

# **RF Crimp Connectors and Assembly**

## **W0TLM Amateur Radio Club Tech Field Day**

**Mike Hoskins, WØMJH  
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# Michael Hoskins, WØMJH

## Presenter Background

- **BSEE 1978, MSEE 1980, Ph.D EE 1983, University of Ill, Champaign/Urbana.**
- **39 yrs experience working as an electrical engineer in RF and uWave integrated circuit development and design**
- **Currently with Analog Devices Inc. developing ultra-wideband microwave sampler and amplifier integrated circuits for high speed A/D and D/A converters (DC - 40GHz)**
- **Involved in emergency preparation for the home for ~5 yrs**
- **Relatively new to ham radio: amateur extra license received  
April 2014**

# Presentation Outline

- **Cable and Connector Selection Tips**
- **Basic Types of RF Connector Assembly Types**
- **Crimp vs. Solder Connectors: the Great Controversy**
  - **My Personal View**
  - **Advantages/Disadvantages of Crimp Connectors**
- **Useful Cable Assembly Tools to Make the Job Easier**
  - **Critical Importance of the Crimping Tool and Die Quality**
- **RF Crimp Connector Assembly Sequence**

# Cable and Connector Selection Tips (1)

- **Recommend choosing the cable first**
  - **Connectors are made for specific cable types/sizes**
  - **Long runs require low attenuation: large cable diameter**
  - **Short runs (like inside the shack) benefit from flexibility: can tolerate added attenuation of smaller cable diameter**
  - **Typical key cable selection criteria:**
    - **Environmental conditions (e.g. underground or inside house)**
    - **Attenuation for frequency range of interest**
    - **Flexibility/routability**
    - **Quality of shielding**

## Cable and Connector Selection Tips (2)

- Life will be much easier if you can standardize on just a few cables/connector combinations
- Example: what I'm using at the W0MJH household
  - Long runs - antenna to house grounding panel, underground runs, etc
    - Davis Bury Flex Underground Cable –LMR400 type with OD=0.405"
  - Short runs - outside panel to inside shack, inter-equipment inside shack
    - Times-Microwave LMR240 Ultraflex (LMR240 type with OD=0.24")

# Cable and Connector Selection Tips (3)

- Choose connector for specific cable
- Type N is superior to UHF connectors (PL-259, SO-239) for impedance precision/SWR, weatherproofing
- Connector standardization can be helpful (keep connector stock)
  - I like to standardize on type N for most cables if possible
  - I use adapters where necessary to convert to different connector types
- All connectors need weatherproofing if outside
  - Highly recommend using marine grade heat shrink tubing with internal adhesive/sealant – nearly bulletproof!

# Cable and Connector Selection Tips (4)

- Some good places I've found to buy connectors and cable
  - Antenna Farm (Online)
  - DX Engineering (Online)
  - HRO
  - RF Parts (Online, my favorite, excellent prices and stock)

# Common RF Connector Assembly Types

- **Full Solder (center conductor and shield)**
- **Full Crimp (center conductor and shield)**
- **Hybrid: Shield Crimp with Solder Center Conductor**
- **Clamp Type: Clamp Shield with Solder Center Conductor)**
- **Compression Connector – provides crimping with waterproof seal (the state of the art in connectors)**
  - **Used extensively in the satellite and cable television industry for RG6 cables**
  - **Recent products emerging for Type N and other formats**
  - **Special tools required, connectors tend to be expensive**



# Crimp vs. Solder Connections?

- **Long running controversy with staunch adherents on both sides**
  - **Solder people typically feel crimp can be susceptible to degraded electrical contact reliability with time**
  - **Crimp people point out the issue of repeated stresses/flexing causing metal fatigue in the solder joint; also have potential issue of dielectric melting**
- **ARRL states that good connections can be made using both techniques when done properly**
- **My opinion: Crimp can be superior to solder if done correctly with the RIGHT TOOLS – most problems with crimp are likely a result of insufficient crimping tool/die quality**

# Crimp Connection Properties

- **Crimp connection: High pressure metal to metal contact resulting in a “cold weld” of metals which is also gas-tight**
  - A proper crimp connection can have electrical conductance as good as solder
  - A proper crimp connection is mechanically strong/stable
    - Resistant to repeated stresses that can induce metal fatigue in a solder connection
  - Crimp connections are used commercially and industrially in countless applications with high reliability (Example: RG6 compression connectors and high current battery terminals)
  - Crimp connections have been the industry standard for auto, aeronautical, aerospace, and marine use for decades.
  - It is reported that Defense Dept. studies concluded they have 10 times lower failure rate than solder connections.

