Testing WL cables for HPHT

26.10.2023

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Cooling effect when bleeding of gas (methane)

7.11. Illustration of cooling effect at cable area across BOP ram (Methane)

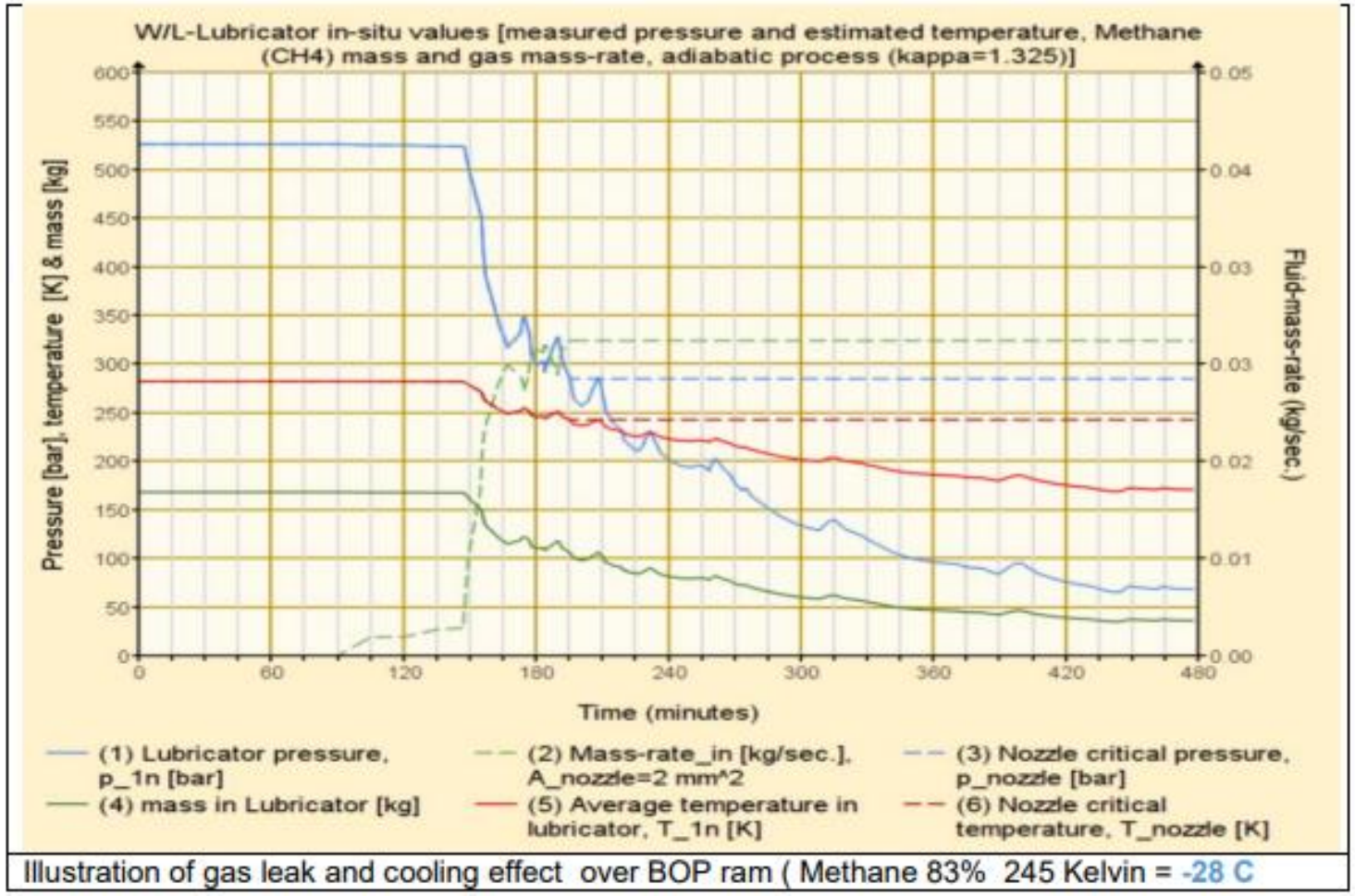


Illustration of gas leak and cooling effect over BOP ram (Methane 83% 245 Kelvin = -28 C

Note: This calculation was done to understand possible impact on BOP rubber seal element and grease viscosity .

