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Assessment of RELAP5/MOD3.2 Against a Main Steam Isolation Valve Closure at TRILLO I Nuclear Power Plant

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EXECUTIVE SUMMARY

This report represents an assessment calculation carried out by Empresarios Agrupados, for the Relap 5/Mod 3.2 code with respect to a main steam isolation valve closure at Trillo I NPP.

Trillo I is a PWR nuclear power plant designed by KWU-Siemens, FRG. It came into operation in 1988.

Trillo I NPP has a nominal thermal reactor power of 3010 MWt and three cooling loops. The steam generators are U-tube (4086) type with a pre-heater. The rated generator output is 1040 MWe.

The code was installed on a Silicon Graphics Onyx workstation at EA, and a post-test calculation on it has been carried out.

The Trillo I model developed by EA with the Relap 5/Mod 3.2 consists of 273 control volumes, 297 junctions, 101 heat structures and 252 control variables.

It can be concluded from this transient study that a reasonable agreement exists between the calculation results and the data obtained during the test (D-100-306).

ABSTRACT

This report includes an assessment of RELAP5/MOD3.2 against a main steam line isolation at 99% power in Trillo I NPP (PWR, KWU-Siemens, 1040 MWe).

The results used are those obtained during test D-100-306 (Ref. 3), performed August 19, 1988 at Trillo I NPP.

The three plant cooling loops are simulated to take into account:

i. A single loop containing a valve in which the disturbance occurs

ii. The remaining two loops are simulated using two separate model loops

The Trillo I model used comprises 273 control volumes, 297 junctions, 101 heat structures and 252 control variables.

From this study it can be concluded that the post-test calculation shows a reasonable agreement with the actual plant data.

1. INTRODUCTION

Empresarios Agrupados, as a participant in the CAMP España Project, has developed a model for Trillo NPP (PWR, KWU-Siemens, 1040 MWe). The main objective of this study is to use this model to analyse the transient caused by closure of one of the main steam line isolation valves at Trillo I NPP with the Relap 5/ Mod 3.2 code (Ref 1) installed on a Silicon Graphics Onyx workstation

The results used are those obtained during test D-100-306 (Ref. 3), performed August 19, 1988 at Trillo I NPP. Table 2 gives a description of the main variables recorded during the test and their corresponding denomination.

In this study, the above test results are compared with those obtained with the model developed with the Relap 5/Mod 3.2 code. It can be seen that the two sets of results largely agree.

This study comprises the following steps:

- Plant modelling
- Steady state calculations
- Transient calculations
- Comparison with actual plant data

2. DESCRIPTION OF PLANT AND TRANSIENT

2.1 PLANT DESCRIPTION

Trillo I nuclear power plant is a PWR design, designed by KWU-Siemens, FRG. It came into operation in 1988. It has a thermal reactor power of 3010 MWt.

The reactor coolant system (RCS) consists of a reactor and three closed reactor cooling loops, connected in parallel to the reactor vessel. Each loop has a coolant pump and a steam generator. The RCS also has a pressuriser that heats the coolant electrically.

The coolant (demineralised water at high pressure) circulates through the reactor core to remove the heat generated by the nuclear reaction. The heated coolant passes from the reactor vessel through the coolant loop pipe (*hot leg*) to the steam generators. Here, it releases its heat in a heat exchanger to generate the steam that goes to the turboalternator in the so-called "*secondary circuit*" of the thermal cycle. The cycle is completed when the coolant is pumped back to the reactor vessel through the so-called *cold leg*.

The coolant pumps are vertical, electric motor powered, single piece, centrifuge type. The power supply to the pumps is designed to maintain sufficient flow to cool the reactor under all circumstances.

The steam generators are vertical with 4086 U-tube units (incoloy material) in order to separate the reactor coolant from feedwater-steam circuit.

The pressuriser is electrically heated and connected to one of the reactor coolant loops by the surge line and maintains the pressure in the RCS in normal operating conditions and controls pressure variations during plant transients and maintains system pressure within design limits in upset conditions.

The thermohydraulic design of the RCS prevents nucleate boiling limit being reached in the fuel assemblies, and ensures that the steam generator size and reactor coolant pump (RCP) power are optimum.

The reactor core arranged in the reactor pressure vessel is the power station's nuclear heat source.

The area of the core where fission occurs consists of an array of closely arranged identical fuel assemblies which contain the nuclear fuel. The water of the reactor coolant system circulates around the assemblies to moderate the reaction and remove heat.

To control the nuclear reaction, part of each fuel assembly contains neutron-absorbing control rods which are moved axially by electro-magnetic drive units.

During reactor trip, the fuel rod assemblies fall by gravity.

Table 1 summarises the main characteristic data for Trillo I NPP.

2.2 TRANSIENT DESCRIPTION

The reference transient analysed in this report ("Main Steam Isolation Valve Closure") was carried out at Trillo I NPP in August 1988, as part of the hot operational test programme. The starting situation of the plant, before carrying out the test, was steady state at 99% power, with all control systems operating correctly in automatic mode.

The plant logic for this type of transient is to cool the plant to a certain ratio (100 K/h) by opening a relief valve in the isolated generator, until the secondary pressure reaches 74 bar, at which point a new steady state (partial shutdown) is established. To minimise releases to the atmosphere as much as possible, a condenser bypass is also used.

The transient began at 17:36:44, starting with manual closure of the main steam isolation valve of generator No. 3 (RA03-S001).

The steam flow and the level in the isolated generator decreased rapidly. The pressure in this generator increased to reach 85 bar, generating reactor protection signals YZ11 and YZ16. These signals caused reactor and turbine trip, respectively, 9 seconds after the transient began.

The main steam relief valve of the isolated generator began to open as the pressure reached 85 bar. In spite of this, the pressure in the isolated generator continued to rise until it reached the set point for the safety valve (87.3 bar), 10.3 seconds after the start of the transient, causing it to open. This limited the pressure rise in the generator to a maximum of 88.7 bar, at which point the pressure began to fall again.

The safety valve of the isolated generator closed when the pressure in it dropped to 82.5 bar.

The level in the isolated generator began to decrease as soon as the isolating valve was closed. At 13 seconds after the start of the transient the level reached 10.2 m, at which moment the order was sent automatically to start the pumps of the RR System (startup/shutdown) to make up the level in the generator.

Unlike generator 3, after isolation, pressure in the intact generators dropped as a consequence of the increased flow of main steam required from the two generators, as the turbine continued demanding full load.

This depressurisation of the intact generators caused the level in them to increase by approximately 0.3 m.

Steam pressure in the header dropped from the start of the transient, to a minimum of 61 bar. As a consequence of reactor and turbine trip, pressure in the intact generators recovered until it reached the set-point of the condenser bypass (80.4 bar). The condenser steam-dump stabilised the pressure in the header to 80.4 bar.

The relief control valve of the isolated generator was used to cool the reactor to 100 K/h, bringing the plant to hot standby, until pressure in the secondary reached 74 bar.

As regards the behaviour of the primary circuit, after the main steam isolation valve closed, pressuriser level rose by 10 cm to reach a maximum value of 7.51 m; coolant pressure rose to 157.62 bar and reactor power varied insignificantly until trip occurred. Power then fell rapidly to decay power, mean temperature fell from 308.6°C to 296°C, which is zero load value, causing pressuriser level to reach 4.2 m.

With partial shutdown, caused by the isolated generator relief regulation valve, due to the thermal coupling between the primary and the secondary, the mean temperature fell to 292.7°C; pressuriser level reached 3.57 m; coolant pressure reached 138.8 bar.

3. CODE INPUT MODEL DESCRIPTION

A simplified diagram of the of the developed model is given in Figure 1. In general terms, this model contains the following main parameters:

Control volumes	273
Junctions	297
Heat structures	101
Mesh point structure heat	667
Control variables	252
Total system volume	1082 m^3
Total system mass	375 388 kg
Trip number	101

3.1 PRIMARY CIRCUIT

3.1.1 Reactor Pressure Vessel (RPV)

The reactor is represented using 200-series components. The core, the downcomer and the bypass of the RPV are subdivided into nodes of uniform axial height. The core is divided into two parallel channels, each with eight axial cells. Cross-flow is allowed between channels.

Radial subdivision of the core is resolved as one internal channel and another around it.

From the point of view of heat structures, the axial power distribution is similar in both channels, so that each one generates 50% of the real power.

3.1.2 Coolant Loops

The model considers the three coolant loops of the primary circuit.

Loop 1: 700-series components
Loop 2: 400-series components
Loop 3: 300-series components

The pressuriser and the surge line (500-series components) are connected to loop 1. The volume control system extraction is taken from Loop 2 (tmdpjun 457).

The injection to the volume control system (tmdpjun 772, 472 and 372) and the additional borate system (tmdpjun 777, 477 and 377) are connected to each loop.

Apart from the connections to the different auxiliary systems of the primary, the three coolant loops of the primary circuit are identical. For these loops, the pipes, the three primary coolant pumps (RCPs), pump (components 365, 465 and 765), and the U-tubes for each steam generator (components 340, 440 and 740) are modelled. The U-tubes of the SG are modelled as 6 axial nodes.

The pressuriser is constructed of vertical volumes (components 510, 520, 530, 535 and 540). The relief valve YP10-S102 (component 575) and the two safety valves YP10-S191/192 (components 576 and 577) are connected to the top of component 535 to take into account its level in the pressuriser. The spray lines (component 552 for the loop spray, 557 for the volume control spray and 559 for the borate addition system) are connected to the top of the pressuriser (component 540).

3.2 SECONDARY CIRCUIT

The secondary circuit considered in the model consists basically of three steam generators (600, 800 and 900 series components), the main steam lines (100-series components), up to the condenser and the turbine. The turbine stop and control valves are modelled with valve component 122. The train of valves to the condenser is modelled with valve component 119. The turbine and the condenser are not modelled explicitly, but are represented by time-dependent control volumes. The safety and the relief valves for each loop are also modelled (valve components 106, 131 and 165 for the relief valves and valve components 104, 129 and 163 for safety valves). Components 105, 107, 130, 132, 169 and 166 represent the atmosphere. The main steam isolation valves are represented by components 110, 135 and 170.

The part corresponding to the feedwater system at the different generators is considered from the feedwater tank (tmdpvol 60) up to the generator connecting pipes (sngljun 90, 96 and 72). The heater train is modelled with pipe component 63. From the rise to the heater train, the system splits into the corresponding three feedwater loops. The full load feedwater control valves are represented with valve components 51, 90 and 66 (RL21/22/23-S002). These valves are controlled by control variables 949, 925 and 914 respectively. The low load control valves are modelled with components 20, 30 and 40 (RL21/22/23-S013). The associated control variables are 950, 926 and 915 respectively.

The main and auxiliary feedwater pumps (RL and RR) are modelled as a time dependent junction (tmpdpjun 61).

