TENNESSEE VALLEY AUTHORITY
CHATTANOOGA, TENNESSEE 37401

400 Chestnut Street Tower II

September 26, 1985

Director of Nuclear Reactor Regulation
Attention: Ms. E. Adensam, Chief
Licensing Branch No. 4
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Ms. Adensam:

In the Matter of the Application of	)	Docket Nos. 50-390
Tennessee Valley Authority	)	50-391

As discussed in our June 17, 1983 and September 6, 1984 letters to the NRC, we provided adequate instrumentation in the auxiliary control room (ACR) to safely shut down and cool down the plant during conditions of main control room uninhabitability. The NRC staff has some concerns about the steam generator secondary side pressure being used to obtain saturation temperature (T-sat), and the subsequent use of T-sat to infer reactor coolant system (RCS) cold-leg temperature (T cold) which, along with RCS hot-leg temperature, will be used to verify adequate natural circulation. These concerns were discussed with the NRC during a March 7, 1985 meeting in Bethesda, Maryland. As a result of that meeting, we, in letters to NRC dated March 28 and August 1, 1985, committed to provide the staff additional information justifying the use of T-sat indication in the ACR to infer T-cold. Enclosed is the additional information.

If there are any questions, please get in touch with C. J. Riedl at FTS 858-2696.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

J. A. Domer

J. A. Domer, Chief
Nuclear Licensing Branch

Sworn to and subscribed before me
this 26th day of Sept, 1985

Bryant M. Lowery

Notary Public
My Commission Expires 4/8/86

Enclosure
cc: U.S. Nuclear Regulatory Commission (Enclosure)
Region II
Attention: Dr. J. Nelson Grace, Regional Administrator
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30323

B001
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Justification for Use of T-sat to Approximate T-cold in the ACR

As discussed in TVA's letter to NRC dated June 17, 1985, TVA has provided adequate instrumentation in the auxiliary control room (ACR) to safely shut down and cool down the plant during conditions of main control room (MCR) uninhabitability.

Due to NRC staff concern about use of steam generator pressure to obtain saturation temperature to infer RCS cold-leg temperature, TVA agreed to provide additional information. Attached are discussions on operator training, uses of steam generator pressure indication, cost estimate for adding T-cold to the ACR, and Sequoyah and Diablo Canyon natural circulation test data.

Any discussion concerning the adequacy of instrumentation in the ACR must be preceded with a discussion regarding the requirements placed on that instrumentation and the conditions under which it will be used. The ACR is designed to safely shut down and cool down the plant to cold shutdown (200^{o}F), under conditions of MCR evacuation. This situation is postulated to exist due to a fire in the control building. According to 10 CFR 50 Appendix R, this postulated fire occurs in only one location (in this case, an area of the control building) and is not coincident with, subsequent to, or preceding any other design-basis event. A loss of offsite power is, however, postulated to exist coincident with the fire. Thus the plant shutdown and subsequent cooldown is simply a natural circulation cooldown via heat transfer to the steam generator and subsequent steam release via the steam generator atmospheric relief valves. This process takes place until approximately 350^{o}F and 380 psig are reached in the RCS. At this point, the residual heat removal system is placed into service and provides forced circulation for the remainder of the cooldown to cold shutdown conditions.

The discussion of the adequacy of T-sat versus T-cold centers around the cooldown from hot standby to 350^{o} F. During this cooldown, RCS T-cold is determined from S/G T-sat and is used for two purposes: 1) along with RCS hot-leg temperature to indicate adequate natural circulation, and 2) to ensure the cooldown rates are maintained within the plant cooldown limits required by 10 CFR 50 Appendix G. As shown in the attached data from Sequoyah and Diablo Canyon (see figures 3 through 8) T-sat and T-cold track together extremely well between hot standby and 350^{o} F. In fact, at most points they are tracking well within the error tolerance on a wide range T-cold indication loop. Any indication of degrading natural circulation (via loop instrumentation) will inherently lag behind core conditions due to delayed fluid transport time under the low flows. This time lag occurs for both direct T-cold and T-sat via steam generator (S/G) pressure indications. This sort of degrading condition would not result in any adverse conditions before it is detected by existing instrumentation. This condition would be detected by RCS loop differential temperatures on both the good loops and the degrading loop and secondary side indications such as S/G levels and auxiliary feedwater flows. As shown on the attached graphs (see figure 1 through 8), T-sat is almost always a few degrees below T-cold and thus T-sat will result in the most limiting (and thus more conservative) cooldown rates.

The ability of the operators to adequately use S/G pressure indication to infer T-cold has been demonstrated during hot functional testing at Watts Bar unit 1 and startup testing at Sequoyah unit 1. Additionally, recent actions have increased the already high level of confidence in this area: 1) Watts Bar operators have again walked through the procedures pertaining to shutdown/cooldown from the ACR, and 2) Watts Bar is in the process of adding a dual scale to the S/G pressure indicators to allow direct reading of T-sat.

In conclusion, TVA believes it has provided sufficient indication in the ACR to safely shut down and cool down the unit under conditions of MCR uninhabitability. Thus, the requirements of 10 CFR 50 Appendix R, section III item L.2.d have been met. TVA cannot justify on a cost-benefit basis the additional $160,000 per unit (initial installation costs only) to provide RCS T-cold instrumentation in the ACR.

A. Impact of Operators Using T-sat

Each licensed operator receives a minimum of 40 hours of classroom training covering heat transfer, thermodynamics, and fluid flow. Each shift technical advisor has 80 hours classroom training covering heat transfer, thermodynamics, and fluid flow in addition to their undergraduate studies in this area.

This training provides the operators with knowledge of thermodynamic principals such as saturation pressure and temperatures. This knowledge is reinforced in simulator training where subcooling margin calculations and RCS cooldowns using the atmospheric relief valves require saturation pressure and temperature manipulations.

Abnormal Operating Instruction-27 (AOI) covers main control room inaccessability. Operators have recently completed another walk-through of this procedure to ensure familiarity and confidence in execution of this AOI. Additionally the AOI refers the operator to Emergency Instruction section ES-0.3 for natural circulation cooldown guidelines. The AOI specifically instructs the operator to use S/G pressure-to-temperature conversions for T-cold.

As an added human factor enhancement, a dual scale will be added to the S/G pressure indicators in the ACR. This second scale will read saturation temperature and thus allow the operator to infer T-cold without the use of steam tables. This is similar to the dual scale used in the main control board (M-5) on RCS pressure to provide a corresponding saturation temperature for subcooling margin calculations. This dual scale will be in place by initial entry into mode 3.

In summary, Watts Bar operators and shift technical advisors are trained in the theory and use of T-sat/saturation pressure (P-sat) calculations. TVA believes the negative impact of the operators utilizing S/G pressure conversion to saturation temperature is negligible. Additionally, the incorporation of a dual scale to allow the operator to directly read saturation temperature will greatly reduce the response time and completely eliminate conversion errors.

B. Benefits That S/G Pressure Indicators Have Versus RCS Wide Range Cold-Leg Temperature Indicators

An ACR has always been a part of the TVA design. The purpose of the ACR is to safely shut down and cool down the plant to cold shutdown under conditions of MCR evacuation.

The design objective was to provide this capability within the constraints of space availability and design complexity. Where possible equipment was chosen to meet several needs.

T-cold indication in the ACR has a limited use. For all practical purposes it had only two functions: 1) in conjunction with T-hot to verify the presence of natural circulation, and 2) as one method to ensure compliance with plant cooldown limits. T-cold indication was not included in the original design requirements for the ACR. It was determined to not be necessary since it could be inferred from S/G pressure indication.

S/G pressure indication, however, has many uses:

1) Verify proper operation of S/G atmospheric relief valves (S/G ARV) controllers used to cooldown from the ACR.

2) Identify potential S/G ARV failures.

3) Identifies approach to S/G pressure limits/safety valve lifting.

4) S/G pressure is an input to the steamline delta pressure safety injection signal. Thus, indication of symmetric S/G cooldown/ depressurization is important to prevent inadvertent actuation. (Although the equipment with control transferred to the ACR will not automatically actuate.)

5) And of course, can be used to determine RCS cold-leg temperature.

In summary, S/G pressure indication is a vital component of a controlled cooldown from the ACR, whereas T-cold indication has essentially only two uses (both which can be approximated by S/G pressure). Thus, TVA believes the decision to not include T-cold in the original design of the ACR was sound.

C. Detailed Cost Estimate of Installing T-cold Indication in the ACR

TVA has prepared detailed cost estimates for installation of RCS wide range cold-leg temperature indications in the ACR for unit 1. Unit 2 costs would be somewhat lower if work could be scheduled prior to that unit's fuel loading.

Total cost for unit 1 = $163,618.00
Design costs = $ 42,000.00
Construction costs = $111,139.00
QA costs = $ 10,479.00

It should be noted that the $163,618.00 only includes initial installation costs, it does not include the routine maintenance, required surveillance testing, or replacement costs over the 40-year life of the plant. Historically, TVA has estimated these additional expenses to at least equal the original cost of the equipment installation.

D. Steam Generator (S/G) Stratification Data

Effects of potential S/G stratification during S/G isolation or reduced steam/feed flow rates around Residual Heat Removal (RHR) System cut-in conditions should be considered as to their effects on T-cold, T-sat relationship. During TVA's Sequoyah Nuclear Plant's initial startup testing program, special test number 4 (ST-4) was run. This test completely isolated two S/Gs. As shown in the attached graphs (figures 1 and 2) actual T-cold and S/G T-sat track very well. This is important when considering that under these conditions, S/G T-sat would be utilized in conjunction with T-hot to identify loss of natural circulation in that loop. The data shown is applicable for lower temperatures since the nominal temperature of the isolated S/G would not affect the response.

