Final Report

Contamination Analysis of SSF Candidate Materials

Contract No. NAS8-36955, D. O. 79
Acount No. 5-32391

Submitted to:

NASA
Marshall Space Flight Center, AL 35812

Submitted by:

Robert Connatser for R. Barry Johnson
University of Alabama in Huntsville
Center for Applied Optics
Huntsville, Alabama 35899

August 1991

52

Table of Contents

Table of Graphs

Preface

The research reported herein was conducted by personnel at the University of Alabama in Huntsville's Center for Applied Optics, under contract titled "Contamination Study". The testing of materials portion of the task was completed at the Materials and Processes Laboratory at NASA's Marshall Space Flight Center. The author would like to express his appreciation to Mr. Roger Linton, Ms. Whitney Hubbs, and Mr. Don Burch for their help and suggestions during this period.

Abstract

NASA's *In Situ* Contamination Effects Facility, Marshall Space Flight Center, has been used to test several candidate materials for use upon Space Station Freedom. Optical measurements were made in the vacuum ultraviolet (VUV) as test mirrors were contaminated by materials in a space-like environment. This was done to determine the effects of the contamination and subsequent exposure to VUV radiation upon optical components that will be used upon the space station.

Introduction

The object of the contract is to help determine which materials are suitable for use upon the space station near optical surfaces. Through testing and analysis, it is possible to reach conclusions about the materials and their possible effects. To aid in the understanding of the information and research performed, an overview of the testing and analysis procedures is necessary.

The major portion of the testing is done in the *In Situ* Contamination chamber. The chamber is cylindrical, 4 feet long with a radius of 1 foot. It is a vacuum chamber, pumped by a mechanical roughing pump and a turbomolecular pump. The VUV source is a microwave powered Krypton discharge lamp that emits primarily at 1600 and 1236 Angstroms. The data gathering instruments inside the chamber are the three photomultiplier tubes, a TQCM, and three thermocouples.

The candidate material is mounted across from the test mirror on a heating plate. The mirror is mounted to a plate that is also temperature controlled. The temperature range for the material heating plate is from 23 to >200 Celsius, and for the mirror mount is -10 to 50 Celsius. Under a good vacuum, the material and mirror are heated and/or cooled to the proper temperatures. This causes any contamination effects to occur. A direct reflectance measurement is taken off of the mirror, to note any specular change in the material during the test.

After the test is completed, an analysis of the contamination and its effect is started. This analysis includes microscope examination, reflectometry, FTIR spectroscopy, and a florescence check. Further testing is also done. The contaminated mirror is sometimes exposed to UV and VUV radiation, to determine whether or not the contamination will photolyze. In the future, mirrors will also be exposed to atomic oxygen. After these exposures, the full range of analysis is redone, and compared with the original analysis.

Test Materials and Results

From January 1991 to July 1991, the following materials were tested in the *In Situ* Facility.

Z-306

This material is a polyurethane binder, and is also known as chemglaze. It is used as a thermo-control coating, with two primary (space environment) uses. First, this material uses carbon black as an absorber and is thereby used to keep objects warm. It is also used as a diffuse black absorber, to keep down stray reflected and scattered light. Z-306 is also highly atomic oxygen sensitive and requires extensive vacuum bakeout for outgassing purposes.

Currently, Z-306 is coated on the inside of the Hubble Space Telescope. One of the questions that the testing was to answer is if it would be safe to turn the telescope so that it faced closer to the sun. Such a move would cause the overall temperature of the telescope to rise to around 155 Celsius. The tests done here show that there is a second level of outgassing done in at about 155 Celsius in the presence of VUV radiation, which would contaminate the optics of the space telescope. Therefore it would be unsafe to turn the telescope to that position.

Silicone, Viton, and EPR

These three materials are candidates for window and docking seals on the space station. The object was to find out which material best fitted the requirements of low outgassing in the space environment.

Silicone is known to be a fairly good seal material, and is useable over a large temperature range. Viton is the best seal material, but is not useable in a large temperature range. EPR is a seal material that was used as a comparison to the other two.

The testing done indicates that Viton is the cleanest material, under the test conditions. This was the expected conclusion, from previous testing.

Solithane 113

This material is used for elastomeric sealing and as a potting compound. It is a candidate material for the European Space Agency's SOHO satellite, as well as for Space Station Freedom. The purpose of the tests on solithane is to gather baseline contamination information, with special concern for the effects of any residue on optical surfaces.

The initial tests have shown that solithane does outgas, even after a proper vacuum bakeout. This outgassing left a residue on the test mirror that could be seen with the naked eye. Analysis of the residue has not been completed at this time.

Tests

Each candidate material was tested individually, and each test is different from the others. They vary in duration and in the temperatures that the mirror and contaminant are set at. For some materials many tests are appropriate, while others only require one or two tests.

Following is a list of the different tests, with descriptions of their conditions. The tests have been labelled as the "Rob Series," and any multiple tests are identified by the "Run" number. For example, the first test of Z-306 has been labelled as Rob Series 1, Run 1. The test mirrors used also have identifying labels, but they have no specific ordering.

Rob Series 1

This is the series of tests made on Z-306. The general conditions for the three tests were identical.

Run	Mirror	Duration	Total TQCM Change	% Specular Change
1	11-91	12,000 sec	488 hz	-27.6%
2	9-91	10,800 sec	362 hz	-5.7%
3	12-91	20,400 sec	1679 hz	-56.5%
4	7-91	15,060 sec	870 hz	-48.0%

Rob Series 2

This is the series of tests that investigated Solithane. Several of the tests had slightly different conditions; these tests will be explained independently.

For Run 1, there were to be three different stages. The first was with the contaminant and the mirror at 50 and 0 Celsius respectively. Then when the optical and TQCM outputs levelled off, the contaminant temperature was to be raised to 100 Celsius, and then 120 Celsius when the outputs had levelled off again. The length of time between level stages caused the last stage of the test to be delayed overnight.

Run 2 was set to be a TQCM test of Run 1. It was done without a mirror, but with the mirror stage taken to the same temperature as in Run 1. This test only repeated the 50 Celsius and 100 Celsius portions of Run 1.

Run 3 was designed to have a steady contamination temperature, but have different stages of mirror temperatures. The mirror was initially taken to 0 Celsius, then lowered to -16 Celsius for the majority of the test, then raised to 30 Celsius for last portion of the test.

Run 4 also had different stages of mirror temperatures. The mirror, TQCM, and contaminant were initially set to 50 Celsius. Then the mirror and TQCM were lowered 10 degrees, and maintained there for 30 minutes. This was repeated until the mirror and TQCM reached -8 Celsius, which was as low as the water chiller would go.

Run	Mirror	Duration	Total TQCM Change	% Specular Change
1	S1	22,798 sec	233 hz	-13.6%
2	na	22,800 sec	105 hz	na
3	R2	82,200 sec	176 hz	-15.4%
4	R2X	26,400 sec	188 hz	-24.3%

Rob Series 3

This test was conducted using Viton as the contaminant. This test was similar to the last run on Silicone (RS2R4). The contaminant was taken to about 60 Celsius, and the mirror and TQCM were lowered to about -10 Celsius. Then the mirror and TQCM temperatures were raised first in 10 degree then 5 degree increments, until they reached 60 Celsius. They were maintained at each temperature for about a half hour. The TQCM result seems to indicate that there was more outgassing off of the crystals as the temperature rose, than any accumulation from the material.

Run	Mirror	Duration	Total TQCM Change	% Specular Change
1	R1	30,000 sec	-204 hz	-15.3%

Rob Series 4

This test used EPR rubber as the candidate material. This test was split into two sections, due to time considerations. The first section had the contaminant, mirror, and TQCM raised to 50 Celsius. Then the mirror and TQCM were lowered to 40 Celsius, then on towards 0.

The second section had the contaminant raised towards 60 Celsius, with the mirror and TQCM taken to about 30 Celsius. The mirror and TQCM temperatures were lowered in 10 degree increments, down to 0 Celsius. They were left at each temperature for a period of twenty to thirty minutes.

Run	Mirror	Duration	Total TQCM Change	% Specular Change
1A	R3	15,000 sec	990 hz	-20.1%
1B	R3	22,800 sec	102 hz	-90.9%

Rob Series 5

These tests will be devoted to the candidate material Solithane 113. Only one test in this series has been completed at this time.

The test performed on the material was different from all others in that a secondary mirror holder was placed in the chamber beneath the primary mirror station. This holder was externally connected to the coolant lines (external to the lines) so as to provide some measure of thermal control over them. It held two test mirrors and two slugs, so as to provide several contaminated samples along the same run.

The mirrors were cooled overnight, to allow for the best temperature to be reached by the secondary mirrors, with a target temperature of 0 Celsius. A facilities test later showed that the secondary mirrors probably reach a temperature of approximately 5 Celsius. For the test, the contaminant was raised to 60 Celsius.

Run	**Mirror**	**Duration**	**Total TQCM Change**	**% Specular Change**
1	R4	22,800 sec	na	-22.4%

Conclusion

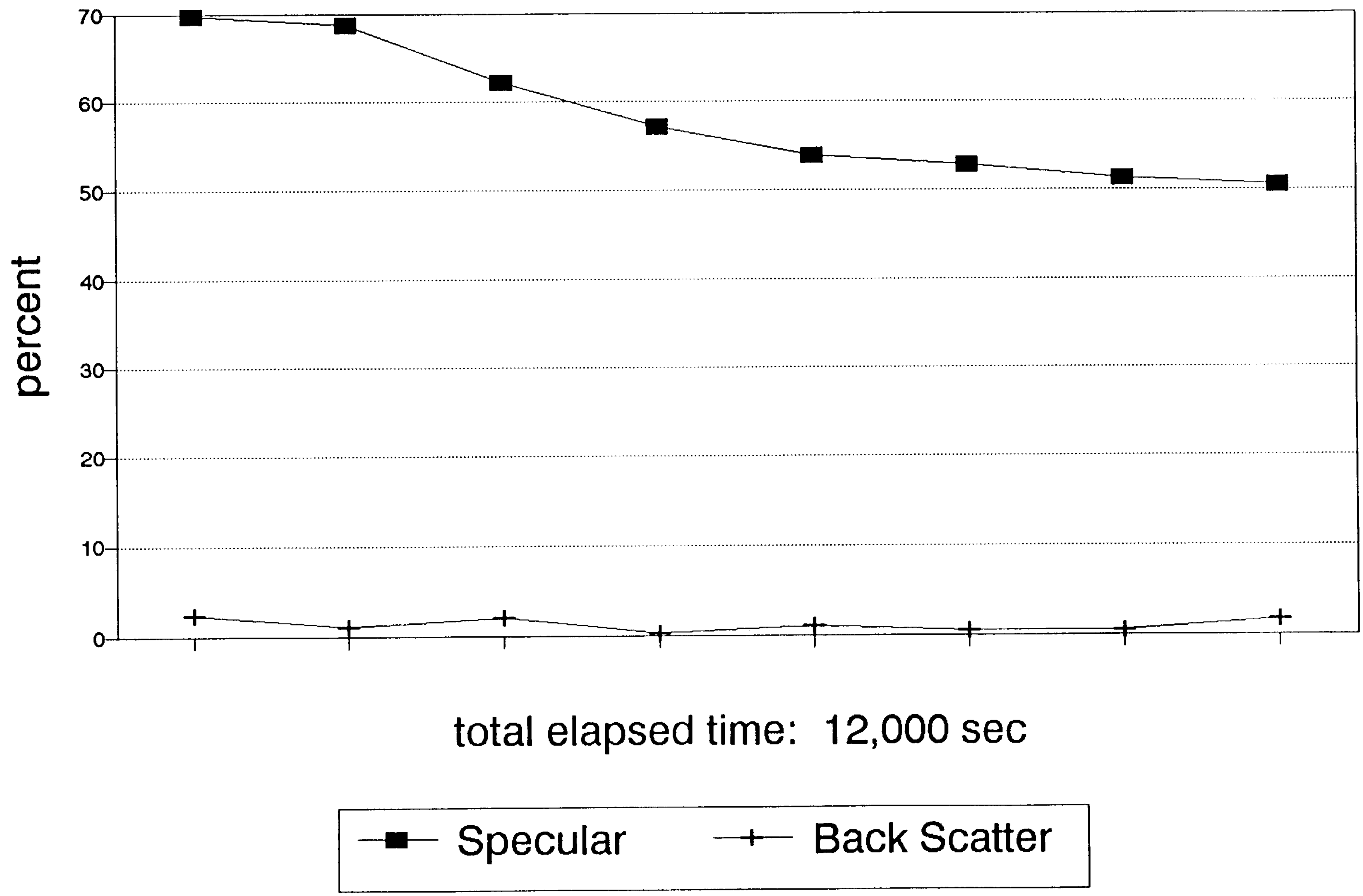
The testing process used at the *In Situ* Contamination Facility provides worthwhile information on the contamination effects of the materials tested. This aids in making recommendations about which materials are suitable for use upon Space Station Freedom. This facility is able to help support any further research on the effects of contamination by space materials on optics.

