Southwire®

Services & Solutions

# Rejuvenation Instructions

# #613 – Large Diameter Cables – SPR


**This NRI covers the following:**

- The SPR injection process for large diameter, feeder sized cables.
- How to set up injection equipment.
- How to read the liquid flow meter.

**WARNING: It is dangerous working around energized high-voltage systems, pressurized systems, and chemicals. Always work in accordance to the Novinium Field Operations Safety Handbook (FOSH) or other local governing safety standards**.

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# Documenting Your Craftwork

It is always a good idea to document your craftwork and upload pictures to Knomentous. This is especially helpful for the critical parts of the installation including:

- The post-swage cutbacks against the template (template ID and ~~date~~ visible) including marking tapes.
- Post installation photos, for example showing the alignment of a splice between the marking tapes.
- As-left photos especially of the accessory fully installed in the transformer or switchgear.
- Pictures should have a placard identifying tag or segment number, phase, and pit number.


**Figure 1:** Example of post swage photo.

**Figure 2:** Example of an as-left photo.


**Figure 3:** Example of a post installation photo.

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# Installing Equipment

## 1. Injection tool (IT).

a. Connect 12 to 18 inches of 1/8” tubing to the injection tool.

b. Connect a 1/8” x 1/8” ball valve for typical injections.

c. Install the liquid flow meter (rotometer).

d. Secure the liquid flow meter to the tank that is being used.

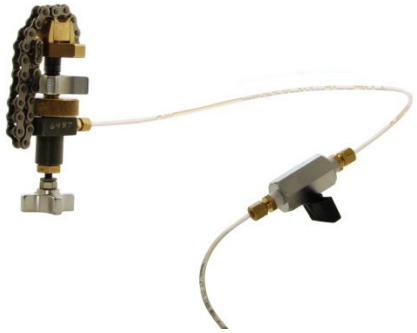

**Figure 4:** Connect a ball valve to the injection tool.

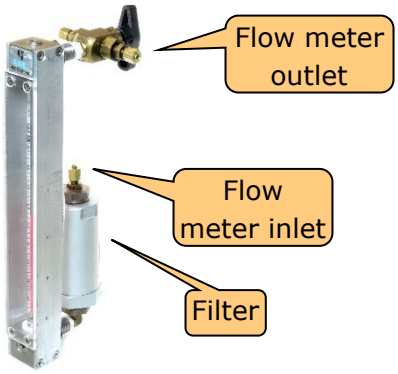


**Figure 5:** Liquid flow meter.

**Figure 6:** Flow meter secured on tank.

e. Connect the tank’s injection port (colored red) to the inlet of the flow meter.

f. Connect the tubing from the ball valve to the outlet of the flow meter.

g. Attach the injection tool to the IA per **NRI 452**.

h. Close all valves on the feed tank, flow meter, tubing, and gas tanks.

## 2. Pressurize feed tanks.

a. Attach an inline pressure gauge to the $CO_2$ regulator of the gas tank that you are using.

b. Select an inline gauge with a pressure range appropriate for the injection.

c. Connect the inline gauge to the feed tank.

d. Wheel the $CO_2$ regulator out to prevent accidental over-pressurization.

e. Slowly pressurize the feed tank to the lesser of the **adjusted flow pressure (AFP)** or to the maximum working pressure rated for the tank.

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- If the AFP isn't known, use **NRI 352** to calculate the AFP.
- The AFP can be increased by 10% for attended operations.
- This helps reduce the effects of any leaks that would have been found if attended.

f. The pressure on both the inline gauge and tank gauge should be close to each other.

g. Check the tank for any leaks.

- If any leaks are found, relieve all pressure immediately and fix the leak.
- A pressure relief valve prevents hardware operation above the design pressure. **Do not** tamper with the pressure relief valve.

## 3. Receiver tanks.

a. On the receiver end of the cable sub-segment, install an injection tool connected to an empty graduated flush bottle with 1/8" tubing. There are many sizes of flush bottles available.

