FORT ST. VRAIN ACCIDENT REANALYSIS CODE (RECA3)
VERIFICATION FOLLOWING A REGION OUTLET TEMPERATURE REDISTRIBUTION

References:
(1) "Response .. NRC Question 222.001," transmitted via P-78138 dated August 11, 1978.

(2) Safety Evaluation Report by the Office of Nuclear Reactor Regulation Supporting Amendment 22 to Facility Operating License No. DPR-34 of Public Service Company of Colorado, Fort St. Vrain Nuclear Generating Station, Docket No. 50-267, dated August 19, 1980.

(3) "Fort St. Vrain Accident Reanalysis Code (RECA3) Verification with Region Constraint Devices Installed," transmitted via P-81303 dated December 1, 1981.

(4) Safety Evaluation Report by the Office of Nuclear Reactor Regulation Supporting Amendment 23 to Facility Operating License No. DPR-34 of Public Service Company of Colorado, Fort St. Vrain Nuclear Generating Station, Docket No. 50-267, dated March 16, 1981.

(5) "Testing at Fort St. Vrain After Installation of Region Constraint Devices," transmitted via P-81047 dated February 5, 1981.

The Reactor Emergency Cooling Analysis (RECA3) code has been utilized in the reanalysis of several of the bounding accident cases postulated in the Fort St. Vrain Final Safety Analysis Report (FSAR). In support of this use of RECA3 and in response to NRC questions, certain verification information was submitted to the Commission in 1978 (Reference 1). As a part of this code verification package, comparisons were made between measured and calculated core region outlet temperatures for four scram transients which occurred during operation of the plant prior to installation of the region constraint devices (RCDs).

In the Safety Evaluation Report supporting Amendment 22 to the Fort St. Vrain Operating License (Reference 2), the Staff expressed concern over the discrepancy between some predicted and measured core region outlet temperatures presented in the comparison of RECA3 predictions and scram data. These discrepancies occurred in the seven regions (numbered 32 through 37 and 20) located in the northwest quadrant of the outside ring of the core. In these regions, the code underpredicted the measured region outlet temperature by as much as 50°F to 100°F in the 40 to 70 minute time frame of the cooldown following the scram. Agreement between RECA3 predictions and all other measured region outlet temperatures was good.

As a result of the expressed concern, the Staff required an additional comparison of predicted and measured core region outlet temperatures during a scram transient subsequent to the installation of the RCDs. Further, the Staff required acceptable[1] predictions including resolution of the northwest quadrant discrepancies prior to operation at full power.

The scram transient of July 8, 1980, was chosen as the subject of the above-described comparison. Results were submitted to the NRC in Reference 3. These showed that predictive uncertainties were not abnormally excessive and that discrepancies in the northwest quadrant were resolved by installation of the RCDs and the use of calculated region peaking factors (RPFs)[2] in the RECA3 simulation. Staff concurrence is documented in Reference 4.

Although no core region outlet temperature fluctuations have been detected following RCD installation, individual core region outlet temperature redistributions have been observed as described in Reference 5. Consequently, at a meeting on February 10, 1981 in Bethesda, the NRC Staff asked that an additional RECA verification analysis be performed for a scram transient following such a redistribution. This work was requested to provide additional evidence of acceptable agreement under post-redistribution conditions.

On April 25, 1981, operation of the plant at 86% power under test conditions was interrupted by a circulator trip. Power was run back as programmed for about two minutes. Subsequently, a reactor trip occurred as a result of high reheat steam temperature, and was followed by a cooldown of the core. This transient occurred about ten hours after a redistribution and was suited for simulation. Therefore, the April 25, 1981 scram transient was selected for comparative analysis.

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[1] Predictive uncertainty should not be abnormally excessive when compared to the average (Reference 2).

[2] Calculated RPFs, described in detail in the Appendix of Reference 3, are the results of Fort St. Vrain core physics calculations. The "measured" RPFs, used throughout the Reference 1 analyses are actually calculated based upon temperature measurements and inferred flows.

Just after the scram, there was a brief (less than one minute) interruption of forced circulation. Following this, primary circulation was reestablished on loop 2 only. At about 50 minutes into the cooldown, there was a five minute period of intermittent cooling during which forced circulation was interrupted for a total of 2.5 minutes. Cooling was again reestablished on loop 2 only. Shortly thereafter, primary coolant flow was stabilized at approximately 15% of rated. At about 90 minutes into the cooldown, primary coolant flow was reduced to 10% of rated. Finally, at about 150 minutes, the operator started closing orifice valves on interior regions in anticipation of restart requirements. The overall cooldown time frame is about the same as that of the July 8, 1980 event.

Methods used were the same as those applied to the analysis of the calculated RPF case of the July 8, 1980 event. The RECA3 core model was initialized with calculated RPFs, indicated orifice valve positions, estimated core inlet temperature (based upon measured circulator inlet helium temperatures) and measured core power. Primary loop flow as measured at the circulator inlet was adjusted downward by 3.5% to bring the RECA-calculated average region outlet temperature into agreement with a best estimate of the actual value. Active core/side reflector flow and leakage flow not passing through the core barrel were calculated utilizing the RECA3 primary loop flow distribution model.

Following the above-described simulation of core initial conditions, a transient calculation was initiated from the 86% power level. This included the two minute runback to the 45% power level at which scram actually occurred. Throughout the transient, core flow was estimated from the measured circulator flow as described above for the initial conditions. Also, core inlet temperature was assumed equal to circulator inlet temperature. Afterheat was calculated based upon plant operating history as applied to the FSAR afterheat curve (FSAR Fig. D.1-9). Both afterheat and runback power were distributed among the regions according to the same calculated RPFs which were used for initialization.

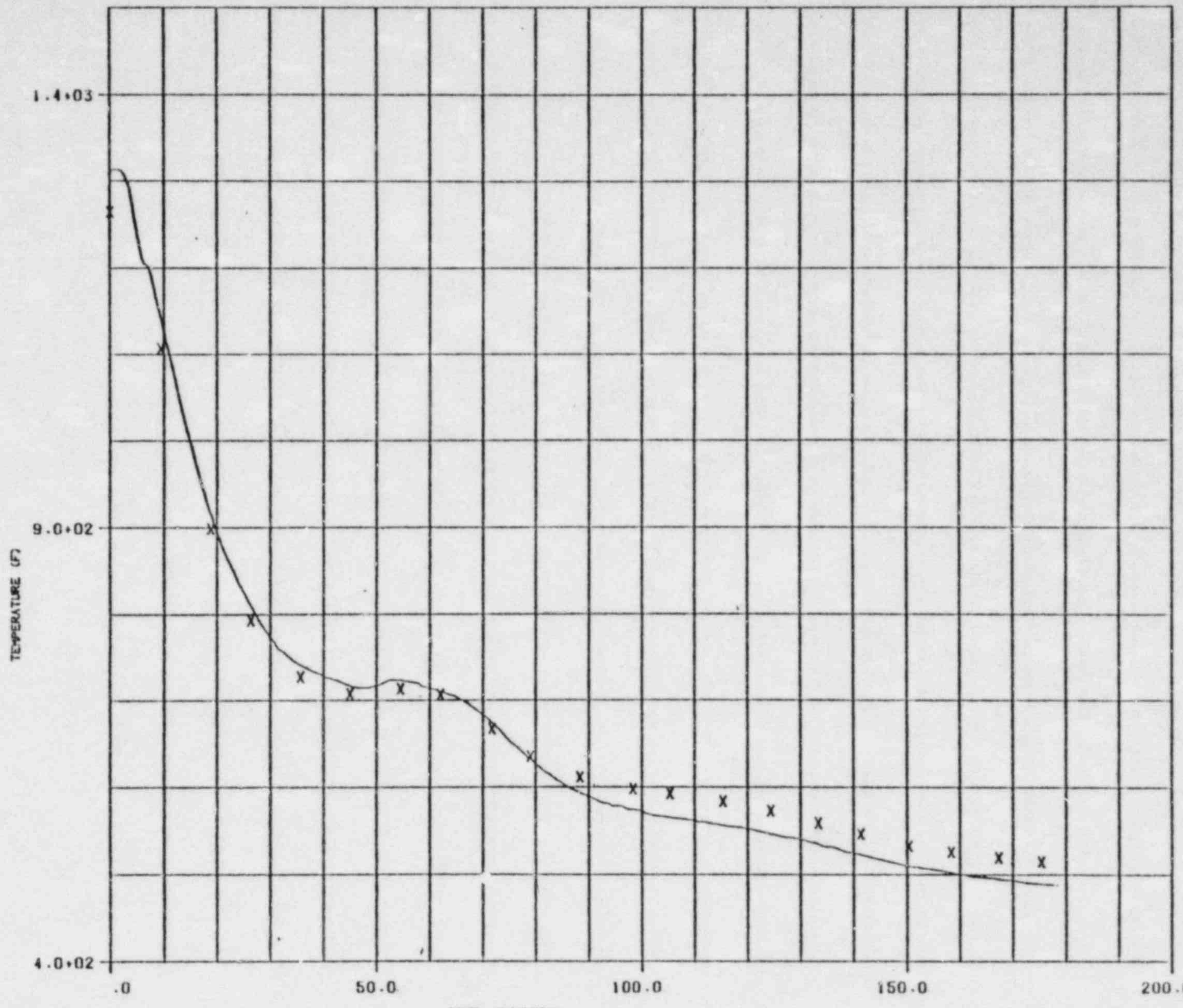
Results of the comparison of predicted and measured core region outlet temperatures after a redistribution are presented in Attachment 1 on a region-by-region basis. Predicted outlet temperatures show good agreement with the measured values. The apparent large differences in some outer regions of the northwest quadrant during the early cooldown are again explained by a steady-state Type II flow which ceases during the cooldown coupled with sensing assembly response characteristics (see Reference 3).

Based on the foregoing considerations and results, it is concluded that region flow and outlet temperature measurement discrepancies can account for the magnitude of the anomalies evident in this RECA3/scram data comparison even following a redistribution. Predictive uncertainties are not abnormally excessive. This analysis further confirms that the temperature measurement discrepancy in the northwest peripheral regions has been correctly diagnosed. Hence, the additional RECA code verification has been completed as requested by the NRC Staff.

ATTACHMENT 1

COMPARISON OF MEASURED DATA (—) TO RECA (X)

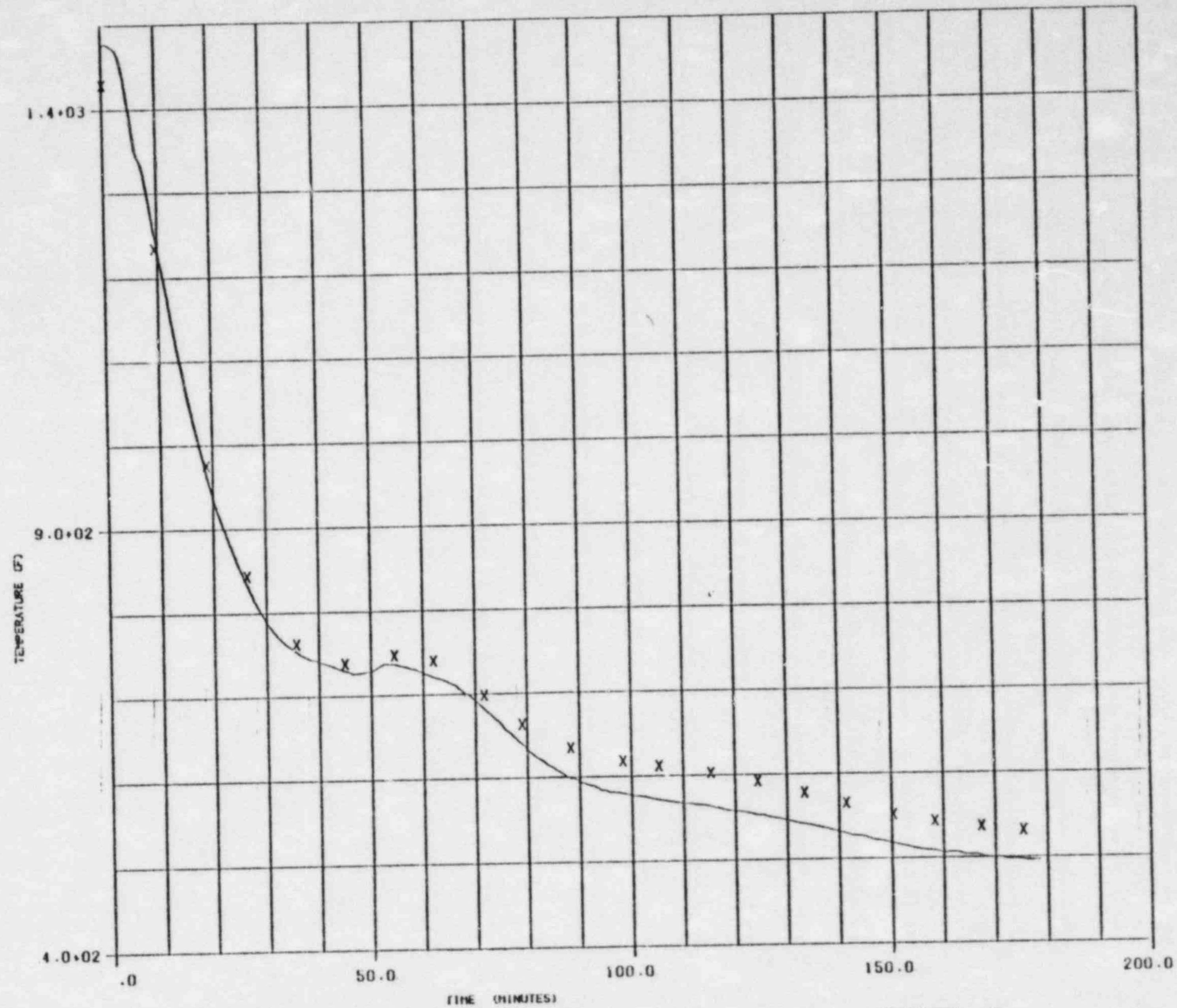
SCRAM FROM 86% POWER ON 04/25/81



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 1

FIGURE 1-1 FRAME 1

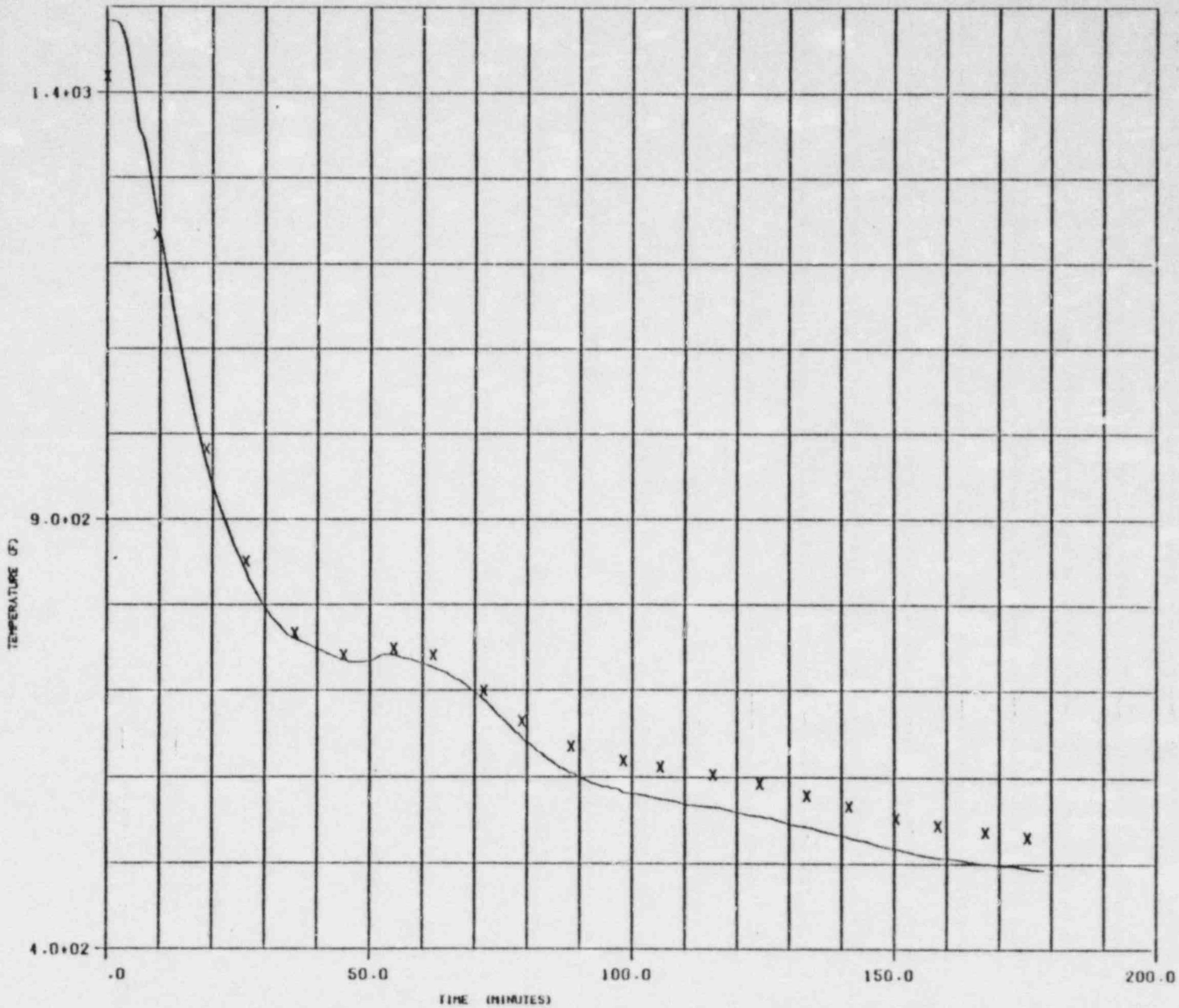
X RECA
– DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 2