R. Barry Johnson
Principal Investigator

8/7/91
Date

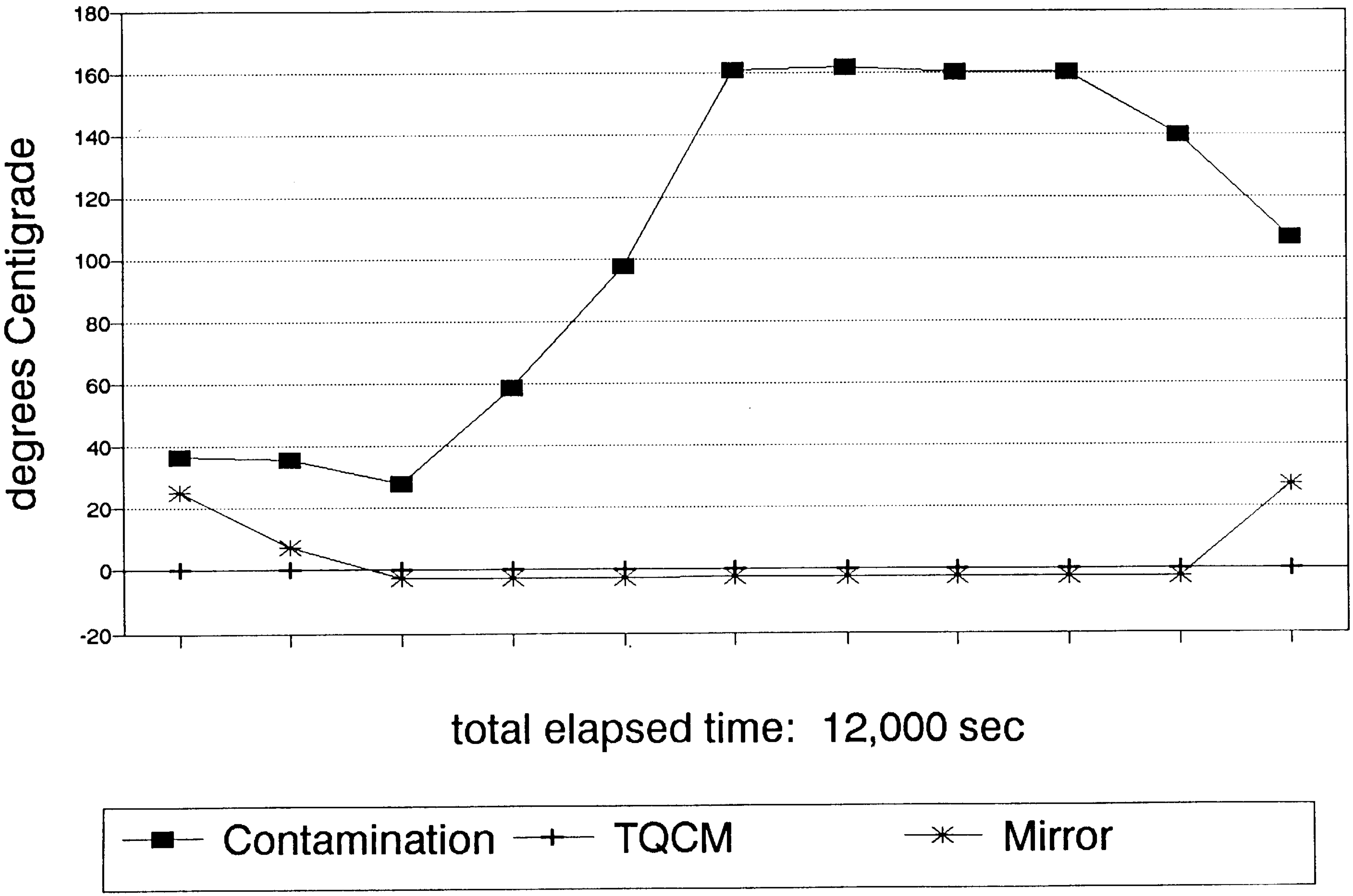
Z-306: Rob Series 1, Run 1

Optical Data



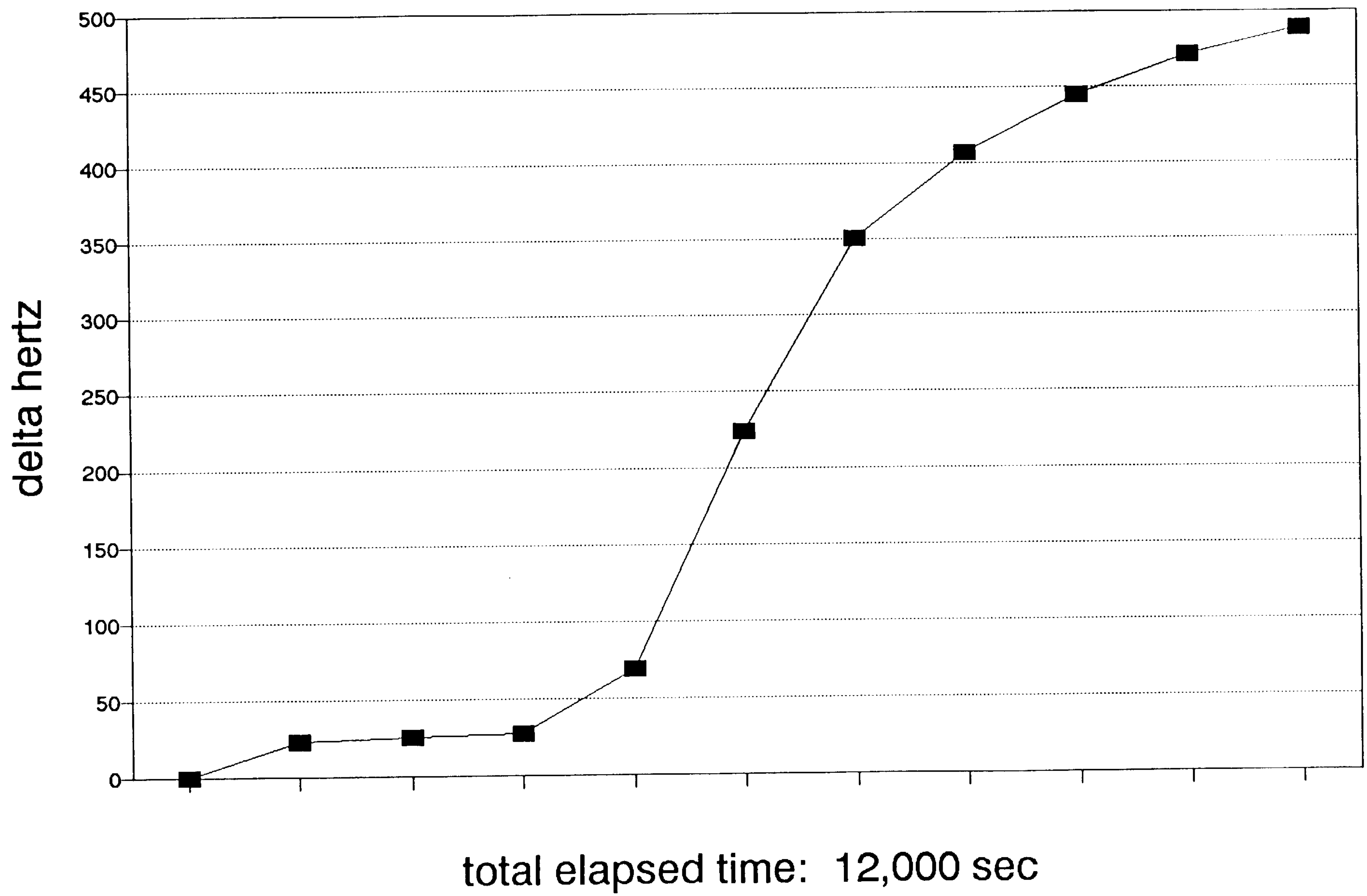
Z-306: Rob Series 1, Run 1

Temperatures



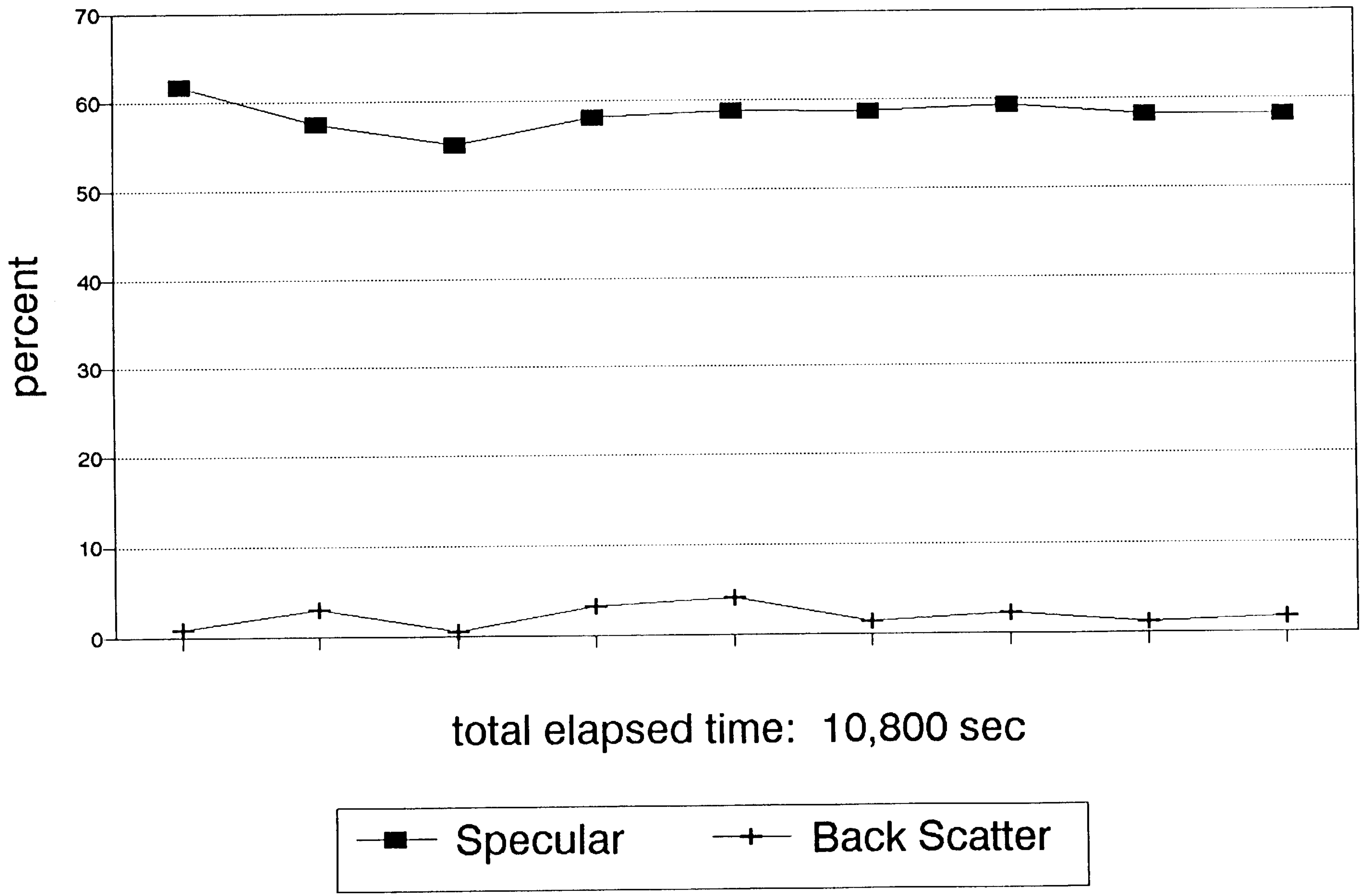
Z-306: Rob Series 1, Run 1

TQCM Data



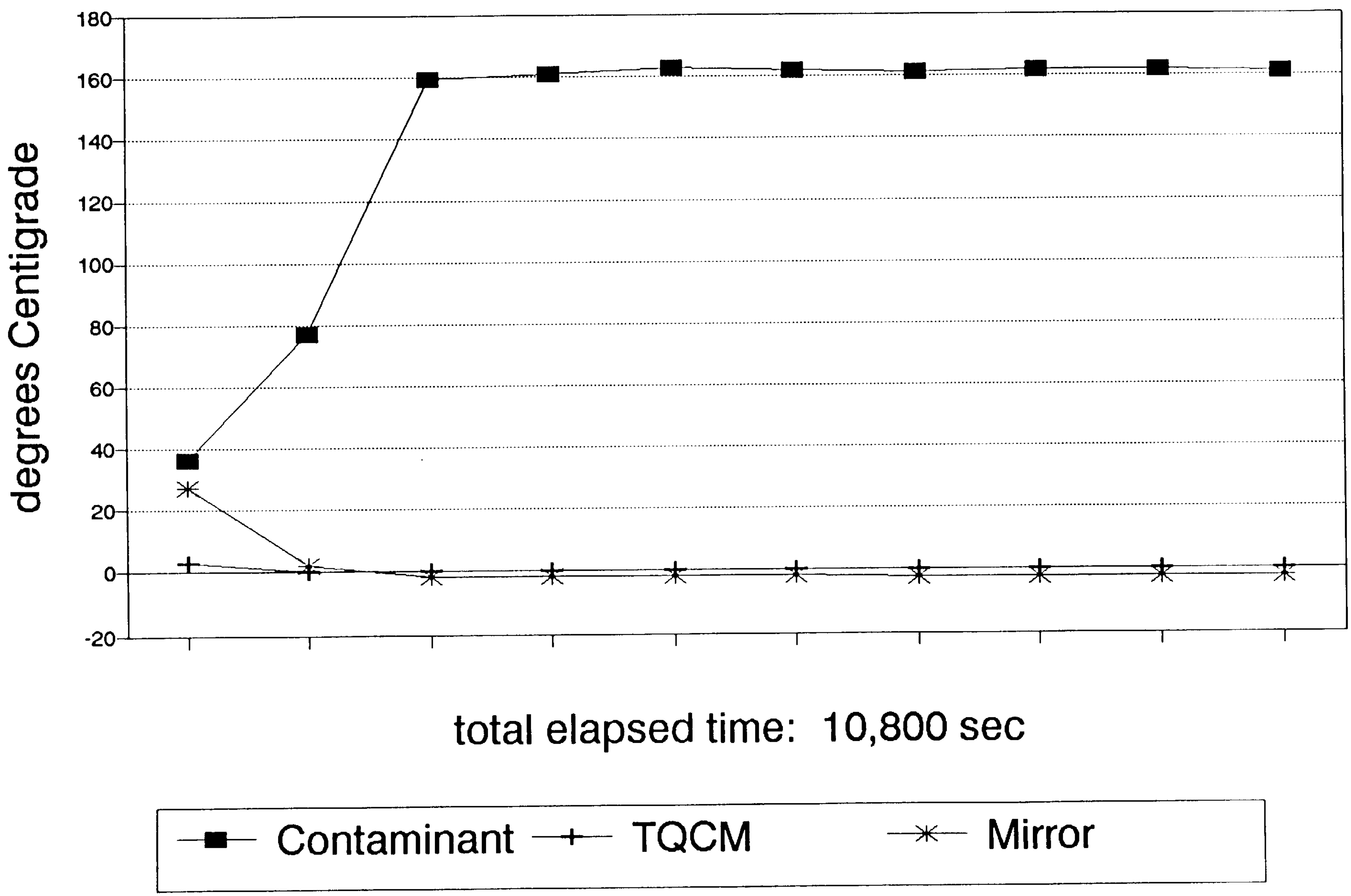
Z-306: Rob Series 1, Run 2

Optical Data



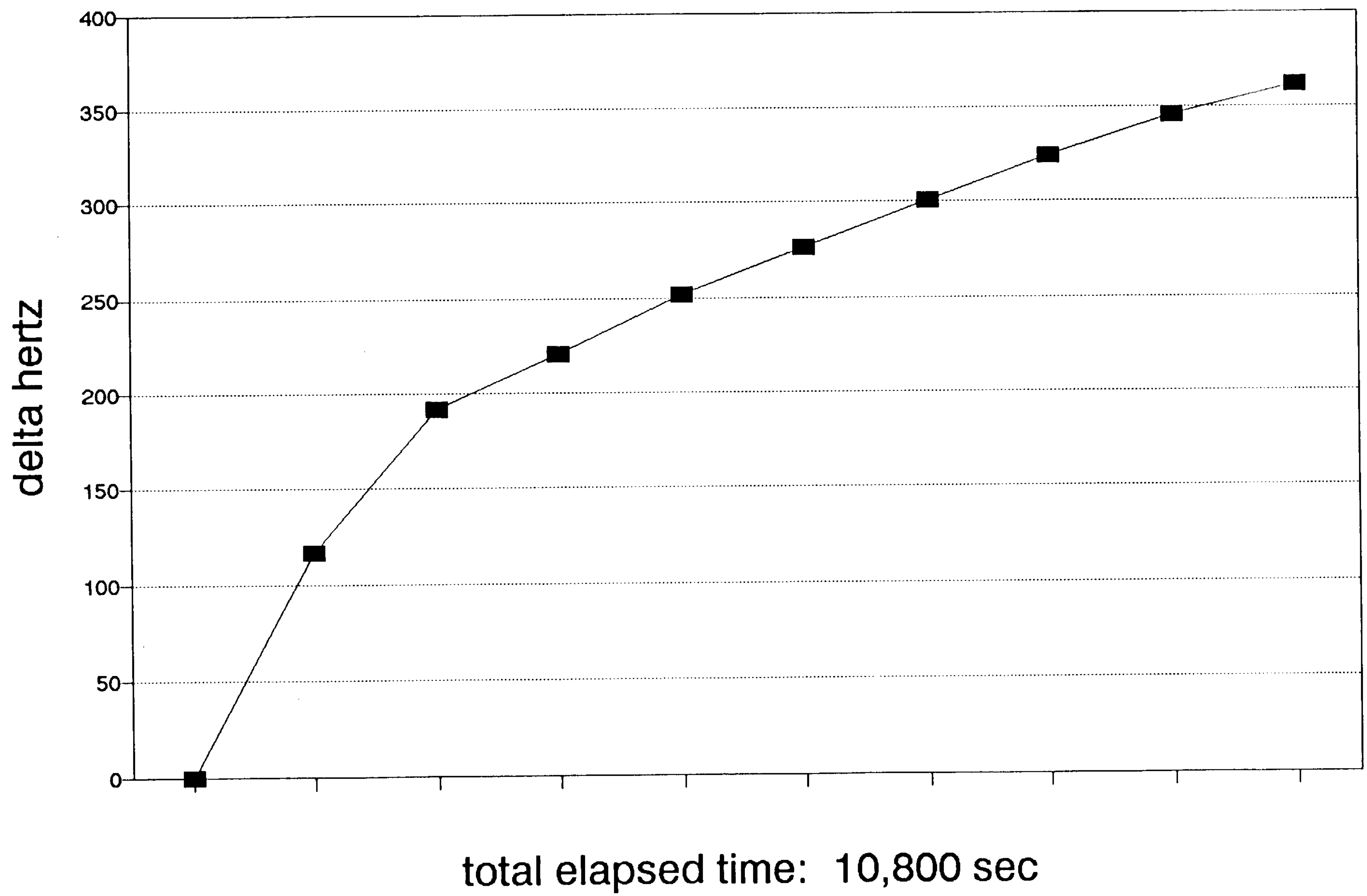
Z-306: Rob Series 1, Run 2

