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FLEXIBLE GLUES FOR BOOKBINDING

Monograph

TECHNICAL BULLETIN NO. 24

FLEXIBLE GLUES FOR BOOKBINDING

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Foreword

THE principal purpose of this publication is to make available to the bookbinding industry information frequently requested concerning formulas for flexible glues developed and used by the United States Government Printing Office.

Since it is not the purpose of this bulletin to cover in general the field of bookbinding adhesives, nor to treat fully the subject of flexible glues, the reader should not be disappointed in the omission of technical data which he might otherwise naturally expect.

Such a limitation in the treatment of the subject appears justifiable in the light of the multiplicity of adhesive formulas, and the myriad uses to which they must be specially adapted, when employed not only for bookbinding but for many other purposes.

The relatively recent introduction of certain compounds, somewhat similar to glycerin in chemical constitution and physical properties, favored research to find a satisfactory substitute for glycerin in the manufacture of bindery adhesives and printing-press roller compositions.

The expediency of finding a suitable substitute for glycerin strongly suggested itself in that this compound might at some time be diverted wholly or in part to the manufacture of munitions of war.

With this expediency in mind, and the desire for possibly increasing the flexibility of certain glue formulas by the complete or partial use of glycerin substitutes as plasticizers, or softening agents, investigational research led to this publication.

It is our confident hope that these developments may prove as valuable to the bookbinding industry in general as they have been in particular to the Bindery Division of the United States Government Printing Office.

THE AUTHORS.

Division of Tests and Technical Control,
United States Government Printing Office,
Washington, D. C. June 1941.

Flexible Glues for Bookbinding

I. INTRODUCTION

Flexible glue is prepared by cooking animal glue with water and a suitable plasticizer or softening agent until it becomes a homogeneous mixture. Glycerin is most generally used as the softening agent, but, owing to marked fluctuations in the price of this chemical which seriously affect production costs, other chemical compounds have been proposed as substitutes and used somewhat successfully. In the preparation of flexible glue the principal ingredients may be combined in varying proportions to give compositions possessing different degrees of flexibility.

The Government Printing Office, since the publication in 1931 of Technical Bulletin No. 14 on Bindery Adhesives, has frequently been requested to furnish information on the subject of animal glue: specifications covering its various grades; formulas for flexible-glue compositions; and the technique of preparing, handling, and storing such compositions. These frequent requests have made it desirable to issue the present publication.

With respect to the formulas given in this publication, one should bear in mind that they are of optimum value only when the specifications given for gel strength, viscosity, and acidity of the glue are strictly adhered to. Any variation in the quality of the glue employed may necessitate corresponding modifications in the formulas. Such modifications may not lead to satisfactory results, when the glue used is of an inferior quality to that recommended.

Bookbinding, like many other industries, demands a variety of adhesives, obtainable from both animal and vegetable sources. Among these may be mentioned animal glue, fish glue, casein glue, starch paste, and dextrin gum. Since all of these substances are at times loosely called "glue," it is necessary that the word "glue" as used in this bulletin, be specifically defined as an adhesive derived from animal hide, cartilage, or bone. Homogeneous mixtures of glue, water, and suitable softening agents will be referred to as flexible glues. The principal softening agents used by the Government Printing Office in compounding flexible glues are glycerin, diethylene glycol, and sorbitol sirup.

II. HISTORICAL

The use of glue as an adhesive dates from the earliest recorded times. Whoever discovered that a strong adhesive could be produced by cooking pieces of animal hide, or perhaps bone, in water has never been ascertained. Archeological discoveries indicate that the Egyptians more than 4,000 years ago used glue to fasten together pieces of wood. The practical manufacture of glue can be traced back directly to the reign of William III of Holland, where it appears to have been introduced in 1690. Shortly afterwards, about the year 1700, England began manufacturing glue and established it as a permanent industry. The earliest British patent on the subject of glue, issued in 1754, refers to a "kind of glue called fish glue." Elijah Upton, the originator of the American Glue Company of Boston, is considered by some authorities to have been the first person to manufacture glue in the United States, in the year 1808. The United States Government in 1810 issued a compendium of manufacturers which listed six manufacturers of glue in the State of Pennsylvania and one in the State of Maryland. The first patent literature mentioning the production of glue from bones appeared in the year 1814.

