Introduction

This catalog presents our Advanced series of high voltage connectors. These connectors are the result of 40 years of technological advancement at Reynolds Industries in the field of high voltage connectors and high voltage interconnect systems. Users of high voltage connectors in the aerospace industry have long sought a miniature high voltage connector that will operate at reduced atmospheric pressure, perform during temperature excursions of -55° to +125° C and at the same time reduce corona to an acceptable level. Reynolds Advanced interface sealing system satisfies all these requirements through the use of a very small, elastomeric interface seal as the key component of the sealing system.

Smaller connectors need smaller high voltage cable. Concurrent with the development of the Avanced interface system, Reynolds developed small diameter wire and cable to match up with the miniature connectors. In addition, a method of coating wire to promote a strong dielectric bond at the users facility, was developed. Lastly, a line of continuously extruded high voltage attenuation cable or “Loss Line” was developed to further complement the Advanced series of connectors.

Where High Voltage Connectors are Used

The systems and major components using Reynolds connectors cover a wide spectrum of industry:

- **Traveling wave tubes, magnetrons and klystrons**
- **Laser systems: Range finders, ring laser gyroscopes and night vision systems**
- **Cathode ray tubes**
- **High energy physics research**
- **High voltage power supplies**

Modifications to Catalog Connectors

The products offered in this catalog provide the user with off-the-shelf technology and when used in accordance with the data sheets, will result in a long term service life. In cases where a modification to a catalog item is required, our engineering department will analyze the requirements, and, where feasible, prepare a technical proposal for the customer to review. If the changes are extensive or beyond the scope of a modification, we may recommend a totally new or “special” connector.

Connector Selection Criteria

Introduction

Today's aerospace operational requirements for electrical connectors dictate simultaneous solutions of mechanics, electronics, materials and processes. Nowhere else in the connector industry do these multi-engineering disciplines require more diligence than the solution to high voltage aerospace connector applications, which is the principal product of Reynolds Industries' Electrical Connector Products Division.

High Altitude Operation

Reynolds Industries pioneered the development of miniature high voltage connectors used within non-pressurized areas of high altitude flying aircraft over twenty five years ago. To help understand the problem, one must look at what happens as a high performance aircraft climbs to and operates at altitudes typically 30,000 to 70,000 feet. At these altitudes air pressure is less than 1/4 that of sea level. As air pressure reduces with altitude, accompanying dielectric strength, or the resistance to arcing, decreases.

Arcing Due to Reduced Atmospheric Pressure

In low voltage electrical connector applications (less than 500 volts D.C.), reduced air pressure presents little concern or special design considerations. But taking, for example, a high voltage connector operating requirement of 10,000 volts D.C., the creep path (arc distance) between two conductors at sea level would be 1/2 inch, and at 70,000 feet it would be 5 inches minimum. If no solution were possible other than the lengthening of creep path, then aerospace high voltage connectors would occupy unreasonable volume and be extremely heavy.

The Solution

To eliminate the need for lengthened creep path, precision silastic seals are incorporated within the connector, effectively blocking high voltage creep at reduced air pressure. Another problem, that of temperature swings between -55° to +125° C typical of aircraft operations, must be considered. Elastomeric materials at these temperatures exhibit compression set, or loss of memory between hot and cold cycles, which can result in voltage creep or breakdown through the elastomeric dielectric. Through proper selection of elastomeric materials and designing the optimum shape, Reynolds connectors can effectively meet the simultaneous exposure of reduced pressure and hot and cold cycling. Reynolds Advanced series of connectors provide the designer with a wide selection of connectors and cable assemblies which will operate with high reliability at 70,000 feet and over a temperature range of -55° to +125° C.

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Connector Selection Criteria

Following are the key parameters to consider when selecting high voltage connectors and cable assemblies from this catalog:

DC Voltage Rating

All the connectors, cable assemblies and cable presented in this catalog have a recommended steady state DC voltage rating. The voltage ratings are based on a number of critical factors:

- Thickness of the dielectric material between the contact(s) and the shell.
- Type of dielectric material.
- Length of the sealed surfaces at the connector interface.
- Geometry of the contacts and cable.
- Amount of partial discharge present.

