Forming and Welding Line for Radio Frequency Cables

UNIWEMA® RF
The specifications for radio frequency cables (RF cables) either require smooth aluminium or copper outer conductors or corrugated copper outer conductors. For special applications, i.e. mainly bigger diameter RF cables, also the inner conductor is specified as a smooth or a corrugated copper tube.

It is obvious that the quality of the outer and inner conductor very much contributes to the quality of the complete cable. This refers both to the electrical as well as to the mechanical characteristics such as

- return loss performance (VSWR)
- conductor resistance
- attenuation
- shielding (to minimize system interference)
- intermodulation performance
- bending radius
- flexibility
- tensile strength
- transverse stability

Of course, for different types of RF cables the specified values of these characteristics are different. However, conductors with a tight and even butt welded seam without any burrs or beads, with a surface without marks and, when corrugated, with consistently good helical or annular corrugations without kinks and marks are always a precondition to achieve the specified characteristics of the complete RF cable. Periodic production irregularities with an amplitude of more than approx. 0.25 % are not allowed as they effect the characteristics of the RF cables and limit their range of application.

The new UNIWEMA® RF process is a further stage of the standard UNIWEMA® incorporating the latest RF cable production experiences of reputed RF cable manufacturers. It perfectly meets the requirements of reliable and economic production of smooth and corrugated conductors for RF Cables.
The UNIWEMA® Process

The UNIWEMA® process is designed to produce from a metal strip a welded smooth or corrugated tube. In this process, a metal strip is introduced into the machine and, in a single operation, the strip edges are trimmed, the strip is placed around a cable core and formed into a tube. The opposing strip edges are butt welded. A special belt type caterpillar capstan located downstream from the welding station pulls the tube together with the cable core through the machine and, if added flexibility is desired, transports it to the corrugator. The perfect coordination of the forming and welding operations with the special caterpillar capstan is a pre-condition for obtaining a uniform welded seam, thus ensuring optimum product quality.

The design and the material of the several stages of the tube forming station are dictated by the characteristics of the metal strip, its wall thickness and the diameter of the welded tube. A precondition for obtaining a good welding seam is the accurate positioning of the strip edges at the welding point. They must exactly meet each other with a minimum gap.

With the TIG (tungsten inert gas) welding method the two strip edges are melted and welded together by an electric arc. The concentrated heat effect of the arc produces a narrow weld area whereby the welding heat is quickly dissipated along the tube surface. The formation of an oxide layer in the weld area is prevented by a protective gas layer. A constant welding current is required to obtain a uniform good quality of the welded seam. This is accomplished by power transistors incorporated in the welding current source.

A current rise control (“Startomatic”) adjusts the welding current automatically to the manufacturing speed. The set welding current vs. manufacturing speed relationship for a given tube or cable sheath can be stored in a computer and retrieved whenever an identical product is to be produced. Restart of the welding operation without any burn-throughs is possible after an intermediate stop.

The standard UNIWEMA® is equipped with a single electrode. In applications where the maximum allowable welding current with one electrode is insufficient for the welding of heavier strip walls or if higher speeds are desired the UNIWEMA® can also be operated with a 3-electrode welding torch (Polyarc welder). For a continuous operation a 2-electrode welding torch (TwinTorch) can be utilized.

As a further development of the UNIWEMA® process we have added a LASER welding alternative which is particularly suited for the welding of thin metallic strips, particularly for small tube sizes.

The belt type caterpillar capstan is an essential component of all UNIWEMA® RF machines. It pulls the tube through the different stations of the UNIWEMA® machine. Especially for RF cable production the caterpillar capstan shall not leave any mark or impression on the welded tube while it has to absorb all torsion forces exerted onto the tube in the subsequent corrugation process. The speed variations, especially the periodical speed variations, have to be better than 0.25%. For a uniform weld seam and thus for an optimum product quality, the perfect coordination of forming tools, welding equipment and caterpillar capstan is an important precondition.

The UNIWEMA® RF belt type caterpillar capstan ensures this performance characteristics.

