

Tilraun með háþrýstiprófun að Urriðavatni
(„hydrofracturing“)

**Sverrir Þórhallsson
Jens Tómasson**

Greinargerð SP-JT-83-05

1 INNGANGUR

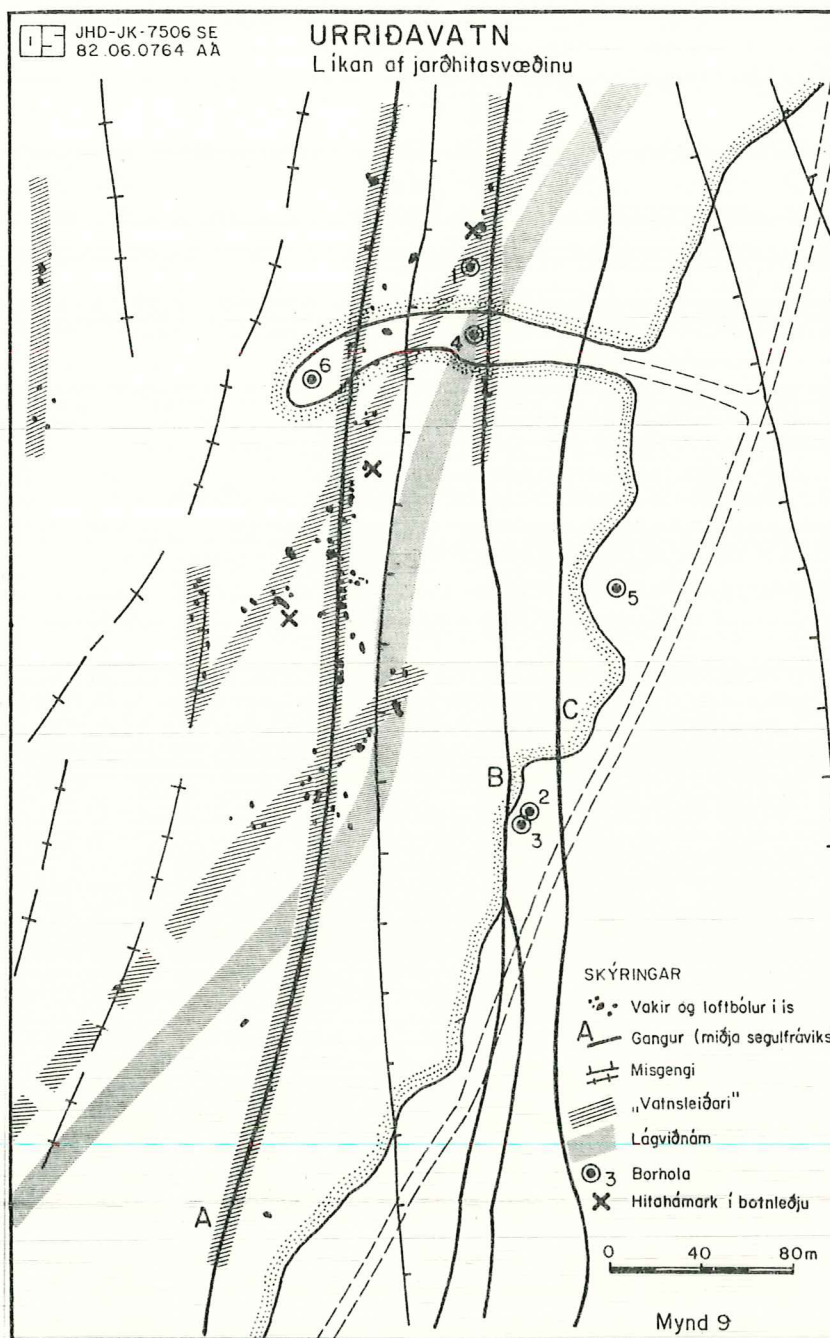
Í greinargerð þessari verður sett fram tillaga að háþrýstiprófun ("hydrofracturing") á holu 3 við Urriðavatn. Fyrirhugað er að dæla vatni með meiri þrýstingi en áður hefur tíðkast hér á landi og á þrengra bili í holunni, til að mynda sprungur í berginu. Með þessum hætti er vonast til að opna leið fyrir vatn úr nærliggjandi vatnleiðara og u.þ.b. 1400 m dýpi og gera holuna þar með nothæfa fyrir hitaveituna.

Notkun háþrýstiprófunar til að mynda sprungur í bergi hefur ekki verið reynd við jarðhitaboranir til þessa hér á landi, en aðstæður eru að mörgu leiti taldar ákjósanlegar að Urriðavatni.

2 LÝSING HOLU 3

Staðsetning holu 3 er sýnd á mynd 1. Hóla þessi var boruð 1976 niður á 1152 m dýpi og dýpkuð árið eftir niður á 1454 m.

Vatnið kemur ofarlega inn í holuna og fengust úr holunni 5-10 l/s af 40° C heitu vatni við dæluprófun. Hóla þessi hefur vegna lágs hitastigs, ekki verið nýtt af Hitaveitu Egilsstaðahrepps og Fella. Hitamælingar gefa til kynna að fyrir neðan 700 m dýpi sé hólán í námunda við 76-79° C heitt vatnskerfi.



