NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

*Technical Memorandum 33-619*

# *The Formation of Hydrochloric Acid Aerosol From the Interaction of the Space Shuttle Rocket Exhaust With the Atmosphere*

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# PREFACE

The work described in this report was performed by the Propulsion Division of the Jet Propulsion Laboratory.

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## ABSTRACT

This report describes the conditions of atmospheric temperature and relative humidity under which hydrochloric acid aerosol is expected upon interaction of the proposed Space Shuttle rocket exhaust products with the atmosphere.

## I. INTRODUCTION

This report describes the conditions of atmospheric temperature and relative humidity under which hydrochloric acid aerosol is expected upon interaction of the proposed Space Shuttle rocket exhaust products with the atmosphere. This work is part of an overall effort to define the effects of the Space Shuttle on the environment (Refs. 1 and 2).

## II. RESULTS AND DISCUSSION

The conditions of temperature and relative humidity that result in hydrochloric acid aerosol upon interaction with the Space Shuttle rocket exhaust products are shown in Figs. 1-10. In Figs. 8-10, afterburning of CO and $H_2$ is assumed. Each figure corresponds to a mixture (wt %) ratio of (air)/(exhaust products), designated in each figure by the term $\gamma$.

In the figures, the region to the right of each curve represents the conditions where aerosol is not expected. In the region to the left, where aerosol is expected, the solid lines represent the expected concentration of HCl (wt %) in the aerosol and the dashed lines the concentration of aerosol in the atmosphere in parts per million.

On a typical ground cloud resulting from the Space Shuttle rocket engines, the estimated weight ratio of (air)/(exhaust) was $10^4$ (Ref. 2). These curves include the range from $10^3$ to $10^5$.

Inspection of the figures indicates that aerosol is expected under conditions of cool weather and high humidity. Including the effect of after burning results in a predicted small increase in the amount of aerosol.

## REFERENCES


1. Environmental Statement for the Space Shuttle Program. Final Statement, National Aeronautics and Space Administration, Washington, D. C., July, 1972.

2. Cramer, H. E., et al., Quantitative Assessment of the Environmental Effects of Rocket Engine Emissions During Space Shuttle Operations at Kennedy Space Center, Report GCA-TR-72-8-G, GCA Corp., Salt Lake City, Utah, February 7, 1972.

