ABSTRACT: The disclosure relates to a temperature-compensated electrical connector comprising a plug and receptacle connector having an environmental seal confined between spring-loaded interfaces for use under variable environmental conditions. Temperature compensation is achieved by independently spring-loading insulators in both the plug and receptacle connectors. This allows the insulator interfaces, which have viscoelastic sealing members between them, to move with temperature-related seal expansion and contraction. The temperature-compensated spring action compresses individual viscoelastic cones formed on tapered entries on the insulator interfaces to ensure reliable environmental sealing under all conditions. An interfacial seal between the two connectors may be of one-piece construction having double-sided cones around each contact. Wire seals interconnect the spring-loaded members to the insulator and may be formed of double-sided cones installed on the wires in the connector. The thermal expansion springs may be permanently attached to rear insert insulators of the plug and receptacle connectors in a preloaded condition, thus, eliminating the need for compressing the spring during installation.
TEMPERATURE-COMPENSATED ELECTRICAL CONNECTOR

The invention relates generally to temperature-compensated electrical connectors, and, more particularly, to a plug and receptacle connector having an environmental seal confined between spring-loaded interfaces for use under variable environmental conditions.

BACKGROUND OF THE INVENTION

With the advent of supersonic aircraft, the need has arisen for electrical connectors capable of withstanding environments which vary over a wide range of temperatures. For example, sealed forms of elastomer materials utilized in connector configurations must be capable of meeting 500°F. 50,000 - hour service life under high stress conditions. It is readily apparent that presently available elastomer materials used in existing connector configurations would not meet the service life objectives, because of loss of elastic characteristics by the materials. Certain elastomers under current development show promise of operating for extended periods of time for a +450°F. to +550°F. environment. None of the elastomers, however, would be able to meet other requirements. While glass-filled Teflon shows promise of meeting the service life in the +350°F. to +500°F. environment, this material lacks the elasticity to provide a reliable seal in present seal configurations.

In order to overcome the attendant disadvantages of prior art elastomer seals, the present invention utilizes presently available resilient materials which would degrade in a relatively short period of time to a point of failure, but would have the ability to retain its elasticity, that is, the environmental capability in spite of the lack of resiliency. Moreover, the present invention has the ability to compensate for sealing member increase or loss of volume at temperature extremes. Further, minimal stresses are placed on the seal during installation, and under service and maintenance conditions. These objectives have been achieved by developing a design that compensates for the thermal expansion and contraction of the sealing members and insulator components under the above-mentioned service conditions. Moreover, a reliable, long-term environmental seal is achieved by taking advantage of the thermal and viscoelastic characteristics of polymeric materials. Moreover, the electrical connector of the present invention reduces the need for highly elastic material in connector-sealing members because their environmental sealing integrity capability is not affected by the lack of elasticity. Also, the sealing member configuration is simplified, thus reducing cost and increasing the number of potential usable materials. By confining the resilient seals between spring-loaded, temperature-compensating interfaces, these interfaces, under spring pressure, adjust for increase or decrease of volume in the sealing materials resulting from temperature changes. The spring loading is preloaded to provide positive compression to the wire seals when the connectors are unmated. When the connectors are mated the assembly provides compression on the interfacial seal between the insert faces and compensates for expansion and contraction caused by temperature changes.

The advantages of this invention, both as to its construction and mode of operation, will be readily appreciated as the same become better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which like referenced numerals designate like parts throughout the figures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 depicts a preferred embodiment, partly in section, of the electrical connector assembly in an unmated condition; and

FIG. 2 shows the electrical connector assembly of FIG. 1 in a mated condition.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, an electrical connector 12 formed of a plug connector 14 and a receptacle connector 16, is shown in accordance with the invention. The plug connector comprises a plug barrel 22 having an enlarged rearward bore 24 which is threaded. An intermediate bore 26 is formed adjacent the rearward bore 24. A rearward-facing shoulder 28 is formed of a junction of the bore 24 and bore 26. The intermediate bore 26 contains a first annular opening 32 near the rear end thereof and a second annular opening 34 at approximately the center thereof. A reduced diameter forward bore 36 in the plug barrel adjoins the intermediate bore 26, and the junction thereof forms a rearward facing shoulder 38. The front bore portion 42 of the plug barrel 22 is beveled to form a sealing surface. The rear outer surface 44 of the plug barrel may be threaded for accepting auxiliary components such as a cable clamp or junction shell. An outwardly extending flange 46 is formed at approximately the center of the plug barrel and defines a forwardly extending shoulder 48 and a rearwardly extending shoulder 52. The front end of the plug barrel contains a plurality of keys 54.

