Crimp Technique

The SUHNER Crimp Technique is a reliable and economic connecting system for RF connectors.

The ever increasing need for RF coaxial connectors, constant shortage of qualified personnel and the need for higher reliability, demands a safe and rational connecting technique. Therefore RF connectors with crimp cable entry («Crimp Technique») gain more and more in importance.

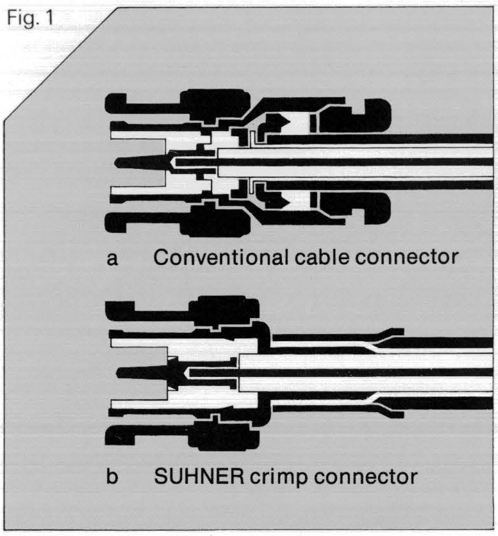
With the crimp technique, conductors and contacts are connected to each other by a single application of defined force. The only accessory needed is a simple, easy to use tool.

Contents:

The demand for an improved connecting technique

Conventional connecting techniques require soldered inner connections, while the screen contact depends on a pressure joint (Fig. 1).
The soldering requires skill and practice. Excessive heat damages the cable dielectric and can cause eccentricity of the cable's inner conductor. Unacceptable reflections result.
A satisfactory pressure joint of the cable's outer conductor is achieved with several components. This means complicated stripping, awkward assembly, and possibly assembly mistakes.

Fig. 1



The requirements for a better connecting technique are accordingly:

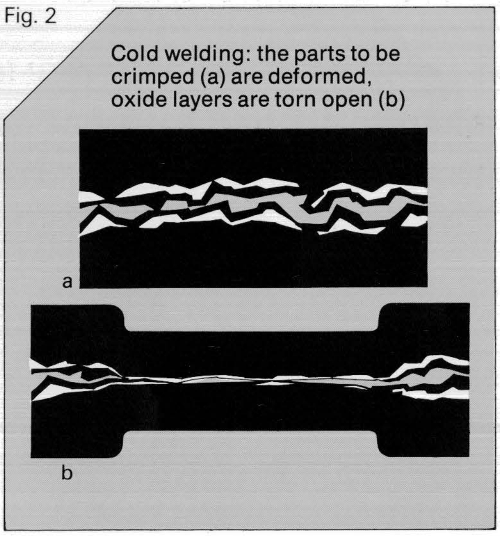
- simple assembly, shorter assembly time
- no heat effect
- less components
- increased reproducibility, i.e. quality independent of the skill of the assembly personnel

A reliable contact and sufficient mechanical strength must obviously be maintained.

Cold welding replaces soldering

Object of the crimping process is the achievement of a positive mechanical compression and cold welded connection. The effect of the force applied by the crimping tool on the contact components must be maintained after crimping.
This is the case when the originally soft connector parts harden during the crimping process and are thereby permanently deformed.
The crimp action should result in a high degree of cold welding between connector parts and cable. For this the metal parts to be connected must be brought within atomic spacing. They are then held by the occurring van der Waal forces (dispersion forces) and partly form a continuous metal structure.