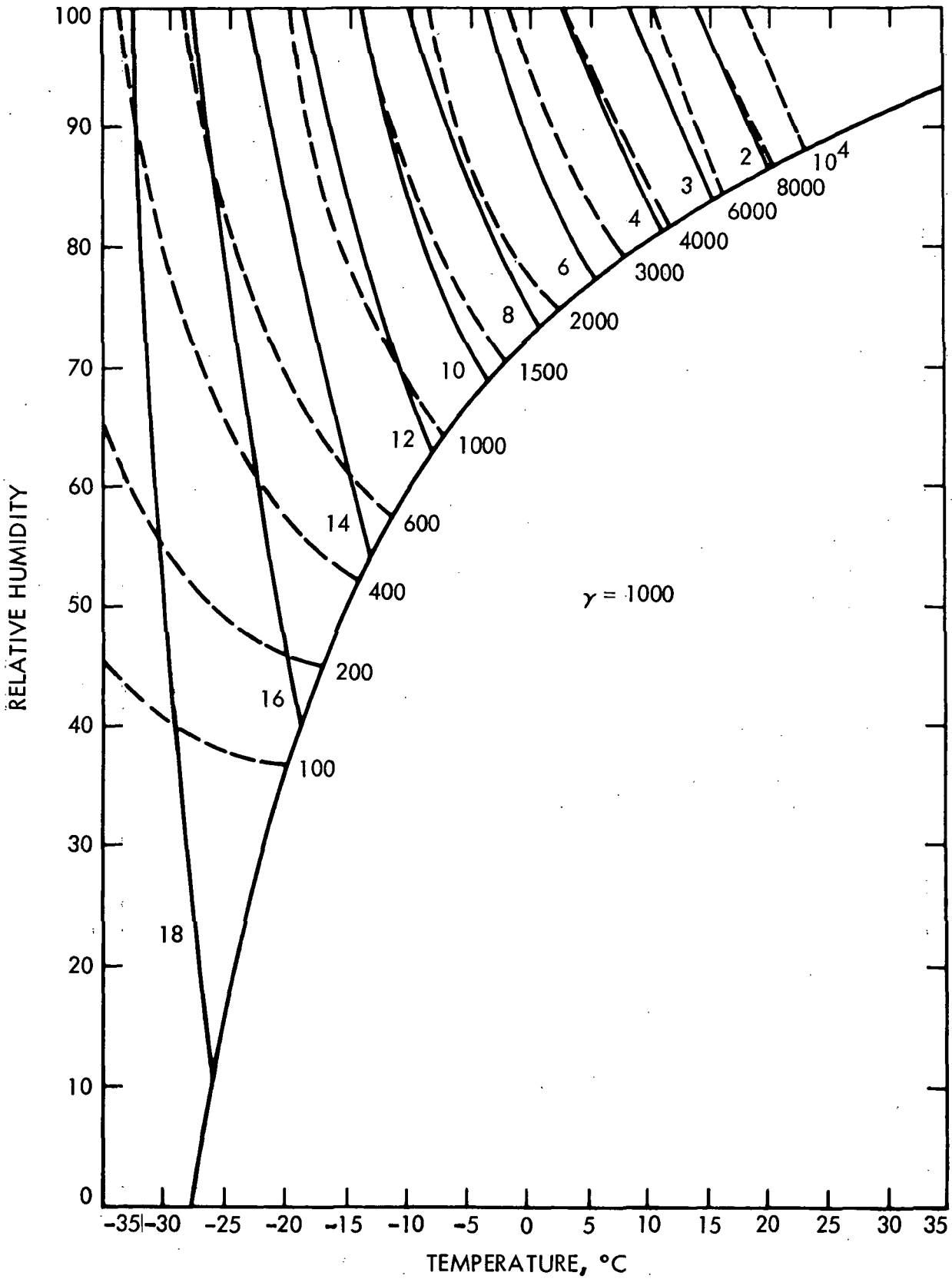


Fig. 1. Aerosol formation for temperature vs relative humidity, ratio of exhaust products δ = 1000

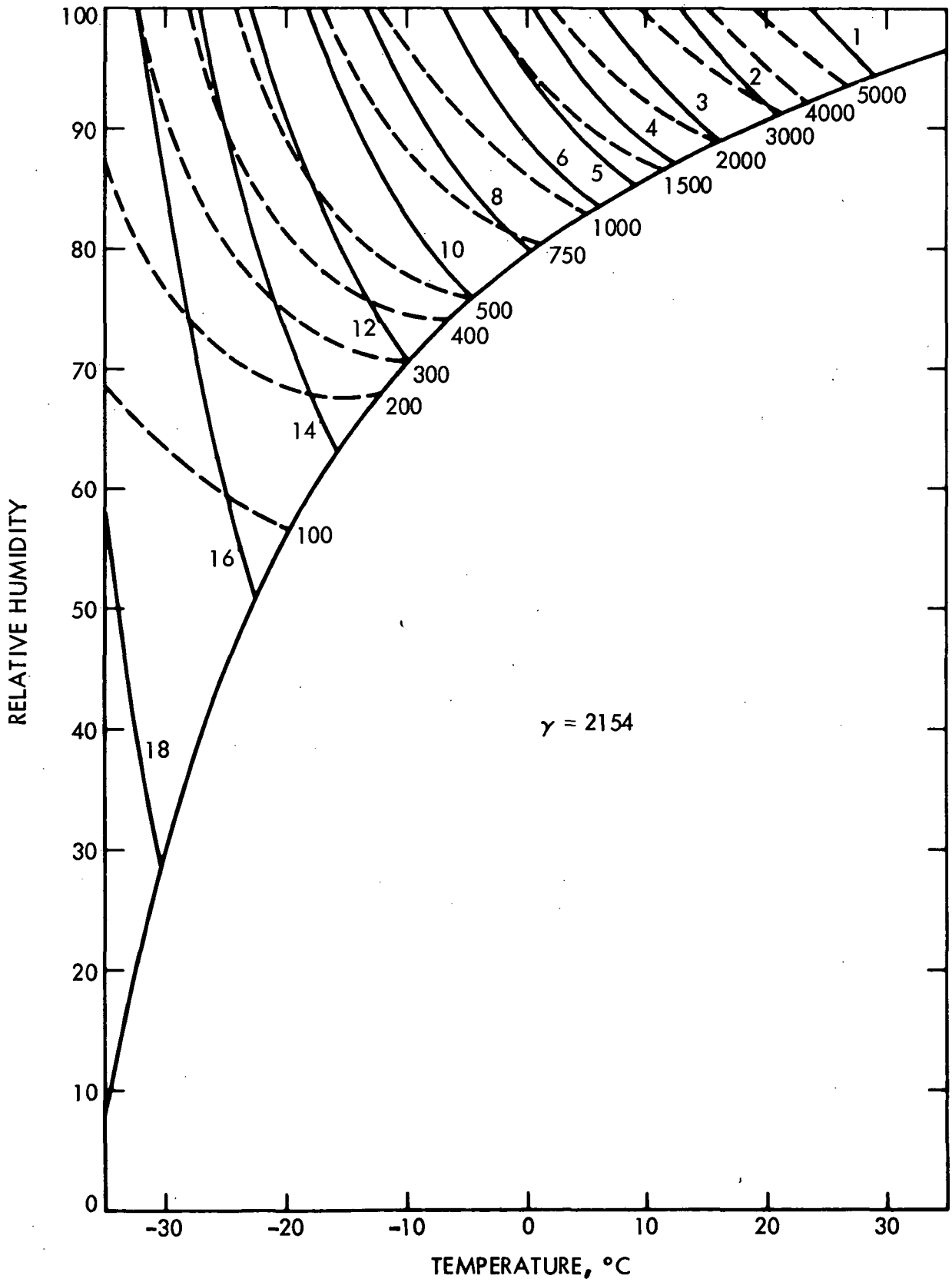


Fig. 2. Aerosol formation for temperature vs relative humidity, ratio of exhaust products δ = 2154

