masters of reliability

Rejuvenation Instructions

#342 – Injection Fluids – iUPR & SPR

This NRI covers the following:

- How to select fluid based upon load, cable size, and temperature.

Trademarks:
http://www.novinium.com/trademarks/

Patents:
http://www.novinium.com/patents/

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.

engineering@novinium.com
Revised: September 28, 2015

Novinium, Inc.
22820 Russell Rd Kent, WA 98032
(253) 395-0200

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Selecting Fluids

This NRI describes the process for selecting the Cablecure fluid tailored to the cable at hand. Fluid mixtures are dictated mainly by cable geometry and location. Honing in on the exact fluid "flavor" depends on the specific attributes of the cable.

EPR insulation and cable size may restrict fluids available for use. Contact Engineering for details in this event.

1. Identify the cable needs.

a. Cables, based on known conditions, fall into one of the P-Classes below. Select the most accurately described class and record it in the "P-Class" field in Knomentous. The five main P-Classes include:

- Preventative, Proactive, Pre-emptive, Problematic, and Post-failure (reactive).

b. If the cable does not fall into the **Pre-emptive**, **Problematic**, or **Post-failure** classes, use **Preventative** if there are no splices, and use **Proactive** if there are splices.

- A sixth class, **Perpetual injection**, may also be used with Engineering approval.

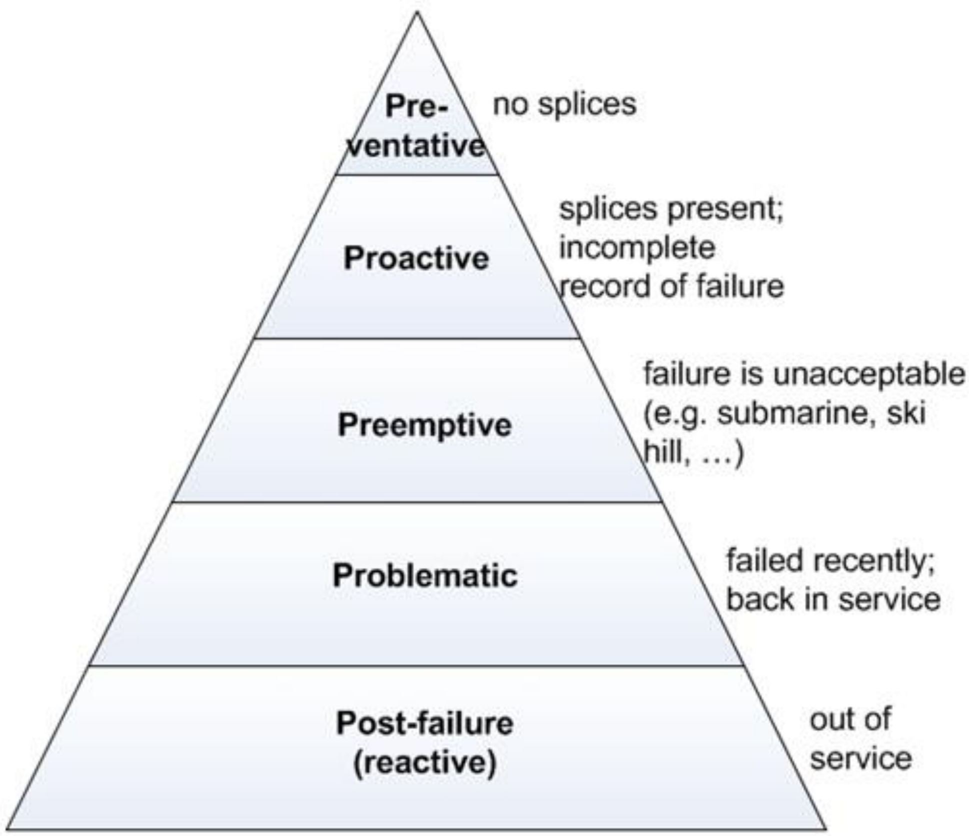

Figure 1: Distribution hierarchy of needs.