3.3 CONTROL SYSTEM

In the model, the control systems and most significant limitations of the plant are simulated using the code's control block. The following controls are modelled:

3.3.1 Primary Circuit

- **Primary mean temperature control**

  This control maintains the temperature in the primary in accordance with the load diagram, in operating situations that could cause (relatively small) non-equilibrium between the power generated in the reactor and that extracted in the generator, which would basically cause a temperature rise. The system regulates the insertion of banks and/or the lowering of the control rods to bring the mean temperature back to normal

- **Control of reactor control rods**

  This control maintains the core reactivity inventory during power operation and shutdown

- **Coolant pressure control**

  This system controls variations in coolant pressure. It includes activation of the sprays, electric heaters and relief and safety valves of the pressuriser

- **Control of pressuriser level**

  This control maintains coolant level by controlling the Volume Injection & Extraction System. The pressuriser reference level is established as a function of the inlet reactor temperature and the temperature rise through the core

3.3.2 Secondary Circuit

- **Steam Generator level control**

  This control maintains the water inventory in the steam generators to ensure production of saturated steam. The level program is constant at any power and the set-point only changes during certain events (eg, tube break). It acts on the full and low load control valves of the feedwater system. The level control takes account of the following variables: feedwater and steam flows to the generator, water level in the generator, and power level

- **Cooldown to 100 K/h control**

  This control system acts on the secondary system relief valves in order to cool the primary system with a gradient of 100 K/h. Therefore, the 100 K/h shutdown valve (secondary relief valve) is simulated, and the discharge of this valve is modelled as tmdpvol, for each cooling loop

- **Control of Secondary System Maximum Pressure**

  This system limits the pressure rise in the secondary system to prevent continued actuation of relief and safety valves.When the main steam pressure rises above its setpoint value the bypass valves open to the condenser, which allow the pressure to be maintained below a specified value

  The operational setpoint of the main steam header pressure is 3 bar above the actual main steam pressure and varies as a function of the output in accordance with the part-load diagram. Variation is performed as a function of the pressure in the main steam header, and it is restricted at the low-load end to a maximum of 80.4 bar

- **Control of Minimum Pressure in Secondary System**

  This system limits main steam pressure drop in the secondary system. When main steam pressure drops below the setpoint minimum, the turbine control valve is actuated to maintain the steam pressure at an adequate value

  The operational setpoint of the main steam header pressure is 3 bar below the actual main steam pressure and varies as a function of the output in accordance with the part-load diagram.

4. STEADY STATE CALCULATION

The steady state of the plant at 99% power was calculated using the null transient method. The model was run for 300 seconds to ensure stabilisation of all model variables.

Table 2 compares the values obtained with the model and those from the test records before the transient began.

5. RESULTS

This section describes the plant-model behaviour and the progress of the transient, using the RELAP5/MOD3.2 code. The plant data and records used are therefore those for the conditions before starting the test and are obtained from Ref 3.

The plant records were quoted as percentages, so it has been necessary to process them to be able to compare them with the results obtained with the RELAP5/MOD3.2 code.

The initial boundary conditions in the model, and the control numbers required by Trillo I NPP are obtained from available project documentation

The situation at the start of the transient is a stationary state calculated beforehand. Its main parameters are shown in Table 2, together with a comparison with plant records at the start of the test.

5.1 SECONDARY SYSTEM

The transient is started at t=0 seconds, closing the main steam isolating valve of generator 3 (trip 430). The isolating valve is represented by component valve 110, and closes linearly in two seconds.

Isolation of generator 3 causes an increase in pressure and a drop in main steam flow. As a consequence, the level of this generator decreases, too.

The drop in main steam flow in generator 3 switches trip 683 to true at 6.5 s, generating an order to open the low load feed valve (valve 040) and a signal to close to the full load feed valve (valve 066).

When trip 683 occurs, the level control in generator 3 (control variable 958) switches to being controlled by the low load valve, which is limited to only opening 57% (to prevent uncontrolled fill-ups).

The pressure in this generator reaches 85 bar at t=10.1 s (trip 415). As a result, three signals are generated:

- Reactor trip signal (trip 716)
- Turbine trip signal (trip 716)

- Open relief and relief control valve signal (trip 680). The relief control valve is modelled with valve component 106. Control variable 658 models its control parameters. This valve serves to cool to a ratio of 100 K/h.

Pressure in generator 3 continues to rise, to reach 87.3 bar (trip 511) at *t*=11.5 s. At this point, the mains steam safety valve opens, modelled as valve 104 and controlled by variable 109. This valve stays open until the pressure in generator 3 falls back to below 82.3 bar (trip 512) and closes fully at *t*=15 s

The level in generator 3 (control variable 958) reaches 10.2 m at *t*=13 s, generating an order to start the startup/shutdown system pumps. When the generator 3 safety valve closes, its relief control valve cools temperature down to 100 K/h, to reach 74 bar at *t*=300 s

As the isolation valve of generator 3 finishes closing, the other two generators increase their flow demand (the turbine follows the power control) until the pressure in the collector falls below 63 bar, causing low pressure control in the turbine.

When reactor and turbine trip occurs, pressure increases in the steam header until it reaches 80.4 bar (trip 598) at *t*=17.35 s, when the condenser bypass valves (represented by valve component 119 and control variable 937) open. These valves stay open until the pressure in the steam header falls back to their setpoint values (80.4 bar). In the model, this event occurs at *t*=148 s. From that moment, the plant is cooled through the relief valve of generator 3.

At *t*=300 s, the plant reaches a new steady state, corresponding to hot standby.

5.2 PRIMARY SYSTEM

Events in the primary circuit after isolation of generator 3 are as follows: Immediately after the isolation valve of generator 3 closes, the primary circuit heats up; the level in the pressuriser (control variable 510) increases to 7.5 m, and coolant pressure reaches 159.5 and mean temperature in the primary increases to 309.45 °C.

As a consequence of the reactor trip, the above-mentioned control variables for the primary fall immediately, and pressure in the primary falls to approximately 8 bar; mean temperature falls by about 5°C, and pressuriser level (due to coolant density reduction) falls by half a meter from its maximum level.

After this, the behaviour of the primary depends on the thermal coupling that is established with the secondary circuit. This means that the average coolant temperature also follows the cooling ratio to 100 K/h. Mean temperature reaches 292.4°C, pressuriser level 3.84 m, and coolant pressure stays at 138.5 bar once the partial shutdown is over (300 s into transient).

6. COMPARISON OF RESULTS

This section gives a qualitative and quantitative comparison of the data recorded in the real test in the plant and the predictions obtained with the RELAP5 model.

Table 3 shows a comparison over time of the sequence of events recorded in the test and those predicted by the model.

6.1 PRIMARY SYSTEM

Figure 2 shows both the recorded signal YR50-P401 and the model variable p 540 01 0000 representing the pressure in the pressuriser. The figure shows that the prediction fits satisfactorily with the data recorded in the plant. In general, the estimated pressure follows the same trend as the measurements. The maximum error between the prediction and real data is calculated as less than 4%. Taking into account the errors inherent in the measuring apparatus and the user-effect, this value is considered acceptable.

Figure 3 shows a comparison between the average coolant temperature recorded in the test (YT10-T101) and corresponding one in the model, control variable 606. As with pressure, there is a good agreement between both values. The maximum error between the two parameters is less than 0.7% throughout the analysis. This temperature error could be caused by a slight difference in the residual heat in the fuel.

Figure 4 shows a comparison between the record of the level in the pressuriser (YR71-L401) and model control variable 510. Overall, the trend is similar with both values. The maximum error between them is about 7%. This is due to the higher mean temperature predicted by the model.

6.2 SECONDARY SYSTEM

Figures 5, 6 and 7 show a comparison between the pressure recorded in each of the three steam generators (YB10/20/30-P951) together with the model's associated variables.

There is a good agreement between the values given by the code and those recorded in the plant. The maximum error is less than 3% in the isolated generator, and less than 1% in the intact generators.

Figures 8, 9 and 10 show the levels recorded in the steam generators (YB10/20/30-L951) together with the corresponding control variables of the model (960, 959 and 958). Overall, there is a good agreement between the levels. Although there are slight differences, the recorded and calculated values do generally agree. The maximum error between them is 4%, which is acceptable considering that the variable calculated by the code is collapsed level and the recorded level is calculated as differential pressure.

Figures 11, 12 and 13 show the variation in steam flow from the generators both recorded in the test (RA01/02/03-F901) and the model variables (mflowj 160, 124 and 100). There is a reasonable similarity between the measured and the calculated values.

The behaviour of the relief and safety valves is shown in figures 14 and 15. Control variable 658 shows the position of the relief valve RA03-S005 of the isolated generator, with control variable 109 representing the position of safety valve RA03-S002 of the same generator. There is good agreement between these two calculated values and those recorded in the test.

7. RUN STATISTICS

The calculation has been performed using the RELAP5/MOD3.2 code, running on ONYX (Silicon Graphics) YP25 1CPU Work-Station.

The main characteristics of the hardware are the following:

- Control processor MIPS-R10000
- Clock frequency 194 MHz
- Performance

MIPS	1000
MFLOPS	400
SPECint92	300
SPECfp92	600

- Main memory 64 Mb
- Disk storage 4.59 Gb
- Operating system IRIS 6.2

Transient calculation took 300 seconds problem time, and 565.5 seconds of CPU time consumtion, with a maximum time step size of 0.1 seconds. The ratio of CPU time to real transient time was consequently 1.88.

8. CONCLUSIONS

The transient corresponding to closure of the main steam isolation valve in steam generator 3 of Trillo I NPP has been simulated using the RELAP5/MOD3.2 code. Except for certain discrepancies listed below, the results in general compare favourably with the plant measurements (test D-100-306):

- It is observed that both the coolant pressure and temperature show slight differences from the test values. This must be related to the difference between the plant power and the calculated reactor power

- There may be differences, since magnitudes of the variables given by the calculation are compared with real values measured by sensors featuring uncertainty in their response and signal processing

- In the behaviour of the secondary, the differences between the model and the test are more significant and are probably due to the fact that during the test the isolating valve of the affected generator did not close completely. This would justify the difference in time between closure of the bypass valve in the test and in the model, and the steam generator fill times

9. REFERENCES

1. RELAP5/MOD3.2, NUREG/CR-5535

2. Trillo document, *Cierre válvula de aislamiento de vapor principal*. Test No. D-100-306. August 1988

3. KWU-Siemens document, *Reactor Coolant and Pressurizer System*. R232/222 000, Rev e. April 1993

4. Trillo documents, *Dossier System: RA, RL/RR, TA, TW, YA, YP.*

5. KWU-Siemens document, *Volumes of the Reactor coolant and Pressuriser System*. R10/86/E2036

Table 1
Main Characteristics of Trillo NPP

Thermal reactor power	3010 MWt
Net electrical output	1040 MWe
Fuel	UO_2, sintered
Number of assemblies	177
Fuel rod assembly	236
Active length of fuel rods	3.4 m
Outer diameter fuel rod	10.75 mm
Cladding tube material	zircaloy 4
Absorber material	Ag-In-Cd
Number coolant loops	3
Reactor operating pressure	158 bar
Coolant flow rate	16.684 kg/s
No. Steam generators	3
No. Tubes in SG	4086
Tube material	Incoloy 800
Average tube length	20.49 m
No. coolant pumps	3
Type	Single-state centrifugal pump
Discharge head	101 m
Design flow rate	5.292 kg/s
Pressuriser operating pressure	156.5 bar
Total nominal PRZ electrical heating capacity	1638 kW
Total pressuriser volume	45 m^3