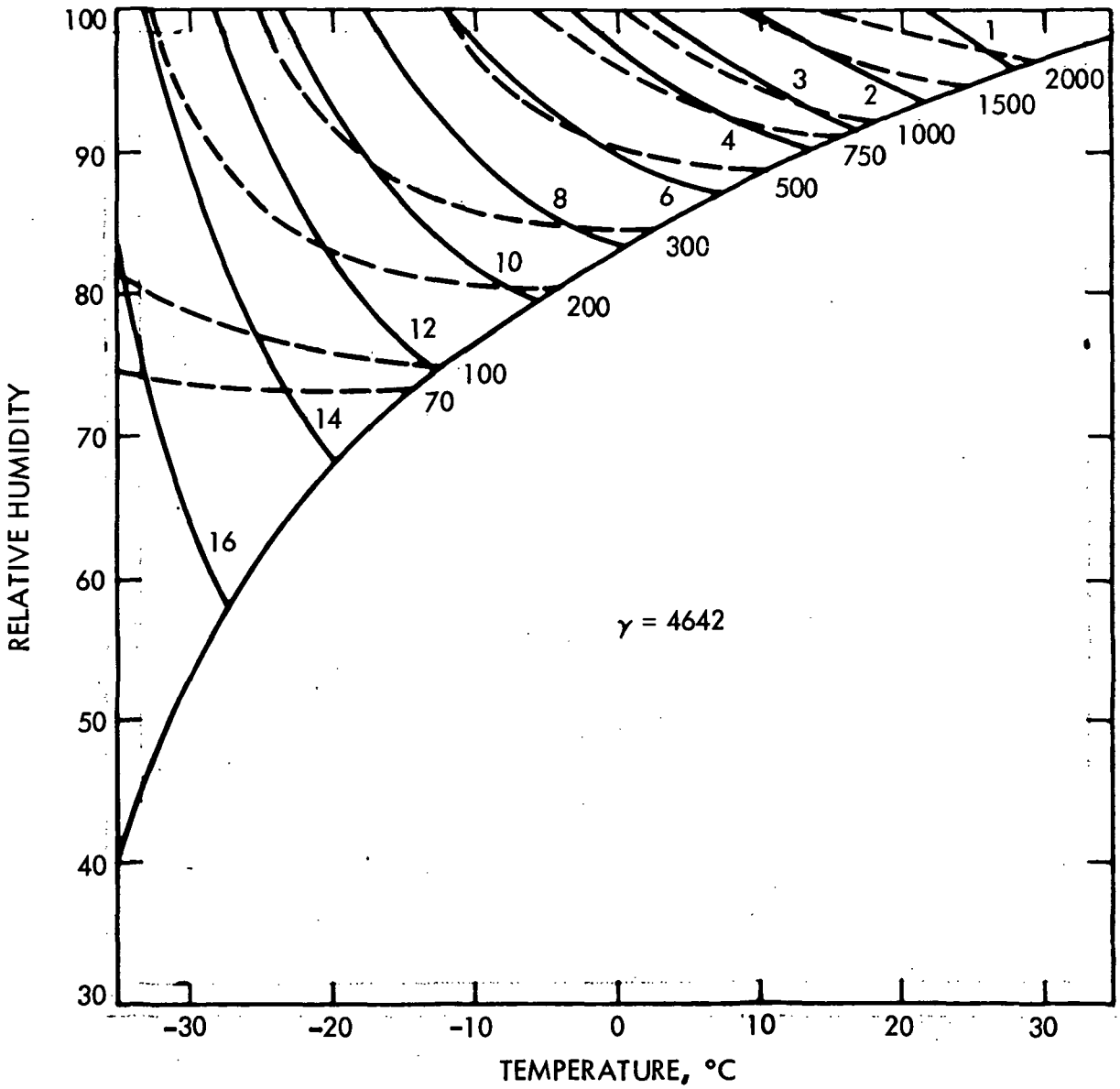


Fig. 3. Aerosol formation for temperature vs relative humidity, ratio of exhaust products δ = 4642

