

Title

GOLF BALL HAVING A POLYURETHANE COVER

Technical Field

The present invention relates to a cover for a golf ball. More specifically, the
5 present invention relates to a golf ball cover layer composed of a polyurethane
formed from a blend of diisocyanate prepolymers.

Background Art

Conventionally golf balls are made by molding a cover around a core. The
core may be wound or solid, and there may be an intermediate layer. Materials
10 previously used as golf ball covers include balata (natural or synthetic), gutta-percha,
ionomeric resins (e.g., DuPont's SURLYN®), and polyurethanes. Balata is the
benchmark cover material with respect to sound (i.e. the sound made when the ball
is hit by a golf club) and feel (i.e. the sensation imparted to the golfer when hitting
the ball). Natural balata is derived from the Bully Gum tree, while synthetic balata
15 is derived from a petroleum compound. Balata is expensive compared to other cover
materials, and golf balls covered with balata tend to have poor durability (i.e. poor
cut and shear resistance). Gutta percha is derived from the Malaysian sapodilla tree.
A golf ball covered with gutta percha is considered to have a harsh sound and feel
as compared to balata covered golf balls.
20 Ionomeric resins, as compared to balata, are typically less expensive and tend
to have good durability. However, golf balls having ionomeric resin covers typically
have inferior sound and feel, especially as compared to balata covers.



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A golf ball with a polyurethane cover generally has greater durability than a golf ball with a balata cover. The polyurethane covered golf ball generally has a better sound and feel than a golf ball with an ionomeric resin cover.

Polyurethanes may be thermosetting or thermoplastic. Polyurethanes are
5 formed by reacting a prepolymer with a polyfunctional curing agent, such as a polyamine or a polyol. The polyurethane prepolymer is the reaction product of, for example, a diisocyanate and a polyol such as a polyether or a polyester. Several patents describe the use of polyurethanes in golf balls. However, golf balls with polyurethane covers usually do not have the distance of other golf balls such as those
10 with covers composed of SURLYN® materials.

Gallagher, U.S. Patent Number 3,034,791 discloses a polyurethane golf ball cover prepared from the reaction product of poly(tetramethylene ether) glycol and toluene-2,4-diisocyanates (TDI), either pure TDI or an isomeric mixture.

Hewitt, et al., U.S. Patent Number 4,248,432 ("the '432 patent") discloses a
15 thermoplastic polyesterurethane golf ball cover formed from a reaction product of a polyester glycol (molecular weight of 800-1500) (aliphatic diol and an aliphatic dicarboxylic acid) with a para-phenylene diisocyanate ("PPDI") or cyclohexane diisocyanate in the substantial absence of curing or crosslinking agents. The '432 patent teaches against the use of chain extenders in making polyurethanes. The '432
20 patent states, "when small amounts of butanediol-1,4 are mixed with a polyester ... the addition results in polyurethanes that do not have the desired balance of properties to provide good golf ball covers. Similarly, the use of curing or

crosslinking agents is not desired”

Holloway, U.S. Patent Number 4,349,657 (“the ‘657 patent”) discloses a method for preparing polyester urethanes with PPDI by reacting a polyester (e.g. prepared from aliphatic glycols having 2-8 carbons reacted with aliphatic
5 dicarboxylic acids having 4-10 carbons) with a molar excess of PPDI to obtain an isocyanate-terminated polyester urethane (in liquid form and stable at reaction temperatures), and then reacting the polyester urethane with additional polyester. The ‘657 patent claims that the benefit of this new process is the fact that a continuous commercial process is possible without stability problems. The ‘657
10 patent further describes a suitable use for the resultant material to be golf ball covers.

Hebert, et al., U.S. Patent Number 5,885,172 (“the ‘172 patent”) discloses a multilayer golf ball giving a “progressive performance” (i.e. different performance characteristics when struck with different clubs at different head speeds and loft angles) and having an outer cover layer formed of a thermosetting material with a
15 thickness of less than 0.05 inches and an inner cover layer formed of a high flexural modulus material.

Although the prior art has disclosed golf ball covers composed of many different materials, none of these golf balls have proven completely satisfactory. Dissatisfaction, for example, remains with processing and manufacturing the balls,
20 and with the balls’ durability and performance.

Specifically, with respect to processing, prior materials are not user friendly because certain starting materials may be unhealthful, such as diamines and

isocyanides. In addition, prior balls using such materials are generally wound balls. Wound balls have tolerances that are more difficult to control due to core sizes and/or windings sizes, and therefore, require thicker cover layers to account for the manufacturing tolerances. With respect to durability problems, prior polyurethane covered balls, because they are wound balls, tend to lose compression and initial velocity due to the windings relaxing over time and use. With respect to performance problems, prior balls, as a general rule, tend to have smaller cores that result in shorter flight distances. Although many golf balls having a polyurethane cover have been provided by the prior art, these golf balls have failed to capture the sound and feel of balata while providing a golf ball with the durability of an ionomer.