FIGURE 1-2 FRAME 2

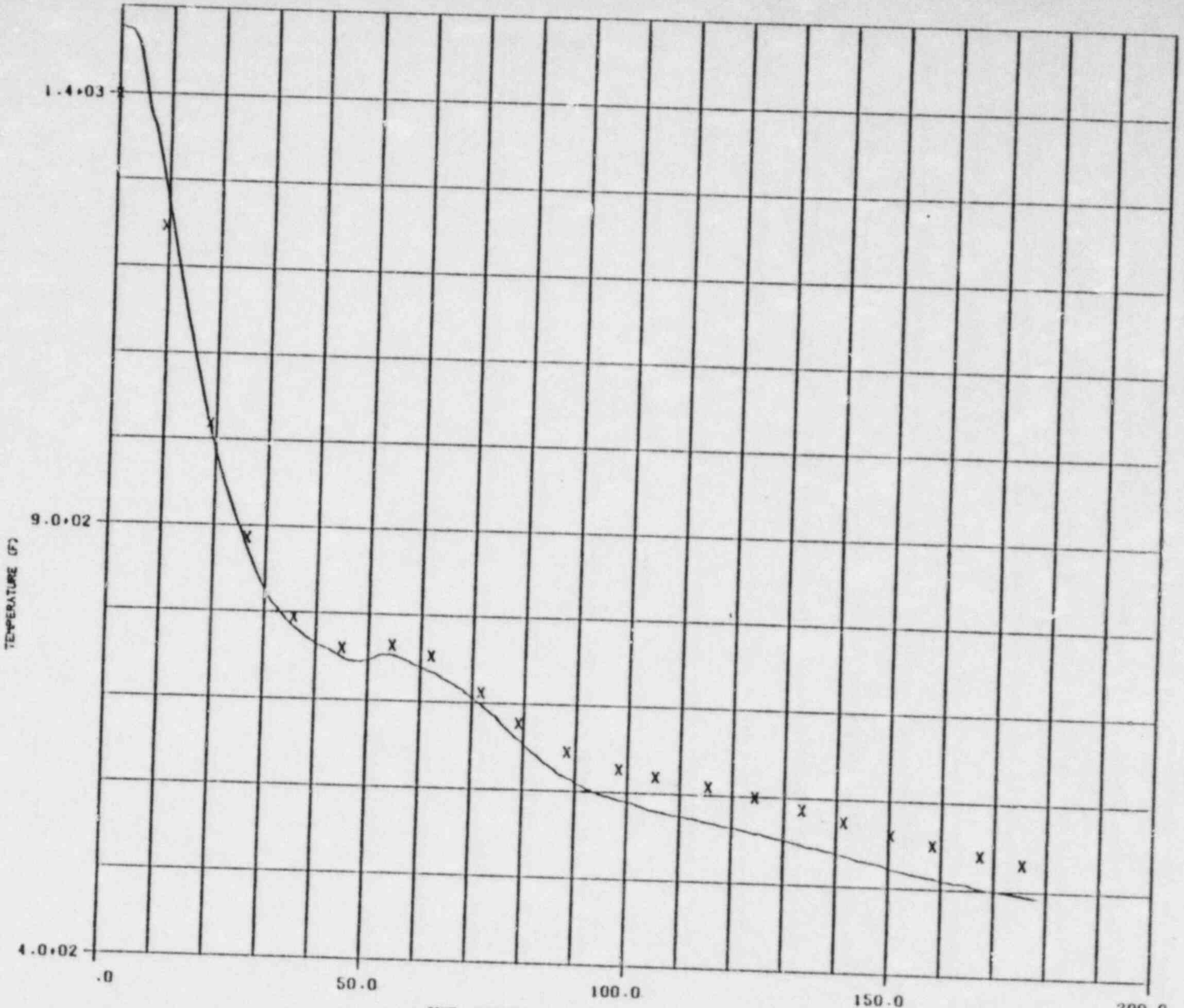
X RECA
- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 3

FIGURE 1-3 FRAME 3

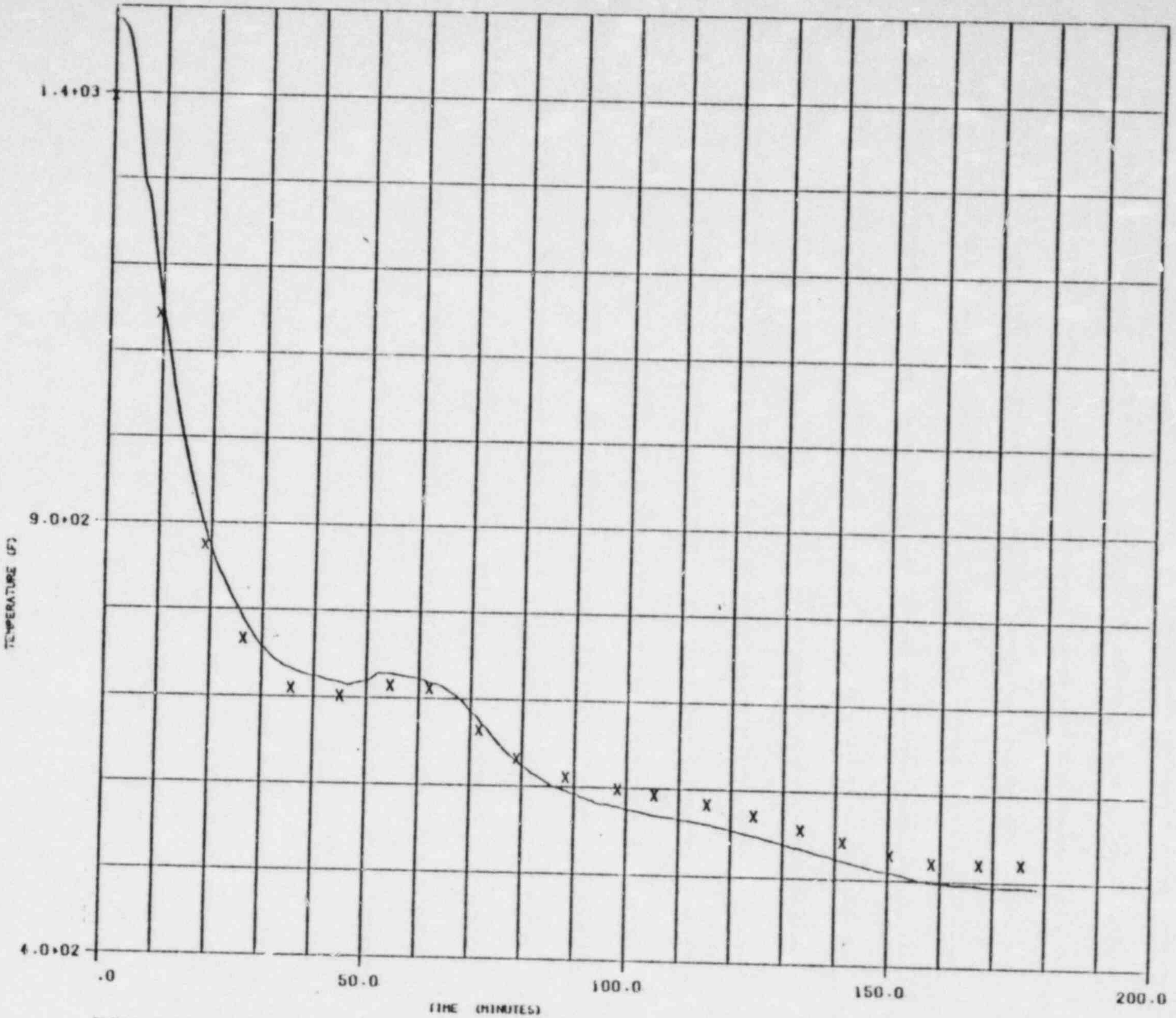
X RECA
- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 4

FIGURE 1-4 FRAME 4

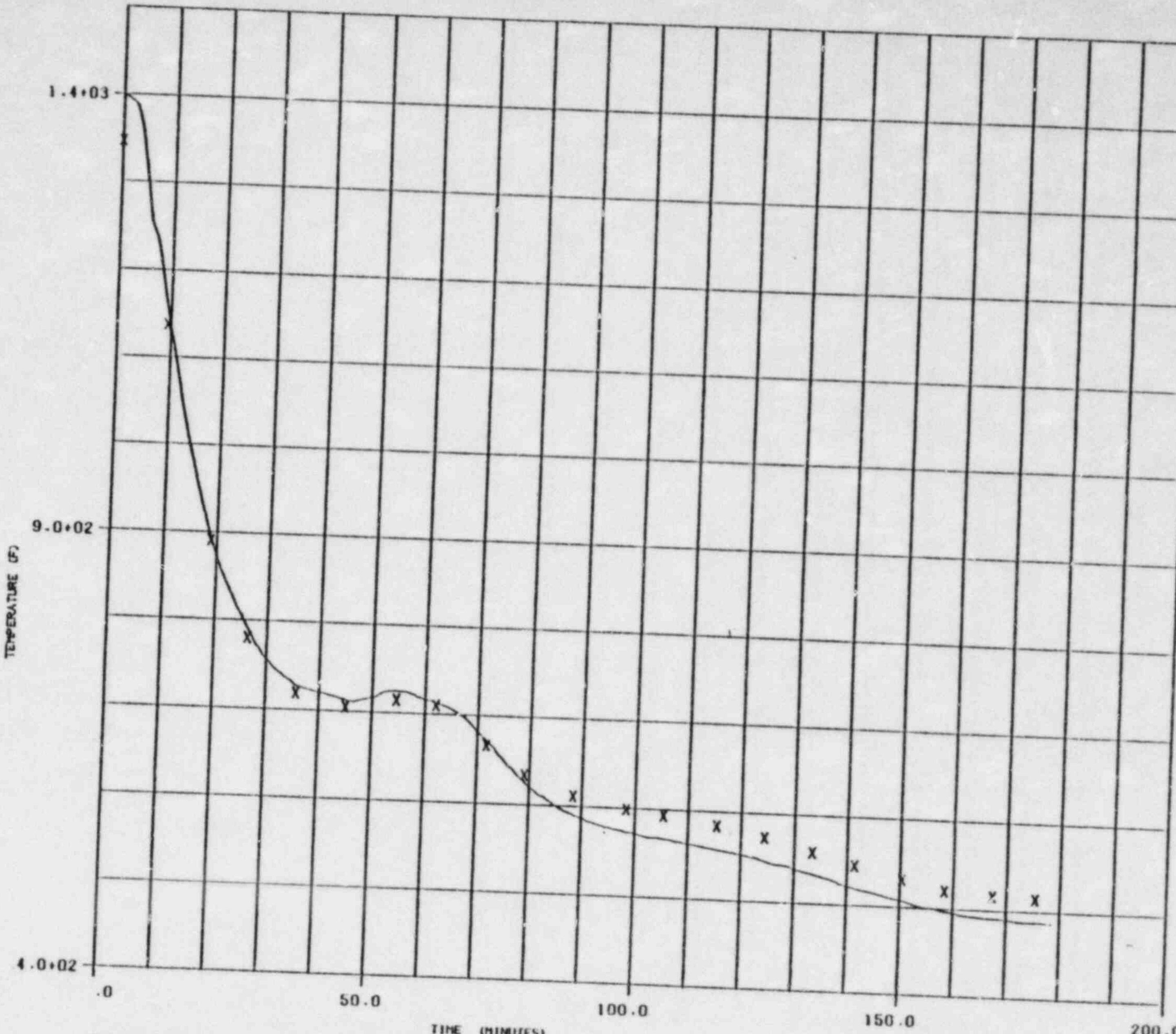
X RECA
\- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 5

FIGURE 1-5 FRAME 5

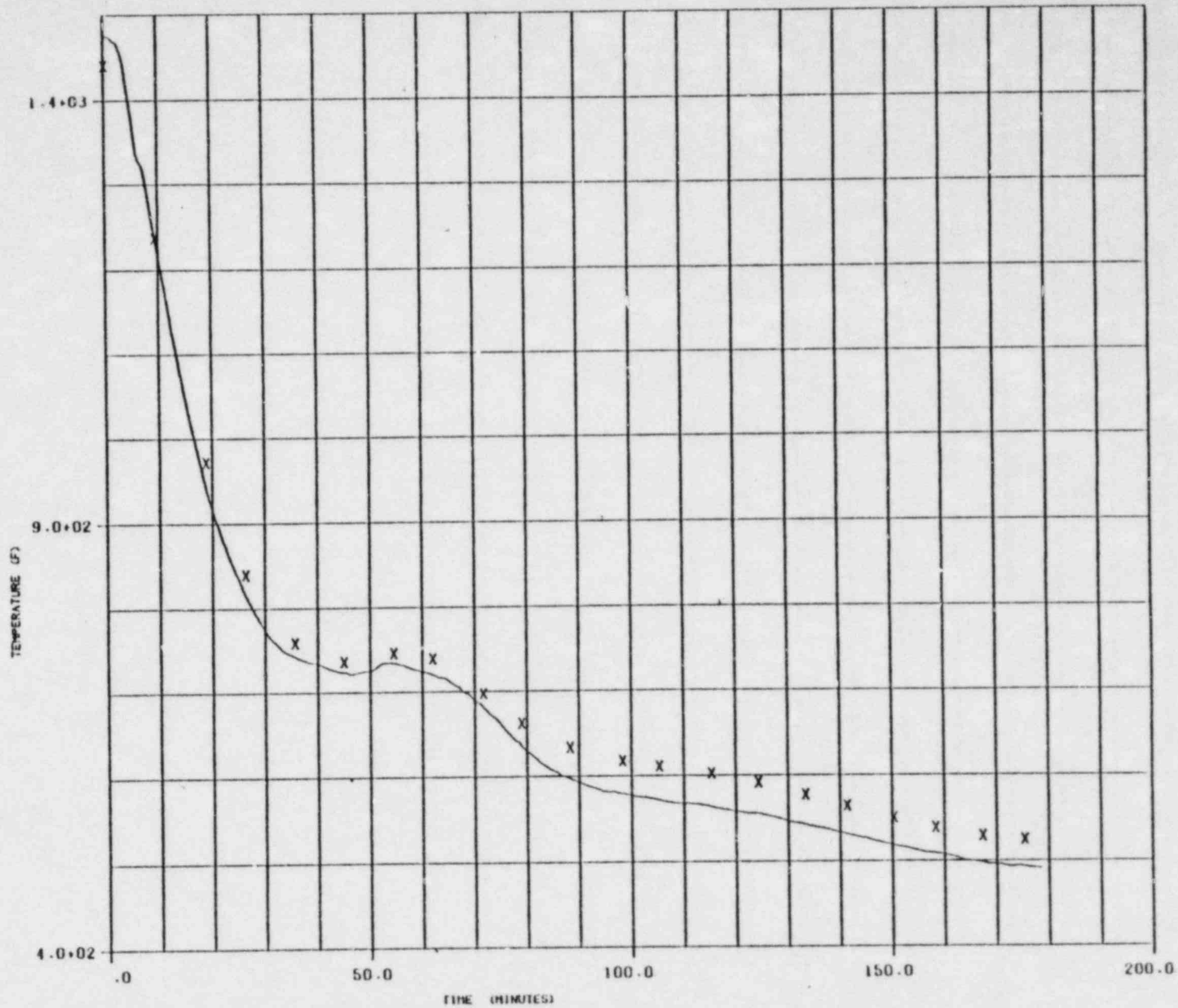
X RECA
\- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 6

FIGURE 1-6 FRAME 6

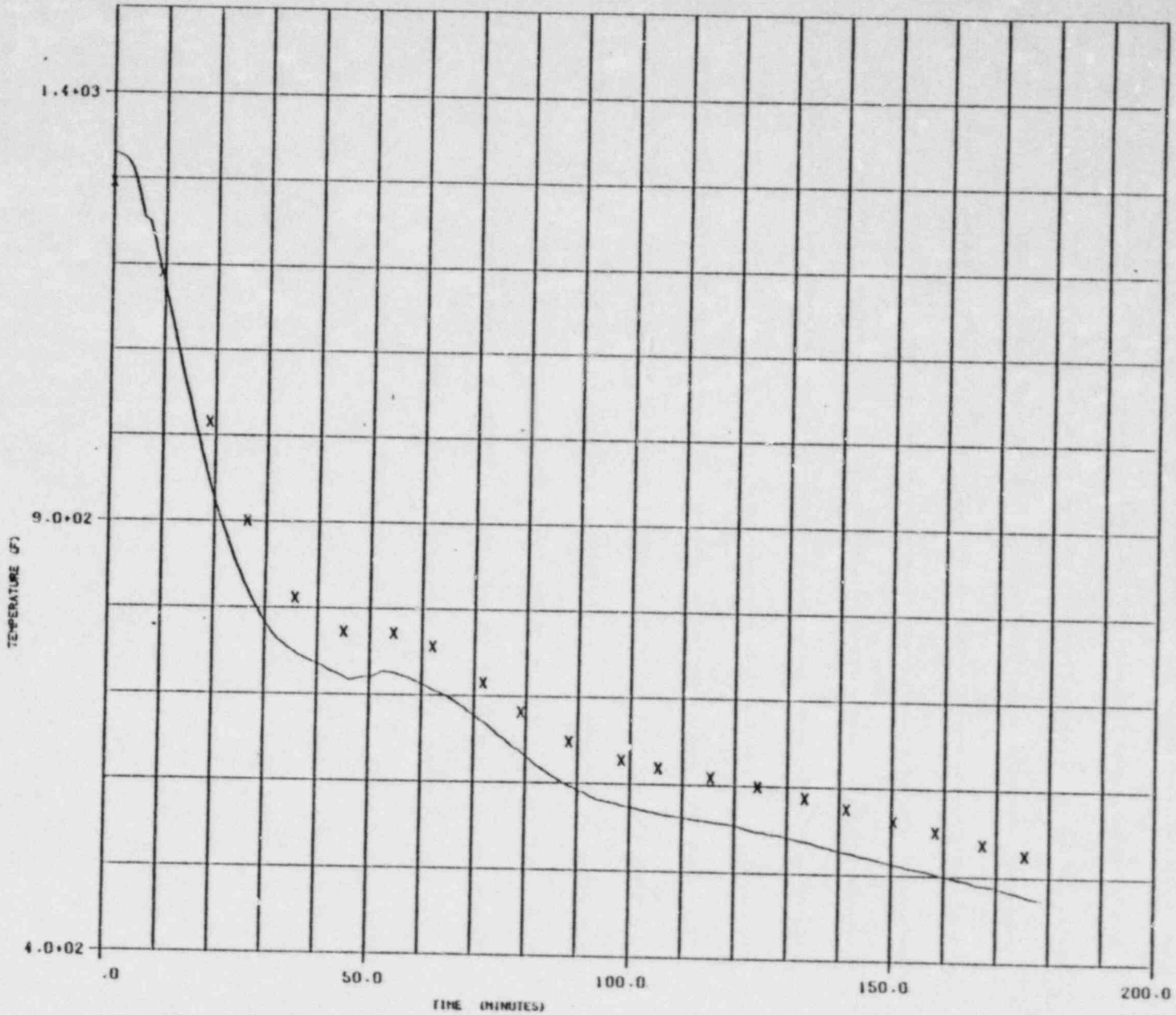
X RECA
\- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 7