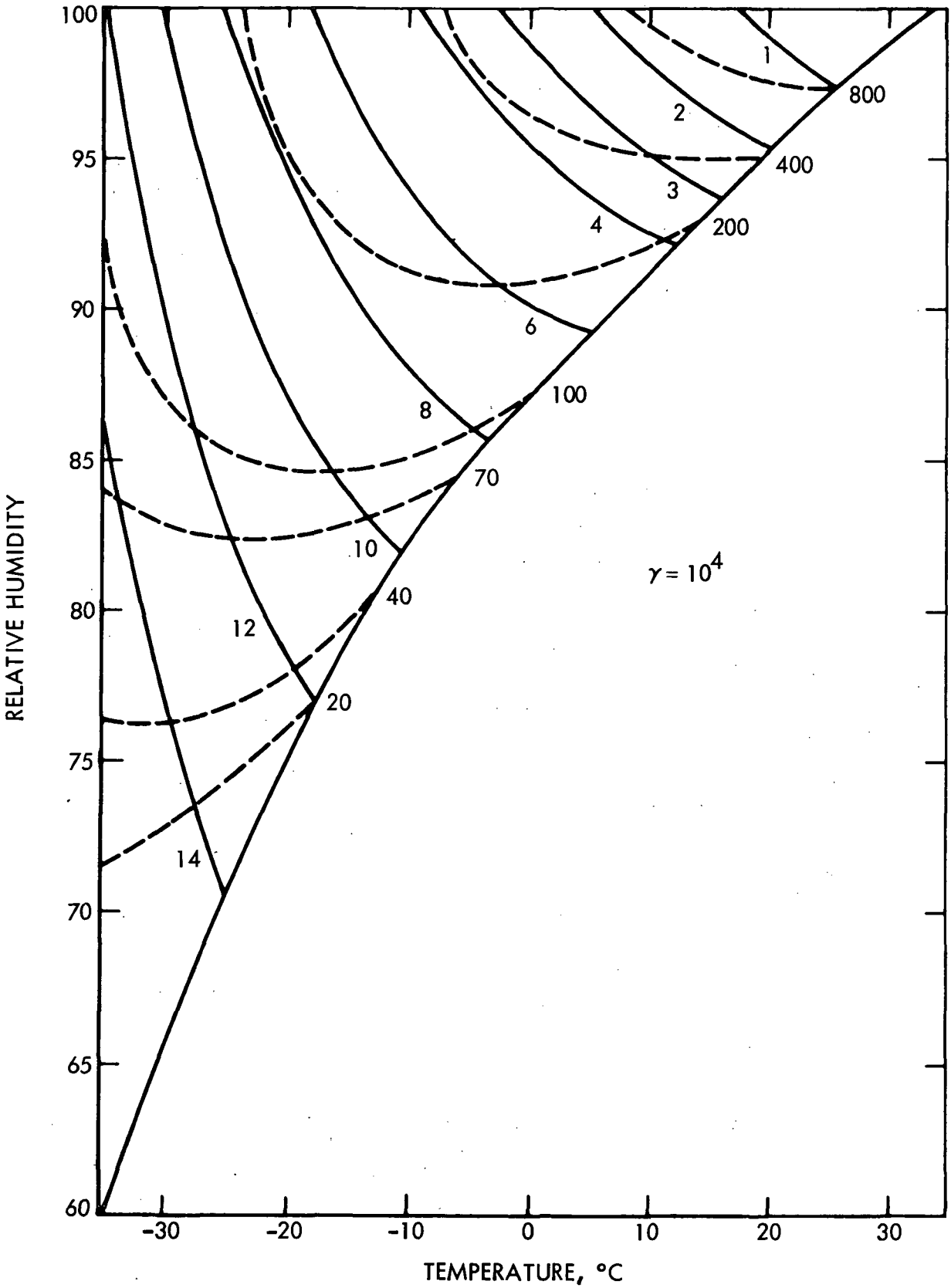


Fig. 4. Aerosol formation for temperature vs relative humidity, ratio of exhaust products $\delta = 10^4$

