location of the engagement of the key within the groove, and thus, where forces and stresses are transferred across the joint by the coupling. Further, known engineering considerations governing the groove geometry and the groove/key contact tend to increase stress in the groove corners, these considerations including the known need to maximize the height of the engagement between the sides of the keys and the sides of the groove for performance purposes while minimizing the depth of the groove, and, for polymeric pipe, minimizing or eliminating compressive forces applied by the key to the bottom of the groove, which act to increase stress at the groove corners. Where other forces, such as bending forces, are applied to the joint and carried only by the key/groove interface, stress is further increased at the groove corners. At those corners, stress concentrations are formed as a natural consequence of the sharp corner or small radius present where the two surfaces meet. Such stress concentrations are exacerbated by the need, in practical pipe couplings, to account for manufacturing tolerances on the coupling and the pipe elements themselves. These manufacturing tolerances create geometric variability in each component, the accommodation of which limits the degree to which coupling designers can reduce the effect of stress concentrations. The increased stress in the groove corners and the stress concentrations naturally occuring there promote the formation of small cracks in some polymer pipe elements, which can lead to an ultimate failure under high applied loads, or fatigue failure under stress inducing cyclic loads. There is clearly an advantage to reducing or eliminating the increased stresses in the corners of the grooves in polymeric pipes and stress concentrations at those locations, including by reducing the effects of geometric variations on the key/groove interface.

Summary

The invention concerns a coupling for connecting pipe elements. The coupling comprises a plurality of segments attached to one another end to end surrounding a central space. Adjustable attachment members are positioned at opposite ends of each segment for attaching the segments to one another. First and second arcuate projections are positioned respectively on opposite sides of each segment. Each arcuate projection faces an axis which extends through the central space and which extends lengthwise along each segment. Each arcuate projection has a semi-circular cross section taken parallel to the axis. The semi-circular cross section extends over at least a portion of the arcuate projection. The coupling further comprises a first and a second relief groove. The first relief groove is positioned adjacent to the first arcuate projection. The second relief groove is positioned adjacent to the second arcuate projection. Each relief groove extends lengthwise along each segment and faces the axis.

In an example embodiment, at least one of the arcuate projections comprises at least one clearance relief region positioned adjacent to an end of one of the segments. Further by way of example, the at least one clearance relief region comprises a surface of increasing radius of curvature on the one arcuate projection. The surface of increasing radius of curvature faces the axis.

In an example embodiment, the coupling comprises no more than two segments. In a further example embodiment, each one of the arcuate projections on each of the segments comprises a first and a second clearance relief region positioned adjacent respectively to a first and a second end of each of the segments. In another example, each one of the first and second clearance relief regions comprises a surface of increasing radius of curvature. The surfaces of increasing radius of curvature face the axis.

An example embodiment further comprises a first shoulder positioned adjacent to the first relief groove. The first relief groove is between the first shoulder and the first arcuate projection. A second shoulder is positioned adjacent to the second relief groove. The second relief groove is between the second shoulder and the second arcuate projection. The first and second shoulders are adapted to contact the pipe elements.

In an example embodiment, each one of the first and second shoulders has a radius of curvature approximately equal to a radius of curvature of an outer surface of the pipe elements. An example embodiment may further comprise at least one attachment member located at an end of each segment. In a specific example embodiment, the attachment members comprise lugs extending outwardly from each segment. Each lug defines a hole for receiving a fastener. Another example comprises attachment members located at opposite ends of each segment. By way of example, the attachment members comprise lugs extending outwardly from opposite ends of each segment. Each lug defines a hole for receiving a fastener.

An example coupling further comprises a ring seal positioned within the central space. The ring seal has an outer surface supporting the segments in spaced apart relation

sufficient to permit insertion of the pipe elements into the central space. The attachment members hold the segments in contact with the ring seal.

The invention also encompasses, in combination, a pipe element and a coupling for joining the pipe element to another pipe element. In an example embodiment the pipe element comprises a sidewall surrounding and defining a bore. The sidewall has an outer surface facing away from the bore. A groove is positioned in the outer surface of the sidewall. The groove extends circumferentially around the bore. By way of example the groove comprises a first side surface contiguous with a first floor surface. The first side surface and the first floor surface together subtend a first 90° circular arc when viewed in cross section taken parallel to an axis extending coaxially through the bore. A second side surface is contiguous with a second floor surface. The second side surface is in spaced relation to and faces the first side surface. The second side surface and the second floor surface together subtend a second 90° circular arc when viewed in cross section taken parallel to the axis extending coaxially through the bore. An example coupling comprises a plurality of segments attached to one another end to end surrounding a central space. Adjustable attachment members are positioned at opposite ends of each segment for attaching the segments to one another. First and second arcuate projections are positioned respectively on opposite sides of each segment. Each arcuate projection faces an axis which extends through the central space and which extends lengthwise along each segment. Each arcuate projection has a semi-circular cross section taken parallel to the axis. The semi-circular cross section extends over at least a portion of the arcuate projection. The coupling further comprises a first and a second relief groove. The first relief groove is positioned adjacent to the first arcuate projection. The second relief groove is positioned adjacent to the second arcuate projection. Each relief groove extends lengthwise along each segment and faces the axis.