# Crimp Connector Advantages/Disadvantage

- **Key Advantages**

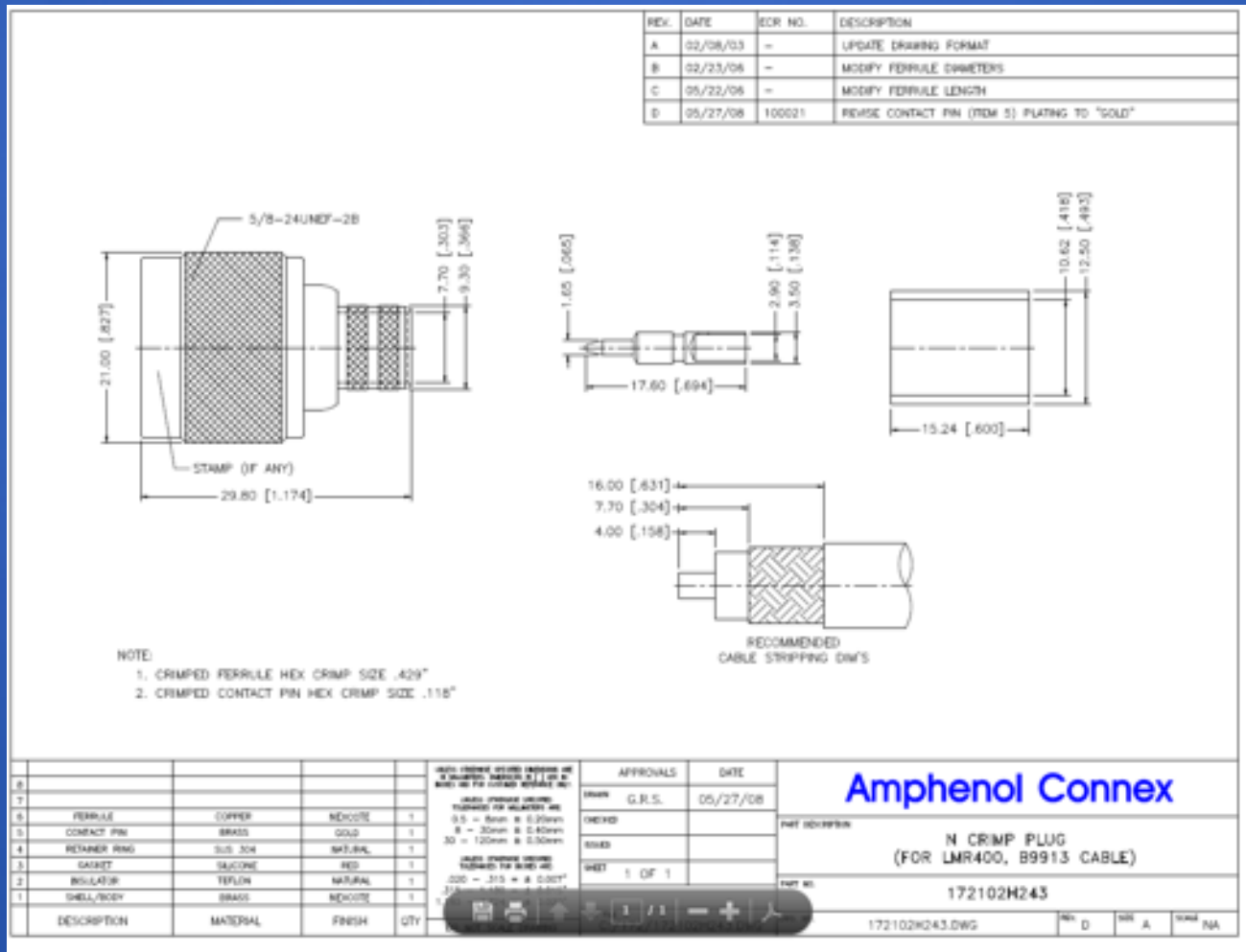
- **Fast and easy assembly**
- **Very repeatable connection quality with the right tools**
- **Amenable to difficult assembly situations (like trees and towers)**
- **Mechanically strong connections, particularly at the shield**