Temperatures



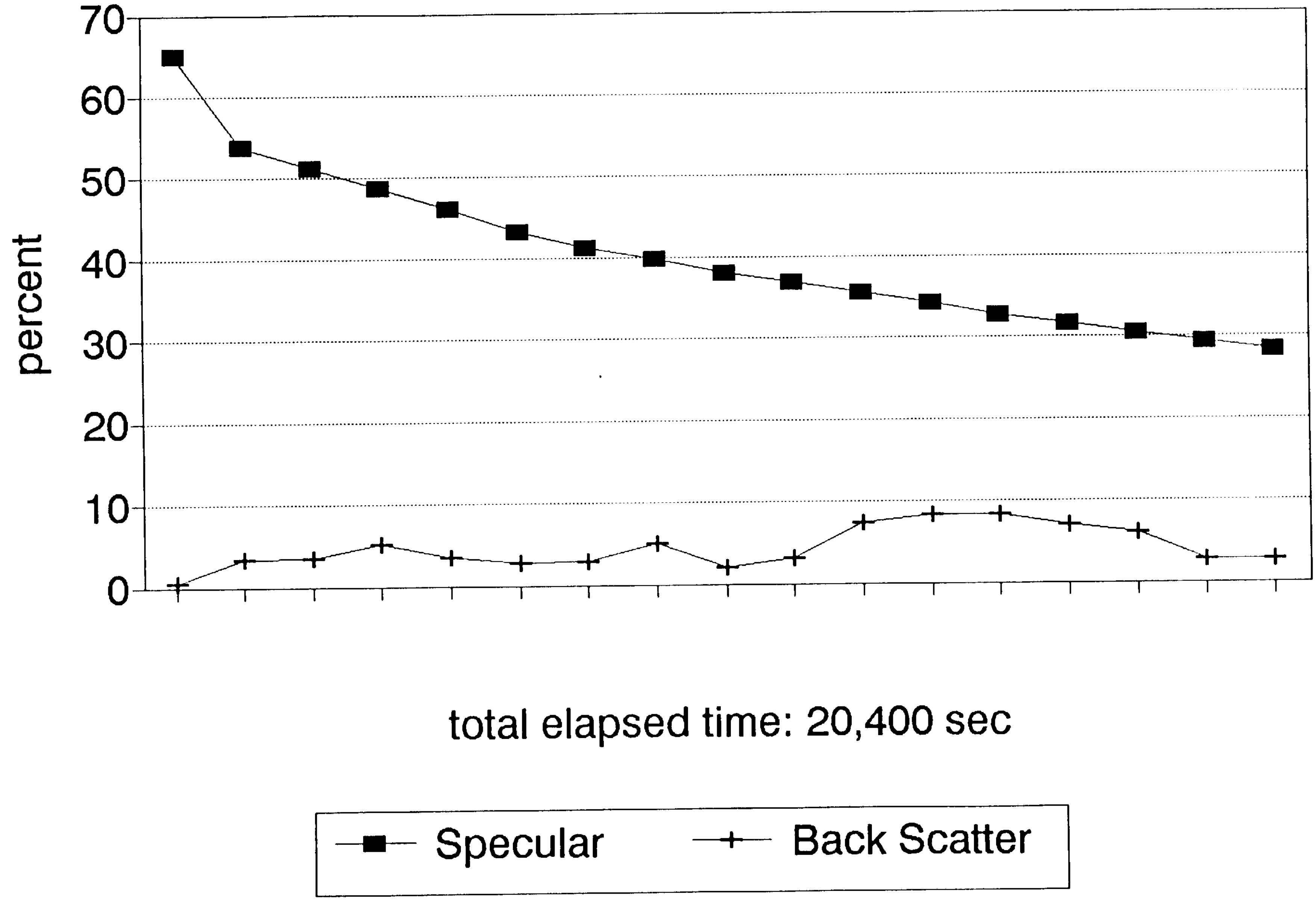
Z-306: Rob Series 1, Run 2

TQCM Data



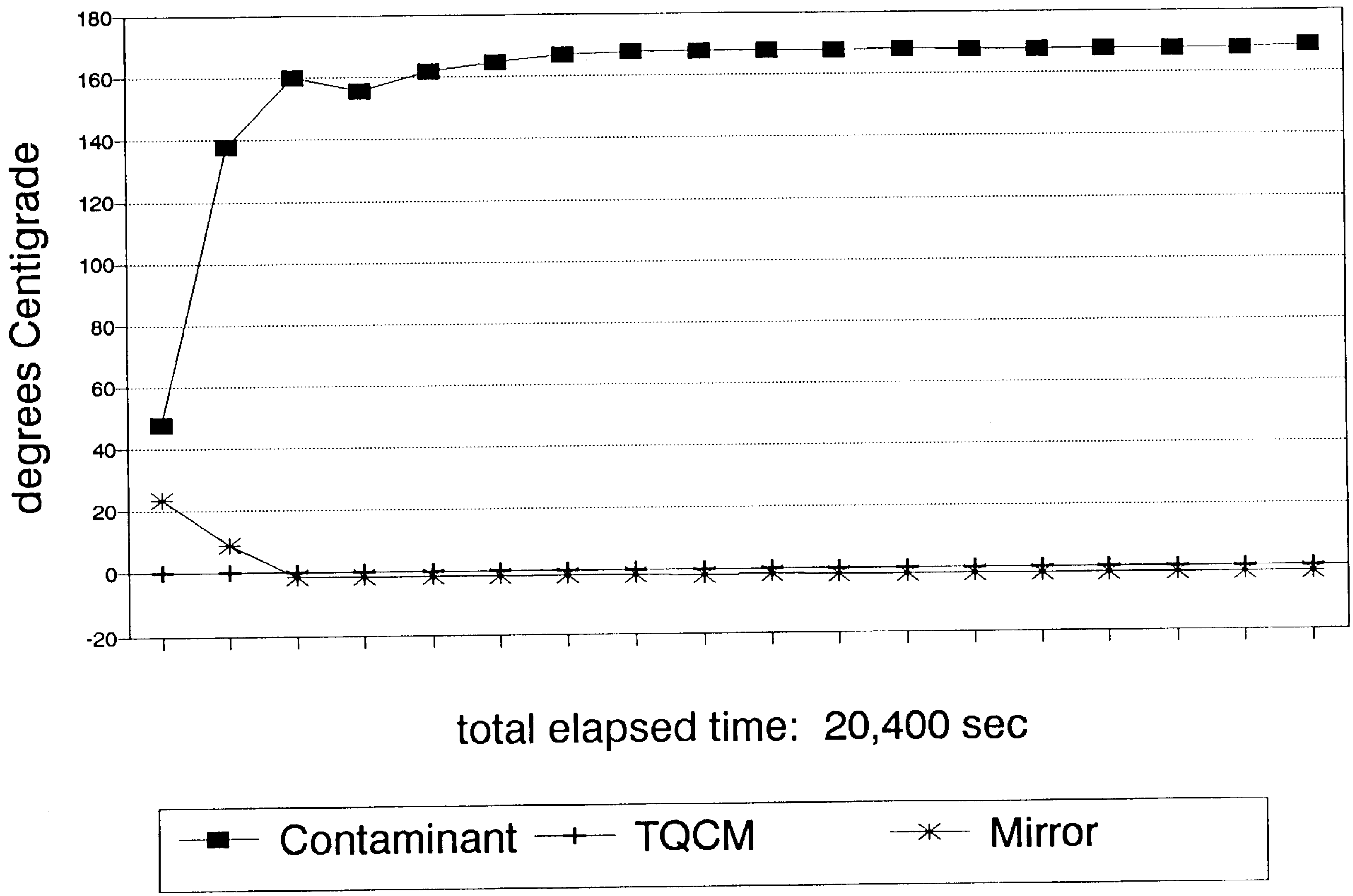
Z-306: Rob Series 1, Run 3

Optical Data



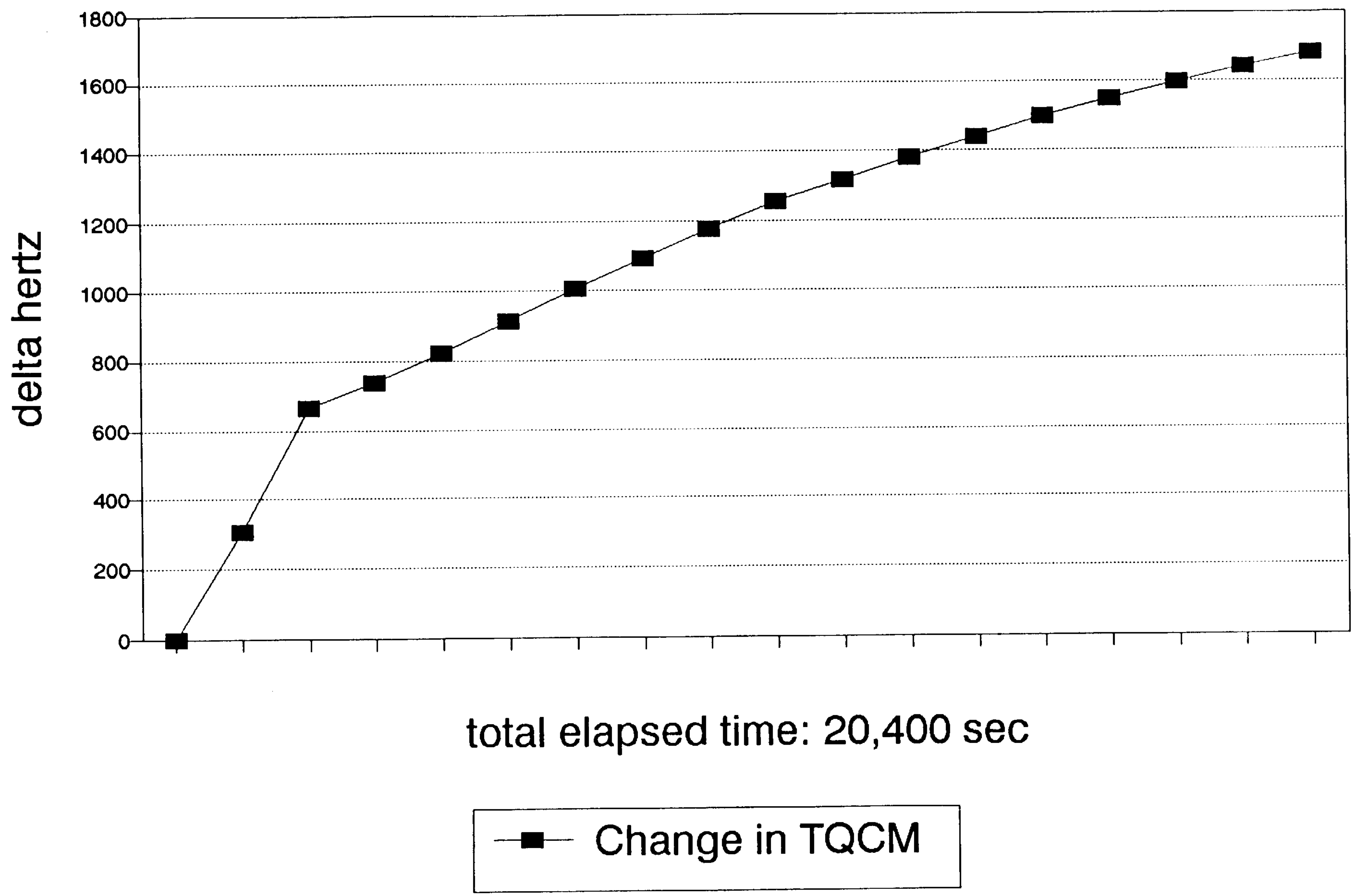
Z-306: Rob Series 1, Run 3

Temperatures



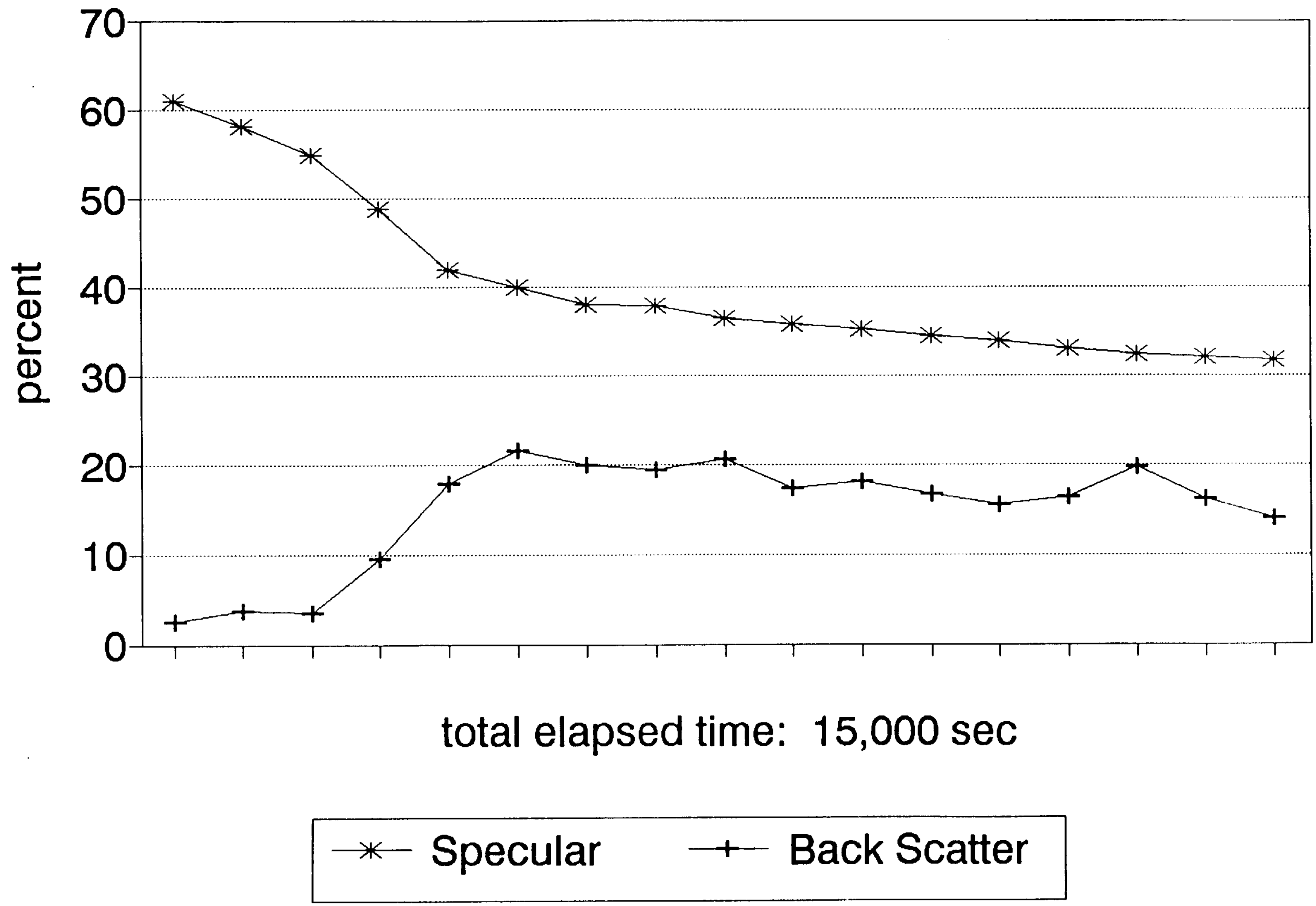
Z-306: Rob Series 1, Run 3

TQCM Data



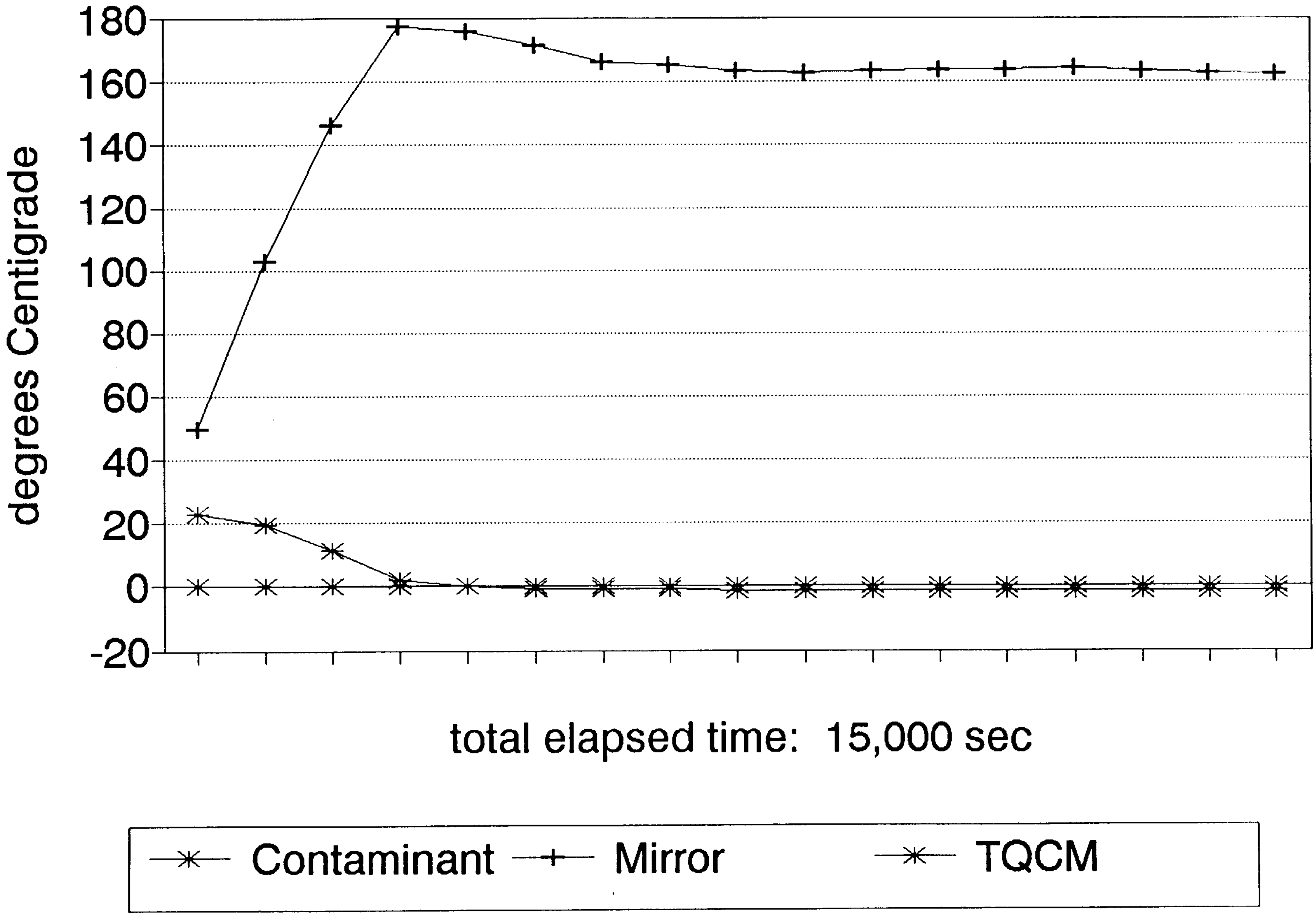
Z-306: Rob Series 1, Run 4

Optical Data



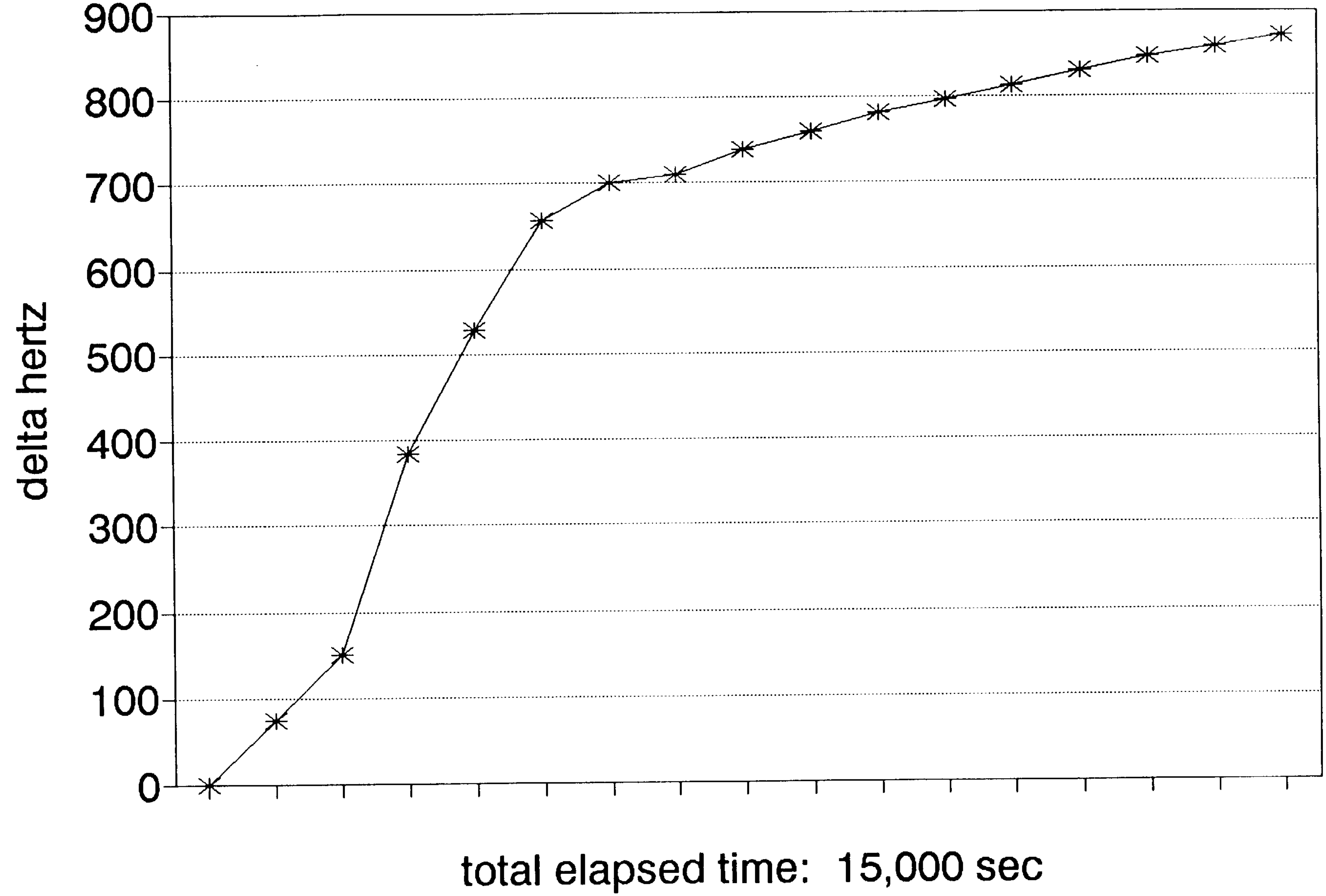