Mounted around the front periphery of the plug barrel 22 is a coupling nut 62. The coupling nut contains a front reduced diameter threaded bore portion 64 and an enlarged central bore portion 66. The junctions of the bores 64 and 66 are defined by a rearwardly facing shoulder 68. An opening 70 in the coupling nut from the outer surface thereof through to the bore surface 66 is utilized as a viewing port as will be explained hereinafter. The rear section of the coupling nut contains an annular groove 74 and a first rearward facing shoulder 76 and a second rearward facing shoulder 78.

Mounted within the annular groove 74 is a retaining ring 82. A detent ring 84 is mounted so that its rear outer surface abuts the retaining ring 82 and its front outer surface abuts a rearward-facing shoulder 76. The outer diameter of the ring 84 is adjacent the rearward inner surface of the coupling nut and the inner surface of the ring 84 is adjacent the outer surface of the plug barrel with the front inner surface of the ring abutting the shoulder 52 of the flange 46. Further, forward facing detents 86 are formed in the detent ring. The flange 46 further comprises a guide ring portion 92. The rearward-facing surface of the ring portion 92 is adjacent the forward-facing surface of the ring 84. The forward outer surface of the ring 92 abuts the shoulder 78 and the outer surface of the ring 92 is adjacent to the rear inner surface of the coupling nut. A trough-shaped indicator cup 102 has an outer portion 104, whose outer rear surface contains a band indicator 105 and is adjacent the bore 66 of the coupling nut and a forward portion 106 adjacent the rearward-facing shoulder 68 and a rear portion 108. Mounted within the cup 102 adjacent the forward portion 106 is an indicator thrust washer 109 and adjacent the washer 109, an indicator wave spring 110. Adjacent the rear surface of the rear portion 108 is an indicator return spring 112. The spring 112 has mounted adjacent thereto, a plurality of spaced locking balls 114 whose diameter is such that it will fit in the openings 94 of the guide ring 92, and a portion of the ball may be moved into the detents 86 of the detent ring 84. The forward outer surface of the coupling nut 62 contains an annularly extending flange 116 having openings therethrough for insertion of a safety wire (not shown) which prevents the coupling nut from being rotated when the plug and receptacle connector are in a mated condition.

In the unmated condition of FIG. 1, the band indicator 105 is positioned forward of the opening 72 and the locking balls are free floating. In the fully mated condition depicted in FIG. 2, visual indication of complete mating is accomplished by observing the markings on the band indicator 105 through the opening 72 in the coupling nut 62. Further, the balls 114 provide an audible click during the last one-half to three-eighths turn of the coupling nut.
The plug connector 14 further comprises a rear insert assembly 122 formed of an insert retainer nut 124 having a reduced diameter rear bore 126 and an enlarged diameter forward bore 128. An annular groove 129 is formed in the forward-facing shoulder 128 for defining the bores 126 and 128. The outer surface 132 of the nut 124 is threaded at the front portion thereof 134, the threads mating with the threads of the bore 24 of plug barrel 22. The rear insert assembly 122 further comprises a rear insert insulator 136 formed of a plurality of passageways 138 having a reduced diameter rear bore 142 and an enlarged outwardly flaring forward tapered bore 144. A forward-facing tapered shoulder 146 is formed at the junction of the bores 142 and 144. The rear outer surface 148 of the insulator 136 abuts the bore 126 of the retainer nut 124. The outer surface of the insulator 136 further contains an outwardly extending annular flange 152 having a rearward-facing shoulder 154 and a forward-facing shoulder 156. An enlarged forward outer surface 158 of the insulator 136 abuts the shoulder 156 at its rear end. A cartridge shell 162 has its outer surface mounted adjacent to the forward bore 128 of the retainer nut and contains a forward inwardly extending flange 164. The cartridge shell 162 further contains a flange 166 at its rear end, which fits into the groove 128 of the retainer nut 124. Mounted within the cartridge shell is a compression spring 168 whose forward end is adjacent the rearward-facing shoulder 154 of the insulator 136 and whose rear end is against the inner surface of the flange 166. Mounted within the bore 144 is a truncated wire seal 172 having a bore 174 therethrough. The rear end 176 of the seal is mounted adjacent the shoulder 146 of the insulator 136 and whose outer surface 178 is adjacent the bore 144, except for the front surface 180 of the seal.