There are two mechanisms for dielectric failure in a cable assembly: Thermal degradation and gradual degradation of the material by partial discharge. If a cable assembly operates below the voltage that sustains partial discharge, then only the connector insulation components need to be considered in the cable assembly design.

As a quality control procedure, each of Reynolds products are, as a minimum, subjected to a dielectric strength test. The purpose of this test is to subject the connector or cable assembly to a voltage greater than the designed operating voltage. The dielectric strength test values used at Reynolds are shown below:

DC RATING	TEST VOLTAGE
0 to 12 KVDC	150% of rated voltage
12.1 to 20.0 KVDC	140% of rated voltage
20.1 to 30.0 KVDC	130% of rated voltage
30.1 KVDC and up	120% of rated voltage

Current

The steady state current rating depends on conductor material, cross-sectional area, thermal capability and resistivity of the insulation and the proximity of other conductors.

Temperature

The storage, transient and operating temperatures need to be specified in order to select the correct insulation material.

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Connector Selection Criteria

Environmental Conditions
The following conditions should be specified:

- **Altitude:** Maximum operating.
- **Temperature:** Both storage and operating, with dwell times, if known.
- **Humidity and Moisture:** Military Standards should be specified when applicable.
- **Radiation:** Specify the type, level and dose rate.
- **Hermeticity:** Specify any differential pressure condition and the acceptable leak rate.
- **Hot and Cold Cycling:** If hot and cold cycling is required, specify extremes, dwell time, rate of change and number of cycles.
- **Dielectric Fluids and Gases:** Fluids should be specified with the degree of exposure. Exposure can range from vapors, to splash, to total immersion. Specify whether or not the connector is required to seal the dielectric from escaping.

Mechanical
- **Size:** Specify the maximum envelope size for the connector plug, receptacle and the mated pair of connectors.
- **Vibration and Shock:** Unusual or excessive vibration or shock levels will require an engineering analysis.
- **Cable Routing:** Whenever possible, a mockup of the cable or harness assembly should be made to observe possible abrasion points, cutting surfaces and excessively acute bends.

Cable Assembly Length Tolerance:

Length (“L”dimension)	
7 1/2' or less	+/- 1/4″
7 1/2' to 12 1/2’	+/- 1″
12 1/2' to 22 1/2’	+/- 1 1/2″
22 1/2' to 35'	+/- 2″
35’to 50'	+/- 3″
50’to 70’	+/- 4″
70' to 100'	+/- 5″

Selection Assistance
Reynolds Engineering Department personnel and your Reynolds Representative will assist you in selecting the best Advanced series connector for your application. In the event a catalog connector or cable assembly will not satisfy your requirements, we will be pleased to submit a proposal for a design to meet your requirements.

Design History of High Voltage Connector Interfaces

High voltage connectors consist of some of the same components as general purpose connectors. There are, however, fundamental differences that set them apart. The Advanced interface connector series is the latest in the evolution of high voltage connectors developed at Reynolds Industries. Figure 1 illustrates this evolution. A discussion follows:

Figure 1A

These connectors, designed for sea level use, were the industry standard prior to 1960. Whenever the connectors were required to operate at reduced atmospheric pressure, the recommended procedure was to apply generous amounts of silicone grease to the interface of the receptacle.

Figure 1B

Reynolds added molded annular seals to the nose of the plug shown in Figure 1A to provide an altitude seal. This worked well except that reliability became marginal at extremely cold temperatures. Reynolds later introduced a special compound of silicone rubber which improved performance under these conditions.

Figure 1C

In 1963, Reynolds introduced a sub-miniature high voltage connector in which a hard plastic nose was used to compress an ‘O’ ring at the base of the male receptacle pin to provide an altitude seal. This same interface concept is used by other high voltage connector manufacturers. This design can lead to compression set of the ‘O’ ring.

Figure 1D

The conical interface works well even though compression set of the elastomer plug insulator member can create the same compression set problems described in Figure 1C. This was improved by Reynolds with the addition of the molded-in-place annular ‘O’ rings in the plug. This interface is widely used by Reynolds in multi-pin connectors but usually with a spring loaded coupling ring to compensate for the compression set of the silicone rubber plug insulator.