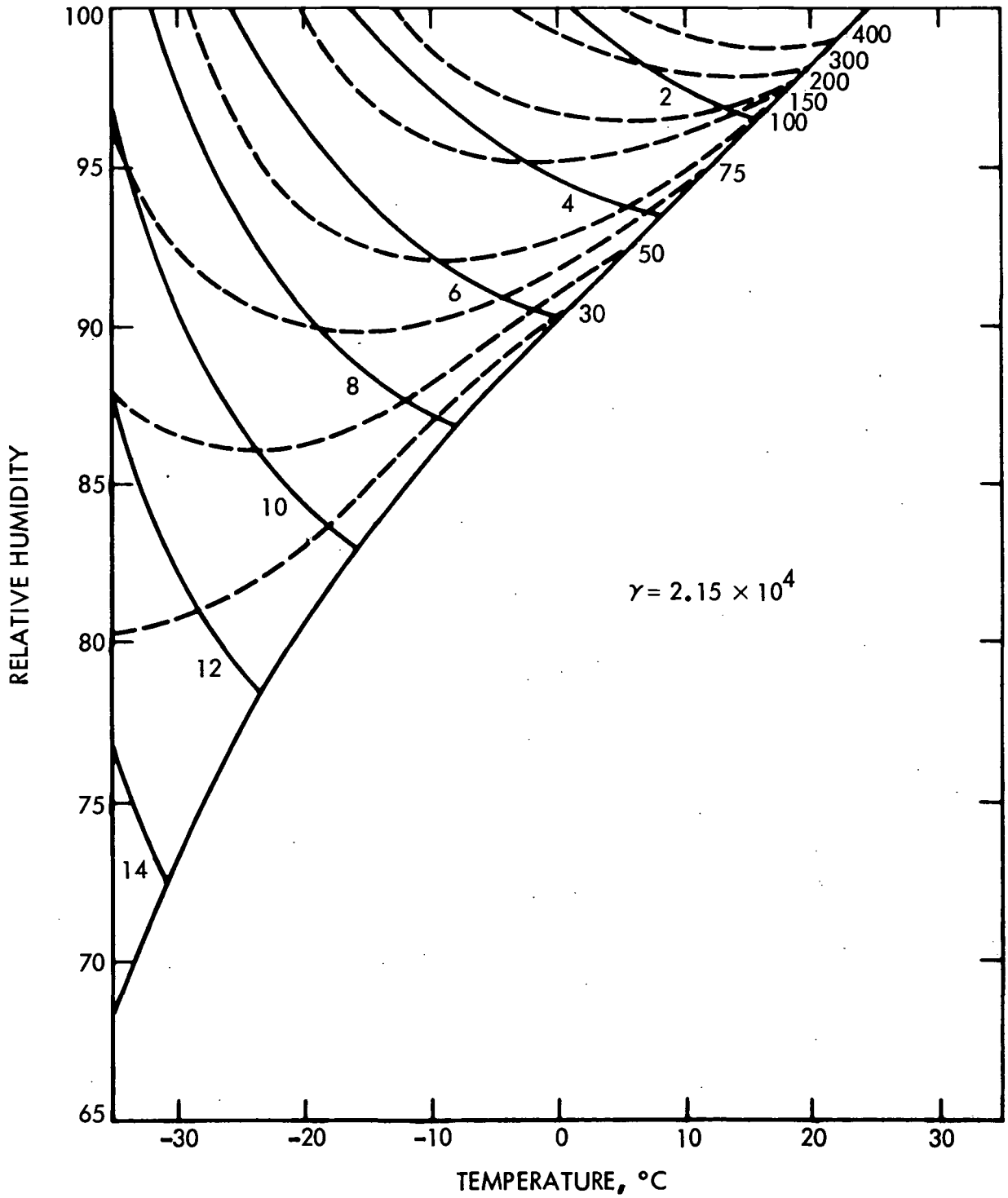


Fig. 5. Aerosol formation for temperature vs relative humidity, ratio of exhaust products $\delta = 2.15 \times 10^4$

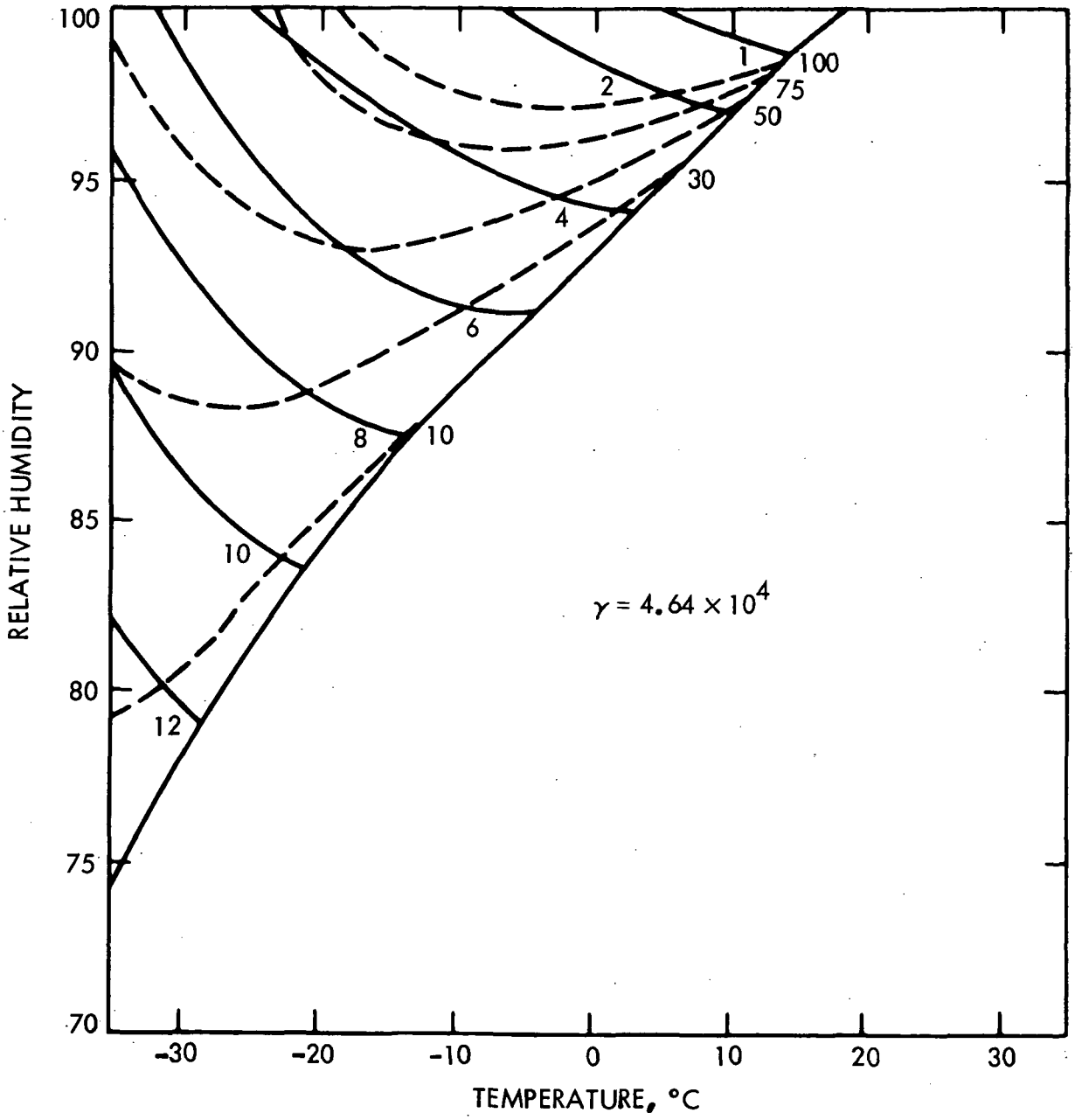


Fig. 6. Aerosol formation for temperature vs relative humidity, ratio of exhaust products $\delta = 4.64 \times 10^4$