III. GENERAL DESCRIPTION

The raw materials used in the process of manufacturing glue may be arranged in the following order with respect to their glue-making qualities: (1) skin or hide, (2) connective tissue, (3) cartilage, and (4) bone. The better glues are derived from skin or hide and the poorer glues from bone. This accounts for the prevalent belief that, in testing glue, it is important to know whether it is a hide glue or a bone glue. The source of a glue is not an important consideration when it is purchased under specifications defining its gel strength and viscosity.

The National Association of Glue Manufacturers, Inc., has established standards for grading animal glue. The best bone glue, according to these standards, has a gel strength lying between 122 grams and 149 grams, which is the same gel strength range as that of the poorest grade of hide glue. Therefore a glue possessing this gel strength range may be either bone or hide glue, or a mixture of the two. Glue which has a gel strength less than 122 grams may be classified as bone glue, while a gel strength above 149 grams indicates the presence of hide glue. The hide glues, as a general rule, are more satisfactory for making flexible-glue compositions. Their higher gel strength and viscosity values result in greater flexibility of the finished product when softening agents are added.

IV. METHODS OF TESTING

Prior to 1923, the methods of testing animal glue were more or less cloaked in mystery, each plant having its own secret method of testing and grading. This secrecy resulted in constant confusion among users whenever attempts were made to secure glue of the same quality from two or more manufacturers. Under the designation "high grade glue" a purchaser might obtain either a low gel strength glue or one with a comparatively high gel strength. The purchaser had no means of stating his specific requirements other than in terms of the glue he was using. Such terms meant nothing to anyone except to the particular manufacturer who supplied that particular glue because of the numerous and varying systems of grading accepted by the Industry.

Bogue[2] listed 12 physical tests for glue, then in use or proposed, at the time of publishing his book in 1922. These were:

1. Jelly strength or consistency.
2. Viscosity.
3. Melting point.
4. Adhesive strength.
5. Tensile strength or elasticity.
6. Optical rotation.
7. Swelling capacity.
8. Rate of setting.
9. Foam test.
10. Grease test.
11. Reaction (whether acid or alkaline).
12. Appearance, odor, color, keeping qualities, etc.

The first two of these tests, the gel strength and viscosity determinations, are the ones most generally used for determining the grade of the glue. Another test, sometimes used, determines the pH value, that is the degree of acidity or alkalinity of a glue.

The gel-strength test is based upon the fact that a solution containing one percent or more of gelatin, when allowed to stand at a temperature of approximately 50 degrees F., will form a firm jelly. This important property is the one around which most of the experimental work on gelatin and glue has centered. If different glue solutions of identical concentration are permitted to chill or set, the quality of the glue will, in general, correspond to the consistency of the jelly formed.

Numerous methods have been proposed for determining the gel strength of glue. Among the tactual methods of comparison the proposal of Peter Cooper in 1844 to establish arbitrary standards for glue is the best known and the one most generally accepted until 1923.

He used a series of 11 types or grades of glue as a basis of comparison. Their regular order of gel strength varied from sample "A Extra," the best, to "No. 2," the poorest. Other manu-

[2] "The Chemistry and Technology of Gelatin and Glue." Robert H. Bogue, McGraw-Hill Book Company, Inc. (1922).

facturers adopted somewhat similar standards but with different designations than those suggested by Peter Cooper. It resulted that purchasers were mystified rather than given any definite knowledge of quality.

