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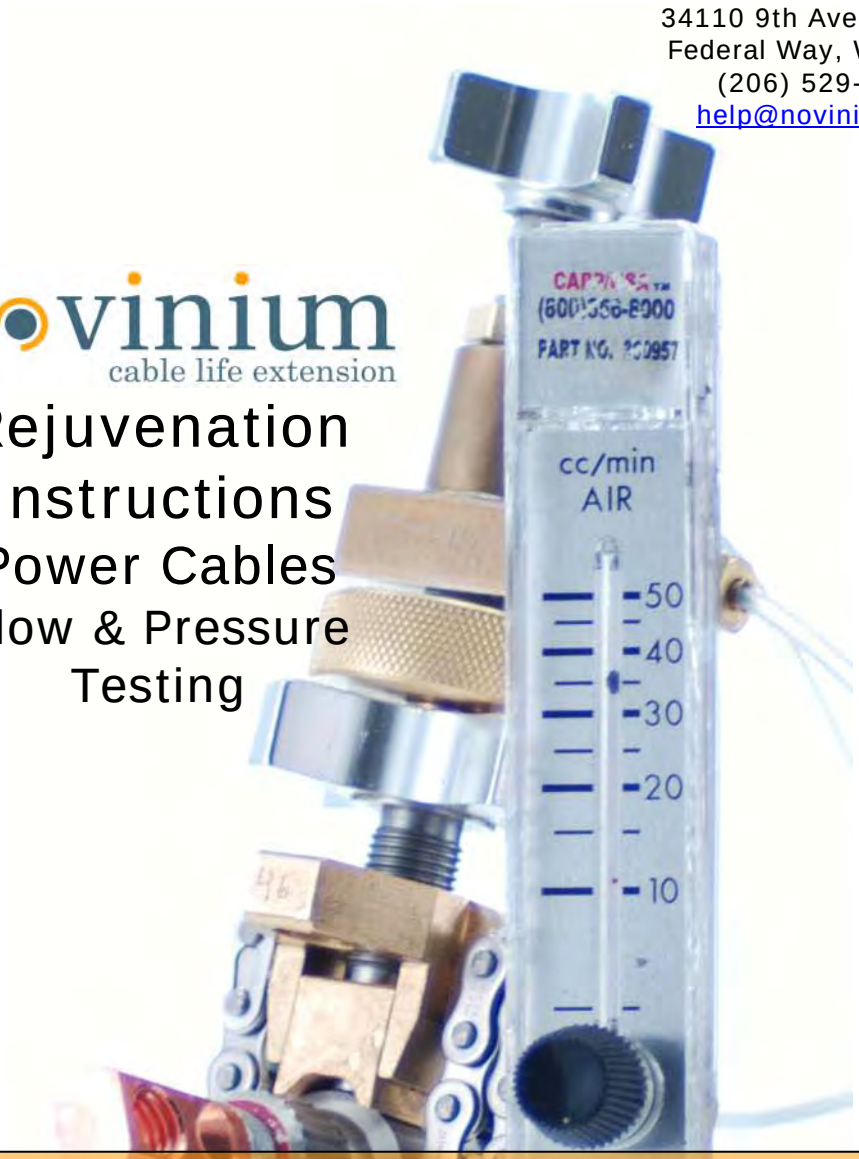


Rejuvenation Instructions

Power Cables

Flow & Pressure Testing

Version 20100607

Flow & Pressure Testing

Each of the numbered testing levels in Figure 1 is an escalation of pre-injection testing. The vast majority (over 95%) of cables to which the Novinium® advanced sustained pressure rejuvenation method (SPR) is applied require no pre-injection testing – level 0. If injection flow problems are encountered or for high value or very long length cables such as submarine cables, it may be appropriate to escalate the level of pre-injection testing as outlined in Figure 1. Each escalating level of testing in Figure 1 is described in the correspondingly numbered instructions on subsequent pages. Each escalation to a higher level should only be executed when the lower levels are completed. The test pressures referred to in this NRI 50 are specified in Figure 2.

