

#342 – Injection Fluids



This NRI covers the following:

How to select fluid based upon loading, cable, and temperature information.



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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Selecting Fluid Flavor

This NRI describes the process for selecting the Cablecure[®] 732 fluid tailored to the project at hand. 732 fluid contains varying levels of additives (referred to as a fluid "flavor") determined by taking into consideration cable geometry, cable type, and location. A fluid "flavor" can be 732/30, 732/50, or 732/80.

EPR insulation and cable size may restrict fluids available for use. Contact Engineering and read <u>NRI 623 -</u> <u>EPR Insulated Cables</u> if you encounter EPR insulated cables.

1. Identify the cable needs.

- a. Cables fall into one of the P-Classes below. Select the most accurate 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.



Figure 1: Distribution hierarchy of needs.

2. Determine the rejuvenation path.

- **Replacement** is always an option, but it is more capital intensive than rejuvenation.
- All XLPE cables and many EPR cables can be treated with Cablecure[®] 732.

3. Identify the cable's environment.

- Find the injection location on the map below and match the color to an average soil temperature range. Contact Engineering if soil temperature range is unclear.
- The full list of ranges is available below the map



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.

4. 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 thermal 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, email <u>engineering@novinium.com</u>.
- a. Cables with detailed load data give the most accurate FWT
 - In this case, use the Novinium FWT Estimation Form at the bottom of this NRI. Contact Engineering for the Word document and when the form is completed.
- b. An approximation can be used if detailed load data are not available.
 - Anticipated load% can be approximated by considering cable fusing and comparing it to the cable ampacity. Match the anticipated load % to one of the categories in Table 2.
 - If none of that information is known, ask the customer for their assessment or use "Unknown" if necessary.
- c. After loading is determined, look at Table 2. The value at the intersection of the soil temperature and load category is the FWT value for the fluid needed.
 - Example: The cable's load is estimated at 25%, which is "Low" load. The soil temperature is Thermic. Low has an FWT of 50 in the Thermic column in Table 2.

Loading (% design max)	Flux Weighted Temperature (FWT)						
Heavy (>60)	50	50	50	80			
Moderate (35-60)	50	50	50	80			
Low (10-35)	30	30	50	50			
None (0-10)	30	30	30	30			
Unknown	30	30	50	50			
Soil Tomporaturo	Cryic /	Mesic /	Thermic /	Hyperthermic /			
son remperature	Frigid	Isomesic	Isothermic	Isohyperthermic			

Table 2: Finding FWT based on loading and soil temperature.

5. Determine the FWT adjustment.

- 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 listed below, increase the FWT by 10°C.
 - The conductor is compressed or compact stranding and is 4/0 size or smaller.

- \circ $\;$ The conductor is #1 AWG or smaller. (In addition to the previous attribute).
- \circ The insulation thickness is less than 120 mils (0.120") thick.
- iUPR injection is being used.
- The previous injections of the cable didn't reach the Fluid Floor amount.
- a. Add the temperature adjustments to the FWT value.
- b. Notify Engineering if the new value is above 90°C.

Replacement or warranty waivers.

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

- a. The circuit owner performs off-line diagnostic testing.
 - Many off-line diagnostic tests are inherently destructive.
- b. The cable is estimated to have been thumped more than 50 times in the last 30 operational days.
 - O Use discretion when estimating the number of thumps. For example, if the thumper was connected for about 20 minutes at 1 thump every 30 seconds → 20min X 2 thump/min = 40 thumps.
 - Minimal voltage and pulses should be used to pinpoint faults by trained technicians. See <u>NRI 275</u>
 <u>– Fault Locating</u> for best practices.
- c. The cable suffers from systemic neutral corrosion, typically Level 3 and 4 corrosion.
- d. The number of splices and/or neutral corrosion repair sites makes treatment uneconomical.
 - See Exhibit D in the rejuvenation proposal or contract to evaluate the economics of rejuvenation versus replacement.
- e. The Adjusted Flow Pressure (AFP) makes injection of the cable impractical. See <u>NRI 352 Fluid</u> <u>Pressure Selection</u>
- f. The circuit owner wishes to deviate from an NRI procedure that effects the termination installation or treatment level.

Supersaturation and Fluid Dilution

1. Supersaturation and dilution with 212

Supersaturation requires three events:

- 1. Excess supply of rejuvenation fluid in the interstices
- Prolonged and substantial temperature variations in a cable (greater than 20C and 1 cycle per day)
- Solubility greater than 5% by weight at 55C. The greater the solubility the greater the risk.

Conditions 1 and 2 are more likely to occur in feeder cables 500MCM and above. URD cables do not require any further consideration.



Figure 3: Interstitial volume in compressed cables

The amount of fluid absorbed by cable insulation (solubility) increases and decreases in proportion to the temperature. If a cable has prolonged and substantial temperature swings, there may be more fluid absorbed in the cable insulation than the cable can handle at a given lower temperature. When this happens the cable insulation will be mechanically stressed by swelling and can fail from supersaturation.

The solution to supersaturation is diluting Cablecure[®] 732 with Cablecure[®] 212. This has low solubility in XLPE and can be easily blended with 732 of any flavor.