The grading of glue by this method was accomplished by means of a tactual comparison of its gel strength or resiliency with that of the arbitrarily selected standards. The glue to be tested and the various grades composing the standard range of comparison were melted separately in definite volumes of water and allowed to stand for a definite period of time in a cool place. The relative gel strength was determined by pressing on the glues with the third finger of the left hand and rated according to the feeling of resistance to the finger pressure. Any difference in temperature between the sample and the standards of comparison affected the decision.

The standards used for making such arbitrary comparisons were themselves glues which, although carefully selected, had to be renewed at intervals. With such crude methods of grading, the human factor played too important a part. Because of the fallibility of human judgment, it is reasonable to conclude that successive standards as selected from time to time would vary among themselves and would eventually show considerable variations in gel strength from the first prepared standards. Thus, a new set of standards might bear slight relationship to a set previously selected.

Other methods of determining gel strength of glue have been proposed. Few of these have met with wide approval because of their inaccuracy or because of the complicated instruments needed to make the test.

The measurement of the viscosity of glue solutions prior to 1924 was generally made with a pipette-type viscometer, or with an Engler viscometer. The Engler instrument met with some opposition, approximately 45 minutes being required for a single determination.

In 1923, a committee of the National Association of Glue Manufacturers investigated the various methods proposed for testing glue and on October 10, 1923, adopted a standard procedure[3] for

[3] Industrial and Engineering Chemistry, Vol. 16, No. 3:310, (March 1924).

testing this material. On April 10, 1930, a slight revision was made and in this finally adopted procedure [4] the gel strength is determined by means of the Bloom gelometer. This instrument is of simple construction, easy to operate, and with it different laboratories secure check results. Viscosity is measured with a standardized pipette and the results are calculated in absolute units called millipoises so that comparisons may be made with those obtained by other types of viscometers.

Viscosity and Gel Strength

The standard procedure now in use for testing glue may be thus briefly described. Fifteen grams of dry glue is placed in a glass container of standard dimensions with 105 grams of distilled water. The glue is allowed to soak in a water-cooled bath at a temperature of 10–15° C. until it softens thoroughly. The container is then removed from the cooling bath and allowed to warm up slightly before placing in a hot water bath, where the solution is brought to a temperature of 62° C. The melting and heating period is carefully regulated to prevent this interval from exceeding 15 minutes. When the desired temperature is reached the sample is transferred to a water-jacketed viscometer of the pipette type and the rate of flow of a unit volume from the pipette is determined at 60° C. The viscosity thus obtained is expressed in millipoises.

After the viscosity has been determined, the sample is quickly cooled to a temperature of approximately 45° C., and then placed in a constant temperature bath at 10° C. for 16 to 18 hours. This bath must be controlled to within plus or minus 0.1° C. At the end of this chilling period the gel strength is determined by means of a Bloom gelometer. The gel strength of glue is the weight in grams required to force a plunger of definite area a distance of 4 millimeters into the gel thus prepared.

Viscosity and gel strength values are indexes of the quality of glue, the best grades possessing the highest values.

This test procedure for gel strength and viscosity applies to glue in the flake or ground condition but it does not give satisfactory

[4] Industrial and Engineering Chemistry, Analytical Edition, Vol. 2:348, (July 15, 1930).

results for testing flexible glue. Because of the variable composition of flexible glues no satisfactory methods of test to indicate quality have been developed. In testing animal glue the standard test procedure depends upon the presence of only one component, the glue itself, which varies with the grade. Three components are present in flexible glue and each of these influence gel strength and viscosity values. These components are animal glue, water, and a softening agent. Gel strength and viscosity values of flexible-glue compositions vary according to the quality and quantity of each of these components. Because of these variables which influence the test results, flexible glues of unknown composition can best be compared by performance tests in the bindery. The adhesive quality of flexible glues can be controlled by mixing the ingredients in accordance with previously established formulas, using animal glue of definite gel strength and viscosity values.

