THE EFFECTS OF TEMPERATURE AND HUMIDITY ON PARACHUTE TEXTILES

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The stress-strain diagram of a textile yarn is, essentially, a birds-eye picture of the manner in which it resists stretching. Generally, the maximum force which can be exerted on it is its own ultimate strength; the amount of stretching required to call out that force is its ultimate elongation. These two parameters, ultimate, or rupture load and extension, are really only the coordinates of one point in a plot of tensile response to strain. A proper evaluation of tensile behavior of textile fibers and yarns entails an appreciation of several other points and regions of the stress-strain diagram.

Very few, if any, uses of textiles depend solely on the ultimate strength of the component yarns. First, initial stiffness (i.e., resistance to low levels of strain) is frequently a consequential characteristic of fibers. This stiffness may be described by a modulus. Second, the levels of load and elongation, at which the initial stiffness starts to change rapidly, known as the yield region, is also of primary significance. Third, the amount of stretch sustainable during "yielding" is important as well as any trend toward stiffening up again prior to rupture.

Finally, the work absorption of the fiber, found from the integrated area under the stress-strain diagram up to given levels of stress or strain, is often a critical performance criterion.

It is fairly well understood that the mechanical behavior of textile fibers is quite sensitive to their temperature and temperature pre-history. Not only rupture characteristics, but stiffness and yielding are susceptible to thermal effects.

The influence of temperature may arbitrarily be classified as "instantaneous," or "cumulative." The first of these categories pertains to such evidences of thermal sensitivity that are apparent only during testing at a given abnormal temperature. The second of the two categories pertains to changes occasioned by exposure to an abnormal temperature which persist after the textile item has been restored to a "normal" operating environment. Both such effects are actually reflections of molecular mechanisms and are detectable on the macroscopic level by analysis of the stress-strain diagrams.

The instantaneous effects of temperature on nylon, dacron, viscose and Fortisan are illustrated in stress-strain diagrams of filament yarns at - 70°F., 70°F., 210°F., and 350°F. The decrease in initial stiffness lowering of yield point, change in post-yield stiffening and drop in tensile strength with increasing temperature are of note. Combined cumulative and instantaneous effects may be detected, and the superimposed moisture effects, induced by temperature change, are also evident.

The cumulative effects of exposure to abnormal temperature are illustrated by stress-strain diagrams of filament yarns of nylon, dacron viscose and Fortisan at 70°F. - 65% R.H. after exposure to temperatures from - 70°F. to 350°F. Thermal degradation, shrinkage, progressive re-crystallization, and other modifications are detectable in the changes observed in the stress-strain curve.

Certain aspects of the visco-elastic nature of textile filaments are well illustrated by the temperature effects noted. The mechanisms of strain response and the influence of temperature on this response can be qualitatively interpreted on a molecular level. The textile polymer partakes of a composite solid-fluid nature. The crystalline and amorphous materials in textile polymer structures are involved in a complex interplay of forces. These forces, as well as the molecular configurations, will be influenced by temperature.

The following graphs show the effects of temperature on the various yarns at 70°F. - 65% R.H., after exposure to temperatures from - 70°F. to 350°F.

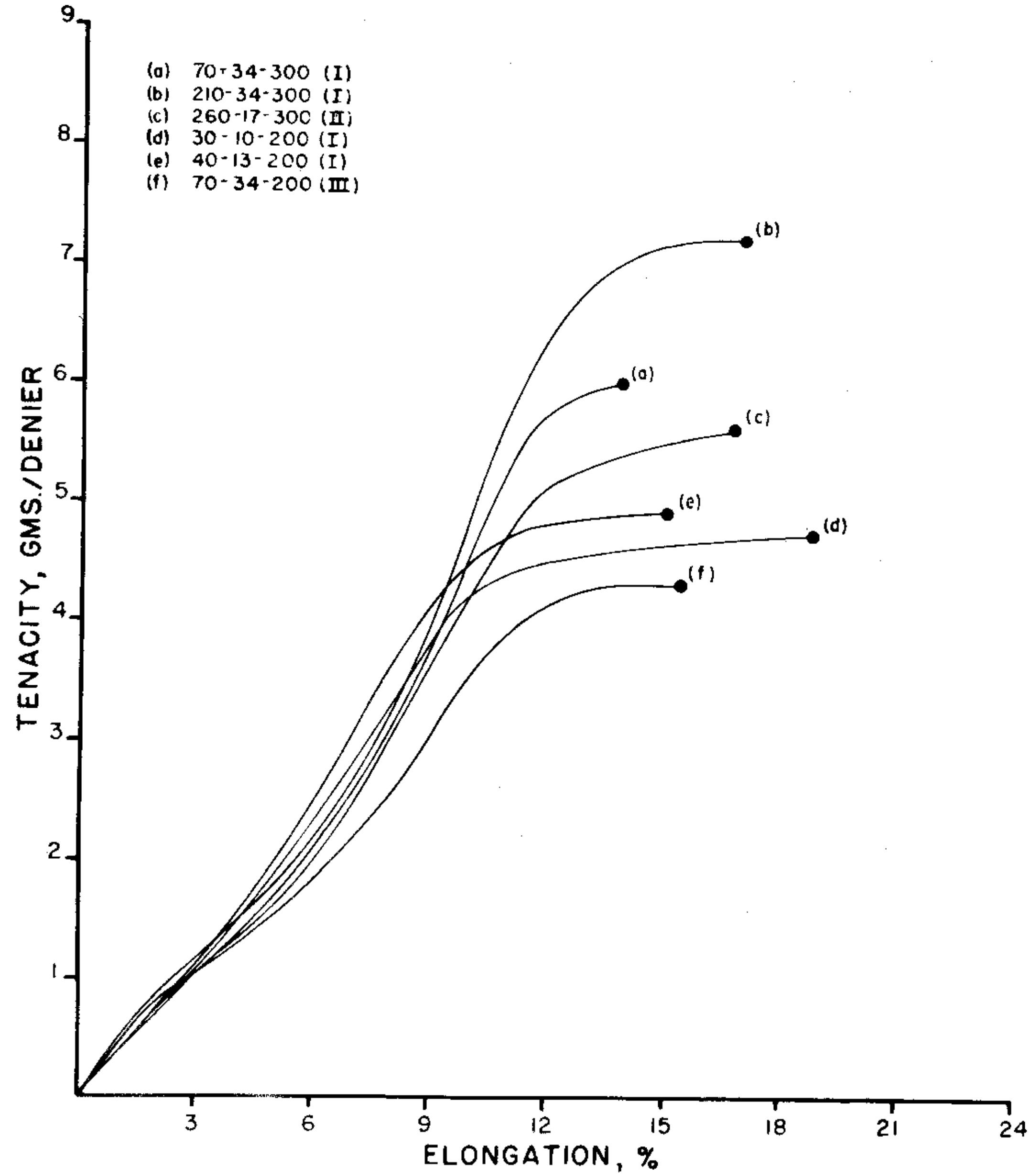

Figure 39. Elongation vs. Tenacity of Nylons at 70°F.-65% R.H.

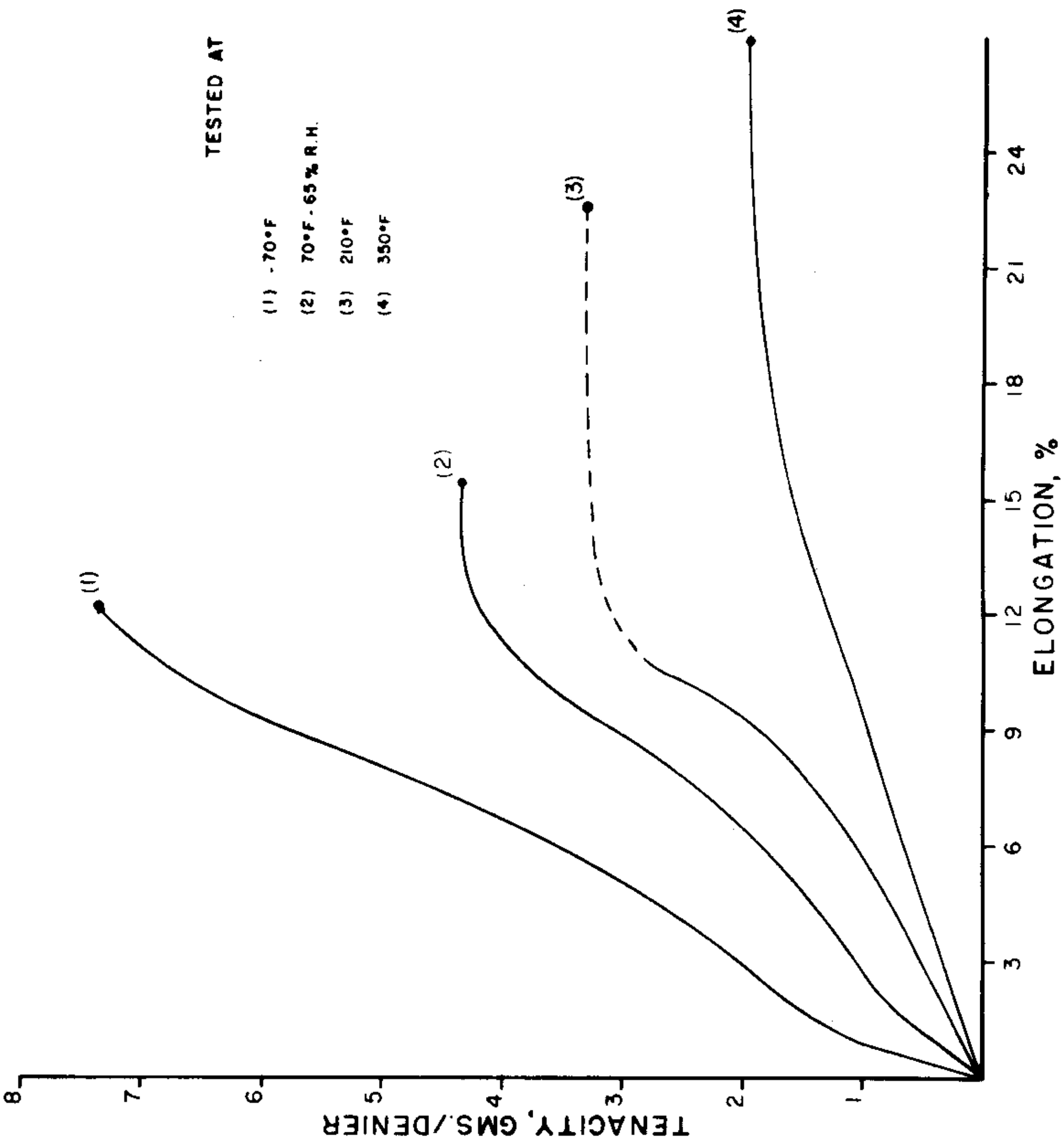

Figure 40. Elongation vs. Tenacity of Nylon 70-34-$\frac{1}{2}$-2-200 Semi Dull.