2. Considerations for dilution

Besides the conditions stated above, the following should be considered:

- Rubber insulated cables (including all sizes of rubber and EPR) should never be diluted with 212. See <u>NRI623 Rubber Insulated Cables</u> for more information.
 - 732/80 has low solubility in approved rubber insulated cables.
 - Tables 3 and 4 only apply to XLPE insulated cables.
- The loading and application of cables. If cables have high variance of loading, they may be prone to supersaturation.
- Feeder cables often have highest loading and loading variance
- The major component of 732/80 has similar solubility to 212 in XLPE.

- Tables 3 and 4 are based on injection data from 2015-2020.
- The risk of supersaturation decreases over time and should be considered significantly decreased one year after injection.

3. Determine the fluid dilution

Tables 3 and 4 show fluid dilution based on fluid flavor, AWG, and stranding type.

732/30 and 732/50 Dilution - XLPE Only															
18	80 mil Insula	tion (15kV)		220 mil Insulation (15kV)											
Cable/Stranding	Concentric	Compressed	Compact	Cable/Stranding	Concentric	Compressed	Compact								
#2				#2											
#1				#1											
1/0				1/0											
2/0	722 Only	722 Only		2/0	722 Only	722 Only									
3/0	732 Only	732 Only	732 Only	3/0	732 Only	732 Only	732 Only								
4/0				4/0											
250				250											
350				350											
500	727/212 1.1	727/212 1.1		500	727/212 1.1	727/212 1.1									
750	/52/212, 1.1	/52/212, 1.1	722/212 1.1	750	/32/212, 1.1	/52/212, 1.1	727/212 1.1								
1000	732/212, 1:2	732/212, 1:2	/32/212, 1.1	1000	732/212, 1:2	732/212, 1:2	/32/212, 1.1								
20	60 mil Insula	tion (25kV)		345 mil Insulation (35kV)											
Cable/Stranding	Concentric	Compressed	Compact	Cable/Stranding Concentric		Compressed	Compact								
#2				#2											
#1				#1			732 Only								
1/0				1/0											
2/0				2/0											
3/0	732 Only	732 Only	722 Only	3/0	722 Only	722 Only									
4/0			732 Offiy	4/0	732 Only	732 Only									
250				250											
350				350											
500				500											
750	722/212 1.1	722/212 1.1		750											
1000	/ 52/212, 1:1	/ 52/212, 1:1	732/212, 1:1	1000	732/212, 1:1	732/212, 1:1									

Table 3: Dilution for 732/30 and 732/50

732/80 Dilution - XLPE Only									
18	80 mil Insula	tion (15kV)		220 mil Insulation (15kV)					
Cable/Stranding	Concentric	Compressed	Compact	Cable/Stranding	Concentric	Compressed	Compact		
#2				#2					
#1				#1					
1/0				1/0					
2/0				2/0					
3/0	732 Only	732 Only	732 Only	3/0	732 Only	732 Only	732 Only		
4/0			732 Only	4/0			732 Only		
250				250					
350				350					
500				500					
750	722/212 1.1	722/212 1.1		750	727/212 1.1	722/212 1.1			
1000	/52/212, 1.1	/52/212, 1.1	732/212, 1:1	1000	/32/212, 1.1	/52/212, 1.1	732/212, 1:1		
26	60 mil Insula	tion (25kV)		345 mil Insulation (35kV)					
Cable/Stranding	Concentric	Compressed	Compact	Cable/Stranding	Concentric	Compressed	Compact		
#2				#2					
#1				#1					
1/0				1/0					
2/0				2/0					
3/0	732 Only	732 Only	722 Only	3/0					
4/0			732 Only	4/0		732 Only			
250				250					
350				350					
500				500					
750	727/212 1.1	727/212 1.1		750					
1000	/ 52/212, 1:1	/ 52/212, 1:1	732/212, 1:1	1000					

Table 4: Dilution for 732/80

4. Mixing different ratios

It may be required to mix different ratios of fluid to produce another ratio. Use the table below in that situation. Do not mix 732 flavors (such as mixing 732/30 and 732/50) except with Engineering approval.

732:212 Ratio Mixing Table by Weight or Volume								
Components on hand	732	212	1:1	1:2				
Make 1:1	1	-	-	3				
Make 1:2	-	1	2	-				

Table 5: Making different ratios from given fluid components

For example, if 732:212-1:2 and pure 732 are on hand and 732:212-1:1 is needed, mix the two components 1:3 to make 732:212-1:1

FWT Estimation Form

Feeder cables require load calculations in order to ensure that the appropriate fluid is selected. 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 is needed from the customer* and can be emailed to <u>engineering@novinium.com</u>.

Customer:		Representative:				
Date:	Ema	l:			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):						Mat	terial:		AI	🗌 Cu
Conductor Stranding	itric 🛛 🗆 Co	ompi	ressed		ompact	# of Strand	ls:			
Insulation Type:	🗆 XLPE	🗆 EPR	Insulation Thickness (mils or mm):							
Semicon Type:	🗆 Extruded	🗌 Таре	ed 90°C Design Load of Cable (Amps):				:			
Cable Location (city)	, state/province	e, or								
latitude and longitude):										
Length of Cable(s) (ft or meters):										
Cable Installation Type: Direct Burial				🗆 Condu	uit	🗌 Sin	gle Cable		🗌 Tri	iplexed

Example SCADA load data:

		AMPS_B	AMPS_R	AMPS_W
Date	Time	Blue	Red	White
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 <u>engineering@novinium.com</u> for more information or assistance.