Acidity and Alkalinity

Acidity and alkalinity of glue are measured in terms of hydrogen ion activity and expressed as pH values. A pH value of 7.0 is neutral; values lower than 7.0 representing acidity and values higher than 7.0 representing alkalinity. Glues having high acidity, that is a low pH value, absorb less water and tend to set more slowly than glues having low acidity, that is a high pH value. Glues having pH values over 7.0, representing alkalinity, tend to foam. Alkaline glues do not keep as well as glues which are slightly acid. Requirements limiting acidity and alkalinity have been included in the Government Printing Office specifications for glue.

The pH value of glue solutions may be determined by color comparison methods, or more accurately, by electrometric methods.

V. DEVELOPMENTAL WORK

Before scientific control methods were introduced into the Government Printing Office, flexible glue was not used to any great extent, and that which was used was not of standard composition. Then all adhesives were prepared in the bindery division where they were cooked in steam-jacketed kettles. The kettles from which glue had been used during the day were refilled with glue and water during the latter part of the afternoon and maintained at a low temperature during the night. Early on the following morning the heat was increased sufficiently to melt the glue, thus preparing it for use during the day. With this cycle in operation the kettles were hardly ever completely emptied, cleaned, or sterilized. Decomposition of the glue, with resulting loss of strength, frequently occurred from lack of cleanliness and overheating. Under such conditions the best possible results were not derived from the grades of glue purchased.

Prior to 1922, when the Division of Tests and Technical Control was established in the Government Printing Office, animal glue was purchased on the basis of samples submitted by bidders and subjected to performance tests in the Bindery to determine their relative merits. This method of testing was not very dependable because of variations in personal judgment in making the selections.

Review of the contracts awarded annually disclosed that in 1908 the Government Printing Office was purchasing three different grades of animal glue, one grade of flexible glue, and one grade of tablet composition. The purchase requirements for animal glue were very general in substance. For example, all three grades were to be of the best quality; one being suitable for general bindery use, another being quick drying and suitable for use on Smyth case-making machines, and a third suitable for making composition rollers. The flexible glue purchased was specified for "gluing books to be rounded and backed." The specifications for the tablet composition were that "it be white and packed in 5-pound or 10-pound cans." Such indefinite specifications were but little changed until the contracts for the fiscal year 1925 were awarded.

After the organization of the Technical Division of the Government Printing Office was completed, studies were made covering: (1) the use of glue in the bindery; (2) the development of formulas for both hard and flexible glues; and (3) suitable methods for preparing and handling the different grades of glue needed for bookbinding purposes. It soon became evident that several different formulas of flexible glue were needed to meet the varying needs for flexibility in bookbindings. As a result of these studies, the glues purchased for the fiscal year of 1925 were awarded on the basis of both laboratory tests and performance tests in the bindery.

More recently the research work on flexible glues has been extended to include the effectiveness of using a single grade of glue of high gel strength and high viscosity in all formulas. As a result of this research, two of the three grades of glue previously used in these formulas were eliminated.

Although glue of low gel strength and low viscosity is frequently used in commercial binderies because of low cost, this does not indicate that it is economical or the most satisfactory. The first cost of a glue is not the correct basis for evaluation. The true economic evaluation of a glue consists rather in the quantity of water it will absorb without loss of essential adhesive properties. A thin mixture of glue and water, with good adhesiveness, will work more satisfactorily than a thick mixture with less adhesiveness. Glue is employed to bind surfaces together rather than to separate them.

One should, therefore, evaluate glue on a water-glue basis rather than on a dry-glue basis. The best grades of glue, those with highest gel strengths and viscosities, will absorb more water than the poorer grades, and will therefore eventually cost less.