Figure 1E

The Advanced interface sealing system was invented, developed and placed into production by Reynolds in the 1980’s. The advent of this unique system of high voltage interface sealing solved nearly every known disadvantage of all the connector designs that preceded it in the field of aerospace high voltage connectors. The capability of this interface sealing system to be scaled up or down in size, depending on the operating voltage, provides the components and systems designers flexibility never before afforded in the selection of high voltage connectors and cable. Pages 10 and 11 more fully describe the Advanced Interface sealing system and the Advanced group of connectors.

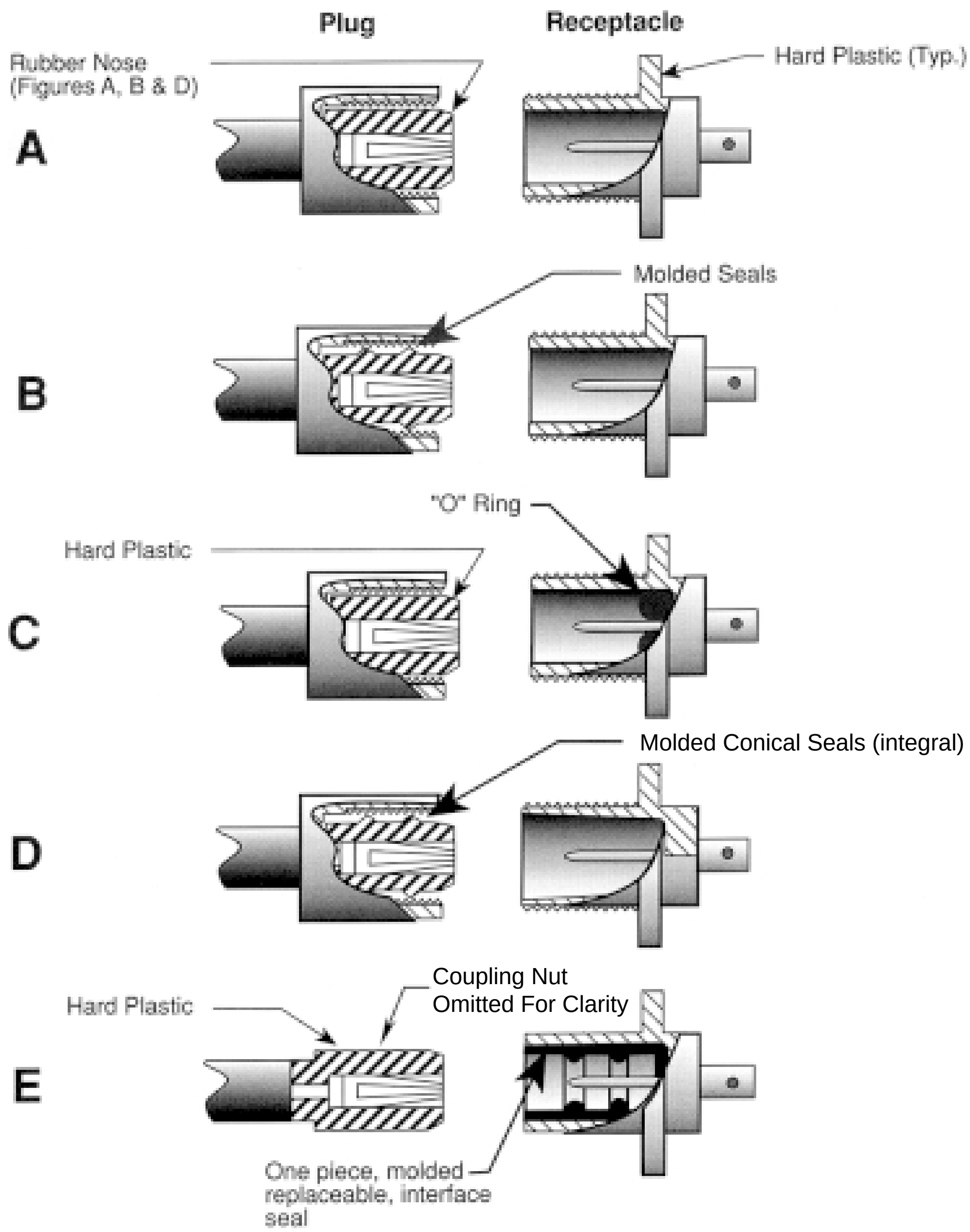

Plug
Receptacle
Rubber Nose
(Figures A, B & D)
Hard Plastic (Typ.)
A
Molded Seals
B
"O" Ring
Hard Plastic
C
Molded Conical Seals (integral)
D
Coupling Nut
Omitted For Clarity
Hard Plastic
E
One piece, molded
replaceable, interface
seal

FIGURE 1

Advantages

The Advanced group of connectors offered in this catalog consists of nine series of connectors. The series are basically distinguished by voltage rating which, in most cases, affects the size. Following are the more significant advantages of selecting from the Advanced group of high voltage connectors in this catalog.

Interface Sealing

Figure 2A illustrates a series of one-piece, molded silicone seals. These seals are molded from a proprietary blend of MIL STD silicone rubber which allows the seal to function over a temperature range of -55° to +125° C. Because the seal is a separate component of the connector, it can be individually inspected, tested and installed. In addition, a defective or damaged seal can be removed and replaced. This is not the case in conventional high voltage connectors where the insulator is one piece and a failure of any one pin or circuit usually results in the entire connector or, worse yet, a total cable assembly being scrapped or subjected to a costly repair operation.