FIGURE 1-7 FRAME 7

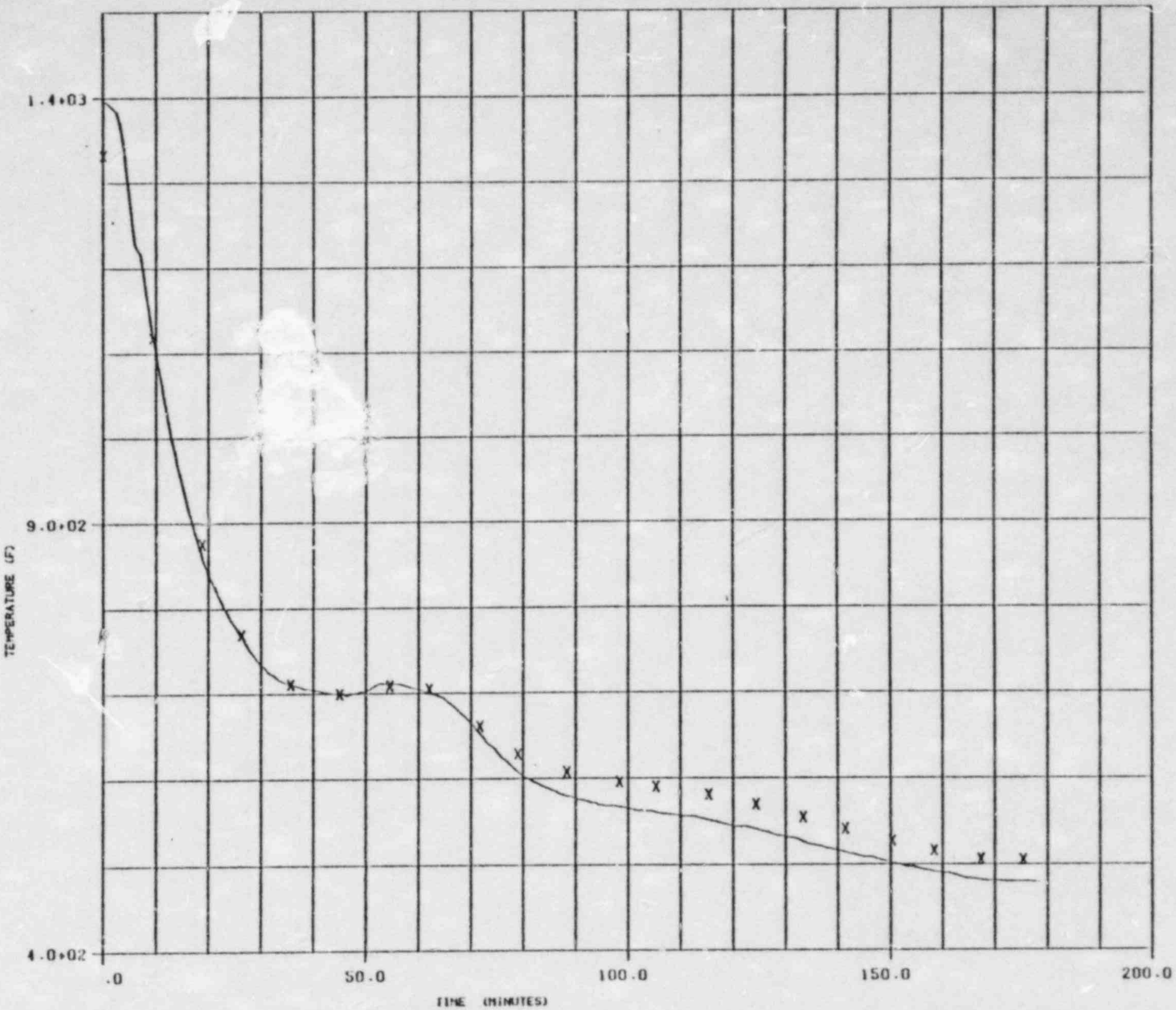
X RECA
\- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 8

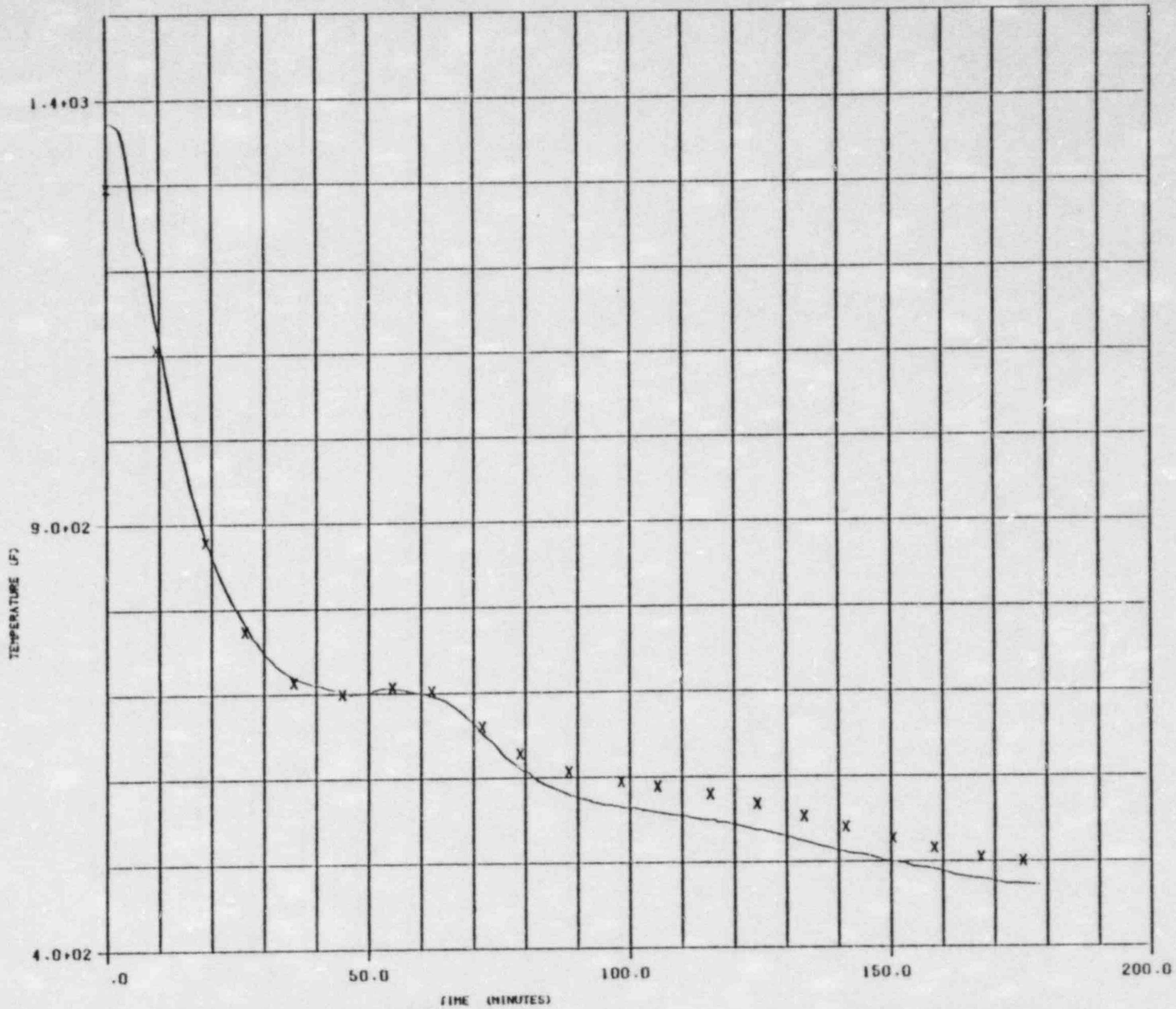
FIGURE 1-8 FRAME 8

X RECA
- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 9

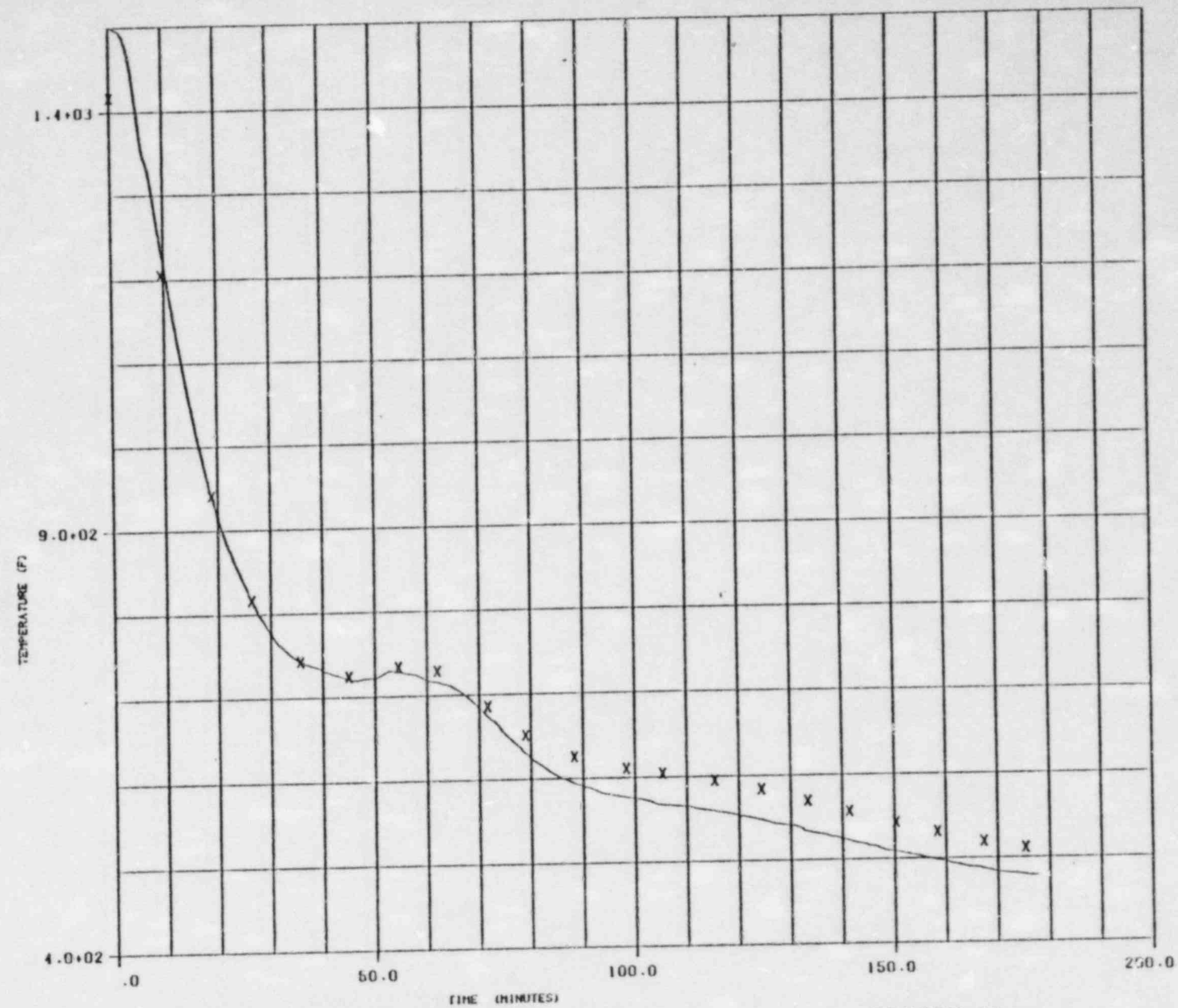
FIGURE 1-9 FRAME 9



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 10

FIGURE 1-10 FRAME 10

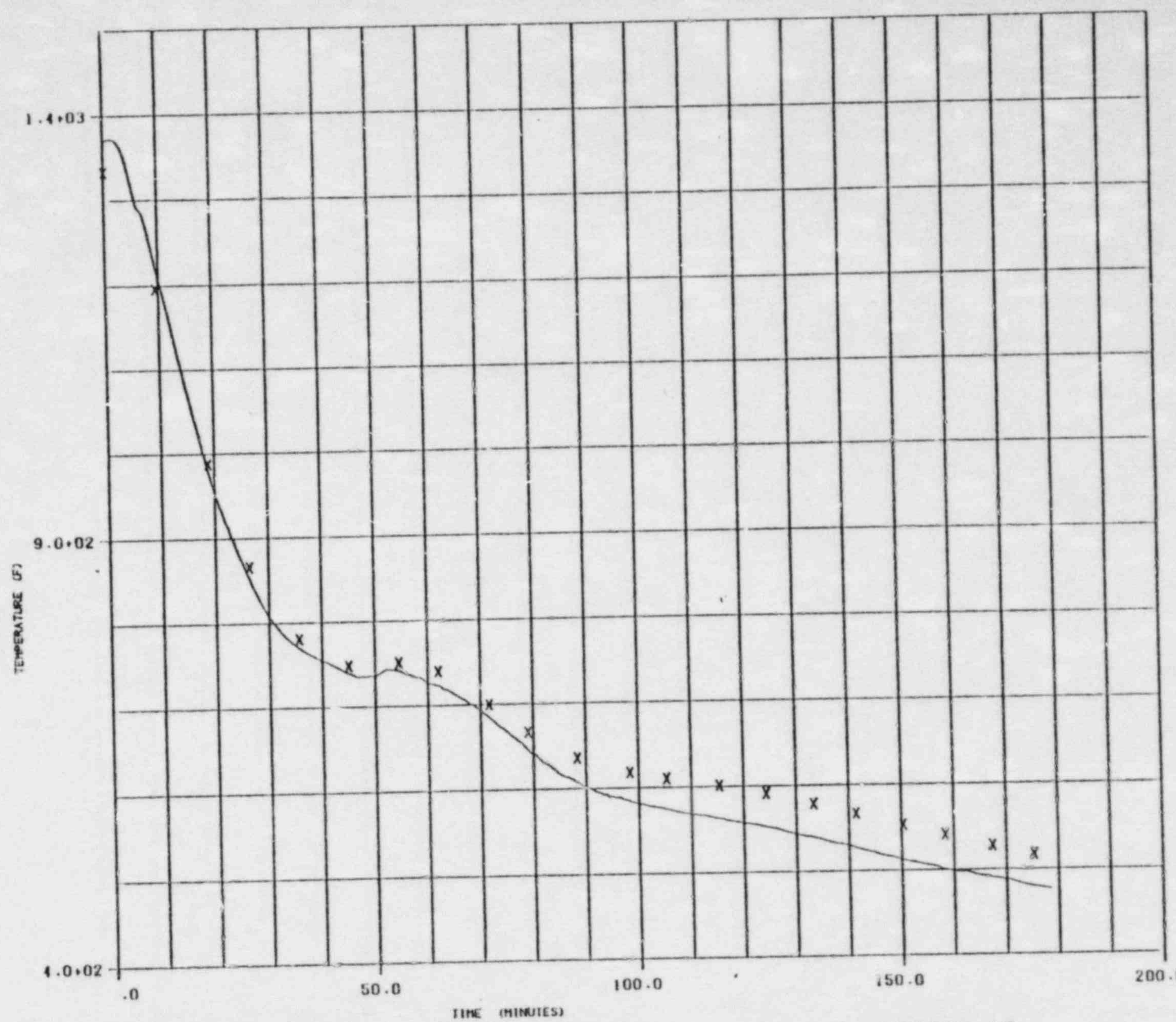
X RECA
\- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 11