MYND 1 Staðsetning borhola við Urriðavatn.

Holan er boruð með 6 3/4" krónu og sýna víddarmælingar að skápar eru algengir á 870-1120 m dýpi, en annarsstaðar séu holuveggir sléttir. Fóðring (10") er aðeins efst (3,2 m) í holunni, fyrir laus jarðlög. Árið 1980 var leitast við að steypa í efstu köldu æðarnar á 90-150 m

dýpi. Neðst í steyputappanum er 4 m langt asbeströr 5" í þvermál. Neðri endi þess er á 142,3 m dýpi. Steypan var síðan boruð út með 6 3/4" borkrónu og 60 cm ofan af asbeströrinu fjarlægðir. Í holunni eru enn 3,4 m af asbeströrinu, en þegar holan var lóðuð reyndist holan opin í botn. Í holunni er einnig 10 m af loftpressuslöngum, sem talið er að fallið hafi til botns (borkýrslur Glaums júlí 1980).

4 HÁPRÝSTIPRÓFUN ("hydrofracturing")

Þrýsiprófanir með pakkara hafa gefið góða raun á kvarterum svæðum hérlandis þó svo að brotþrýstingi bergsins hafi ekki verið náð. Á tertíerum svæðum hefur þetta aðallega verið notað til að hreinsa borsvarf úr æðum. Á Urriðavatni (tertíert svæði) hafa þrýstiprófanir gefið góða raun í að opna holur ofan 500 m, en lítil áhrif haft þar fyrir neðan. Við þessar þrýstiprófanir var dæluþrýstingur 10-30 bör og einn pakkari settur rétt við væntanlegt fóðurrörsdýpi. (150-250 m). Erlendis hafa þrýstiprófanir verið gerðar við mun hærri dæluþrýsting, þannig að sprungur myndast í berginu.

Á Urriðavatni er áhugi á að mynda slíkar sprungur djúpt í svæðinu því botninn á holu 3 á að vera mjög nærri svonefndum lágviðnámsgangi. Gangur þessi er talinn vatnsleiðandi og mögulegt að sprungurnar frá holu 3 næðu yfir í hann. Staðsetning gangsins á yfirborði er sýnt sem skyggt svæði um 50 m vestan við holuna á mynd 1 og hallar honum til austurs að henni.

Í rannsóknarholunni á Reyðarfirði IRDP-1 voru gerðar prófanir með háþrýstipökkurum til að meta spennuástand bergsins. Byggt á reynslu þaðan má reikna út nauðslynglegan dæluþrýsting til að mynda sprungur í berginu (Haimson o.fl. 1982). Lámarsþrýstingur sem þarf til að brjóta bergið er háður þyngd jarðvegsstafalans ofan pökkunarstaðar. Miðað við eðlisþyngd bergs 2,8 g/cm³.

Við þetta bætist um 27,5 bör vegna brotstyrks (tenstile strenght) bergsins til að mynda sprunguna. Í holu 3 þarf því að beita 260-300 bara þrýstingi. Til þess að ná þessum þrýstingi þarf að setja tvöfaldan pakkara í holuna og nota háþrýstari dælur en eru á borum almennt.

Til prófunar af þessu tagi með háþrýstingi (300 bör) þarf að kaupa tvöfaldan pakkara en hentug dæla til verksins er ný steypudæla Jarðborana ríkisins (Halliburton HT-400).

