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HISTORICAL TRENDS IN TANK 241-SY-103 WASTE TEMPERATURES

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SUMMARY

The gas release and fluctuating level of the waste in tank 241-SY-103 have prompted more detailed interest in its historical behavior, in hopes of achieving a better understanding of its current status. To examine the historical behavior, essentially all of the tank waste temperature data record has been retrieved, examined, and plotted.

This report documents the retrieval, critical examination, and graphic presentation of the 241-SY-103 temperature history. The graphic presentations clearly indicate that the long-term tank cooling trend has continued unabated even after late 1991 when vent air flow rates decreased.

ACKNOWLEDGMENTS

The author wishes to thank the following individuals: J. Cordero of PNL for retrieving the temperature data, and patiently entering it into a database and I. Husa and G. Fox of WHC for transferring recent temperature and level data.

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INTRODUCTION

Liquid wastes from the processing of nuclear materials have been stored in tank 241-SY-103 since 1977 (Fox, Stepnewski, and Anantatmula 1993). Initially, temperature data were collected in the form of manual thermocouple readings and logbook entries. Data collection has been automated since 1991, and is now in electronic format.

Various mitigation strategies to reduce flammable gas concentrations are being considered for Tank 241-SY-103 (as well as for other tanks with similar wastes). Therefore, examination of the 241-SY-103 temperature record becomes an important element in both understanding and predicting its behavior.

TEMPERATURE RECORD

A thermocouple tree consisting of 18 thermocouples mounted in a 2-in. Schedule 40 pipe was originally installed in Tank 241-SY-103, and remains operational. Thermocouples are located starting 4 inches from the tank bottom, and every 24 inches thereafter. During the early years of tank farm surveillance, the main concern was with temperatures of the tank structure, and temperature readings were taken to ensure that temperatures remained below design limits and that no structural problems were developing. Typically, temperatures were recorded weekly, and only for every other thermocouple (a total of 7 out of the 18 available - see Table 1). Readings were taken by switching to the appropriate thermocouple and manually recording its reading on a form developed for that purpose. This procedure was not always reliable (quality standards for the early data were not equal to those imposed since about 1991), and bad data had to be culled from the record to select data for subsequent plotting (This is further discussed in the Temperature Data Transcription section below).

Table 1. Location and Condition of Recorded Thermocouples in Tank 241-SY-103.

Thermocouple Number (# 1 is near the tank bottom)	Elevation above Tank Bottom, inches	Current Condition of Thermocouple Extension Wire[1]
2	28	Failing
4	76	Good
6	124	Good
8	172	Failing
10	220	Failing
12	268	Good
14	316	Good

[1]Johnson, G. D. 1994. Personal communication from WHC, dated January 6.

Since 1991, because of the heightened interest in hydrogen generation and its periodic release from Tank 241-SY-103, data for the 7 thermocouples has been recorded by a data acquisition system. The data are taken approximately weekly.

A new tree with 22 thermocouples (the so-called multi-functional instrument tree, or MIT) will be installed in the summer of 1994 to replace the old tree, The old tree is in riser 4A at a radius of 20 feet and the MIT will be in riser 17B at a radius of 28 feet.

TEMPERATURE DATA TRANSCRIPTION

The early (1977-1990) temperature data record for Tank 241-SY-103 was located in storage in Seattle, and the boxes containing the record were retrieved. Because of the varying legibility of data entry (for example, on occasion a datum was crossed out and re-entered), it was felt that only a critical review and manual re-entry of these readings would provide a valid data base. This data base was electronically transmitted to the author, who also examined it critically, discarding an entire 7-thermocouple data set if either of the following statements were true:

1. One or more thermocouple readings were missing from the data set

2. One or more thermocouples exhibited anomalous readings, either in comparison with their companions, or with earlier or later data from other data sets. For example, a 10 °F temperature drop of all readings in one day would be discarded as physically impossible (In overturn events, some readings go up, while others go down).

The data were then processed, using several spreadsheet and short FORTRAN programs, into a format acceptable to a sophisticated plotting program. Although other options are available, it was found easiest to format the data into a computer record (i.e., line) of input consisting of the triplet: day of year, thermocouple elevation, and thermocouple reading. A complete data set for each year was thus assembled into a D x 7 matrix, with D equal to the number of days with valid data in the year, by 7 elevations. All the temperature plots included herein were produced using a commercial 3-dimensional plotter program.

For the temperature data beginning in 1991, when data became available in machine-readable format, several short FORTRAN programs were written to manipulate the data. Thereafter, the filtered data were examined in detail for each year, in the manner previously described. The temperature data were then quickly plotted, to aid in further identifying and discarding any potentially bad data.

TEMPERATURE PLOTS

The temperature plots contained herein represent temperature ranges with differing shades of color. The plots cover the years 1978 to early 1993; it appears that only a small amount of relatively cool ($< 80\ ^0$F) waste was present in 1977, so no plot is included here. Data are available for 1993 to the present, but have not been examined or plotted because of programmatic constraints.

Note that the tank was filled only to about the 190 inch level in 1980 (the filling with hot waste is very evident in Figure 3). It was filled to about 220 inches in 1985 (with cooler waste, see Figure 8).

The final major fill occurred in 1988 (visible in Figure 11), and subsequent small waste additions have increased the tank waste level to the current 273 inches (Fox, Stepnewski and Anantatmula 1993). Therefore, thermocouples number 10 and 12 became immersed in the waste only in 1988 or thereafter; prior to 1988 they indicated dome air temperature. Thermocouple number 14 continues to measure dome air temperature. Tank waste level prior to 1980 is uncertain, and seems to have fluctuated, based on examination of Figures 1 and 2.

It appears that one or more thermocouples (see Table 1) became unreliable in the second half of 1990 (see Figure 13). Most of the time since then, thermocouples number 8 and 10 have given unrealistically high readings that make it appear as if there were a cool region at about 125 inches elevation that is centered between two higher-temperature layers. Obviously, such is not the case, as no mechanism exists for selectively removing heat from 103-SY at that level, nor can differential heat generation by the waste account for this temperature profile. Thermocouple number 2 has also been described as failing; its condition is not as readily deducible from the plots as is the case for thermocouples number 8 and 10. The data for the errant thermocouples have not been edited out, and all the plots (even after 1990) include readings taken at thermocouples number 2, 8 and 10.

In recent years tank 241-SY-103 has experienced large variations in vent air flowrates[2]. Any effect on waste temperatures of flow rate changes is difficult to detect from the temperature plots.

Although in many ways tank 241-SY-103 is similar to 241-SY-101, the temperature record for SY-103 is less amenable to mechanistic interpretation. A distinct demarcation between convective/non-convective waste layers is usually not present in SY-103. Gas release events (GREs) are also not as obvious as was the case for SY-101 (Antoniak 1993), although some recent GREs have been clearly identified (Fox, Stepnewski and Anantatmula 1993). An inexplicable major event (possibly a GRE) took place in early 1982 (see Figure 5), reducing waste temperatures significantly and permanently.

SUGGESTED FOLLOW-ON WORK

It is suggested that initial follow-on activities entail a critical examination of the theories and proposed schemes listed in Table 2. Further activities should consider the implications of the observed phenomena on gas production and release events, how these might impact safety, and mitigation strategies. More specifically, it is recommended that the TEMPEST code be used for waste heat transfer modeling. TEMPEST can handle the 3-dimensional heat transfer and convection that occurs in the waste, but some complexities of the tank geometry would have to be treated as lumped coefficients in the preliminary 2-dimensional model. For example, a loss coefficient through the bottom wall would represent the cooling air channels. At first, the analyses should consist of correctly predicting past temperatures (a preliminary TEMPEST model has been developed and exercised). Thereafter, the model could be used to predict future trends, and to evaluate the impact of mitigation strategies.

[2]Coates, T. 1993. Personal communication from WHC, dated December.

Table 2. Tank 241-SY-103 Behavior Models

Observed Phenomenon	Causative Theory/Model	Proposed Verification
Waste cooling trend	Decrease in chemical heat	Re-evaluate chemistry
	Radioactive species different than assumed	Re-evaluate species present in waste
	Increased heat transfer rate	Consider changes in waste; earth moisture content
	Recently increased air flow rate in dome	Calculate heat loss, based on current flow rates
Depth of, and any changes in, non-convective layer	Location of thermocouple tree	Data from second MIT tree may help
	Change in waste characteristics	Re-evaluate waste rheology
Increased period between GREs	Change in waste characteristics	Re-evaluate waste rheology
	Cooling trend	Re-evaluate waste rheology

As noted earlier, the temperature records plotted in this report are based on data sets that were reconstructed by filtering the raw data records. To access the raw data directly, contact the author of this report.

CONCLUSIONS

Retrieval, plotting, and analysis of the waste temperature historical record for Tank 241-SY-103 has provided clear evidence of continued waste cooling at a rate that is inconsistent with waste radioactive decay (Fox, Stepnewski and Anantatmula 1993). Various theories have been proposed to explain this trend. These theories, as well as others, should be examined and tested, preferably with the TEMPEST code.