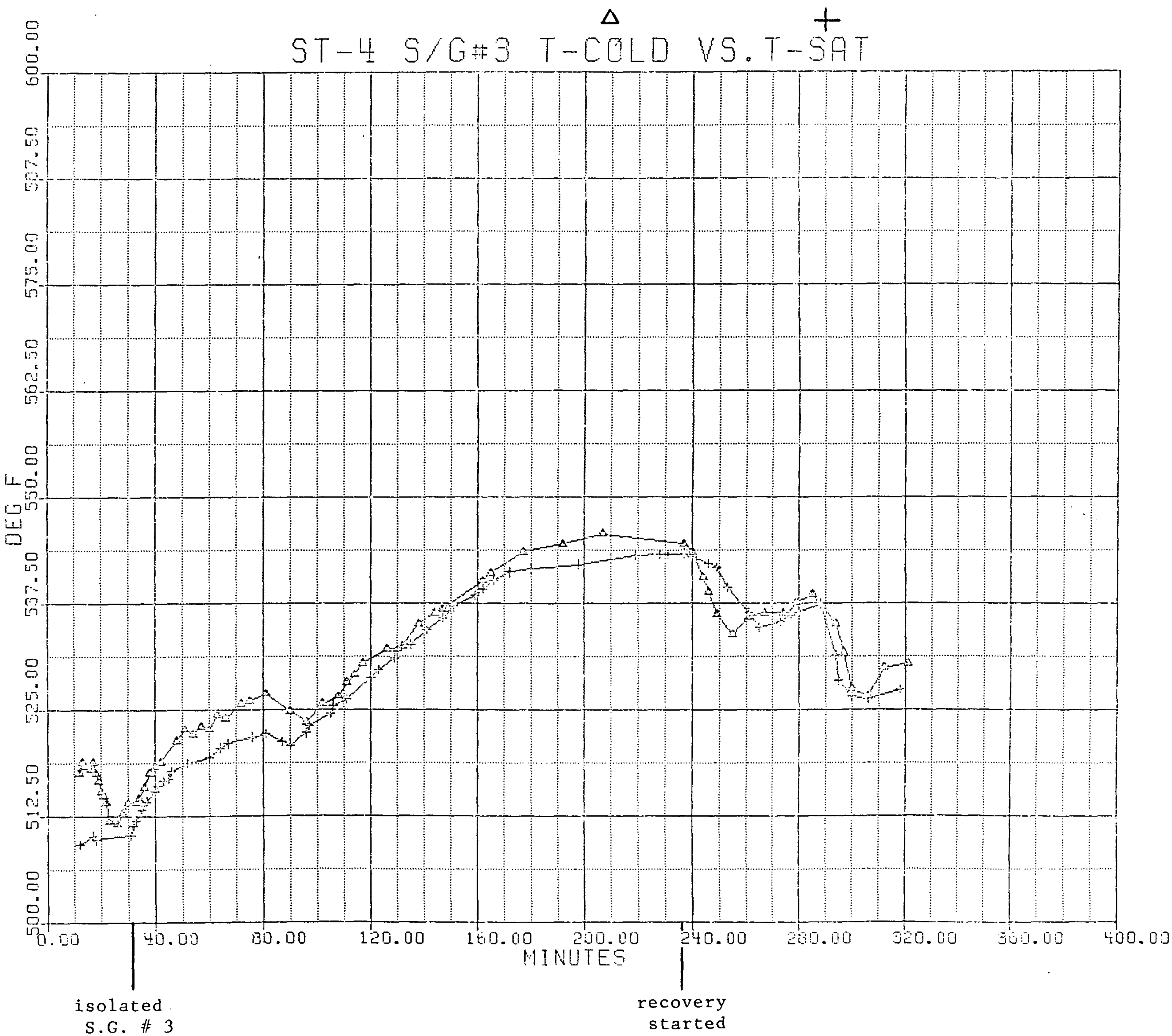
Additionally, figures 5, 6, 7, and 8, which show the Diablo Canyon natural circulation test data, show that at steam/feed flow rates at RHR cut-in ($\sim$ 350 degrees F) conditions T-cold and S/G T-sat continue to track very well. Since the enthalpy rise of the auxiliary feedwater to saturated steam condition is essentially the same at 500 degrees F and 350 degrees F (RHR cut-in conditions), the only effect on steam/feed mass flow rates is the amount of decay heat generated. Normally, decay heat will decrease to one-half between post trip conditions (1 hour after trip) and the time necessary to reach hot shutdown conditions (RHR cut-in conditions - at the most 24 hours). Thus, the most the steam flow/feed flow rate will decrease by is one-half. This is still a substantial feed/steam flow rate and would not result in any appreciable S/G stratification.

E. Sequoyah Natural Circulation Test

During Sequoyah Nuclear Plant's initial startup testing program, special test number 9B (ST-9B) was run. This test demonstrated exceptable boron mixing and cooldown capabilities during natural circulation. As shown in the attached graphs (figure 3 and 4), throughout the test, T-sat tracked T-cold very well.

F. Diablo Canyon Natural Circulation Test

In order to reinforce and validate the test data from Sequoyah, Watts Bar requested T-sat and T-cold data from the recent Diablo Canyon natural circulation test. Attached are graphs (figures 5, 6, 7, and 8) of that data for all four steam generators. T-sat tracked T-cold extremely well down to about 300^{0} F when residual heat removal system (RHR) was put into service.



Δ +
ST-4 S/G#3 T-CØLD VS. T-SAT
DEG F
600.00
587.50
575.00
562.50
550.00
537.50
525.00
512.50
500.00
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
320.00
360.00
400.00
MINUTES
isolated
S.G. # 3
recovery
started

Fig. 1

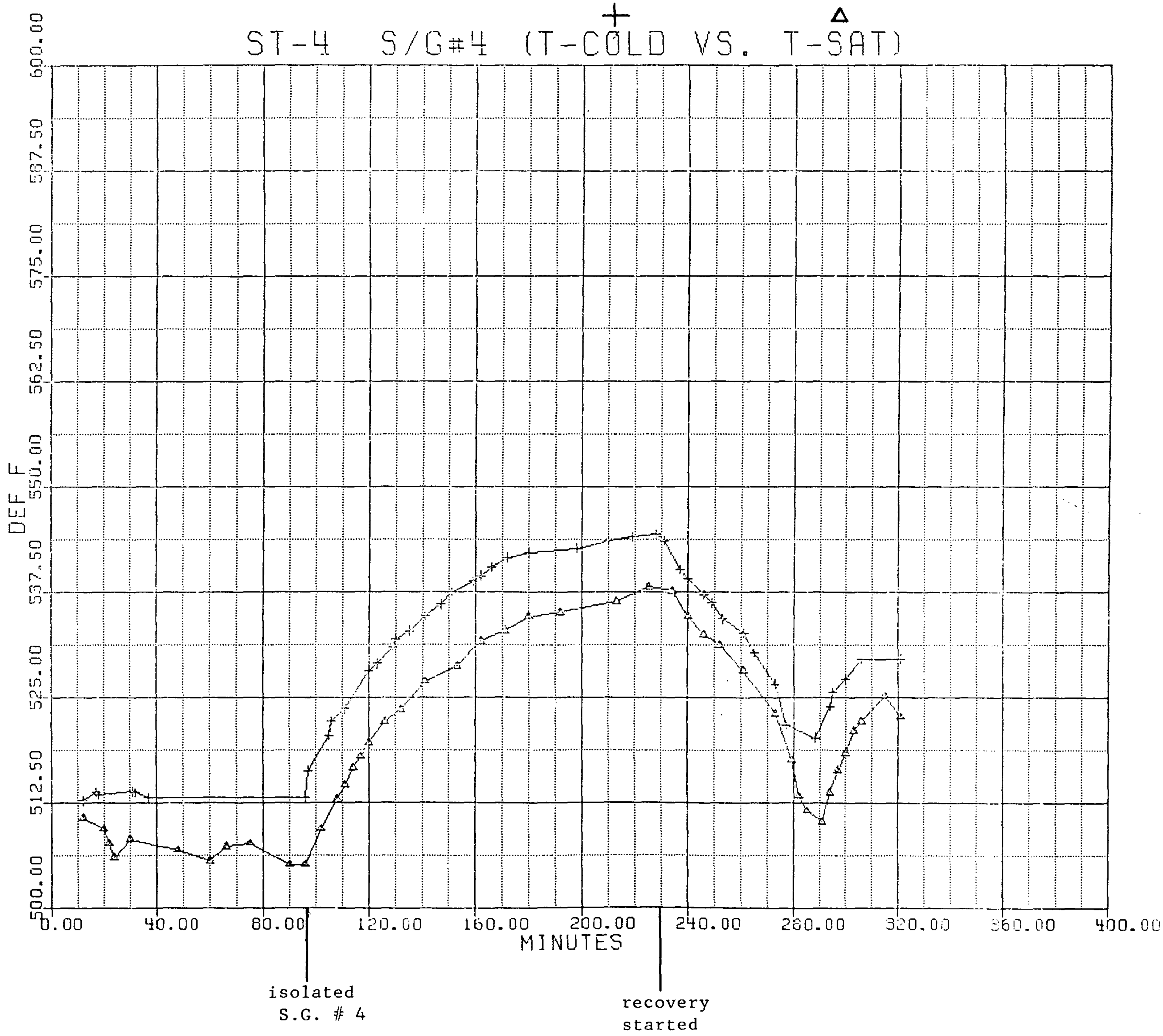

ST-4 S/G#4 (T-COLD VS. T-SAT)
+
Δ
DEG F
MINUTES
600.00
587.50
575.00
562.50
550.00
537.50
525.00
512.50
500.00
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
320.00
360.00
400.00
isolated
S.G. # 4
recovery
started