- **Key Disadvantages**

- **It's critical to have a good set of crimpers and dies – these are expensive (there's a lot of junk out there)**
- **Connectors cannot be reused (once assembled)**

# Connector Documentation Example

## Amphenol 172102H243 Type N Connector (for LMR400)



# Crimping Basics (1)

## Flush and Straight!



### PREFERRED

1. Equal compression on all 6 crimp surfaces
2. Crimp die positioned within pin step down

### Defective Crimps



### NONCONFORMING

1. Position of crimp die is outside crimp area
2. Body of pin is no longer concentric
3. Impedance of connector will be affected



### NONCONFORMING

1. Pin has been distorted, is no longer straight
2. Pin has begun to break at crimp Pin shows "dog ear" of excess material
3. Possible cause: wrong crimp die or too much pressure applied

# Crimping Basics (2)

## No Dog Ears!



### FERRULE CROSS SECTION

1. Good ferrule crimps into hexagon shape with equal pressure on all sides
2. Reject "dog ear" causes unequal pressure and excess material forms "ears"
3. Possible cause is wrong crimp die, too much pressure applied or ferrule material too hard

# Crimping Basics (3)

## Shield Crimp Bell Allows Flexibility

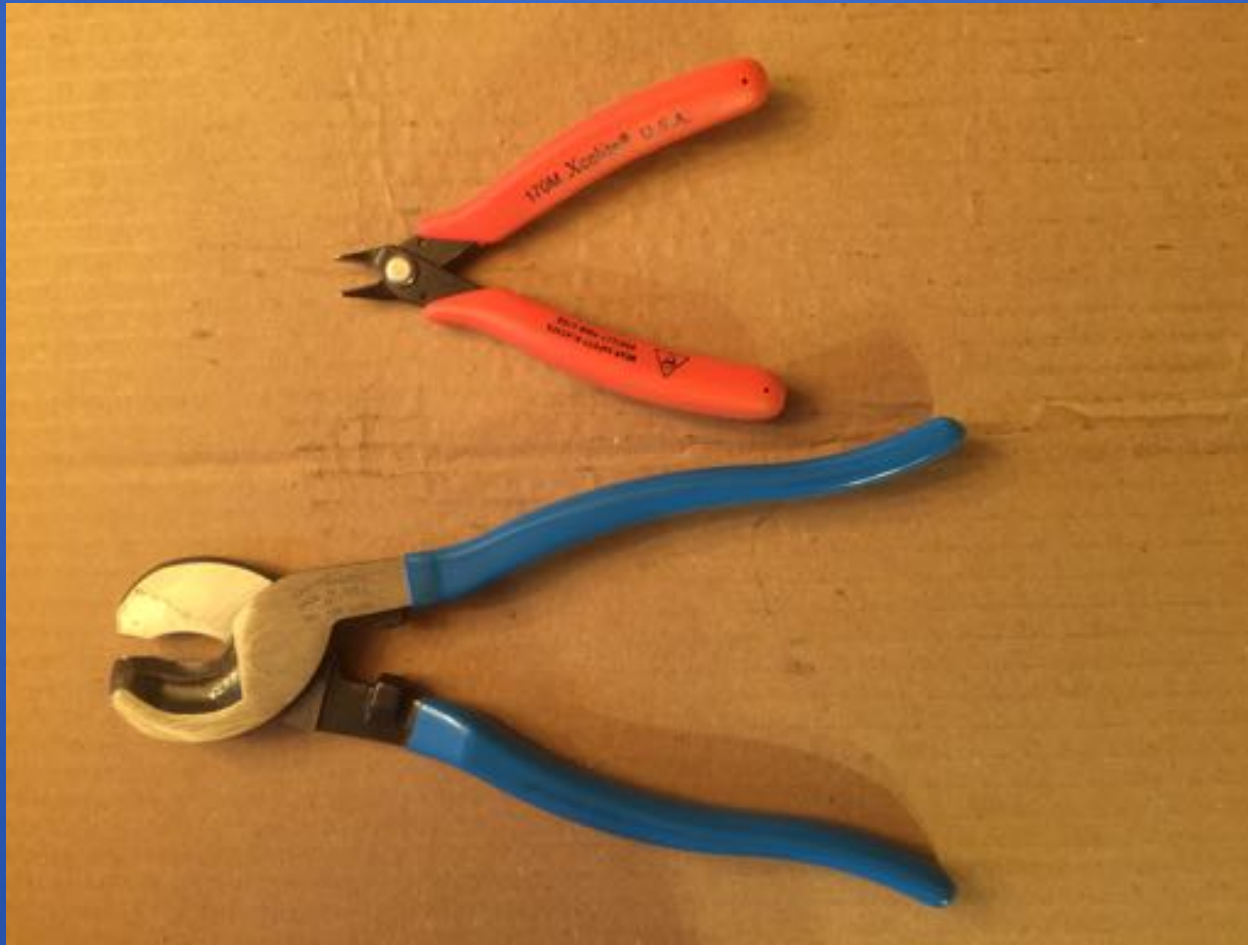


### PREFERRED

1. Crimp die positioned at front of ferrule, near connector
2. Equal pressure from crimp die on all sides
3. "Bell" at rear of ferrule allows cable flexibility

# Useful Cable Prep Tools

## Precision Cutters



Xcelite 170M  
Precision  
Shield Trim

Channellock 911  
Clean + Square  
whole cable cut



# Useful Cable Prep Tools

## Cable Strippers



Cable Devil  
Stripper and  
Deburrer

Cablematic  
Deburring  
Tool

RF Industries  
RFA-4087  
Adjustable  
Multiblade  
Auto Stripper  
(SUPERFAST and  
ABSOLUTELY  
INCREDIBLE!)

# Useful Cable Prep Tools

## Crimpers and Dies



DX Engineering  
Standard Crimper  
Good for center conductors  
and small diameter shields

RF Industries  
RFA-4009-20  
Heavy Duty  
Piston Crimper  
(HIGH QUALITY  
DIES AND CRIMPER  
ESSENTIAL FOR  
GOOD CRIMPS!)