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Fox, G. L. Jr., D. D. Stepnewski and R. P. Anantatmula. 1993. Tank 241-SY-103 Hazard Assessment. WHC-SD-WM-SAR-061, Rev. 0. Westinghouse Hanford Company, Richland, WA.

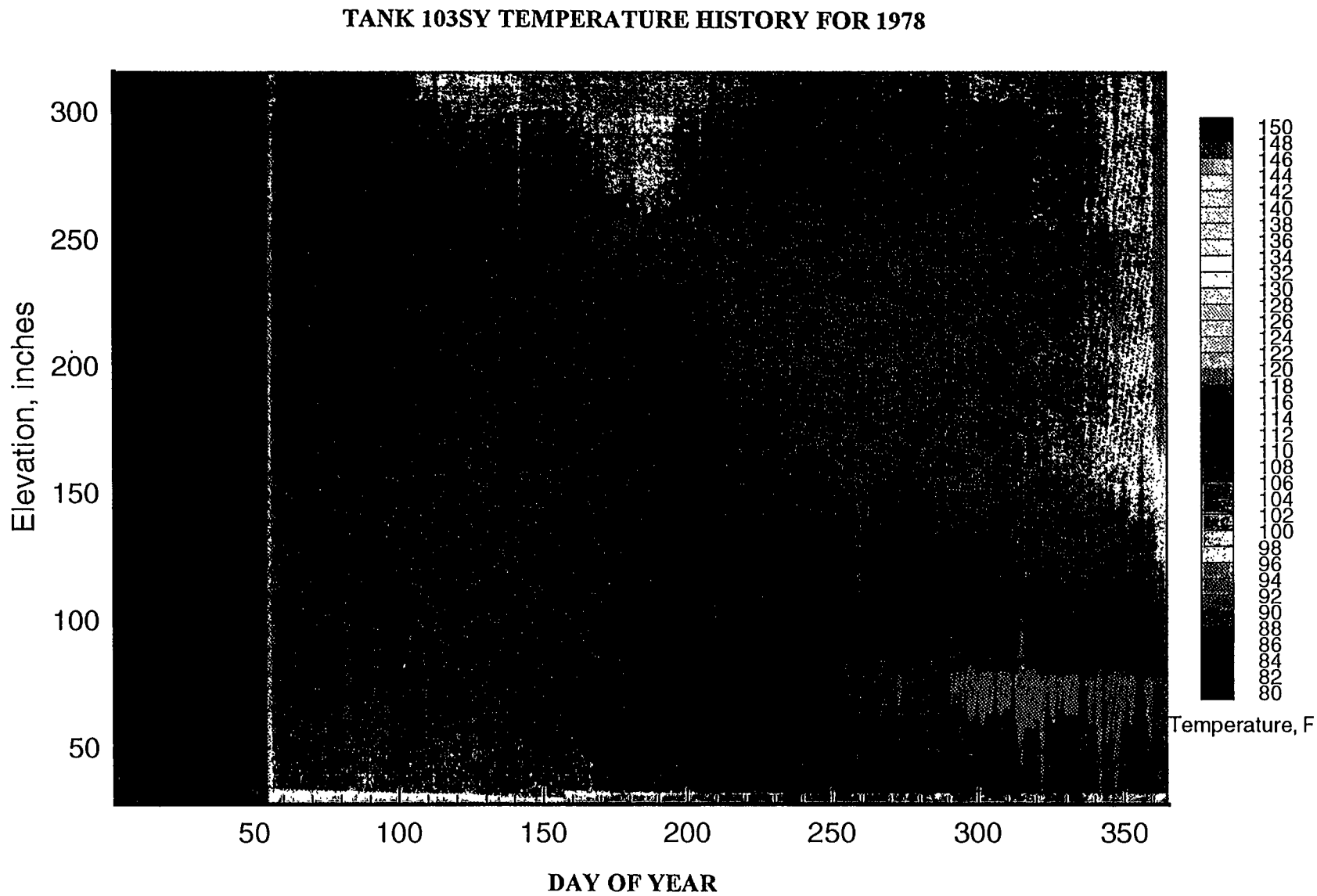