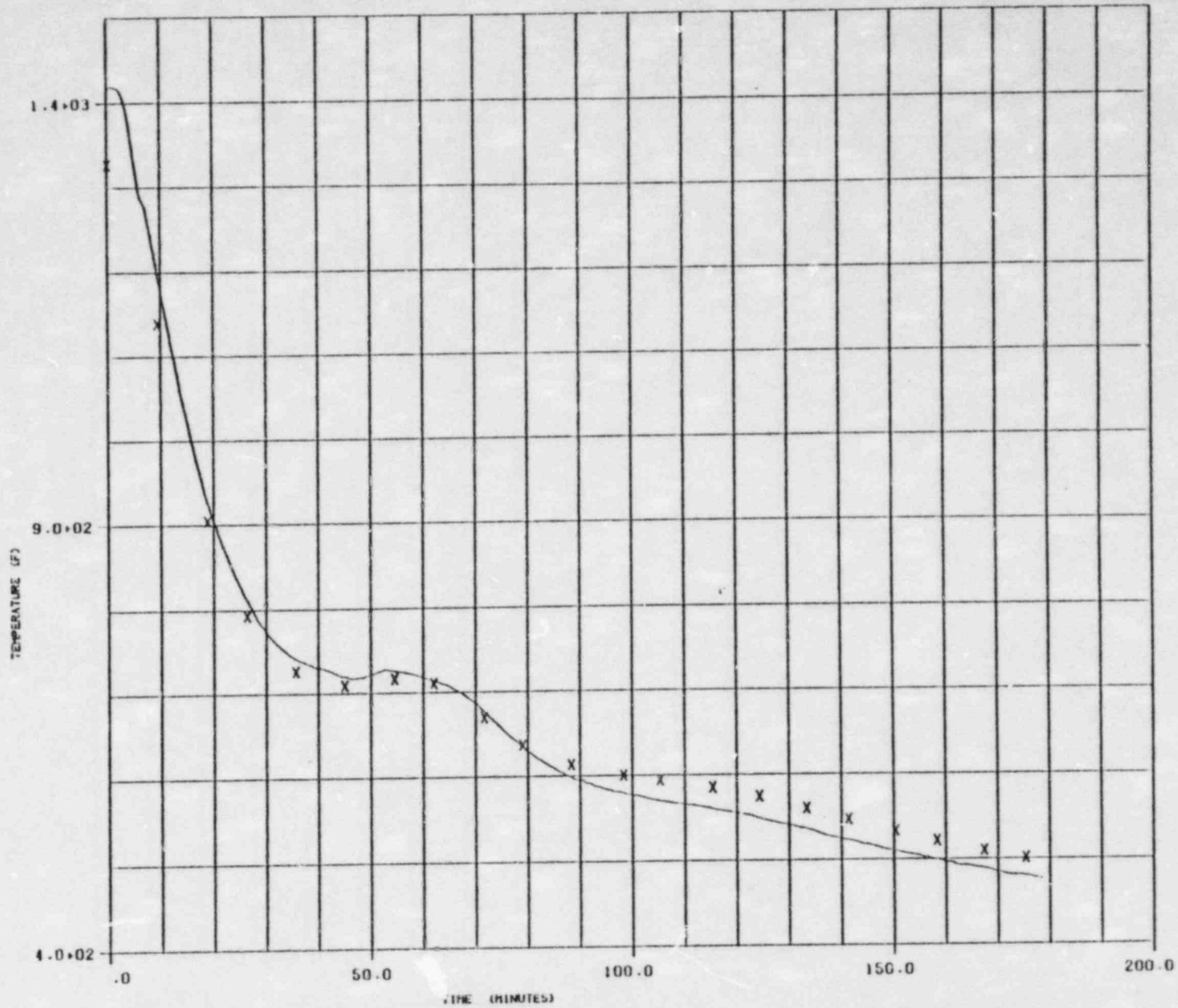
FIGURE 1-11 FRAME 11

X RECA
- DATA



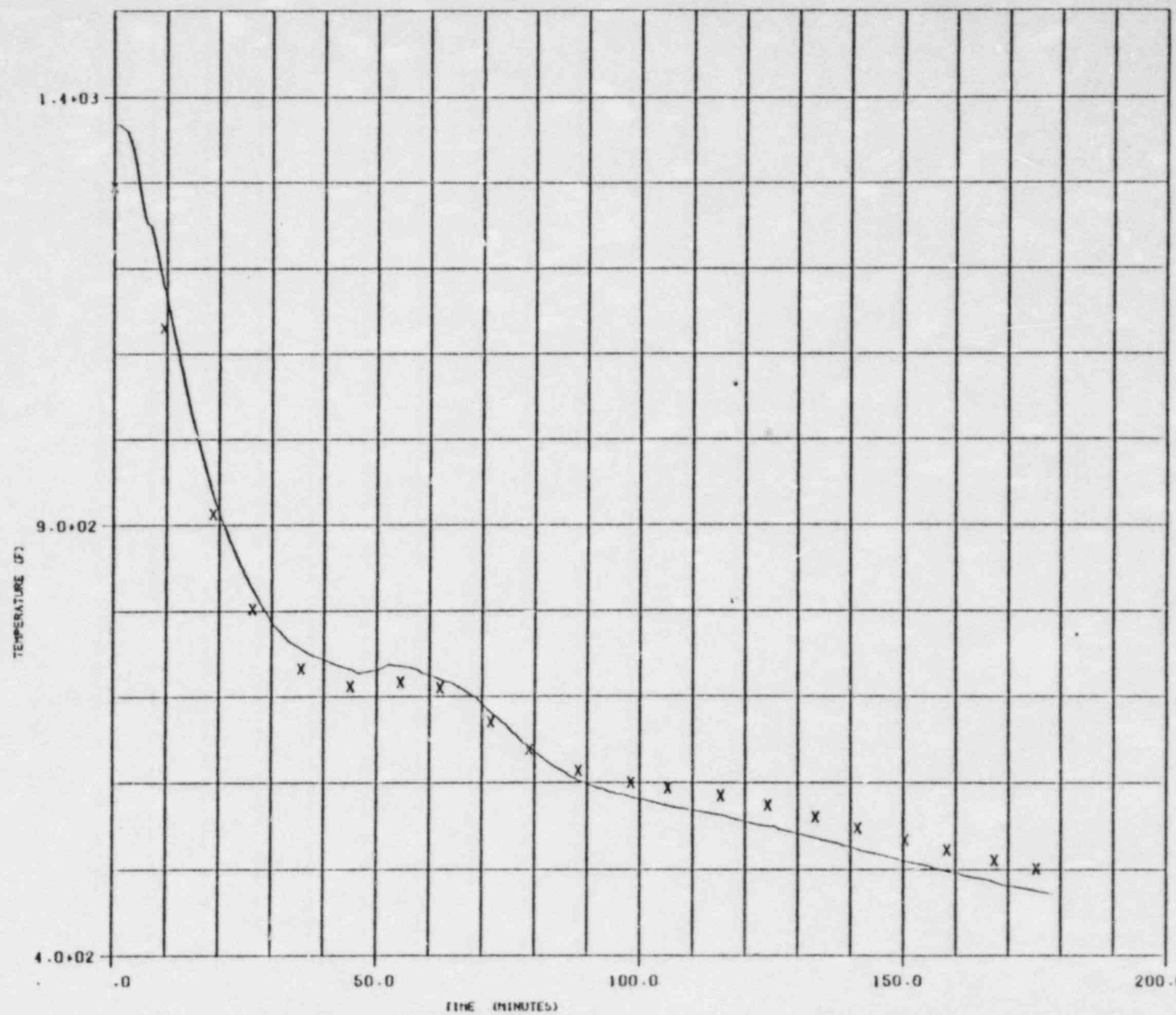
FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 12

FIGURE 1-12 FRAME 12



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 13

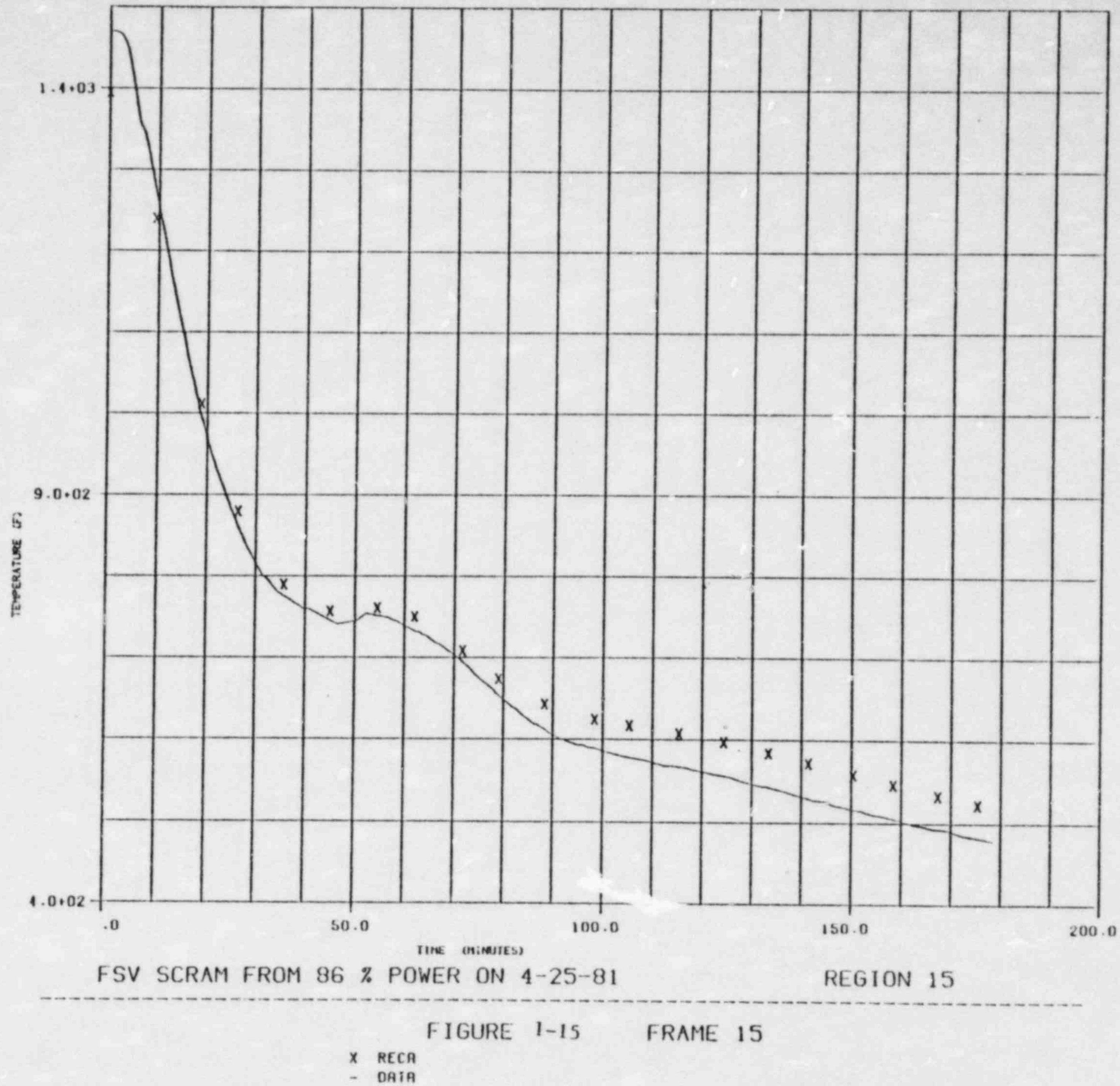
FIGURE 1-13 FRAME 13



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 14

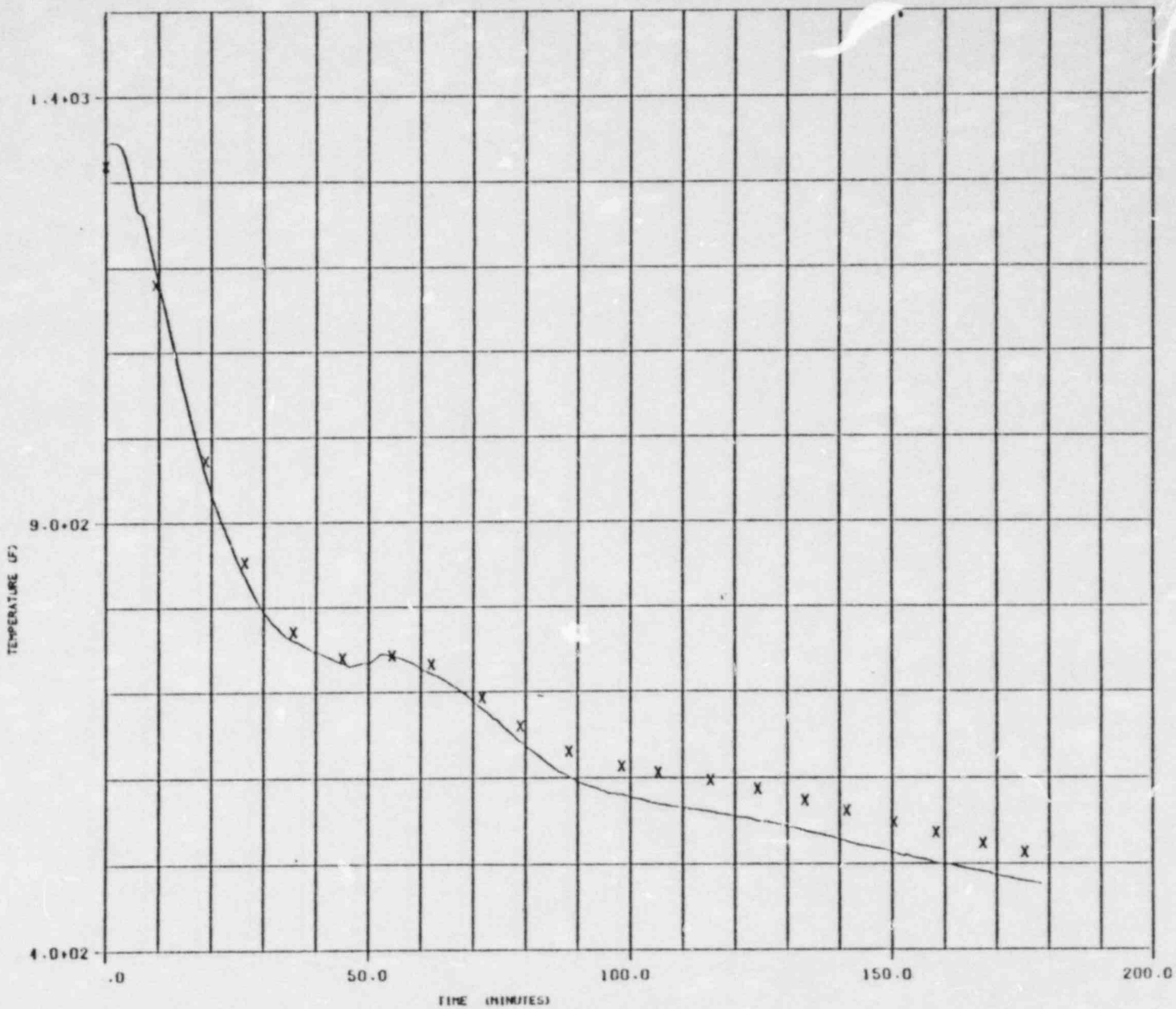
FIGURE 1-14 FRAME 14

X RECA
- DATA



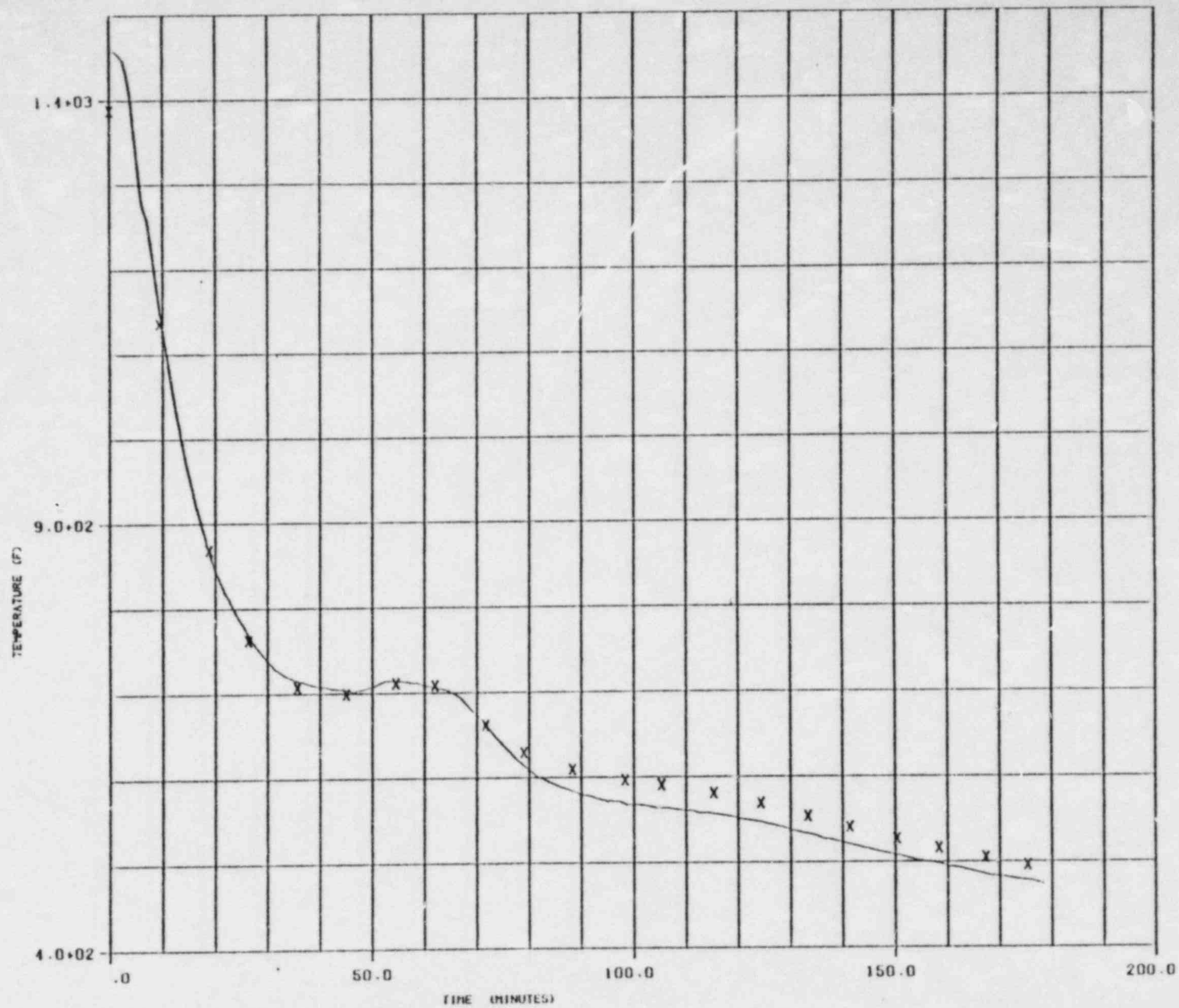
FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 15

FIGURE 1-15 FRAME 15



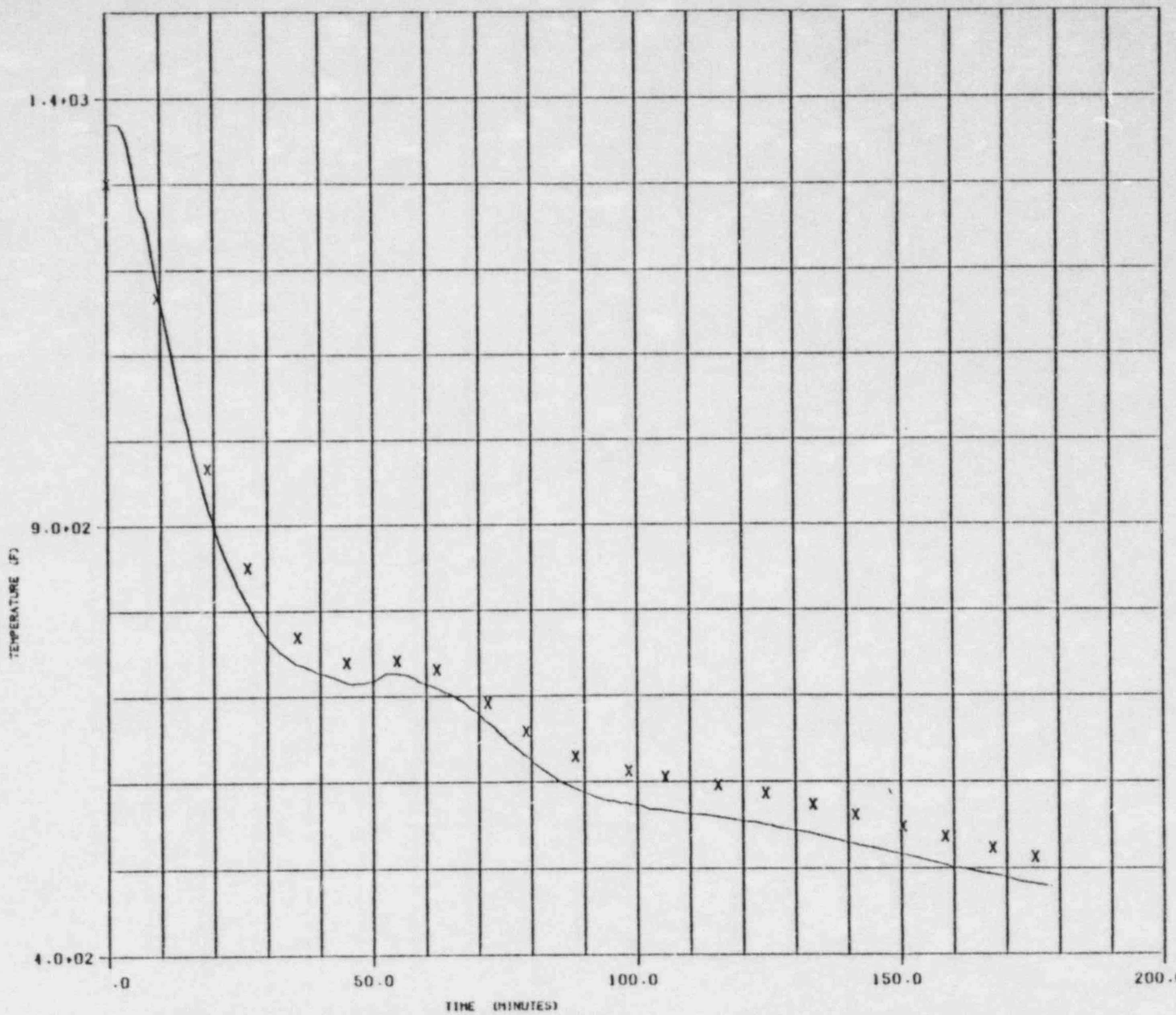
FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 16