Table 2
Comparison of Steady-State Values

Variable	Recorded		RELAP5	
	Signal	Value	Variable	Value
Reactor power	YT00-X111	2979.9 MW	rktpow	2982.5 MW
Real pressuriser level	YR71-L401	7.35 m	cntrlvar 510	7.32 m
Required pressuriser level	YR71-L411	7.41 m	cntrlvar 517	7.43 m
Coolant pressure	YR50--P401	154.26 bar	p 540010000	154 bar
Reactor inlet temperature loop 3	YA30-T955	293.8°C	tempf 390010000	293.116°C
Reactor inlet temperature loop 2	YA20-T955	--	tempf 490010000	293.124°C
Reactor inlet temperature loop 1	YA10-T955	293.35°C	tempf 790010000	293.118°C
Heating range loop 3	YA30-T951	30°C	cntrlvar 515	32.27°C
Heating range loop 2	YA20-T951	31.2°C	cntrlvar 514	32.27°C
Heating range loop 1	YA10-T951	31.2°C	cntrlvar 513	32.27°C
Steam Generator 3 pressure	YB30-P951	67.87 bar	p 650010000	67.723 bar
Steam Generator 2 pressure	YB20-P951	67.5 bar	p 850010000	67.72 bar

Table 2 (cont'd)
Comparison of Steady-State Values

Variable	Recorded		RELAP5	
	Signal	Value	Variable	Value
Steam Generator 1 pressure	YB10-P951	66.9 bar	p 950010000	67.725 bar
Steam flow outlet SG3	RA03-F901	540 kg/s	mflowj 100000000	544.28 kg/s
Steam flow outlet SG2	RA02-F901	540 kg/s	mflowj 124000000	544.73 kg/s
Steam flow outlet SG1	RA01-F901	522 kg/s	mflowj 160000000	543.92 kg/s
Steam Generator 3 level	YB30-L951	12.07 m	cntrlvar 958	11.949 m
Steam Generator 2 level	YB20-L951	11.9 m	cntrlvar 959	11.949 m
Steam Generator 1 level	YB10-L951	11.9 m	cntrlvar 960	11.949 m
Coolant average temperature	YT10-T101	308.15°C	cntrlvar 606	308.3°C
SG3 inlet water flow	RL23-F901	547.31 kg/s	mflowj 720000000	547.80 kg/s
SG2 inlet water flow	RL22-F901	564.81 kg/s	mflowj 960000000	542.71 kg/s
SG1 inlet water flow	RL21-F901	550.0 kg/s	mflowj 980000000	543.45 kg/s

Table 3

Sequence of Transient (seconds)

Event	Plant-test	RELAP Model Prediction
SG3 isolation valve begins to close	0.0	0.0
SG3 isolation valve fully closed	2.0	2.0
SG3 full and low control valves begin to close and open, respectively	6.0	6.5
Reactor and turbine trip	9.0	10.1
SG3 Relief Valve begins to open	9.0	10.1
SG3 Safety Valve opens	10.3	11.5
SG3 Safety Valve closes	14.75	15.0
Turbine bypass opens	16.0	17.35
Turbine bypass closes	100	148
SG3 partial shutdown completion	300	300