Scaling

The unique design of the Advanced interface sealing system permits the size of the seal and the connector to be scaled up or down to accommodate higher or lower operating voltages and larger or smaller mounting spaces. Our largest seal is in the Max and Maxxum series and the smallest in the JR series. Figure 2A illustrates the seals.

Mating

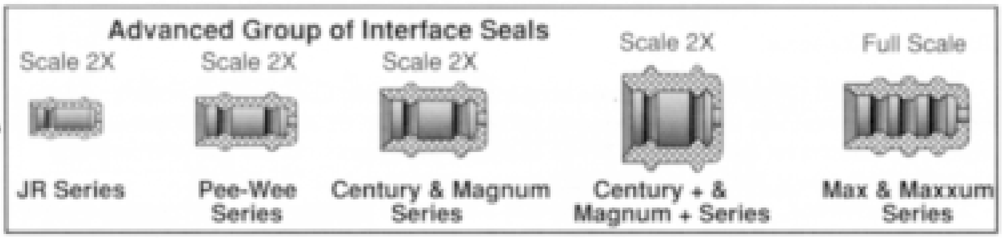
Conventional high voltage connectors require very high mating torque levels in order to effect and maintain an axial high voltage seal. In addition, they must continually compensate for the effects of compression set which is common in connectors using a cone shape or axial compression to achieve a seal. Compensating devices are expensive, bulky and often require special tools and even gauges to reliably mate the connectors.

Connectors using the Advanced interface sealing system require no undue mating forces and no compensation is ever required to maintain the integrity of the mated interface seal. In fact, once these connectors are fully mated, they need only be sufficiently held in place to resist vibration and shock. This is due to the use of redundant radial seals in the Advanced interface sealing system. Once the hard plastic nose of the plug engages the radial rings on the receptacle seal, the high voltage interface seal is complete and will remain so until the plug nose is withdrawn during any subsequent un-mating operation. The engagement of the seal is illustrated in Figure 2B.