Fig. 2

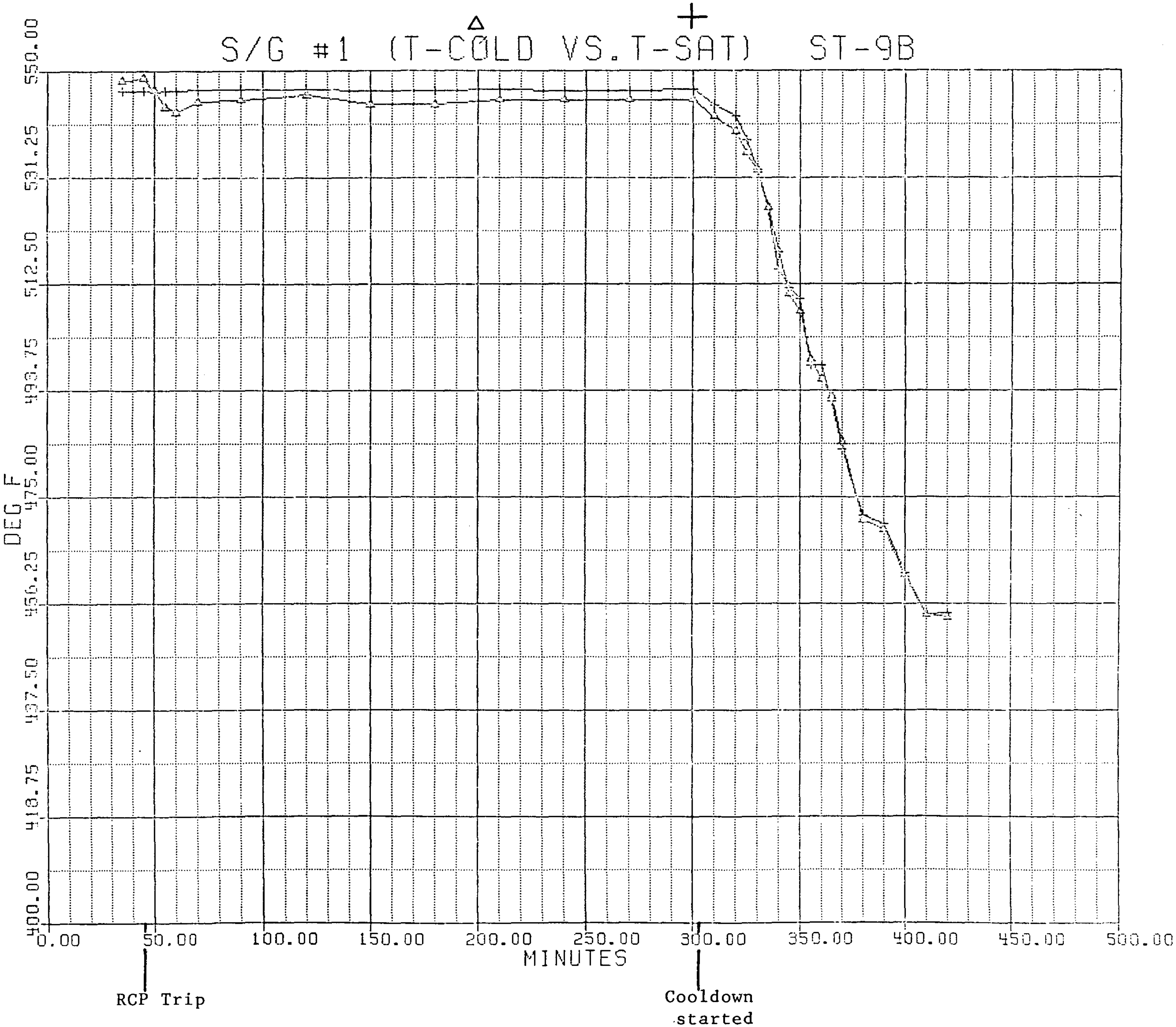
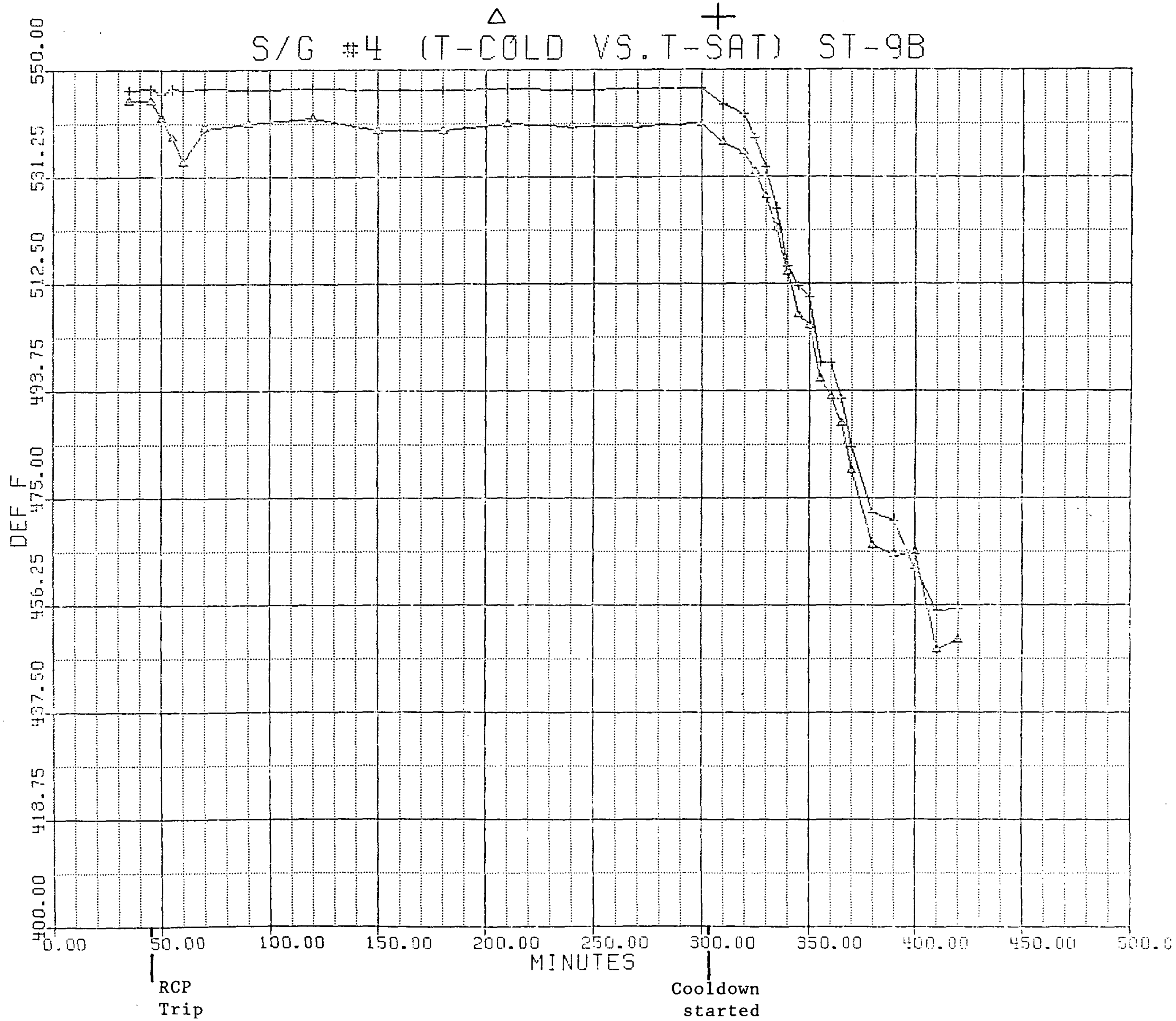

S/G #1 (T-COLD VS. T-SAT) ST-9B
DEG F
550.00
531.25
512.50
493.75
475.00
456.25
437.50
418.75
400.00
MINUTES
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
500.00
RCP Trip
Cooldown started

Fig. 3



△ +
S/G #4 (T-COLD VS. T-SAT) ST-9B
DEF F
550.00
531.25
512.50
493.75
475.00
456.25
437.50
418.75
400.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
500.00
MINUTES
RCP Trip
Cooldown started