Cooling effect when bleeding off gas (Nitrogen)

7.12. Illustration of cooling effect at cable area across BOP ram Nitrogen

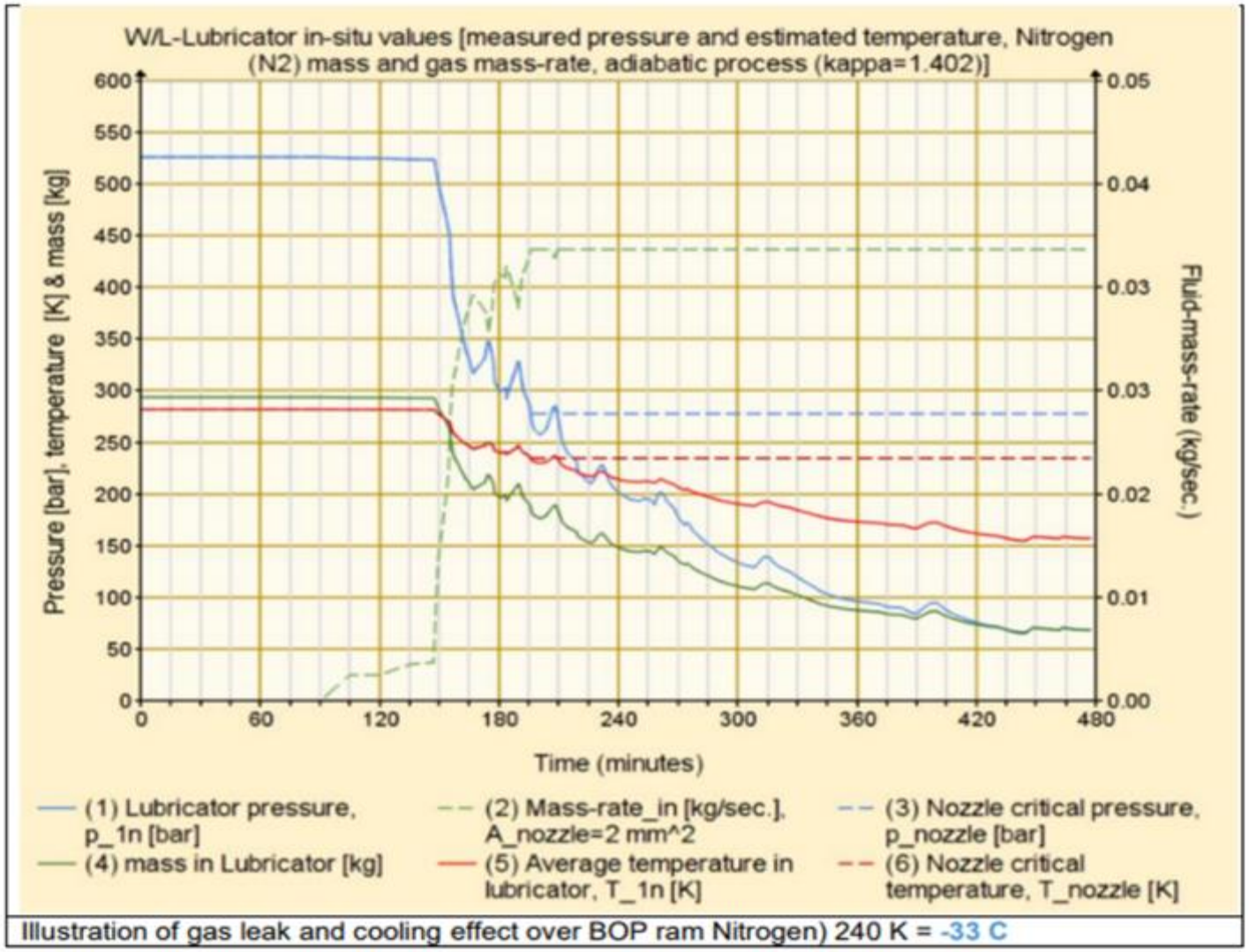


Illustration of gas leak and cooling effect over BOP ram Nitrogen) 240 K = -33 C

Note:this test was done to compare possible impact during testing.