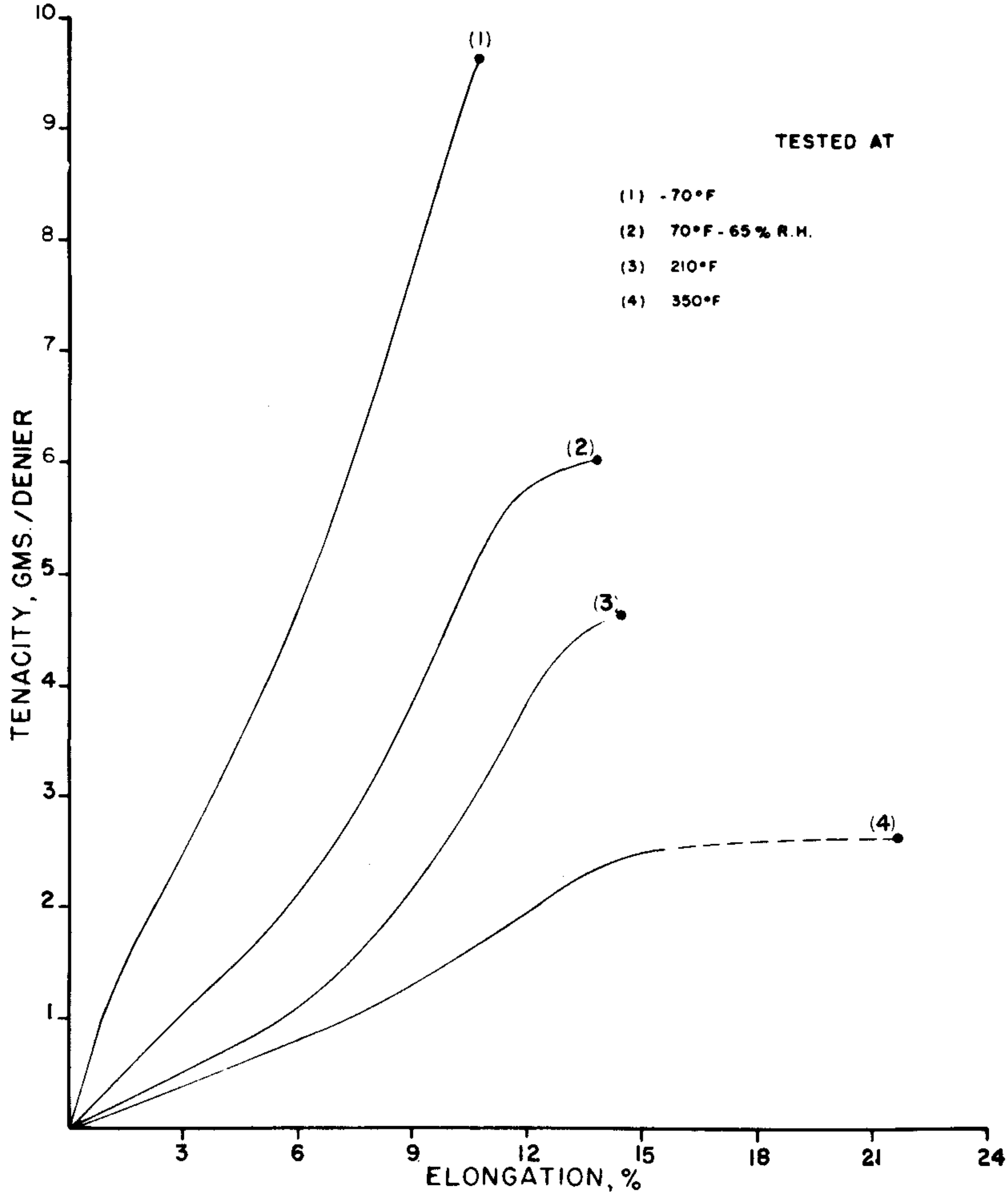

Figure 41. Elongation vs. Tenacity of Nylon 70-34-$\frac{1}{2}$-Z-300 Bright.

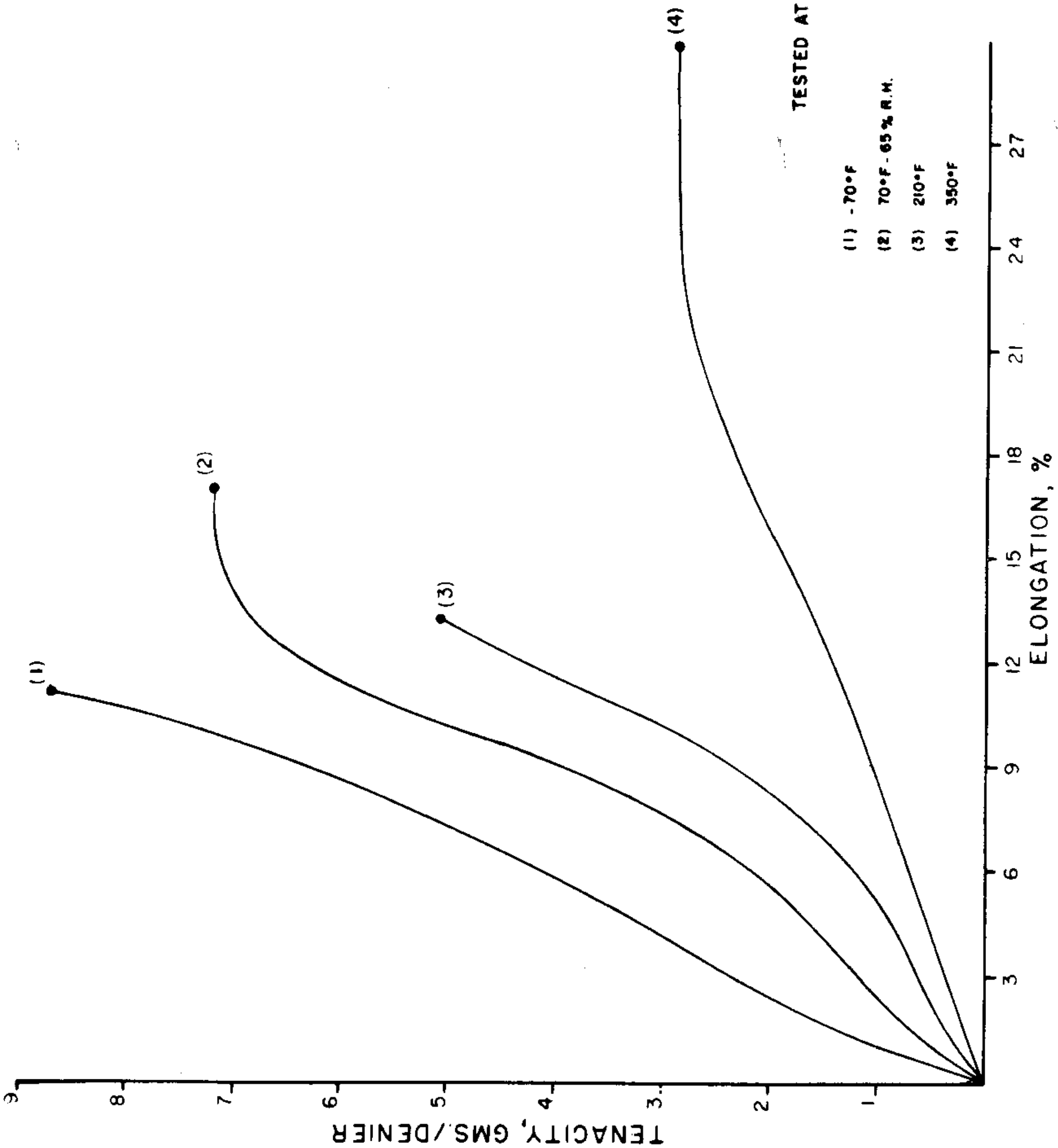

Figure 42. Elongation vs. Tenacity of Nylon 210-34-1-Z-300 Bright.

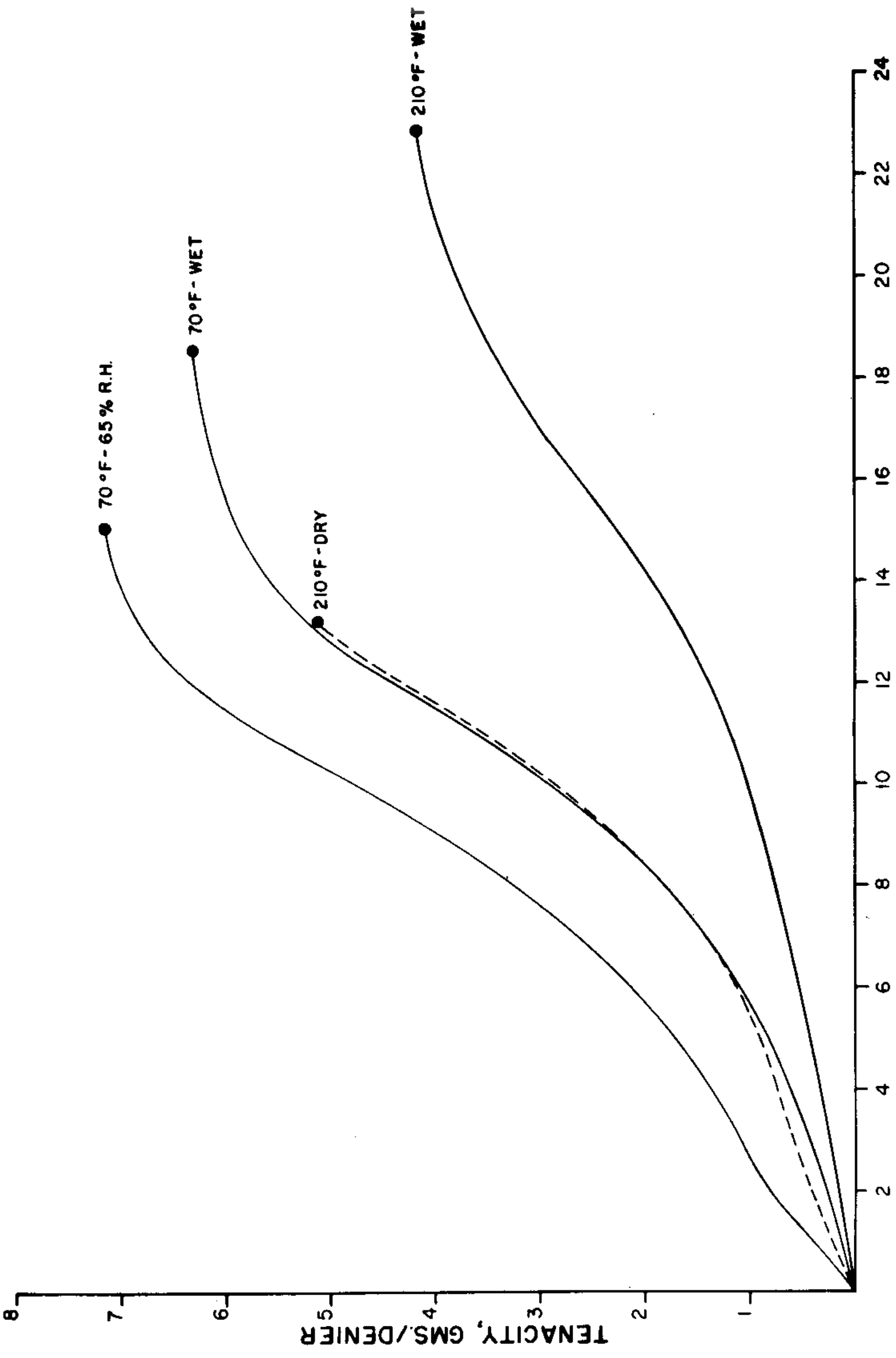

Figure 43. Elongation vs. Tenacity of Nylon 210-34-1-Z-300 Bright.

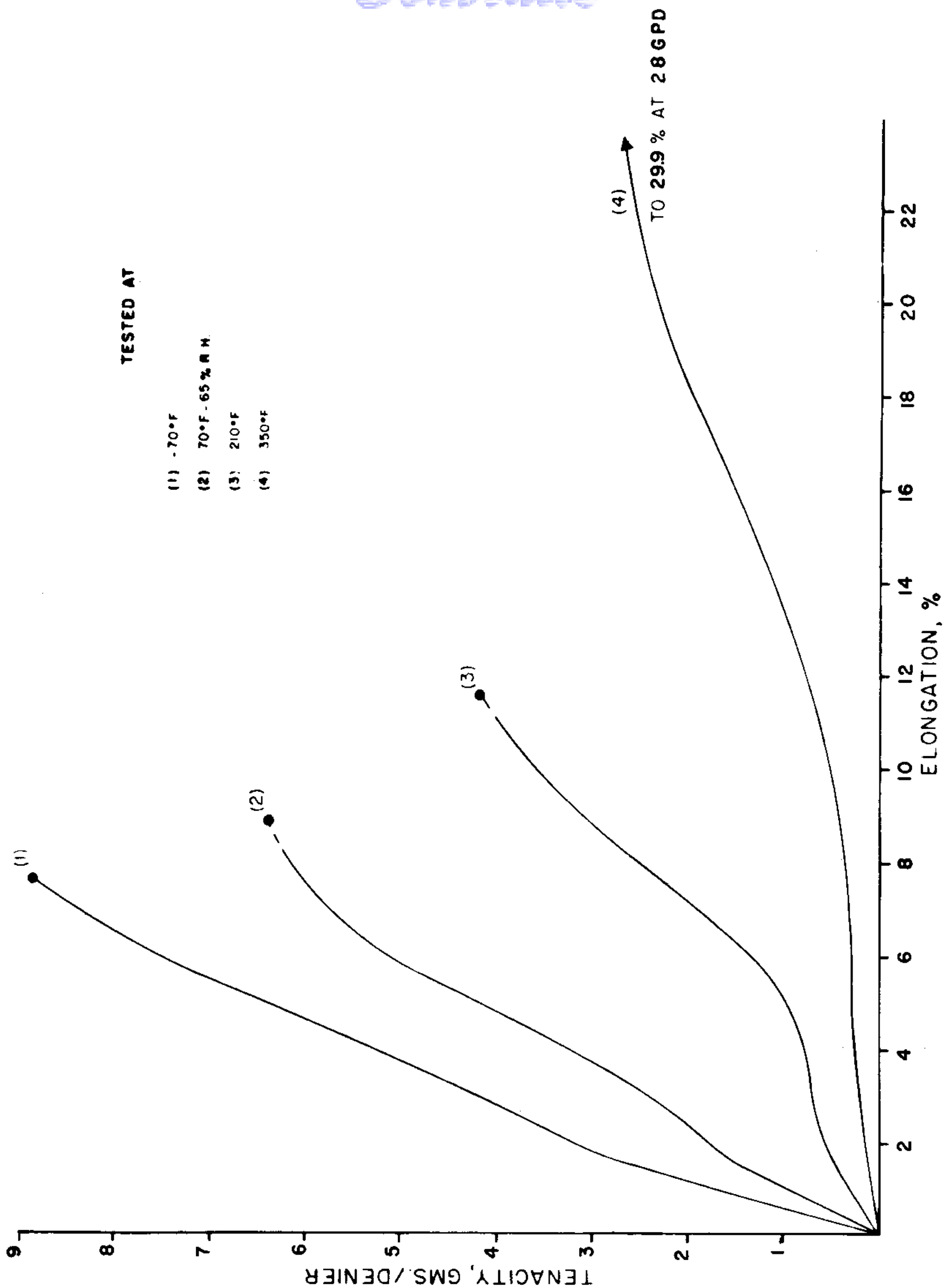

Figure 44. Elongation vs. Tenacity of Dacron 210-34-1-Z-5100.