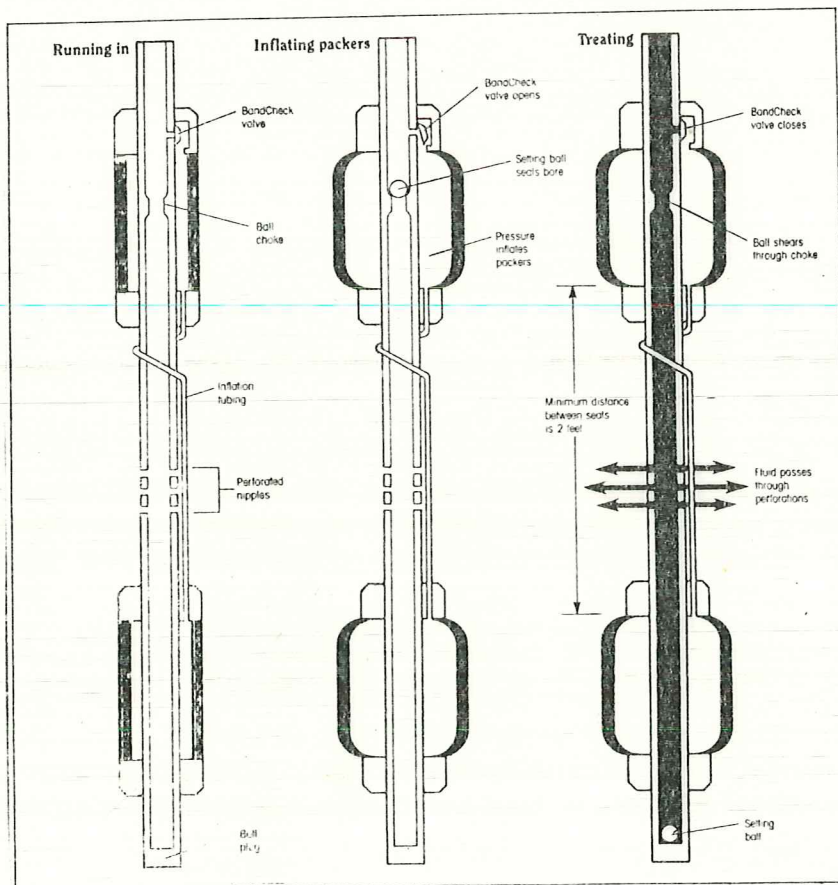
5 KAUP Á TVÖFÖLDUM PAKKARA

Síðastliðinn vetur voru fyrirsprunir sendar til tveggja fyrirtækja um pakkara í 6 3/4" holu sem þyldu 320 bör. Í viðauka I og II eru tilboð og upplýsingar frá þessum fyrirtækjum.

Verð (fob verksm). Lynes Int USD 23.680
Tam Int USD 12.164

Auk þessa þarf að kaupa stálleiðslu (liðaleiðslu) frá dælu yfir í borstangir sem þolir þennan háa þrýsting.

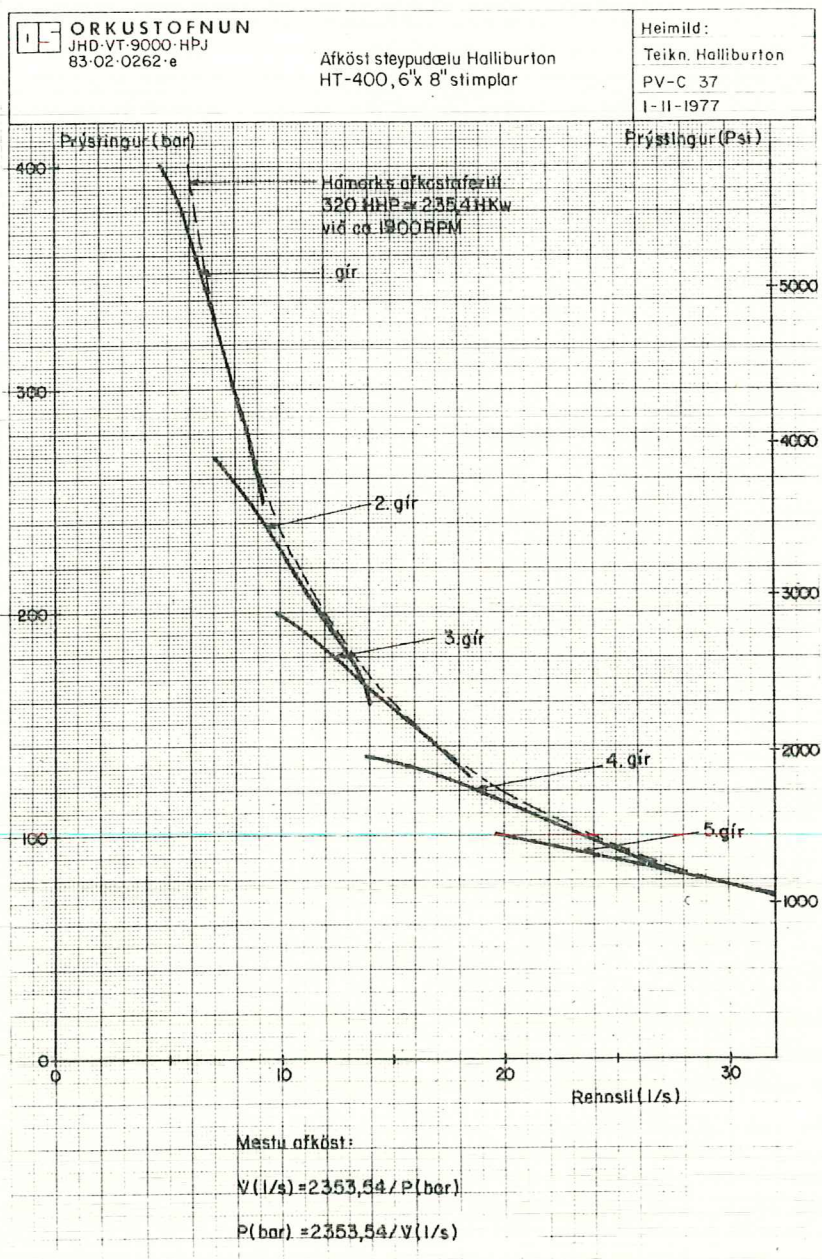
Virgni pakkaranna verður best lýst á mynd 2, en ítarlegri upplýsingar er að finna í viðaukum.



MYND 2 Tvöfaldur pakkari.

6 HÁPRÝSTIDÆLA

Við háprýstipakkanir erlendis er algengt að not stimpildælu sömu gerðar og steypudælu Jarðborana ríkisins. Á mynd 3 er sýnd þrýsti- og afkastageta dællunnar.