Fig. 4

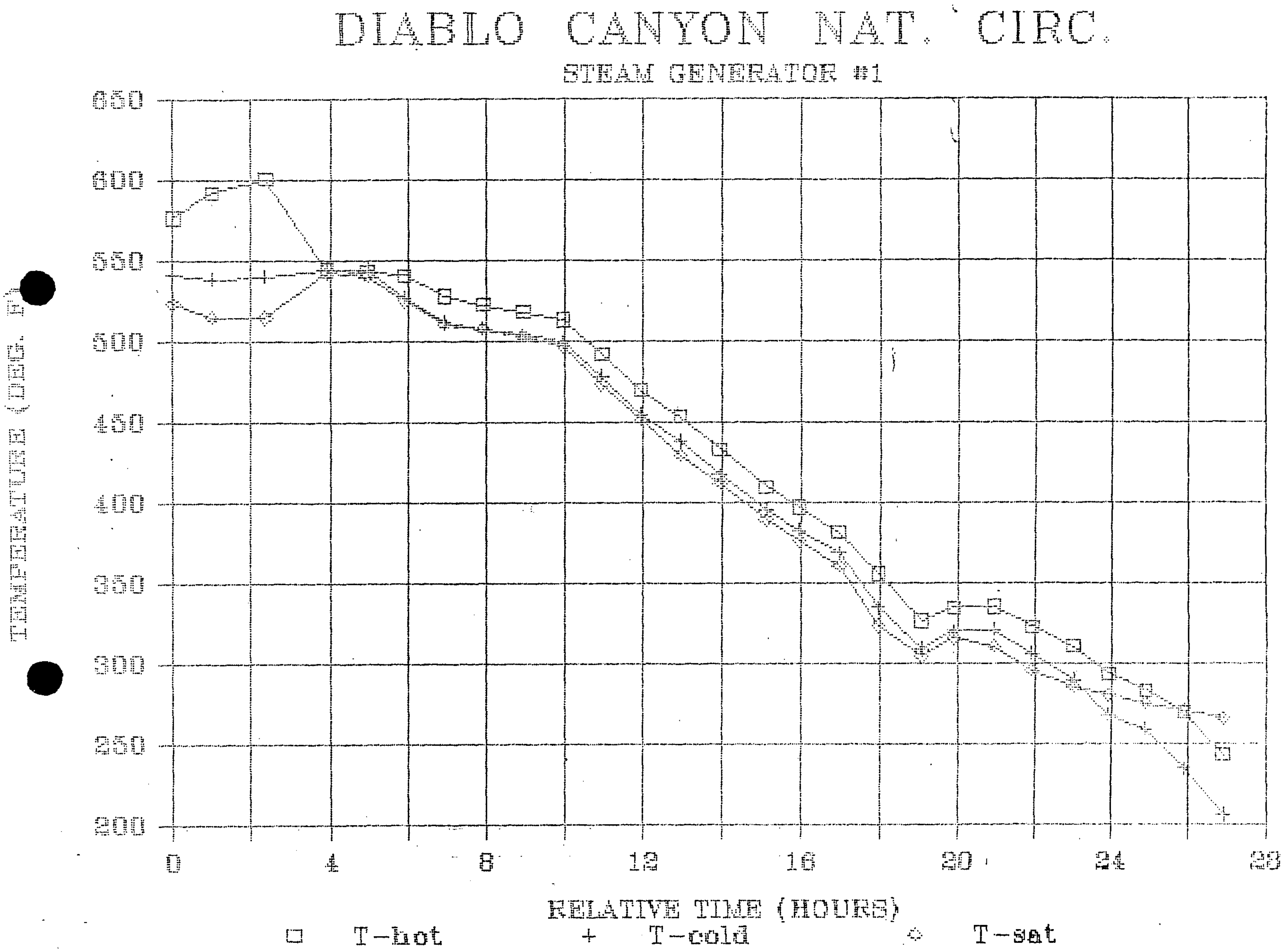

DIABLO CANYON NAT. CIRC.
STEAM GENERATOR #1
650
600
550
500
450
400
350
300
250
200
TEMPERATURE (DEG. F)
0
4
8
12
16
20
24
28
RELATIVE TIME (HOURS)
T-hot
T-cold
T-sat

Fig. 5

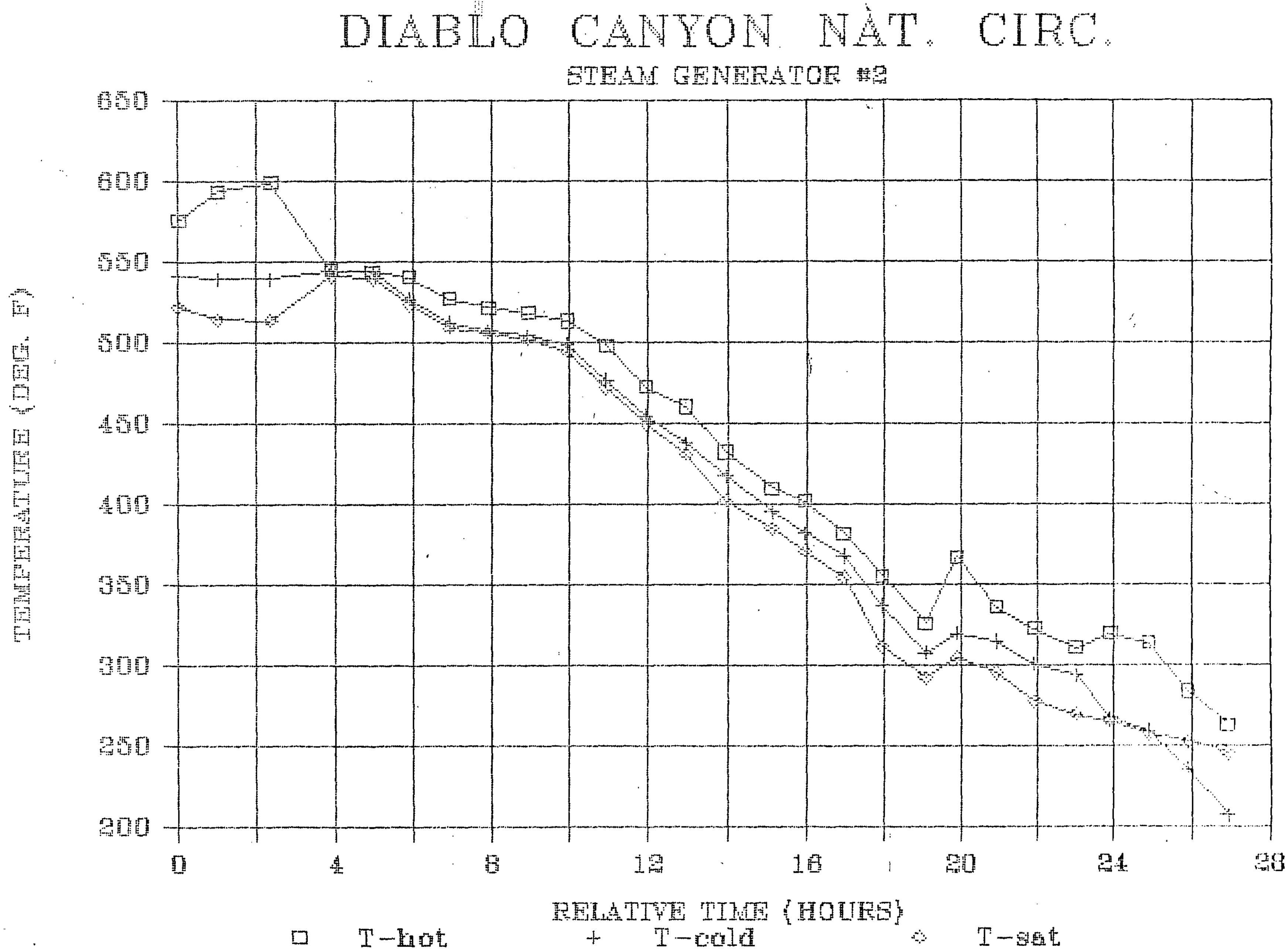

DIABLO CANYON NAT. CIRC.
STEAM GENERATOR #2
650
600
550
500
450
400
350
300
250
200
TEMPERATURE (DEG. F)
0
4
8
12
16
20
24
28
RELATIVE TIME (HOURS)
T-hot
T-cold
T-sat