Compressed Nitrogen increased temperature Inside etst equipment up to 21 + deg c during testing

Gas leak in wireline armored cables

7.2. Cable illustration type Mono / Dyfrom

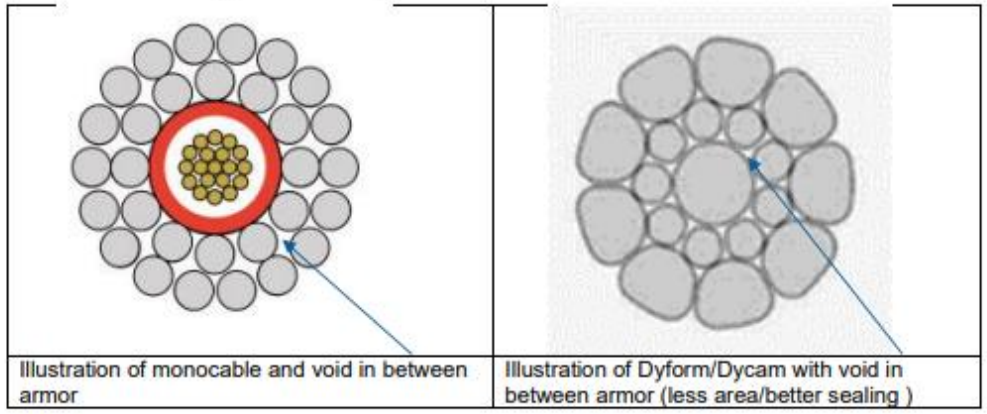
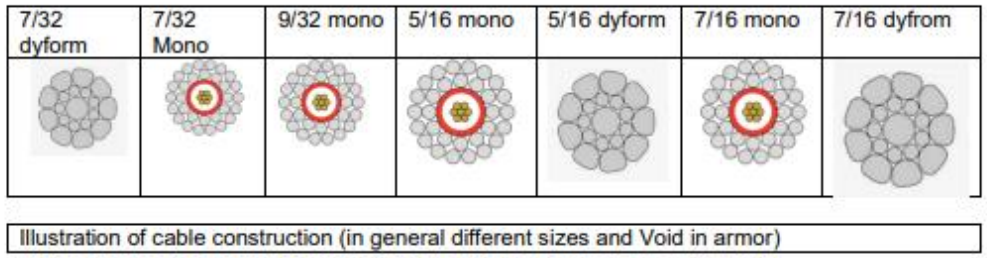


Illustration of monocable and void in between armor	Illustration of Dyform/Dycam with void in between armor (less area/better sealing)



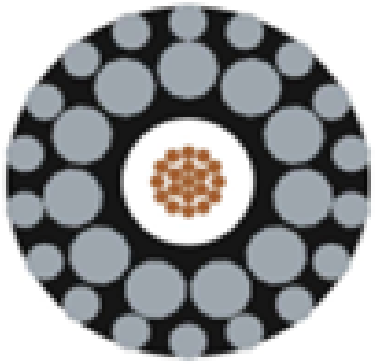
7/32 dyform	7/32 Mono	9/32 mono	5/16 mono	5/16 dyform	7/16 mono	7/16 dyfrom

Illustration of cable construction (in general different sizes and Void in armor)