In this connection an example of the benefits to be derived from the use of a high grade of glue will be interesting. For several years the Government Printing Office used on a Sheridan case-making machine an adhesive composed of water and glue in the ratio of 1:1, the glue itself having a gel strength of 160 grams. The quantity of water in this mixture could not be increased without a decided loss in working quality. In other words, the machine operator could not thin the mixture after placing it in the machine. This case-making machine, because of the drag due to the viscous nature of the glue-water mixture, could be operated only at a low speed and a considerable number of covers had to be repaired after each run because of insufficient adhesion of the turn ins. This occurred especially in hot, humid weather on buckram cover-fabrics. To overcome these conditions, a new case-making glue was prepared with a 400-gram gel strength glue in the proportion of 2 parts of water to 1 part of glue. Frequently the machine operator found it possible to add additional water to this mixture after placing it in the machine, at times bringing the proportion of water to glue as high as 4 to 1. Better adhesion of the cover turn-ins to the boards was obtained with such mixtures and repairing was sometimes reduced as much as 75 percent. The use of the thinner composition decreased the drag on the case-making machine, allowing the speed of the operation to be increased with a corresponding increase in production.

This experience illustrates the fact that the initial cost should not be the primary consideration in evaluating a glue, and that some consideration should also be given to increasing the speed of operations and decreasing wastage.

VI. FLEXIBLE GLUE COMPOSITIONS

Another advantage in using glue of high gel strength and viscosity, especially where flexibility is desirable, is that more-flexible bindery compositions may be made from this grade of material. The percentage of glycerin or other softening agent used with glue largely determines the flexibility of the resulting compositions. Larger proportions of such softening agents may be used with glues of high gel strength.

Formulas Containing Glycerin

As a result of the change to one grade of glue for bindery work it became necessary to revise all glue formulas containing animal glue of lower gel strength and viscosity than the quality adopted as standard. Before revisions of the formulas were made, experimental testing of the various ingredients in different proportions was continued until the most desirable qualities of the original formulas were obtained. A saving in the cost of materials also favored the changes.

The Government Printing Office, prior to the introduction of certain substitutes for glycerin, used the following formulas in preparing flexible glues for bindery operations. The glue used in each formula had the properties defined by the specifications on page 16 of this bulletin. The figures represent proportions by weight.

Beta naphthol functions as a preservative against the formation of bacterial molds or other decomposition usually occurring in organic substances such as glue or similar colloids.

Terpineol has no effect on the working qualities of the glue but is added to the composition to mask unpleasant and undesirable odors.

FORMULAS—SERIES 1, WITH GLYCERIN

A-1 For general bindery use, utilizing waste roller composition:

	Percent
Glue	20.80
Glycerin	16.60
Waste roller composition	9.80
Water	52.50
Beta naphthol	.15
Terpineol	.15
	100.00

B-1 For use on gathering, stitching, and covering machines:

	Percent
Glue	36.30
Glycerin	16.60
Water	46.80
Beta naphthol	.15
Terpineol	.15
	100.00

C-1 For use on Perfect Binding Machine:

	Percent
Glue	39.90
Glycerin	33.30
Water	26.50
Beta naphthol	.15
Terpineol	.15
	100.00

D-1 Tablet composition:

	Percent
Glue	26.50
Glycerin	26.50

Water	46.70
Beta naphthol	.15
Terpineol	.15
	100.00

D–W Tablet composition utilizing waste roller composition:

	Percent
Glue	17.00
Waste roller composition	42.50
Water	39.60
Zinc Oxide	.90
	100.00

Formulas Containing Glycerin Substitutes

Several years ago, when a scarcity of glycerin caused marked fluctuations in the price of this commodity, the Government Printing Office instituted research to find suitable compounds which might serve as satisfactory substitutes for glycerin in flexible-glue compositions. It was foreseen that such substitutes for use in flexible-glue and press-roller manufacture would become necessary provided that glycerin should become scarce or unobtainable from increased demands, which could not be commercially met, or from restrictions placed upon its use, as in the event of war.

The essential requirements which a substitute must meet are: (1) it should possess the property of glycerin to absorb moisture from the air and retain an appreciable portion of moisture under changing atmospheric conditions and (2) the cost of the substitute should compare favorably with that of glycerin.