Disclosure of the Invention

In one broad form the present invention provides in the body of a golf ball comprising:

- a core; and

- a polyurethane cover formed from reactants comprising a toluene diisocyanate based polyurethane prepolymer, a second diisocyanate polyurethane prepolymer and at least one curing agent.

In another broad form the present invention provides in the body of a golf ball comprising:

- a core comprising a polybutadiene;

- a boundary layer encompassing the core, the boundary layer comprising at least one ionomer, and having a shore D hardness in the range of 56 to 70; and

- a thermosetting polyurethane cover encompassing the boundary layer, the thermosetting polyurethane cover having a Shore D hardness in the range of 46 to 54, and a thickness in the range of 0.02 to 0.05 inches (0.5 to 1.3mm);

wherein the golf ball has a durability of at least 3.5 on a scale of 1 to 5 based on a cover strike plate drop test.

In another broad form the present invention provides in the body of a golf ball comprising:

- a core;

- a boundary layer encompassing the core; and

- a polyurethane cover formed from reactants comprising a p-phenylene diisocyanate terminated polyester prepolymer in an amount up to 90 parts, a p-phenylene

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diisocyanate terminated polyether prepolymer in an amount up to 90 parts, 10-40 parts of a toluene diisocyanate polyurethane prepolymer.

In another broad form the present invention provides in the body of a golf ball comprising:

a solid core composed of a polybutadiene material, the solid core having a diameter ranging from 1.45 inches (36.8mm) to 1.60 inches (40.6mm) and a PGA compression ranging from 55 to 80;

a boundary layer disposed over the solid core, the boundary layer composed of an ionomer material and having a thickness ranging from 0.02 inch (0.5mm) to 0.067 inch (1.7mm), the boundary layer having a hardness of 52 to 65 based on ASTM D-2240; and

a cover disposed over the boundary layer, the cover composed of a thermoset polyurethane material, the cover having a thickness ranging from 0.02 inch (0.5mm) to 0.04 inch (1.0mm) and a Shore D hardness ranging from 45 to 60 based on ASTM D-2240 and a flexural modulus ranging from 12,000 psi (83 MPa) to 35,000 psi (241 MPa) based on ASTM D790;

wherein the golf ball has a PGA compression of less than 98, a diameter less than 1.70 inches (43mm), and a coefficient of restitution of at least 0.778 at a speed of 143 feet per second (43.6m/s).

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BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. 1 illustrates a perspective view of a golf ball of the present invention including a cut-away portion showing a core, a boundary layer, and a cover.

5 FIG. 2 illustrates a perspective view of a golf ball of the present invention including a cut-away portion core and a cover.

Best Mode(s) For Carrying Out The Invention

As illustrated in FIG. 1, the golf ball of the present invention is generally indicated as 10. The golf ball 10 includes a core 12, a boundary layer 14 and a cover 16. Alternatively, as shown in FIG. 2, the golf ball 10 may only include a core 12 and a cover 16.

The cover 16 is a polyurethane cover having a predetermined hardness and a predetermined durability as measured on a cover strike plate drop test as further described below. The polyurethane cover 16 is composed of a polyurethane material formed from a PPDI-based polyurethane prepolymer and preferably a blend of diisocyanate prepolymers. The blend of diisocyanate prepolymers includes at least one TDI-based polyurethane prepolymer and at least one other diisocyanate-based polyurethane prepolymer. In a preferred embodiment, the blend of diisocyanate prepolymers includes at least one PPDI-based polyurethane prepolymer and at least one TDI-based polyurethane prepolymer. Alternative embodiments have a blend which includes at least two different PPDI-based polyurethane prepolymer

and at least one TDI-based polyurethane prepolymer. Yet further embodiments may include at least one TDI-based polyurethane prepolymer and at least one MDI-based polyurethane prepolymer. Those skilled in the pertinent art will recognize that multiple variations of diisocyanate prepolymers may be utilized without departing
5 from the scope and spirit of the present invention.

The polyurethane cover 16 encompasses a boundary layer 14, as shown in FIG. 1, or alternatively the cover 16 may encompass the core 12 as shown in FIG. 2.

The boundary layer 14 is composed of a thermoplastic material that has a predetermined hardness. The boundary layer 14 will encompass the core 12. Each
10 component of the golf ball 10 of the present invention will be described below in greater detail.

The most important feature of the present invention is the durability of the cover. A golf ball 10 is subjected to tremendous forces when impacted with a golf club during a "golf shot." The golf ball 10 of the present is capable of enduring,
15 more than polyurethane covered golf balls of the prior art, slices or other incorrect hits by golfers. The unique polyurethane formulation for the cover 16 of the present invention provides this enhanced durability. Durability as defined herein is objectively measured through comparative testing of available golf balls versus the golf ball 10 of the present invention. The testing methods and results will be
20 described below.