Fig. 2



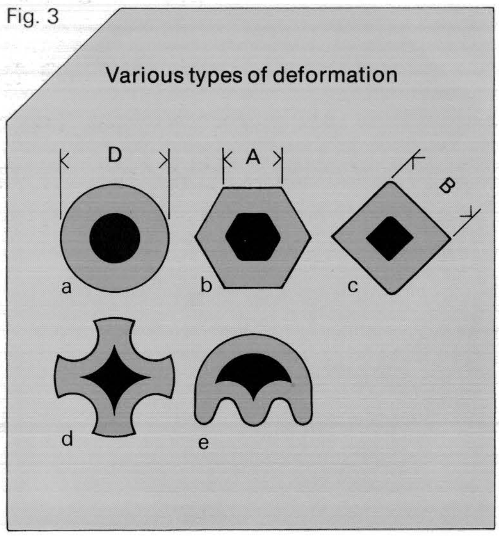
An approach to the required spacing is only possible through deformation of the components. Thereby the surface is smoothed (Fig. 2) and the oxide and impurity layers are torn open.
Good cold welding and high contact pressure require accordingly:

- largest possible deformation
- use of soft materials
- clean, oxide- and grease-free surfaces

Crimping inner conductor

Excessive deformation of the contact parts leads to a mechanical weakness, embrittlement and cracking of the crimped joint. With coaxial connectors the effect is aggravated, in that, for reasons of impedance matching, much deviation from the circular form is not possible.
Hence only type b and c of the deformations shown in Fig. 3 are suitable for RF connectors. Moreover, soft materials (e.g. copper) cannot be used for contact pins and contact sockets.
Tests made with square and hexagonal crimpings prove that unacceptable embrittlement or formation of cracks occurs, as soon as the circumference of the crimped part becomes smaller than that of the uncrimped part.

Fig. 3



The basis for dimensioning crimp joints with maximum acceptable deformation is: $D\pi = 6A = 4B$.
Assuming this law of equal periphery, the cross-sectional area of a square is 78.6% of the original circle area (area deformation degree), but is still 90.5% for a hexagon.
The area reduction for square crimping is accordingly 2.25 times as large as for the hexagonal crimping!

Crimping outer conductors

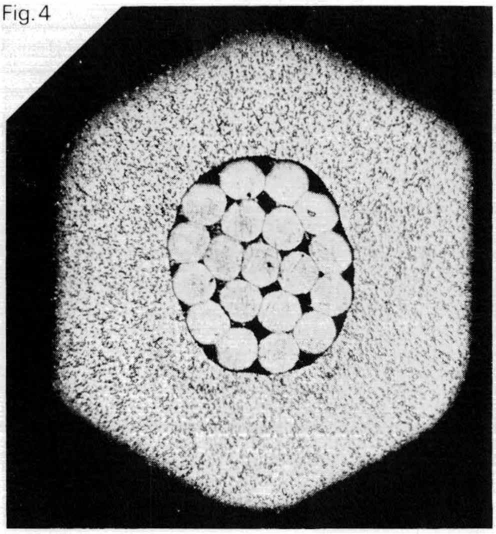
This means a considerably greater pressure effect on the conductor to be connected, a better cold welding and therefore a connection of higher reliability.
Fig. 4 shows microsections of hexagonal and square crimpings (RG 58 C/U, BNC) which were both dimensioned according to the law of equal periphery. The force necessary for crimping is in both cases 320 kp.

In Fig. 5 are shown the results of a series of tests on crimped inner conductors of series N connectors and RG 214/U cable. The relationship of crimp recesses to the uncrimped pin circumferences are given as percentages, and are shown relative to the pull out force. Optimum results are achieved with circumference ratios of 100% to 104%.