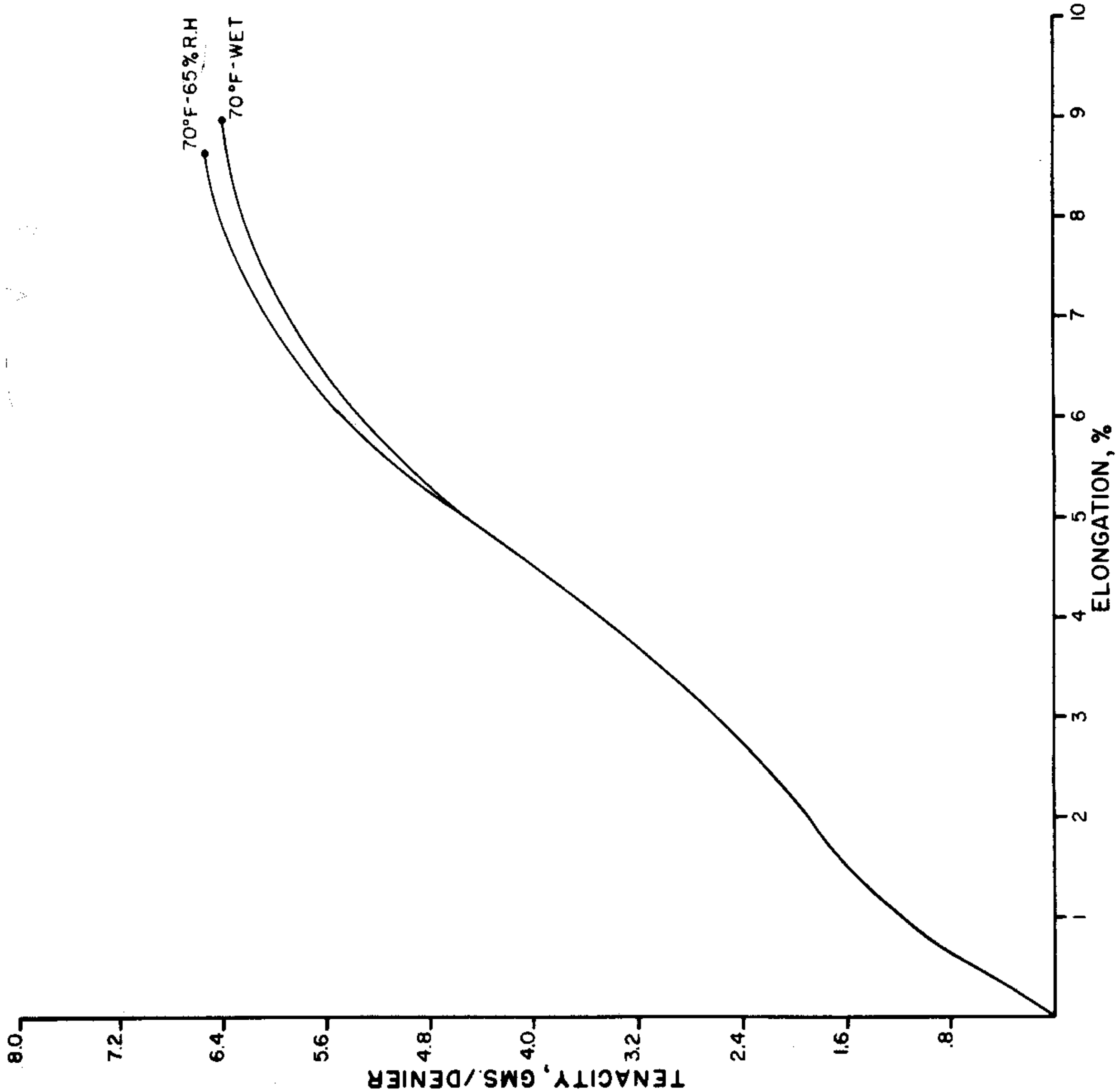

Figure 45. Elongation vs. Tenacity of Dacron 210-34-1Z-5100.

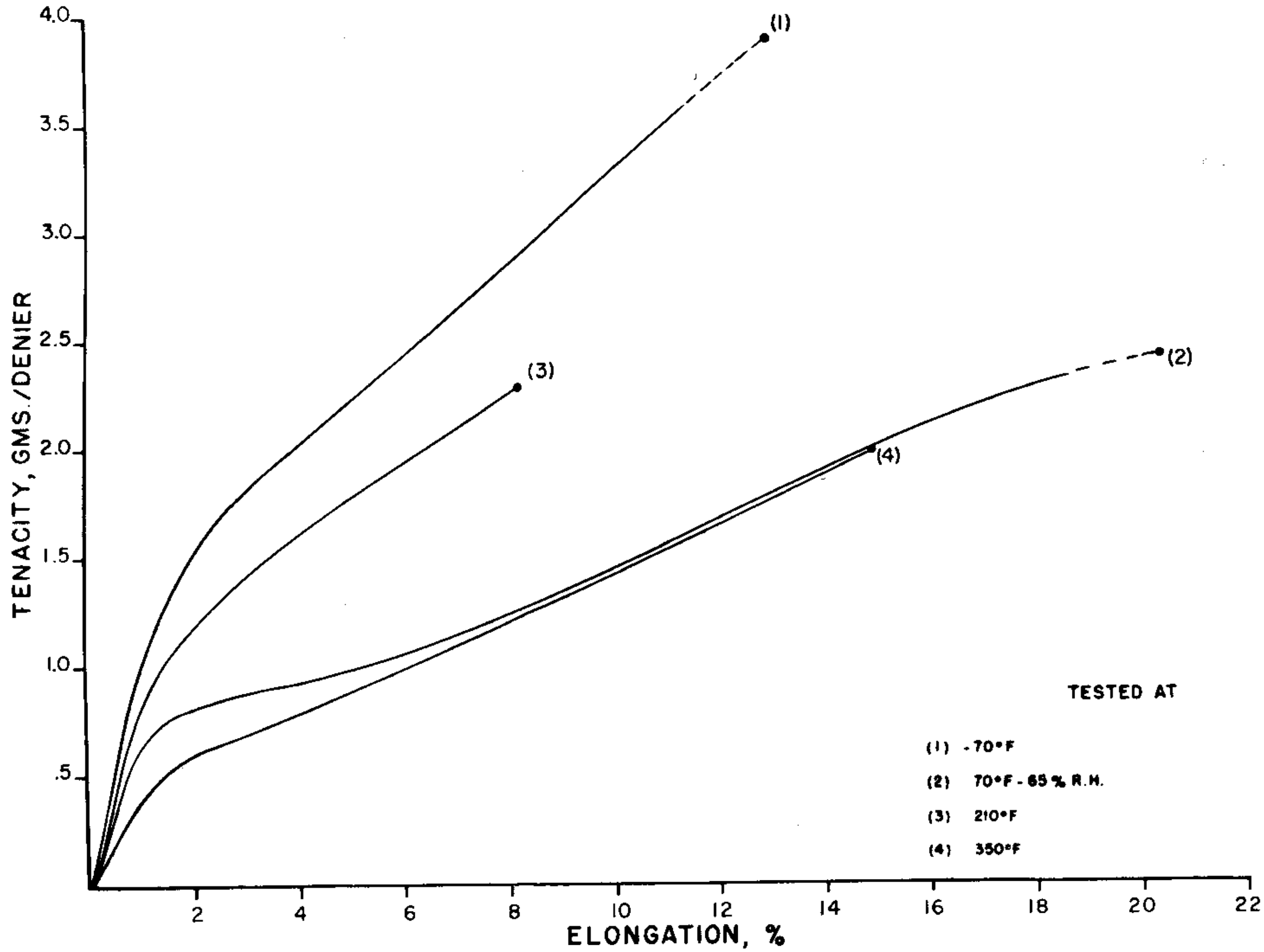

Figure 46. Elongation vs. Tenacity of H. T. Viscose Rayon 300 Den., 120 Fila., Lot No. 1092 Bright.

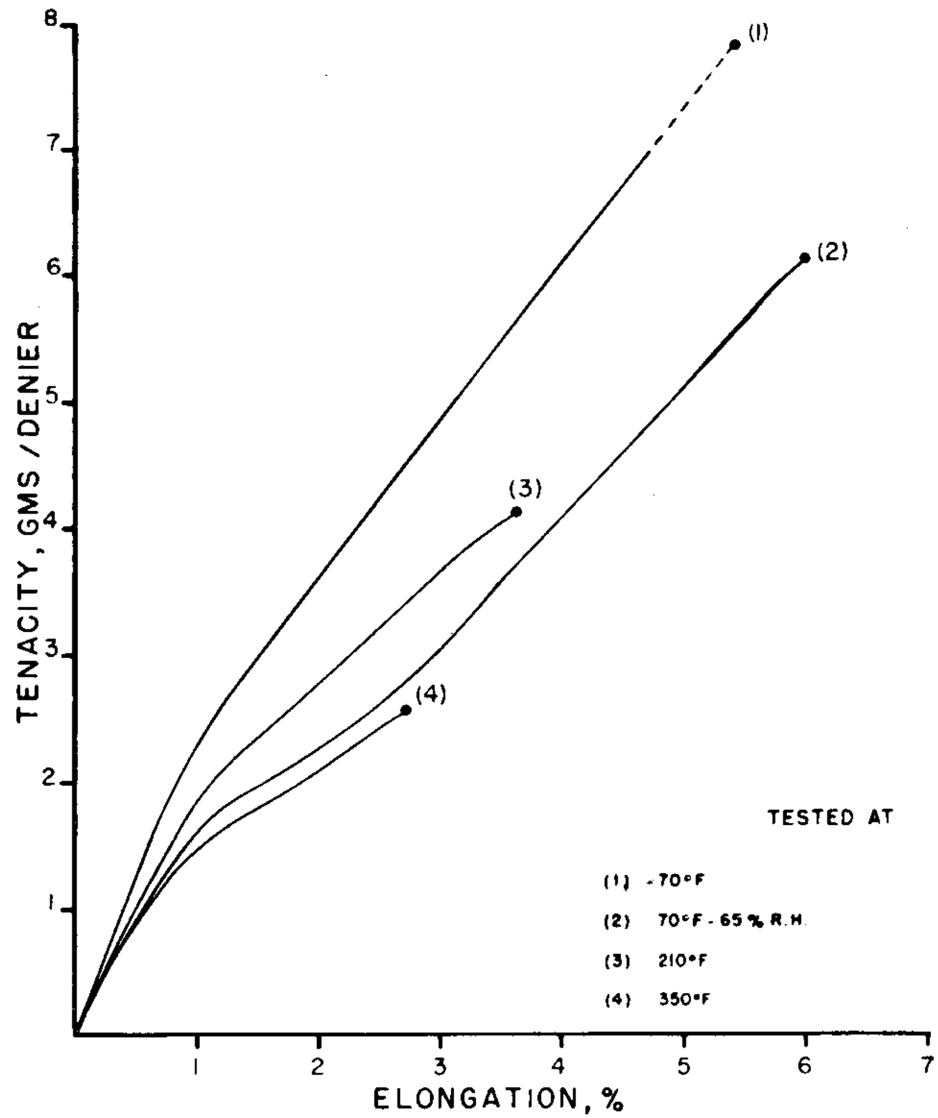

Figure 47. Elongation vs. Tenacity of H. T. Fortisan 270-LTD-360 Lot No. CDPUA-C.