MYND 3 Afköst steypudælu Halliburton HT-400

7 VERKÁÆTLUN

1. Borinn Narfi fluttur á holu 3.
2. Leifar af asbeströri boraðar út með 6 3/4" borkrónu.
3. Holan lóðuð til að ganga úr skugga um að hún sé opin í botn og lofdæld til að meta vatnsgæfni.
4. Pakkarar settir í holuna með borstöngum borsins. Bil á milli pakkara 5-10 metrar.
5. Pakkarar settir niður á u.þ.b. 1400 m dýpi og þandir samkv. leiðbeiningum frá framl.
6. Þrýstiprófun hefst og dælt út á milli pakkara þar til þrýstifall verður (brotþrýstingi náð).
7. Æðin prófuð með því að létta af þrýsingi og auka við aftur.
8. Afpakkð samkv. leiðbeiningum frá framl. og tekið upp.
9. Þökkunin endurtekin nokkrum sinnum á öðrum dýptarbilum eftir frekari fyrirmælum.
10. Holan lofdæld til að meta árangur.
11. Ef holan verður talin nýtanleg þarf að rýma og setja fóðringu í hana. Kostaður við það er ekki talinn hluti af framangeindri tilraun.

8 KOSTNAÐARÁÆTLUN

1. Tækjakaup (USD 30.000)	120.000
2. Borleiga (4 verk dagar)	360.000
3. Háþrýstidæla (leiga)	120.000
4. Mælitæki (þrýstimælir)	60.000
	<u>660.000 kr</u>
Ófyrirséð 20%	132.000
Samtals	<u>892.000 kr</u>

ATHUGASEMDIR

Verðlag miðað við júlí 1983.

Reiknað er með að bor verði á staðnum þannig að flutningskostnaður vegna borsins sé í lágmarki.

Afgreiðslufrestur frá verksmíju á pökkurum er 4-6 vikur.

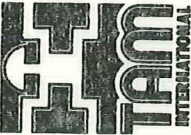
Kostnaður við frágang á holunni þannig að hægt sé að setja dælur í hana er ekki innifalinn.

Kostnaður Jarðhitadeildar Orkustofnunar af tilrauninni er ekki meðtalinn.

Sverrir Þórhallson

Jens Tómasson

VIĐAUKI I



4047 Hollister = Houston, Texas 77080 = Ph: (713) 462-7617 = Cable: TAMINCO = TWX: 910-881-1659

February 15, 1983

National Energy Authority
Geothermal Division
Grensasvegur 9
108 Rejovik
Iceland

Attention: Mr. Sverrir Thorhallsson

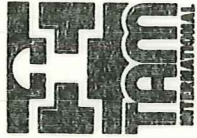
Reference: Your TLX Inquiry 061/83
2-11-83

Gentlemen:

We are including with this letter our quotation on two straddle packer arrangements for your stimulation program. We are also including two copies of our general catalog and a detailed instruction sheet on each of the assemblies.

We wish to point out that the force applied at 5000 psi differential would be 146,500 lbs. In a 6-3/4" ID bore hole using a 2-7/8" OD packer tube, the cross sectional area is 29.30". We use N-80 grade material in our tubes and have used this size pup joints in our straddle wash tool. The minimum tensile requirements for this material is 144,960 lbs so the maximum differential pressure applied should be held to 4947 psi. On any competitive tool, you should be sure that the tensile strength would meet your requirements.

In reviewing our quote and the running instructions, you will note there is a small difference in the prices of the two assemblies. The straddle wash tool does have an outside inflation line, but it is resettable, which would enable you to do more than one zone. We are presently using this tool in the U.S. and it works very well. This could offer you more flexibility in either this particular program or others you may be doing. The extra elements and check valves work on either assembly.



4047 Hollister = Houston, Texas 77080 = Ph: (713) 462-7617 = Cable: TAMINCO = TWX: 910-881-1659

QUOTATION TO: National Energy Authority
Geothermal Division
Grensasvegur 9
108 Rejovik
Iceland

QUOTATION NO.: 308

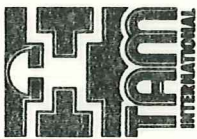
DATE: February 15, 1983

ATTENTION: Mr. Sverrir Thorhallsson

INQUIRY NO.: Your TLX Inquiry 061/83 2-11-83

PRICES VALID FOR: June 1, 1983

ITEM	QUANTITY	DESCRIPTION	DELIVERY:		F.O.B. POINT		DESTINATION:		
			Net 30/Days	4-6 Weeks	ARO	Houston	UNIT PRICE	TOTAL	
2	6-3/16" OD x 2-1/2" ID TAM Single Set Packers						4789.00	9578.00	
1	Bull Plug for Lower Packer						108.00	108.00	
1	2-7/8" EUE 8 R Box & Pin TAMPOR (Pressure Actuated Sleeve) w/4-1.25" Holes						900.00	900.00	
2	4" I F Box x 2-7/8" EUE 8 R Pin Cross Over Subs						526.00	1052.00	
1	2-7/8 EUE 8 R Box x 4" IF Pin Cross Over Sub						526.00	526.00	
						TOTAL		\$12,164.00	
		Above Parts for a Single Set Straddle Assembly							
		6-3/16 Packer Elements					2839.00	2,839.00	
		6-3/16 x 2-7/8" Band Check Shear Pins for TAM PORT					129.00	129.00	
							1.00	1.00	
1	6-3/16" x 2-1/2 Straddle Wash Tool						10,440.00	10,440.00	
1	4" IF x 2-7/8" EUE 8R Crossover Sub						526.00	526.00	
		40' - 1/4" SS Extension Tube					124.00	124.00	
3	2-7/8" EUE 8R x 10' N-80 Pup Joints						343.00	1,029.00	
3	2-7/8 EUE 8R N-80 Couplings						31.00	93.00	
10	2-1/4" Setting Balls						32.00	320.00	
						TOTAL		12,532.00	