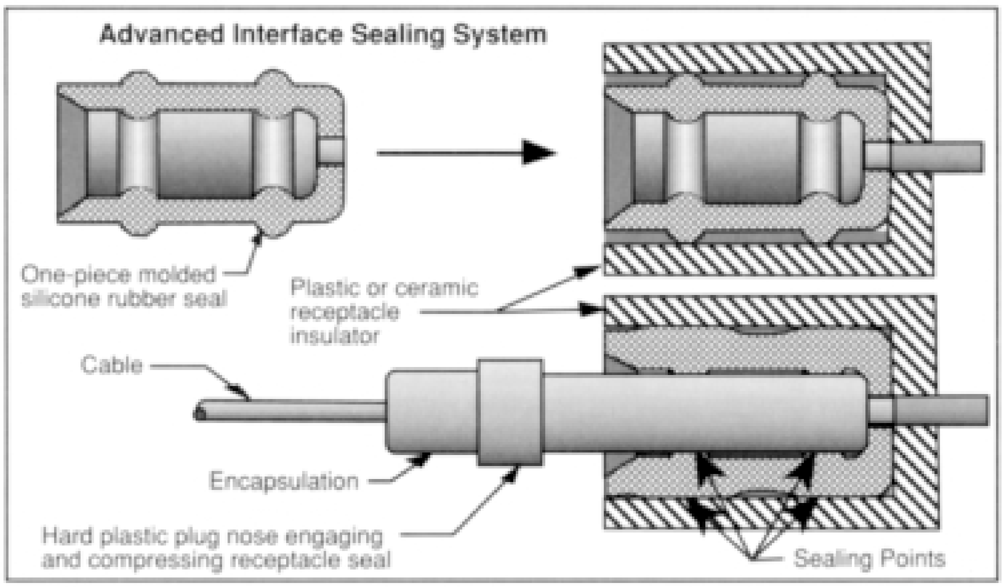
Design Flexibility

Systems and component packaging engineers will find connectors and the appropriate cable in this catalog to satisfy a wide range of voltage and current ratings, shielded or non-shielded, ceramic or plastic, and single or multi-pin configurations. These choices allow the designer to utilize available space and maximize package density. Figure 2C depicts several possible shapes and contact arrangements that can be assembled from products in this catalog.

A


Advanced Group of Interface Seals
Scale 2X
Scale 2X
Scale 2X
Scale 2X
Full Scale
JR Series
Pee-Wee Series
Century & Magnum Series
Century + & Magnum + Series
Max & Maxxum Series

B


Advanced Interface Sealing System
One-piece molded silicone rubber seal
Plastic or ceramic receptacle insulator
Cable
Encapsulation
Hard plastic plug nose engaging and compressing receptacle seal
Sealing Points

C

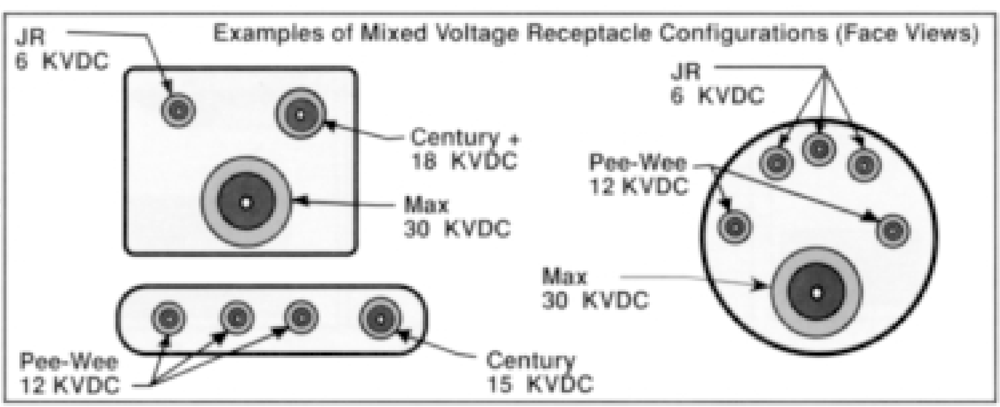

Examples of Mixed Voltage Receptacle Configurations (Face Views)
JR
6 KVDC
Century +
18 KVDC
Max
30 KVDC
Pee-Wee
12 KVDC
Century
15 KVDC
JR
6 KVDC
Pee-Wee
12 KVDC
Max
30 KVDC

FIGURE 2

CRT Information Display Systems
Information Display Systems use CRT’s to display vital information to airplane crew members, and is a rapidly expanding part of the Avionics industry. These display systems typically are either “heads up” or “heads down” and are found in the avionics suites of both military and commercial aircraft. The CRT uses high voltage for the anode element which ranges from 15 to 30 KVDC depending on the size of the tube and whether it is chromatic or mono-chromatic. The high voltage is provided by a power supply integral to the system.