The polyurethane utilized in the present invention is preferably composed of blend of a TDI-based prepolymer, a second diisocyanate-based polyurethane

prepolymer and a curing agent. The TDI-based prepolymer is preferably formed from TDI and a polyether polyol. The second diisocyanate-based polyurethane prepolymer is preferably a PPDI-based prepolymer formed from PPDI and a polyester polyol, preferably a polycaprolactone. The prepolymer blend is cured with

5 a curing agent. The curing agent, or curative, may be a diol (e.g., 1,4 butane diol, trimethylpropanol), a mixture of diols (e.g., 1,4 butane diol and ethylene glycol, or other suitable glycols), a hydroquinone, a mixture of hydroquinones, a triol, a mixture of triols, a diamine, a mixture of diamines, an oligomeric diamine, a triamine, or a blend of some or all of these materials. Preferably, the curing agent is

10 a blend of a diamine and a mixture of diols.

In an alternative embodiment, the blend of prepolymers includes three diisocyanate-based polyurethane prepolymers. In this embodiment, the TDI-based prepolymer is preferably formed from TDI and a polyether polyol. The second diisocyanate-based polyurethane prepolymer is preferably a PPDI-based prepolymer

15 formed from PPDI and a polyester polyol, preferably a polycaprolactone. The third diisocyanate-based polyurethane prepolymer is a PPDI-based prepolymer formed from PPDI and a polyether polyol. Preferably, the curing agent is a blend of a diamine and a mixture of diols. As mentioned above, alternative embodiments may have variations of the dual blend or the tri-blend, and may use a TDI-based

20 polyurethane prepolymer with other non-PPDI-based polyurethane prepolymers.

An alternative embodiment has only a PPDI-based polyurethane prepolymer that provides a polyurethane with a higher rebound at a lower hardness, greater

durability and improved sound and feel. However, although the use of only a PPDI-based polyurethane prepolymer provides greater durability for a polyurethane cover, the polyurethane cover 16 of the present invention is preferably formed from a blend of prepolymers to provide even greater durability.

- 5 The blending of a TDI-based prepolymer with other diisocyanate-based polyurethane prepolymers lowers the viscosity of the mixture, lowers the temperature of the exothermic reaction that occurs when the prepolymers are reacted with the curing agent, and increases the durability. The TDI-based prepolymer may range from 10 to 40 percent of the polyurethane prepolymer blend. Preferably, the
- 10 TDI-based prepolymer is 30 percent of the polyurethane prepolymer blend. A preferred TDI based prepolymer is a TDI terminated polyether prepolymer available from Uniroyal Chemical Company of Middlebury, Connecticut.

- The dual blend and tri-blend formulations will preferably contain a PPDI terminated polyester prepolymer and/or a PPDI terminated polyether prepolymer. A
- 15 preferred PPDI terminated polyester prepolymer is available from Uniroyal Chemical. A preferred PPDI terminated polyether prepolymer is available from Uniroyal Chemical.

- The polyurethane prepolymer blend may have 10 to 40 parts of a TDI terminated polyether prepolymer blended with 60 to 90 parts of a PPDI terminated
- 20 polyether prepolymer. Alternatively, the polyurethane prepolymer blend may have 10 to 40 parts of a TDI terminated polyether prepolymer blended with 60 to 90 parts of a PPDI terminated polyester prepolymer. Further, the polyurethane prepolymer

blend may have 10 to 40 parts of a TDI terminated polyether prepolymer blended with 5 to 90 parts of a PPDI terminated polyether prepolymer and 5 to 90 parts of a PPDI terminated polyester prepolymer. More specific blend formulations are set forth in the Examples below. The PPDI-based polyurethane prepolymer may be
5 polyether or polyester terminated.

The cover 16 of the golf ball 10 of the present invention is most preferably composed of a polyurethane formed from a polyurethane prepolymer blend composed of a TDI-based polyurethane prepolymer and a PPDI-based polyurethane prepolymer, and cured with a mixture of curing agents such as a diamine and a blend
10 of 1,4 butane diol and glycols. A suitable diamine is toluene ethylene diamine. Other agents which may be utilized during the curing process include dimethylthio-2,4-toluenediamine; trimethyl glycol di-p-aminobenzoate; cyclohexane dimethanol; hydroquinone-bis-hydroxyethyl ether; phenyldiethanol amine mixture; methylene dianiline sodium chloride complex; and/or prionene amine. This list of preferred
15 agents (including chain extenders, cross-linkers and curing agents) is not meant to be exhaustive, as any suitable (preferably polyfunctional) chain extender, cross-linker, or curing agent may be used.