Fig. 6

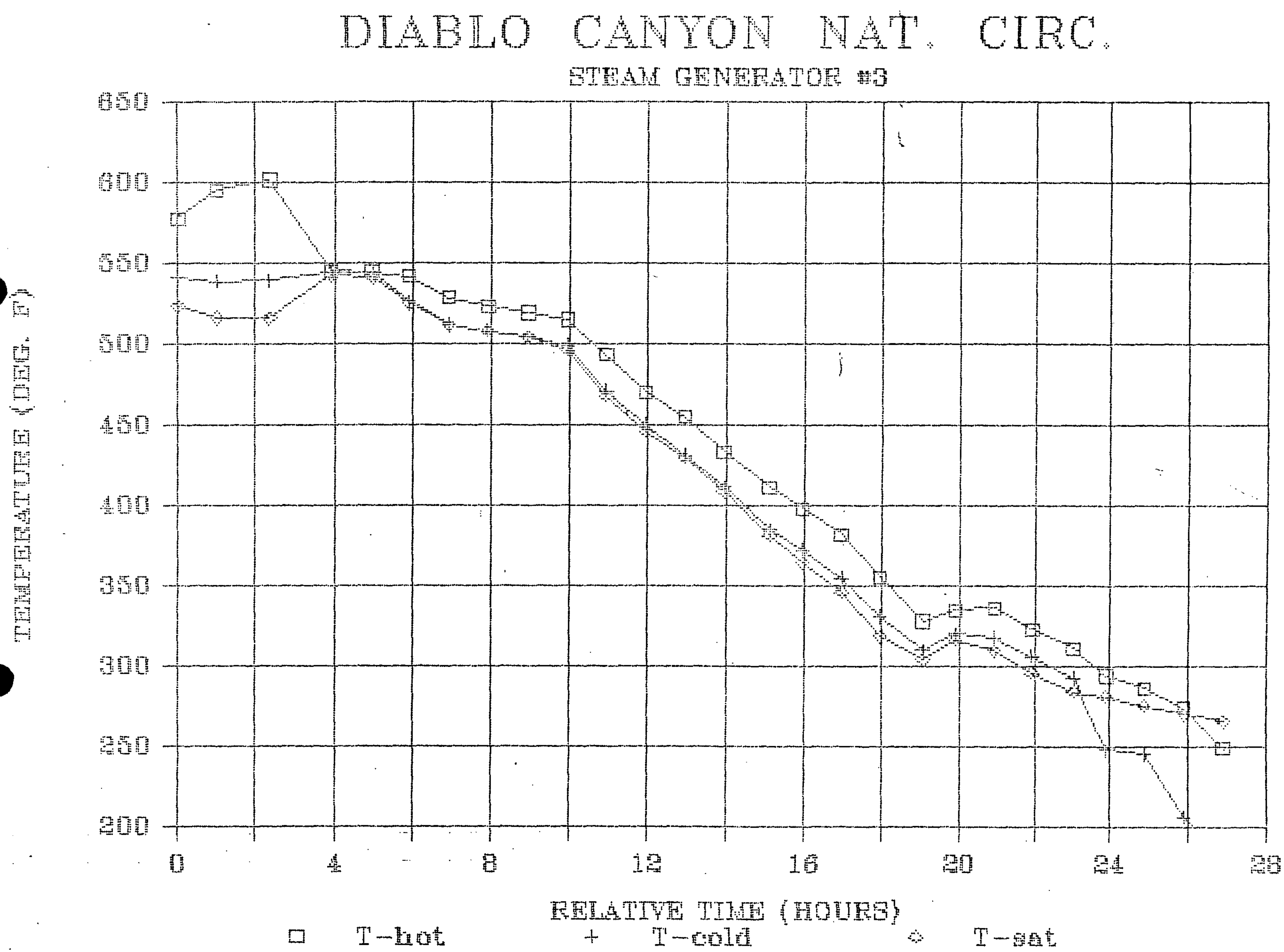
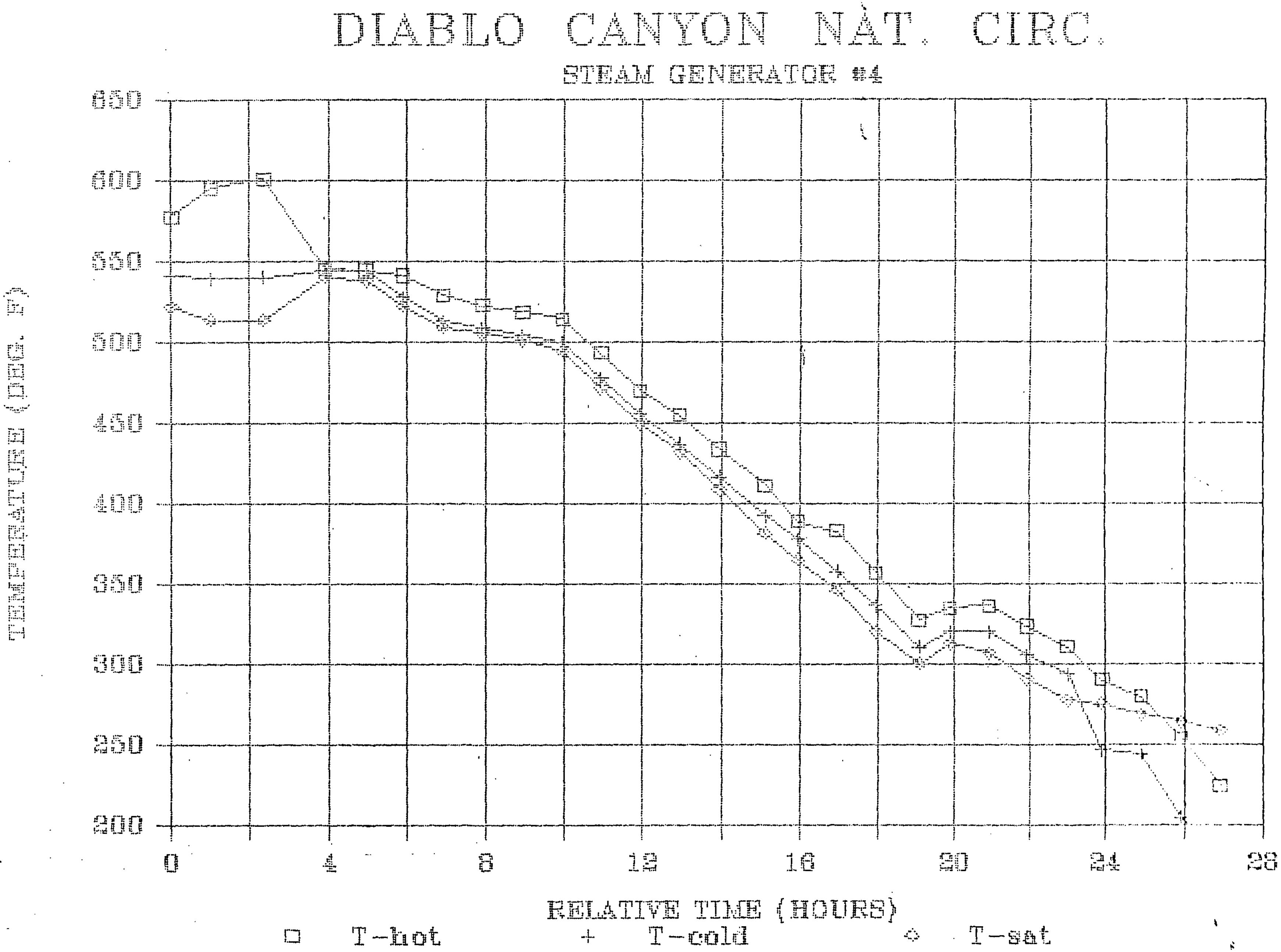
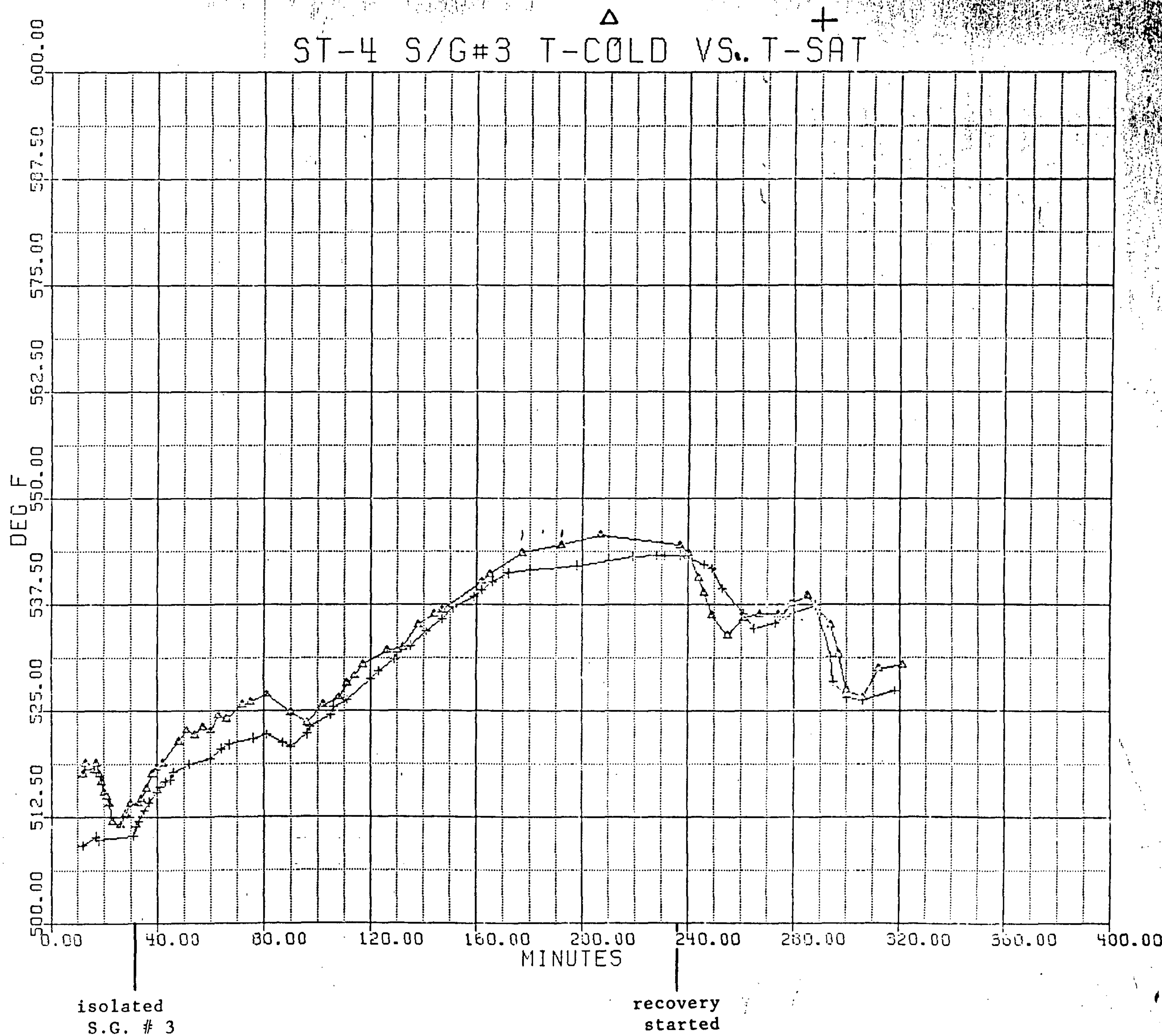

DIABLO CANYON NAT. CIRC.
STEAM GENERATOR #3
650
600
550
500
450
400
350
300
250
200
TEMPERATURE (DEG. F)
0
4
8
12
16
20
24
28
RELATIVE TIME (HOURS)
T-hot
T-cold
T-sat

Fig. 7



DIABLO CANYON NAT. CIRC.
STEAM GENERATOR #4
TEMPERATURE (DEG. F)
650
600
550
500
450
400
350
300
250
200
0
4
8
12
16
20
24
28
RELATIVE TIME (HOURS)
□ T-hot
+ T-cold
◇ T-sat

Fig. 8



ST-4 S/G#3 T-COLD VS. T-SAT
△
+
DEG F
600.00
587.50
575.00
562.50
550.00
537.50
525.00
512.50
500.00
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
320.00
360.00
400.00
MINUTES
isolated S.G. # 3
recovery started