The Anode Interconnect System (traditional)
Figure 3B illustrates the traditional method of interconnecting the CRT anode elements to a high voltage power supply. One end of a .280 diameter silicone rubber cable is connected to the high voltage power supply. The other end is electrically terminated to the CRT anode pin and then potted with a pourable silicone rubber potting material to the the glass envelope of the tube in an attempt to achieve an altitude seal and a moisture barrier. The disadvantages are threefold: (1) A failure to the the CRT or the cable itself results in a costly, labor-intensive process to disconnect and re-connect the CRT. (2) The shape and size of the potting at the anode presents a high profile inconsistent with today’s requirement for compactness. (3) The large cable diameter and the relatively large mass of silicone rubber used to effect a moisture and altitude seal makes a reliable seal difficult after numerous hot and cold cycles due to expansion and contraction.

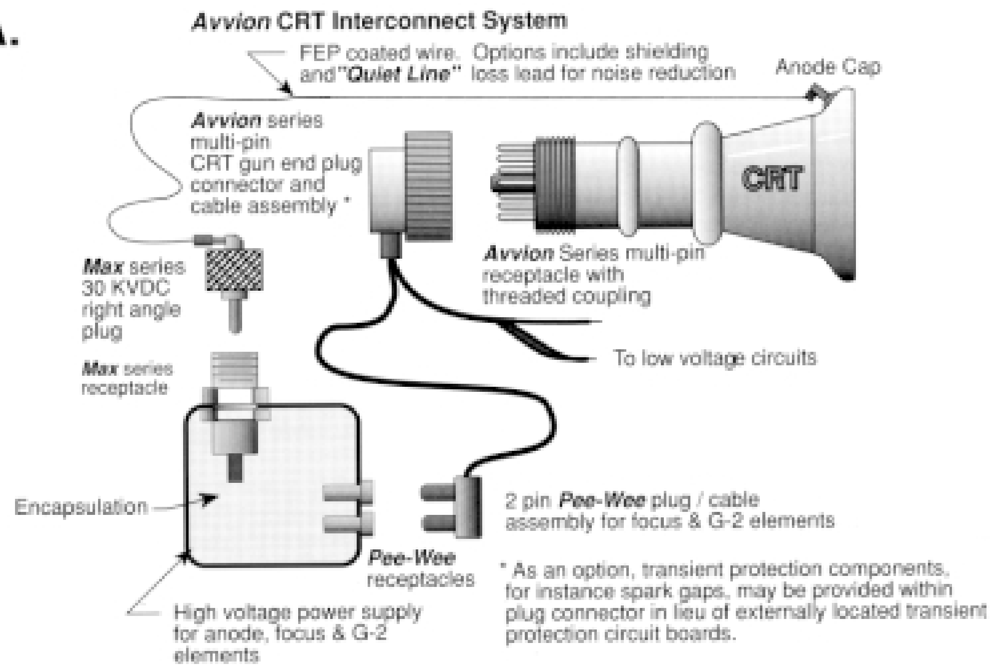
The Max Series Solution
Figure 3A depicts an anode to power supply interconnection using a Max series anode lead assembly that is easy to install, is replaceable and will provide long term reliability. A pre-test of the CRT is possible due to the annular “O” ring on the inner surface of the rubber anode lead cap. Once successful operation is proved, the cup and cap can be pulled off the anode pin and an adhesive applied. When cured, it affords a moisture seal and permits operation at 70,000 feet at the rated voltage.

The Gun End Interconnect System (traditional)
Figure 3B illustrates the gun or stem end of a CRT and how it is terminated. CRT’s have all the gun end elements exit the tube at the base or stem. Wires are soldered to the tube pins and the entire area, the wires, the tube pins and a portion of the glass stem, are encapsulated. Two of the wires, the focus and the G-2 leads, require high voltage and are connected into the high voltage power supply. This method of construction makes replacement of the CRT a costly procedure since the silicone rubber must be cut away to expose and replace the wires and the entire assembly re-potted.