Figure 1. Trillo I NPP RELAP5/MOD 3.2 Model

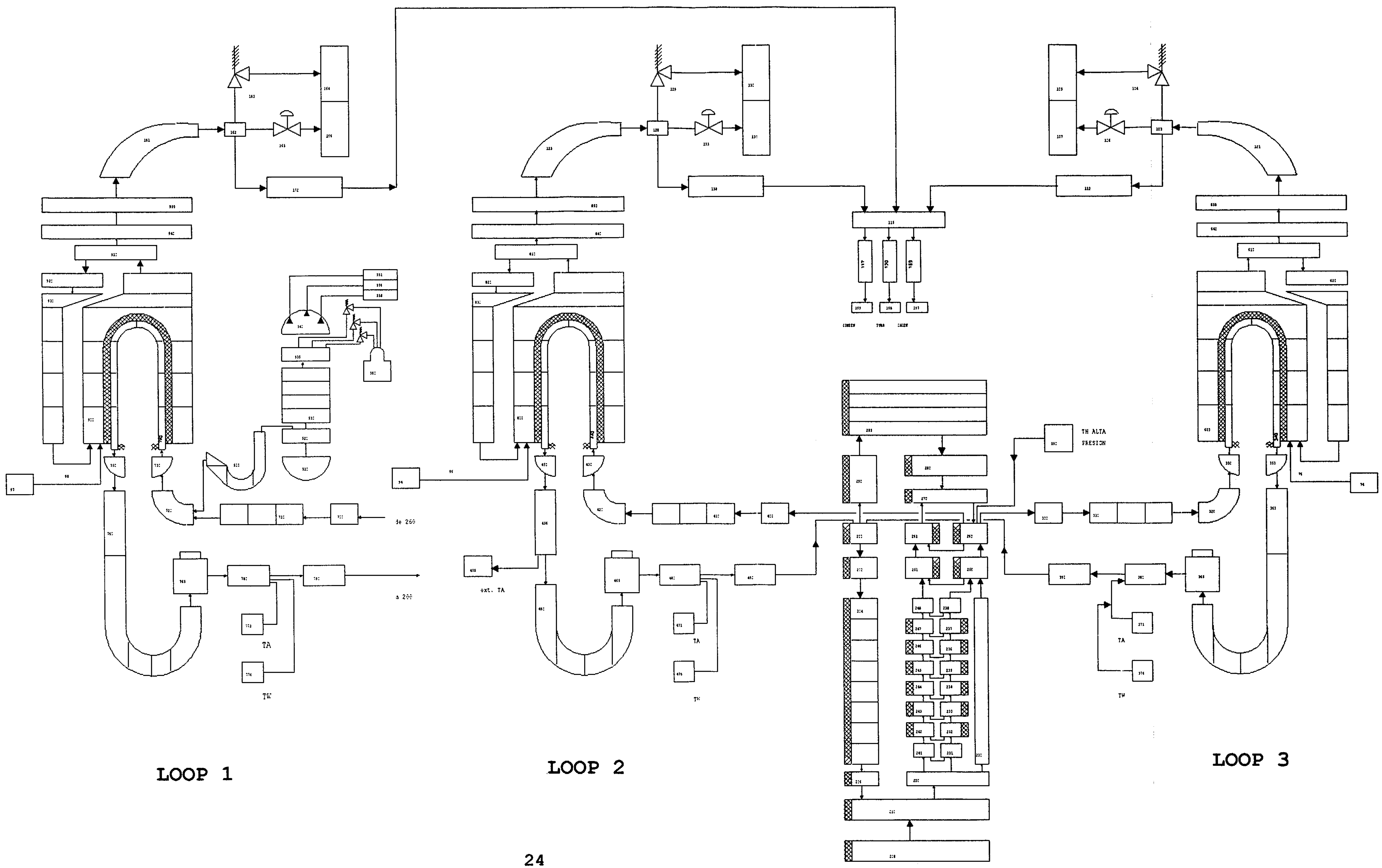


Figure 1 (cont'd) Trillo1 RELAP5//MOD3.2 Model

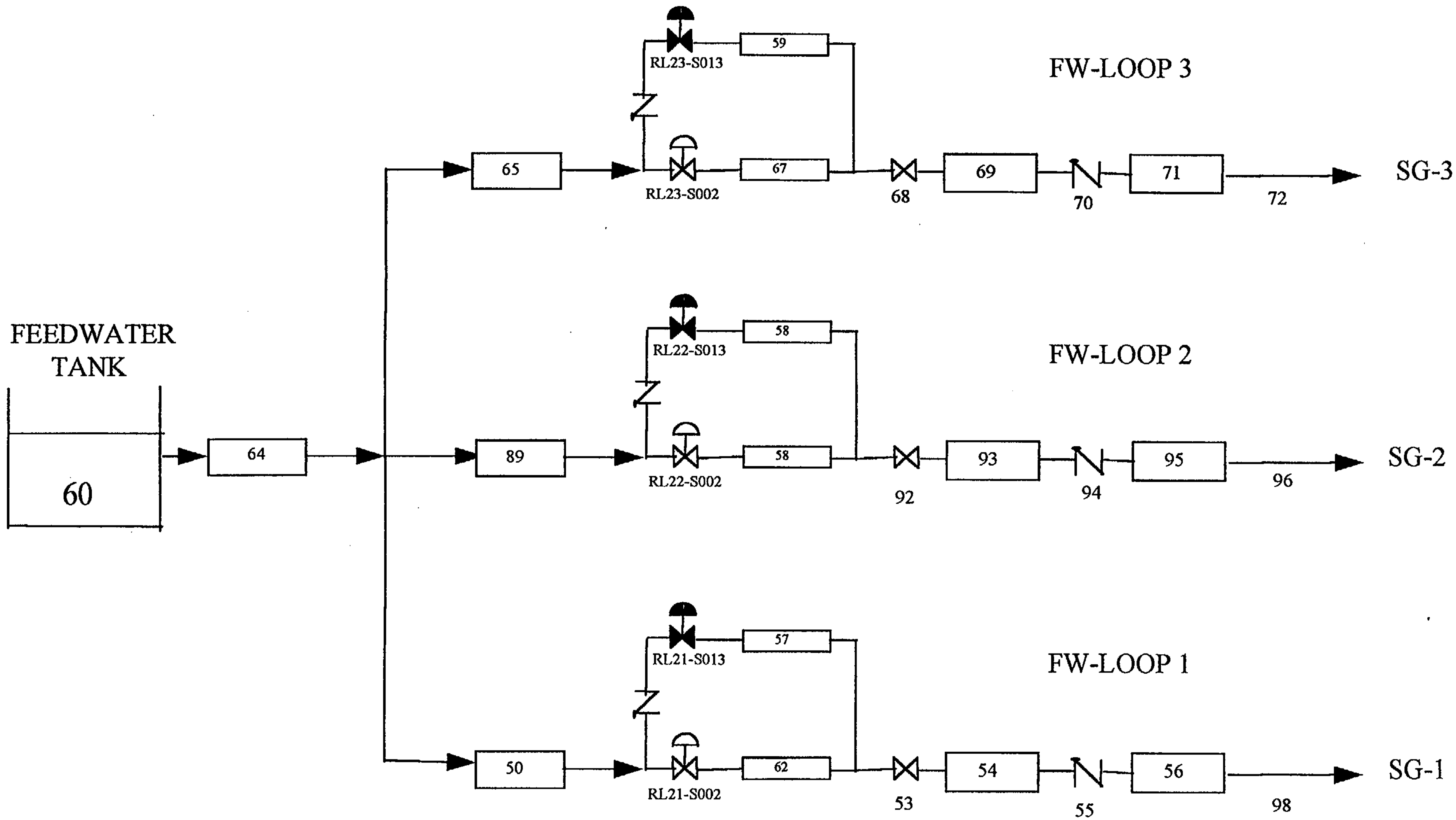


Figure 2
PRIMARY SIDE PRESSURE PRESSURIZER
MSIV CLOSURE TRILLO 1 NPP

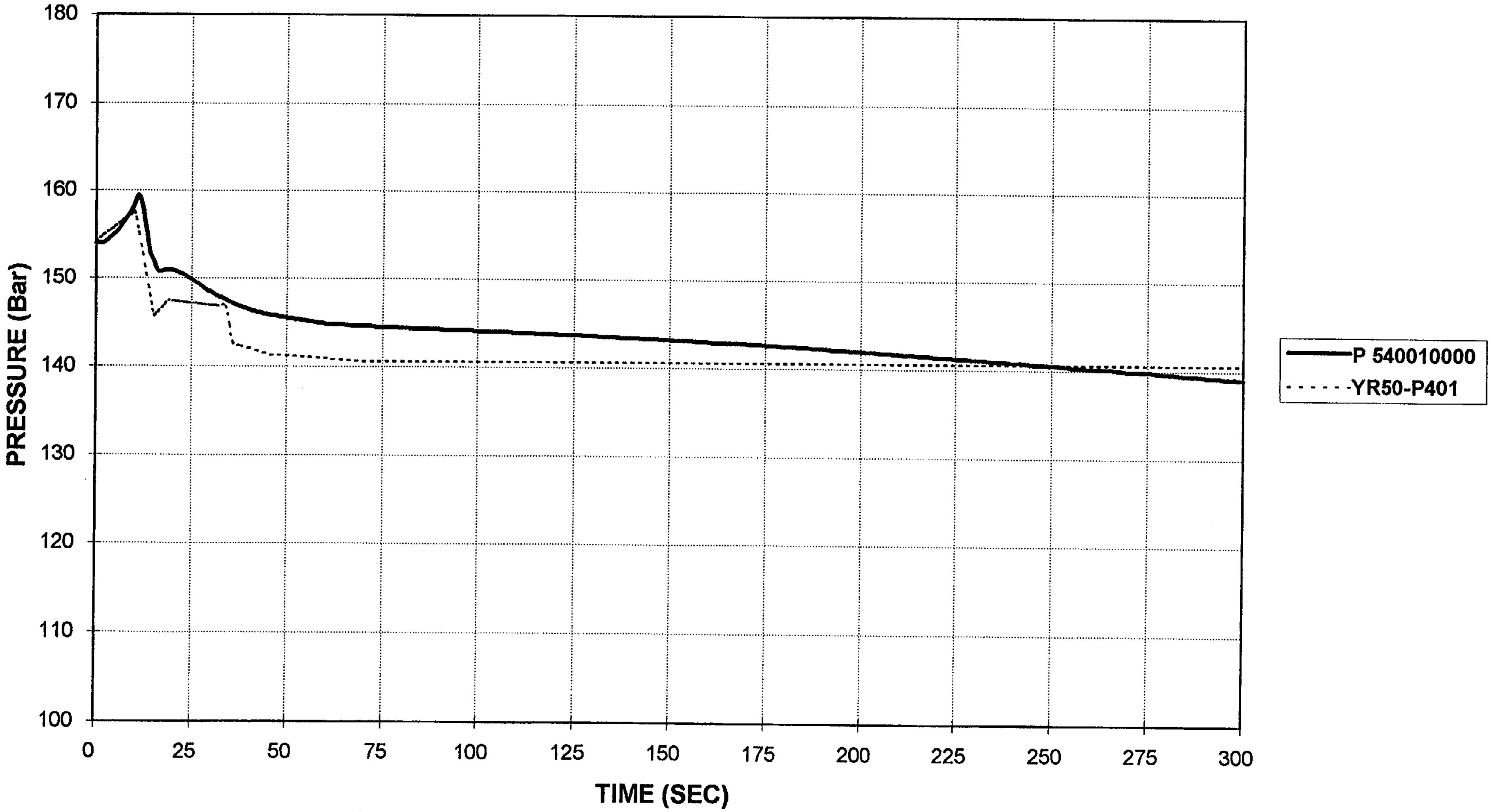


Figure 3
COOLANT AVERAGE TEMPERATURE
MSIV CLOSURE TRILLO 1 NPP

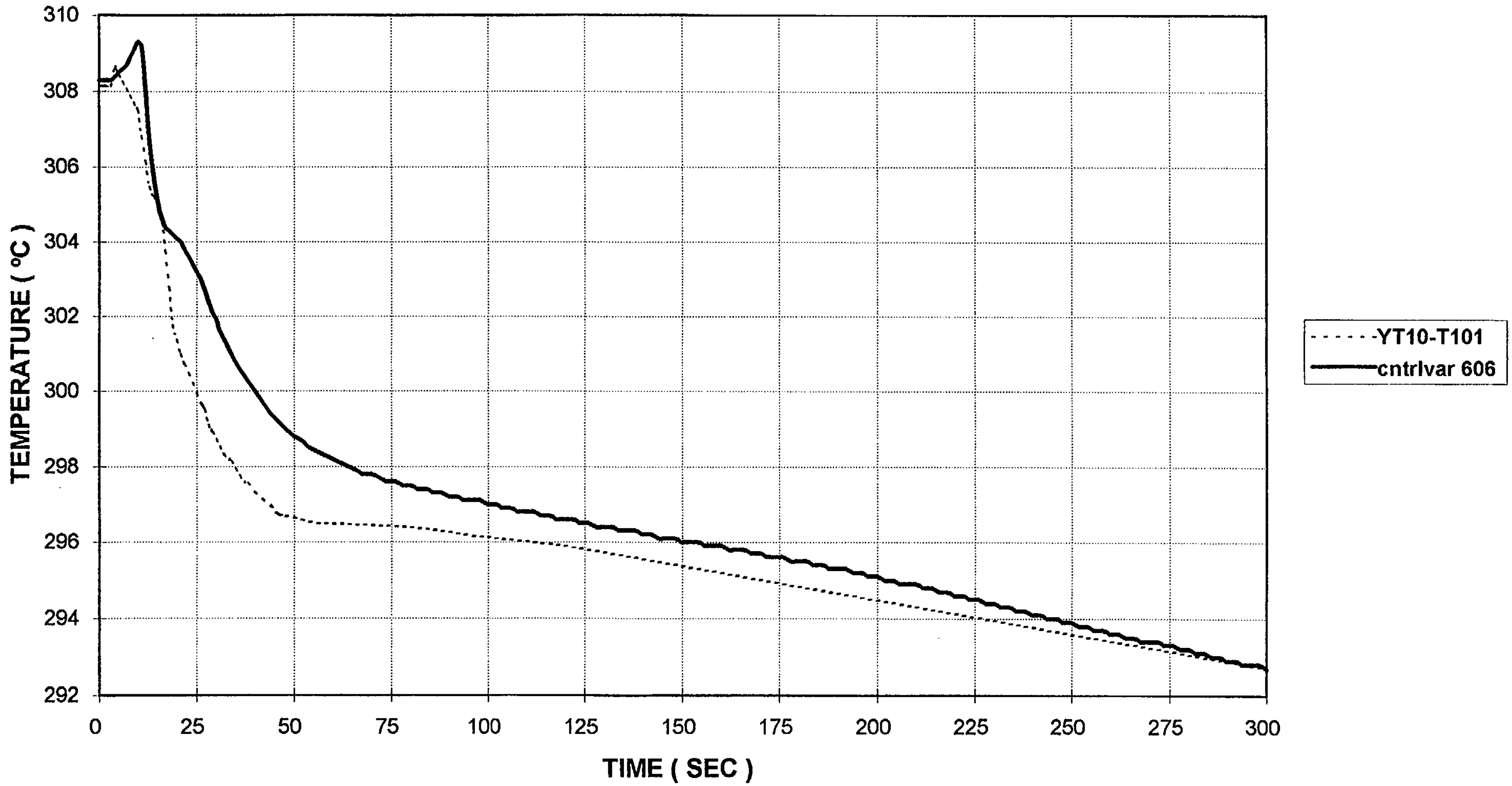


Figure 4
PRESSURIZER LIQUID LEVEL
MSIV CLOSURE TRILLO 1 NPP

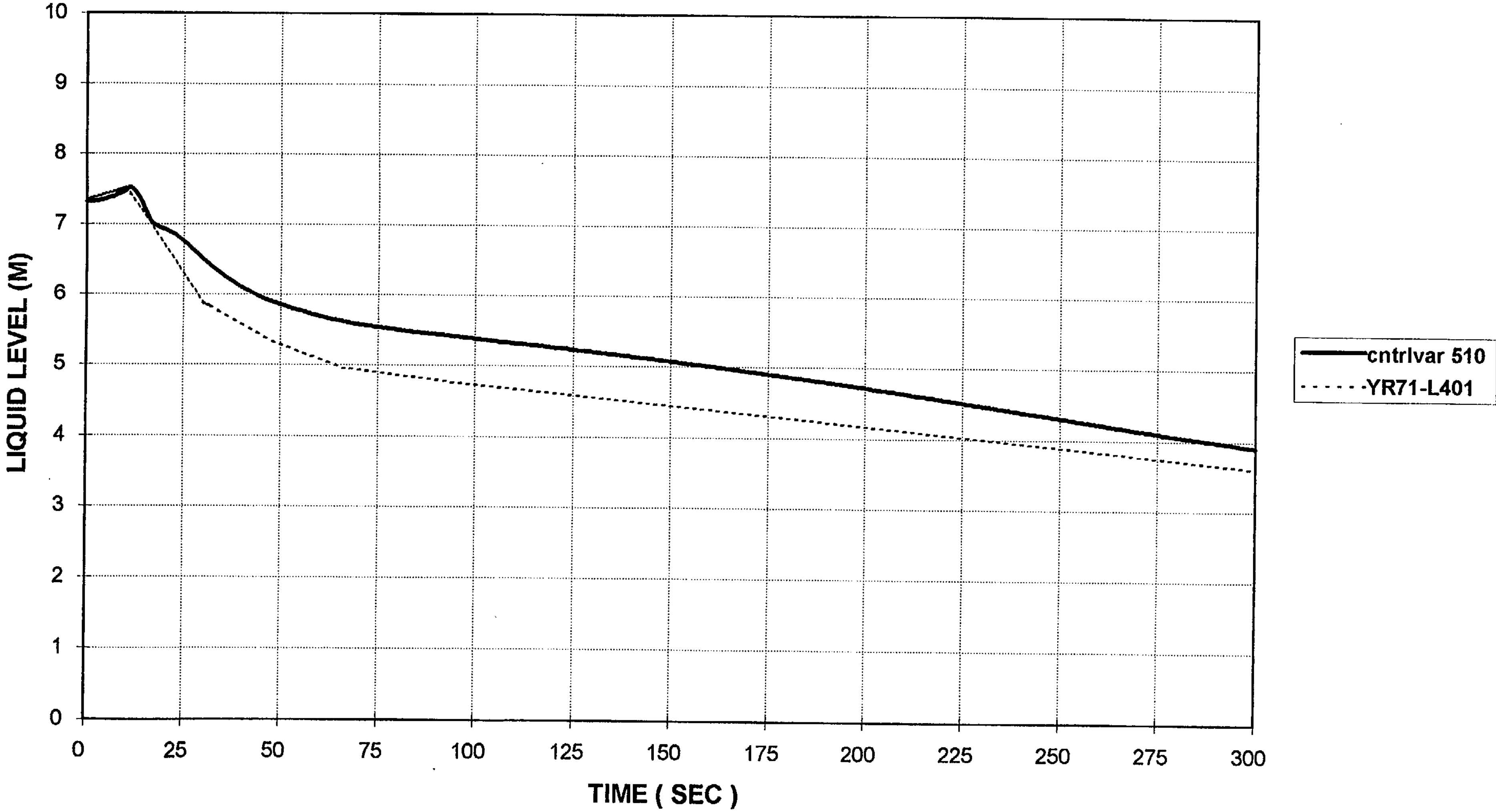


Figure 5