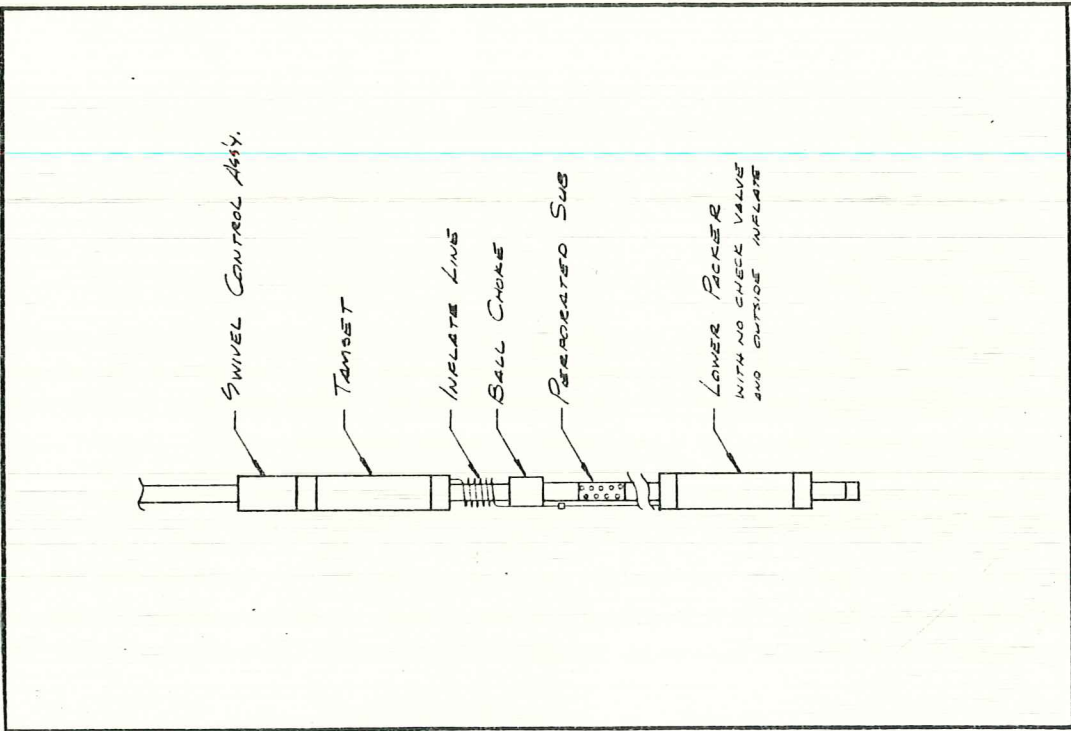
4047 HOLLISTER • HOUSTON, TEXAS 77090 • PH: (713) 462-7617 • CABLE: TAMINCO • TWX: 910-861-1659

Running Instructions For a TAM 2-7/8"
EUE 8R Single Set Straddle Assembly
with a TAMPORT

1. Components are: (Top to Bottom)
 - a. TAM Single Set Packer
 - b. TAMPORT (Pressure Actuated circulating Sleeve)
 - c. Straddle Pipe
 - d. TAM Single Set Packer with bottom end blanked, usually with a bull plug.
2. Connect first joint of straddle pipe to lower packer and lower into hole. Add desired amount of straddle pipe. If straddle pipe is other than 2-7/8" EUE 8R, the necessary cross over sub would be installed into top packer connection.
3. TAMPORT with desired inflation shear pins installed is then placed on top of straddle pipe. Again, if straddle pipe is other than 2-7/8" EUE 8R, the cross over sub required would be installed.
4. Install upper TAM Single Set packer.
5. Screw first joint of running string on top of upper packer with cross over, if necessary.
6. Commence running into hole. If hole is full of fluid, the running string should be filled approximately every 300-500 feet. If hole is not full and if fluid level is not known, filling should be made when packer assembly is at proper depth. When finally fill up of running string is made, enough waiting time should be allowed to allow most or all of the entrapped air to work to surface. Another fill up would then be made and pressure line connected.
7. A differential pressure of approximately 300-500 psi

should be applied to packers and held for approximately 5 minutes. This will allow packers to inflate and "square off". Pressure should then be slowly increased until pins in TAMPORT shear.