The curing agent mixture for the cover 16 of the present invention may have numerous variations. In a preferred embodiment, the curing agent is composed of 30
20 to 70 parts of a diol blend to 70 to 30 parts of a diamine. Alternatively, the diamine component may be a blend of different diamines.

The ratio of the polyurethane prepolymer blend to curing agent is determined

by the nitrogen-carbon-oxygen group ("NCO") content of the polyurethane prepolymer blend. For example, the NCO content of the TDI-terminated polyether or TDI-terminated polyester is preferably in the range of 4.0% to 9.0%, while the NCO content of the PPDI-terminated polyether is preferably in the range of 5.0% to 8.0%. The NCO content of the PPDI-terminated polyester is preferably in the range of 2.0% to 6.0%. The NCO content of the polyurethane prepolymer blend ranges from 2% to 8% of the polyurethane prepolymer blend. The amount of curing agent should correspond to 90% to 110% of the mol equivalence of the NCO content of the polyurethane prepolymer blend. The weight ratio of the polyurethane prepolymer blend to the curing agent is preferably in the range of about 10:1 to about 30:1.

Prior to curing, the polyurethane prepolymer blend and curing agent are preferably stored separately. The polyurethane is formed by first heating and mixing the polyurethane prepolymer blend with the curing agent in a mold, and then curing the mixture by applying heat and pressure for a predetermined time period. Additionally, a catalyst (e.g. dibutyl tin dilaurate, a tertiary amine, etc.) may be added to the mixture to expedite the casting process.

The polyurethane prepolymer blend material is preferably degassed and warmed in a first holding container prior to processing of the cover 16. The processing temperature for the polyurethane prepolymer blend is preferably in the range of about 100-220°F, and most preferably in the range of about 120-200°F. The polyurethane prepolymer blend is preferably flowable from the first holding

container to a mixing chamber in a range of about 200-1100 grams of material per minute, or as needed for processing. In addition, the polyurethane prepolymer blend material may be agitated in the first holding container, in the range of 0-250 rpm, to maintain a more even distribution of material and to eliminate crystallization.

- 5 The curing agent is preferably degassed and warmed in a second holding container prior to processing of the cover 16. The processing temperature for the curative is preferably in the range of about 50-230°F, and most preferably in the range of about 80-200°F. The curing agent is preferably flowable from the second holding container to the mixing chamber in the range of about 15-75 grams of
- 10 material per minute, or as needed. If a catalyst is used for processing the cover 16, then the catalyst is added to the curing agent in the second holding container to form a curative mixture. Suitable catalyst are described above. The curing agent and catalyst are agitated, in the range of about 0 to 250 rpm, to maintain an even distribution of catalyst in the curative mixture in the second holding container. It is
- 15 preferred that the catalyst is added in an amount in the range of about 0.25-5% by weight of the combined polyurethane prepolymer blend and curing agent. Additives may be added to the curative mixture as desired.

- The polyurethane prepolymer blend and curative mixture are preferably added to the common mixing chamber at a temperature in the range of about 160-220°F. A
- 20 colorant material, such as, for example, titanium dioxide, barium sulfate, and/or zinc oxide in a glycol or castor oil carrier, and/or other additive material(s) as are well known in the art, may be added to the common mixing chamber. The amount of

colorant material added is preferably in the range of about 0-10% by weight of the combined polyurethane prepolymer blend and curative materials, and more preferably in the range of about 2-8%. The entire mixture is preferably agitated in the mixing chamber in the range of about 1 to 250 rpm prior to molding.

5 Although the golf ball cover 16 of the present invention is preferably manufactured in a casting process, the cover material may alternatively be provided as a thermoplastic polyurethane for injection molding of the cover 16 over the boundary layer 14 and/or core 12. For a thermoplastic polyurethane, the PPDI-based prepolymer is formed by reacting a polyol with PPDI. The PPDI-based prepolymer
10 is then reacted with a chain extender, such as, for example, a diol or mixture of diols, a triol or mixture of triols, a diamine or mixture of diamines, etc. The resulting product is modified using conventional procedures to form a desired thermoplastic material for injection molding of the cover 16 over the boundary layer 16 and/or core 12.

15 The PPDI-based polyurethane cover 16 of the present invention exhibits good tensile strength, tear properties, and flexural modulus at lower hardnesses. In addition, because the preferred material is PPDI-based, the cover 16 has a $\tan \delta$ value lower than conventional (e.g. MDI- and TDI-based) thermoplastics and thermosetting urethanes. Thus, the PPDI-based polyurethane cover 16 of the present
20 invention loses less energy as heat upon a high distortion or impact event (i.e. hysteresis) compared to these other polyurethane materials. It is believed that the relative superior mechanical and physical properties of the PPDI-based polyurethane

cover 16 of the present invention is due to both the rigid rod-like structure of PPDI and the distribution of that structure throughout the polyurethane.

