scrtch.h statec.h stcom.h \
        trnhlp.h tsctlc.h ufiles.h voldat.h

simul.obj: ufiles.h

srestf.obj: comctl.h contrl.h fast.h genrl.h ufilef.h ufiles.h

sstchk.obj: comctl.h contrl.h fast.h machaf.h machas.h sscntr.h trnhlp.h \
        ufiles.h voldat.h

stacc.obj: cmpdac.h cmpdat.h comctl.h contrl.h fast.h jundat.h lpdat.h \
        lvectr.h machaf.h machas.h machnf.h machns.h machof.h machos.h \
        statec.h stcblk.h stcom.h trnhlp.h ufiles.h voldat.h

state.obj: cmpdac.h cmpdat.h comctl.h contrl.h fast.h invtbl.h jundat.h \
        lpdat.h lvectr.h machaf.h machas.h machof.h machos.h scrtch.h \
        statec.h trnhlp.h tsctlc.h ufiles.h voldat.h
```

```
statep.obj: comctl.h contrl.h fast.h lpdat.h lvectr.h machaf.h machas.h \
        machof.h machos.h mxnfcd.h scddat.h scrtch.h statec.h stcblk.h \
        stcom.h trnhlp.h ufiles.h voldat.h

stcset.obj: comctl.h fast.h stcblk.h stcom.h

std2x1.obj: machsf.h machss.h

std2x3.obj: machsf.h machss.h

std2x6.obj: machsf.h machss.h

stdry.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h lpdat.h lvectr.h \
        machaf.h machas.h machnf.h machns.h przdat.h scrtch.h separ.h \
        statec.h trnhlp.h ufiles.h voldat.h

stdsp.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h lpdat.h lvectr.h \
        machaf.h machas.h machnf.h machns.h przdat.h separ.h statec.h \
        trnhlp.h ufiles.h voldat.h

stgodu.obj: cmpdat.h comctl.h contrl.h fast.h invtbl.h jundat.h lpdat.h \
        lvectr.h machaf.h machas.h machof.h machos.h scrtch.h statec.h \
        stcom.h trnhlp.h tsctlc.h ufiles.h voldat.h

stread.obj: stcom.h

strip.obj: comctl.h contrl.h fast.h machaf.h machas.h machnf.h machns.h \
        machof.h machos.h machsf.h machss.h maxmem.h ufiles.h

strpu.obj: machsf.h machss.h stcom.h

strpx.obj: stcom.h

strsat.obj: stcom.h

strtp.obj: machsf.h machss.h stcom.h

strx.obj: machsf.h machss.h stcom.h

stvrpx.obj: comctl.h fast.h machaf.h machas.h machof.h machos.h machsf.h \
        machss.h scrtch.h stcom.h trnhlp.h voldat.h

suboil.obj: contrl.h fast.h htrcom.h machaf.h machas.h machsf.h machss.h \
        stcblk.h stcom.h ufiles.h voldat.h
```

```
svh2x2.obj: fast.h machaf.h machas.h machof.h machos.h machsf.h machss.h \
        scrtch.h trnhlp.h voldat.h

sysitr.obj: comctl.h contrl.h fast.h jundat.h lpdat.h machaf.h machas.h \
        scrtch.h trnhlp.h ufiles.h voldat.h

syssol.obj: bplu1.h comctl.h contrl.h fast.h jundat.h lpdat.h scrtch.h \
        trnhlp.h ufiles.h voldat.h

tcnvsl.obj: comctl.h convarc.h fast.h gentblc.h

tfront.obj: cmpdat.h comctl.h contrl.h eccmxc.h fast.h invtbl.h jundat.h \
        lpdat.h machaf.h machas.h machnf.h machns.h machof.h machos.h \
        machsf.h machss.h przdat.h scrtch.h statec.h stcblk.h stcom.h \
        trnhlp.h ufiles.h voldat.h

tran.obj: comctl.h contrl.h fast.h machaf.h machas.h pvmvr5.h scddat.h \
        scrtch.h trnhlp.h ufiles.h voldat.h

trip.obj: comctl.h contrl.h fast.h machaf.h machas.h machsf.h machss.h \
        trpblk.h

trnctl.obj: contrl.h

trnfin.obj: comctl.h contrl.h fast.h intrac.h maxmem.h ufiles.h

trnset.obj: cmp3dt.h cmpdac.h cmpdat.h cmpdtv.h comctl.h contrl.h coupl.h \
        cpmdat.h fast.h fpfast.h gentblc.h htrflb.h htscr.h htsrcm.h \
        intrac.h invhtb.h invtbl.h iparm.h jundat.h k3point.h lcntrl.h \
        lpdat.h lvectr.h machaf.h machas.h machnf.h machns.h machof.h \
        machos.h miedtc.h pltloc.h przdat.h pumpblk.h radhtc.h rflhtc.h \
        rkinc.h scddat.h scrtch.h sscntr.h stcblk.h tdpptr.h trnhlp.h \
        trpblk.h tstpct.h turbin.h ufiles.h usrvar.h voldat.h

tsetsl.obj: bplu1.h cmp3dt.h cmpdat.h comctl.h contrl.h fast.h intrac.h \
        invtbl.h jundat.h lpdat.h lvectr.h machaf.h machas.h rflhtc.h \
        scrtch.h statec.h temp3d.h trnhlp.h tstpct.h ufiles.h voldat.h

tstate.obj: cmpdat.h comctl.h contrl.h fast.h jundat.h machaf.h machas.h \
        machof.h machos.h mxnfcd.h statec.h stcblk.h stcom.h tdpptr.h \
        trpblk.h ufiles.h voldat.h zalfag.h