FIGURE 1-16 FRAME 16



FSV SCRAM FROM 8S % POWER ON 4-25-81 REGION 17

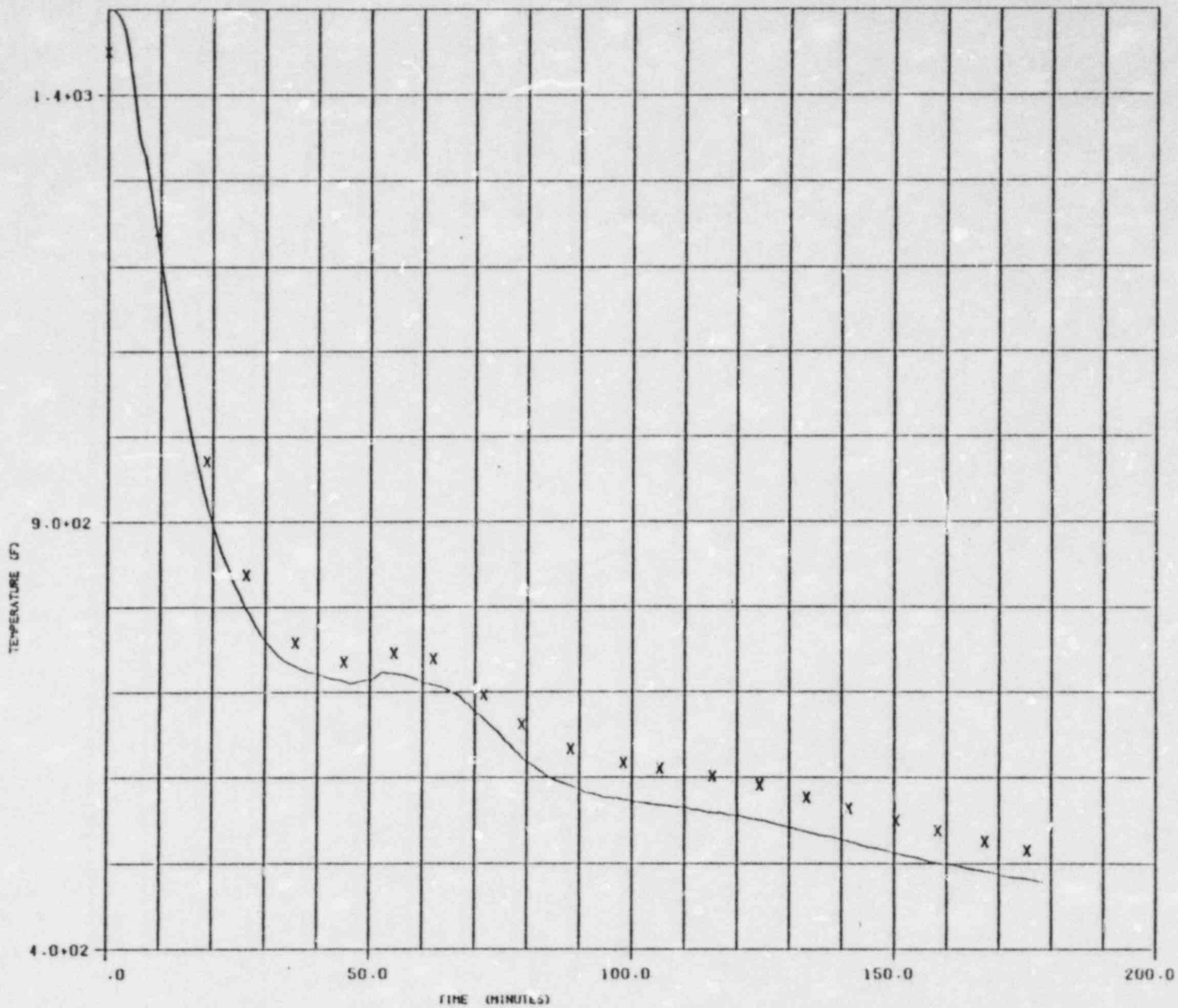
FIGURE 1-17 FRAME 17



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 18

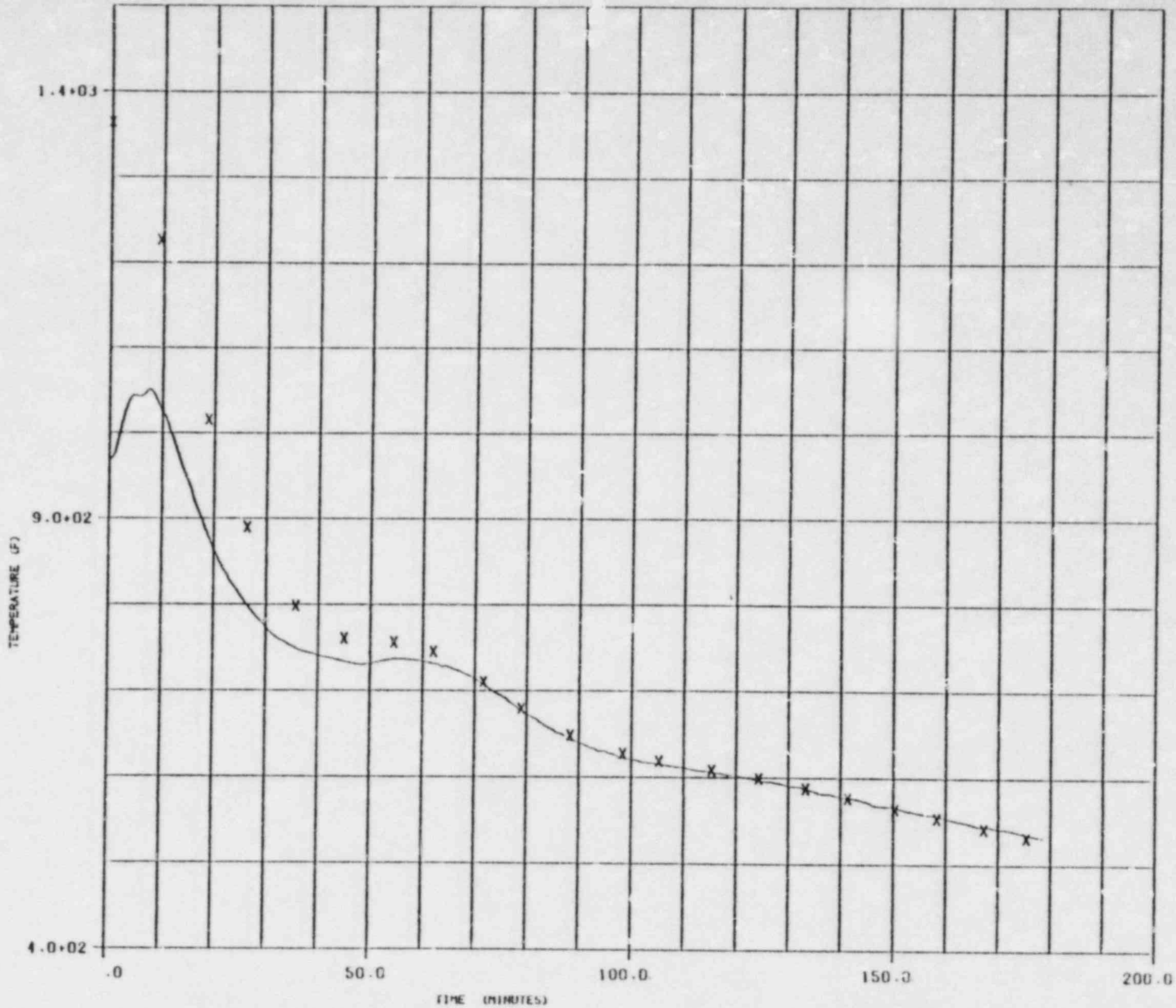
FIGURE 1-18 FRAME 18

X RECA
\- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 19

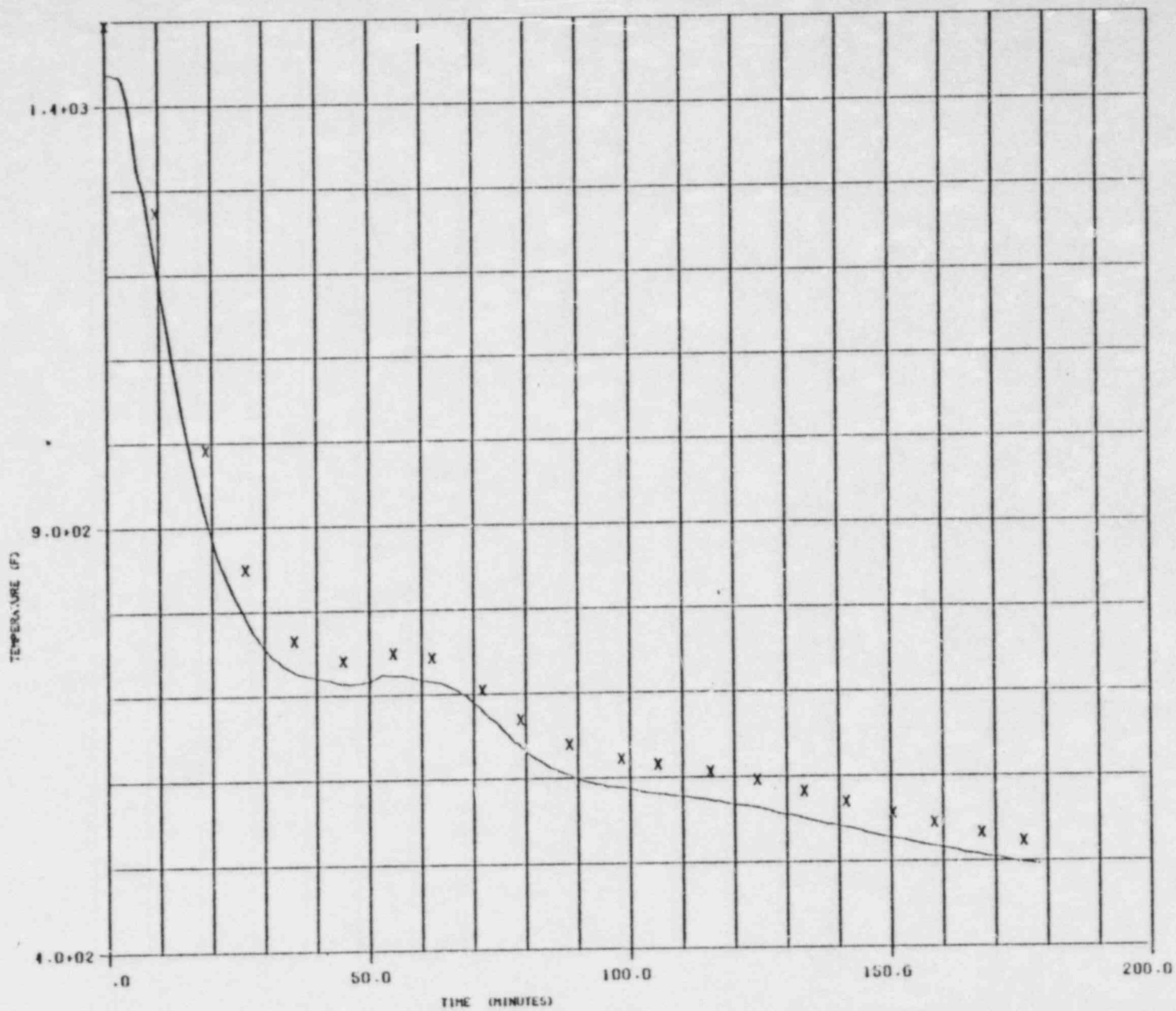
FIGURE 1-19 FRAME 19



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 20

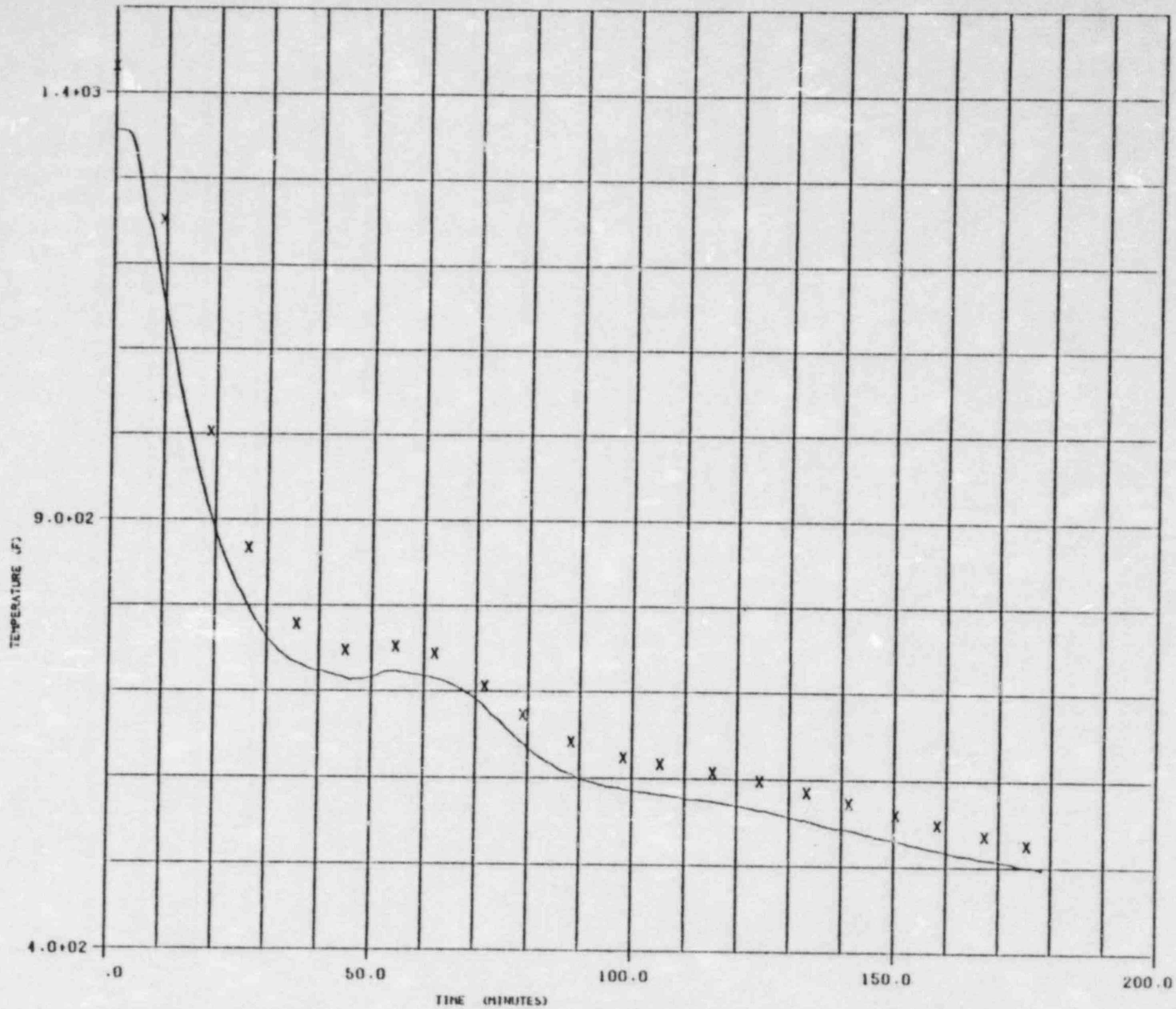
FIGURE 1-20 FRAME 20

x RECA
- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 21

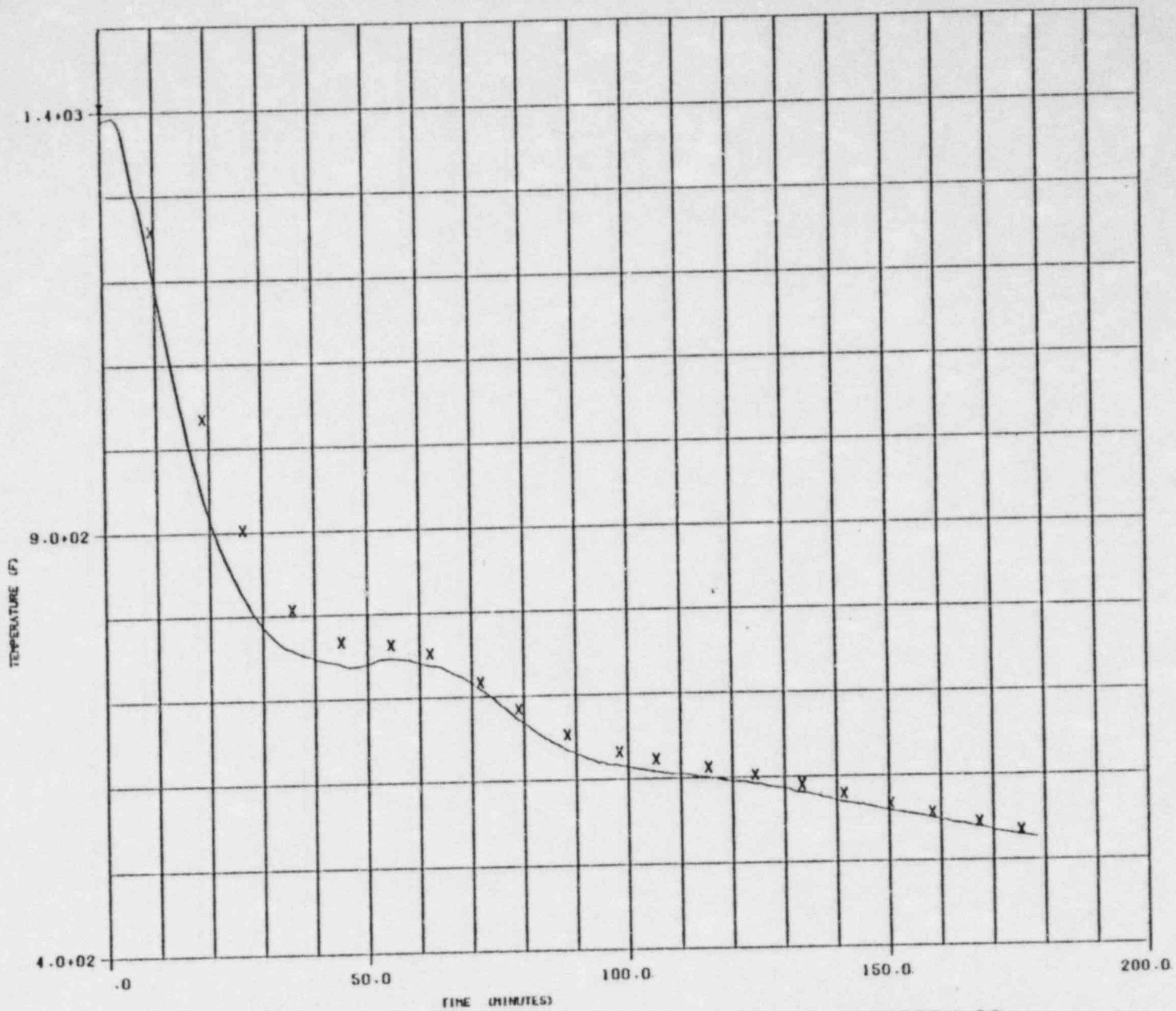