Z-306: Rob Series 1, Run 4

Temperature Data



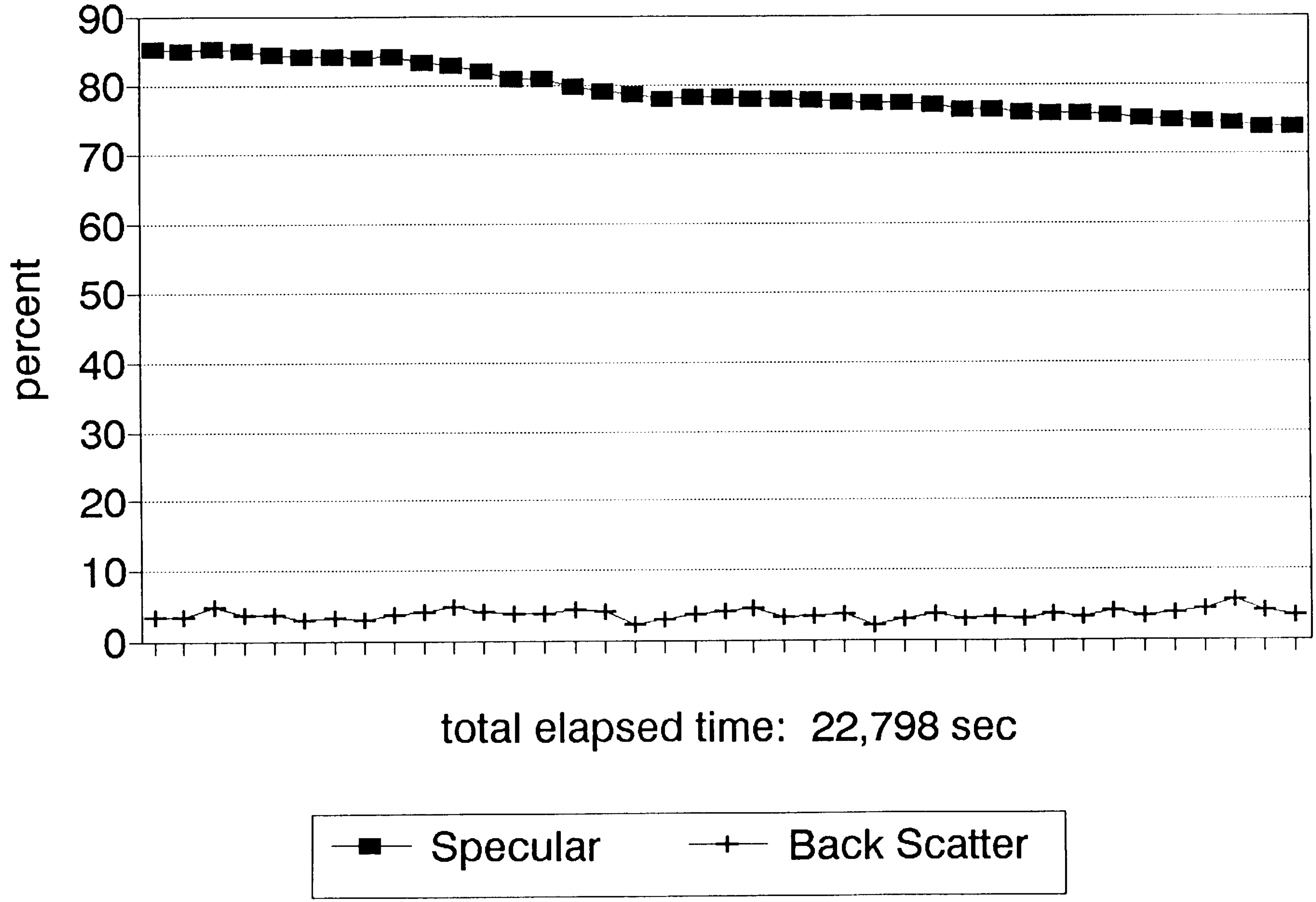
Z-306: Rob Series 1, Run 4

TQCM Change



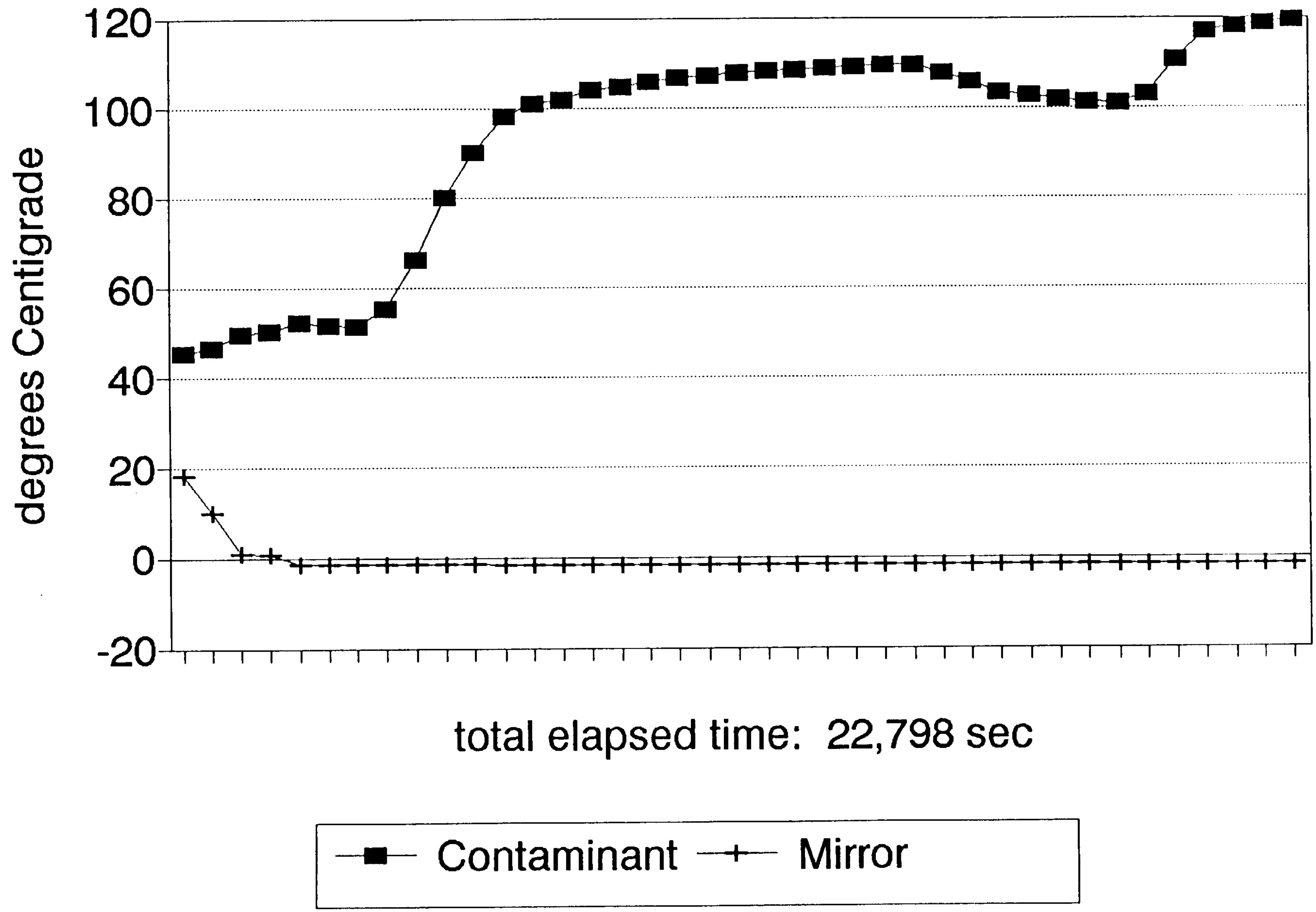
Silicone: Rob Series 2, Run 1

Optical Data



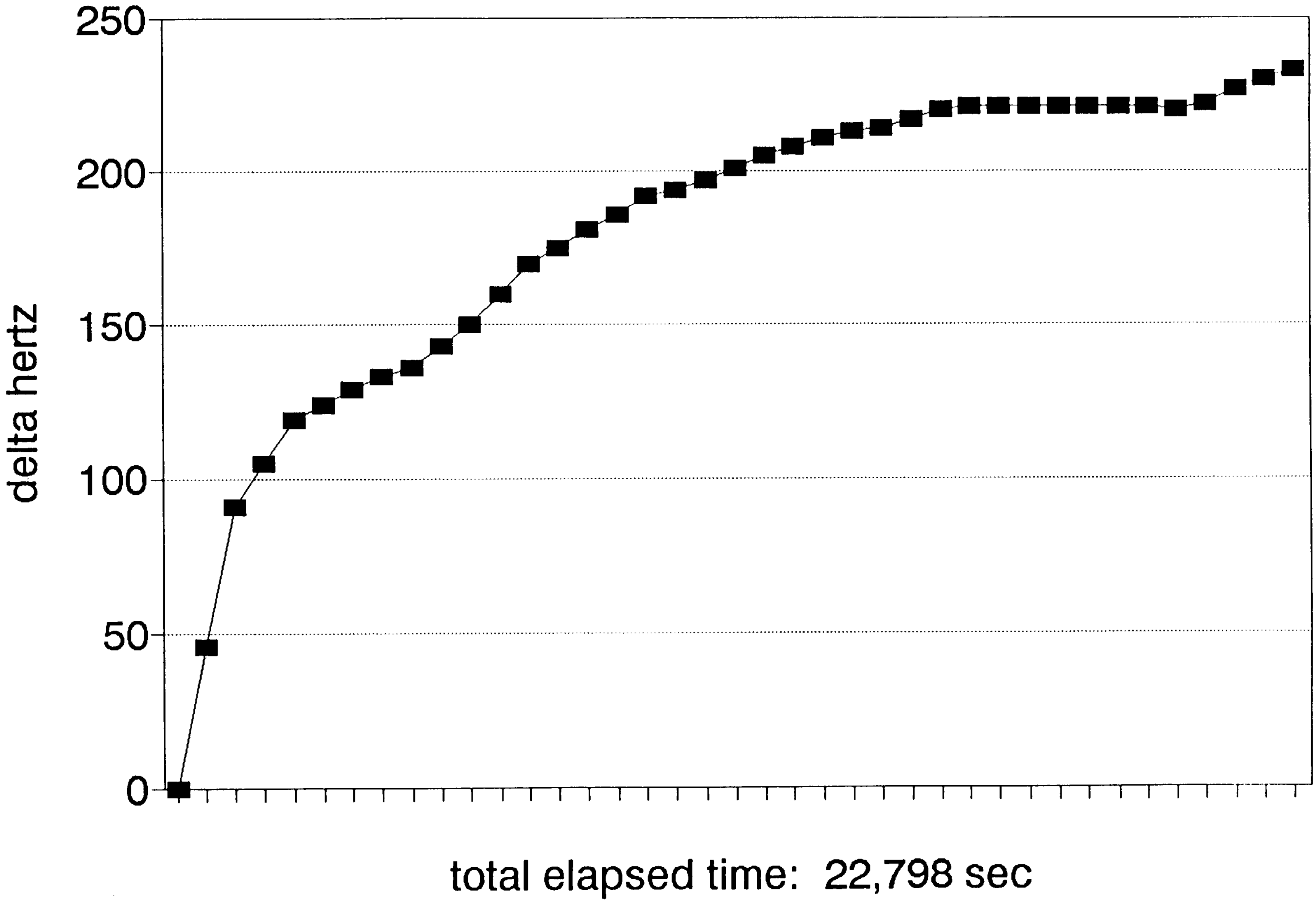
Silicone: Rob Series 2, Run 1

Temperature Data



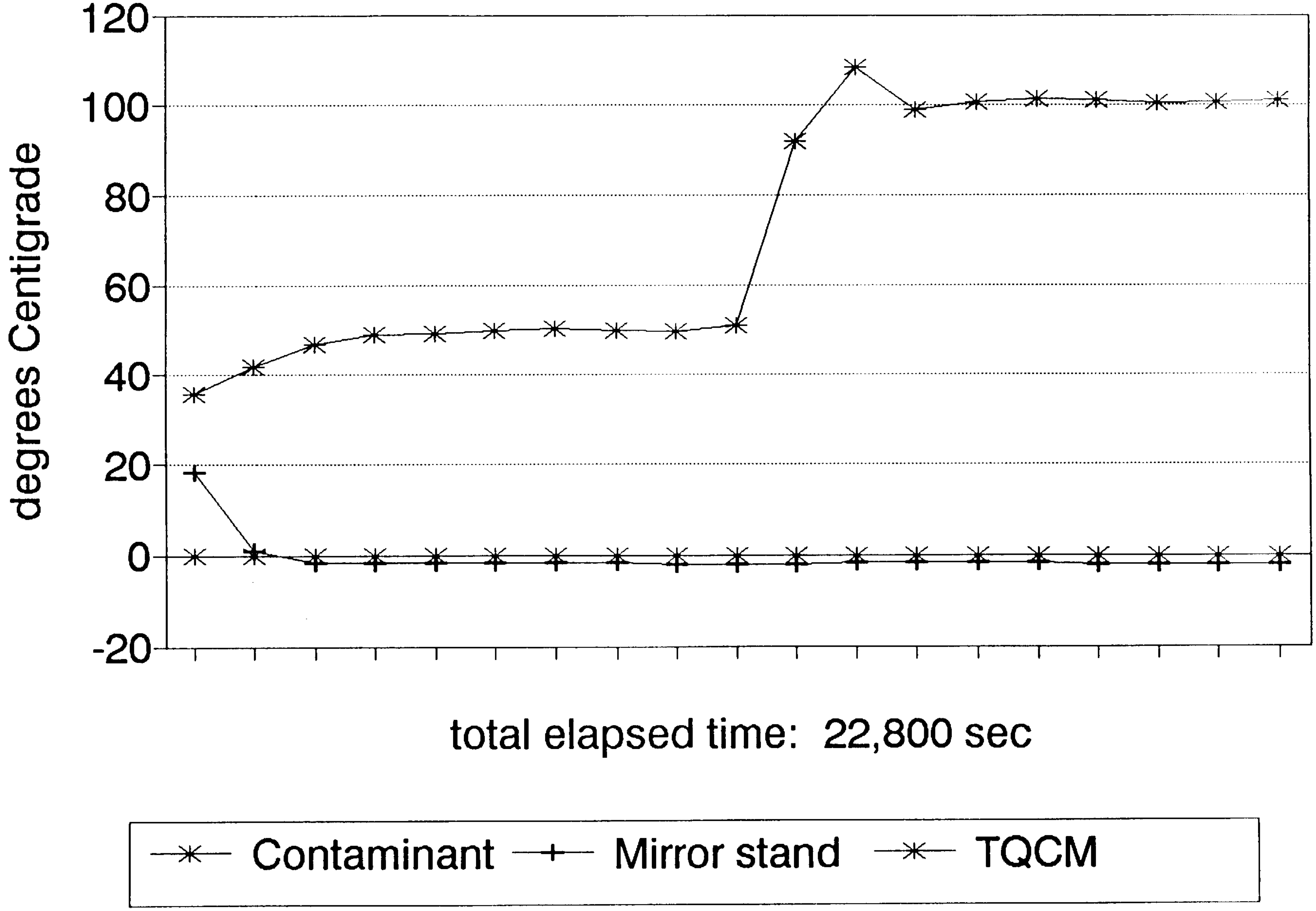
Silicone: Rob Series 2, Run 1

TQCM Change



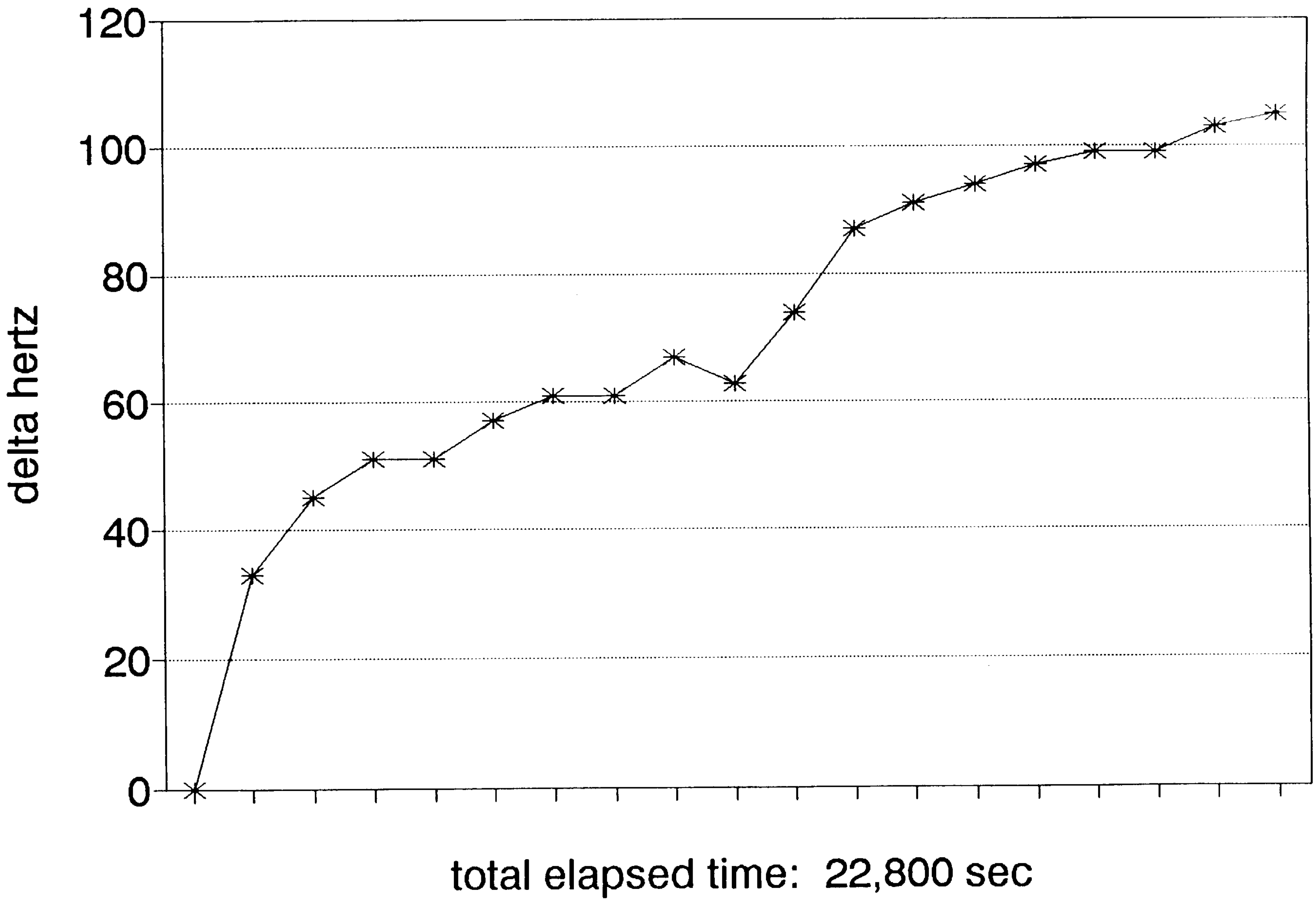
Silicone: Rob Series 2, Run 2