2. Identify the cable's environment.

- Find the injection location on the map below and match the color to an average soil temperature range.
- The full list of ranges is below the map and a full-page map can be found at the end of this NRI.

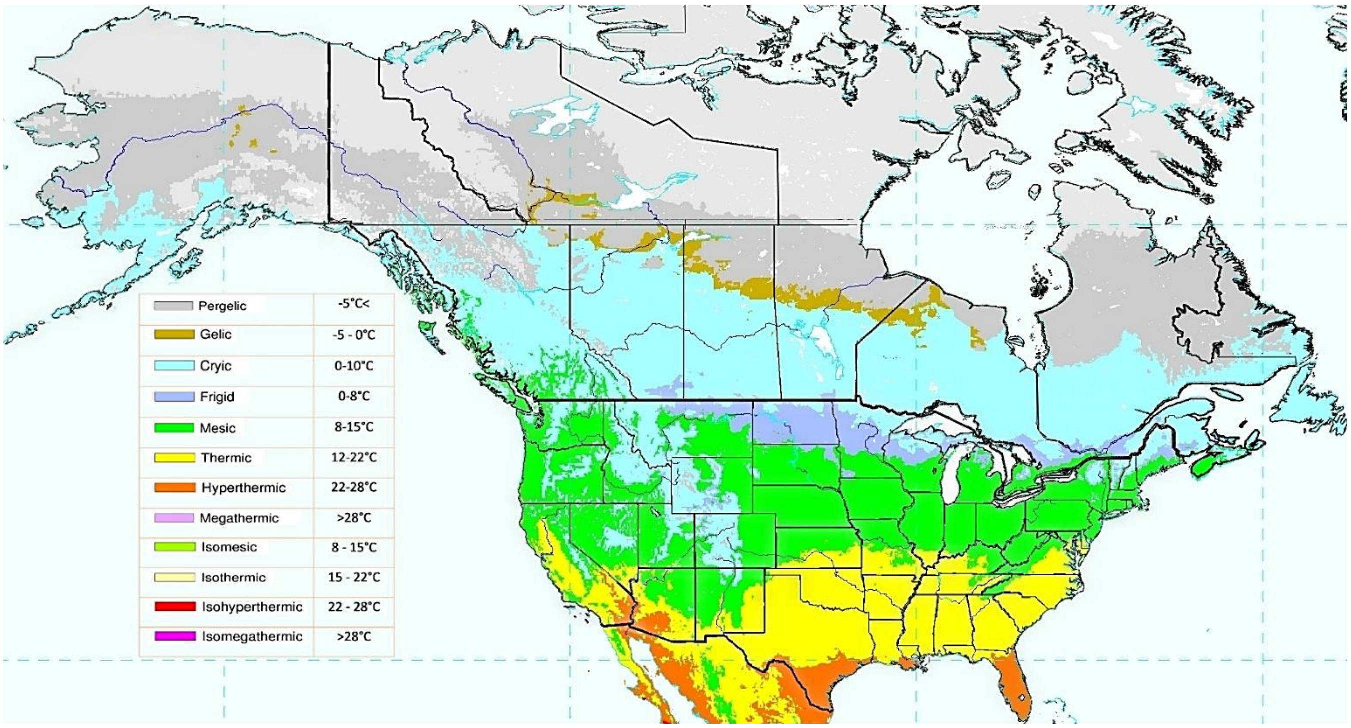

Figure 2: Map of soil temperature ranges.

For ranges starting with "Iso", treat them as follows:

- **Isomesic** becomes **Mesic** soil.
- **Isothermic** becomes **Thermic** soil.
- **Isohyperthermic** becomes **Hyperthermic** soil.
- **Isomegathermic** becomes **Megathermic** soil.

Pergelic	-5°C<
Gelic	-5 - 0°C
Cryic	0-10°C
Frigid	0-8°C
Mesic	8-15°C
Thermic	12-22°C
Hyperthermic	22-28°C
Megathermic	>28°C
Isomesic	8 - 15°C
Isothermic	15 - 22°C
Isohyperthermic	22 - 28°C
Isomegathermic	>28°C

Table 1: Soil temperature ranges.