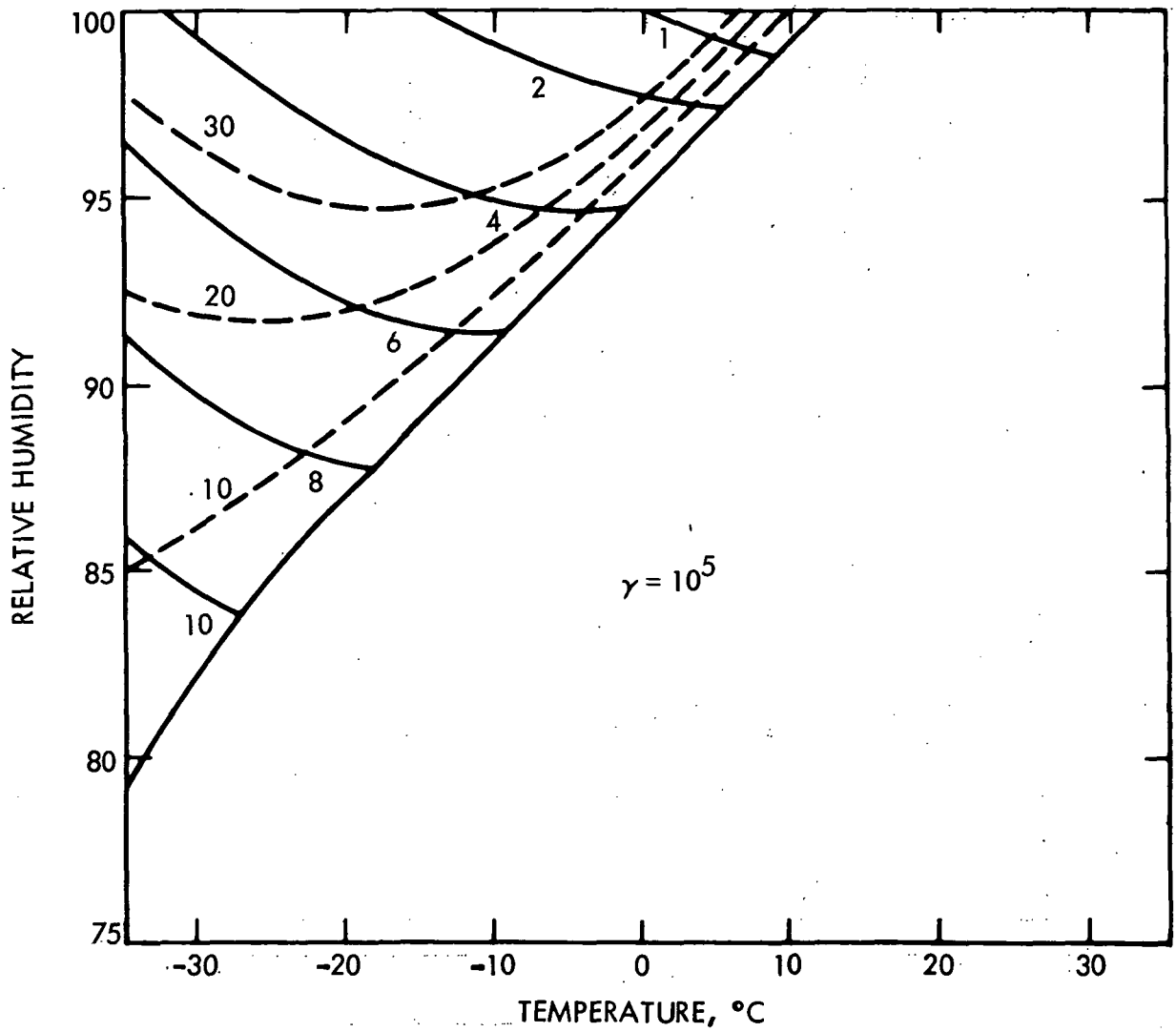


Fig. 7. Aerosol formation for temperature vs relative humidity, ratio of exhaust products $\delta = 10^5$