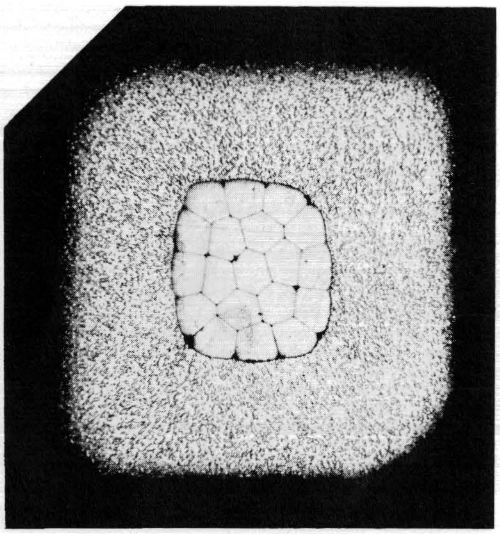
Here the same points of view apply. The wires of the cable screen are pressed on to the crimp spigot by means of an additional ferrule (Fig. 6). The crimp spigot must be of sufficient strength not to be deformed or flattened under the crimping pressure.

For obvious reasons, hexagonal crimping is used exclusively. The law of equal periphery is again valid for dimensioning. It is especially advantageous to provide the crimp spigot with a knurl in order to obtain an additional form of locking.

Fig. 4

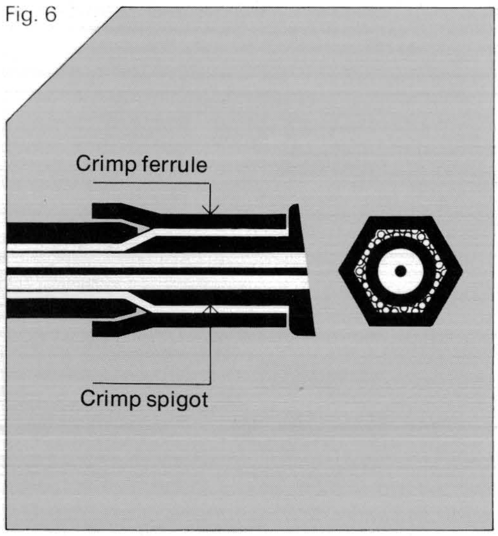


Crimping in accordance with MIL-C-39012, Category D, Pin 16–10
Pull-out force: 7 kp



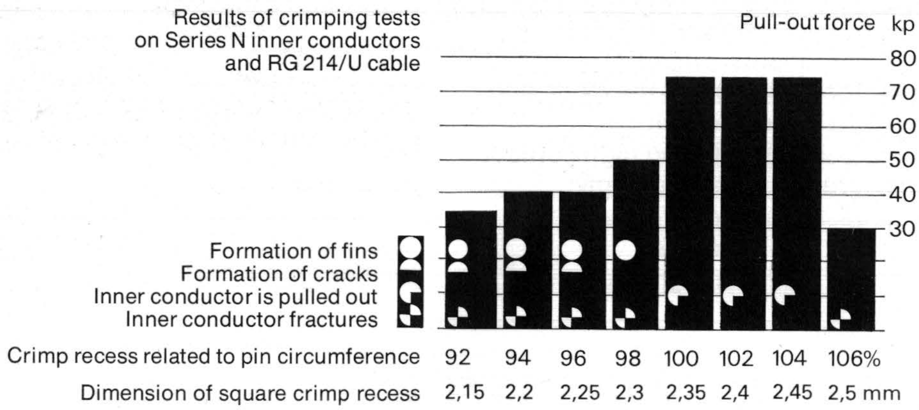
SUHNER square crimping
Pull-out force: 12 kp

Fig. 6



Crimping outer conductor

Fig. 5



High demands on material, dimensions and tools

Narrow tolerances and accurately controlled materials, together with connectors, cables and tools made to fit one another, are indispensable in achieving a reliable crimp connection. The requirements of the crimp inserts are:

- exact maintenance of size
- high strength and hardness
- fine surface finish

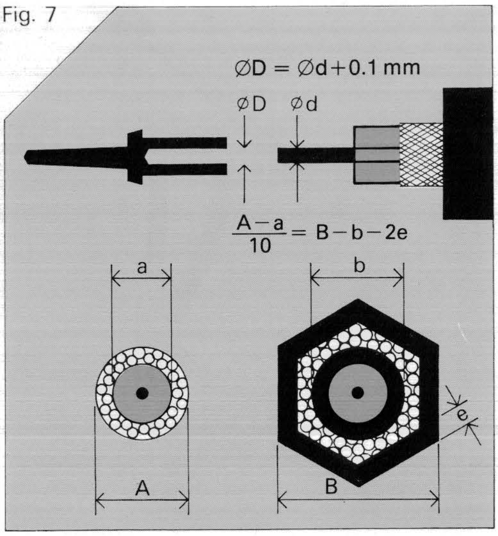
As can be seen in Fig. 5, the best results were obtained with square dimensions of 2.35–2.45 mm. Permissible tolerances of ± 0.05 mm can be derived therefrom. For smaller square dimensions (e.g. for subminiature connectors of the Series SMA, SMB, SMC, SMS) tolerances of ± 0.03 mm are in fact necessary.
The demands upon the crimp inserts are very high. With crimping forces of 300–700 kp (Fig. 10), surface pressures up to 70 kp/mm² occur. Oil or air-hardened steels must therefore be used, which are profile ground in the hard state. This process permits maintenance of size and high surface finish.
The most important requirements of the contact parts are:

- matched exactly to the cable to be crimped
- close tolerances
- use of soft materials with controlled hardness

The dimensions of the crimping components must be individually adjusted to the different RF cables. The formulas shown in fig. 7 are valid as a basis for dimensioning. In order to guarantee a constant quality of the crimped joint, the dimensions of the inner conductor must be maintained to 0.03 mm, those of the outer conductor to 0.05 mm.

D = pin hole
d = diameter of the inner conductor
A = outside diameter of screen
a = dielectric diameter
B = hexagonal width of the crimp ferrule
b = outside diameter of the crimp spigot
e = wall thickness of crimp ferrule

Fig. 7



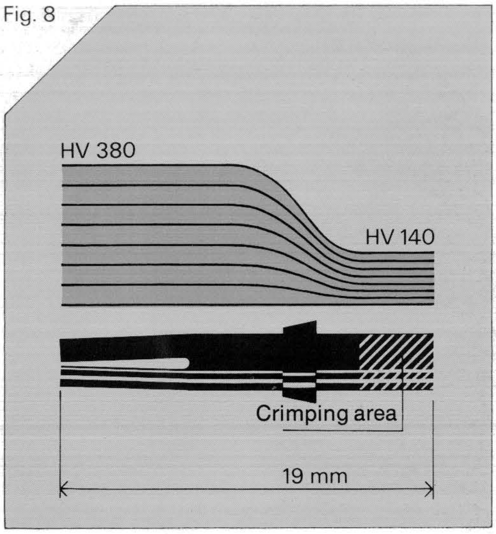
Basic rules for dimensioning crimp components

The components to be deformed should be made of the softest possible material. This allows a strong deformation without embrittlement or formation of cracks. Further, the necessary crimping forces can be kept low, which facilitates the construction of lighter and handier crimp tools.

Soft-annealed copper (HV 40–50) is specially suitable for crimp ferrules. The use of drawn tubes permits the maintenance of a diameter tolerance of ± 0.025 mm, which is difficult to achieve with free-cutting machining.

Centre contacts must be manufactured from a hard, non-abrasive material in order to provide a durable working life. Most coaxial connector specifications specify brass for contact pins and heat-treated beryllium copper (HV 380) for contact sockets. To make satisfactory crimping possible despite this, these parts are either made of different materials or partially annealed. This partial annealing involves complicated methods (e.g. RF induction heating), results however in contacts with greater conductivity and higher reliability than bonding various metals.