The core 12 of the golf ball 10 is the "engine" for the golf ball 10 such that the inherent properties of the core 12 will strongly determine the initial velocity and distance of the golf ball 10. A higher initial velocity will usually result in a greater overall distance for a golf ball. In this regard, the Rules of Golf, approved by the United States Golf Association ("USGA") and The Royal and Ancient Golf Club of Saint Andrews, limits the initial velocity of a golf ball to 250 feet (76.2m) per second (a two percent maximum tolerance allows for an initial velocity of 255 per second) and the overall distance to 280 yards (256m) plus a six percent tolerance for a total distance of 296.8 yards (the six percent tolerance may be lowered to four percent). A complete description of the Rules of Golf are available on the USGA web page at www.usga.org. Thus, the initial velocity and overall distance of a golf ball must not exceed these limits in order to conform to the Rules of Golf.

Therefore, the core 12 for a USGA approved golf ball is constructed to enable the golf ball 10 to meet, yet not exceed, these limits.

The core 12 of the golf ball 10 is generally composed of a blend of a base rubber, a cross-linking agent, a free radical initiator, and one or more fillers or processing aids. A preferred base rubber is a polybutadiene having a cis-1,4 content above 90%, and more preferably 98% or above.

The use of cross-linking agents in a golf ball core is well known, and metal acrylate salts are examples of such cross-linking agents. Free radical initiators are

used to promote cross-linking of the base rubber and the cross-linking agent.

Suitable free radical initiators for use in the golf ball core 12 of the present invention

include peroxides such as dicumyl peroxide, bis-(t-butyl peroxy) diisopropyl

benzene, t-butyl perbenzoate, di-t-butyl peroxide, 2,5-dimethyl-2,5-di-5-

- 5 butylperoxy-hexane, 1,1-di (t-butylperoxy) 3,3,5-trimethyl cyclohexane, and the like, all of which are readily commercially available.

Zinc oxide is also preferably included in the core formulation. Zinc oxide may primarily be used as a weight adjusting filler, and is also believed to participate in the cross-linking of the other components of the core (e.g. as a coagent).

- 10 Additional processing aids such as dispersants and activators may optionally be included. In particular, zinc stearate may be added as a processing aid (e.g. as an activator). Any of a number of specific gravity adjusting fillers may be included to obtain a preferred total weight of the core 12. Examples of such fillers include tungsten and barium sulfate. All such processing aids and fillers are readily
- 15 commercially available

- In the present invention, the core components are mixed and compression molded in a conventional manner known to those skilled in the art. In a preferred form, the finished core 12 has a diameter of about 1.35 to about 1.64 inches for a golf ball 10 having an outer diameter of 1.68 inches. The core weight is preferably
- 20 maintained in the range of about 32 to about 40 g. The core PGA compression is preferably maintained in the range of about 50 to 90, and most preferably about 55 to 80.

As used herein, the term "PGA compression" is defined as follows:

$$\text{PGA compression value} = 180 - \text{Riehle compression value}$$

The Riehle compression value is the amount of deformation of a golf ball in inches under a static load of 200 pounds, multiplied by 1000. Accordingly, for a
5 deformation of 0.095 inches under a load of 200 pounds, the Riehle compression value is 95 and the PGA compression value is 85.

As is described above, the present invention preferably includes at least one boundary layer 14 that preferably is composed of a thermoplastic (e.g. thermoplastic or thermoplastic elastomer) or a blend of thermoplastics (e.g. metal containing, non-
10 metal containing or both). However, the golf ball 10 may have several boundary layers 14 disposed between the core 12 and the cover 16. Most preferably the boundary layer 14 is composed of at least one thermoplastic that contains organic chain molecules and metal ions. The metal ion may be, for example, sodium, zinc, magnesium, lithium, potassium, cesium, or any polar metal ion that serves as a
15 reversible cross-linking site and results in high levels of resilience and impact resistance. Suitable commercially available thermoplastics are ionomers based on ethylene copolymers and containing carboxylic acid groups with metal ions such as described above. The acid levels in such suitable ionomers may be neutralized to control resiliency, impact resistance and other like properties. In addition, other
20 fillers with ionomer carriers may be used to modify (e.g. preferably increase) the specific gravity of the thermoplastic blend to control the moment of inertia and other like properties. Exemplary commercially available thermoplastic materials suitable

for use in a boundary layer 14 of a golf ball 10 of the present invention include, for example, the following materials and/or blends of the following materials:

HYTREL® and/or HYLENE® products from DuPont, Wilmington, Delaware,
PEBAX® products from Elf Atochem, Philadelphia, Pennsylvania, SURLYN®

5 products from DuPont, and/or ESCOR® or IOTEK® products from Exxon
Chemical, Houston, Texas.