Figure 1. Waste Temperature Contours for 1978

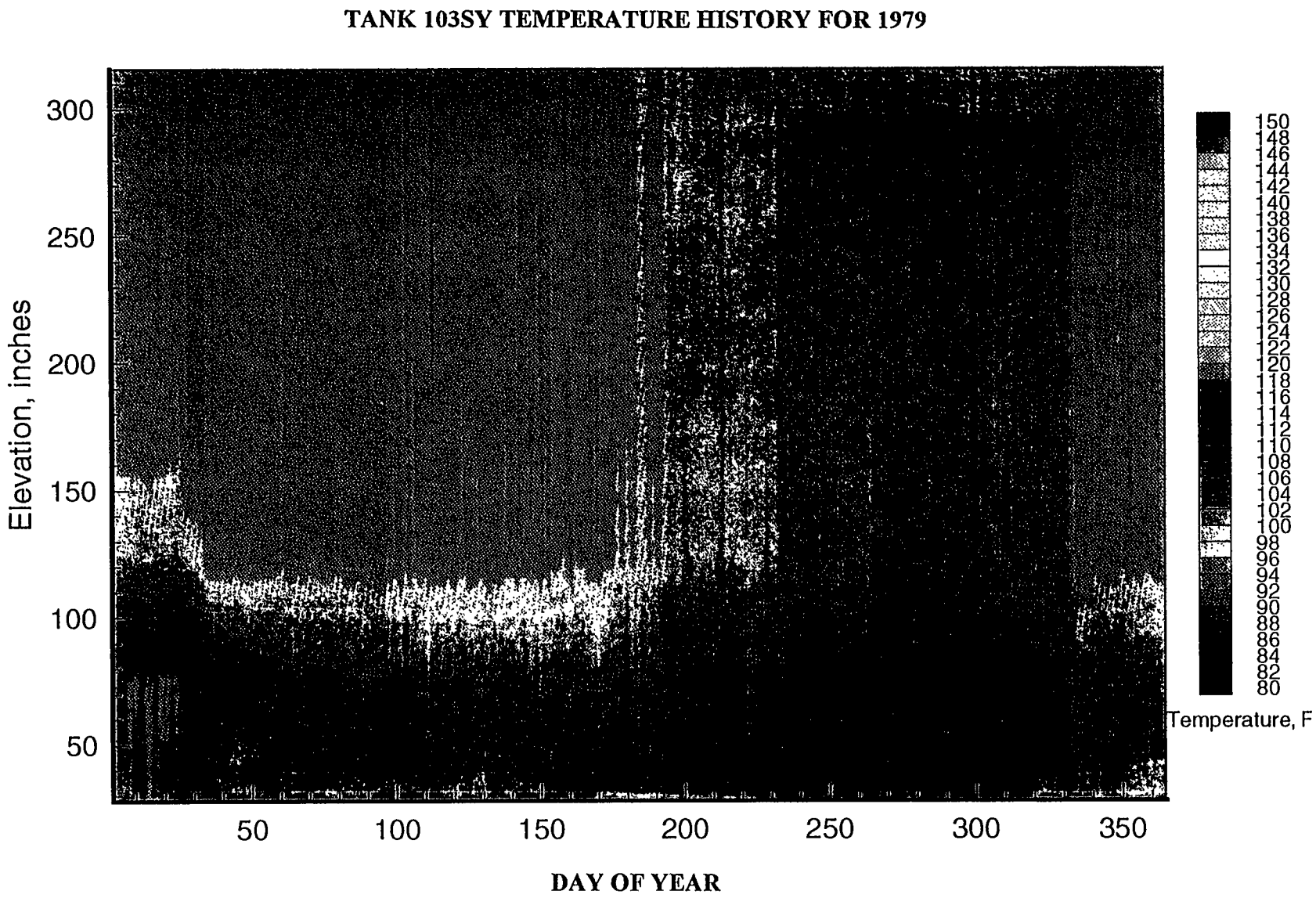

Figure 2. Waste Temperature Contours for 1979

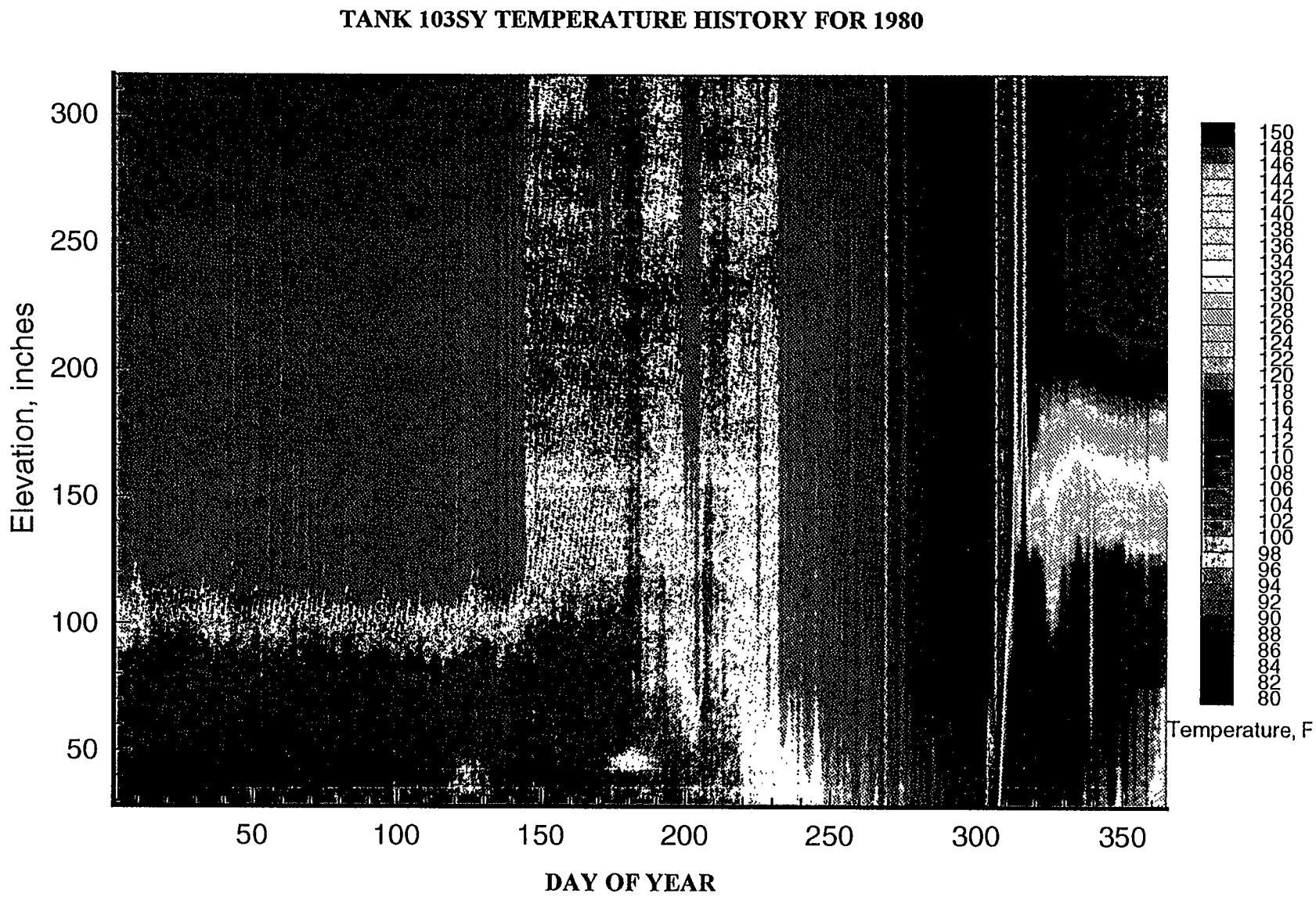

Figure 3. Waste Temperature Contours for 1980