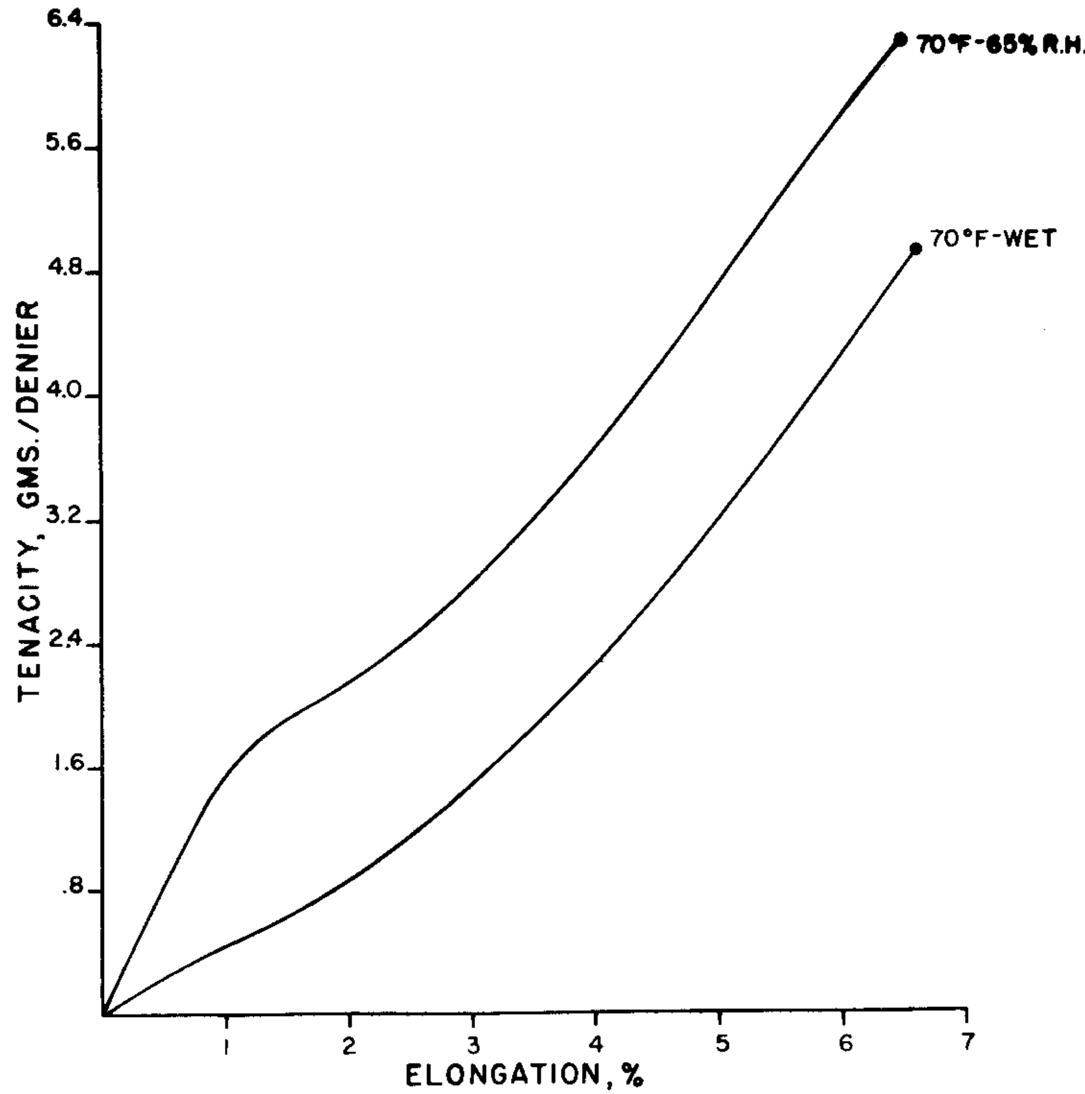

Figure 48. Elongation vs. Tenacity of H. T. Fortisan 270-LTD-360 Lot No. CDPUA-C.

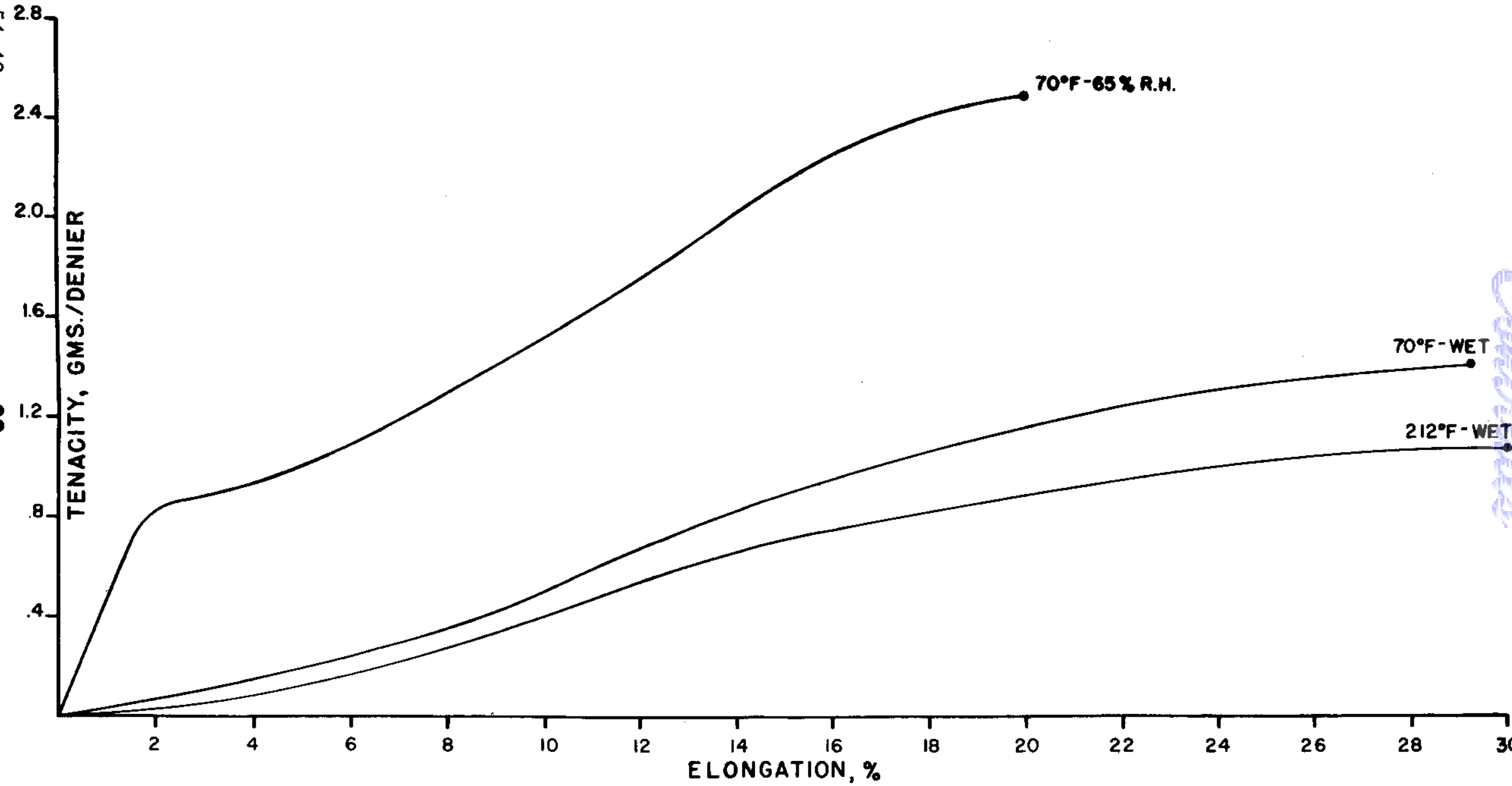

Figure 49. Elongation vs. Tenacity of H. T. Viscose Rayon 300 Den., 120 Fila., Lot No. 1092 Bright.

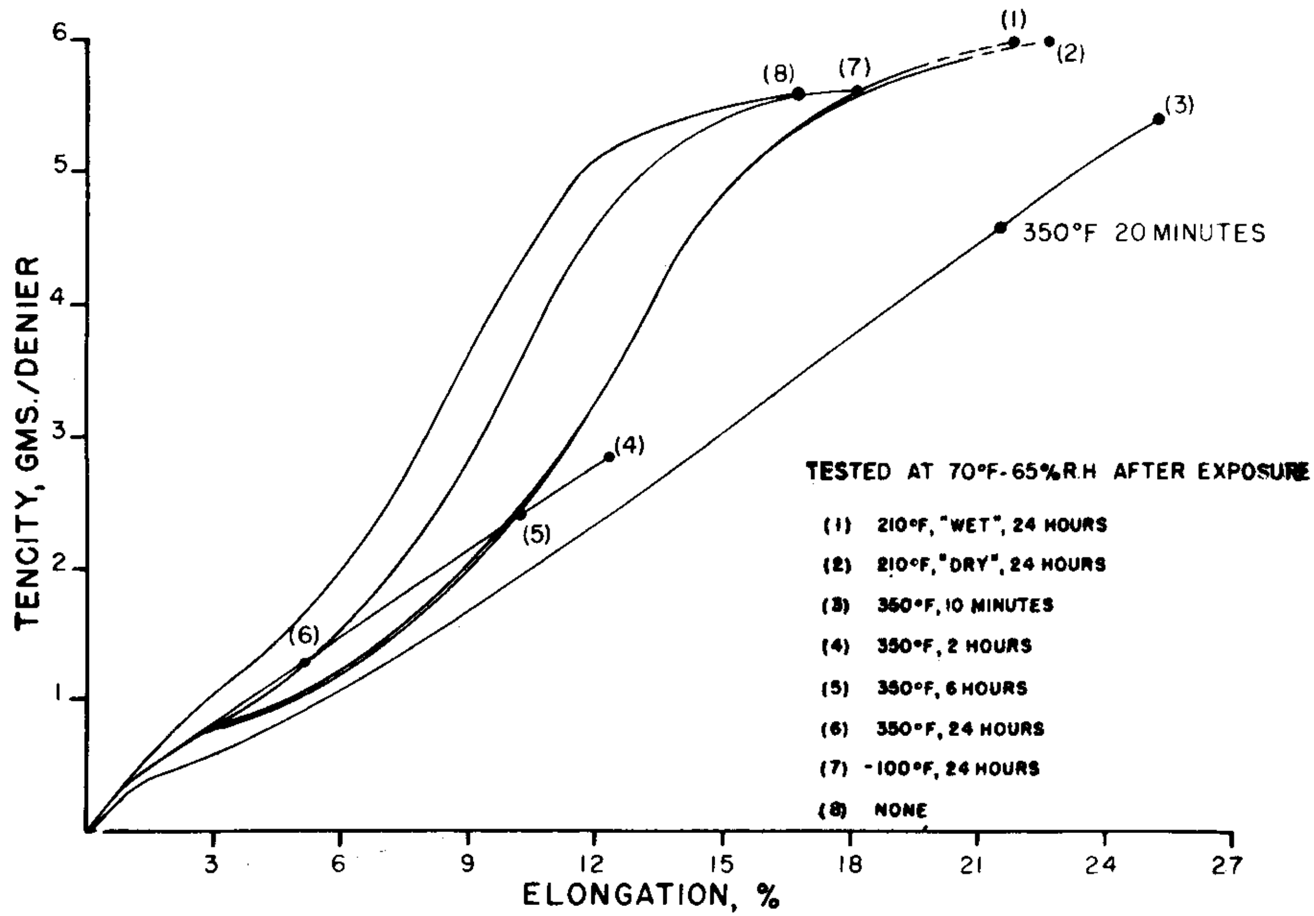

Figure 50. Elongation vs. Tenacity of Nylon 260-17-1-Z-300 Bright.