The caterpillar capstan moves the welded tube to the corrugation unit. A freely rotating corrugating ring which can be adjusted in radial direction and in its angle imparts corrugations to the tube whereby pitch and corrugation depth can be regulated. The corrugated tube grips the cable core tightly. Through the choice of a suitable corrugation tool helical or annular corrugations can be produced.
Several types of UNIWEMA® machines are available, ensuring optimal production conditions for a specific diameter range.

Overview
The machine consists of the following major sub-units:

- Cable core pay-off
- Strip pay-off
- Forming table
- Welding station
- Belt type caterpillar capstan
- Corrugation unit
- Cable take-up
- Electrical equipment
- Accessories for continuous production

Cable core pay-off
Different types of cable core pay-offs can be installed in-line with the UNIWEMA®. We do recommend traversing portal pay-offs which are synchronized with the line speed via dancer.

Strip pay-off
The design of the strip pay-off depends on the packaging of the metal strip supply. For synchronization with the following production stages the pay-off stands are motor driven and dancer arm controlled. It can be supplied with a number of desired accessories, e.g. with horizontal shifting and vertical lift unit.

Forming table
The following sub-units are mounted on the forming table: strip brake and strip edge guide, strip edge trimmer and the strip forming station. The welding torch with a video microscope and a draw-down unit are mounted at the far end of the forming table.

The strip must be completely free of dust and grease and the strip edges must be free of oxides. This is a pre-condition for obtaining a perfect welded seam, which is particularly important in TIG welding. Absence of dust and grease must be ensured by the strip supplier. Likewise, proper storage of the strip coils is essential. In order to obtain oxide-free strip edges, the strip must be slightly trimmed on both sides which is accomplished by rotary knives. The waste strip is then transported over guide rollers to take-up spools located on both sides of the forming table. The waste strip take-up is tension controlled. The width of the cut strip can be adjusted during the operation, thus obtaining the required strip width for the subsequent forming step.

The separate stages of the forming tool are mounted on a base plate and adjusted so that the base plate can be lifted easily and replaced by another set of forming tools, whenever a change of cable type or tube diameter is desired. A complete tool set consists of a base plate with forming stages, guide bushings and the corrugator disc. Change-over from one diameter size to another can be accomplished in a very short time. The cable core, i.e. inner conductor incl. dielectric, enters the pre-formed outer conductor before the final stage of the forming station.

The material, design and the number of forming stages is determined by the strip material, the wall thickness and the tube diameter. If a smooth outer conductor is required it is drawn down to its final dimension after welding through a drawing die.
Welding station

The welding station with the TIG welding head is located in the center of the UNIWEMA® machine. The design concept is based on the requirement for reliable continuous operation of the machine whereby, after a production halt, an automated restart is assured. For this purpose, the welding head is movable in all three directions in its mounting. For the start of the machine, the welding head is moved perpendicularly to the seam to be welded and placed in the working position. From this position, the welding torch is lowered by a motor to a location above the seam and via an electronically controlled distance adjustment placed in the proper working position. It is also possible to move the welding head in the direction of the welded seam to ensure restart without burn-through.

The welding electrode in the welding torch is water-cooled and can be vertically moved. A protective gas is supplied through a nozzle which envelops the welding arc and the weld area in order to prevent oxidation of the melted area and the heated metal surface.

The welding current, protective gas and cooling water are supplied to the welding torch through a cable and in a tube harness. The insertion of electrodes into the welding torch from above makes the change of electrodes particularly easy.

Through a video microscope the tip of the electrode, the arc and the melt can be continuously observed on a monitor.

The Polyarc Welder can be used for special applications. This unit has three electrodes arranged in a row. The torch can be operated with one, two or three electrodes, independent of each other. Each electrode has its own individually adjustable current, protective gas and water supply and can be raised or lowered. This makes it possible to select the optimum welding parameters for a given material, wall thickness and manufacturing rate.

Belt type caterpillar capstan

The belt type caterpillar capstan pulls the welded outer conductor through the different stations of the UNIWEMA® RF machine. By the specially designed belt type caterpillar capstan recurring impressions on the conductor surface are avoided on the one hand, and the perfect coordination of forming tool, welding equipment and corrugator with the capstan is ensured on the other hand.