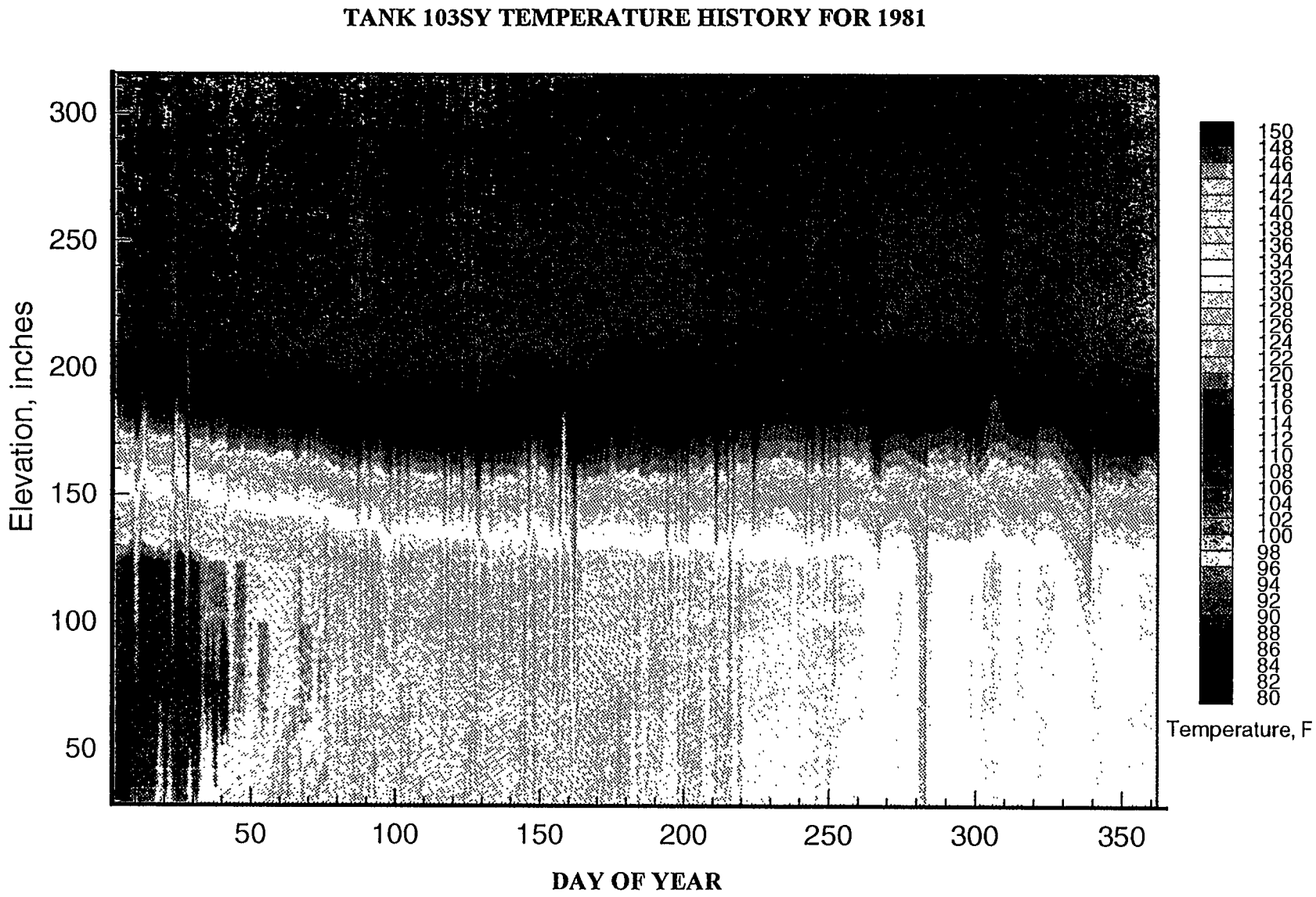

Figure 4. Waste Temperature Contours for 1981

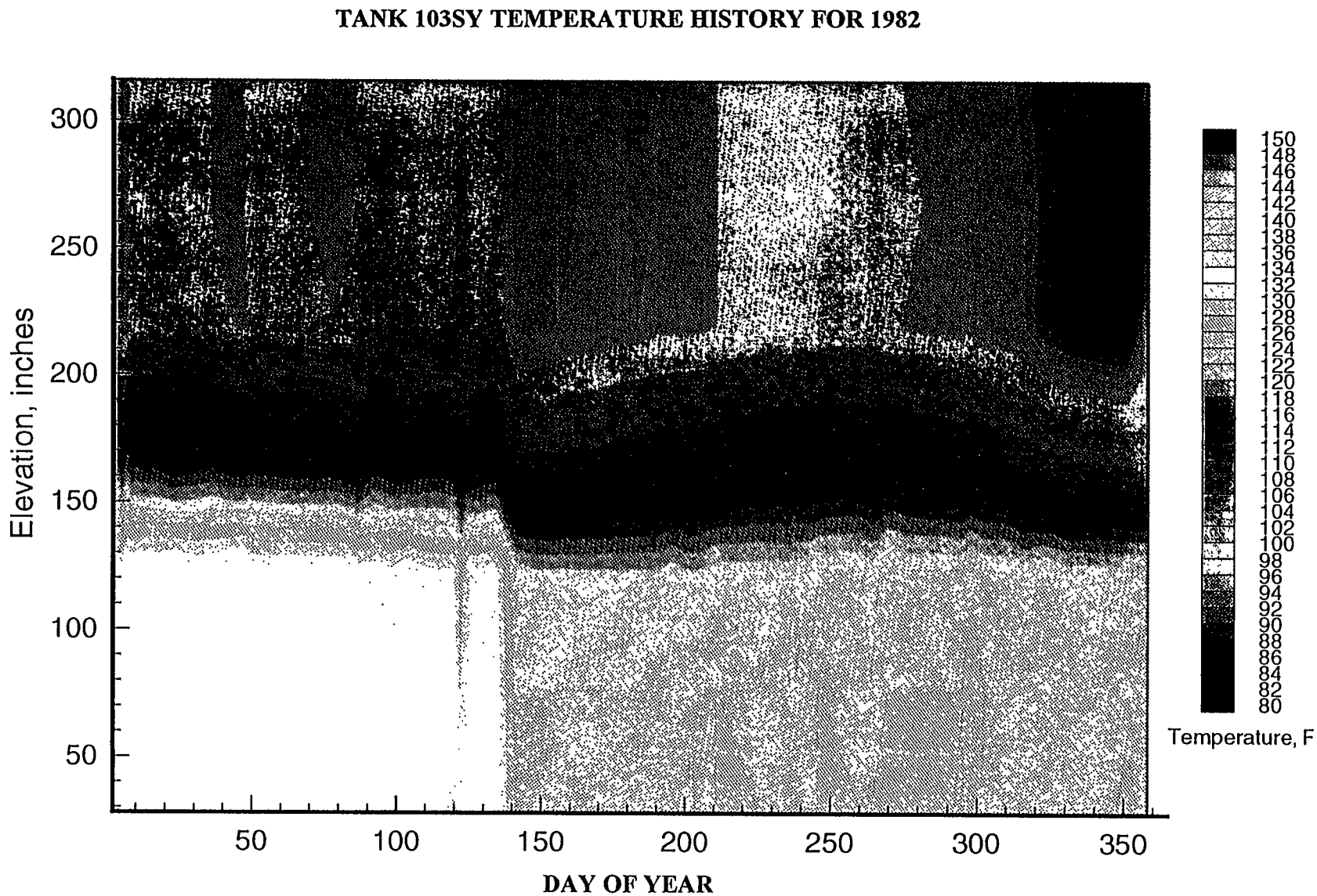

Figure 5. Waste Temperature Contours for 1982

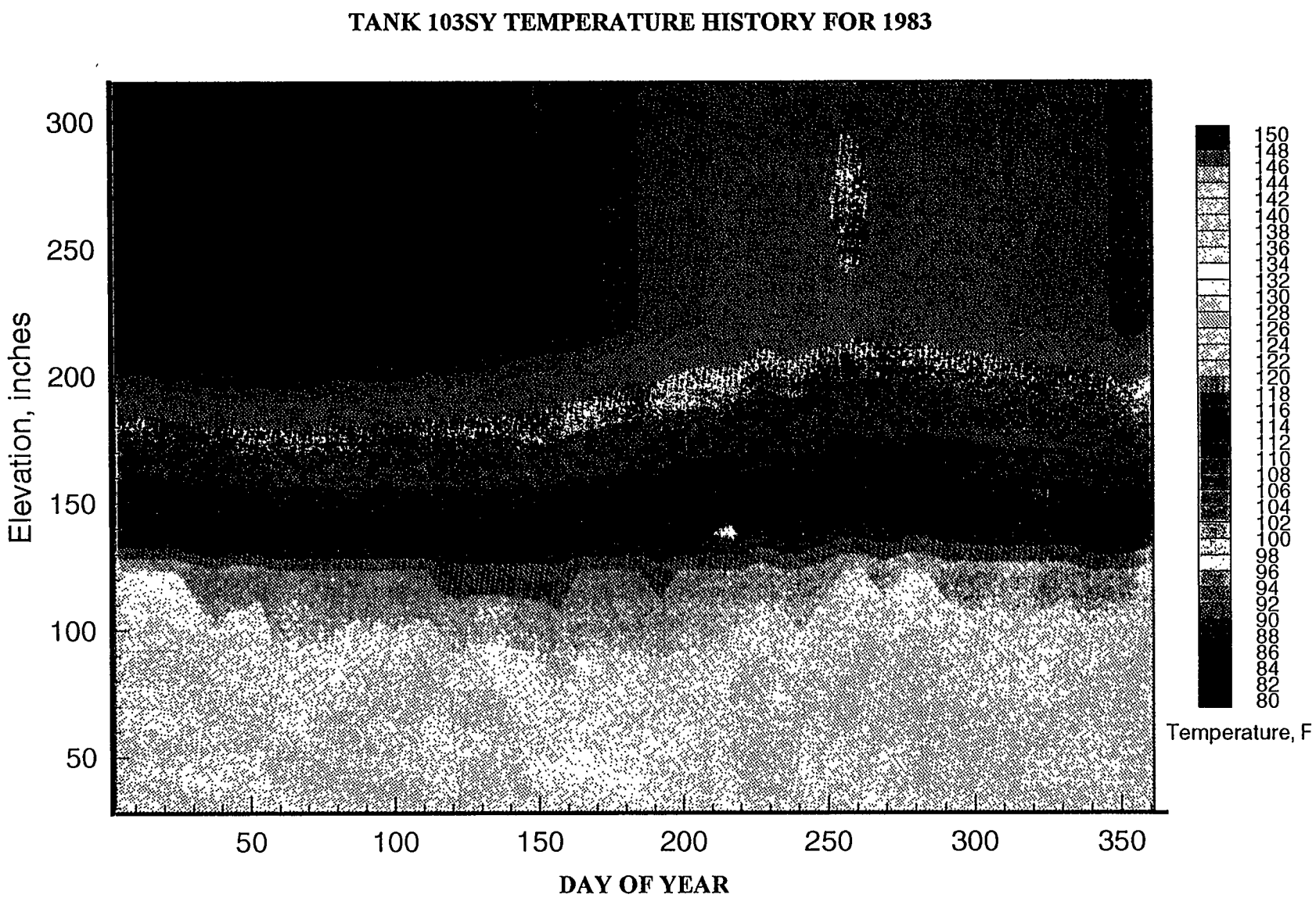

Figure 6. Waste Temperature Contours for 1983