The Shore D hardness of the boundary layer 14 should be about 65 or less. It is preferred that the boundary layer 14 have a hardness of between about 50-65 Shore D. In a preferred embodiment, the boundary layer 14 has a Shore D hardness
10 in the range of about 57-65. One reason for preferring a boundary layer 14 with a Shore D hardness of 65 or lower is to improve the feel of the resultant golf ball.

Examples

Twelve golf balls of the present invention were compared to a Maxfli
REVOLUTION, a Titleist PROFESSIONAL, a Titleist DT-2, and a Bridgestone
15 PRECEPT. All of the golf balls were subjected to a durability test to determine the durability of the golf balls in an objective manner. The durability tests were conducted on a cover shear apparatus as known in the golf industry. The apparatus includes a ten pound metal block with a strike plate on its bottom, mounted on a frame. A golf ball is placed within a holder and held by a set of pins. The strike
20 plate is angled at 54 degrees from vertical. The strike plate is dropped from six inches above the golf ball.

The golf balls are measured on a cover shear criteria. The scale for each is

from 1 to 5, with 1 being poor, 2 being below average, 3 being average, 4 being above average and 5 being excellent. The cover shear criteria is as follows: 1-portion of the cover has been completely sheared off and dimples have been greatly reduced or removed; 2-the cover material has been sheared to the extent that the flaps of the cover are visible, and severe bunching or peeling back of the cover material is evident; 3-there is moderate cutting of the cover material to the extent that internal portions of the cover are exposed, but the cover is intact; 4-indentations in the cover are evident, but there is no bunching of the cover material ; 5-groove marks are difficult to see and slight score marks may or may not be visible, and there is no deformation of the cover material.

Table One sets forth data for each of the twelve overall golf balls 10 and each of the cores 12. The weight of each of the golf balls 10 varies from 45.65 grams to 45.92 grams. The PGA compression of each of the golf balls 10 varies from 92 to 101. The average diameter of each of the golf balls 10 is consistently 1.684 inches. The core diameter of each of the cores 12 is 1.489 inches or 1.515 inches. The PGA compression of each of the cores 12 varies between 60 and 75 points.

The twelve example golf balls of the present invention each had a boundary layer 14 composed of an ionomer blend with a thickness varying from 0.0525 and 0.058 inches, and a Shore D hardness varying between 58 and 62. Additionally, golf balls 10, each having a cover 16 composed of a single PPDI-based polyurethane prepolymer were produced and subjected to the durability test to measure cover shear. These single PPDI-based polyurethane prepolymer cover materials ranged in

thickness from 0.0265 inch to 0.038 inch, had a tensile strength range of 6500 to 7900 pounds per square inch, a specific gravity of 1.142 to 1.220, a Bayshore Rebound range of 5-65 percent, a Shore D hardness of 47 to 53 and a flexural modulus greater than 10,000 psi. The shear rating for each of these golf balls was

5 3.0.

TABLE ONE					
Ball	Ball Weight Compression (grams)	Ball Compression (points)	Average Diameter (inches)	Core Diameter (inches)	Core (points)
1	45.65	92	1.684	1.489	60
2	45.86	98	1.684	1.515	70
3	45.92	101	1.684	1.515	75
4	45.82	94	1.684	1.489	60
5	45.83	99	1.684	1.489	65
6	45.90	99	1.684	1.489	65
7	45.86	96	1.684	1.515	70
8	45.84	100	1.684	1.515	75
9	45.84	101	1.684	1.515	75
10	45.89	98	1.684	1.515	65
11	45.83	95	1.682	1.515	65
12	45.84	97	1.681	1.515	69

TABLE TWO							
Ball Ex. No.	Polyurethane prepolymer			PPDI-3	PPDI-4	Thickness (inches)	Shore D Hardness
	TDI	PPDI-1	PPDI-2				
1	30	70				0.0375	47
2	30		20	50		0.0300	53
3	30				70	0.0300	47
4	30				70	0.0375	47
5	30	50	20			0.0375	47
6	30				70	0.0375	47
7	30	50	20			0.0300	47
8	30		20	50		0.0300	53
9	<u>30</u>	<u>70</u>				<u>0.0300</u>	<u>53</u>
10	20	80				0.0300	47
11	30	70				0.0300	47
12	30	70				0.0300	47

Table Two sets forth the properties of each of the cover layers 16 for each of the twelve golf balls 10. The number of parts of each polyurethane prepolymer for each of the cover layers 16 is provided in columns 2 through 6. Column 2 includes the number of parts of the TDI-terminated polyether prepolymer. Column 3 includes the number of parts of the first PPDI terminated polyether prepolymer.