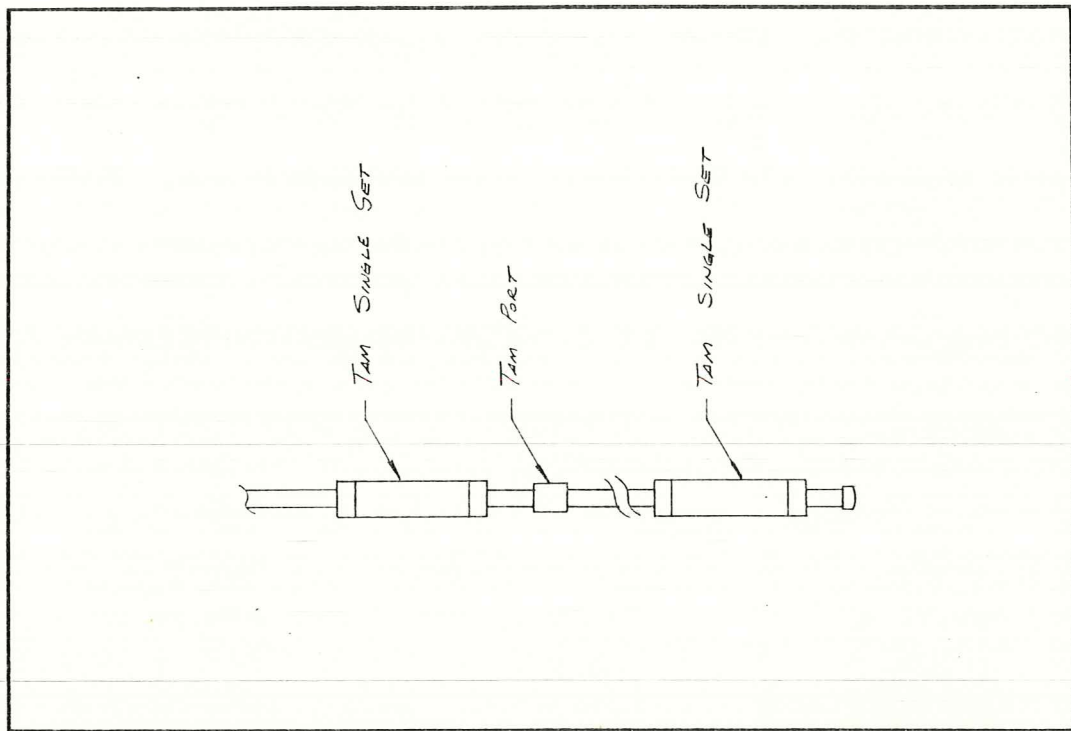
8. Treating, testing, injection, or producing can now be done.
9. When operation 8, above, is completed, pressure is bled off running string and pressure lines are disconnected. Running string should be rotated to right so that at least 6 turns are made at packers. Packers will deflate.
10. Allow approximately 5 minutes for packers to completely deflate and pull from hole.



TAMSET STRADDLE WASH TOOL			
DWG. NO.	SCALE	REV	REV
LOGAN	AS SHOWN	0	0
MATL.	HT. TRT.	FIN.	DATE
TR	TR	TR	2-14-83
CRD	APP.	DWG. NO.	DATE

UNIVERSAL 82-433

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TAM SINGLE SET STRADDLE			
DWG. NO.	SCALE	REV	REV
LOGAN	AS SHOWN	0	0
MATL.	HT. TRT.	FIN.	DATE
TR	TR	TR	2-14-83
CRD	APP.	DWG. NO.	DATE

UNIVERSAL 82-433

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VIĐAUKI II



LYNES INTERNATIONAL, INC. P.O. Box 12468 Houston, Texas 77217 Phone: (713) 943-0170 Telex: 774243 Cable: LYNESINC
16 February 1983

National Energy Authority
Geothermal Division
Grensasvegur 9
108 Reykjavik, Iceland

Attention: Mr. Sverrir Thorhallsson

Reference: Your Telex 060/83 dated February 11/1983

Dear Mr. Thorhallsson:

Thank you for your inquiry referenced above.

Enclosed is Lynes Quotation Number 417/134/83/2303 which details and prices the equipment which we recommend to perform the procedure. Also enclosed are technical brochures and information on the equipment as per your request.

Please let us know if we can be of further assistance. Again, thank you for your interest in our products.

Very truly yours,

LYNES INTERNATIONAL, INC.

André Arnold
André Arnold
Quotations Specialist

AA/bkp
Enclosures

If you should have further questions, please contact us.

Best regards,

TAM International

Howard B. Karstetter

Howard B. Karstetter

HBK:rc

enclosures: 1. quotation
2. 2 copies catalog
3. detailed instruction sheet on each assembly