MAIN STEAM PRESSURE GENERATOR Nº1

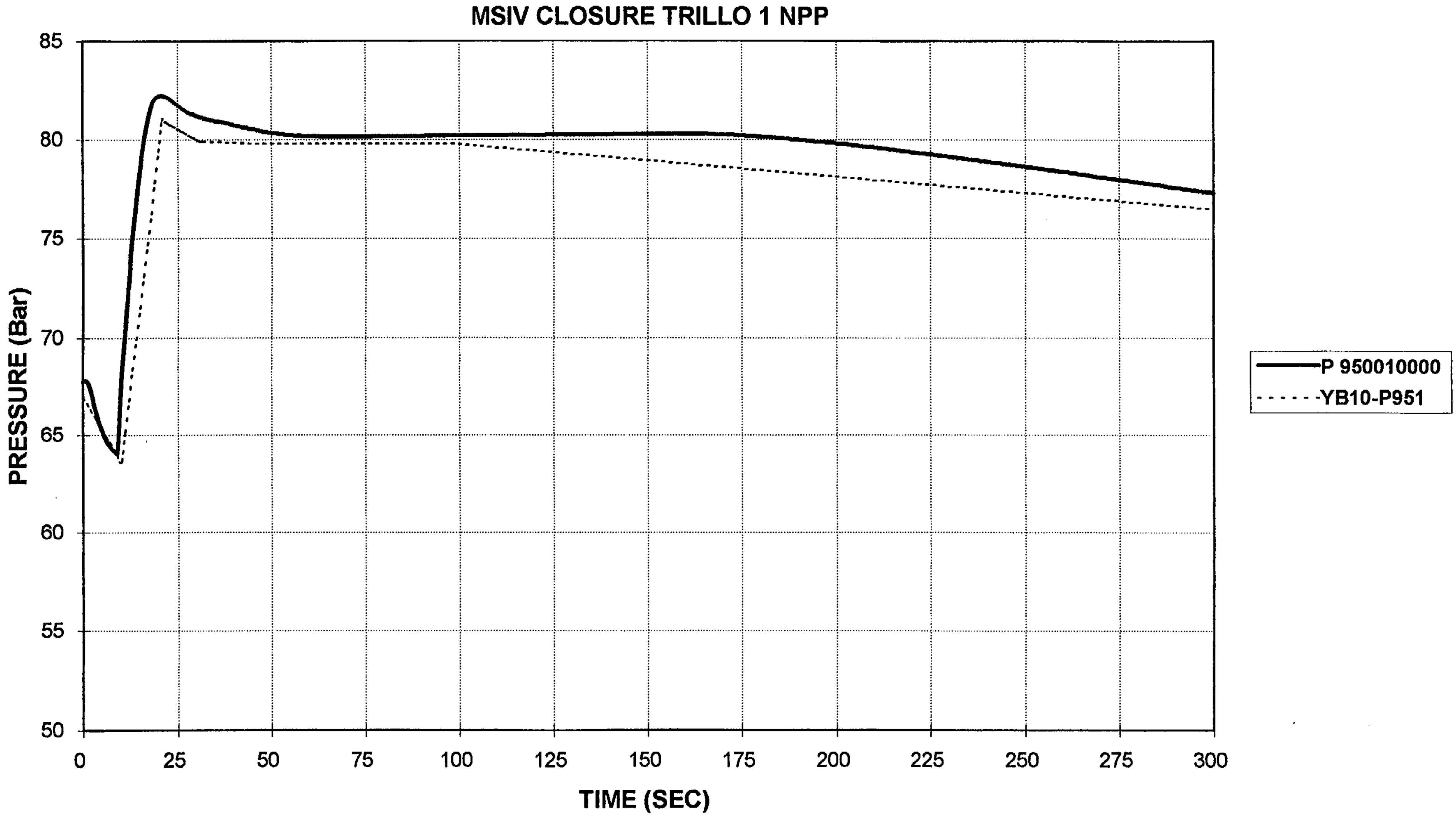


Figure 6

MAIN STEAM PRESSURE GENERATOR Nº2

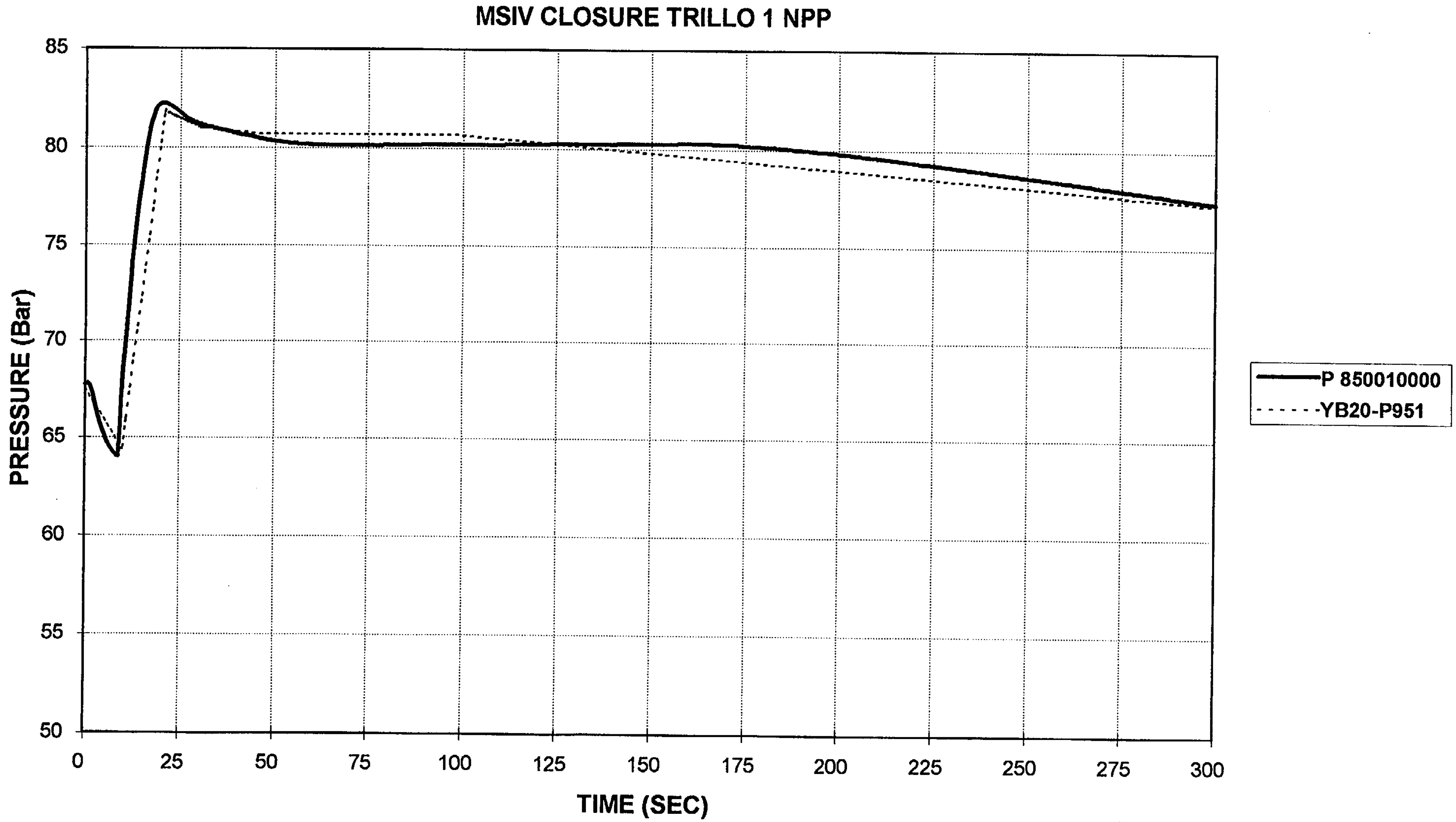


Figure 7
MAIN STEAM PRESSURE GENERATOR Nº3
MSIV CLOSURE TRILLO 1 NPP

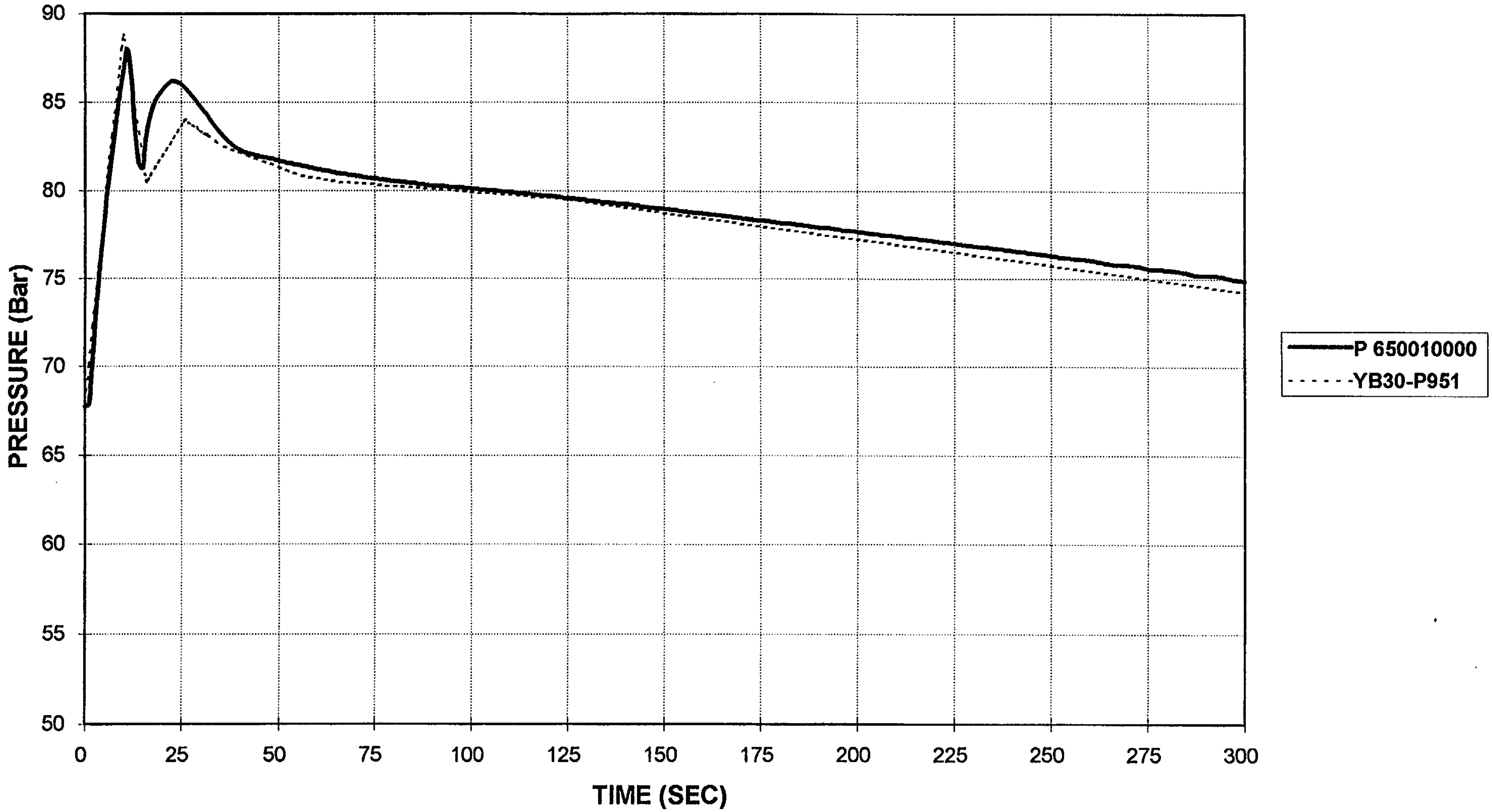


Figure 8
LIQUID LEVEL STEAM GENERATOR Nº1

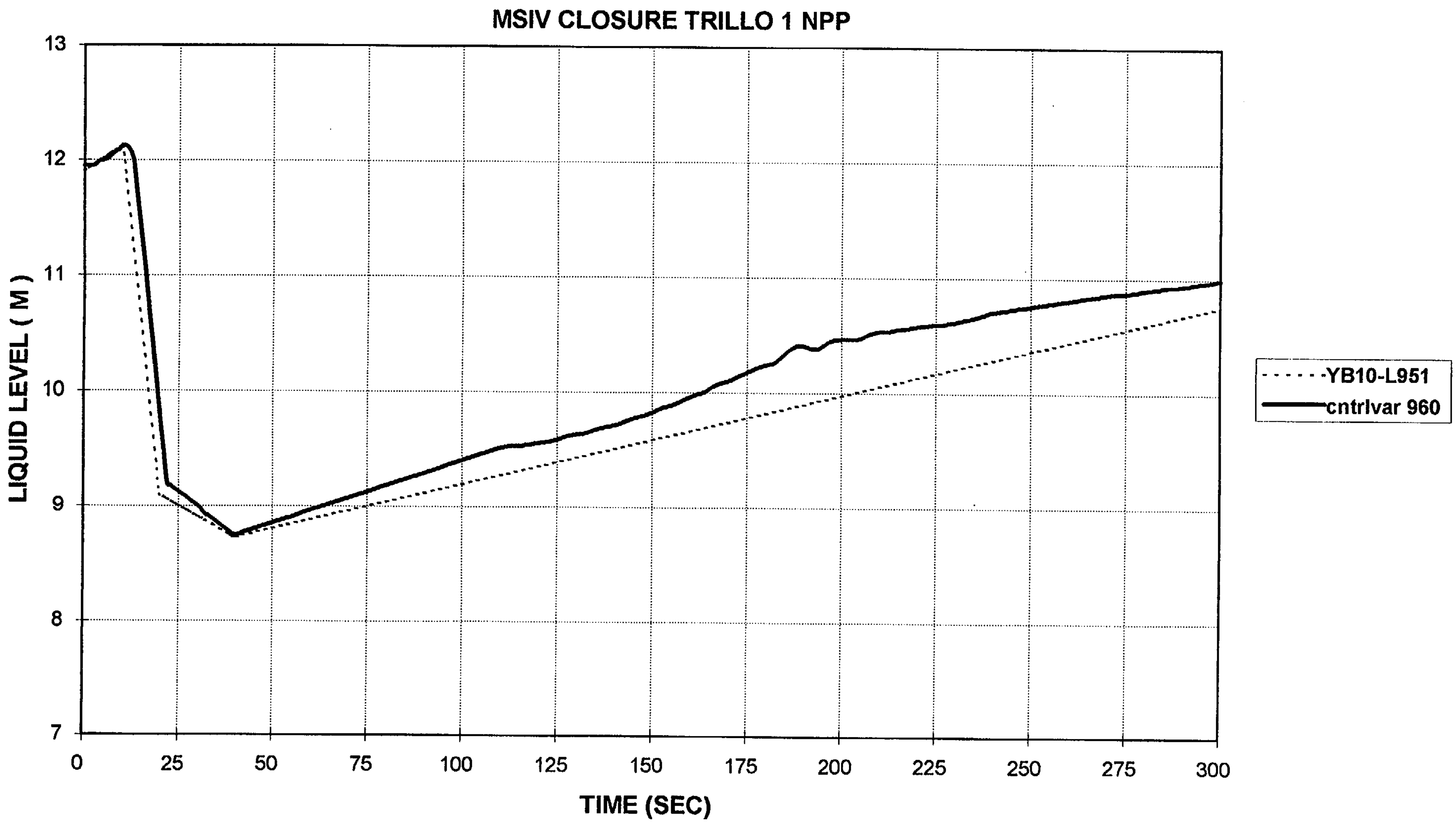


Figure 9
LIQUID LEVEL STEAM GENERATOR Nº2
MSIV CLOSURE TRILLO 1 NPP

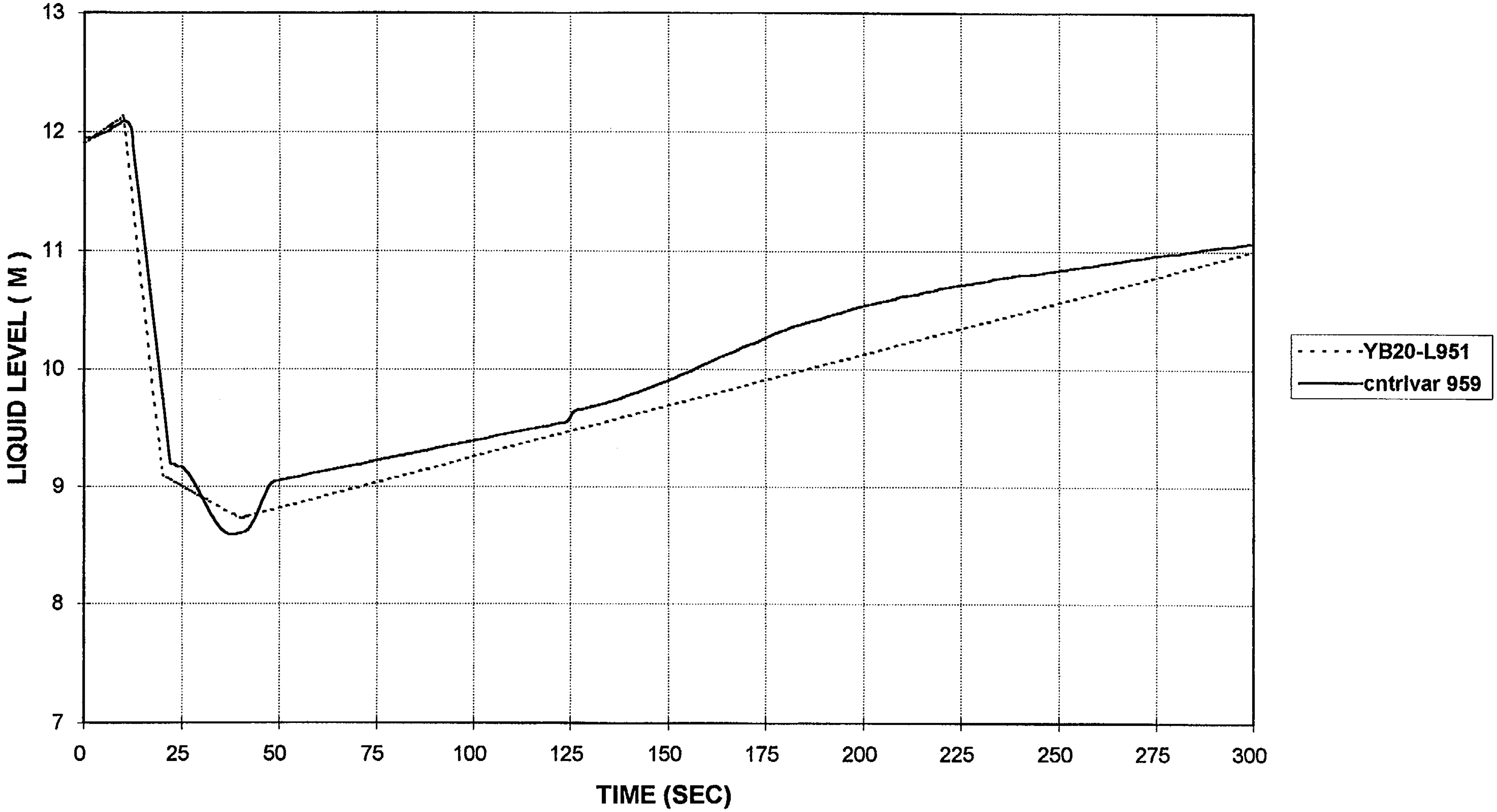


Figure 10

LIQUID LEVEL STEAM GENERATOR Nº3