# Useful Cable Prep Tools Crimper and Die Kit



RF Industries  
RFA-4009-200  
Heavy Duty  
Piston Crimper  
And Die Kit

# Useful Cable Prep Item

## Marine Grade Heat Shrink Tubing with Internal Waterproof Adhesive (Up to 3:1 shrink ratio)



Ancor 1" Marine Grade

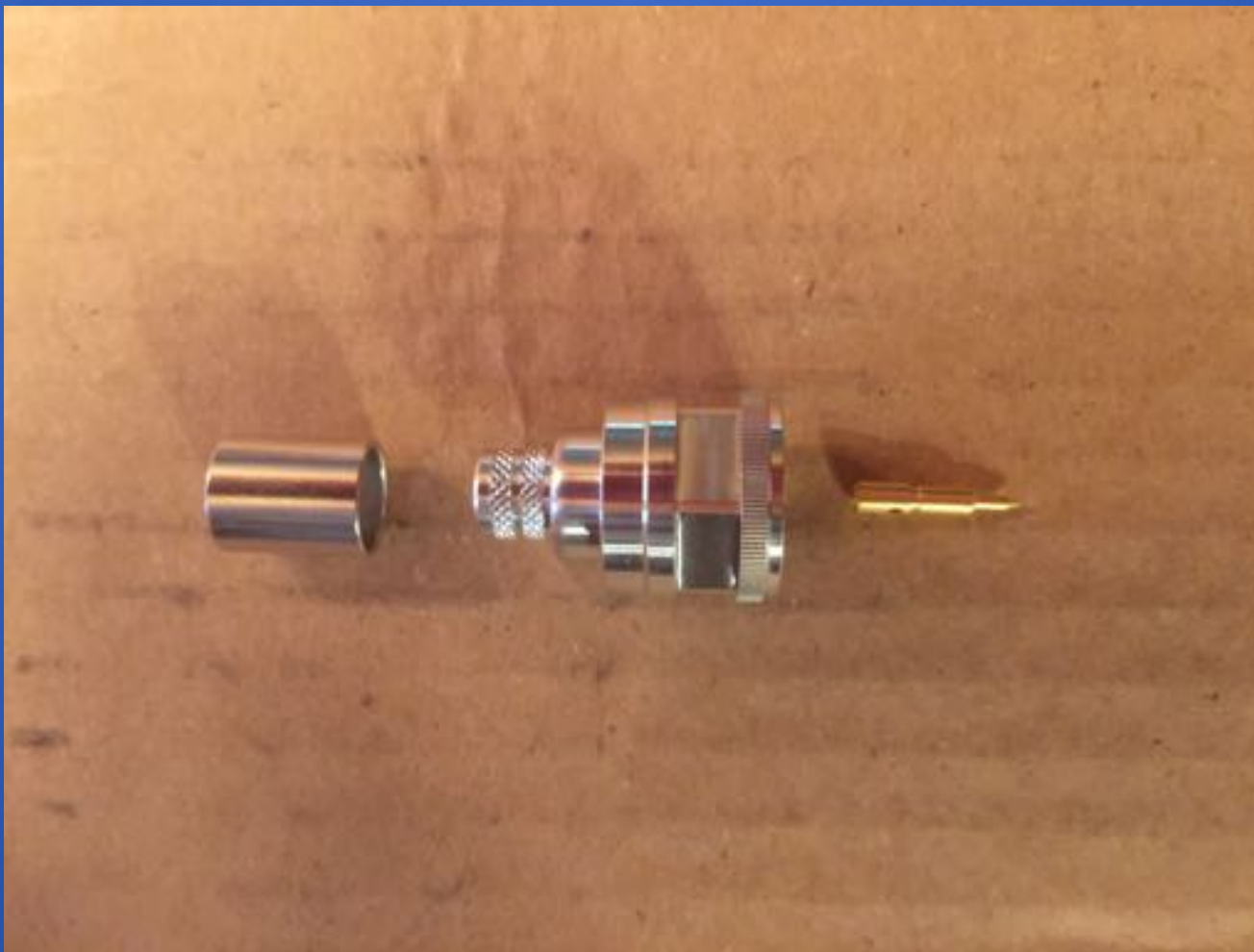
Ancor 3/4" Marine Grade

# Useful Cable Prep Tools

## Heat Gun and Butane Torch for Heat Shrink



# Amphenol 172102H243 Type N Connector Parts (for LMR400)



# Type N Connector Assembly Sequence

## Step 1) Stripped to Spec and Ready for Assembly



Ferrule should be  
on cable now!

# Type N Connector Assembly Sequence

## Step 2) Center Conductor Pin Inserted/Crimped





# Type N Connector Assembly Sequence

## Step 3) Flare Shield Slightly (for Body Insertion)



# Type N Connector Assembly Sequence

## Step 4) Body Insertion till CC Tip Flush with Right Body Edge



# Type N Connector Assembly Sequence

## Step 5) Slide Ferrule over Shield and Crimp



Leave Bell at Cable End of Crimp for Flexibility and Strain Relief!