No. 417/134/83/2303

PLEASE REFER TO THIS NUMBER WHEN ORDERING
417/134/83/2303

Quotation

To: NATIONAL ENERGY AUTHORITY
GEOTHERMAL DIVISION
GRENSASVEGUR 9
108 REYKJAVIK, ICELAND

Date: 16 FEBRUARY 1983

Attn: MR. SVERRIR THORHALSSON Your Reference: TLX 060/83 dated 2/11/83

ITEM	QUANTITY	COMMODITY NO.	DESCRIPTION	UNIT	EXTENSION
<u>STRADDLE EQUIPMENT:</u>					
1.	1	469-01-XXXX	CROSSOVER SUB - 4.5 X H BOX (SAME AS 4.0 IF) X 2.38 EU 8RD PIN		1,421.00
2.	1	300-50-1301	LYNES J-TYPE CIRCULATING SLEEVE, 2.38 EU BOX X 2.38 EU PIN		3,089.00
3.	1	300-01-7505	LYNES SINGLE SET INFLATABLE PRODUCTION INJECTION PACKER WITH NO TURN TAILPIPE 5.63 INCH O.D. X 2.0 INCH BORE X 66 INCH GRIT ELEMENT LENGTH 2.38 EU BOX UP X 2.38 EU PIN DOWN		7,378.00
4.	1	469-01-XXXX	CROSSOVER SUB - 2.38 EU BOX UP X 4.5 XH PIN DOWN		1,421.00
5.	1 JOINT		4.0 INCH 14 LB/FT GRADE E DRILL PIPE WITH 4.0 INCH IF TOOL JOINTS (CUSTOMER SUPPLIED)		N/C
6.	1	469-01-XXXX	CROSSOVER SUB - 4.5 XH BOX X 2.38 EU 8 RD PIN		1,421.00
7.	1	300-55-5301	LYNES "MODEL P" PRESSURE ACTUATED CIRCULATING SLEEVE, 2.38 EU BOX UP X 2.38 PIN DOWN SET WITH 1580 PSI SHEAR PIN SETTING		1,047.00
8.	1	300-01-7412	LYNES SINGLE SET INFLATABLE PRODUCTION INJECTION PACKER, 5.63 INCH O.D. X 2.0 INCH BORE X 66 INCH GRIT ELEMENT LENGTH, SHEAR PLUG DELETED, 2.38 EU BOX UP X 2.88 EU PIN DOWN		5,907.00

The applicable Dept. of Commerce Schedule "B" Commodity Number is: 728.3522 881.3704

Page Total

SIGNATURE: 
ANDRE ARNOLD
QUOTATIONS SPECIALIST

ITEM	QUANTITY	COMMODITY NO.	DESCRIPTION	UNIT	EXTENSION
9.	1	300-55-1601	LYNES MODEL "B" BAR-BALL ACTUATED CIRCULATING SLEEVE, 2.88 EU BOX UP X 2.88 EU PIN DOWN		1,047.00
10.	1	457-60-2202	TUBING COLLAR, 2.88 EU 8 RD BOX X 2.88 EU 8RD BOX		81.00
11.	1	457-61-6412	TUBING NIPPLE 3 FEET LENGTH, 2.88 EU 8RD PIN X 2.88 EU 8RD PIN		371.00
12.	1	469-50-XXXX	BULL PLUG, 2.88 EU 8RD BOX UP		497.00
<u>SPARE PARTS:</u>					
13.	2	04-04384-00	GRIT TYPE INFLATABLE ELEMENT, 5.63 INCH O.D. X 2 INCH BORE X 66 INCH LENGTH (FOR ITEMS 3 & 8)	3,650.00	7,300.00
14.	2	04-19006-00	O-RING REDRESS KIT 5.63 INCH O.D. X 2 INCH I.D. TOOLS (FOR ITEMS 3 & 8)	76.00	152.00
15.	1	04-02551-00	PACKING REDRESS KIT FOR J-TYPE CIRCULATING VALVE FOR ITEM 2		25.90
16.	1	WW-8232-H40	O-RING (FOR ITEM 7)		3.60
17.	1	WW-8229-H40	O-RING (FOR ITEM 7)		3.40
18.	2	04-00457-15	.188 INCH DIAMETER X .437 INCH LONG SHEAR PINS 2 REQUIRED FOR EACH 1580 PSI SHEAR SETTING, (FOR ITEM 7)	2.10	4.20
19.	2	WW-8329-H40	O-RING (FOR ITEM 9)	3.40	6.80
20.	1	04-00457-15	.188 INCH DIAMETER X .437 INCH LONG SHEAR PIN, 1 REQ'D FOR EACH SETTING (FOR ITEM 9)		2.10
TOTAL EQUIPMENT PRICE, F.O.B. LYNES PLANT, HOUSTON, TEXAS USA:					31,178.00

Page Total



LYNES INTERNATIONAL, INC. P.O. Box 12468 Houston, Texas 77217 Phone: (713) 943-0170 Telex: 774243 Cable: LYNESING
STRADDLE PIP ASSEMBLY

PROCEDURE

COMPONENT PARTS (From top of assembly):