MSIV CLOSURE TRILLO 1 NPP

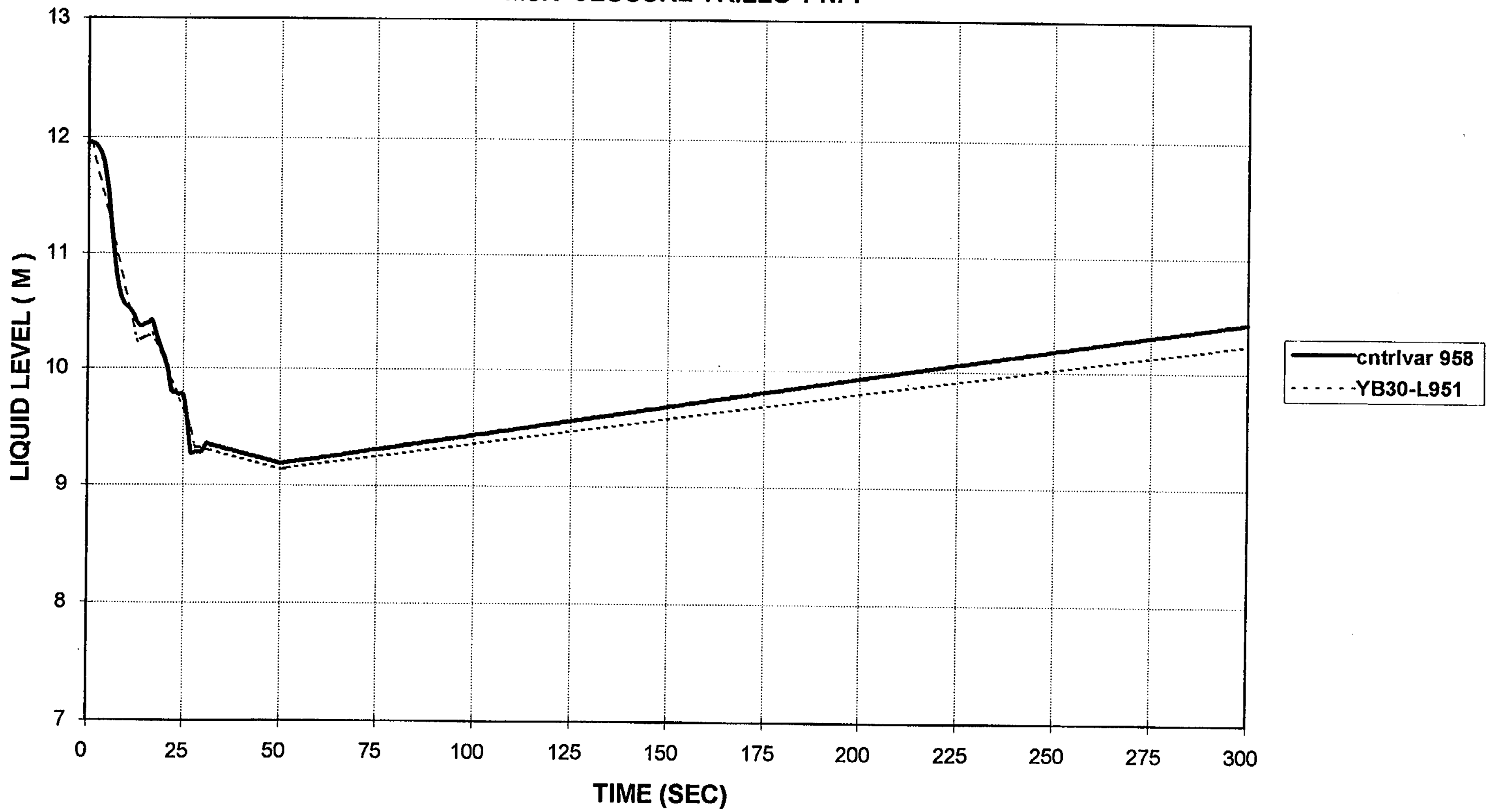


Figure 11

MAIN STEAM FLOW STEAM GENERATOR Nº1

MSIV CLOSURE TRILLO 1 NPP

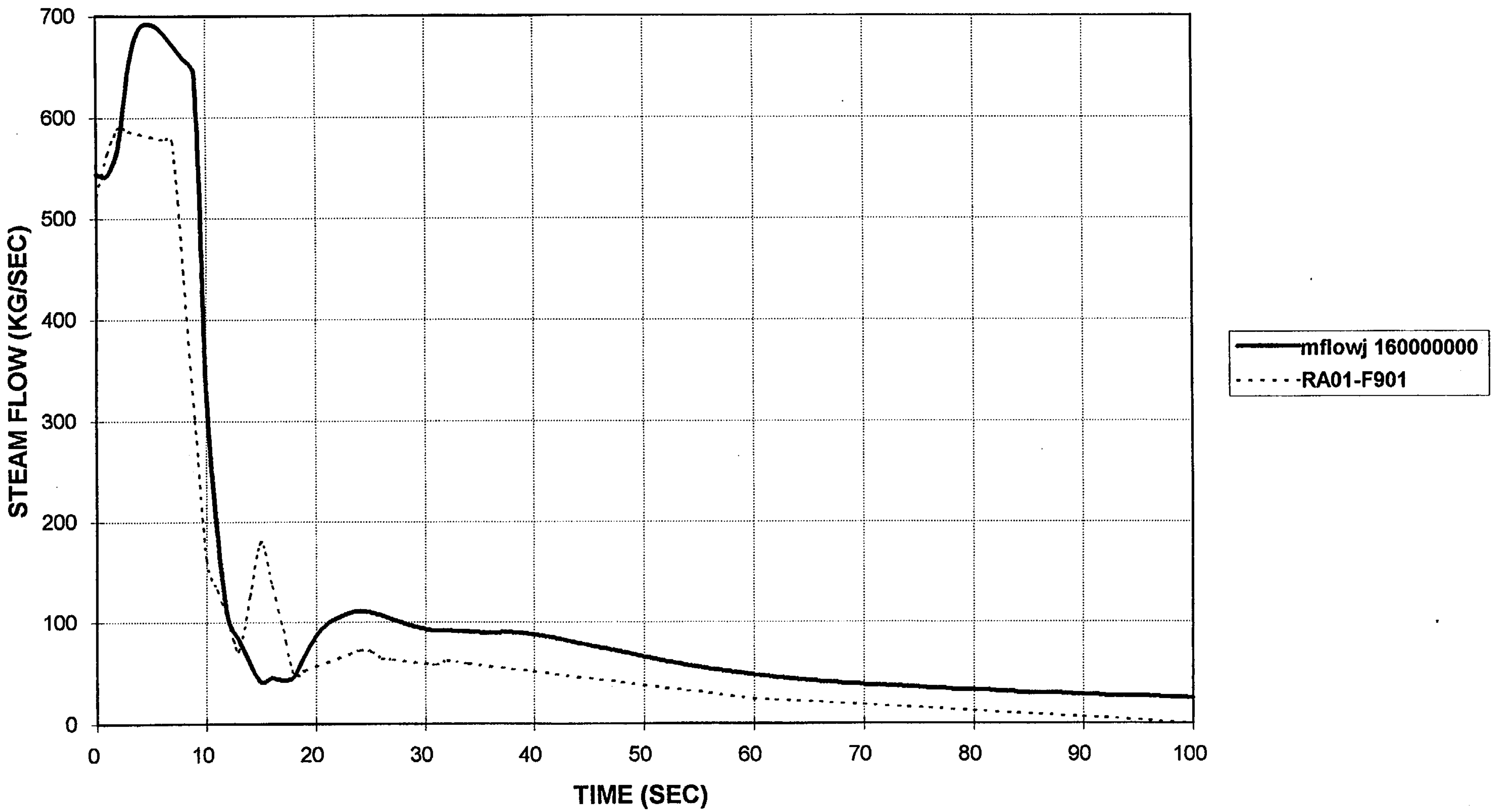


Figure 12
MAIN STEAM FLOW STEAM GENERATOR Nº2
MSIV CLOSURE TRILLO 1 NPP

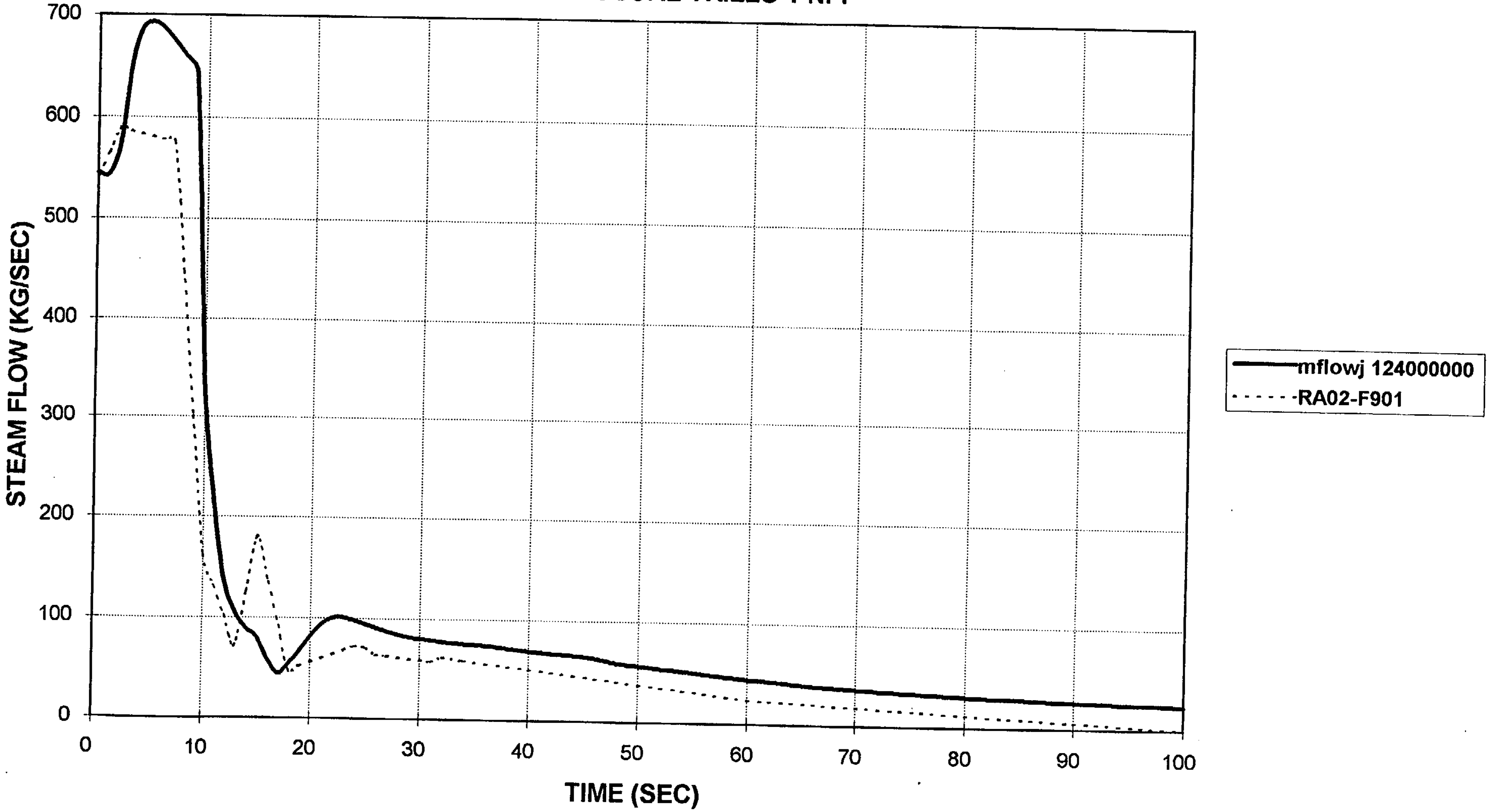


Figure 13
MAIN STEAM FLOW STEAM GENERATOR Nº3

MSIV CLOSURE TRILLO 1 NPP

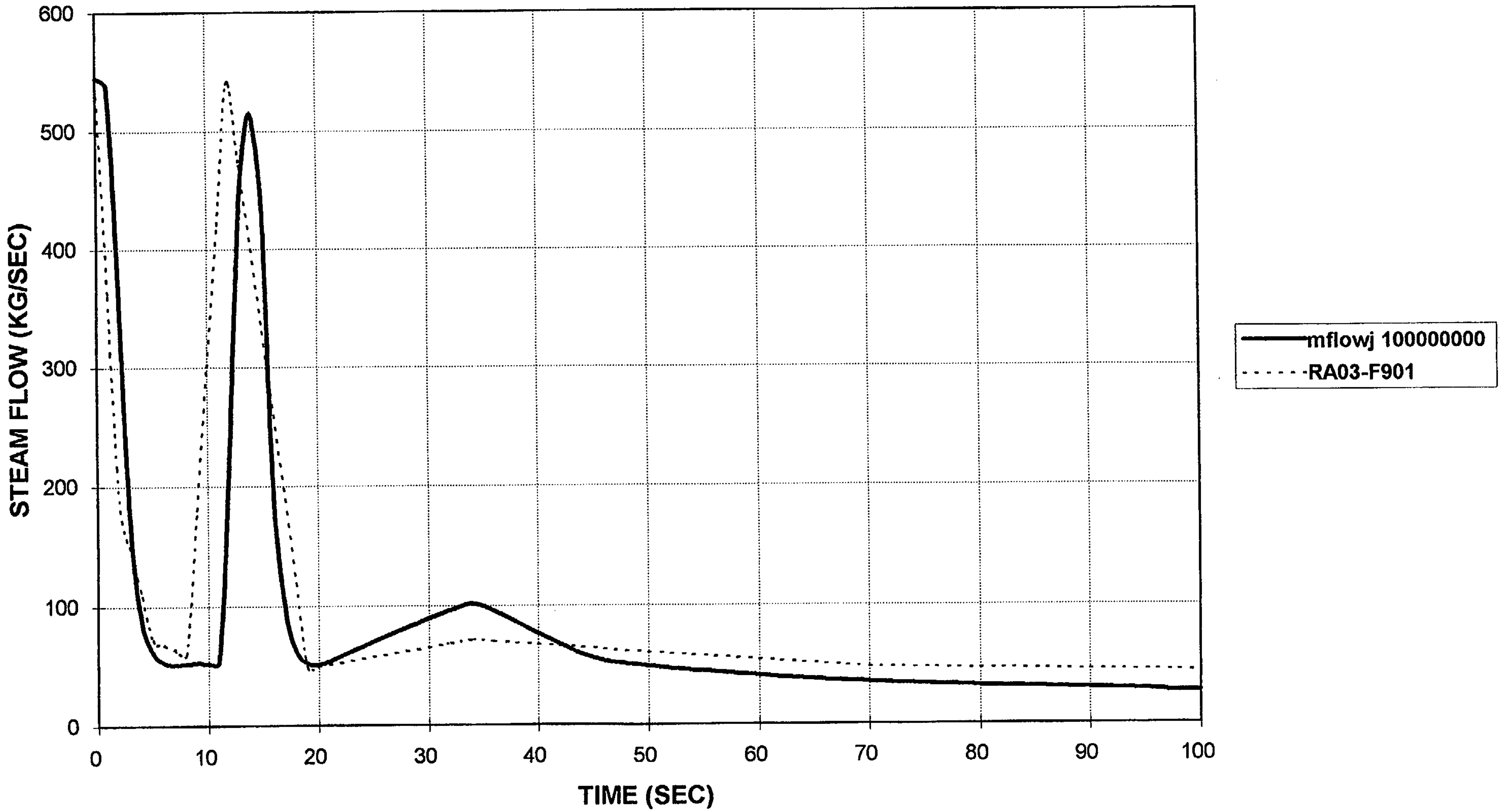


Figure 14
MAIN STEAM RELIEF VALVE STEAM GENERATOR Nº3
MSIV CLOSURE TRILLO 1 NPP