3. Determine the cable's flux weighted temperature (FWT).

- The FWT helps tailor the fluid for the cable. It is determined by the soil temperature, the cable loading through the year, and factors in any potential growth of loading.
- Higher FWT values mean greater stress is/will be placed on the cable, while low FWT values mean lower stress.
- All Feeder FWT calculations must be reviewed by Engineering. For this and all other questions related to FWT determination, call (253) 395-0200.
- More accurate FWT values can be gained from using detailed load information, but an approximation can be used if load data is not available.
- For URD cables without detailed loading data, match the anticipated load % to a category in Table 2. If the anticipated load % is unknown, use "Unknown."
- Look at Table 3. The value at the intersection of the soil temperature and load category is the FWT value for the fluid needed.

Category	**Load** (% of design max)
None	0-10% (normal open)
Low	10-35%
Moderate	35-60%
Heavy	>60%

Table 2: Load category.

	Cryic / Frigid	Mesic / Isomesic	Thermic / Isothermic	Hyperthermic / Isohyperthermic
Heavy	50	60	70	80
Moderate	40	50	60	70
Low	20	30	40	50
None	0	10	20	30
Unknown	20	30	40	40

Table 3: URD cable loading and FWT.

- Example: The cable's load is estimated at 25%, which is "Low" load in Table 2. The soil temperature is Thermic. Low has a FWT of 40 in the Thermic column in Table 3.
- Cables with detailed load data can be used in the Novinium "FWT Tool." Contact and send the load data to Engineering with the form (found at the end of this NRI) filled out.

4. Determine the rejuvenation path.

- **Replacement** is always an option, but it is the least capital effective.
- **All cables may be rejuvenated** with Cablecure™ 732/733.
- When 20-25 years of extended life is desired, low loaded cables in cryic, frigid, mesic, or isomesic soils may be **rejuvenated** with Perficio™ 011 or mixtures of Perficio™ 011 and Ultrinium™ 212. This relates to an FWT of 30 or less.

5. Replacement or warranty waivers.

Designate the cable for replacement or execute a warranty waiver if:

- The circuit owner insists on performing off-line diagnostic testing.
- **ALL** off-line diagnostic testing is inherently destructive.
- The cable was subjected to more than 40 thumps during the last 30 operational days.
  - Minimally destructive arc reflection fault locating equipment should be used to pinpoint faults by trained technicians.
  - The number of thumps should be minimized.
- The cable suffers from systemic neutral corrosion.
  - Systemic neutral corrosion, where much of the cable's neutral is gone, is rare.
- The number of splices and/or neutral corrosion repair sites makes treatment uneconomical.
  - To evaluate the economics of rejuvenation versus replacement, see the "Rehabilitation Analysis" tool available from Novinium or an authorized Novinium service partner, or refer to Exhibit D in the rejuvenation proposal or contract.
- The Adjusted Flow Pressure (AFP) makes injection of the cable impractical.

6. Inspect the cable.

- Determine the cable geometry, voltage class, and other characteristics as in **NRI 200 Visual Inspection and Measurement**. Record this information into Knomentous.
- Taped shields are rare, but the cable takes significantly more fluid than with an extruded conductor shield.
- Tape shields leave gaps between the strands and shield since they are not formed together.
- If the cable has a taped conductor shield, contact Novinium Engineering.

Figure 3: Taped shielded cable.

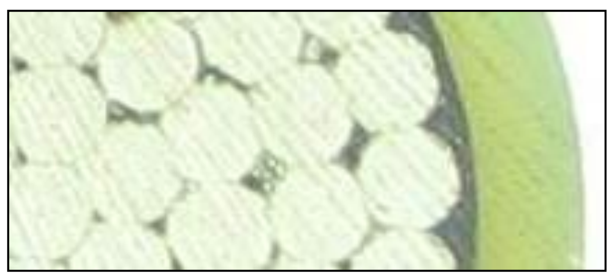

Figure 4: Extruded shielded cable.