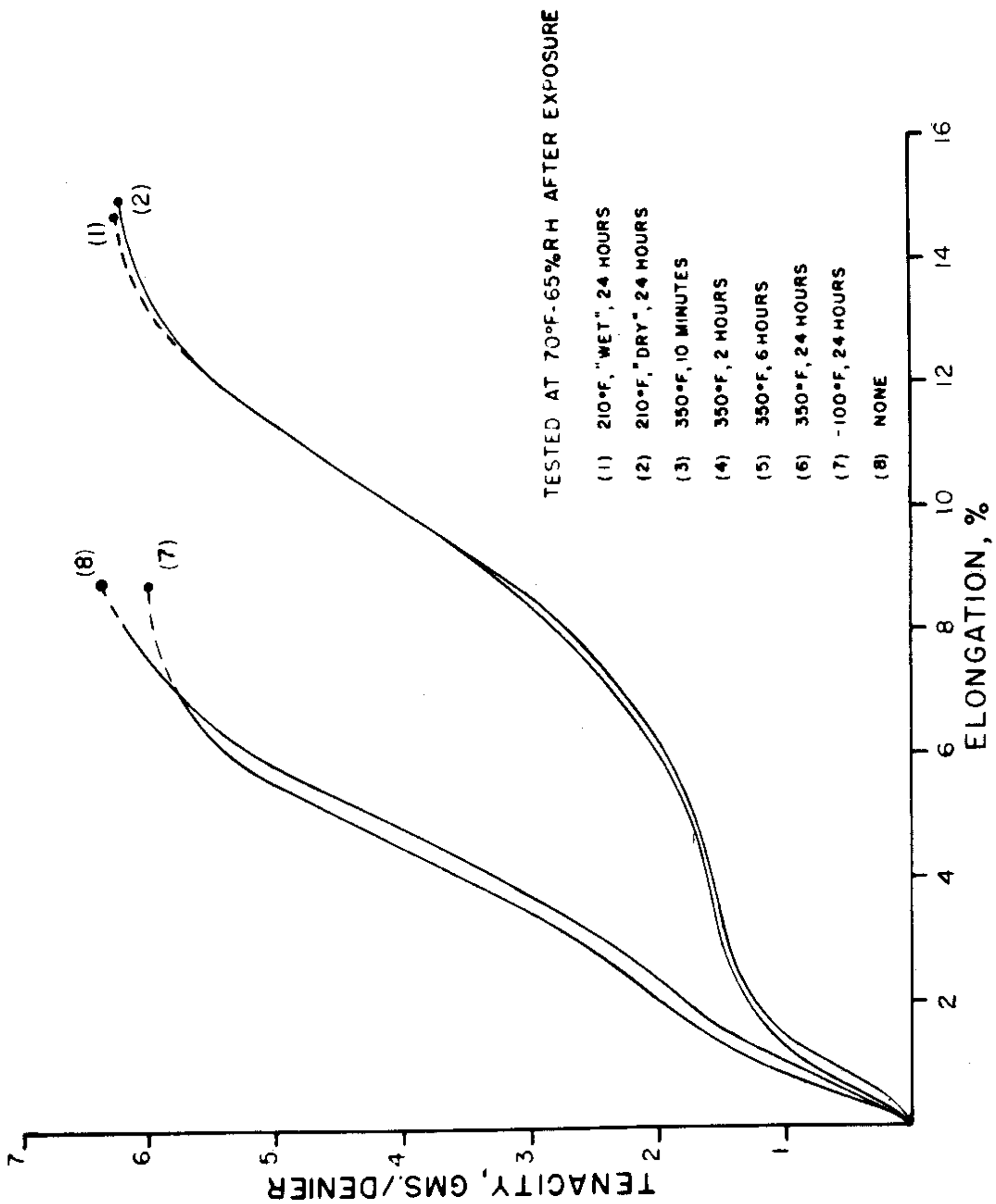

Figure 51. Elongation vs. Tenacity of Dacron 210-34-1Z-5100.

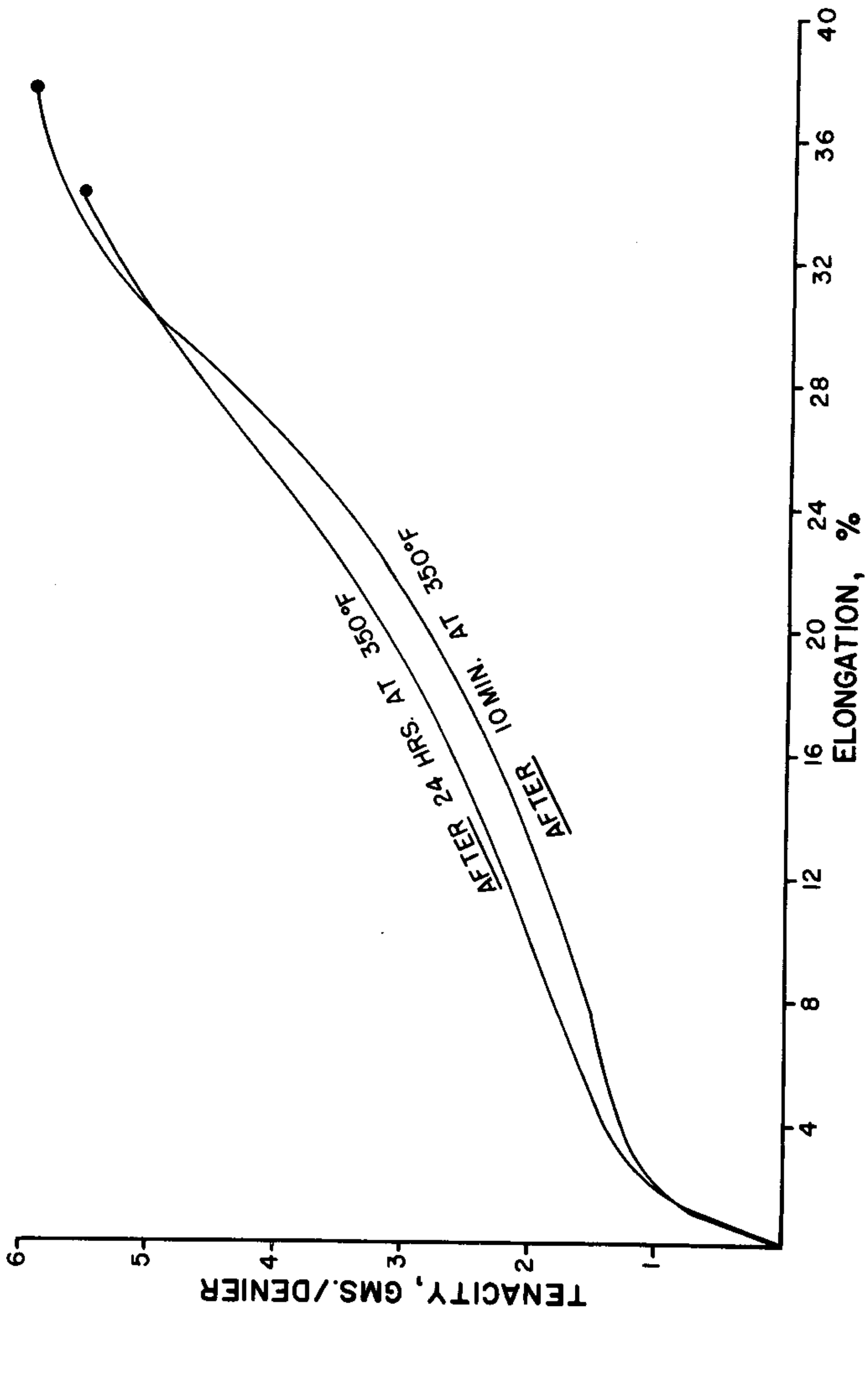

Figure 52. Elongation vs. Tenacity of Dacron 210-34-1Z-5100.

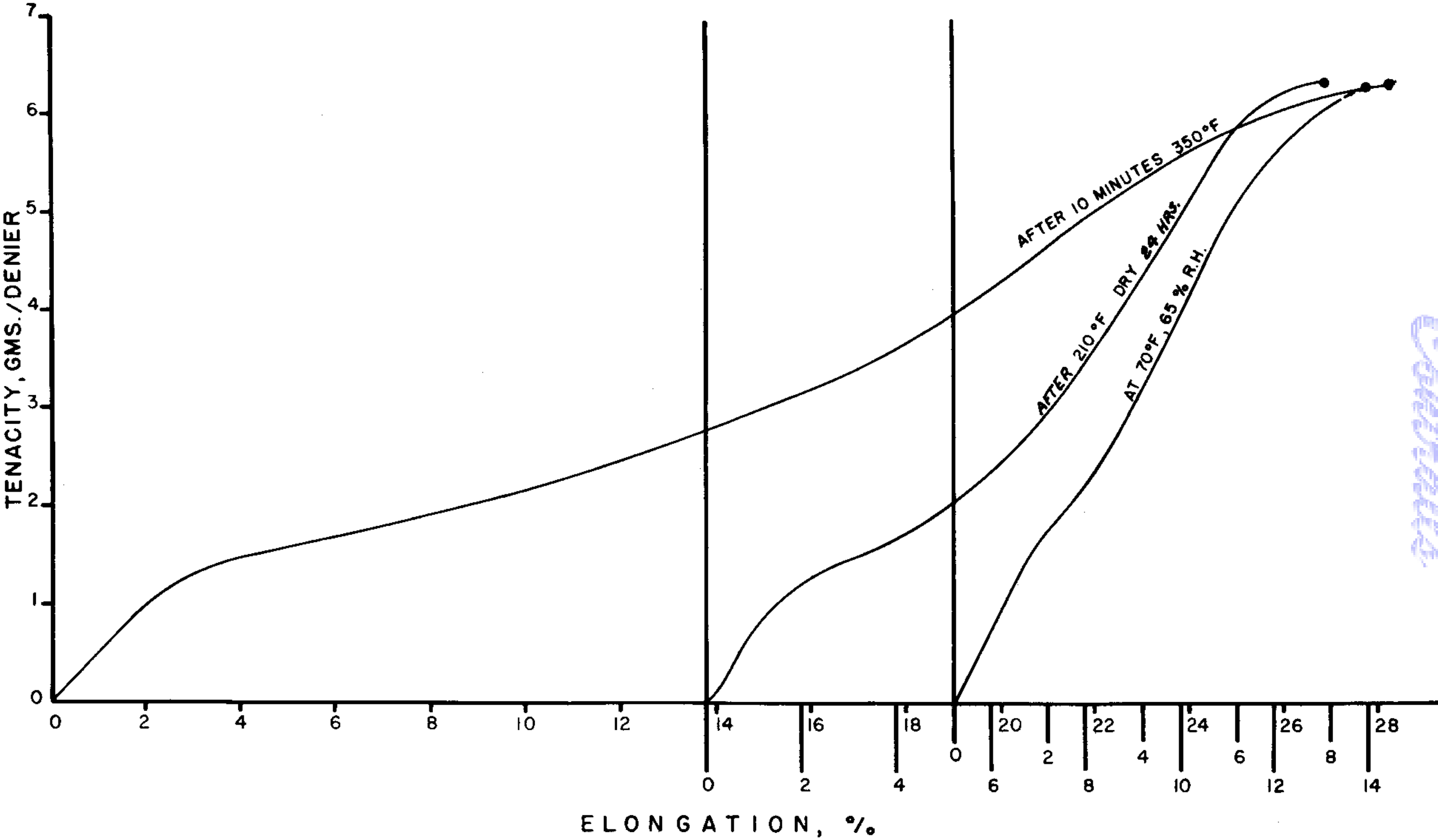

Figure 53. Elongation vs. Tenacity of Dacron 210-34-1Z-5100.