Fig. 8



Hardness profile of a partially annealed contact socket

Crimp tools are precision tools

The following points should be noted concerning coaxial cables:

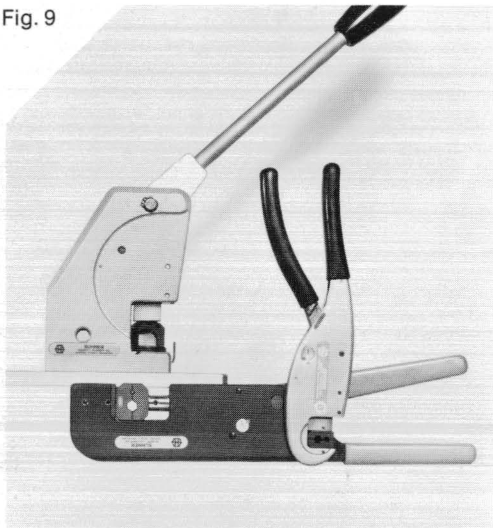
- Use only cables for which the appropriate crimp connector is specified
- Use only cables which correspond exactly to the respective standards

Crimp connectors for all standard cables (MIL, VDE, UR, CCTU, etc.) are available in proven designs today. The user should however verify in every case that the cable used corresponds to the given standard.

Should a crimp connector for a non-standard cable be required, it is advisable to contact the connector manufacturer.

With the dimensioning of connector components, crimp inserts, and the selection of materials and type of cable, the force necessary for crimping has been determined (Fig. 10). The crimp tools must be constructed to withstand this force without overstressing the tool frame. A small amount of flexing which results in an air gap between the inserts in some cases cannot be prevented. It must however be kept within controlled limits. It must be taken into account when dimensioning connector components and inserts.

Fig. 9



SUHNER crimp tools

Crimp tools should withstand a maximum crimp force of 1000 kp with a 1.5 safety margin. This dictates the use of high-tensile materials for practically all tool parts.

The exact alignment of the crimp inserts is of the utmost importance. Inserts that are mis-aligned in any plane cause formation of fins, cracks or insufficient crimping.

In order that the crimp process is concluded in every case, crimp tools must be provided with a ratchet, which permits the tool to be opened only after completion of the crimping cycle.
If the crimping cannot be concluded (e.g. using a wrong connector component), an emergency release must be provided to make interruption possible. This interference must however be detectable afterwards (seal).

Crimp tools are precision instruments. They determine to a great extent the quality of the crimping. Therefore only tools clearly recommended by the connector supplier should be used.

Severe tests demonstrate the reliability

Before SUHNER crimp connectors are released for manufacture and use by the customer, they are submitted to severe tests. Certain tests are repeated periodically on production batches.

Crimping force
This measurement is made on a bench press with built-in force transducer. In addition the distance between the inserts is recorded in order to obtain a force/distance diagram (Fig. 10).

Pull-out force (holding-force of cable)
This measurement is made on a tensile tester. This is one of the most important measurements. Besides the absolute magnitude of the force, the type of fracture is of interest. Where possible fracturing of the centre conductor or braid wires is aimed at. In the case of pulling-out from the connector, the pull-out force should be at least 80% of the tensile strength of the cable (Fig. 10).

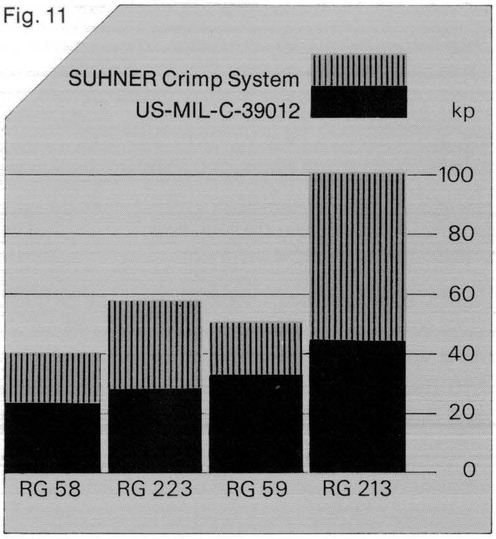
Fig. 10

Cable	Crimp force Inner conductor kp	Crimp force Outer conductor kp	Pull-out force Inner conductor kp	Pull-out force Outer conductor kp	Pull-out force of complete connector kp
RG 196	400	400	3	9	11
RG 188	400	400	8	11	18
RG 58	370	600	12	33	40
RG 223	370	650	14	47	55
RG 59	425	500	14	45	50
RG 213	320	680	75	75	100
RG 214	320	600	75	85	100

In Fig. 11 the values attained with optimum dimensioning are compared with those required by MIL.