A socket insulator 182 is mounted within the plug barrel 22 and comprises a rearward tapered opening 184 which abuts the front surface 180 of the wire seal. The socket insulator 182 further comprises a reduced diameter rear bore 186, an enlarged central bore 188 and a reduced diameter forward bore 192. A forward-facing shoulder 194 is formed at the junction of the bores 186 and 188 and a rearward-facing shoulder 196 is formed at the junction of the bores 188 and 192. At the front end of the bore 192 the socket insulator contains a flared opening 198. Mounted within the enlarged bore 188 is a contact retainer clip 202 which is secured within the bore 188 by means of the shoulders 194 and 196. The clip 202 further contains tangs 204 which extend forwardly and inwardly. The socket insulator 182 is held within the plug barrel by means of a retaining ring 206 mounted within the annular opening 32, and sealing is provided by means of an O-ring 208 mounted in the annular opening 34, the O-ring 208 being adjacent the outer surface of the insulator 182. An interfacial seal 212 has its outer surface abutting the bore 36 of the plug barrel 22. The interfacial seal 212 further contains a bore 214 which is aligned with the bore 192 of the insulator 182. The rear surface of the seal 212 fits adjacent to the front surface of the insulator 182 and contains flared rear sections 216 and front sections 218, immediately adjacent the bore 214. The rear section 216 fits into the flared opening 198 of the insulator 182.

A socket contact 222 is mounted within the bores of the insulator 182 and seal 212. The socket contact comprises a forwardly extending contacting portion 224 which extends beyond the seal 212 and a collar 226, whose rear surface abuts the tangs 204 of the retainer clip. The rear end of the contact contains a mounting section 228 within which the bared end of a wire conductor may be soldered or crimped.

The receptacle connector 16 comprises a shell 252 which is threaded on its front outer surface 254 and its rear outer surface 256. The center of the shell contains an outwardly extending flange 258. The front inner surface of the shell 252 contains a plurality of keyways 264 which cooperate with the keys 54 of the plug connector for correctly polarizing the plug and receptacle connectors. The rear inner surface 266 of the shell 252 is threaded. The shell contains a central reduced diameter bore 268 having a large annular groove 272 at approximately the center thereof and a smaller annular groove 274 near the rear end thereof. Further, the junction of the bore 268 and the rear surface 266 contains a rearward-facing shoulder 276. At the termination of the keyways 264 is a forward-facing sealing shoulder 278 having a notch 282 therein. A bore 284 in the shell 252 is adjacent the shoulder 278 at its front end, and at its rear end is a rearward-facing shoulder 286 which is also adjacent the bore 268. The rear insert assembly 292 of the receptacle connector is similar to that of the plug connector, and therefore, will not be described in detail. The rear insert assembly 292 contains a rear insert retainer nut 294 which is threaded at its outer surface to the receptacle shell 252. The rear insert assembly further comprises an insulator 296 having secured thereto at its front end, a wire seal 298. Further, a cartridge shell 302 contains a compression spring 304 therein.

A pin insulator 306 contains a tapered rear opening 308 which abuts the front face of the wire seal 298 and has a reduced diameter rear bore 312, an enlarged intermediate bore 314, and a reduced diameter central bore 316. The junction of the side of the bore 314 and the intermediate bore 314 contains a forward-facing shoulder 318, and at the junction of the intermediate bore 314 and the reduced diameter central bore 316 there is a forward-facing shoulder 322. An annular groove 324 is formed forward of the central bore 316, and to the rear of the forward bore 326. The front end of the insulator 306 contains a flared opening 328 which communicates with the forward bore 326. Mounted within the bore 314 is a contact-retaining clip 332 having forwardly and inwardly extending tang 334 similar to the retaining clip 202 of the plug connector. Mounted within the groove 324 is a contact seal 336 having a bore 338 through which a contact 342 extends. The pin contact contains a shoulder 344 which is retained in the insulator by the tangs 334, thus preventing rearward axial movement of the pin contact. The pin contact further contains a tubular rear portion 346 to which the bared end of a wire conductor 348 may be crimped. Further, a retaining ring 352 is mounted in the groove 274 and an O-ring 354 in the groove 272.