The Avvion Series Interconnect Systems
Figure 3A depicts a gun end interconnect system that does away with the need for encapsulation and allows the user to easily install and replace the major components of an Information Display System. The CRT is replaced by un-threading the Avvion series multi-pin plug coupling ring from the receptacle on the tube gun end. The entire harness can be replaced by un-plugging the Avvion series plug, the Pee-Wee series plug and the low voltage circuit plug.

After installation, the Avvion Interconnect system will operate reliably at the rated voltage at 70,000 feet over a temperature range of -55 to +125° C. Avvion interconnect systems are available for a range of CRT tubes depending on the stem size. The Avvion series of interconnect systems begins on page 56.

A.


Avvion CRT Interconnect System
FEP coated wire. Options include shielding and "*Quiet Line*" loss lead for noise reduction
Anode Cap
Avvion series multi-pin CRT gun end plug connector and cable assembly *
CRT
Max series 30 KVDC right angle plug
Avvion Series multi-pin receptacle with threaded coupling
Max series receptacle
To low voltage circuits
Encapsulation
2 pin *Pee-Wee* plug / cable assembly for focus & G-2 elements
Pee-Wee receptacles
* As an option, transient protection components, for instance spark gaps, may be provided within plug connector in lieu of externally located transient protection circuit boards.
High voltage power supply for anode, focus & G-2 elements

B.

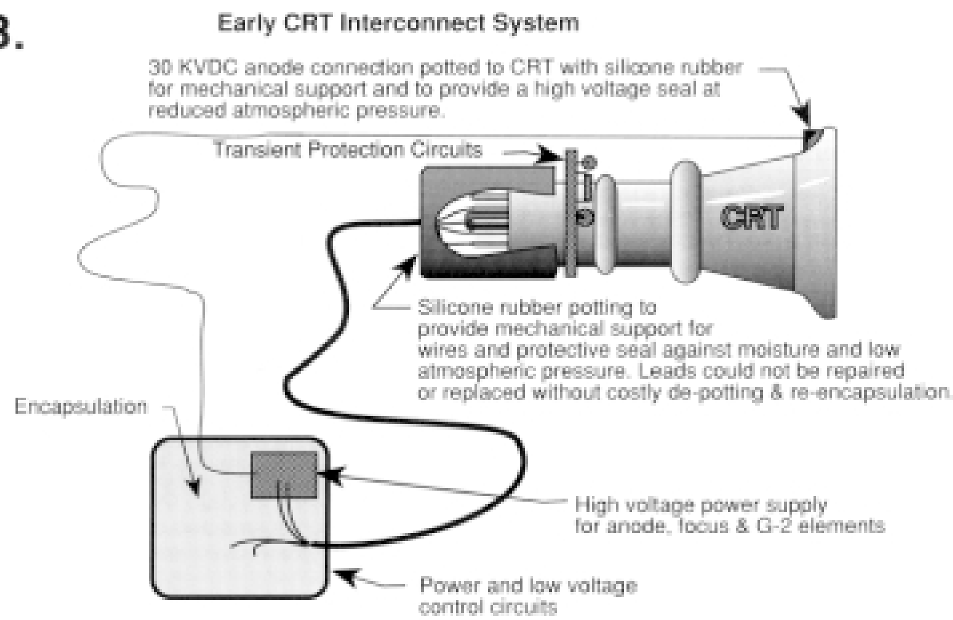

Early CRT Interconnect System
30 KVDC anode connection potted to CRT with silicone rubber for mechanical support and to provide a high voltage seal at reduced atmospheric pressure.
Transient Protection Circuits
CRT
Silicone rubber potting to provide mechanical support for wires and protective seal against moisture and low atmospheric pressure. Leads could not be repaired or replaced without costly de-potting & re-encapsulation.
Encapsulation
High voltage power supply for anode, focus & G-2 elements
Power and low voltage control circuits

FIGURE 3