Temperature Data



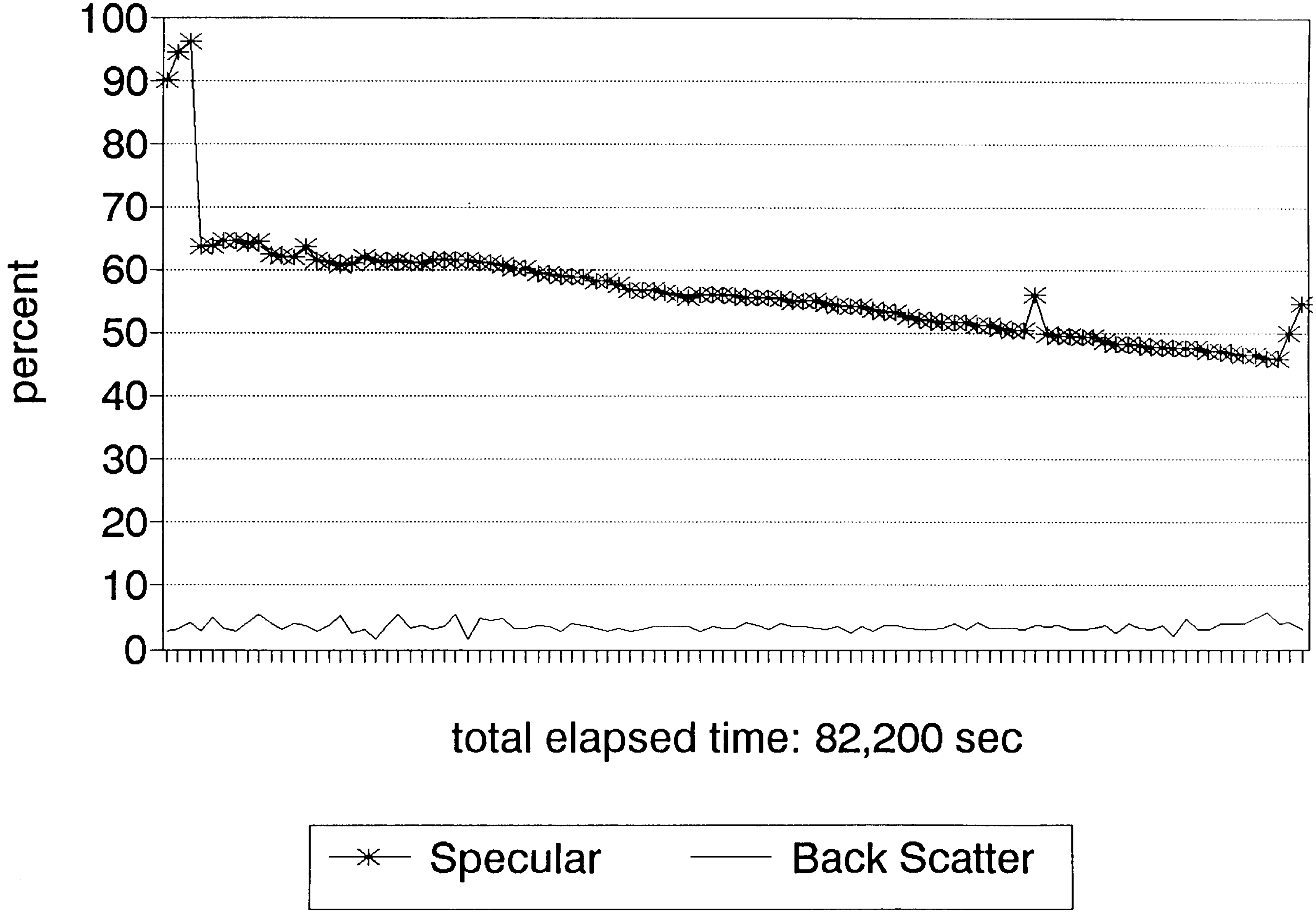
Silicone: Rob Series 2, Run 2

TQCM Change



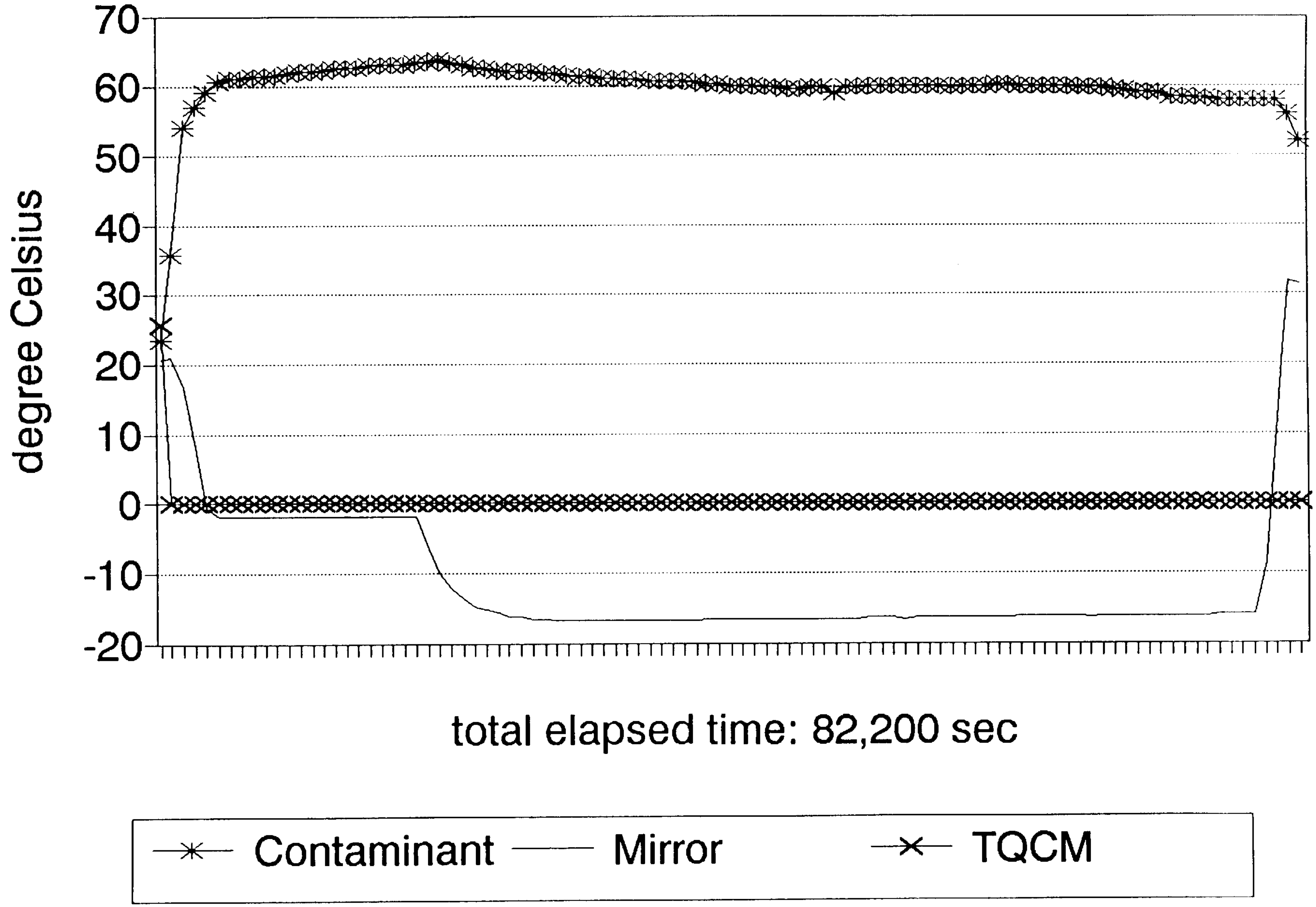
Silicone: Rob Series 2, Run 3

Optical Data



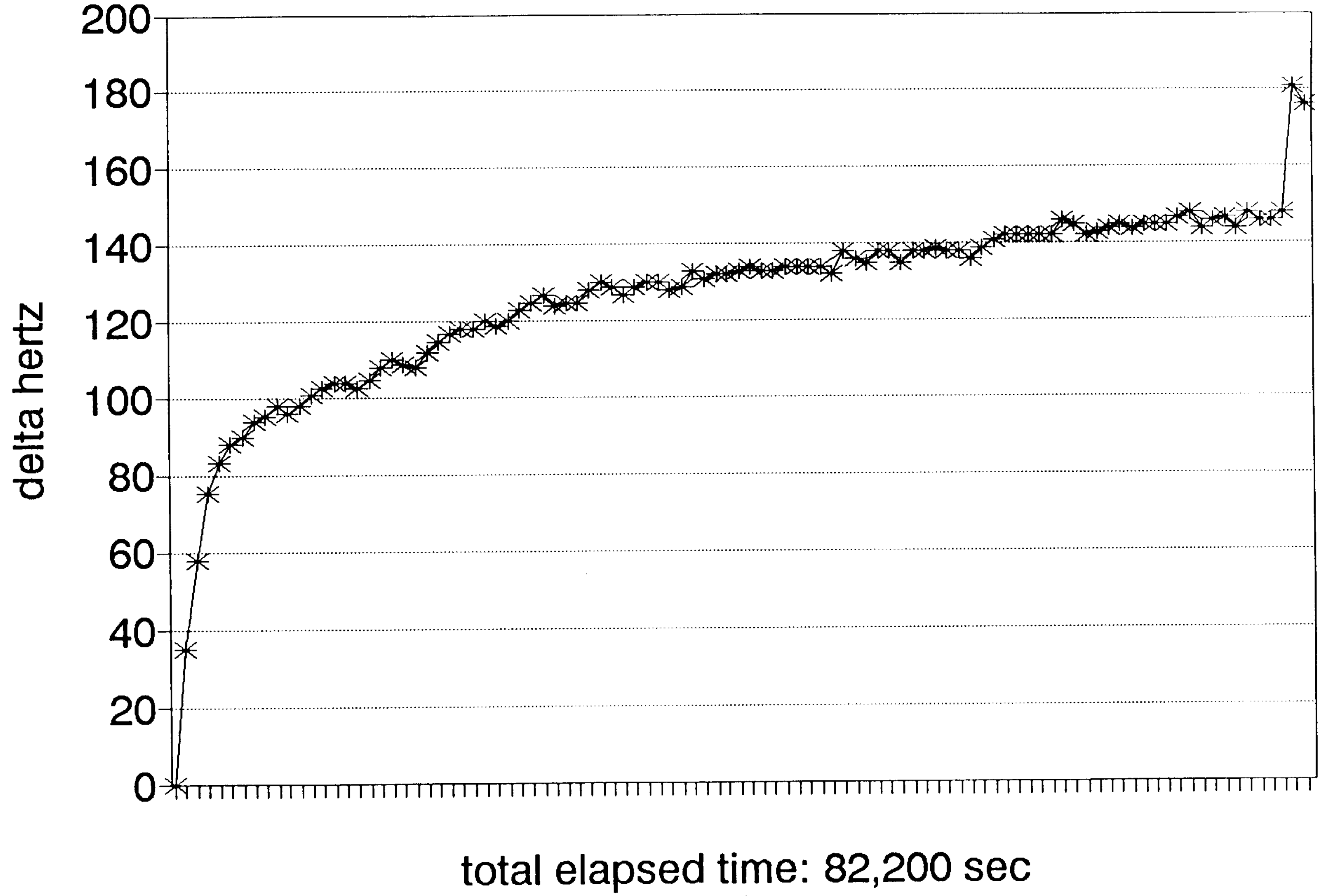
Silicone: Rob Series 2, Run 3

Temperature Data



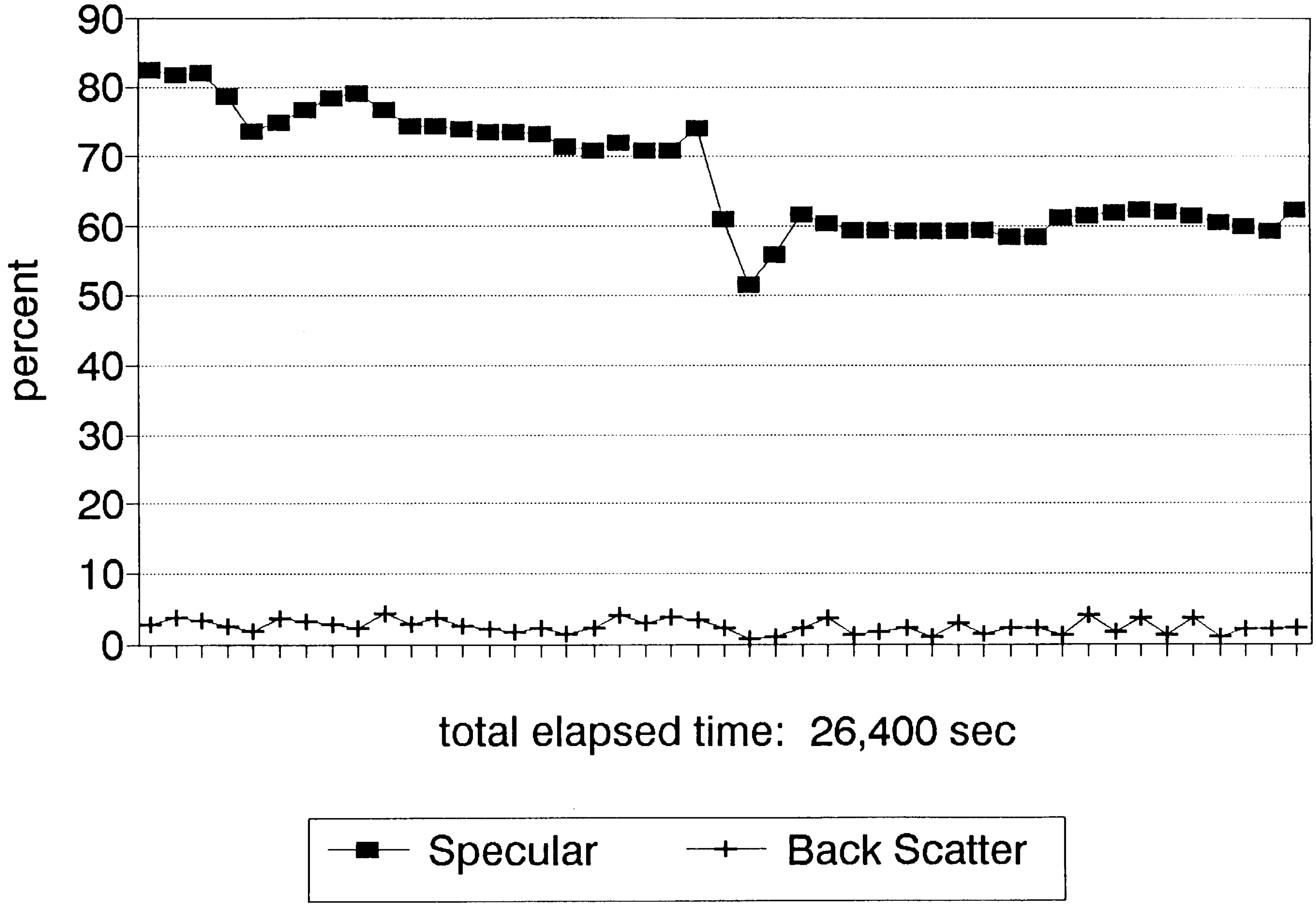
Silicone: Rob Series 2, Run 3

TQCM Change



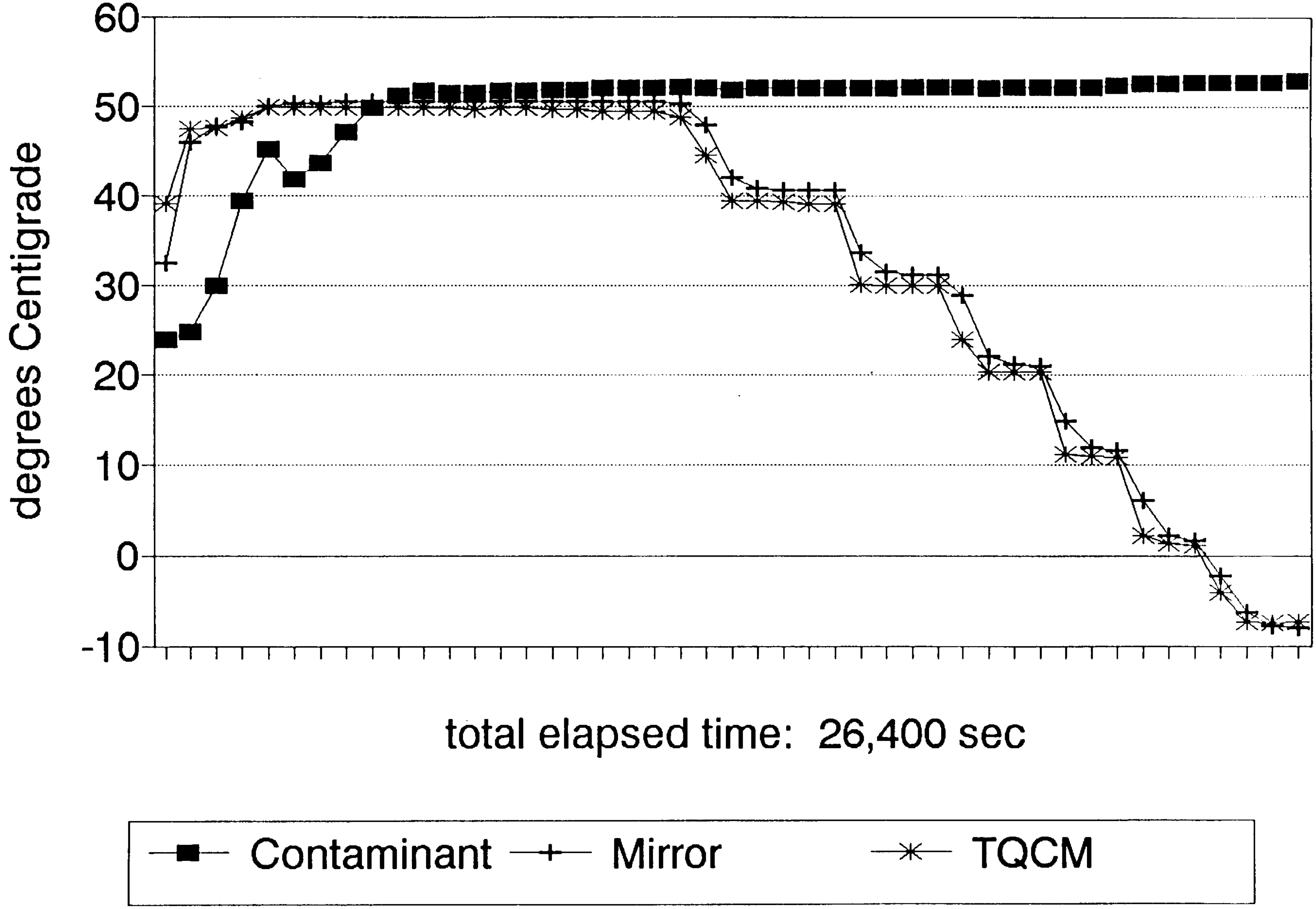
Silicone: Rob Series 2, Run 4