TANK 103SY TEMPERATURE HISTORY FOR 1984

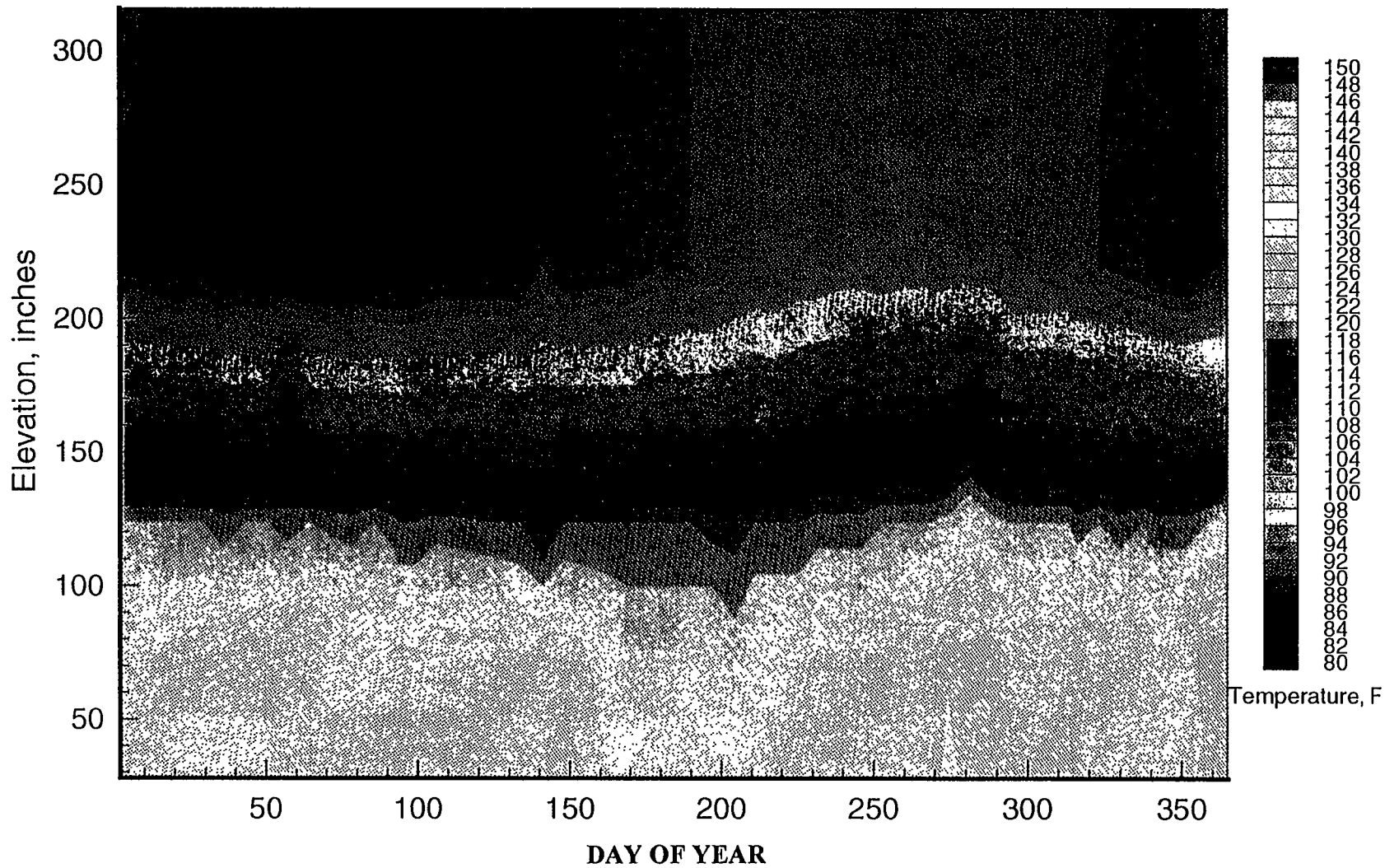

Figure 7. Waste Temperature Contours for 1984

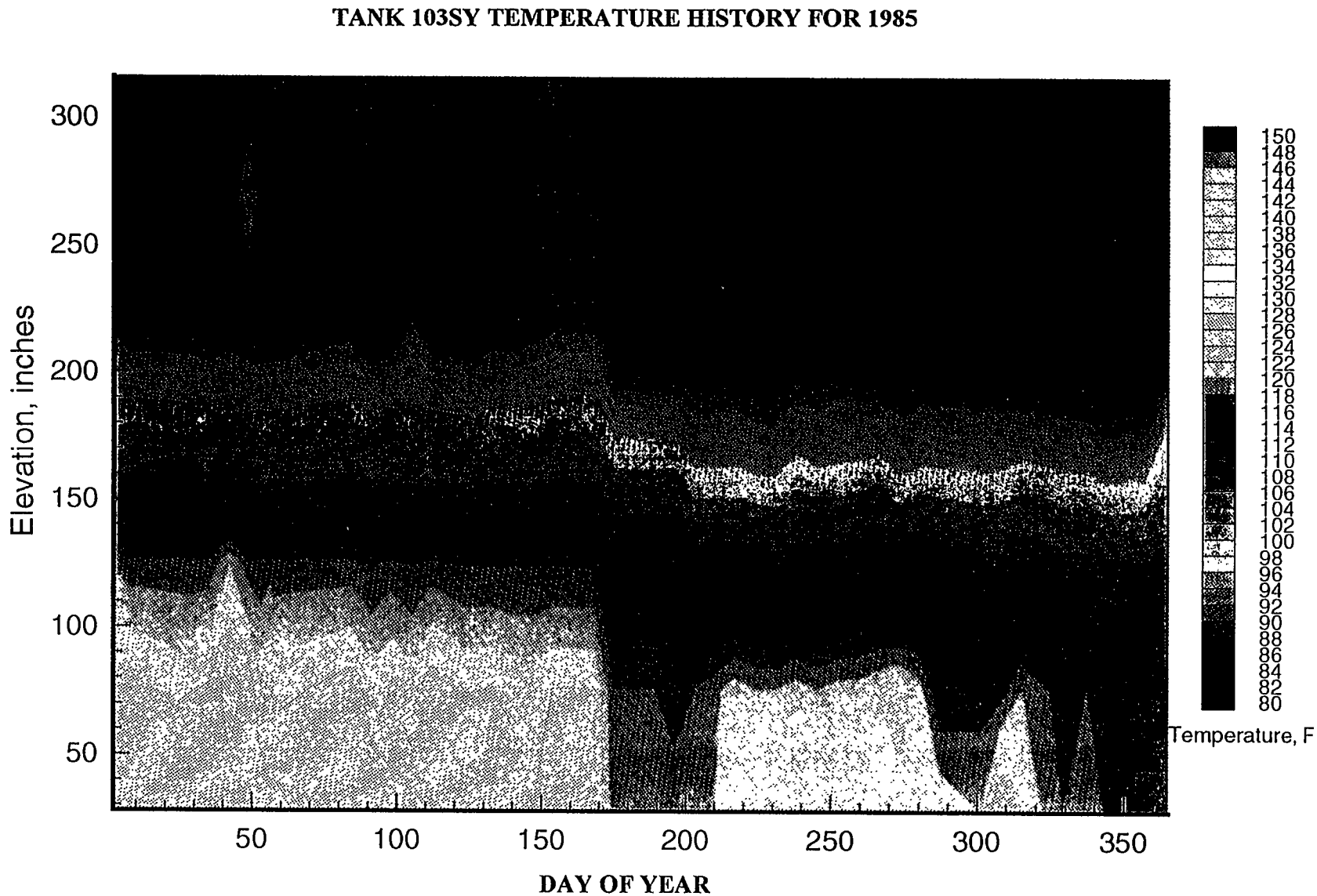

Figure 8. Waste Temperature Contours for 1985

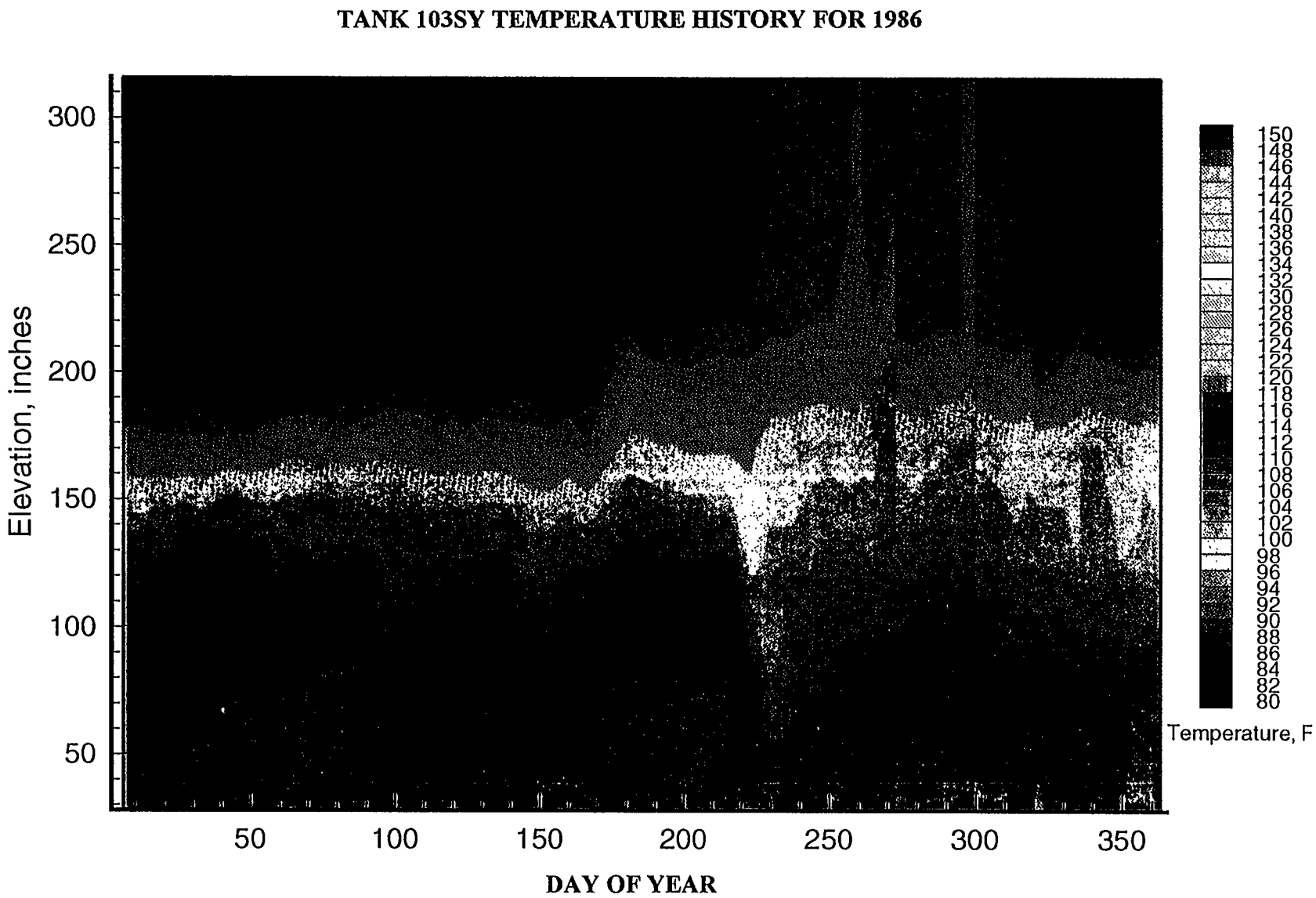