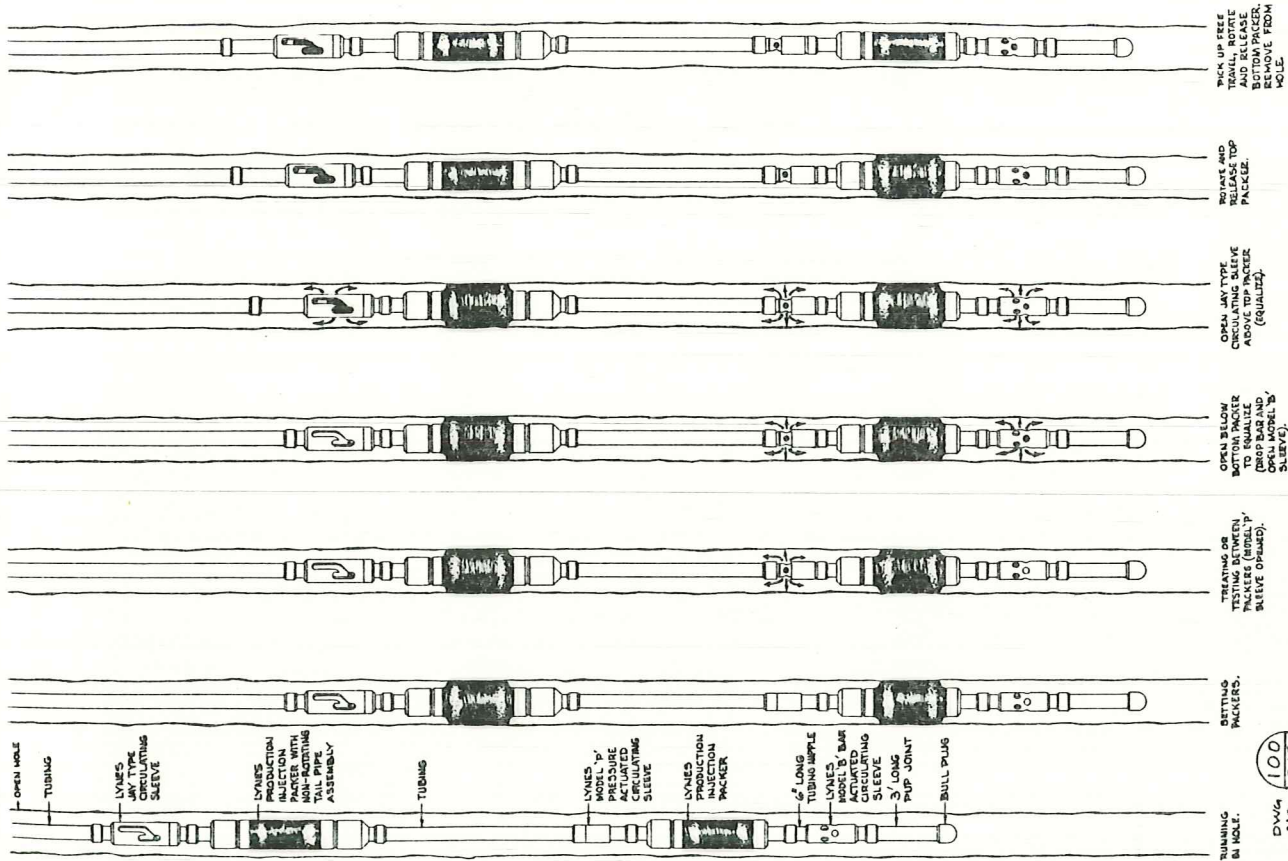
- J-Type Circulating Sleeve
- PIP Packer with Non-Rotating Tailpipe Assembly
- Straddle Spacing
- Model "p" Pressure Actuated Circulating Sleeve
- PIP Packer
- Model "g" Bar Actuated Circulating Sleeve

OPERATING PROCEDURE:

- 1) Pickup tools and run in hole with straddle assembly. Fill entire assembly and two to three joints above assembly with clean fluid (but only if assembly is immersed in well fluid) and run to full depth.
- 2) When the desired depth is reached, finish filling the string.
- 3) Pressure up slowly to approximately 1500 PSI "differential" pressure and continue to pump until pronounced pressure drop is noted. At this point, packers will have been inflated and set and Model "p" sleeve is opened.
- 4) Open the J-Type Circulating Sleeve above the top packer by lifting the weight of the pipe string, plus pulling an additional 5,000 lbs. Torque tubing to the left and hold torque while lowering string back down until about 2,000 lbs. tubing weight on bottom. While still holding left hand torque, lift string back up slowly. A free movement of 8" to 12" should be noted. Continue to lift until about 2,000 lbs up weight is noticed and continue to hold. J-Type Circulating Sleeve is now open.
- 5) Displace contents of tubing or pipe string with intended injection fluid.
- 6) Close J-Type Sleeve by application of right hand torque and slowly lowering tubing until 2,000 lbs is setting down. Maintain torque and lift tubing slowly back up to lock valve closed.
- 7) Proceed with planned injection treatment procedure.
- 8) When treatment is complete, drop a .75 to 1.0 inch (maximum) O.D. bar and allow to fall to bottom to open bar actuated Circulating Sleeve. Then open the J-Type Sleeve (see step 4 above) and allow 15 minutes or more for pressure to equalize across both packers.
- 9) Once equalized, rotate the string eight (8) turns to the right while holding a slight upward pull. Twelve (12) inches of free move should be observed when the top packer is released. Allow ten (10) minutes for the element to fully retract.

.....Continued

- 10) Pull up approximately 5,000 lbs against the bottom packer and again rotate tubing to the right eight (8) complete turns. When free movement is again observed, allow a further ten (10) minutes for full packer deflation to occur.
- 11) Pull out of hole, procedure complete.



TRICK UP FREE
PACKER AND
RELEASE
BOTTOM PACKER.
REMOVE FROM
HOLE.

ROTATE AND
RELEASE TOP
PACKER.

OPEN AWK TYPE
CIRCULATING SLEEVE
ASSEMBLY
(EQUALIZER).

OPEN BELOW
BOTTOM PACKER
(DROP BAR AND
OPEN MODEL 'B'
SLEEVE).

TREATING OR
TESTING BETWEEN
SLEEVES (IF
SLEEVE OPENED).

SETTING
PACKERS.

RUNNING
& HOLE.

(EIO)
001
DWA
N^o