Optical Data



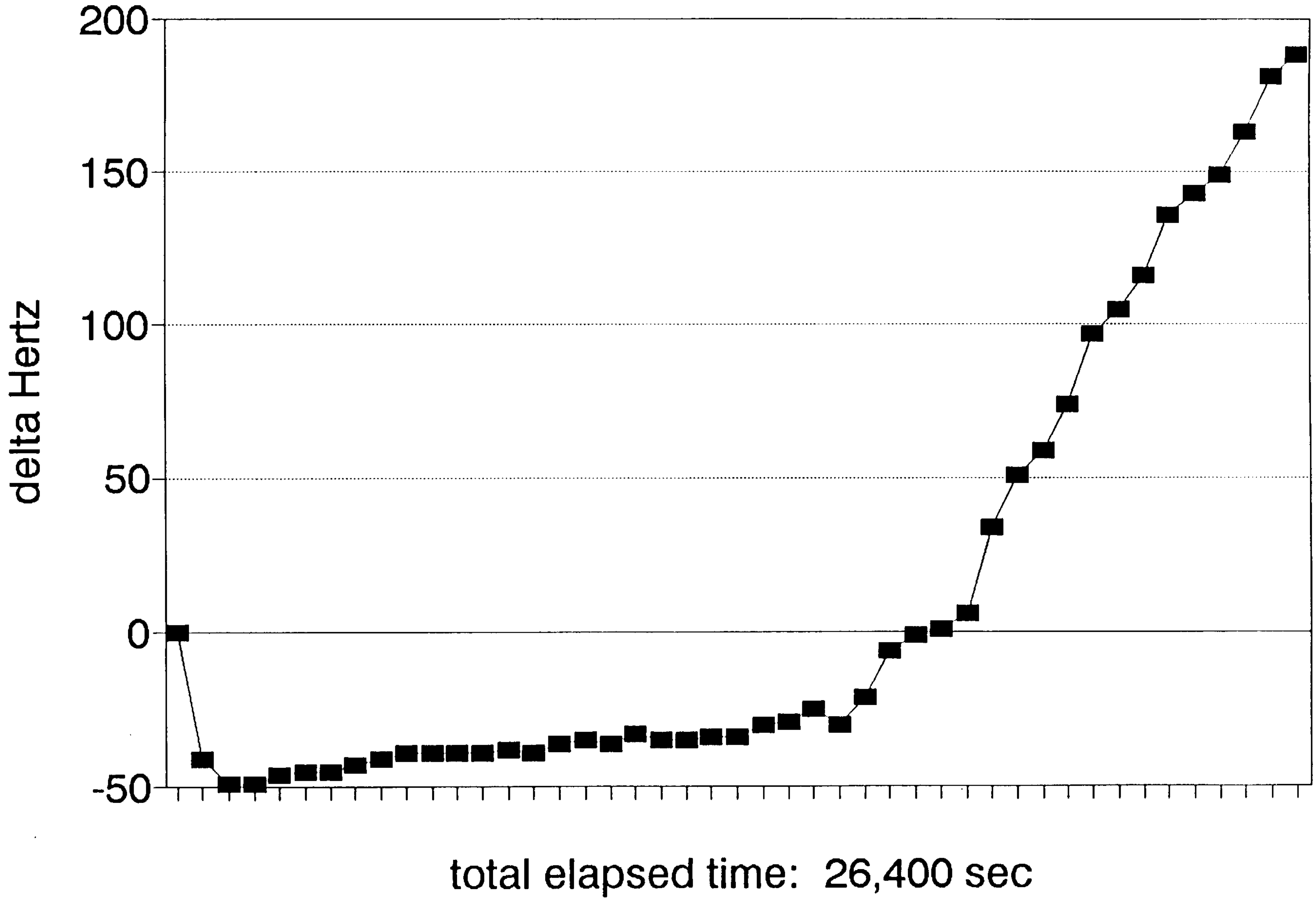
Silicone: Rob Series 2, Run 4

Temperature Data



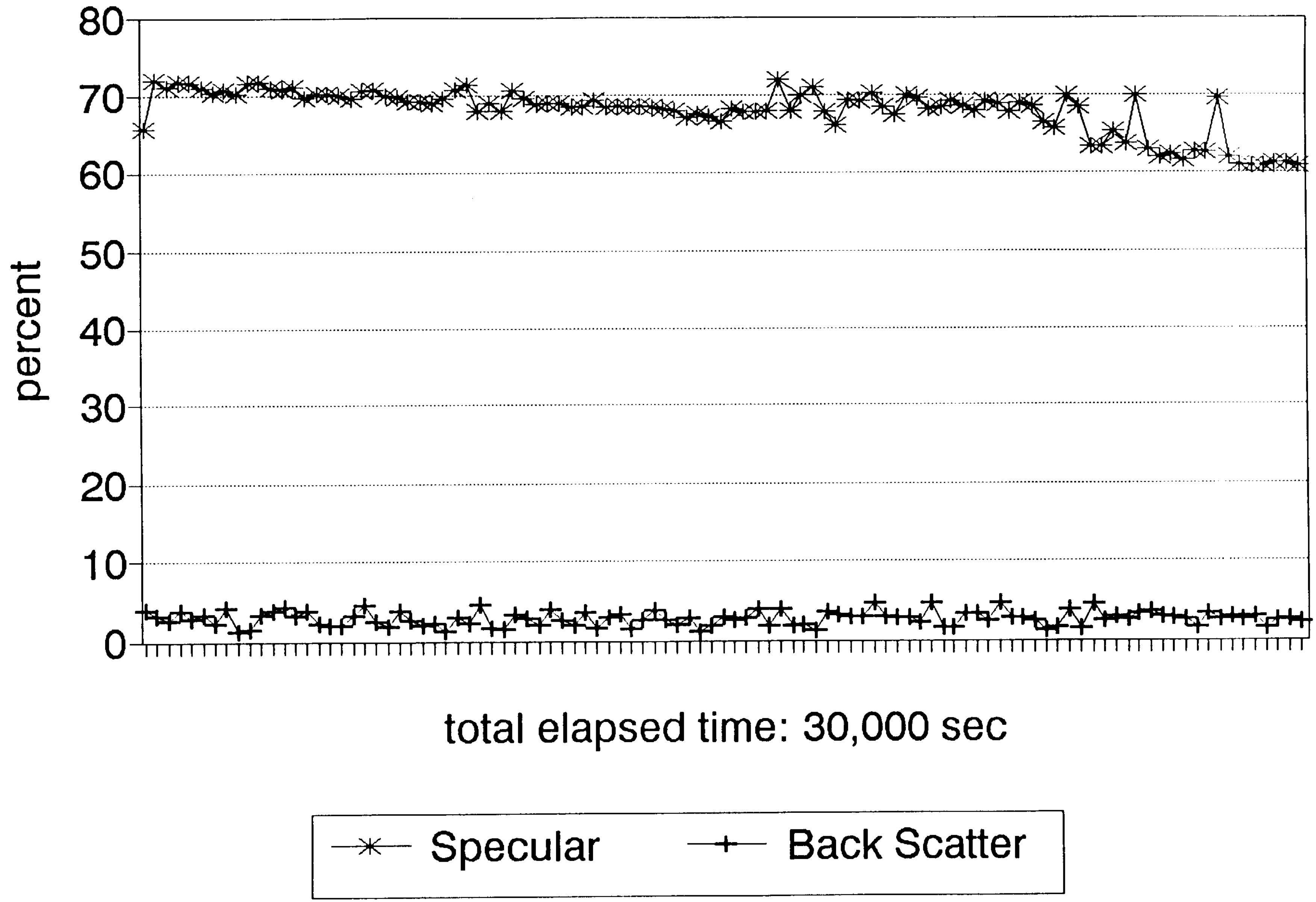
Silicone: Rob Series 2, Run 4

TQCM Change



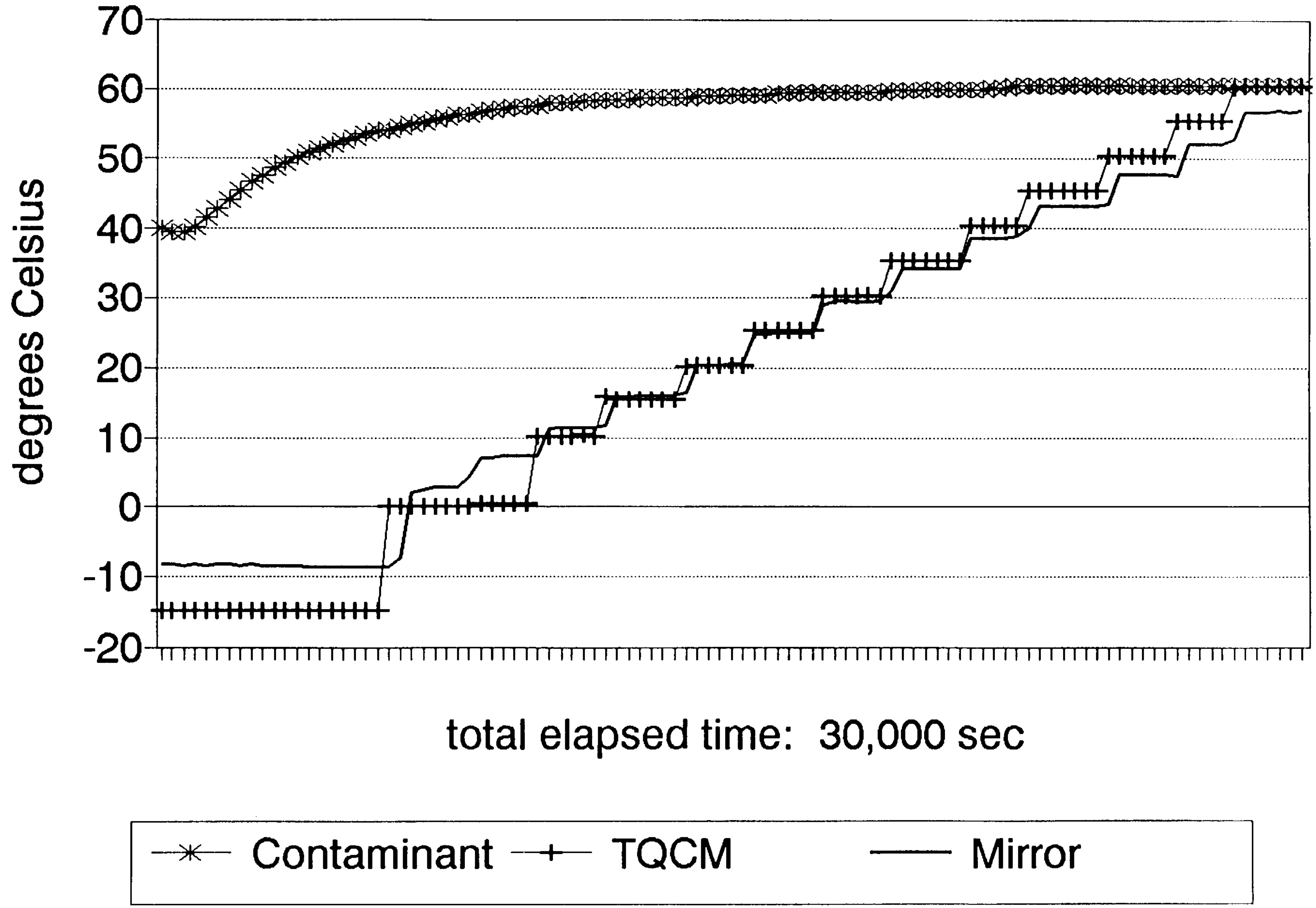
Viton: Rob Series 3, Run 1

Optical Data



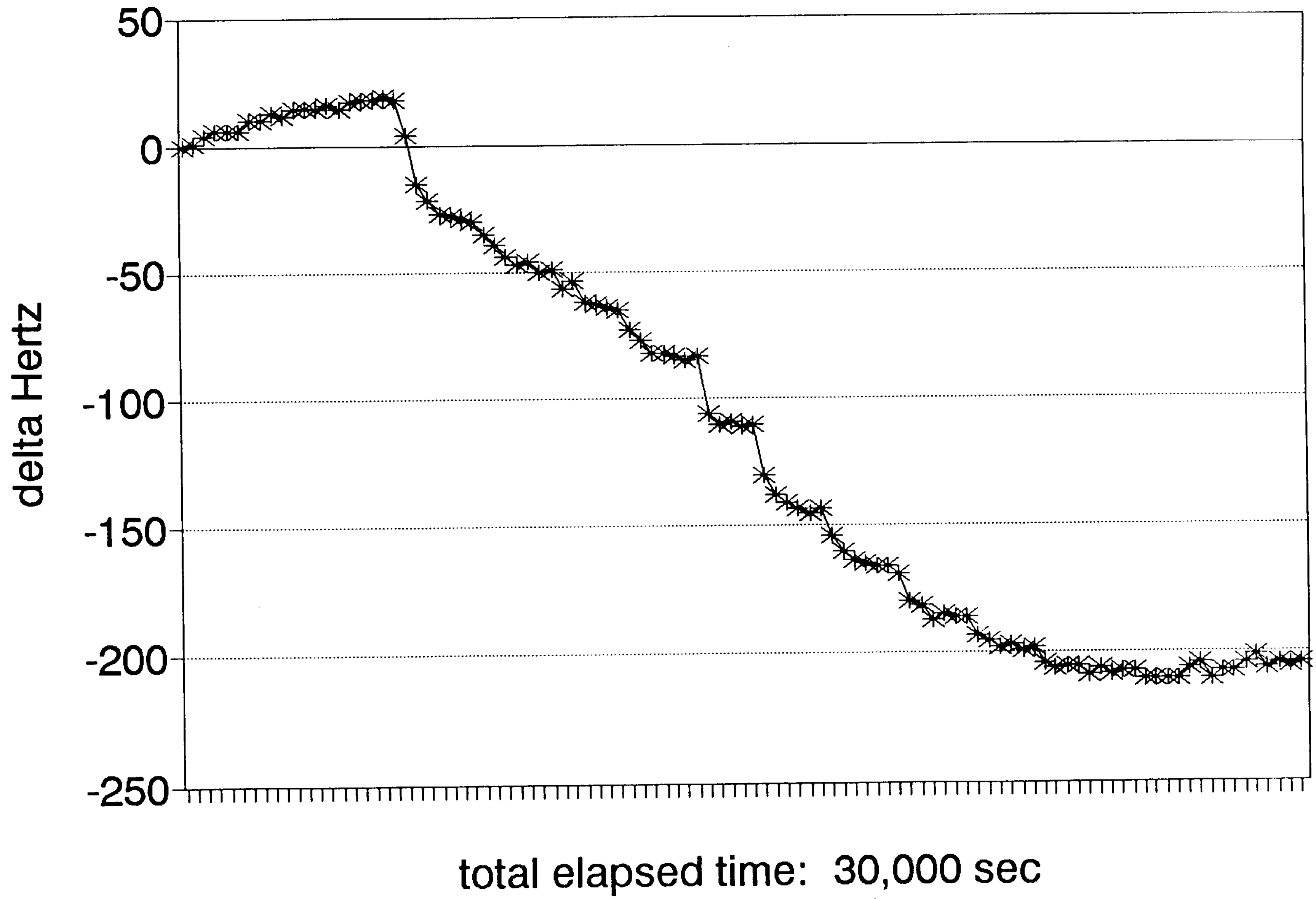
Viton: Rob Series 3, Run 1

Temperature Data



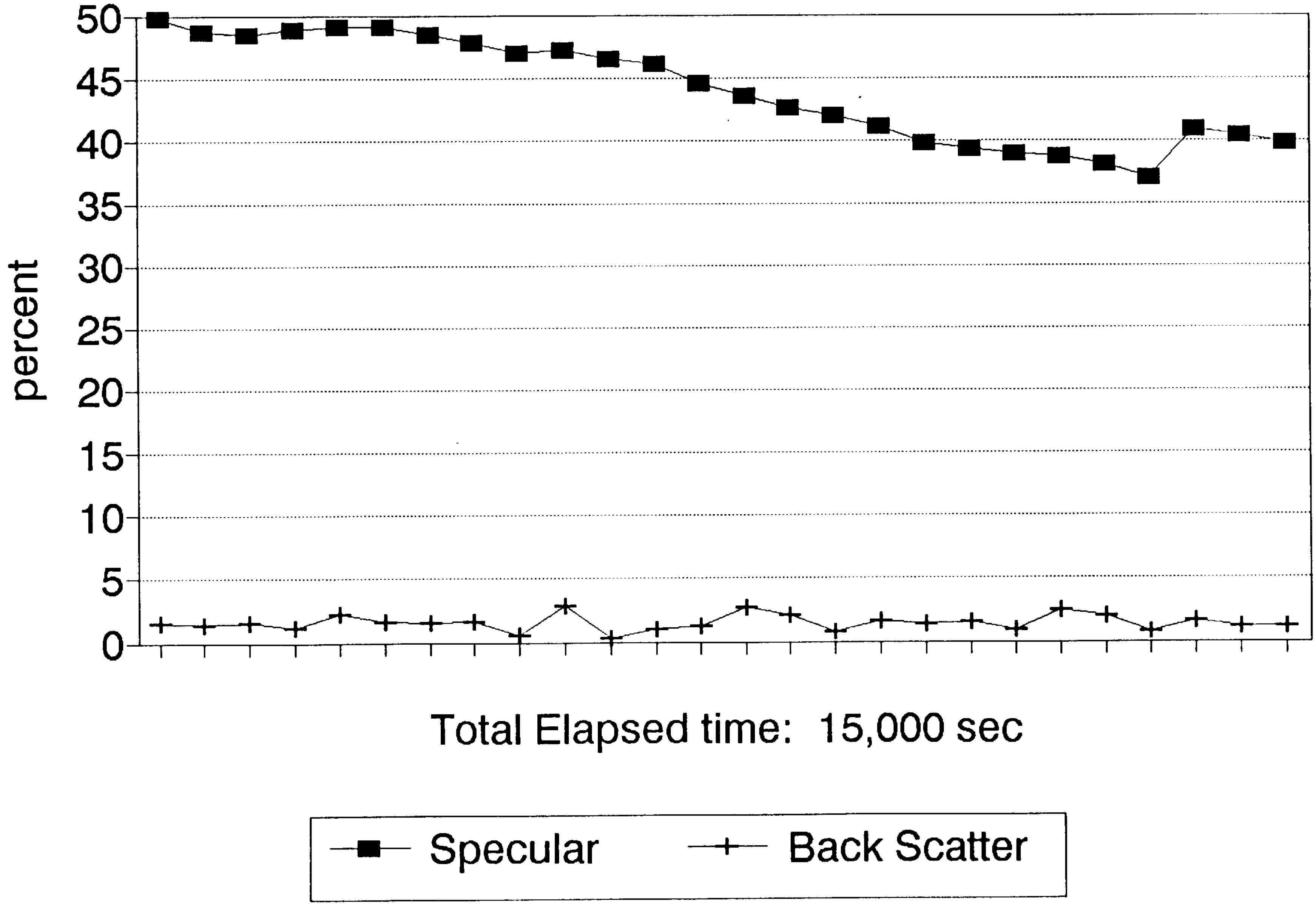
Viton: Rob Series 3, Run 1

TQCM Change