FIGURE 1-21 FRAME 21



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 22

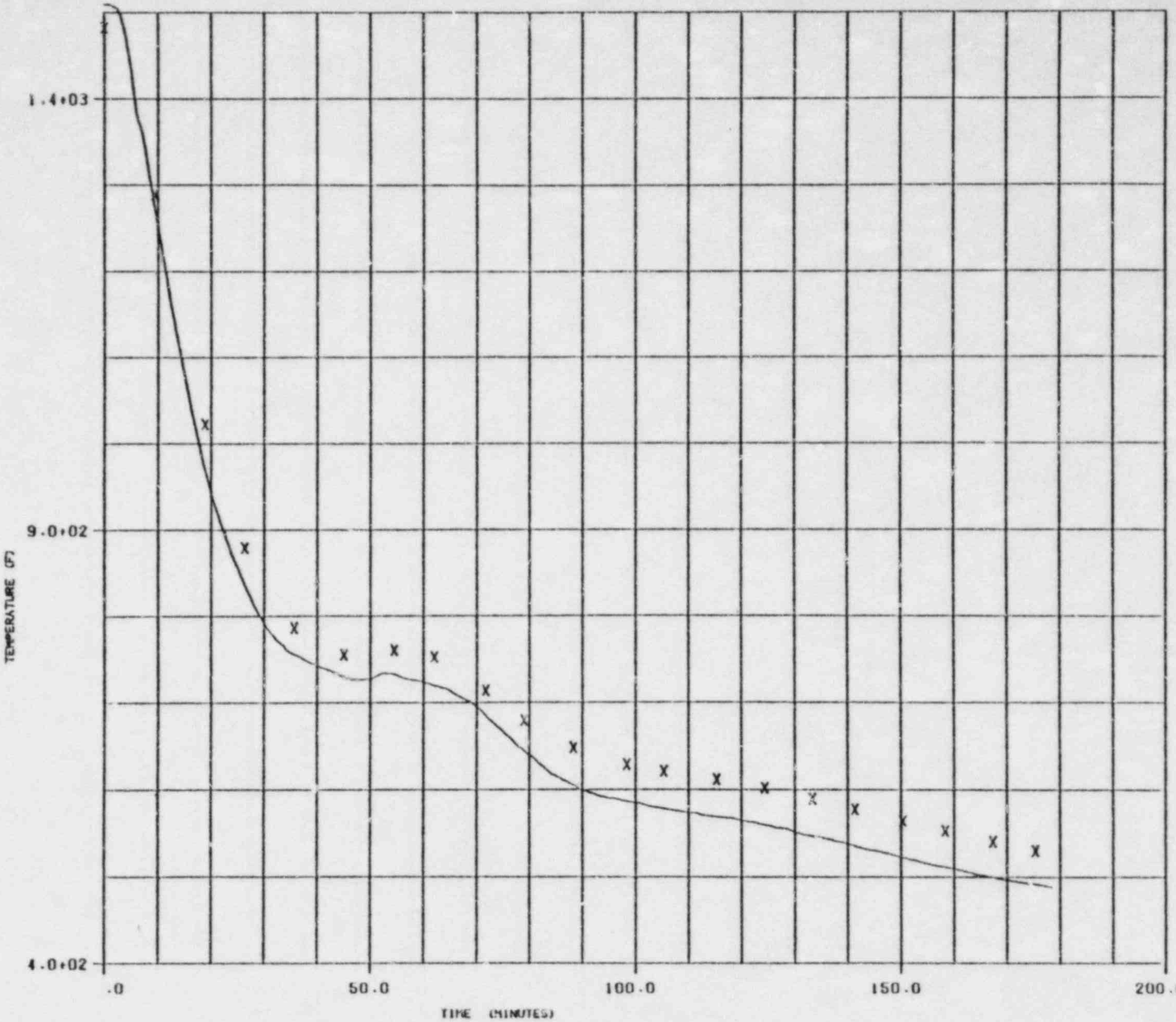
FIGURE 1-22 FRAME 22

X RECA
- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 23

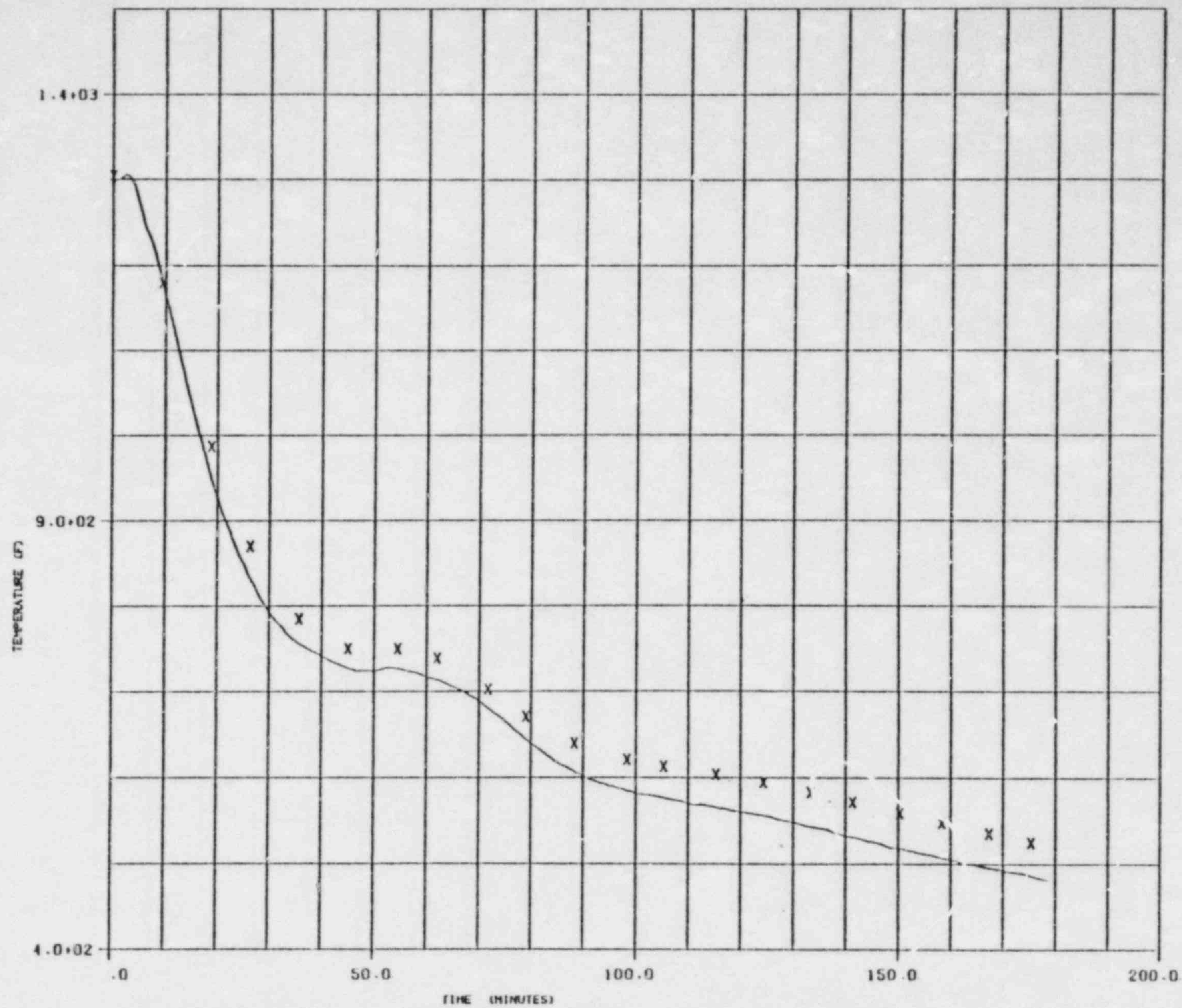
FIGURE 1-23 FRAME 23



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 24

FIGURE 1-24 FRAME 24

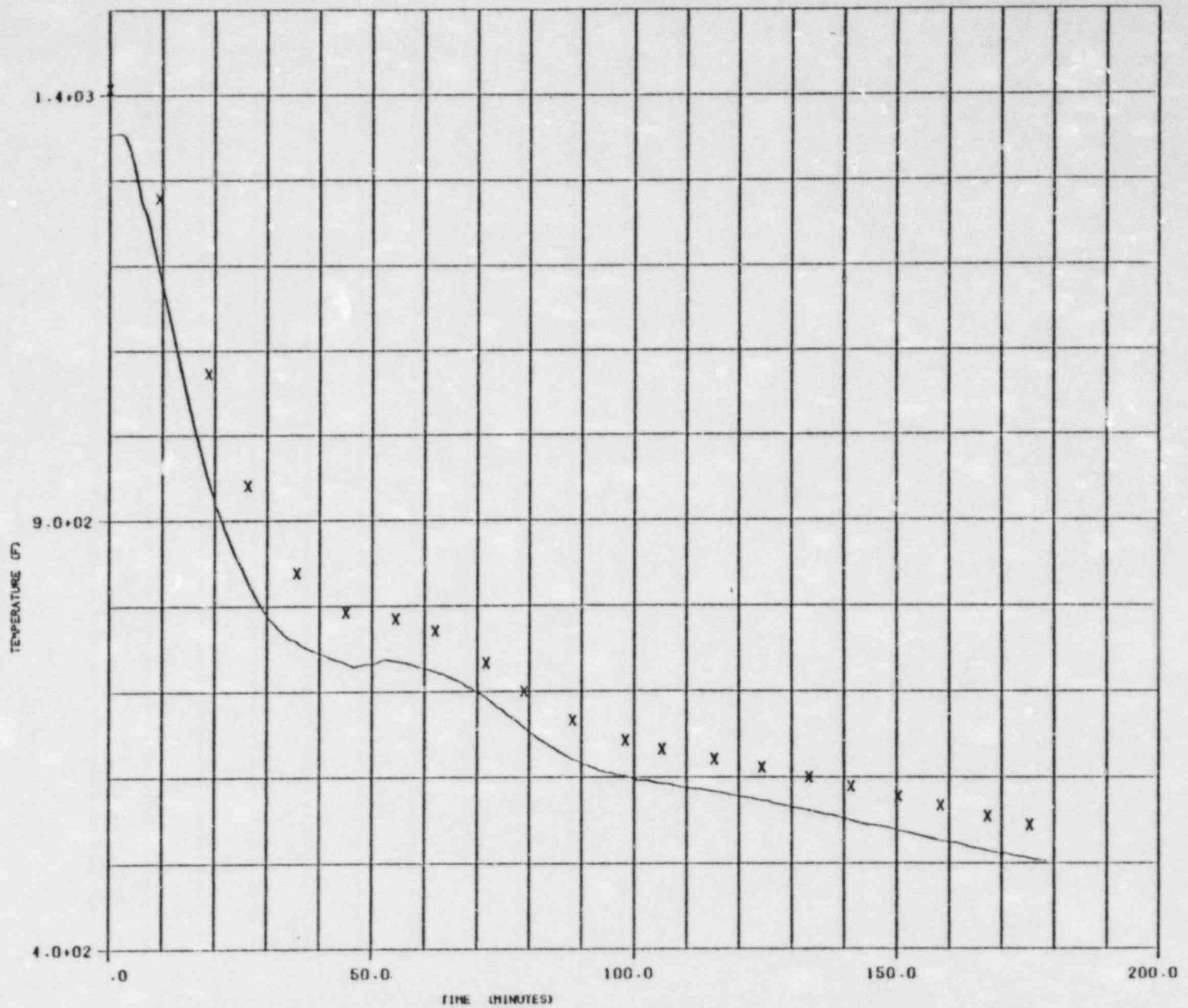
X RECA
- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 25

FIGURE 1-25' FRAME 25

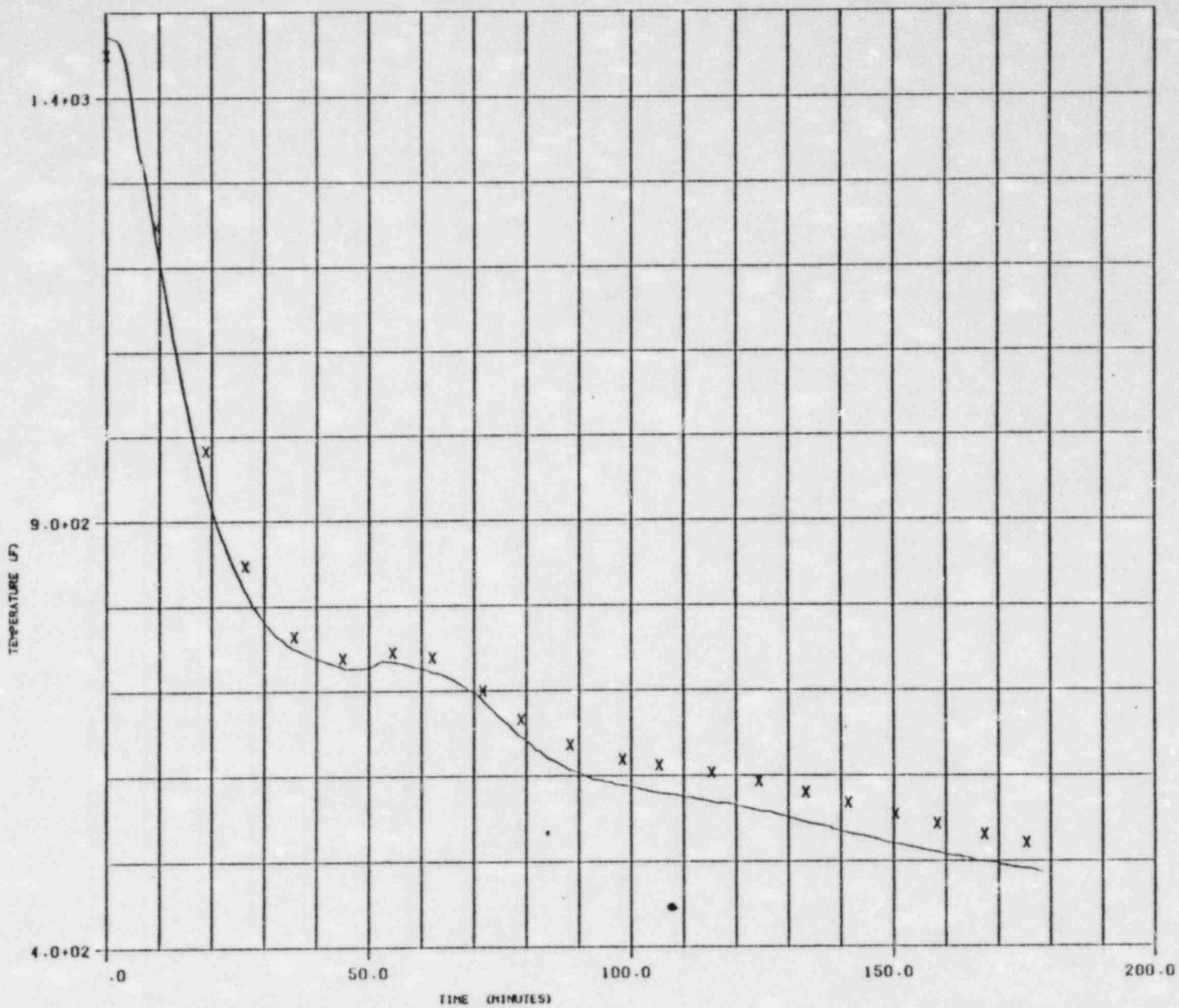
X RECA
- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 26