Figure 9. Waste Temperature Contours for 1986

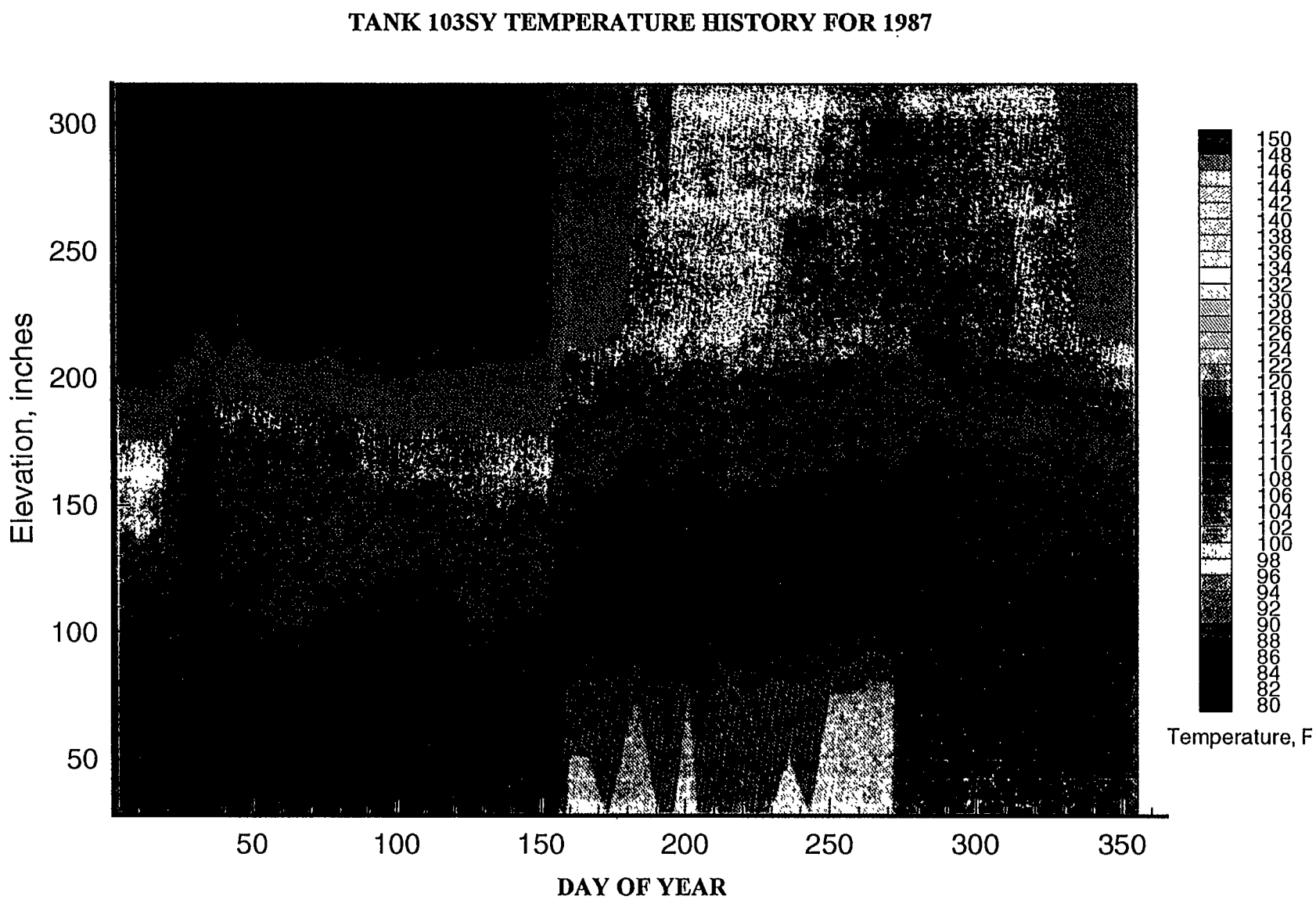

Figure 10. Waste Temperature Contours for 1987

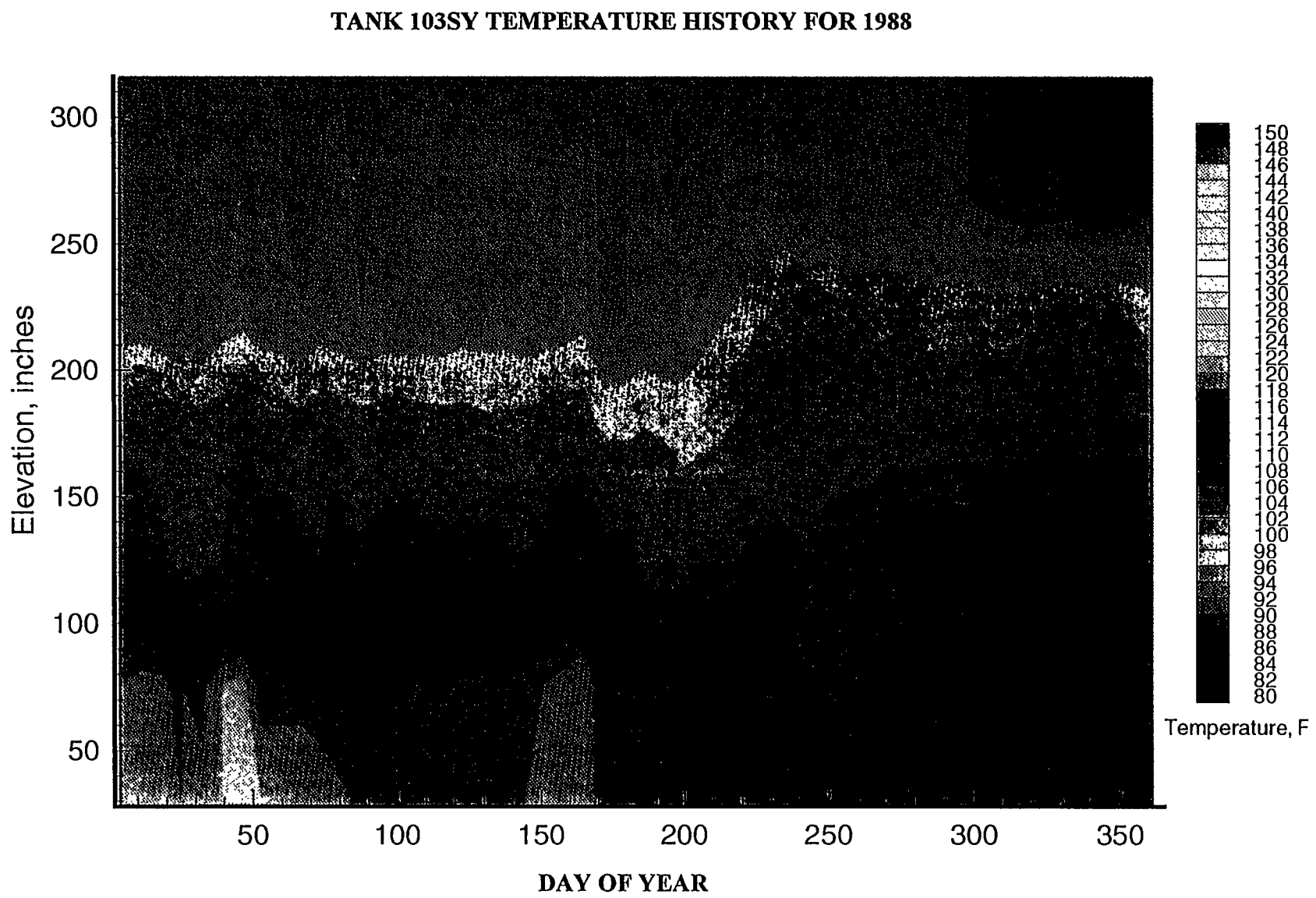

Figure 11. Waste Temperature Contours for 1988