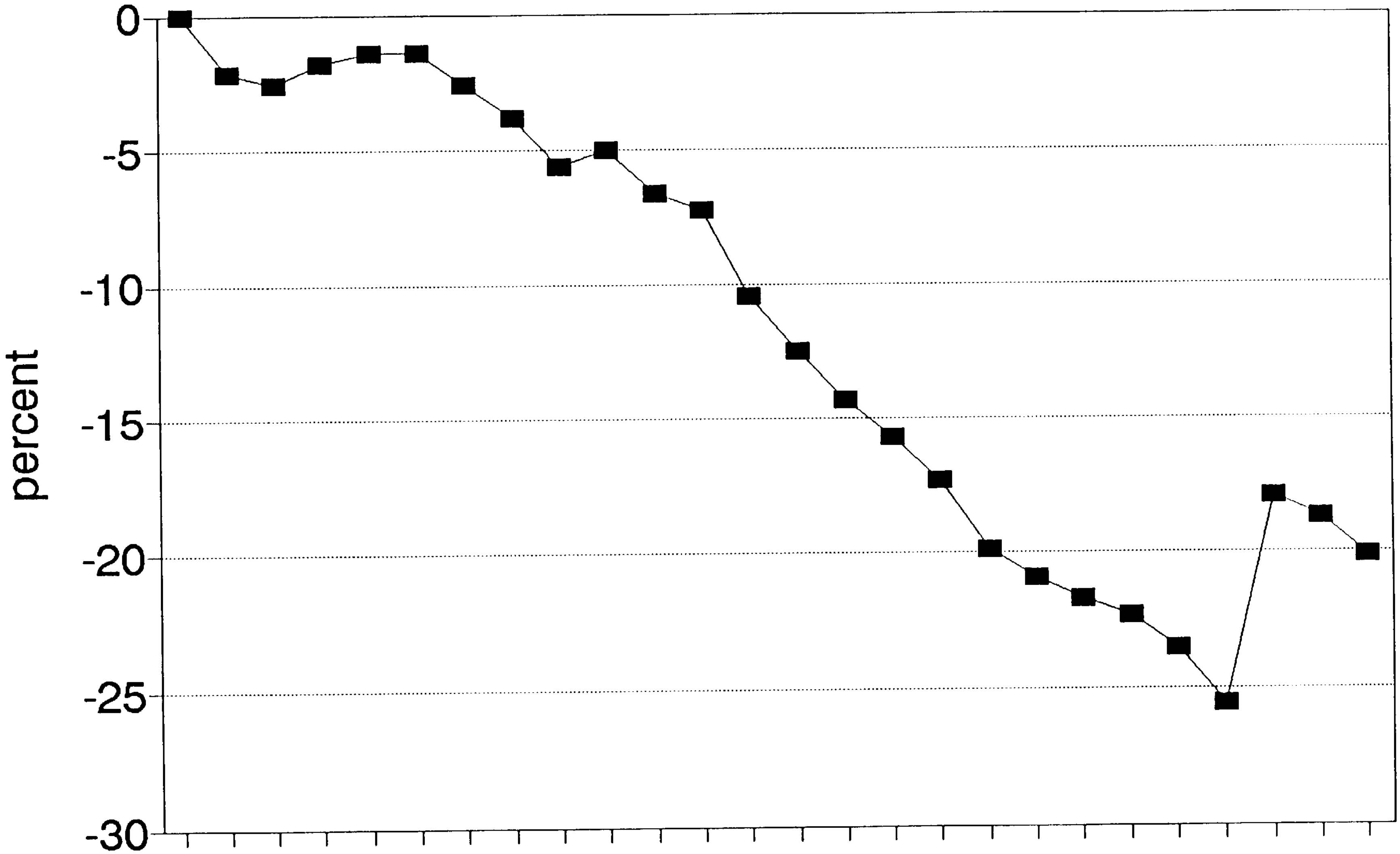
EPR: Rob Series 4, Run 1A

Optical Data



EPR: Rob Series 4, Run 1A

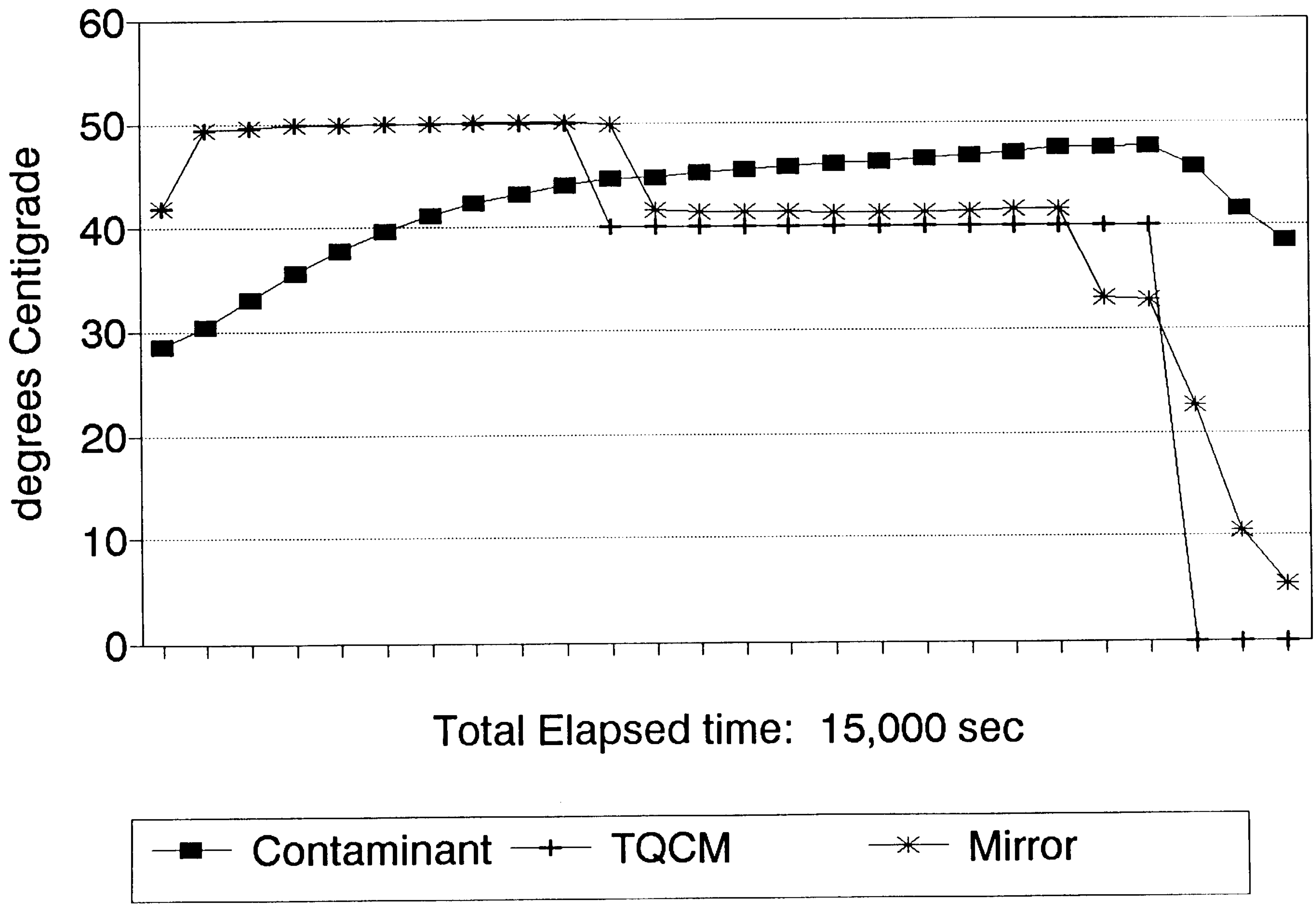
Percent Reflectance Change



Total Elapsed time: 15,000 sec

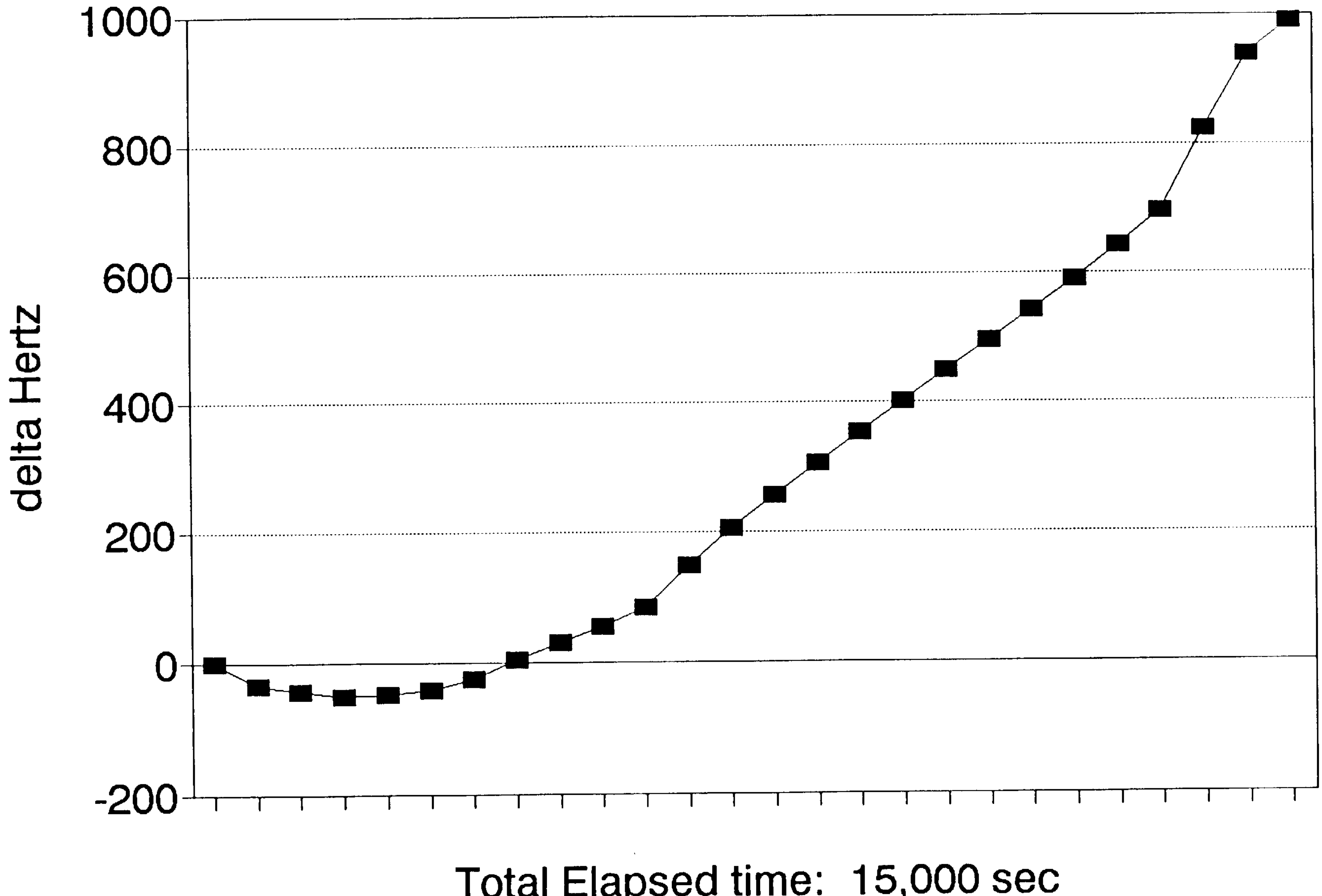
EPR: Rob Series 4, Run 1A

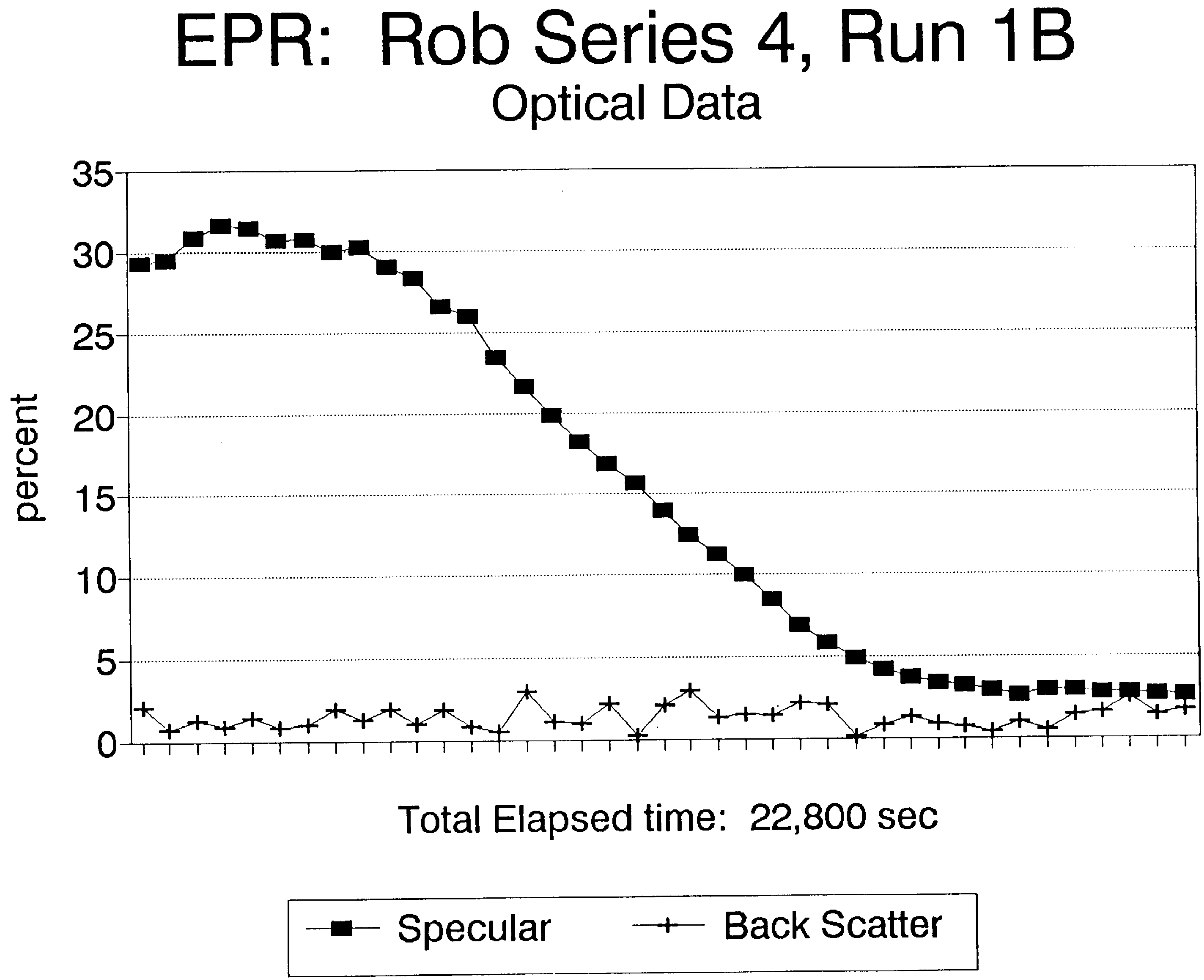
Temperature Data



EPR: Rob Series 4, Run 1A

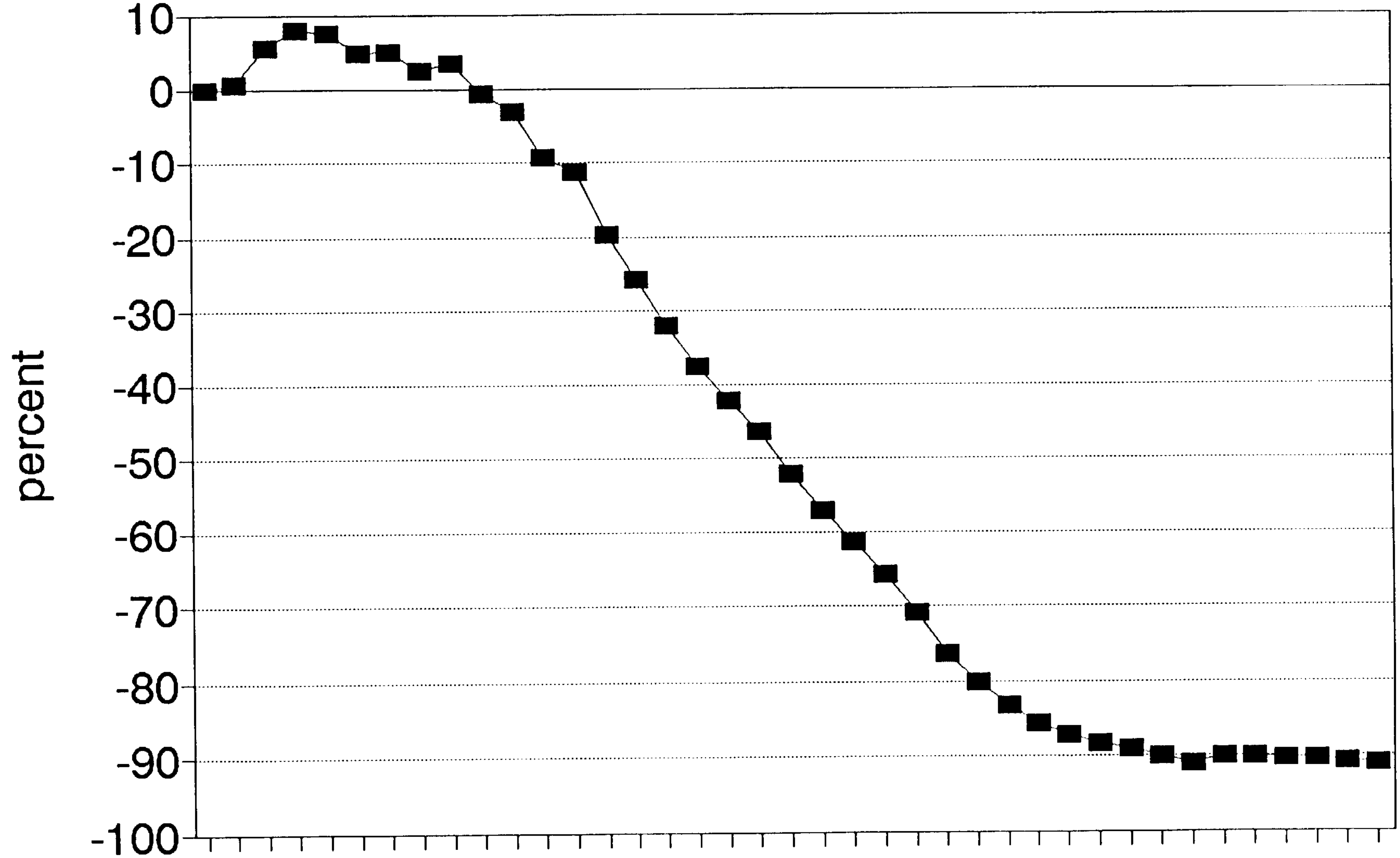
TQCM Change




EPR: Rob Series 4, Run 1B
Optical Data
percent
35
30
25