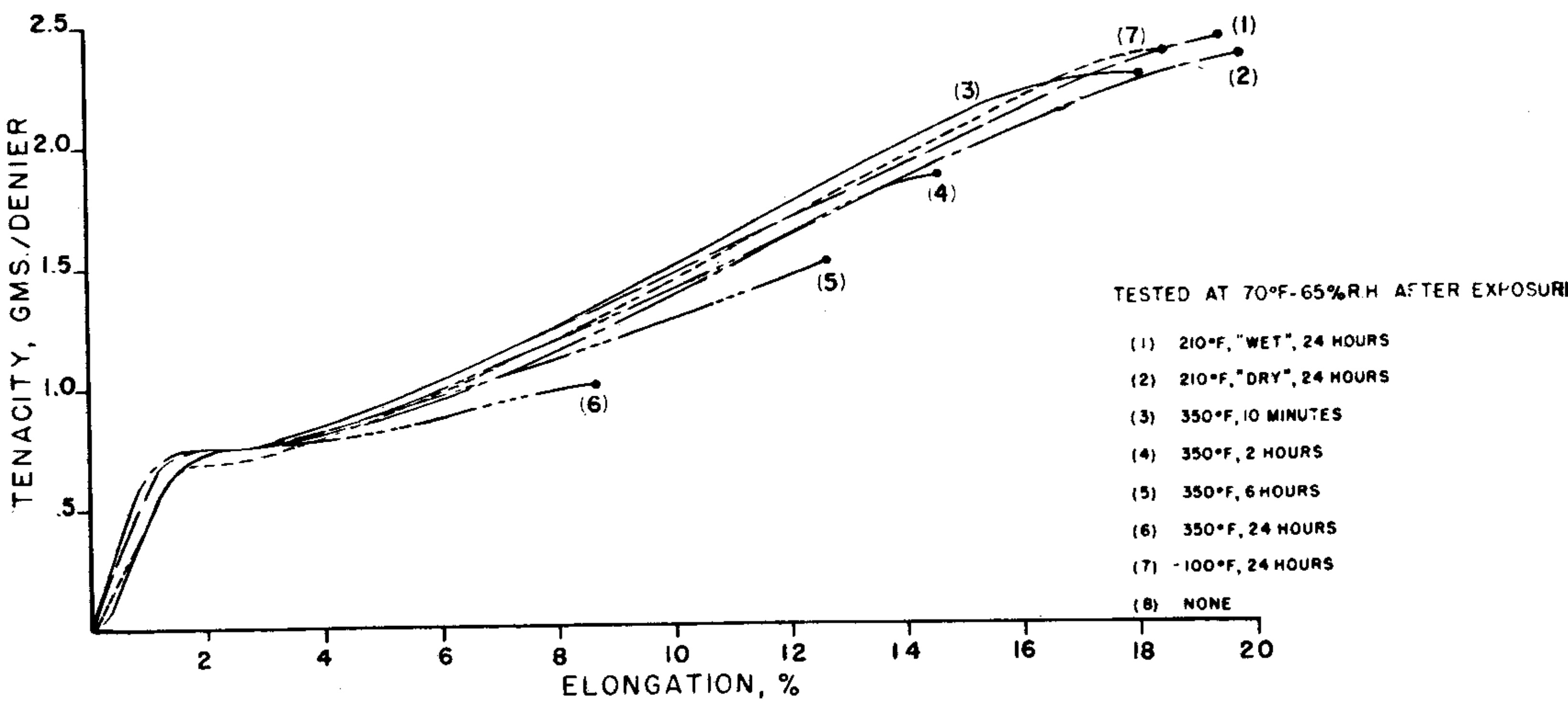

Figure 54. Elongation vs. Tenacity of H. T. Viscose Rayon 300 Den. -120 Fila., Lot No. 1092 Bright.

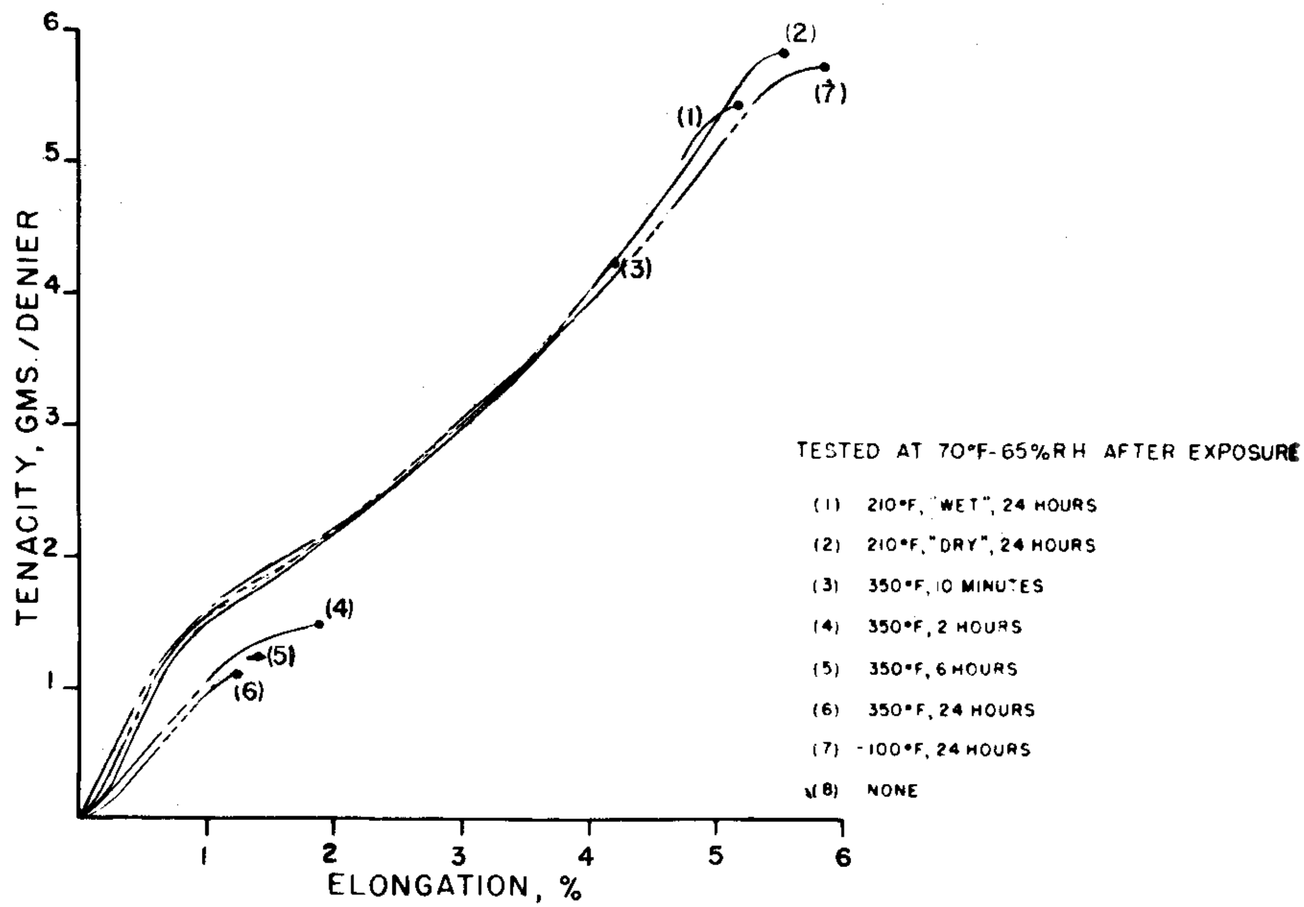

Figure 55. Elongation vs. Tenacity of H. T. Fortisan 270-LTD-360, Lot No. CDPUA-C.

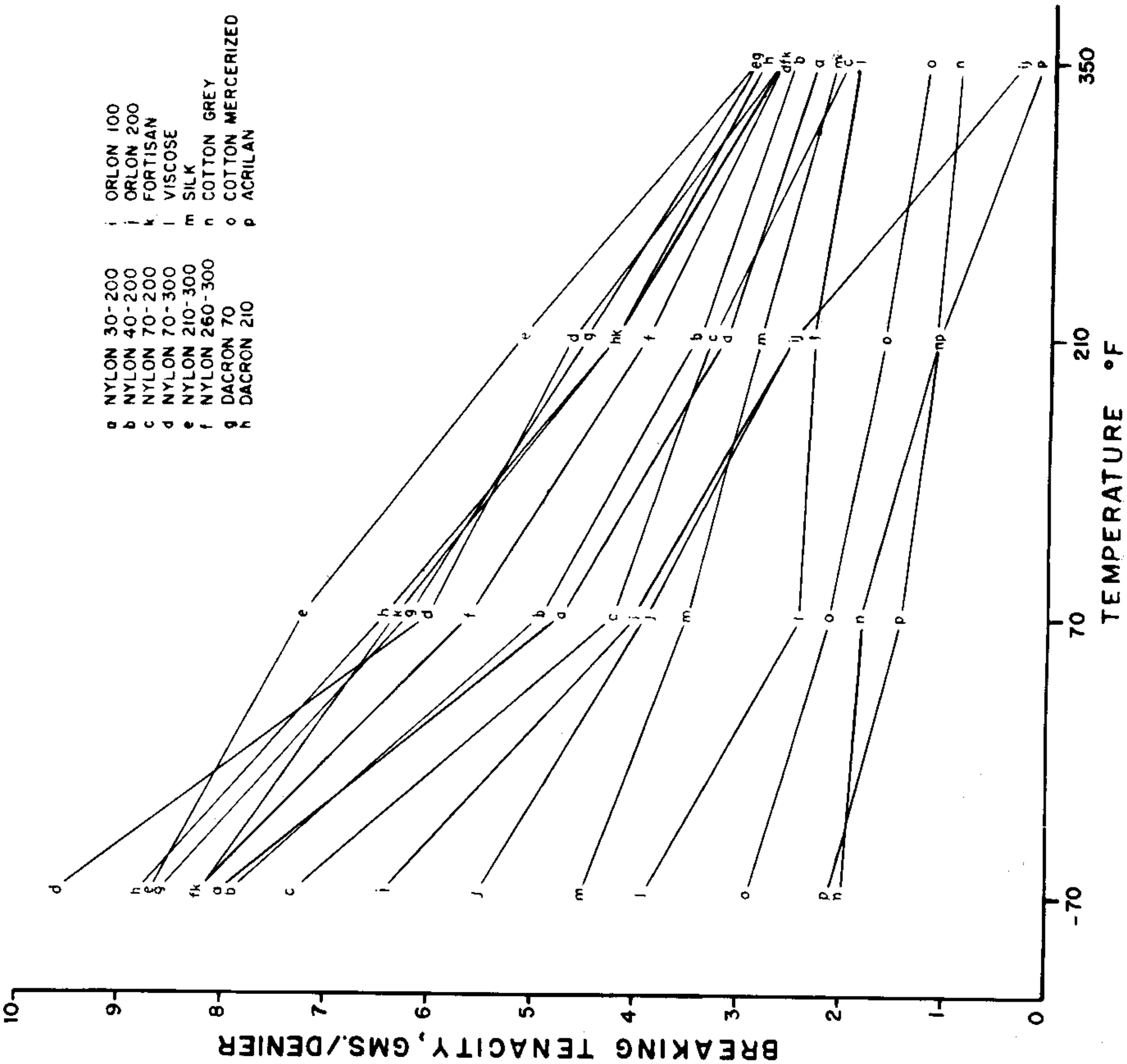

Figure 56. Temperature vs. Breaking Tenacity.

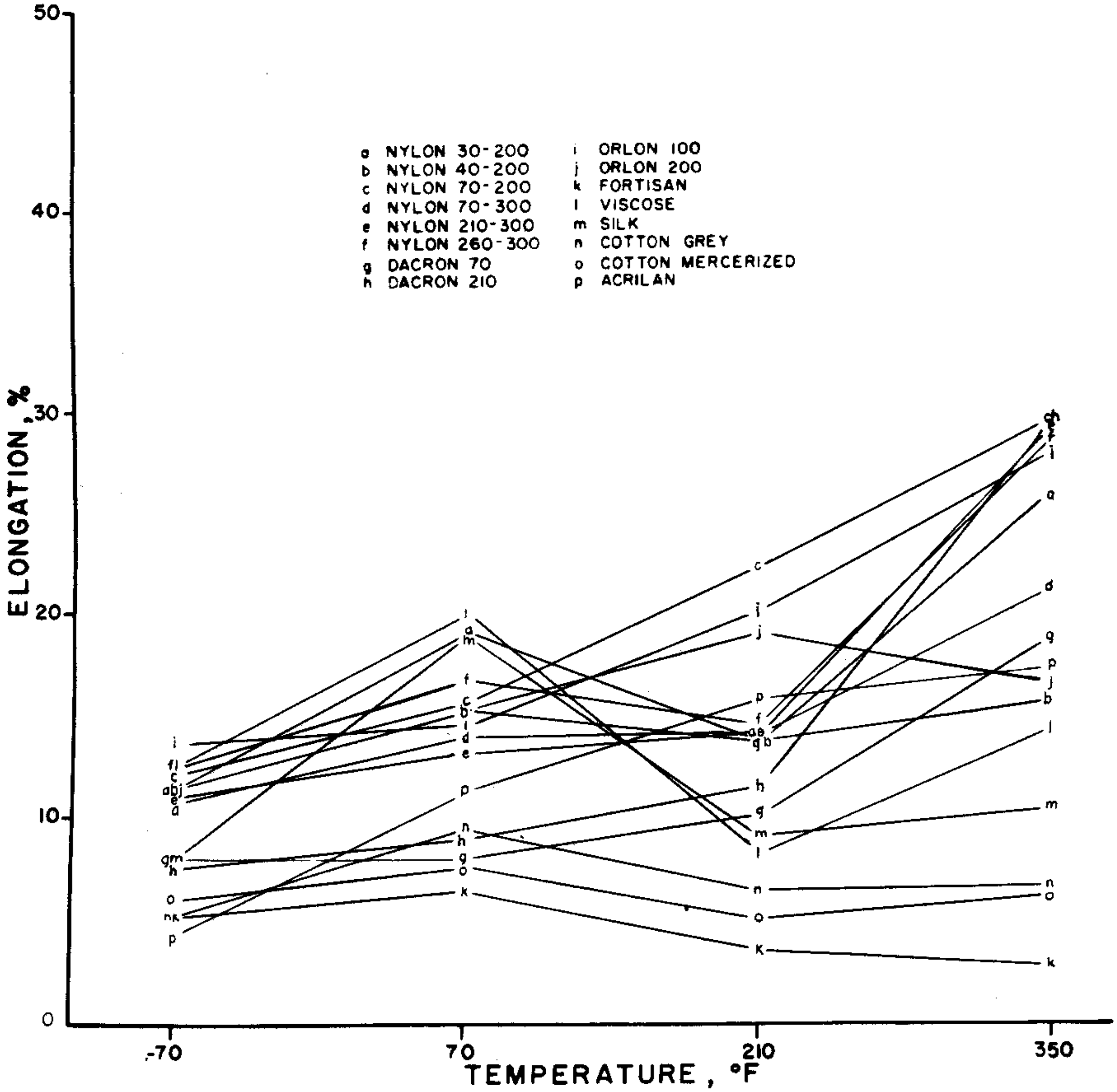

Figure 57. Temperature vs. Elongation.