Fig. 1

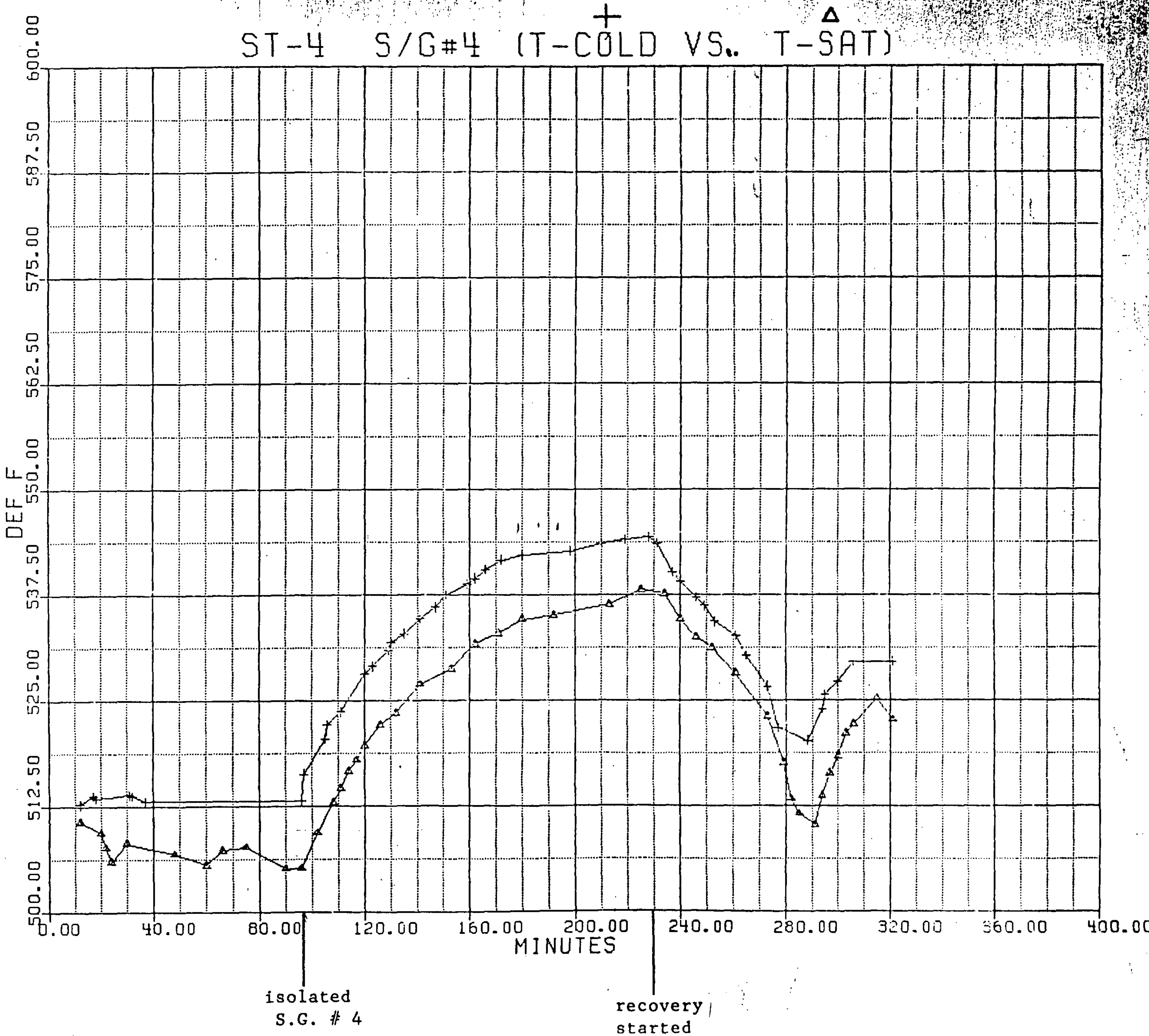
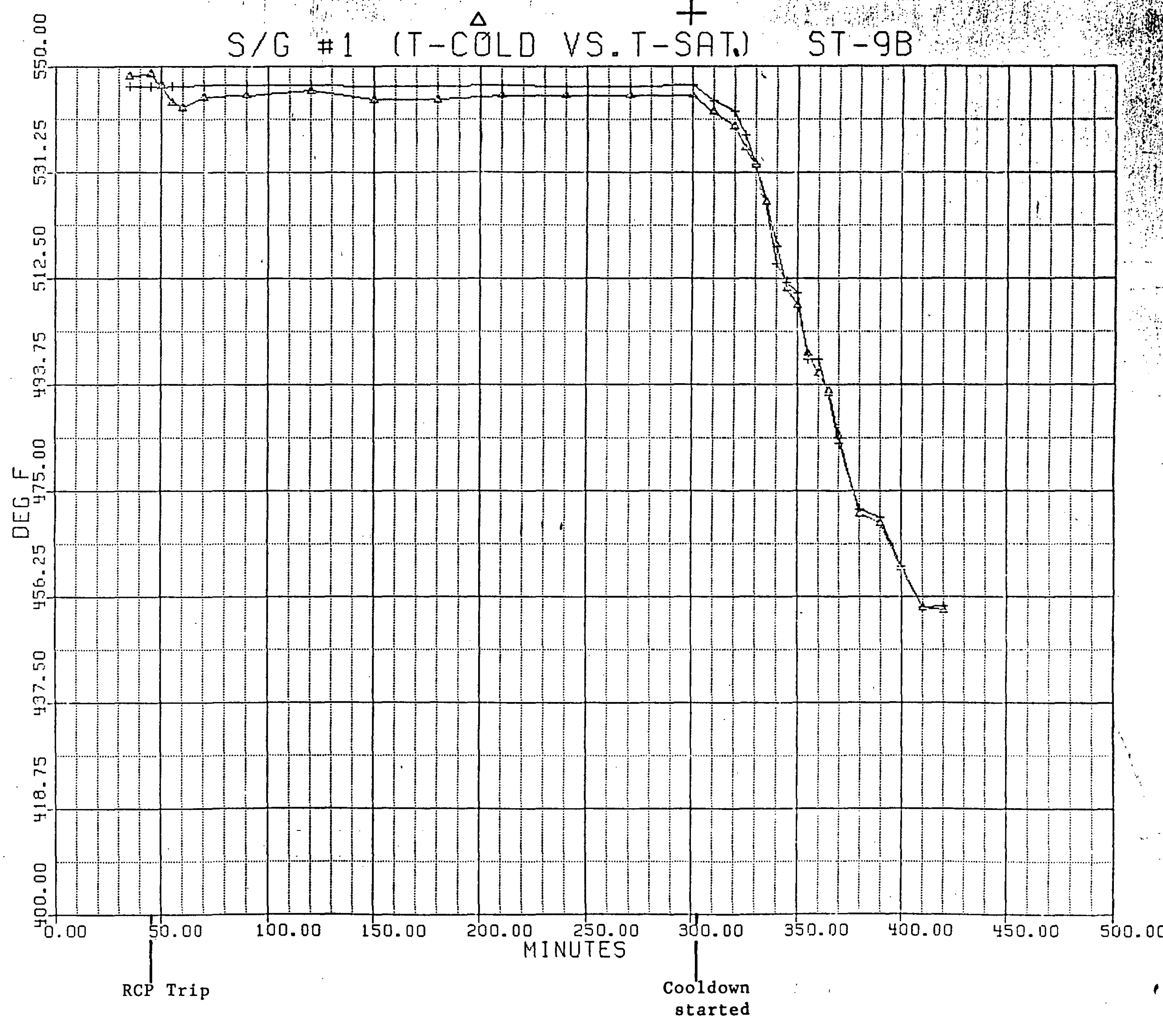
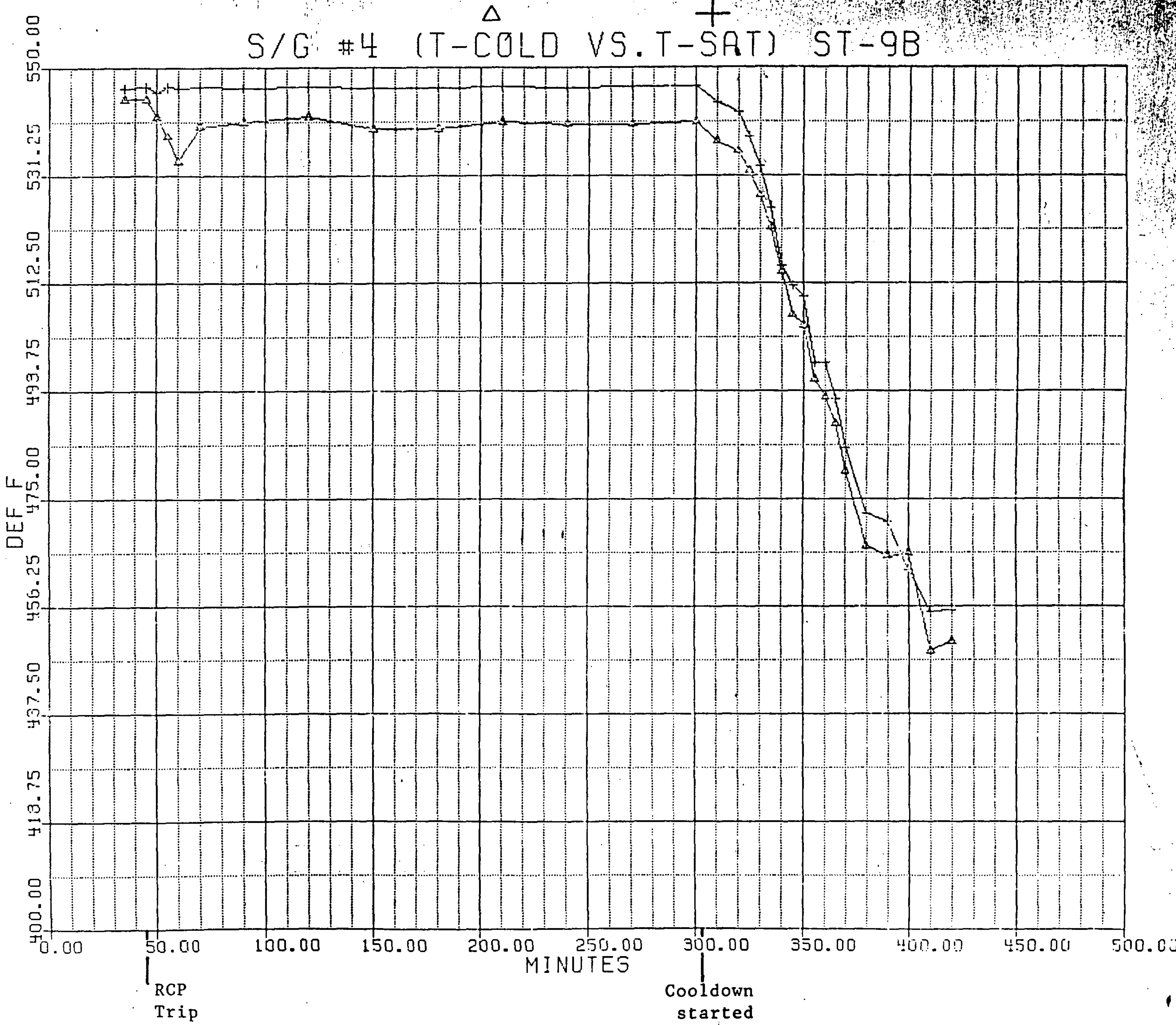