Column 4 includes the number of parts of the first PPDI terminated polyester (polycaprolactone) prepolymer. Column 5 includes the number of parts of the second PPDI terminated polyether prepolymer. The difference between the first and second PPDI terminated polyether prepolymers is the NCO content and the

5 molecular weight of the polyol (ether) backbone, with the first having a NCO content in the range of approximately 5.45% to approximately 5.75%, and the second having a NCO content in the range of approximately 5.6% to approximately 6.2%. Column 6 includes the number of parts of the second PPDI terminated polyester (polycaprolactone) prepolymer. The difference between the first and

10 second PPDI terminated polyester (polycaprolactone) prepolymers is the NCO content, with the first having a NCO content in the range of approximately 3.55% to approximately 3.85%, and the second having a NCO content in the range of approximately 4.45% to approximately 5.05%. Each of the polyurethane prepolymer blends for examples 1-9 and 11-12 were cured with a blend of curing

15 agents. The blend of curing agents was composed of 50 parts of a diamine curing agent and 50 parts of a blend of a 1,4 butane diol and glycol. Example 10 of the golf balls 10 of the present invention was cured with a blend of 70 parts of a diamine and 30 parts of a 1,4 butane diol and glycol. The thickness of the cover layer 16 for each of the twelve golf balls 10 of present invention is either 0.0300 inches or

20 0.0375 inches. The shore D hardness of the cover layer 16 for each of the twelve golf balls 10 of present invention is either 47 degrees or 53 degrees.

TABLE THREE							
	Ball 5-Iron	Shear (1-5)	110 mph Driver		90 mph Driver		79 mph
5			Carry (yds)	Total (yds)	Carry (yds)	Total (yds)	Carry (yds)
10	Revolution	5	251.5	269.6	194.5	218.6	158.1
	Precept EV	4	253.1	270.6	196.2	220.4	162.7
	Professional	4	248.2	266.1	190.3	216.0	158.4
	DT 2-piece	1	256.1	274.7	197.1	222.8	164.8
15	1	4.25	253.9	271.1	195.7	220.6	161.2
	2	4.0	255.5	274.1	196.7	222.4	163.2
	3	4.0	257.3	272.2	199.2	221.8	162.0
	4	4.0	253.9	269.7	197.0	220.4	160.4
	5	4.0	254.3	274.1	198.2	220.4	159.1
	6	4.25	254.4	269.4	197.4	220.6	160.1
	7	4.25	255.9	271.4	198.3	221.9	161.6
20	8	3.75	257.2	273.2	198.2	222.7	163.6
	9	3.75	256.8	273.6	197.2	222.7	163.8
	10	3.75	256.7	275.5	197.5	222.6	161.3
	11	4.5	255.5	273.3	196.8	222.5	160.9
	12	4.5	257.3	274.2	196.8	221.5	161.1
25							

Table Three illustrates the comparison testing between the twelve sample golf balls 10 of the present invention, and the four well-known and well-played golf balls. All of the golf balls in Table Three were subjected to the afore-mentioned shear test and rated. The golf balls were also subject to a standard robot swing test at 110 miles per hour ("mph") using a BIG BERTHA® HAWKEYE ® driver, at 90 mph using a BIG BERTHA® HAWKEYE ® driver, and at 79 mph using a BIG BERTHA® X-12® five iron. Although the REVOLUTION® had the best shear

rating, its carry and total distance was only better than the Titleist PROFESSIONAL®. Example 12 of the golf balls 10 of the present invention had a durability rating of 4.5, and it had a carry six yards better than the REVOLUTION at 110 mph using a BIG BERTHA® HAWKEYE ® driver. The best distance at 110

5 mph using a BIG BERTHA® HAWKEYE ® driver was example 10 of the golf balls 10 of the present invention which had a carry yardage of 256.7 yards and a total distance of 275.5 yards with a durability of 3.75. The next closest golf ball in distance was the DT-2, however, it only had a durability of 1. Table Three demonstrates that the golf ball 10 of the present invention provides objectively the

10 best overall durability with the best overall distance.

CLAIMS

1. A golf ball comprising:
a core; and
a polyurethane cover formed from reactants comprising a toluene diisocyanate based polyurethane prepolymer, a second diisocyanate polyurethane prepolymer and at least one curing agent.
2. The golf ball according to claim 1 further comprising at least one boundary layer disposed between the core and the polyurethane cover.
3. The golf ball according to claim 1 wherein the second diisocyanate polyurethane prepolymer is a p-phenylene diisocyanate based polyurethane prepolymer.
4. The golf ball according to claim 1 wherein the toluene diisocyanate based polyurethane prepolymer comprises toluene diisocyanate and polyether polyol.
5. The golf ball according to claim 3 wherein the p-phenylene diisocyanate based polyurethane prepolymer comprises p-phenylene diisocyanate and one or more polyester polyols, polyether polyols or a mixture thereof.
6. The golf ball according to claim 3 wherein the p-phenylene diisocyanate based polyurethane prepolymer comprise p-phenylene diisocyanate and polycaprolactone polyol.
7. The golf ball according to claim 1 wherein the polyurethane cover has a hardness of between about 40-60 Shore D, a flexural modulus of between 12,000-35,000 psi (83-241 MPa), a Bashore resilience of between 50-70, and a tensile strength of between 5900 -7500 psi (41-52 MPa).
8. The golf ball according to claim 3 wherein the polyurethane cover further comprises a second p-phenylene diisocyanate based polyurethane prepolymer.
9. The golf ball according to any of the previous claims wherein the polyurethane cover has a thickness of less than 0.04 inches (1mm).
10. A golf ball comprising:
a core comprising a polybutadiene;
a boundary layer encompassing the core, the boundary layer comprising at least one ionomer, and having a shore D hardness in the range of 56 to 70; and
a thermosetting polyurethane cover encompassing the boundary layer, the thermosetting polyurethane cover having a Shore D hardness in the range of 46 to 54, and a thickness in the range of 0.02 to 0.05 inches (0.5 to 1.3mm);