turbst.obj: cmpdat.h comctl.h fast.h jundat.h lpdat.h lvectr.h machsf.h \
        machss.h trnhlp.h turbin.h voldat.h
```

valve.obj: cmpdat.h cmpdtv.h comctl.h cons.h contrl.h fast.h gentblc.h \
jundat.h lpdat.h lvectr.h machaf.h machas.h machnf.h machns.h \
machof.h machos.h stcom.h trnhlp.h trpblk.h ufiles.h voldat.h

vexplt.obj: cmpdac.h cmpdat.h comctl.h contrl.h eccmxc.h fast.h jundat.h \
lpdat.h lvectr.h machaf.h machas.h machof.h machos.h machsf.h \
machss.h pumpblk.h scrtch.h statec.h stcblk.h stcom.h trnhlp.h \
turbin.h ufiles.h voldat.h

vfinl.obj: comctl.h contrl.h fast.h jundat.h lpdat.h machaf.h machas.h \
scrtch.h statec.h trnhlp.h ufiles.h voldat.h

vimplt.obj: cmp3dt.h cmpdac.h cmpdat.h comctl.h contrl.h eccmxc.h fast.h \
invtbl.h jundat.h lpdat.h lvectr.h machaf.h machas.h machof.h \
machos.h pumpblk.h scrtch.h statec.h stcom.h trnhlp.h turbin.h \
ufiles.h voldat.h

viscos.obj: ufiles.h

vlvela.obj: comctl.h contrl.h fast.h invtbl.h jundat.h lpdat.h lvectr.h \
machaf.h machas.h scrtch.h statec.h stcom.h trnhlp.h ufiles.h \
voldat.h

volvel.obj: comctl.h contrl.h fast.h invtbl.h jundat.h lpdat.h lvectr.h \
machaf.h machas.h machsf.h machss.h scrtch.h statec.h trnhlp.h \
ufiles.h voldat.h

wrplid.obj: cmpdat.h cmpdtv.h comctl.h contrl.h convarc.h fast.h htsrcm.h \
jundat.h machaf.h machas.h machnf.h machns.h ufiles.h usrvar.h \
voldat.h vreqd.h vreqs.h

zfslgj.obj: comctl.h contrl.h fast.h jun

Appendix D. Guides for Installation of RELAP5/MOD3.2 PC Version

Requirements

1. Lahey Fortran F77L3 or LF90
2. Free Disk Space More Than 30 MB (For Execution, More Than 50 MB)
3. IBM Compatible Personal Computer with CPUs of 486 or Pentium
4. Memory Space More Than 8 MB

Procedure

1. Make directories in which you want to have RELAP5 executables (e.g. c:\relap5) and copy the files in DISK 1 into the directories;

```
mkdir c:\relap5              (make RELAP5 home directory)
cd c:\relap5
copy a:\*.exe                (two files, tar.exe and gzip.exe, are copied for uncompressing)
mkdir selap                  (make subdirectories, sources and environment)
mkdir envrl
cd selap
copy a:\selap.taz            (copy a compressed source file)
cd c:\relap5\envrl
copy a:\envrl.taz            (copy a compressed library file)
```

2. Uncompress two source files

```
c:\relap5\gzip -d envrl.taz  (uncompress environmental library files)
cd c:\relap5\selap
c:\relap5\gzip -d selap.taz  (uncompress source files)
```

3. Conversion of tar format files

```
cd c:\relap5\envrl
c:\relap5\tar -xvf envrl.tar  (environmental library files and makefile generated)
cd c:\relap5\selap
c:\relap5\tar -xvf selap.tar  (source files and makefile generated)
```

4. Compilation and Linking under Lahey Fortran

```
cd c:\relap5\envrl
make                         (compile environmental library)
cd c:\relap5\selap
make                         (compile and link to RELAP5 executable)
```

5. Steam Table Generation

```
cd c:\relap5\envrl
f77l3 stgh2o.for             (compile steam table generation program)
386link stgh2o.obj -exe stgh2o.exe -lib c:\relap5\envrl\envrl.lib   (link)
stgh2o < stgh2o.i > stgh2o.pr   (run program and generate tpfh2o file)
```

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J. Uhle, NRC Project Manager

11. ABSTRACT *(200 words or less)*

RELAP5/MOD3.2 has been installed on Intel Chip based personal computers at KNFC. This report is to present the installation procedures and test results for CPU time comparison and installation verification. Installation of RELAP5/MOD3.2 on PC has been done using Lahey Fortran F77L3 compiler under Windows 95 environment. The "dinstls" script with proper modifications was used to extract the source for conversion and then several modifications were done for installation on PC. Compilation and linking has been done using a MAKE utility and generation of TPFH2O has been done also. Four test cases were used to verify the conversion and installation of RELAP5/MOD3.2 on PC. CPU time benchmark calculation was also done. The results show that the use of PC version could be an option for the users based on the availability of hardware and the speed of the CPU.

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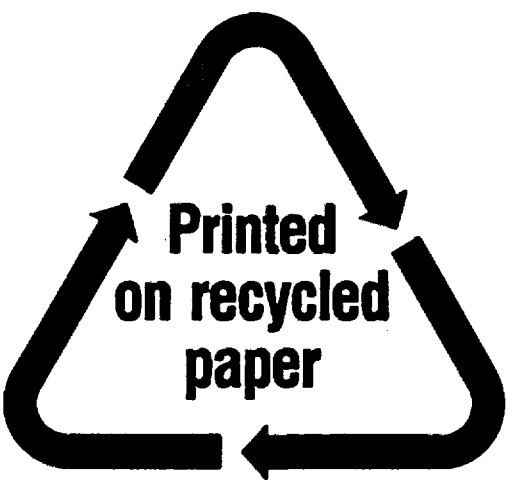

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