**Figure 7:** Connect a flush bottle to the receiving injection tool.

b. A 140mL aluminum tank with a ball valve may substitute for the flush bottle in normal and unattended injections. The ball valve allows injection to continue while the valve is closed.

**Figure 8:** A 140mL tank with ball valve.

c. When possible, attach the graduated flush bottle for easy measurement of flushed fluid.

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d. If left unattended under any circumstance, place the flush bottle or tank in a basin to prevent accidental spills.

**Figure 9:** Use a spill basin to guard against spills and overflow.

# Pre-Injection Check

## 1. Check for leaks.

a. Before sending fluid straight to the cable, make sure each part of the injection assembly is leak-free.
   - If any leaks are found in the following process, close all valves, relieve pressure, and fix the leak.

b. Double-check that all valves on the feed tank, flow meter, tubing, and gas tank are closed.

c. Open the valve on the feed tank's injection port.
   - This will send fluid to the liquid flow meter.
   - Wait three to four seconds and watch for leaks.

d. Open the valve on the liquid flow meter.
   - This will send fluid to the inline ball valve.
   - Wait another three to four seconds and watch for leaks.

e. If no leaks are seen in the assembly, open the ball valve to send fluid to the injection tool.
   - Watch for leaks coming from the injection tool or the interface between the tool and the IA.

# Recording Tank Levels

## 1. Record the injection start time and feed tank level.

a. Look at the sight gauge and record the feed tank's beginning fluid level in millimeters (mm) from the bottom of the meniscus.

b. Record the time the injection was started.

c. Enter this information into Knomentous.

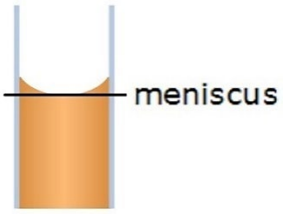


**Figure 10:** Read the level from the bottom of the fluid meniscus.

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# Starting the Injection

## 1. Flow check.

a. Verify flow into the cable by looking at the BBs in the liquid flow meter.
   - The BBs should go to the top of the glass tube when flow starts and then slowly drop as flow stabilizes.
   - If the BBs are dropping rapidly, then there is a restriction in the cable.

b. Verify flow through the cable by checking the tubing on the receiver end of the cable.

c. Build up pressure in the line or submerge it into water.

d. Relieving the built-up pressure should be audible, and air flow should cause bubbles in the water.
   - Bubbles may appear slowly due to restrictions in the cable.

## 2. Flush water and other fluids.

a. If water or other fluids are in the cable, you may need to empty the receiver bottle or tank multiple times during injection.

b. To measure the amount of flushed fluid, transfer all of the fluid to a graduated flush bottle, if not already in one.

c. Let the bottle sit for a few minutes. Water and other fluids should separate if left still.

d. Read the water and fluid levels on the side of the bottle.

e. Record all fluid and water flush and enter the total volume into Knomentous.

**Figure 11:** Transfer all fluids collected in the 140mL tank to a graduated flush bottle.

## 3. Read the liquid flow meter.

- The liquid flow meter tells the volume of fluid flowing through the glass tube every minute. It does this by moving the two small BBs (one black and one silver) in the liquid flow meter's glass tube.
- The black BB is tinted black glass, while the silver BB is stainless steel. The black BB is more sensitive to flow than the silver ball and must be located above the silver BB.
- If the BBs are reversed, clearly label and contact supply chain to exchange for a new liquid flow meter.

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- The backing behind the glass tube has two scales printed on it. The left side, marked with “Silver ball,” is the scale to read the silver BB’s position. The right side, marked with “Black ball,” is the scale to read the black BB’s position. The unit of measurement for both scales is mL/min, which is the same as cc/min.