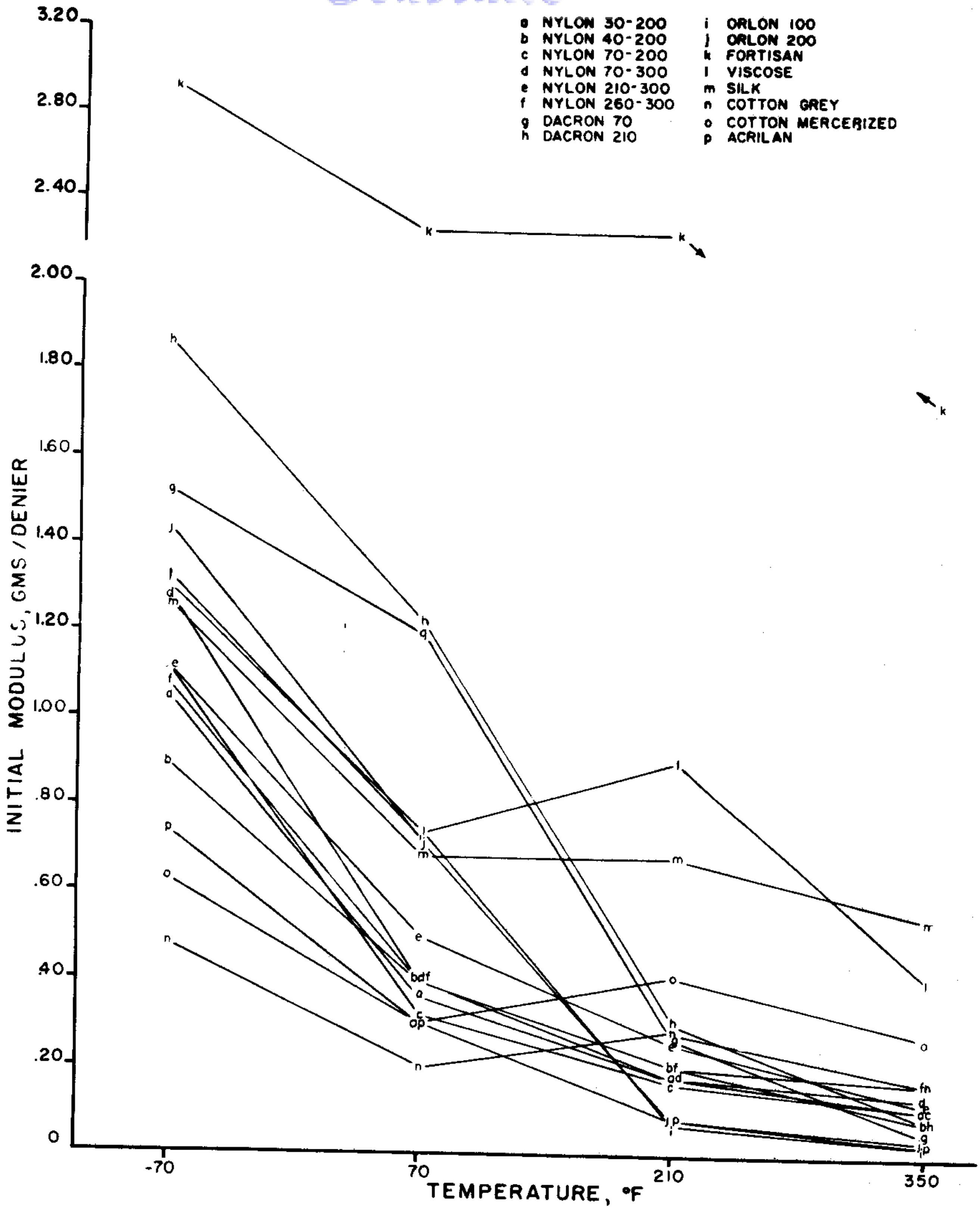

Figure 58. Temperature vs. Initial Modulus.

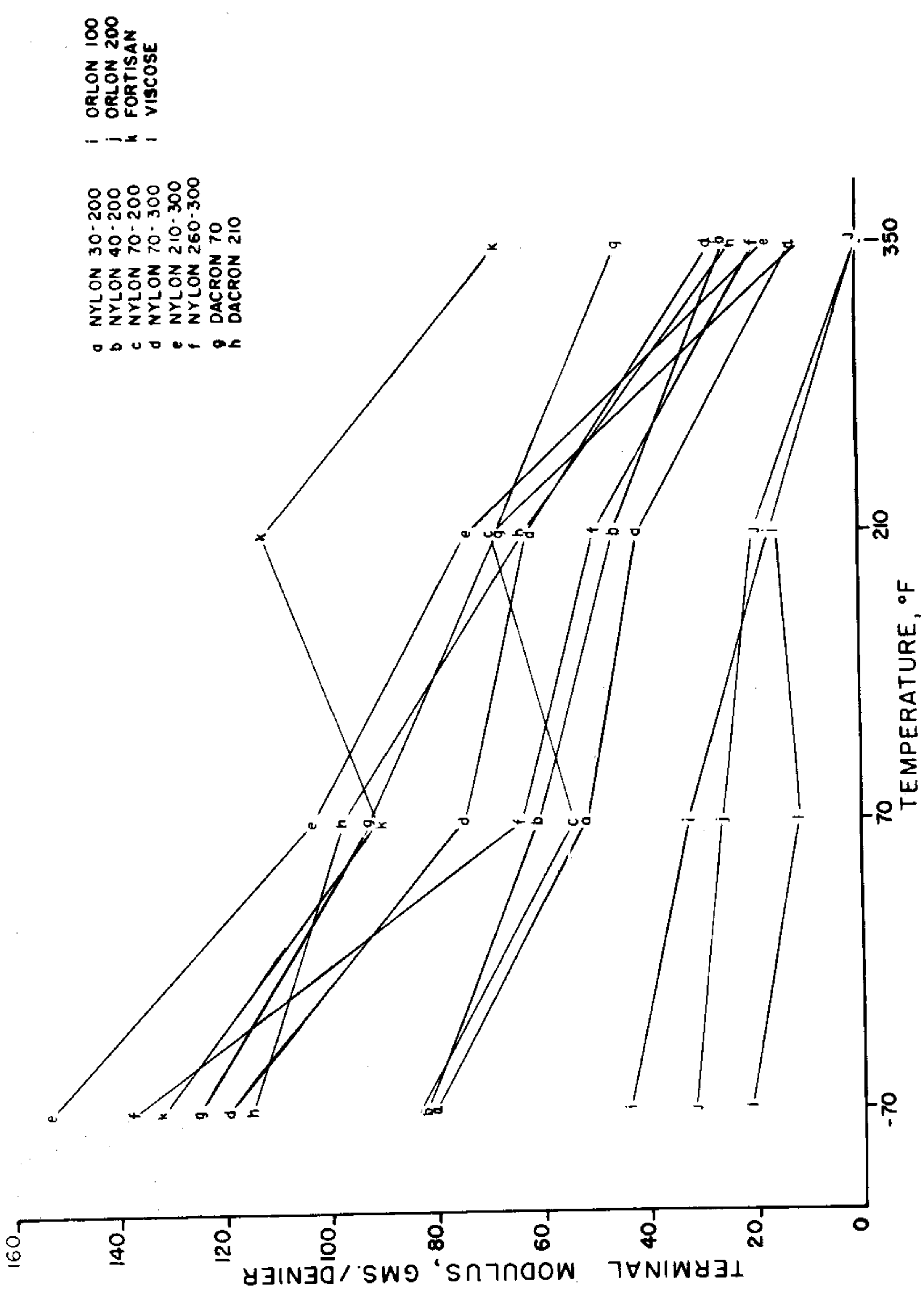

Figure 59. Temperature vs. Terminal Modulus.

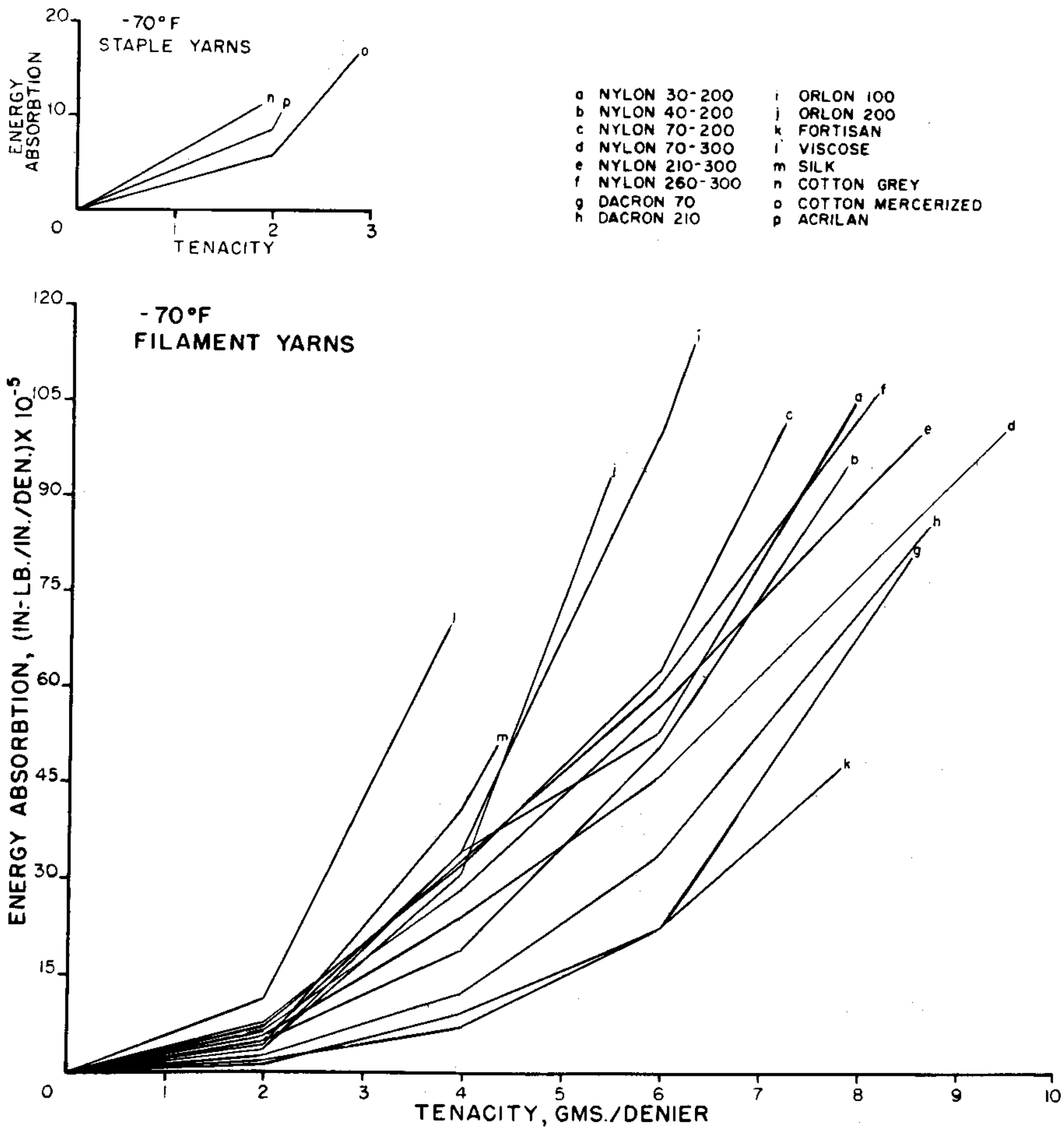

Figure 60. Tenacity vs. Energy Absorption.