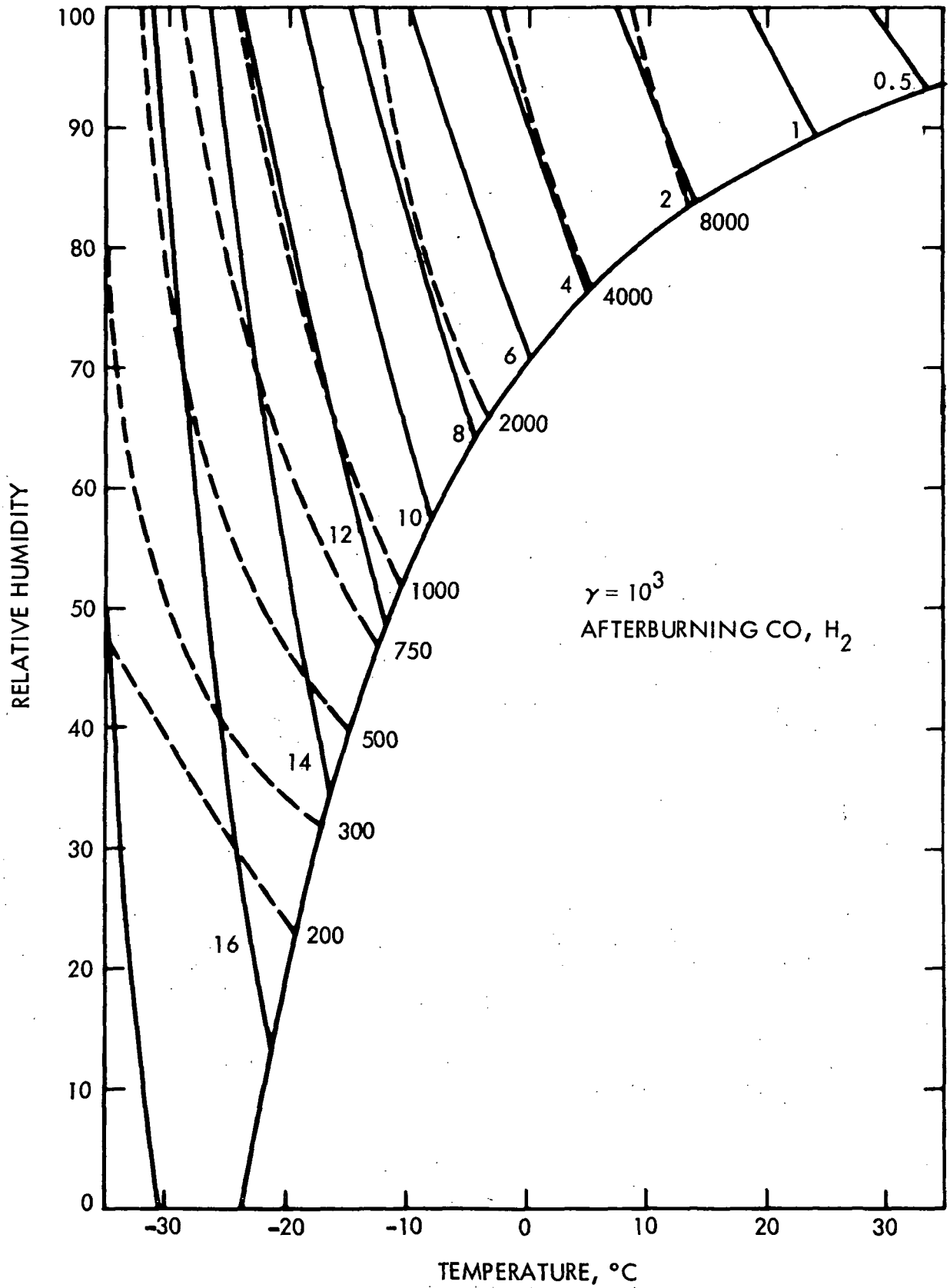


Fig. 8. Aerosol formation for temperature vs relative humidity, ratio of exhaust products $\delta = 10^3$, afterburning of exhaust products included