+ Δ
ST-4 S/G#4 (T-COLD VS. T-SAT)
DEF F
600.00
587.50
575.00
562.50
550.00
537.50
525.00
512.50
500.00
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
320.00
360.00
400.00
MINUTES
isolated
S.G. # 4
recovery
started

Fig. 2



Δ +
S/G #1 (T-COLD VS. T-SAT) ST-9B
DEG F
550.00
531.25
512.50
493.75
475.00
456.25
437.50
418.75
400.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
500.00
MINUTES
RCP Trip
Cooldown
started

Fig. 3



Δ +
S/G #4 (T-COLD VS. T-SAT) ST-9B
DEG F
550.00
531.25
512.50
493.75
475.00
456.25
437.50
418.75
400.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
500.00
MINUTES
RCP Trip
Cooldown started

Fig. 4

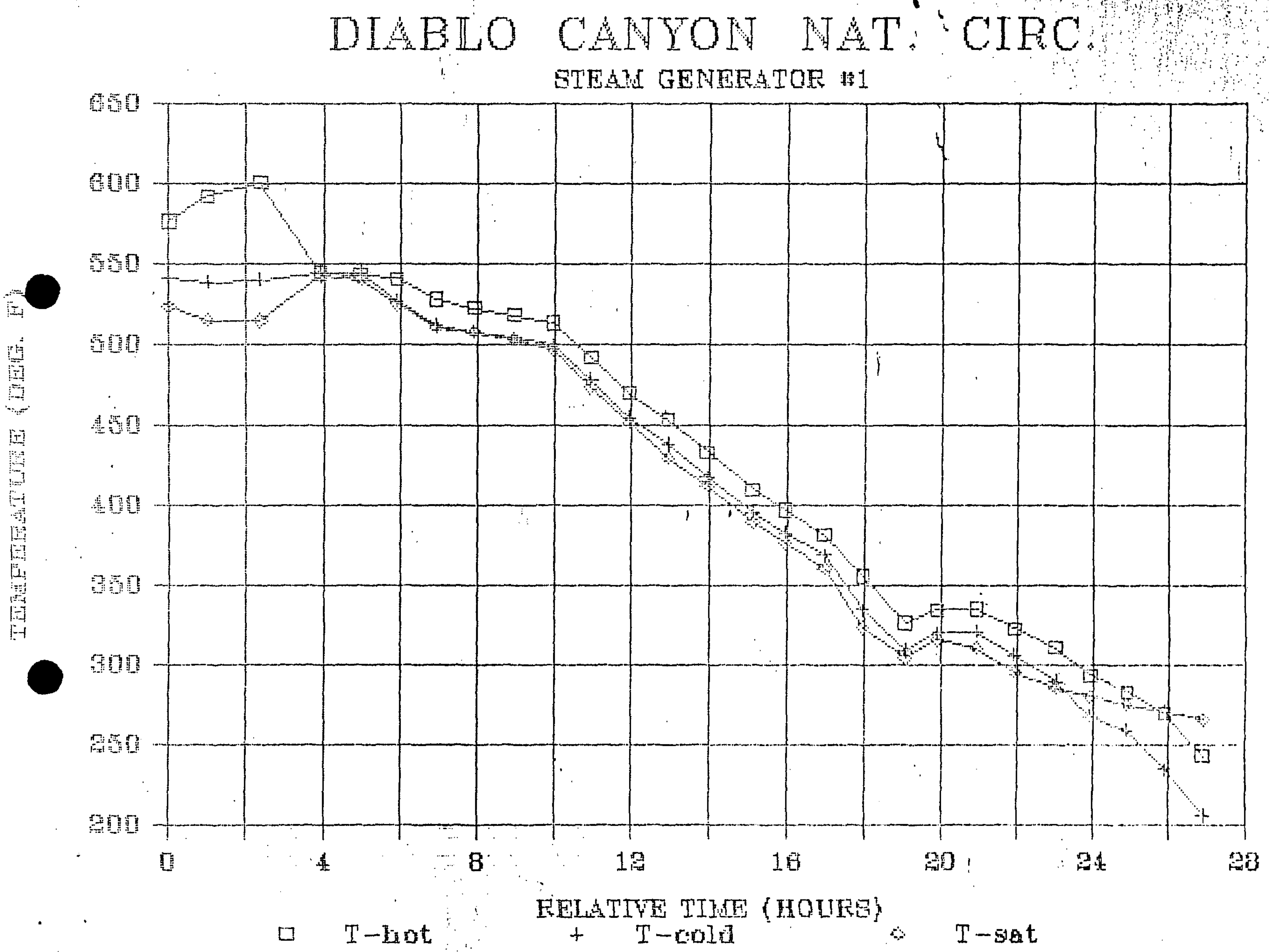
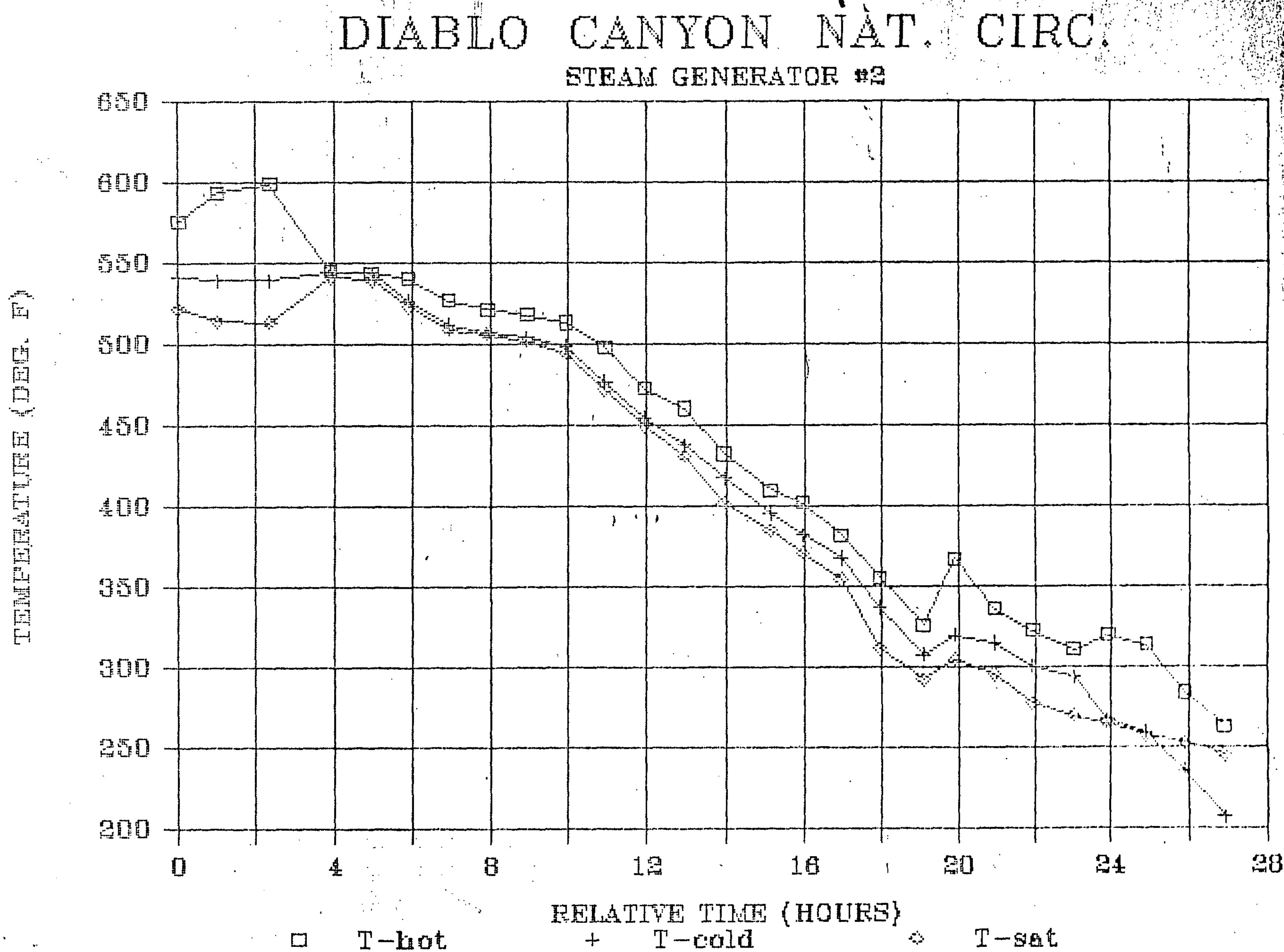