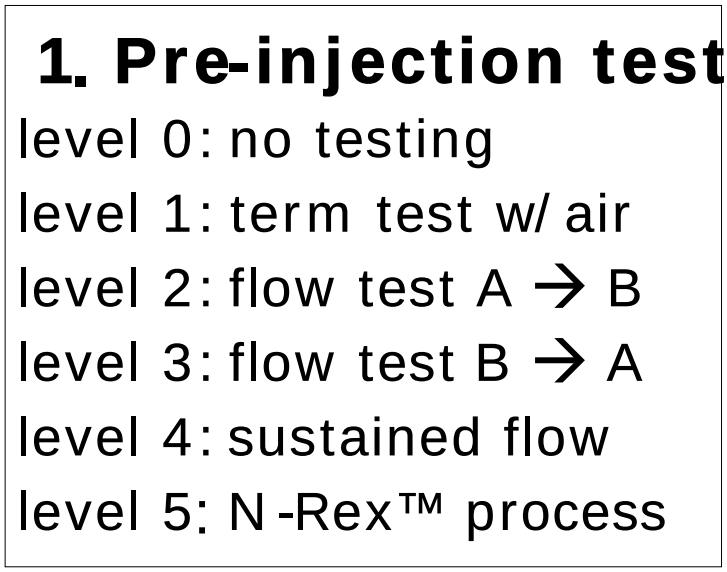


Figure 1: Overview of pre-injection testing escalation

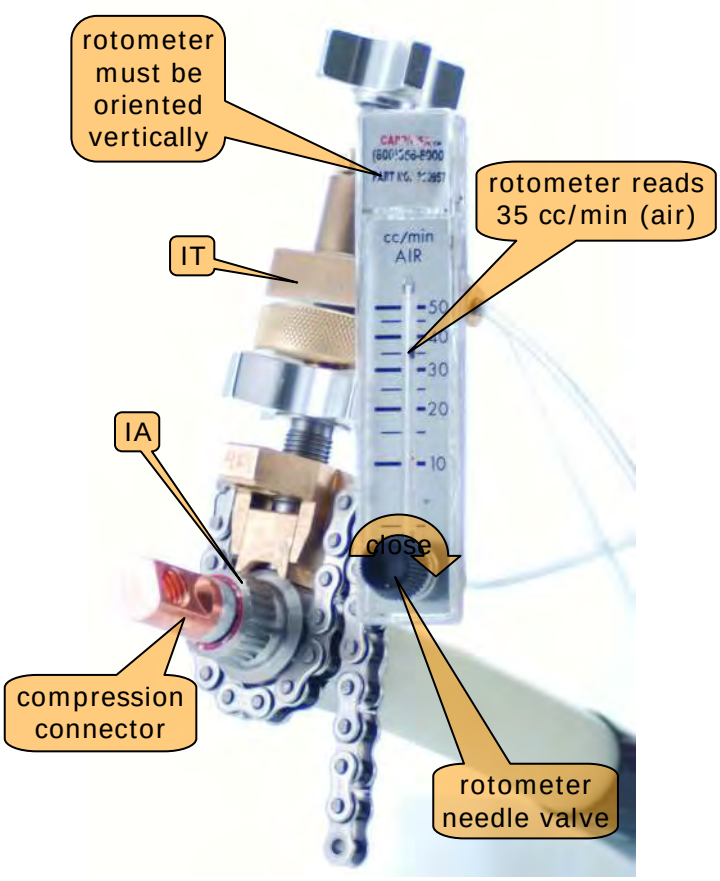
Rejuvenation Method	Flow test	Multiple	Pressure test
Sustained Pressure (SPR)	44 psig (3 bar)	4	88 psig (6 bar)
Unsustained Pressure (UPR)	<29 psig (<2 bar)	(P+14.7)/14.7	<29 psig (<2 bar)

Figure 2. Injection test pressures and flow test multiples.

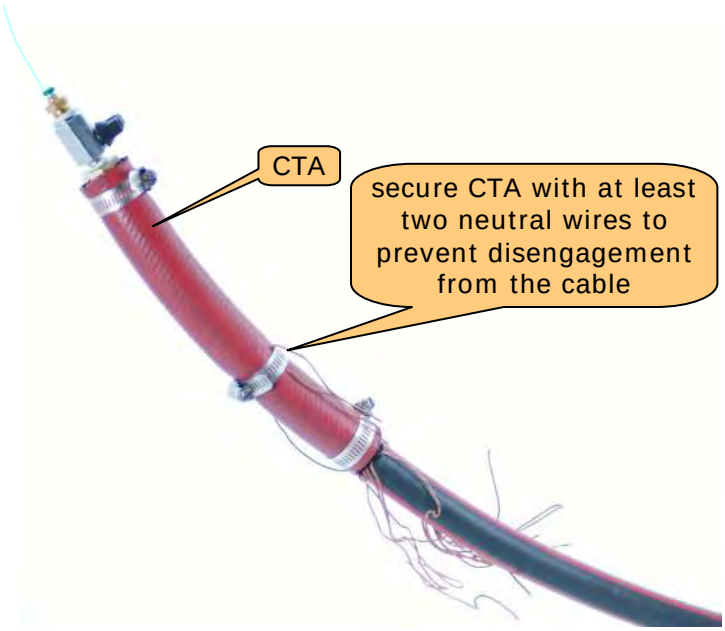
Caution: Working around energized high-voltage systems may cause serious injury or death. These instructions should be performed by personnel familiar with good safety practice in handling high-voltage electrical equipment. De-energize, test and ground all electrical systems before proceeding.

Caution: Working around pressurized fluid systems may cause serious injury. The procedures in these instructions should be performed by personnel familiar with good safety practice in handling moderate pressure pneumatic and hydraulic equipment. Always wear safety glasses with side shields.