wherein the golf ball has a durability of at least 3.5 on a scale of 1 to 5 based on a cover strike plate drop test.

11. The golf ball according to claim 10 wherein the thermosetting polyurethane cover is formed from components comprising a p-phenylene diisocyanate terminated polyether prepolymer, a toluene diisocyanate terminated polyether prepolymer and at least one other component selected from the group consisting of a chain extender, a cross-linking agent, a curative and mixtures thereof.

12. The golf ball according to claim 10 wherein the thermosetting polyurethane cover is formed from components comprising a p-phenylene diisocyanate terminated polyester prepolymer, a toluene diisocyanate terminated polyether prepolymer and at least one other component selected from the group consisting of a chain extender, a cross-linking agent, a curative and mixtures thereof.

13. The golf ball according to claim 10 wherein the thermosetting polyurethane cover is formed from components comprising a p-phenylene diisocyanate terminated polyether prepolymer, a p-phenylene diisocyanate terminated polyester prepolymer, a toluene diisocyanate terminated polyether prepolymer and at least one other component selected from the group consisting of a chain extender, a cross-linking agent, a curative and mixtures thereof.

14. The golf ball according to claim 10 wherein the thermosetting polyurethane cover is formed from components comprising a p-phenylene diisocyanate terminated polyester prepolymer and at least one other component selected from the group consisting of a chain extender, a cross-linking agent, a curative and mixtures thereof.

15. The golf ball according to any one of claims 11 to 14 wherein the at least one other component is a blend of a diamine curing agent and a diol curing agent.

16. A golf ball comprising:

a core;

a boundary layer encompassing the core; and

a polyurethane cover formed from reactants comprising a p-phenylene diisocyanate terminated polyester prepolymer in an amount up to 90 parts, a p-phenylene diisocyanate terminated polyether prepolymer in an amount up to 90 parts, 10-40 parts of a toluene diisocyanate polyurethane prepolymer.

17. The golf ball according to claim 16 polyurethane cover formed from reactants comprising 20 parts of a p-phenylene diisocyanate terminated polyester

prepolymer, 50 parts of a p-phenylene diisocyanate terminated polyether prepolymer, 30 parts of a toluene diisocyanate polyurethane prepolymer.

18. The golf ball according to claim 16 polyurethane cover formed from reactants comprising 70 to 80 parts of a p-phenylene diisocyanate terminated polyether prepolymer, 20 to 30 parts of a toluene diisocyanate polyurethane prepolymer.

19. A method for producing a golf ball according to any of the previous claims.

20. A golf ball comprising:

a solid core composed of a polybutadiene material, the solid core having a diameter ranging from 1.45 inches (36.8mm) to 1.60 inches (40.6mm) and a PGA compression ranging from 55 to 80;

a boundary layer disposed over the solid core, the boundary layer composed of an ionomer material and having a thickness ranging from 0.02 inch (0.5mm) to 0.067 inch (1.7mm), the boundary layer having a hardness of 52 to 65 based on ASTM D-2240; and

a cover disposed over the boundary layer, the cover composed of a thermoset polyurethane material, the cover having a thickness ranging from 0.02 inch (0.5mm) to 0.04 inch (1.0mm) and a Shore D hardness ranging from 45 to 60 based on ASTM D-2240 and a flexural modulus ranging from 12,000 psi (83 MPa) to 35,000 psi (241 MPa) based on ASTM D790;

wherein the golf ball has a PGA compression of less than 98, a diameter less than 1.70 inches (43mm), and a coefficient of restitution of at least 0.778 at a speed of 143 feet per second (43.6m/s).

21. The golf ball according to claim 20 wherein the cover has a thickness of approximately 0.030 inch (0.76mm).

22. The golf ball according to claim 20 wherein the golf ball has a shear durability of at least 3.0 on a scale of 1.0 to 5.0.

23. The golf ball according to claim 20 wherein the golf ball has a PGA compression of 89.