7. Determine the fluid mixture.

- 732, 733, and 011 fluid mixtures depend on the cable geometry and connector size.
- Two sets of charts are on the pages that follow. Charts showing the relationship between conductor size and conductor compression for 732, 733, and Perficio fluids, and charts outlining the fluid mixtures for the more common conductor size range.

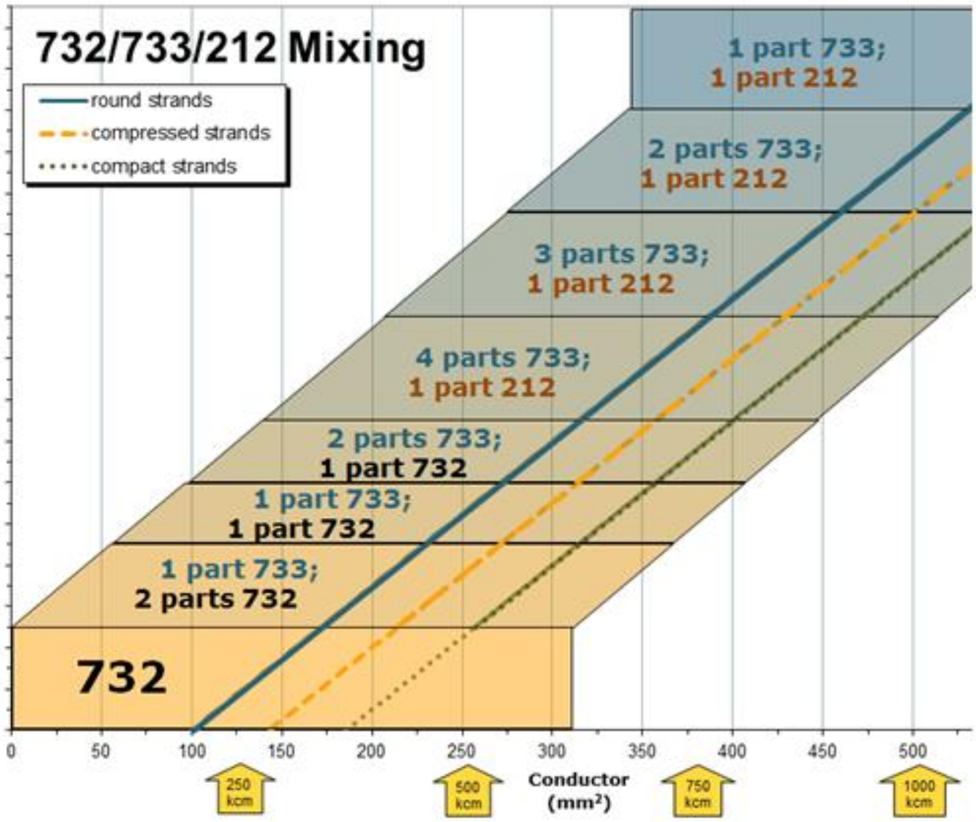

Figure 5: 732/733/212 mixing.

<table>
<tr><th colspan="4">732 and 733 Mixtures</th></tr>
<tr><th></th><th colspan="3">Strand Compaction</th></tr>
<tr><th>Cable Size</th><th>Concentric Round</th><th>Compressed</th><th>Compact</th></tr>
<tr><td>#2 AWG</td><td rowspan="8">732 only</td><td rowspan="10">732 only</td><td rowspan="11">732 only</td></tr>
<tr><td>#1 AWG</td></tr>
<tr><td>1/0 AWG</td></tr>
<tr><td>2/0 AWG</td></tr>
<tr><td>3/0 AWG</td></tr>
<tr><td>4/0 AWG</td></tr>
<tr><td>250MCM</td></tr>
<tr><td>300MCM</td></tr>
<tr><td>350MCM</td><td rowspan="2">2:1, 732/733</td></tr>
<tr><td>400MCM</td></tr>
<tr><td>500MCM</td><td>1:1, 732/733</td><td>2:1, 732/733</td></tr>
<tr><td>600MCM</td><td>1:2, 732/733</td><td>1:1, 732/733</td><td>2:1, 732/733</td></tr>
<tr><td>750MCM</td><td>4:1, 733/212</td><td rowspan="2">4:1, 733/212</td><td>1:2, 732/733</td></tr>
<tr><td>800MCM</td><td rowspan="2">3:1, 733/212</td><td rowspan="2">4:1, 733/212</td></tr>
<tr><td>900MCM</td><td>3:1, 733/212</td></tr>
<tr><td>1000MCM</td><td>2:1, 733/212</td><td>2:1, 733/212</td><td>3:1, 733/212</td></tr>
</table>

Table 4: 732/733 mixtures.