FIGURE 1-26 FRAME 26

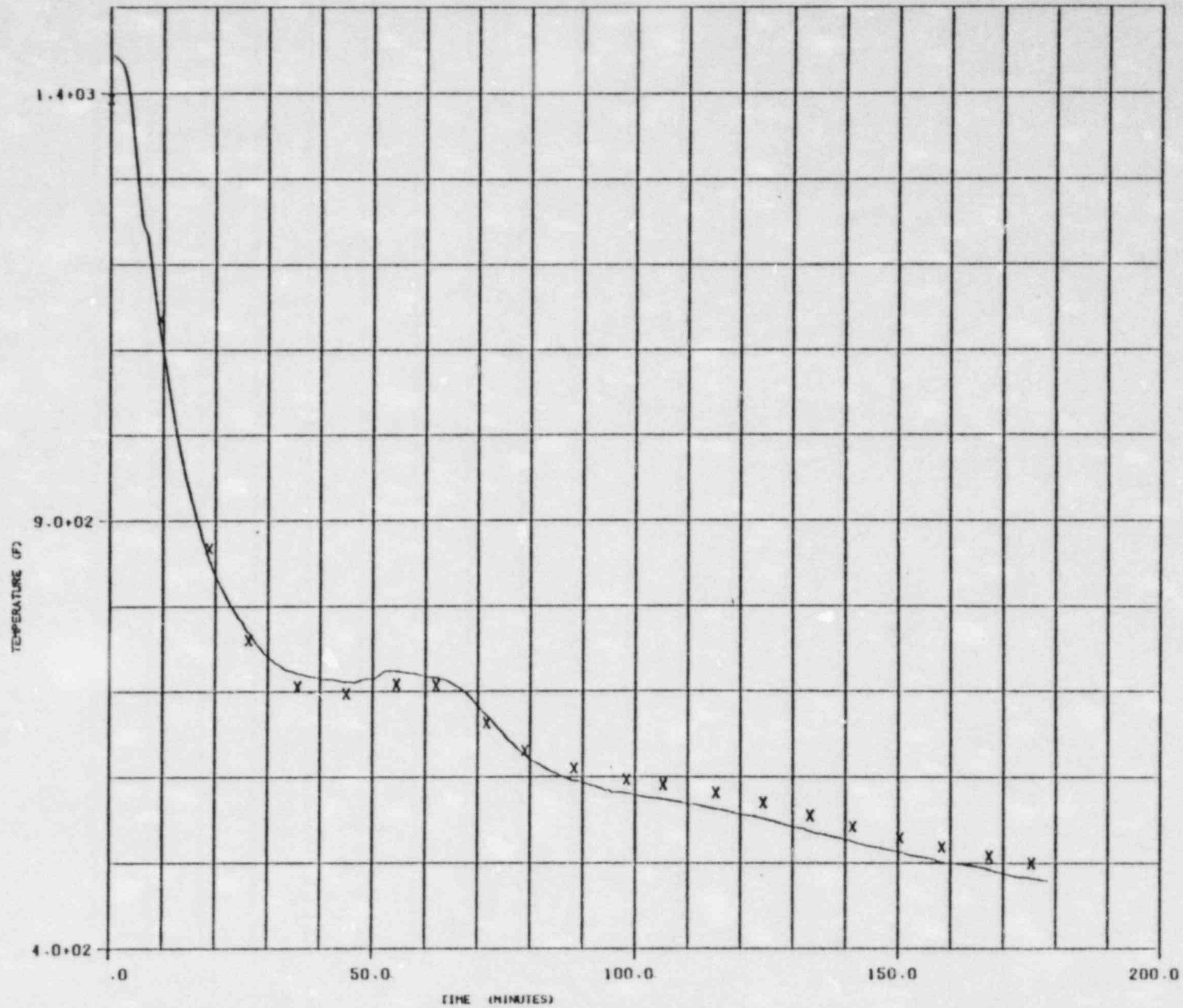
X RECA
- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 27

FIGURE I-27 FRAME 27

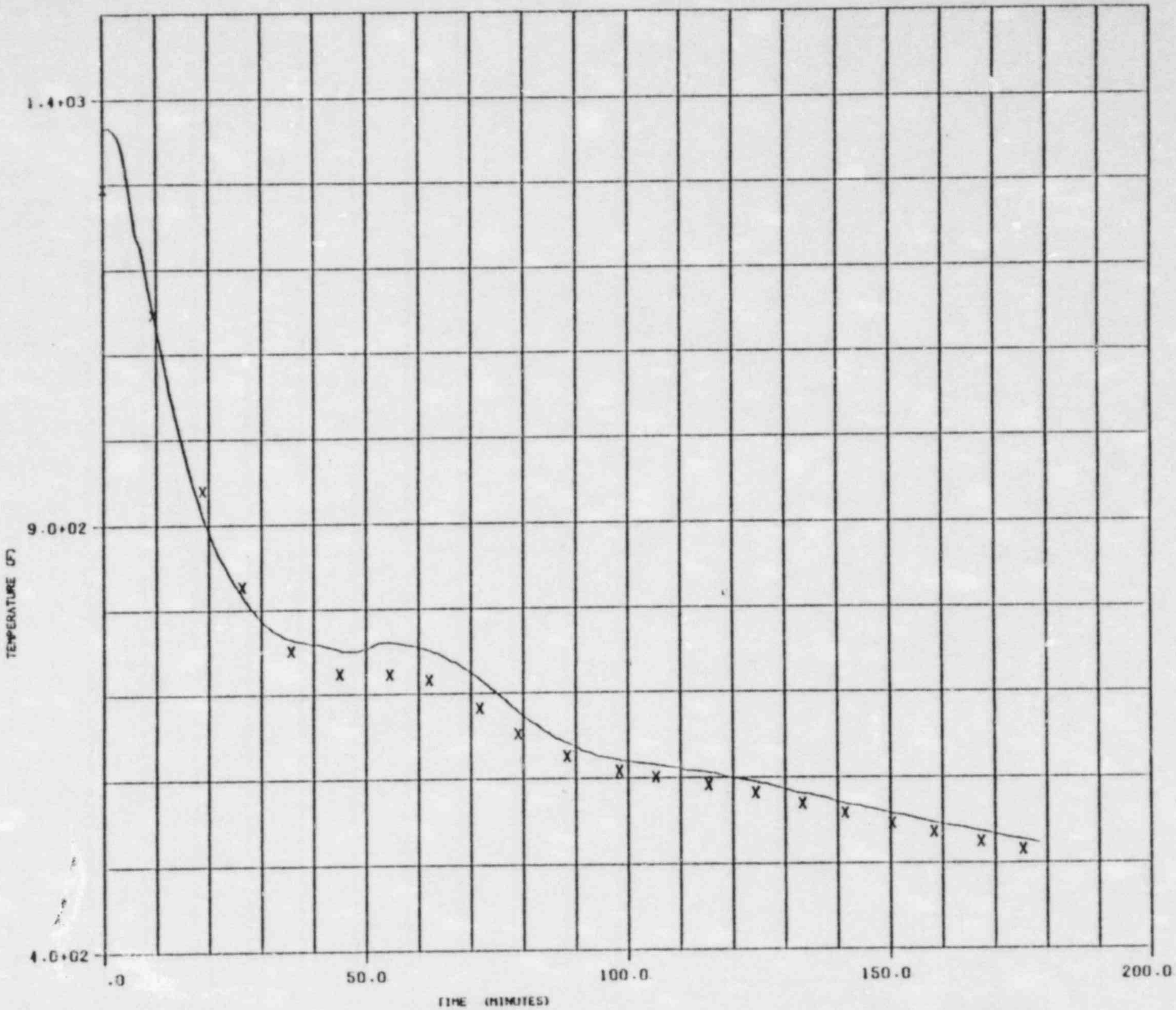
X RECA
- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 28

FIGURE 1-28 FRAME 28

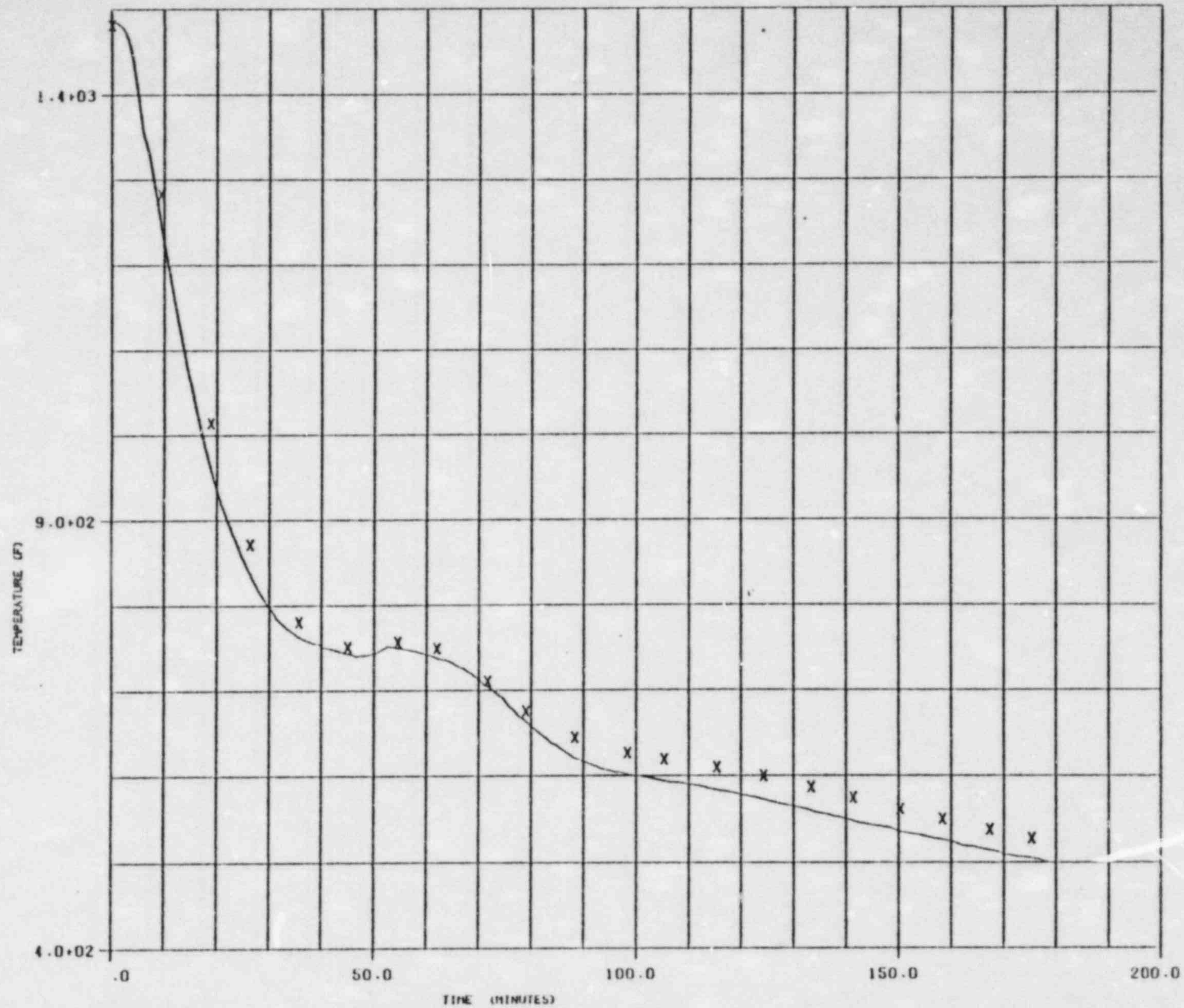
X RECA
\- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 29

FIGURE 1-29 FRAME 29

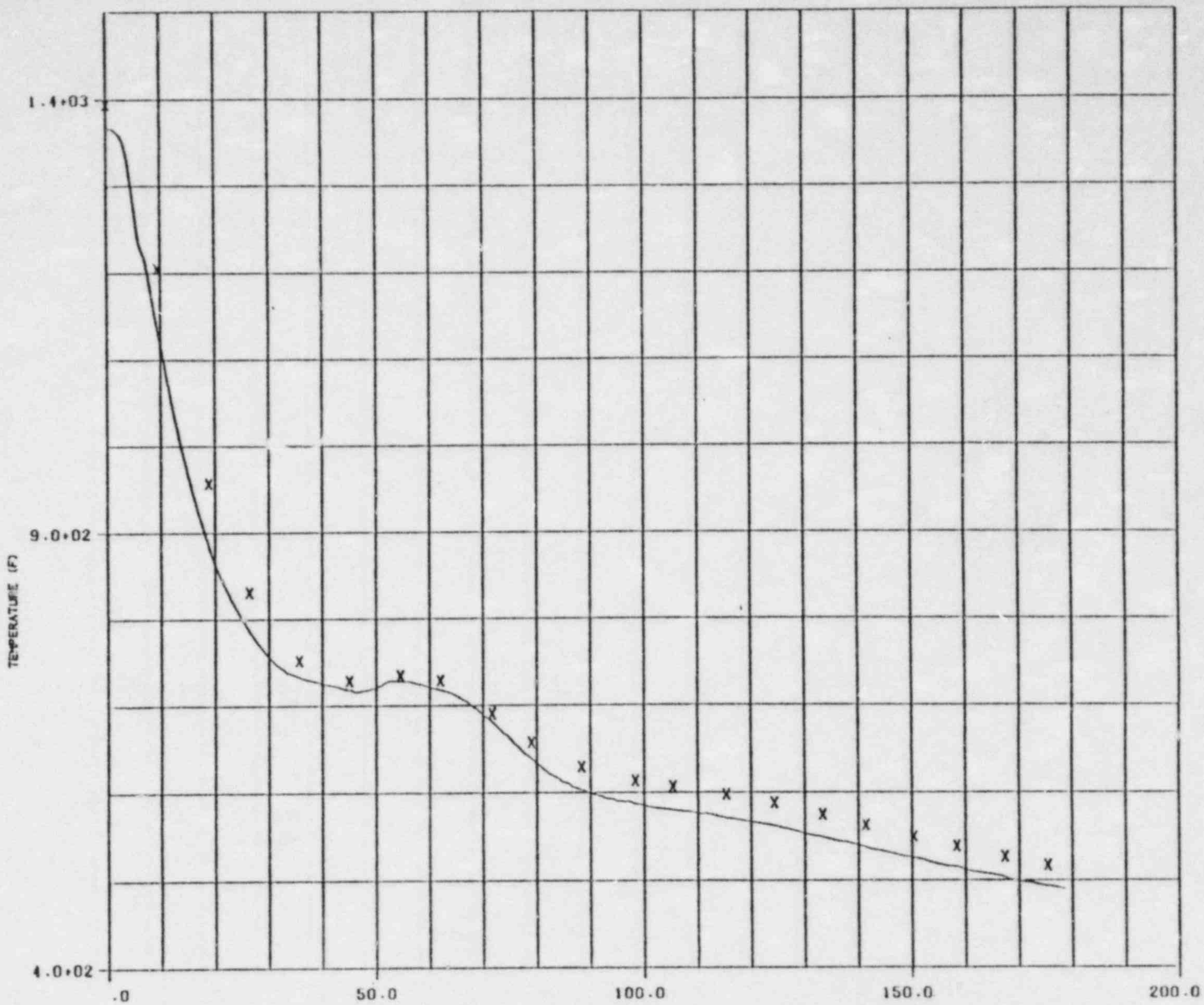
X RECA
\- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 30

FIGURE I-30 FRAME 30

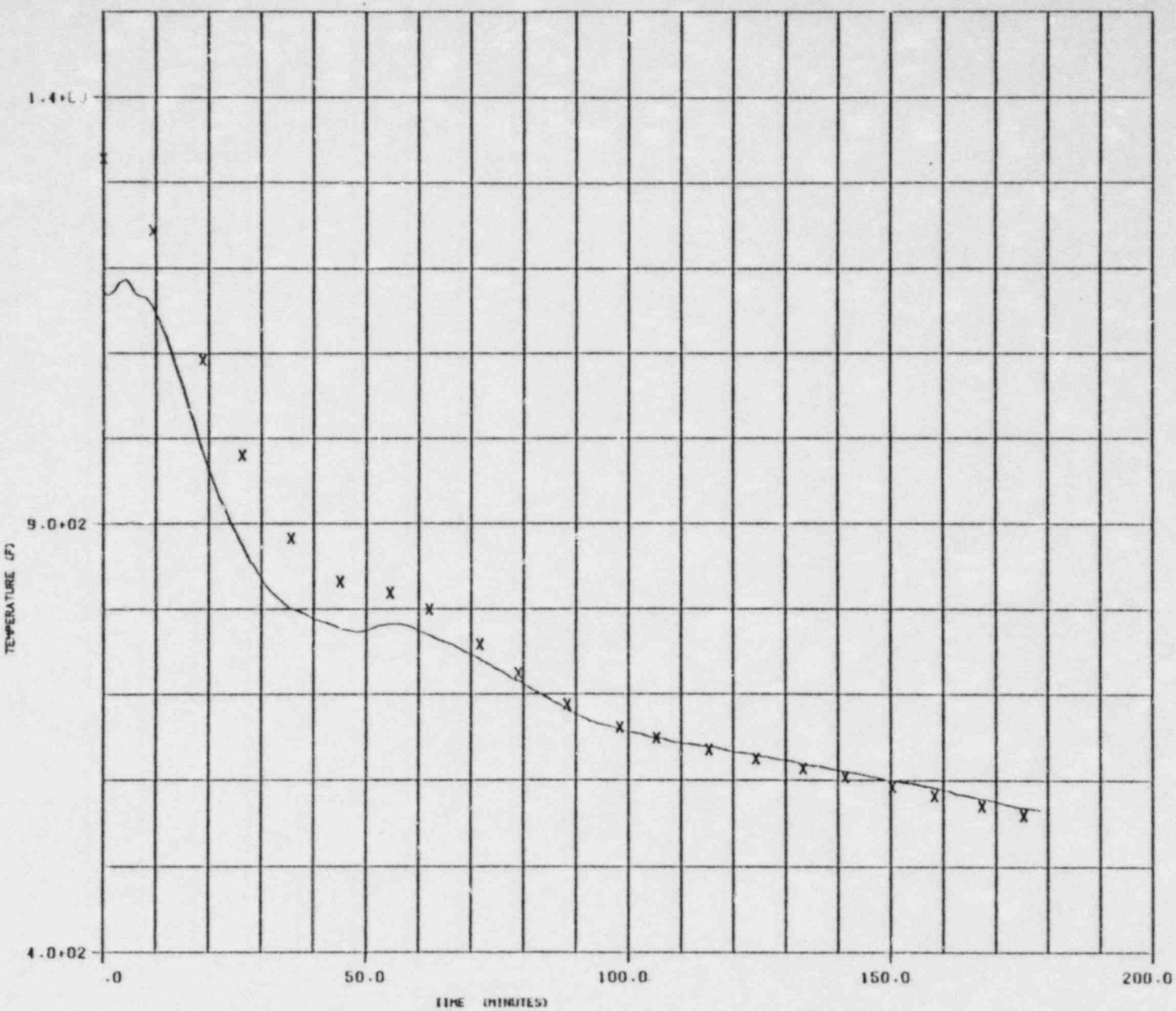
X RECA
- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 31