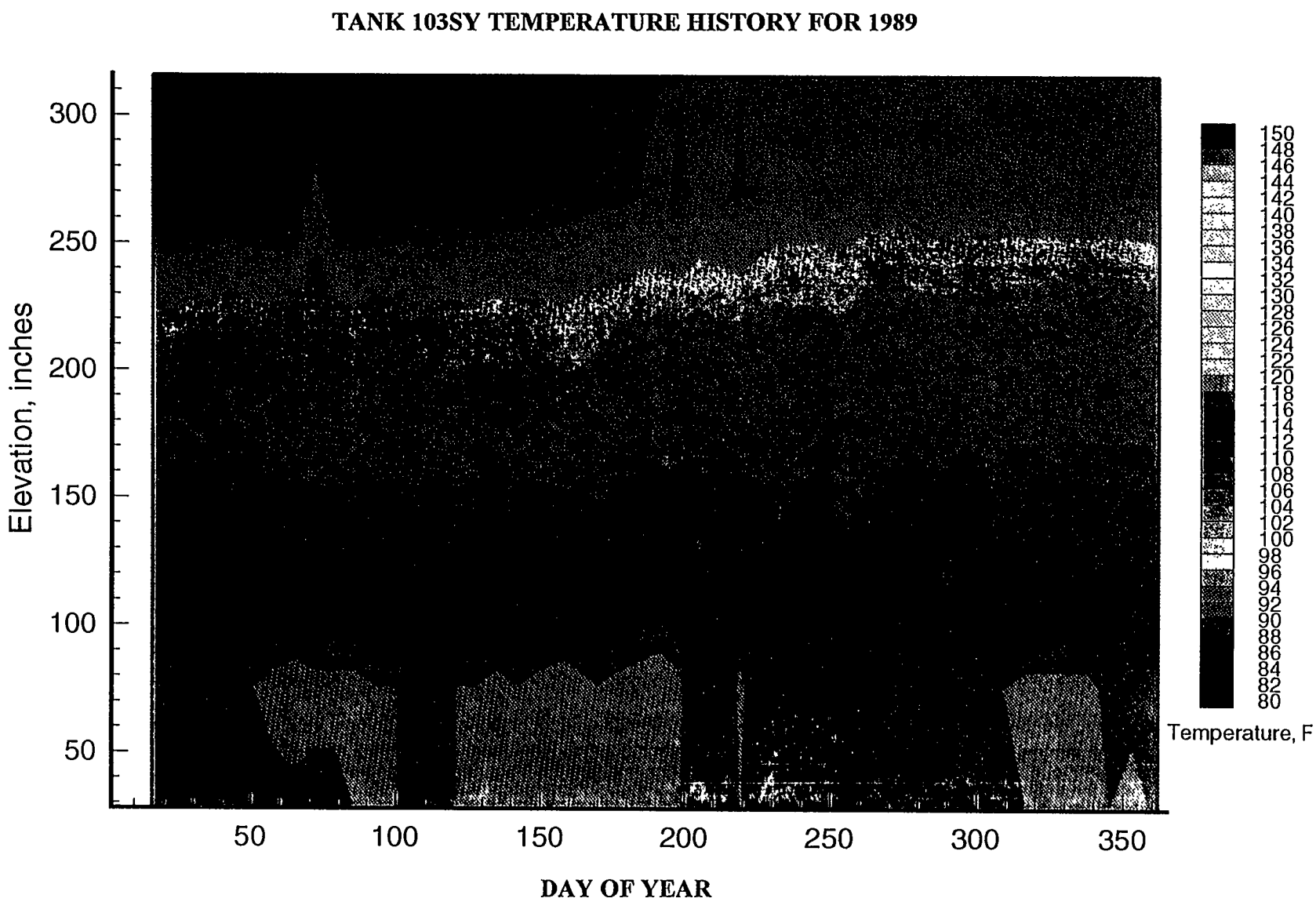

Figure 12. Waste Temperature Contours for 1989

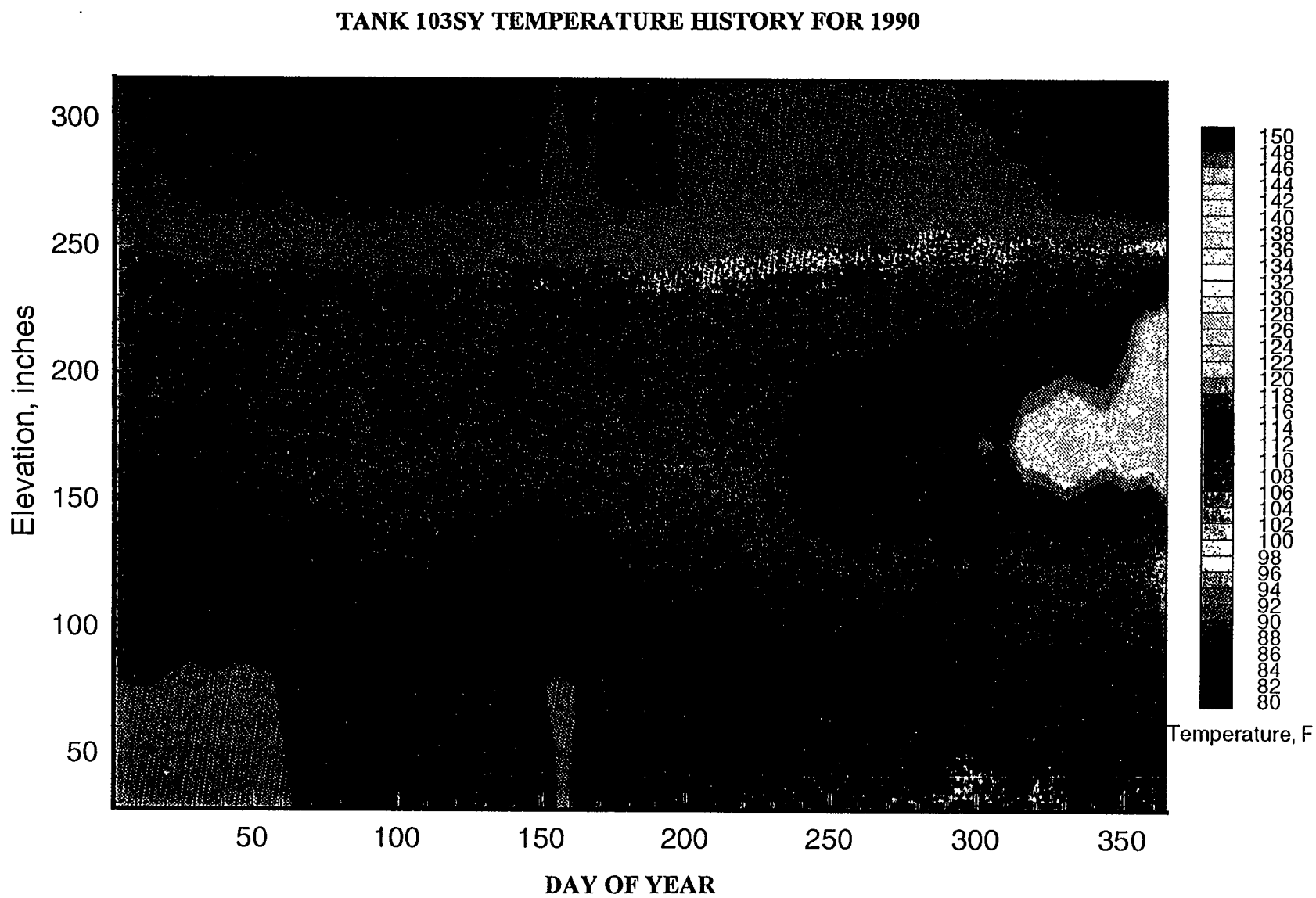

Figure 13. Waste Temperature Contours for 1990

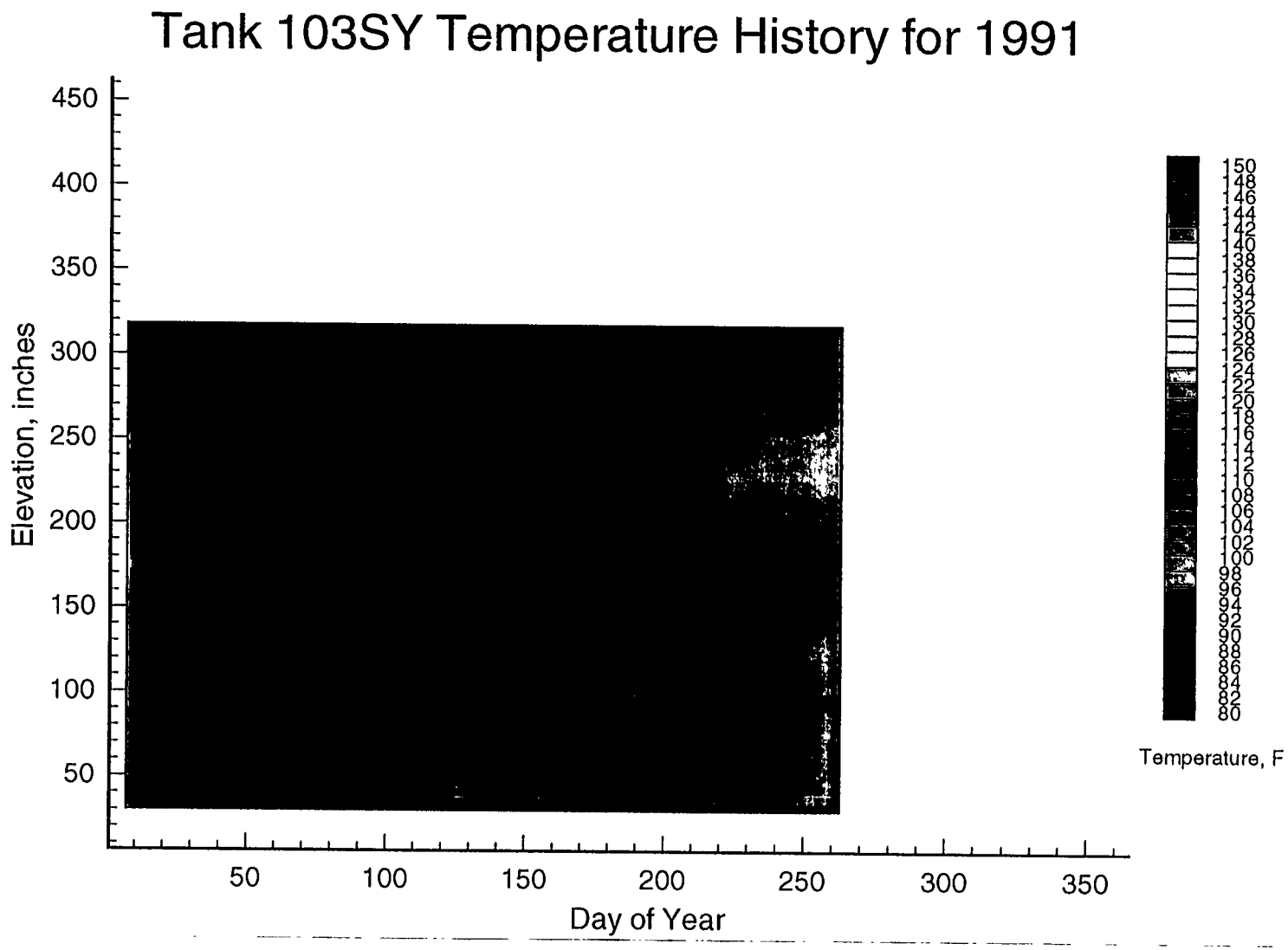

Figure 14. Waste Temperature Contours for 1991