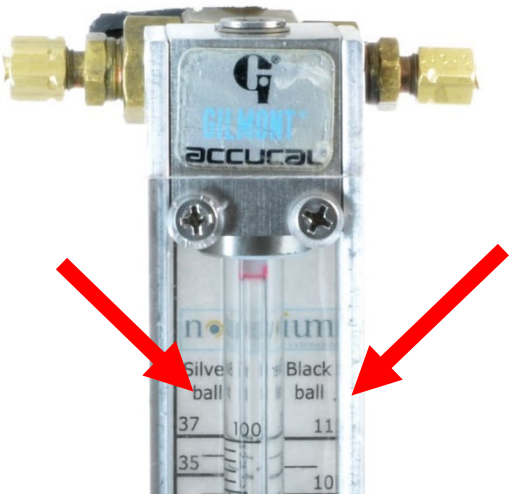


**Figure 12:** Black and silver ball scales.

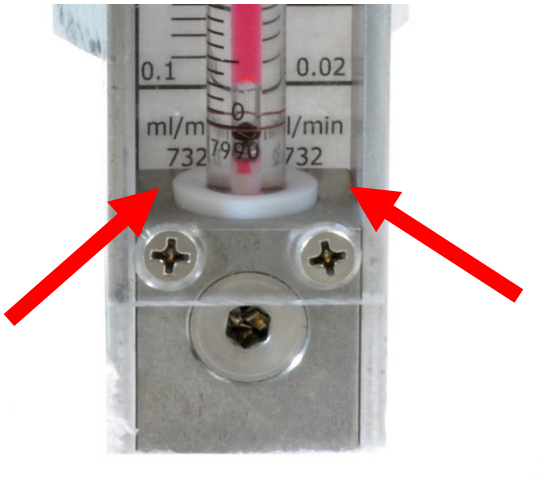


**Figure 13:** Units of both scales.

- When the black BB is above 11 cc/min on its scale, begin using the silver BB and its scale for readings until the black BB drops back below 11 cc/min.

- Monitoring the flow through the liquid flow meter can reveal much about the cable.
  - A gradual decline in flow rate means a clean cable.
  - A sharp drop off in flow rate means a restriction or blockage.
  - A sharp drop near the start of injection is a restriction/blockage near the feed end of the cable.
  - The longer it takes to reach a sharp flow rate drop, the farther the restriction/blockage is along the cable.

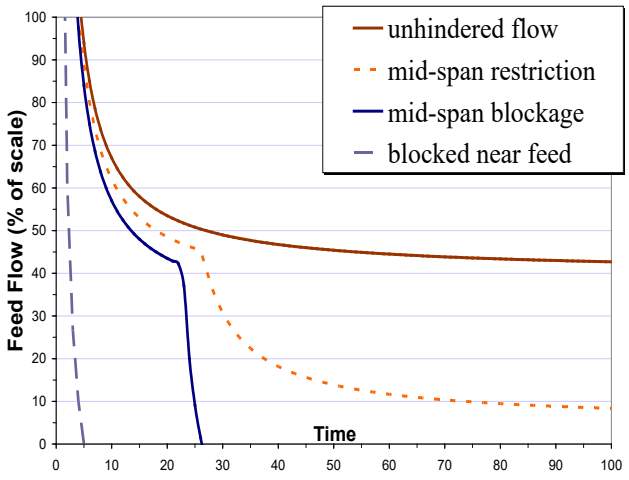


**Figure 14:** Depiction of flow rates.

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# Estimating Fluids

## 1. Estimate the current fluid supplied.

a. Take the current fluid level in millimeters (mm).

b. Subtract the current level from the starting level.

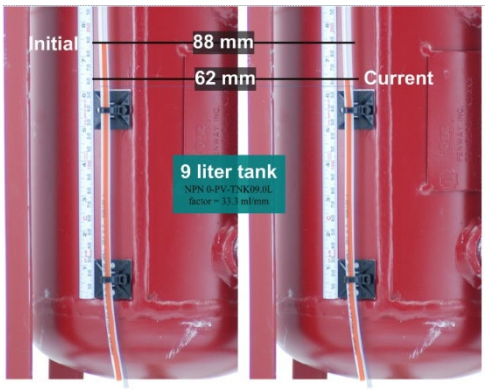


**Figure 15:** Find the start and current fluid level.

c. To find the total fluid volume in cubic centimeters (cc), multiply the difference by the tank factor for the feed tank being used. Tank Factors can also be found on a sticker on the tank or in **NRI 412**.