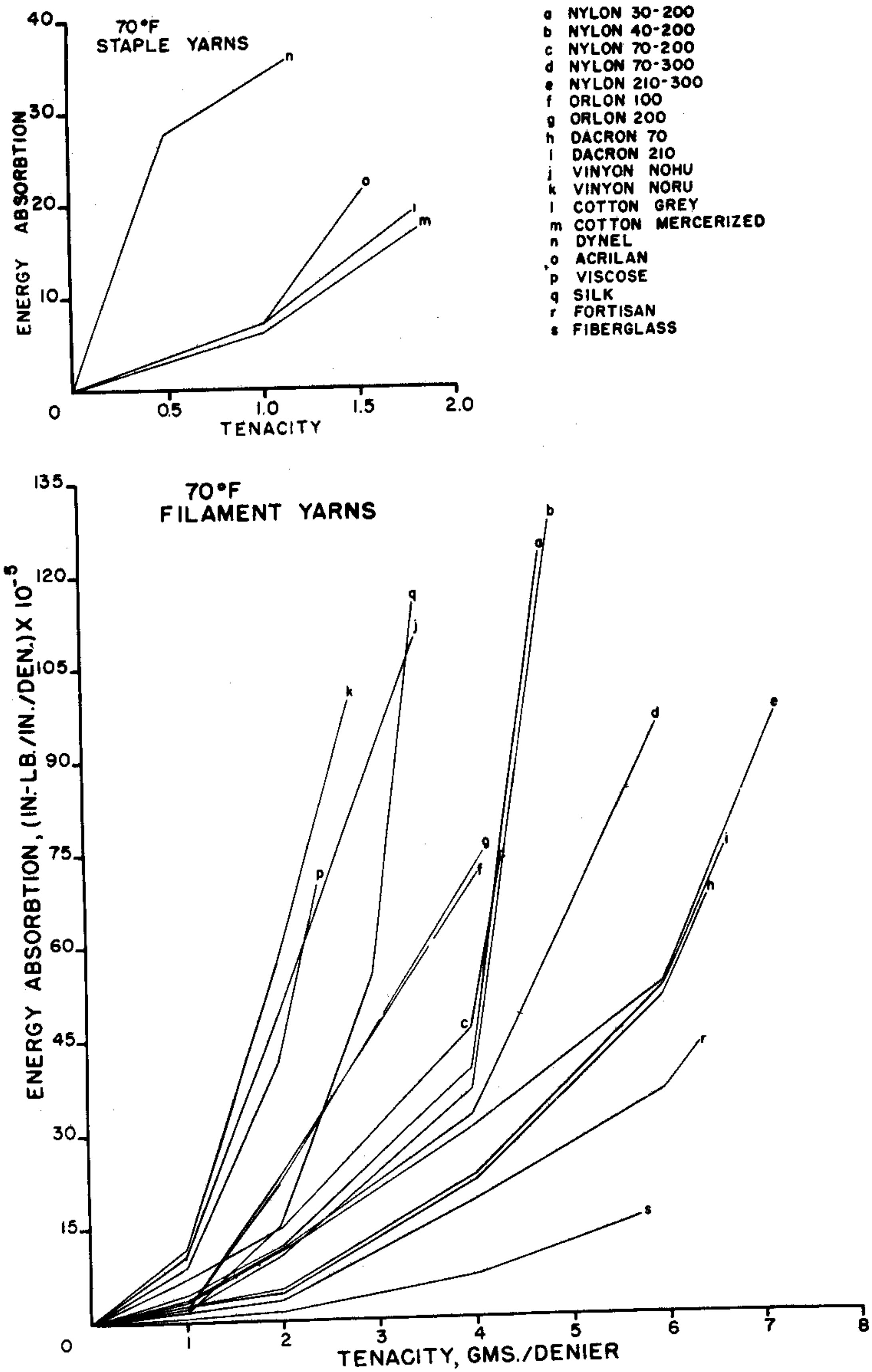

Figure 61. Tenacity vs. Energy Absorption.

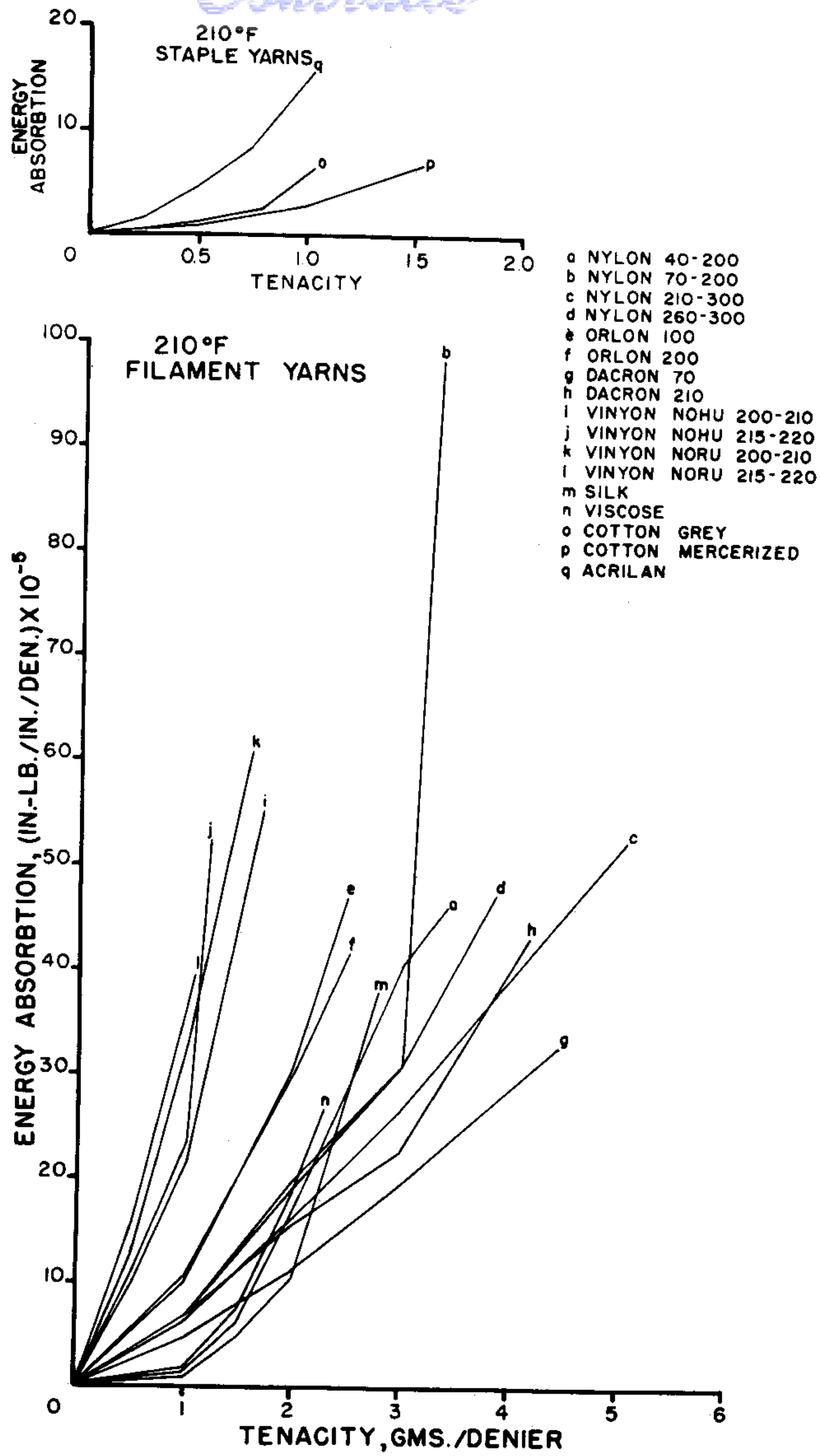

Figure 62. Tenacity vs. Energy Absorption.

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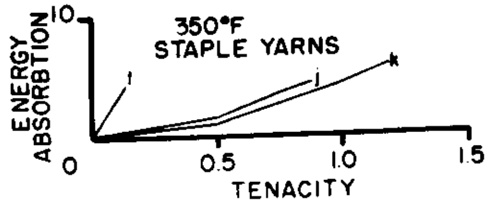

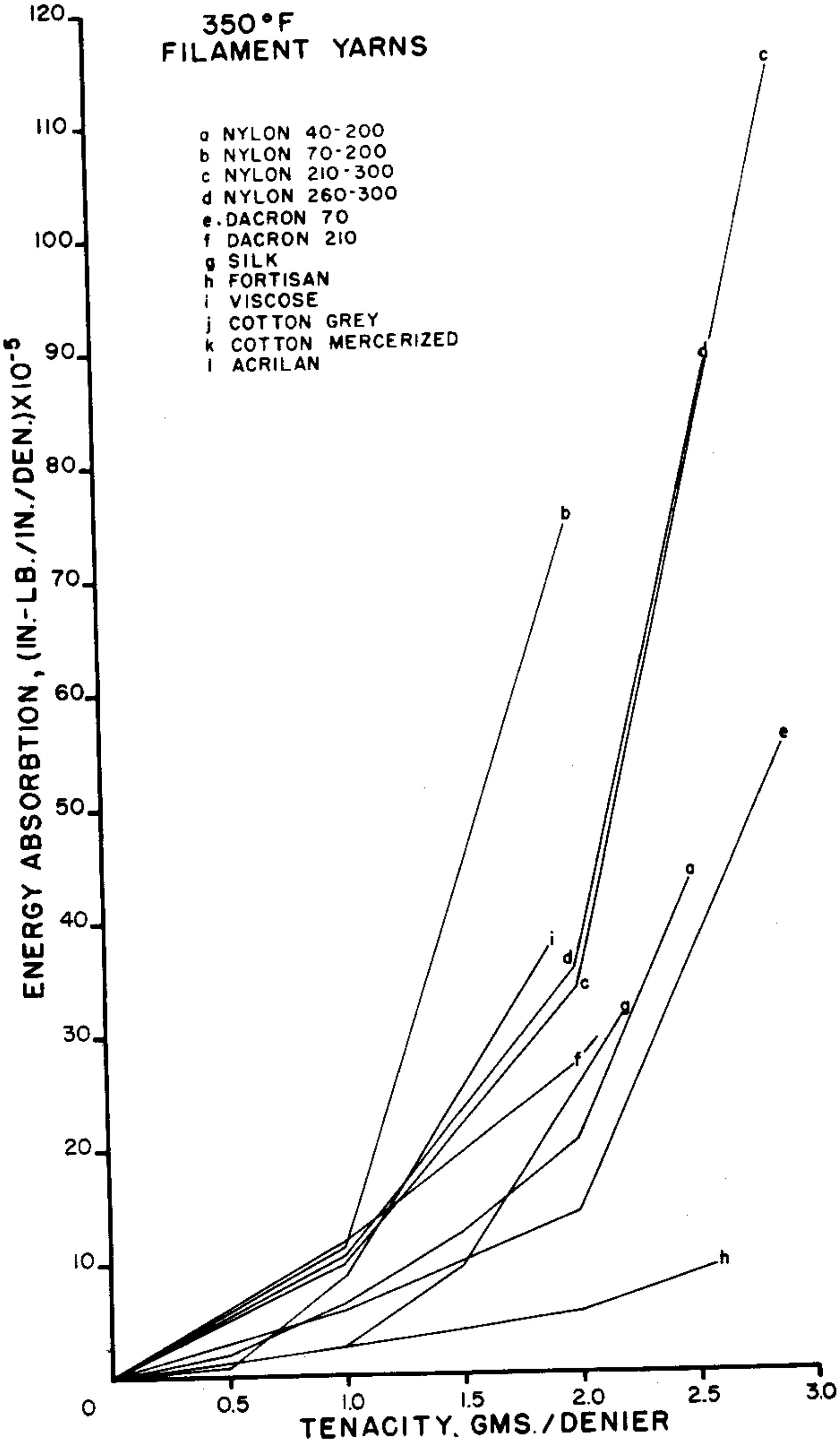

Figure 63. Tenacity vs. Energy Absorption.