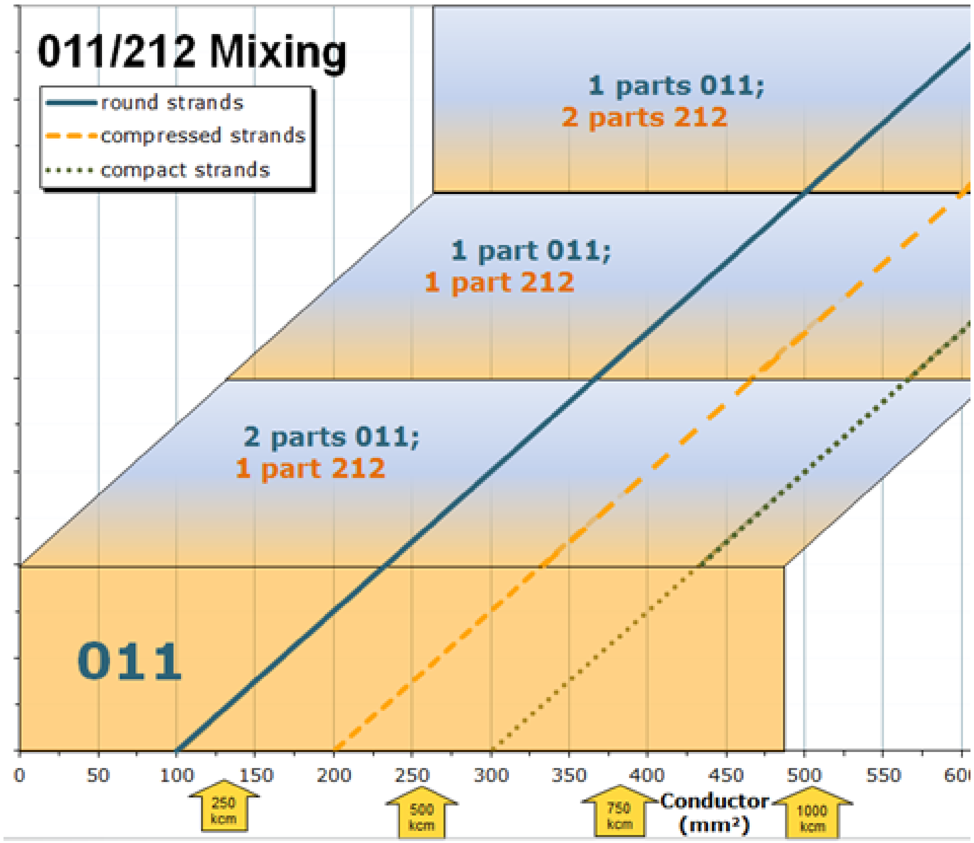

Figure 6: 011/212 mixing.

<table>
<tr><th colspan="4">011 Mixtures</th></tr>
<tr><th></th><th colspan="3">Strand Compaction</th></tr>
<tr><th>Cable Size</th><th>Concentric Round</th><th>Compressed</th><th>Compact</th></tr>
<tr><td>#2 AWG</td><td rowspan="10">011 only</td><td rowspan="12">011 only</td><td rowspan="14">011 only</td></tr>
<tr><td>#1 AWG</td></tr>
<tr><td>1/0 AWG</td></tr>
<tr><td>2/0 AWG</td></tr>
<tr><td>3/0 AWG</td></tr>
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<tr><td>250MCM</td></tr>
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<tr><td>600MCM</td></tr>
<tr><td>750MCM</td><td rowspan="3">1:1, 011/212</td><td rowspan="3">2:1, 011/212</td></tr>
<tr><td>800MCM</td></tr>
<tr><td>900MCM</td><td rowspan="2">2:1, 011/212</td></tr>
<tr><td>1000MCM</td><td>1:2, 011/212</td><td>1:1, 011/212</td></tr>
</table>

Table 5: 011 mixtures.