FORMULAS—SERIES 2, WITH DIETHYLENE GLYCOL

Diethylene glycol, one of the compounds studied in connection with the development of suitable substitutes for glycerin, gave satisfactory results in flexible-glue compositions. This compound is a water-white, hygroscopic liquid, having a lower specific gravity and viscosity than glycerin. It is miscible with water in all proportions and is a solvent for numerous organic compounds. Flexible-glue compositions in which diethylene glycol is partially or completely substituted for glycerin are slightly thinner, but not sufficiently so to interfere with the working qualities of the compositions. The formulas, in which diethylene glycol has been used, are modifications of those given on page 11 of this Bulletin, which have been revised as follows:

A–2 For general bindery use:

	Percent
Glue	22.60
Diethylene glycol	22.10
Water	55.00
Beta naphthol	.15
Terpineol	.15
	100.00

B–2 For use on gathering, stitching, and covering machines:

	Percent
Glue	36.30
Glycerin	8.30
Diethylene glycol	8.30
Water	46.80
Beta naphthol	.15
Terpineol	.15
	100.00

D–2 Tablet composition:

	Percent
Glue	26.50
Glycerin	13.25
Diethylene glycol	13.25
Water	46.70
Beta naphthol	.15
Terpineol	.15
	100.00

FORMULAS—SERIES 3, WITH SORBITOL SIRUP

Another compound tested to determine its usefulness as a substitute for glycerin in flexible-glue compositions was sorbitol, a hexahydric alcohol. This compound, like glycerin, belongs to the series of higher alcohols. Chemically speaking, it contains six hydroxyl groups, which is twice the number contained in glycerin. From their chemical structures, it is to be expected, that these two compounds would have somewhat similar physical properties, and they do.

Sorbitol is a very effective hygroscopic agent. It has a narrower humectant range and therefore is less susceptible to changes in atmospheric conditions than glycerin. At high atmospheric humidities it takes on less moisture than glycerin and at low humidities gives up less moisture.

During the year 1938, commercial sorbitol in sirup form, became available in quantities and at a price which justified an investigation into its suitability as a glycerin substitute in flexible-glue compositions. In the pure form sorbitol is a white, crystalline powder, which possesses a faint, pleasant taste. Its melting point is 97° C. The sorbitol sirup used in our experimental work has a pure sorbitol content of approximately 85 percent.

The formulas in which sorbitol sirup has been used are revisions of those on page 11 of this Bulletin, and are as follows:

A–3 For general bindery use.

	Percent
Glue	22.60
Sorbitol sirup	20.50
Water	56.60
Beta naphthol	.15
Terpineol	.15
	100.00

B–3 For use on gathering, stitching, and covering machines:

	Percent
Glue	36.40
Sorbitol sirup	16.60
Water	46.70
Beta naphthol	.15
Terpineol	.15
	100.00

C–3 Experimental:

Experimental work with sorbitol sirup led to the complete replacement of glycerin in flexible glues with the exception of formula C–1. In that formula, at the time of this publication, only part of the glycerin has been experimentally replaced and practically tested in bindery operations with satisfactory results following successive partial substitutions.

It is believed that a C–glue formula will soon be developed to completely replace glycerin with sorbitol sirup. The present indications are that the percentage of softener will require some modification to compensate for the higher viscosity of the sorbitol sirup as compared with glycerin. Otherwise, there seems no good reason for not completely substituting sorbitol for glycerine with satisfactory results.

D–3 Tablet composition:

	Percent
Glue	26.50
Sorbitol sirup	26.50
Water	46.70
Beta naphthol	.15
Terpineol	.15
	100.00

L–3 For gluing-off large, thick books previous to rounding and backing:

	Percent
Glue	22.50
Sorbitol sirup	25.90
Water	51.30
Beta naphthol	.15
Terpineol	.15
	100.00

Formula L–3 was developed to overcome a tendency on the part of large, thick books to crack open between the signatures, along the backbone of the book, during the rounding and backing operations.