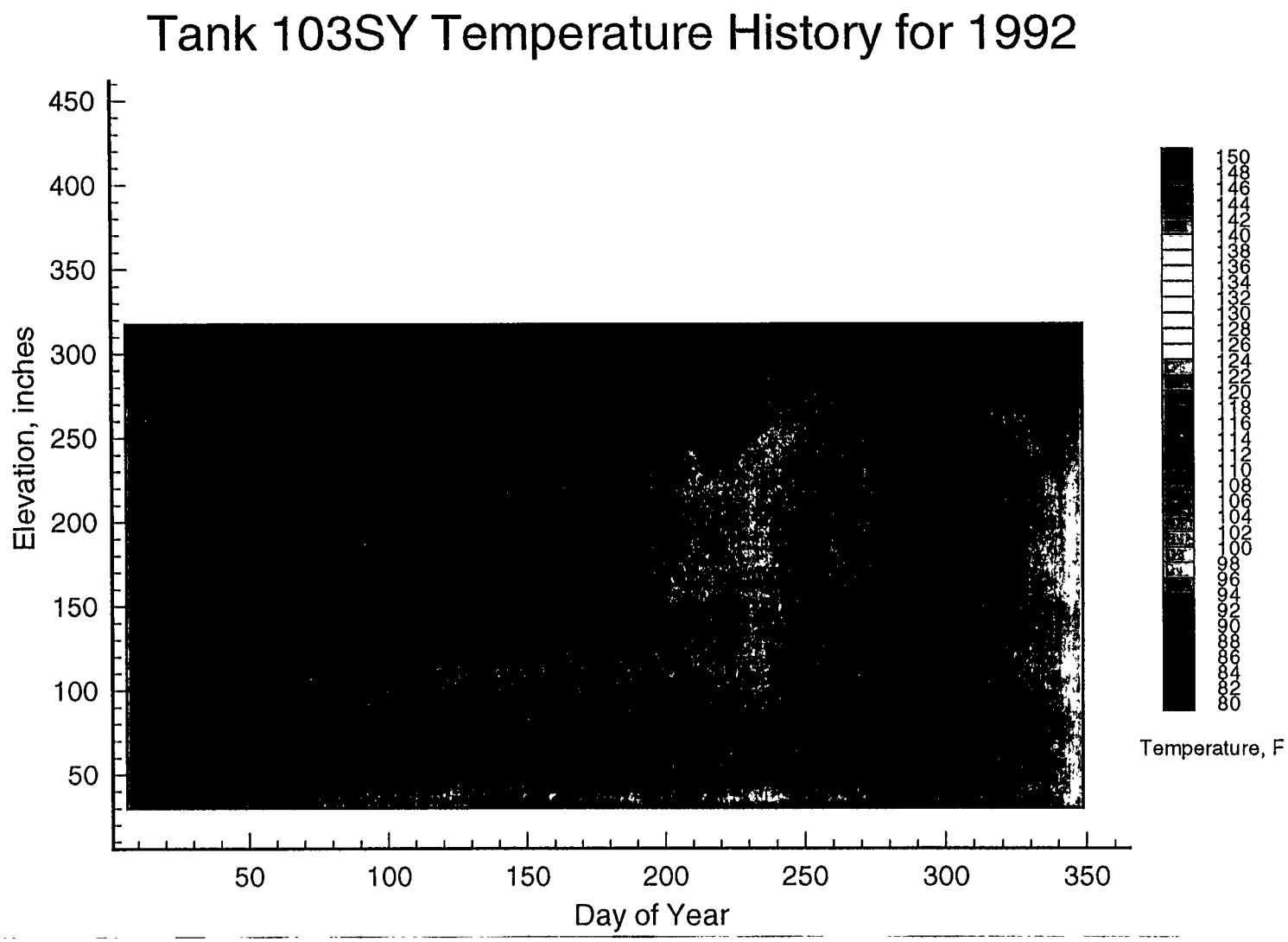

Figure 15. Waste Temperature Contours for 1992

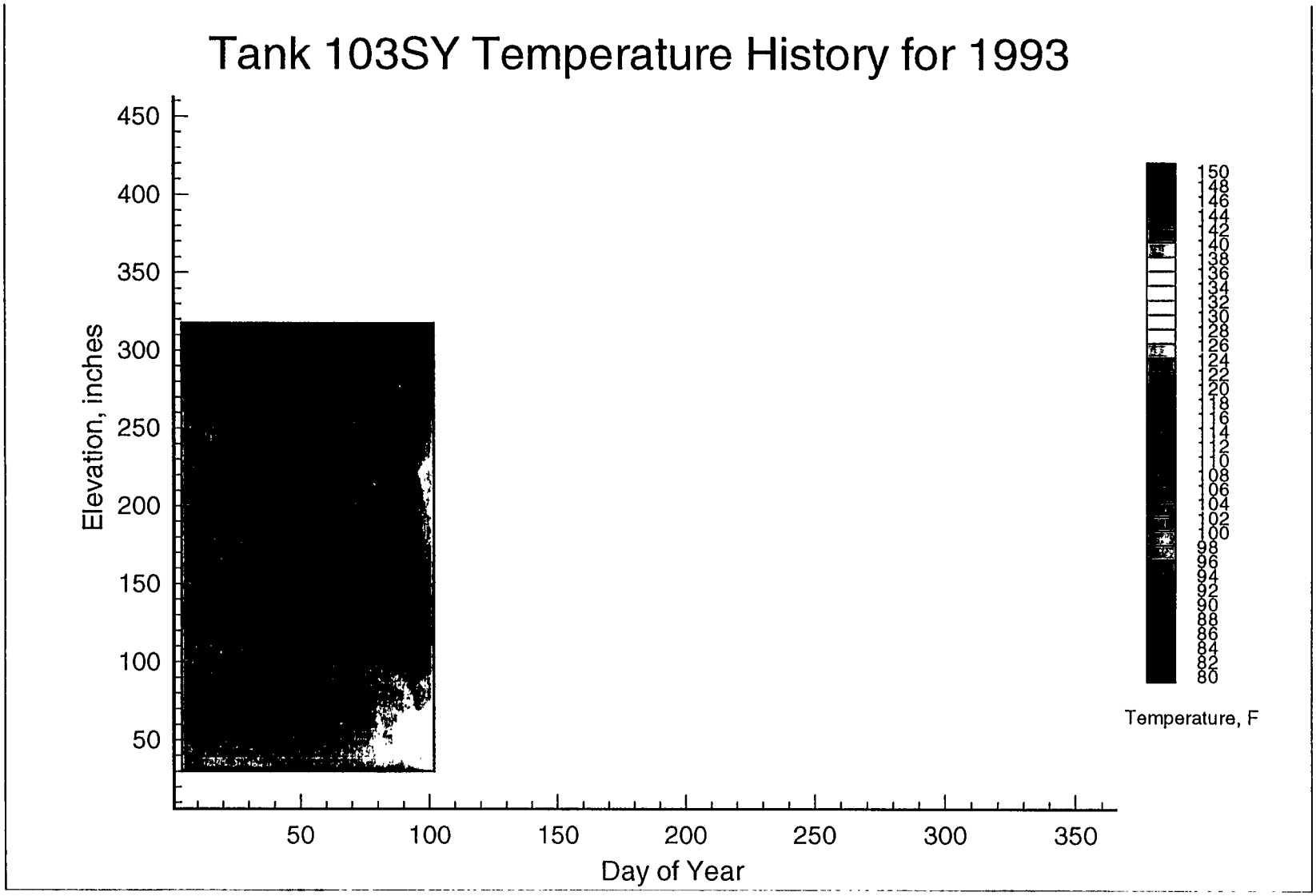

Figure 16. Waste Temperature Contours for 1993

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