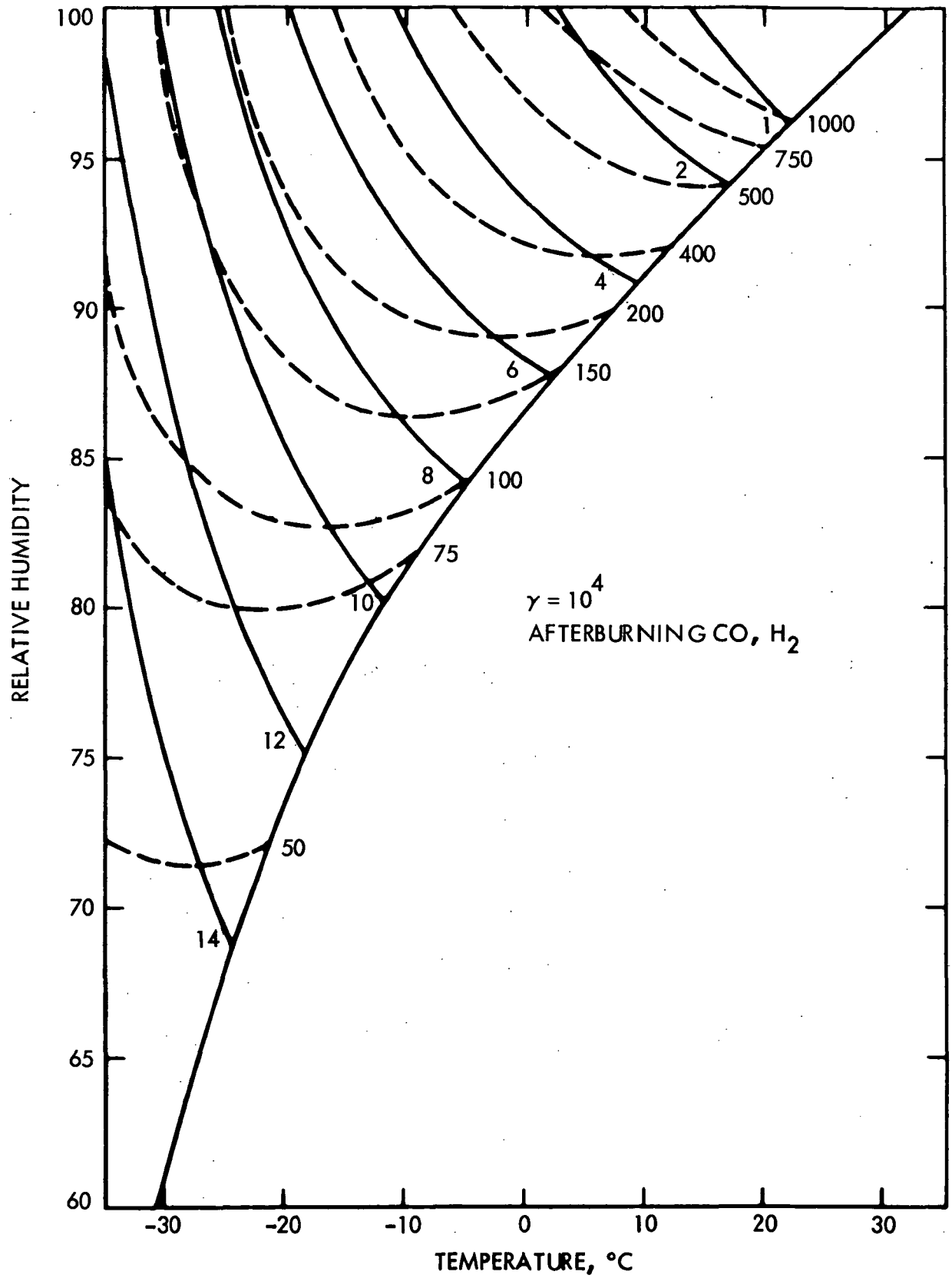


Fig. 9. Aerosol formation for temperature vs relative humidity, ratio of exhaust products $\delta = 10^4$, afterburning of exhaust products included

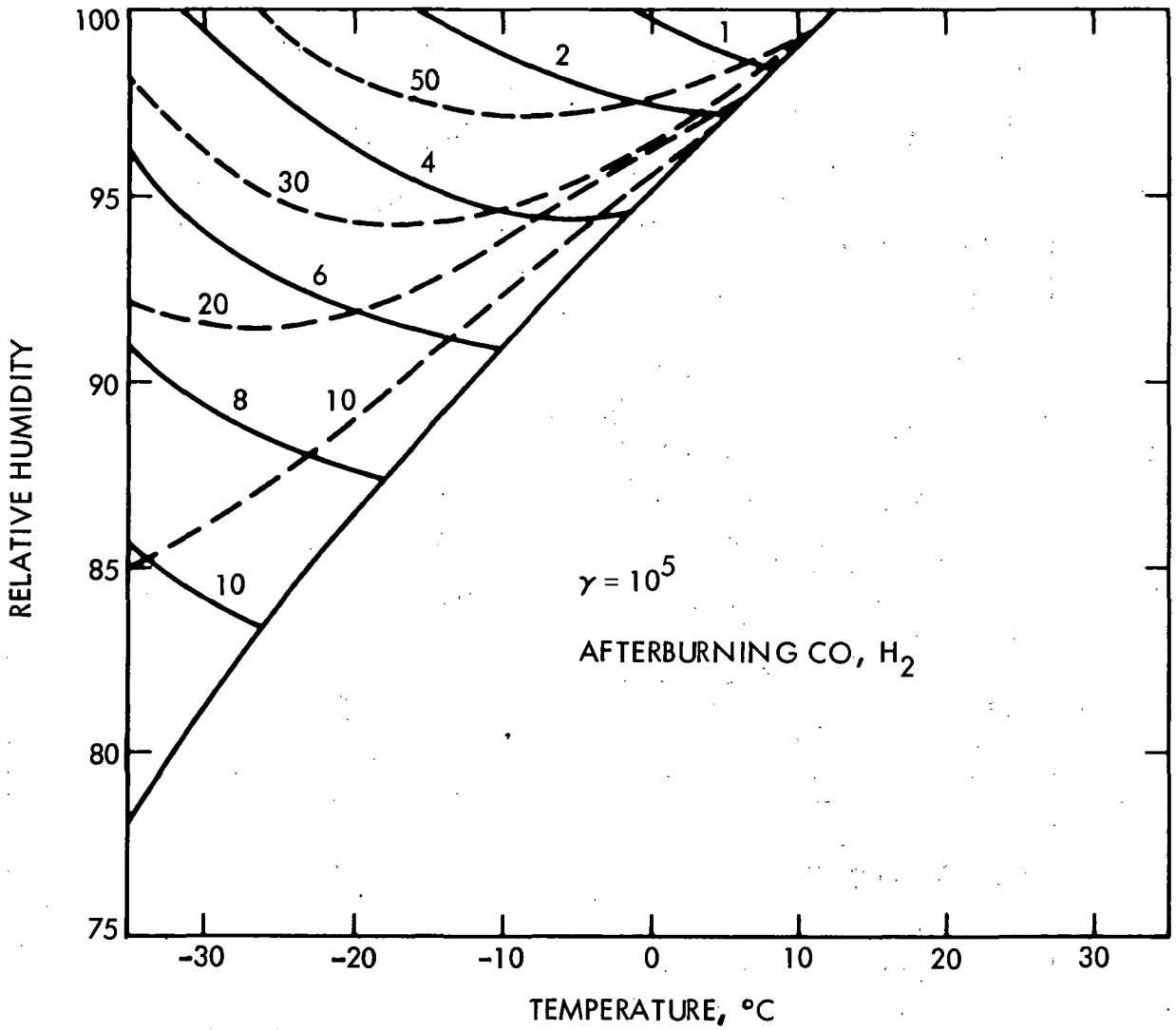


Fig. 10. Aerosol formation for temperature vs relative humidity, ratio of exhaust products $\delta = 10^5$, afterburning of exhaust products included



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