1. **Level 1:** Termination test with gas. The majority of flow problems occur at terminations. Connect a gas source at the flow test pressure of Figure 2 to the base of an air rotometer (**NPN: 3-FH-FL-AIR100**) and the top of the air rotometer to an IT (injection tool), which is connected to the IA (Injection Adaptor) and compression connector (lug). Open the rotometer needle valve keeping the rotometer vertically oriented. If there are no blockages at the termination, the black rotometer ball will go a high value and then slowly decline to a steady non-zero value over the next minute. If the termination is blocked, the ball will jump high for just a moment, until the annular space in the IA and the tubing are pressurized (typically just a couple of seconds), then it will drop to zero. If the termination is blocked, follow the instructions of NRI 70, "Troubleshooting Cable Flow."



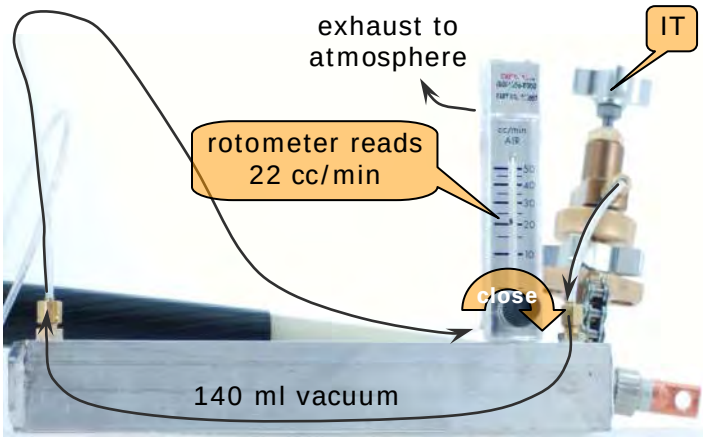
If it is desired to test the flow of air through the cable before a termination is applied, a cable test adaptor (CTA) may be installed on the cable end. CTAs are available to cover any cable size. The Novinium part numbers (NPN) for the CTA follow the form 0-FH-CTAxxxx-yyyy, where xxxx and yyyy are the lowest and highest recommended insulation diameters in mils respectively. **CTAs must be secured with at least two neutral wires (or other means) to assure that the CTA does not slip or launch off the cable end. Nobody may enter the space downrange and within 30 feet (10 meters) of a pressurized CTA.**



2. **Level 2:** Flow test A → B.
   a. Inject air, nitrogen or carbon dioxide into cable end A through a rotometer at the flow test pressure of Figure 2. At end B connect a tube from the IT to the bottom of a vacuum tank to trap any water exiting the cable and then to an air rotometer (npn: 3-fh-fl-air100). The rotometer needle valve should be open. Monitor the inlet flow rate and outlet flow rate until both stabilize. The outlet flow rate (end B) should be the product of the inlet flow rate (end A) and the flow test multiple indicated in Figure 2. The pneumatic resistance to flow is the feed pressure divided by the **outlet** flow rate (end B).

   b. **Pressure Test.** To identify potential system leaks including difficult-to-identify splices, close the outlet needle valve, set the pressure to the pressure test value specified in Figure and allow the entire system to pressurize. In a leak-free system, the inlet flow rate will drop slowly to zero.

3. **Level 3:** Flow test B → A. If the pneumatic resistance is high and the circumstances warrant the level 2 test can be repeated in the opposite direction. Flow resistance is often not symmetric. The injection leader should use field judgment to determine if the time spent performing the level 3 test is potentially justified by an improved injection flow rate.



exhaust air flow as shown

Example: If the outlet flow rate is 22 cc/min for a 44 psig feed, the pneumatic resistance is 2 (44 ÷ 22). The higher the resistance the slower fluid will flow into a cable.

If the inlet flow rate does not drop to zero, use leak detection fluid or soapy water to check all inlet and outlet plumbing and IA interfaces to confirm there are no leaks. Repair any identified leaks. If there are no leaks at either termination, the cable is leaking. The leak is either from a fault or a splice. Contact Novinium operational support for advice on how to proceed.

B → A

4. **Level 4:** Sustained flow. If the pneumatic resistance in both directions (level 2 and level 3) is high and the circumstances warrant, gas can be permitted to continue to flow over a sustained period (at least overnight) to remove some water or other fluids from the strands. The flow rate should be monitored periodically during sustained flow to determine when there is no more to be gained by this approach. The injection leader uses field judgment to determine if the time spent performing the level 4 sustained flow is potentially justified by an improved injection flow rate.

   - Sustained flow is best applied down grade to flush water from the strands.
   - Over very long periods of time, water in strands can be dried by evaporation.
   - A flush tank should be placed on the outlet side, vented to the atmosphere with sufficient volume to accumulate all potential water in the cable strands.
   - If flushing is to performed on energized cable, use a high voltage fluidic interfaces (HVFI) on the outlet as described by NRI-69 (N-Rex™ process), Phase 0, steps 7-8.

5. **Level 5:** For very long runs apply the N-Rex™ process (see NRI 69 “N-Rex™”).