# Type N Connector Assembly Sequence

## Step 6) 3/4" Heat Shrink in Place



# Type N Connector Assembly Sequence

## Step 7) Heat Shrink Shrunken! (apply heat uniformly)



You're done when tube is uniformly shrunk down and adhesive oozes out of both ends to form watertight seal

# Conclusions/Summary

- **Crimp Technology is Well Accepted in Industry and Government as the Most Reliable Electrical Connection Method for Challenging Environmental Conditions (repeated thermal expansion/contraction and vibration)**
- **High Quality Dies and Crimper are Absolutely Essential for Good Crimps - the larger the cable, the more critical this is.**
- **OHIO! Only handle it once: Use marine grade adhesive lined heat shrink for maximum waterproofing**
- **Consider standardizing on a few cable types and connectors for efficiency and simplicity (Type N connector generically useful)**
- **Questions? Feel free to contact Mike at [acoustiman@comcast.net](mailto:acoustiman@comcast.net)**

# References

1. **ARRL Antenna Book, 22<sup>nd</sup> Edition, ARRL, 2011, ISBN 978-0-87259-694-8**
2. **RF Industries White Paper, Crimp vs. Solder: Pros and Cons, [http://www.rfcoaxconnectors.com/Technical\\_CrimpvsSolder.htm](http://www.rfcoaxconnectors.com/Technical_CrimpvsSolder.htm)**