Sealing between armor and insulation

Leak path for gas in between armor

Illustration of Sealed armor 5/16 cable



Note: there are different sealed and coated cables in the market

Test rod to confirm sealing and leak path inside armor

7.3. Cable and test rod

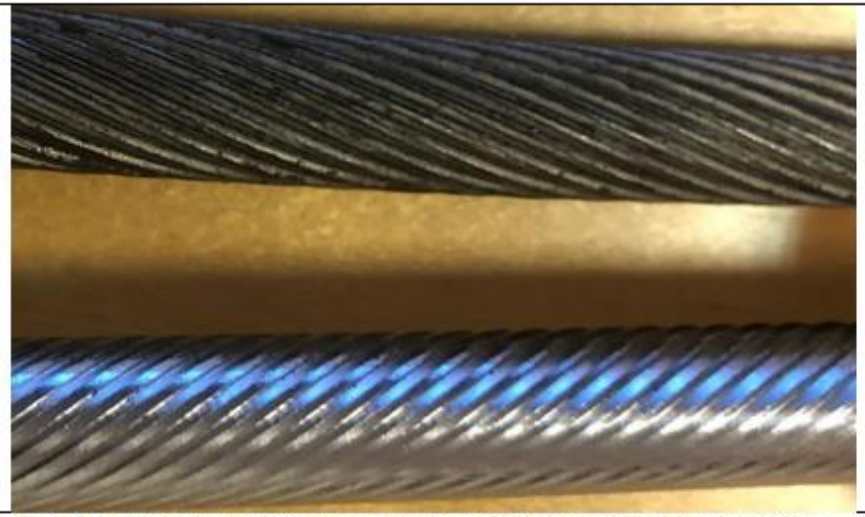
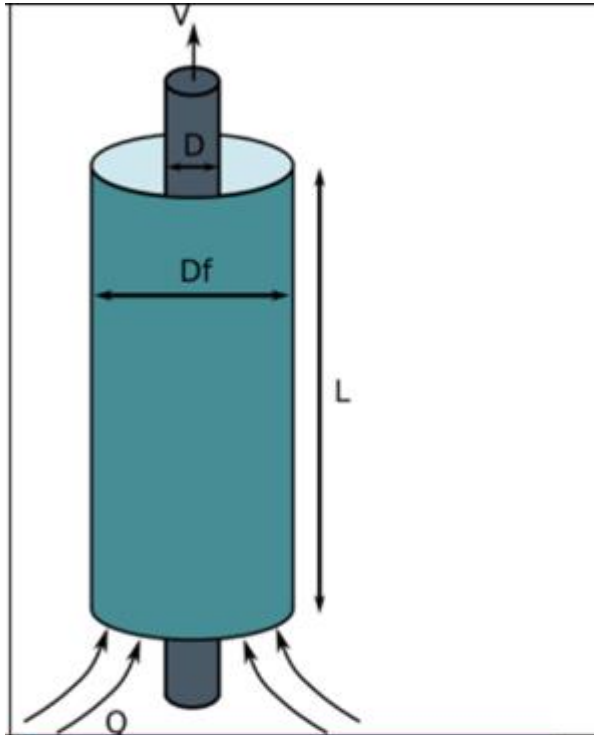


Illustration of test rod 8 mm (lower) and construction of 5/16 mono cable (upper) (void in between amor)

Temp (°C)	Viscosity (cSt)	
	V500	Polybutene
40	500	2,353
35	690	-
30	960	-
25	1,400	4,773
20	2,000	5,734
15	3,000	8,267
10	4,700	11,509
5	8,000	16,883*
0	13,000	22,622
-5	23,000	37,244
-10	44,000	61,072

* measured at 4°C



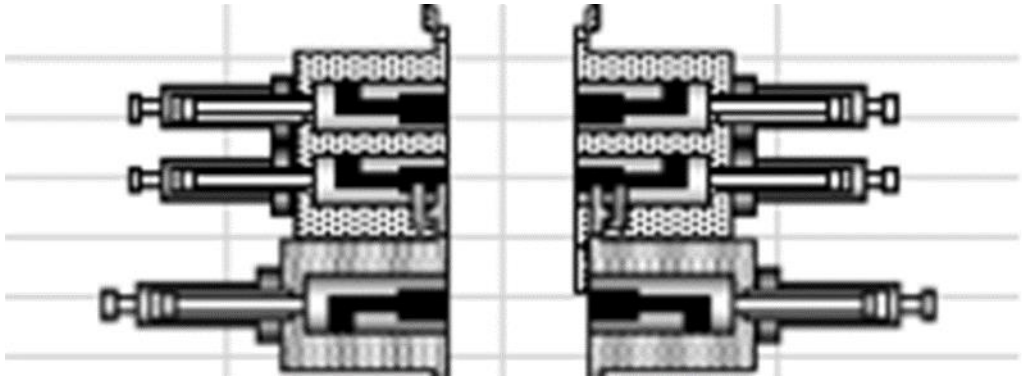
Altus Flowtube Calculator

Parameter	Symbol	Value	Unit
Wireline fluid		V500 2	
Line size	D	0.314	inch
Flowtube size	Df	0.324	inch
Flowtube length	L	12	inch
Flow rate	Q	0.09	l/min
Wireline velocity	V	50	m/min
Temperature	T	8	°C
Pressure drop	ΔP	9790.14	psi

Nitrogen testing and gas leak at different pressures in BOP with different cables

Cable	Dry cable Upper ram N2 press Leak start	V500 on cable Upper ram N2 press Leak start	Polybutene on cable Upper ram N2 press Leak start	Polybutene on cable Upper &middleram N2 press Leak start	Leak rate bubbles pr minute
5/16 Dyform	160 bar	162 bar	190 bar	506 bar	60-80
5/16 mono	70 bar	70 bar	100 bar	240 bar	80-100
9/32 mono	175 bar	175 bar	230 bar	430 bar	80-100
7/16 dyform	158 bar	158 bar	200 bar	200 bar	100 -140