When sorbitol sirup is completely substituted for glycerin in flexible-glue formulas, the viscosity of the composition increases due to the fact that sorbitol has a higher viscosity than that of glycerin. This may be compensated by increasing the percentage of water present, provided one desires to retain the same viscosity as in the original formula. When the substitution is made without increasing the percentage of water, the flexible glue will set more slowly but will possess greater flexibility. This increased flexibility is especially desirable in gluing-off operations previous to rounding and backing, and also facilitates hand work.

The time required for flexible glue to set and the flexibility of the composition may be increased or decreased by varying the relative percentages of glue, water, and softening agent in the composition. Any increase in the percentage of softening agent will in general decrease the rate of setting and increase flexibility. Conversely, any decrease in the percentage of softening agent will increase the rate of setting and decrease the flexibility of the composition. It is to be noted that different softening agents when added in equal proportions do not vary these qualities to an equal degree.

VII. PREPARATION AND STORAGE

In the Government Printing Office flexible-glue compositions are prepared and stored in the following manner. The necessary weight of cold water is placed in a large steam-jacketed cooking kettle, which is equipped with mechanical agitators. The dry, ground glue is added slowly while the agitators are operating. Steam is then turned into the jacket of the kettle and the glue is cooked until it becomes a smooth mixture. Then the softening agent, the beta naphthol, and the terpineol, are added and the cooking is continued at a temperature of approximately 150° F. until the mixture becomes homogeneous. It is then allowed to run from the kettle through wire screens to remove foreign matter and placed in pans greased with lard oil to solidify.

Identification symbols cast from type-metal are placed in the bottoms of the pans before running in the hot glue. After solidification the cakes are removed from the pans, leaving the symbol marking on each cake, and stored at a temperature of approximately 55° F. until used.

Prior to using, strips are cut from the cakes and melted in small, electrically heated, constant-temperature, glue pots which are easily cleaned and in which decomposition of the glue is minimized.

VIII. APPENDIX

Government Printing Office Specifications for Glue Making Materials

ANIMAL GLUE

General Requirements:

All glue shall be clean and free from foreign matter and be foamless. A solution of any grade shall not develop a strong or sour odor when kept 48 hours at a temperature of 25–35° C. Tests for viscosity and gel strength will be made according to the methods adopted by the National Association of Glue Manufacturers. Tests for moisture, non-foaming, and pH value will be made according to Federal Specification No. C–C–451.

Deliveries shall be made in paper-lined bags or paper-lined wooden barrels.

Detailed Requirements:

Viscosity—Not less than 130 nor more than 140 millipoises.
Gel strength—Not less than 400 grams.
pH value—Not less than 6.4 nor more than 7.0.

GLYCERIN

Specific Gravity—Not less than 1.250 at 25° C.
Odor—Slight and inoffensive.
Color—Not darker than No. 2 Union Colorimeter.
Acidity or alkalinity—50 cubic centimeters of glycerin shall not require more than 0.3 cubic centimeter of normal acid or alkali for neutralization.
Ash—Not more than 0.1 percent.
Chlorine—Not more than 0.01 percent.

SORBITOL

Sorbitol content—Not less than 82 percent.
Water content—Approximately 16 percent.
Glucose—Not more than 0.3 percent.
Specific gravity—1.31 at 25° C.
Viscosity—Not less than 3,000 centipoises at 25° C.
Refractive index—1.48 at 25° C.

DIETHYLENE GLYCOL

Color—Water white.
Specific gravity—At 20° C.=1.117–1.120.
Water—Not more than 0.3 percent.
Acidity—Not more than 0.02 percent as acetic acid.
Boiling range (760 mm.): Below 230° C.—none.
Below 240° C.—not more than 20 percent.
Below 250° C.—not less than 85 percent.
Below 270° C.—not less than 95 percent.

BETA NAPHTHOL

This Office purchases beta naphthol in powdered form under the following specification:

Powdered beta naphthol, technical grade.

TERPINEOL

Specific gravity: at $\frac{15.5°}{15.5}$ C. = 0.935–0.936.

Refractive index: at 25° C. = 1.480–1.484.

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