An example combination further comprises a third floor surface contiguous with both the first and second floor surfaces. The third floor surface may comprise a flat surface. By way of example, the groove has a semi-circular cross sectional shape comprising the first 90° circular arc and the second 90° circular arc. In an example embodiment, at least one of the arcuate projections comprises at least one clearance relief region positioned adjacent to an end of one of the segments. By way of example, the at least one clearance relief region comprises a surface of increasing radius of curvature on the one arcuate projection. The surface of increasing radius of curvature faces the axis.

An example coupling may comprise no more than two segments.

By way of example, each one of the arcuate projections on each of the segments may comprise a first and a second clearance relief region positioned adjacent respectively to a first and a second end of each of the segments. In an example embodiment, each one of the first and second clearance relief regions comprises a surface of increasing radius of curvature. The surfaces of increasing radius of curvature face the axis.

An example combination may further comprise a first and a second relief groove. The first relief groove is positioned adjacent to the first arcuate projection. The second relief groove is positioned adjacent to the second arcuate projection. Each relief groove extends lengthwise along each segment and faces the axis.

An example combination may further comprise a first shoulder positioned adjacent to the first relief groove. The first relief groove is between the first shoulder and the first arcuate projection. A second shoulder is positioned adjacent to the second relief groove. The second relief groove is between the second shoulder and the second arcuate projection. The first and second shoulders are adapted to contact the pipe elements.

In an example combination, each one of the first and second shoulders has a radius of curvature approximately equal to a radius of curvature of an outer surface of the pipe elements. By way of example, the combination may further comprise at least one attachment member located at an end of each segment. In a specific example embodiment, the attachment members comprise lugs extending outwardly from each segment. Each lug defines a hole for receiving a fastener. By way of example, attachment members are located at opposite ends of each segment.

In an example embodiment, the attachment members comprise lugs extending outwardly from opposite ends of each segment. Each attachment lug defines a hole for receiving a fastener. An example embodiment may further comprise a ring seal positioned within the central space. The ring seal has an outer surface supporting the segments in spaced apart relation sufficient to permit insertion of the pipe elements into the central space. The attachment members hold the segments in contact with the ring seal.

There is disclosed a pipe element for use with a pipe coupling comprising a plurality of segments attached to one another end to end surrounding a central space for receiving the pipe element. In an example embodiment, at least a first arcuate projection is positioned on one side of the coupling and facing an axis extending

What is claimed is:

1. A coupling for connecting pipe elements, said coupling comprising:

a plurality of segments attached to one another end to end surrounding a central space;

adjustable attachment members positioned at opposite ends of each said segment for attaching said segments to one another;

first and second arcuate projections positioned respectively on opposite sides of each said segment, each said arcuate projection facing an axis extending through said central space and extending lengthwise along each said segment, each said arcuate projection having a semi-circular cross section taken parallel to said axis, said semi-circular cross section extending over at least a portion of said arcuate projection; and

a first and a second relief groove, said first relief groove positioned adjacent to said first arcuate projection, said second relief groove positioned adjacent to said second arcuate projection, each said relief groove extending lengthwise along each said segment and facing said axis.

2. The coupling according to claim 1, wherein at least one of said arcuate projections comprises at least one clearance relief region positioned adjacent to an end of one of said segments.

3. The coupling according to claim 2, wherein said at least one clearance relief region comprises a surface of increasing radius of curvature on said at least one of said arcuate projections, said surface of increasing radius of curvature facing said axis.

4. The coupling according to claim 1, wherein said coupling comprises no more than two said segments.

5. The coupling according to claim 4, wherein each one of said arcuate projections on each of said segments comprises a first and a second clearance relief region positioned adjacent respectively to a first and a second end of each of said segments.

6. The coupling according to claim 5, wherein each one of said first and second clearance relief regions comprises a surface of increasing radius of curvature, said surfaces of increasing radius of curvature facing said axis.

7. The coupling according to claim 1, further comprising:

a first shoulder positioned adjacent to said first relief groove, said first relief groove being between said first shoulder and said first arcuate projection;

a second shoulder positioned adjacent to said second relief groove, said second relief groove being between said second shoulder and said second arcuate projection, wherein

said first and second shoulders are adapted to contact said pipe elements.