Nitrogen test with dry test cable indiacte low sealing capacity on 5/16 Mono

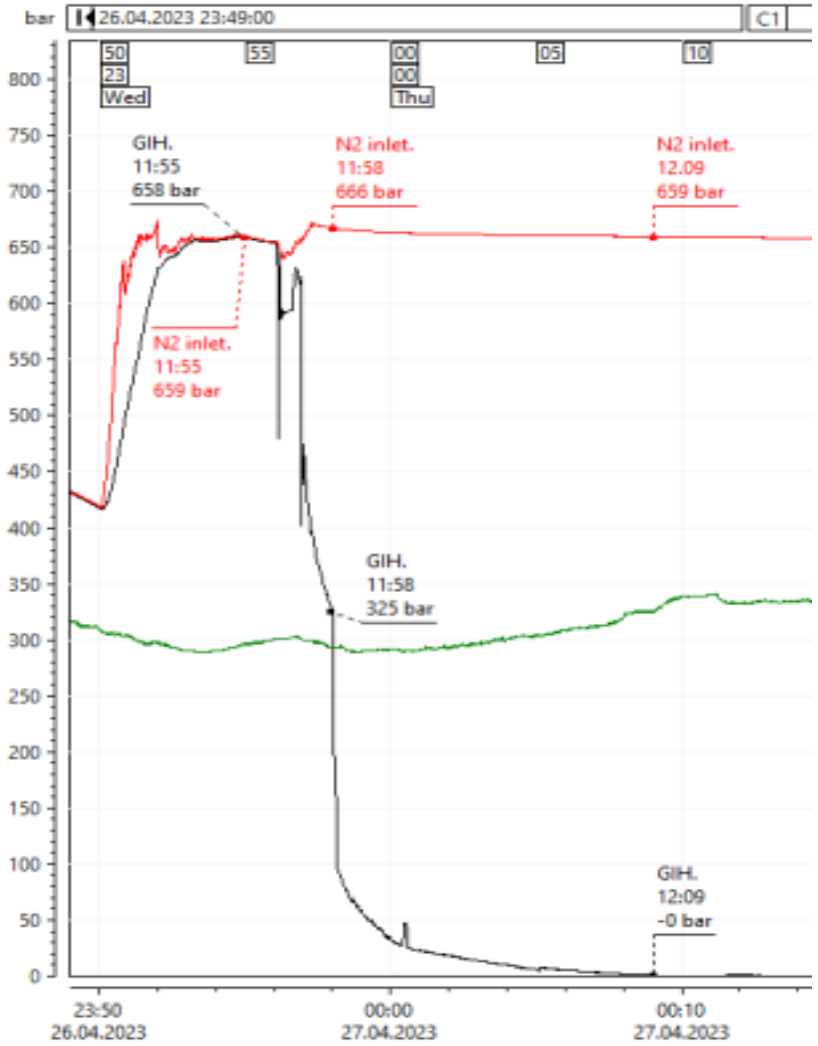


BOP Sealing ram Set up

Cable	Nitrogen press Bar	V 500 press Bar	Gas break Bar V500	Gas break Bar Poly	Grease l/m V500	Result V500
7/32 Mono	610	650	Leak 610	300/380	0,14	ok
7/32 Dyform	620	650	Seal	Seal	0,01	ok
9/32 mono	350	380	350/380		0,25	ok
	425	500	425/500	Seal	0,3	
	540	570	540/570	425/480	0,3	
	590	650	590/650	520/630	0,7	
9/32 mono	380	**Glycol**	380/380		0	ok
5/16 mono	350	380	350/380	340/500	0,28	
	390	500	390/500	380/570	0,48	
	440	570	440/570	400/650	0,55	ok
	550	650	550/650	420/690		
5/16 Dyform	250	250	Seal	250/250	0,24	
	380	380	Seal	380/380	0,12	
	500	500	seal	500/500	0,12?	
	565	570	565/570	565/570	0,14	
	617	621	Seal	Leak	0	ok
7/16 mono	280	380	280		1,81	NO
7/16 Dyform	410	380	seal	250/250	0,12	
	500	500	seal	300/380	0,12	
	570	570	seal	320/500	0,12	
	620	650	620/650	360/570	0,12	ok

Nitrogen testing with grease pressure and flow indicate variation in sealing capacity

Illustration of bleed off and sealing on a Sealed Armor size 3/8 ‘’cable



	N2 Pressure below BOP	Start bleed off	Stop bleed off	Bleed off time	Result
Test 1 BOP TL	631 bar	10:02	11:18	76 minutes	0 bar OK
Test 2 BOP TL	649 bar	11:58	12:09	11 minutes	0 bar OK
Test 3 BOP TL	641 bar	13:38	13:52	14 minutes	0 bar OK

Summary and variation in test result with regular armored cables in closed BOP.