8. Determine the fluid temperature adjustment.

- 732 and 733 fluids have varying "flavors," which is related to the proportions of ingredients in the formulation.
- This "flavor" is denoted by the adjusted fluid temperature number or "**NN**" after the name of the formulation.
- The cable's physical attributes increase the initial flux weighted temperature (FWT) by 10°C each. We found the FWT in Step 3 on page 4.
- For every attribute the cable has from the list below, increase the FWT by 10°C.
  - The conductor is compressed or compact stranding and is 4/0 size or smaller.
  - If the conductor is #1 AWG or smaller. (In addition to the previous attribute)
  - If the insulation is EPR or butyl rubber. Contact Engineering if there is rubber insulation.
  - The insulation thickness is less than 120 mils (0.120") thick.
  - If iUPR injection is being used.
  - If previous injections of the cable didn't reach the Fluid Floor amount.

a. Add all of the temperature adjustments to the FWT value.

b. Contact Engineering if the new value is above 80°C.

Example:

- A 15kV, 180mil insulated, concentric stranded, 1/0, EPR insulated cable is going to be injected with iUPR and Cablecure 732. It is found in a mesic environment and is lowly loaded.
- The cable's initial FWT will be 30°C based upon the load and soil temperature.
- The fluid temperature adjustment would go as follows:
  - EPR insulation increases the FWT by 10.
  - iUPR increases the FWT by 10.
- The "flavor" or "NN" of the Cablecure 732 fluid to be used is now 50.
- Contact Supply Chain and order Cablecure 732/50 fluid.

FWT Estimation Form

Feeder cables require load calculations in order to ensure that the appropriate fluid is selected. This allows for a 40 year warranty period. Fluids with too low a Flux Weighted Temperature (FWT) will not persist in the cable at elevated temperatures, while fluids with an FWT which is too high will not effectively treat the cable in the short term. In order to select the optimum fluid for the application, the following information* (which may be emailed to engineering@novinium.com) is needed from the customer.

Customer:			**Representative:**		
Date:		**Email:**		**Phone:**	

Load and Circuit Data

a. SCADA (or similar) outputs in excel format (.csv, etc). One year of continuous data required, in one hour maximum time intervals between current readings. Date / Time and loading for each phase are needed: current (in Amps) on each phase.

b. Units of measure (if not indicated in data outputs).

c. Estimated percent load growth per year.

d. Operating voltage: nominal and actual _________________________

e. Single-phase or 3-phase.

CABLE DATA				
Cable or Circuit Identifier (Designation):				
Conductor Size (MCM or mm^2):		**Material:**	☐ Al	☐ Cu
Conductor Stranding:	☐ Concentric	☐ Compressed	☐ Compact	**# of Strands:**
Insulation Type:	☐ XLPE	☐ EPR	**Insulation Thickness (mils or mm):**	
Semicon Type:	☐ Extruded	☐ Taped	**90°C Design Load of Cable (Amps):**	
Cable Location (city, state/province, or latitude and longitude):				
Length of Cable(s) (ft or meters):				
Cable Installation Type:	☐ Direct Burial	☐ Conduit	☐ Single Cable	☐ Triplexed

Example SCADA load data:

		AMPS_B	AMPS_R	AMPS_W
Date	**Time**	**B**	**R**	**W**
6/1/2011	0:00	96	110	107
6/1/2011	0:15	98	113	108
6/1/2011	0:30	95	111	107

**If Novinium does not receive sufficient load data, cable load will be estimated as 30% of the cable's overcurrent protection device rating, with an annual load growth of 2.5%. Maximum design load will be estimated based upon the ratings of similar cables. Contact Engineering at engineering@novinium.com for more information or assistance.*