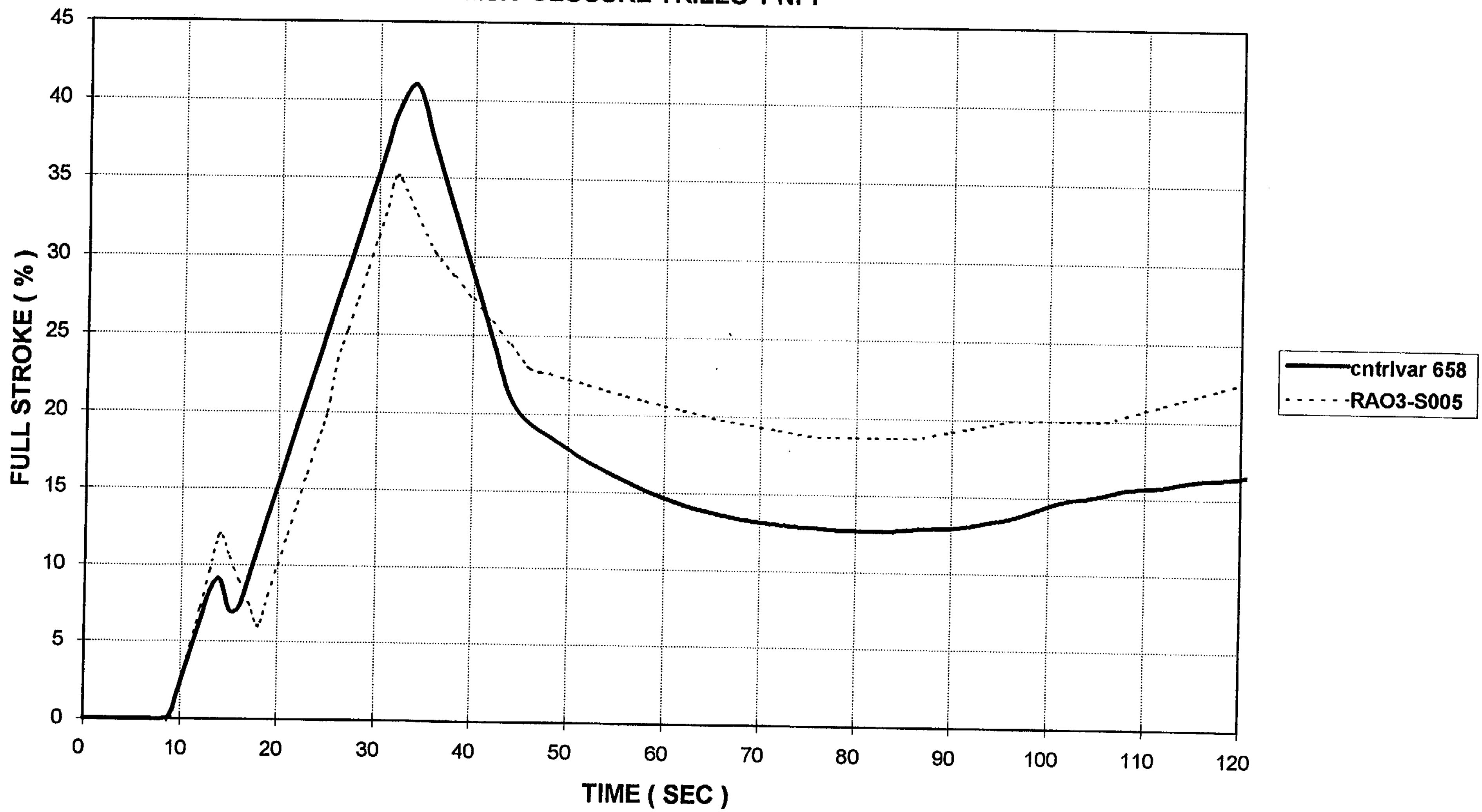
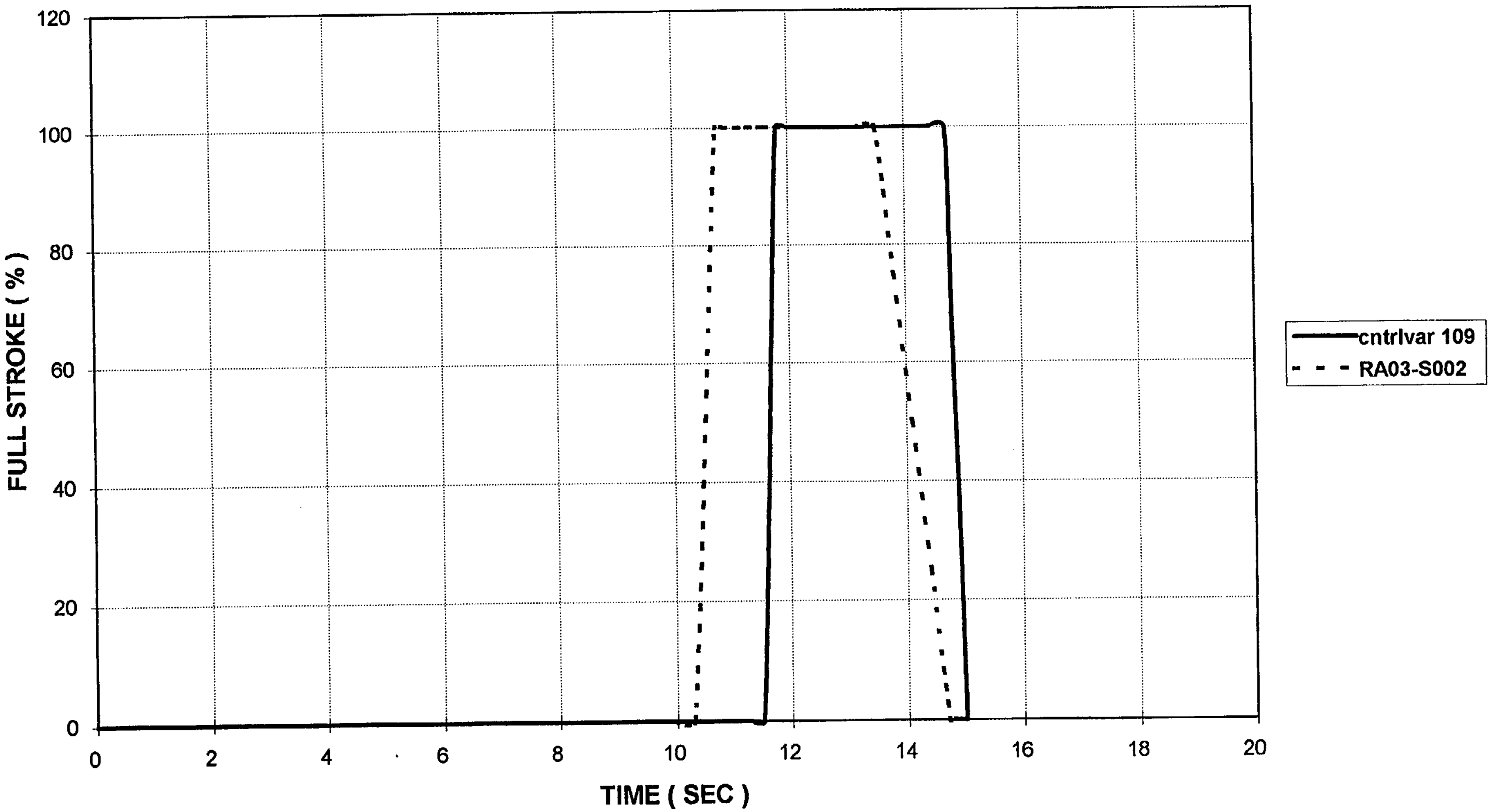


Figure 15

MAIN STEAM SAFETY VALVE STEAM GENERATOR Nº3

MSIV CLOSURE TRILLO 1 NPP



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10. SUPPLEMENTARY NOTES

11. ABSTRACT *(200 words or less)*

This report includes an assessment of RELAP5/MOD3.2 against a main steam line isolation at 99% power in TRILLO I NPP (PWR, KWU-Siemens, 1040 MWe). The results used are those obtained during test D-100-306 (Ref. 3), performed August 19, 1988 at TRILLO I NPP. The three plant cooling loops are simulated to take into account: i. A single loop containing a valve in which the disturbance occurs; ii. The remaining two loops are simulated using two separate model loops. The TRILLO I model used comprises 273 control volumes, 297 junctions, 101 heat structures and 252 control variables. From this study it can be concluded that the post-test calculation shows a reasonable agreement with the actual plant data.

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