When the plug connector and receptacle connector of FIG. 1 are fully mated as shown in FIG. 2, the surface 42 of the plug barrel 22 abuts the outer edge of surface 278 to form a metal-to-metal seal. Further, the spring 168 abuts the shoulder 154, forcing the member 136 to exert a force against the rear end 176 of the wire seal 232, hence, in turn, is transferred from the forward surface 180 of the insulator to the insulator at its opening 184. The front surface flared opening 198 of the insulator 182, in turn, transfers this force to the interfacial seal 212. The receptacle connector operates in a similar manner with the spring 304 exerting a force which is ultimately transferred to the interfacial seal 212. The insulator 182 of the plug connector has interfaces with the wire seal 172 and the interfacial seal 212. Further, the insulator 306 of the receptacle connector has interfaces with the wire seal 298 and the interfacial seal 212. Thus, should either of the insulator interfaces start to separate when the connector is operational and in its fully mated condition, the springs 168 and 304, respectively, will tend to return the interfacial surfaces together again. Thus, the insulator interfaces which have viscoelastic sealing members between them, can move with temperature related seal expansion and contraction. The temperature-compensating spring action compresses the viscoelastic cones in the tapered entries on the insulator interfaces to ensure reliable environmental sealing under all conditions.

The interfacial seal 212 between the two connector halves is of one-piece construction with double sided cones 216, 218 around each contact. If accidentally damaged, the seal 212 is easily replaceable. Replacement of the seal is not likely, however, because the seal is recessed in the plug barrel 22, and further protected by the forwardly extending contact portion 224. The wire seals 172, 298 are double-sided cones, easily installed on the wires 232, 348, respectively, either before or
after contact attachment. The insert thermal expansion springs 168, 304 are permanently attached to the rear insert insulator 136, 296, respectively, in a preloaded condition. This serves to reduce the number of parts that must be handled by the assembly, and eliminates the need for compressing the spring in order to install the threaded retainer nuts 124 and 294.

While only one wire 238 and 348 is depicted in the plug and receptacle connectors, respectively, it should be understood, of course, that each connector may contain a plurality of wires for mating with each other by the connector.

We claim:

1. A temperature-compensated electrical connector comprising:
   a first connector member having a shell;
   a first insulator member having a front surface and a rear surface and being secured within said first connector shell;
   a contact member positioned within said insulator member;
   an interfacial seal having a first surface and a second surface, said first surface being positioned adjacent said insulator member front surface; and
   spring-loaded means mounted in said connector urging said insulator front surface toward said interfacial seal, said spring-loaded means comprising a compression spring mounted in a self-contained cartridge shell, and
   a first rear insert insulator having a front surface, said spring-loaded means being mounted on said rear insert insulator so as to tend to force said rear insert insulator in a forward direction.

2. A temperature-compensated electrical connector in accordance with claim 1 and further comprising a first wire seal having a rear surface mounted against the front surface of said rear insert insulator and a front surface mounted against the rear surface of said insulator member, said spring-loaded means allowing the insulator interfaces to move with temperature-related expansion and contraction.

3. A temperature-compensated electrical connector in accordance with claim 2 and further comprising a second connector member having a shell for mating with said first connector member shell comprising a second insulator member having a front surface and a rear surface for positioning a second contact member therein; a second rear insert insulator having a front surface and mounted in said second connector member, a second wire seal having a rear surface mounted adjacent the front surface of said second rear insert insulator and a front surface mounted against the rear surface of said second insulator member, a second spring-loaded means mounted on said second rear insert insulator for allowing the second connector insulator interfaces to move with temperature related expansion and contraction and said second insulator front surface to move toward said interfacial seal when said first connector member is mated with said second connector member.

4. A temperature-compensated electrical connector in accordance with claim 3 wherein said first contact member extends through said interfacial seal, and forms a conductive path with said second contact member when said connector members are mated and wherein said second insulator member front surface abuts said interfacial seal second surface.