20
15
10
5
0
Total Elapsed time: 22,800 sec
Specular
Back Scatter

EPR: Rob Series 4, Run 1B

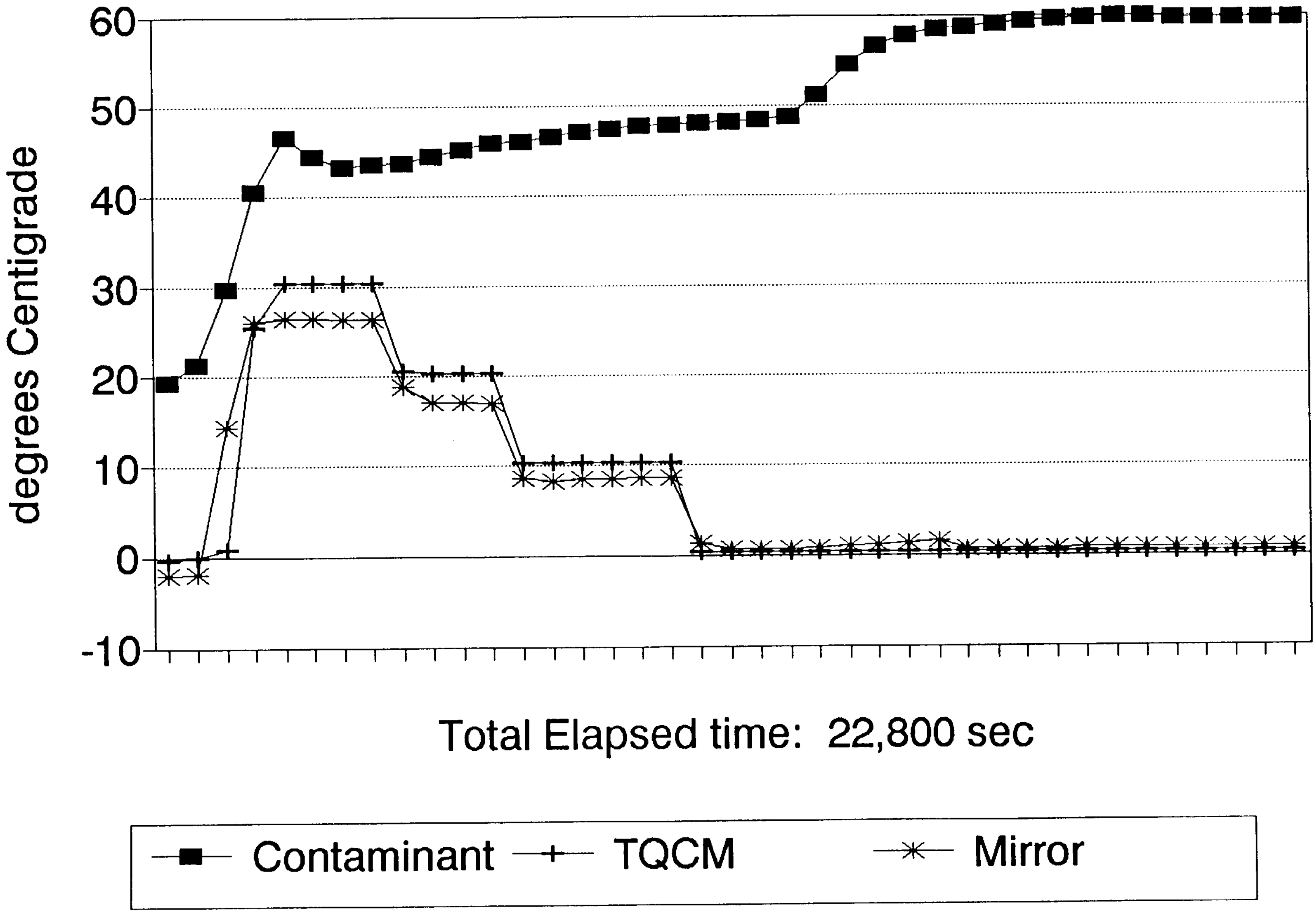
Percent Reflectance Change



Total Elapsed time: 22,800 sec

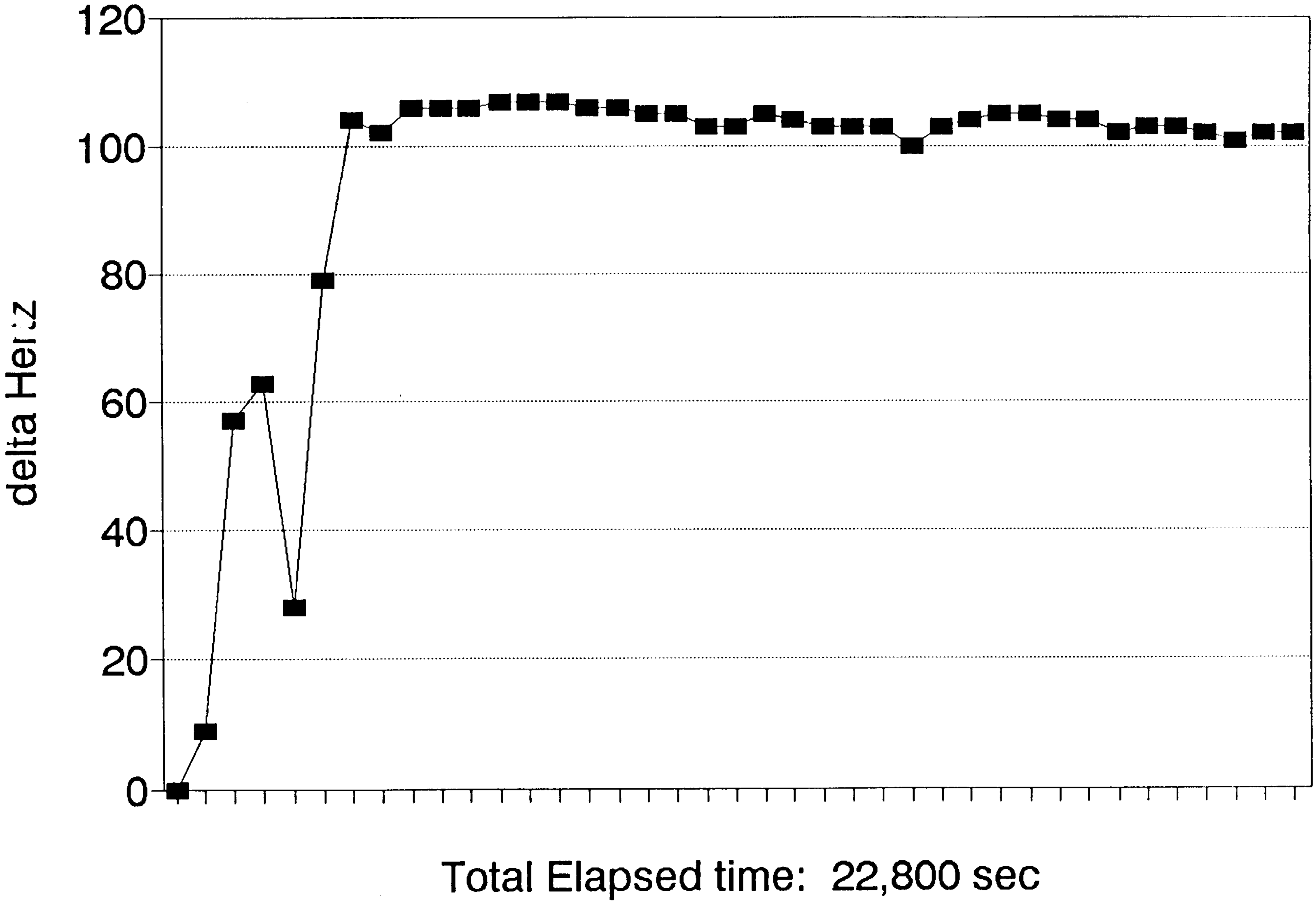
EPR: Rob Series 4, Run 1B

Temperature Data



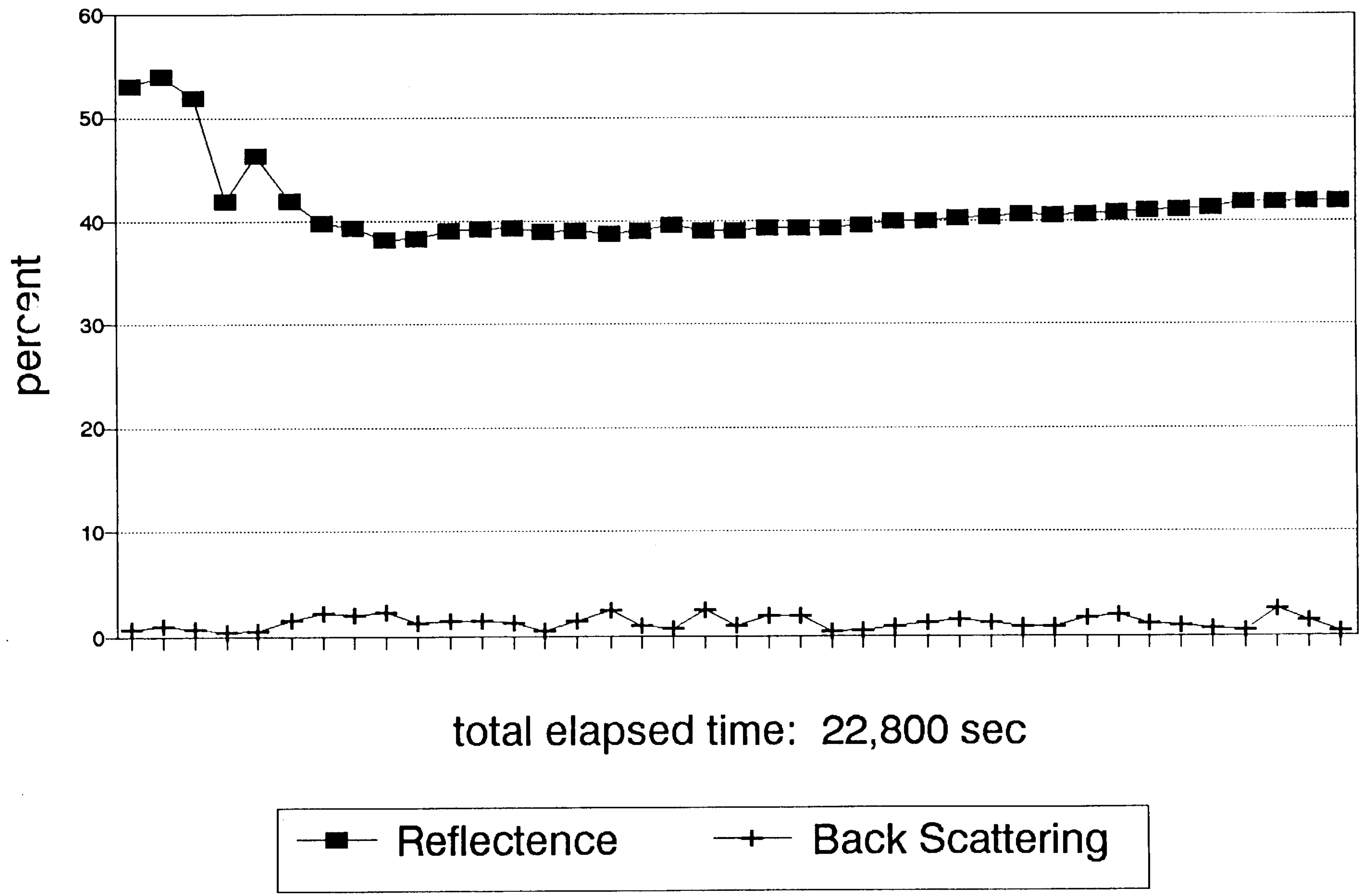
EPR: Rob Series 4, Run 1B

TQCM Change



Solithane: Rob Series 5, Run 1

Optical Data



Solithane: Rob Series 5, Run 1

Temperature Data