8. The coupling according to claim 7, wherein each one of said first and second shoulders has a radius of curvature approximately equal to a radius of curvature of an outer surface of said pipe elements.

9. The coupling according to claim 4, further comprising at least one attachment member located at an end of each said segment.

10. The coupling according to claim 9, wherein said attachment members comprise lugs extending outwardly from each said segment, each said lug defining a hole for receiving a fastener.

11. The coupling according to claim 4, further comprising attachment members located at opposite ends of each said segment.

12. The coupling according to claim 11, wherein said attachment members comprise lugs extending outwardly from opposite ends of each said segment, each said lug defining a hole for receiving a fastener.

13. The coupling according to claim 11, further comprising a ring seal positioned within said central space, said ring seal having an outer surface supporting said segments in spaced apart relation sufficient to permit insertion of said pipe elements into said central space, said attachment members holding said segments in contact with said ring seal.

14. In combination, a pipe element and a coupling for joining said pipe element to another pipe element, said pipe element comprising:

a sidewall surrounding and defining a bore, said sidewall having an outer surface facing away from said bore;

a groove positioned in said outer surface of said sidewall, said groove extending circumferentially around said bore, said groove comprising:

a first side surface contiguous with a first floor surface, said first side surface and said first floor surface together subtending a first 90° circular arc when viewed in cross section taken parallel to an axis extending coaxially through said bore;

a second side surface contiguous with a second floor surface, said second side surface being in spaced relation to and facing said first side surface, said second side surface and said second floor surface together subtending a second 90° circular arc when viewed in cross section taken parallel to said axis extending coaxially through said bore; and

said coupling comprising:

a plurality of segments attached to one another end to end surrounding a central space;

adjustable attachment members positioned at opposite ends of each said segment for attaching said segments to one another;

first and second arcuate projections positioned respectively on opposite sides of each said segment, each said arcuate projection facing an axis extending through said central space and extending lengthwise along each said segment, each said arcuate projection having a semi-circular cross section taken parallel to said axis, said semi-circular cross section extending over at least a portion of said arcuate projection; and

a first and a second relief groove, said first relief groove positioned adjacent to said first arcuate projection, said second relief groove positioned adjacent to said second arcuate projection, each said relief groove extending lengthwise along each said segment and facing said axis.

15. The combination according to claim 14, further comprising a third floor surface contiguous with both said first and second floor surfaces, said third floor surface comprising a flat surface.

16. The combination according to claim 14, wherein said groove has a semi-circular cross sectional shape comprising said first 90° circular arc and said second 90° circular arc.

17. The combination according to claim 14, wherein at least one of said arcuate projections comprises at least one clearance relief region positioned adjacent to an end of one of said segments.

18. The combination according to claim 17, wherein said at least one clearance relief region comprises a surface of increasing radius of curvature on said at least one of said arcuate projections, said surface of increasing radius of curvature facing said axis.

19. The combination according to claim 14, wherein said coupling comprises no more than two said segments.

20. The combination according to claim 19, wherein each one of said arcuate projections on each of said segments comprises a first and a second clearance relief region positioned adjacent respectively to a first and a second end of each of said segments.

21. The combination according to claim 20, wherein each one of said first and second clearance relief regions comprises a surface of increasing radius of curvature, said surfaces of increasing radius of curvature facing said axis.

22. The combination according to claim 14, further comprising:

a first shoulder positioned adjacent to said first relief groove, said first relief groove being between said first shoulder and said first arcuate projection;

a second shoulder positioned adjacent to said second relief groove, said second relief groove being between said second shoulder and said second arcuate projection, wherein

said first and second shoulders are adapted to contact said pipe elements.

23. The combination according to claim 22, wherein each one of said first and second shoulders has a radius of curvature approximately equal to a radius of curvature of an outer surface of said pipe elements.

24. The combination according to claim 19, further comprising at least one attachment member located at an end of each said segment.

25. The combination according to claim 24, wherein said attachment members comprise lugs extending outwardly from each said segment, each said lug defining a hole for receiving a fastener.

26. The combination according to claim 19, further comprising attachment members located at opposite ends of each said segment.

27. The combination according to claim 26, wherein said attachment members comprise lugs extending outwardly from opposite ends of each said segment, each said attachment lug defining a hole for receiving a fastener.

28. The combination according to claim 26, further comprising a ring seal positioned within said central space, said ring seal having an outer surface supporting said segments in spaced apart relation sufficient to permit insertion of said pipe elements into said central space, said attachment members holding said segments in contact with said ring seal.