DIABLO CANYON NAT. CIRC.
STEAM GENERATOR #1
TEMPERATURE (DEG. F)
650
600
550
500
450
400
350
300
250
200
0
4
8
12
16
20
24
28
RELATIVE TIME (HOURS)
T-hot
T-cold
T-sat

Fig. 5



DIABLO CANYON NAT. CIRC.
STEAM GENERATOR #2
TEMPERATURE (DEG. F)
650
600
550
500
450
400
350
300
250
200
0
4
8
12
16
20
24
28
RELATIVE TIME (HOURS)
T-hot
T-cold
T-sat

Fig. 6

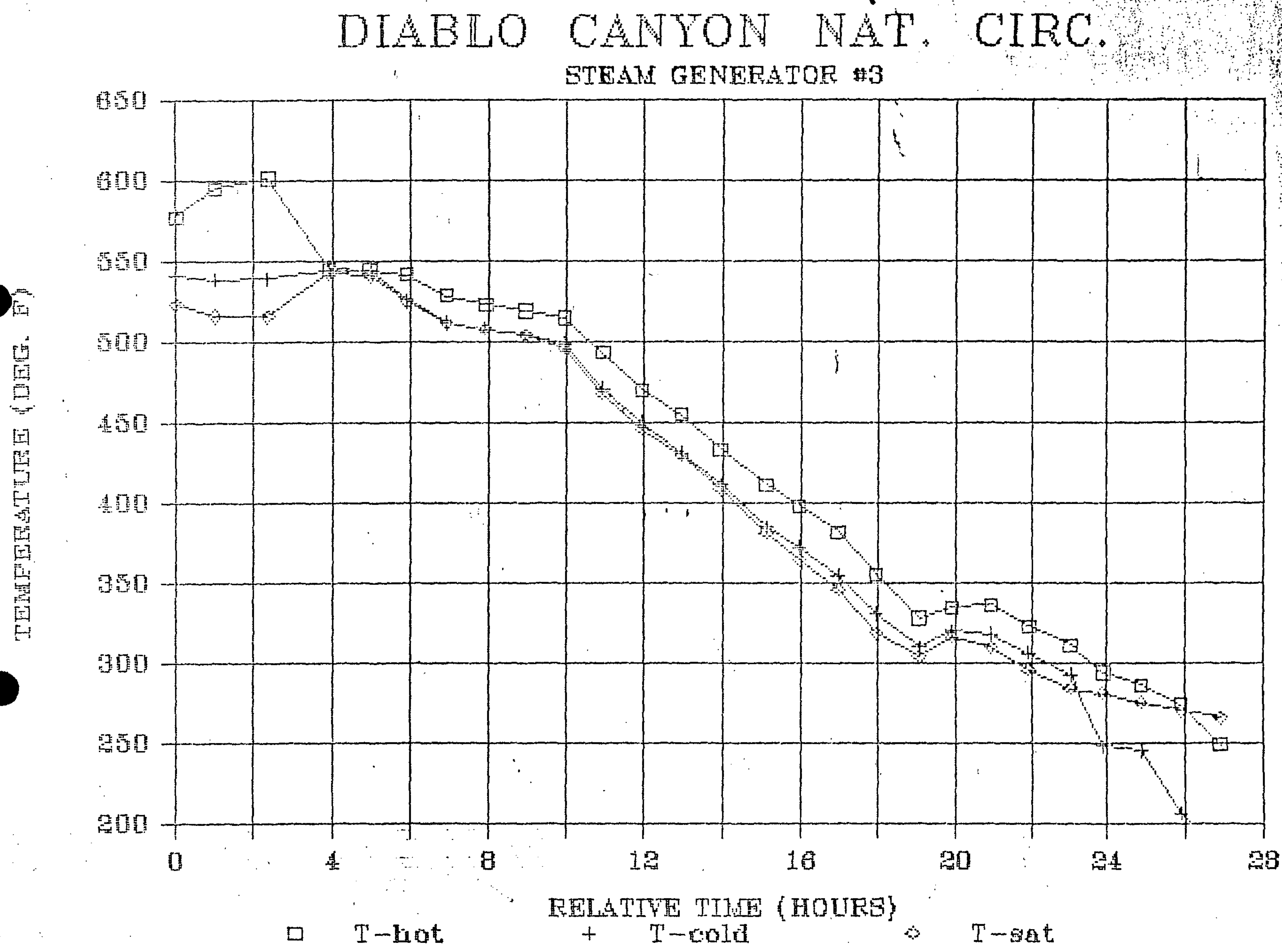
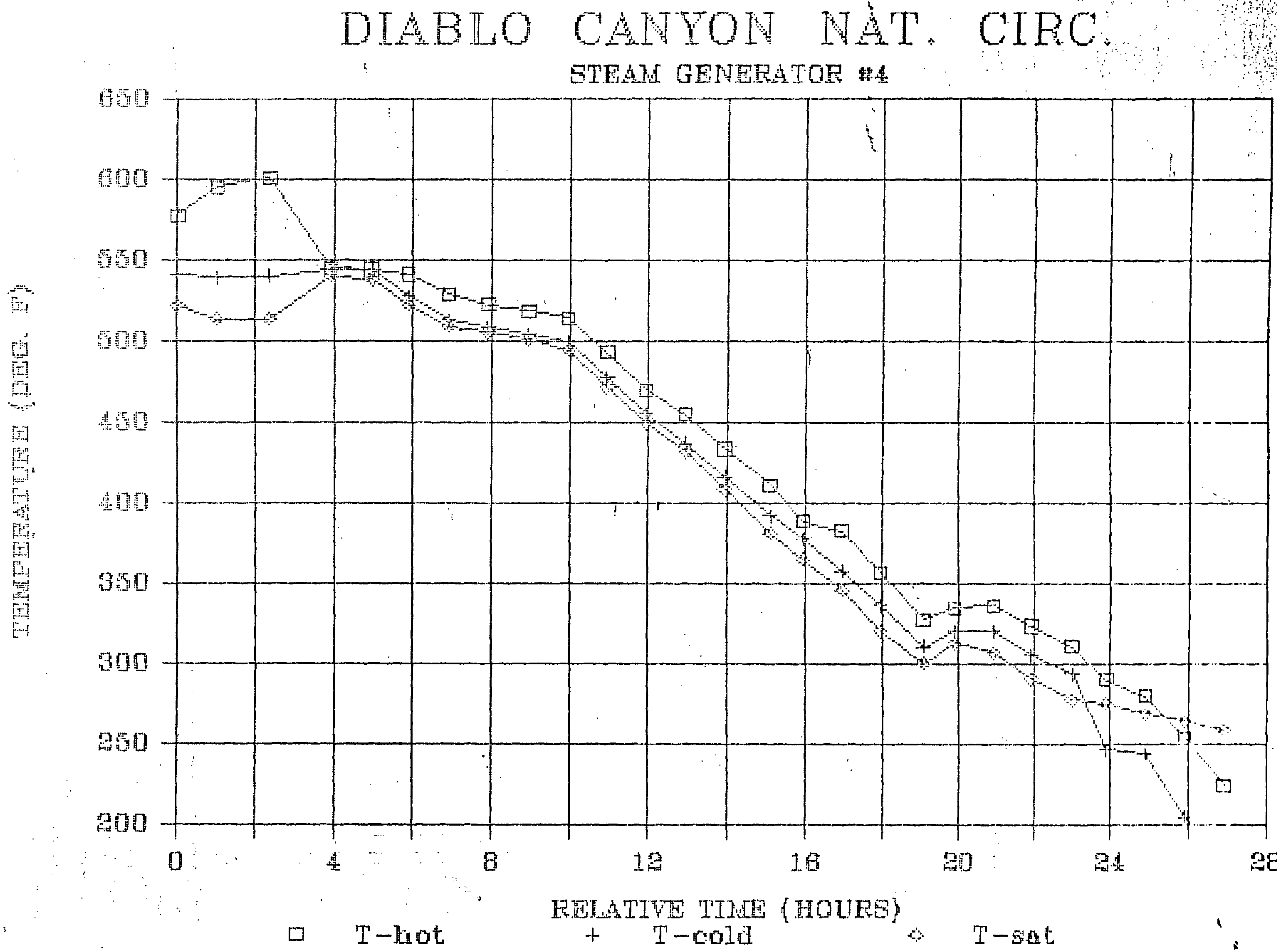

DIABLO CANYON NAT. CIRC.
STEAM GENERATOR #3
TEMPERATURE (DEG. F)
650
600
550
500
450
400
350
300
250
200
0
4
8
12
16
20
24
28
RELATIVE TIME (HOURS)
T-hot
T-cold
T-sat

Fig. 7



DIABLO CANYON NAT. CIRC.
STEAM GENERATOR #4
TEMPERATURE (DEG. F)
650
600
550
500
450
400
350
300
250
200
0
4
8
12
16
20
24
28
RELATIVE TIME (HOURS)
T-hot
T-cold
T-sat

Fig. 8