- **9 Liter Tank Factor: 33.3 cc/mm.**
- **50 Liter Tank Factor: 71.4 cc/mm.**


**Figure 16:** Tank factor sticker.

## 2. Estimate the time for fluid to arrive.

a. Find how much time has passed since the injection began.

b. Use **NRI 302 The Cable Table** to calculate the target fluid amount the cable will take in millimeters of tank height.

c. Divide the calculated target by the millimeters of fluid currently injected into the cable.

d. Multiply this number by the amount of time the injection has currently taken.

- This is the estimated amount of time left for injection.

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# Fluid Arrival

## 1. Flush the cable.

a. Flush any contaminants out of the cable.

b. Continue to flush until at least 25cc of clear, clean fluid comes out of the cable.

**Figure 17:** Flush the cable.

## 2. Reduce the pressure to the tailored injection pressure (TIP).

- Reduce the adjusted feed pressure (AFP) to the tailored injection pressure (TIP) for the insulation type.
    - The XLPE insulation TIP can be found in **NRI 302, "The Cable Table."**
    - If the EPR insulation TIP is needed, calculate by dividing the XLPE TIP by 4.

## 3. Pin the Outlet

a. Close the ball valve to the injection tool to prevent fluid spray.

b. Use the injection tool to insert the plug pin into the IA; then remove the injection tool from the IA.

c. Check the plug pin hole for leaks and tap the pin in if it is not flush.

d. Wrap the saddle chain around a rag to protect and keep debris out of the injection tool.

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# Feeder Cables and Pressurization

**Not all large diameter feeder-sized cables require pressurizing.**

- A cable needs to be pressurized when the conductor's interstitial area is small compared to the size of the insulation.
- In general, 350MCM and larger cables do not need to be pressurized because there is sufficient fluid volume in the strands to effectively treat the insulation.

- The exception is cables of larger insulation thickness. For example, the cable having a higher voltage rating (insulation thickness increases with the rating).
- This means that cables smaller than 350MCM generally require pressurizing to inject a sufficient amount of fluid. Follow the pressurization procedure as stated in **NRI 603 Small Diameter Cables (URD)**.
- If an injection of a feeder cable will continue unattended (overnight), reduce the pressure to half of the TIP or the pressure used for attended injection.

**Figure 17:** Thick insulation compared to the conductor.

## 1. Compare fluid supplied to the target.

The fluid target is the ideal injected amount of fluid in the cable. During normal injection, the fluid floor and target amounts will typically be reached or exceeded.

a. Verify that the fluid injected into the cable is between the floor and target fluid amounts.
b. Find the current millimeters of fluid injected.
c. Find the floor and target millimeters of fluid the cable will take (the same way to find the target when estimating the time for fluid arrival).
d. Compare the current amount of supplied fluid to the floor and target.
e. Continue injection until the fluid floor amount has been reached.

## 2. Pin the inlet.

a. Close the ball valve to the injection tool to prevent fluid spray.
b. Use the injection tool to insert the plug pin into the IA; then remove the injection tool from the IA.
c. Check the plug pin hole for leaks and tap the pin in if it is not flush.
d. Wrap the saddle chain around a rag to protect and keep debris out of the injection tool.

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# Record Tank Levels

1. **Record the injection end time and feed tank level.**
   a. Record the feed tank's ending fluid level in **millimeters** (mm) from the sight gauge.
   b. Record the time the injection ended.
   c. Enter this information into Knomentous.
2. **Remove the injection equipment.**
   a. Close all valves on the injection assembly and turn off the CO2 supply.
   b. Vent all pressure from the tanks if they will be moved or stored for the night.
   c. Open the valve on the feed tank's injection port to vent pressure and fluid from the liquid flow meter back into the feed tank.
3. **The SPR injection process is complete.**

# Resume Component Installation

After SPR injection is complete, component installation can be completed using the associate NRI, template and manufacturer instructions. After the terminations are complete, warranty tags can be attached.

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