Moreover, it absorbs the torsional forces generated, for instance, by the subsequent corrugating operation. These performance characteristics are mainly achieved by separately controlled speeds of the upper and lower belt and reproducible operating pressure which is electronically controlled. The belt shows a groove with the same shape as the welded tube, through which the tube is gripped on its full circumference.
**Corrugation unit**
In the manufacture of the corrugated outer conductors the welded smooth tube is conveyed to a chamber where it is rinsed with cooling and lubricating liquids and corrugated by means of a rotating corrugation tool. By this operation either helical or annular corrugations can be produced.

The ratio of corrugator rpm to pull-off speed can be continuously varied, making it possible to produce corrugations of different shape and pitch.

**Cable take-up**
Different types of cable take-ups can be installed in-line with the UNIWEMA® RF. We do recommend traversing portal take-ups which are synchronized with the line speed via dancer.

**Electrical equipment**
Separate motors for the belt type caterpillar capstan and the corrugation unit allow variation of the corrugator rpm independently of the production speed. During operation, the corrugation rpm is automatically adjusted to the pull-off speed so that the corrugation pitch remains constant.

The welding current is supplied through a transistor rectifier. An automatic control (Startomatic) adjusts the welding current to the manufacturing speed. Protective gas for the welding torch is furnished from standard gas bottles and controlled by corresponding devices in the electrical cabinet. For cooling the welding rectifier and the welding current cable, cooling water is supplied by a chiller.

All important functions of the machine can be activated and controlled from a centrally placed control panel. A computer program (PLC) controls the switching functions of the entire electrical system. The PLC system indicates the reference data for the welding operation, including the control of the current rise. The system can also store nine different welding current vs. manufacturing speed characteristics. A text display is provided to indicate faults in the welding and drive electric systems.

Optionally, a remote error maintenance system can be integrated in the machine.

**Accessories for continuous production**
For the manufacture of long continuous lengths of HF cable it is necessary to join strips supplied by the tape manufacturer. This is accomplished by a cross-welding device and a cutting unit (guillotine) which are placed in line between the strip pay-off and the UNIWEMA® machine. The cross-welded seam must meet the same quality requirements as the longitudinal seam produced on the UNIWEMA® equipment.

For continuous operation a dual strip pay-off is needed. Also, in addition to the cross-welder and the cutting unit, a strip accumulator with a straightener is required which supplies strip to the UNIWEMA® during the cross-welding process. This makes it possible to operate without stops.

For continuous production with TIG welding, an electrode change without interruption of the welding process is needed. For this purpose the machine can be equipped with the TwinTorch system, which consists of two welding sources and a special 2-electrode TIG torch.
The small wall thicknesses apply to small tube diameters whereas the heavier wall thicknesses are preferably used with the larger tube diameters. The type of welding system (TIG or LASER) used depends on the required wall thickness and tube materials. If required, the Polyarc TIG welding torch must be employed for heavier walls and faster manufacturing speeds.

*) In addition to these standard UNIWEMA© RF machines also UNIWEMA© RF machines for diameter below 5 mm and beyond 60 mm have been supplied. So far the smallest diameter of an outer conductor produced on the UNIWEMA© RF machines is 2 mm whereas the biggest diameter is 254 mm. For special applications it is even possible to furnish UNIWEMA© machines for larger diameters. The largest machine supplied so far was for a smooth tube diameter of 450 mm.

### Technical Data of Standard UNIWEMA© RF

<table>
<thead>
<tr>
<th></th>
<th>U 25 RF*)</th>
<th>U 60 RF*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smooth Outer Diameter</td>
<td>mm</td>
<td>5 - 25</td>
</tr>
<tr>
<td>Corrugated Outer Diameter</td>
<td>mm</td>
<td>5 - 25</td>
</tr>
<tr>
<td>Standard Wall Thickness</td>
<td>Copper</td>
<td>mm</td>
</tr>
<tr>
<td></td>
<td>Aluminium</td>
<td>mm</td>
</tr>
<tr>
<td>Caterpillar Capstan Speed</td>
<td>m/min</td>
<td>4 - 60</td>
</tr>
<tr>
<td>Corrugator Speed</td>
<td>1/min</td>
<td>8000</td>
</tr>
</tbody>
</table>