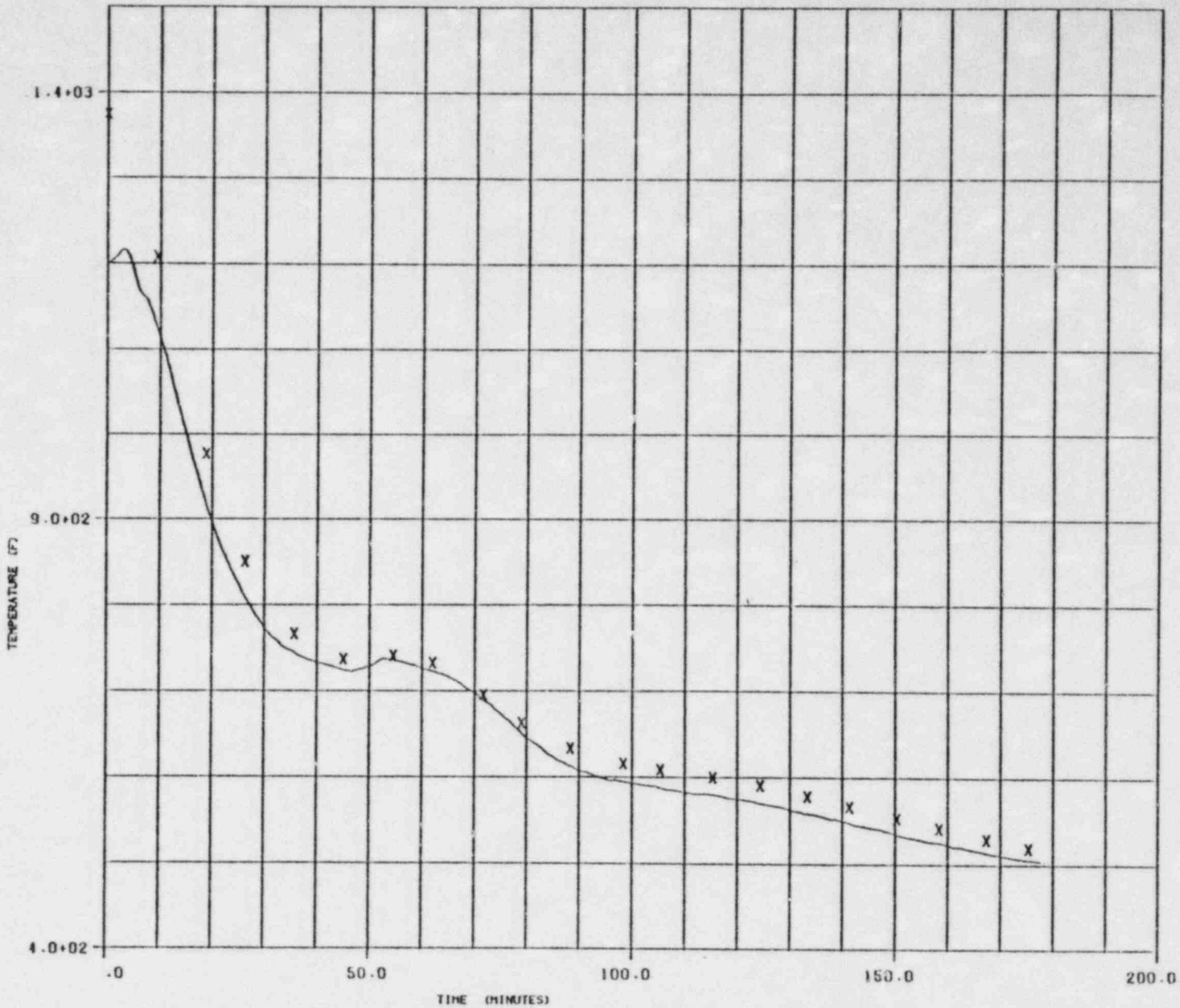
FIGURE 1-31 FRAME 31

x RECA
- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 32

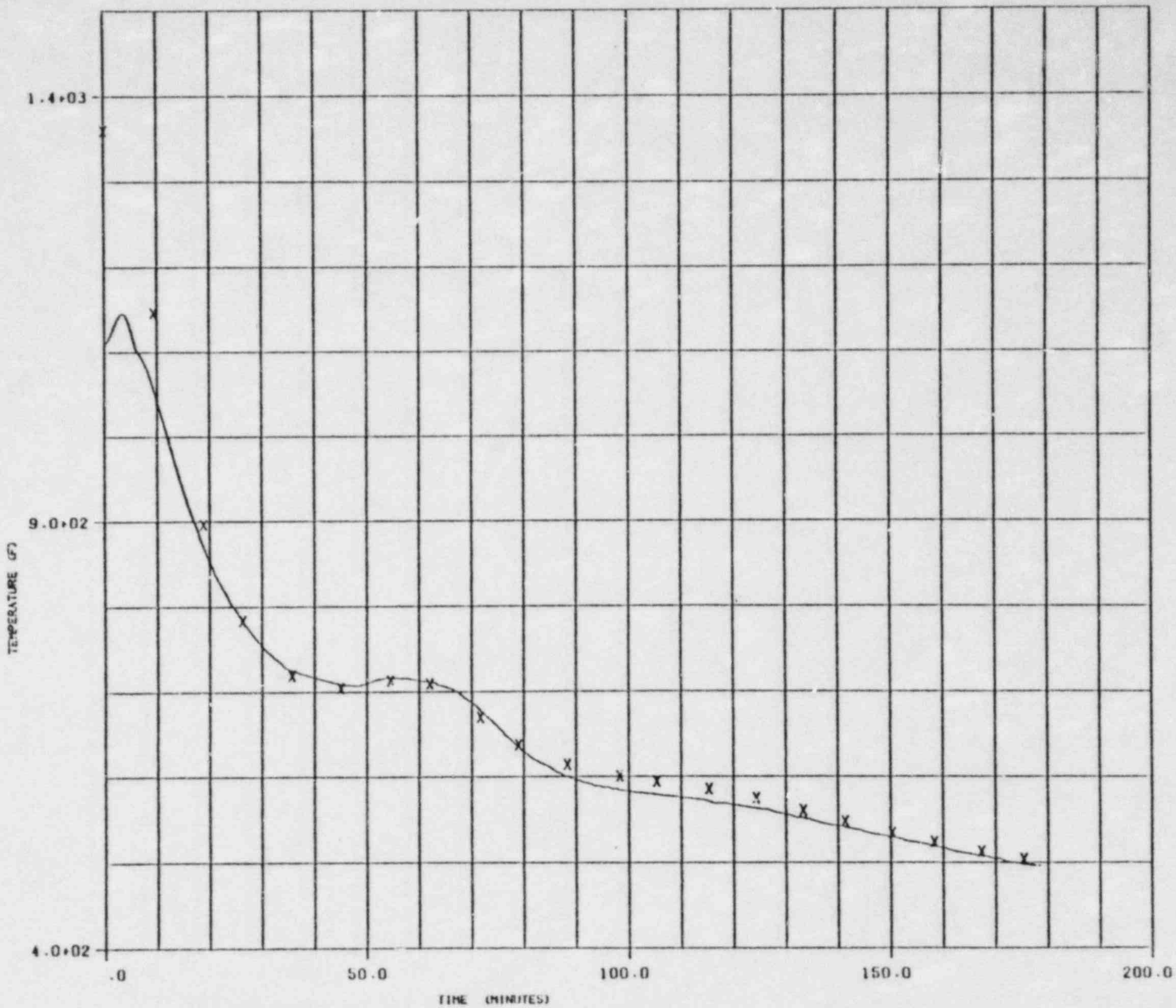
FIGURE I-32 FRAME 32



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 33

FIGURE 1-33 FRAME 33

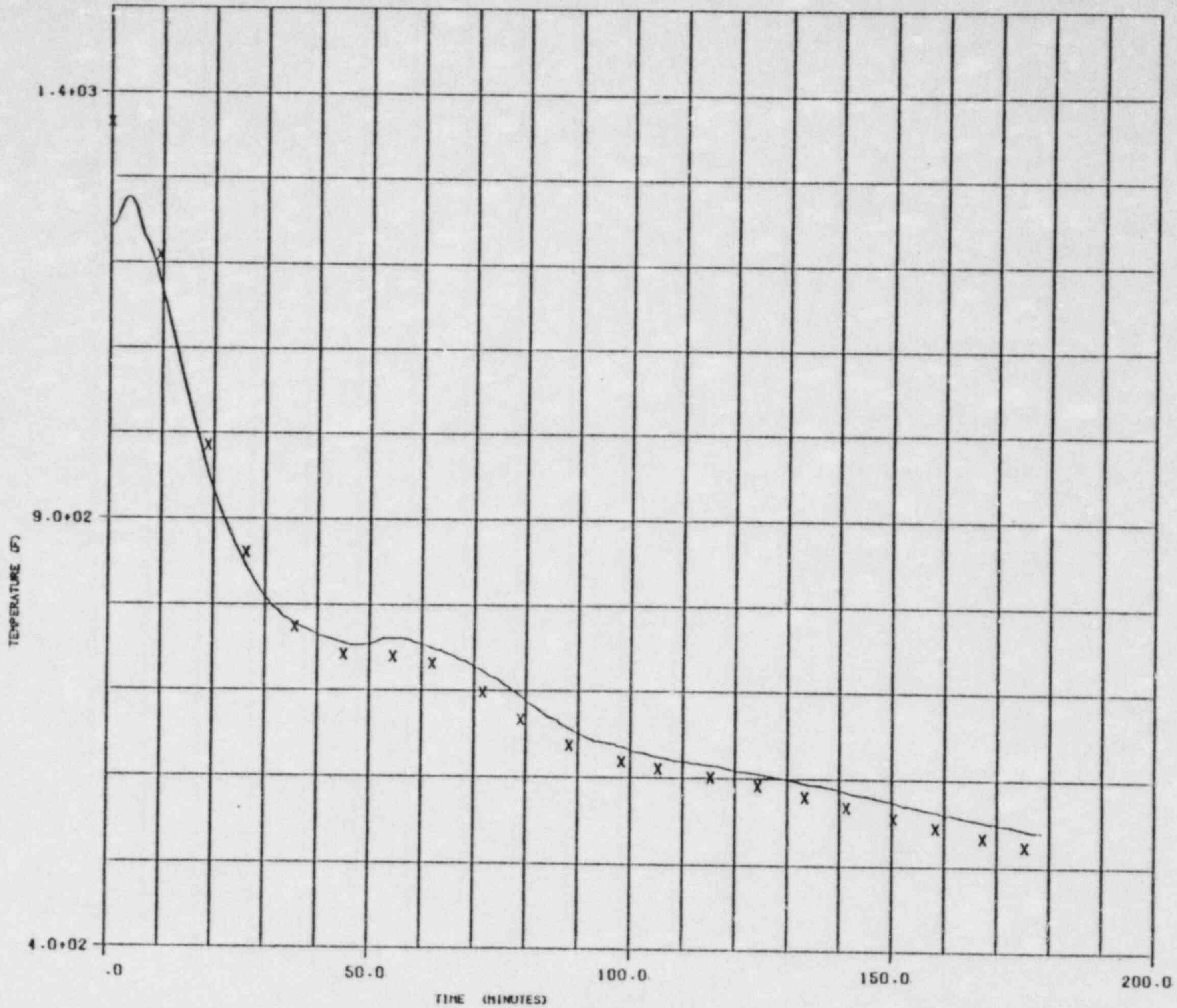
X RECA
- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 34

FIGURE 1-34 FRAME 34

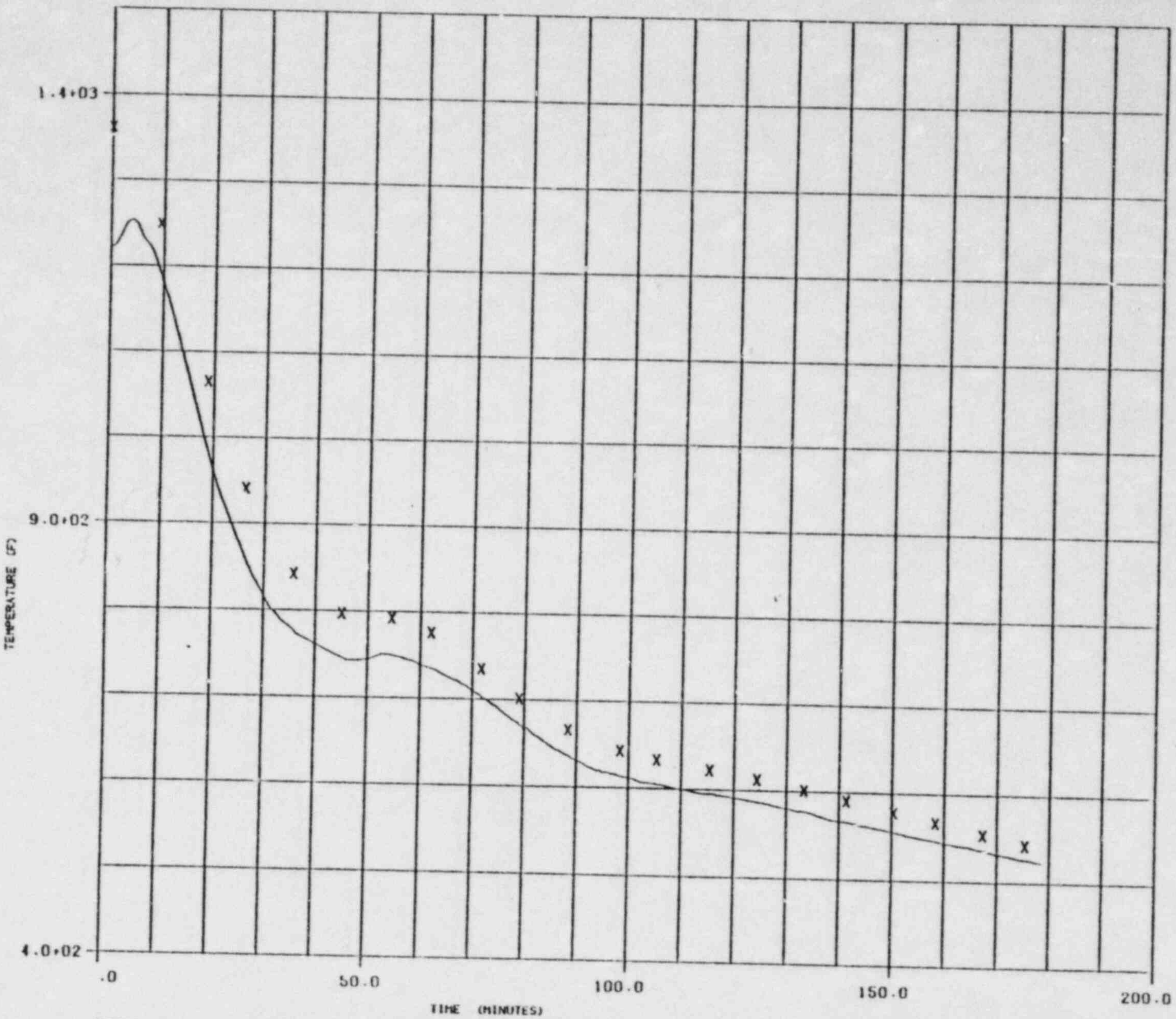
X RECA
\- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 35

FIGURE 1-35 FRAME 35

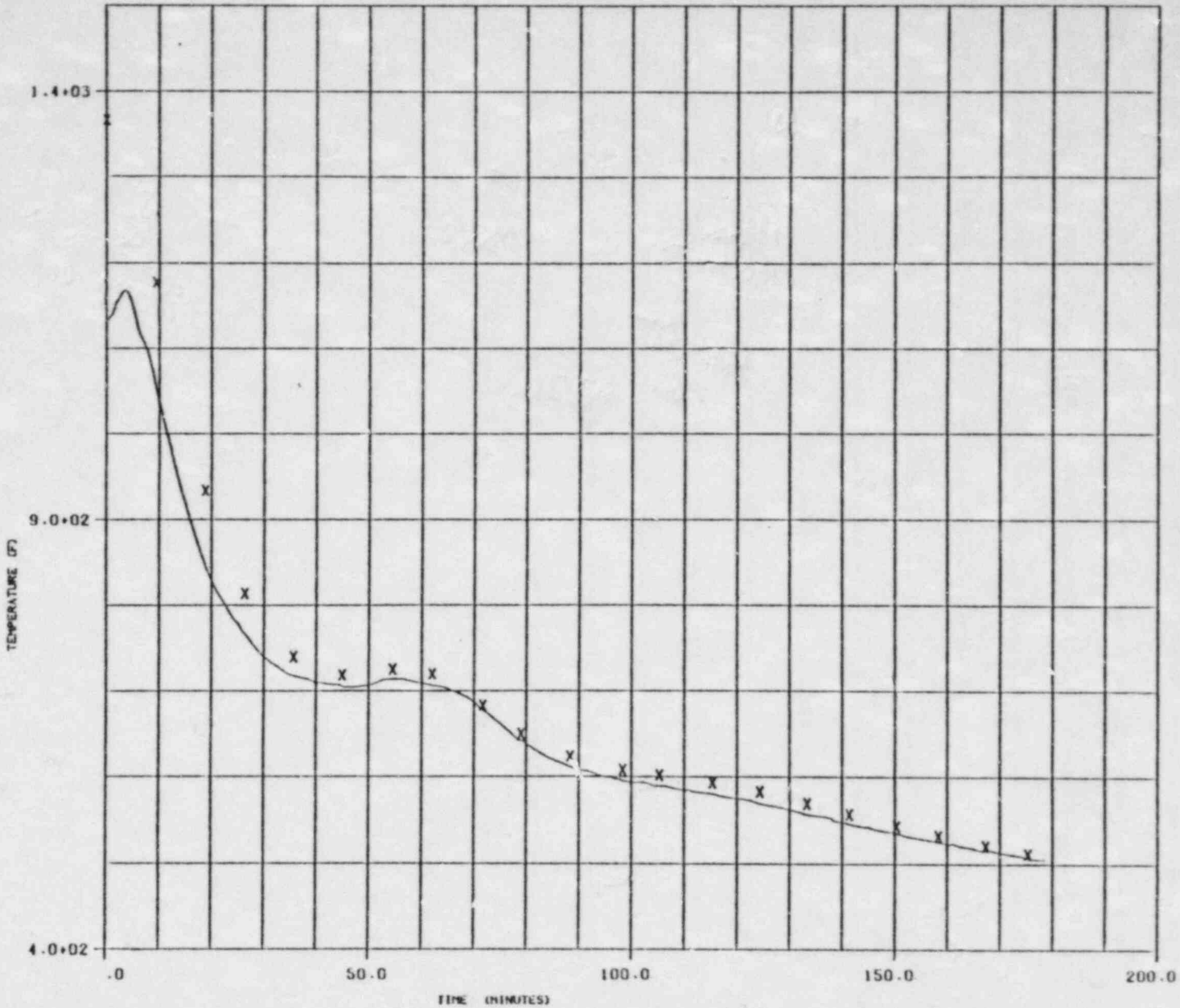
X RECA
- DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 36

FIGURE 1-36 FRAME 36

X RECA
– DATA



FSV SCRAM FROM 86 % POWER ON 4-25-81 REGION 37

FIGURE 1-37 FRAME 37

X RECA
- DATA