First test : Triple 10 K BOP with cable to monitor leak start in cable void Ambient temp 15-18 deg C

Cable	Dry cable Upper ram N2 press Leak start	Upper ram V500 N2 press Leak start	Upper ram Polybutene N2 press Leak start	Upper/middle ram Polybutene N2 press Leak start	Leak rate bubbles pr minute	Open / No cap
5/16 Dyform	160 bar	162 bar	190 bar	506 bar	60-80	
5/16 mono	70 bar	70 bar	100 bar	240 bar	80-100	
9/32 mono	175 bar	175 bar	230 bar	430 bar	80-100	

Second test: Trippel 10 K BOP with cable and monitor difference between grease type and pump capacity (Ambient temp 12-15 deg C)

Cable	Nitrogen press Bar	V 500 press Bar	Gas break Bar V500	Gas break Bar Poly	Grease l/m V500	Open/ No cap
7/32 Mono	610	650	Leak 610	300/380	0,14	
7/32 Dyform	620	650	Seal	Seal	0,01	
9/32 mono	350	380	350/380		0,25	
	425	500	425/500	Seal	0,3	
	540	570	540/570	425/480	0,3	
	590	650	590/650	520/630	0,7	
9/32 mono	380	**Glycol**	380/380		0	
5/16 mono	350	380	350/380	340/500	0,28	
5/16 mono	390	500	390/500	380/570	0,48	
5/16 mono	440	570	440/570	400/650	0,55	
5/16 Mono	550	650	550/650	420/690		

Third test: **Quad BOP** 15 K Test with increased pressure and flow to verify and repeat seal (Ambient temp Cold -10 deg C , grease heated 5-15 deg C)

Cable 5/16 mono	Nitrogen Bar	BCS press V 500	Max press BCS	Grease volume tot	Grease l/m V 500	Time/ minutes CAP
Pump test 1	641	**1135**	**1135**		0,6	17:16
Start seal	641	967		4,9	0,7	17:21
Seal	641	937		8,5	0,3	17:31 /seal
Pump test 2	641	**1127**	**1127**		0,6	18:00
Start seal	641	960		5,9	0,5	18:06
Seal	641	893		8,9	0,2	18:16/seal
Pump test 3	636	**1104**	**1104**		0,7	18:42
Start seal	636	934		4,2	0,4	18:47
Seal	636	950		7,4	0,3	18:57/seal

Recommended BOP ram set up for different cables and well pressures

See table below with recommended BOP and Ram set up for sealing in case of repair of different cable sizes and pressures that require breaking lubricator above BOP.

BOP Ram set up >	BOP with 2 Ram Standard Inverted	BOP with 3 Ram Standard Standard Inverted	BOP with 4 Ram Standard Inverted Standard Inverted	Recommended Grease flow for dynamic seal set to max 50% and 30% of pump capacity
SS=Stainless GIPS = Galvanized steel				
Cable Size & type	**SIWHP Bar**	**SIWHP Bar**	**SIWHP Bar**	**50% or 30%**
7/32 Mono SS	175 Bar	380 Bar	550 Bar	Max 50%
7/32 Mono GIPS	175 Bar	500 Bar	550 Bar	Max 50%
7/32 Dyform GIPS	175 Bar	515 Bar	620 Bar	Max 50%
9/32 Mono SS	175 Bar	380 Bar	550 Bar	Max 50%
9/32 Mono GIPS	175 Bar	515 Bar	550 Bar	Max50%
5/16 Mono SS	70 Bar	240 Bar	550 Bar	Max 50%
5/16 Mono GIPS	70 Bar	350 Bar	550 Bar	Max 50%
5/16 Dyform GIPS	160 Bar	550 Bar	600 Bar	Max 50%
7/16 Mono SS	50 Bar	150 Bar	530 Bar	Max 30%
7/16 Mono GIPS	50 Bar	200 Bar	530 Bar	Max 30%
7/16 Dyform GIPS	150 Bar	250 Bar	530 Bar	Max 30%

Baker Hughes