Resistance of the crimp joint
The resistance between the cable and the crimped contact is measured (inner or outer conductor). In order to exclude thermal voltages, the measurement is carried out at 1 kHz. The voltage applied across the crimp joint is 200 microvolts, the current is limited to 150 mA.
The measurement of the resistance is usually carried out after the temperature tests.

Fig. 11



Microsection
A microsection of the crimp joint gives information on the degree of deformation and cold welding (Fig. 4).

Temperature shock
(in accordance with MIL-STD-202C/107B)
The specimens are exposed several times to a temperature shock (−55° to +200°C). Cracks due to overstressing during crimping will come to light. After the test resistance and pull-out force are measured.

Temperature cycling
(in accordance with MIL-STD-202C/102A)
This is an accelerated life test which includes several cycles −55°C/18°C/125°C. Subsequently resistance and pull-out force are measured.

High temperature storage
This test also simulates aging of the crimp joint. The specimens are exposed for 1000 hours to a temperature of 125°C and continuously loaded to 1 A DC. After the test the resistance and pull-out force are measured.

Corrosion test
This test is to determine the degree of cold welding between connector parts and cable. The specimens are exposed to 0.5% concentrations of H_2S and SO_2 (24 hours each). The resistance is then measured.

Results of tests on Series N inner conductors and RG 214/U cable

	Crimp force	Crimp joint resistance before	Crimp joint resistance after	Pull-out force before	Pull-out force after
Temperature cycling	approx. 350 kp for all specimens	0.06 mΩ	0.03 mΩ	Inner conductor fractures at approx. 75 kp	Inner conductor fractures at approx. 75 kp
Temperature shock		0.03 mΩ	0.03 mΩ		
High temperature storage		0.05 mΩ	0.02 mΩ		
Corrosion test		0.05 mΩ	0.06 mΩ		

SUHNER Crimp Technique: economical, reliable, simple

The SUHNER crimp technique completely fulfills the requirements for a better connecting technique as outlined at the beginning:

- The quality of the connection remains constant from connector to connector. It is almost independent of the skill of assembly personnel.
- Crimp connectors are simple in construction and therefore favourable in price. SUHNER crimp connectors are supplied as only 3 individual components! (Fig. 1b).
- Crimping means reduced assembly times, personnel training and inspection. On average the assembly time is 40–50% shorter than with conventional connectors. Even for small batches it is economical to purchase a crimping tool and use crimp connectors.
- The SUHNER crimp technique does not impose any heat effect on cable or connector. The assembly can be carried out anywhere, even where no power is available: in the open, on building sites, at sea, and places with explosion hazards.
- The SUHNER crimp technique requires only 5 different crimp inserts for the preferred cable and connectors series.

SUHNER Crimp tool size	Connector series	Cable types (e.g.) single screen	double screen	Diel. ∅ of cable
1/2 A	SMA, SMB, SMC, SMS, BNC, MCX, QLA	RG178, RG196	—	1 mm
		RG174, RG188 RG316	K02252-d	2 mm
2 B	SMA, BNC, TNC C, N, UHF, M, H4, SHV	RG58 RG141 RG303	RG223 RG142	3 mm
2 C	BNC, TNC, C, N, UHF, M, H4, SHV	RG59	G04233-d	4 mm
2 D	N (75 Ohm)	RG11	RG216/U	7 mm
3 D	C, N, UHF, 7 – 16	RG213	RG214	7 mm